EFT Phenomenology of IR/UV relations

Francesco Riva
(Geneva University)

Forbidden Symmetries

in Scalar theories

Natural Effective Field Theories are shaped by symmetries

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Goldstone symmetry

$$\pi \to \pi + \alpha$$

$$\mathcal{L} = g_2(\partial\pi)^4 \quad \blacktriangleright \quad A \sim g_2(s^2 + t^2 + u^2)$$

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Bellazzini,Elias-Miro,Rattazzi,Riembau,FR'20
Hinterbichler,Joyce'14

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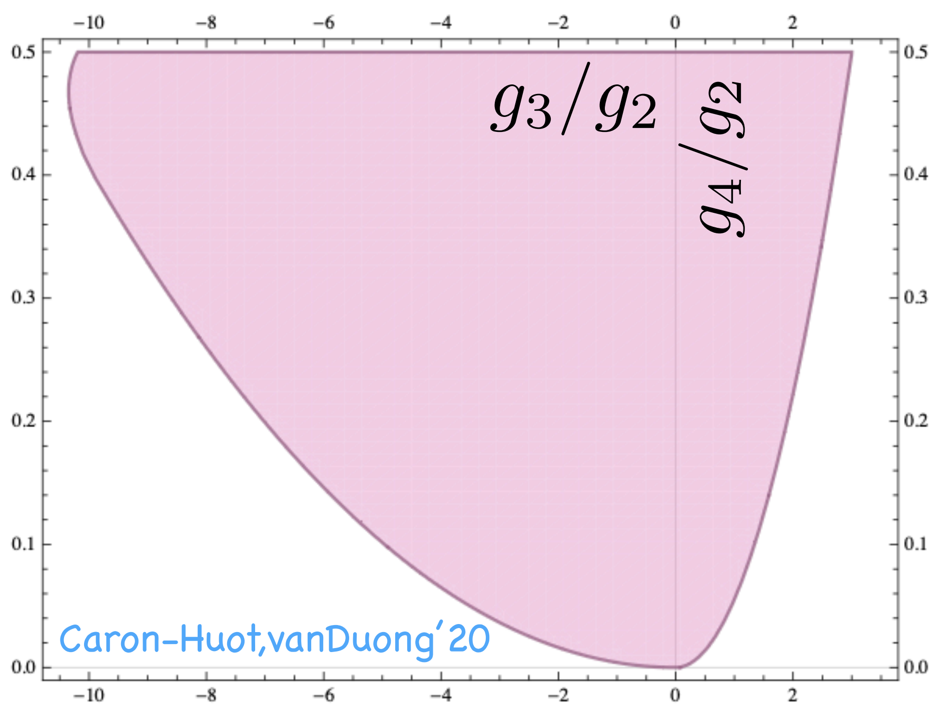

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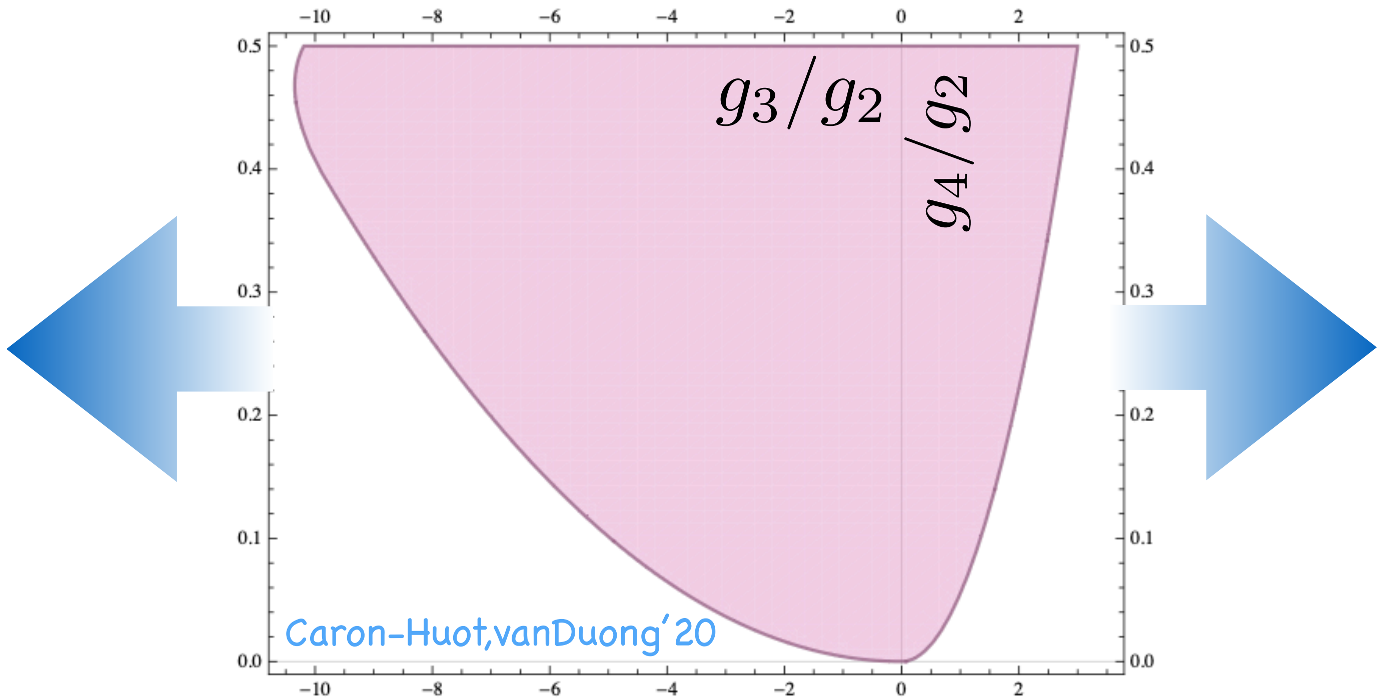

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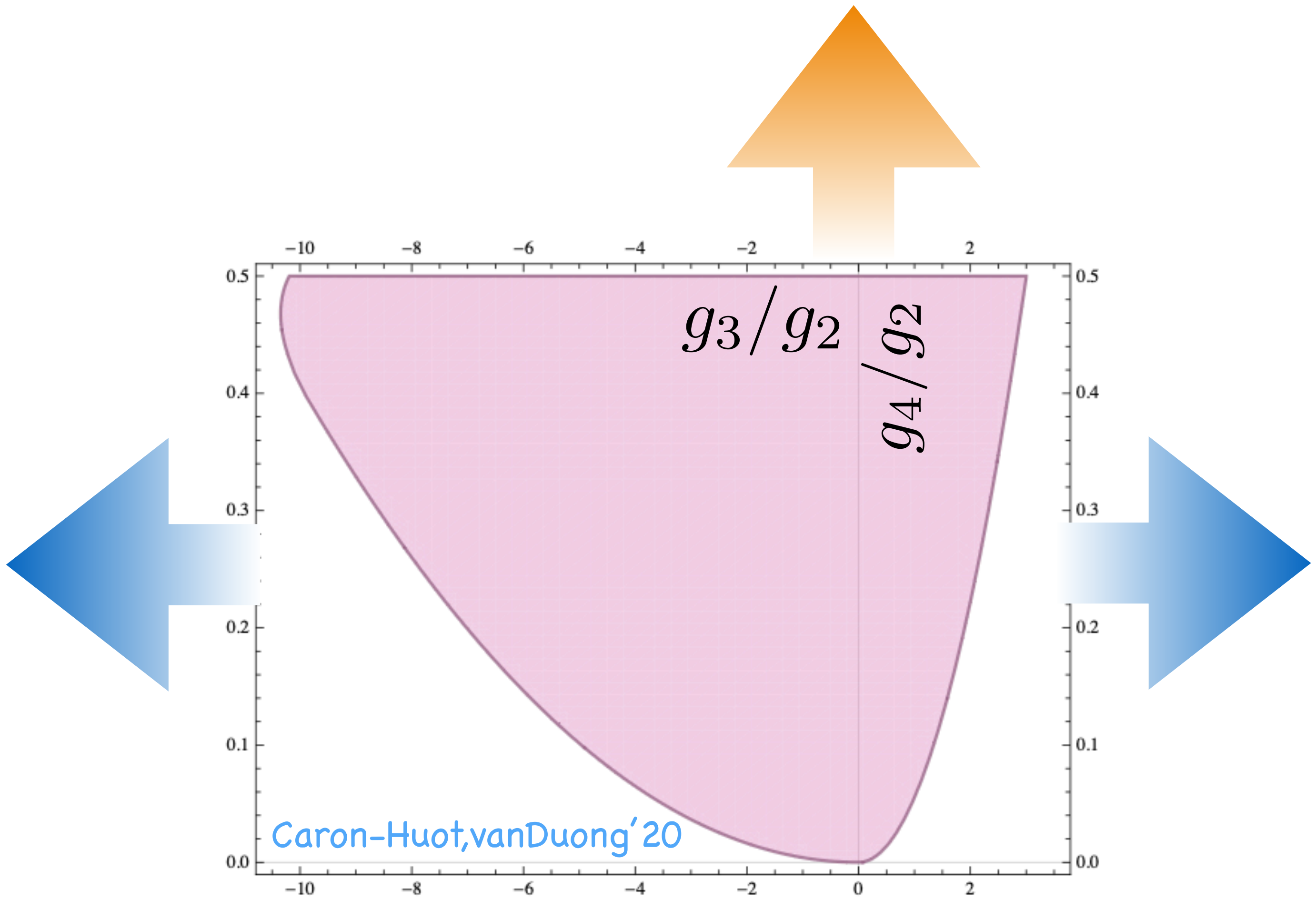

