

# First look to exclusive $\rho^0$ production with the Recoil Detector at HERMES

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European Graduate School  
The Nucleon Structure  
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# Outline

- The Spin Structure of the Nucleon
- Generalized Parton Distributions (GPDs)
- Hard meson electroproduction
- Exclusive  $\rho^0$  production at Hermes
- First look 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

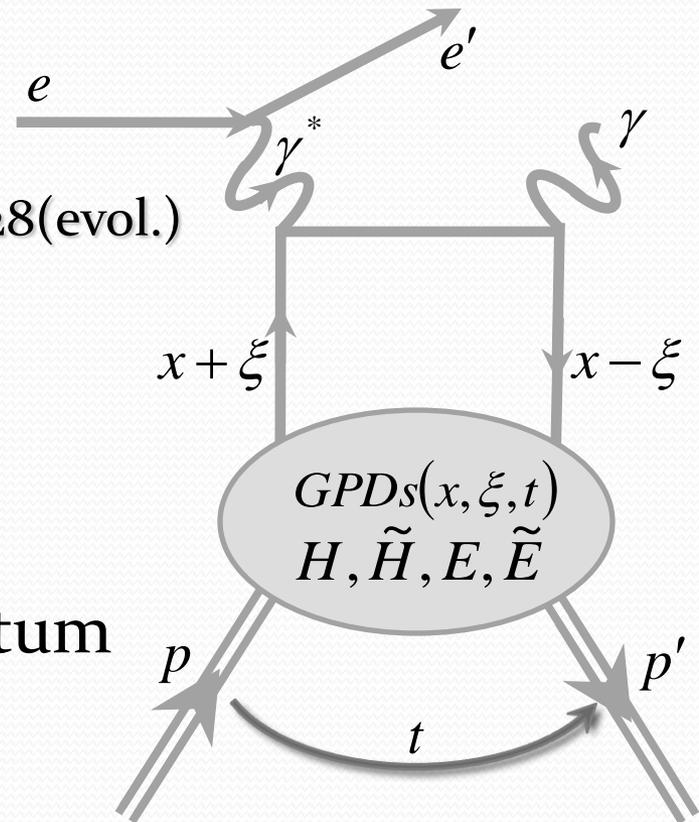
■  $\Delta\Sigma = 0.330 \pm 0.011(\text{theo.}) \pm 0.025(\text{exp.}) \pm 0.028(\text{evol.})$

*Airapetian et al. [HERMES Collaboration]*

*Phys. Rev. D 75, 012007 (2007)*

## ■ $L_q$ Orbital angular momentum

## ■ $J_{q,g}$ Total orbital angular momentum



# Generalized Parton Distributions

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

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

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

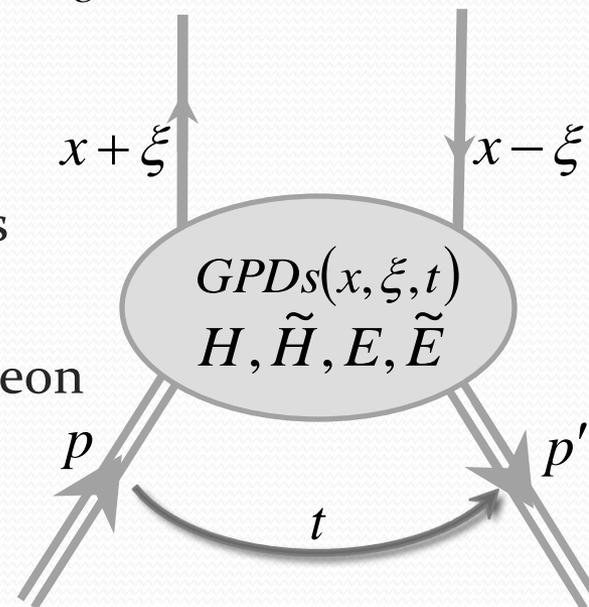
$x \pm \xi$  parton longitudinal momentum fractions

