Interaction of external particles with molecular states

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p f1(1285)

K f1(1285)

π f1(1285), η f1(1285)

K Ds0*(2317)

π Tcc

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

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

Phys.Rev.D 113 (2026) 11, L111502

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

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

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

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

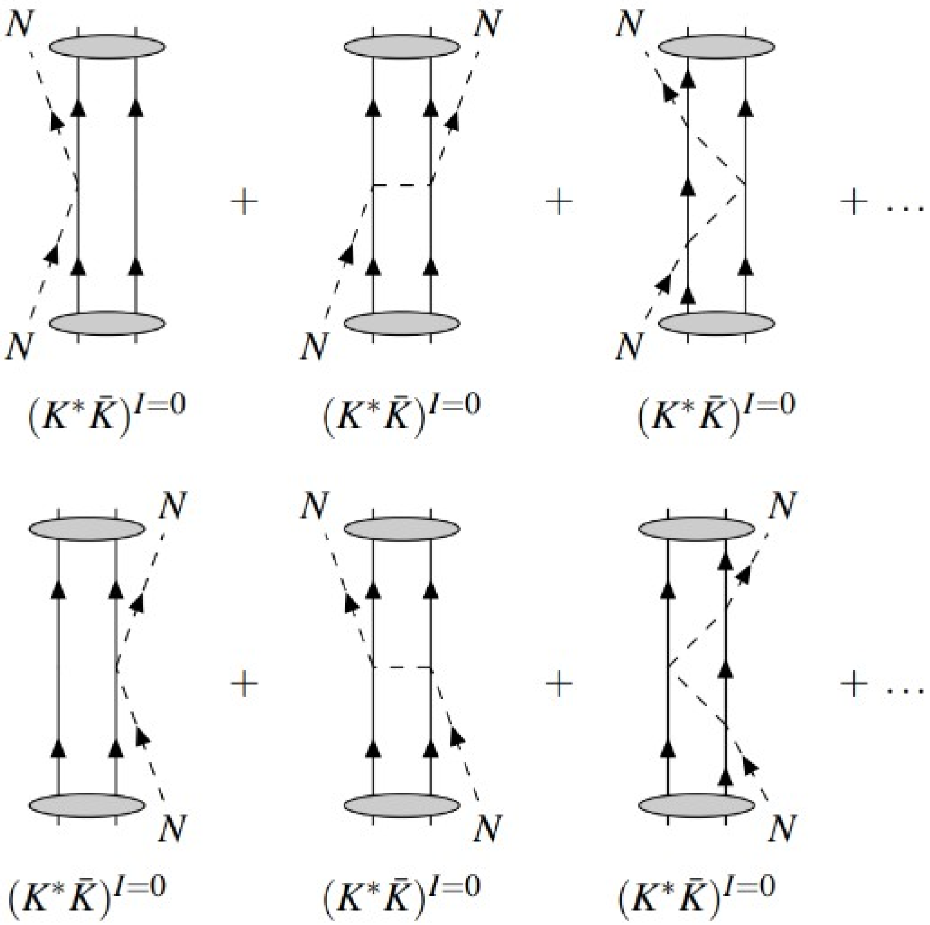
Define optical potential and solve the Lippmann Schwinger Equation

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

The FCA

Partition functions

$$T_{11} = t_1 + t_1 \tilde{G} T_{21},$$
$$T_{12} = t_1 \tilde{G} T_{22},$$
$$T_{21} = t_2 \tilde{G} T_{11},$$
$$T_{22} = t_2 + t_2 \tilde{G} T_{12},$$



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

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

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

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

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

Version for students. Schroedinger Eqn. $(H_0 + V)|\psi\rangle = E|\psi\rangle$ $H_0|\phi\rangle = E|\phi\rangle$.

$$(E - H_0)|\psi - \phi\rangle = V|\psi\rangle,$$

$$|\psi - \phi\rangle = \frac{1}{E - H_0} V|\psi\rangle,$$

$$|\psi\rangle = |\phi\rangle + \frac{1}{E - H_0} V|\psi\rangle$$

define T such that $T|\phi\rangle = V|\psi\rangle$

$$T|\phi\rangle = V|\phi\rangle + V\frac{1}{E - H_0} V|\psi\rangle \qquad T = V + V\frac{1}{E - H_0}T$$

Lippmann Schwinger eqn.

Assume $\langle \boldsymbol{p}'|V|\boldsymbol{p}\rangle = V(\boldsymbol{p}', \boldsymbol{p}) = v\theta(\Lambda - p')\theta(\Lambda - p),$

$$\langle \boldsymbol{p}|T|\boldsymbol{p}'\rangle = \langle \boldsymbol{p}|V|\boldsymbol{p}'\rangle + \int d^3p'' \frac{\langle \boldsymbol{p}|V|\boldsymbol{p}''\rangle}{E - m_1 - m_2 - \boldsymbol{p}''^2/2\mu} \langle \boldsymbol{p}''|T|\boldsymbol{p}'\rangle$$

$$\langle \boldsymbol{p}|T|\boldsymbol{p}'\rangle \equiv \theta(\Lambda - p')\theta(\Lambda - p)t,$$

which has the solution

$$t = v + vGt = \frac{v}{1 - vG} = \frac{1}{v^{-1} - G} \qquad G = \int_{p<\Lambda} d^3p \frac{1}{E - m_1 - m_2 - \boldsymbol{p}^2/2\mu + i\epsilon}$$

Wave functions

$$(H_0 + V)|\psi\rangle = E|\psi\rangle$$

$$\langle\vec{p}|\psi\rangle = \int d^3k \int d^3k' \langle\vec{p}|\frac{1}{E-H_0}|\vec{k}'\rangle\langle\vec{k}'|V|\vec{k}\rangle\langle\vec{k}|\psi\rangle$$

$$|\psi\rangle = \frac{1}{E-H_0}V|\psi\rangle,$$

$$= v\frac{\Theta(\Lambda - p)}{E - m_1 - m_2 - \frac{\vec{p}^2}{2\mu}}\int_{k<\Lambda} d^3k\langle\vec{k}|\psi\rangle,$$

Generalization to coupled channels

$$\langle\vec{p}|\psi_i\rangle = \Theta(\Lambda - p)\frac{1}{E - M_i - \frac{\vec{p}^2}{2\mu_i}}\sum_j v_{ij}\int_{k<\Lambda} d^3k\langle\vec{k}|\psi_j\rangle,$$

$$g_i = \sum_j v_{ij}\int_{k<\Lambda} d^3k\langle\vec{k}|\psi_j\rangle$$

$$T = V + V\frac{1}{E-H}V.$$

$$\sum_i\langle\psi_i|\psi_i\rangle = \int d^3p\sum_i|\langle\vec{p}|\psi_i\rangle|^2$$

$$T_{ij} = v_{ij} + \sum_{mn} v_{im}\int_{k<\Lambda} d^3k\langle\vec{k}|\psi_m\rangle\frac{1}{E-E_\alpha}\times\int_{k'<\Lambda} d^3k'\langle\vec{k}'|\psi_n\rangle v_{nj},$$

$$\sum_i g_i^2\frac{dG_{ii}}{dE}\bigg|_{E=E_\alpha} = -1$$

$T_{ij} \approx g_i\, g_j / (E-E_\alpha)$

Around the pole

Each term with minus sign gives the probability of the corresponding channel

$$F_c(q) = \tilde{F}_c(q)/\tilde{F}_c(0)$$

with

$$\begin{aligned}
\tilde{F}_c(q) = & \int \frac{d^3p}{(2\pi)^3} \frac{1}{M_c - \omega_{K^*}(p) - \omega_{\bar{K}}(p)} \\
& \times \frac{1}{M_c - \omega_{K^*}(\vec{p}-\vec{q}) - \omega_{\bar{K}}(\vec{p}-\vec{q})} \\
|\vec{p}| & < q_{max} \\
|\vec{p}-\vec{q}| & < q_{max}
\end{aligned}$$

Based on

$$\Psi(p) \sim \frac{\Theta(q_{\max} - |\vec{p}|)}{M_c - \omega_{K^*}(\vec{p}) - \omega_{\bar{K}}(\vec{p})}$$

