ARDENT

Advanced Radiation Dosimetry European Network Training

THE ARDENT PROJECT AND MEDIPIX

MEDIPIX MEETING, NOV 28TH 2012

ARDENT

February 2012 – January 2016

Advanced Radiation Dosimetry European Network Training initiative

Marie Curie Initial Training Network under EU FP7 – 4 M€

7 (8) Full Partners and 5 Associate Partners

Coordinator: CERN, Scientist-in-Charge: Dr. M. Silari

CERN (coordinator), Switzerland
AIT Vienna, Austria / Siebersdorf Laboratories
CTU- IAEP Prague, Czech Republic
IBA Dosimetry, Schwarzenbruck, Germany
Jablotron, Prague, Czech Republic
MI.AM, Milano, Italy
Politecnico, of Milano, Italy
ST Microelectronics, Italy
University of Erlangen, Germany
University of Houston, USA
University of Ontario, Canada
University of Wollongong, Australia

Development of advanced instrumentation for radiation monitoring…

Three main technologies

- Gas detectors [e.g., gas electron multipliers (GEM), tissue equivalent proportional counters (TEPC)]
- Solid state detectors [e.g., Medipix, silicon micro-dosimeters]
- Track detector techniques [e.g., CR-39, nano-dosimeters]

We can still add detectors / technologies we think are worth investigating!

OBJECTIVES & APPLICATIONS

- Main objectives
  - Radiation dosimetry
  - Micro- and nano-dosimetry
  - Photon and neutron spectrometry
- Applications
  - Characterization of radiation fields at particle accelerators (research, industry, medical)
  - Characterization of radiation fields on-board aircrafts and in space
  - Assessment of secondary dose to RT patient
  - Measurement of properties of clinical hadron beams

