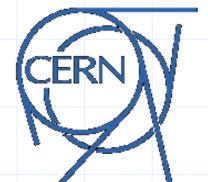




Journey with hybrid pixel detectors from biomedical imaging through particle physics up to extraterrestrial space

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on behalf of Medipix2/3/4 collaborations*





Lecture outline

- To remind briefly the development of ***Medipix/Timepix hybrid semiconductor pixel detectors*** and methodology of their use for ***high resolution (micrometric and nearly nanometric) imaging by means of X-rays and neutrons***.
- To document development of Timepix pixel detector for ***visualisation of individual particle tracks in solid state*** similarly to nuclear emulsions, cloud chambers, bubble chamber, Micro-Pattern Gaseous Detectors etc.
- To present some results of ***microscopic investigation of interactions of charged particles and neutrons in silicon sensors*** in a broad energy range (500 keV up to GeV region) by means of ***ToF technique***.
- To demonstrate broad ***applications of Timepix detectors for measurements of composition and spectral characteristics of mixed radiation fields around physics experiments (ATLAS, MoEDAL) and in space***.
- To reveal ***the latest achievement in 3D high resolution particle tracking and ToF applications of Timepix3 detectors for particle accelerator experiments, hadron therapy and astroparticle physics***



Soft tissue X-ray imaging

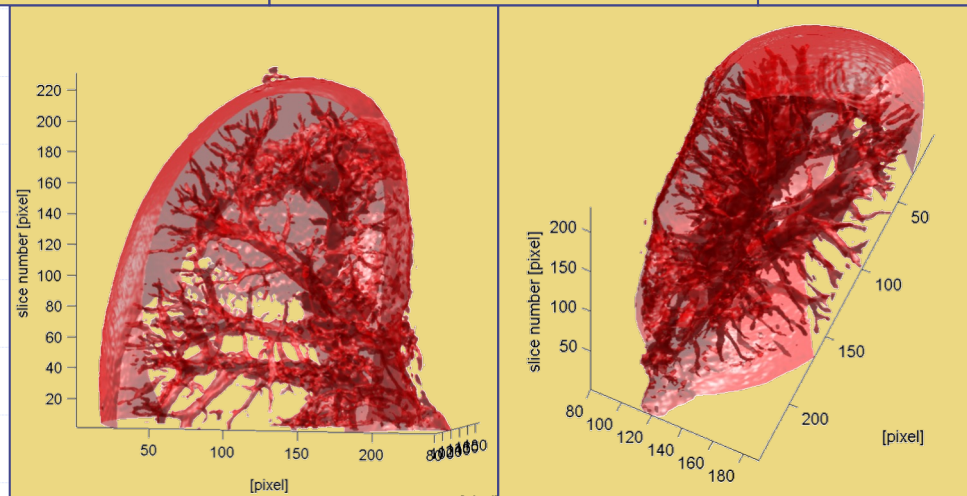
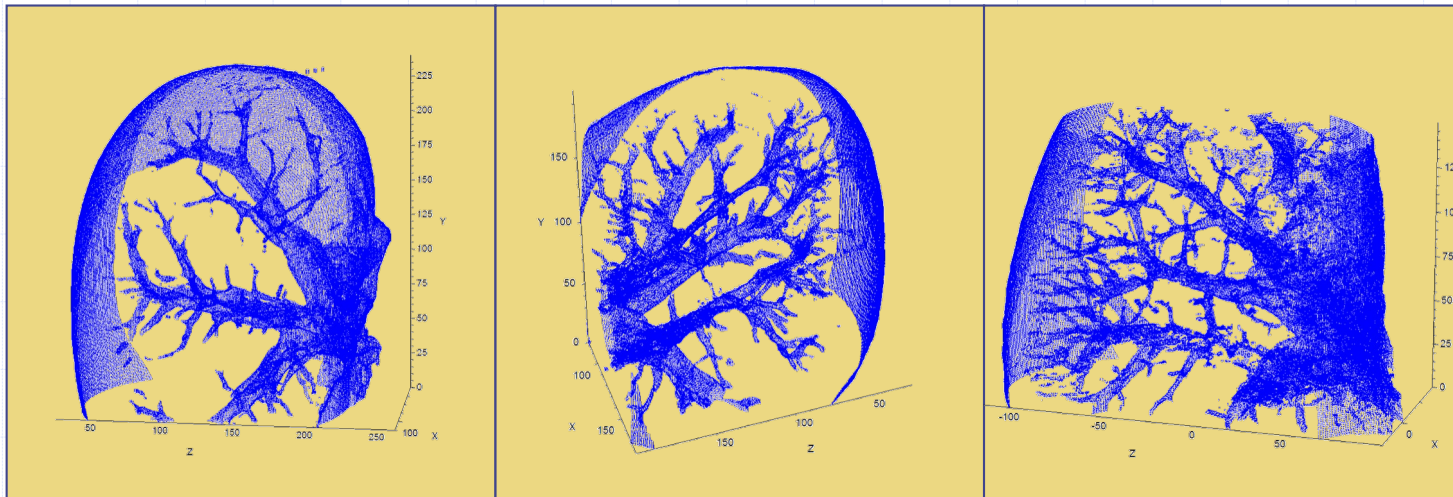


