IWORID 7:
Industrial Applications

Applications and new Developments in X-ray Materials Analysis

PANalytical
K. Bethke, R. de Vries,
V. Kogan, J. Vasterink,
R. Verbruggen, J. Bethke

P. Kidd, P. Fewster /
PAN Sussex Research

Outline

- Background
- Medipix Tech-Transfer
- First results on detector properties
- Expectations for XRD applications
- First results of Medipix in XRD
- New EUREKA project “RELAXD”
- Conclusions

X-ray Diffraction and Fluorescence for Scientific and Industrial Research

Winning by Sharing

know-how and experience

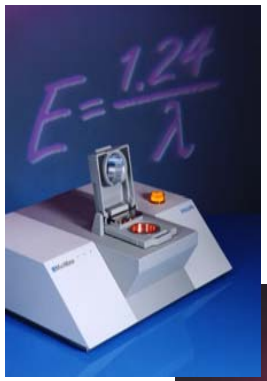
in X-ray diffraction and fluorescence

Main Activities

- XRF (Industry and Research)
  - Elemental Analysis (qualitative and quantitative)
  - Applications: Cement, Petrochemical, Plastics, Steel, Aluminium, Environmental, Geology
  - Automation
- XRD (Research and Industry)
  - Phase Analysis (qualitative and quantitative)
  - Applications: Pharmaceuticals, Cement, Minerals
  - Other: Thin Films and Semiconductors, Nanotech,
  - Automation

PANalytical is located in Almelo for over 35 years

MiniMate



CubiX

Axios

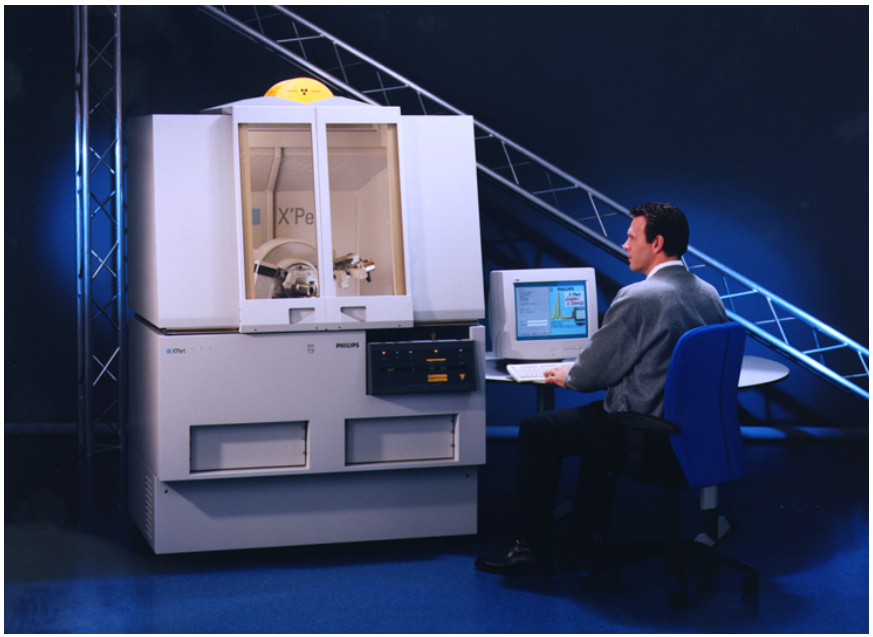
MiniPal 2

Venus

MagiX FAST

Product range (Phase analysis)

X'Pert PRO



CubiX PRO

X'Pert PRO MRD

- Advanced X-ray analysis for new materials research and development
- For thin films, semiconductors and microstructures

X'Pert PRO MRD XL

- X-ray analysis for research and process development of advanced materials
- Analysis of wafers up to 300 mm diameter
- Automatic wafer loading

X'Pert PRO MRD XL

- X-ray analysis for research and process development of advanced materials
- Analysis of wafers up to 300 mm diameter
- Automatic wafer loading

X'Celerator

- The standard in X-ray powder diffraction
- Speed and resolution
- Rapid data collection of complete powder diffractograms

X'Pert Software

- A complete range of software packages for X-ray diffraction
- Based on the universal standard for data sharing and file transfer and XML

CSI MIAMI

- FORENSIC SCIENCE

XRD X'PERT PRO MRD system overview

Acrobat Document

PANalytical

Outline

- Background
- Medipix Tech-Transfer
- First results on detector properties
- Expectations for XRD applications
- First results of Medipix in XRD
- New EUREKA project “RELAXD”
- Conclusions

Medipix Collaboration at work

CAPRI

IWORID 7 Grenoble

Acknowledgement

CERN team

Michael Campbell

Xavier Llopart

Erik Heijne

CERN ETT

Marilena Streit-Bianchi

Beatrice Bressan

NIKHEF team

Jan Visschers

Medipix Collaboration

Paolo Russo, Hans Erik Nielsson

Chip design

Tech-transfer Office

+combined exhibitions

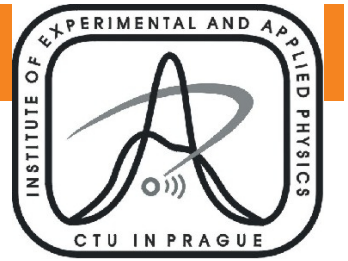
IEEE/Rome, Salon Paris

R/o electronics,
partnership new project

Origin Medipix activities

PARIS: Salon de la Recherche et l'Innovation















- Univ + INFN Cagliari
- CEA-LIST Saclay
- CERN Genève
- Univ d'Auvergne
- Univ Erlangen
- ESRF Grenoble
- Univ Freiburg
- Univ Glasgow
- IFAE Barcelona
- Mitthoegskolan Sundsvall
- MRC-LMB Cambridge
- Univ + INFN Napoli
- NIKHEF Amsterdam
- Univ + INFN Pisa
- FZU CAS Prague
- IEAP CTU Prague
- SSL Berkeley

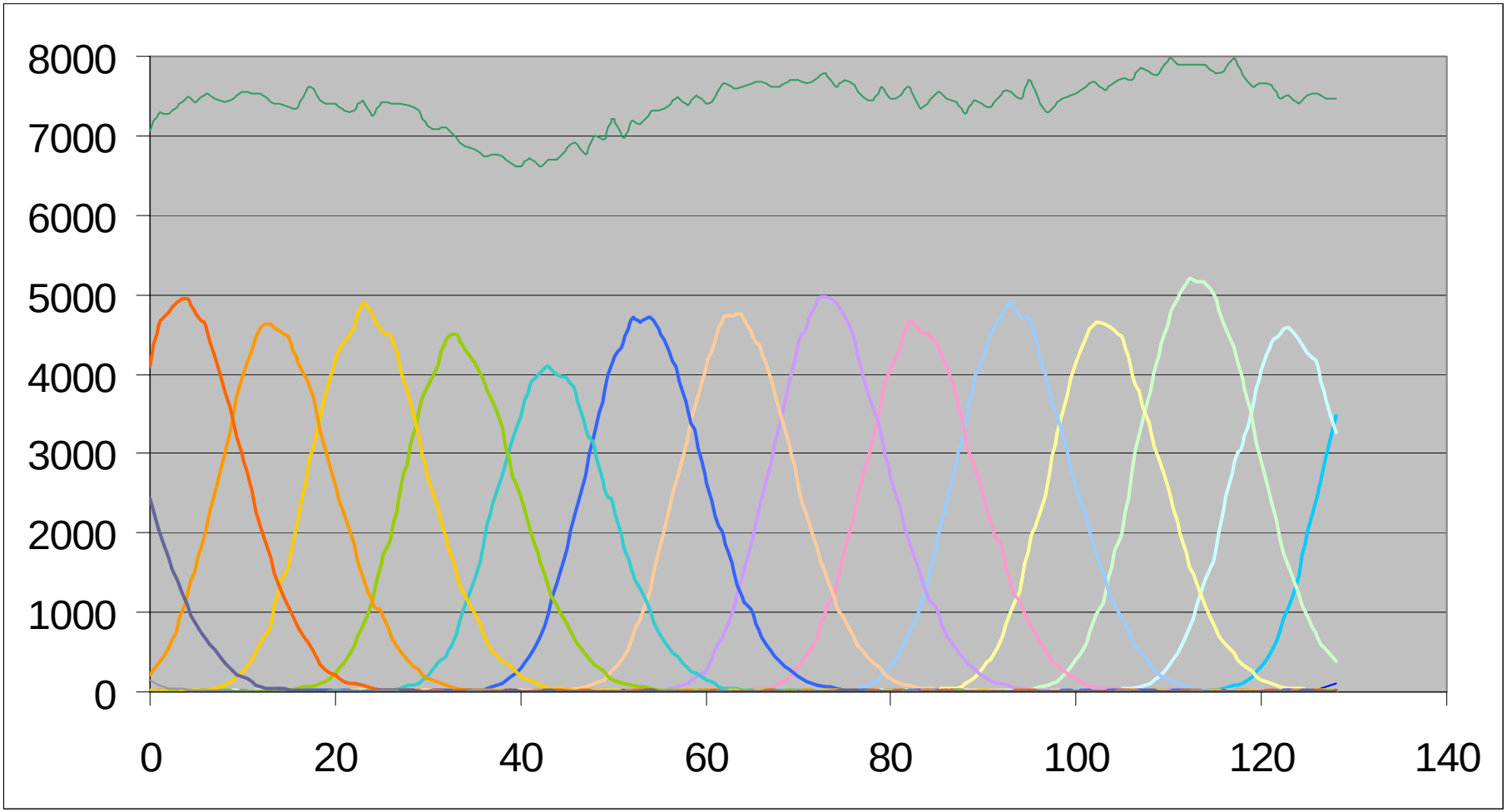
Spokespersons:
Michael CAMPBELL CERN
Jan VISSCHERS NIKHEF

Outline

- Background
- Medipix Tech-Transfer
- First results on detector properties
- Expectations for XRD applications
- First results of Medipix in XRD
- New EUREKA project “RELAXD”
- Conclusions