$\xi$  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

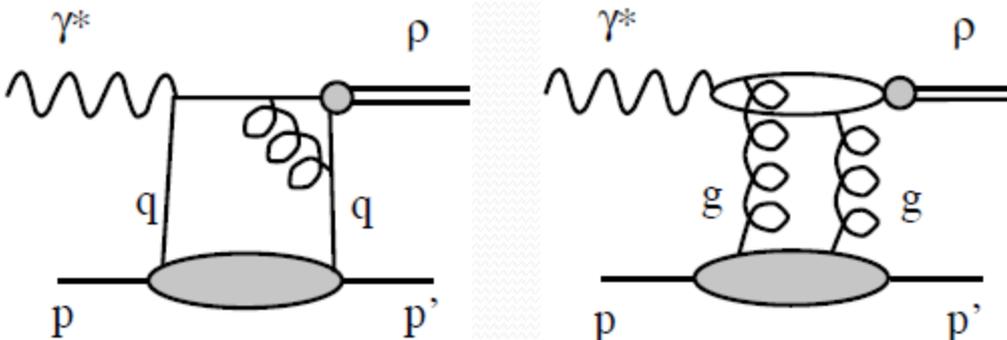
- The quark helicity is conserved in hard scattering process
- The meson acts as a helicity selector:
  - The longitudinally polarized vector meson channels ( $\rho_L^{0,\pm}$ ,  $\omega_L$ ,  $\phi_L$ ) are sensitive only to the unpolarized GPDs ( $H$  and  $E$ )
  - The pseudo-scalar channels ( $\pi^{0,\pm}$ ,  $\eta$ , ...) 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 $\rho^0$ production

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

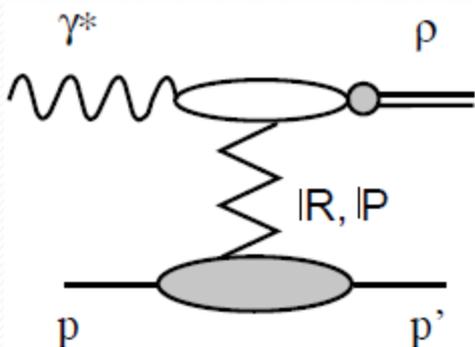
*M. Diehl, A. V. Vinnikov, Phys.Lett.B609,286-290,(2005)*



