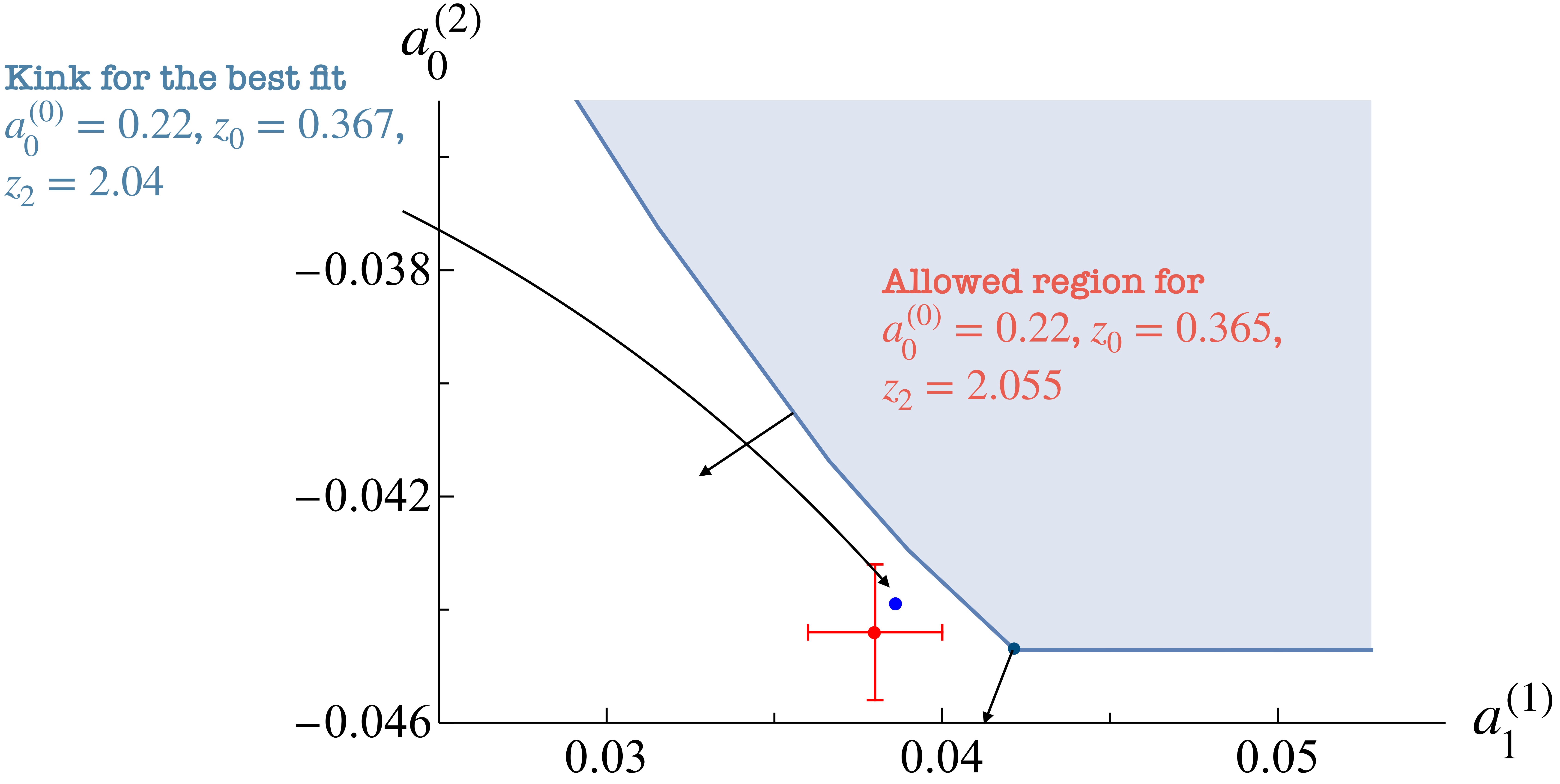
The Kink

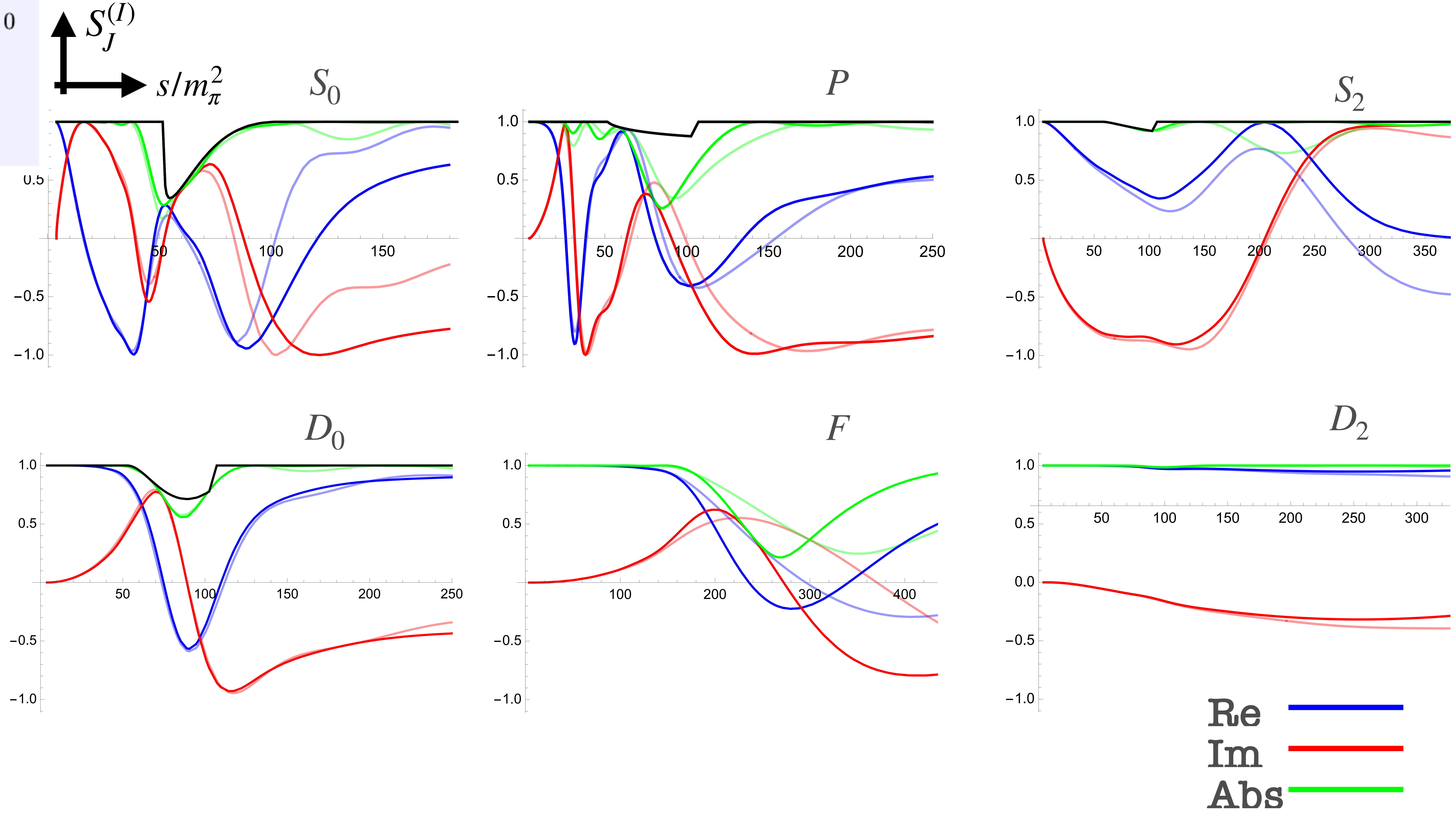
$$Obj(\theta) = a_1^{(1)} \cos\theta + a_0^{(2)} \sin\theta$$