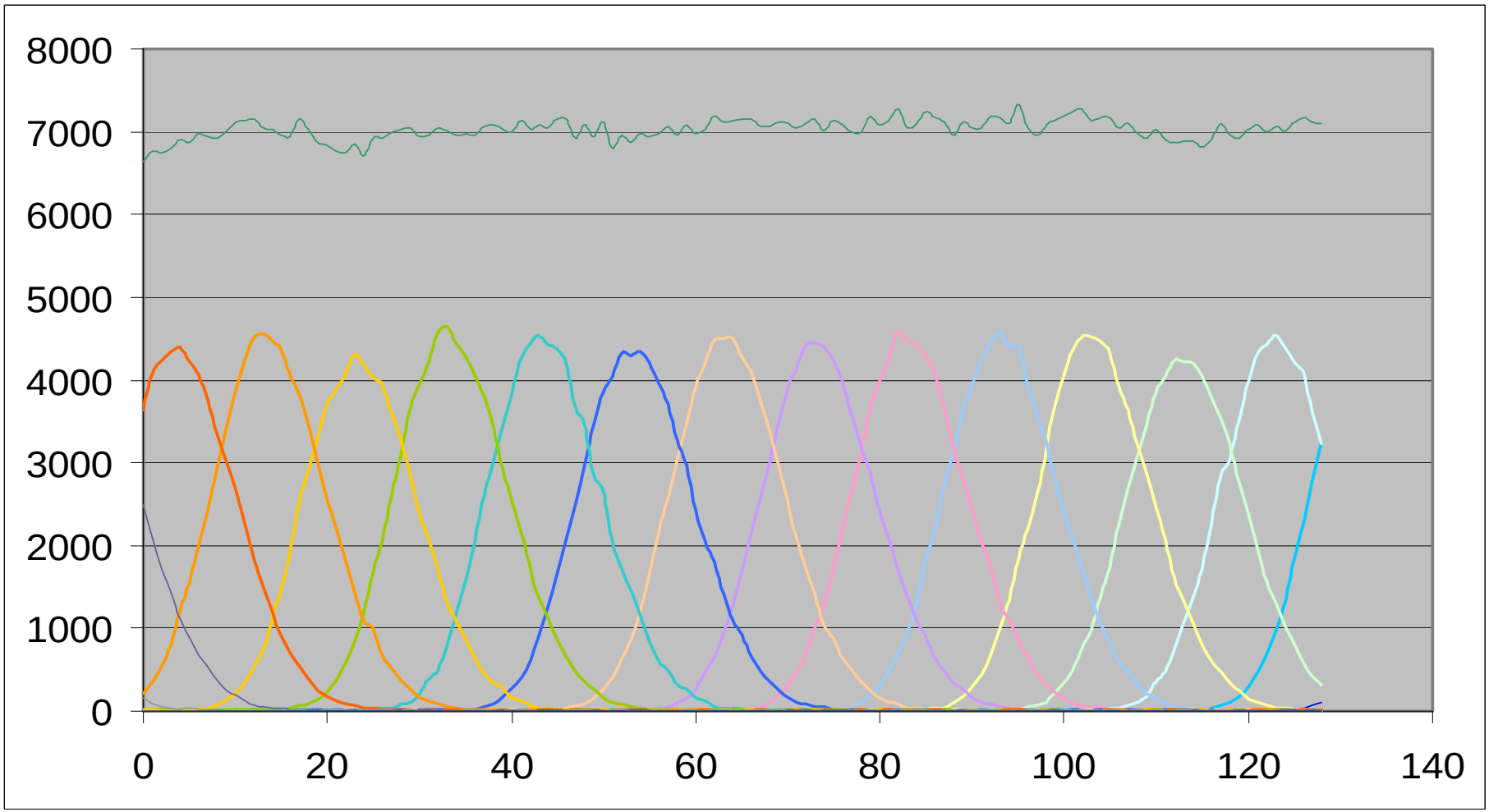
PANalytical

Pixel response (before flatfield correction)

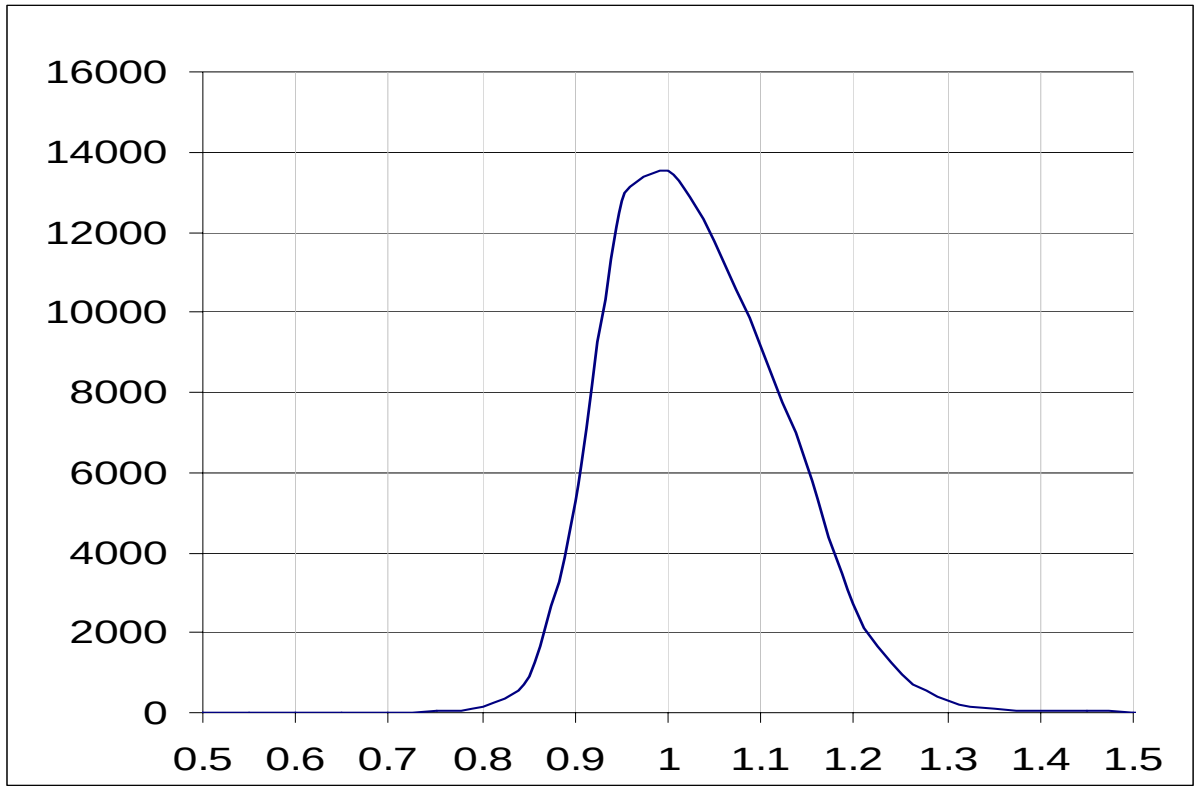


PANalytical

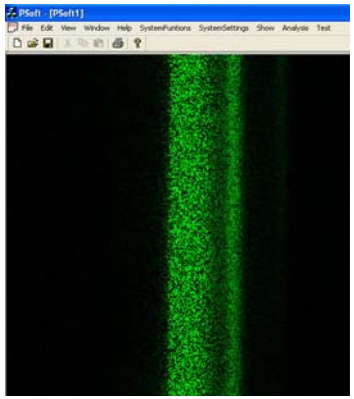
Pixel response (after flatfield correction)

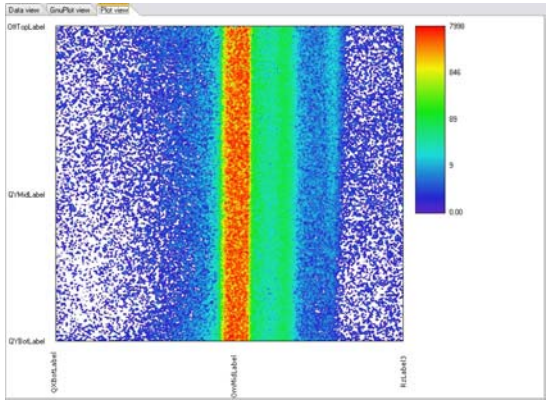


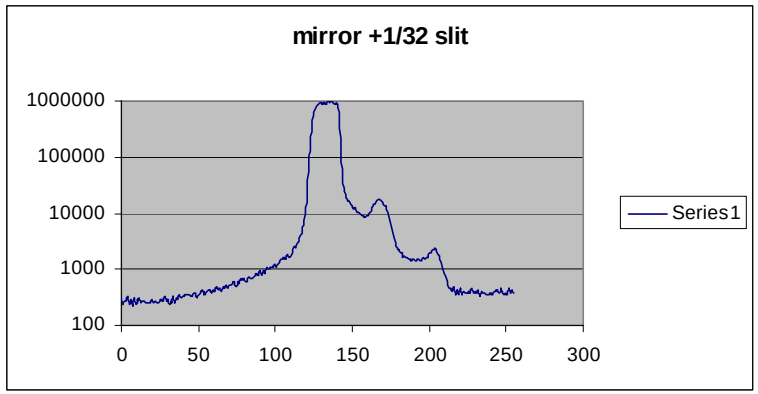
Flatfield correction factors (all pixels)

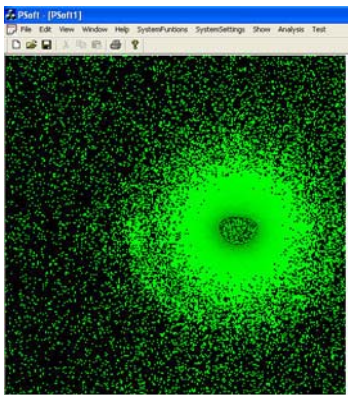


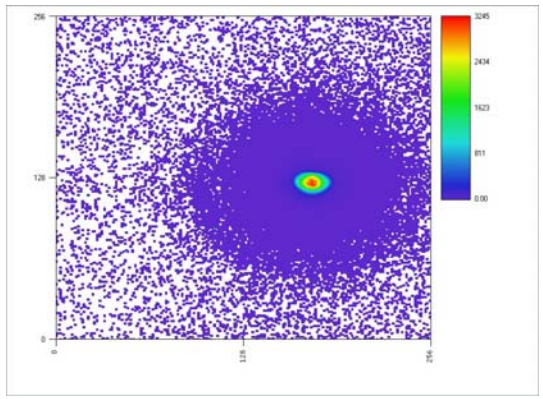
Medipix at PARC: Images of the direct beam

