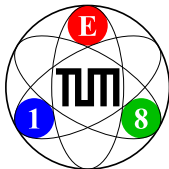


Extraction of the amplitude of the $\pi^+\pi^-$ subsystem in diffractively produced $\pi^-\pi^+\pi^-$ at COMPASS

Fabian Krinner
for the COMPASS collaboration

Physik-Department E18
Technische Universität München

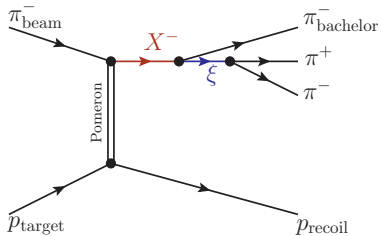


HK 23.5
DPG Frühjahrstagung 2016
Darmstadt



The channel $\pi^- p \rightarrow \pi^- \pi^+ \pi^- p$

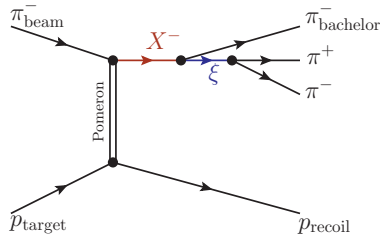
Conventional PWA method



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Conventional PWA method

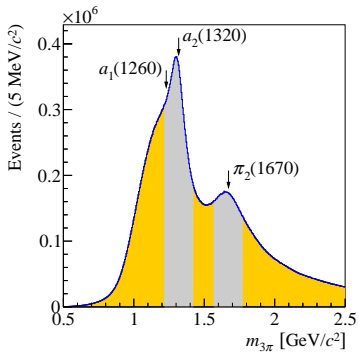
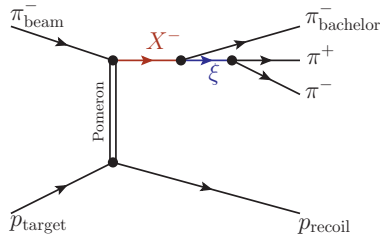
- Assumption: Intermediate state X^- undergoes subsequent two-particle decays



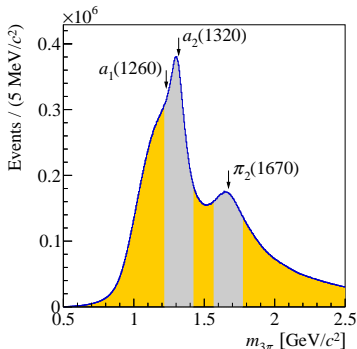
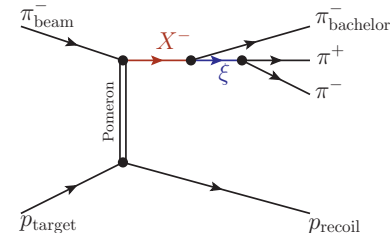
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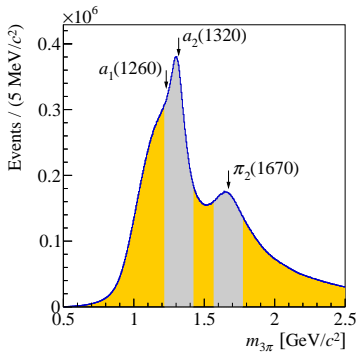
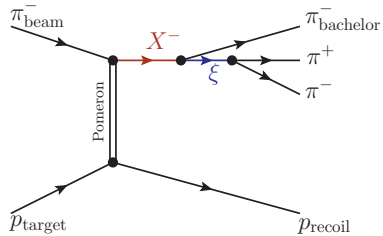
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- Narrow binning in $m_X = m_{3\pi}$:
No assumptions on X^-