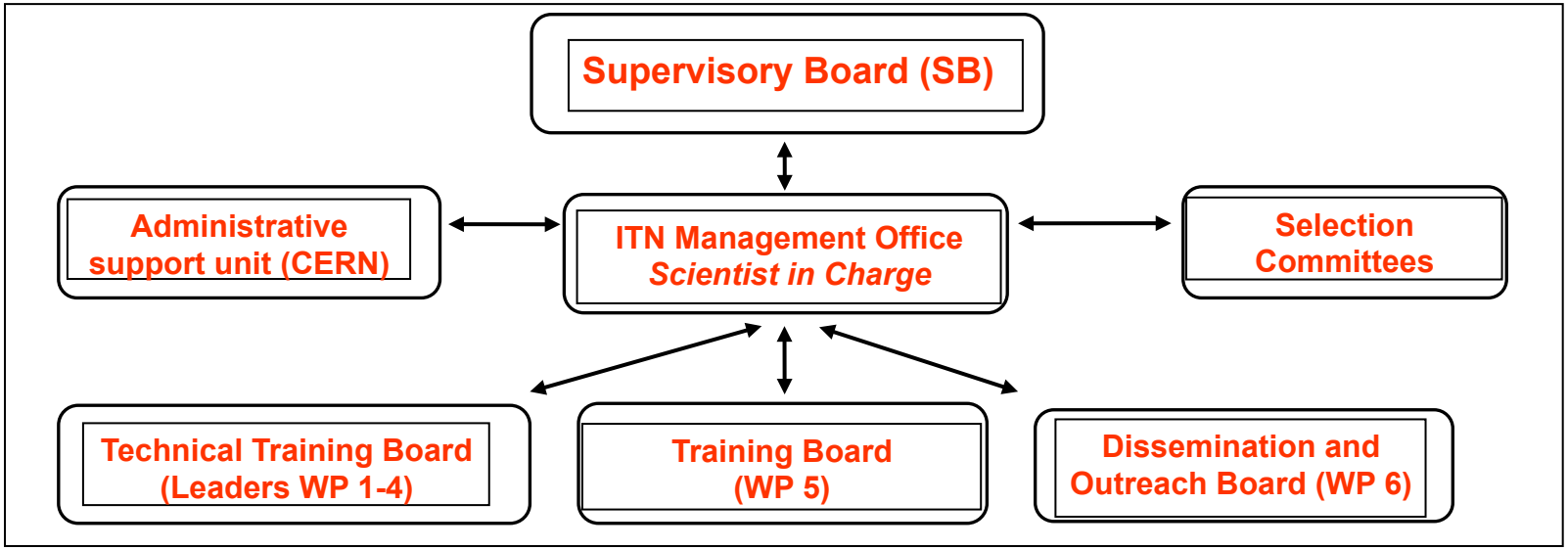
RESEARCHER RECRUITMENT

- 15 Early Stage Researchers (ESR), 9 already recruited
  - 4 at CERN: Eleni Aza (Gr), Erik Fröjdh (SE), Stuart George (GB), Silvia Puddu (It)
  - 2 ait AIT / SL, Vienna: Andrej Sipaj (SI)
  - 3 at CTU, Prague: Benedikt Bergmann (DE), Kevin Loo (AU)
  - 2 at IBA Dosimetry, Schwarzenbruck
  - 1 at Jablotron, Prague: Vijayaragavan Viswanathan (India)
  - 1 at MI.AM, Milano: Alvin Sashala Naik (Mauritius)
  - 2 at the Politecnico, Milano: Chris Cassell (AU), Eleni Sagia (Gr)
- Up to 1/3 of time can be spent on secondments
- Work performed within the project to be used for PhD
- Generous training allowance for researchers

WORK PACKAGES

- Seven Work Packages
  - WP1: gas detectors *(Sofia Rollet, AIT, Vienna)*
  - WP2: solid state detectors *(Zdenek Vykydal, CTU, Prague)*
  - WP3: track detectors *(Marco Caresana, Politecnico, Milano)*
  - WP4: instrument inter-comparison *(Matteo Magistris, CERN)*
  - WP5: training
    - Individual training programs
    - Network-wide training
  - WP6: dissemination and outreach
  - WP7: ITN management

ARDENT Structure



http://cern.ch/ardent

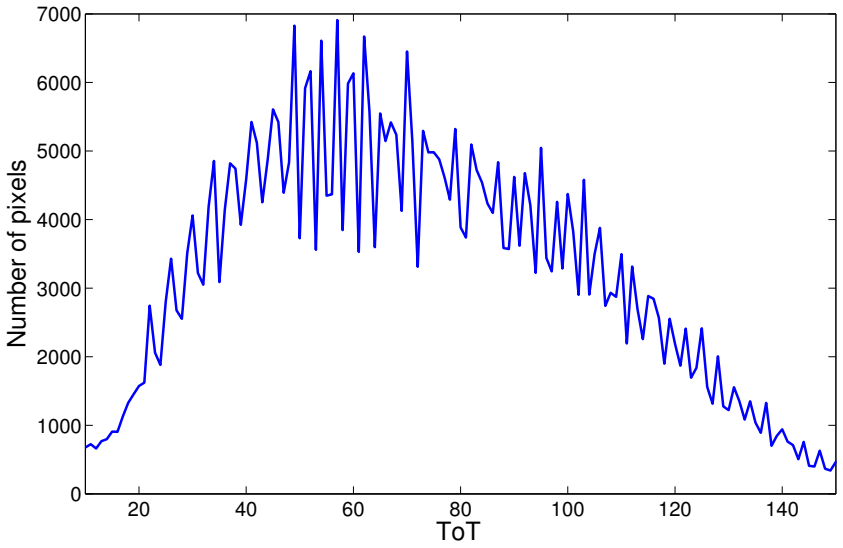
ERIK FRÖJDH – ESR 2

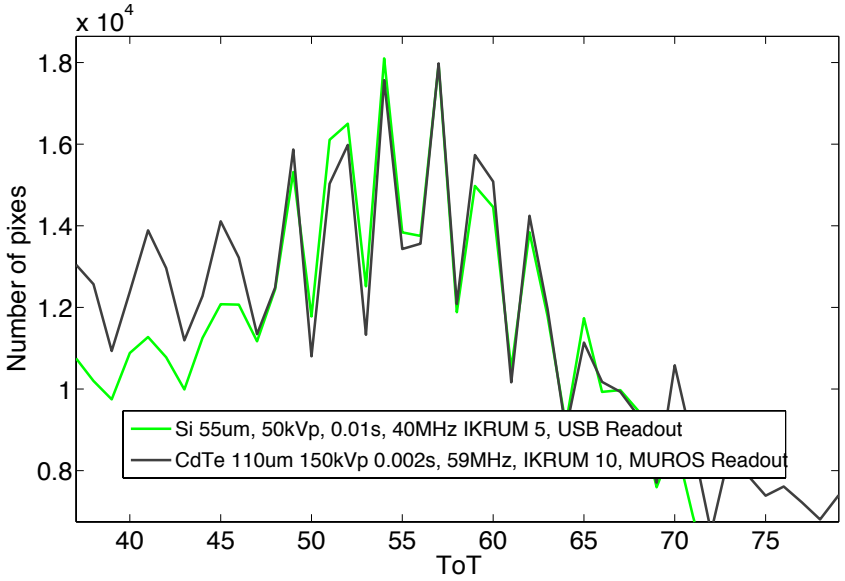
- **28 Years old**
- **Born in Sundsvall, Sweden**
- **Education**
  - Master of Science degree in Physics from Mid Sweden University jan 2010
  - Admitted as a PhD student at Mid Sweden University (feb 2010)

