# 3rd INTERNATIONAL CONFERENCE
# 3D MEASUREMENT AND IMAGING

MEDZINÁRODNÁ KONFERENCIA 3D ZOBRAZOVANIE A MERANIE (3. ročník)

## *MODERN CONTACTLESS MEASUREMENTS IN INDUSTRIAL PRACTICE*

*MODERNÉ BEZKONTAKTNÉ MERANIA V PRIEMYSELNEJ PRAXI*

SEA
Agentúra pre vzdelanie a vedu

# Abstracts and Presentations

*Abstrakty a prednášky*

**10th - 11th OCTOBER, 2018**
ODOBORÁRSKA 21, BRATISLAVA

# ABSTRACTS AND PRESENTATIONS

3rd INTERNATIONAL CONFERENCE **3D MEASUREMENT AND IMAGING**

***MODERN CONTACTLESS MEASUREMENTS IN INDUSTRIAL PRACTICE***

**10th-11th OCTOBER, 2018**

ODOBORÁRSKA 21, BRATISLAVA

**Expert Guarantors**:

RESEARCH FOR PEOPLE — VÝSKUMNÉ CENTRUM ŽILINSKEJ UNIVERZITY V ŽILINE

International Laser Centre

**Organized by:**

SEA — Agentúra pre vzdelanie a vedu

**Main Partners:**

3DMI

Allied Vision

KVANT®

**Partners:**

TESCAN — PERFORMANCE IN NANOSPACE

Nikon

EXPERT FOR 3D LANDSCAPE

VEXCEL IMAGING

RIEGL

euclideon UNLIMITED.

simactive

HySpex

# Contents

# GENERAL TRENDS IN COMPUTER VISION

**Michael Ross** [1]

[1] Allied Vision Technology

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# 3D MEASUREMENT AND IMAGING

*MODERN CONTACTLESS MEASUREMENTS IN INDUSTRIAL PRACTICE*

Allied Vision

## SEEING THE BIGGER PICTURE - GENERAL TRENDS IN COMPUTER VISION

Michael Ross, Sales Development Manager EMEA

# HIGH-PERFORMANCE DIGITAL CAMERAS


**Quality designed and made by Allied Vision**

- In-house development and manufacturing
- Widest product range in the market for nearly all machine vision applications
- Cutting-edge digital technology
    - High resolution, high sensitivity
    - Visible and infrared spectrum
    - Large choice of standard interfaces

Allied Vision

# APPLICATIONS EXAMPLES

## Industrial Inspection

**Ziemann & Urban**
Inspection of BMW instrument panel carriers

## Healthcare & Medical

**Carl Zeiss Meditec**
Opthtalmologic examination device

## Science & Nature

**NASA**
ISS astronaut-robot Robonaut 2

## Security & Traffic

**Kria**
Radar-free speed enforcement

## Multimedia & Entertainment


**Forever 21/space150**
Times Square, NYC giant interactive billboard

# A GLOBAL PLAYER


- 8 locations worldwide
- Distribution partners in more than 30 countries

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# Application and technology trends

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# LATEST APPLICATION TRENDS IN COMPUTER VISION

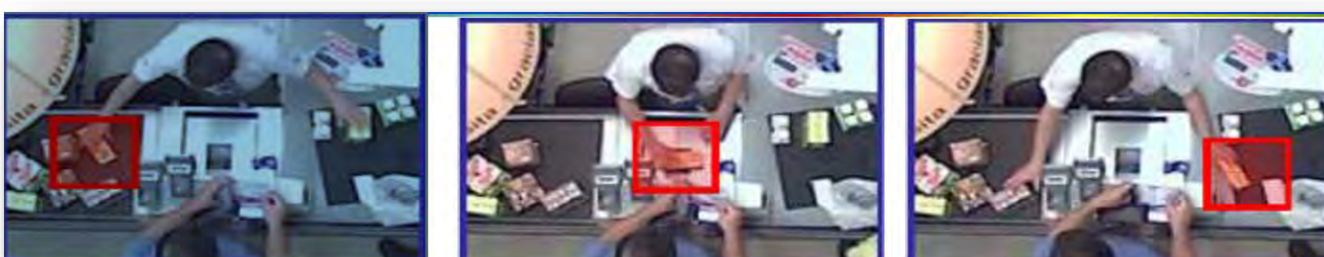
- Autonomous Systems (drones, service robots …)


- Virtual / Augmented Reality


# LATEST APPLICATION TRENDS IN COMPUTER VISION

- Security / Surveillance


- New Retail concepts (vision based checkout, automated inventory and delivery, smart vision based theft protection …)



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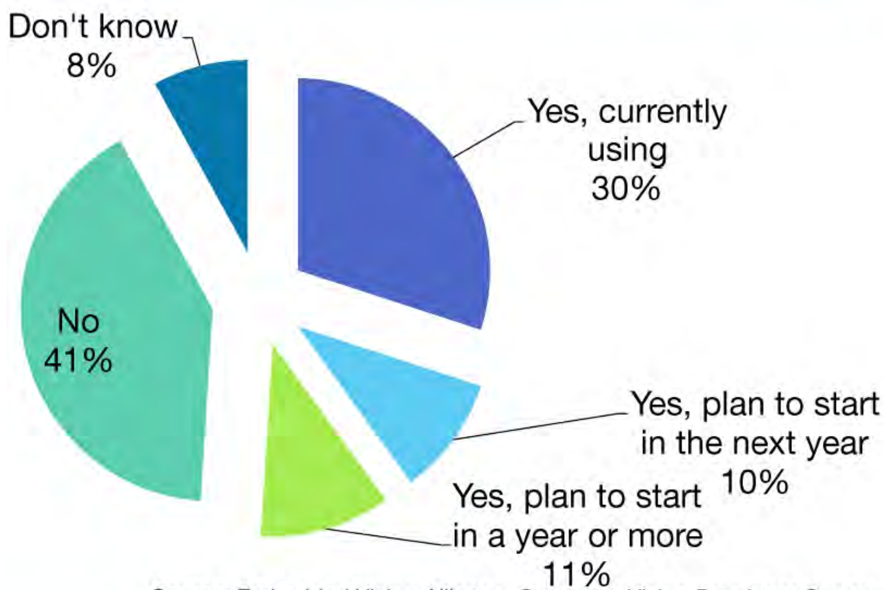
# EMERGING TECHNOLOGY TRENDS (TO ENABLE APPLICATION TRENDS)

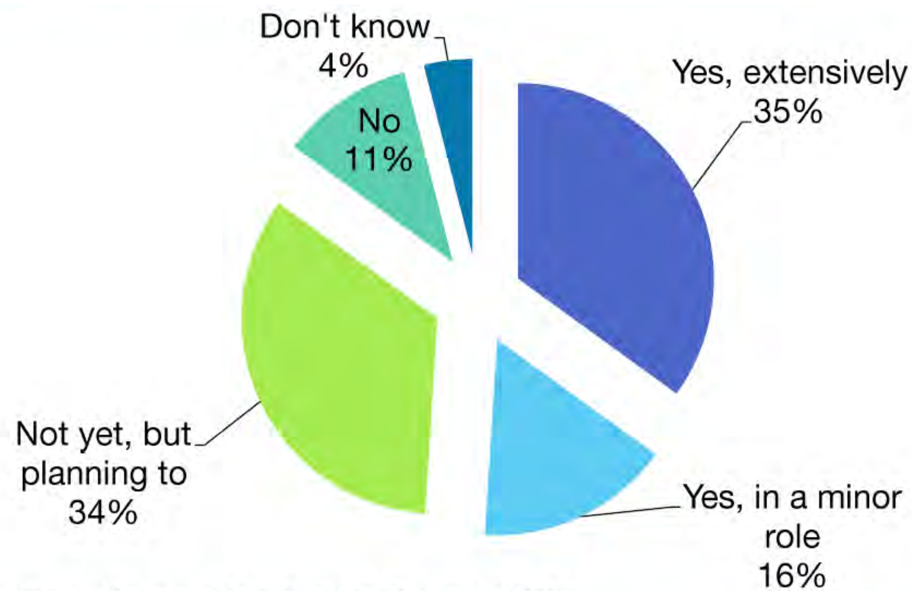
- 3D technologies: current use of 3D perception in products




Source: Embedded Vision Alliance, *Computer Vision Developer Survey, 11/2017*

# EMERGING TECHNOLOGY TRENDS (TO ENABLE APPLICATION TRENDS)

- AI/neural networks: current use neural networks to perform computer vision functions




Source: Embedded Vision Alliance, *Computer Vision Developer Survey, 11/2017*

# EMERGING TECHNOLOGY TRENDS (TO ENABLE APPLICATION TRENDS)

- Embedded vision -> separate presentation

# The new BonitoPRO cameras

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# BONITOPRO AS A CAMERA FOR HIGH PERFORMANCE 3D APPLICATIONS


- //**High** Speed
- //**High** Resolution
- //**High** Performance
- //**High** Quality

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# BONITO PRO COAXPRESS CAMERA SERIES

// Works with any Frame Grabber SDK

// Mono, color and NIR version available

// Very accurate triggering capability with real time behavior

// No additional trigger cable or power supply needed

- **Application examples:**
  - **High speed and high resolution 3D imaging (stereo vision or structured light setup)**
  - Automated Optical inspection, e.g PCBs
  - Surface inspection, e.g. glass, flat panel display, printing etc.
  - Aerial surveillance

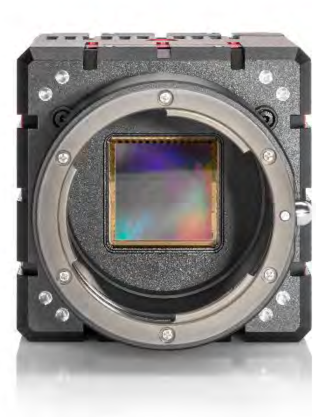

CXP-6

Allied Vision

# BONITO PRO – MODEL AND FEATURE OVERVIEW

| Model | Sensor | Type | ADC [bits] | Resolution | Pixel Size [µm] | Sensor Size | Frame Rate [fps] | Order Code |
|---|---|---|---|---|---|---|---|---|
| **X-1250B/C/NIR** | PYTHON 12k | CMOS | 10 | 4096 × 3072 | 4.5 × 4.5 | 4/3” | 142.6 | 02-2880D/02-2881D/02-2882D |
| **X-2620B/C/NIR** | PYTHON 25k | CMOS | 10 | 5120 × 5120 | 4.5 × 4.5 | APS-H | 79.7 | 02-2884D/02-2885D/02-2886D |

- CXP-6
- High Ambient Operating Temperature Range
- F/EF/M42/M58 Mount
- Canon EF lens control



- Power over CoaXPress (PoCXP)
- Trigger over CoaXPress (ToCXP)
- Opto isolated Inputs/Outputs
- Temperature monitoring

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# WHAT IS COAXPRESS?

## The CoaXPress Interface

- Developed for high speed image data transmission in Machine Vision applications
- Also suitable for other imaging applications and high speed data transmission in other fields
- First demonstrated in 2008, officially released as a standard in March 2011
- Japan Industry Imaging Association (JIIA) regulates the standard and overlooks compliancy
- Up to 6.25Gbps over single coax cable → 25Gbps using four cables (CXP-6 Quad)
- Long cable lengths possible without repeaters/hubs. Maximum cable lengths bit rate dependant
- **CoaXPress frame grabber always required**

# TESTED FRAME GRABBERS

- Euresys Coaxlink Quad G3
- Active Silicon FireBird Quad CXP-6
- Teledyne Dalsa Xtium-CXP PX8
- Silicon Software microEnable 5 ironman
- Bitflow Cyton-CXP
- … More will be tested later (Aval Data, Matrox, Kaya)
- **Should work with all CoaXPress standard certified frame grabbers**

Allied Vision

# BONITOPRO AS A CAMERA FOR HIGH PERFORMANCE 3D APPLICATIONS

# Thank you very much!

**Michael Ross**
Sales Development Manager EMEA

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**Allied Vision Technologies GmbH**
www.alliedvision.com

# ROBOTIC 3D VISION TECHNOLOGIES WITH GOCATOR 3D SMART SENSORS

**Edwin Popp** [1]

[1] LMI Technologies

3rd INTERNATIONAL CONFERENCE

# 3D MEASUREMENT AND IMAGING

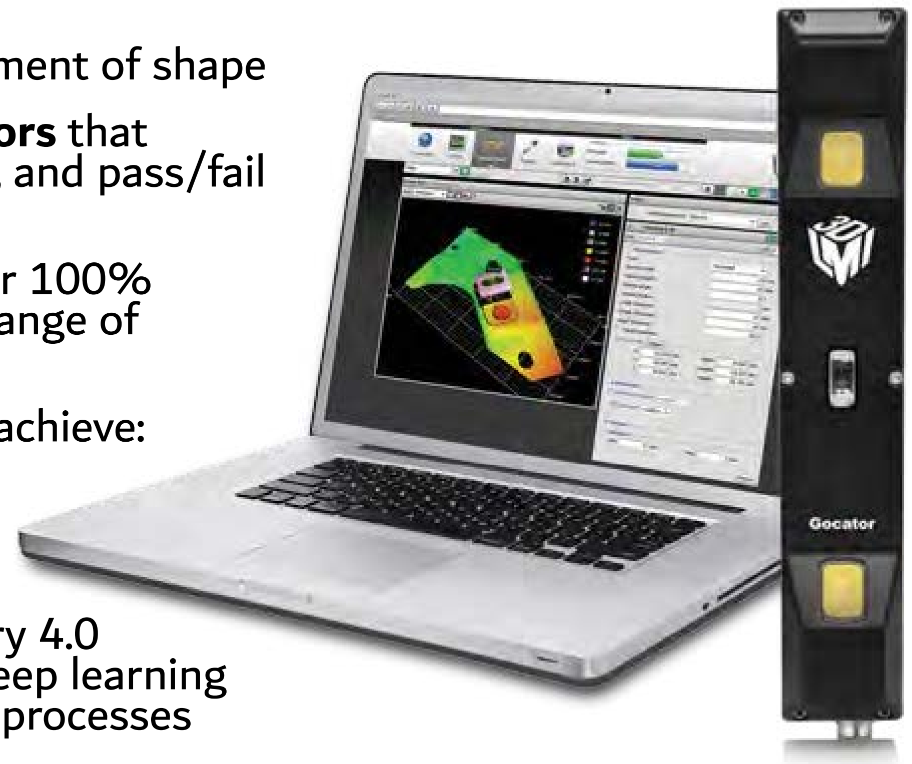
*MODERN CONTACTLESS MEASUREMENTS IN INDUSTRIAL PRACTICE*

## ROBOTIC 3D VISION TECHNOLOGIES WITH GOCATOR 3D SMART SENSORS

Edwin Popp, Territory Manager, LMI Technologies

# 3D SCANNING AND INSPECTION

- 3D technology enables the measurement of shape
- We design and build **3D smart sensors** that perform 3D scanning, measurement, and pass/fail decisions in an **all-in-one package**
- Our smart sensors are used inline for 100% scanning and inspection in a broad range of markets and applications
- Smart sensors enable customers to achieve:
    - Automation
    - Optimization
    - Quality control
- Smart sensors are the key to Industry 4.0 delivering actionable data to drive deep learning systems for dynamic manufacturing processes



# QUICK FACTS

**Owned by TKH Group**

- Dutch public company (AMS: TWEKA)
- €1.35B annual revenue
- Focused on vision & security, communication, connectivity and production systems

**39+ years experience**

1978 – Present


*One of our Selcom displacement sensors developed in the 1970s*

**100+ patents**

and 280+ employees

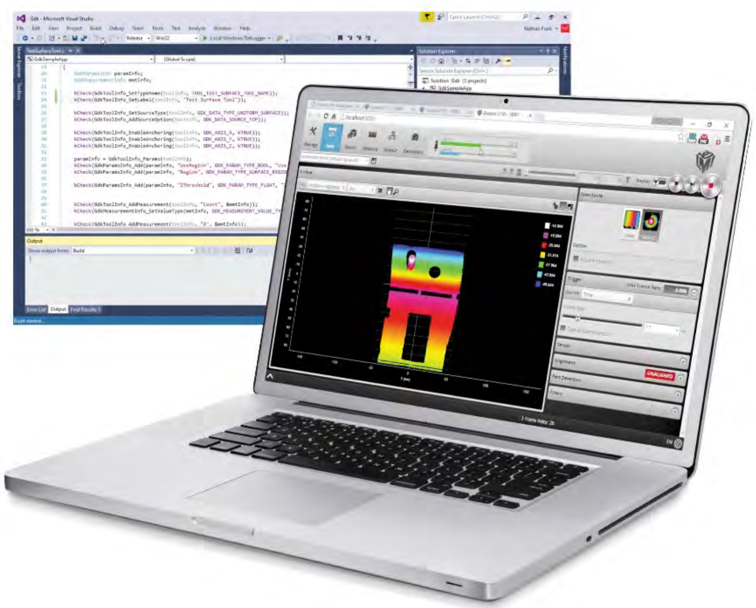
**110,000+ sensors**

in the field

# GLOBAL PRESENCE

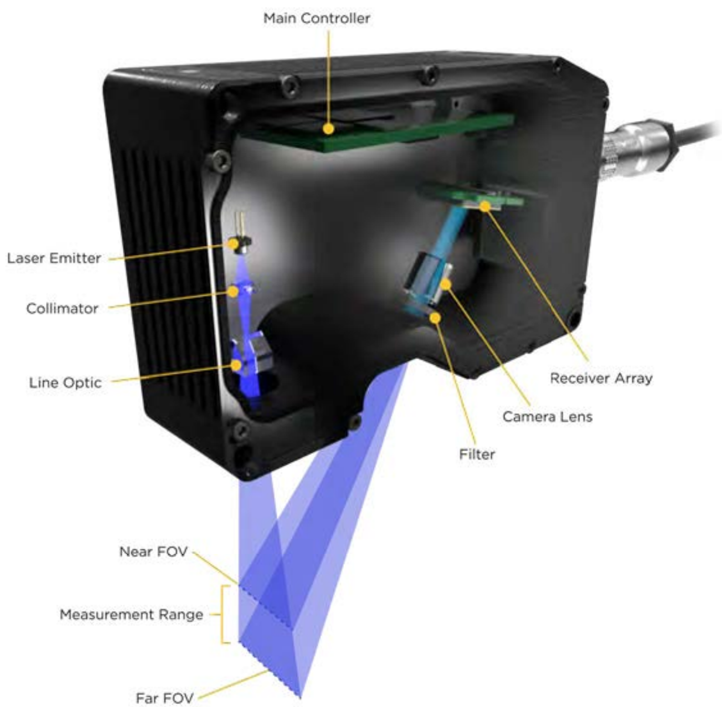
# 3D SCANNING AND INLINE INSPECTION

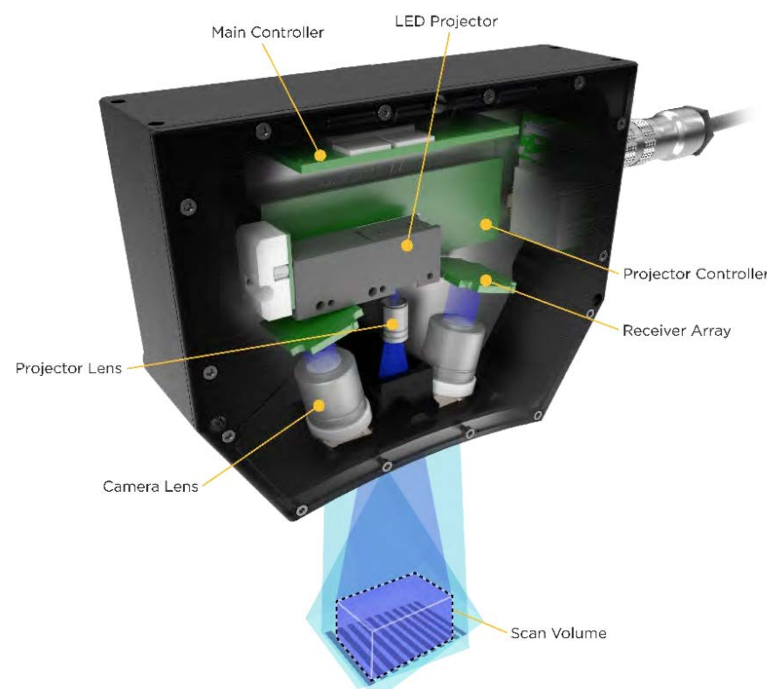
- HIGH SPEED, HIGH ACCURACY 3D SENSORS
- HIGH PERFORMANCE 3D MEASUREMENT ALGORITHMS

# TWO 3D TECHNOLOGIES FOR METROLOGY-GRADE INSPECTION

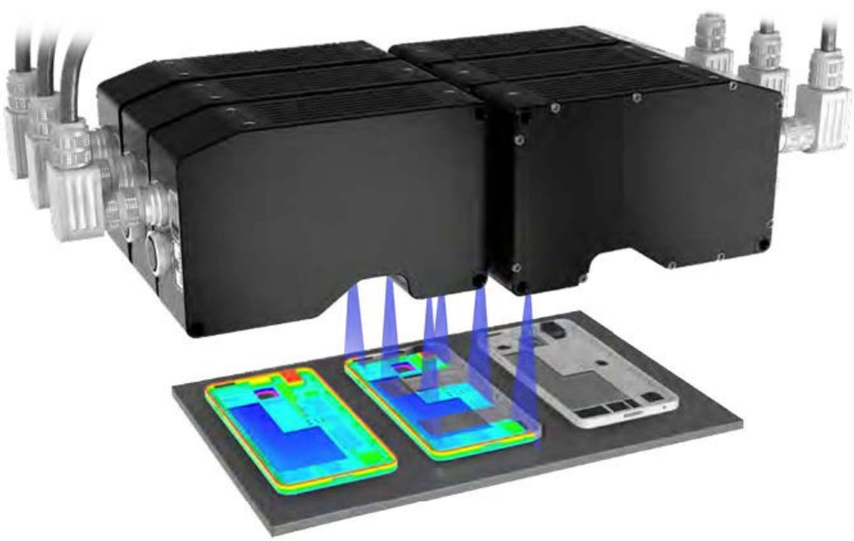
- LASER (TRIANGULATION) PROFILERS
- STRUCTURED LIGHT SNAPSHOT SENSORS

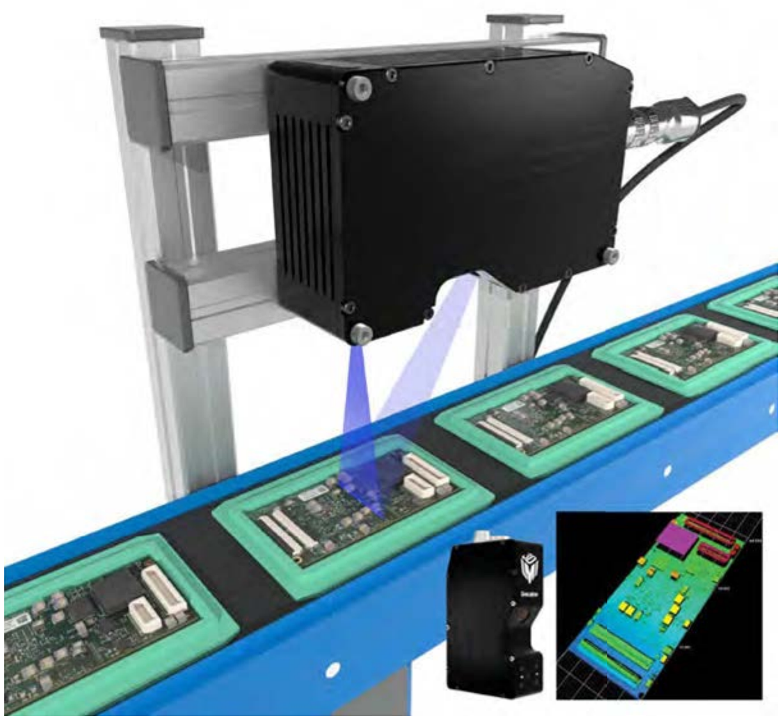


# GOCATOR LASER PROFILERS

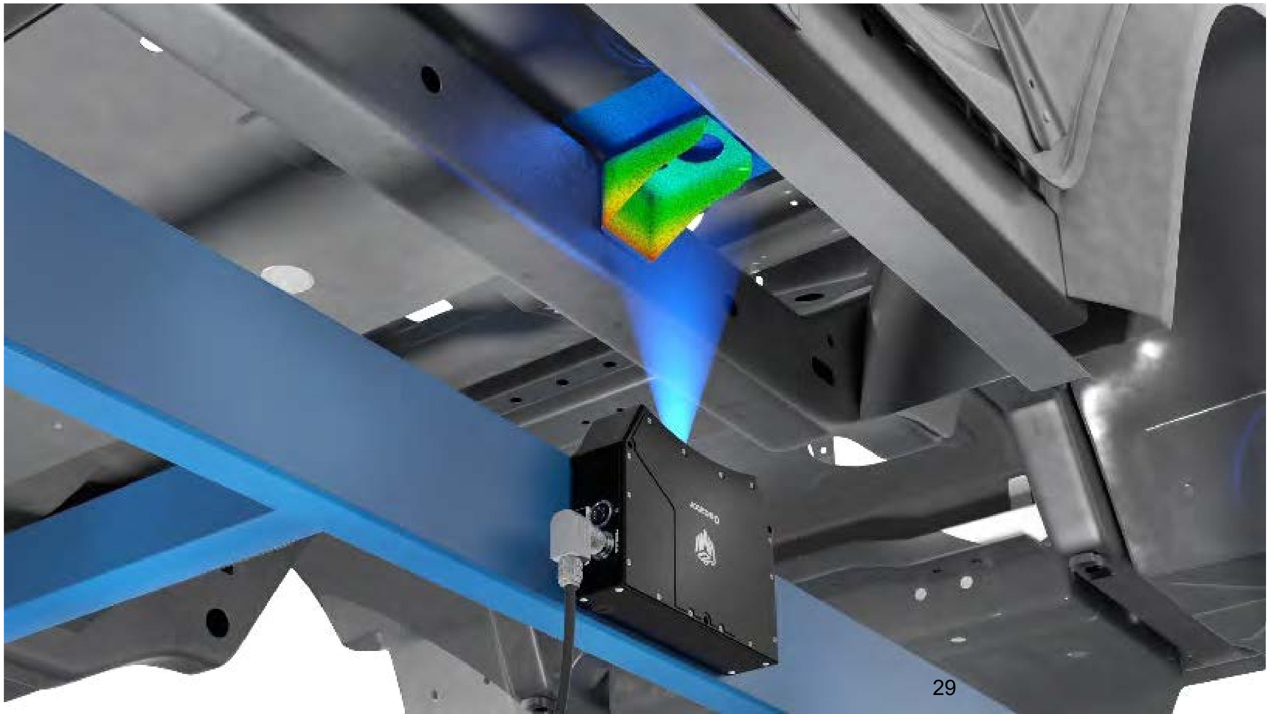
- Gocator point and line profile sensors can inspect any moving target inline with resolutions down to 6 μm and sampling speeds up to 32 kHz

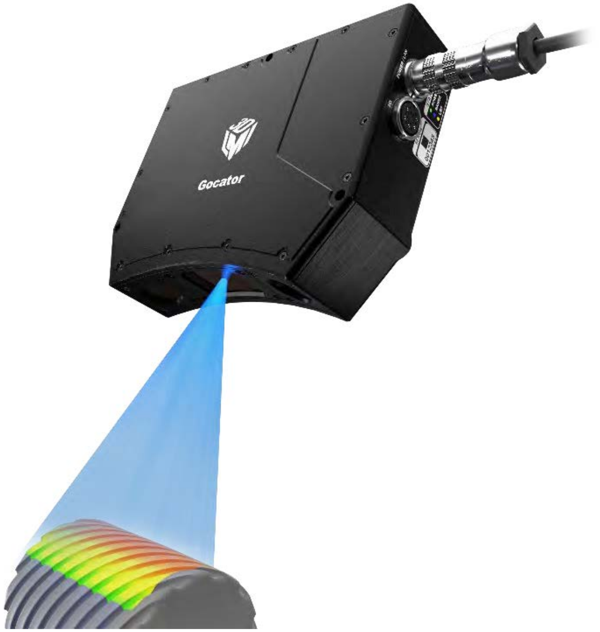




# GOCATOR SNAPSHOT SENSORS

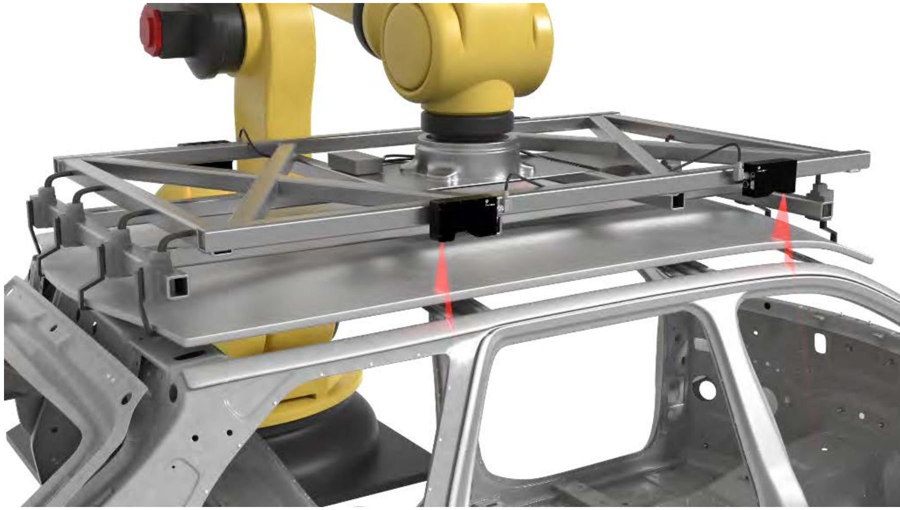
- Gocator stereo snapshot sensors generate full-field 3D point clouds with a single scan trigger to inspect any target with start/stop motion in an inline process





# DRIVERS OF VISION-GUIDANCE SYSTEMS

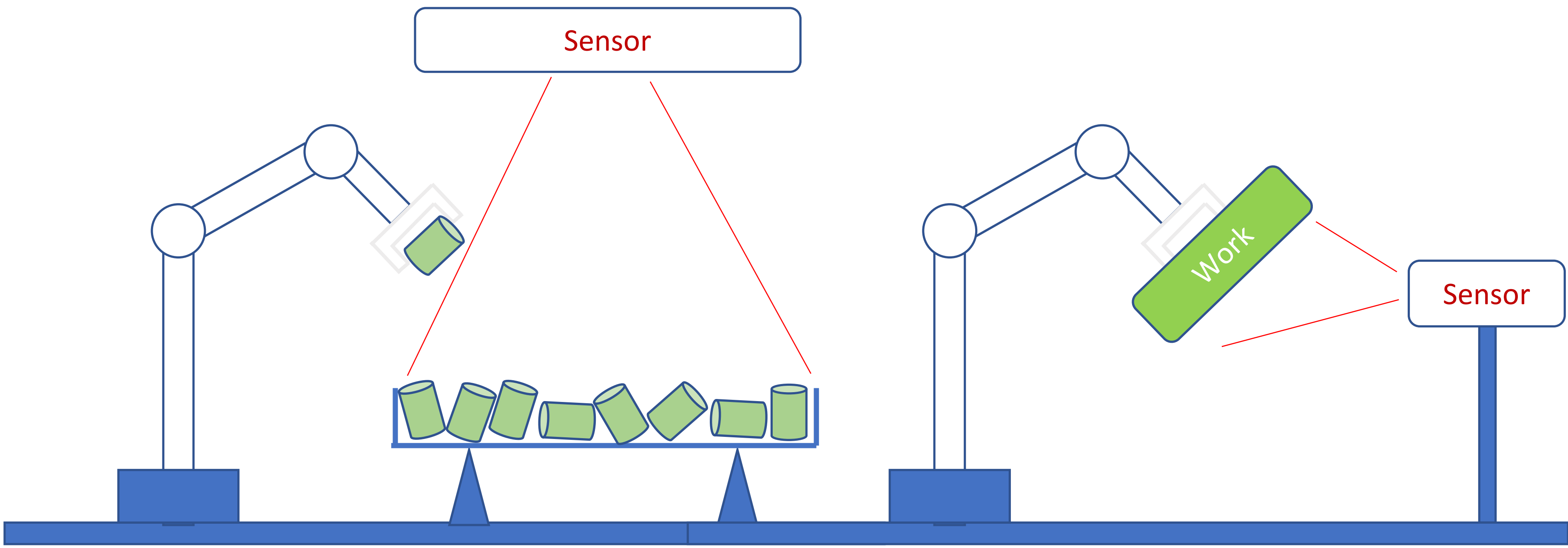
- Need to reduce labor costs
- Reduced fixture and tooling cost
- 3D vision sensors and greater processing power
- Robust image-processing software and algorithms
- Guidance increases applications spectrum for robots



# ROBOTIC 3D VISION

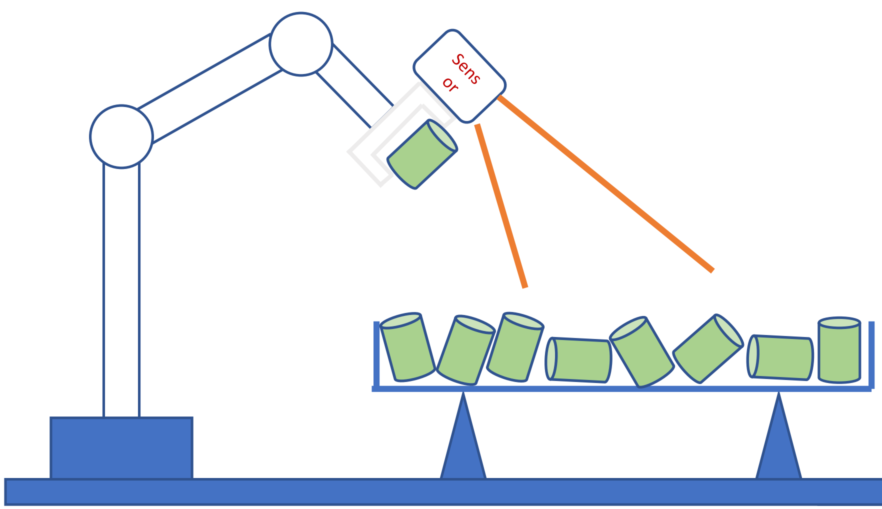
## 1. Mounted on Frame

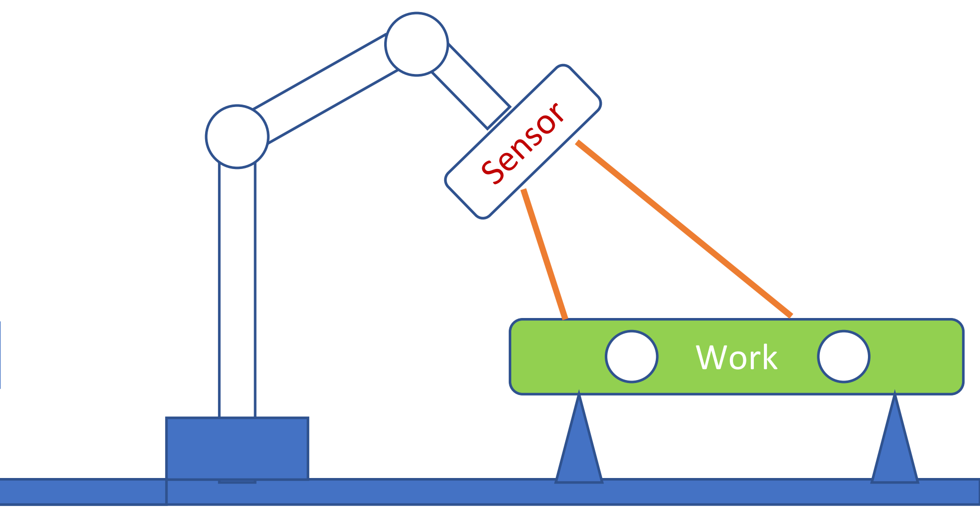
- On frame scanning pick and place system: scan through on frame sensor, and let the robotic arm pick up the pieces.
- Key dimensions of the pieces mounted o a robotic arm will be inspected by sensor. Inspection and sorting will be completed during loading and unloading period.



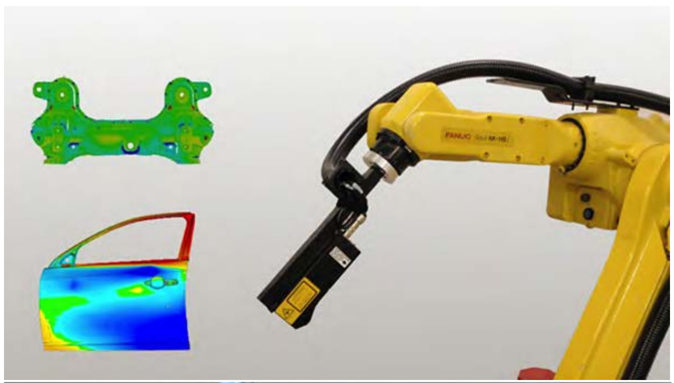
# ROBOTIC 3D VISION

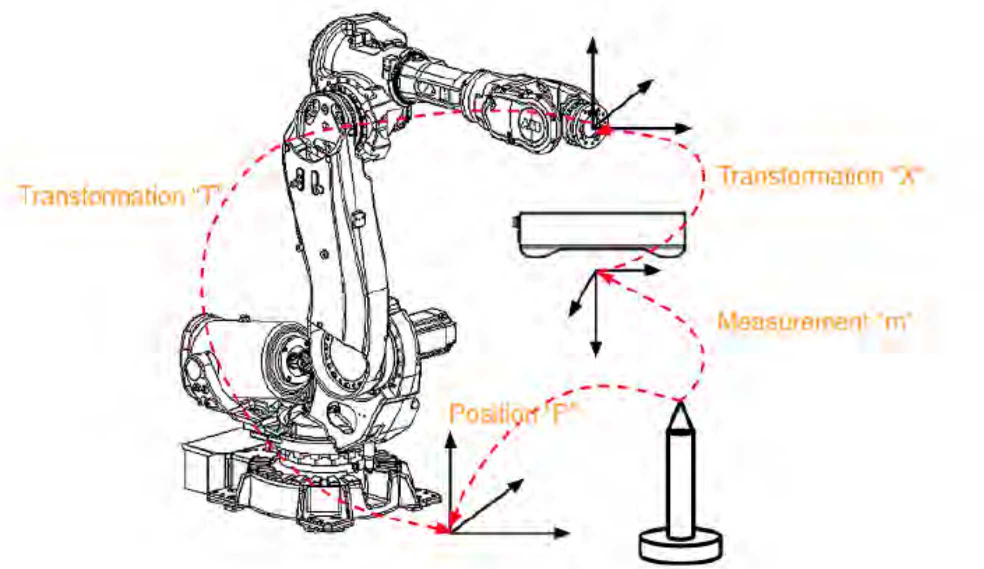
- Mounted on Robotic Arm
  - On hand sensors perform real-time positioning, and realize real-time integration such as pick-and-place, welding tracking, positioning and installation
  - A large object can be inspected by a robotic arm mounted with the sensor. While ensuring the accuracy, it also breaks through the limitations of sensor measurement, and achieves complete inspection for large objects.



# ROBOT HAND-EYE CALIBRATION




$P_1 = [T_1] \cdot [X] \cdot m_1;$

$P_2 = [T_2] \cdot [X] \cdot m_2;$

......

$P_n = [T_n] \cdot [X] \cdot m_n$

# CHALLENGES OF ROBOTIC 3D VISION

## Communication

- Different communication protocols due to variety of robots
- Only I/O protocol available communicating with robot, and cannot achieve more advanced communication
- Multiple signals can not be outputted
- Communicate via the host computer

## Calibration

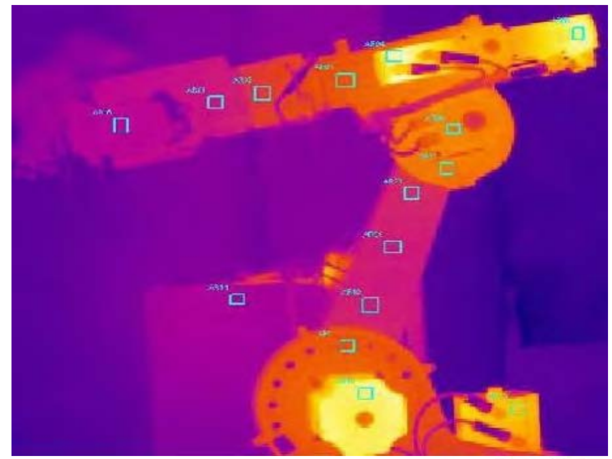
- Need to start with camera calibration and cannot be calibrated directly with the robot
- The sensor itself does not have a mature calibration algorithm
- Calibration error cannot be guaranteed
- Calibration via PC software

## Algorithm Development

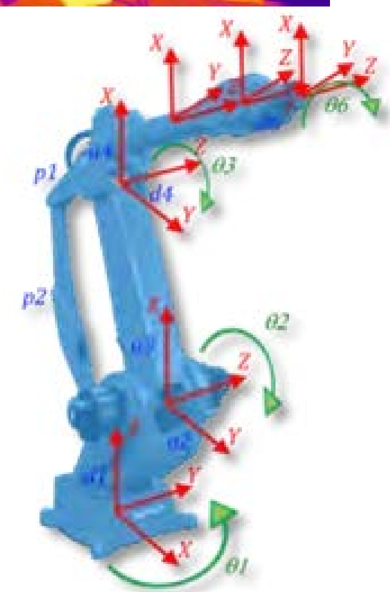
- Non-smart sensors are not able to measure size
- No rich algorithms and need to rely on third party software
- Not support further development
- Need extra PC and software, which will increase the cost

# CHALLENGES OF ROBOTIC 3D VISION

## Temperature Compensation



- Most industrial robots consist of aluminum alloys which are subject to the temperature changes
- Most robot calibration depends on the repeatability of the robot itself, such as robot welding, assembly and inspection, etc.
- Compensation of robotic error caused by outside temperature changes is particularly important, temperature compensation is a real-time monitoring robot tool center point (TCP) process with temperature changes.
- Based on monitoring of change value and the parameters of robot DH model, the corresponding DH model parameter settings can be calculated to compensate for the variation of TCP with the temperature changes



# MORE THAN JUST A SENSOR


Gocator is a complete inspection platform – combining 2D and 3D data **acquisition**, **measurement** tools and control logic supported by industry-first **customization tools** running within a web browser **user experience**.

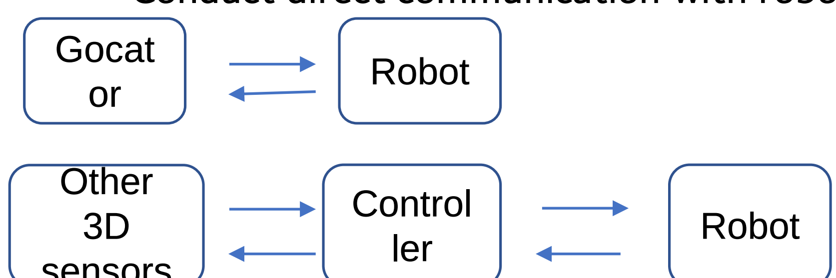
# THE GOCATOR ADVANTAGE

## Communication

- Different communication protocols due to variety of robots
- Only IO protocol available communicating with robot, and can not achieve more advanced communication
- Multiple signals can not be output
- Communicate via the host computer

## Gocator Solution

- Gocator all-in-one 3D smart sensor, no need host computer or controller, support for "plugging into" PLCs or robot controllers
- Gocator gives you the flexibility to simultaneously output data and decisions to a wide variety of I/O
- Allows you to easily communicate with your existing hardware including PLCs and robot controllers via TCP/IP or Ethernet IP protocols
- Conduct direct communication with robots



# THE GOCATOR ADVANTAGE

## Calibration

- Need to start with camera calibration and cannot be calibrated directly with the robot
- The sensor itself does not have a mature calibration algorithm
- Calibration error can not be guaranteed
- Calibration via PC software

## Gocator Solution

- Factory pre-calibrated, and the user only needs to consider the coordinate conversion between the robot and camera
- Through direct communication, robot calibration, without other host computer or software can be realized
- A mature calibration algorithm that can be used to calibrate sensor and robot
- Gocator is a highly accurate sensor, is far greater than the repetitive positioning accuracy of the robot itself, which can ensure minimize the calibration error even realize the correction of the robot itself through specific method (such as robot origin error and the error caused by the temperature change or abrasion )
- Performing robot hand eye calibration can be available through third party software

# THE GOCATOR ADVANTAGE

## Algorithm Development

- Non-smart sensors are not able to measure size
- No rich algorithms and need to rely on third party software
- Not support further development
- Need extra PC and software, which will increase the cost

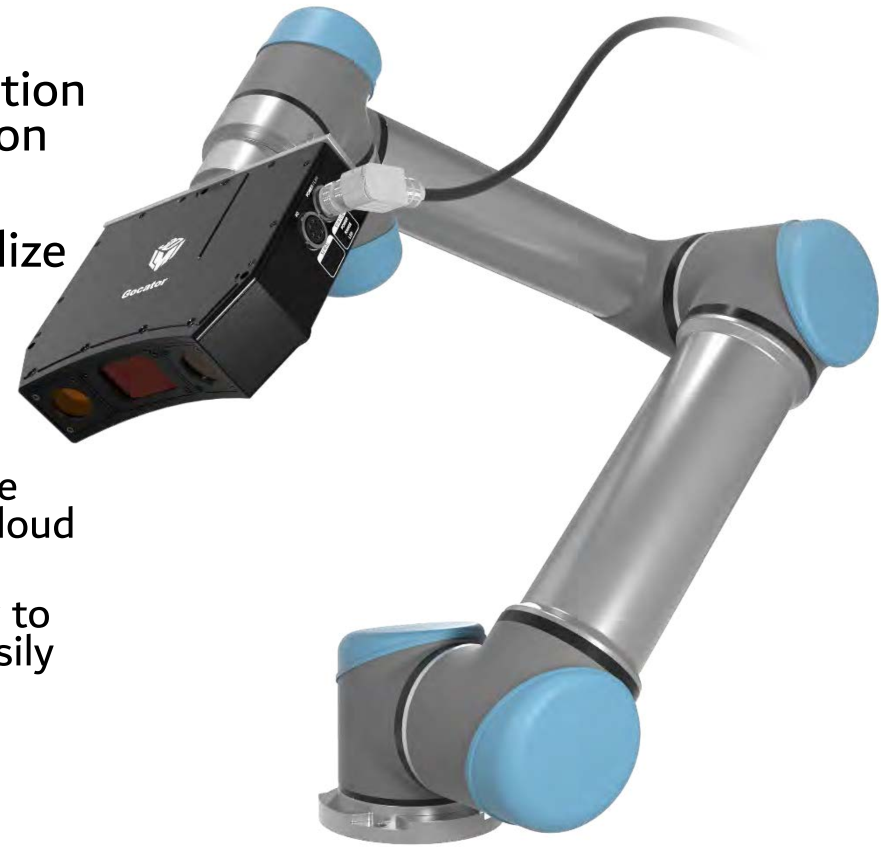
## Gocator Solution

- Rich SDK and Gocator Development Kit (GDK) tools, and free open to users
- No need for third party software, and can be integrated into the sensors. No other hardware required.
- Standard tools within Gocator are able to achieve many measurements out of the box and are a result of extensive

# THE GOCATOR ADVANTAGE

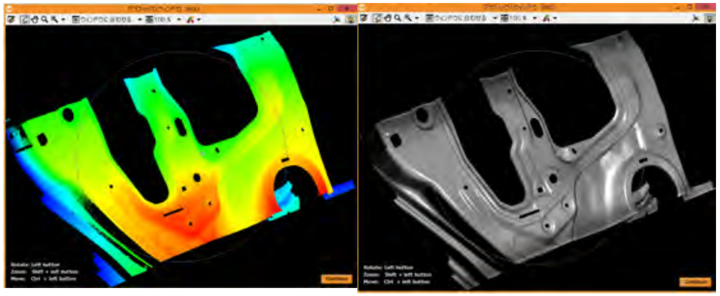
## Temperature Compensation

- The key of robot temperature compensation is to precisely determine the TCP variation caused by the temperature change
- Gocator snapshot sensors can easily realize the calibration of temperature compensation:
    - The 3D point cloud data can be obtained without any movement
    - DLP projection and stereo cameras acquire high accuracy and high density 3D point cloud data
    - All-in-one design, compact footprint, easy to use without any controller and PC, and easily integrated into the robot arm
    - Rugged IP67 construction for harshest industrial environments
    - Build-in temperature compensation

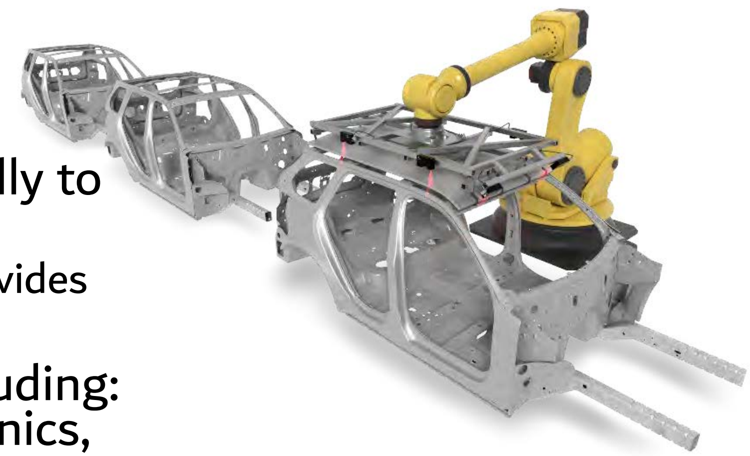


# FLEXIBLE AUTOMATION

- The ability for a robot to be quickly and easily re-tasked on-the-fly
  - Requires the solution to have the ability to sense, think, and act
  - Ultimately adapt to changes in manufacturing
  - Ex) multi-model production
- Size and weight is critical when mounted on robots
- Gocator 3210:
  - 100 x 154mm Scan view
  - IP67, dust-proof and water resistant
  - Shock and vibration resistance
  - Built-in 3D measurement tools



# BENEFITS OF ROBOT VISION GUIDANCE



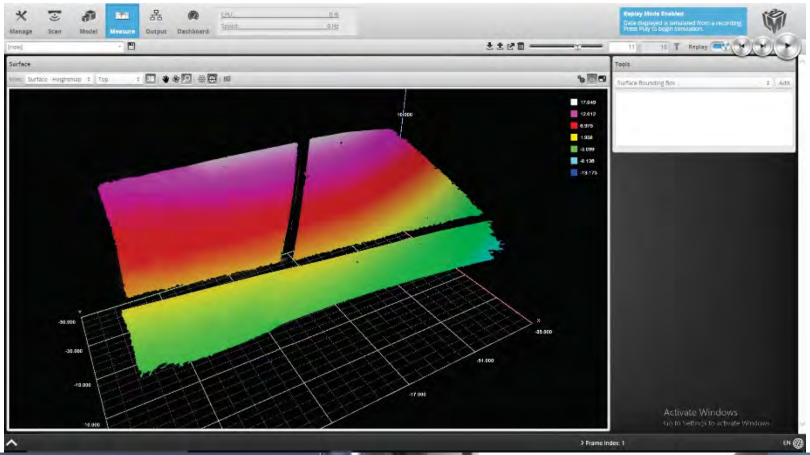
- Normally, a robot moves blindly but repeatedly to a known position within the arm's reach
  - With robot vision guidance, machine vision provides the robot with a position for its motion
- Widespread use across many industries, including: automotive, pharmaceutical, medical, electronics, and food and beverage
- Switching between products and batch runs is software controlled and very fast, with no mechanical adjustments.
- High residual value of the system, even if production is changed
- High machinery efficiency, reliability, and flexibility
- Reduces manual labor/work costs

# CASE STUDY - AUTOMOTIVE ROBOTIC VISION GUIDANCE

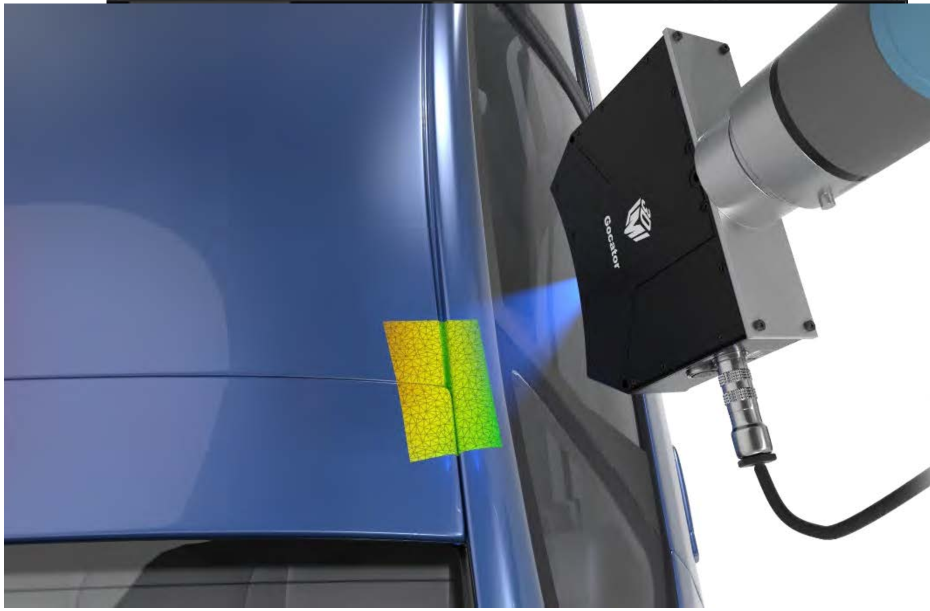
**Vision-guidance for accurate robotic insertion of windshields, roofs, and rear windows**

- Data will be sent to robot
- The robot carries the cover to the roof opening and near the windshield opening, then measures position
- Make the best fit for the opening and top or measurements, and calculate final TCP of 6 degrees of freedom
- Weld the roof to the roof opening
- Measure the final roof fit dimensions, such as gap & flush
- Challenges solved with Gocator:
  - Part variability
  - Environmental conditions (vibration of machine parts, lighting, temperature) not a concern with 3D sensors

# GAP & FLUSH INSPECTION WITH SNAPSHOT SENSOR



- Snapshot sensors are able to measure multiple gap & flush features within a single field of view
- 3D surface data is cross-sectioned and measured for multiple profile views
- Built-in measurement tool
- Robot moves sensor to key locations
- Exposure modification allows for use on all vehicle colors
- Result of measurement:
  - Correct and error proof any build problem
  - Reduce unexpected cost in repairing misassembled panels
  - To reduce waste from discarding damaged panels due to fit problems



# FORENSIC DOCUMENT EXAMINATION – 3D RECONSTRUCTION OF CROSSING LINES

**Ing. Adriana Jabconová [1], RNDr. Bohumil Bohunický [2]**
[1] Kriminalistický a expertízny ústav policajného zboru
[2] KVANT spol. s r.o.

**Abstract**
*A collection of state-of-the-art analytical methods of optical microscopy, stereoscopy and electron microscopy were applied to set of simulated and real cases of line crossings. The processes were evaluated and compared. In the results we present suitability of each method for each different type of line crossing.*

3rd INTERNATIONAL CONFERENCE

# 3D MEASUREMENT AND IMAGING

*MODERN CONTACTLESS MEASUREMENTS IN INDUSTRIAL PRACTICE*

## FORENSIC DOCUMENT EXAMINATION
### 3D RECONSTRUCTION OF CROSSING LINES

Ing. Adriana Jabconová, Kriminalistický a expertízny ústav PZ
RNDr. Bohumil Bohunický, KVANT, spol. s r. o.

# KRIMINALISTICKÉ SKÚMANIE DOKUMENTOV

- Kriminalistické skúmanie dokumentov je odvetvie kriminalistiky, ktoré sa zaoberá súdnoznaleckým technickým skúmaním dokumentov s cieľom overiť ich pravosť, autenticitu, zistiť ich pôvod a zdroj.
- Skúmaním sa tiež zisťuje spôsob ich vyhotovenia, analyzujú sa materiály a zariadenia použité na ich vyhotovenie.
- Ide o skúmanie sporných dokumentov, u ktorých vznikla pochybnosť o ich pravosti, pôvode, spôsobe vyhotovenia.
- Cieľom preskúmania či posúdenia sporných dokumentov je potvrdiť alebo vylúčiť tieto pochybnosti.

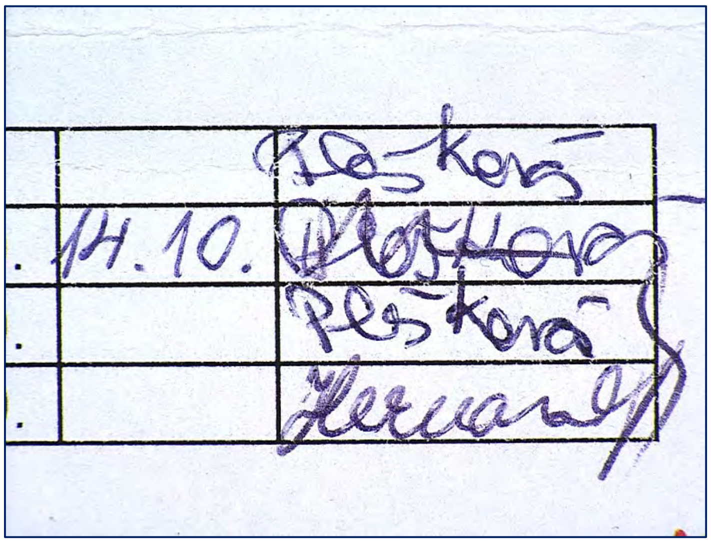
# KRIMINALISTICKÉ SKÚMANIE DOKUMENTOV

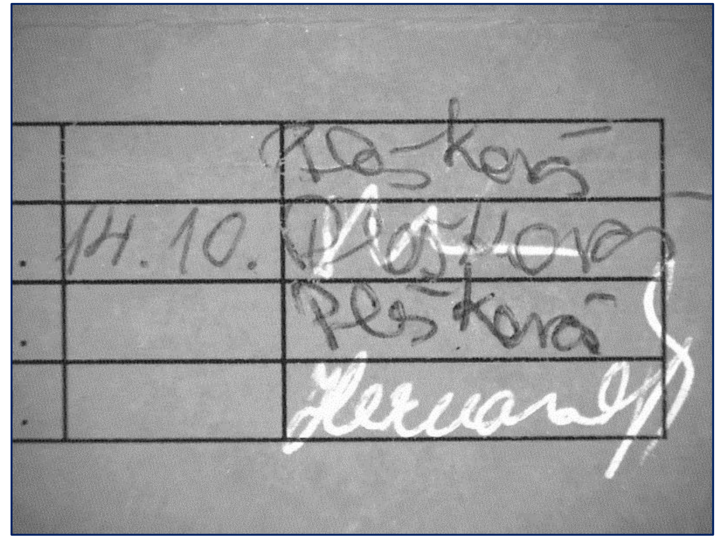
- skúmanie dokumentov všetkého druhu: úradných a neúradných listín, účtovných a bankových listín, fotokópií, identifikačných dokladov, preukazov, dokladov k motorovým vozidlám, skúmanie bankoviek, cestovných a platobných šekov, e-kolkov a iných cenín, tlačív a tlačovín a ich komponentov, anonymných zásielok a pod.
- antedatovanie a postdatovanie písomností
- identifikácia a zviditeľňovanie odstránených, dopísaných, prepísaných a skrytých údajov
- zisťovanie technického falšovania dokumentov a neoprávneného zásahu do ich celistvosti
- skúmanie stotožňovanie reprodukcií/kópií dokumentov
- skúmanie predmetov, ktoré sa k dokumentom vzťahujú: skúmanie písacích prostriedkov, reprodukčných zariadení a ich náplní, odtlačkov pečiatok a samotných pečiatok, pečatenia listín, razby, nitov a skôb, papierového/plastového podkladu, ochranných fólií, hologramov, obalov, šitia, a pod.,
- skúmanie perforácií, strihov, rezných a tržných hrán na listinách a pod.,
- skúmanie znehodnotených dokumentov - skartovaných, spálených, zhnitých, inak znehodnotených

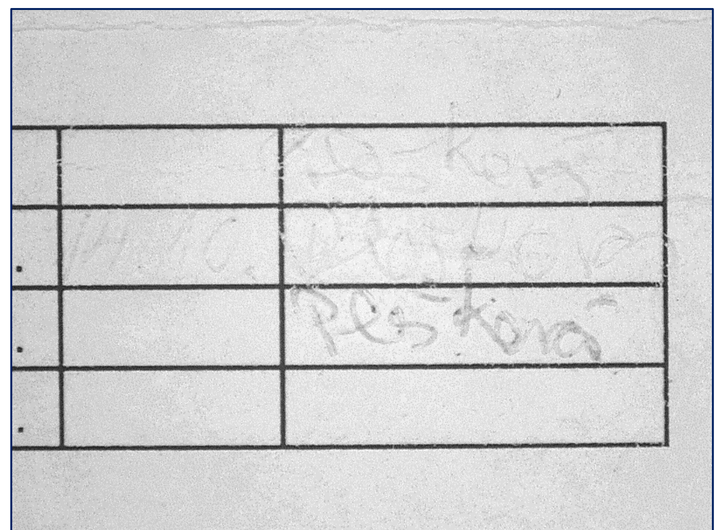
# KRIMINALISTICKÉ SKÚMANIE DOKUMENTOV

- zisťovanie časovej postupnosti/poradia vzniku záznamov
- križujúce/prelínajúce sa línie vyhotovené kombináciou rôznych záznamových prostriedkov a substancií:
  - písací prostriedok (atrament, pasta, gél...)
  - počítačová tlačiareň, písací stroj (atrament, toner, farbivo pásky..)
  - pečiatka (pečiatková farba)

# PASTA - PASTA







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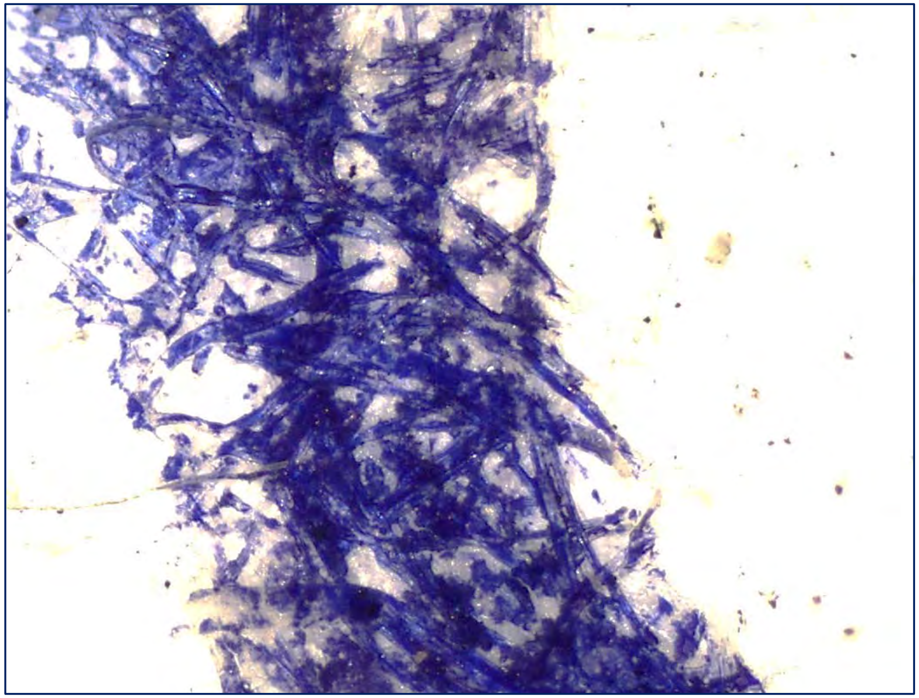

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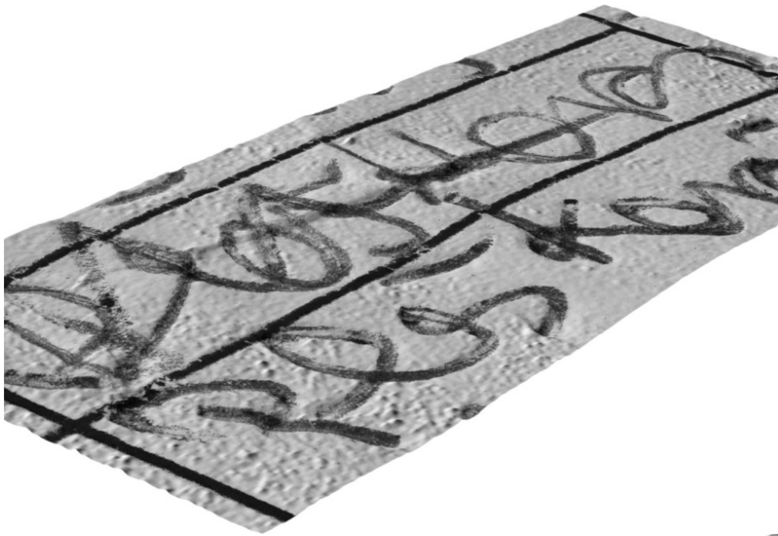

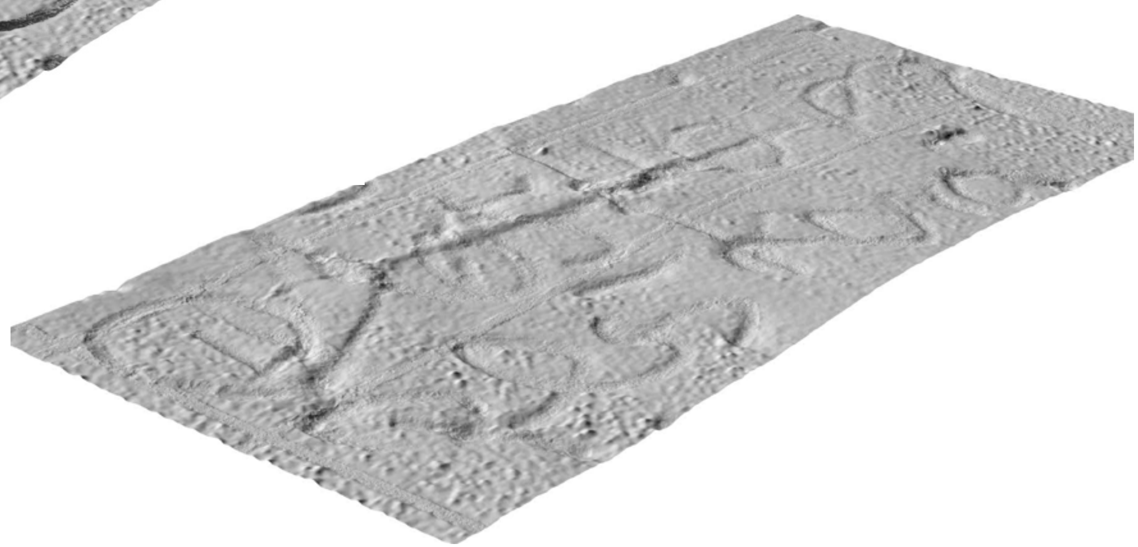

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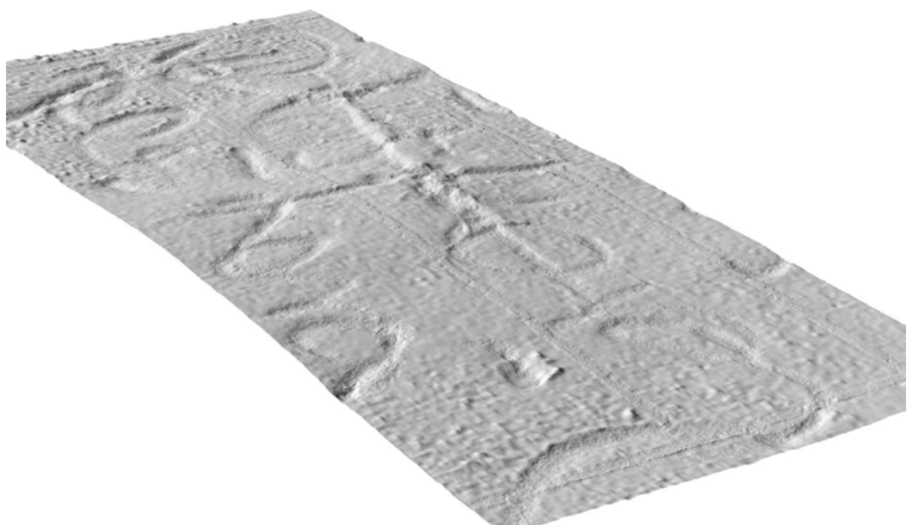

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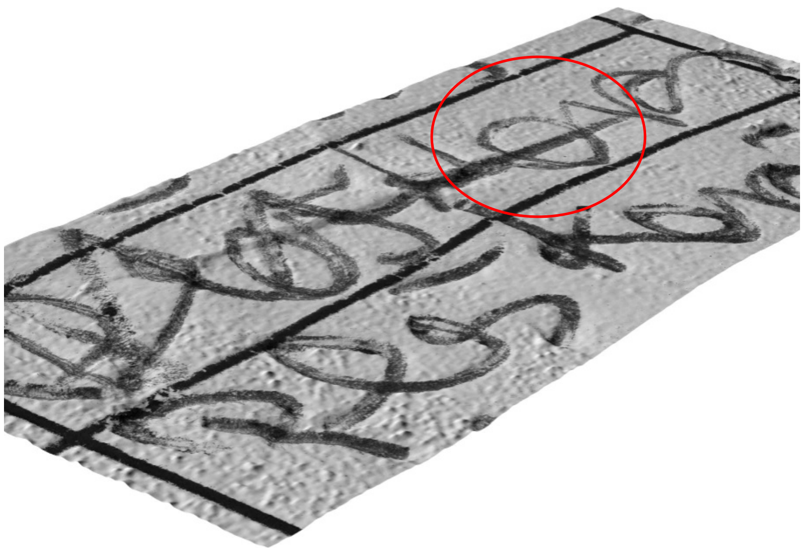
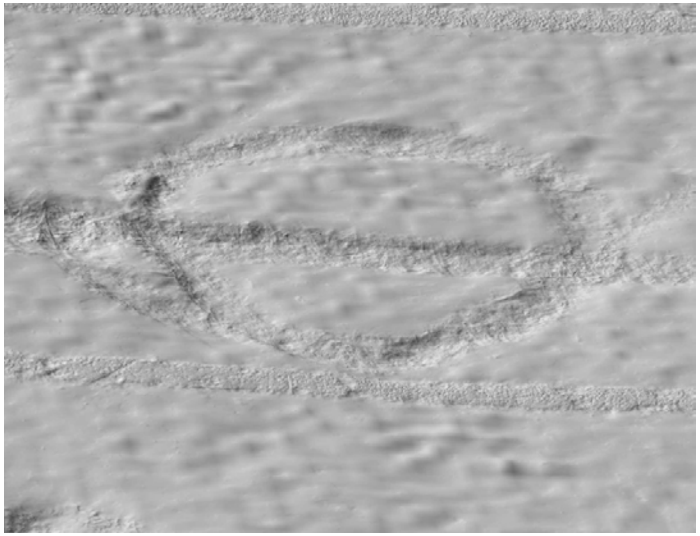
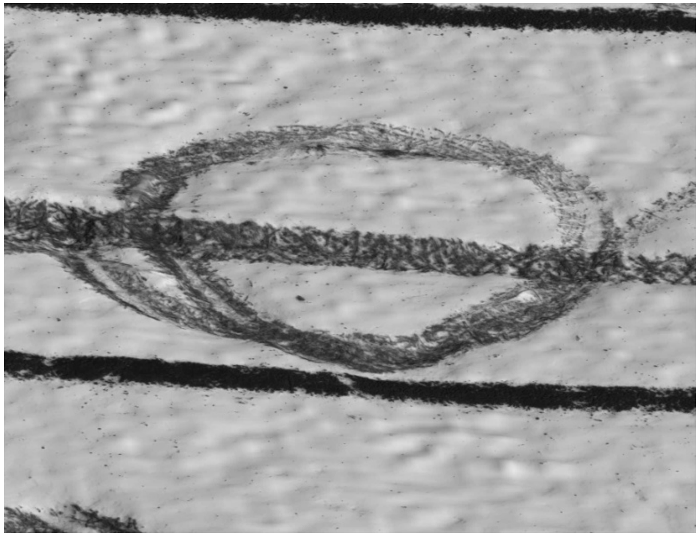
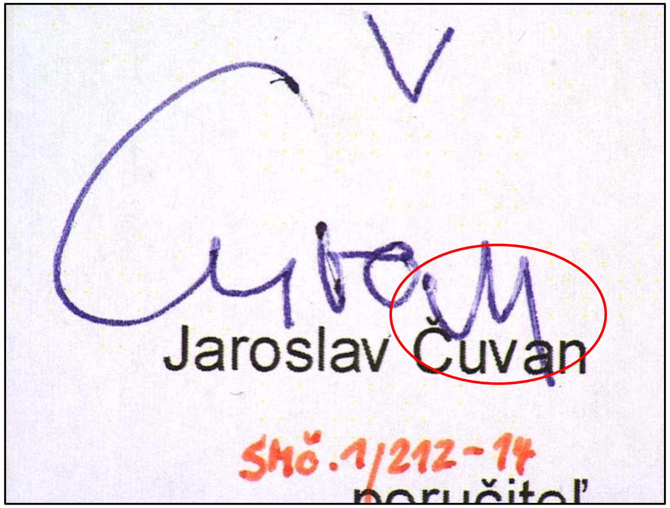
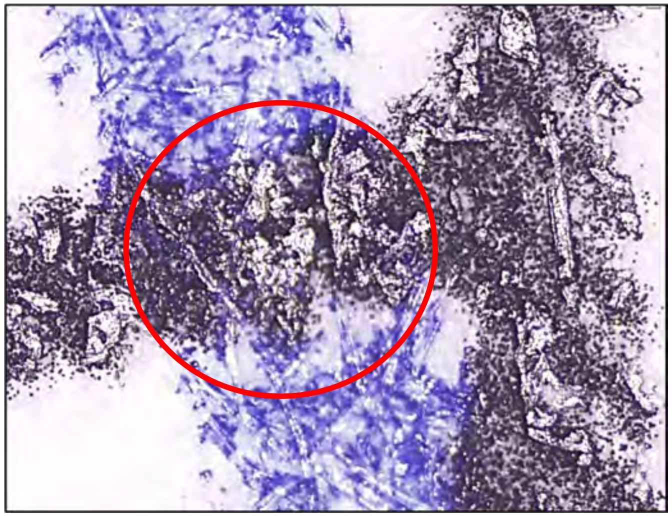


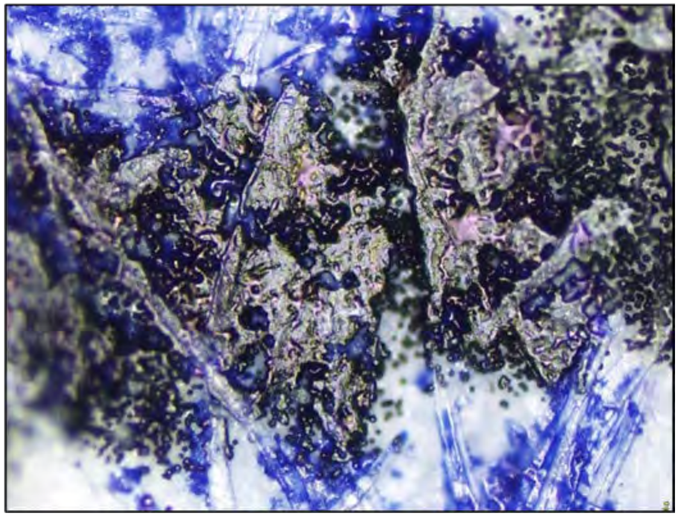




# TONER - PASTA





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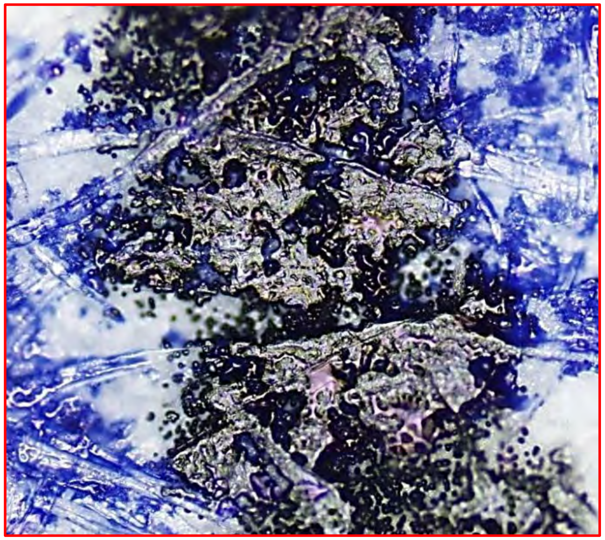

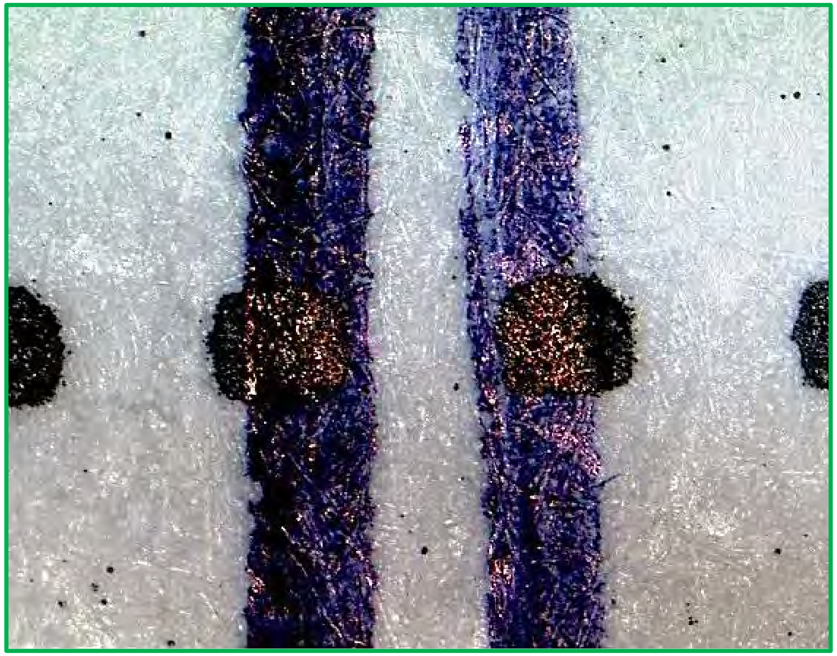

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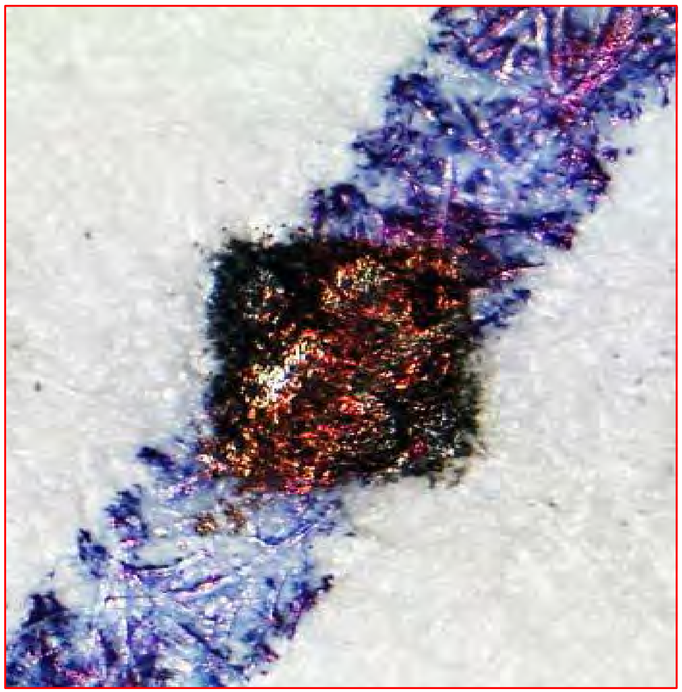
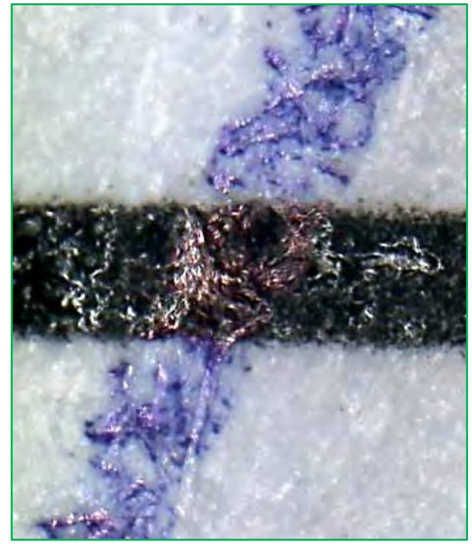
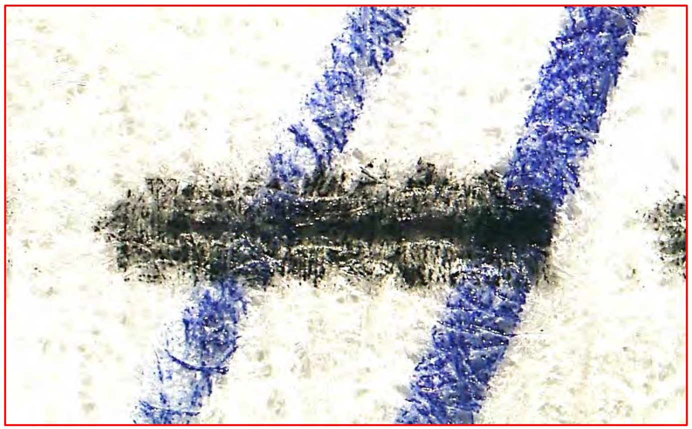
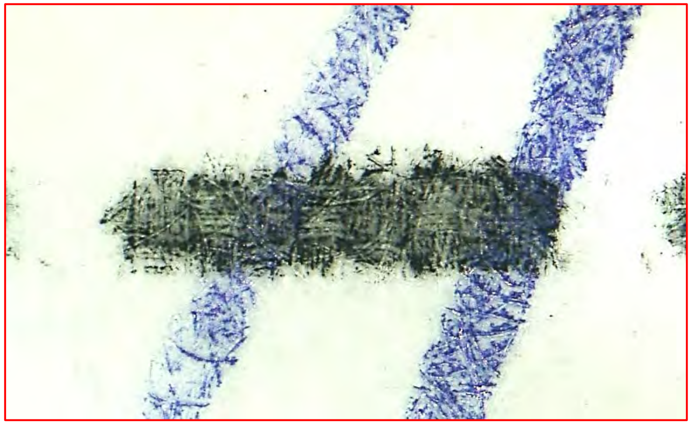
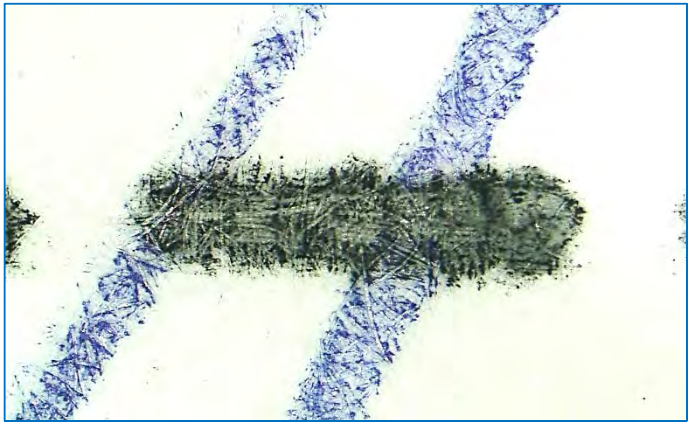




# TONER - GÉL

# PASTA – SUBSTANCIA PÁSKY PÍSACIEHO STROJA



# „PHYSICAL-CHEMISTRY STUDY OF CROSSED LINE INTERSECTION“

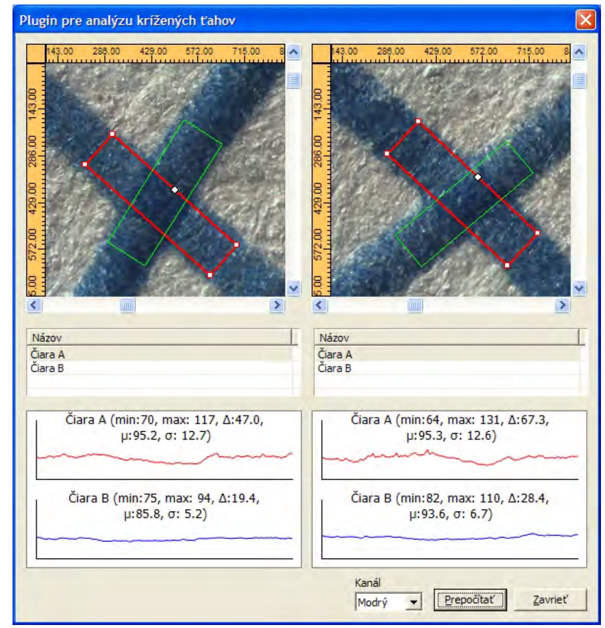
- **Medzinárodný projekt (2011-2016) zameraný na skúmanie fyzikálno-chemických vlastností krížených línií, bol realizovaný pod záštitou generálneho sekretariátu Interpolu v Lyone a jeho partnera AIEED (L'Académie Internationale des Experts en Écritures et Documents).**
- **Kriminalistický a expertízny ústav PZ sa do projektu zapojil na základe ponuky generálneho sekretariátu Interpolu Lyon v roku 2011.**

# „PHYSICAL-CHEMISTRY STUDY OF CROSSED LINE INTERSECTION“

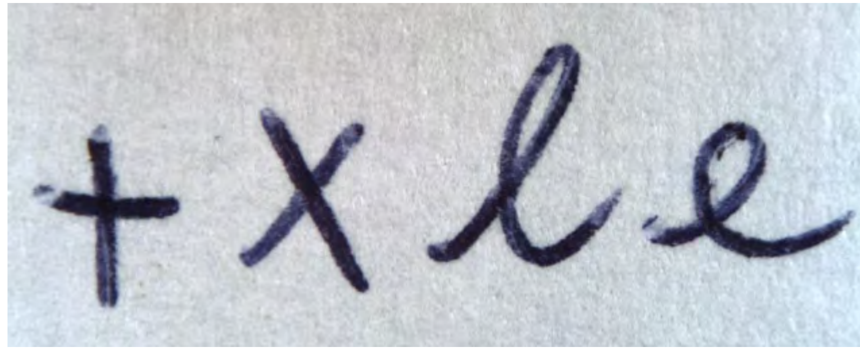
- **Cieľom projektu bolo na základe výsledkov výskumu krížených ťahov prispieť do tejto náročnej forenznej problematiky.**
- **Komplexnou hypotézou štúdia krížených ťahov je konštatácia, že miesto kríženia dvoch križujúcich sa línií vytvorených rôznymi substanciami (atramentmi a pastami písacích prostriedkov, pečiatkovými farbami, atramentmi tlačiarní) je miestom fyzikálnych a chemických reakcií, ktoré sú závislé od niekoľkých faktorov vrátane kvality použitých substancií, poradia použitých substancií a času ich vyhotovenia.**

