Predictive UV signals from our IR measurements on EWSB from Amplitudes

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Outline

Why I am thinking about this?

The idea is that perhaps the IR precision measurements (Low energy lepton collider) can tell us more on UV physics (High energy hadron collider) from the 1st principle.

- Some background knowledge
- The use of the analyticity. The dispersion relation.
- Use Nima's EFT-hedron methods.
- Outlook.

Great potential motivation for CEPC

Some background knowledge: the use of amplitude in QCD and EW theory

The Adler-Weinberg Sum Rule

A very recent progress in QFT is that some types of theories completely reconstructed from purely the IR theory.

Nonlinear sigma model, DBI, Galiean, etc.

A key ingrediate is the use of recursion relation

In QCD, we have the Adler-Weinberg sum rule!

$$\frac{2}{v^2} = \frac{2}{\pi}\int_0^\infty \frac{ds}{s}\left[\tfrac{1}{3}\sigma^{I=0}(s) + \tfrac{1}{2}\sigma^{I=1}(s) - \tfrac{5}{6}\sigma^{I=2}(s)\right]$$

The Generalized-AW Sum Rule

Application to the EW theory has been done based on the pi pi to pi pi scattering:

Generalized Adler-Weinberg sum rule:

$$1 - a^2 = \frac{v^2}{6\pi} \int_0^\infty \frac{ds}{s} \left(2\sigma^{\text{tot}}_{I=0}(s) + 3\sigma^{\text{tot}}_{I=1}(s) - 5\sigma^{\text{tot}}_{I=2}(s) \right) .$$

EW basis:

$$c_H = \frac{f^2}{4\pi} \int_0^\infty \frac{ds}{s} \left[\sigma^{\text{tot}}_{00}(s) + \sigma^{\text{tot}}_{10}(s) + \sigma^{\text{tot}}_{01}(s) - 3\sigma^{\text{tot}}_{11}(s) \right] .$$

Prediction of EW UV physics from 1st principle

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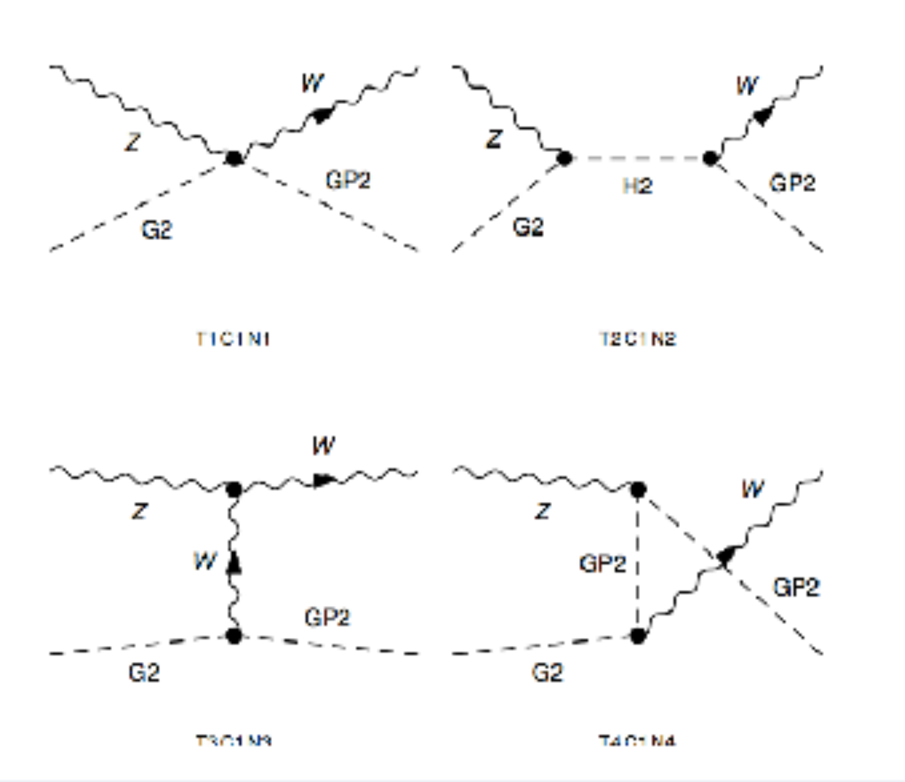
Constraining SM Amplitudes

