A Scintillating Fibre Tracker for the HERMES Recoil Detector

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for the HERMES Collaboration

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

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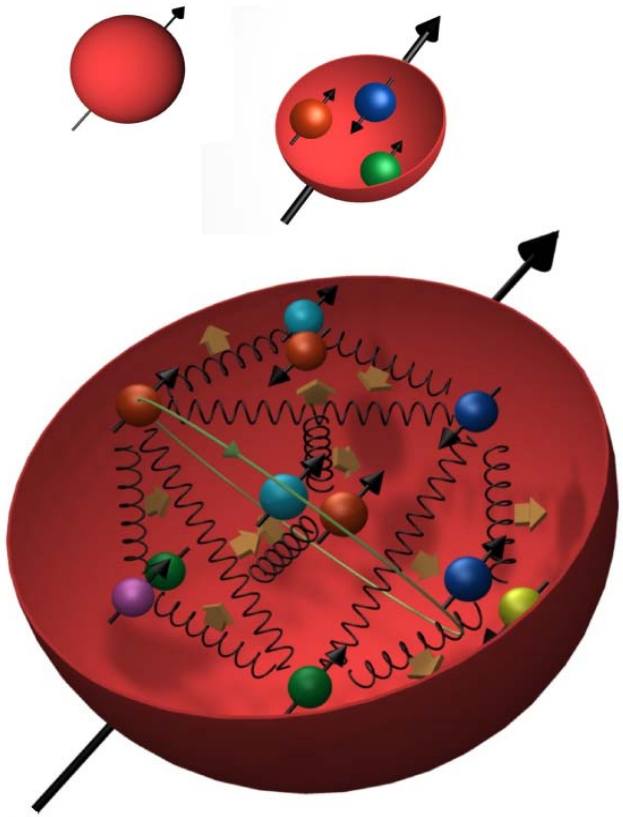
bmb+f - Förderschwerpunkt
HERMES
Großgeräte der physikalischen Grundlagenforschung

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
- ΔG Spin of gluons
- L_q Orbital angular momentum of quarks
- L_g Orbital angular momentum of gluons

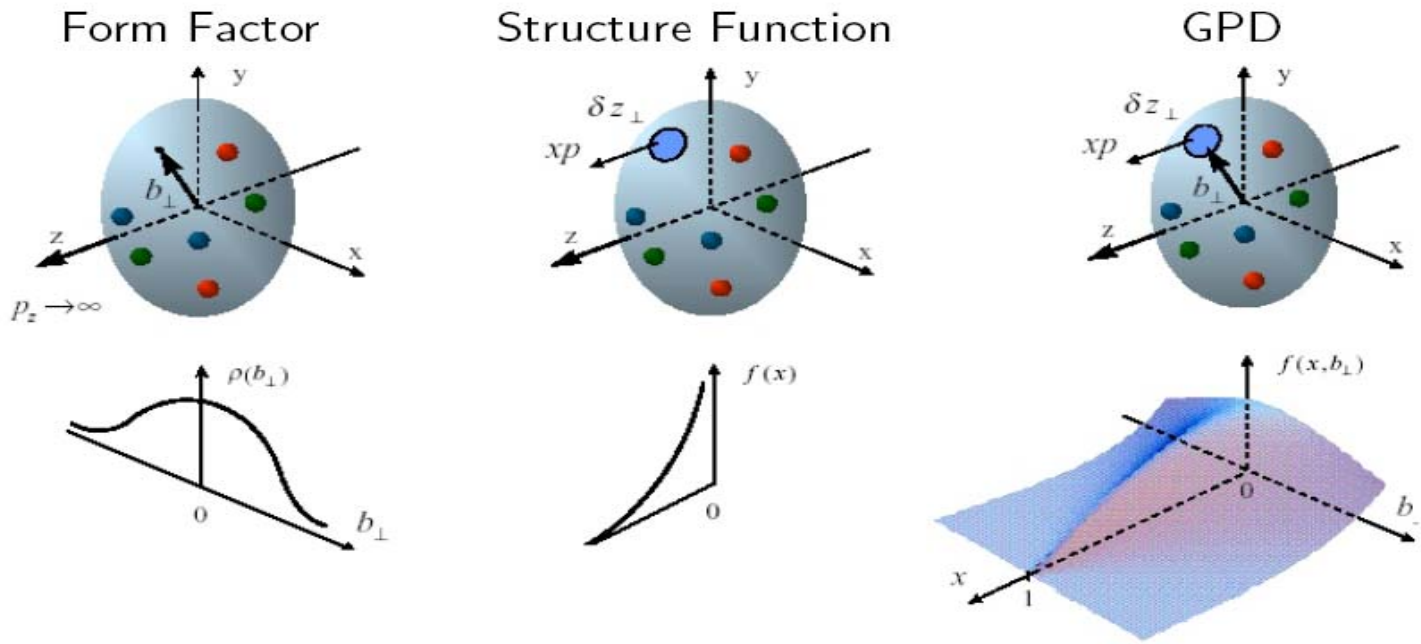


Contribution from quarks?

$\Delta\Sigma$ ~ 30%!

How to access L_q ?

