Results from the HERMES Recoil Detector

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on behalf of the hermes Collaboration

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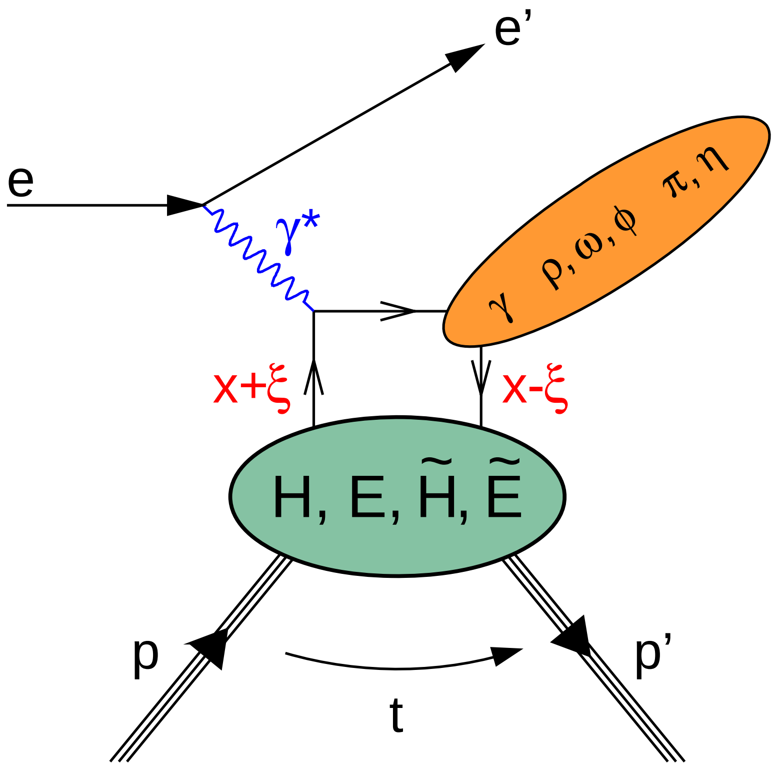
Physics Motivation and Detector Requirements



- Cleanest process to access GPDs — Deeply Virtual Compton Scattering (DVCS) $ep \rightarrow e' p\gamma$
- Background:

-associated Bethe-Heitler

$$ep \rightarrow e'\Delta^{+}\gamma$$

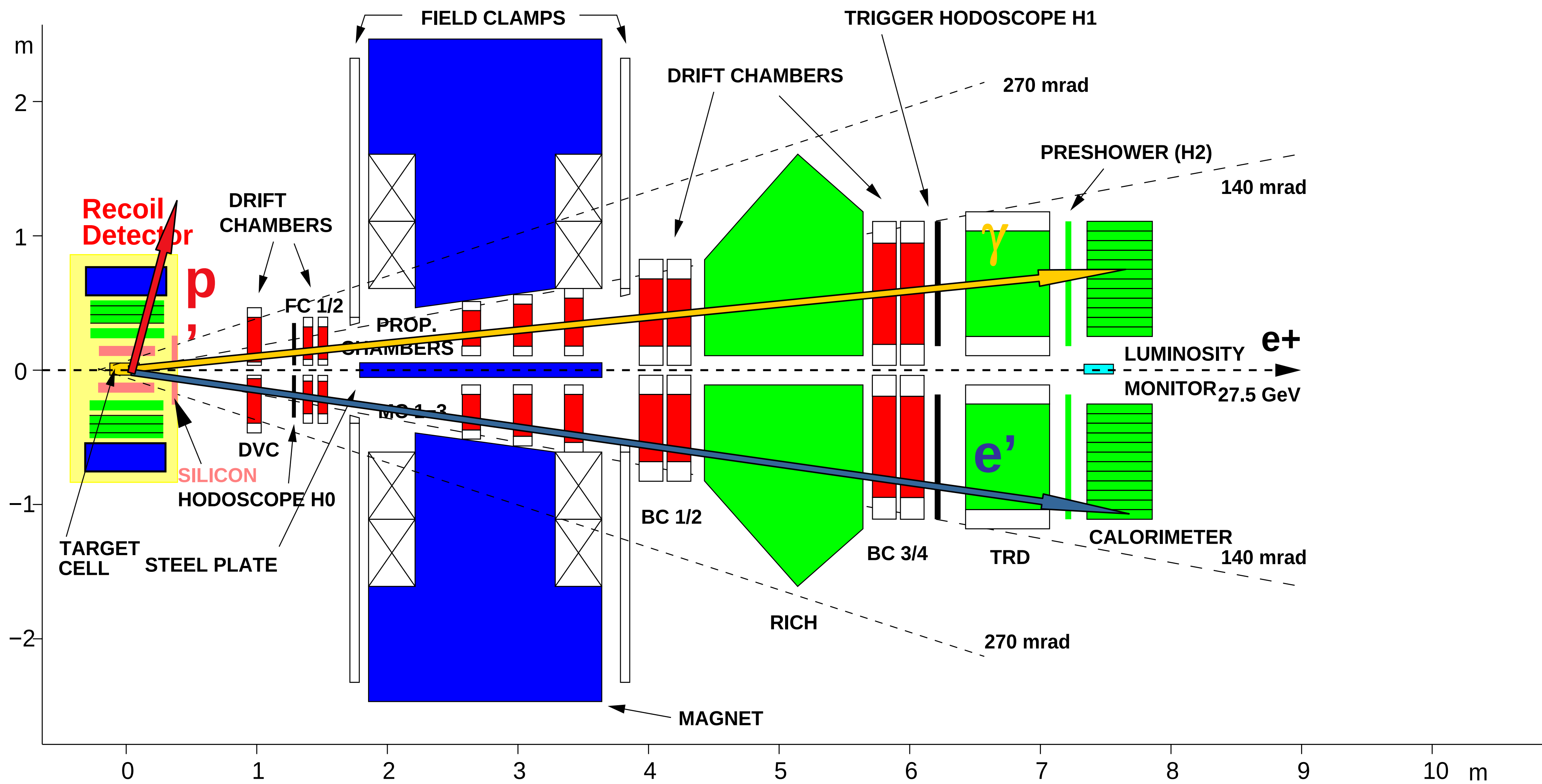
-semi-inclusive pion production

- Study of exclusive processes at HERMES to constrain Generalized Parton Distributions (GPDs)
- GPDs incorporate knowledge about form-factors and parton distribution functions
- Access to the quark orbithal momentum via Ji relation

$$J_q = \lim_{t\to 0} \int_{-1}^{1} dx\, x\left[H_q(x,\xi,t) + E_q(x,\xi,t)\right]$$

