Role of Deck-like backgrounds in diffractive production of $\pi^-\pi^-\pi^+$ and $\pi^-\pi^0\pi^0$ systems at COMPASS

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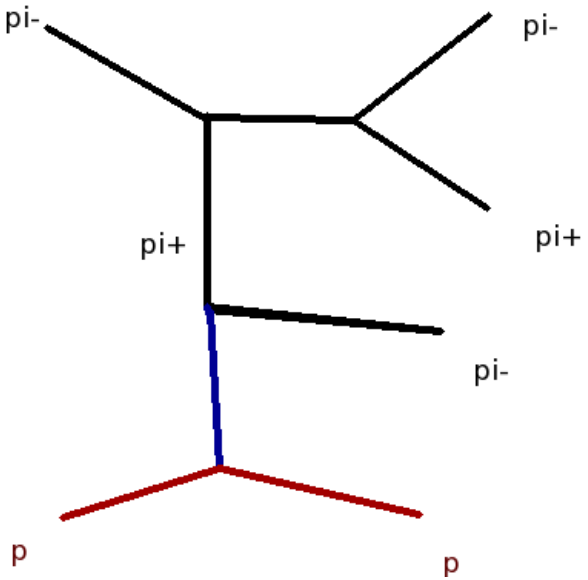
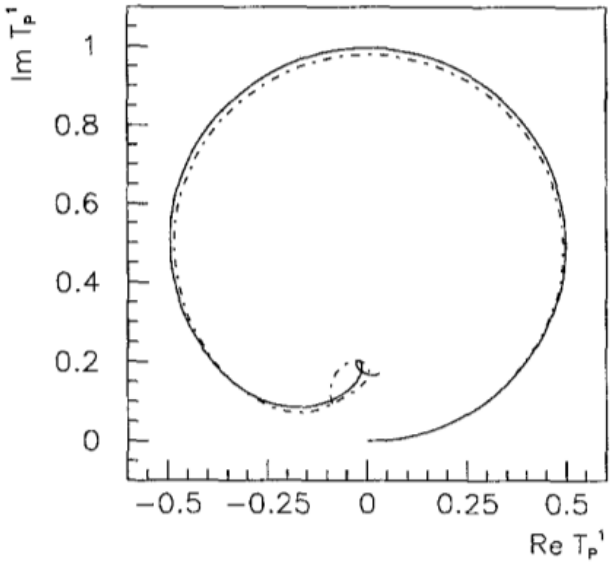
Quick introduction





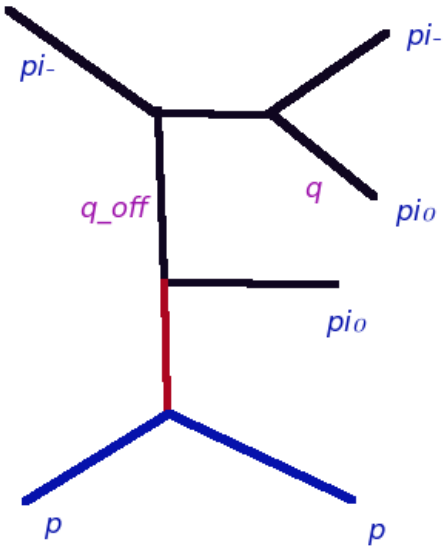
$(\pi\pi) \leftrightarrow (\pi\pi)$ amplitude: $M = -8\pi \frac{m}{q} \sum_l (2l+1) T_l(m) P_l(cos\theta)$

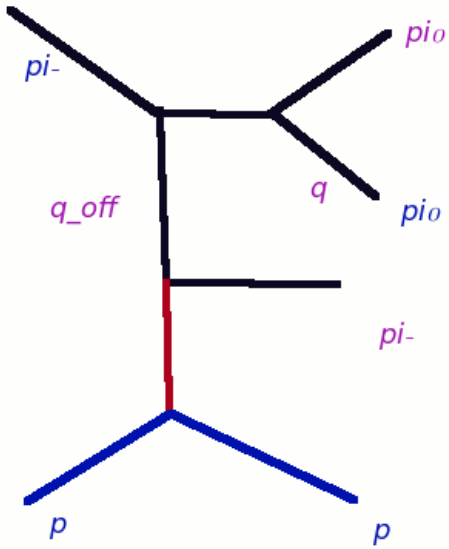
is linear sum of amplitudes $(\pi\pi)_S$, $\rho(770)$, $f_2(1260)$ and $\rho_3(1690)$

$(\pi N) \leftrightarrow (\pi N)$ amplitude: $T_{\pi N}(s_{\pi N}, t') = s_{\pi N}\ e^{-8t'}$

Pion propagator: $P(t_\pi) = \frac{m_\pi^2 e^{bt_\pi}}{m_\pi^2 - t_\pi}$ with b $= 1.7\ GeV^{-1}$ and $m_\pi = m_{\pi^c}$

Diagrams for $\pi^-\pi^0\pi^0$ Deck



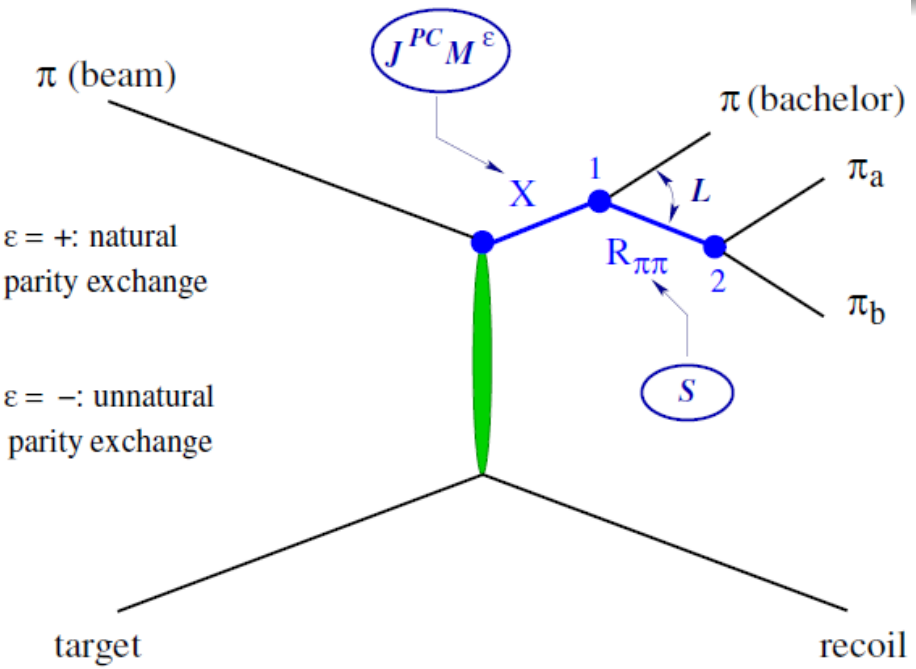


Pion propagator: $P(t_\pi) = \frac{m_\pi^2 e^{bt_\pi}}{m_\pi^2 - t_\pi}$

$m_\pi = m_{\pi^c}$ for diagrams with $(\pi^0\pi^0)\pi^-$ topology

$m_\pi = m_{\pi^0}$ for diagrams with $(\pi^-\pi^0)\pi^0$ topology

The method of Deck amplitude decomposition



Isobar model decay amplitudes: $\Psi_i(\tau, m)$

Quantum numbers $i = J^{PC} M^{\epsilon} [isobar] \pi \quad L$

Deck amplitude decomposition:

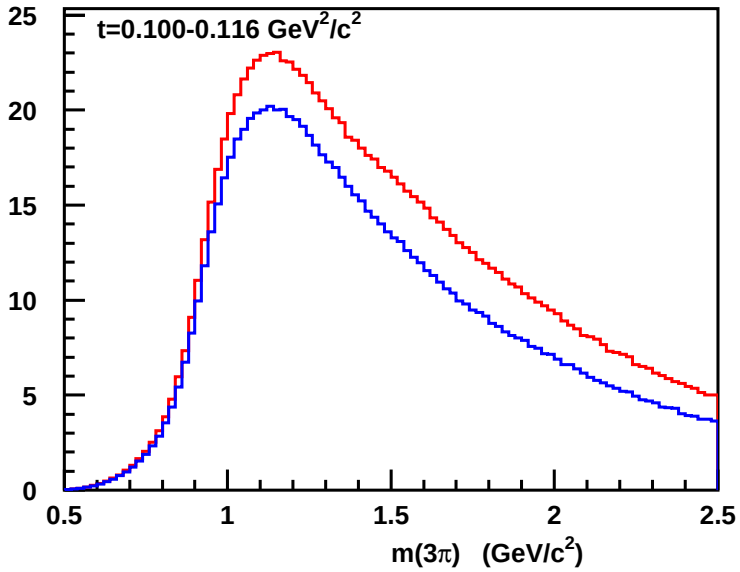
$$\Psi_{Deck}(\tau, m, t') \sim \sum C_i(m, t') \Psi_i(\tau, m)$$

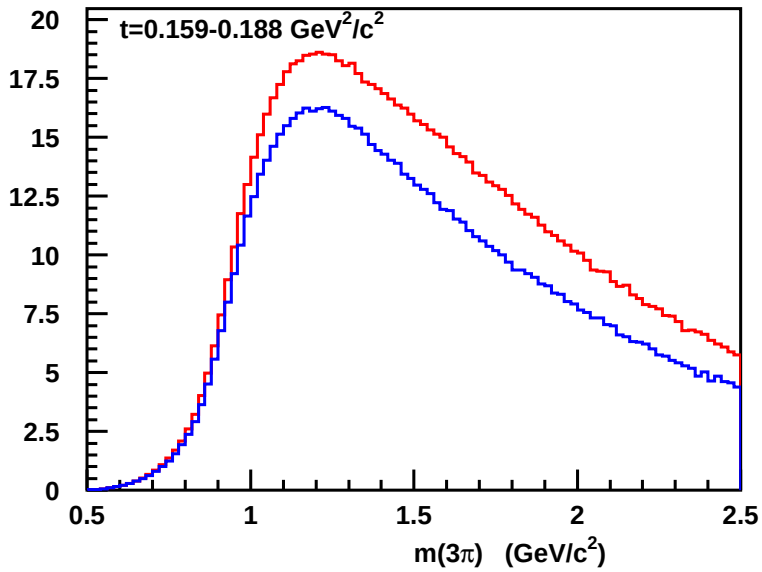
Features of Deck amplitude decomposition

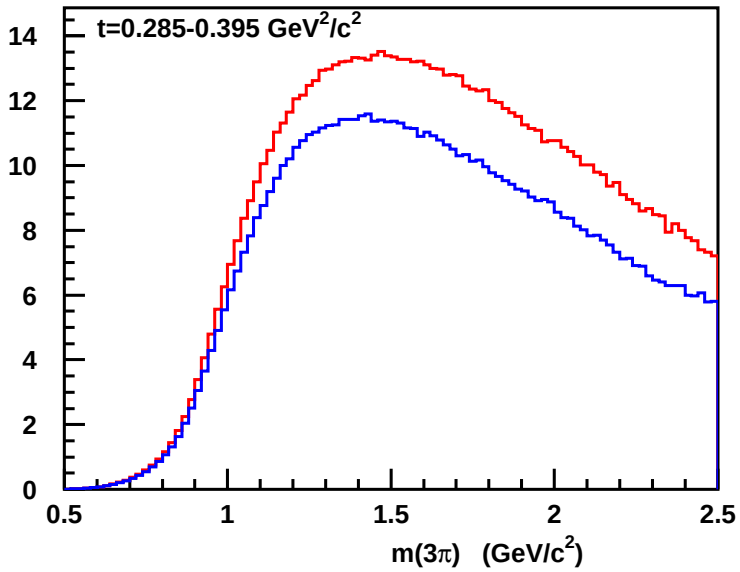
- Both $\Psi_{Deck}(\tau, m, t')$ and $\Psi_i(\tau, m)$ bose-symmetrized
- Different $J^{PC} M^{\epsilon}$ assumed orthogonal
- Building Deck model: using all componens of $(\pi\pi) \leftrightarrow (\pi\pi)$ or adding them partly $\rightarrow$ the resulting decomposition can change

Deck model using $(\pi\pi) \leftrightarrow (\pi\pi)$ without $(\pi\pi)_S$ but with $\rho(770), f_2(1260)$ and $\rho_3(1690)$ is decomposed into set of 67 isobaric amplitudes in $\pi^-\pi^-\pi^+$ and $\pi^-\pi^0\pi^0$ systems

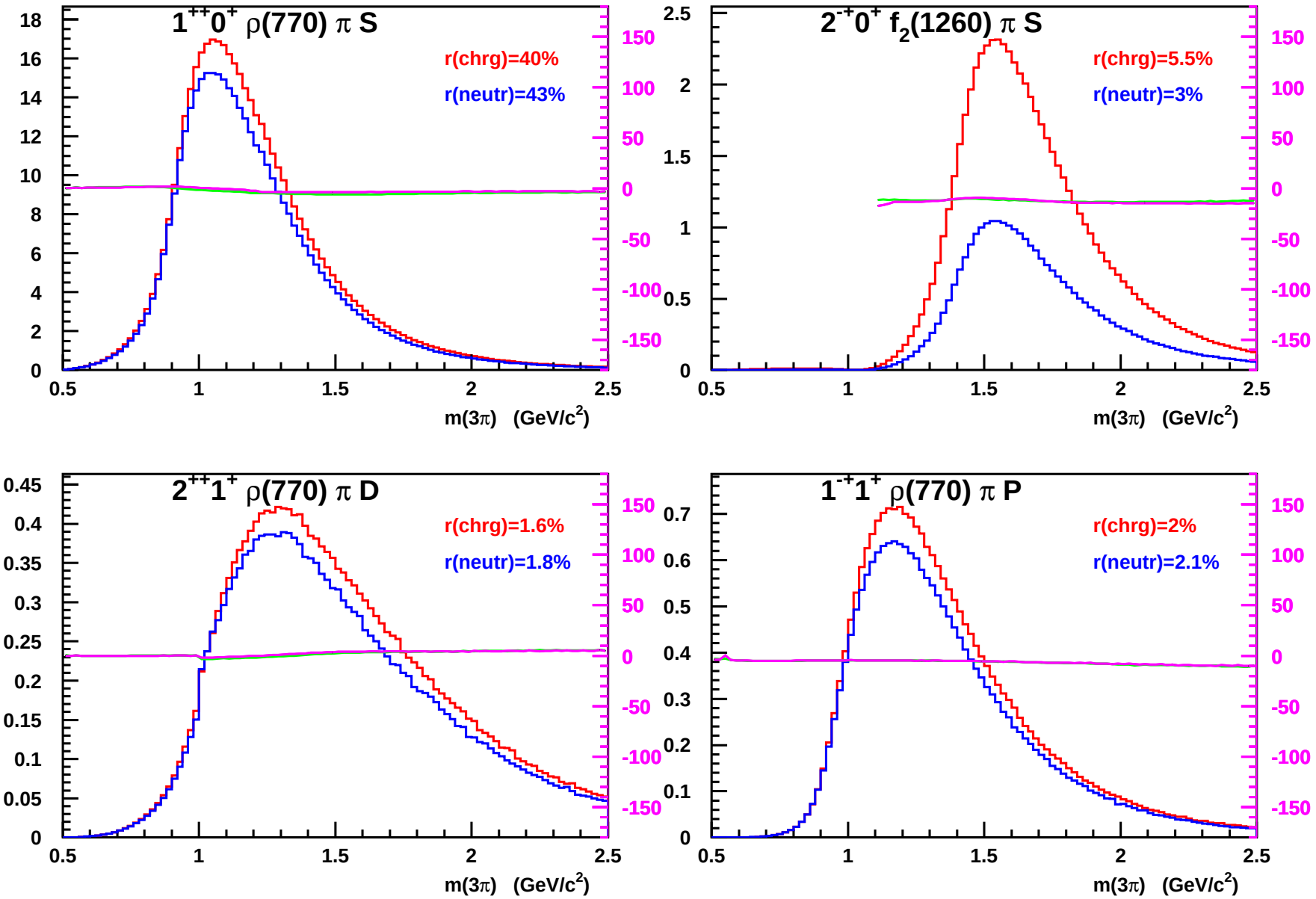
Deck total intensity $\pi^-\pi^-\pi^+$ and $\pi^-\pi^0\pi^0$



