Monte Carlo simulations of EPIC-pn background with Geant4

Christoph Tenzer, Eckhard Kendziorra, Andrea Santangelo

Institut für Astronomie und Astrophysik, Universität Tübingen, Germany

EBERHARD KARLS
UNIVERSITÄT
TÜBINGEN

outline

- MC simulations of X-ray detectors with GEANT4
  - introduction to Geant4
- simulations concerning XMM-Newton's EPIC-pn camera
  - simulation goals and parameters
  - geometry used for simulations
  - results from simulation with assumed internal photon spectrum
  - results from simulation with external cosmic-ray protons
  - current work + outlook

EBERHARD KARLS
UNIVERSITÄT
TÜBINGEN

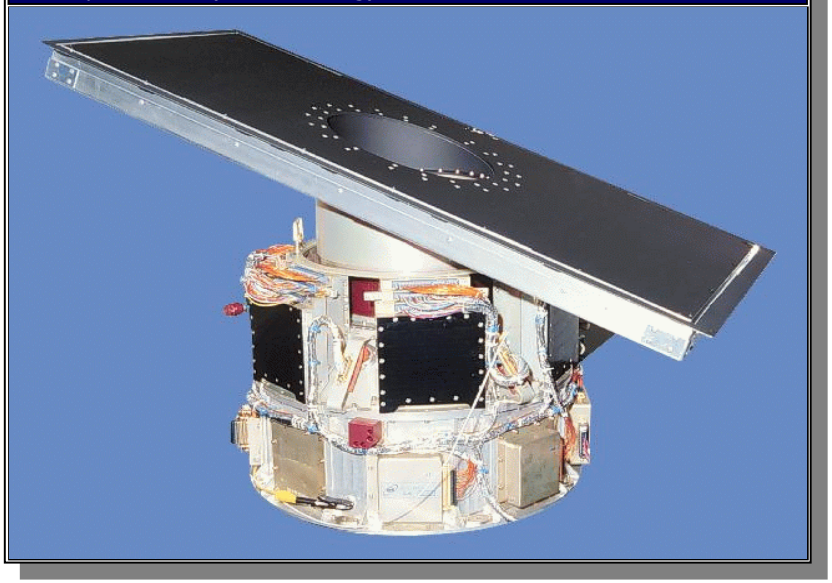
introduction to Geant4

- different aspects of a simulation that can be covered using Geant4
  - the geometry of the system
  - the materials involved
  - the fundamental particles of interest
  - the physical processes for particle interactions
  - tracking particles through materials and electromagnetic fields
  - analyzation of particle trajectories
  - generation of event data
  - visualization of geometry and trajectories

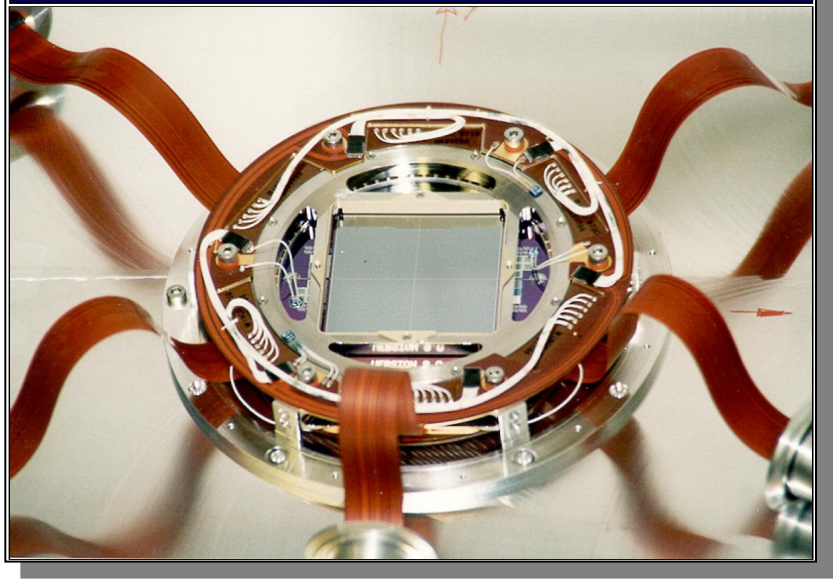
details of this simulation

- goals of this simulation
  - recreate internal (cosmic-ray induced) background in the pn-camera, generated directly by particles and indirectly by the fluorescence of satellite material

EPIC pn-camera (MPE Garching)



the focal plane assembly of the pn camera (L. Strüder et al. 2001)



