Rescattering effect in $J/\Psi(\Psi') \to \rho\pi \to 3\pi$ decay

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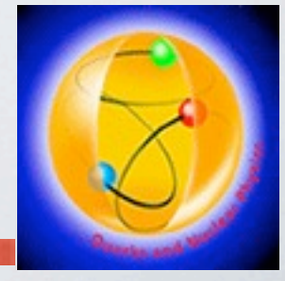
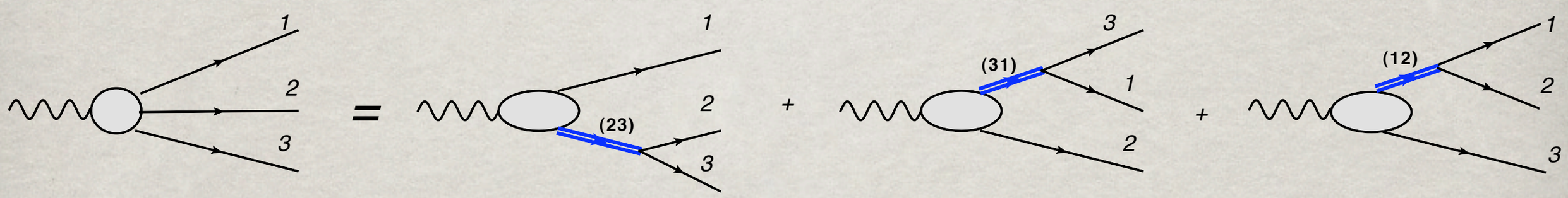


Isobar Model: quasi two-body decays



Outline

- Motivation: Rescattering effect
  (corrections to isobar model) in $J/\Psi(\Psi') \to \rho\pi \to 3\pi$
- Method: Unitarity + Analyticity
- Conclusion

rho-pi puzzle

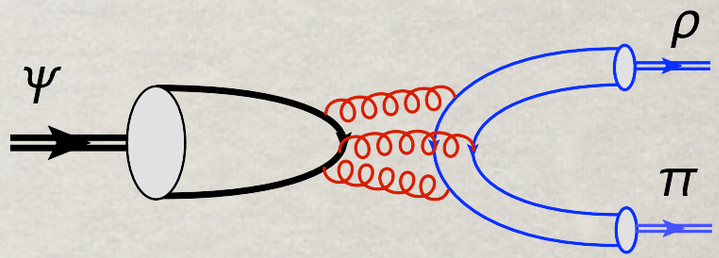
Experiment measurement

$$\frac{Br(\Psi' \to \rho(770)\pi)}{Br(J/\Psi \to \rho(770)\pi)} = 0.2 \pm 0.1\%$$