- **Previous work**
  - Characterization of silicon sensors produced at Mid Sweden University
  - Evaluation of x-ray techniques for measurements of paper coating compositions
  - Characterization of CdTe sensors
  - Investigation of excessive noise in Timepix ToT mode

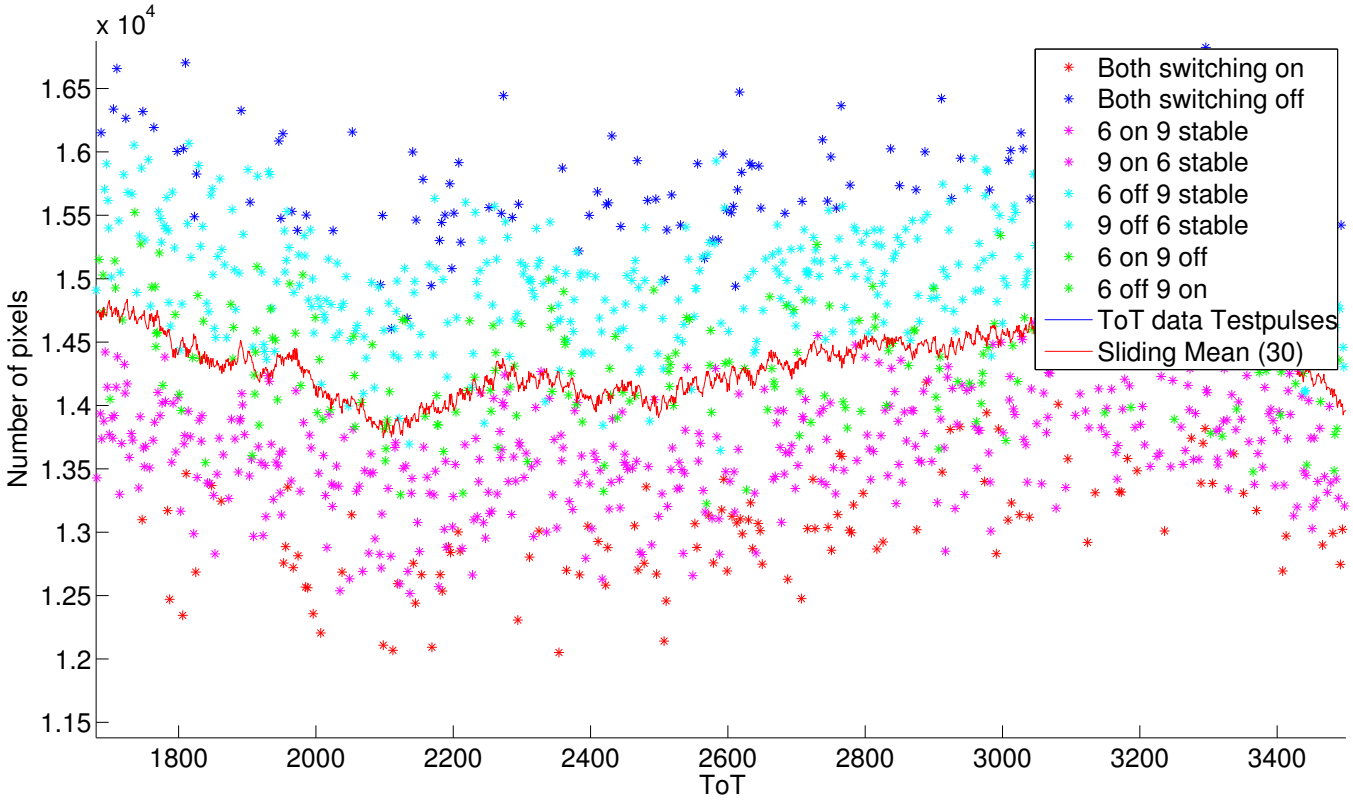
- **Work within ardent**
  - Application of Timepix as a dosimeter in space and around accelerators
  - Characterization of Medipix3RX and Timepix 3
  - Medipix support for the other ESRs

