THE HERMES RECOIL DETECTOR

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on behalf of the HERMES Collaboration

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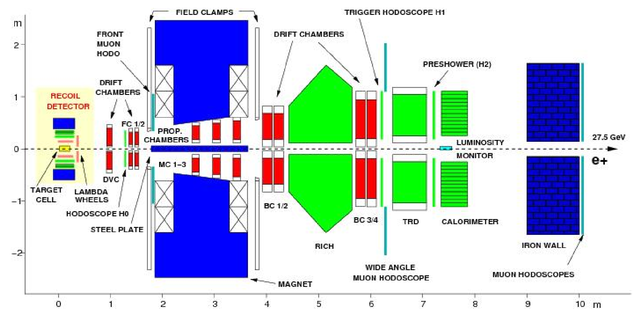
HERA at DESY

- 27.6 GeV electron/positron beams with polarization up to 65%
- Unpolarized gas targets at HERMES

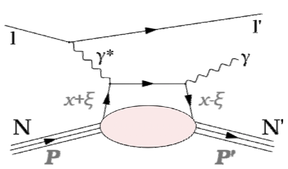
The HERMES Spectrometer



- Tracking: $\Delta p/p < 2\%$, $\Delta\theta < 0.6$ mrad
- Particle identification: TRD, preshower, calorimeter (hadron/lepton separation), RICH (π, K, p separation)

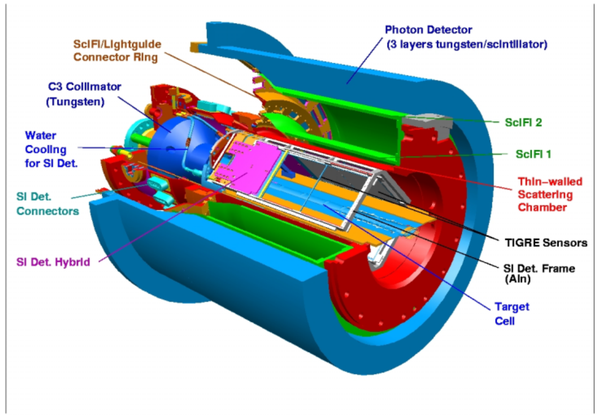
Recoil Detector for HERMES

- The primary goal of HERMES is to explore the spin of nucleon, disentangle different contributions to the nucleon's spin
- The generalized parton distributions (GPDs) offer a possibility to derive the orbital angular momentum of quarks L_z^q, which can be accessed by studying the Deeply Virtual Compton Scattering (DVCS) process

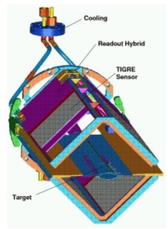


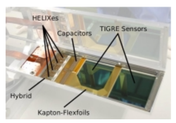
The internal variable x and the skewedness parameter ξ describe the longitudinal momentum transfer between two partons: the parton taken out of the proton carries the longitudinal momentum fraction x + ξ and the one put back into the proton carries the fraction x - ξ

- To improve the measurement of exclusive processes a Recoil Detector was built for the HERMES experiment
- The Recoil Detector can measure recoiling protons (135-1400 MeV/c), improve the t-resolution, and suppress the background
- The Recoil Detector consists of a silicon strip detector (SSD), a scintillating fibre tracker (SFT), and a photon detector (PD); a solenoid magnet provides 1T longitudinal magnetic field for the measurement of momentum in the SFT and to reduce the background fro Møller electrons in the SSD



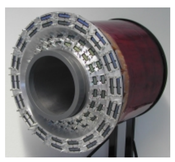
Silicon Strip Detector

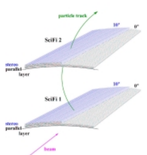




- Consists of 8 modules of 2 double-sided silicon strip detectors (TIGRE) arranged in two layers around the target cell at a distance of 5 cm to the electron beam inside the accelerator vacuum (10^{-9} mbar)
- Position and energy measurement and identification of low momentum protons (135-450 MeV/c)
- Nearly complete coverage in polar angle, 76% coverage in azimuthal angle
- TIGRE sensor (MICRON): 300 µm thick, 99x99 mm² active area, 128 strips/side, 758 µm pitch
- Strips on both sides perpendicular to each other
- Readout based on HELIX 128-3.0 chips
- Each strip is connected to two readout channel with different gains to cover a dynamic range from 86 keV (1 MIP in 300 µm of silicon) to 6 MeV (a stopped proton in 300 µm of silicon)