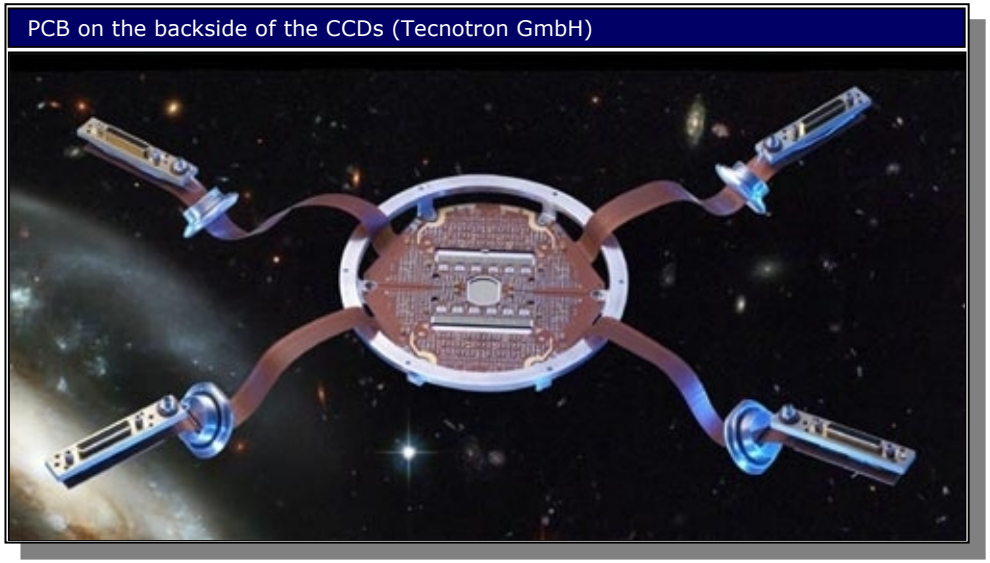
details of this simulation

- goals of this simulation
  - recreate internal (cosmic-ray induced) background in the pn-camera, generated directly by particles and indirectly by the fluorescence of satellite material
- parameters of the two different approaches
  - pn-CCDs as active sensor elements
  - geometry includes camera head and printed circuit board with ASICs, ICs and some SMD components
  - readout process and properties of readout electronics are not simulated

1. assumed a flat, isotropic photon spectrum inside the camera as first approach, 0.1-25 keV
2. simulated an isotropic cosmic-ray proton spectrum focused from outside on the camera head (solar max., as calculated for the SIMBOL-X launch date)

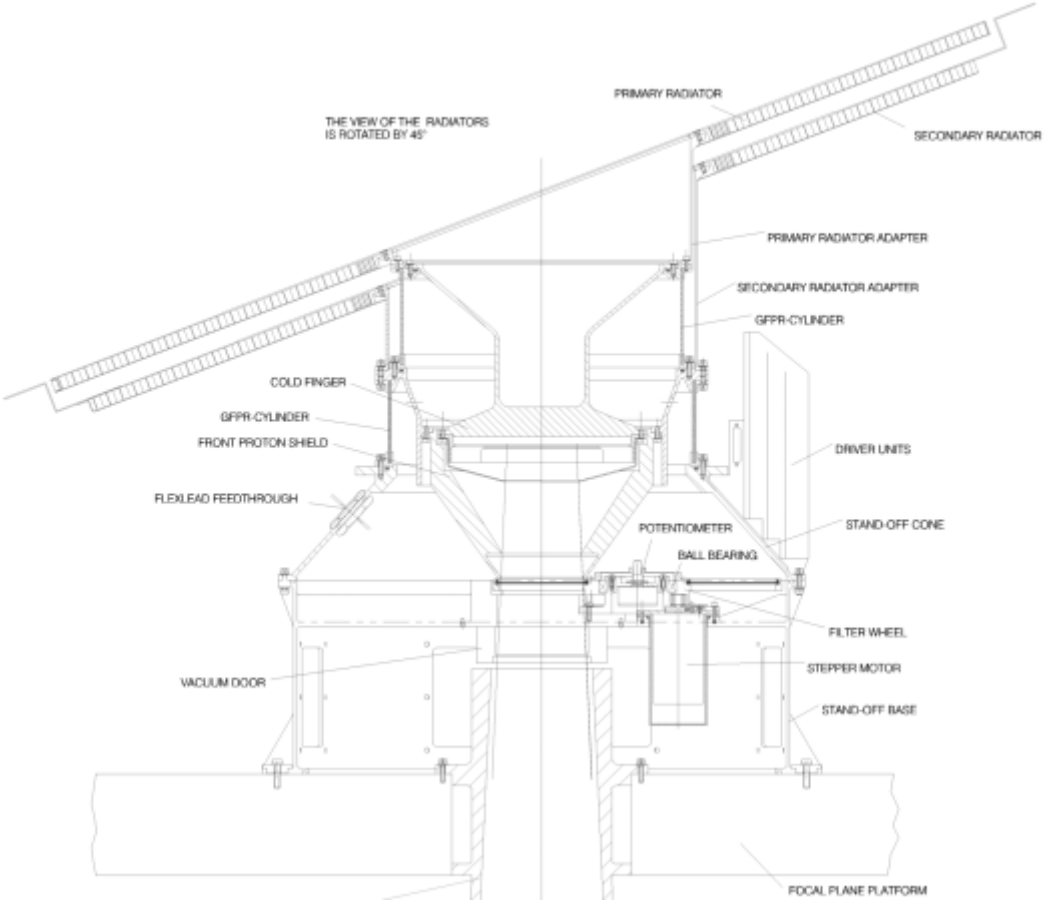
details of this simulation

- EPIC-pn focal plane PCB below the CCDs
  - Molybdenum core
  - Copper layers
  - ASICs, ICs and SMD-parts with Ni- and Au-layers