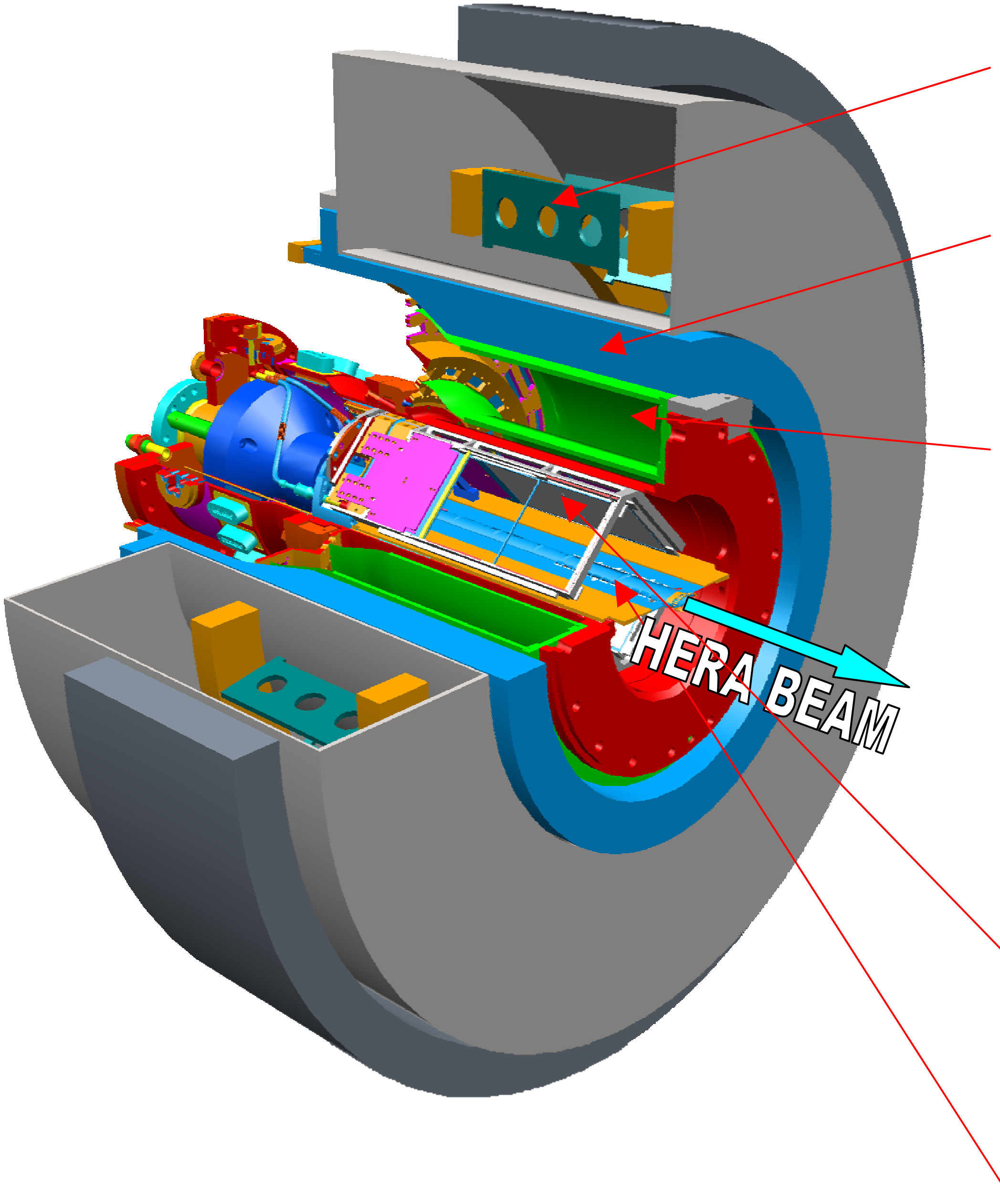
- Detection of proton from exclusive processes and pions and photons from the background
- Momentum range 0.1 - 1.4 GeV/c, detection particles from stopped protons and deuterons to minimum ionizing particles

HERMES with the Recoil Detector



- Last two years of data taking with the Recoil Detector
- Two beam helicities, electron and positron beams
- Unpolarized hydrogen target: 38 Mio DIS (41.000 DVCS)
- Unpolarized deuterium target: 10 Mio DIS (7.500 DVCS)

HERMES Recoil Detector



1 Tesla Superconducting Solenoid

Photon Detector (PD)

3 layers of tungsten-scintillator
detect gammas, p/π PID

Scintillating Fiber Tracker (SFT)

2 barrels of scintillation fibers with 2 parallel and 2 stereo layers

Lepton Beam

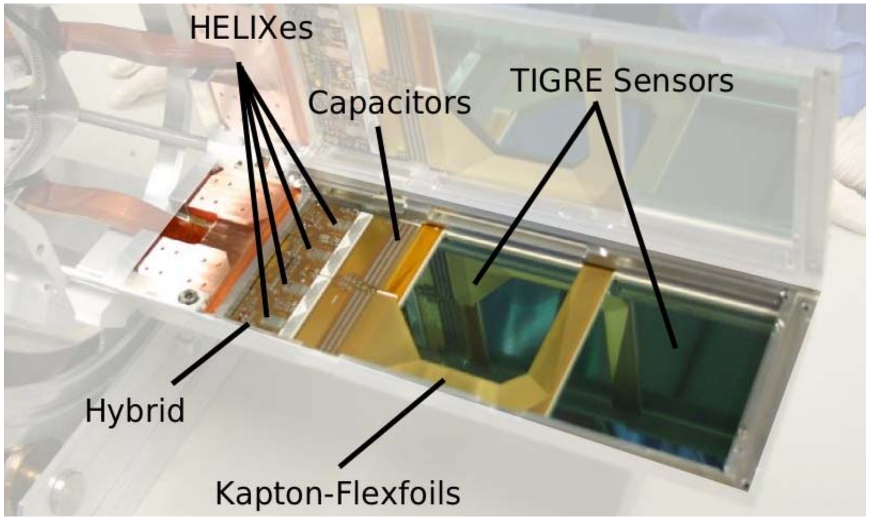
10.4 MHz bunch frequency
30 ps bunch length
25 mA average beam current

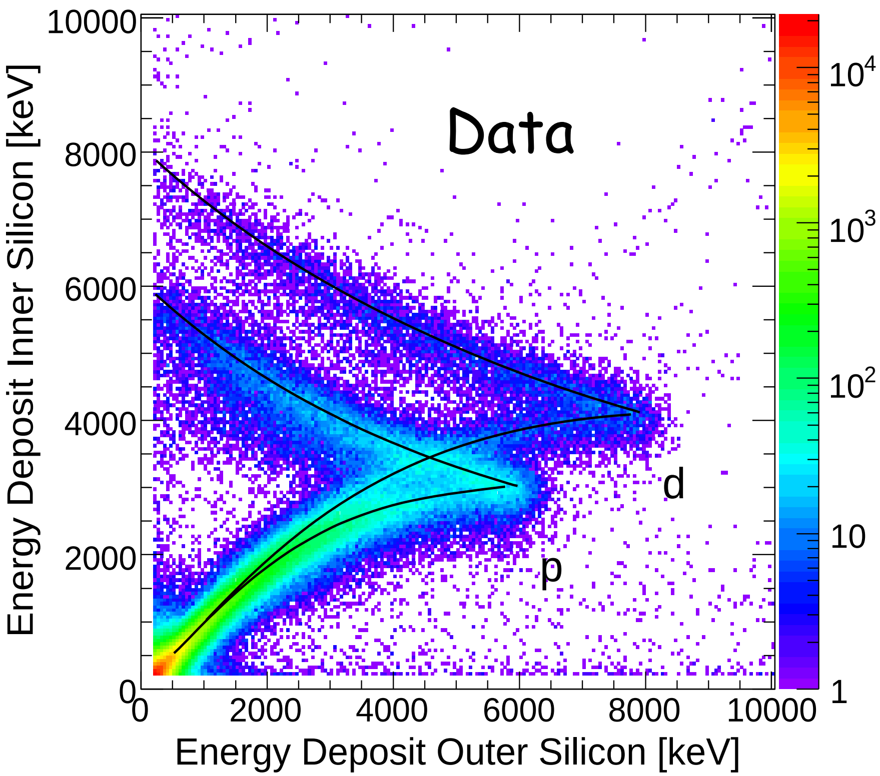
Silicon Strip Detector (SSD)

