Higgs coupling measurements and W'/Z' physics

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based on work in collaboration with
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PRD 92 05516 [arXiv:1507.01185]

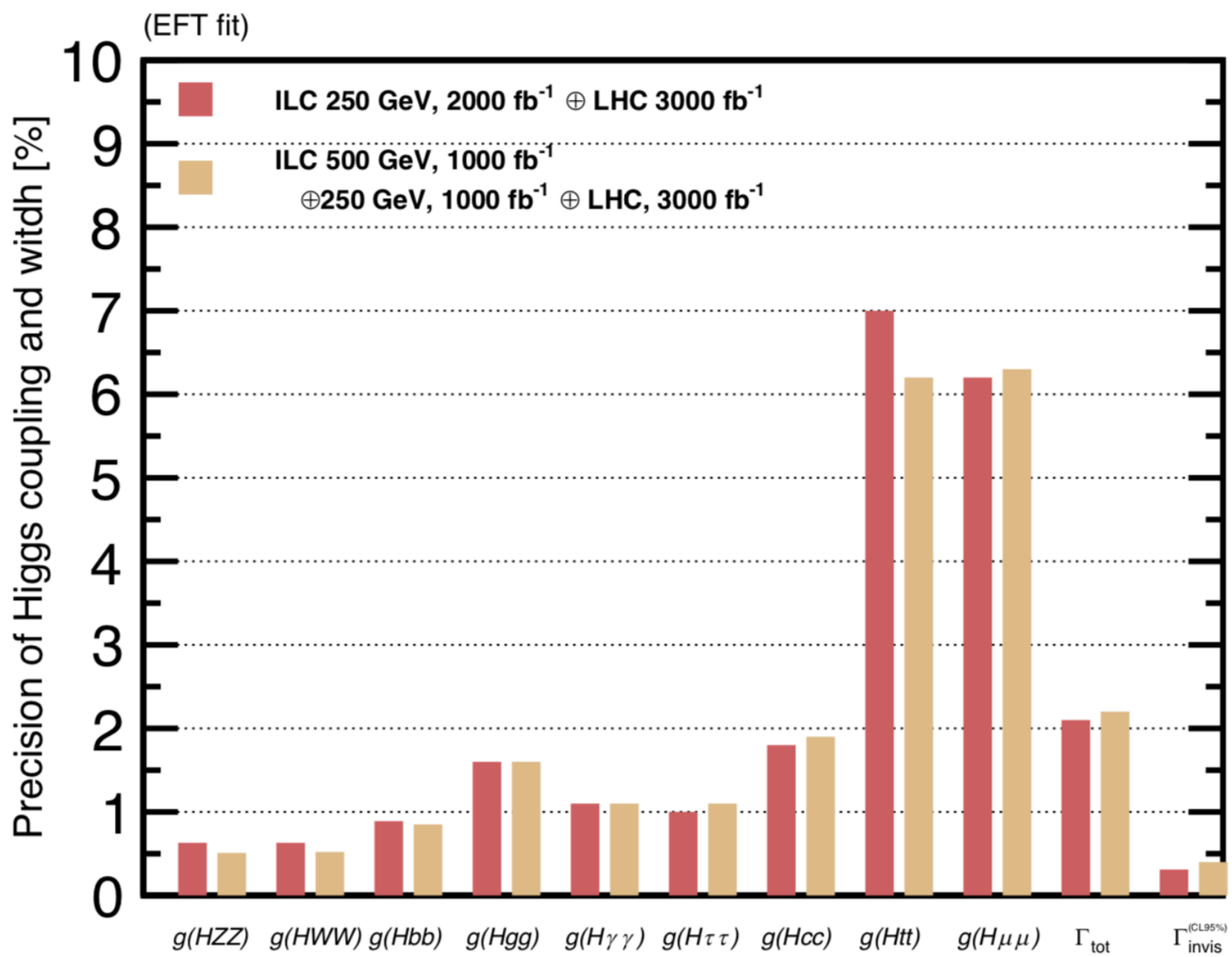
Asian Linear Collider Workshop 2018
Thu, May. 31, 2018

