PolaPix

Using a GridPix detector for the 3D detection of polarized X-ray photons

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Outline

- Introduction
- Motivation
- Experimental setup
- Physics
- Detector design
- Applications
- Summary

Introduction

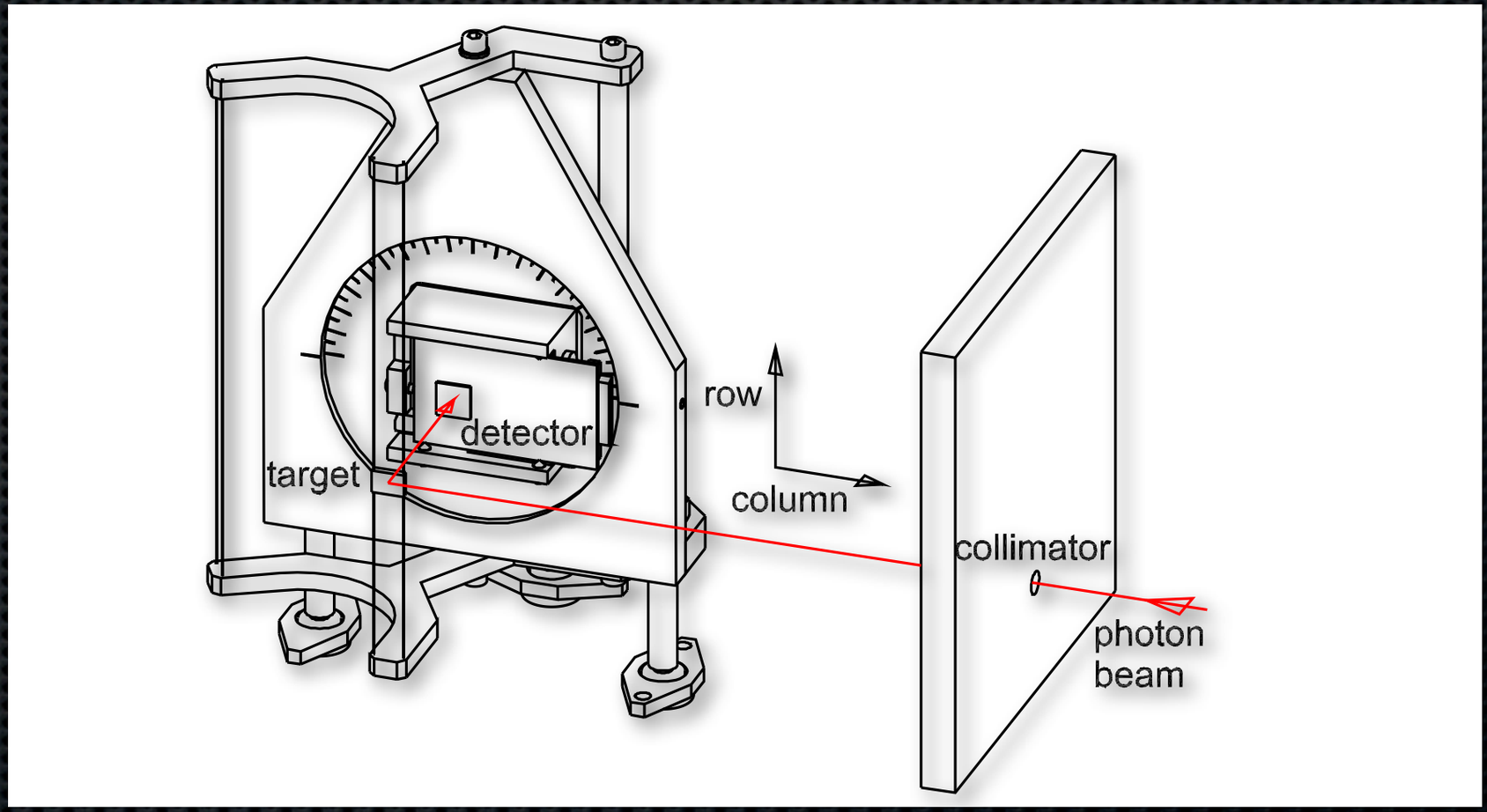
- Request from univ. Erlangen Astroparticle physics group:
  - Is it possible to build a detector for polarized X-rays based on a GridPix detector?
  - Collaboration between univ. Erlangen and Nikhef

Motivation

- Why use a micro-pattern gaseous detector for this application?
  - In theory, 3D imaging of electron clouds is possible!
  - The GridPix system makes it possible to read out the TPC digitally in 3D

