Results on exclusive ρ^0 production from COMPASS at CERN

- Physics of the incoherent exclusive ρ^0 production
- ρ^0 production analysis on COMPASS experiment
- First results

D. Neyret *CEA Saclay DAPNIA SPhN*

Exclusive ρ^0 production

$$\mu + N \rightarrow \mu' + N' + \rho^0$$

Cross section $\propto L_{\mu\nu} T^{\mu\nu}$ where

$$L_{\mu\nu} = \sum m_\mu^2 \langle \mu' | j_\mu^{el} | \mu \rangle \langle \mu' | j_\nu^{el} | \mu \rangle^*$$

$$T^{\mu\nu} = \sum \langle N' \rho^0 | j^{el\,\mu} | N \rangle \langle N' \rho^0 | j^{el\,\nu} | N \rangle^*$$

Factorization of the interaction:

leptonic part

$\mu \rightarrow \mu + \gamma^*$

hadronic part

$\gamma^* + N \rightarrow \rho^0 + N$

photon density matrix:

$$\rho(\gamma)_{\lambda\lambda'} = \frac{1-\epsilon}{Q^2} L_{\lambda\lambda'}$$

vector-meson density matrix

$$\rho(V)_{\lambda\lambda'} = \frac{1}{2} T\, \rho(\gamma)\, T^+$$

Decomposition on 9 orthogonal hermitian matrices:

$$\rho(\gamma)_{\lambda\lambda'} = \frac{1}{2} \sum_{\alpha=0}^{8} \tilde{\Pi}_\alpha \Sigma^\alpha$$

$$\rho(V)_{\lambda\lambda'} = \sum_{\alpha=0}^{8} \tilde{\Pi}'_\alpha \rho^\alpha$$

The vector-meson density matrix

$\rho^{\alpha}_{\lambda\lambda'}$ can be expressed from Σ^{α}: $\rho^{\alpha}_{\lambda_V \lambda_V'} = \frac{1}{2 N_{\alpha}} \sum_{\text{helicities}} T \, \Sigma^{\alpha}_{\lambda_\gamma \lambda_\gamma'} \, T^{*}$

where λ_V, λ_V' helicity of ρ^0

each ρ^{α} represents production by different γ^* polarization states:

$\alpha = 0$: unpolarized transverse γ^* $\alpha = 1, 2$: linear polarized transverse γ^* (x & y)

$\alpha = 3$: circular polarized transverse γ^* $\alpha = 4$: longitudinaly polarized γ^*

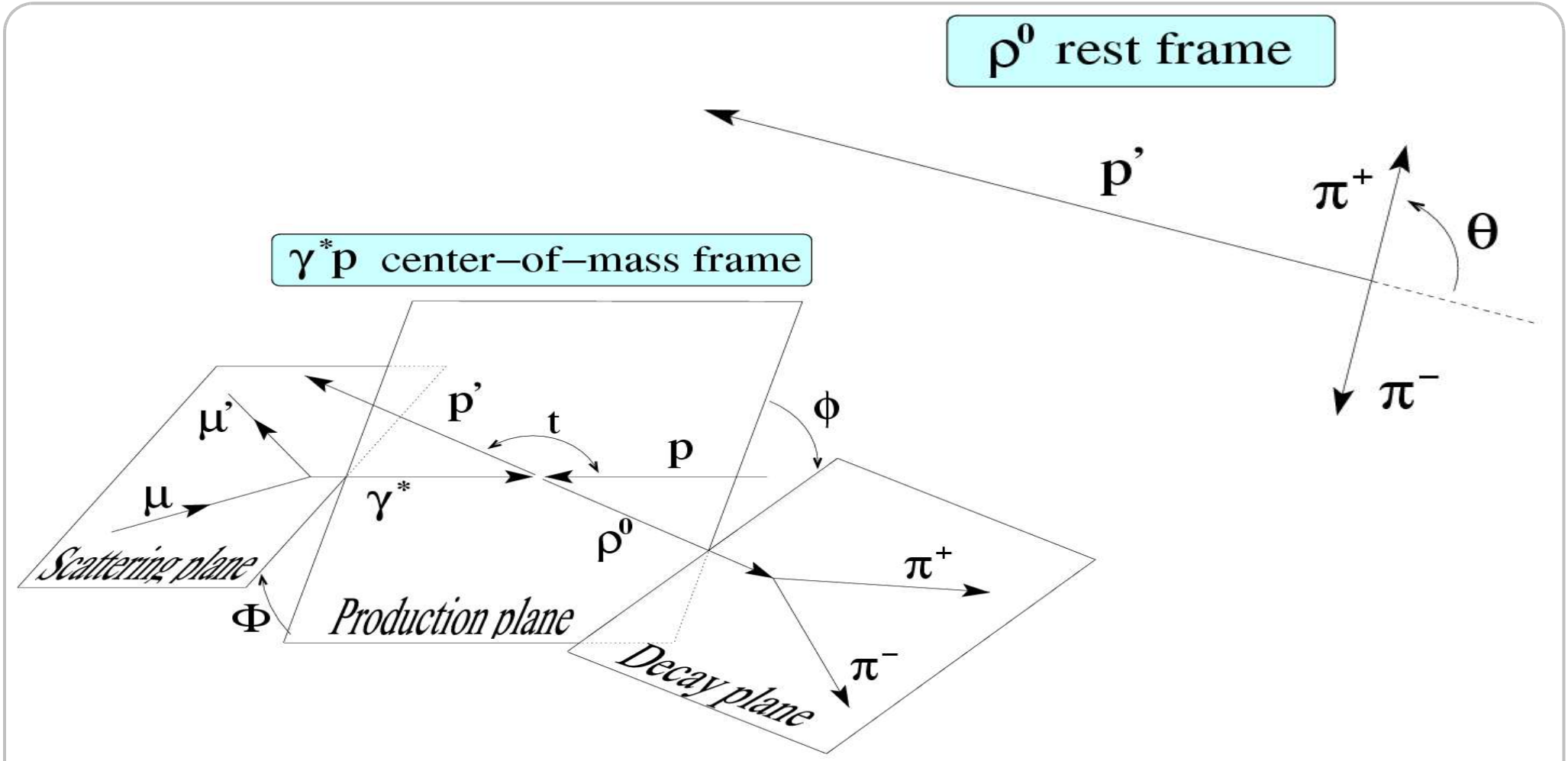
$\alpha = 5$ to 8: interferences between transverse and longitudinal

