

First look to exclusive ρ^0 production with the Recoil Detector at HERMES

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Outline

- The Spin Structure of the Nucleon
- Generalized Parton Distributions (GPDs)
- Hard meson electroproduction
- Exclusive ρ^0 production at Hermes
- First result from the Recoil Detector at Hermes
- Outlook

The Spin Structure of the Nucleon

$$S_z = \frac{1}{2} = J_q + J_g = \frac{1}{2} \Delta\Sigma + L_q + J_g$$

- $\Delta\Sigma$ Spin of quarks

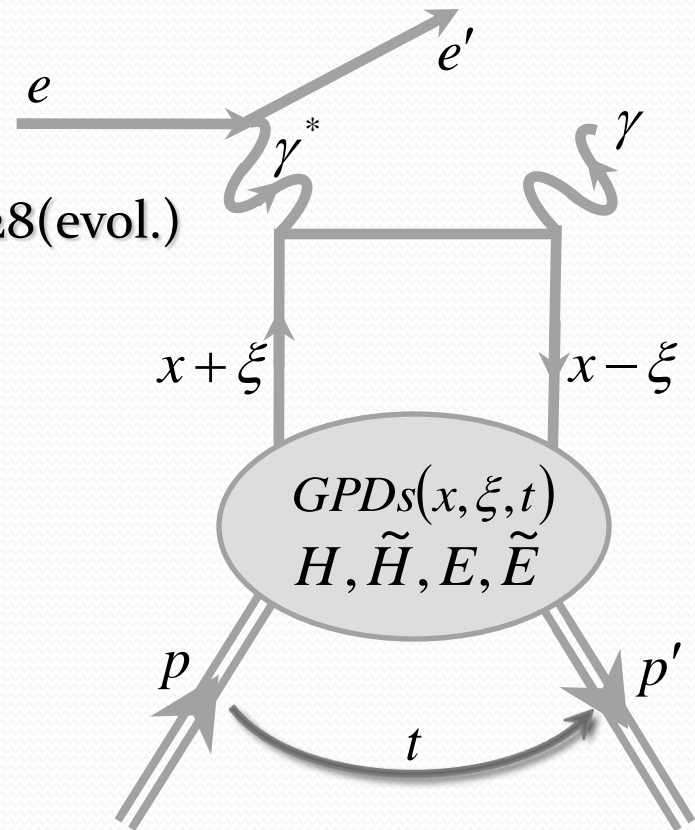
- $\Delta\Sigma = 0.330 \pm 0.011(\text{theo.}) \pm 0.025(\text{exp.}) \pm 0.028(\text{evol.})$

Airapetian et al. [HERMES Collaboration]

Phys. Rev. D 75, 012007 (2007)

- L_q Orbital angular momentum

- $J_{q,g}$ Total angular momentum



Generalized Parton Distributions

Ji Relation *Ji, Phys. Rev. Lett. 78, 610 - 613 (1997)*

$$J_q = \lim_{t \rightarrow 0} \int_{-1}^1 x dx \{H_q(x, \xi, t) + E_q(x, \xi, t)\}$$

$$J_g = \lim_{t \rightarrow 0} \int_0^1 dx \{H_g(x, \xi, t) + E_g(x, \xi, t)\}$$

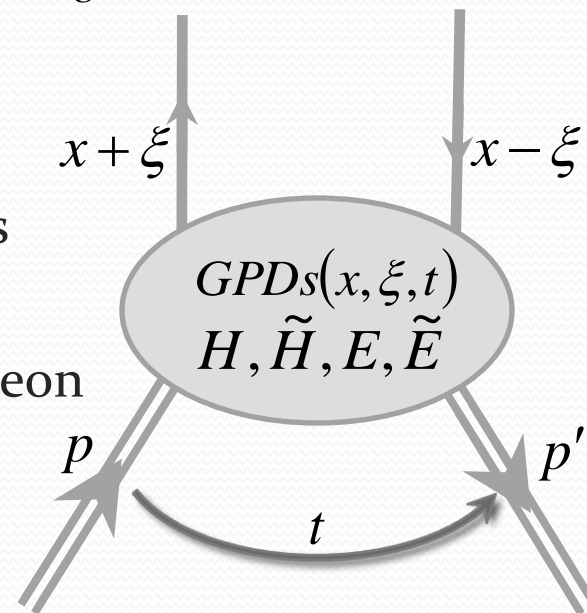
$x \pm \xi$ parton longitudinal momentum fractions

