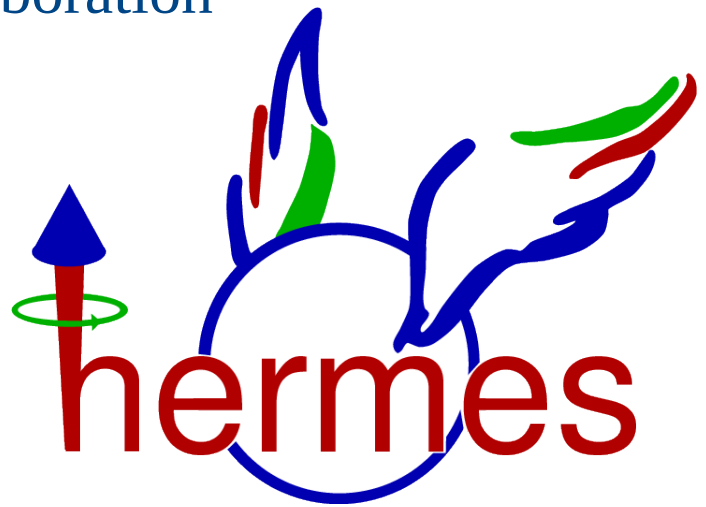
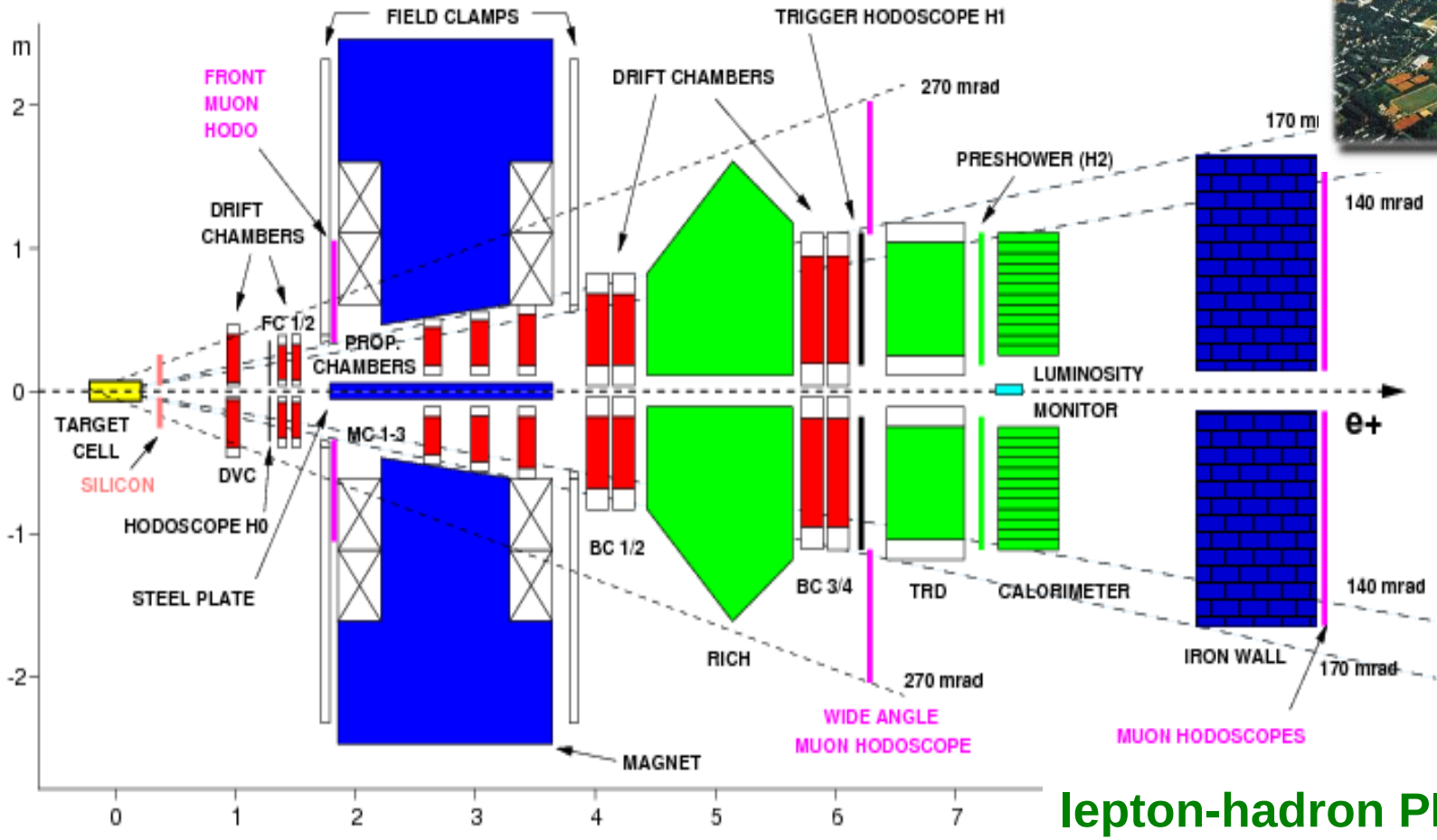
The HERMES Recoil Detector

Charlotte Van Hulse, University of Ghent
on behalf of the HERMES collaboration



TIPP09

HERMES: HERA MEASUREMENT of SPIN



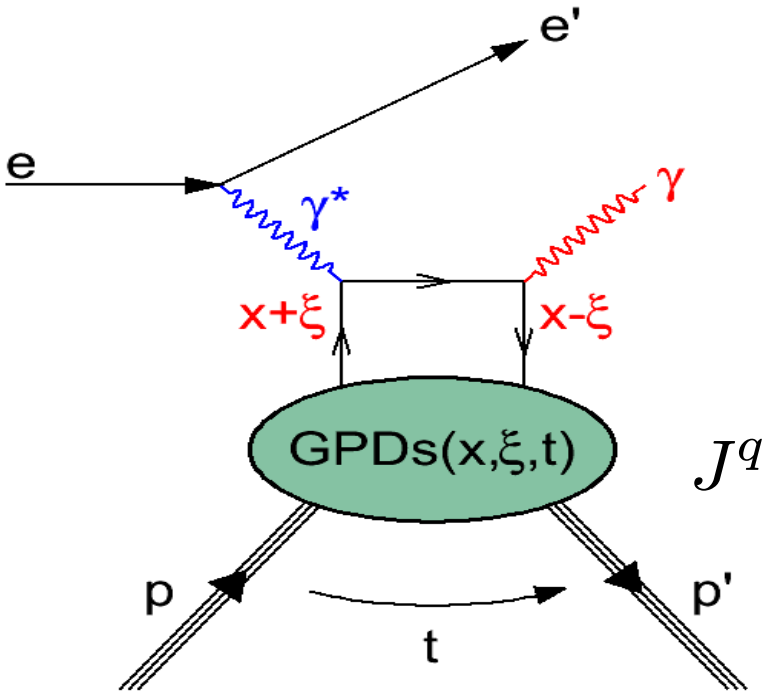
data taking from 1995 until June, 30 2007

lepton-hadron PID efficiency:~98%
hadron PID: RICH 2-15 GeV/c
$\delta E\gamma/E\gamma \cong 5\%$
$\delta P/P < 2\%$
$\Delta\theta < 1$mrad

Beam
longitudinally pol.
e^+ & e^-
E= 27.6 GeV

Gaseous internal target
longitudinally pol. H,D,He
transversely pol. H
unpol. H,D,Ne,Kr,..

Deeply virtual Compton scattering



nucleon spin decomposition

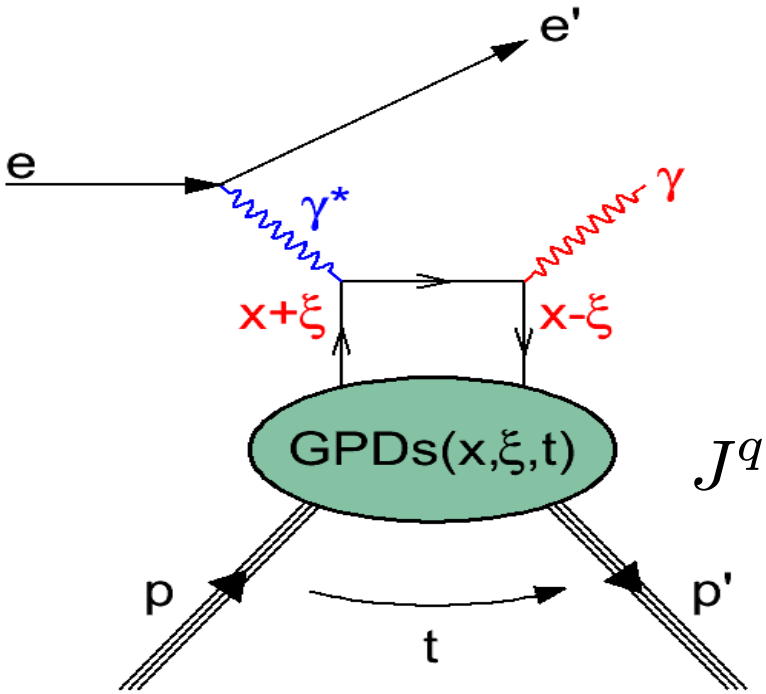
$$\frac{1}{2} = \sum_q J^q + J^g$$
$$= \frac{1}{2}\underbrace{\Delta\Sigma}_{\sim 30\%} + \sum_q L^q + J^g$$

$$J^q = \lim_{t\to 0}\frac{1}{2}\int_{-1}^{1} dx x[H^q(x,\xi,t) + E^q(x,\xi,t)]$$

GPDs

access quark orbital angular momentum

Deeply virtual Compton scattering



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GPDs

access quark orbital angular momentum

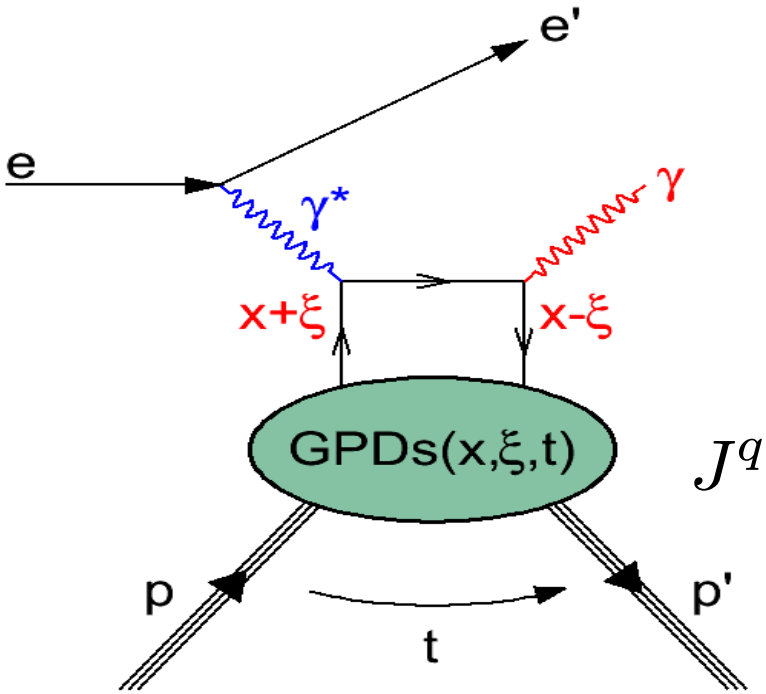
deeply virtual Compton scattering (DVCS) at HERMES

- reconstruction by detecting e' and γ
- background contributions:
  - associated Bethe-Heitler ~12%:

$$\Delta^+ \to p\pi^0 \to p\gamma\gamma$$
$$\to \pi^+ n$$

  - semi-inclusive ~3%

Deeply virtual Compton scattering



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$$\Delta^+ \to p\pi^0 \to p\gamma\gamma$$
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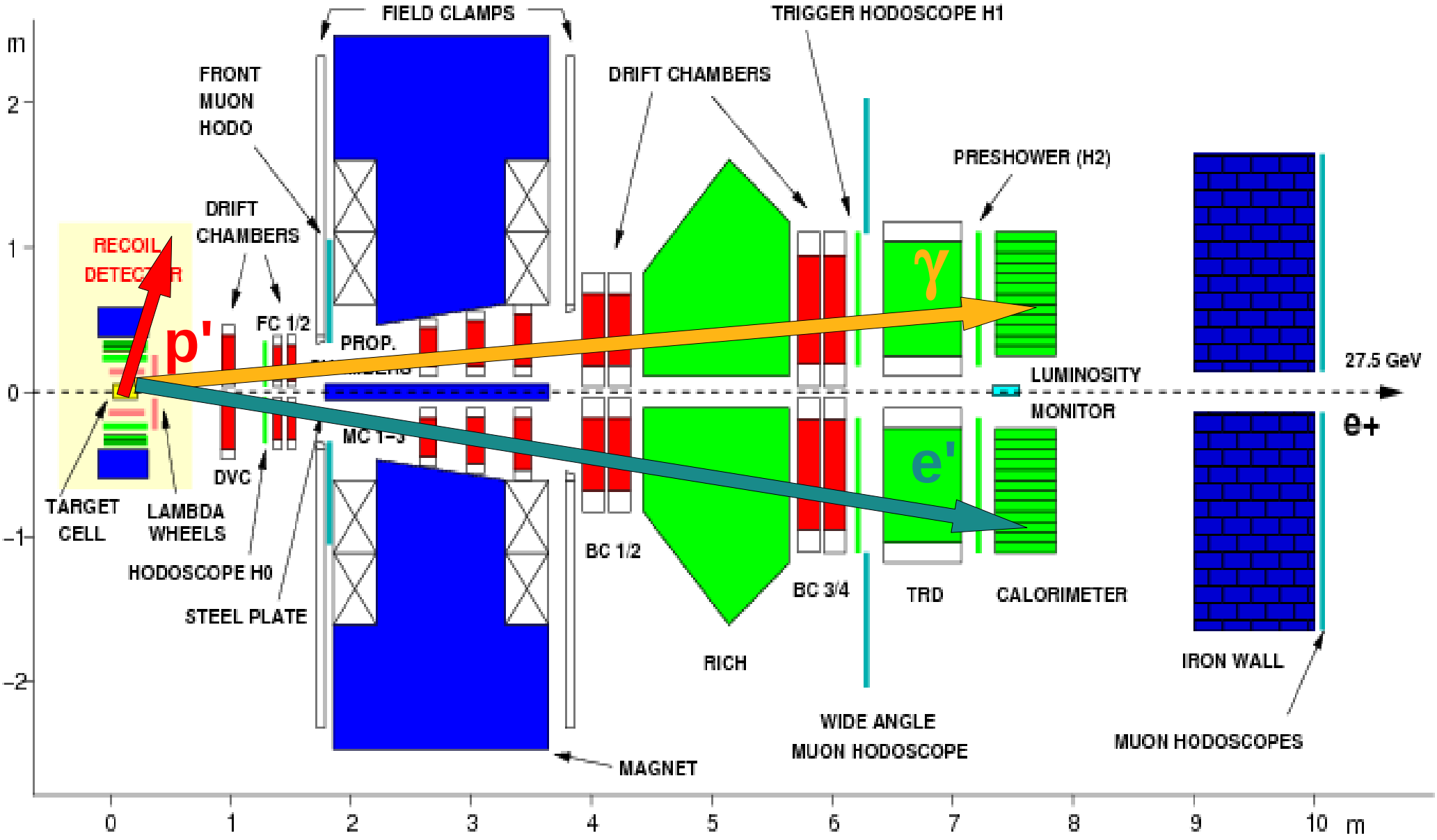
  - semi-inclusive ~3%