Goals: to determine these $\rho^{\alpha}_{\lambda\lambda'}$ matrices

to test s channel helicity conservation (SCHC) hypothesis (same helicity for γ^* and ρ^0)

to determine $R = \sigma_L/\sigma_T$ assuming SCHC

Angular distribution of the ρ^0 production



The angular distributions of interaction and $\pi^+\pi^-$ production give access to the ρ^0 helicity

all matrix elements $\rho^{\alpha}_{\lambda\lambda'}$ can be determined from W(cos θ, ϕ, Φ)

ρ^0 production at Compass

With one beam energy no $\sigma_L - \sigma_T$ separation at Compass

$\Rightarrow$ can't access directly ρ^0 and ρ^4 matrices

$\rightarrow$ determination of $r^{04}_{\lambda\lambda'}$ linear combinations of $\rho^0_{\lambda\lambda'}$ and $\rho^4_{\lambda\lambda'}$ (other $r^{\alpha}_{\lambda\lambda'} \propto$ to $\rho^{\alpha}_{\lambda\lambda'}$)

We extract up to now only 1-dimensional angular distributions W

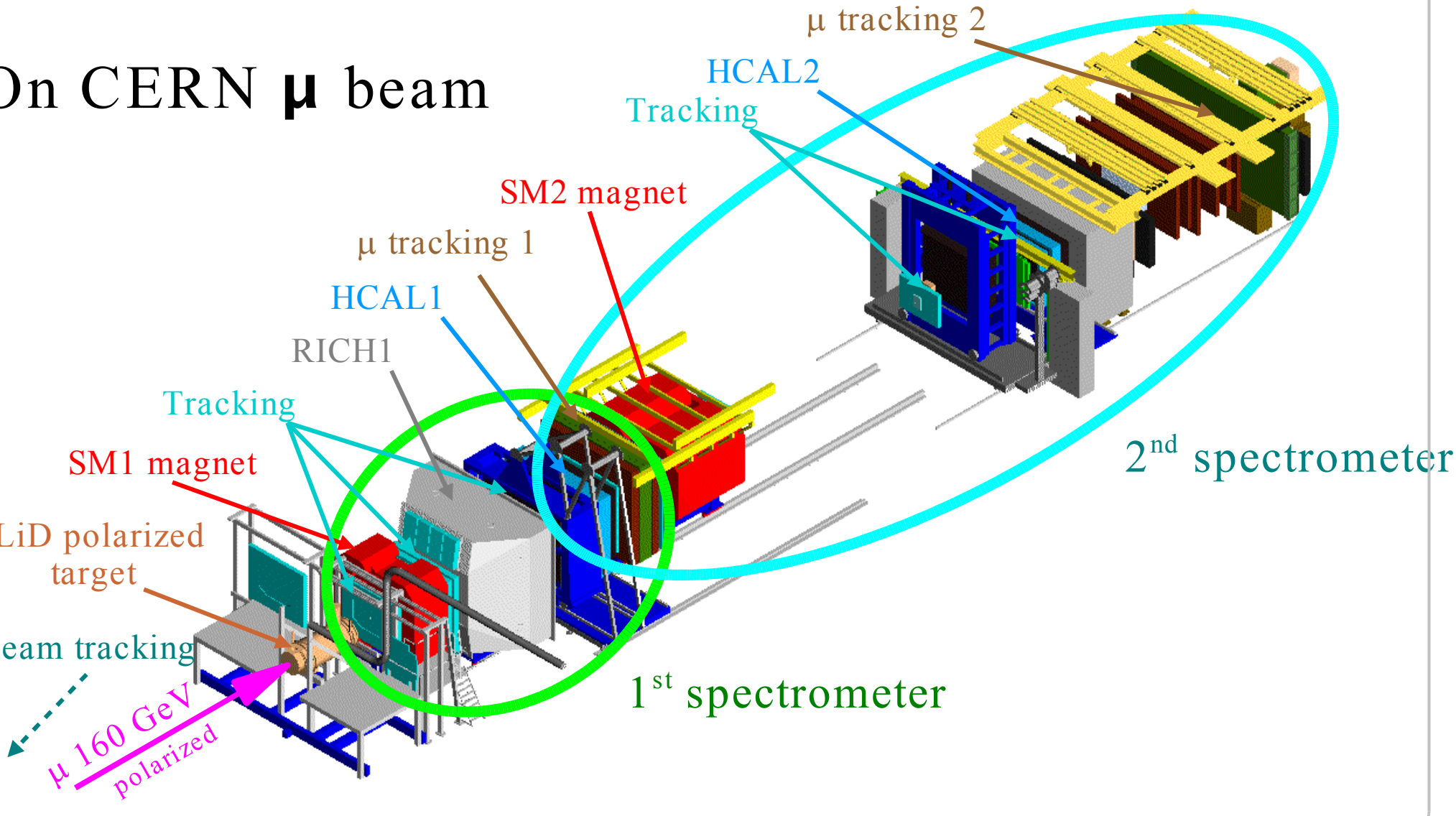
$\Rightarrow$ access to only r^{04}_{00}, r^{1}_{1-1}, r^{04}_{1-1} and $\Im m\ r^{3}_{1-1}$ from W(cos θ), W(ϕ), W(ψ)

If SCHC valid R= σ_L/σ_T can be determined from r^{04}_{00}

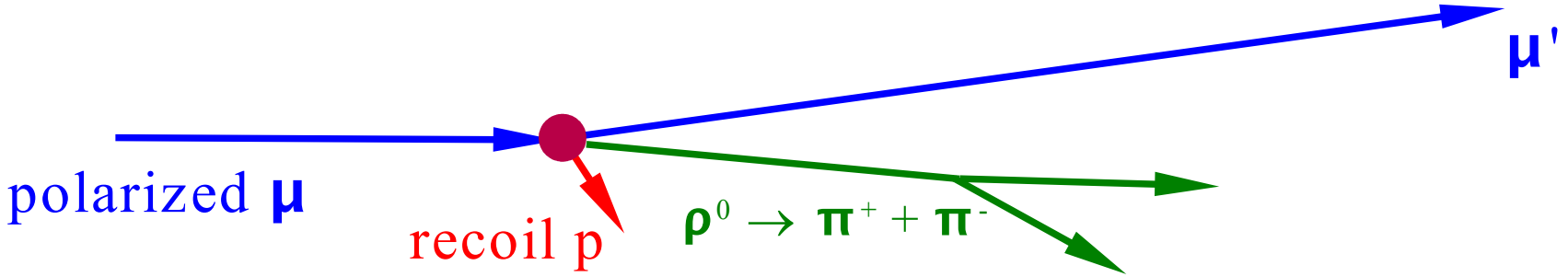
Test of SCHC hypothesis with r^{04}_{1-1} and $\Im m\ r^{3}_{1-1}$ (= 0 if SCHC)

The COMPASS spectrometers

On CERN **μ** beam



Selection of exclusive ρ^0 events



Topological selections:

beam track, scattered muon, 2 remaining tracks of opposite charges, vertex

Selection of hadrons:

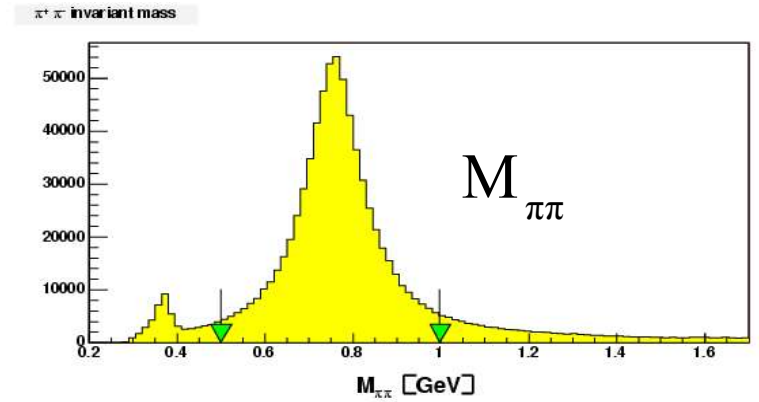
$0.5 < m_{\pi\pi} < 1$ GeV, $-2.5 < E_{miss} < 2.5$ GeV, $0.15 < p^2_t < 0.5$ GeV^2