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

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

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

Formalism developed in N. Ikeno, E. Oset

Phys.Rev.D 112 (2025) 9, 094019

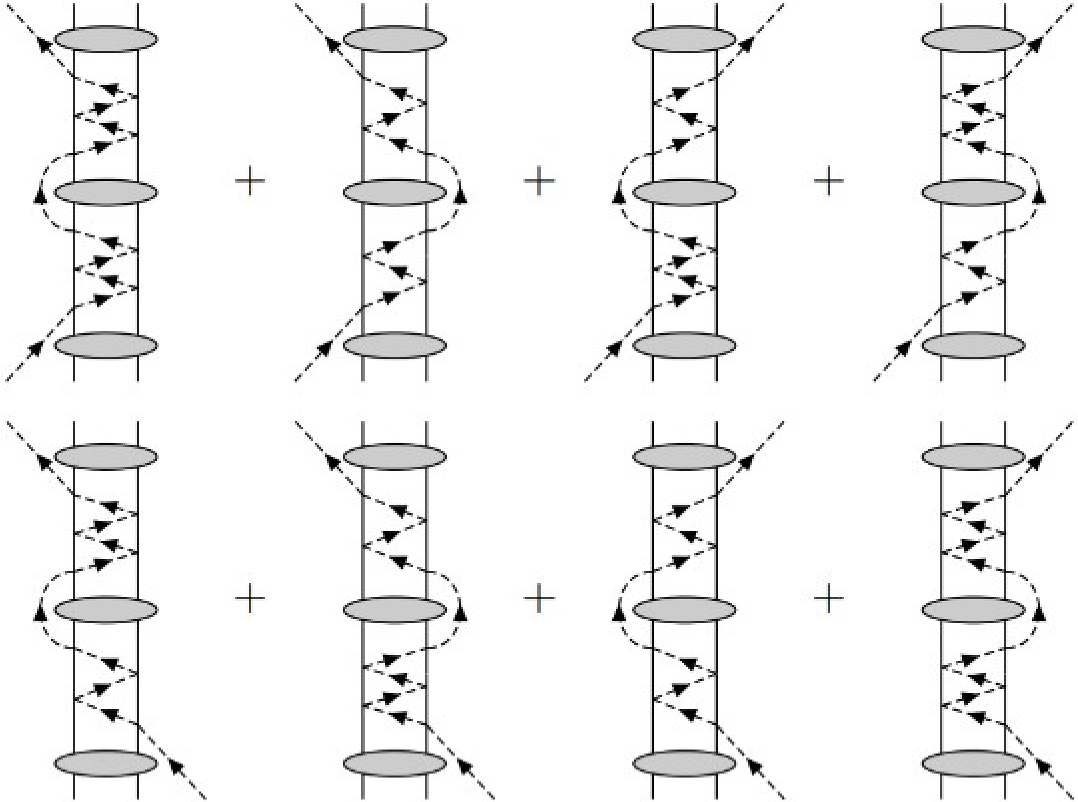


FIG. 2. Diagrams required for the unitarization of the $p f_1(1285)$

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

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

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

Yamagata
Nieves
PRD 83

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

unitarity

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

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

Exact unitarity proved in B. Agatao, P. Brandao, A. Martinez, K. Khemchandani, L. Abreu, E. Oset

Eur.Phys.J.C 85 (2025) 10, 1136

(1) $\bar{K}N$, $I = 0$

We obtain this one using the chiral unitary approach of [92] with the coupled channels $\bar{K}N, \pi\Sigma, \eta\Lambda, K\Xi$. The T matrix is given by

$$T = [1 - VG]^{-1} V \tag{A1}$$

with G the loop function regularized with a cutoff $q_{\mathrm{max}} = 630$ MeV, and with

$$V_{ij} = -\frac{1}{4f^2} D_{ij}(k^0 + k'^0), \tag{A2}$$

(2) $\bar{K}N$, $I = 1$

We follow the same work [92] with the coupled channels $\bar{K}N, \pi\Sigma, \pi\Lambda, \eta\Sigma, K\Xi$. The potential is now given by

$$V_{ij} = -\frac{1}{4f^2} F_{ij}(k^0 + k'^0), \tag{A3}$$

[92] E. Oset and A. Ramos, Nonperturbative chiral approach to S-wave KN interactions, Nucl. Phys. A635, 99 (1998).

$$
\frac{1}{a_0} = \frac{8\pi\sqrt{s}}{2M_N} (T^{\text{tot}}_{K^*\bar{K}})^{-1}|_{\text{th}}
$$

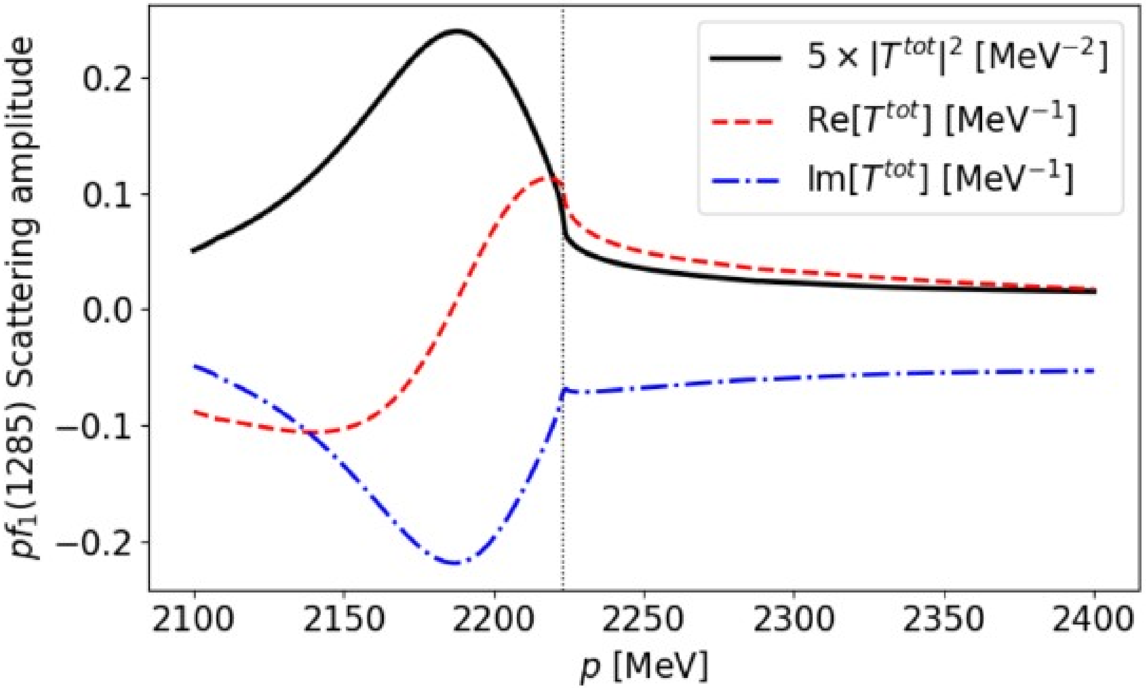
$$
r_0 = \frac{1}{\mu}\left[\frac{\partial}{\partial\sqrt{s}}\left(-\frac{8\pi\sqrt{s}}{2M_N}(T^{\text{tot}}_{K^*\bar{K}})^{-1} + iq_{cm}\right)\right]_{\text{th}}
$$

