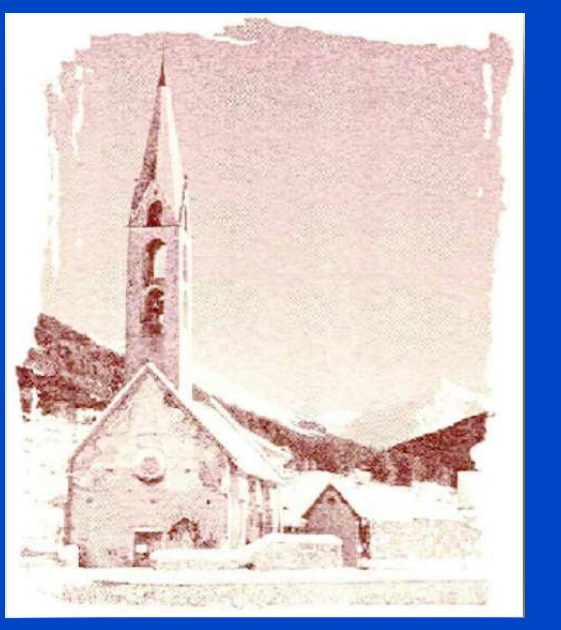




# Partial-Wave Analysis of Centrally Produced Two-Pseudoscalar Final States in $pp$ Reactions at COMPASS

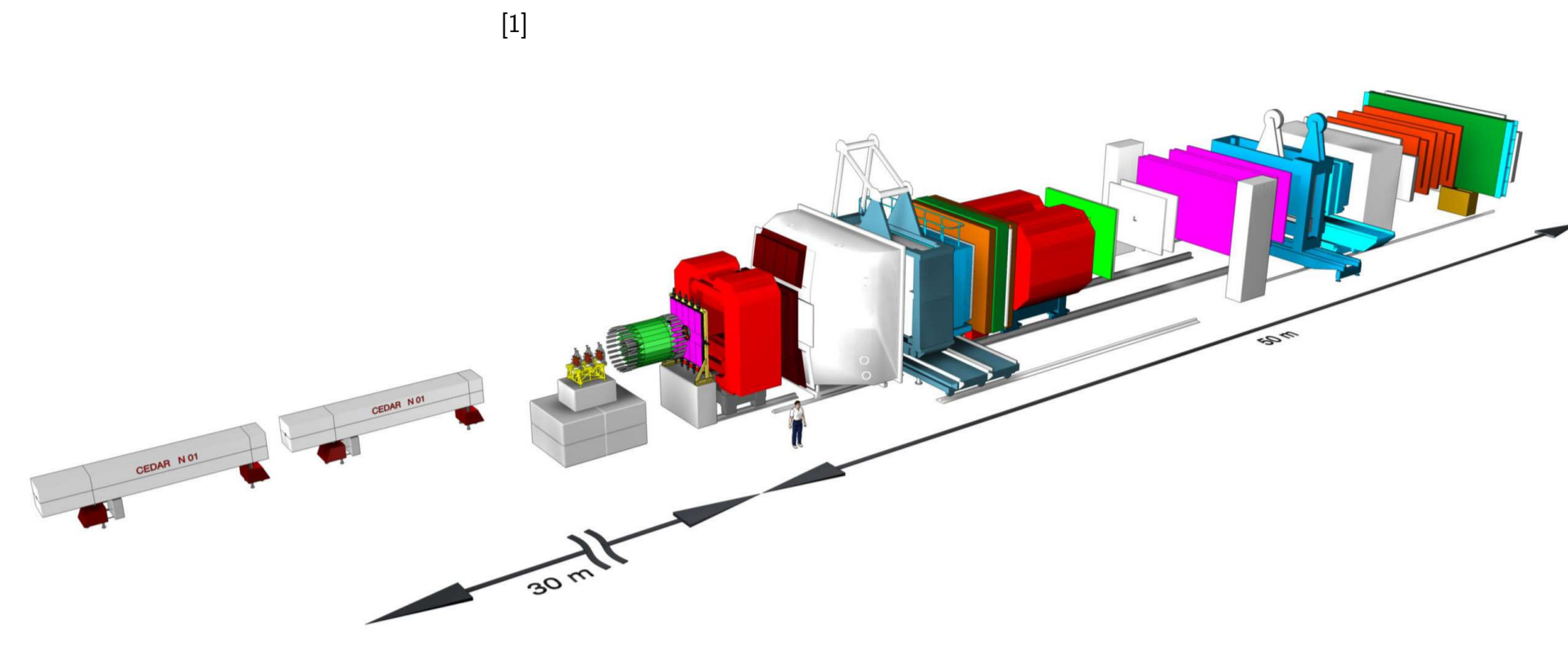
Alexander Austregesilo for the COMPASS Collaboration  
Physik Department E18, Technische Universität München, 85748 Garching, Germany



