HERMES Recoil Detector

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On behalf the HERMES Collaboration

Exclusive Reactions at High Momentum Transfer
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JUSTUS-LIEBIG-
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GIESSEN

Outline

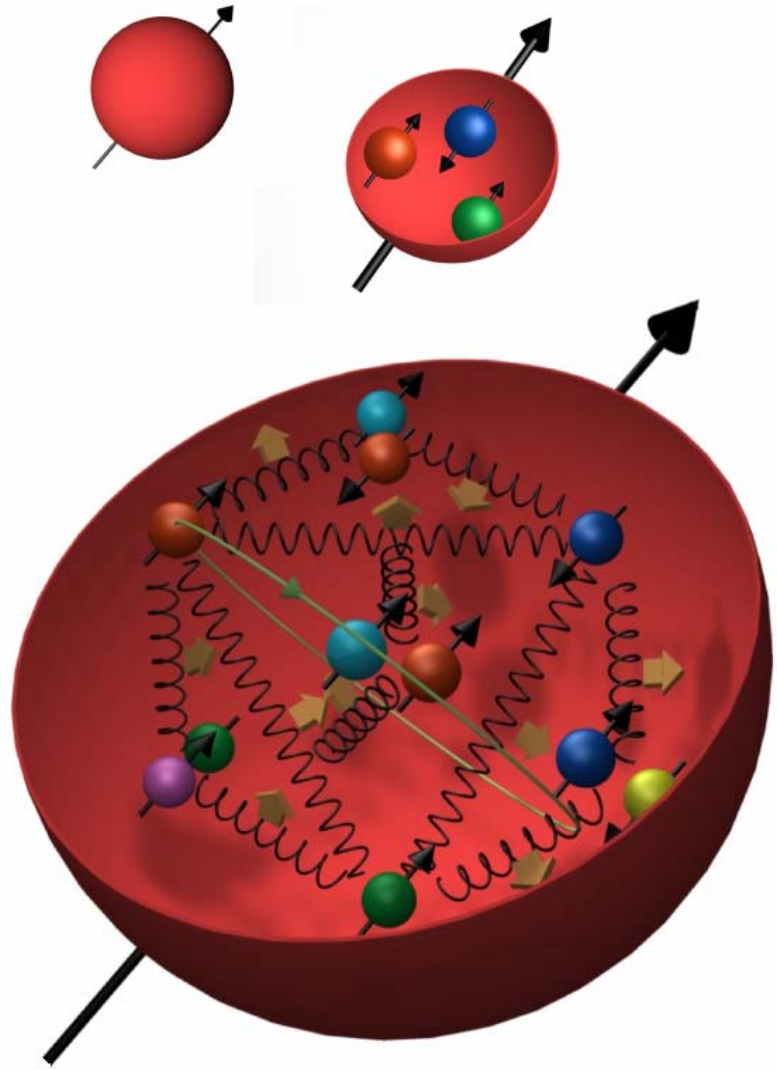
- Motivation
  - Spin of the Nucleon
  - General Parton Distribution (GPD)
  - DVCS & BH
- HERMES
  - Hermes Recoil Detector
  - Design Requirement
- Recoil Detector (RD)
  - Silicon Strip Detector (SSD)
  - Scintillating Fiber Tracker (SFT)
  - Photon Detector (PD)
- Performance

Spin of the nucleon

$$S_z = \frac{1}{2} = J_q + J_g = \frac{1}{2}\Delta\Sigma + \Delta G + L_q + L_g$$

- $\Delta\Sigma$ Spin of quarks

  $\Delta\Sigma$~ 30% !
- ΔG Spin of gluons
  - expected to be small
- L_q Orbital angular momentum of quarks
- L_g Orbital angular momentum of gluons



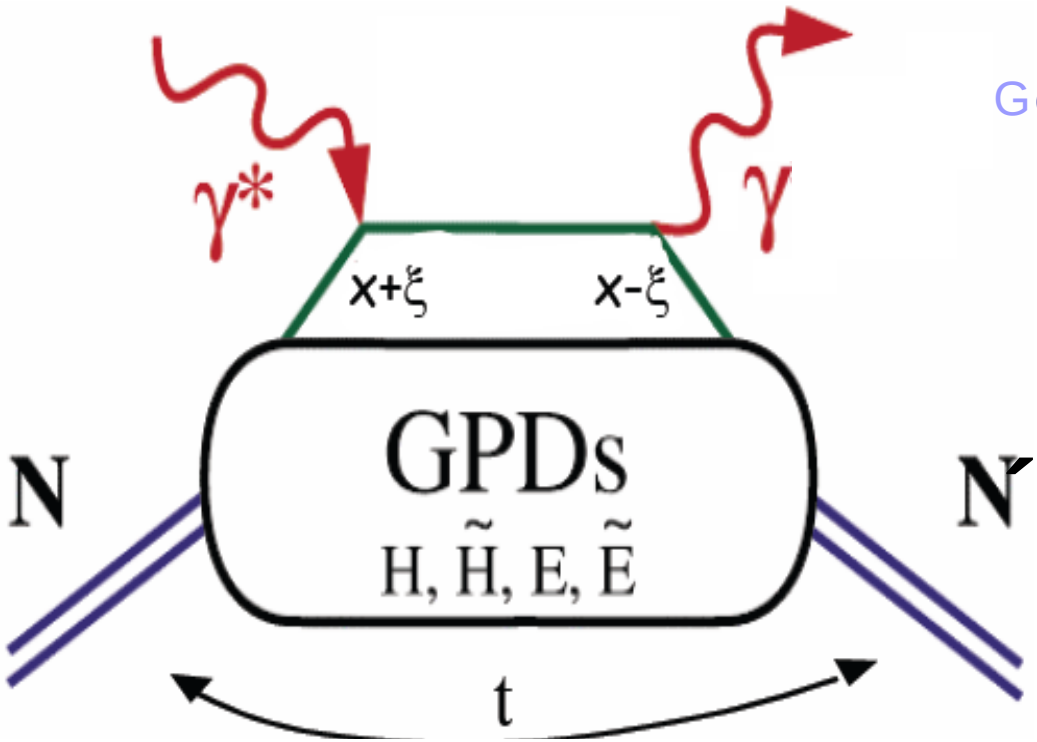
HERMES:

$$\Delta\Sigma = 0.330 \pm 0.011(\text{theo.}) \pm 0.025(\text{exp.}) \pm 0.028(\text{evol.})$$

A. Airapetian et al, Phys. Rev. D75(2007)012007

How to access L_q ?

Generalized Parton Distributions



Study of hard exclusive processes leads to a new class of PDF's

Generalized Parton Distributions

$$H^q, E^q, \tilde{H}^q, \tilde{E}^q$$

possible access to orbital angular momentum

Ji´s sumrule [hep-ph/9603249]

$$J_q = \frac{1}{2}\left(\int_{-1}^{1} x dx \left(H^q + E^q\right)\right)_{t\to 0}$$

$$J_q = \frac{1}{2}\Delta\Sigma + L_q$$

from DIS HERMES

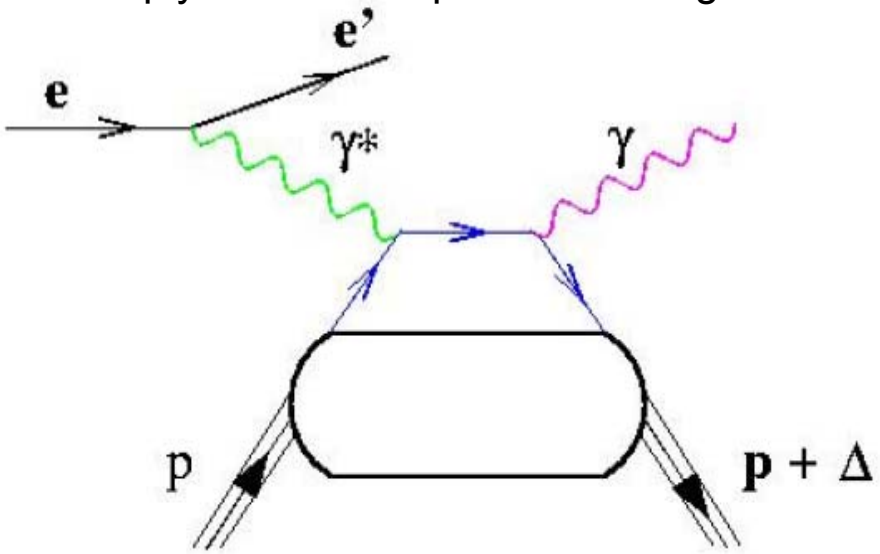
GPDs can be accessed in Deeply Virtual Compton Scattering (DVCS)

DVCS at HERMES

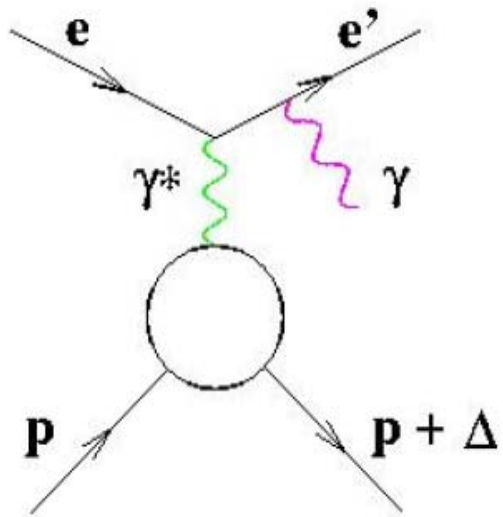
two experimentally undistinguishable processes:

Same initial and final state

Deeply Virtual Compton Scattering



Bethe-Heitler

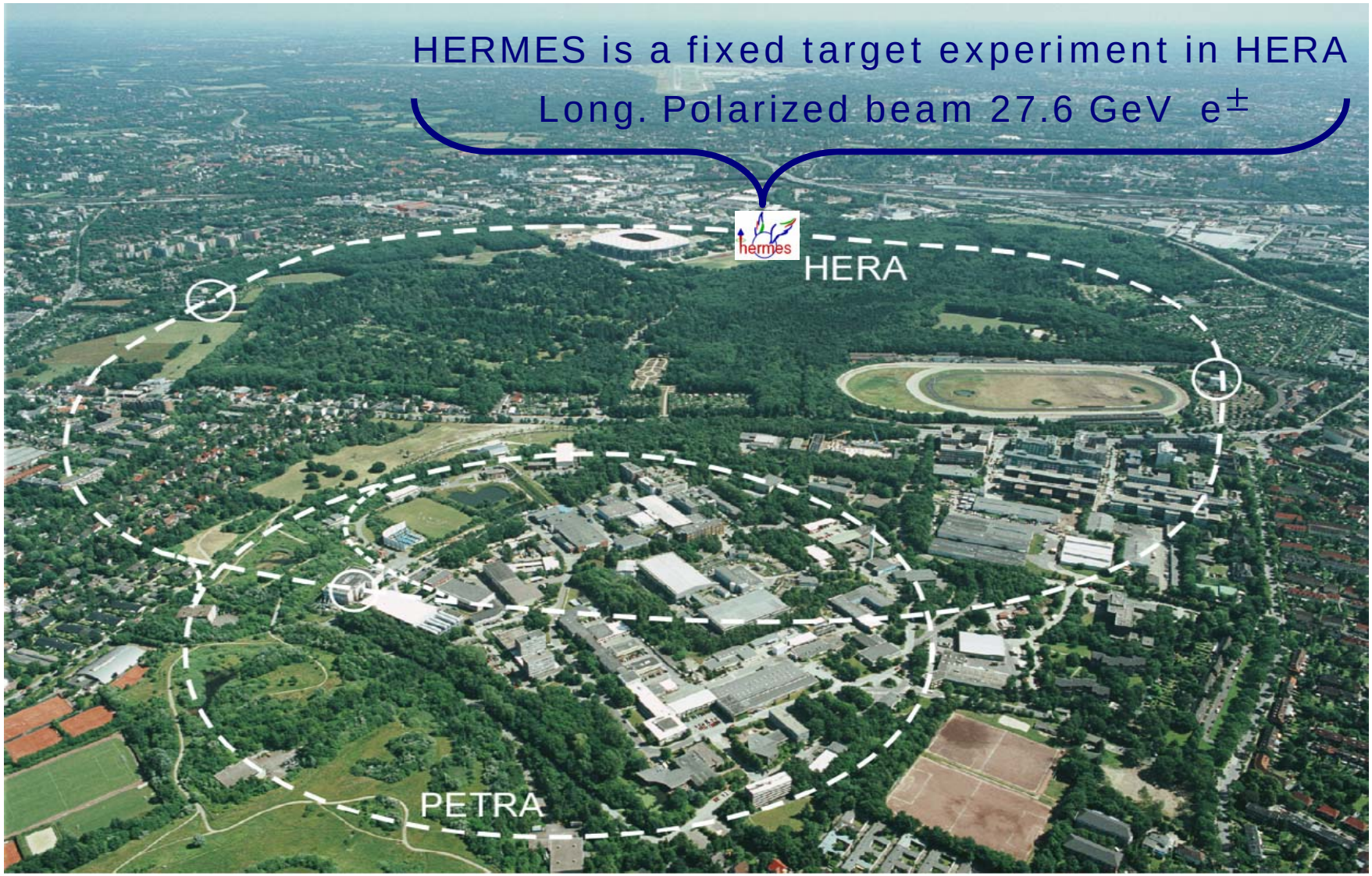


$$d\sigma \sim \left(\tau^{*}_{BH}\tau_{DVCS} + \tau^{*}_{DVCS}\tau_{BH} \right) + |\tau_{BH}|^2 + |\tau_{DVCS}|^2$$

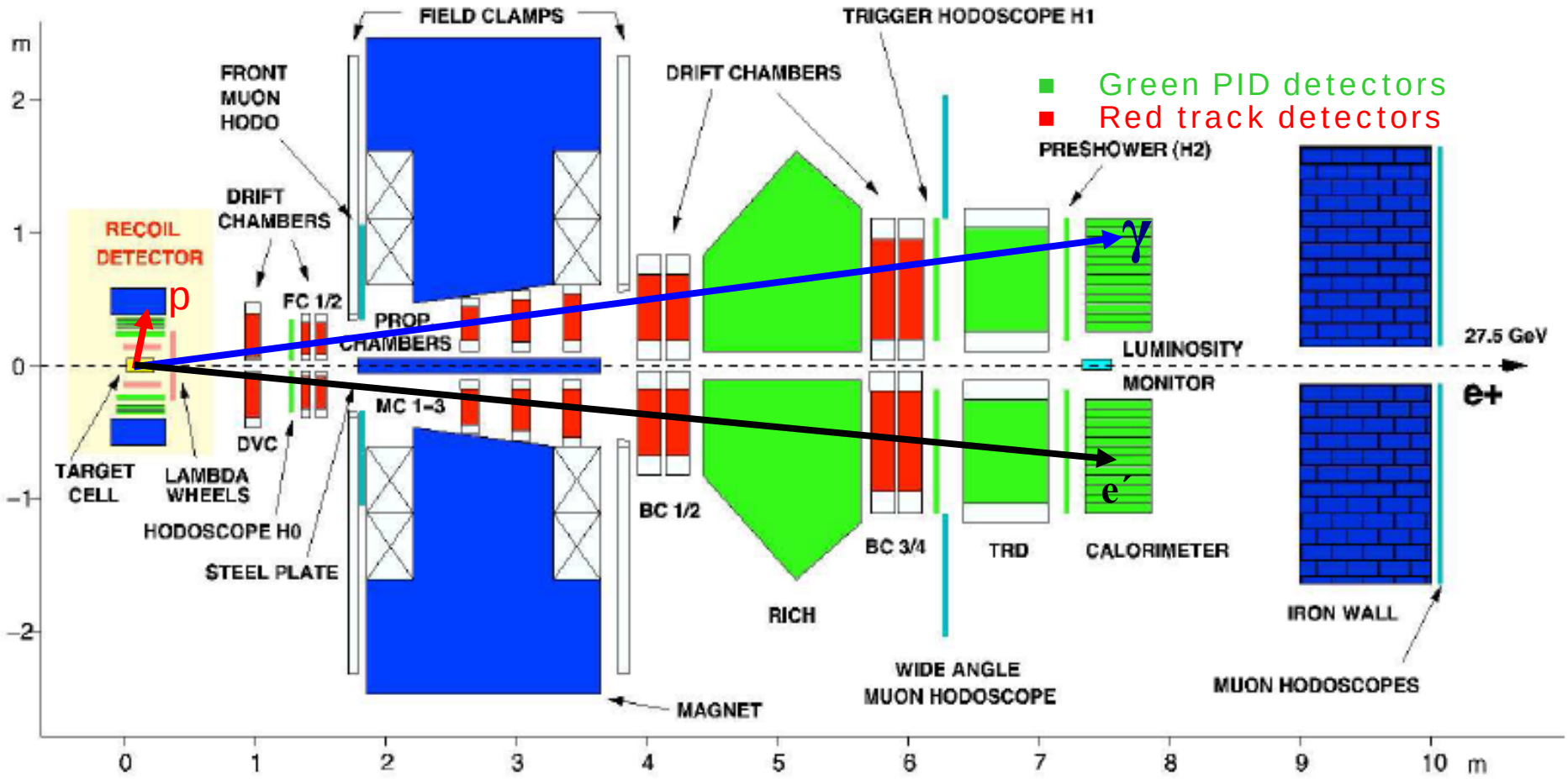
BH dominates at HERMES kinematics

The DVCS can be measured through azimuthal asymmetries

HERMES in Hamburg - Germany

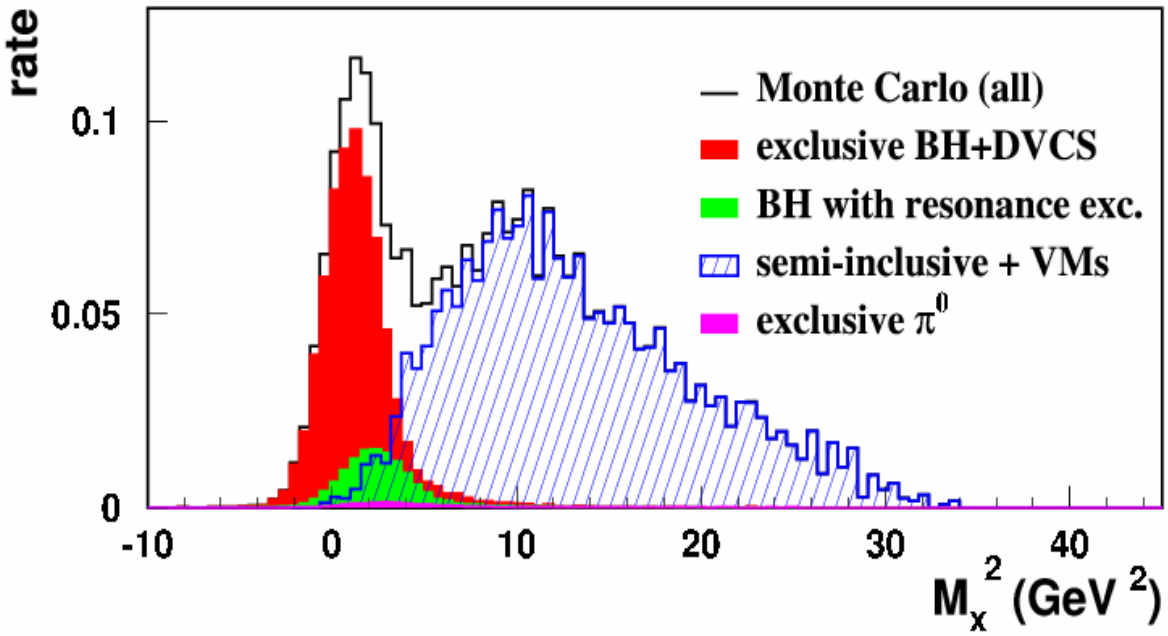


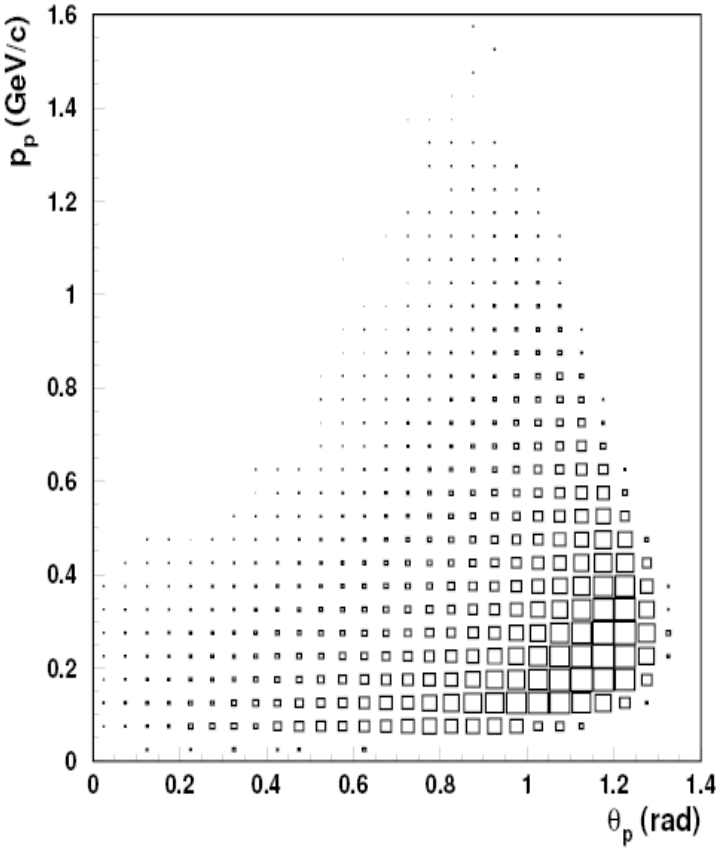
HERMES Detector



- 95 - 05 exclusivty through missing mass cut
- 06 - 07 Recoil detector installed to identify the recoiling proton