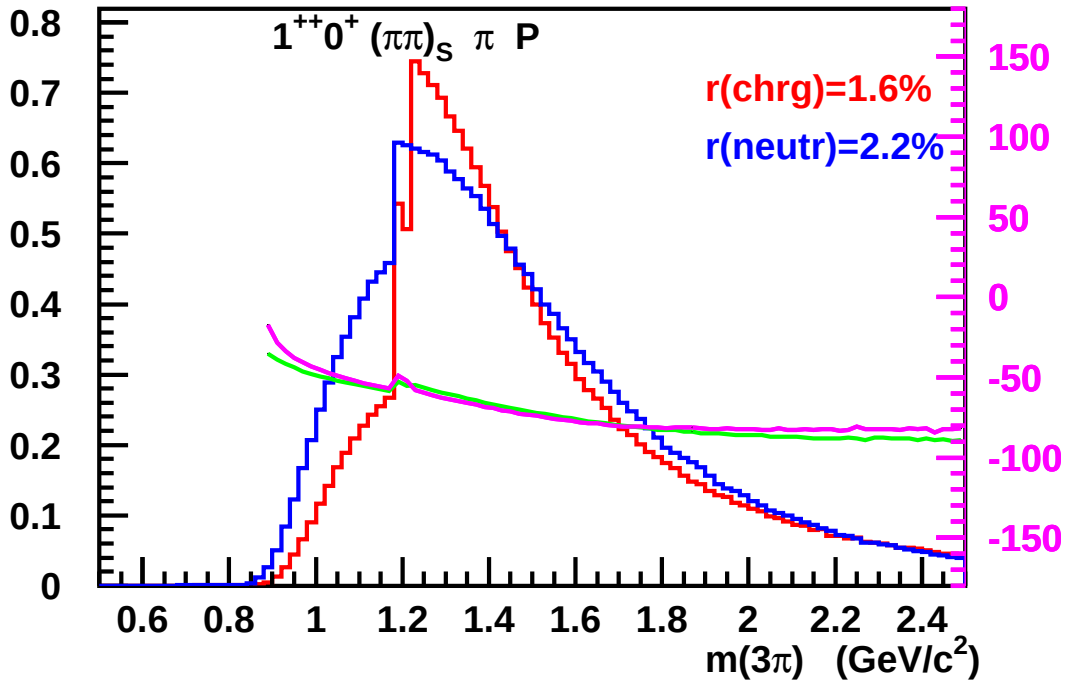




Deck components $\pi^-\pi^-\pi^+$ and $\pi^-\pi^0\pi^0$



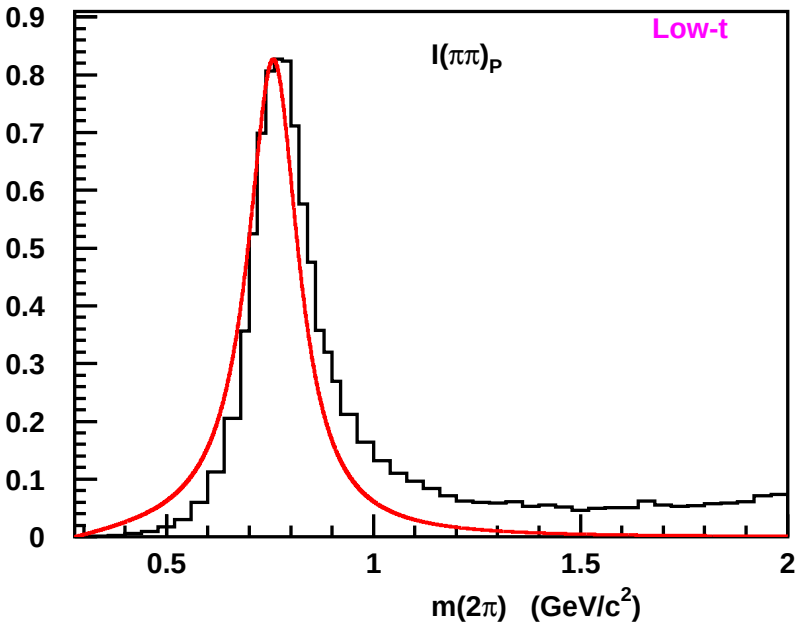
$1^{++}0^{+}(\pi\pi)_S\pi P$ Deck component $\pi^-\pi^-\pi^+$ and $\pi^-\pi^0\pi^0$

