

JPAC recent results: Analyzing COMPASS $\eta^{(')}\pi$ data

A.Rodas

XIIIth Quark Confinement and the Hadron Spectrum

A. Jackura, M. Mikhasenko, A.Pilloni et al. (JPAC & COMPASS), PLB779, 464-472
AR, A.Pilloni et al. (in preparation)

Joint Physics Analysis Center
Universidad Complutense de Madrid

August 3, 2018



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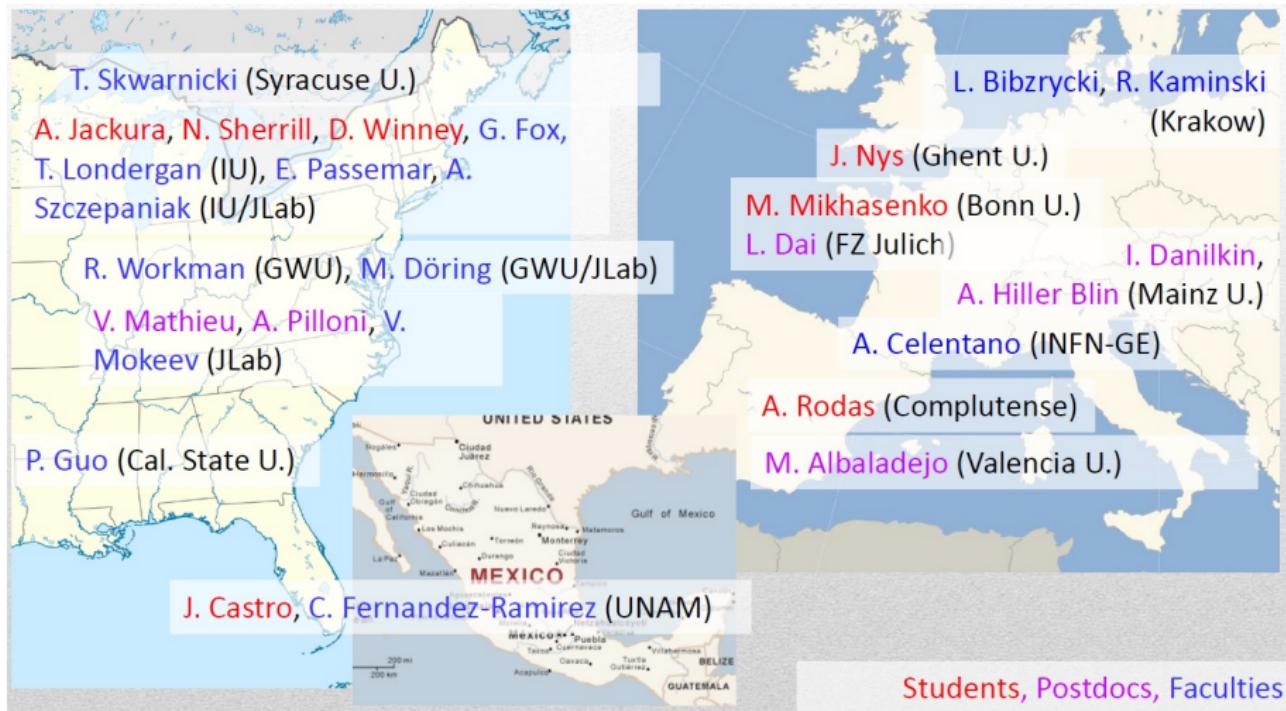
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- Data

