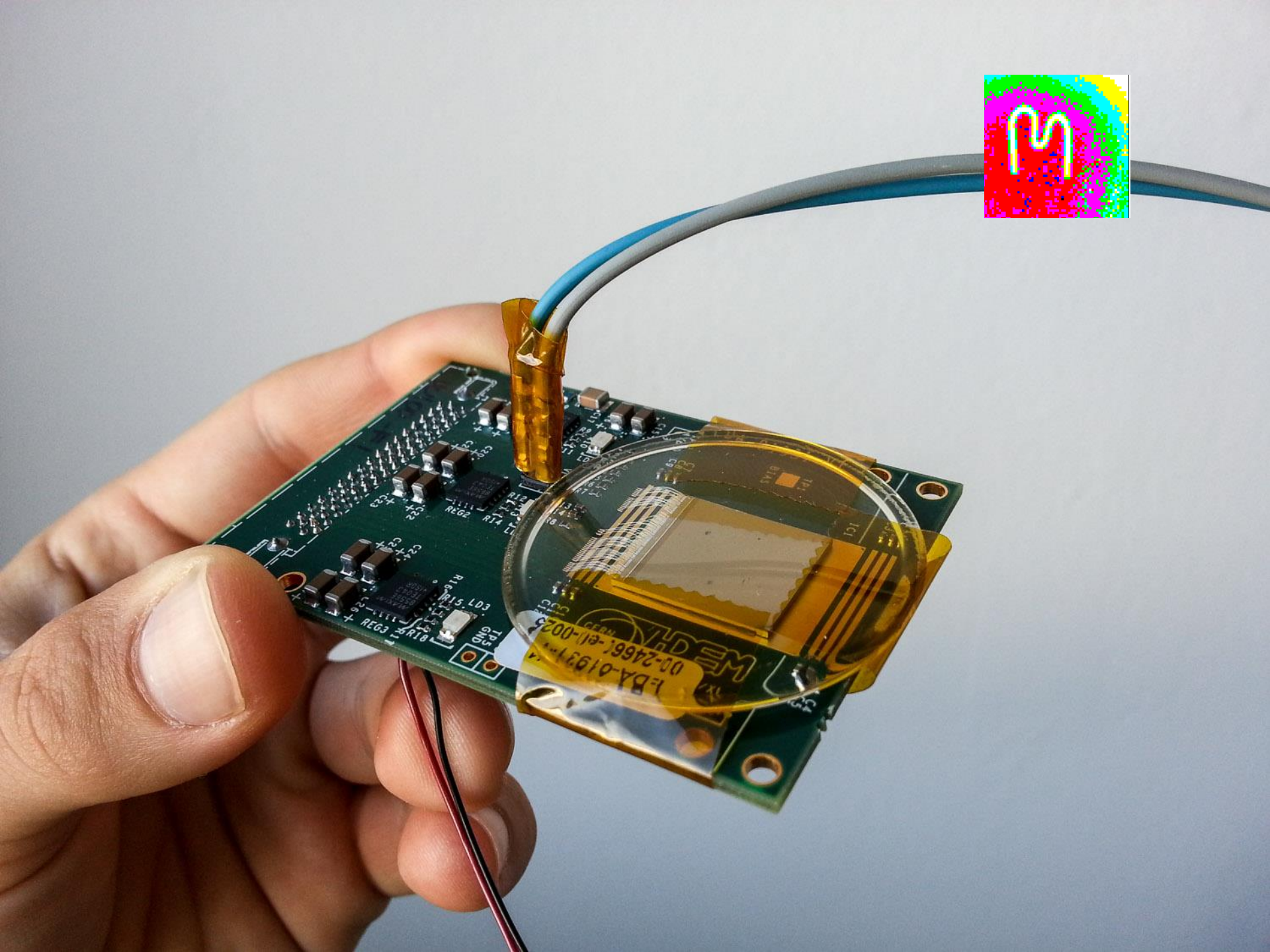
Erik Fröjdh

CERN, Mid Sweden University

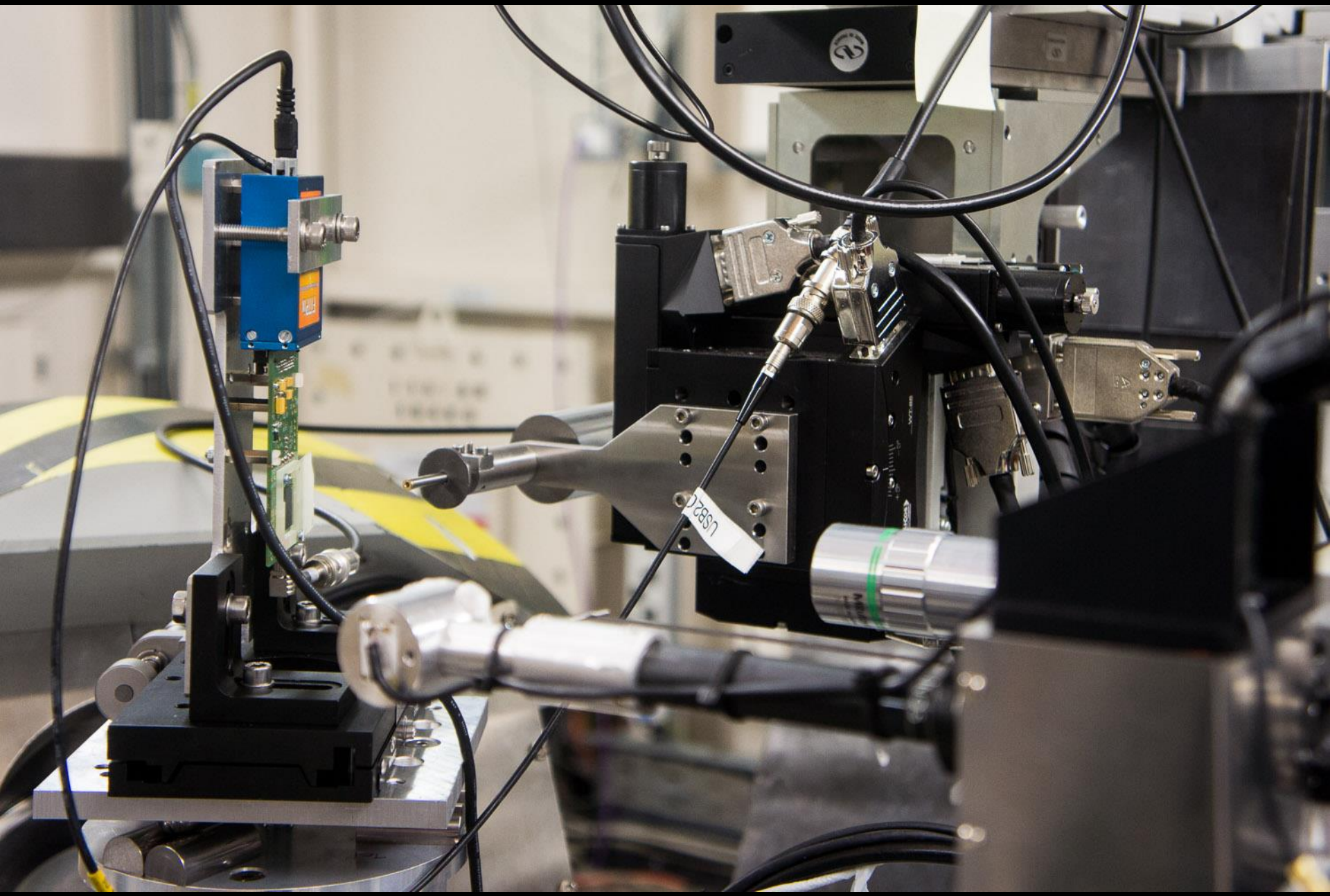


Characterization of hybrid pixel detectors

Applications for dosimetry in mixed radiation fields


Accelerating Science


STOP

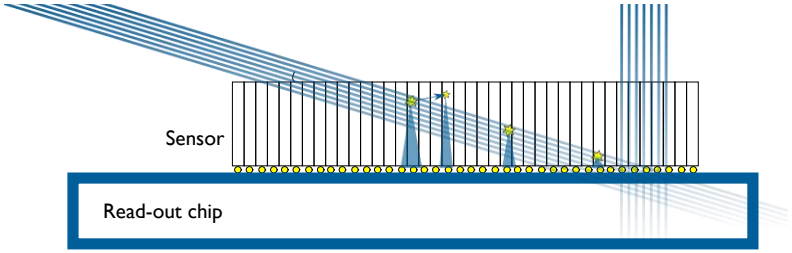


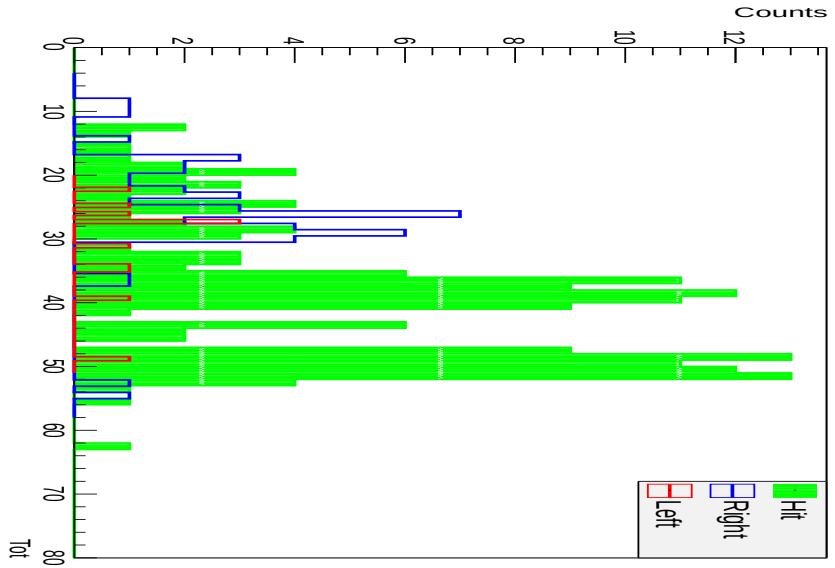
Mittuniversitetet

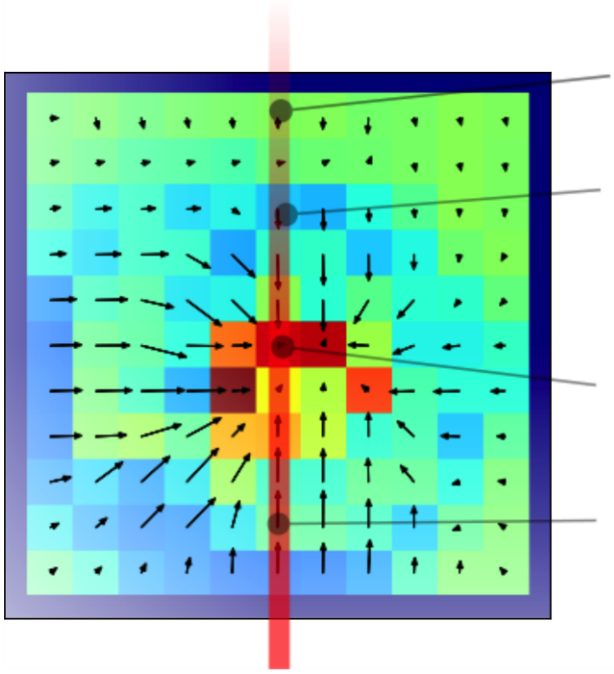
MID SWEDEN UNIVERSITY


VIA VERITAS VITA
University
of Glasgow


diamond





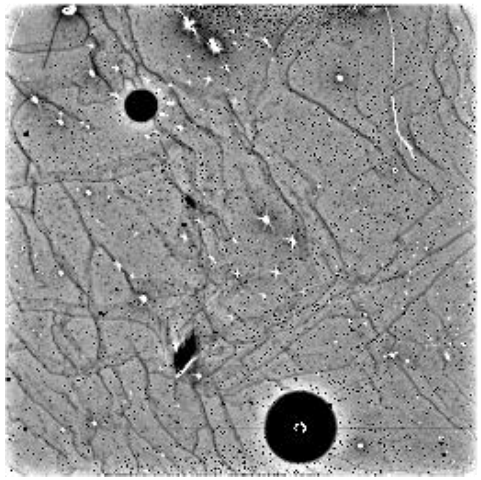


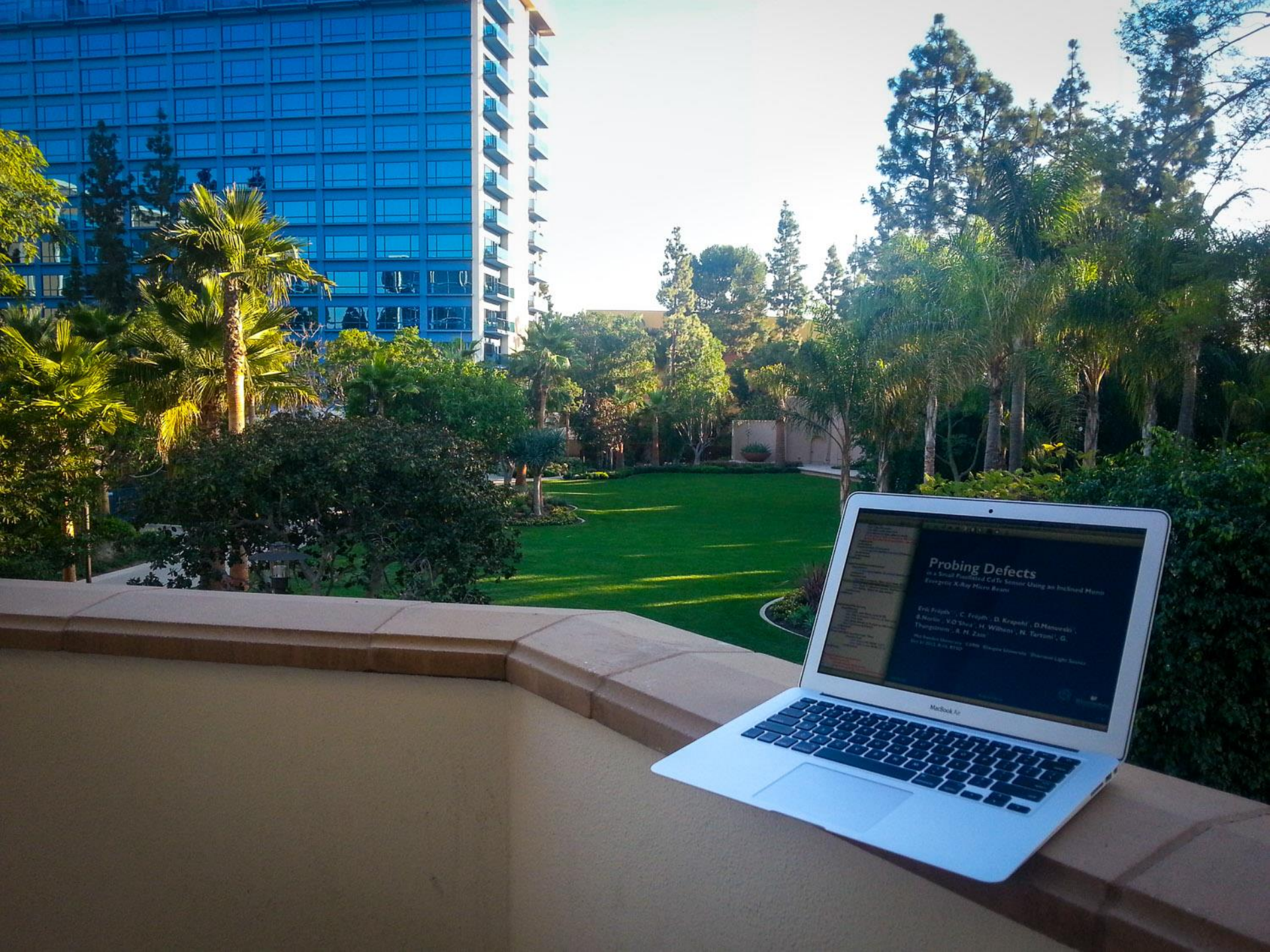
Pixel 4: 900um
good field

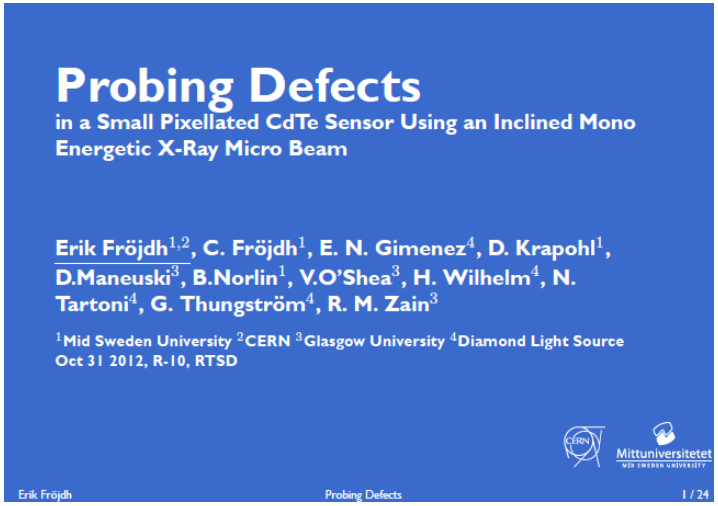
Pixel 3: 760um
disturbed field
but close to pixel

Pixel 2: 570um
charge drifts in

Pixel 1: 320um
disturbed field




Probing Defects
MacBook Air



Probing Defects in a Small Pixellated CdTe Sensor Using an Inclined Mono Energetic X-Ray Micro Beam

Erik Fröjdh[1,4] *Member, IEEE,* C. Fröjdh[1] *Member, IEEE,*, E.N. Gimenez[3], D. Krapohl[1] *Member, IEEE,* D.Maneuski[2], B.Norlin[1], V.O'Shea[2], H. Wilhelm[3], N. Tartoni[3] G. Thungström[1], R. M. Zain[2]