Mouse Kidney Tomography

2006

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Missing angles => Iterative algorithm instead of Filtered back projection (3 iterations in OSEM 5)

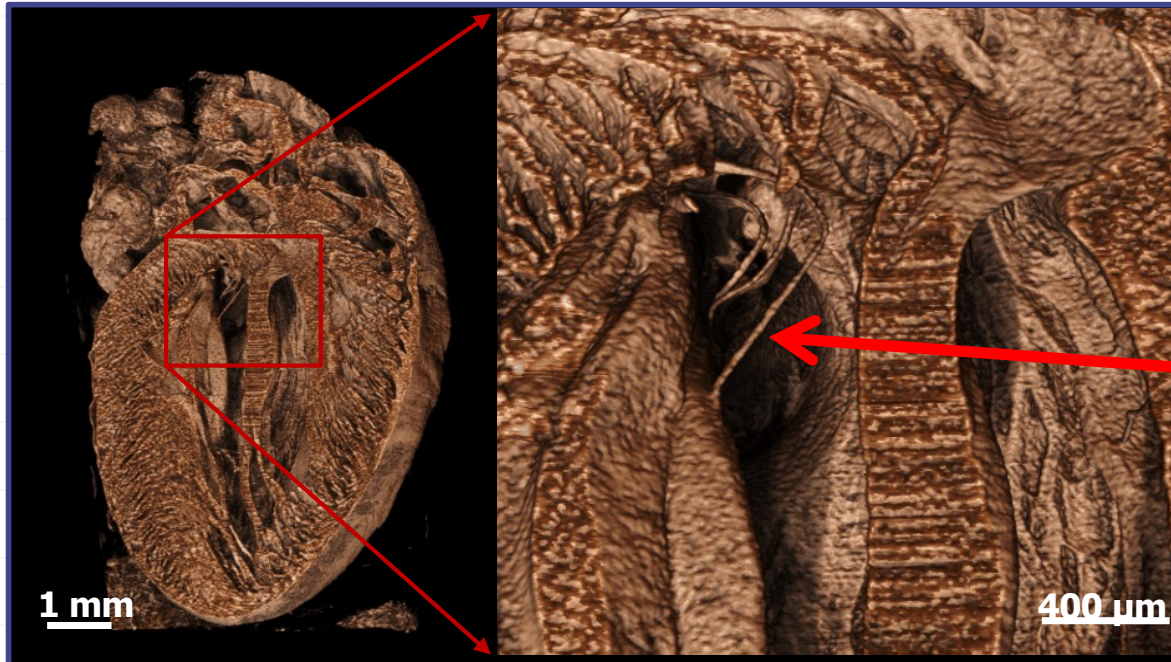




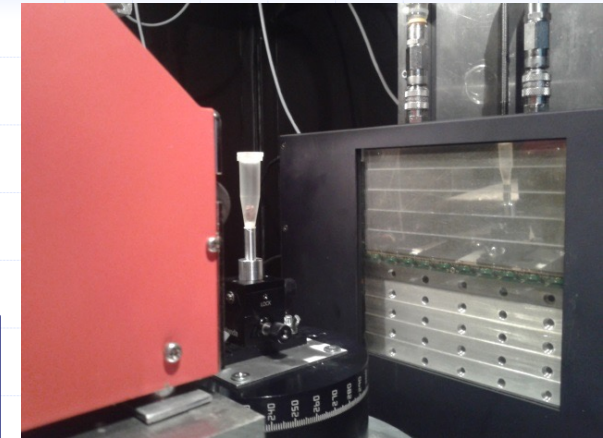
Virtual histology: Micro-CT analysis of soft biology samples



- ◆ Micro-CT becomes a non-destructive competitor to tissue histology, as the achievable resolution of micro-CT techniques continuously improves
- ◆ Typically, sample staining by high-Z contrast agents is needed
- ◆ Timepix technology provides micro-CT data with reasonable contrast without any dedicated X-ray contrast agents



Volume rendering of an **ethanol-preserved mouse heart** scanned using the WidePIX_{10x5} detector with resolution of 7 μm



Micro-CT scanner at laboratory of IEAP is equipped with WidePIX_{5x10} detector

Chondrae tendineae:

Fine tendon fibers keeping tension to heart valves and, therefore, maintaining a proper function of the heart.

Jan Dudák, PhD Thesis "Energy sensitive X-ray radiography and tomography optimized for small animal imaging", FBMI CTU in Prague, 2020