2 Method

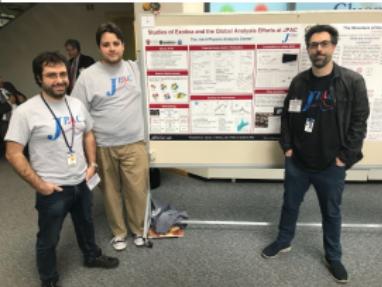
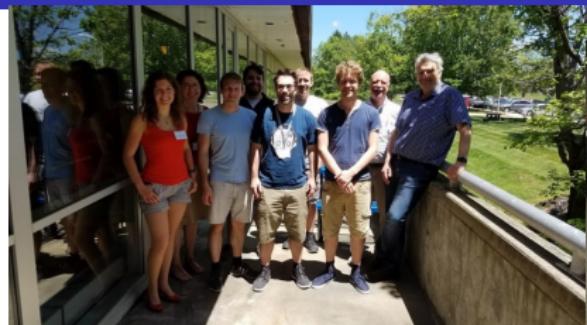
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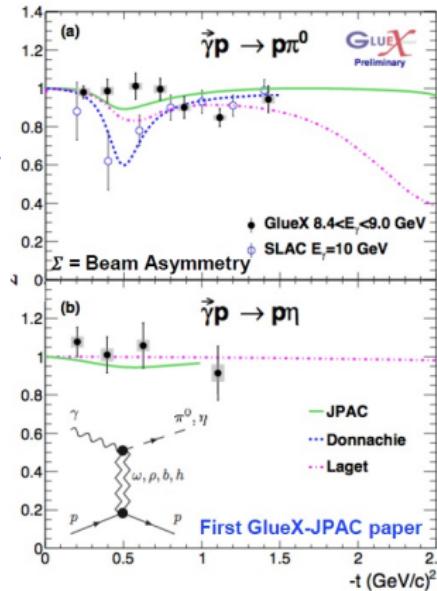
- JPAC: theory, phenomenology and analysis tools in support of experimental data from JLab12 and other accelerator laboratories.
- Contribute to education of new generation of practitioners in strong interactions.



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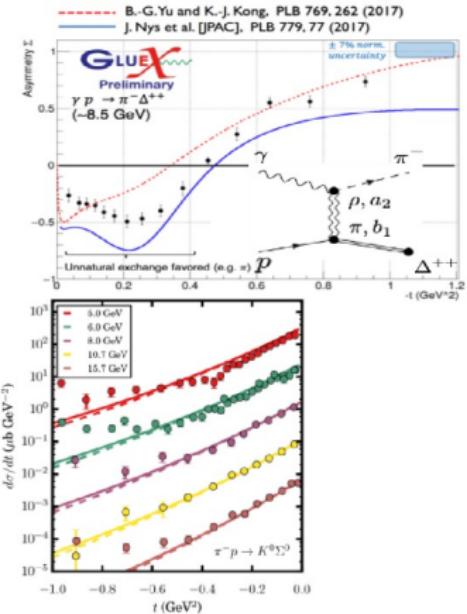
- Single meson production

H. Al Ghoul et al. [GlueX], V. Mathieu and J. Nys [JPAC], Phys. Rev. D 94 (2016) 034002



- SDMEs of vector production

J. Nys et al. [JPAC], Phys. Lett. B 779 (2018) 77



- Global analysis

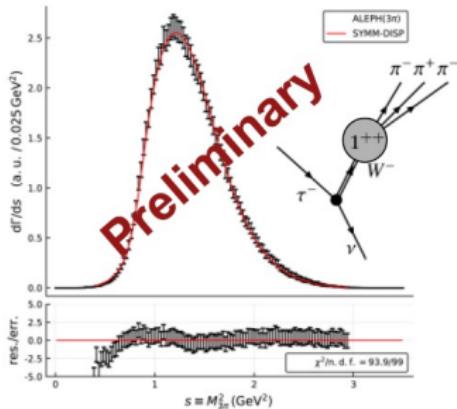
J. Nys et al. (JPAC), arXiv:1806.01891

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- $\tau \rightarrow 3\pi\nu$

