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

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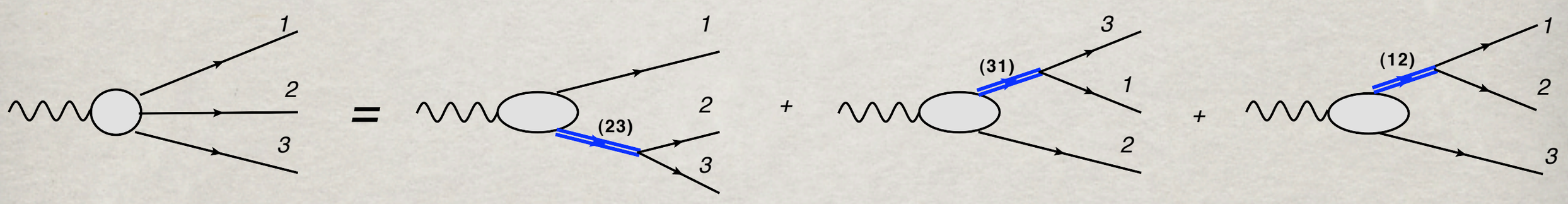
Seattle, Nov. 2009

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

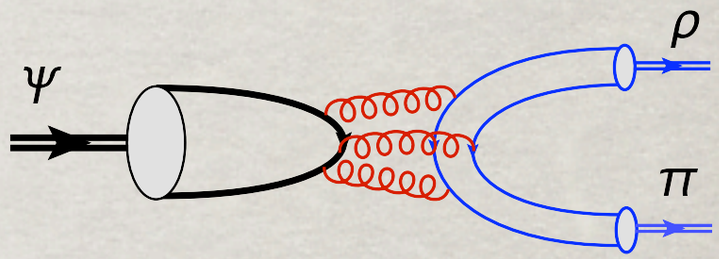
Experiment measurement

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

vs

PQCD

12%



$J/\Psi \to 3\pi$

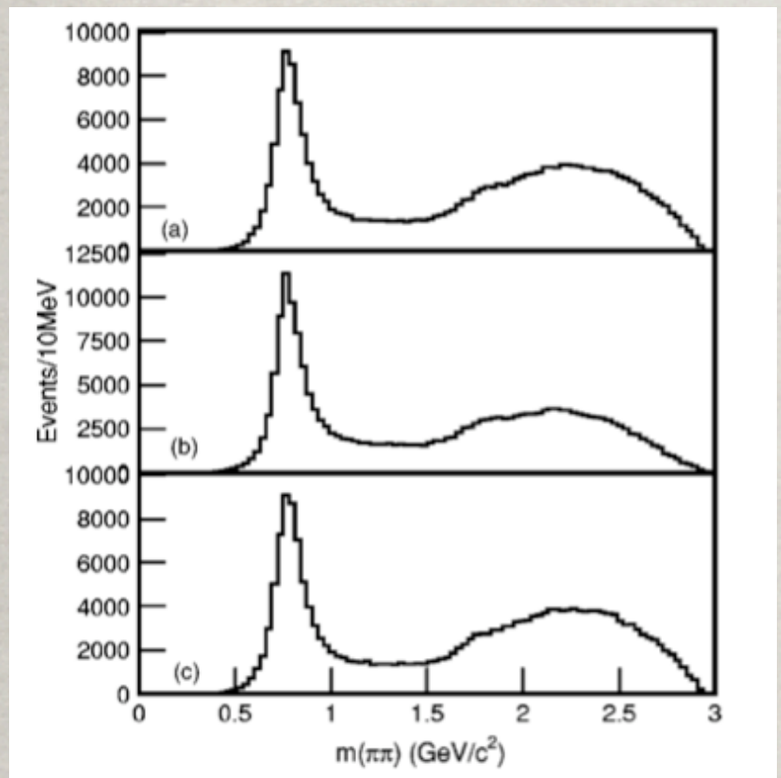


FIG. 4. The distributions of the invariant mass of two pions for (a) $m_{\pi^+\pi^0}$, (b) $m_{\pi^+\pi^-}$, and (c) $m_{\pi^-\pi^0}$.

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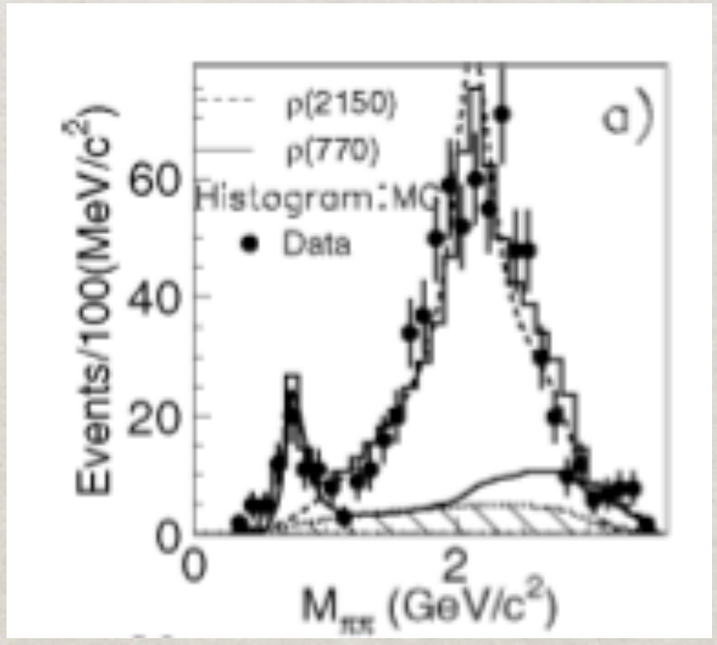
Phys.Rev.D70:012005,2004

