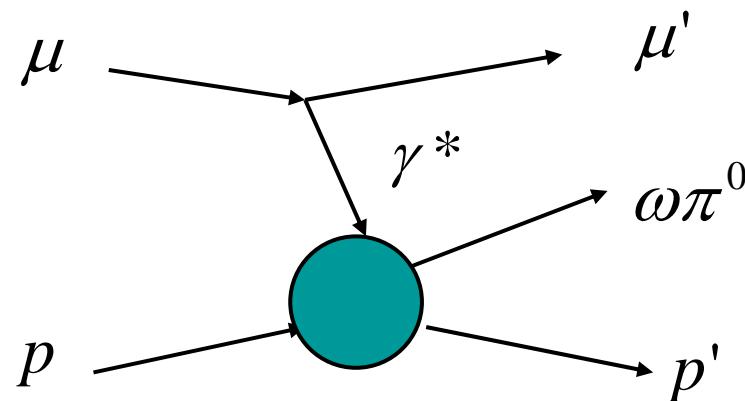




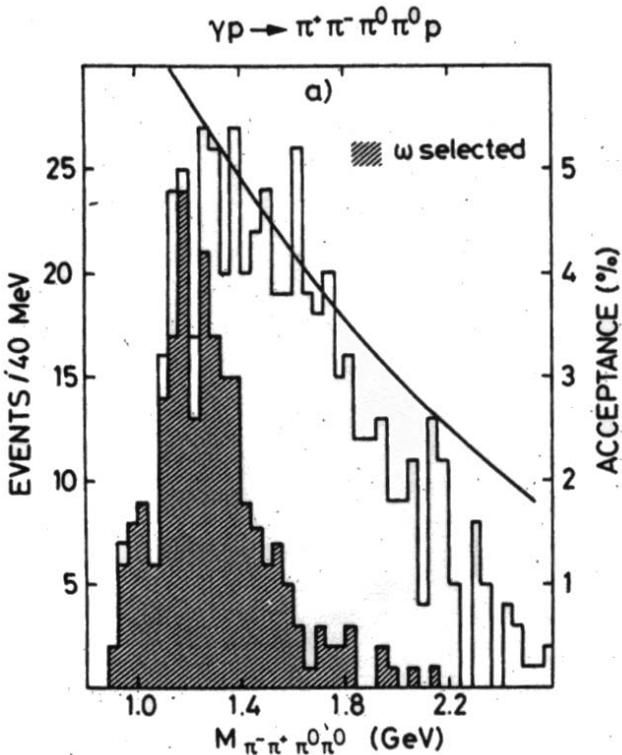
Exclusive $\omega\pi^0$ production with muons



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(LMU, Muenchen)

*On Behalf of the
COMPASS Collaboration*

Photoproduction



- Aston *et al.*, CERN SPS (Phys. Lett. 92B (1980)), $E_\gamma = 20\text{-}70 \text{ GeV}$, assuming *s-channel helicity conservation* (SCHC)
→ mixture of $b_1(1235)$, $J^{PC} = 1^{+-}$ and a dominant $\rho'(1250)$, 1^{--}
- Not supported by results for linearly polarized photons:
 - Atkinson *et al.*, CERN SPS (Nucl. Phys., B243 (1984), $\langle E_\gamma \rangle \sim 30 \text{ GeV}$)
 - Brau *et al.*, SLAC (Phys. Rev. D37 (1988)), $E_\gamma = 20 \text{ GeV}$→non-SCHC production, b_1 dominant