2 layers of double-sided silicon strip sensors located in the HERA vacuum

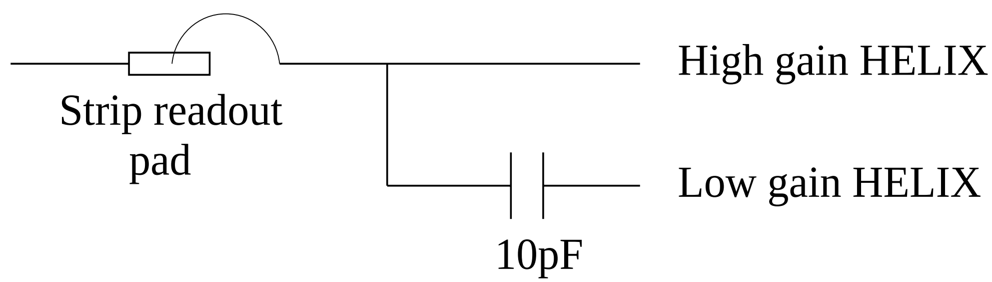
Target Cell of unpolarized target

Silicon Strip Detector (SSD)

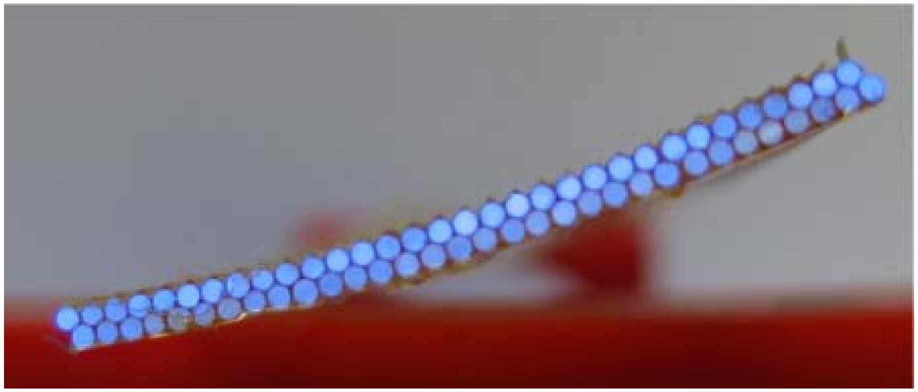


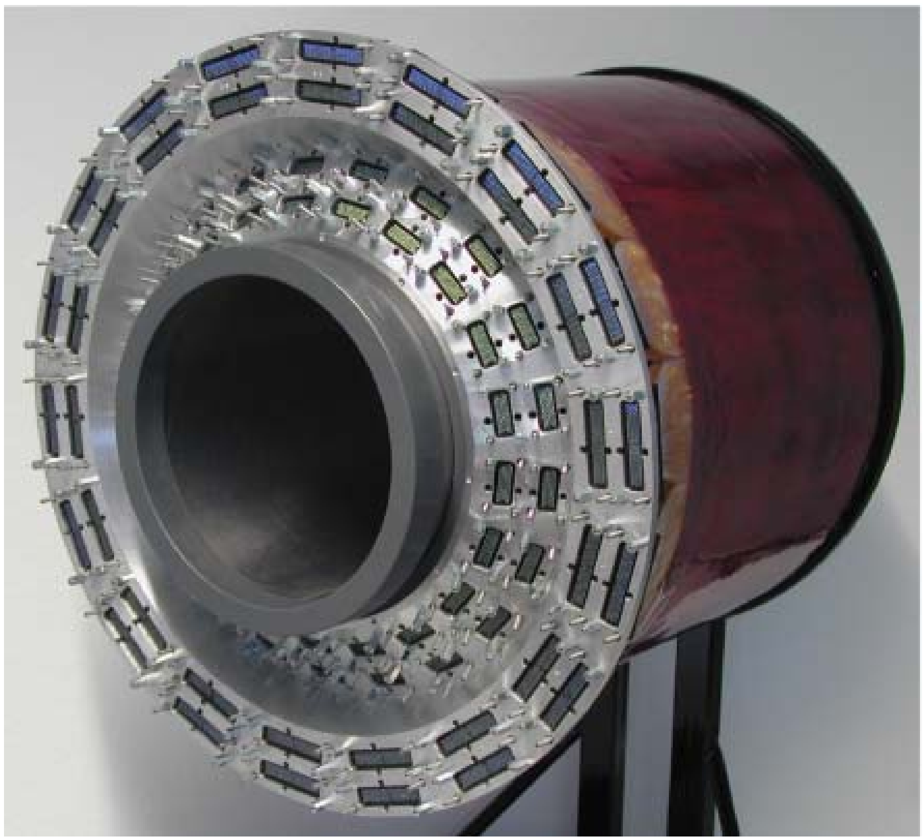


- 2 layers of double-sided silicon strip sensors located in the HERA beam vacuum
- Provide 2 space-points for track reconstruction
- Sensor size: 10x10cm^2 Strips: 758 μm pitch, 300μm thick
- Readout by HELIX 3.0 chips: signals divided to high and low gain to increase dynamic range



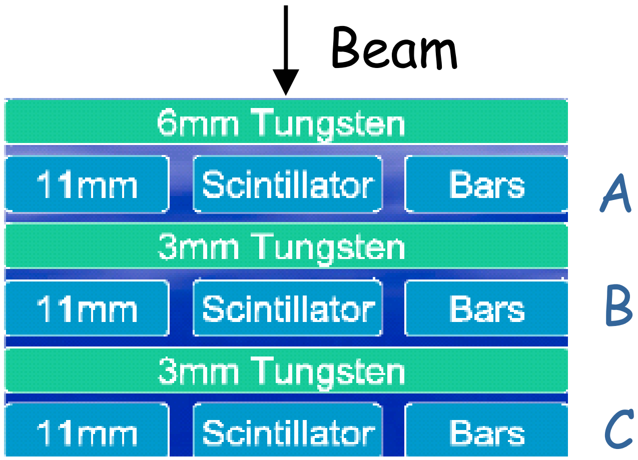
Scintillating Fiber Tracker (SFT)





- 2 cylinders:
  - 2 layers parallel to the beam axis
  - 2 stereo layers at 10 degrees
- KURARAY fibers: 1mm diameter
- Read out by multi-anode PMTs
- GASSIPLEX chips
- Proton momentum 0.25-1.4 GeV/c from bending in the magnetic field

Photon Detector (PD)