vs

PQCD

12%



$J/\Psi \to 3\pi$

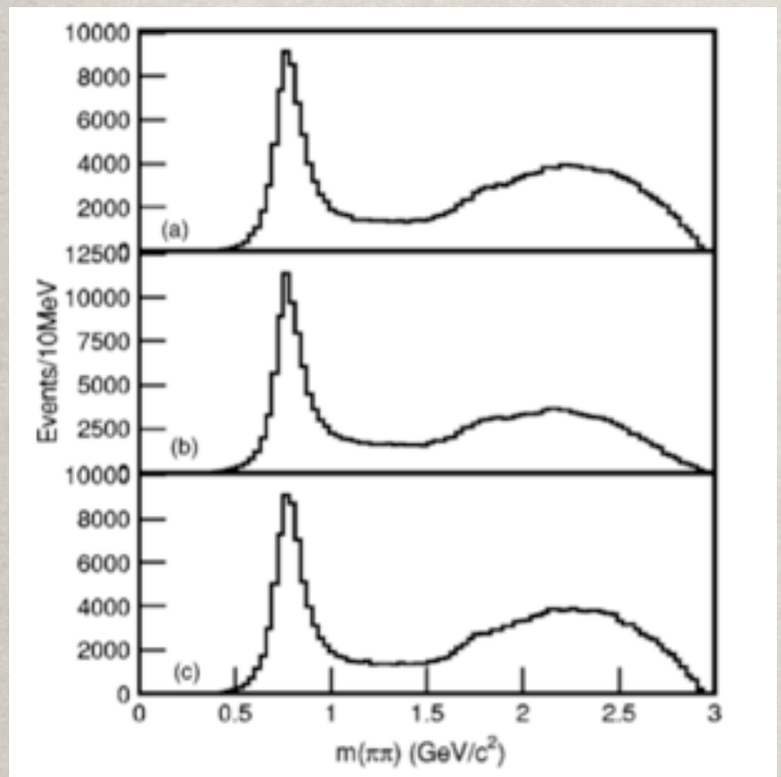
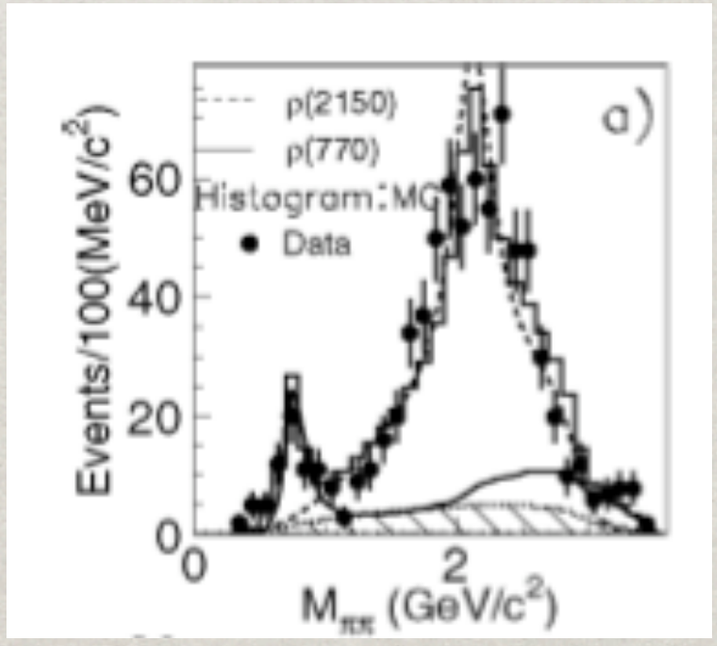


FIG. 4. The distributions of the invariant mass of two pions for (a) $m_{\pi^+\pi^0}$, (b) $m_{\pi^+\pi^-}$, and (c) $m_{\pi^-\pi^0}$.