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

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

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

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



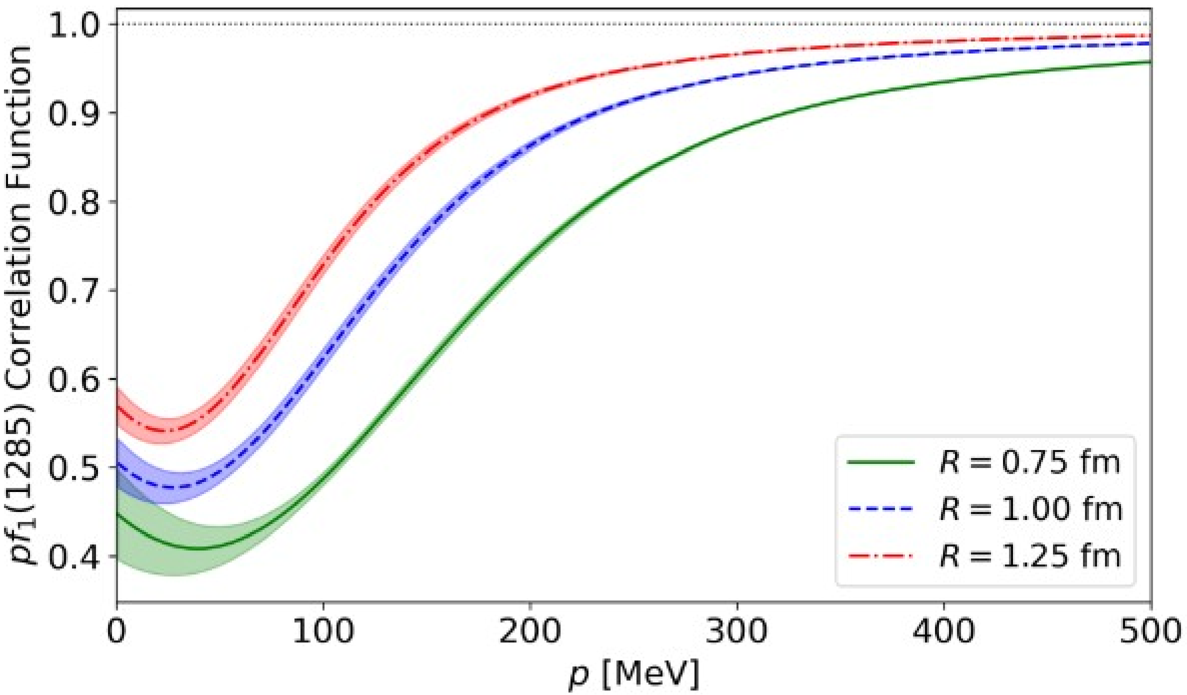
Correlation function

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

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

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

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



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

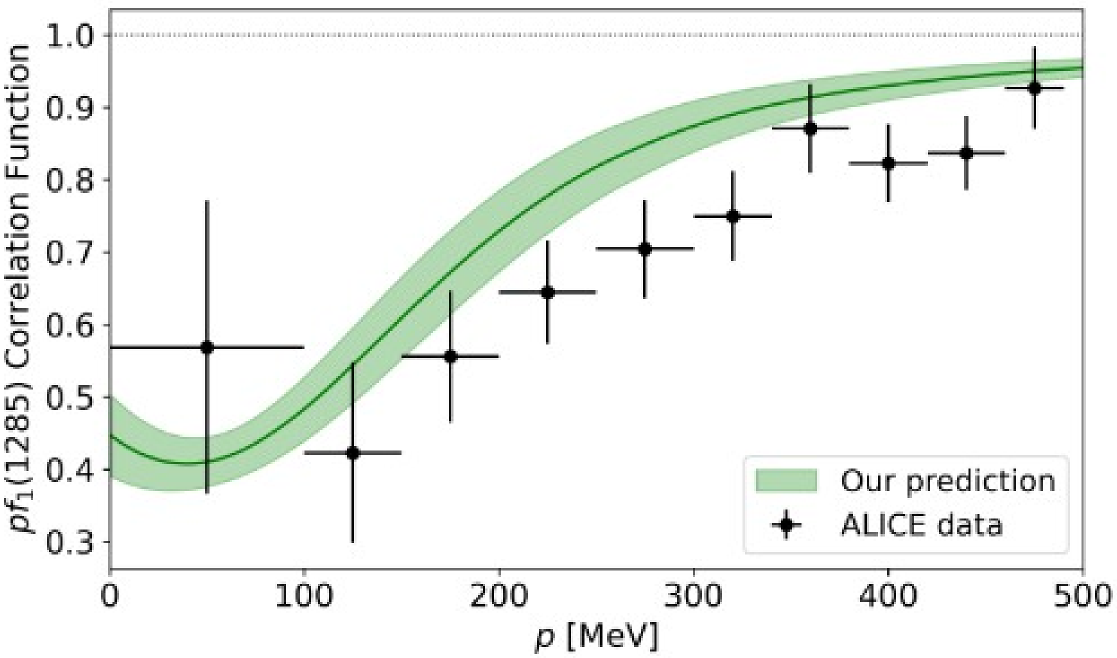


FIG. 5. $pf_1(1285)$ CF for $R = 0.75$ fm with the corresponding error band, compared with the ALICE experimental data taken from [54].

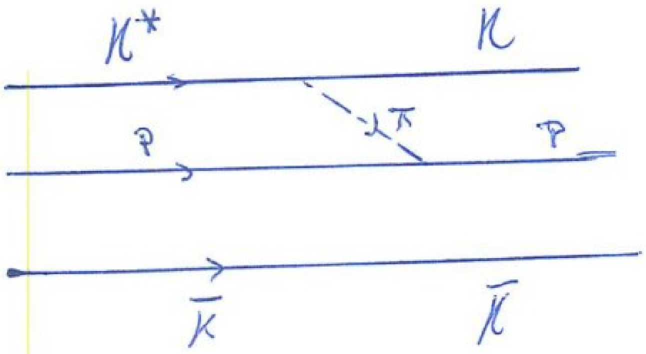
How to observe the state ?

$f_1(1285)$ 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



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

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.

K f1(1285) interaction

Wen Hao Jia, Jing Song, Wei Hong Liang, E. Oset   Eur.Phys.J.C 86 (2026) 7, 761

We replace a proton by a kaon.

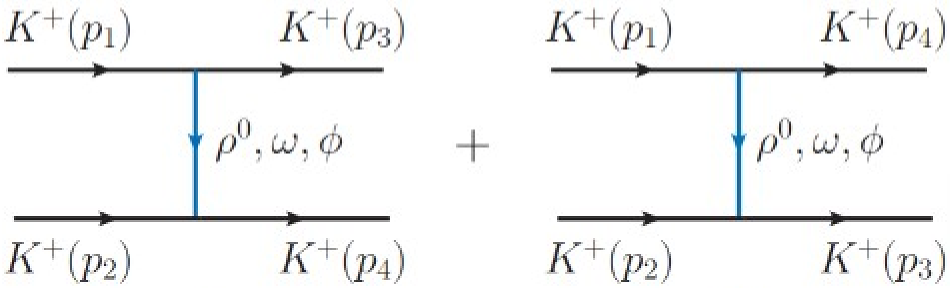
The formalism is identical, but we need now the amplitudes

K K* , K Kbar, K K*bar , K K

$$\mathcal{L}_{VPP} = -ig\,\langle [P, \partial_\mu P]\, V^\mu \rangle\,,$$

with $g = \frac{M_V}{2f}$, $M_V = 800$ MeV and $f = 93$ MeV.

$$P = \begin{pmatrix} \frac{1}{\sqrt{2}}\pi^0 + \frac{1}{\sqrt{3}}\eta & \pi^+ & K^+ \\ \pi^- & -\frac{1}{\sqrt{2}}\pi^0 + \frac{1}{\sqrt{3}}\eta & K^0 \\ K^- & \bar{K}^0 & -\frac{1}{\sqrt{3}}\eta, \end{pmatrix} \qquad V = \begin{pmatrix} \frac{1}{\sqrt{2}}\rho^0 + \frac{1}{\sqrt{2}}\omega & \rho^+ & K^{*+} \\ \rho^- & -\frac{1}{\sqrt{2}}\rho^0 + \frac{1}{\sqrt{2}}\omega & K^{*0} \\ K^{*-} & \bar{K}^{*0} & \phi \end{pmatrix}$$



(a) (b)

$$V_{KK}^{I=1} = \frac{4g^2}{M_V^2}\left(\frac{3}{2}s - 2M_K^2\right)$$

$$T = \frac{V}{1 - \frac{1}{2}VG}.$$

$$V_{KK}^{I=0} = 0.$$

K K* interaction

$$\mathcal{L}_{VVV} = ig\,\langle\,(V^\mu\partial_\nu V_\mu - \partial_\nu V^\mu V_\mu)\,V^\nu\,\rangle$$

For I=1

$$V' = \frac{2g^2}{M_V^2}\left[\frac{3}{2}s - (M_K^2 + M_{K^*}^2) - \frac{1}{2s}(M_{K^*}^2 - M_K^2)\right], \tag{A10}$$

$$T = \frac{V'}{1 - V'G}$$

$$V_{KK^*}^{I=0} = 0;$$

The K Kbar amplitudes we take form the chiral unitary approach , Oller, Oset

The K K*bar also, One gets the axial vector meson states.

We use the results of Luis Roca and Singh PRD 72, Geng et al. PRD 90

1) $I=0,\ C=+,\ f_1(1285)$

$$f_1(1285) \equiv \frac{1}{\sqrt{2}}\left[-\frac{1}{\sqrt{2}}\left(K^+K^{*-}+K^0\bar{K}^{*0}\right)\right.$$
$$\left.+\frac{1}{\sqrt{2}}\left(K^-K^{*+}+\bar{K}^0K^{*0}\right)\right]$$
$$=\frac{1}{\sqrt{2}}\left[K\bar{K}^*(I=0)+\bar{K}K^*(I=0)\right].$$

2) $I=1,\ C=+,\ a_1(1260)$

$$a_1(1260) \equiv \frac{1}{\sqrt{2}}\left[-\frac{1}{\sqrt{2}}\left(K^+K^{*-}-K^0\bar{K}^{*0}\right)\right.$$
$$\left.+\frac{1}{\sqrt{2}}\left(K^-K^{*+}-\bar{K}^0K^{*0}\right)\right]$$
$$=\frac{1}{\sqrt{2}}\left[K\bar{K}^*(I=1)-\bar{K}K^*(I=1)\right].$$

3) $I=0,\ C=-,\ h_1(1170),\ h_1(1415)$

$$h_1 \equiv \frac{1}{\sqrt{2}}\left[K\bar{K}^*(I=0)-\bar{K}K^*(I=0)\right]$$

4) $I=1,\ C=-,\ b_1(1235)$

Here we have analogy to in Eq. (A15)

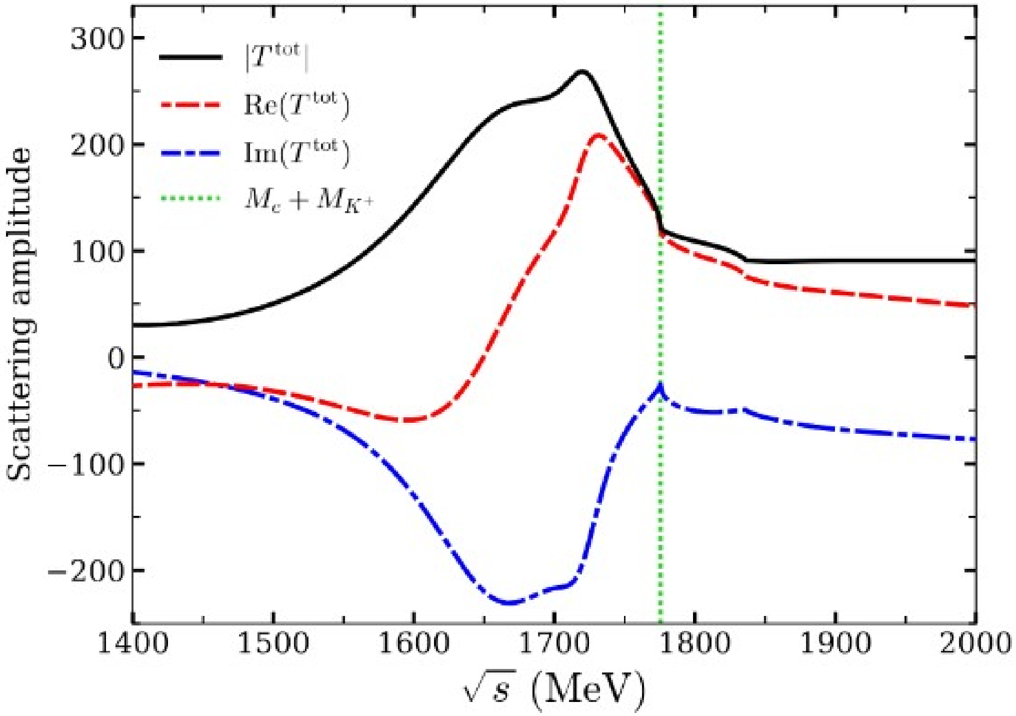
$$b_1(1235)=\frac{1}{\sqrt{2}}\left[K\bar{K}^*(I=1)+\bar{K}K^*(I=1)\right]$$