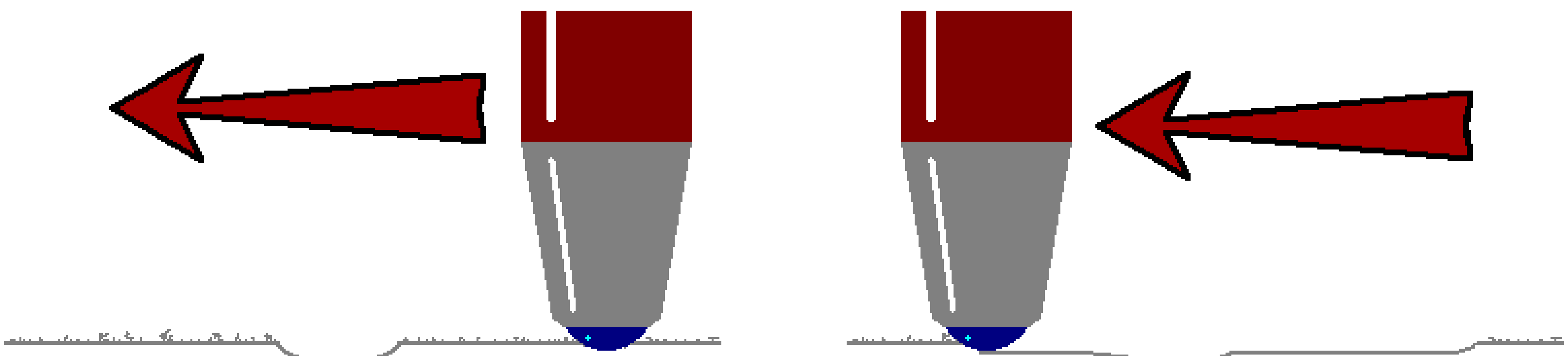
# METÓDY

- Stereografia
- „Focus variation“
- Odlesky
- SEM



# MODEL

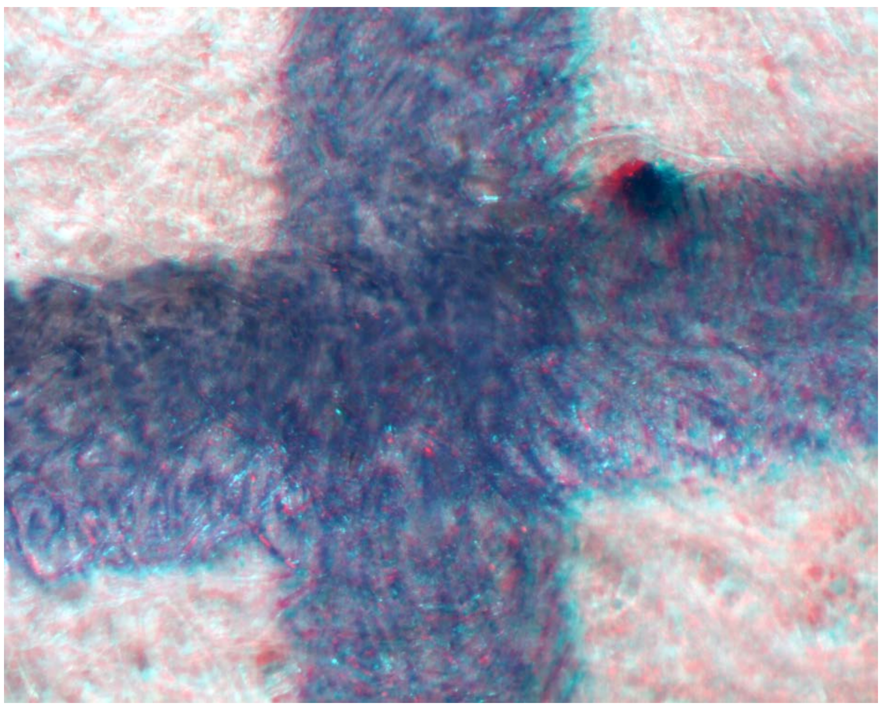


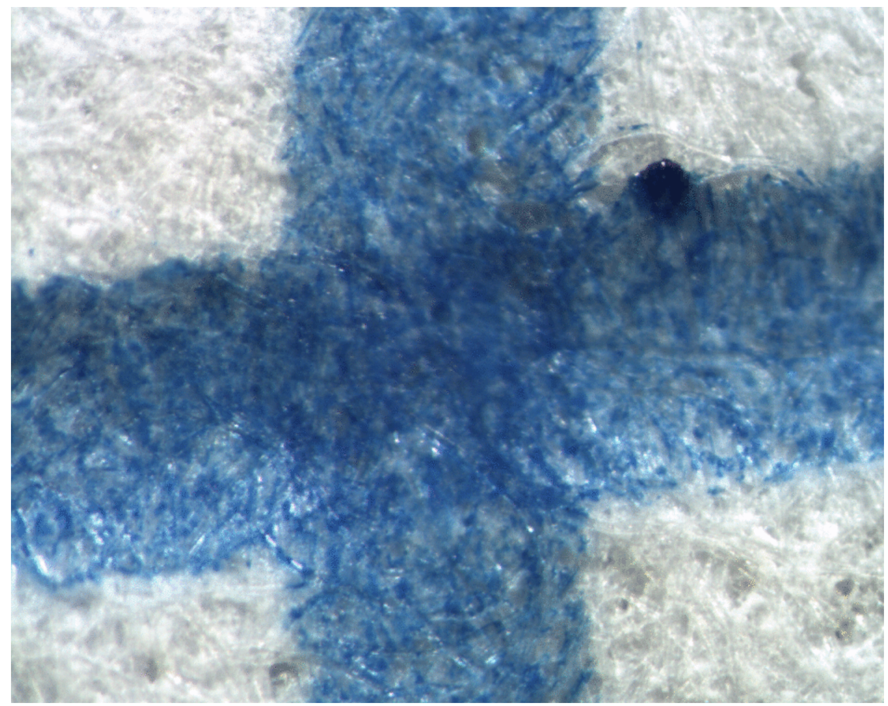


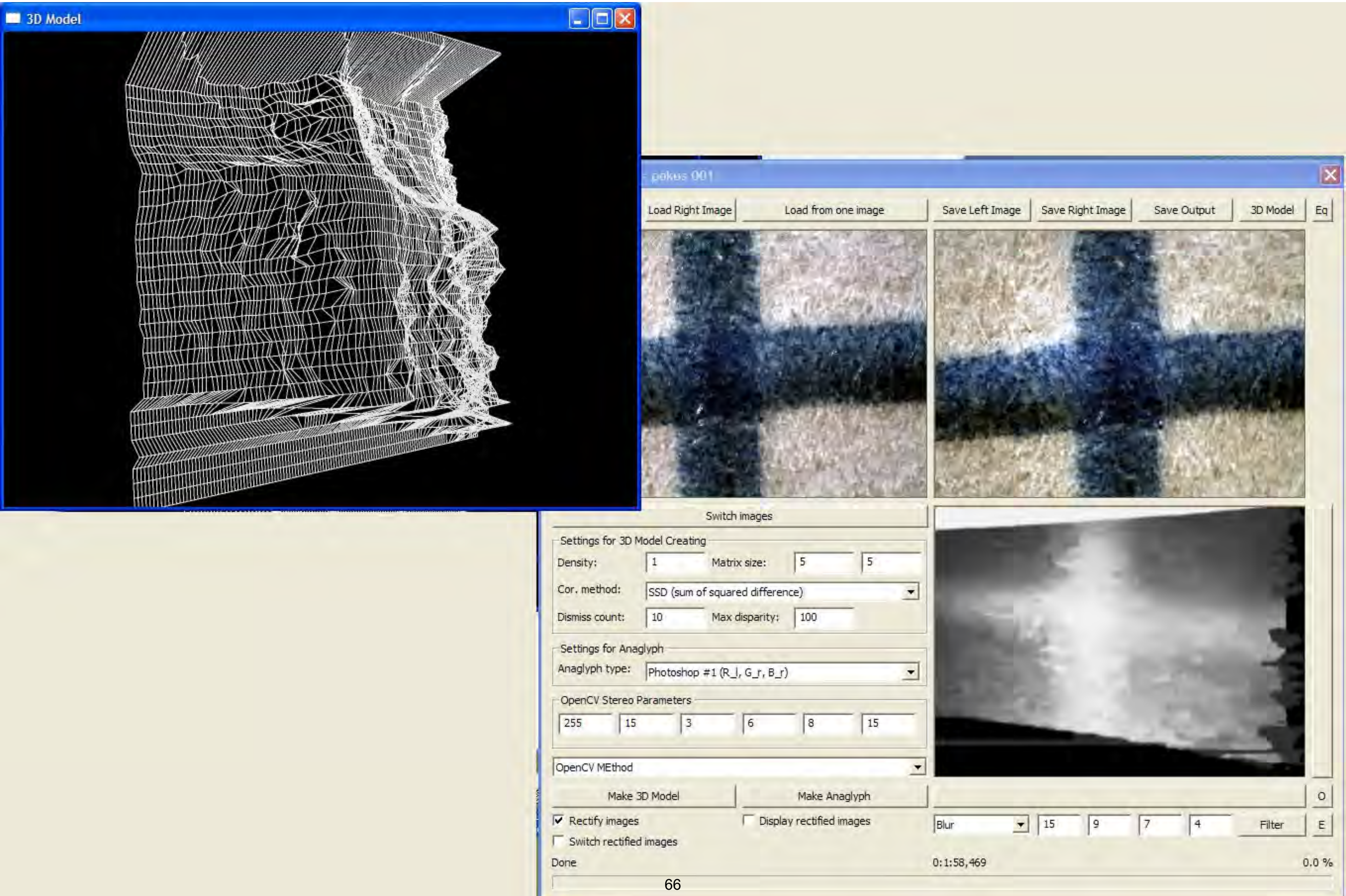
# STEREOGRAFIA

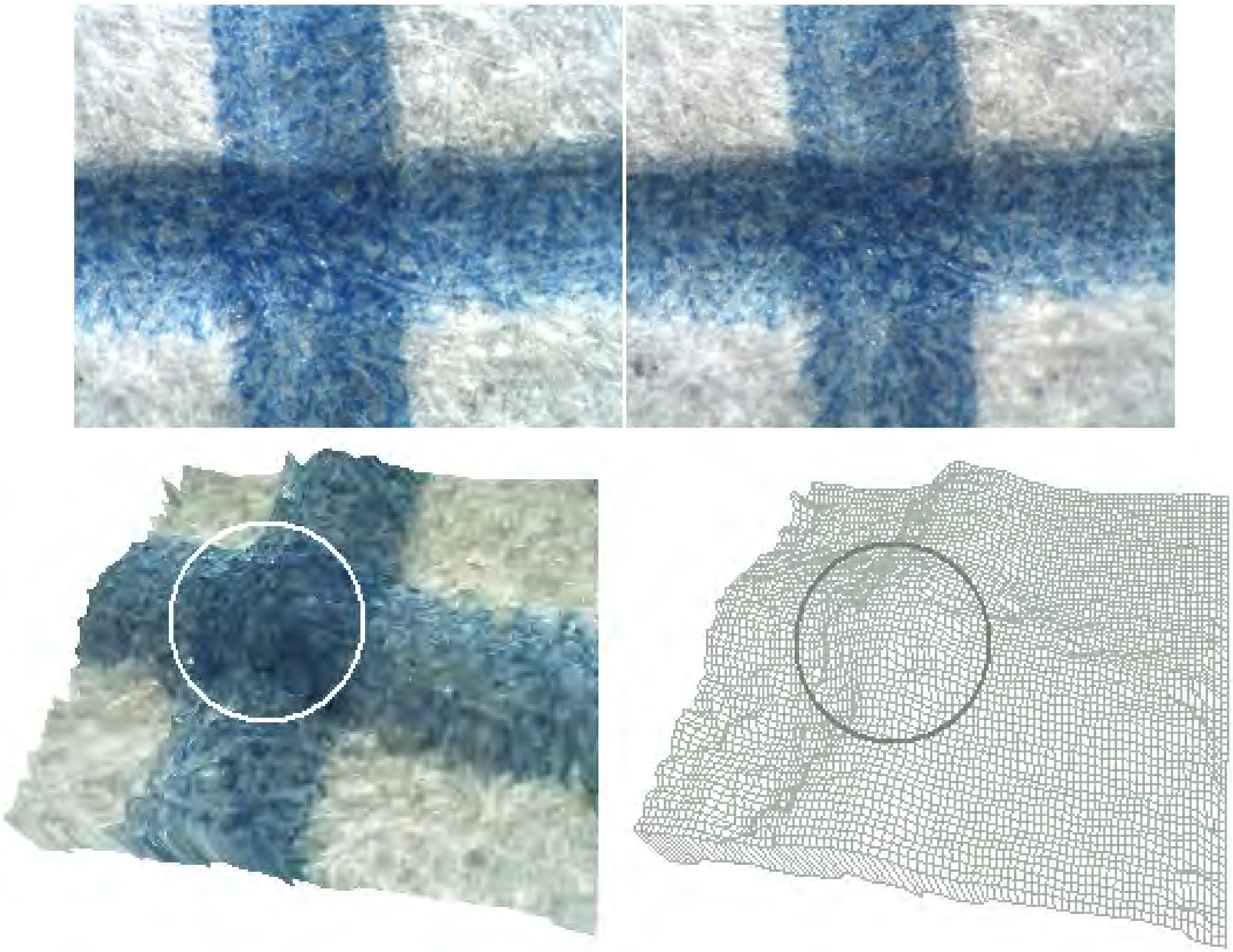
- Dve samostatné optické cesty, dve samostatné kamery
- Posunutie znakov medzi ľavým a pravým pohľadom v osi X určuje súradnicu Z

# STEREO - ZÁZNAM






3D Model
Load Right Image
Load from one image
Save Left Image
Save Right Image
Save Output
3D Model
Eq
Switch images
Settings for 3D Model Creating
Density: 1
Matrix size: 5 5
Cor. method: SSD (sum of squared difference)
Dismiss count: 10
Max disparity: 100
Settings for Anaglyph
Anaglyph type: Photoshop #1 (R_l, G_r, B_r)
OpenCV Stereo Parameters
255 15 3 6 8 15
OpenCV MEthod
Make 3D Model
Make Anaglyph
Rectify images
Display rectified images
Switch rectified images
Blur 15 9 7 4 Filter
O
E
Done
0:1:58,469
0.0 %



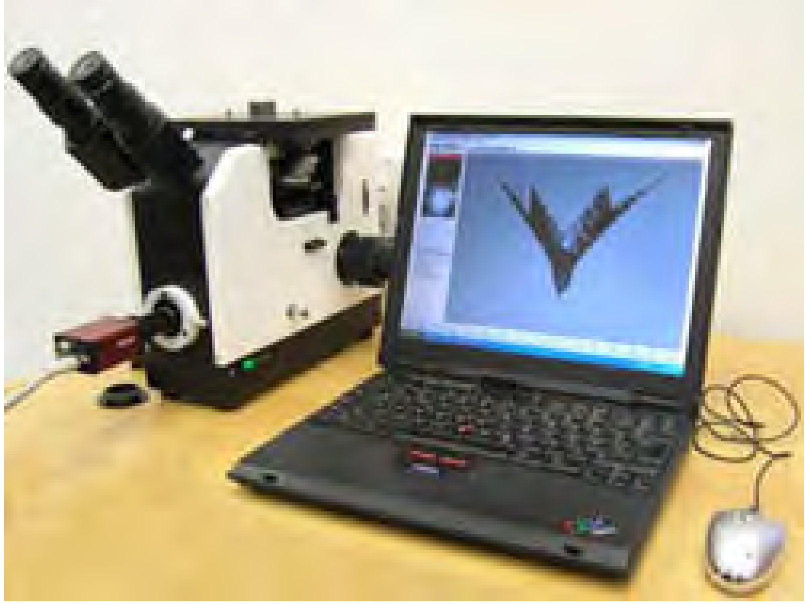
# STEREOGRAFIA

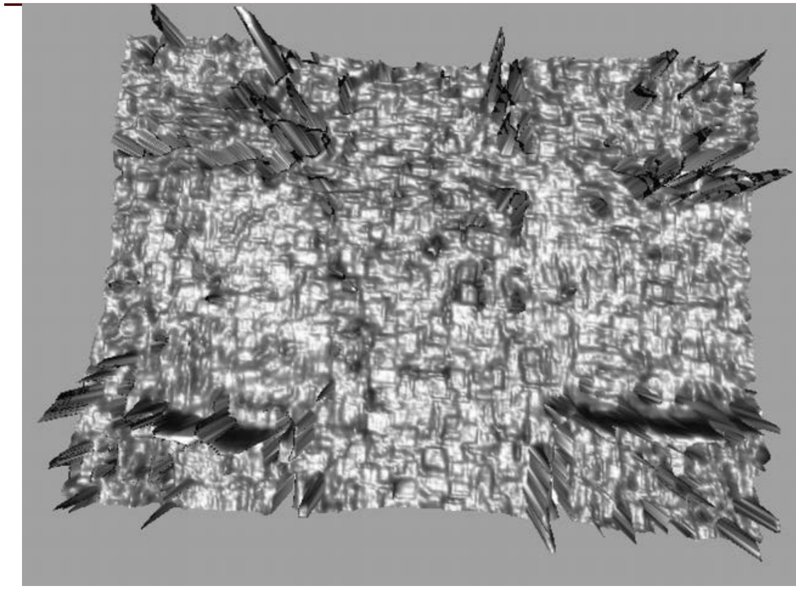
- Farebný obraz
- Rýchla metóda
- Konzistentná s rutinne používanými metódami
- Vhodná pre papier

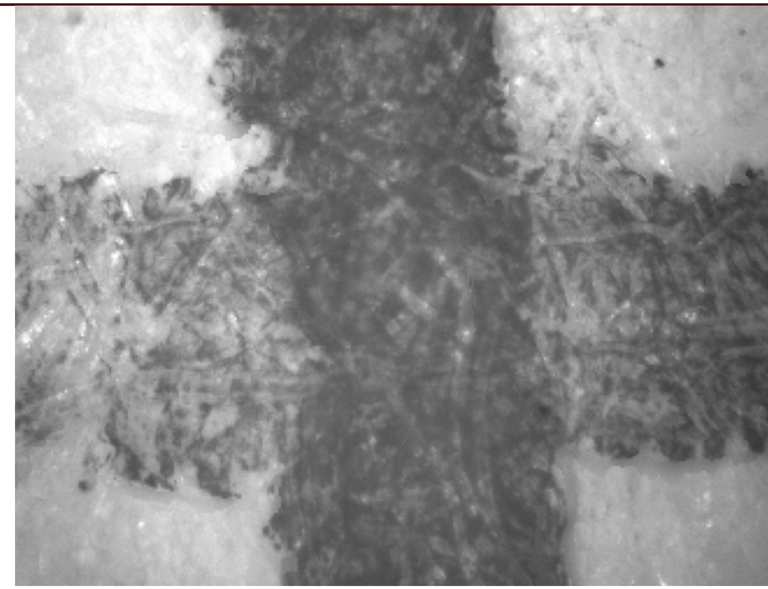
- Nutná precízna kalibrácia
- Vysoké nároky na kvalitu obrazu
- Odlesky
- Obmedzené rozlíšenie v osi Z

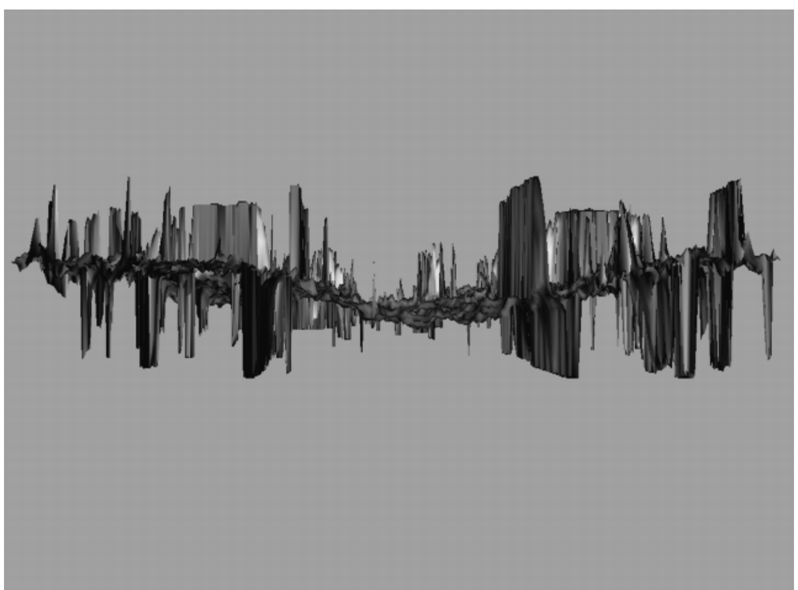
# „FOCUS VARIATION“

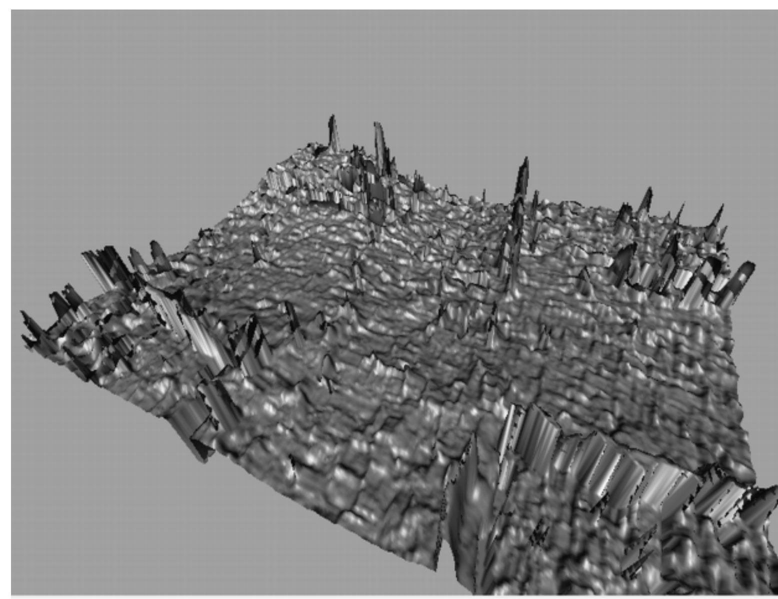
- Digitálny mikroskop,
- motorizovaná os Z
- Kalibrovaný posun osi Z











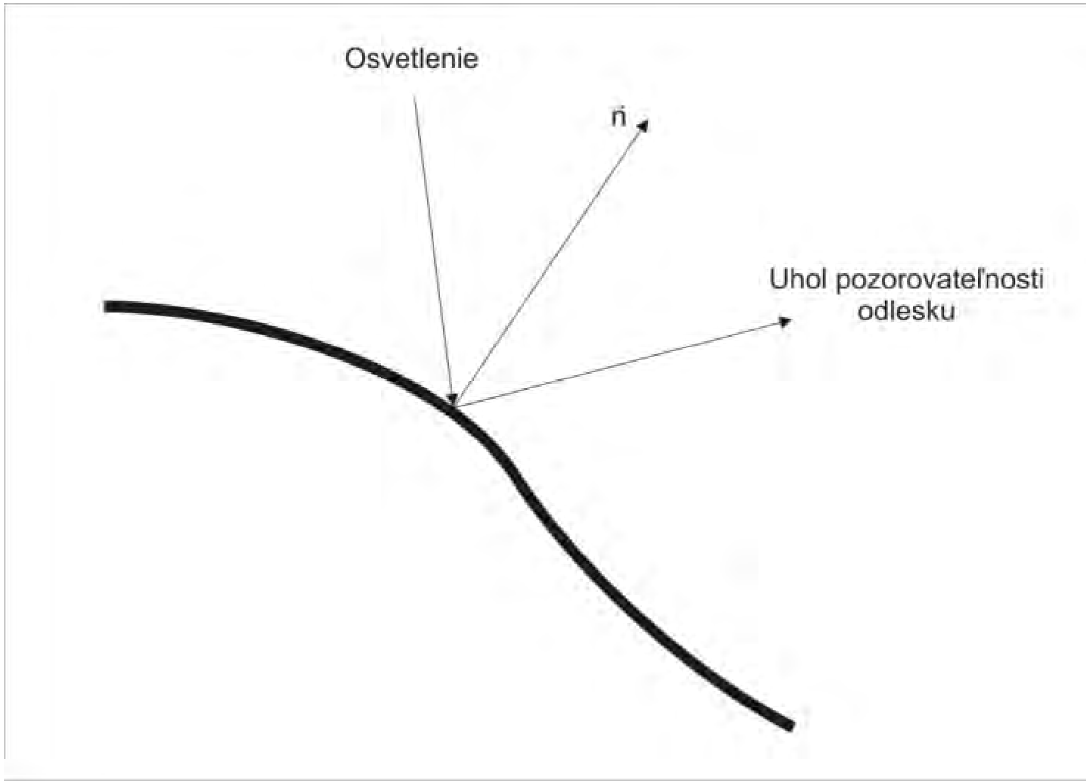
# FOCUS VARIATION

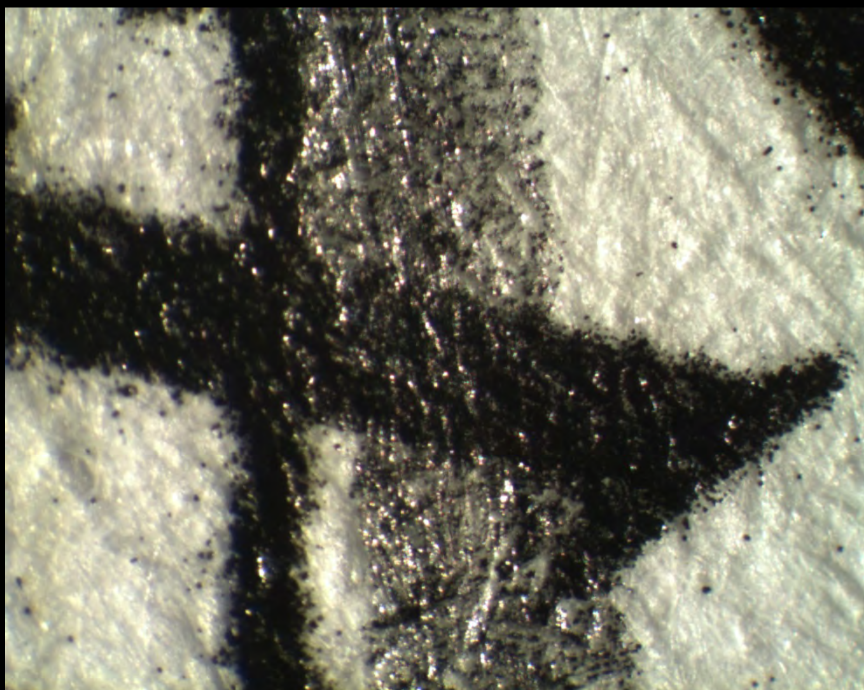
- Priame meranie hĺbky
- Dnes zahrnutá v každom motorizovanom digitálnom mikroskope

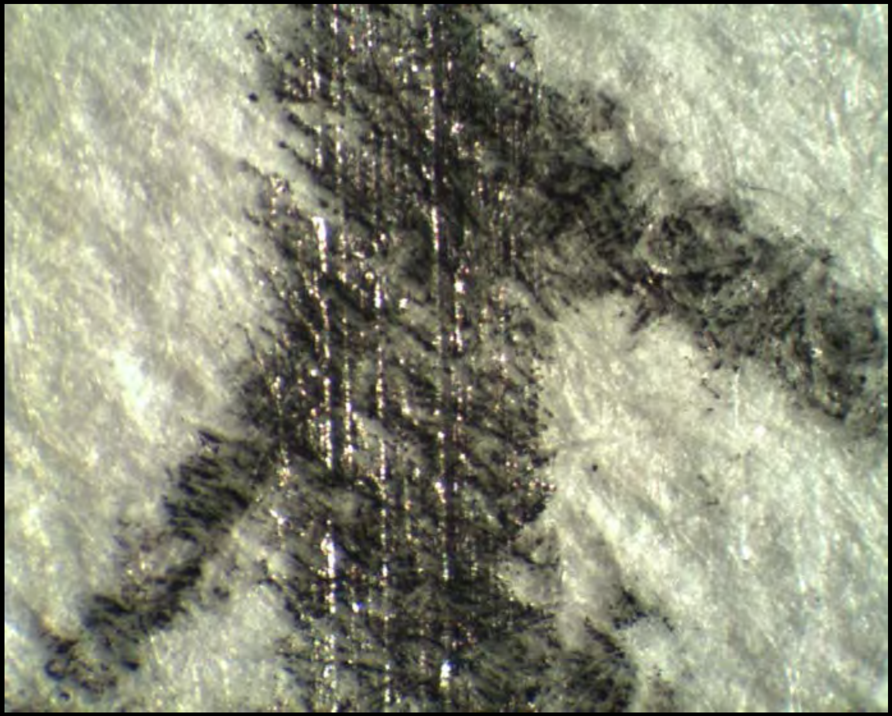
- Malé rozlíšenie v osi Z
- „Výpadky“
- Nutnosť interpolácie a filtrácie

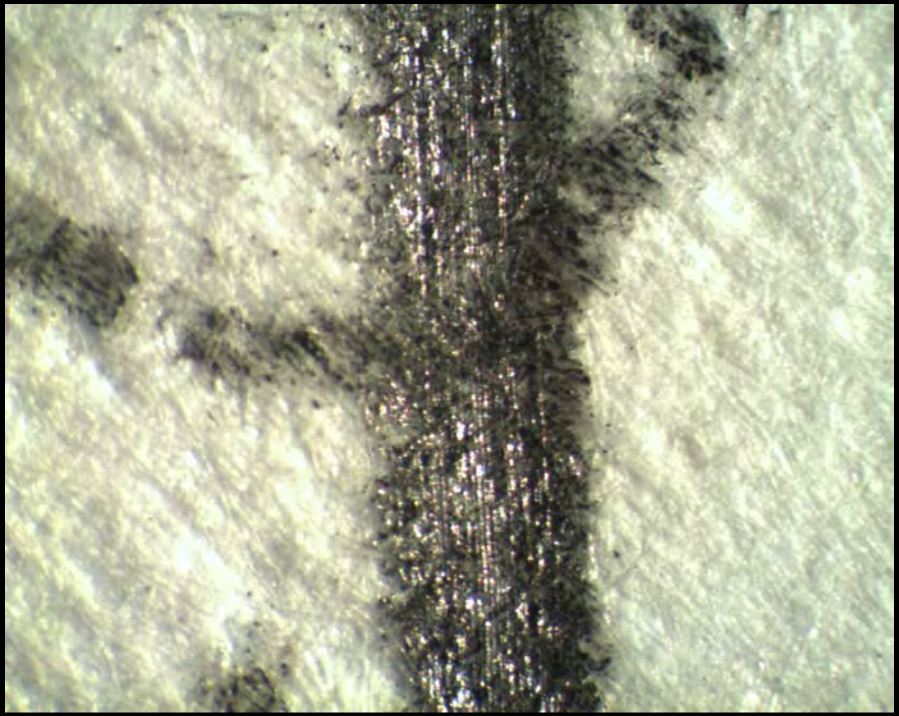
# ODLESKY

- Písacie prostriedky sa lesknú
- Štruktúra lesku nesie informáciu o normále povrchu
- Zvýrazňuje morfológiu písaného ťahu

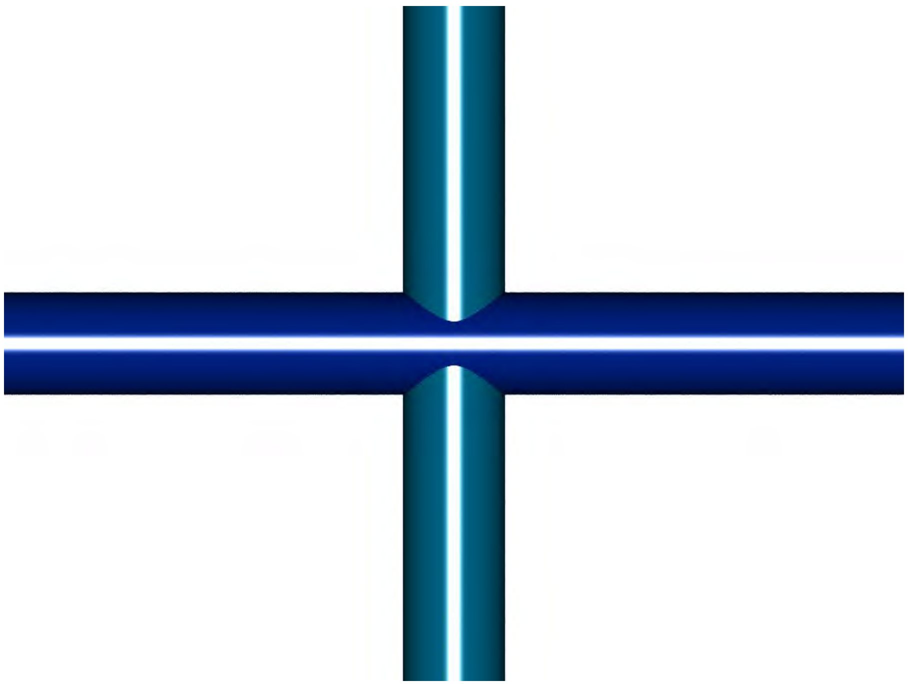


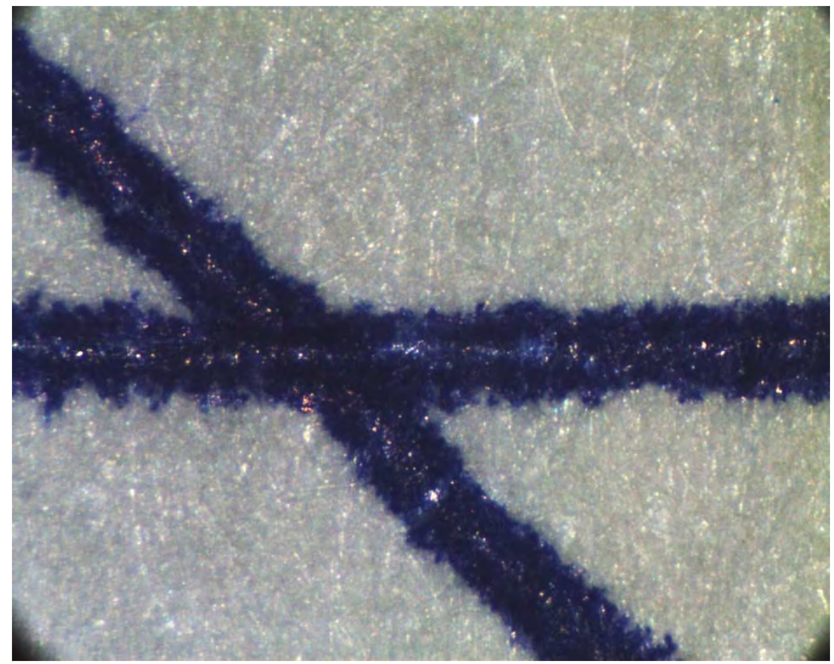




# KOAXIÁLNE SVETLO





# ODLESKY

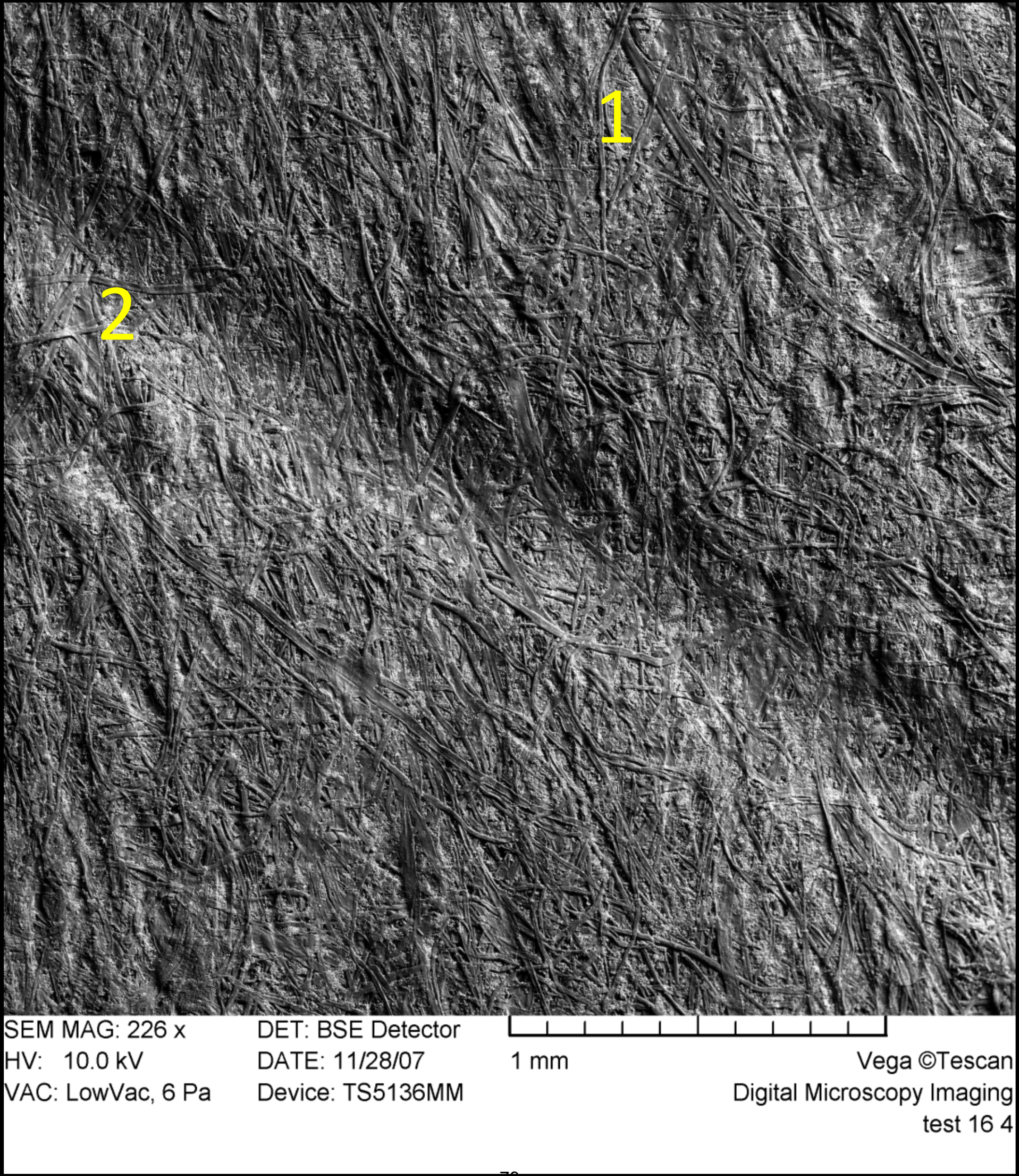
- Dostupné na každom pracovisku
- Rýchla metóda
- Intuitívne vyhodnotenie

- Použiteľné iba na úzku skupinu prípadov

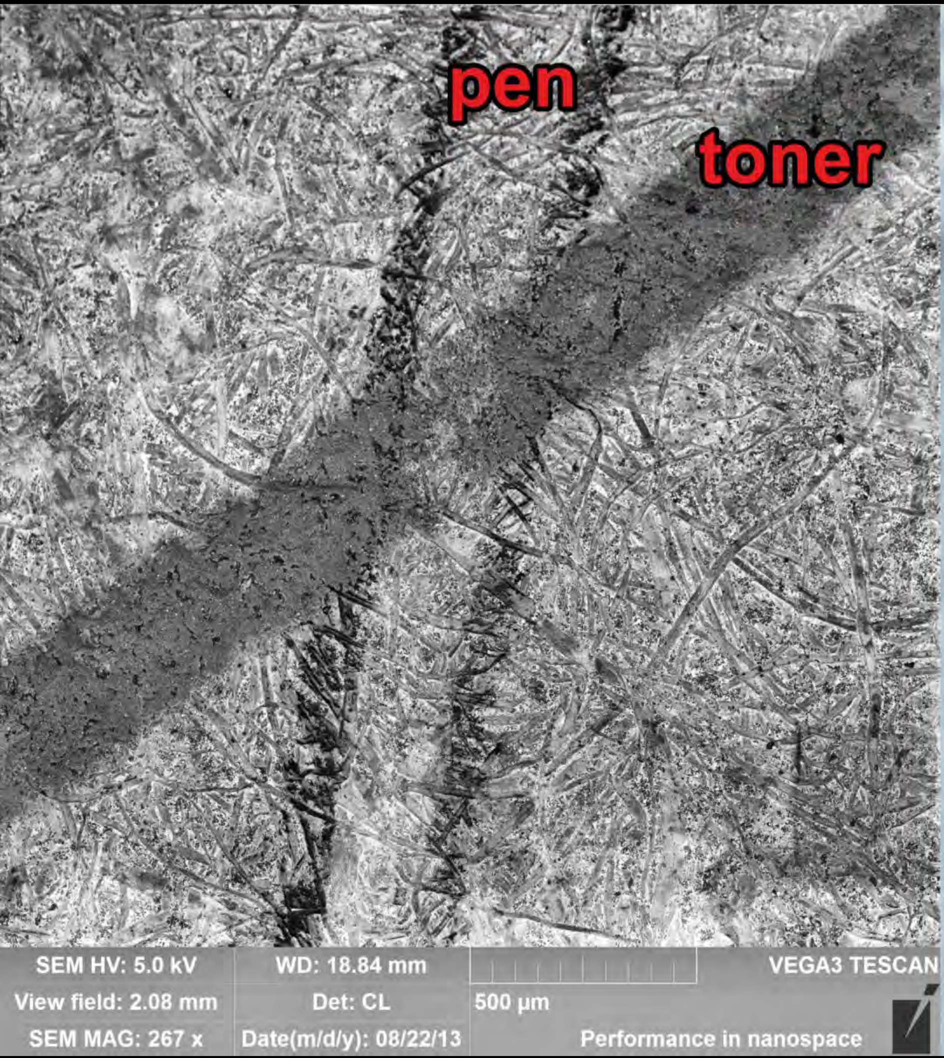
# SEM

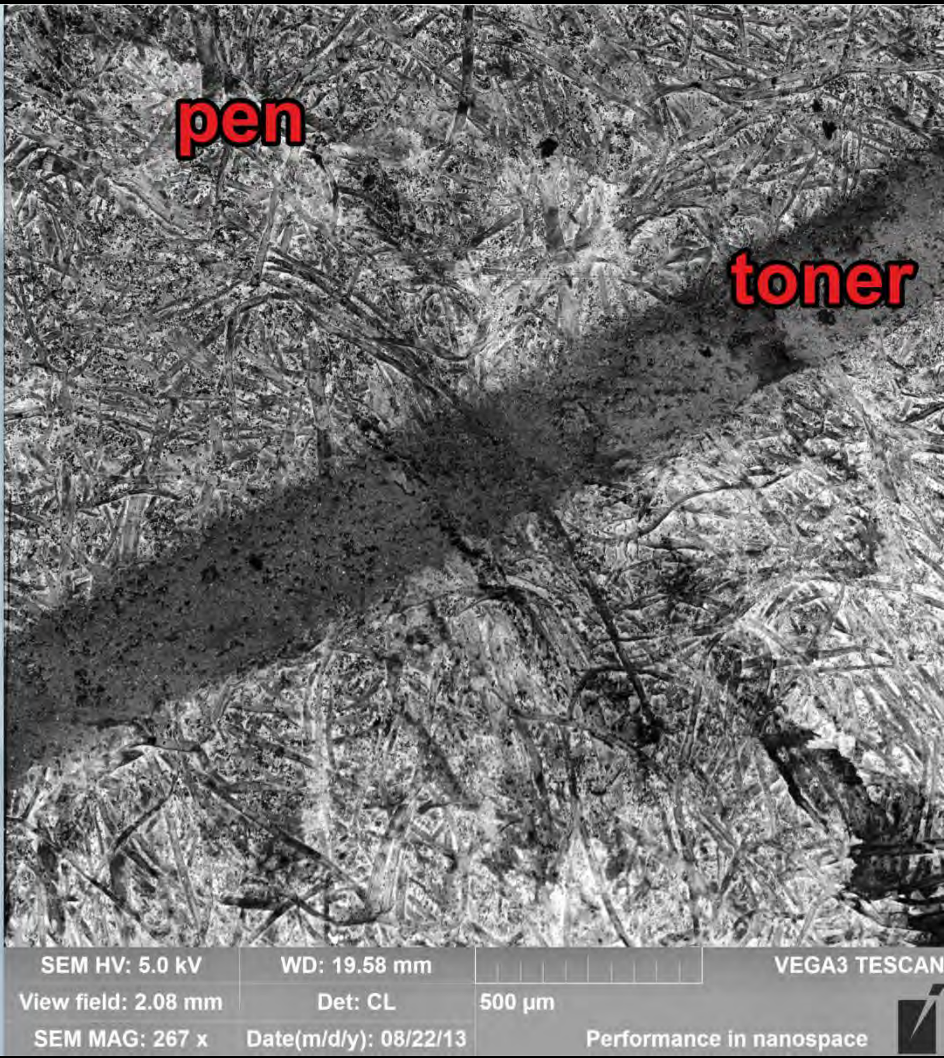
Elektrónová rastrovacia mikroskopia

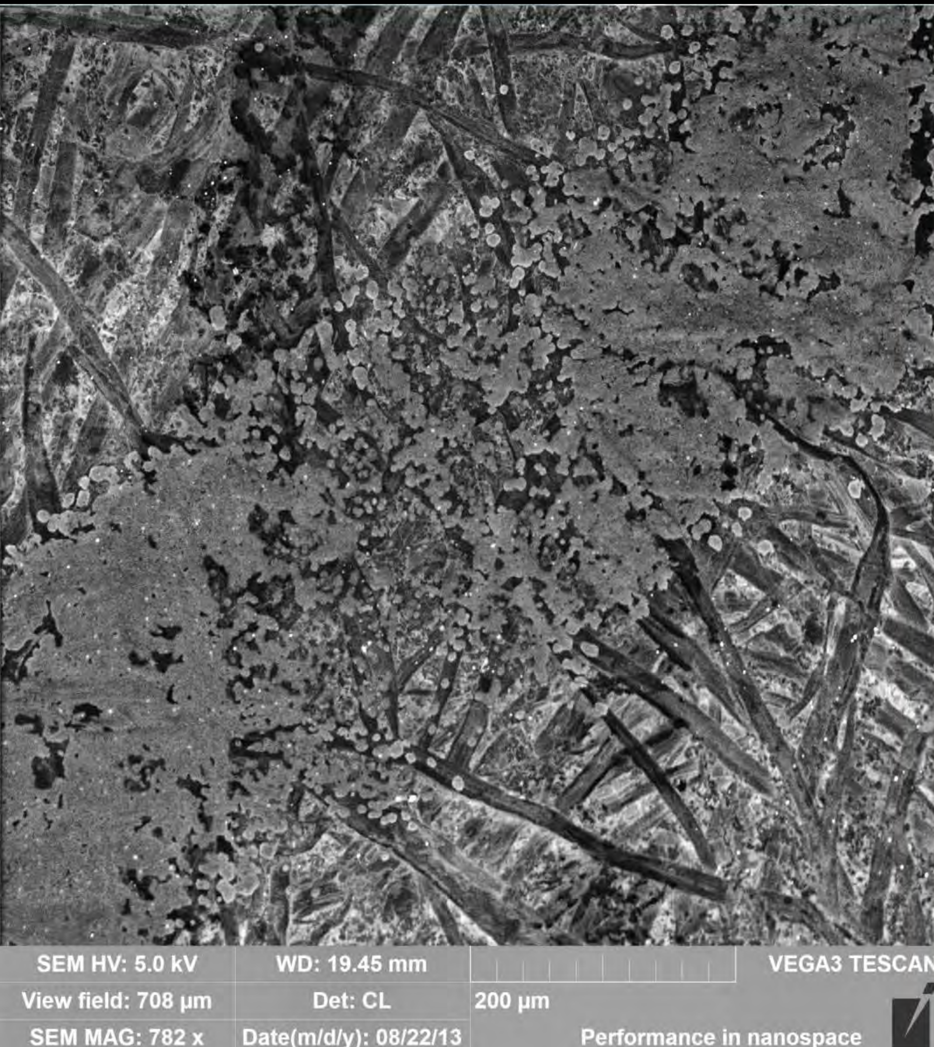
- Sekundárne elektróny
- Odrazené elektróny
- Katódoluminiscencia


1
2
SEM MAG: 226 x
HV: 10.0 kV
VAC: LowVac, 6 Pa
DET: BSE Detector
DATE: 11/28/07
Device: TS5136MM
1 mm
Vega ©Tescan
Digital Microscopy Imaging
test 16 4


SEM HV: 15.0 kV
WD: 15.00 mm
VEGA3 TESCAN
WD: 15.00 mm
Det: LVSTD
500 µm
VEGA3 SBU
Date(m/d/y): 08/22/13
Performance in nanospace


pen
toner
SEM HV: 5.0 kV
WD: 18.84 mm
VEGA3 TESCAN
View field: 2.08 mm
Det: CL
500 µm
SEM MAG: 267 x
Date(m/d/y): 08/22/13
Performance in nanospace


pen
toner
SEM HV: 5.0 kV
WD: 19.58 mm
VEGA3 TESCAN
View field: 2.08 mm
Det: CL
500 µm
SEM MAG: 267 x
Date(m/d/y): 08/22/13
Performance in nanospace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WD: 19.45 mm
VEGA3 TESCAN
View field: 708 µm
Det: CL
200 µm
SEM MAG: 782 x
Date(m/d/y): 08/22/13
Performance in nanospace


SEM HV: 5.0 kV
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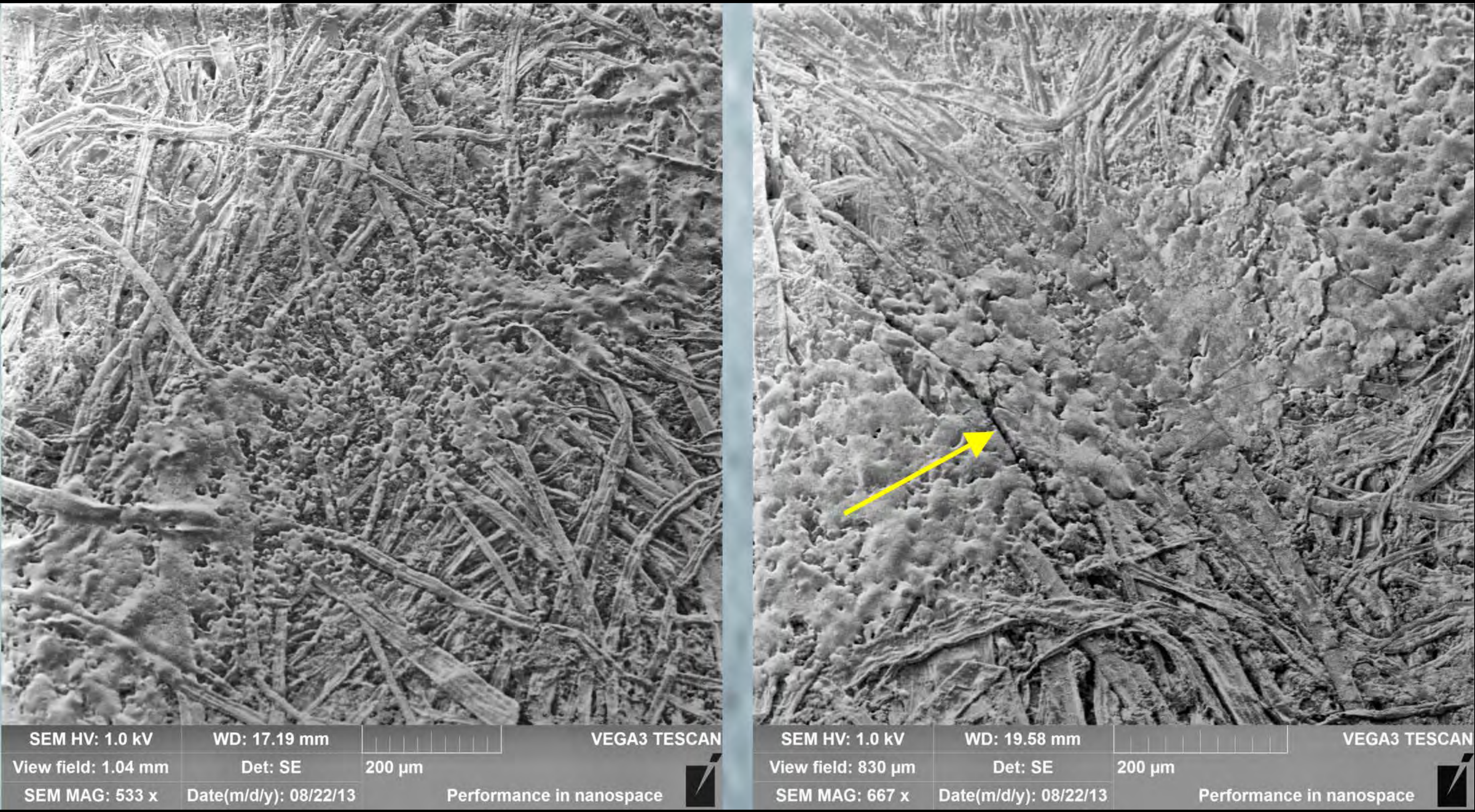
VEGA3 TESCAN
View field: 593 µm
Det: CL
100 µm
SEM MAG: 933 x
Date(m/d/y): 08/22/13
Performance in nanospace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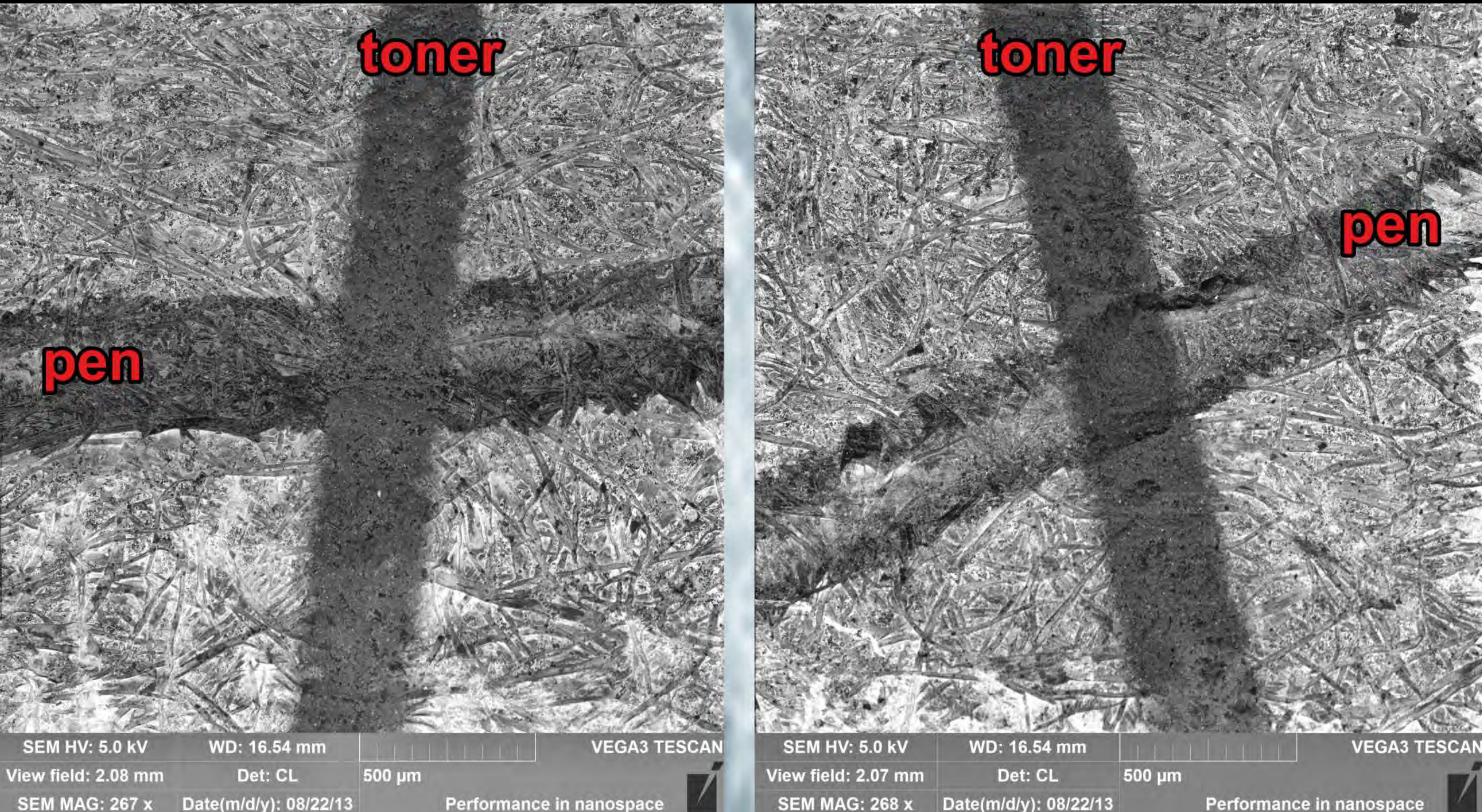
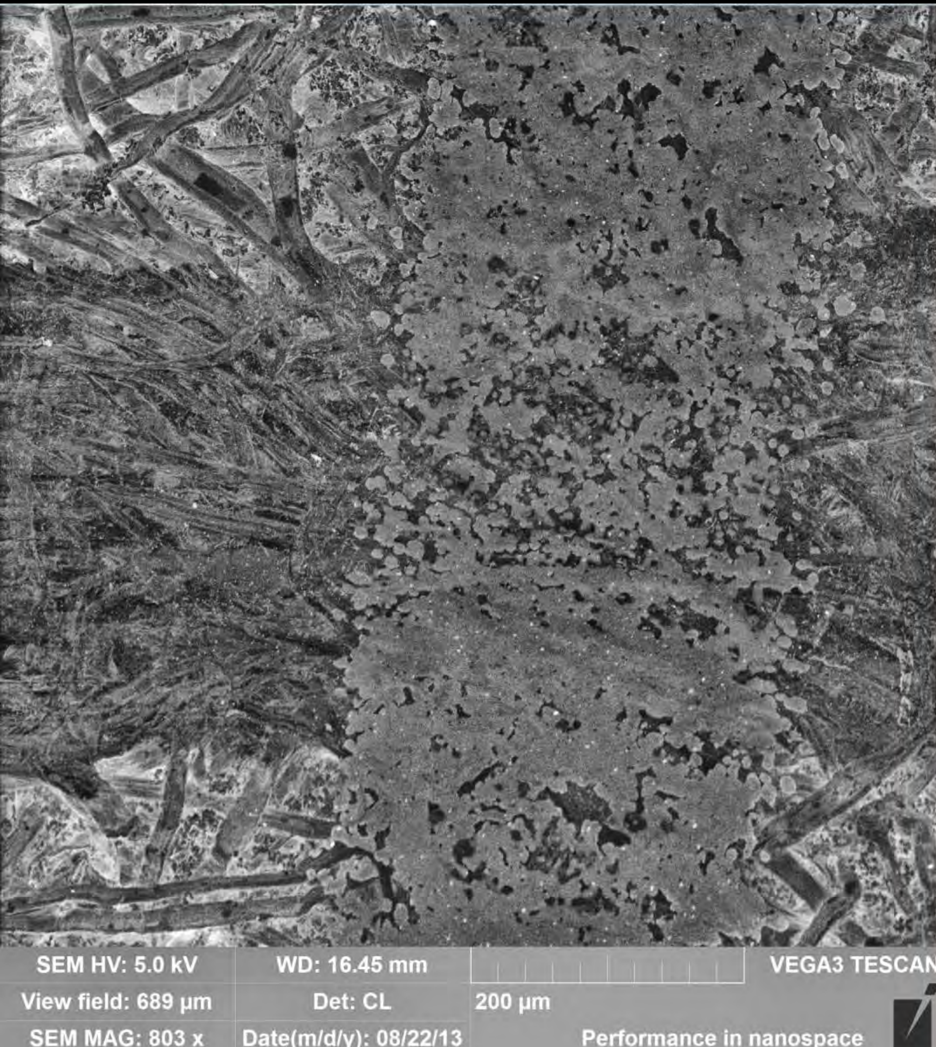
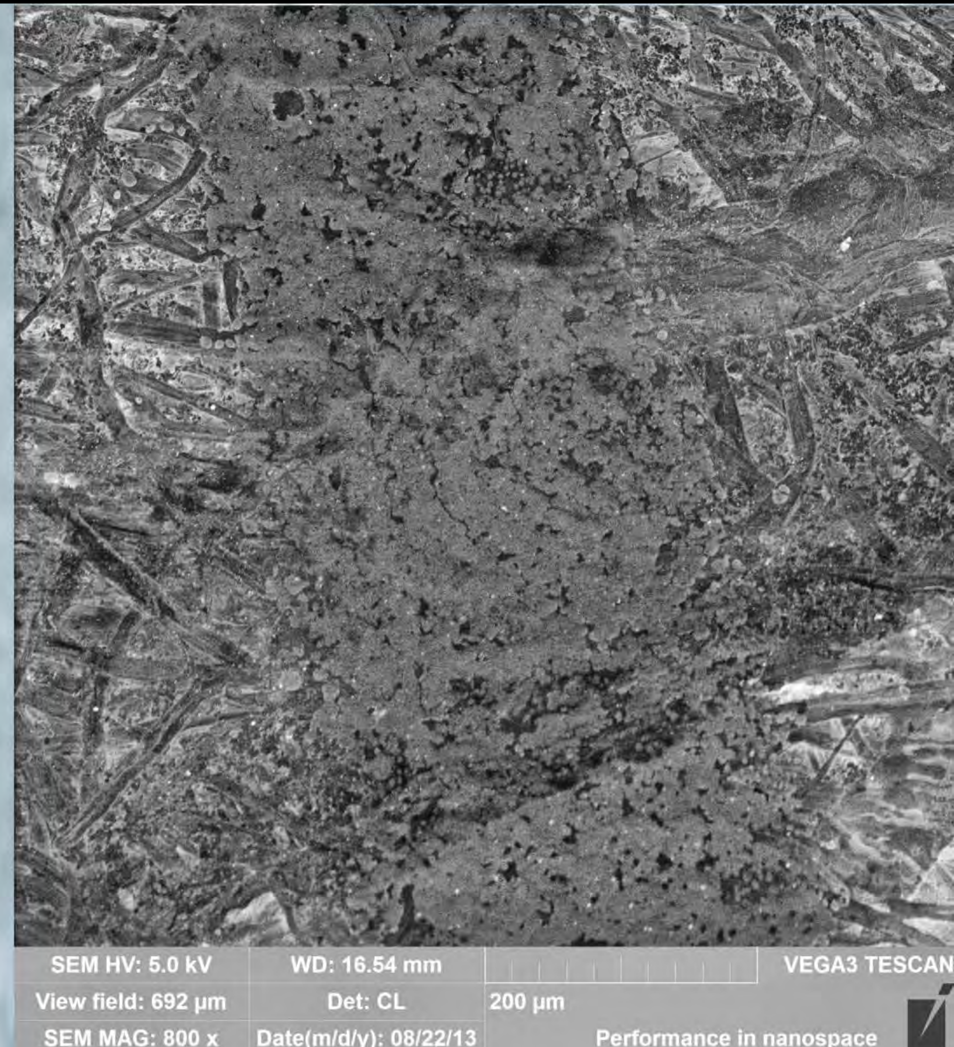
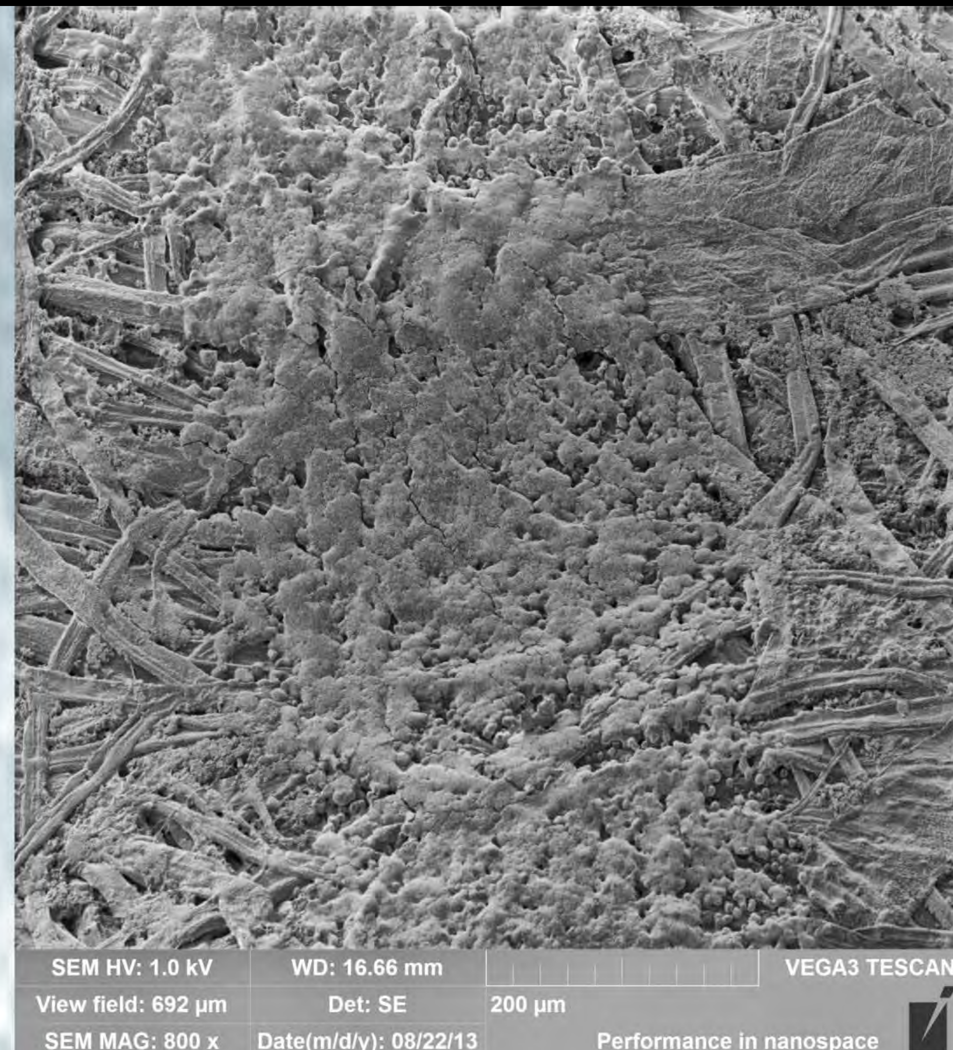
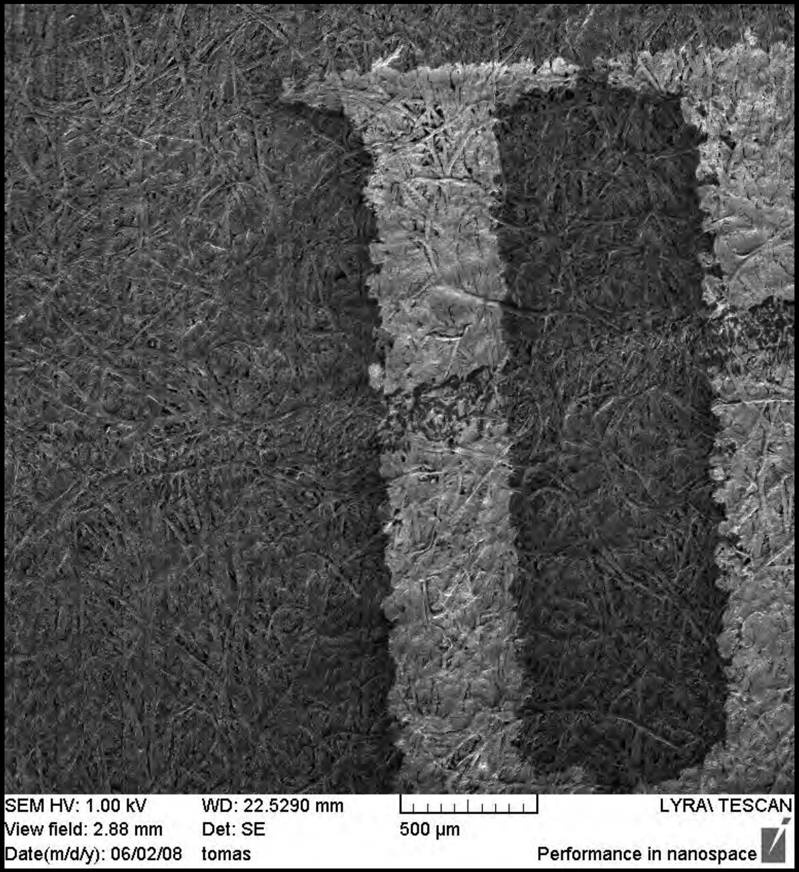
WD: 17.19 mm
VEGA3 TESCAN
View field: 1.04 mm
Det: SE
200 µm
SEM MAG: 533 x
Date(m/d/y): 08/22/13
Performance in nanospace
SEM HV: 1.0 kV
WD: 19.58 mm
VEGA3 TESCAN
View field: 830 µm
Det: SE
200 µm
SEM MAG: 667 x
Date(m/d/y): 08/22/13
Performance in nanospace

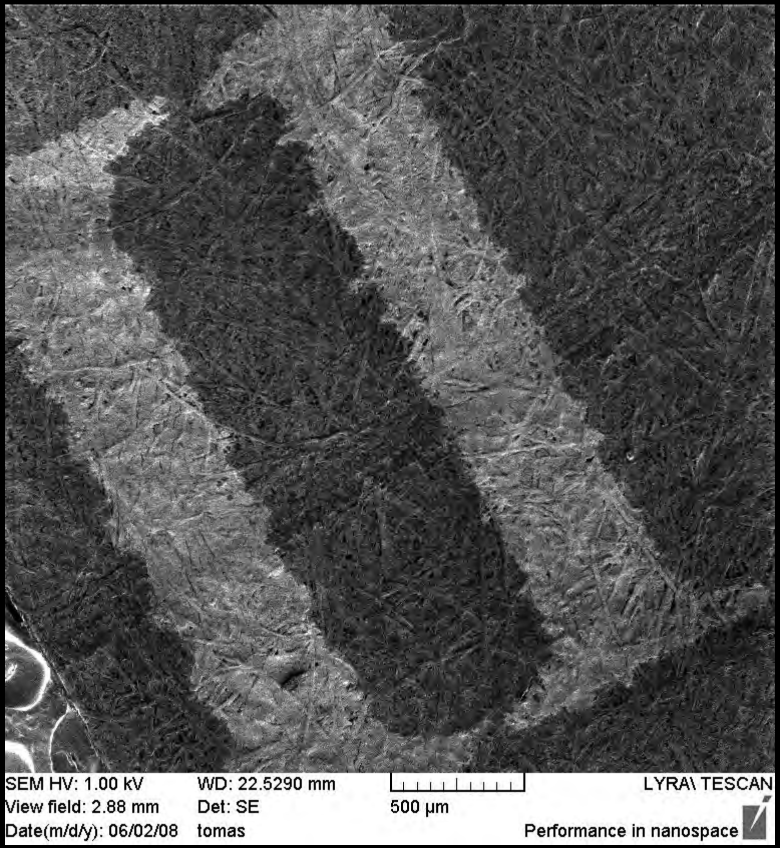

toner
pen
SEM HV: 5.0 kV
WD: 16.54 mm
VEGA3 TESCAN
View field: 2.08 mm
Det: CL
500 μm
SEM MAG: 267 x
Date(m/d/y): 08/22/13
Performance in nanospace
toner
pen
SEM HV: 5.0 kV
WD: 16.54 mm
VEGA3 TESCAN
View field: 2.07 mm
Det: CL
500 μm
SEM MAG: 268 x
Date(m/d/y): 08/22/13
Performance in nanospace


SEM HV: 5.0 kV
WD: 16.45 mm
VEGA3 TESCAN
View field: 689 µm
Det: CL
200 µm
SEM MAG: 803 x
Date(m/d/y): 08/22/13
Performance in nanospace


SEM HV: 5.0 kV
WD: 16.54 mm
VEGA3 TESCAN
View field: 692 µm
Det: CL
200 µm
SEM MAG: 800 x
Date(m/d/y): 08/22/13
Performance in nanospace


SEM HV: 1.0 kV
WD: 16.28 mm
VEGA3 TESCAN
View field: 692 μm
Det: SE
200 μm
SEM MAG: 800 x
Date(m/d/y): 08/22/13
Performance in nanospace

SEM HV: 1.0 kV
WD: 16.66 mm
VEGA3 TESCAN
View field: 692 μm
Det: SE
200 μm
SEM MAG: 800 x
Date(m/d/y): 08/22/13
Performance in nanospace


SEM HV: 1.00 kV
WD: 22.5290 mm
LYRA\ TESCAN
View field: 2.88 mm
Det: SE
500 µm
Date(m/d/y): 06/02/08
tomas
Performance in nanospace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LYRA\ TESCAN
View field: 2.88 mm
Det: SE
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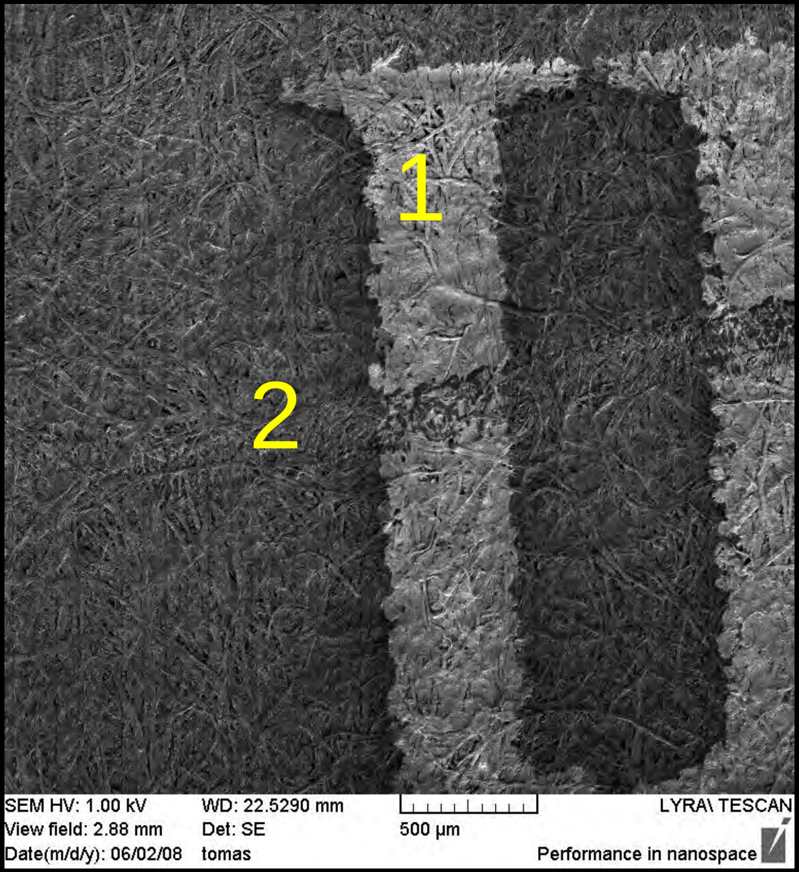
Date(m/d/y): 06/02/08
tomas
Performance in nanospace


1
2
SEM HV: 1.00 kV
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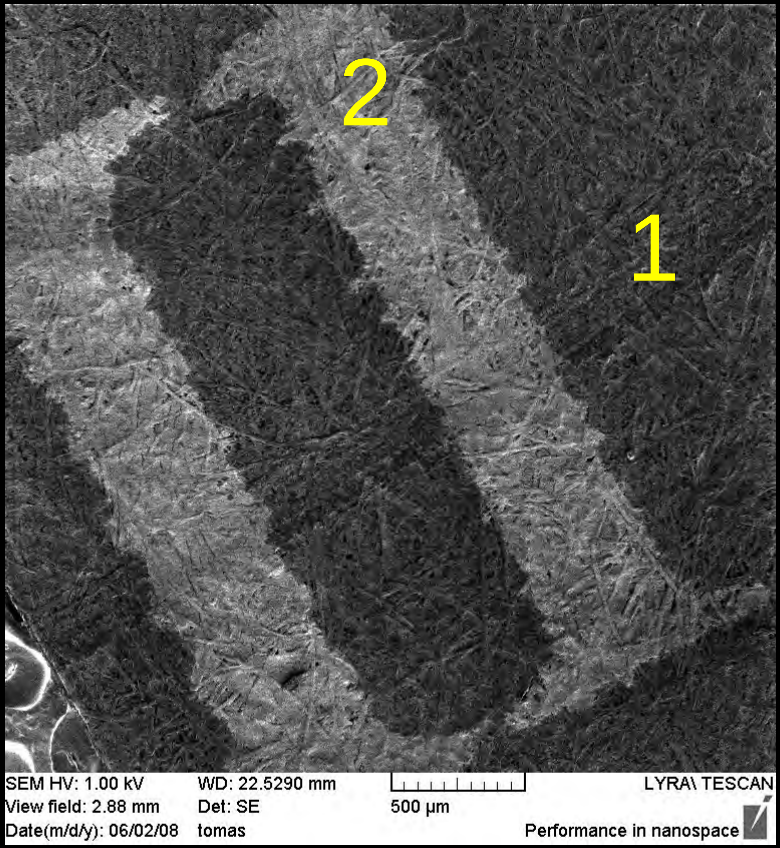
LYRA\ TESCAN
View field: 2.88 mm
Det: SE
500 µm
Date(m/d/y): 06/02/08
tomas
Performance in nanospace


2
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SEM HV: 1.00 kV
WD: 22.5290 mm
LYRA\ TESCAN
View field: 2.88 mm
Det: SE
500 µm
Date(m/d/y): 06/02/08
tomas
Performance in nanospace

# SEM

- Vysoká hĺbka ostrosti
- Možnosť zobraziť iba morfológiu papiera bez písacích prostriedkov
- Intuitívne vyhodnotenie
- Chemická analýza

- Vákuum
- Nutnosť skladať dokument
- Závislé od chemického zloženia písacích prostriedkov
- Cena

# ZÁVER

- Výskumná úloha nám ako výsledok nedáva jednu univerzálnu metódu, ktorá by všeobecne riešila krížené ťahy.
- Výsledkom je súbor metód, pri ktorých sme preskúmali ich aplikovateľnosť.
- Nasadením každej metódy sa nám otvára nový pohľad na problém a zviditeľňujú sa nám nové charakteristické znaky jednotlivých ťahov.
- Výsledkom výskumnej úlohy je kategorizácia vzoriek a následné priradenie najvhodnejšej metódy pre daný typ úlohy

# 3D MEASUREMENT OF SURFACE STRUCTURES IN DEFECTOSCOPY

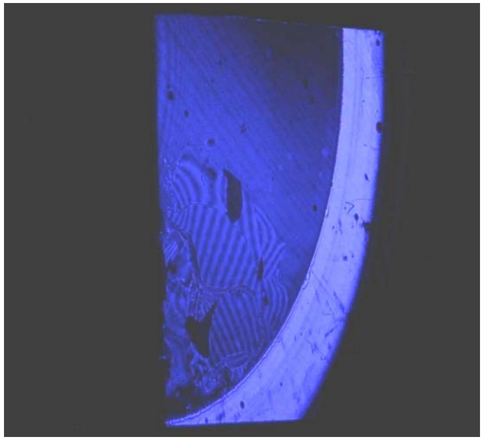
**RNDr. Milan Držík, PhD.** [1]
[1] International Laser Centre, Bratislava

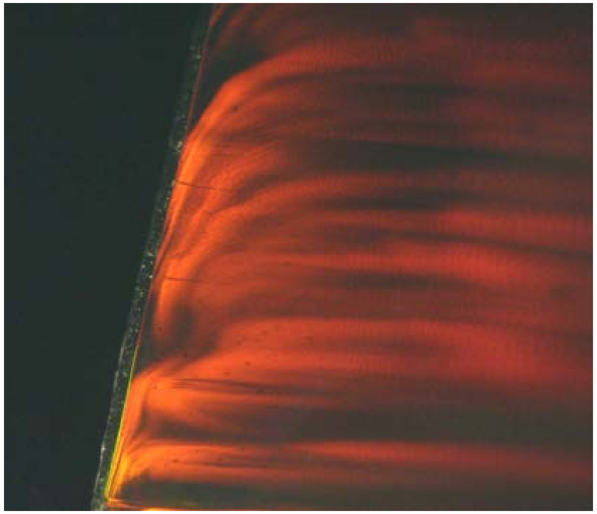

# 3D SURFACE STRUCTURES MEASUREMENT IN DEFECTOSCOPY

## Optical contactless methods

# Využitie optickej filtrácie a tmavého poľa na určenie tvaru defektov tenkých vrstiev

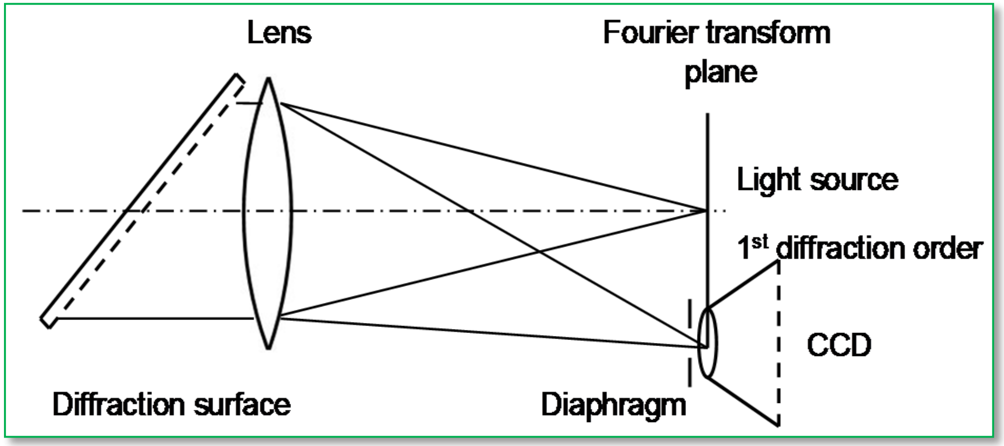
- **Nasnímaním povrchového mikroprofilu pomocou AFM prípadne SEM možno zistiť jeho základné geometrické rozmery a vlastnosti, okrem laterálnych rozmerov aj hĺbkový profil. Tento prístup je však realizovateľný len na malých vybraných oblastiach povrchu s plochou niekoľkých štvorcových mikrometrov. Aby bolo možné diagnostifikovať profil štruktúry, jeho homogenitu a tiež identifikovať defekty nanoštruktúr na oveľa väčších plochách, navrhli sme a realizovali optické metódy založené na využití šikmého bočného osvetlenia ako aj difrakcie svetla na periodických povrchových štruktúrach.**
- **Princíp merania spočíva v osvetlení povrchu diagnostifikovanej štruktúry pod vhodným uhlom a pozorovaní rozptýleného svetla alebo svetla difragovaného na periodickej nanoštruktúre. Pozorovanie celého zorného poľa je zabezpečené v optickej schéme s využitím tzv. high-pass fourierovskej optickej filtrácie.**





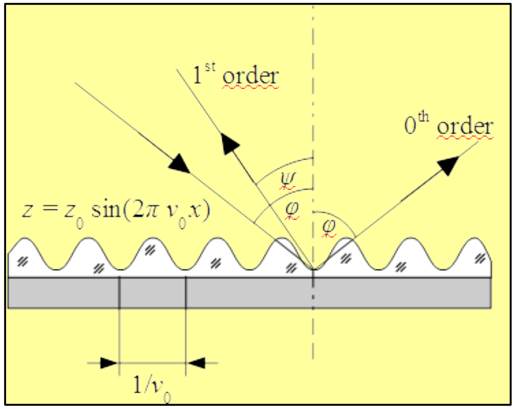
# 3D tvary defektov periodickej štruktúry

- **Základné výhody, ktoré diagnostický postup poskytuje spočívajú predovšetkým v tom, že možno pozorovať a naraz zosnímať veľké plochy t.j. 6, 8 i viac-palcové substráty. Na celej ploche sa pritom výrazne vizualizujú defekty povrchu s periodickou nanoštruktúrou. Metóda je nenáročná na prístrojové vybavenie a realizovateľná aj s použitím zdroja bieleho svetla.**
- **Keďže difrakčná účinnosť periodickej štruktúry je priamo úmerná hĺbke modulácie, jej vyhodnotením pomocou optickej schémy na obrázku, je umožnená aj kvantifikácia hĺbky povrchového profilu t.j. hĺbky modulácie štruktúry.**
- **Skúsenosti ukázali, že ľudské oko pri vhodnom osvetlení môže sledovať aj väčšie oblasti, pri zisťovaní oblastí defektov a bodových defektov > 100 µm.**

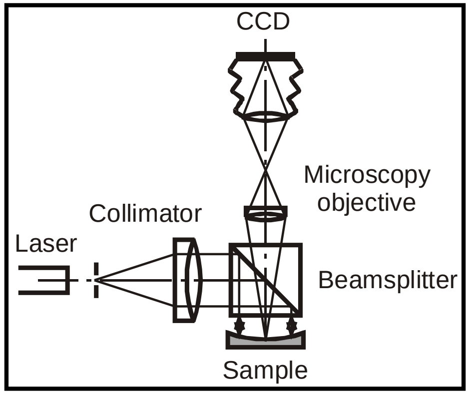


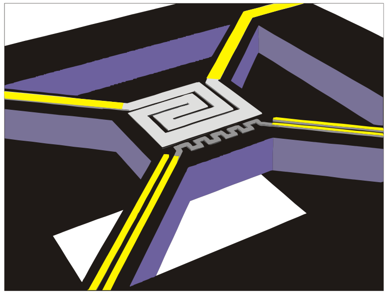
# Kvantifikovanie parametrov periodického 3D povrchového profilu

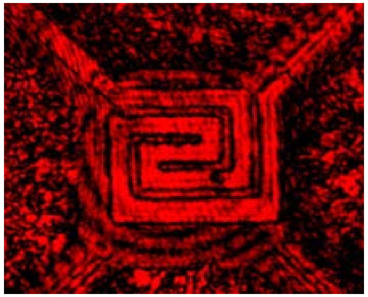
- **Diagnostika mriežkových periodických štruktúr optickými prostriedkami. Štruktúry sú vytvorené ako transparentné vrstvy submikrónovej hrúbky s periodickou moduláciou povrchového profilu. Ich primárnym účelom je využitím vlastností skrížených mriežok zabezpečiť antireflexné vlastnosti vrstiev. Keďže profil má sledovať harmonický priebeh, dôležité je aj diagnostifikovanie jeho geometrie.**
- **Rozpracovali sme metódu, ktorá umožňuje s využitím merania difrakčnej efektivity určiť hĺbku modulácie a prípadne deformáciu „harmonického priebehu“ povrchového profilu. Na základe skalárnej teórie difrakcie svetla na fázových mriežkach sme odvodili vzťahy pre interpretáciu nameraných veličín difrakčnej efektivity v jednotlivých difrakčných rádoch. Súčasne bola realizovaná schéma fotoelektrického snímania difrakčných uhlov a účinnosti fázových štruktúr vytvorených na povrchu zrkadlovo odrážajúcich substrátov. Experimentálne testovanie potvrdilo aplikovateľnosť takéhoto prístupu aj na štruktúry s periódou blízkou λ/2.**
- **Použitím svetla Nd:YAG lasera v oblasti kratších vlnových dĺžok (λ=473 nm) sme zabezpečili diagnostiku mriežok s periódou p=259 nm.**

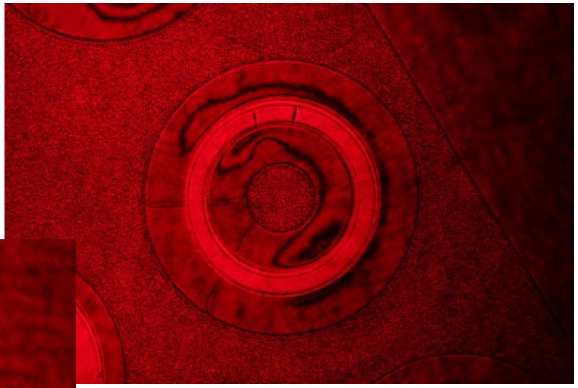


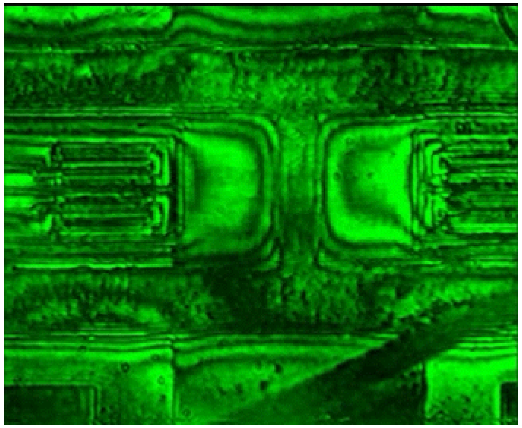
# Interferenčné sledovanie defektov a profilu membrán

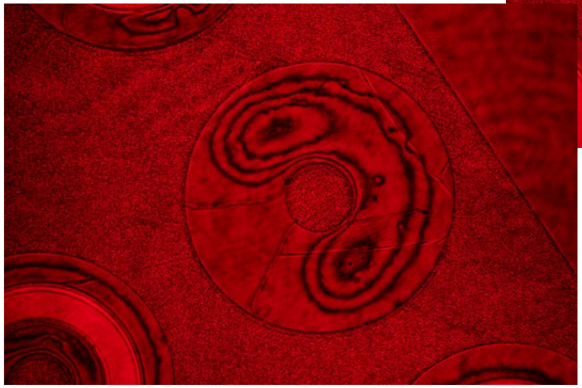




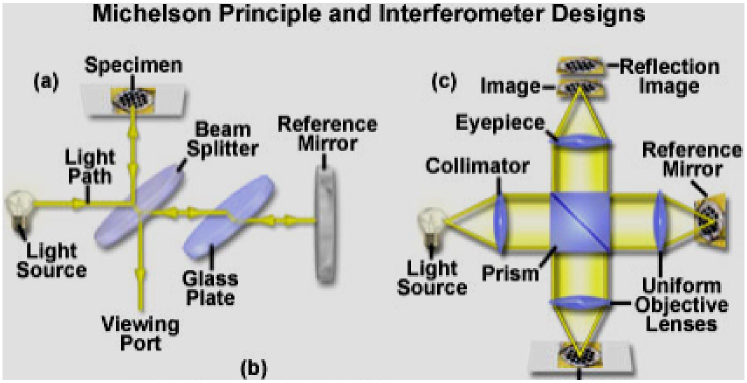






# Interferenčný mikroskop

## Metóda dvojlúčovej interferencie



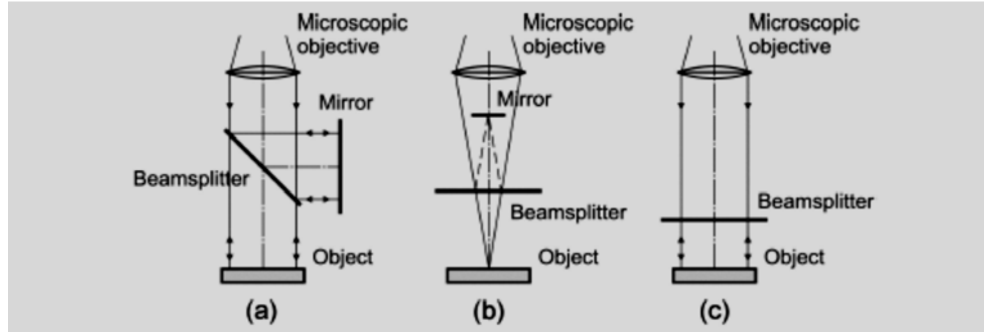
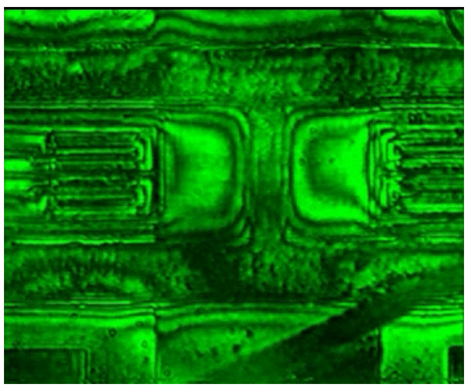
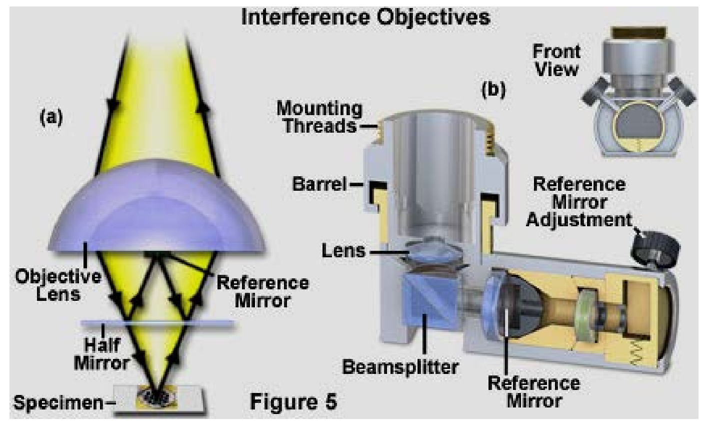



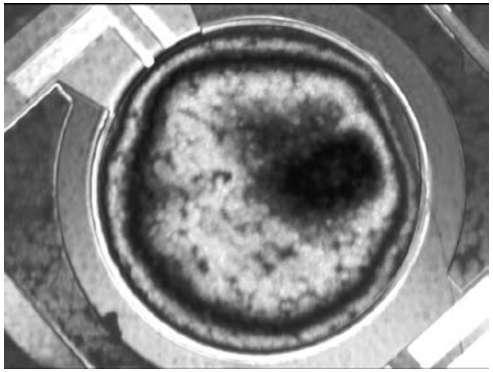

FIGURE 27. Types of interference microscope based on, (a) Michelson, (b) Mirau, and (c) Tolansky scheme.