BES Collaboration
Phys.Rev.D70:012005,2004

$\Psi' \to 3\pi$

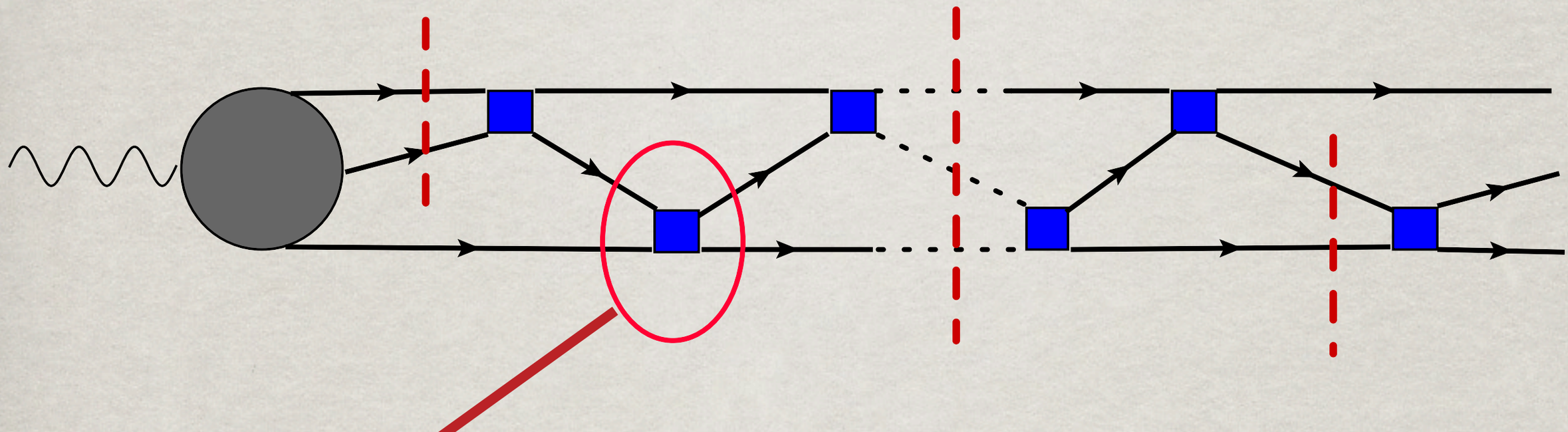
vs

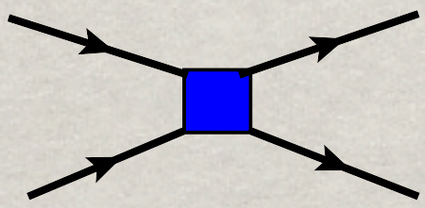


BES Collaboration
Phys.Lett.B619:247,2005

Corrections to naive isobar model

I.J.R.Aithison & R.Pasquier
Phys.Rev.152:1274,1966





$$\propto \frac{\eta_l e^{2i\delta_l} - 1}{2i}$$

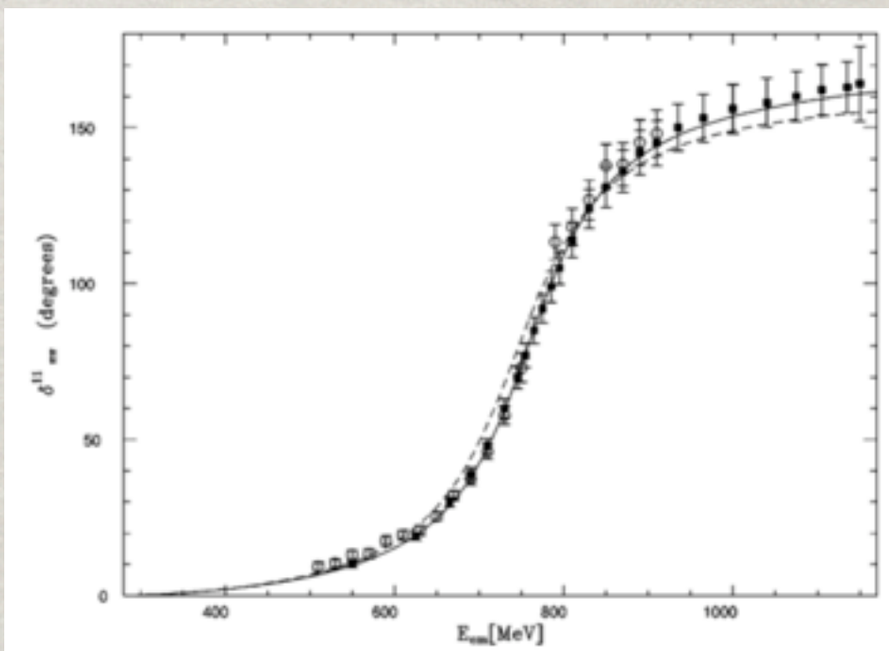
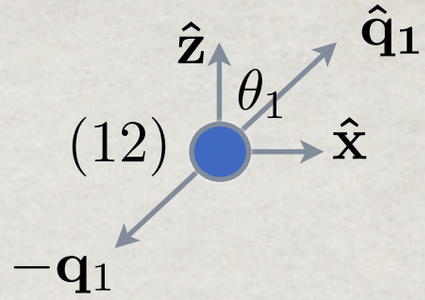
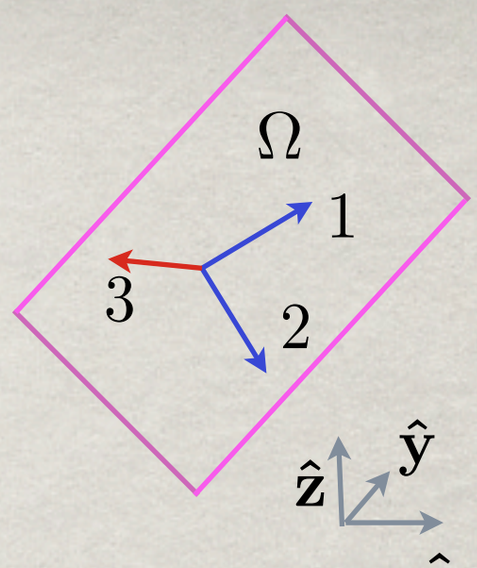


FIG. 2. Isovector $\pi\pi$ elastic phase shifts from threshold up to $\sqrt{s} \lesssim 1.2$ GeV. The dashed line corresponds to taking $g_v^2 = 1$ and $\bar{a}^{SL} = 0$. The continuum line corresponds to the simultaneous fit to the ρ and K^* channels, given by Eq. (59). Data: circles [32]; squares [33].