$$
\begin{aligned}
&\langle f_1|\,t\,|f_1\rangle + \langle h_1|\,t\,|h_1\rangle \\
=&\langle K\bar{K}^*,\, I=0|\,t\,|K\bar{K}^*,\, I=0\rangle \\
&+\langle \bar{K}K^*,\, I=0|\,t\,|\bar{K}K^*,\, I=0\rangle \\
=&2\langle K\bar{K}^*,\, I=0|\,t\,|K\bar{K}^*,\, I=0\rangle,
\end{aligned}
$$

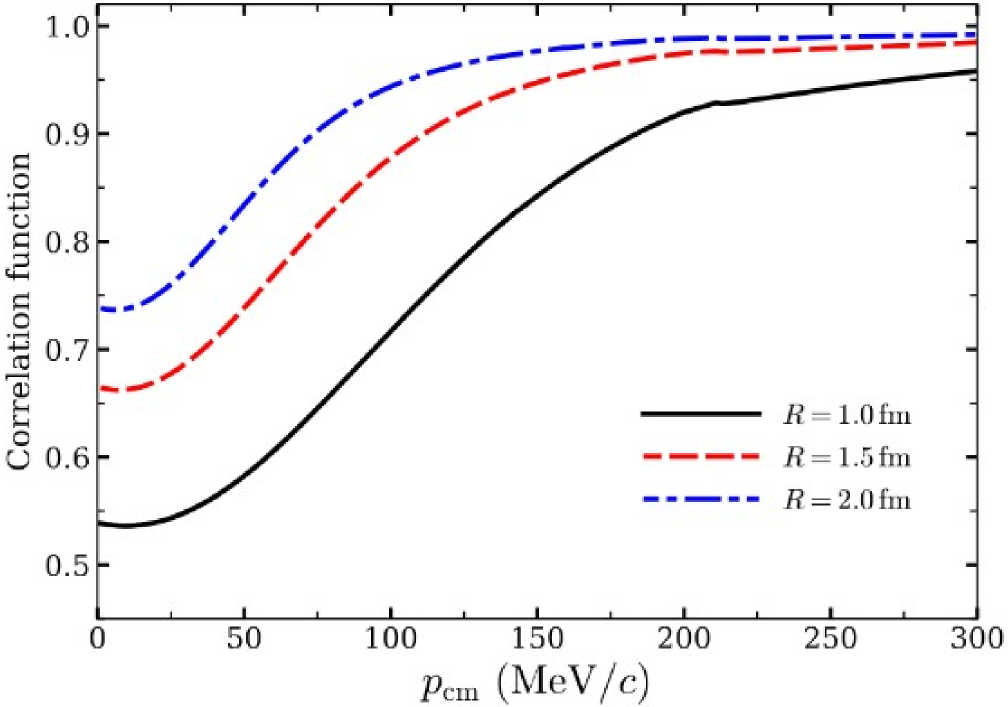
$$
\langle a_1|\,t\,|a_1\rangle + \langle b_1|\,t\,|b_1\rangle = 2\left\langle K\bar{K}^*,\, I=1\right|t\left|K\bar{K}^*,\, I=1\right\rangle
$$

$$
\langle R_i|\,t\,|R_i\rangle = \frac{g_i^2}{s - M_{R_i}^2 + iM_{R_i}\Gamma_{R_i}},
$$

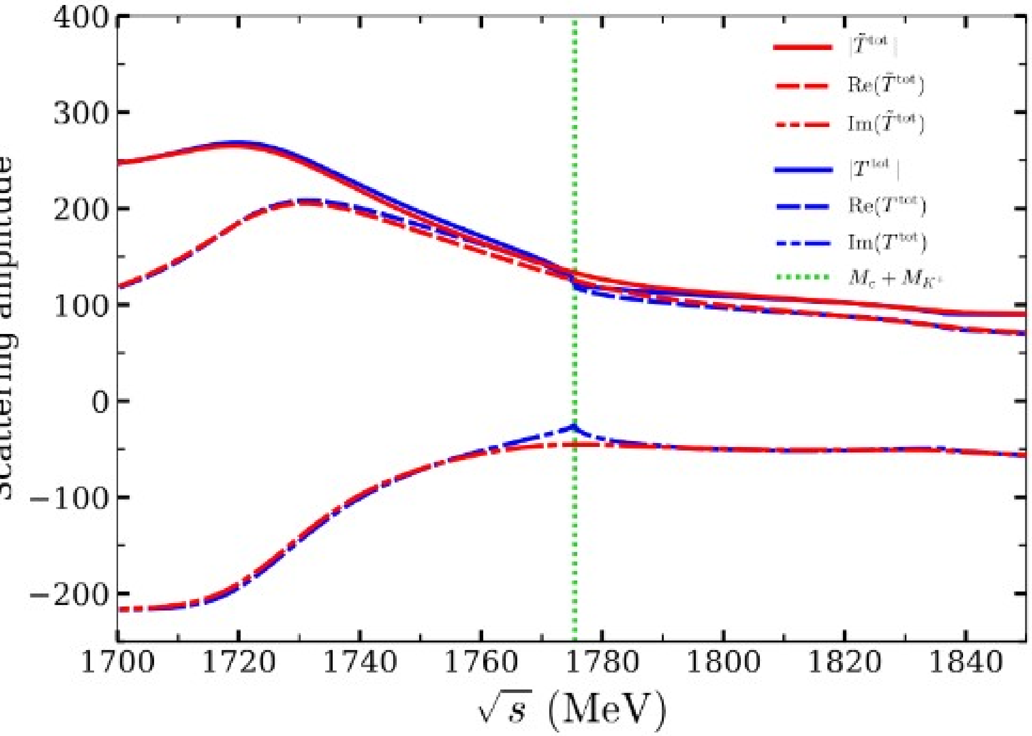
We take mass and with from experiment and the couplings from the paper of Roca Singh



$|T^{\rm tot}|$
$\mathrm{Re}(T^{\rm tot})$
$\mathrm{Im}(T^{\rm tot})$
$M_c + M_{K^+}$
Scattering amplitude
300
200
100
0
−100
−200
1400
1500
1600
1700
1800
1900
2000
$\sqrt{s}$ (MeV)



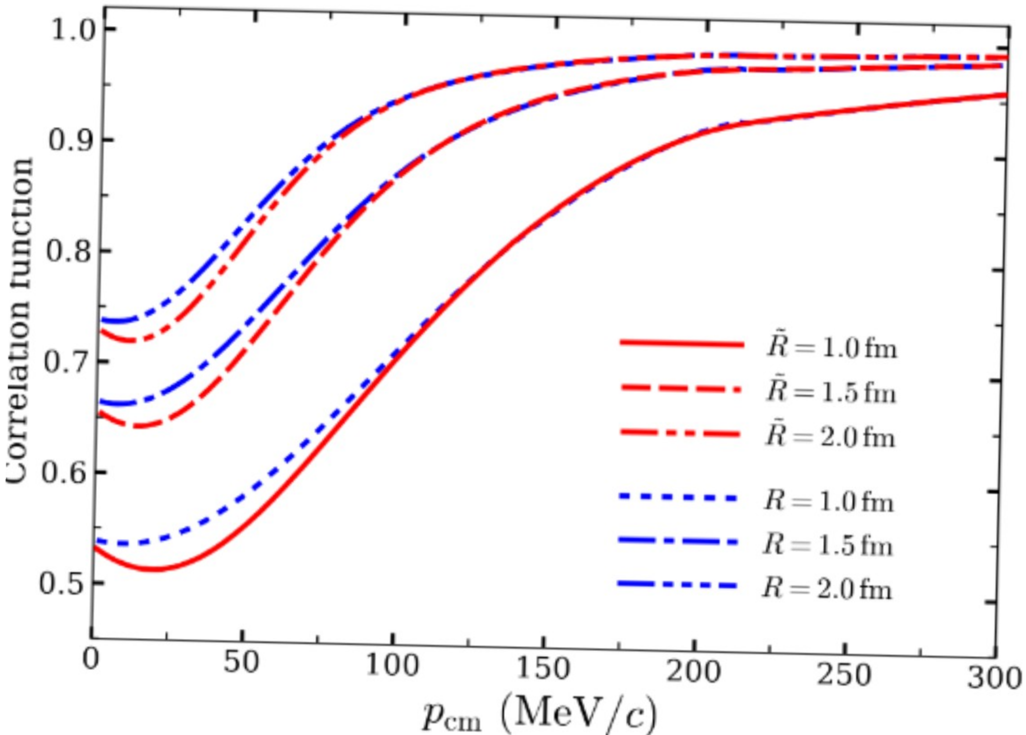
Correlation function
1.0
0.9
0.8
0.7
0.6
0.5
$R = 1.0\,\mathrm{fm}$
$R = 1.5\,\mathrm{fm}$
$R = 2.0\,\mathrm{fm}$
0
50
100
150
200
250
300
$p_{\rm cm}$ (MeV/c)