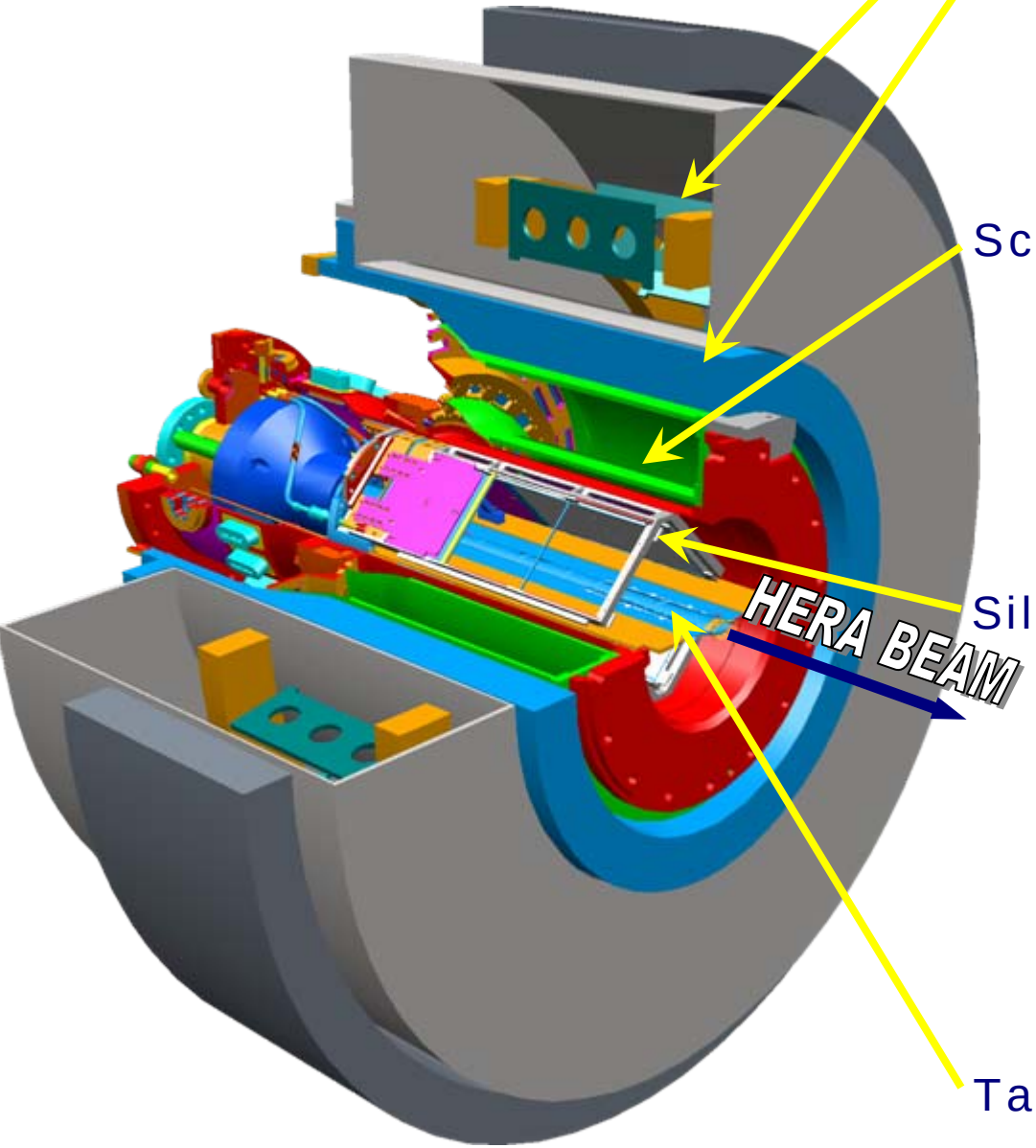
RD - Design Requirements





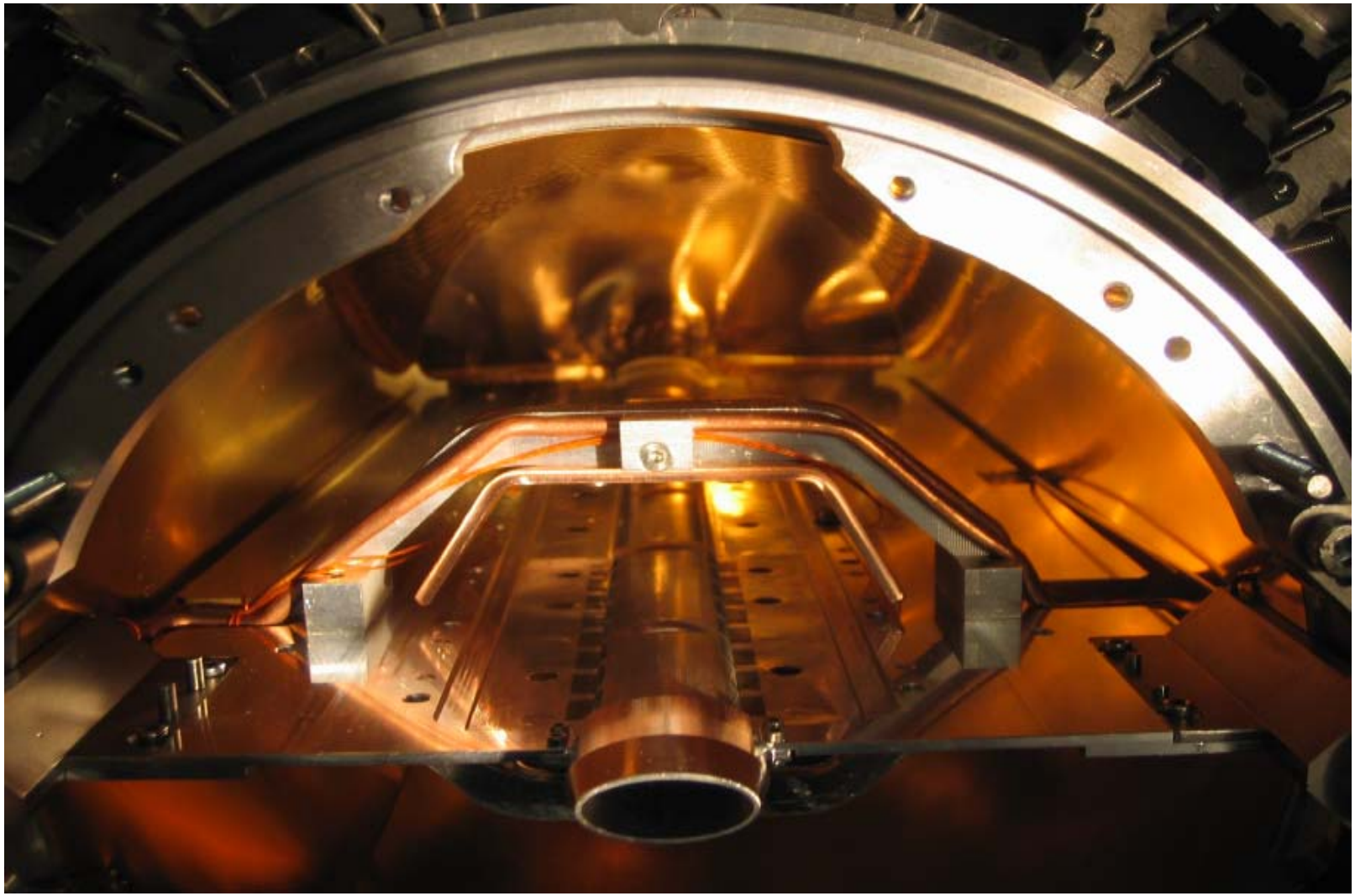
- Improve Exclusivity
- Detect recoiling proton
- Background suppression
  - semi-incl. : 5%→<<1%
  - BH with resonace excitation: 11%→~1%

Recoil Detector



- 1 Tesla Superconducting Solenoid
- Photon Detector
  - 3 layers of Tungsten/Scintillator
  - PID for higher momentum
  - detects $\Delta^+ \rightarrow p\pi^0$
- Scintillating Fiber Detector
  - 2 Barrels
  - 2 Parallel- and 2 Stereo-Layers in each barrel
  - 10° Stereo Angle
  - Momentum reconstruction & PID
- Silicon Detector
  - 16 double-sides sensors perpendicular with respect to each other
  - 97×97 mm^2 active area each
  - 2 layers
  - Inside HERA vacuum
  - Momentum reconstruction & PID
- Target Cell