$\Psi' \to 3\pi$

vs



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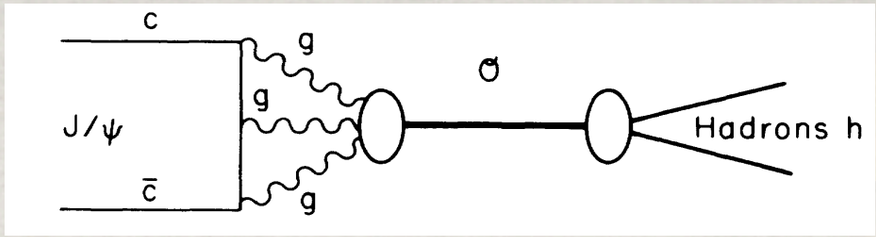
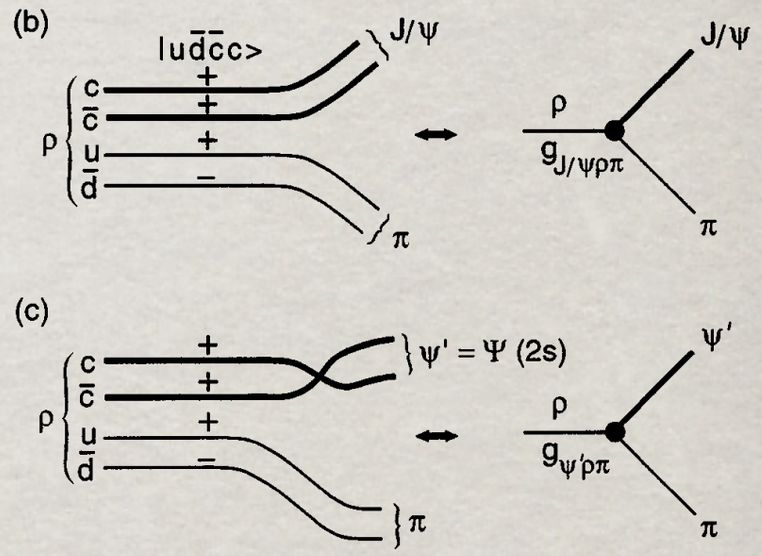
Phys.Lett.B619:247,2005

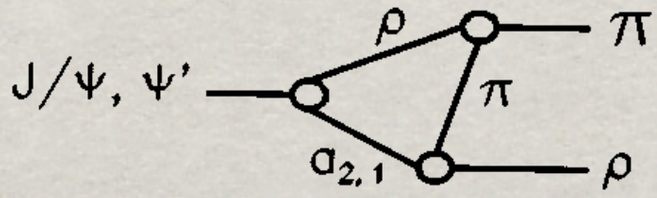


S.J.Brodsky, G.P.Lepage & S.T.Tuan
Phys.Rev.Lett. 59:621,1987

- Glueball near the mass of J/Psi
- Intrinsic charm component of rho
- 2S-1D wave mixing in Psi'
- Hybrid
- Final state interaction



S.J.Brodsky & M.Karliner
Phys.Rev.Lett 78:4682,1997

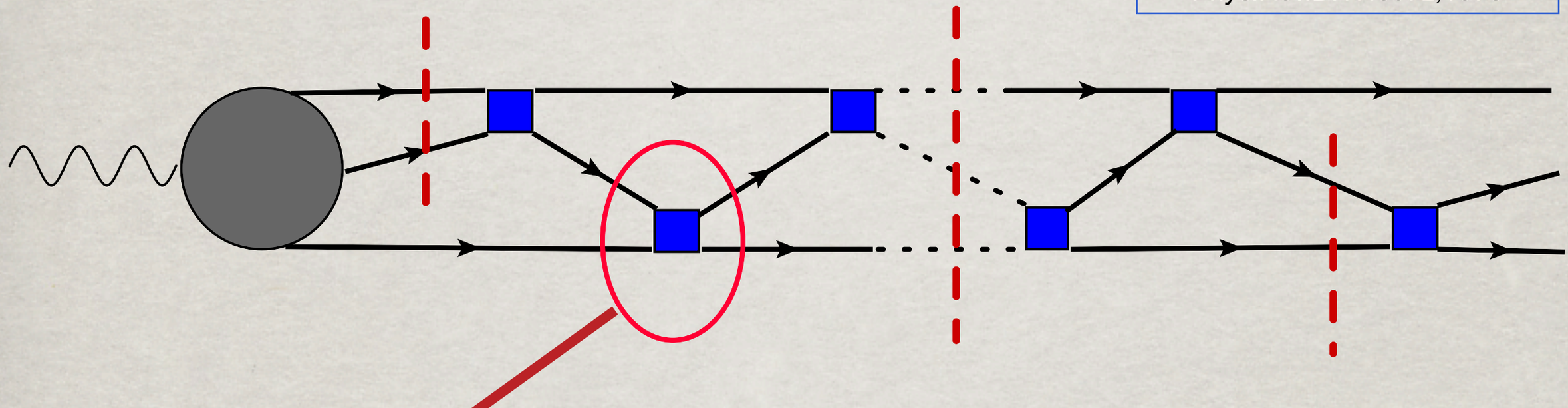


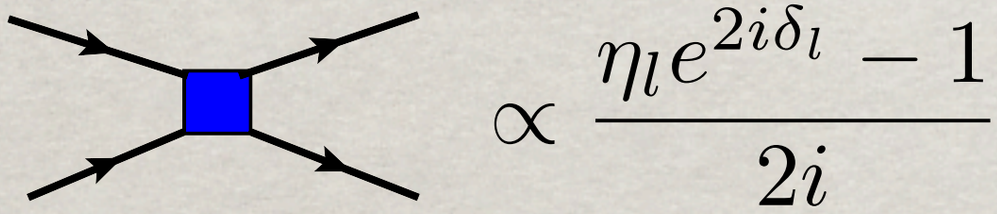
X.Q.Li, D.V.Bugg & B.S.Zou
Phys.Rev.D 55:1421,1997

