Some ideas for BGOOD

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N*(1920) from K Kbar N bound state

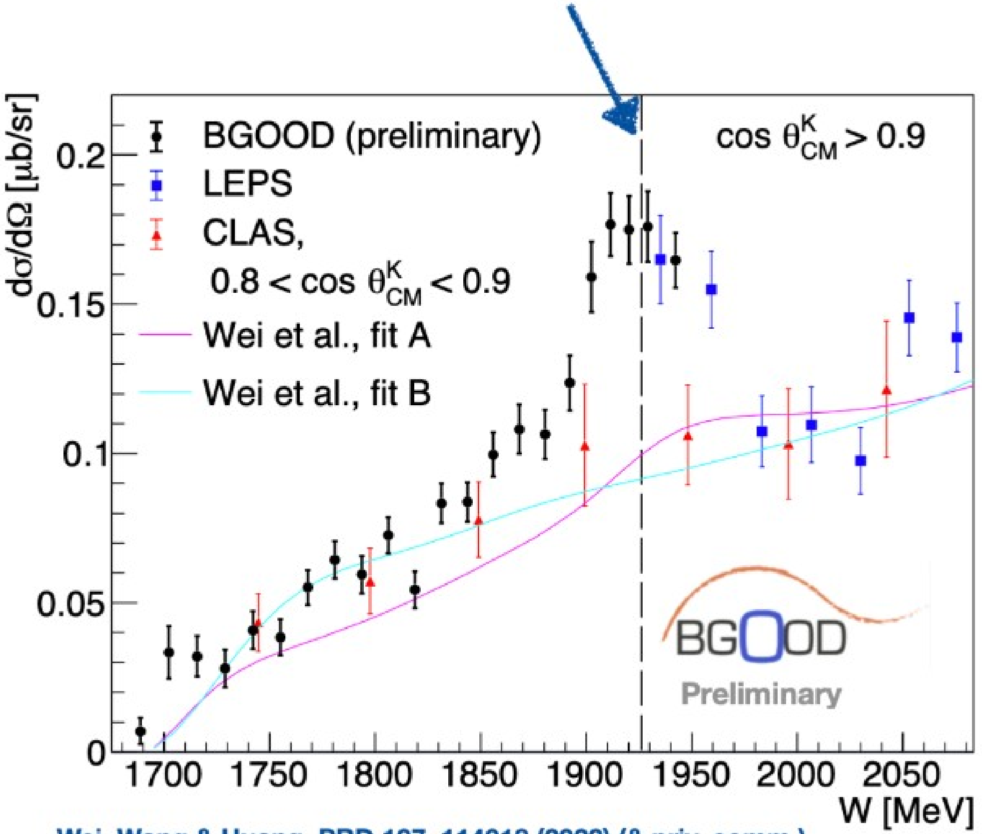
Σ(1430) (1/2-)

Σ(1380) (1/2-) ?????

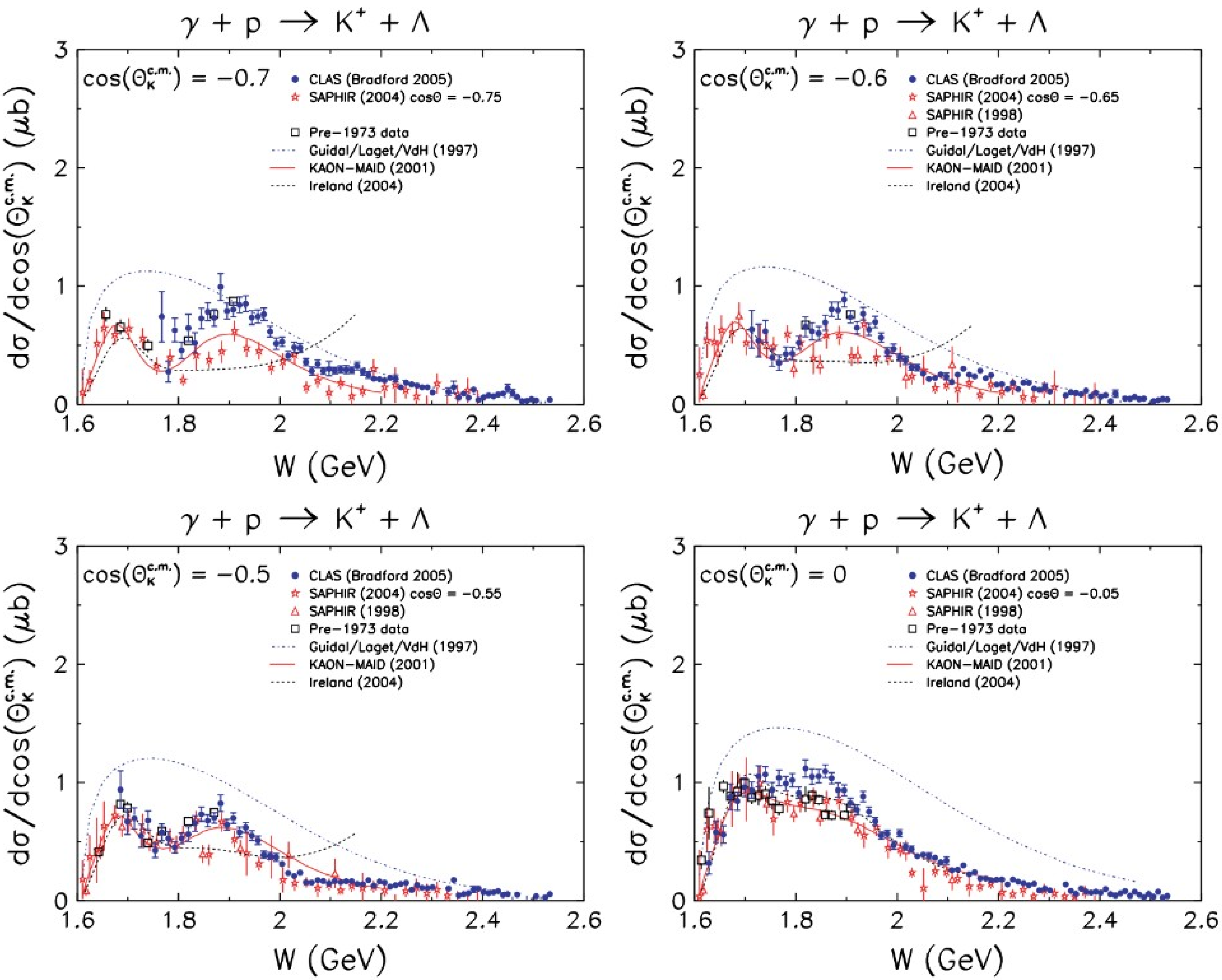
N*(2190) from p f1(1285) (p K K*bar)

Forward $K^+\Sigma^-$ photoproduct

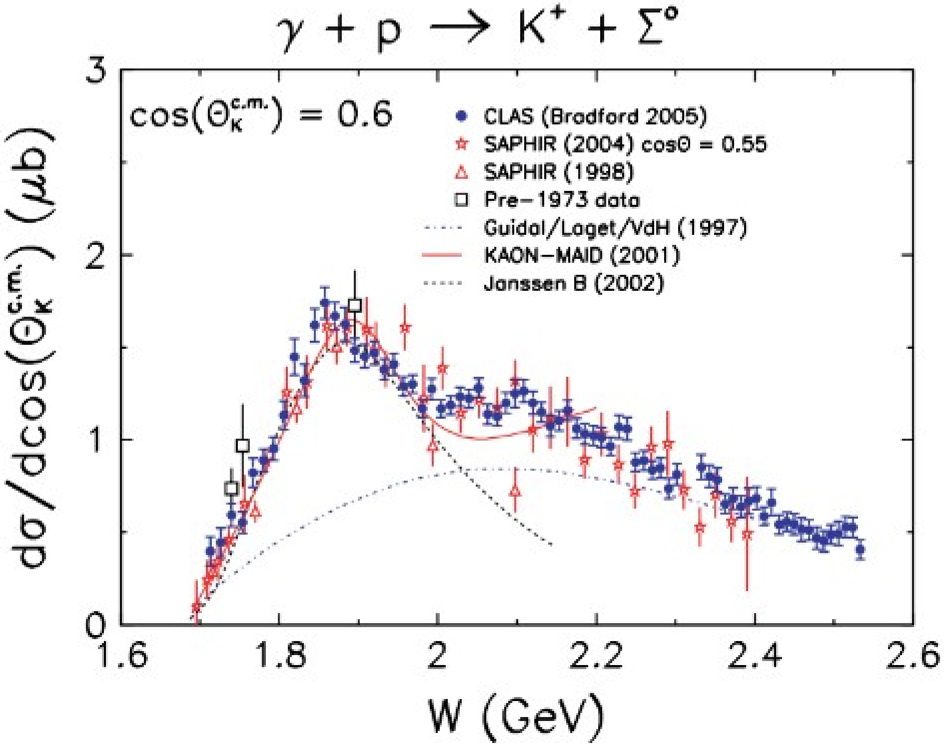
Structure close to K^+K^-p threshold?