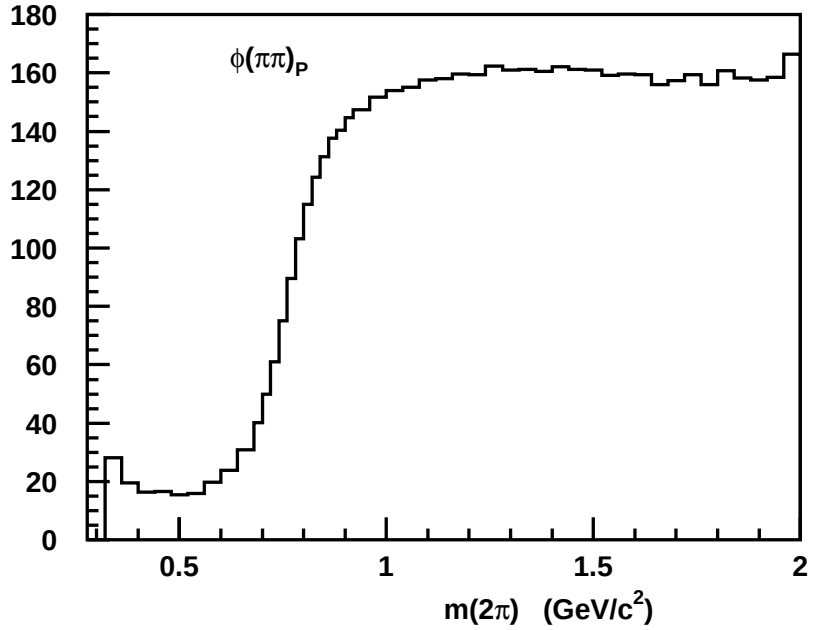


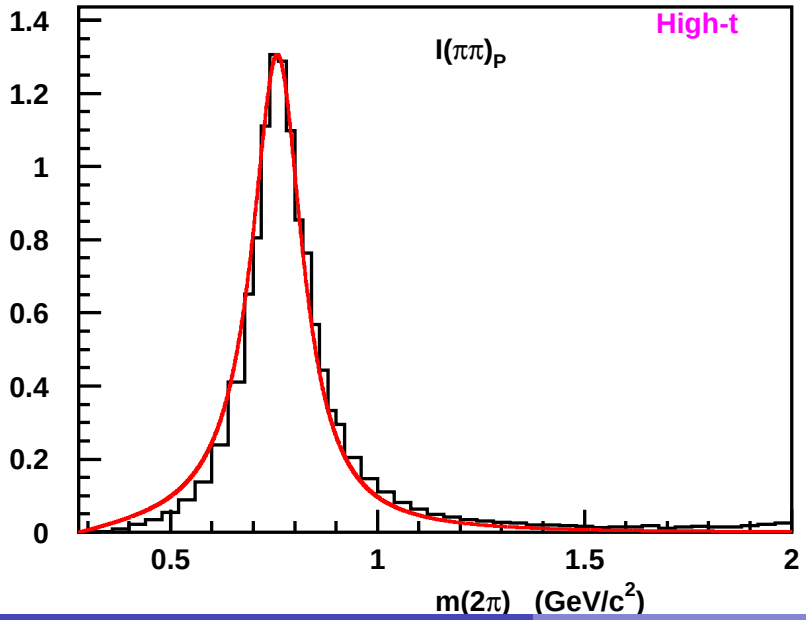
Surprise to find amplitude with $(\pi\pi)_S$ isobar reconstructed as $(\pi\pi)_S$ scattering amplitude was excluded from Deck model !

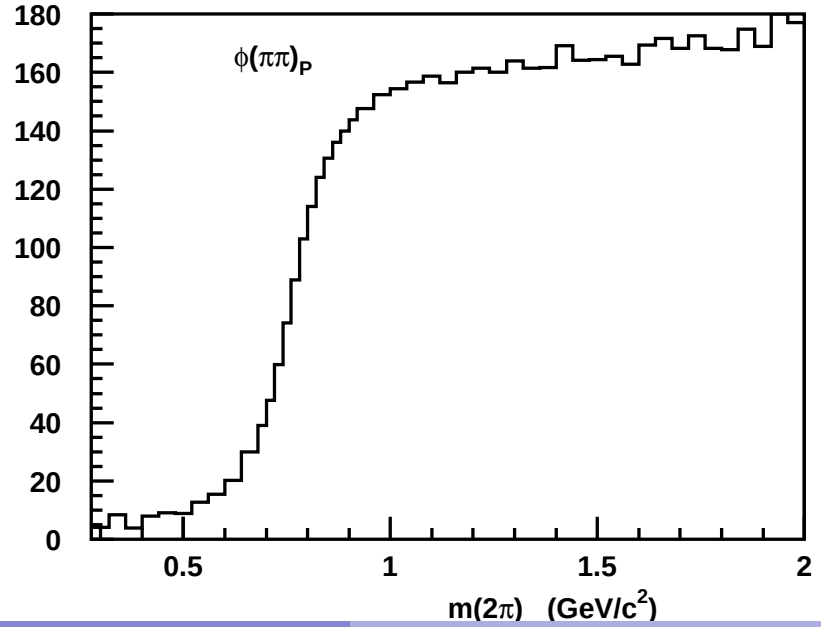
The reason for "amplitude leakage": possible effective distortion of isobar shapes by Deck kinematics $\rightarrow$
try free shape of $(\pi\pi)_P$ in dominant $1^{++}0^+\rho(770)\pi$ S decay amplitude