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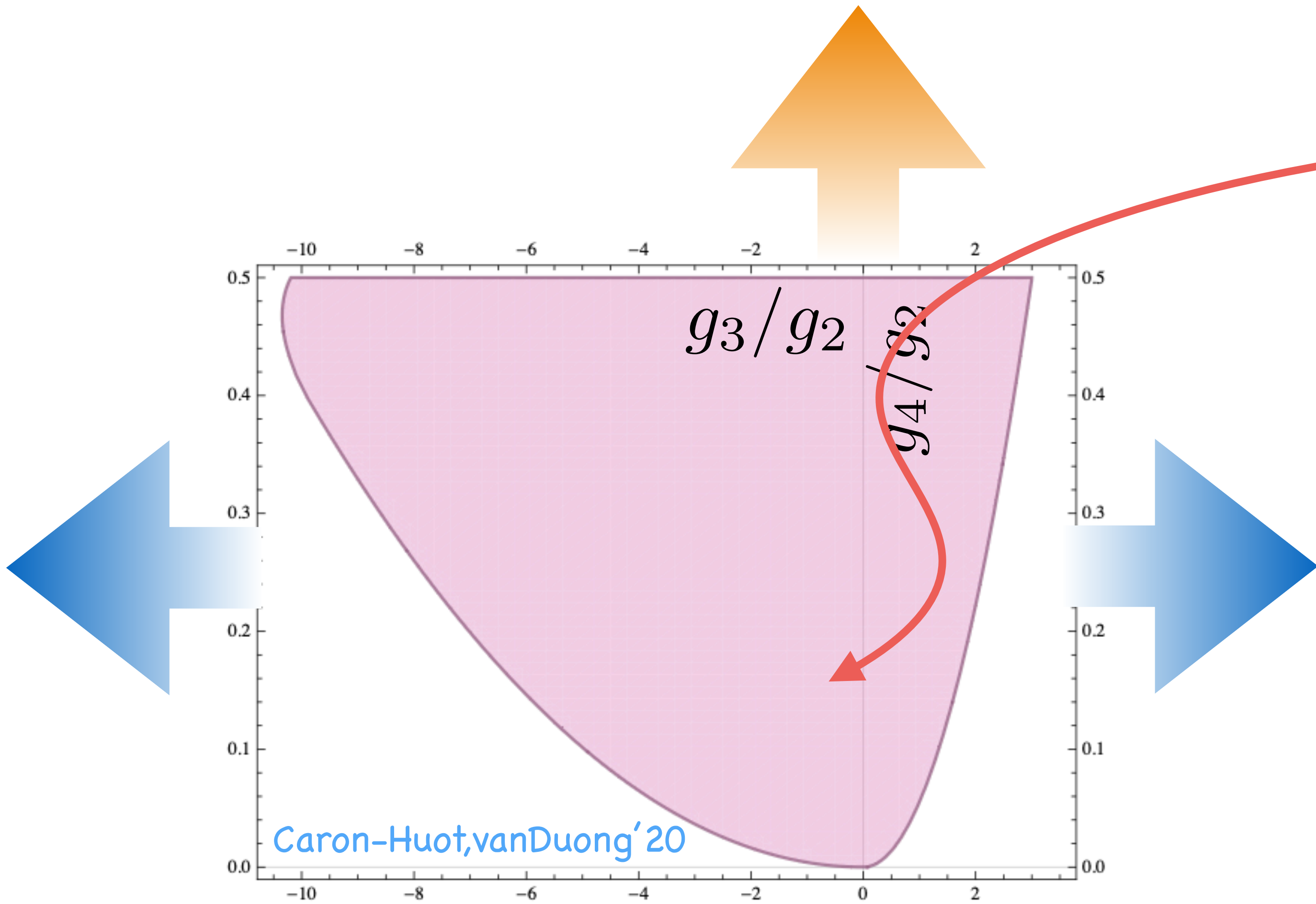

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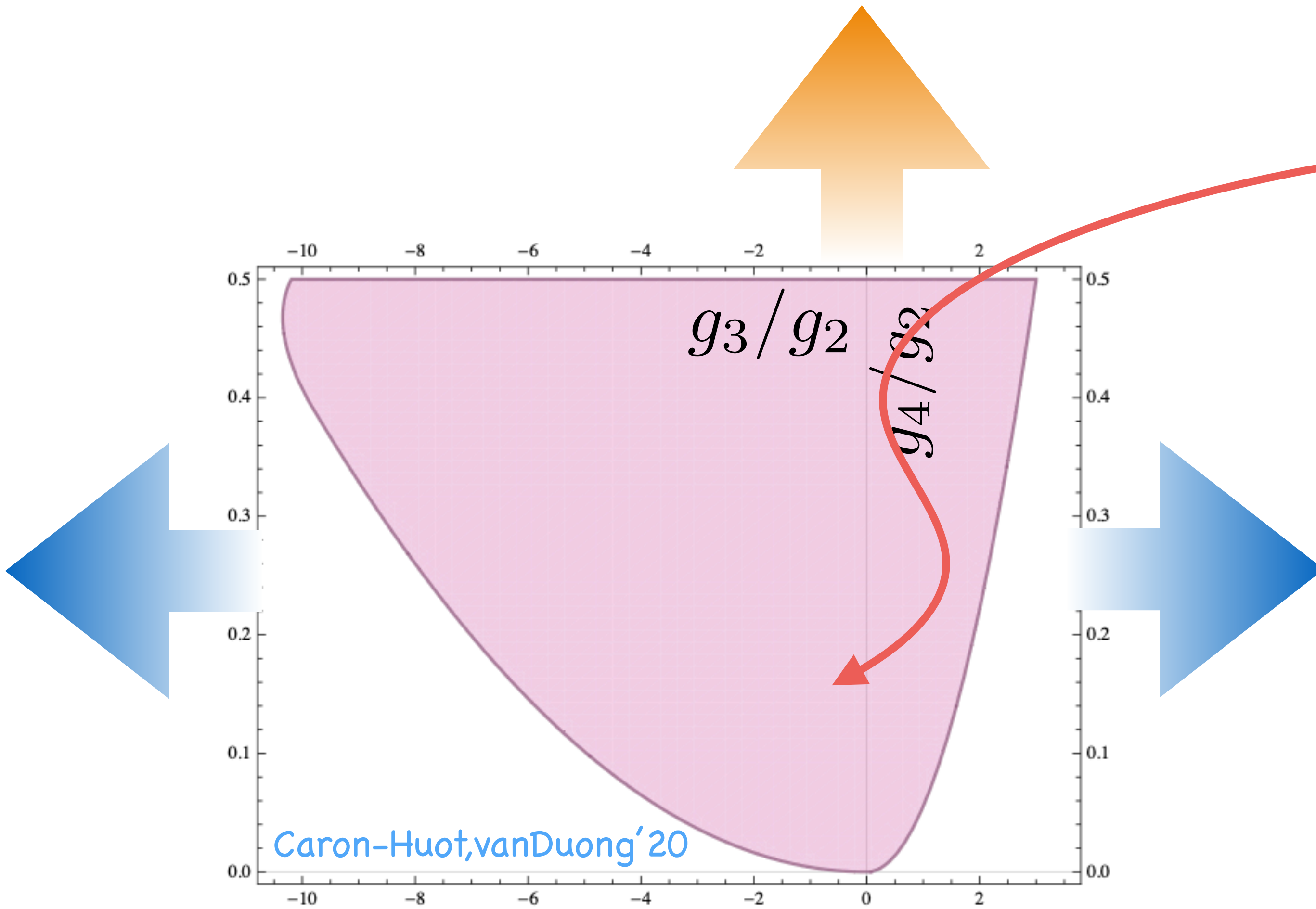

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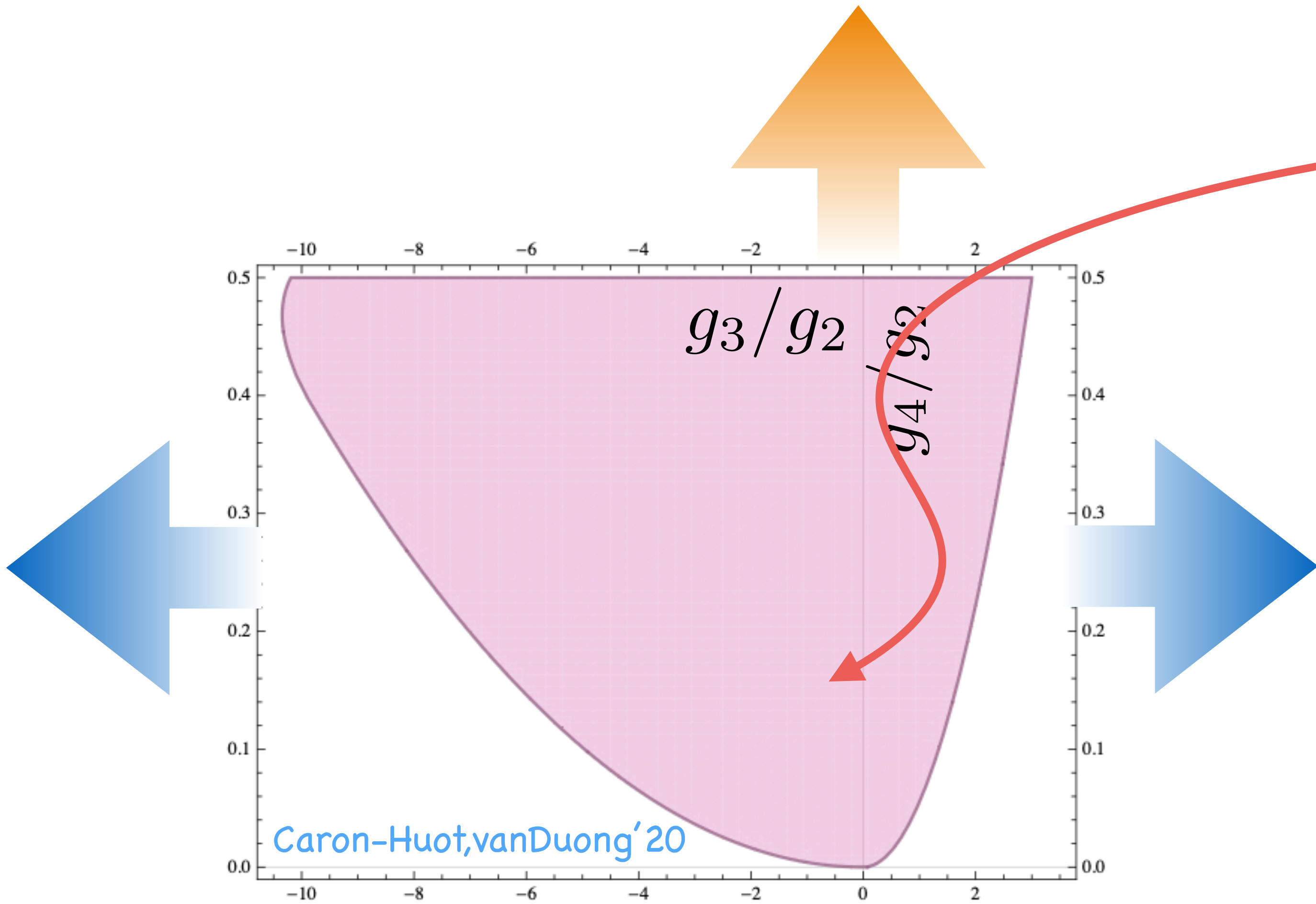

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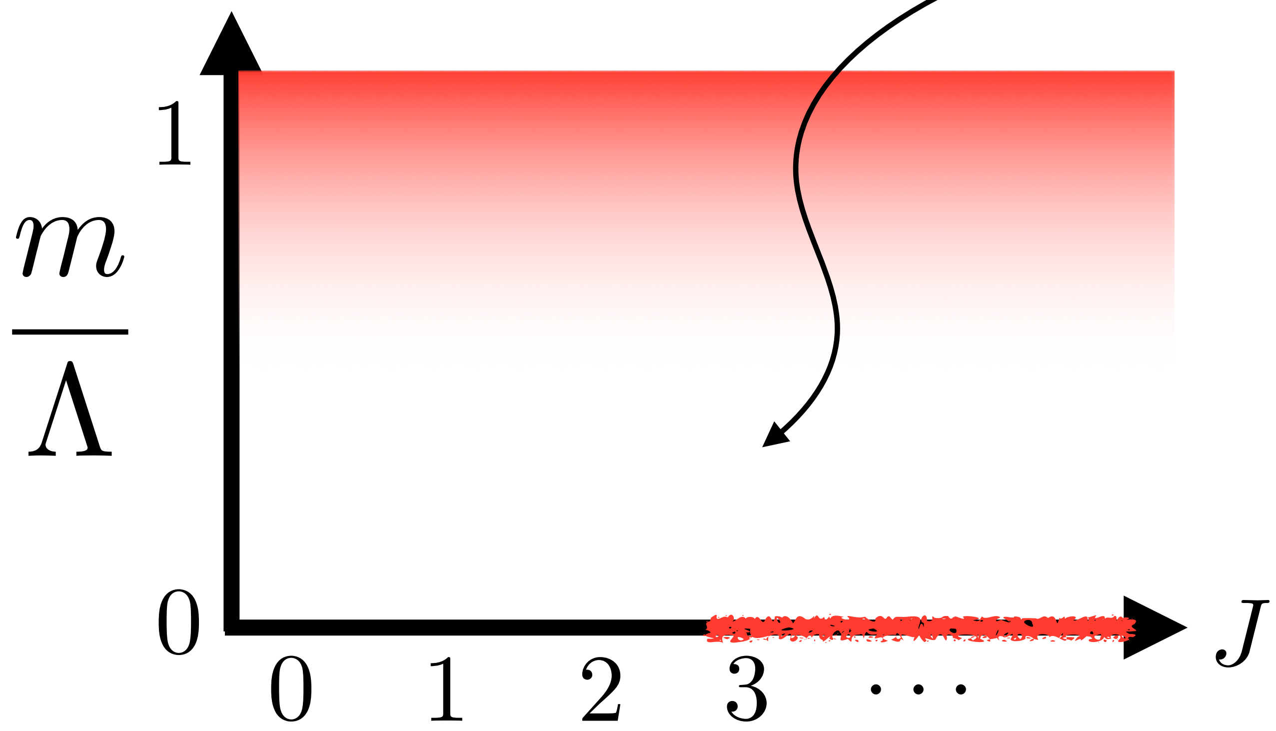
▶ Ordinary U(1) Goldstones are the softest particles