J.A.Oller & E.Oset
Phys.Rev.D60:074023,1999

$$J/\Psi(\Psi') \to \rho\pi \to 3\pi$$





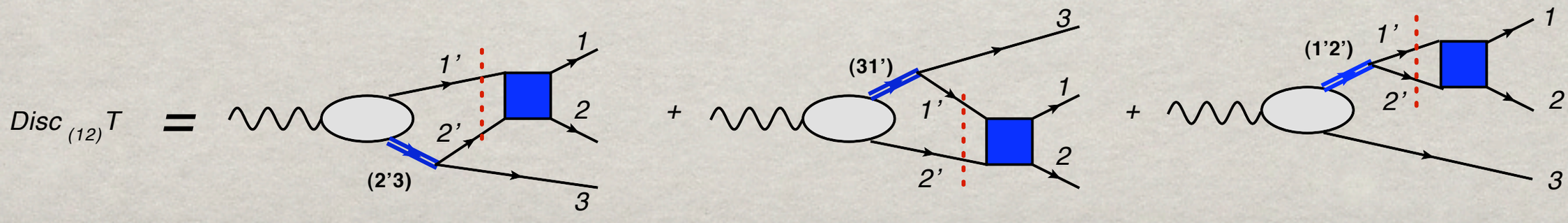
$$H_M = \frac{1}{\sqrt{2}}[D^1_{M,1}(\Omega) + D^1_{M,-1}(\Omega)] \sum_{j=odd} N_j$$

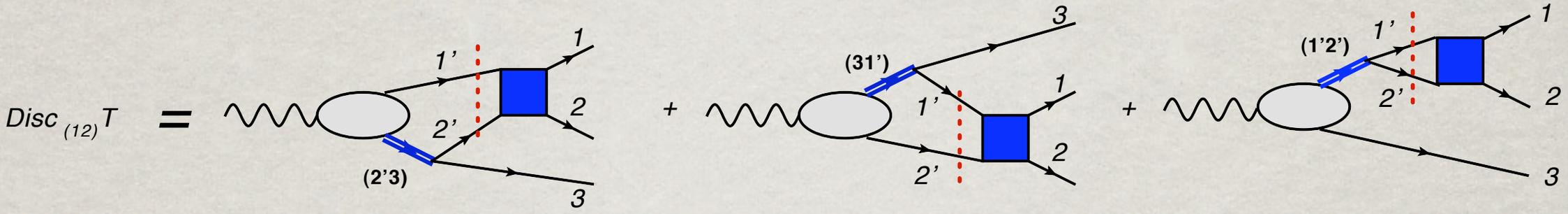
$$\times \quad [d^j_{10}(\theta_1)T_j(s, s_{12}) + d^j_{10}(\theta_2)T_j(s, s_{23}) + d^j_{10}(\theta_3)T_j(s, s_{31})]$$

Subenergy Unitarity

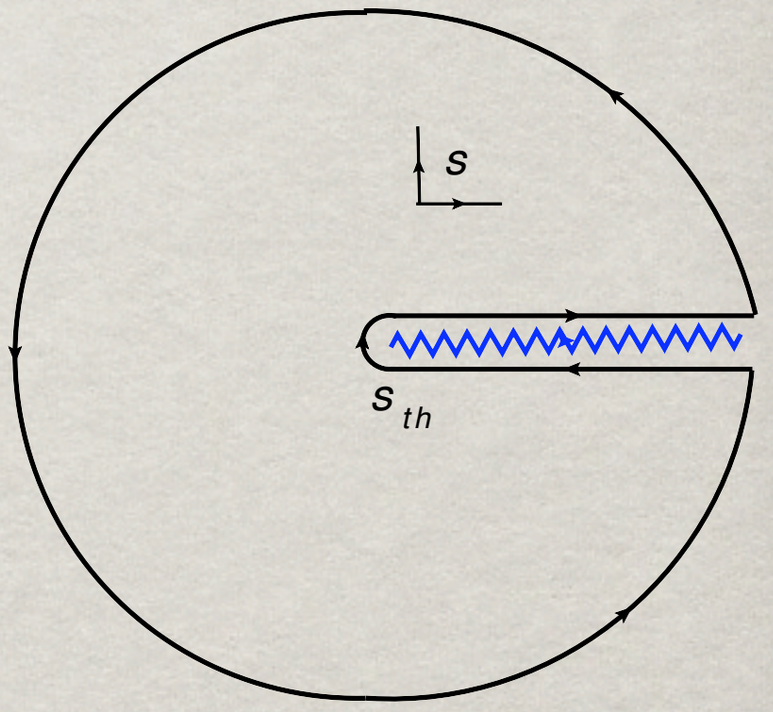
$$\rho(s_{12}) \propto \sqrt{1 - \frac{4m_\pi^2}{s_{12}}}$$