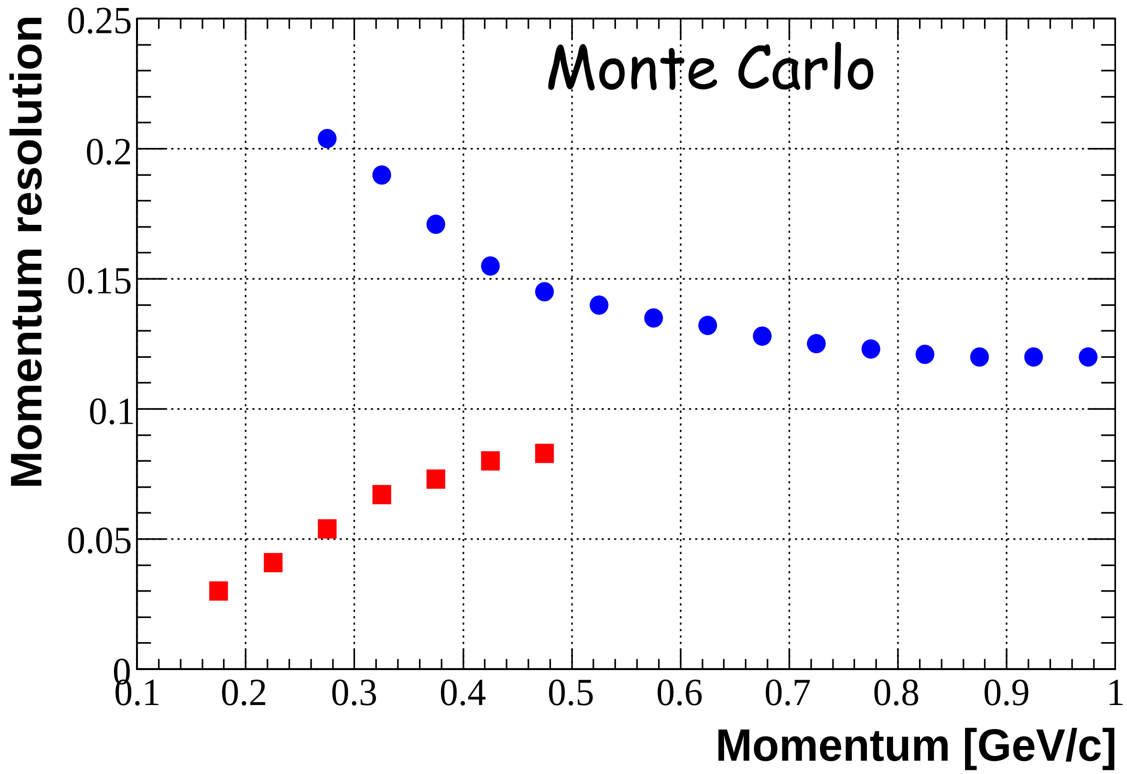
- Sandwich of 3 layers of tungsten-scintillator:
  - A-layer parallel to the beam axis
  - B/C: under +45/-45 degree angle
- Strips: 2x1x28 cm^3
- Read out by multi-anode PMTs
- Detect γ from π^0 decay
- Reconstruct π^0 if 2 γ's detected

Recoil Detector Status

- All sub-detectors are calibrated
  - SFT and PD with positively and negatively charged pions
  - SSD with low-momentum protons
- Tracking and momentum reconstruction
  - By bending in the magnetic field and by energy deposit in the SSD for low-momentum particles
  - Sub-detectors are aligned relative to each other using cosmic data and data with and without magnetic field
- Particle identification for protons and pions is possible in all sub-detectors for momentum below 0.8 GeV/c
- Data and Monte Carlo productions are ready for preparation of physics analysis

Momentum Reconstruction

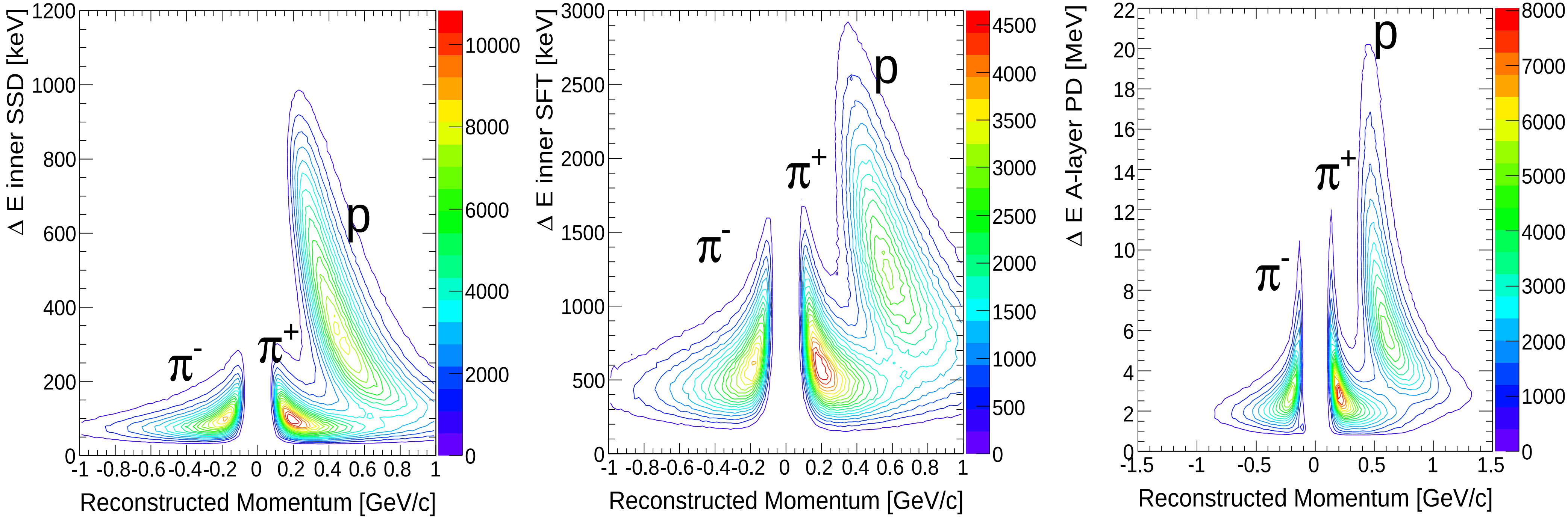
- By bending in the magnetic field (coordinates in SSD and SFT)
- By sum of energy deposits in two layers of SSD for stopped protons and deuterons
- By coordinates in the SSD and SFT taking energy deposits in SSD into account for intermediate momentum range below 0.5 GeV/c