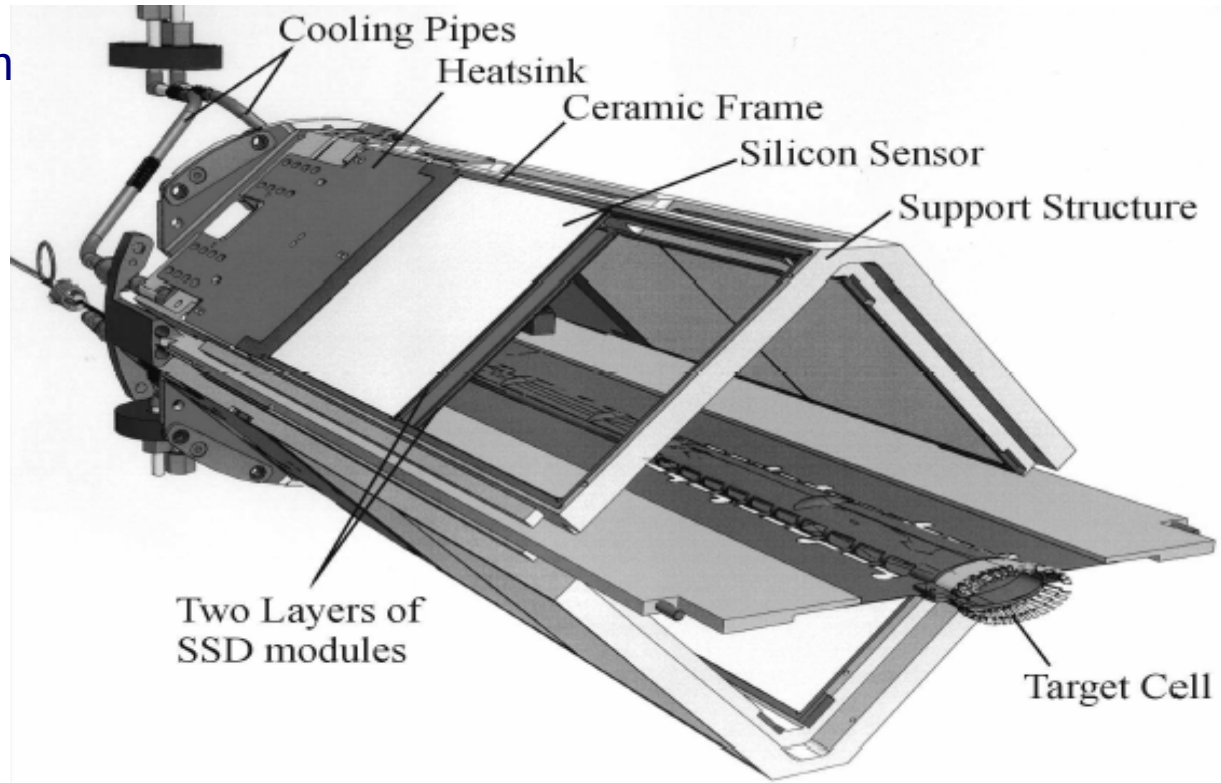
Target Cell



Target cell inside beam pipe

Silicon Strip Detector (SSD)

- 2 layers of double sided TIGRE sensors
- 16 TIGRE sensors operate in beam vacuum few cm close to the beam
- Size 97mmX 97mm, thickness=300μm
- 128 strips per side, perpendicular w.r.t. each other, pitch=758μm
- HELIX chips are ADC and running under same condition
- The high and low gain yield s from charge sharing
  - 8192 channels in total
- Proton momentum 135-500 MeV/c



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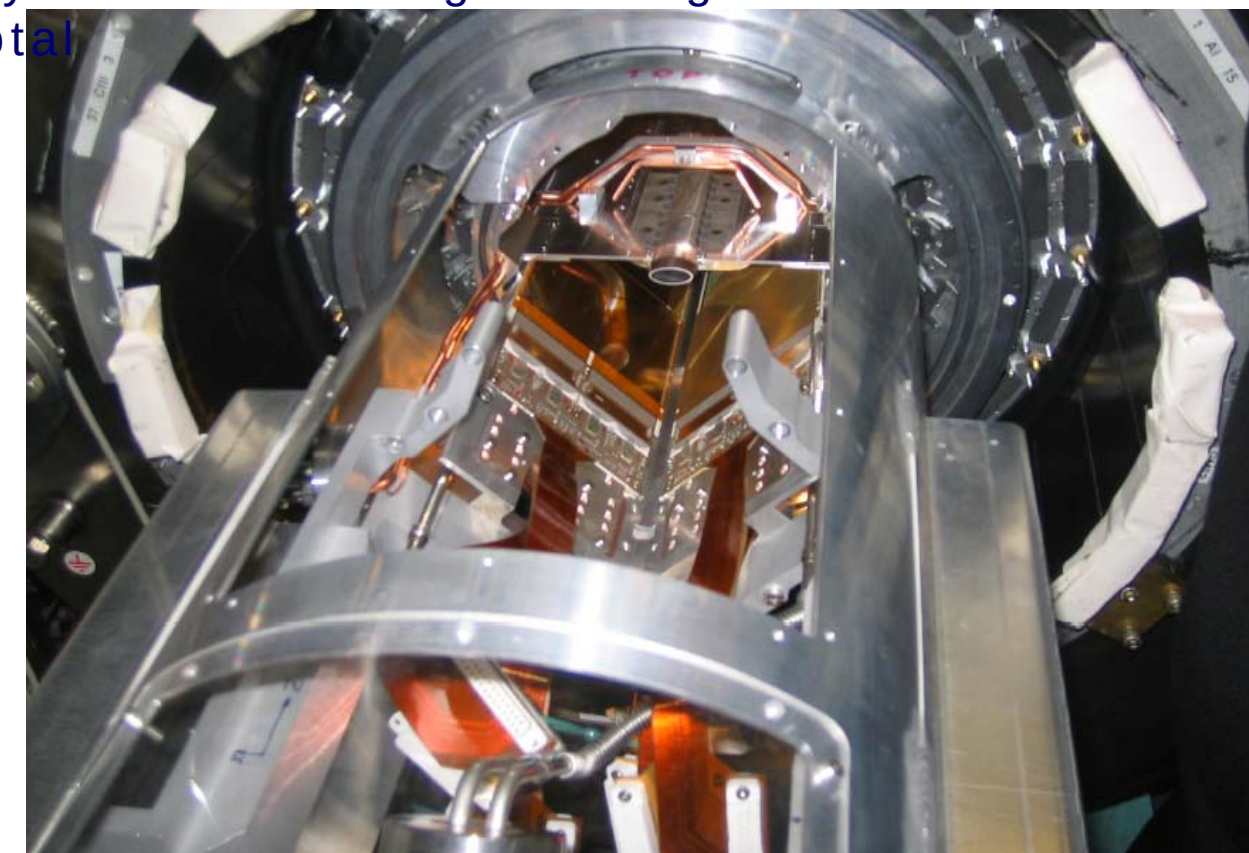

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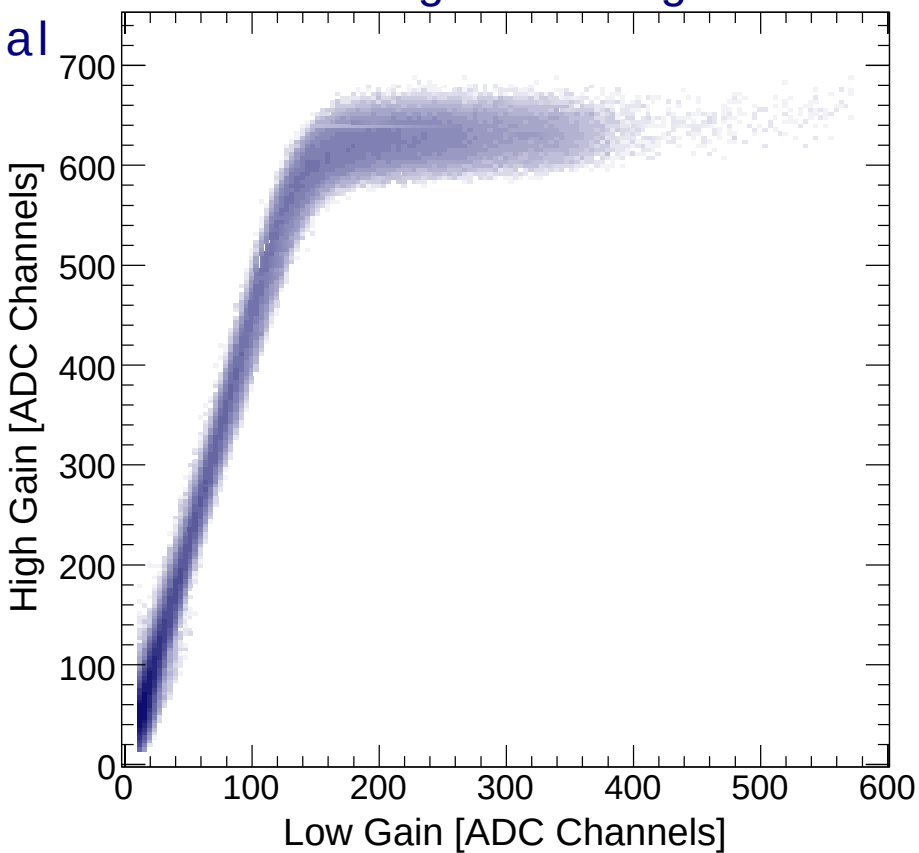

