The HERMES Recoil Detector:

A combined Silicon Strip and Scintillating Fiber Detector for Tracking and Particle Identification

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EPS HEP2005 Lisboa - 27.07.2005

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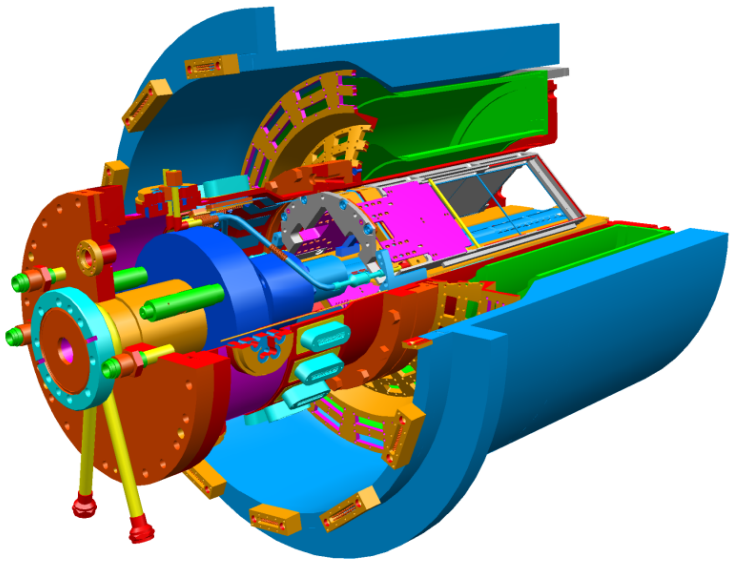
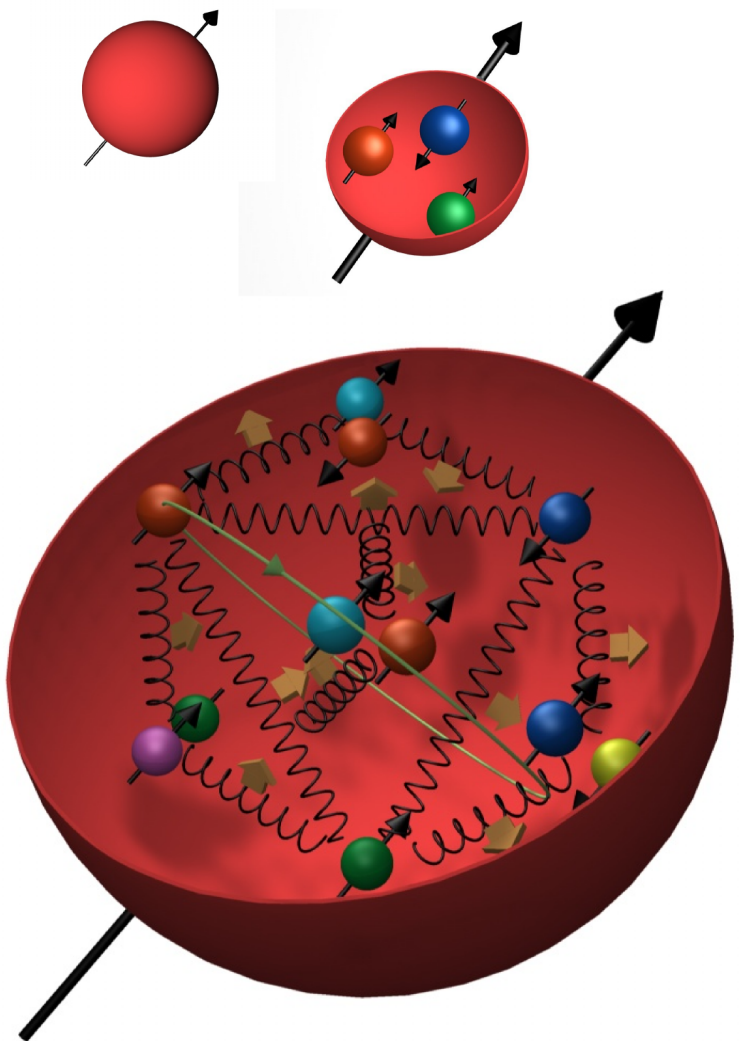


The Spin of the Nucleon



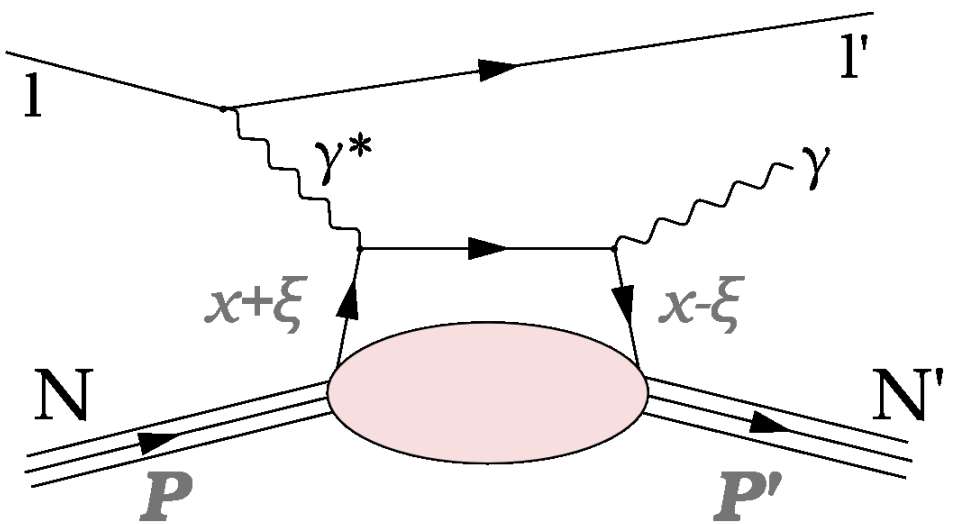
$$\langle s_Z \rangle = \tfrac{1}{2}\Delta\Sigma + L_Z^q + \Delta G + L_Z^G = \tfrac{1}{2}$$

