Technische Universität München

Study of interference of Coulomb and strong diffractive production of $\pi^-\pi^-\pi^+$ systems produced off Pb target at COMPASS

D. Ryabchikov, S. Grabmüller, J. Friedrich

Institute for High Energy Physics, Protvino; Physik-Department, E18 Technische Universität München

HADRON2011 talk

Motivations

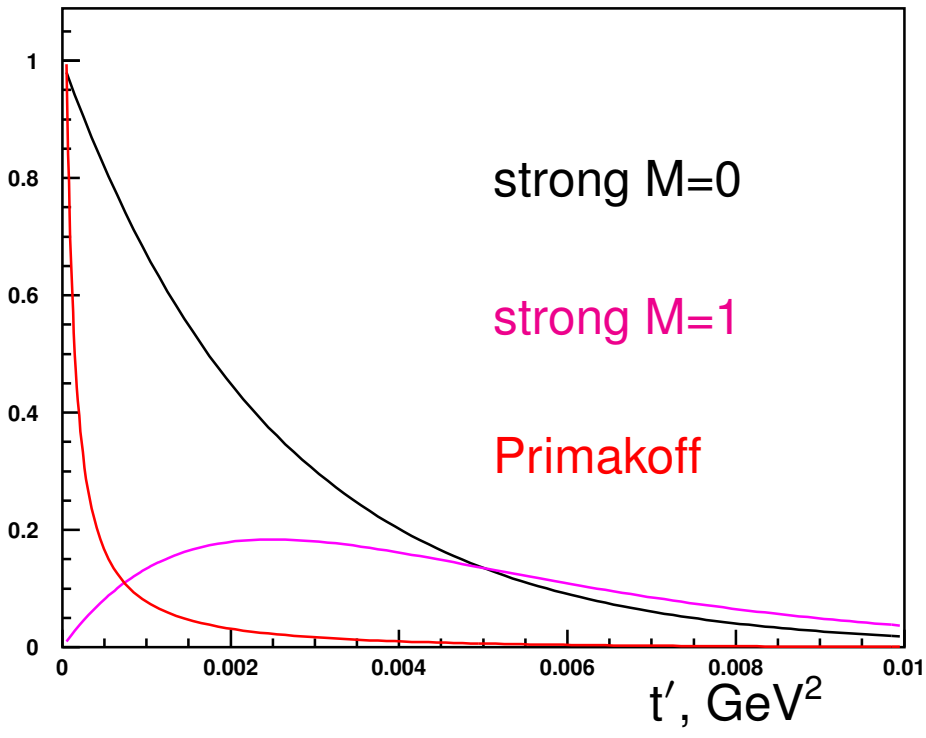
- Use heavy nuclei as clean source of quasi-real photon flux (Primakoff method) $\rightarrow$ measurement of $\pi\gamma$ interactions
- $\pi\gamma \rightarrow 3\pi$ controlled by Chiral-Perturbation theory (LO up to about $5m_\pi$) $\Rightarrow$ experimental test at COMPASS.
  Higher energies: loops and diagrams with $\rho(770)$ meson
- Primakoff method can be also used to determine radiative widths $\Gamma(\pi\gamma)$ of mesonic resonances $\rightarrow$ investigation of known widths and search for new radiative decays or upper limits
- Measuring of production phases of electromagnetic and strong interaction $\rightarrow$ detailed insight into the production mechanisms and their interference