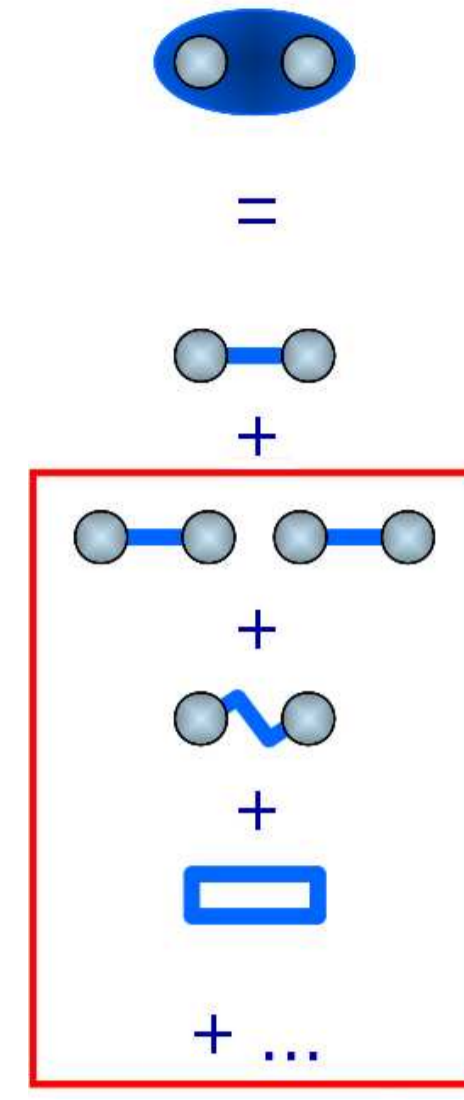
## COMPASS

### Common Muon and Proton Apparatus for Structure and Spectroscopy

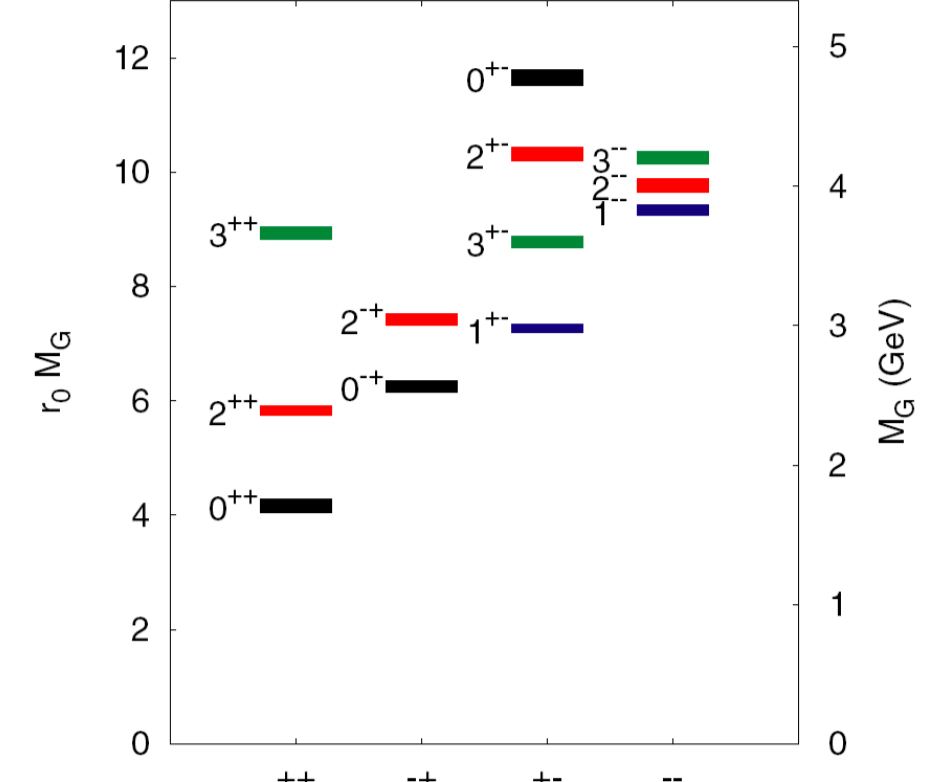
- Fixed target experiment
- Located at CERN SPS
- Data taking since 2002
- Physics objectives:
  - Hadron spectroscopy
  - Test of chiral perturbation theory
  - Nucleon spin structure
- 2 types of beam
  - 190 GeV/c secondary hadron beams ( $p$ ,  $\pi^+$  or  $\pi^-$ ,  $K^-$ )
  - 160 GeV/c tertiary muon beams ( $\mu^+$  or  $\mu^-$ )