The Spectrum of EFTs

Healthy EFTs have cutoff $\Lambda \gg m$



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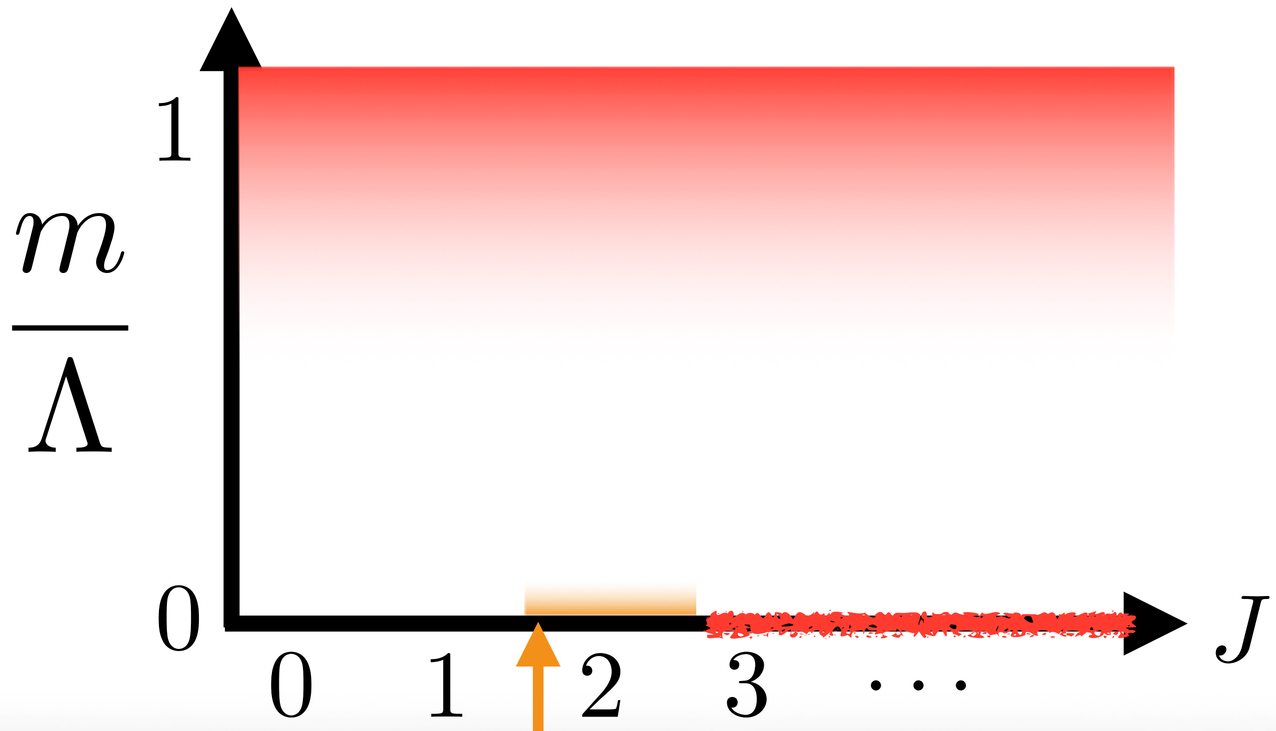
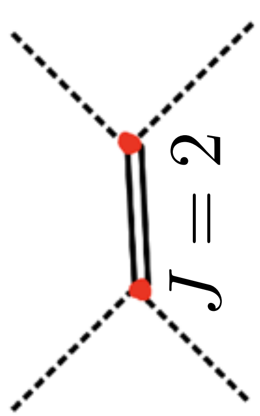
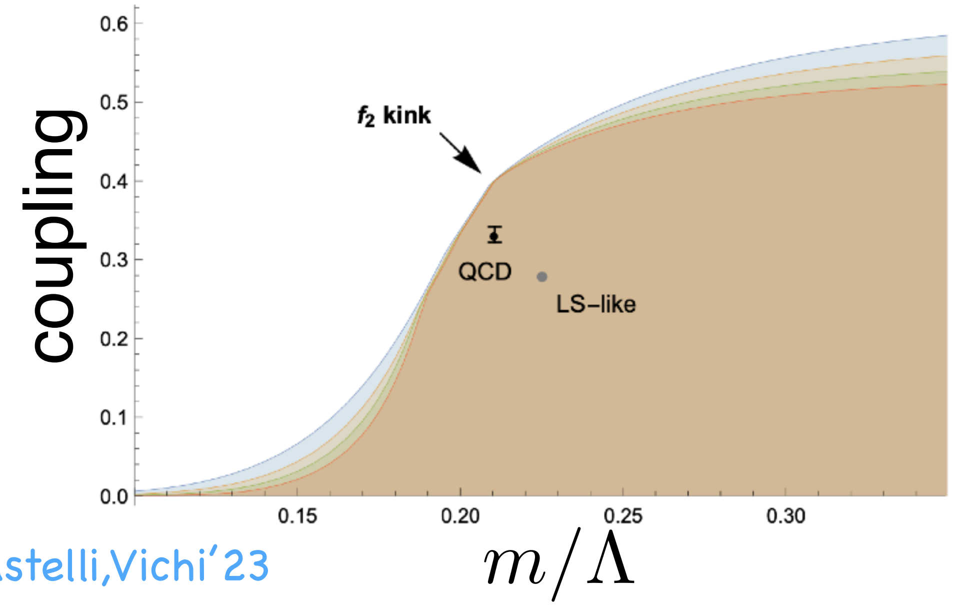


Probing Higher Spin with pions





Albert,Henriksson,Rastelli,Vichi'23

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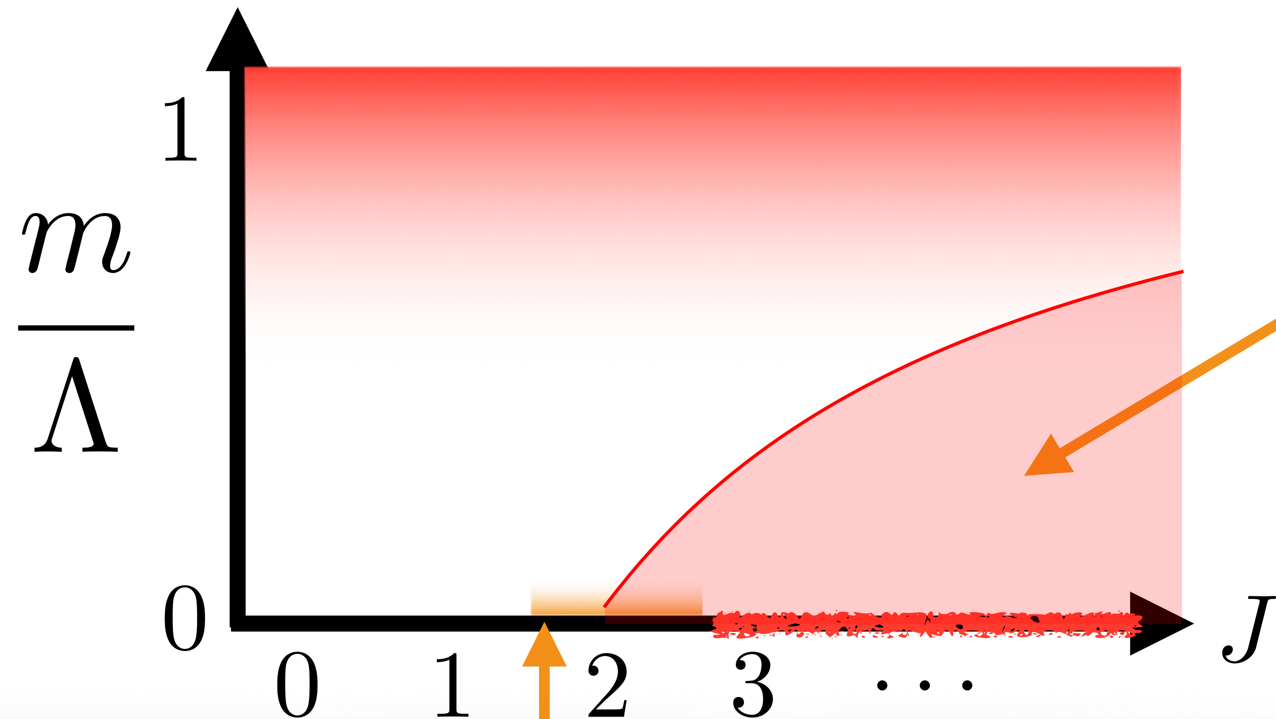
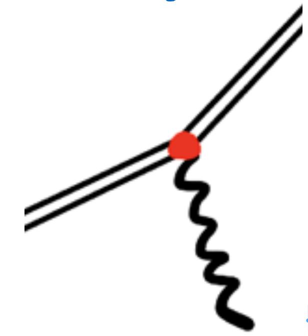


Probing HS with photons



$$\frac{m}{\Lambda} \gtrsim q^{\frac{1}{2J-1}}$$

Porrati,Rahman'08

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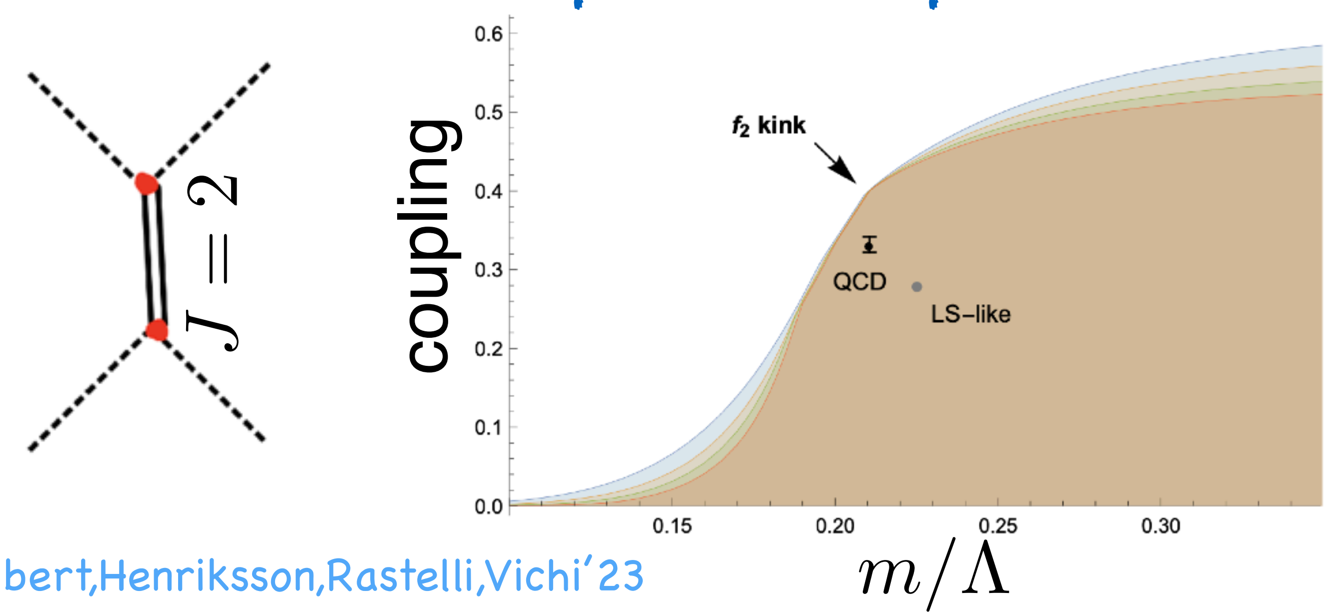