With convolution for the f1 width

$$a = (0.55 - i\,0.20)\,\text{fm},$$

$$r_0 = (-1.85 + i\,0.26)\,\text{fm}.$$



π^0 f1(1285), η f1(1285) scattering

Wen Hao Jia, Hai Peng Li, Wei Hong Liang, Jing Song, E. Oset

Chinese Physics C 50 103103 (2026)

π^0 scattering

$$t_1 = \frac{2}{3}\, t_{\pi K^*}^{I=3/2} + \frac{1}{3}\, t_{\pi K^*}^{I=1/2}$$

$$t_2 = \frac{2}{3}\, t_{\pi K}^{I=3/2} + \frac{1}{3}\, t_{\pi K}^{I=1/2}$$

η scattering

$$t_1 = t_{\eta K^*}^{I=1/2},$$

$$t_2 = t_{\eta \bar{K}}^{I=1/2} = t_{\eta K}^{I=1/2}$$

Related to work

M.-J. Yan, J. M. Dias, A. Guevara, F.-K. Guo, and B.-
S. Zou, On the η1(1855), π1(1400) and π1(1600) as Dynamically Generated States and Their SU(3) Partners,
Universe 9, 109 (2023), arXiv:2301.04432 [hep-ph].

axial-vector mesons are assumed as matter fields, which provides the Weinberg-Tomozawa interaction of order O(1/f 2), and these interaction give zero.

TABLE I. Transition potentials V_{ij} for the $\pi^- K^+$, $\pi^0 K^0$, and ηK^0 channels.

	$\pi^- K^+$	$\pi^0 K^0$	ηK^0
$\pi^- K^+$	$\frac{-1}{6f^2}\left[\frac{3}{2}s - \frac{3}{2s}\left(m_\pi^2 - m_K^2\right)^2\right]$	$\frac{1}{2\sqrt{2}f^2}\left[\frac{3}{2}s - m_\pi^2 - m_K^2 - \frac{\left(m_\pi^2 - m_K^2\right)^2}{2s}\right]$	$\frac{1}{2\sqrt{6}f^2}\left[\frac{3}{2}s - \frac{7}{6}m_\pi^2 - \frac{1}{2}m_\eta^2 - \frac{1}{3}m_K^2 + \frac{3}{2s}\left(m_\pi^2 - m_K^2\right)\left(m_\eta^2 - m_K^2\right)\right]$
$\pi^0 K^0$		$\frac{-1}{4f^2}\left[-\frac{s}{2} + m_\pi^2 + m_K^2 - \frac{\left(m_\pi^2 - m_K^2\right)^2}{2s}\right]$	$-\frac{1}{4\sqrt{3}f^2}\left[\frac{3}{2}s - \frac{7}{6}m_\pi^2 - \frac{1}{2}m_\eta^2 - \frac{1}{3}m_K^2 + \frac{3}{2s}\left(m_\pi^2 - m_K^2\right)\left(m_\eta^2 - m_K^2\right)\right]$
ηK^0			$-\frac{1}{4f^2}\left[-\frac{3}{2}s - \frac{2}{3}m_\pi^2 + m_\eta^2 + 3m_K^2 - \frac{3}{2s}\left(m_\eta^2 - m_K^2\right)^2\right]$

$$T = \left[1 - VG\right]^{-1} V,$$

Reminiscent of the $\pi_1(1400\text{-}1600)$

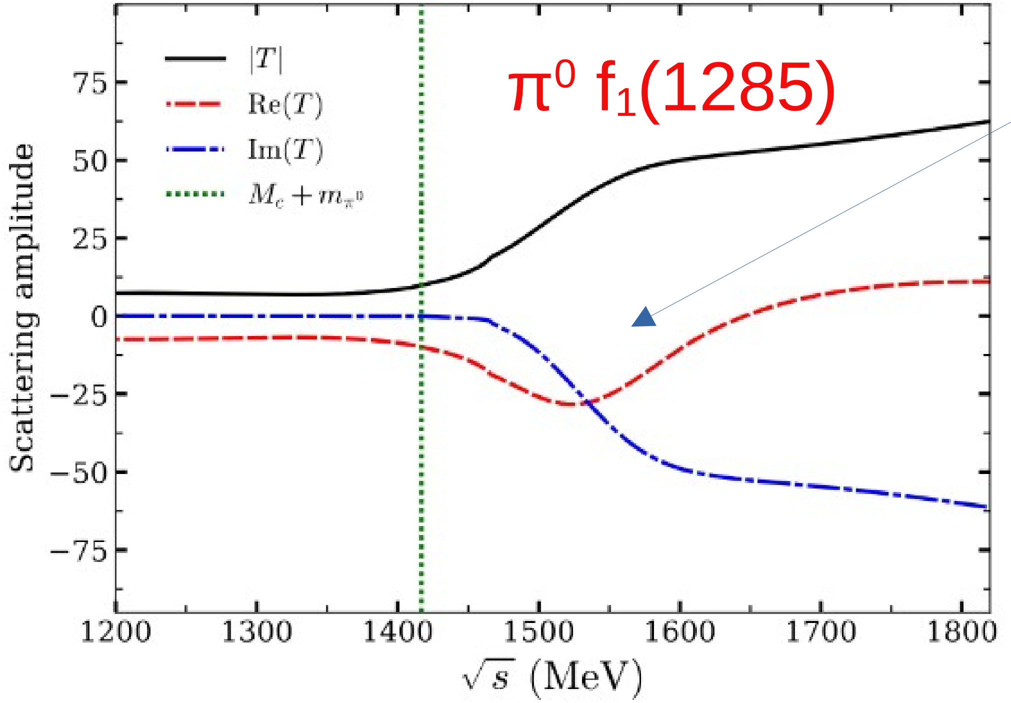


FIG. 3. $\pi^0 f_1(1285)$ scattering amplitude $T^{\text{tot}}_{\pi^0 f_1}$ as a function of $\sqrt{s}$.

$$a = -0.06\,\text{fm},$$

$$r_0 = (-46.00 - i\,0.43)\,\text{fm}$$

r_0 is stable, large value tied to resonance above threshold

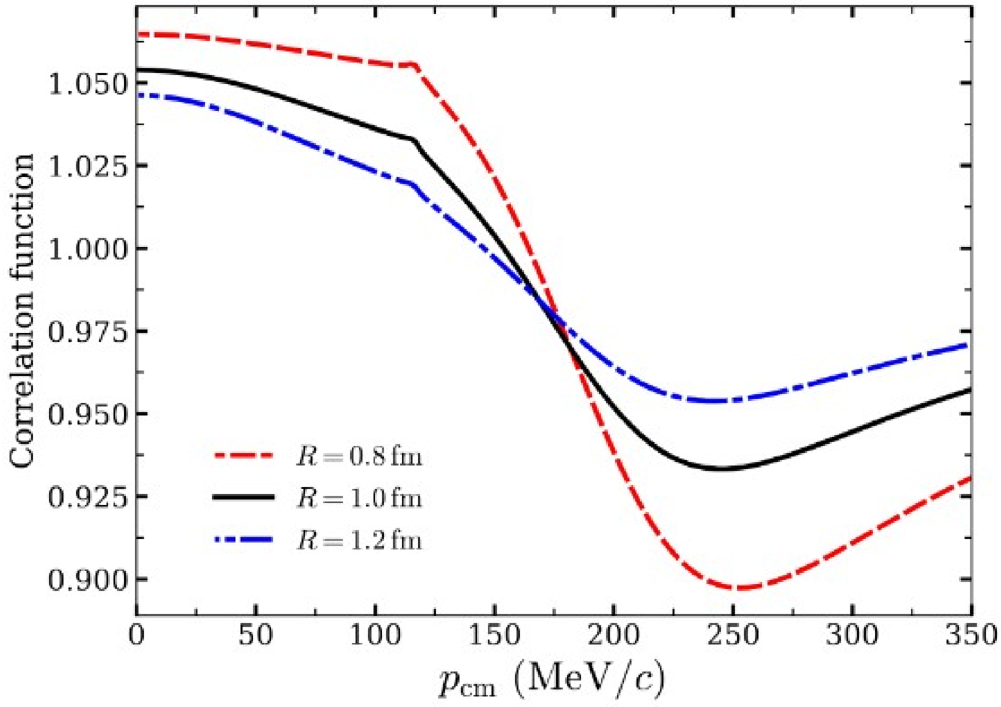


FIG. 5. Correlation functions for the $\pi^0 f_1(1285)$ system as a function of momentum p_{cm}, with different values of the source radius R.