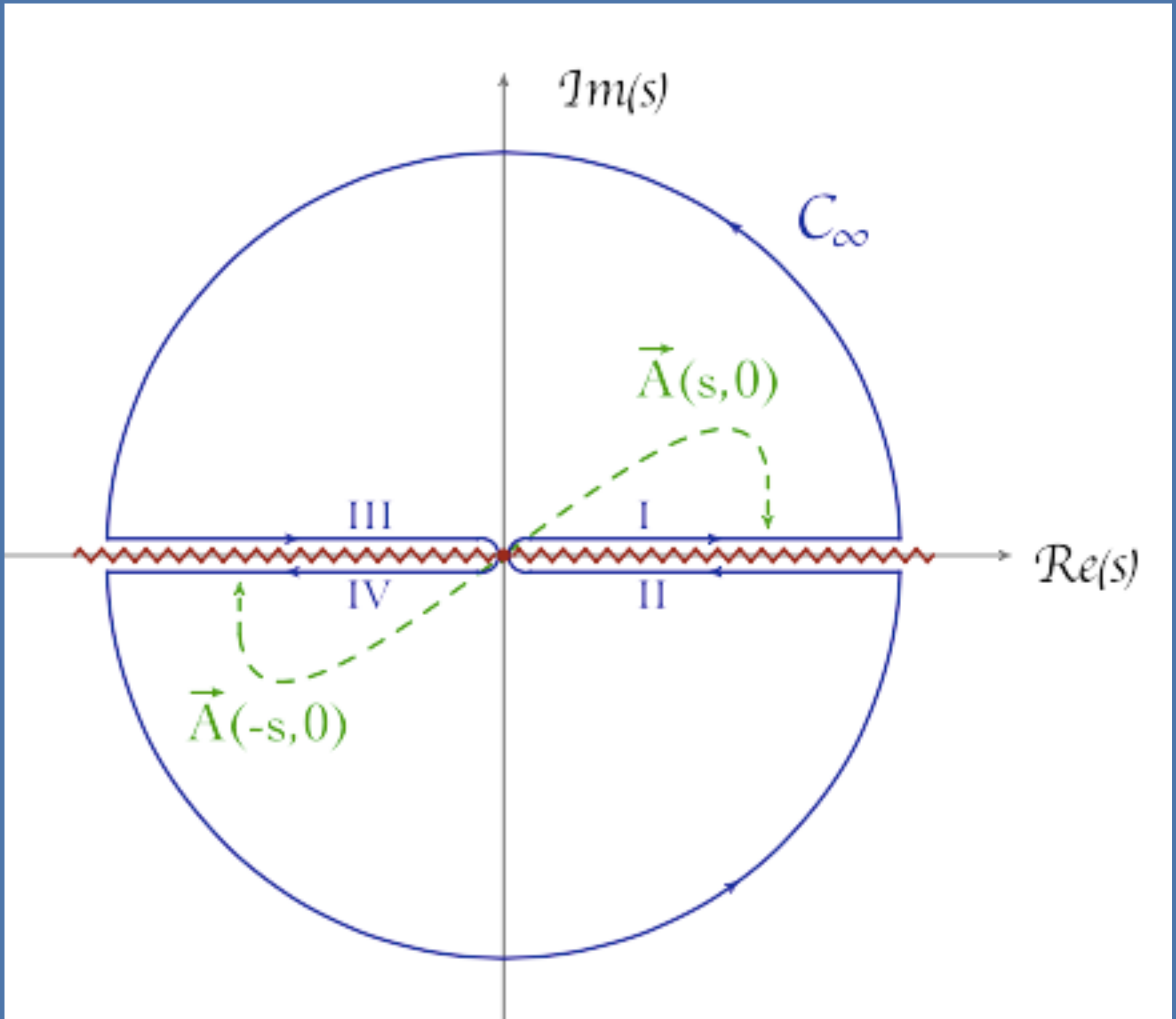
- Looking at the general WW or WH scattering amplitudes

$\mathcal{O}^{H}_{SM} = (D_\mu H)^\dagger D_\mu H$	$W_\mu \pi \to W_\mu \pi$
$\mathcal{O}^{\lambda}_{SM} \equiv \frac{1}{2}(H^\dagger H)^2$	$\pi\pi \to \pi\pi$
$\mathcal{O}^{G}_{SM} \equiv -\frac{1}{4} W^{a}_{\mu\nu} W^{a}_{\mu\nu}$	$W_\mu W_\nu \to W_\mu W_\nu$
$\mathcal{O}_H = \frac{1}{2}\partial^\mu (H^\dagger H)\partial_\mu (H^\dagger H)$	$\pi\pi \to \pi\pi$
$\mathcal{O}_T \equiv \frac{1}{2}(H^\dagger \overleftrightarrow{D}_\mu H)(H^\dagger \overleftrightarrow{D}_\mu H)$	$\pi\pi \to \pi\pi$
$\mathcal{O}_W \equiv i\frac{g}{2}(H\sigma^i \overleftrightarrow{D}_\mu H)(D^\nu W_{\mu\nu})^i$	$W\pi \to W\pi$
$\mathcal{O}_{HW} \equiv ig(D_\mu H)^\dagger \sigma^i (D_\nu H) W^i_{\mu\nu}$	$W\pi \to W\pi$
$\mathcal{O}_{2W} \equiv -\frac{g^2}{2}(D_\mu W_{\mu\nu})^i (D_\rho W^{\rho\nu})^i$	$W_\mu W_\nu \to W_\mu W_\nu$
$\mathcal{O}_{3W} = g^3 \epsilon_{ijk} W^{i\nu}_{\mu} W^{j}_{\nu\rho} W^{k\rho\mu}$	$W_\mu W_\nu \to W_\mu W_\nu$

Consider BSM with D=6 operators



Matching amplitudes



Matching amplitudes in the residue of the IR and UV

Similar relations

LL scattering

$$c_H = \frac{f^2}{4}\int_0^\infty \frac{ds}{s^2}\left[\frac{1}{3}\mathrm{Im}\,\mathcal{T}_0(s) + \frac{1}{2}\mathrm{Im}\,\mathcal{T}_1(s) - \frac{5}{6}\mathrm{Im}\,\mathcal{T}_2(s)\right]$$

LT scattering

$$C_W + C_{HW} = c'_\infty + \frac{1}{2\pi g^2}\int_0^\infty \frac{ds}{s}\left[\frac{1}{3}\sigma_0^{W\pi}(s) + \frac{1}{2}\sigma_1^{W\pi}(s) - \frac{5}{6}\sigma_2^{W\pi}(s)\right].$$

TT scattering

$$\beta = \frac{1}{8\pi g^4}\int_0^\infty \frac{ds}{s}\left[\frac{1}{3}\sigma_0^{WW}(s) + \frac{1}{2}\sigma_1^{WW}(s) - \frac{5}{6}\sigma_2^{WW}(s)\right],$$

Model Examples………

However, the problems are sometimes we do not know what happens at the big circle…………

Going to case by case is complicated……

Methods from the EFT-hedron

What is the EFT-hedron?