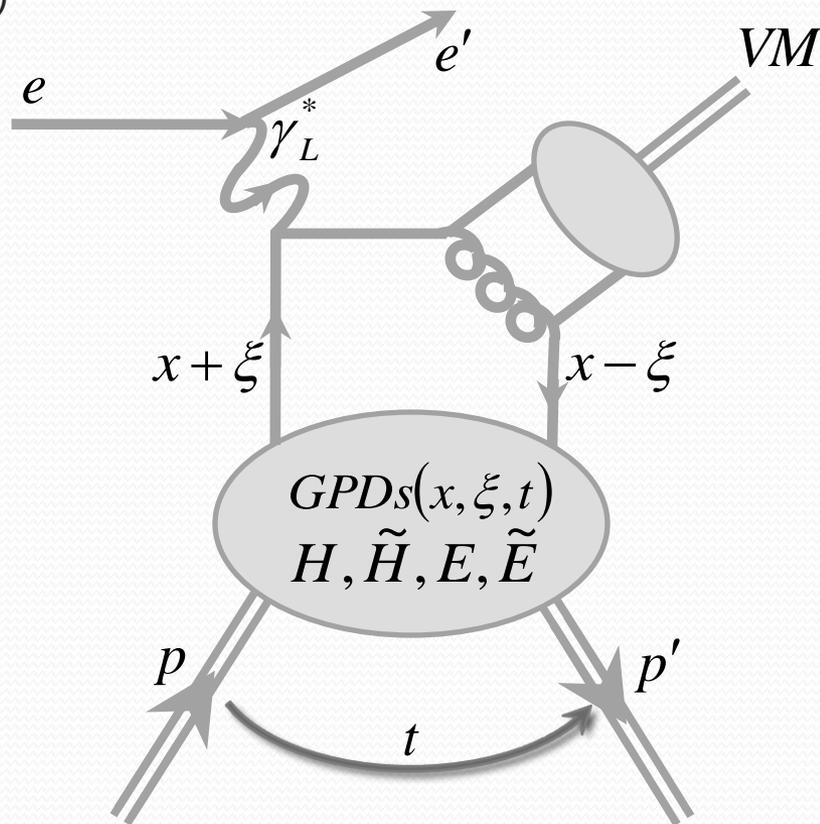
quark exchange

two-gluon exchange

models inspired by perturbative QCD



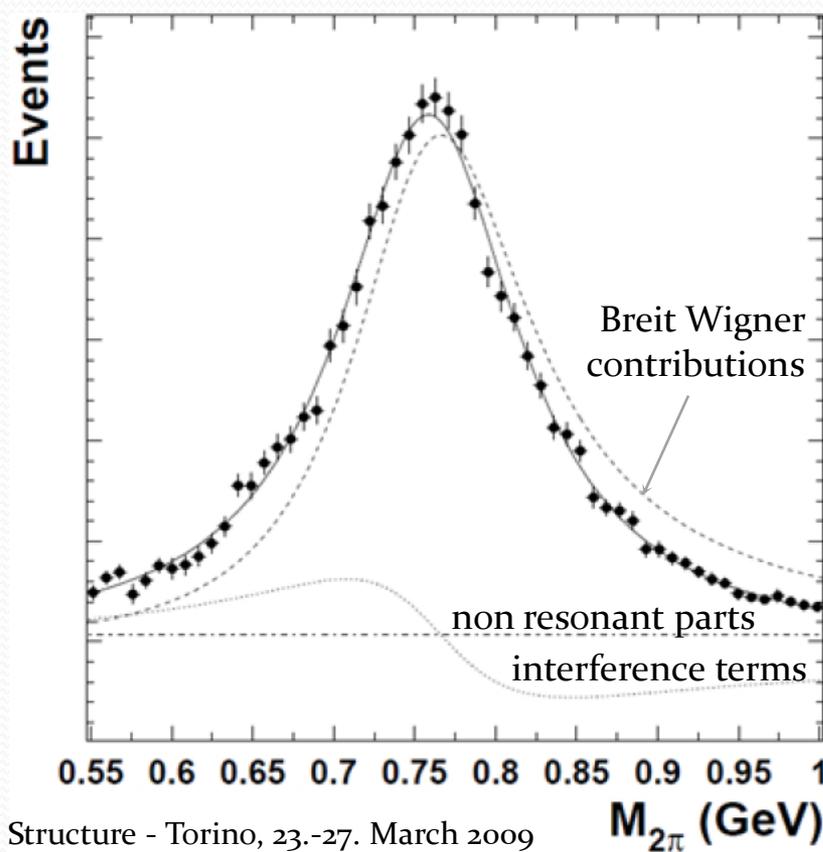
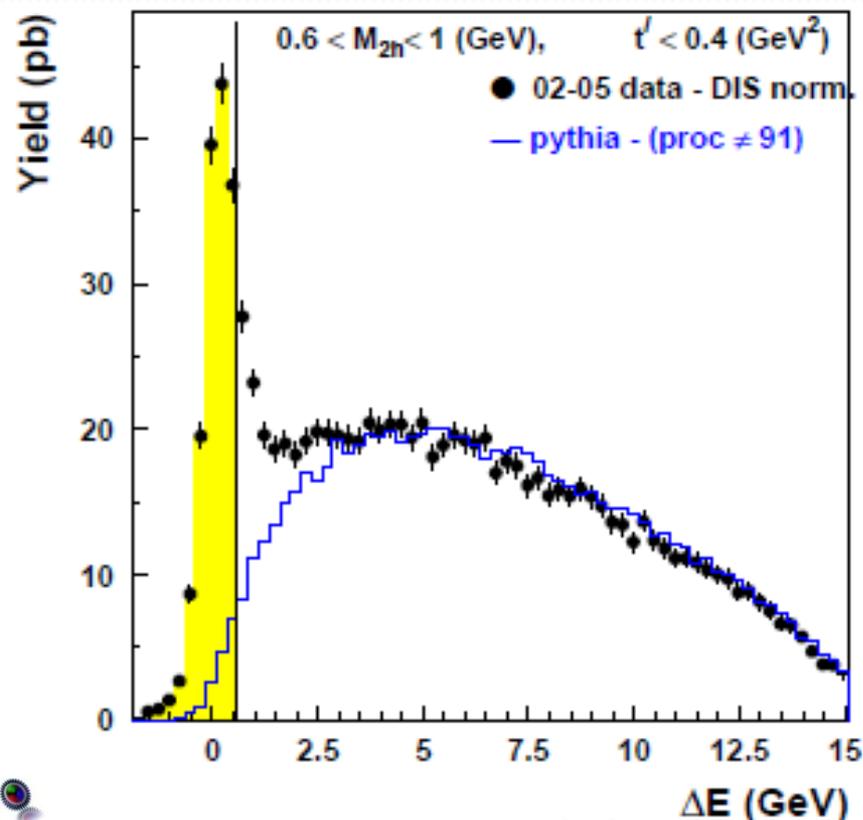
Reggeon or Pomeron exchange in models based on Regge theory