Contributions:

- Quark polarisation $\Delta\Sigma$ (valence + sea)
- Quark orbital angular momentum L_Z^q
- Gluon polarisation ΔG
- Gluon angular momentum L_Z^G

Deeply Virtual Compton Scattering

Information on the angular momentum of the nucleon's quarks can be accessed via DVCS ($l\,N \rightarrow l'\,\gamma\,N'$):



Process parametrised by:

- x: fraction of momentum
- ξ: skewedness
- $t := (\mathbf{P} - \mathbf{P}')^2$

DVCS on proton is described by four Generalized Parton Distributions (H, $\tilde{H}$, E and $\tilde{E}$).

Generalised Parton Distributions

From GPDs information to the angular momentum of the quarks inside the nucleon can be gained eg. via Ji's sum rule:

$$\int_{-1}^{+1} dx\, x(H^q(x,\xi) + E^q(x,\xi)) = 2L_z^q + \Delta\Sigma \quad \text{for } t = 0$$

GPDs contain form factors as integrals, eg.:

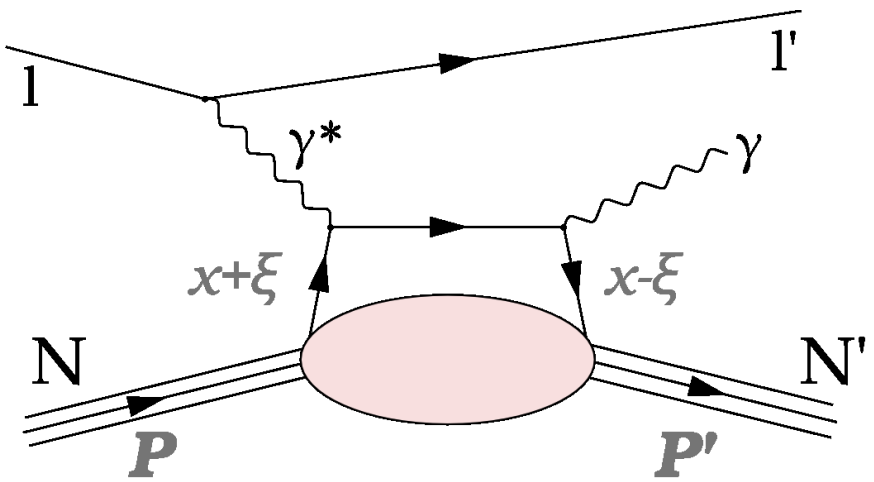
$$\int_{-1}^{+1} dx\, H^q(x,\xi,t) = F_1(t)$$

and structure functions as limits, eg.:

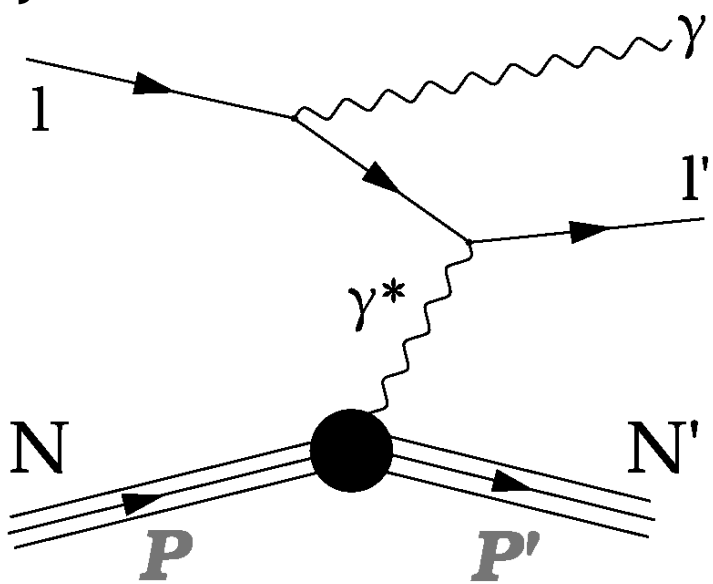
$$\tilde{H}^q = \begin{cases} \Delta q(|x|) & : \quad x > 0 \\ \Delta \bar{q}(|x|) & : \quad x < 0 \end{cases} \qquad \text{for } \xi = 0 \text{ and } t = 0$$

Interference with Bremsstrahlung

At HERMES energies ($\sqrt{s}$ = 7 GeV/c) bremsstrahlung processes dominate the cross section for $l\,N \rightarrow l'\,\gamma\,N'$, but interference leads to measurable azimuthal asymmetries.