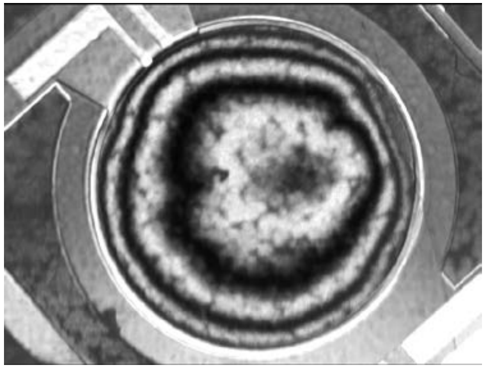


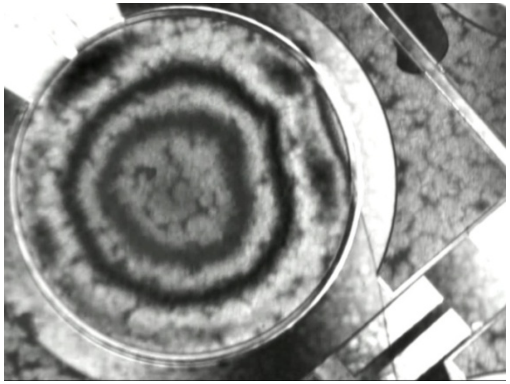
# Meranie defektov tvaru membránových štruktúr

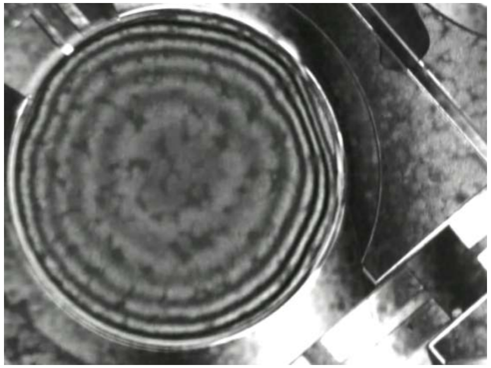
## White light interferometry Bruker Contour GT-K1



$$\sigma_0 + \sigma_P = \frac{PR}{2t}$$

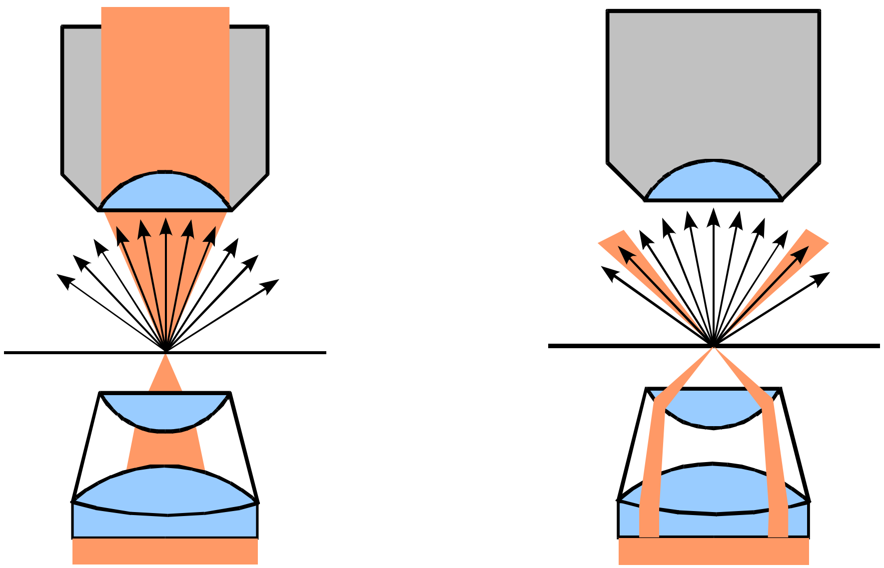






# Pozorovanie v tmavom/svetlom poli

## Zlepšenie kontrastu obrazu – tmavé pole/svetlé pole



Základným princípom **metódy svetlého poľa** je podmienka sústrediť všetko nerozptýlené (nedifragované) svetlo do objektívu

## Pozorovanie v tmavom poli

**zobrazovanie objektu iba svetlom rozptýleným na jeho hranách, drobných detailoch a nehomogenitách – pozadie obrazu je tmavé**

Optický princíp - vylúčenie svetla z kondenzora, ktoré by nerozptýlené vchádzalo do objektívu

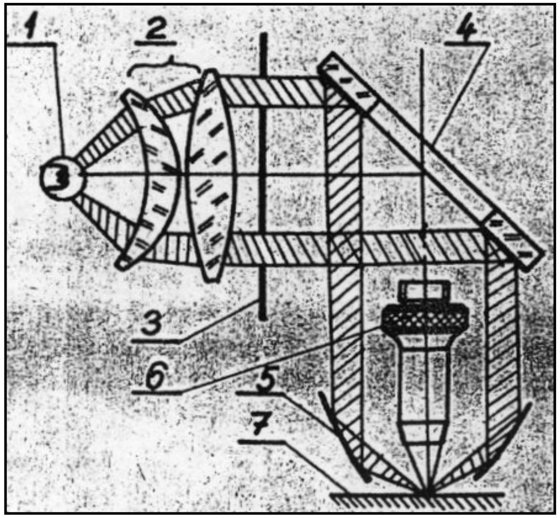
Najjednoduchšie - pri šikmom osvetlení tak, aby zrkadlovo odrazená, alebo priamo prechádzajúca časť svetla nezasiahla objektív

# Identifikácia 3D tvaru defektov metódou tmavého poľa

- **Reflected Light Microscopes**

  **Priemyselné reflexné mikroskopy so širokým zorným poľom a konfokálne mikroskopy sú nástroje monitorovania procesov a kontroly kvality v oblasti polovodičových technológií. Defektoskopia integrovaných obvodov, nehomogenita vrstiev, a chyby technologických procesov pri depozícii vrstiev na substrátoch si vyžadujú sofistikované svetelné mikroskopické prístroje. Vyspelý optický systém by mal poskytovaťoptimálne osvetlenie,veľkú hĺbku ostrosti, vysokokorigované objektívy, dobrý kontrast obrazu.**

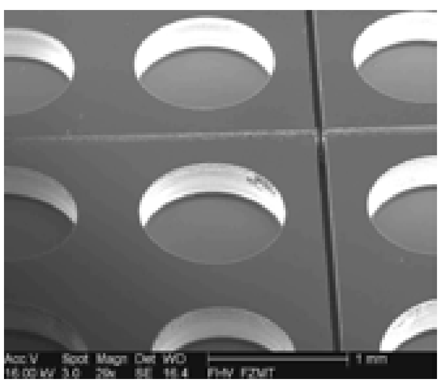
- **Jedným z dôležitých prístupov je využitie osvetlenia diagnostifikovaného objektu metódou tmavého poľa.**

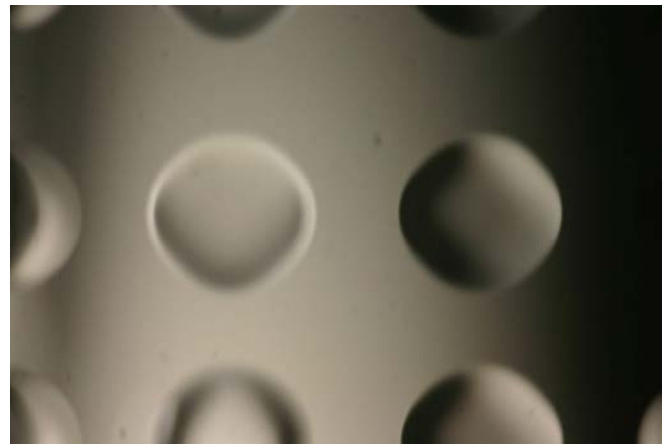



*Epi-iluminátor osvetlenie zrkadlovo odrážajúceho povrchu zboku pod uhlom – zrkadlový odraz sa nedostáva do pozorovacieho objektívu*

# Pozorovanie tvarových nepresností Si membrán

## Difúzne biele šikmé osvetlenie



**Meranie tvaru a veľkosti vybúlenia membránových prvkov pod difúznym šikmým osvetlením**

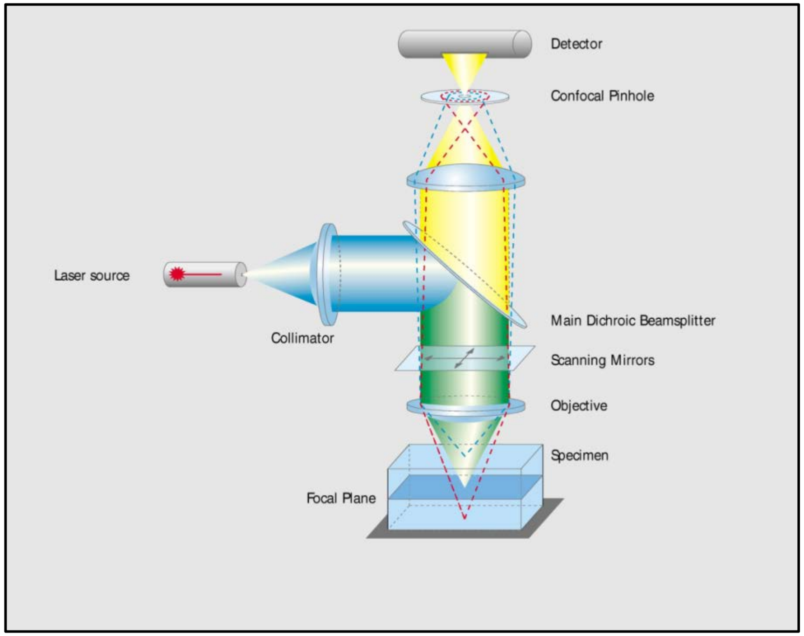
**Optické metódy mikromechaniky**

# Konfokálna mikroskopia

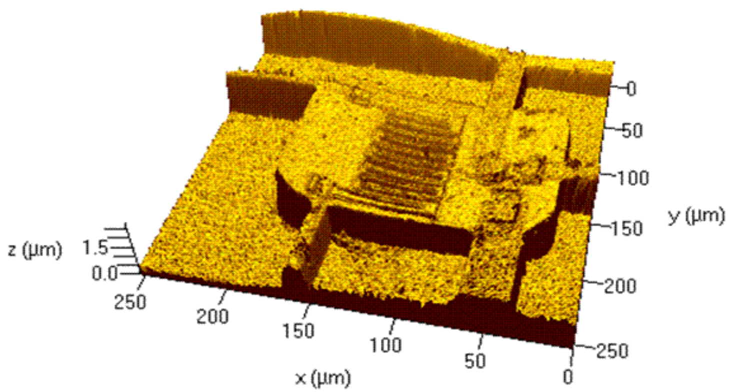
**Konfokálna optická mikroskopia**
**- sústreďuje svetlo odrazené/vyžarované z jednej roviny vzorky**

**Pinholová clona je v rovine konjugovanej k ohniskovej rovine – iba svetlo z bodu objektu v ohnisku môže byť zachytené detektorom.**

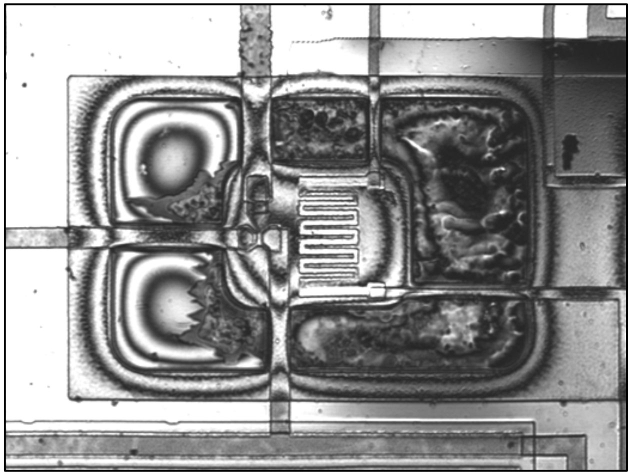
**Laserový sfokusovaný lúč rastruje vzorku po pixeloch v rôznych rovinách. Obrazy vytvorené v jednotlivých rovinách rastrovania sú skombinované do 3-D obrazu**



# Konfokálny mikroskop





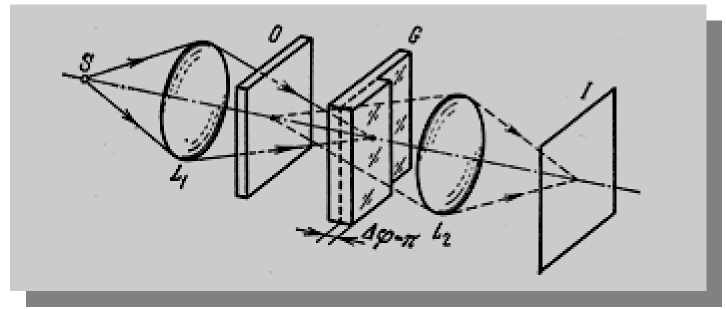


**Interferencia na tenkej vrstve**

# Vizualizácia fázy

**Fázový objekt**

$$t(x) = e^{i\phi(x)}$$



## Amplitúdové filtre s meniacou sa priepustnosťou

- efekt šikmého osvetlenia
- filter s lineárne sa meniacou priepustnosťou

## Fázový nôž

(Zernikeho fázový kontrast)
- problém s kvantifikáciou

$$t(x) = 1 + i\varphi(x)$$

Fourier transform

$$\psi \sim \left[\frac{2\pi f}{k}\delta(x) + i\Phi\left(\frac{kx}{f}\right)\right]\delta(y)$$

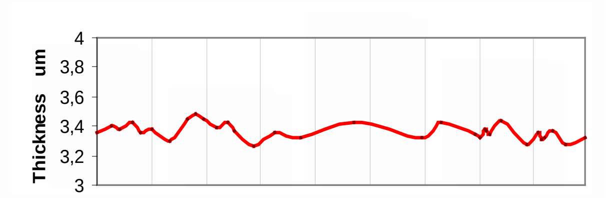
optical filtration by opaque stop

Fourier transform of *t*(*x*)

v obrazovej rovine ⇒ variácie intenzity ukazujú fázovú štruktúru objektu

$$I_i \sim \phi^2(x)$$

# Shadow and phase visualization techniques




$$t(x) = e^{i\phi(x)}$$

intensity transmittance ~ $|t(x)|^2 \Rightarrow$ constant

Fourier plane

$$\psi \sim \left[\frac{2\pi f}{k}\delta(x) + iT\left(\frac{kx}{f}\right)\right]\delta(y)$$

optical filtration by opaque stop

Fourier transform of $t(x)$

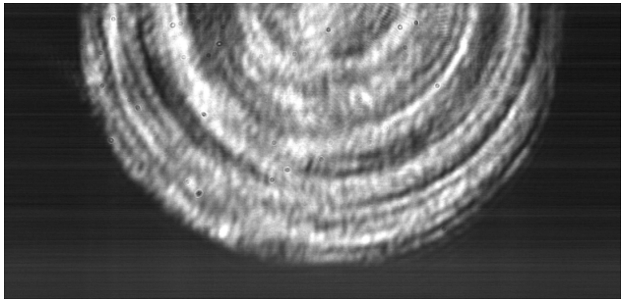
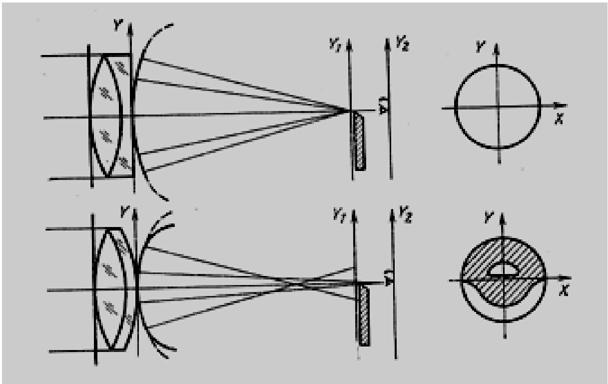
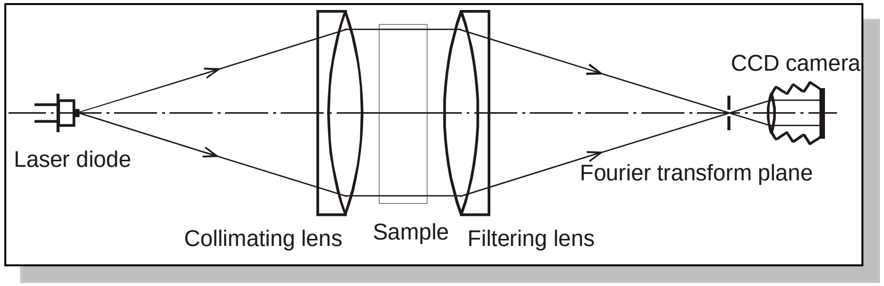


image plane

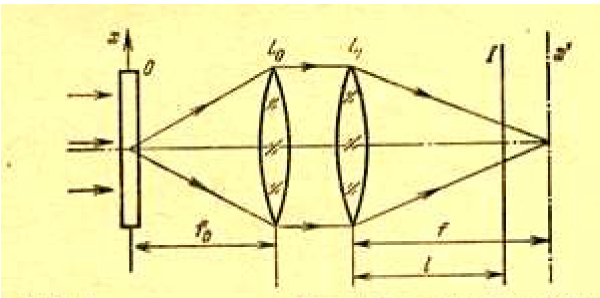
$$I_i \sim \phi^2(x)$$

**intensity variation shows the nature of phase object**





# Fázová vizualizácia defektov – profil priehlbiny



$$b = \frac{\lambda f}{4\pi}(1 - l/f),$$

rozostrenie

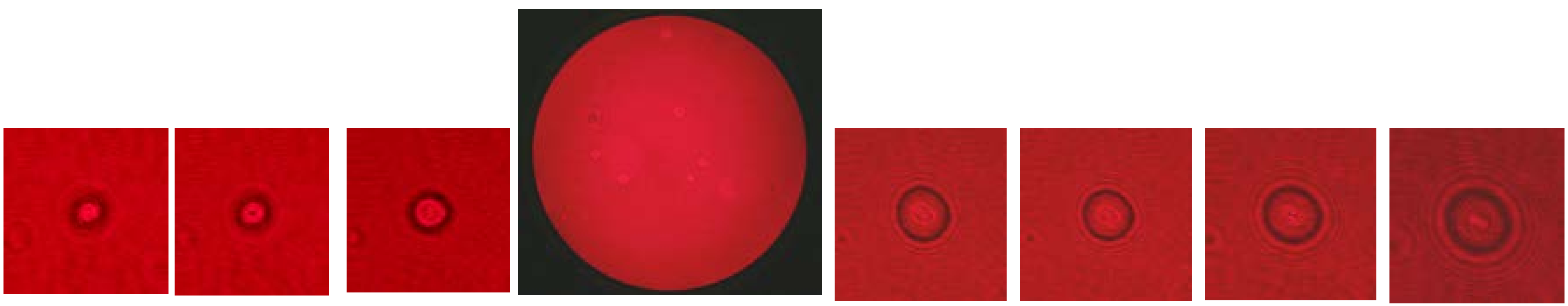
$$t(x) = \exp[i\varphi(x)],$$

$$\int T(\omega)\,\omega^2 \exp(i\omega x)\,d\omega = -\frac{d^2 t(x)}{dx^2}.$$

Fourier transform vlastnosti

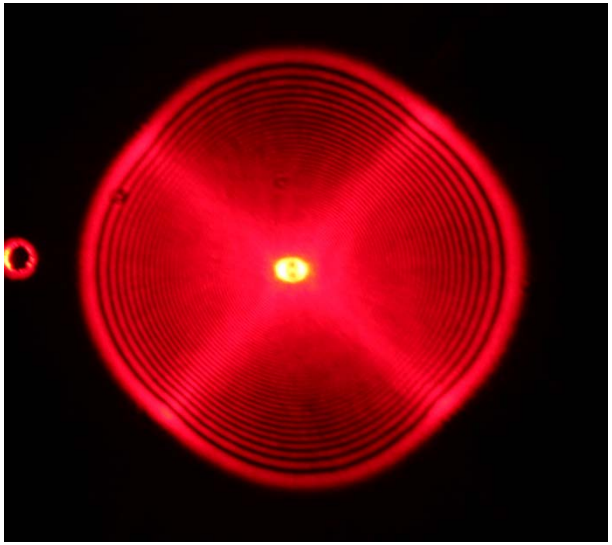
$$I_1(x) = |t_1(x)|^2 \approx 1 + 2b\,\frac{d^2\varphi(x)}{dx^2}.$$

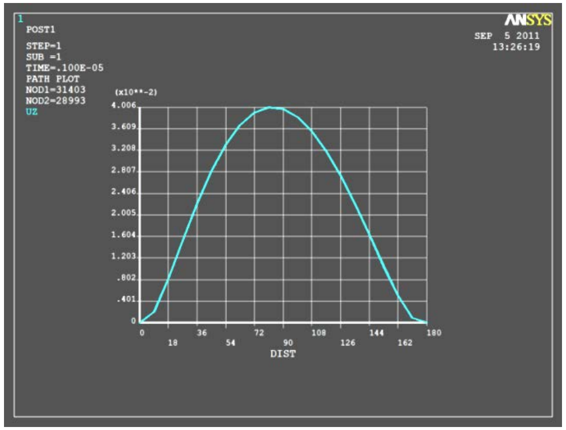
určenie hĺbkového profilu
– postupné rozostrenie

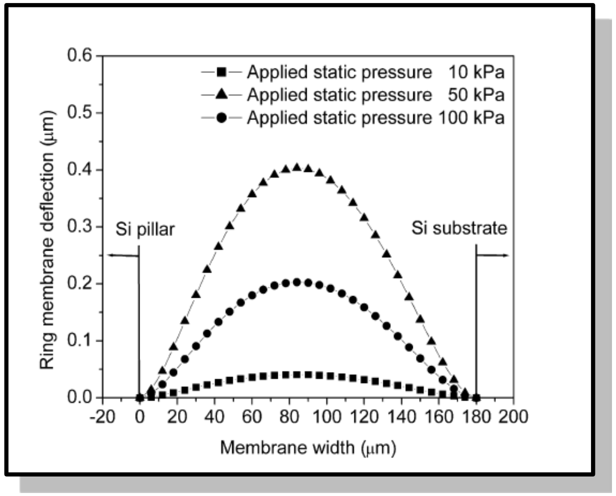


# Odchýľky od sférického tvaru vybúlenia membrán

## Fázová vizualizácia – anizotrópia kremíka
## - veľmi citlivá metóda určenia 3D odchýliek tvaru

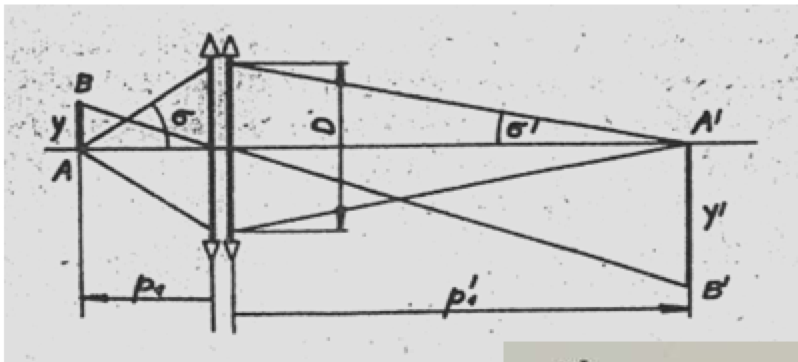




# Obraz v mikroskope – laterálne rozlíšenie

**Rozlišovacia schopnosť** najmenšia vzdialenosť dvoch bodov, ktorú môžeme rozlíšiť Rayleighovo kritérium

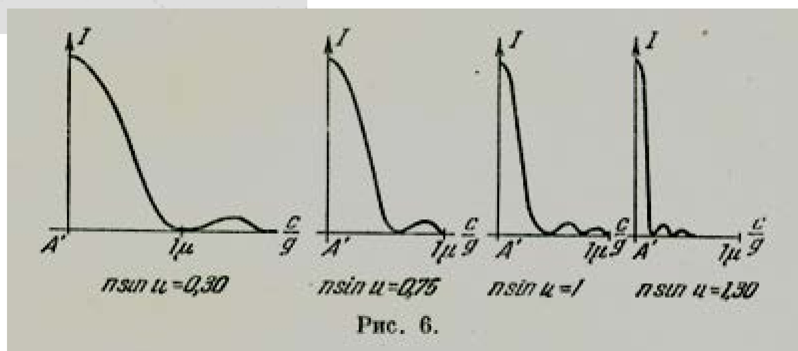




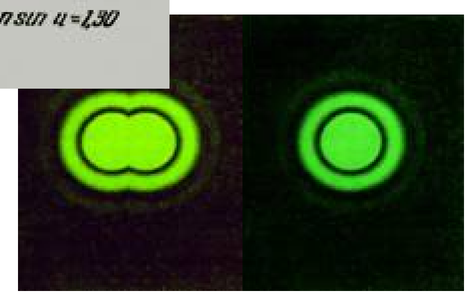
$$y' = 1{,}22\frac{\lambda}{D}p'_1$$

$$ny\sin\sigma = n'y'\sin\sigma'$$

$$\Downarrow$$

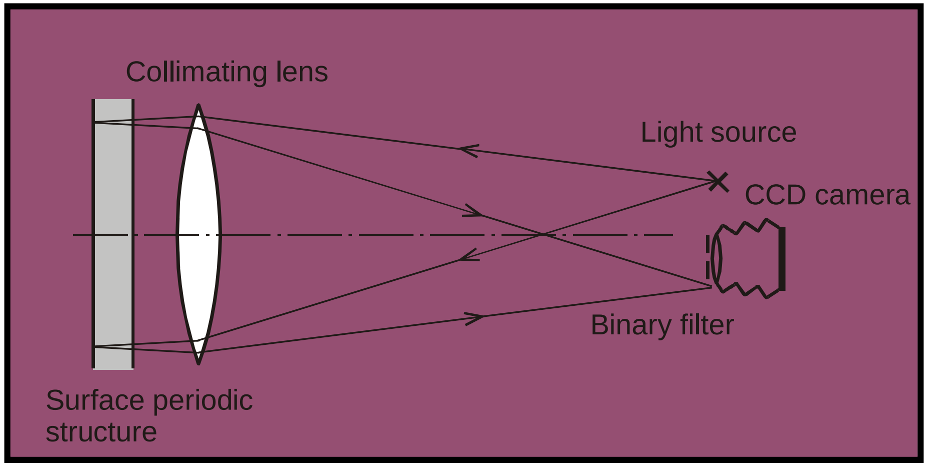


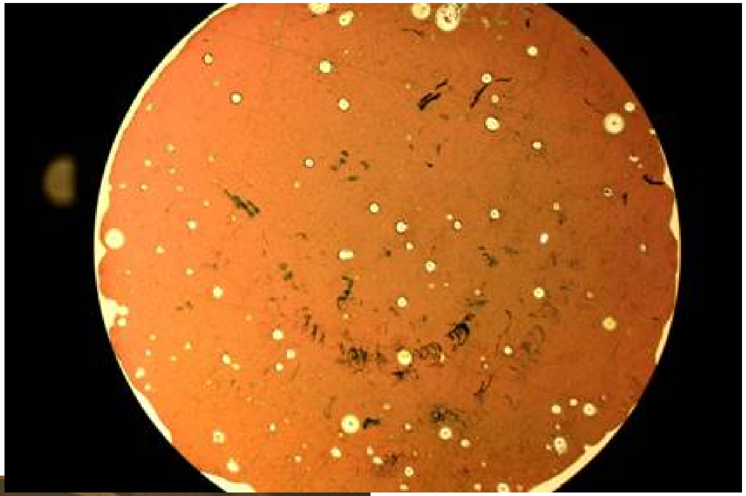

$$R = \frac{0.61\lambda}{n\sin\sigma} \quad \Rightarrow \quad R = \frac{0.61\lambda}{N.A.}$$

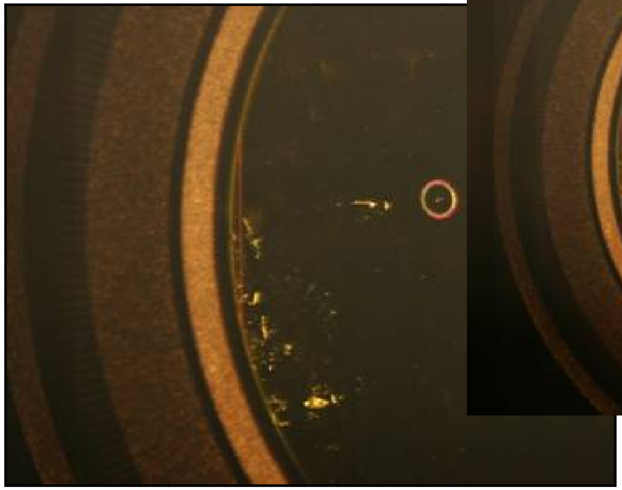


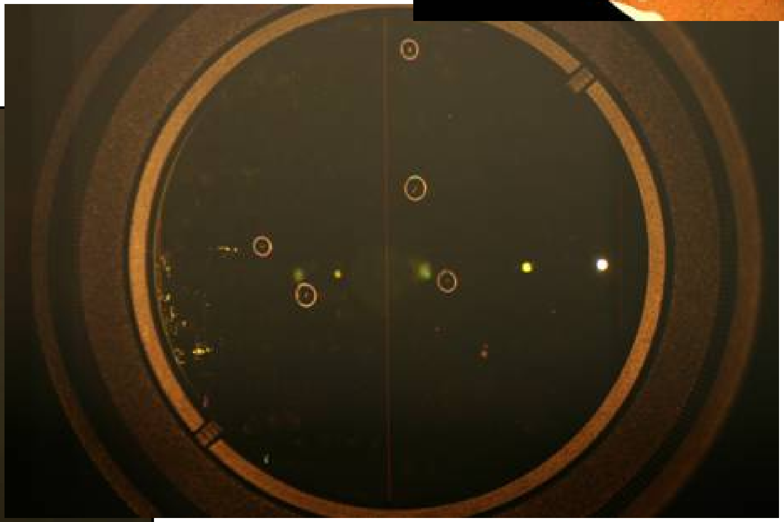
nekoherentné svetlo

# Dark-field images formed by the diffracted light around the 1st order diffraction



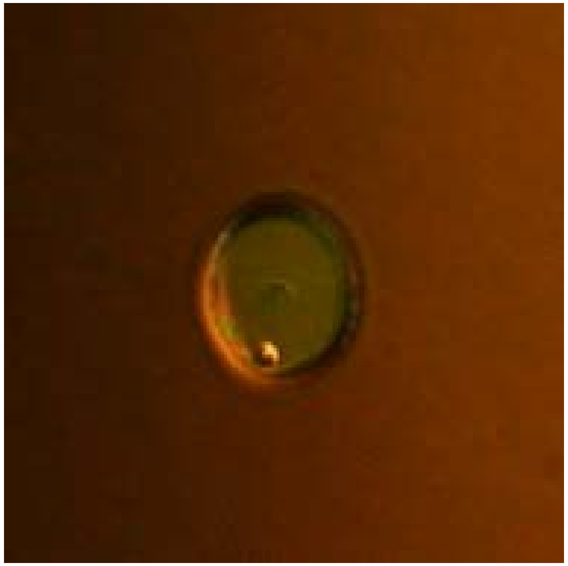



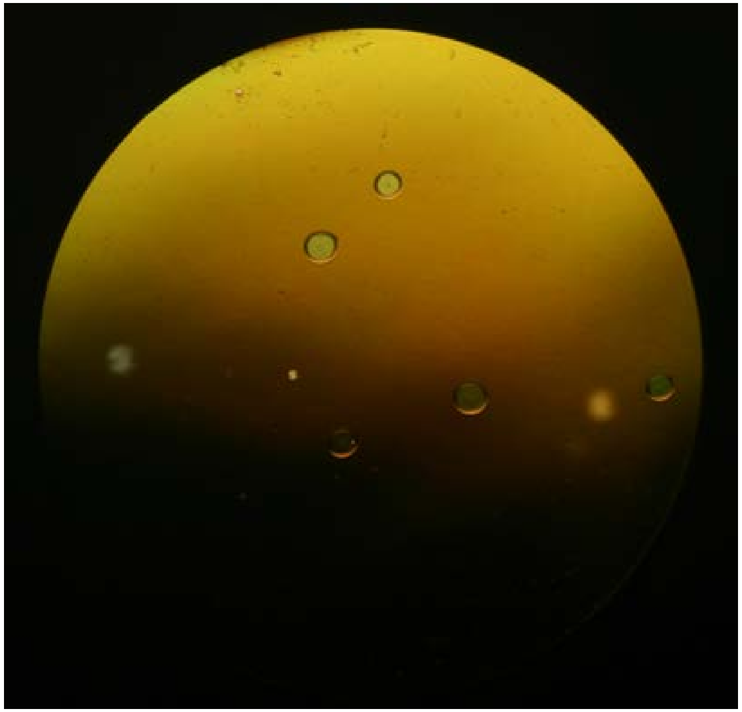




# 3D vizualizácia defektov vrstvy s periodickou štruktúrou

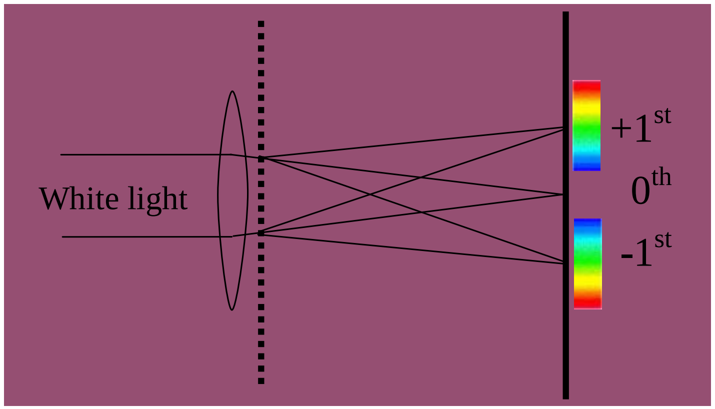
**Dark-field images were formed using the binary filter opening positioned in Fourier zone diffraction. By proper adjustment of the filter position the optimum illumination conditions can be aligned with varying of the angle of illumination**

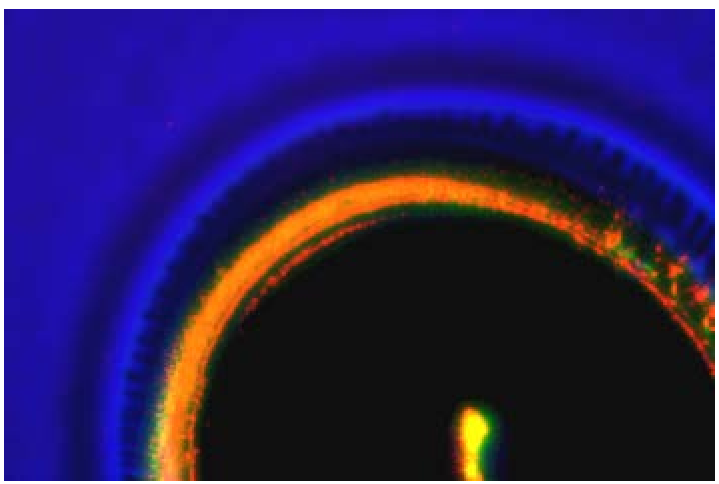


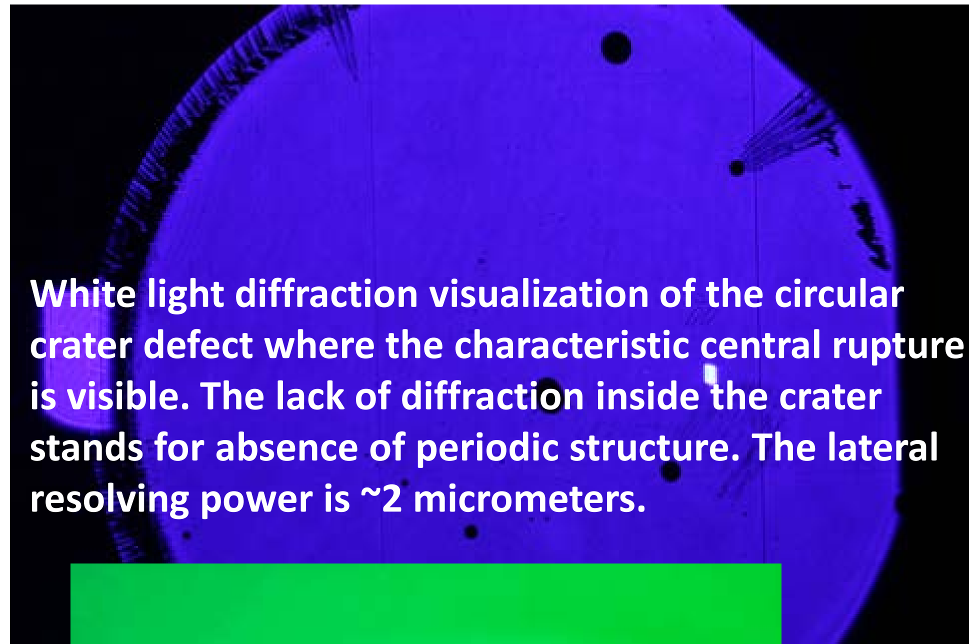


**Visualization of dimple-like defects of the surface layer by grazing angle illumination. Depth of the superficial crater ~1000 nm, diameter ~1.5 mm**

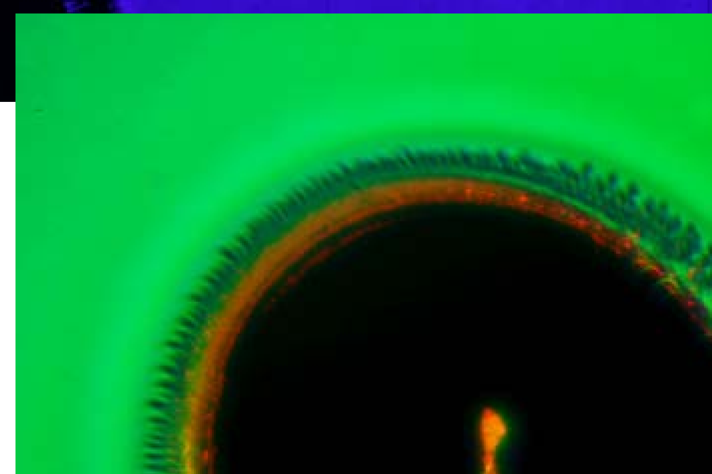
# Inšpekcia defektov optickou filtráciou v bielom svetle



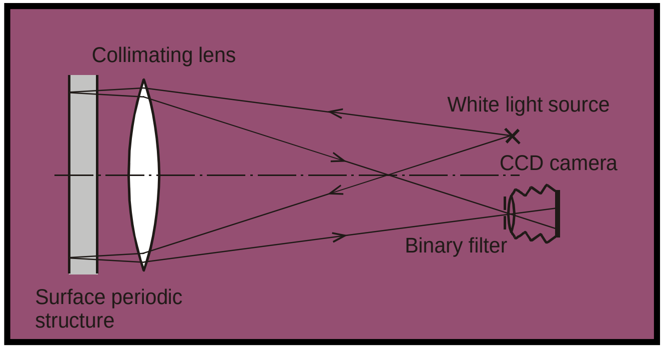



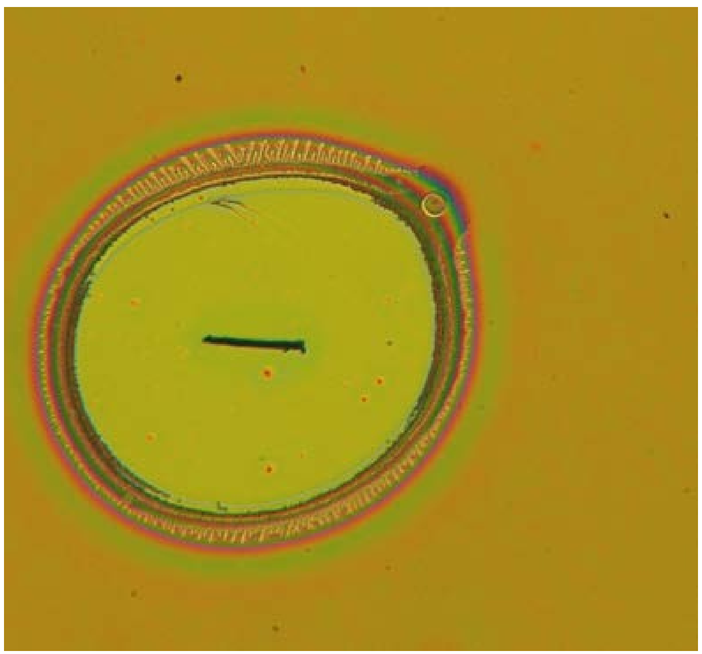


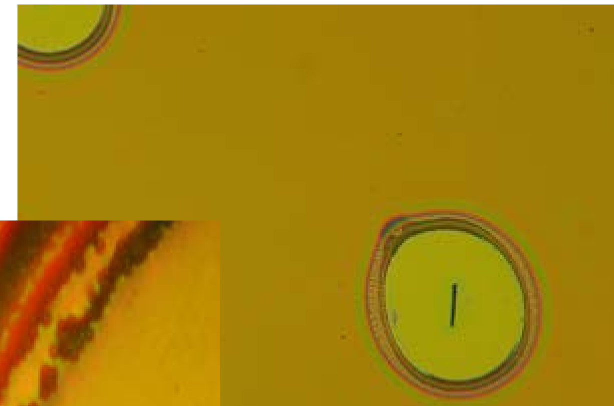
White light diffraction visualization of the circular crater defect where the characteristic central rupture is visible. The lack of diffraction inside the crater stands for absence of periodic structure. The lateral resolving power is ~2 micrometers.

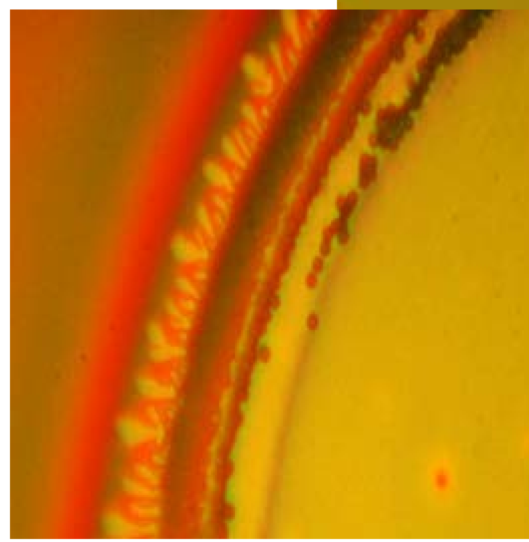


# Interferencia na tenkej vrstve – svetlé pole, periodická štruktúra



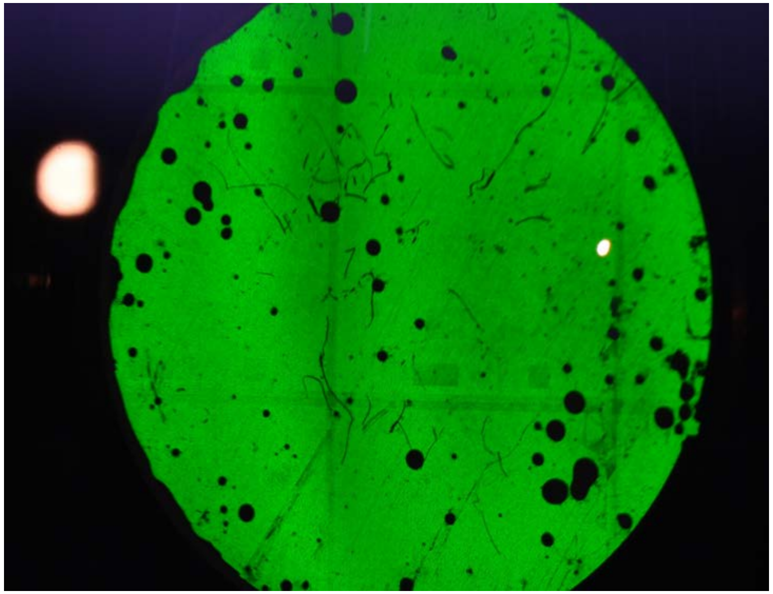


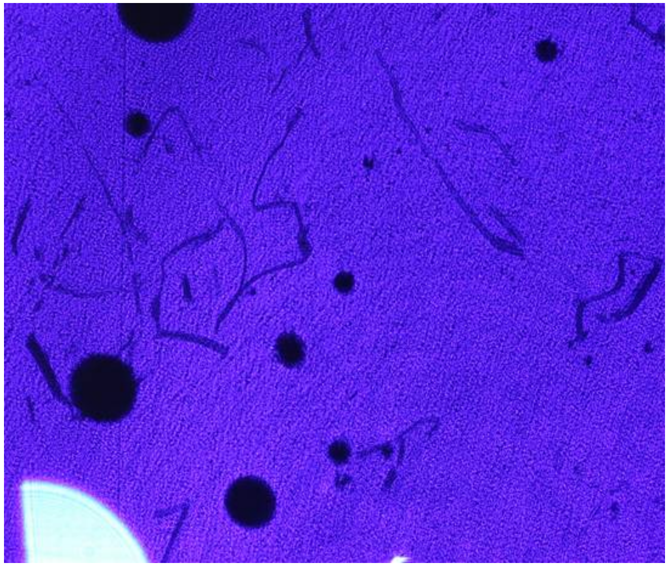


**Microobjective**
**10/0.25**
**∞/0**

**Mikroskopický obraz**
**laterálne rozlíšenie ~ 1 μm**
**hĺbkové rozlíšenie ~ 10-20 nm**

# Príklady vizualizácie defektov

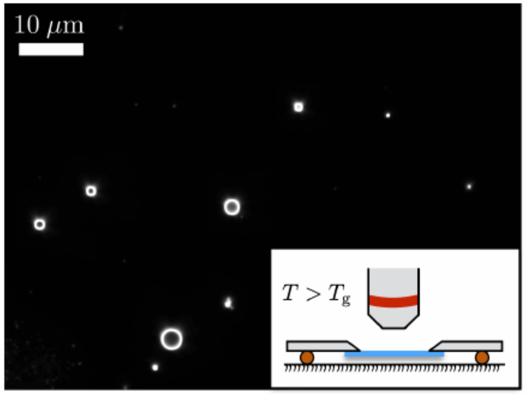


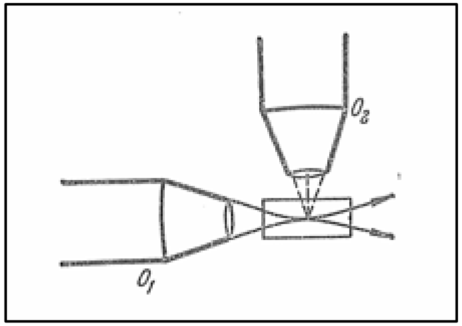


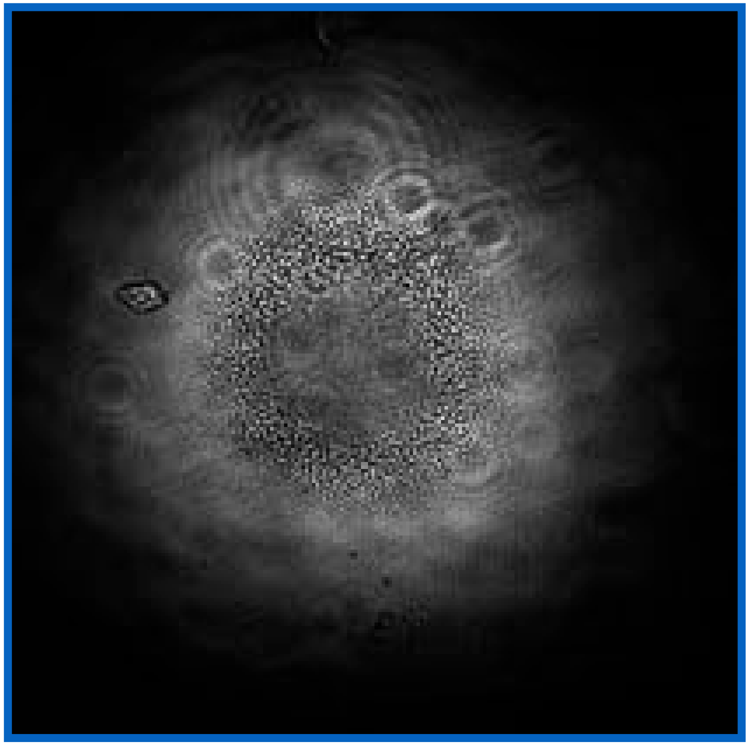
# Mikro/nano-metrológia

## Mikroskopické pozorovanie častíc
### s rozmermi pod difrakčným limitom

pozorovanie v tmavom poli
využitie rozptylu Mie
nemožno určiť tvar častice



**V mikroskope možno vidieť častice rádove nanometrových rozmerov**

# CONVERTING DATA FROM PRODUCTION TO INFORMATION USING INDUSTRY 4.0

**Robin Mitana** [1]
[1] SIDAT Digital s.r.o.

3rd INTERNATIONAL CONFERENCE

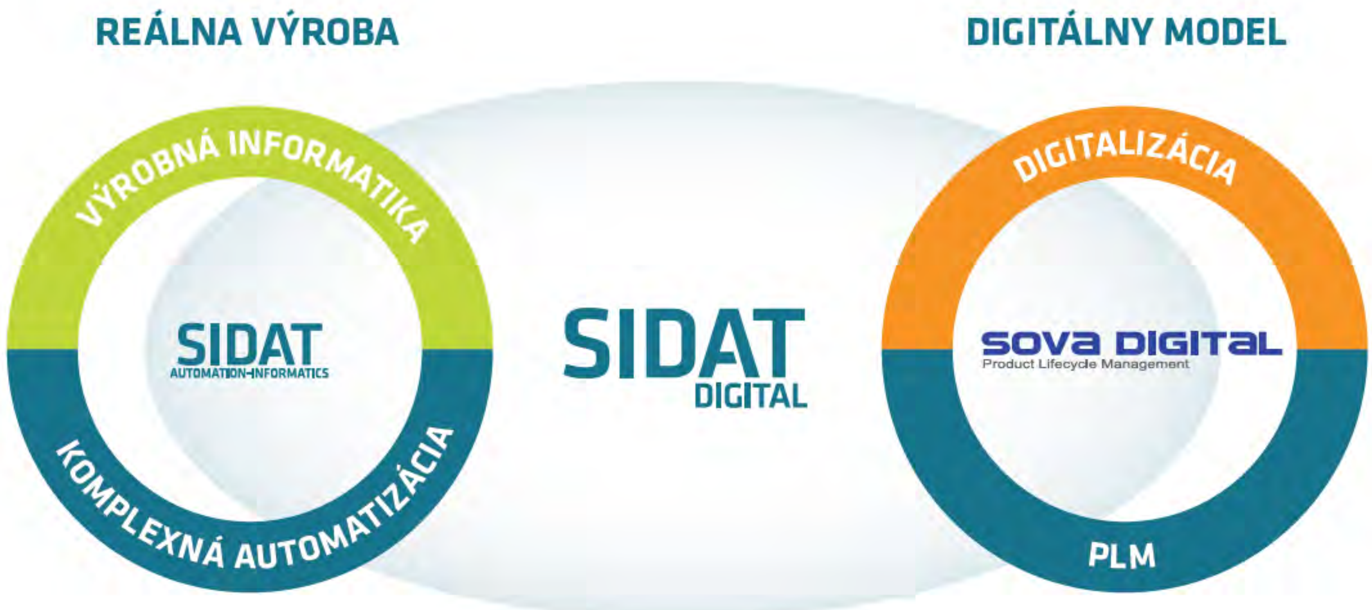
# 3D MEASUREMENT AND IMAGING

*MODERN CONTACTLESS MEASUREMENTS IN INDUSTRIAL PRACTICE*

# TRANSFORMATION OF PRODUCTION DATA TO INFORMATIONS (I40 STRATEGY)

Robin Mitana, robin.mitana@sidatdigital.sk , +421 903 432 036

# JOINT VENTURE & SYNERGY SIDAT + SOVA DIGITAL



# SIDAT DIGITAL PRODUCT PORFOLIO

CONSULTING - INCREASING THE EFFICIENCY OF PRODUCTION PROCESSES, REDUCING COSTS

MODERNIZATION OF PRODUCTION TECHNOLOGIES (ELECTRICAL & AUTOMATION) + PREPARATION FOR DIGITIZATION

DIGITIZATION OF PRODUCTION PROCESSES & LOGISTICS (RTLS)

DIGITIZATION OF ENERGY / ENERGY SOURCES

PRACTICAL IMPLEMENTATION OF INDUSTRY 4.0 SOLUTIONS

SIM - DIGITAL SIMULATION AND OPTIMIZATION OF PRODUCTION, ASSEMBLY, MACHINING, LOGISTICS, WAREHOUSING, ENERGY

VIS - VISUALIZATION OF PRODUCTION, TECHNOLOGY, BUSINESS PROCESSES

SCADA/DCS – SUPERVISORY CONTROL SYSTEMS & DATA ACQUISITION / DECENTRALISED CONTROL SYSTEMS

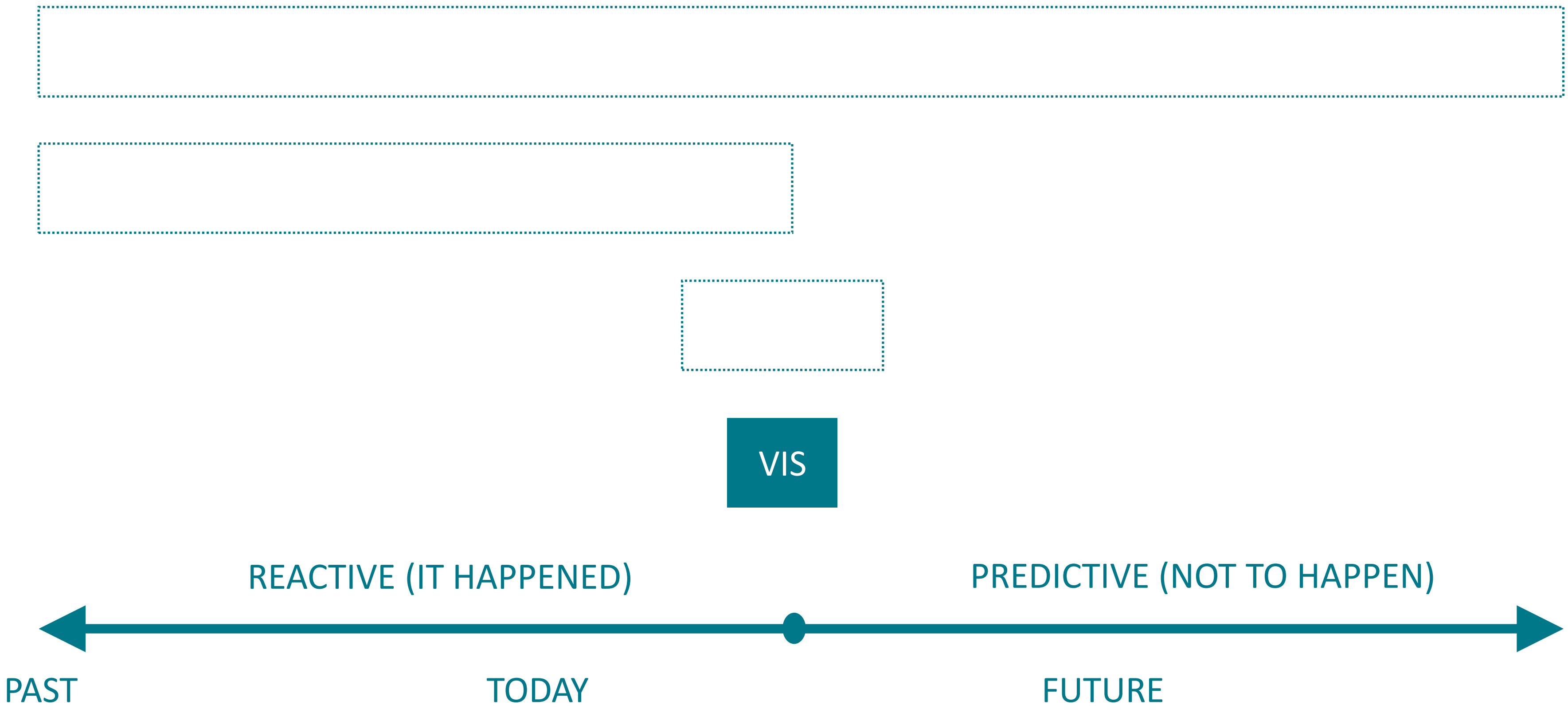
MES – MANUFACTURING EXECUTION SYSTEMS / CONVERSION OF DIGITAL DATA INTO SMART INFORMATIONS

I40/DT – CREATION OF DIGITAL TWIN & CONNECTION TO REAL PRODUCTION

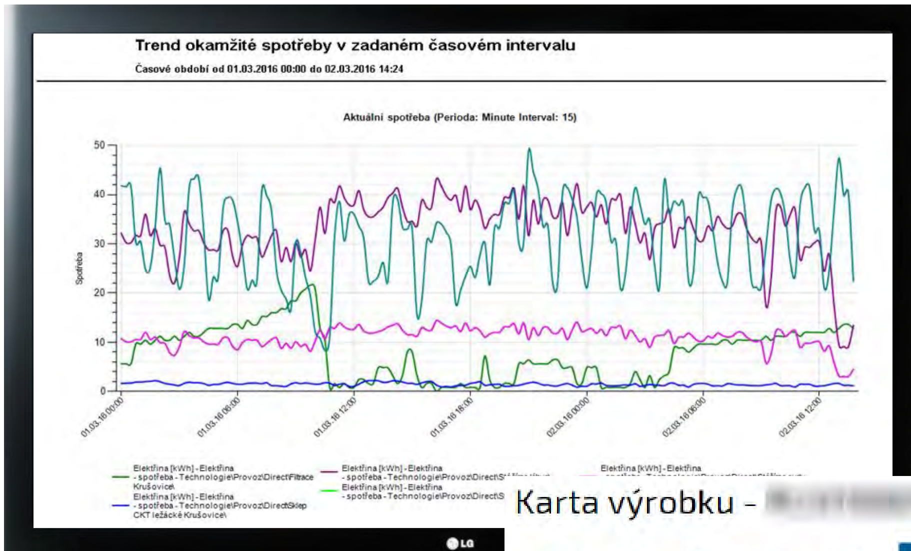
TRAINING - INDUSTRIAL AUTOMATION (PLC, OP, SW)

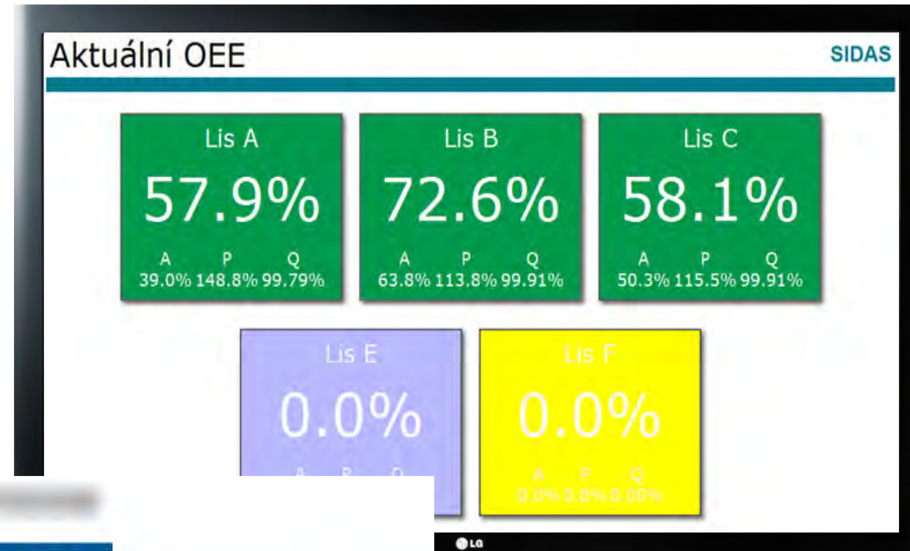
TRAINING – INDUSTRY 4.0 / DIGITAL TWIN + APPLICATIONS FOR INDISTRY

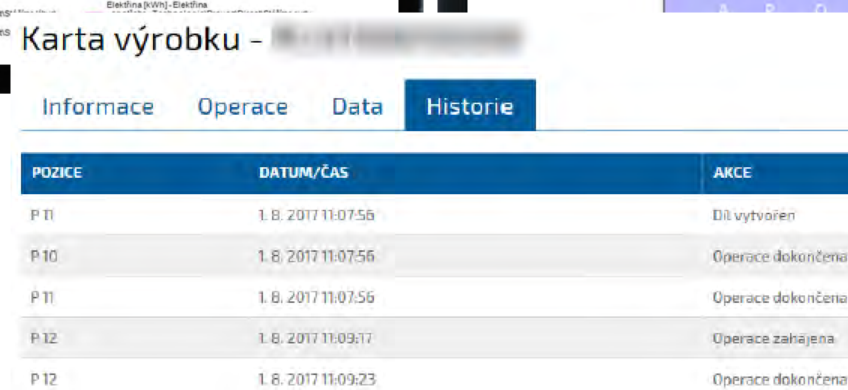
# 4 LEVELS OF INFORMATIONS FROM PRODUCTION



# LEVEL 1 - VISUALIZATION



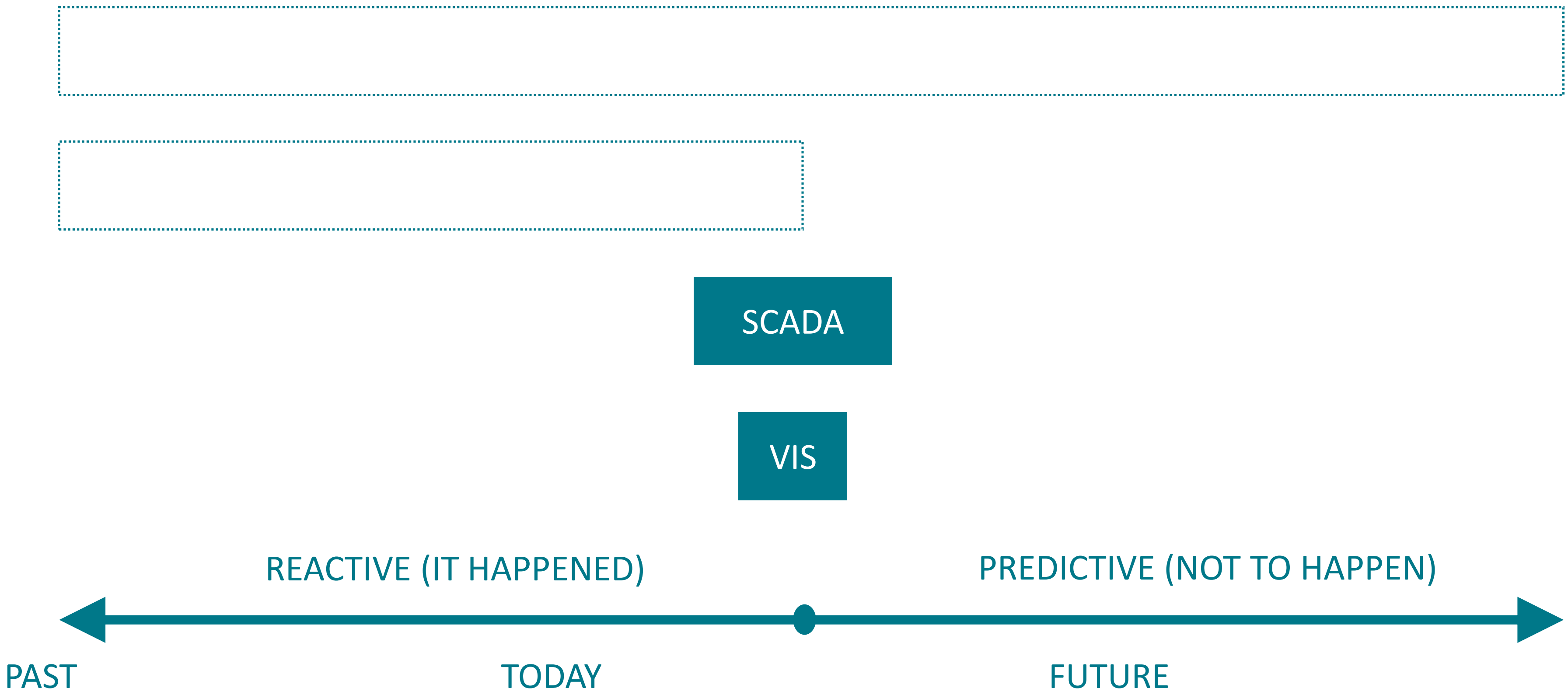


Karta výrobku -

Informace | Operace | Data | Historie

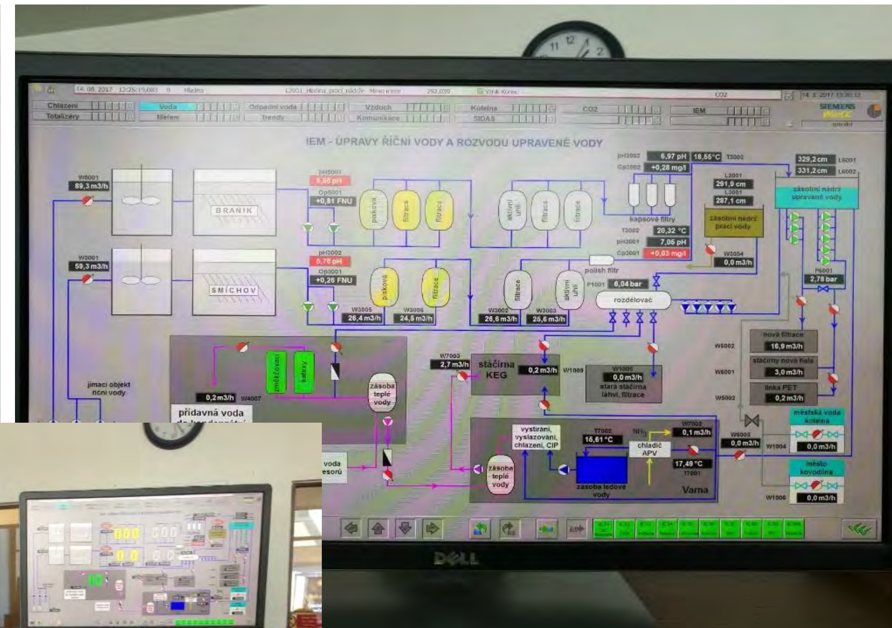
| POZICE | DATUM/ČAS | AKCE |
|---|---|---|
| P 11 | 1. 8. 2017 11:07:56 | Díl vytvořen |
| P 10 | 1. 8. 2017 11:07:56 | Operace dokončena |
| P 11 | 1. 8. 2017 11:07:56 | Operace dokončena |
| P 12 | 1. 8. 2017 11:09:17 | Operace zahájena |
| P 12 | 1. 8. 2017 11:09:23 | Operace dokončena |

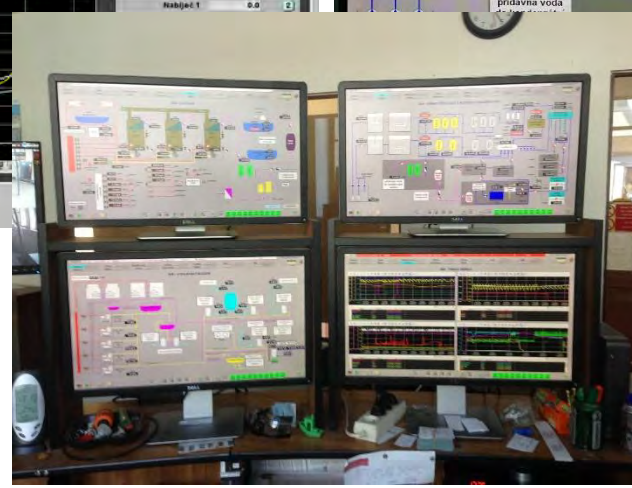
# LEVEL 1 – „SMART BUSINESS“ VIZUALIZATION – ASSEMBLY CENTER

# 4 LEVELS OF INFORMATIONS FROM PRODUCTION

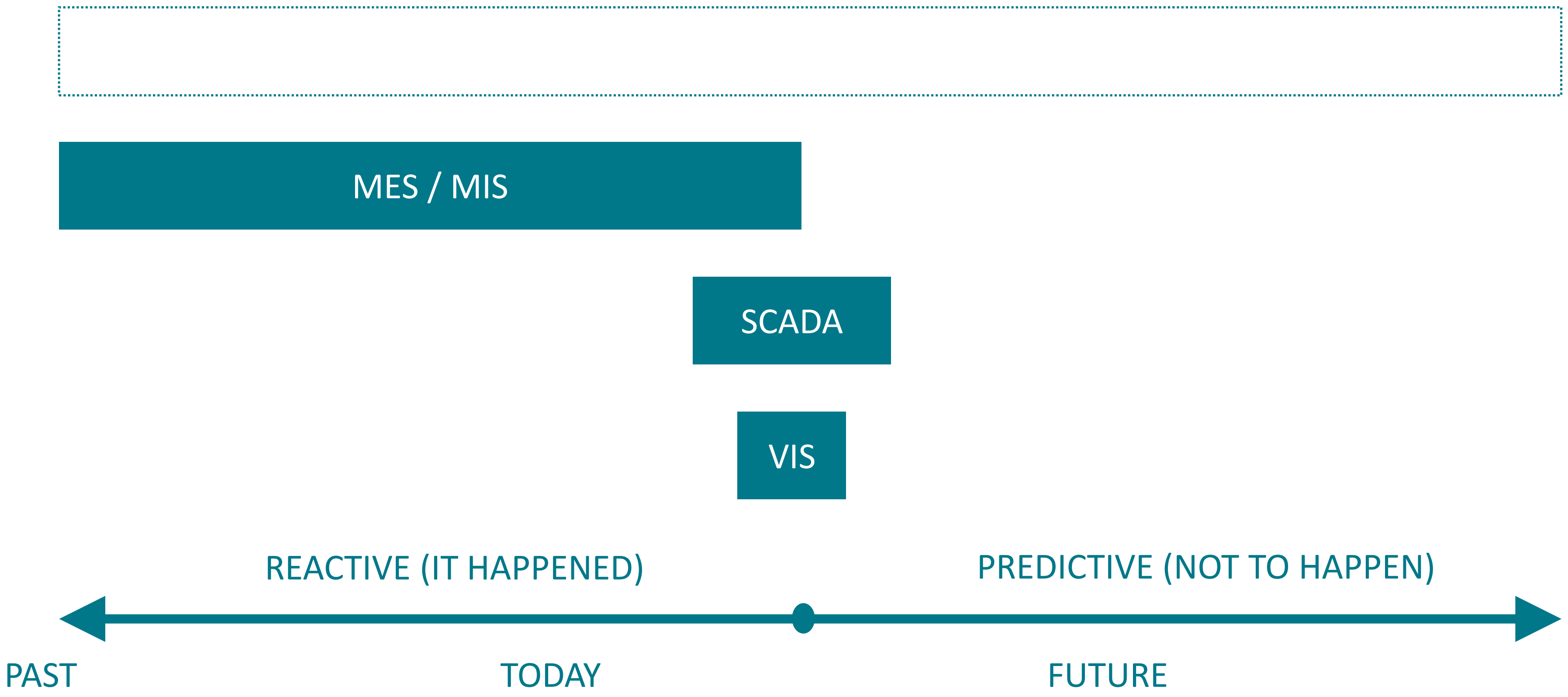


# LEVEL 2 – SCADA + DCS

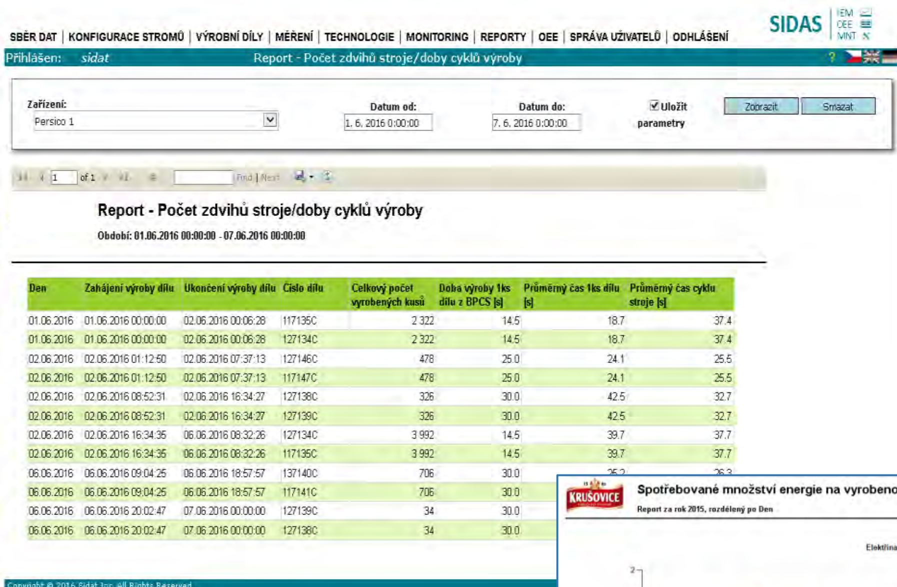



# 4 LEVELS OF INFORMATIONS FROM PRODUCTION



# LEVEL 3 – MES/MIS




Report - Počet zdvihů stroje/doby cyklů výroby

Období: 01.06.2016 00:00:00 - 07.06.2016 00:00:00

| Den | Zahájení výroby dílu | Ukončení výroby dílu | Číslo dílu | Celkový počet vyrobených kusů | Doba výroby 1ks dílu z BPCS [s] | Průměrný čas 1ks dílu [s] | Průměrný čas cyklu stroje [s] |
|---|---|---|---|---|---|---|---|
| 01.06.2016 | 01.06.2016 00:00:00 | 02.06.2016 00:06:28 | 117135C | 2 322 | 14.5 | 18.7 | 37.4 |
| 01.06.2016 | 01.06.2016 00:00:00 | 02.06.2016 00:06:28 | 127134C | 2 322 | 14.5 | 18.7 | 37.4 |
| 02.06.2016 | 02.06.2016 01:12:50 | 02.06.2016 07:37:13 | 127146C | 478 | 25.0 | 24.1 | 25.5 |
| 02.06.2016 | 02.06.2016 01:12:50 | 02.06.2016 07:37:13 | 117147C | 478 | 25.0 | 24.1 | 25.5 |
| 02.06.2016 | 02.06.2016 08:52:31 | 02.06.2016 16:34:27 | 127138C | 326 | 30.0 | 42.5 | 32.7 |
| 02.06.2016 | 02.06.2016 08:52:31 | 02.06.2016 16:34:27 | 127139C | 326 | 30.0 | 42.5 | 32.7 |
| 02.06.2016 | 02.06.2016 16:34:35 | 06.06.2016 08:32:26 | 127134C | 3 992 | 14.5 | 39.7 | 37.7 |
| 02.06.2016 | 02.06.2016 16:34:35 | 06.06.2016 08:32:26 | 117135C | 3 992 | 14.5 | 39.7 | 37.7 |
| 06.06.2016 | 06.06.2016 09:04:25 | 06.06.2016 18:57:57 | 137140C | 706 | 30.0 | 25.2 | 26.3 |
| 06.06.2016 | 06.06.2016 09:04:25 | 06.06.2016 18:57:57 | 117141C | 706 | 30.0 | [illegible] | [illegible] |
| 06.06.2016 | 06.06.2016 20:02:47 | 07.06.2016 00:00:00 | 127139C | 34 | 30.0 | [illegible] | [illegible] |
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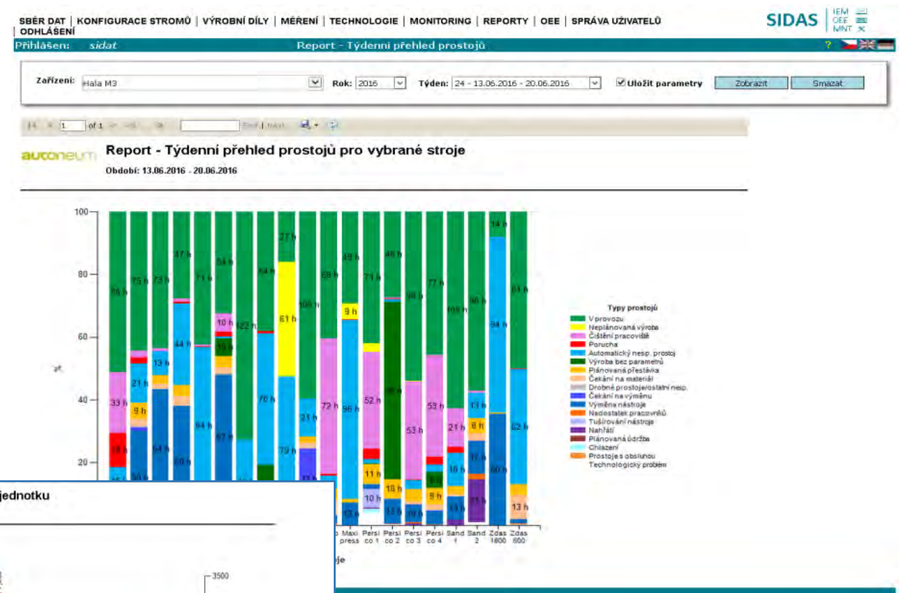
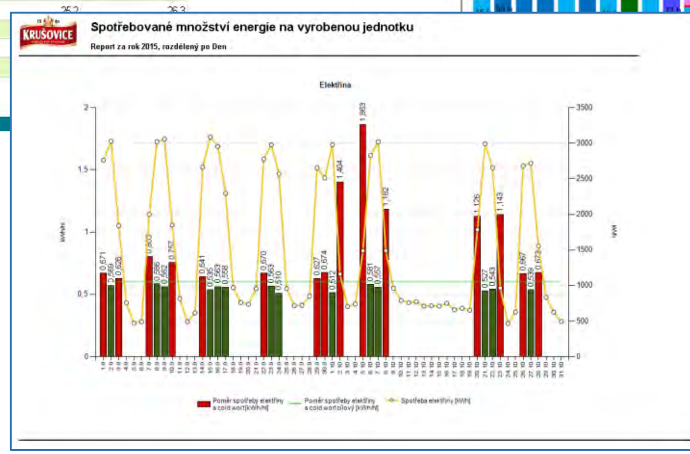
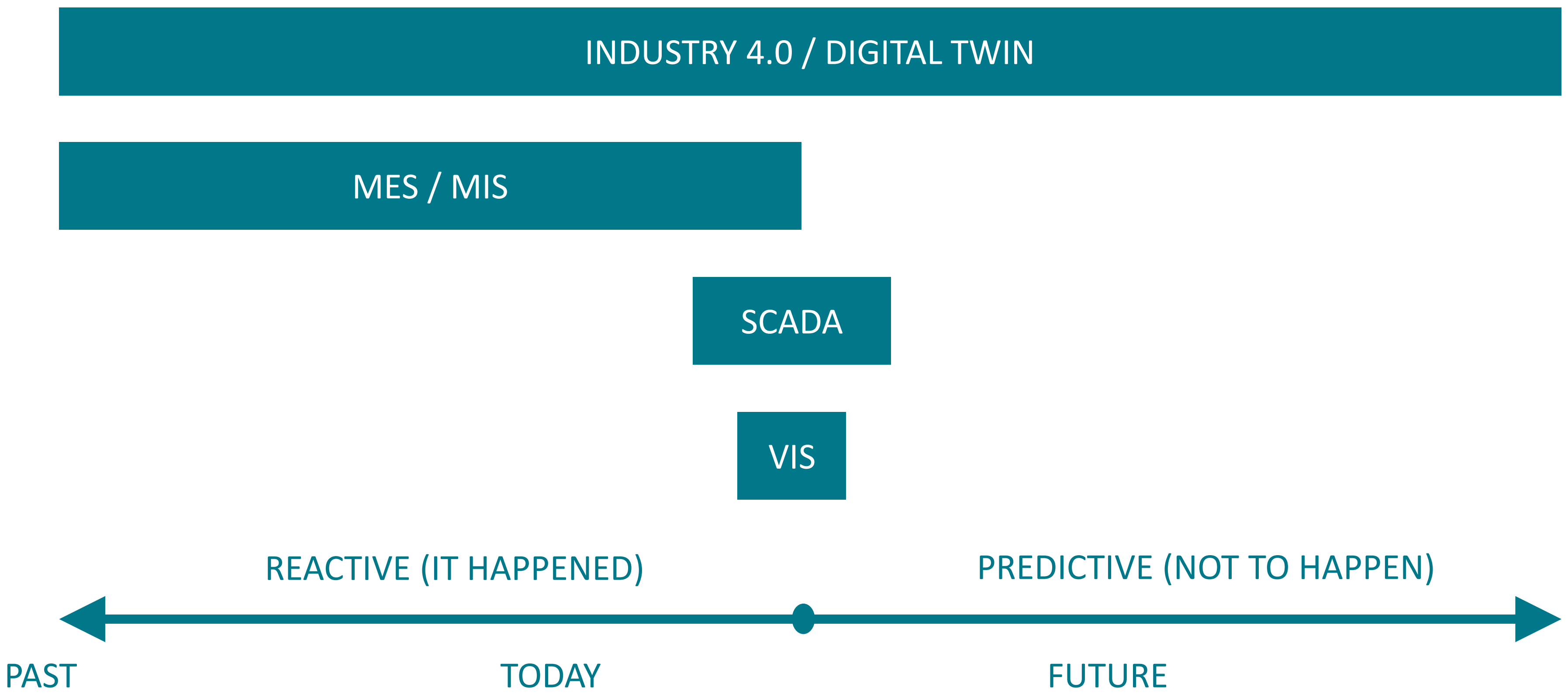
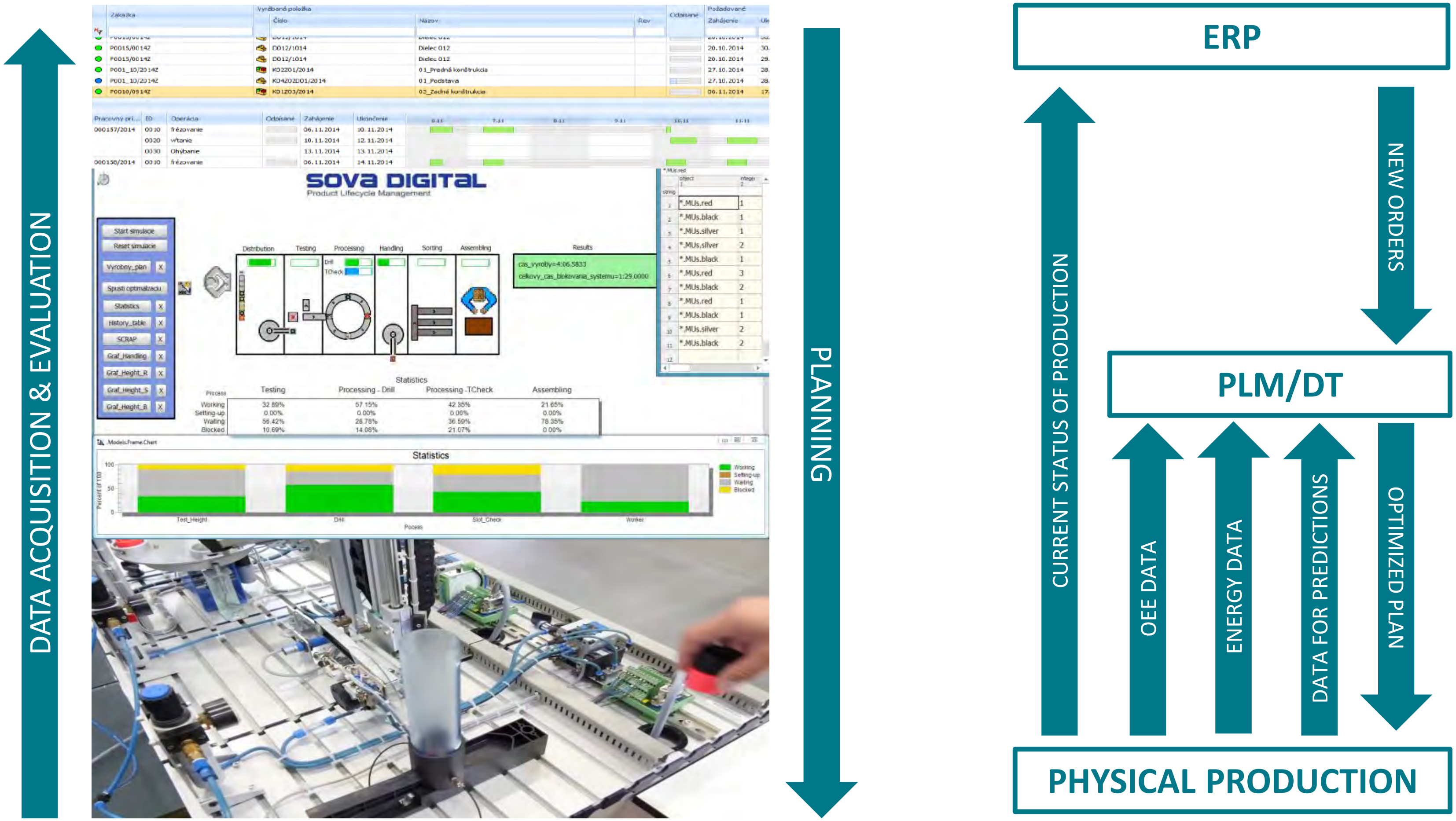