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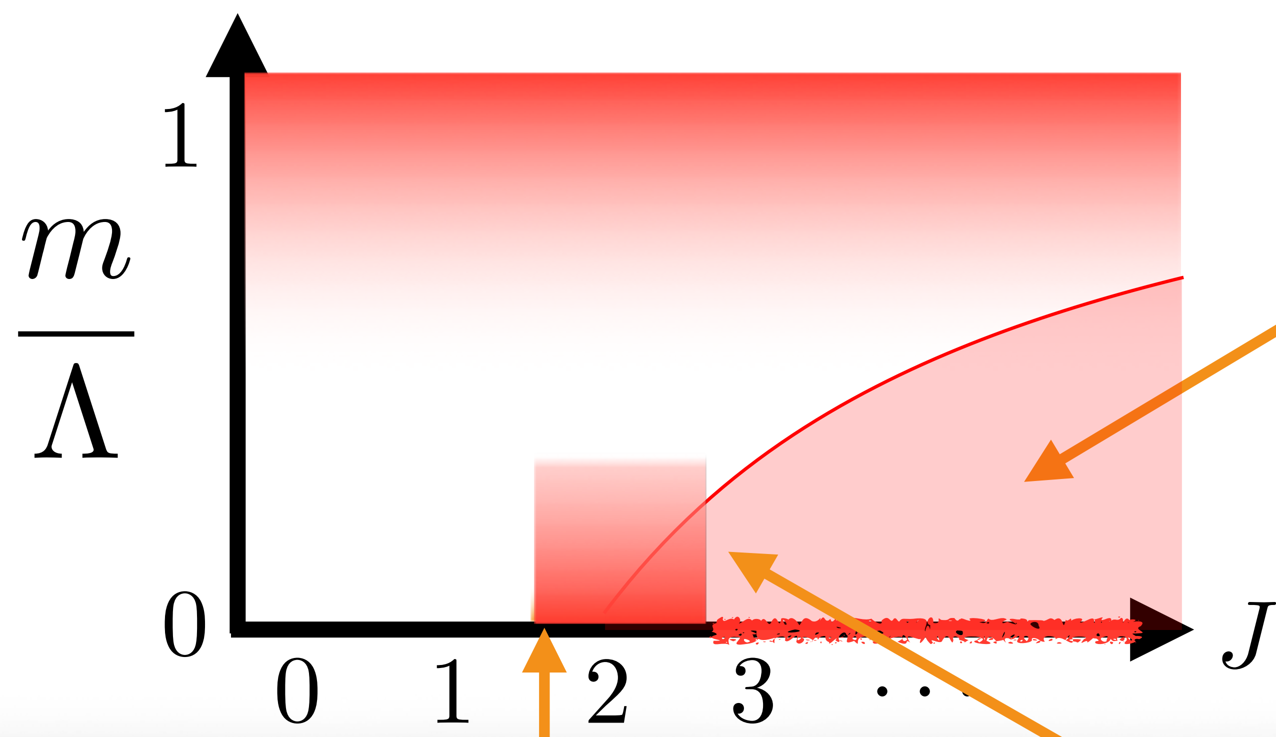

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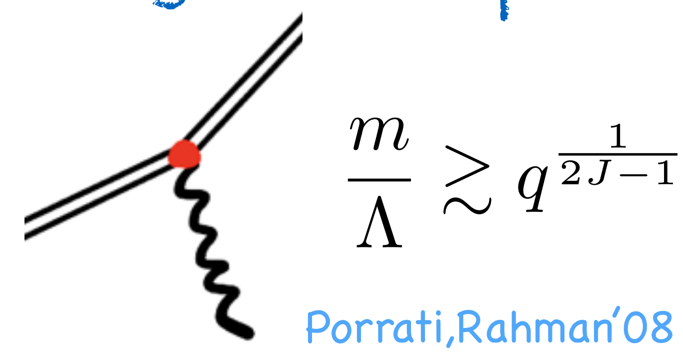

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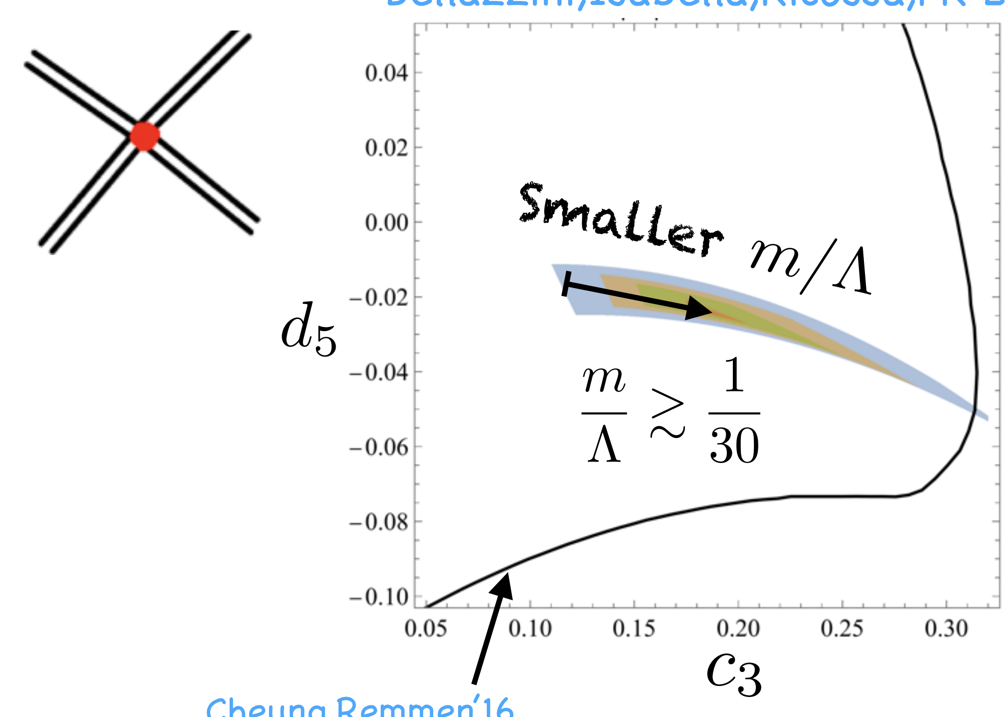
Probing HS with HS (J=2)

Bellazzini,Isabella,Ricossa,FR'23



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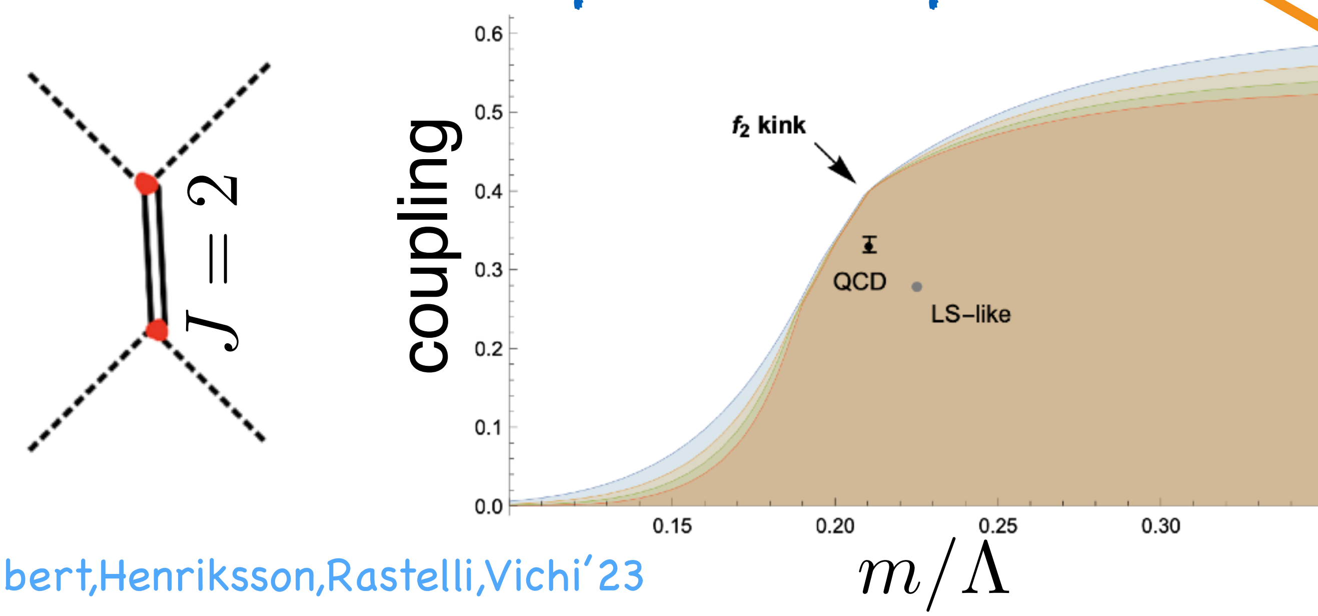