Wei, Wang & Huang, PRD 107, 114018 (2023) (& priv. comm.)
CLAS: Pereira et al., PLB 688 (2010) 289
LEPS: H. Kohri et al., PRL 97 (8 2006) 082003



γ + p → K⁺ + Λ
cos(Θ_K^c.m.) = −0.7
CLAS (Bradford 2005)
SAPHIR (2004) cosθ = −0.75
Pre−1973 data
Guidal/Laget/VdH (1997)
KAON−MAID (2001)
Ireland (2004)
γ + p → K⁺ + Λ
cos(Θ_K^c.m.) = −0.6
CLAS (Bradford 2005)
SAPHIR (2004) cosθ = −0.65
SAPHIR (1998)
Pre−1973 data
Guidal/Laget/VdH (1997)
KAON−MAID (2001)
Ireland (2004)
γ + p → K⁺ + Λ
cos(Θ_K^c.m.) = −0.5
CLAS (Bradford 2005)
SAPHIR (2004) cosθ = −0.55
SAPHIR (1998)
Pre−1973 data
Guidal/Laget/VdH (1997)
KAON−MAID (2001)
Ireland (2004)
γ + p → K⁺ + Λ
cos(Θ_K^c.m.) = 0
CLAS (Bradford 2005)
SAPHIR (2004) cosθ = −0.05
SAPHIR (1998)
Pre−1973 data
Guidal/Laget/VdH (1997)
KAON−MAID (2001)
Ireland (2004)
dσ/dcos(Θ_K^c.m.) (μb)
W (GeV)



γ + p → K⁺ + Σ°
cos(Θ_K^c.m.) = 0.6
CLAS (Bradford 2005)
SAPHIR (2004) cosθ = 0.55
SAPHIR (1998)
Pre–1973 data
Guidal/Laget/VdH (1997)
KAON–MAID (2001)
Janssen B (2002)
dσ/dcos(Θ_K^c.m.) (μb)
W (GeV)
0
1
2
3
1.6
1.8
2
2.2
2.4
2.6

D. Jido, Y. Kanada-En'yo, Phys. Rev. C 78, 035203 (2008)

They find a bound state of K Kbar N , in the a0(980) N mode
using variational calculations, with mass 1910 MeV

Martinez-Torres, Khemchandani, Oset Phys.Rev.C 79 (2009) 065207

We use Faddeev equations and find with coupled channels, pi pi N, K Kbar N, eta pi N
a state at 1920 MeV coupled to f0(980)N and a0(980)N

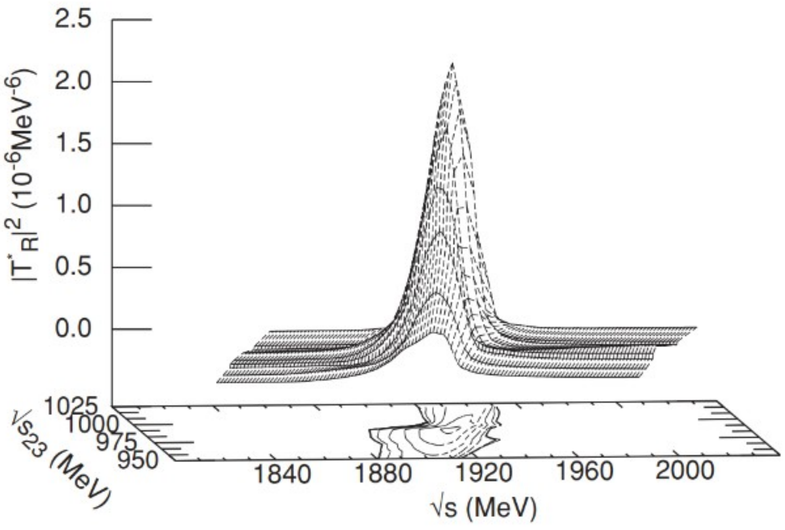


FIG. 7. A possible $N^*(1910)$ in the $NK\bar{K}$ channels.

The state has I=1/2

J^p= 1/2+

Martinez-Torres, Khemchandani, Meissner, Oset

Eur.Phys.J.A 41 (2009) 361-368

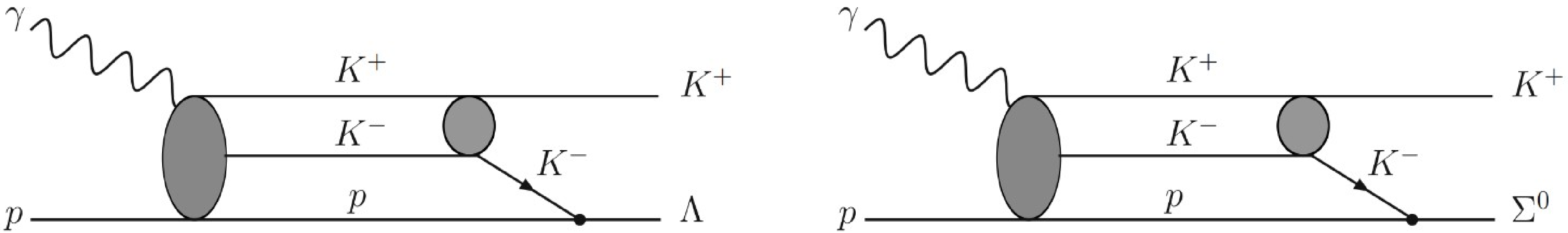


Fig. 1. Diagrams depicting the $\gamma p \to K^+ \Lambda$, $\gamma p \to K^+ \Sigma^0$ processes through the $1/2^+$ N^* K^+K^-N-resonance of [16,21].

$$V_{K^-p\to\Lambda} = -\frac{2}{\sqrt{3}}\frac{D+F}{2f} + \frac{1}{\sqrt{3}}\frac{D-F}{2f}\,, \qquad -1.26$$

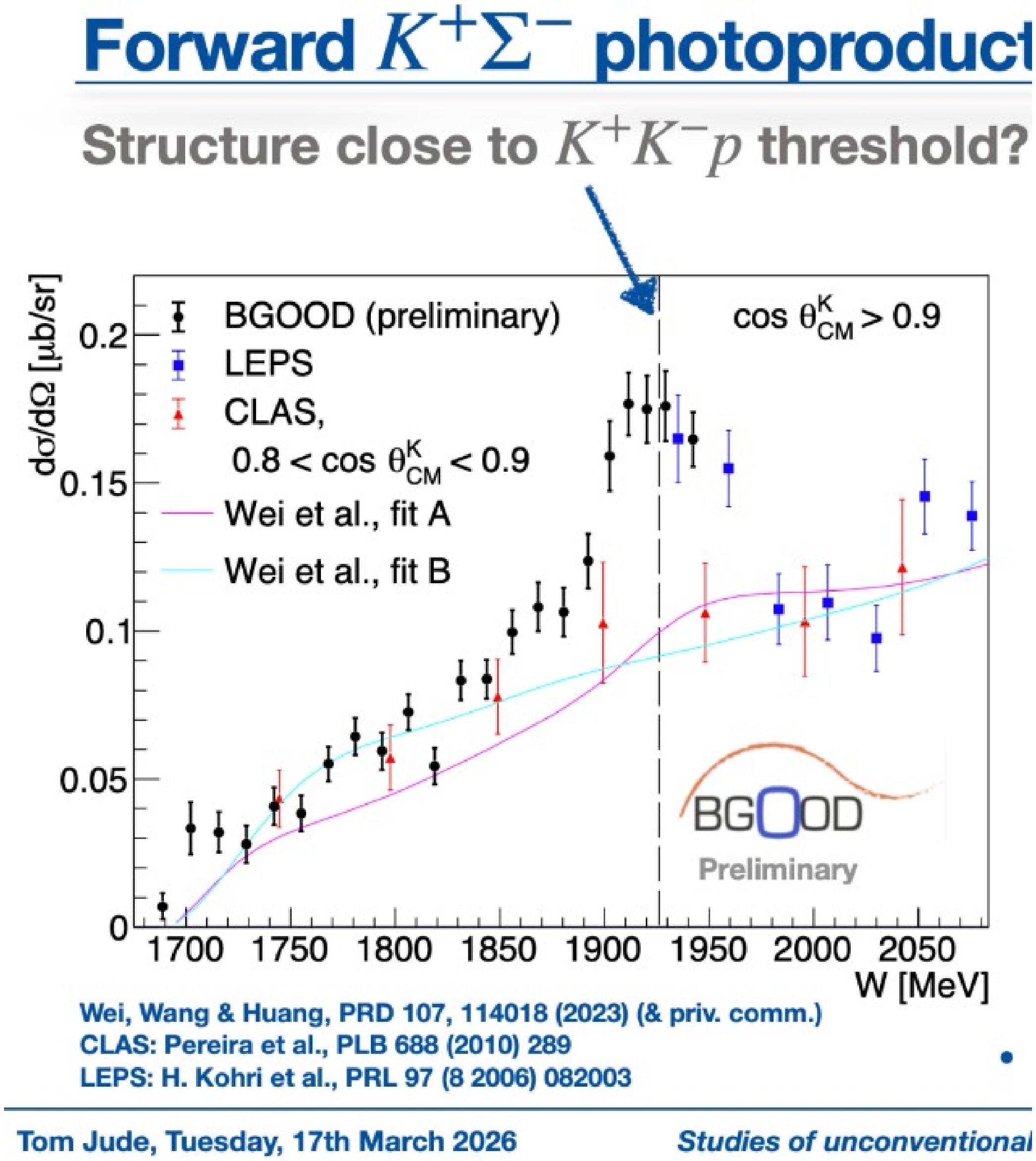
$$V_{K^-p\to\Sigma^0} = \frac{D-F}{2f} \qquad 0.33$$

Is that peak related to that state?