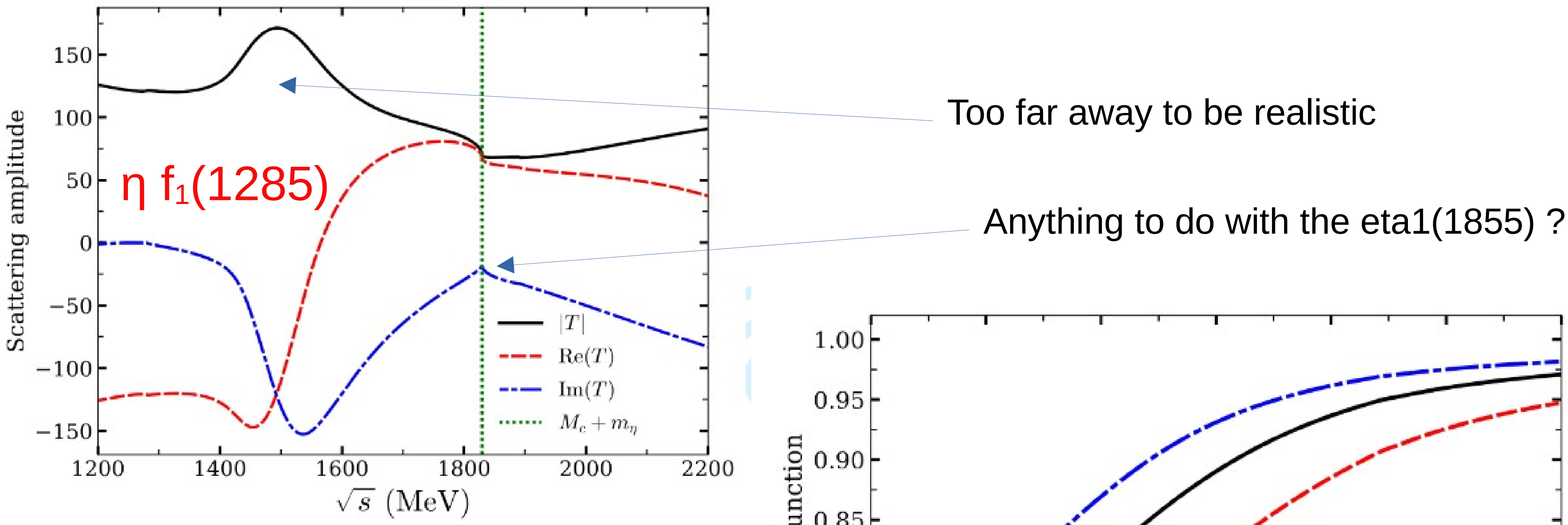
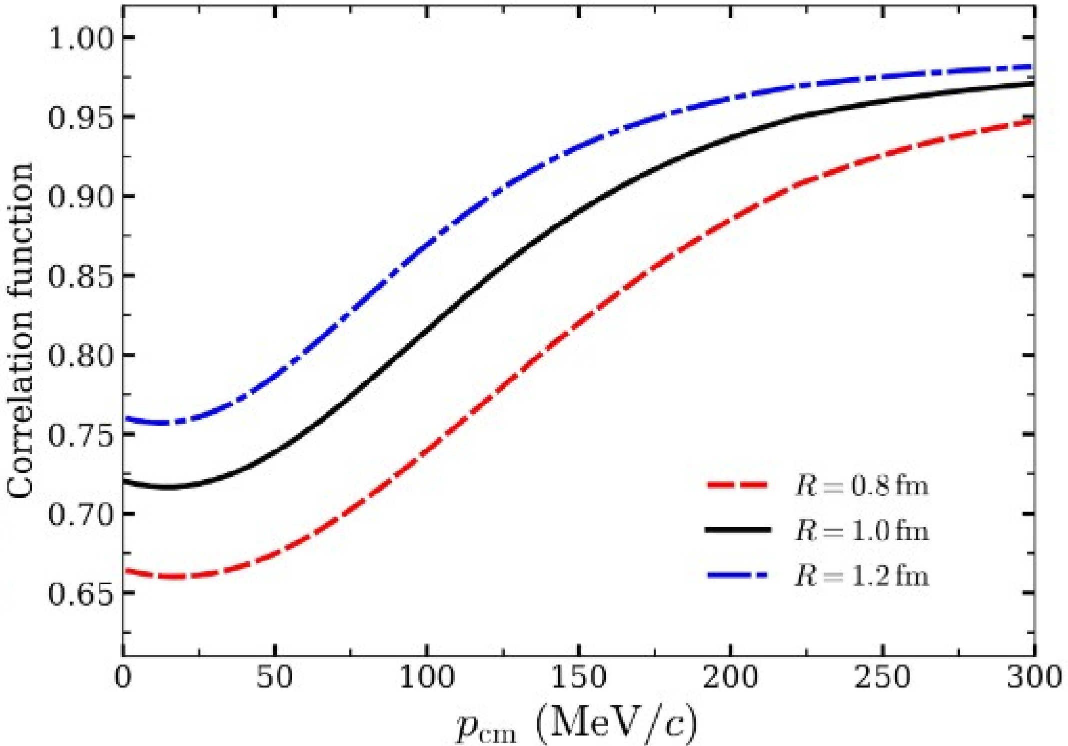


FIG. 4. $\eta f_1(1285)$ scattering amplitude $T^{\rm tot}_{\eta f_1}$ as a function of $\sqrt{s}$.

$$a = (0.29 - i\,0.07)\,\text{fm},$$

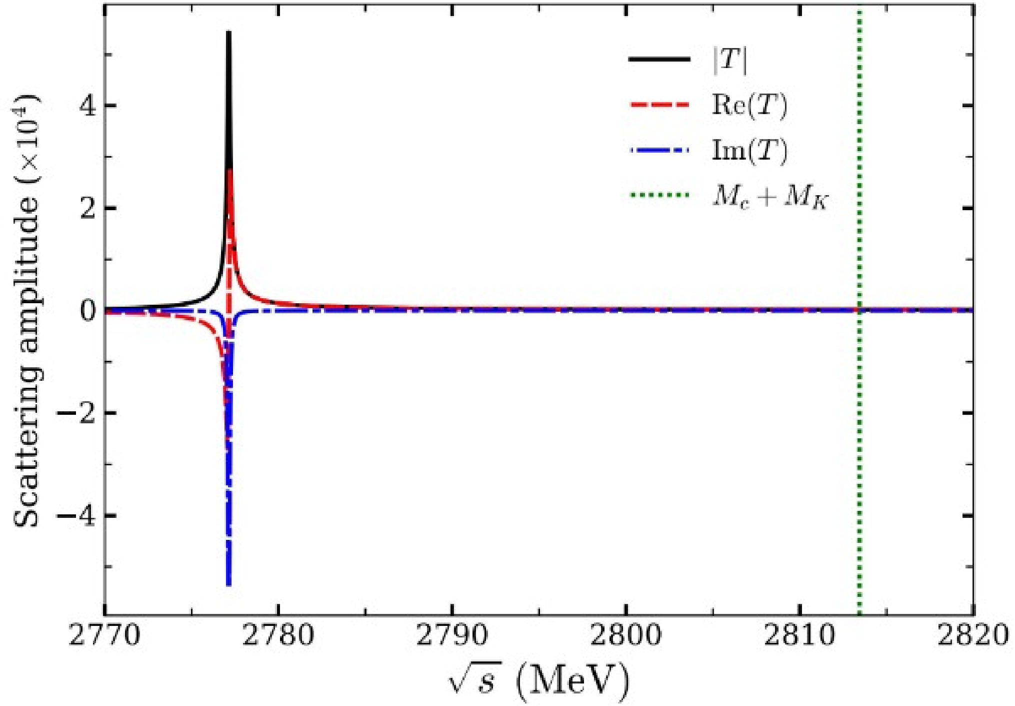
$$r_0 = (0.42 + i\,0.45)\,\text{fm}.$$

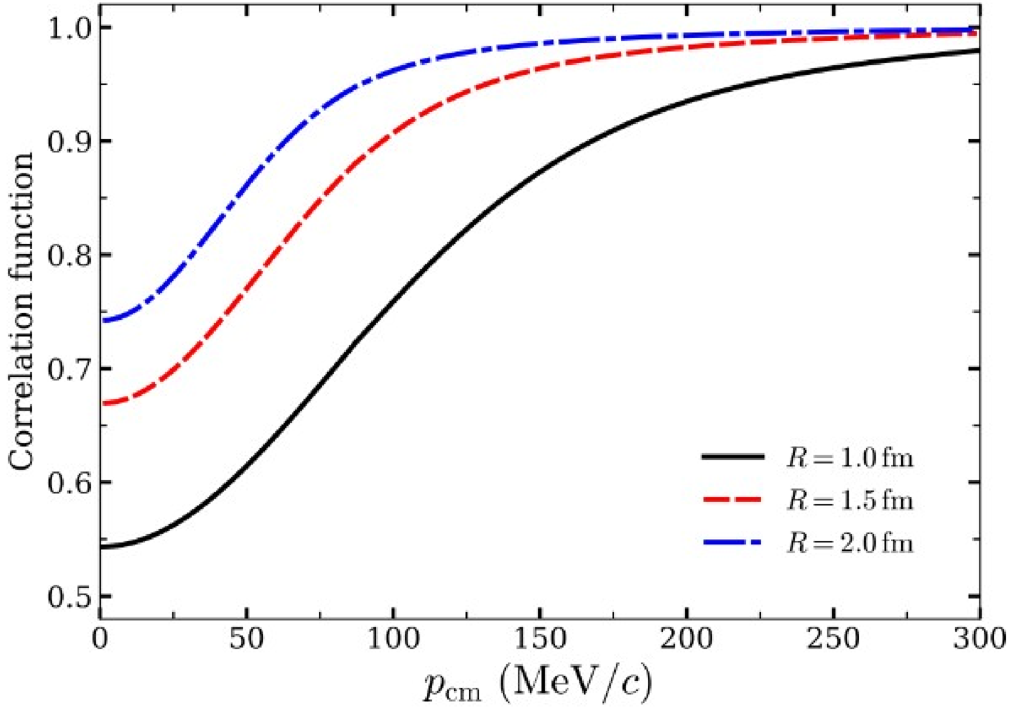


Correlation function and bound state from the $KD_{s0}^*(2317)$ interaction

Wen-Hao Jia,[1,2] Hai-Peng Li,[1,2] Wei-Hong Liang,[1,2] Jing Song,[3,1,*] and Eulogio Oset[1,4,†]