Corrections to naive isobar model

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

I.J.R.Aithison & J.J.Brehm
Phys.Rev.D.17:3072,1978





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

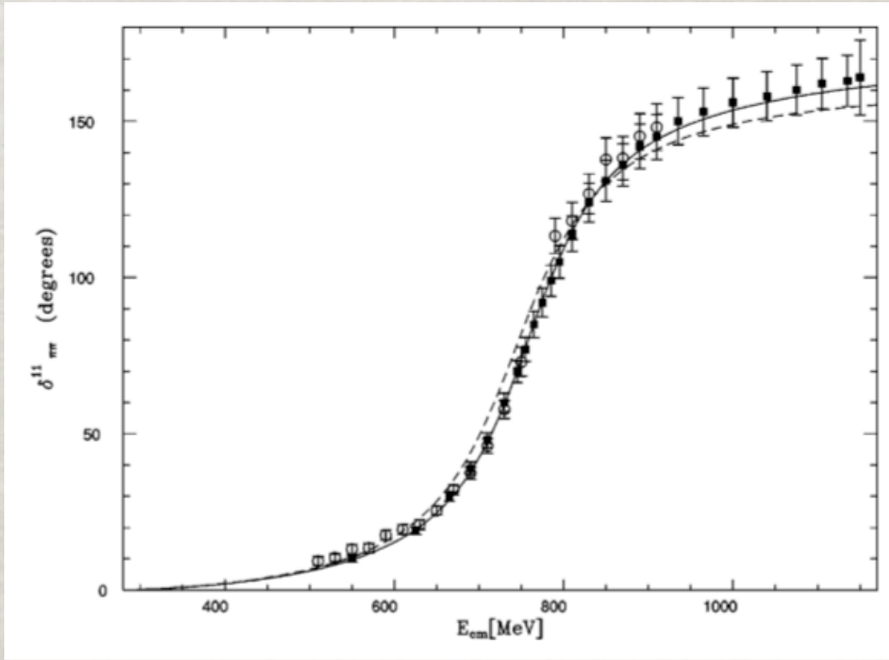
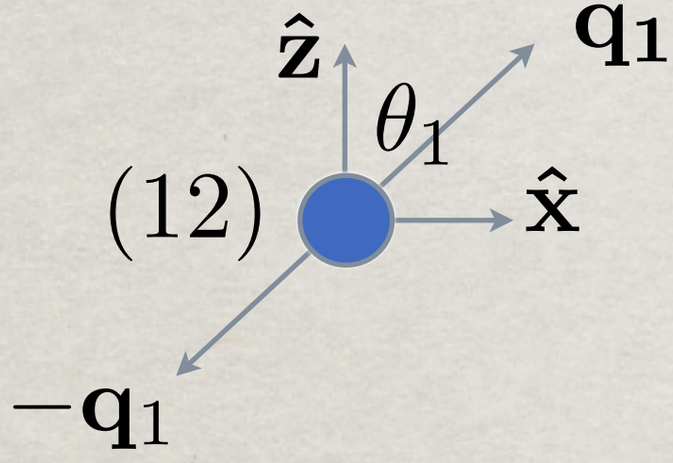
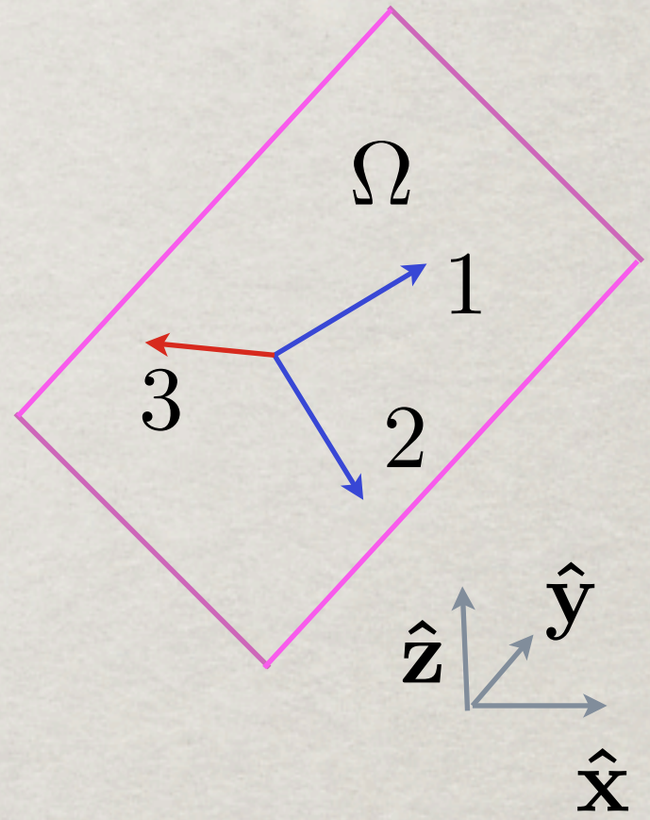


FIG. 2. Isovector $\pi\pi$ elastic phase shifts from threshold up to $\sqrt{s} \lesssim 1.2$ GeV. The dashed line corresponds to taking $g_v^2 = 1$ and $\bar{a}^{SL} = 0$. The continuum line corresponds to the simultaneous fit to the ρ and K^* channels, given by Eq. (59). Data: circles [32]; squares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

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

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





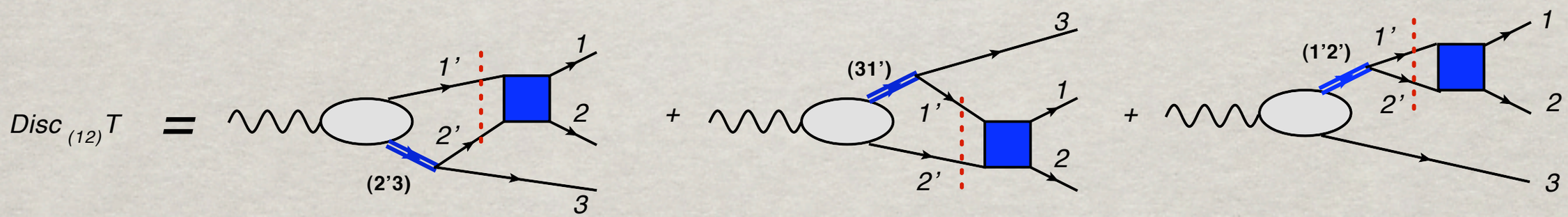
$$H_M = \frac{1}{\sqrt{2}}[D^1_{M,1}(\Omega) + D^1_{M,-1}(\Omega)] \sum_{j=odd} N_j$$