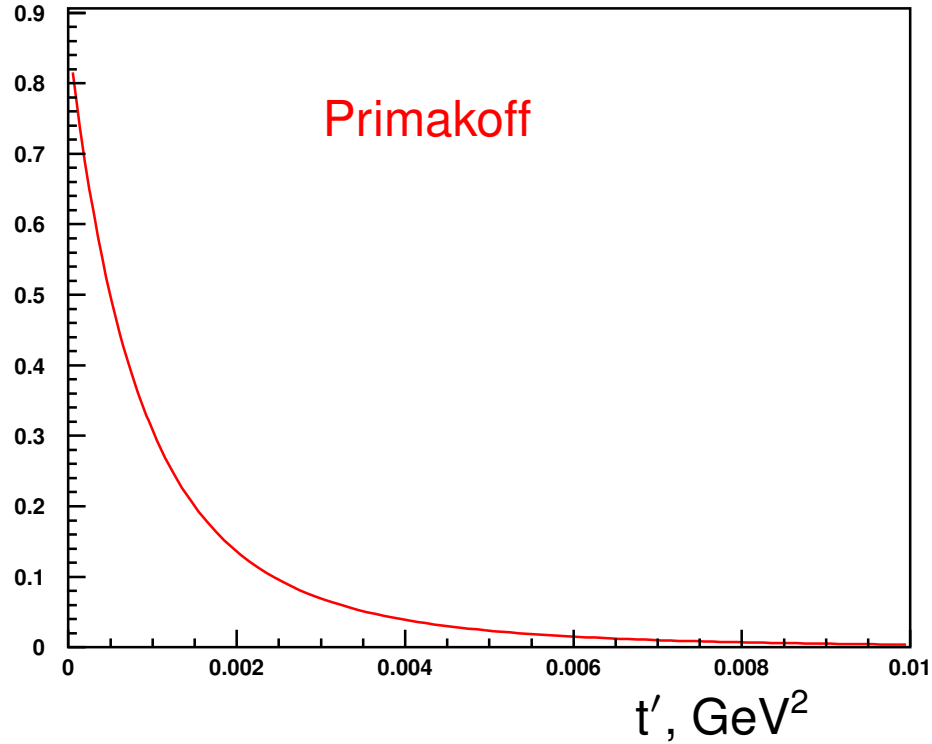
Production mechanisms: t′ dependence

Technische Universität München

before resolution

after resolution

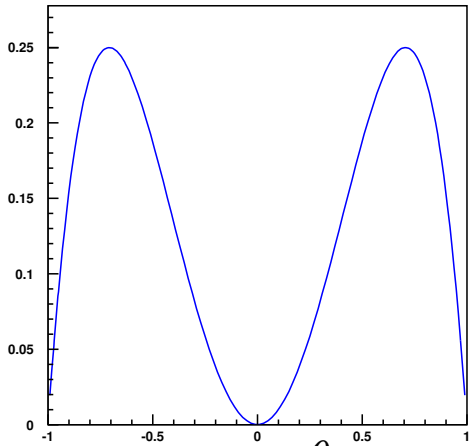


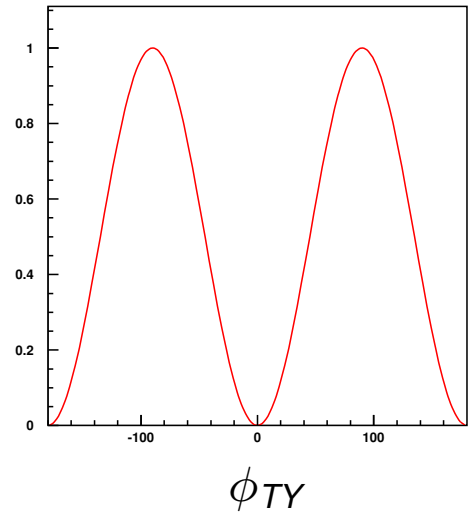


Resolution at $t' \to 0$

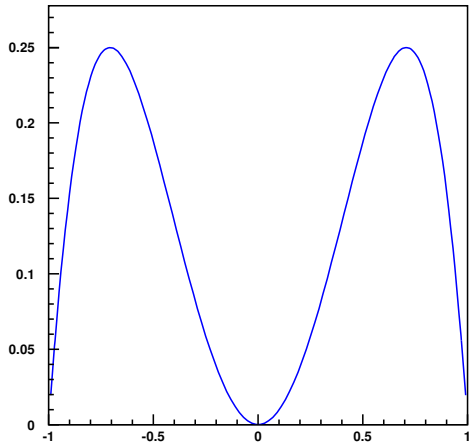
Technische Universität München

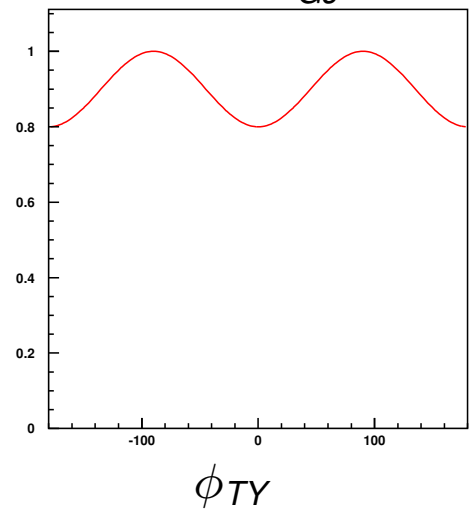
before resolution





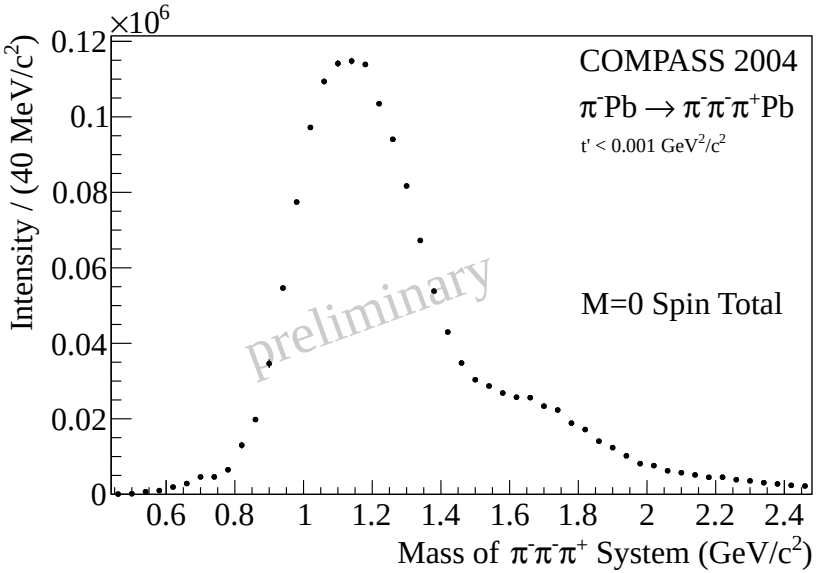
after resolution

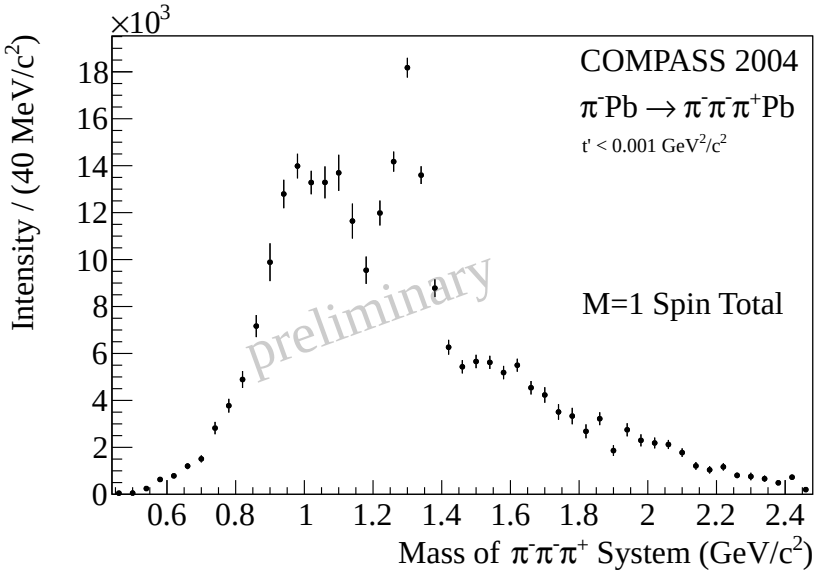


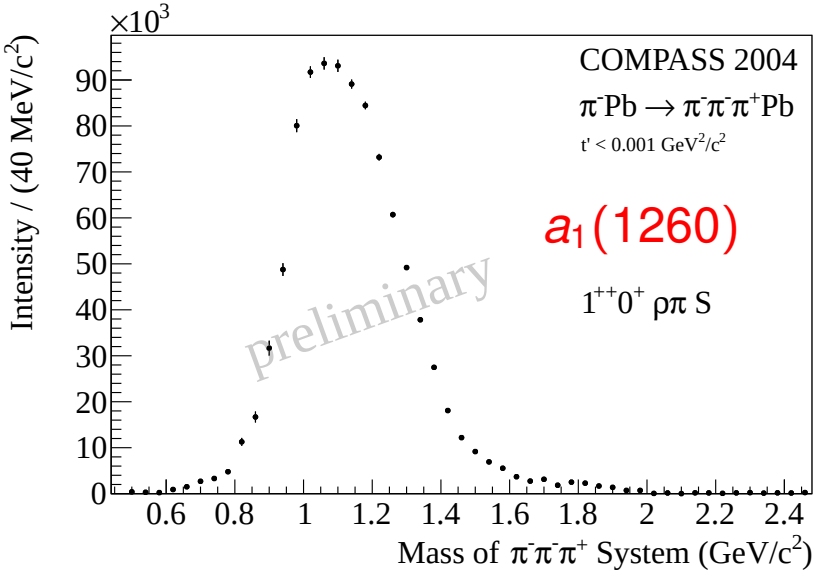


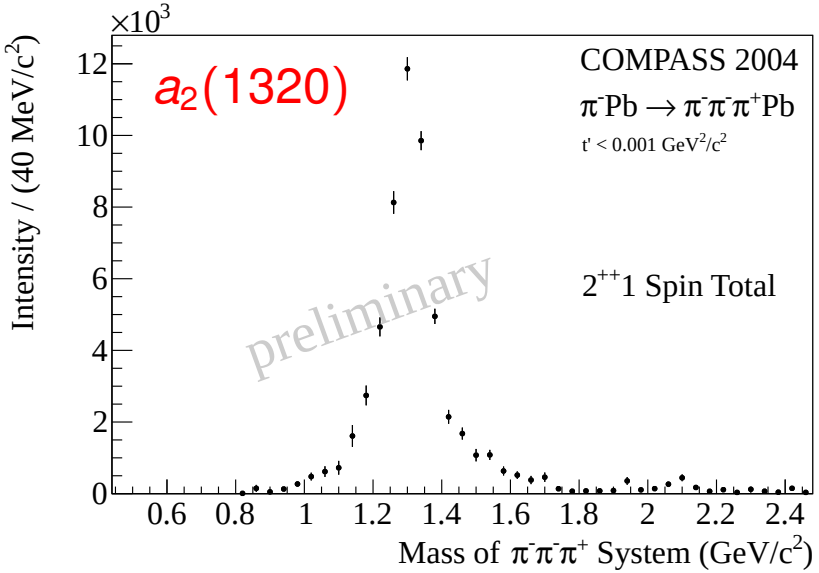
- Negative reflectivity component "produced" by angular smearing
- Full coherence for 3π appears broken. Traditional approach: PWA with rank=2
- In this analysis: rank=1 introducing decoherence as $\rho_{i,j} = r_{i,j} T_i T_j^*$
- relative phases proven (by MC study) to be not distorted by resolution

Major intensities in m(3π)-bins (acceptance corrected)