# 4 LEVELS OF INFORMATIONS FROM PRODUCTION



# LEVEL 4 – INDUSTRY 4.0/DIGITAL TWIN



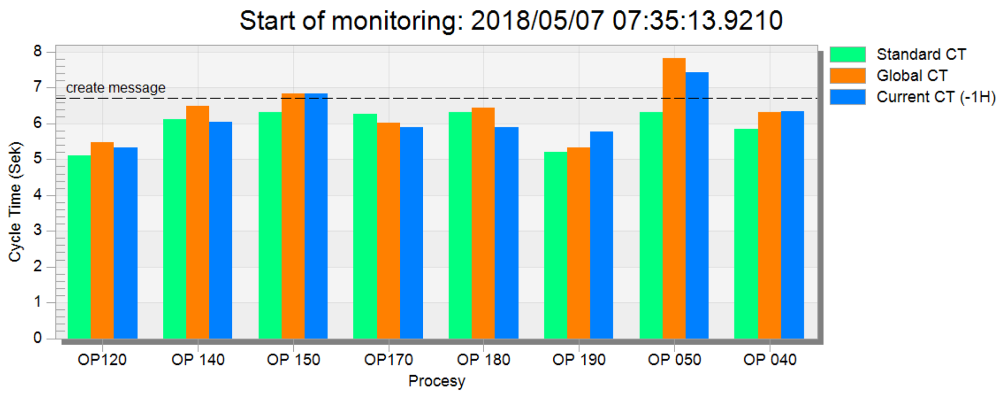
# LEVEL 4 – INDUSTRY 4.0/DIGITAL TWIN - APPS

- SIMULATION & CONCEPT EVALUATION ((LINE) PRODUCTION, ASSEMBLY, MACHINING, LOGISTIC, WAREHOUSES, ENERGY, …)
- REAL TIME PROCESS VISUALIZATION
- PROCESS REWIND „JUMP IN TIME BACK“ WHEN PROBLEM OCCURRED
- BALANCING OF PRODUCTION RESOURCES
- CYCLE TIMES MONITORING FOR BETTER PLANNING
- DOWN-TIMES & MICRO DOWN-TIMES / DELAYS & MICRO-DELAYS IDENTIFICATION
- PREDICTIVE LOGISTIC – AUTOMATIC REQUIREMENTS FOR LOGISTIC
- PREDICTIVE REAL TIME QUALITY MONITORING
- PREDICTIVE MAINTENANCE BASED ON REAL TIME RESOURCES MONITORING
- ADVANCED PLANNING (APS) FOR OPERATIVE (EACH DAY) PRODUCTION PLANNING

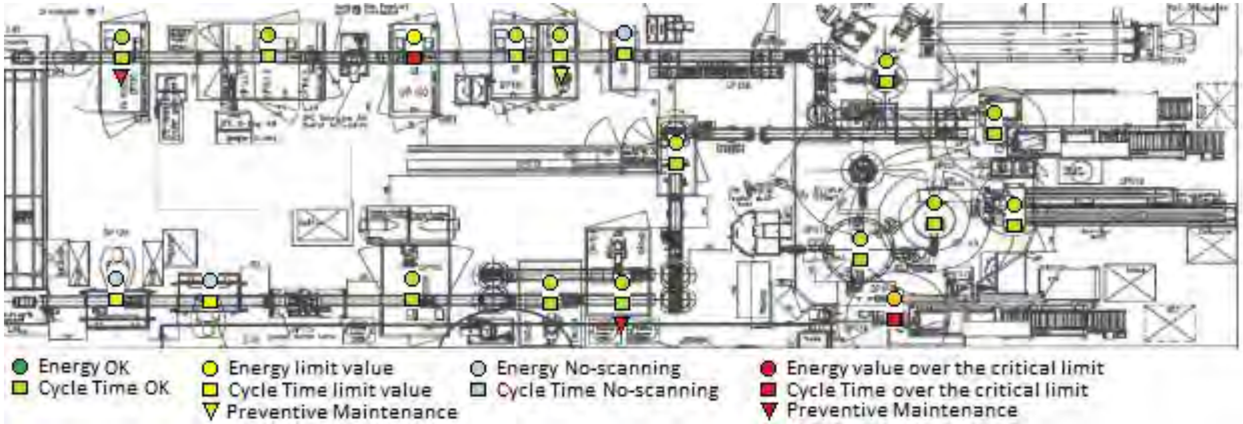
- OTHERS … DIGITAL TWIN SW PLATFORM IS ALMOST WITHOUT LIMITS

# LEVEL 4 – INDUSTRY 4.0/DIGITAL TWIN SMART OUTPUTS (EXAMPLES)

## CYCLE TIME STABILITY ANALYSE




## SMART PRODUCTION DASHBOARD



# INDUSTRY 4.0 PATH

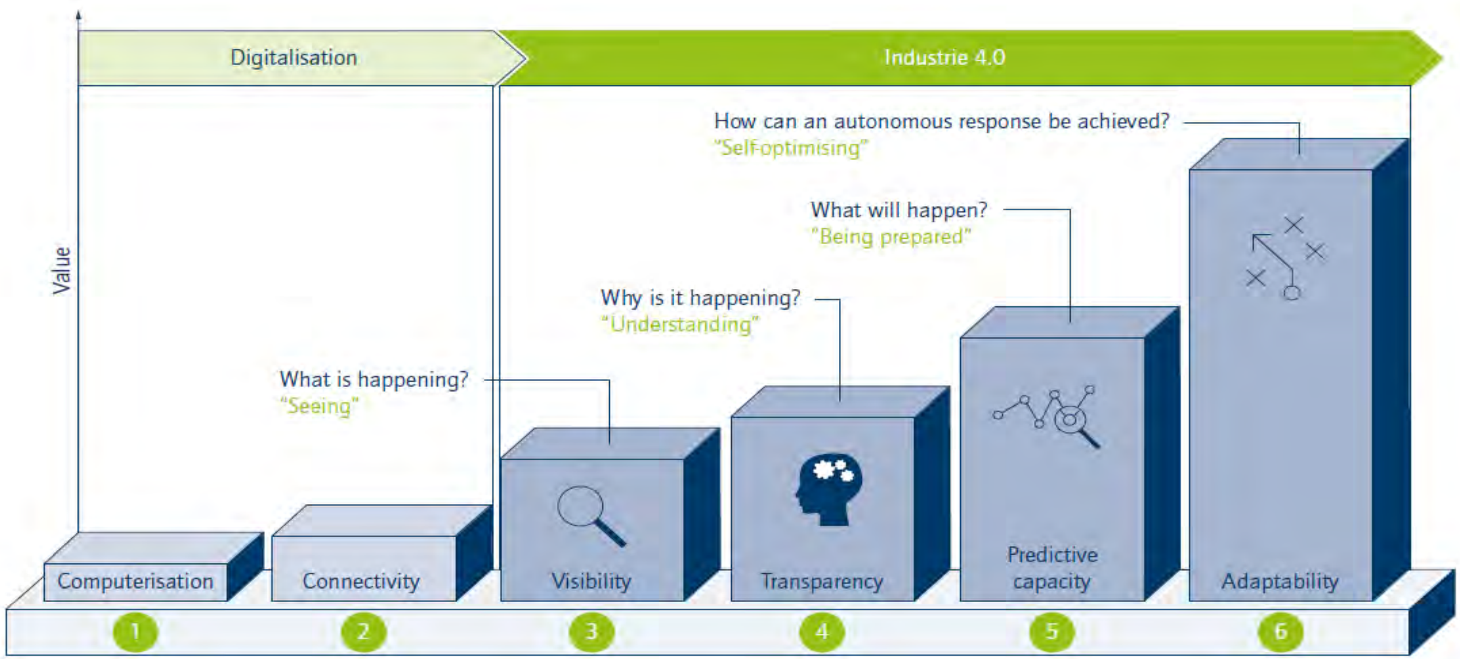
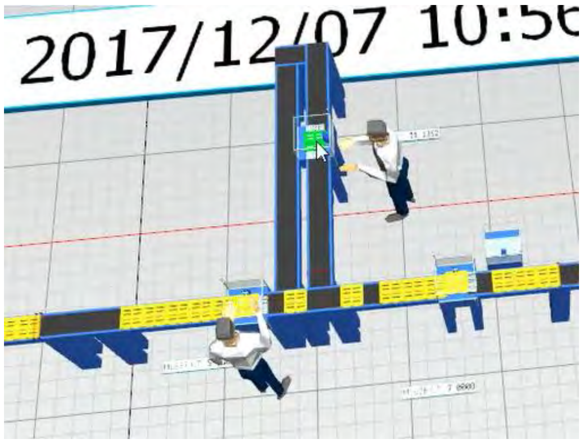
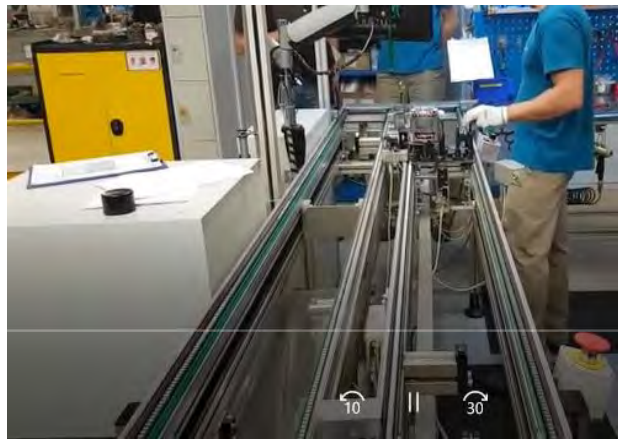



Figure 5: Stages in the Industrie 4.0 development path (source: FIR e. V. at RWTH Aachen University)

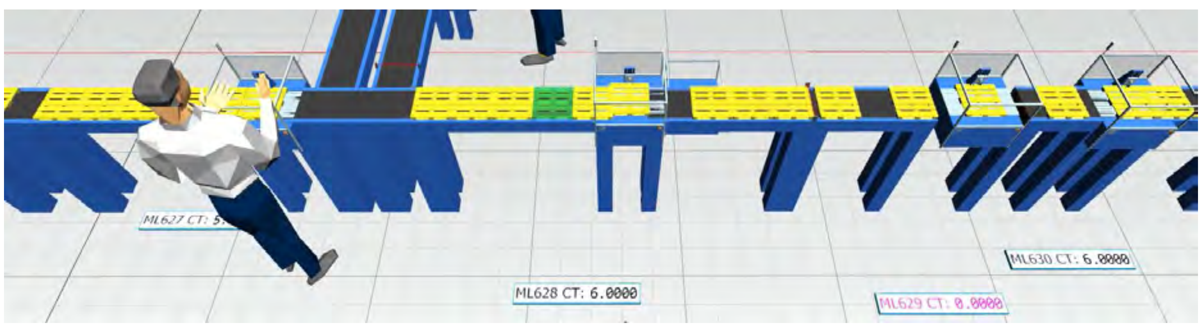
# I40/DD –OEE IMPROVING FOR LINE PRODUCTION



DIGITÁLNE DVOJČA

FYZICKÁ LINKA




REALIZED I40/DD APPLICATIONS

PUBLISHED WITH APPROVAL OF EMBRACO SLOVAKIA FOR SOVA DIGITAL

VISUALIZATION OF CURRENT STATUS OF PRODUCTION

REAL CYCLE TIMES

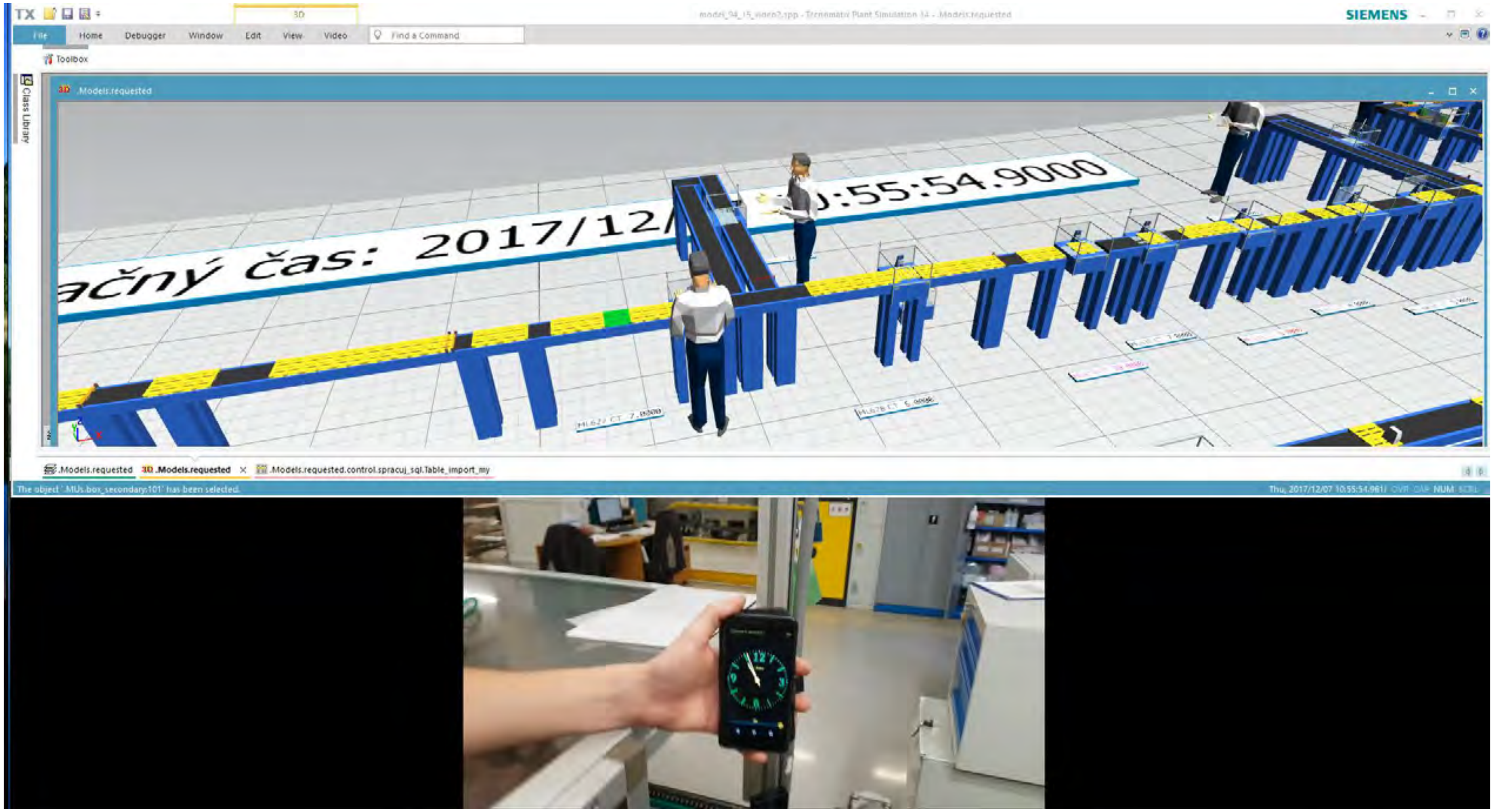
REAL UTILISATION OF RESOURCES

IDENTIFICATION OF DELAYS & MICRO-DELAYS + DOWNTIMES & MICRO-DOWNTIMES

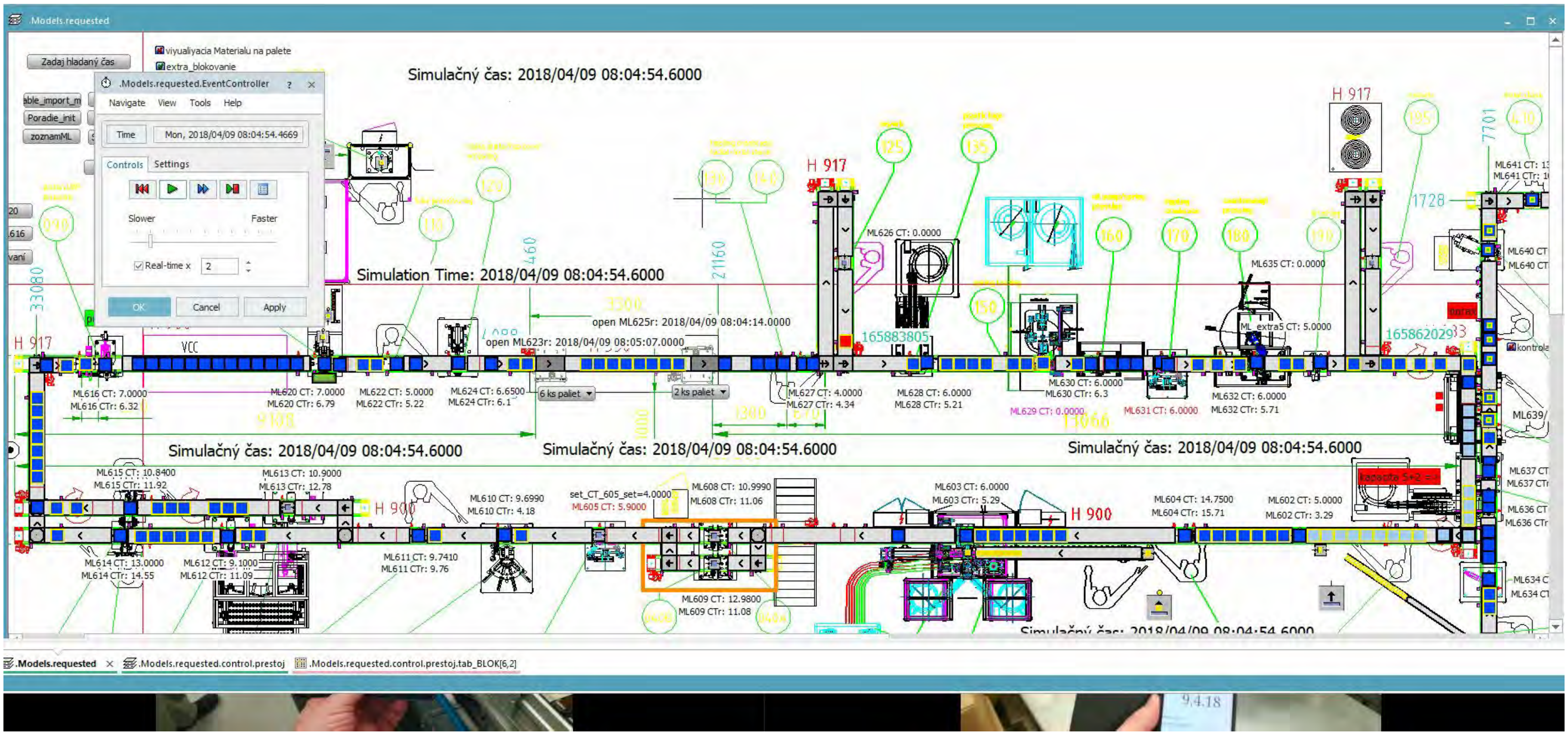
COLLECTED & EVALUATED APPROX. 800000 LINES OF INFORMATIONS PER SHIFT

IMPROVED OEE BY +3% (APPROX. +300PCS) = APPROX. +1MIL EUR/YEAR BENEFIT

# I40/DD –OEE IMPROVING FOR LINE PRODUCTION



# I40/DD – OEE IMPROVING FOR LINE PRODUCTION



# THANK YOU

Robin Mitana,
robin.mitana@sidatdigital.sk
+421 903 432 036

# RADAR USAGE FOR TRANSPORT AND INDUSTRY

**Ing. Lukáš Maršík [1]**
[1] Camea image & signal processing

**Abstract**

*In CAMEA traffic monitoring and industry systems, the use of radar has many advantages. It can generate information about immediate speed of multiple objects and their distance and angular position in the scene. As well, radar performance is nearly not affected by amount of light or bad weather conditions. Thus, it can well supplement current video-detection systems with new information that can significantly improve reliability and success rate of the detection.*

3rd INTERNATIONAL CONFERENCE

# 3D MEASUREMENT AND IMAGING

*MODERN CONTACTLESS MEASUREMENTS IN INDUSTRIAL PRACTICE*

# USING RADAR IN TRAFFIC AND INDUSTRY SYSTEMS

camea

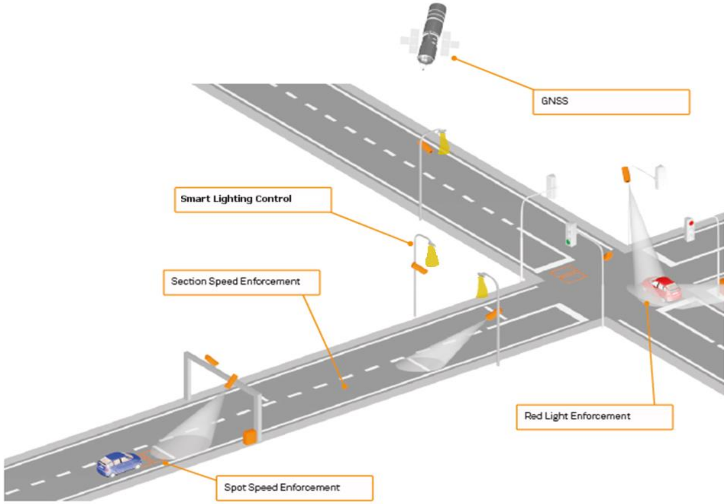
Lukáš Maršík (l.marsik@camea.cz)

# CAMEA IMAGE & SIGNAL PROCESSING

- Founded in 1995 by a group of researchers
- Located in BRNO (CZ), currently 70+ employees
- Focus on industrial and traffic applications
- R&D, manufacturing, selling, servicing, maintenance of components, systems, custom solution
- Has produced and deployed around the world hundreds of visual systems with thousands of video cameras and real-time processing units

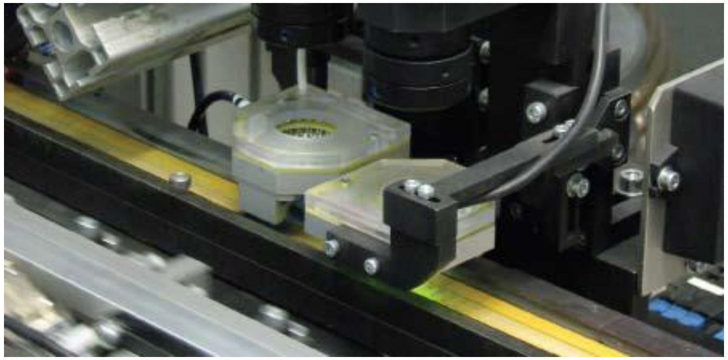
# CAMEA'S ITS SYSTEMS

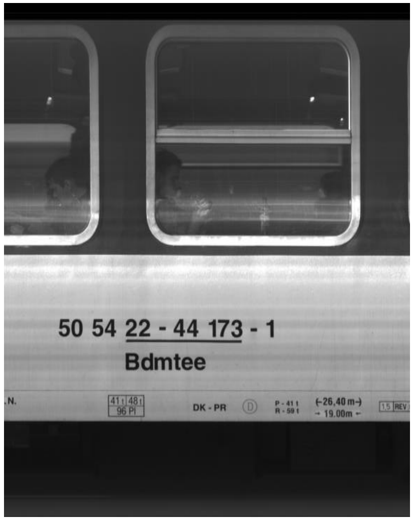
- UNICAM platform
- Weigh-In-Motion
- Enforcement Systems
- Traffic Monitoring
- Vehicle Identification
- ITS Technologies

# CAMEA'S INDUSTY SYSTEMS

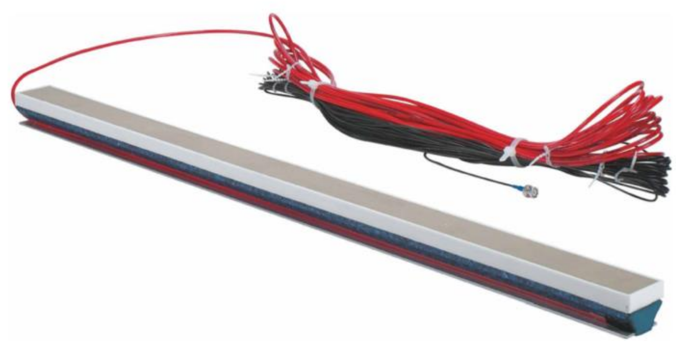
- Web Inspection
- Bottle Inspection
- Component Inspection
- Laser Beam Deflector
- 3D reconstruction
- Label Inspection
- Automatic identification of railway carriages





# SENSORS IN CAMEA SYSTEMS

- Video cameras (optionally with IR flashes)
- Induction loops
- Laser scanners
- Piezoelectric sensors
- FMCW radars

# RADAR IN CAMEA SYSTEMS

- Mobile multi-lane enforcement system
- Spot speed enforcement
- Camera triggering
- Vehicle presence detection
- Vehicle counting (statistics)
- Train speed recording


# FMCW RADAR FUNDAMETALS

- Frequency Modulated Continuous Wave
- Waves transmitted and reflected (or absorbed)
- Doppler frequency - speed measurement
- Frequency Modulation - distance measurement
- MIMO technique - angular position

# RADAR ADVANTAGES

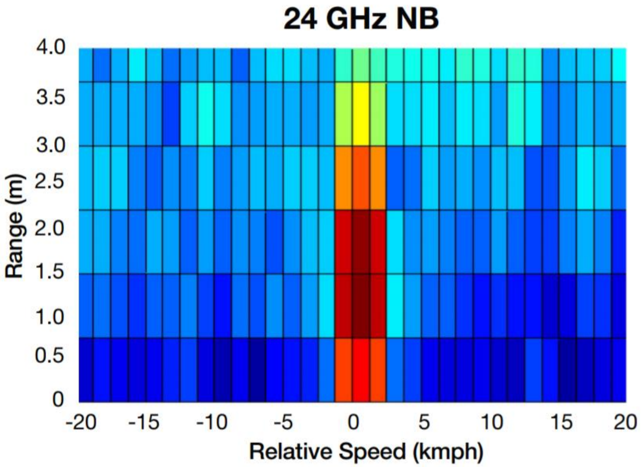
- Direct speed measurement
- Distance and angle position measurement
- Independence on daylight
- Very low influence of bad weather condition
- Can be installed as hidden
- No problem with GDPR

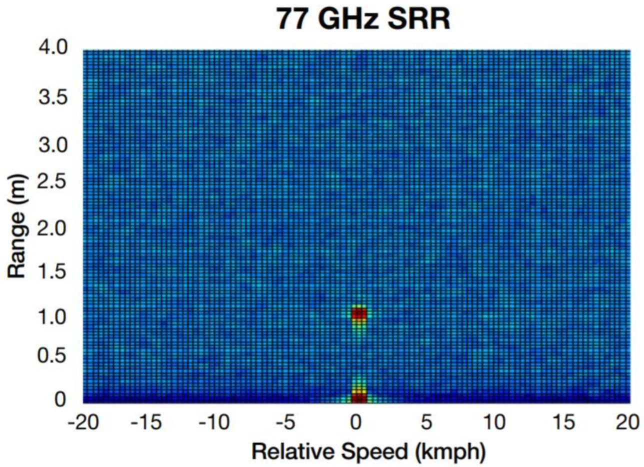
# RFBEAM K-MC4

- 24GHz **analog** radar module
- FMCW (ISM - 250MHz)
- Speed or/and range
- Angle measurement
- Separate embedded processing

# FROM 24GHZ TO 77GHZ

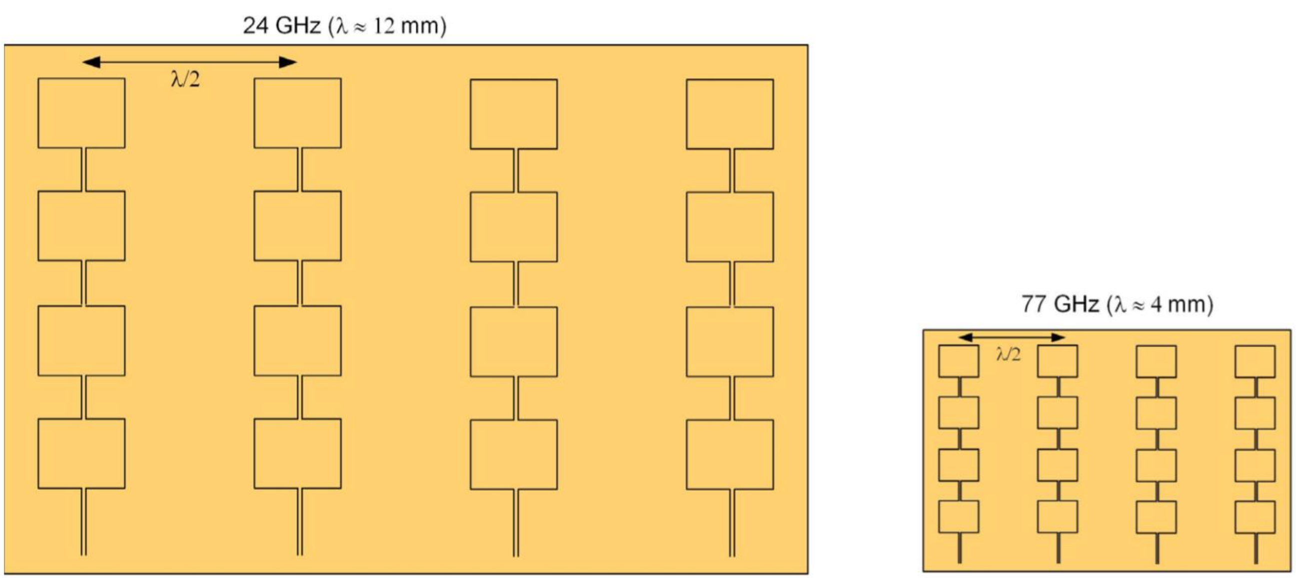
- Bandwidth (legacy 250MHz / UWB 5GHz)
  - 1GHz (76-77GHz LRR) / 4GHz (77-81GHz SRR)
- ~20x better range resolution, 3x better velocity resolution



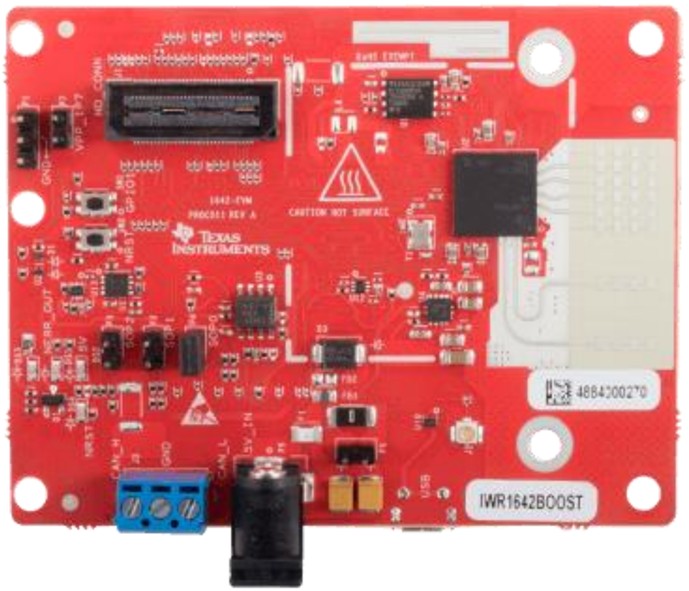
# FROM 24GHZ TO 77GHZ

- 3x smaller form factor
  - narrower (more focused) beam
  - small final system (automotive, drones, ...)

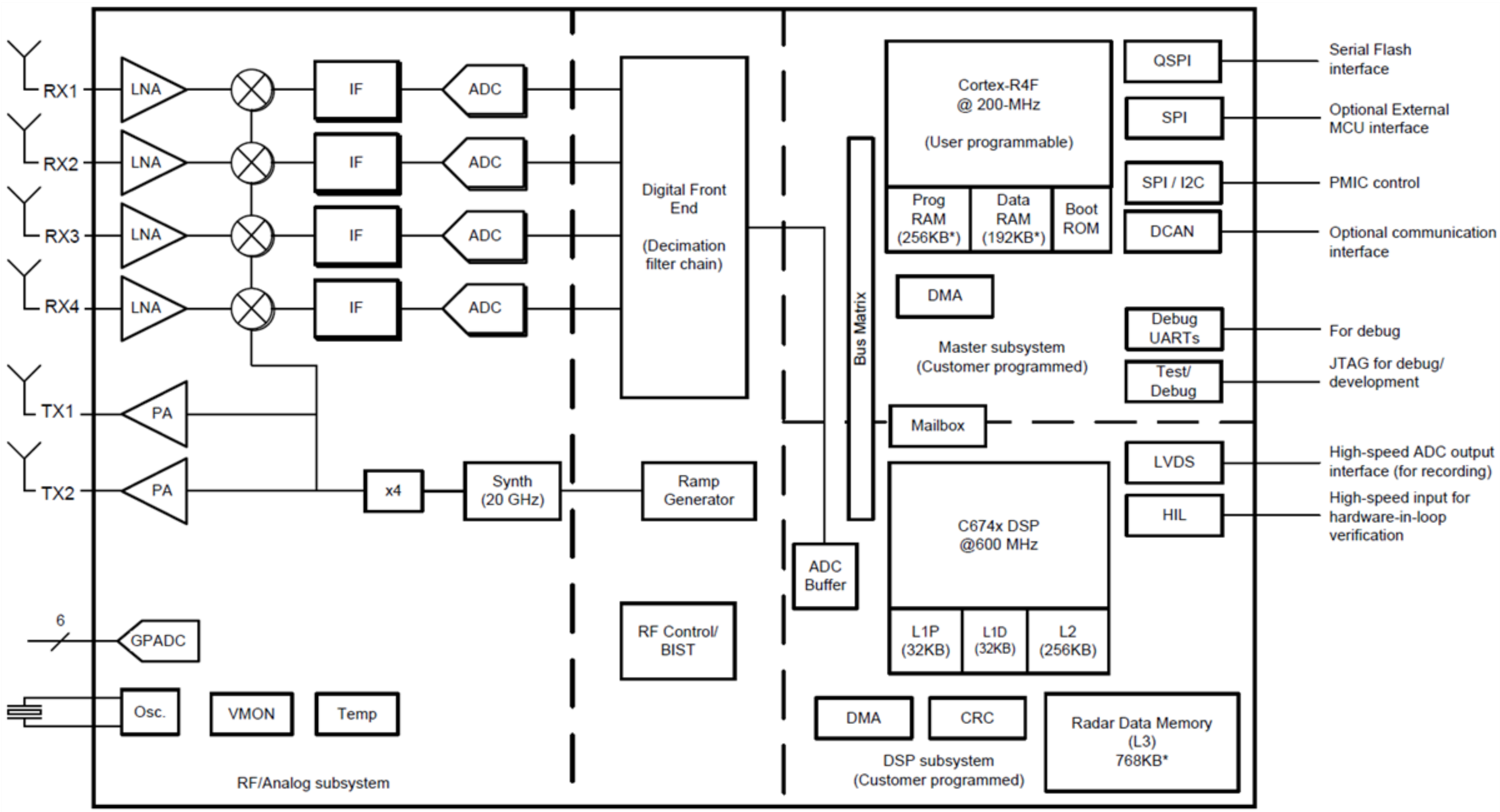


# TI IWR1642BOOST

- Radar-on-chip solution
- Processing fast ramps (2D FFT's)
- Sampling frequency 5Ms/s
- Distance / velocity / angle
- TI launchpads compatible
- Ethernet capture card
- Price 299$

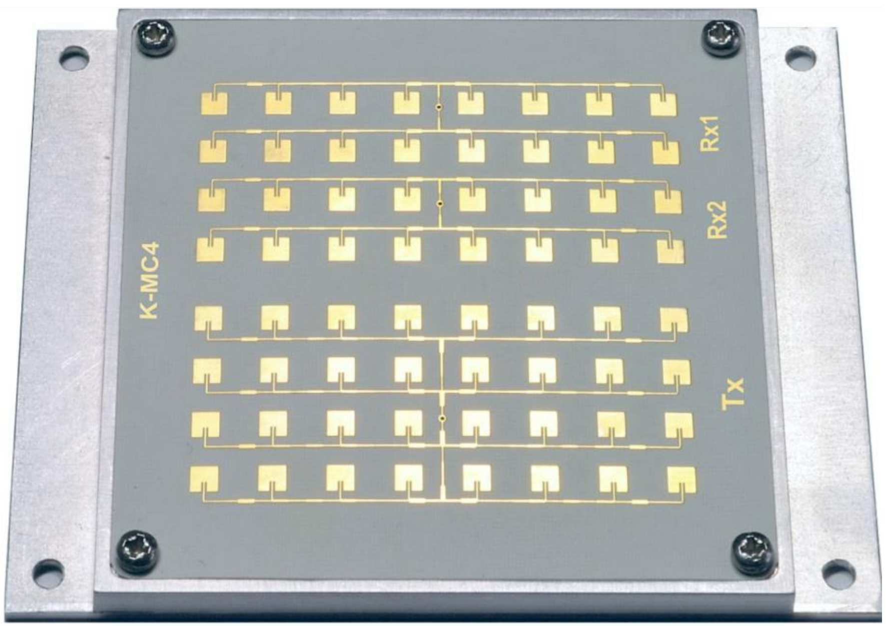


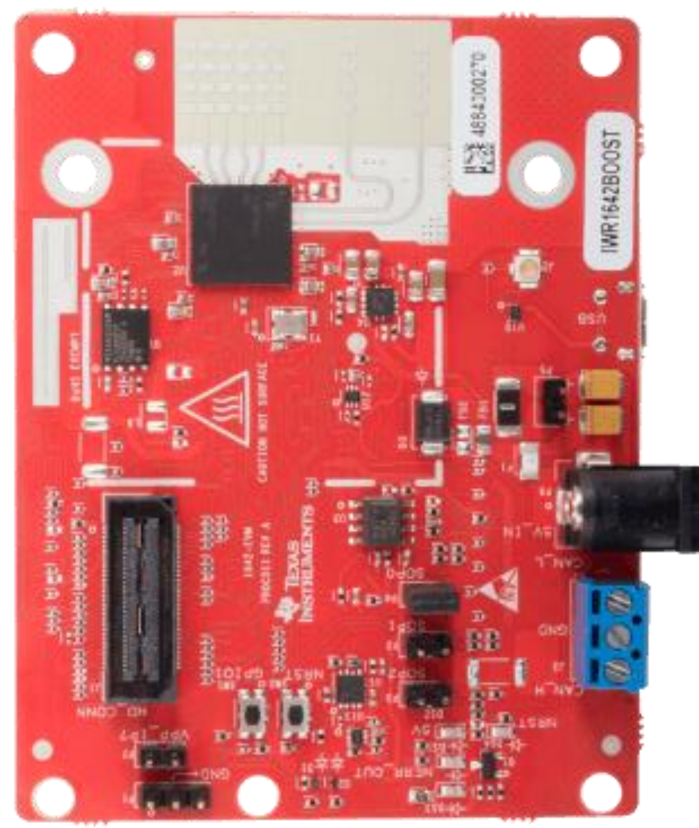
# TI IWR1642




* Up to 512KB of Radar Data Memory can be switched to the Master R4F if required

# TI IWR1642BOOST VS. K-MC4



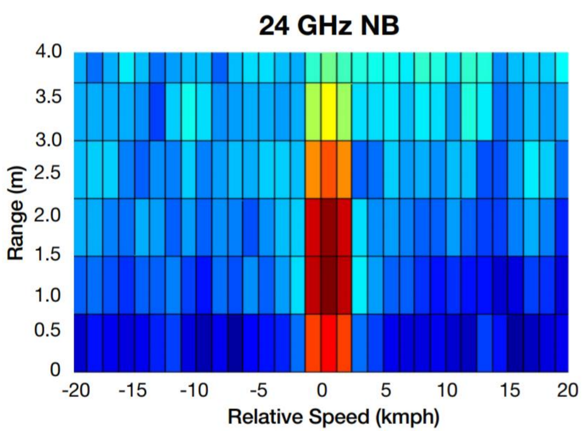
# IWR1642BOOST PARAMETERS

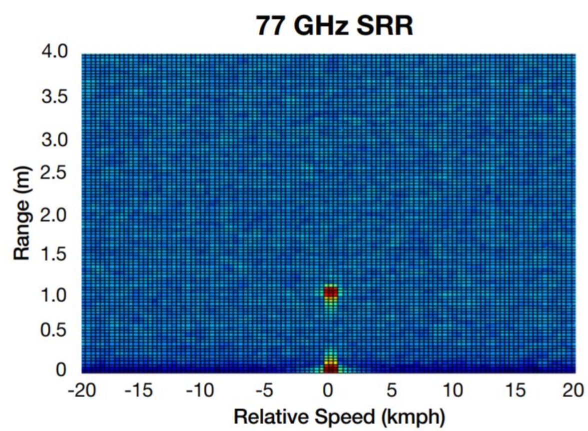
- FOV 30x70deg
- Speed accuracy less than 0.1kph
- Range accuracy less than 1mm
- Angle accuracy about 1deg
- Angle resolution 15deg (2TX, 4RX antennas)
- Power consumption 2W (2TX, 4RX, 50% duty)
- Transmitted power about 12mW

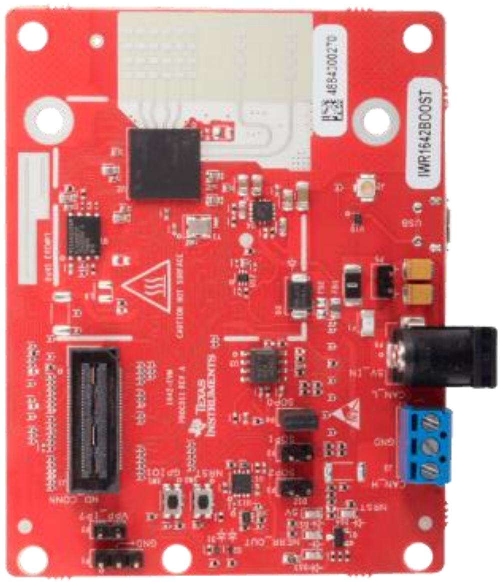
# CONCLUSIONS

- SOTA 77GHz radar sensor
- 3rd party modules manufacturers
- Very fine range measurement (< 1mm)
- Variable antenna design
- mmWave SDK (Code Composer Studio)
- Power consumption less than 3W (DEV kit)
- Possibility to hide sensor

# THANK YOU FOR YOUR ATTENTION



# LASER, MULTISPECTRAL AND HYPERSPECTRAL SCANNING

**Ing. Marko Paško [1]**
[1] Expert_for_3D_Landscape, spol. s r.o., Slovakia, www.x3d.sk

**Abstract**

*In this presentation we will discuss similarities in laser, multispectral and hyperspectral scanning. There are also differences, which are unique for each type of data acquisition and can be used with advantage. We described possibility of combined usage of mentioned measuring sensors, which rise the added value of results and is suitable for scientific analyses, with highest geometrical and georeferencing accuracy.*

*Data fusion from terrestrial, mobile and aerial 3D mapping enables complete coverage of complex objects. As during data processing will be created a big datasets, we provide also solutions for further data processing and data fusion.*

*Key words:*

- *Laser, multispectral and hyperspectral scanning*
- *Riegl LMS* - *airborne, mobile, UAS and terrestrial laser scanning and mapping systems*
- *Vexcel Imaging* - *airborne, mobile and terrestrial digital photogrammetry and mapping systems*
- *HySpex* - *field/outdoor, lab, aerial and industrial hyperspectral scanning in VNIR and SWIR spectral bands*
- *3D mapping and data acquisition*
- *advantage of combination / data fusion from multiple sources,*
- *outputs from complex mapping systems,*
- *detailed high density data*
- *processing software*

3rd INTERNATIONAL CONFERENCE

# 3D MEASUREMENT AND IMAGING

*MODERN CONTACTLESS MEASUREMENTS IN INDUSTRIAL PRACTICE*

# LASER, MULTISPECTRAL AND HYPERSPECTRAL SCANNING

Ing. Marko Paško, Expert_for_3D_Landscape, spol. s r.o.

# LASEROVÉ, MULTISPEKTRÁLNE A HYPERSPEKTRÁLNE SKENOVANIE

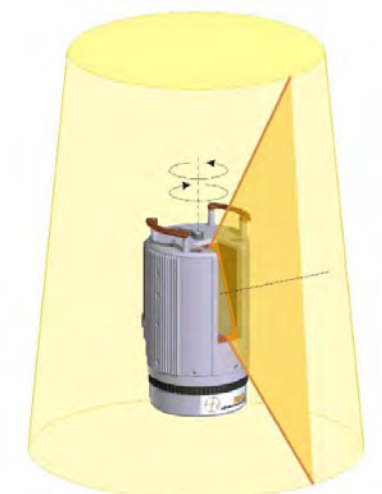
Novinky z pohľadu
**Expert_for_3D_Landscape, spol. s r.o.**, www.x3d.sk
autorizovaného distribútora nasledovných značiek pre Slovensko:

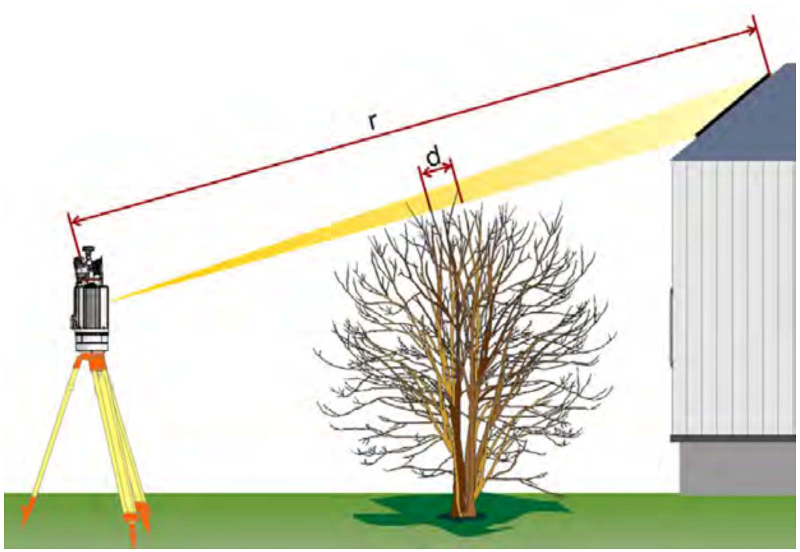
Digitálna fotogrametria — VEXCEL IMAGING

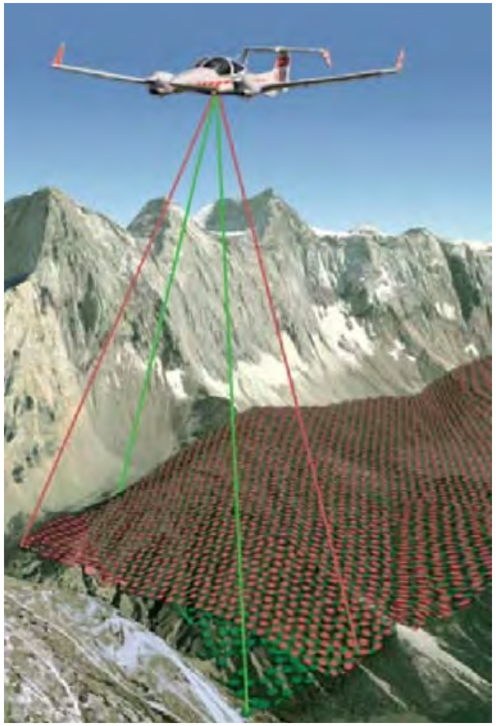
Laserové skenovanie — RIEGL®

Hyperspektrálne skenovanie — HySpex

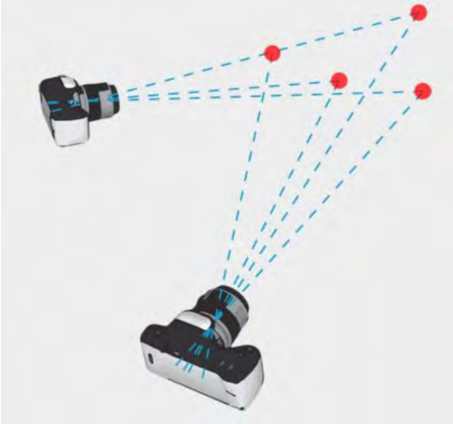
**Laserové skenovanie** – laserový skener aktívne vysiela z daného miesta daným smerom modulovaný signál s vlnovou dĺžkou blízkeho infračerveného spektra (príp. zeleného svetla) a zachytáva vrátený signál, toto mnohokrát za sekundu opakuje, čím postupne meria v 3D **bod po bode** okolitý priestor



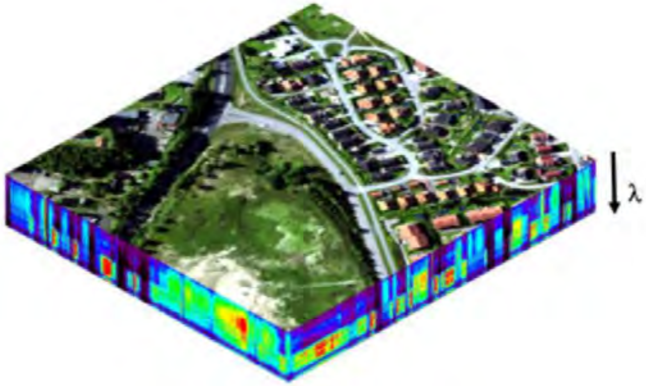


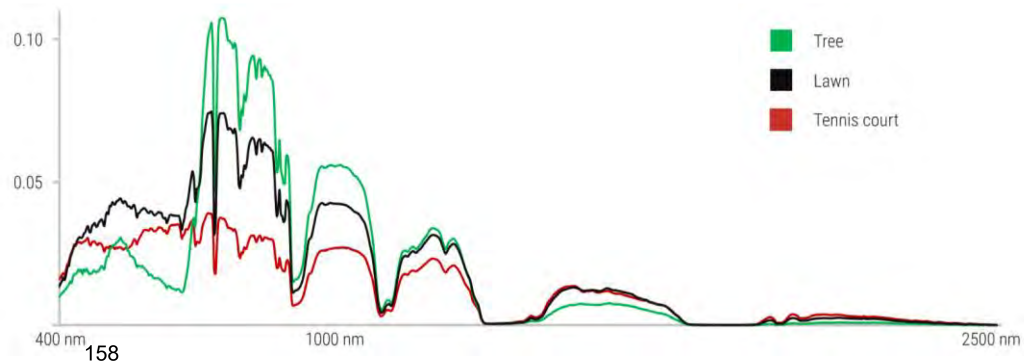



**Multispektrálne skenovanie** – vychádzajúc z digitálnej fotogrametrie : pasívne zaznamenávanie viditeľného elektromagnetického žiarenia a meranie na digitálnych snímkach, pričom štandardná farebná digitálna snímka je multispektrálny záznam v 3 kanáloch R,G,B. Ak automatizovane zaznamenávame digitálne snímky s vysokým prekrytom -> môžeme využiť automatickú relatívnu orientáciu – prehľadávanie snímky po snímke, **pixel po pixli** hľadáme identické body. Keď ich nájdeme, pretínaním spojnice bodu na snímke a optického centra príslušnej snímky dostaneme bod v 3D.



**Hyperspektrálne skenovanie** – hyperspektrálny skener zaznamenáva z daného miesta s danou šírkou záberu pre každý pixel prijatý signál po kanáloch, pričom pre každý kanál je vyhranený presne definovaný malý rozsah vlnových dĺžok spektra elektromagnetického žiarenia od viditeľného do stredného infračerveného pásma, toto mnohokrát za sekundu opakuje a postupne sa posúva určitým smerom, čím postupne zaznamenáva pixel po pixli toľko dátových vrstiev, koľko má kanálov. Pokiaľ ide o reálny záznam krajiny, georeferencovaný výsledok vyžaduje poskytnutie informácie o 3D povrchu, na ktorý sa daný hyperspektrálny záznam prekresľuje, napr. z laserového skenera.



# Riešenia RIEGL Laser Measurement Systems

RIEGL®


*** Terestrické: -** VZ-400i ... dosah 800m, presnosť 5mm, georeferencovanie v reálnom čase, cloud

- VZ-2000i ... dosah 2500m, presnosť 5-10mm

*** Mobilné:** - **VMX-1HA/2HA** ... mobilné presné skenovanie,

- **VMQ-1HA** ... light-verzia s 1 skenovacou hlavou

*** Letecké + UAV:**

- VUX-1 ... rôzne hlavy **miniVUX-1DL** + RiCopter / VP1
- VQ-880-G, -GH ... topo-hydro mapovanie
- VQ-1560i ... city mapping, veľkoplošné mapovanie, duálny skener, online waveform, cloud

# Riešenia Vexcel Imaging

VEXCEL IMAGING

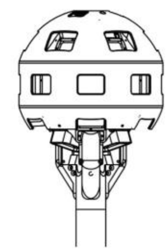
- fotogrametrické technológie na 3D mapovanie
- **Letecké riešenia**
  - Flexibilné – vymeniteľné objektívy **UC Eagle Mark 3**, **najväčšia šírka záberu 26460 px**
  - Šikmé snímkovanie – **UC Osprey Mark 3 Premium** -
  - Konkurencia satelitným senzorom – **UC Condor Mark1**
- **Mobilné riešenia:**
  - **UltraCam Mustang** – mobilný zber dát autom
- **Pochôdzne riešenia:**
  - **UltraCam Panther** – zber dát pešo človekom
- Jedno softvérové prostredie **UltraMap**

# Riešenia Vexcel Imaging


PANORAMIC HEAD

Field of view: 360° full spherical coverage

Camera resolution: 172 Megapixels



Maximum frame rate: 1.5 frames per second

Number of cameras: 26

CAMERA

| | |
|---|---|
| Imaging sensor | CMOS |
| Sensor size | 3,088 x 2,152 pixels |
| Pixel pitch | 1.4 x 1.4 µm |
| Color filtering type | Bayer Pattern |
| Focus type | Fixed focus |
| Focal length | 3.24 mm |
| F-number | 2.00 |
| Depth of field | 1.5 m to infinity |
| Optical format | 1/3.6 inch |

# Riešenia Vexcel Imaging


## COMPUTER AND DATA STORAGE

- Type: Industrial PC Core i7 USB3 & Ethernet interface available
- Storage capacity: 4 TB SSD hot-swappable
- Interface: Ruggedized tablet PC

## BATTERY SYSTEM

- Type: V-Mount Li-Ion high load battery 14.4 V
- Operating time at continous data capture: Several hours depending on application
- Capacities & weight: 294 Wh, 1.4 kg; 155 Wh, 1.0 kg; 89 Wh, 0,8 kg

# Riešenia Vexcel Imaging

VEXCEL IMAGING


## MODULES

| | |
|---|---|
| Orientation | Applanix APX-15L |
| Odometry | Stereo camera system for indoor localization and enhanced outdoor localization in dense cities and covered areas |
| LiDAR | Velodyne VLP-16 |

## ACCURACY

| | |
|---|---|
| Relative accuracy (outdoor and indoor) | cm range* |
| Absolute accuracy (outdoor) | cm to dm range* |
| Absolute accuracy (indoor) | Accuracy depends on scene structure, loop closures and track length |

*Accuracy depends on location and user compliance with walking regulations based on application area.

## APPLICATION AREAS

### DOCUMENT

Visual Documentation & Exploration

- Mobile mapping
- Disaster response
- Progress documentation
- Risk analysis
- Quality control
- Damage inspection

### EXTRACT

Feature Extraction & Classification

- Forest management
- Topographic mapping
- Object detection
- Asset inventory

### MODEL

Feature Measurement & Reconstruction

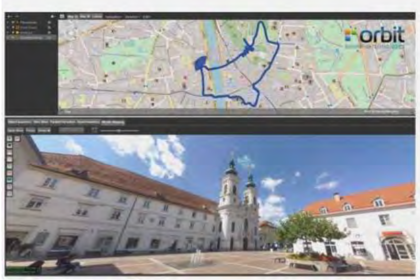
- Clearance measurements
- Volumetric analysis
- As-built verification

# Riešenia Vexcel Imaging

VEXCEL IMAGING

## DATA FORMATS

| | |
|---|---|
| Image | JPEG, TIFF<br>Camera images (26 x 6.6 Megapixels)<br>360° x 180° equi-rectangular panorama (1 x 105 Megapixels)<br>Cube-face panorama (6 x 16.7 Megapixels) |
| Trajectory | Various formats - position and orientation for each cube |
| Point cloud | Laser File Format (LAS) - coordinates, reflectivity, color images |



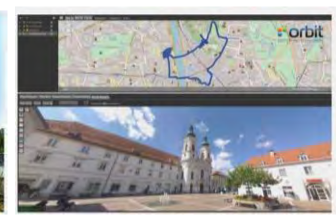

# Riešenia Vexcel Imaging

VEXCEL IMAGING

## Spracovanie dát z mobilného zberu dát z UltraCam Mustang a UltraCam Panther Mark2:

- Jedno prostredie – **UltraMap Terrestrial v1.1**
- Produkty:
  - **rektifikované (neskreslené) meračské snímky na presné fotogrametrické merania**
  - **georeferencované mračná bodov laserového skenovania v tvare las**
  - **kvalitné obrazové panorámy**
- Priamy výstup do softvérového prostredia **OrbitGT 3DM,** prepojenie s dátami z Riegl LMS

orbit GEOSPATIAL TECHNOLOGIES



- Štandardný výstup Default použiteľný v softvéroch:

RealityCapture — CapturingReality

Euclideon Geoverse Complete — euclideon UNLIMITED. geoverse CONVERT geoverse MDM

PhotoModeler Premium — PHOTOMODELER TECHNOLOGIES

# Riešenia HySpex

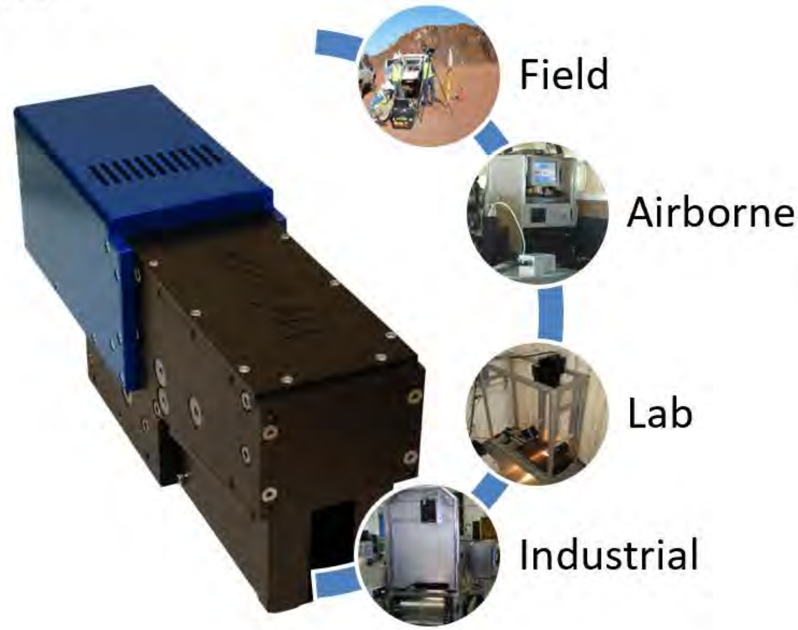
## HySpex

*Hyperspectral imaging systems for all applications*

***The same instrument*** can be used for:

- Lab measurements
- Field/outdoor scanning
- Airborne Applications
- Industrial applications

Thus making it a very versatile instrument.



# Riešenia HySpex

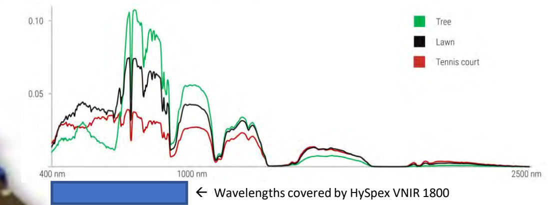
HySpex

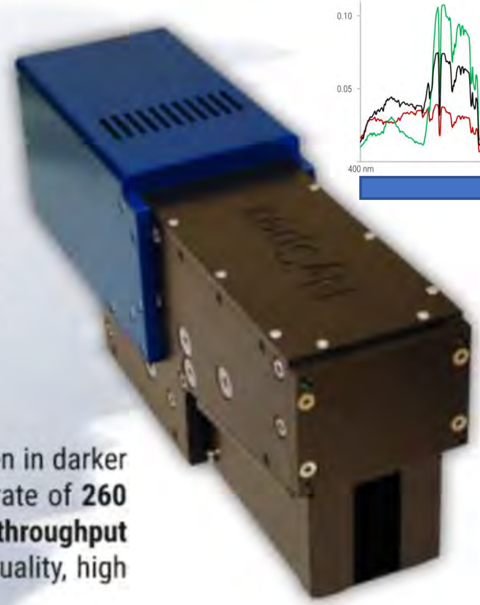
## HySpex VNIR-1800

The HySpex VNIR-1800 **hyperspectral camera**, is developed for **field, laboratory, airborne** and **industrial** applications.

HySpex VNIR-1800 utilize a cutting edge **actively cooled and stabilized scientific CMOS** detector. This makes VNIR-1800 the ideal camera for high-end data acquisitions where **high radiometric accuracy** is required.

The dynamic range of 20 000 ensures **outstanding SNR levels** even in darker areas of an image of highly dynamic scenes. With a max frame rate of **260 fps**, combined with **aberration corrected optics** and **high optical throughput** (f/2.5), HySpex VNIR-1800 offers a unique combination of data quality, high speed and sensitivity.

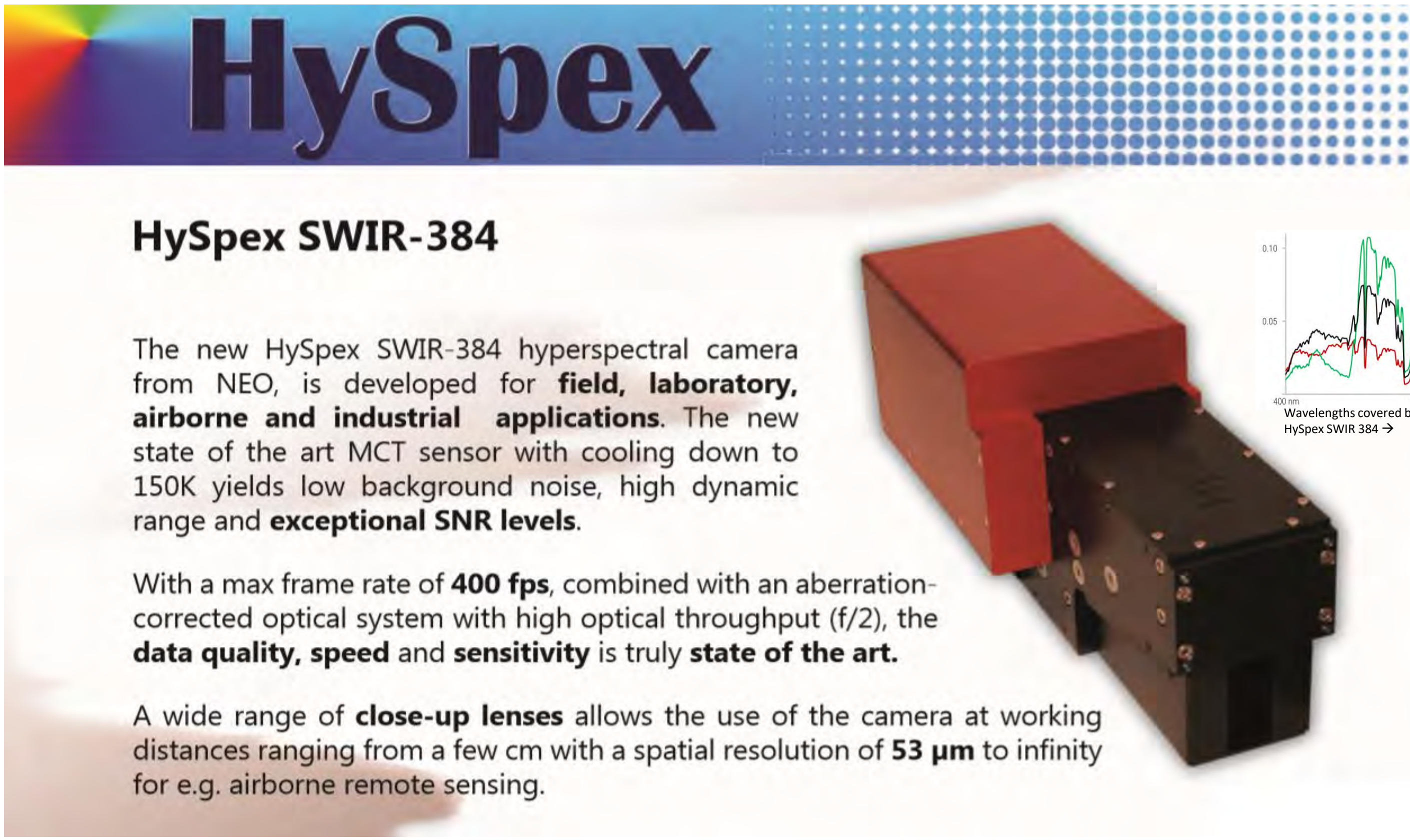


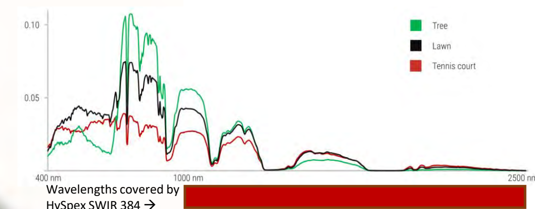



*HySpex VNIR-1800.*

A wide range of **close-up lenses** allows the use of the camera at working distances ranging from a few cm **with a spatial resolution of 24 µm**, to infinity for e.g. **airborne remote sensing**.

# Riešenia HySpex

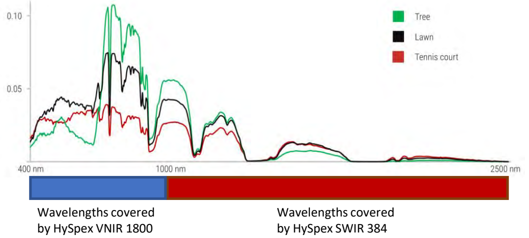


# Riešenia HySpex

## Spoločné použitie 2 hláv VNIR-1800 a SWIR-384 naraz:

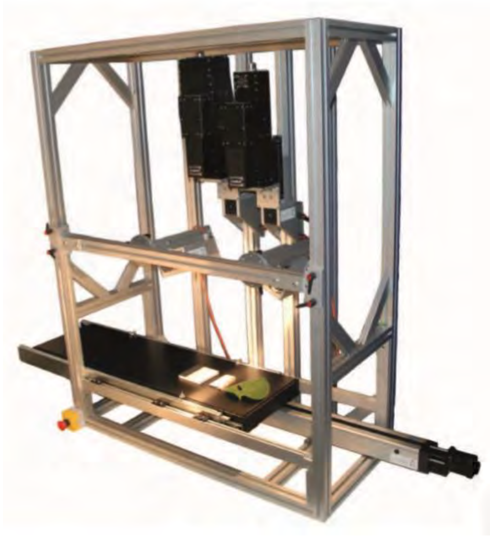
- široké pokrytie spektra od 400nm do 2500nm




## Mnohonásobné využitie

- nasadenie v konfigurácii field, lab aj aerial

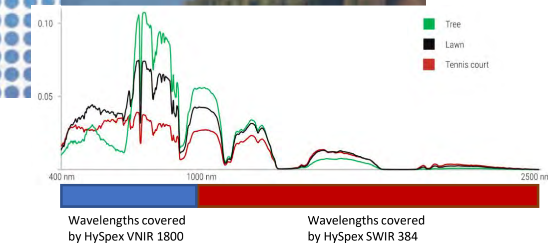
Field – poľné



Lab – laboratórne

Aerial - letecké

# Riešenia HySpex




## HySpex MJOLNIR-VS-620

Combining HySpex Mjolnir V-1240 and HySpex Mjolnir S-620 into a common housing, **HySpex Mjolnir** VS-620 provides 620 **coregistered pixels** in the VNIR and SWIR spectral range, **400 - 2500 nm**.


For applications requiring low mass, combined with high performance specifications and **scientific grade** data quality on the full VNIR-SWIR range, HySpex Mjolnir VS-620 is an ideal solution. In addition to the high quality hyperspectral data cube, covering the spectral range from 400 - 2500 nm, with 490 bands, **double resolution** data in the VNIR range is always readily available.
With smile and keystone less than 0.1 pixel for each spectral range, the merged Mjolnir VS-620 data product will have co- registration/keystone **better than** 0.2 **pixel** for the full VNIR-SWIR range. **Mjolnir VS-620** is delivered in a rugged bundle with a high end data acquisition unit and normally also with the Trimble Applanix APX-15 IMU/GPS.

# Zhrnutie

**Laserové, multispektrálne a hyperspektrálne skenovanie** má veľa spoločného. To, čo ich odlišuje, ich robí jedinečnými zdrojmi dát.

**Spoločné využívanie senzorov** v rôznych kombináciách zvyšuje pridanú hodnotu výsledku.

**Kombinované spracovanie dát** zo zeme, z auta a z leteckého nosiča umožňuje kompletné zameranie aj priestorovo členitých objektov.

Ďakujem za pozornosť. Viac na www.x3d.sk

EXPERT FOR 3D LANDSCAPE

euclideon UNLIMITED
simactive
VEXCEL IMAGING
RIEGL
HySpex

# 3D IN RADAR METEOROLOGY

**RNDr. Vladimír Jorík [1]**
[1] SWORAD s. r. o.

**Abstract**

*Throughout the history of radar meteorology, measurements are made in horizontal areas with large elevation steps and the measured values are degraded to the area, or measurements are made in vertical areas, and the gaps in the elevation steps are counted.*

*SkySCANner – our meteorological radar - provides such a measurement technology that captures the real values at each point of the measured volume during the measurement and records the data into the spatial data structure. These data provide new insights into the structure of the clouds and lead to new knowledge about processes in them.*


# 3D in radar meteorology

## other meteorological radar measurement technology

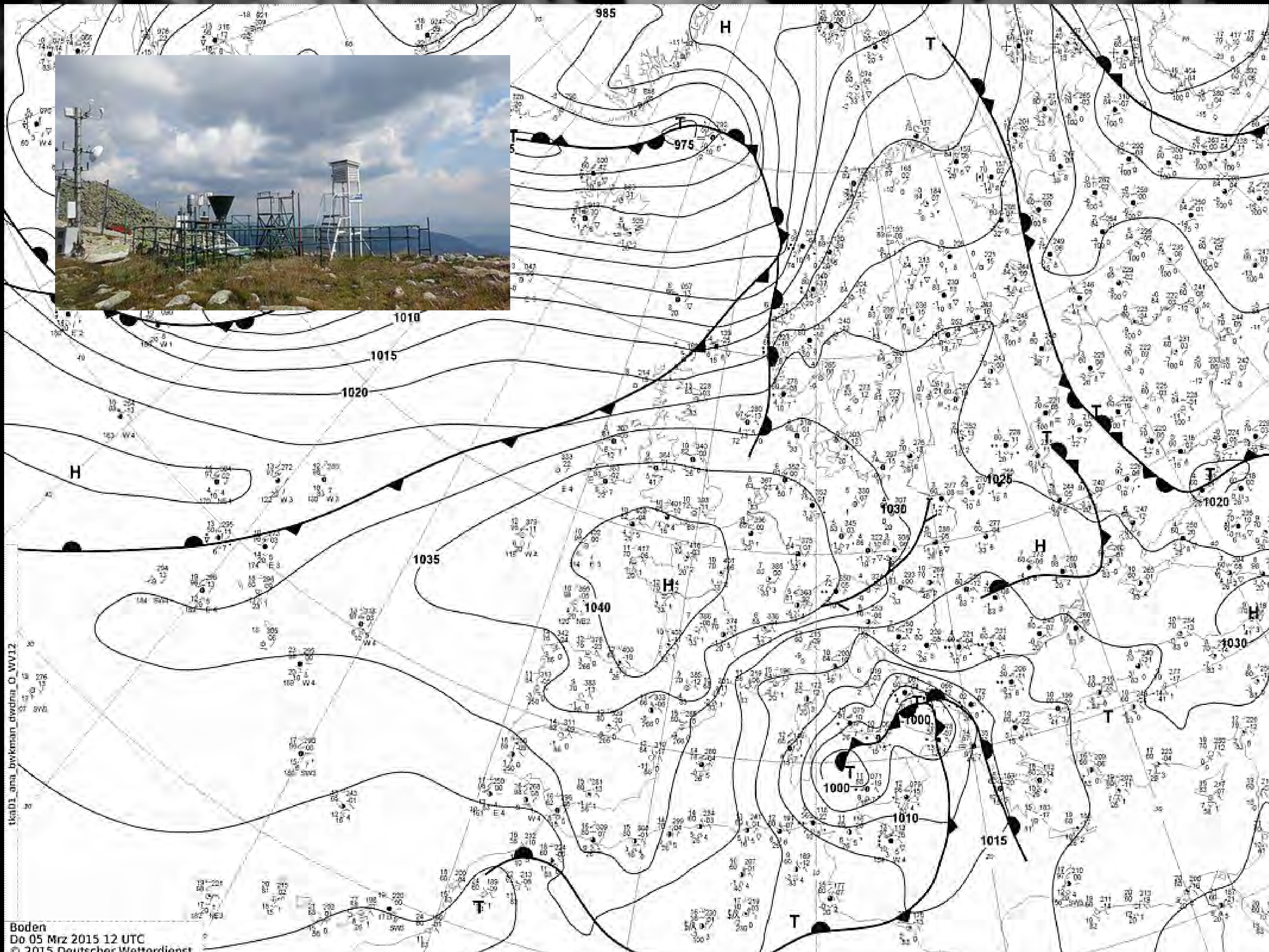
# od 0D v meteorológii po 3D v radarovej meteorológii


- ABSTRAKT :
- V celej histórii radarovej meteorológie sa vykonávajú merania v horizontálnych plochách s veľkými elevačnými krokmi a namerané hodnoty sú degradované do plochy alebo sa robia merania vo vertikálnych plochách a medzery v elevačných krokoch sú dopočítavané.
- Náš meteorologický radar skySCANner poskytuje takú technológiu merania, ktorá zachytáva počas merania reálne hodnoty v každom bode meraného objemu a zaznamenáva dáta do priestorovej dátovej štruktúry. Takéto dáta poskytujú nové poznania o štruktúre oblakov a vedú novým k poznatkom o procesoch v nich.

