Diffractive ρ° production at COMPASS

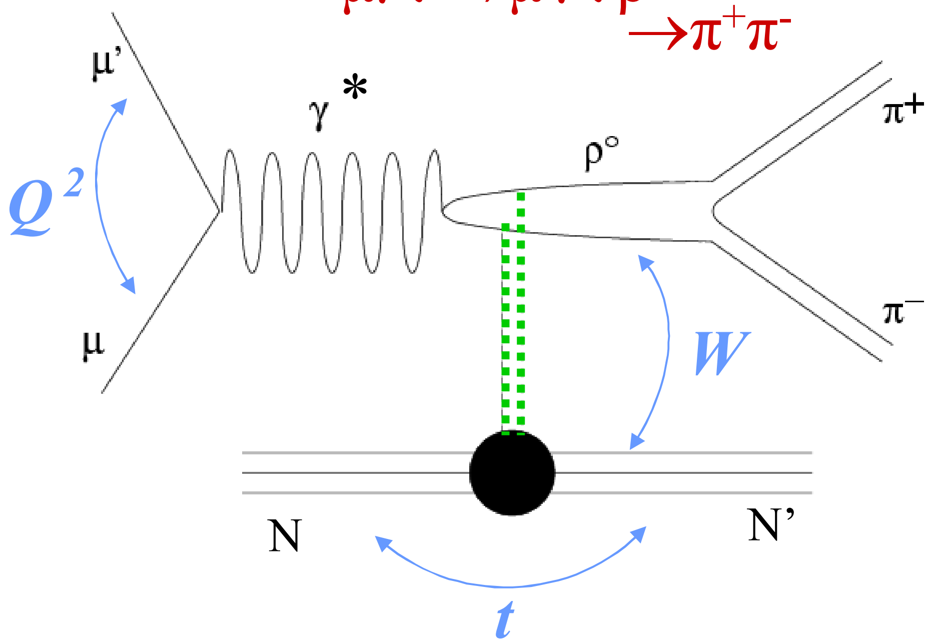
Nicole d'Hose, CEA-Saclay
On behalf of the COMPASS collaboration

- Physics motivations
- COMPASS experiment
- Ongoing analysis
- Preliminary results
- Prospects for the future

DIS 2005, Madison, USA, April 27-May 1, 2005

Description of the diffractive ρ° production

$\mu N \to \mu' N' \rho_{\to \pi^+\pi^-}$



COMPASS: $10^{-2} < Q^2 < 10$ GeV^2,
$\langle W \rangle = 10$GeV, t small

Regge theory,
pQCD calculations (for σ_L), …

At low energy W < 5 GeV:
exchange of 2 quarks
or of Reggeon
- ρ, ω ($J^P=1^-$),
- a_2, f_2 ($J^P=2^+$),
- a_3, f_3 ($J^P=3^-$), …

At higher energy :
exchange of 2 gluons
or of Pomeron

Experimental observations (NMC, E665, ZEUS, H1, HERMES):
the helicity of γ^* is approximatively retained by the ρ° meson ≡ ***SCHC***
the exchange object has natural parity **$P=(-1)^J$** ≡ **NPE**

Spin properties of the production amplitudes

Angular Distribution of the production and decay of $\rho \rightarrow \pi^+\pi^-$

⇨ Spin density matrix elements $\equiv$ bilinear combinations of the helicity amplitudes $A(\gamma^*(\lambda_\gamma) \rightarrow \rho(\lambda_\rho)) \equiv T_{\lambda\rho\,\lambda\gamma}$

$\lambda_\gamma = \pm 1, 0 \quad \lambda_\rho = \pm 1, 0$

if NPE $\quad T_{-\lambda\rho\,-\lambda\gamma} = (-1)^{\lambda\rho-\lambda\gamma}\, T_{\lambda\rho\,\lambda\gamma}$

9 helicity amplitudes reduce to five 5 independent amplitudes :

$A(L\rightarrow L)$, $A(T\rightarrow T)$ >> $A(T\rightarrow L)$ > $A(L\rightarrow T)$ > $A(T\rightarrow -T)$