For 2 to 2 elastic scattering, the TWO coupling in between is the same

- Calculate the amplitude with coupling square
- Matching to the EFT for the s-linear term. (Higgs low energy theorem/limit)
- Wilson coefficient to the cross section/ parameters.

Goldstone scatterings

Let's start with the pi pi to pi pi scattering

$$\pi^a : \mathbf{4} \equiv \{\mathbf{2}, \mathbf{2}\}$$

$$SO(4) \equiv SU(2)_L \times SU(2)_R$$

$$A_\mu^{bL} + A_\mu^{bR} : \mathbf{6} \equiv \{\mathbf{3}, \mathbf{1}\} + \{\mathbf{1}, \mathbf{3}\},$$

pi pi to \rho (Not just spin-one, general spin, color, etc)

$$M^{h_1 h_2}_{\{\alpha_1 \alpha_2 \ldots \alpha_{2S}\}} = \frac{g_\rho c_{abe} \left(\lambda_1^{S+h_2-h_1} \lambda_2^{S+h_1-h_2}\right) [12]^{S+h_1+h_2}}{m_\rho^{2S+h_1+h_2-1}},$$

The form of direct four point interaction is fixed from the gauge symmetry.

Goldstone scatterings

$$\pi^a \pi^b \to \pi^c \pi^d.$$

The 2 to 2 pi pi scattering can be constructed from the pi pi to \rho (singlet scalar) amplitude

$$M^{abcd}(s,t) = -g_\rho^2 \left(\frac{c_{abe} c_{cde} m_\rho^2}{s - m_\rho^2} + \frac{c_{ade} c_{cbe} m_\rho^2}{u - m_\rho^2} + \frac{c_{ace} c_{bde} m_\rho^2}{t - m_\rho^2} \right).$$

At the low energy, this amplitude is described the polynomial of s and t, etc., which can be mapped to the higher dimensional operators

Singlet channel

Low energy limit:

(1,1): amplitude of SU(2)_L times SU(2)_R:

$$M_{(\mathbf{1},\mathbf{1})} = -g_\rho^2 c_{abe} c_{abe} m_\rho^2 \left(\frac{8}{s-m_\rho^2} + \frac{1}{u-m_\rho^2} + \frac{1}{t-m_\rho^2}\right)$$

Similarly as before, we can exact out the s linear term around the IR s=0

$$\mathcal{I}_I = \oint_C \frac{ds}{2\pi i} \frac{M_I(s,t)}{s^2}.$$

$$\mathcal{I}_{(\mathbf{1},\mathbf{1})} = c_{abe} c_{abe} \left(\frac{8}{m_\rho^2} - \frac{m_\rho^2}{(m_\rho^2+t)^2}\right)$$

Singlet channel

The imaginary of s-channel amplitude for fixed t must be positive if the UV theory is unitary:

$$c_{abe}c_{abe} > 0$$

The low energy EFT contribution is from the O_H operator:

$$\mathcal{O}_H = \frac{c_H}{2}\partial^\mu(H^\dagger H)\partial_\mu(H^\dagger H)$$

$$M^{\text{IR}}_{(\mathbf{1},\mathbf{1})} = 3c_H s$$

In the forward limit t=0, we have

$$c_H = \frac{7c_{abe}c_{abe}}{3m_\rho^2} > 0.$$

Vector channel

Now we consider the massive vector exchange:

$$M^{abcd}(s,t) = g_\rho^2\Big[\frac{c_{abe}c_{cde}(-2t-m_\rho^2)}{s-m_\rho^2} + \frac{c_{ace}c_{bde}(-2s-m_\rho^2)}{t-m_\rho^2} + \frac{c_{ade}c_{cbe}(-2t-m_\rho^2)}{u-m_\rho^2}\Big]. \quad (13)$$

$$M_{(\mathbf{3},\mathbf{1})} = g_\rho^2 c_{abe}c_{abe}\Big[\frac{(-2t-m_\rho^2)}{s-m_\rho^2} + \frac{5}{4}\frac{(-2s-m_\rho^2)}{t-m_\rho^2} - \frac{1}{4}\frac{(-2t-m_\rho^2)}{u-m_\rho^2}\Big] \quad (14)$$

Vector channel

The linear s term

$$\mathcal{I}_{(\mathbf{3},\mathbf{1})} = g_\rho^2 c_{abe} c_{abe} \left[\frac{1}{m_\rho^2}\left(1 + \frac{2t}{m_\rho^2}\right) + \frac{5}{2(m_\rho^2 - t)} + \frac{1}{4(m_\rho^2 + t)}\left(1 + \frac{t}{t + m_\rho^2}\right)\right].$$

Matching to the EFT O_H operator in the forward limit, we have:

$$c_H = \frac{15 c_{abe} c_{abe} f^2}{4 m_\rho^2} > 0.$$

(3,3) scalar channel

Consider the (3,3) scalar exchange:

$$M^{abcd}(s,t) = -g_\rho^2\Big[\frac{c_{abe}c_{cde}m_\rho^2}{s-m_\rho^2} + \frac{c_{ace}c_{bde}m_\rho^2}{t-m_\rho^2} + \frac{c_{ade}c_{cbe}m_\rho^2}{u-m_\rho^2}\Big],$$

$$M_{(\mathbf{3},\mathbf{3})} = -g_\rho^2 c_{abe}c_{cde}m_\rho^2\Big[\frac{4}{s-m_\rho^2} + \frac{1}{t-m_\rho^2} + \frac{1}{u-m_\rho^2}\Big],$$

(3,3) scalar channel

The linear s term

$$\mathcal{I}_{(\mathbf{3},\mathbf{3})} = \frac{4 c_{abe} c_{abe}}{m_\rho^2} - \frac{c_{abe} c_{abe} m_\rho^2}{(m_\rho^2 + t)^2}.$$