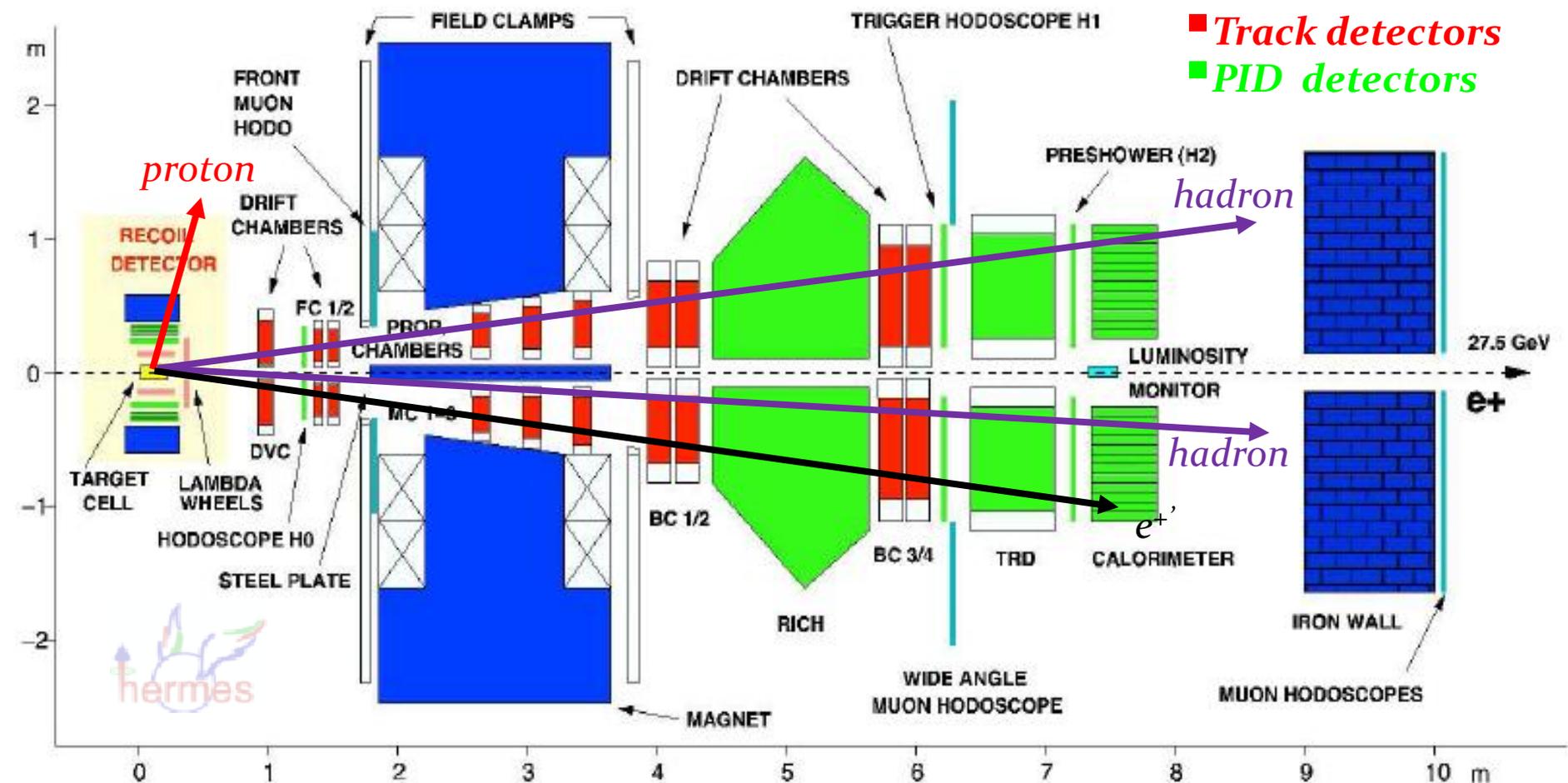
# Exclusive $\rho^0$ production at Hermes