Annihilation

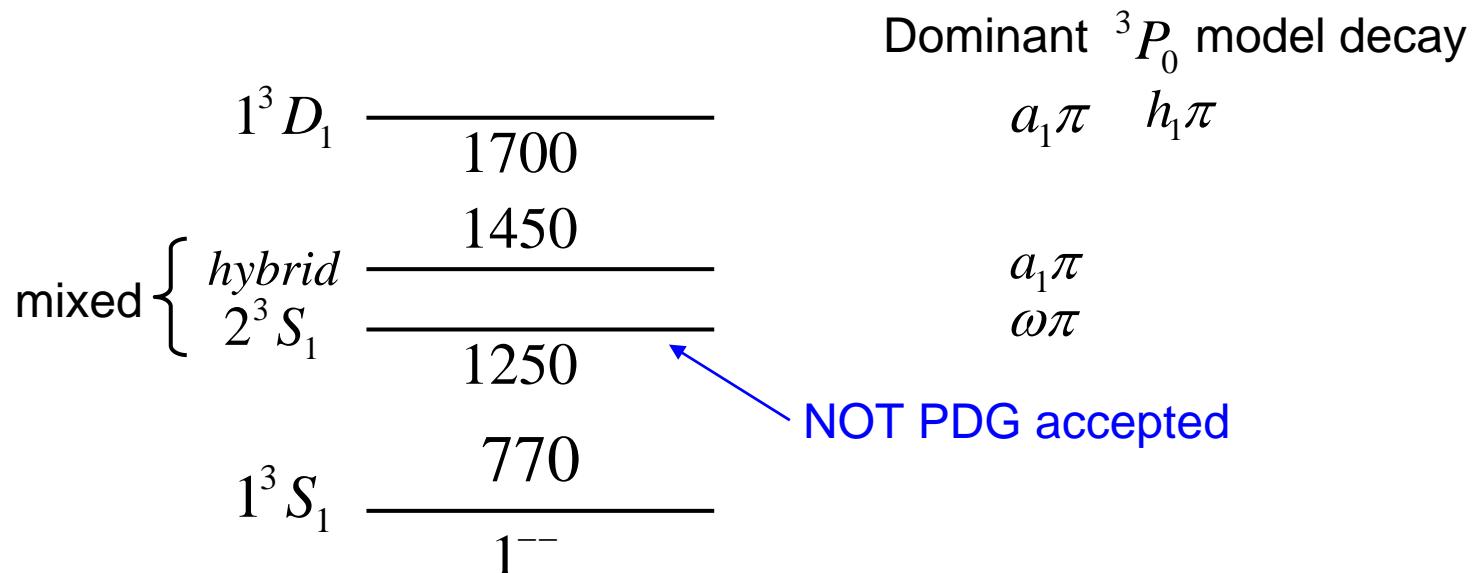
$\bar{p}n \rightarrow \omega\pi^-\pi^0$, Crystal Barrel (Nucl. Phys. A740 (2004))

suggest $3\rho'$ states at:

- 1200 MeV, $\omega\pi$ decay dominant
- 1450 MeV, 3π (non - ω) π “
- 1700 MeV, “ “ “

Interpretation

Reviewed by *Donnachie and Kalashnikova*, HADRON 01,
including results from e^+e^- and τ -decay



COMPASS experimental setup

~ 250 physicists from 28 institutes

use 160 GeV/c polarised muon
beam from the CERN SPS

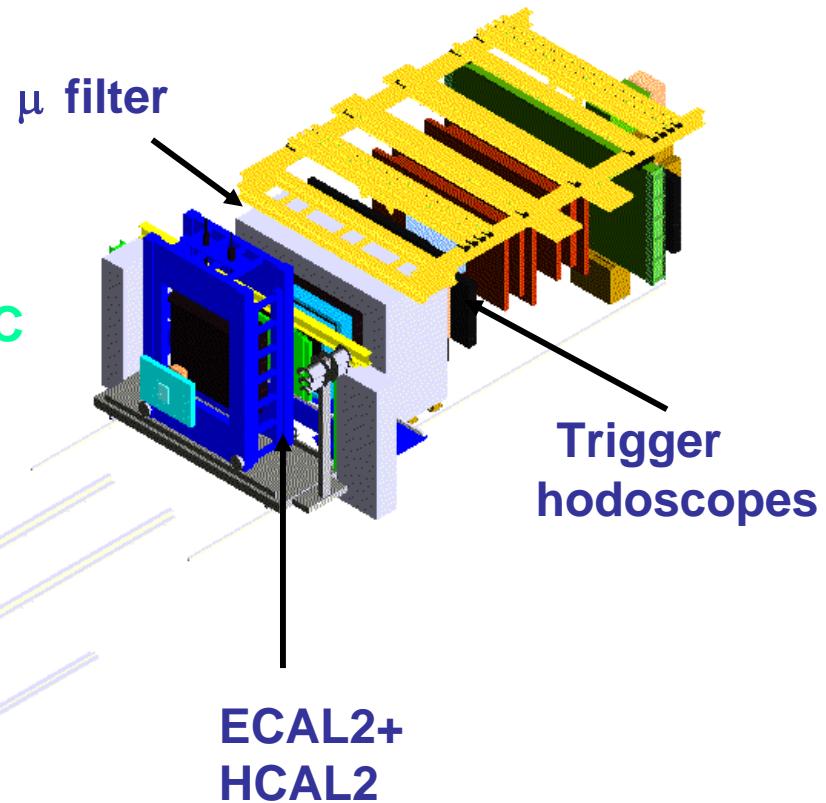
Trackers:
**Si, SciFi, Micromegas,
GEM, DC, Straw, MWPC**