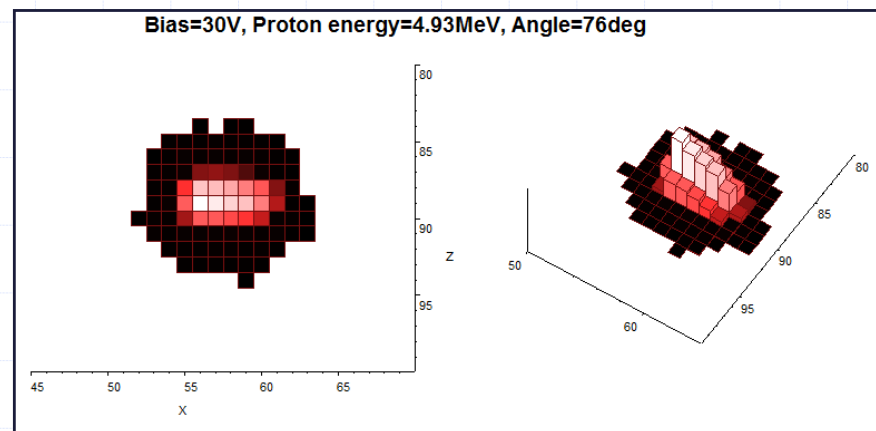
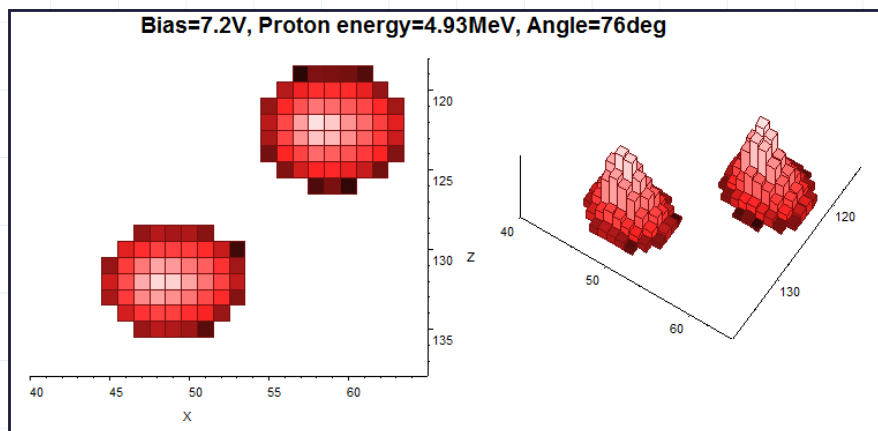
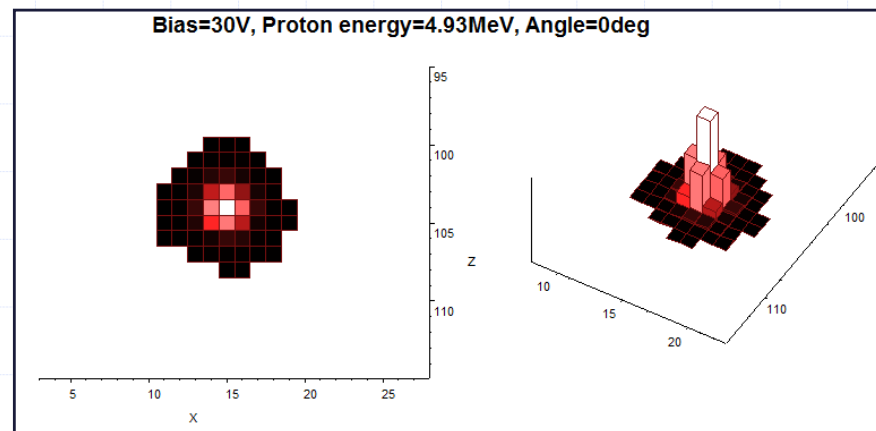
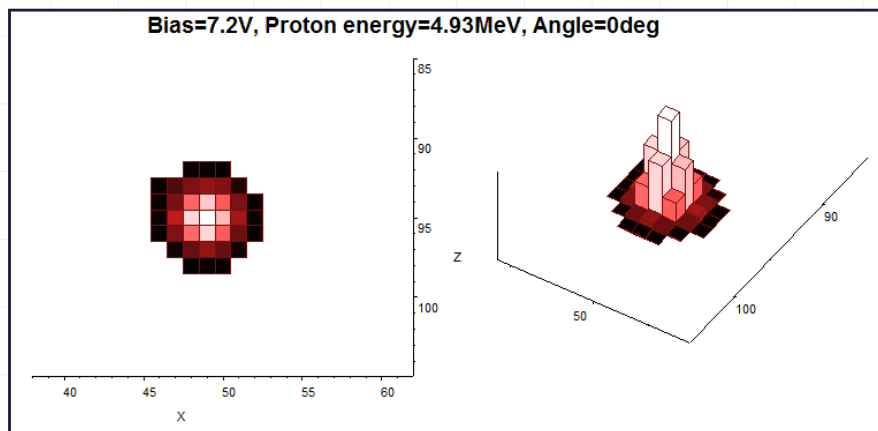


4.93 MeV proton tracks recorded by Timepix silicon detector in Time-over-Threshold mode.



Illumination under different angles and different applied detector biases.