Matching to the EFT O_H operator in the forward limit, we have:

$$c_H = -\frac{3 c_{abe} c_{abe}}{m_\rho^2} < 0.$$

Goldstone W/Z scatterings

Let's start with the pi W to pi W scattering

W stands for the general gauge bosons (different helicity)

$M^{abcd}_{h_1 h_2}$, of initial and final gauge boson

$$M^{abcd}_{++}(s,t) = g_\rho^2\Big(\frac{c_{abe}c_{cde}[31]^2}{s-m_\rho^2} + \frac{c_{ade}c_{cbe}[31]^2}{u-m_\rho^2}\Big)$$

Can not take the t=0 forward limit, must do the Wagner d-matrix expansion of the amplitude $d^1_{1,-1}(x) = \frac{1-x}{2}$.

$$M^{abcd}_{++}(s,t) = -g_\rho^2 d^1_{1,-1}(\cos\theta)\Big(\frac{c_{abe}c_{cde}s}{s-m_\rho^2} + \frac{c_{ade}c_{cbe}s}{u-m_\rho^2}\Big)$$

Goldstone W/Z scatterings

Elastic scattering: $a = c$ and $b = d$:

$$c_{abe}c_{abe} > 0.$$

Other helicity:

$$\begin{aligned} M^{abcd}_{+-}(s,t) &= \frac{g_\rho^2 \langle 23\rangle^2 [12]^2}{m_\rho^2}\left(\frac{c_{abe}c_{cde}}{s-m_\rho^2} + \frac{c_{ade}c_{cbe}}{u-m_\rho^2}\right) \\ &= -\frac{g_\rho^2}{m_\rho^2} d^1_{1,1}(\cos\theta) \\ &\quad \left(\frac{c_{abe}c_{cde}s^2}{s-m_\rho^2} + \frac{c_{ade}c_{cbe}s^2}{u-m_\rho^2}\right), \end{aligned}$$

Goldstone W/Z scatterings

Other helicity:

$$M_{--}^{abcd}(s,t) = g_\rho^2\Big(\frac{c_{abe}c_{cde}\langle 31\rangle^2}{s-m_\rho^2} + \frac{c_{ade}c_{cbe}\langle 31\rangle^2}{u-m_\rho^2}\Big)$$
$$= g_\rho^2 d^1_{1,-1}(\cos\theta)\Big(\frac{c_{abe}c_{cde}s}{s-m_\rho^2} + \frac{c_{ade}c_{cbe}s}{u-m_\rho^2}\Big) \quad (25)$$

(0,0) channel already discussed in the Goldstone scattering

Extract out the s-linear term:

$$\mathcal{I}^{+-/-+} = 0$$
$$\mathcal{I}^{++/--} = g_\rho^2 d_{1,-1}(c_\theta)\Big(\frac{c_{abe}c_{cde}}{m_\rho^2} + \frac{c_{ade}c_{cbe}}{m_\rho^2+t}\Big).$$

Goldstone W/Z scatterings

Quantum number:

$$W^L \oplus \pi \ : \ (3,1) \otimes (2,2) = (4,2) \oplus (2,2)$$

EFT contribution at the low energy:

$$M^{++/--}_{\frac{3}{2}\frac{1}{2}} = \frac{g^2}{4} d_{1,-1}(c_\theta)\Big((C_{HW} + C_W)c_\theta + C_{HW} - C_W\Big)s$$

$$M^{+-/-+}_{\frac{3}{2}\frac{1}{2}} = \frac{g^2}{4} d_{1,1}(c_\theta)(C_{HW} + C_W)(c_\theta - 5)s$$

$$M^{++/--}_{\frac{1}{2}\frac{1}{2}} = \frac{g^2}{2} d_{1,-1}(c_\theta)\Big((C_{HW} + C_W)(1 - c_\theta) + C_{HW}\Big)s$$

$$M^{+-/-+}_{\frac{1}{2}\frac{1}{2}} = \frac{g^2}{2} d_{1,1}(c_\theta)(C_{HW} + C_W)(5 - c_\theta)s$$

Goldstone W/Z scatterings

Contribution from the amplitude

$$\mathcal{I}^{+-/-+}_{\frac{3}{2}\frac{1}{2}} = 0 \quad \mathcal{I}^{+-/-+}_{\frac{1}{2}\frac{1}{2}} = 0$$

$$\mathcal{I}^{++/--}_{\frac{3}{2}\frac{1}{2}} = g_\rho^2 d_{1,-1}(c_\theta)\left(\frac{c_{abe}c_{abe}}{m_\rho^2} + \frac{c_{abe}c_{abe}}{3(m_\rho^2+t)}\right)$$

$$\mathcal{I}^{++/--}_{\frac{1}{2}\frac{1}{2}} = g_\rho^2 d_{1,-1}(c_\theta)\left(\frac{c_{abe}c_{abe}}{m_\rho^2} - \frac{c_{abe}c_{abe}}{3(m_\rho^2+t)}\right).$$

Do the matching, we have:

$$C_W = -C_{HW}$$

$$C_{HW} = \frac{8g_\rho^2 c_{abe}c_{abe}}{3g^2 m_\rho^2} > 0 \text{ for } \rho \in (\frac{3}{2}\frac{1}{2}),$$

$$C_{HW} = \frac{4g_\rho^2 c_{abe}c_{abe}}{3g^2 m_\rho^2} > 0 \text{ for } \rho \in (\frac{1}{2}\frac{1}{2})$$

W/Z scatterings

- Coupling to the scalar: $c_{abc}\phi^c W^a_{\mu\nu} W^b_{\mu\nu}$.