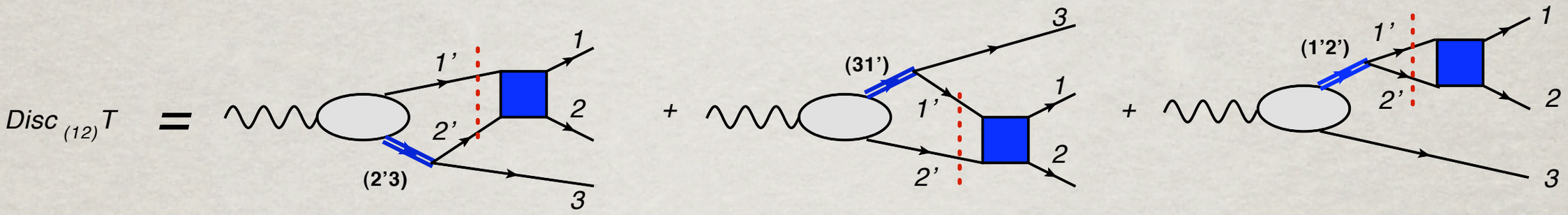
$$\times \quad [d^j_{10}(\theta_1)T_j(s, s_{12}) + d^j_{10}(\theta_2)T_j(s, s_{23}) + d^j_{10}(\theta_3)T_j(s, s_{31})]$$

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

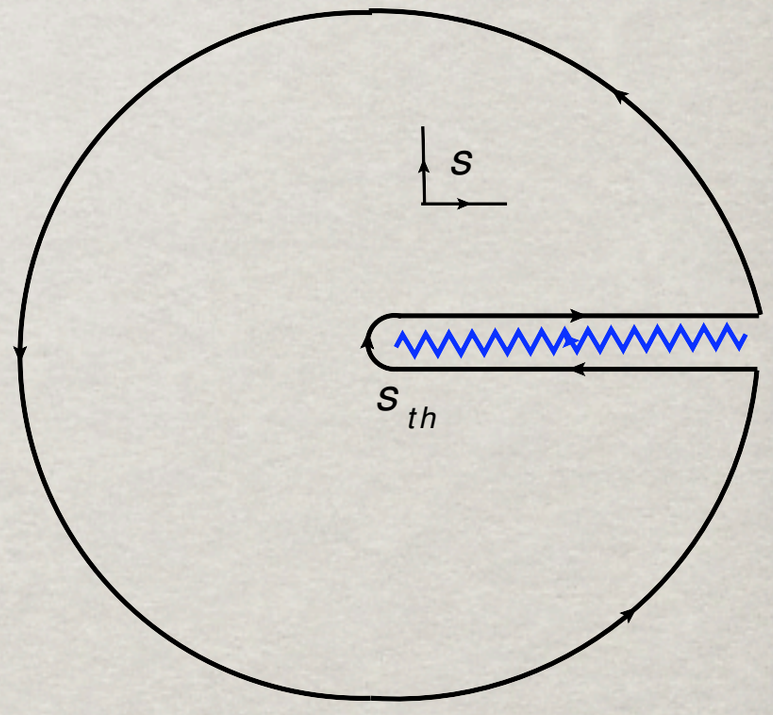
Subenergy Unitarity

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





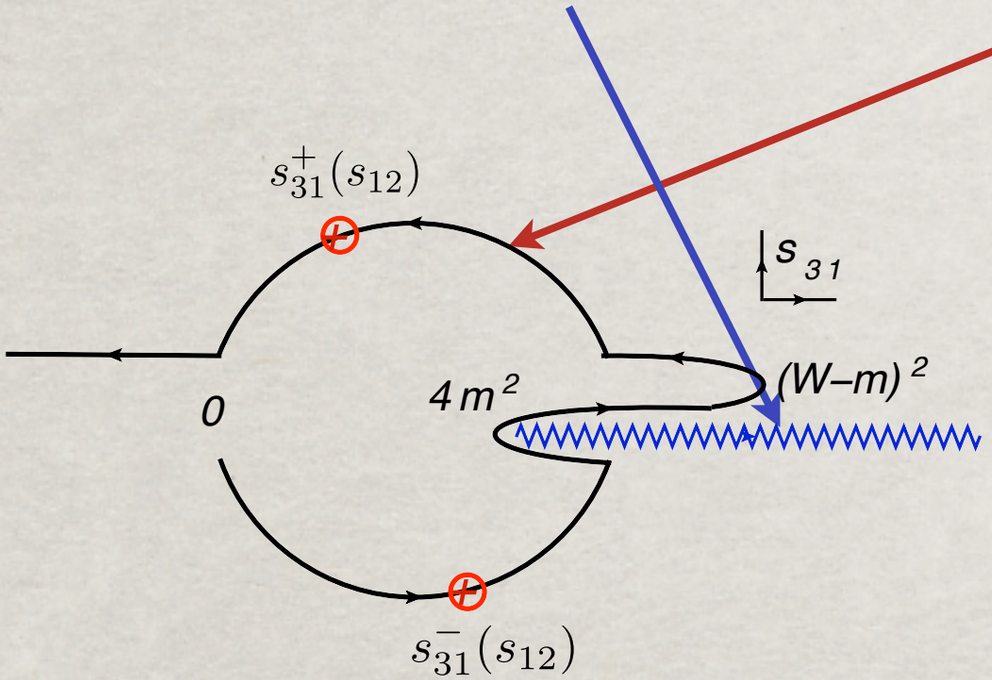
Dispersion Relation



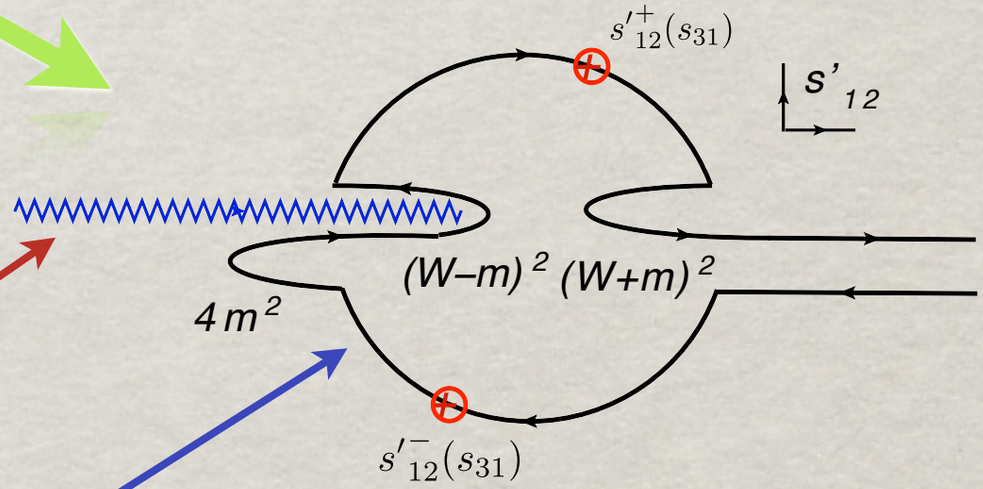
$$T_1(s, s_{12}) = \frac{1}{\pi} \int_{4m_\pi^2}^{\infty} ds'_{12} \frac{Disc_{s_{12}} T_1(s, s'_{12})}{s'_{12} - s_{12}}$$