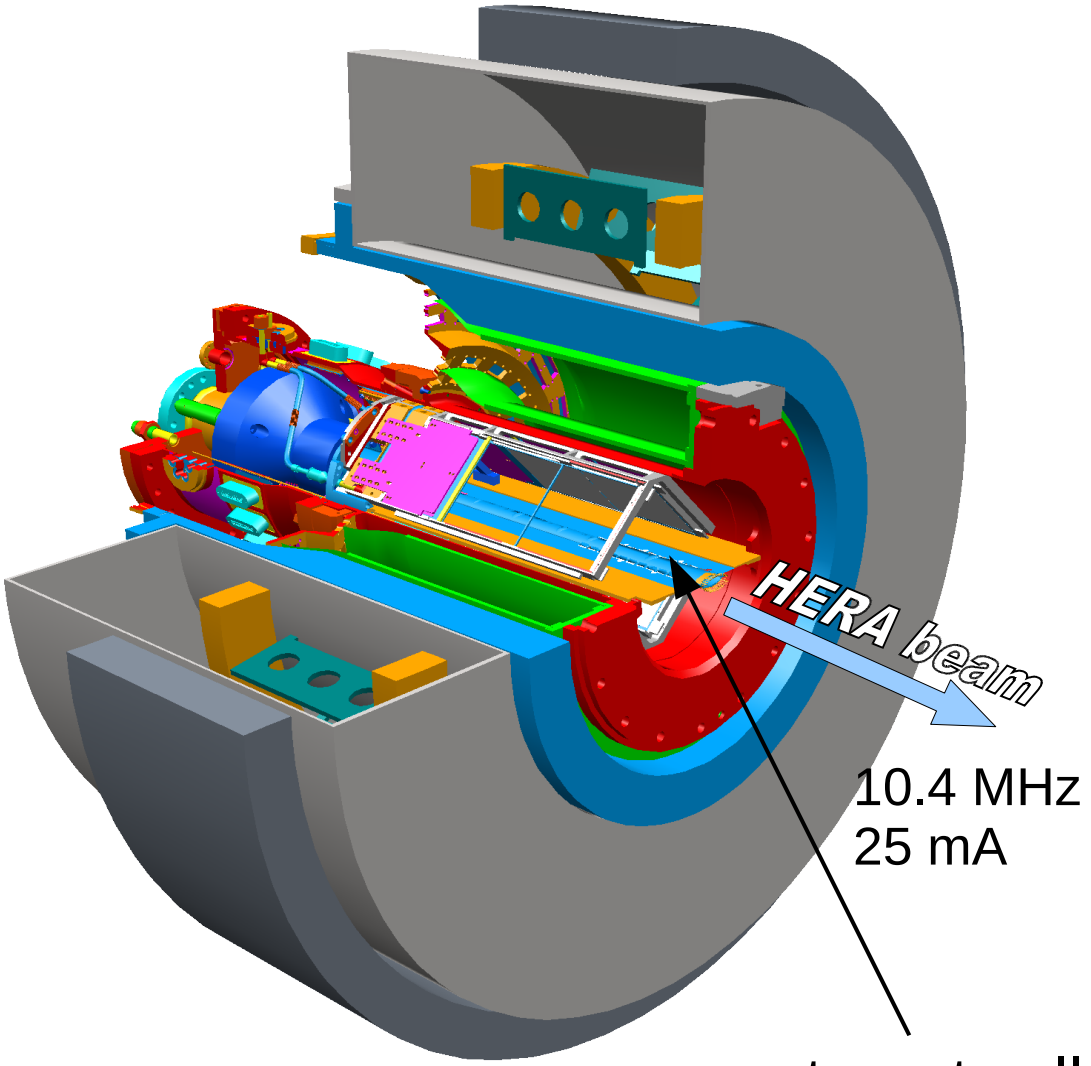
improve exclusivity and reduce background by detecting recoil proton photons and pions

Installation of the Recoil Detector in 2006



Recoil Detector: background contribution to DVCS ⟶ 1%

Recoil detector

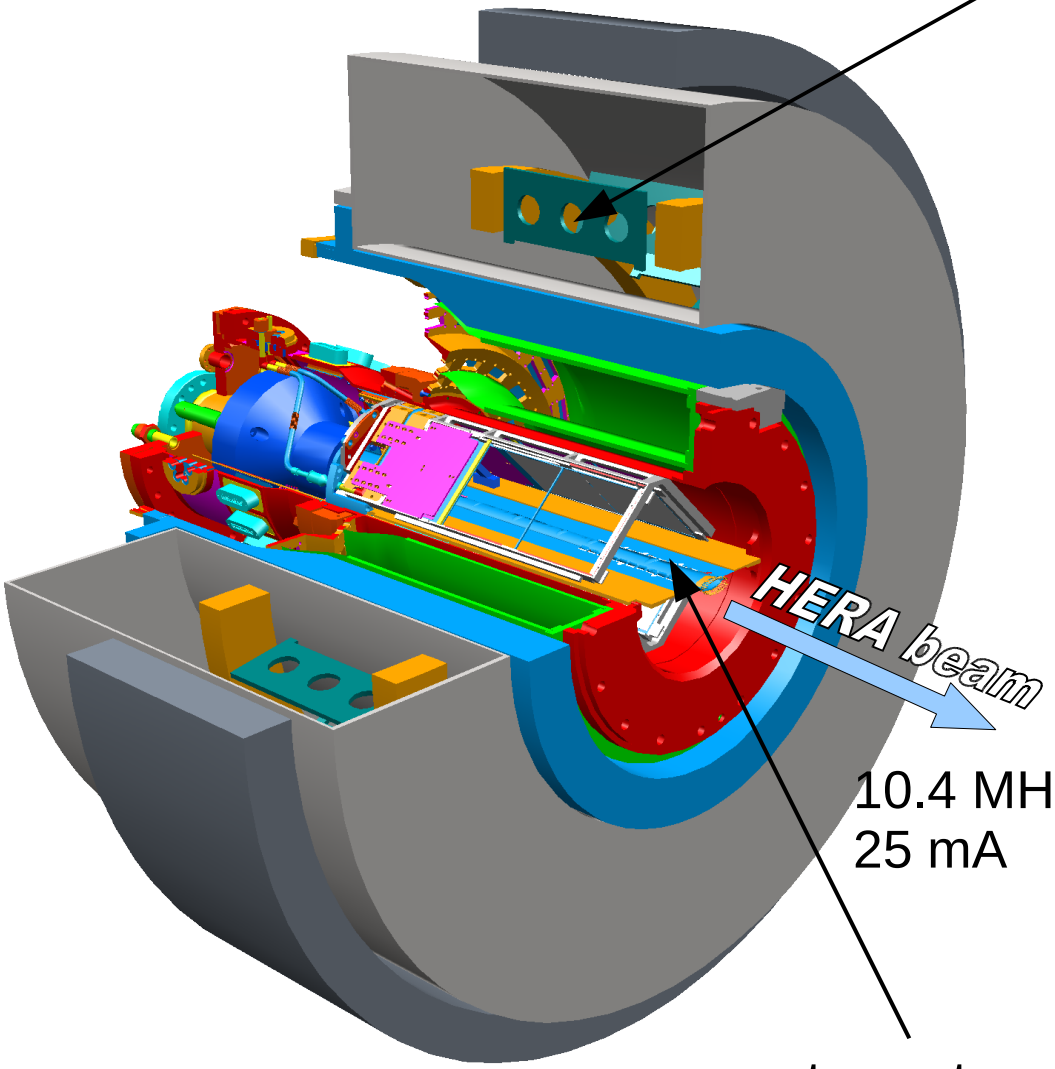


10.4 MHz
25 mA

target cell:
unpolarized H or D

Recoil detector

1 Tesla superconducting solenoid



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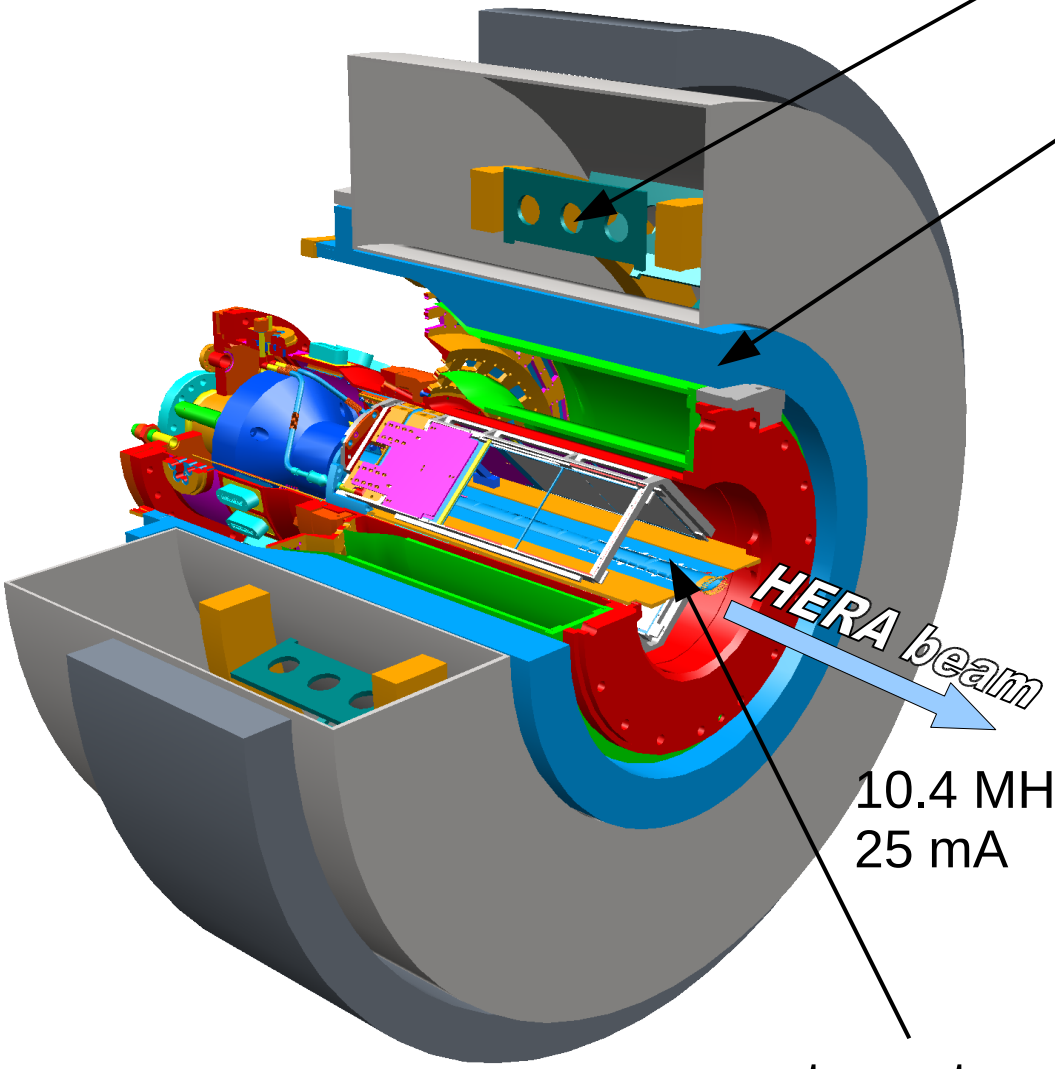
Recoil detector

1 Tesla superconducting solenoid

Photon Detector (PD)

detect γ's
p/π for p > 0.6 GeV/c



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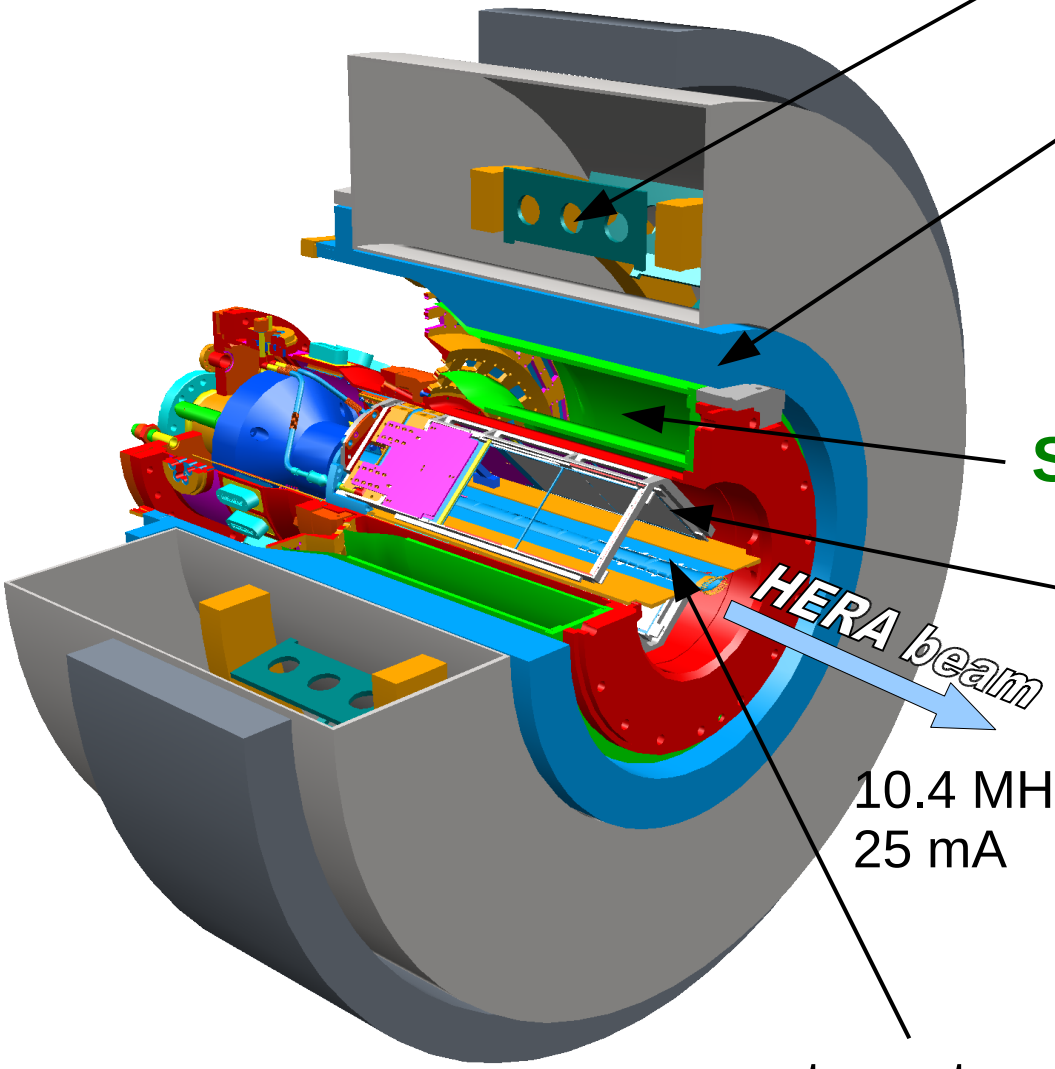