Kinematical selections on μ:

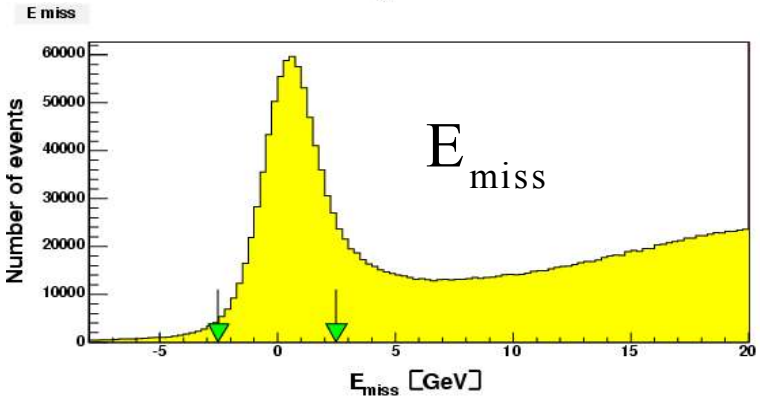
$E_{\mu'} > 20$ GeV, $Q^2 > 0.01$ GeV^2, $\nu > 30$ GeV

695 500 accepted events from 2002 data

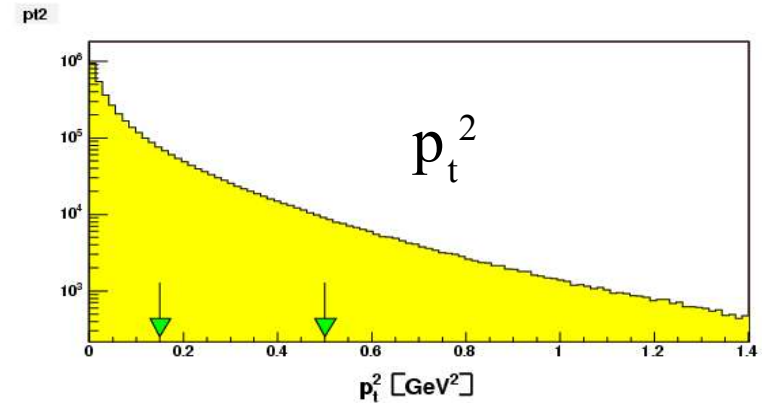
Cuts for hadrons selection



Cuts to select production of ρ_0



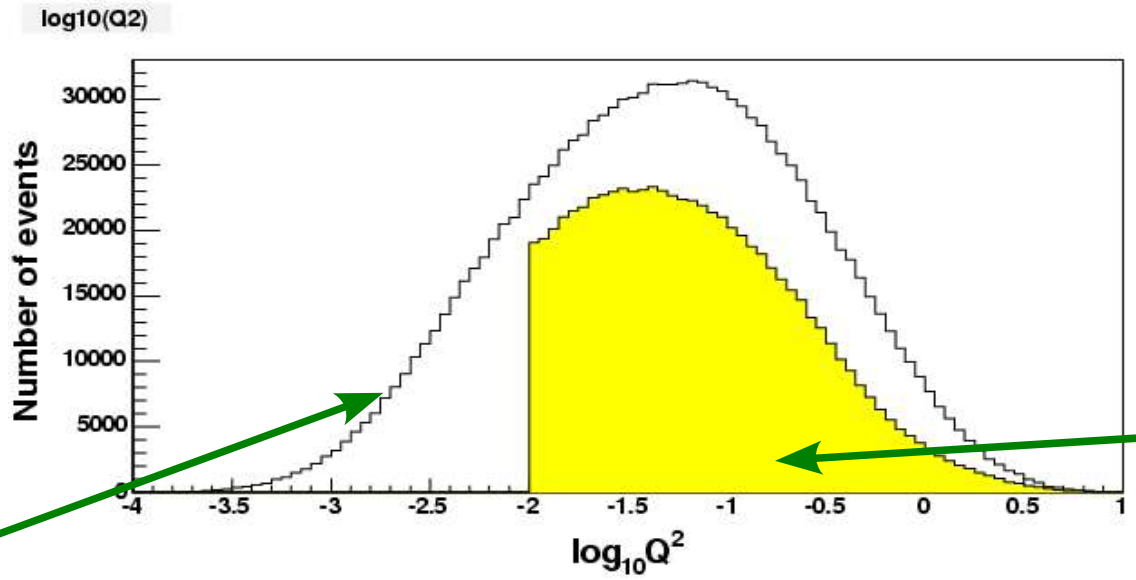
Cuts to ensure the exclusivity of the interaction