I think so.

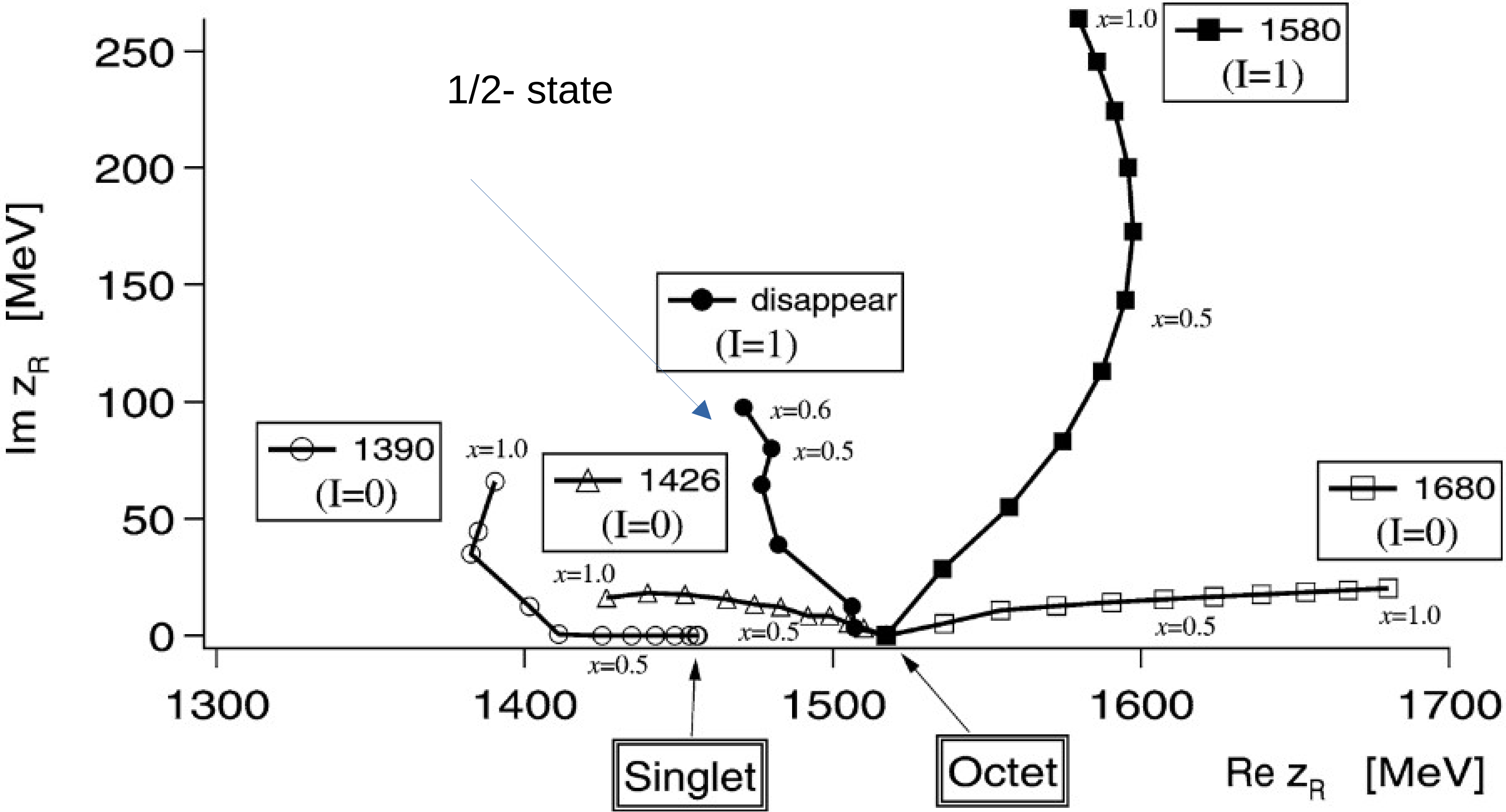
What can one do experimentally to determine isospin, and J^P ?

Partial wave analysis can help



The Σ(1430) state

D.~Jido, J.~A.~Oller, E.~Oset, A.~Ramos and U.~G.~Meissner,
%``Chiral dynamics of the two Lambda(1405) states,''
Nucl. Phys. A \textbf{725}, 181-200 (2003)



Many works supporting the existence and nature of this state

M. F. M. Lutz and E. E. Kolomeitsev, On meson resonances and chiral symmetry, Nucl. Phys. A **730**, 392 (2004), arXiv:nucl-th/0307039.

L. Roca, E. Oset, and J. Singh, Low lying axial-vector mesons as dynamically generated resonances, Phys. Rev. D **72**, 014002 (2005), arXiv:hep-ph/0503273.

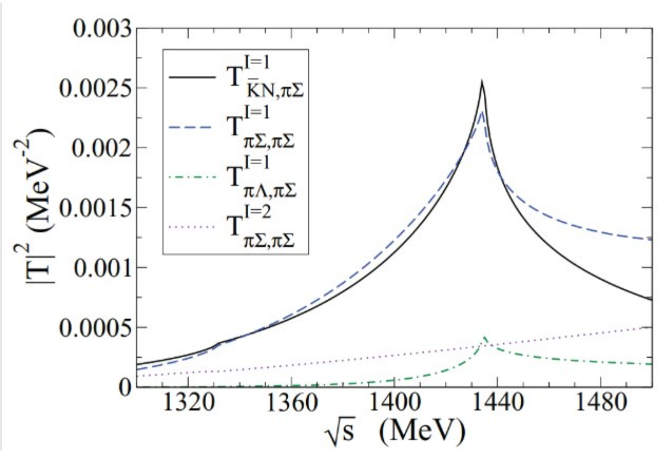
C. Garcia-Recio, L. S. Geng, J. Nieves, and L. L. Salcedo, Low-lying even parity meson resonances and spin-flavor symmetry, Phys. Rev. D **83**, 016007 (2011), arXiv:1005.0956 [hep-ph].

Y. Zhou, X.-L. Ren, H.-X. Chen, and L.-S. Geng, Pseudoscalar meson and vector meson interactions and dynamically generated axial-vector mesons, Phys. Rev. D **90**, 014020 (2014), arXiv:1404.6847 [nucl-th].

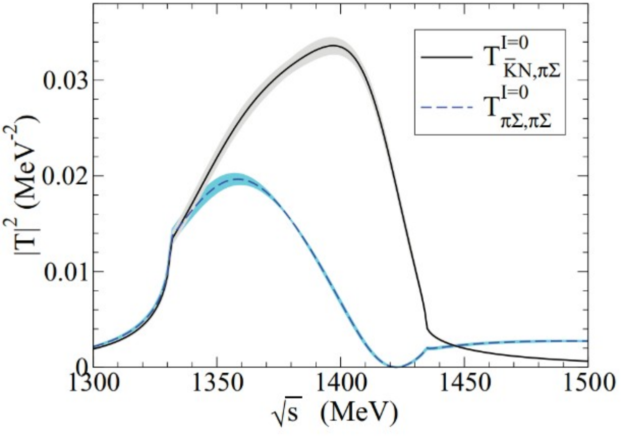
L.-S. Geng, X.-L. Ren, Y. Zhou, H.-X. Chen, and E. Oset, *S*-wave KK^* interactions in a finite volume and the $f_1(1285)$, Phys. Rev. D **92**, 014029 (2015), arXiv:1503.06633 [hep-ph].

P.-L. Lü and J. He, Hadronic molecular states from the $K\bar{K}^*$ interaction, Eur. Phys. J. A **52**, 359 (2016), arXiv:1603.04168 [hep-ph].