Generalized Parton Distributions



- Form factors -> Transverse position <- Elastic scattering
- PDFs -> Longitudinal momentum distribution <- DIS
- GPDs -> Access to transverse position and longitudinal momentum distr. <- Exclusive reactions

Generalized Parton Distributions

- Total angular momentum of quarks via GPDs :

$$J_q = \frac{1}{2} \lim_{t \to 0} \int dx \cdot x[H_q(x, \xi, t) + E_q(x, \xi, t)]$$

x -> momentum fraction of strcut quark

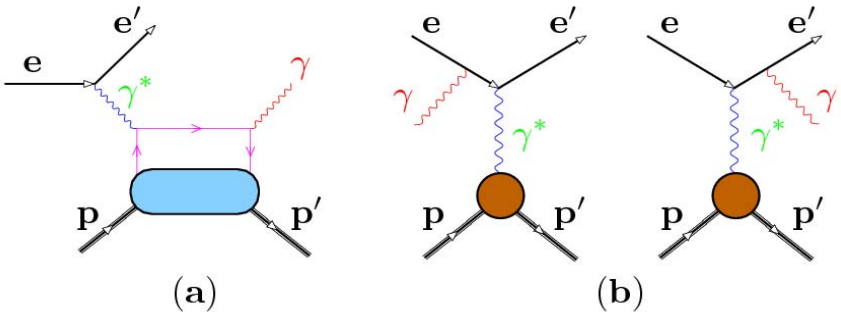
ξ -> skewedness variable

t -> momentum transfer to the target

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

Deeply Virtual Compton Scattering

- The same final state in DVCS(a) and Bethe-Heithler(b) => interference



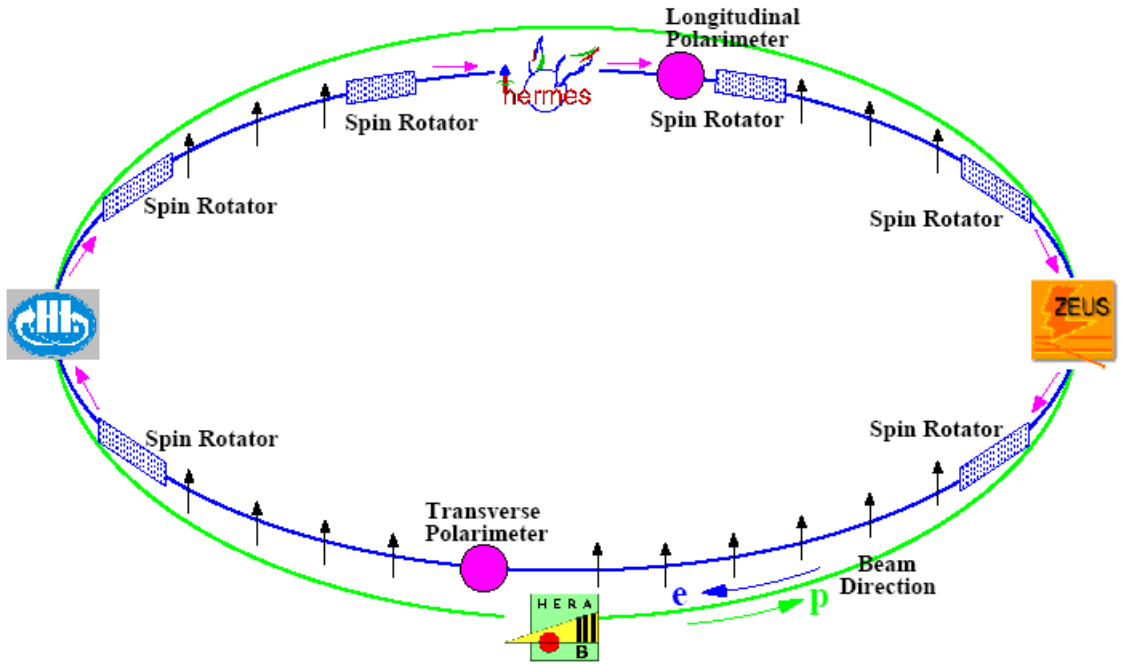
$$\sigma \propto |\tau_{BH}|^2 + |\tau_{DVCS}|^2 + \underbrace{(\tau_{BH}\tau^*_{DVCS} + \tau^*_{BH}\tau_{DVCS})}_{I}$$

- BH dominates at HERMES kinematics
- The DVCS can be measured through azimuthal asymmetries : BSA, BCA ...