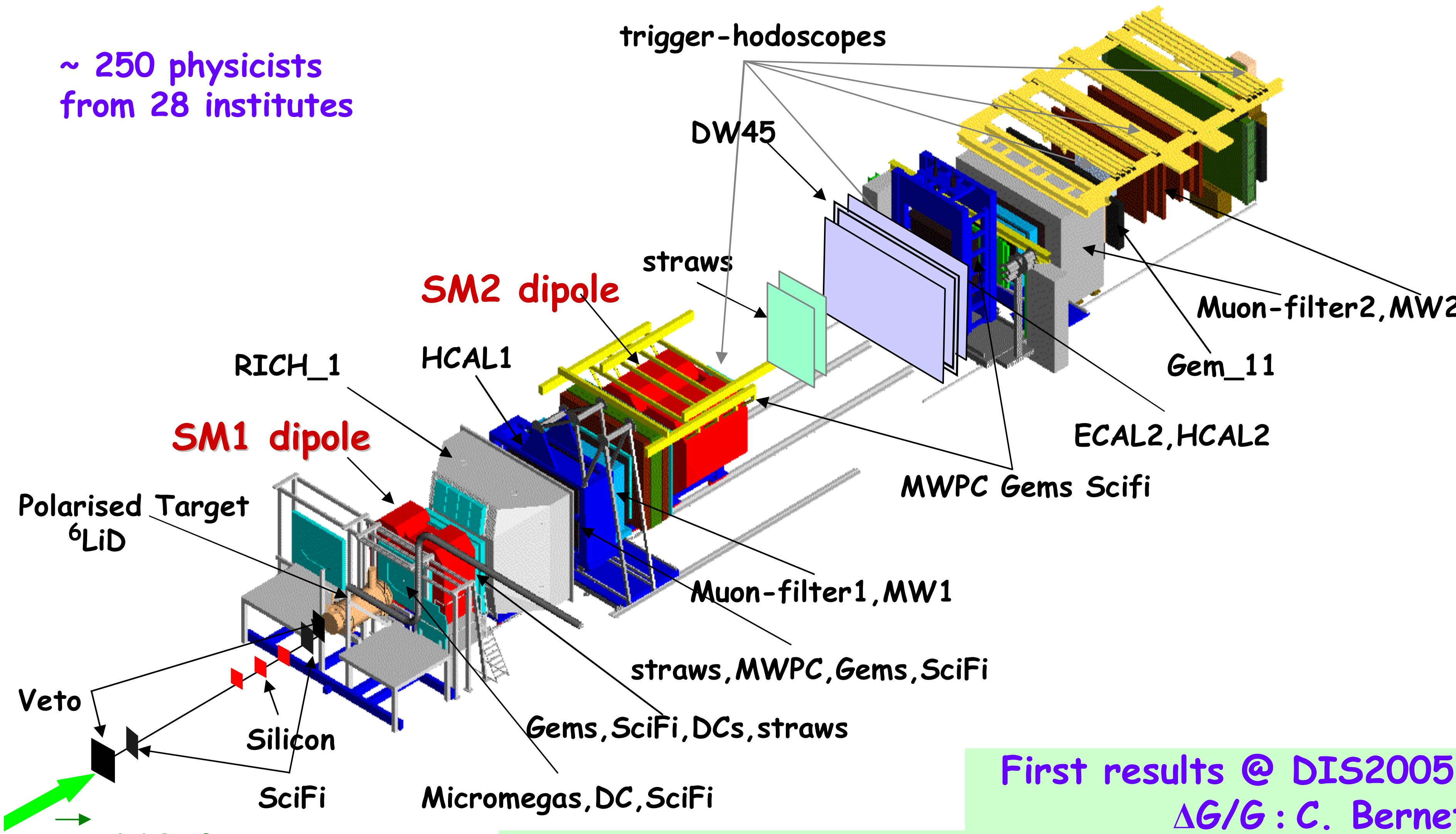
i.e. T_{00}, T_{11} >> T_{01} > T_{10} > T_{-11}

SCHC >> single helicity flip > double helicity flip

SCHNC

COMPASS experiment

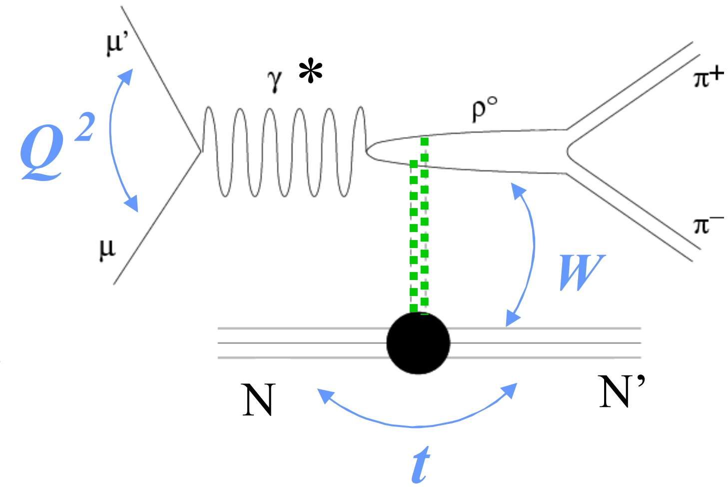
~ 250 physicists
from 28 institutes



First results @ DIS2005:
$\Delta G/G$: C. Bernet
Longitudinal spin depdt g_1^d : J. Hannappel
Transversity : 1) Collins and Sivers asym: P. Pagano
2) 2 hadrons correlation: R. Joosten

Selection of the sample

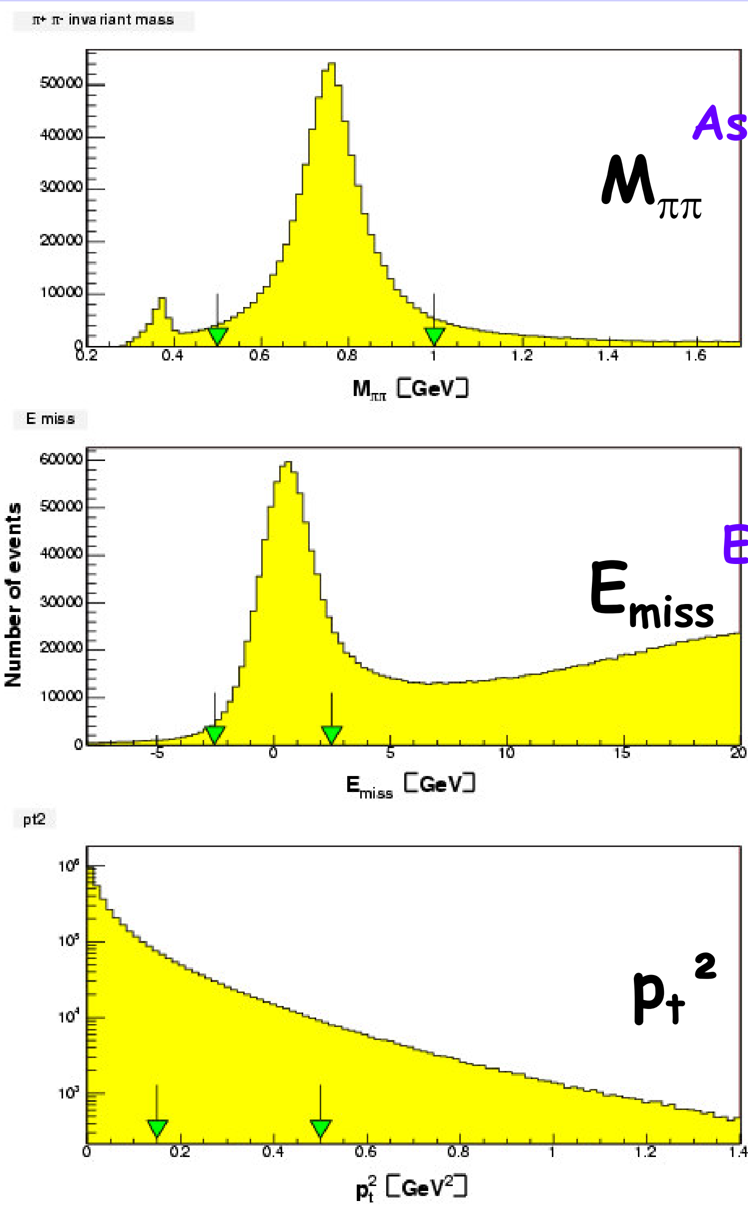
- Topology :
  - 1 incoming μ and 1 scattered μ
  - only 2 hadrons of opposite charge
  - vertex in the ^{6}LiD polarized target