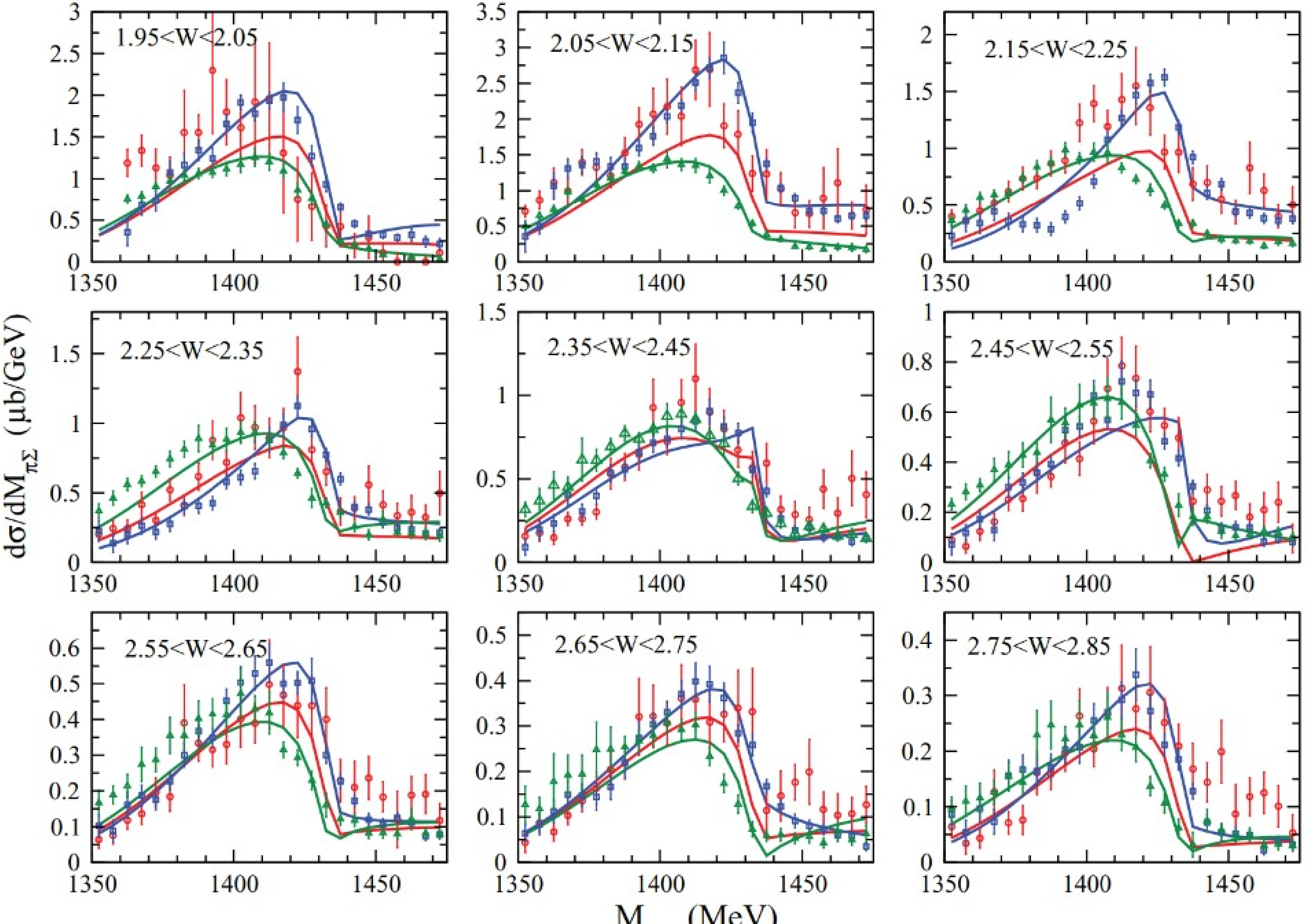
Lin,Song, Albaladejo, Feijoo, Oset Phys.Rev.D 112 (2025) 1, 014044



$|T|^2$ (MeV^{-2})
$\sqrt{s}$ (MeV)
$T^{I=1}_{\bar{K}N,\pi\Sigma}$
$T^{I=1}_{\pi\Sigma,\pi\Sigma}$
$T^{I=1}_{\pi\Lambda,\pi\Sigma}$
$T^{I=2}_{\pi\Sigma,\pi\Sigma}$
0.003
0.0025
0.002
0.0015
0.001
0.0005
0
1320
1360
1400
1440
1480



$|T|^2$ (MeV^{-2})
$\sqrt{s}$ (MeV)
$T^{I=0}_{\bar{K}N,\pi\Sigma}$
$T^{I=0}_{\pi\Sigma,\pi\Sigma}$
0.03
0.02
0.01
0
1300
1350
1400
1450
1500



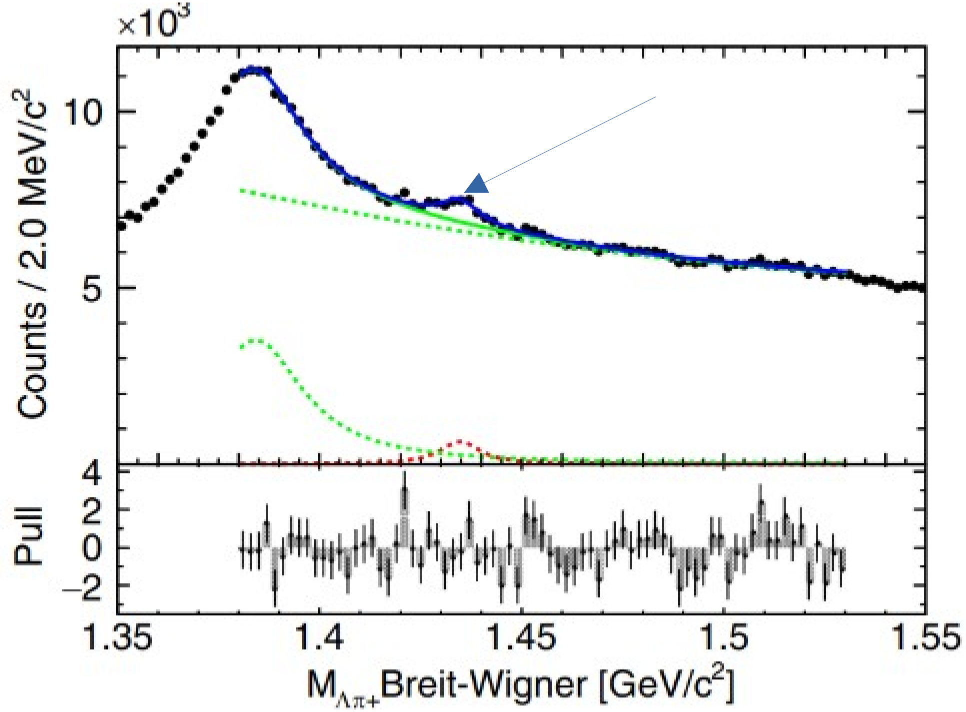
$d\sigma/dM_{\pi\Sigma}$ (μb/GeV)
1.95<W<2.05
2.05<W<2.15
2.15<W<2.25
2.25<W<2.35
2.35<W<2.45
2.45<W<2.55
2.55<W<2.65
2.65<W<2.75
2.75<W<2.85
1350
1400
1450

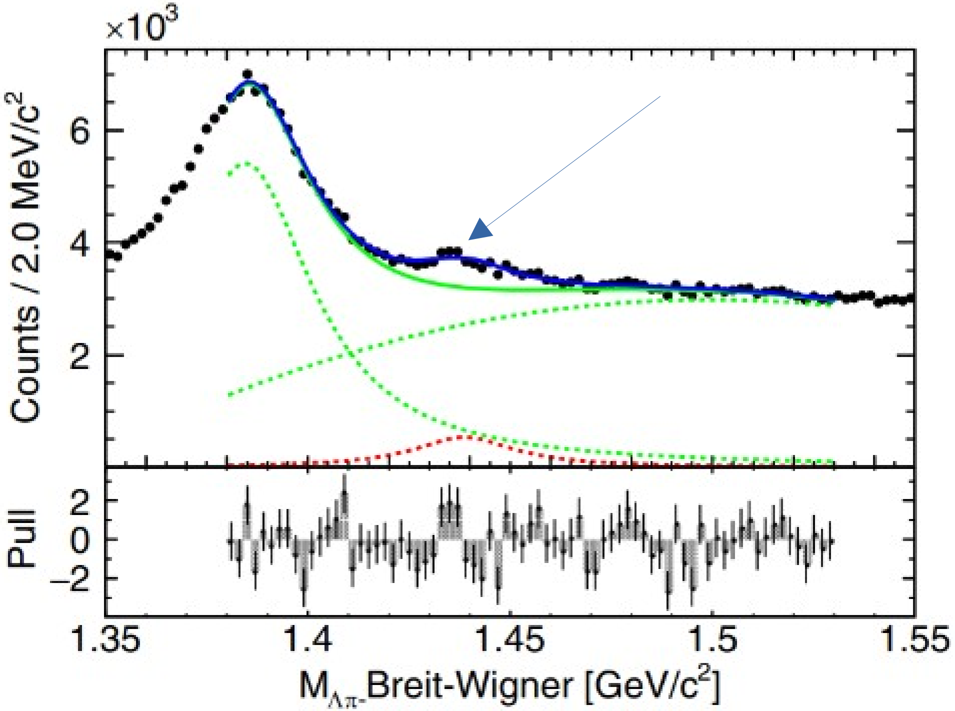
J.-J. Xie, E. Oset, Phys. Lett. B 792, 450 (2019)

studied $\Lambda_c^+ \rightarrow \pi^+\pi^0\pi^-\Sigma^+$ and proposed $\Lambda_c^+ \rightarrow \Lambda\pi^+\pi^+\pi^-$