Do not contribute to the dimension six operator, only vector exchange:

$$M^{abcd}_{++++} = g_\rho^2 m_\rho^2 \Big(\frac{c_{abe} c_{cde} [34]^2 [12]^2}{s^2 (s - m_\rho^2)} + \{u\} + \{t\} \Big)$$

$$M^{abcd}_{----} = g_\rho^2 m_\rho^2 \Big(\frac{c_{abe} c_{cde} \langle 34 \rangle^2 \langle 12 \rangle^2}{s^2 (s - m_\rho^2)} + \{u\} + \{t\} \Big) \quad (35)$$

S-linear term:

$$\mathcal{I}_1^{++++/----} = -\Big(\frac{4 c_{abe} c_{abe} g_\rho^2}{m_\rho^2} - \frac{4 c_{abe} c_{abe} g_\rho^2 m_\rho^2}{3 (m_\rho^2 + t)^2} \Big)$$

$$\mathcal{I}_5^{++++/----} = -\Big(\frac{4 c_{abe} c_{abe} g_\rho^2}{m_\rho^2} - \frac{2 c_{abe} c_{abe} g_\rho^2 m_\rho^2}{3 (m_\rho^2 + t)^2} \Big) \quad (36)$$

W/Z scatterings

- Coupling to the scalar: $c_{abc}\phi^c W^a_{\mu\nu} W^b_{\mu\nu}$.

Do not contribute to the dimension six operator O_{2W}

$$M^{abcd}_{++++} = g_\rho^2 m_\rho^2 \Big(\frac{c_{abe} c_{cde} [34]^2 [12]^2}{s^2 (s - m_\rho^2)} + \{u\} + \{t\} \Big)$$

$$M^{abcd}_{----} = g_\rho^2 m_\rho^2 \Big(\frac{c_{abe} c_{cde} \langle 34 \rangle^2 \langle 12 \rangle^2}{s^2 (s - m_\rho^2)} + \{u\} + \{t\} \Big) \quad (35)$$

S-linear term:

$$\mathcal{I}_1^{++++/----} = -\Big(\frac{4 c_{abe} c_{abe} g_\rho^2}{m_\rho^2} - \frac{4 c_{abe} c_{abe} g_\rho^2 m_\rho^2}{3 (m_\rho^2 + t)^2} \Big)$$

$$\mathcal{I}_5^{++++/----} = -\Big(\frac{4 c_{abe} c_{abe} g_\rho^2}{m_\rho^2} - \frac{2 c_{abe} c_{abe} g_\rho^2 m_\rho^2}{3 (m_\rho^2 + t)^2} \Big) \quad (36)$$

W/Z scatterings

$$M^{abcd}_{++--} = \frac{g_\rho^2}{m_\rho^2}\left(\frac{c_{abe}c_{cde}[12]^2\langle 34\rangle^2}{s-m_\rho^2}\right)$$

Under SU(2) quantum number:

$$\begin{aligned}
M_1^{++++/----} &= 2g^4(C_{2W}+6C_{3W})s \\
M_1^{++--/--++} &= 4g^4 C_{2W}s \\
M_5^{++++/----} &= -\frac{1}{2}M_1^{++++} \\
M_5^{++--/--++} &= -\frac{1}{2}M_1^{++--}
\end{aligned}$$

Do the matching:

$$C_{2W} = 0 \quad C_{3W} = -\frac{2g_\rho^2 c_{abe}c_{abe}}{9g^4m_\rho^2}$$

$$C_{2W} = 0 \quad C_{3W} = \frac{5g_\rho^2 c_{abe}c_{abe}}{9g^4m_\rho^2}.$$

W/Z scatterings

Exchange the vector bosons:

$$M^{abe}_{h_1 h_2} = \frac{g_\rho c_{abe}}{m_\rho^{1+h_1+h_2}} \lambda_1^{1+h_2-h_1} \lambda_2^{1+h_1-h_2} [12]^{1+h_1+h_2}$$

$$M^{abcd}_{++++} = -g_\rho^2 \Big(\frac{c_{abe} c_{cde} (2t + m_\rho^2) [34]^2 [12]^2}{s^2 (s - m_\rho^2)} + \{u\} + \{t\} \Big)$$

s-linear term:

$$\mathcal{I}_3^{++++/----} = g_\rho^2 \Big(\frac{c_{abe} c_{abe} (2t + m_\rho^2)}{m_\rho^4} \Big)$$

W/Z scatterings

The amplitude M^{abcd}_{++--}

$$M^{abcd}_{++--} = \frac{g_\rho^2}{m_\rho^4}\Big(\frac{c_{abe}c_{cde}\left(2\langle 13\rangle\langle 24\rangle\langle 34\rangle[12]^3 - m_\rho^2\langle 34\rangle^2[12]^2\right)}{s-m_\rho^2}$$

EFT results:

$$\begin{aligned} M_3^{++++/----} &= g^4(C_{2W}+6C_{3W})s \\ M_3^{++--/++--} &= 4g^4(C_{2W}-3C_{3W})s. \end{aligned}$$

Matching:

$$C_{2W} = 3C_{3W} \quad C_{2W} = \frac{g_\rho^2 c_{abe}c_{abe}}{3g^4 m_\rho^2} > 0.$$

Goldstone top scatterings

Operators for Goldstone fermion scattering:

LH fermion:

$$\mathcal{O}_{1q} = iH^\dagger \overleftrightarrow{D}_\mu H \bar{q}_L \gamma^\mu q_L$$
$$\mathcal{O}_{3q} = iH^\dagger \sigma^i \overleftrightarrow{D}_\mu H \bar{q}_L \sigma^i \gamma^\mu q_L.$$