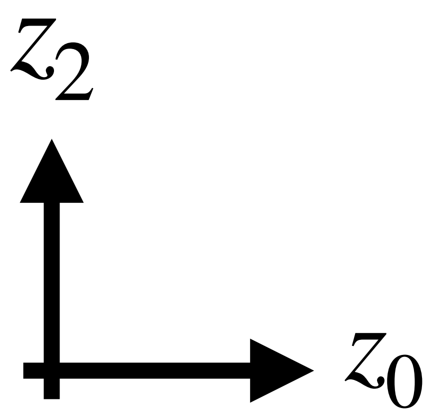
Step 1: Solution from the Bootstrap

Fit Ansatz

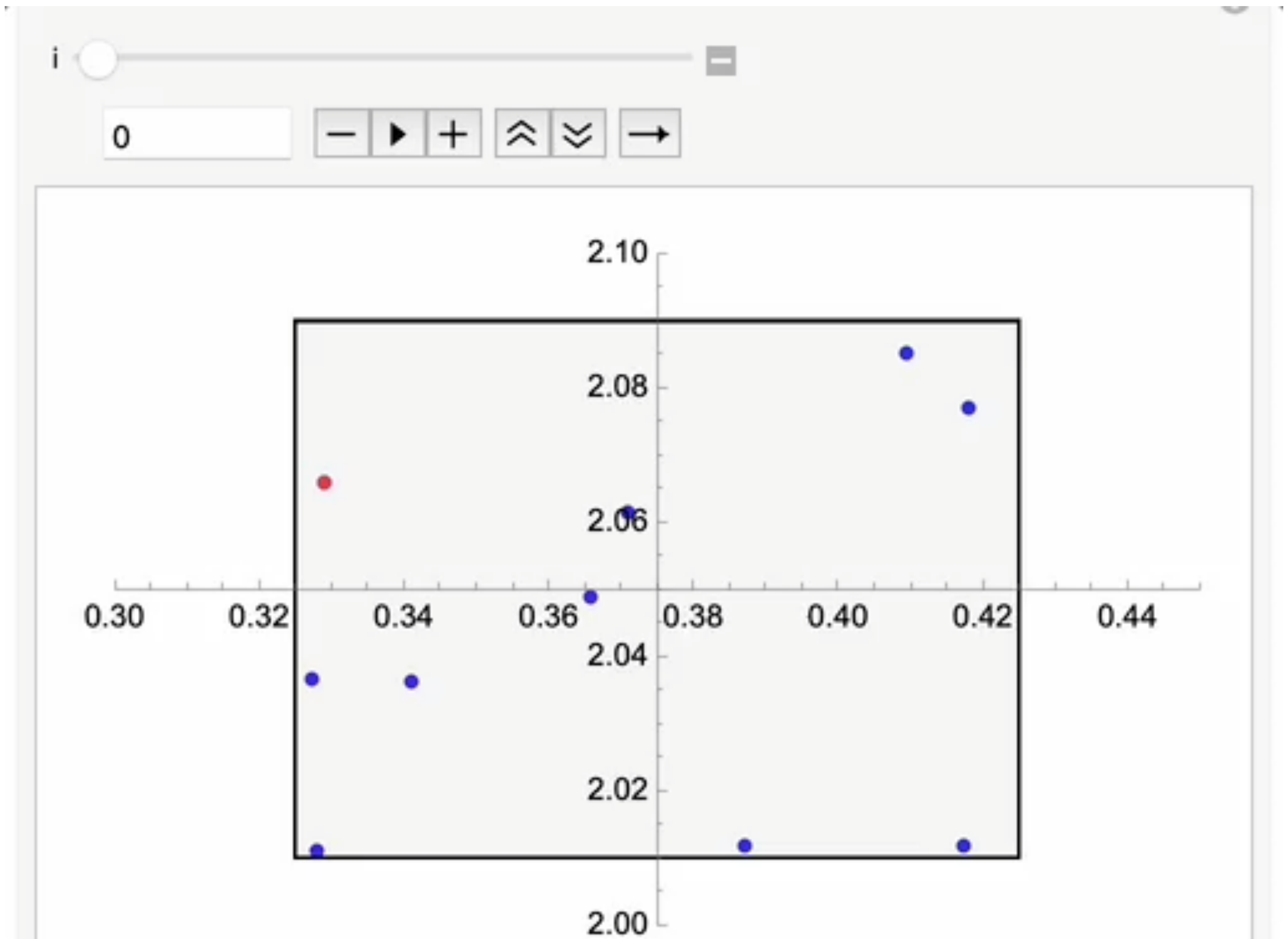
Given	$\Theta = \{\theta, a_0^{(0)}, z_0, z_2, m_\rho^2, m_{f_0}^2, m_{f_0'}^2, m_{f_2}^2\}$
Maximize in $\mathcal{A}^{\text{ansatz}}(s,t,u)$	$\text{Obj}(\theta)$
constr. by	$t_0^{(0)}(4) = 2a_0^{(0)}, t_0^{(0)}(z_0) = 0, t_0^{(2)}(z_2) = 0$
	$S_1^{(1)}(m_\rho^2){=}0, S_0^{(0)}(m_{f_0}^2){=}0$
	$S_0^{(0)}(m_{f_0'}^2){=}0, S_2^{(0)}(m_{f_2}^2){=}0$
$s \geq 4$	$\mathcal{U}_\ell^{(I)} \succeq 0$ for $\ell \in \mathbb{N}$, $I = 0, 1, 2$ (9)



