The HERMES Recoil Detector: a combined Silicon Strip and Scintillating Fibre Detector for Tracking and Particle Identification

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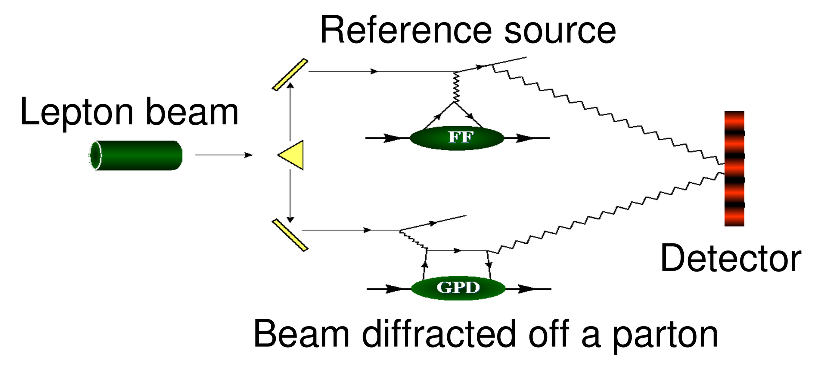
on behalf of the HERMES Collaboration

The Physics case: Hard Exclusive Reactions

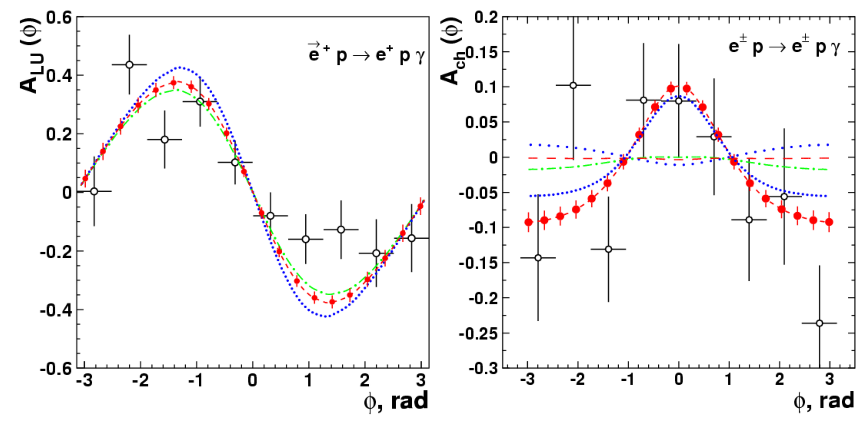


Hadron tomography

- Work towards a 3D picture of the nucleon
- Use interference between known phenomena (Formfactors, distribution functions) and new physical description (Generalised Parton Distributions)
- Key to success: exclusive reactions

Expected performance for key reaction DVCS:

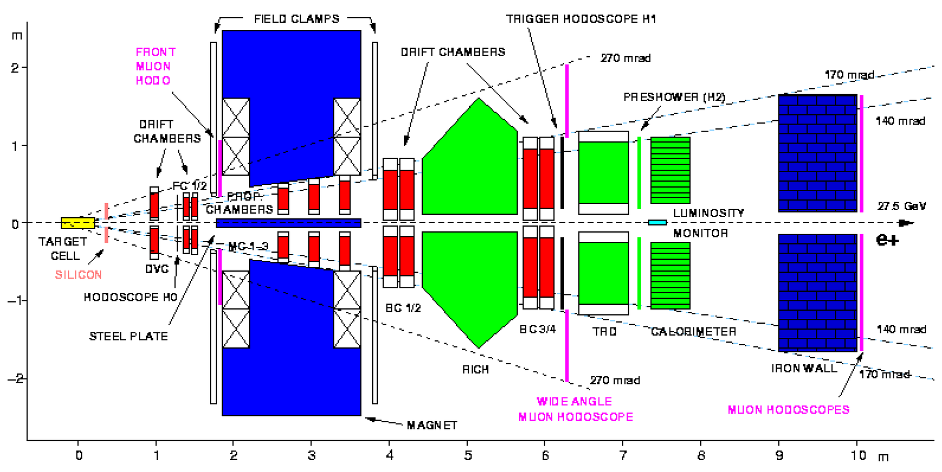
- two main observables: beam spin and beam charge asymmetry
- Systematic uncertainty comparable to statistical precision