HERMES Experiment

- HERMES is a fixed target experiment in HERA

  long.polarized HERA 27.6 GeV $e^{\pm}$ beams

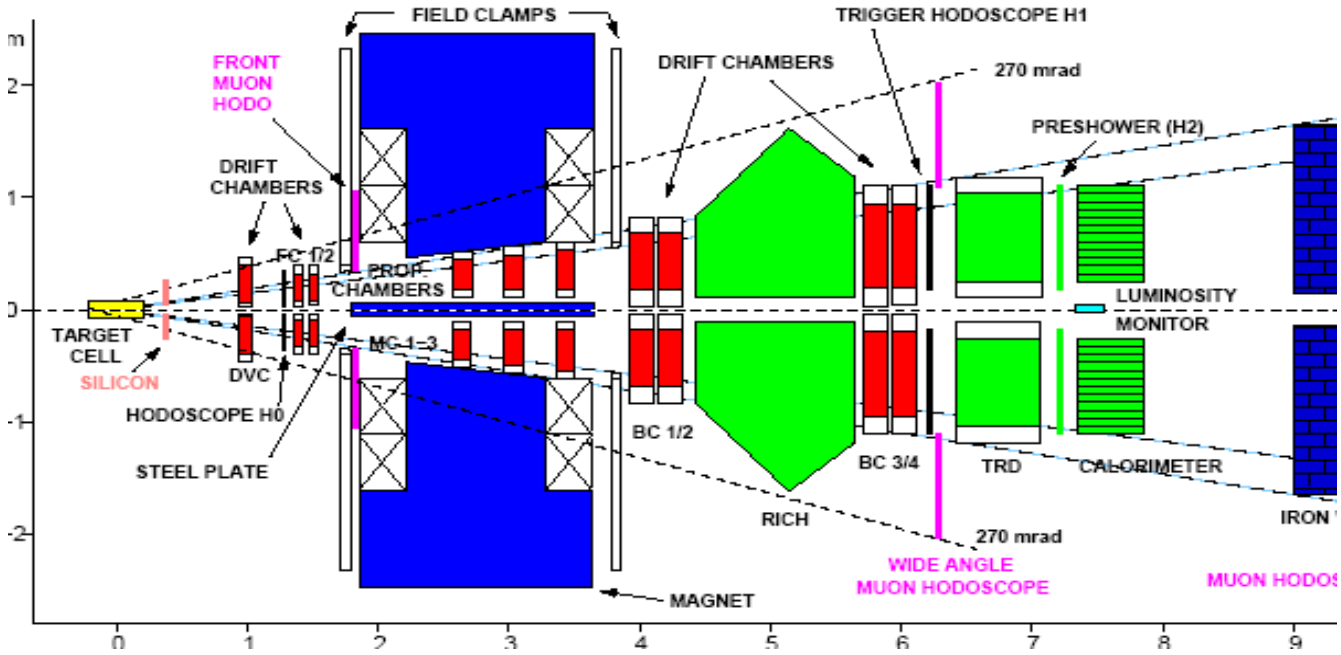


HERMES Experiment

- HERMES is a fixed target experiment in HERA

  long.polarized HERA 27.6 GeV $e^{\pm}$ beams

  final state particles detected by the spectrometer

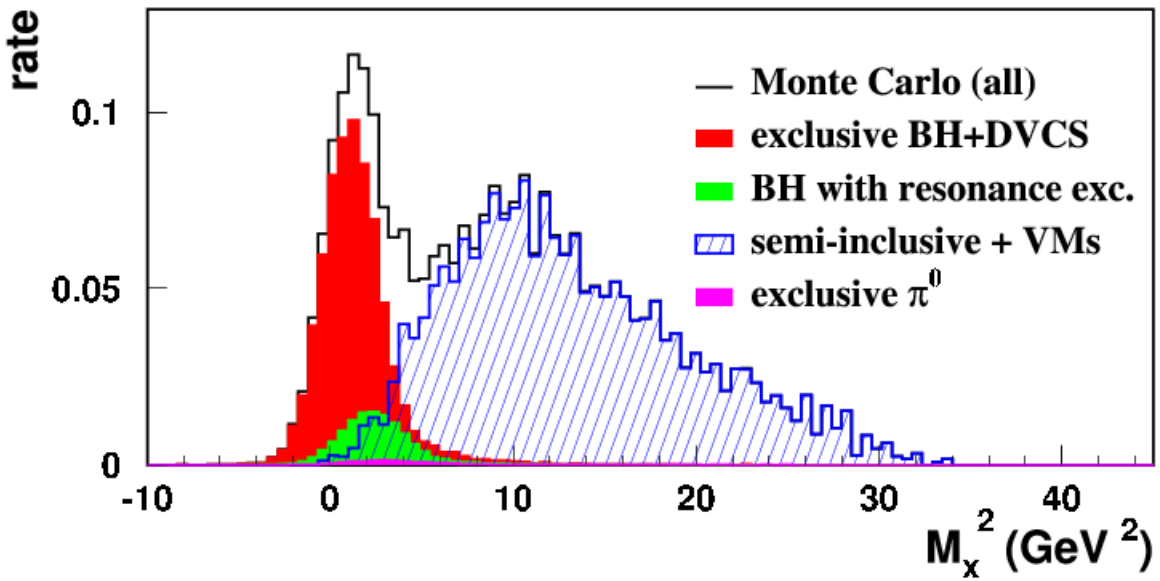


DVCS @ HERMES

- Recoiling protons were not detected => maintain exclusivity through missing mass

