The HERMES Recoil Detector

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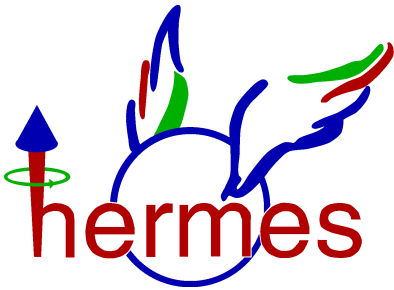
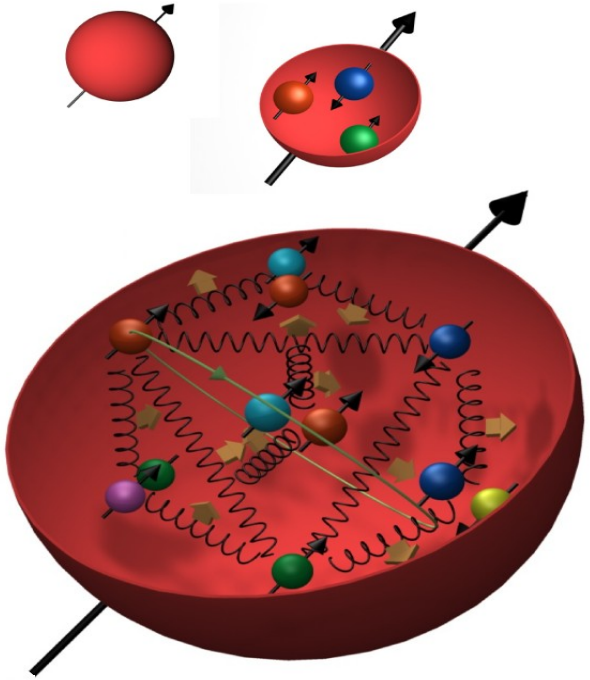
for the HERMES Collaboration

- Spin of the nucleon, GPDs and DVCS
- HERMES experiment
- Recoil Detector



bmb+f - Förderschwerpunkt
HERMES
Großgeräte der physikalischen Grundlagenforschung

Nucleon Spin and GPDs



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

J_q J_g

$\Delta\Sigma \approx 0.33$ **HERMES :** Phys. Rev. **D75**(2007)

ΔG First measurements ---- small

L_q, L_g Accessible through

Generalized Parton Distributions (GPDs)

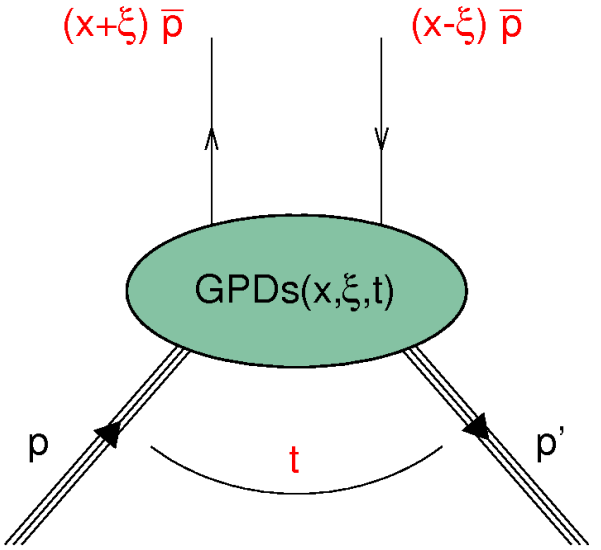
Ji Sum Rule :

$$J_{q,g} = \lim_{t\to 0} \int_{-1}^{1} dx\, x \{ \overbrace{H_{q,g}(x,\xi,t) + E_{q,g}(x,\xi,t)}^{\text{GPDs}} \}$$

$x \pm \xi$ -> momentum fraction of struct quark

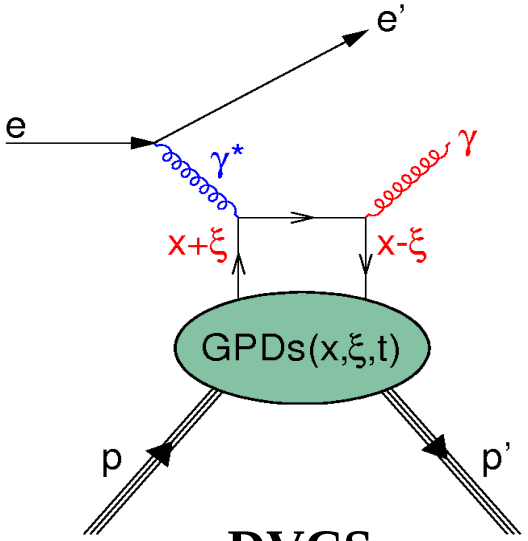
ξ -> fraction of the momentum transfer

t -> momentum transfer to the target

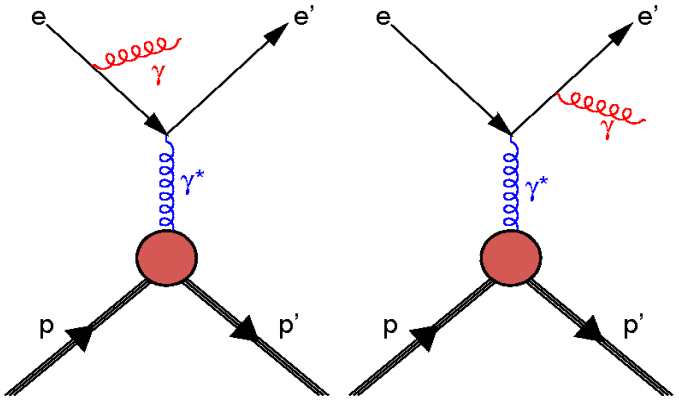


Deeply Virtual Compton Scattering (DVCS)

DVCS : simplest/cleanest Hard Exclusive Process to access GPDs



DVCS



Bethe-Heitler

$$d\sigma(eN \to eN\gamma) \propto |T_{BH}|^2 + |T_{DVCS}|^2 + T_{BH}T^{*}_{DVCS} + T^{*}_{BH}T_{DVCS}$$

Interference term

- The same final state in DVCS and Bethe-Heitler
- BH dominates at HERMES kinematics
- GPDs accessed by measuring the azimuthal asymmetries via the Interference term

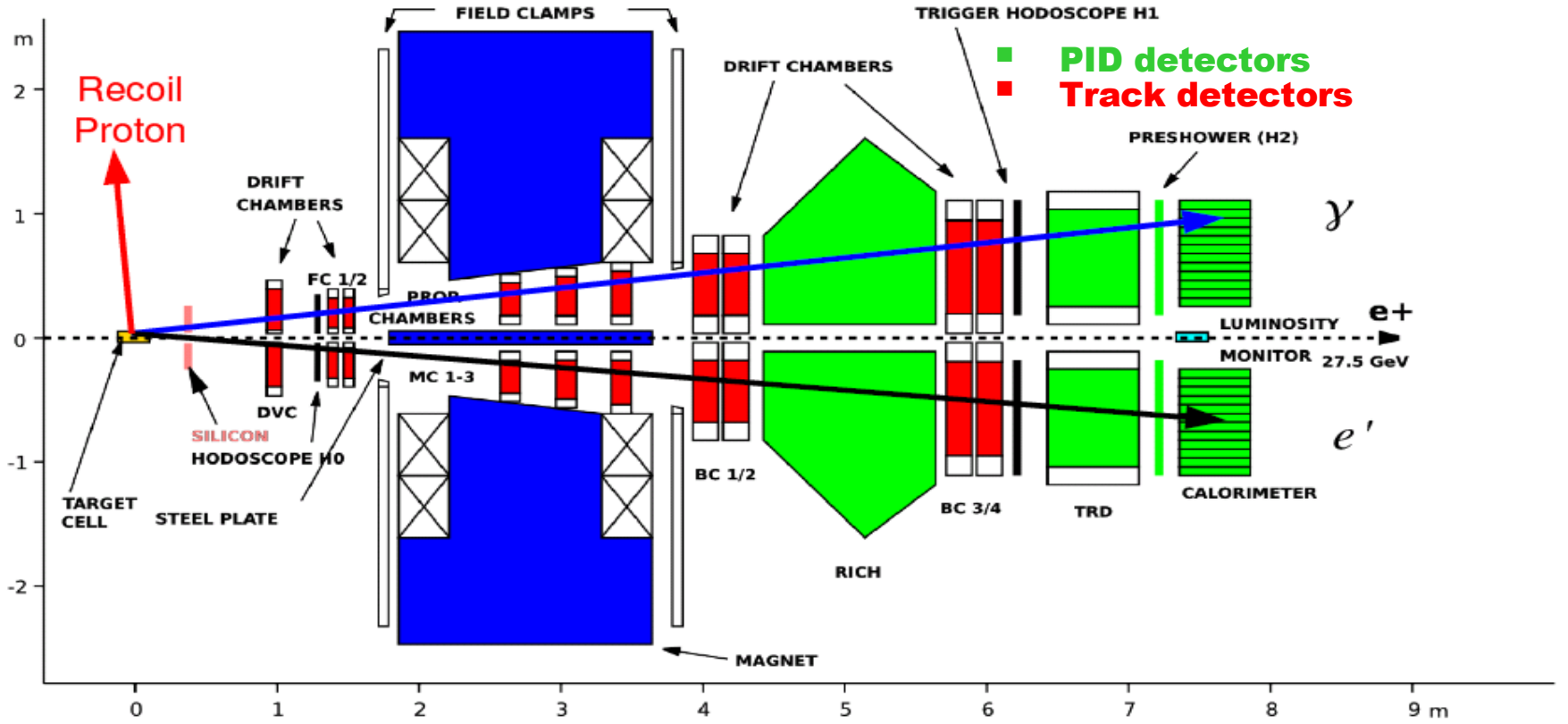
(See talk from C.Riedl T27.3)