Blue – accuracy of momentum reconstruction by bending in the magnetic field

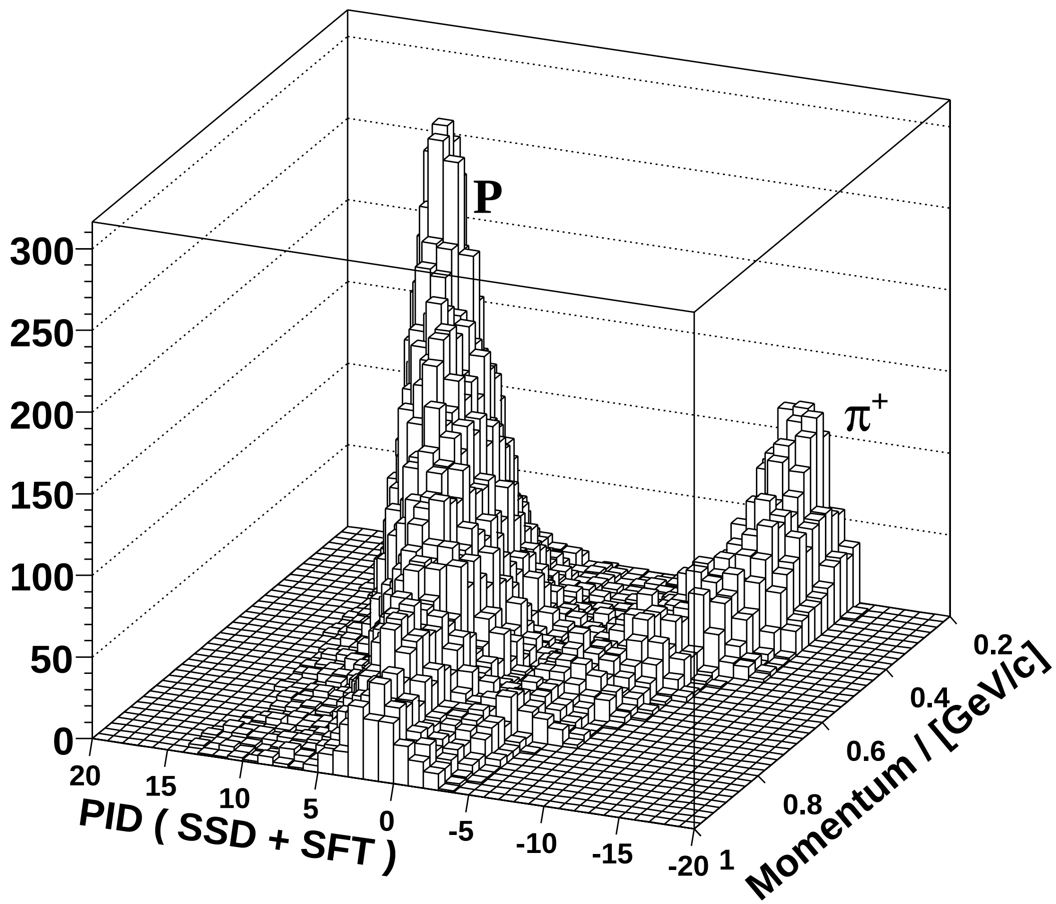
Red - accuracy of momentum reconstruction taking energy deposit in the SSD into account

Particle Identification



- Proton/pion separation in all 3 sub-detectors
- p < 0.6 GeV/c – SSD and SFT
- P > 0.6 GeV/c – SSD, SFT and PD

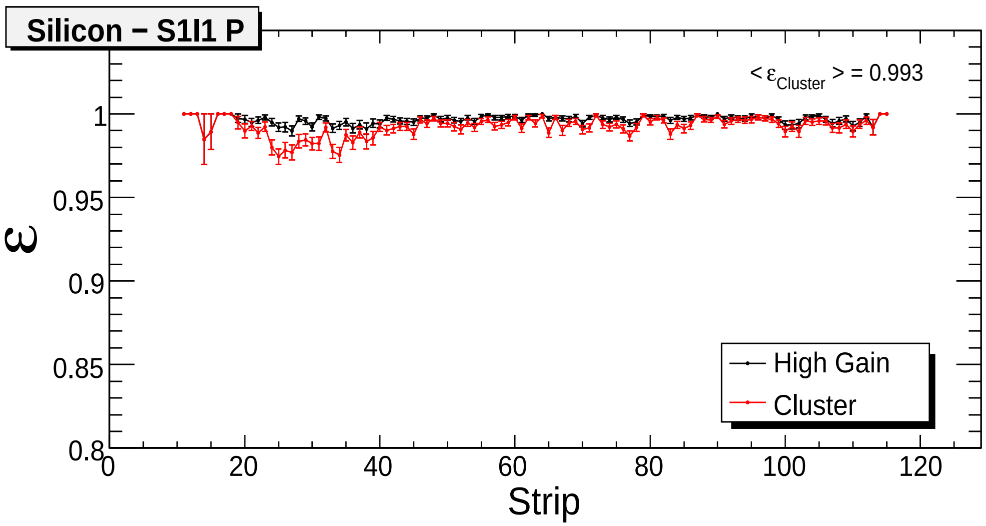
Particle Identification

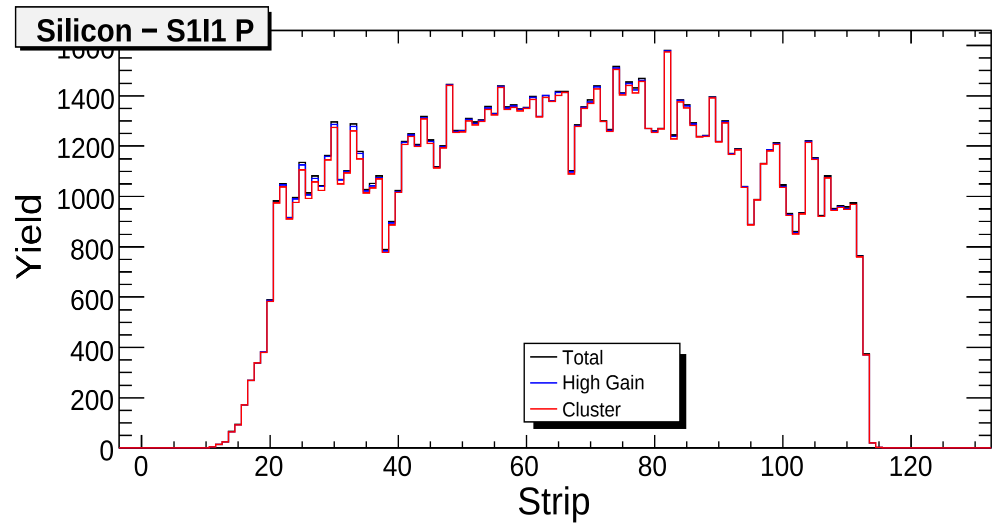


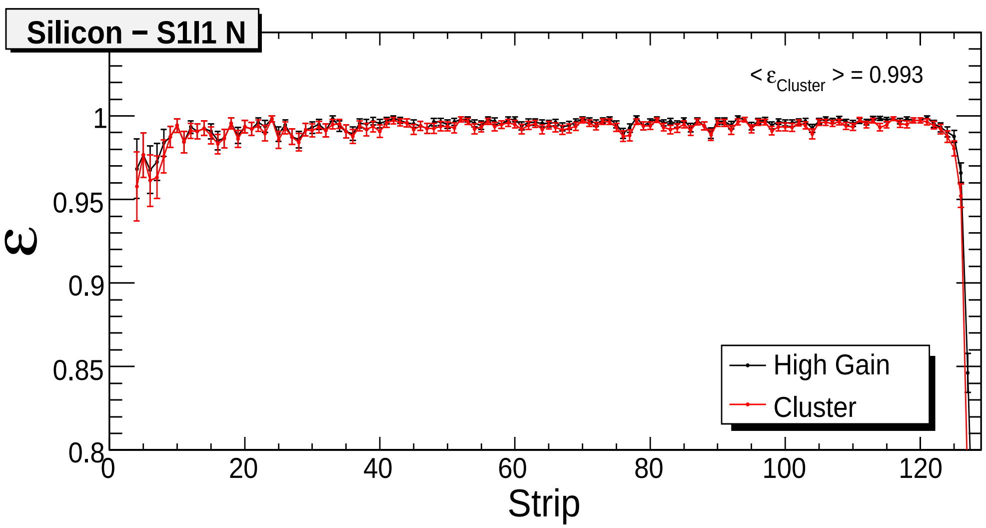
- Particle identification values for all sub-detectors
- Parent distributions for SSD, SFT and PD
- Easy to combine information from all sub-detectors