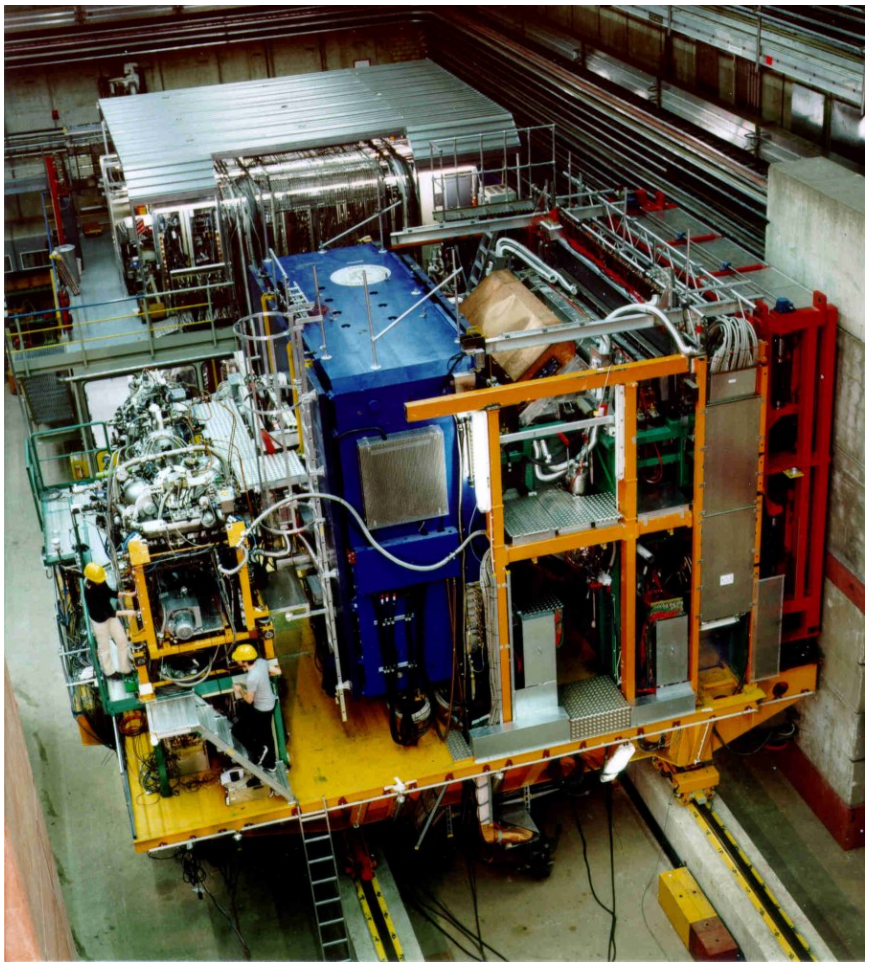


DVCS



Bremsstrahlung

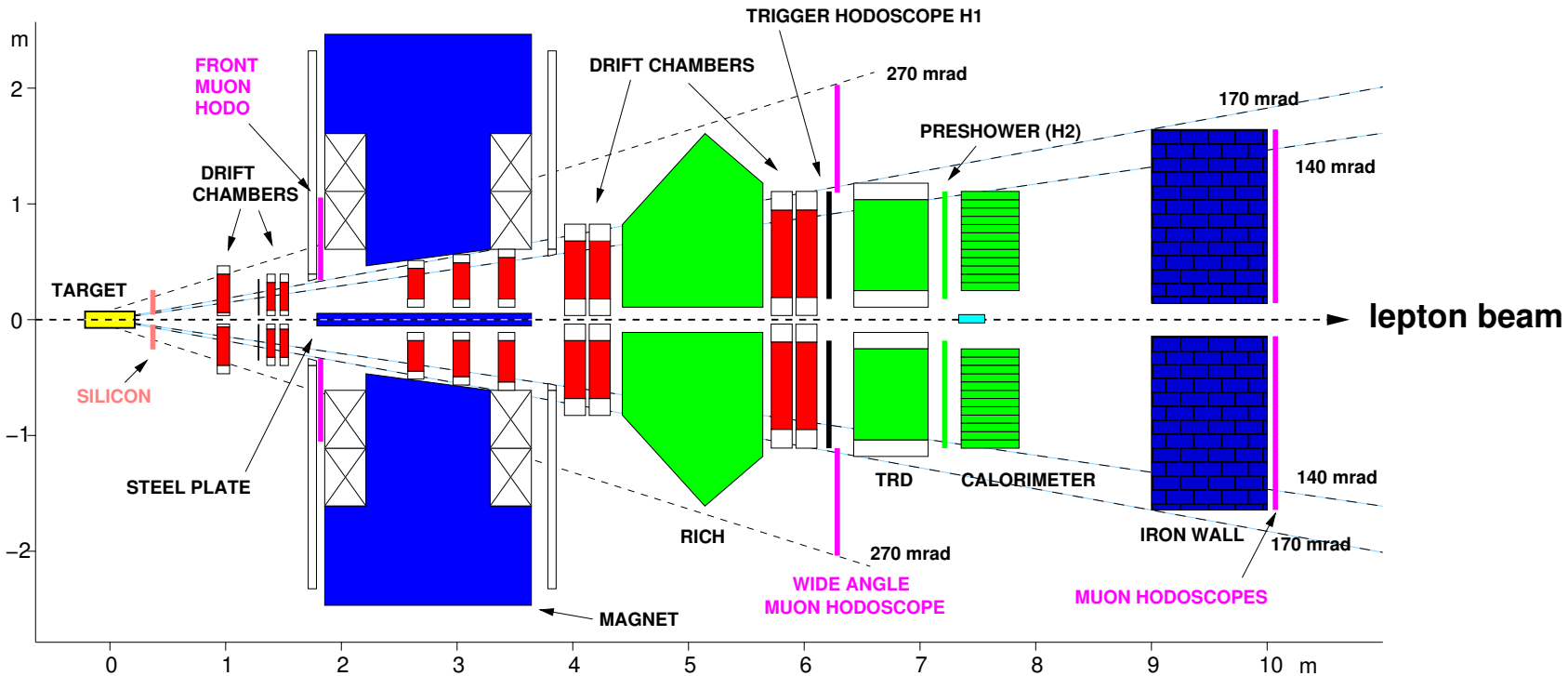
The HERMES Experiment @ DESY



HERa MEasurement of Spin

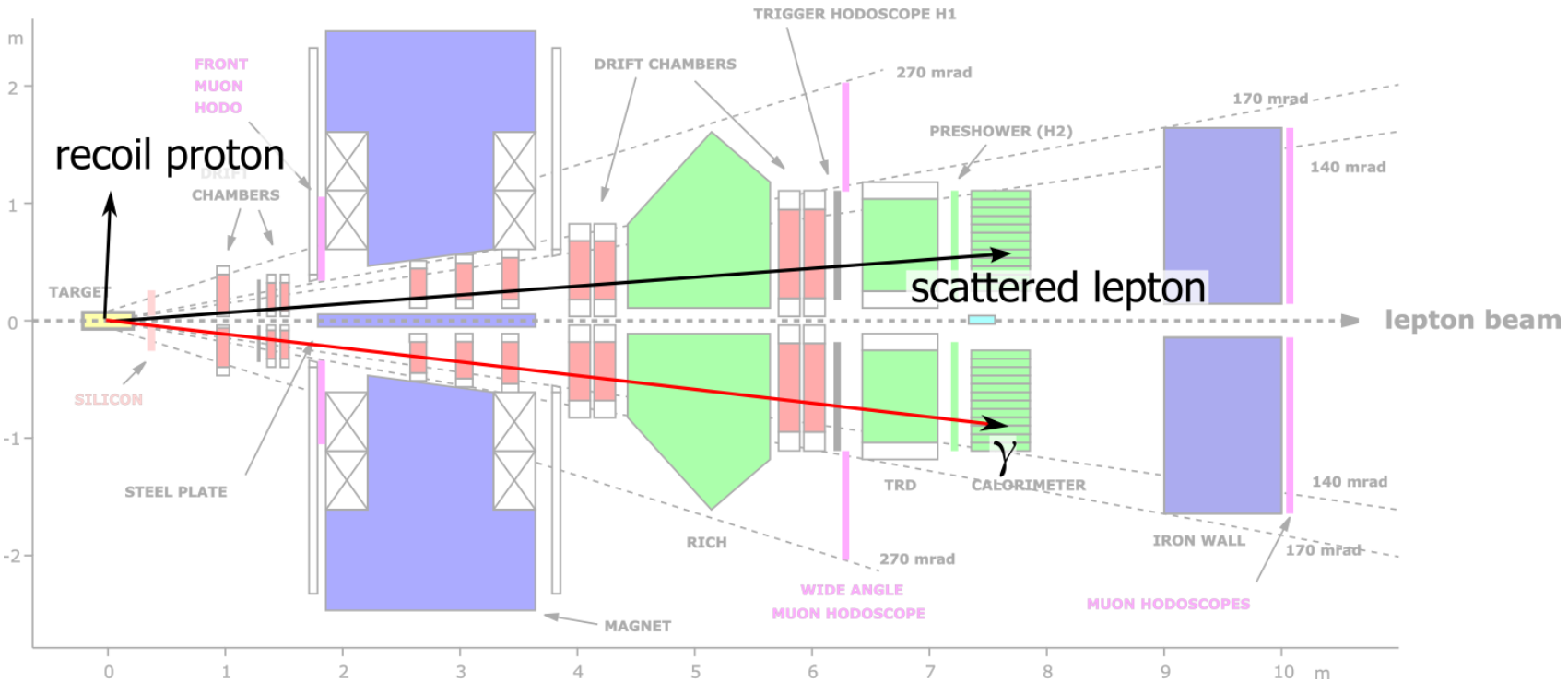
- located at HERA/DESY
- internal polarised hydrogen gas target