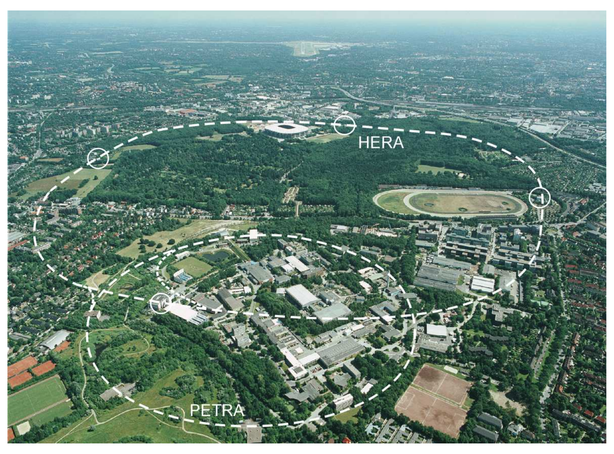
open symbols: current results filled: expectation after 2y of data taking

The HERMES Spectrometer

- Kinematical coverage: $0.02 < x < 0.8$ for $Q^2 > 1$ GeV^2 and $W^2 > 4$ GeV^2
- tracking: 57 tracking planes, $\Delta P/P < 1.3\%$
- PID: Calorimeter, Cherenkov, TRD electron efficiency 0.99, hadron contamination < 1%
- Proton, Kaon, Pion separation with RICH