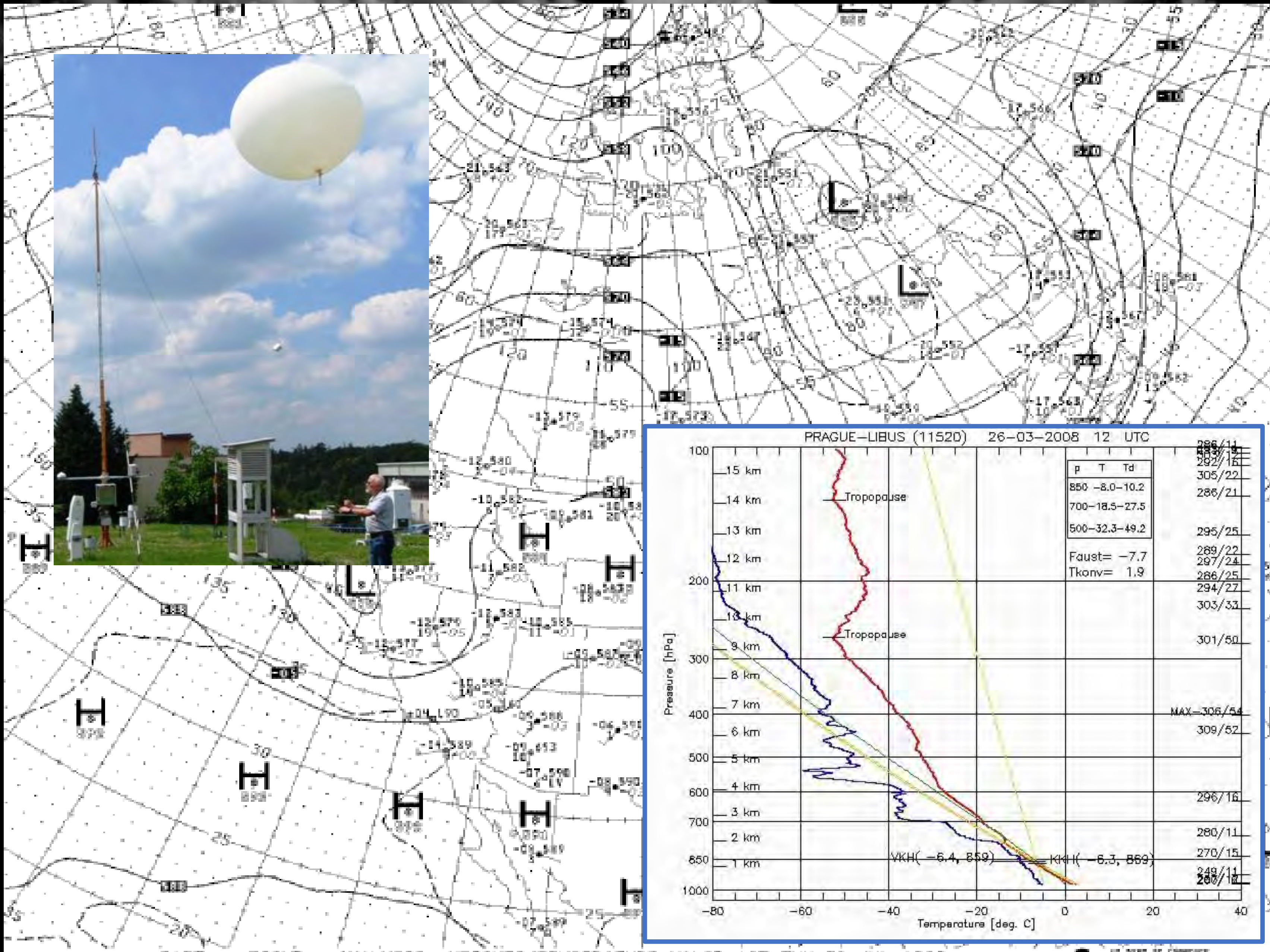
# od 0D v meteorológii po 3D v radarovej meteorológii

MetRad skySCANner VerejnáSlužba mySKYwatch Vytvorené SWORAD

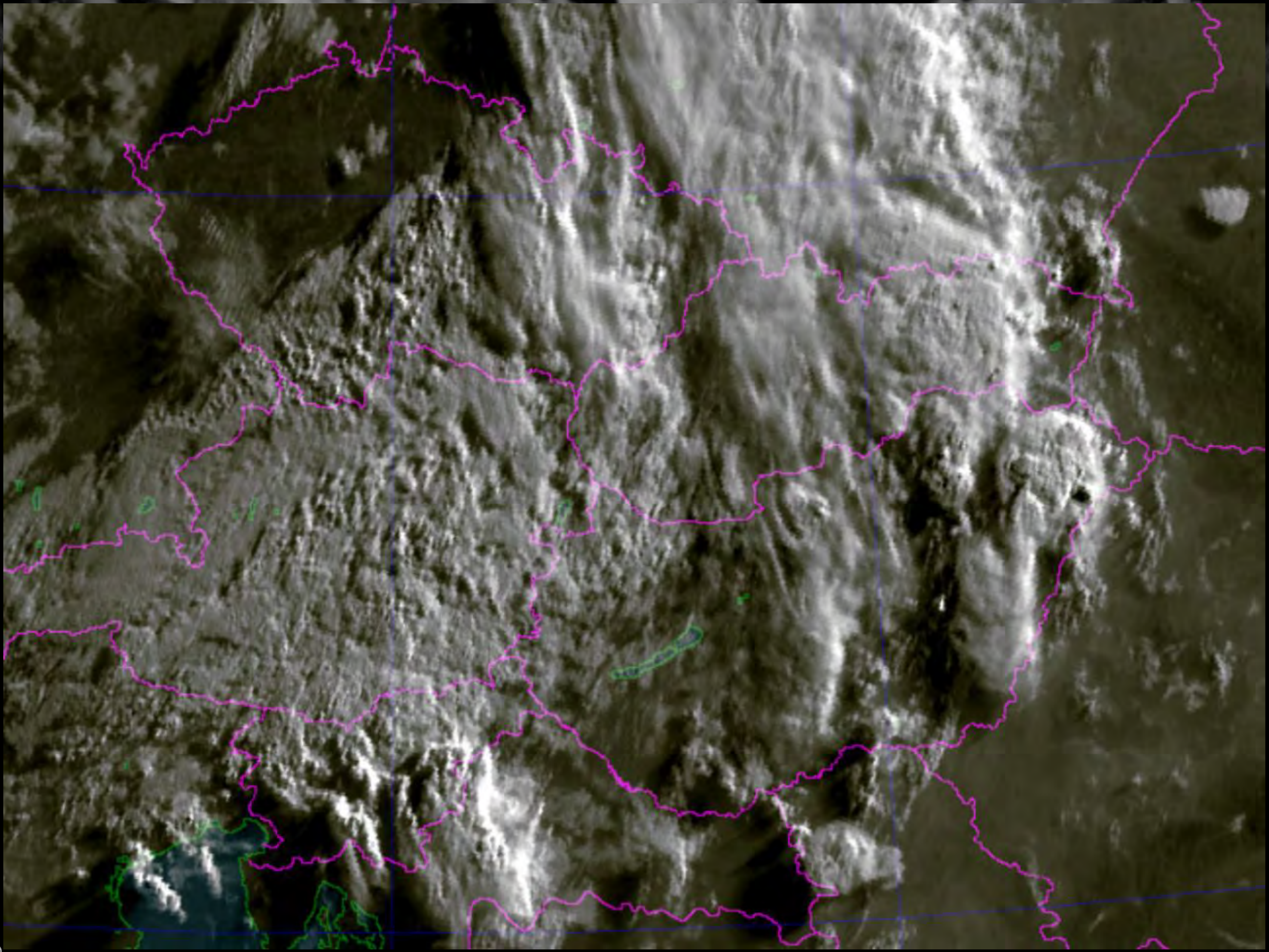
# 0D : „bodové“ merania synoptických staníc : 2D : prízemná mapa



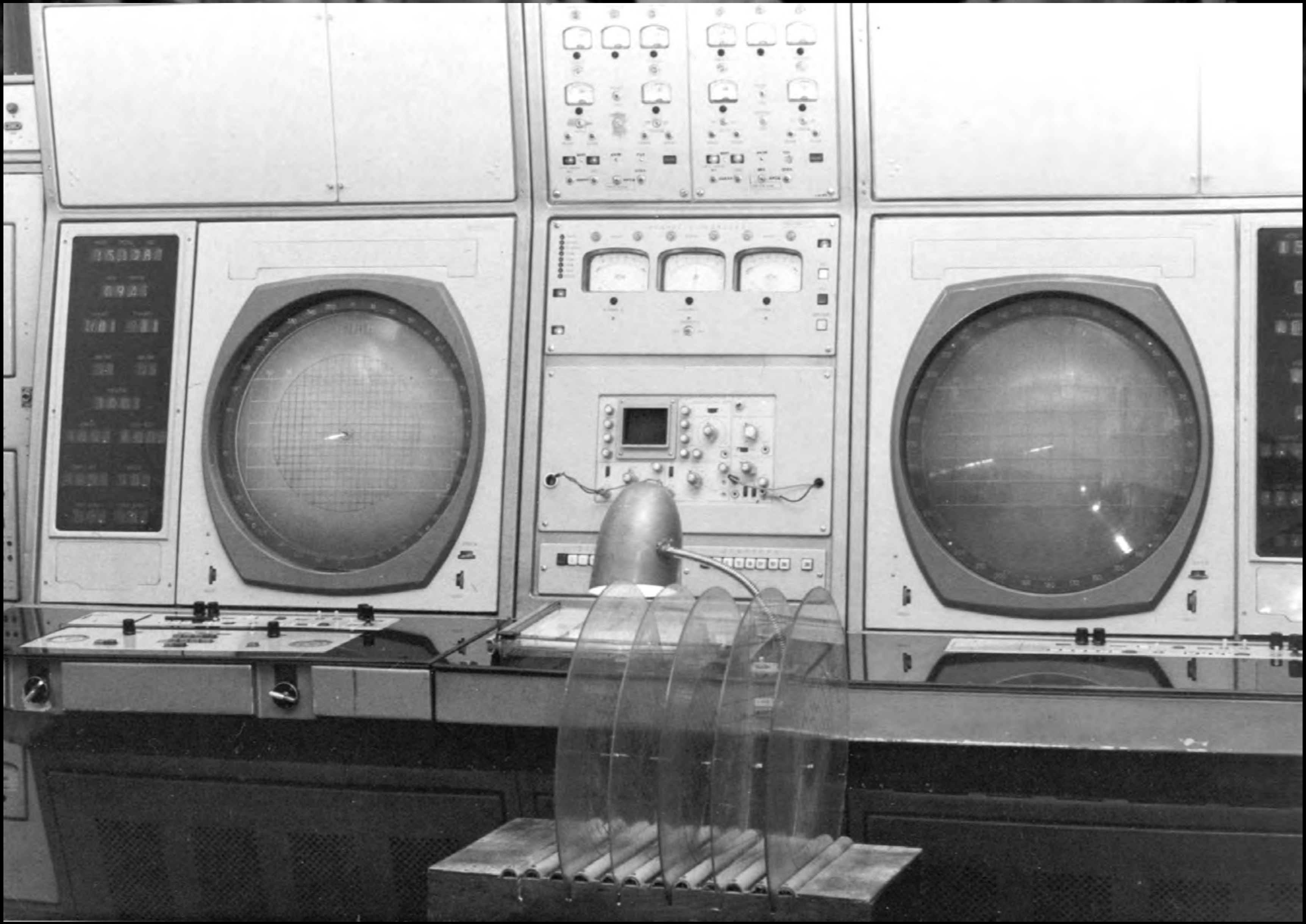
# 1D : „lineárne“ merania aerologických staníc : 2D : výškové mapy



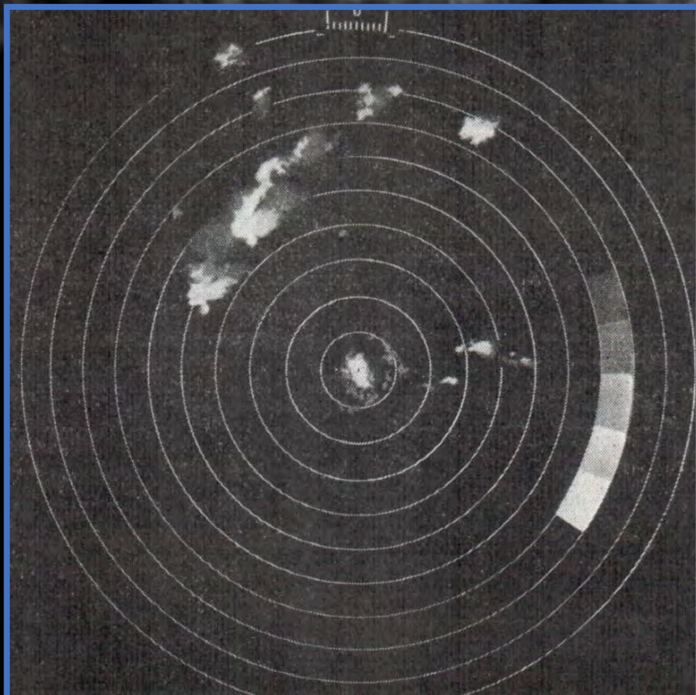
# 2D : snímanie meteorologickej družice : 2D : snímky

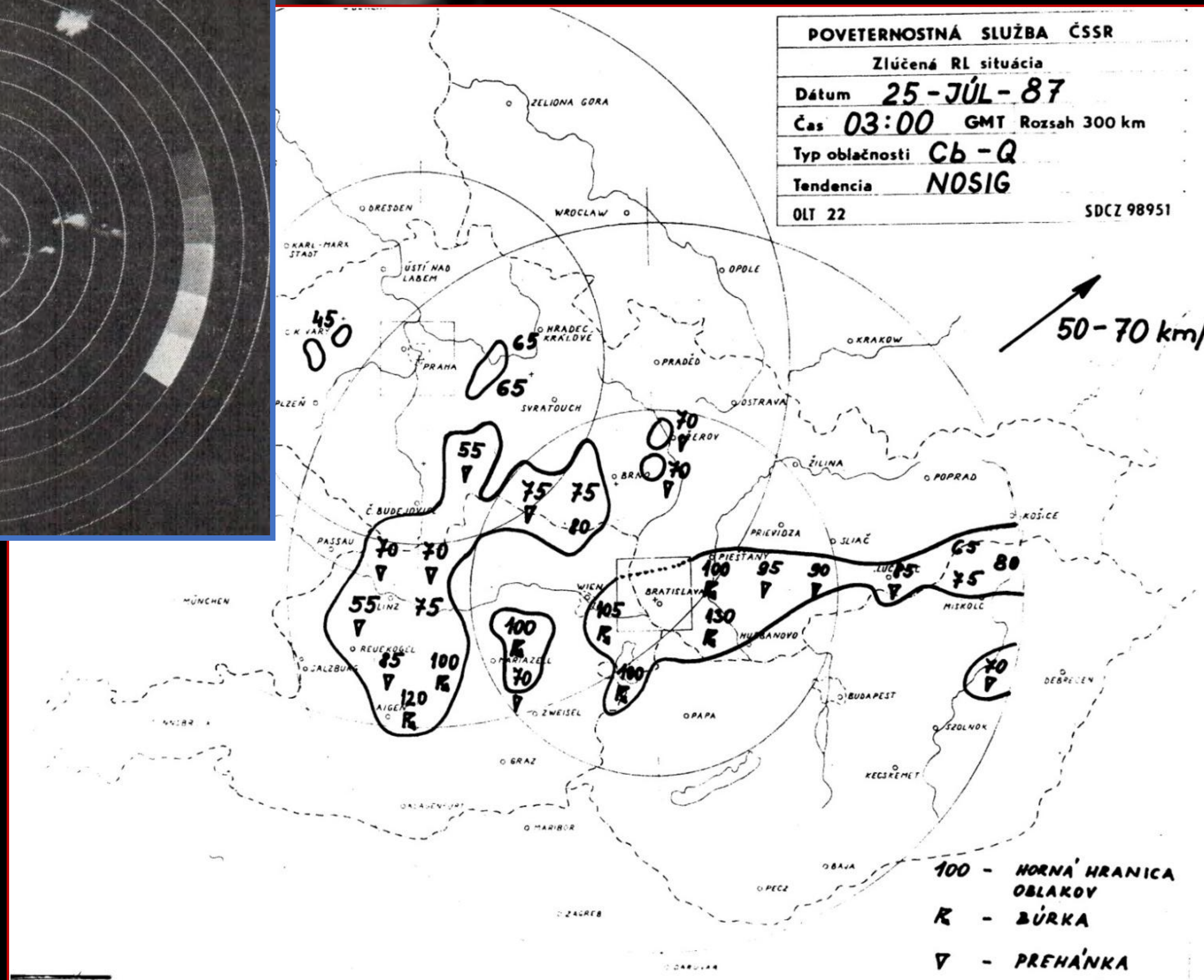


# 2D : manuálne zakresľovanie radarovej meteorologickej situácie : história

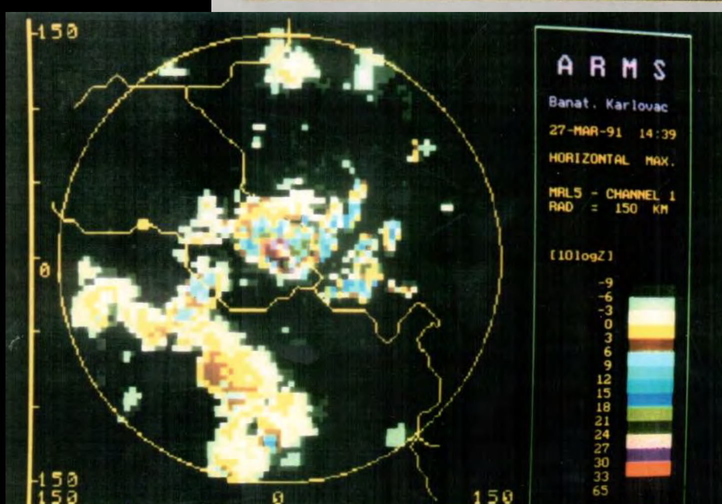


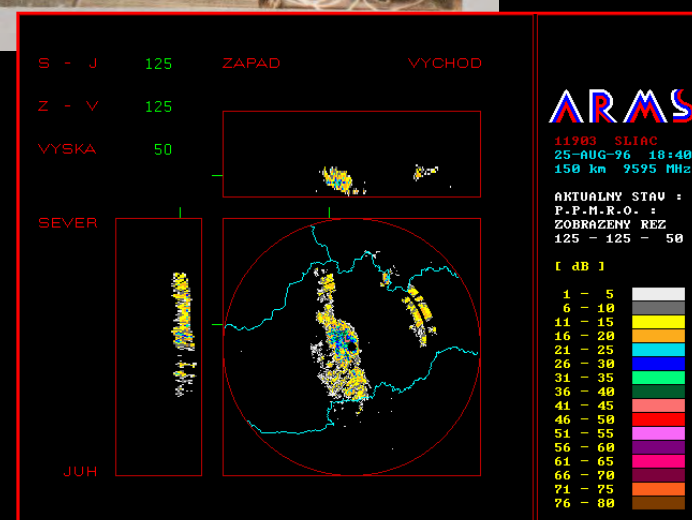
# 2D : ručné prekresľovanie radarovej meteorologickej situácie : história



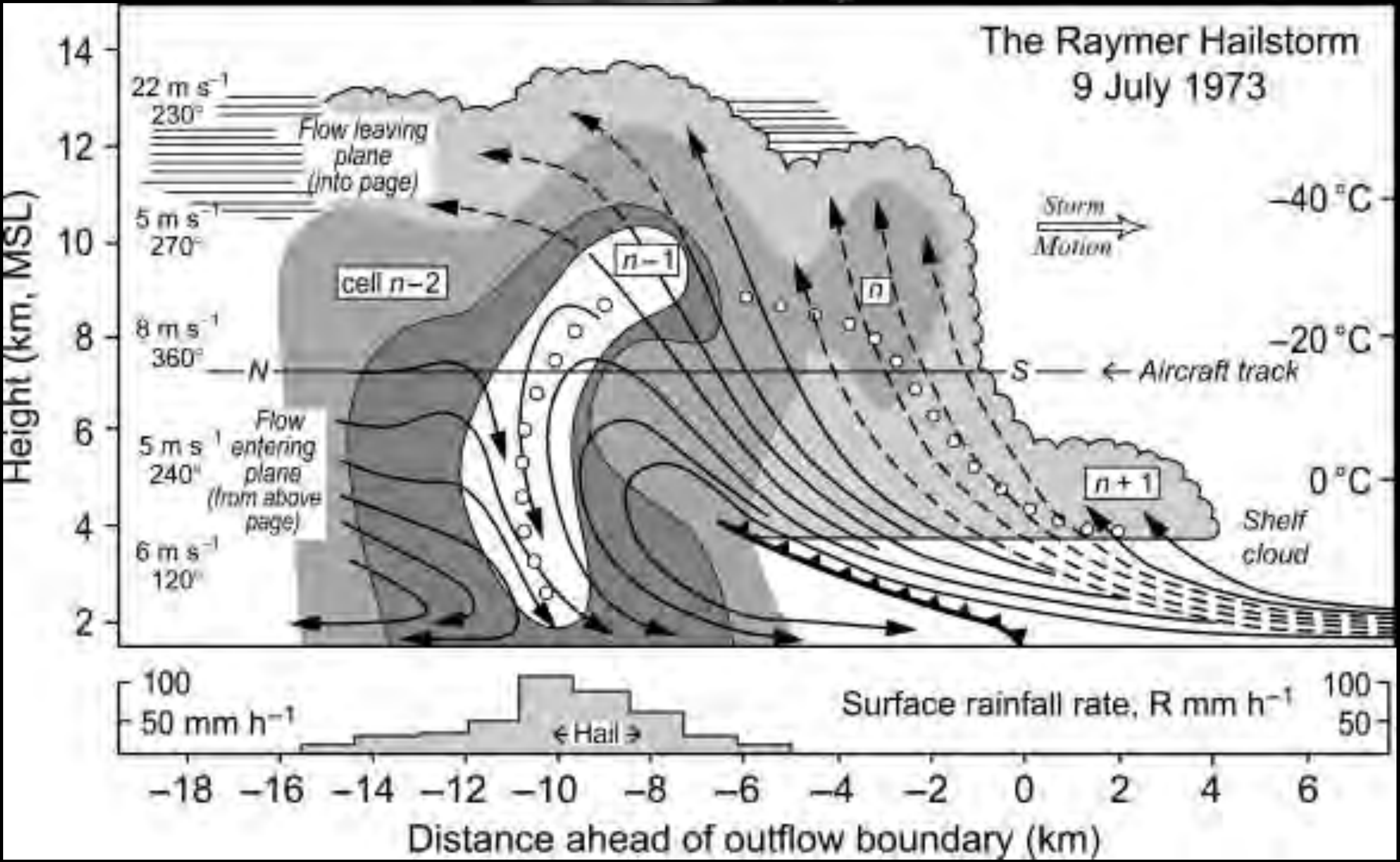


# kvázi 3D : meranie radarovej meteorologickej situácie : prvé automatizácie



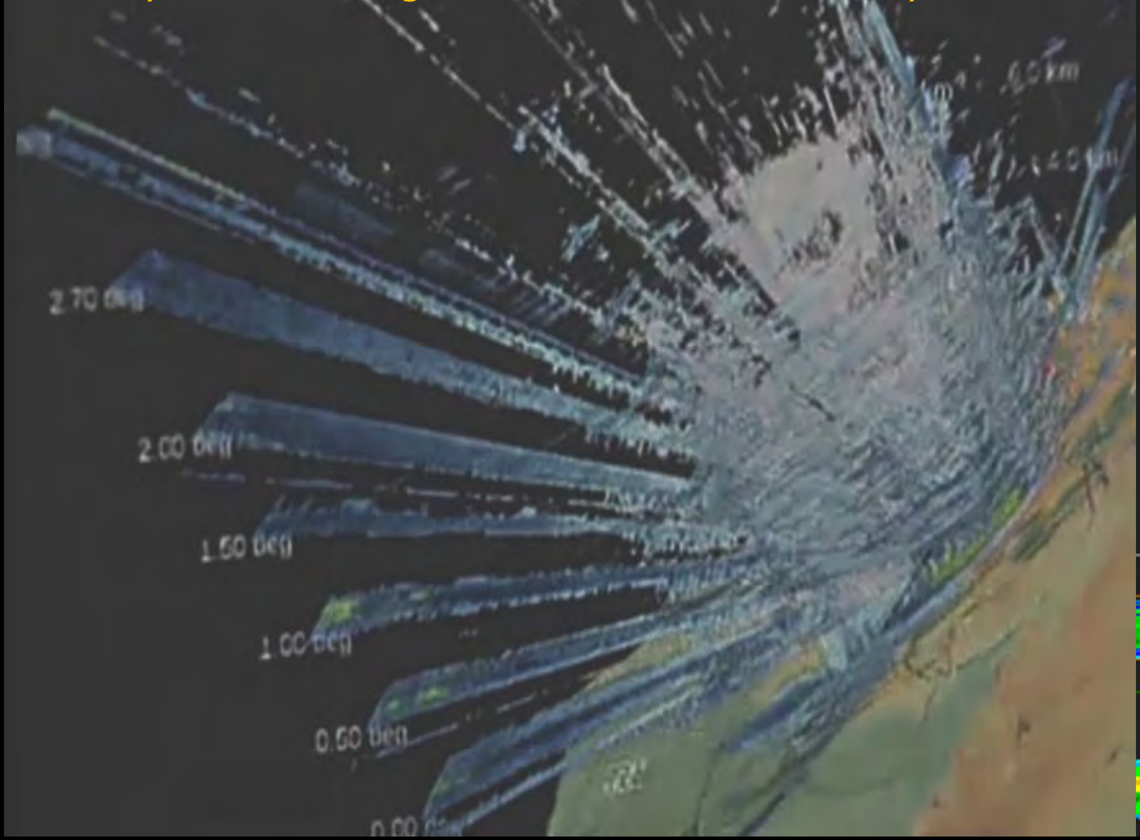



# schéma konvektívneho oblaku podľa modelov vychádzajúcich zo spomínaných vstupných dát ( 0D , 1D , 2D )

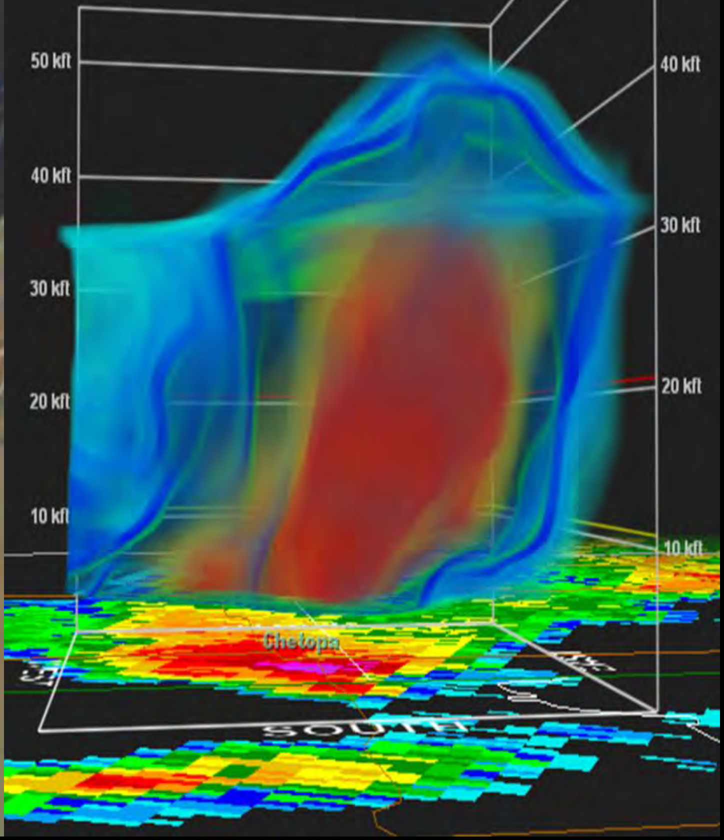


# meteorologické radary : ich bežne používaná technológia merania

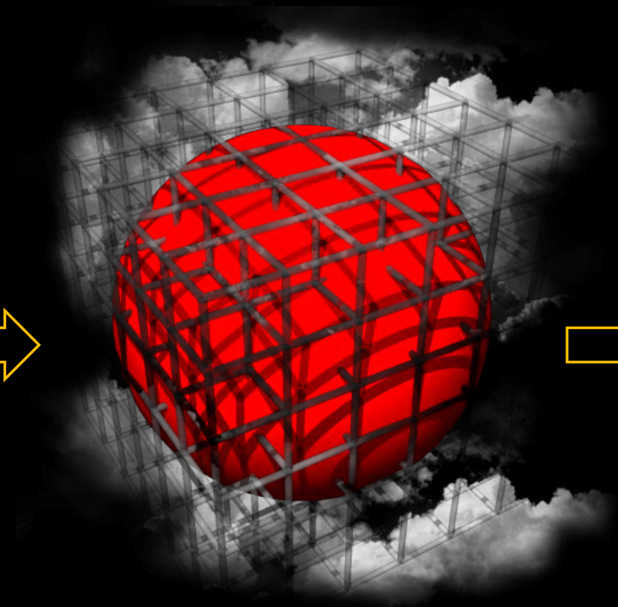
takto vyzerá technológia merania : trinásť elevačných krokov




kvázi 3D obraz vzniká renderovaním



# skySCANner podrobná priestorová technológia merania dát

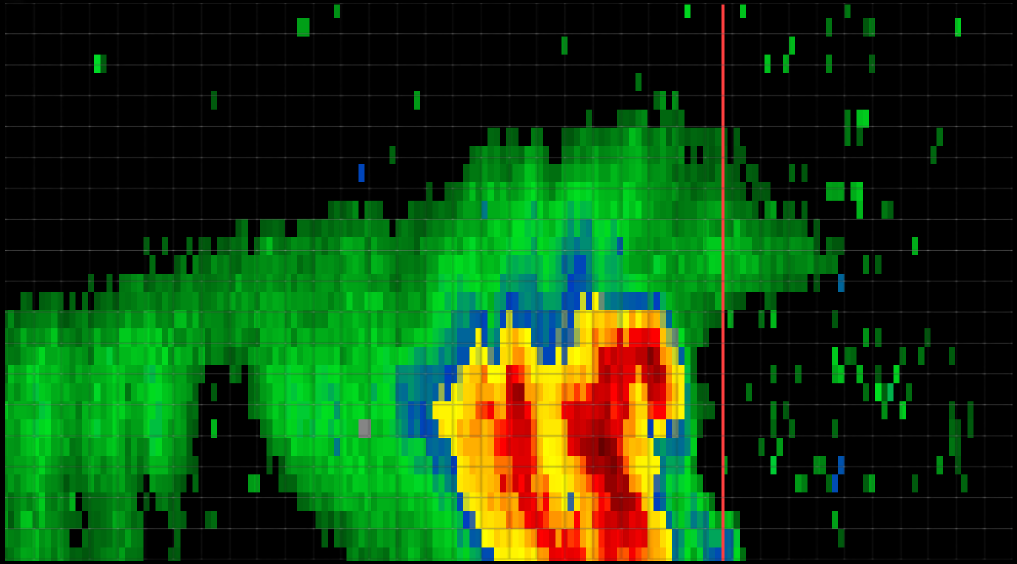



pri meraní sa využíva
elevačná kroková funkcia

dáta sú v reálnom čase odkladané do
priestorovej dátovej štruktúry - PMO

PMO je zmenšená realita,
resp. virtuálny oblak

# skySCANner výsledok technológie merania

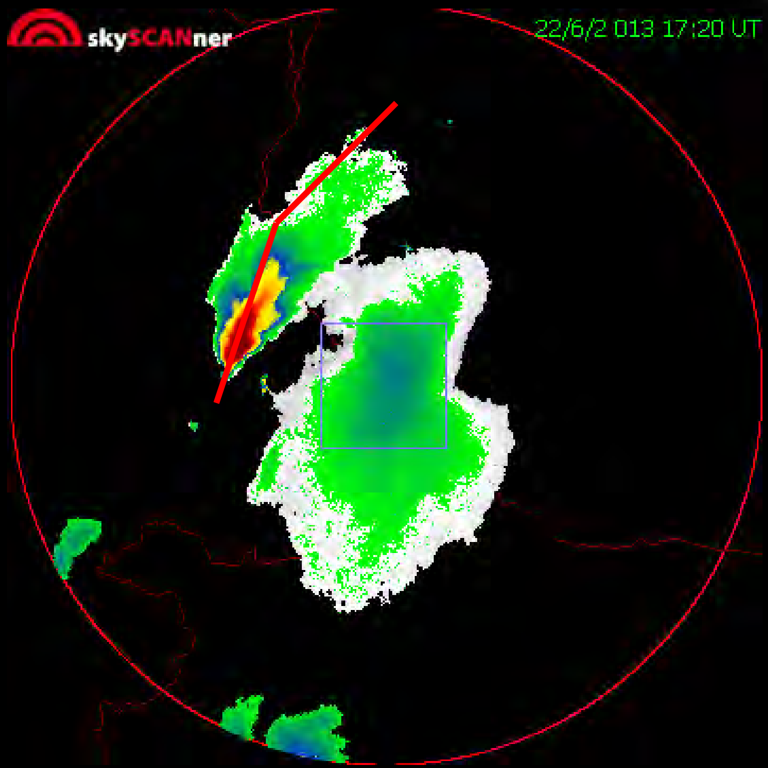


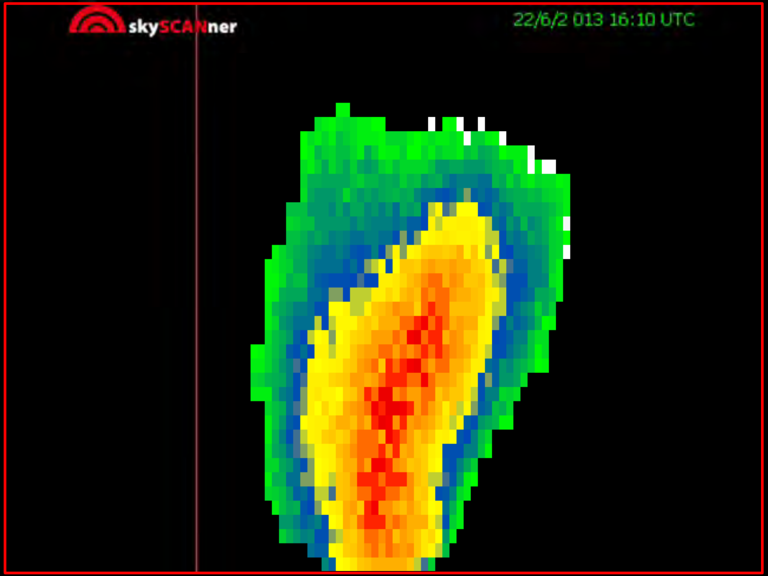
aktuálny Cb ( cumulonimbus )
skenovaný do PMO

digitálny Cb môže byť zobrazovaný
v každom priestorovom reze
v časovej a priestorovej animácii

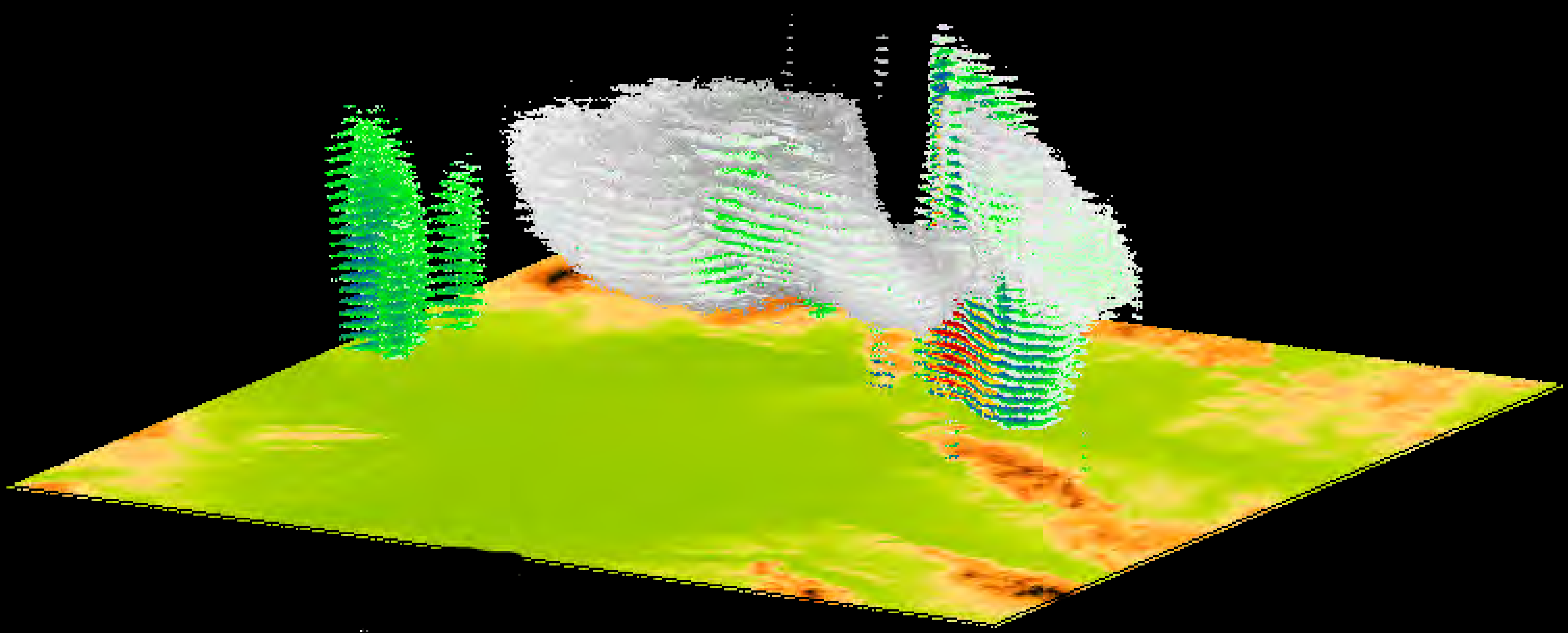
# skySCANner nameraný a skutočný oblak

porovnanie nameraných dát zo skySCANneru s podobným oblakom po dráhe letu

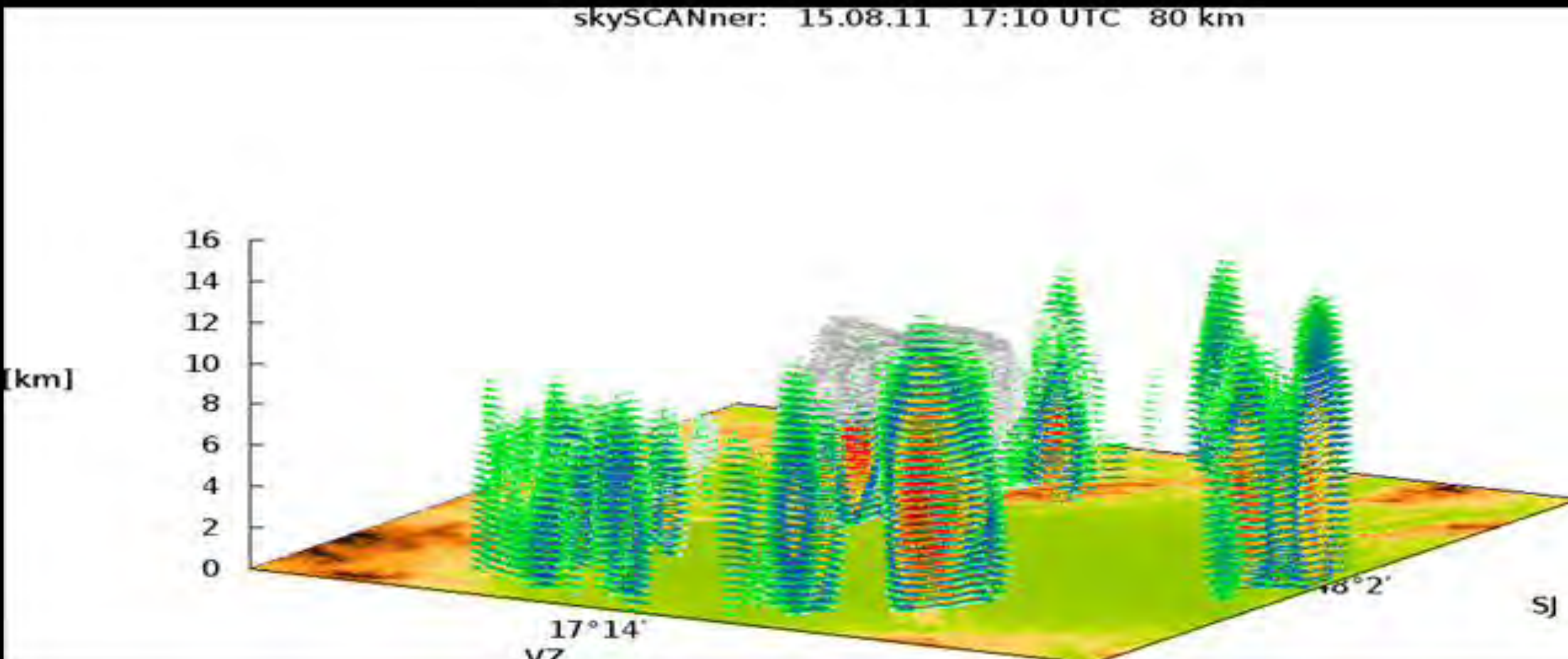


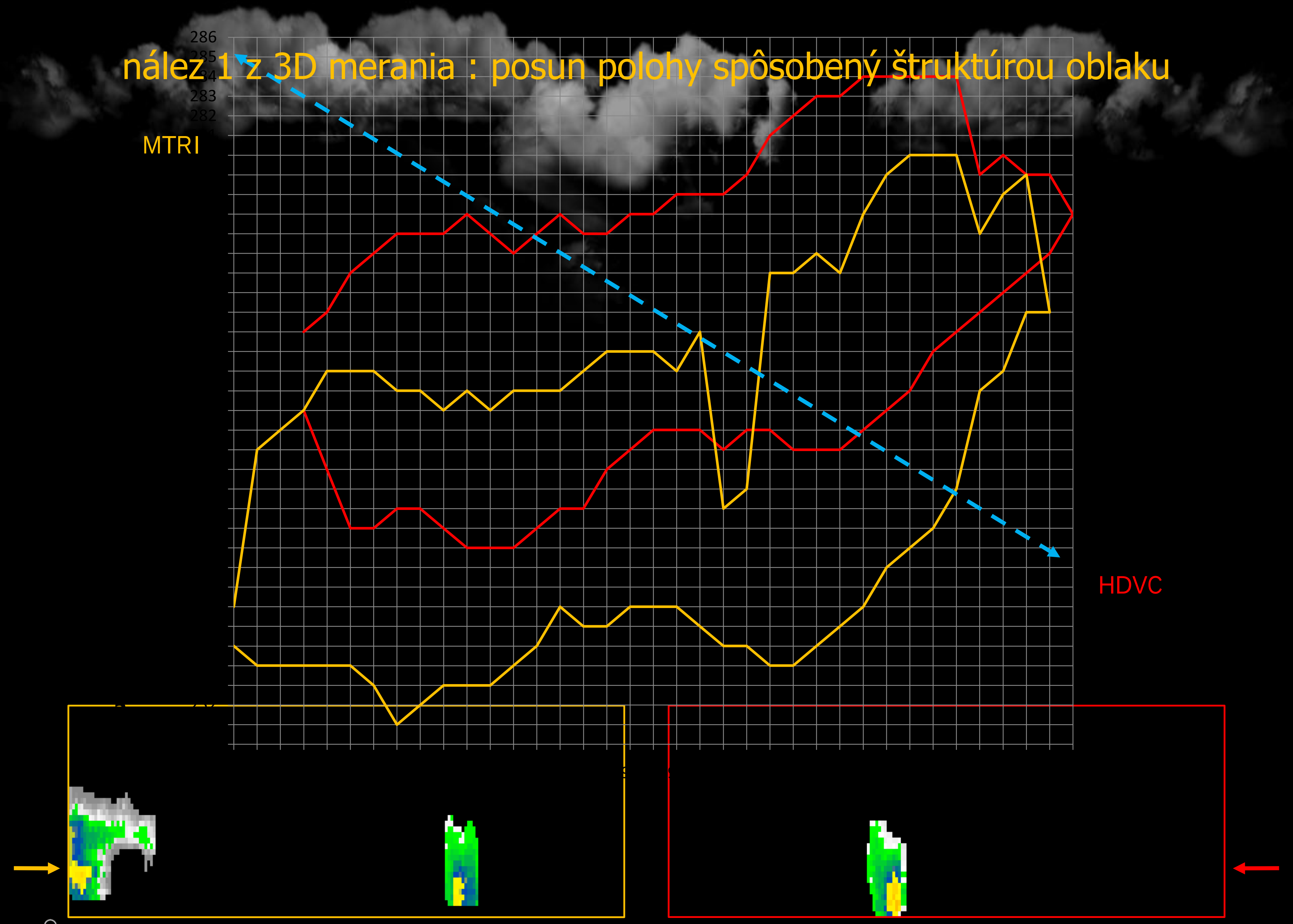

# 3D skySCANner : výsledok technológie merania



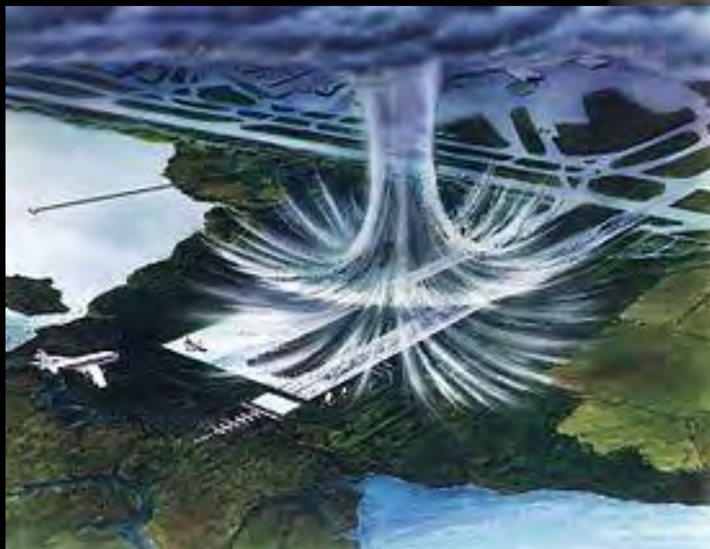
# skySCANner : časo-priestorová dynamika vývoja konvektívnych oblakov

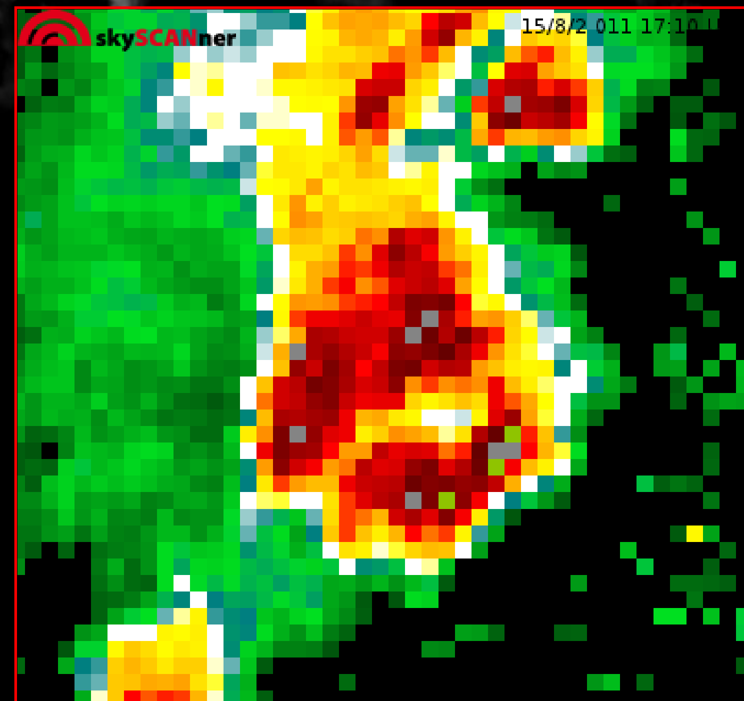


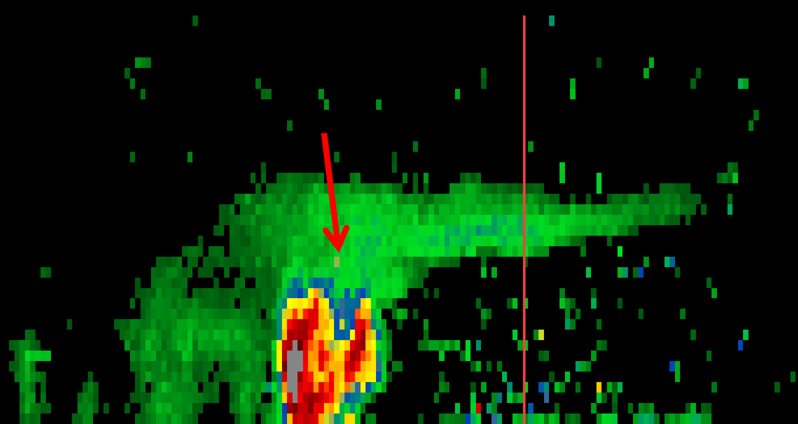
# nález 1 z 3D merania : posun polohy spôsobený štruktúrou oblaku

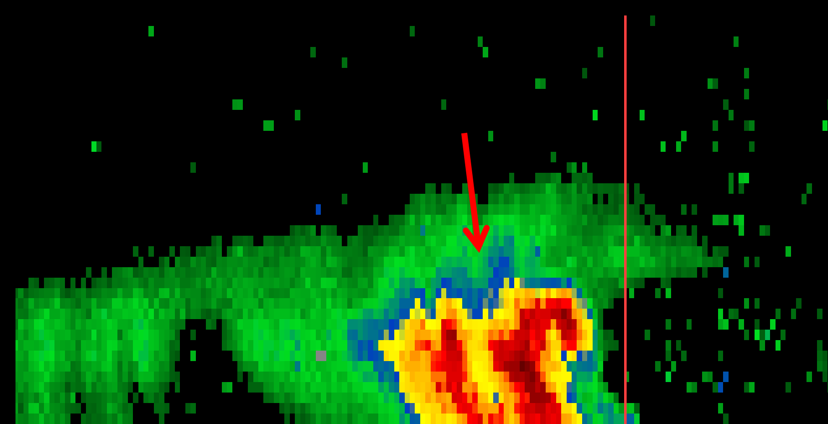


# nález 2 z 3D merania : microburst detekovaný meraním skySCANner-u







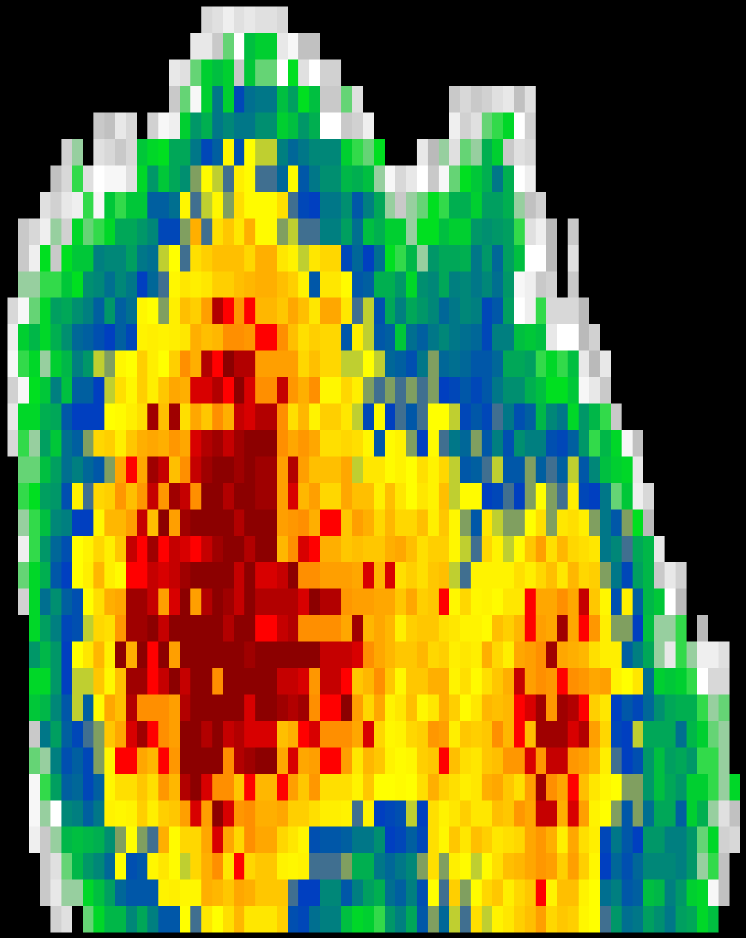
SWORAD

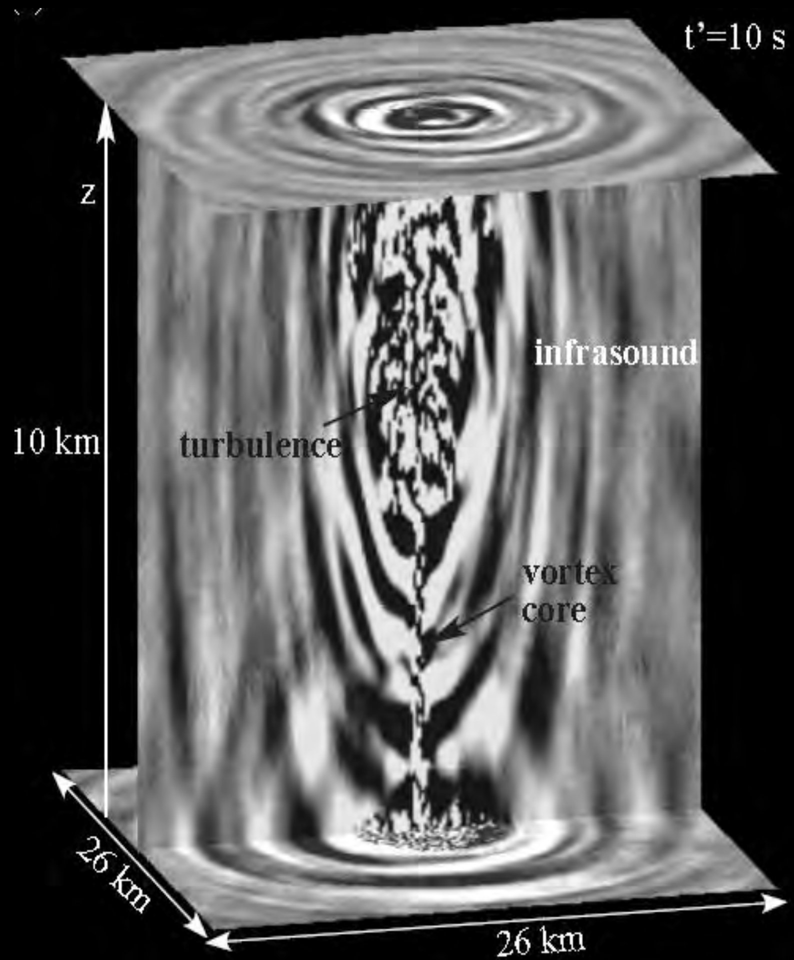
SWORAD s.r.o.

# nález 3 z 3D merania : infrazvuk v konvektívnom oblaku : meranie skySCANnerom a akustický model

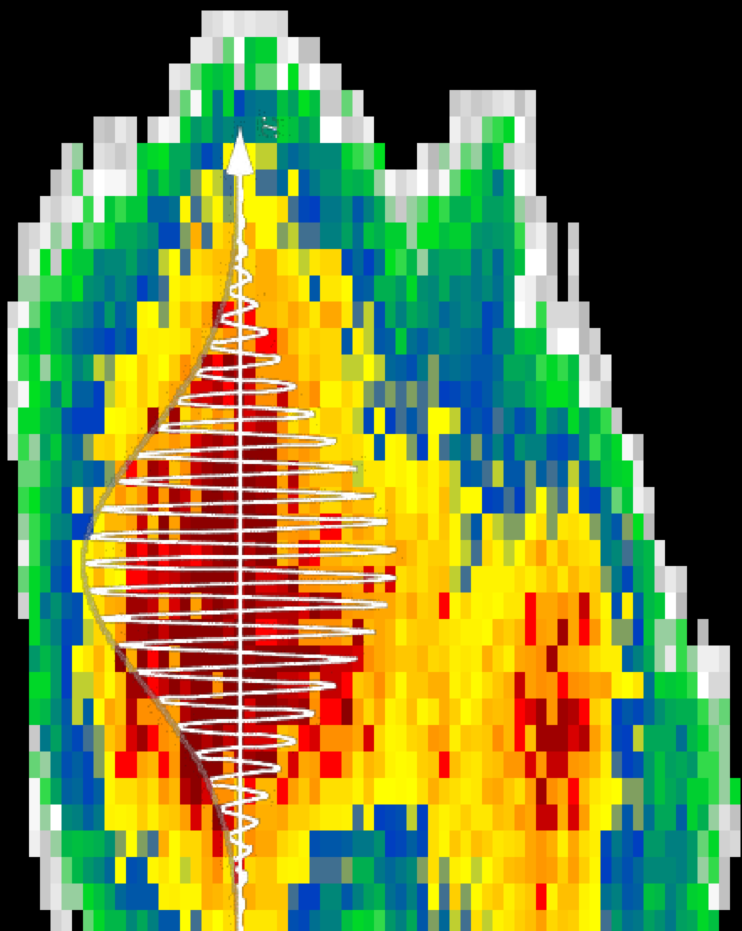
skySCANner

15/8/2 011 17:10 UTC

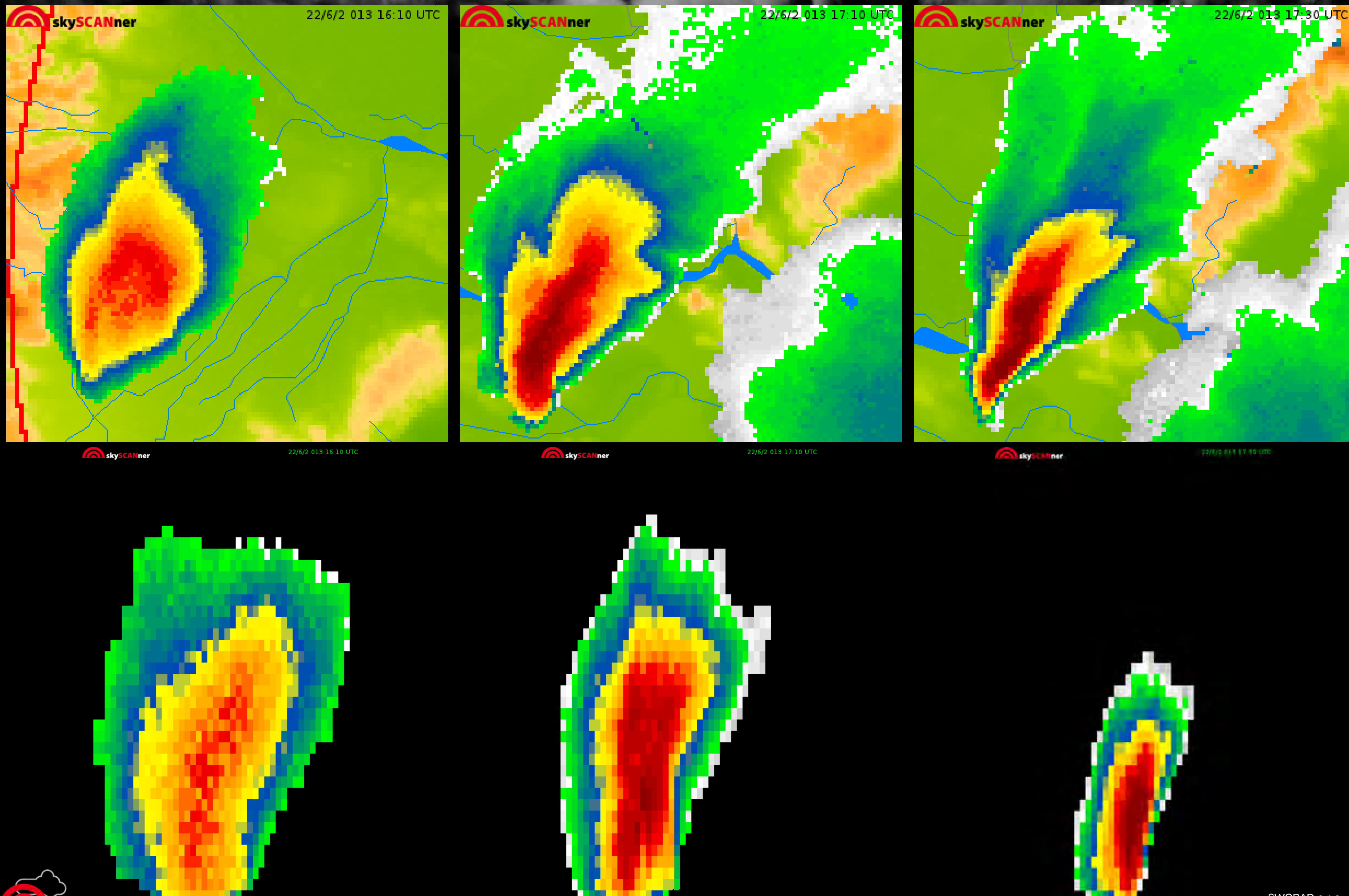




# nález 3 z 3D merania : infrazvuk v konvektívnom oblaku : podobnosť akustickej štruktúry s oblakom a vplyv akustiky na levitáciu kvapky




# nález 3 z 3D merania : mení infrazvuk štruktúru konvektívneho oblaku ?



# skySCANner na Meteorologicko Telekomunikačnej Rozhľadni Inovec


# informácie z experimentálnych meraní poskytujeme verejnosti na našej stránke www.myskywatch.sk

# ION BEAM ANALYSIS AND MODIFICATION OF MATERIALS AT MTF STU

**Ing. Pavol Noga, PhD.** [1]
[1] Slovak University of Technology in Bratislava

**Abstract**

*An ion beam laboratory for materials research was commissioned recently at the Slovak University of Technology within the University Science Park CAMBO located in Trnava. The facility will support research in the field of materials science, physical engineering and nanotechnology. Ion-beam materials modification as well as ion-beam analysis are covered and deliverable ion energies are in the range from tens of keV up to tens of MeV. Two systems have been put into operation. First, a high current version of the HVEE 6 MV Tandetron electrostatic tandem accelerator with duoplasmatron and cesium sputtering ion sources, equipped with two end-stations: a high-energy ion implantation and IBA end-station which includes RBS, PIXE, ERDA and NRA analytical systems. Second, a 500kV implanter equipped with a Bernas type ion source and two experimental wafer processing end-stations. Capabilities of the laboratory are presented together with an introduction to the technology itself and its applications.*

3rd INTERNATIONAL CONFERENCE

# 3D MEASUREMENT AND IMAGING

*MODERN CONTACTLESS MEASUREMENTS IN INDUSTRIAL PRACTICE*

# ION BEAM ANALYSIS AND MODIFICATION OF MATERIALS AT ATRI MTF STU

Pavol Noga

Slovak university of technology in Bratislava,
Faculty of materials science and technology,
Advanced technologies research institute

STU MTF

ATRI Advanced Technologies Research Institute

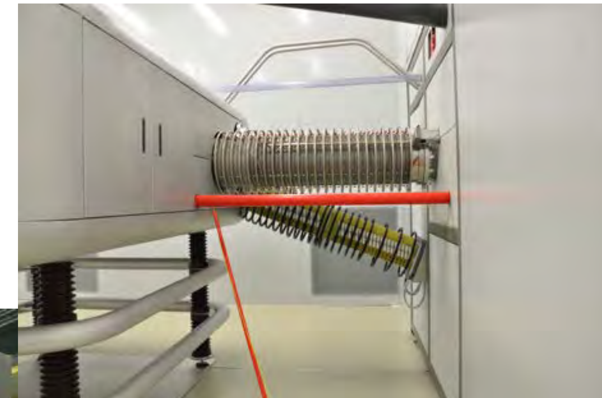
# NEW LABS AT ATRI MTF STU


STU MTF

ATRI Advanced Technologies Research Institute

Commissioned in December 2015

# NEW EQUIPMENT

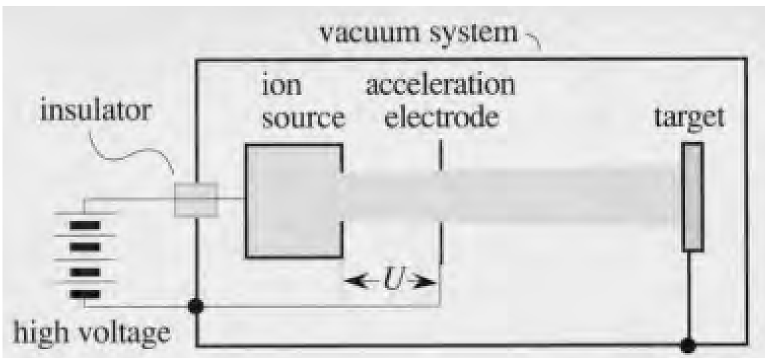


# OUTLINE

- **Introduction to ion beams**
- **Ion beam modification of materials**
  - Ion implantation
  - Ion irradiation induced changes in structure
  - Ion irradiation induced activation
- **Equipment**
- **Ion beam analysis of materials**
  - Rutherford Backscattering Spectrometry
  - Elastic Recoil Detection Analysis
  - Ion Channeling
  - Particle induced x-ray emmission
  - Nuclear reaction analysis

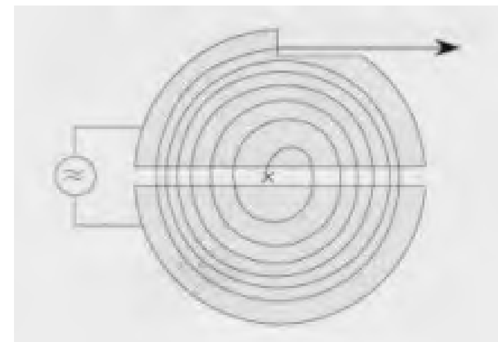
# ION ACCELERATOR

## Electrostatic



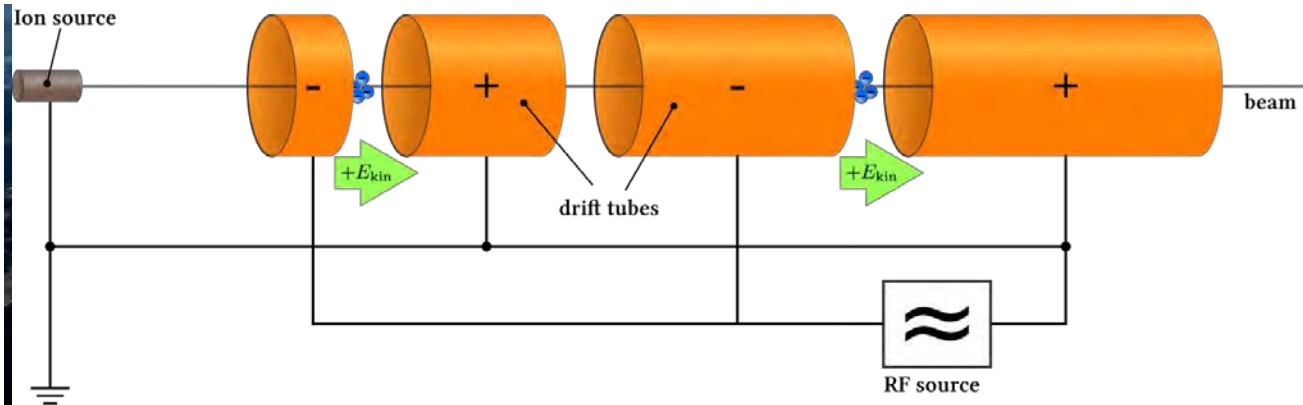

We have this one

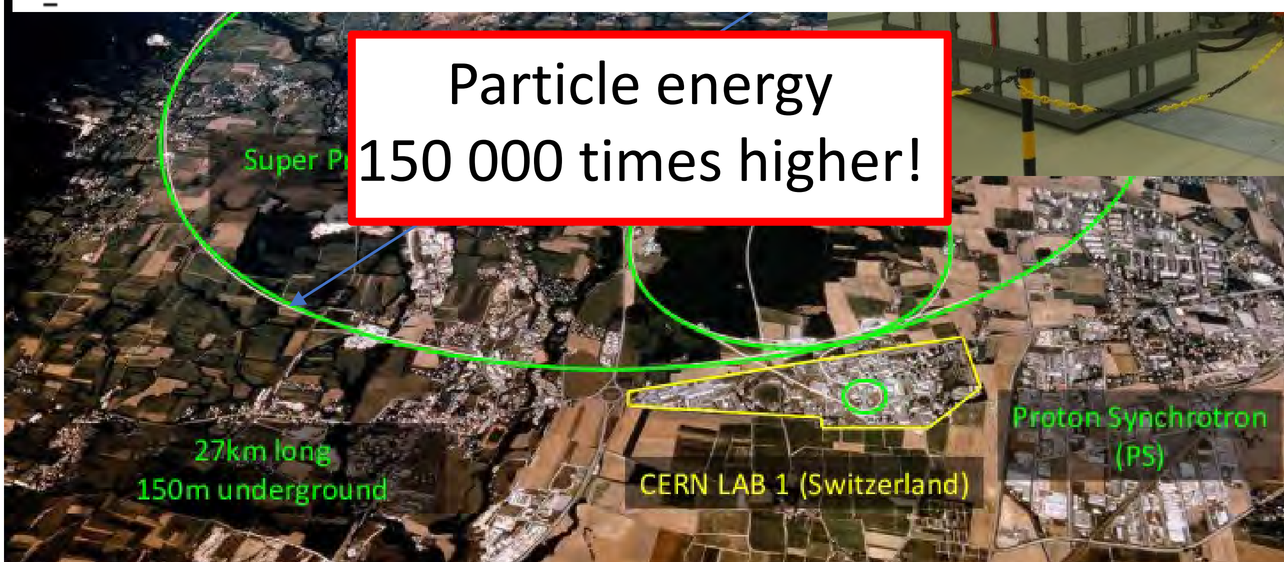
## Cyclotron



# BY NO MEANS „SMALL CERN“

CERN uses this




Particle energy
150 000 times higher!

# WHAT IS IT GOOD FOR?

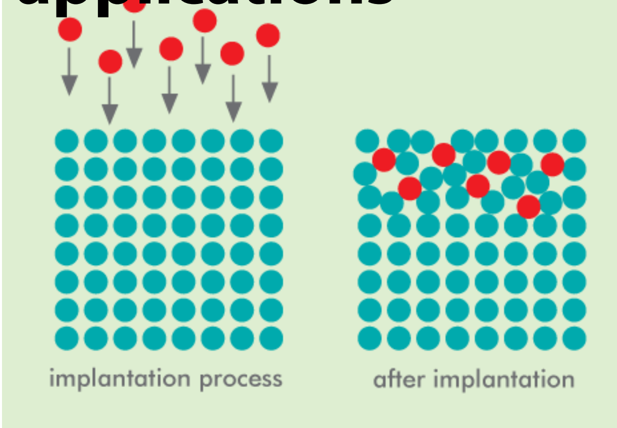
- **Exploring physics of matter and the Universe (CERN)**

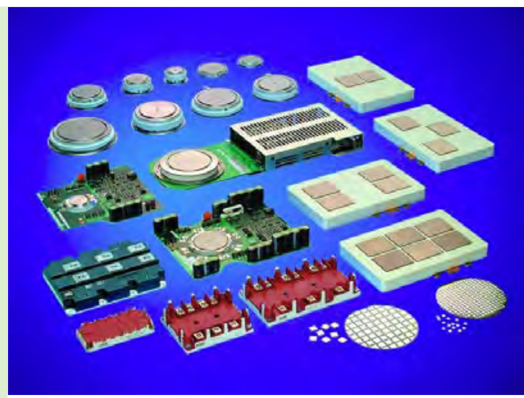
Closer to everyday life and what we do:

- **Ion beam modification of materials**
  - Doping, synthesis of otherwise infeasible materials
  - Structure (tuning crystallinity, interface mixing etc.)
  - Activation and isotope production
- **Ion beam analysis of materials**
  - Elemental composition, contamination, trace elements
  - Structure

# ION BEAM MODIFICATION

## Well known: Ion implantation and its applications

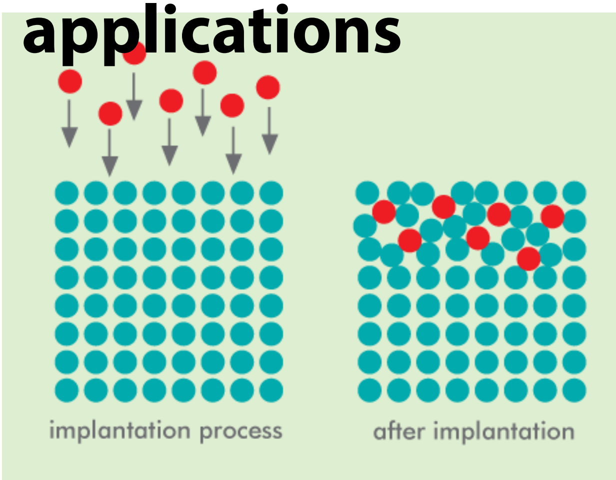


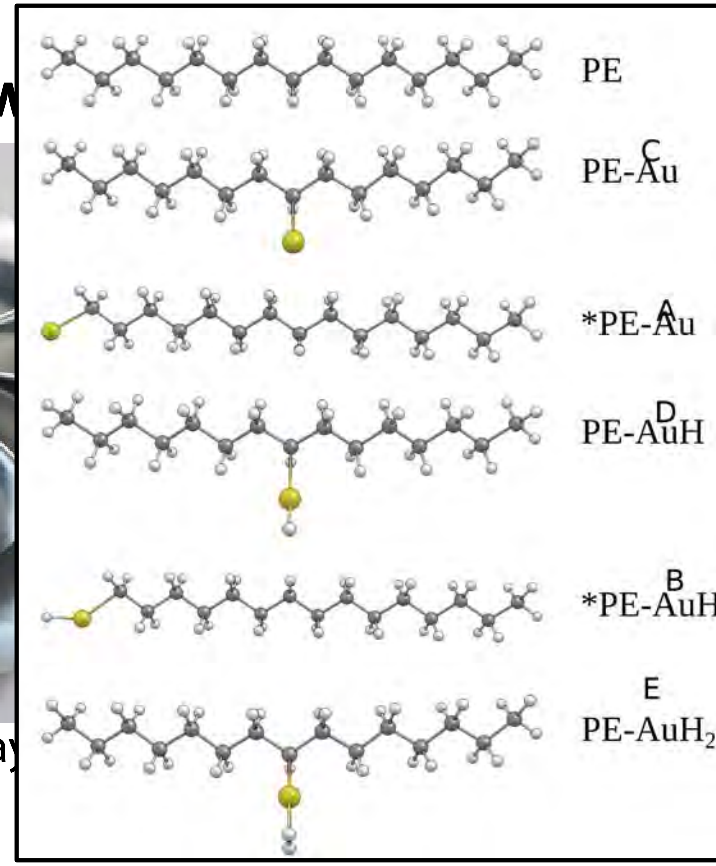
All kinds of electronics

# ION BEAM MODIFICATION

## Ion implantation and its less know applications




Wear resistant lay



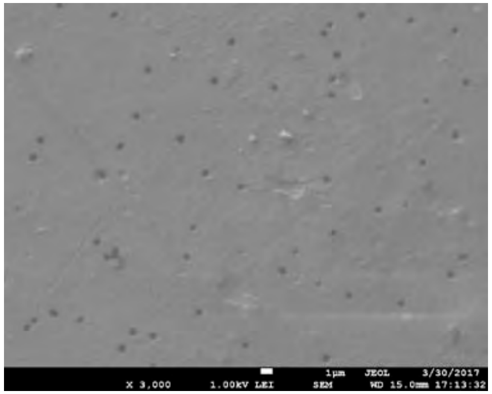

Biocompatiblity

And many more...

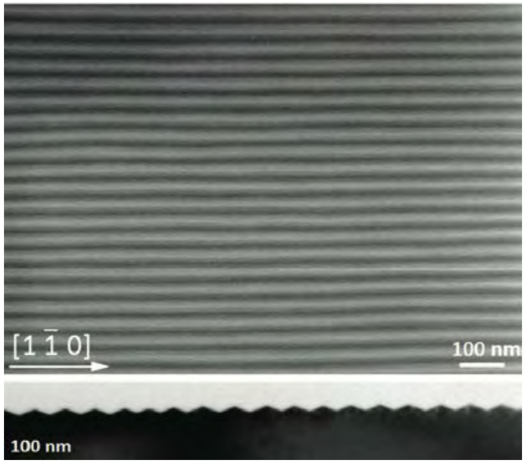
# ION BEAM MODIFICATION

## Tuning the structure

- **Amorphous to crystalline and vice versa**
- **Interface mixing**
- **Ion beam annealing**
- **Nanostructures**

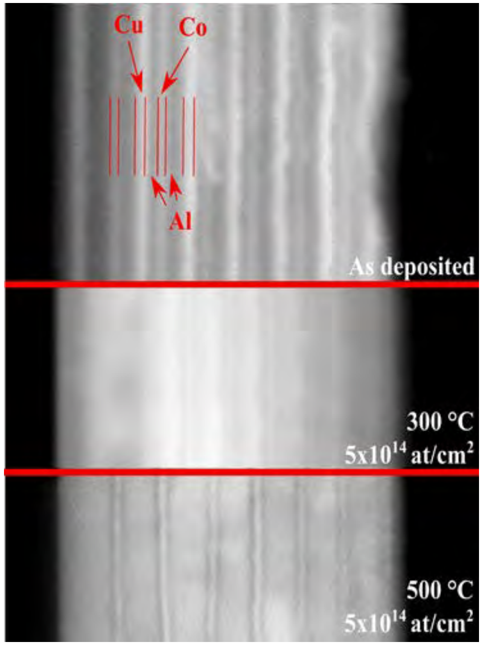


Ion-tracks



Self assembled nanostructures

X. Ou et Al. Nanoscale, 2015, 7, 18928

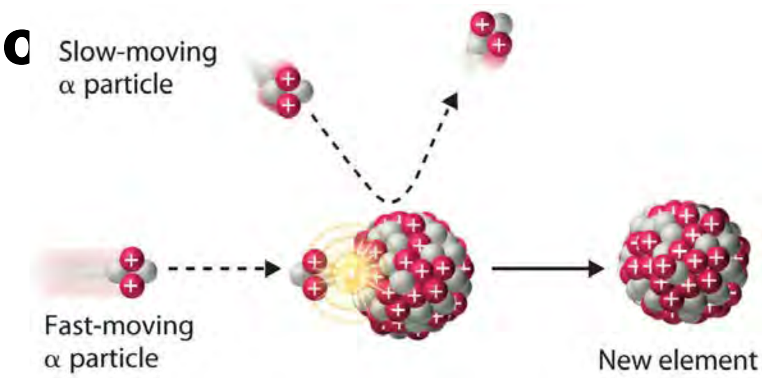


Ion beam mixing

Applications in optics, data storage, molecular filters, functional layers etc.

# ION BEAM MODIFICATION

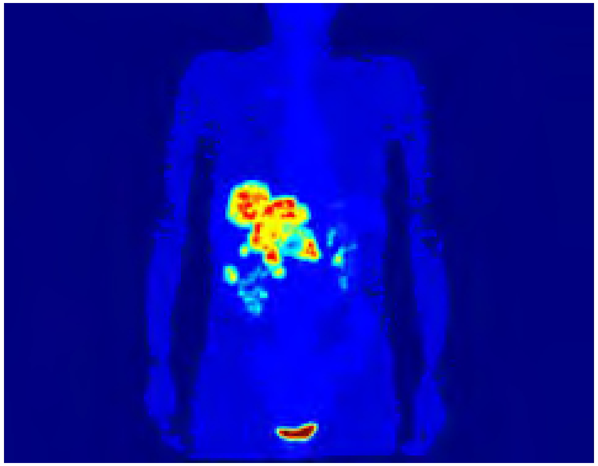
## Activation and isotope productio

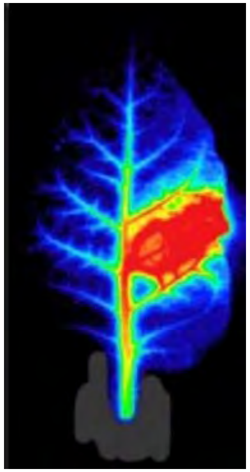



- **Nano-wear measurement**

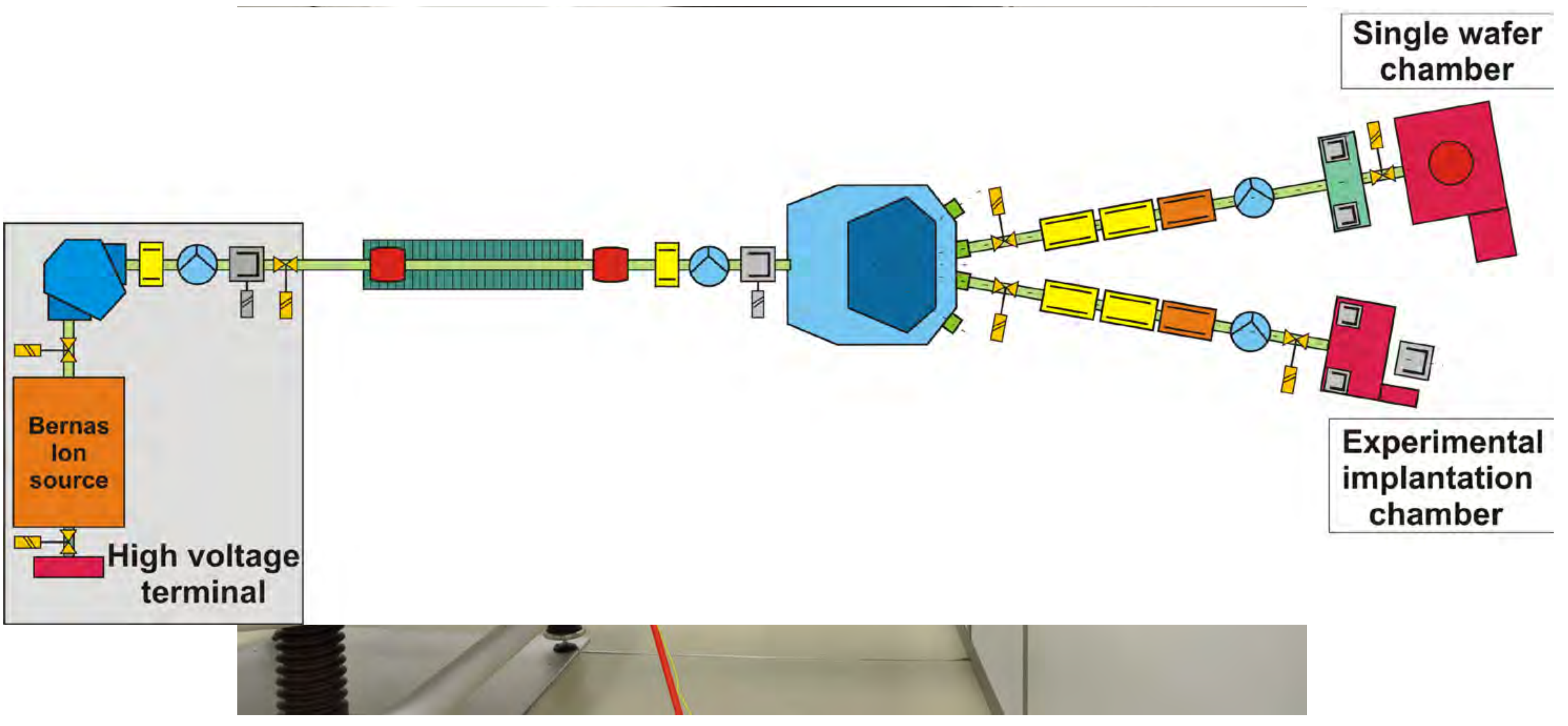
  e.g. in engines, compressors, bearings etc.
- **Cancer diagnostics and treatment**
- **Exotic radionuclides used as markers**

  e.g. migration of nutrients in plants, diffusion measurements etc.