***Abstract*—High quantum efficiency is important in X-ray imaging applications. This means using high-Z sensor materials. Unfortunately many of these materials suffer from defects that cause non-ideal charge transport. In order to increase the understanding of these defects, we have mapped the 3D response of a number of defects in two 1 mm thick CdTe sensors with different pixel sizes (55μm and 110μm) using a monoenergetic microbeam at 79 keV. The sensors were bump bonded to Timepix read out chips. Data was collected in photon counting as well as time-over-threshold mode. The time-over-threshold mode is a very powerful tool to investigate charge transport properties and fluorescence in pixellated detectors since the signal from the charge that each photon deposits in each pixel can be analyzed. Results show distorted electrical field around the defects, indications of excess leakage current and large differences in behavior between electron collection and hole collection mode. The experiments were carried out on the Extreme Conditions Beamline I15 at Diamond Light Source.**

I. Introduction

IN order to achieve high quantum efficiency in hard X-ray imaging, there is a need to use high-Z detector materials. GaAs has sometimes been proposed as a medium-Z material [1], [2], [3] but Cadmium Telluride (CdTe) and Cadmium Zinc Telluride (CZT) are the two main candidates that have been investigated since the early 1970s. However, despite recent progress [4], [5], these materials suffer from defects such as twins, sub-grain boundaries, dislocations and inclusions that cause non-ideal charge transport [6], [7], [8].

CdTe detectors are mainly made from crystals grown using methods as the Modified Bridgman method [9] or the Travelling Heater Method [10] but also some attempts to grow polycrystalline layers have been made [11]. The grown crystals are characterized using destructive and non destructive methods

Most of the detector development work concernes single pad detectors or detectors with large pixels [21], [22], [23] where a main problem was the difference in charge collection between electrons and holes. However, recently, CdTe detectors with pixel sizes down to 55 x 55 μm^2 have been fabricated and mounted on pixellated readout chips [24]. With that pixel size the small pixel effect largely makes the device a single carrier device and the resolution approaches the resolution of other characterization methods.