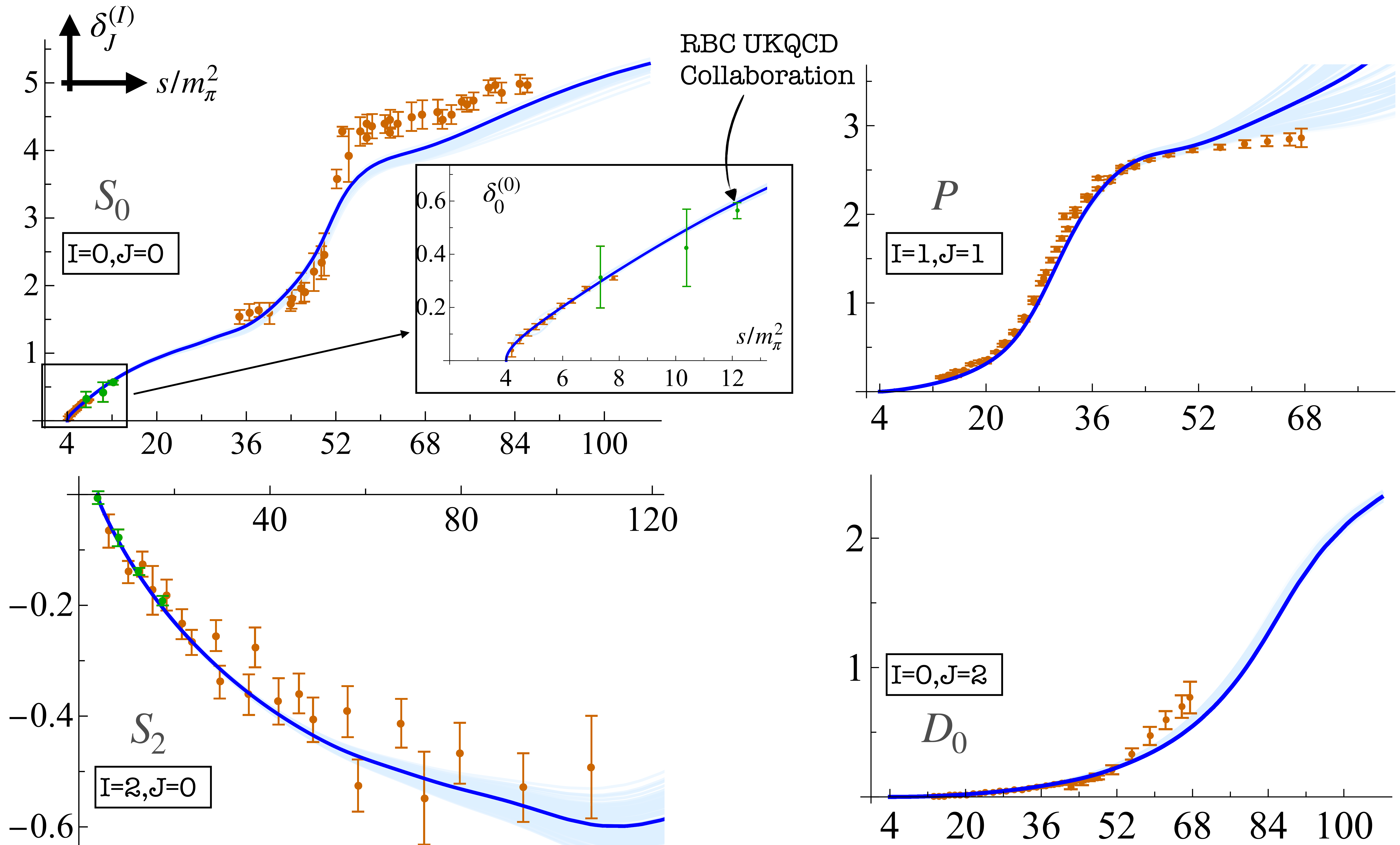
Step 2: Particle Swarm Optimization



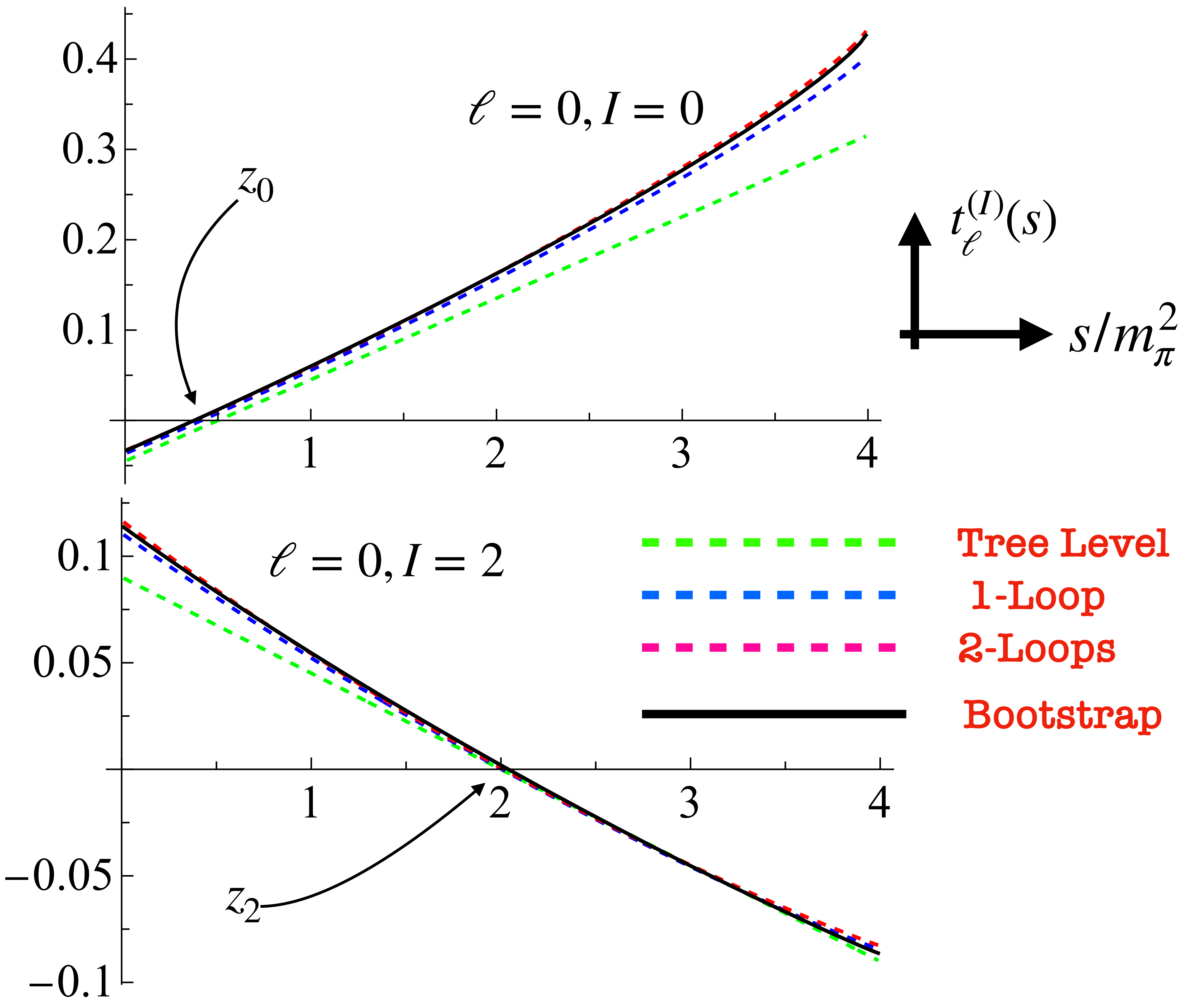
$$
\begin{aligned}
v_{n+1}^{(i)} &= \omega v_n^{(i)} + c_1 r_1 (\Theta_n^{(i)} - X_n^{(i)}) + c_2 r_2 (\Theta_n^{(i)} - Y_n), \\
\Theta_{n+1}^{(i)} &= \Theta_n^{(i)} + v_{n+1}^{(i)}.
\end{aligned}
\tag{11}
$$

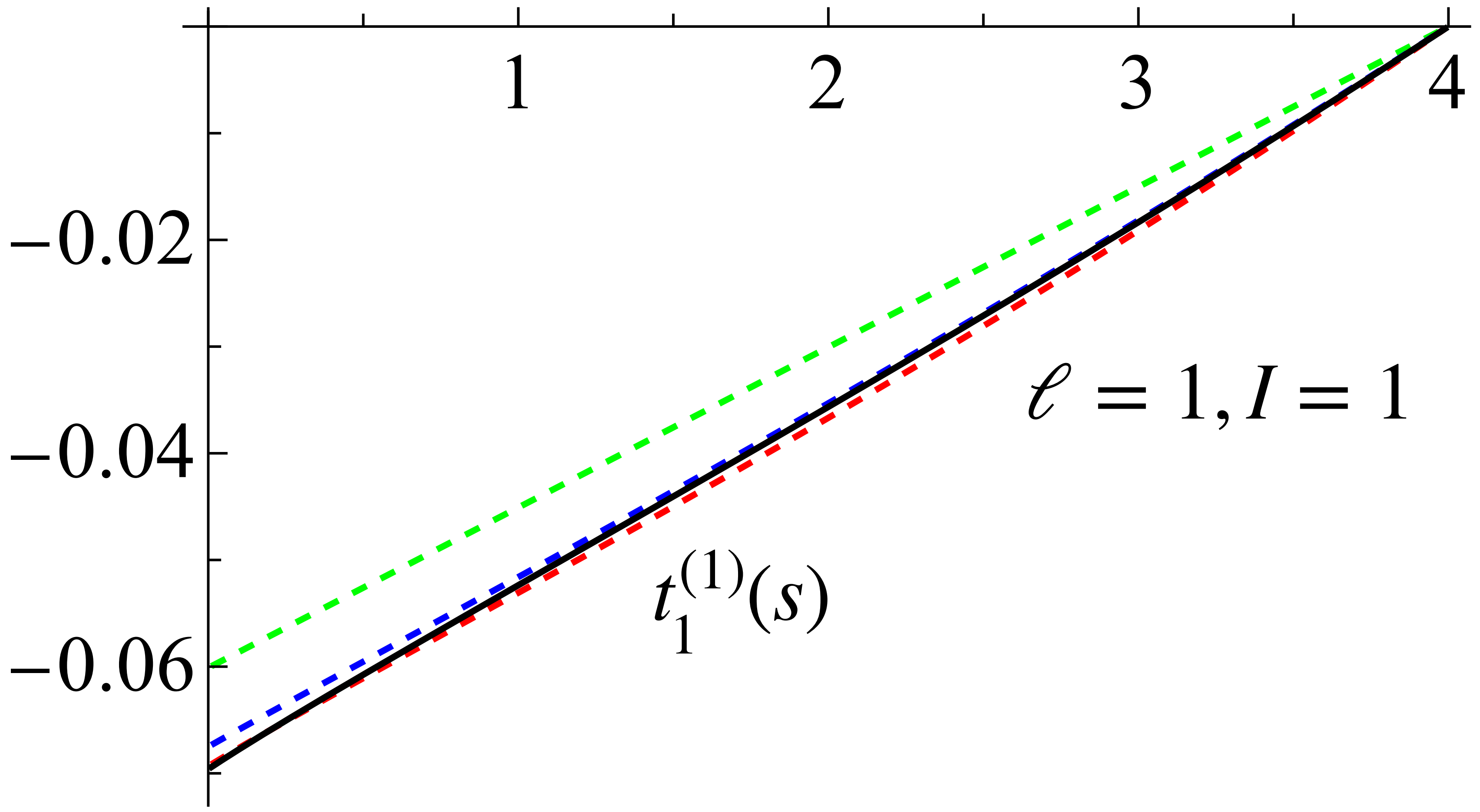


The Best-Fit


$\delta_J^{(I)}$
s/m_π^2
S_0
I=0,J=0
$\delta_0^{(0)}$
RBC UKQCD
Collaboration
P
I=1,J=1
S_2
I=2,J=0
D_0
I=0,J=2