- Kinematical conditions:
  - ν > 30 GeV
  - $E_{\mu'}$ > 20 GeV
  - Q^2 > 0.01 GeV^2

Focus on Incoherent Exclusive ρ^0 production...

Incoherent exclusive ρ^0 production



Assuming both hadron are π

$0.5 < M_{\pi\pi} < 1$ GeV

Exclusivity of the reaction

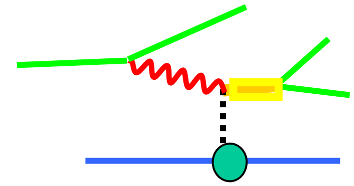
$E_{miss} = (M^2_X - M^2_N) / 2M_N$

$-2.5 < E_{miss} < 2.5$ GeV

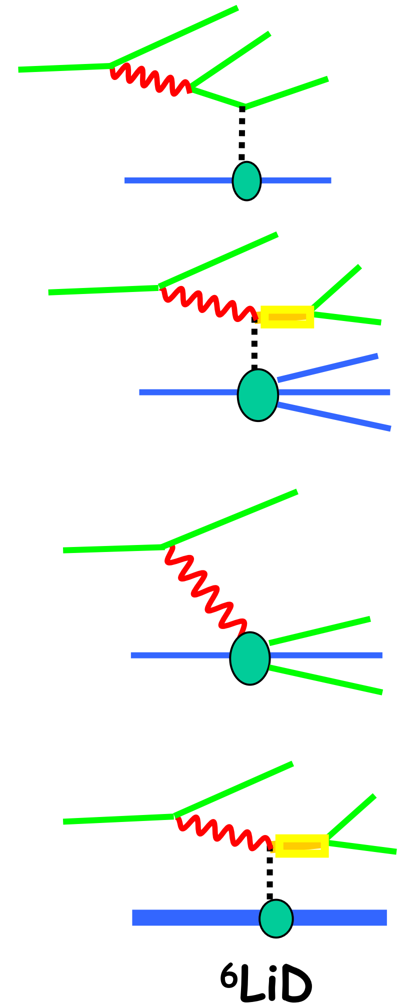
Incoherent production

$0.15 < p_t^2 < 0.5$ GeV^2