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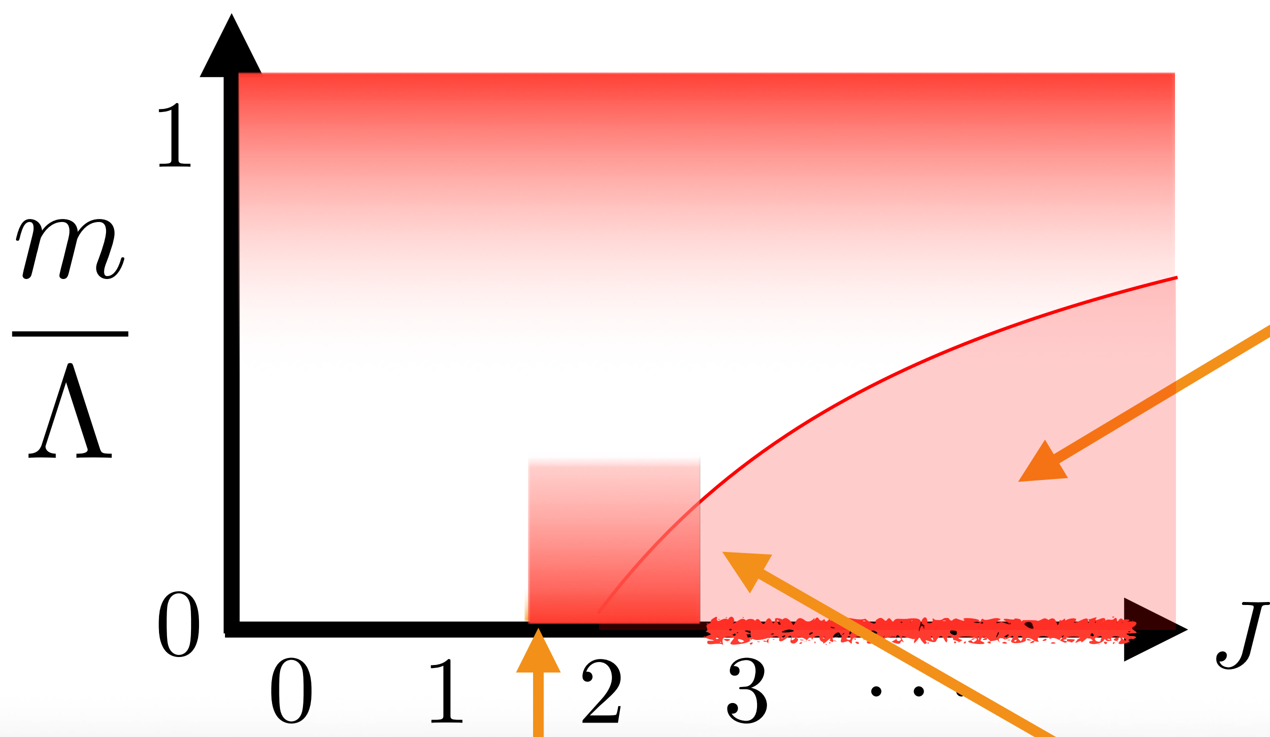

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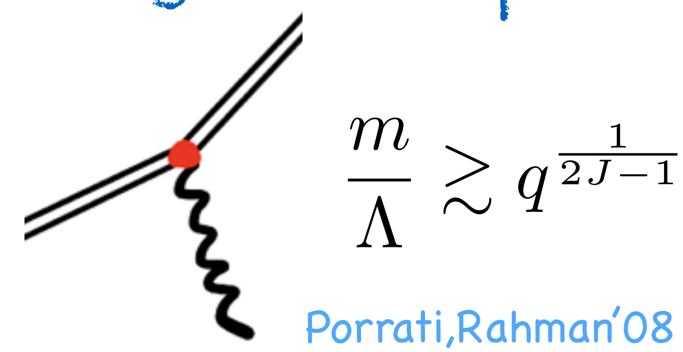

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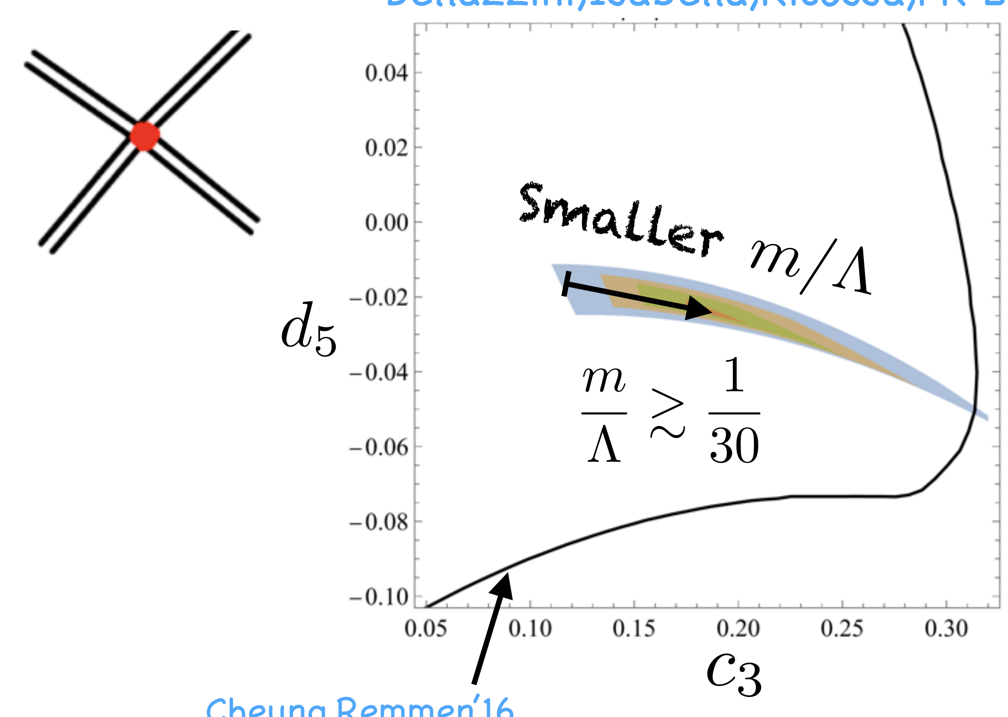

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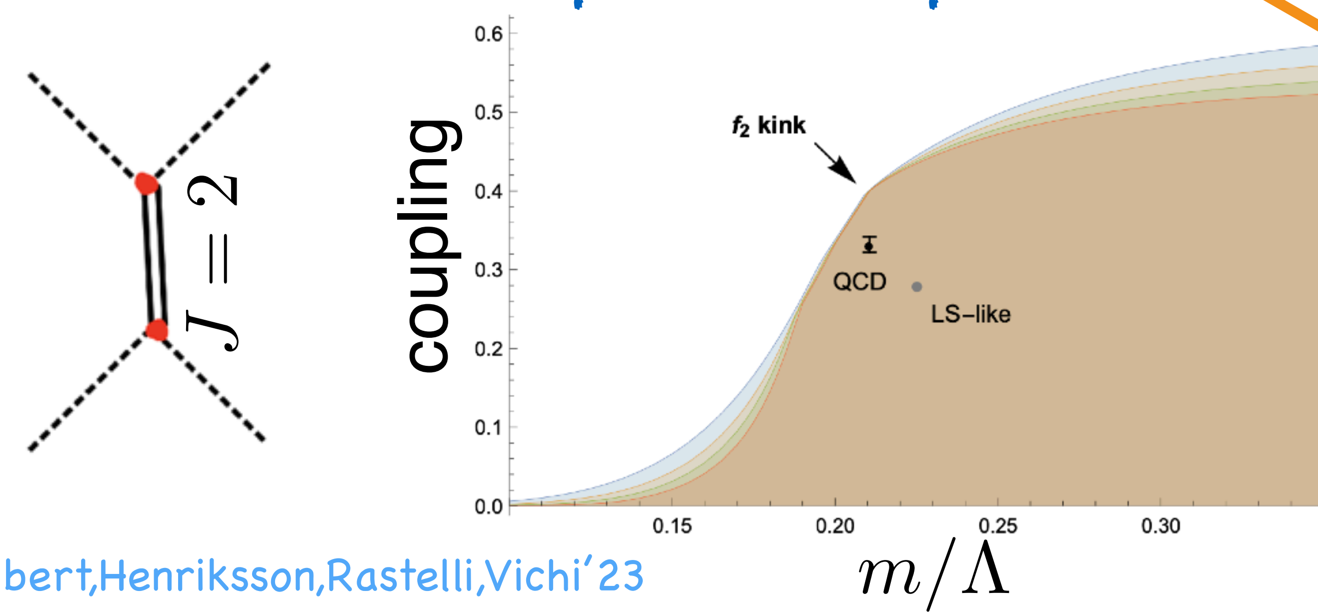

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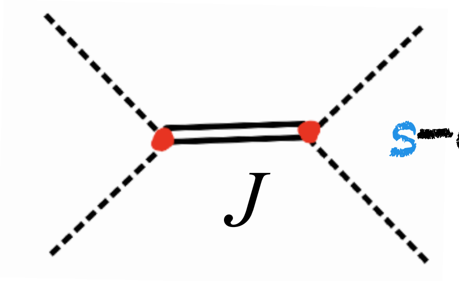
- Massive Higher Spin EFT has small validity range

Pions (at Large-N_c)



s-channel discontinuity must reproduce t-channel features

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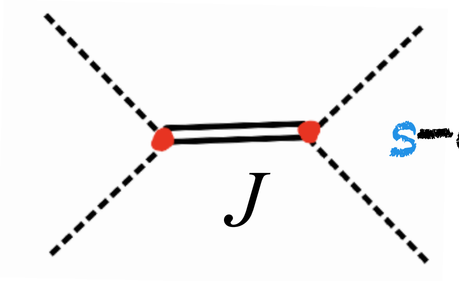

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UV Spin-1   UV Spin>1

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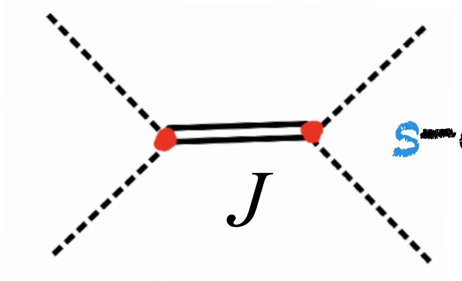

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... spin>1 smaller!

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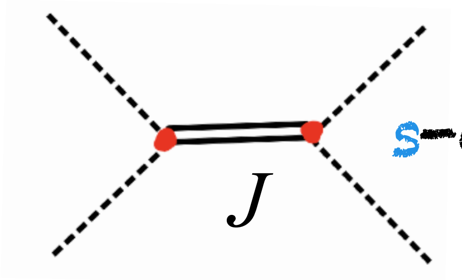

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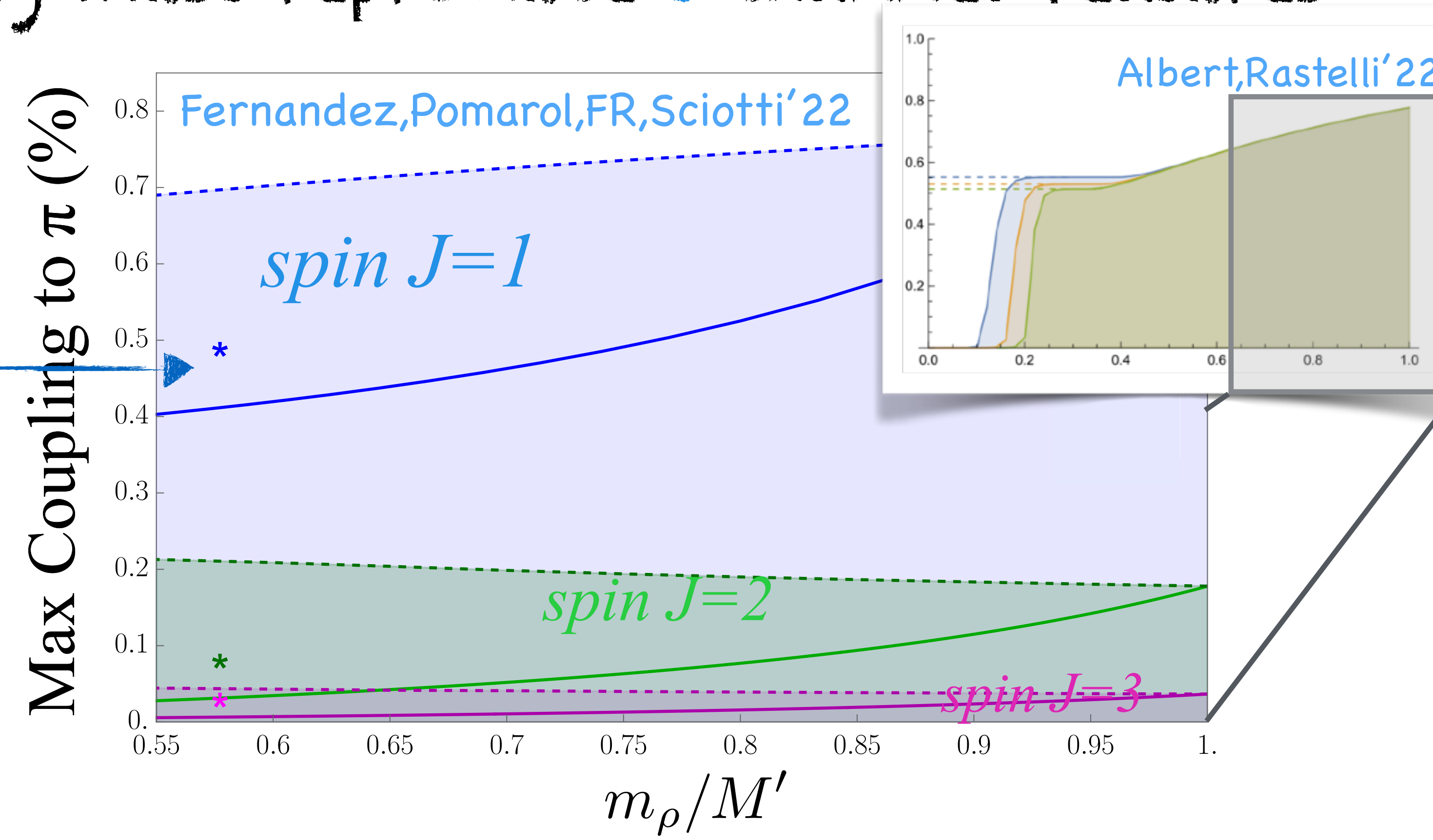