ξ fraction of the momentum transfer

t invariant momentum transfer to the nucleon

H_q, \tilde{H}_q conserve nucleon helicity

E_q, \tilde{E}_q flip nucleon helicity



Hard meson electroproduction

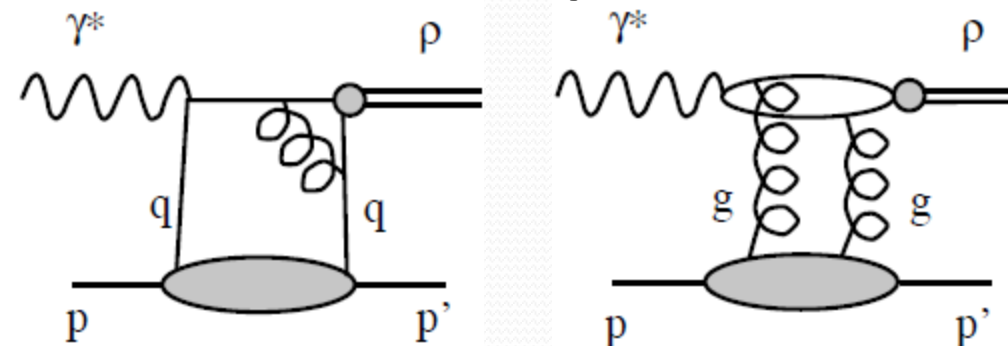
- The quark helicity is conserved in hard scattering process
- The meson acts as a helicity selector:
 - The longitudinally polarized vector meson channels ($\rho_L^{0,\pm}$, ω_L , ϕ_L) are sensitive only to the unpolarized GPDs (H and E)
 - The pseudo-scalar channels ($\pi^{0,\pm}$, η , ...) are sensitive only to the polarized GPDs (\tilde{H} and \tilde{E})
- DVCS depends on both, the unpolarized (H and E) and polarized (\tilde{H} and \tilde{E}) GPDs.
- Hard meson electroproduction reactions are complementary to the DVCS process, as they provide an additional tool to disentangle the different GPDs.

K. Goeke, M V. Polyakov, M. Vanderhaeghen, Prog.Part.Nucl.Phys.47,401-515(2001)

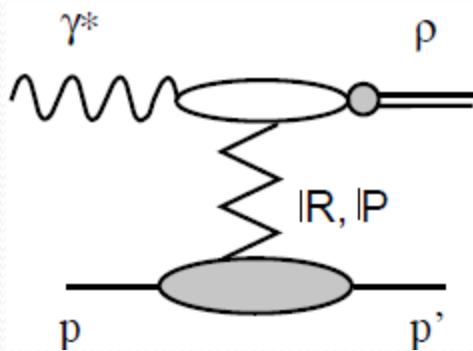
Advantage of exclusive ρ^0 production

- the only process where the gluon contribution enters in LO
- exclusive ρ^0 sensitive to $H_{q,g}$ and $E_{q,g}$ at the same order in α_s