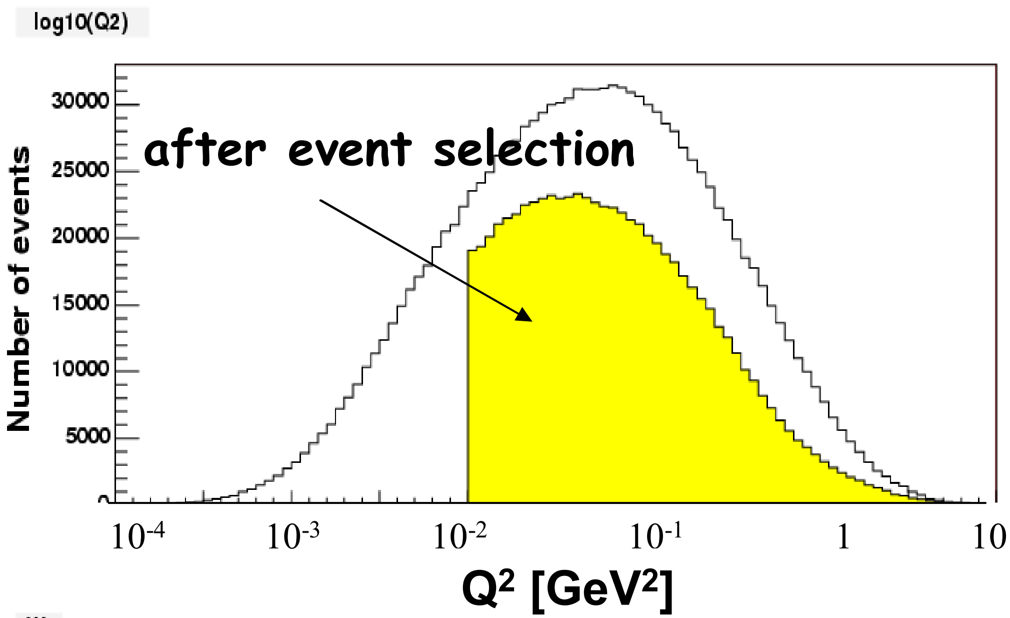
scattering off a quasi-free nucleon

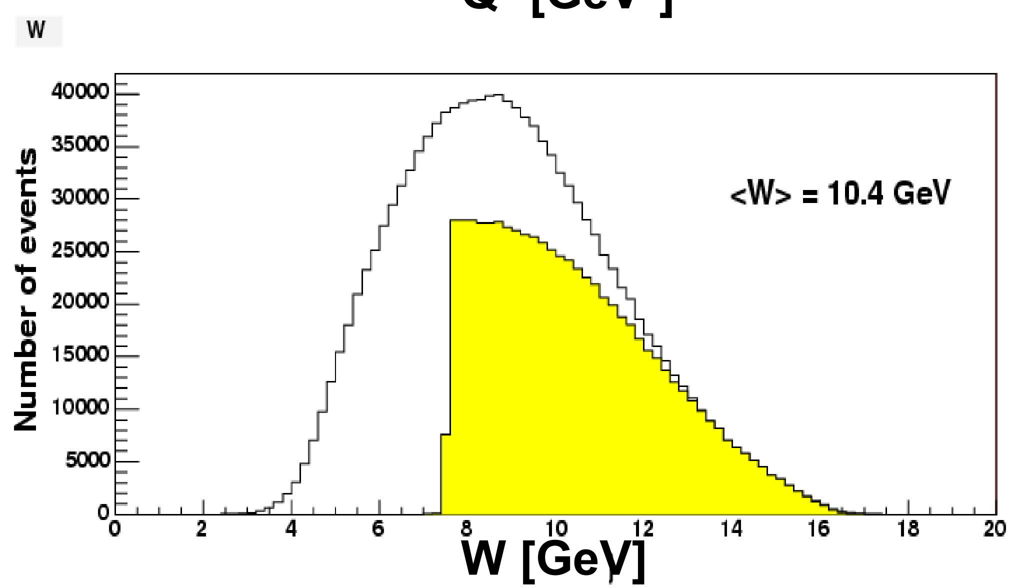


Background proc. rejected :



Kinematical domain of the final sample





2002 : this analysis

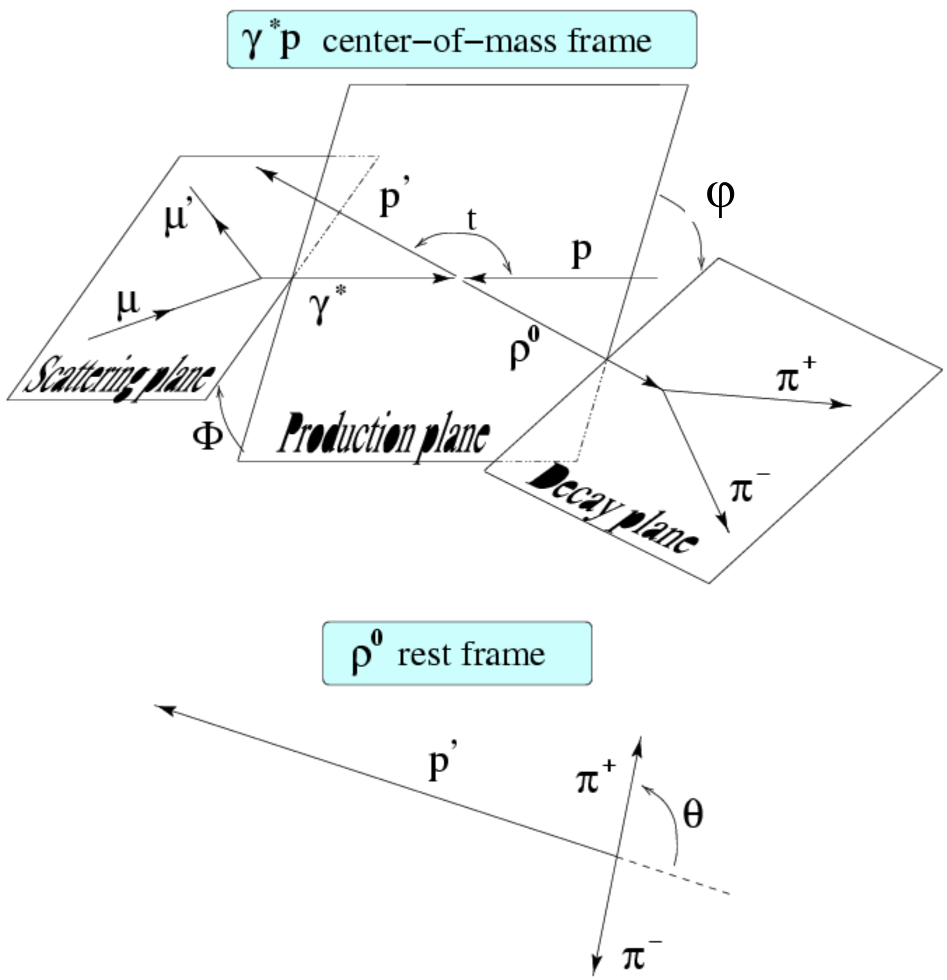
~ 700,000 evts (whole range)

~ 20,000 evts ($Q^2 > 1 GeV^2$)

2003 and 2004:

- trigger coverage improved
- enlarged acceptance at high Q^2 (up to 20 GeV)
- ~ 4 times more statistics