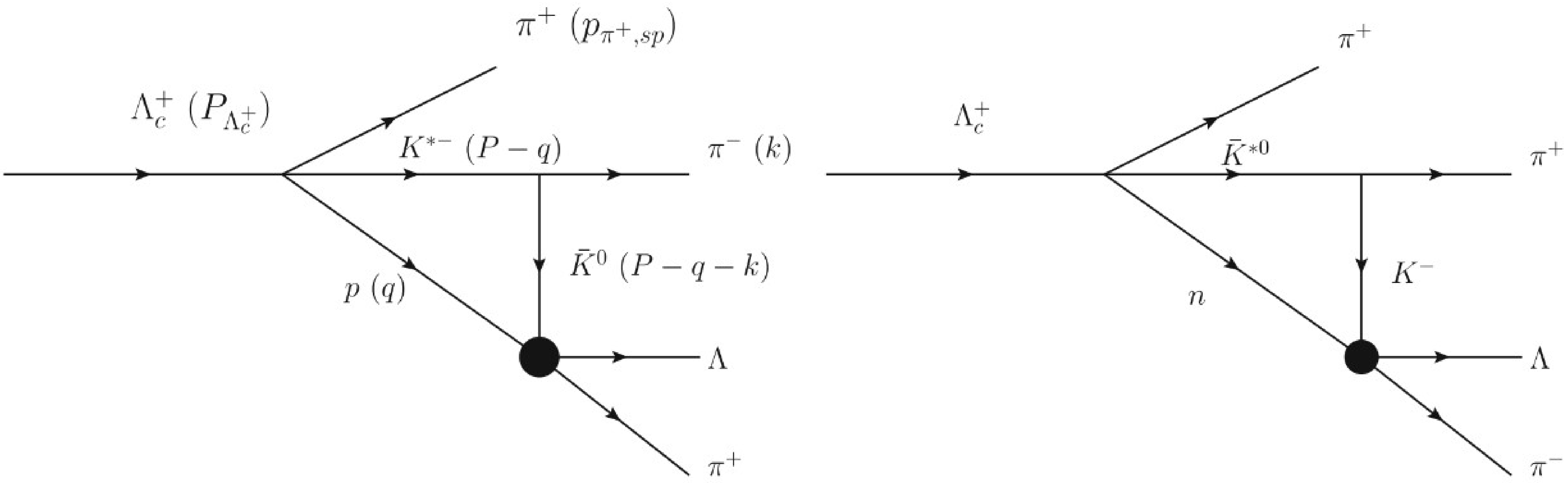
The latter reaction has been done by Belle,

Y. Ma et al. [Belle], Phys. Rev. Lett. 130, 151903 (2023)





Y.~Y.~Li, J.~Song, E.~Oset, W.~H.~Liang and R.~Molina,
%``The $\Lambda _c^+\rightarrow \Lambda \pi ^+\pi ^+\pi ^-$ reaction, and a triangle singularity producing the $\Sigma ^*(1430)$ state,''
Eur. Phys. J. C \textbf{85}, no.9, 1086 (2025)



One can obtain the properties of the Belle peak and its strength

More experiments to find it would be welcome

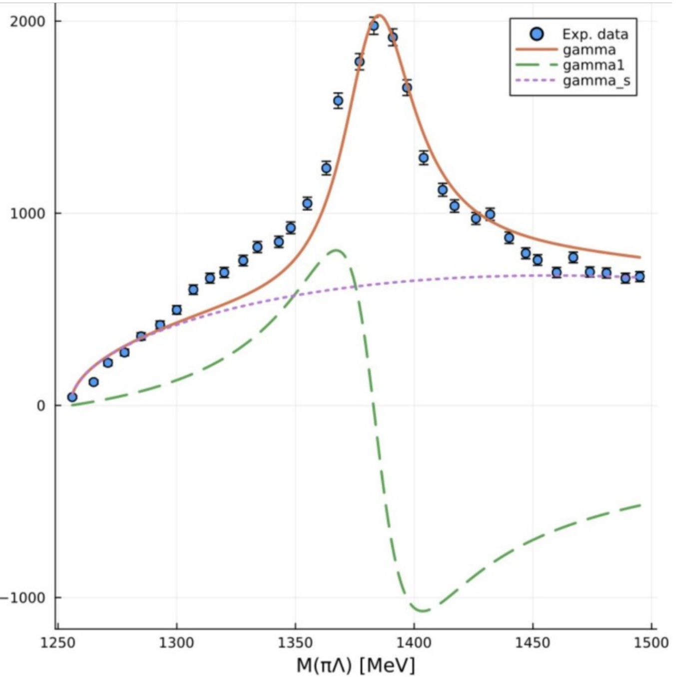
Identifying $\Sigma(1380)$ and $\Sigma(1430)$ in the $J/\psi \to \bar{\Lambda}\pi\Sigma$ reaction

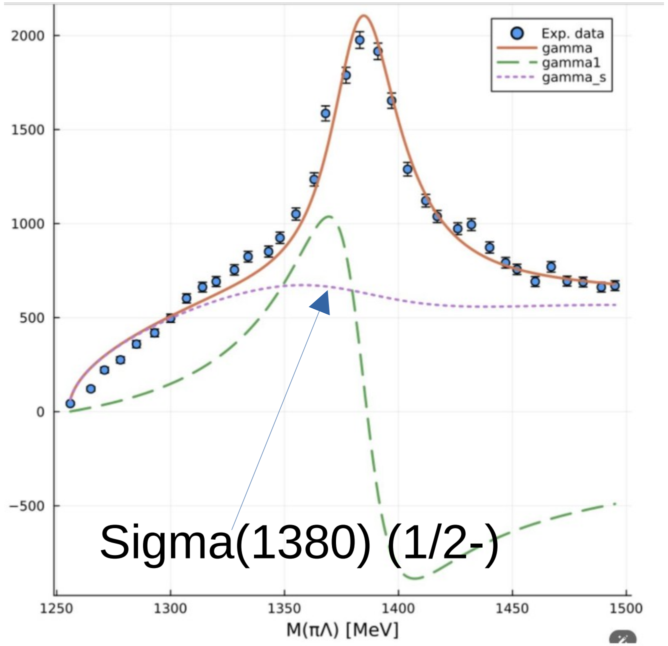
Wen-Tao Lyu,[1,2,*] Eulogio Oset,[2,†] De-Min Li,[1,‡] and En Wang[1,§]

$\Sigma(1385)$ 3/2+

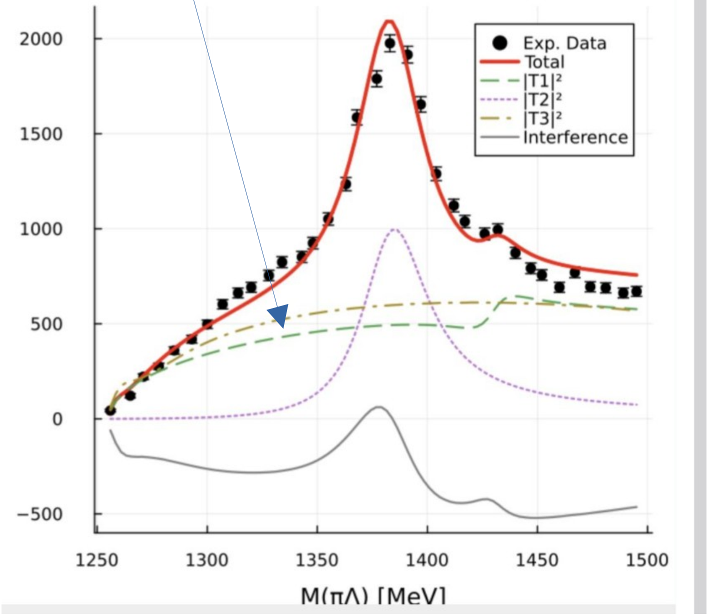
No $\Sigma(1380)$
but π Σ interaction

M. Ablikim et al. [BESIII], Phys. Rev. D 108, 112012 (2023)





Sigma(1380) (1/2-)



Scattering observables and correlation function for $p\ f_1(1285)$ revisited

Arxiv: 2603.09852

P.~Encarnacion, A.~Feijoo and E.~Oset,
%``Correlation function for the pf1(1285) interaction,''
Phys. Rev. D \textbf{111}, no.11, 114023 (2025)

$$f_1(1285) = -\frac{1}{\sqrt{2}}(K^*\bar{K})^{I=0} - \frac{1}{\sqrt{2}}(\bar{K}^*K)^{I=0}$$

I^G(J^PC)=0^+(1^++)

For p f1 interaction we follow the traditional method of particle-nucleus interaction:

Define optical potential and solve the Lippmann Schwinger Equation

The optical potential is provided by the Fixed Center Approach to Faddeev equations,
which is particularly suited to this case, since we have a well defined “cluster” the f1 molecule