NOISE IN TIMEPIX TOT SPECTRUM



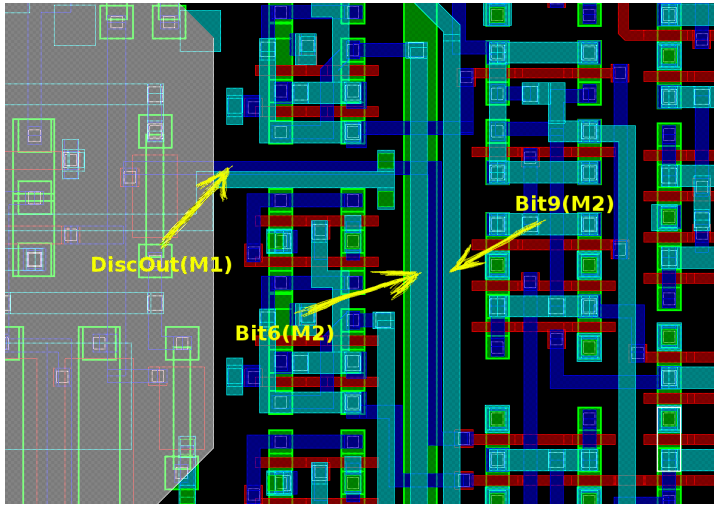


NOISE IN TIMEPIX TOT SPECTRUM



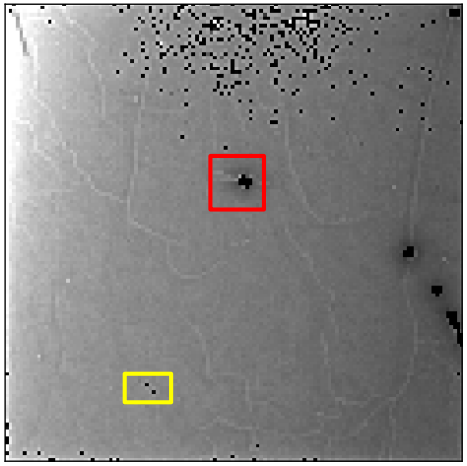
NOISE IN TIMEPIX TOT SPECTRUM

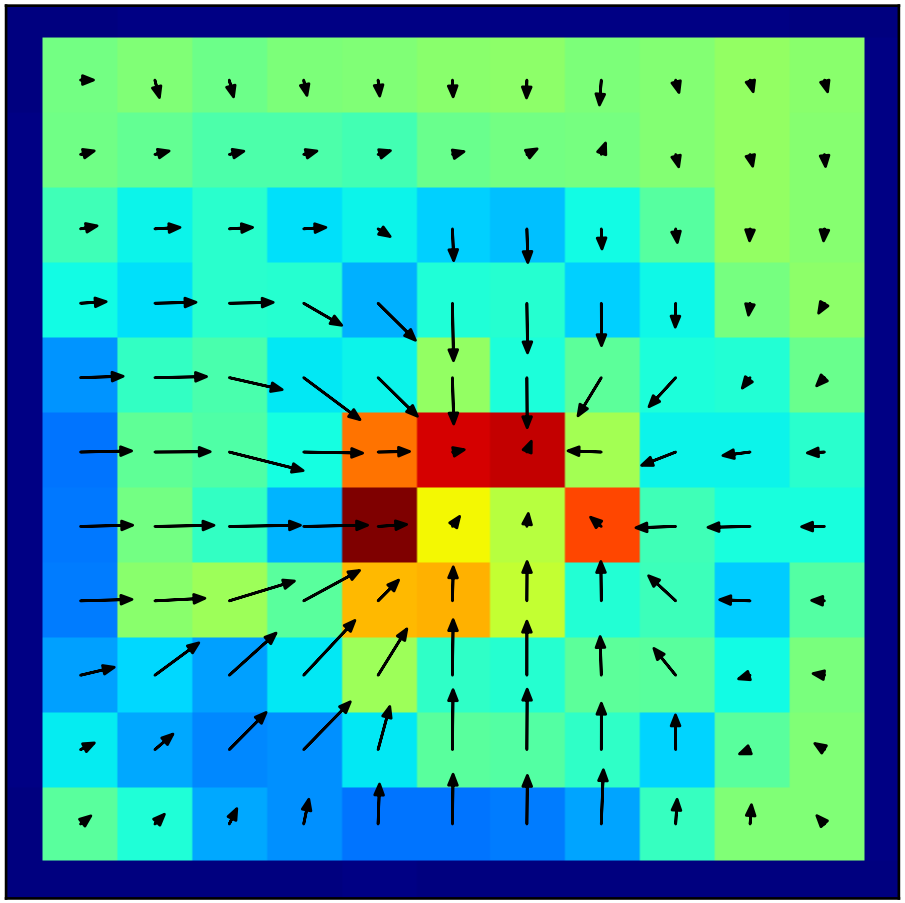
- There is a capacitive coupling between DiscOut and Bit6 and9.
- When the counter goes from 0 to 1 the pulse becomes longer and therefore it can tip over to the next value.
- When the counter goes from 1 to 0 the pulse gets shorter and therefore the value more likely.