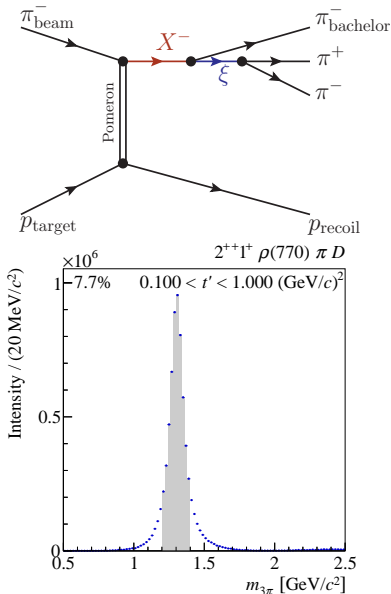
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- Fixed amplitudes of the *isobars* ξ
e.g. $\rho(770) \rightarrow \pi^+ \pi^-$



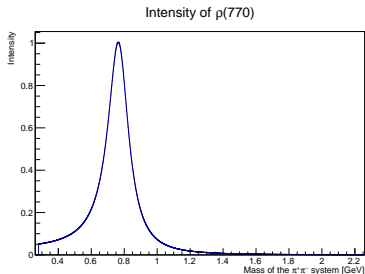
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Extracted by a maximum-likelihood fit



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- Result: Amplitudes for different X^- as function of $m_{3\pi}$

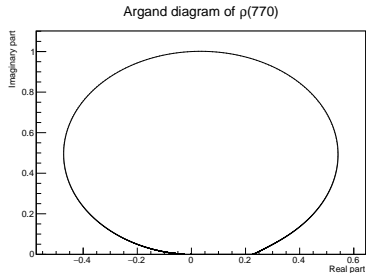
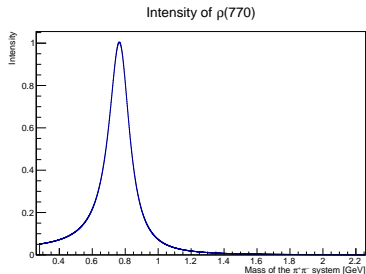


- Isobar amplitudes in conventional PWA for different $[\pi\pi]_{JPC}$:



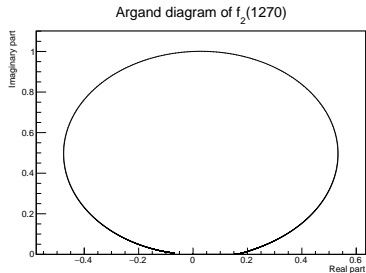
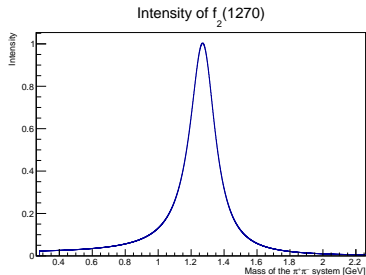
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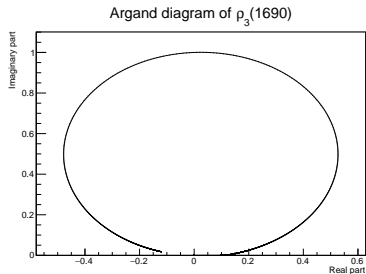
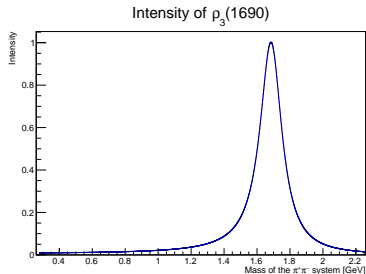
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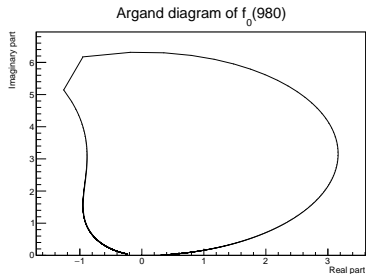
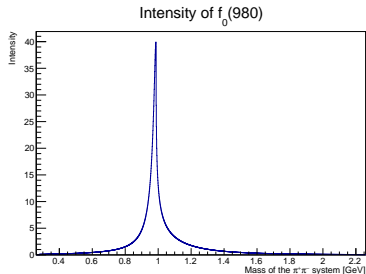
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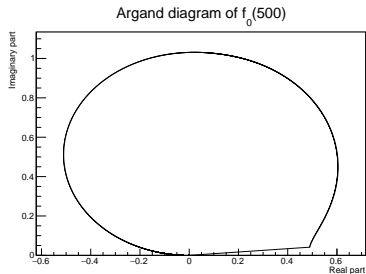
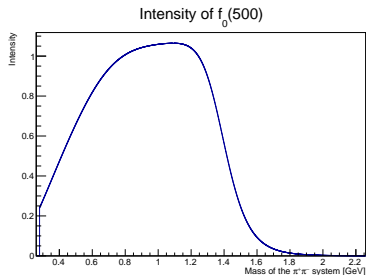
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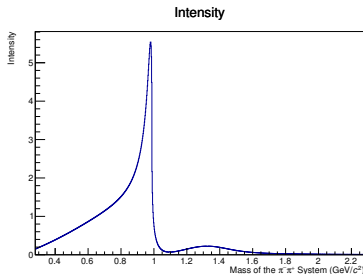
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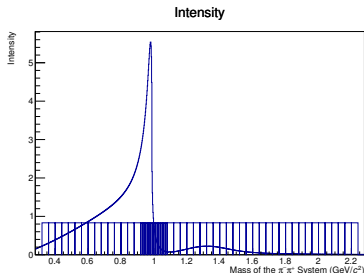


