Diboson production in the SMEFT at dimension-8

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with H. El Faham and E. Vryonidou, based on 2511.04338

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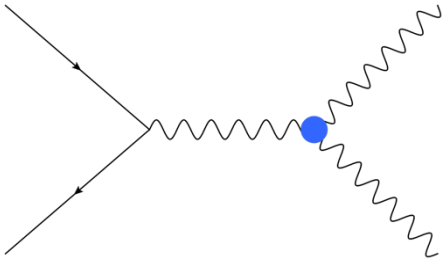
Diboson production in the SMEFT

- We focus on diboson production (WW and WZ) in the (anti)quark-channel

$$\mathcal{O}_W = \epsilon_{IJK} W^I_{\mu\nu} W^{J,\nu\rho} W^{K,\mu}_{\rho}$$



c_W , affects triple-gauge couplings TGCs

$$\sigma_{\text{SMEFT}} = \sigma_{\text{SM}} + \frac{c_W}{\Lambda^2}\sigma_{W,\text{int.}} + \frac{c_W^2}{\Lambda^4}\sigma_{W,\text{sq.}}$$

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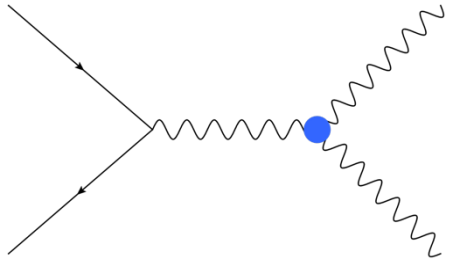

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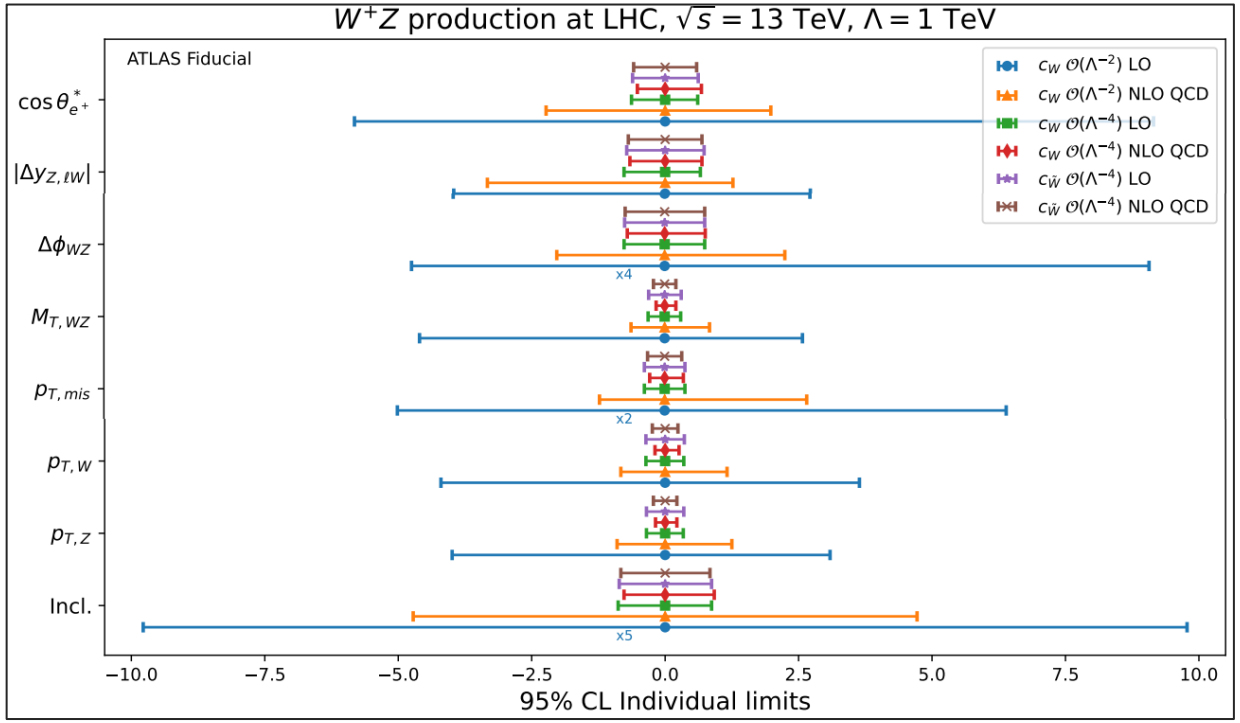
Strongest constraints for c_W come from $O(\Lambda^{-4})$