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

- 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%**

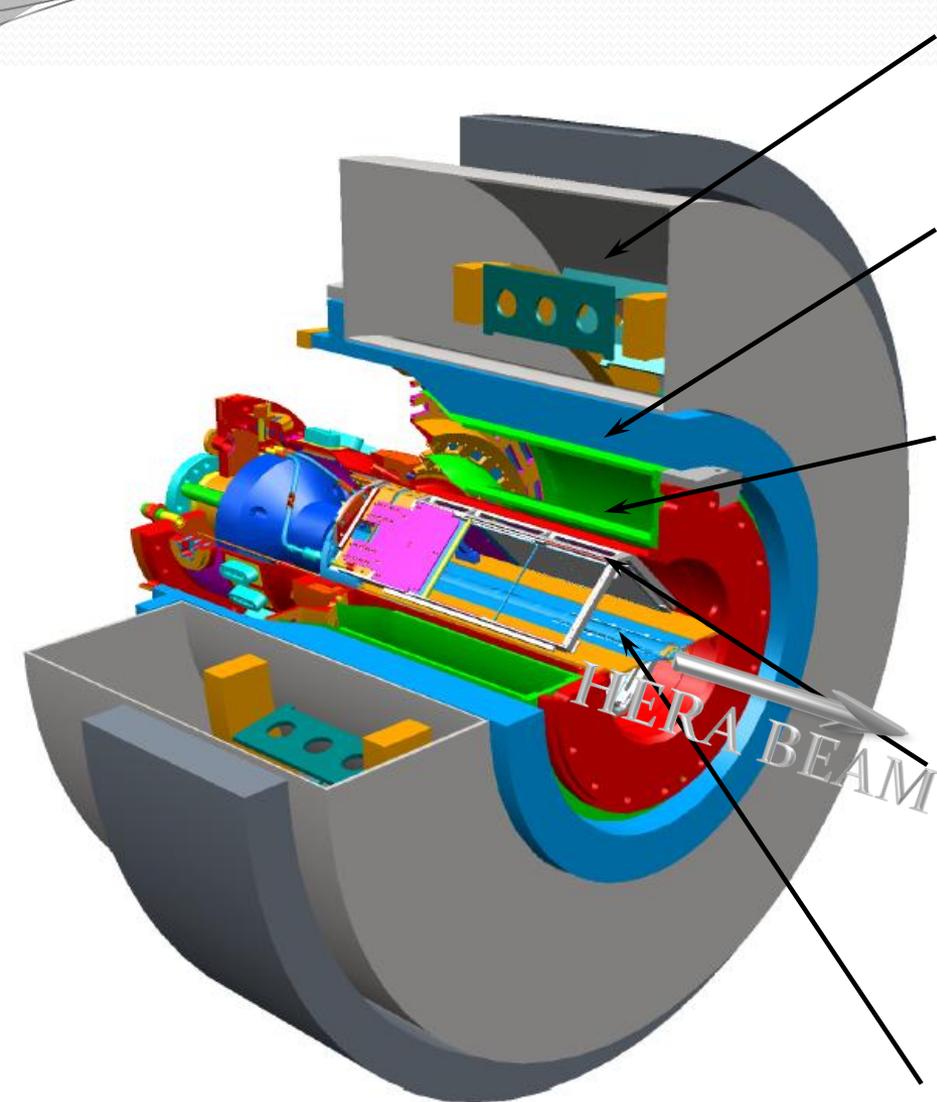


# Hermes with Recoil Detector



- 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,  $p/\pi$  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