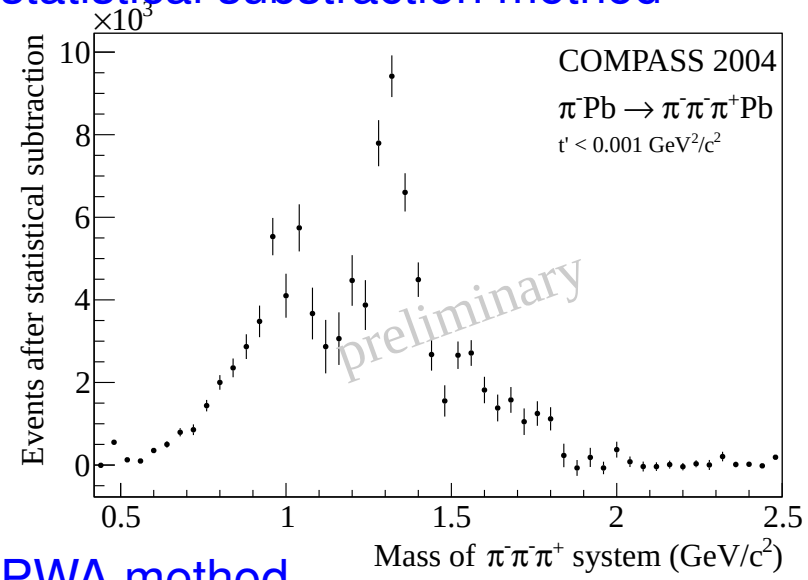




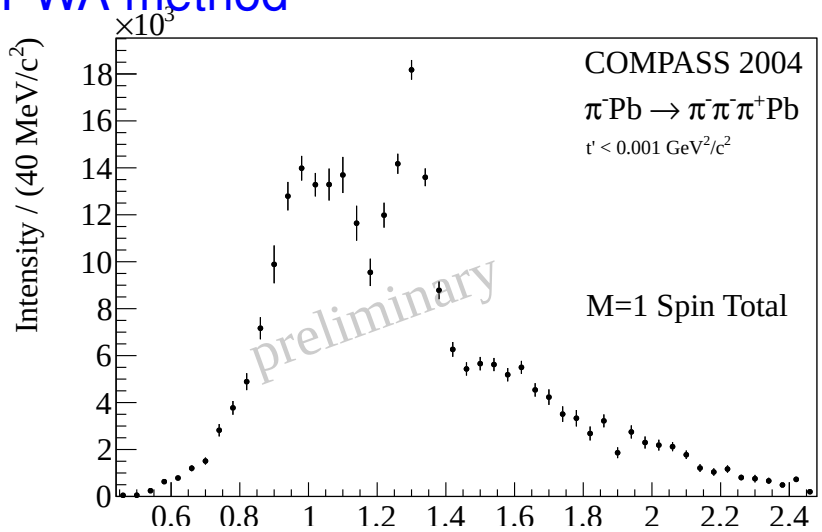
Primakoff signal extracting

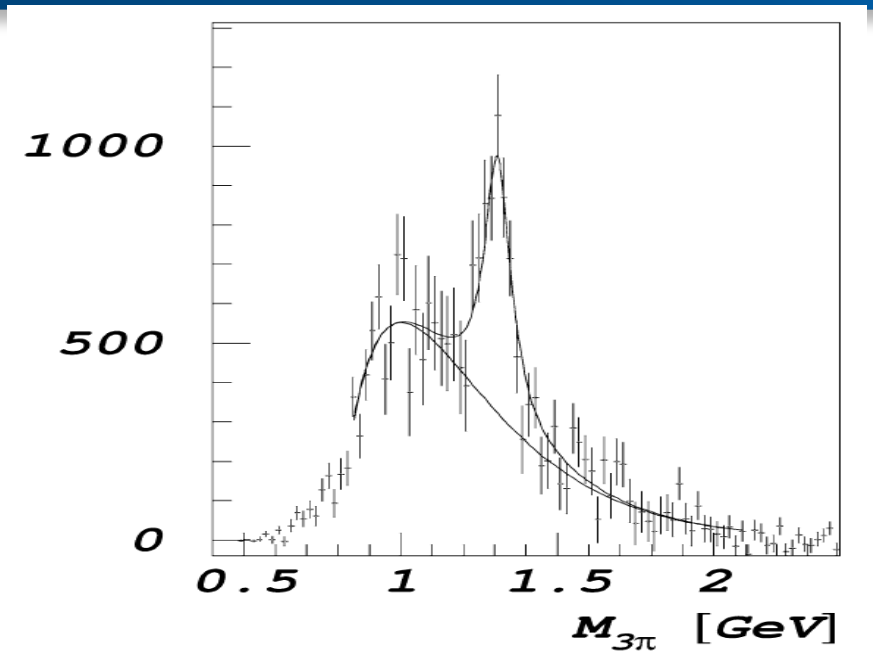
Technische Universität München

statistical substraction method



PWA method





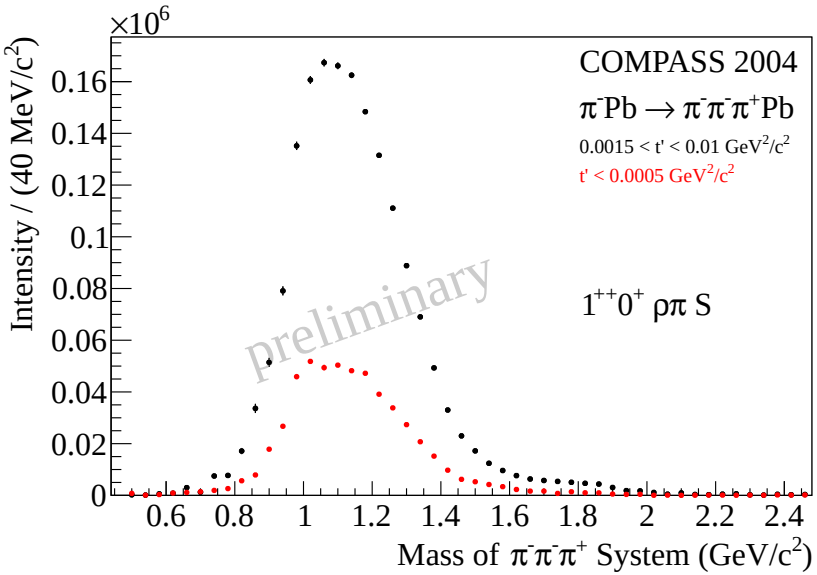
SELEX, $\pi^- Cu \to \pi^- \pi^- \pi^+ Cu$

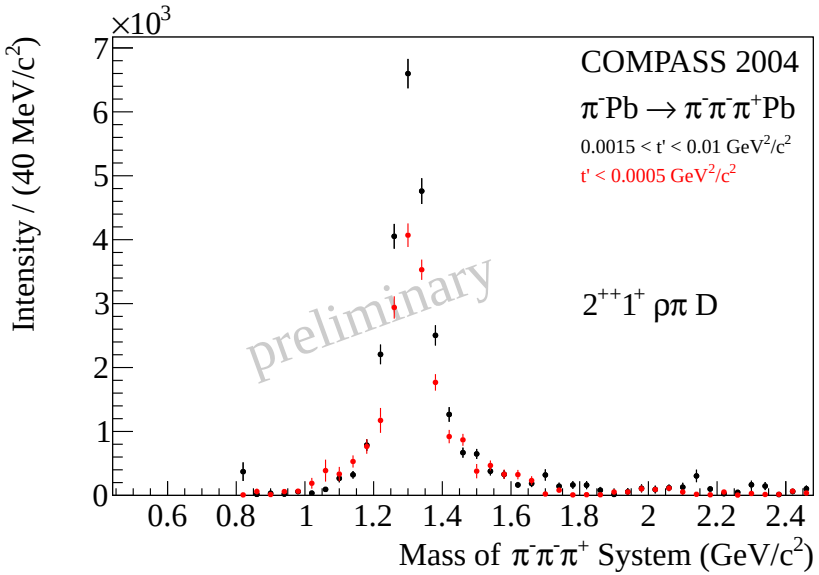
p_{beam}=600 GeV/c

V.V. Molchanov et al, Phys.Lett. B521, 171

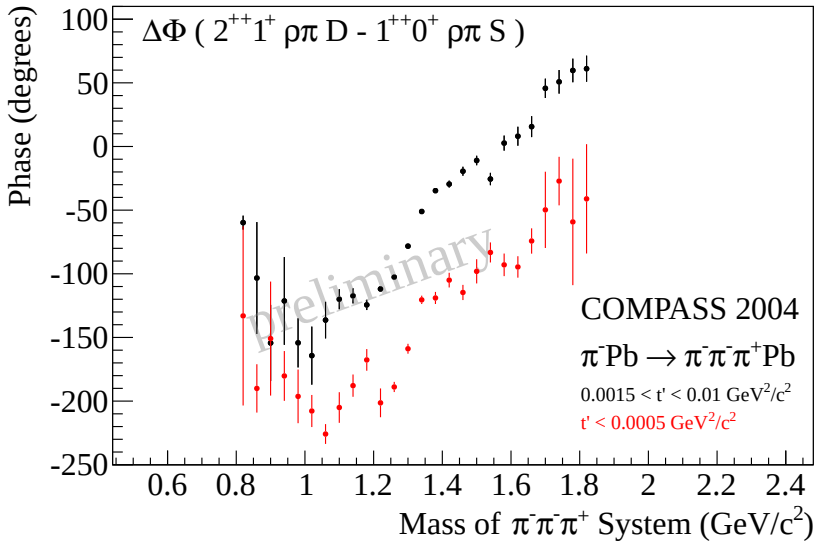
a1(1260) and a2(1320): fits in two regions of t′

Technische Universität München

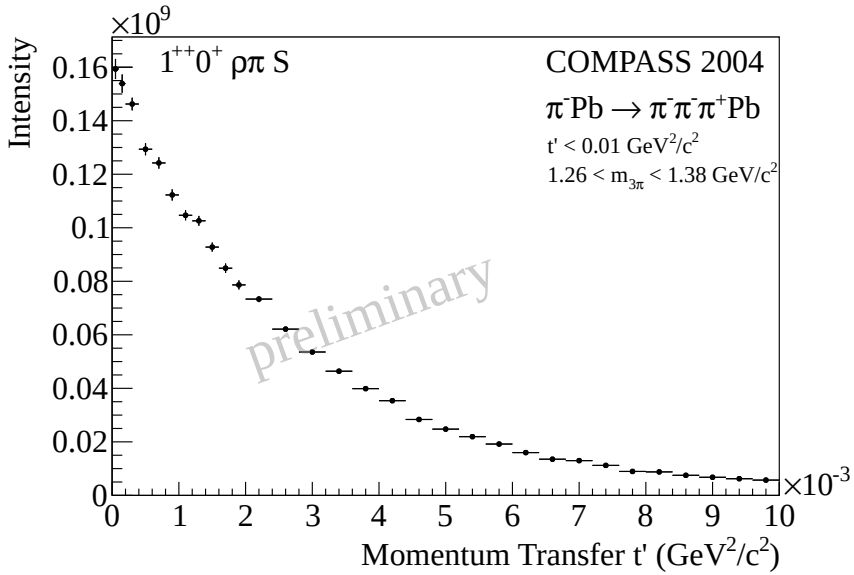


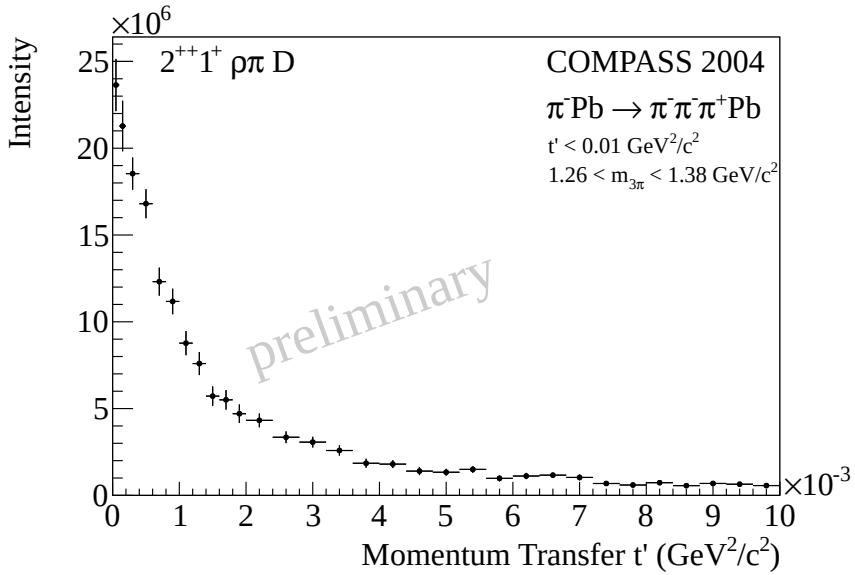


$J^{PC} = 2^{++}$ amplitude shows resonant nature in two t' regions.
Phase is shifted by $\sim 90^0$ between those two fits.