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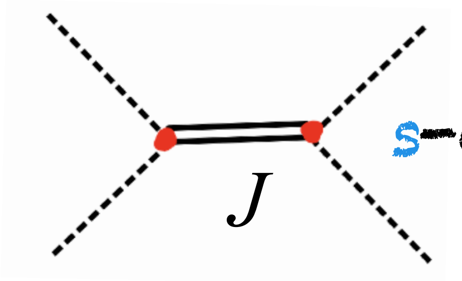

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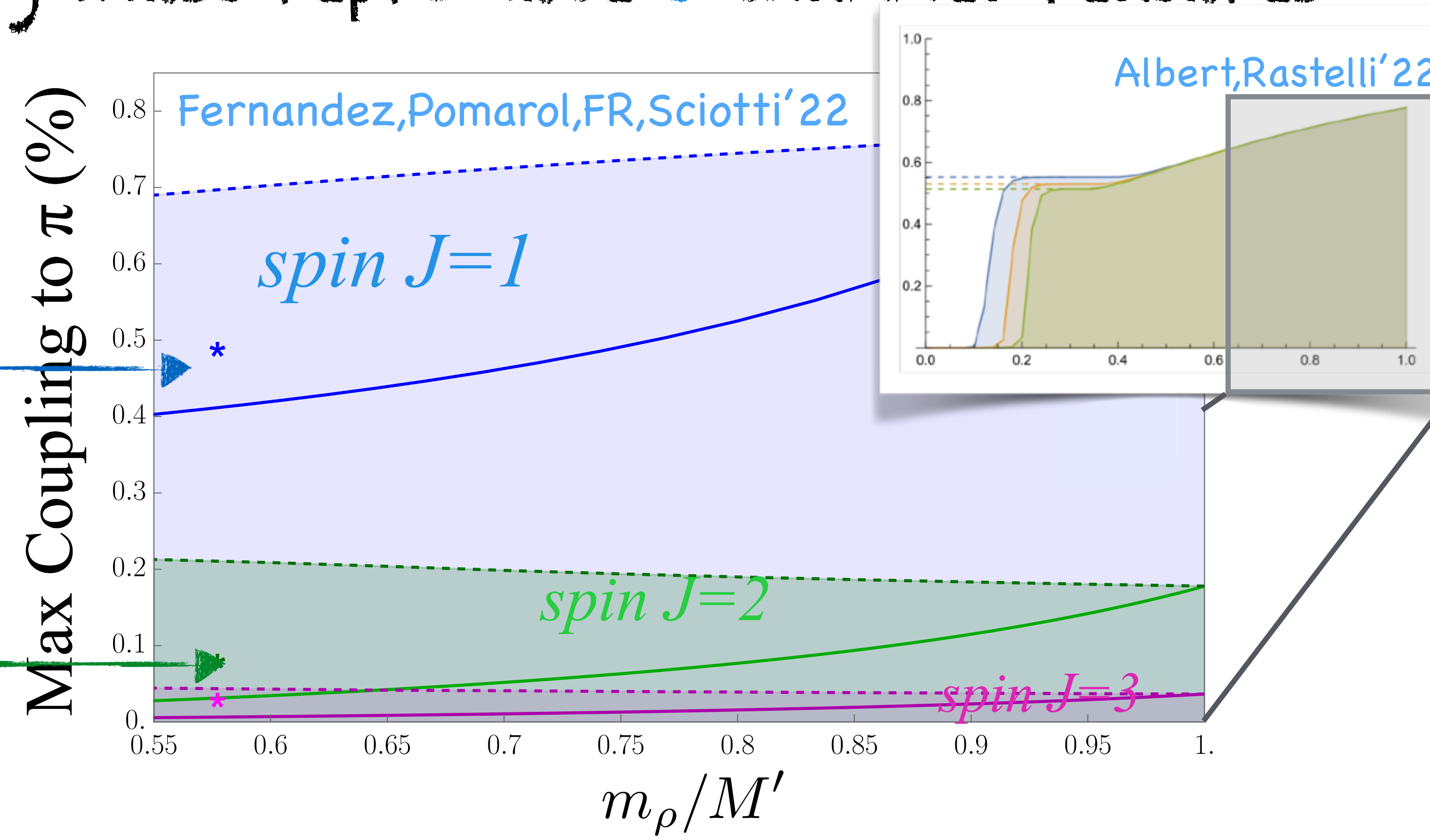

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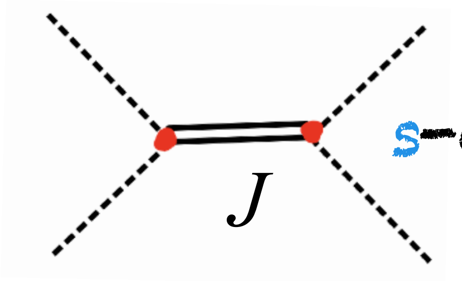

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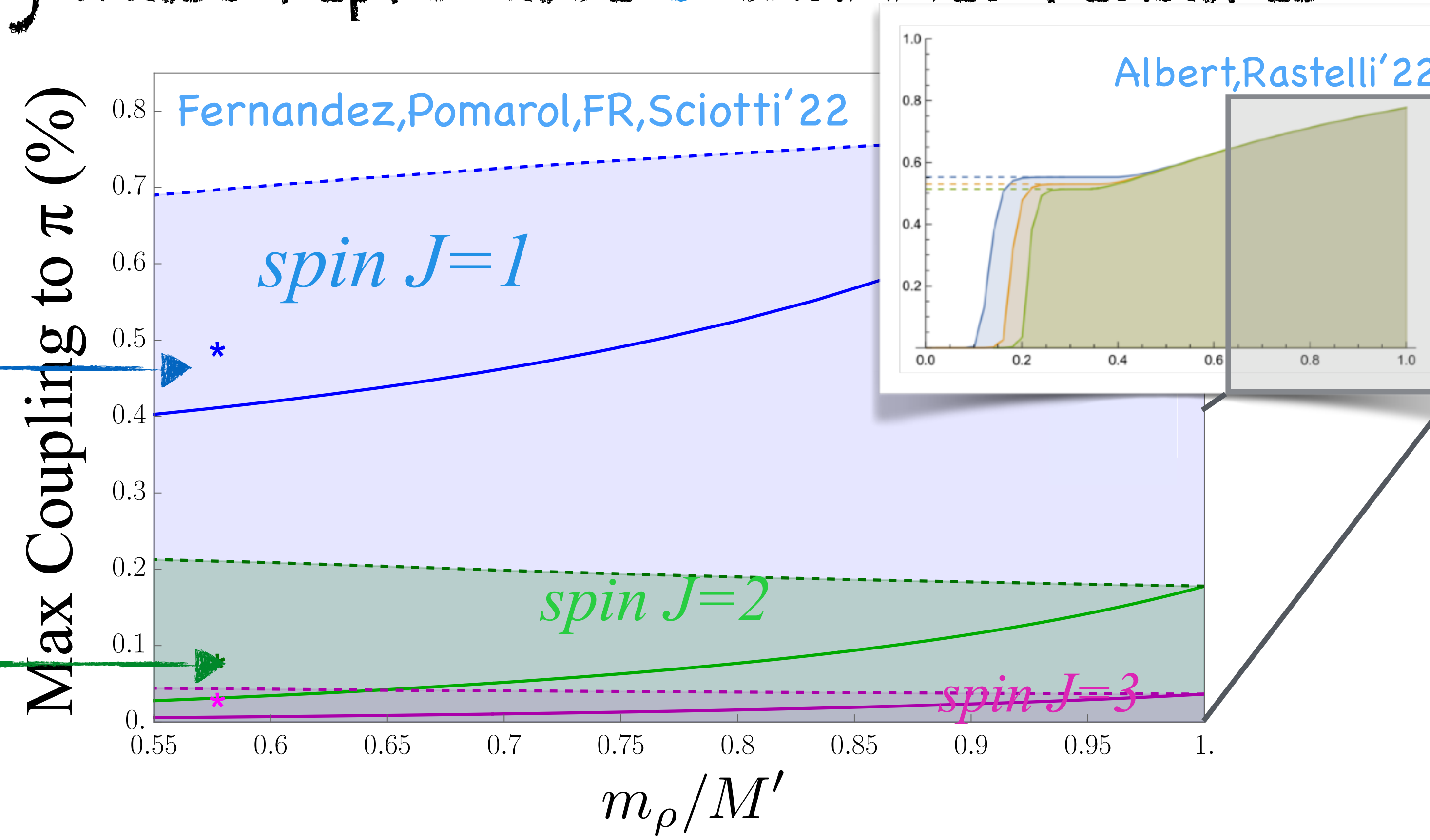

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▶ IR dominated by UV spin-1 = Vector Meson Dominance

(and holographic models)

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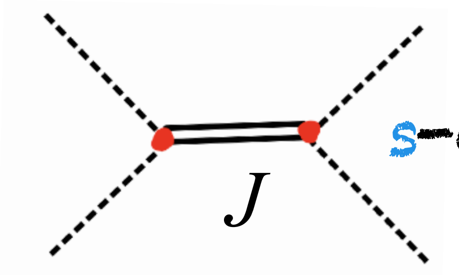