Magnets

Polarised
Target (Li₆ D)

beam

RICH

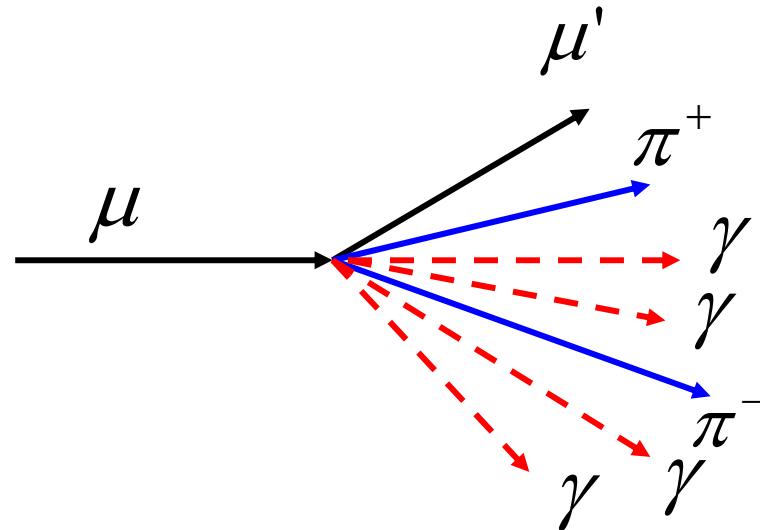


Event selection

- 8 weeks in 2004 - longitudinal target polarization
- best primary vertex with identified incoming beam track and scattered muon + 2 oppositely charged tracks
- no RICH information used; pion mass hypothesis
- 4 and only 4 ECAL2 clusters in event (no associated charged tracks; cluster energy $E > 1$ GeV)
- pi0 selection: $120 < m(\gamma\gamma) < 150$ MeV and $\theta_{\gamma\gamma} < 0.025$ rad
- omega selection:
 $750 < m(\pi^+\pi^-\pi^0) < 815$ MeV
- exclusivity cut:
 $-6 < \text{missing energy} < 4$ GeV

Final sample:

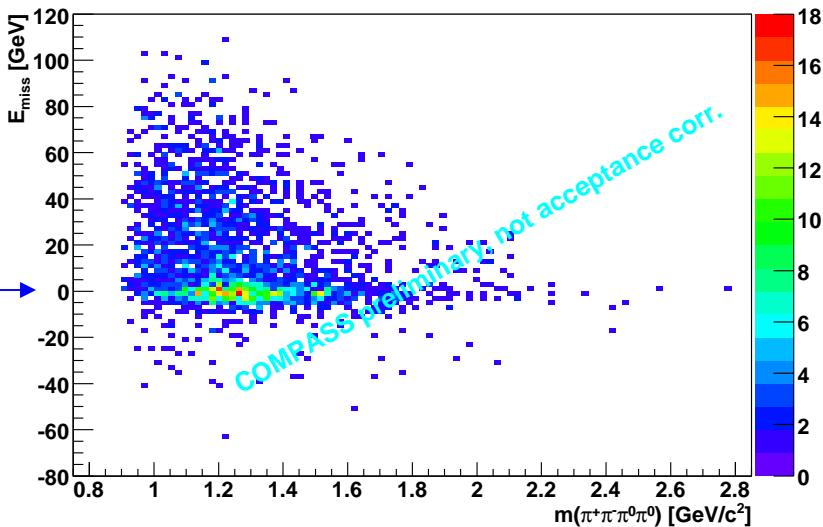
943 events with ONE and only ONE $\omega\pi^0$



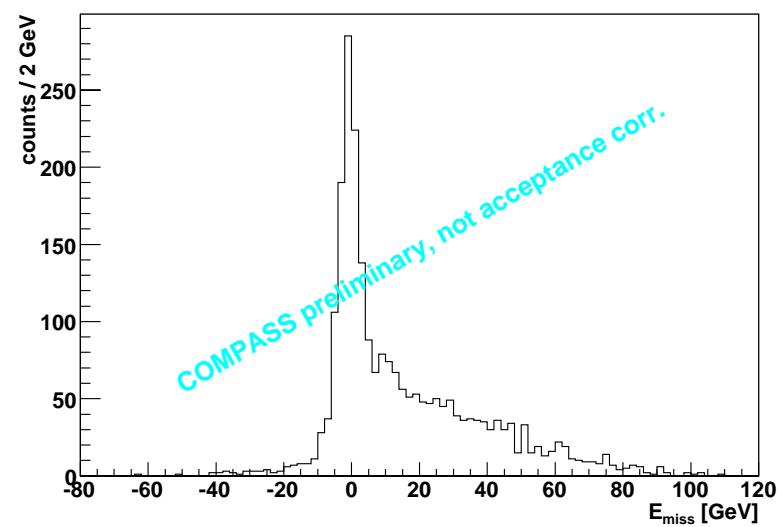
$$E_{miss} = \frac{M_{miss}^2 - M_P^2}{2M_P}$$