2007

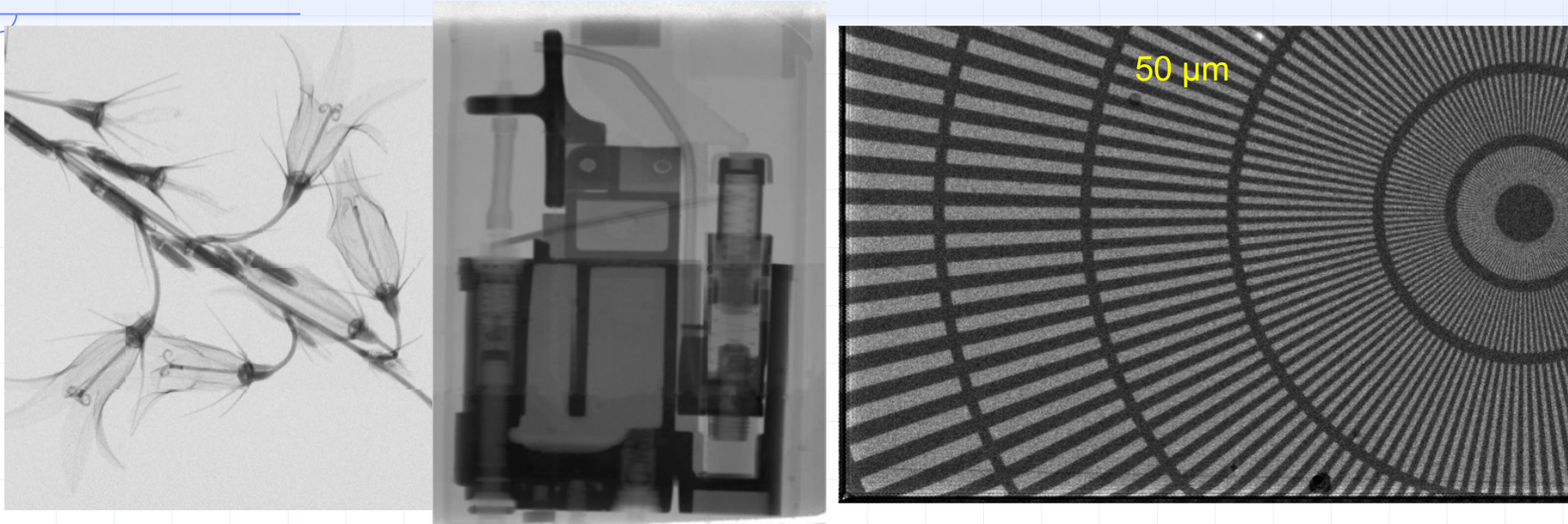


What is the spatial resolution? X- and Y-coordinates are determined with a precision of about 500nm. Determination of angle is with a precision of about 1°. It needs additional experiments.



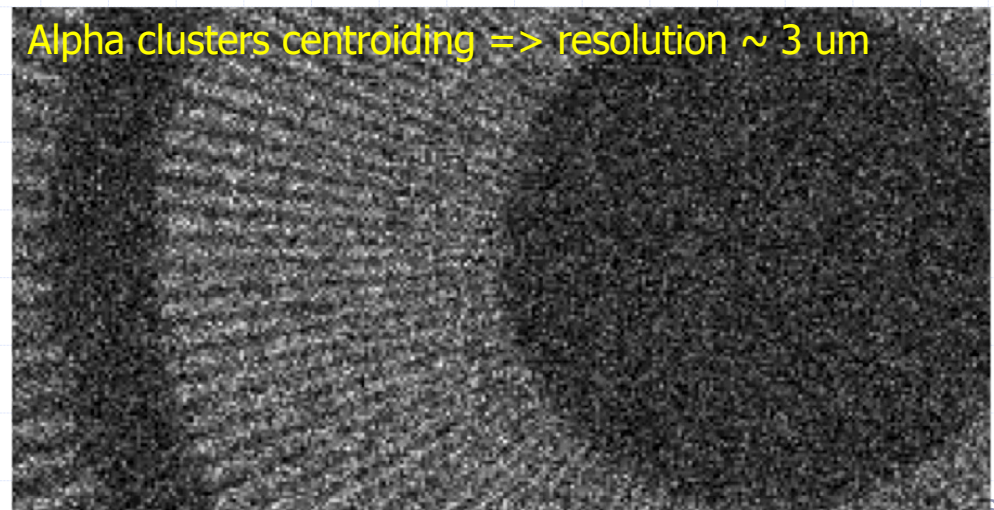
Neutron images with Timepix detector and resolution calibrated by Siemens star

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Neutron images of Bluebell flower
and cigarette lighter. The detector
calibration was performed at PSI
on the cold neutron beam of Neutra
facility