Outline

- Introduction
- W'/Z' and Higgs coupling
- Summary

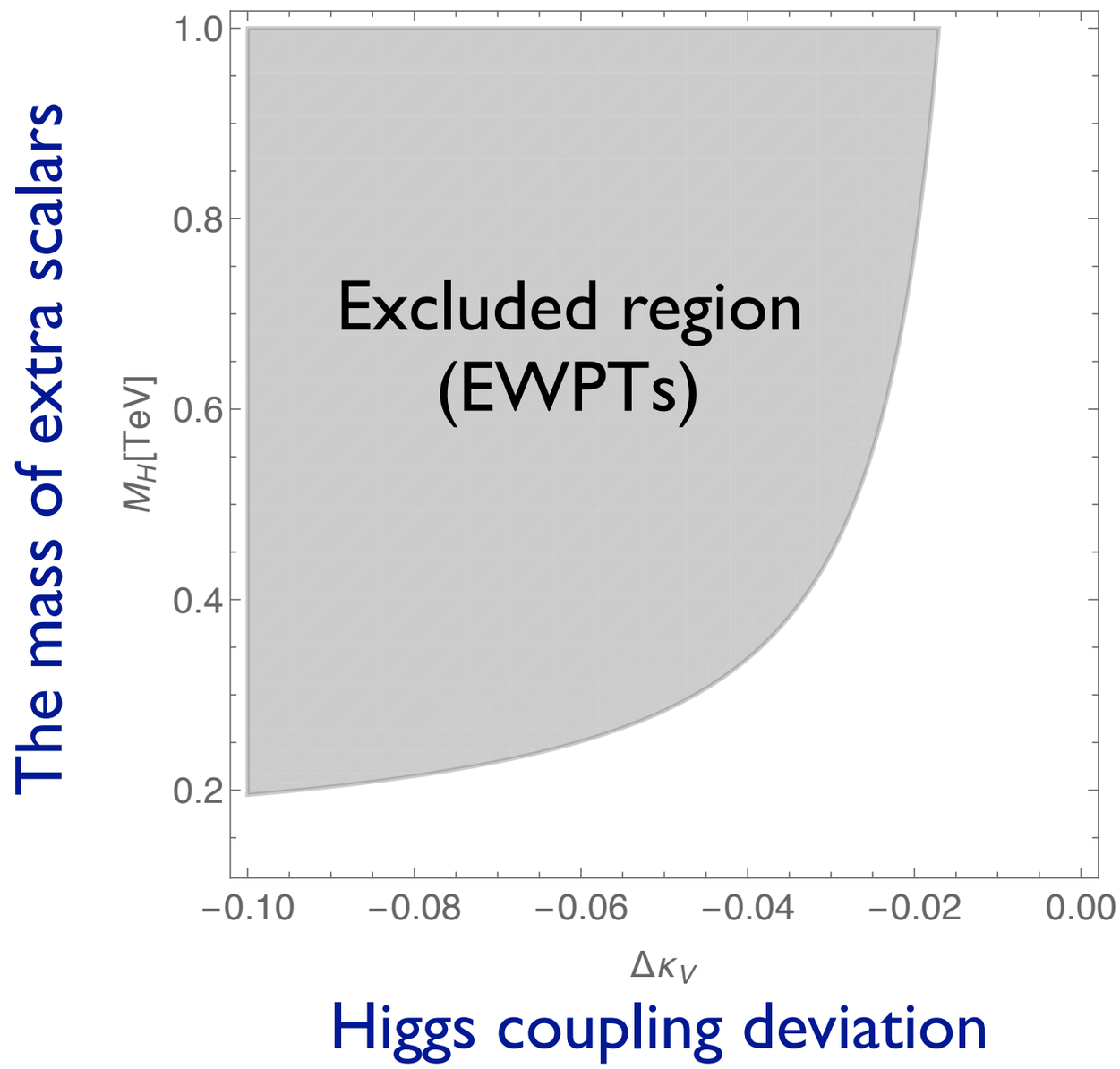
ILC(250)

- ILC opens the era of "precise" Higgs physics !!



Precise g(hVV) measurements

SM + singlet scalars



Nagai-Tanabashi-Tsumura (2015)

Precise g(hVV) measurements

- Impact on physics BSM
  - Study on Extended Higgs Sector

    Search for extra scalars

Precise g(hVV) measurements

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  - Study on Extended Higgs Sector

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  - Study on **Extended Gauge Sector**

    Search for **extra spin-1 vectors (V')**

Extra spin-1 particles (V')

- Various BSMs predict them
  - Extra dimension models (KK gauge boson)
  - Unification models (W_R, ….)
  - Dynamical EWSB scenarios (ρ' meson)
  - …….

Extra spin-1 particles (V')

- Various BSMs predict them
  - Extra dimension models (KK gauge boson)
  - Unification models (W_R, ….)
  - Dynamical EWSB scenarios (ρ' meson)
  - …….
- What do the precise g(hVV) measurements tell us about V' physics?