Example: Shape of 0^{++} resulting from interference of $f_0(500)$ and $f_0(980)$

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- Isobar-amplitudes not determined by the fit
- Fit of isobar resonance-parameters not practical \rightarrow “binned isobars”

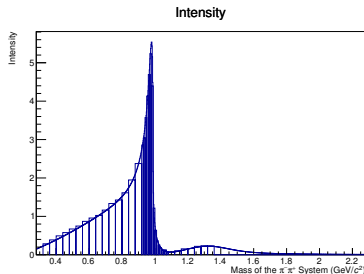


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- Extract binned amplitudes of the $\pi^-\pi^+$ subsystem



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- Conventional analysis: Amplitudes binned in the three-pion mass $m_{3\pi}$:

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 - ▶ $0^{-+}0^+[\pi\pi]_{0^{++}} \pi S$
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- In principle also possible for 1^{--} , 2^{++} , ... isobars

Two-dimensional intensity distributions $\mathcal{I}(m_{3\pi}, m_{\pi^+\pi^-}) = |T(m_{3\pi}, m_{\pi^+\pi^-})|^2$

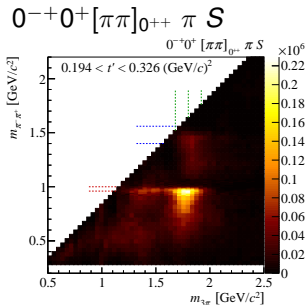
MASS OF THE $\pi^-\pi^+\pi^+$ SYSTEM

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These plots should not be mistaken as Dalitz plots

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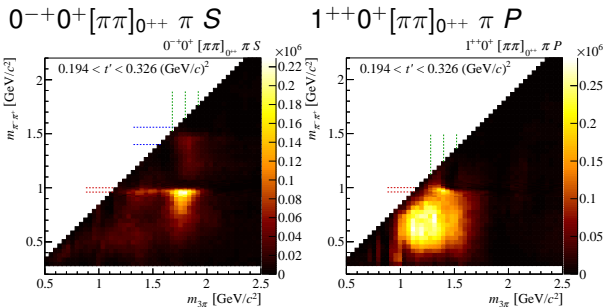


