Modification of π-π amplitudes and position of the sigma pole

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Outline

- ***Definition of the problem***
- ***Why it is so important?***
- ***How to solve it?***
- ***Method***
- ***Results***

Definition of the problem

- **Amplitudes which exist for meson interactions specially Pion - Pion scattering are badly described.**
- **Threshold behavior problem.**
- **Position of the Sigma pole is suspicious.**
- **Parameters of Sigma meson are not well defined.**

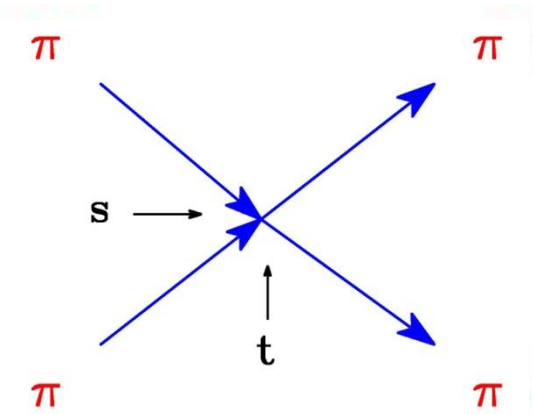
Why it is so important?

- ***Pions are the lightest mesons and they play an important role in explaining the low-energy properties of the strong nuclear force.*** $I^G J^{PC} = 0^+ 0^{++}$
- ***width of Sigma is comparable to the mass ~ 500 MeV***
- ***Sigma decays only on one channel. Pair of Pion-Pion should be easy to describe***
- ***Has vacuum quantum number***
- ***Raised up lots of controversy for years***

History (σ)

- It disappeared from 1978 to 1994
- Formerly known as " ε " or " σ "
- Later known as $f_0(400-1200)$, $f_0(600)$
- Since 2012 $f_0(500)$

Crossing Symmetry + Dispersion Relations



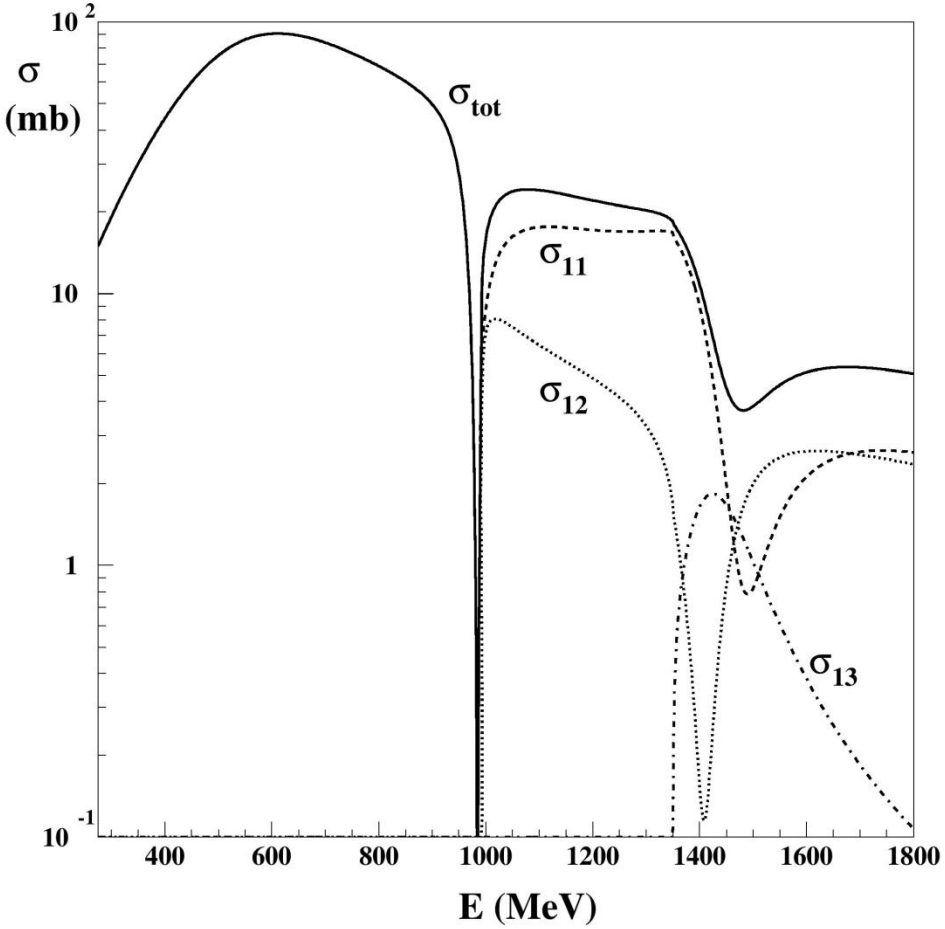
$$\rightarrow \vec{T}_s(s,t) = \hat{C}_{st}\vec{T}_t(t,s)$$