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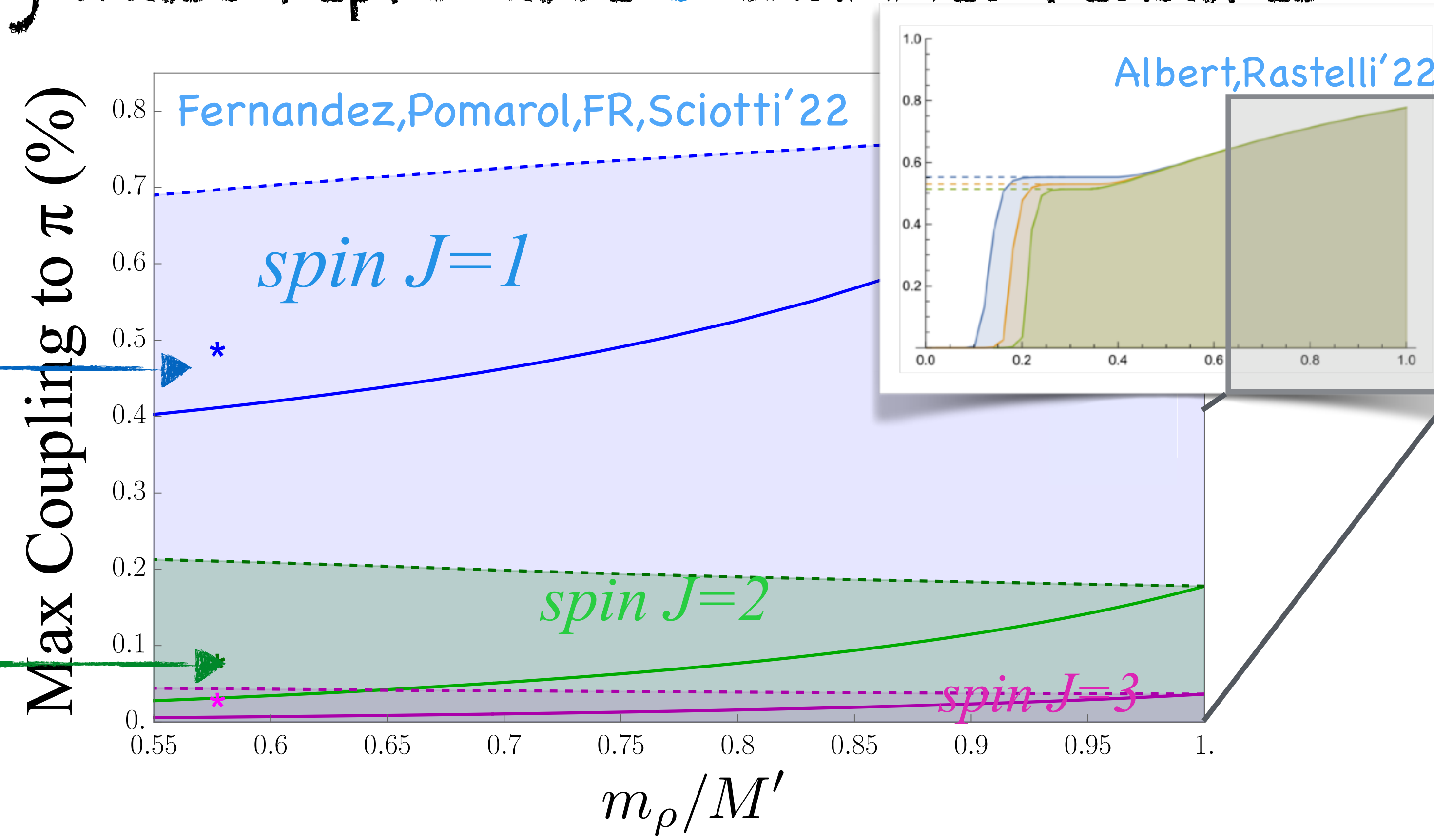

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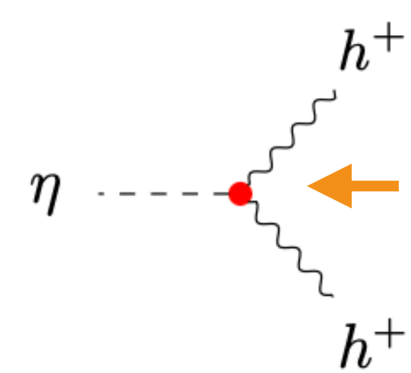
(and holographic models)

In models with a gravitational anomaly: η

Dong,Ma,Pomarol,Sciotti'24



$$\mathcal{M}_{\eta++} = \frac{\kappa_g}{F_\pi M_P^2}[23]^4$$

▶ New spin-4 states must appear at $\Lambda_{\rm caus} \sim \sqrt{\frac{M_P F_\pi}{\kappa_g}} < \Lambda_{QG}$

(relevant in holographic/5D models with only spin-0,2 states)

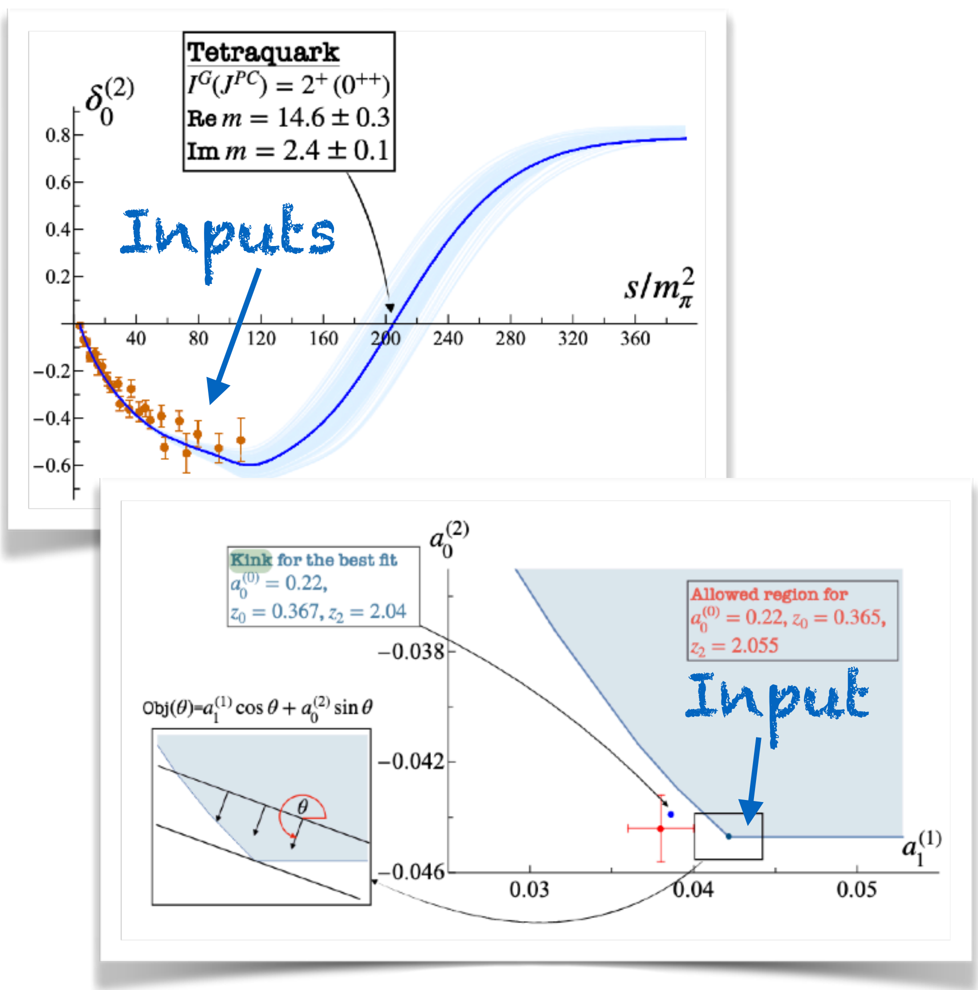
Towards real Pions

Guerrieri, Haring, Su'24

Unitary, analytic and crossing symmetric ansatz:

$$\mathcal{F}_\sigma^N(s|t,u) = \sum_{0\le n+m\le N} \alpha_{n,m}^{(\sigma)} \rho_\sigma(s)^n (\rho_\sigma(t)^m + \rho_\sigma(u)^m) + \sum_{\substack{n+m\le N\\ 1\le n\le m}} \beta_{n,m}^{(\sigma)} (\rho_\sigma(t)^n \rho_\sigma(u)^m + \rho_\sigma(u)^n \rho_\sigma(t)^m), \qquad (2)$$

...with experimental data:



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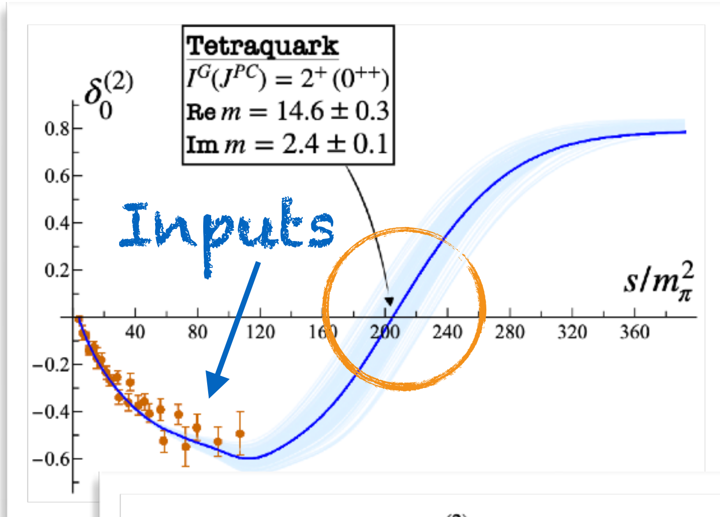