M. Mikhasenko et al.

[JPAC], In Preparation

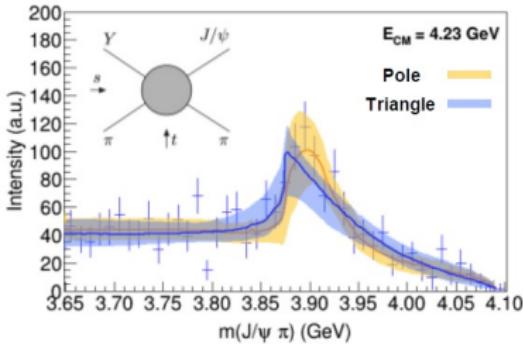


- $Z_c(3900)$

A. Pilloni et al. [JPAC],

Phys. Lett. B 772

(2017)200

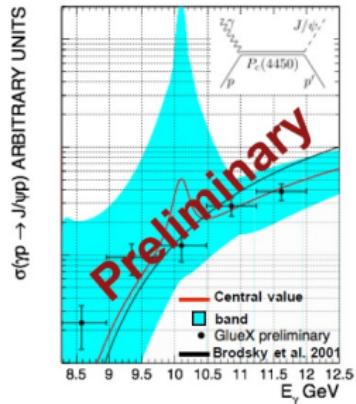


- $P_c(4450)$

A. Hiller Blin et al.

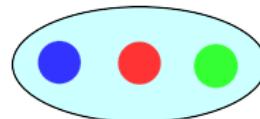
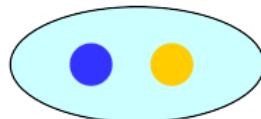
[JPAC], Phys. Rev. D

94 (2016)034002

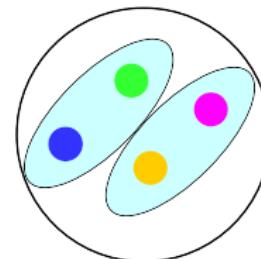
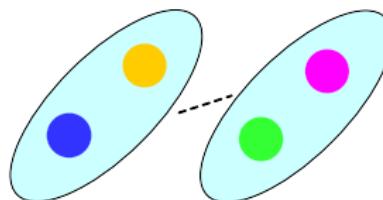


Motivation

- In this talk: Recent analysis on spectroscopy
- Ordinary hadrons → first part of the talk



- Not so ordinary



- Hybrids: Ongoing analysis

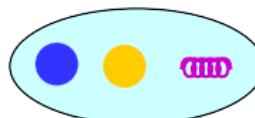


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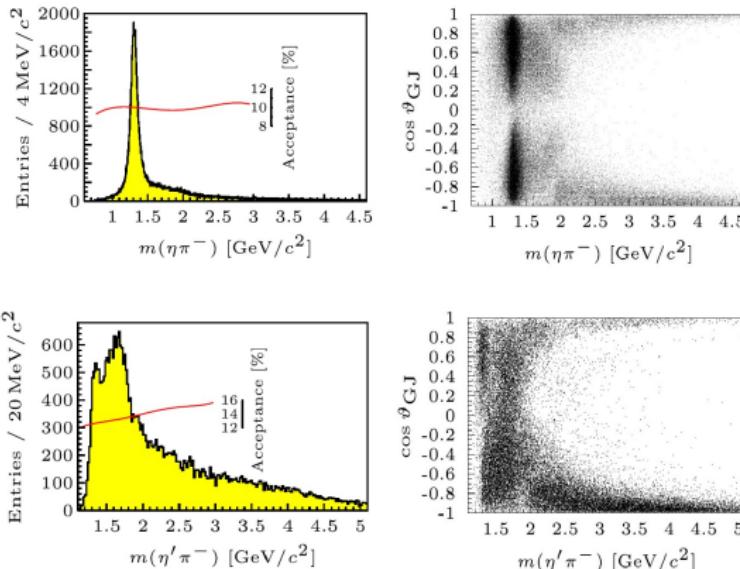
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Data: COMPASS experiment

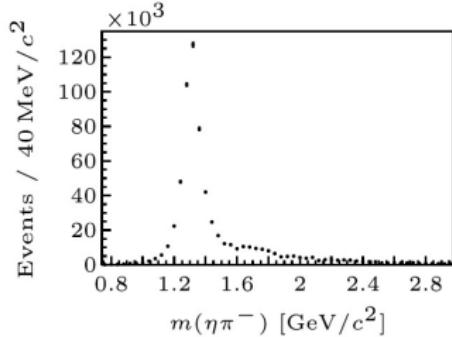
- $E_{Beam} = 190\text{GeV} \Rightarrow$ Peripheral production
- Dominated by $J^{PC} = 2^{++} \Rightarrow$ Ordinary meson.