1 Tesla superconducting solenoid

Photon Detector (PD)

detect γ's
p/π for p > 0.6 GeV/c

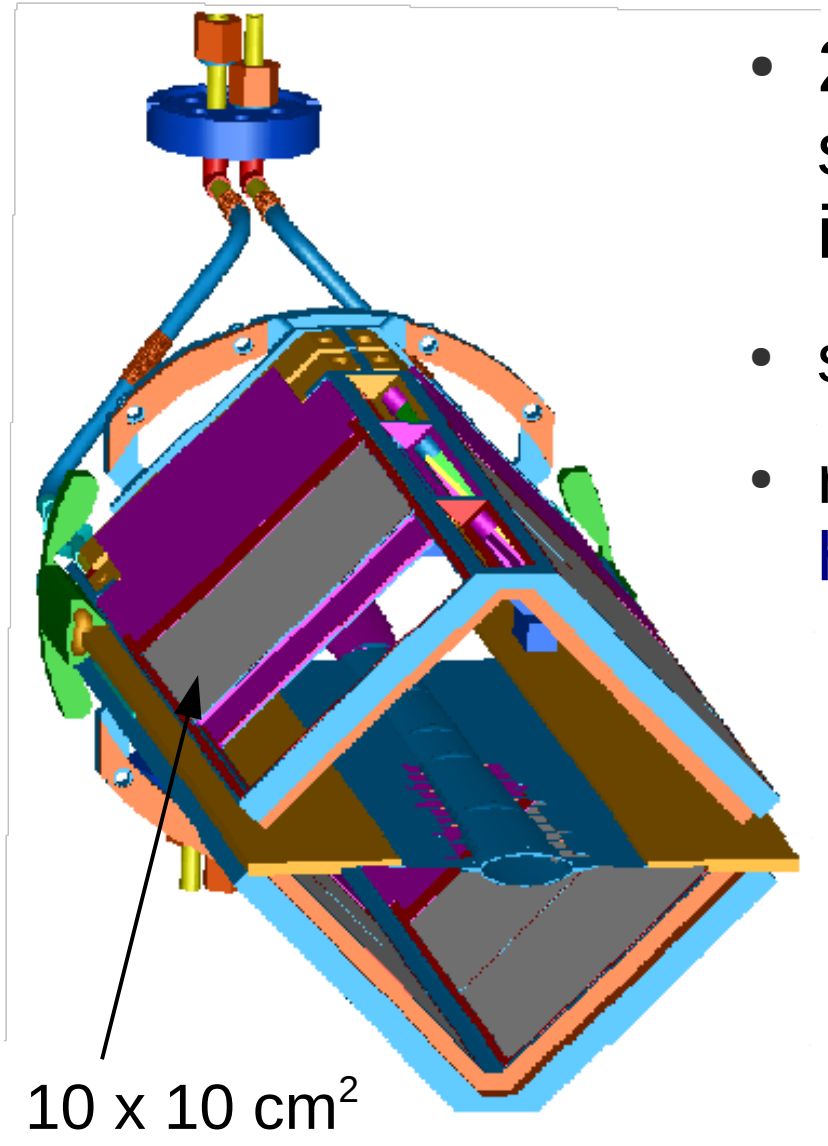
Scintillating Fiber Tracker (SFT)
&
Silicon Detector (SD)

p_p in [0.125,1.40] GeV/c
p/π for p < 0.6 GeV/c
76% azimuthal acceptance

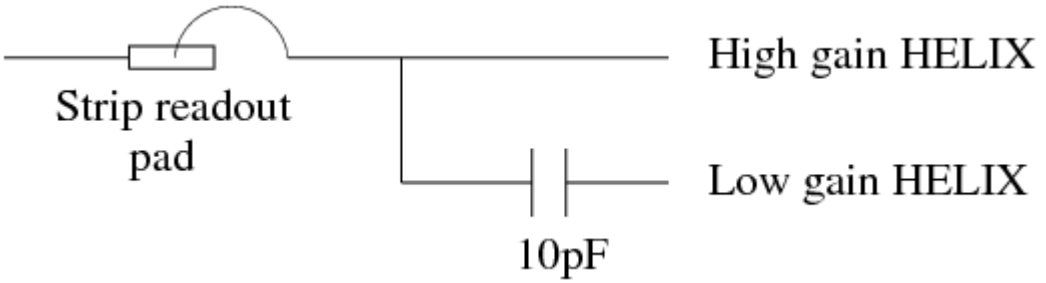
10.4 MHz
25 mA

target cell:
unpolarized H or D

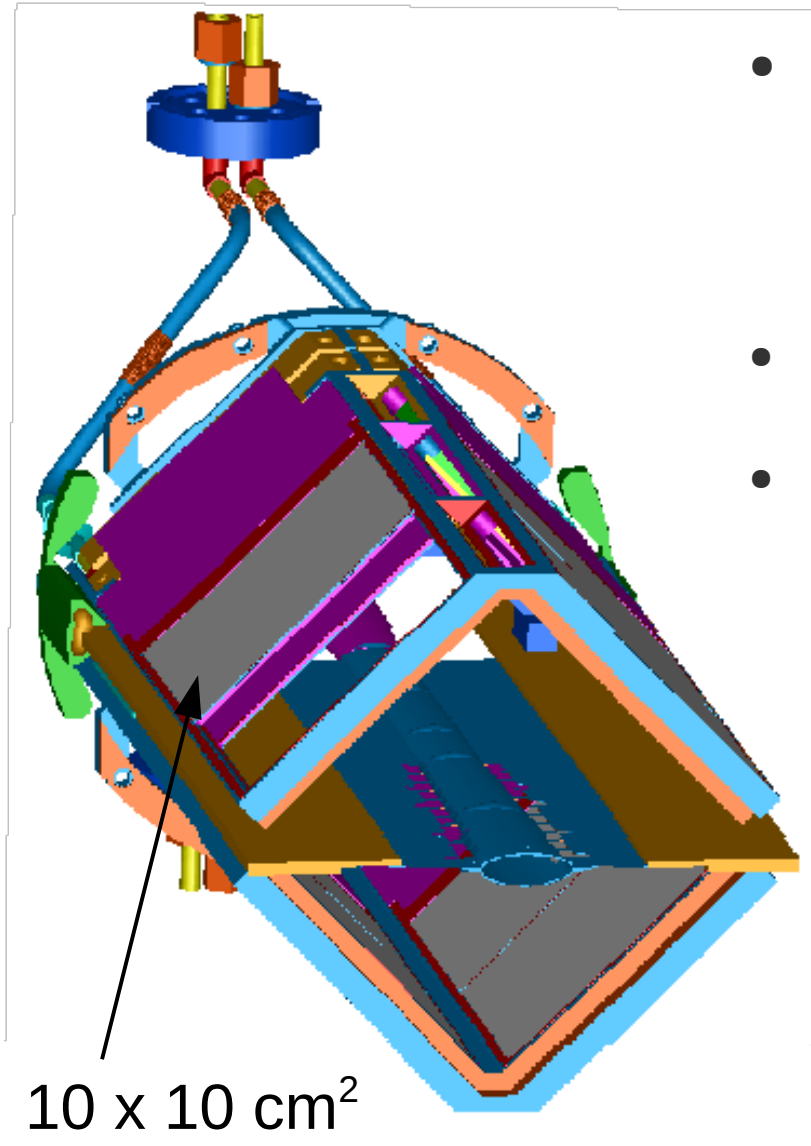
Silicon Detector



- 2 layers of double-sided silicon micro-strip sensors in beam vacuum
- strips: $\perp$, pitch=758 μm, 300 μm thick
- read out by HELIX chips: high and low gain ⟶ 1-70 MIPs



Silicon Detector



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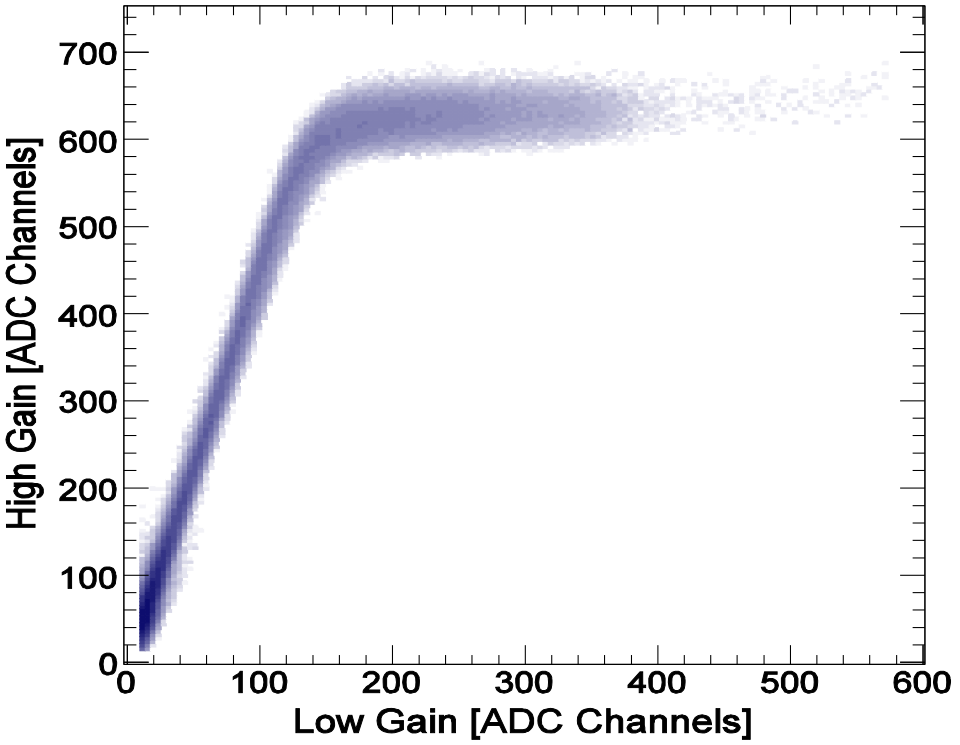
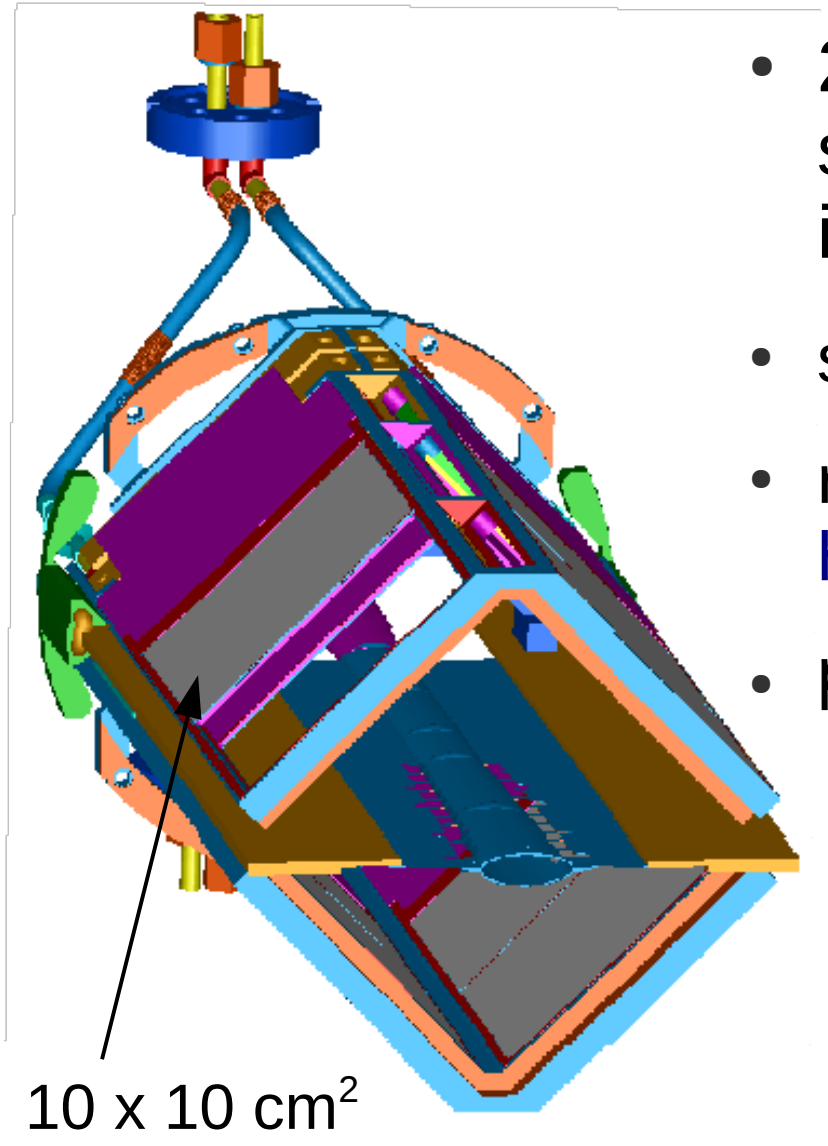