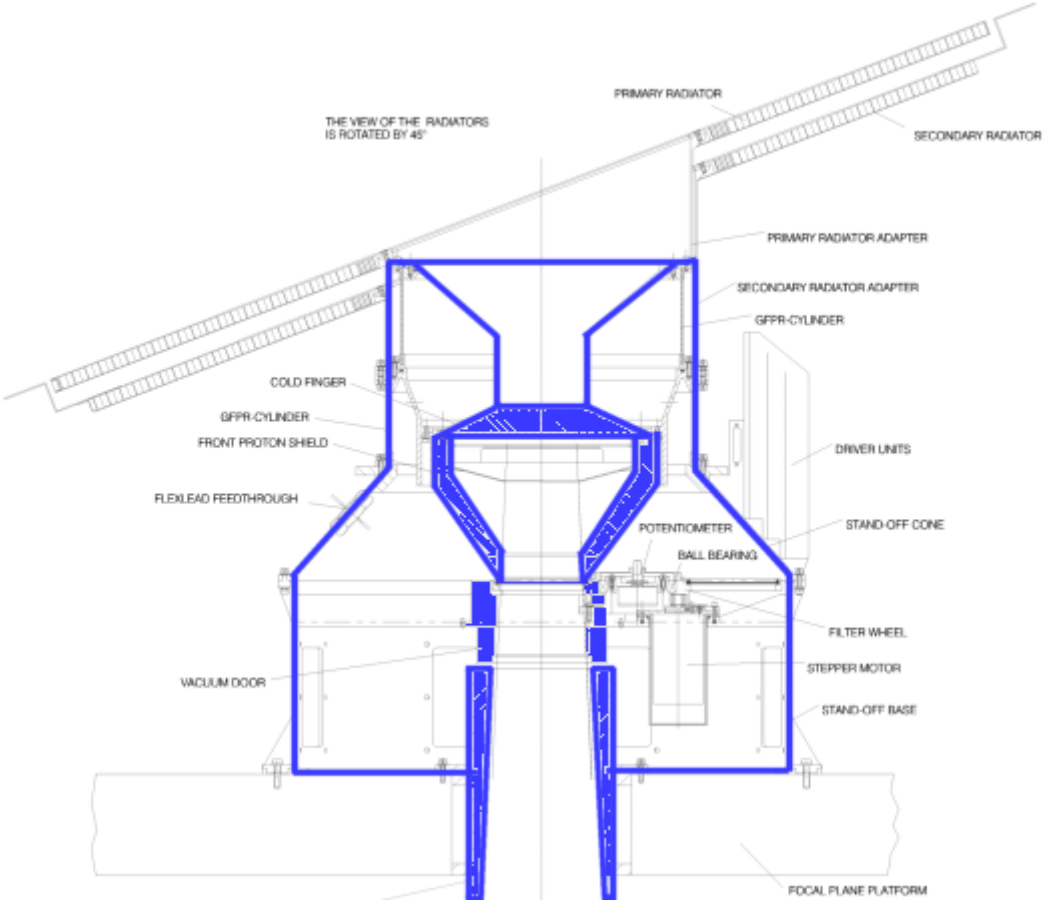
simulations: geometry

- the pn-camera head



simulations: geometry

- the pn-camera head



simulations: geometry

- the PCB layout

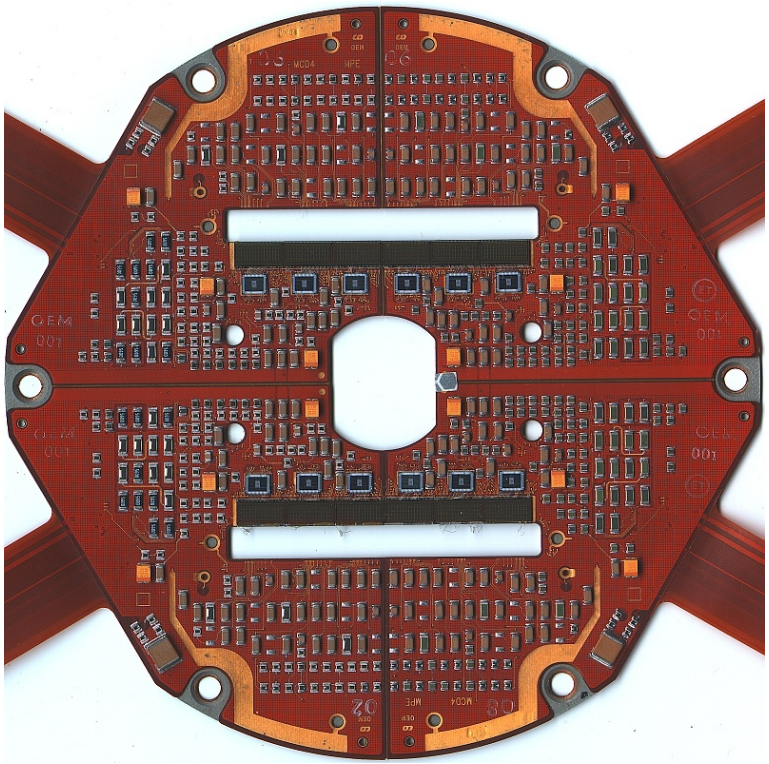
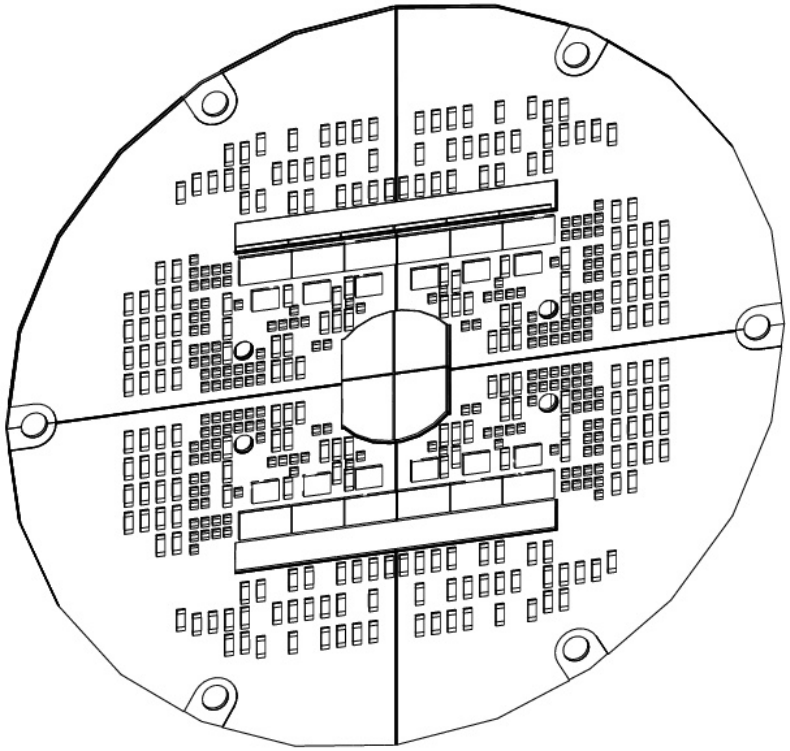