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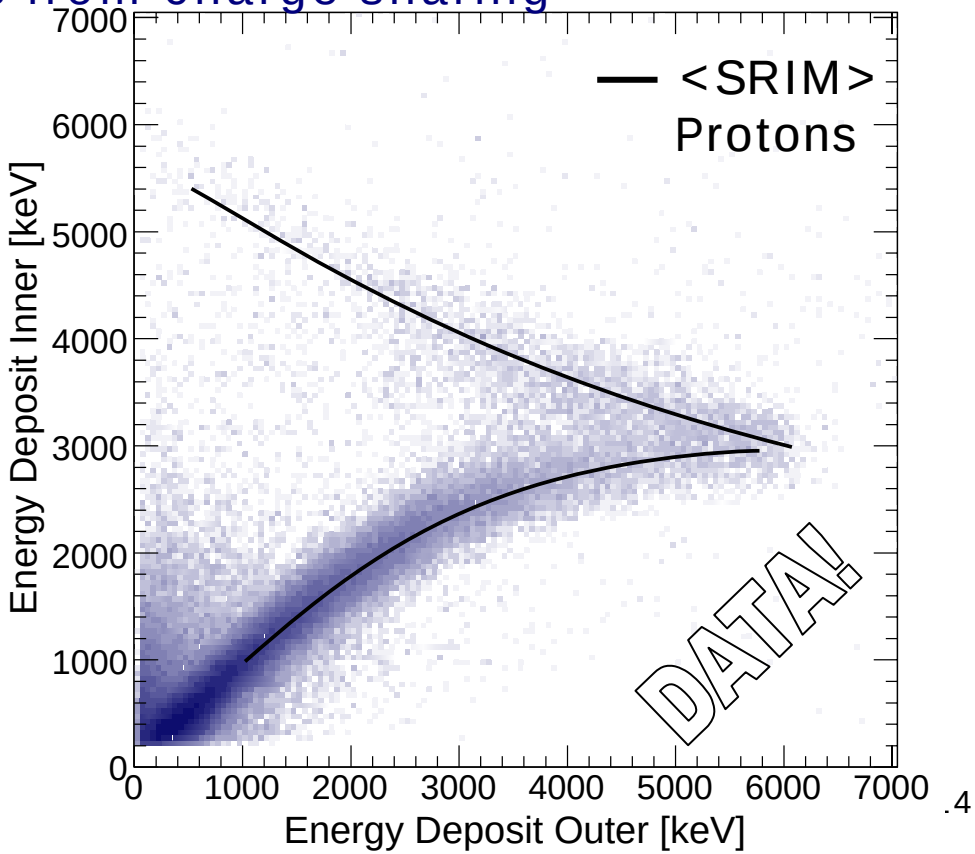
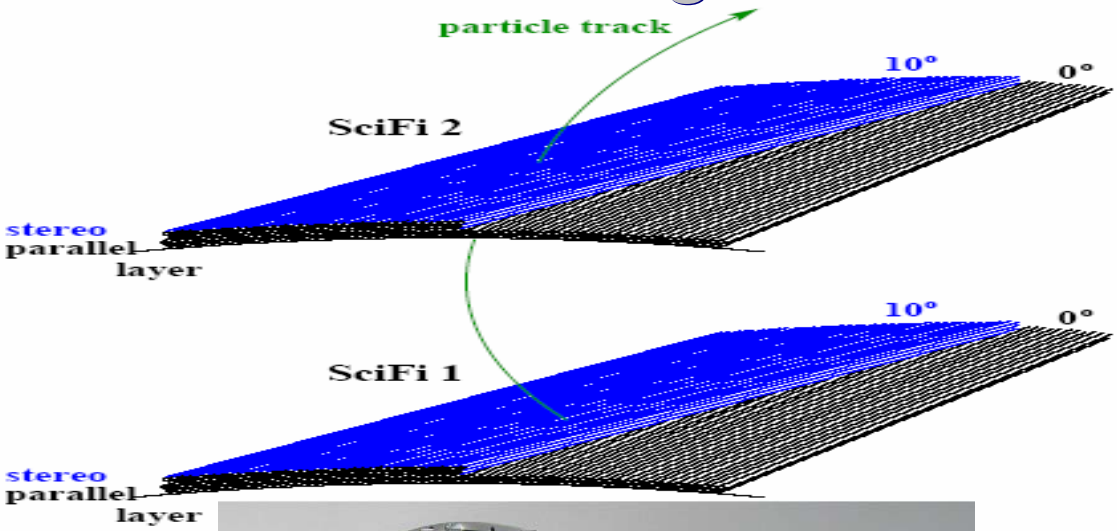
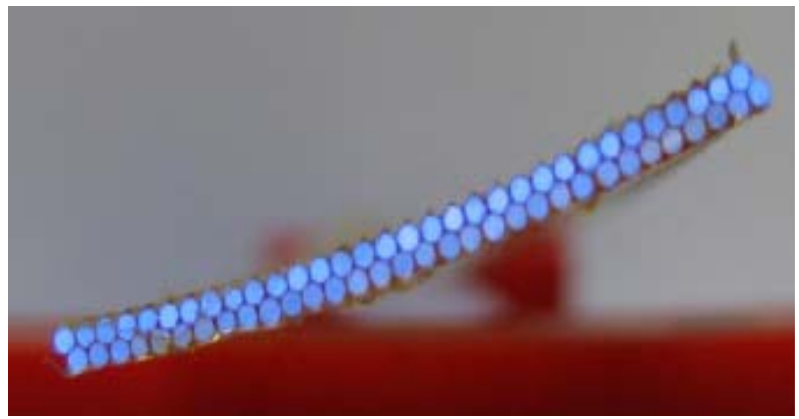


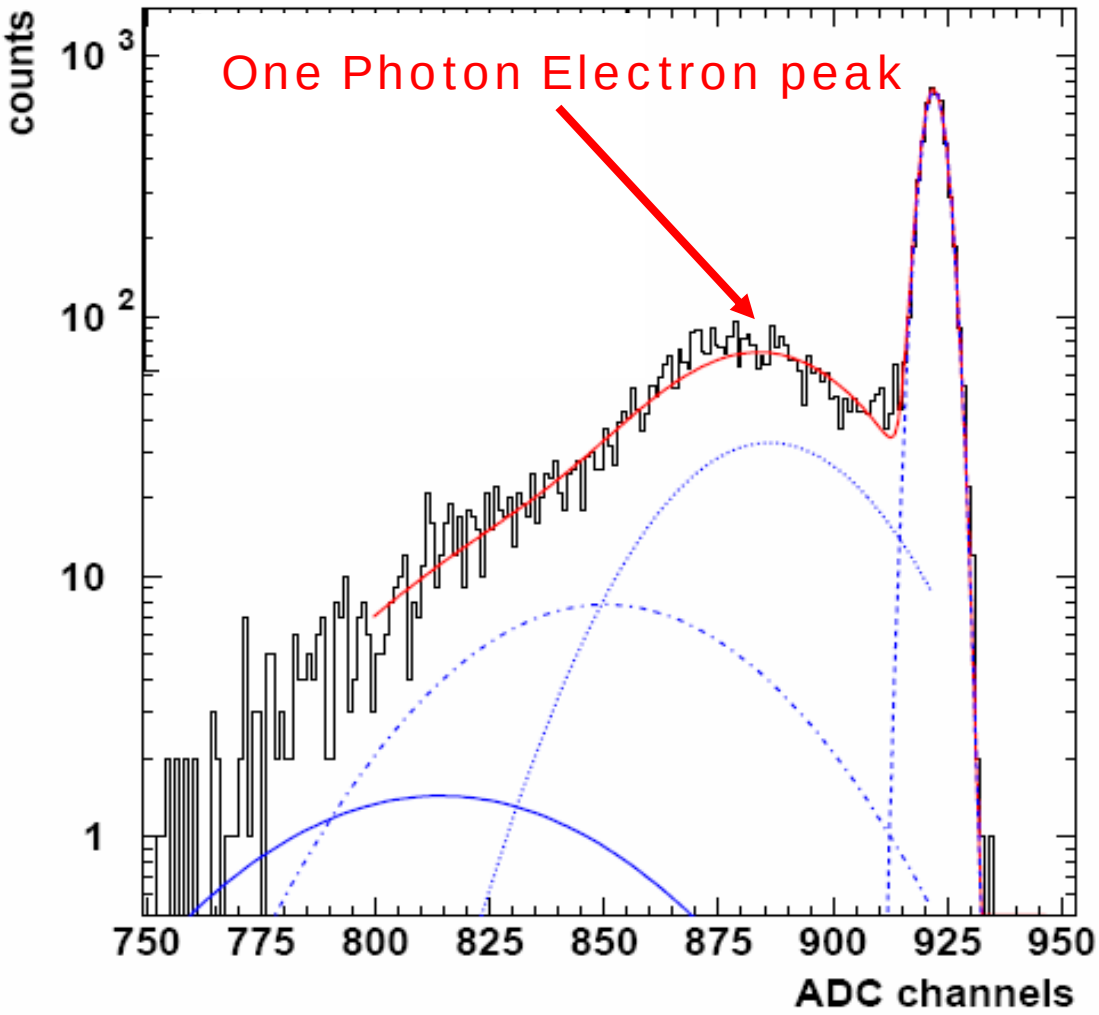
Scintillating Fiber Tracker



- 2 cylinders of 2X2 layers,
  - 10° stereo angle
- 1mm Kuraray fibers, mirrored ends and double cladding
- PMT Hamamatsu 64 channels
  - 5120 channels in total
- Proton momentum 250-1200 MeV/c