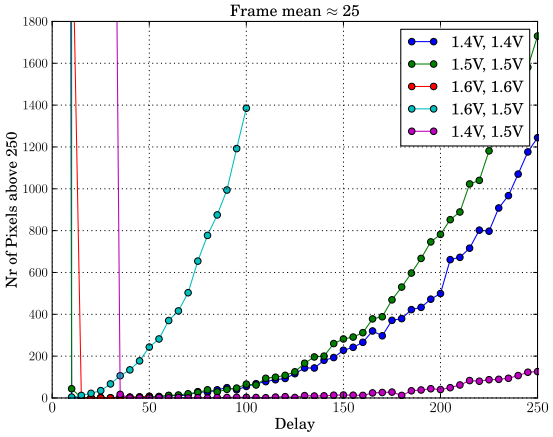
In this project several defects on pixellated CdTe detectors with pixel sizes of 55 x 55 μm^2 and 110 x 110 μm^2 have been probed with a monoenergetic microbeam. The results are compared to similar measurements made on small pixel detectors and to results obtained using other characterization methods.

II. Measurement Setup

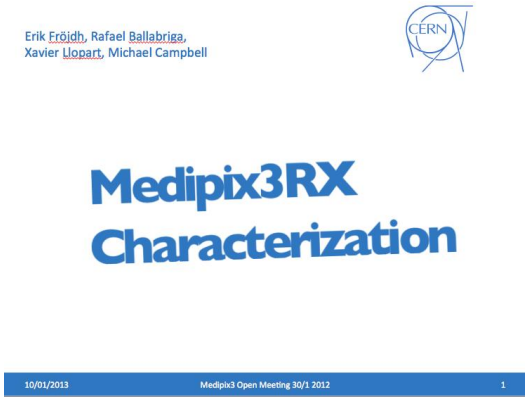
The measurments were carried out at the I15 Extreme Conditions Beamline at Diamond Light Source [25]. For the measurements we used two different types of CdTe sensors bump-bonded to Timepix readout chips. The sensors had pixel sizes of 55 x 55 μm^2 and 110 x 110 μm^2. The thickness of both sensors was 1 mm The Fitpix [26] USB2 readout system and the Pixelman [27] software from The Institute of Experimental and Applied Physics (IEAP) of Czech Technical University in Prague were used to control the chip.

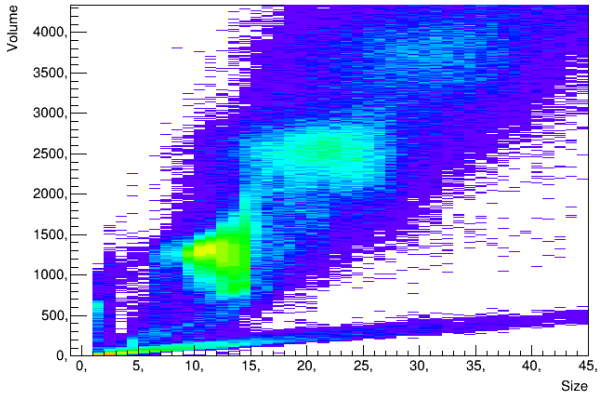
A. Timepix

The Timepix [28] chip is developed by the Medipix2 [29] collaboration and is a hybrid pixel ASIC with single photon processing capability. The chip can be operated in either