Free Shape of $(\pi\pi)_P$ in isobaric wave $1^{++}0^+(\pi\pi)_P\pi S$

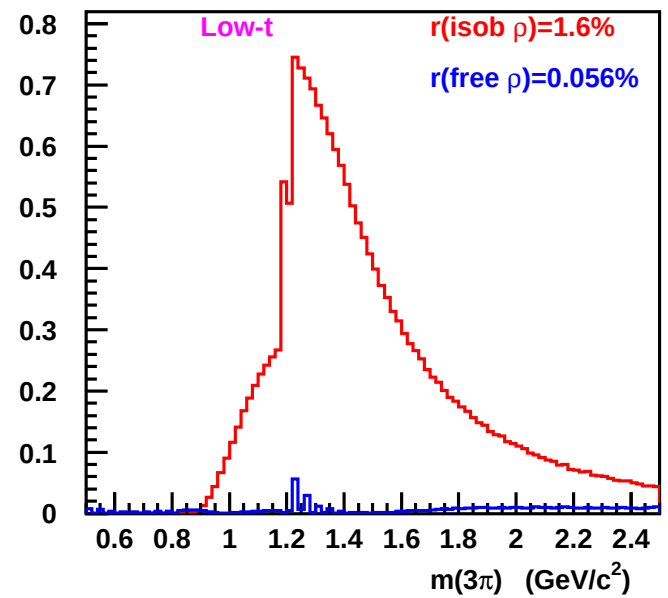


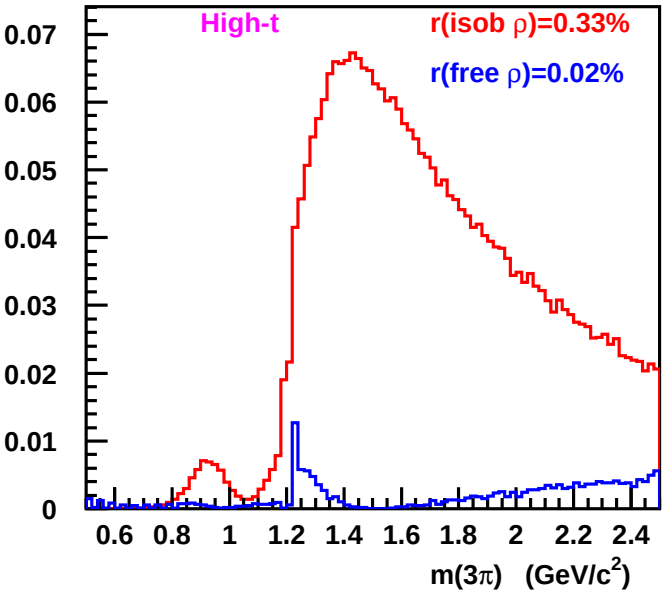






$1^{++}0^{+}(\pi\pi)_S\pi P$ before and after free-isobarring $(\pi\pi)_P$

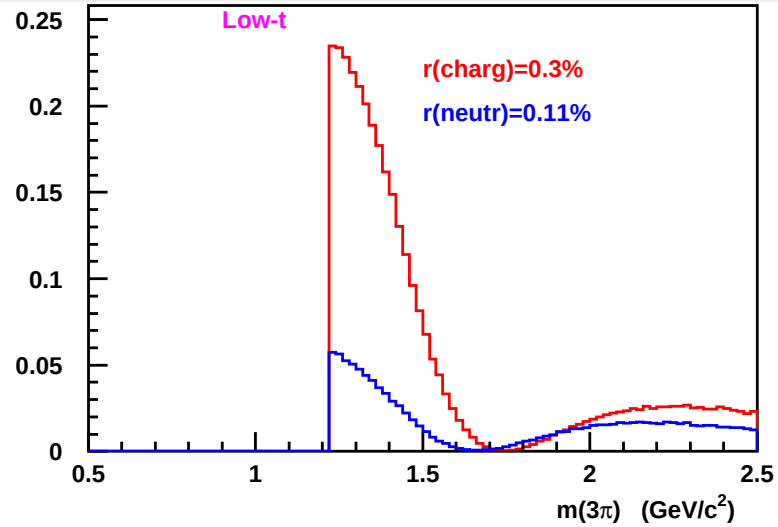


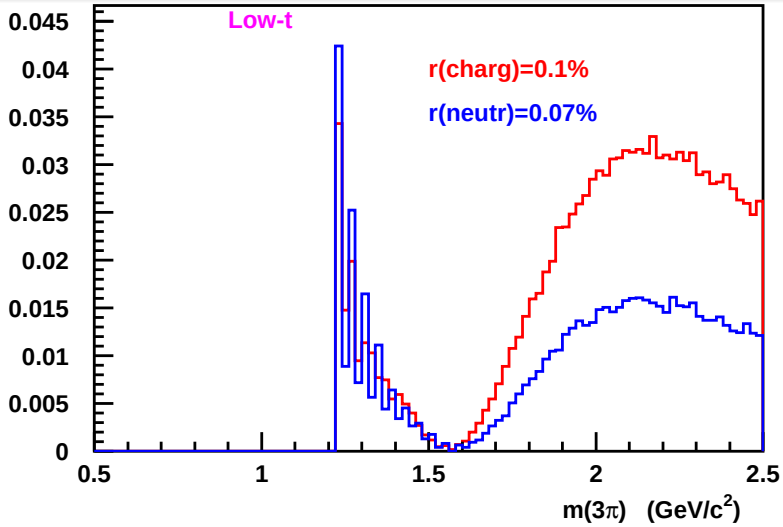


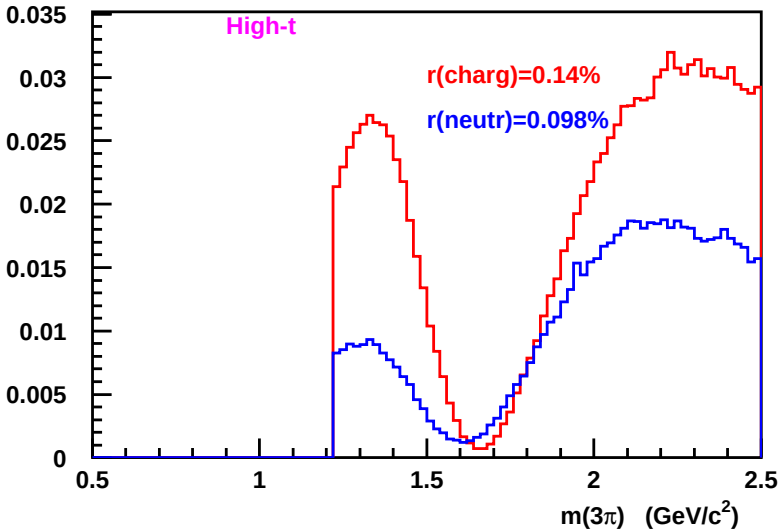
before free-isobarring $1^{++}0^{+}\rho(770)\pi S$

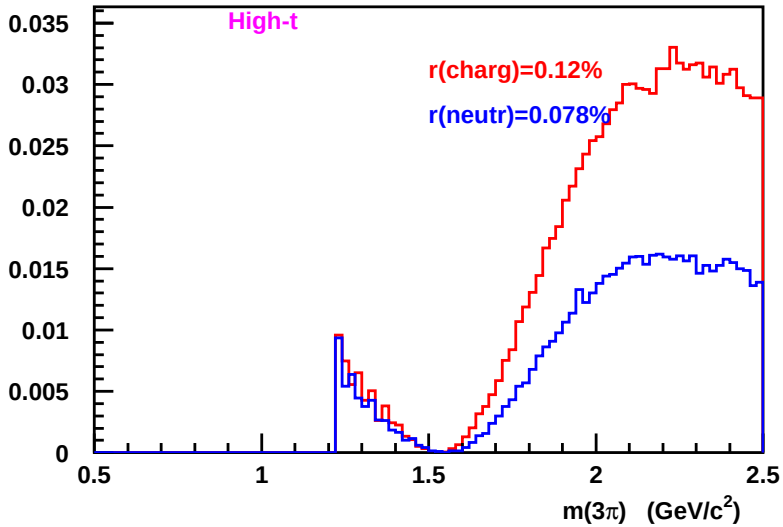
after free-isobarring $1^{++}0^{+}(\pi\pi)_P\pi S$