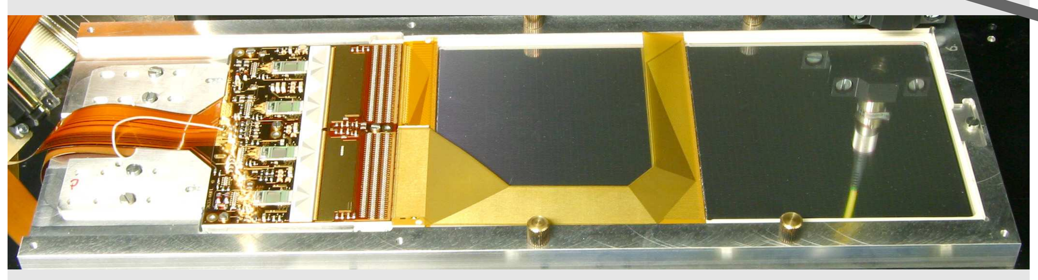


The accelerator: HERA @ DESY

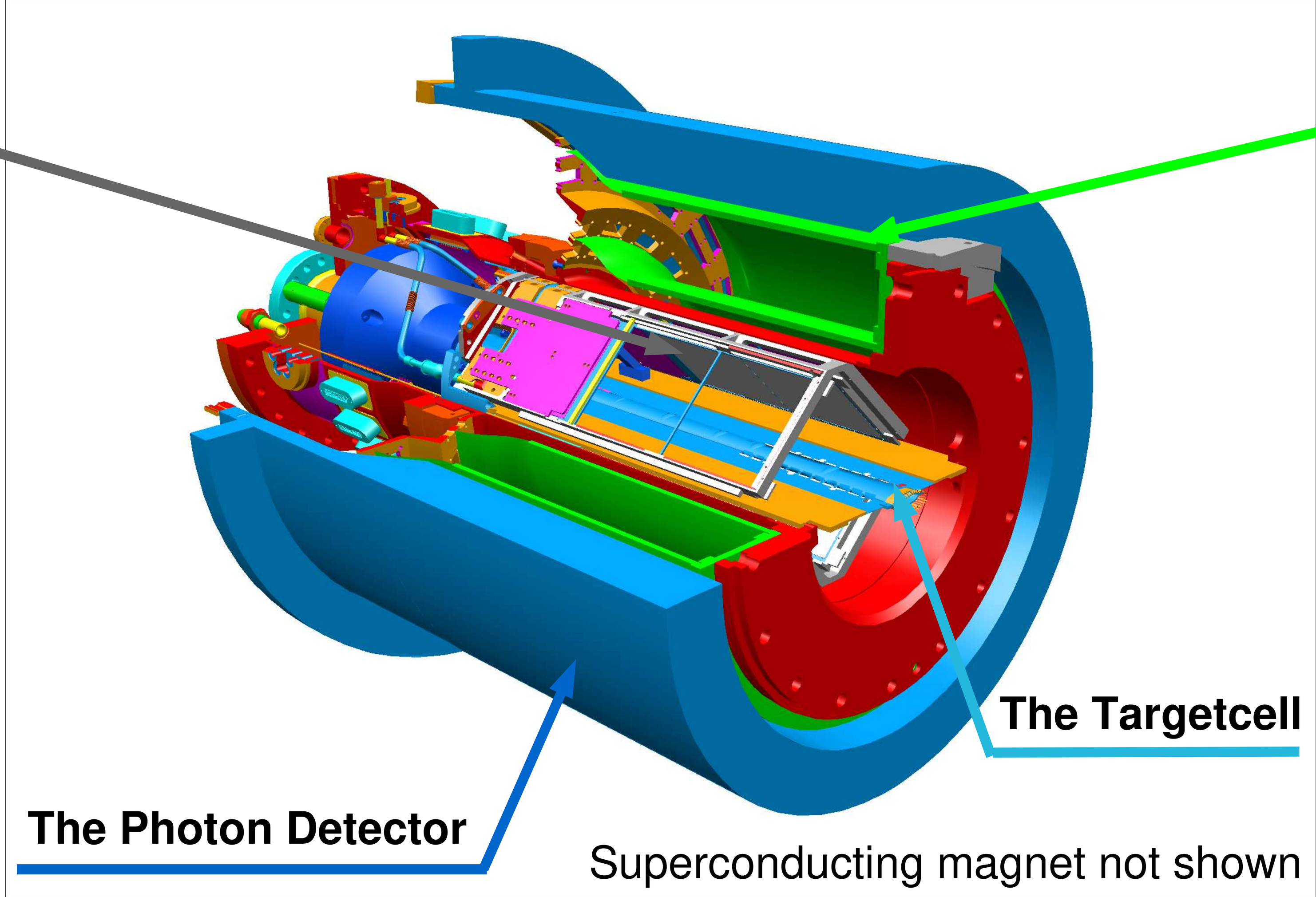


- 27.5 GeV e^+/e^- beam on fixed gas target
- lepton beam polarisation up to 65%
- for recoil detector: unpolarised targets (Hydrogen, Deuterium, heavy nuclei)

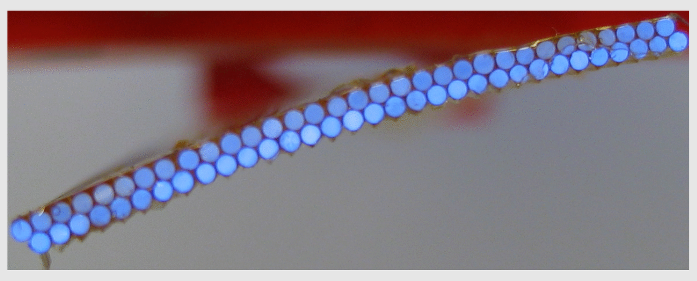
The Silicon Strip Detector



- 16 double sided TIGRE sensors (MICRON), active area 99 x 99 mm^2, 300 μm thick, 758 μm pitch
- Nearly complete coverage in polar angle, 76% coverage in azimuth
- Placed inside vaccuum to detect low momentum particles
- Strips on *p* and *n* side perpendicular to each other for position measurement

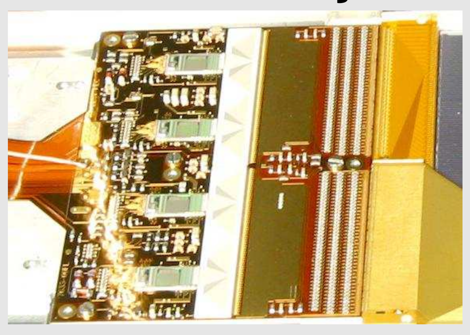


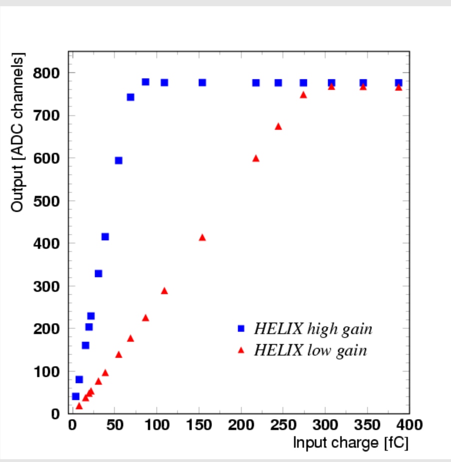
The Scintillating Fibre Detector



- 2 Barrels of 4 layers Kuraray SCSF-78 scintillating fibres of 1mm diameter
- End side mirrored for higher light yield
- Each barrel has a parallel and stereo layer for space point reconstruction.
- Momentum reconstruction by bending in 1T magnetic field
- ADC information for Particle Identification
- Barrels built from 32mm wide strips as selfsupporting structure

