Breakthrough innovation by R&I collaborations

…in X-ray diffraction and imaging

EUREKA project E!3624 RELAXD

PANalytical

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Roelof de Vries
Sander Weijers
Klaus Bethke

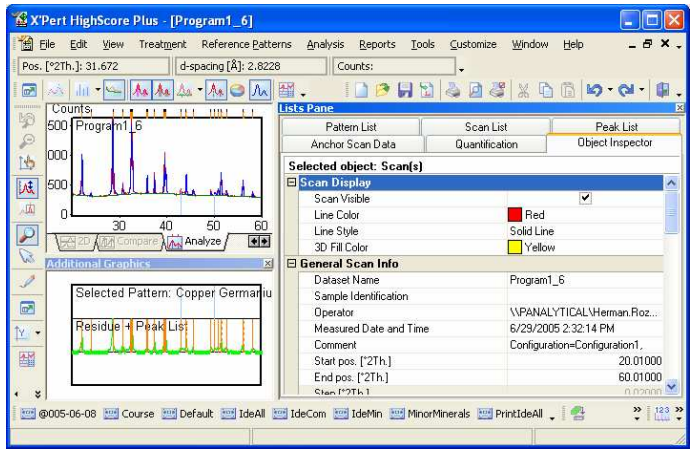
X2D group

Vladimir Kogan
Jan Visser
Johannes Bethke

Agenda

- Short introduction
- Innovations – detector roadmap
  - PIXcel – Medipix2
  - RELAXD technologies (large area)
- Examples
  - 2D- X-ray diffraction
  - X-ray imaging
- Conclusions and outlook

Materials analysis with XRD and XRF



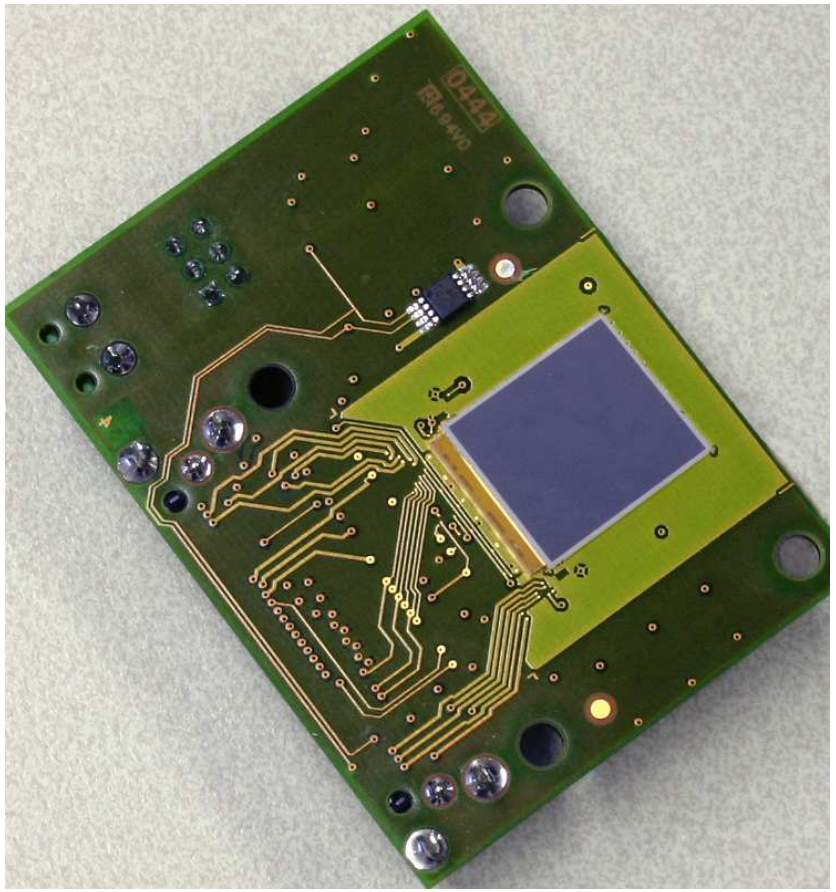
Relation with different fields

- E electrons
- N neutrons
- P particle physics
- B beta / radioact.
  G gamma
  A alpha
- X X-rays

=> applications	specs of priority
• Electron microscopy	large area, low noise, high-res
• Neutron radiography	other sensors
• High-energy physics	rad-hard
• Nuclear industry and Security	other sensors, large area
• Synchrotron	high dyn. range
• Medical imaging	other sensors, large area
• Astrophysics	high-speed r/o
• XRD / XRF NDT/CT of materials	everything

TWO EXTREMES

ATLAS End-Cap Toroïd
Schelde-Exotech, Vlissingen
Machine Fabriek Amersfoort, IJsselstein
HMA Power Systems, Ridderkerk



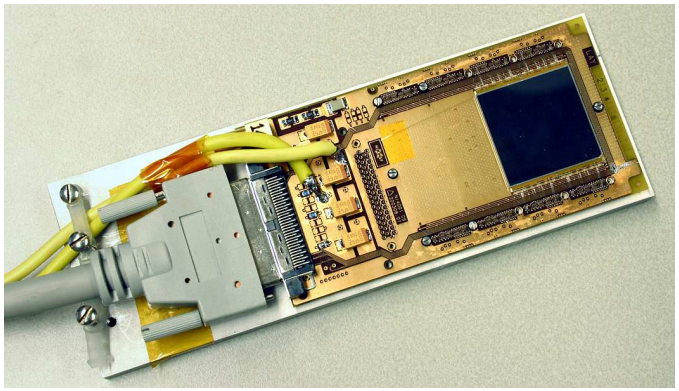
Medipix X-ray Imager
PANalytical, Almelo
INCAA, Apeldoorn
Hymec, Sittard

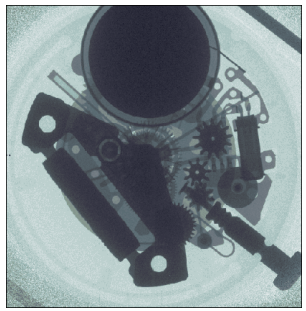
Quad-chip module

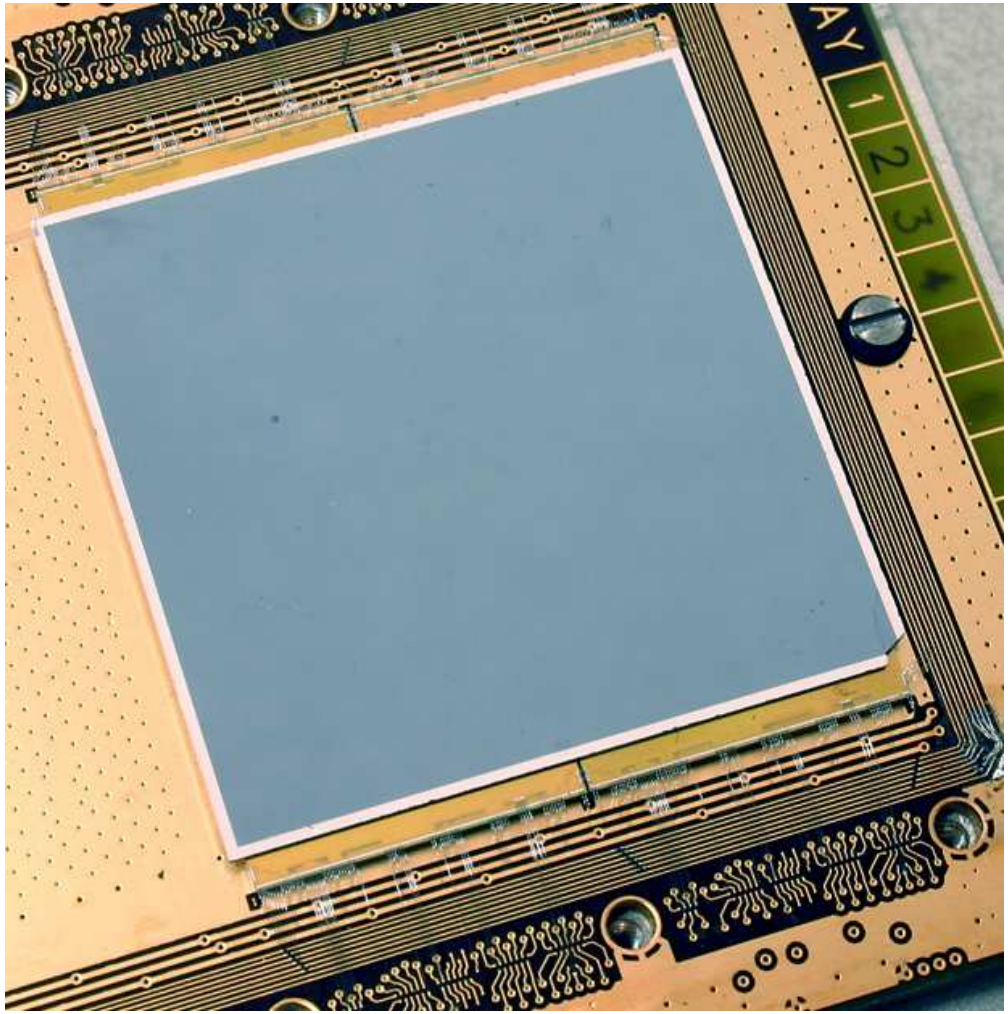
2x4 chip carrier

2x2 sensor

Swatch movie





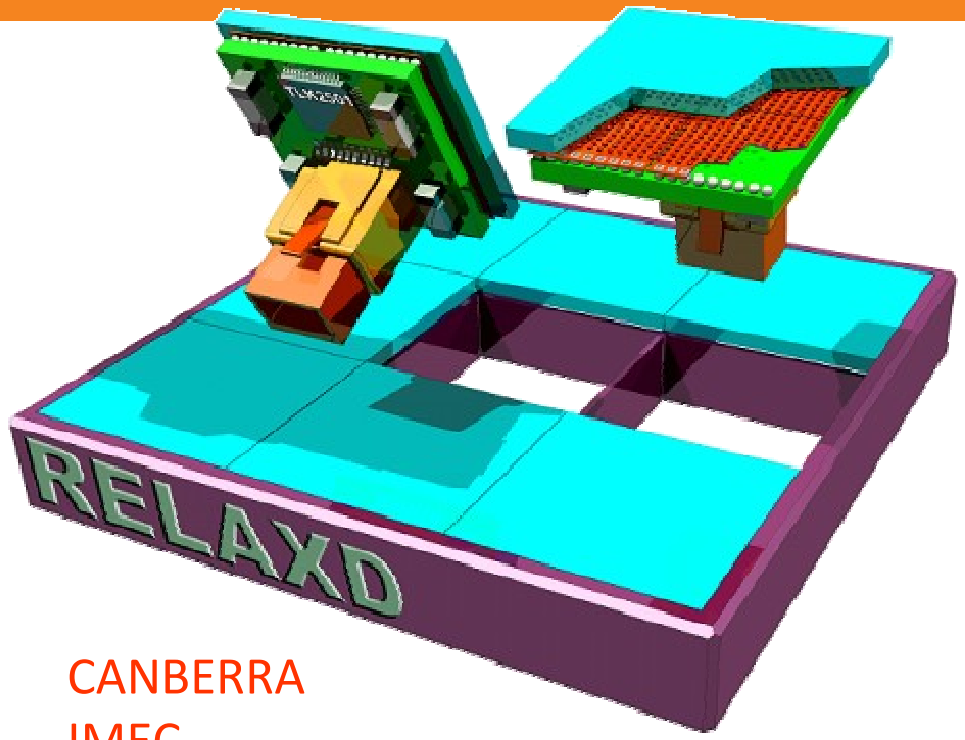


Present Design (5)

RELAXD

PANalytical

High **RE**solution **L**arge **A**rea **X**-ray **D**etector Fully tiled X-ray imager