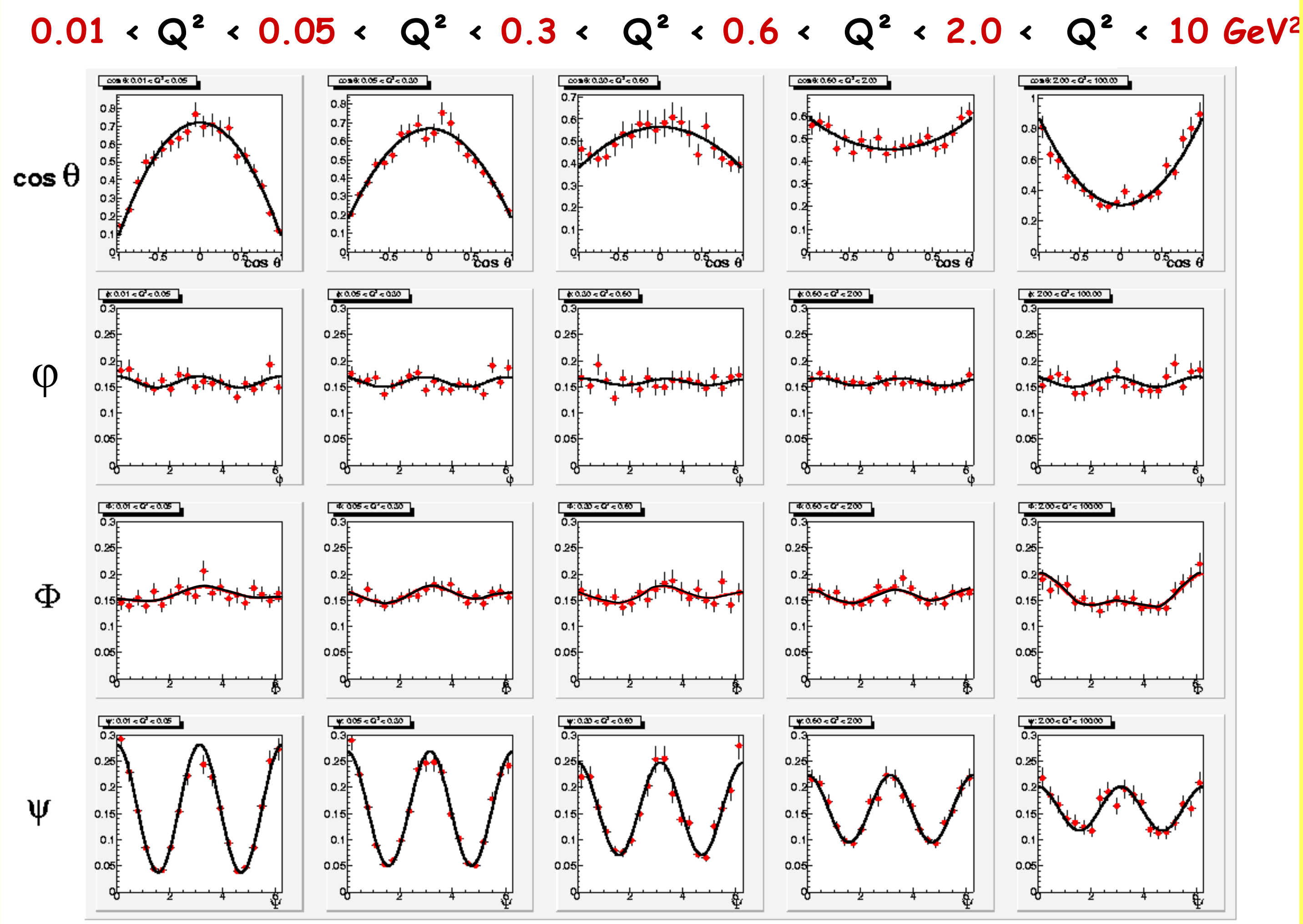
ρ° angular distributions $W(\cos\theta, \varphi, \Phi)$
depends on the Spin density matrix elements
⇨ 23 (15) observables with polarized (unpolarized) beam



This analysis:
only one-dimensional angular distribution

We will use also:
$\psi = \varphi - \Phi$

Angular distributions



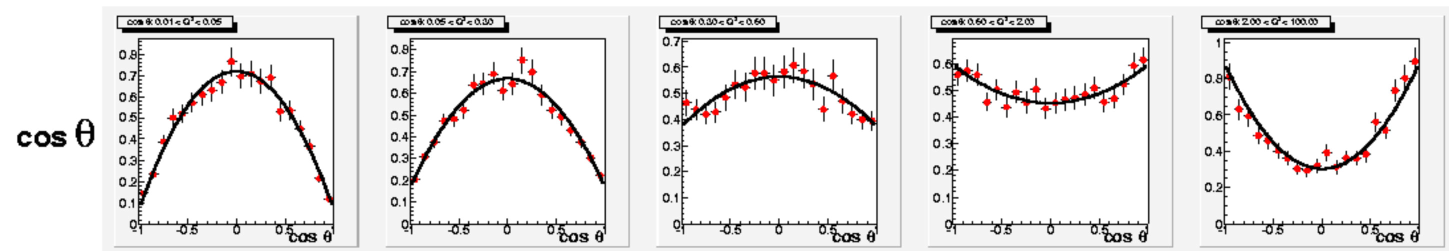
Statistical error only, limited by MC

Preliminary :

- Corrected for Acceptance, smearing and efficiency (MC:DIPSI gen)

- Background not subtracted

Measurement of r^{04}_{00}



Distribution :