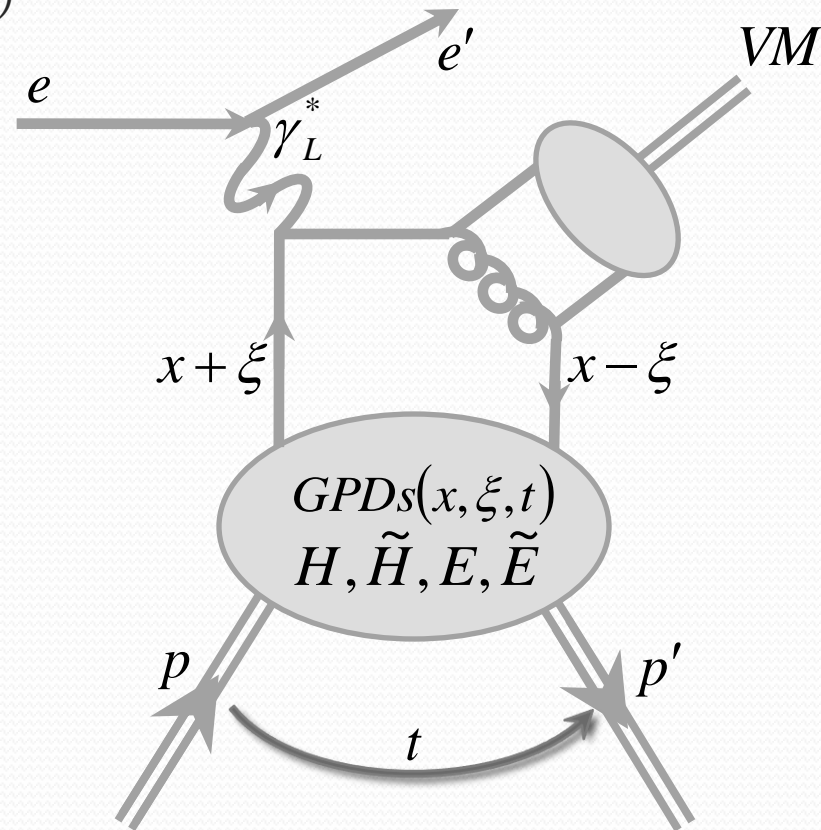
M. Diehl, A. V. Vinnikov, Phys.Lett.B609,286-290,(2005)



quark exchange
two-gluon exchange
models inspired by perturbative QCD