CANBERRA
IMEC
NIKHEF
PANalytical

2006-2010

Four-side tilable Quad-Medipix modules

Fast serial readout at 3.125 Gigabit/s

http://www.nikhef.nl/pub/experiments/medipix

RELAXD

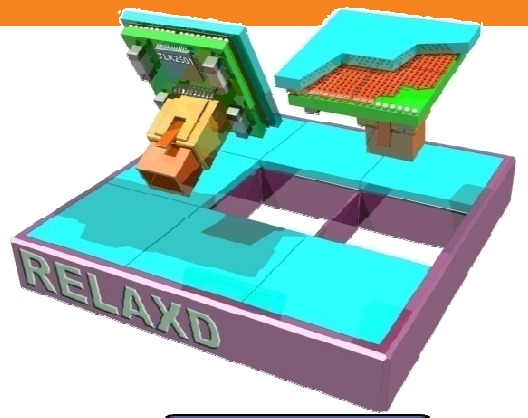
PANalytical

Software, Evaluation, Application
Data acquisiton strategies
Calibration procedures

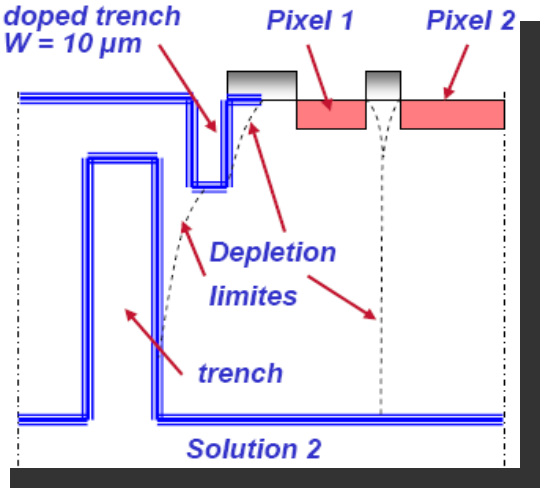
RELAXD work packages

- Edgeless Silicon Sensors (seamless tiling)
- Thinned CMOS pixel ASICs
  with Through-Silicon Via contacting
- High bandwidth readout
- Pixel redistribution (not funded)

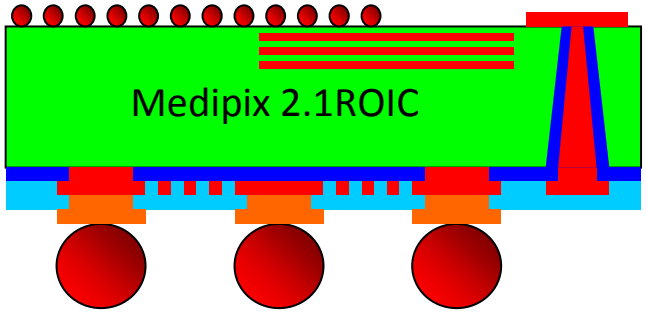
➢ Tile-able Microsystems, produced in Industry



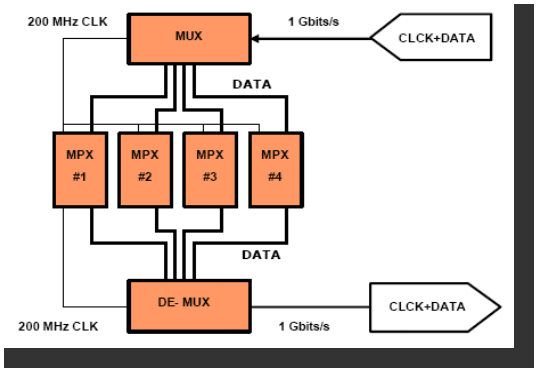
PANalytical



Canberra



IMEC

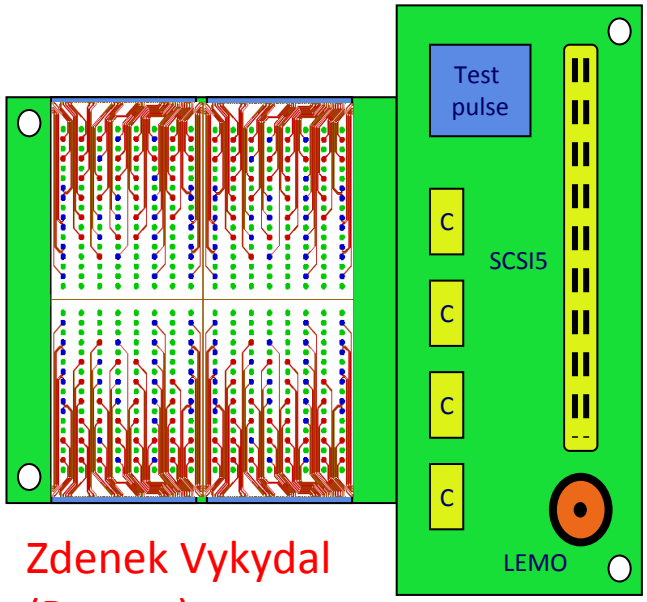


NIKHEF

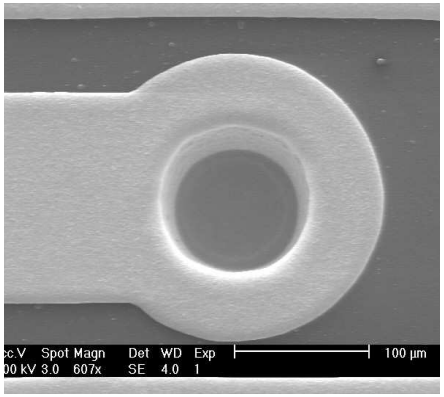
IMEC

Ball-Grid-Array replaces wire bonds
Robust, Easy Carrier design, better HF,
Thermal conductivity, Cooling

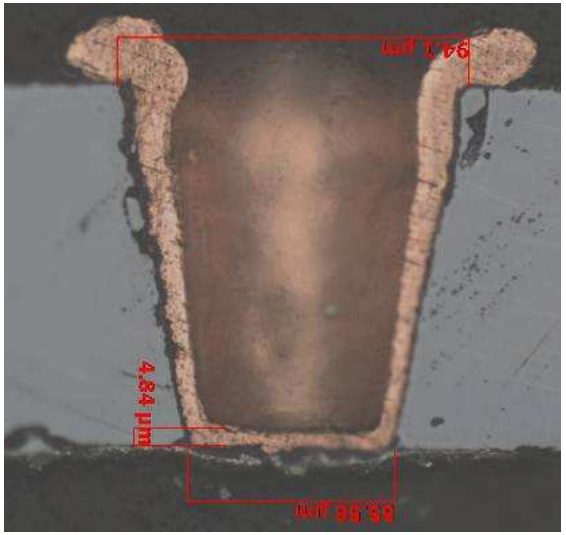
	3D-WLP via	1mm wirebond
R	20-30mΩ	~40mΩ *(25µm wire)*

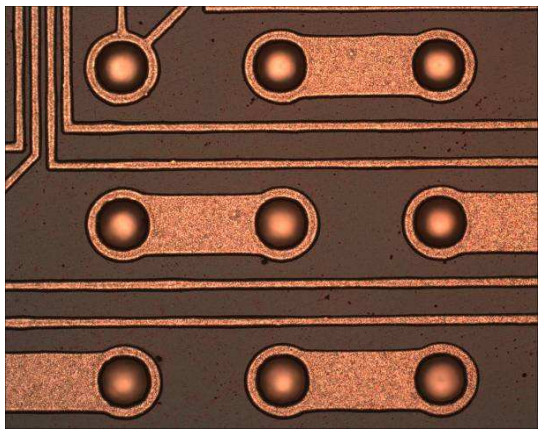


Zdenek Vykydal (Prague)



Through-Si Via's
Piet de Moor (IMEC)

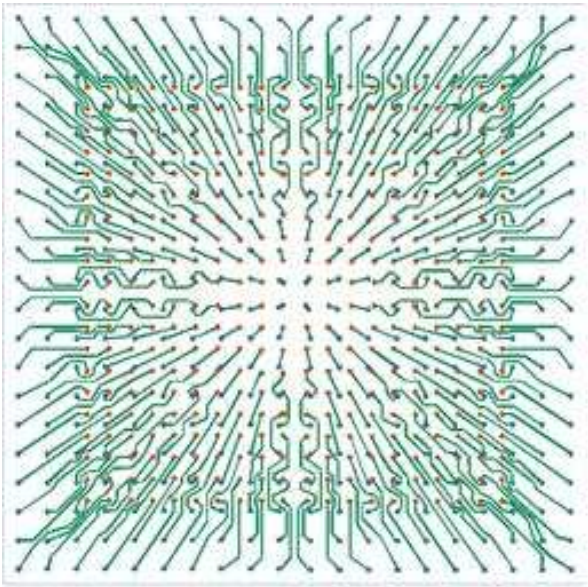


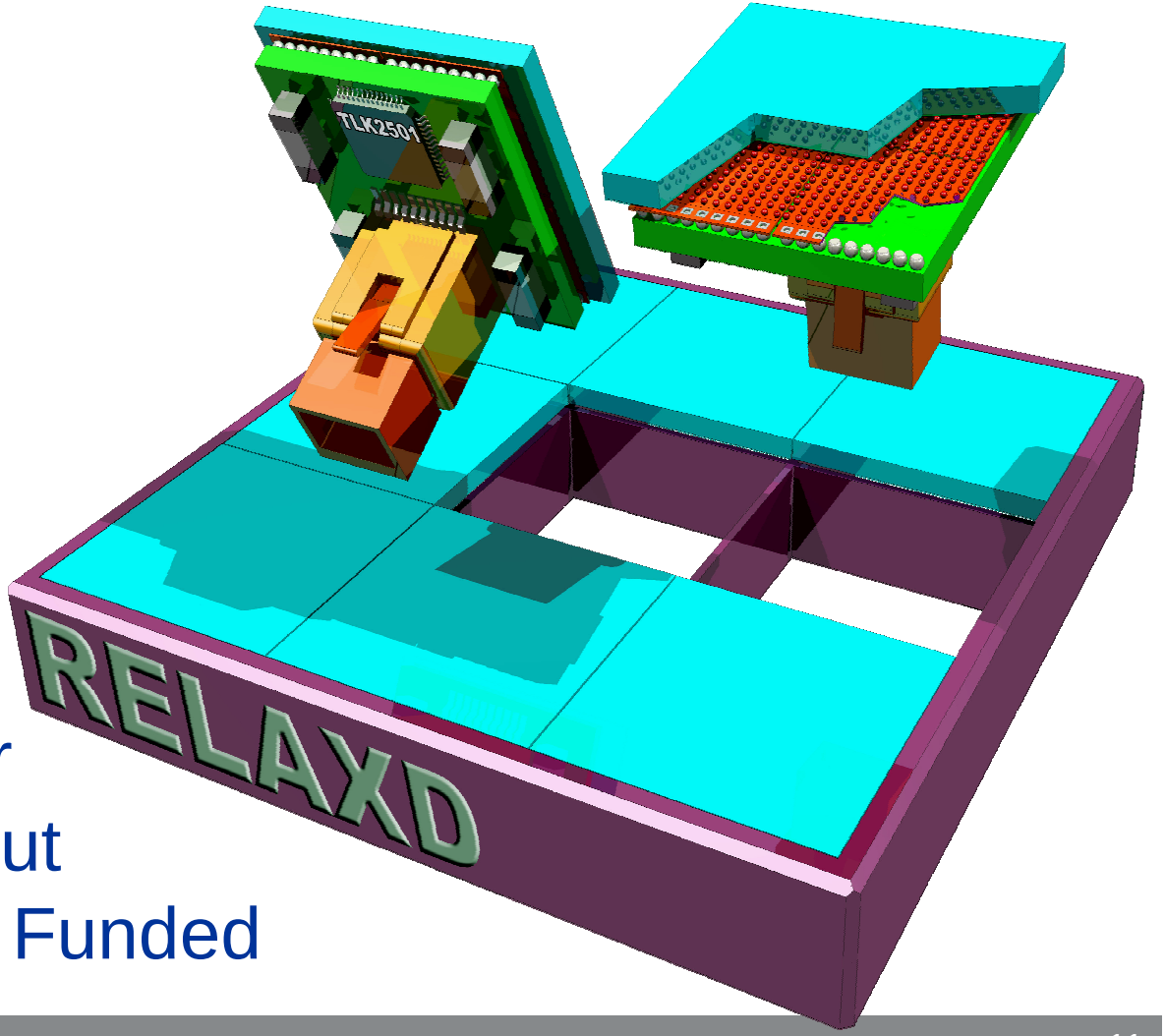


RELAXD

PANalytical

High **RE**solution **L**arge **A**rea **X**-ray **D**etector Fully tiled X-ray imager

