Diffractive ρ^0 production at COMPASS

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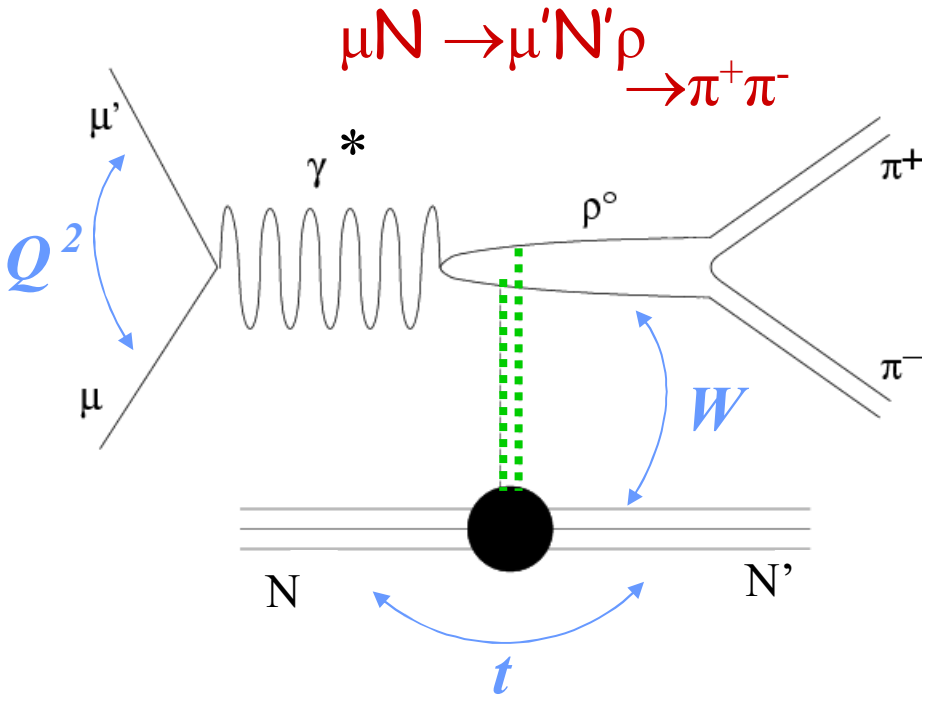
On behalf of the COMPASS collaboration

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



COMPASS: $10^{-2}<Q^2<10$ GeV², $\langle W\rangle$=10GeV, 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 ≡ 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 $T_{-\lambda\,\rho\,-\lambda\gamma} = (-1)^{\lambda\rho-\lambda\gamma} T_{\lambda\rho\,\lambda\gamma}$

9 helicity amplitudes reduce to five 5 independent amplitudes :

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

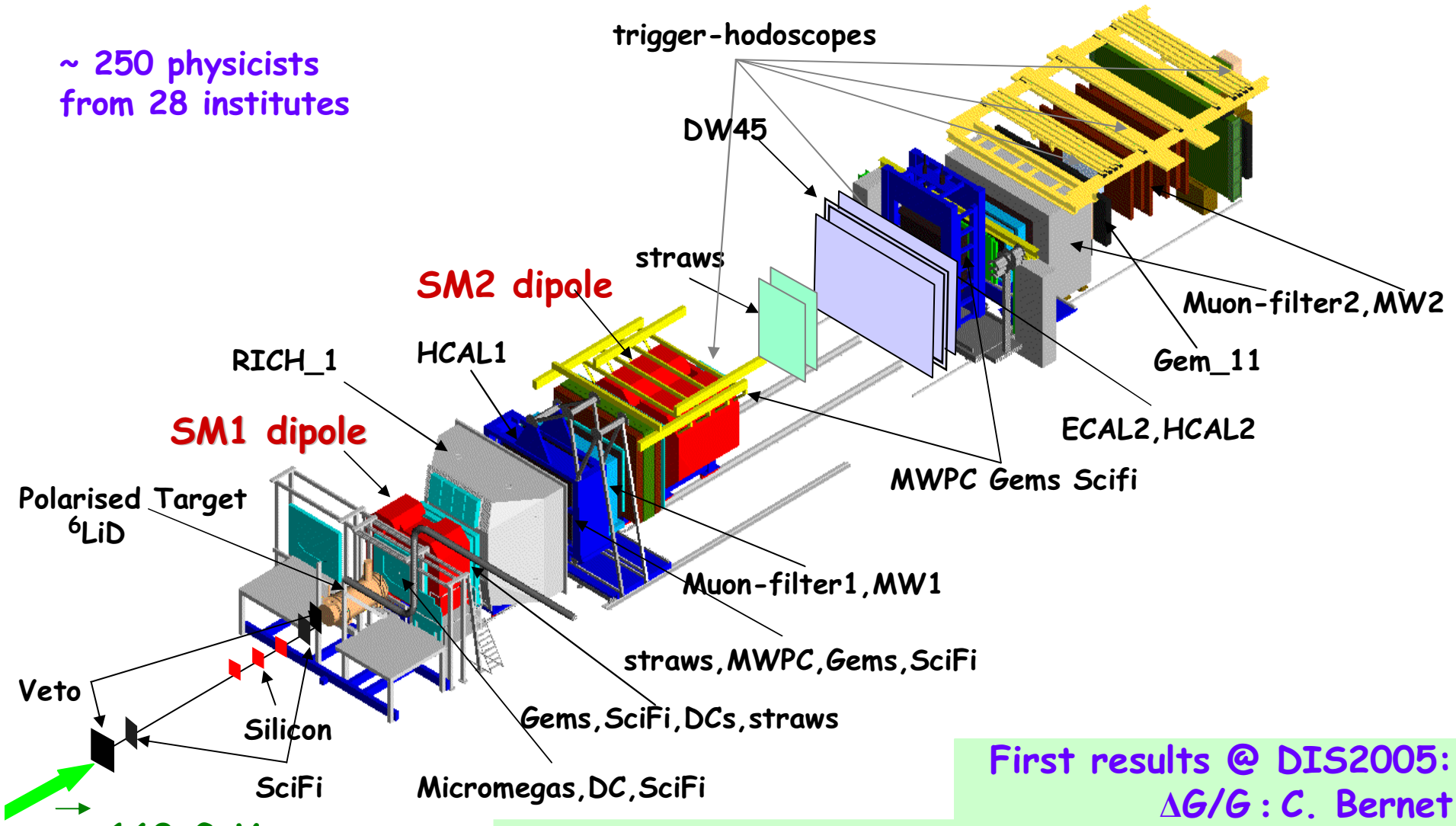
i.e. $T_{00}, T_{11} >> T_{01} > T_{10} > T_{-11}$