Silicon Detector



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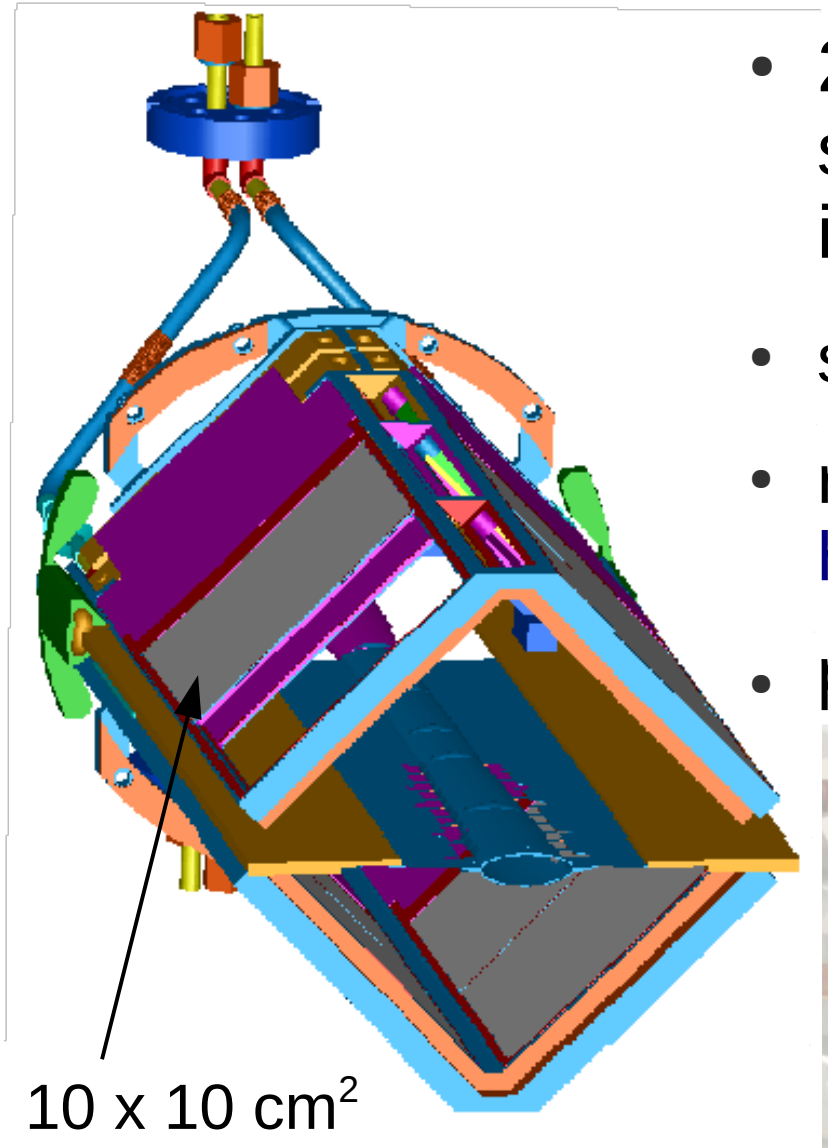
- p_p: 0.125-0.450 GeV/c

Silicon Detector



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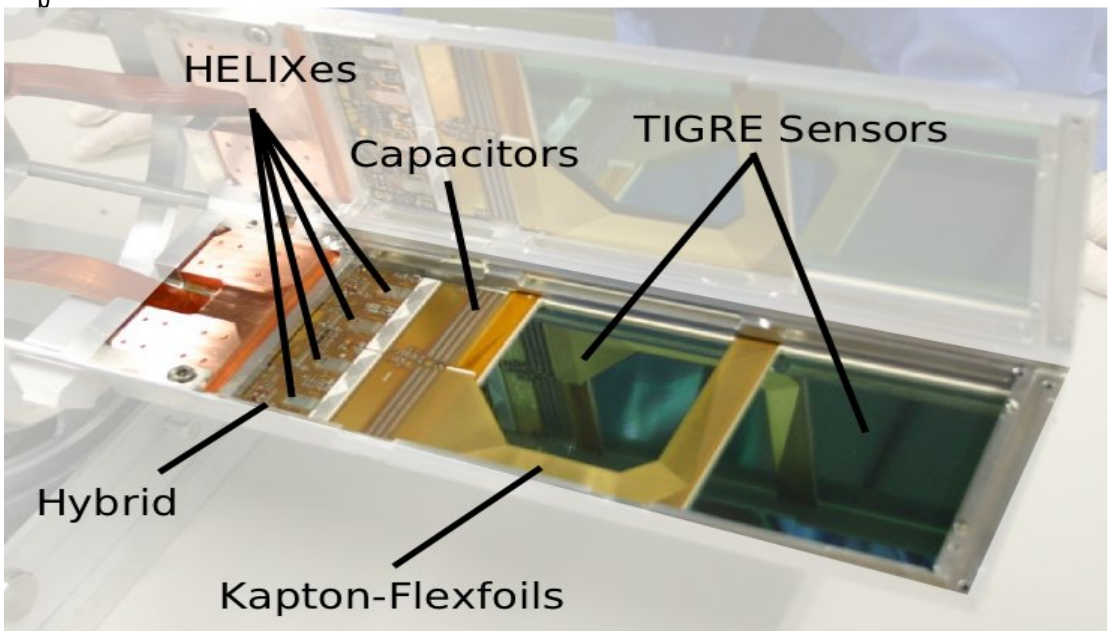
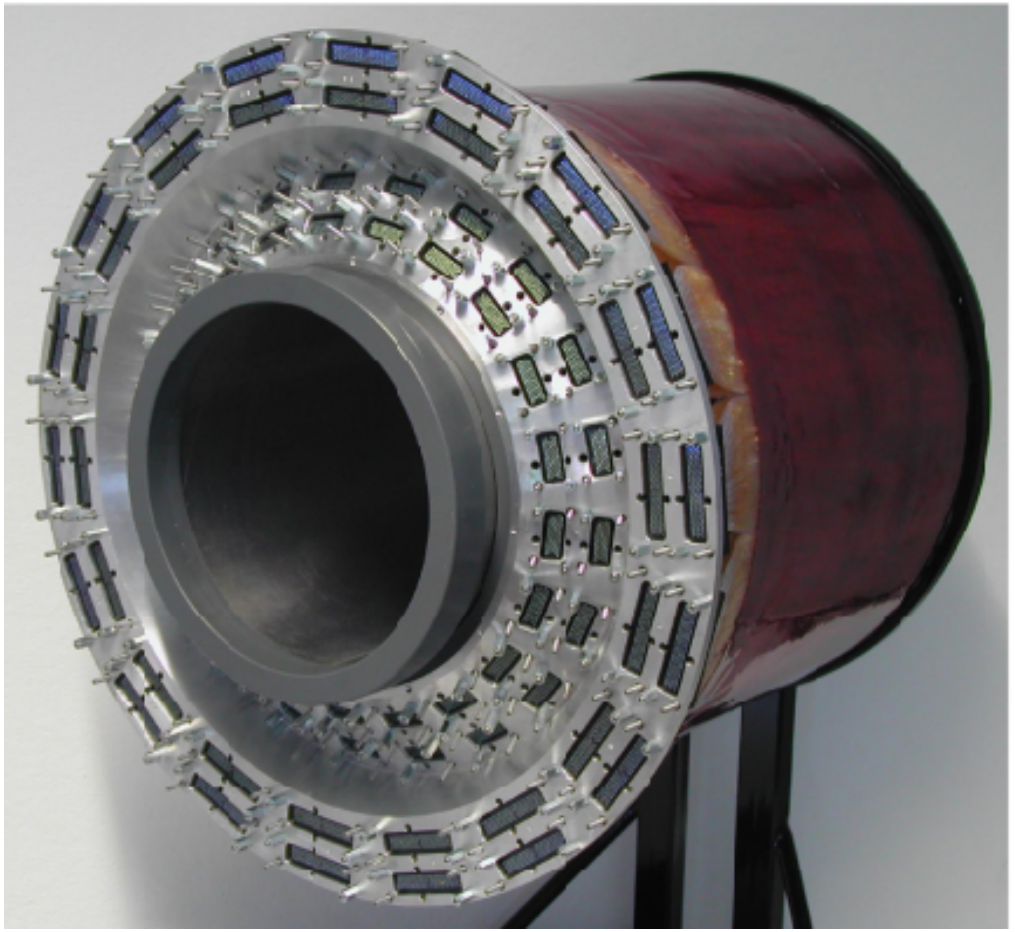
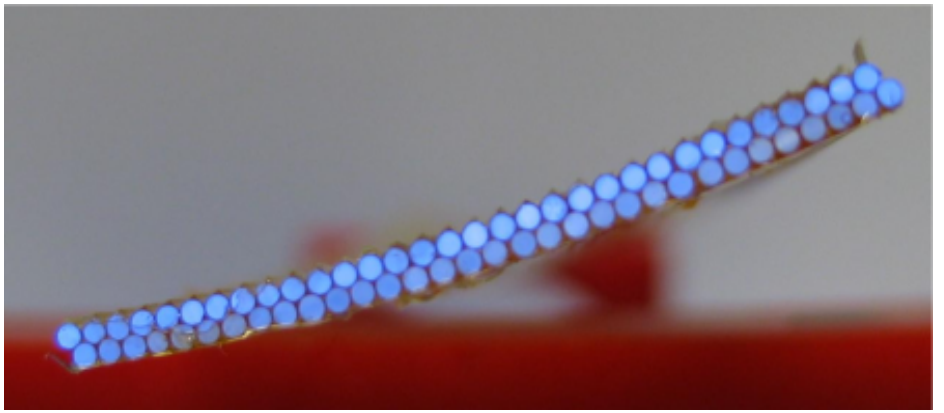


Scintillating Fiber Tracker



- 2 cylinders
  - 2 parallel layers
  - 2 10°-stereo layers
- fibers: 1 mm diameter



- read out: multi-anode PMTs
- GASSIPLEX chips: 1-5 MIPs
- p_p: 0.25-1.40 GeV/c from bending in magnetic field

Photon Detector

- 3 layers of tungsten-scintillator:

  A layer parallel to beam axis
  B/C layer under +45°/-45° angle

W: 1 r.l. = 3.5 mm

- strips: 2x1x28 cm^3
- read out: multi-anode PMTs
- detect γ's from decaying π^0
- p/π separation $p > 0.6$ GeV/c

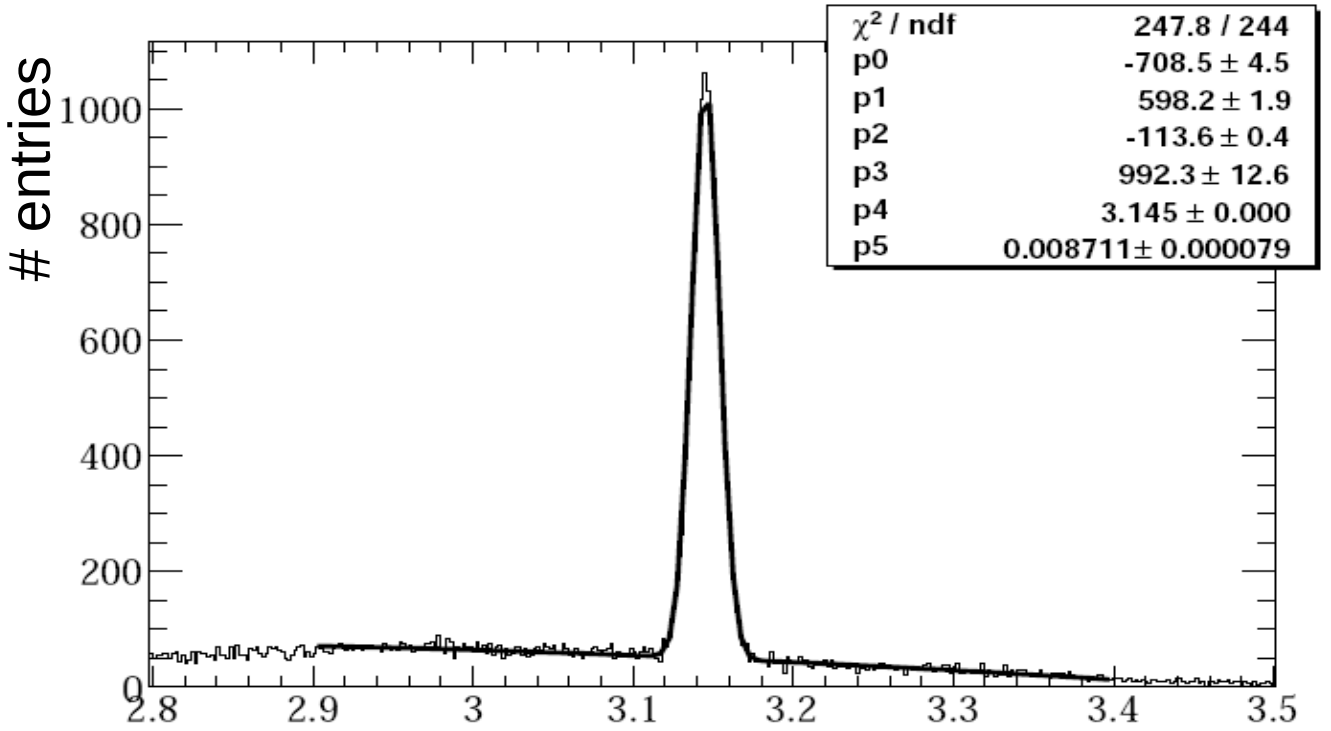
Performance of the Recoil Detector

- February 2006: first data taking with e^- beam
  Scintillating Fiber Tracker operational
- March 2006: problems with target cell
- May 2006: de-installation and repair of Silicon Detector
- June 2006: re-installation of Silicon Detector
- July 2006: switch to e^+ beam
- September: all detectors operational, 95% data taking efficiency
- June 2007: end of data taking
- amount of collected data

e^- beam, SFT only	e^+ beam, all detectors
H: 3 M DIS	H: 28 M DIS
D: 0.8 M DIS	D: 7 M DIS