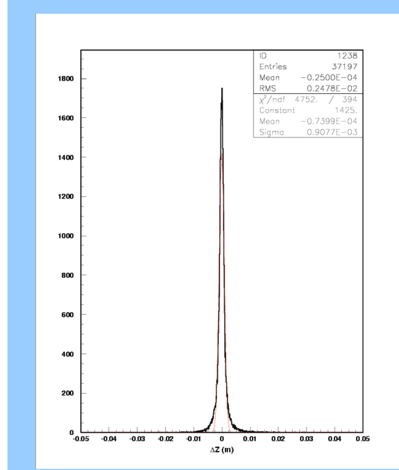
The Silicon Hybrid

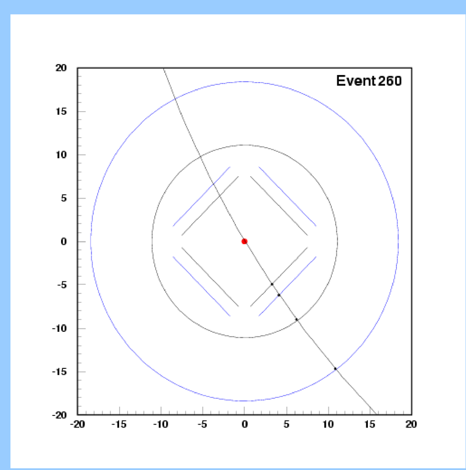




- Readout based on HELIX 128-3.0 chips
- Implemented capacitive charge division on hybrid
- Each strip connector to two readout channels (high gain and low gain) to cover complete dynamic range required

Expected Performance of the HERMES Recoil Detector



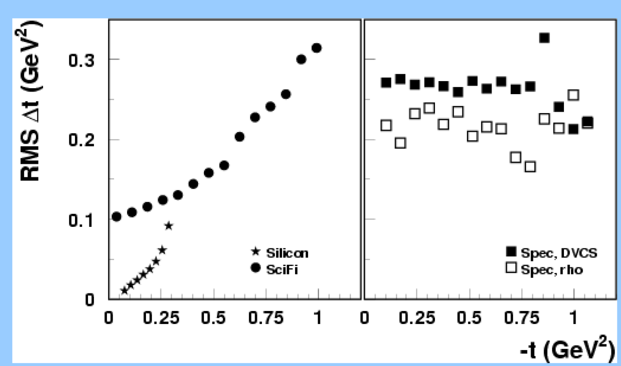


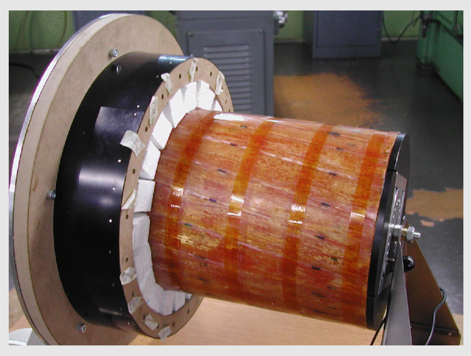
Simulated t-resolution

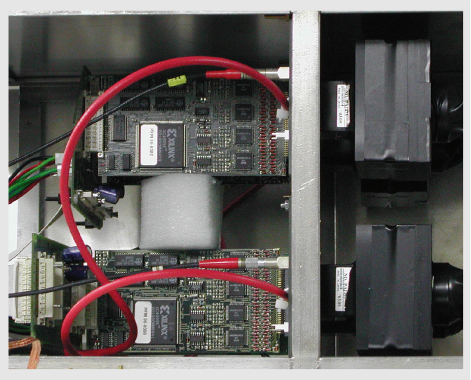
- Mandelstam *t* is important variable to understand DVCS
- High resolution is mandatory
- Recoil detector significantly improves Spectrometer resolution for low values of *t*

Tracking and Vertex reconstruction

- Field inhomogeneity 10-20 % in tracking volume
- Energy loss contributes significantly
- Use track following method to find and fit tracks
- Vertex position from spectrometer used as starting value