- Lepton-Beam, 27.5 GeV/c, self-polarised by synchrotron radiation

The HERMES Spectrometer



Acceptance: horizontal ± 170 mrad, vertical ± (40 - 140) mrad

The HERMES Spectrometer

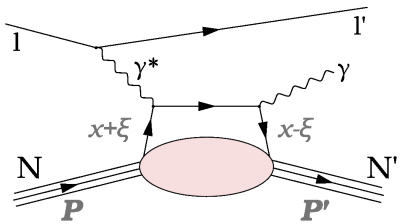


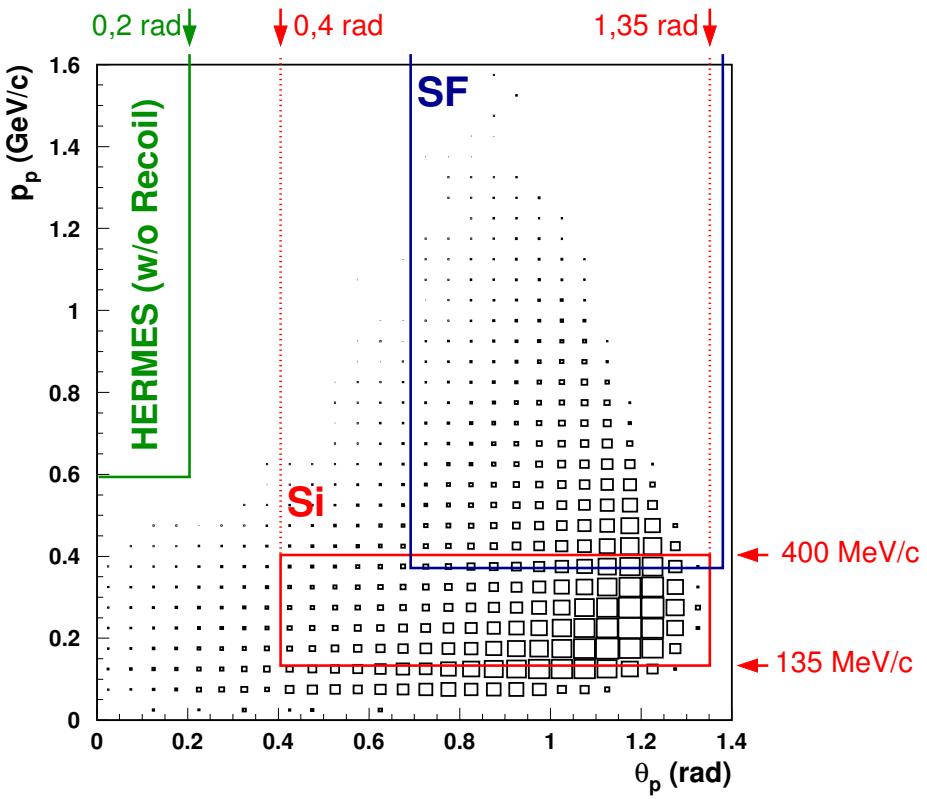
Acceptance: horizontal ± 170 mrad, vertical ± (40 - 140) mrad