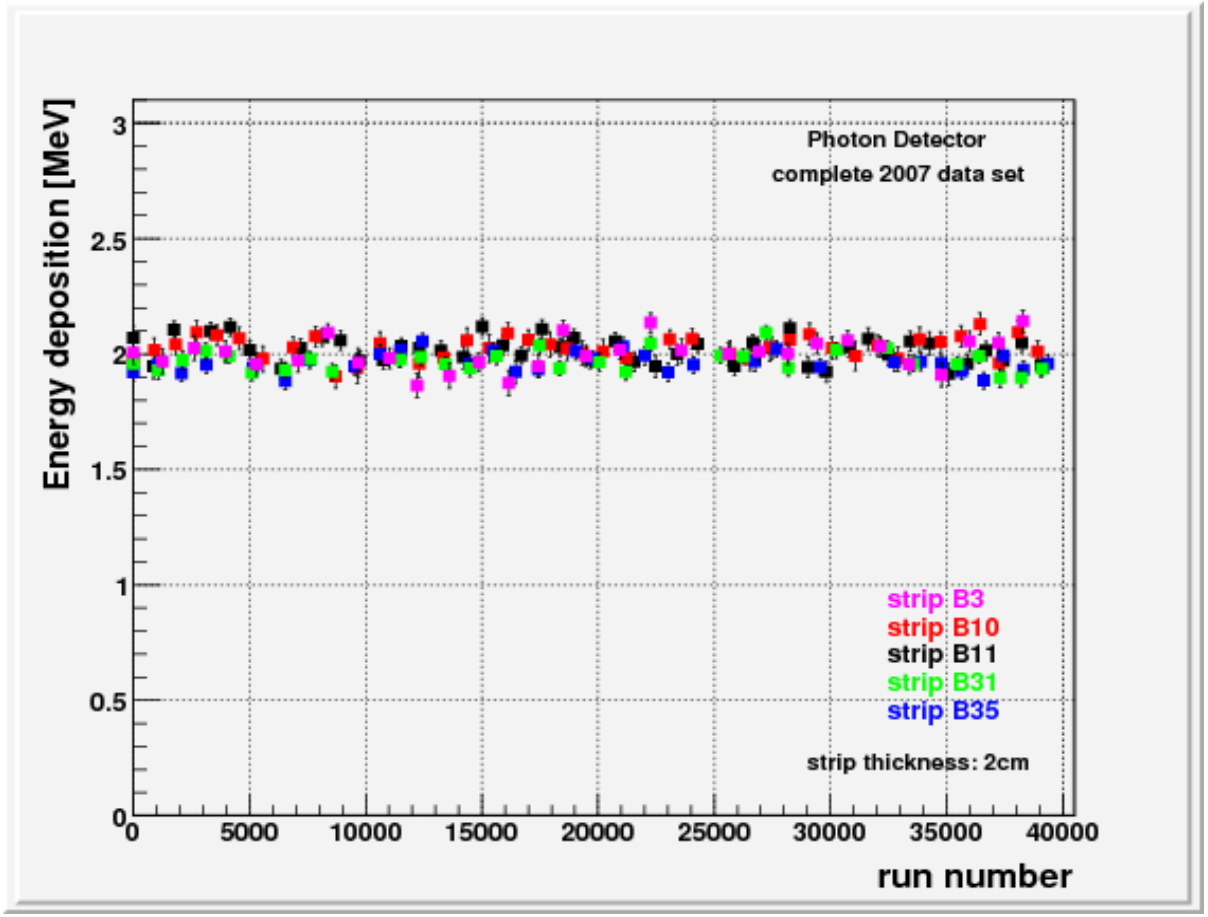
Alignment of the Recoil Detector

- relative alignment of detectors:
  signals from cosmics and straight tracks (magnet-off)
- alignment Recoil Detector wrt. forward spectrometer: e-p elastic



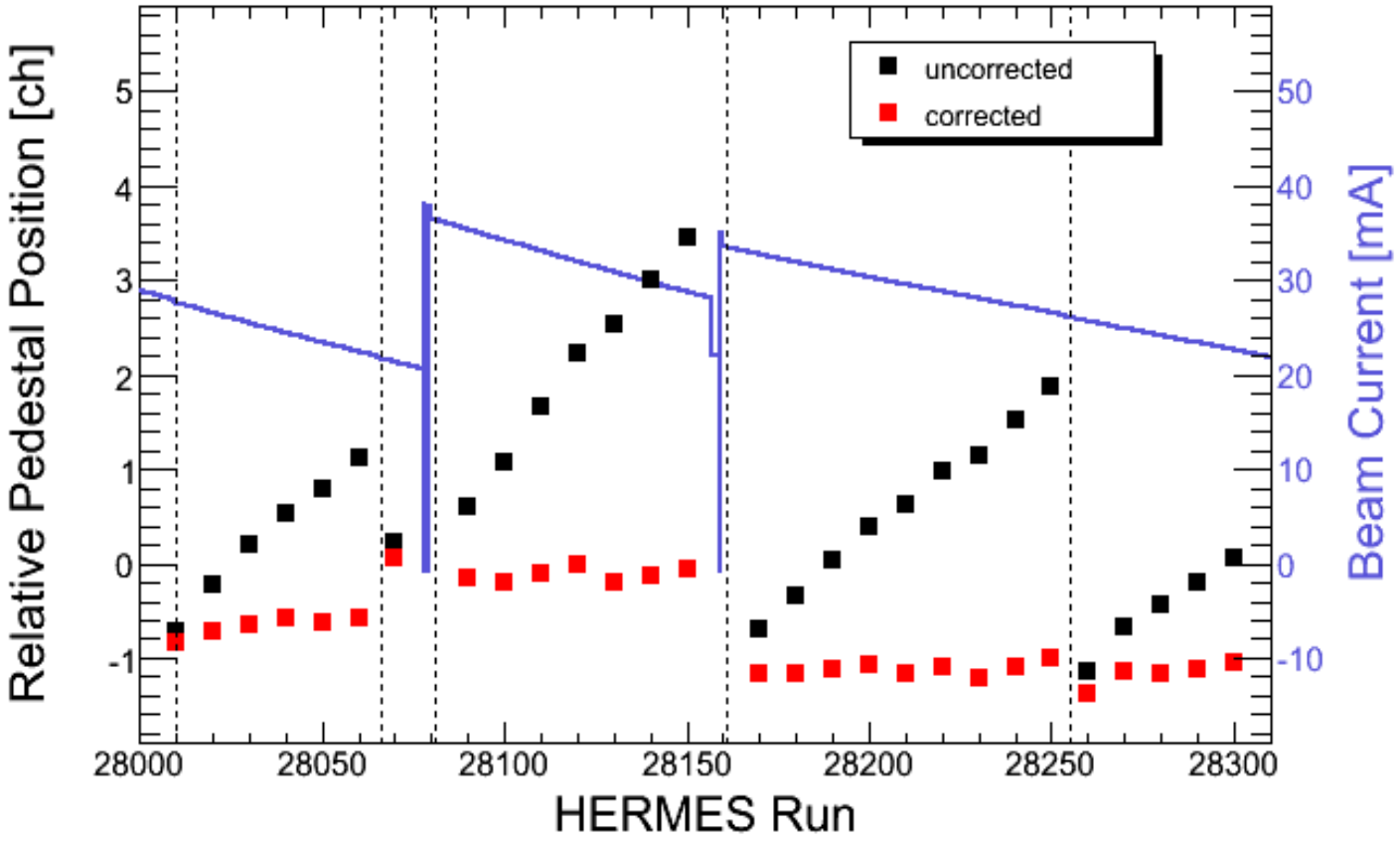
Calibration SFT and PD

- pedestal stable
- SFT and PD: signal from minimum-ionizing pions



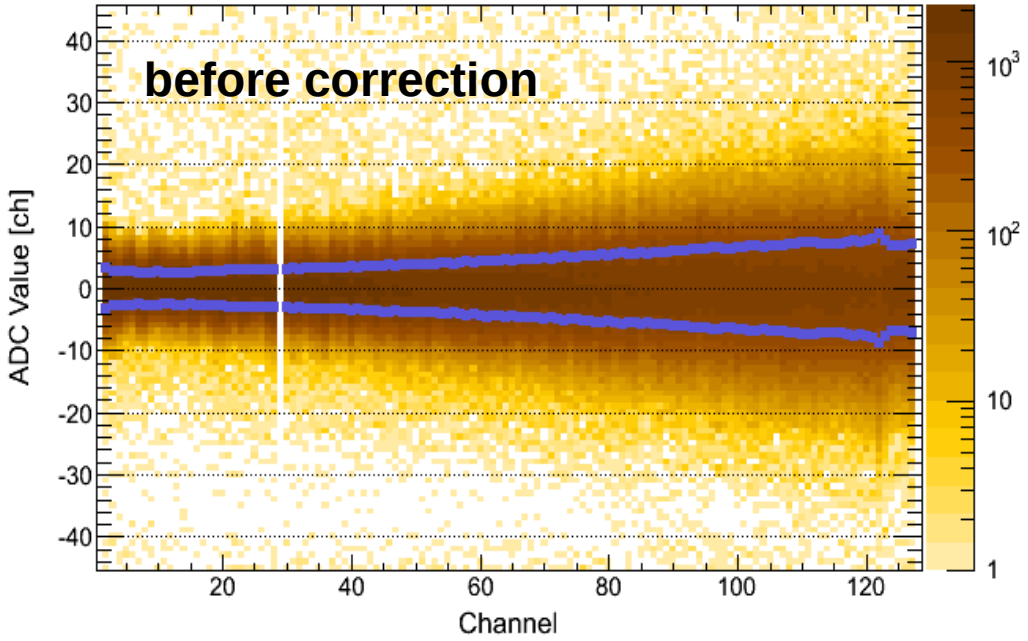
Calibration SD I

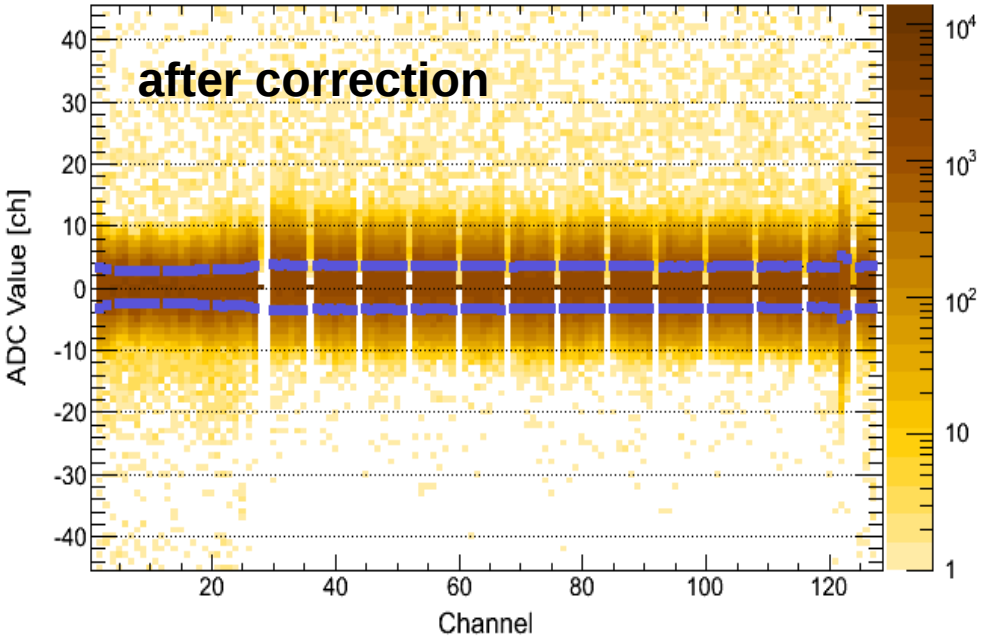
- correction for drifting pedestal with beam current



Calibration SD I

- correction for drifting pedestal with beam current
- correction for correlated noise



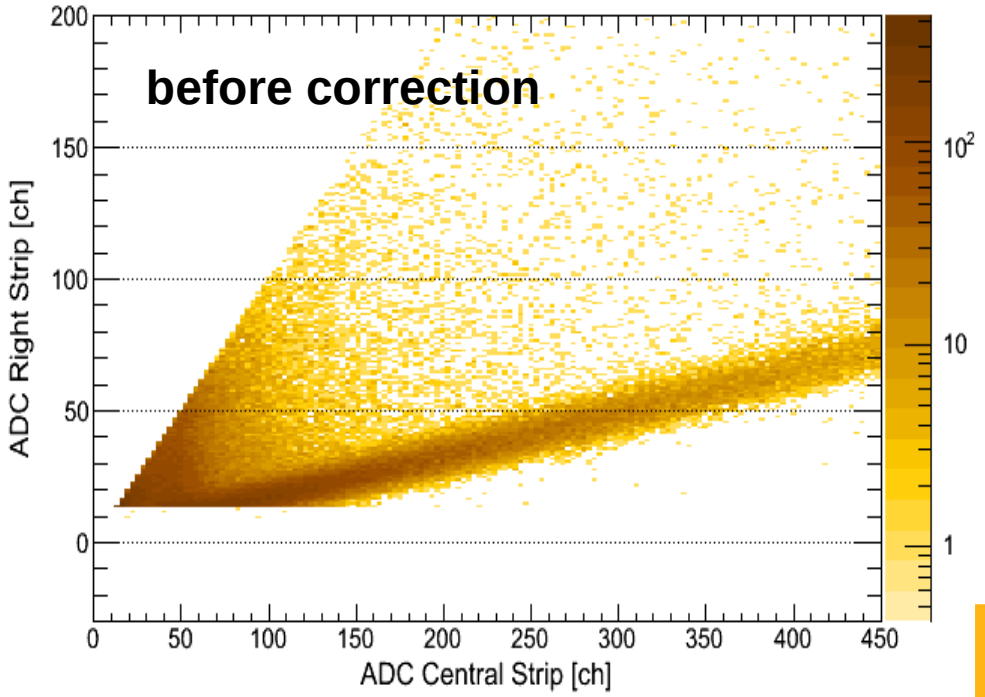


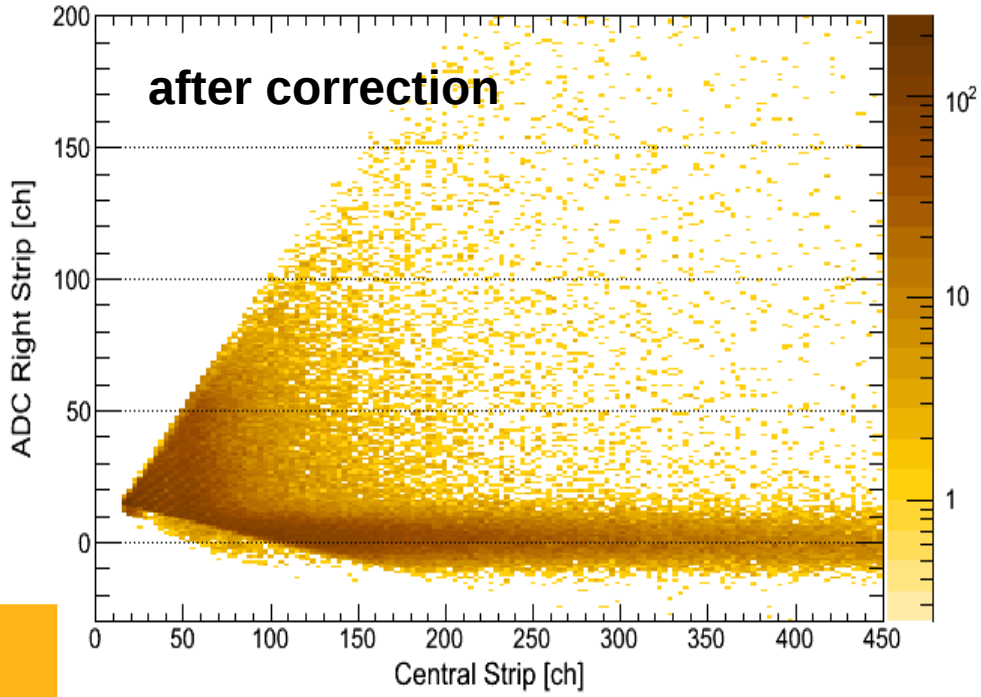
after common mode noise correction (based on 32 first channels of chip), increase of pedestal width with strip number