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

~limited by spectrometer resolution,background and t-resolution

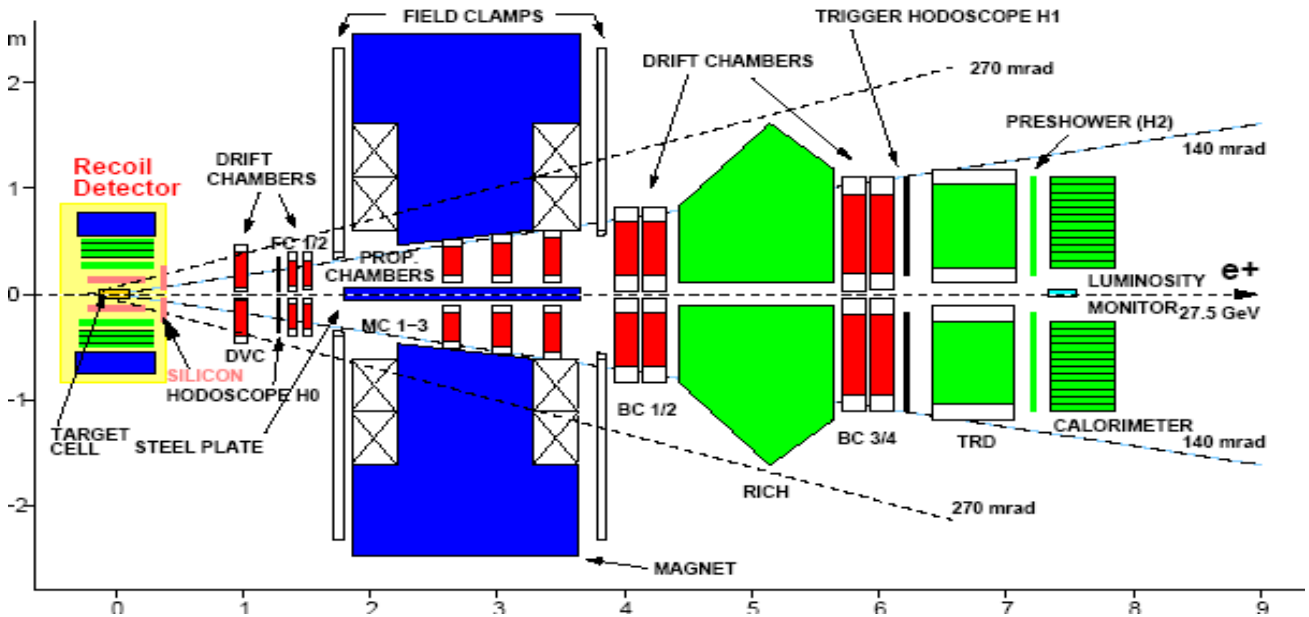


The Recoil Detector

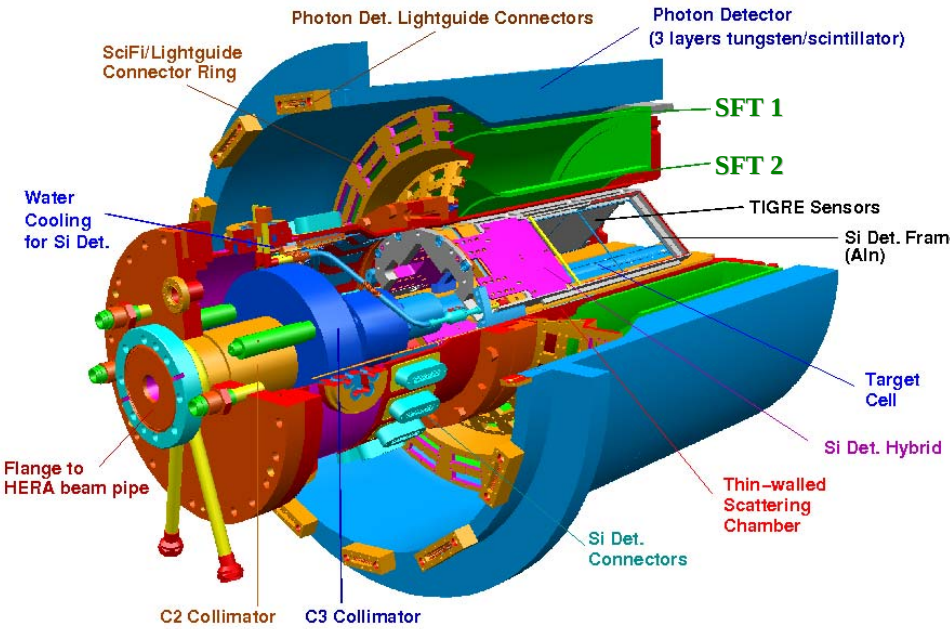
- Recoiling protons were not detected => maintain exclusivty through missing mass