now: exclusivity via missing mass

future: real exclusive measurement via additional detector for recoil protons

Design Requirements

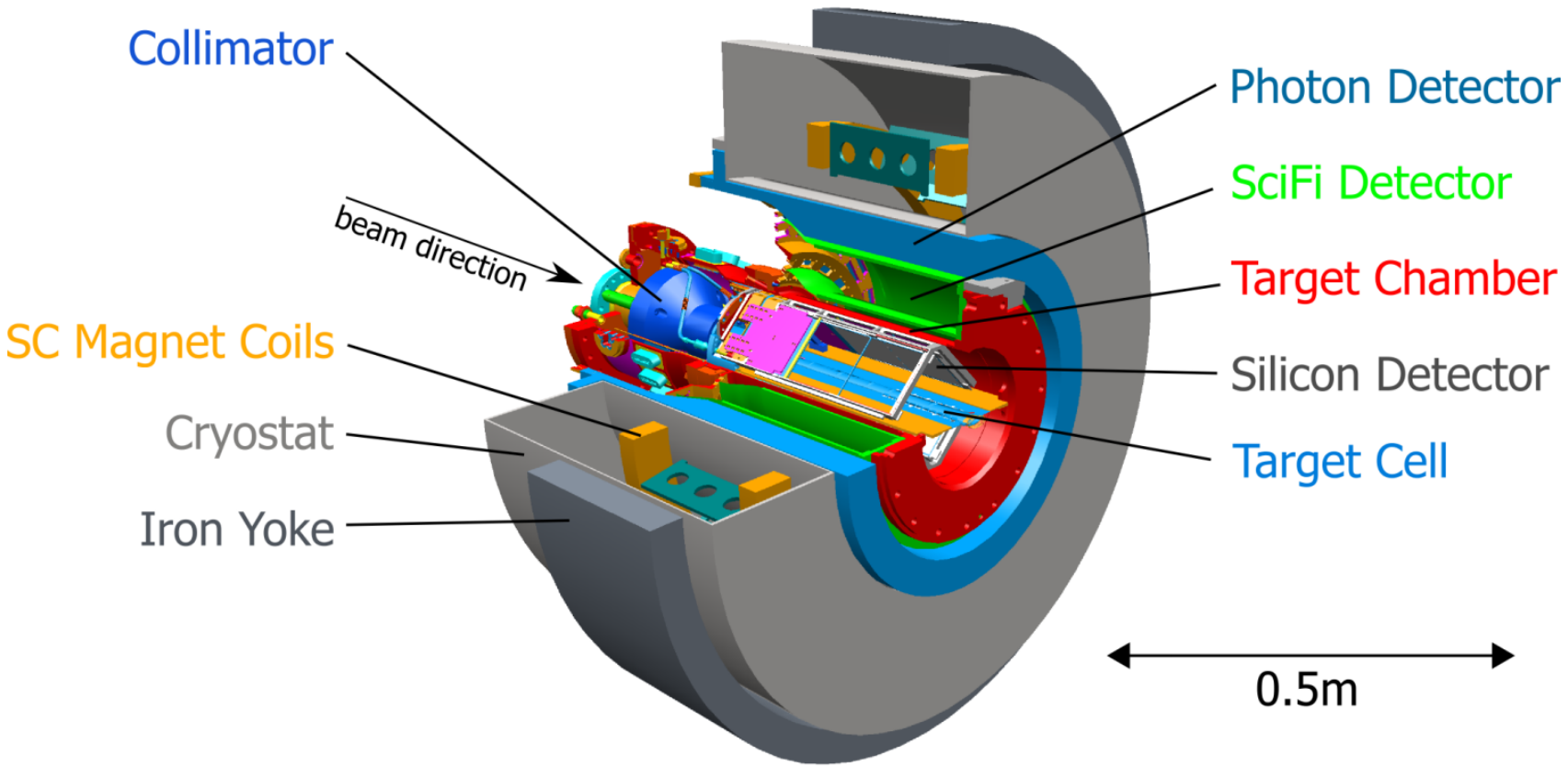




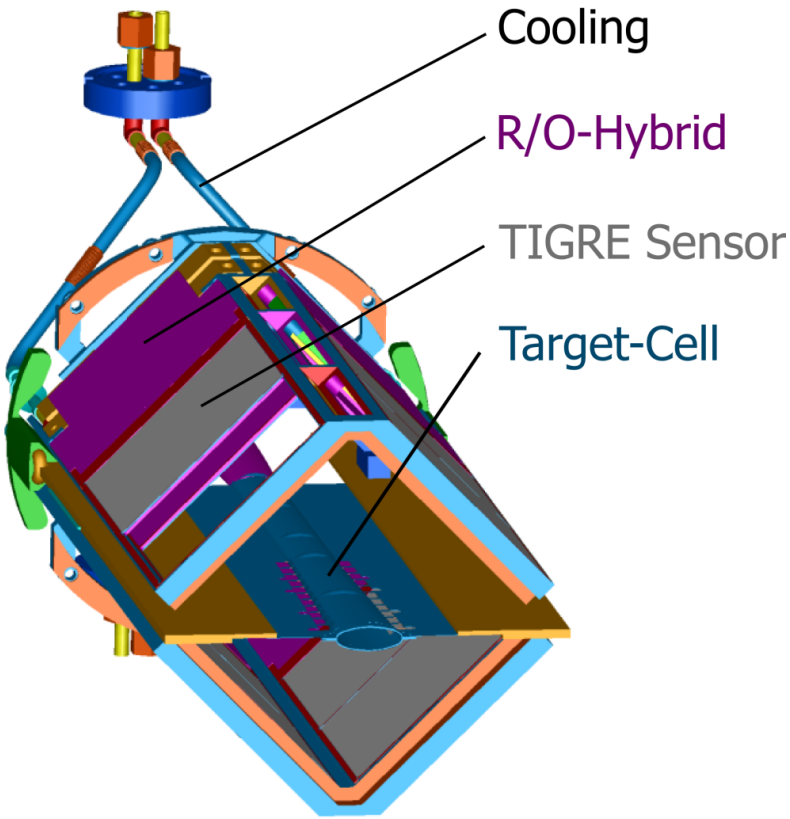
The detector should detect:

- Protons
  - Recoiling Protons (50 - 600 MeV/c)
  - Protons from decay of Δ-Resonances (< 1.4 GeV/c)
- Pions (< 800 MeV/c)
- Photons from π^0 decays

The Recoil Detector



Silicon Strip Detector



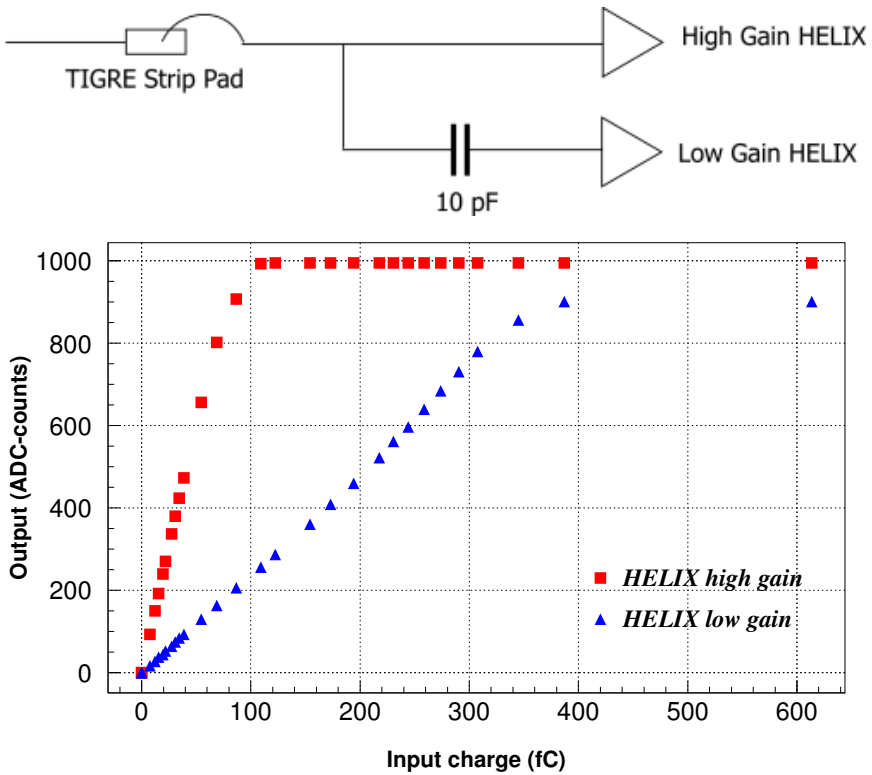
16 TIGRE sensors in two layers

- 10×10 cm^2, 300 μm thick
- double sided
- 128 strips per side (p$\perp$n), 758 μm strip pitch
- inside beam vacuum
- read-out chips need cooling

Provide:

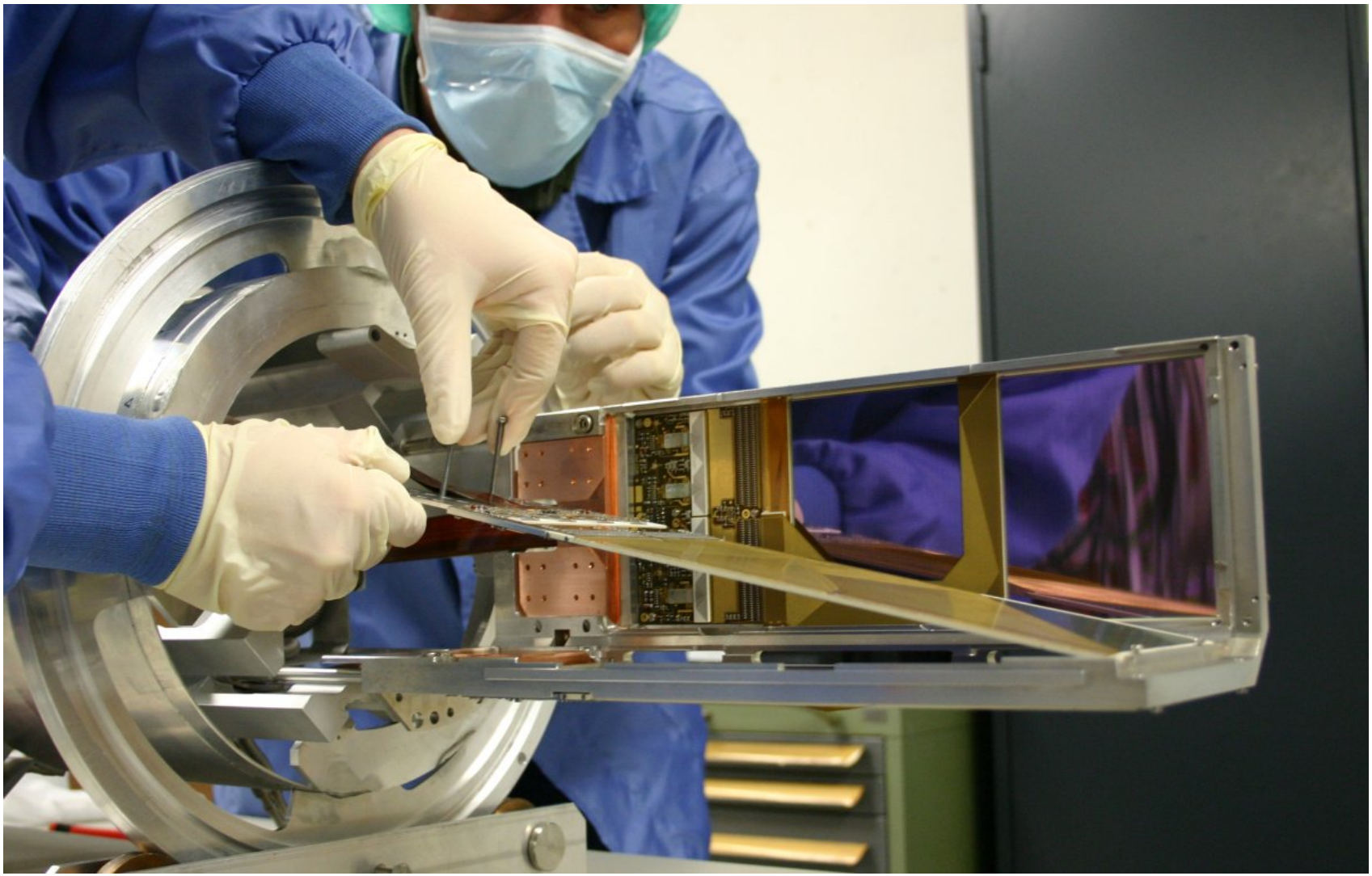
- energy measurement per dE/dx
- space points for tracking