Figure: El Faham, Pelliccioli, Vryonidou [arXiv:2405.19083]



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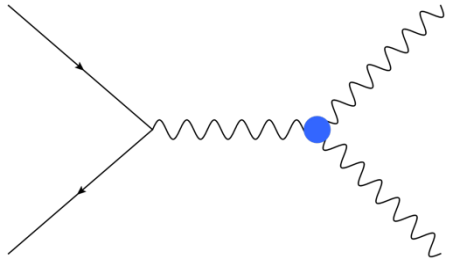

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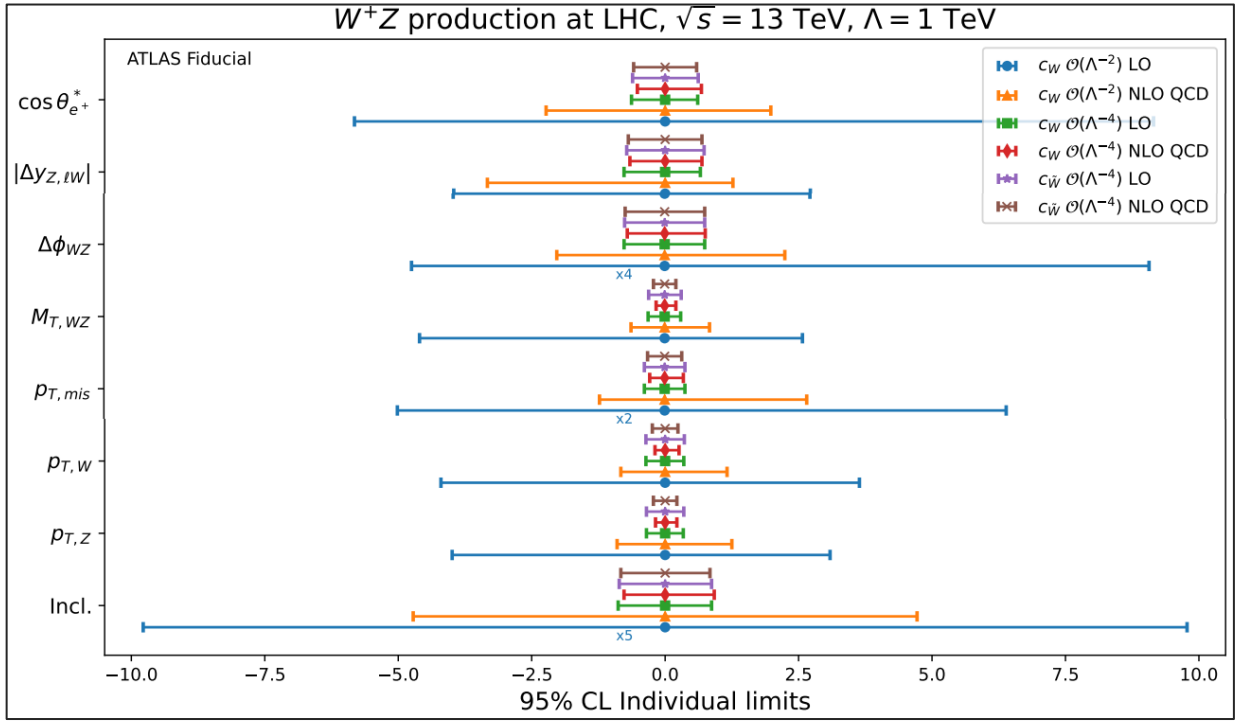
Figure: El Faham, Pelliccioli, Vryonidou [arXiv:2405.19083]