Amplitude linear to s (from vector fermion exchange)

$$\mathcal{I}_1^{+-} = -g_f^2 d^{1/2}_{1/2,1/2}(c_\theta)\frac{c_{abe}c_{abe}}{m_f^2},$$
$$\mathcal{I}_3^{+-} = -g_f^2 d^{1/2}_{1/2,1/2}(c_\theta)\frac{c_{abe}c_{abe}}{m_f^2}$$

Amplitude from EFT

$$M_1^{++} = 0 \quad M_1^{+-} = -2(3C_{L3} - C_{L1})d^{1/2}_{1/2,1/2}(\cos\theta)s$$
$$M_3^{+-} = 0 \quad M_3^{+-} = 2(C_{L1} + C_{L3})d^{1/2}_{1/2,1/2}(\cos\theta)s,(51)$$

Goldstone top scatterings

Matching:

$$(3C_{L3} - C_{L1}) = \frac{g_f^2 c_{abe} c_{abe}}{2m_f^2} < 0$$

$$(C_{L3} + C_{L1}) = -\frac{g_f^2 c_{abe} c_{abe}}{2m_f^2} > 0$$

RH fermion: $\mathcal{O}_{fR} = iH^\dagger \overleftrightarrow{D}_\mu H f_R \gamma^\mu f_R,$

$$C_{R1} = -\frac{g_f^2 c_{abe} c_{abe}}{2m_f^2} > 0.$$

Overall:

I need to do the current or expected future precision constrain on the dim six operators, then use it to constrain the UV physics:

Outlook:

- First use of amplitude on the EW theory.
- Get tons of theoretical relations, results.
- Use the EWPT results or other low energy limit to constrain the high energy physics.

Backup slice

Higgs physics

$$f^2 \sin^2 \frac{h}{f} = f^2 \left[\sin^2 \frac{\langle h \rangle}{f} + 2 \sin \frac{\langle h \rangle}{f} \cos \frac{\langle h \rangle}{f} \left(\frac{h}{f} \right) + \left(1 - 2 \sin^2 \frac{\langle h \rangle}{f} \right) \left(\frac{h}{f} \right)^2 + \dots \right]$$
$$= v^2 + 2v\sqrt{1-\xi}\, h + (1-2\xi)\, h^2 + \dots$$

W boson mass

modification of hVV coupling

$$a = \sqrt{1-\xi} \qquad b = 1 - 2\xi$$

Similarly for fermions.

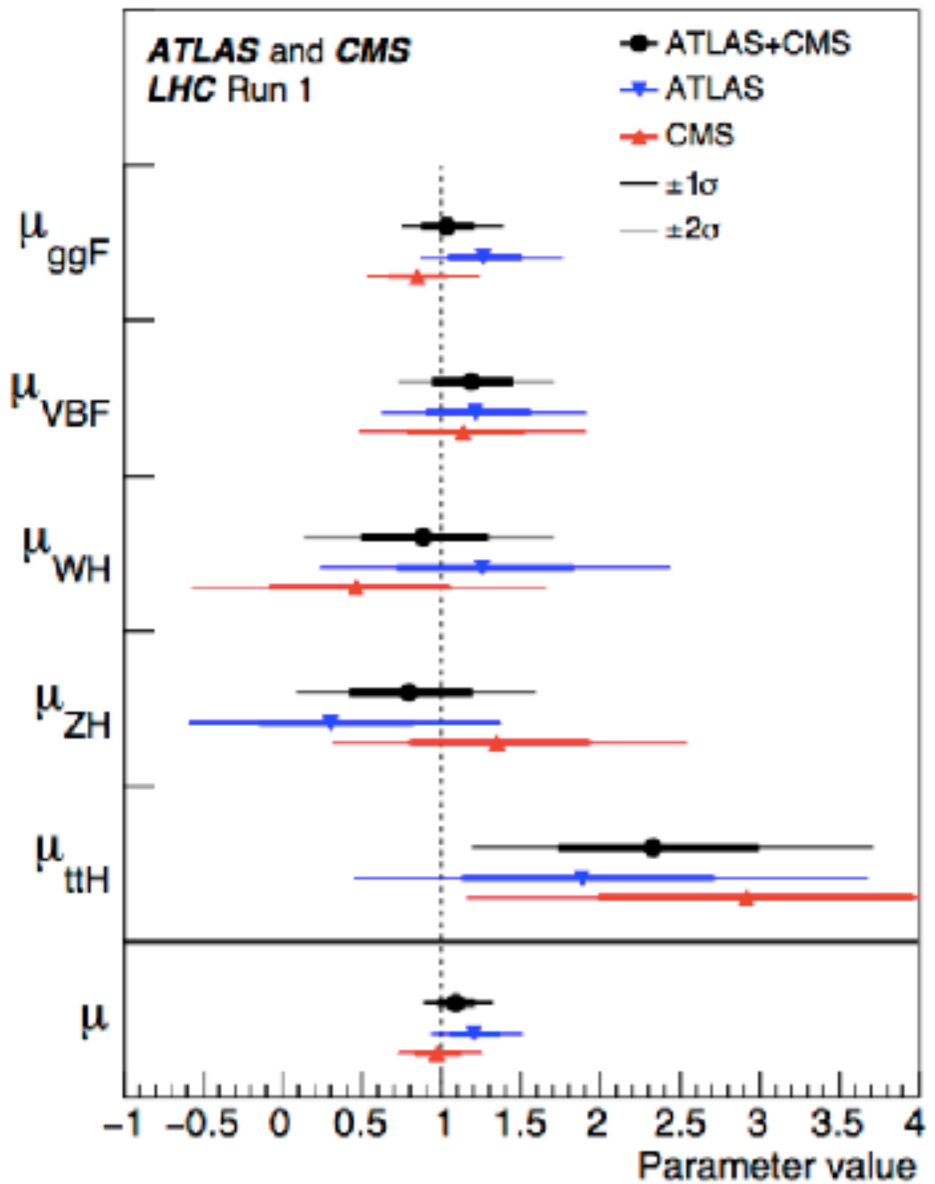
$$m_f(h) \propto \sin\left(\frac{2h}{f}\right) \qquad c = \frac{1-2\xi}{\sqrt{1-\xi}}$$