Silicon Read Out

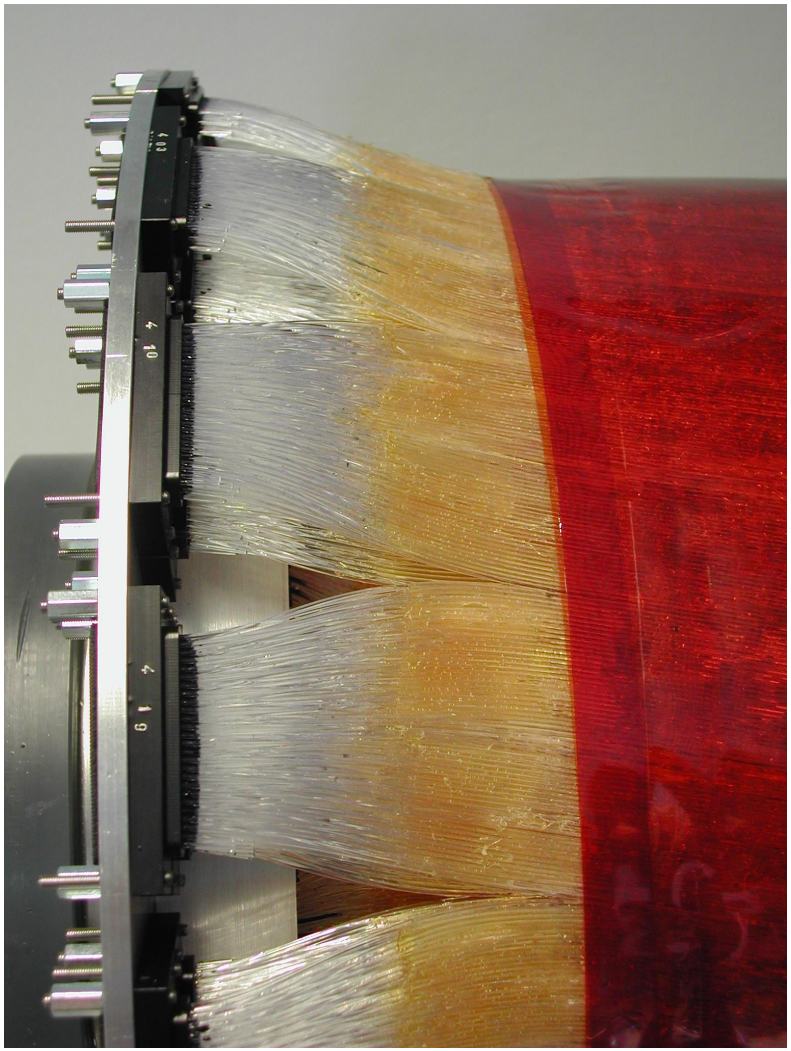


- Signal split into High- and Low-Gain-Channel
- 2 HELIX read-out chips per sensor side
- Resulting dynamic range of up to 350 fC (1 MIP ~ 3.5 fC)
- Signal to Noise of 6.5 for a MIP at Testbeam
- Calibrated at DESY T22 (e^-, MIP) and Erlangen Tandem Accelerator (low energy p) to < 2% error

Silicon Detector Installation



Scintillating Fibre Tracker



- 2 cylinders of 2×2 Layers, stereo-angle 10°
- 1 mm round fibres, 5120 channels in total
- 64 Channel PMTs
- read out using GASSIPLEX chips (sample and hold)
- TDC for timing information