Missing energy vs. $\omega\pi^0$ mass

Missing energy vs. $\omega\pi^0$ mass

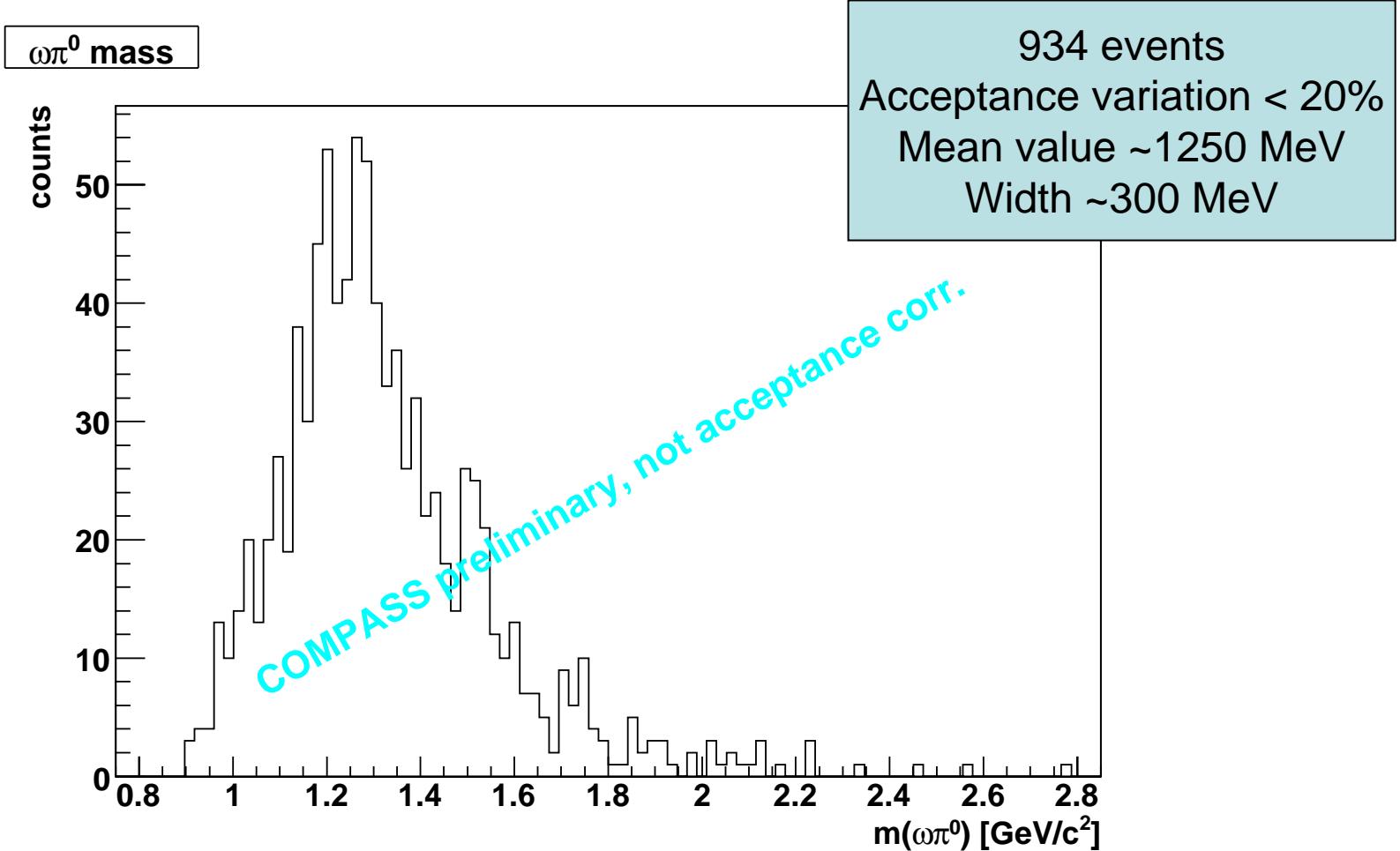


Missing energy



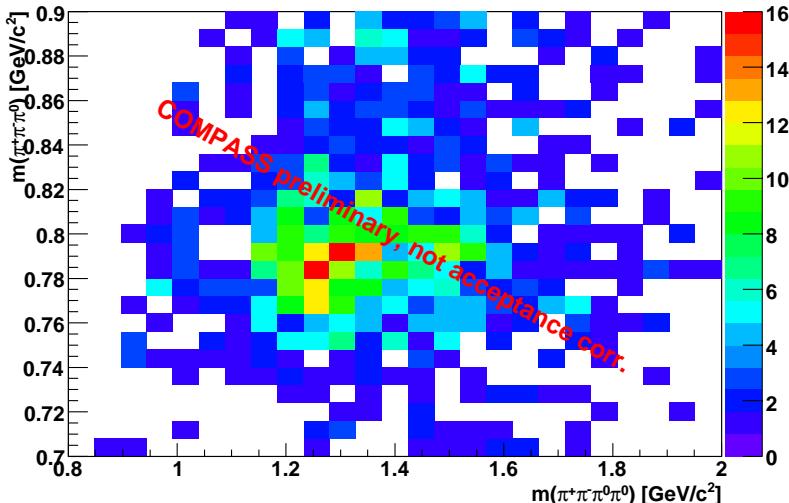
Exclusive events

$\omega\pi^0$ invariant mass for exclusive events

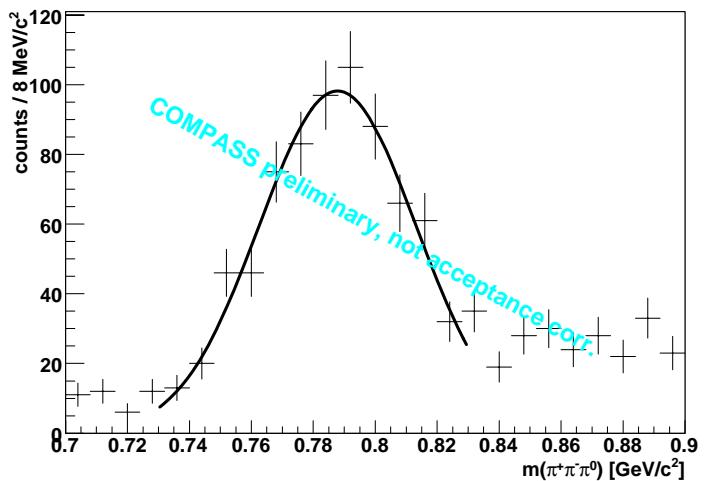