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Set up

- Particle contents :

SM + (V', V'', ...) SU(2) triplet vectors

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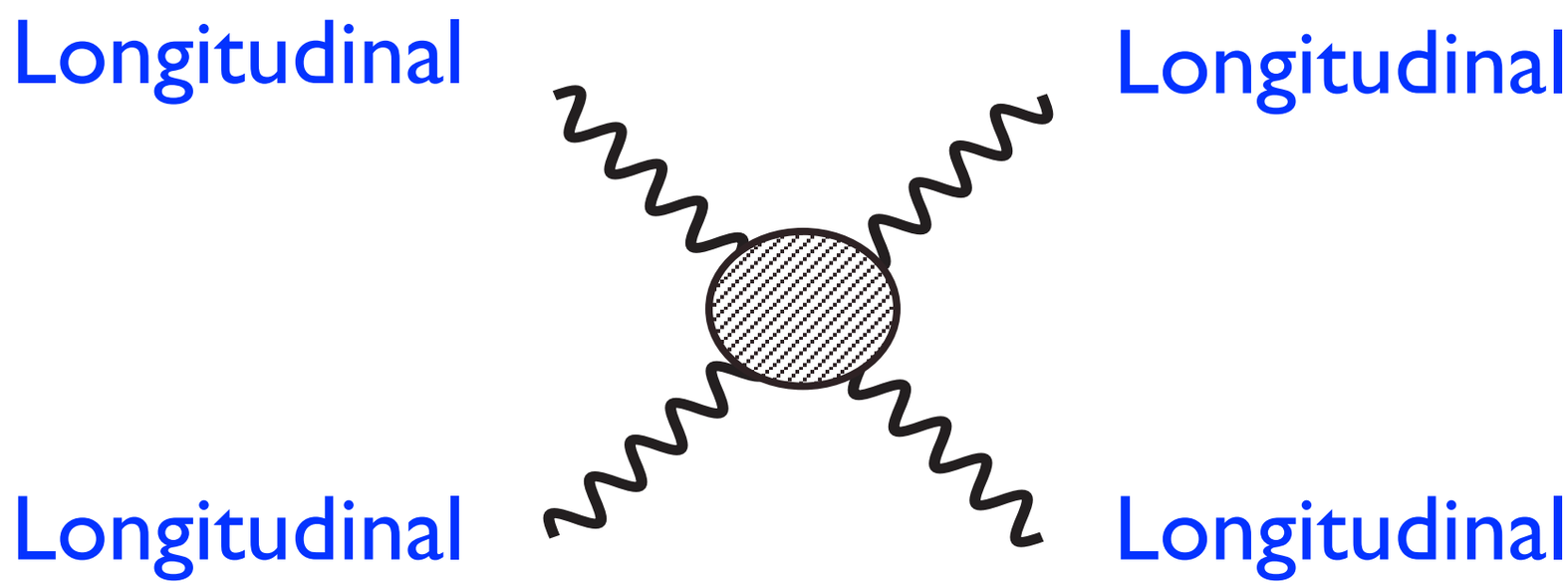
$$\mathcal{L}_{VVV} = \frac{1}{2} g_{V_1 V_2 V_3} \epsilon^{abc} V^a_{1\mu\nu} V_2^{b\mu} V_3^{c\nu}$$

$$\mathcal{L}_{hVV} = \frac{1}{2} g_{hV_1 V_2} h V^a_{1\mu} V_2^{a\mu} \qquad \cdots\cdot$$