SCHC >> single helicity flip > double helicity flip

SCHNC

COMPASS experiment

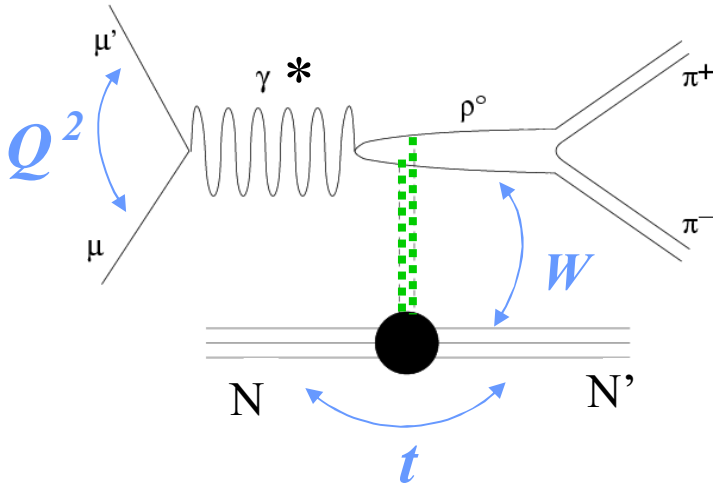
~ 250 physicists
from 28 institutes



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

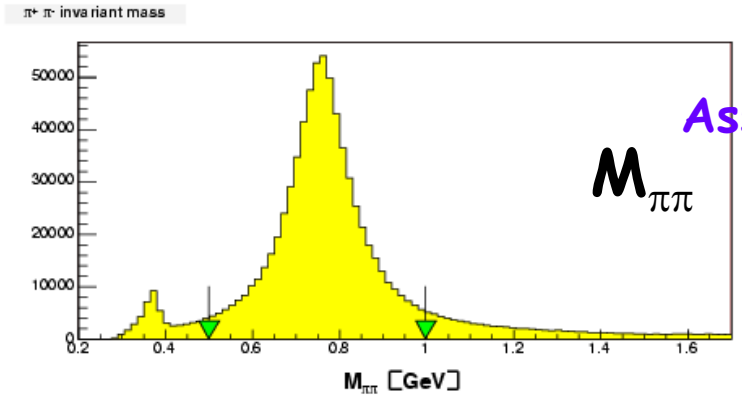
- Topology :
  - 1 incoming μ and 1 scattered μ
  - only 2 hadrons of opposite charge
  - vertex in the ^{6}LiD polarized target



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

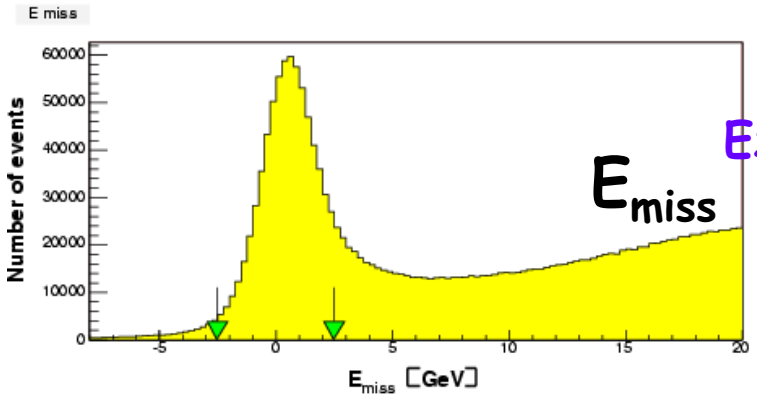
Focus on Incoherent Exclusive ρ^0 production...