# $\Delta E$ distributions with Recoil Detector

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

$$1.04 < M(KK)$$

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

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

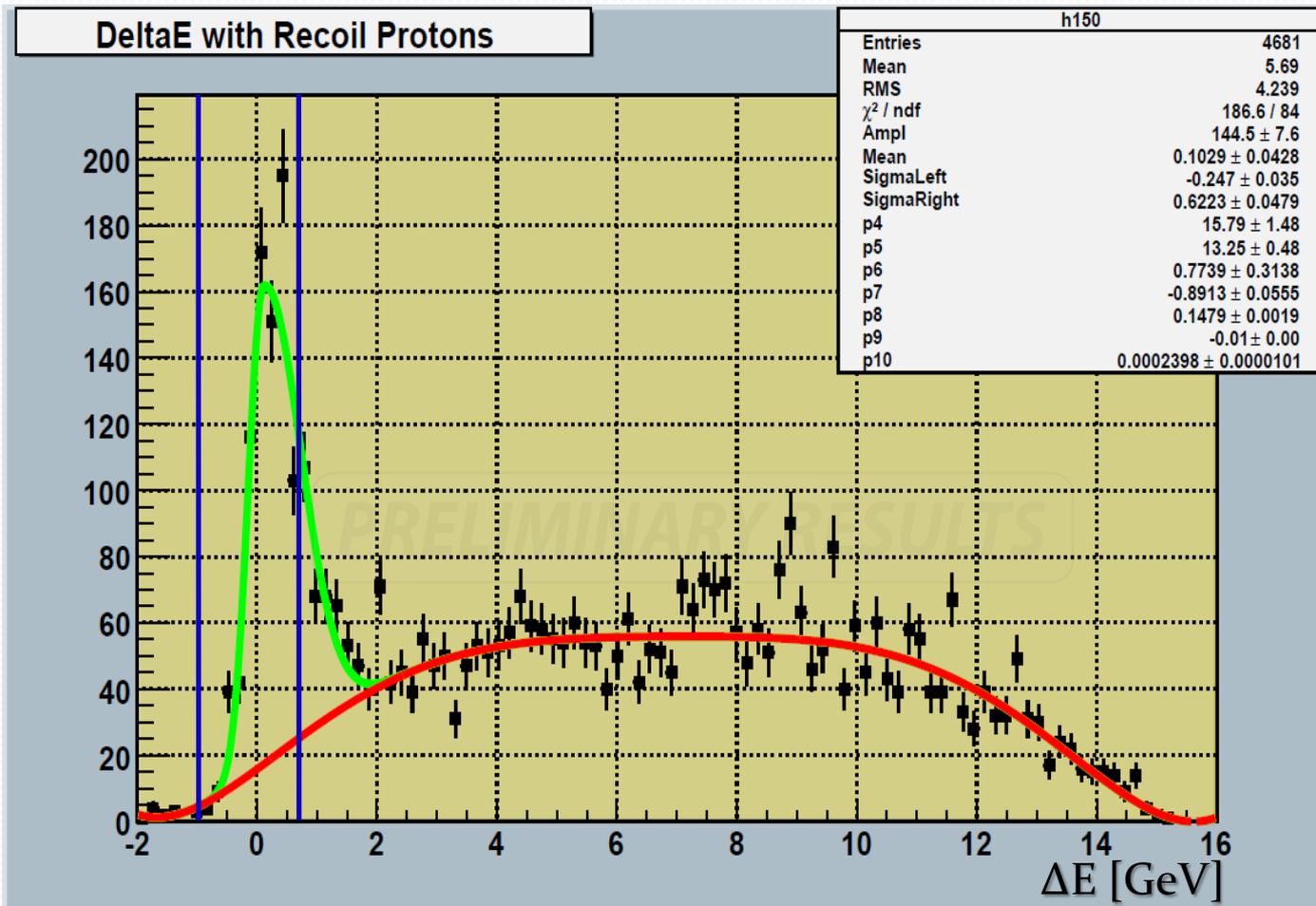
$$-t' < 0.4$$

$$7.0 > q^2 > 0.5$$

$$w^2 > 7$$

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

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



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

# $\rho^0$ mass distributions with Recoil Detector

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

$$1.04 < M(KK)$$

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

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