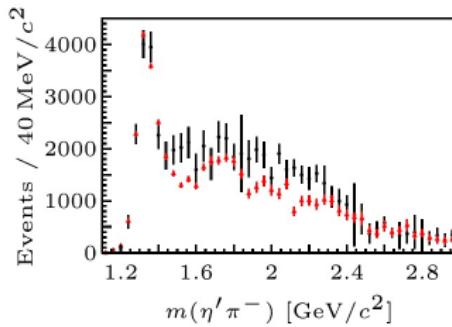
- Asymmetry \rightarrow odd (exotic) waves.
- Dominated by $J^{PC} = 1^{-+} \Rightarrow$ non $q\bar{q}$ quantum numbers.

Status

- Clear $a_2(1320)$ decaying into $\eta\pi$ and $\eta'\pi$?

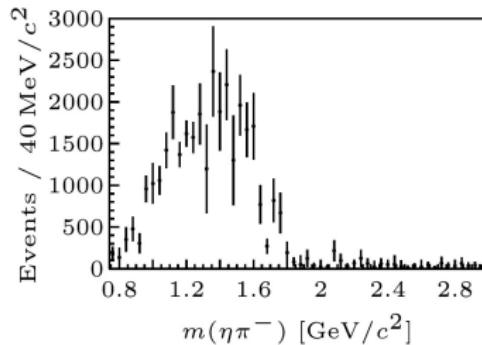


- Is there a clear $a'_2(1700)$? What are its parameters?

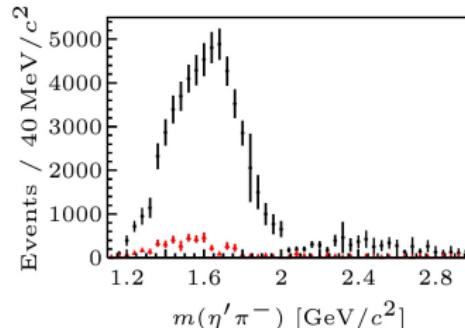


Status

- $\pi_1(1400)$ decaying into $\eta\pi^-$?

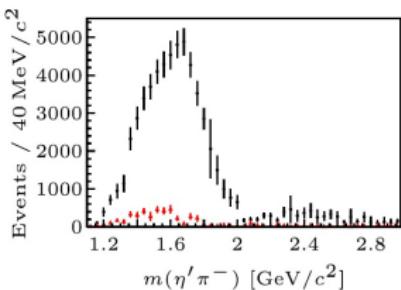


- Different $\pi_1(1600)$ decaying into $\eta'\pi^-$?

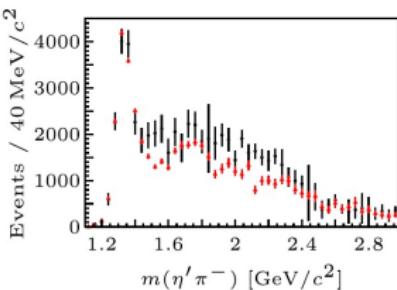


Partial waves

- Coupling to $\eta\pi$ much smaller than $\eta'\pi \Rightarrow$ Hybrid nature?
- Ordinary mesons have similar couplings.
- Data looks suspicious above 2 GeV.