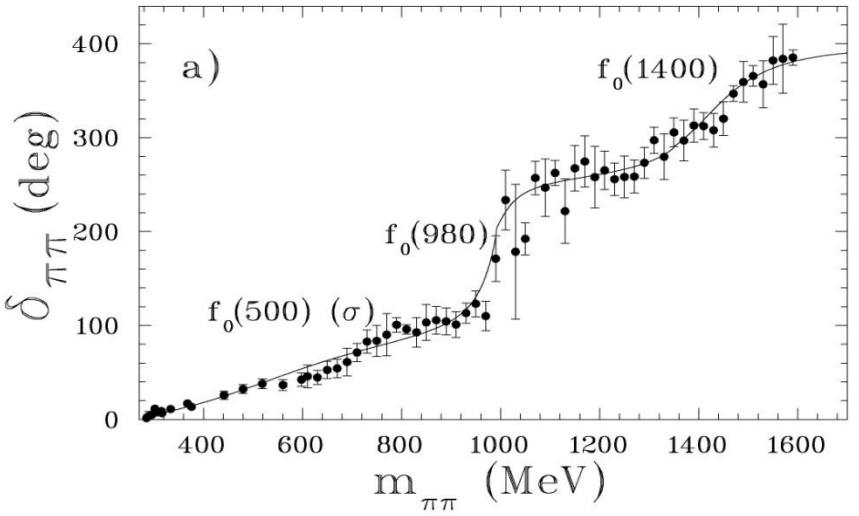
$$\mathrm{Re}\, t_l^{I(OUT)}(s) = \sum_{I'=0}^{2} C_{st}^{II'} a_0^{I'} + \sum_{I'=0}^{2}\sum_{l'=0}^{4} \int_{4m_\pi^2}^{\infty} ds' K_{ll'}^{II'}(s,s')\,\mathrm{Im}\, t_{l'}^{I'(IN)}(s')$$

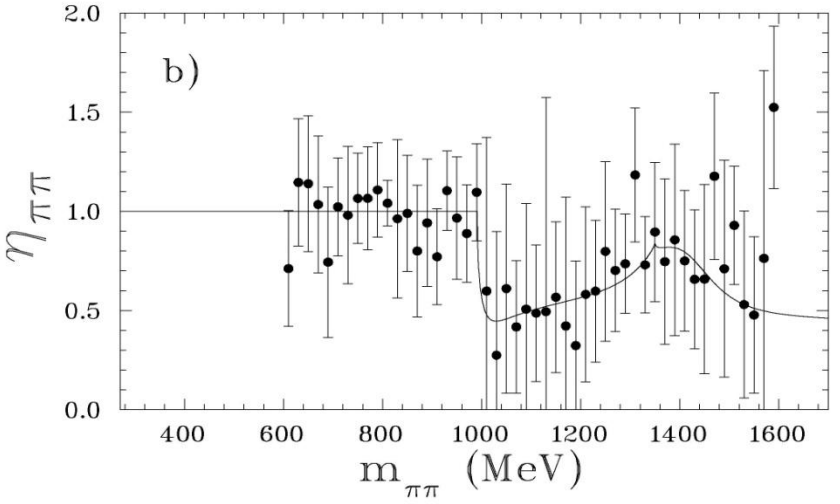
$a_0^{I'}$ ***Constant for interaction at threshold*** $\vec{T}_s(s = 4m_\pi^2, t = 0)$

The general rule: $\mathrm{Re}\, t_l^{I(OUT)}(s) - \mathrm{Re}\, t_l^{I(IN)}(s) \rightarrow 0$