Experimental setup

- Detector housing built by university of Erlangen



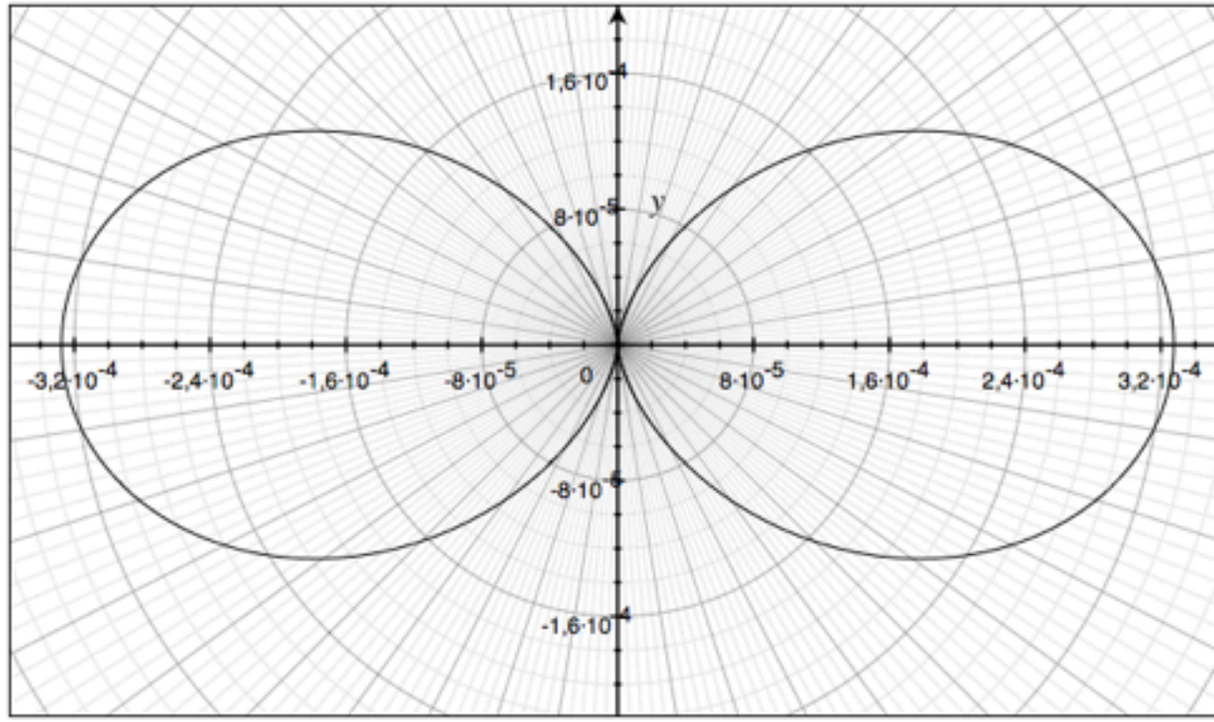
T. Michel, et al., NIMA 594 (2008) 188-195

Physics

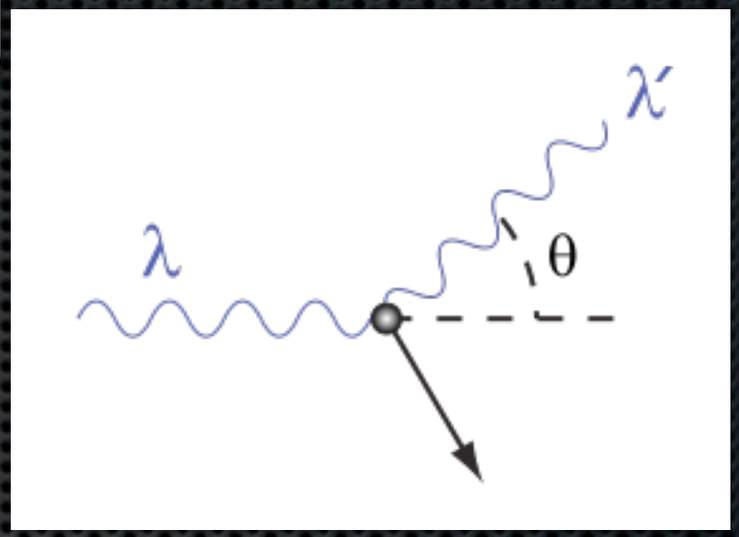
- Linearly polarized photons
- Energies of photons used: ~10-100 keV
- Two types of interaction are expected:
  - Photoelectric effect
  - Compton scattering

Photoelectric effect

- Photoelectron (anisotropic)
  - Mainly from inner orbitals
- Secondary processes:
  - Secondary X-ray photon
  - Auger electron (isotropic ejection)
    - From outer orbitals
- Proportional with $\frac{Z^4}{E^3}$



Compton scattering



- Photon interacts with (free) electron, changes wavelength
- Outgoing: electron and photon with smaller λ
- Direction of electron and photon also dependent on polarization direction
- Secondary photon interaction: photoelectric or again compton
- Proportional with: $\frac{Z}{E^{0.5}}$