HERMES Experiment

- HERMES is a fixed target experiment in HERA

  Longitudinally polarized HERA 27.6 GeV lepton beam

  A forward spectrometer to detect the particles

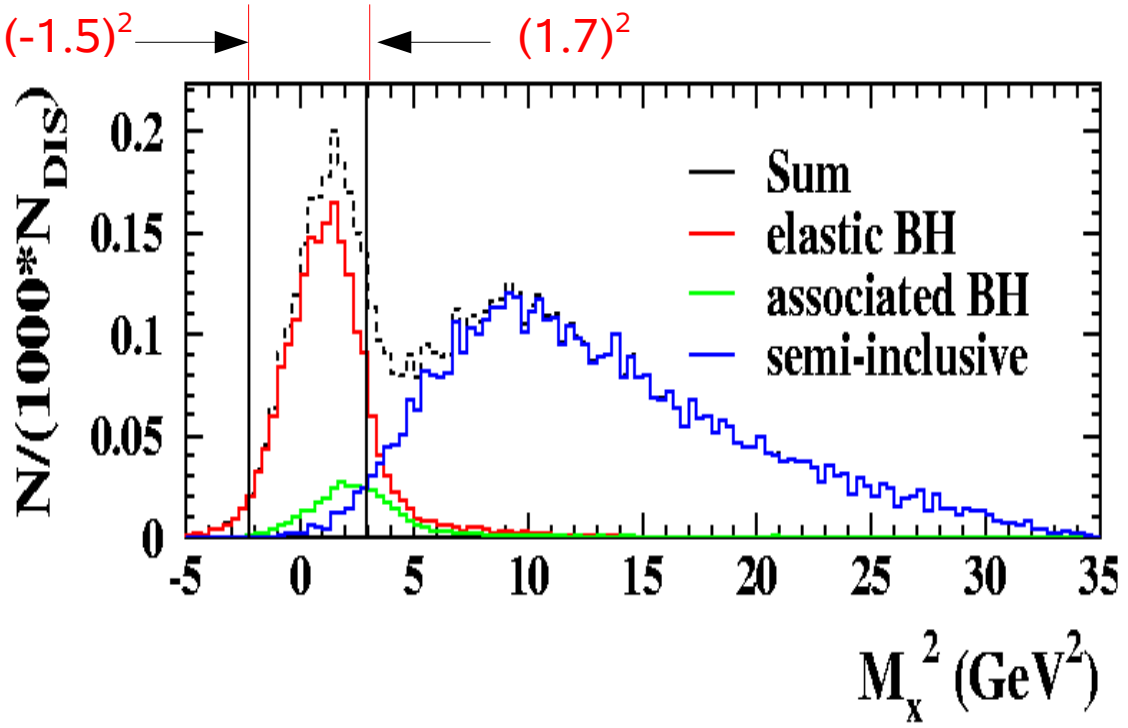


DVCS @ HERMES Before Recoil

- By detecting one lepton and one photon in the calorimeter
- Recoiling protons were not detected

  => maintain exclusivity through missing mass

$$M_x^2 = (P_e + P_P - (P_{e'} + P_\gamma))^2$$



$e\,p \rightarrow e'\,p'\,\gamma$

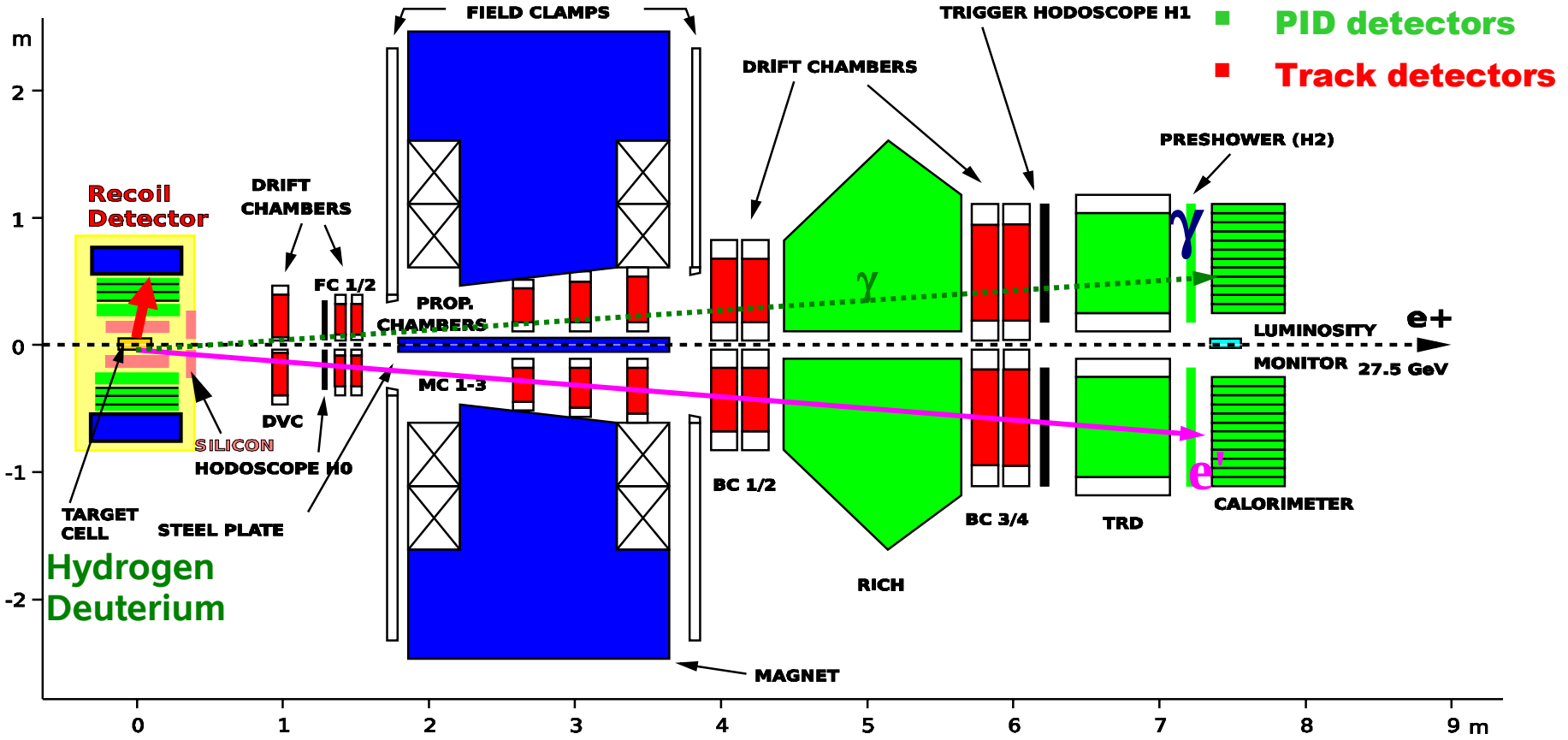
$e\,p \rightarrow e'\,\Delta^+\,\gamma$

$e\,p \rightarrow e'\,\pi^0\,X$

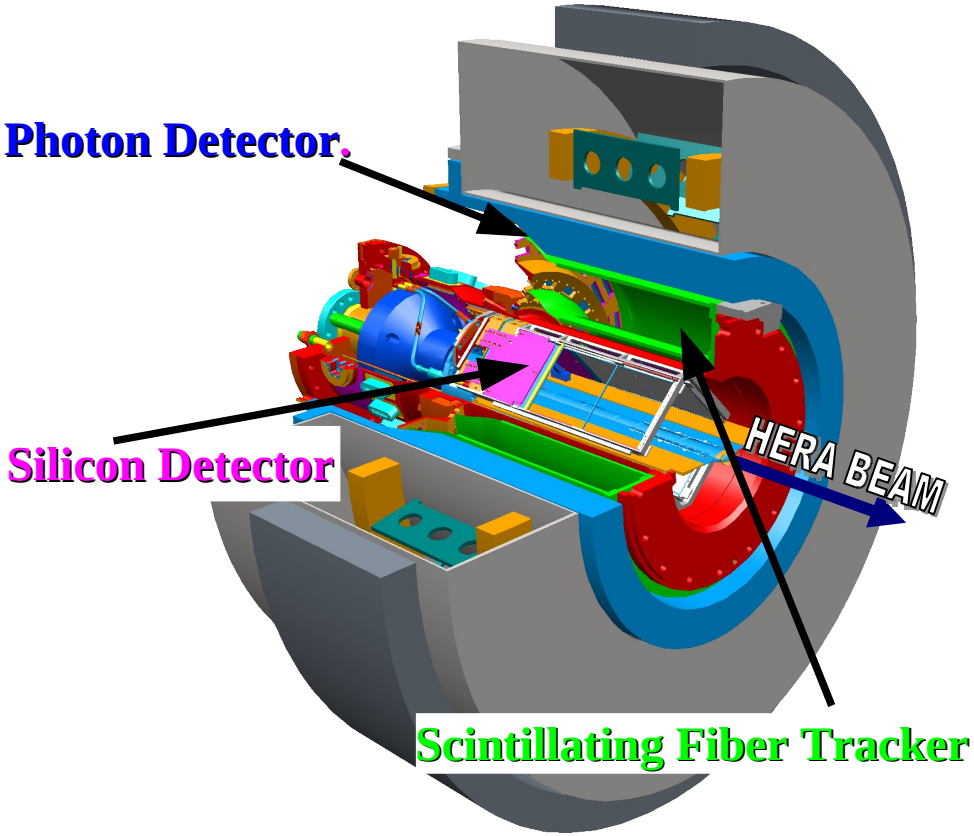
~15% overall background and limited by spectrometer resolution.

The Recoil Detector

- A Recoil Detector installed to identify the recoiling protons
- Dedicated high luminosity run in 2006~2007 with unpolarized hydrogen and deuterium target.