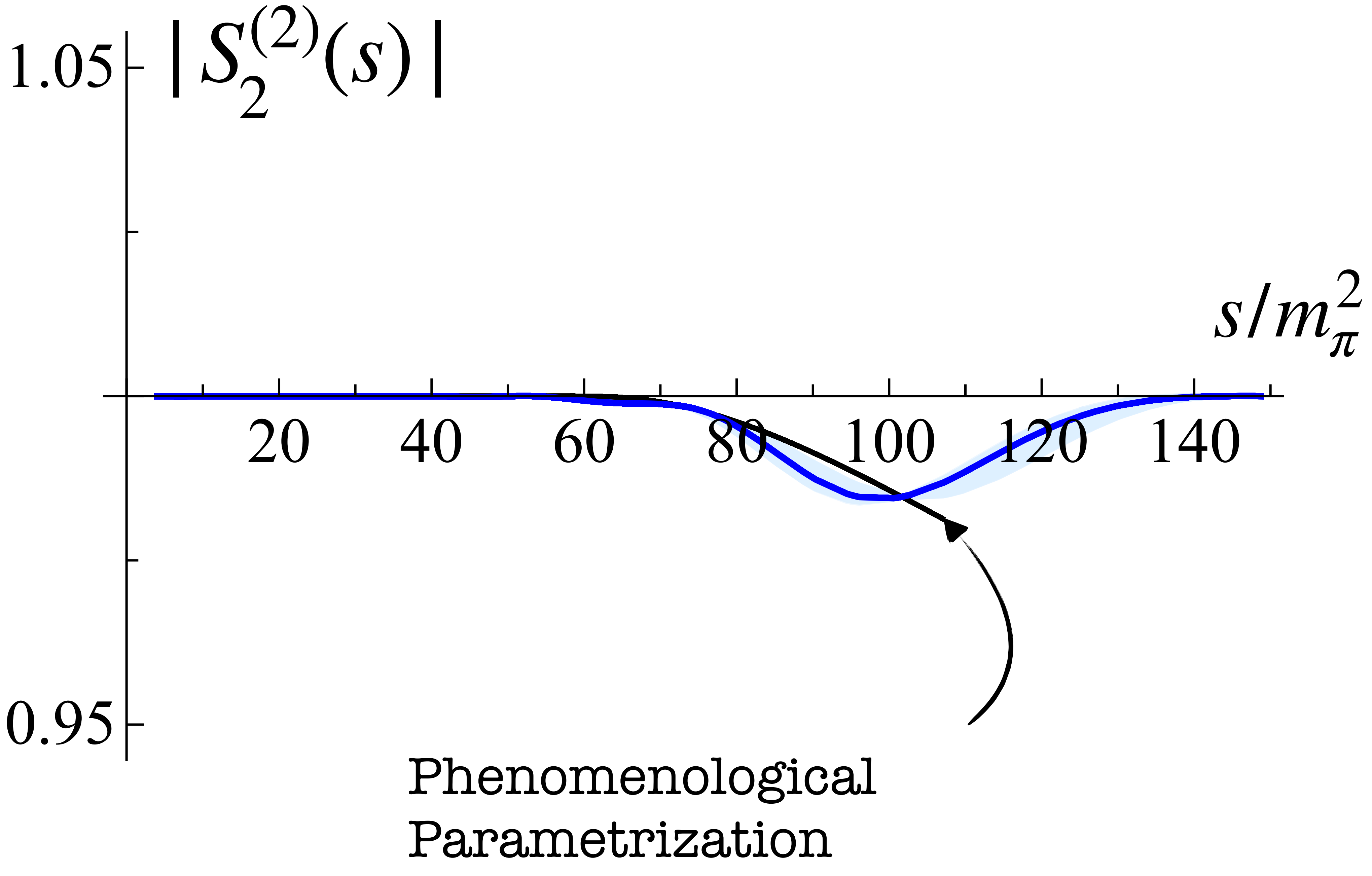
Check against 2-loops χPT

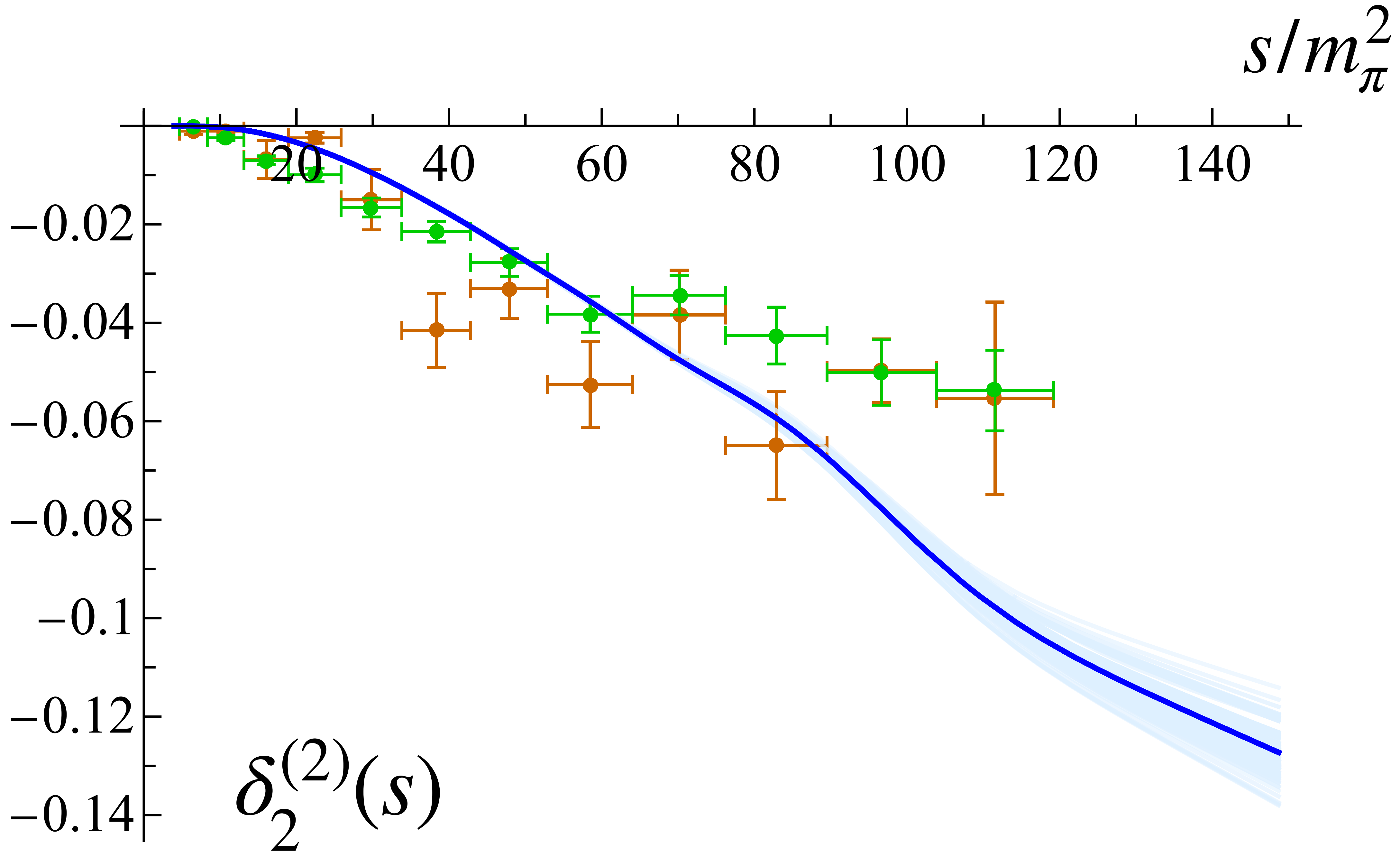




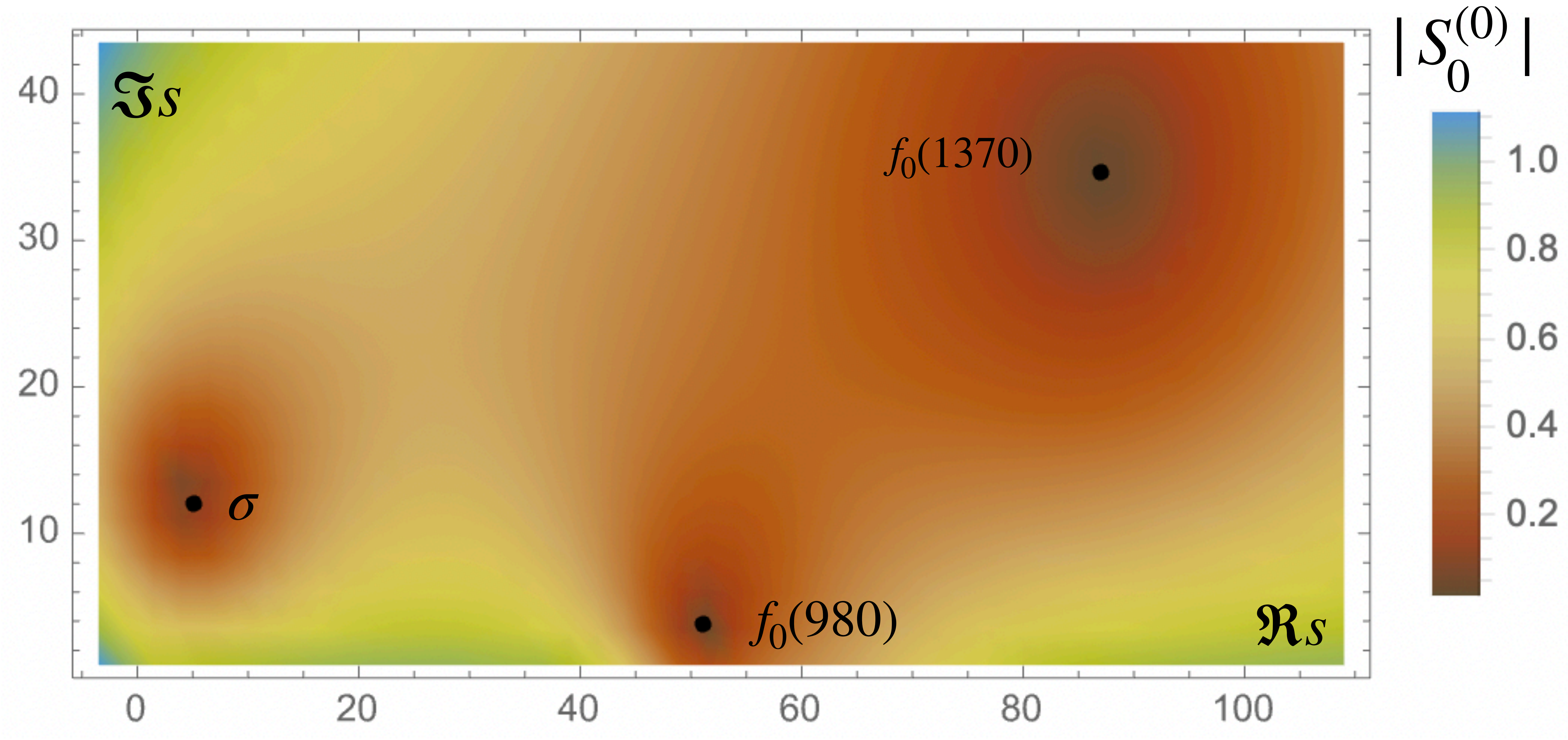
	Bootstrap Fit	Literature
$a_0^{(2)}$	$(-0.432 \pm 0.001) \times 10^{-1}$	$(-0.444 \pm 0.012) \times 10^{-1}$
$a_1^{(1)}$	$(0.380 \pm 0.002) \times 10^{-1}$	$(0.379 \pm 0.05) \times 10^{-1}$
$b_0^{(0)}$	0.265 ± 0.030	0.276 ± 0.006
$b_0^{(2)}$	$(-0.797 \pm 0.002) \times 10^{-1}$	$(-0.803 \pm 0.012) \times 10^{-1}$
$b_1^{(1)}$	$(0.61 \pm 0.02) \times 10^{-2}$	$(0.57 \pm 0.01) \times 10^{-2}$
$a_2^{(0)}$	$(0.53 \pm 0.11) \times 10^{-2}$	$(0.175 \pm 0.003) \times 10^{-2}$
$a_2^{(2)}$	$(0.51 \pm 0.18) \times 10^{-3}$	$(0.170 \pm 0.013) \times 10^{-3}$
$a_1^{(3)}$	$(1.5 \pm 0.4) \times 10^{-4}$	$(0.56 \pm 0.02) \times 10^{-4}$