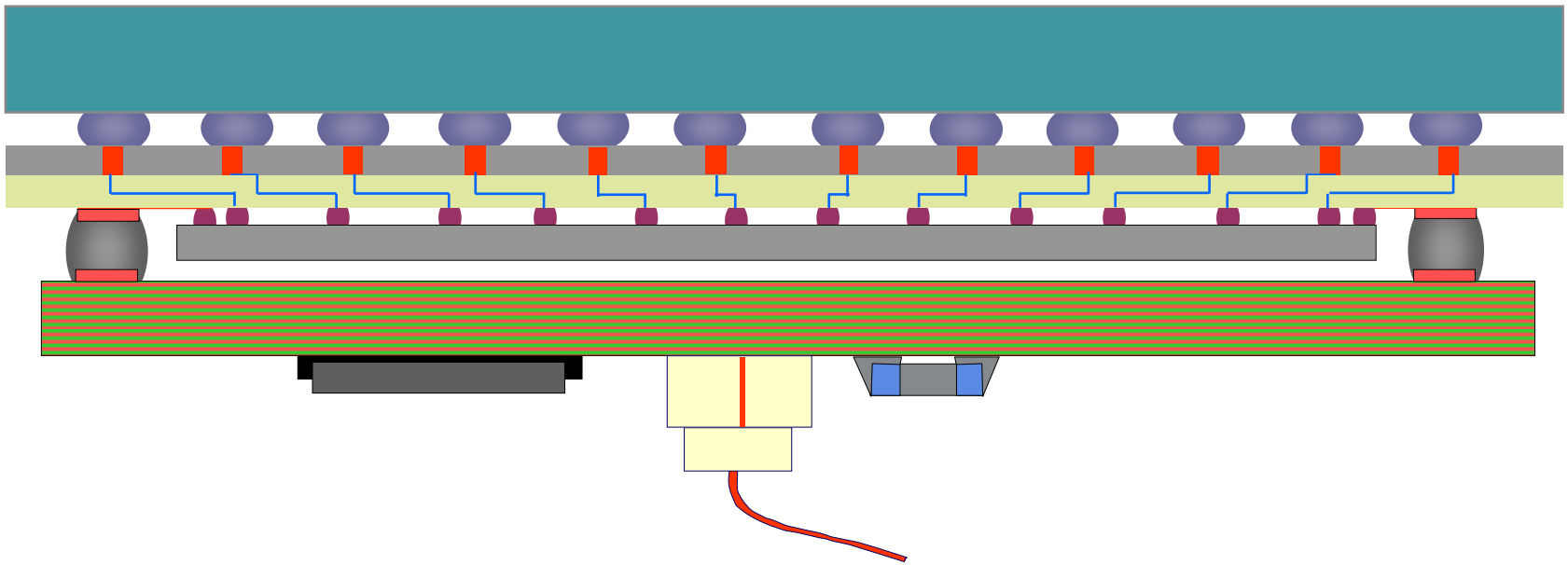




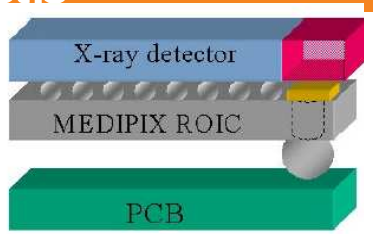
need pitch adapter
Gbit/s serial readout
Innovation Project Funded

IMEC interposer P. de Moor

- Starting now

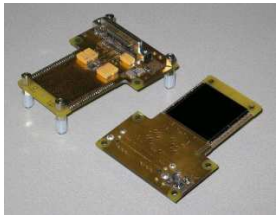


Nikhef roadmap

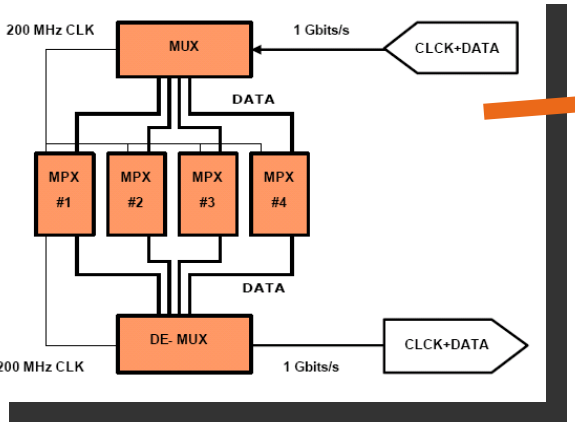


Sensor: **Canberra**
Through-via: **IMEC**
BGA: **ACB**

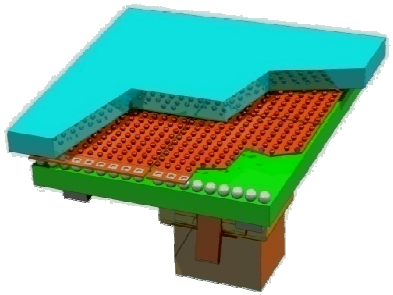
Frame, Power Cooling (2009)