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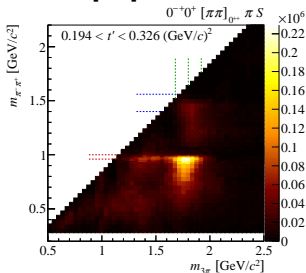
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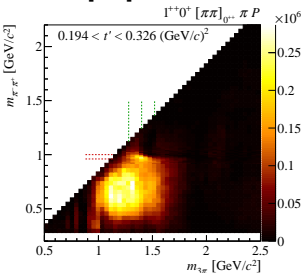
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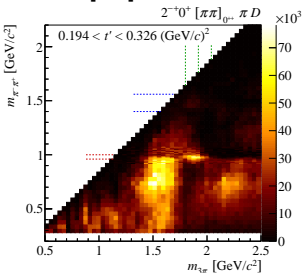
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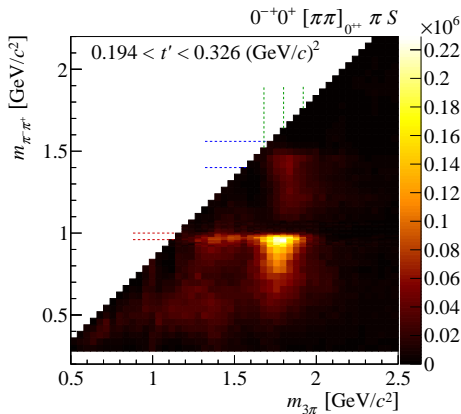
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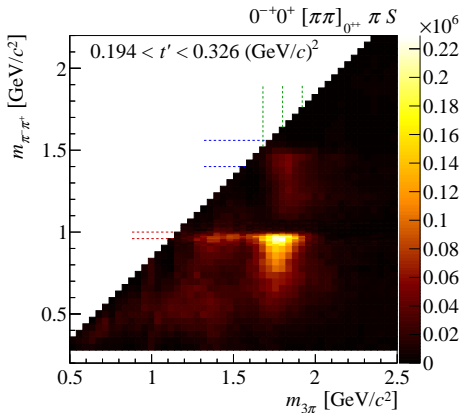
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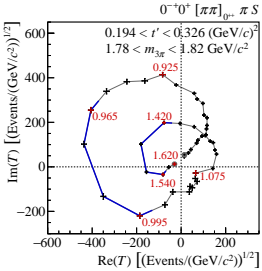
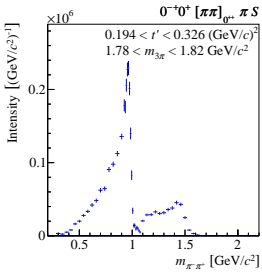
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- Main peak: $\pi(1800) \rightarrow f_0(980)\pi^{-}$
- Smaller peak:
 $\pi(1800) \rightarrow f_0(1500)\pi^{-}$
- Broad structures at small masses.
Mainly non-resonant origin.



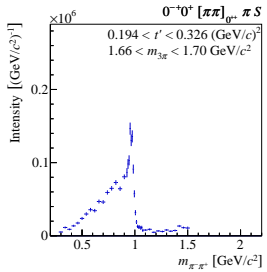
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Mainly non-resonant origin.
- Make slices at constant $m_{3\pi}$
(Green lines)
- Phase information available. Look
at Argand-diagrams



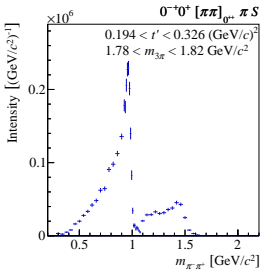
$0.19 < t' < 0.32 (\text{GeV}/c)^2$
On $\pi(1800)$ 

$0.19 < t' < 0.32(\text{GeV}/c)^2$

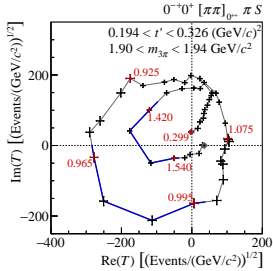
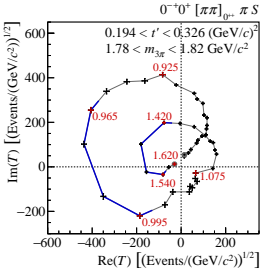
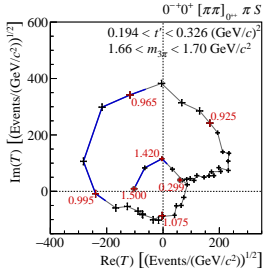
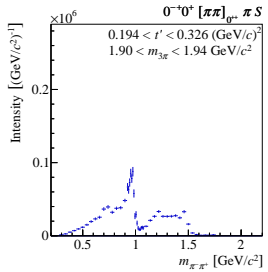
Below $\pi(1800)$