Incoherent exclusive ρ^0 production



Assuming both hadron are π

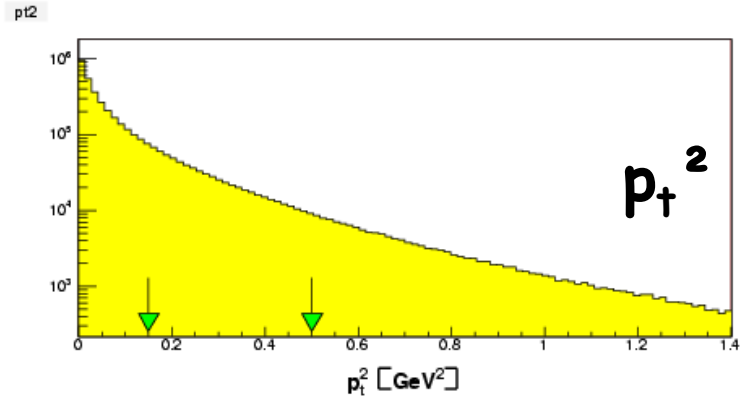
$0.5 < M_{\pi\pi} < 1$ GeV



Exclusivity of the reaction

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

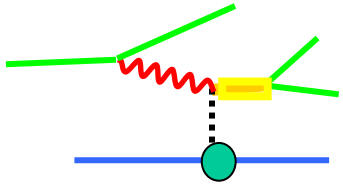
$-2.5 < E_{miss} < 2.5$ GeV



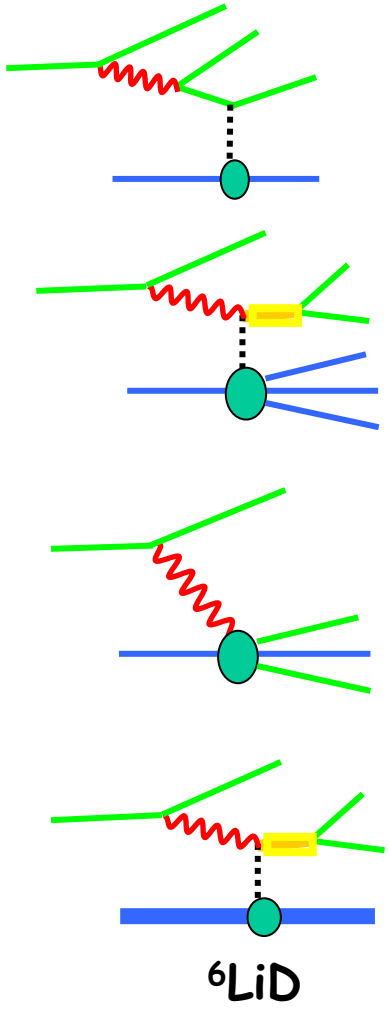
Incoherent production