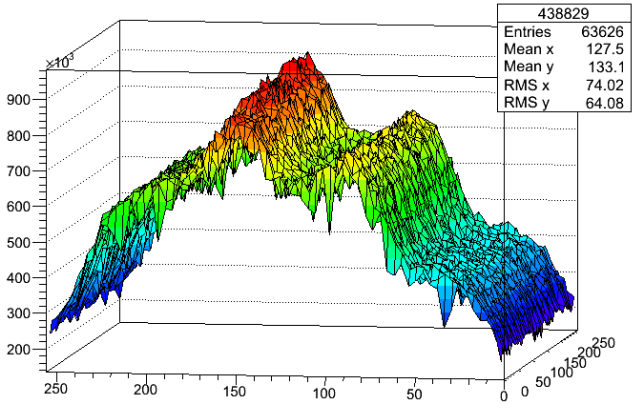


Characterization of Medipix3RX counters



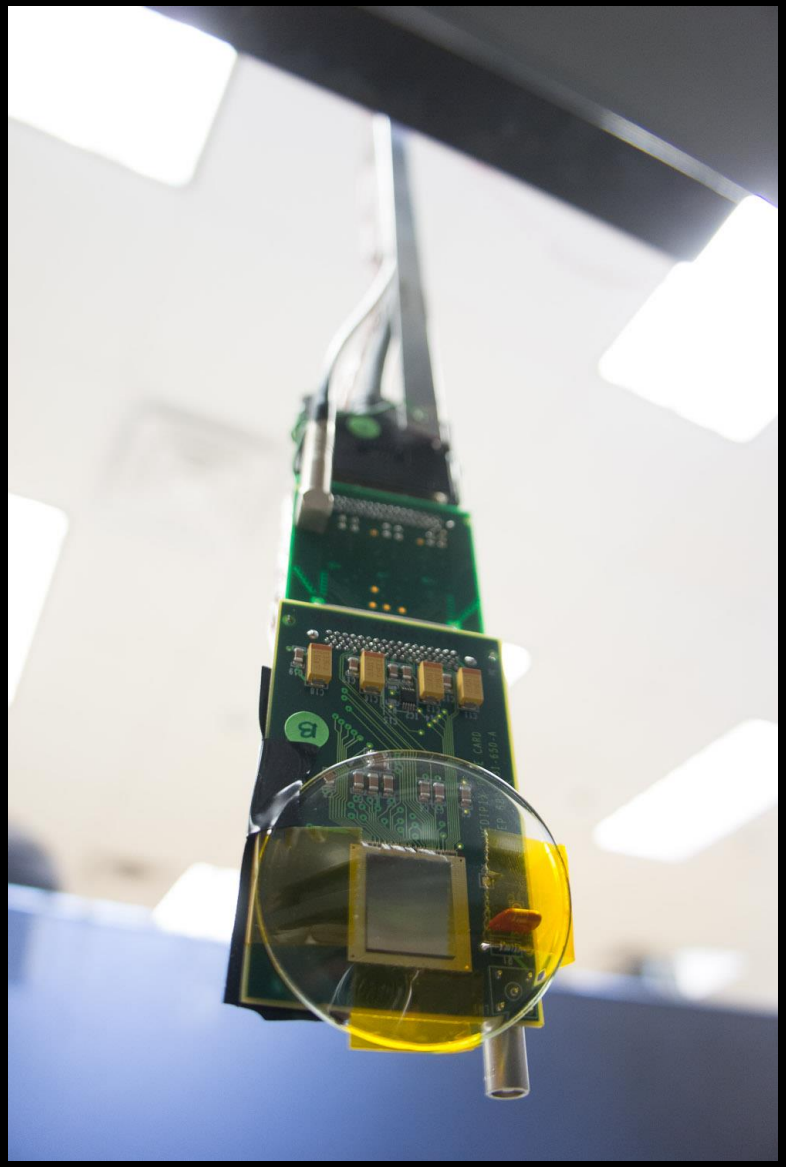


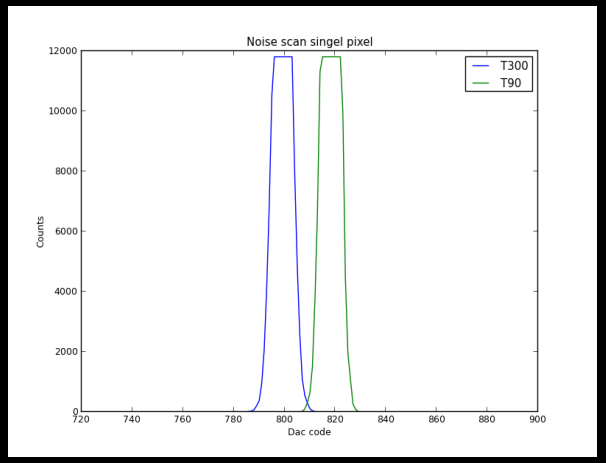
First measurements with protons in Bern

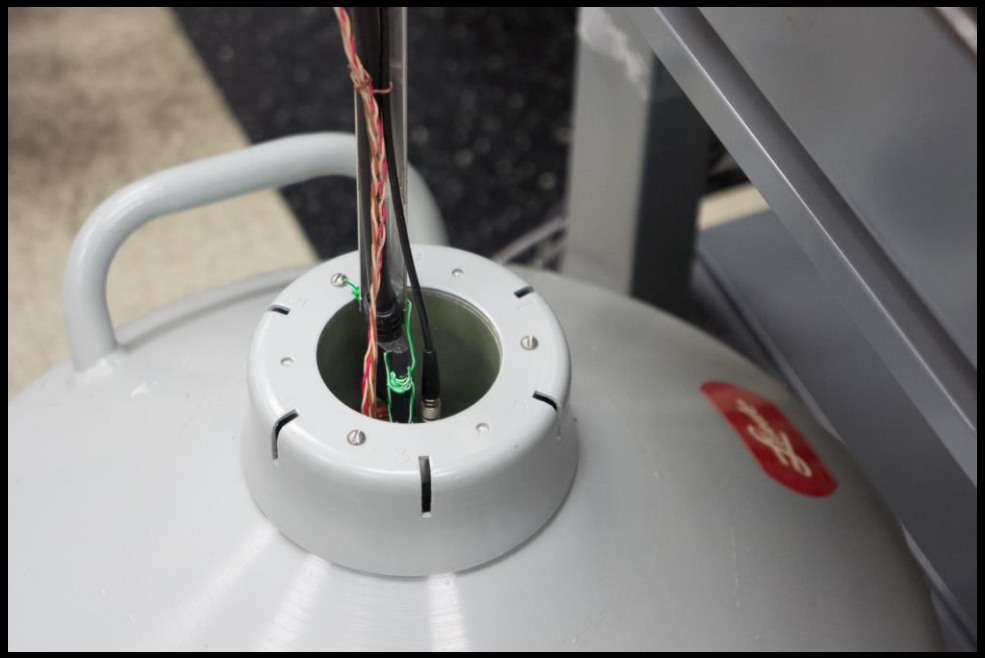


Measurements of scattered radiation and beam profile, CHUV Lausanne.


Ford
BS1-6815

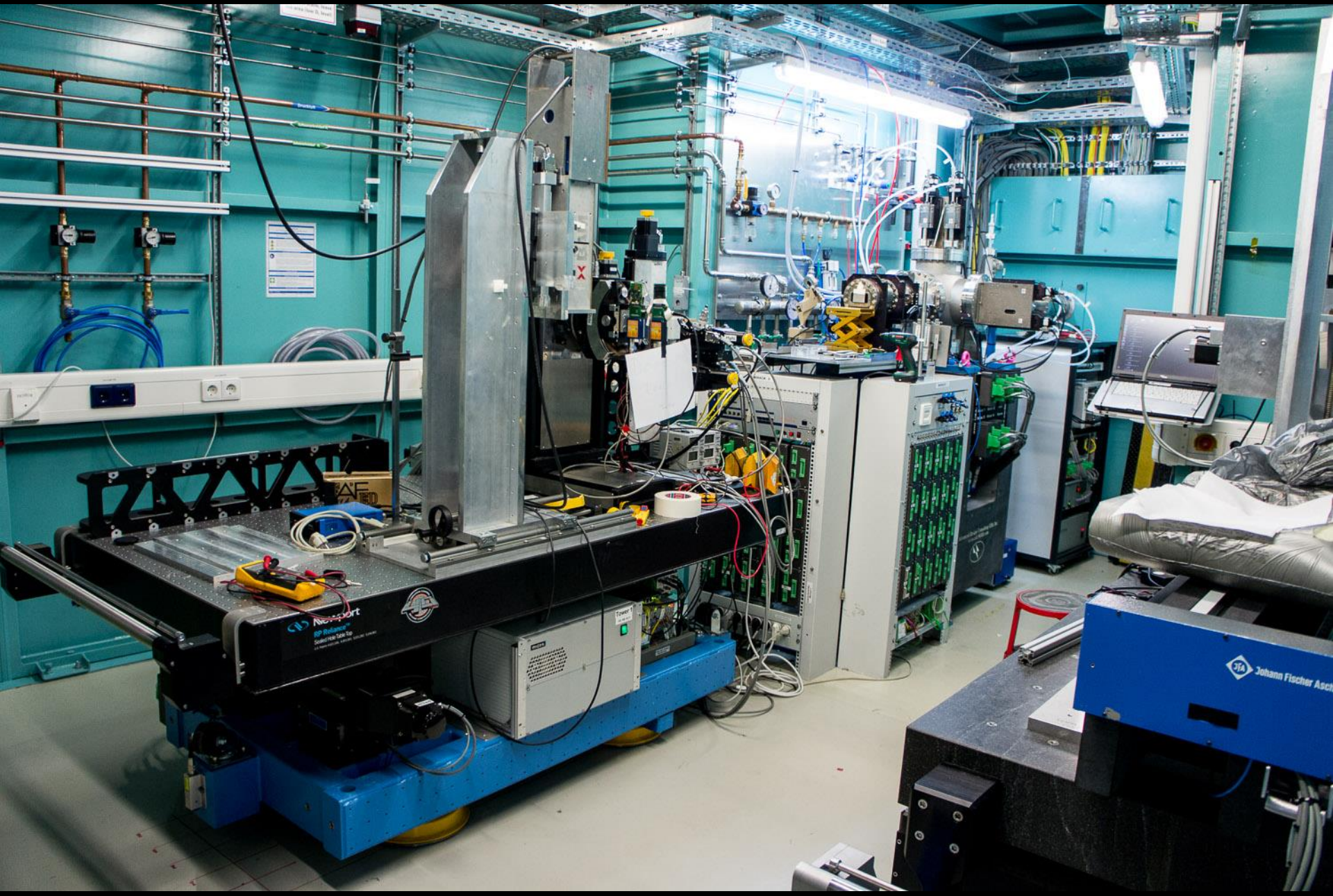



Noise scan singel pixel
T300
T90
Counts
Dac code
12000
10000
8000
6000
4000
2000
0
720
740
760
780
800
820
840
860
880
900