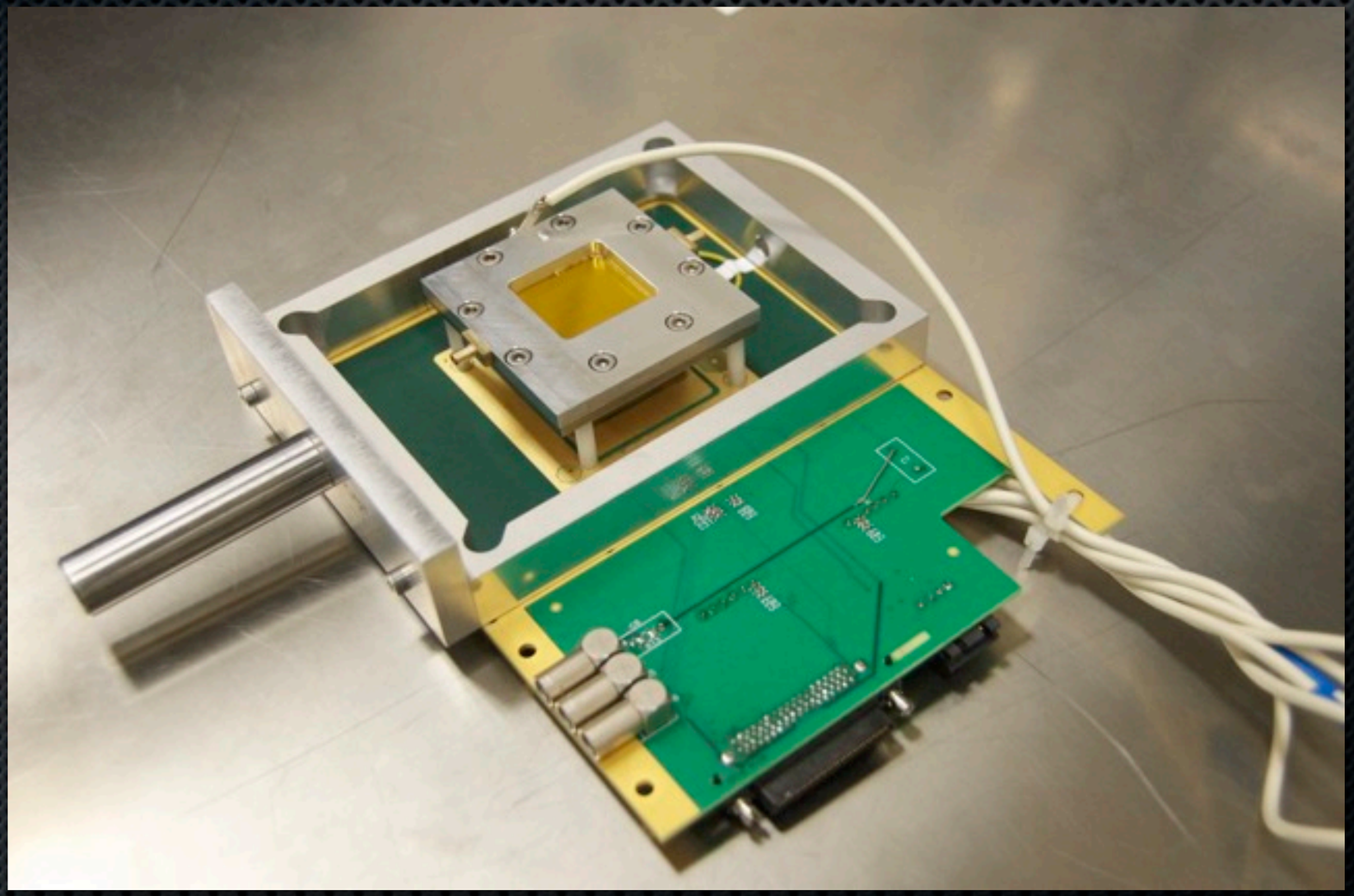
What do we want to measure?

- Tracks of electrons resulting from photoelectric and Compton interactions
- 3D imaging of electron tracks
- Interactions of secondary photons

Detector design

- Detector design based on DICE detector design:
  - 20 mm driftgap
  - TimePix chip (with grid 50 μm above it [pitch 55 μm)
  - Guard electrode for uniform E-field
- PolaPix:
  - X-ray transparent kapton window
  - Bottom layer kapton foil conducting (few hundred nm)

Detector design (II)



Detector design (III)

- Gasses to be used:
  - He/iC_4H_{10}
  - Ar/iC_4H_{10}
  - Xe/iC_4H_{10}
  - DME mixtures (DME/CO_2,Xe) (High voltages needed)
  - High Z increases probability for detection

Outlook

- Things that need to be done:
  - Chip testing:
    - Different voltages
    - Different gas mixtures
    - Operation in non-polarized beams (e.g. ^{55}Fe)
  - Measurements in polarized beams (in Erlangen)

Applications

- Direction of polarization gives new information about radiation source
- Astrophysical applications:
  - Polarized X-ray radiation from e.g. black holes

Summary

- New detector for 3D detection of polarized X-rays
- Different gas mixtures have to be examined
- Possible application: imaging of astronomical sources
- For more information, consult:
  - T. Michel et al., NIMA **594** (2008) 188-195
  - T. Michel et al., NIMA **603** (2009) 384-392

Thank you for your attention!

- Questions?