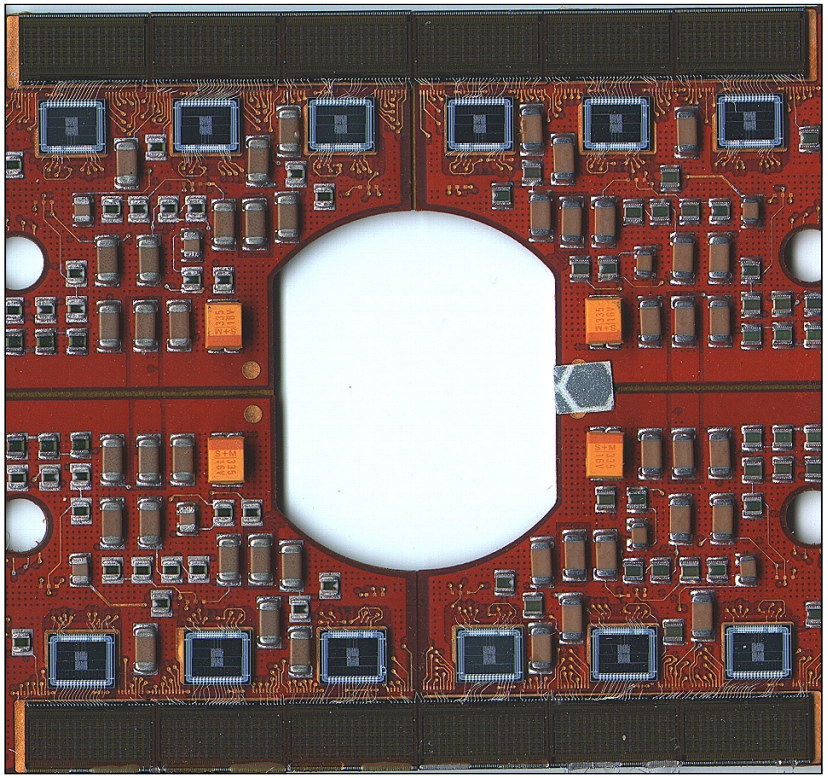
photo of a spare pcb from MPE Garching



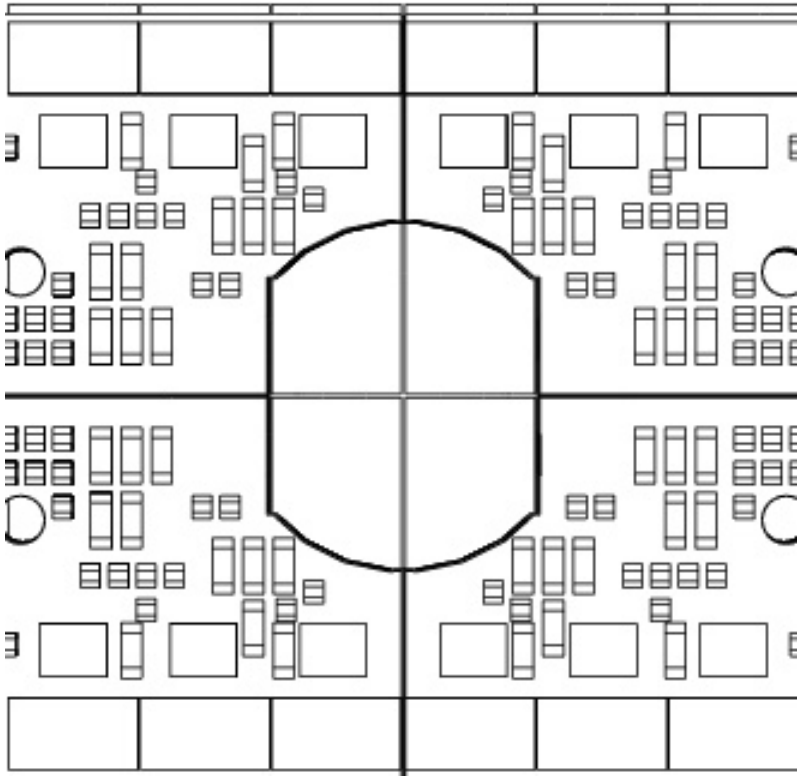
DAWN image of the simulated components

simulations: geometry

- closeup: the PCB layout behind the CCDs



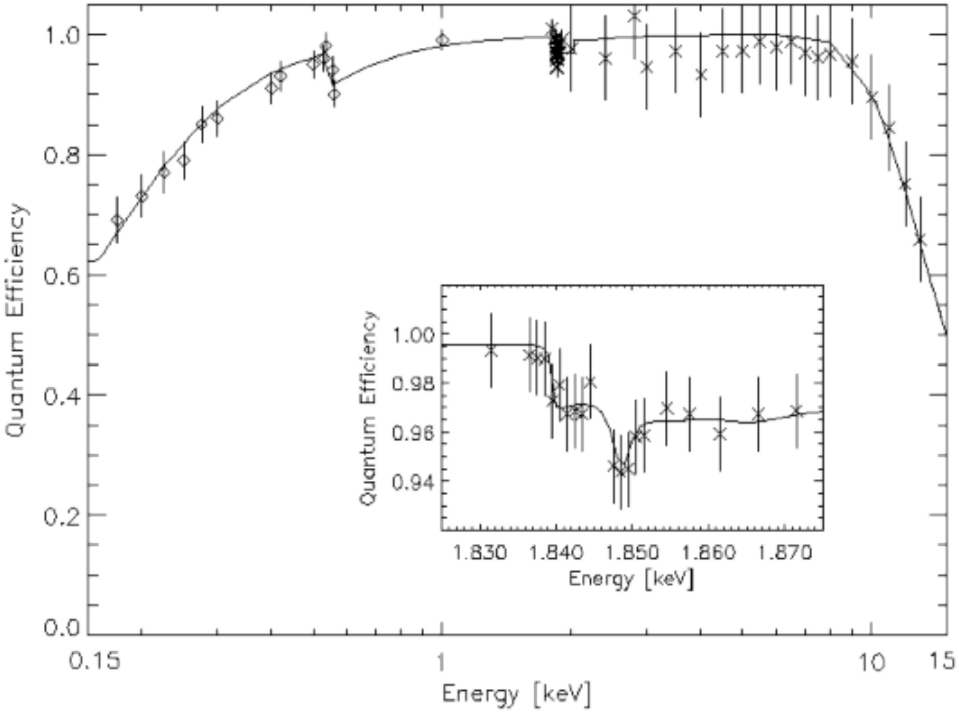