DEFECTS IN CDTE SENSORS

- Charge difts towards the center of the defect
- Indication of high leakage current. (field/ ikrum)





STUART GEORGE – ESR4

- I'm 24 and from the UK
- Completed a Masters degree in physics from the University of Sheffield in computational stat mech.
- My project focuses on the medical applications of the Medipix device as well as other active detector systems (for example GEM's).

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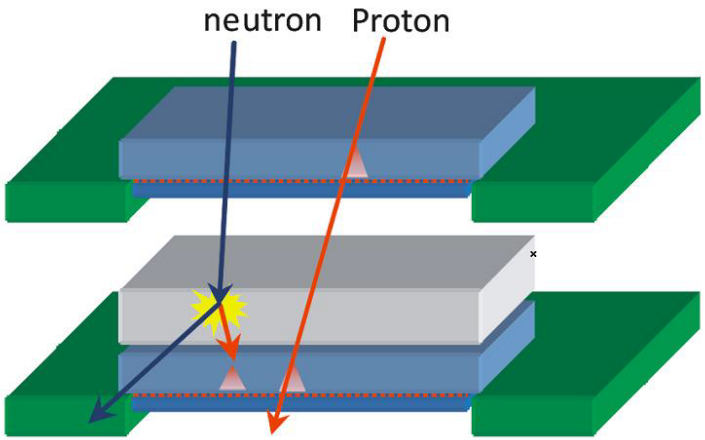
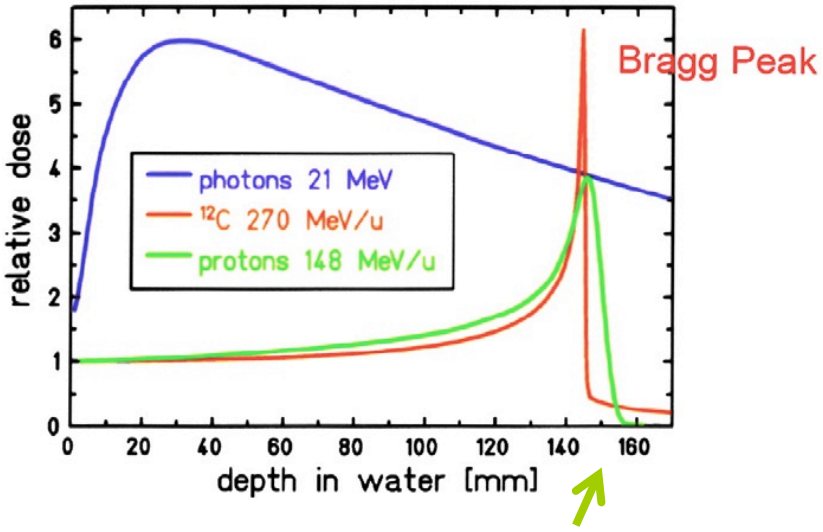
UNDUE RADIATION TO THE (CONVENTIONAL) RADIOTHERAPY PATIENT

- In-phantom measurement of out-of-field radiation doses.
- Some work has been done on characterising doses outside of phantoms and in-phantom with *passive* dosimeters.
- In addition, neutrons are generated for electron energies E > 10 MeV.
- Medipix2 with converter layers should allow us to measure neutrons inside the phantom out-of-field and in-field, actively discriminating against the intense photon field.
- We plan to carry out similar measurements in particle therapy.

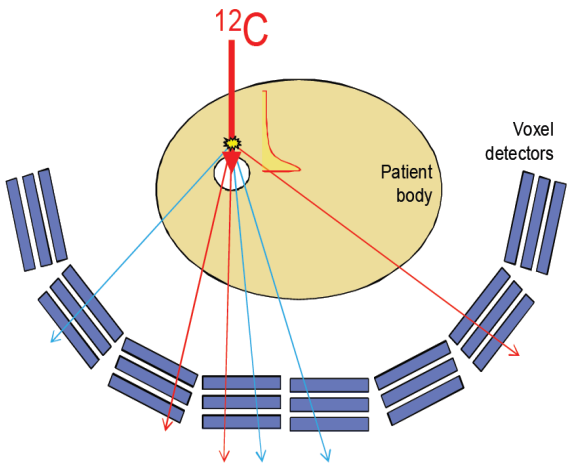


ION FRAGMENTS IN CARBON ION THERAPY

- During therapy with carbon ions the carbon beam suffers high levels of fragmentation before the Bragg Peak.
- The small size of the timepix chip allows us to measure these fragments inside the phantom.
- In addition we plan to continue the work done at CTU on vertex imaging from secondary radiation (0.1 secondaries/carbon)