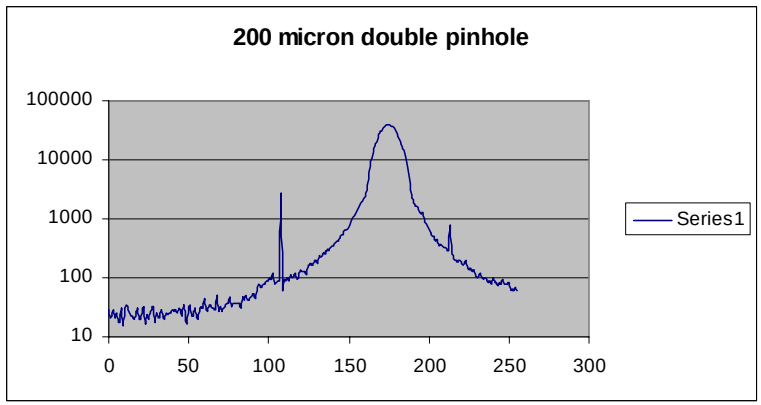




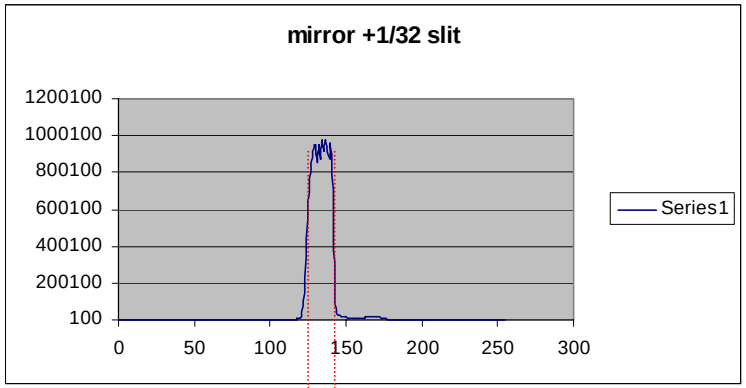


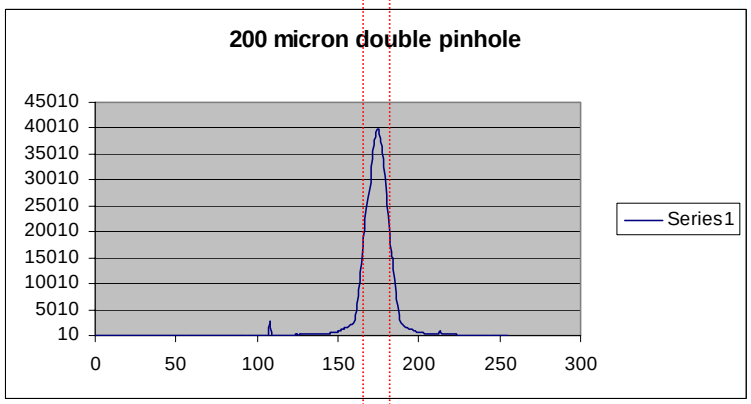


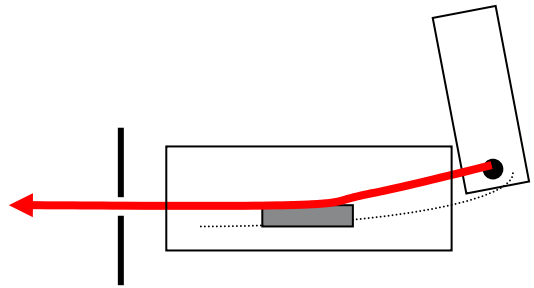


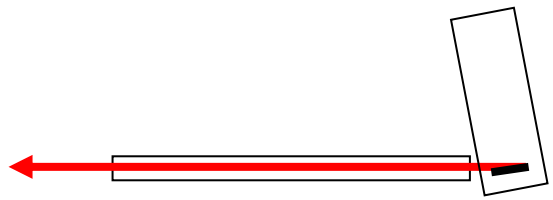


Medipix at PARC: Images of the direct beam





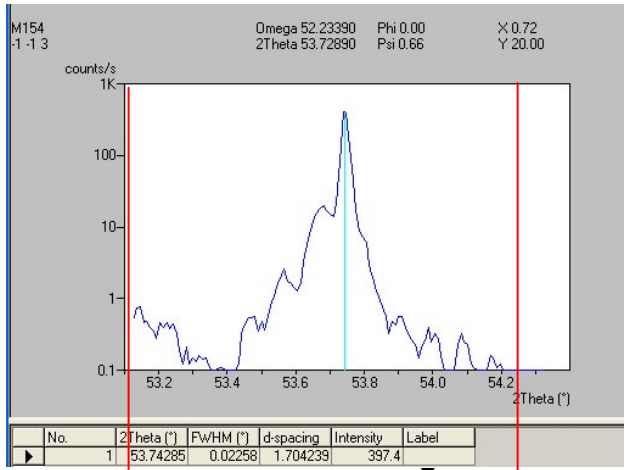




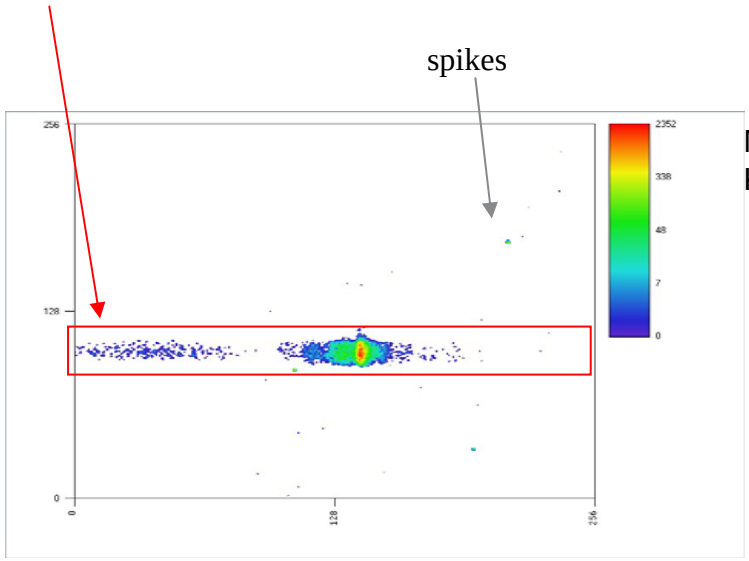
Long fine focus

Early comparison with X'Celerator Static

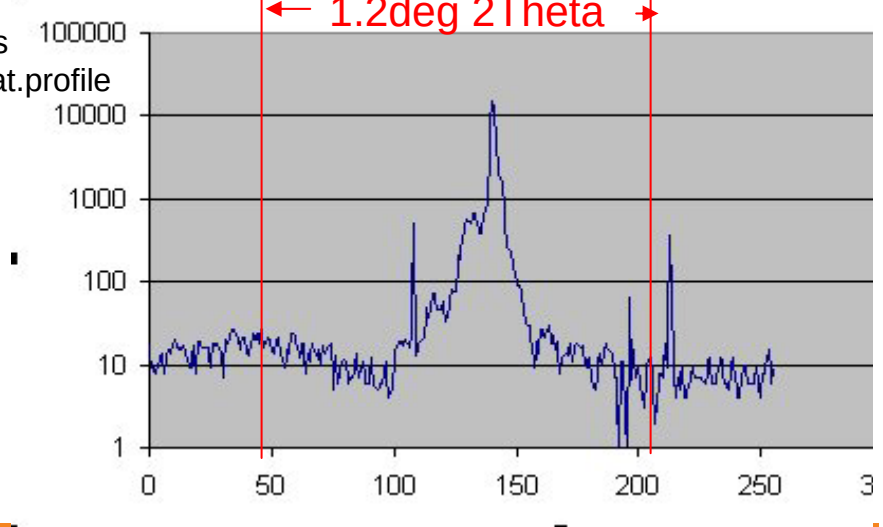
X'celerator 100s
KX0427B



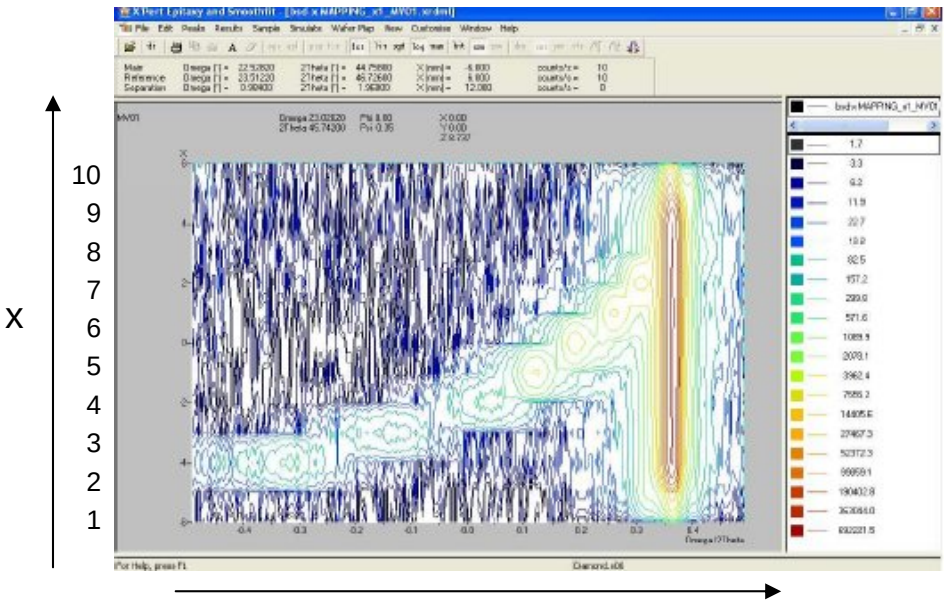
Improve data by isolating useful pixels



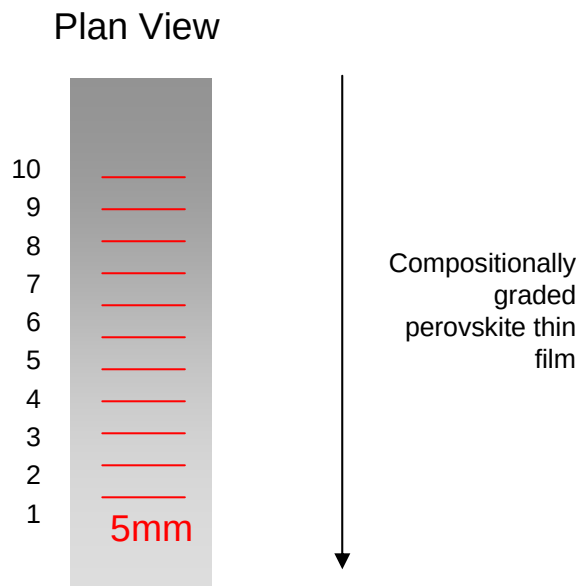
Medipix 100s
KM0427C.dat.profile



- Rapid feedback on samples with compositional grade: 12 measurements in 12 minutes!