Reggeon or Pomeron exchange in
models based on Regge theory

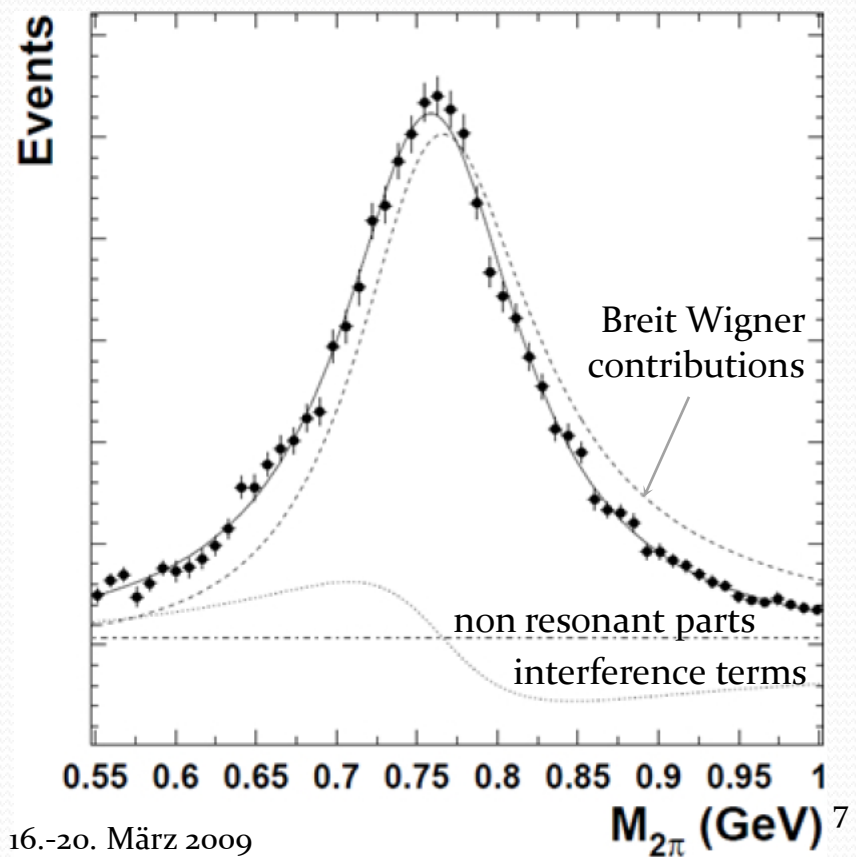
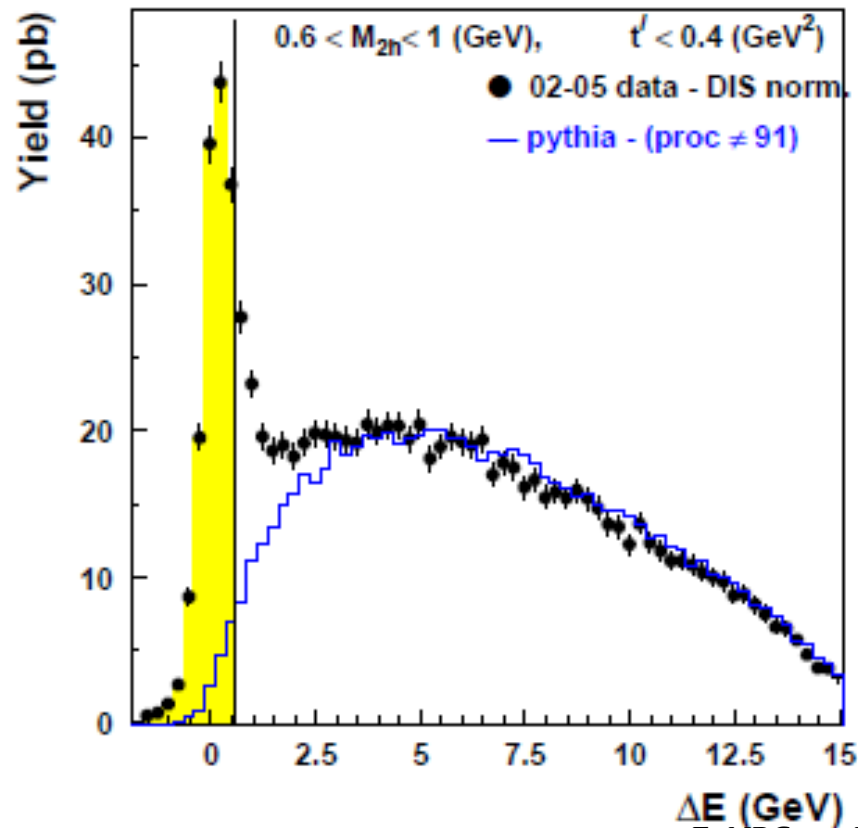