Single integral equation: suitable for data fitting

$$T_1(s,s_{12}) \propto (12) + \int_{-\infty}^{(\sqrt{s}-m_\pi)^2} ds_{31}[\int_{s'^{-}_{12}(s_{31})}^{s'^{+}_{12}(s_{31})} ds'_{12} \frac{\widetilde{\mathcal{M}}_1^*(s'_{12})K_{11}(s'_{12},s_{31})}{s'_{12}-s_{12}}]T_1(s,s_{31})$$



R.Pasquier & J.Y.Pasquier
Phys.Rev.170:1294,1968



$$T_1(s,s_{12}) \propto (12) + \int_{-\infty}^{(\sqrt{s}-m_\pi)^2} ds_{31}[\int_{s'^{-}_{12}(s_{31})}^{s'^{+}_{12}(s_{31})} ds'_{12} \frac{\widetilde{\mathcal{M}}_1^*(s'_{12})K_{11}(s'_{12},s_{31})}{s'_{12}-s_{12}}]T_1(s,s_{31})$$

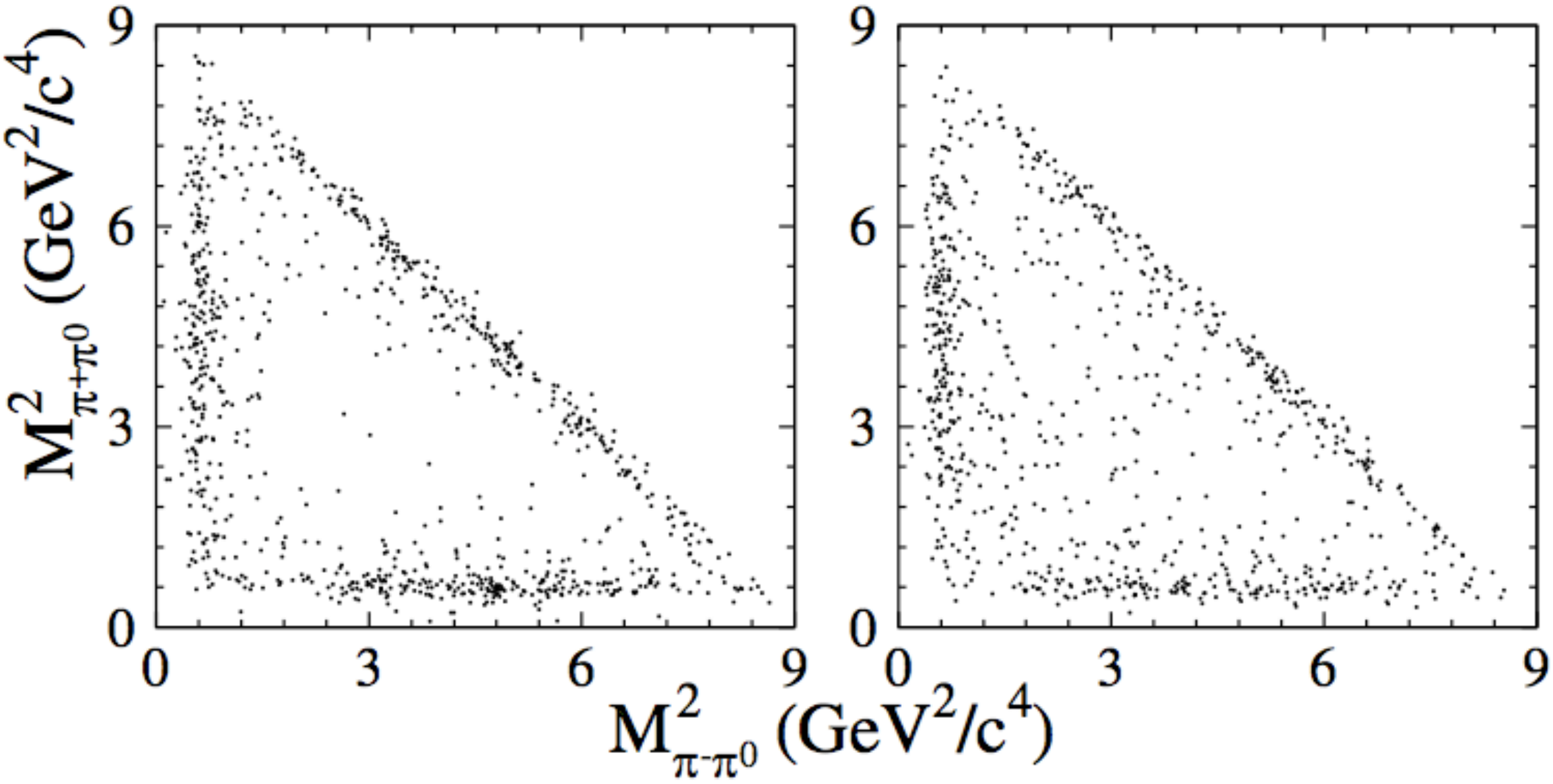
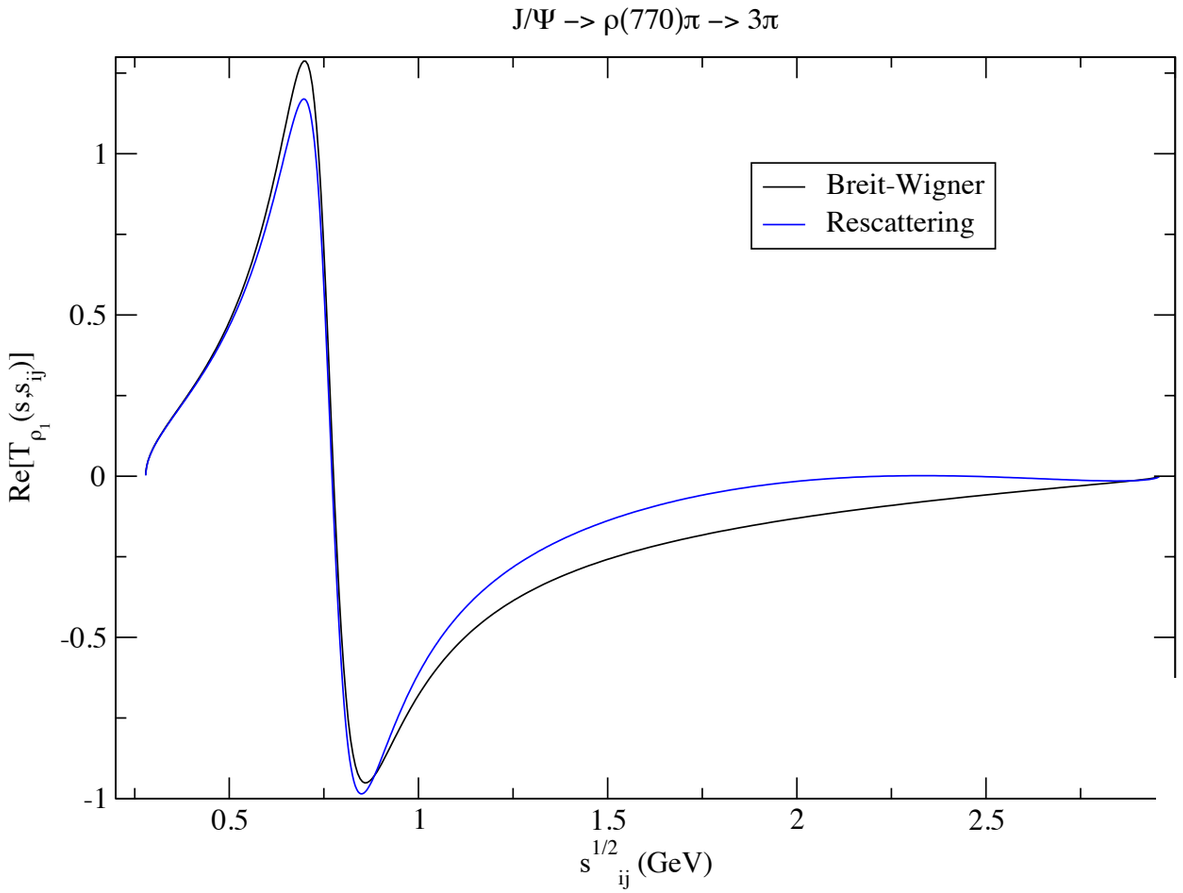
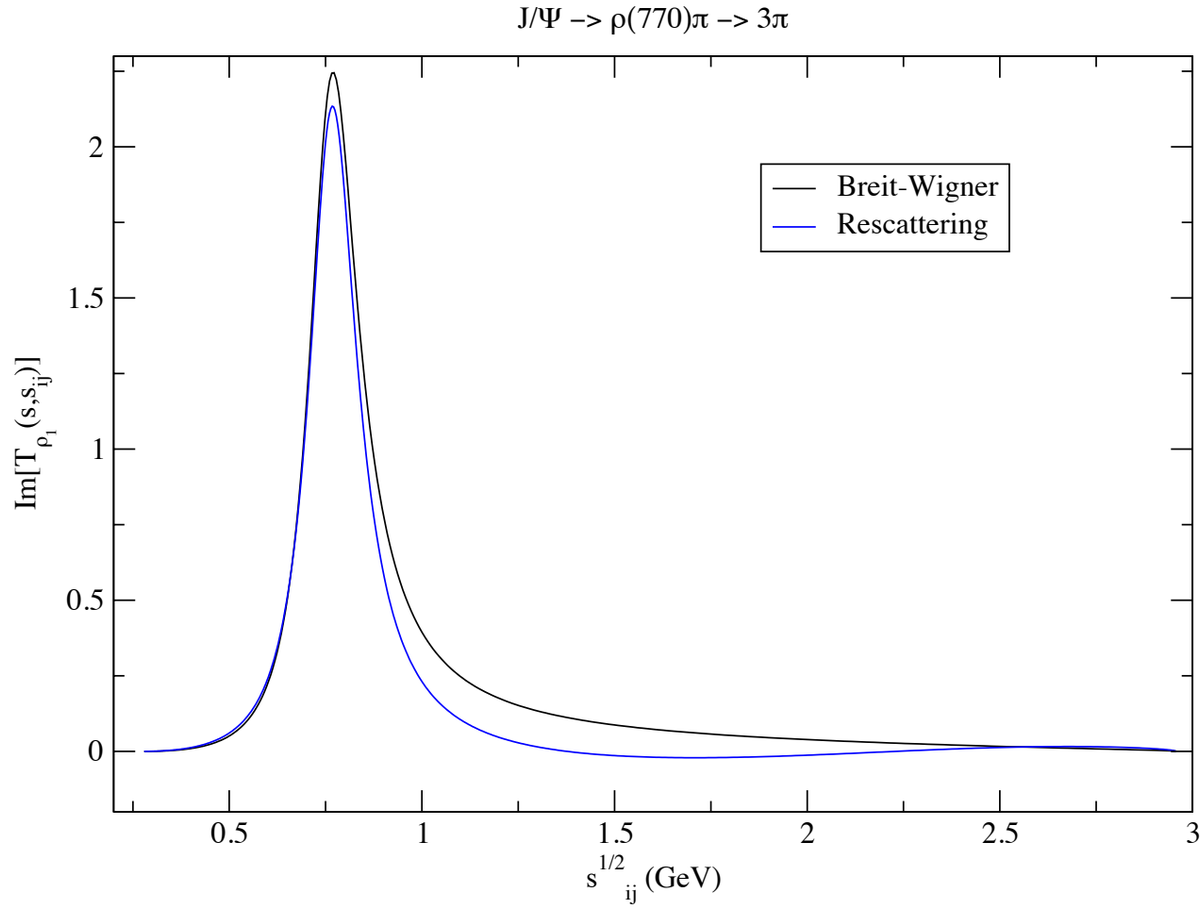
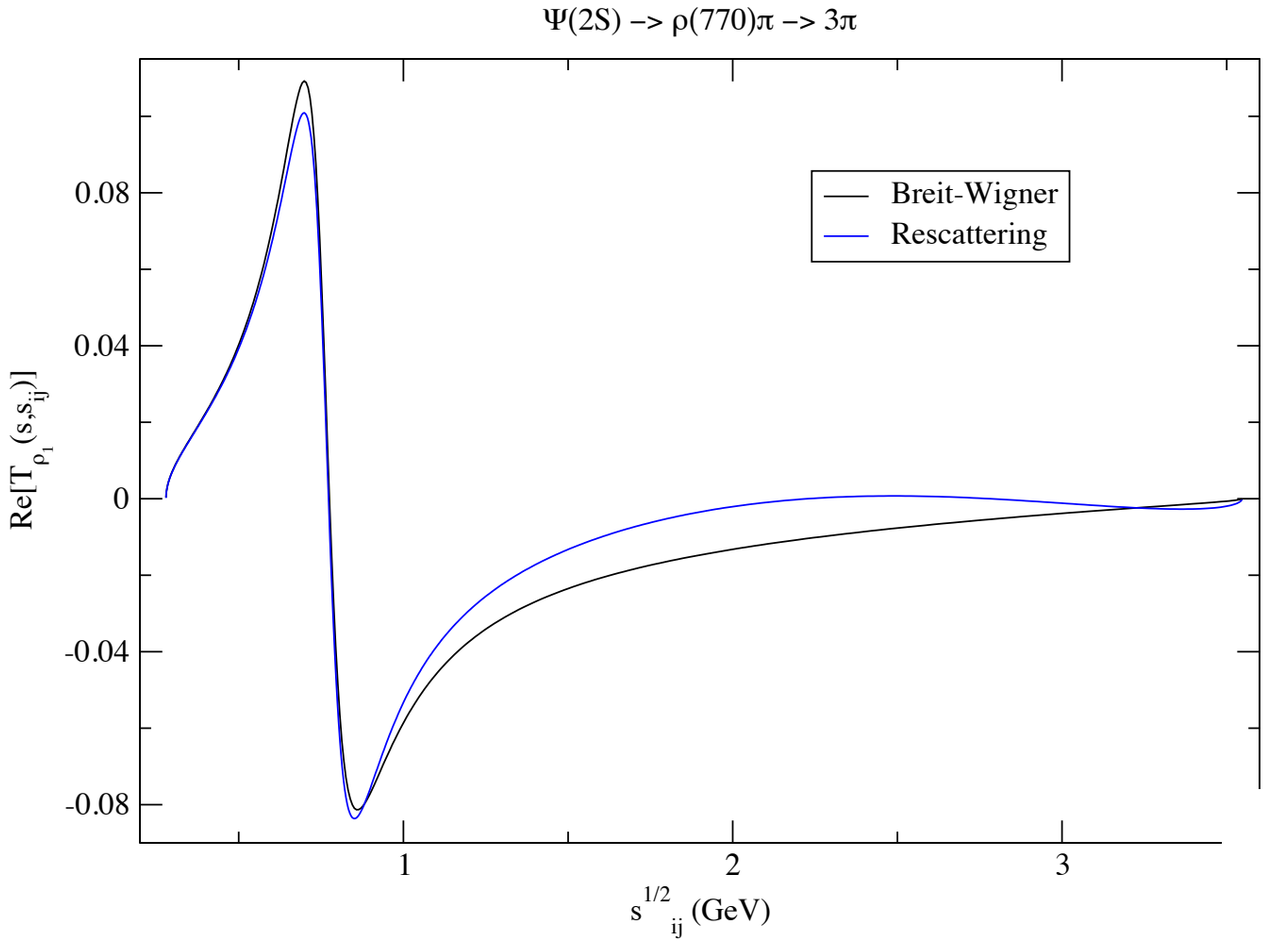
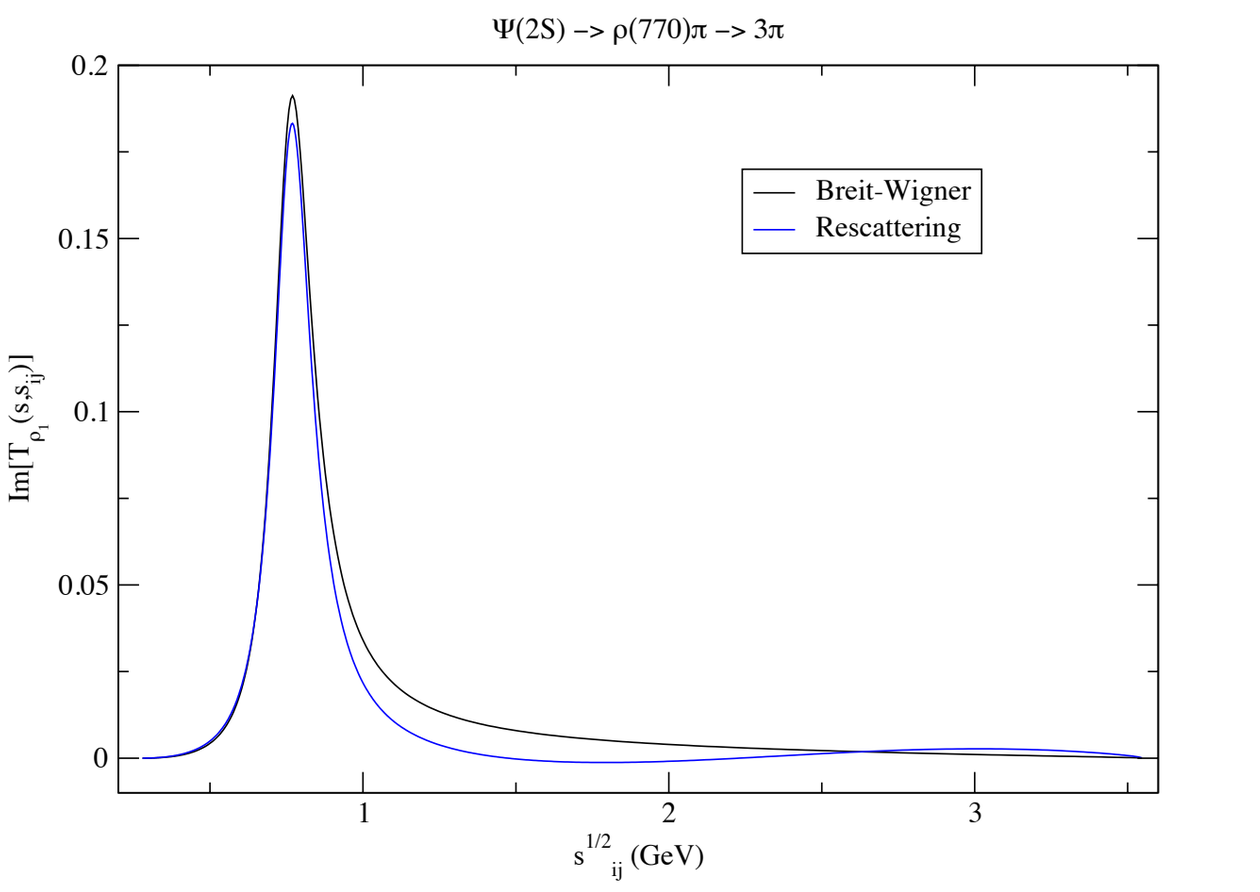