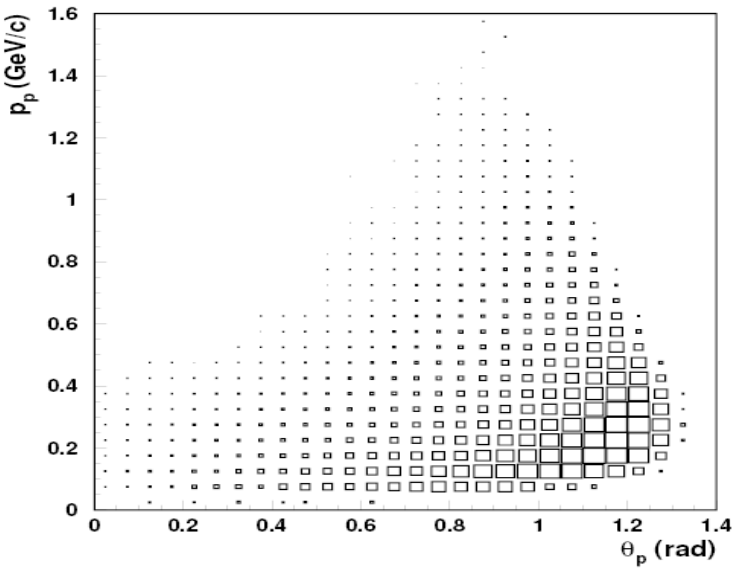


The Recoil Detector

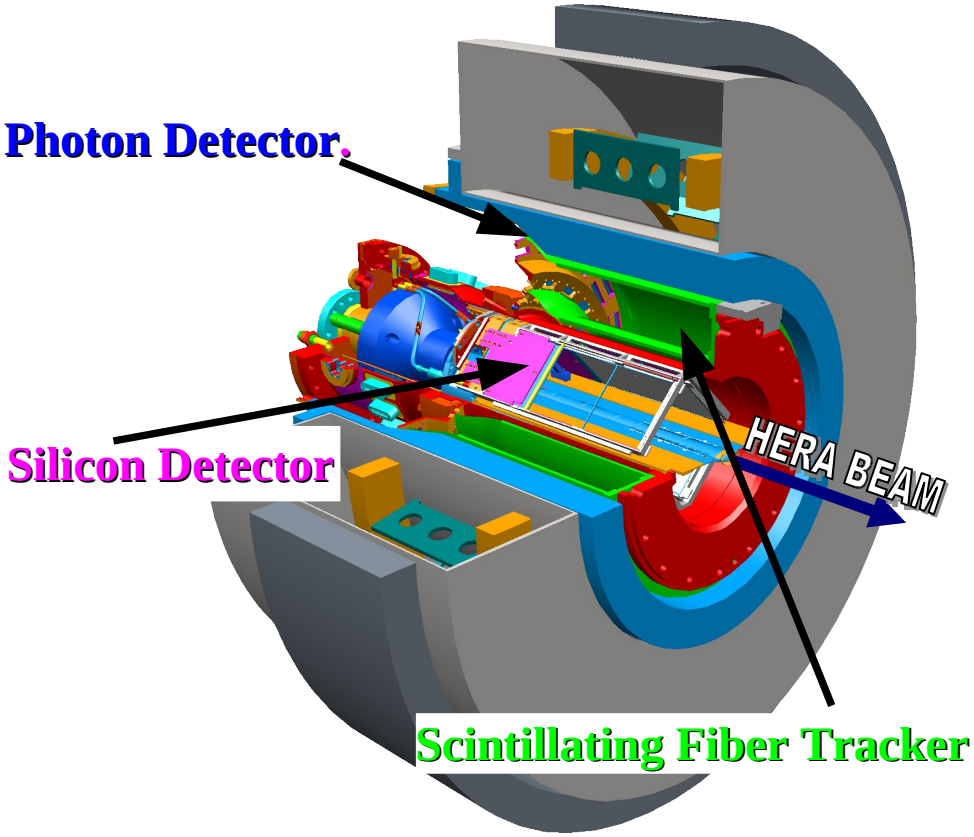


1 tesla magnetic field

- Consists of silicon detector, scintillating fiber tracker and photon detector
- Detection of recoiling proton
  - p-measurement 135-1400 MeV/c
  - 76% ϕ acceptance
  - π/P PID via dE/dx



The Recoil Detector



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- Detection of recoiling proton
  - p-measurement 135-1400 MeV/c
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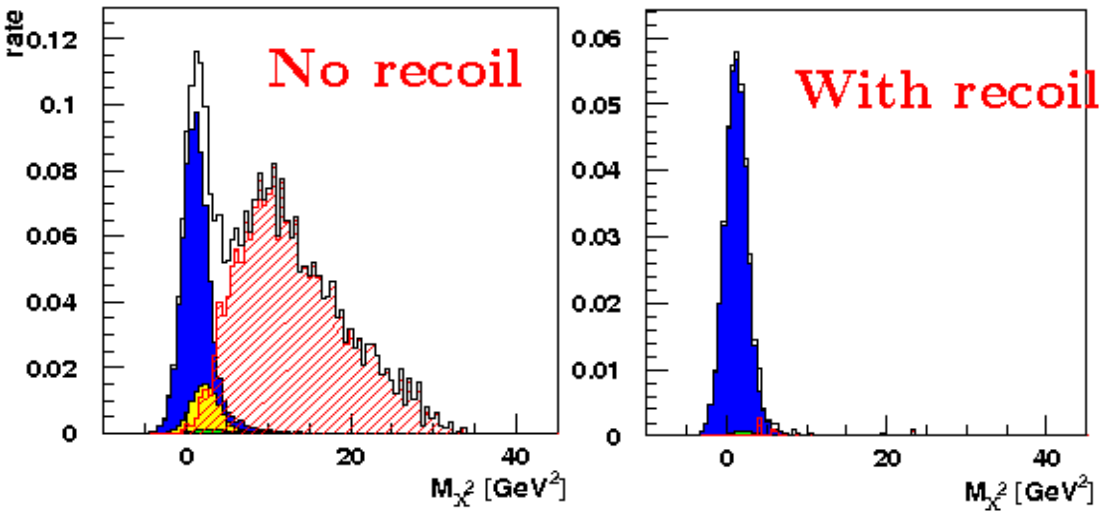
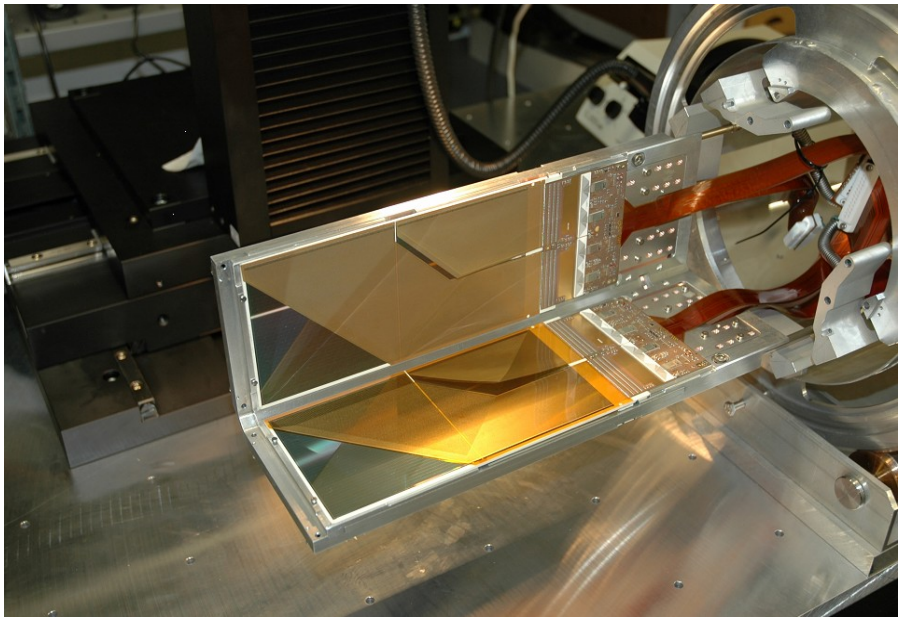
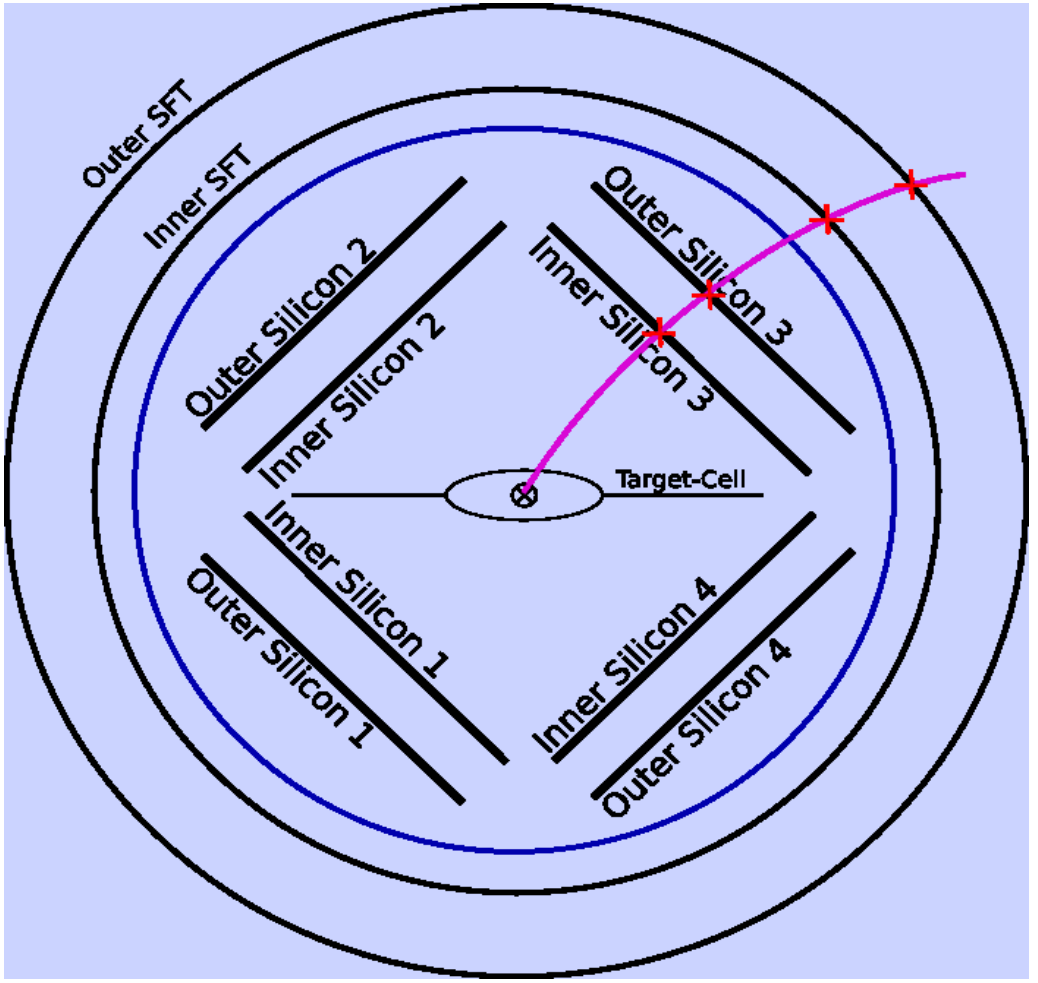
- Improvement of t-resolution
  - study kinematical dependence
- Backgroud suppression
  - semi-incl. : 5% -> <<1%
  - associated : 11% -> ~1%