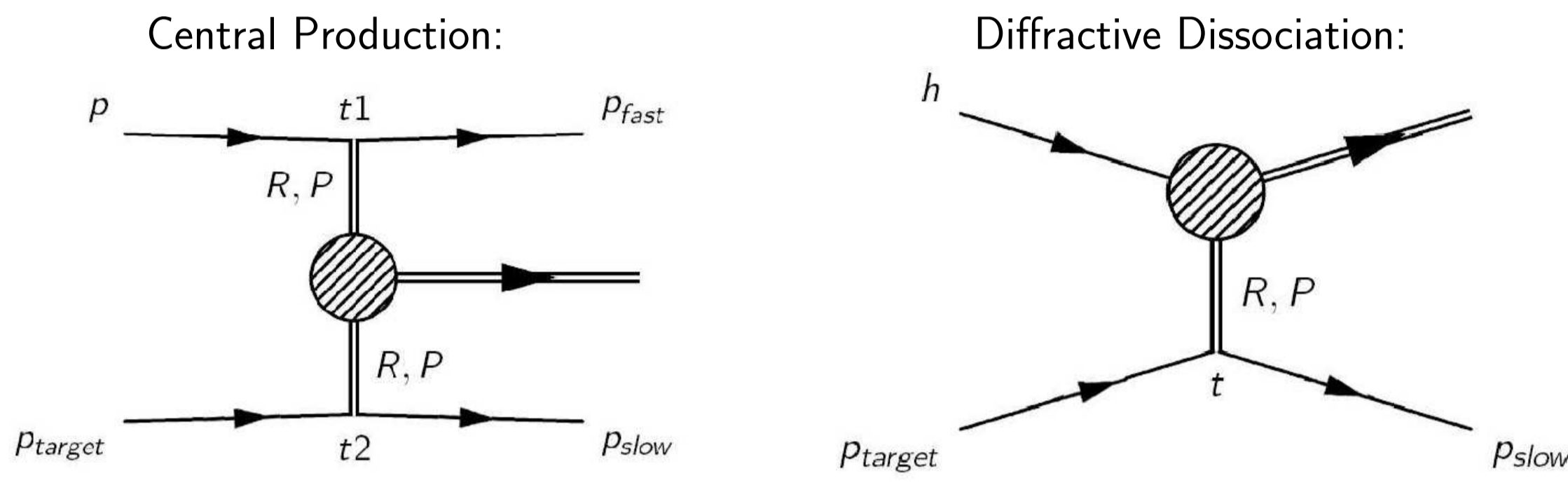
## Exotic Mesons



- Quark model: Meson described as  $q\bar{q}$  bound state with quantum numbers  $J^G J^PC$
- Quantum Chromo-Dynamics: other colour neutral configurations allowed (multi-quark states, hybrids, glueballs)
  - ⇒ Identify additional states in meson spectrum
- Predictions from quenched LQCD: lightest glueball has  $J^{PC} = 0^{++}$  and  $M \approx 1.6 \text{ GeV}/c^2$  [2]