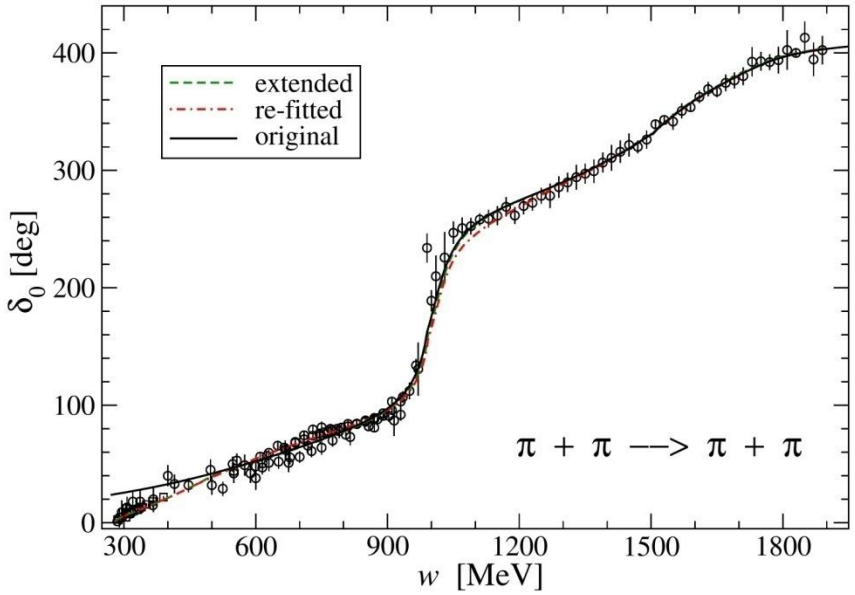
π - π interaction

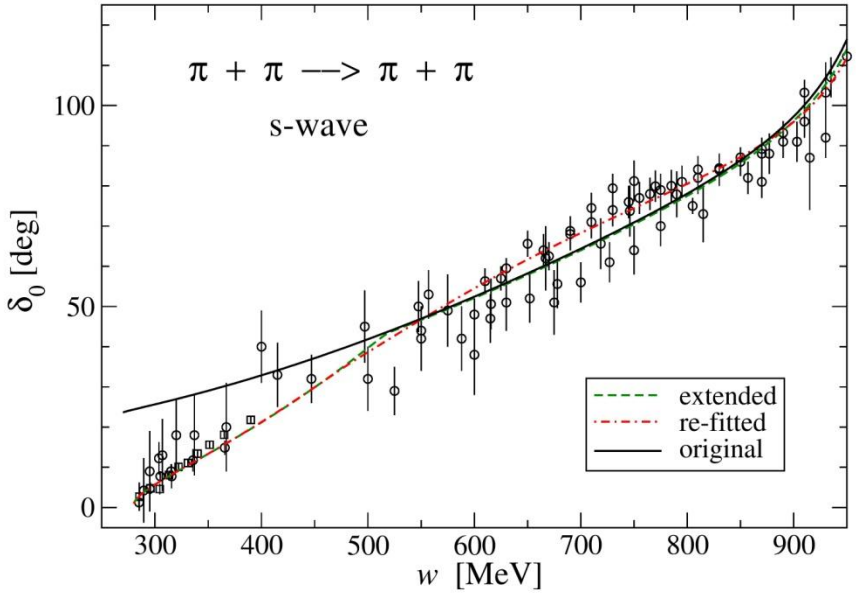






practical application





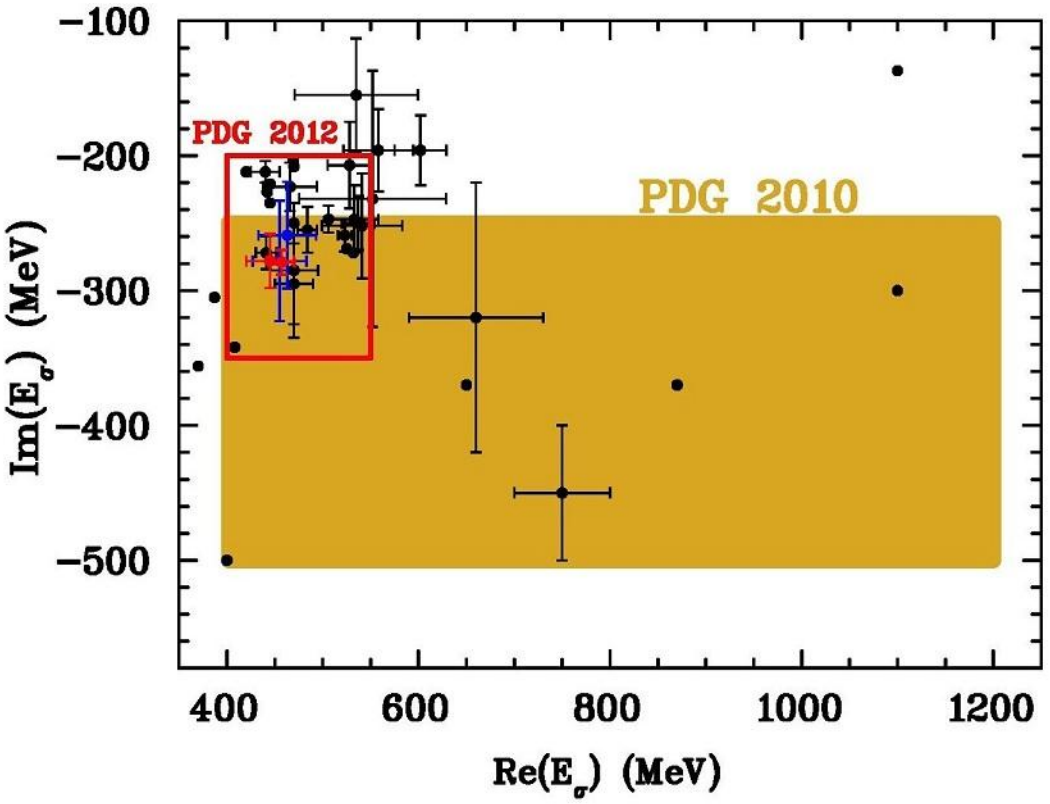
The f0(500) pole moved from 617 + i554 MeV for the original amplitude to 474 + i298 MeV

for the re-fitted one and the χ^2 changed from 571 to 66/55 points