Prediction for I=2, J=2

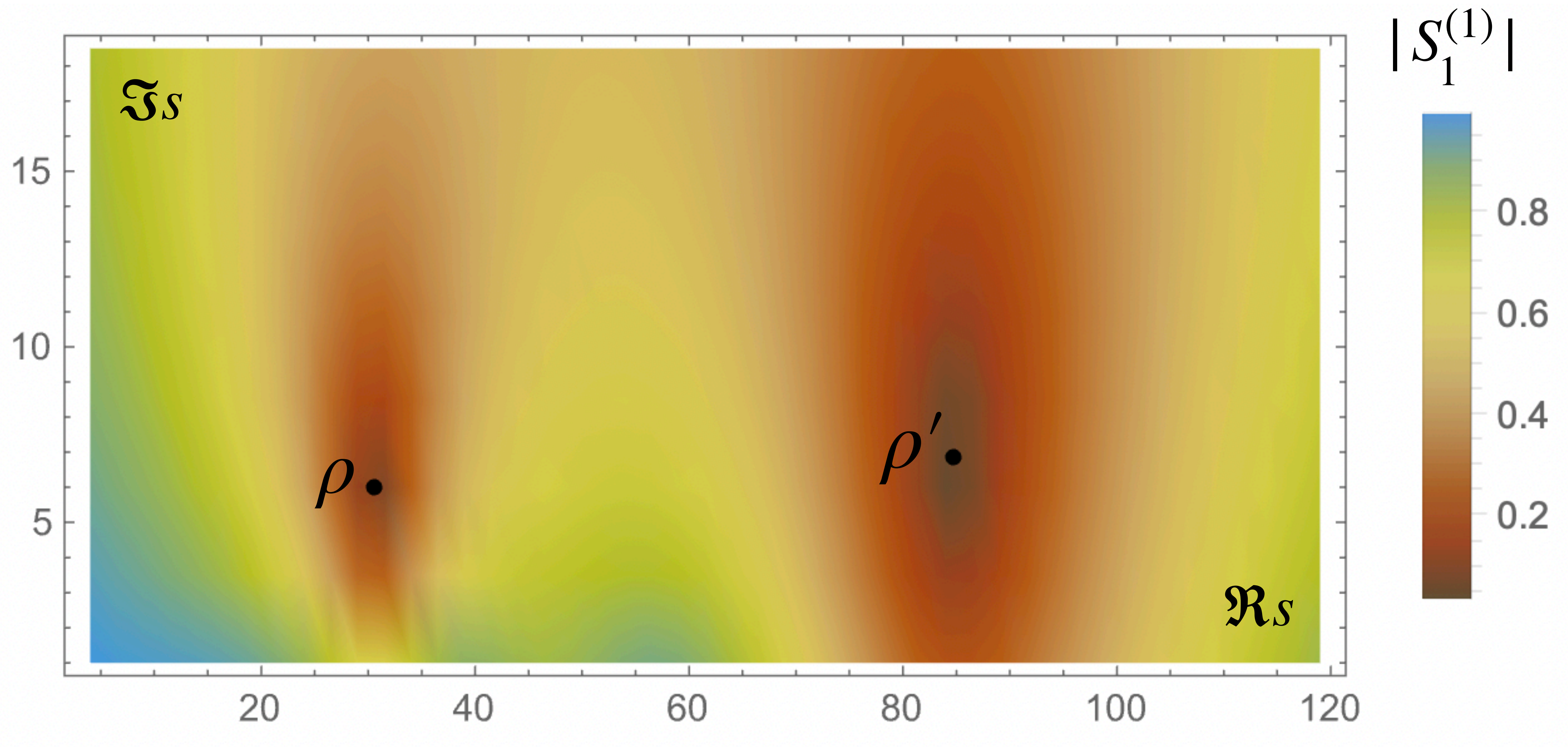




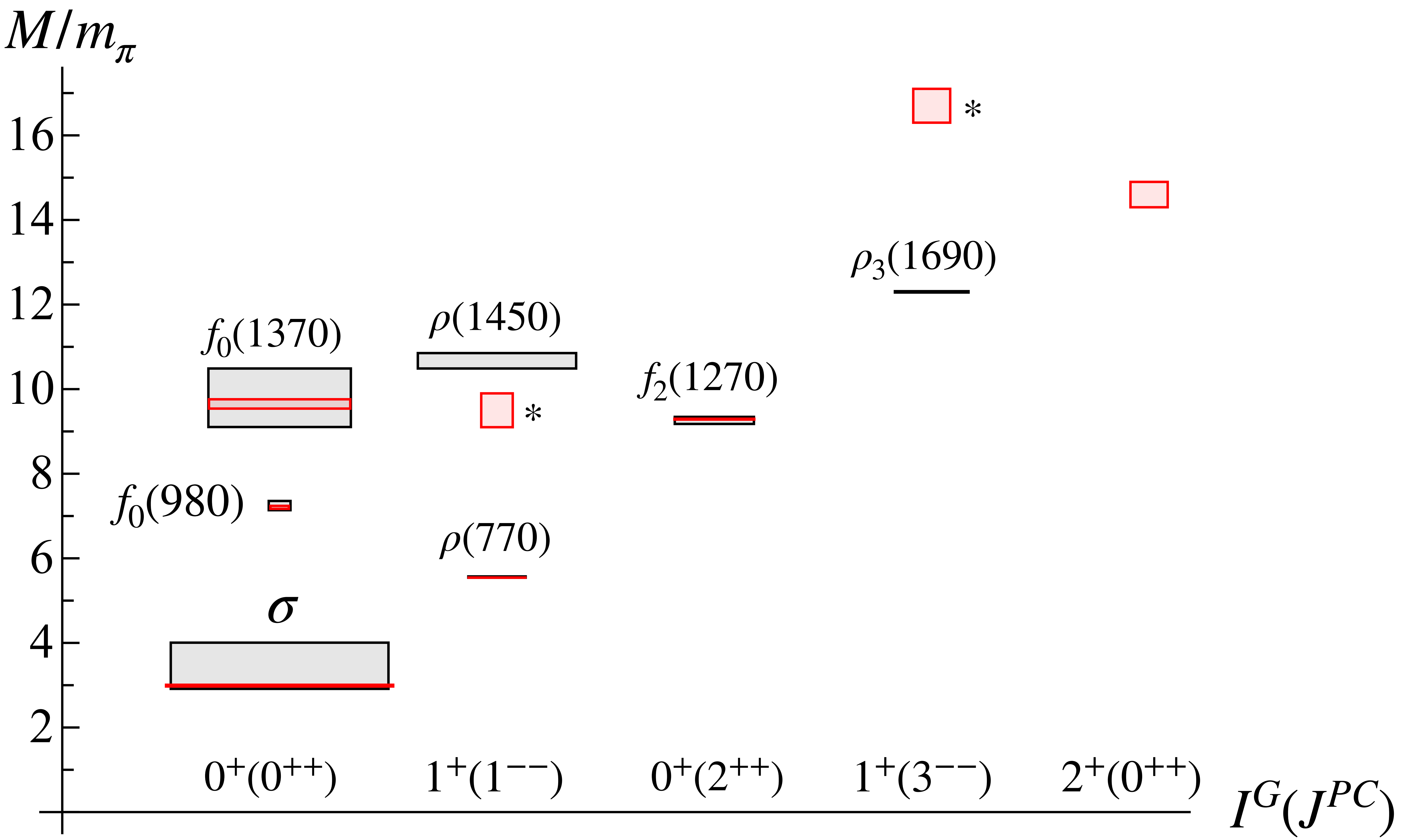
Spectrum for I=0, J=0