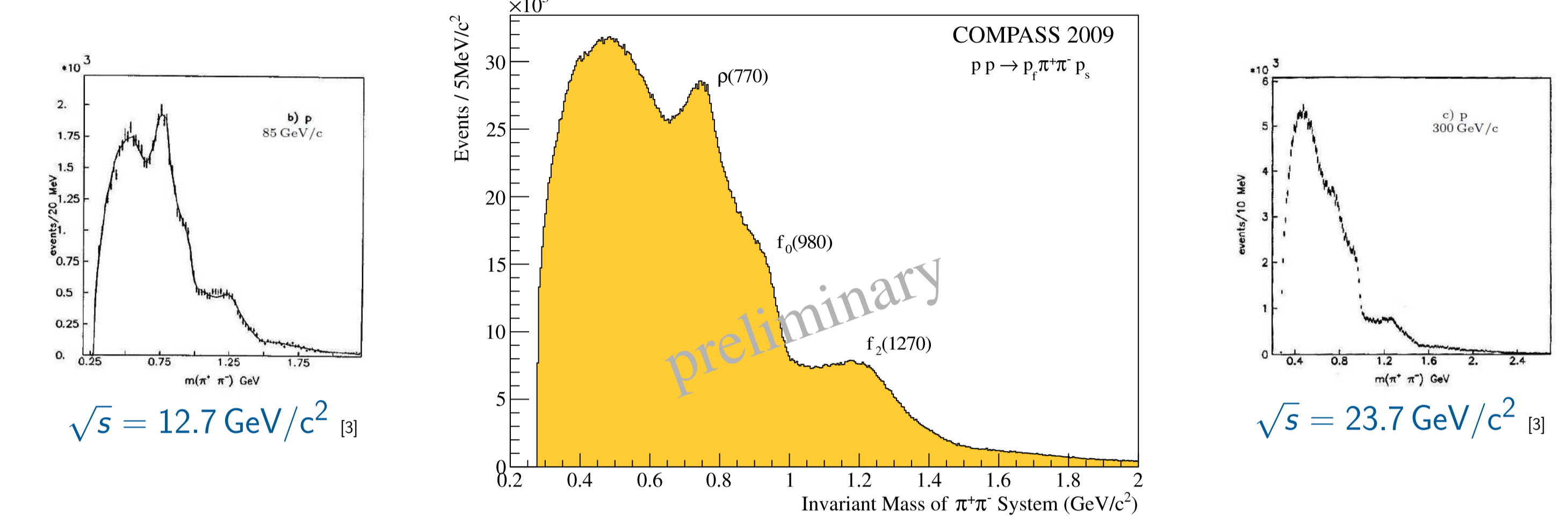


## Hadron Spectroscopy



- Proton beam impinging on liquid hydrogen target
- Double-Pomeron-exchange as glue-rich environment
  - ⇒ Production of non- $q\bar{q}$ -mesons (glueballs, hybrids) enhanced at central rapidities

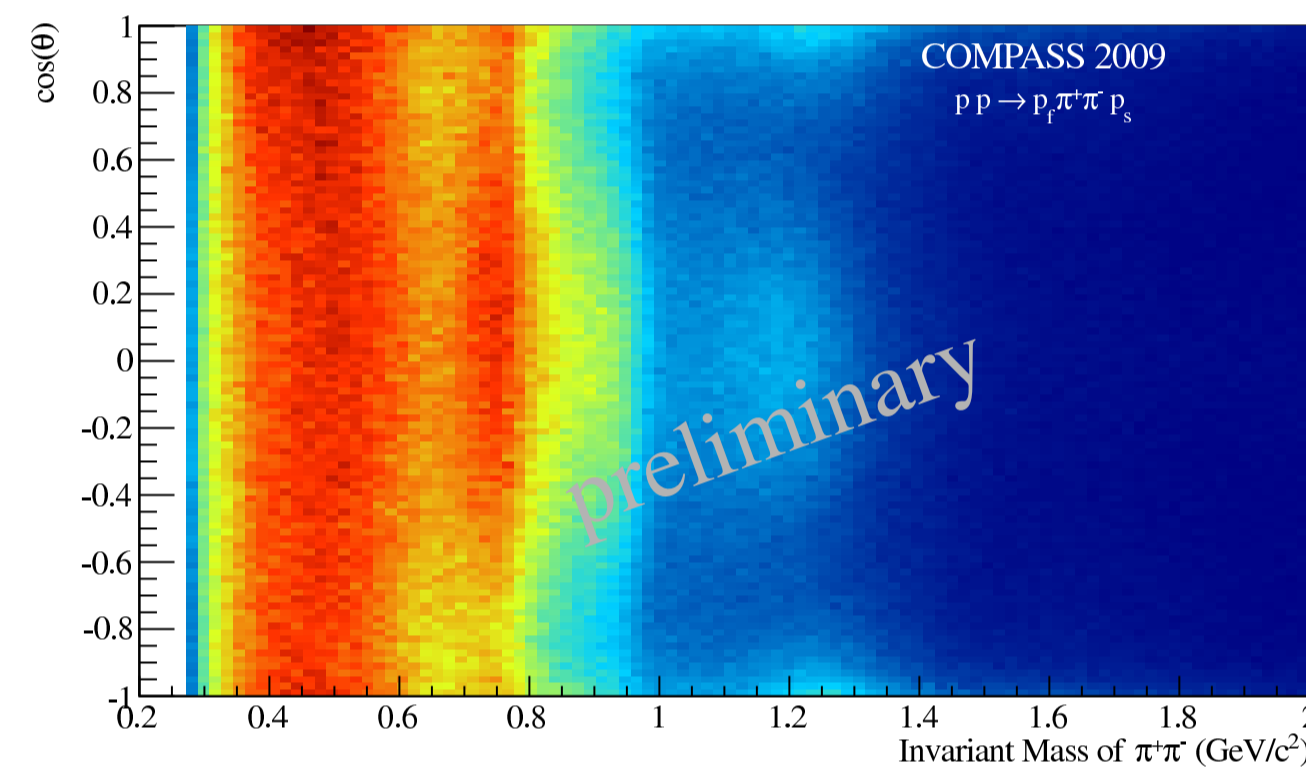
## $pp \rightarrow p_{\text{fast}} \pi^+ \pi^- p_{\text{slow}}$