On $\pi(1800)$



Above $\pi(1800)$



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Mainly non-resonant origin.

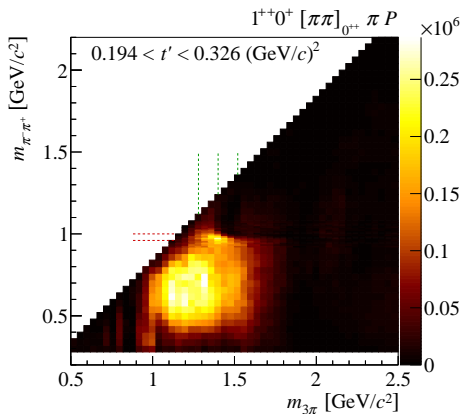
- Small peak:
 $a_1(1420) \rightarrow f_0(980)\pi^-$

- New $a_1(1420)$ not an artifact of
the $f_0(980)$ parametrization

Phys. Rev. Lett. 115, 082001

Boris Grube HK 32.1

Stefan Wallner HK 32.2



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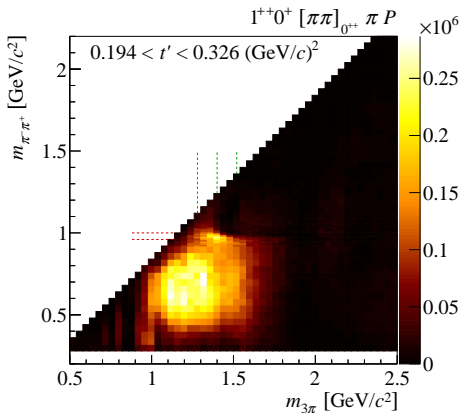
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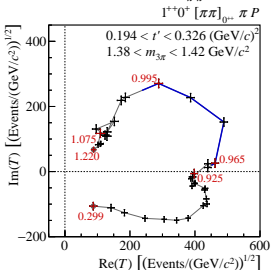
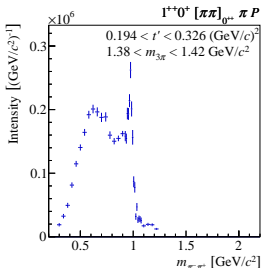
Boris Grube HK 32.1

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(Green lines)



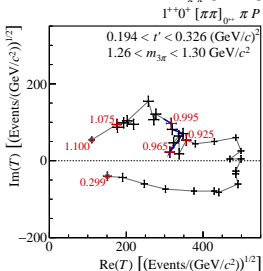
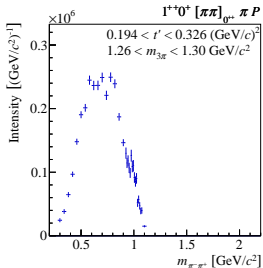
On $a_1(1420)$