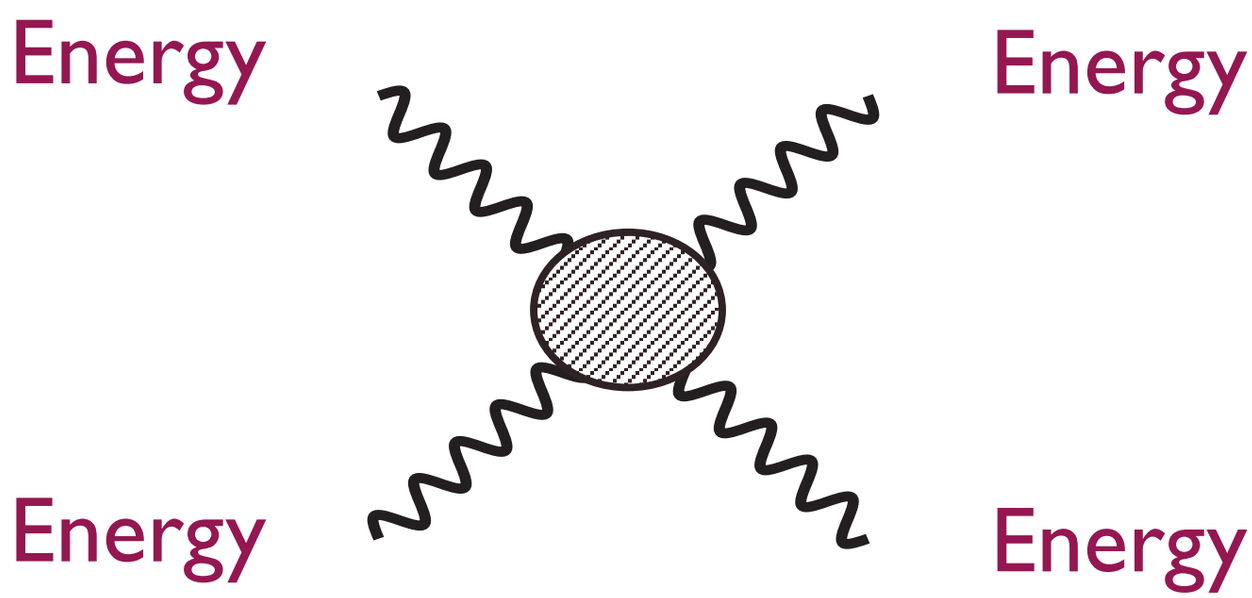
$V_L V_L$ scattering

The longitudinal polarization vector scattering



$V_L V_L$ scattering

The longitudinal polarization vector grows as energy



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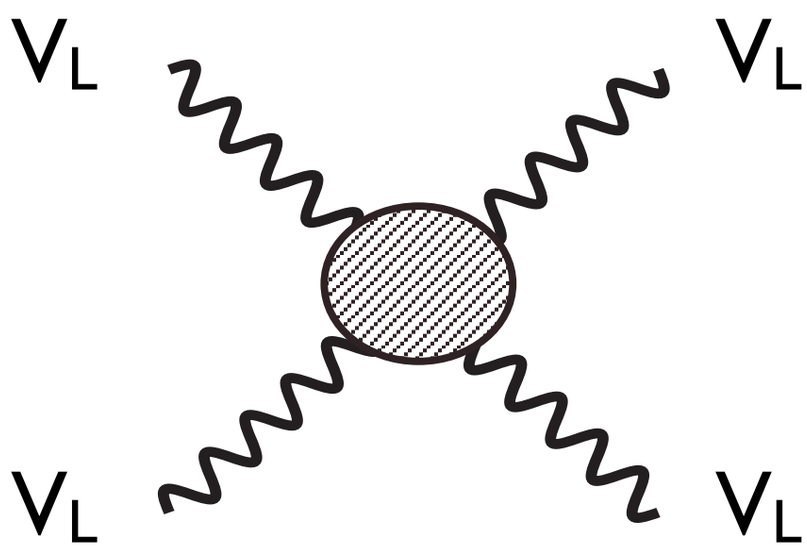

$$\sim \frac{E^4}{M^4} + \frac{E^2}{M^2} + \cdots$$

(Perturbative) unitarity
is violated in high E .. ?

$V_L V_L$ scattering

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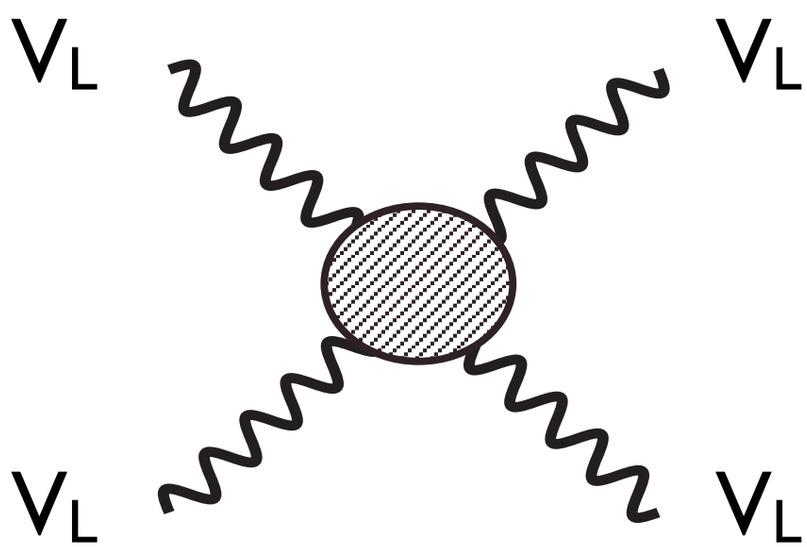