High p_t cut to avoid non-exclusive events

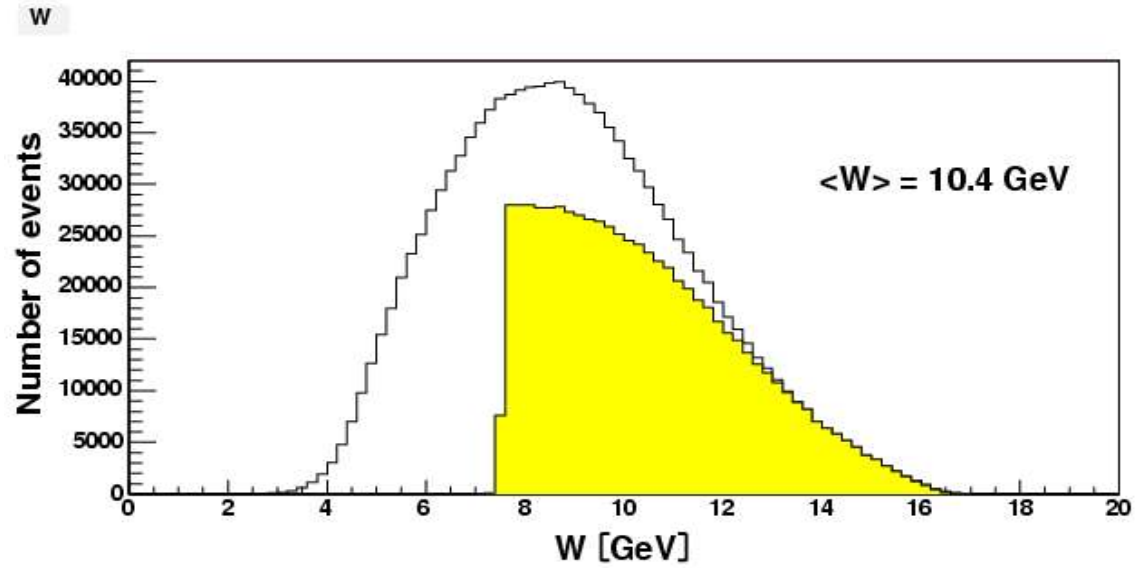
Low p_t cut to suppress coherent ρ_0 production

Q^2 and W distributions for selected evts



without kinematical selections

with kinematical selections on μ



Acceptance correction by Monte Carlo

Goal: to use Monte Carlo simulation to correct the data for acceptance, smearing and efficiency effects