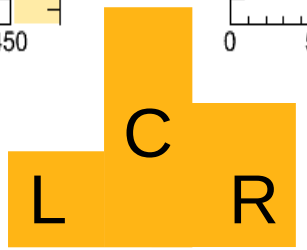
read out every 8th strip unsparsified (= 90% of data written to tape)
correction via spline interpolation

Calibration SD I

- correction for drifting pedestal with beam current
- correction for correlated noise
- correction for cross-talk





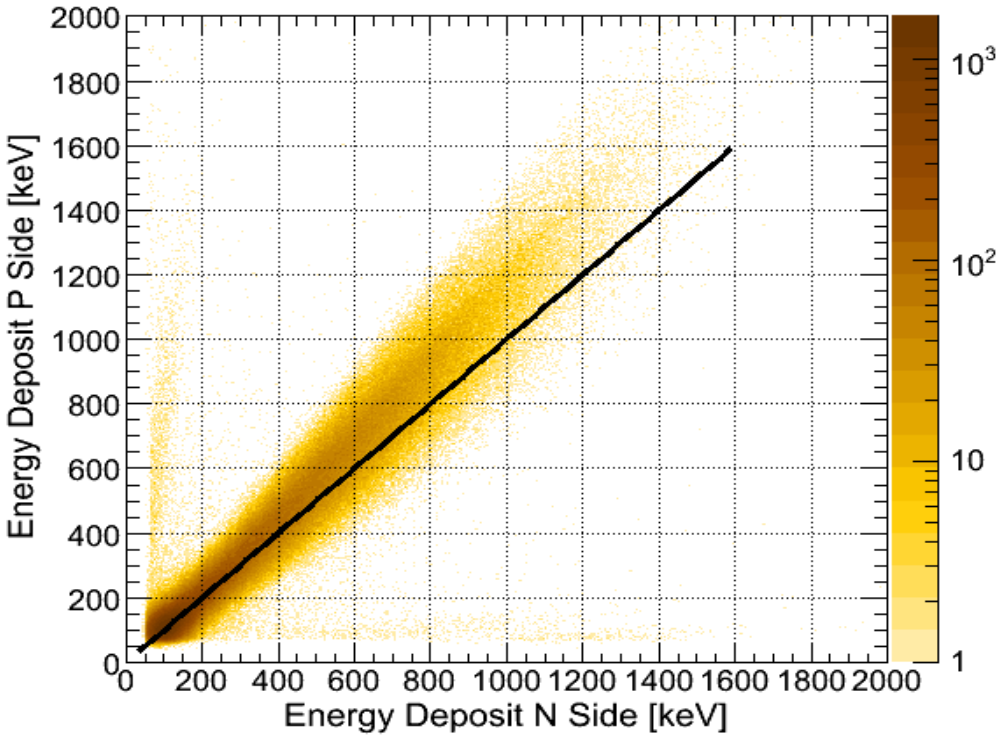


11-16% 15-21%

correction coefficients stable over full data taking period

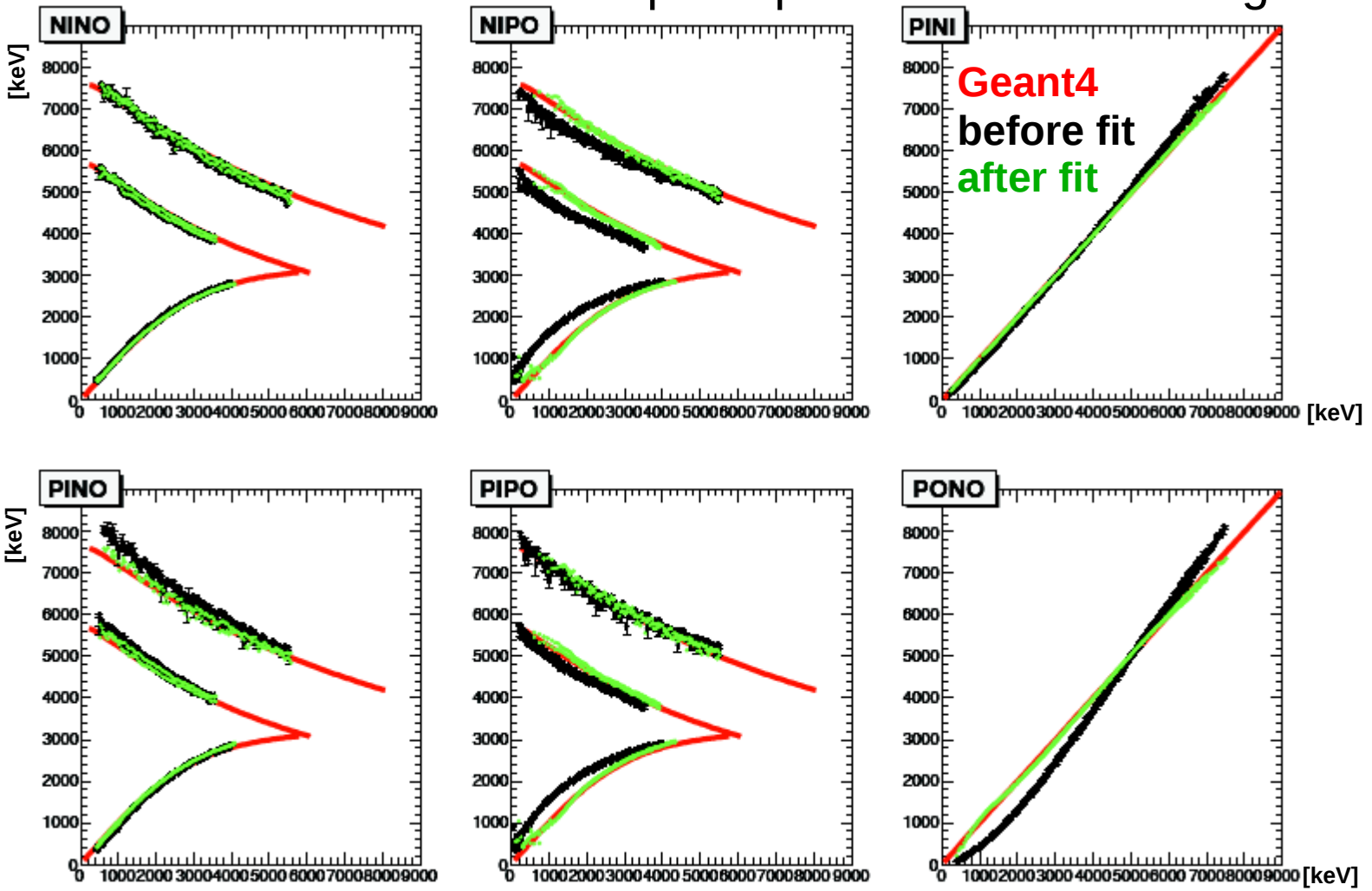
Calibration SD II

- high gain calibration (E deposition < 1MeV):
  - individual strip calibration possible
  - π^- with 0.2 < p < 0.5 GeV/c
  - compare ADC spectra from data with energy spectra from Geant4 (taking into account path length)
  - ~5% channel to channel gain variation
  - extrapolation to low gain not possible
  - use this information in next iteration

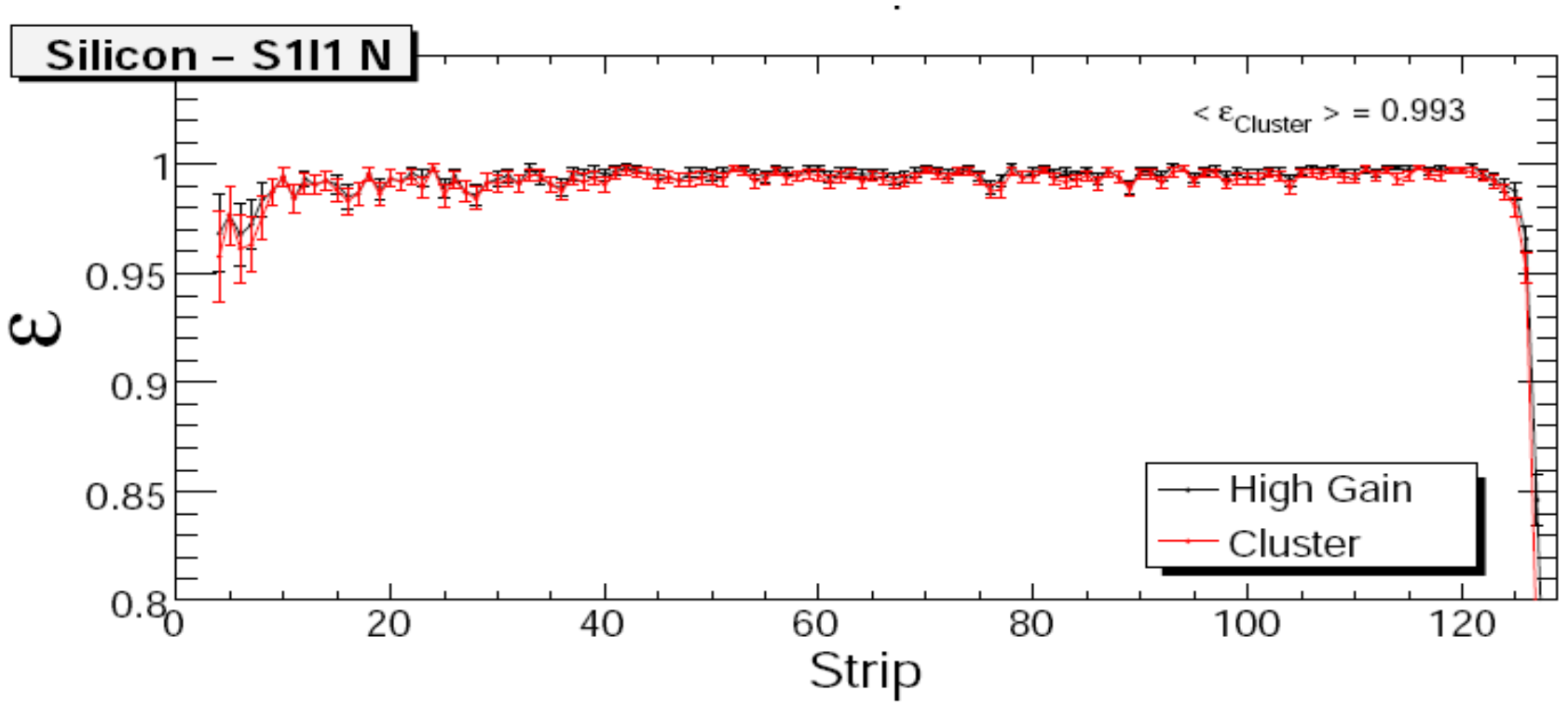


Calibration SD II

- low gain calibration
  - observed non-linearity for different sensor sides
  - compare for 2 layers of sensors E deposition in inner/outer/p-side/n-side ⟶ 6 combinations
  - fit simulations all data points to Geant4 calculations
  - calibration for individual strip not possible cf. not enough statistics



Detector efficiencies



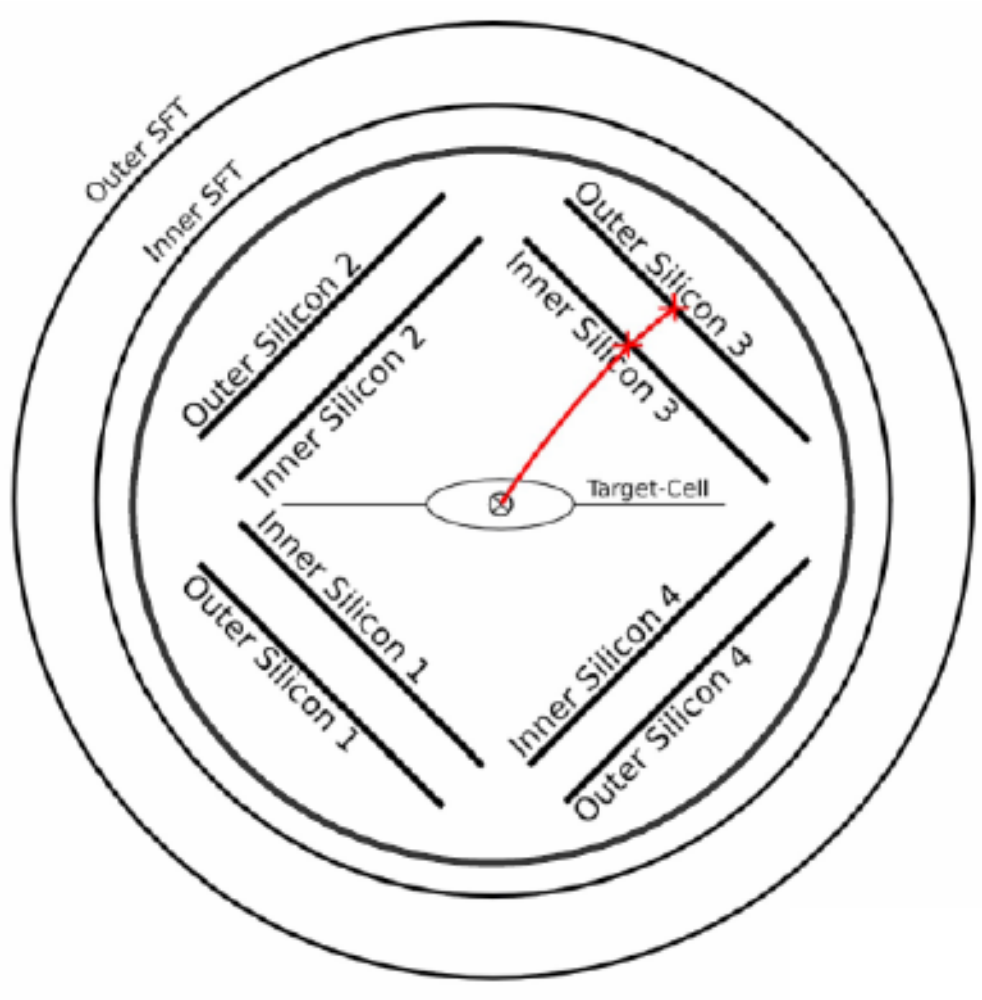
preliminary:

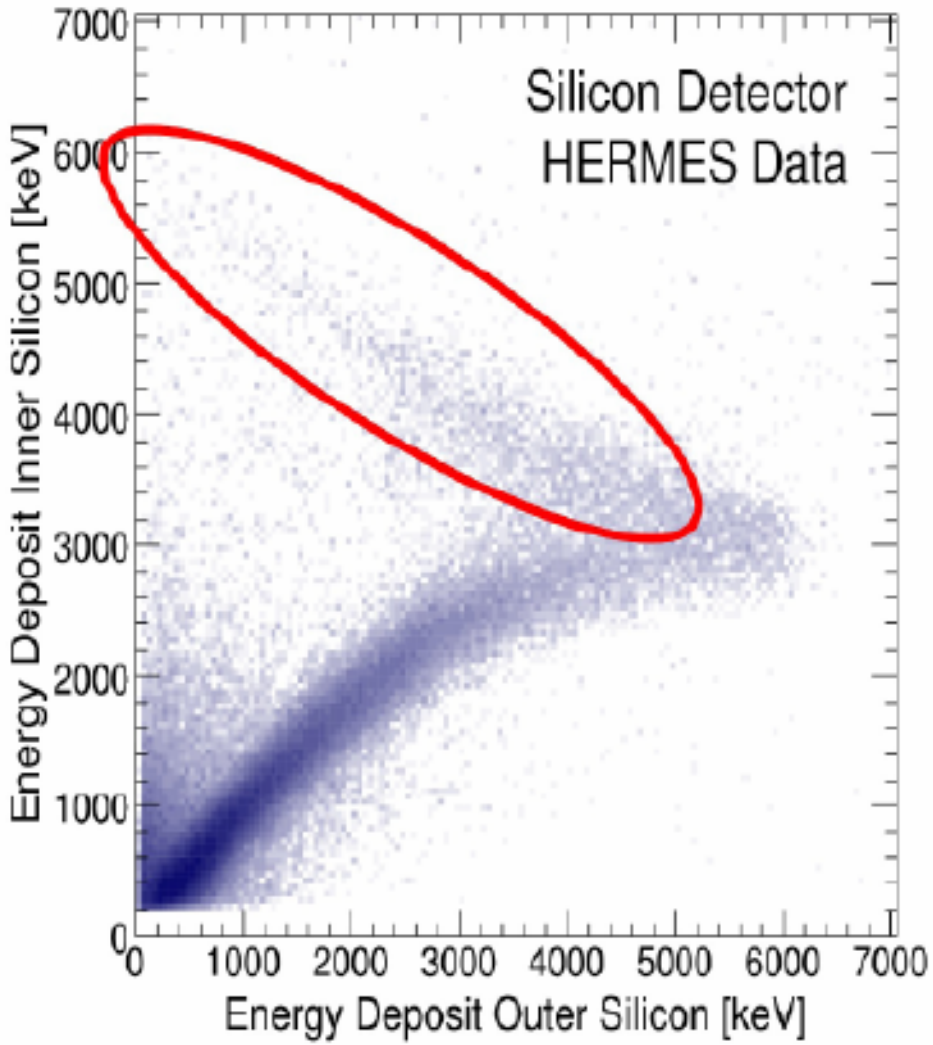
SD
protons > 99%
number dead strips < 1%

SFT
protons: 99%
pions: 98%

PD
protons: 98%
pions: 94%

Momentum reconstruction

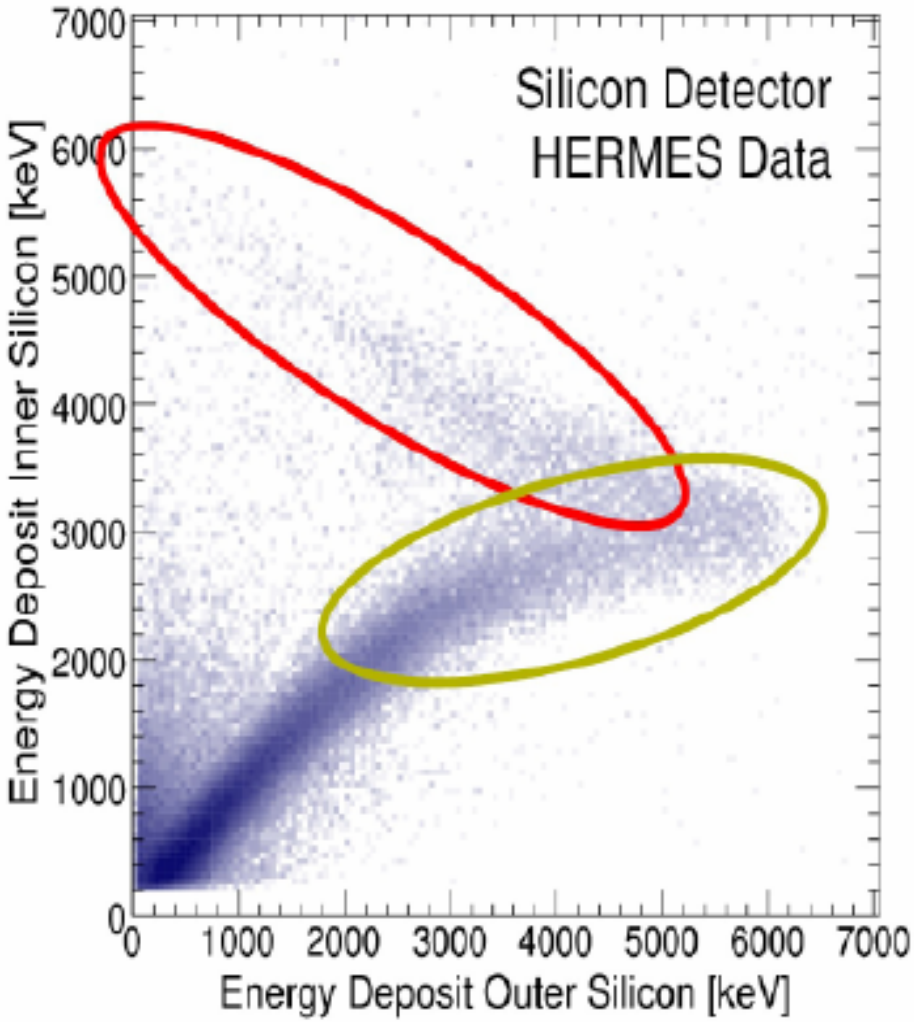




<u>low momentum protons</u>

momentum reconstruction via sum of total E deposition

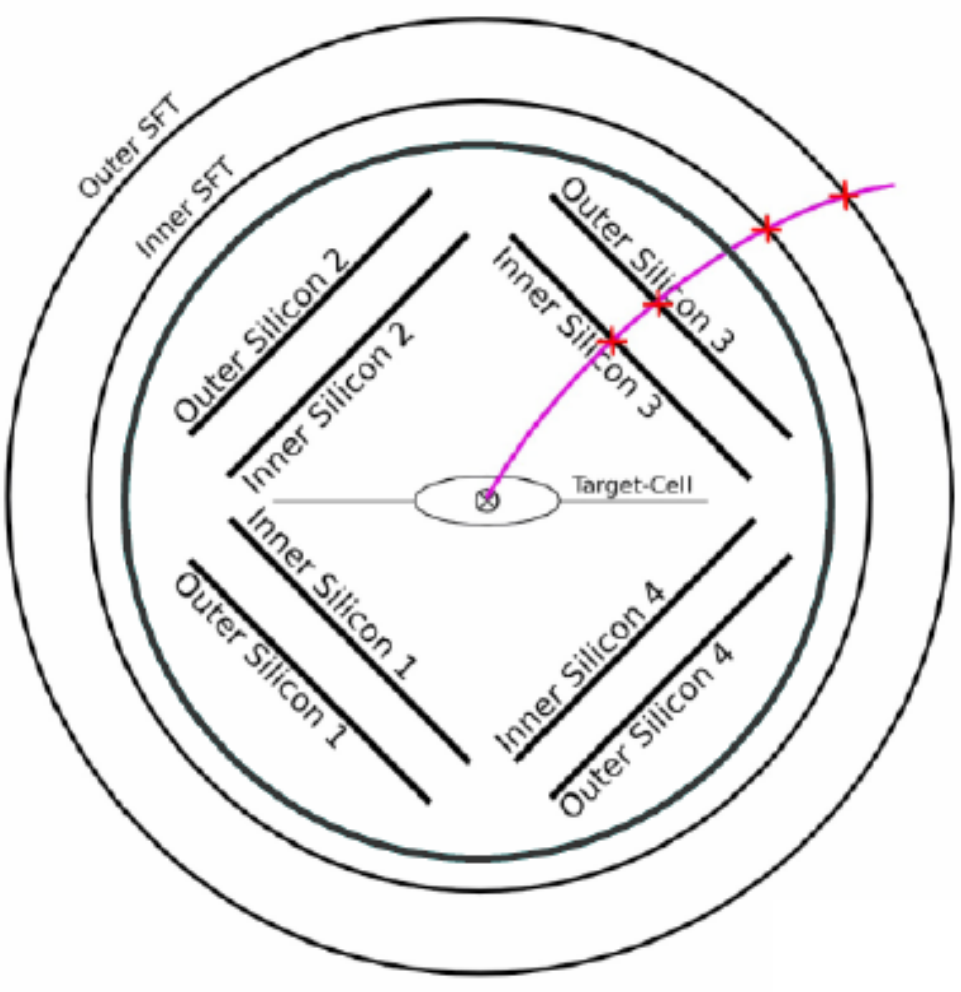
Momentum reconstruction

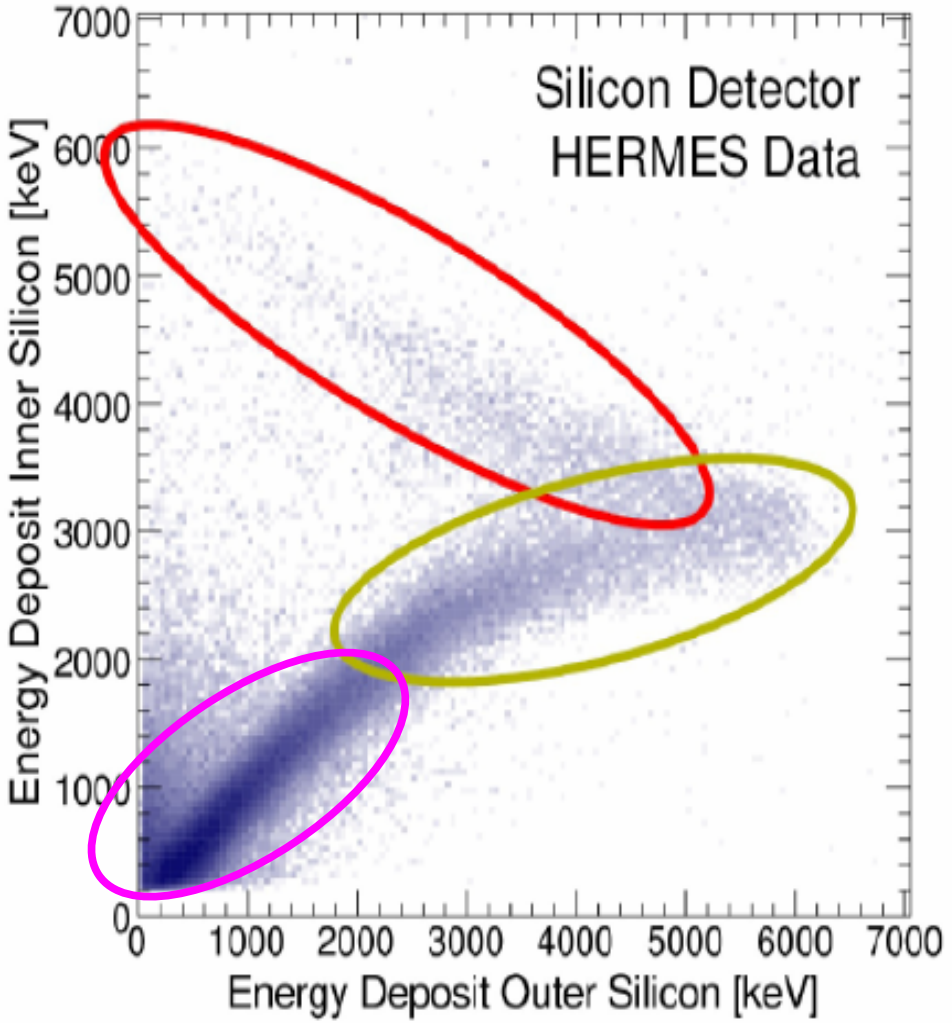


<u>higher momentum protons</u>

momentum reconstruction via E deposition vs. path length (Bethe-Bloch)