(a) P -wave, $L = 1$



(b) D -wave, $L = 2$

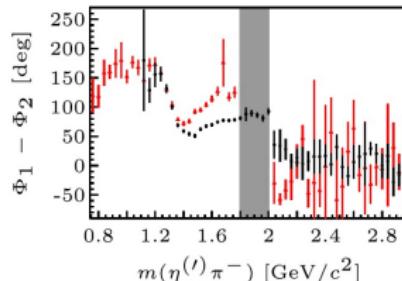


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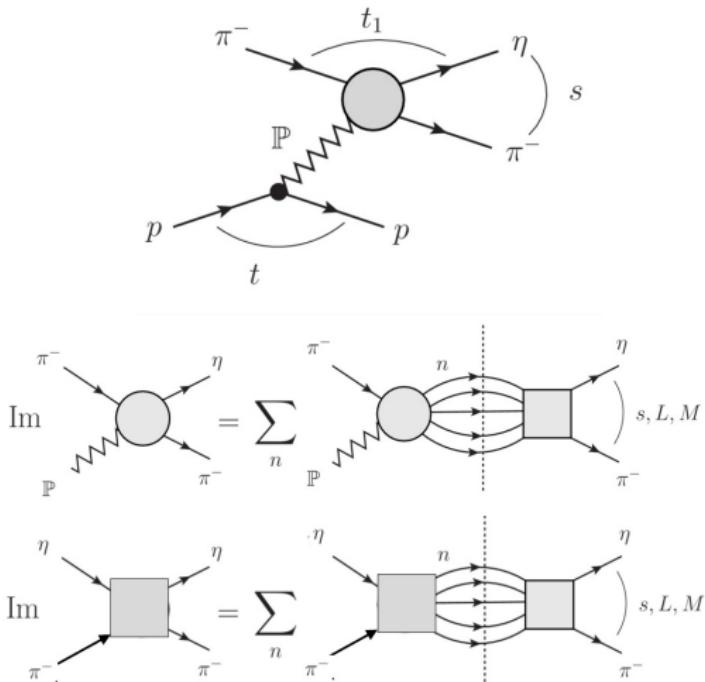
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Method

- Peripheral production \Rightarrow factorization of the pomeron
 $\Rightarrow \text{Im}a(s) = \rho(s)t^*(s)a(s).$

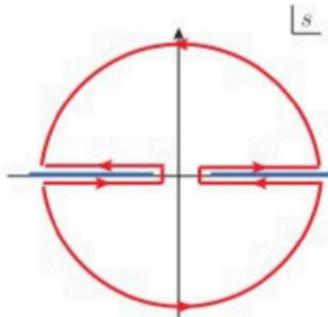
- Amplitude built around
 $t(s) = \frac{N(s)}{D(s)}$ method
 $\Rightarrow a(s) = p^2 q \frac{n(s)}{D(s)}.$

- They are smooth polynomials
 $n(s) = \sum_j a_j w^j(s)$, where
 $w(s) = \frac{s}{s+s_0}.$

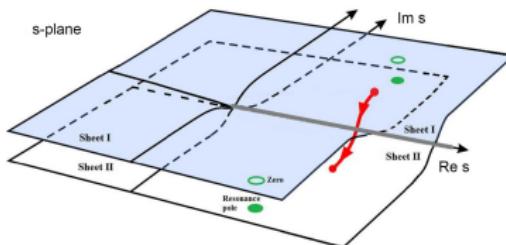


Method

- $N(s)$ and $n(s)$ are process dependent, they have only left hand cuts.
- $D(s)$ has a right hand cut, altogether $t(s)$ has the correct analytic structure.



- By adding this discontinuity over the RHC one could go to the direct continuous Riemann sheet.