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

- A new recoil detector installed to identify the recoiling proton



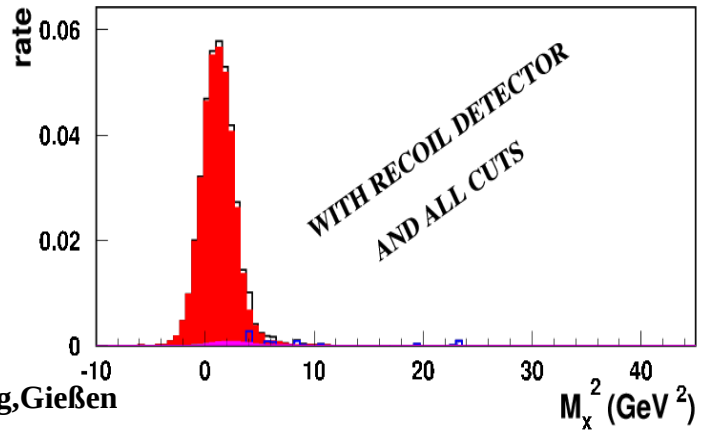
The Recoil Detector



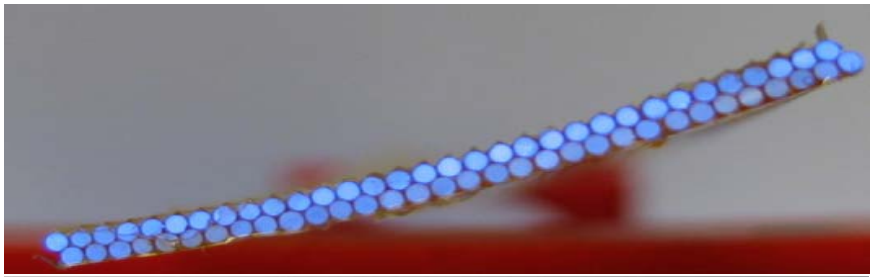
1 tesla magnetic field

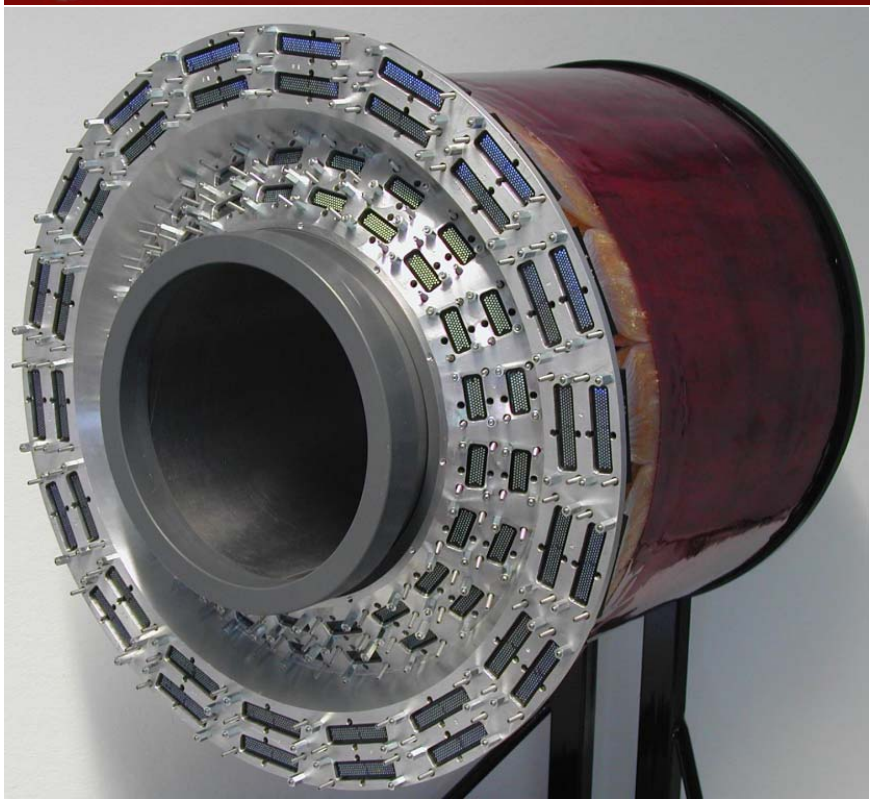
- Consisted of silicon detector, scintillating fibre tracker and photon detector
- Detection of recoiling proton
  - p-measurement 135-1400 MeV/c
  - 76% ϕ acceptance
  - π/p PID via dE/dx

- Improved t-resolution
  - study kinematical dependence
- Backgroud suppression
  - semi-incl. : 5%→<<1%
  - associated : 11%→~1%



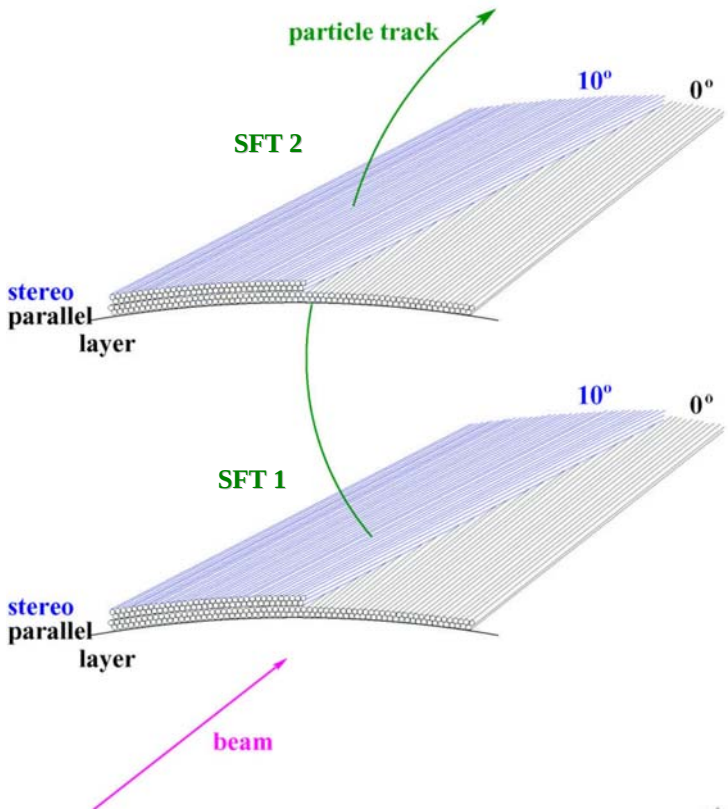
Scintillating Fibre Tracker(SFT)