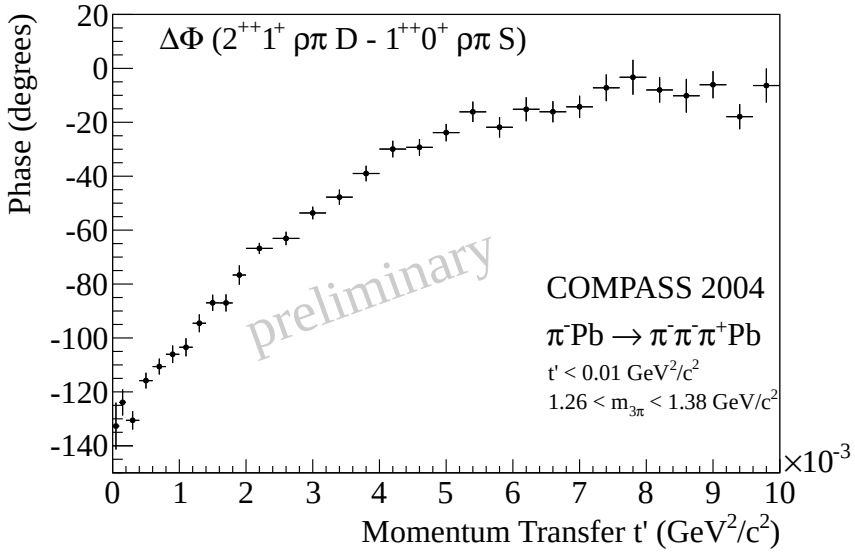


a1(1260) and a2(1320): fits in t′ bins

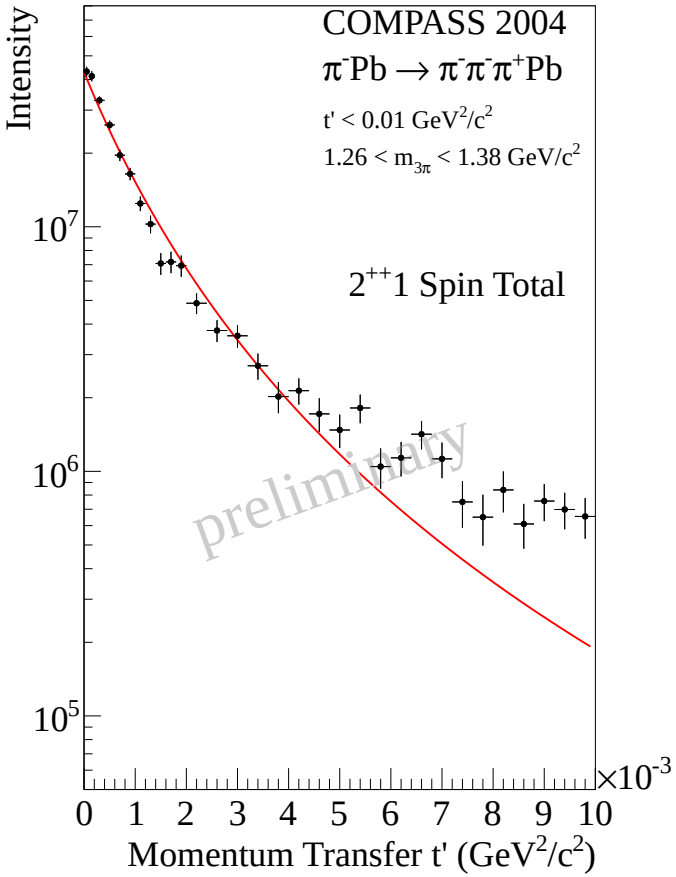


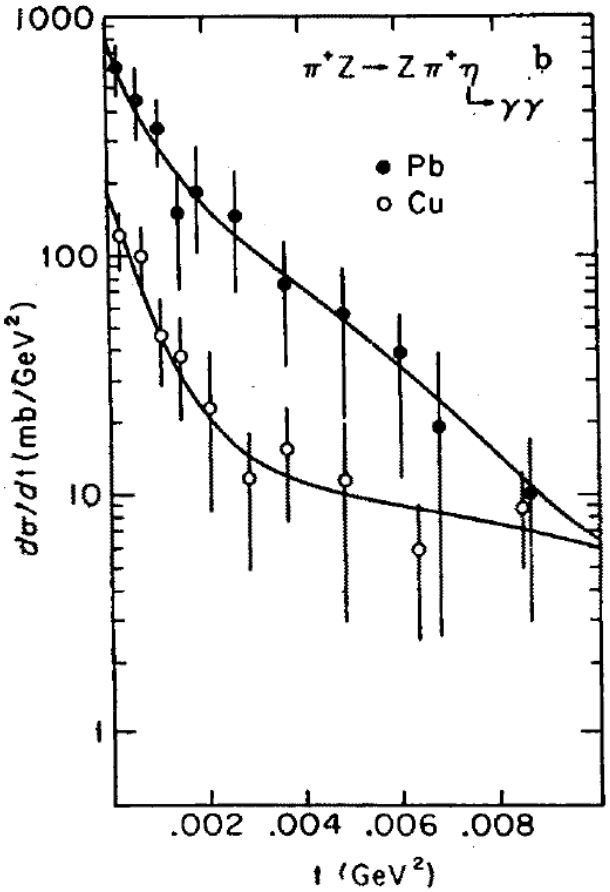


PWA performed in rather wide m(3π) region $\rightarrow$ the breit-wigner amplitudes of a1(1260) and a2(1320) are multiplied on $1^{++}0^{+}\,\rho\pi\,S$ and $2^{++}1^{+}\,\rho\pi\,D$ decay amplitudes