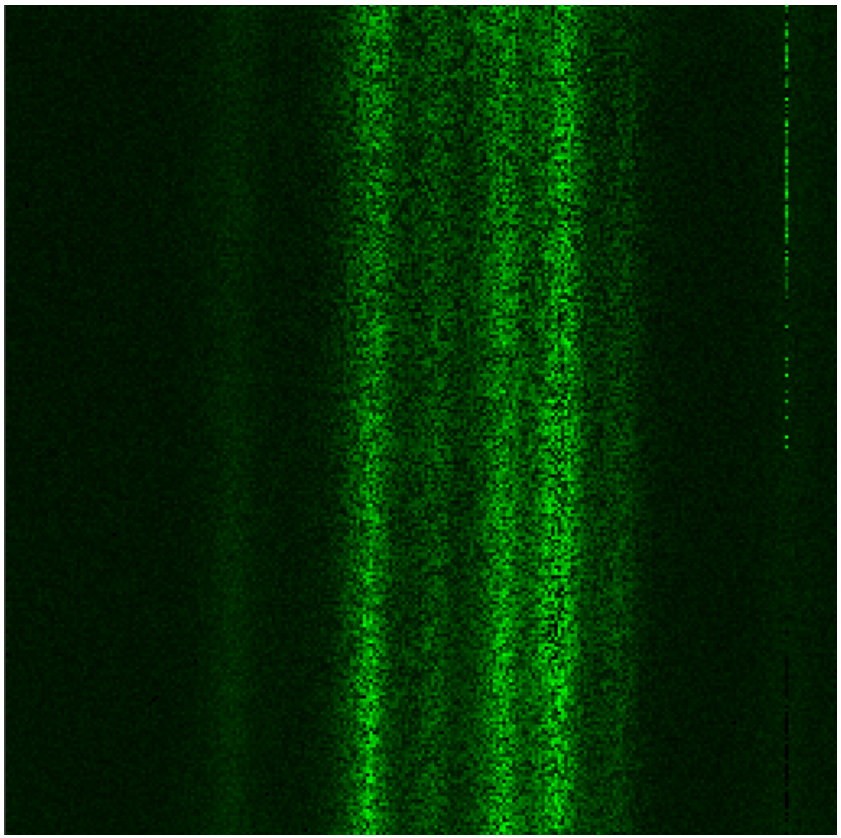
1º range 2Theta/Omega



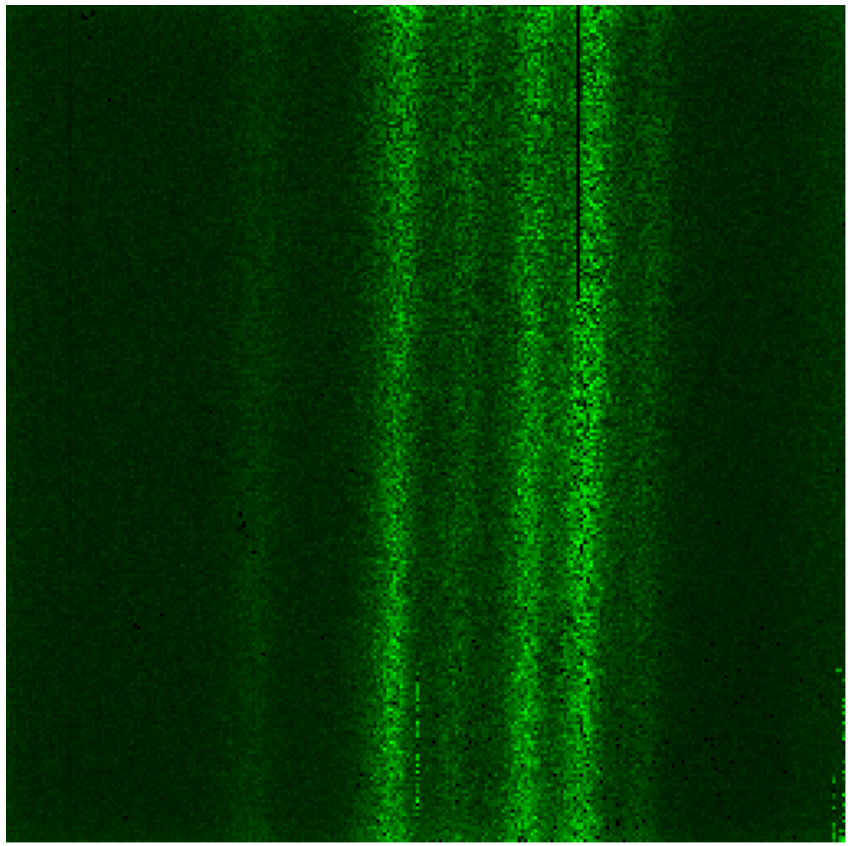
rapid 2Theta/Omega scans

PANalytical

“Five fingers of quartz”, 300 vs 700 micron sensor

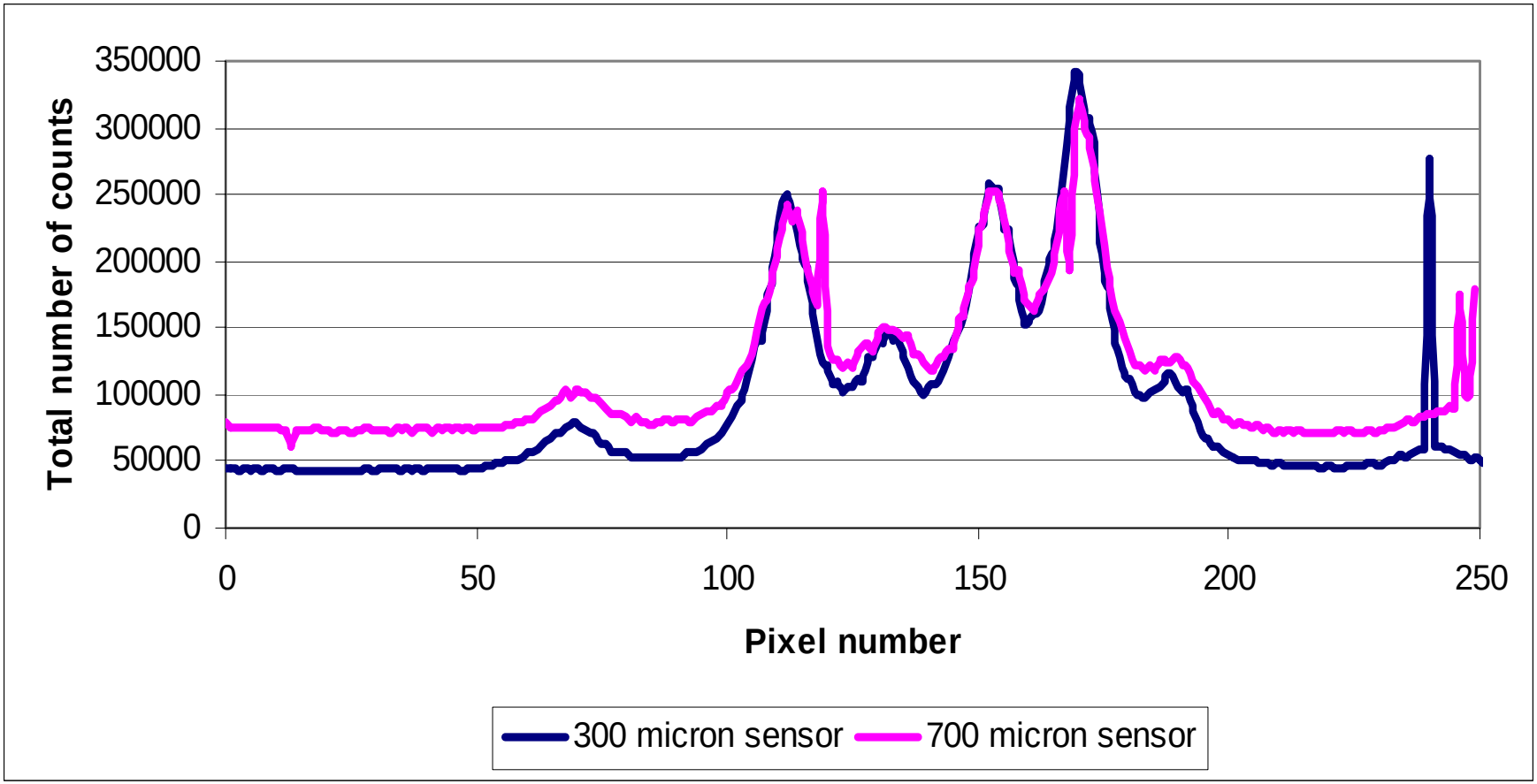


300 micron sensor



700 micron sensor

“Five fingers of quartz”, 300 vs 700 micron sensor

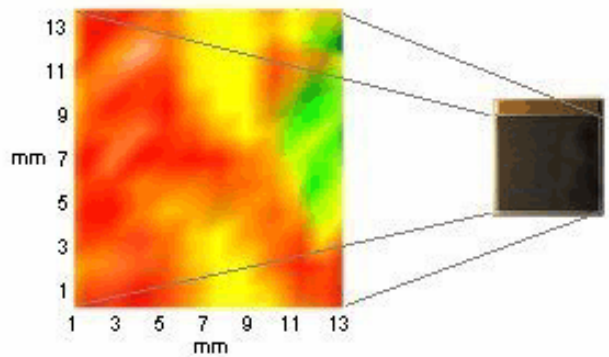


XRD as tool for detector development (www. Dannalab.com)

XRD Use for Production Quality Assurance

Novel Devices from Particle Physics

Mapping the surface of Si sensor bump-bonded onto the large IC chip helps to identify the areas of stress concentration and optimize the production process.

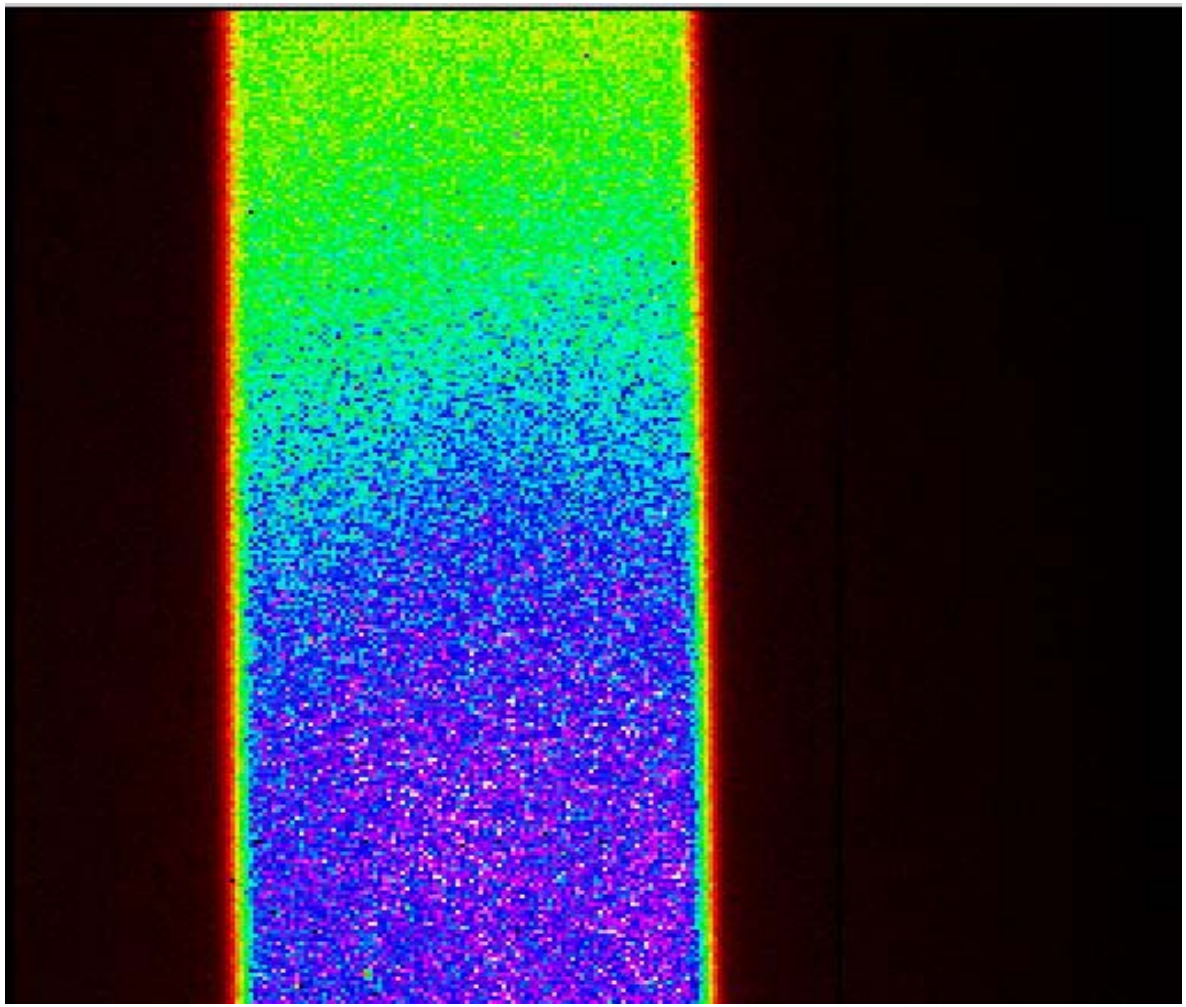


Mapping performed by measuring rocking curves at the different points of the sensor. Red color represents non-stressed Si and green indicates the presence of stress.