$$Disc_{s_{12}} T_1(s, s_{12}) = \rho(s_{12})\mathcal{M}_1(s_{12})[T_1(s, s_{12}) + \int_{s_{31}^-(s_{12})}^{s_{31}^+(s_{12})} ds_{31} K_{11}(s_{12}, s_{31}) T_1(s, s_{31})]$$

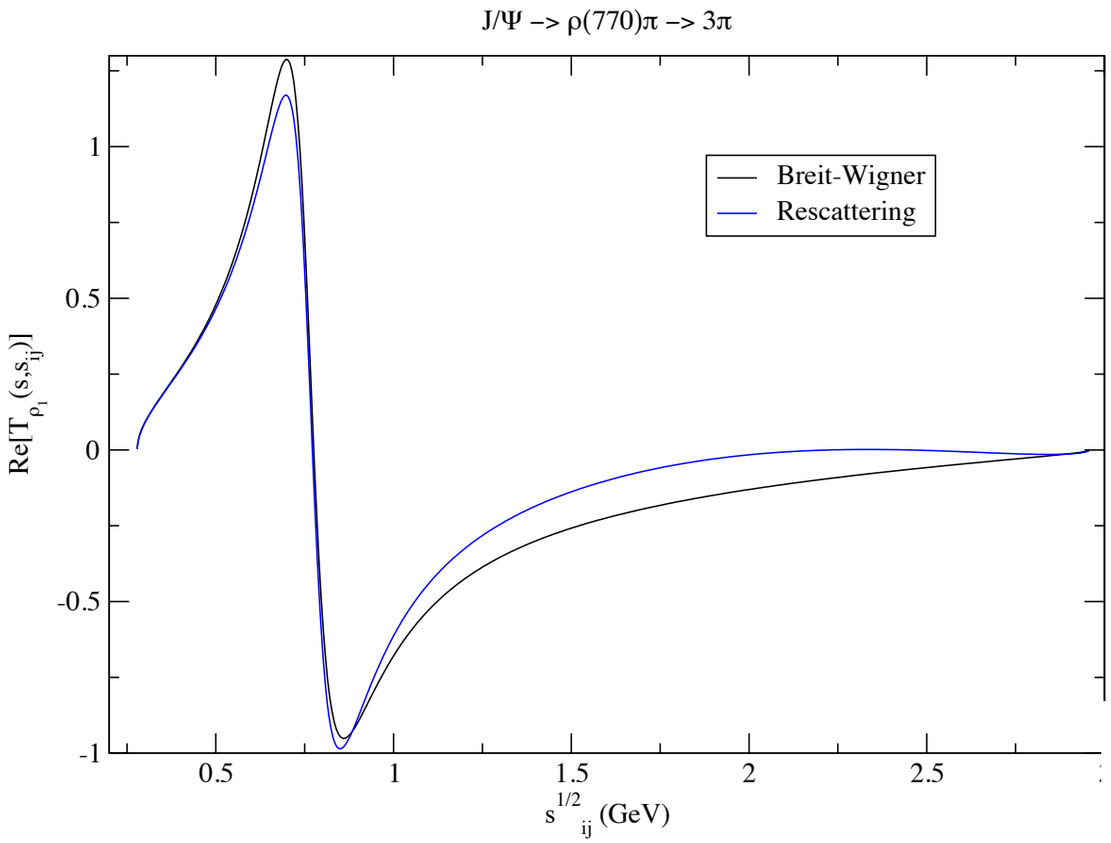


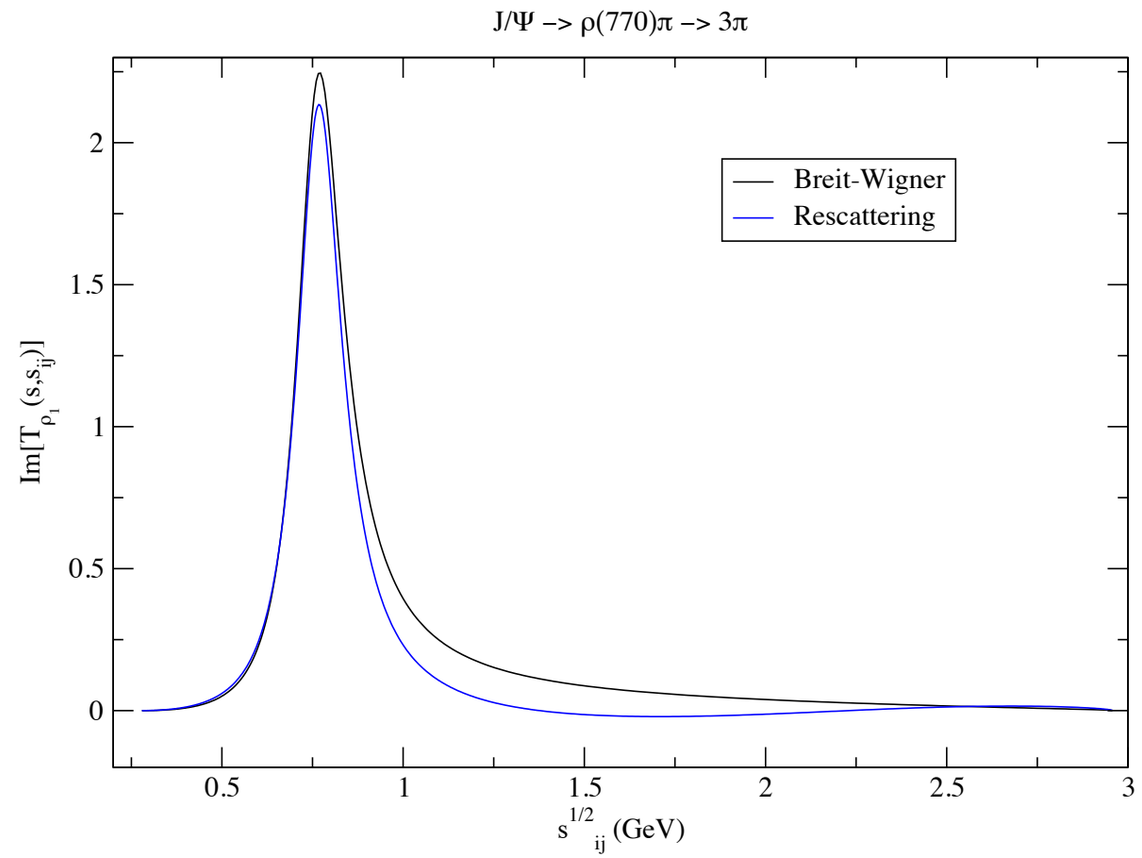


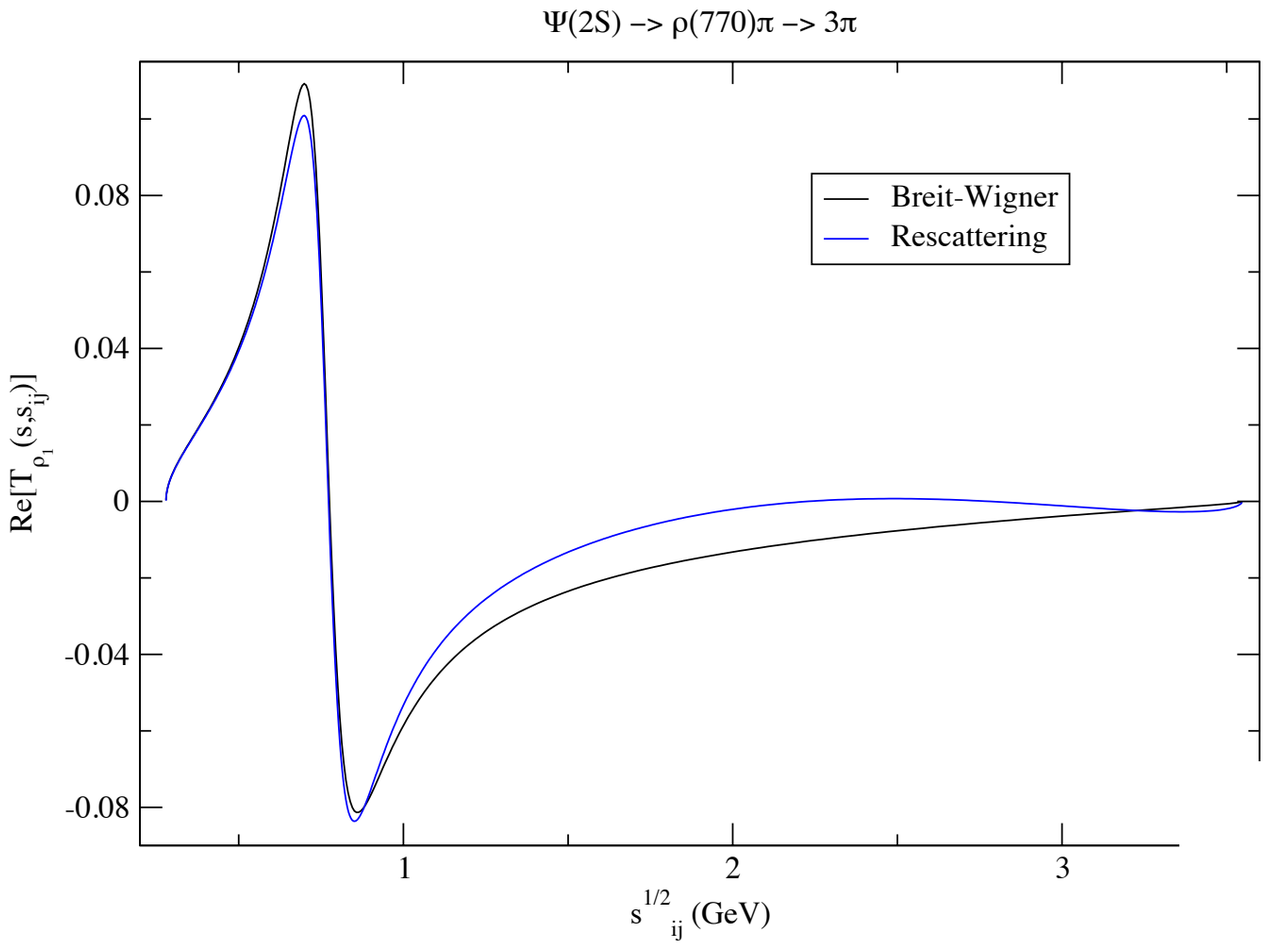
Dispersion Relation