$GPDs(x, \xi, t)$
 $H, \tilde{H}, E, \tilde{E}$

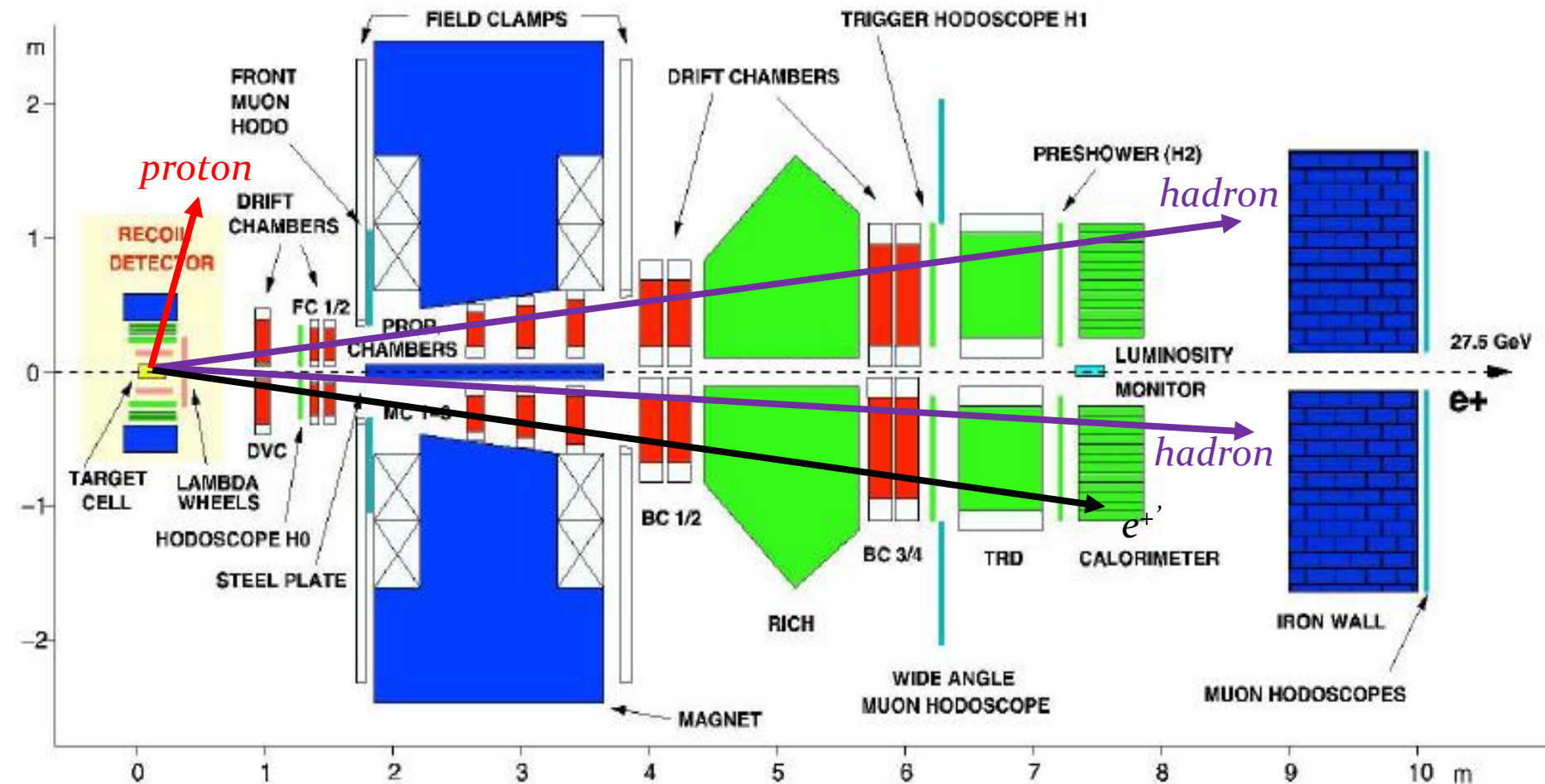
Exclusive ρ^0 production at Hermes

$$ep \rightarrow e'p\rho^0, \rho^0 \rightarrow \pi^+\pi^-$$

- exclusive events: main contribution at small values of $\Delta E = E_e + E_p - E_{e'} - E_\rho - E_{p'}$ and $t' = t - t_0$
- non-exclusive events ($\Delta E > 0$) contribute due to the experimental resolution and restricted acceptance
- Event produced in non-exclusive processes as an estimate of background size: **11%**