- Built by JLU Giessen
- 2 cylinders of 2 X 2 layers, 10^0 stereo angle
- 1 mm Kuraray fibres, mirrored ends
- 4992 channels totally
- Kuraray lightguides, 64 channels Hamamatsu PMTs
- Readout by VME boards on GASSIPLEX chips
- Dynode signal used for timing

Scintillating Fibre Tracker(SFT)

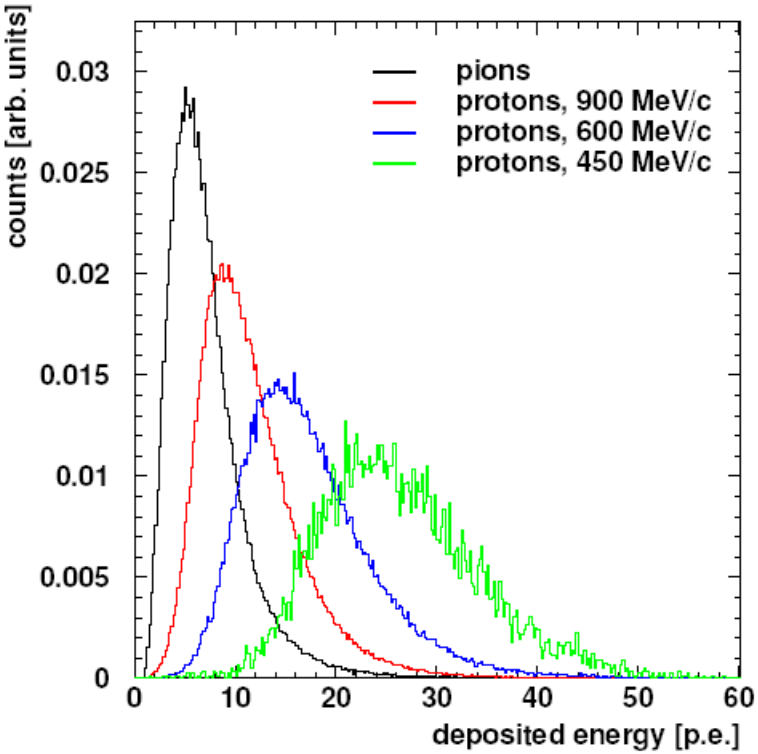


- Momentum measured in full azimuthal angle and reconstructed by bending 1 Tesla magnetic field
- The range of momentum measurement 250-1400 MeV/c
- π/p PID from dE/dx