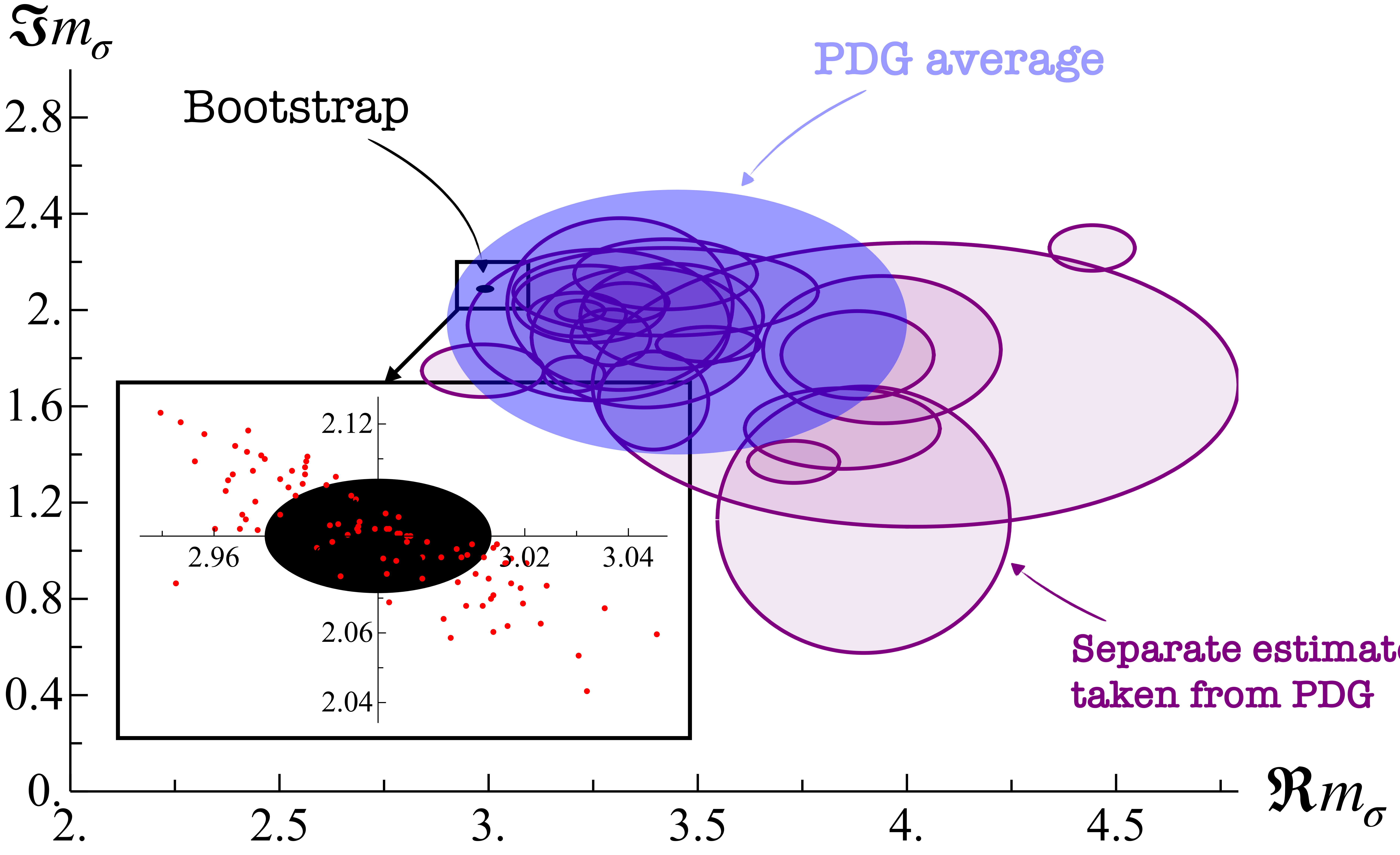
Spectrum for I=1, J=1



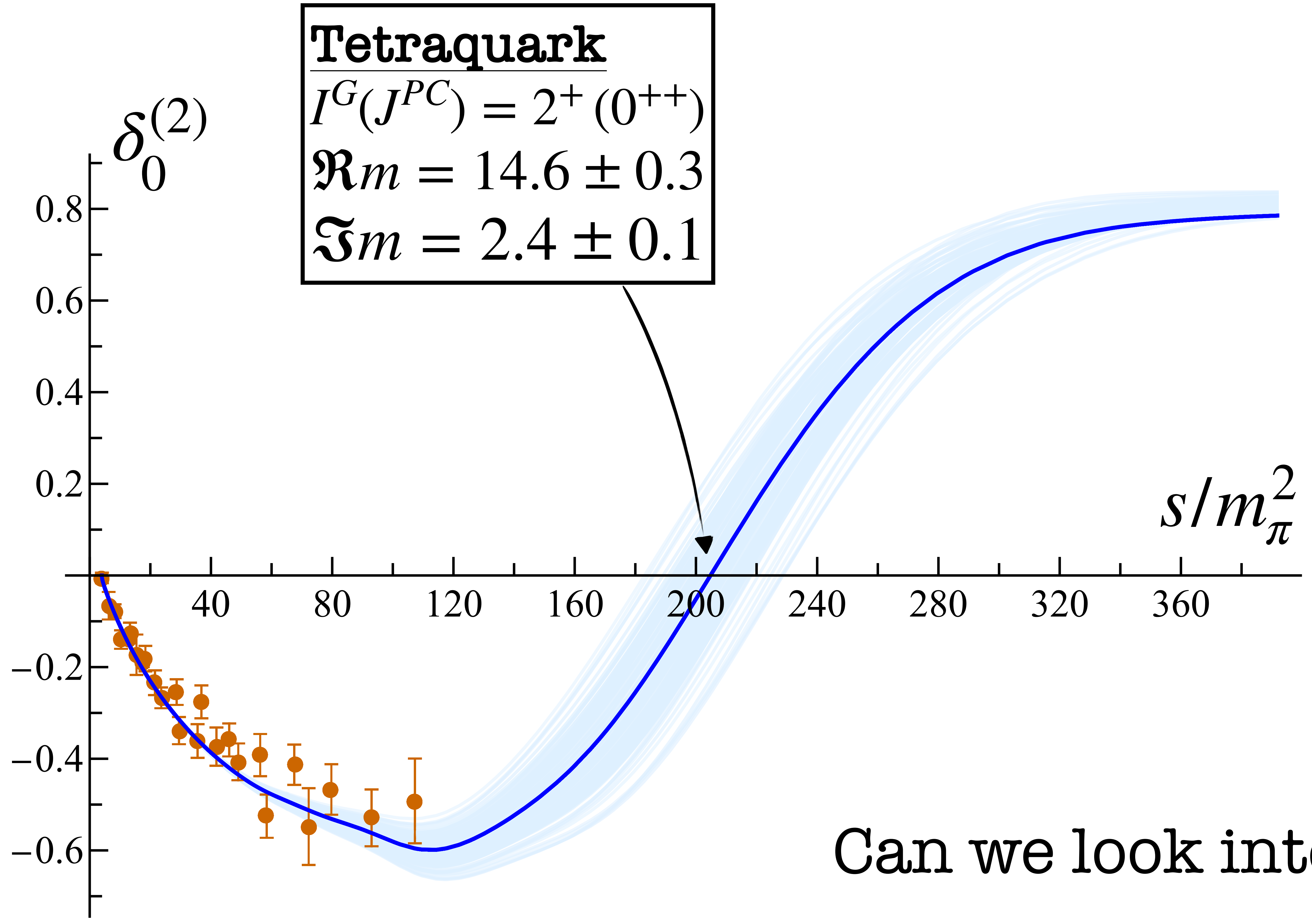
Full Spectrum < 1.4 GeV, with G-parity +1