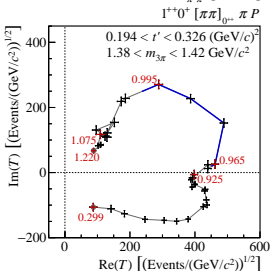
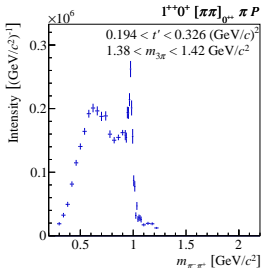
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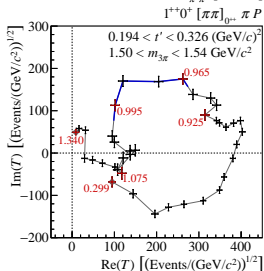
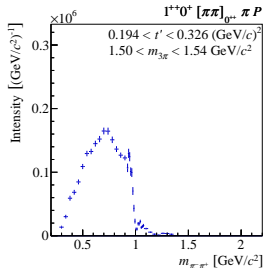
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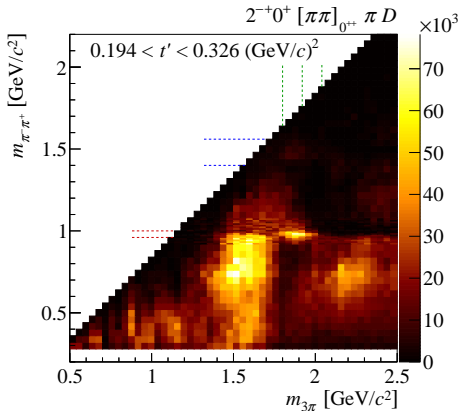
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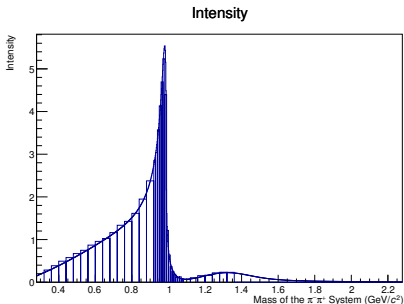
$2^{-+}0^{+}[\pi\pi]_{0^{++}}\pi D$

Intensity distribution

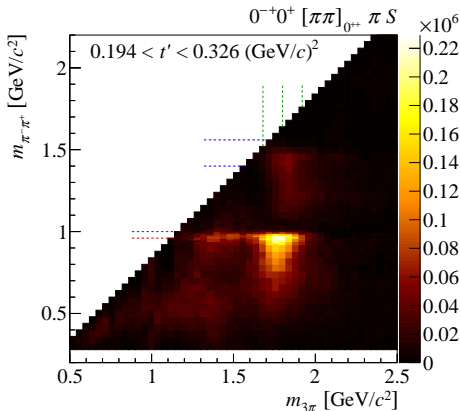
- Broad structure at $m_{3\pi} \simeq 1.6$ GeV. Probably artifact from cross-talk with fixed-isobar waves.
- $\pi_2(1880) \rightarrow f_0(980)\pi^{-}$ visible
- \rightarrow Free more waves to reduce cross-talk



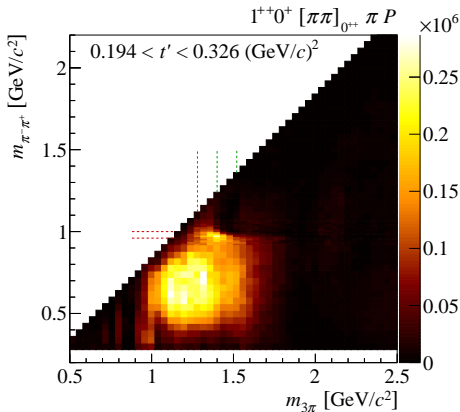
- Isobar amplitudes are replaced by sets of binned functions $[\pi\pi]_{JPC}$
- Novel method allows to extract amplitudes of the isobars



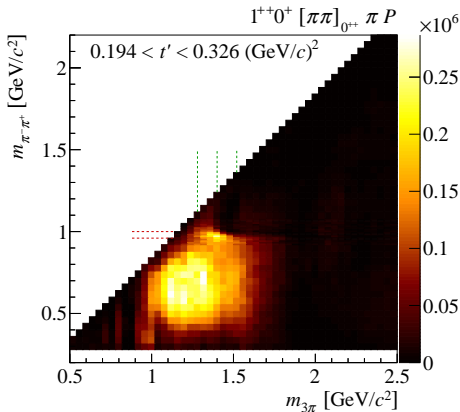
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- Also the new $a_1(1420) \rightarrow f_0(980)\pi^-$ is seen