Silicon Strip Detector (SSD)

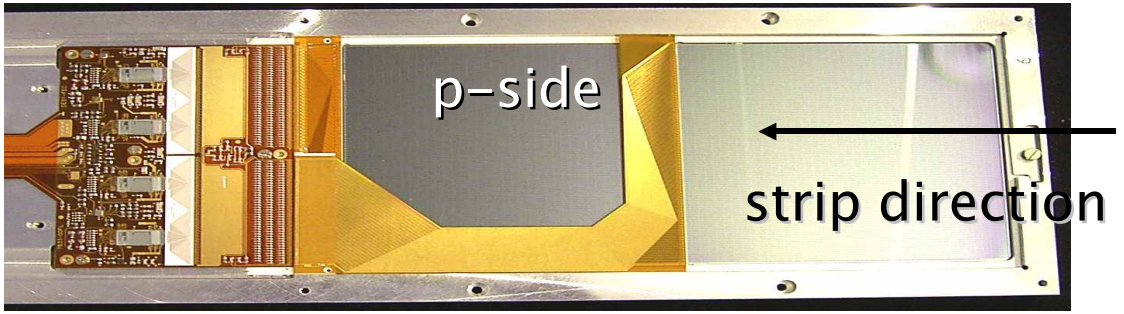
- 16 double sided sensors inside beam vacuum around the beam
- 2 layers of sensors, each sensor has the area of 97mmx97mm, thickness =300um

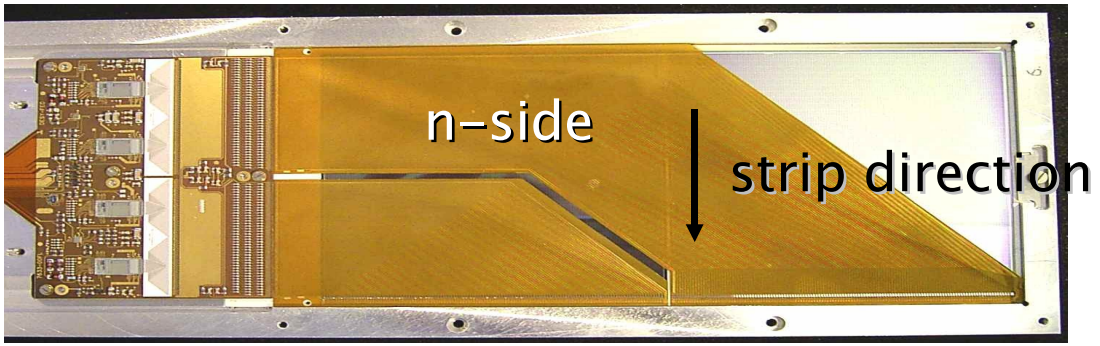


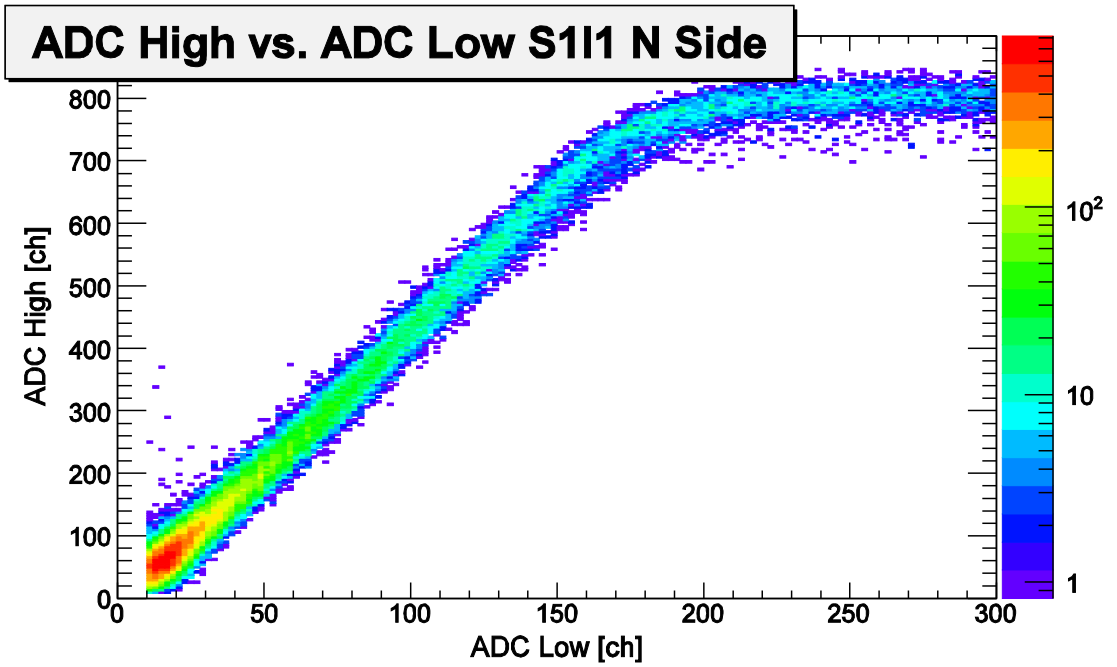


Silicon Strip Detector (SSD)

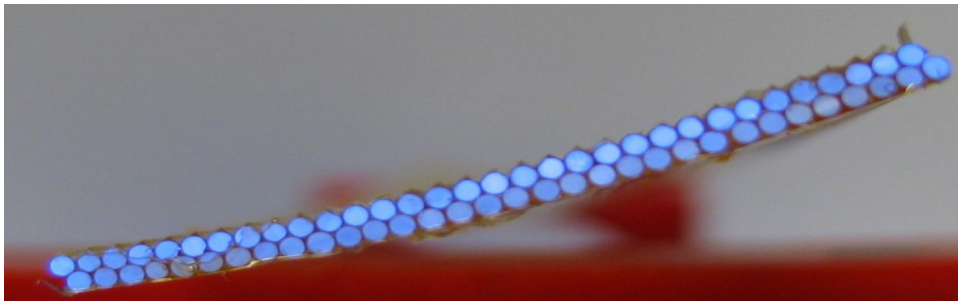
- 16 double sided sensors inside beam vacuum around the beam
- 2 layers of sensors, each sensor has the area of 97mmx97mm, thickness =300um
- 128 strips per side, perpendicular to each other and pitch=758um
- The high and low gains to expand dynamic range
- Helix 3.0 readout