t′spectrums of a2(1320): comparison with E272 result

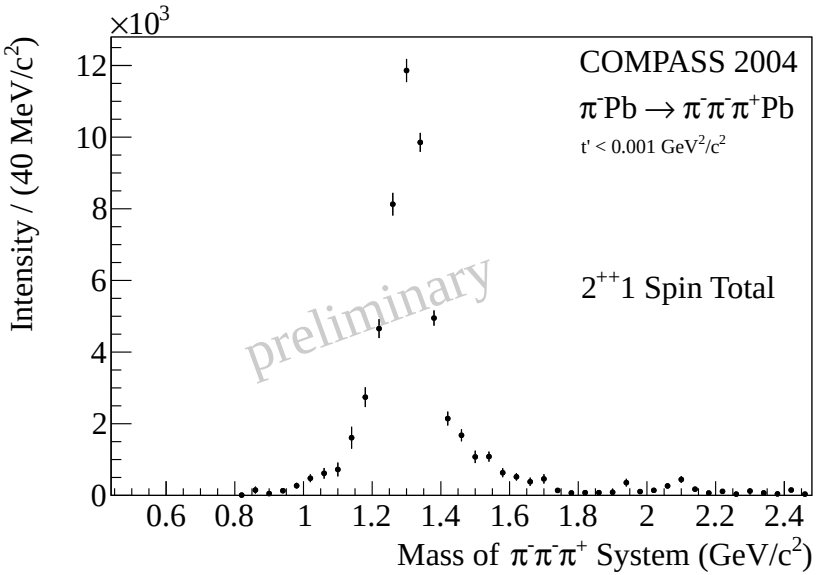


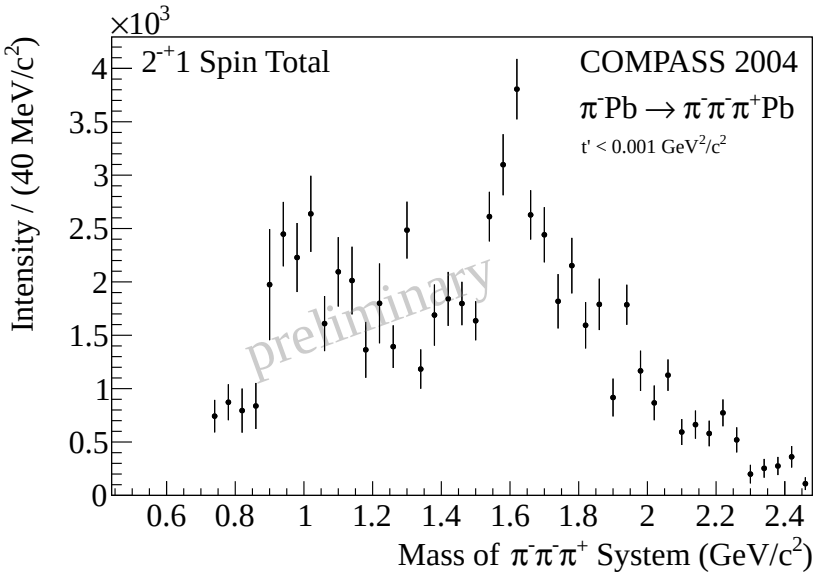


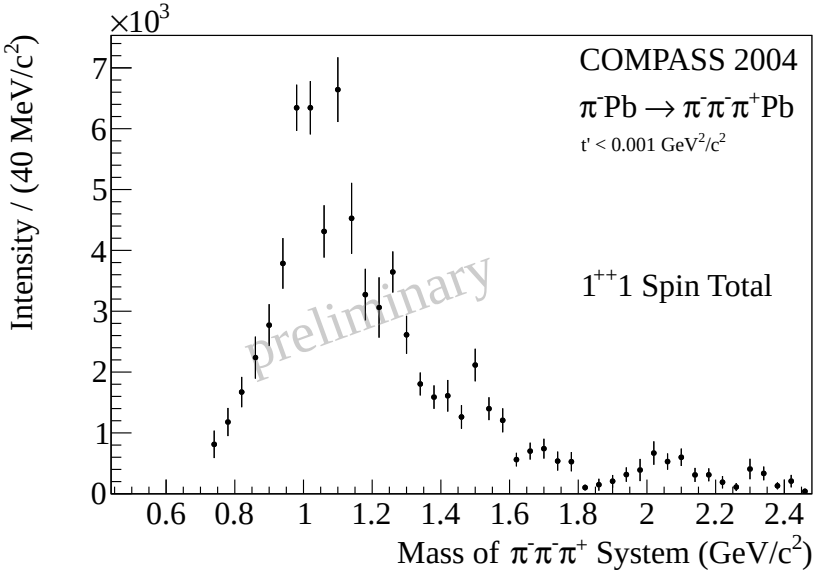
S. Cihangir et al, Phys.Rev. vol.117B, 119

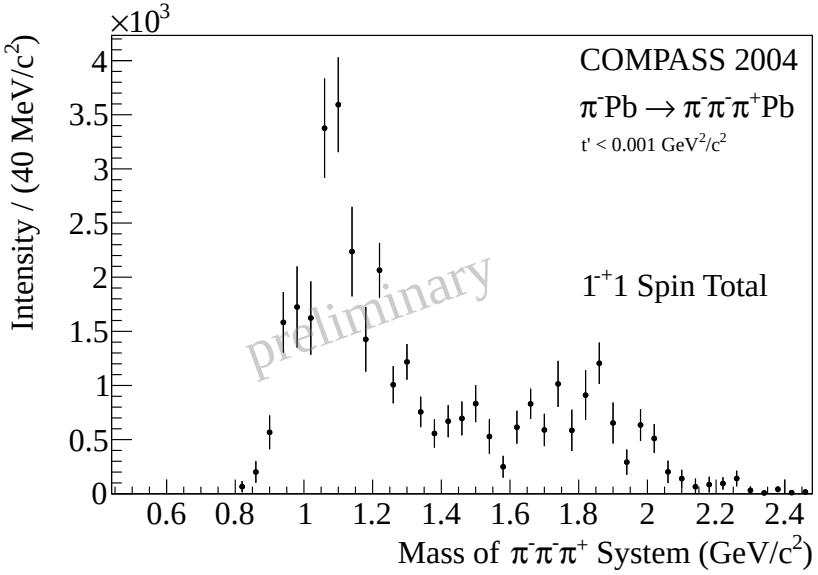
Various Primakoff produced J^{PC}-intensities