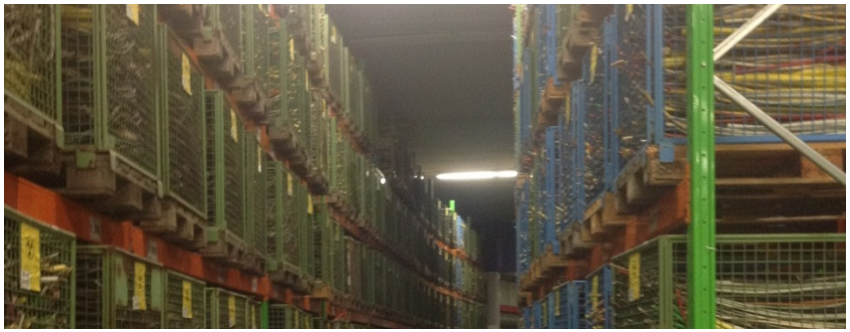


Biochimica et Biophysica Acta **1796** (2009) 216–229



^{55}FE WASTE CHARACTERISATION

- CERN has lots of low level radioactive waste stored at the old ISR site.
- Some of this waste may be suitable for free release depending amongst other radionuclides, on ^{55}Fe levels (2.7 year half life).
- ^{55}Fe is hard to detect with conventional spectrometry due to its low energy of emission (5.9 keV x-ray).



BENEDIKT BERGMANN – ESR 9

Born on 12th February 1987 in Kronach, Germany

Finished Master`s courses in Physics at FAU Erlangen in October 2012

- "Application of a time-resolving X-ray pixel detector in the detection of coincident fluorescence emissions after double K-shell vacancy production in the electron capture decay of Fe-55" , Master Thesis, ECAP

Since October 2012: PhD-student at FAU in Erlangen within the ARDENT project

- Work at the Institute of Exerimental and Applied Physics at CTU in Prague
- PhD-thesis will be supervised by Dr. Thilo Michel and Dr. Gisela Anton

Topic: "Optimization of mixed field data evaluation"

- Evaluate data taken by the ATLAS-Medipix detector network concerning dosimetric issues (neutron dosimetry)
- Contribute to the ATLAS upgrade from MPX to TPX during next shut down

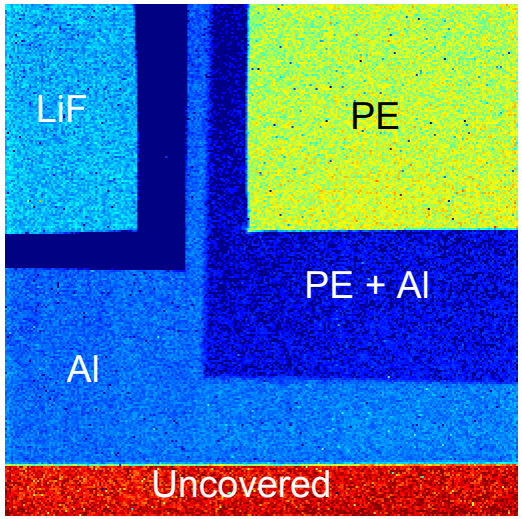
NEUTRON DETECTION

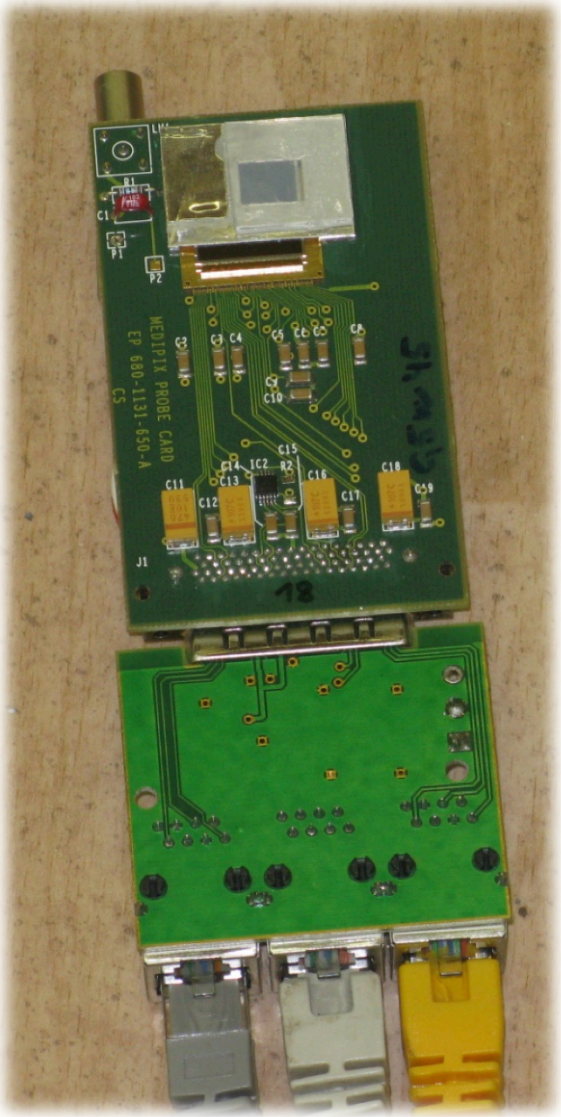
Medipix 2 ASIC with 300µm Silicon layer

- 256 x 256 pixel

Converter foils:

- $^{6}Li(n,\alpha)^{3}H$ -> thermal neutrons
- PE: recoiled protons -> fast neutrons



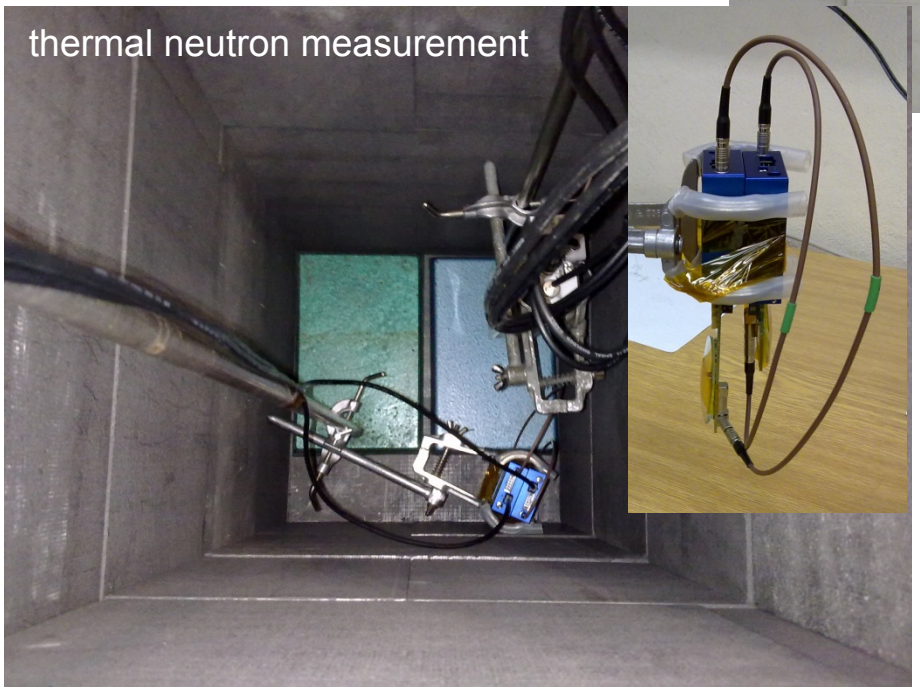


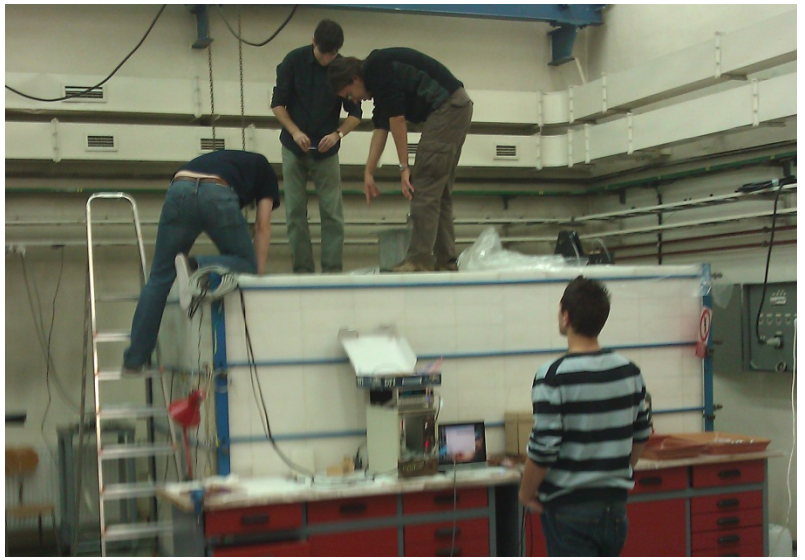
ATLAS UPGRADE: MEASUREMENT AT CZECH METROLOGICAL INSTITUTE

- **Upgrade from MPX to TPX**
- **Comparison of response of MPX and TPX to thermal neutron and fast neutron impact (Cf, AmBe)**
- **Calibrate TPX**