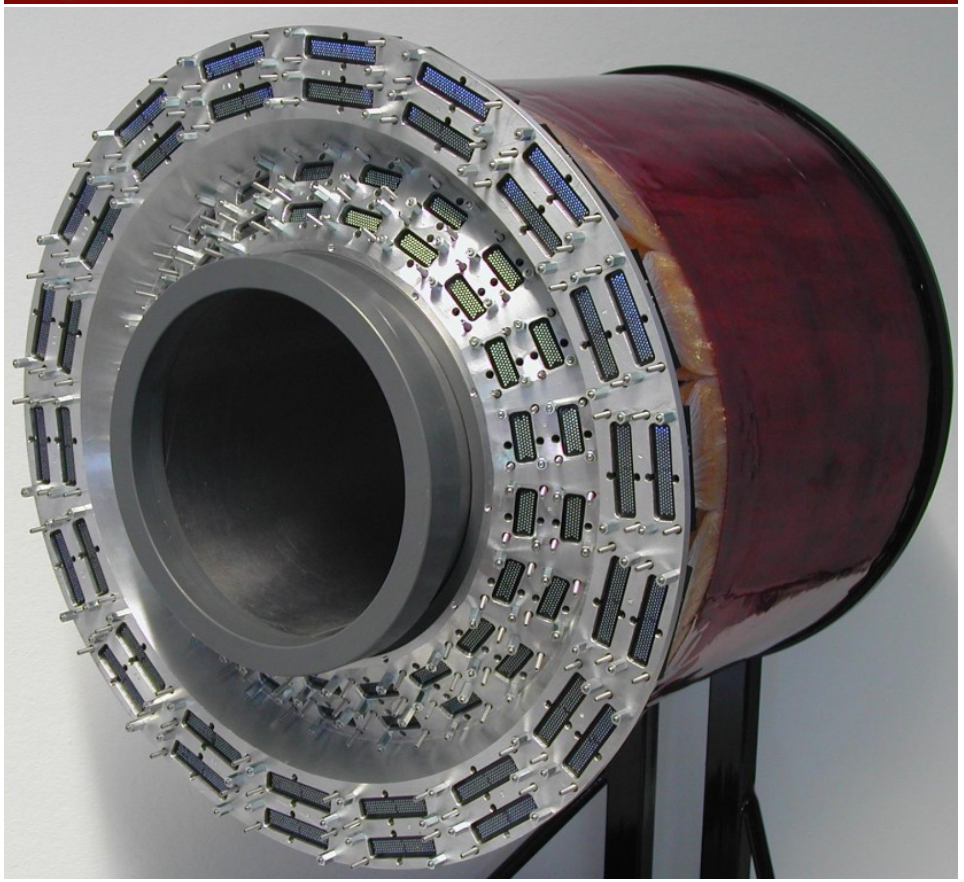






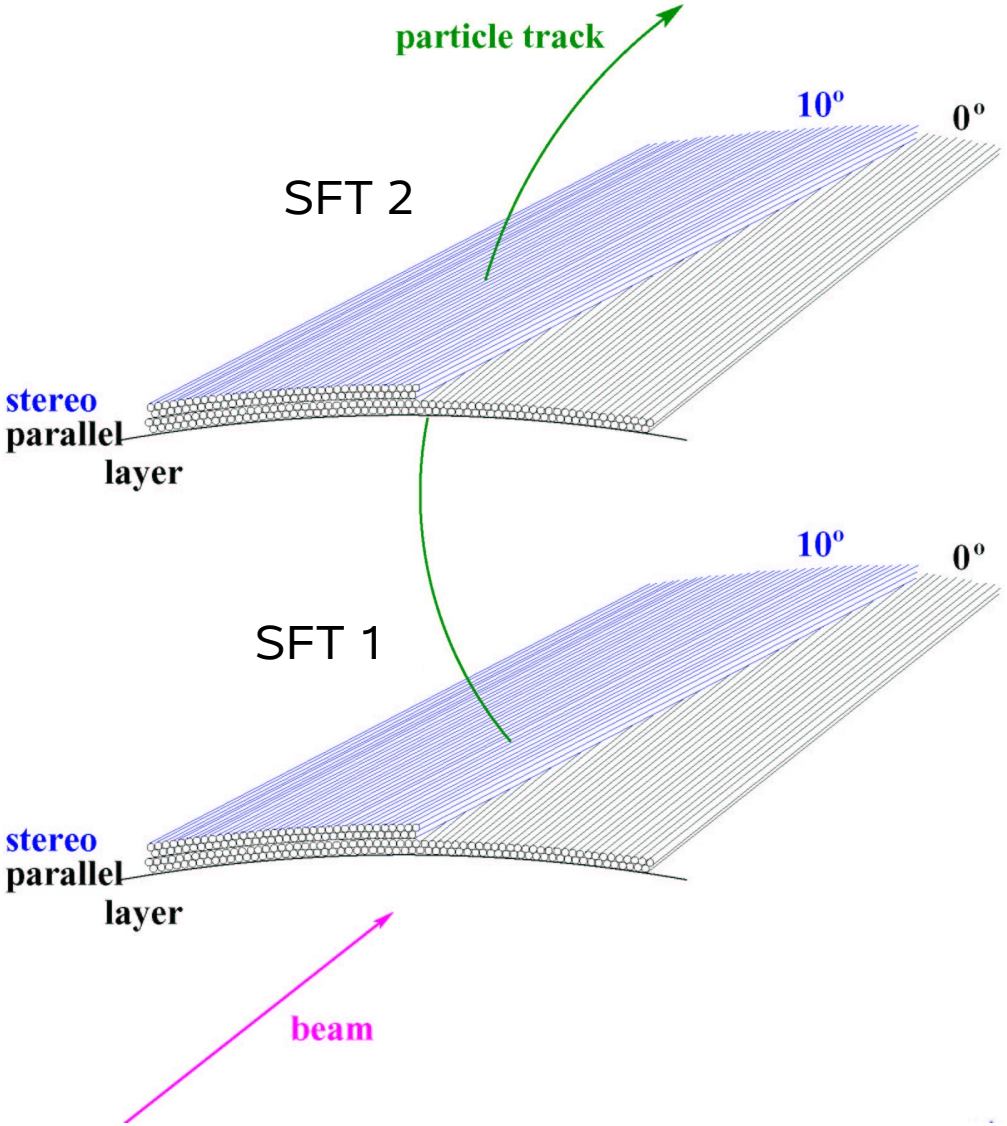
Scintillating Fiber Tracker (SFT)





- 2 cylinders of 2 X 2 layers, 10^0 stereo angle
- 1 mm Kuraray fibers, mirrored ends
- 6910 fibers mapped on 4882 readout channels
- Kuraray lightguides, 64 channels Hamamatsu PMTs
- Readout by GASSIPLEX chips
- Signal from last dynode channel used for timing

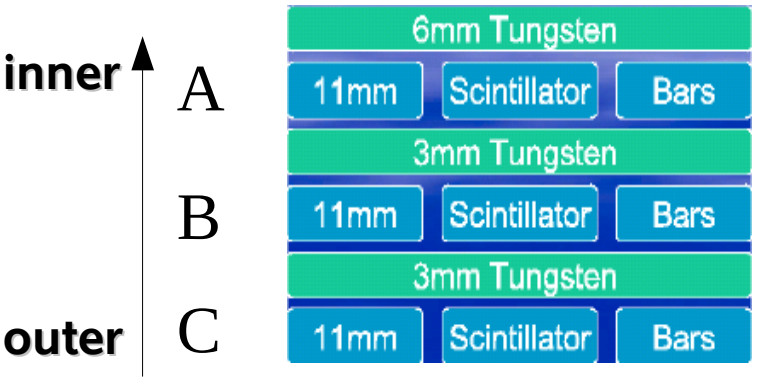
Scintillating Fiber Tracker (SFT)



- Momentum reconstructed by the bending of the charge particles inside 1 Tesla magnetic field
- The range of momentum measurement 250-1400 MeV/c
- PID from dE/dx
  $250 < p < 650$ MeV/c
- ϕ resolution 8mrad

Photon Detector (PD)

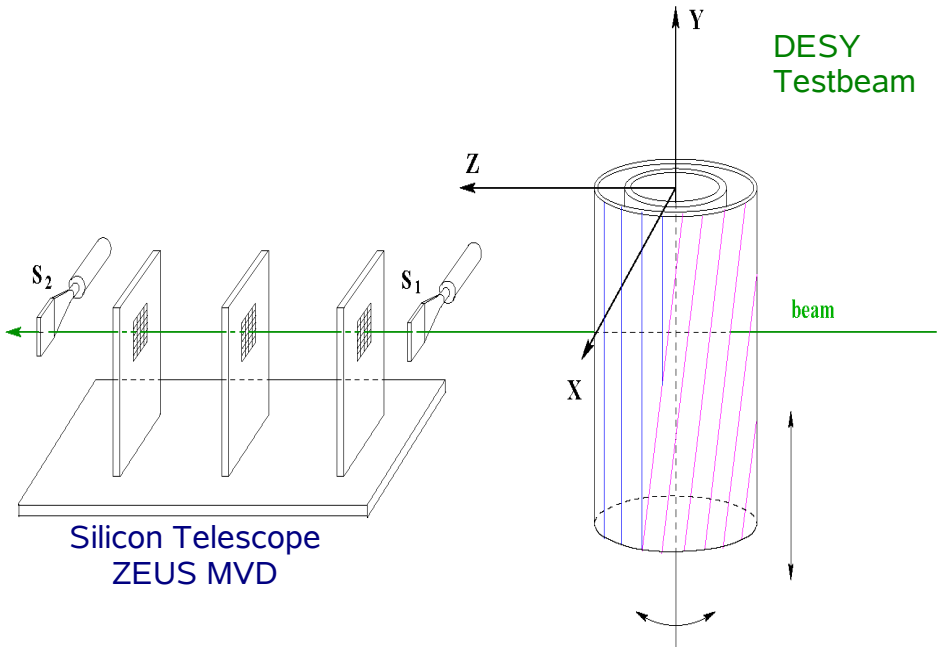
- 3 layers of Tungsten/Scintillator
  A layer parallel to beam line, B and C stereo layers under +44.5º/ -46.5º
- Same PMTs as SFT
- Main purpose :
  1 γ from π^0 decay
  Reconstruct π^0 if 2 γ's are detecteted