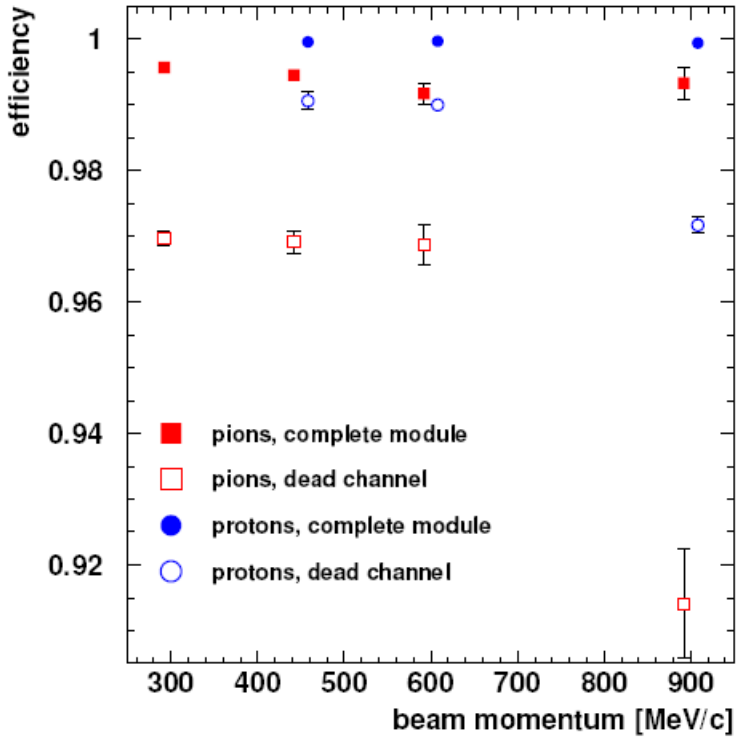
  $250 < p < 650$ MeV/c

GSI Test Beam for SFT

- Pion and proton beams were used to test SFT in GSI

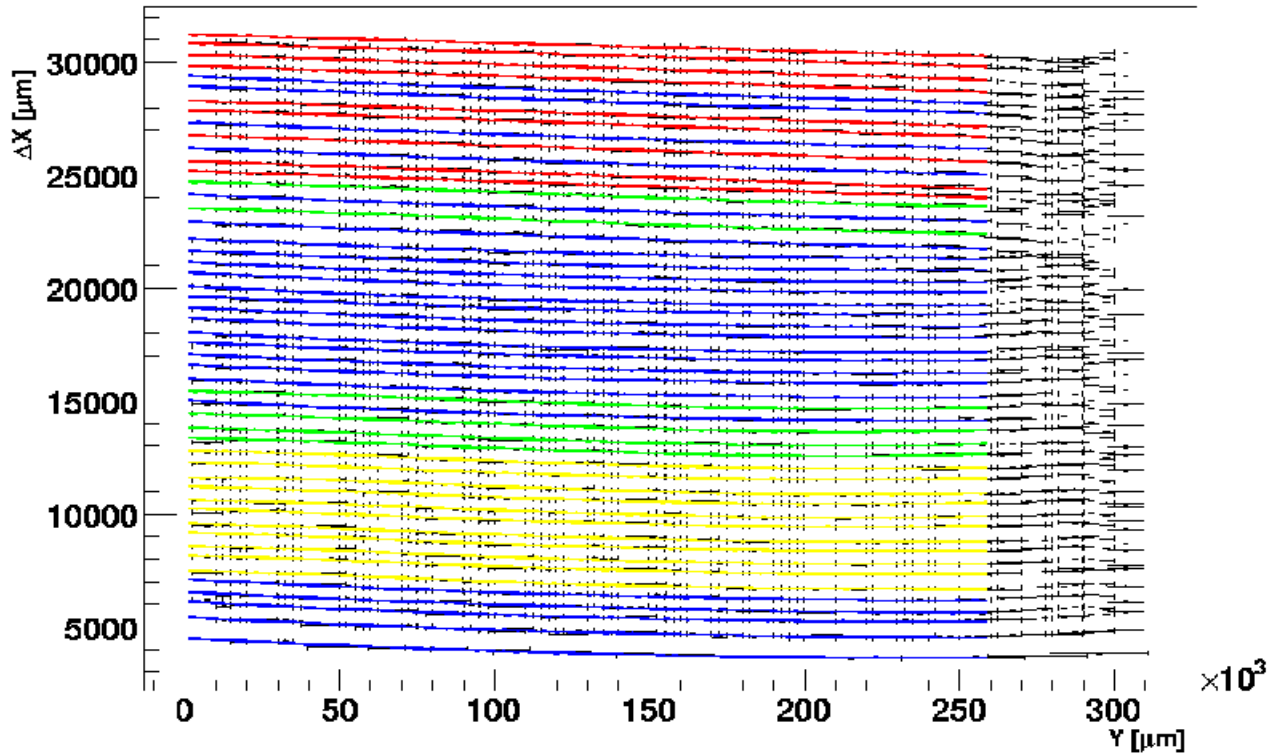


SFT response for different proton mementa



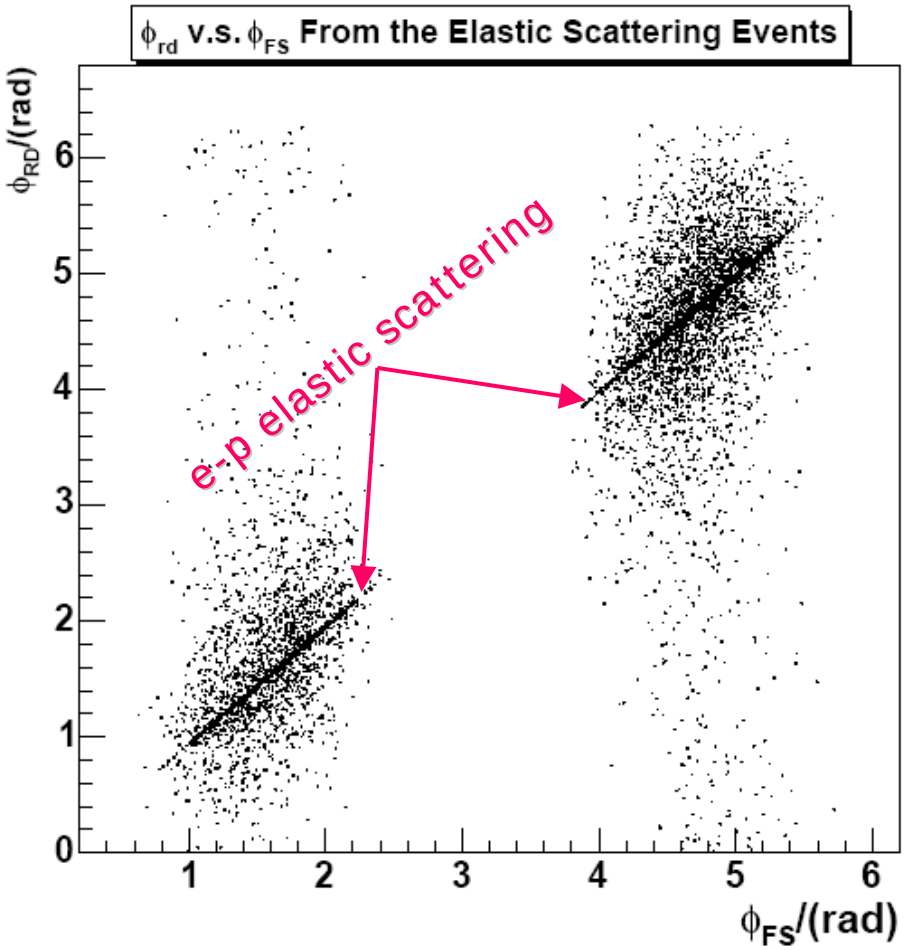
SFT module effieciencies (module = double layers of fibres; 2 modules to get one space point)