Current Quad

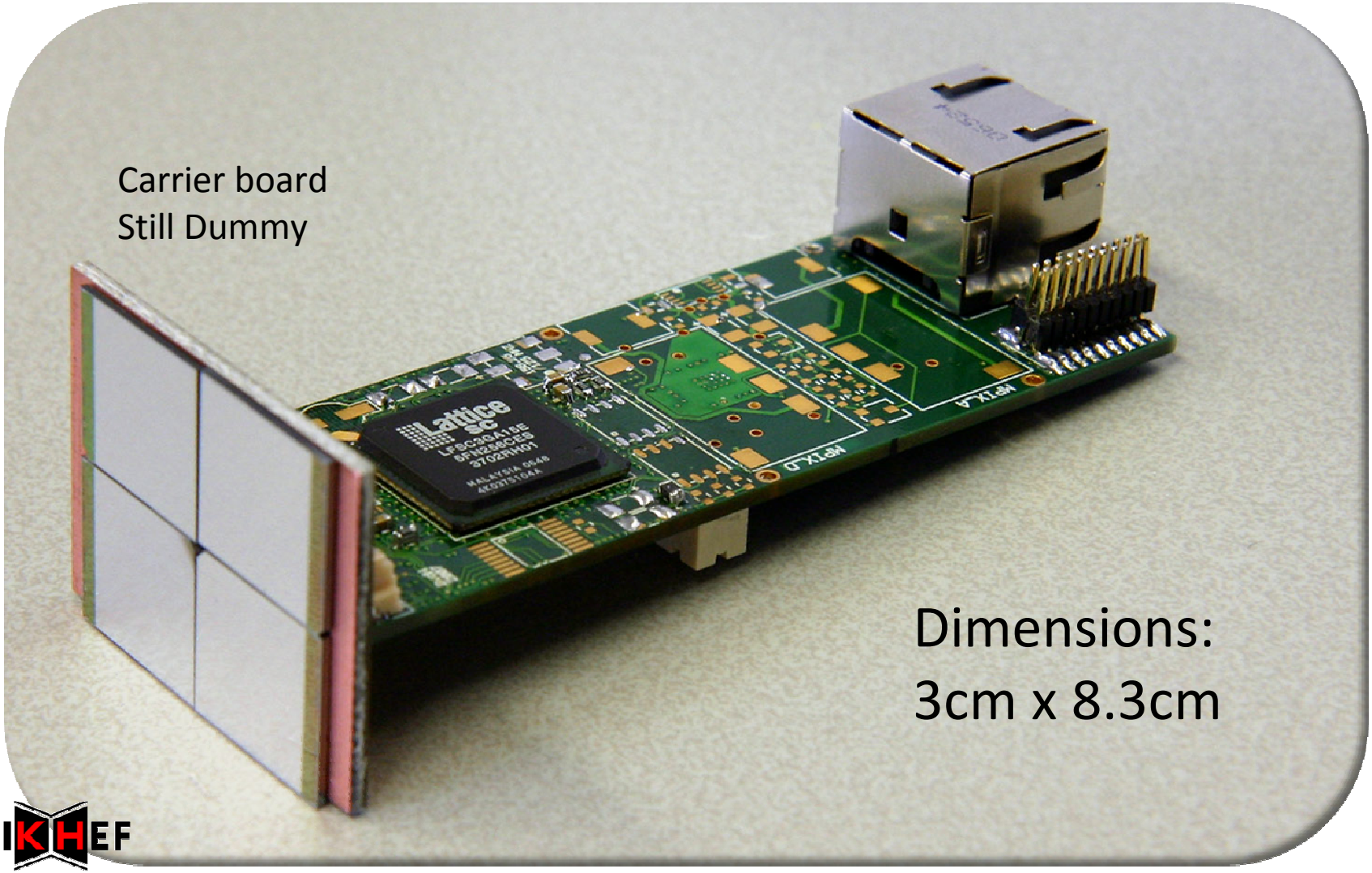


Multi-Gbps prototype



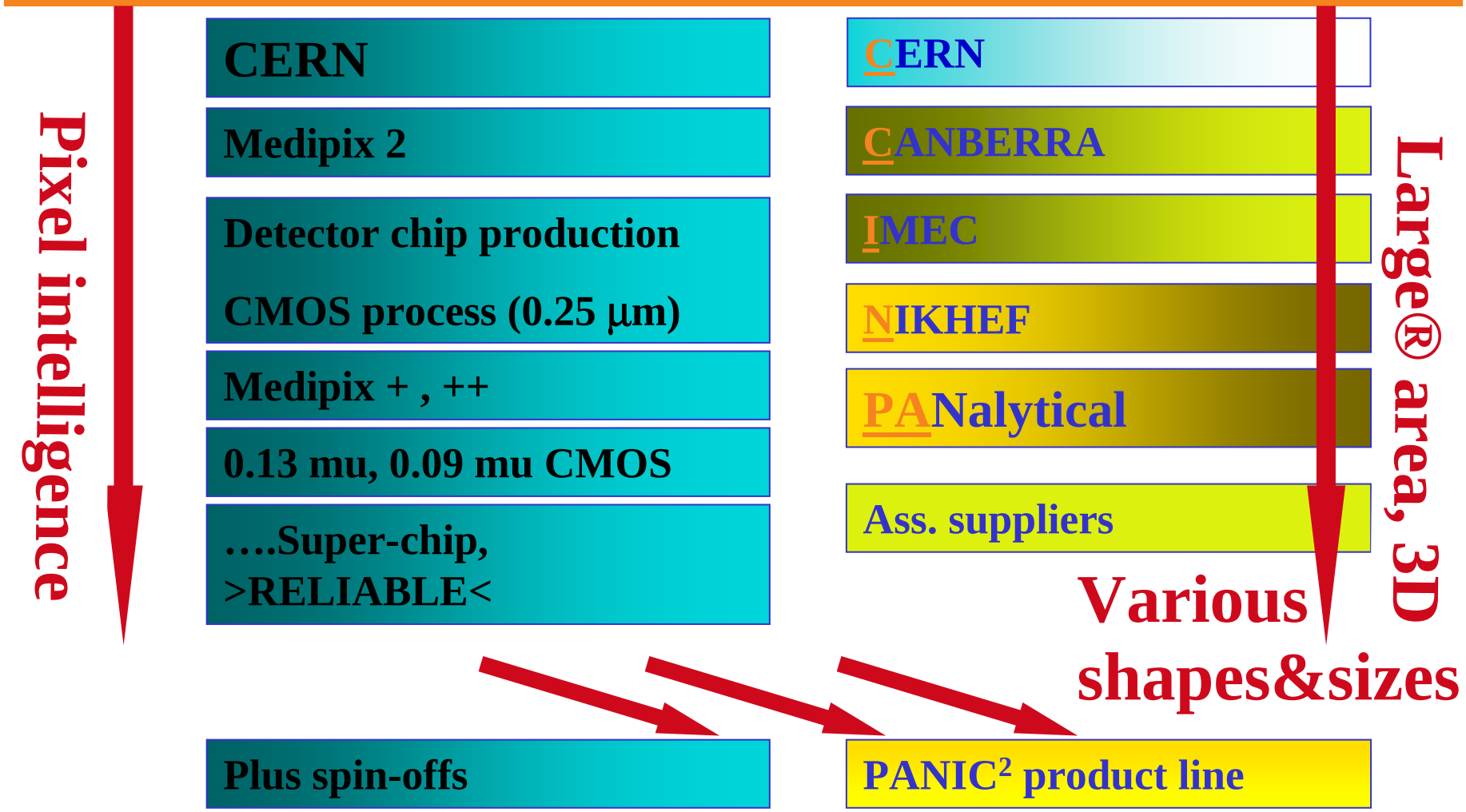
RELAXD quad (2008)

First Prototype



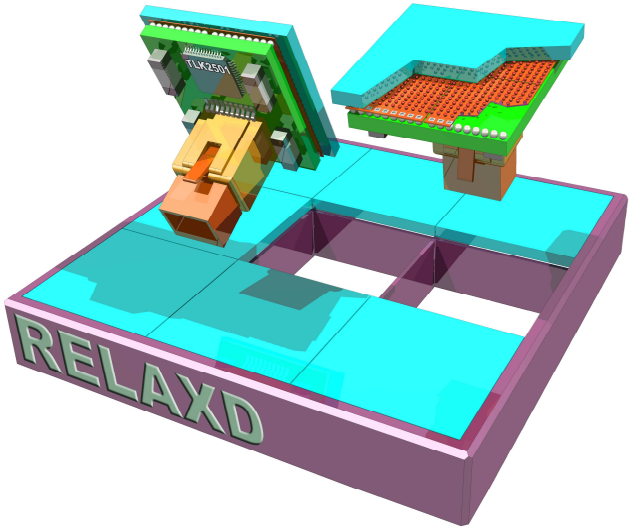
PANalytical

Relevance: PANIC² Detectors



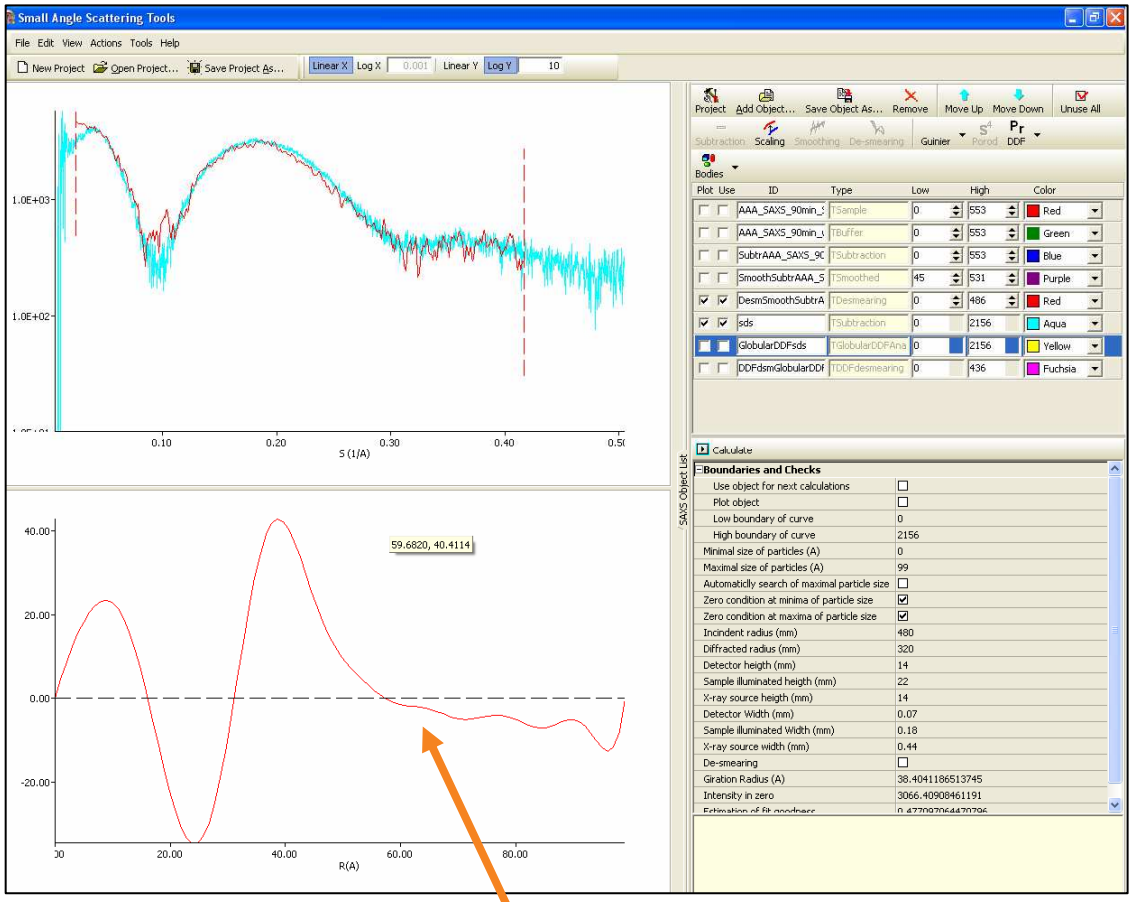
Increasing the dimensions – New Applications

- RELAXD (2D large)
  - Single crystal business (Lab + Synchrotron)
    Protein structure and function
  - Anti-disease research:
    Drug discovery and design
  - Nanomaterials, Polymers
  - Computer Tomography: non-destructive testing
  - OEM detectors
  - Potentially: medical applications mammography, cardio-vascular imager



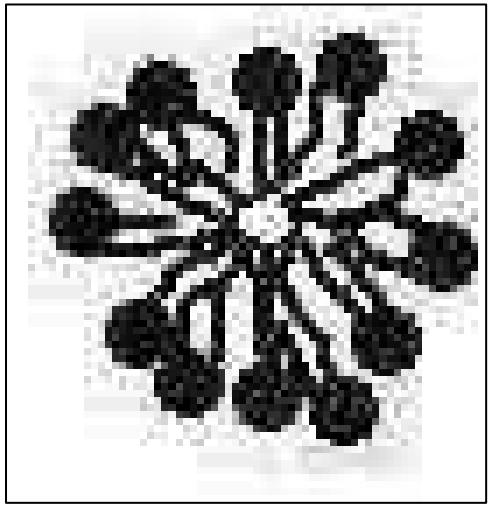
High –Resolution Large X-ray Detector

Micelles Formation in Sodium Lauryl Sulphate (SDS)



LAB (90 min)

Synchrotron (4 min)