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

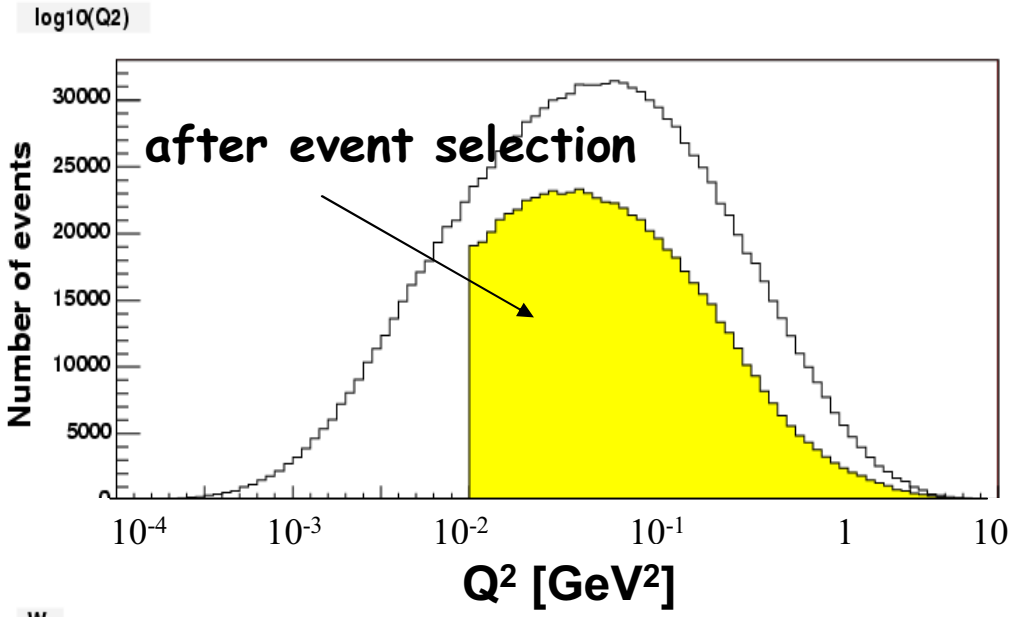
scattering off a quasi-free nucleon

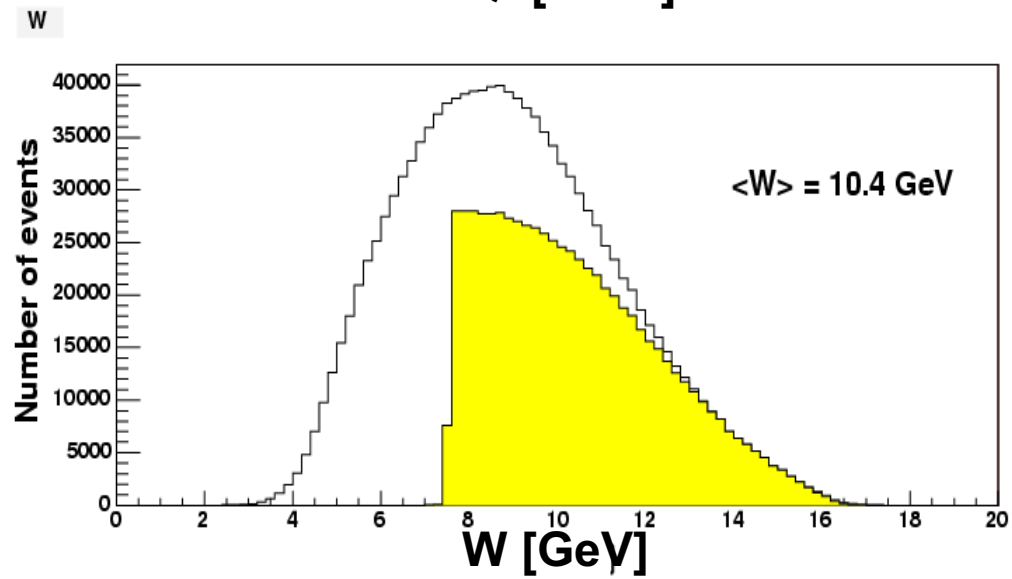


Background proc. rejected :



Kinematical domain of the final sample



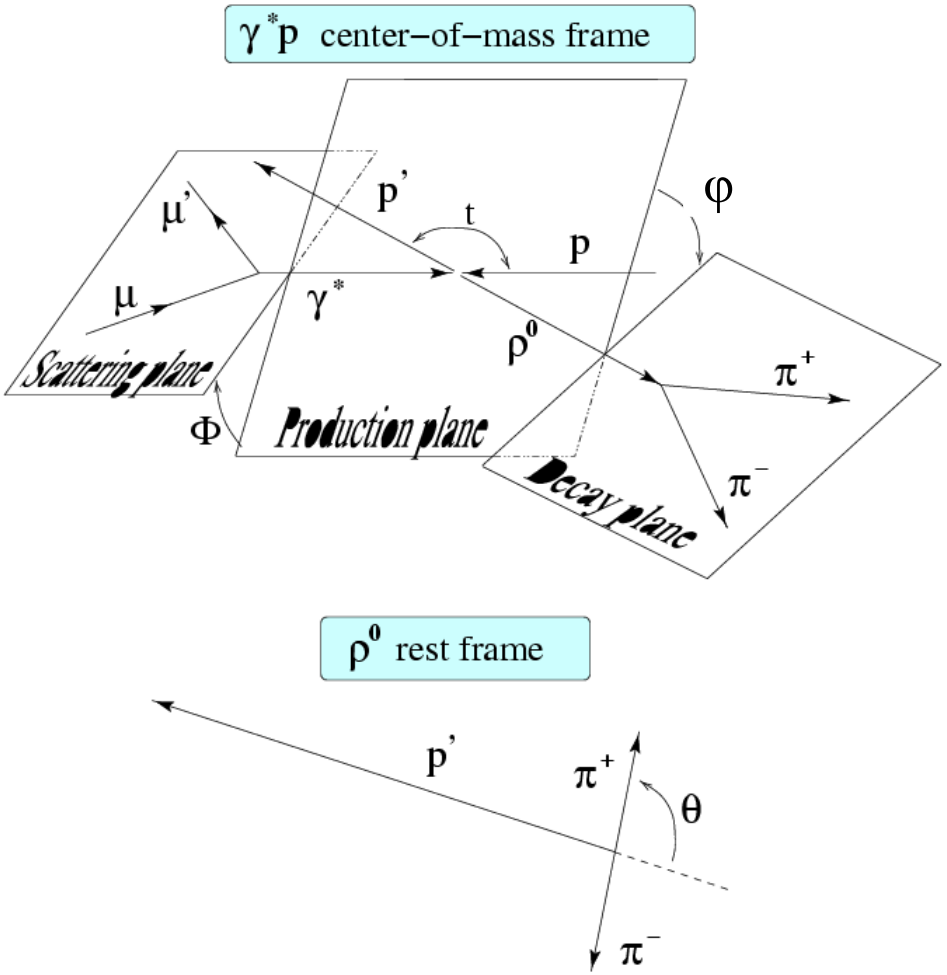


2002 : this analysis
~ 700,000 evts (whole range)
~ 20,000 evts (Q^2 >1GeV^2)