SFT Alignment Measurement



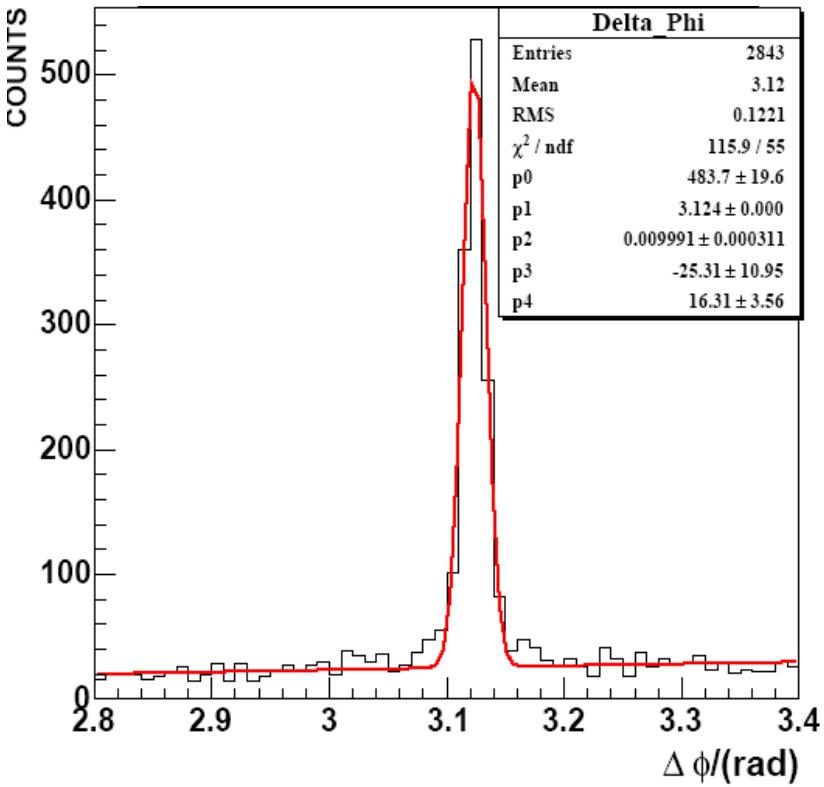
- 5.5 GeV e^+/e^- test beam was used with Zeus Si-Reference system
- x/y reconstruction < 100 μm
- parameterizes fibres with polynoms O(4)

E-P Elastic Scattering in SFT

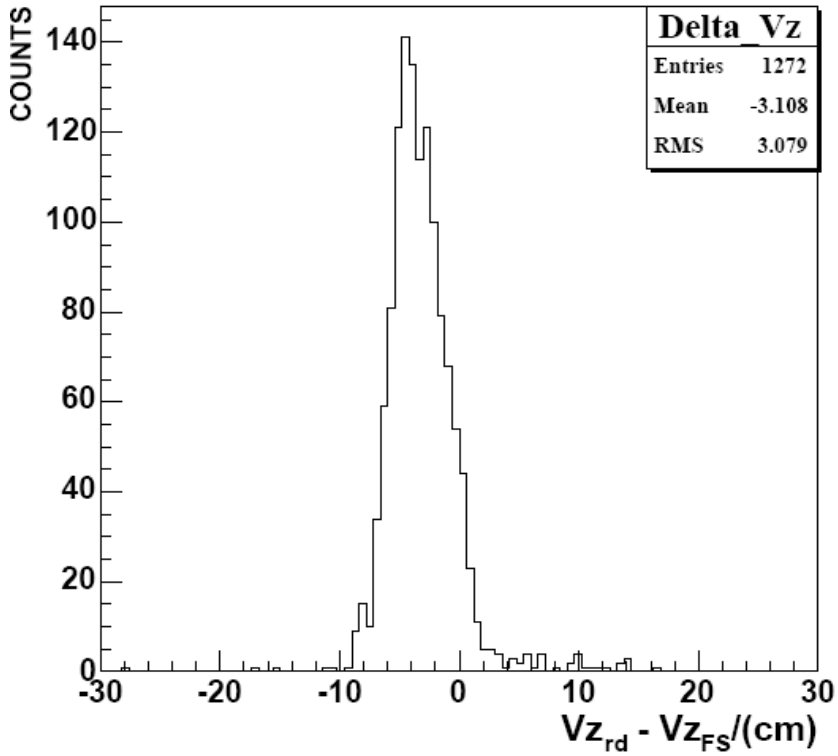


- e-p elastic scattering process was studied combined with the recoil detector and the HERMES forward spectrometer(FS)
- Clear correlation can be seen between the azimuthal angle measured from the forward spectrometer and the one measured from the SFT

E-P Elastic Scattering in SFT



The difference of the azimuthal angle from SFT and forward spectrometer



The vertex measured from SFT correlates to the vertex from forward spectrometer

Conclusions

- With the recoil detector, DVCS and other hard exclusive reactions can be precisely measured
- The recoil detector was successfully installed and will take data until the end of HERA - June, 2007
- The scintillating fibre tracker is one of the main components of the recoil detector