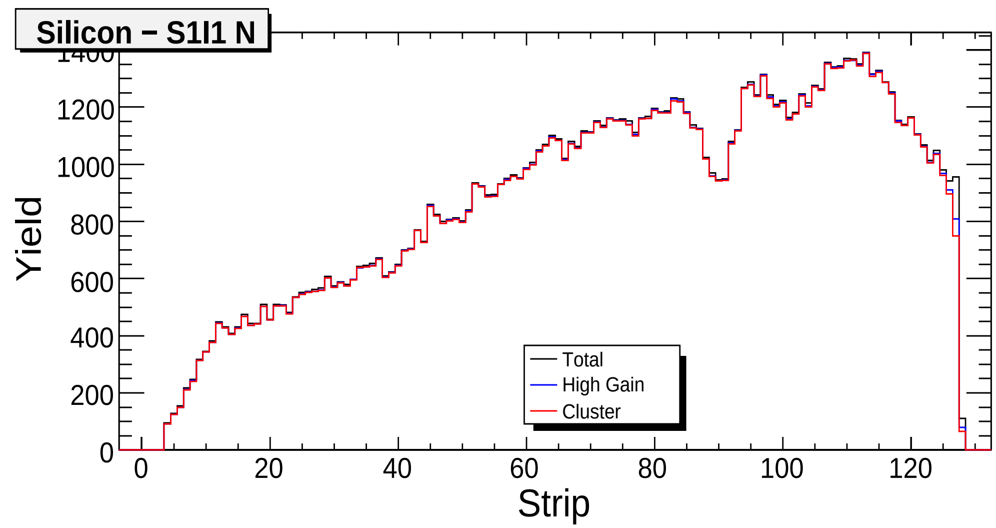
$$PID = \log_{10} \frac{P_p(\Delta E, p)}{P_{\pi^+}(\Delta E, p)}$$

SSD Efficiency for Protons



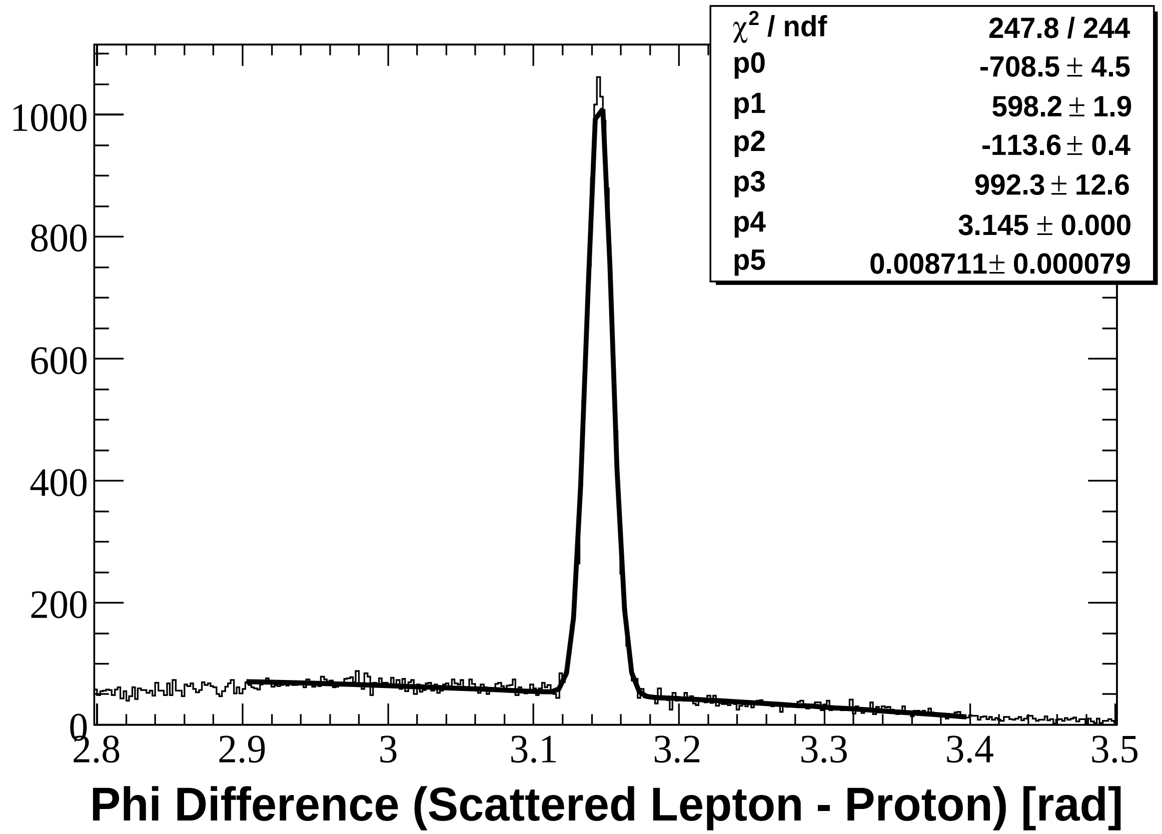






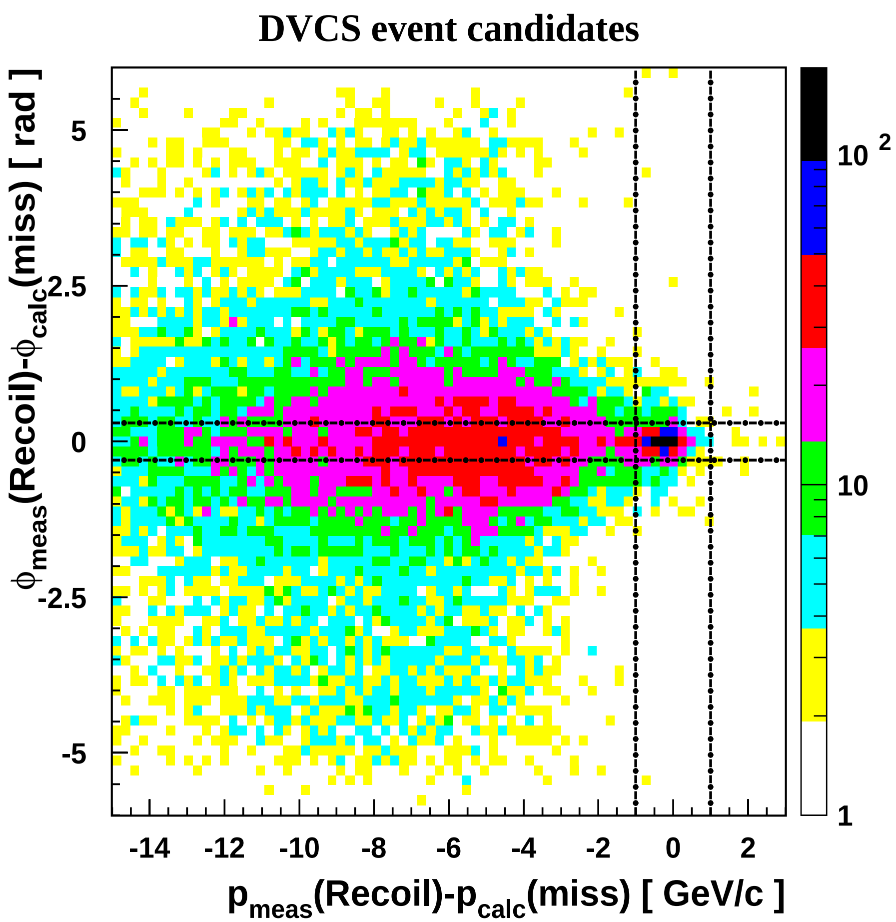
- Efficiency > 99% for all 16 sensors
- Drops in statistics related to acceptance holes and dead strips in other silicon layer