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 - Free isobar-amplitudes for all large waves

- Reduce effects from imperfect parametrizations in fixed waves
 → Free isobar-amplitudes for all large waves
- Goal at the moment: 11 freed waves

$$0^{-+} 0^{+} [\pi\pi]_{0^{++}} \pi S$$

$$1^{++} 0^{+} [\pi\pi]_{0^{++}} \pi P$$

$$2^{-+} 0^{+} [\pi\pi]_{0^{++}} \pi D$$

$$0^{-+} 0^{+} [\pi\pi]_{1^{--}} \pi P$$

$$1^{++} 0^{+} [\pi\pi]_{1^{--}} \pi S$$

$$1^{++} 1^{+} [\pi\pi]_{1^{--}} \pi S$$

$$2^{-+} 0^{+} [\pi\pi]_{1^{--}} \pi P$$

$$2^{-+} 0^{+} [\pi\pi]_{1^{--}} \pi F$$

$$2^{-+} 1^{+} [\pi\pi]_{1^{--}} \pi P$$

$$2^{++} 1^{+} [\pi\pi]_{1^{--}} \pi S$$

$$2^{-+} 0^{+} [\pi\pi]_{2^{++}} \pi S$$

- Reduce effects from imperfect parametrizations in fixed waves
 - Free isobar-amplitudes for all large waves
- Goal at the moment: 11 freed waves
 - ▶ 75% of the total intensity
 - ▶ All waves with more than 1% of the total intensity

$$0^{-+} 0^{+} [\pi\pi]_{0^{++}} \pi S$$

$$1^{++} 0^{+} [\pi\pi]_{0^{++}} \pi P$$

$$2^{-+} 0^{+} [\pi\pi]_{0^{++}} \pi D$$

$$0^{-+} 0^{+} [\pi\pi]_{1^{--}} \pi P$$

$$1^{++} 0^{+} [\pi\pi]_{1^{--}} \pi S$$

$$1^{++} 1^{+} [\pi\pi]_{1^{--}} \pi S$$

$$2^{-+} 0^{+} [\pi\pi]_{1^{--}} \pi P$$

$$2^{-+} 0^{+} [\pi\pi]_{1^{--}} \pi F$$

$$2^{-+} 1^{+} [\pi\pi]_{1^{--}} \pi P$$

$$2^{++} 1^{+} [\pi\pi]_{1^{--}} \pi S$$

$$2^{-+} 0^{+} [\pi\pi]_{2^{++}} \pi S$$

- Reduce effects from imperfect parametrizations in fixed waves

→ Free isobar-amplitudes for all large waves

- Goal at the moment: 11 freed waves

- ▶ 75% of the total intensity
- ▶ All waves with more than 1% of the total intensity

- Some challenges:

- ▶ Freeing isobars heavily increases the number of fit parameters (~ 500 to 1000)
- ▶ Some problems with linear dependences of Partial Waves

$$0^{-+} 0^{+} [\pi\pi]_{0^{++}} \pi S$$

$$1^{++} 0^{+} [\pi\pi]_{0^{++}} \pi P$$

$$2^{-+} 0^{+} [\pi\pi]_{0^{++}} \pi D$$

$$0^{-+} 0^{+} [\pi\pi]_{1^{--}} \pi P$$

$$1^{++} 0^{+} [\pi\pi]_{1^{--}} \pi S$$

$$1^{++} 1^{+} [\pi\pi]_{1^{--}} \pi S$$

$$2^{-+} 0^{+} [\pi\pi]_{1^{--}} \pi P$$

$$2^{-+} 0^{+} [\pi\pi]_{1^{--}} \pi F$$

$$2^{-+} 1^{+} [\pi\pi]_{1^{--}} \pi P$$

$$2^{++} 1^{+} [\pi\pi]_{1^{--}} \pi S$$

$$2^{-+} 0^{+} [\pi\pi]_{2^{++}} \pi S$$