closeup photo of the PCB



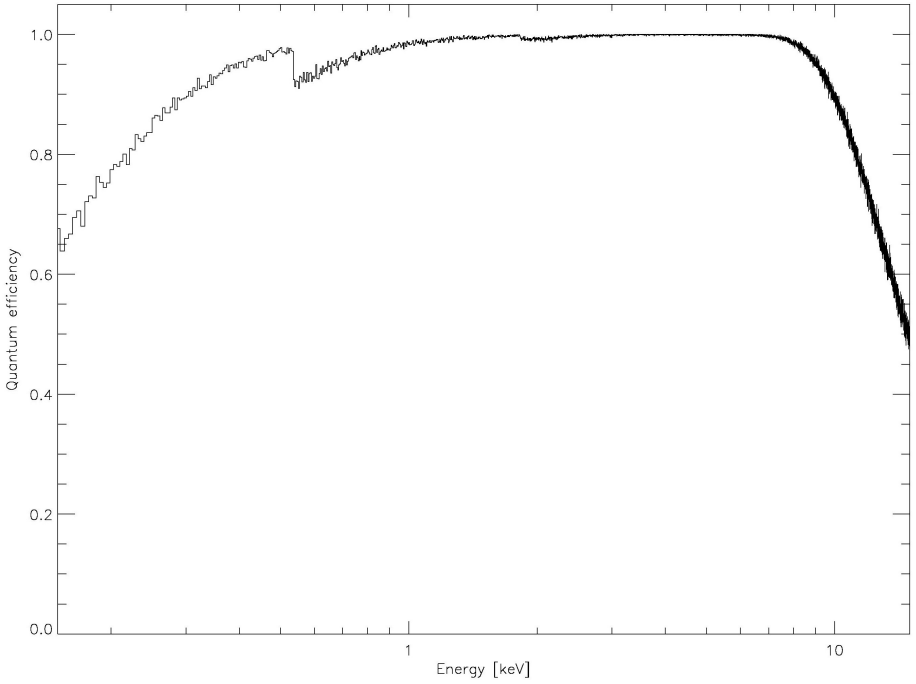
closeup on the simulated image

photon simulation results: quantum efficiency

- quantum efficiency of the pn-CCDs



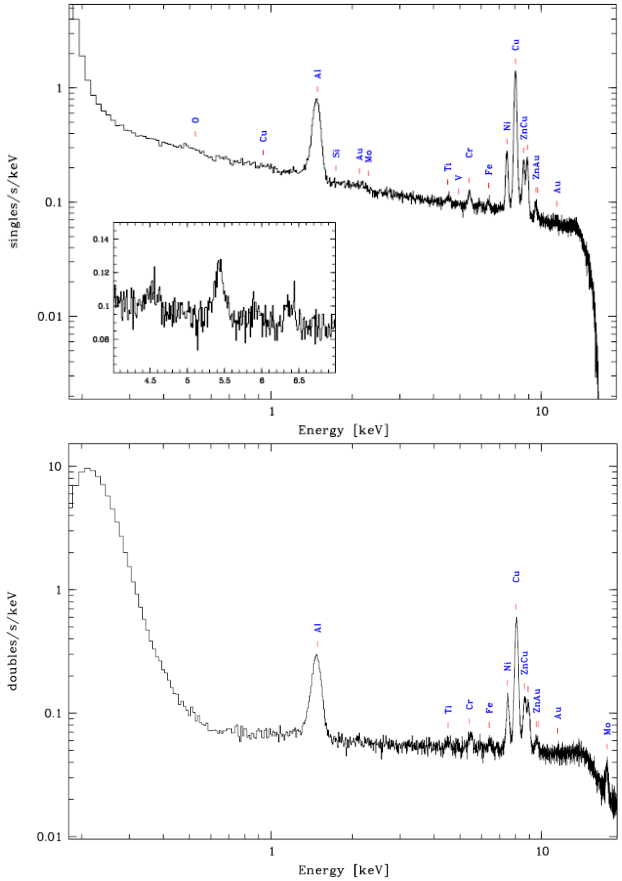
measured *(Strüder et al., 2001, A&A 365, L18, Fig. 5)*