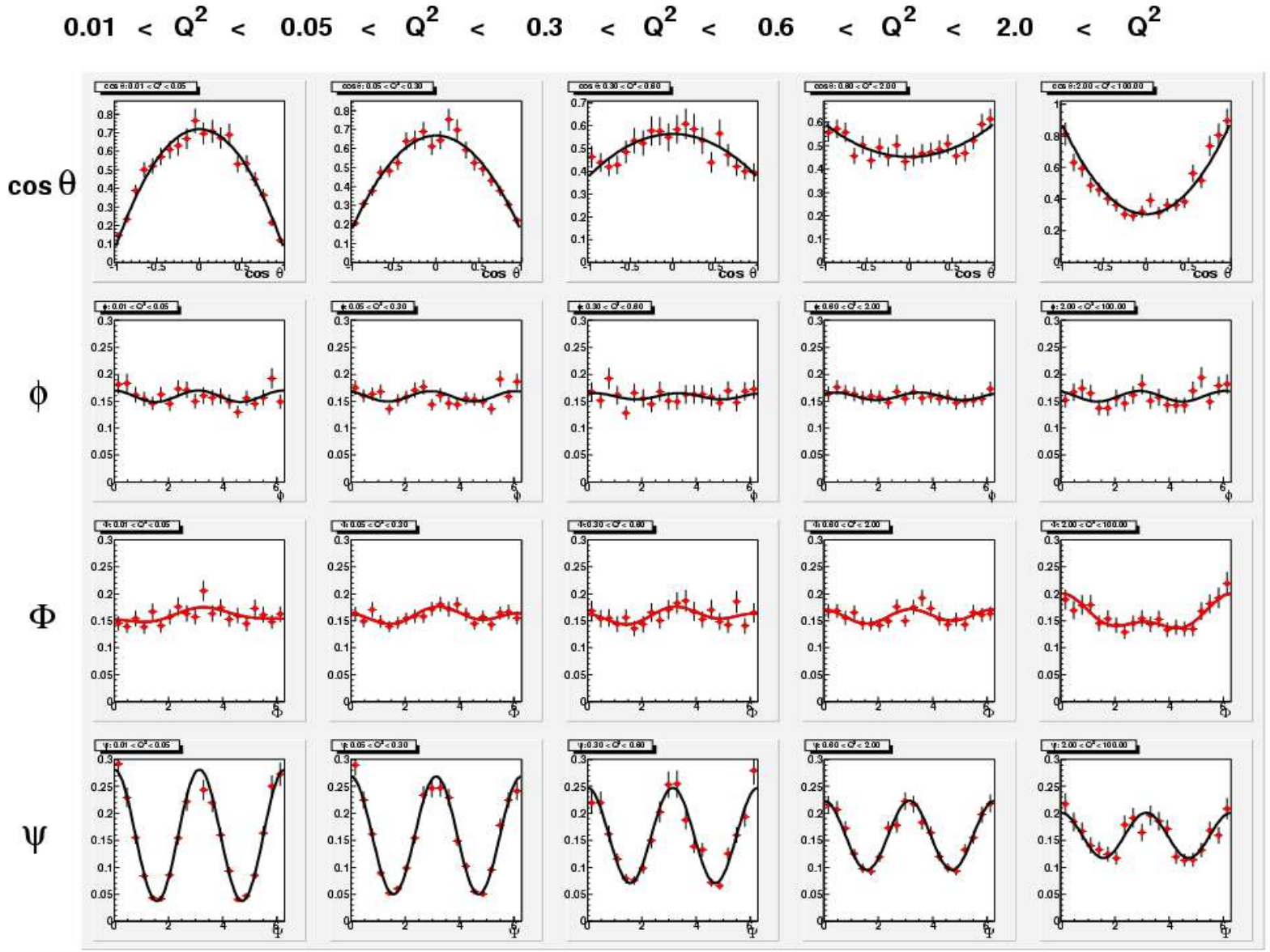
Generator used: **DIPSI**

- dedicated for exclusive vector mesons production on protons
- based on pQCD model by M.G. Ryskin
- written for ZEUS and adapted for fixed target experiments
- can be used at very low Q^2 as effective tool
- Generator parameters tuned to reproduce E665 and NMC data (20-40 % agreement)

Used to generate acceptance correction functions of Q^2 and angles

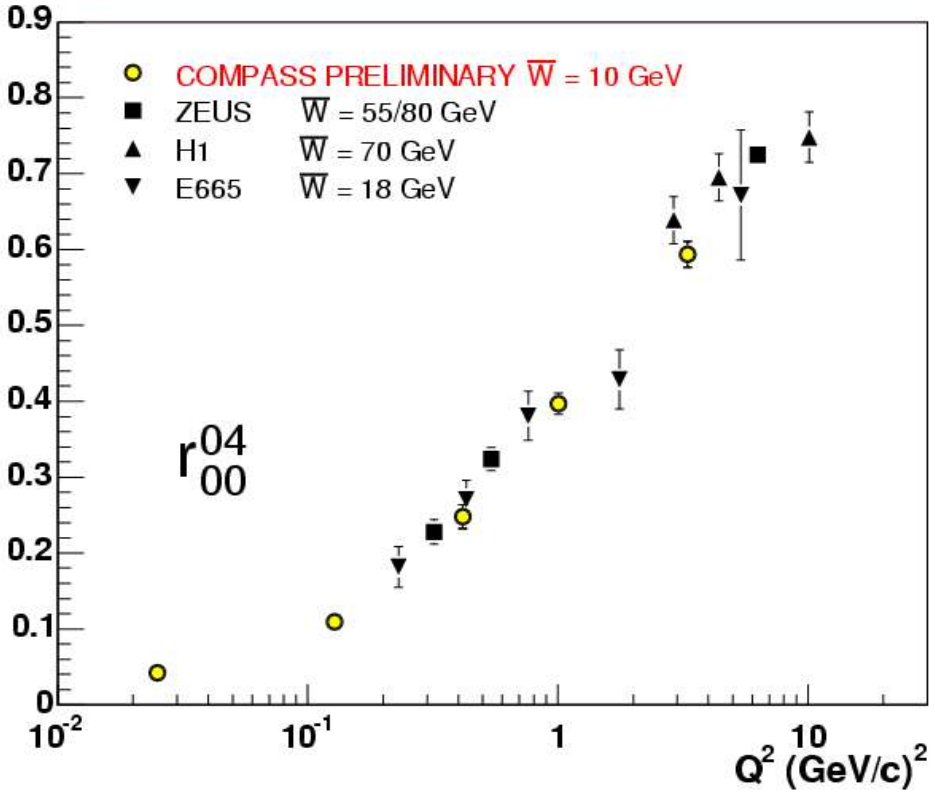
functions almost flat, effects of Q^2 distributions varies by less than 2 %