Provides

- space points for tracking
- proton momentum measurements

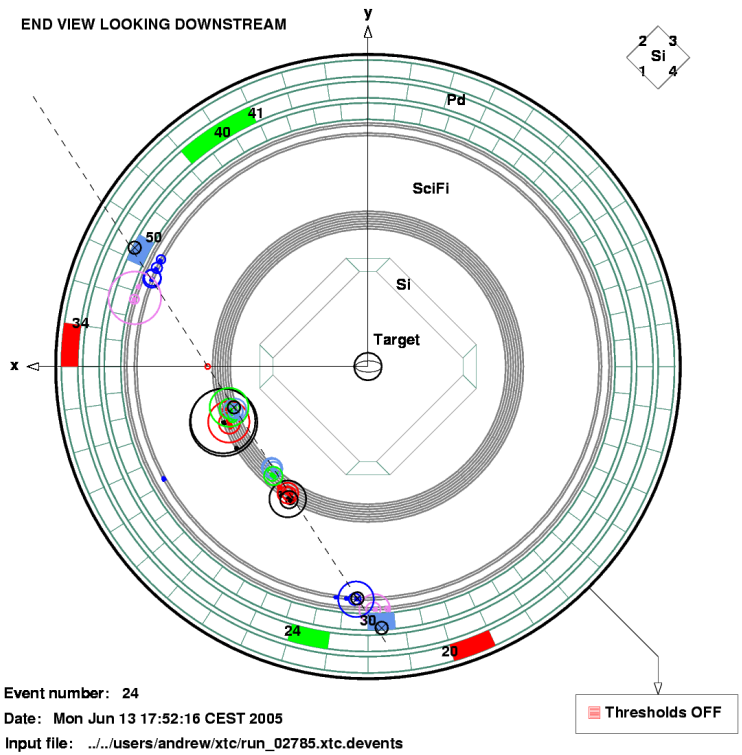
Photon Detector

- 3 layers of scintillators $2 \times 1 \times 28$ cm, 164 channels
- tungsten convertor before each layer
- 1 layer parallel to beam, 2 stereo layers at $\pm$ 45°
- read out with 64 channel PMTs

Provides:

- Photon detection from $\Delta^+ \rightarrow p\pi^0$
- Pion/Proton PID for $p >$ 600 MeV/c
- cosmics trigger

Cosmics Test



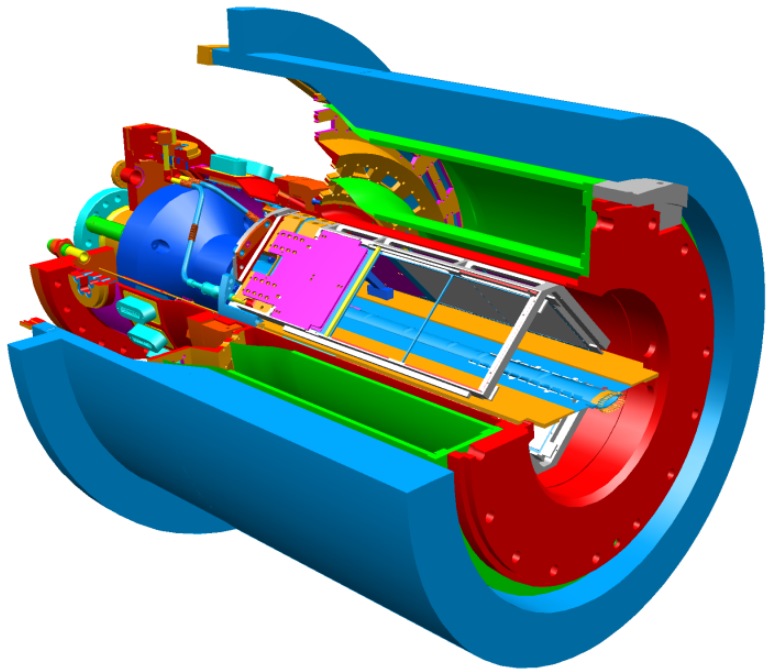
Detector fully mounted and in operation at a test site, cosmics run until August 2005.

- Successful operation with magnetic field on
- All detectors see Muons
- Tracking and resolution studies underway
- Calibration for SciFi and PD

Overview and Outlook

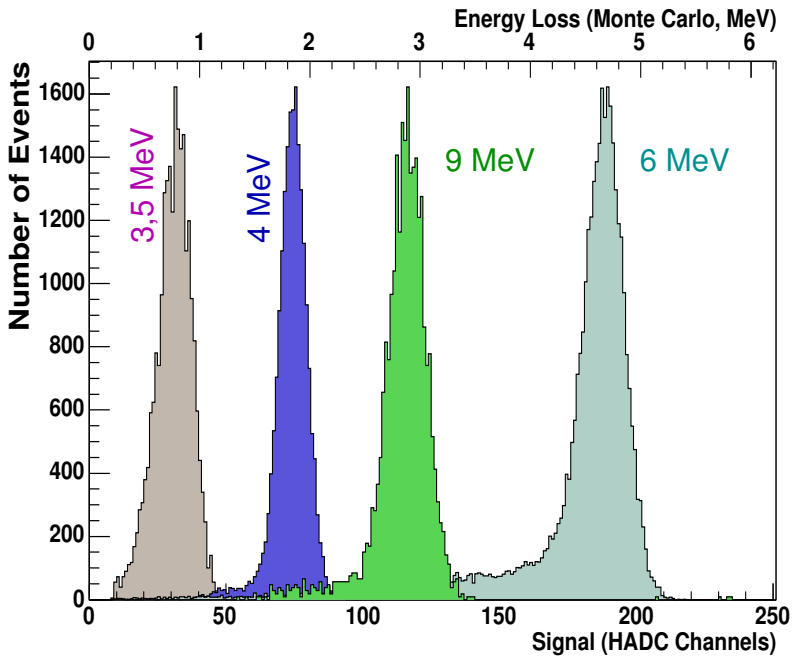
The HERMES Recoil Detector is ready for installation in December 2005.
It consists of

- a silicon strip detector for tracking and energy measurements
- a scintillating fibre tracker
- a photon detector



The aim of the detector is to guarantee exclusivity on a single event base to provide measurements of asymmetries which allow access to GPDs.

Si-Calibration



Silicon calibrated

- at DESY T22 with 3 GeV/c electrons (error ~ 2%, high gain channel only)
- at Erlangen Tandem facility with 60 - 150 MeV/c protons (error < 2%, high and low gain channel)