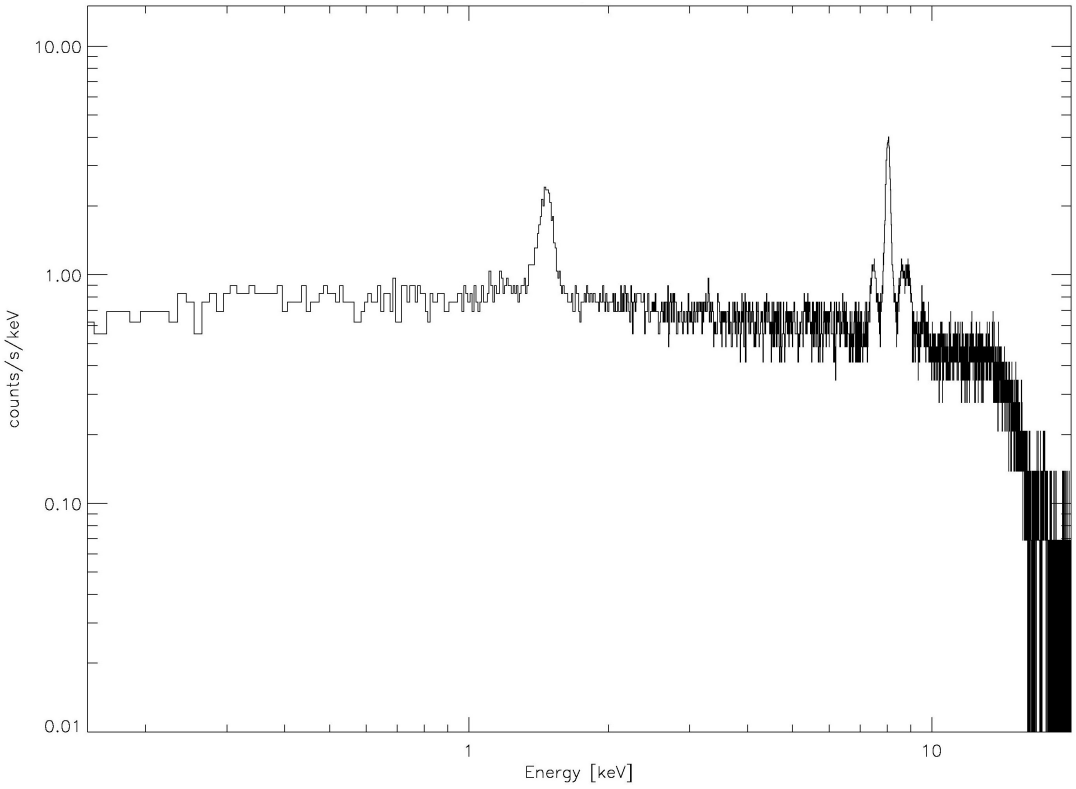
simulated

proton simulation results: spectrum

- spectrum in „closed“ filter position



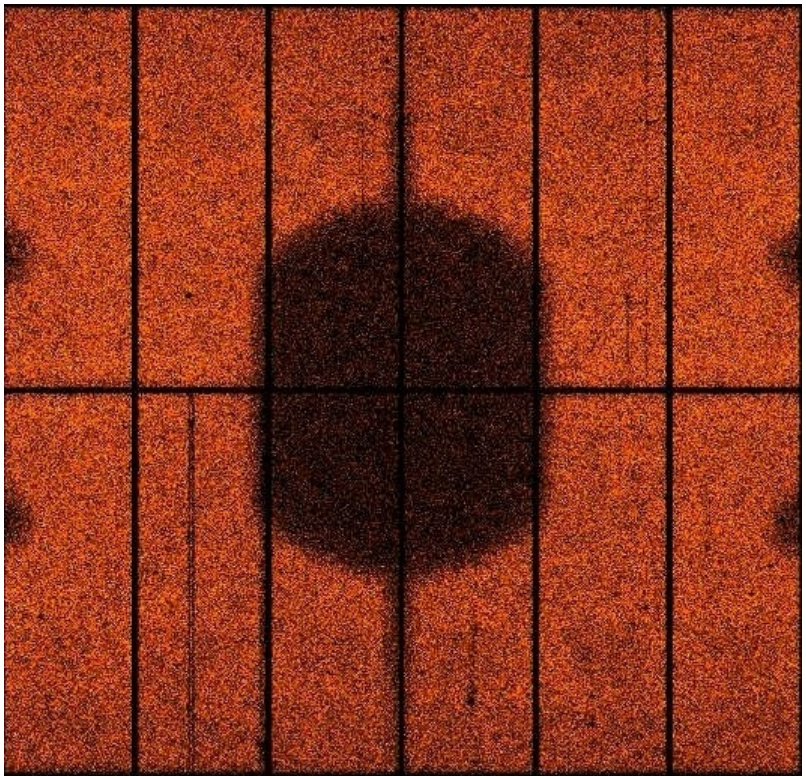
measured (M. Freyberg et al., 2004)