Angular distributions



$\psi = \phi - \Phi$

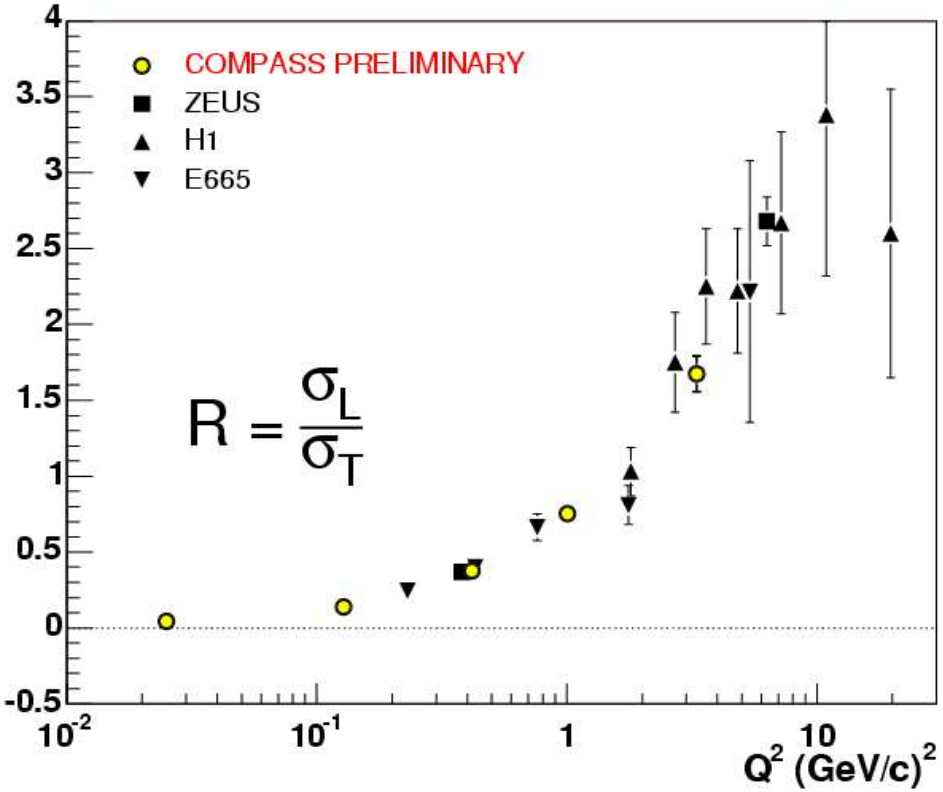
Preliminary results



$$W(\cos\theta) = \frac{3}{4}\left(\left(1 - r_{00}^{04}\right) + \left(3\ r_{00}^{04} - 1\right)\cos^2\theta\right)$$

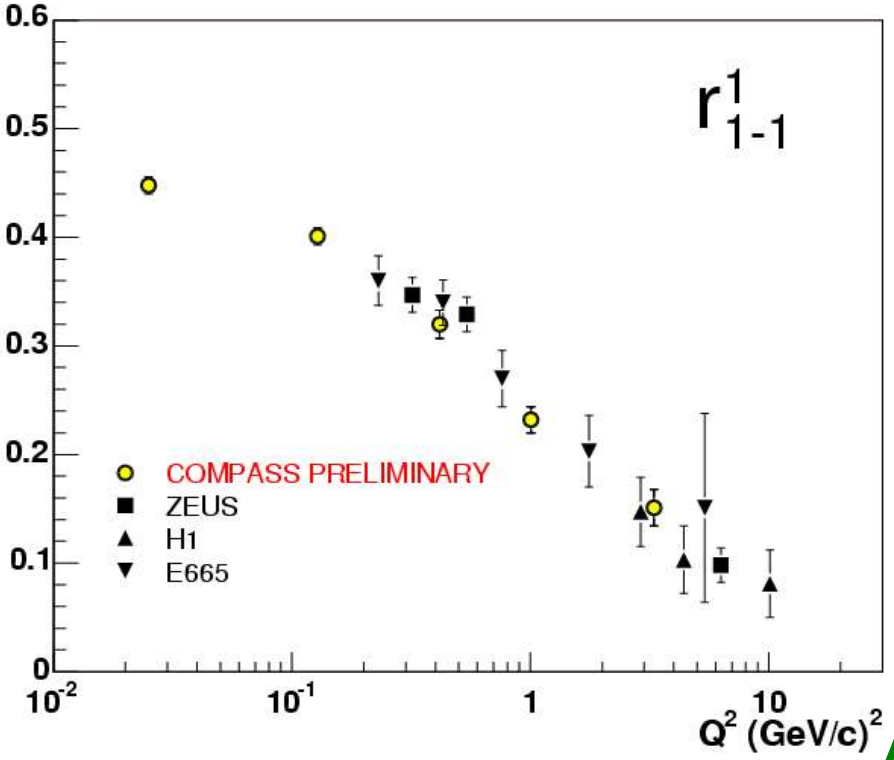
if SCHC assumed:

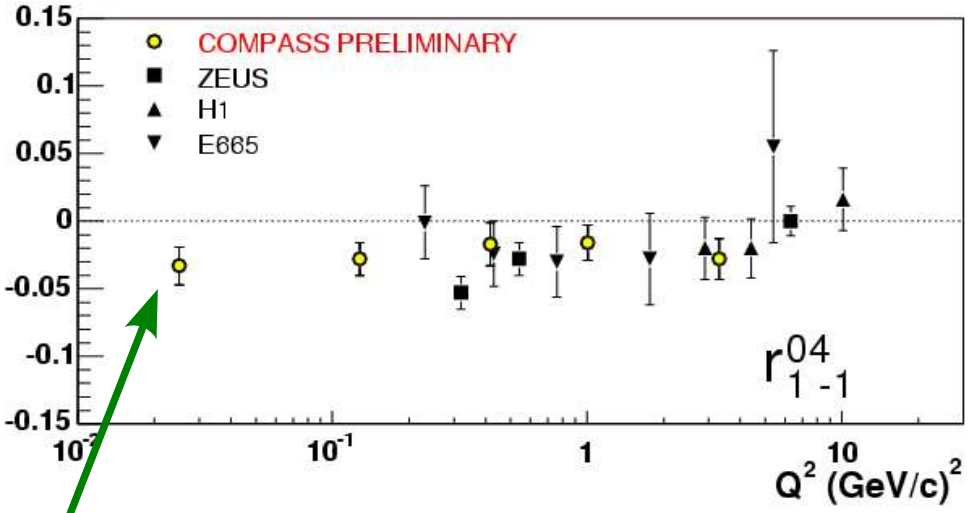
$$r_{00}^{04} = \frac{(\epsilon + \delta)\,R}{1\ + (\epsilon + \delta)\,R}$$

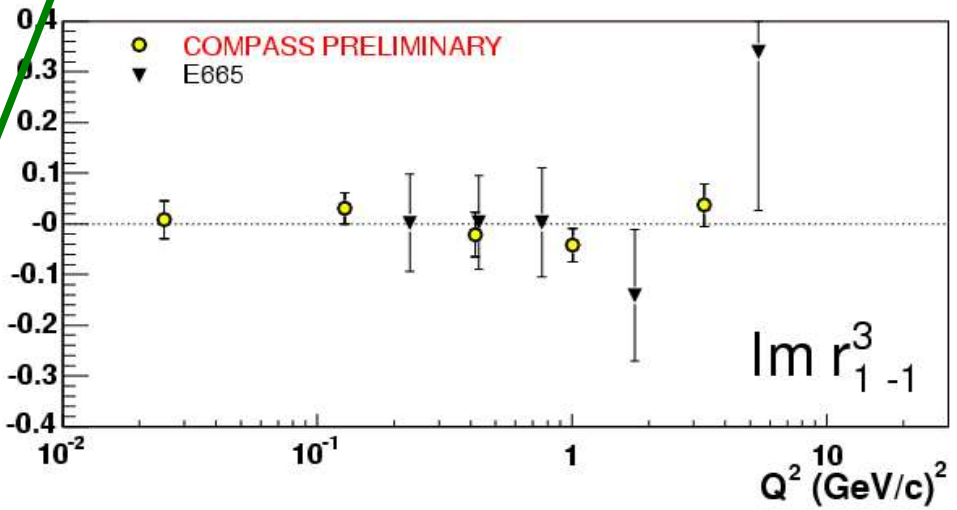


Preliminary results

$$W(\psi) = \frac{1}{2\pi}(1 + 2\epsilon\, r^1_{1-1} \cos 2\psi)$$







non-0 values indicates a weak violation of SCHC

$$W(\phi) = \frac{1}{2\pi}(1 - 2\, r^{04}_{1-1} \cos 2\phi + P_\mu \sqrt{1-\epsilon^2}\, 2\, \Im m\, r^3_{1-1} \sin 2\phi)$$

Conclusion

First determination of r^{04}_{00}, r^{04}_{1-1}, $\Im m\ r^{3}_{1-1}$, r^{1}_{1-1} and R at Compass

using 2002 data with <W>~10 GeV and on Q^2 range between 0.01 and 10 GeV^2

- Good agreement with Zeus, H1, E665, with better statistical accuracy
- Consistent with an increase of R with Q^2
- r^{04}_{1-1} shows a weak violation of SCHC

To do next:

- to complete analysis
- more statistics using 2003 and 2004 data (Q^2 up to 25 GeV^2 expected)
- study of the whole $W(\theta, \phi, \Phi)$ distribution to extract all $r^{\alpha}_{\lambda\lambda'}$ matrices