FIG. 20. The Dalitz plot for $J/\psi \to 3\pi$ candidates in data (left) and simulation (right).


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


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

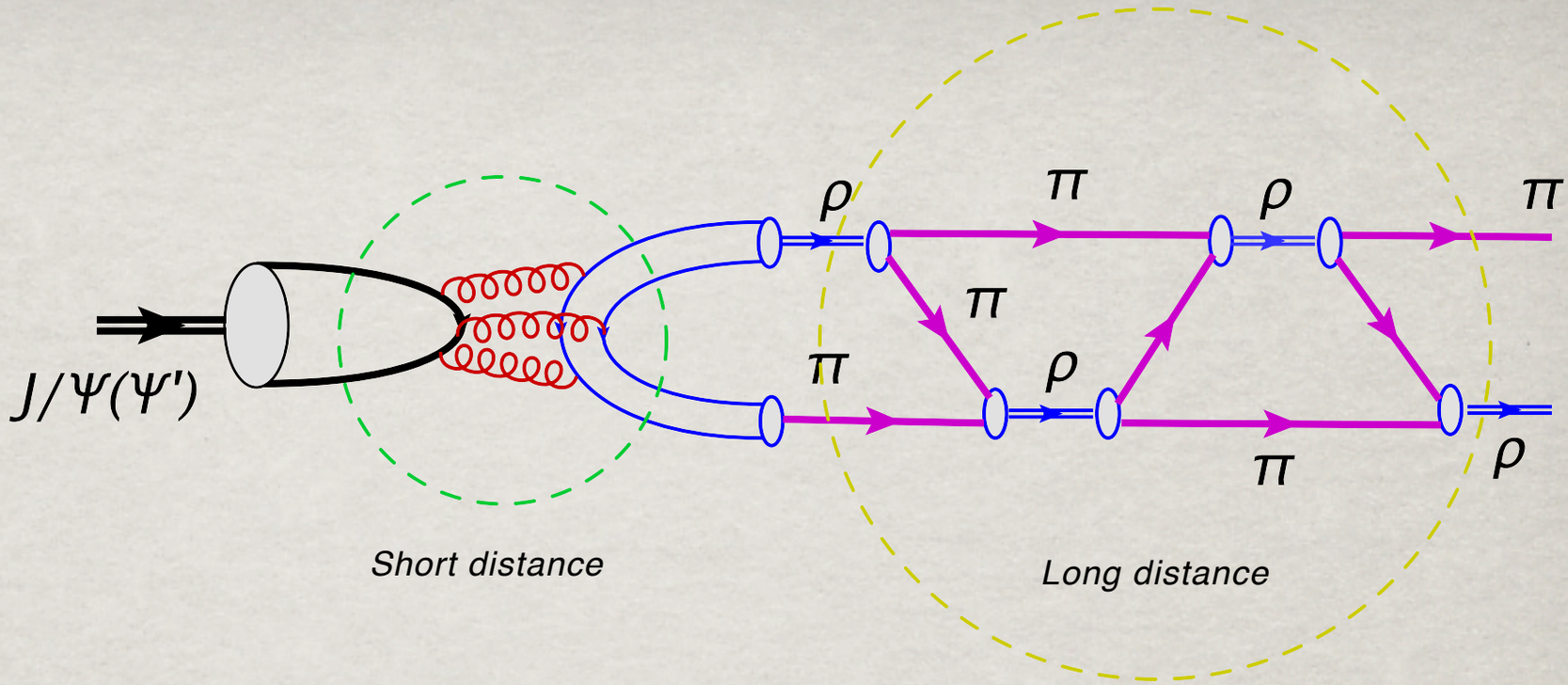

Ψ(2S) –> ρ(770)π –> 3π
Breit-Wigner
Rescattering
0.08
0.04
0
-0.04
-0.08
Re[T_ρ1 (s,s_ij)]
1
2
3
s^1/2_ij (GeV)


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%

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

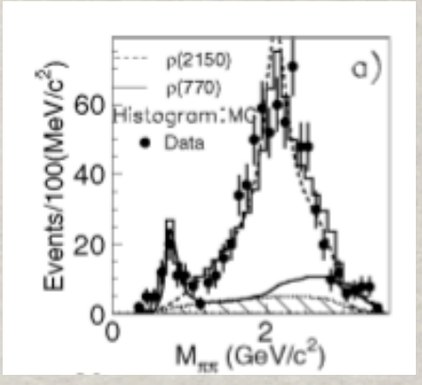
Summary



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

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

$\Psi' \to 3\pi$



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Phys.Lett.B619:247,2005