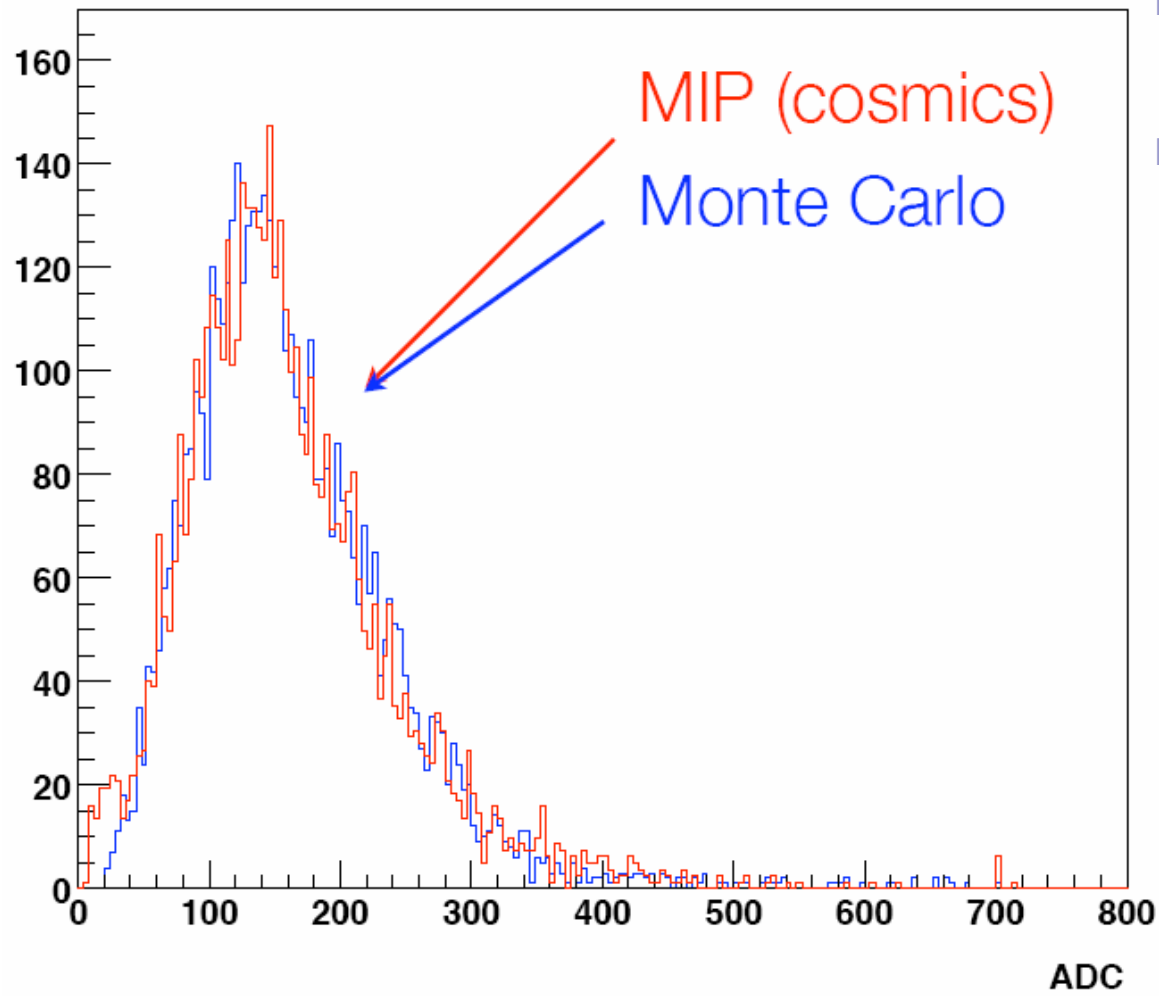


Scintillating Fiber Tracker



- Calibration data (blue LED pulser) fitted with Poisson & Gauß

Scintillating Fiber Tracker



- reasonable energy reponse of the SFT
- MC and cosmics data agree

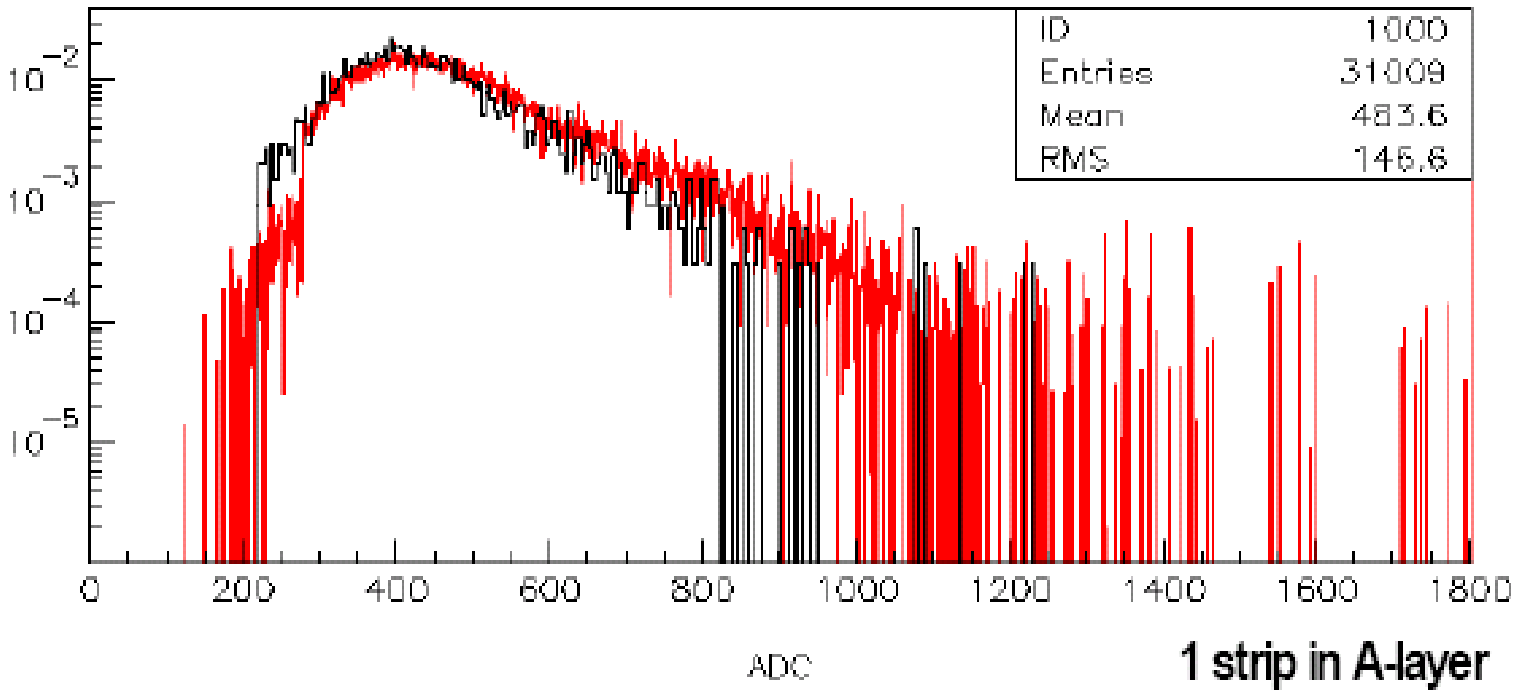
Photon Detector

- 3 layers of Tungsten/Scintillator
  - A layer parallel to beam line, B and C layer stereo under +45°/-45°
- Strips: 2x1x28cm³
- same PMTs as for SFT are used
- Main purpose
  - 1γ from π° decay
  - Reconstruct π° if 2 γ's detected

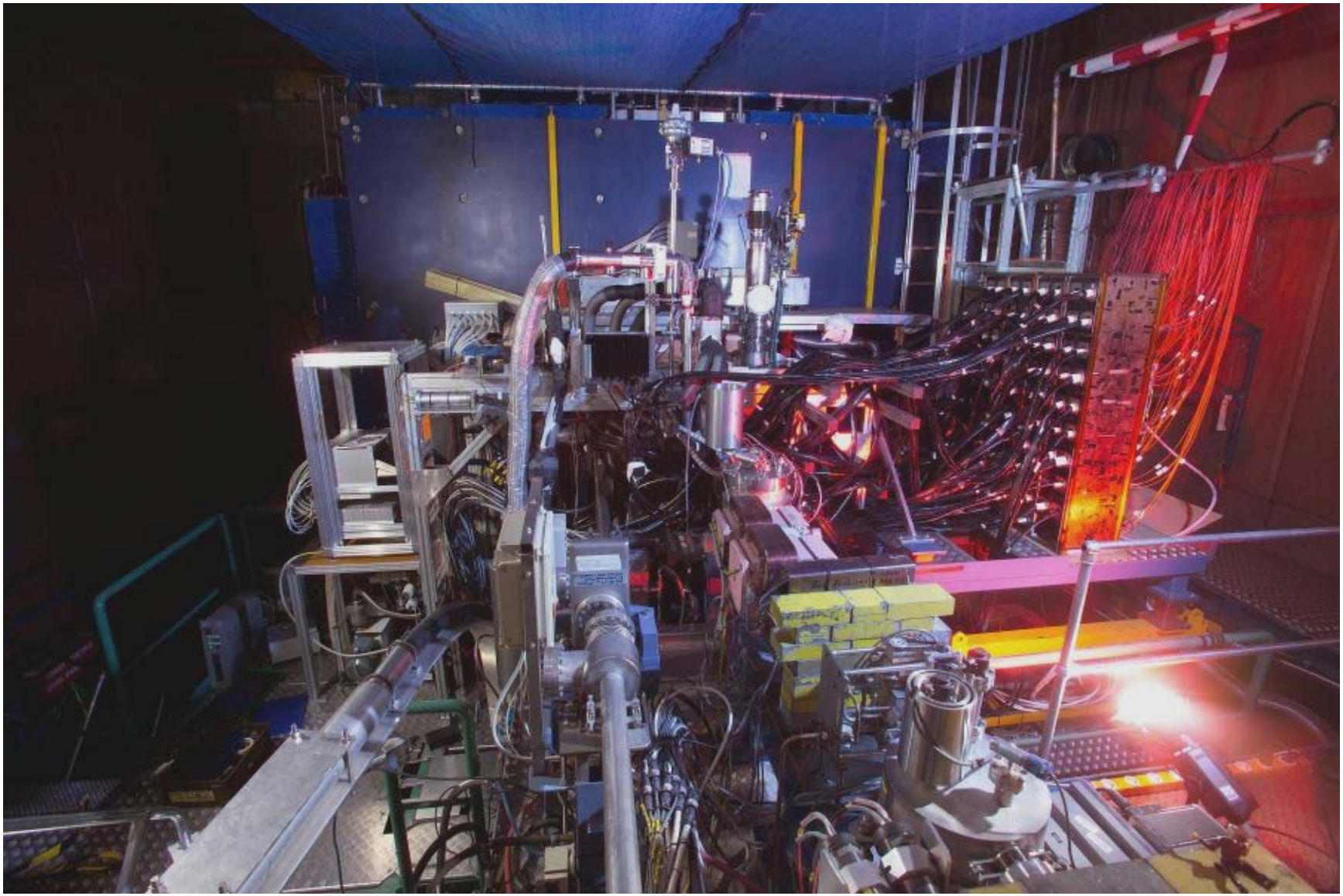
Photon Detector

- Data-MonteCarlo comparison:
  - Minimum 1 lepton track in spectrometer
  - Select exactly 1 hit per layer
- MC and data agree