$1^{++}0^{+}f_2(1270)\pi P$ $\pi^-\pi^-\pi^+$ and $\pi^-\pi^0\pi^0$





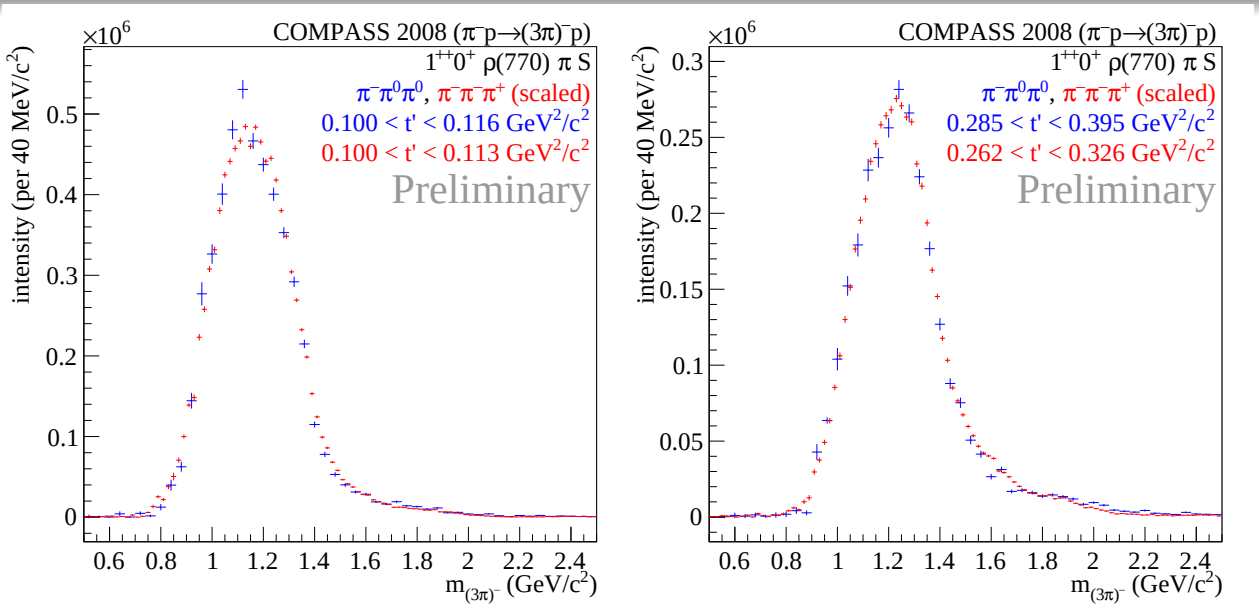




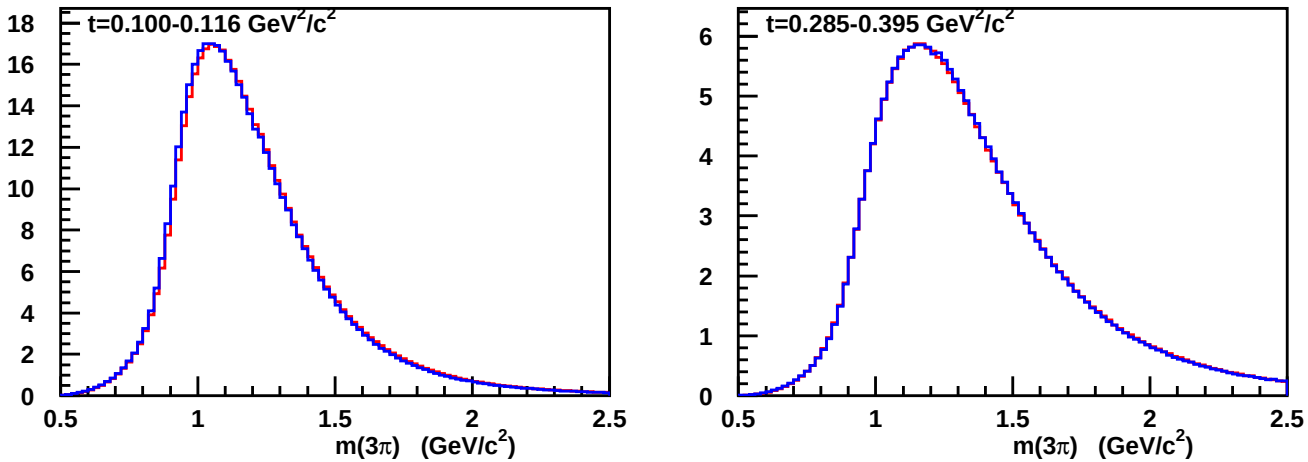
Before free-isobarring of
$1^{++}0^{+}\rho(770)\pi S$

After free-isobarring of
$1^{++}0^{+}(\pi\pi)_P\pi S$

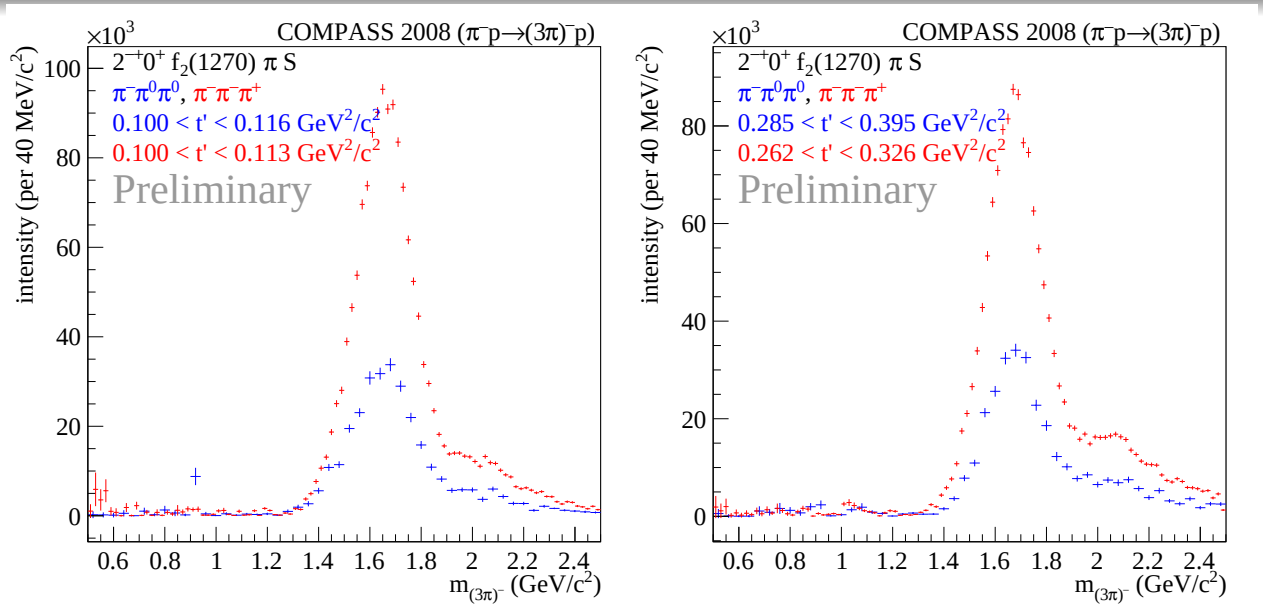
The Data $\pi^- p \to \pi^-\pi^-\pi^+ p$ $\pi^- p \to \pi^-\pi^0\pi^0 p$



Deck decomposition $\pi^- p \to \pi^-\pi^-\pi^+ p$ $\pi^- p \to \pi^-\pi^0\pi^0 p$



The Data $\pi^- p \to \pi^- \pi^- \pi^+ p$ $\pi^- p \to \pi^- \pi^0 \pi^0 p$



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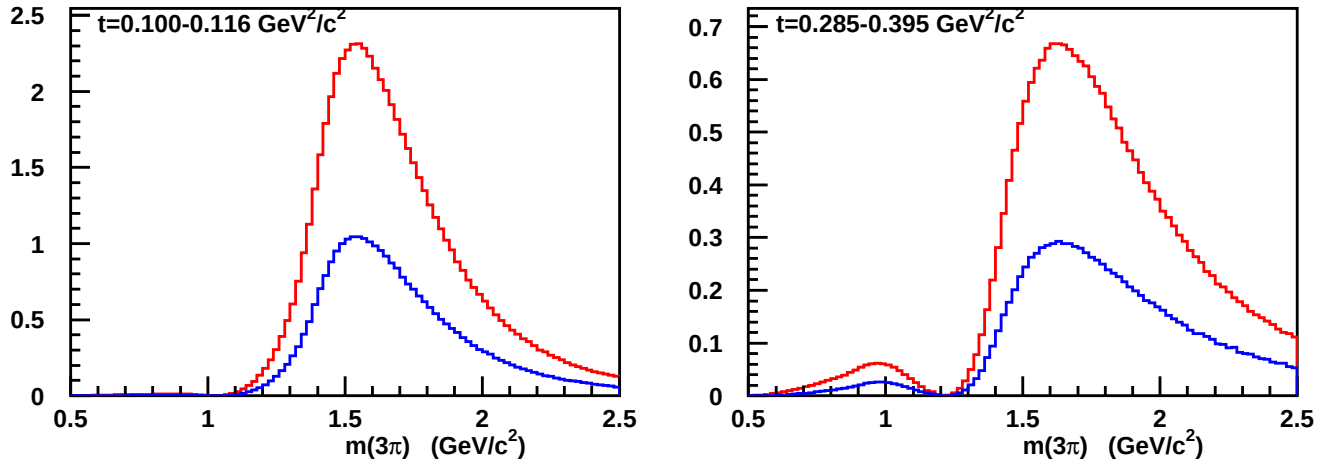
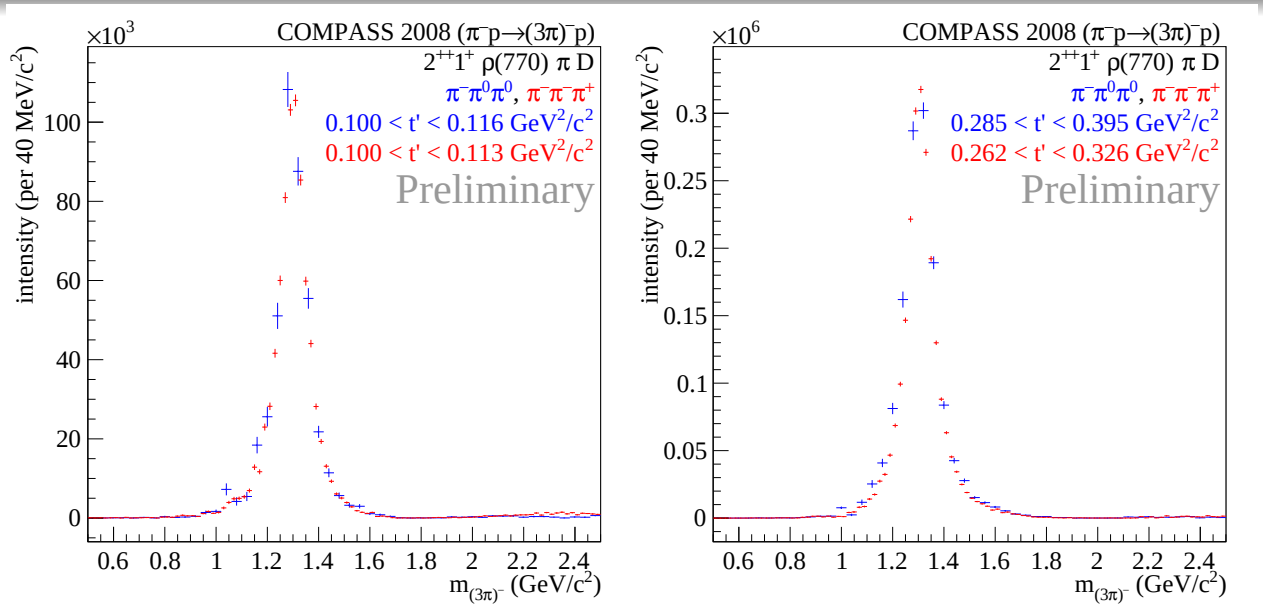