Precise determination of meson $f_0(500)$ (σ)

PDG 2010:
M= 400-1200 MeV
Γ = 2 x (250-500 MeV)

PDG 2012:
M= 400-5500 MeV
Γ = 2 x (200-350 MeV)



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Threshold Parameter:

$$a_0^0 = 0.220 \pm 0.008 m_{\pi^-}$$

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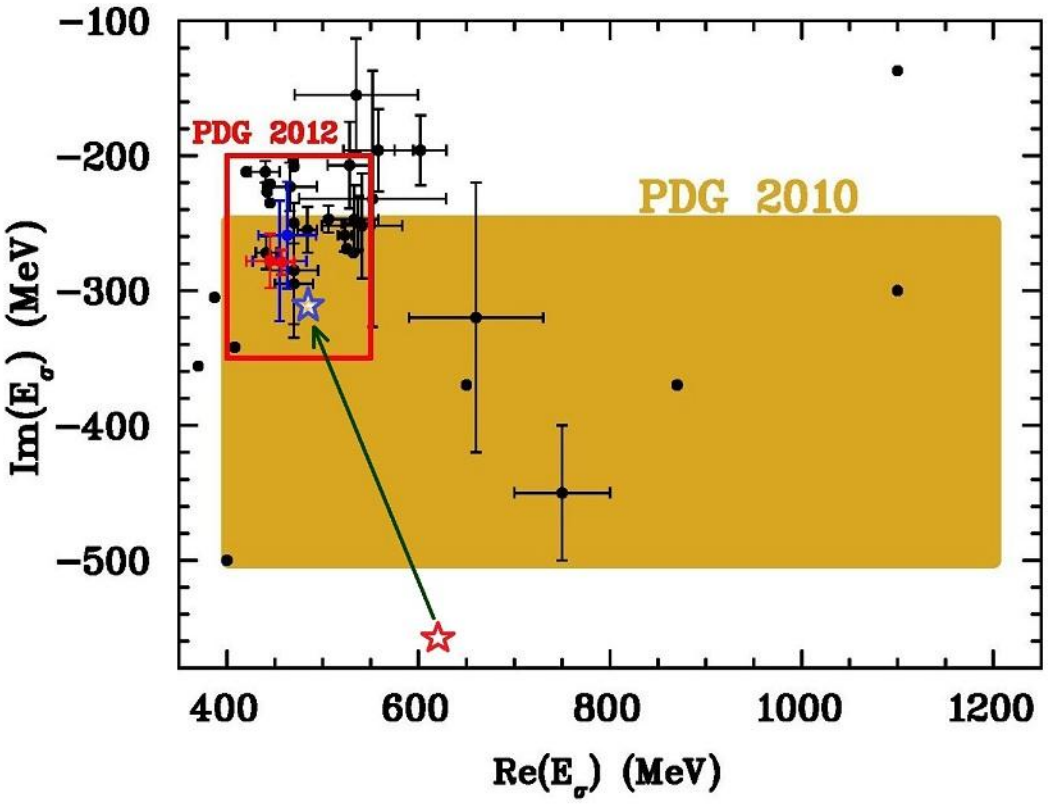