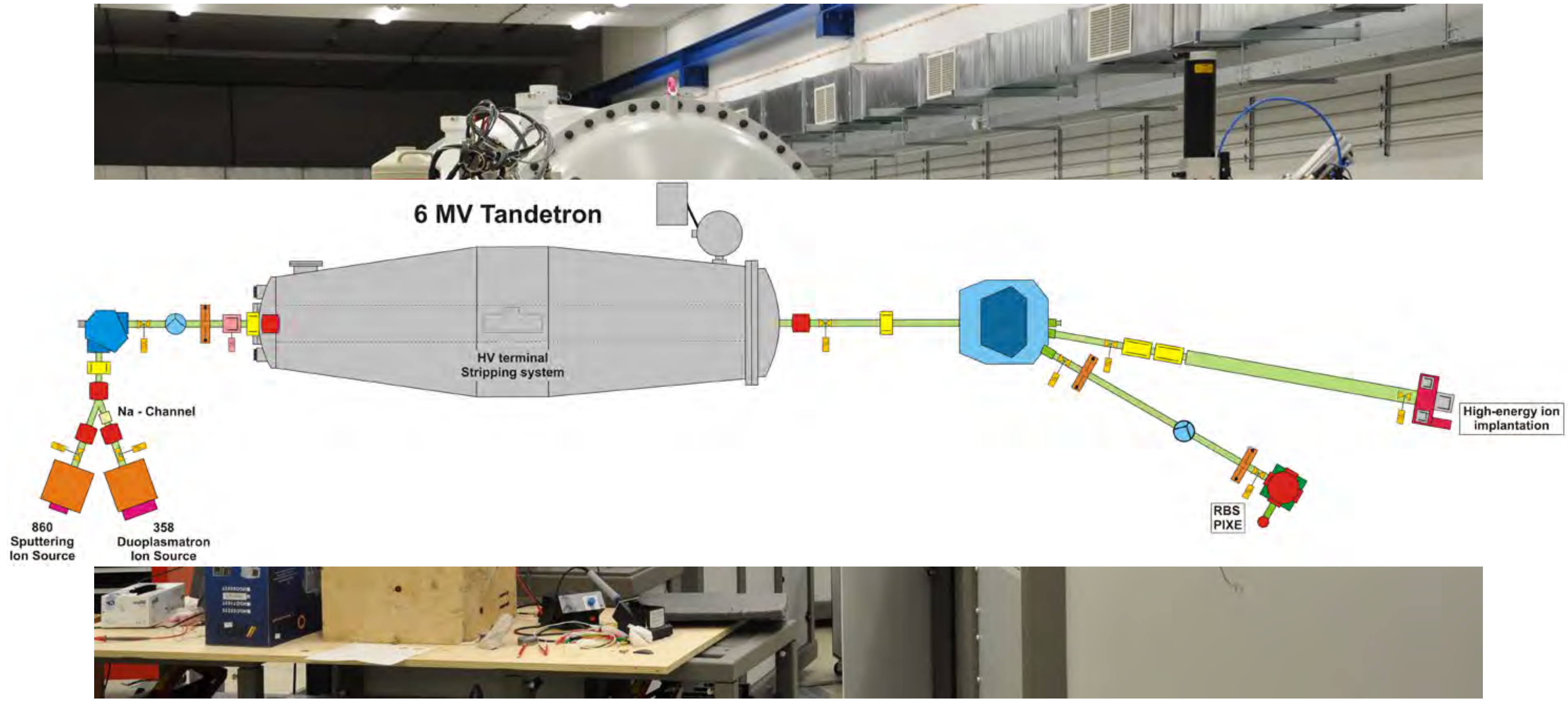
# EQUIPMENT: ION IMPLANTER



# ION IMPLANTATION END-STATIONS

# 6 MV TANDEM ION ACCELERATOR

# 6 MV TANDEM ION ACCELERATOR

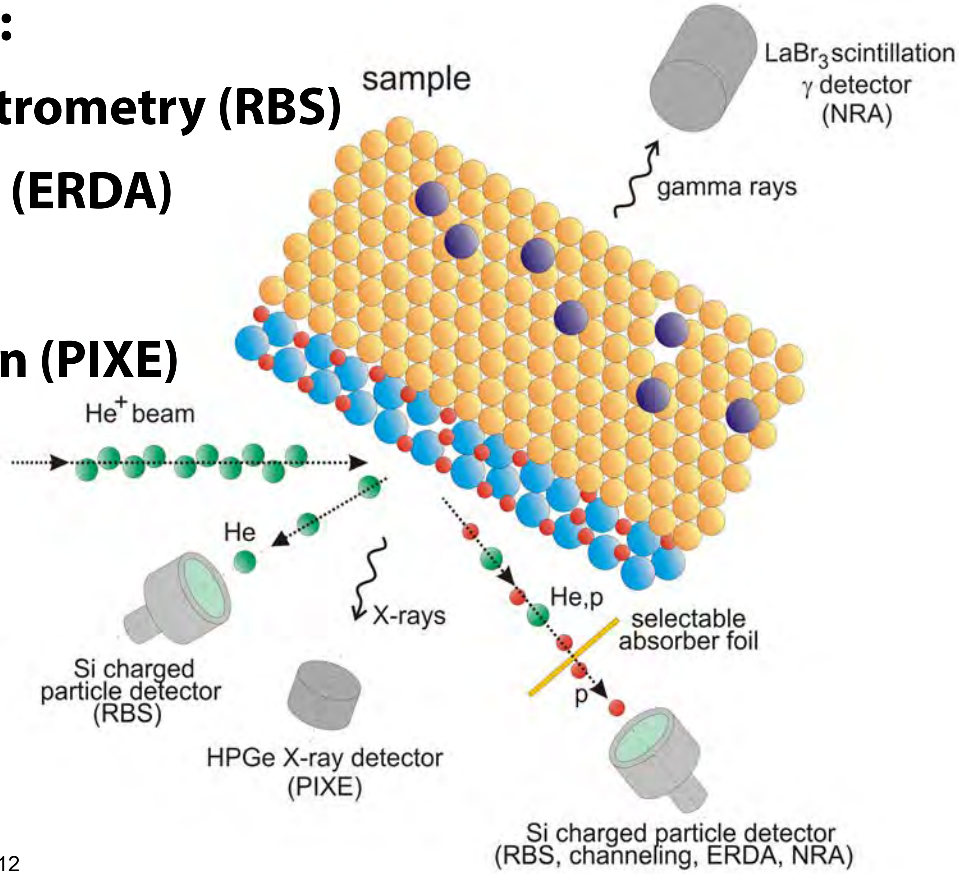


# ION BEAM ANALYSIS

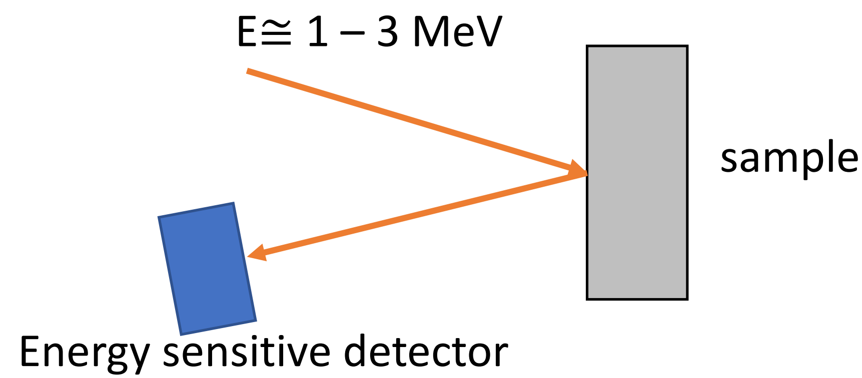
## Non-destructive method for materials analysis

**Detects any element of the Periodic table utilizing the whole pallette of ion-matter interactions:**

- **Rutherford Backscattering Spectrometry (RBS)**
- **Elastic Recoil Detection Analysis (ERDA)**
- **RBS – Channeling (RBS/c)**
- **Particle Induced X-ray Emmission (PIXE)**
- **Nuclear Reaction Analysis (NRA)**

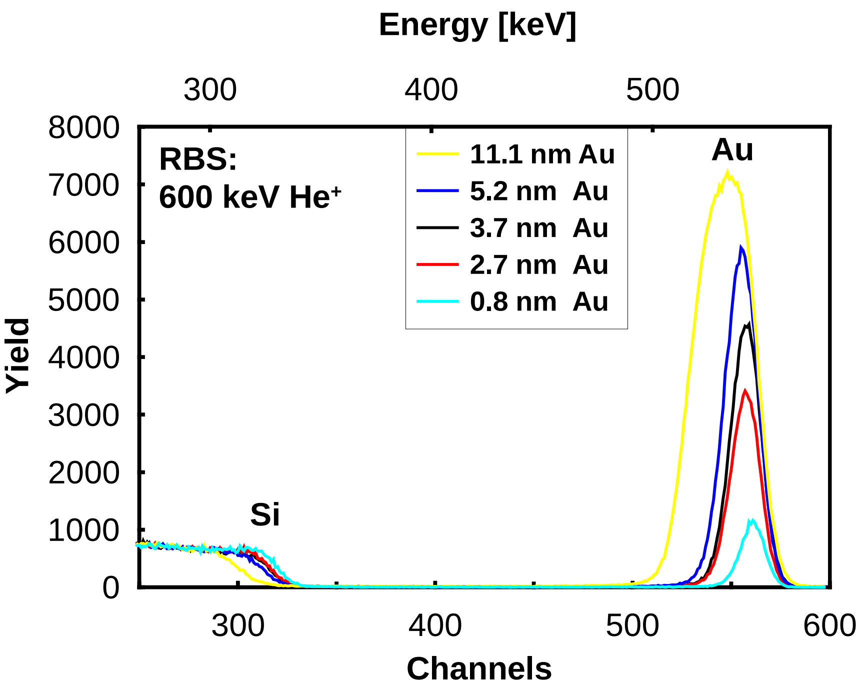


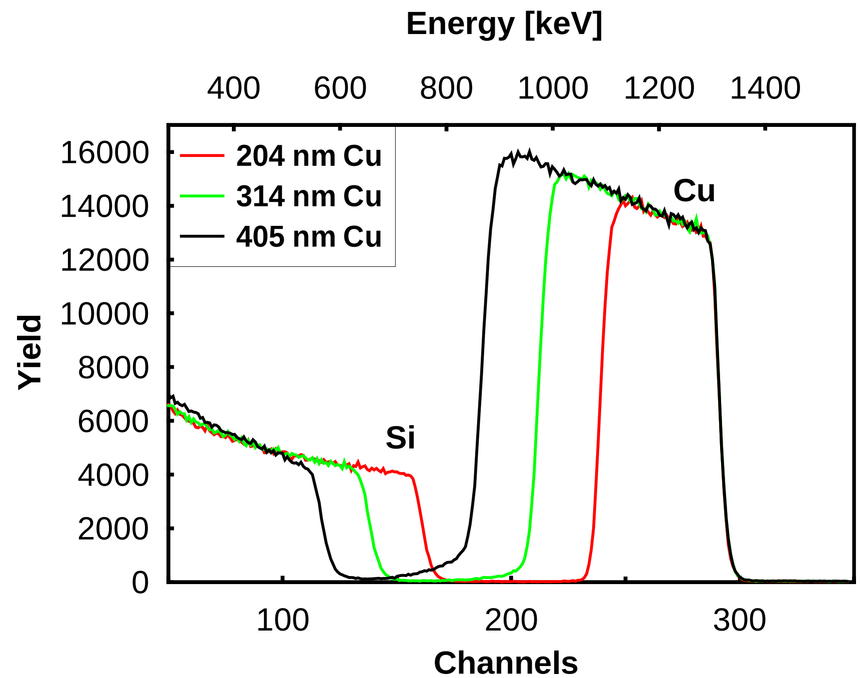
# RUTHERFORD BACKSCATTERING SPECTROMETRY




- **Near surface / thin layer analysis**
- **Concentration depth profiling**
- **Quantitative and standard-free**
- **Analysable elements: O to U**
- **Analyzed depth up to 20 μm**
- **Depth resolution 2 – 20 nm**
- **Very sensitive to heavy elements in a light matrix or substrate**
- **Insensitive to light elements in a heavy matrix or substrate**
- **Detection limit (heavily depend on the sample) down to 0.001 at%**

# RUTHERFORD BACKSCATTERING SPECTROMETRY




## Measuring thin-layer thickness

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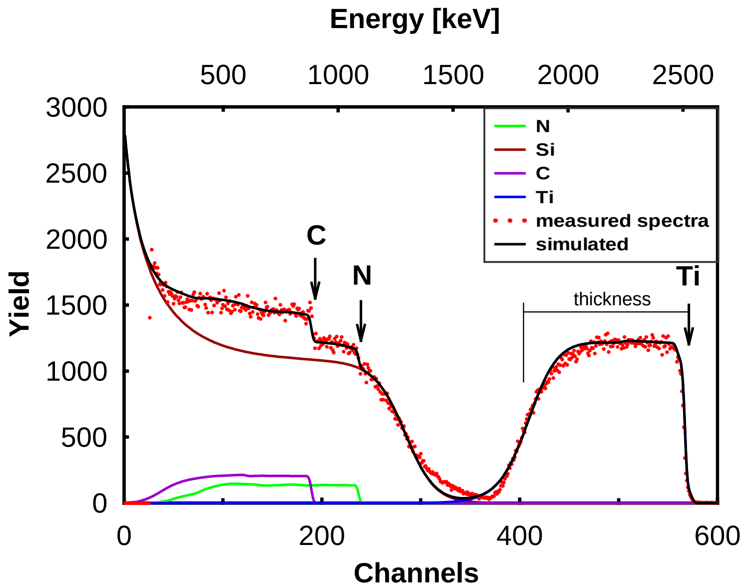
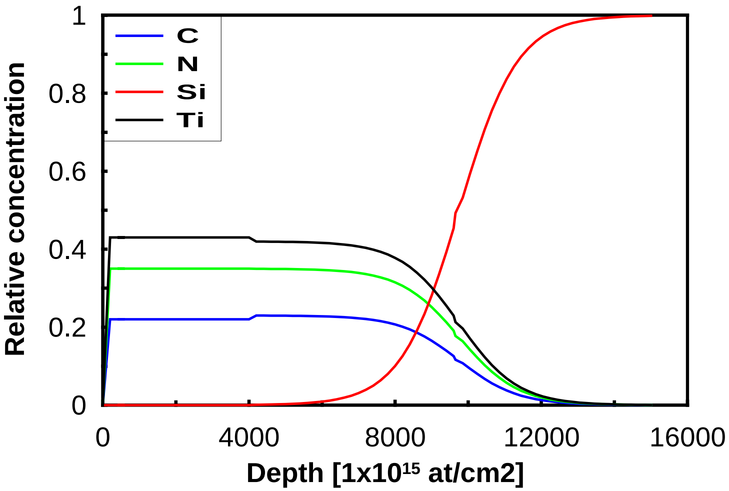
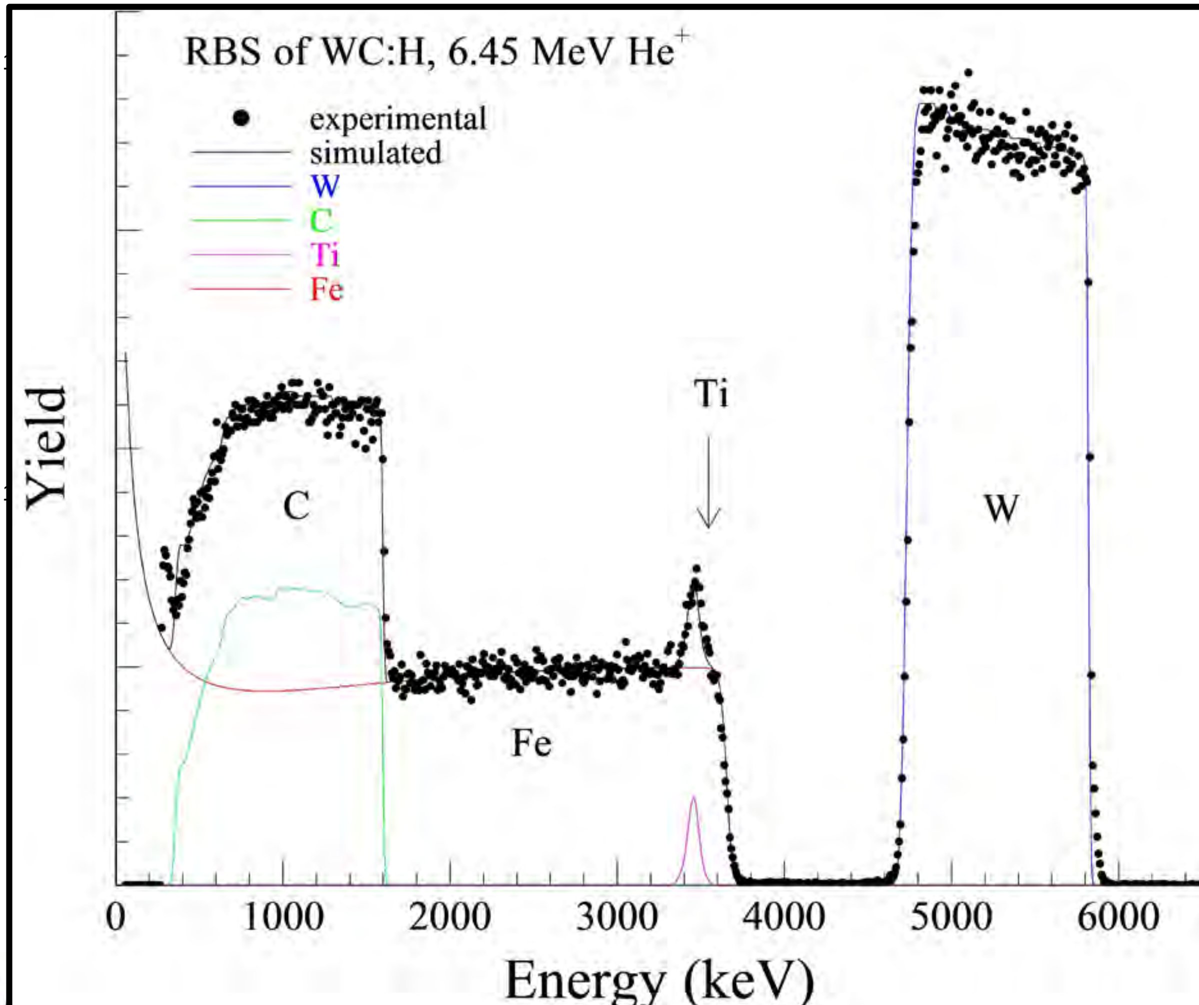
# RUTHERFORD BACKSCATTERING SPECTROMETRY



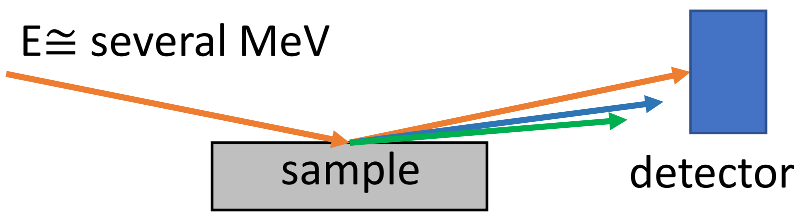




## Measuring concentration profiles

# NON-RUTHERFORD BACKSCATTERING SPECTROMETRY

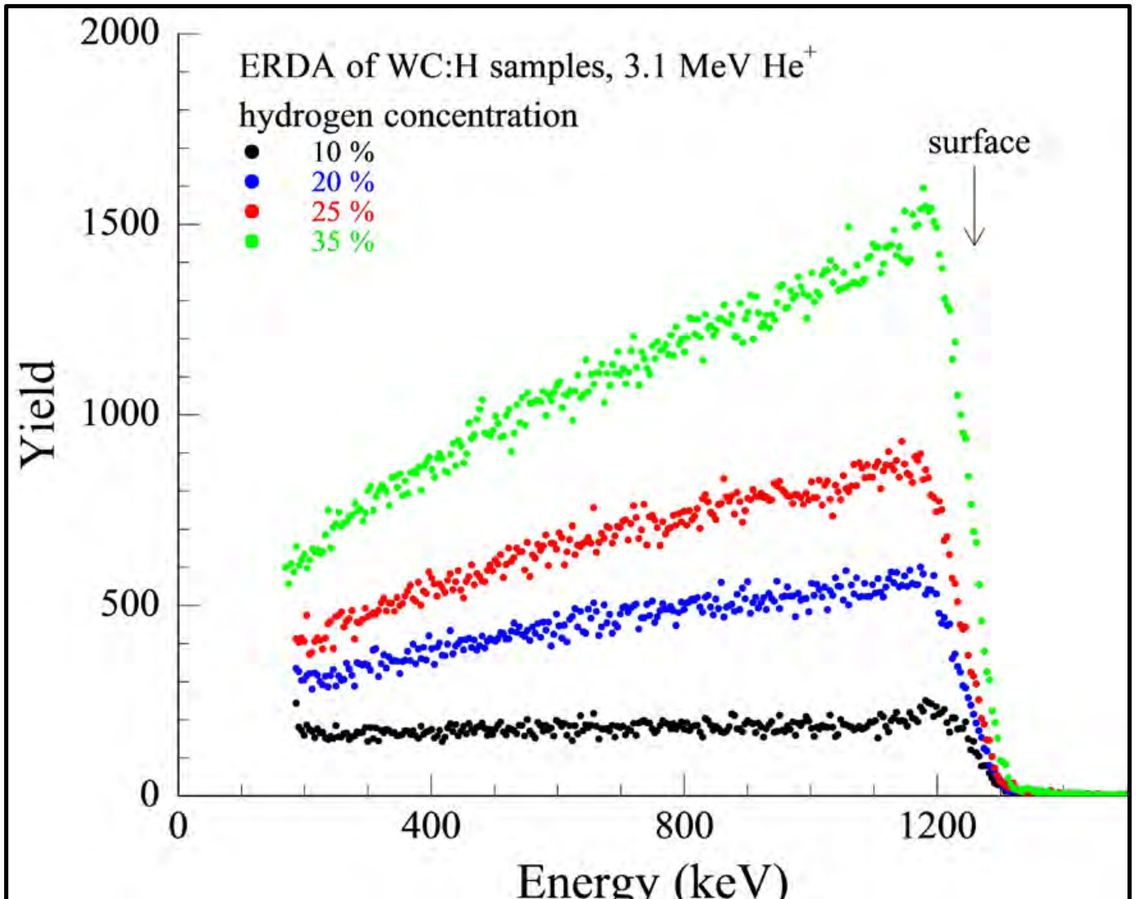


# ELASTIC RECOIL DETECTION ANALYSIS



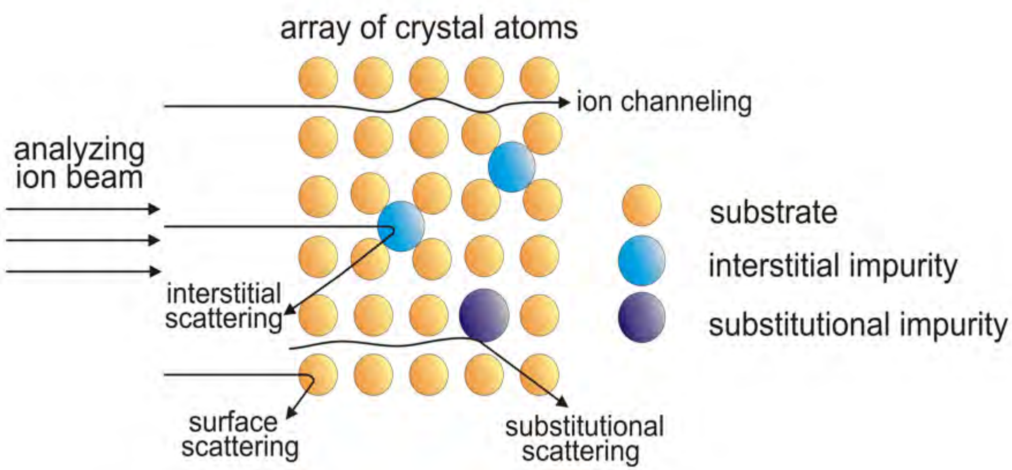

- **Concentration depth profiling**
- **Quantitative and standard-free**
- **Analysable elements: H to U (at ATRI only H at the moment, extension planned soon)**
- **Analyzed depth up to 1 μm**
- **Depth resolution 20 - 50 nm**
- **Sensitive to light elements in a heavy matrix or substrate**
- **Insensitive to heavy elements in a light matrix or substrate**
- **Detection limit: 0.01 at%**

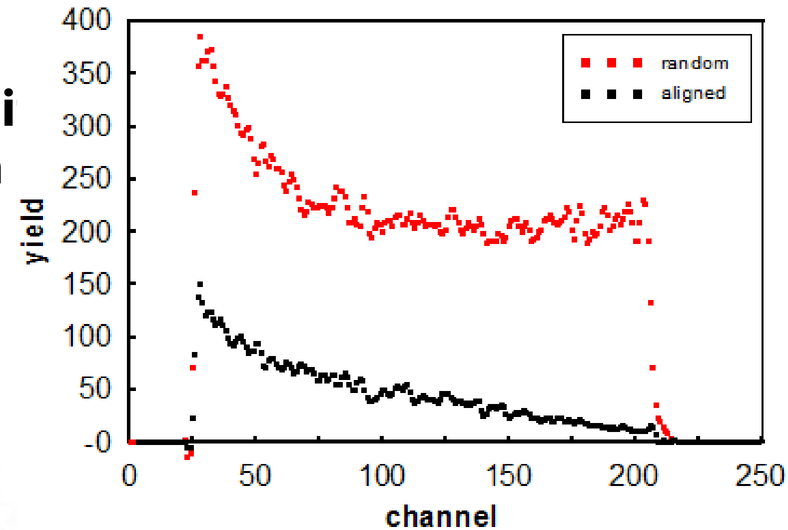
# ELASTIC RECOIL DETECTION ANALYSIS

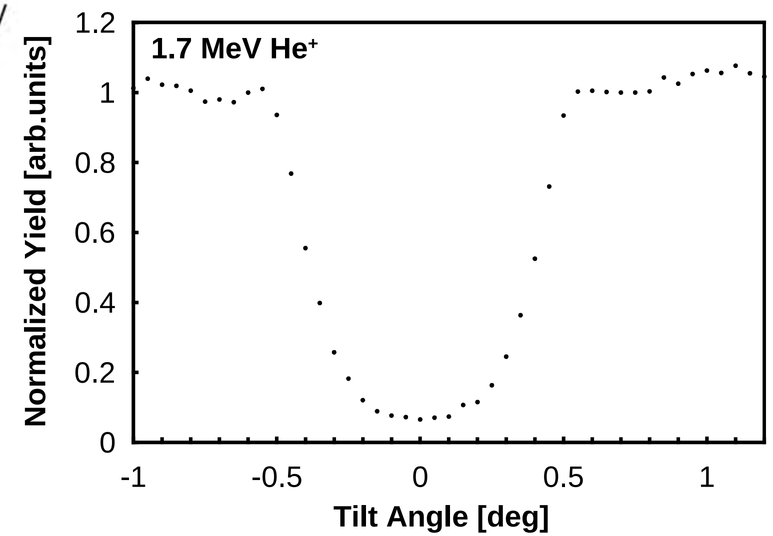


# ION CHANNELING (RBS/C)

- **Gives information on the crystal quali defects and degree of amorphization**

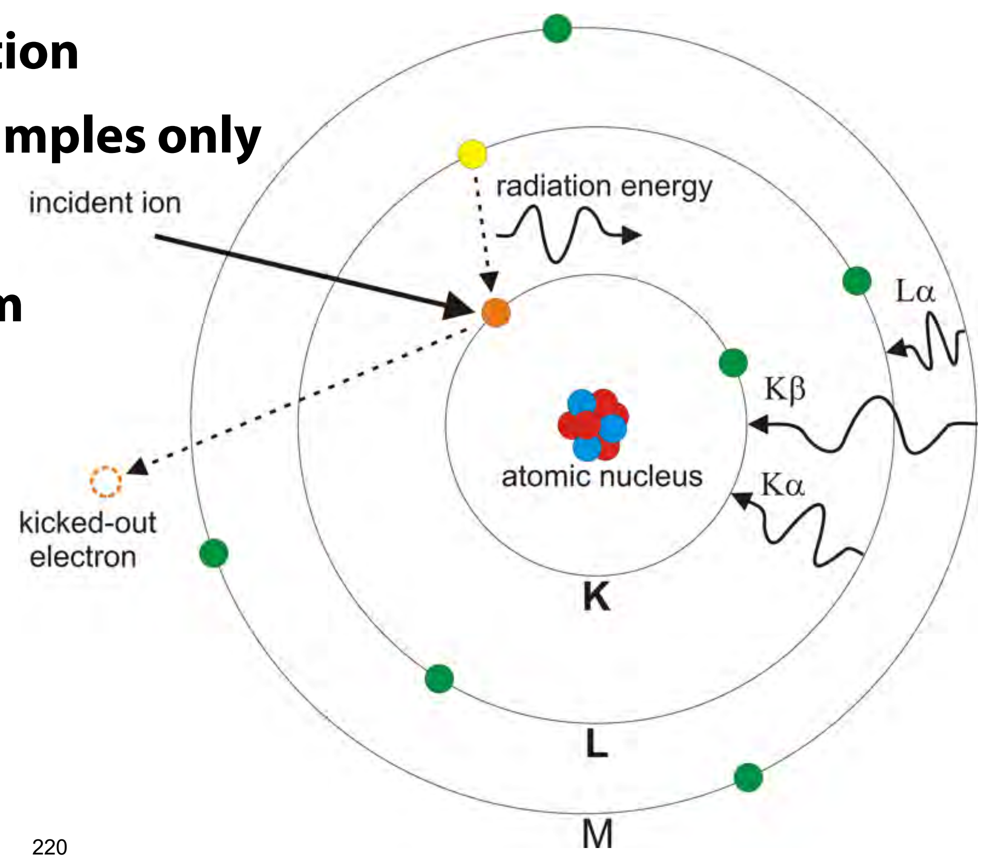


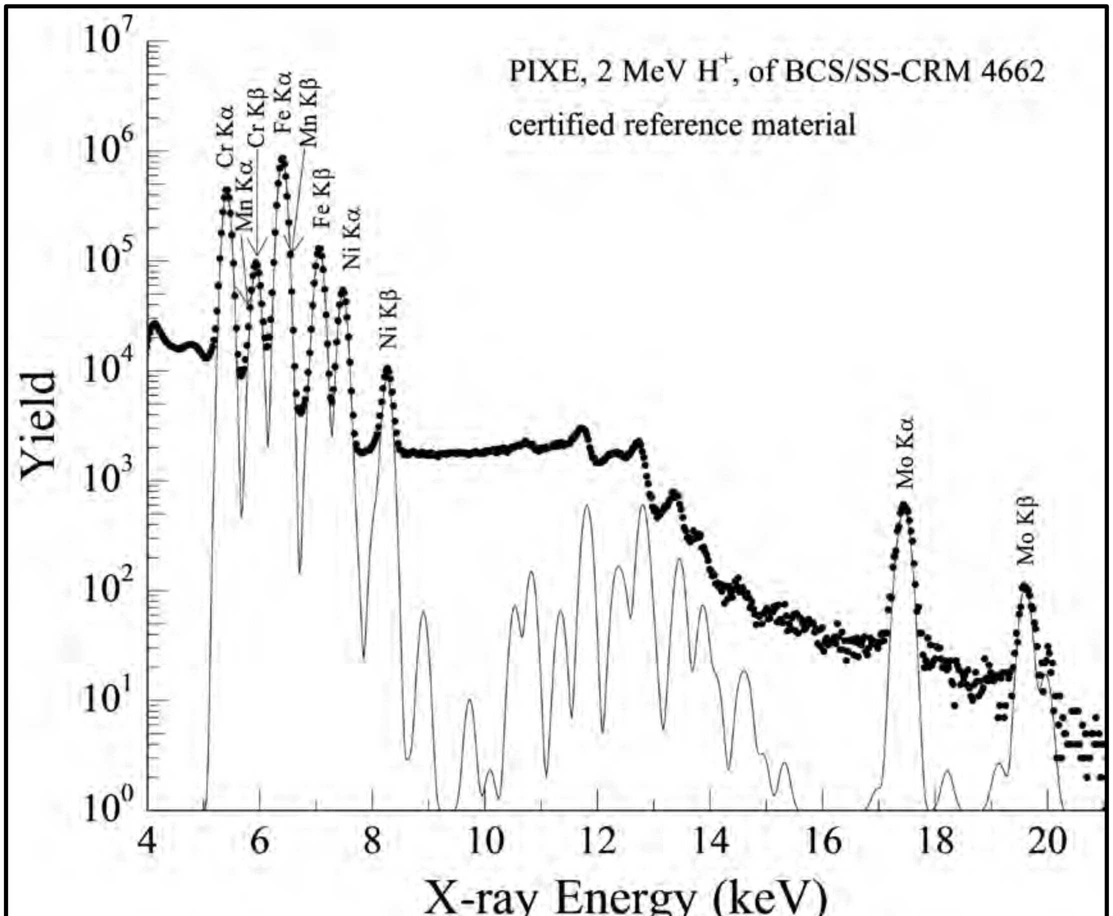



# PARTICLE INDUCED X-RAY EMMISSION

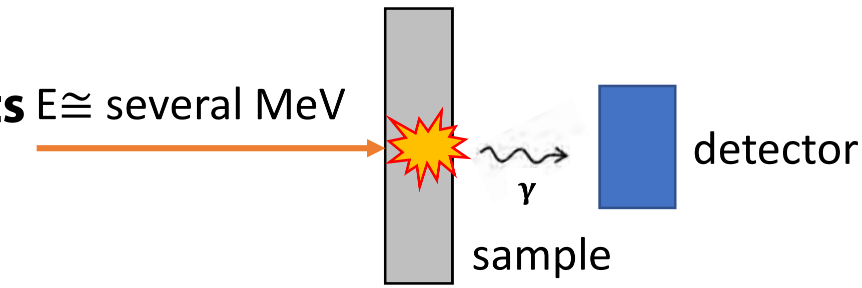
- **Sensitive trace element detection**
- **Quantitative with reference samples only**
- **Analysable elements: Na to U**
- **Analyzed depth up to 5 - 10 µm**
- **No depth resolution**
- **Detection limits sub-ppm**



# PARTICLE INDUCED X-RAY EMMISSION



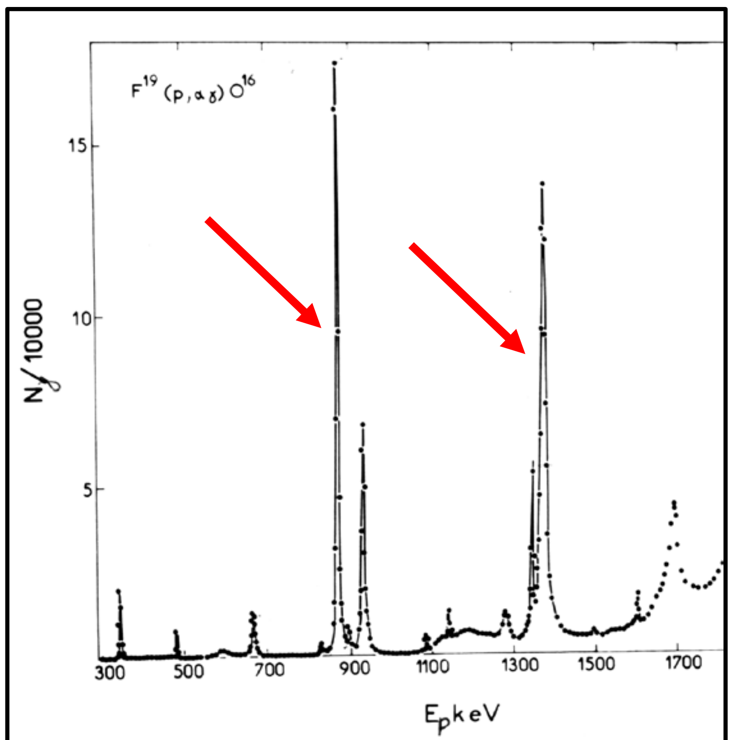
# NUCLEAR REACTION ANALYSIS



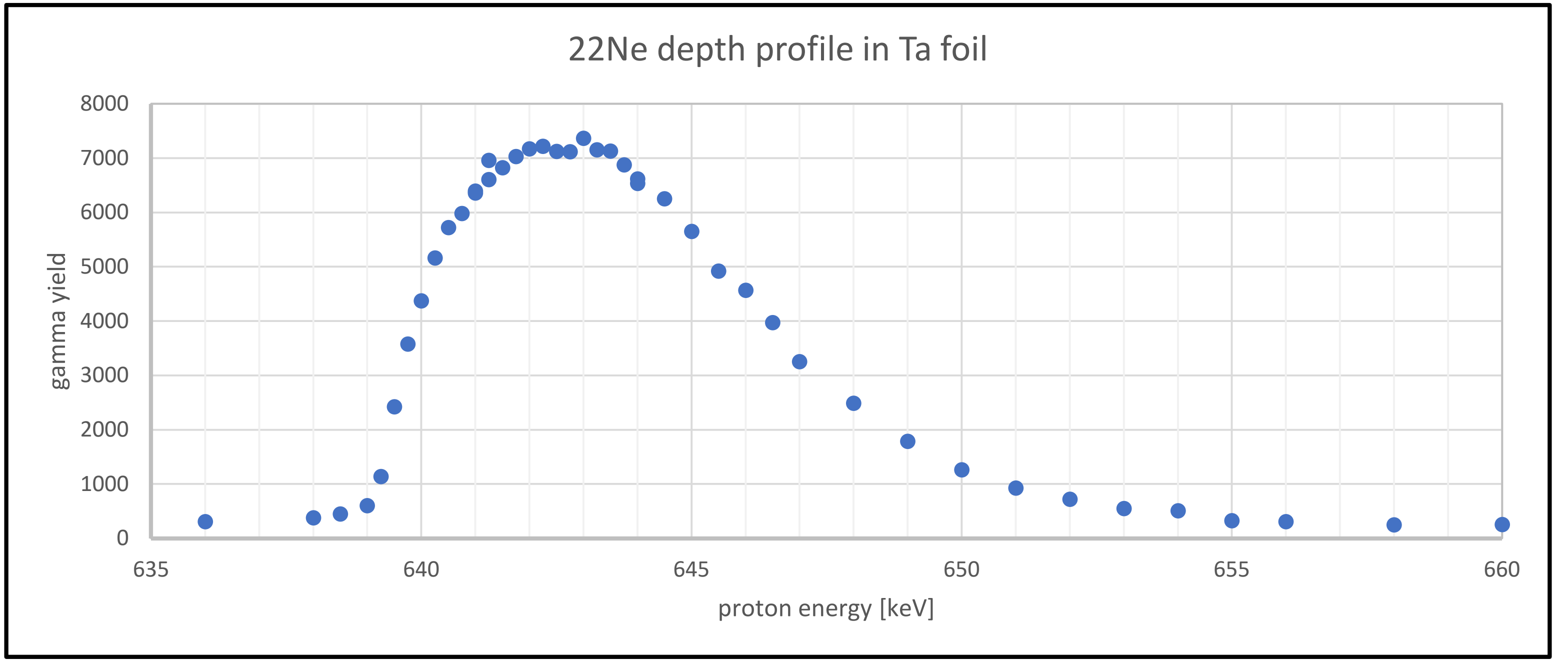

- **Selective analysis of light elements**
- **Isotope sensitive**
- **Concentration depth profiling**
- **Analysable elements: H to P**
- **Analyzed depth up to 5 µm**
- **Depth resolution 10 nm (matrix dependent), 1 nm at grazing incidence**
- **Detection limit: 0.001 - 1 at%**

# NUCLEAR REACTION ANALYSIS

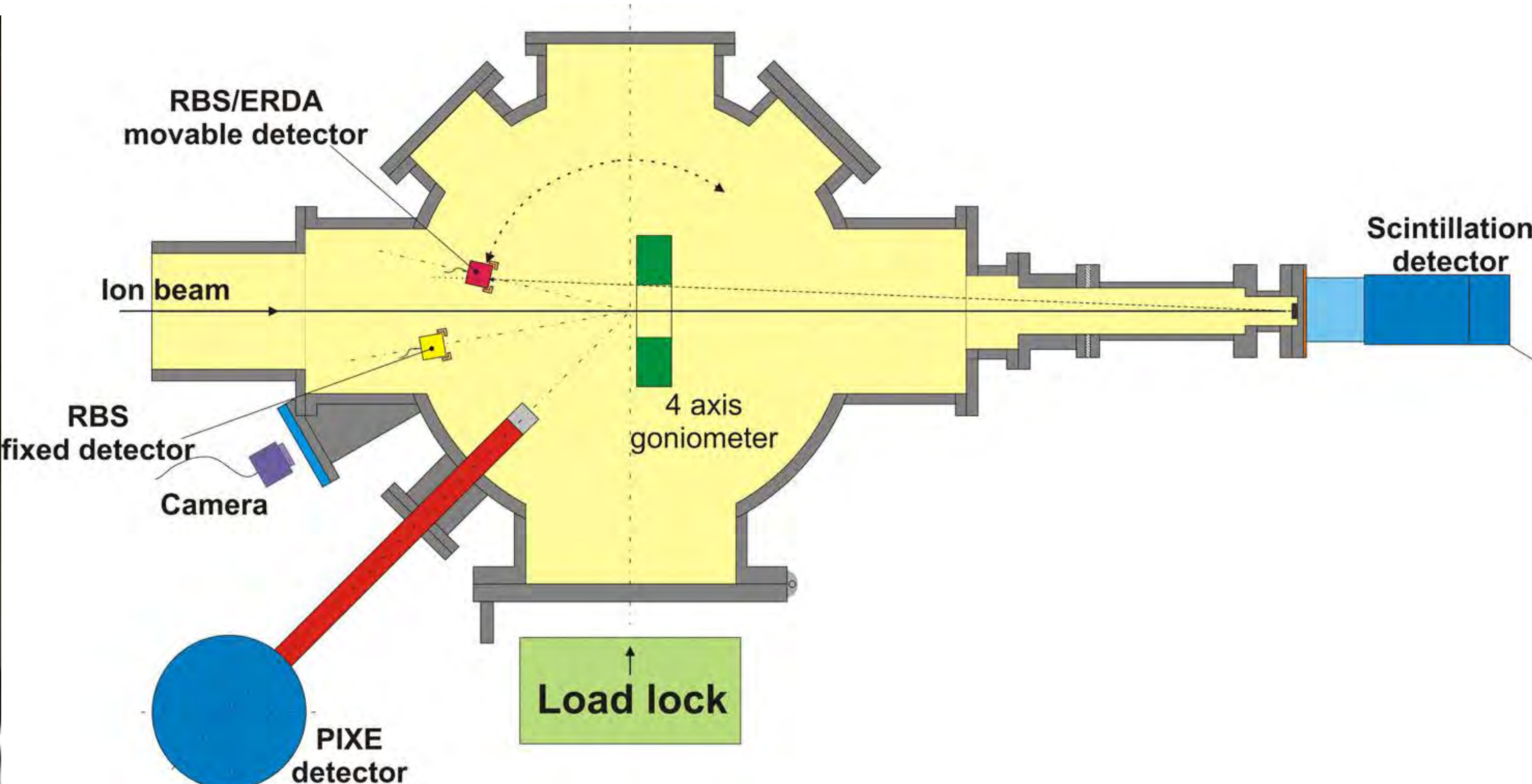
**We take advantage of the fact, that some nuclear reactions take place in a narrow energy range, i.e. they have resonances, where the probability of these reactions to happen, rises by orders of magnitude**



# NUCLEAR REACTION ANALYSIS



# ANALYSIS END-STATION

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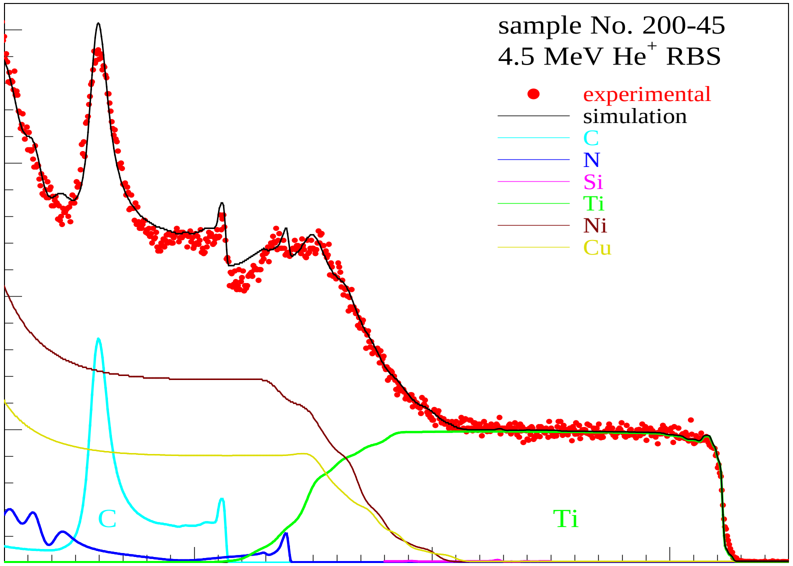
# ION BEAM ANALYSIS

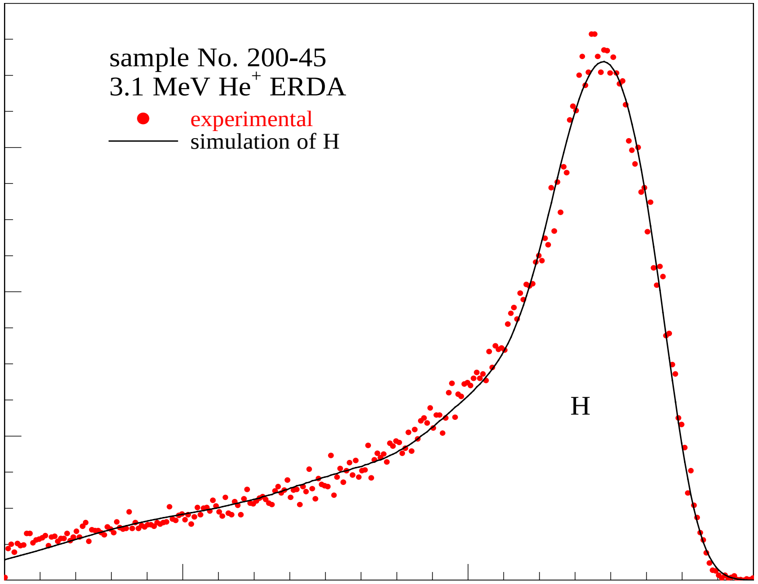
## Combination of IBA techniques gives the full information




Take the first information from RBS

# ION BEAM ANALYSIS

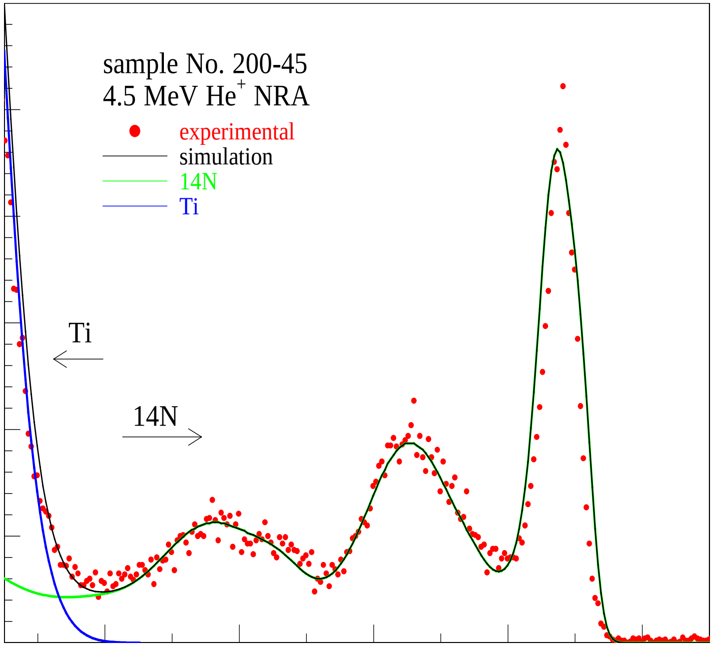
**Combination of IBA techniques gives a complex elemental depth profile**




Add ERDA to determine hydrogen content

# ION BEAM ANALYSIS

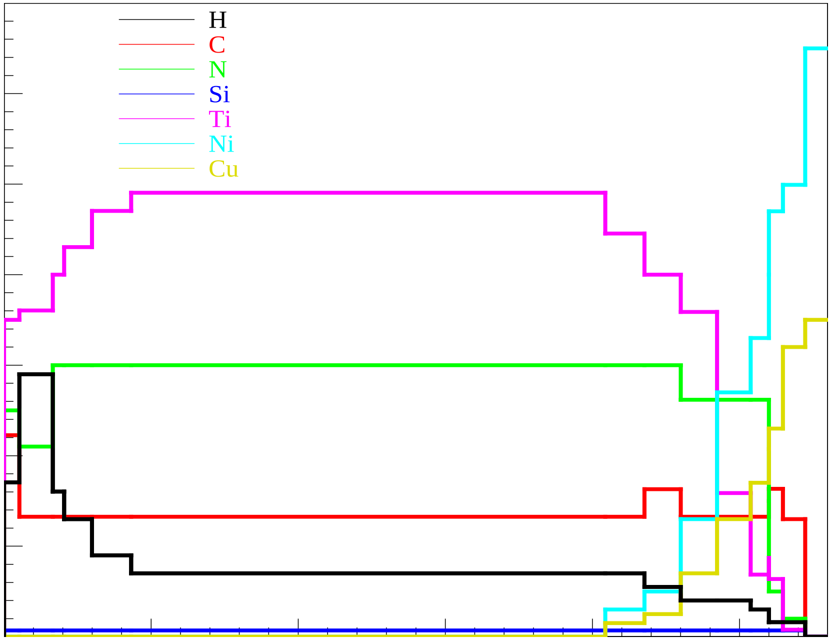
**Combination of IBA techniques gives a complex elemental depth profile**




Improve accuracy and cross-check with NRA

# ION BEAM ANALYSIS

**Combination of IBA techniques gives a complex elemental depth profile**




Put together and deliver the depth profile

# CREDITS

## ATRI-IBC team

**Matúš Beňo**

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**Radoslav Halgaš**

**Martin Muška**

**Dušan Vaňa**

**Anna Závacká**

## ATRI Directors

**Oliver Moravčík**

**Maximilián Strémy**

**Róbert Riedlmajer**

STU MTF

ATRI Advanced Technologies Research Institute

# ACKNOWLEDGMENT

This work was financially supported by:

- The European Regional Development Fund, Research and Development Operational Programme, project No. ITMS:26220220179,
- The European Commission under Horizon 2020, contract No. 664526
- The Slovak Research and Development Agency under contract No. APVV-15-0049
- Grant Agency VEGA under contracts No. 1/0018/15, 1/0503/15, 1/0219/16, 1/0330/18
- The Ministry of Education, Science, Research and Sport of the Slovak Republic under contract No. 003STU-2-3/2016.

STU MTF

ATRI Advanced Technologies Research Institute

# THANK YOU FOR ATTENTION!

# VIDEO PROCESSING RESEARCH AT FIT

**Ing. Roman Juránek, PhD. [1]**
[1] University of Technology, Brno

**Abstract**

*In this talk, I will introduce active research topics in the field of traffic surveillance on Faculty of Information Technology, Brno University of Technology. I will talk mainly about detection of vehicles, license plate recognition, and vehicle speed measurement which I will present in more detail. Precise measurement of vehicle speed from a single camera is active research topic since it potentially offers cheaper installation compared to current industrial practice. It requires only one camera capturing multiple vehicles simultaneously. The main part of the measurement is calibration of the camera. In most cases today, the calibration is solved either by patterns (e.g. checkerboard) or manually. We developed methods that can automatically calibrate the camera just by observing passing vehicles.*

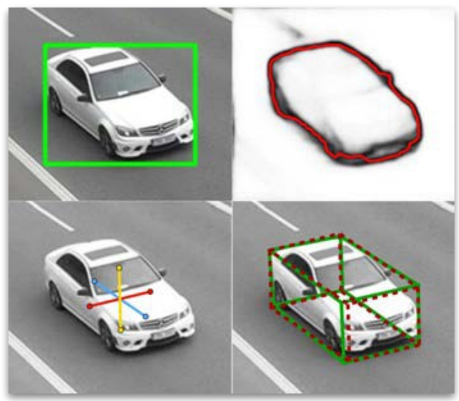
*We captured a large dataset with precisely annotated speeds of passing vehicles and evaluated our method which gives mean speed estimation error of 1.1 kph. The dataset is freely available for non-commercial purposes.*

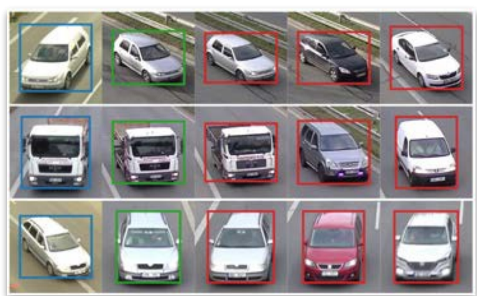

Automatic vehicle speed measurement
And other traffic applications
Roman Juranek, Brno University of Technology
3rd International conference, 3D Measurement and Imaging
Modern contactless measurements in industrial practice
10 - 11.10. 2018, Bratislava, SK

# Research topics

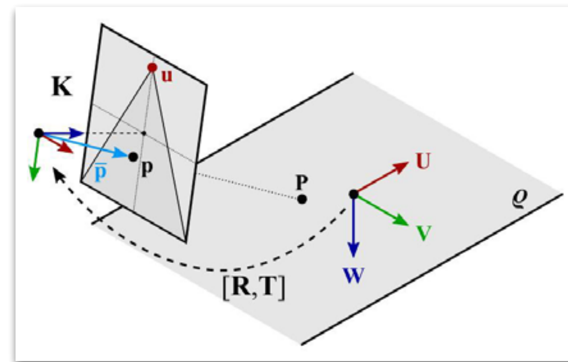
License plate detection and recognition


Vehicle detection, recognition, and re-identification





Camera calibration

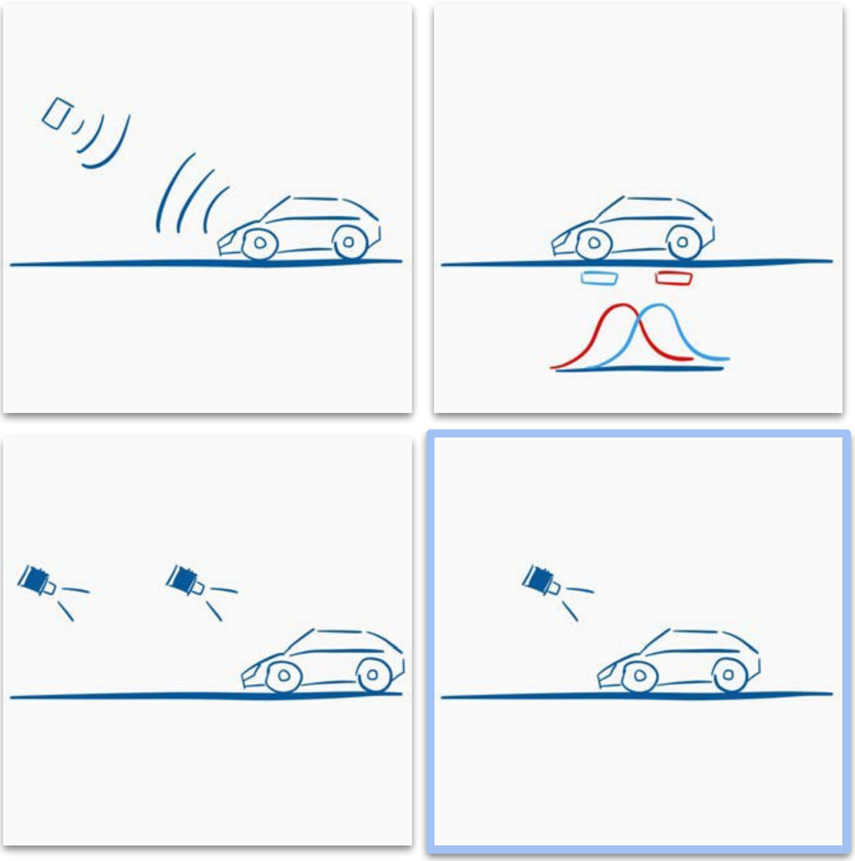


# Speed measurement

Sensors

- Radar
- Inductive loops
- Section speed - two cameras
- Single camera

Radars and loops are usually equipped with cameras to capture license plate



# Speed measurement

## Scenarios

- Industrial/Law enforcement
  - Accuracy better than **3 km/h**
  - Often one camera per lane
  - High resolution, IR flash, **controlled conditions**
  - Mostly section speed
- Overview cam - informative only
  - **Single camera** capturing all lanes, low resolution
  - For other applications like **traffic volume**, **travel time** estimation, etc.

# **Single camera** speed measurement

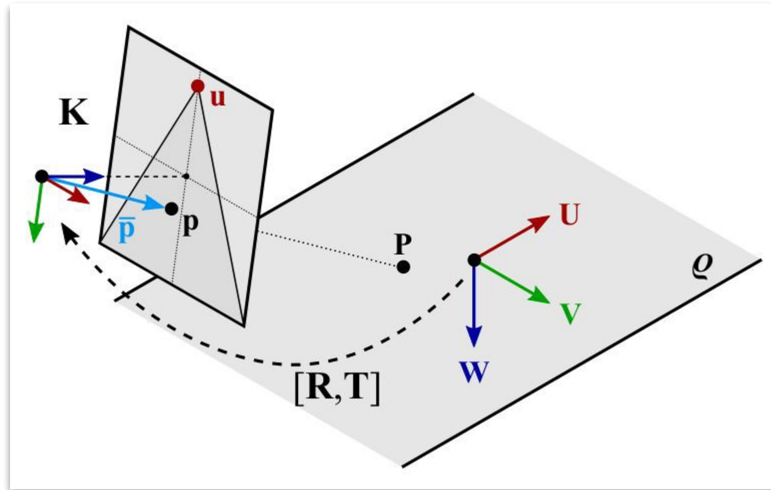
Camera calibration - **K**, **R** and **T** parameters

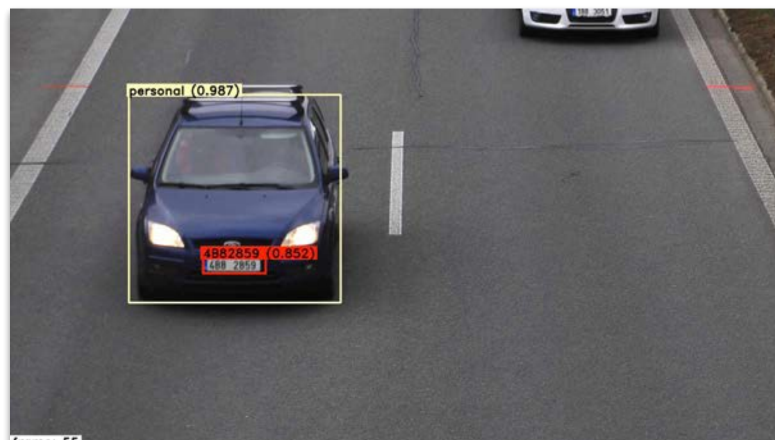
- Intrinsic parameters (focal length)
- Orientation
- Height above road

Vehicle detection and tracking

Traveled distance calculation

$$v = s / t$$



# Typical solutions

- Lots of research papers in last 20 years!
- Constraints on camera installation - front facing, known focal length and height above road
- Constraints on vehicle motion - linear motion
- Simple algorithms
- Mostly **not automatic**
- Often poor results or not evaluated at all
- There are NO common data for evaluation :(

# So what did we do...

**Fully automatic** camera calibration

- (Almost) **no prior knowledge** about camera - **arbitrary view**
- **Linear motion** scenario (for speed measurement)
- **Arbitrary motion** scenario (parking lots, roundabouts, intersections)

Speed measurement from video

- Reliable **detection** and **tracking** and **classification** of vehicles

**Datasets** for **evaluation** and **benchmarking** of camera calibration and speed measurement

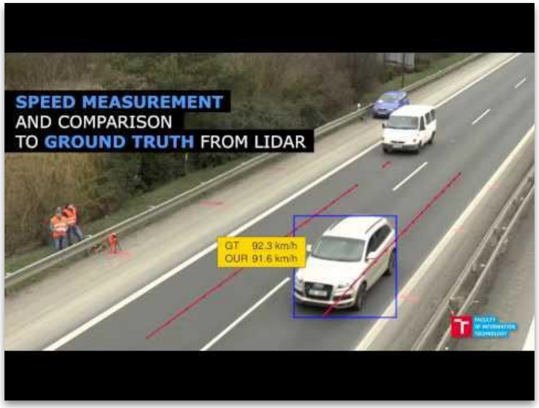
# Detection, tracking and classification

We use neural network-based tools

- **Faster-RCNN** detector
- Vehicle type **classifier** (make, model, year)

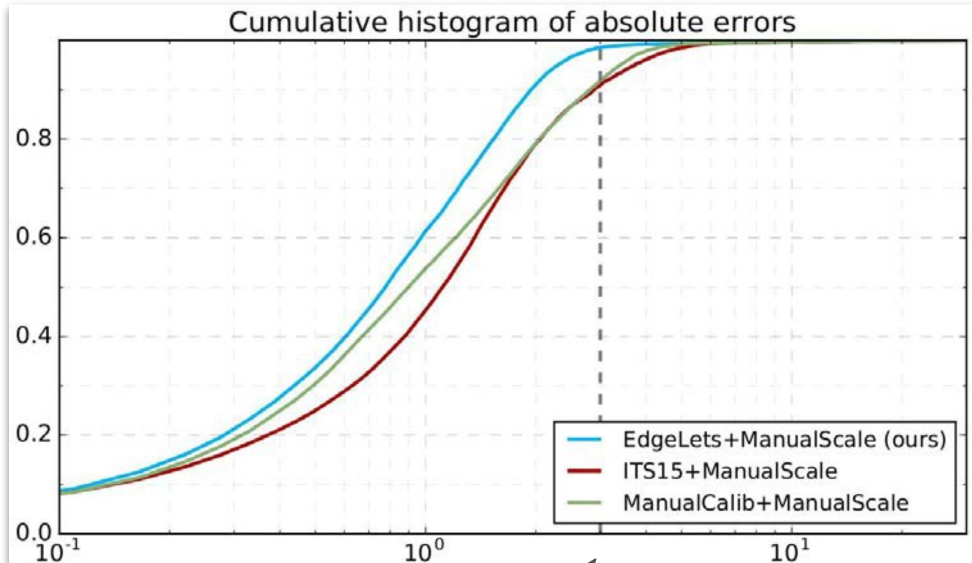
# Linear motion case

- Detection of **vanishing points**
- **Detection** and **classification** of cars
- Alignment of of known **3D shape** to observations




# Accuracy

- Mean error **1.1 km/h**
- **99 % of observations** with error better than **3 km/h**
- **Max error > 10km/h** due to tracking errors




**3 km/h**

# Arbitrary motion case

**Work in progress**

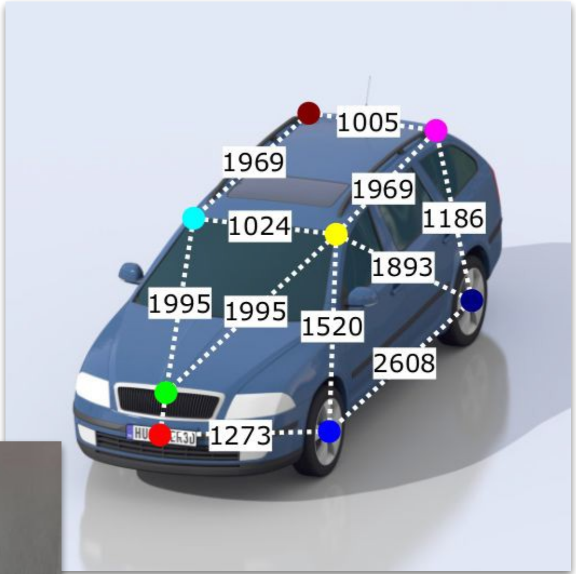
**Detection** and **classification** of cars

**Landmarks** on cars

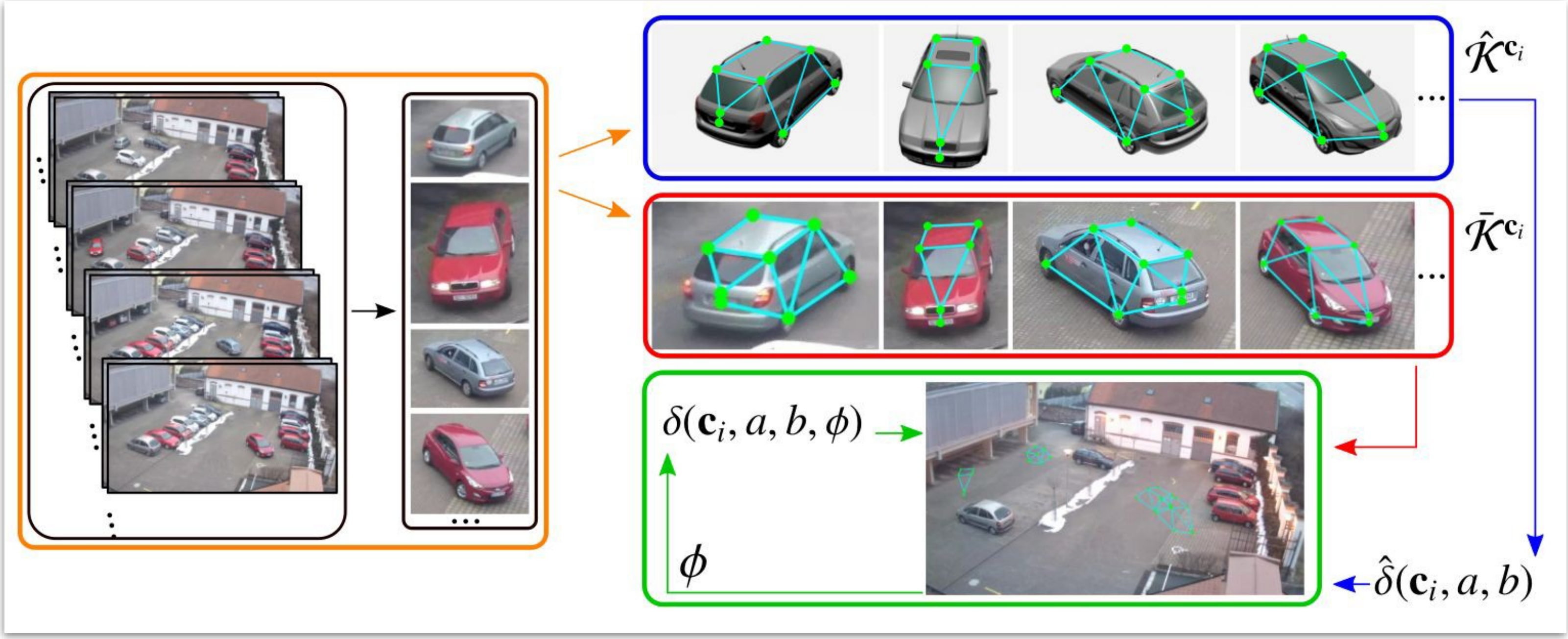
**Global optimization** to find focal length, orientation of camera and its position in 3D space

Works in linear motion case too!

Known **3D locations** and **distances** for few vehicle types



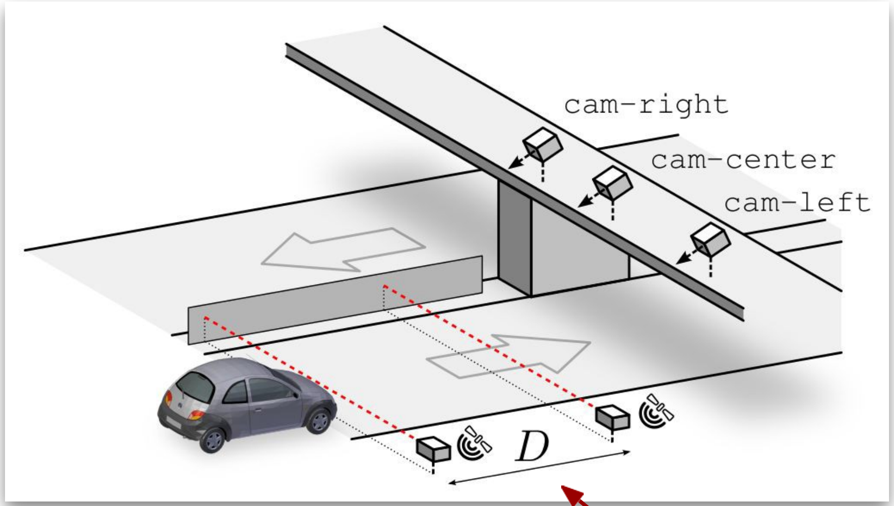

Detected **landmarks**




Optimization of calibration

# Evaluation of speed measurement

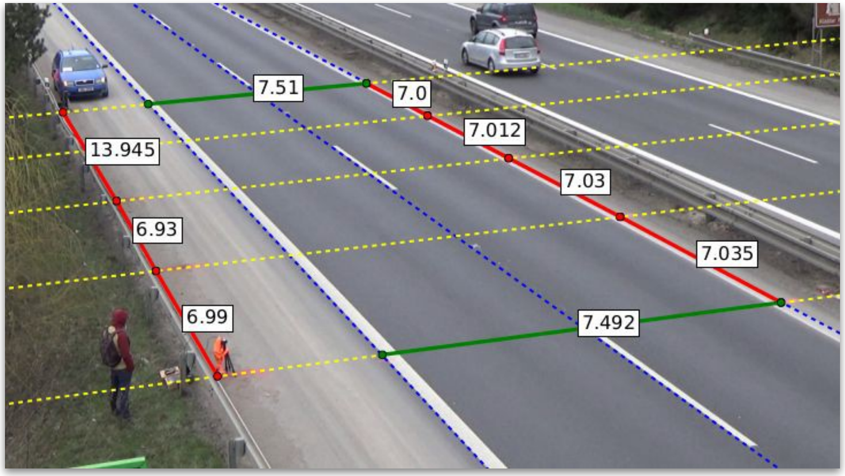
- **There are absolutely no reliable public data for evaluation**
- So we decided to record our own dataset - **BrnoCompSpeed**

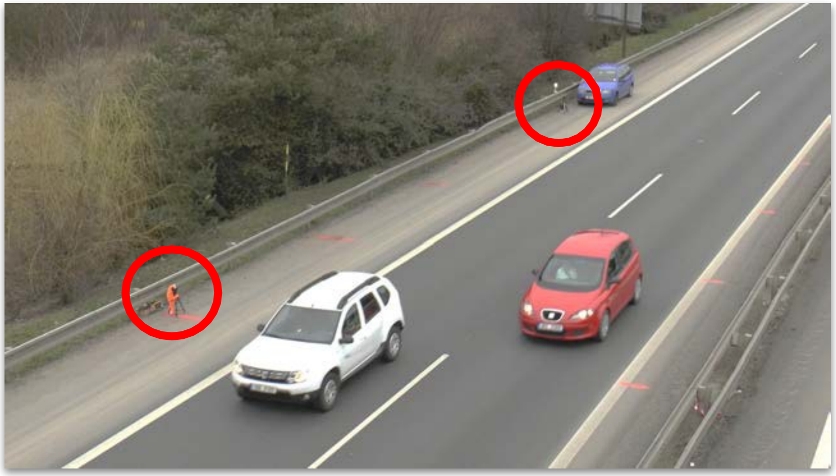



LIDAR gates for ground truth acquisition

# **BrnoCompSpeed** dataset

- Overview camera scenario, linear motion
- **18 of Full HD videos** (approx. 1h each)
- 6 sessions, 3 cameras
- Manually measured distances in scene
- **LIDAR gates** for ground truth speed acquisition
- **> 20K** measured vehicles
- **Freely available for non commercial purposes**



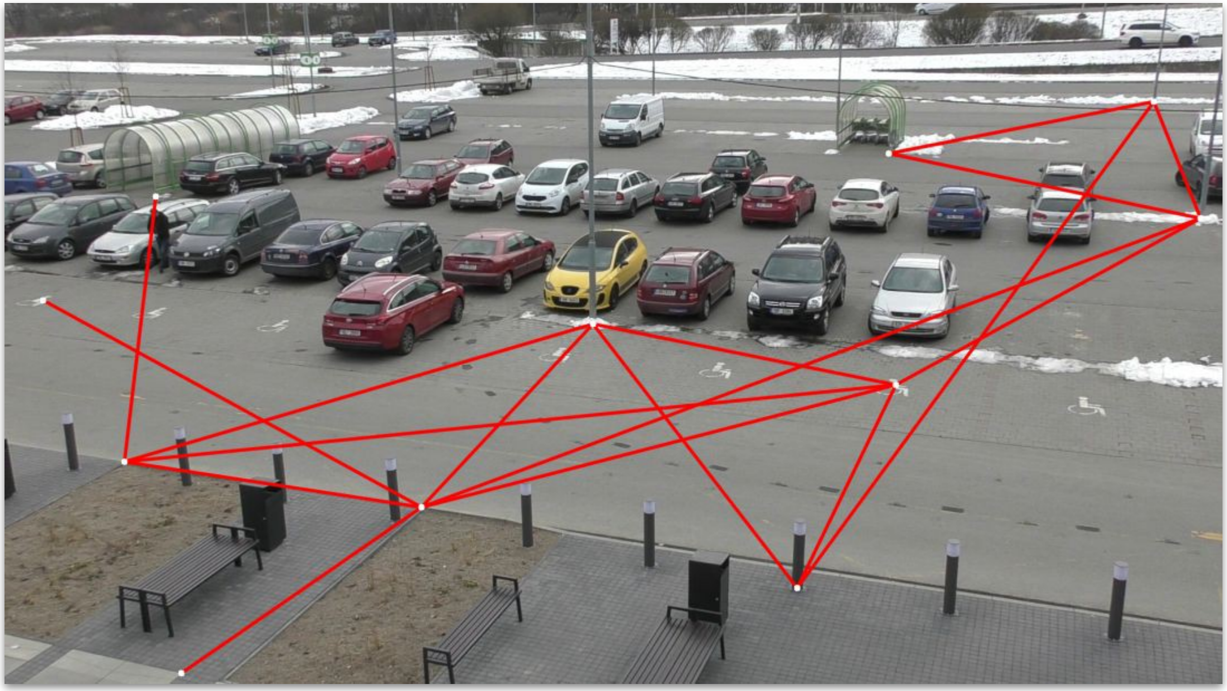



# **BrnoCarPark** dataset

- **Free movement** of cars on parkinglots
- **2 locations**, multiple views
- Total **46h** of FullHD video
- Calibration only, no speed measurement
- Measured distances in scene for reference calibration

# BrnoCarPark Dataset

- Example of measured distances



# Future

- Speed measurement from observation of license plates (we need new dataset)
- 3D reconstruction of cars for better calibration
- Improvements in license plate reading in hard conditions
- Faster detection of license plates, cars, etc.
- Reliable re-identification of cars
- Embedded processing - put things in a device like NVidia Jetson
- …

# Thank you

https://medusa.fit.vutbr.cz/traffic

# Publications


- BARTL Vojtech, ŠPAŇHEL Jakub, DOBES Petr, JURÁNEK Roman, HEROUT Adam. Automatic **Camera Calibration by Landmarks on Rigid Objects**. Computer Vision and Image Understanding (under review)
- SOCHOR Jakub, JURÁNEK Roman, ŠPAŇHEL Jakub, MARŠÍK Lukáš, ŠIROKÝ Adam, HEROUT Adam a ZEMČÍK Pavel. **Comprehensive Data Set for Automatic Single Camera Visual Speed Measurement**. IEEE Transactions on Intelligent Transportation Systems. 2018, roč. 2018, č. 99, s. 1-11. ISSN 1524-9050.
- SOCHOR Jakub, JURÁNEK Roman a HEROUT Adam. **Traffic Surveillance Camera Calibration by 3D Model Bounding Box Alignment for Accurate Vehicle Speed Measurement**. Computer Vision and Image Understanding. 2017, roč. 2017, č. 161, s. 87-98. ISSN 1077-3142.
- DUBSKÁ Markéta, HEROUT Adam, JURÁNEK Roman a SOCHOR Jakub. **Fully Automatic Roadside Camera Calibration for Traffic Surveillance**. IEEE Transactions on Intelligent Transportation Systems. 2014, roč. 2014, č. 1, s. 1-10. ISSN 1524-9050.
- DUBSKÁ Markéta, SOCHOR Jakub a HEROUT Adam. **Automatic Camera Calibration for Traffic Understanding**. In: Proceedings of BMVC 2014. Nottingham: The British Machine Vision Association and Society for Pattern Recognition, 2014, s. 1-10. ISBN 1-901725-49-9.

# EMBEDDED VISION TREND AND A REVOLUTIONARY CAMERA SERIES

**Michael Ross [1]**
[1] Allied Vision Technology

3rd INTERNATIONAL CONFERENCE

# 3D MEASUREMENT AND IMAGING

*MODERN CONTACTLESS MEASUREMENTS IN INDUSTRIAL PRACTICE*

Allied Vision

## EMBEDDED VISION TREND AND A REVOLUTIONARY CAMERA SERIES

Michael Ross, Sales Development Manager EMEA

# TOPICS

- Embedded Vision – definition, goal and challanges
- A new approach with ALVIUM technology
- The ALVIUM product line as a game changer

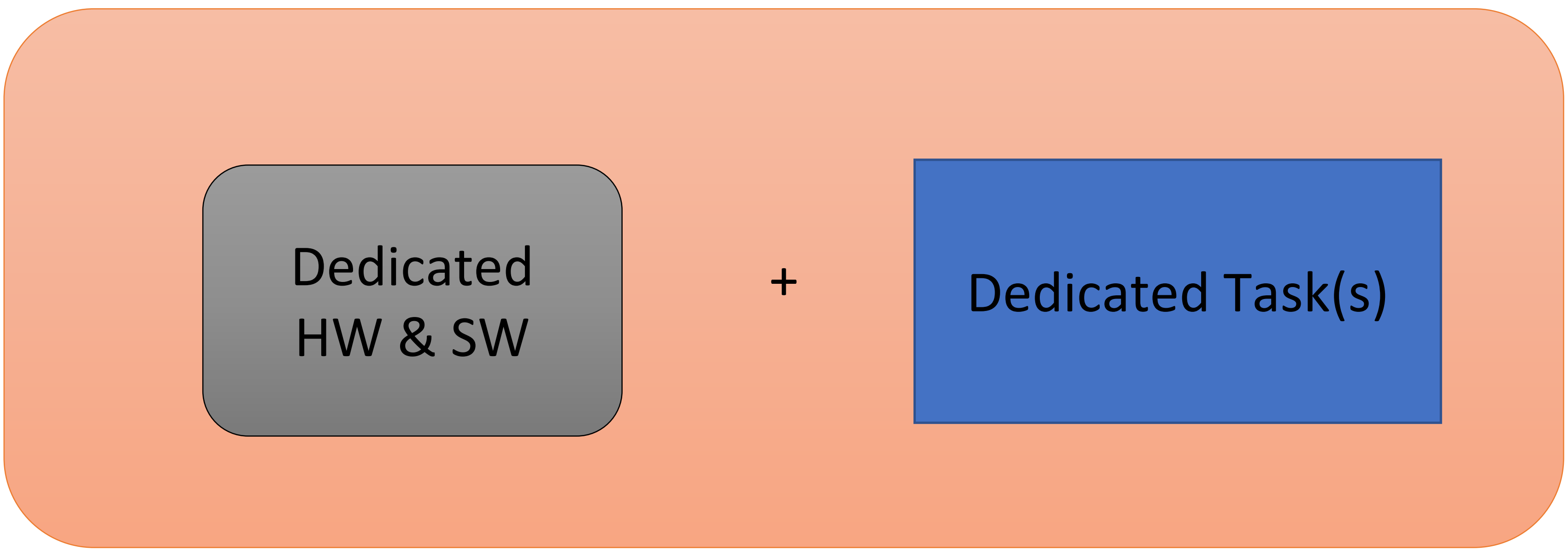
Allied Vision

# Embedded Vision – Definition, goal and challanges

Allied Vision

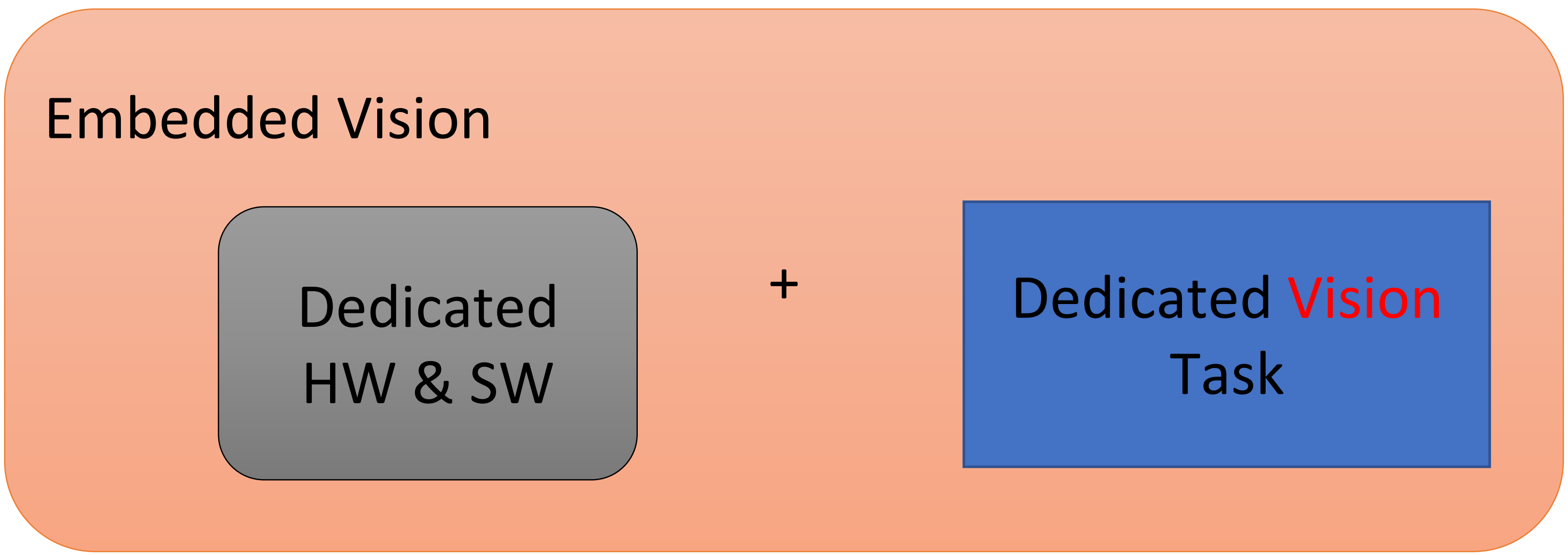
# DEFINITION EMBEDDED SYSTEM

A dedicated and specialized computing system (HW + SW)
Carries out a single or a few dedicated task(s)



# DEFINITION EMBEDDED VISION SYSTEM

Allied Vision definition of Embedded Vision:
Embedded System + Computer Vision

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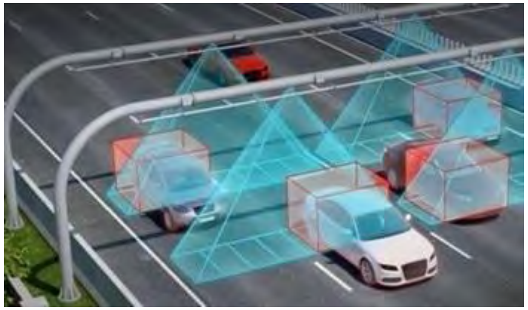
# APPLICATIONS EXAMPLES

Source: www.zeiss.com



Source: www.azosensors.com

Source: www.intense.de

Source: www.coherentnews.com

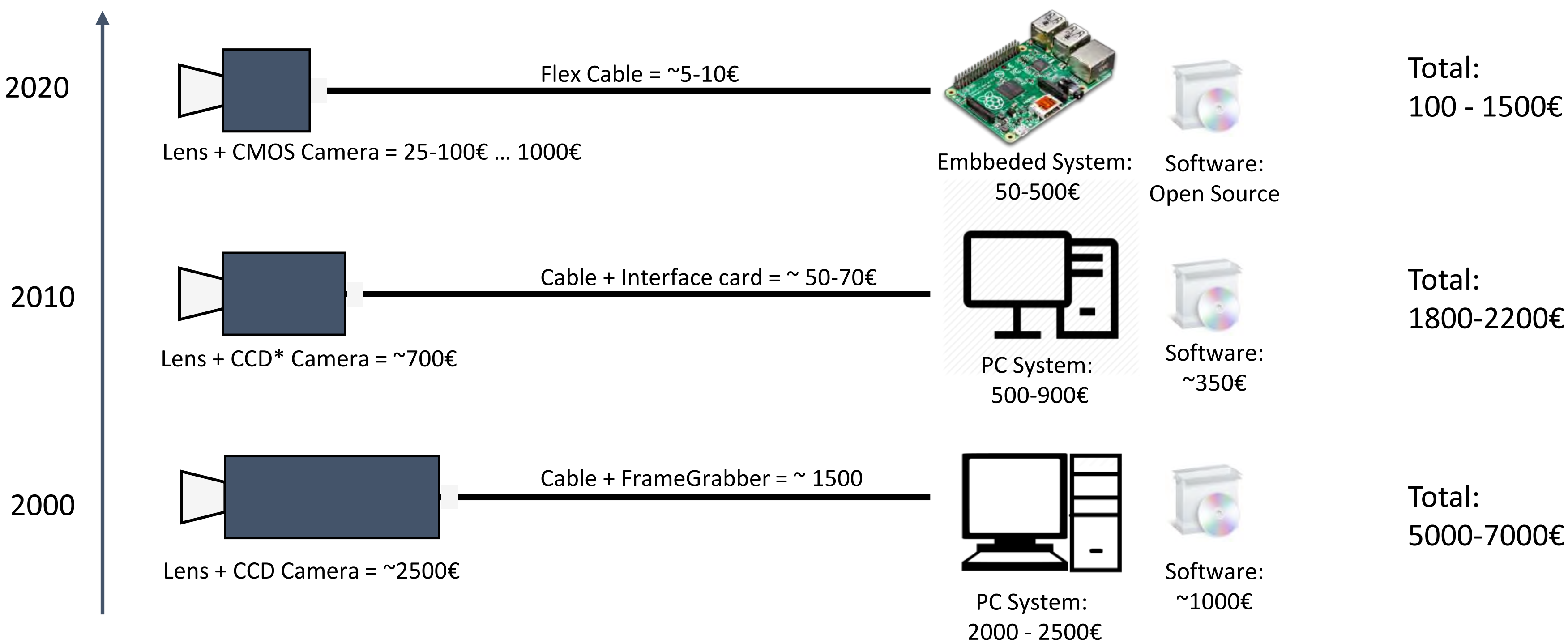
Allied Vision

# EMBEDDED SYSTEM VS. PC BASED SYSTEM

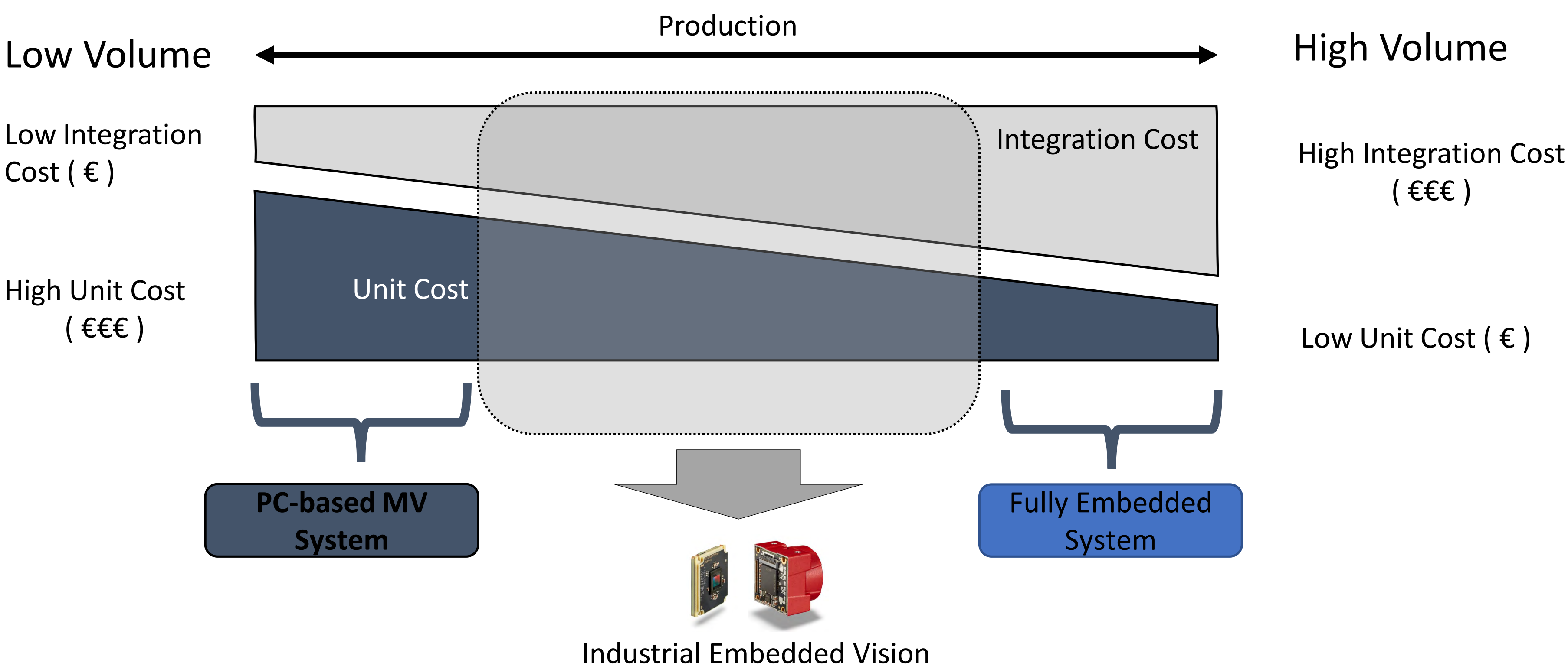
| | Embedded System | PC-based System |
|---|---|---|
| Size and Weight | Low | High |
| Power Consumption | Low | irrelevant |
| Expansion/Changes | No | flexible |
| System Environment | flexible | static |

Allied Vision

# PRICE EROSION



# UNIT COSTS VS. DESIGN COSTS




Allied Vision

# A new approach with ALVIUM technology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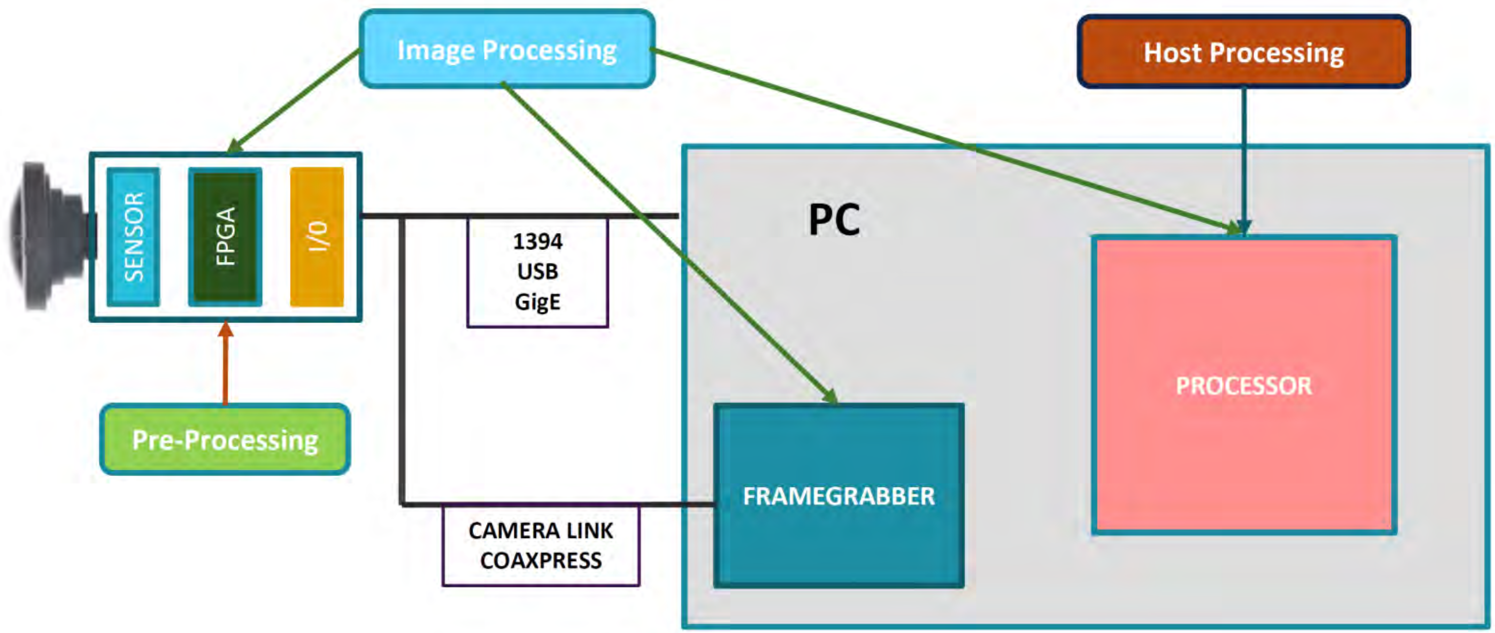
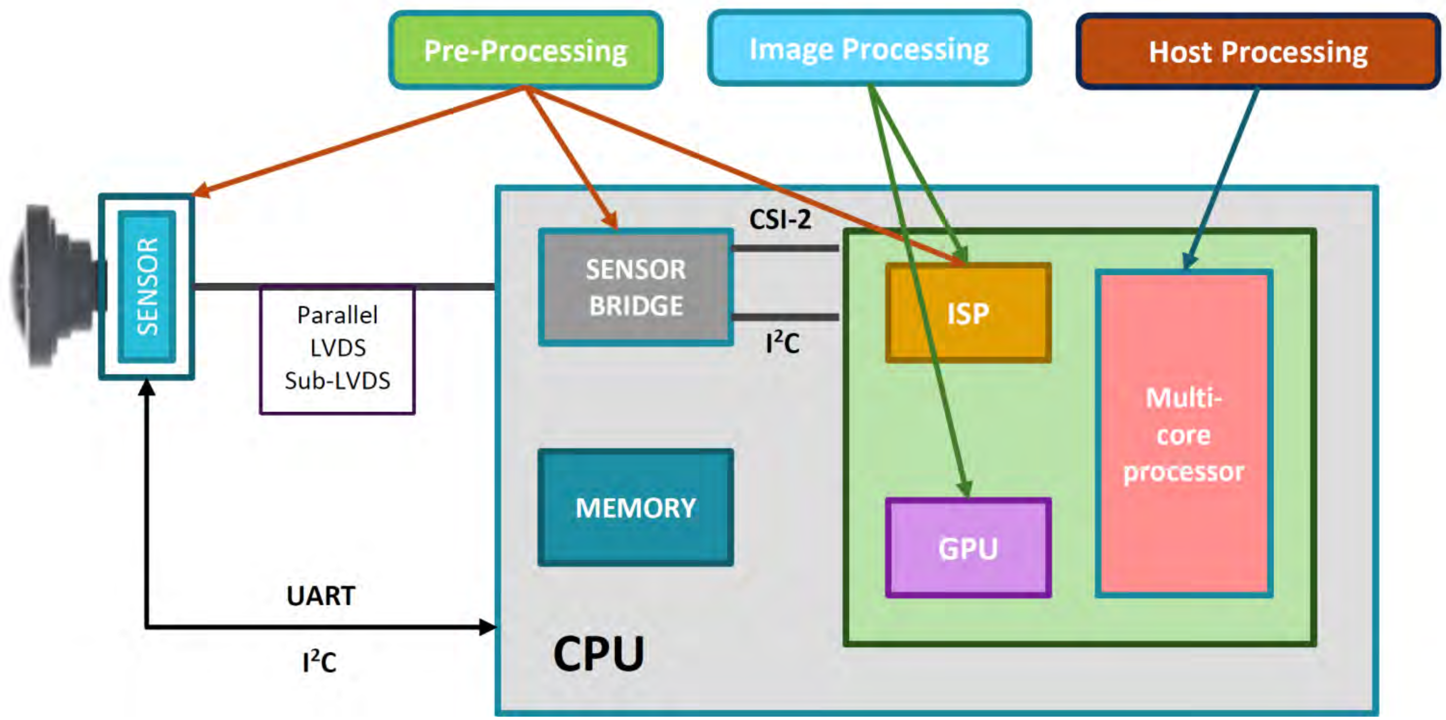
# TYPICAL MACHINE VISION ARCHITECTURE