Single channel

- A. Jackura, M. Mikhasenko, A. Pilloni et al. (JPAC & COMPASS), PLB779, 464-472

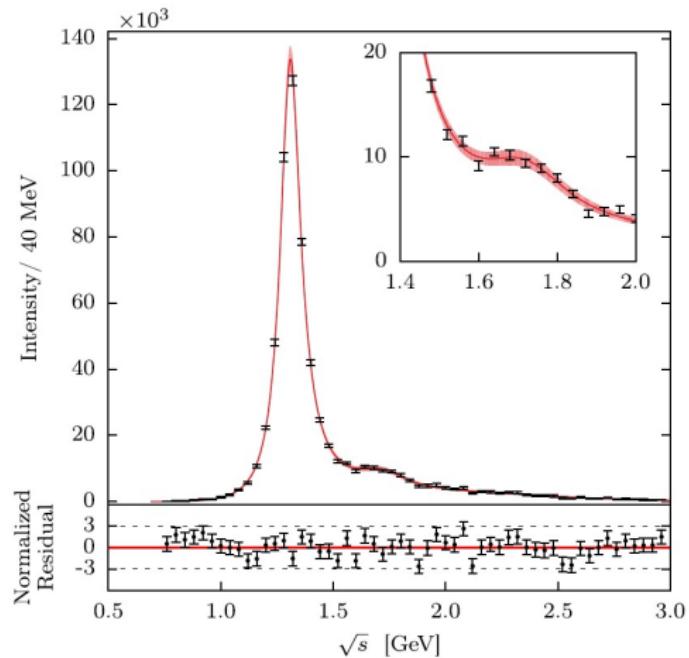
- $\text{Im}t(s) = \rho(s)|t(s)|^2 \Rightarrow \text{Im}D(s) = -\rho(s)N(s)$, so that

$$D(s) = D_0(s) - \frac{s}{\pi} \int_{s_{th}}^{\infty} ds' \frac{\rho(s')N(s')}{s'(s'-s)},$$

where $D_0(s) = c_0 - c_1 s - \frac{c_2}{c_3 - s} \rightarrow$ CDD poles.

- And $\rho(s)N(s) = g \frac{\lambda^{(2l+1)/2}(s, m_\eta^2, m_\pi^2)}{(s + s_R)^{2l+3}}$.

Single channel

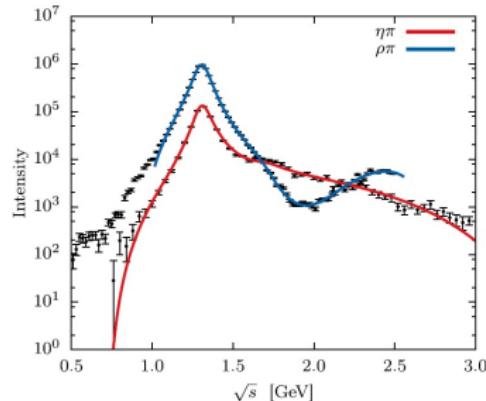
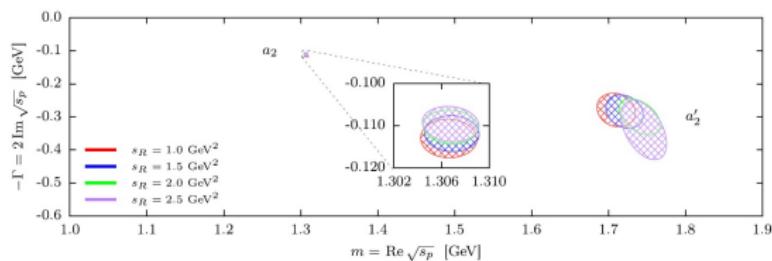


- 12 parameters, $\chi^2 \approx 2$.
- Good description of both peaks, the residuals of the fits follow a Gaussian distribution.

Single channel

- Various systematics

- ① Effective mass of the pomeron.
- ② Different values for $N(s)$ scale parameters.
- ③ Including $\rho\pi$ channel.



- $m(a_2) = 1307 \pm 1 \pm 6 \text{ MeV}$ $\Gamma(a_2) = 112 \pm 1 \pm 8 \text{ MeV}$
- $m(a'_2) = 1720 \pm 10 \pm 60 \text{ MeV}$ $\Gamma(a'_2) = 280 \pm 10 \pm 70 \text{ MeV}$

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Coupled channel

- $\eta^{(\prime)}\pi$ coupled channel up to 2 GeV.
- $\rho\pi$ cannot be included without including big systematic contribution (Deck).
- We use a K-matrix approach with a Chew-Mandelstam phase space.