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Gauge symmetry

Higgs physics

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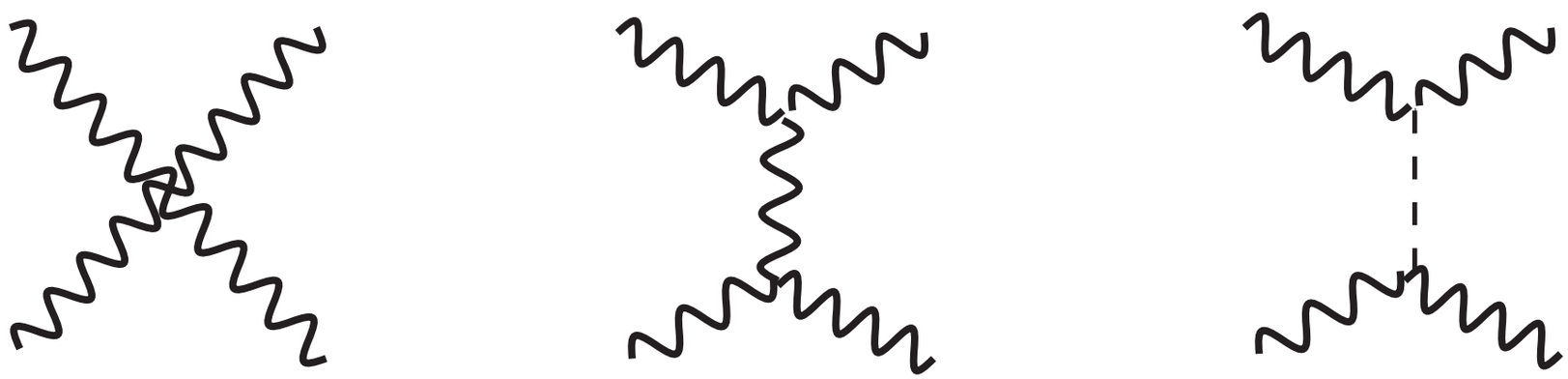
$V_L V_L$ scattering

$V_L V_L \to V_L V_L$



- $O(E^2)$ term in the scattering amplitude:

$$\mathcal{M}|_{E^2} \sim \left[g_{VVVV} - \frac{3}{4} g_{VVV}^2 - \frac{3}{4} \sum_{V'} \frac{M_{V'}^2}{M_V^2} g_{VVV'}^2 - \frac{1}{4M_V^2} \sum_h g_{hVV}^2 \right] \frac{E^2}{M_V^2}$$

$V_L V_L$ scattering

- In order to cancel $O(E^2)$ terms, g(hVV) should satisfy

VV → VV

$$\sum_h g_{hVV}^2 = 4M_W^2 g_{VVVV} - 3M_V^2 g_{VVV}^2 - 3\sum_{V'} M_{V'}^2 g_{VVV'}^2$$

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VV → VV'

$$\sum_h g_{hVV} g_{hVV'} = (3M_V^2 + M_{V'}^2) g_{VVVV'} - 3M_V^2 g_{VVV} g_{VVV'} - 3\sum_{V''} M_{V''}^2 g_{VVV''} g_{VV'V''}$$

VV → V'V'

$$\sum_h g_{hVV'}^2 = (2M_V^2 + 2M_{V'}^2) g_{VVV'V'} - M_V^2 (2g_{VVV'}^2 + g_{VVV} g_{VV'V'}) - \sum_{V''} M_{V''}^2 (2g_{VV'V''}^2 + g_{VVV''} g_{V'V'V''})$$

Our finding

- Combining VV → VV, VV → VV', and VV → V'V' sum rules, we obtain

$$\frac{g_{hVV'}}{M_V g_{VVV}} = \left(\frac{g_{hVV}}{M_V g_{VVV}}\right) \frac{g_{VVV'}}{g_{VVV}} \frac{M_V^2}{M_{V'}^2}$$

$$\kappa_V \equiv \frac{g_{hVV}}{M_V g_{VVV}}$$

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- This equation leads

LHC target

$$\kappa_V^2 = \frac{\Gamma(V' \to Vh)}{\Gamma(V' \to VV)}$$

ILC can measure it very precisely

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- Various BSM models predict extra spin-1 particles (V').
- We find that perturbative V' models with neutral scalars predict

LHC target

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ILC target

- Precise measurement of hVV coupling (κ_V) is also important for investigating exotic particles predicted in physics BSM.