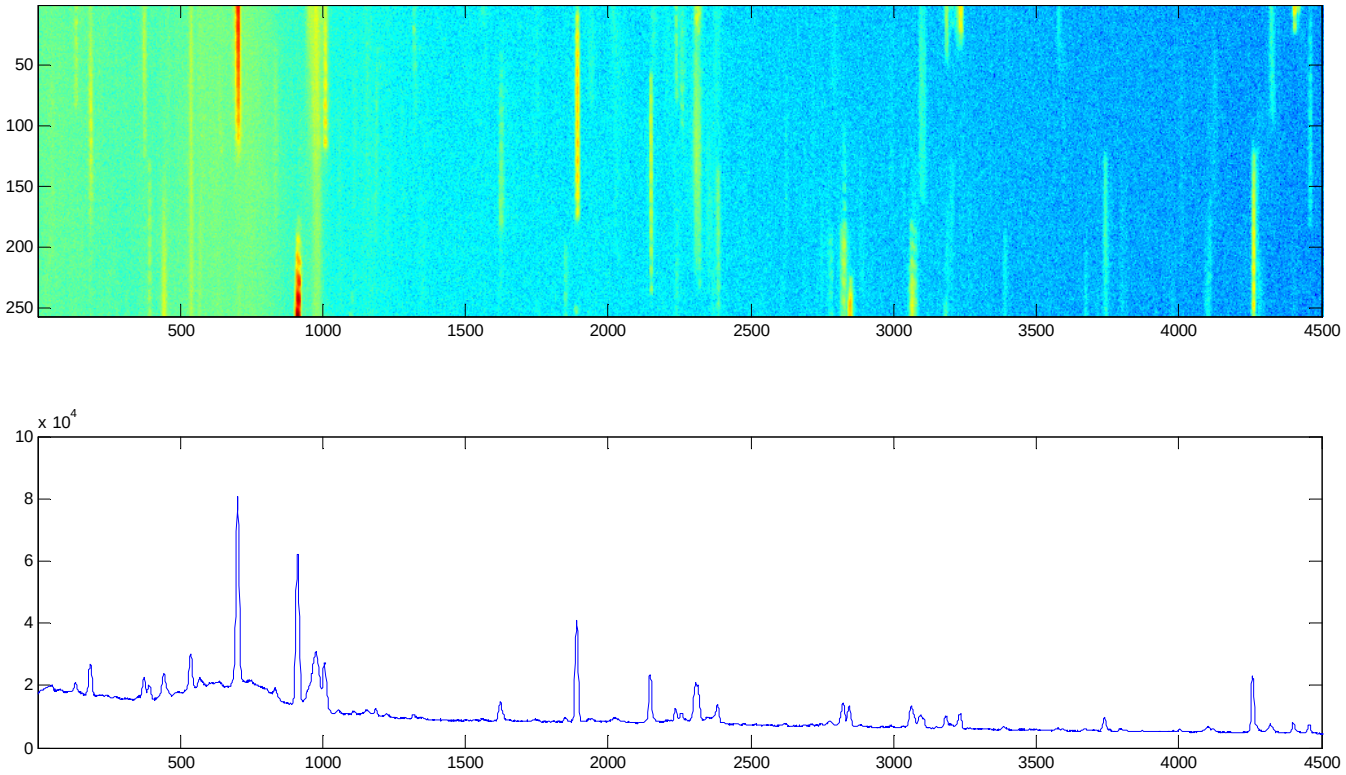


1 wt.% SDS Surfactant

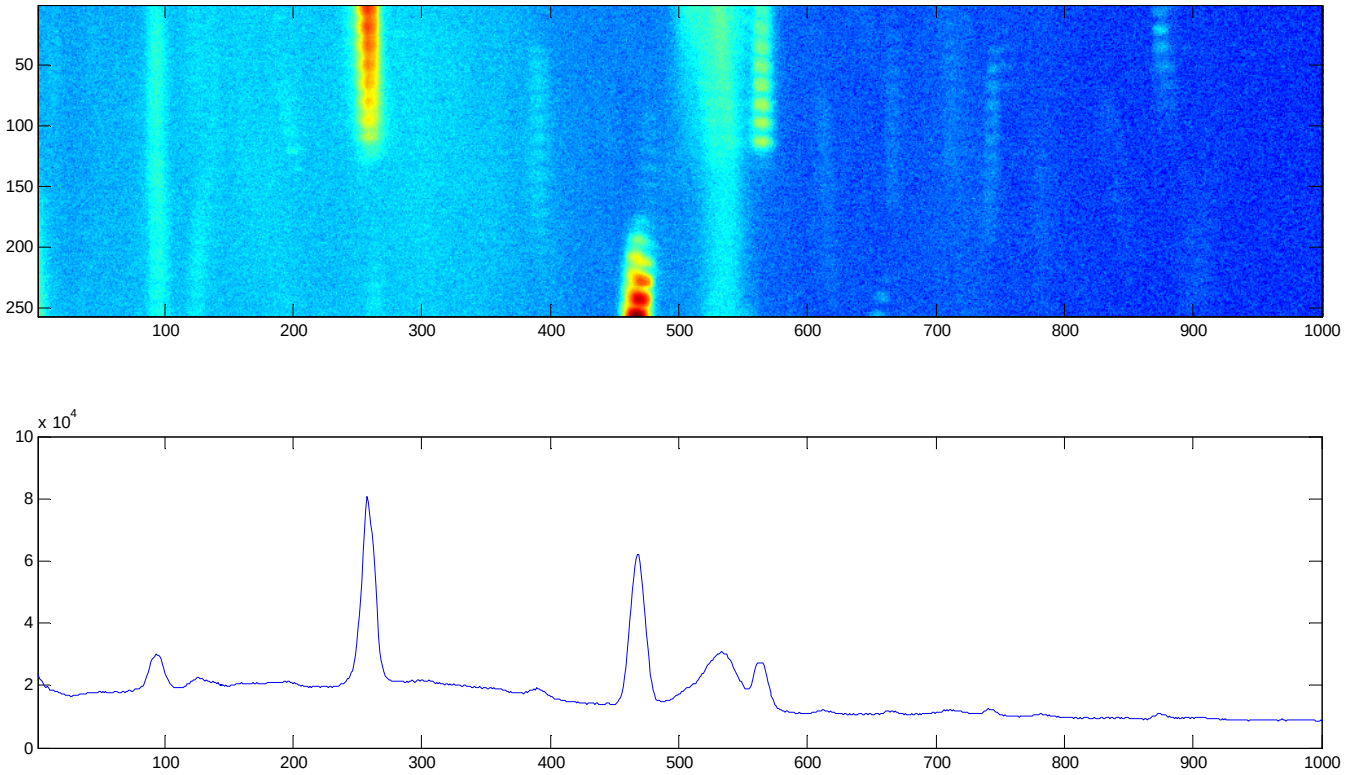
in 0.003M KCl solution

D = 5.5 nm

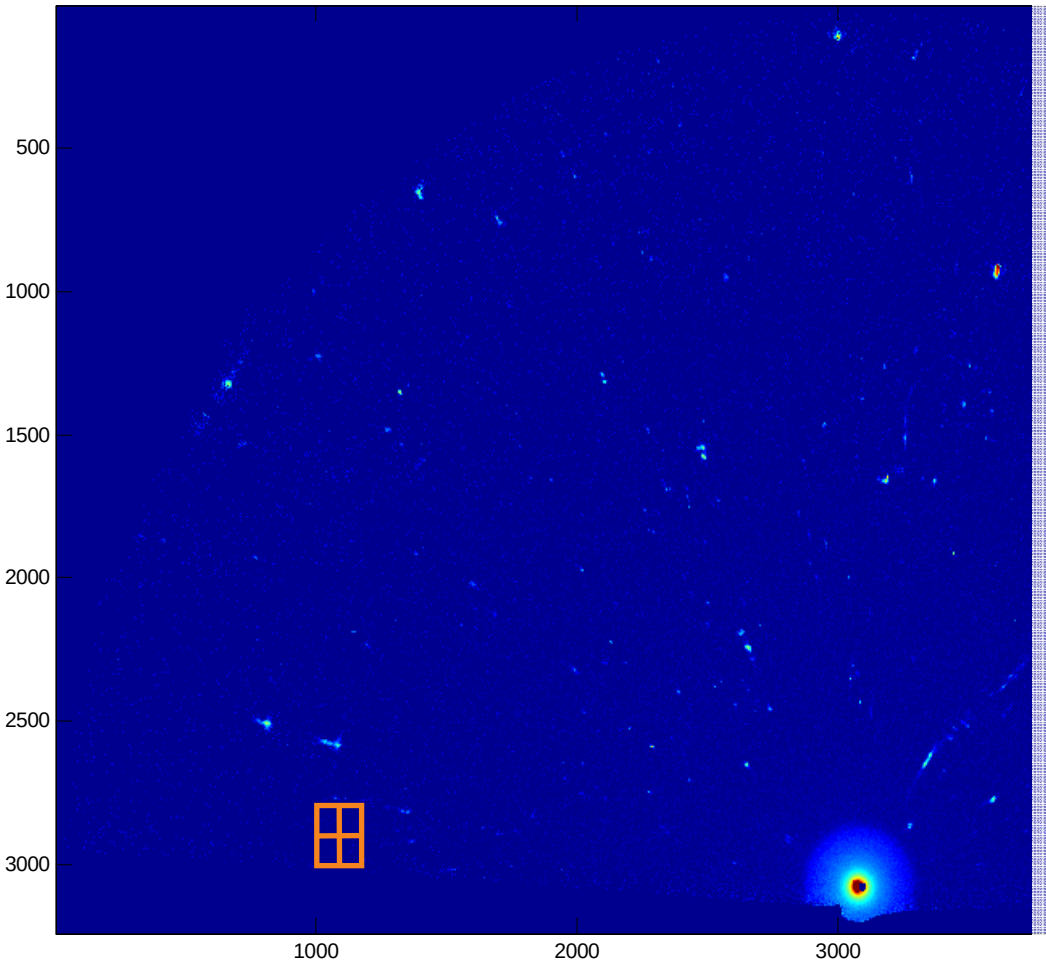
Sugar, 2theta Scan, 2D vs. 1D.



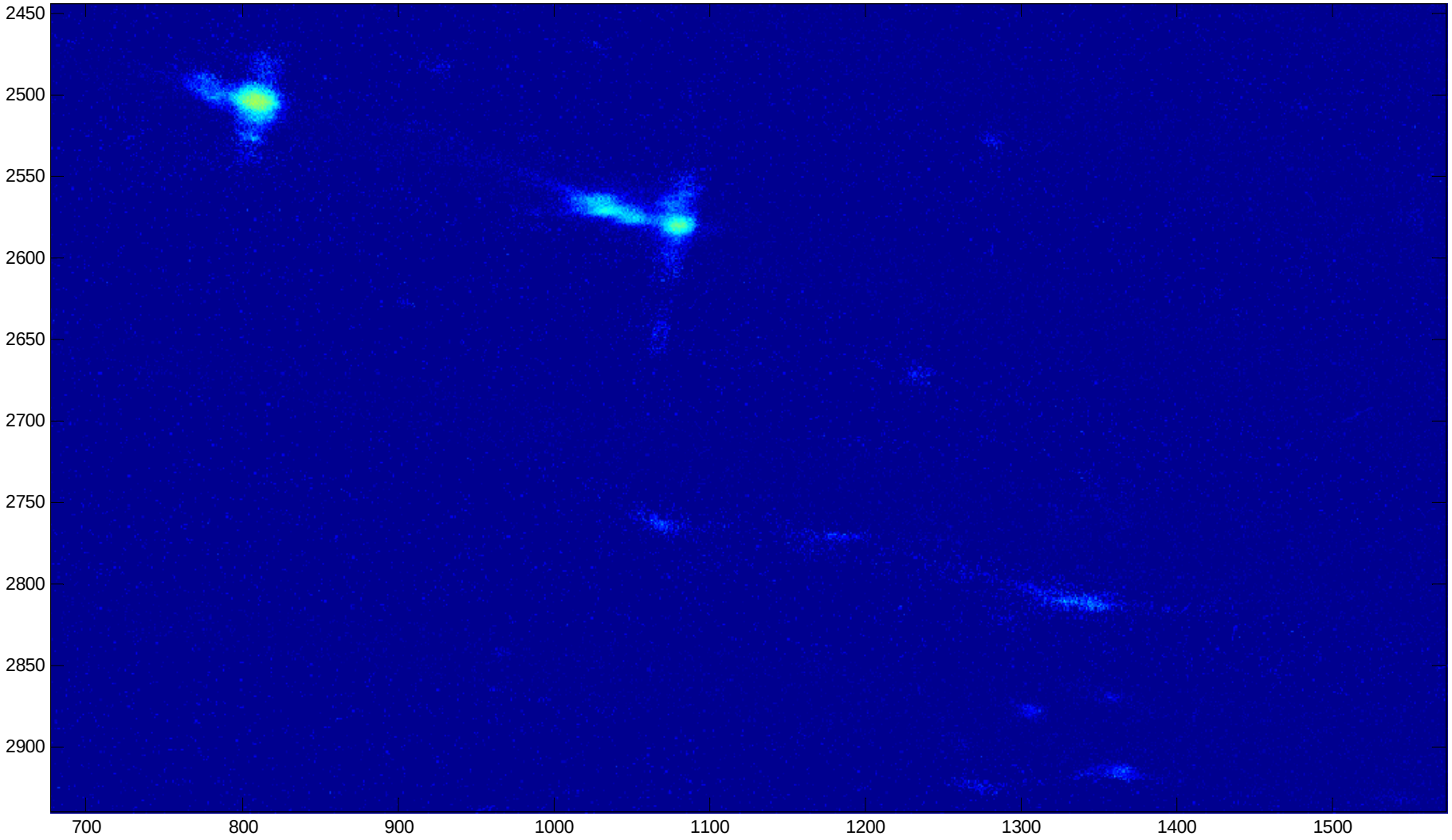
Sugar, 2theta Scan, 2D vs. 1D. Detail.