5, 10

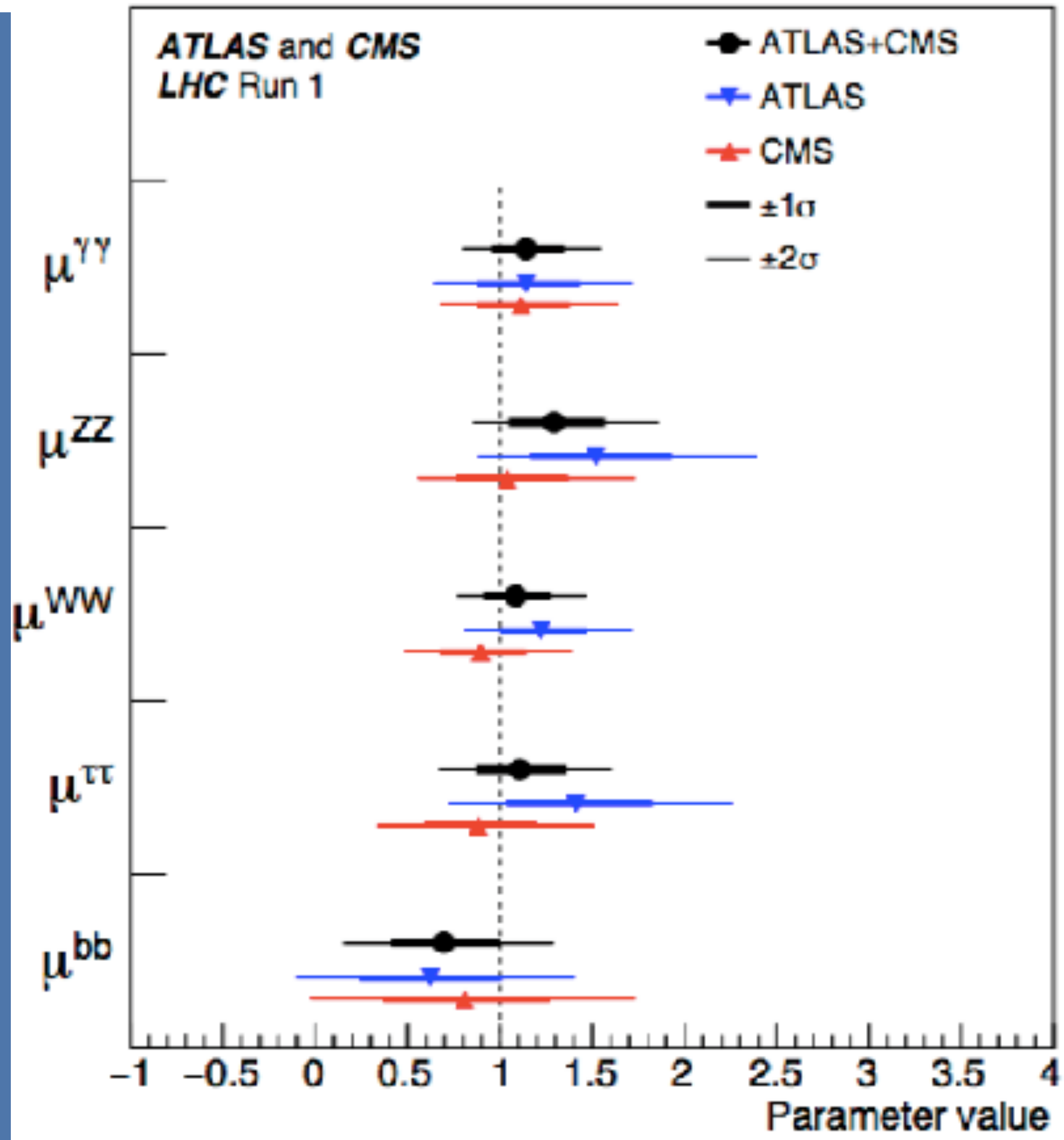
$$m_f(h) \propto \sin\left(\frac{h}{f}\right) \qquad c = \sqrt{1-\xi}$$