Courtesy of Daniel Vavřík





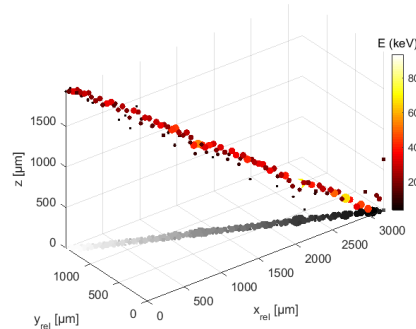
3D-visualisation of particle tracks in Timepix3 detector with 2mm thick CZT sensor



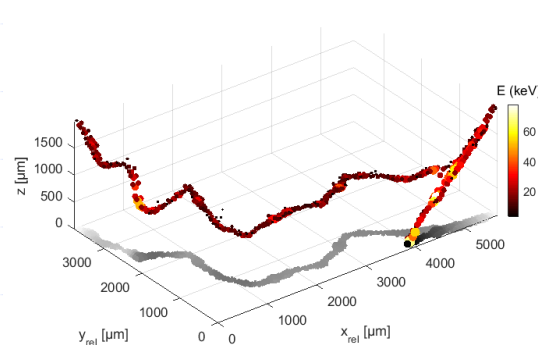
It operates as TPC and/or real time bubble chamber
(measured at CERN SPS)

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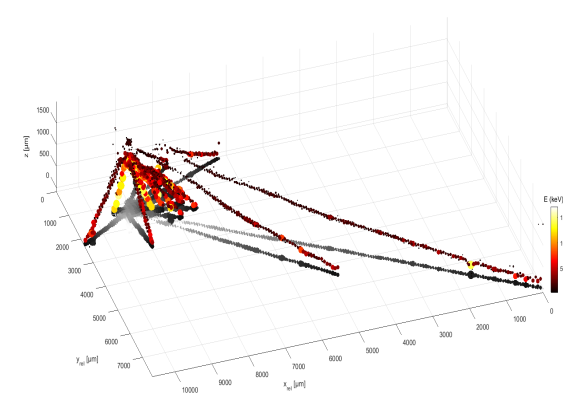
Muon