Half Sphere, Microdiffraction
“Virtual Large Area Detector”



- Low-Resolution Rendering 6200x3300 pixels
- ~20 Megapixels
- Original: 2.8 Gigapixels
- Logarithmic Scale
- Dynamic Range: 8 orders of magnitude


2450
2500
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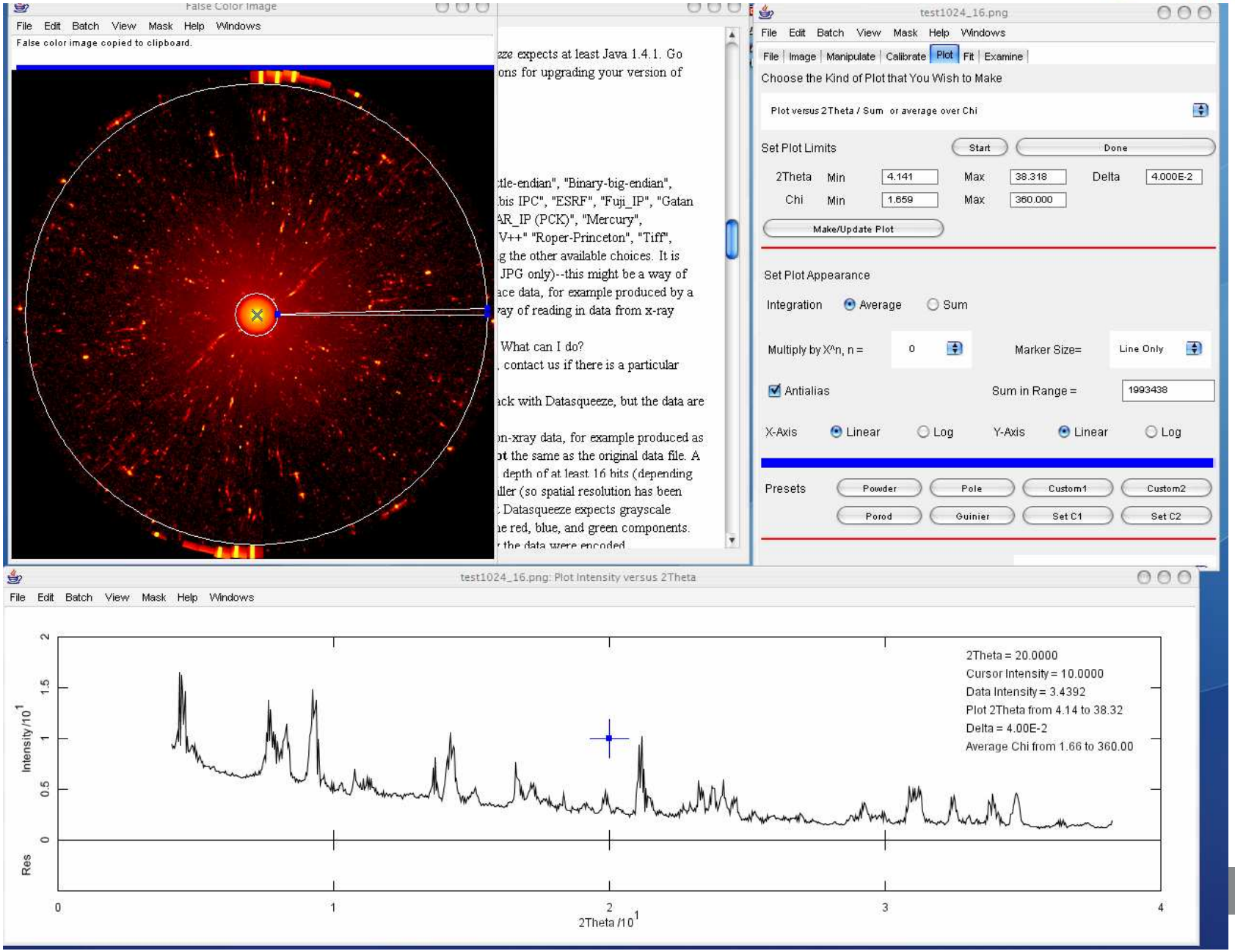
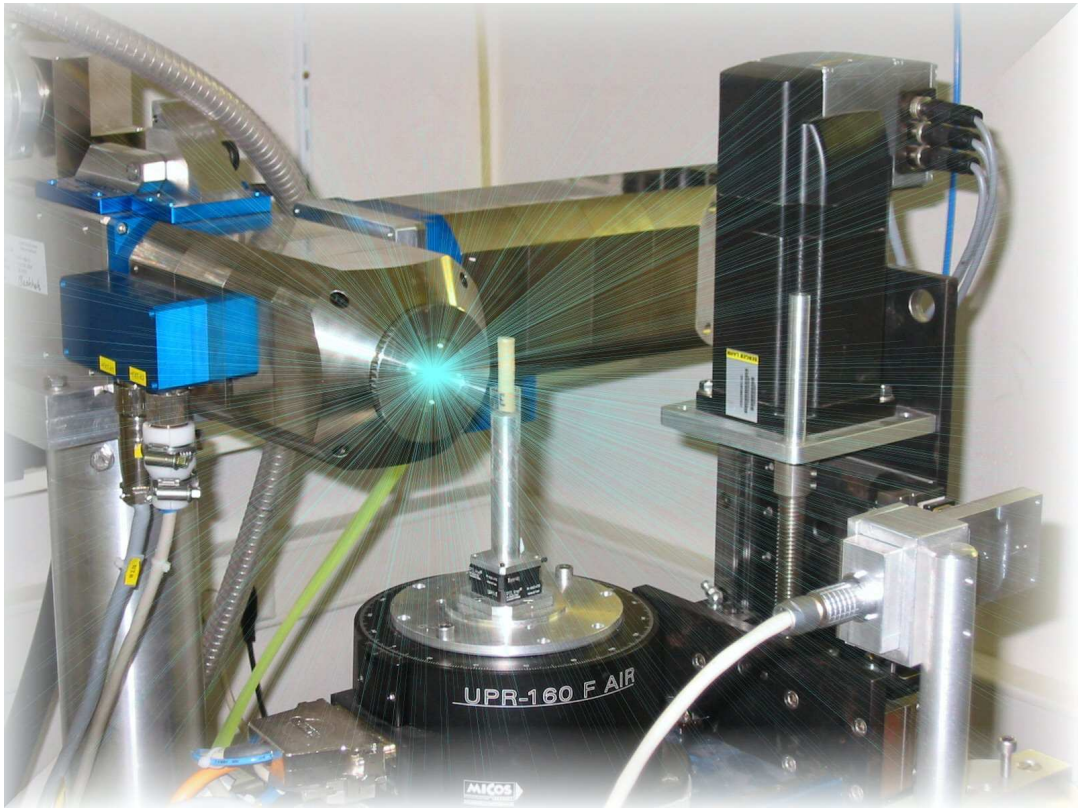

False Color Image
File Edit Batch View Mask Help Windows
False color image copied to clipboard.
test1024_16.png
File Edit Batch View Mask Help Windows
File Image Manipulate Calibrate Plot Fit Examine
Choose the Kind of Plot that You Wish to Make
Plot versus 2Theta / Sum or average over Chi
Set Plot Limits
Start
Done
2Theta Min 4.141 Max 38.318 Delta 4.000E-2
Chi Min 1.659 Max 360.000
Make/Update Plot
Set Plot Appearance
Integration Average Sum
Multiply by X^n, n = 0
Marker Size= Line Only
Antialias
Sum in Range = 1993438
X-Axis Linear Log Y-Axis Linear Log
Presets
Powder
Pole
Custom1
Custom2
Porod
Guinier
Set C1
Set C2
test1024_16.png: Plot Intensity versus 2Theta
File Edit Batch View Mask Help Windows
2Theta = 20.0000
Cursor Intensity = 10.0000
Data Intensity = 3.4392
Plot 2Theta from 4.14 to 38.32
Delta = 4.00E-2
Average Chi from 1.66 to 360.00
Intensity /10^1
Res
2Theta /10^1

Computer tomography

Butterfly antenna with Medipix
Micro-Nano X-Ray Tomography

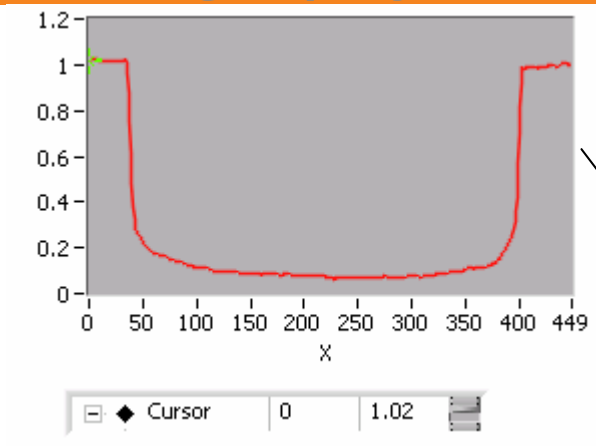
UGCT Ghent - PANalytical

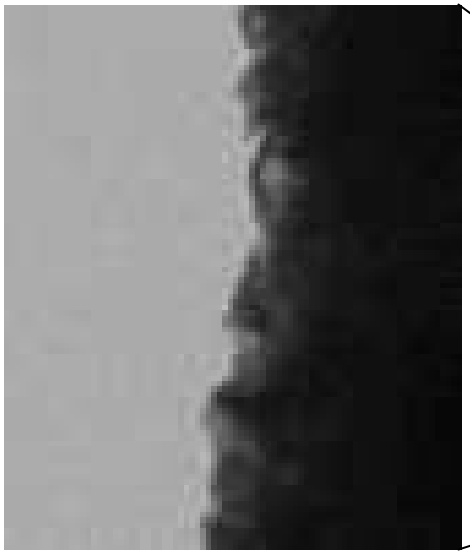
Set-up UGCT Ghent



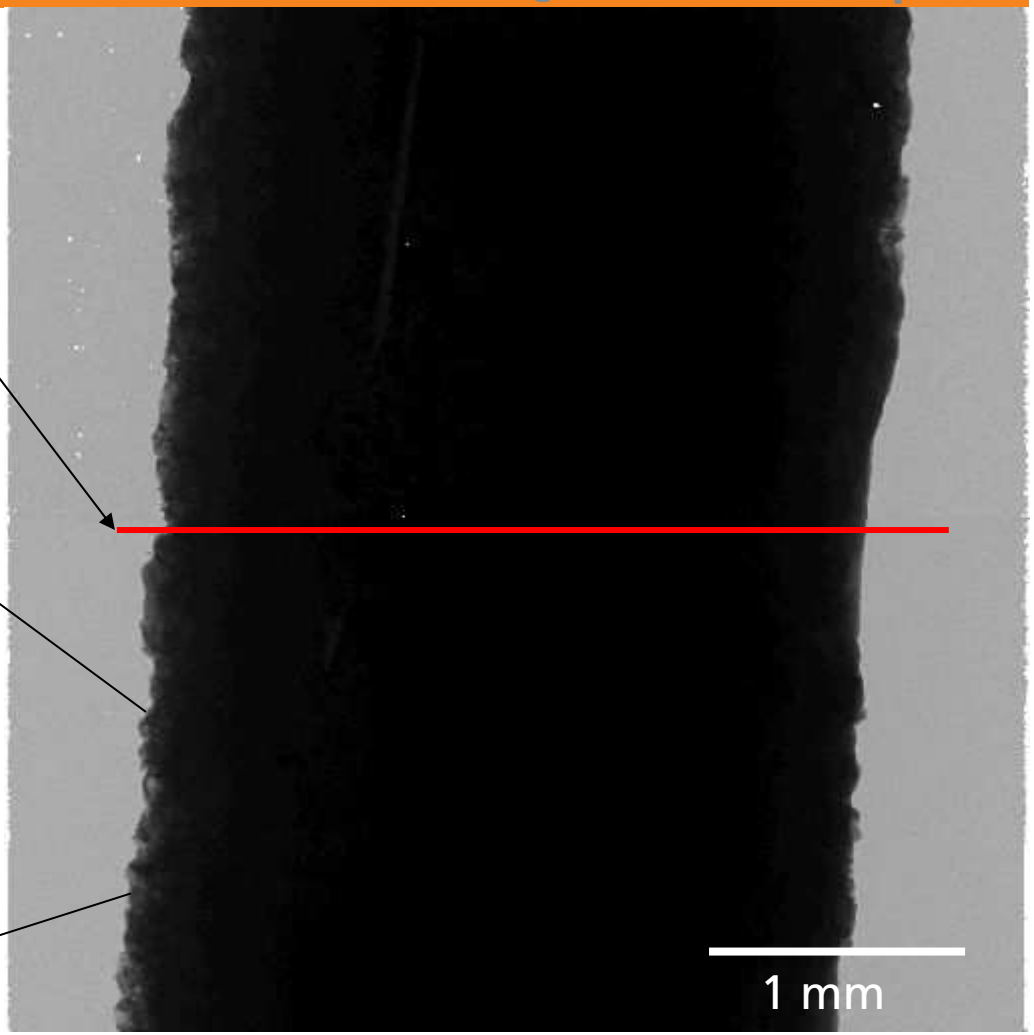
Nano-focus tube at 60 kV. Measurement done in microfocus mode.
Spot size around 3 µm.