$\pi^+\pi^-\pi^0$ vs. $\pi^+\pi^-\pi^0\pi^0$ invariant mass for exclusive events

ω mass vs. $\omega\pi^0$ mass



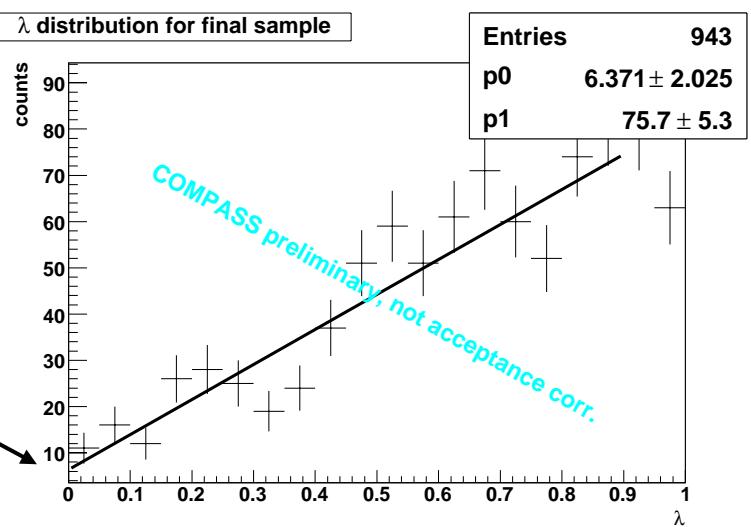
ω mass



$$\lambda = \frac{\left| \vec{p}_{\pi^+} \times \vec{p}_{\pi^-} \right|^2}{\lambda_{\max}}$$

λ is flat outside exclusivity peak
Background from $3\pi(\text{non-}\omega)\pi$
 $< 12\%$