- $\rho(770)$  and  $f_2(1270)$  peaks, sharp drop at  $1 \text{ GeV}/c^2$  due to  $f_0(980)$
- Production of  $\rho(770)$  disappears rapidly with increasing  $\sqrt{s}$
- Enhancement at low mass ( $\sigma$ ) and  $f_0(980)$  remain unchanged
  - characteristic for  $s$ -independent Pomeron-Pomeron scattering

## Reference Frame

- Assumption: central  $\pi^+\pi^-$  system produced by the collision of two objects
- Space-like exchange particles define  $z$ -axis and production plane
- Decay fully described by  $M(\pi^+\pi^-)$ ,  $\theta$  and  $\phi$
- Linear combination of spherical harmonics as eigenstates of reflectivity  $\varepsilon = \pm 1$



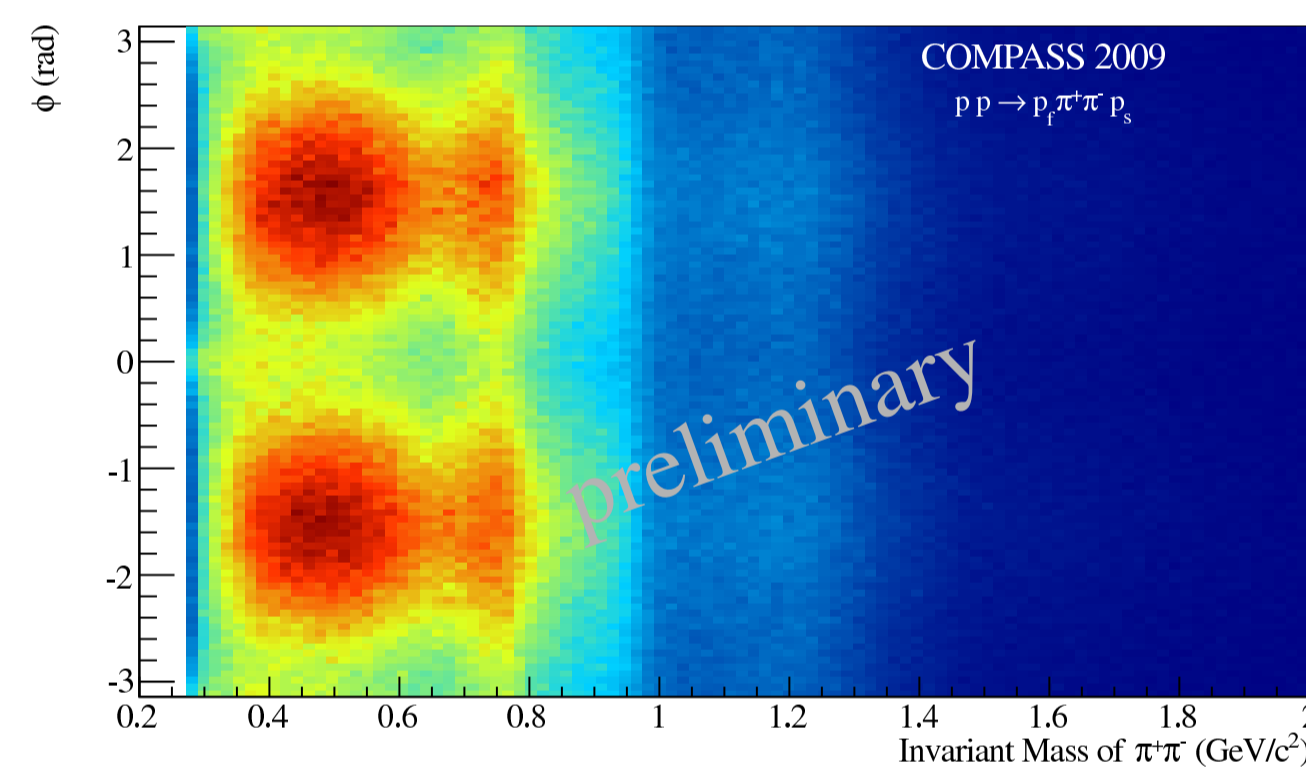
$$Y_m^{\varepsilon\ell}(\theta, \phi) = c(m) \left[ Y_m^{\ell}(\theta, \phi) - \varepsilon(-1)^m Y_{-m}^{\ell}(\theta, \phi) \right]$$