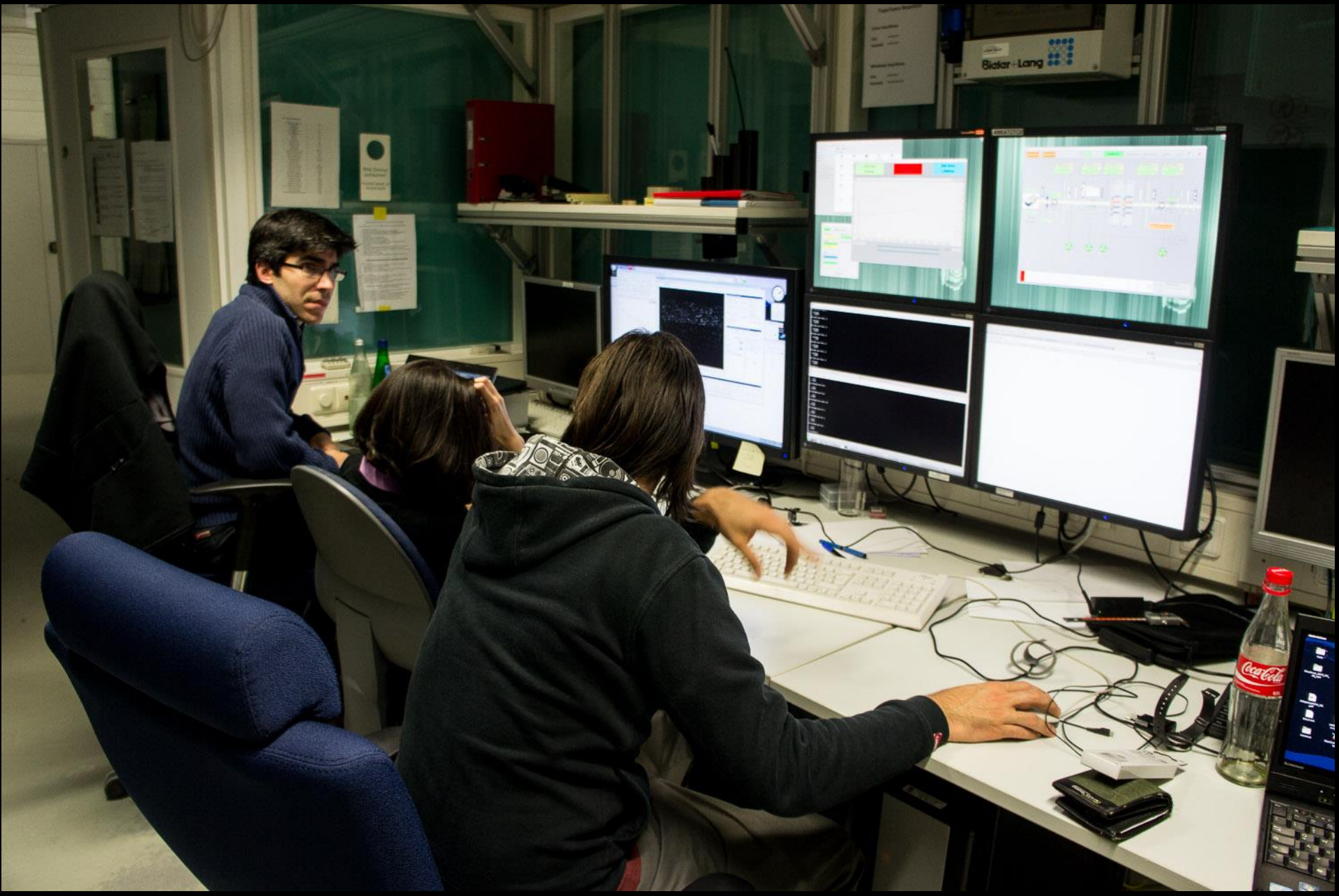


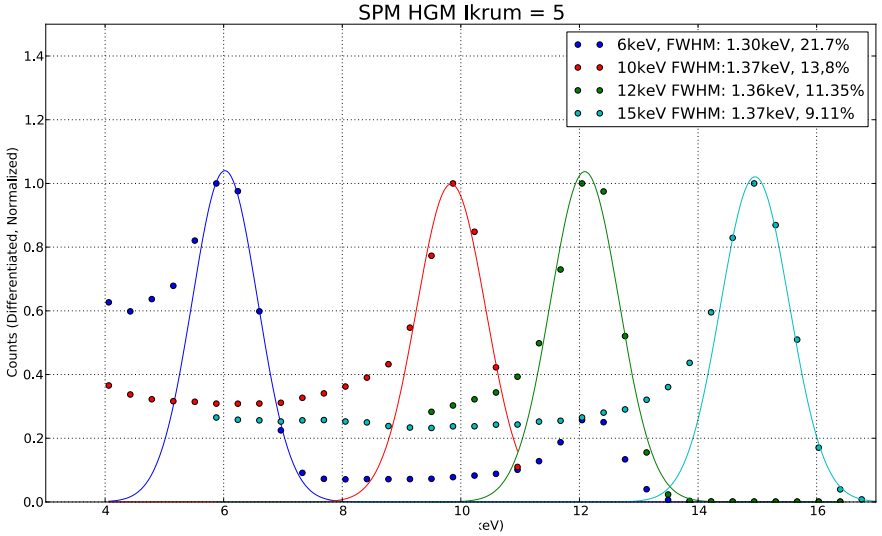

ZUM LÖWEN

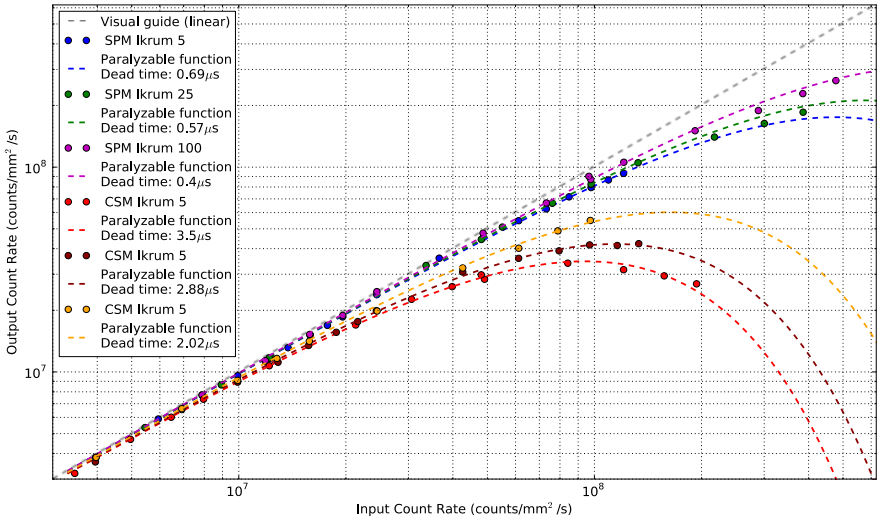

TOPO-TOMO
Topographie
Tomographie
B3.1.1125

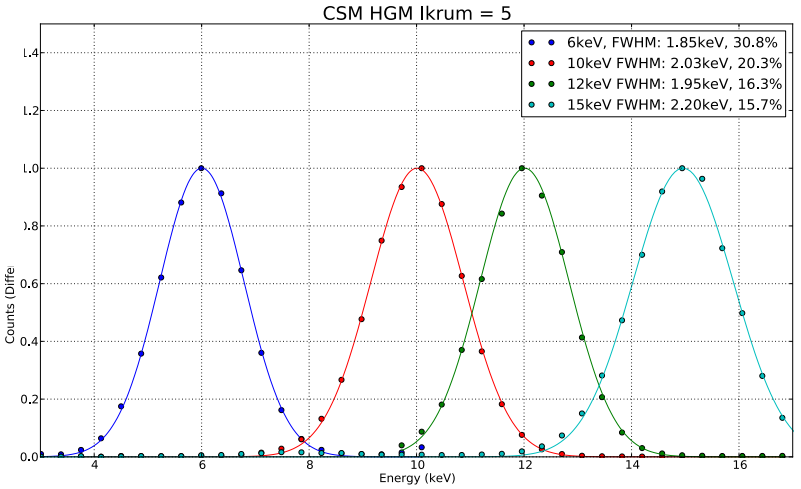

Newport
Johann Fischer

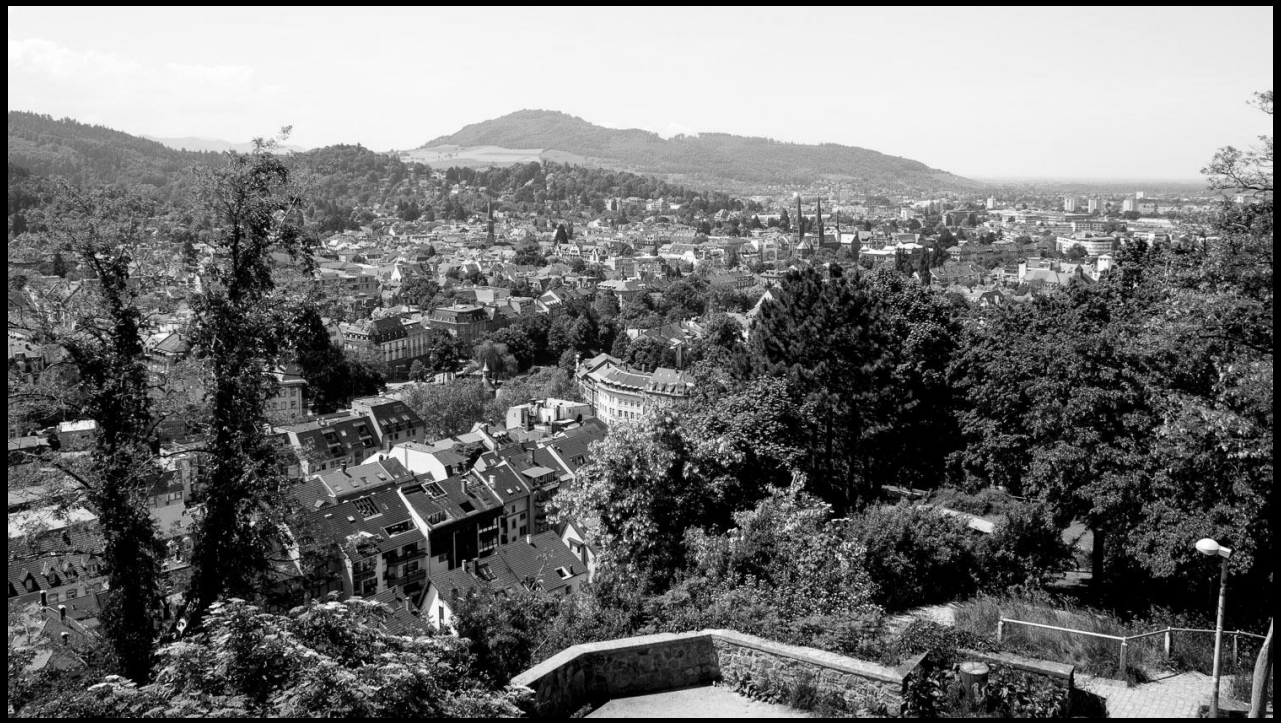

BAM


Bielar + Lang
Coca-Cola


SPM HGM Ikrum = 5
6keV, FWHM: 1.30keV, 21.7%
10keV FWHM:1.37keV, 13,8%
12keV FWHM: 1.36keV, 11.35%
15keV FWHM: 1.37keV, 9.11%
Counts (Differentiated, Normalized)
:eV)


Visual guide (linear)
SPM Ikrum 5
Paralyzable function
Dead time: 0.69μs
SPM Ikrum 25
Paralyzable function
Dead time: 0.57μs
SPM Ikrum 100
Paralyzable function
Dead time: 0.4μs
CSM Ikrum 5
Paralyzable function
Dead time: 3.5μs
CSM Ikrum 5
Paralyzable function
Dead time: 2.88μs
CSM Ikrum 5
Paralyzable function
Dead time: 2.02μs
Output Count Rate (counts/mm² /s)
Input Count Rate (counts/mm² /s)


CSM HGM Ikrum = 5
6keV, FWHM: 1.85keV, 30.8%
10keV FWHM: 2.03keV, 20.3%
12keV FWHM: 1.95keV, 16.3%
15keV FWHM: 2.20keV, 15.7%
Energy (keV)



Publications

1. Frojdh, E.; et al., *Probing Defects in a Small Pixellated CdTe Sensor Using an Inclined Mono Energetic X-Ray Micro Beam, Nuclear Science, IEEE Transactions on* , vol.PP, no.99, pp.1,1, 0 doi: 10.1109/TNS.2013.2257851
2. D Krapohl et al*, Investigation of charge collection in a CdTe-Timepix detector* 2013 *JINST* **8** C05003 doi:10.1088/1748-0221/8/05/C05003
3. FRÖJDH, C.; NORLIN, B.; FRÖJDH, E. Spectral X-ray imaging with single photon processing detectors. *Journal of Instrumentation*, 2013, 8.02: C02010.
4. BALLABRIGA, R., et al. The Medipix3RX: a high resolution, zero dead-time pixel detector readout chip allowing spectroscopic imaging. *Journal of Instrumentation*, 2013, 8.02: C02016.