- Data
- Monte Carlo

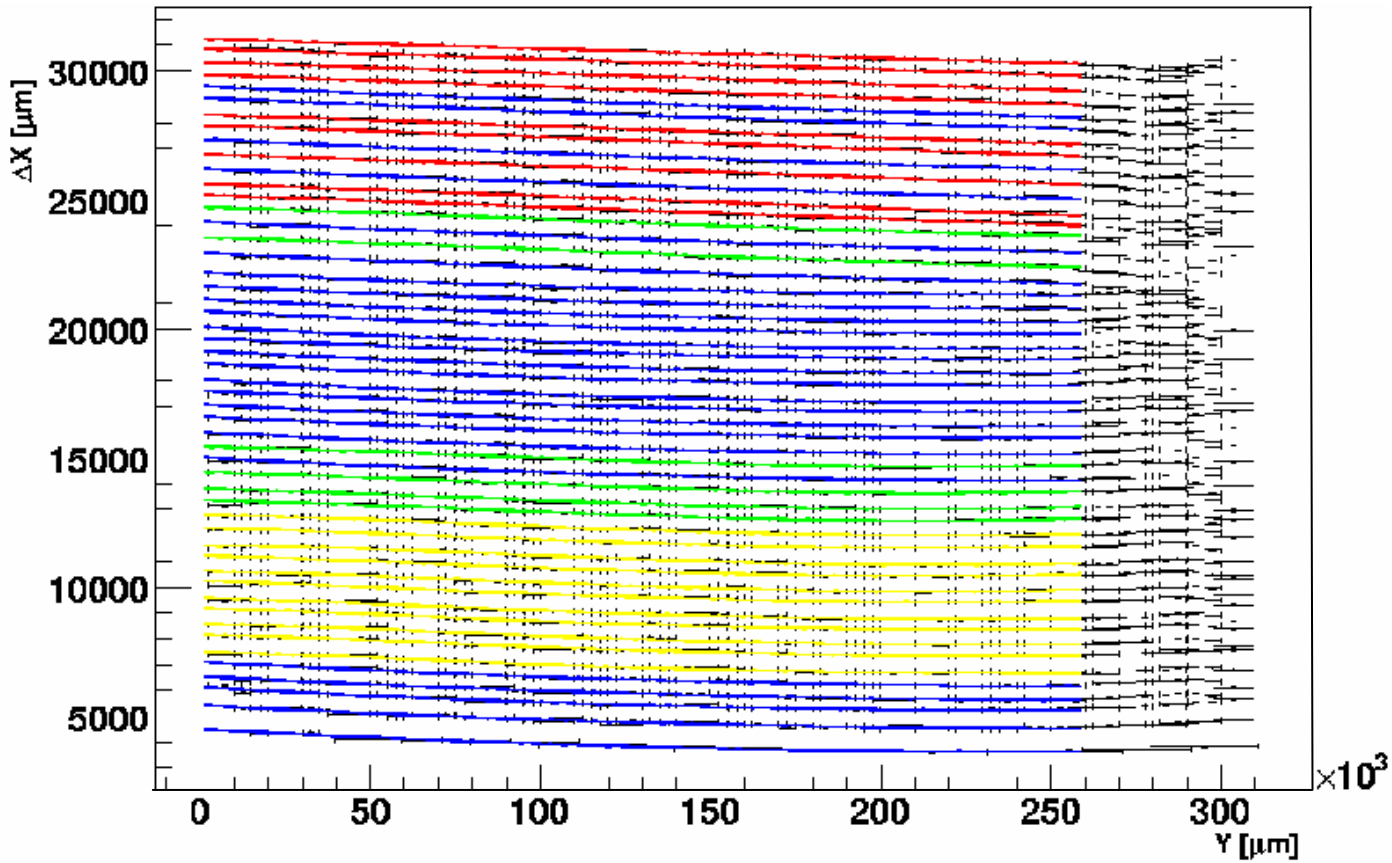


Recoil Detector



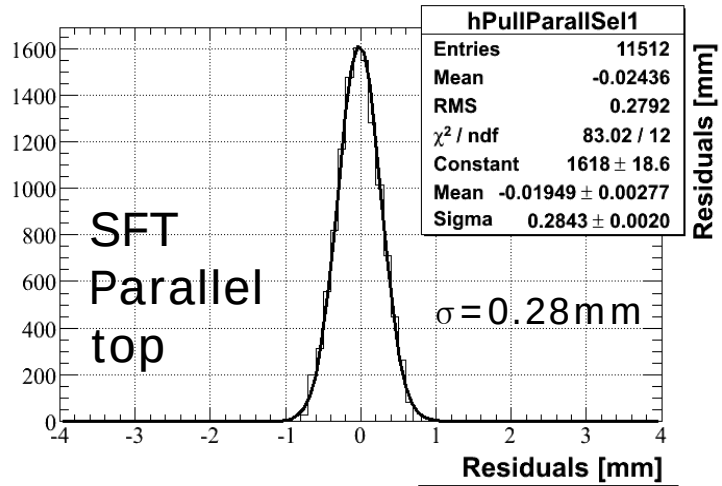
Recoil detector Alignment

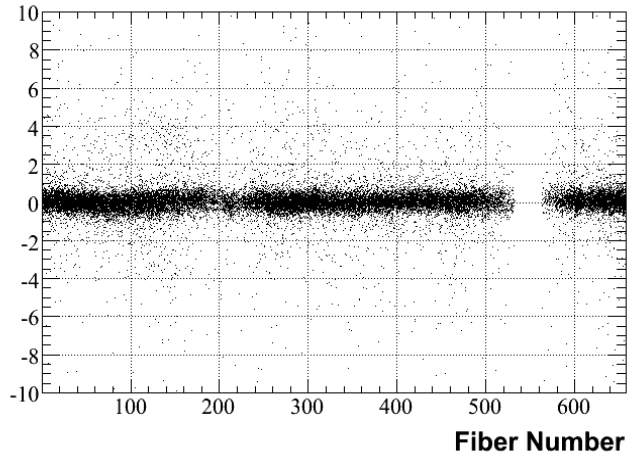
- 5 GeV electron test beam was used with Si Reference system
- X/Y reconstruction < 100μm
- Parameterizes fibers with polynoms O(4)

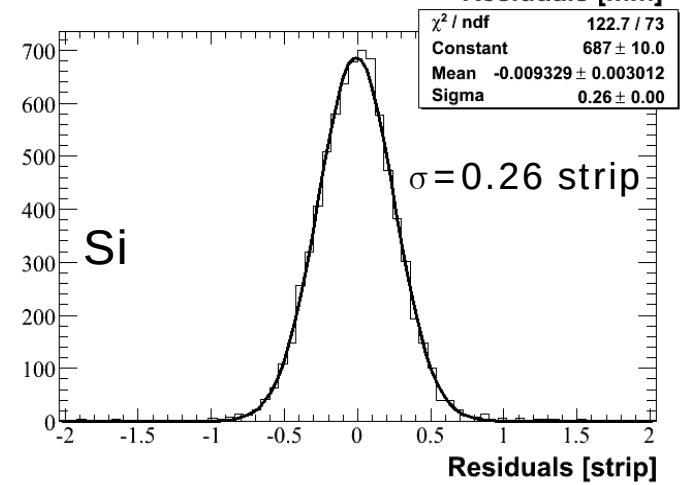


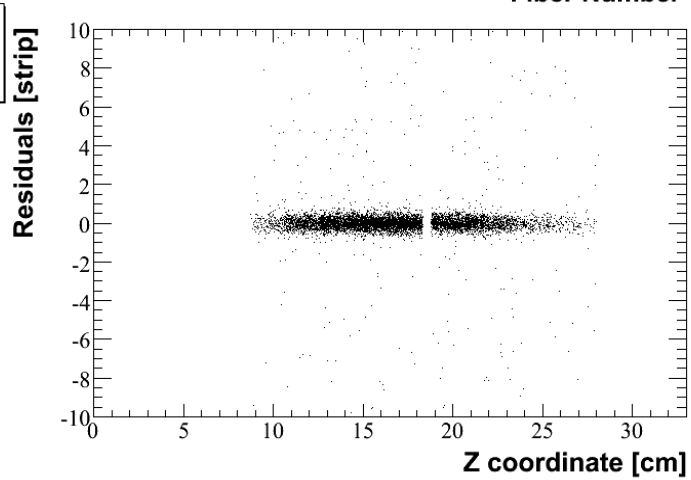
Recoil detector Alignment

- Six parameters (three translations and three rotations) which are common for all tracks are fitted
- Residuals and dependence of residuals on coordinates used as a tool to check alignment procedure