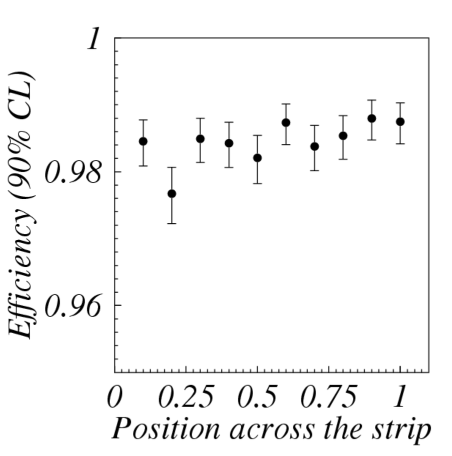


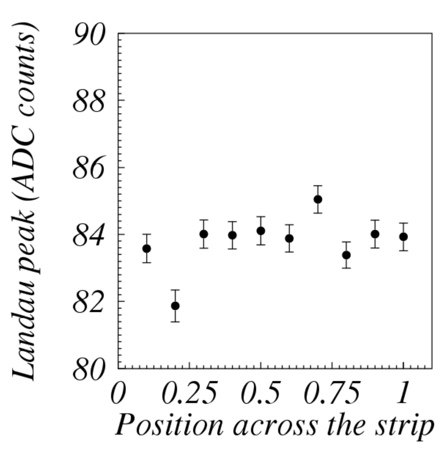


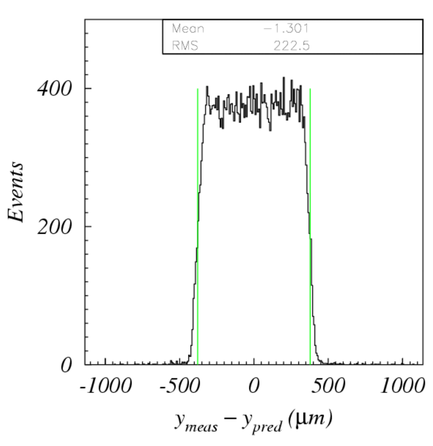


- Use HAMAMATSU H-7546 64 channel PMTs for high channel density
- Scintillating fibres connected to PMT by 3.5m long light guides (Kuraray clear fibres)
- Readout by VME boards based on GASSIPLEX chips, 64 channels per board
- Compensation of gain variations by customized circuits for each PMT channel
- Dynode signal used for fast timing

Testbeam at DESY T22

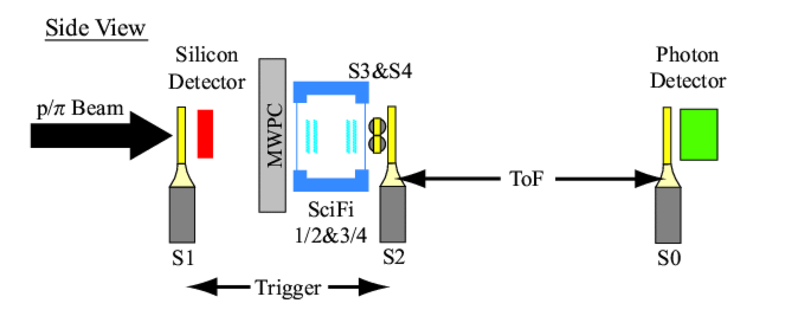


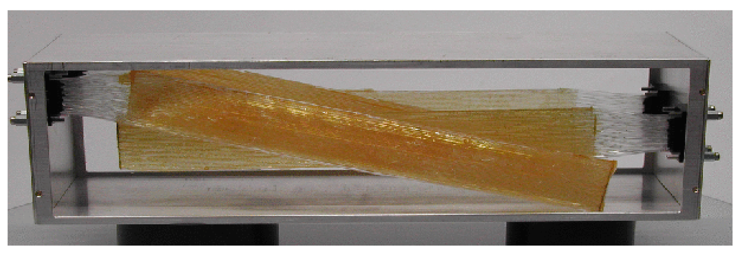




- Use 6 GeV electron beam to measure response to Minimum Ionising Particles
- Module unter test placed between Si-telescope for precise position and efficiency determination. Position resolution of Si-telescope better than 25 μm
- Efficiency and energy deposition measured to be uniform along a strip
- Spatial resolution measured to be pitch/sqrt(12) according to expectations