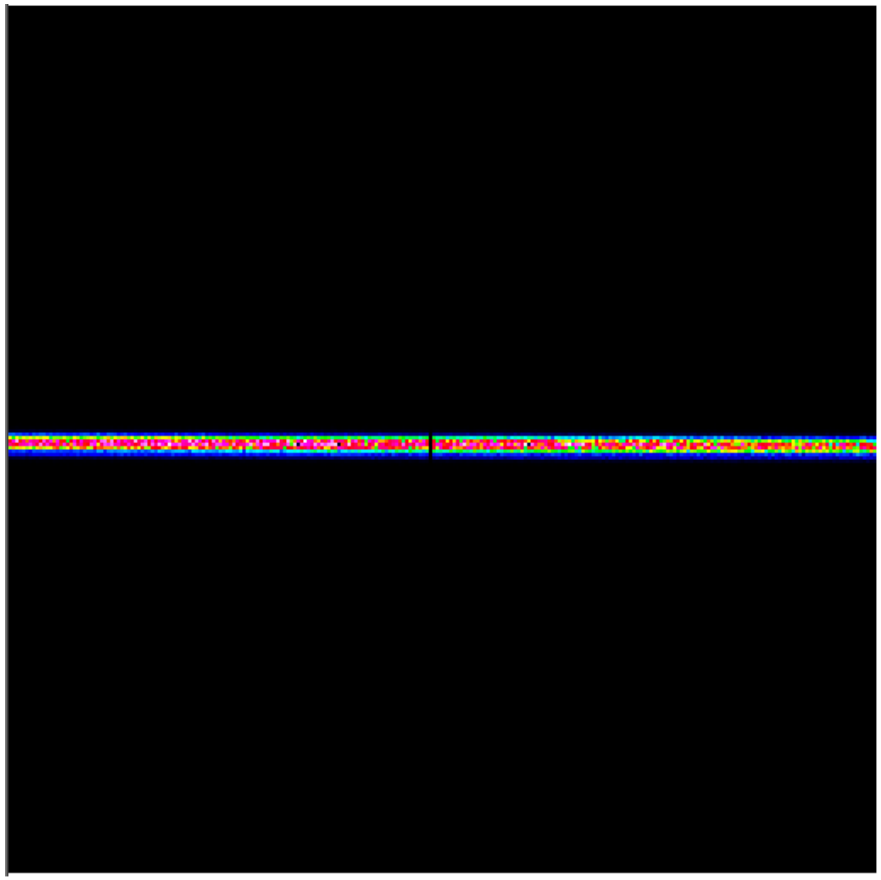
Project of CERN

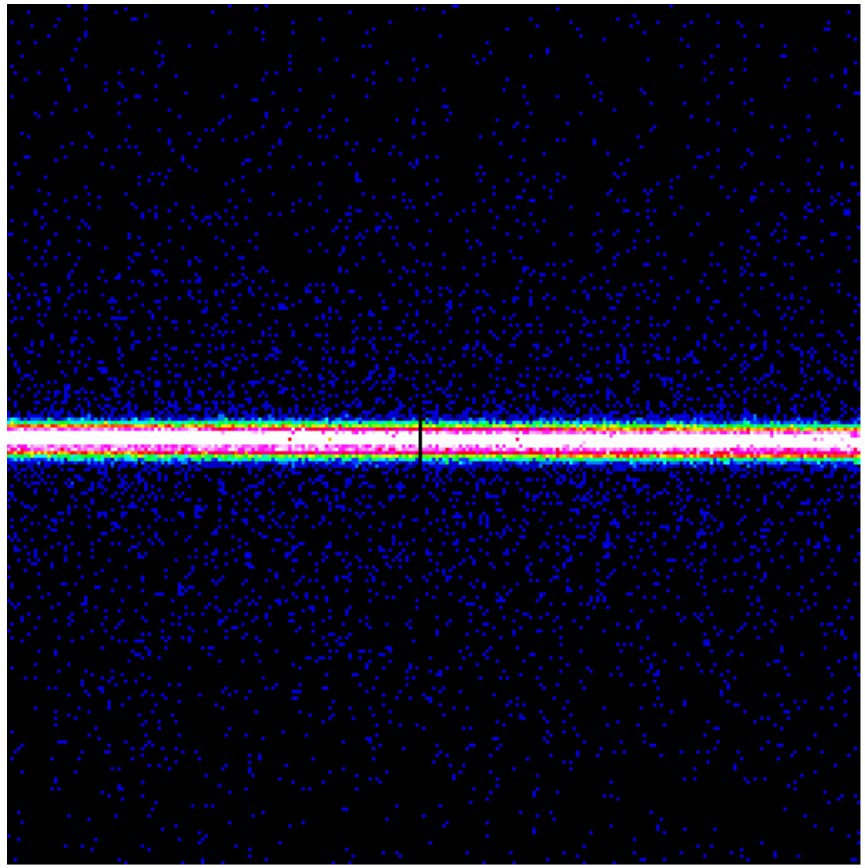
PANalytical

First shot: direct beam



Direct beam



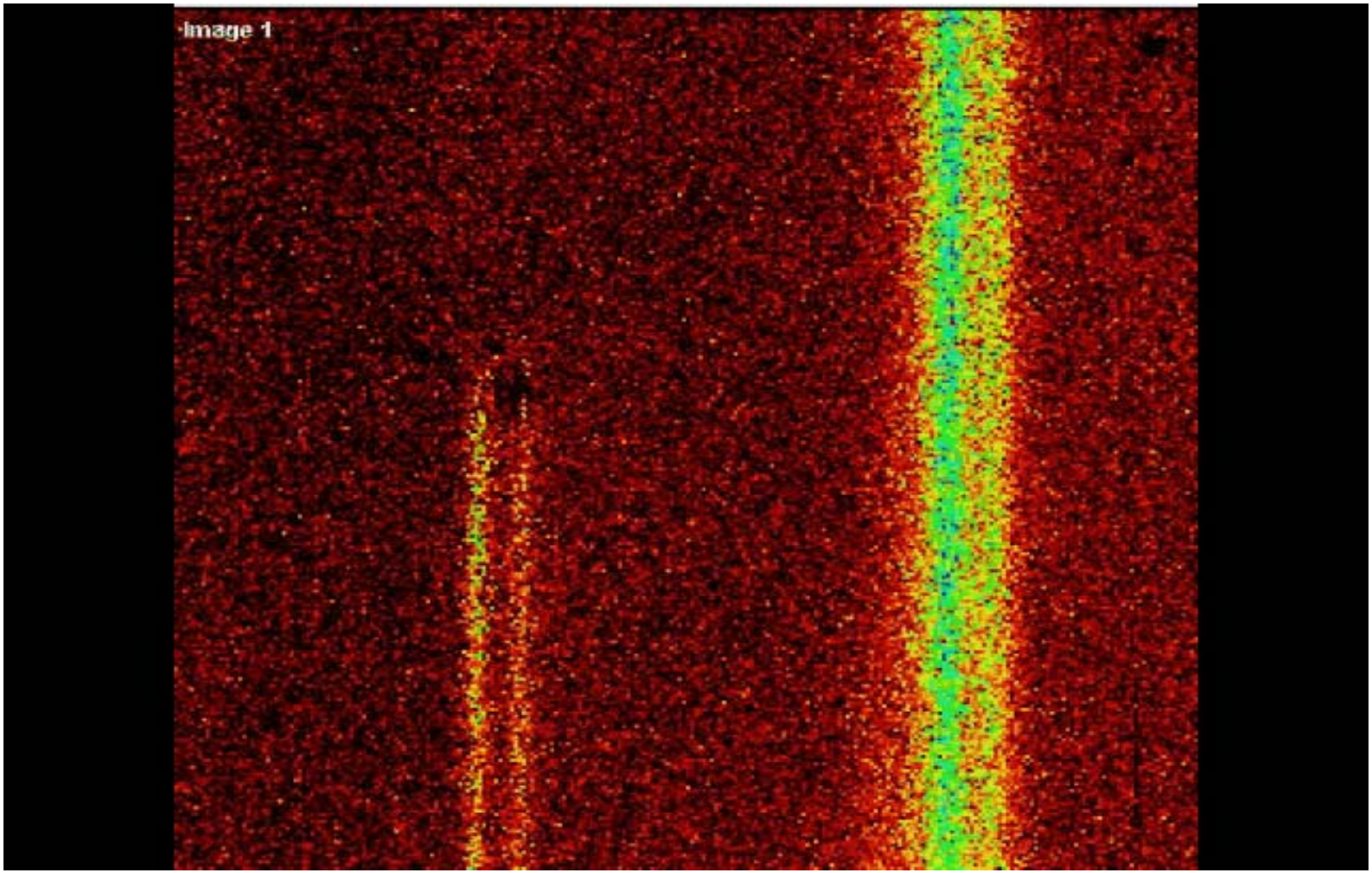


Linear scale

Logarithmic scale

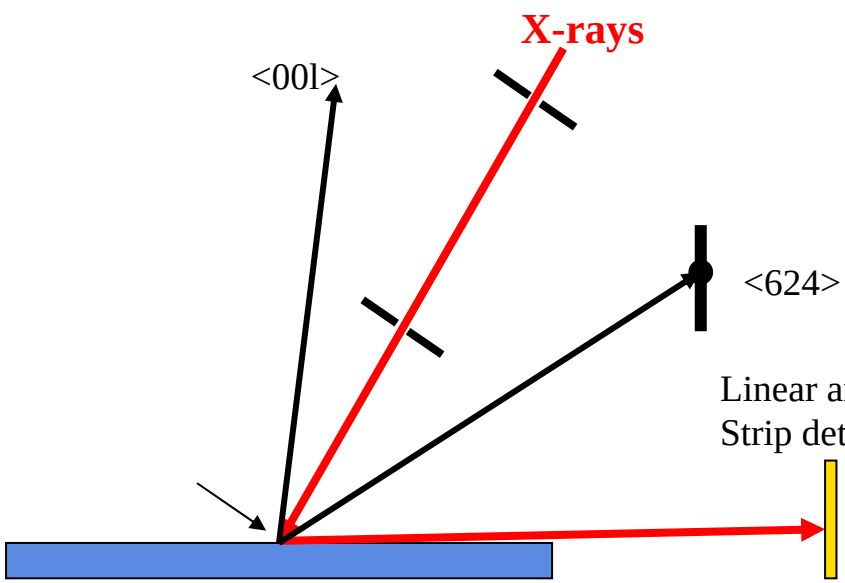
PANalytical

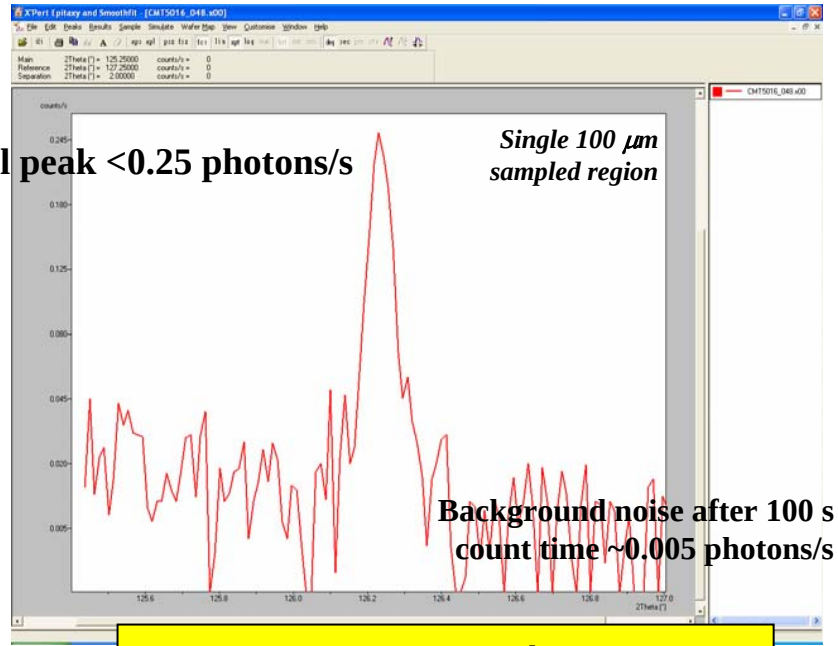
R&D: Medipix collaboration - PANalytical



Micro–high-resolution wafer mapping

"Static" measurement geometry for wafer screening of CdHgTe diode arrays for thermal imaging cameras