Technische Universität München

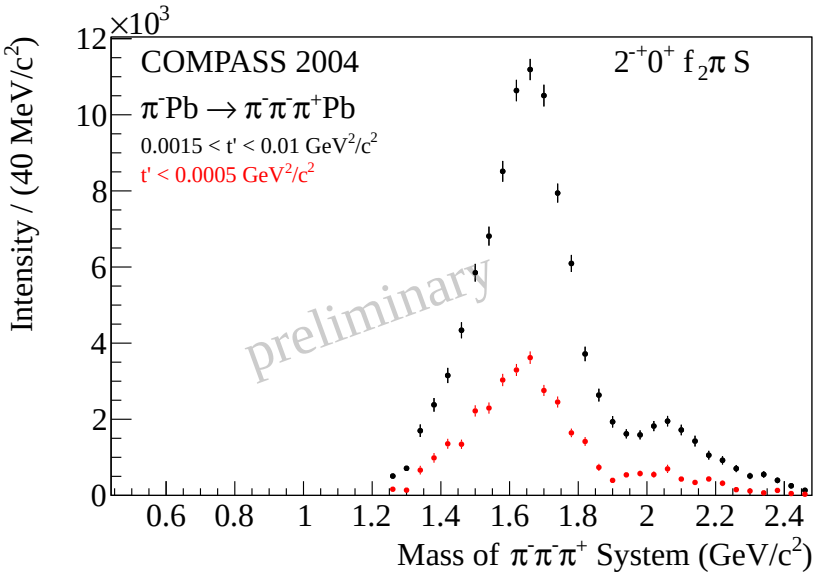


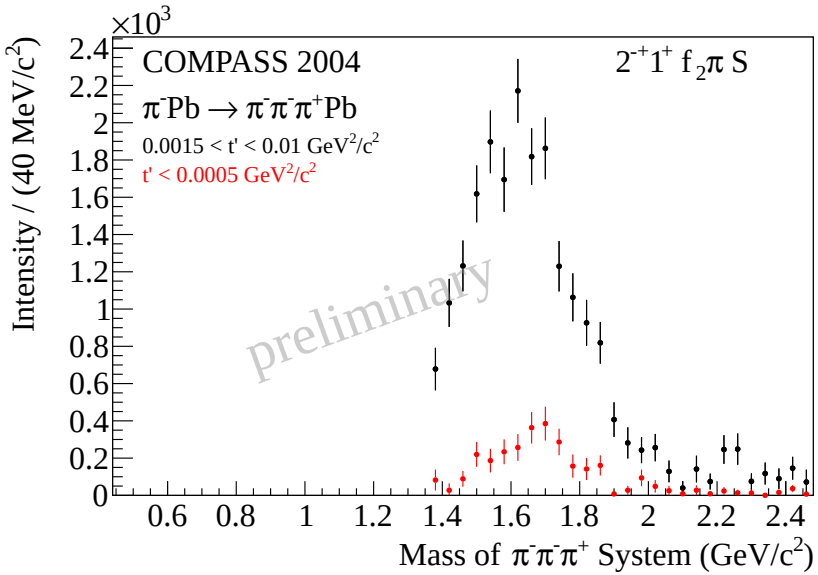




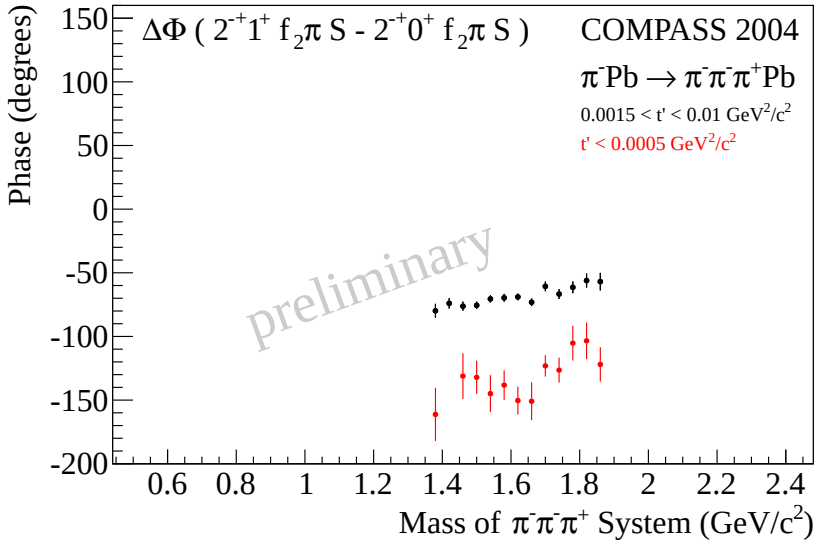


$\pi 2(1670)$: fits in two regions of t′



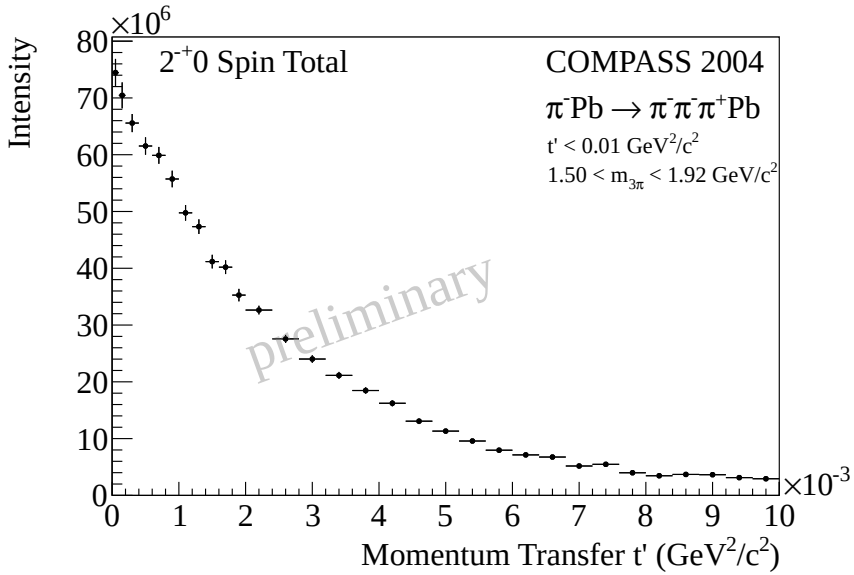


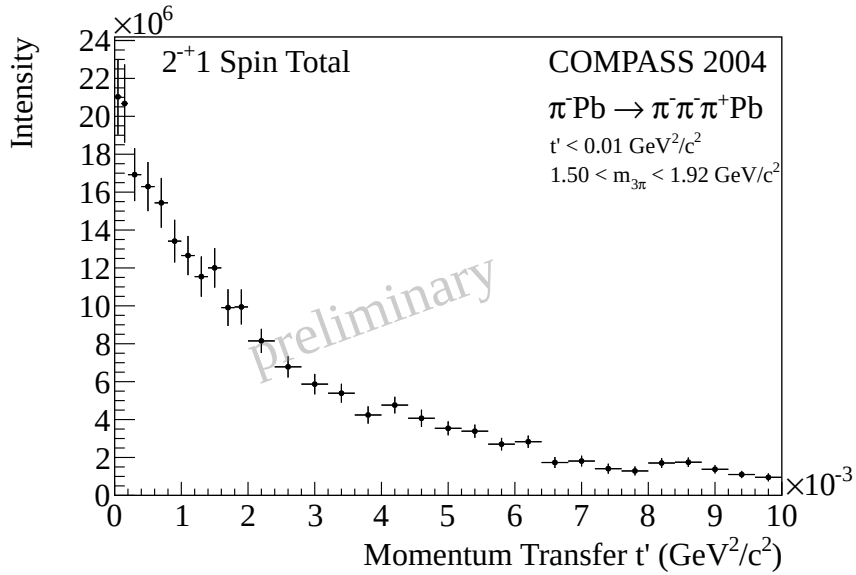
"Phase-locking" effect between two 2^{-+} components $\rightarrow$
resonant nature of Primakoff produced 2^{-+}, i.e. $\pi_2(1670) \rightarrow \pi\gamma$