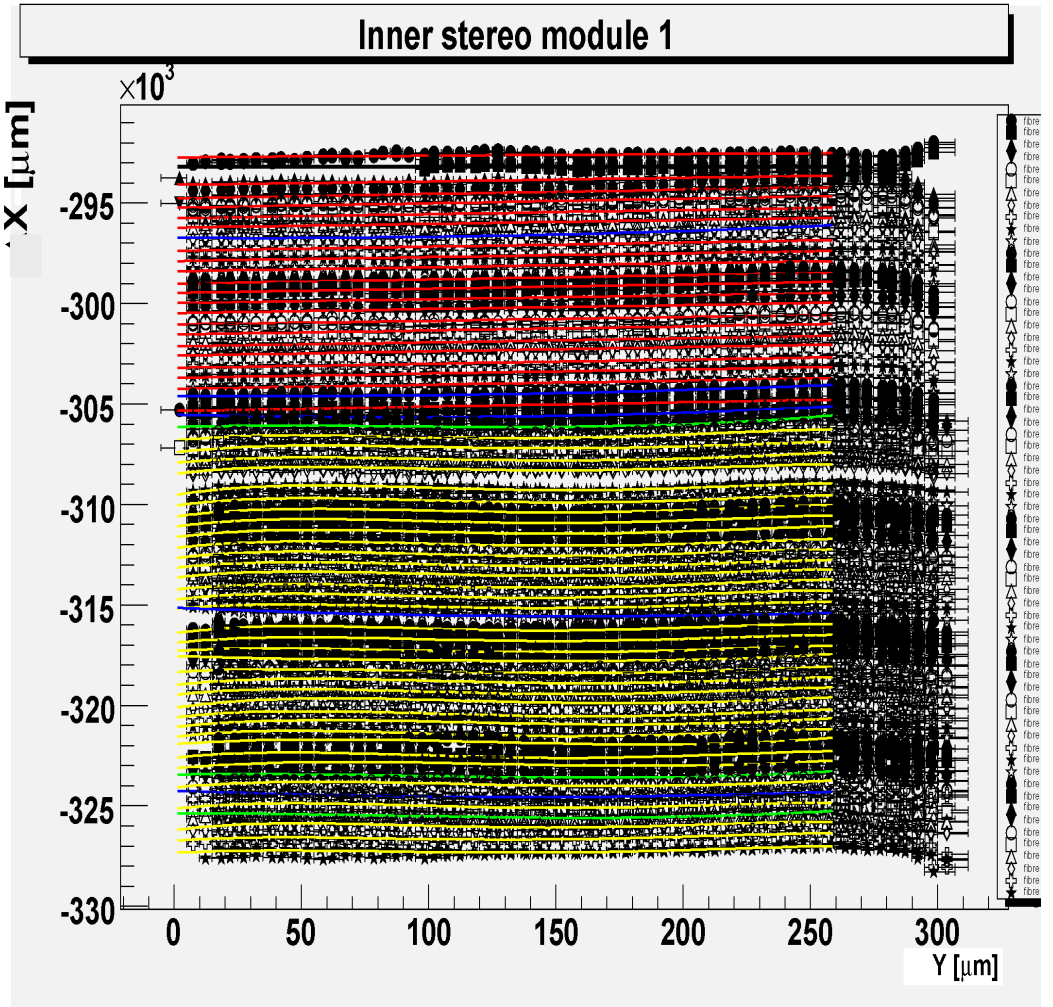


Recoil Detector Alignment

- Fiber positions measured in testbeam

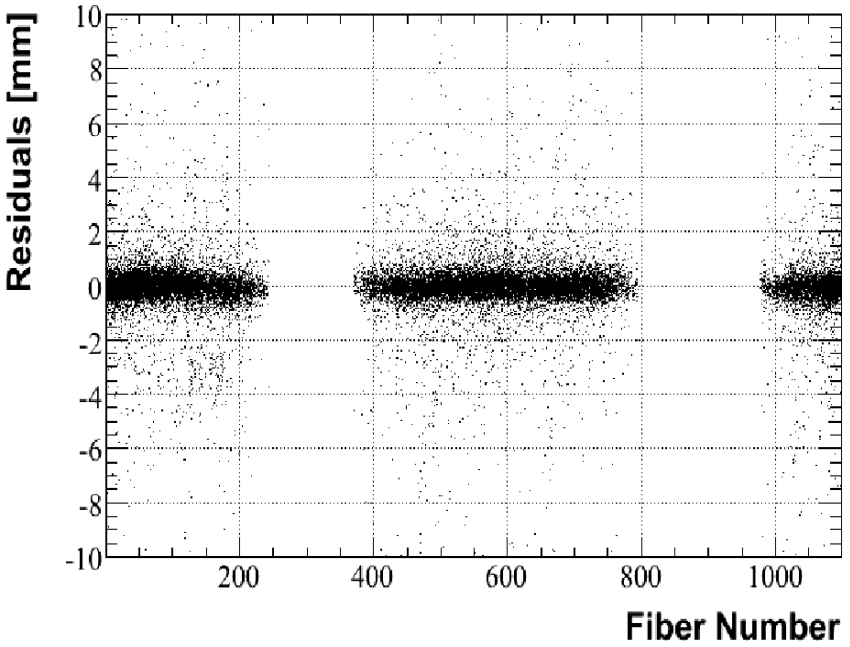
  Fit with variable order polynomial (color).

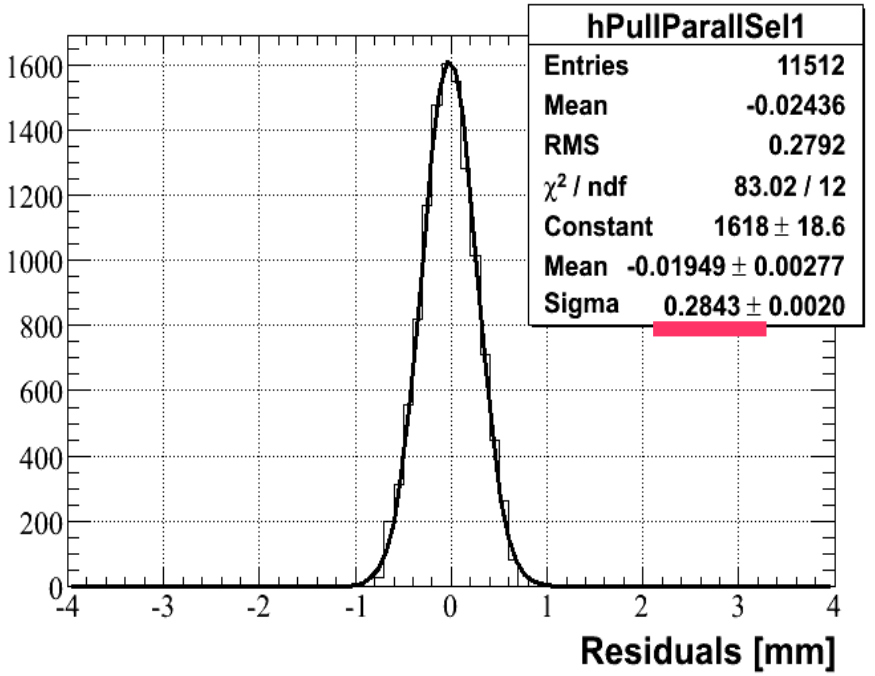




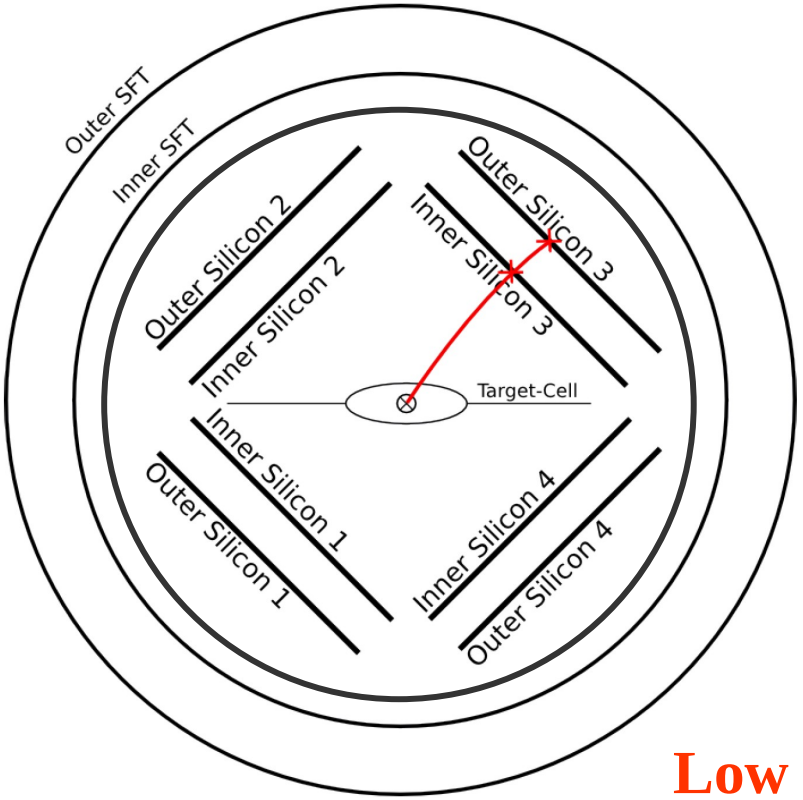
Recoil Detector Alignment

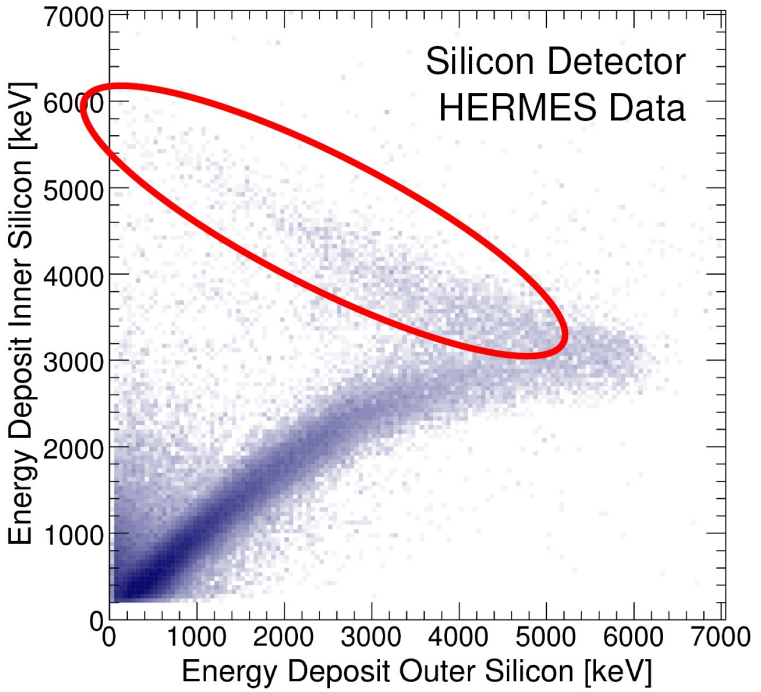
- Fiber positions measured in testbeam
- Alignment optimized by using cosmic rays
- SSD and PD aligned with respect to SFT
- Recoil-Hermes Forward Spectrometer will be aligned by e-p elastic scattering process