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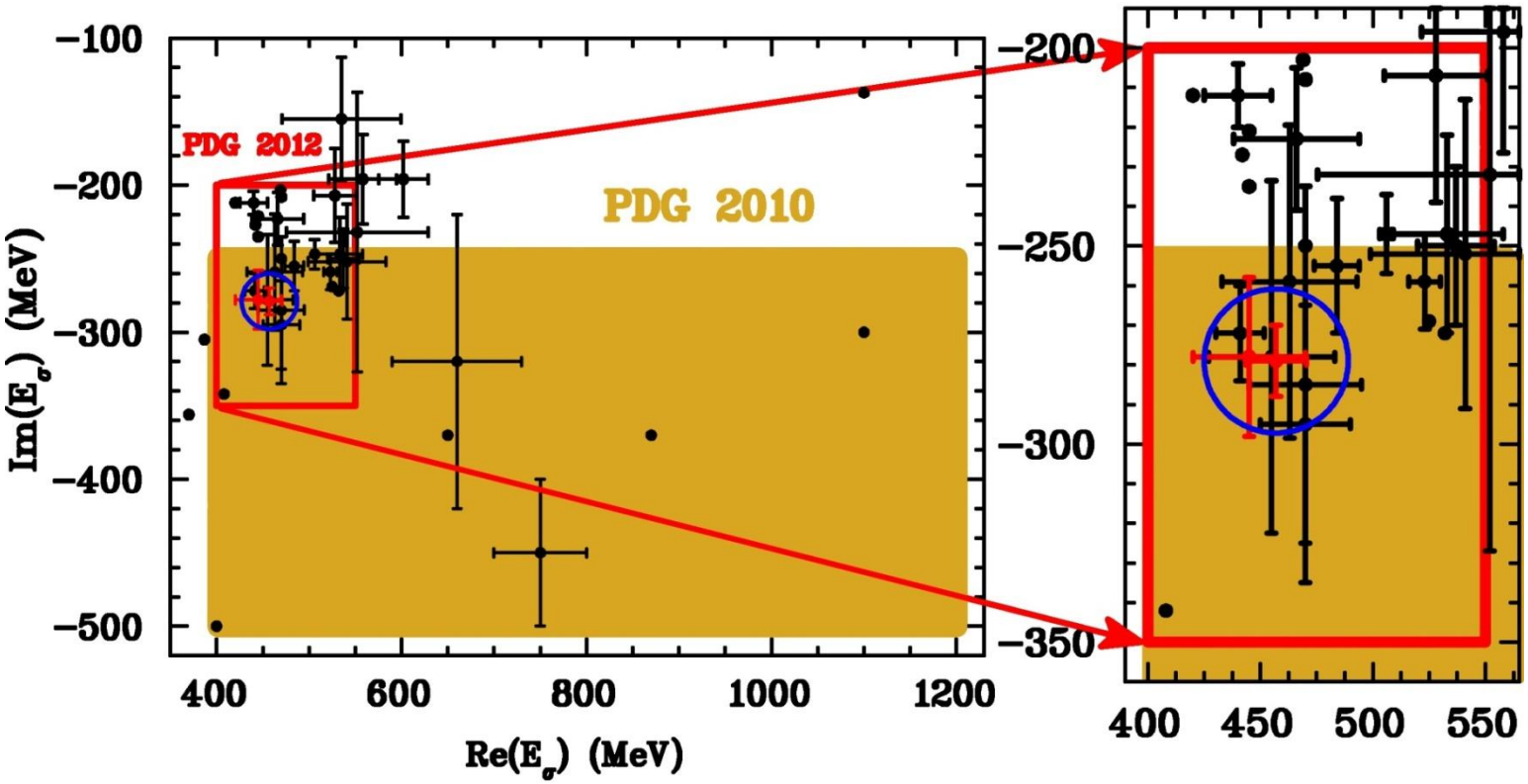

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Conclusions

✓ Achieve to new amplitudes for S and P wave which very well describe the experimental data on scattering from threshold up to 1.8GeV and fulfilled crossing symmetry very well.

✓ The biggest improvement was for DR contribution of χ^2 for both S and P wave.

✓ Position of Sigma pole changes a lot .

✓ Theory of applying DR to improve the amplitudes of S and P wave works very well.

Thank you