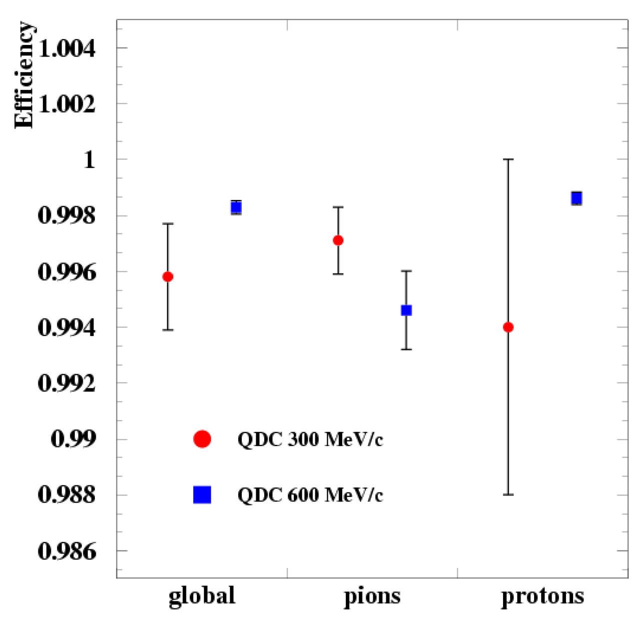
Testbeam at GSI Cave A

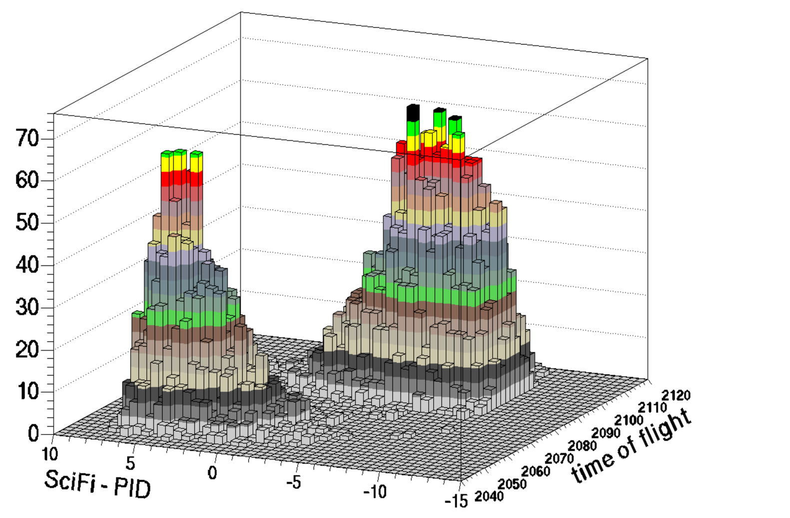




- Mixed proton/pion beam at 0.3 GeV/c, 0.6 GeV/c, 0.9 GeV/c
- MWPC for position determination
- ToF for independent Proton/Pion separation
- Plastic scintillators for efficiency determination

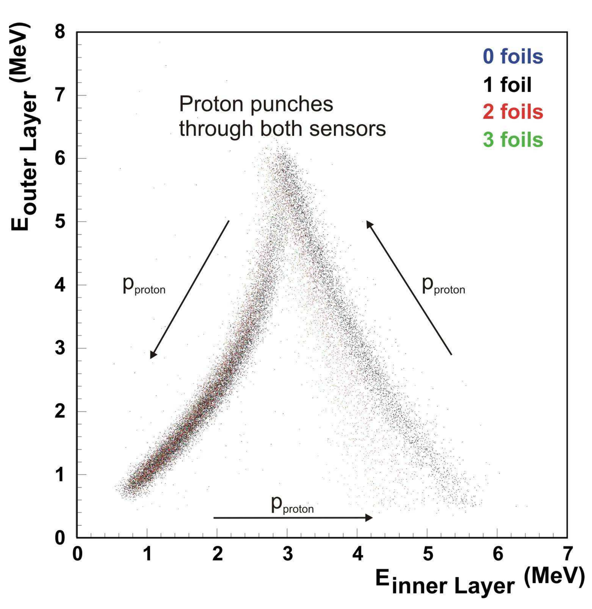
Fibres arranged corresponding to final configuration to study PID response and space point reconstruction (2 parallel and 2 stereo modules)





- Efficiency of single module exceeds 99% for all particle types in the relevant momentum range
- Particle Identification based on the energy deposition in four staggered SciFi modules evaluated by a Likelihood algorithm shows good proton/pion separation even at the highest momenta required
- PID cross checked by ToF measurement

Testbeam at the Erlangen Tandem Accelerator



- 9 MeV proton tandem accelerator at Erlangen University
- Measure response to stopping protons corresponding to low momentum protons in the HERMES recoil environement
- Monte Carlo predictions confirmed by test beam data

Measured vs. Simulated energy loss