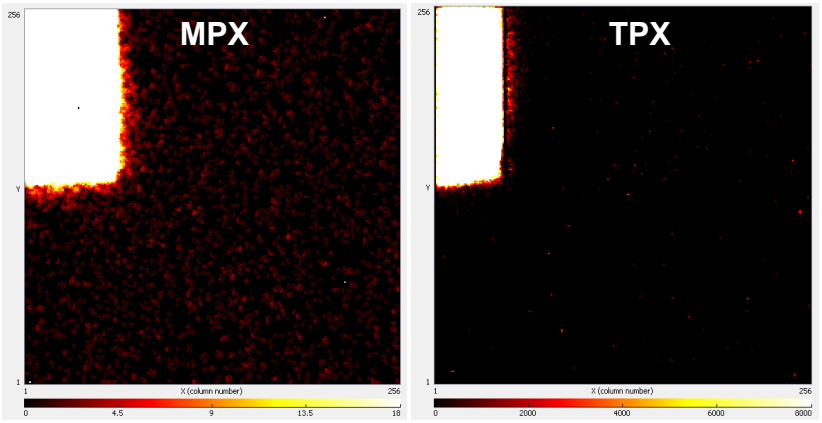
fast neutron measurement

thermal neutron measurement



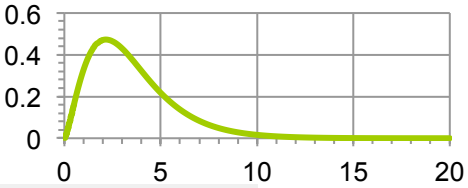


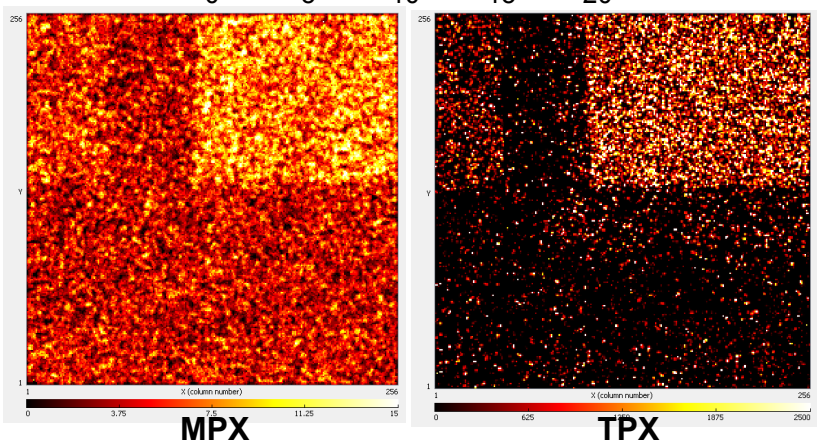
FIRST COMPARISON: MPX VS. TPX

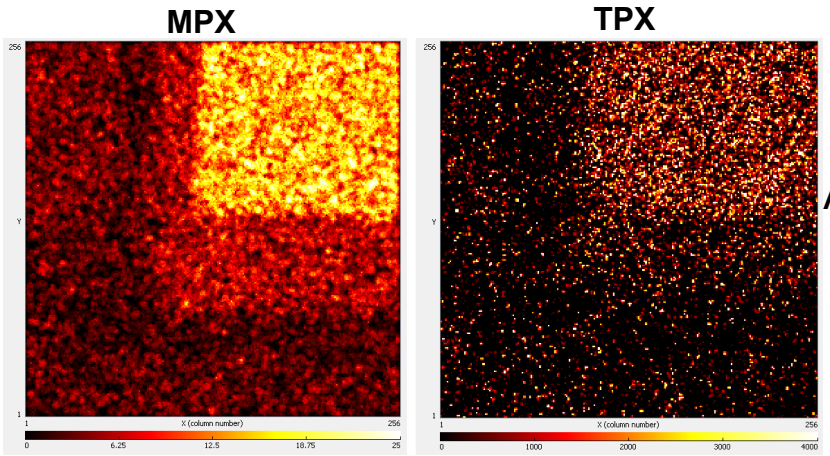


thermal neutrons (E < 0.5eV)

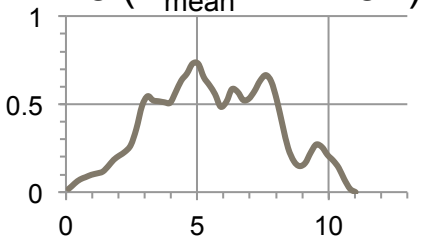
^{252}Cf (E_{mean} = 2 MeV)







AmBe (E_{mean} = 4 MeV)



MEASURED ENERGY SPECTRUM FOR THE THERMAL NEUTRON MEASUREMENT – ONLY TPX

Consists of Tritium and α-Peaks smeared out due to different interaction depths in the convertor

Criteria used:

- Minimum cluster size: 8 pixel
- Minimum cluster height: 100 keV
- Minimum cluster roundness: 0.76

$N_{selected}$ = 97799
N_{all} = 618657