Scintillating Fibre Tracker





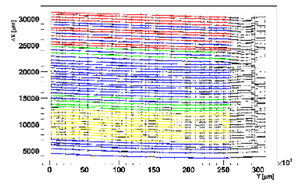
- Consists of 2 barrels of 8 layers of Kuraray SCSF-78 mirrored ending scintillating fibres
- Each barrel has 2 parallel and 2 stereo layers (10 degree with respect to parallel layer) for space point reconstruction
- Momentum measured from 250-1400 MeV/c in full azimuthal angle range and reconstructed by bending in 1T magnetic field
- Particle identification by energy deposition
- HAMAMATSU H-7546B 64-channel PMTs are used for high channel density, with 4992 channels in total
- Scintillating fibres are connected to PMT by 3.5 m long light guides (Kuraray clean fibres)
- Readout by VME boards based on GASSIPLEX chips, 64 channels per board
- Dynode signals are used for timing

Photon Detector

- Detects photons from intermediate Δ resonances
- Reconstruct π^0 if both photons are detected
- π/p separation together with the Scintillating Fibre Detector
- Consists of 3 layers with parallel and stereo strips
  - A layer: 60 strips along z axis
  - B layer: 44 strips -45° stereo angle
  - C layer: 44 strips +45° stereo angle
- Two wave length shifters on both sides of each strip
- Dimensions of strips: 2 cm x 1 cm x 28 cm
- Provides cosmic trigger

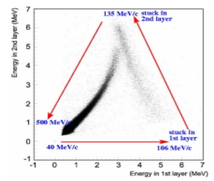
Test Beam Measurements

Alignment measurement for the Scintillating Fibre Tracker



- 5.5 GeV e^+/e^- beam was used with ZEUS Si-reference system
- x/y reconstruction was < 100 µm
- fiber positions were parameterized with 4-order polynomials

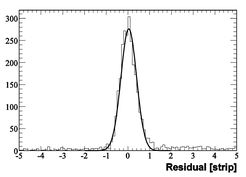
Energy calibration of the Silicon Strip Detector



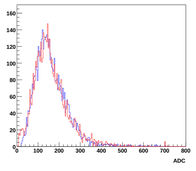
- Expected energy deposition in the Silicon Strip Detector (simulation)
- Tested at the Erlangen Tandem accelerator

Cosmic Tests

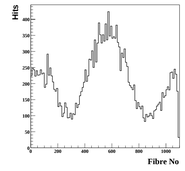
- The Recoil Detector was assembled and tested with cosmic particles from June to September 2005
- The performance of the detector was fine and the cosmic particles could be clearly seen by all the three sub-detectors
- The efficiency of the detector was as expected



Residuals for the Silicon Strip Detector σ = 0.359 strips, layer efficiency ~ 80%



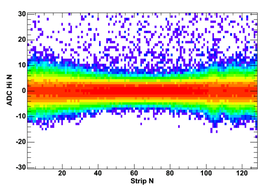
ADC spectra in the Scintillating Fibre Tracker (SFT) for cosmic particles (red) in comparison with Monte-Carlo simulation (blue)



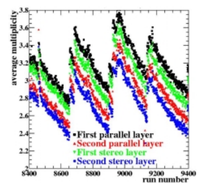
Cosmic hits distribution from outer module of SFT, fibres 1 and 1098 are close to the top of the barrel

Installation and Commissioning

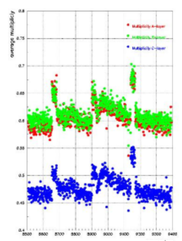
- Installed in January 2006
- The Scintillating Fibre Tracker and the Photon Detector have been commissioned
- Silicon Strip Detector under commissioning
- Data taking till the HERA shutdown at the end of July 2007



Noise distribution for one of the Silicon sensors after the common mode noise corrections and pedestal subtraction



Hit multiplicity distributions for different layers of the Scintillating Fibre Tracker



Hit multiplicity distributions for different layers of the Photon Detector