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

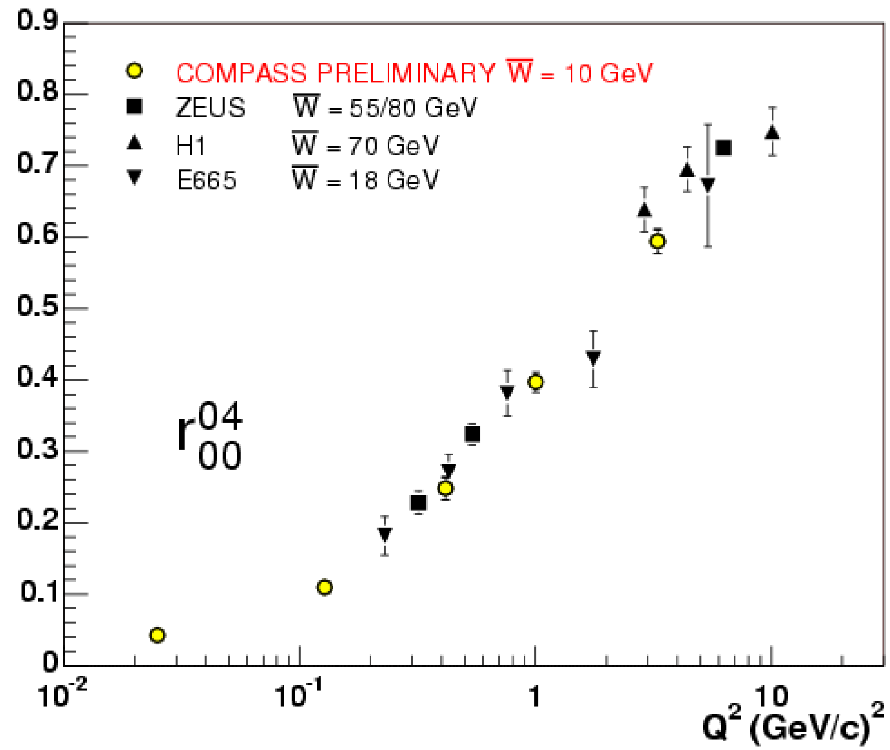
Spin density matrix elements:

$$r^{04}_{00} = \frac{|T_{01}|^2 + (\varepsilon+\delta)|T_{00}|^2}{N_T(1+(\varepsilon+\delta)R)} \xrightarrow{\text{SCHC}} \frac{\sigma_L}{\sigma_{Tot}}$$

$$R = \sigma_L/\sigma_T \qquad N_T = |T_{11}|^2 + |T_{-11}|^2 + |T_{01}|^2$$

$T_{\lambda\rho\,\lambda\gamma}$ are helicity amplitudes

meson photon



Determination of $R_{\rho^\circ} = \sigma_L / \sigma_T$

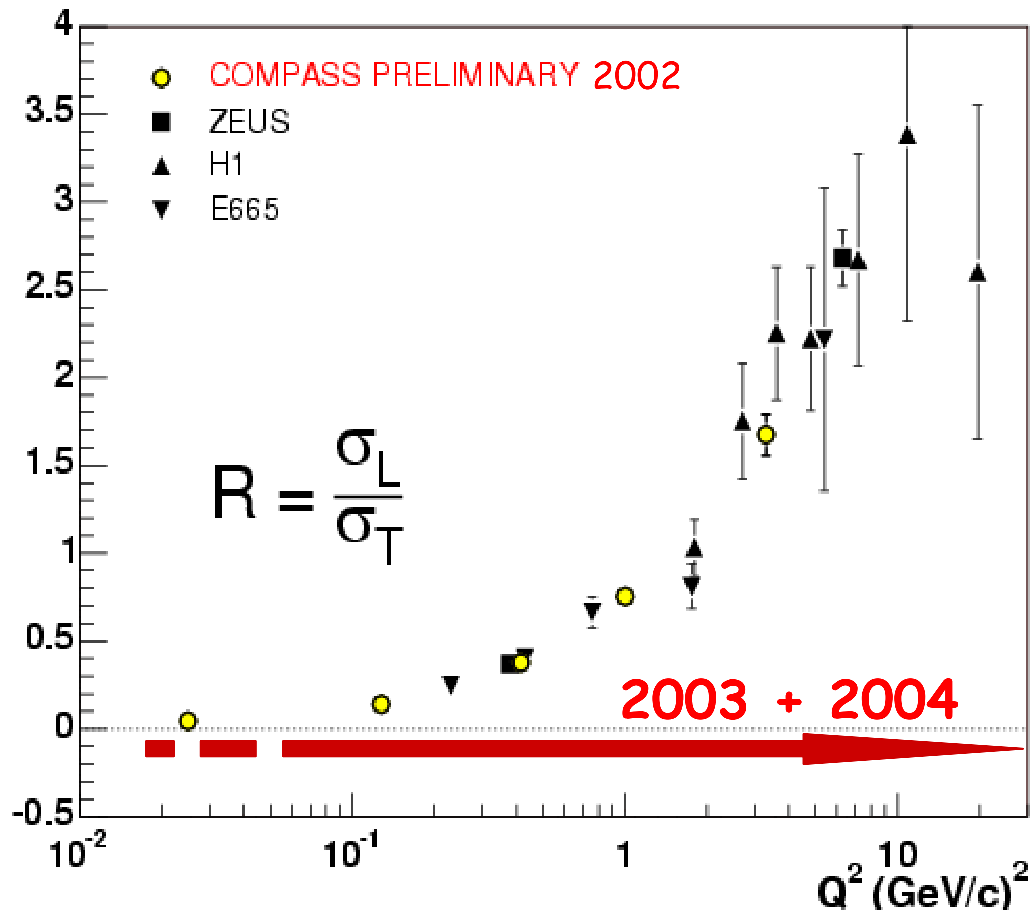
If SCHC holds :

only $T_{00} \neq 0$

$T_{11} \neq 0$

Then :

$$R = \frac{\sigma_L}{\sigma_T} = \frac{1}{(\varepsilon + \delta)} \frac{r^{04}_{00}}{1 - r^{04}_{00}}$$