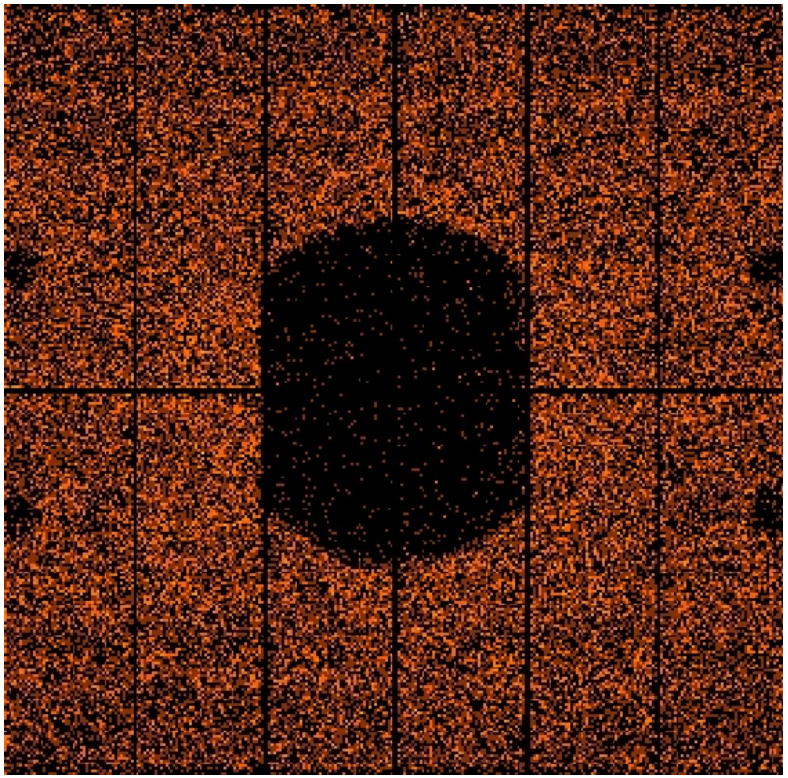
simulated

photon simulation results: images

- around the Cu-Kα line 7800 eV – 8200 eV



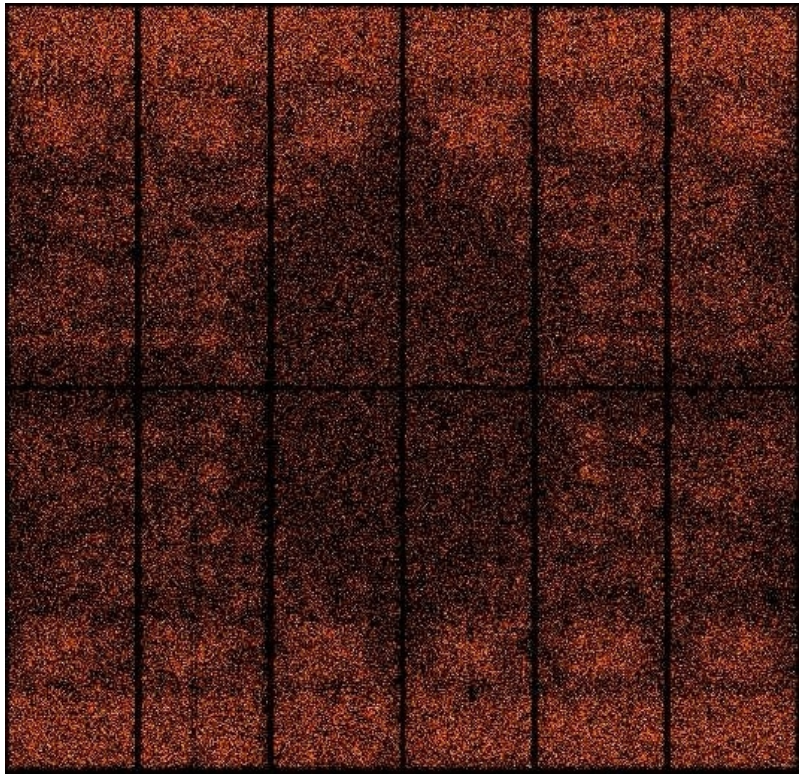
measured



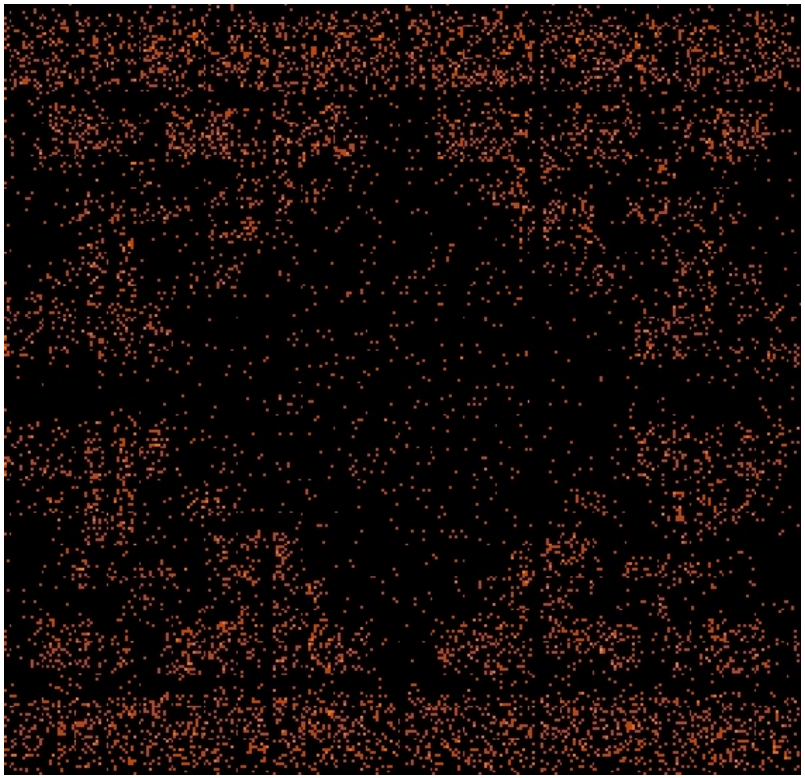
simulated

photon simulation results: images

- around the Ni-Kα line 7300 eV – 7600 eV



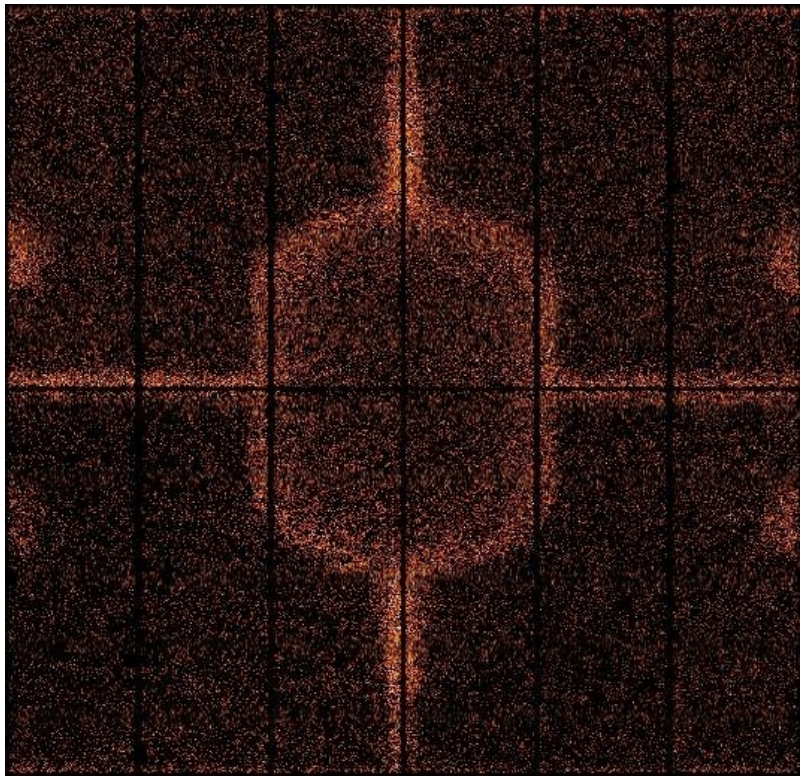
measured



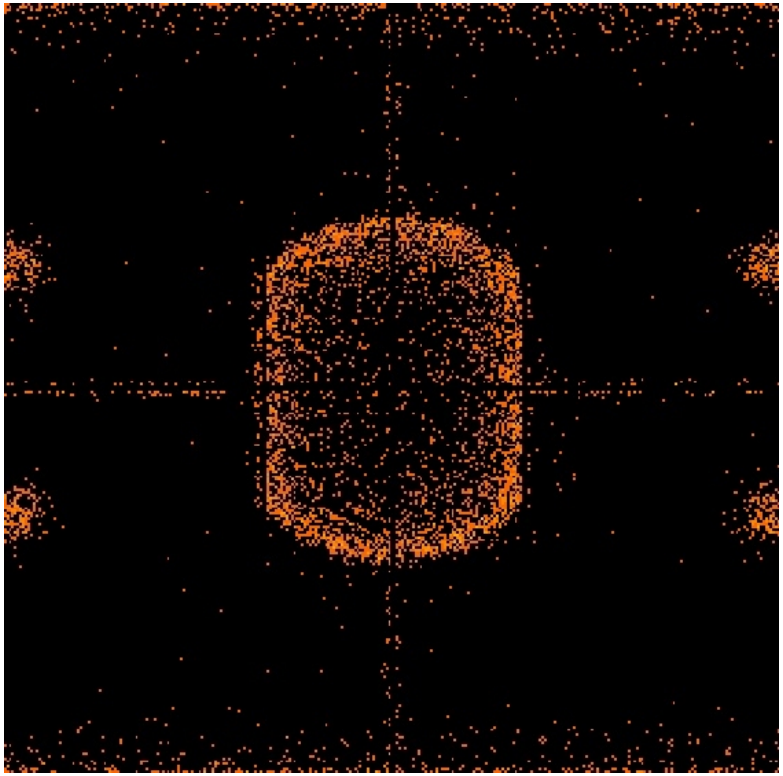
simulated

photon simulation results: images