## Partial Wave Decomposition

Expand intensity  $I(\theta, \phi)$  in terms of partial-waves:

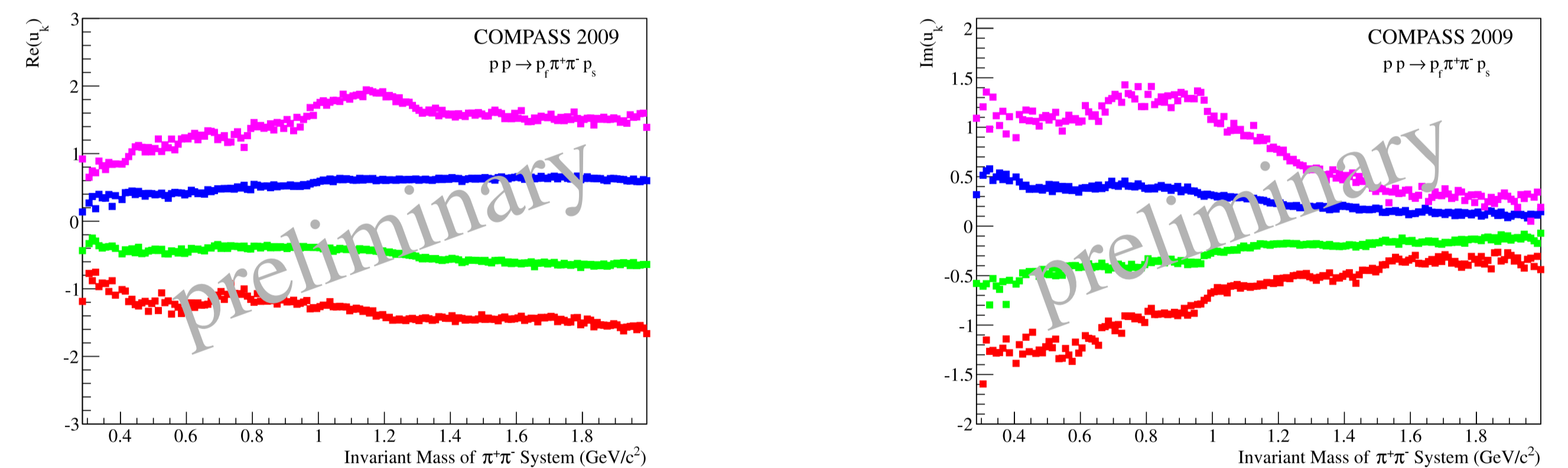
$$I(\theta, \phi) = \sum_{\varepsilon} \left| \sum_{\ell m} T_{\varepsilon\ell m} Y_m^{\varepsilon\ell}(\theta, \phi) \right|^2$$