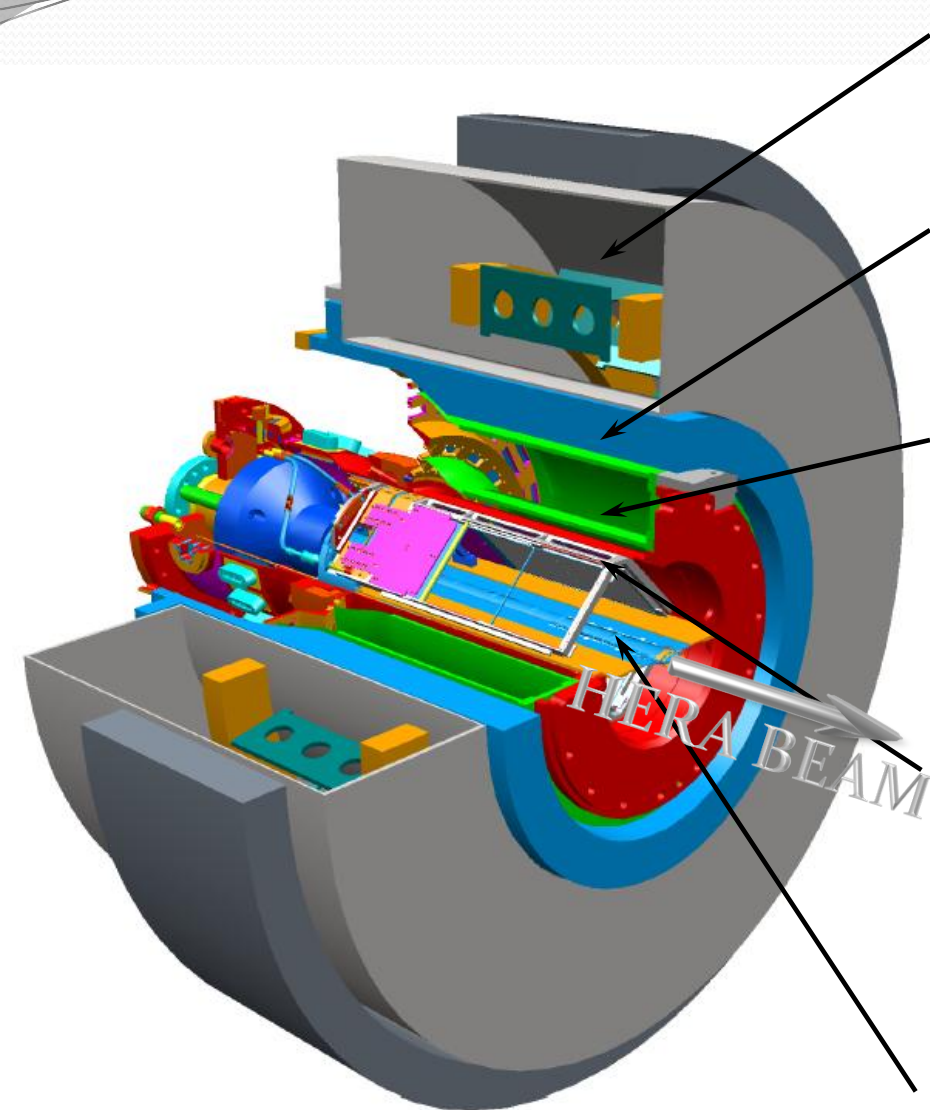


Hermes with Recoil Detector



- Unpolarized hydrogen target: 38Mio DIS
- Unpolarized deuterium target: 10Mio DIS
- Two beam helicities, electron and positron beam

Recoil Detector at Hermes



1 Tesla Superconducting Solenoid

Photon Detector(PD)

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

Scintillating Fiber Tracker (SFT)

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

Momentum reconstruction by bending in
magnetic field

Silicon Strip Detector (SSD)