λ distribution for final sample



Dalitz plot and λ distribution

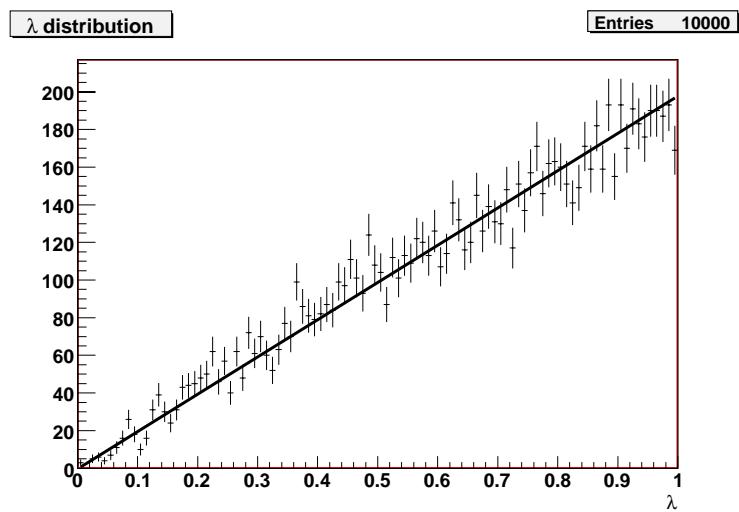
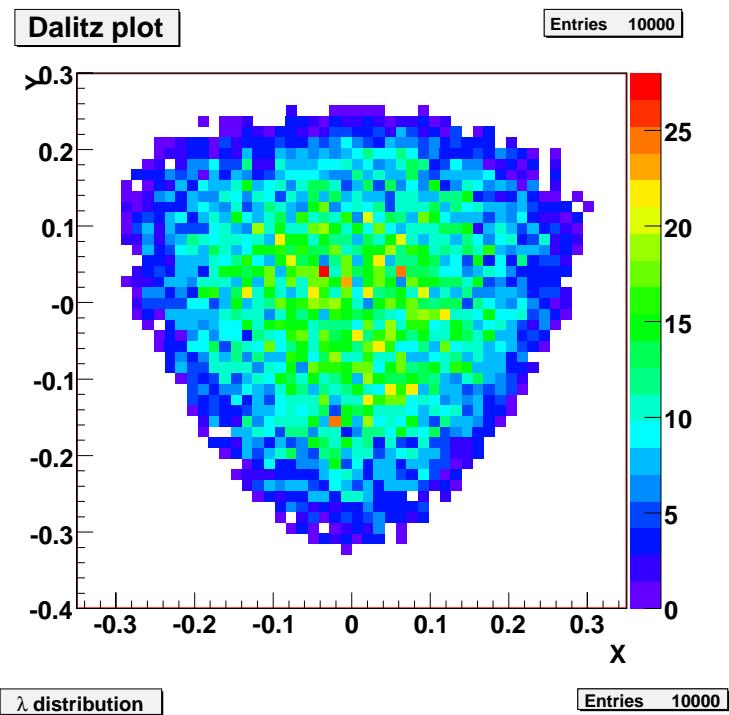
Monte Carlo generated
 $\omega \rightarrow \pi^+ \pi^- \pi^0$ decay

$$X = \frac{T_1 - T_2}{Q\sqrt{3}} \quad Y = \frac{T_0}{Q} - \frac{1}{3};$$
$$Q = T_0 + T_1 + T_2;$$

T_0, T_1, T_2 pion kinetic energies

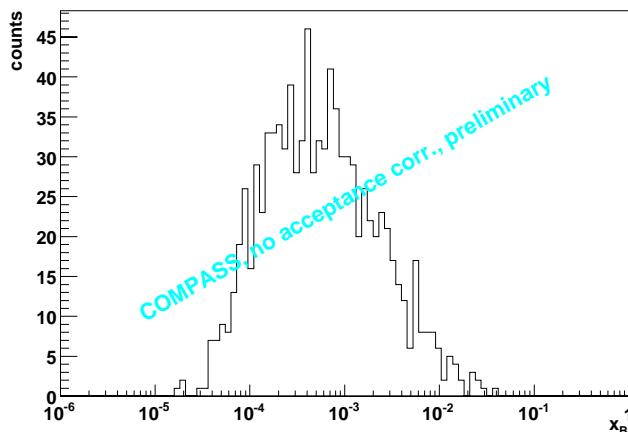
$$\lambda = \frac{\left| \vec{p}_1 \times \vec{p}_2 \right|^2}{\left| \vec{p}_1 \times \vec{p}_2 \right|_{MAX}^2}$$

For $\omega(J^P = 1^-) \rightarrow \pi^+ \pi^- \pi^0$:
intensity $\sim \lambda$.