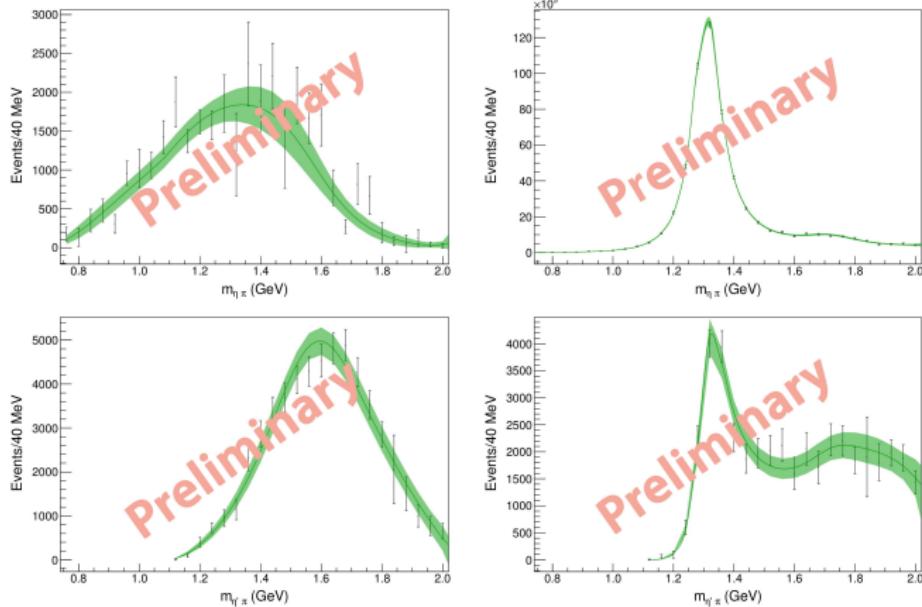
$$D(s)_{ij} = (K^{-1})_{ij}(s) - \frac{s}{\pi} \int_{s_{th}}^{\infty} ds' \frac{\rho(s') N(s')}{s'(s' - s)}, \quad (1)$$

$$K(s)_{ij} = \sum_R \frac{g_i^R g_j^R}{m_R^2 - s} + c_{ij} + d_{ij}s. \quad (2)$$

- Just 1 K-matrix pole for the P-wave.

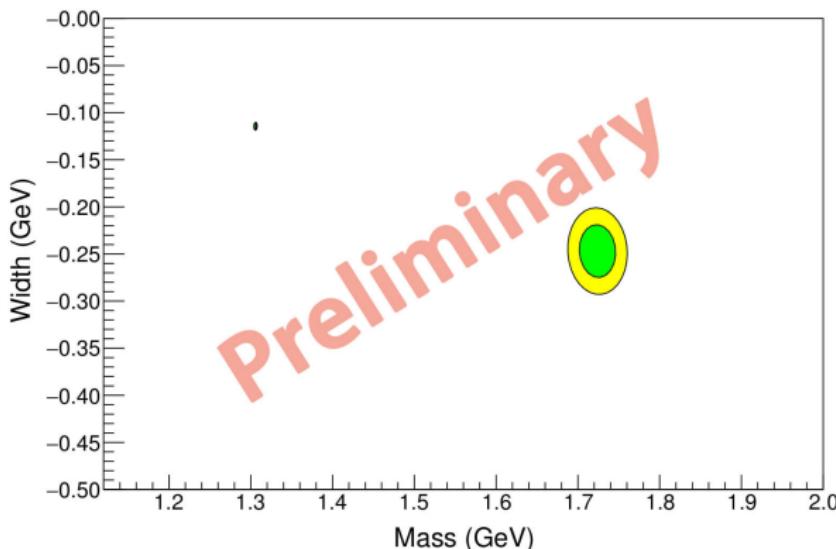
Coupled channel

- We use an average of 6 parameters for each figure.
- $\chi^2 \approx 1.4$, no significant deviation for any partial wave.
- 1 K-matrix pole produces 2 different peaks for the P-wave $\rightarrow 300$ MeV distance.