Other Activities

Workshops

- Semiconductor Materials Simulation Workshop, Didcot UK

Talks

- Medipix introduction at the Swiss radioprotection course
- Medipix overview, SMU Dallas
- Mid Time Seminar

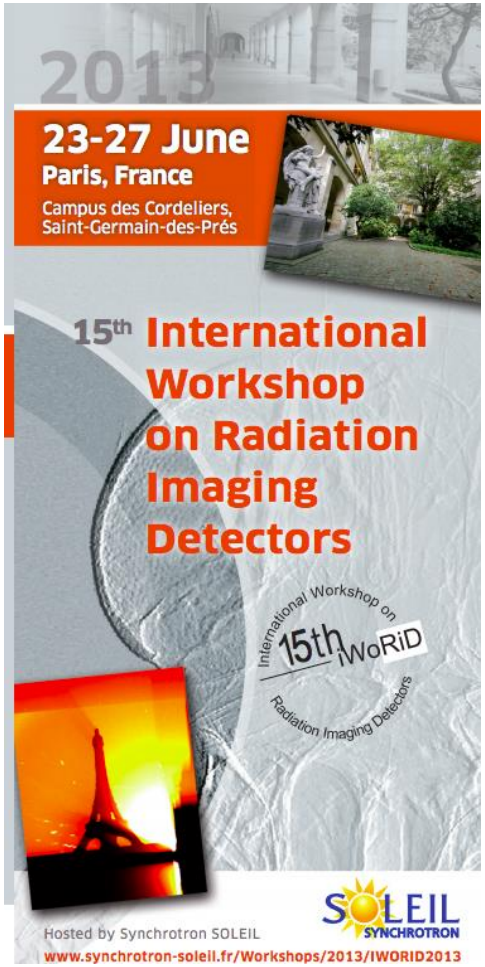
Courses

- French level 1, CERN
- Higher Education and Flexible learning (15ECTS) Mid Sweden University
- Semiconductor Devices (15ECTS), Mid Sweden University

Seminars

- Particle Therapy using Proton and Ion
- Introduction to Physics at CERN
- Various seminars in PH-ESE


ONE WAY


2013
23-27 June
Paris, France
Campus des Cordeliers,
Saint-Germain-des-Prés
15th International Workshop on Radiation Imaging Detectors
International Workshop on
15th IWoRiD
Radiation Imaging Detectors
SOLEIL
SYNCHROTRON
Hosted by Synchrotron SOLEIL
www.synchrotron-soleil.fr/Workshops/2013/IWORID2013


Institute of Electrical and Electronics Engineers
2013 IEEE NSS/MIC/RTSD
Nuclear Science Symposium & Medical Imaging Conference
& Workshop on Room-Temperature Semiconductor X-Ray and Gamma-Ray Detectors
"Beyond Imagination of Future Science"
October 27 - November 2, COEX, Seoul, Korea
Abstract Submission Deadline: May 13, 2013
Radiation Detectors and Instrumentation for Nuclear, High-Energy, Space, Solid-State and Bio- Physics Applications, and Homeland Security
Instrumentation and Methods for PET, SPECT, CT, MR, Optical, Multi-Modality and Application-Specific Medical Imaging, and Radiotherapy
Plenary Sessions | Oral Sessions | Poster Sessions | Short Courses
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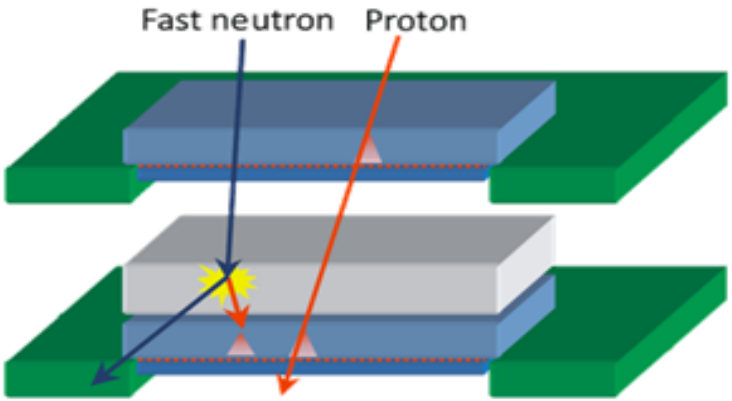
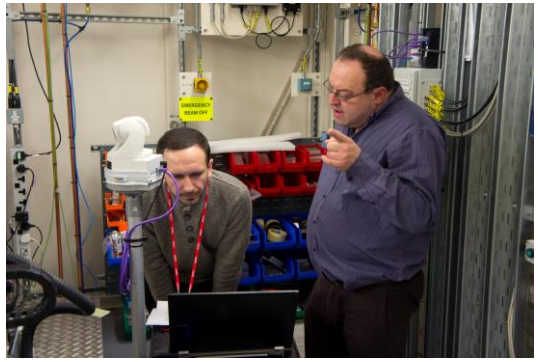


Graphics Z. Vykydal



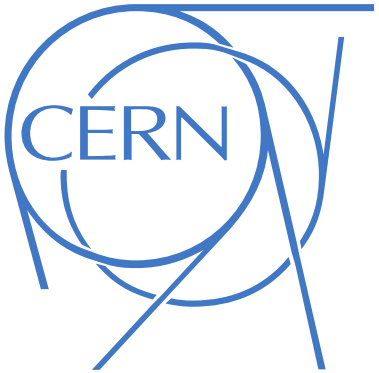
diamond

Timepix3

- Data driven
- Simultaneous ToT and ToaA
- 1.56ns timestamp


United States

Advanced Radiation Dosimetry European Network Training



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BACKUP SLIDES

Experimental Activities

- Characterization of CdTe Sensors at Diamond Light Source (Measurements in May 2012 and March 2013)
- Characterization of Medipix3RX – Counter Upsets
- Characterization of Medipix3RX - High flux conditions
- Proton Measurements with Timepix Measurement in Bern
- Noise performance of Timepix cooled by LiN
- Count Rate Linearity and Energy response of Medipix3RX under high flux conditions at the ANKA synchrotron in Karlsruhe

Conferences and Presentations

- IEEE NSS/RTSD Conference Anaheim (Oral Presentation)

- Various meetings and workshops
  - Medipix meeting 19-20 September 2012 CERN
  - Medipix meeting 29-29 November 2012, CERN, (Oral Presentation)
  - Medipix meeting 30-31 January 2013, CERN, (Oral Presentation)
  - Detector Material Simulations Workshop 22 March, Didcot UK
  - Medipix meeting 5-6 June 2013 Freiburg, GE, (Oral Presentation)
- Planned
  - iWoRID 2013 Paris, (Poster)
  - NSS Seoul, (abstract submitted)
  - Medipix Meetings

Training Courses and Seminars

- Particle Therapy using Proton and Ion Beams - From Basic Principles to Daily Operations and Future Concepts
- Seminar - Introduction to Physics at CERN
- French level 1
- Seminars at The 1st ARDENT Workshop
- Higher Education and Flexible Learning (15ECTS)

Planned Activities

- iWoRID Conference June 2013
- Medipix3RX characterization measurements at Diamond Light Source, July 2013
- Abstract submitted to IEEE NSS Seoul
- Pre-study for a radiation monitor system using hybrid pixel detectors
- Characterization of Timepix3