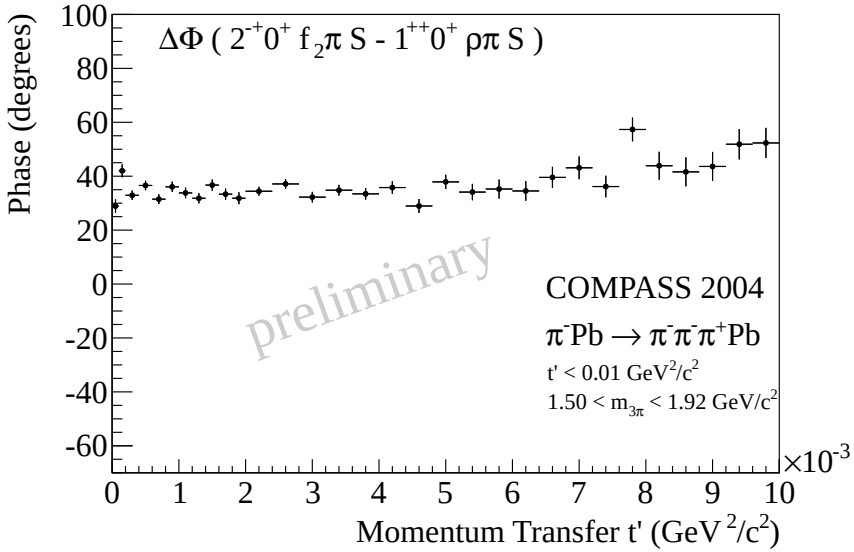


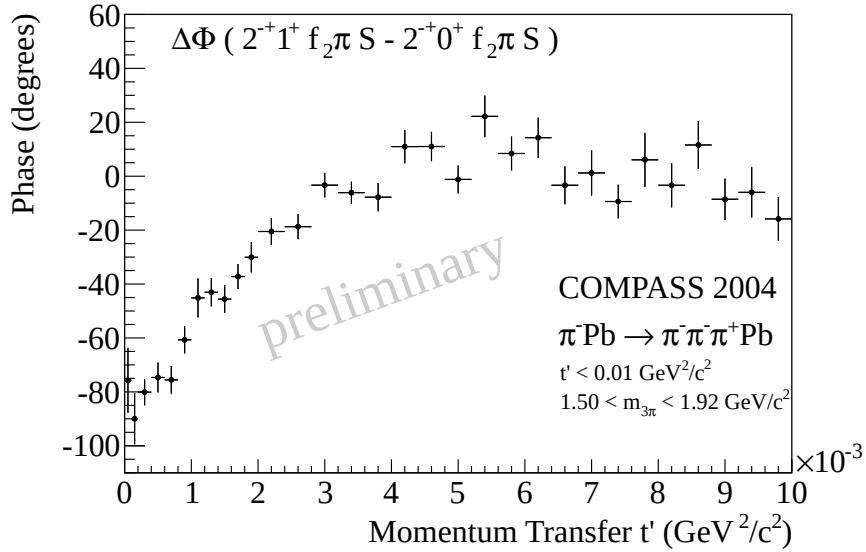
$\pi 2(1670)$: fits in t′ bins

Technische Universität München

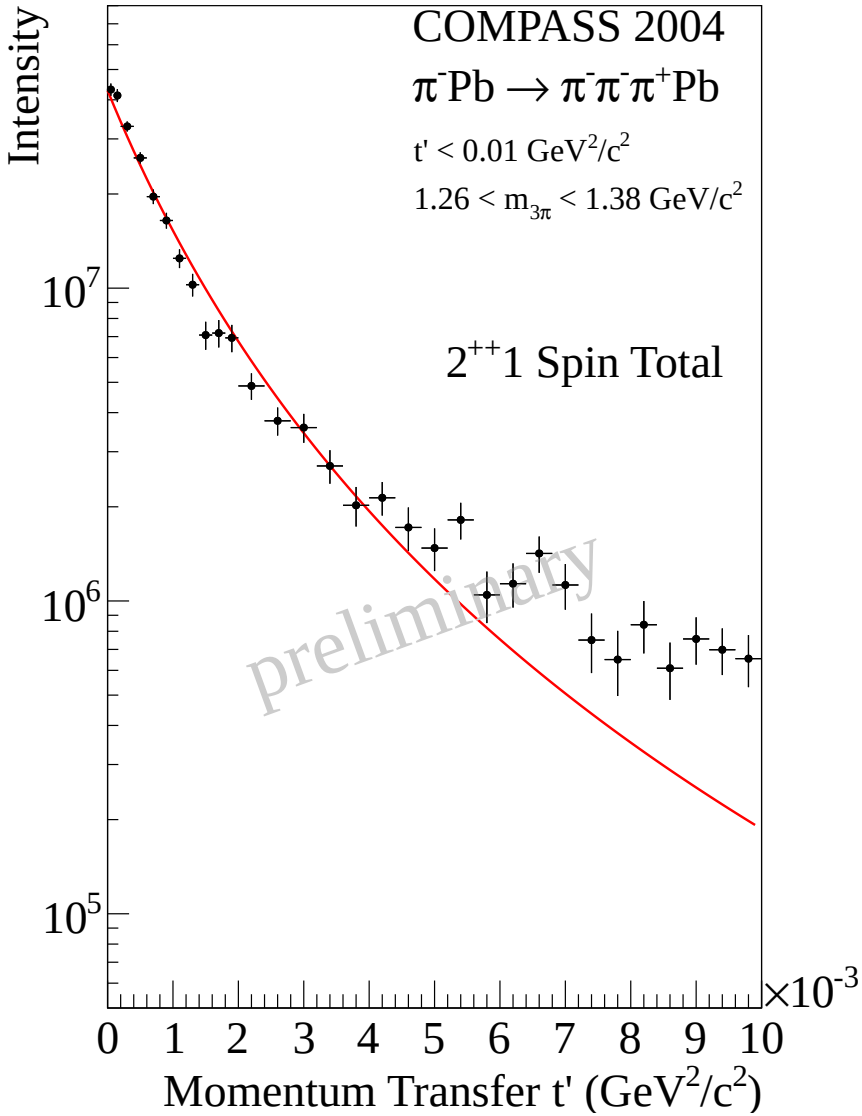


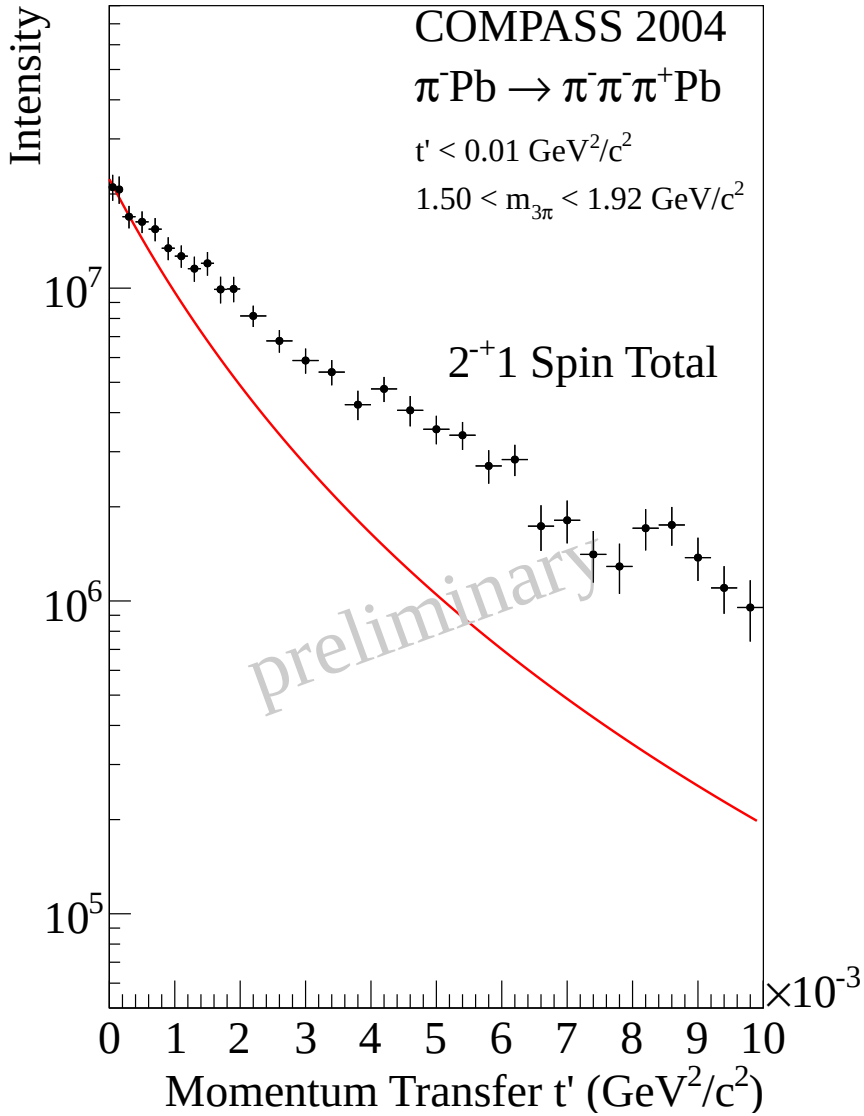




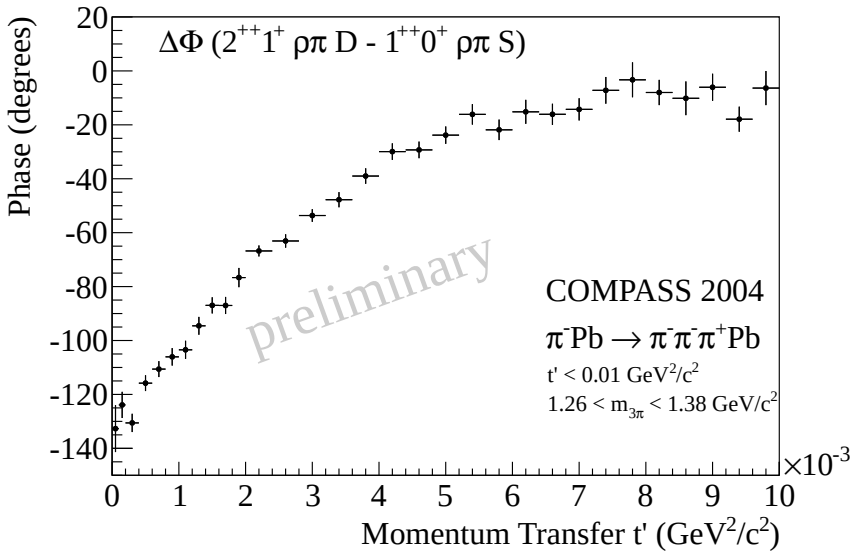


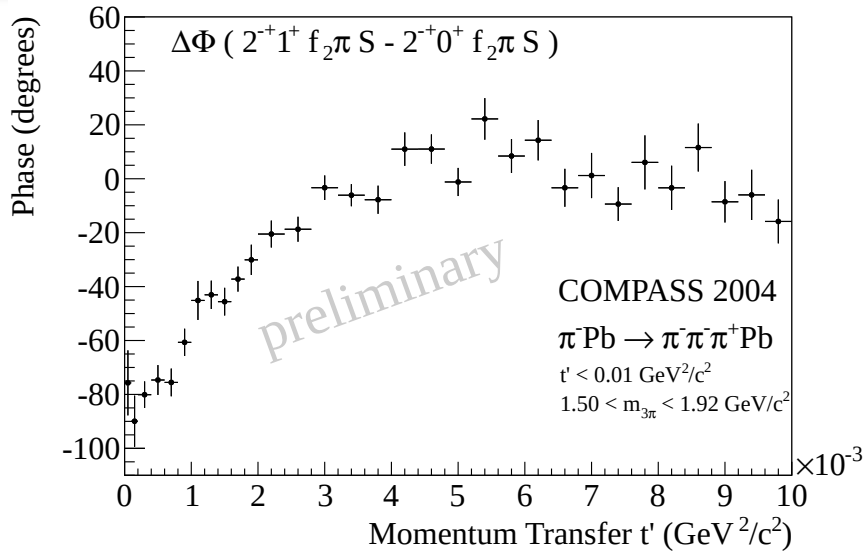
$J^{PC}M = 2^{++}1$ and $2^{-+}1$ (red: Primakoff only)