Radiography: fossile limestone with Quad Medipix

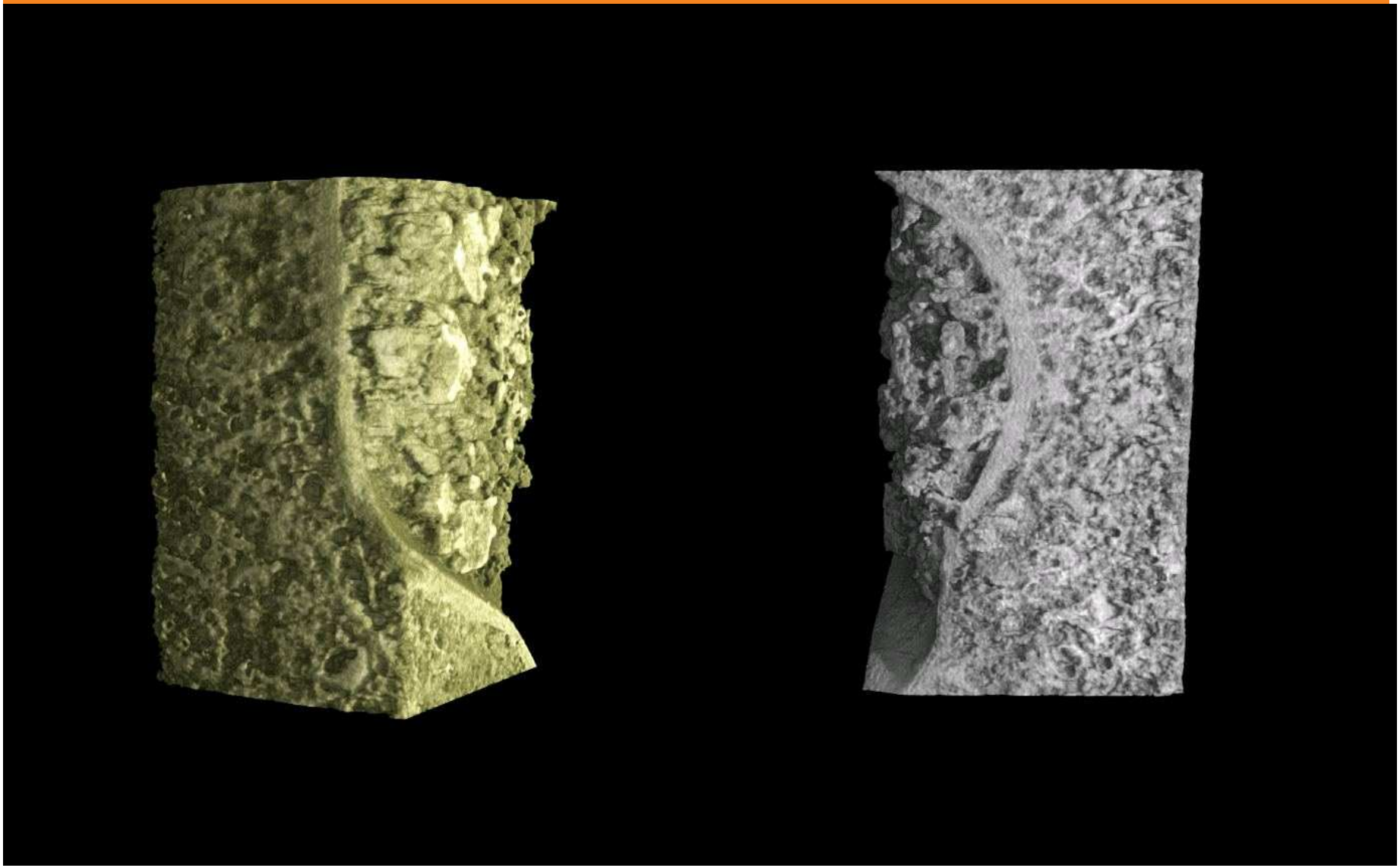




Zoom



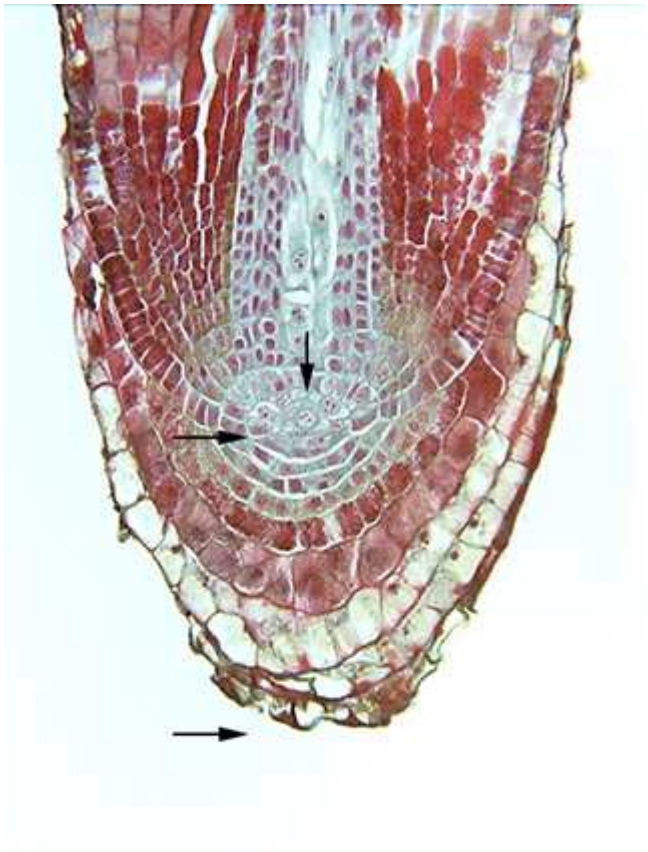
CT Reconstruction: limestone



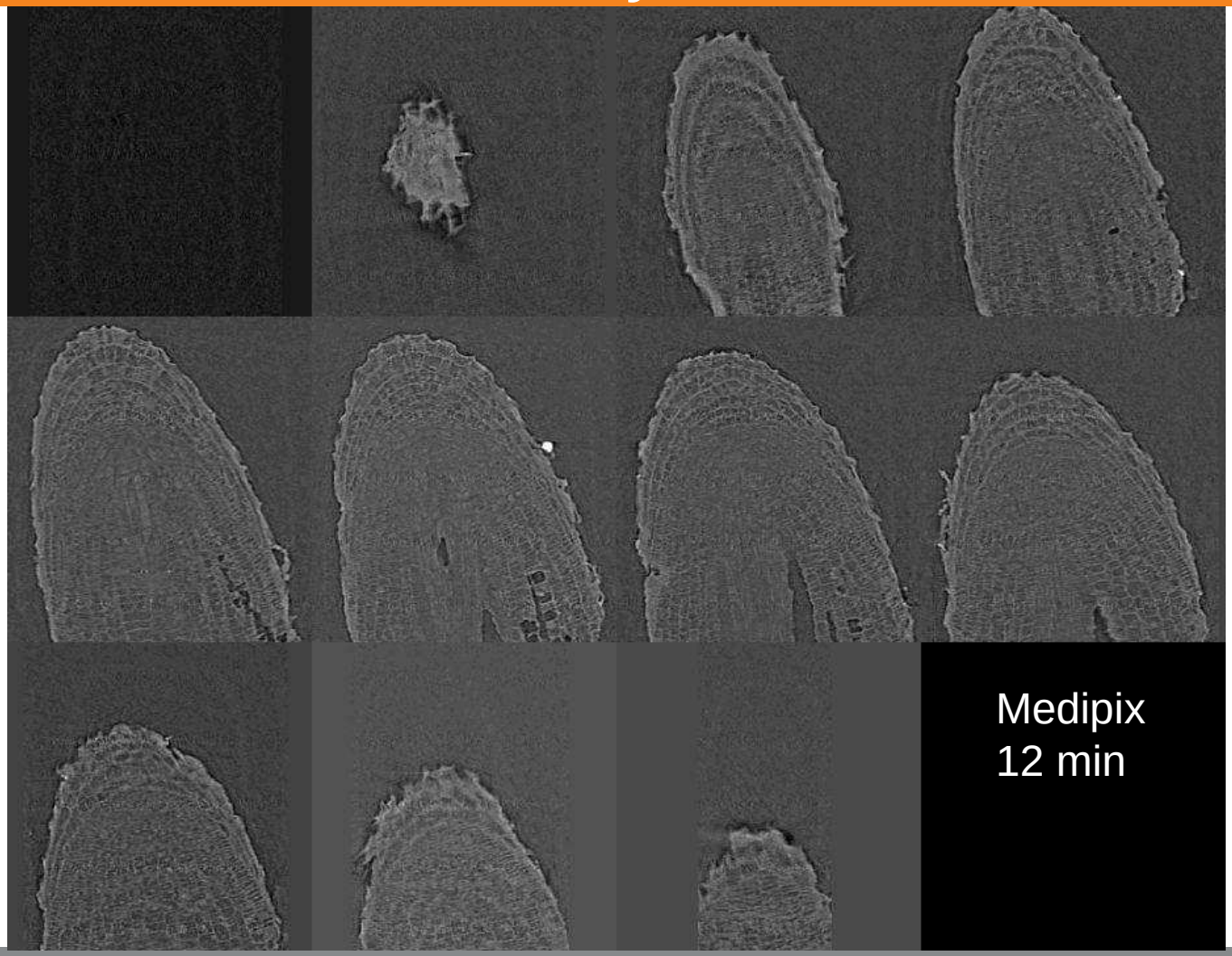
CT together with University of Ghent

Anatomy

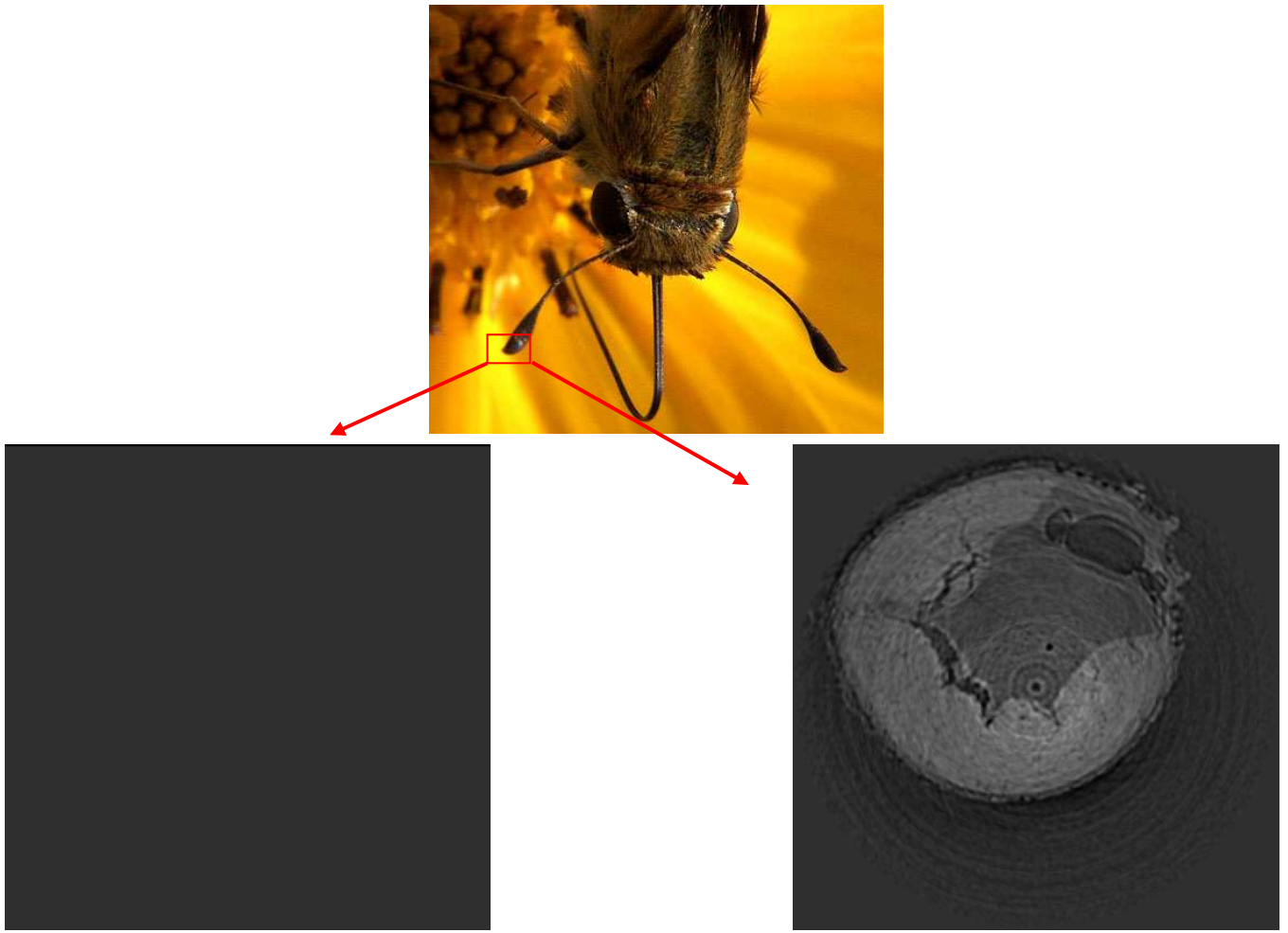
- Fern tip
- 0.5-1 mm



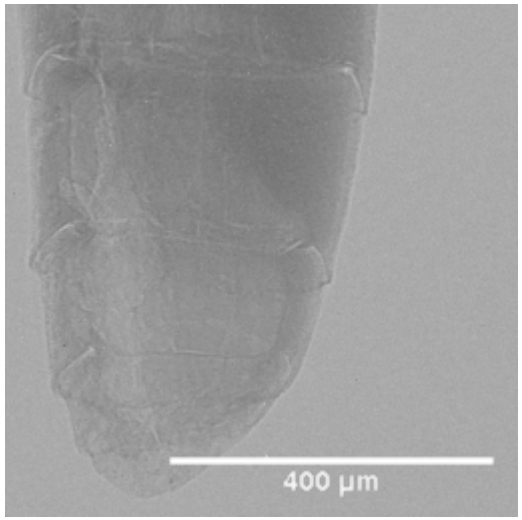
CT together with University of Ghent

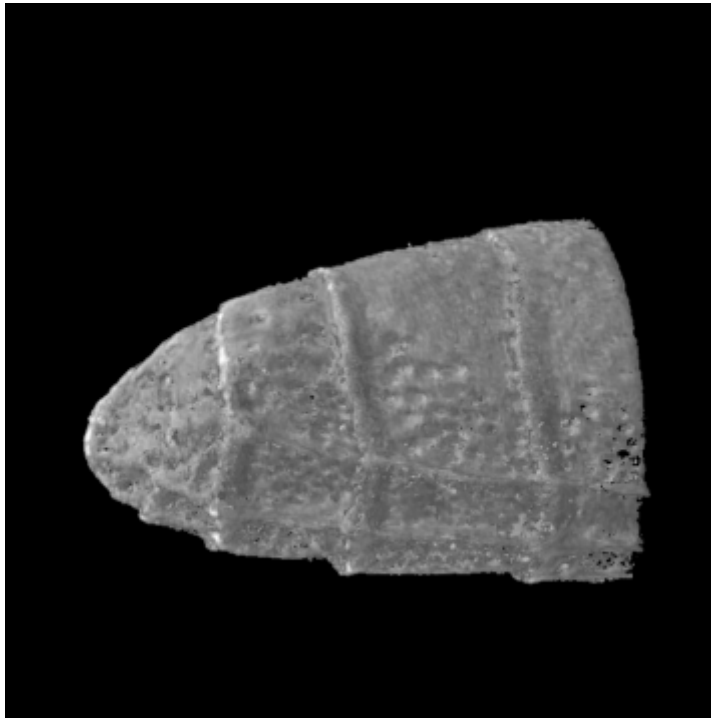


Sections parallel + perpendicular

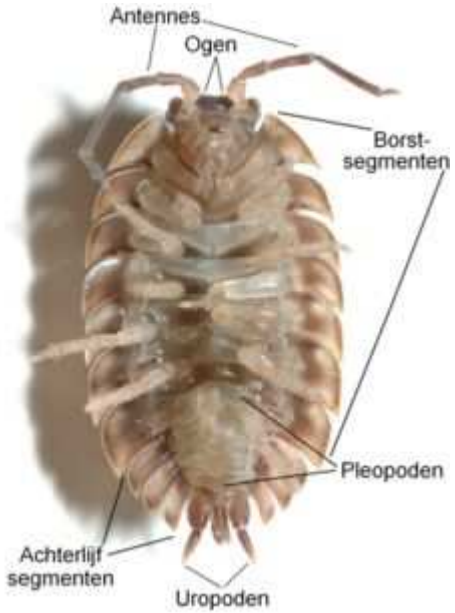


CT projections and 3D reconstructions





The woodlouse (porcellio scaber)



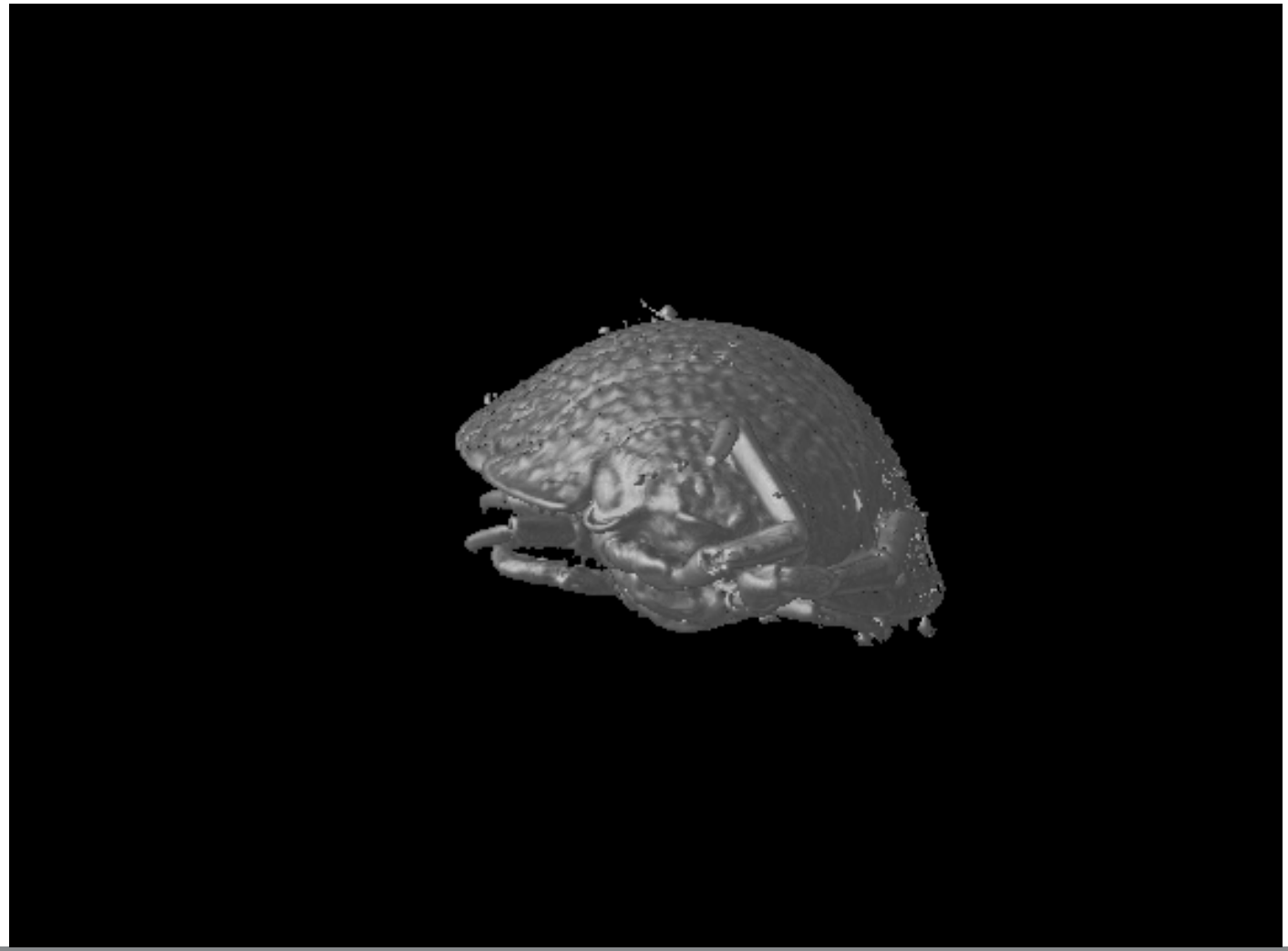