Momentum reconstruction

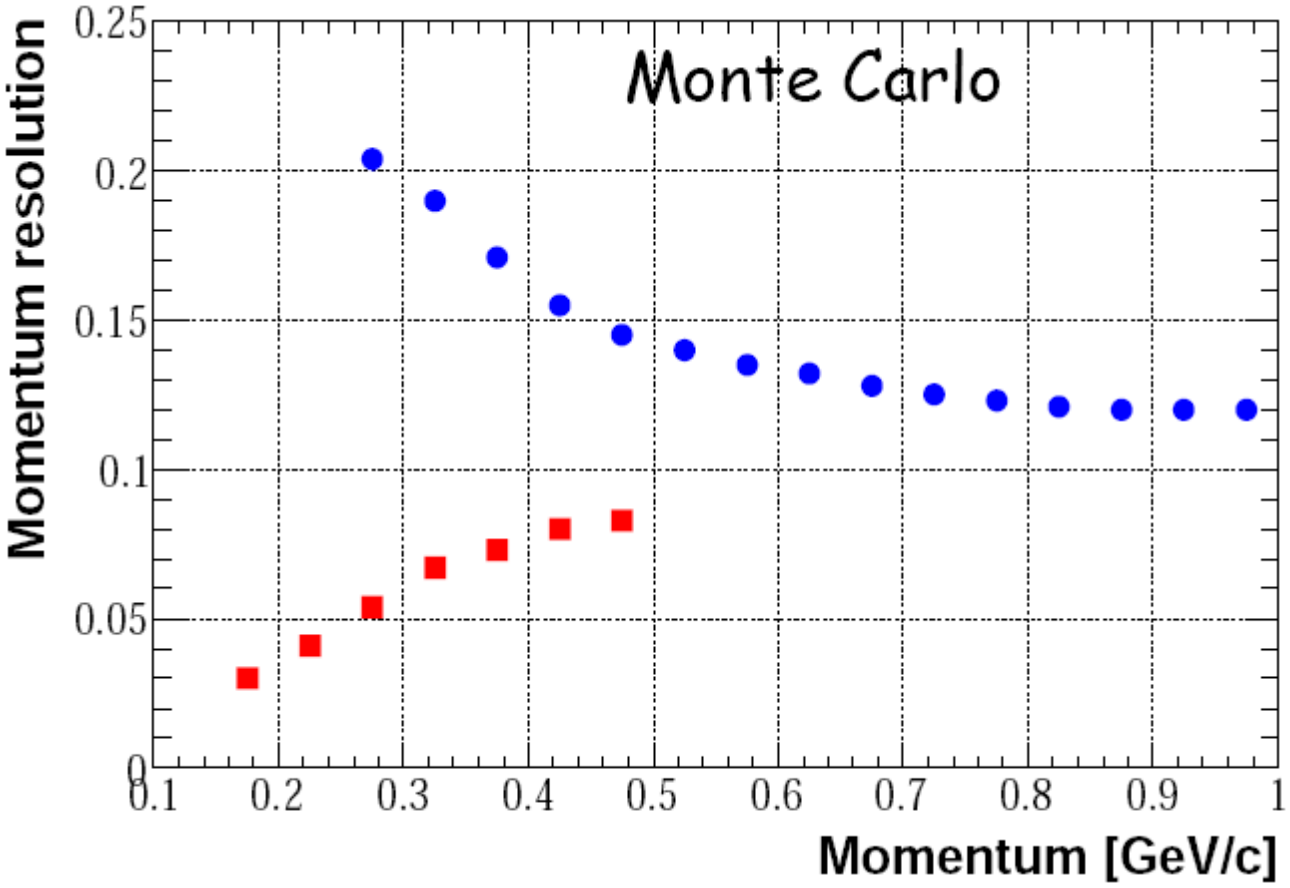




'high' momentum particles

momentum reconstruction via bending in magnetic field

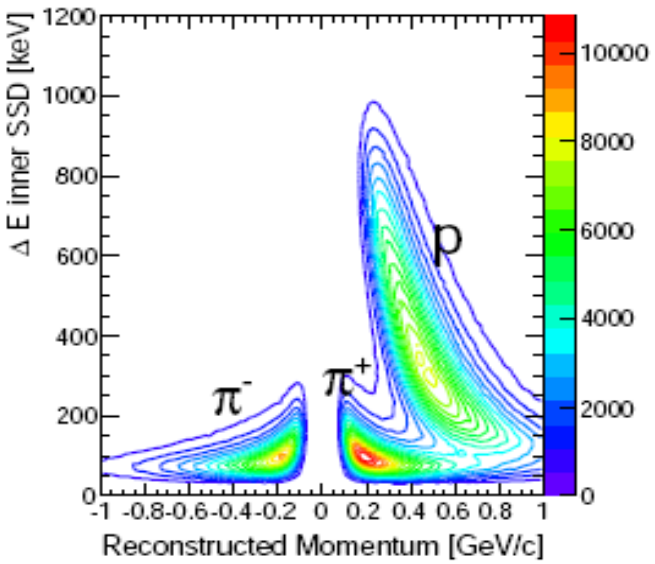
Momentum resolution

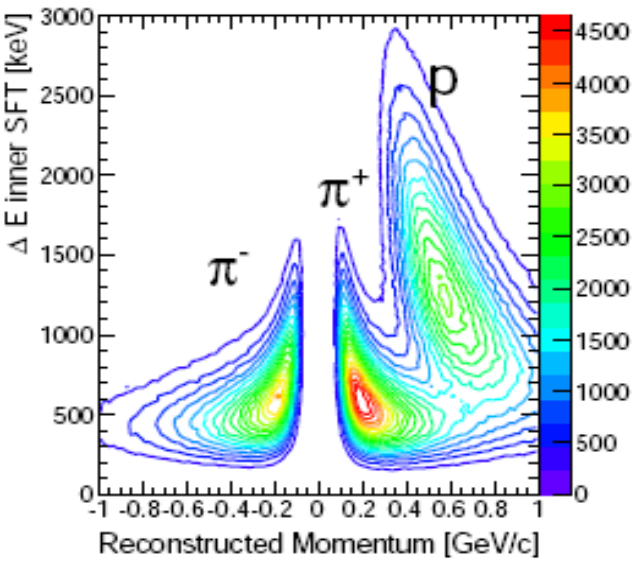


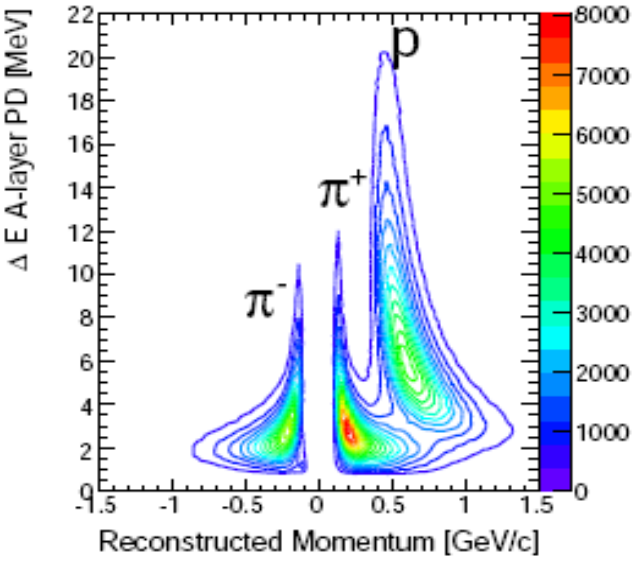
momentum reconstruction via bending in magnetic field

momentum reconstruction taking into account E deposit in SD

Particle identification



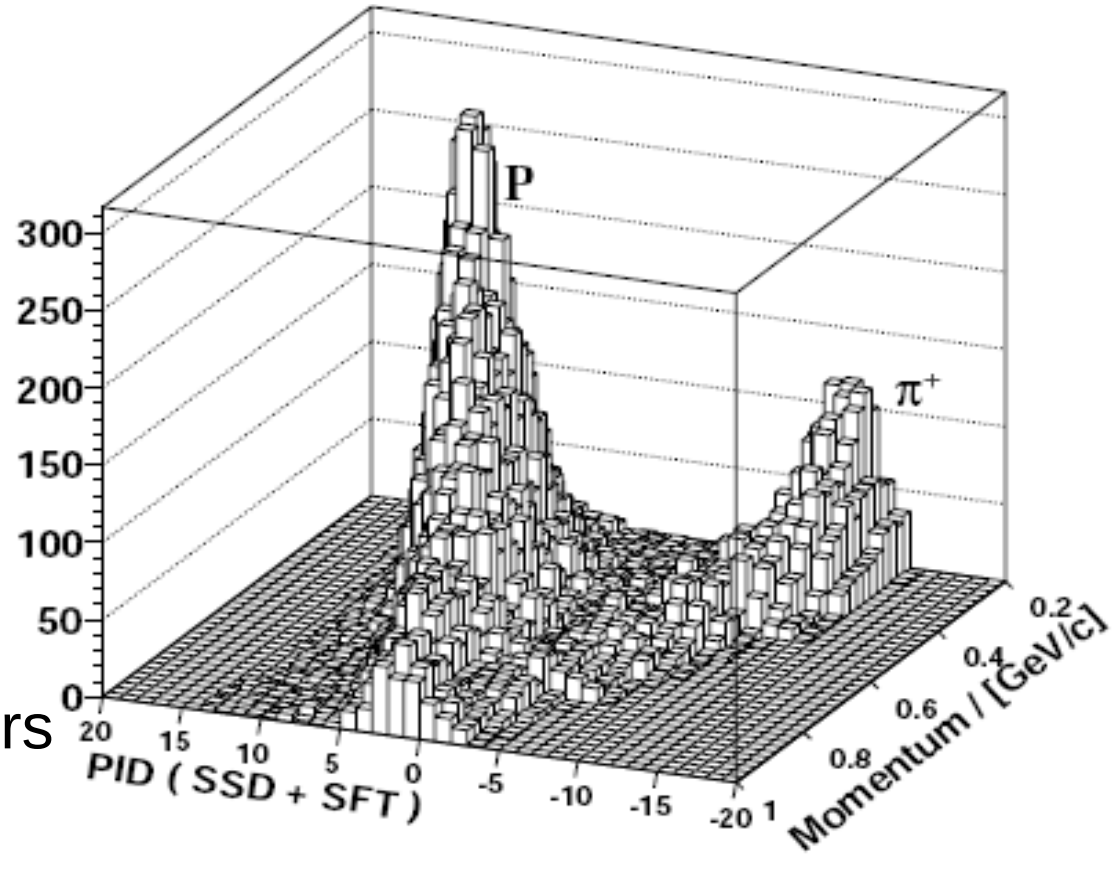




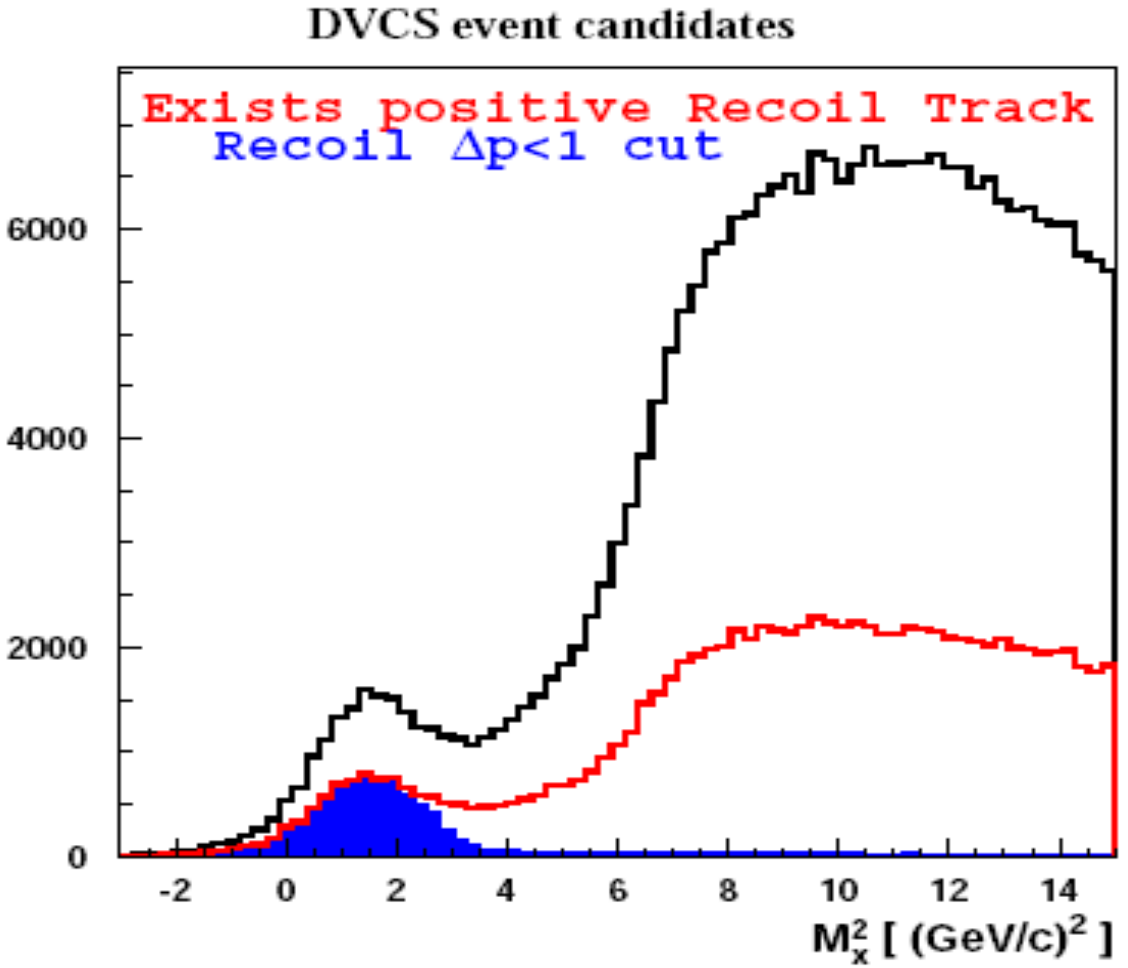
- p/π separation
  SD/SFT for p < 0.6 GeV/c
  include PD for p > 0.6 GeV/c
- determination of PID values:

$$\log_{10} \frac{P_p(\Delta E, p)}{P_{\pi^+}(\Delta E, p)}$$

easily combine different detectors



First glimpse at DVCS



- select lepton and photon in forward spectrometer
- reconstruct missing mass
- require a positive track in Recoil Detector
- require $\Delta p < 1$ GeV

Summary and outlook

- all detectors aligned and calibrated
- momentum reconstruction:
  E deposit and bending in magnetic field
- particle identification for all detectors
- first look at DVCS: encouraging results

- further fine tuning of
  - particle identification, efficiency mapping
  - event selection criteria

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stay tuned for more!