Momentum reconstruction by energy
deposit for low-momentum protons and
deuterons

Inside the HERA vacuum

Target Cell of Unpolarized Target

ΔE distributions with Recoil Detector

$$0.6 < M(\pi^+ \pi^-) < 1.0$$

$$1.04 < M(KK)$$

$7.0 < \text{Energy of vector meson}$

$3.5 < \text{momentum of lepton}$

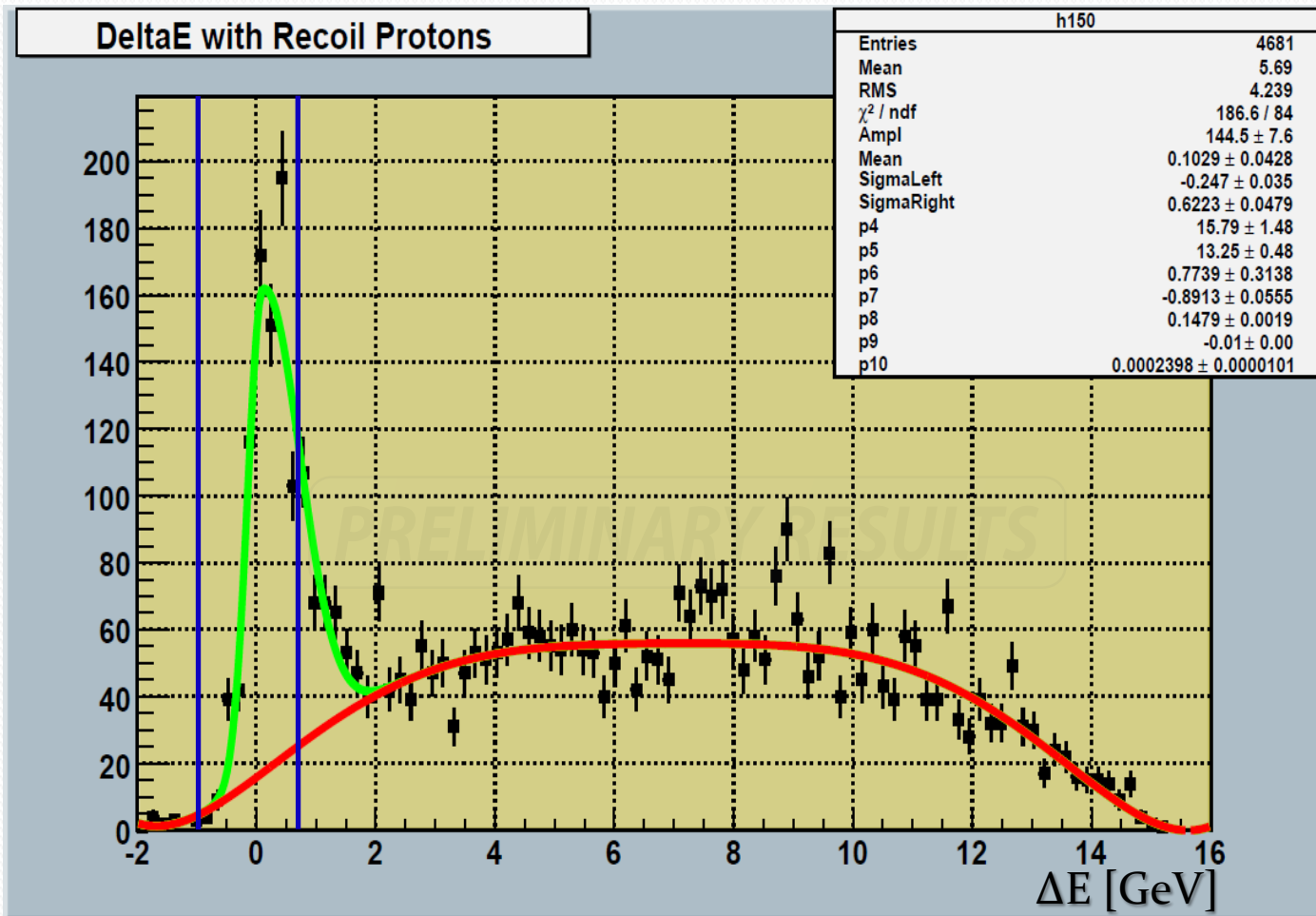
$$-t' < 0.4$$

$$7.0 > q^2 > 0.5$$

$$w^2 > 7$$

$$Y_{\text{bjorn}} > 0.85$$

$5\text{cm} < Z \text{ Vertex} < 20 \text{ cm}$



Further cuts on the recoil proton
(e.g. coplanarity cut)
will improve signal/background.