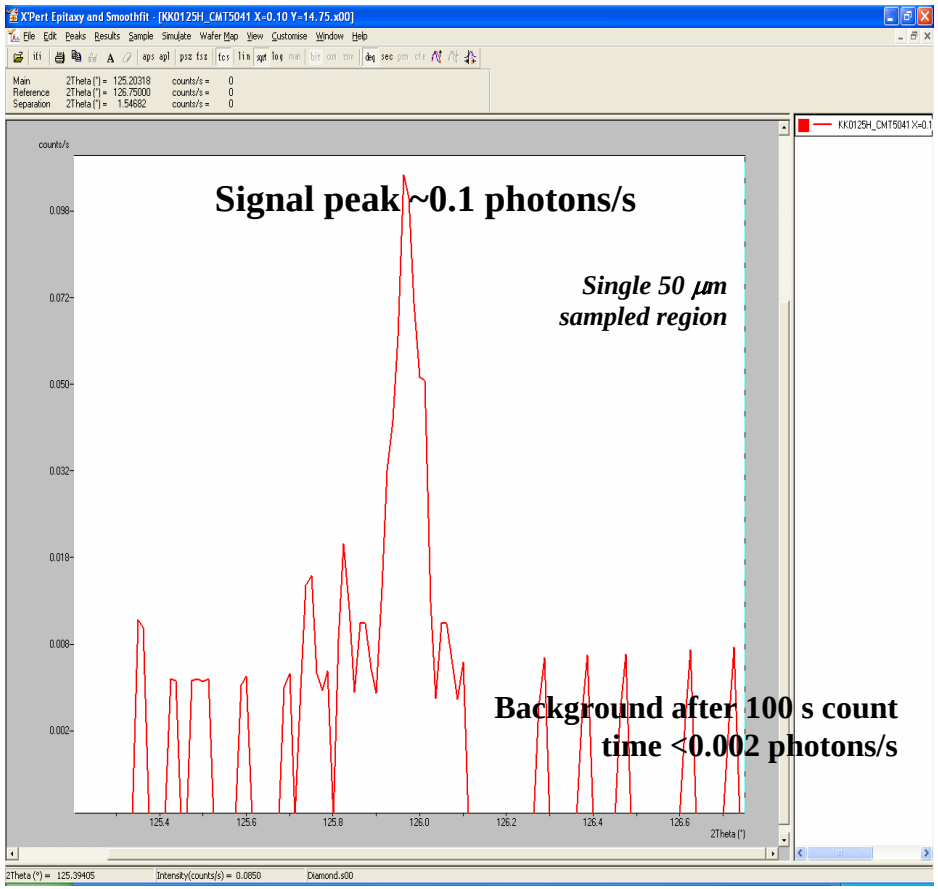


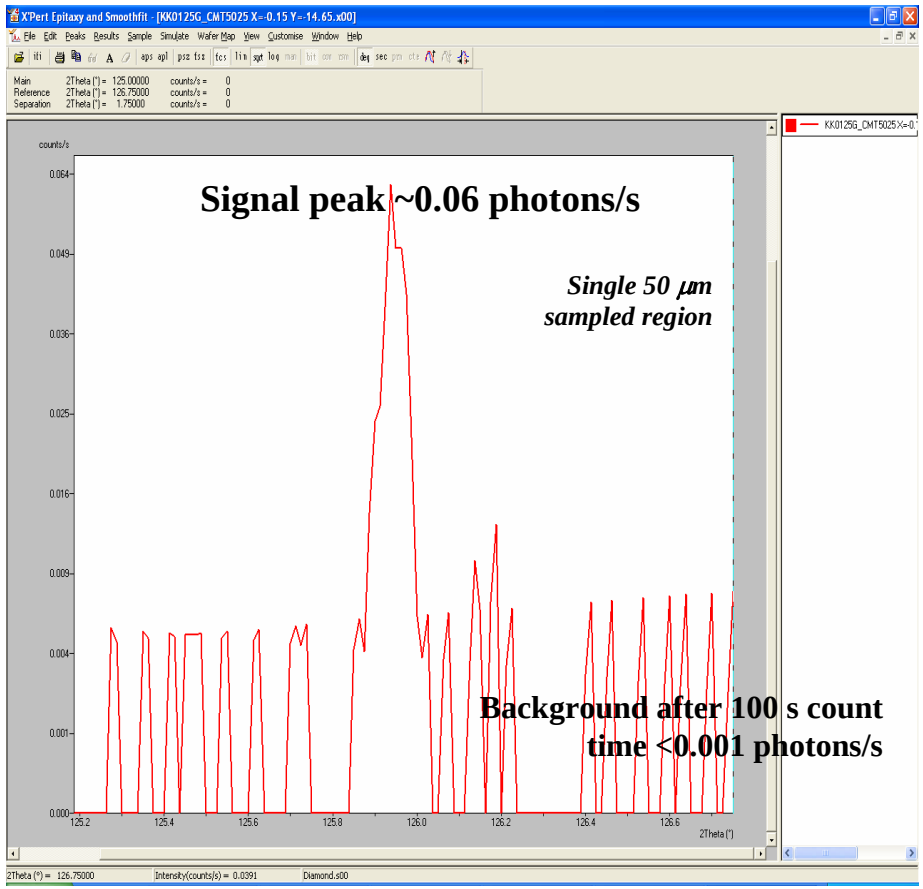


Discrimination on every photon separates very weak scattering from random noise in measurement

- Signal peak gets enhanced with counting time
- Random residual noise statistically cancels with counting time
- Results in an enhanced dynamic range

Still weaker signals; very small residual noise





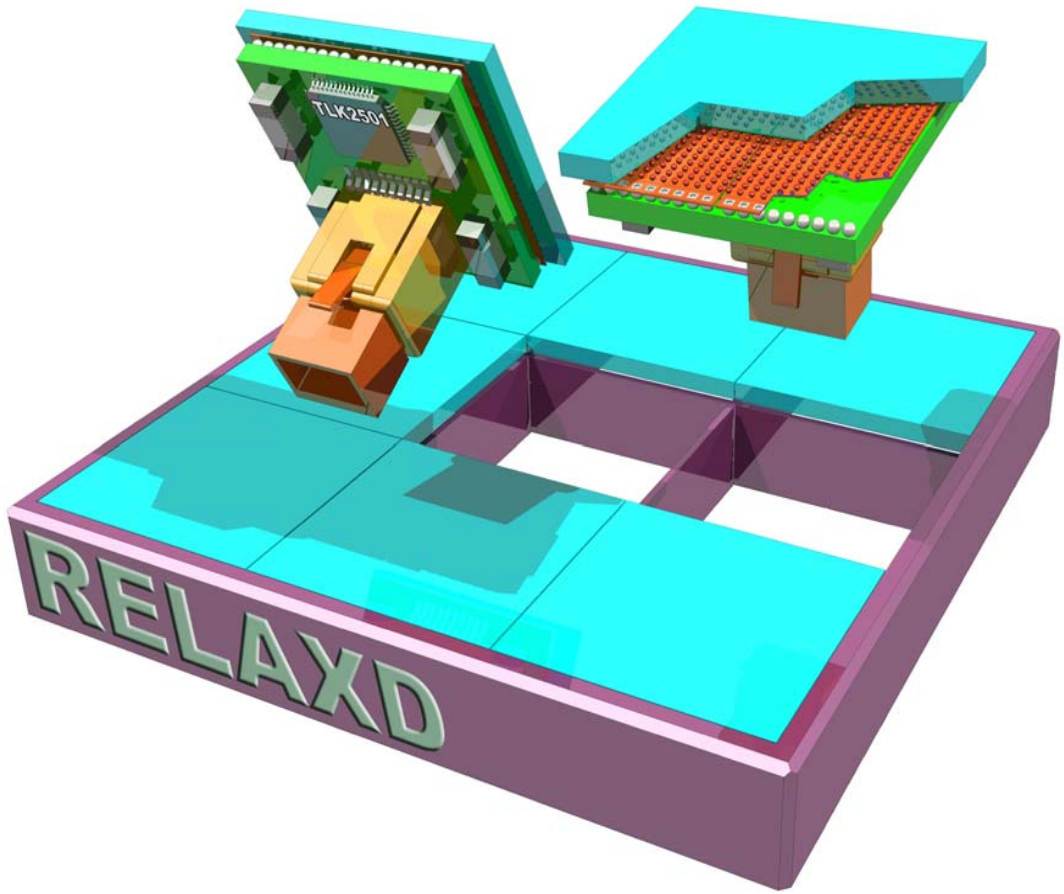
Outline

- Background
- Medipix Tech-Transfer
- First results on detector properties
- Expectations for XRD applications
- First results of Medipix in XRD
- New EUREKA project “RELAXD”
- Conclusions

RELAXD

PANalytical

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



IWORID 7 Grenoble Innovation Collaboration EUREKA Project

RELAXD Partners

RELAXD Consortium

- CANBERRA Olen, Belgium
- IMEC Leuven, Belgium

- NIKHEF Amsterdam, Netherlands
- PANalytical as Penholder:
  Almelo, Netherlands