Spinorial 4

Higgs产生和衰变

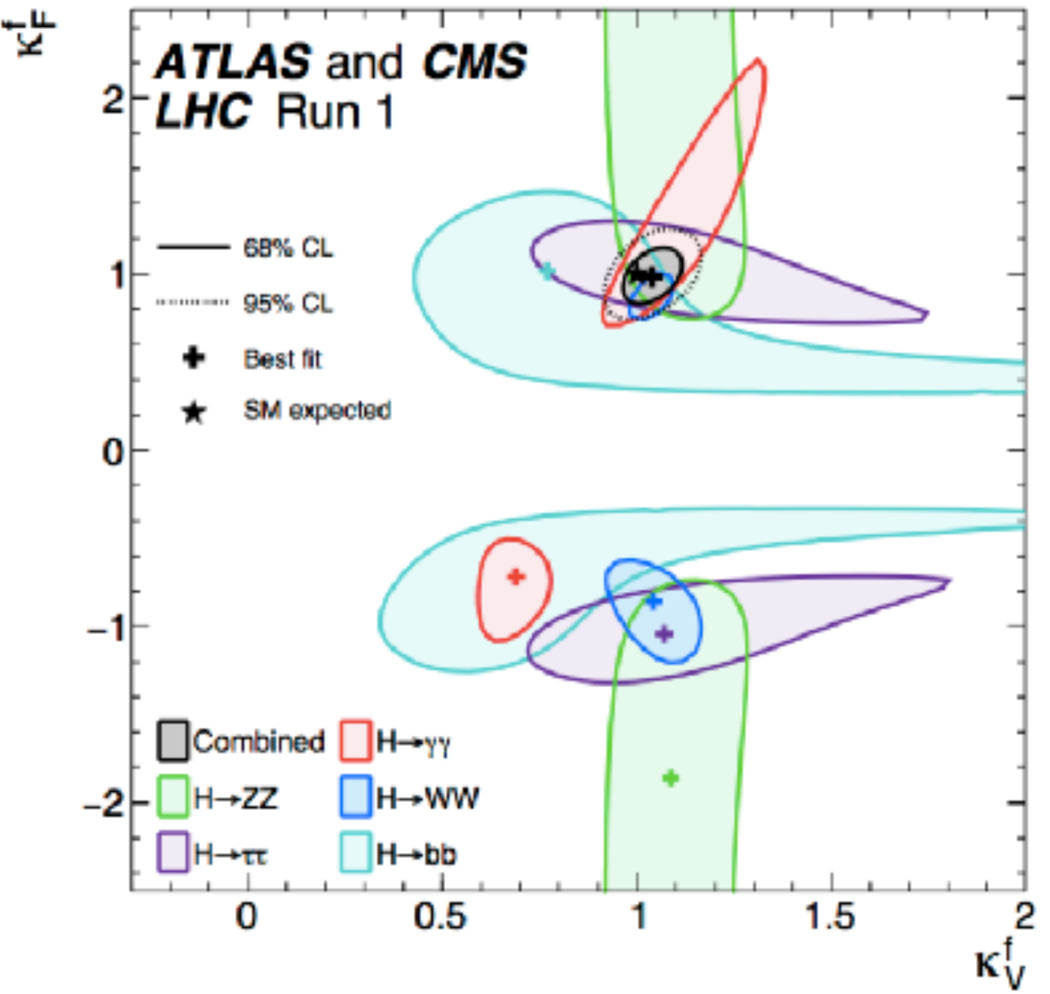


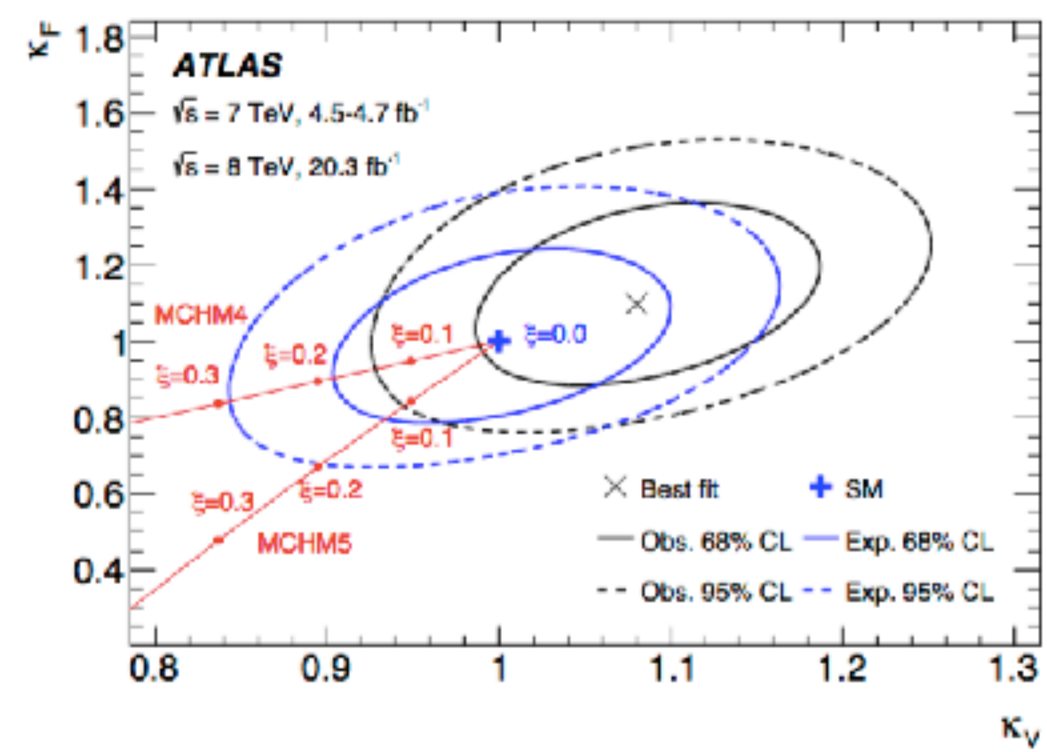
ATLAS and CMS
LHC Run 1
ATLAS+CMS
ATLAS
CMS
±1σ
±2σ
μ_{ggF}
μ_{VBF}
μ_{WH}
μ_{ZH}
μ_{ttH}
μ
−1 −0.5 0 0.5 1 1.5 2 2.5 3 3.5 4
Parameter value



ATLAS and CMS
LHC Run 1
ATLAS+CMS
ATLAS
CMS
±1σ
±2σ
$\mu^{\gamma\gamma}$
μ^{ZZ}
μ^{WW}
$\mu^{\tau\tau}$
μ^{bb}
−1 −0.5 0 0.5 1 1.5 2 2.5 3 3.5 4
Parameter value

Higgs物理





Top耦合为负的情况不再存在

Higgs 拟合 $\xi < 0.1$