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



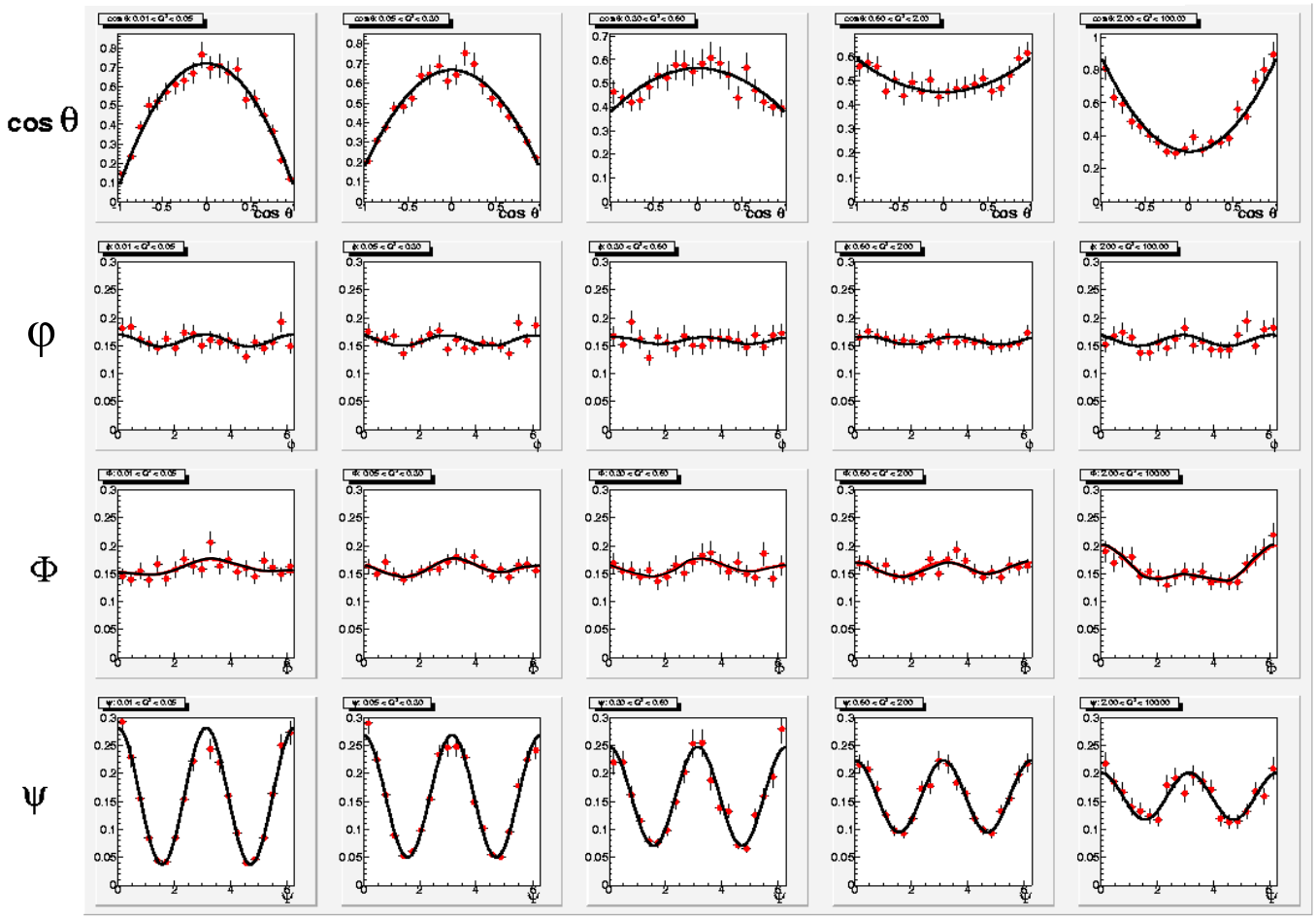
This analysis:

only one-dimensional angular distribution

We will use also:

$\psi = \varphi - \Phi$

Angular distributions



Preliminary :

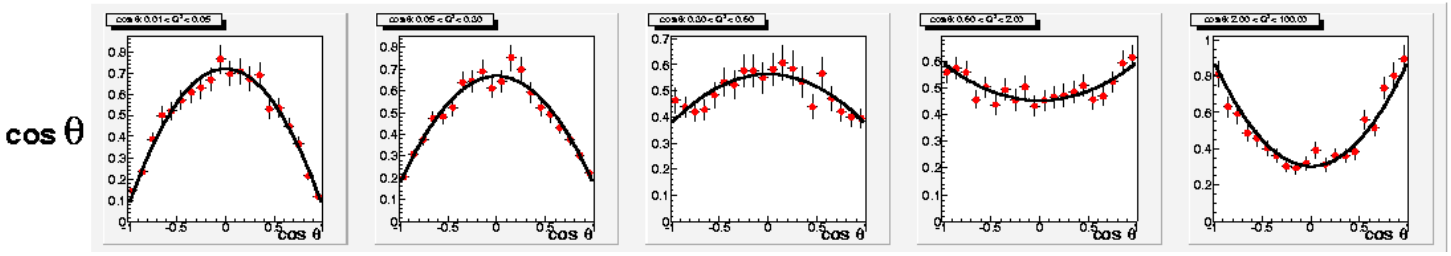
- Corrected for Acceptance, smearing and efficiency (MC:DIPSI gen)

- Background not subtracted

Statistical error only, limited by MC

Measurement of r_{00}^{04}

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



Distribution :