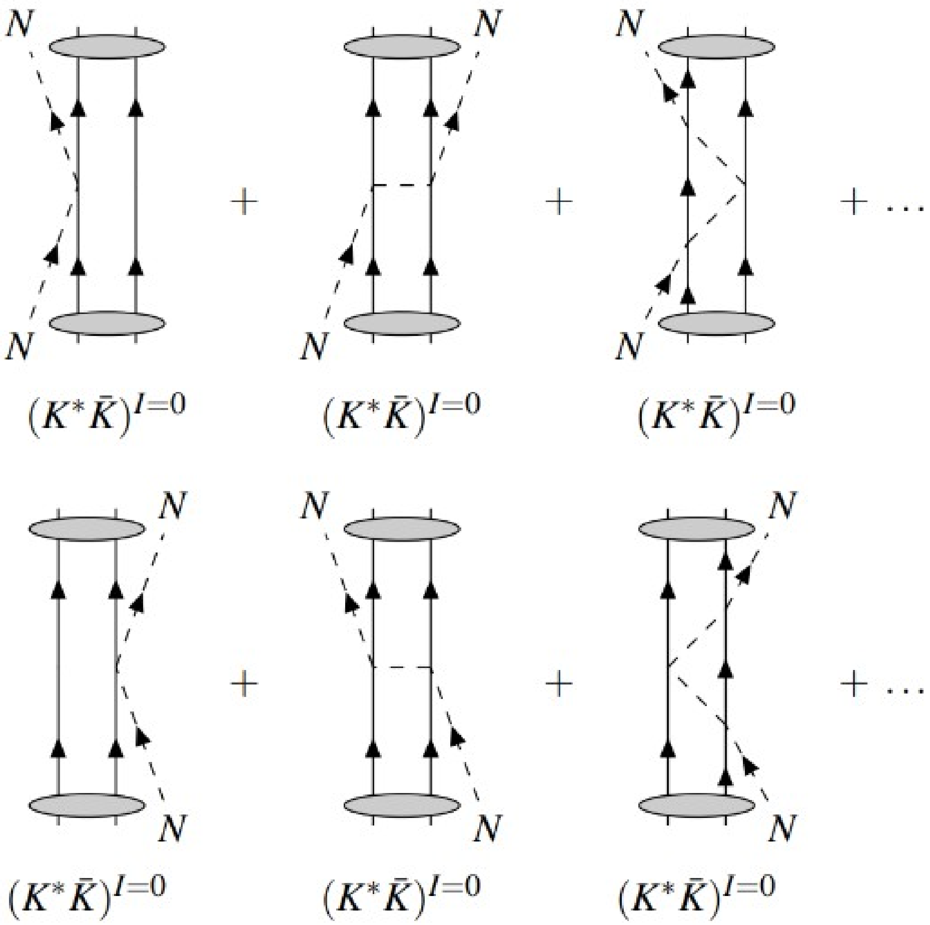
$$t_1 = \frac{3}{4} t^{(1)}_{pK^*} + \frac{1}{4} t^{(0)}_{pK^*}$$
$$t_2 = \frac{3}{4} t^{(1)}_{p\bar{K}} + \frac{1}{4} t^{(0)}_{p\bar{K}}$$

The FCA

$$\widetilde{t}_1 = \frac{M_C}{M_{K^*}} t_1 \quad ; \quad \widetilde{t}_2 = \frac{M_C}{M_K} t_2$$

$$\widetilde{T}_{11} = \frac{\widetilde{t}_1}{1 - \widetilde{t}_1 \widetilde{t}_2 G_0^2} \quad ; \quad \widetilde{T}_{22} = \frac{\widetilde{t}_2}{1 - \widetilde{t}_1 \widetilde{t}_2 G_0^2}$$
$$\widetilde{T}_{12} = \widetilde{T}_{21} = \frac{\widetilde{t}_1 \widetilde{t}_2 G_0}{1 - \widetilde{t}_1 \widetilde{t}_2 G_0^2}$$

$$G_0(\sqrt{s}) = \int \frac{d^3q}{(2\pi)^3} \frac{2M_N}{2E(q)2\omega_C(q)} \frac{F_C(q)}{\sqrt{s} - E(q) - \omega_C(q) + i\varepsilon} \times \theta(q^{(1)}_{max} - q^*_1)\theta(q^{(2)}_{max} - q^*_2) \quad (8)$$



$$\widetilde{T} = \begin{pmatrix} \widetilde{T}_{11} & \widetilde{T}_{12} \\ \widetilde{T}_{21} & \widetilde{T}_{22} \end{pmatrix}$$

$$\widetilde{T}' = [1 - \widetilde{T} G_C]^{-1} \widetilde{T}$$

$$G_C = \begin{pmatrix} G_C^{(1)} & 0 \\ 0 & G_C^{(2)} . \end{pmatrix}$$

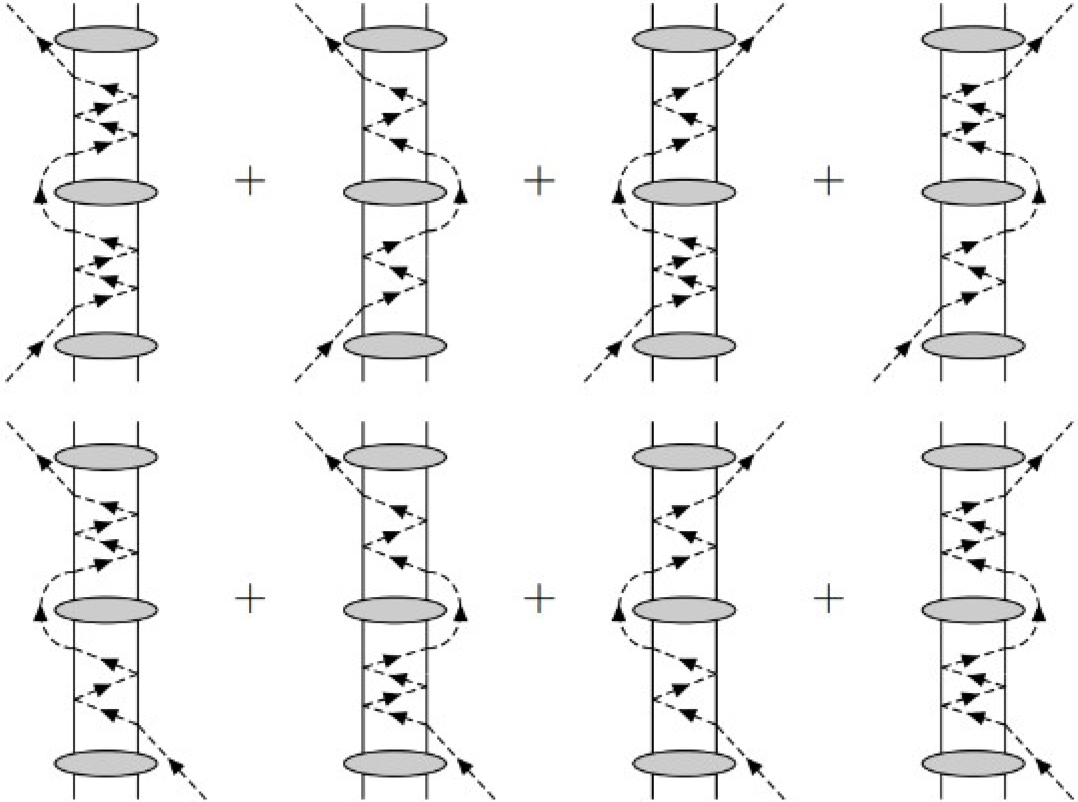


FIG. 2. Diagrams required for the unitarization of the $pf_1(1285)$

$$G_C^{(i)}(\sqrt{s}) = \int \frac{d^3q}{(2\pi)^3} \frac{2M_N}{2E(q)2\omega_C(q)} \frac{[F_C^{(i)}(q)]^2}{\sqrt{s} - E(q) - \omega_C(q) + i\varepsilon} \times \theta(q_{max}^{(i)} - q_i^*) , \quad (15)$$

$$F_C^{(1)}(q) = F_C\left(\frac{m_{\bar{K}}}{m_{K^*} + m_{\bar{K}}} q\right)$$

$$F_C^{(2)}(q) = F_C\left(\frac{m_{K^*}}{m_{K^*} + m_{\bar{K}}} q\right)$$

$$T^{\text{tot}}_{K^*\bar{K}}(\sqrt{s}) = \sum_{i,j} \widetilde{T}'_{ij} = \frac{\widetilde{t}_1 + \widetilde{t}_2 + (2G_0 - G_C^{(1)} - G_C^{(2)})\widetilde{t}_1\widetilde{t}_2}{1 - G_C^{(1)}\widetilde{t}_1 - G_C^{(2)}\widetilde{t}_2 - (G_0^2 - G_C^{(1)}G_C^{(2)})\widetilde{t}_1\widetilde{t}_2} \tag{17}$$

unitarity

$$-\frac{8\pi\sqrt{s}}{2M_N}(T^{\text{tot}}_{K^*\bar{K}})^{-1} = (f^{QM})^{-1} \simeq -\frac{1}{a_0} + \frac{1}{2}r_0 q_{cm}^2 - iq_{cm}$$