Sigma parameters determination



The Tetraquark

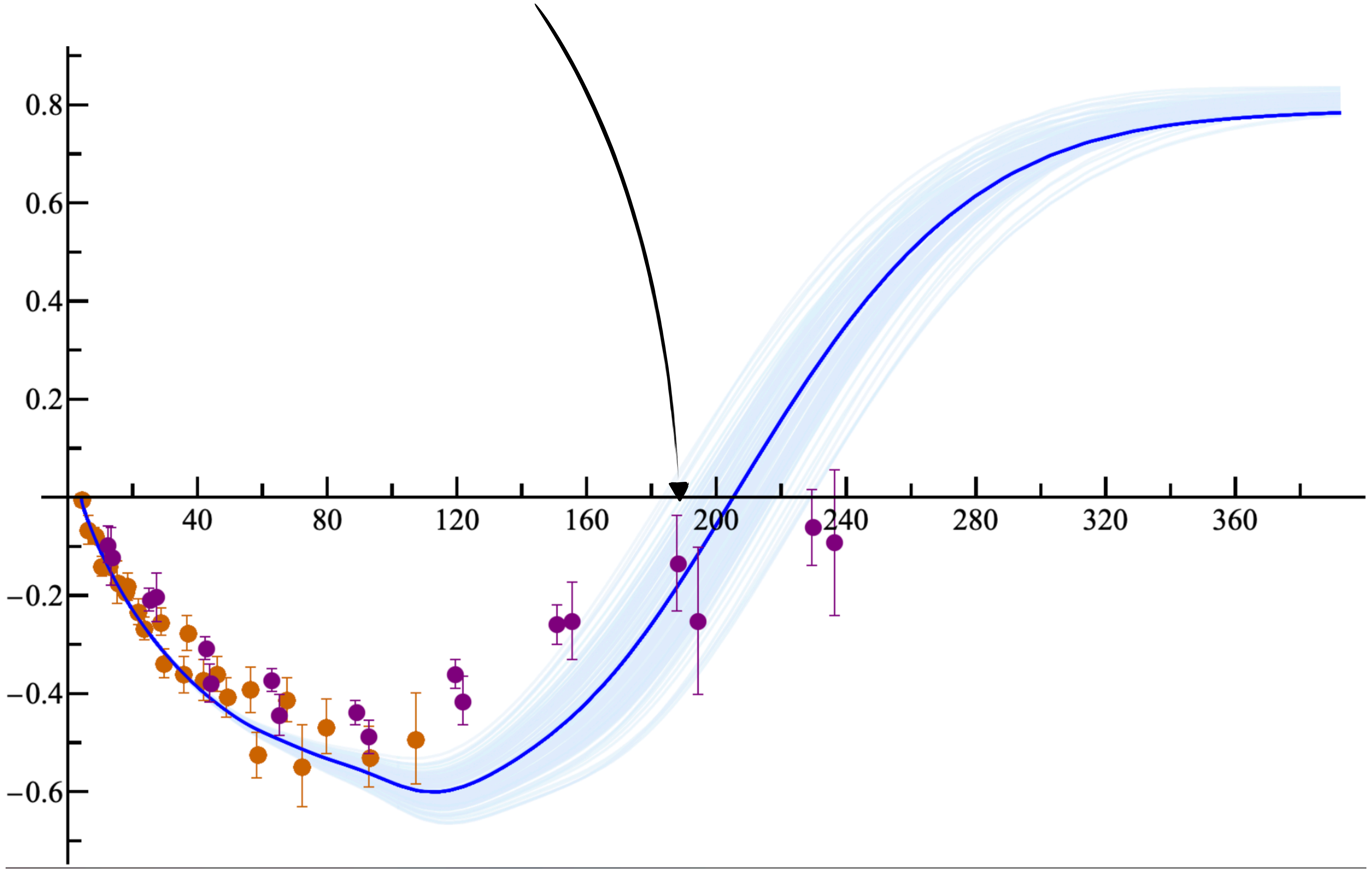


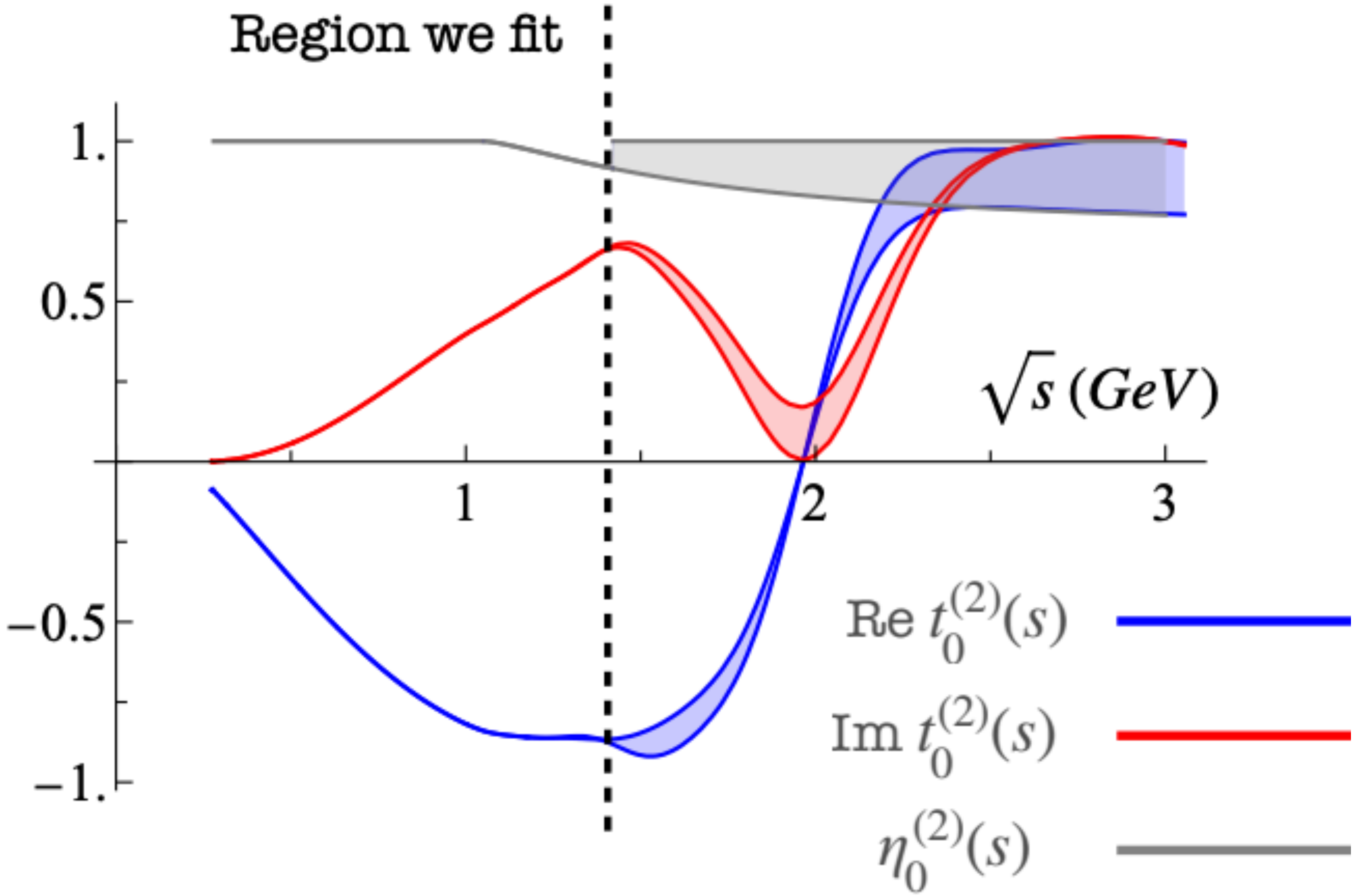
$M \sim 2GeV,$
$\Gamma \sim 600MeV$

Can we look into $B^+ \to D^-\pi^+\pi^+$?