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

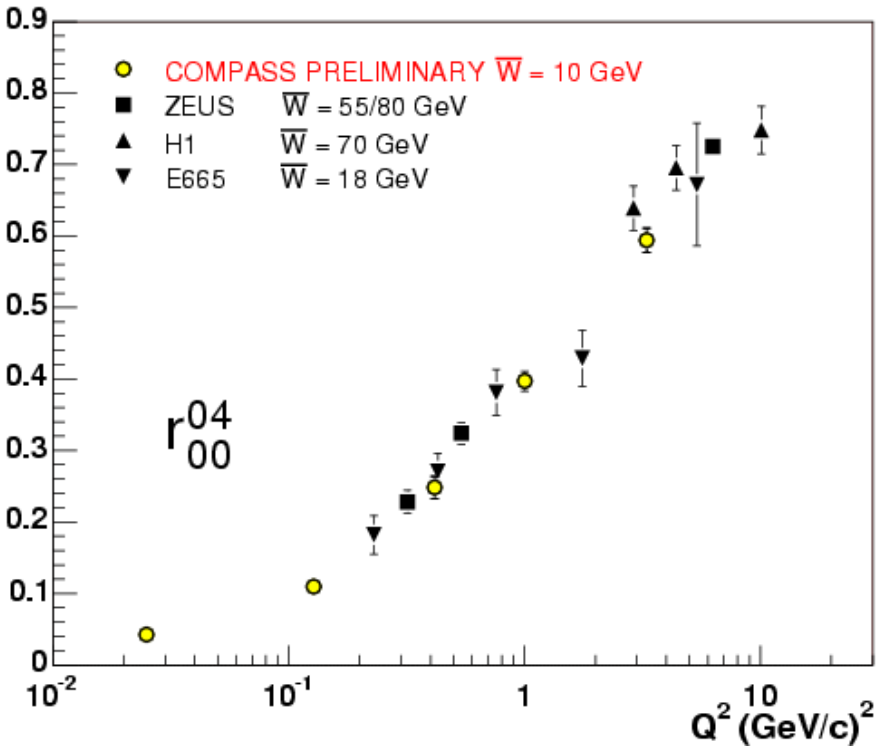
Spin density matrix elements:

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

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

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

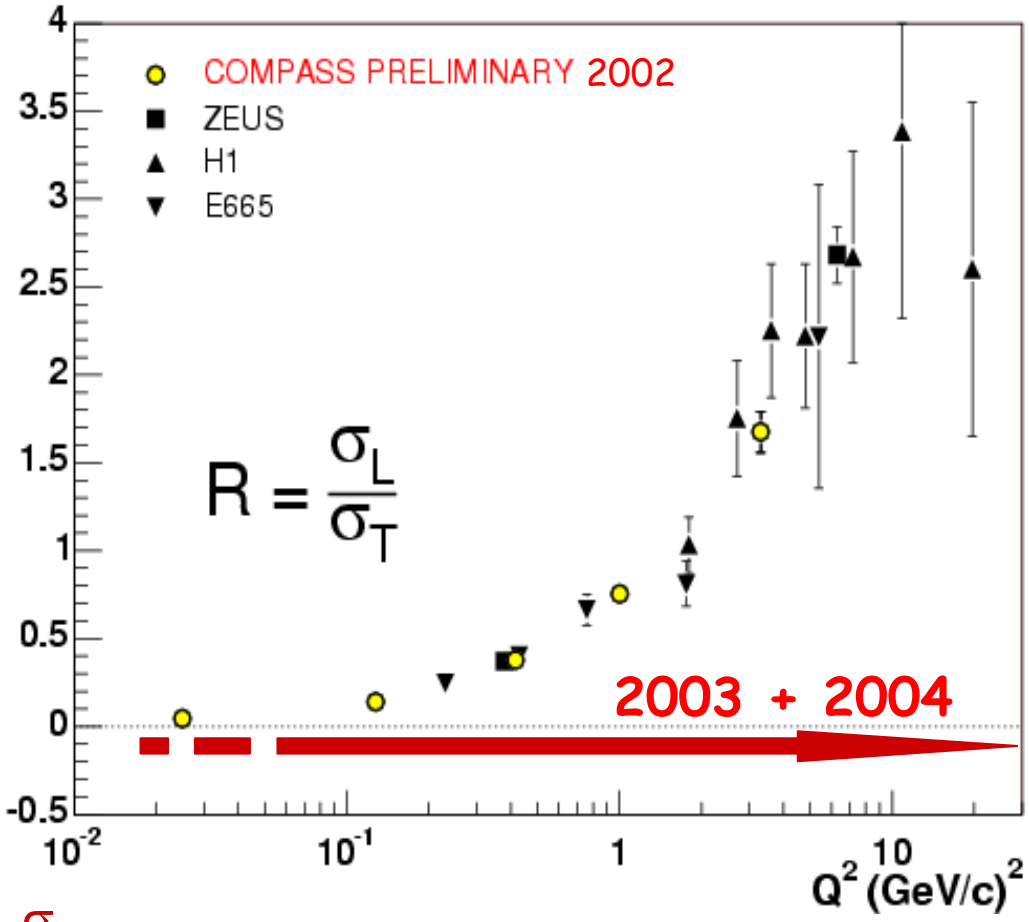
meson photon



Determination of $R_{\rho^0}=\sigma_L/\sigma_T$

If SCHC holds :
only $T_{00}\neq 0$
$T_{11}\neq 0$
Then :

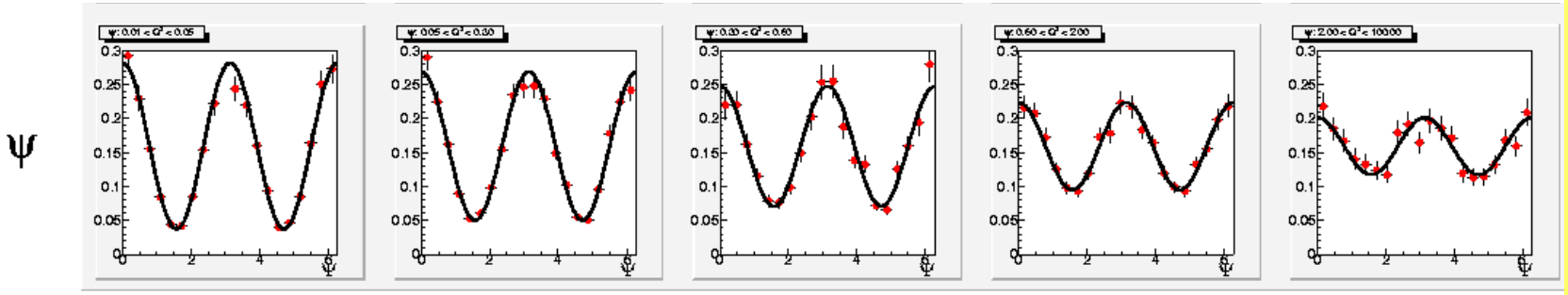
$$R=\frac{\sigma_L}{\sigma_T}=\frac{1}{(\varepsilon+\delta)}\frac{r_{00}^{04}}{1-r_{00}^{04}}$$