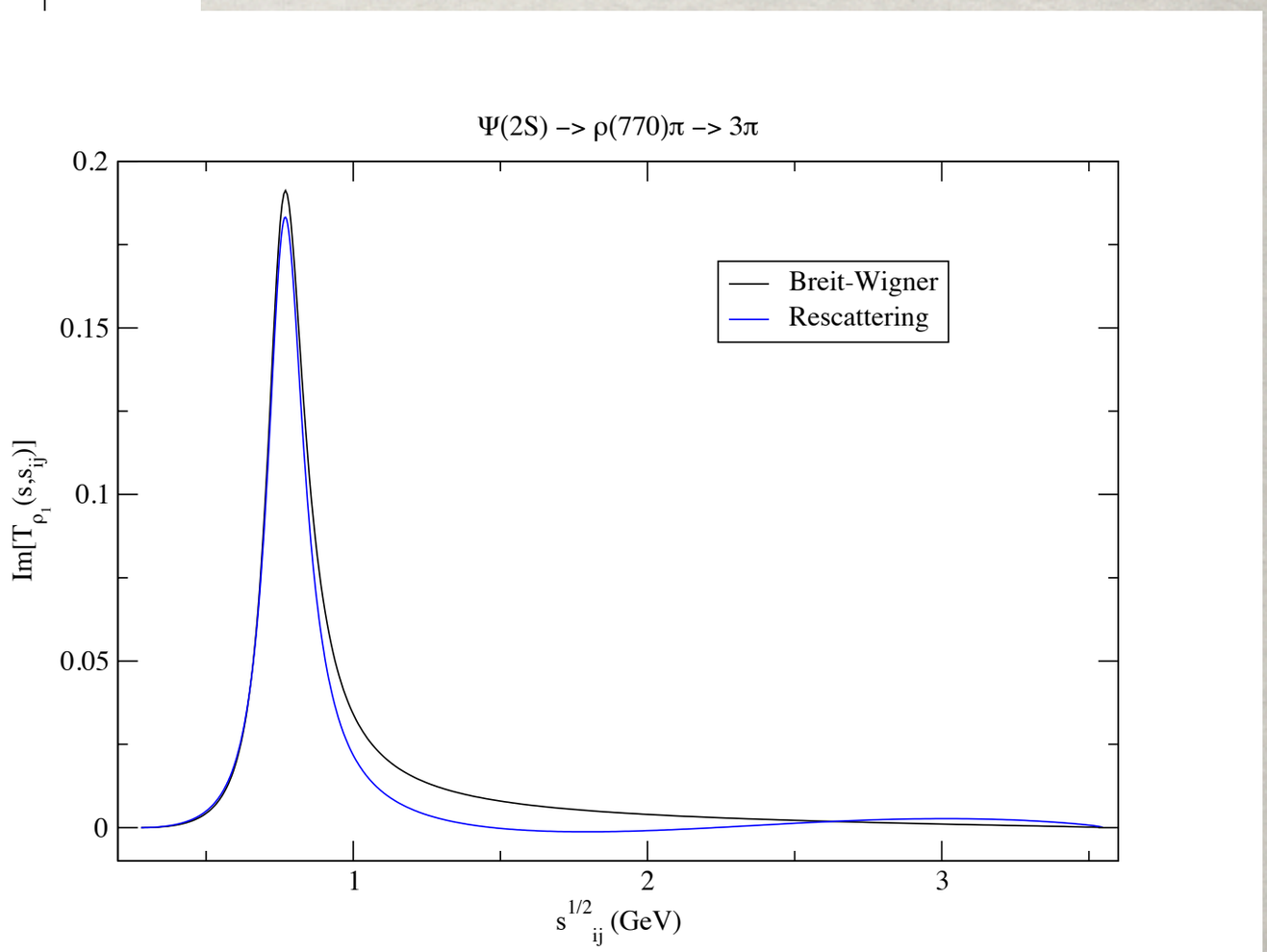


$$T_1(s, s_{12}) = \frac{1}{\pi} \int_{4m_\pi^2}^{\infty} ds'_{12} \frac{Disc_{s_{12}} T_1(s, s'_{12})}{s'_{12} - s_{12}}$$


J/Ψ –> ρ(770)π –> 3π
Breit-Wigner
Rescattering
Re[T_ρ1 (s,s_ij)]
s^1/2_ij (GeV)
1
0.5
0
-0.5
-1
0.5
1
1.5
2
2.5


J/Ψ –> ρ(770)π –> 3π
Breit-Wigner
Rescattering
Im[T_ρ1 (s,s_ij)]
s^1/2_ij (GeV)
2
1.5
1
0.5
0
0.5
1
1.5
2
2.5
3


Ψ(2S) –> ρ(770)π –> 3π
Breit-Wigner
Rescattering
0.08
0.04
0
-0.04
-0.08
Re[T_ρ1(s,s_ij)]
1
2
3
s^1/2_ij (GeV)


Ψ(2S) –> ρ(770)π –> 3π
Breit-Wigner
Rescattering
0.2
0.15
0.1
0.05
0
Im[T_ρ1(s,s_ij)]
1
2
3
s^1/2_ij (GeV)

	$\Gamma^{Res}/\Gamma^{BW} - 1$
$J/\Psi \to \rho(770)\pi \to 3\pi$	-32.3%
$\Psi' \to \rho(770)\pi \to 3\pi$	-31.4%

$r \equiv \frac{Br(\Psi' \to \rho(770)\pi)}{Br(J/\Psi \to \rho(770)\pi)}$	$r^{Res}/r^{BW} - 1 = 1.38\%$

Summary

- Long distance final states rescattering cannot be the cause of rho-pi puzzle.

- Interference between rho(770) and rho(2150) might be important.