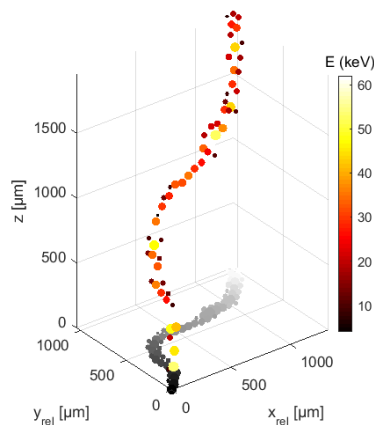
Pion + delta electron



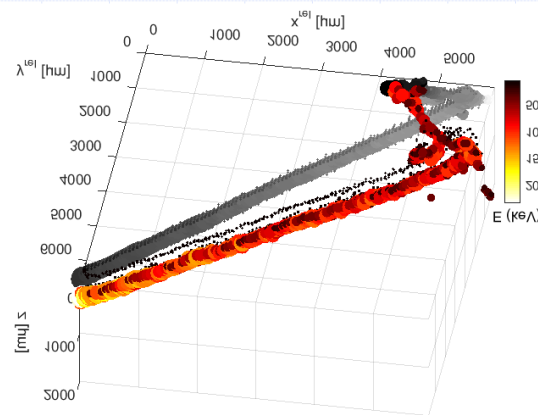
Fragmentation



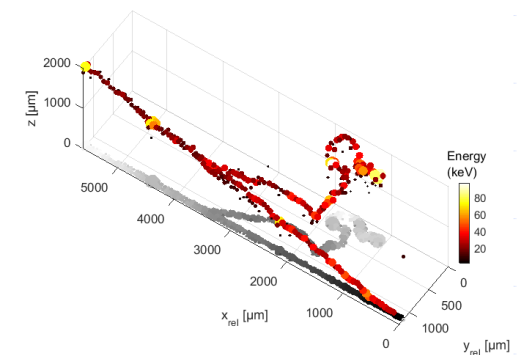
Electron