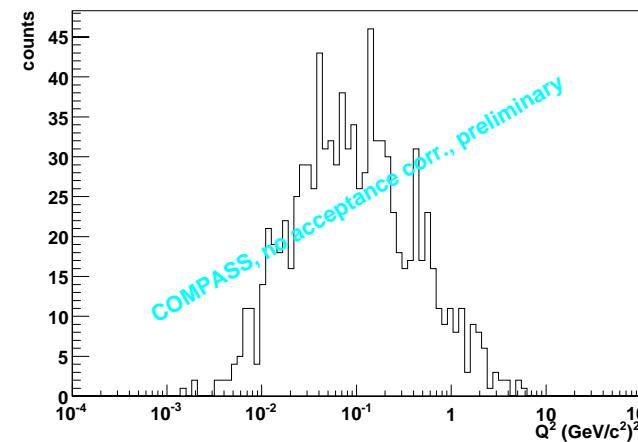


Kinematic distributions for final sample

Bjorken variable

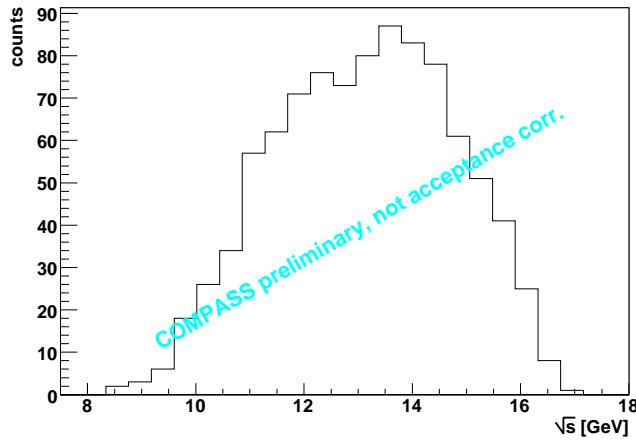


Virtual photon mass squared

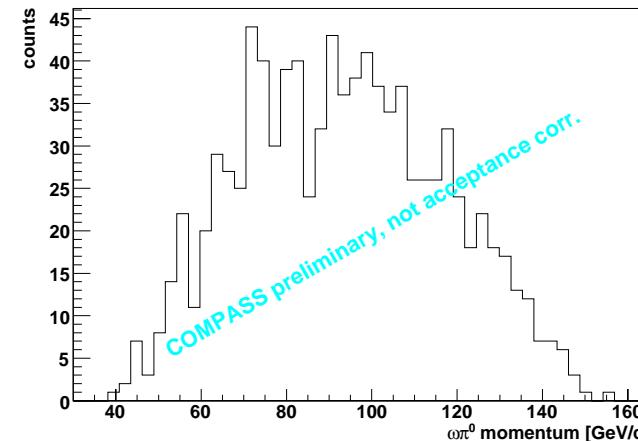


$$\langle Q^2 \rangle \approx 0.1 \text{ GeV}^2$$

\sqrt{s} ($\gamma^* p$) center of mass energy



$\omega\pi^0$ momentum (LAB)

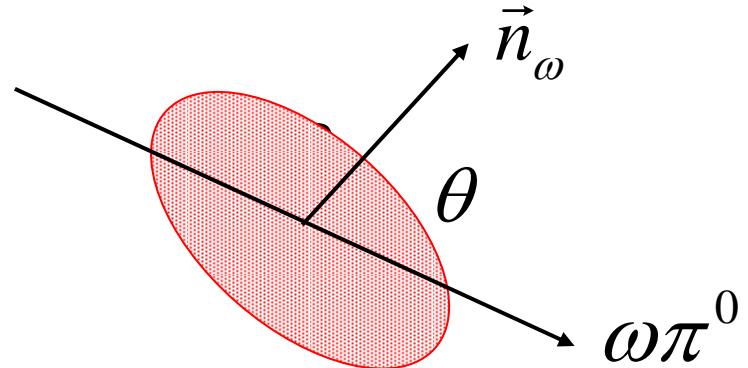
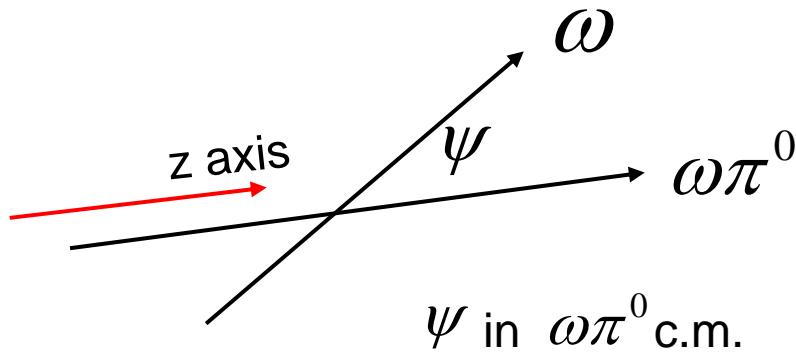


$$\langle E_{\gamma^*} \rangle \approx 90 \text{ GeV}$$

Momentum-transfer-squared distribution (not released): diffractive (exponential) shape

Decay angular distributions

(in $\gamma^* p$ overall c.m. system)



Omega decay plane
in omega c.m.

Assumption:

SCHC (s-channel helicity conservation)