Consequences of RELAXD for the partners

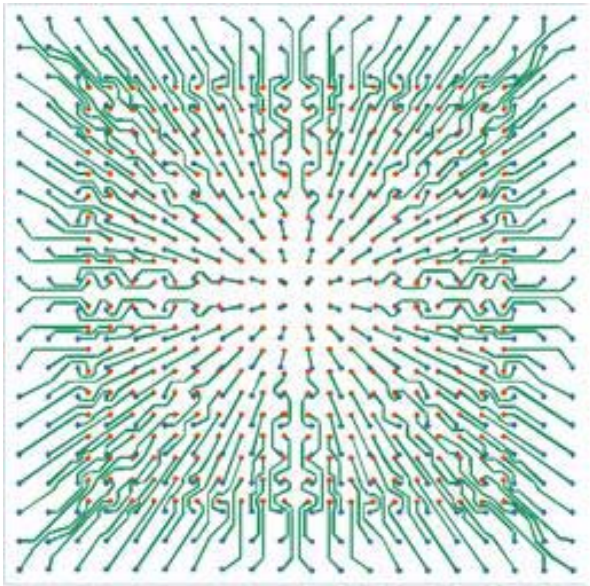
PANalytical

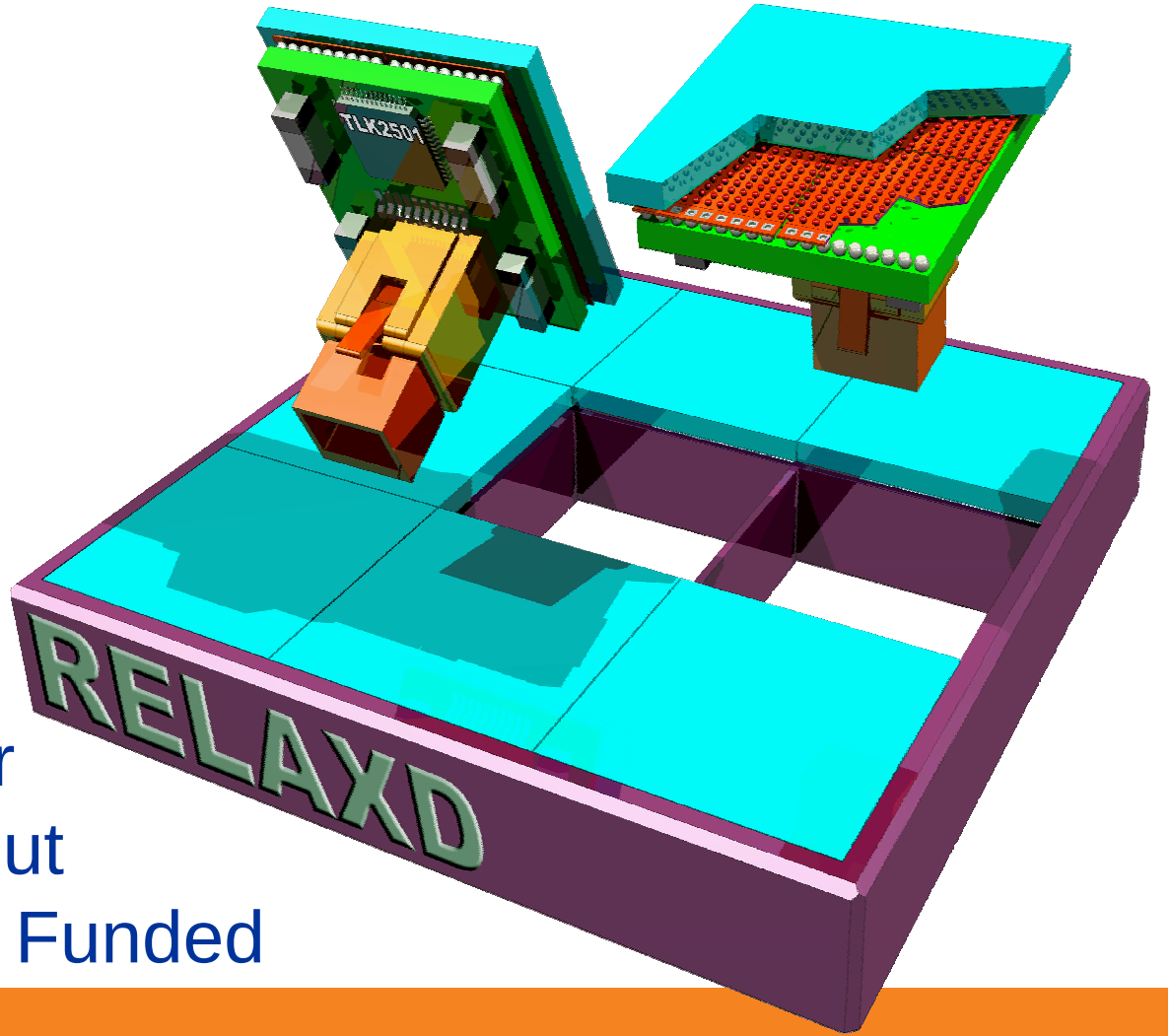
- Cost & Subsidy (plan! not yet officially approved!)
  - 2690 kE total project
  - 1138 kE PAN 60% funding => 455 KE own & **683 kE IS**
  - 922 kE NIKHEF 553 kE IS
  - 633 kE CANBERRA 331 kE IWT
  - 0 IMEC funded by CAN mainly and also by PAN
  - If you go larger (area) => the s/w r/o and acquisition algorithms have to be done anyway!

- 5 elements
  - Fan-out structure – pitch adaption
  - Minimized dead spaces
  - Through Si via technology – 4 side buttability
  - High-speed Gbit/s read-out
  - Software for data acquisition,
    homogenization of large area pixel response calibrations,
    control software
    => X-ray detector (‘low’ energies)

PANalytical

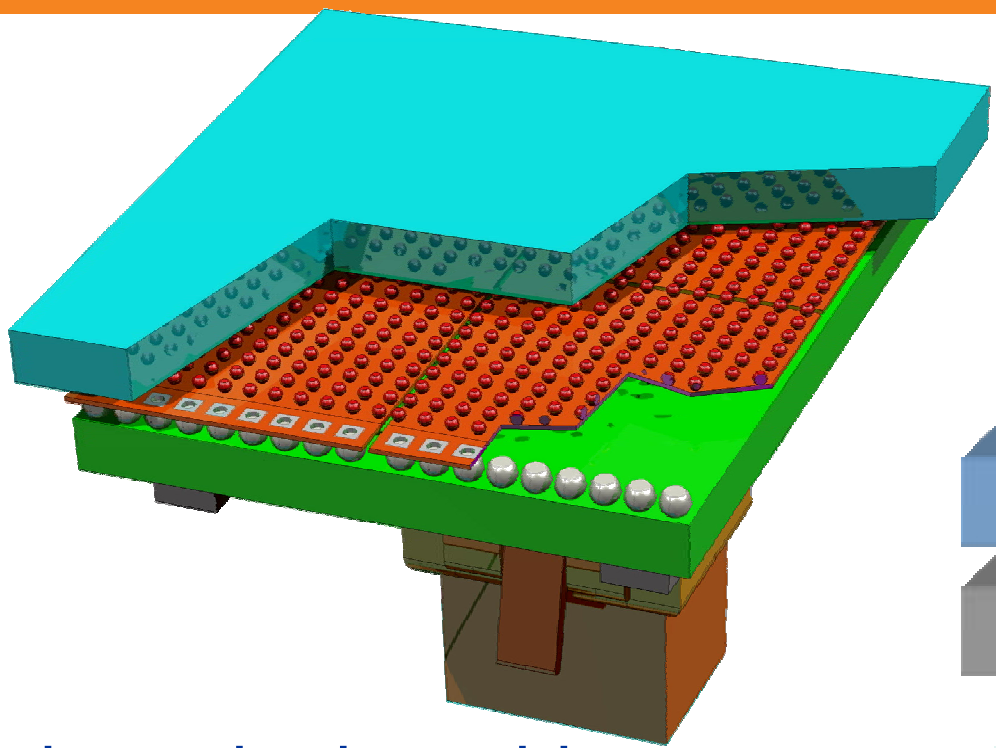
Fully tiled X-ray imager

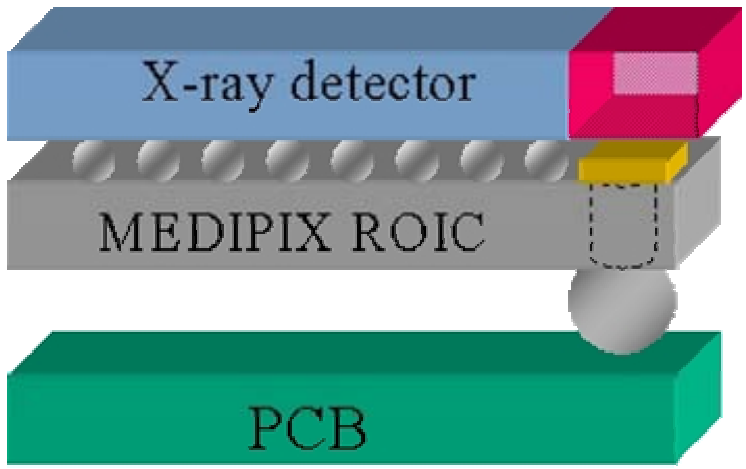




need pitch adapter
Gbit/s serial readout
Innovation Project Funded

The Future: Medipix2 tiling

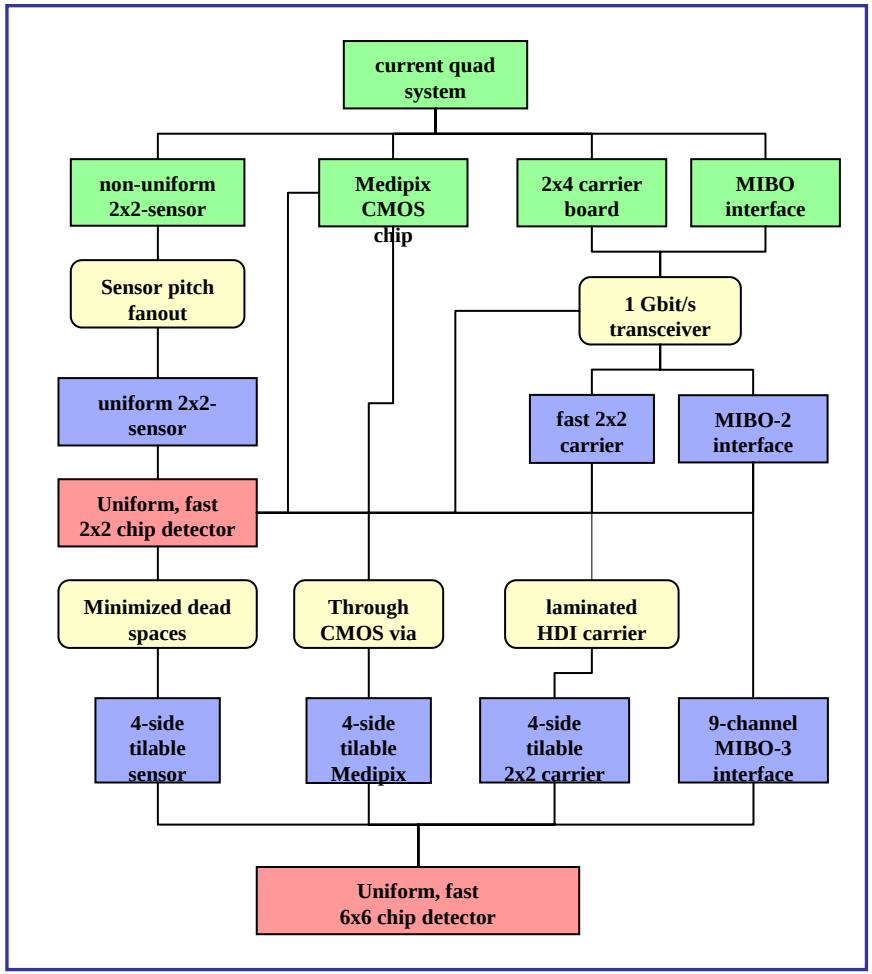




through-via etching
wafer thinning
3D stacking

PANalytical

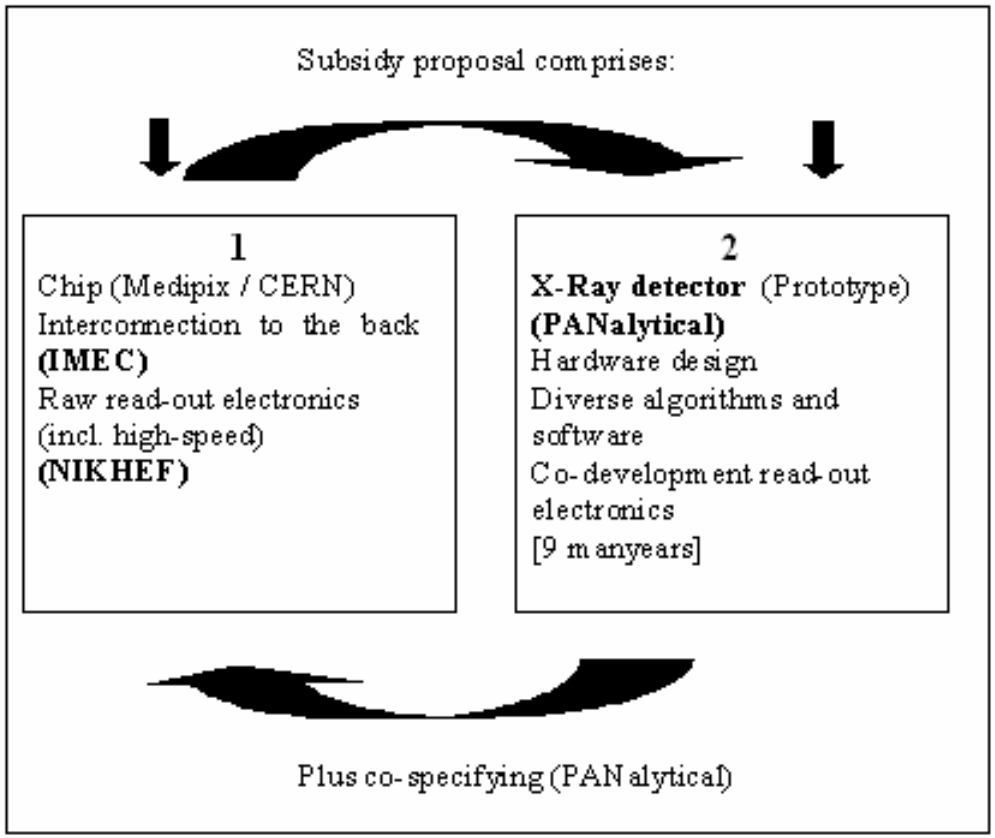
Project Flow



PANalytical

Pictures of the MIBO

Role PAN



3
System Integration on X-ray machines
Plus **series production** of detectors + X-ray systems
(outside subsidy proposal)
(PANalytical)