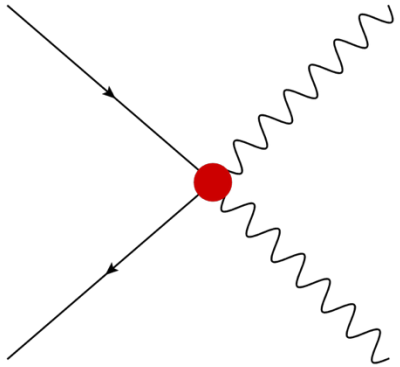
Motivation to explore SMEFT effects beyond dimension-six



Diboson production at dimension-8

- Dimension-8 operators contributing to $qq \to VV$ are classified

Degrande, Li [arXiv:2303.10493]



- Amplitudes grow with energy (S, S^2)
- Hierarchy among operators

We only consider maximally growing operators $\sigma_{i,int}^{(8)} \propto S^2$

WW

$$\mathcal{O}_{10} = iW^{I\mu}{}_{\nu} W^{I\nu}{}_{\lambda} \left(\bar{q}\gamma^{\lambda} \overleftrightarrow{D}_{\mu} q\right)$$

$$\mathcal{O}_{12} = i\epsilon^{IJK} \tilde{W}^{I\mu}{}_{\nu} W^{J\nu}{}_{\lambda} \left(\bar{q}^{i}\gamma^{\lambda}\tau_{i}^{Kj} \overleftrightarrow{D}_{\mu} q_{j}\right)$$

$$\mathcal{O}_{13} = i\epsilon^{IJK} W^{I\mu}{}_{\nu} \tilde{W}^{J\nu}{}_{\lambda} \left(\bar{q}^{i}\gamma^{\lambda}\tau_{i}^{Kj} \overleftrightarrow{D}_{\mu} q_{j}\right)$$

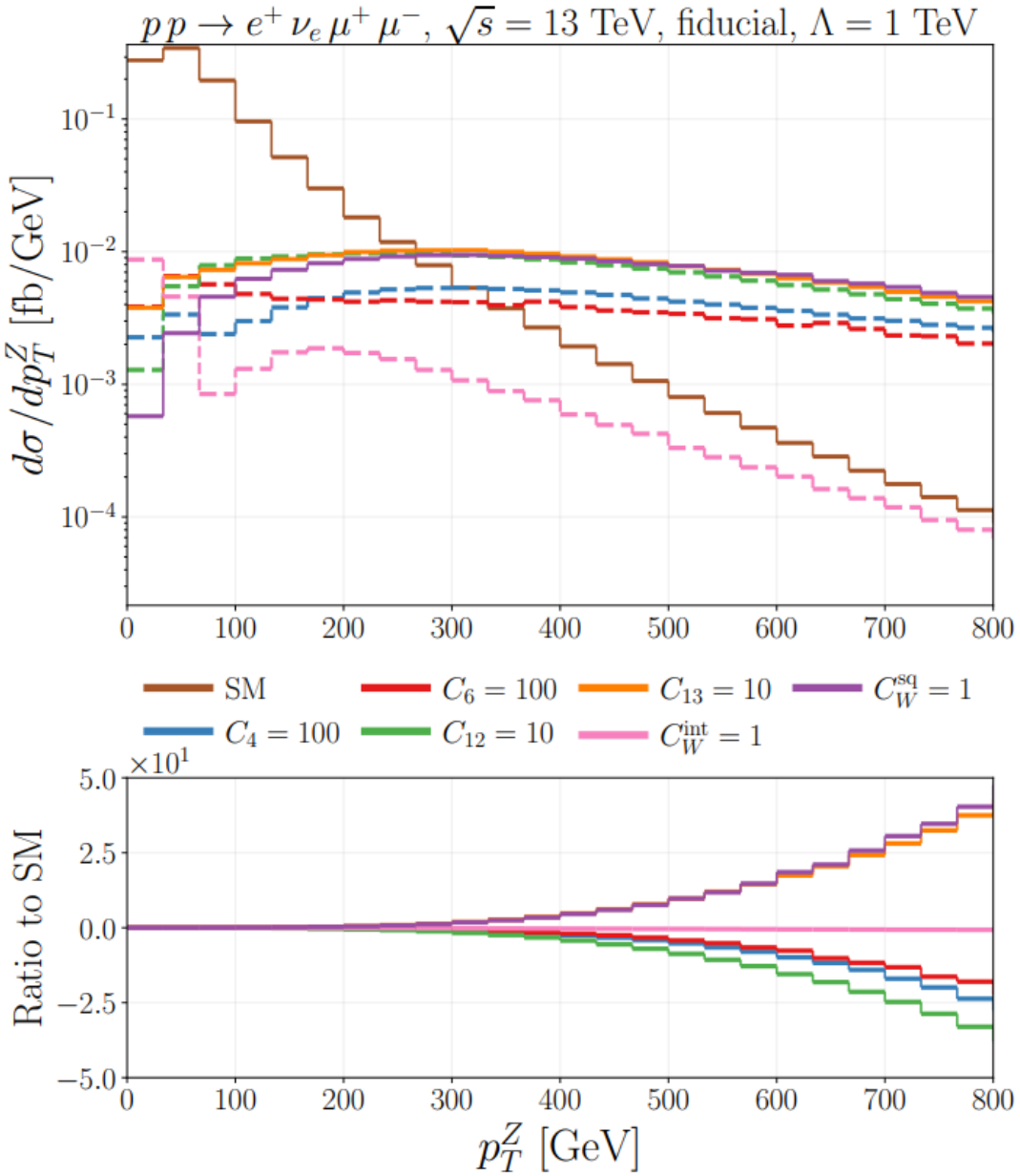
$$\mathcal{O}_{4} = iW^{I\mu}{}_{\lambda} B^{\nu\lambda} \left(\bar{q}^{i}\gamma_{\nu}\tau_{i}^{Ij} \overleftrightarrow{D}_{\mu} q_{j}\right)$$