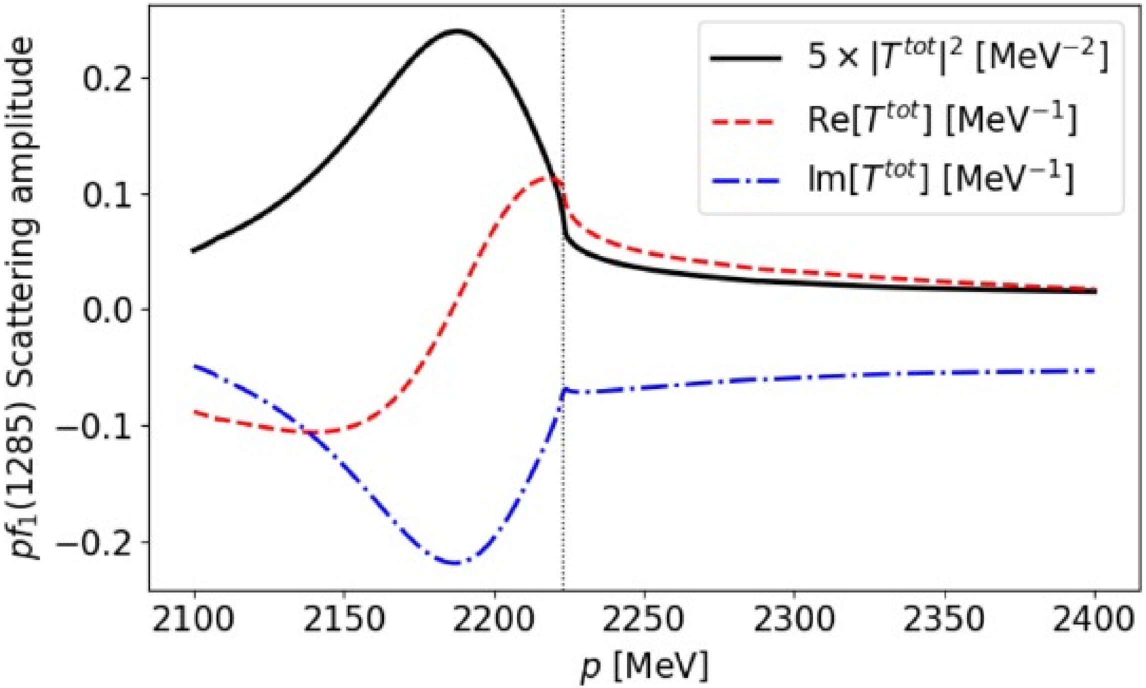
$$(T^{\text{tot}})^{-1} = \frac{1}{2}\left[(T^{\text{tot}}_{K^*\bar{K}})^{-1} + (T^{\text{tot}}_{\bar{K}^*K})^{-1}\right]$$

$$M_R = 2189 \pm 10 \text{ MeV},$$

$$\Gamma_R = 53 \pm 12 \text{ MeV},$$

$$a_0 = [0.689 \pm 0.040] - [0.413 \pm 0.084] i \text{ fm},$$

$$r_0 = [-0.025 \pm 0.077] + [0.146 \pm 0.084] i \text{ fm}.$$



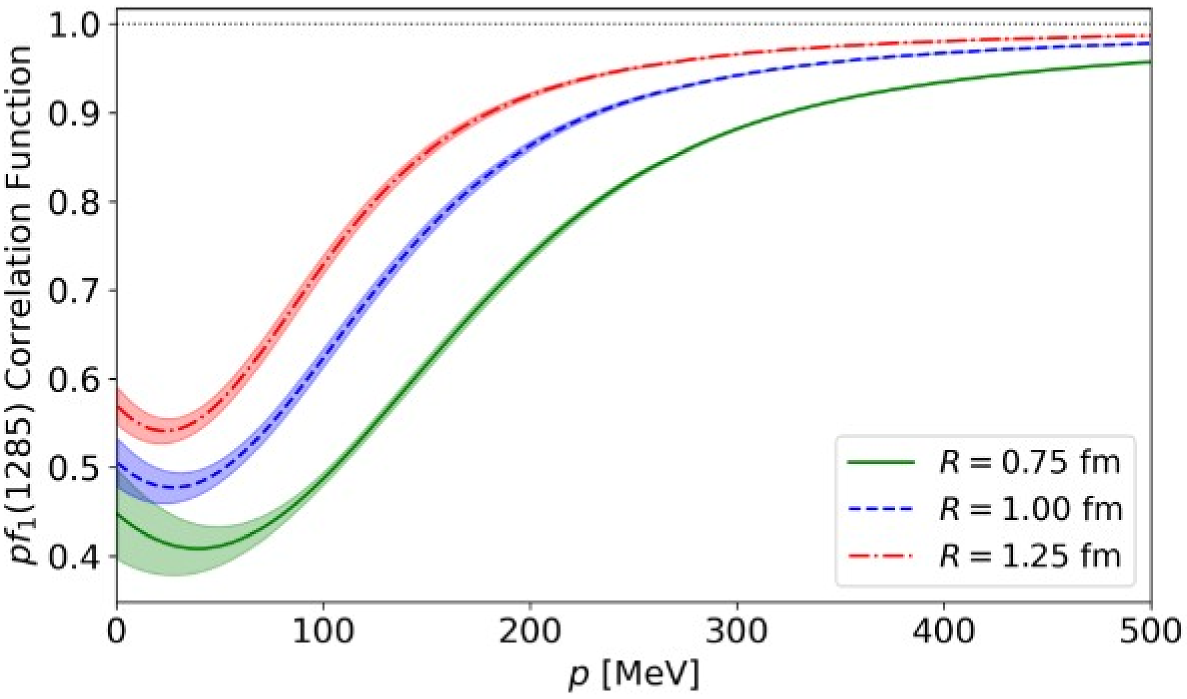
Correlation function

$$C_{pf_1}(p) = 1 + 4\pi \int_0^\infty dr\, r^2 S_{12}(r) \times \left\{ |j_0(pr) + TG|^2 - j_0^2(pr) \right\}$$

$$S_{12}(r) = \frac{1}{(4\pi R^2)^{3/2}} e^{-r^2/4R^2}$$

$$\begin{aligned} TG &\simeq \left(\widetilde{T}'_{11} + \widetilde{T}'_{21} + \widetilde{T}'_{12} + \widetilde{T}'_{22}\right) \frac{1}{2} \left(G_1(\sqrt{s}, r) + G_2(\sqrt{s}, r)\right) \\ &= T^{\text{tot}} \frac{1}{2} \left(G_1(\sqrt{s}, r) + G_2(\sqrt{s}, r)\right) \qquad (25) \end{aligned}$$

$$G_i(\sqrt{s}, r) = \int \frac{d^3q}{(2\pi)^3} \frac{2M_N}{2E(q) 2\omega_C(q)} \frac{F_C^{(i)}(q) j_0(qr)}{\sqrt{s} - E(q) - \omega_C(q) + i\varepsilon} \times \theta(q_{max}^{(i)} - q_i^*) . \qquad (24)$$



1.0
0.9
0.8
0.7
0.6
0.5
0.4
$pf_1(1285)$ Correlation Function
0
100
200
300
400
500
p [MeV]
$R = 0.75$ fm
$R = 1.00$ fm
$R = 1.25$ fm

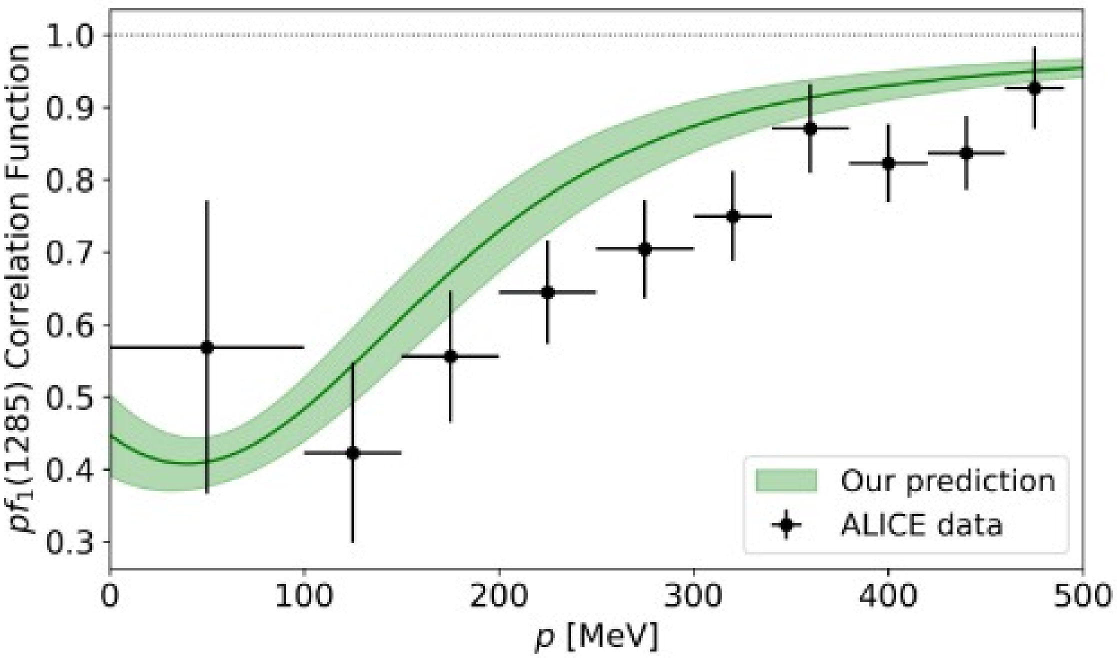


FIG. 5. $pf_1(1285)$ CF for $R = 0.75$ fm with the corresponding error band, compared with the ALICE experimental data taken from [54].