$$-1 < \Delta E < 0.6$$

this cut can be revisited with
Recoil protons to gain statistics

ρ^0 mass distributions with Recoil Detector

$$0.3 < M(\pi^+ \pi^-) < 1.2$$

$$1.04 < M(KK)$$

$$7.0 < \text{Energy of vector meson}$$

$$3.5 < \text{momentum of lepton}$$

$$-t' < 0.4$$

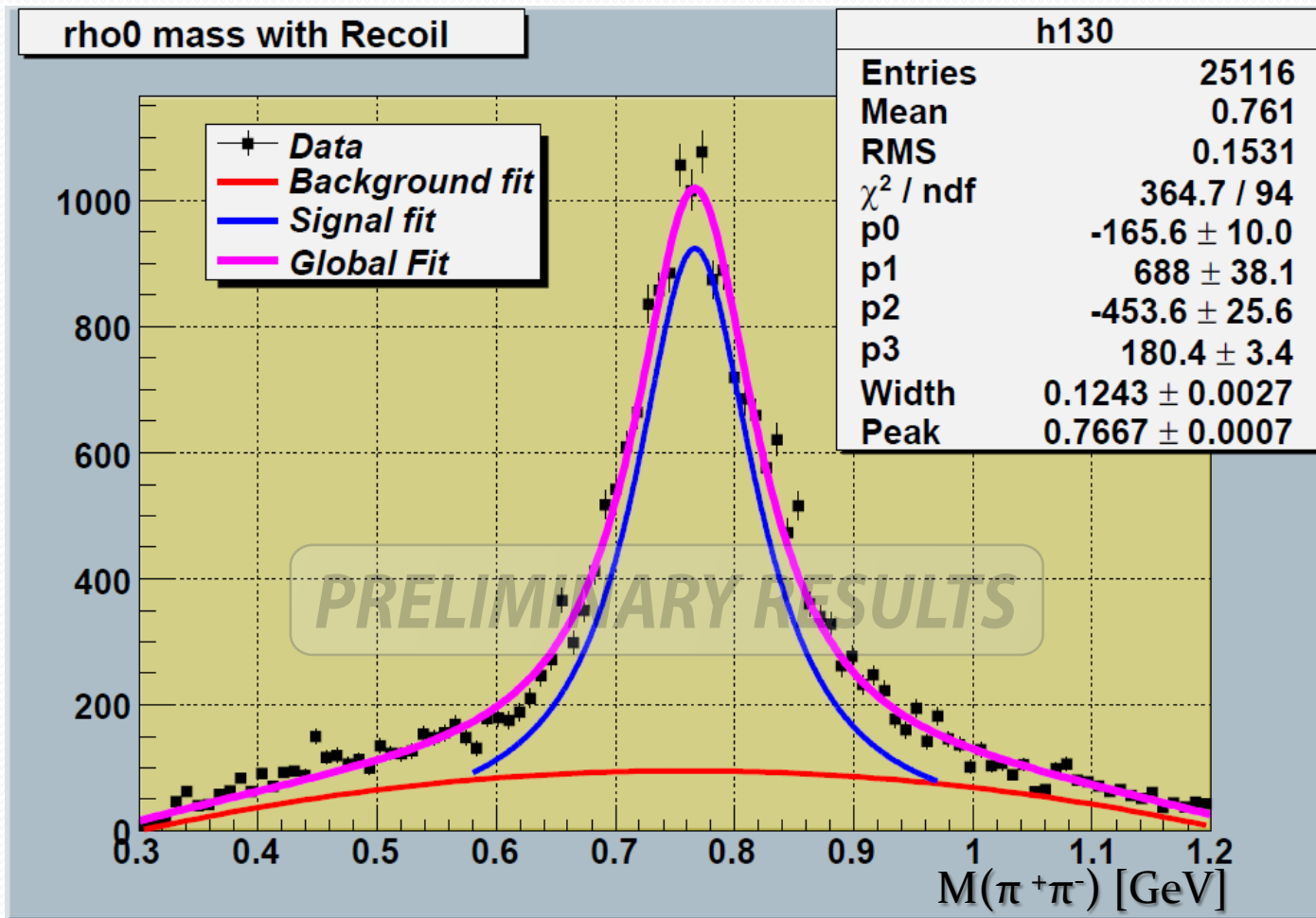
$$7.0 > q^2 > 0.5$$

$$w^2 > 7$$

$$Y_{\text{bjorn}} > 0.85$$

$$5\text{cm} < Z \text{ Vertex} < 20 \text{ cm}$$

$$-1 < \Delta E < 0.6$$



$$\text{mass } \rho(770) = 775.49 \pm 0.34 \text{ MeV}$$

C. Amsler *et al.* (Particle Data Group), PL B667, 1 (2008)

Summary and Outlook

- New data from Hermes using the Recoil Detector are ready for physics analysis
- First look at ρ^0 production with the Recoil Detector
- Possible exclusive ρ^0 physics analyses:
 - b slope analysis of exclusive ρ^0_L and ρ^0_T
 - Exclusive ρ^0 cross section ratio on Deuterium and Hydrogen Target
 - Beam Spin Asymmetries in exclusive ρ^0 production
 - ...