Allied Vision

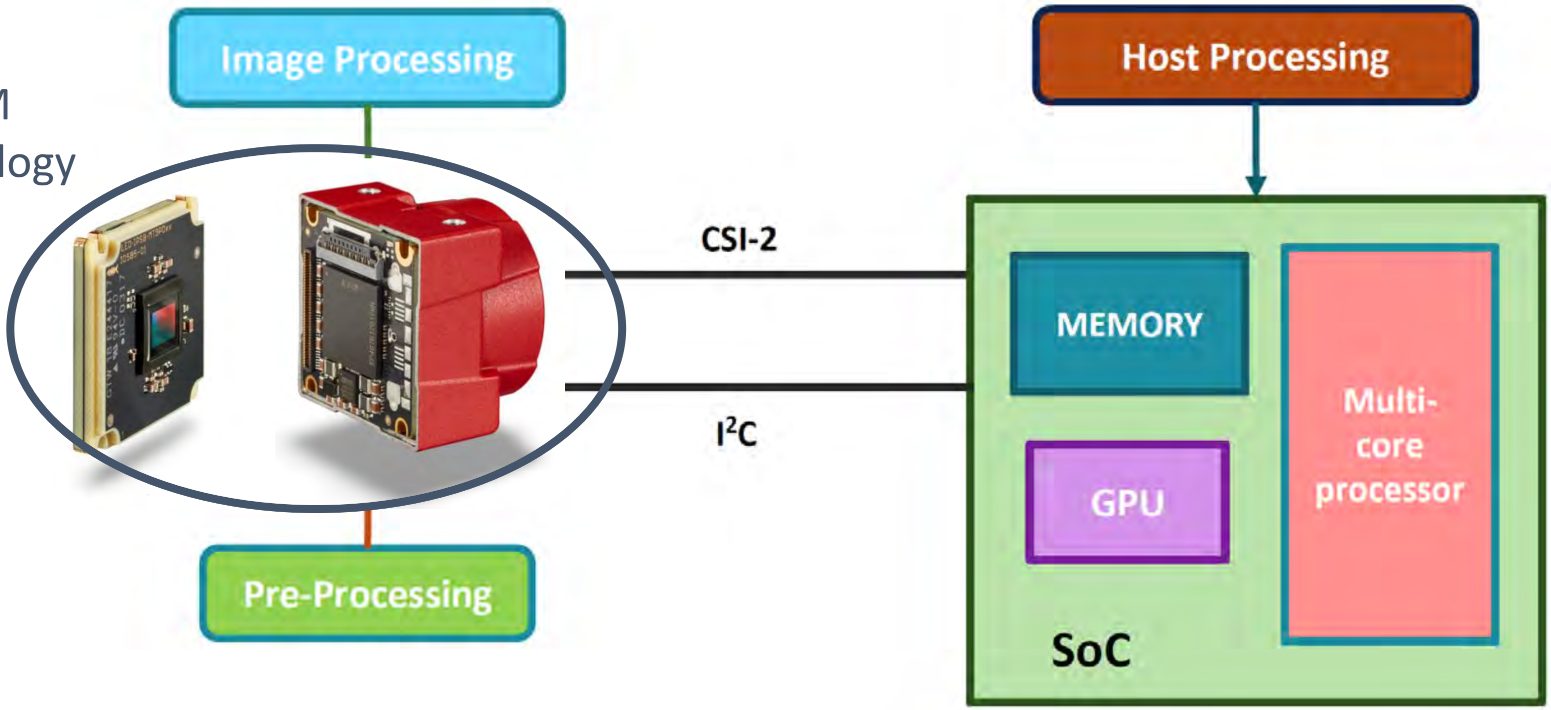
# CONSUMER EMBEDDED VISION ARCHITECTURE




Allied Vision

# INDUSTRIAL EMBEDDED VISION ARCHITECTURE

ALVIUM
Technology




Allied Vision

# WHAT IS ALVIUM TECHNOLOGY

## ALVIUM Technology

USB3 VISION

mipi

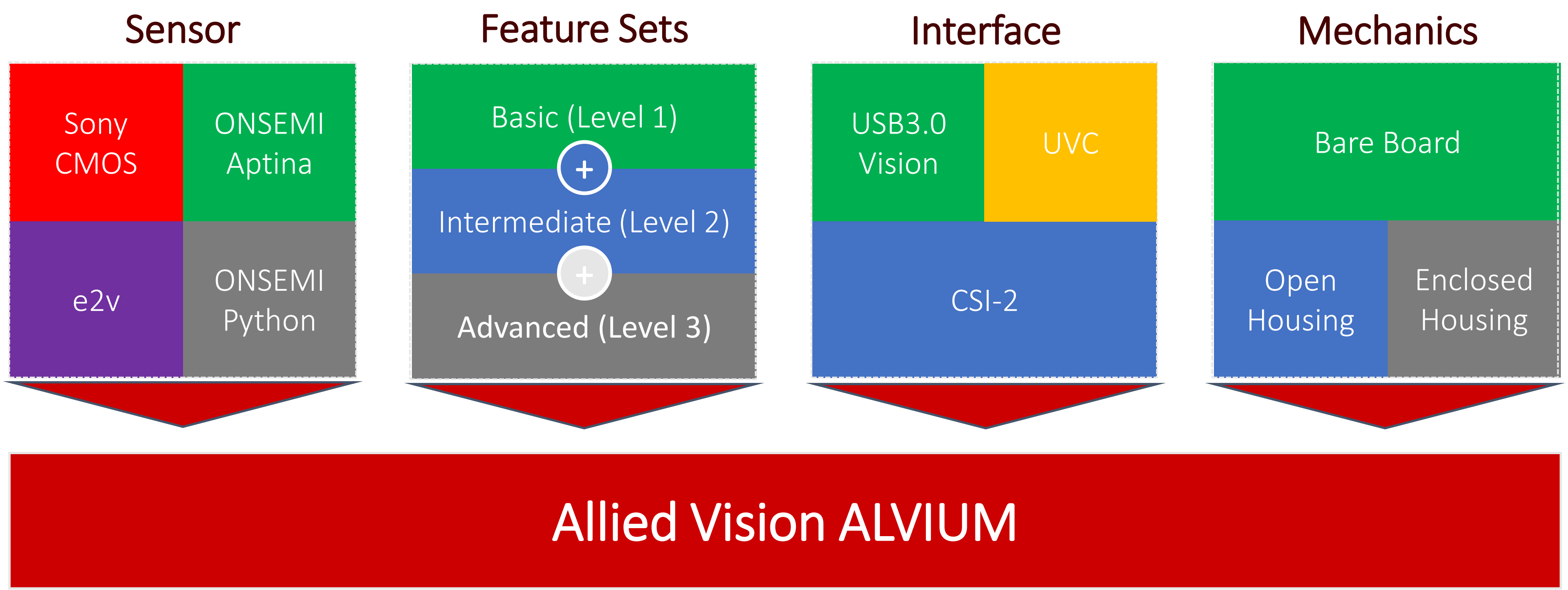
- // Over 25 years of Machine Vision experience in one single chip
- // Self-developed Vision Processor with integrated Image Processing Library
- // Unreached 90 features from nice image capability to advanced functionality
- // Integrated host interfaces MIPI CSI-2 D-PHY TX and USB3.1 Gen 1


Allied Vision

# The ALVIUM product line as a game changer

Allied Vision

## ALVIUM PRODUCT LINE AT ONE GLANCE

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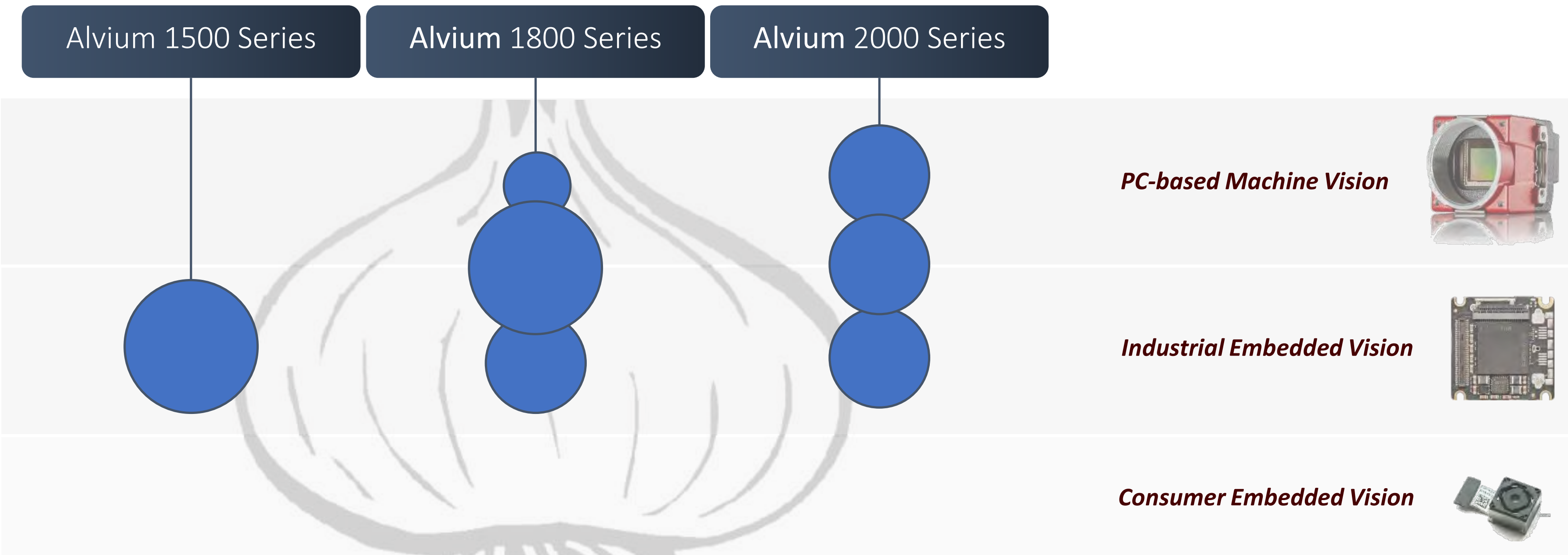
# ALVIUM POSITIONING IN TERMS OF HORIZONTAL TECHNOLOGY



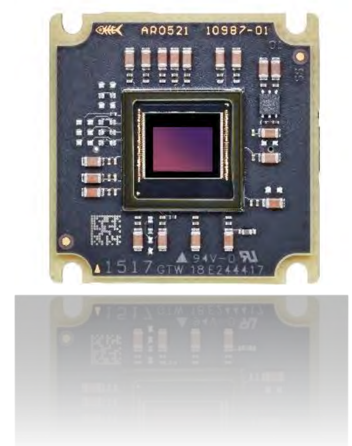

Allied Vision

# PRODUCT PROFILE: ALVIUM 1500 SERIES

## Alvium 1500 Series

Embedded Vision

- // Within the **Alvium 1500 Series**, it is all about EASY VISION for Embedded Vision
- // Broad range of **MIPI CSI-2** and **UVC compliant USB3** cameras
- // **V4L2, GStreamer, UVC Standard API or Direct Register Access**
- // **Basic (Level I) on-board image processing**
- // Easy sensor evaluation via UVC, final development with MIPI cameras
- // Broad driver support with **i.MX6, i.MX8, TX1/TX2 and Xavier**
- // Various housing and broad sensor options




Allied Vision

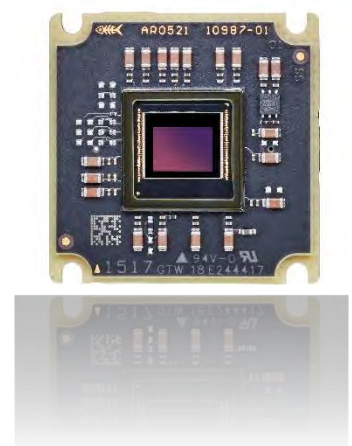
# PRODUCT PROFILE: ALVIUM 1800 SERIES

## Alvium 1800 Series

- // Within the **Alvium 1800 Series**, it is all about BRIDGING EV and MV
- // Broad range of **MIPI Vision** and **USB3 Vision** cameras
- // **Vimba SDK or Third Party Software**
- // **Intermediate (Level II) on-board image processing** beyond V4L2 and UVC
- // **GeniCam Standard Compatibility** with MIPI and USB3 Transport Layer
- // Broad driver support with **i.MX6, i.MX8, TX1/TX2 and Xavier**
- // Various housing and broad sensor options

Embedded Vision

Machine Vision




Allied Vision

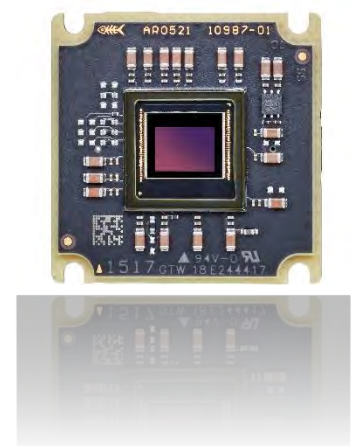
# PRODUCT PROFILE: ALVIUM 1800 SERIES

## Alvium 2000 Series

- // Within the **Alvium 2000 Series**, it is all about expert image processing for EV and MV
- // Broad range of **MIPI Vision, USB3 Vision** and **GigE Vision** cameras
- // **Vimba SDK or Third Party Software**
- // **Advanced (Level III) on-board image processing**
- // **GeniCam Standard Compatibility** with MIPI, USB3 and GigE Transport Layer
- // Broad driver support with **i.MX6, i.MX8, TX1/TX2 and Xavier**
- // Various housing and broad sensor options

Embedded Vision

Machine Vision

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# CSI-2 DRIVER ENVIRONMENT

- NXP i.MX6
- NXP i.MX8
- Jetson TX1
- Jetson TX2
- Jetson Xavier

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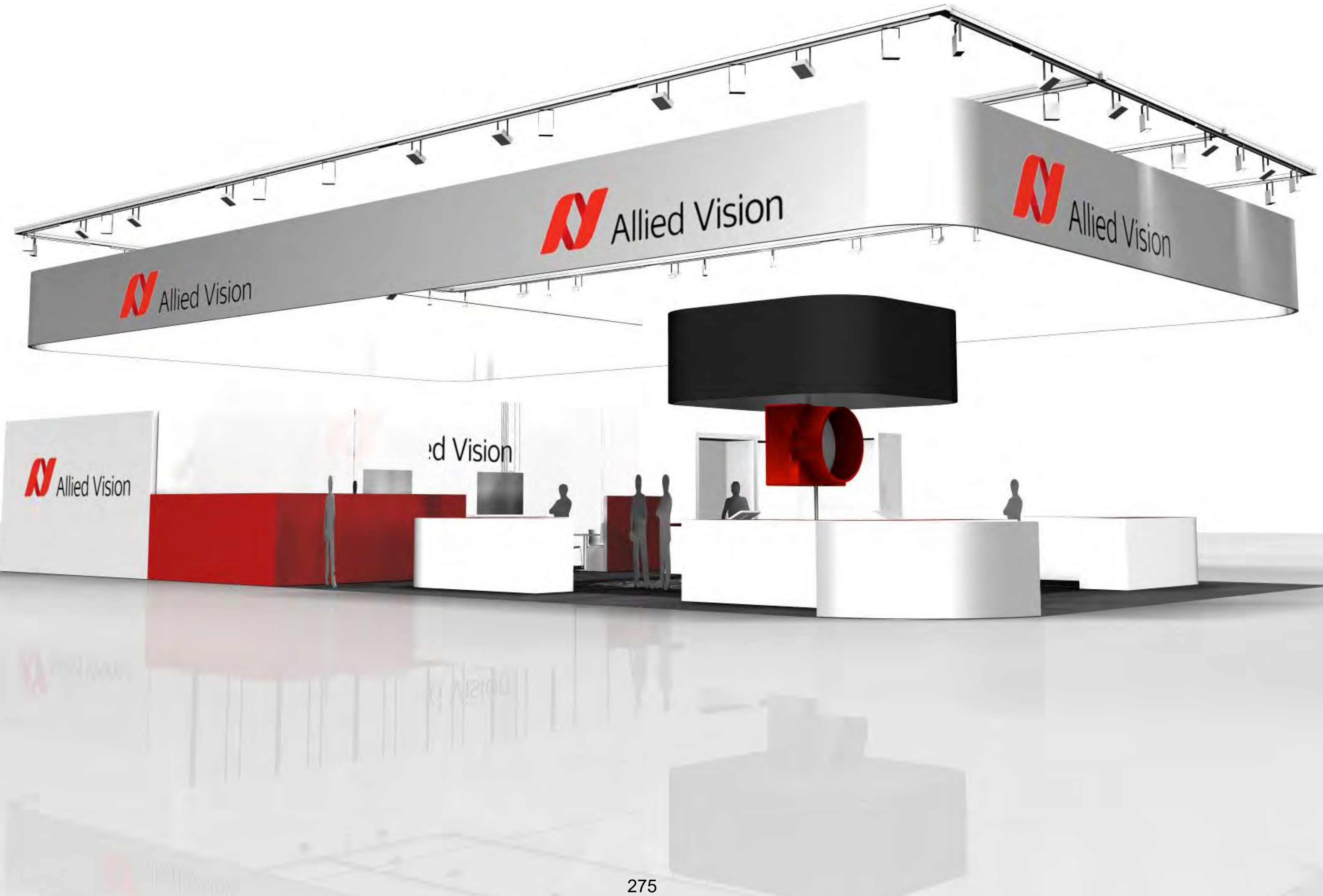
# WELCOME TO VISION SHOW STUTTGART (NOV. 06 – 08, 2018)



# Thank you very much!

**Michael Ross**
Sales Development Manager EMEA

michael.ross@alliedvision.com

**Allied Vision Technologies GmbH**
www.alliedvision.com

Allied Vision

# THE JOURNEY TO NANO WORLD USING ELECTRON MICROSCOPY SCANNING

**Ing. Hana Tesařová, PhD.** [1]
[1] TESCAN ORSAY HOLDING, a.s.

**Abstract**

*TESCAN is one of the global suppliers of scientific instruments. The company is building its reputation and brand name in the field of designing and manufacturing scanning electron microscopes and system solutions for different applications. During the workshop the presentation will contain several sections: In the first, the history and working principle of the Scanning electron microscopy will be introduced. Then, the comparison of the optical, scanning and transmission electron microscopy will be shown as well as application for all of this fields. The last part will highlight the latest progress in the 3D application field.*

MEDZINÁRODNÁ KONFERENCIA

# 3D MERANIE A ZOBRAZOVANIE

3. ročník

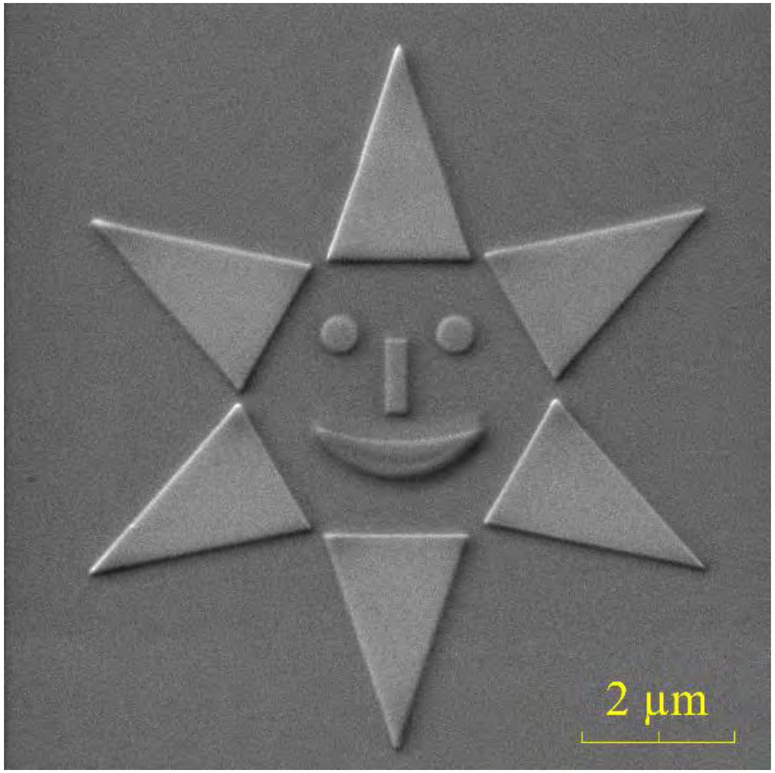
*MODERNÉ BEZKONTAKTNÉ MERANIA V PRIEMYSELNEJ PRAXI*

# CESTA DO NANOSVĚTA POMOCÍ SKENOVACÍ ELEKTRONOVÉ MIKROSKOPIE

Hana Tesařová, Ph.D.

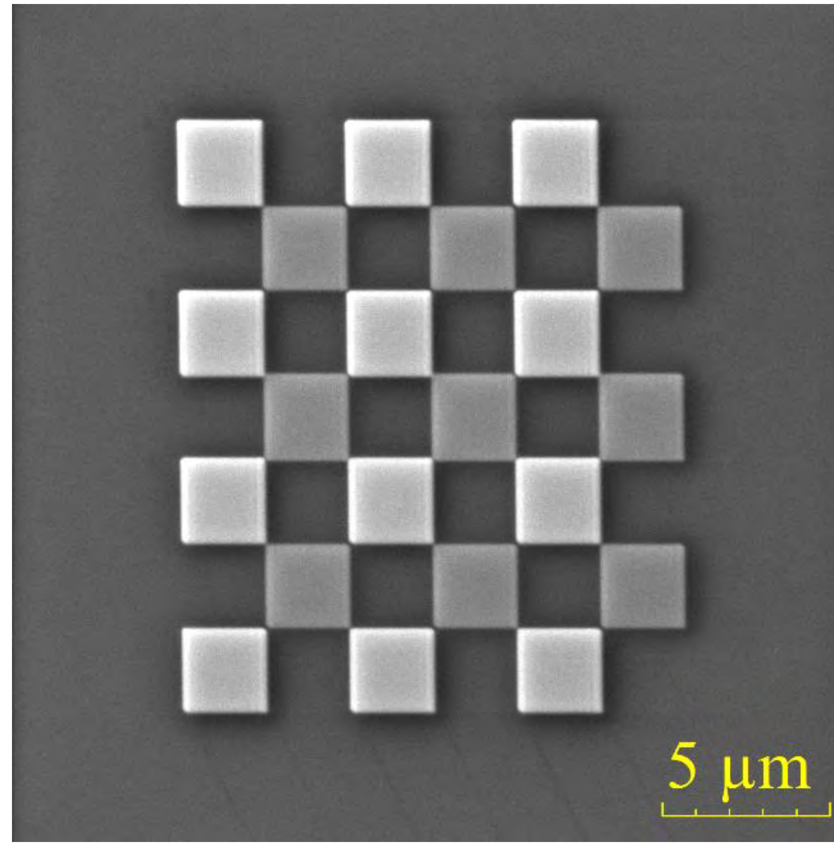
TESCAN ORSAY HOLDING
EXCELLENCE IN SCIENTIFIC INSTRUMENTATION

- TESCAN
- PROČ ELEKTRONOVÁ MIKROSKOPIE
- HISTORIE ELEKTRONOVÉ MIKROSKOPIE
- SROVNÁNÍ OPTICKÉ A ELEKTRONOVÉ MIKROSKOPIE
- PRINCIPY ELEKTRONOVÉ MIKROSKOPIE
- OBLASTI VYUŽITÍ



# TESCAN

- PROČ ELEKTRONOVÁ MIKROSKOPIE
- HISTORIE ELEKTRONOVÉ MIKROSKOPIE
- SROVNÁNÍ OPTICKÉ A ELEKTRONOVÉ MIKROSKOPIE
- PRINCIPY ELEKTRONOVÉ MIKROSKOPIE
- OBLASTI VYUŽITÍ



# TESCAN

**TESCAN ORSAY HOLDING**
HQ


**TESCAN BRNO**
High-end R&D

# TESCAN


TESCAN, s.r.o. established
MIRA Schottky FE-SEM introduced
Chinese branch established
FERA3 and TIMA introduced
1000 SEM installed & ISO certification
Merger of TESCAN and ORSAY PHYSICS resulted in TESCAN ORSAY HOLDING, a.s.
TESCAN-UK Ltd. established
XEIA3 and Q-PHASE introduced
TESCAN Benelux + TESCAN Do Brasil established
S8000G introduced
1991
1999
2005
2007
2009
2010
2011
2012
2013
2014
2015
2016
2017
VEGA SEM introduced
LYRA FIB-SEM introduced
Acquisition of TESCAN USA
Third generation of TESCAN SEMs introduced
MIRA3 AMU introduced
Acquisition of App Five
GAIA3 and RISE introduced
NEW UHR Series Triglav™

- TESCAN
- **CO JE TO MIKROSKOPIE?**
- HISTORIE ELEKTRONOVÉ MIKROSKOPIE
- SROVNÁNÍ OPTICKÉ A ELEKTRONOVÉ MIKROSKOPIE
- PRINCIPY ELEKTRONOVÉ MIKROSKOPIE
- OBLASTI VYUŽITÍ

# CO JE TO MIKROSKOPIE?

- Mikroskopie je technická a vědecká disciplína zabývající se pozorováním věcí neviditelných okem


*Okem*

*Pomocí optického mikroskopu*

*Pomocí elektronového mikroskopu*


*Okem*

*Mikroskopem*

*Elektronovým mikroskopem*

1 mm

¼ mm (250 µm)

250 µm

1/1000 mm (1 µm)

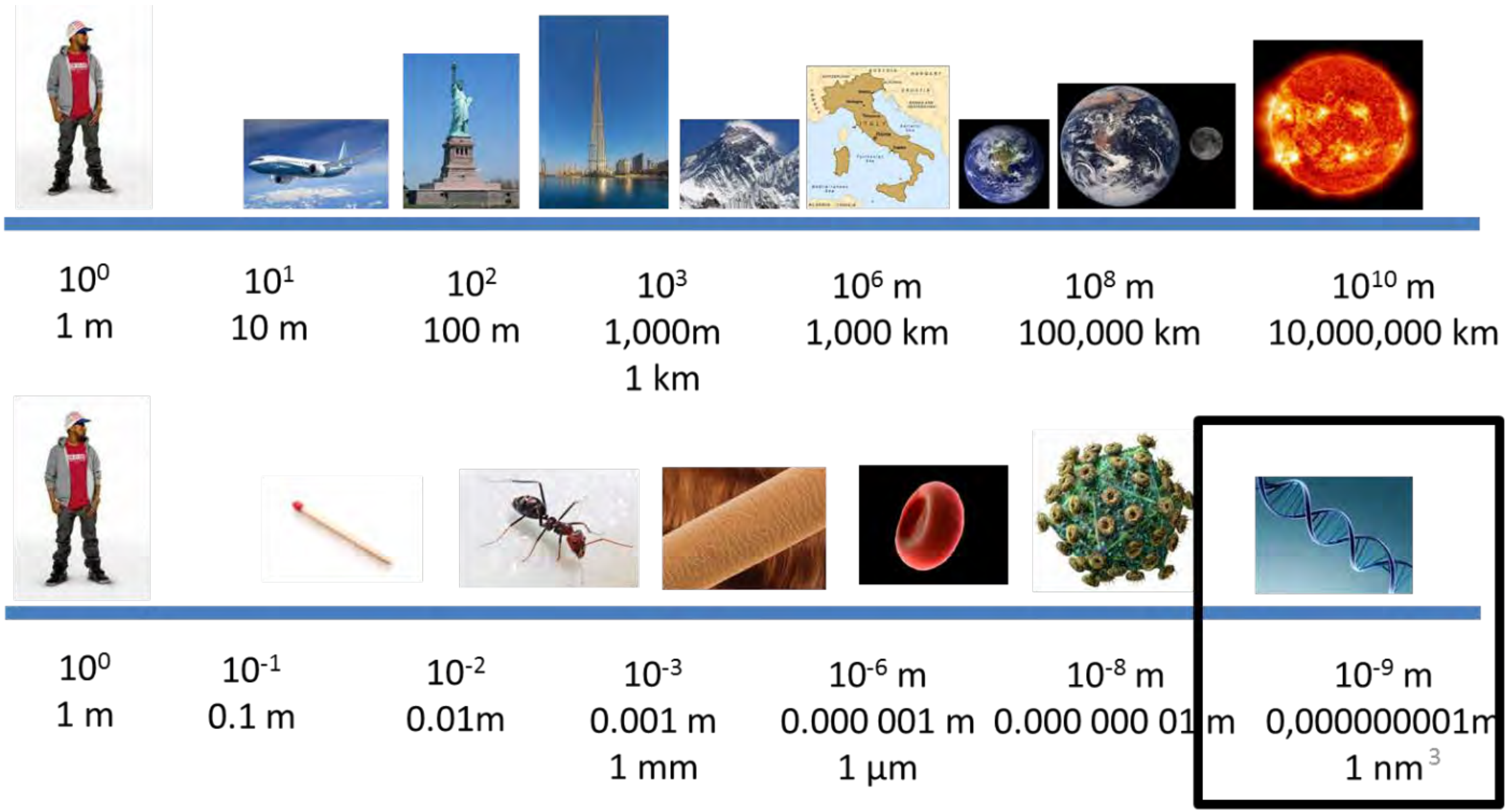
1 µm

1/1000 µm (1 nm)

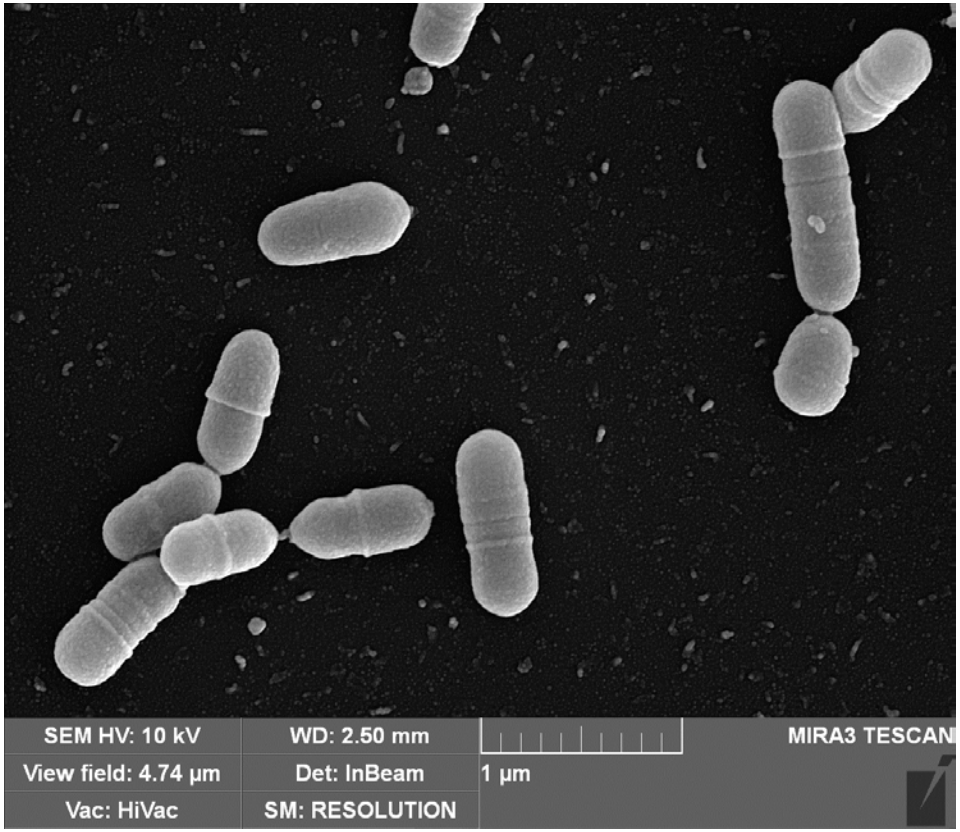
- *Vlas*
- *Vlákno žárovky*
- *Tenká čára tužkou*

- *Struktura rostlin*
- *Živé buňky*

- *Nanostruktury polovodičů*
- *Mikropraskliny v materiálech*
- *Virus v živých vědách*


10^0 1 m
10^1 10 m
10^2 100 m
10^3 1,000m 1 km
10^6 m 1,000 km
10^8 m 100,000 km
10^10 m 10,000,000 km
10^0 1 m
10^-1 0.1 m
10^-2 0.01m
10^-3 0.001 m 1 mm
10^-6 m 0.000 001 m 1 µm
10^-8 m 0.000 000 01 m
10^-9 m 0,000000001m 1 nm [3]

- TESCAN
- CO JE TO MIKROSKOPIE?
- **HISTORIE ELEKTRONOVÉ MIKROSKOPIE**
- SROVNÁNÍ OPTICKÉ A ELEKTRONOVÉ MIKROSKOPIE
- PRINCIPY ELEKTRONOVÉ MIKROSKOPIE
- OBLASTI VYUŽITÍ
- NENÍ MIKROSKOP JAKO MIKROSKOP



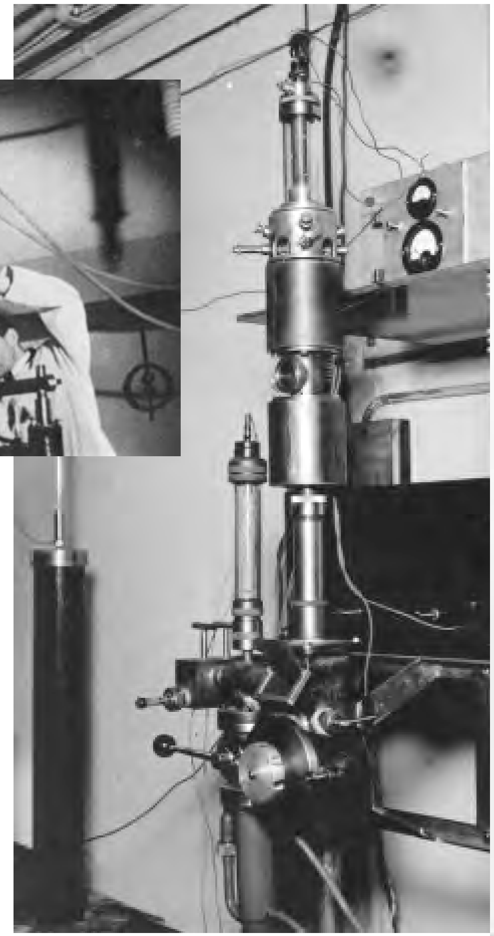
# HISTORIE ELEKTRONOVÉ MIKROSKOPIE

- 1887 – objev elektronu (J.J. Thompson, Cambridge)
- 1924 – dualismus vln a částic (Louis de Broglie, Paříž)
- 1926 – první elektromagnetická čočka (Hans Busch, *Německo*)
- 1931 – prototyp transmisního elektronového mikroskopu – TEM (Ernst Ruska, Max Knoll, *Německo*)
- 1938 – první (komerční) rastrovací transmisní elektronový mikroskop – STEM (Manfred von Ardenne, Berlin, SIEMENS)
- 1942 – první rastrovací elektronový mikroskop – SEM (Vladimir Kosmich Zworykin, *USA*)
- **1950 – pokusné zařízení se dvěma magnetickými čočkami (Armin Delong)**
- **1951 – první komerčně dostupný československý mikroskop s označením Tesla BS 241 (TESLA Brno, A. Delong, V. Drahoš, Zobač)**
- 1986 – Ernst Ruska – Nobelova cena

# HISTORIE ELEKTRONOVÉ MIKROSKOPIE

TEM, E. Ruska (1933)

E. Ruska,
M. Knoll



Pokusné zařízení

Tesla BS 241

- TESCAN
- CO JE TO MIKROSKOPIE?
- HISTORIE ELEKTRONOVÉ MIKROSKOPIE
- **SROVNÁNÍ OPTICKÉ A ELEKTRONOVÉ MIKROSKOPIE**
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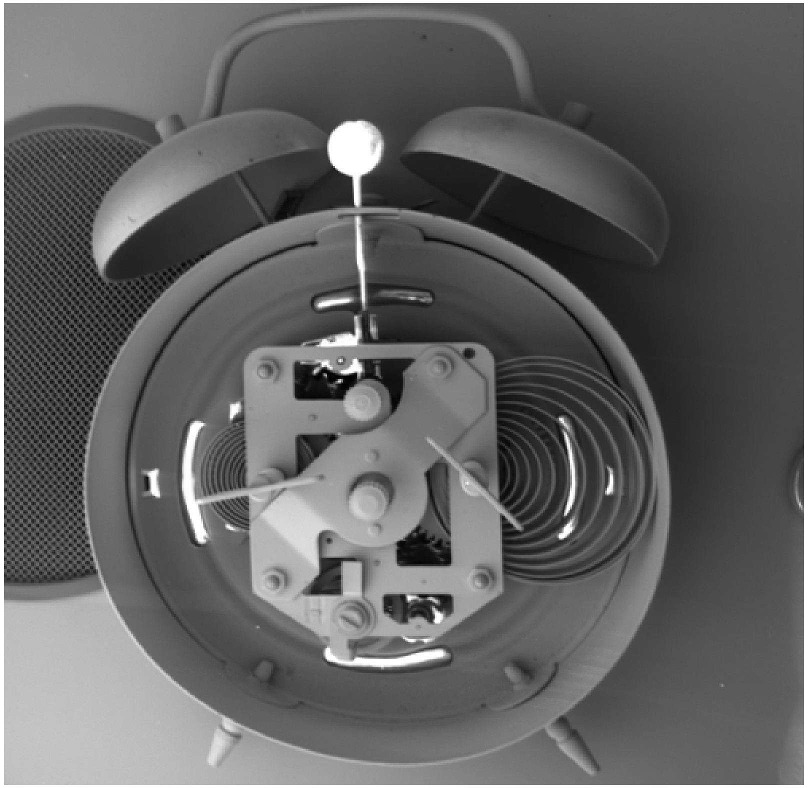
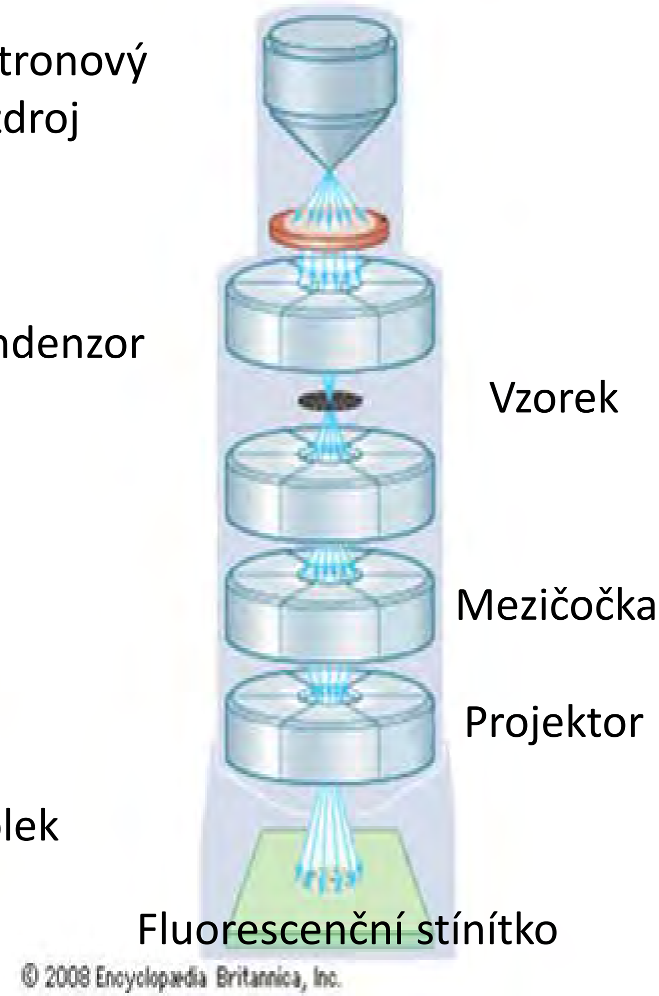


# OPTICKÁ VS ELEKTRONOVÁ MIKROSKOPIE


Elektronový mikroskop

SEM

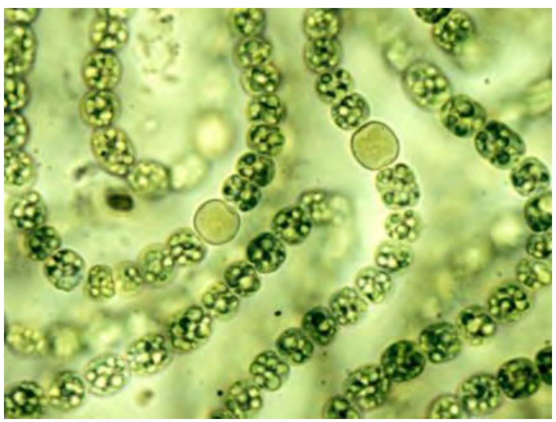

TEM



# OPTICKÁ VS ELEKTRONOVÁ MIKROSKOPIE

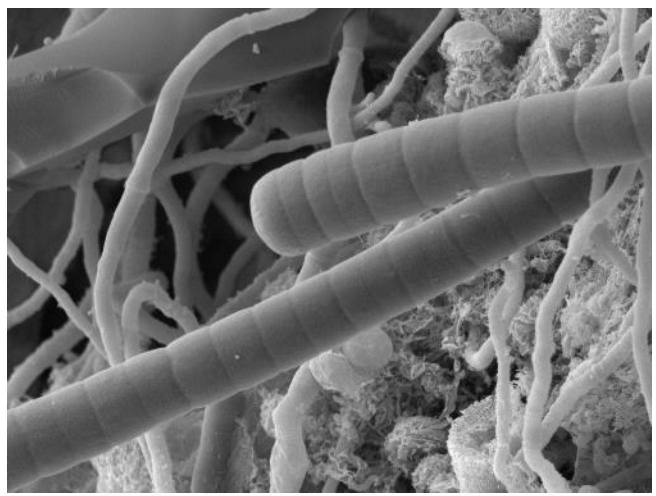
- **SINICE**

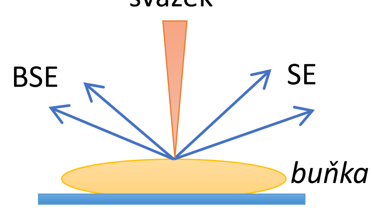
Světelný mikroskop



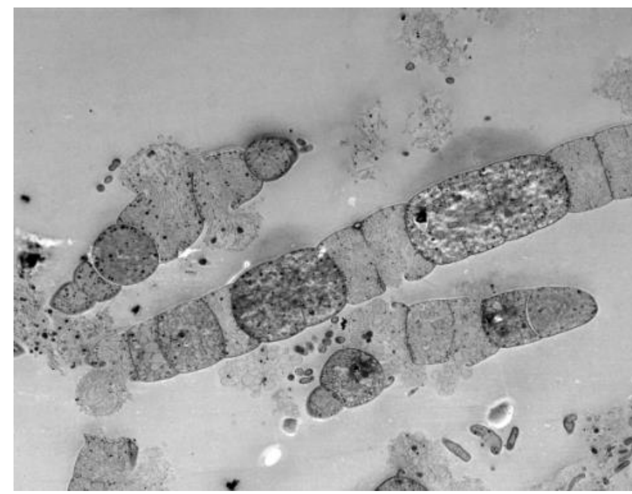
Williams, A. Mic. Phys., 2006

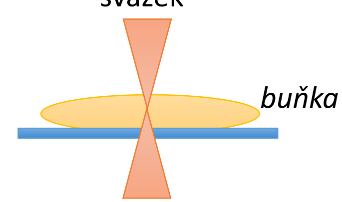
SEM





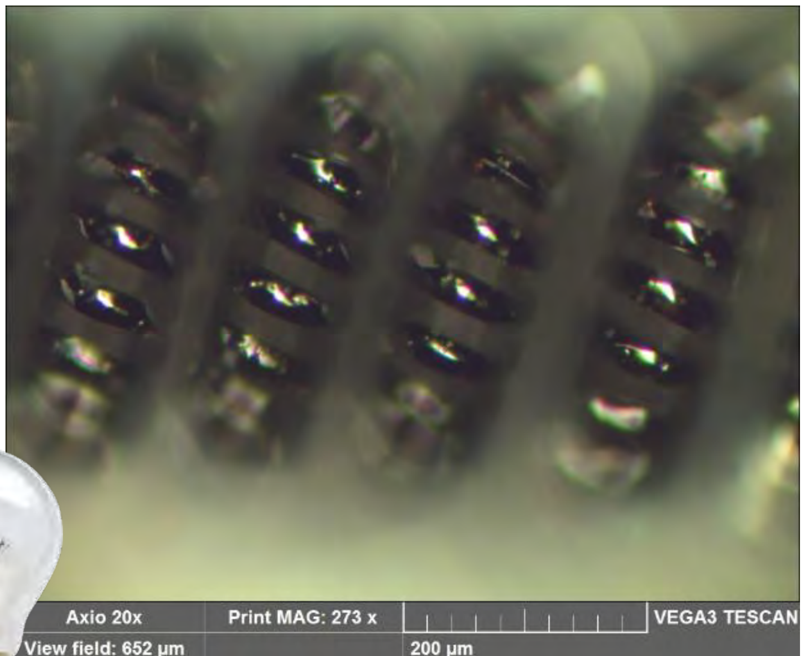

TEM

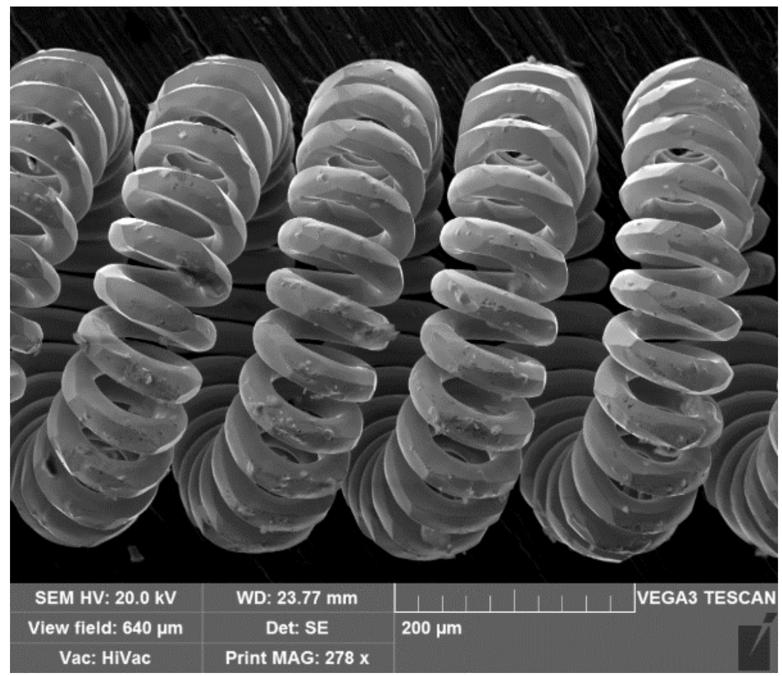




# OPTICKÁ VS ELEKTRONOVÁ MIKROSKOPIE

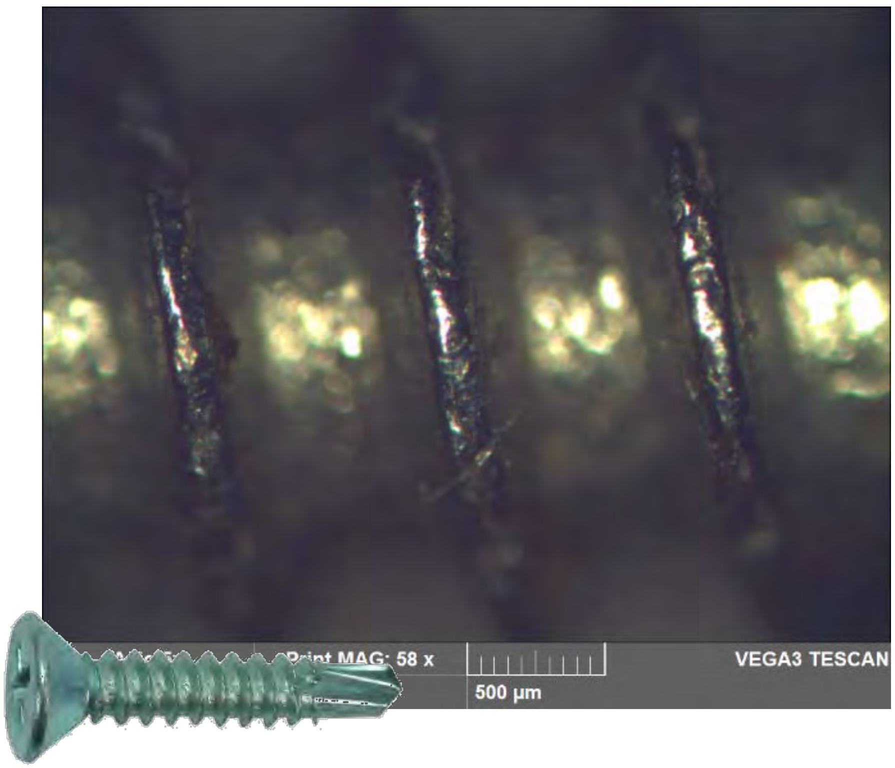
## ➢ VLÁKNO ŽÁROVKY – VÝHODA HLOUBKY OSTROSTI

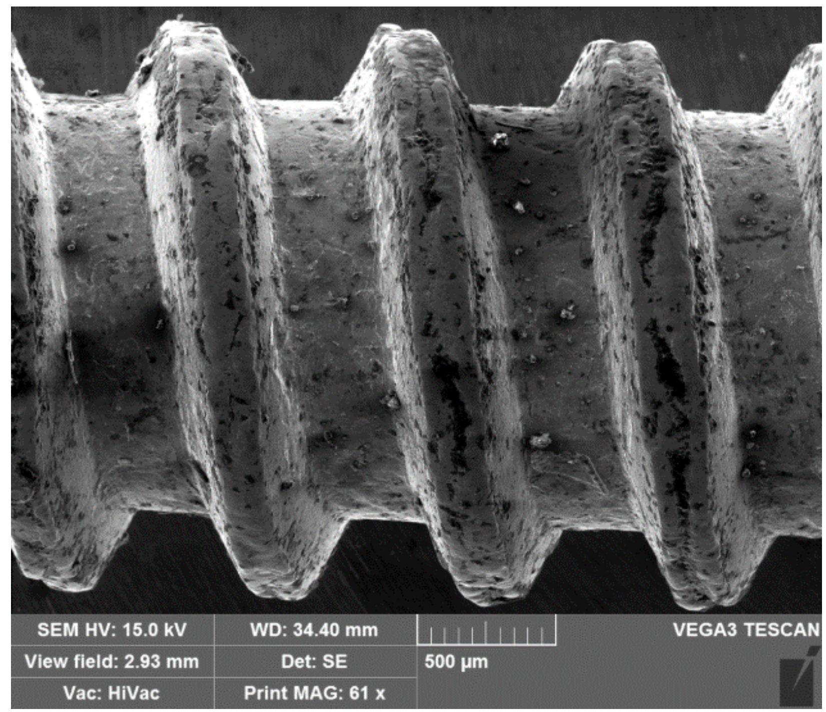



# OPTICKÁ VS ELEKTRONOVÁ MIKROSKOPIE

## ➢ ŠROUB – VÝHODA HLOUBKY OSTROSTI



- TESCAN
- CO JE TO MIKROSKOPIE?
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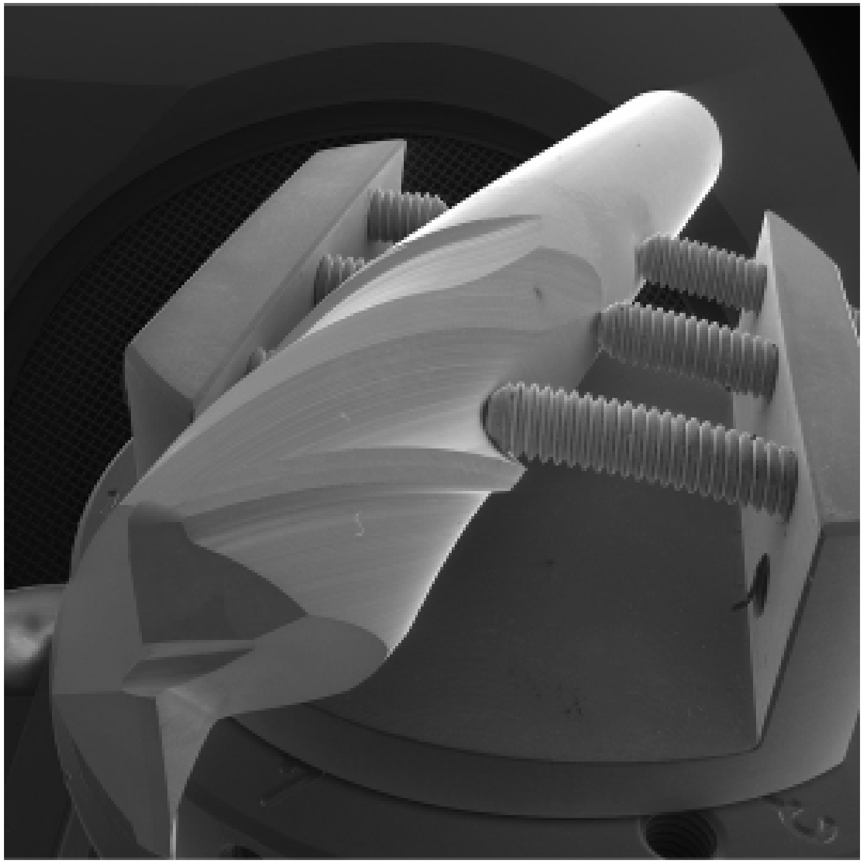
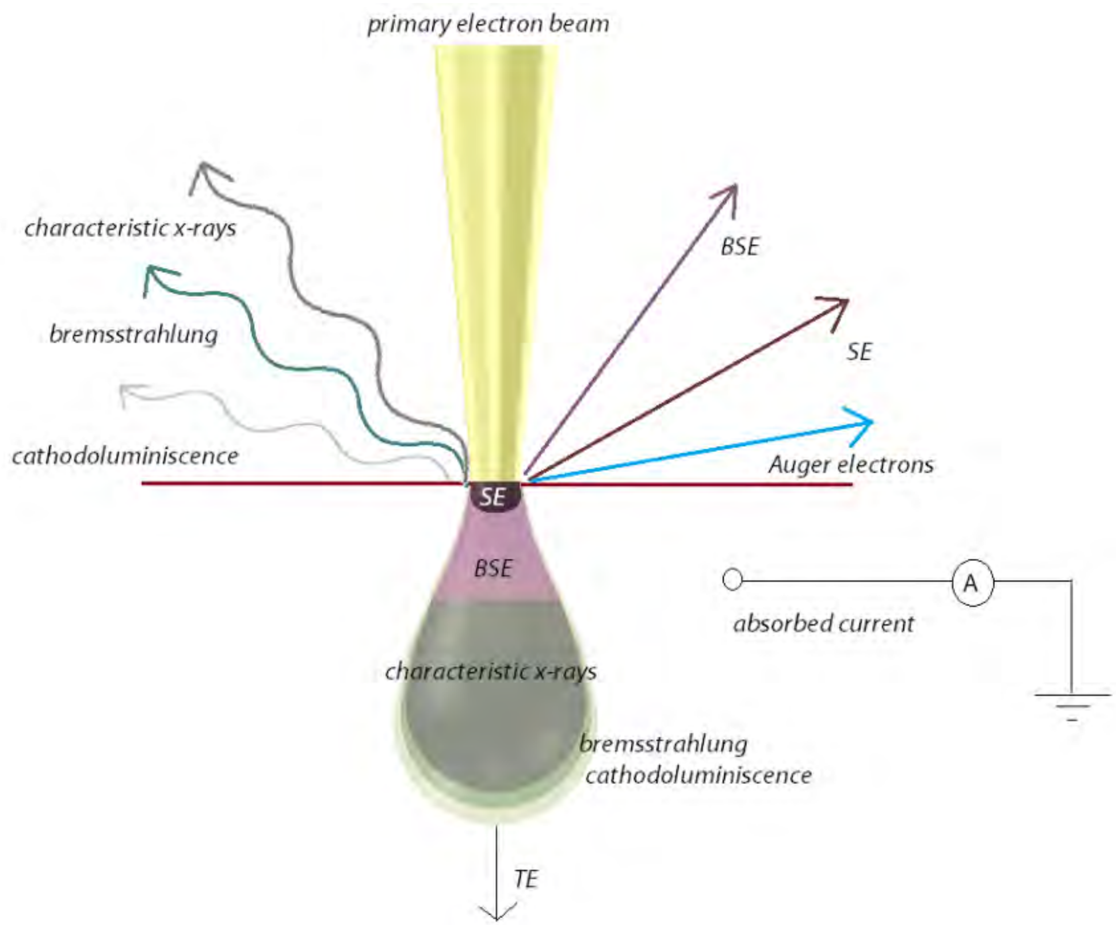
- **PRINCIPY ELEKTRONOVÉ MIKROSKOPIE**
- OBLASTI VYUŽITÍ
- NENÍ MIKROSKOP JAKO MIKROSKOP

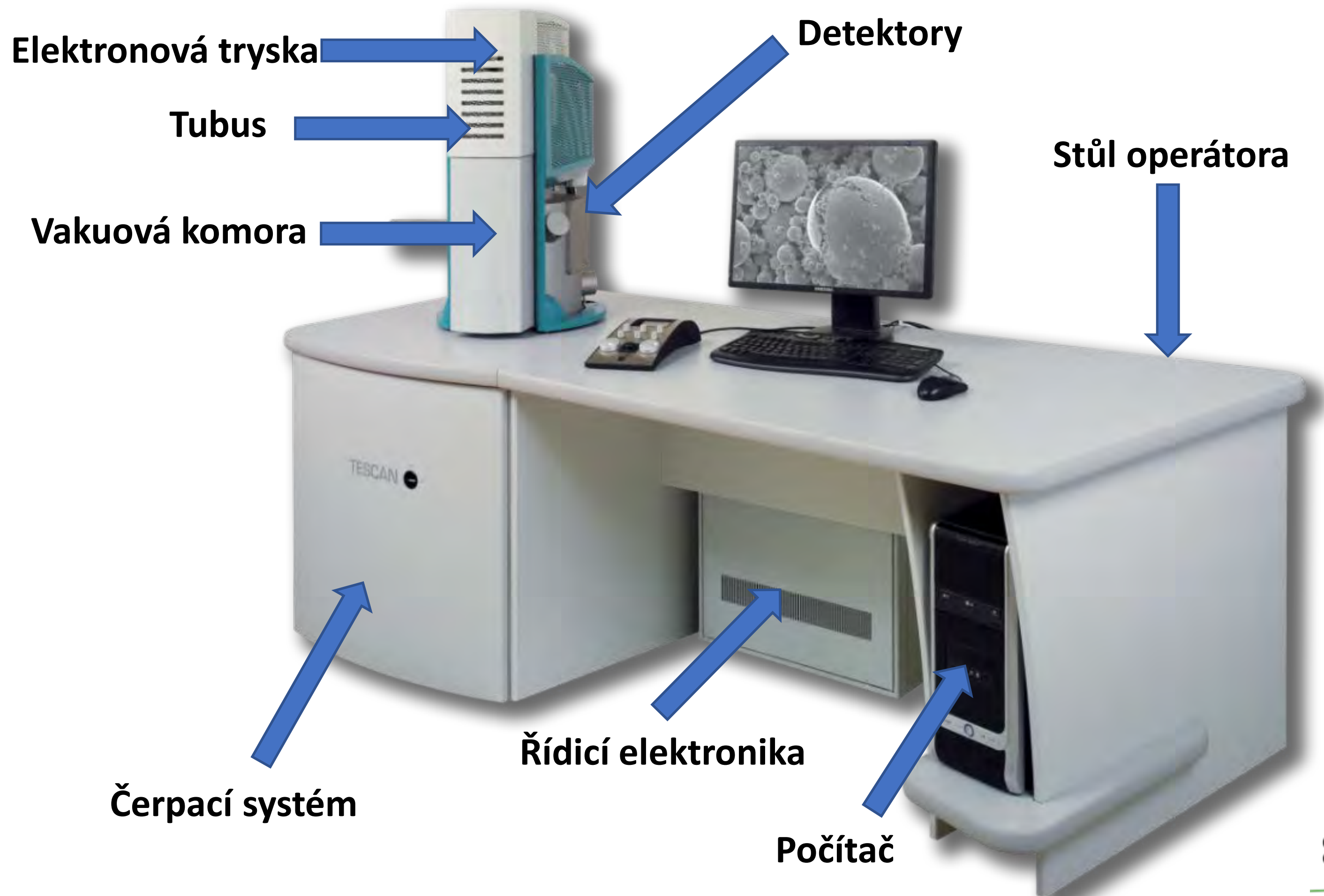


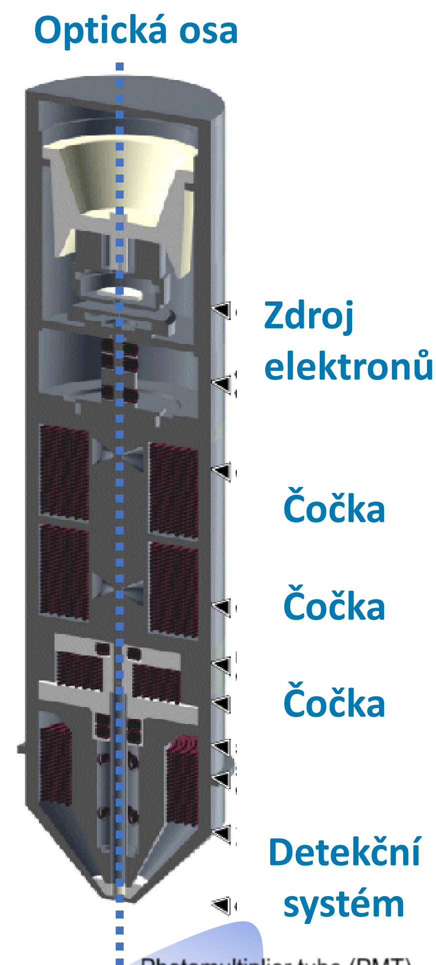
# ELEKTRONOVÁ MIKROSKOPIE

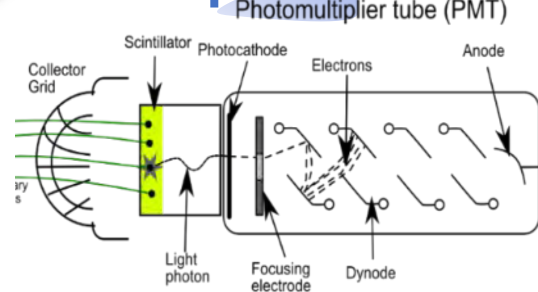
## ➢ INTERAKCE ČÁSTIC S PEVNOU LÁTKOU



# ELEKTRONOVÁ MIKROSKOPIE

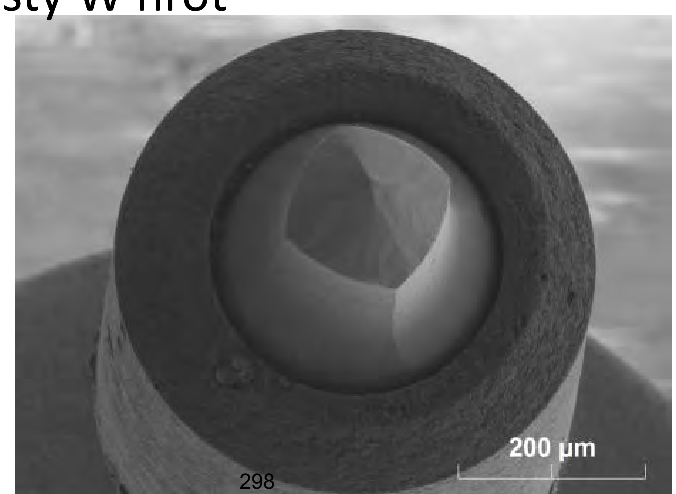


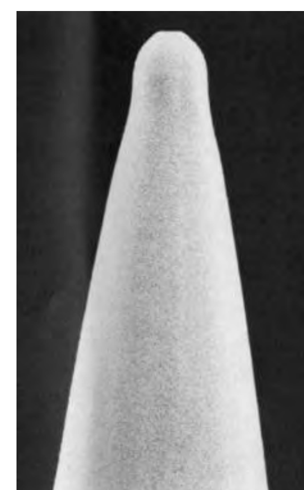



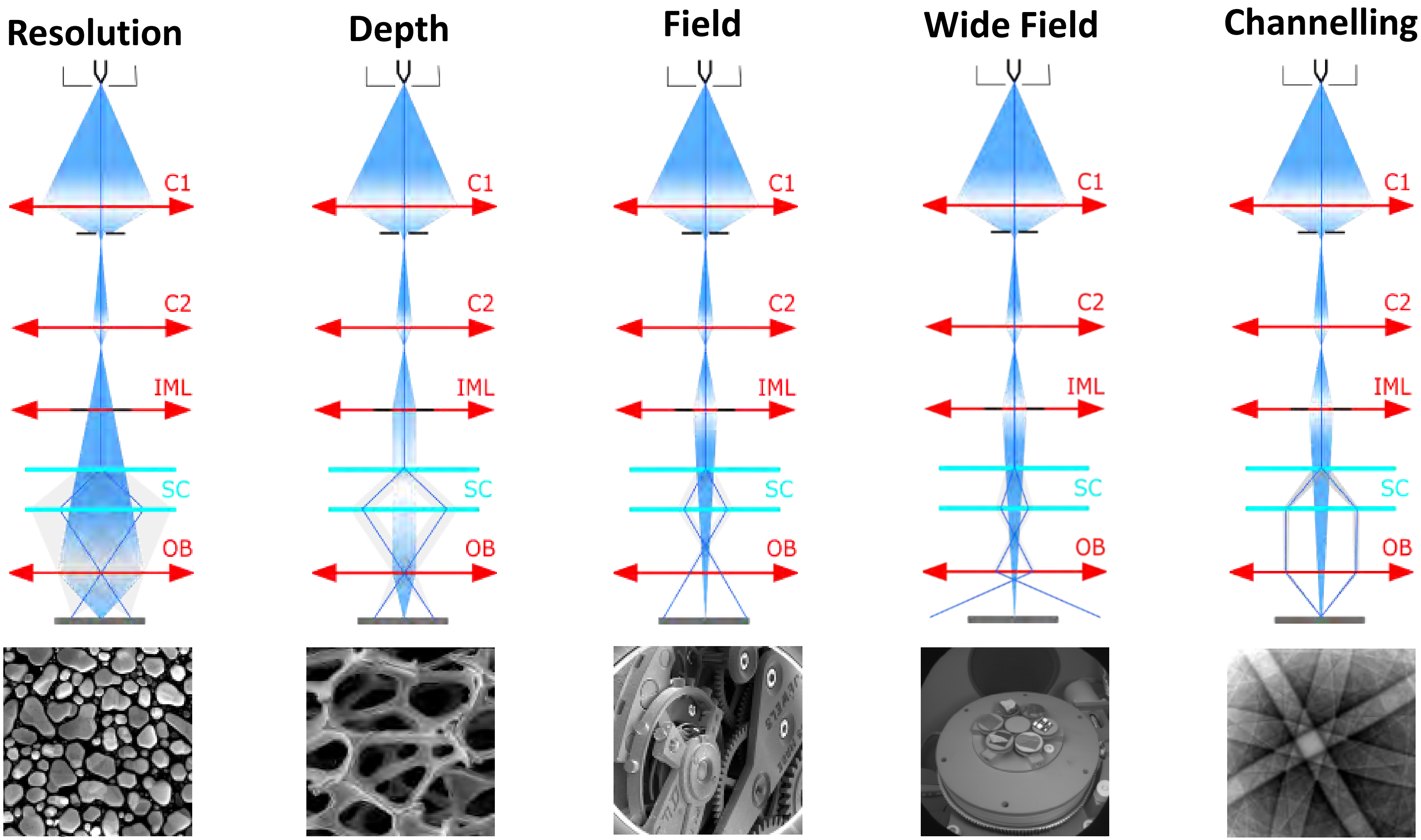

SEM TESCAN VEGA3

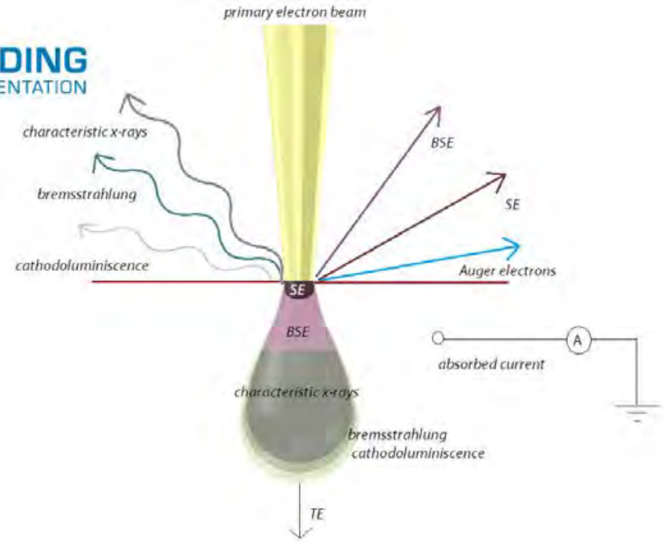
- **ZDROJ ELEKTRONŮ - ELEKTRONOVÁ TRYSKA**
  - Vygenerování svazku primárních elektronů
  - Urychlení primárních elektronů
  - Formování svazku přímo do tubusu
- TYPY ELEKTRONOVÝCH TRYSEK
  - Termální emise – žhavené W vlákno, krystal $LaB_6$
  - Schottkyho autoemisní katoda – žhavený W hrot s emisní vrstvou
  - Studená emise – čistý W hrot



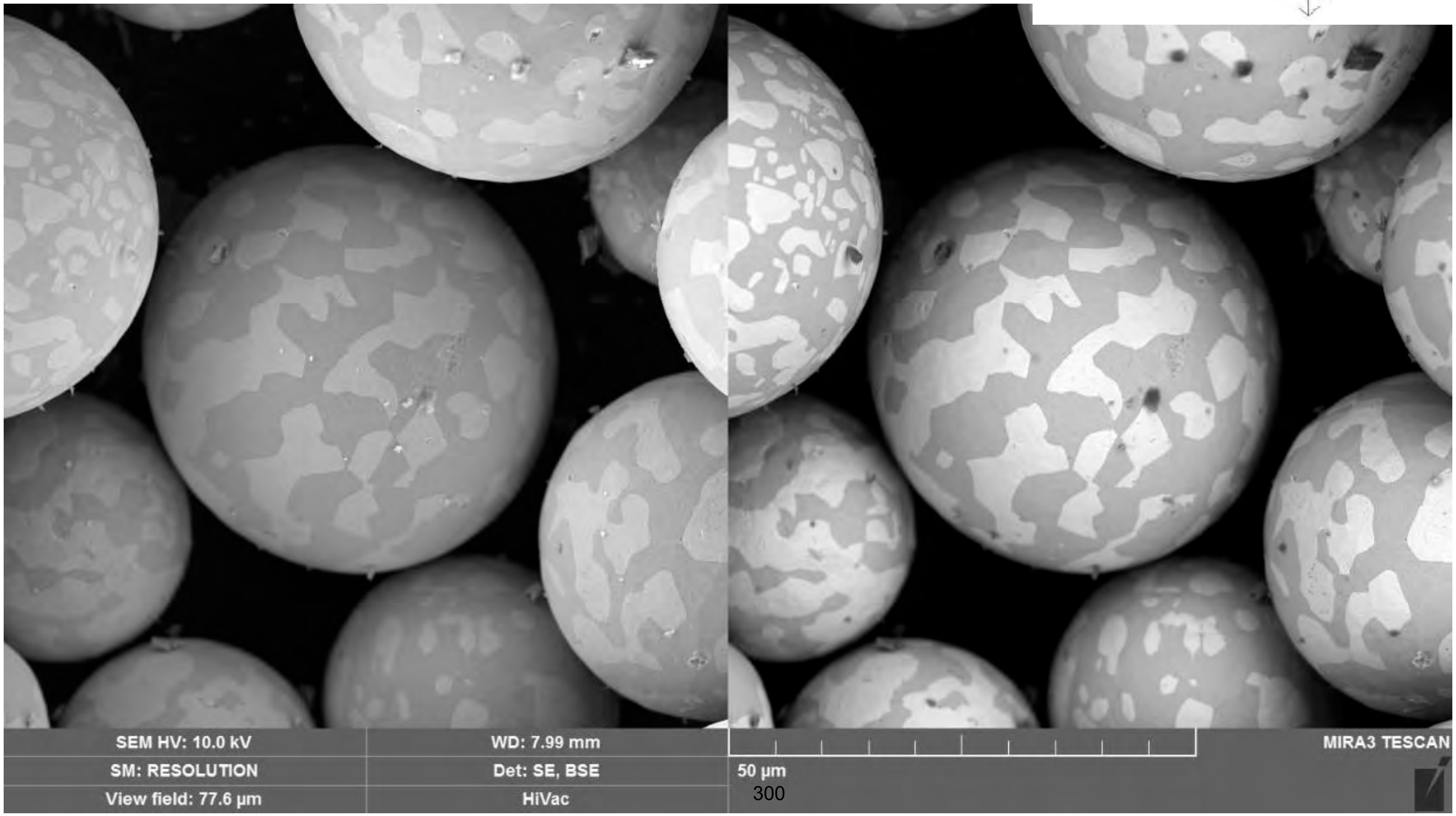
## ➢ ZOBRAZOVACÍ REŽIMY



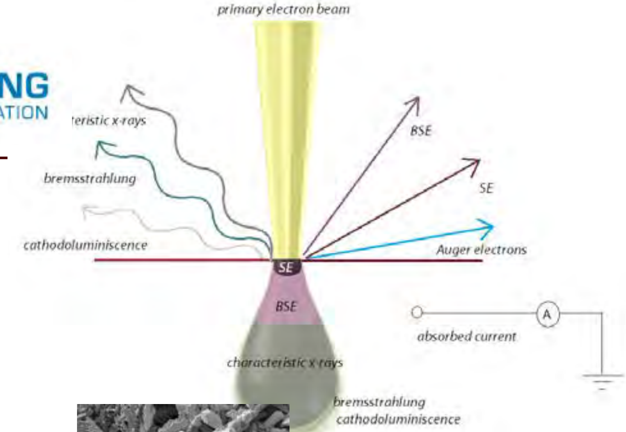



## ➢ TYPY SIGNÁLŮ

- ➢ Sekundární elektrony (SE)
- ➢ Zpětně-odražené elektrony (BSE)

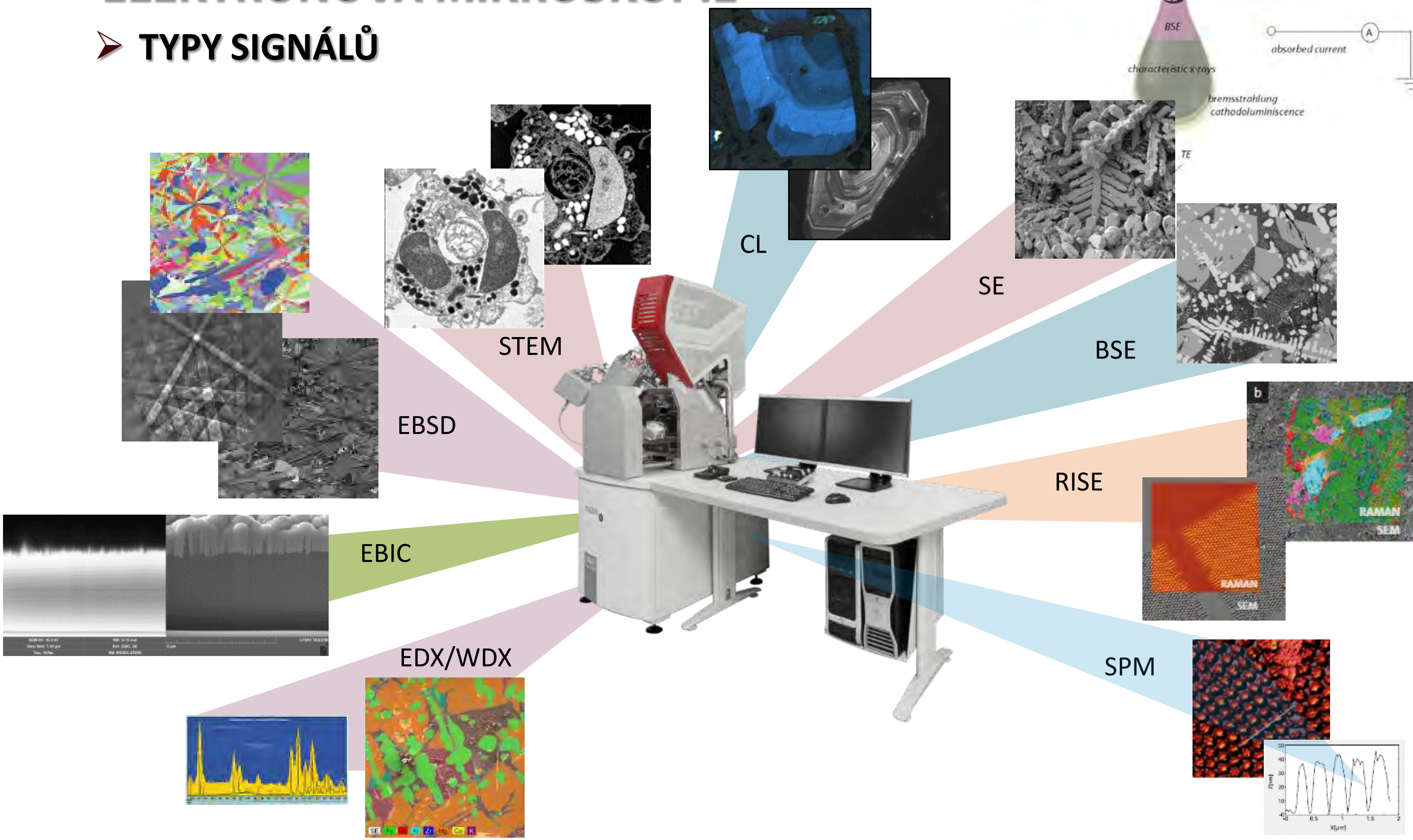


TESCAN ORSAY HOLDING
EXCELLENCE IN SCIENTIFIC INSTRUMENTATION




# ELEKTRONOVÁ MIKROSKOPIE

## ➢ TYPY SIGNÁLŮ



- TESCAN
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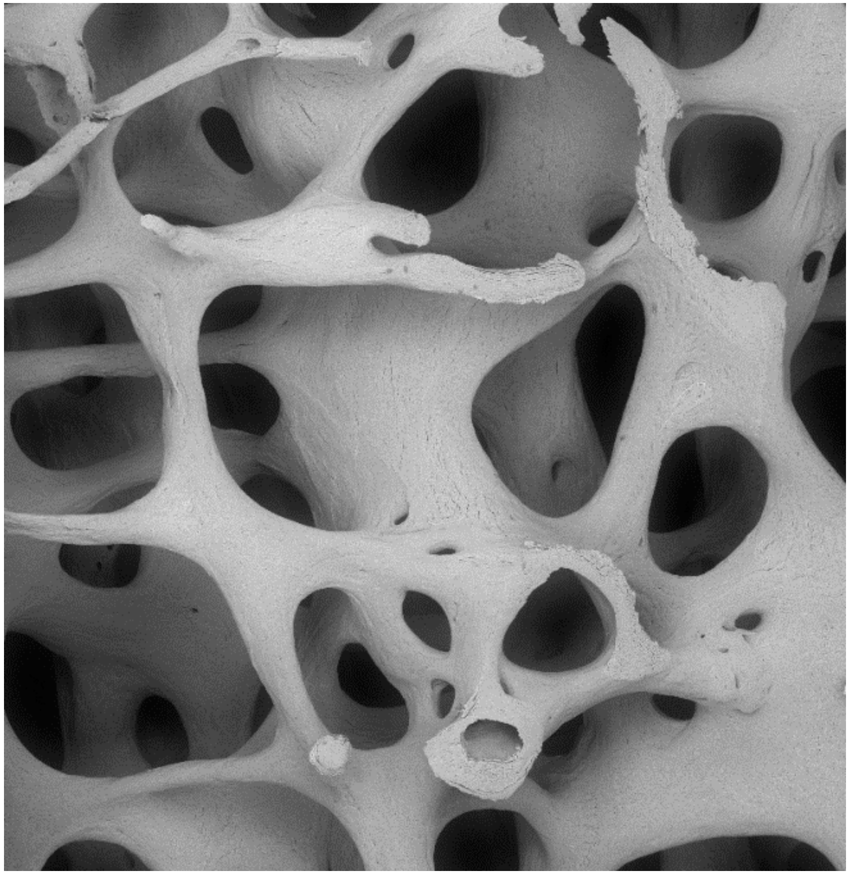
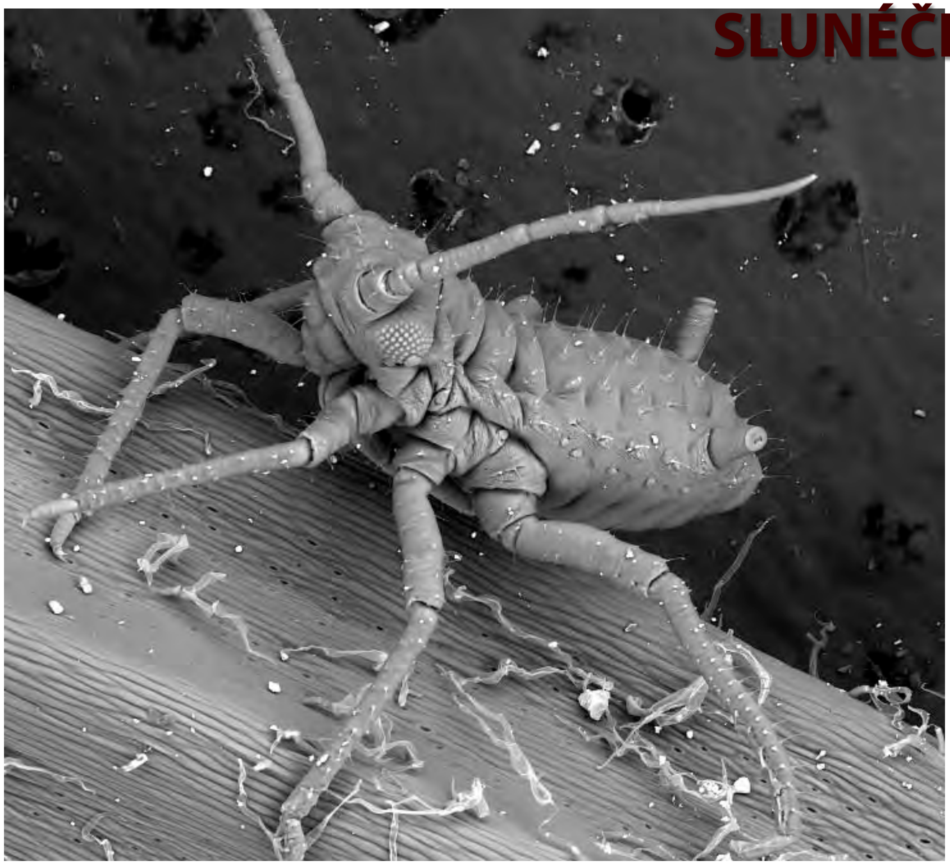
- PRINCIPY ELEKTRONOVÉ MIKROSKOPIE
- **OBLASTI VYUŽITÍ**
- NENÍ MIKROSKOP JAKO MIKROSKOP