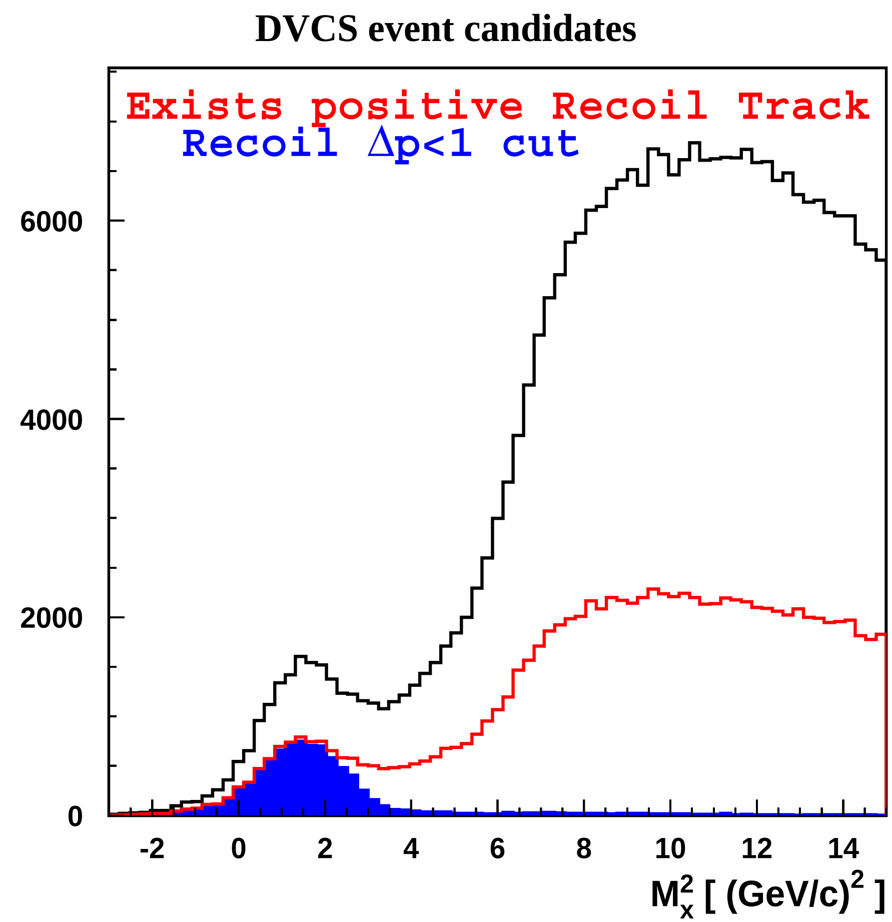
Physics Process Selection with the Recoil (ep-elastic)



- Single lepton in the Forward spectrometer with momentum > 25 GeV/c
- Particle with highest momentum and positive charge in the Recoil
- Phi resolution is in agreement with expectations
- Use for relative alignment of the Recoil and the Forward spectrometer

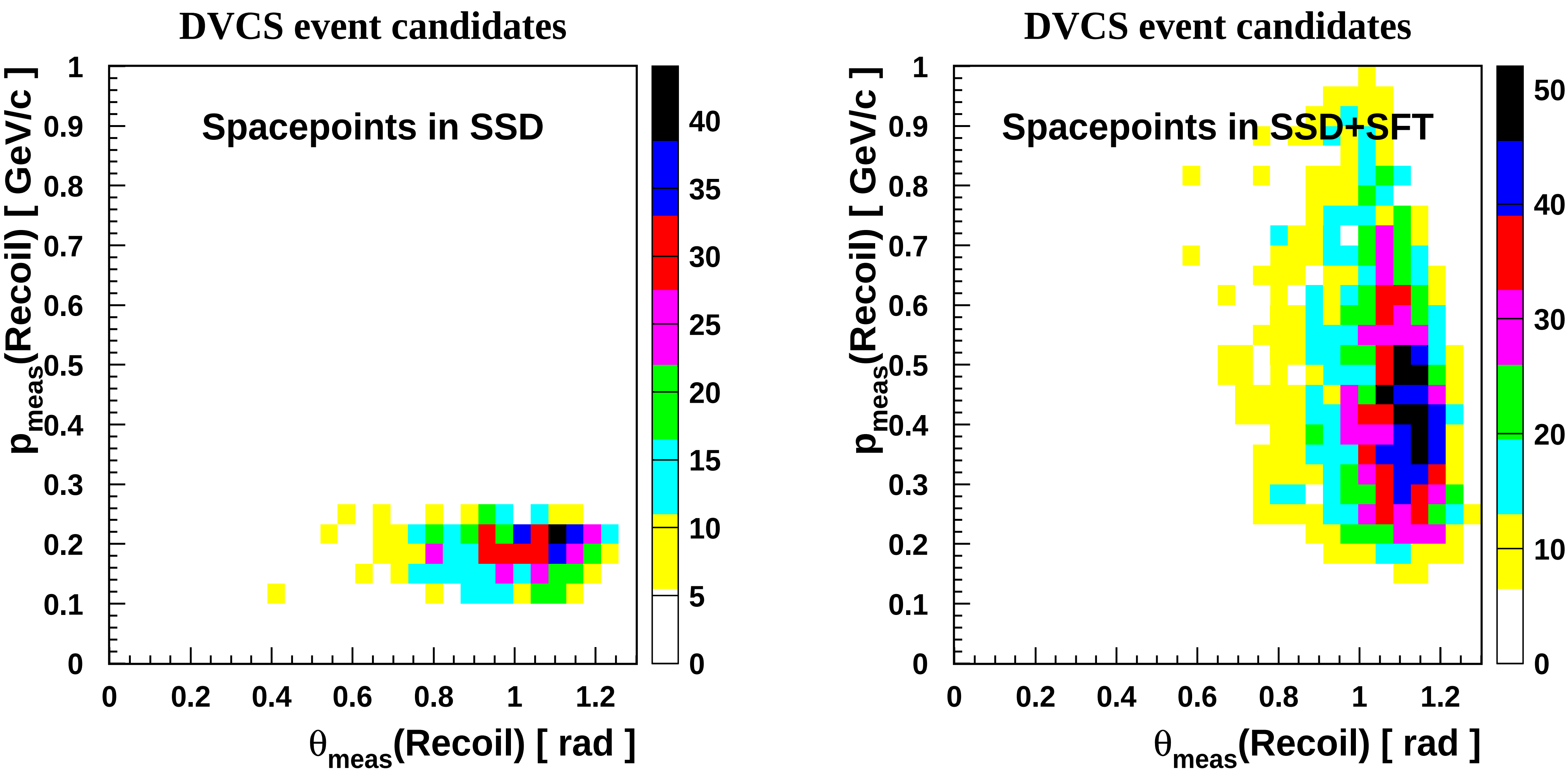
Physics Process Selection with the Recoil (DVCS)