The Data $\pi^- p \to \pi^- \pi^- \pi^+ p$ $\pi^- p \to \pi^- \pi^0 \pi^0 p$



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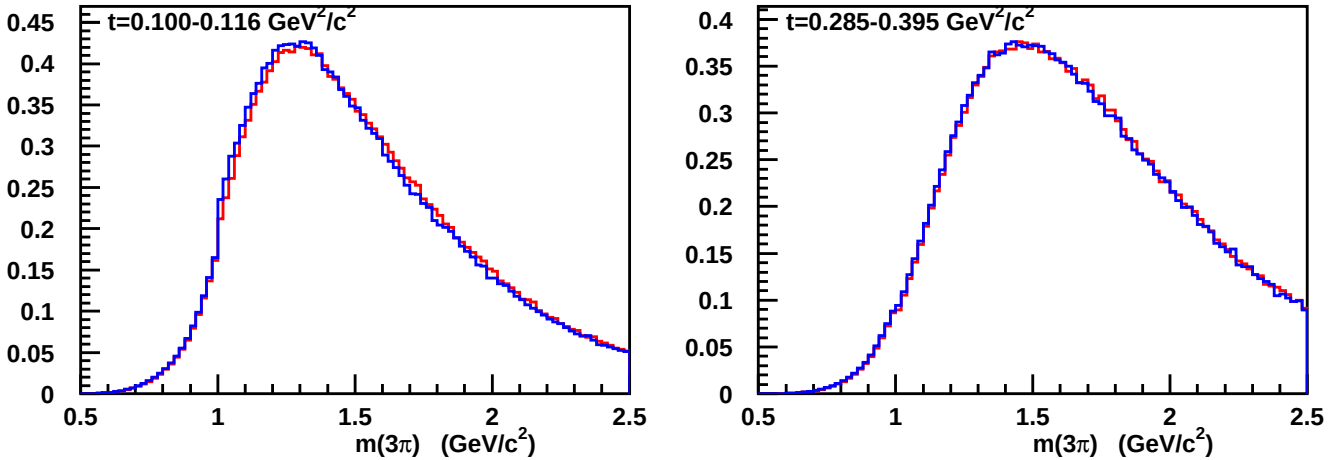

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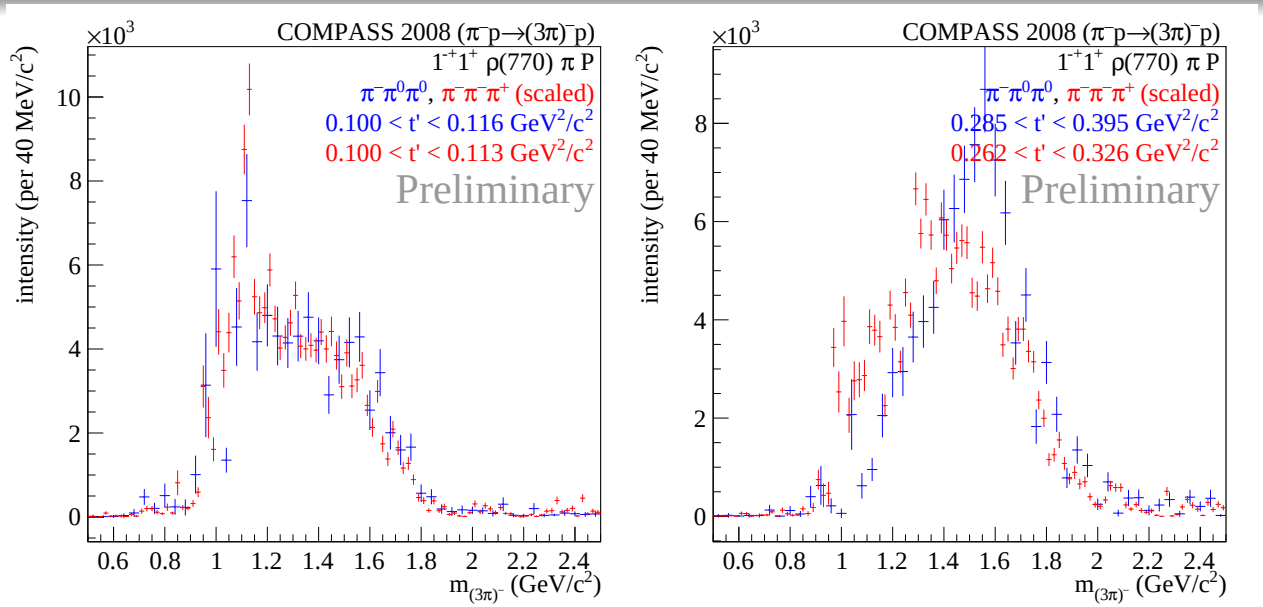
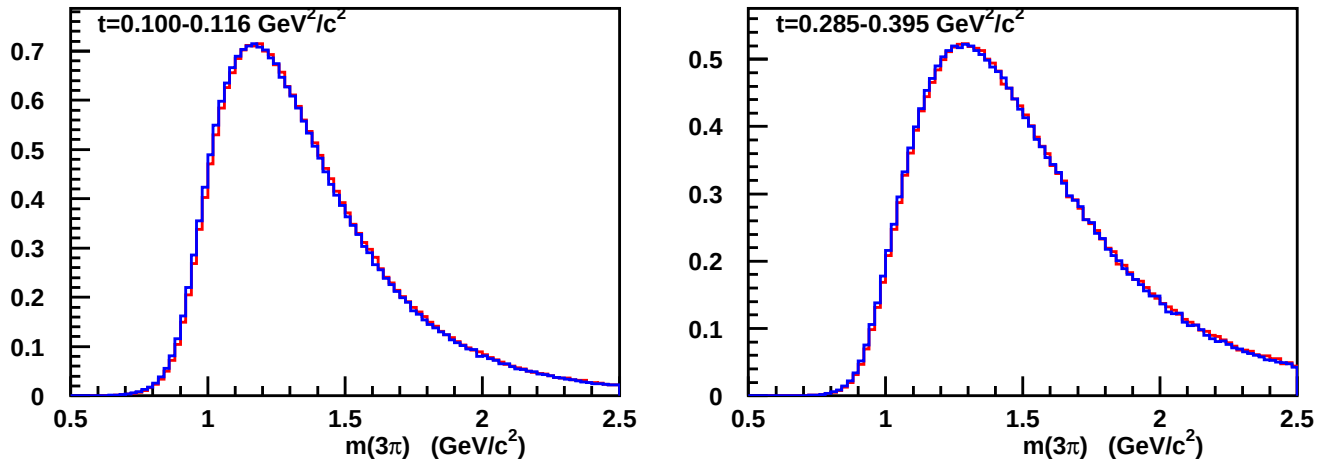