Collab. PAN - UGCT Ghent

Gabriel Blaj
Bert Masschaele
Jelle Vlassenbroeck

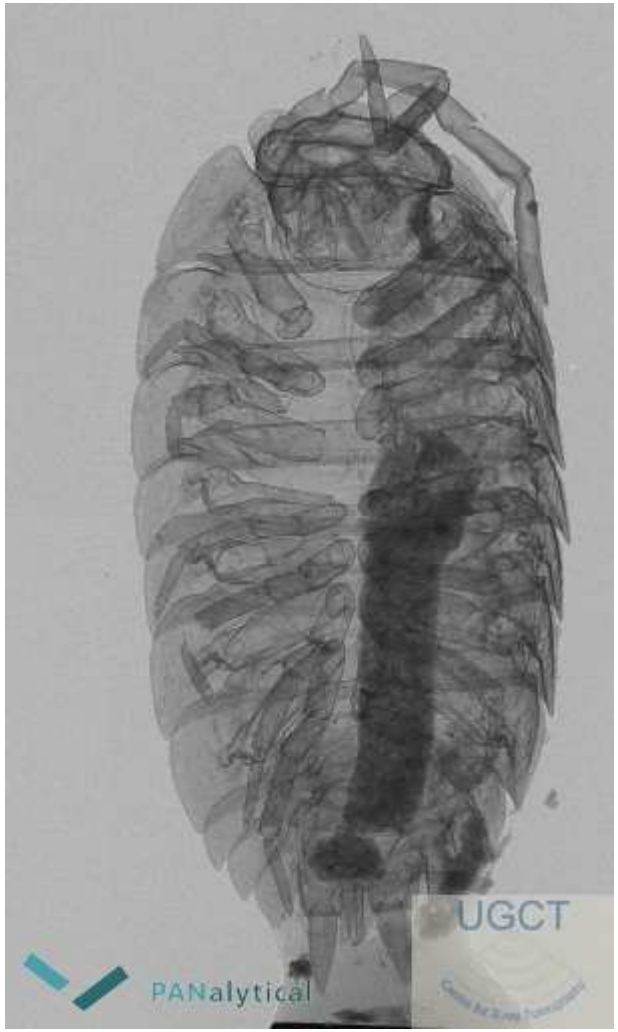
Feinfocus nano-tube at 60 kV
Microfocus setting (2.8 W)
Measuring time: 360 s
Quad Medipix Detector

3D reconstruction

3D total reconstruction



Projections / Medipix Quad



Conclusions

- Medipix+RELAXD
  - Examples of successful collaborations of R&I
  - Truely breakthrough
- Results
  - Very positive results for X-ray materials analysis and imaging
  - Huge potential for future applications
- MPGD technologies complementary
- R&I collaborations: The key for the future

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