E-Print:
2604.07261, PRD



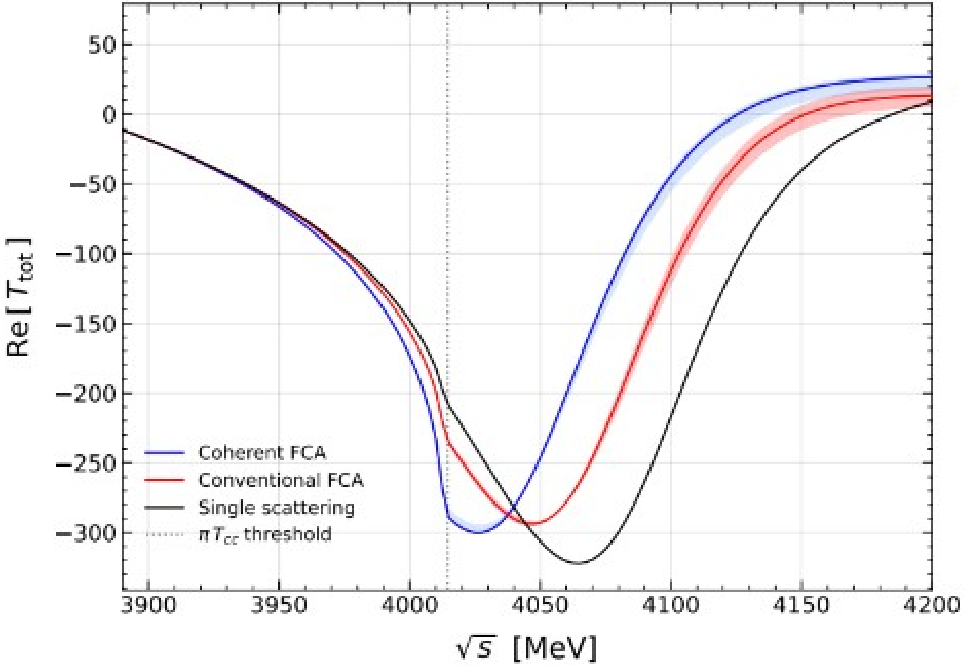


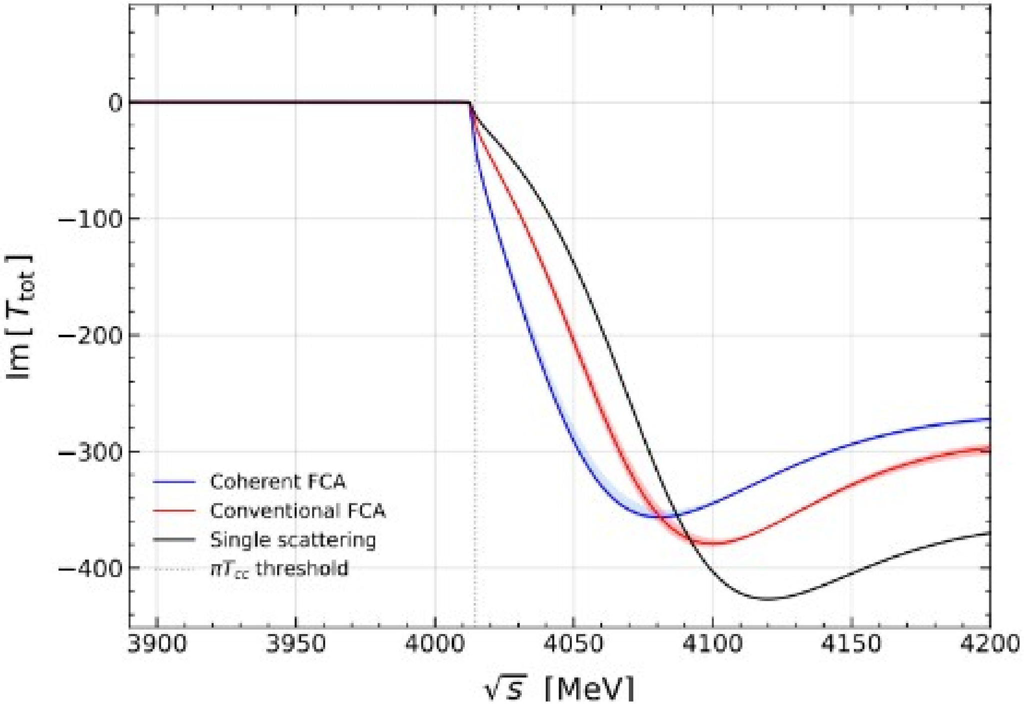
A pion-driven near-threshold enhancement in the πT_{cc} system

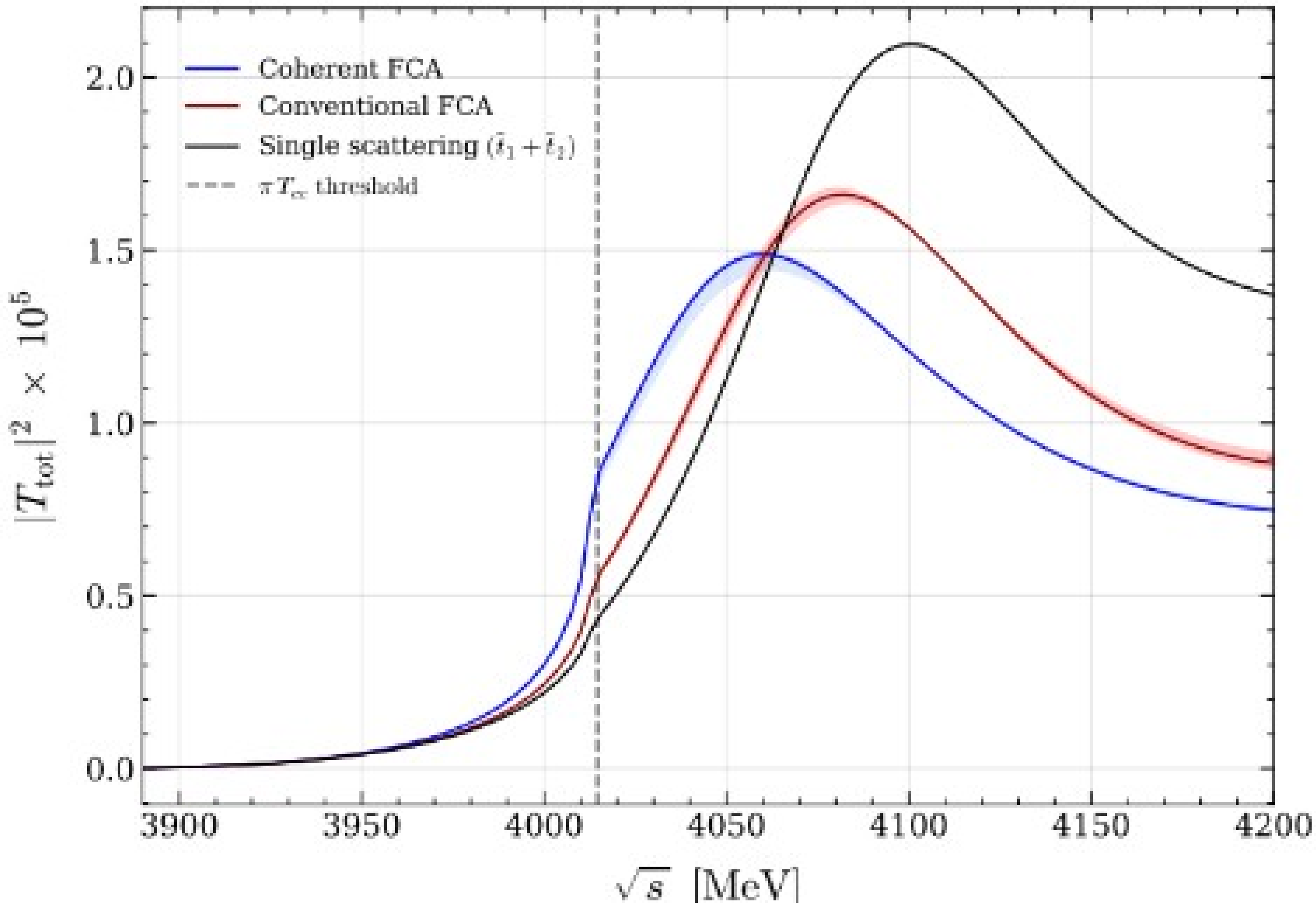
Pedro Brandão[1,*] Jorgivan Morais Dias[2,†] and Luciano M. Abreu[1,‡]

e-Print: 2608.13525

π Tcc







Coherent FCA
Conventional FCA
Single scattering $(\tilde{t}_1 + \tilde{t}_2)$
πT_{cc} threshold
2.0
1.5
1.0
0.5
0.0
$|T_{\rm tot}|^2 \times 10^5$
3900
3950
4000
4050
4100
4150
4200
$\sqrt{s}$ [MeV]

