(Plans of) Probing new physics with the measurements of $e^+e^- \to W^+W^-$ at CEPC with optimal observables

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Snowmass EF04 meeting
Oct 23, 2020

based on LOI with
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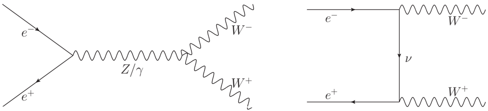
Why is $e^+e^- \to W^+W^-$ important?



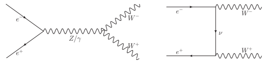
- Important for probing the new physics that contributes them.
  - conventionally parameterized by 3 aTGCs
  - additional contributions in the EFT framework, can be parameterized by:

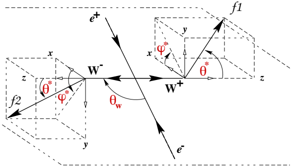
$$\delta g_{1,Z}, \quad \delta\kappa_\gamma, \quad \lambda_Z, \quad \delta g^{ee}_{Z,L}, \quad \delta g^{ee}_{Z,R}, \quad \delta g^{e\nu}_{W}, \quad \delta m_W$$

- Very important for Higgs coupling fits in the EFT framework!
  - related to anomalous *hVV* couplings, contact *hVff* couplings...
- Current projections for future lepton colliders are rather incomplete.
  - ILC: full analysis but within the 3-aTGCs framework.
    [PhD thesis by I. Marchesini, 2011], see also the previous talk
  - **CEPC** and FCC-ee: only simplified analysis used as inputs for the Higgs EFT fit.
  - CLIC: currently ongoing studies.

A refined *WW* analysis using Optimal Observables (OO)

- TGCs (and additional EFT parameters) are sensitive to the differential distributions!
  - One could do a fit to the binned distributions of all angles.
  - Not the most efficient way of extracting information.
  - Correlations among angles are sometimes ignored.



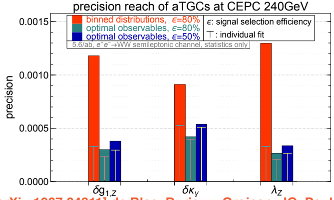


- What are optimal observables?

  (See *e.g.* Z.Phys. C62 (1994) 397-412 Diehl & Nachtmann)
  - For a given sample, there is an upper limit on the precision reach of the parameters.
  - In the limit of large statistics (everything is Gaussian) and small parameters (leading order dominates), this "upper limit" can be derived analytically!

$$\frac{d\sigma}{d\Omega} = S_0 + \sum_i S_{1,i}\, g_i \,,$$

- The optimal observables are given by $\mathcal{O}_i = \frac{S_{1,i}}{S_0}$, and are functions of the 5 angles.



[arXiv:1907.04311] de Blas, Durieux, Grojean, JG, Paul

How to do a practical OO analysis?

- In reality, we cannot just simply derive the results!
  - ISR effects, jet resolutions, reconstruction of the neutrino momentum, ...
  - The $\frac{d\sigma}{d\Omega}$ that we actually measure can be a bit different from the ideal "parton level" one.
- Apply parton level OO to real events
  - The results can be biased, and the bias may take some effort to estimate.
- Directly construct "detector-level" OOs with numerical methods?
  - may require a lot of MC simulation...
  - End up with machine learning in the end?
- Full EFT parameterization: flat directions exist in the *WW* measurements, which needs the *Z*-pole measurements to be lifted.

$$\delta g_{1,Z}, \quad \delta\kappa_\gamma, \quad \lambda_Z, \quad \delta g^{ee}_{Z,L}, \quad \delta g^{ee}_{Z,R}, \quad \delta g^{e\nu}_{W}, \quad \delta m_W$$