Deck decomposition $\pi^- p \to \pi^- \pi^- \pi^+ p$ $\pi^- p \to \pi^- \pi^0 \pi^0 p$



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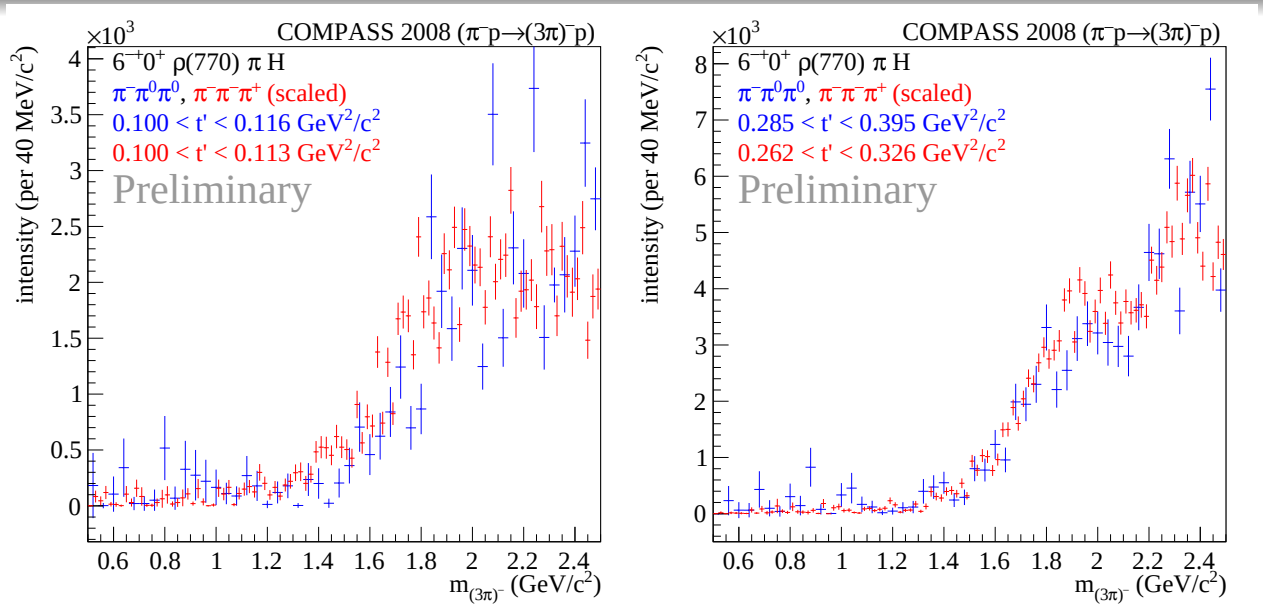

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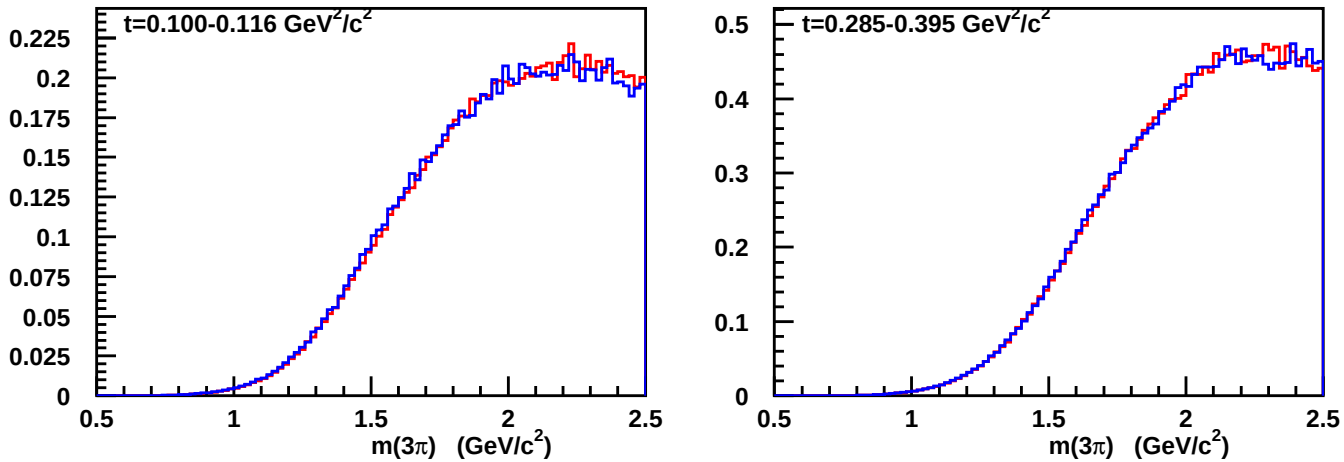

CONCLUSIONS

- The method produces continuous intensities and flat phases depending on $m(3\pi)$ for most of amplitudes
- Isobaric decomposition produces artifacts:
  - Leakage to $1^{++}0^{+}(\pi\pi)_S\pi P$ amplitude
  - Low-mass leakage and distortion of $1^{++}0^{+}f_2(1260)\pi$
- Remedy - free-isobarring of dominant isobaric amplitudes

COMPARISON with DATA

- Data shows shifts of the mass spectrums with t' for dominant $1^{++}0^{+}\rho(770)\pi S$
- The mass shapes of high-spin waves is fully reproduced by Deck
- The $J^{PC}M^{\epsilon} = 1^{-+}1^{+}$ exotic wave is has dominating contribution from Deck at low t'

OUTLOOK

- Apply to different targets, t′-regions
- Develop the model
  - Off-shell behavior for $\pi\pi \to \pi\pi$ amplitiudes
  - Understand I=2 (incl $\pi^-\pi^0$, $\pi^0\pi^0$, $\pi^+\pi^-$, $\pi^-\pi^-$)
- Develop the methods
  - Make fits with non-linear parameters (as suggested by Adam Szczepaniak and Vincent Mathieu).
- Other models: Bowler, Berger, 3-component Deck model ... Rescattered Deck.

BACKUP: The Data: relative phase of $J^{PC} M^{\epsilon} = 1^{-+}1^{+}\rho\pi P$