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 GeV²



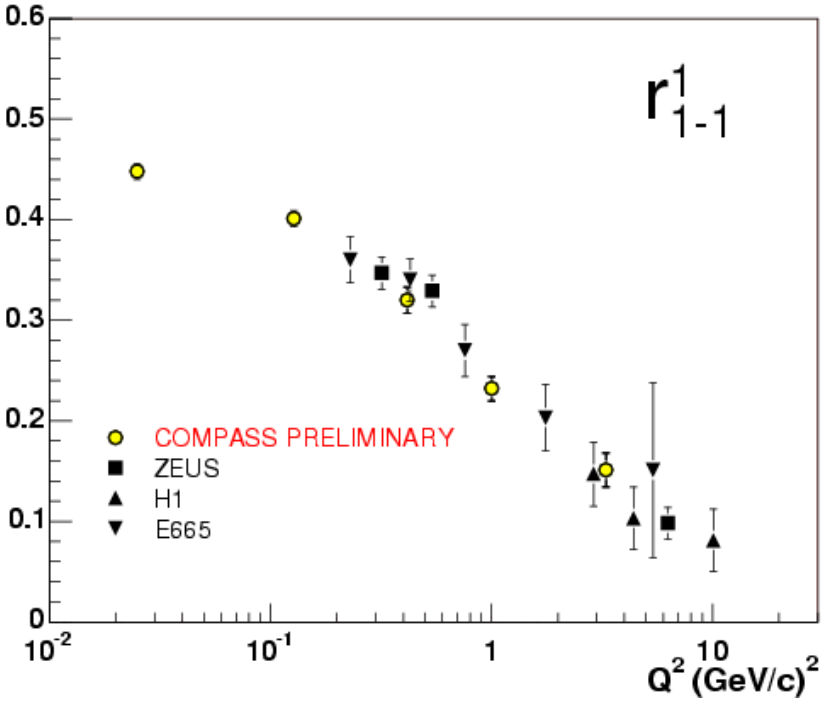
Distribution, if SCHC holds:

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

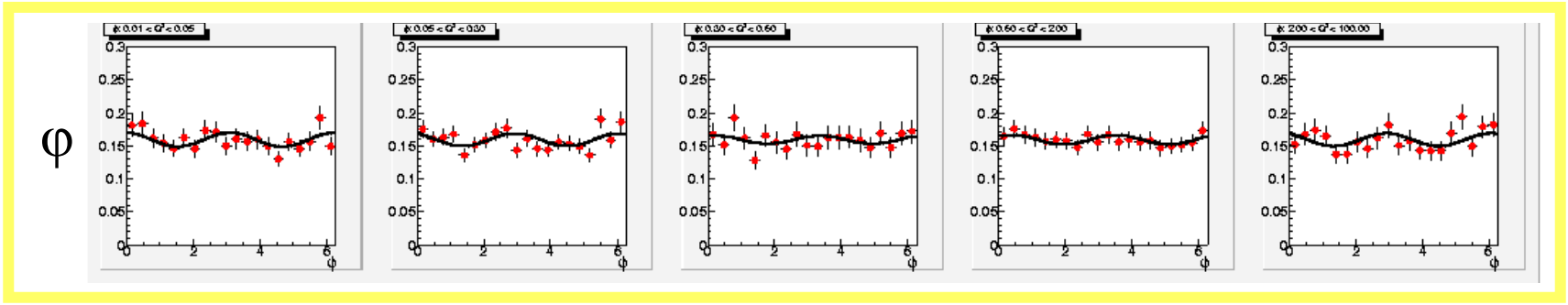
with $\psi = \varphi - \Phi$

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 :