4
X-ray Analysis
(outside subsidy proposal)

(PANalytical)

>> 30 manyears (PANalytical)

Potential Partners

Tech & Application Center PANalytical

Product / Integration / Software

Core Partners

CERN / NIKHEF / CANBERRA / IMEC

Chip design / Electronics / Software

Output => PLATFORM

Basic detector modules

Tiling- RELAXD

Mainstream

+ spin-offs

Suppliers

IBM

MCNC

Electronics companies

Outsourcing

PANalytical

Relevance: PAN Detector center

Pixel intelligence

CERN

Medipix 2

Detector chip production

CMOS process (0.25 μm)

Medipix + , ++

0.13 mu, 0.09 mu CMOS

….Super-chip,
>RELIABLE<

CANBERRA

IMEC

NIKHEF

PANalytical

(MCNC)

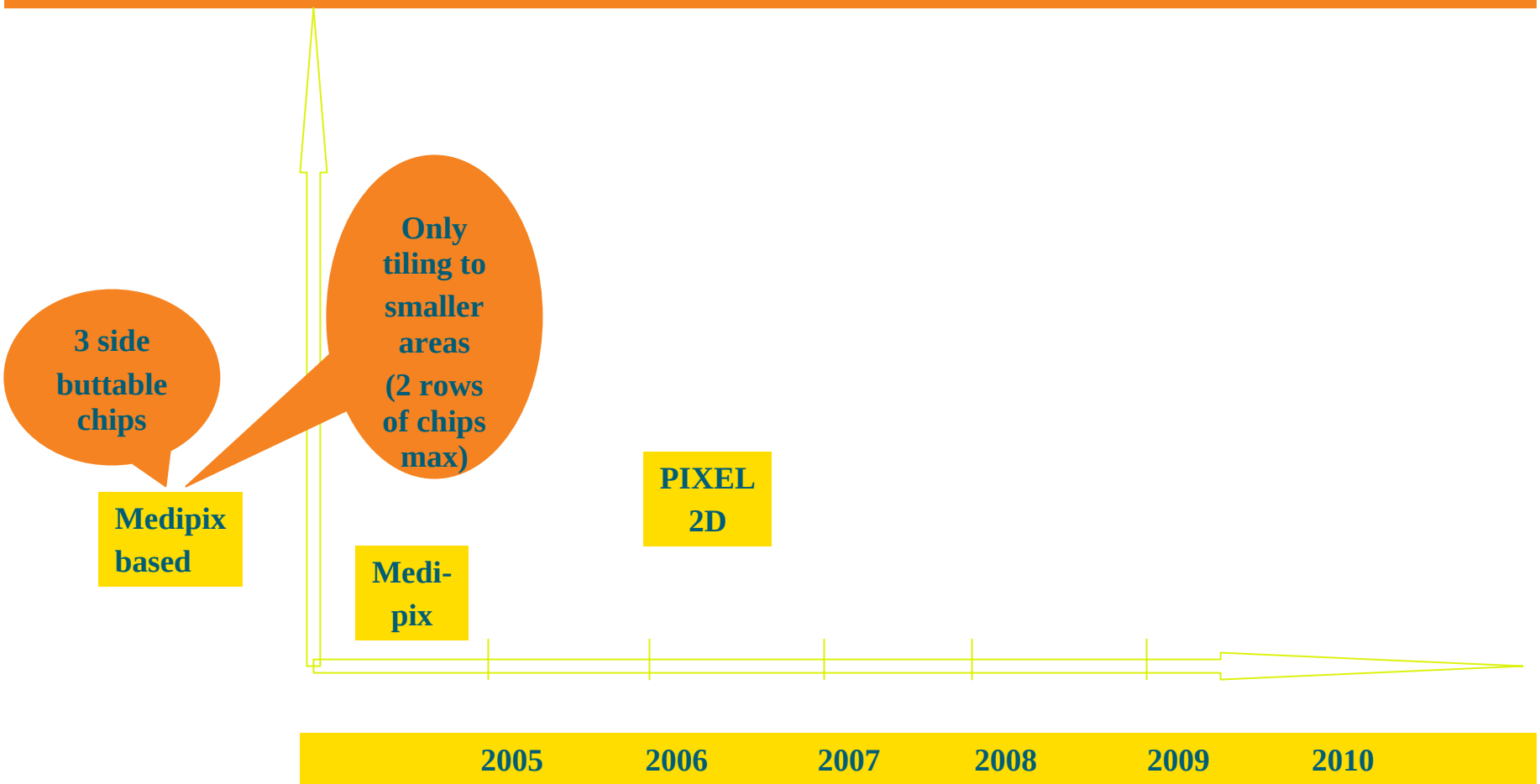
Large® area

Various shapes&sizes

Plus spin-offs

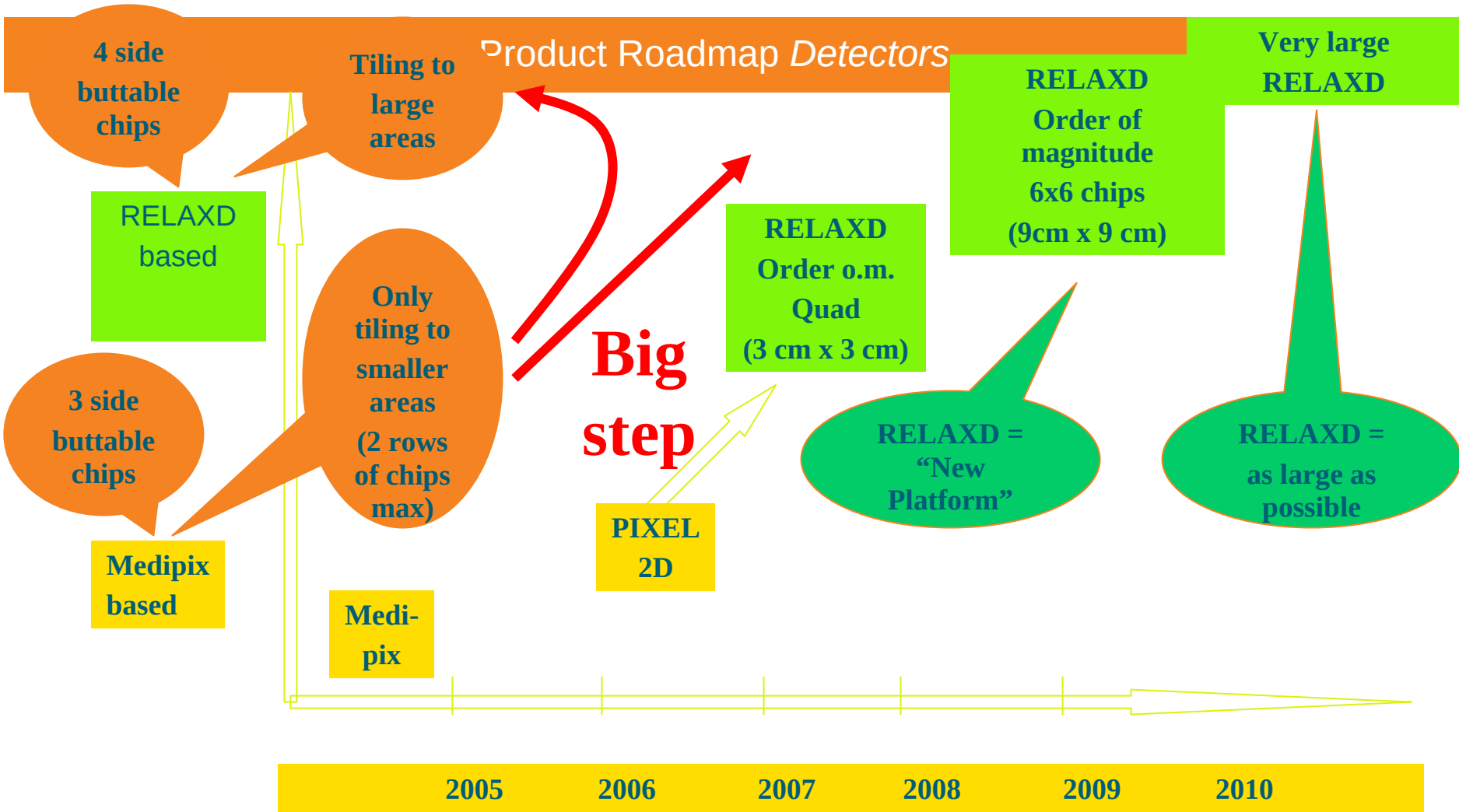
PANalytical (+CANBERRA)

Product Roadmap *Detectors*



PANalytical

Product Roadmap *Detectors*



Conclusions

PANalytical

Detectors

- Medipix
  - Mature, may come soon
- RELAXD
  - Starts soon
- RELA-XRD
  - Prepared in time
- Question
  - Who has fun in a collaboration / (different chips)?
  - Who has enthusiam for another subsidy project ?

BACKGROUND in Medipix2 CHIP

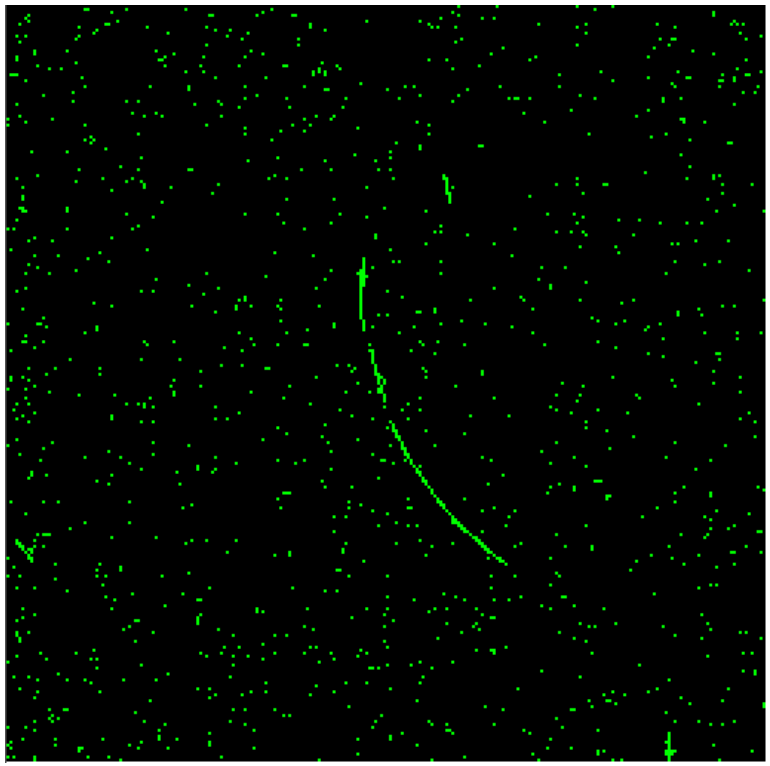
EXPOSURE at Panalytical

Roelof de Vries

TRACK over ~ 140 PIXELS

RADIUS of CURVATURE
r = 6.9 mm
PROBABLY MUON
BENT by EARTH FIELD ?

B = 5 x 10^{-5} T
p = 0.3 B r
--> momentum
p ~ 100 eV
(not possible ??
10 MeV μ has range ~5 mm)
(in reality field higher ?)



PANalytical