$J^{PC}M = 2^{++}1$ and $2^{-+}1$ phases in t′ bins



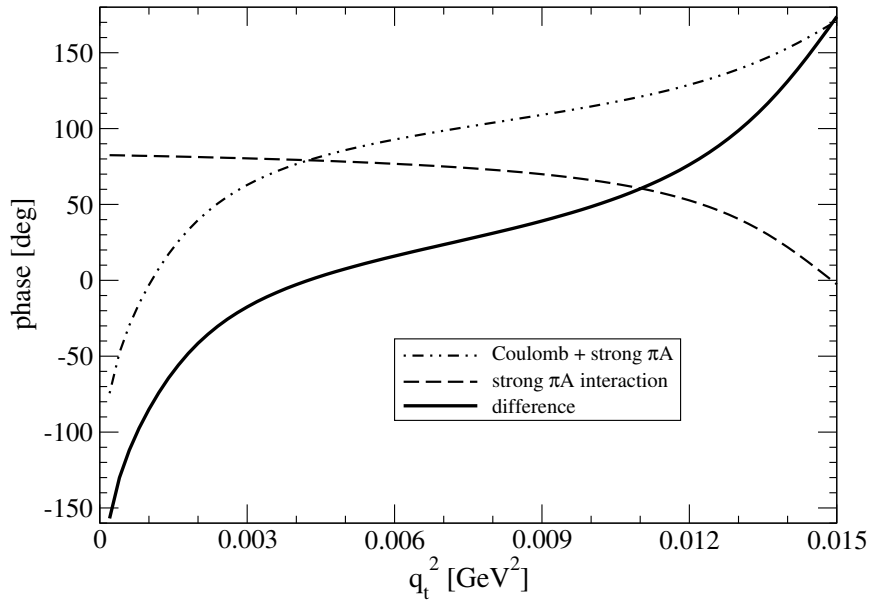


Glauber modell →

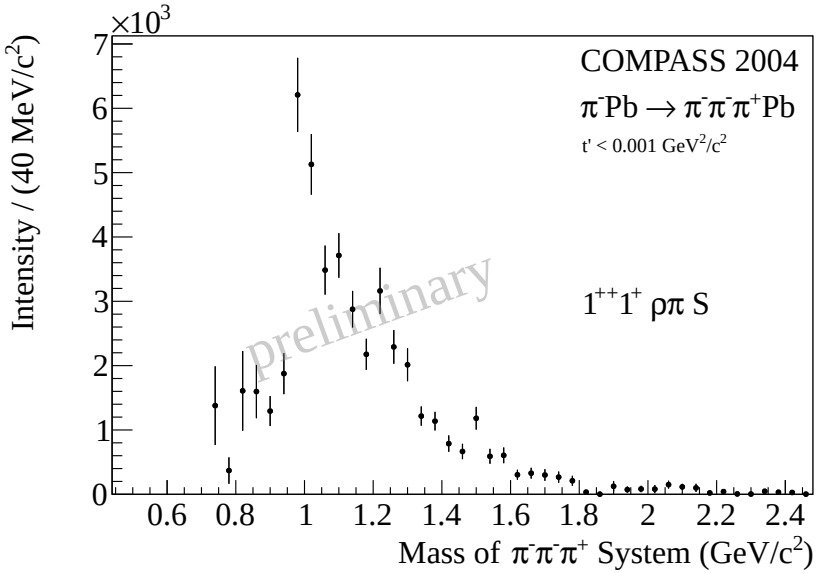
G. Fäldt and U. Tengblad,

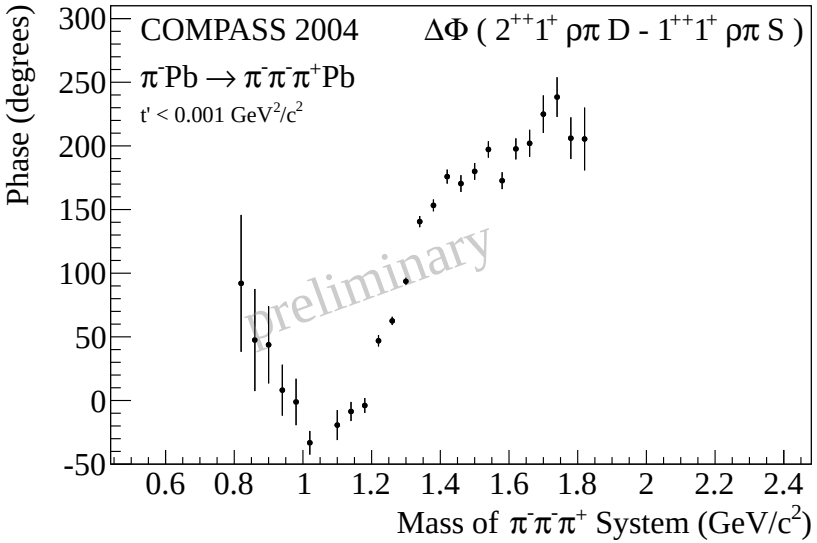
Phys.Rev.C79, 014607(2009)

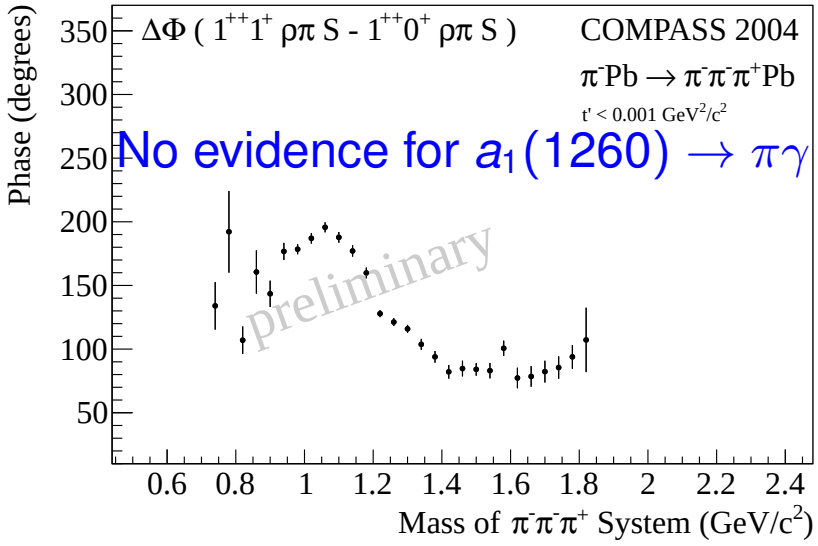
Plot: N. Kaiser (TU München)

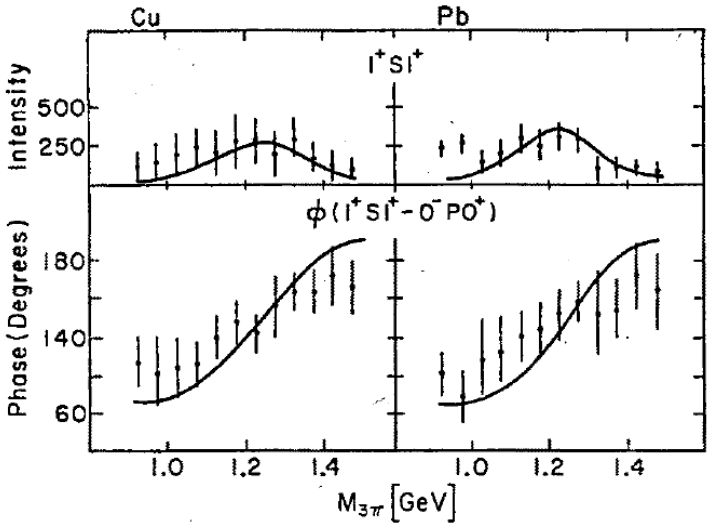


Primakoff production of a1(1260); bottom left: E272 result



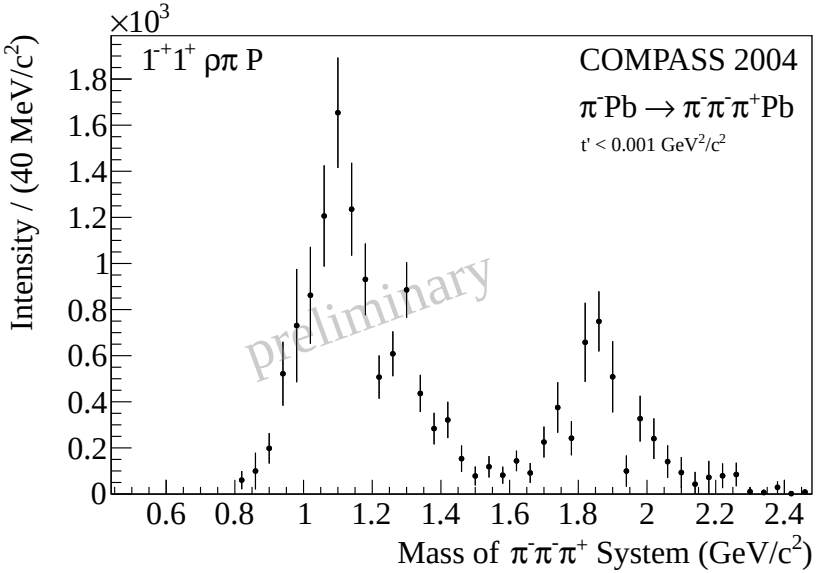


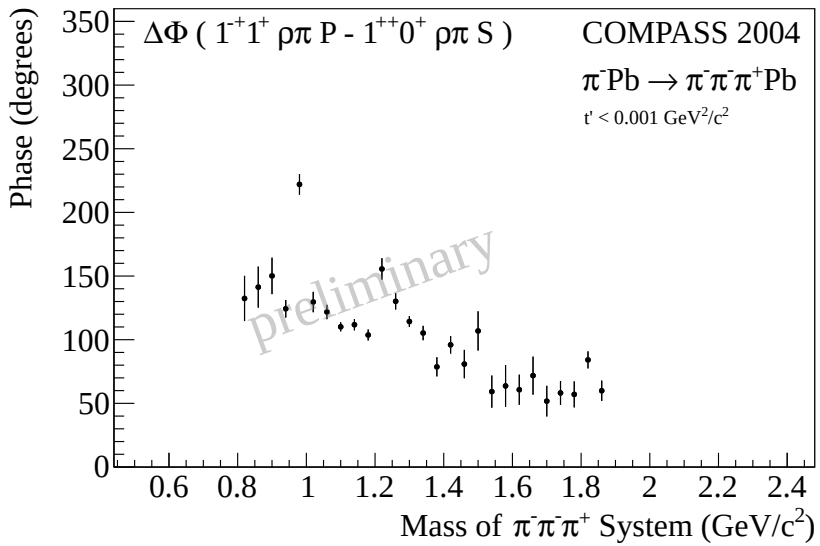




M. Zielinski et al, Phys.Rev.Lett.vol.52, 14, 1195

Primakoff production of exotic 1^{-+}





No evidence for $\pi_1(1600)$ Primakoff production

Conclusions

- Primakoff contribution in π^-Pb$\rightarrow \pi^-\pi^-\pi^+$Pb in COMPASS 2004 Pilot run
  - Sharp Coulomb spike $t' \rightarrow 0$ already in raw data. Statistical substraction method reveals the specific Primakoff m(3π) spectrum (very different from dominating diffractive pattern).
  - Detailed study with special PWA:
    M=1 total mass spectrum found similar to stat. substr. result.
  - M=1 intensities with much narrower t′ distribution than expected for strong production $\rightarrow$ Coulomb contribution
  - M=1 production phases of a_2 and π_2 (relative to M=0) show rapid increase as function of t'
- $a_2(1320)$ at t′ $<$0.01 predominantly Primakoff produced
- $\pi_2(1670)$ at t′ $<$0.01 shows both Primakoff and strong contributions
- Interference effects between electromagnetic and strong amplitudes visible

Outlook

- Detailed study of interference effects for Coulomb and strong production amplitudes by modelling of t' dependence using Glauber theory
- Determine $\Gamma(\pi\gamma)$ for $a_2(1320)$ and $\pi_2(1670)$
- Obtain $\Gamma(\pi\gamma)$ upper limits for $a_1(1260)$ and $\pi_1(1600)$
- Possible future measurements:
  - using both π^- and π^+ beam - Coulomb phase flips sign $\rightarrow$ experimentally disentangle Coulomb and strong contributions, determination of absolute production phases
  - different beam energy and nuclear targets