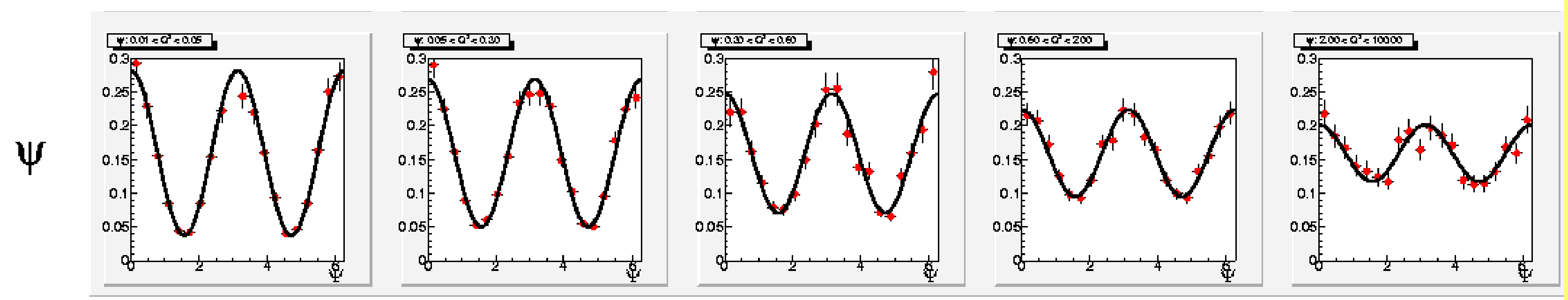
Impact on GPD study:

easy determination of σ_L

factorisation only valid for σ_L

Measurement of r^1_{1-1}

0.01 < Q^2 < 0.05 < Q^2 < 0.3 < Q^2 < 0.6 < Q^2 < 2.0 < Q^2 < 10 GeV^2



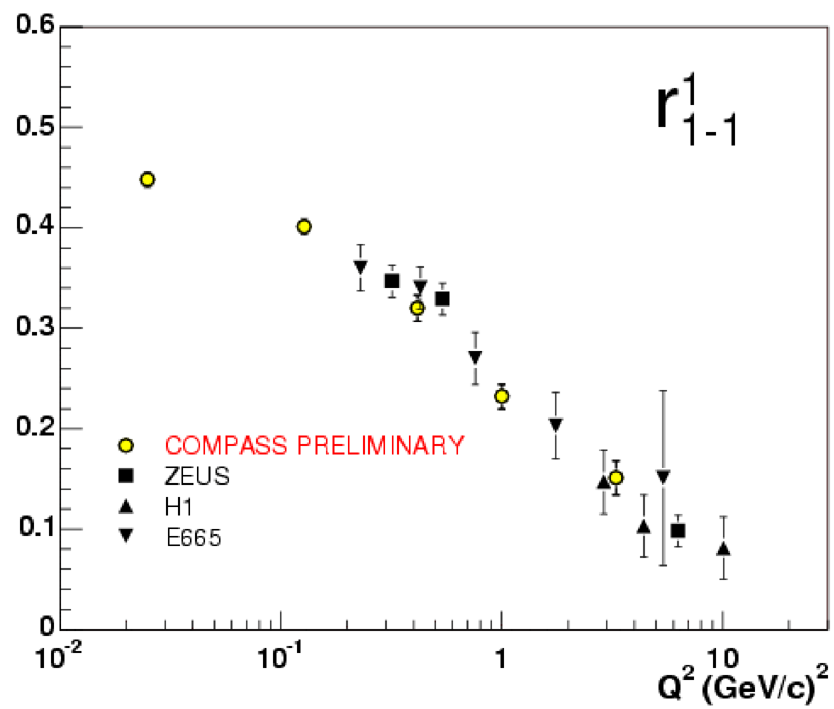
Distribution, if *SCHC* holds:

$$W(\psi) = \frac{1}{2\pi}\left[1 + 2\varepsilon \cdot r^1_{1-1}\cos 2\psi\right]$$

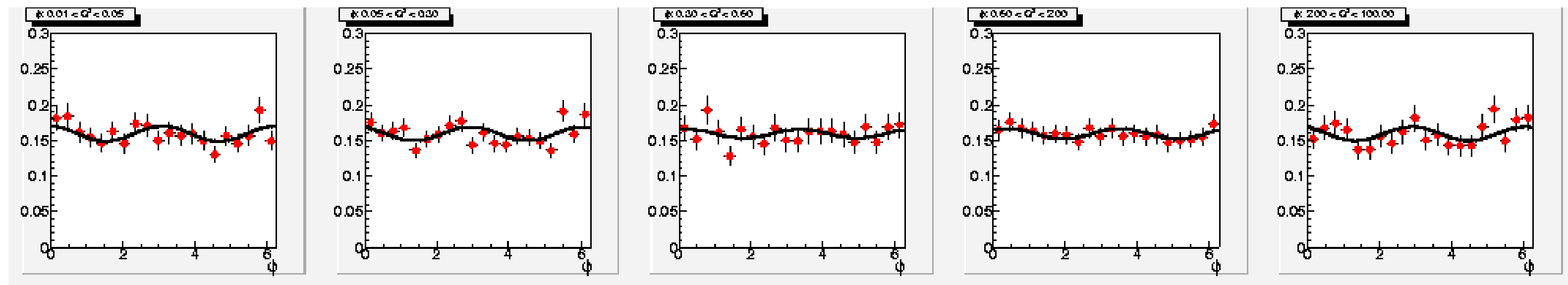
with $\psi = \varphi - \Phi$

if in addition, NPE holds:

$$r^1_{1-1} = \frac{1}{2}\left(1 - r^{04}_{00}\right)$$



Measurement of r^{04}_{1-1} and Im r^{3}_{1-1}



Distribution :

$$W(\varphi) = \frac{1}{2\pi}[1 - 2r^{04}_{1-1}\cos 2\varphi$$
$$+ 2\mathrm{Im}\ r^{3}_{1-1} P_{\mu} \sqrt{1-\varepsilon^2}\sin 2\varphi]$$

beam polarisation

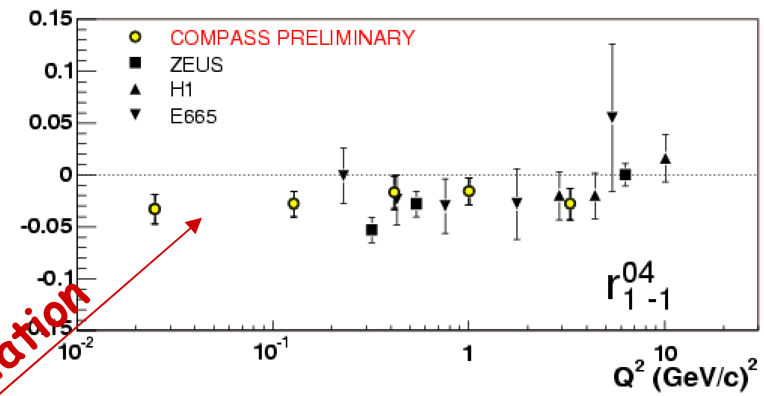
Spin density matrices:

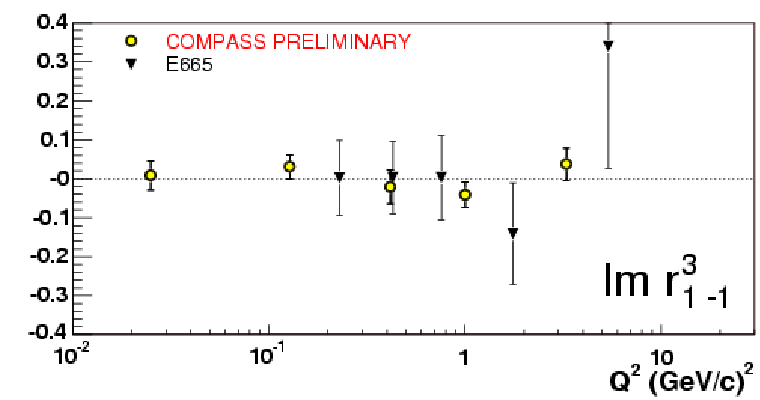
$$r^{04}_{1-1} = \frac{\mathrm{Re}(T_{11}T^{*}_{-11}) - (\varepsilon+\delta)|T_{10}|^2}{N_T(1+(\varepsilon+\delta)R)} = 0$$

$$\mathrm{Im}\ r^{3}_{1-1} = \ldots = 0$$

If SCHC holds

weak violation





Conclusions and perspectives

Incoherent exclusive ρ° production under investigation:
- high statistics from photo-production to the hard regime
- larger acceptance at high Q^2 in 2003 and 2004 (up to 20 GeV^2)

Preliminary results on a few Spin Density Matrix Elements:
- only statistical errors are shown (dominated by MC)
- systematics to be evaluated (background contamination)
- SDME in agreement with other experiments
- weak violation of SCHC observed

Double spin longitudinal asymmetry for ρ° production (NPE control)

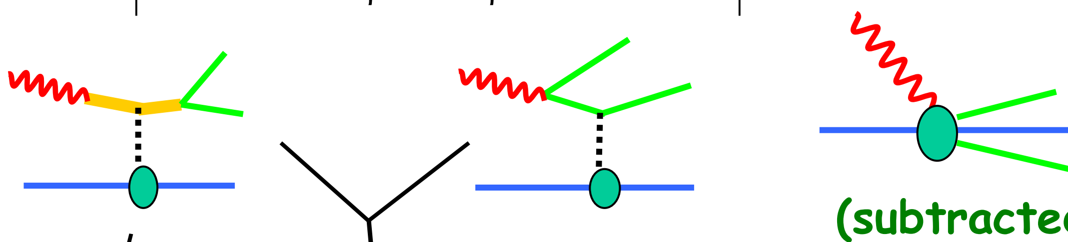
Spin asymmetries for transversally polarised target (GPD study)

Exclusive production of ϕ and J/Ψ also observed and will be studied

ρ^0 mass distribution

Söding parametrization:

$$\frac{dN}{dm_{\pi\pi}} = \left| A \cdot \frac{\sqrt{m_{\pi\pi} m_\rho \Gamma(m_{\pi\pi})}}{m_{\pi\pi}^2 - m_\rho^2 + i m_\rho \Gamma(m_{\pi\pi})} + B \right|^2 + f_{PS} \qquad \Gamma(m_{\pi\pi}) = \Gamma_\rho \left(\frac{q}{q_0}\right)^3 \frac{m_\rho}{m_{\pi\pi}}$$



No acceptance corrections yet !