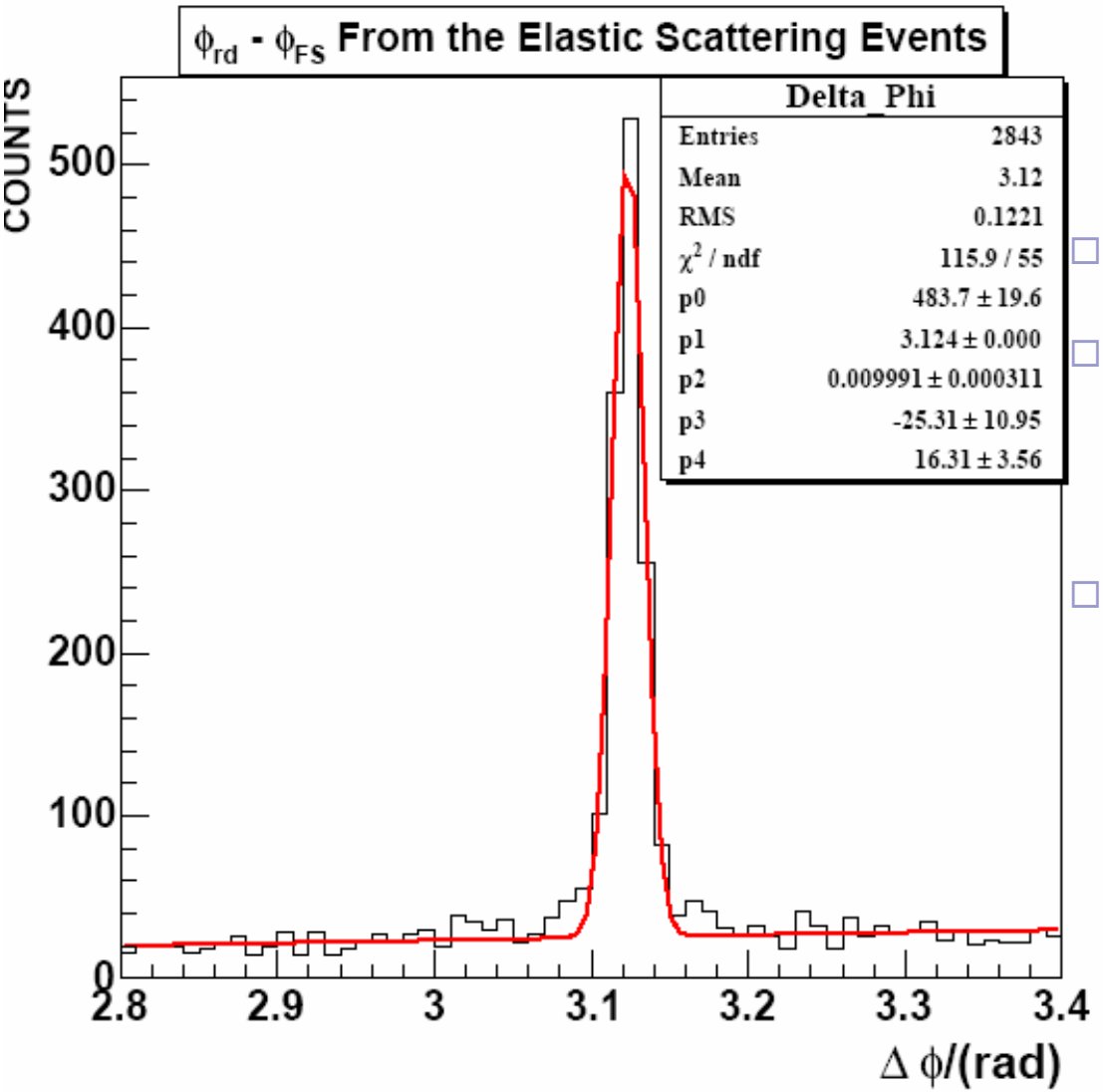




Si alignment respect SFT with tracks

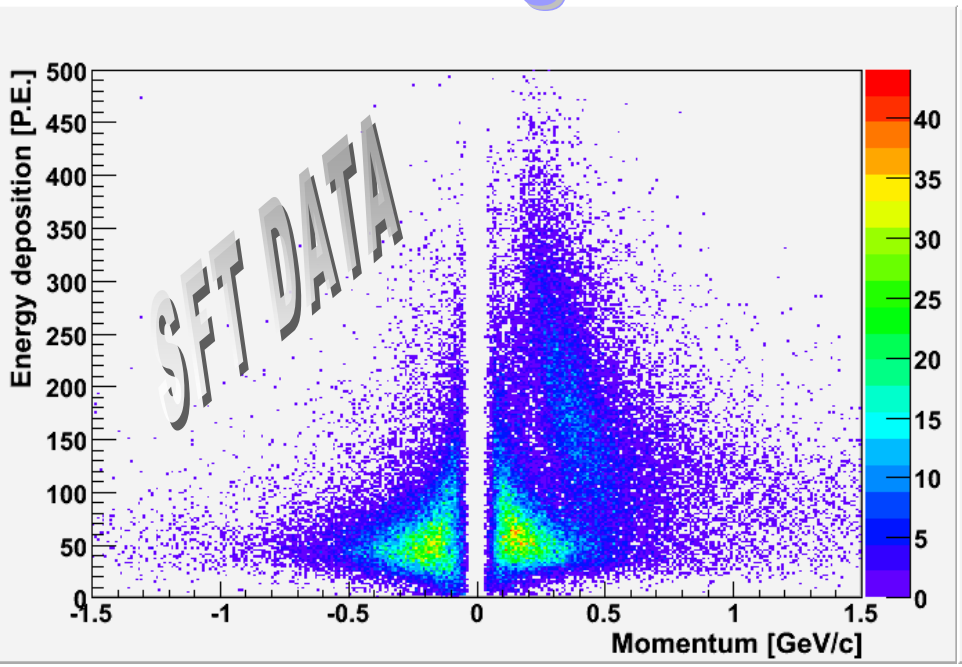
Next step is Recoil-Hermes alignment using e-p elastic

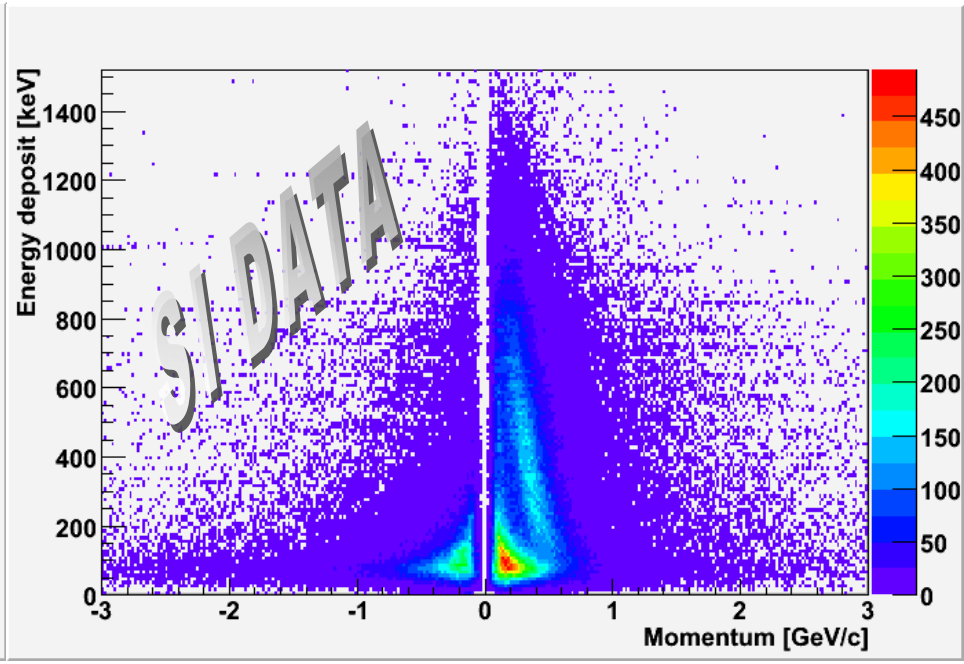
e – p elastic scattering



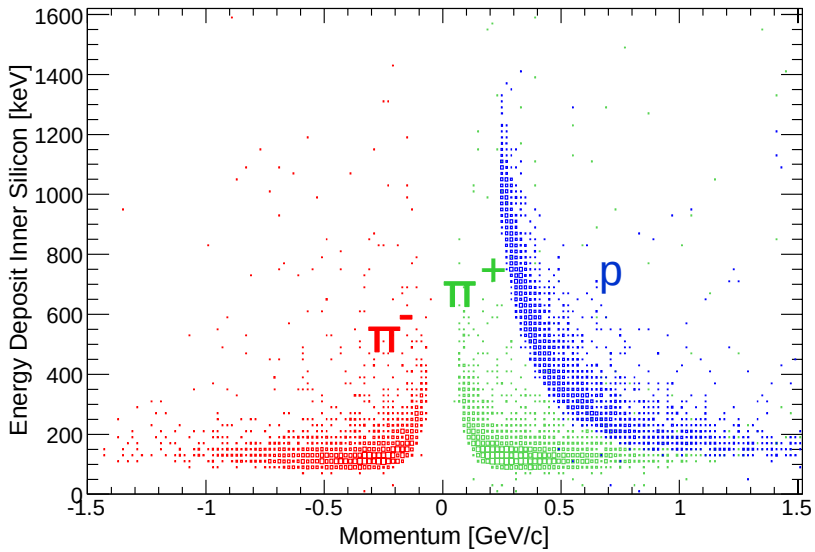
- We can observe clear correlation.
- Selection of single tracks protons by making cuts on the momentum of the lepton detected by the forward spectrometer.
- Only SFT tracking.

Tracking

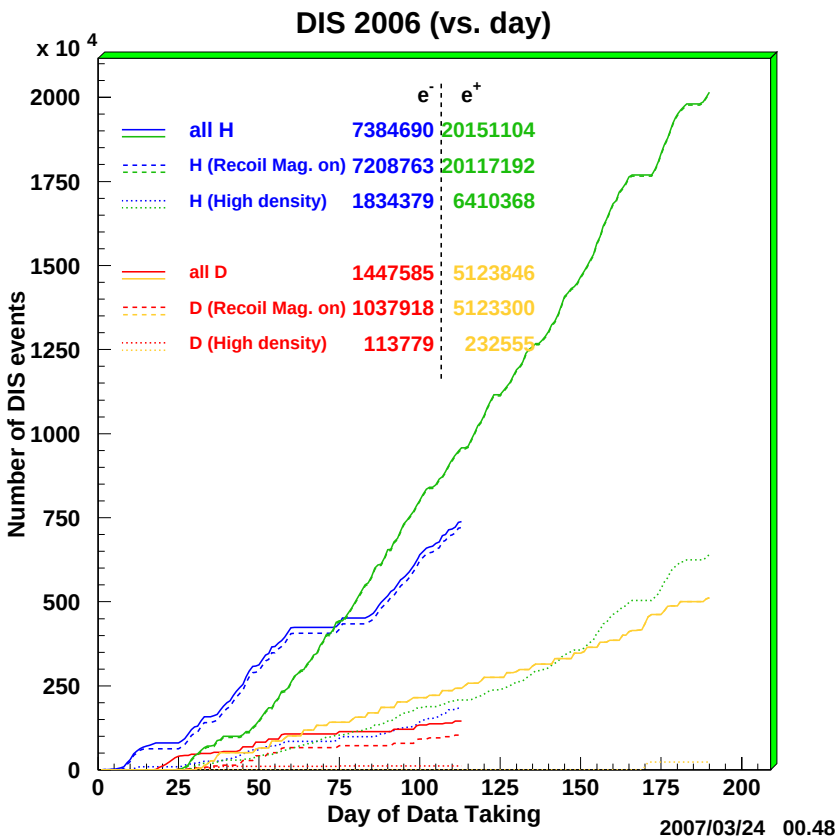


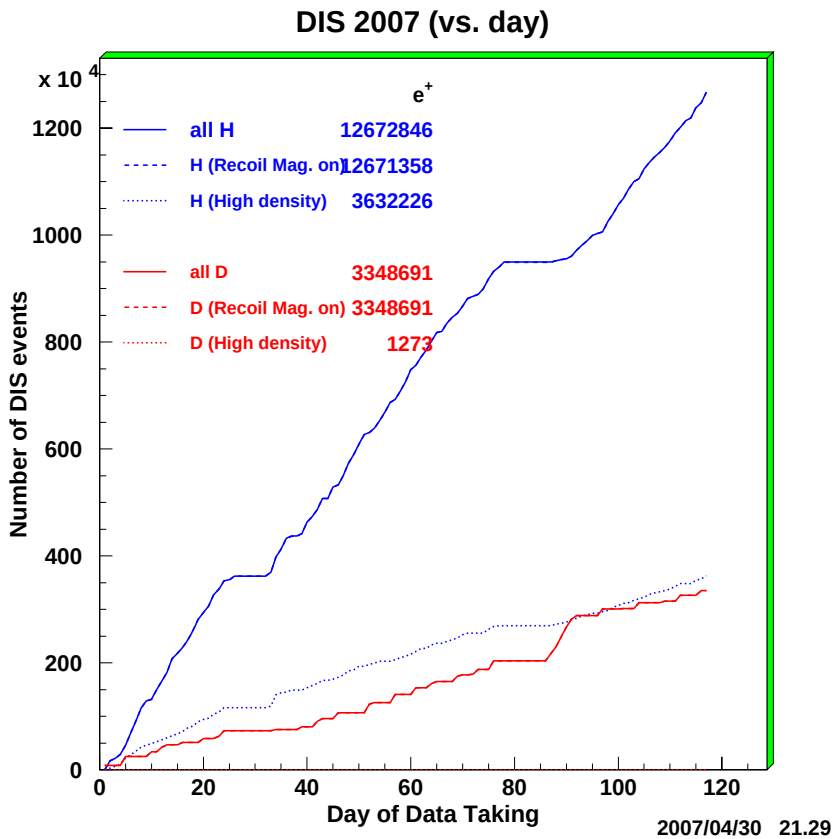


- Full tracking including alignment is in production
- Efficiency of the tracking algorithm studied on MC and found to be above 98%
- Starting to study the efficiencies, residuals and ghost tracks



Running





- 7M e- 2006
- 20M e+ 2006
- 13M e+ 2007
  - maybe 20M until July
- In total 47M DIS for the unpol. run

- SFT was working for large set of e- data
- Si working since September 2006

Conclusion

- Recoil Detector:
  - installed January 2006
  - Fully commissioned in September 2006 and taking data until the end of HERA – July 2007

- DVCS and other hard exclusive reactions can be precisely measured with the recoil detector