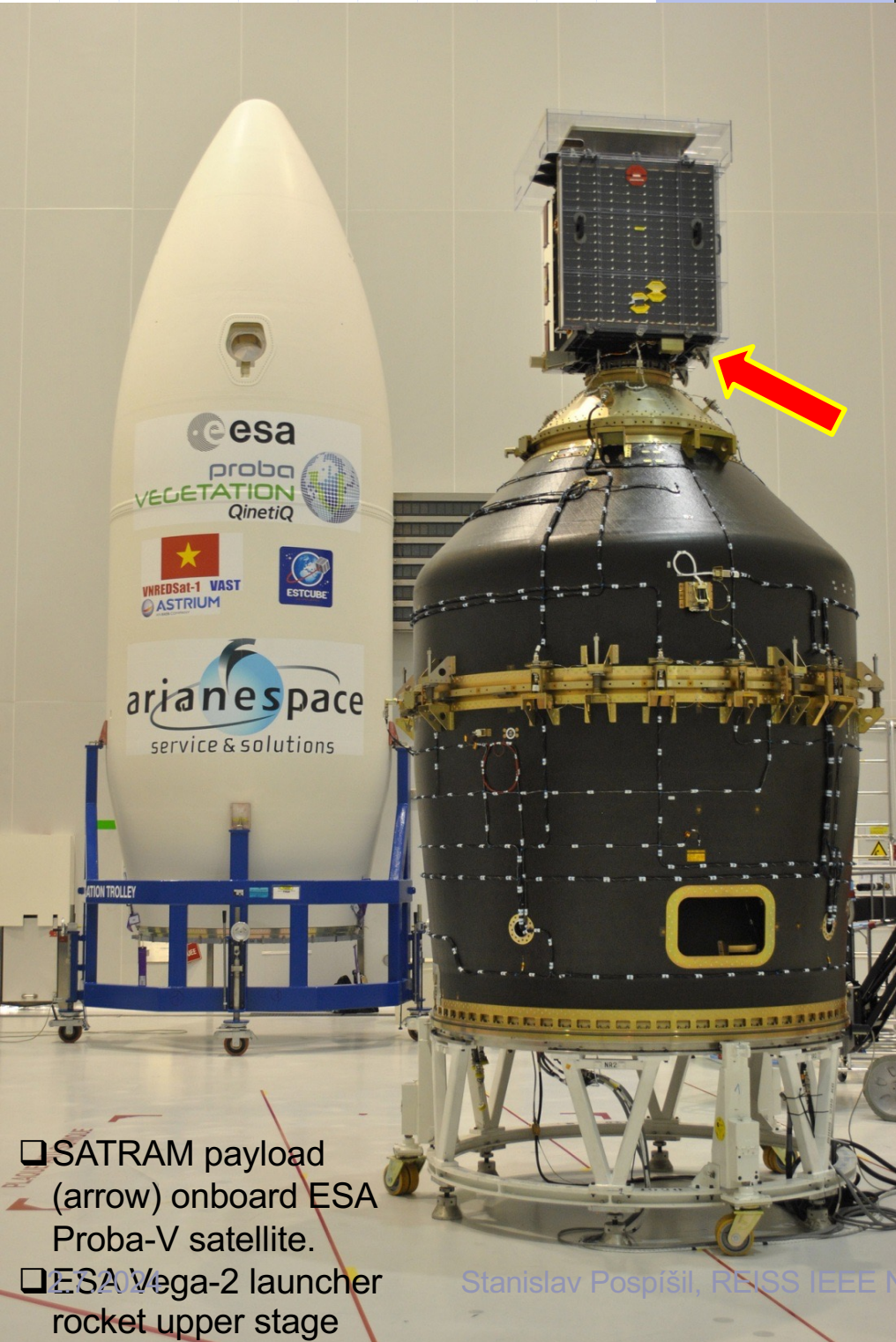
Heavy track



Pion + delta electron



Courtesy of Benedikt Bergmann



- SATRAM payload (arrow) onboard ESA Proba-V satellite.
- ESA Vega-2 launcher rocket upper stage