π Tcc

Conclusions

We have developed a framework to study the interaction of an external particle with a molecular state, and applied it to study
p f1(1285), Kf1, pi0 f1, eta f1, K Ds0(2317)

We calculate the scattering amplitude and the correlation function

For pf1 and Kf1, K Ds0(2317) we find a bound state of the three body system

For π^0 f1, we find a structure above threshold, reminiscent of the π_1(1400-1600)

For η f1 the only structure that could be associated to the eta1(1855)
is a threshold effect at that the η f1 threshold.

The experimental results from ALICE for the correlation function of p f1 give a particular credibility to the results that we obtain.

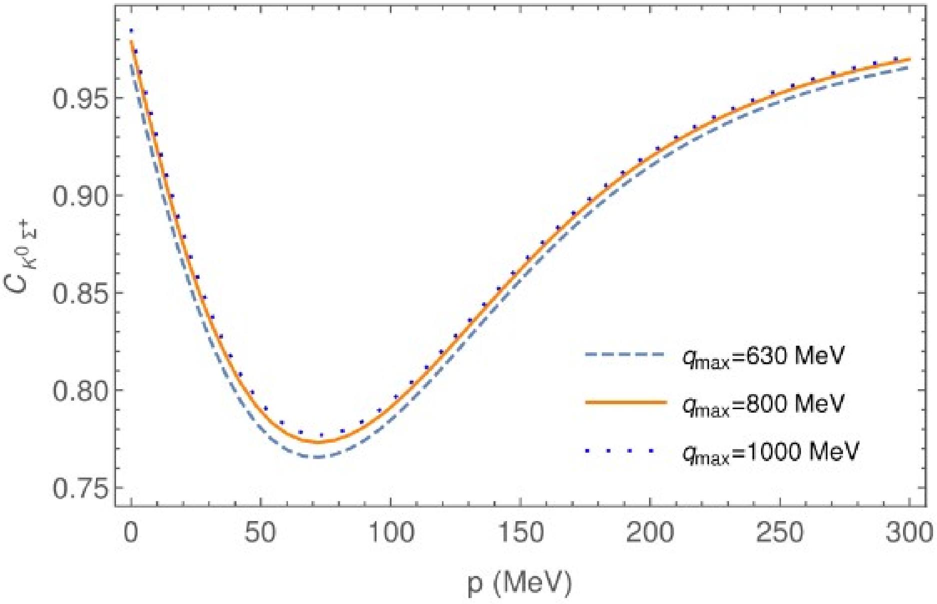


FIG. 1. Correlation function of the $K^0\Sigma^+$ channel for different cutoffs and $R = 1$ fm.

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)

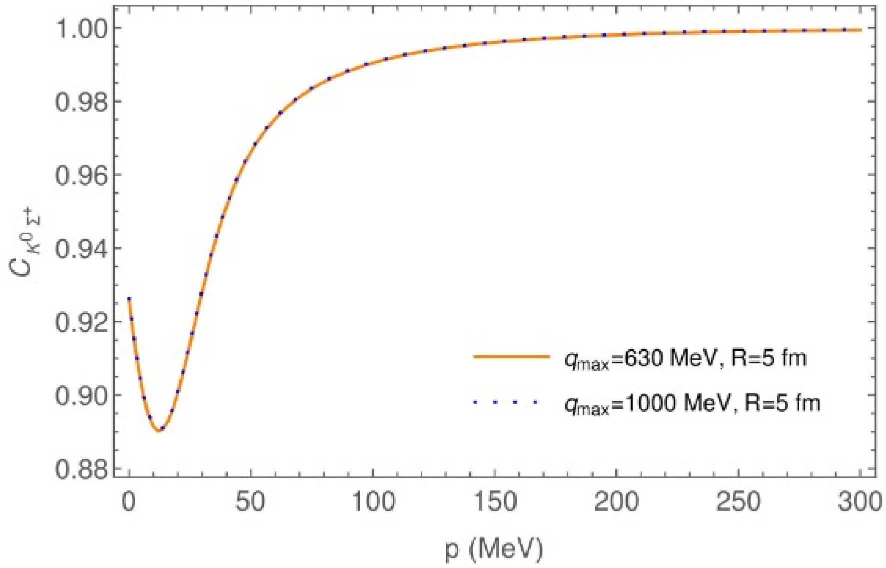


FIG. 5. Correlation function of the $k^0\Sigma^+$ channel for $R = 5$ fm and different cutoffs.

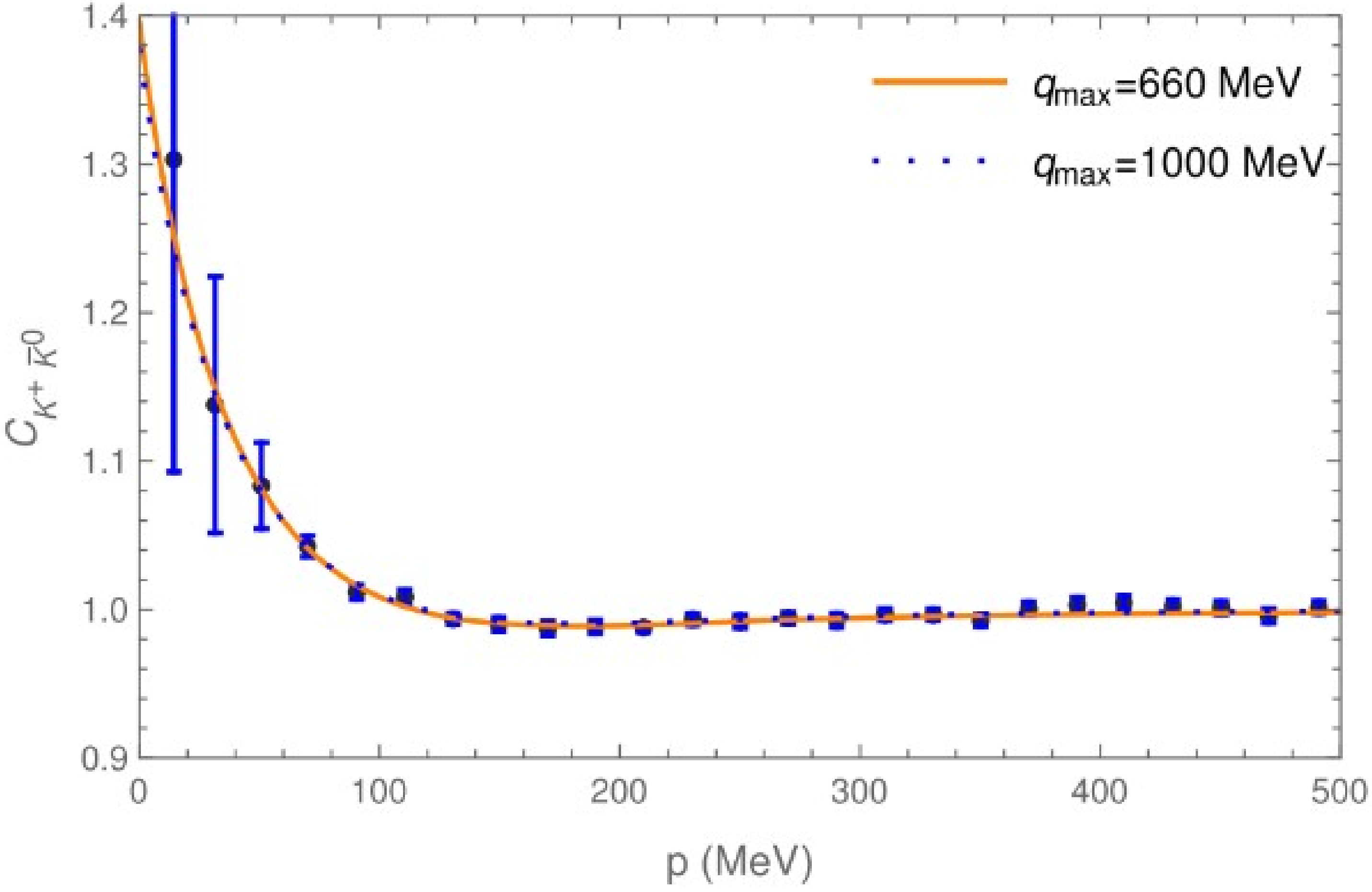


FIG. 6. Correlation function for Fit II in [23] for two different values of the cutoff in $\tilde{G}$.