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

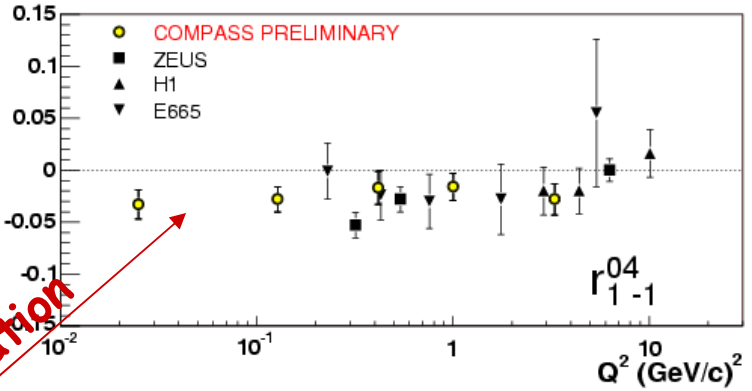
beam polarisation

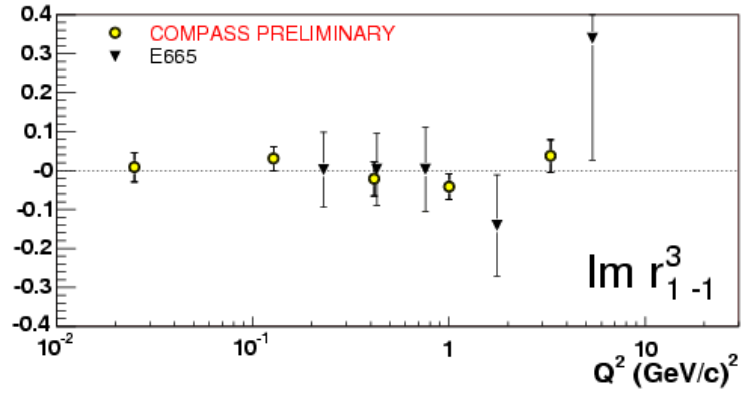
Spin density matrices:

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

$$\mathrm{Im}\; r^{3}_{1-1} = \ldots = 0 \longleftarrow \text{If SCHC holds}$$

weak violation





Conclusions and perspectives

Incoherent exclusive ρ^0 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^0 production (NPE control)

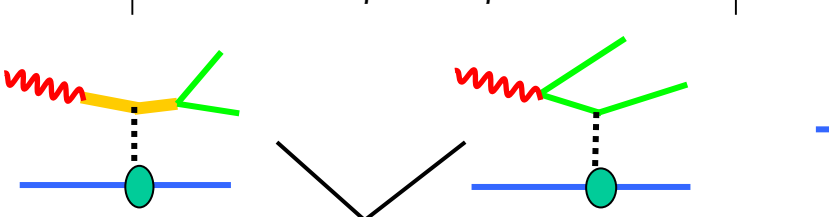
Spin asymmetries for transversally polarised target (GPD study)

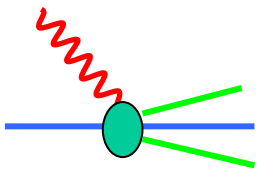
Exclusive production of ϕ and J/Ψ also observed and will be studied

ρ^0 mass distribution

Söding parametrization:

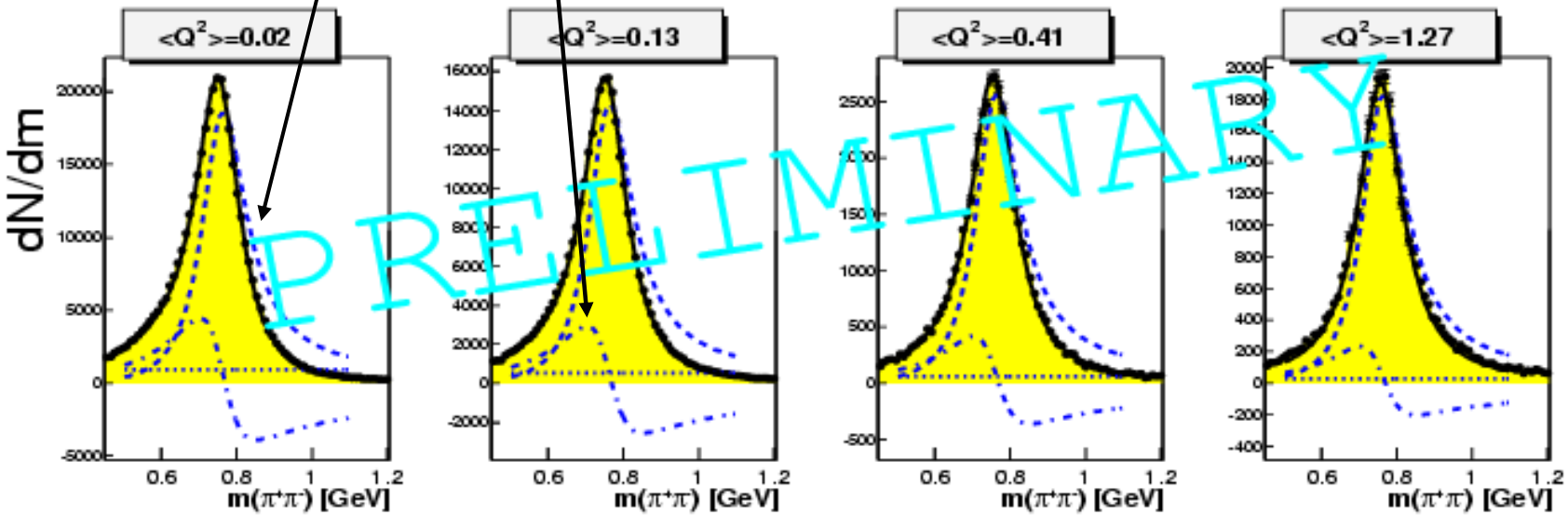
$$\frac{dN}{dm_{\pi\pi}} = \left| A \cdot \frac{\sqrt{m_{\pi\pi} m_\rho \Gamma(m_{\pi\pi})}}{m_{\pi\pi}^2 - m_\rho^2 + i m_\rho \Gamma(m_{\pi\pi})} + B \right|^2 + f_{PS} \qquad \Gamma(m_{\pi\pi}) = \Gamma_\rho \left(\frac{q}{q_0} \right)^3 \frac{m_\rho}{m_{\pi\pi}}$$





(subtracted)

No acceptance corrections yet !



PRELIMINARY