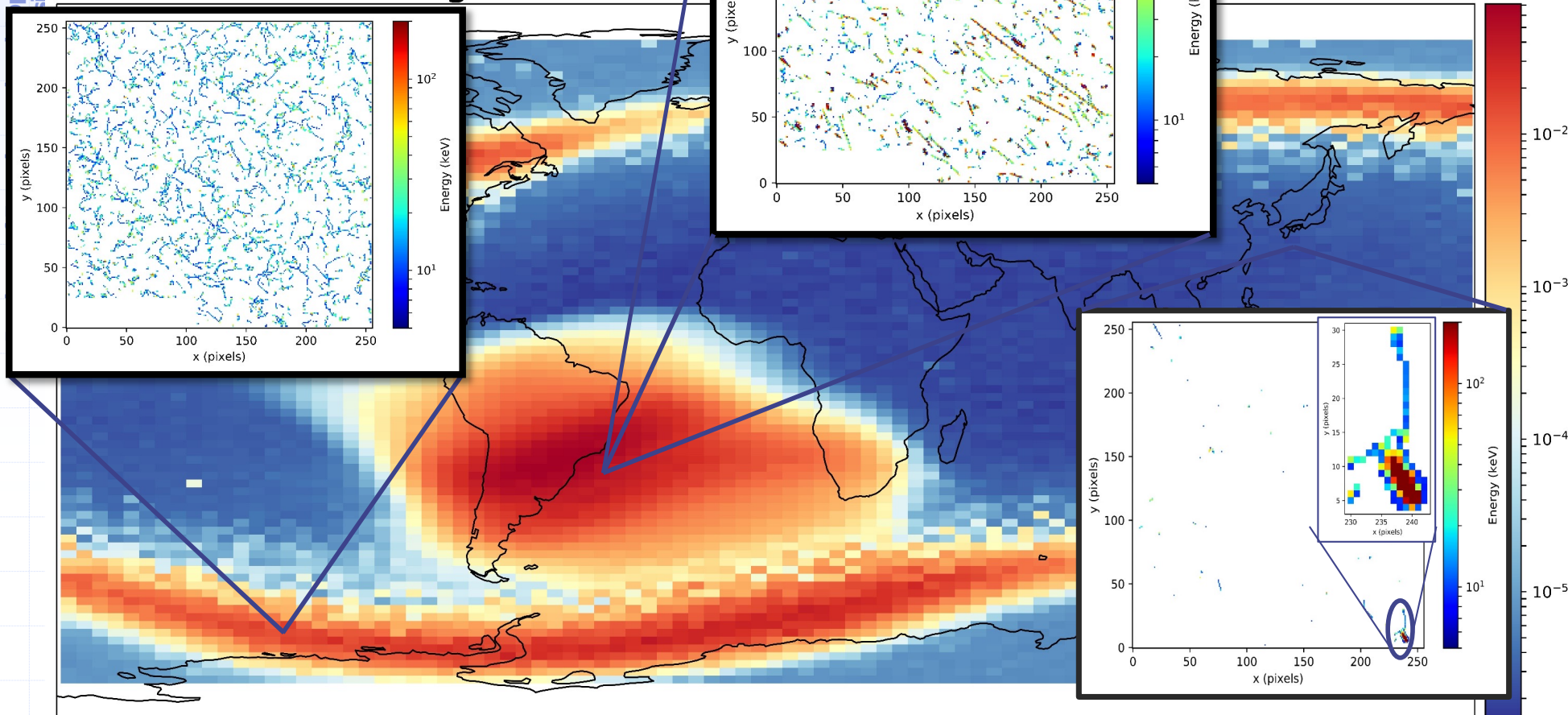
SATRAM

Average dose rate 2015-2018 in Mgy/h on orbit 820 km

Applied Physics
University in Prague

SATRAM - Average dose rate

Altitude: 820 km





I look forward to our meeting in Rabat!

Stanislav