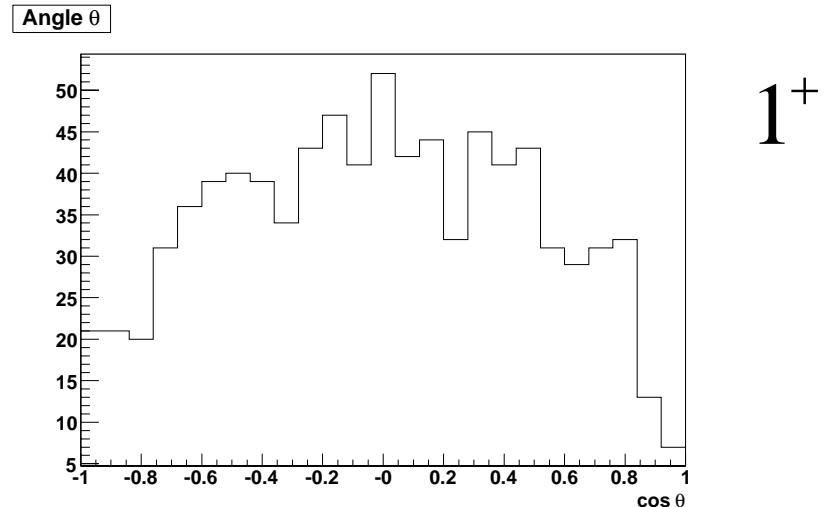
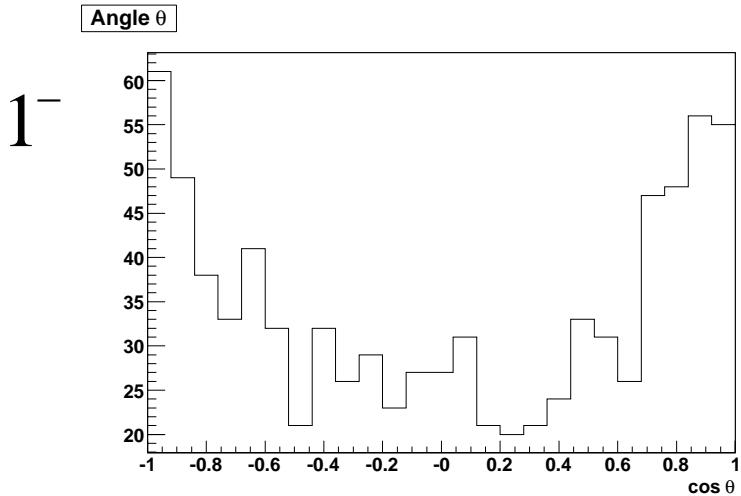
$$\begin{array}{ll} b_1, \ 1^+ & I(\psi) \sim 1 + x \cos^2 \psi \quad I(\theta) \sim \sin^2 \theta \\ \rho', \ 1^- & I(\psi) \sim 1 + \cos^2 \psi \quad I(\theta) \sim 1 + \cos^2 \theta \end{array}$$

$$x = (D/S \text{ amplitude ratio})^2 \approx 0.07$$

MC simulation for $\omega\pi^0 \rightarrow \pi^+\pi^-\gamma\gamma\gamma$

- Estimated acceptance 0.5% total (geom. x interaction x reconstruction x selection); 10% ECAL geometry only
- ψ dependence strongly, θ dependence only weakly affected

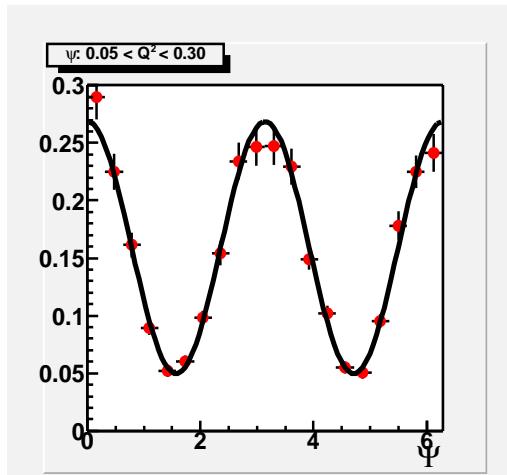
Theta distribution (SCHC assumed)



- $1 + \cos^2 \theta$ and $\sin^2 \theta$ shape for 1^- and 1^+ , resp., roughly maintained
- Not released data resemble 1^- case

Correlation with μ scattering plane

- SCHC: $W(\Psi) \approx 1 + \varepsilon \cos 2\Psi$ (1)
- Ψ = angle of “spin analyzer” \vec{a} vs. μ scattering plane
- ε = linear polarization of γ^*
- $\vec{a} = \vec{n}_\omega \times \vec{p}_\omega$ for $(\omega\pi^0)_{1^-}$
- $\vec{a} = \vec{p}_{\pi^+} \times \vec{p}_{\pi^-}$ “ $(\pi^+\pi^-)_{\rho(770)}$



$(\pi^+\pi^-)_{\rho(770)}$
muoproduction at COMPASS

Longitudinal photon contribution
 ~ 0.1 at $Q^2 = 0.1 \text{ GeV}^2$,
increasing with Q^2

- Non released data for $\vec{a} = \vec{n}_\omega \times \vec{p}_\omega$ show same modulation, but with smaller amplitude

(1) valid for transverse photons (helicity ± 1),
see Schilling, Wolf, Nucl. Phys. B61 (1973) 381 and quoted photoproduction experiments



Conclusions

- $\omega\pi^0$ production with ~ 90 GeV virtual photons observed in μ scattering
- broad (~ 300 MeV) peak at $m \sim 1250$ MeV, in agreement with previous photoproduction experiments
- preliminary results on angular correlations indicate dominant $J^{PC} = 1^{--}$ contribution – if SCHC holds
- appreciable increase of statistics expected with 2006 and 2007 data