Poles

- Statistical uncertainties calculated through bootstrapping
- $m(a_2) = 1306 \pm 1$ MeV $\Gamma(a_2) = 114 \pm 2$ MeV
- $m(a'_2) = 1724 \pm 15$ MeV $\Gamma(a'_2) = 250 \pm 20$ MeV
- Clearly compatible with the single channel case.
- Systematics (different LHC masses, numerator models ...) still ongoing.



Poles

- Only one pole for the P-wave $\rightarrow m(\pi_1) = 1569 \pm 25$ MeV
 $\Gamma(\pi_1) = 501 \pm 58$ MeV.

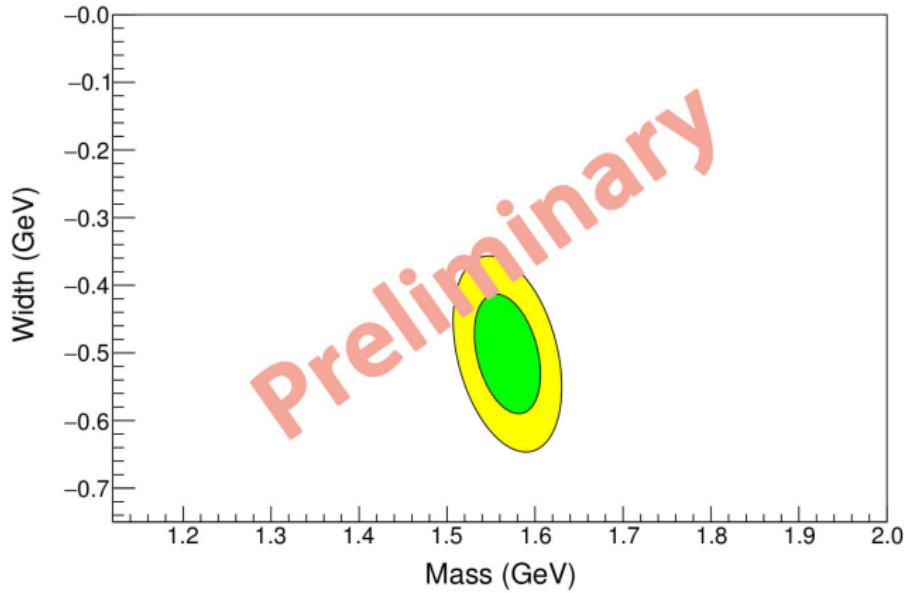


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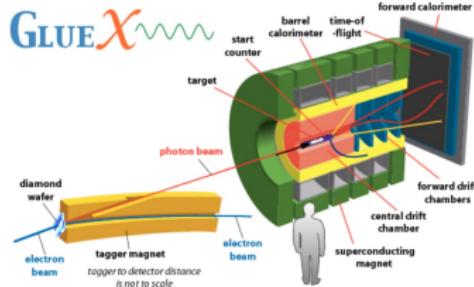
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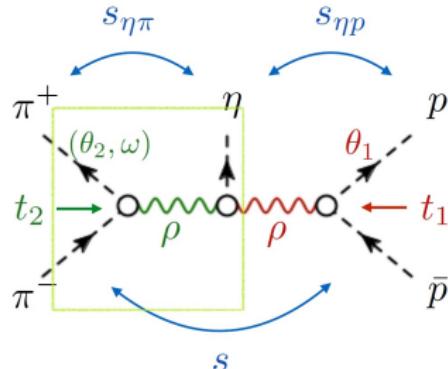
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Future

- New Gluex data?



- $2 \rightarrow 3$ FESR
- $\pi p \rightarrow \eta^{(\prime)} \pi p$ at COMPASS kinematics.



Summary

- Phenomenological analysis of COMPASS data → Analyticity and Unitarity.
- Past: JPAC and COMPASS collaboration to extract the ordinary $a_2(1320)$ and $a'_2(1700)$ resonances.
- Ongoing: New method to analyze also the non-ordinary π_1 .
- Future: Understanding Gluex exchanges.
- Analytic dispersive constraints for $2 \rightarrow 3$.

Thank you for your attention!