and fit complex transition amplitudes  $T_{\varepsilon\ell m}$



## Ambiguities in the Two-Pseudoscalar System

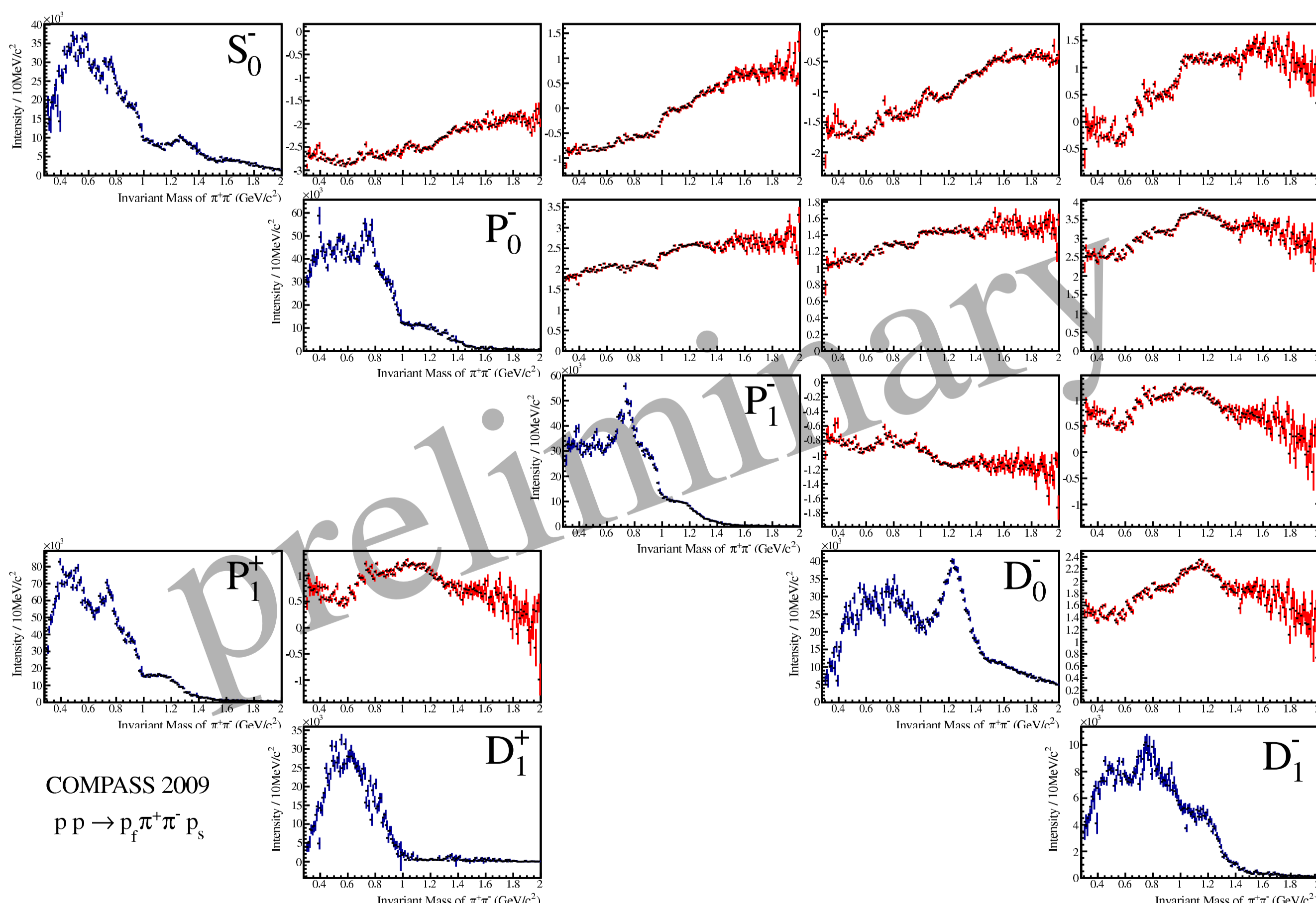
- Intensity expansion can be transformed into a 4<sup>th</sup>-order polynomial in the variable  $u = \tan(\theta/2)$  [4]
- Complex conjugation of the roots ('Barrelet zeros') results in the same angular distribution