Momentum Reconstruction

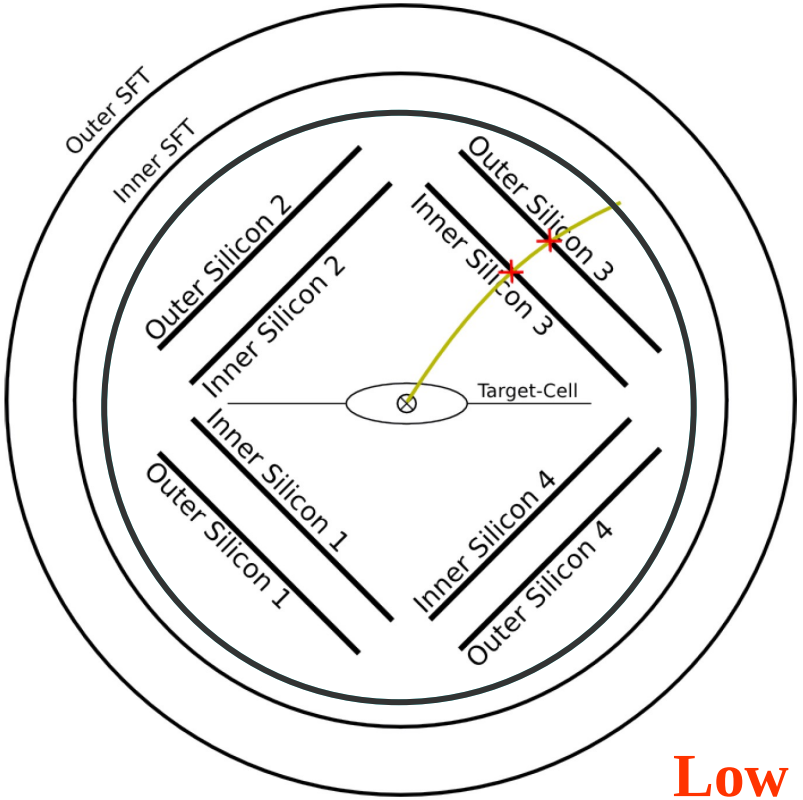


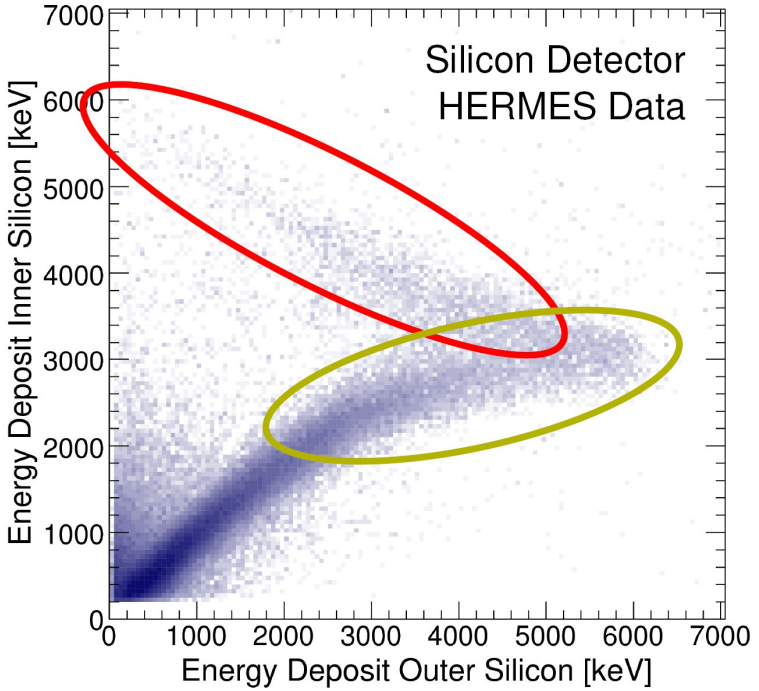


Low momentum protons (stopped in outer Silicon);

--> Sum of energy deposits

Momentum Reconstruction





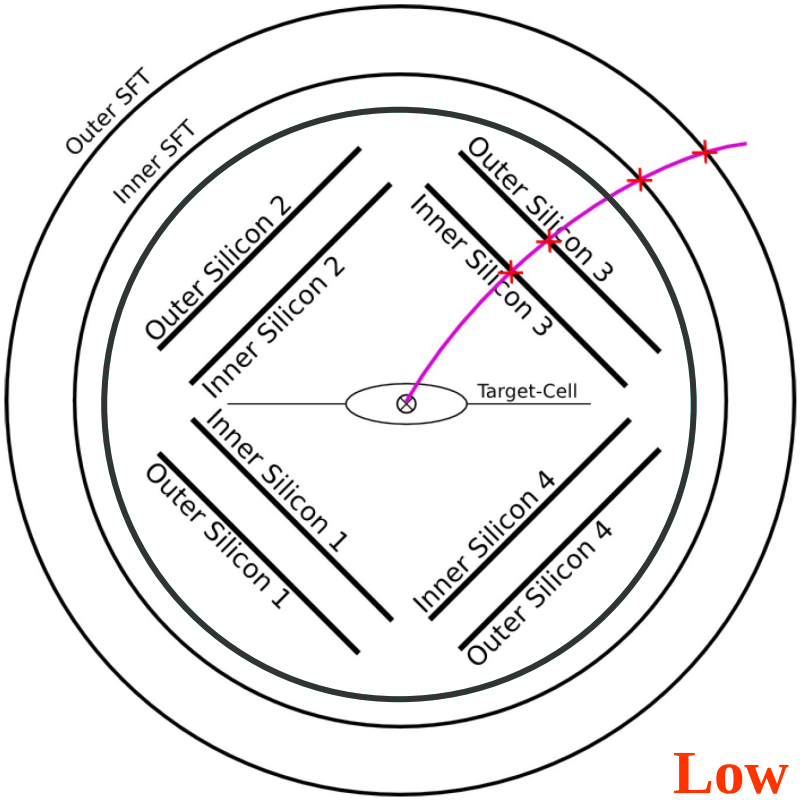
Low momentum protons (stopped in outer Silicon);

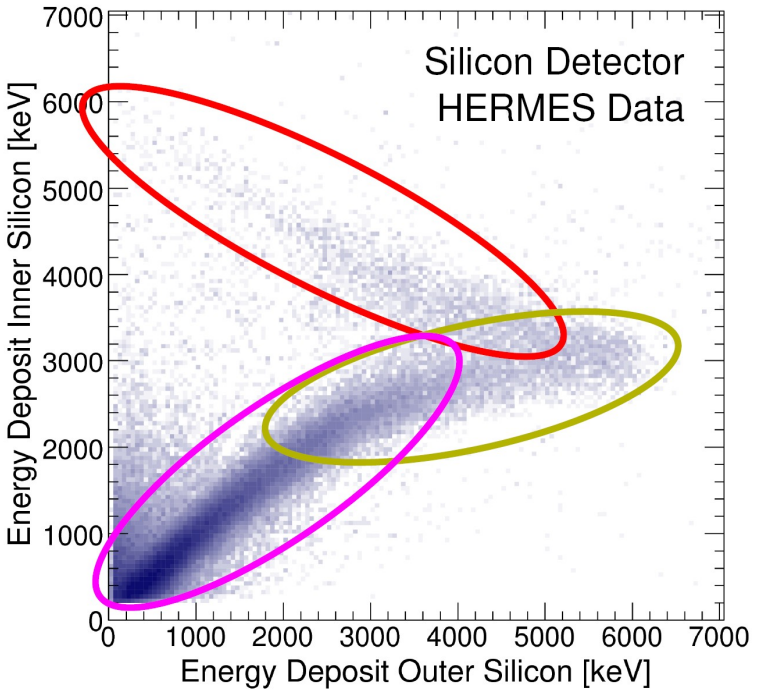
--> Sum of energy deposits

Higher momentum protons;

--> dE/dx (Bethe-Bloch)

Momentum Reconstruction





Low momentum protons (stopped in outer Silicon);

--> Sum of energy deposits

Higher momentum protons;

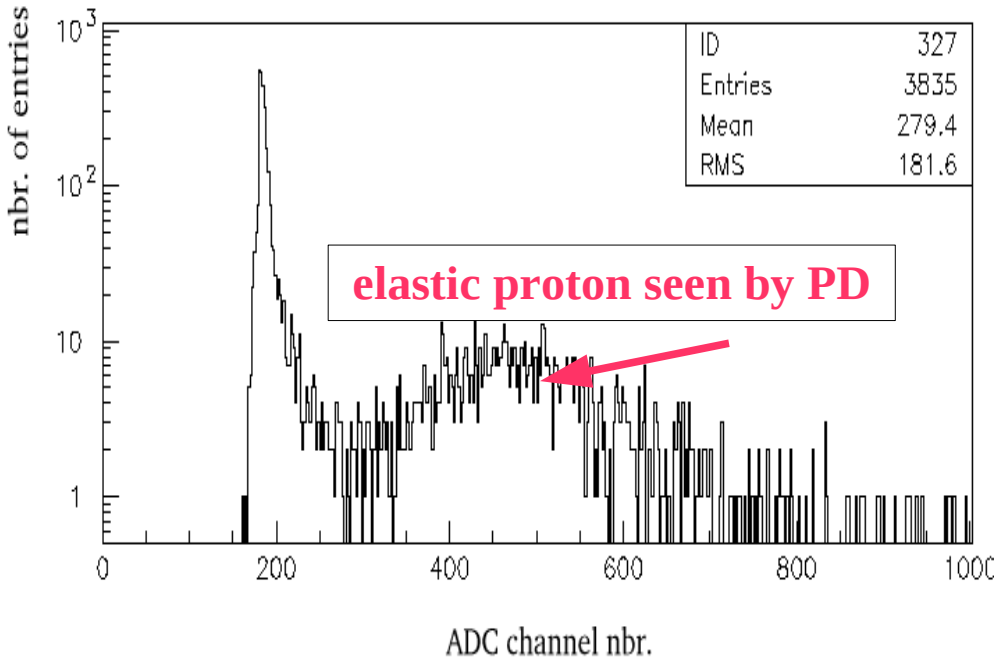
--> dE/dx (Bethe-Bloch)

High momentum particles;

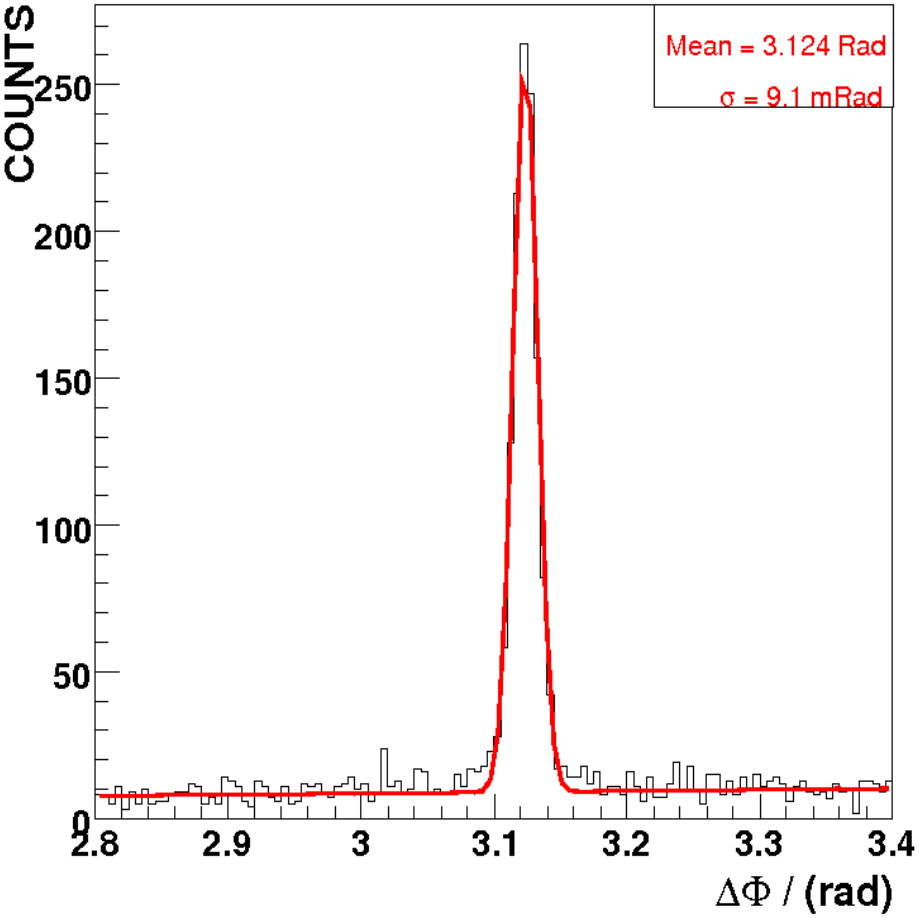
--> Bending in magnetic field

E-P Elastic Scattering

- The first time to see the ep elastic scattering in HERMES
- Clear correlation seen both in PD and SFT
- It maybe used for the Alignment