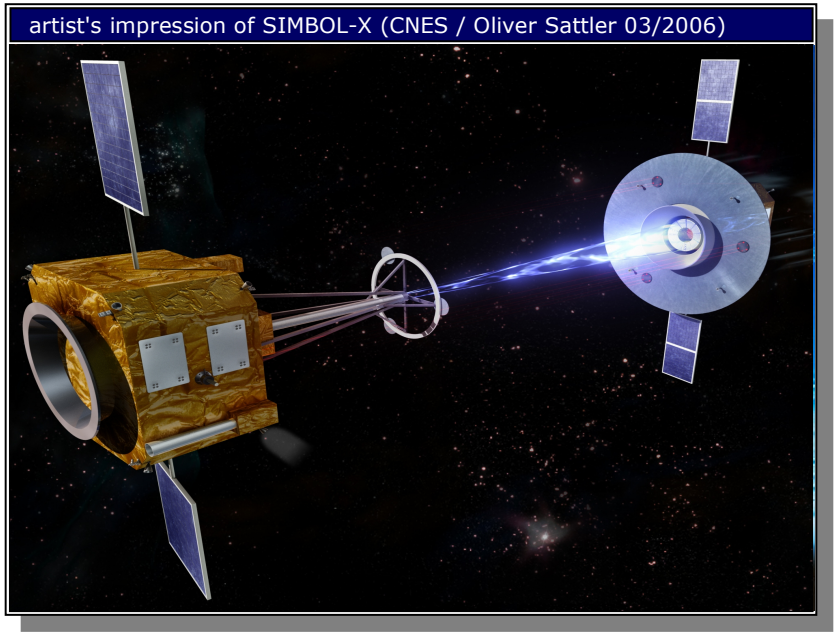
- around the Mo-Kα line 17100 eV – 17700 eV



measured



simulated

summary

- summary:
  - X-ray fluorescence lines of the PCB materials can be reproduced with our MC simulations
  - images of the PCB materials/components can be simulated
- current work:
  - studying influence of CdZnTe fluorescence on Macro Pixel Detector (SIMBOL-X mission)
  - optimizing the (SIMBOL-X) detector geometry and materials to reduce internal background