$$-t' < 0.4$$

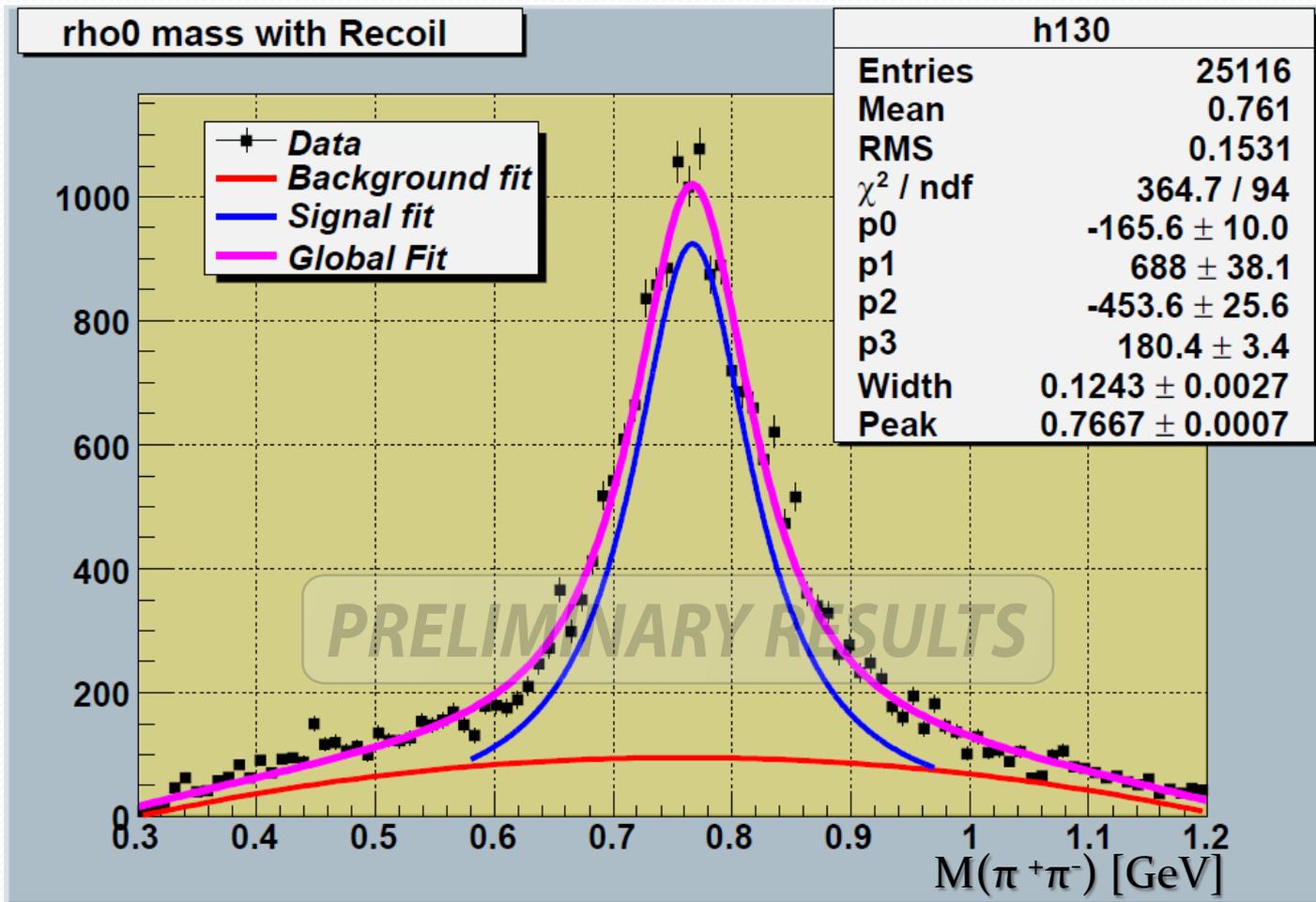
$$7.0 > q^2 > 0.5$$

$$w^2 > 7$$

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

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

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



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

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  $\rho^0$  production with the Recoil Detector
- Possible exclusive  $\rho^0$  physics analyses:
  - b slope analysis of exclusive  $\rho^0_L$  and  $\rho^0_T$
  - Exclusive  $\rho^0$  cross section ratio on Deuterium and Hydrogen Target
  - Beam Spin Asymmetries in exclusive  $\rho^0$  production
  - ...