- Selection of single electron and photon in the Forward spectrometer
- Calculate expected momentum and phi angle of proton
- Compare calculated and measured momentum and phi angle
- No PID to select protons yet

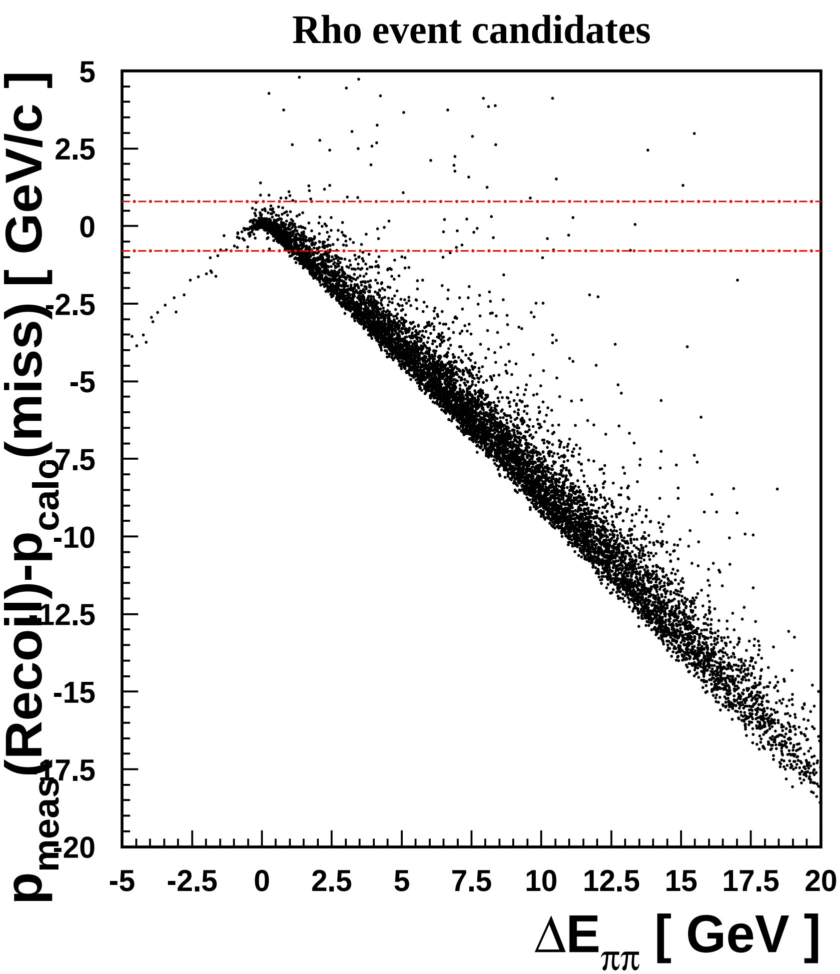
Momentum Reconstruction for DVCS

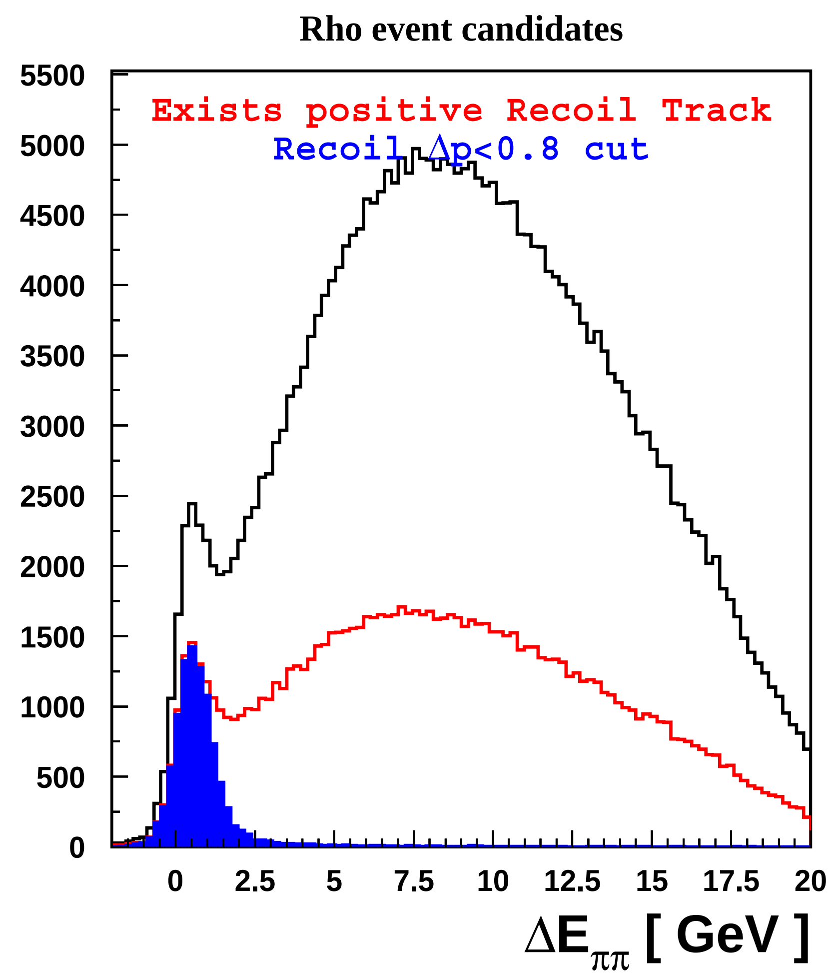


- Momentum reconstruction in SSD – low t region important to constrain GPDs and as a result quark angular momentum via Ji relation

$$J_q = \lim_{t \to 0} \int_{-1}^{1} dx\, x \left[H_q(x, \xi, t) + E_q(x, \xi, t) \right]$$

ρ^0 Production Process Selection with the Recoil





- Traditional pre-Recoil selection of ρ^0 candidates
- Comparison of calculated and measured proton momentum
- No PID to select protons yet

Summary and Outlook

- Great progress in understanding of the Recoil Detector
  - All sub-detectors are calibrated
  - Momentum reconstruction by bending in the magnetic field and energy deposit in the SSD
  - Particle identification in all sub-detectors
- First look to physics processes is promising
- Further work in progress
  - Refinement of the SSD calibration
  - Exploit Recoil PID in physics analysis
  - Event reconstruction (kinematic fitting)
- Physics results with the recoil expected in the near future
  - DVCS and exclusive meson production
  - Neutron structure function via spectator proton tagging