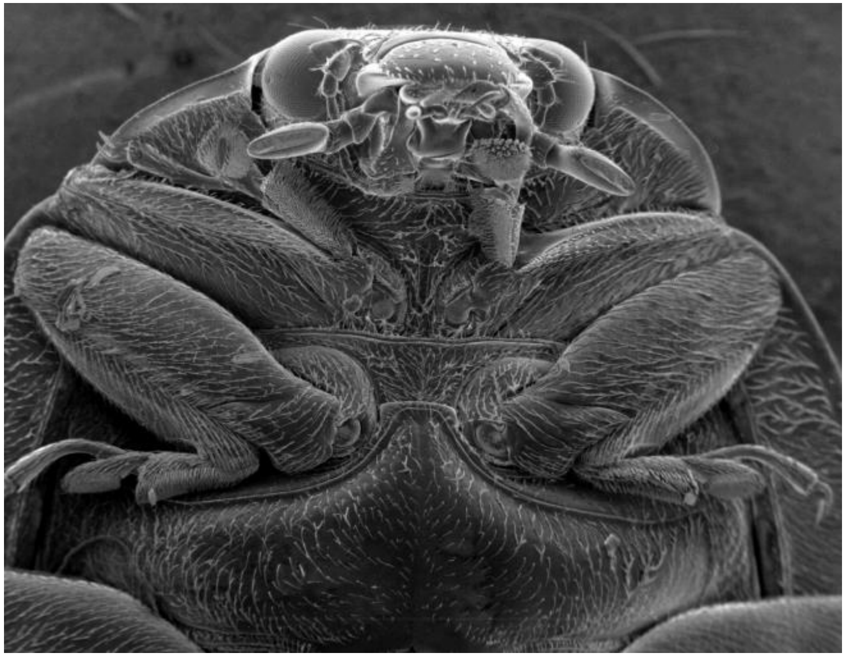
# OBLAST VYUŽITÍ EM

- **ZOBRAZOVÁNÍ – makrosvět**

## MŠICE



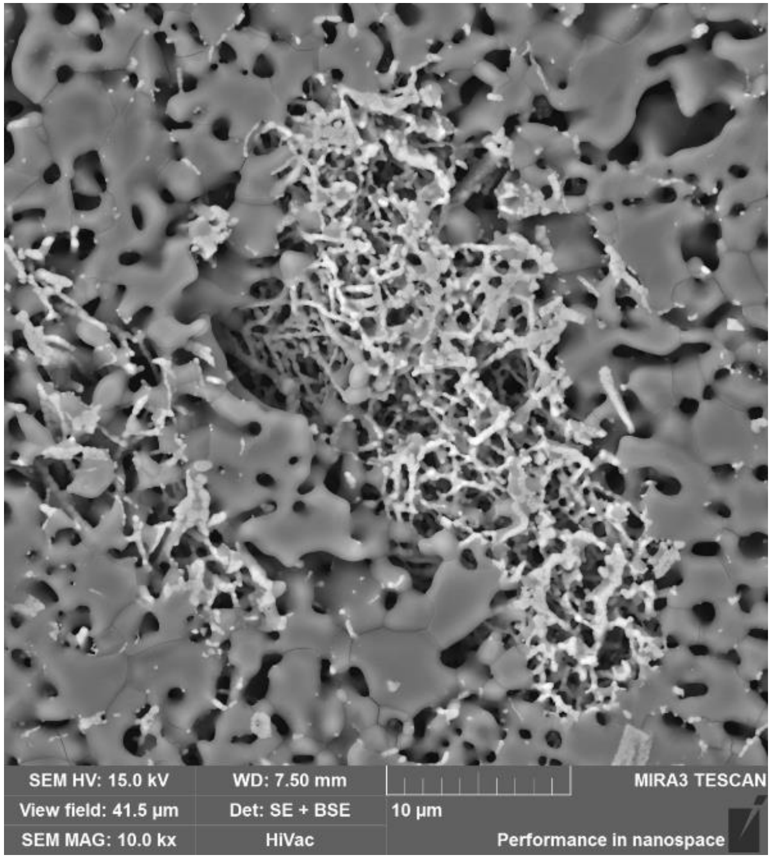
## SLUNÉČKO SEDMITEČNÉ

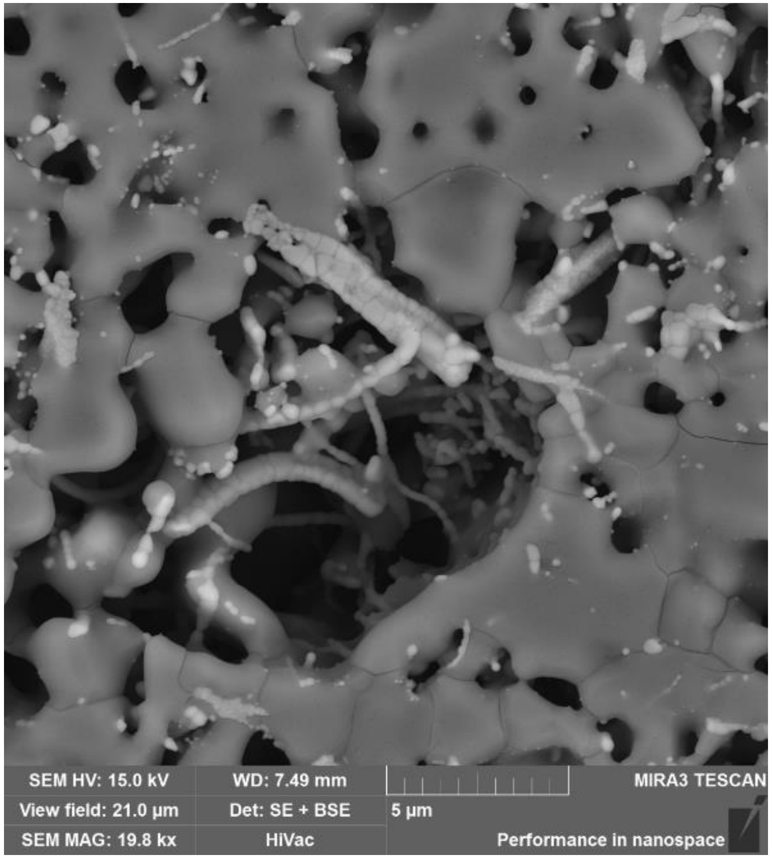


# OBLAST VYUŽITÍ EM

- **ZOBRAZOVÁNÍ - mikrosvět**

# VLÁKNA V KONSTRUKČNÍCH MATERIÁLECH

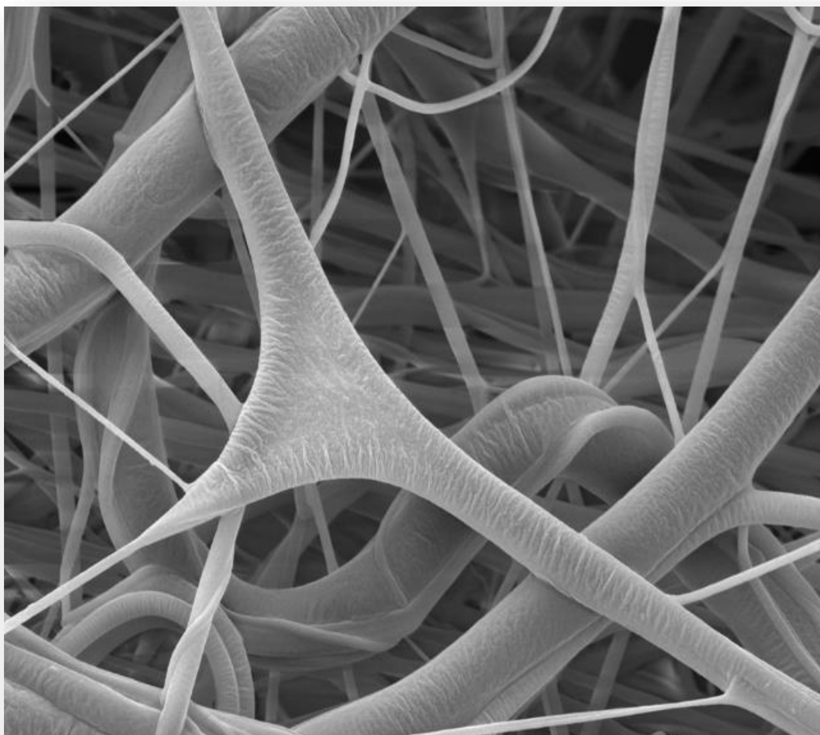


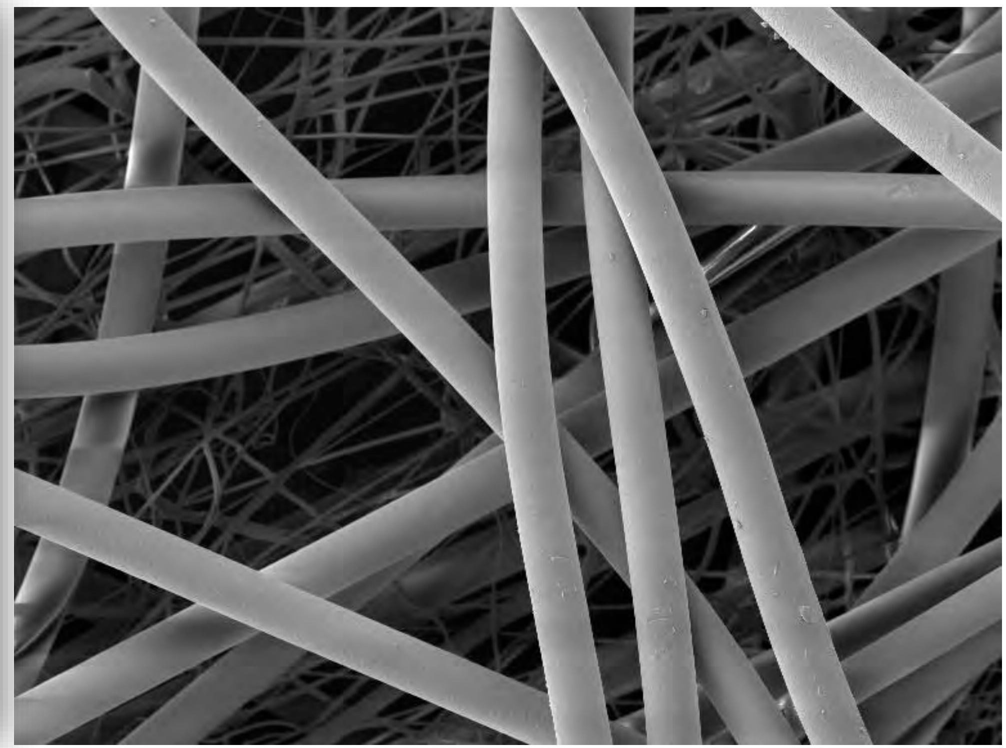



# OBLAST VYUŽITÍ EM

- **ZOBRAZOVÁNÍ - mikrosvět**

## VLÁKNA

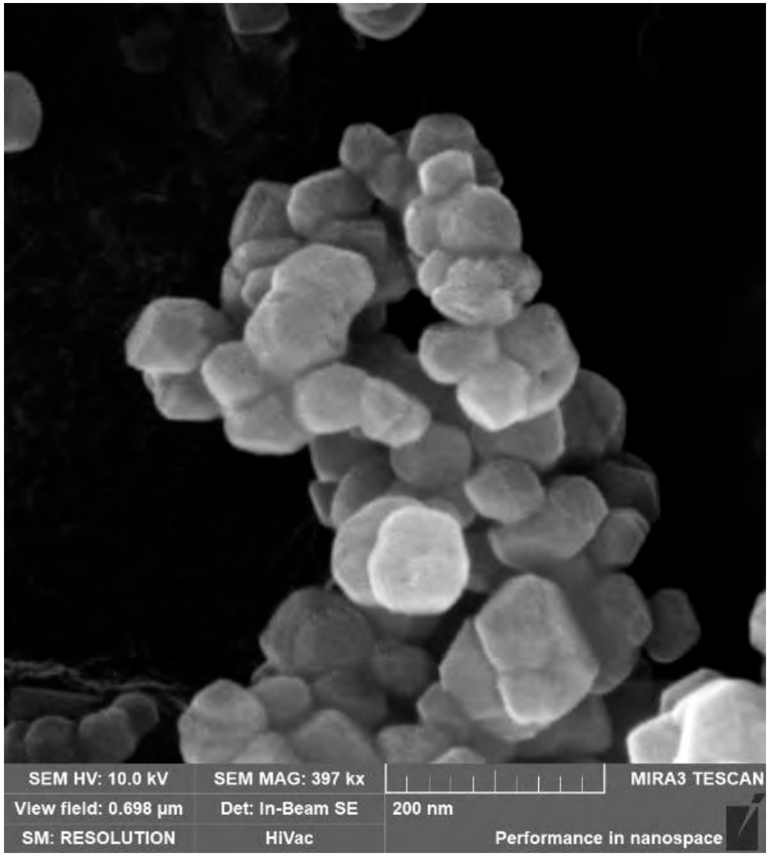


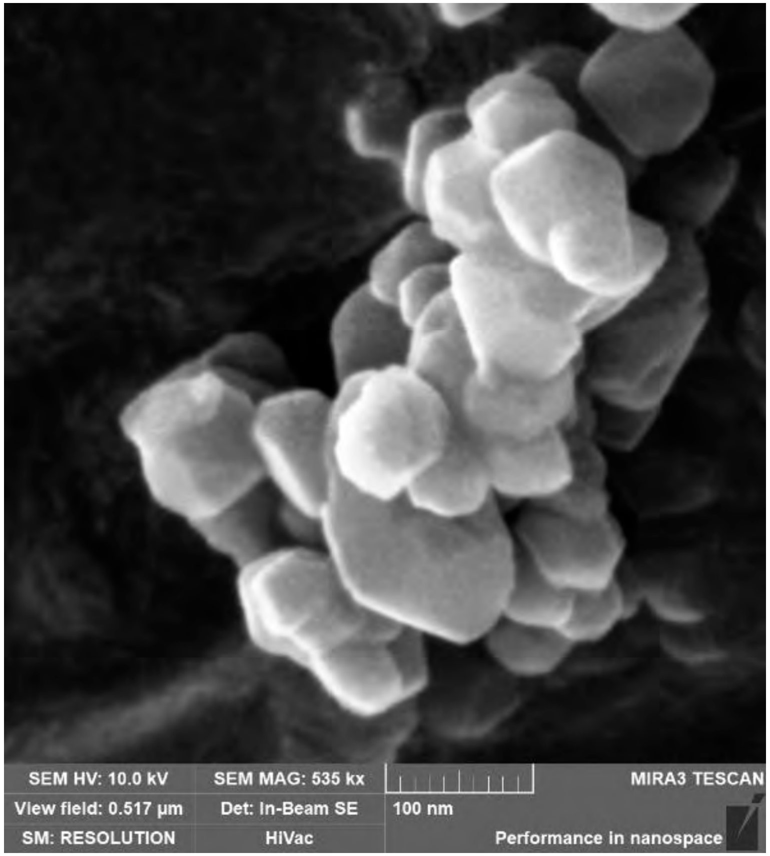


# OBLAST VYUŽITÍ EM

- **ZOBRAZOVÁNÍ - nanosvět**

## NANOČÁSTICE V BARVÁCH



# OBLAST VYUŽITÍ EM

- **ZOBRAZOVÁNÍ – HODNOCENÍ KONSTRUKČNÍCH MATERIÁLŮ**

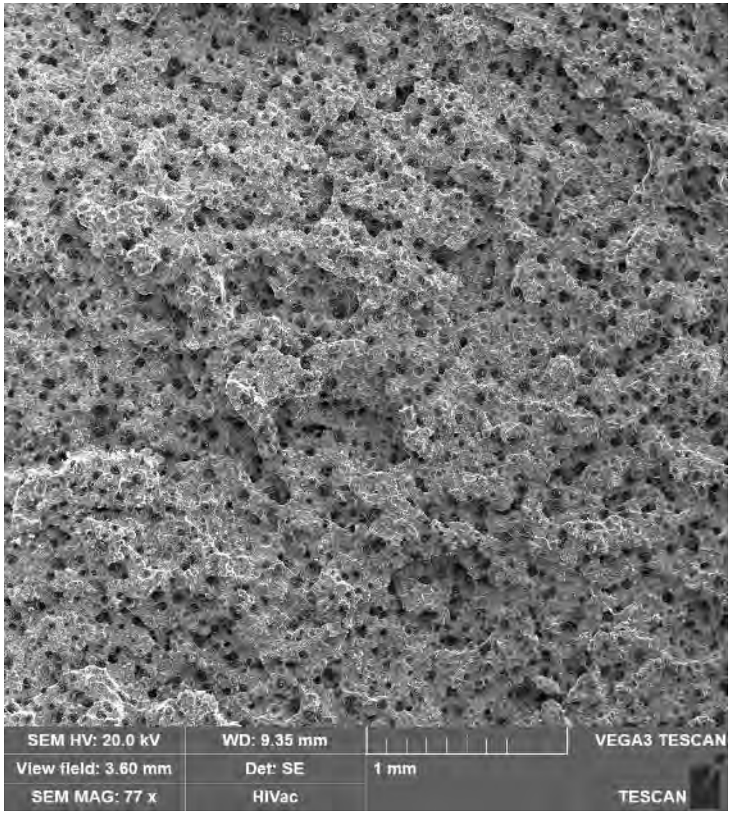
**S.S. Schenectady (1942)**

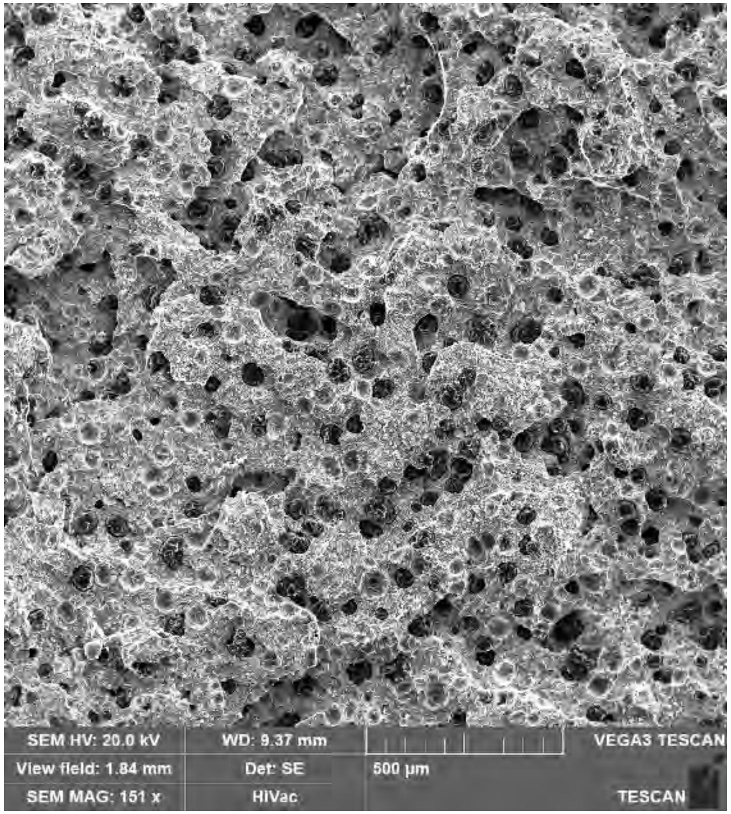
**Nákladní loď (2017)**

# OBLAST VYUŽITÍ EM

## ➢ ZOBRAZOVÁNÍ – HODNOCENÍ KONSTRUKČNÍCH MATERIÁLŮ

**ADI**



# OBLAST VYUŽITÍ EM

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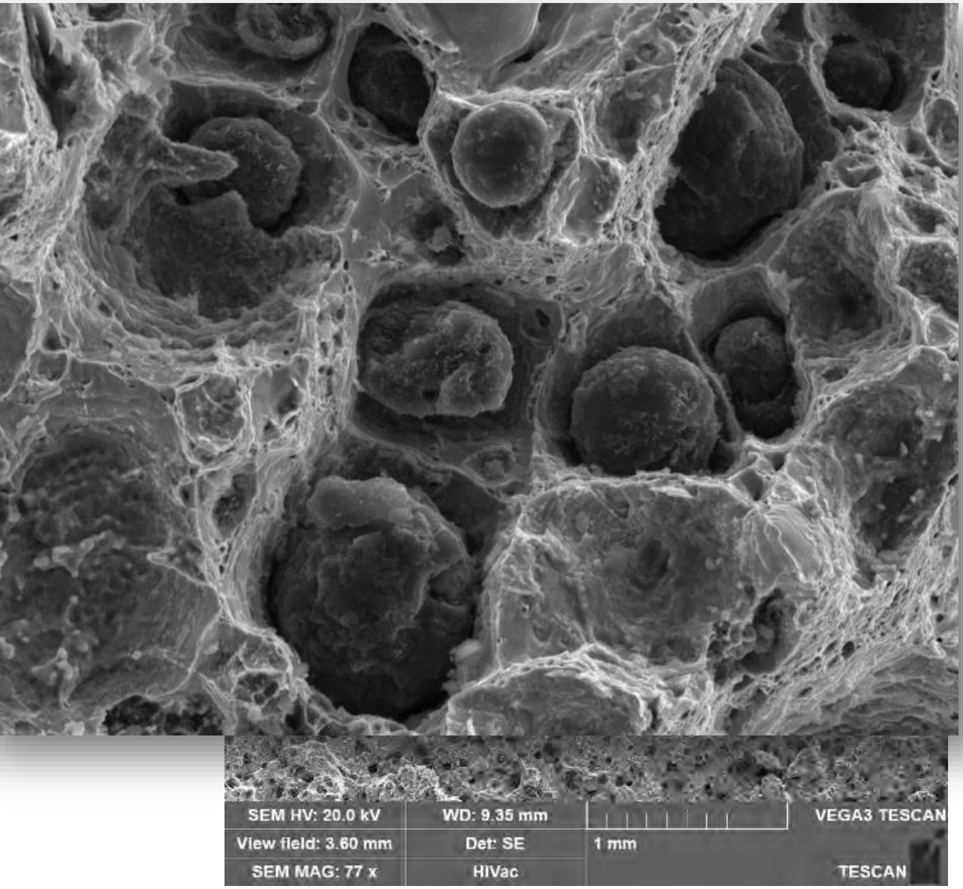


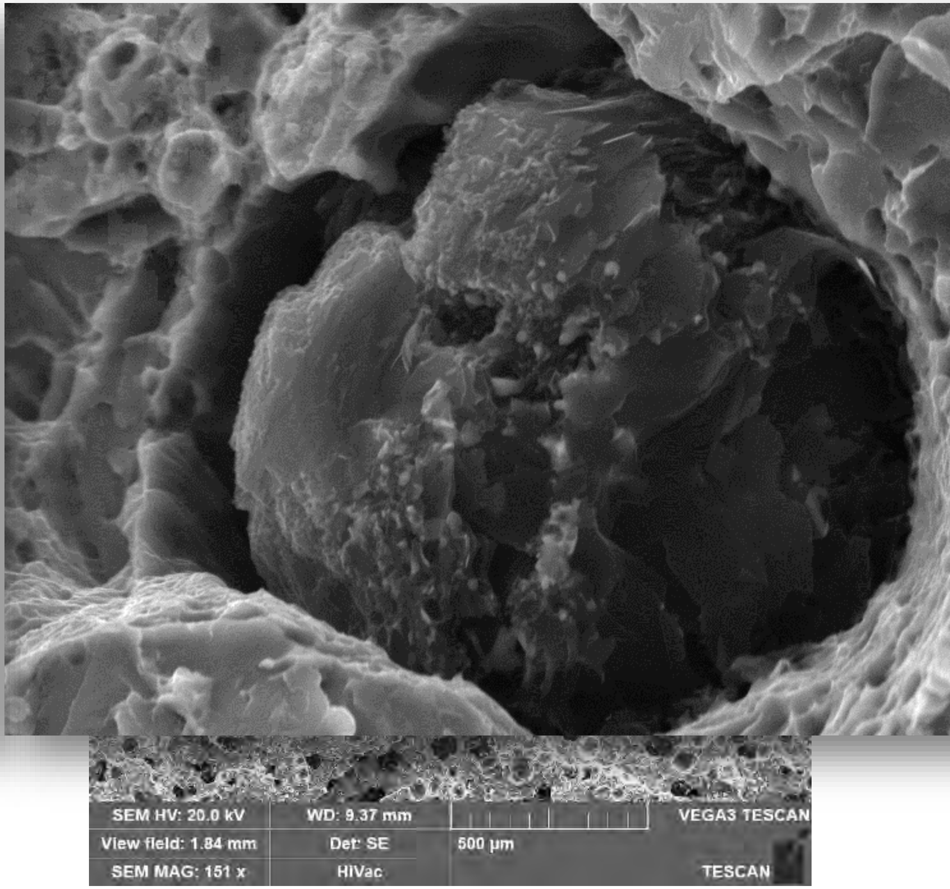

# OBLAST VYUŽITÍ EM

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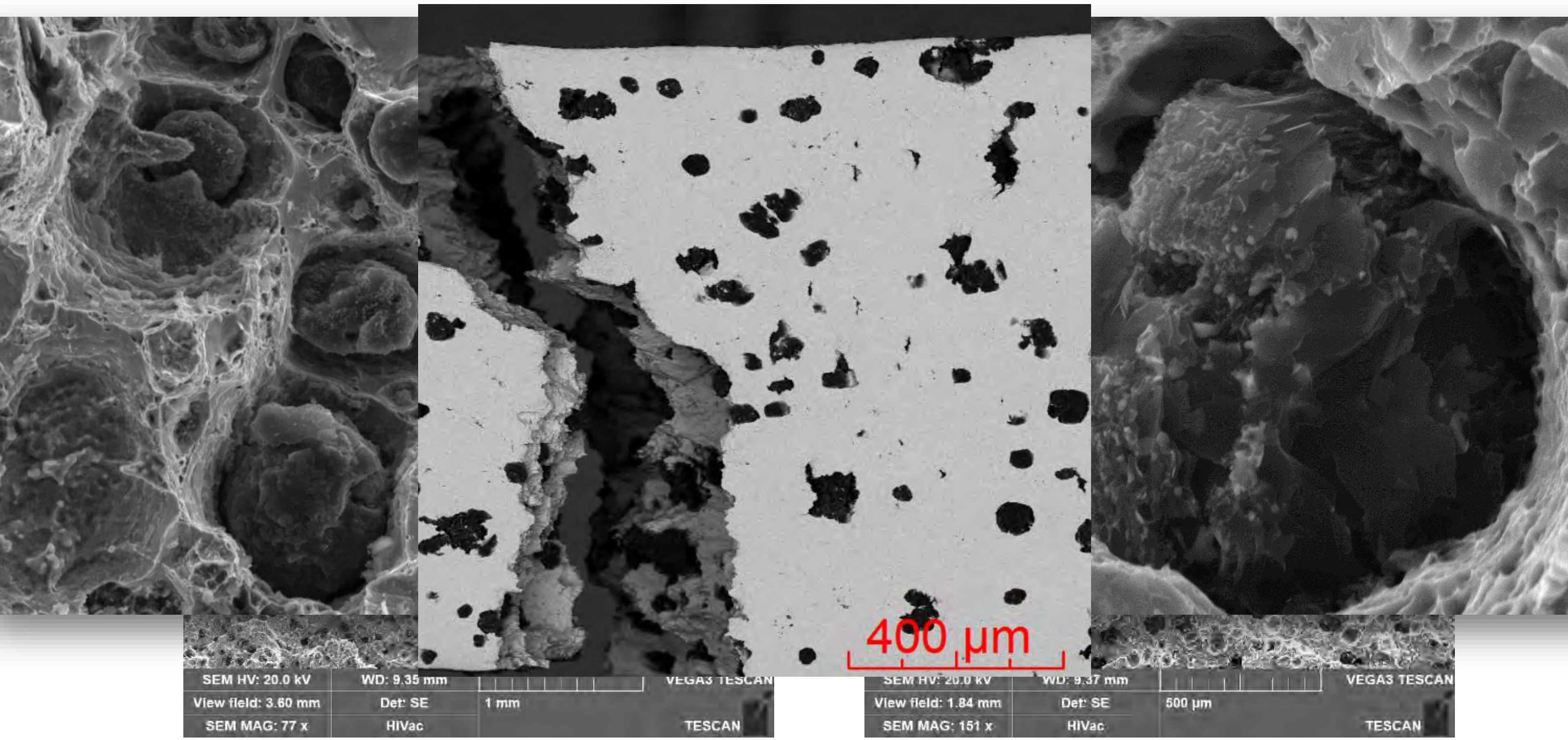
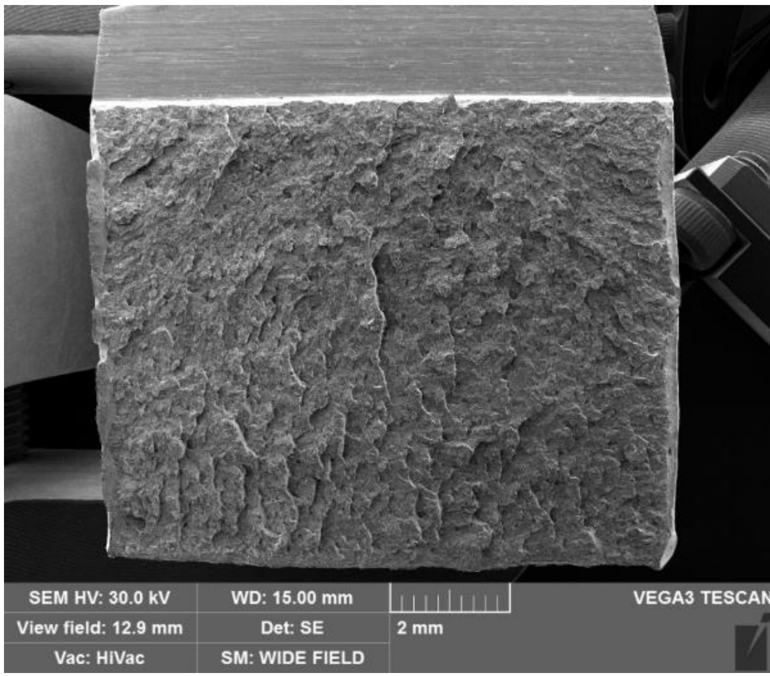
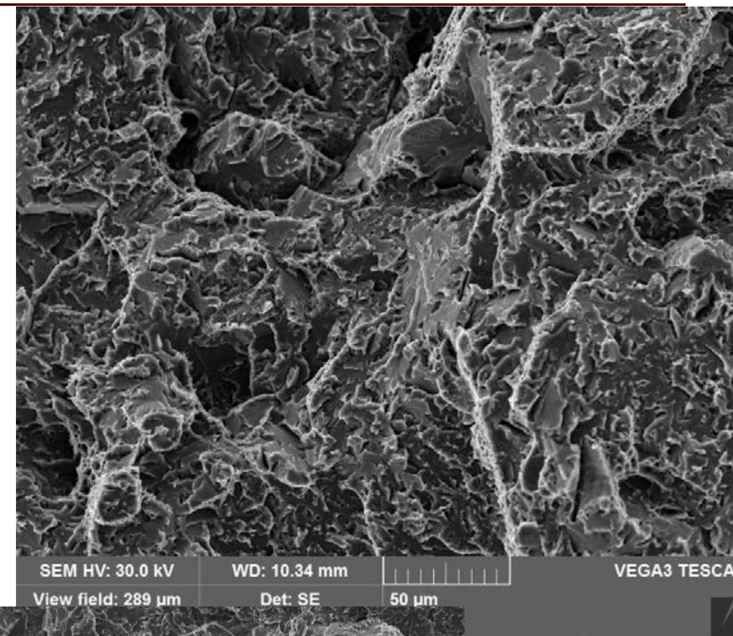
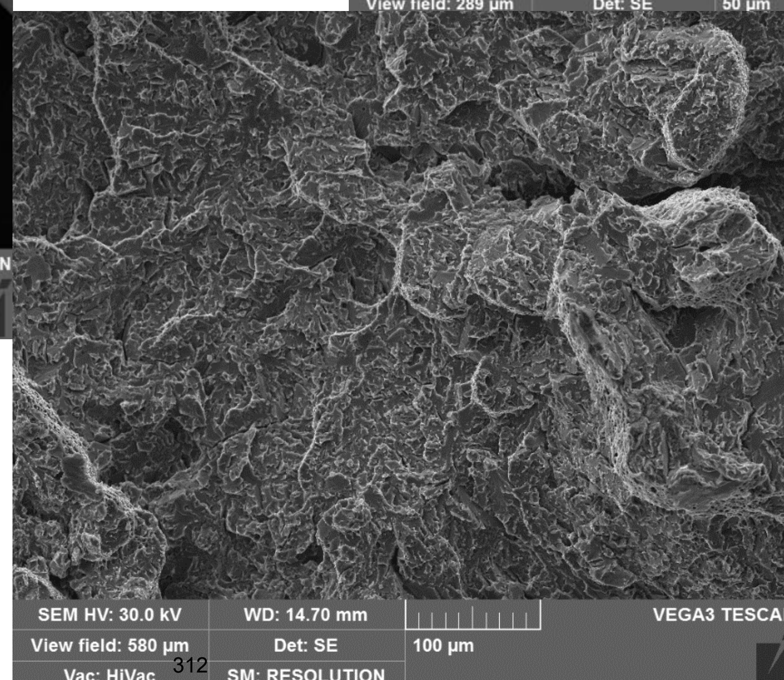


# OBLAST VYUŽITÍ EM

- **ZOBRAZOVÁNÍ – IDENTIFIKACE LOMŮ**



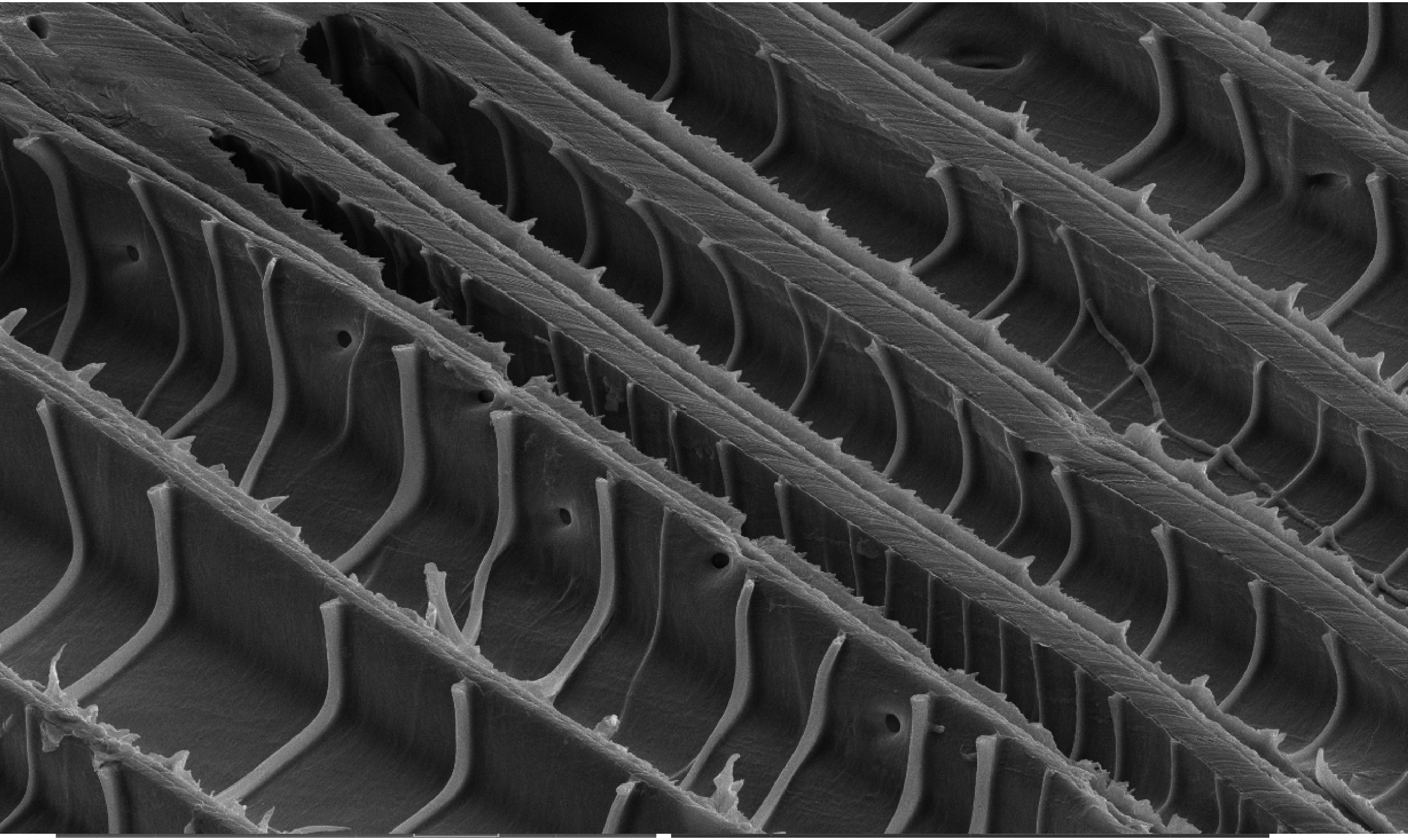



# OBLAST VYUŽITÍ EM

## ➢ ZOBRAZOVÁNÍ – BIO INSPIROVANÉ INŽENÝRSTVÍ

# OBLAST VYUŽITÍ EM

## ➢ ZOBRAZOVÁNÍ – BIO INSPIROVANÉ INŽENÝRSTVÍ



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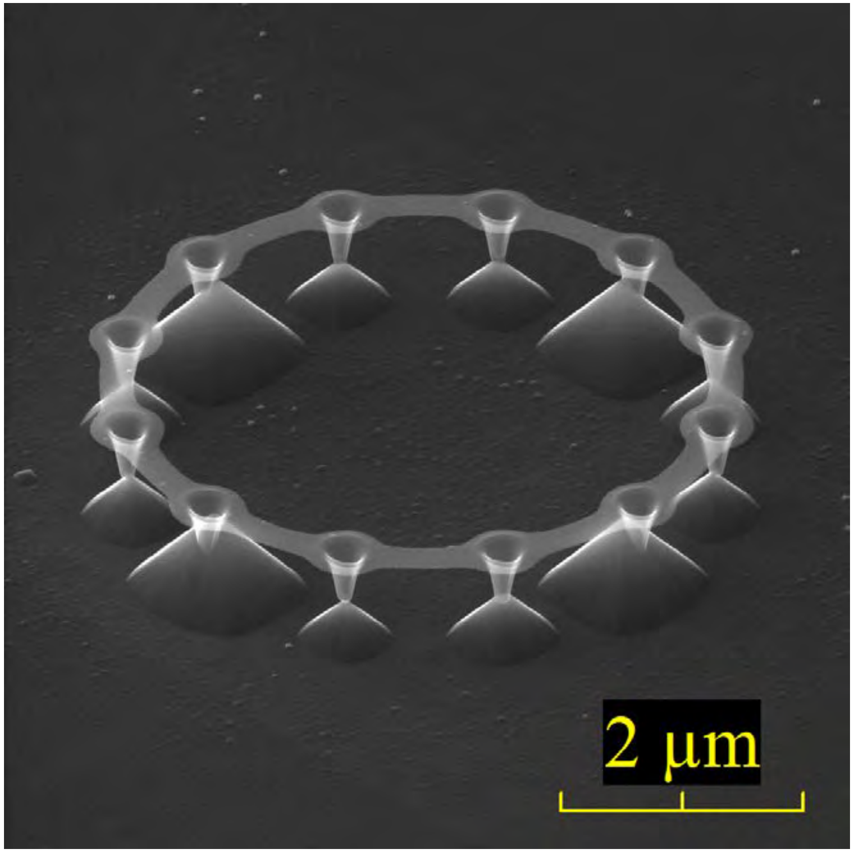
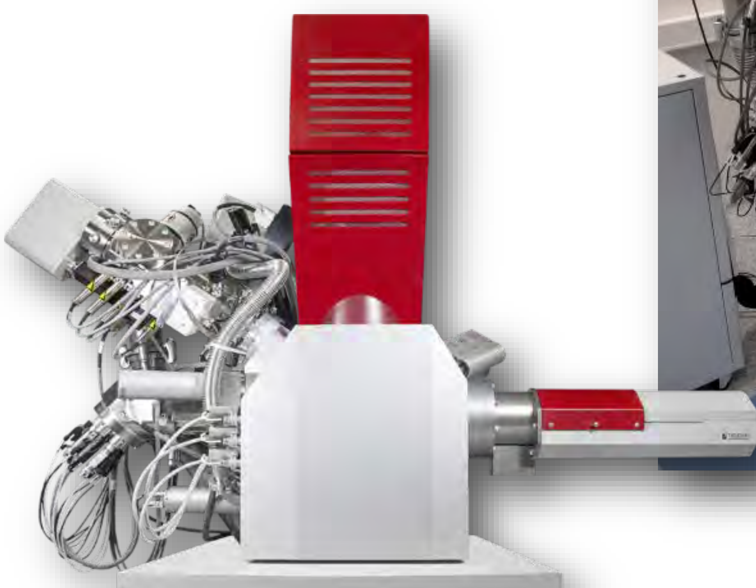
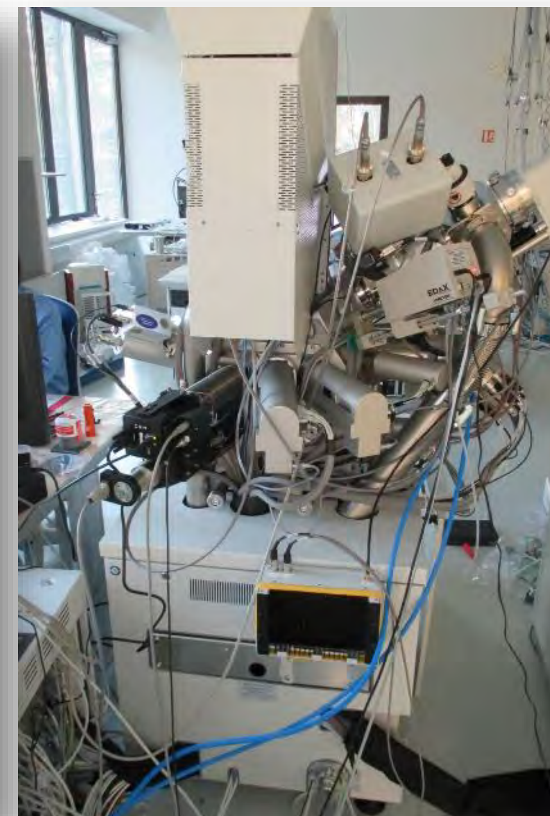
- **NENÍ MIKROSKOP JAKO MIKROSKOP**



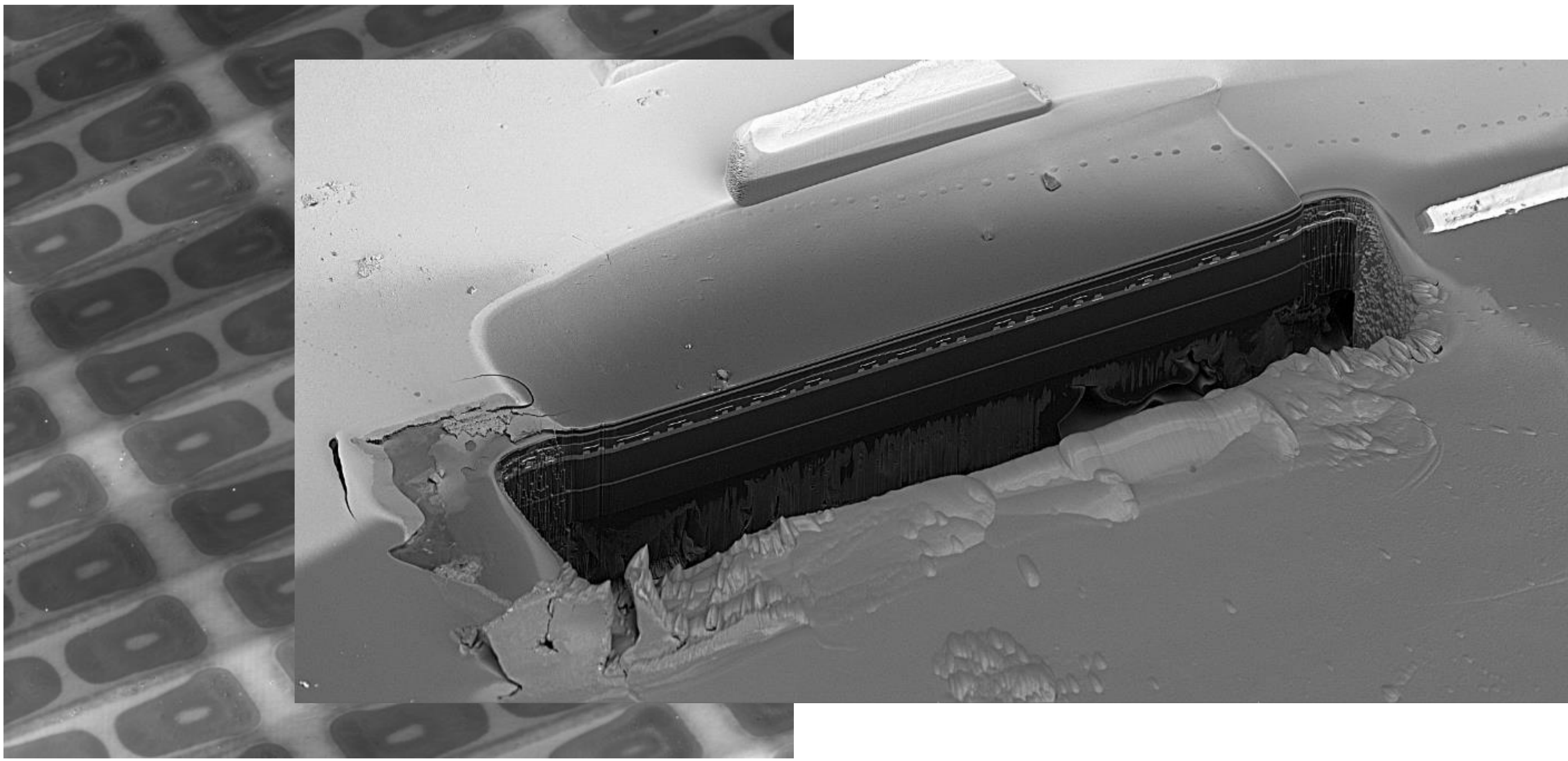



TESCAN



# NENÍ MIKROSKOP JAKO MIKROSKOP

## ➢ ŘEŠENÍ PROBLÉMU V NANOSVĚTĚ



# NENÍ MIKROSKOP JAKO MIKROSKOP

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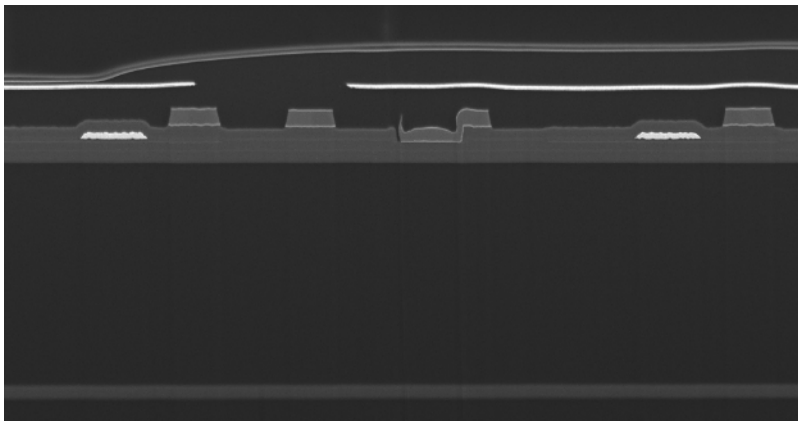
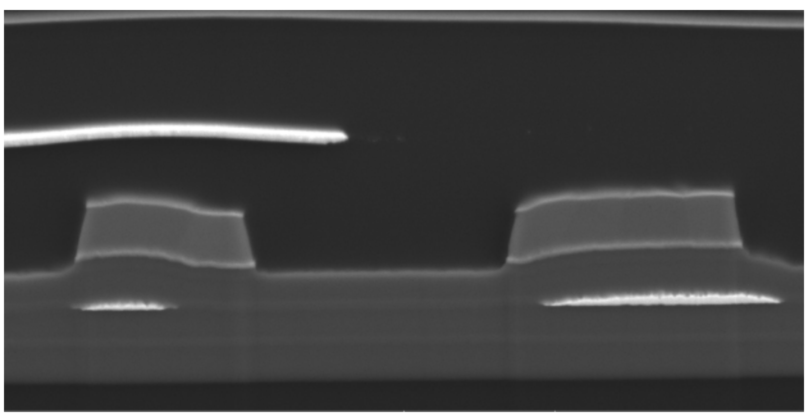
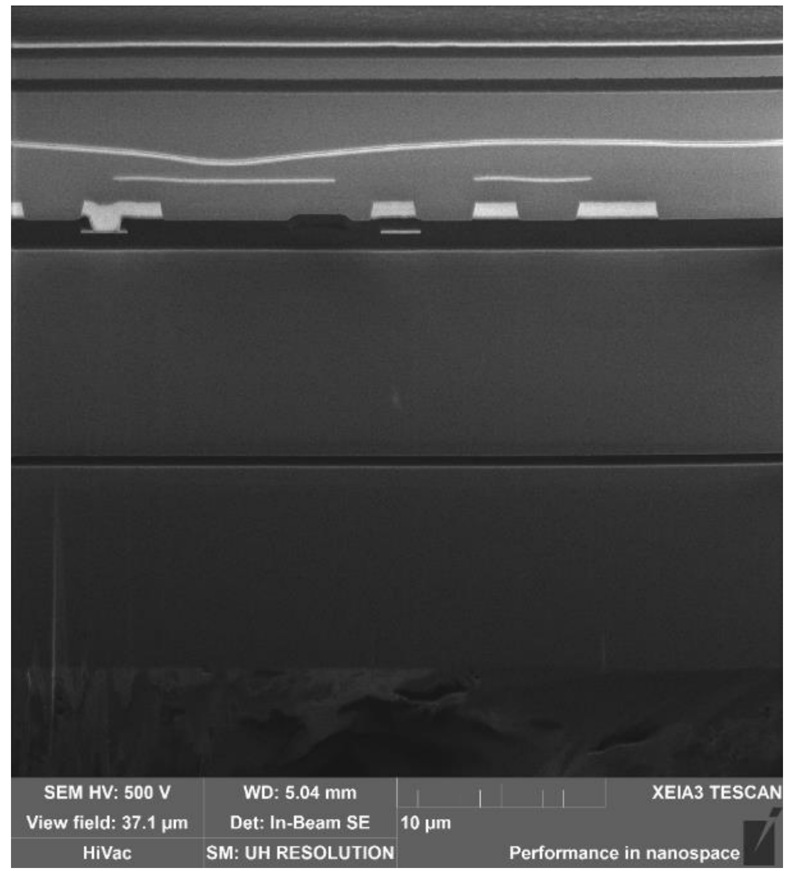
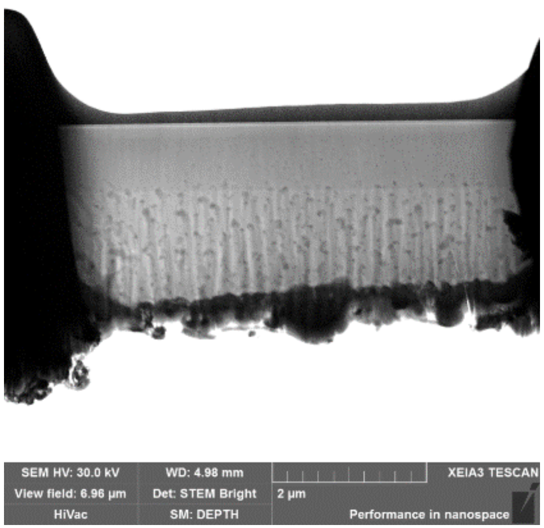




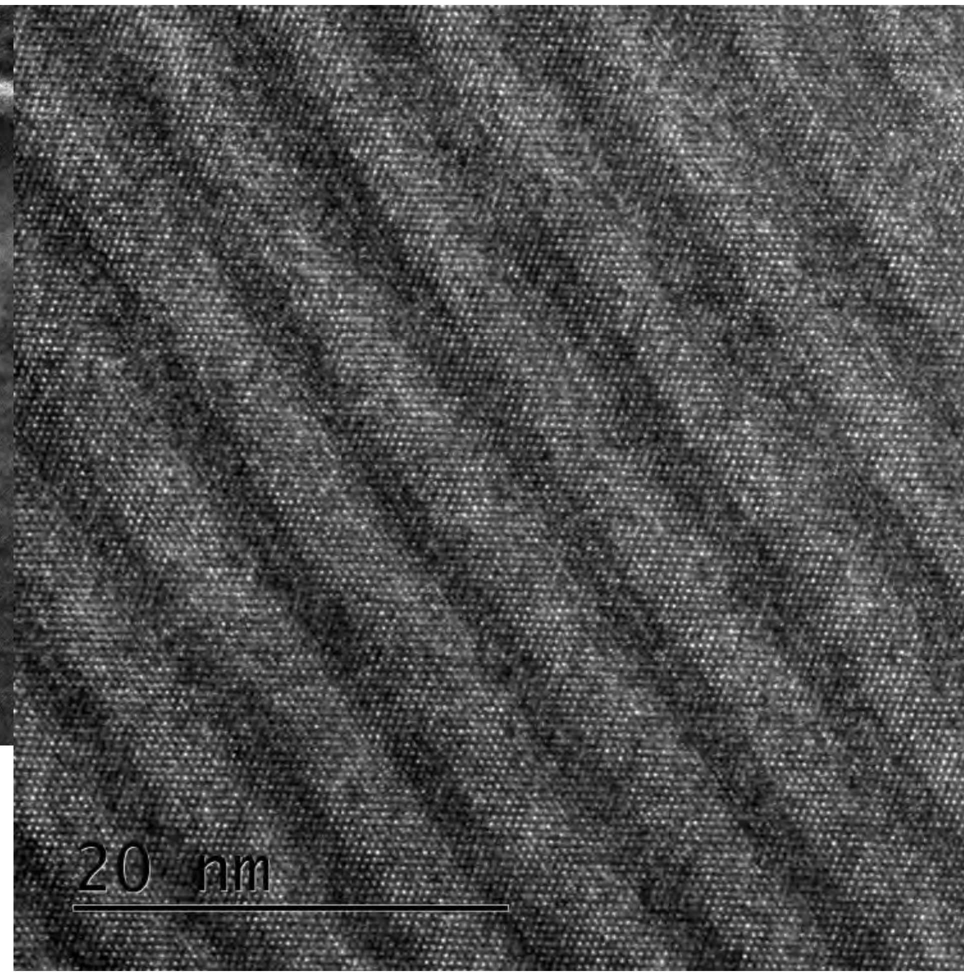


# NENÍ MIKROSKOP JAKO MIKROSKOP

## ➢ ŘEŠENÍ PROBLÉMU V NANOSVĚTĚ

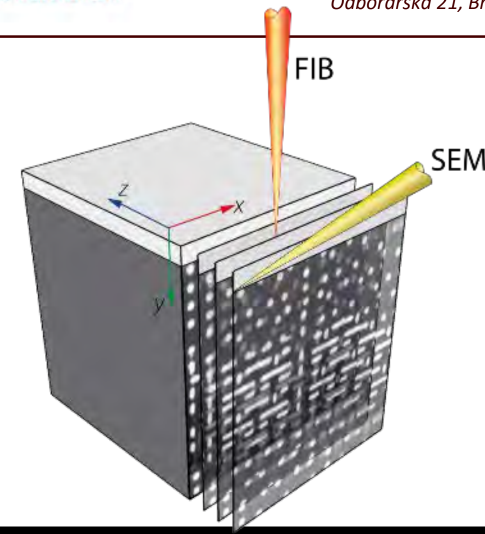


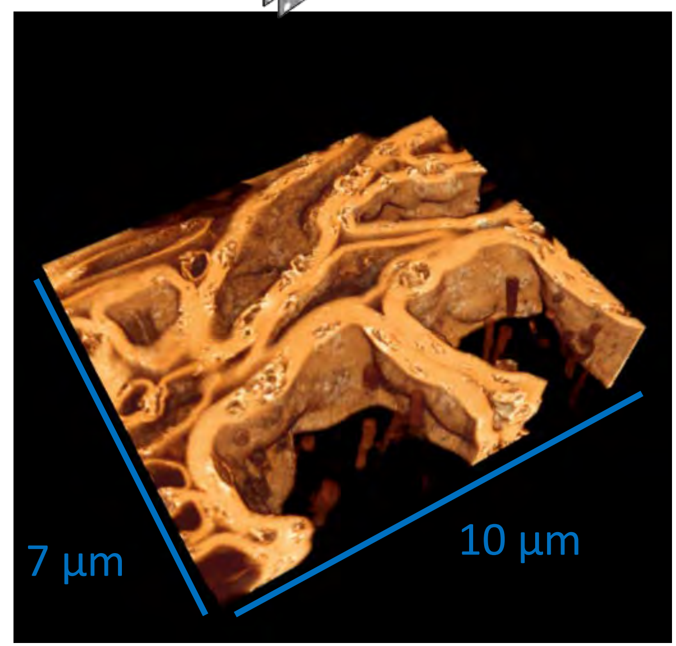


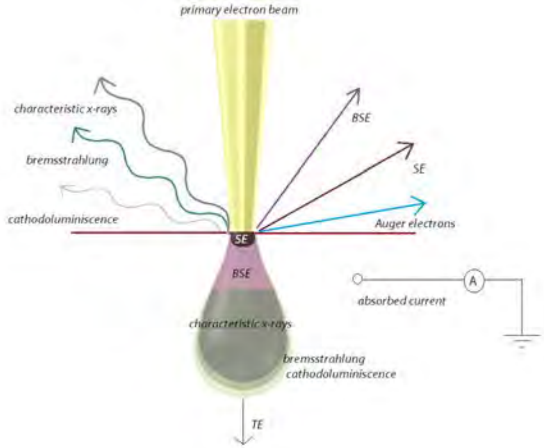


# NENÍ MIKROSKOP JAKO MIKROSKOP

- **3D REKONSTRUKCE TKÁNĚ**

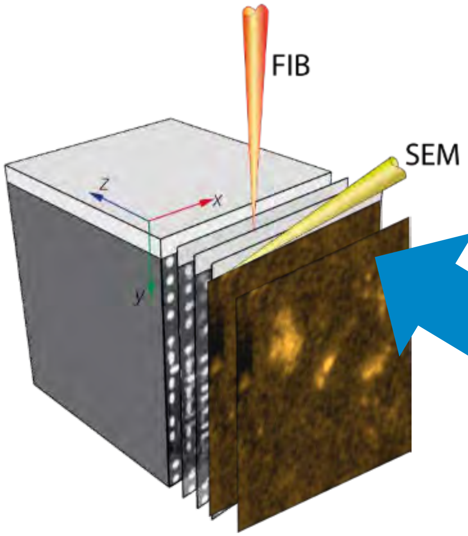


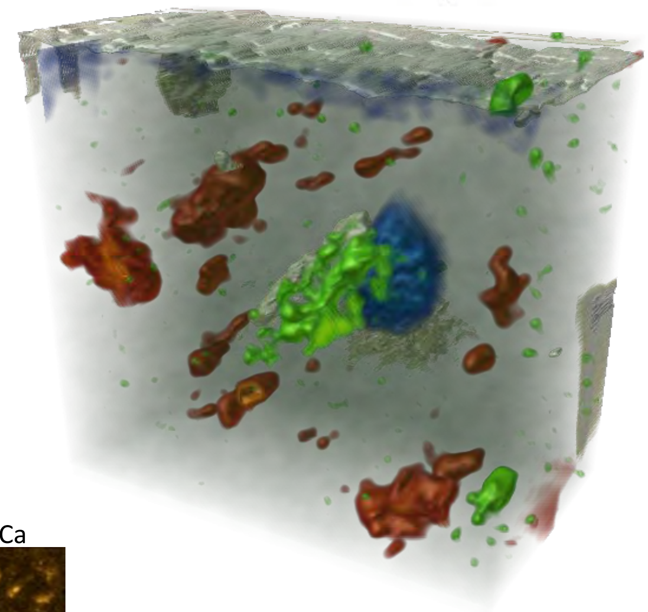


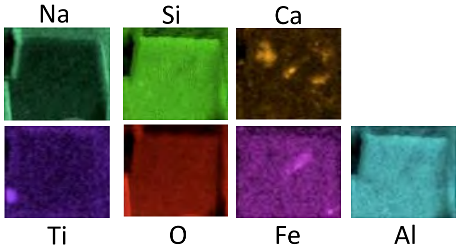

# NENÍ MIKROSKOP JAKO MIKROSKOP

## ➢ CHEMICKÁ ANALÝZA - EDX




Chemické zobrazování

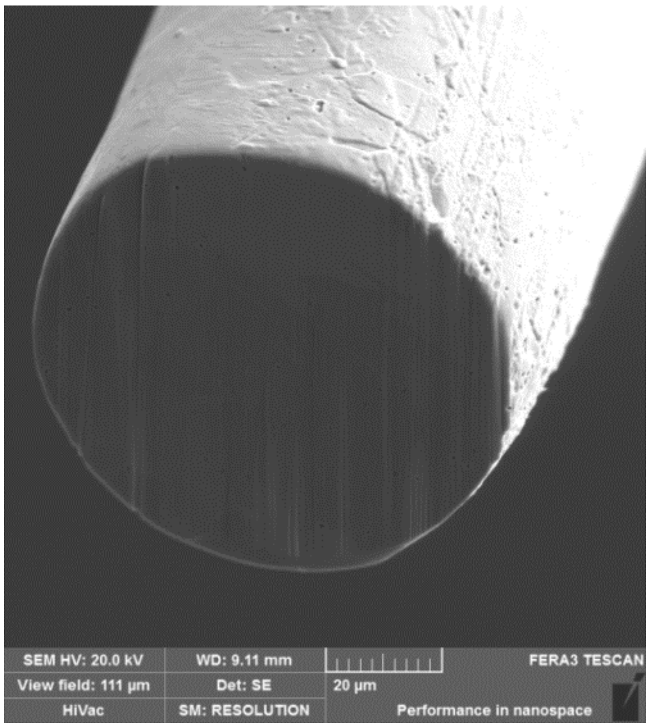


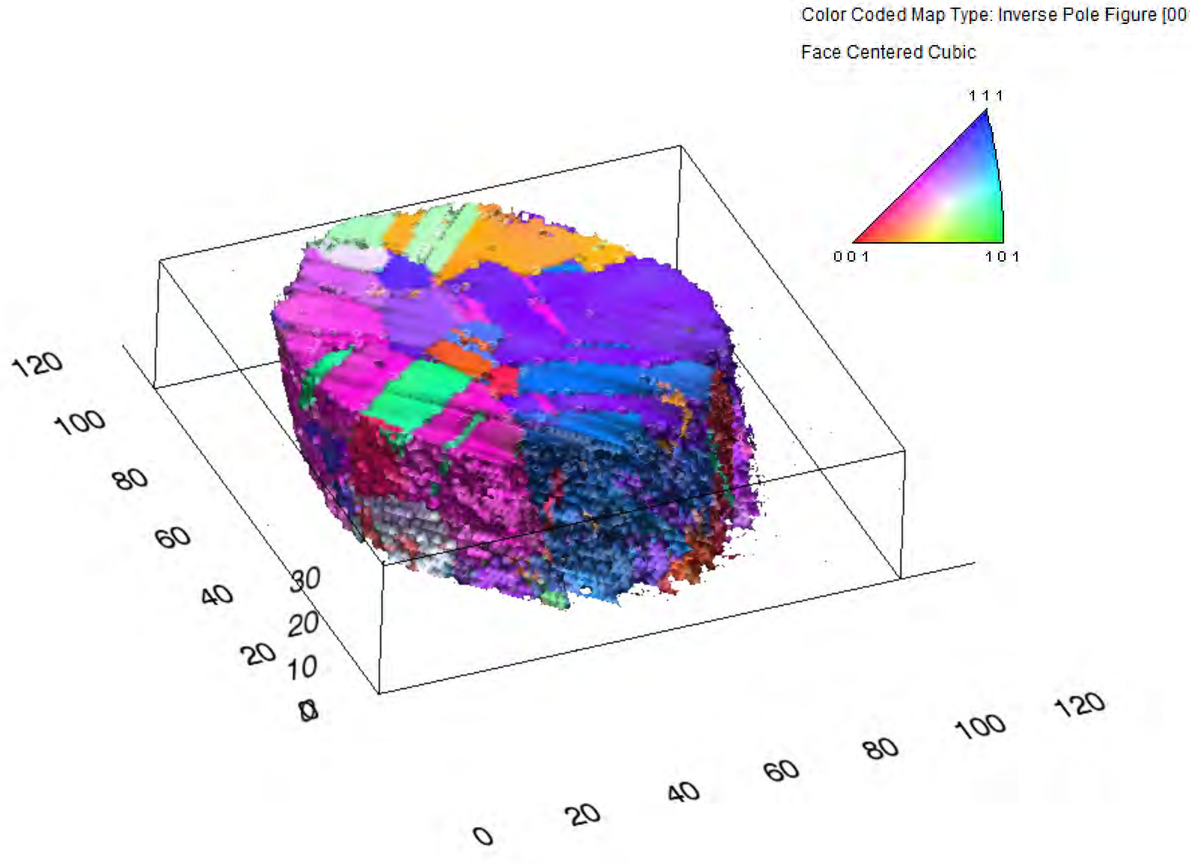



3D EDX analýza

# NENÍ MIKROSKOP JAKO MIKROSKOP

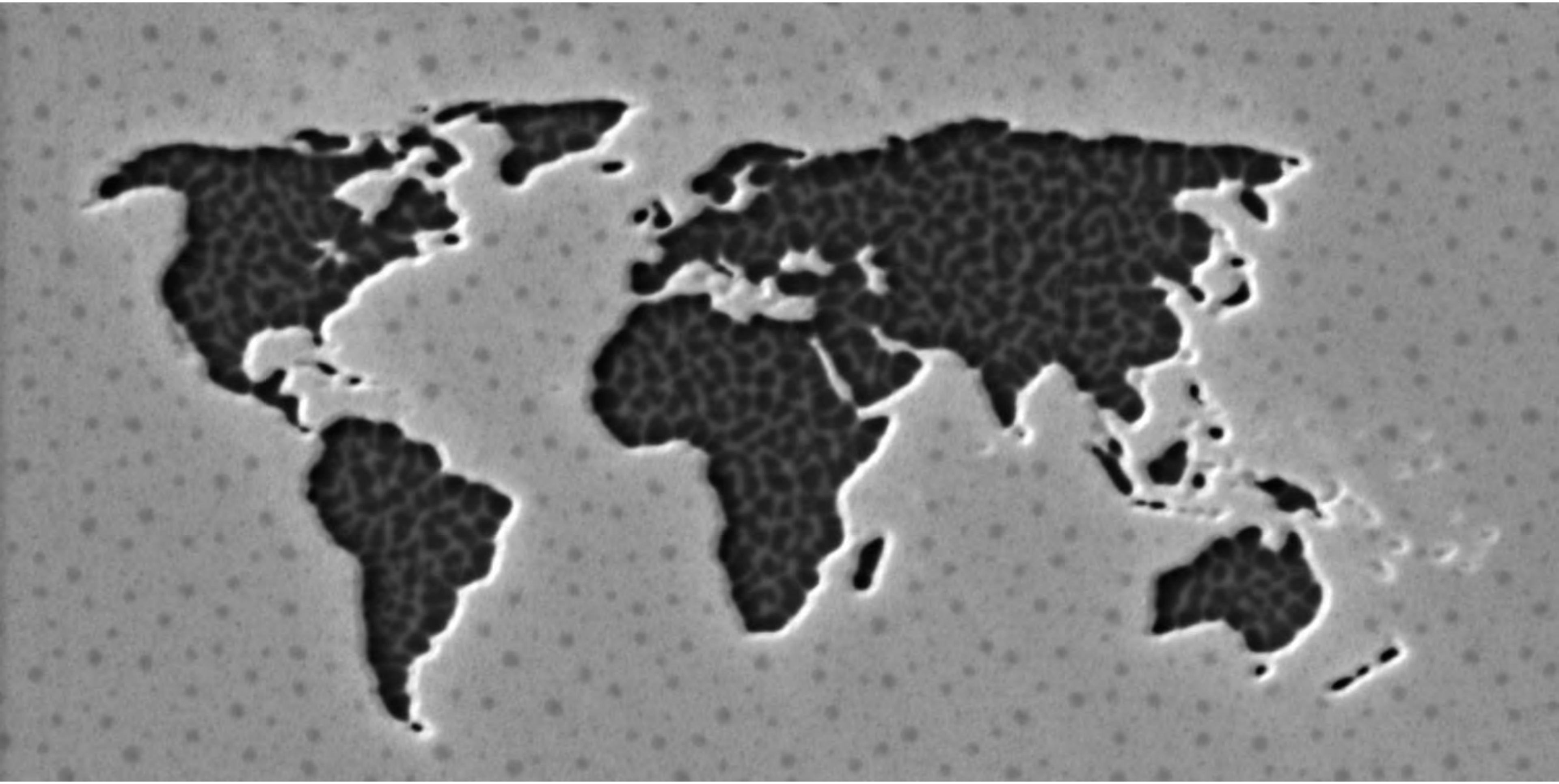
- **EBSD**




3D EBSD analýza

# DĚKUJI ZA POZORNOST



# CONTACTLESS MULTIDIMENSIONAL RIVER BED MEASUREMENT

**Ing. Martin Kalafut, PhD.** [1]

[1] AGIS Slovakia, spol. s r.o.

**Abstract**

*The main goal of the presentation was to provide a basic information about contactless mapping system designed for mapping and inspection of river's bed. Such complex measuring system consists of the two integrated multibeam sonar heads transmitting sound signals in the interval of 200-400 kHz adjustable by the user with 10 kHz step. The signals – after their echo reception – are processed in real time by an appropriate managing software. Additional important parts of the whole mapping system are gyrocompass, velocity sensor and a GNSS receiver for positioning. All devices are mounted on a measuring vessel. After a mapping mission of an area of interest, all recorded data is processed in a suitable postprocessing software package, where everything is analysed, graphically presented and exported into a corporate GIS (Geographical Information System) for their integration and further analysis.*

*Key words: multibeam echosounder, gyrocompass, GNSS, real-time and postprocessing software, GIS*

3rd INTERNATIONAL CONFERENCE

# 3D MEASUREMENT AND IMAGING

*MODERN CONTACTLESS MEASUREMENTS IN INDUSTRIAL PRACTICE*

# CONTACLESS MULTIDIMENSIONAL MEASUREMENT OF RIVER´S BED

Ing. Martin Kalafut, Ph.D.

# BEZKONTAKTNÉ VIACDIMENZIONÁLNE MERANIE RIEČNEHO DNA

- Projekt:

***FAIRway Danube***
***INEA/CEF/TRAN/M2014/1043119***

# BEZKONTAKTNÉ VIACDIMENZIONÁLNE MERANIE RIEČNEHO DNA

- Meracie plavidlo

# BEZKONTAKTNÉ VIACDIMENZIONÁLNE MERANIE RIEČNEHO DNA

- Merací systém

# BEZKONTAKTNÉ VIACDIMENZIONÁLNE MERANIE RIEČNEHO DNA

- Merací systém Kongsberg
  - MBES EM2040C Dual Head

The EM 2040C (C for Compact) is a shallow water multibeam echo sounder based on the EM 2040 technology, an ideal tool for any high resolution mapping and inspection application. The receiver and transmitter are integrated in a common sonar head, with the same dimensions as its predecessor EM 3002. The system fulfils and even surpasses the IHO-S44 special order and the more stringent LINZ specification.

## EM 2040C multibeam system features

- High resolution
- Wide frequency range
- Short pulse lengths and large bandwidth
- Extended range due to Frequency Modulated (FM) chirp
- Complete roll and pitch stabilization
- Nearfield focusing both on transmit and receive
- Water column data (standard)
- Seabed image (standard)
- Sonar head is depth rated to 50 m
- Easy to install, convenient for small boats
- Single and Dual Head models
- Dual swath (multiple pings)

Dual head configuration

# BEZKONTAKTNÉ VIACDIMENZIONÁLNE MERANIE RIEČNEHO DNA

| | |
|---|---|
| Frequency range: | 200 to 400 kHz in steps of 10 kHz |
| Beam width: | 1 * 1 degree at 400 kHz |
| Max ping rate: | 50 Hz |
| Swath coverage sector: | Up to 130 degrees (single head) / 200 degrees (dual head) |
| Sounding patterns: | Equiangular, equidistant and high density |
| No. of soundings per ping: | 400 (single head, single swath)<br>800 (single head, dual swath)<br>1600 (dual head, dual swath) |
| Roll stabilised beams: | +/-15 degrees |
| Pitch stabilised beams: | +/-10 degrees |
| Yaw stabilised beams: | +/-10 degrees (Dual head) |

| Coverage example for EM 2040C in cold ocean water with bottom type rock (BS = - 10 dB), NL = 45 dB, FM mode | | | |
|---|---|---|---|
| **Operating frequency** | **Max depth** | **Max coverage across** | |
| | | **Single head** | **Dual head** |
| 200 kHz | 520 m | 580 m | 700 m |
| 300 kHz | 450 m | 580 m | 670 m |
| 350 kHz | 400 m | 510 m | 600 m |
| 400 kHz | 350 m | 375 m | 530 m |

| | **200 - 400 kHz in 10 kHz step** | **200 - 400 kHz in 10 kHz step** |
|---|---|---|
| | **CW** | **FM** |
| **Pulse lengths** | 14, 27, 54, 135, 324 and 918 µs | 3 and 12 ms |

# BEZKONTAKTNÉ VIACDIMENZIONÁLNE MERANIE RIEČNEHO DNA

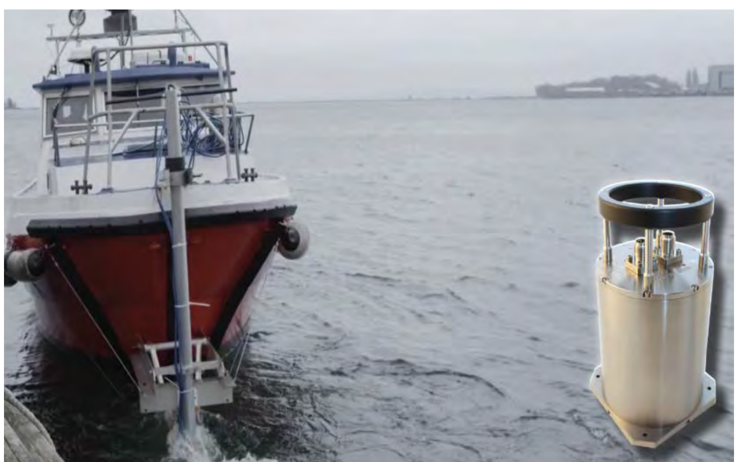
| Physical dimensions (excluding connectors and mounting arrangements) | | | |
|---|---|---|---|
| Sonar head EM 2040C | 332 x 119 (diameter x height) | 18.8 kg (8.4 kg in water) | Depth rating 50 m |
| Sonar head EM 2040CX | 332 x 122 (diameter x height) | 26.1 kg (17 kg in water) | Depth rating 1500 m |
| Processing Unit (2U 19" rack) | 482.5 x 424 x 88.6 mm (WxDxH) | 10.5 kg | NA |

# BEZKONTAKTNÉ VIACDIMENZIONÁLNE MERANIE RIEČNEHO DNA

## MGC R3 SB50

**Typical applications**

The MGC R3 SB50 is designed for portable seabed mapping systems where the MGC is to be mounted on the multibeam transducer head. With input of data from a GNSS system, the MGC R3 SB50 is a fully inertial navigation system (INS). It can output heading, roll, pitch, heave and position. Acceleration and velocity of linear motions, as well as angular rates, are output from the unit. The MGC product outputs both processed and raw (gyro and accelerometer) sensor data.



### FEATURES MGC R3 SB50

- 0.01° roll and pitch accuracy
- 0.08° secant latitude heading accuracy with GNSS aiding
- Includes INS capability
- Delivered in titanium housing, depth rated to 50 metres
- Outputs on RS-422 and Ethernet
- High output data rate (200 Hz)
- Precise heave at long wave periods by use of PFreeHeave® algorithms
- Lever arm compensation to two individually configurable monitoring points
- Small size and low power consumption
- Each MGC delivered with a Calibration Certificate
- Selectable communication protocols in the Windows based configuration software

# BEZKONTAKTNÉ VIACDIMENZIONÁLNE MERANIE RIEČNEHO DNA

| **ORIENTATION OUTPUT** | |
|---|---|
| Angular orientation range | ±180° |
| Resolution in all axes | 0.001° |
| Accuracy roll, pitch | 0.01° RMS |
| Accuracy heading (GNSS aided) | 0.08° RMS sec.lat |
| Heading settling time (typical) | 17 min from start-up |

| **GYRO OUTPUT** | |
|---|---|
| Angular rate range | ±149°/s |
| Angular rate noise | 0.010°/s RMS |
| Bias stability (absolute bias) | 0.008°/h RMS |
| Angle Random Walk | 0.008°/ √h |
| Scale factor error | 0.001 % RMS |

| **ACCELERATION OUTPUT** | |
|---|---|
| Acceleration range (all axes) | ±45 m/s2 |
| Bias stability (absolute bias) | 80 µg RMS |
| Acceleration noise | 0.0002 m/s2 RMS |
| Velocity Random Walk | 3.3 µg/√h |
| Scale factor error | 0.008% RMS |

| **HEAVE OUTPUT** | |
|---|---|
| Output range | ±50 m, adjustable |
| Periods (real-time) | 0 to 25 s |
| Periods (delayed) | 0 to 50 s |
| Heave accuracy (real-time) | 5 cm or 5% whichever is highest |
| Heave accuracy (delayed) | 2 cm or 2% whichever is highest |

| **POSITION OUTPUT** | |
|---|---|
| Free inertial | 5 nm/h |

| | |
|---|---|
| Analog channels (junction box) | # 4, ±10 V, 14 bit resolution |
| Ethernet output ports | 5 |
| Ethernet UPD/IP | 10/100 Mbps |
| Digital output variables | 24 (max), Serial or Ethernet |
| Data output rate (max) | 200 Hz |
| Timing | < 1 ms |

| **ENVIRONMENTAL SPECIFICATIONS** | |
|---|---|
| Temperature range | -5 °C to +55 °C |
| Humidity range, electronics | Sealed, no limit |
| Vibration | IEC 60945/EN 60945 |

| **ELECTROMAGNETIC COMPATIBILITY** | |
|---|---|
| Compliance to EMCD, immunity/emission | IEC 60945/EN 60945 |

| **OTHER DATA** | |
|---|---|
| MTBF (computed) | 50000 h |
| Dimensions (HxLxW) | 275 x 184 x 184 mm |
| Material | Anodised aluminium |
| Dry weight | 10.5 kg |
| Submerged weight | 5.5 kg |
| Connector | 2 8-pin Seacon 5506-1508 (male) |

**INPUT FORMATS**
NMEA 0183, incl. GGA, VBW, VTG, ZDA or MRU Normal format

**OUTPUT FORMATS**

| | |
|---|---|
| - MRU normal | - Sounder |
| - NMEA 0183 proprietary | - EM3000 |
| - Atlas Fansweep | - TSS1 |
| - Seapath binary 23, 25, 26 | - PFreeHeave® |

| **ELECTRICAL** | |
|---|---|
| Power requirements | 12 to 28 V DC, max 12 W |
| Serial ports: | |
| Com1 | Bidirectional RS-422 |
| Com2 | Output only, RS-422 |
| Com3 & Com4 | Input only, user configurable RS-232, RS-422 |

# BEZKONTAKTNÉ VIACDIMENZIONÁLNE MERANIE RIEČNEHO DNA

- MiniSVS (Sound Velocity Sensor)


## Sound Velocity Measurement

Each sound velocity measurement is made using a single pulse of sound travelling over a known distance, so is independent of the inherent calculation errors present in all CTDs. Our unique digital signal processing technique virtually eliminates signal noise, and gives almost instantaneous response; the digital measurement is also entirely linear, giving predictable performance under all conditions.

| | | |
|---|---|---|
| Range: | 1375 - 1900m/s | |
| Resolution: | 0.001m/s | |
| Accuracy: | Dependent on sensor size | |
| 100mm | Random noise (point to point) | ±0.002m/s |
| | Max systematic calibration error | ±0.013m/s |
| | Max systematic clock error | ±0.002m/s |
| | **Total max theoretical error** | **±0.017m/s** |
| 50mm | Total max theoretical error | ±0.019m/s |
| 25mm | Total max theoretical error | ±0.020m/s |

Acoustic Frequency: 2.5MHz

# BEZKONTAKTNÉ VIACDIMENZIONÁLNE MERANIE RIEČNEHO DNA

- miniSVP (Sound Velocity Profiler)


The miniSVP has been developed to provide a cost effective tool for the collection of Sound Velocity Profiles without compromising the quality of the data. Ideally suited to ROV, coastal, or small boat applications, the miniSVP will appeal to survey companies, military and academia alike, being simple to use and easy to handle.

**Sensors**

The miniSVP is fitted with Valeport's digital time of flight sound velocity sensor, a PRT temperature sensor, and strain gauge pressure transducer.

| | |
|---|---|
| **Sound Velocity** | |
| Range: | 1375 - 1900m/s |
| Resolution: | 0.001m/s |
| Accuracy: | ±0.02m/s |
| **Temperature** | |
| Range: | -5°C to +35°C |
| Resolution: | 0.001°C |
| Accuracy: | ±0.01°C |
| **Pressure** | |
| Range: | 5, 10, 30, 50, 100, 300 or 600 Bar |
| Resolution: | 0.001% range |
| Accuracy: | ±0.05% range |

# BEZKONTAKTNÉ VIACDIMENZIONÁLNE MERANIE RIEČNEHO DNA

- GNSS prijímač Trimble R10-2 (NMEA: GGA, GST, ZDA, VTG, 1PPS, SKPOS)

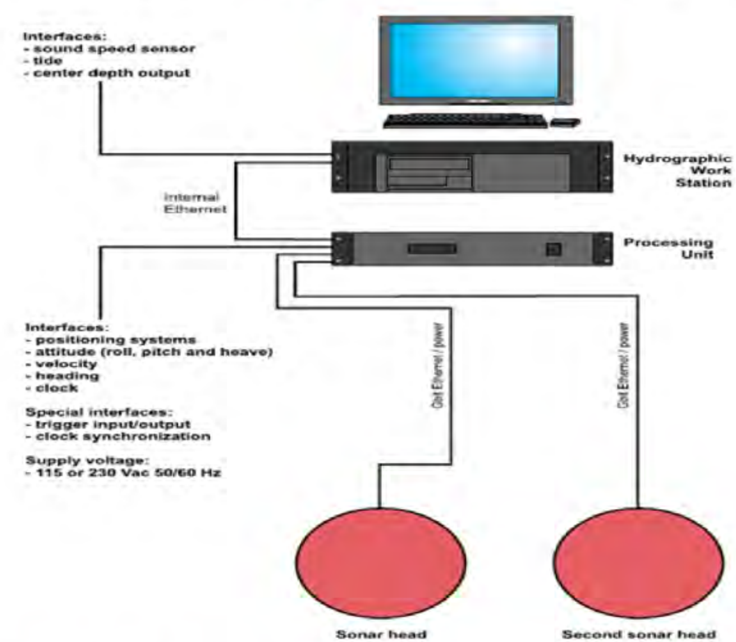
A new level of productivity

| 8 mm H / 15 mm V | 672 | Integrated |
|---|---|---|
| Max. Precision | Channels | Antenna |

# BEZKONTAKTNÉ VIACDIMENZIONÁLNE MERANIE RIEČNEHO DNA

- Schéma zapojenia

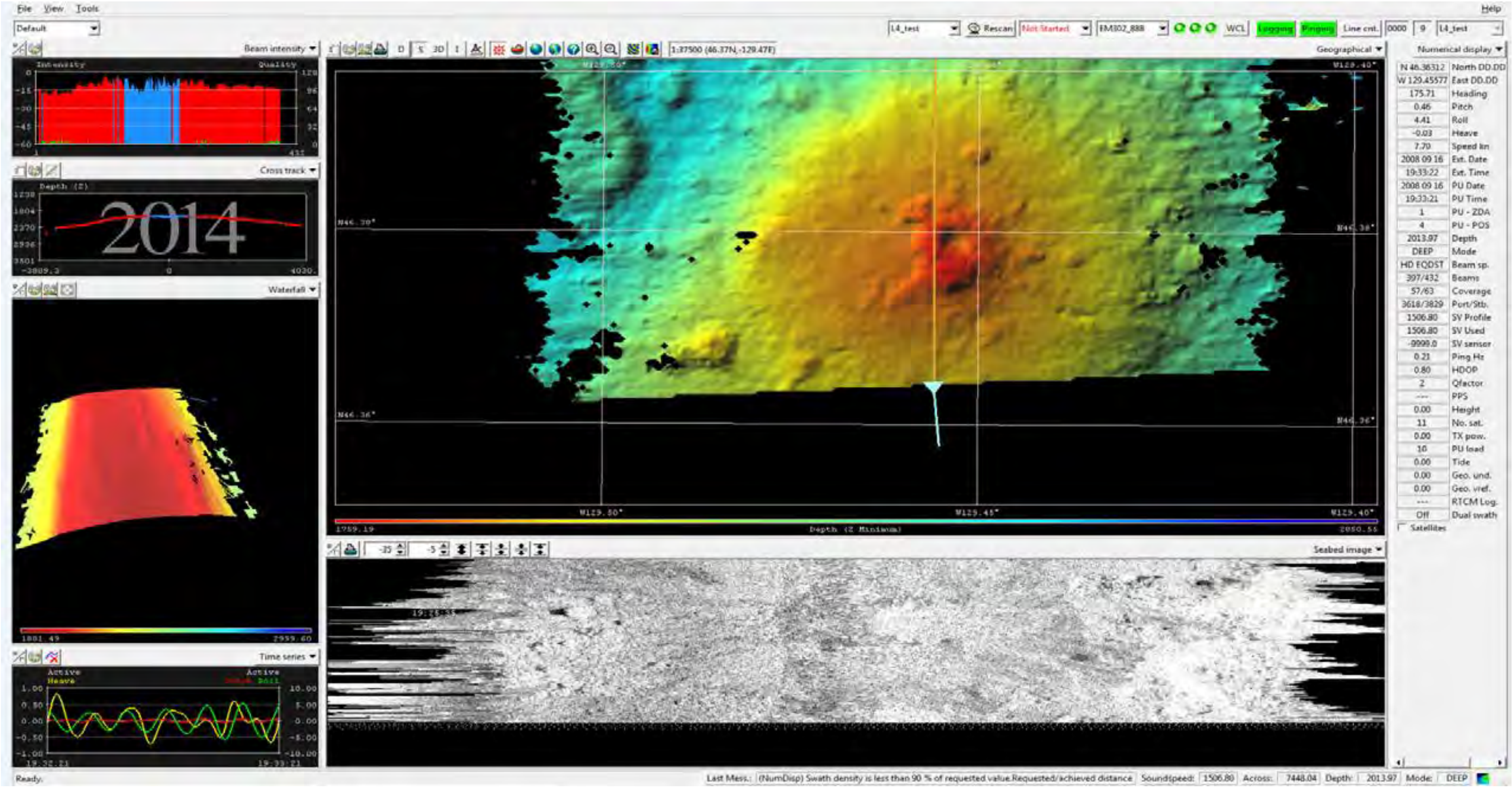
**4.1.1 System Diagram EM® 2040C Dual Head, Single Swath**




*Note: Dual Swath (1600 soundings per ping) is archeived for an EM 2040C Dual Head, Single Swath System by adding a second Processing Unit with 2 (two) CBMF (beamforming) cards installed.*

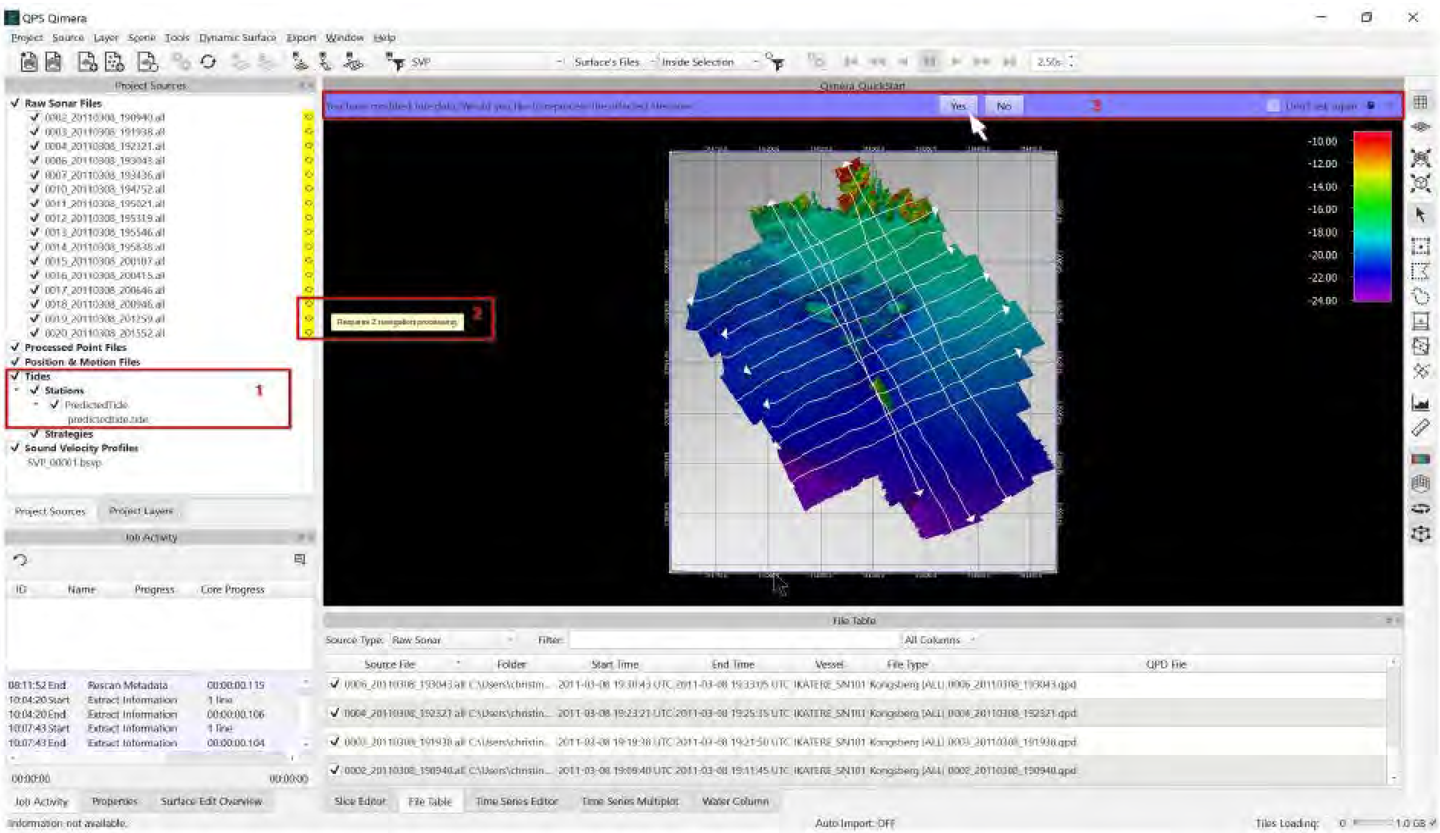
# BEZKONTAKTNÉ VIACDIMENZIONÁLNE MERANIE RIEČNEHO DNA

- SIS (Seabed Information System) riadiaci softvér



# BEZKONTAKTNÉ VIACDIMENZIONÁLNE MERANIE RIEČNEHO DNA

- QIMERA + FLEDERMAUS spracovateľský softvér



# ĎAKUJEM ZA POZORNOSŤ

***Title:*** Abstrakty a prednášky z 3. ročníka konferencie 2018 (Abstracts and Presentations of the 3rd International Conference **3D MEASUREMENT AND IMAGING**, held in Bratislava, Odborárska 21, Slovakia), October 10-11, 2018.
***Published by:*** SEA - Agentúra pre vzdelanie a vedu
***Editors and designers:*** Mgr. Michaela Reichelová, Mgr. Melinda Hegyiová
***Number of pages:*** 386

ISBN 978-80-972082-5-7 (e-document)

ISBN 978-80-972082-5-7