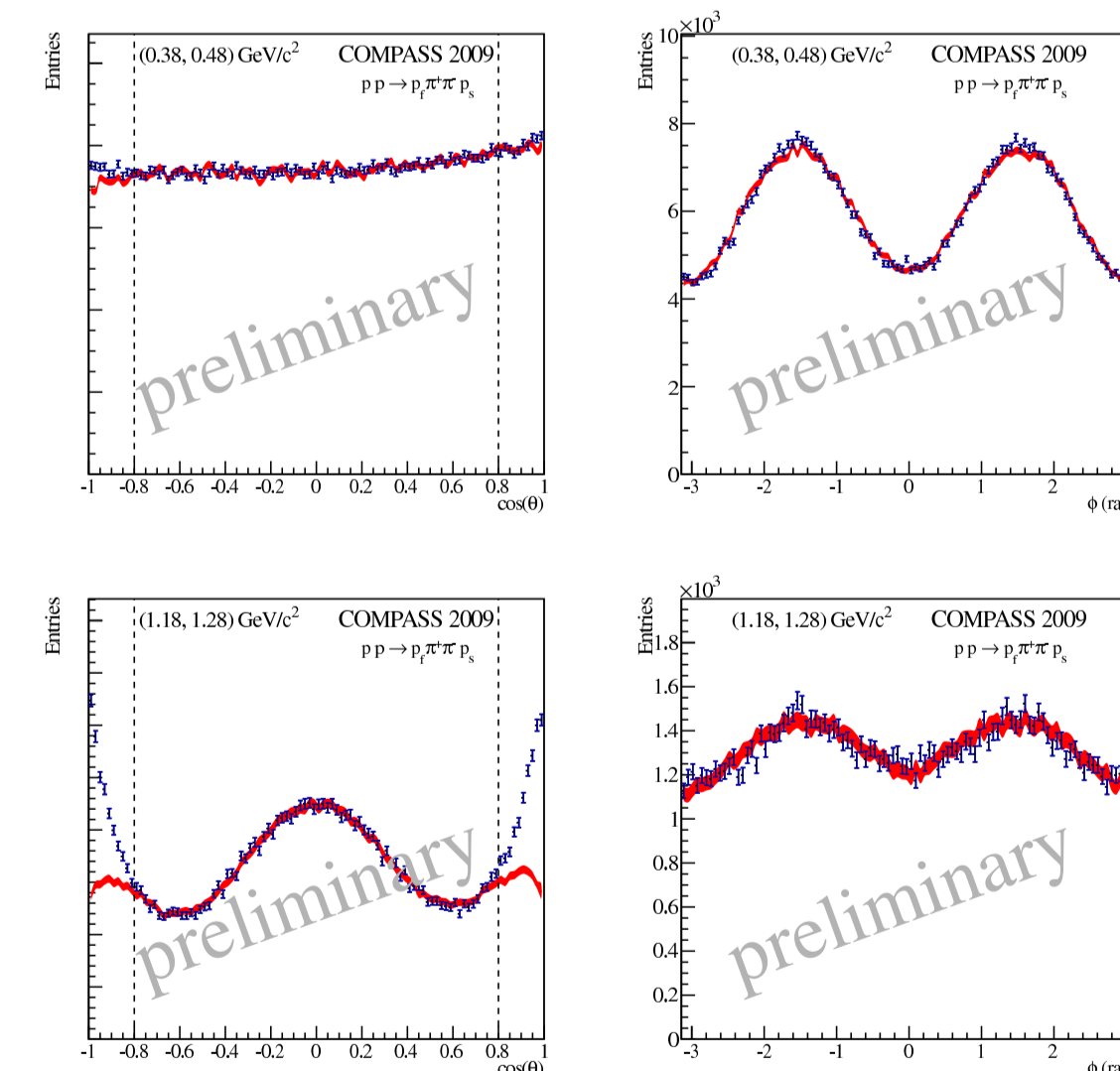
- 8 different mathematically ambiguous solutions can be uniquely identified and calculated analytically
- Differentiation requires additional input (e.g. behaviour at threshold, physics content)

## Physical Solution

blue: intensity, red: relative phase



## Evaluation of Fit with Weighted Monte-Carlo



- Blue: data
- red: phase-space MC weighted with fit result
- Sharply peaking distribution for  $|\cos(\theta)| > 0.8$  cannot be described by fit
- May hint to different production process
  - ⇒ Excluded from fit, loss of  $\approx 20\%$  of data

[1] P. Abbon et al. NIM A 577, 455 (2007)  
[2] Y. Chen et al., Phys. Rev. D 73, 014516 (2006)  
[3] T.A. Armstrong et al., Z. Phys. C51, 351 (1991)  
[4] S.-U. Chung, Phys. Rev. D 56, 7299 (1997)

## Conclusion and Outlook

Centrally produced sample orders of magnitude larger than that of previous experiments

Partial-wave analysis of two-pseudoscalar system successfully performed

⇒ High potential to study light glueball spectrum, combining all accessible decay channels ( $K^+K^-$ ,  $K_S K_S$ ,  $\pi^0\pi^0$ ,  $\eta\eta$ , ...)