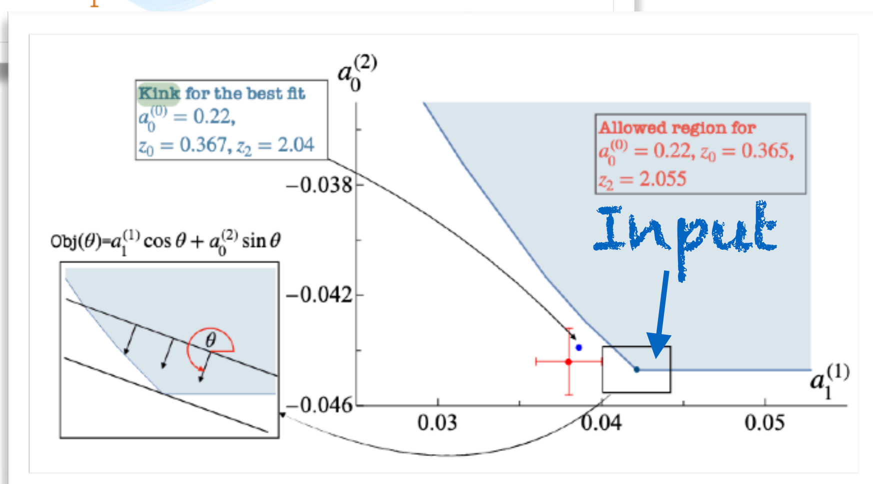

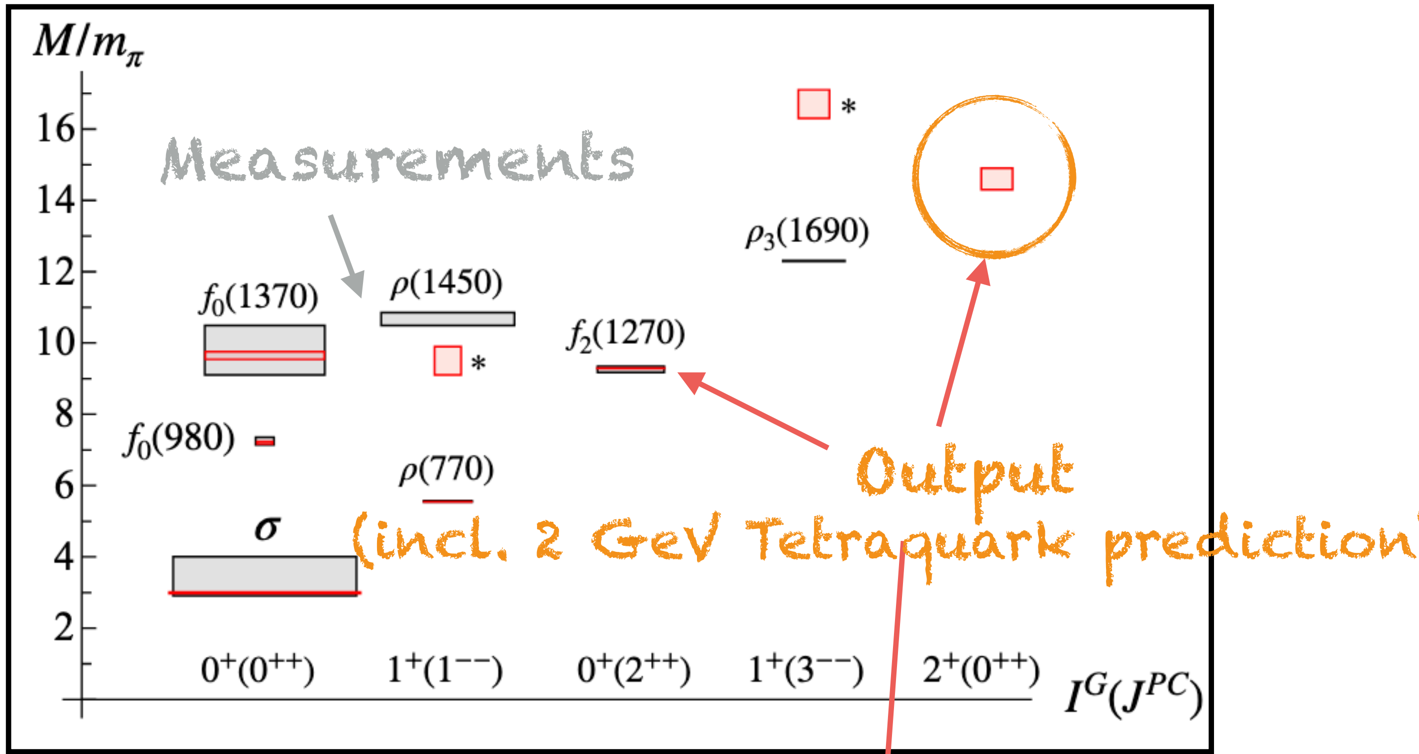

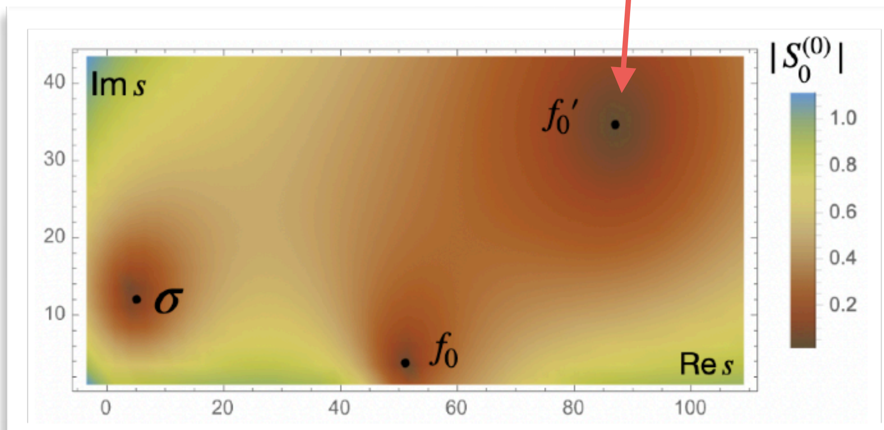

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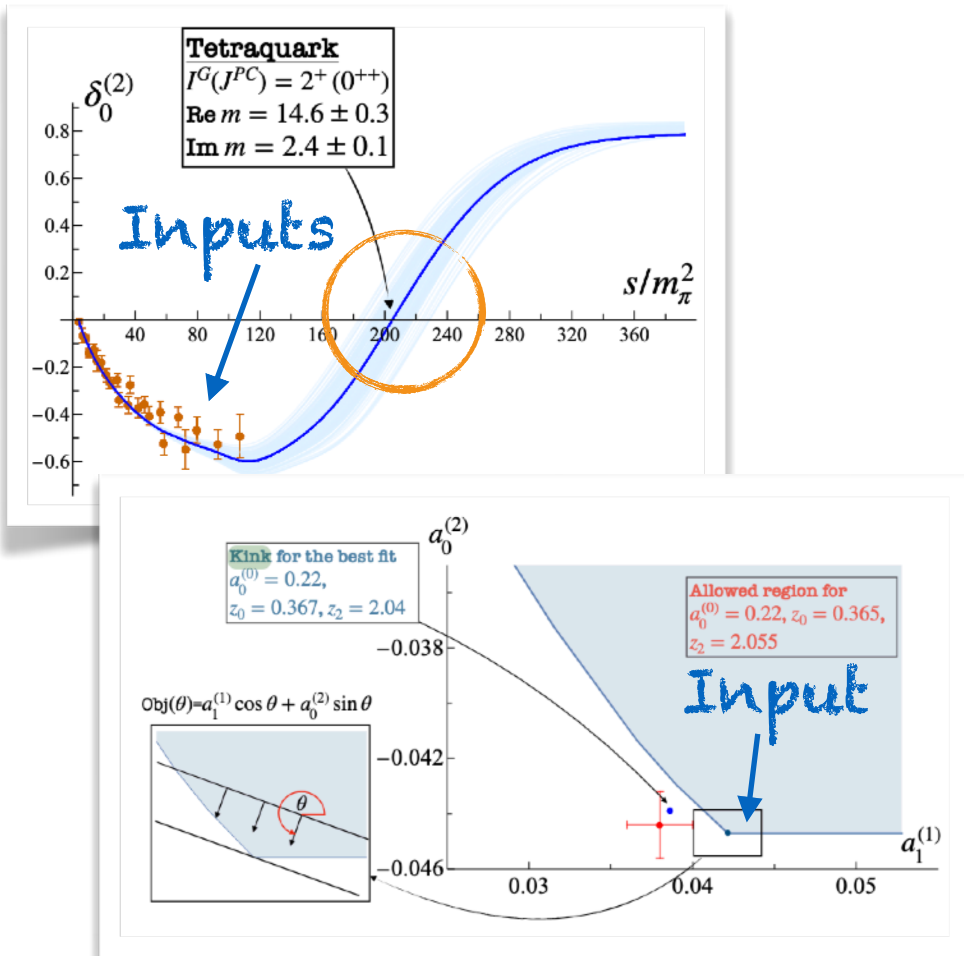

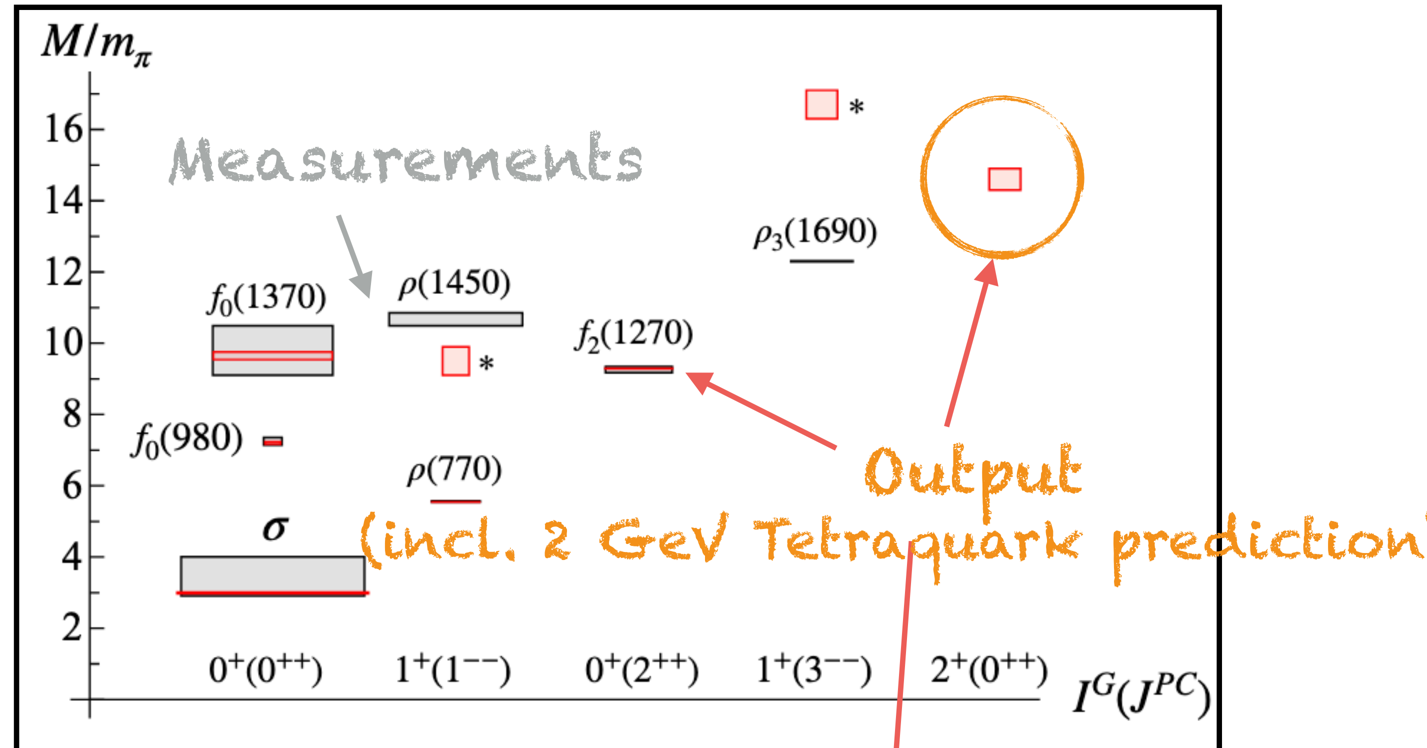

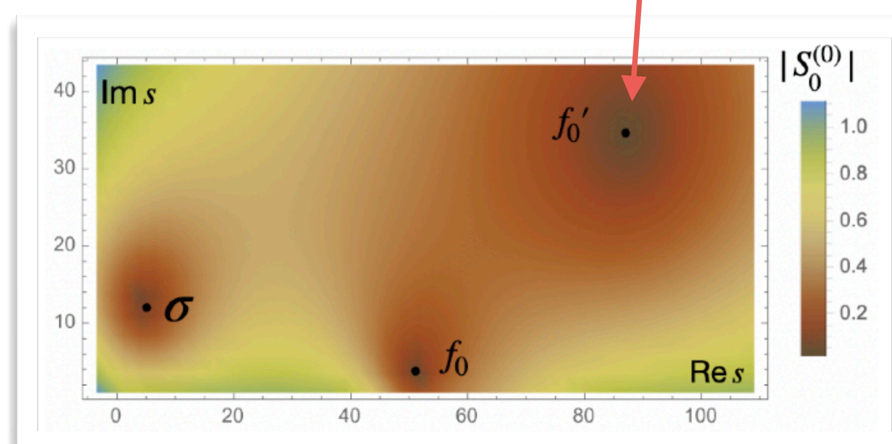

- S-Matrix Bootstrap offers new avenues for model-building, at strong coupling and with infinitely many states