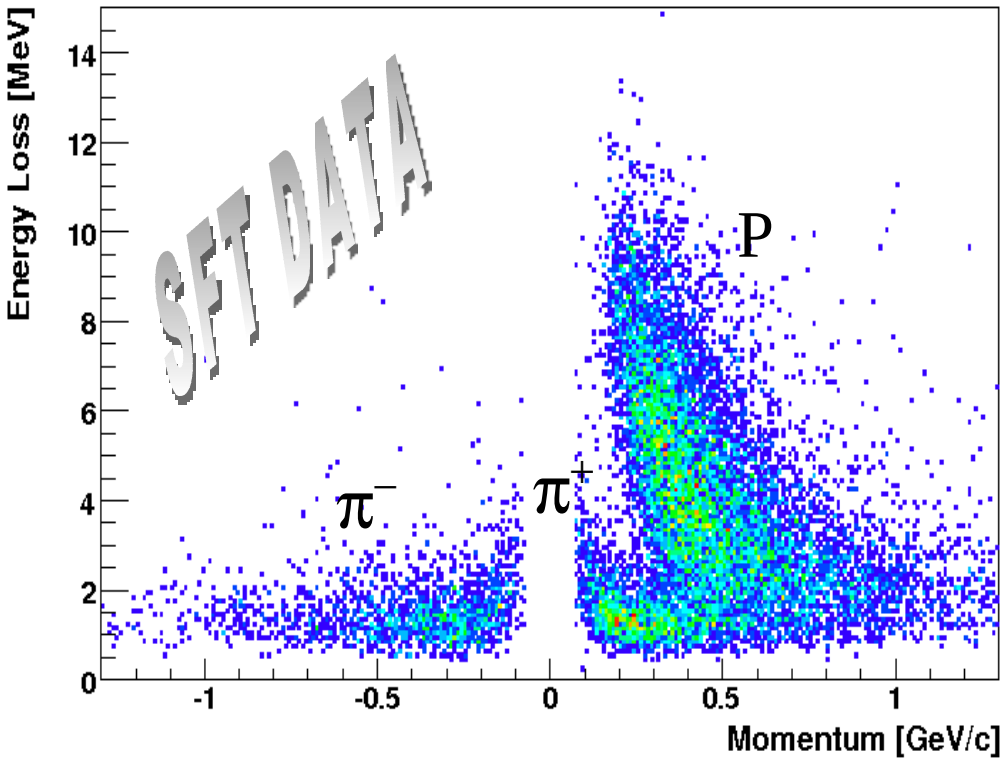


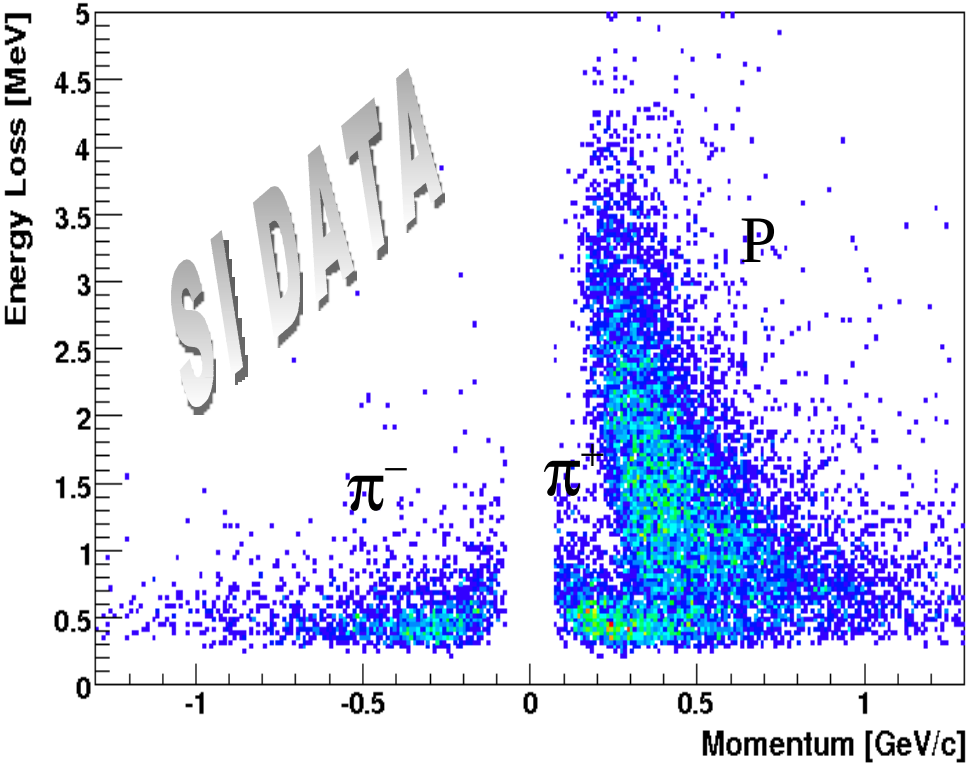
Difference in the ϕ angle of the elastic protons measured from forward spectrometer and SFT



Present Status of Particle Identification

- Energy deposits in SSD and SFT allow proton / π separation (will be refined)
- Energy signal from MIPs (pions) used for calibration of all the 3 sub-detectors



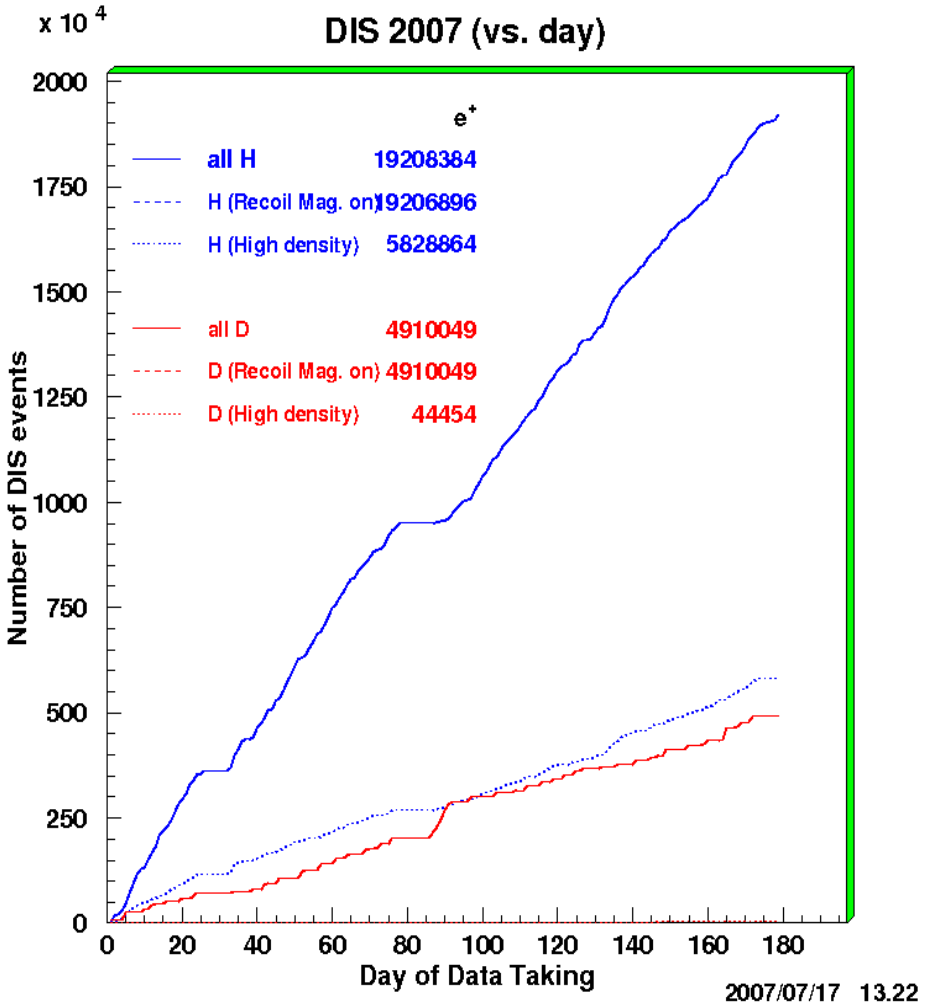


Data Taking

- The recoil detector took data from 2006 to the June of 2007
- Statistics collected with the recoil detector, larger number of DVCS events than the number from pre-recoil data taking

Electron beam 2006 (only SFT)
H2/D2: 11.8K DVCS (9.6 Mil. DIS)

Positron beam 2006/07(all subdetectors)
H2: 41K DVCS (37.9 Mil. DIS)
D2: 7.6K DVCS (9.8 Mil. DIS)



Conclusions

- The recoil detector was successfully installed and took data until the end of HERA - June, 2007.
- With the recoil detector, DVCS can be directly measured and the backgrounds can be rejected.
- Pre-recoil results can be refined once the background processes are measured.