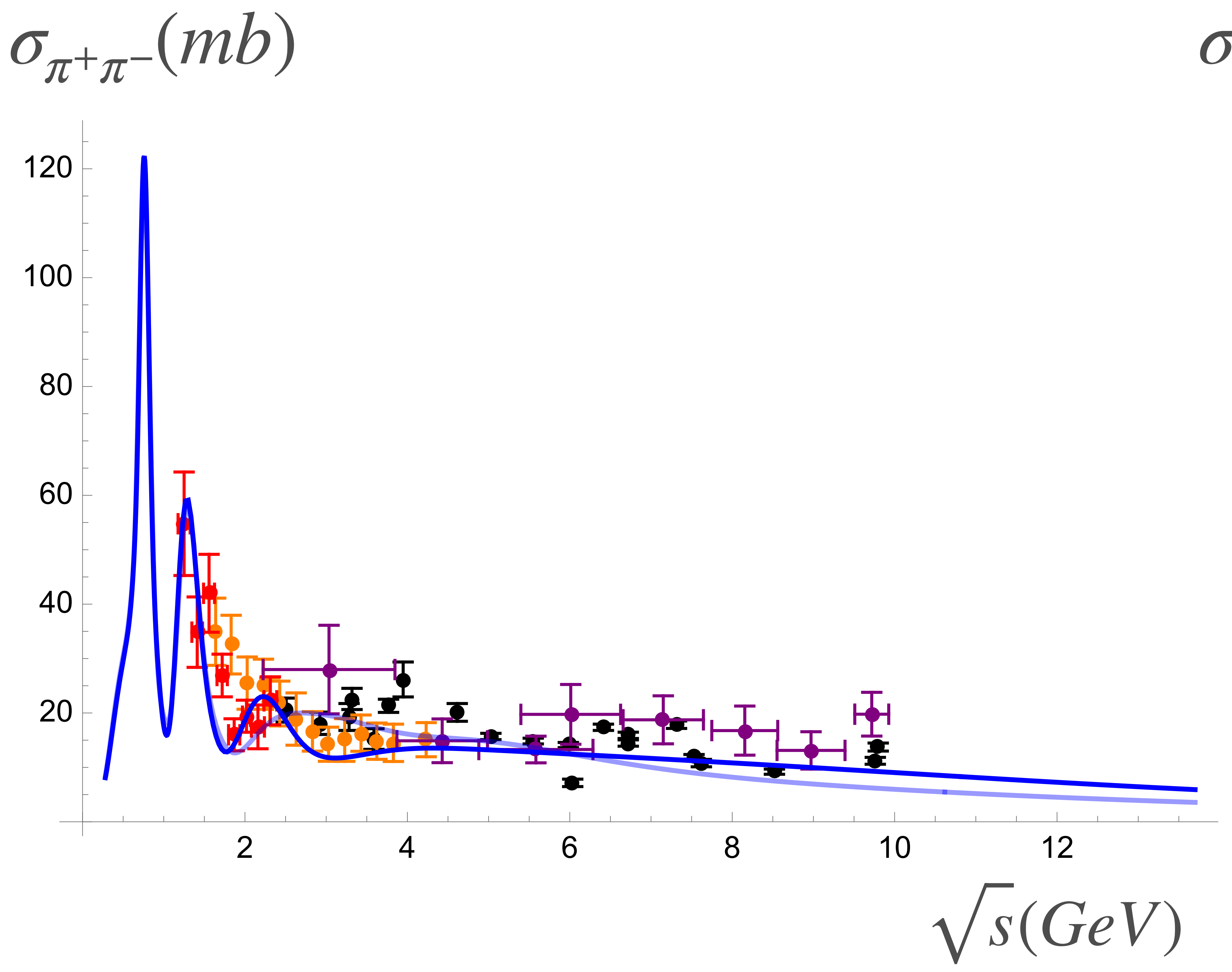
The Tetraquark (news)

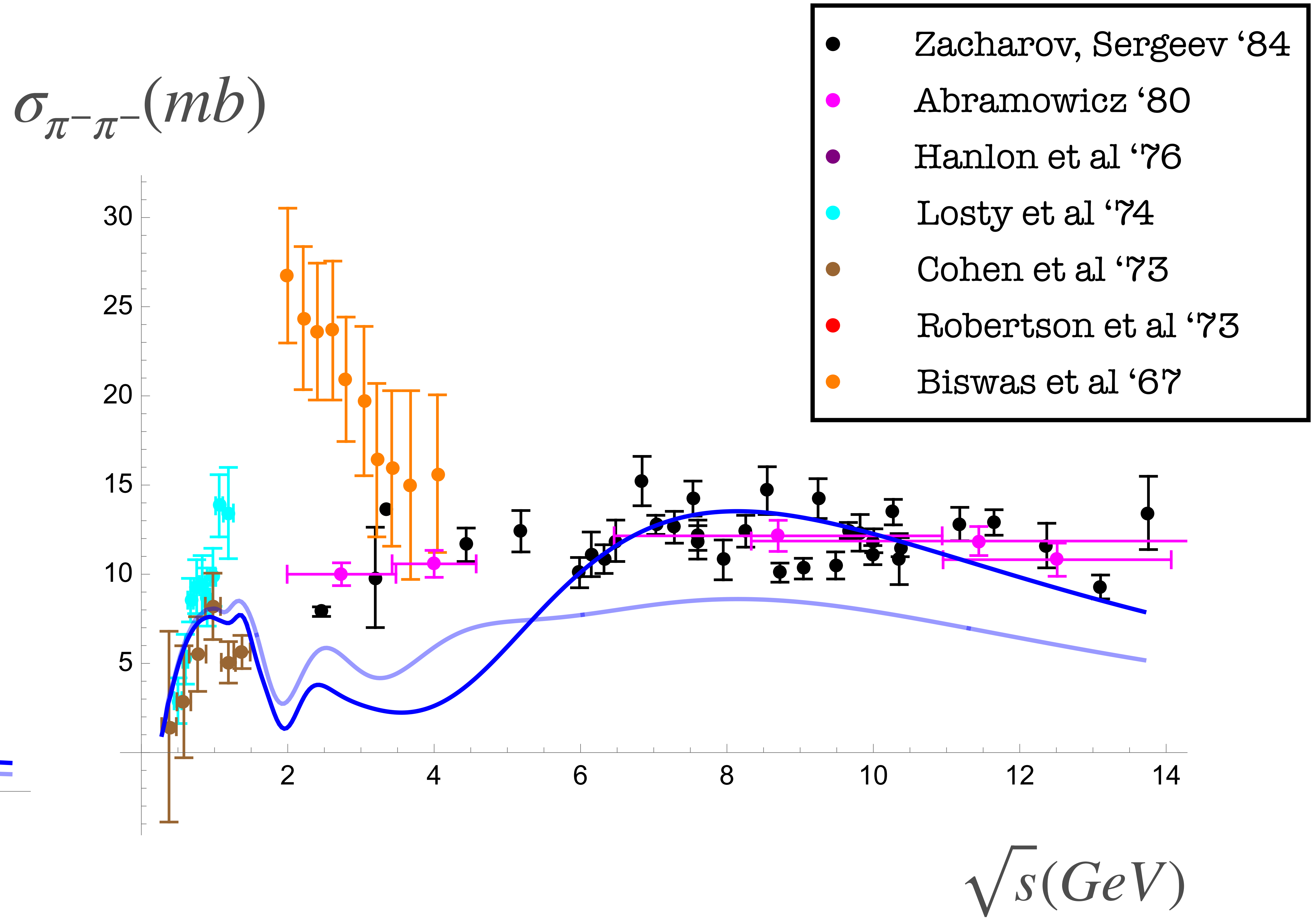
Data we had no idea about





High energy behaviour





Overview

Input

★ Experimental phase shifts data for S_0, S_2, P, D_0 waves

★ Inelasticity model for S_0, S_2, P, D_0 waves

★ ∃ chiral zeros

★ ∃ resonances $\rho(770)$, $f_0(980)$, $f_0(1370)$, $f_2(1270)$

Output

✤ Fit for the phase shifts, chiral zeros, resonances positions

✤ Scattering lengths and effective ranges for any isospin and spin $\ell < 2$

✤ S_0, S_2, P waves for $0 < s < 4$ compatible with χPT

✤ D_2 phase shift and inelasticity compatible with experiments

✤ Dynamical generation of σ, $\rho(1450)$, ρ_3 resonances, plus a tetra quark

✤ $\sigma_{\pi^+\pi^-}$ and $\sigma_{\pi^-\pi^-}$ cross sections

Outlook

1) Remove Spectrum assumptions and generate the whole spectrum dynamically

2) Study complex spin Regge trajectories and understand their non-perturbative pattern

3) Include better data from lattice and other experiments

4) Study the couples system $\pi\pi \to \pi\pi$, $\pi\pi \to KK$, $KK \to KK$ and fit inelasticity (systematic at the moment)

5) Work in synergy with lattice groups and study properties of glueballs