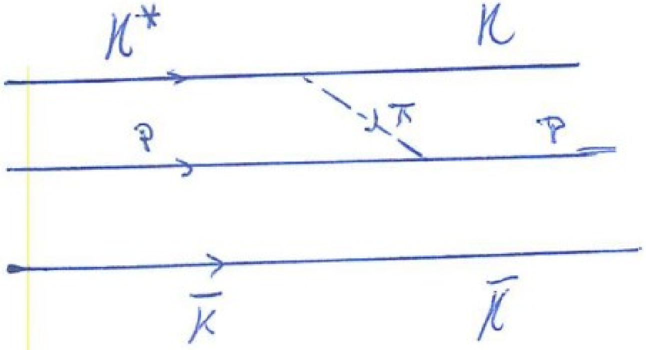
How to observe the state ?

$f_1(1285)$ DECAY MODES

Γ_9	$a_0(980)\pi$ [ignoring $a_0(980) \to K\overline{K}$]	(38 ± 4) %
Γ_{11}	$K\overline{K}\pi$	(9.0 ± 0.4) %

One must look at mass distribution of a proton + these other products

4 body



$pK\bar{K}$ $I = 1/2$, $J^P = 1/2^+, 3/2^+$

3 body final state

The world of three body bound states involving mesons and baryons is a new frontier in Hadron Physics. ELSA could say something about.

R.~Molina and E.~Oset,
%``Determination of off-shell ambiguities in correlation functions: Strategies to minimize them,''
Phys. Rev. D \textbf{112}, no.9, 096006 (2025)

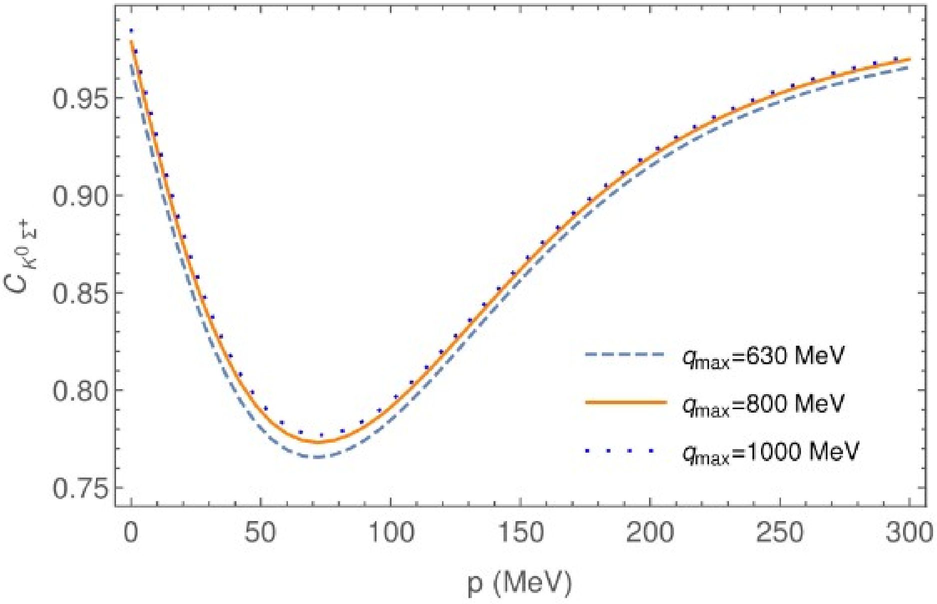


FIG. 1. Correlation function of the $K^0\Sigma^+$ channel for different cutoffs and $R = 1$ fm.

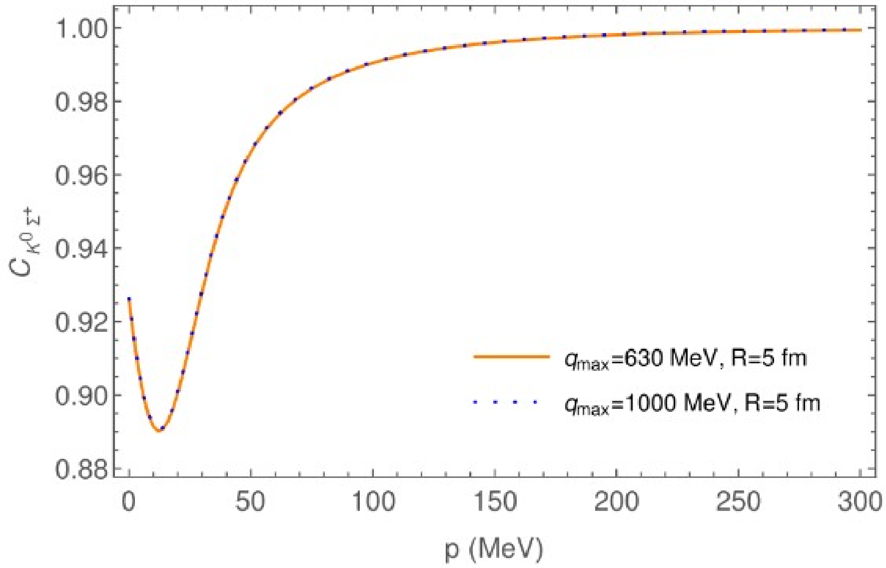


FIG. 5. Correlation function of the $k^0\Sigma^+$ channel for $R = 5$ fm and different cutoffs.

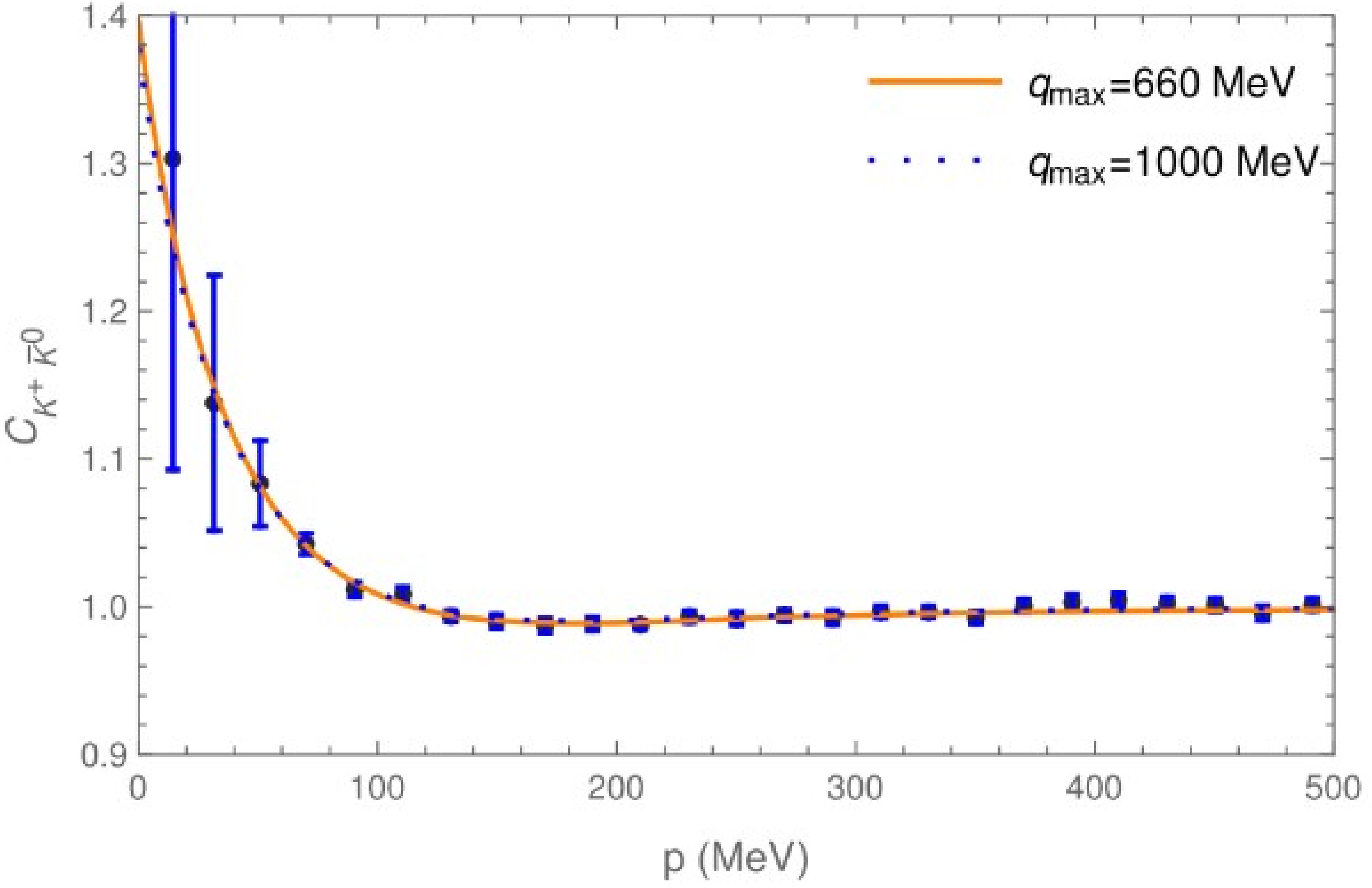


FIG. 6. Correlation function for Fit II in [23] for two different values of the cutoff in $\tilde{G}$.