$$\mathcal{O}_{6} = iW^{I\nu}{}_{\lambda} B^{\mu\lambda} \left(\bar{q}^{i}\gamma_{\nu}\tau_{i}^{Ij} \overleftrightarrow{D}_{\mu} q_{j}\right)$$

WZ

Differential distributions: WZ

- Energy growth induced by dimension-eight operators same as $\sigma_{W,sq}$.
- $c_4 = c_6 = 100$ and $c_{12} = c_{13} = 10$ to compete with $c_W = 1$



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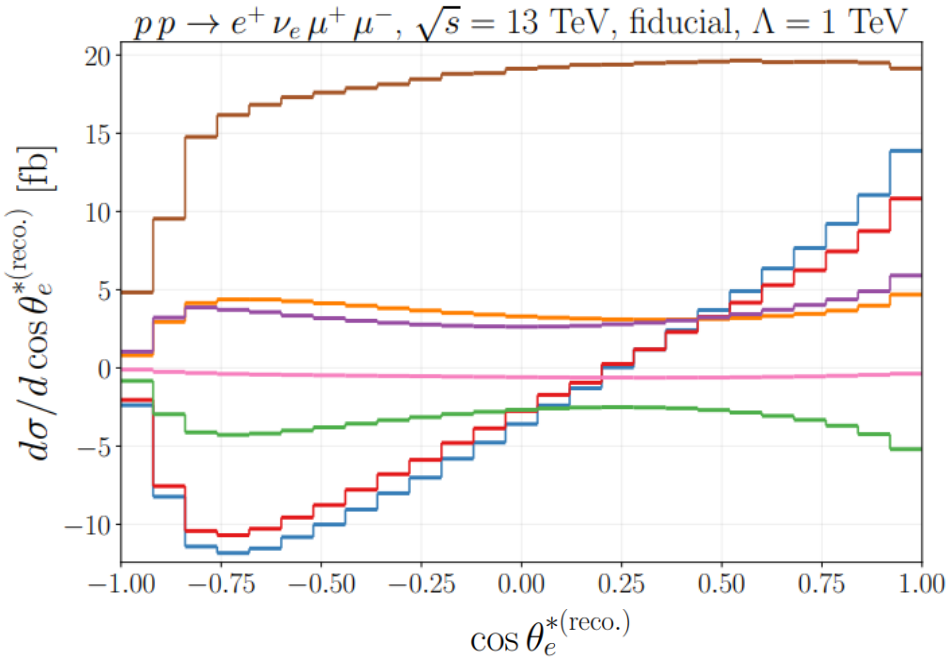
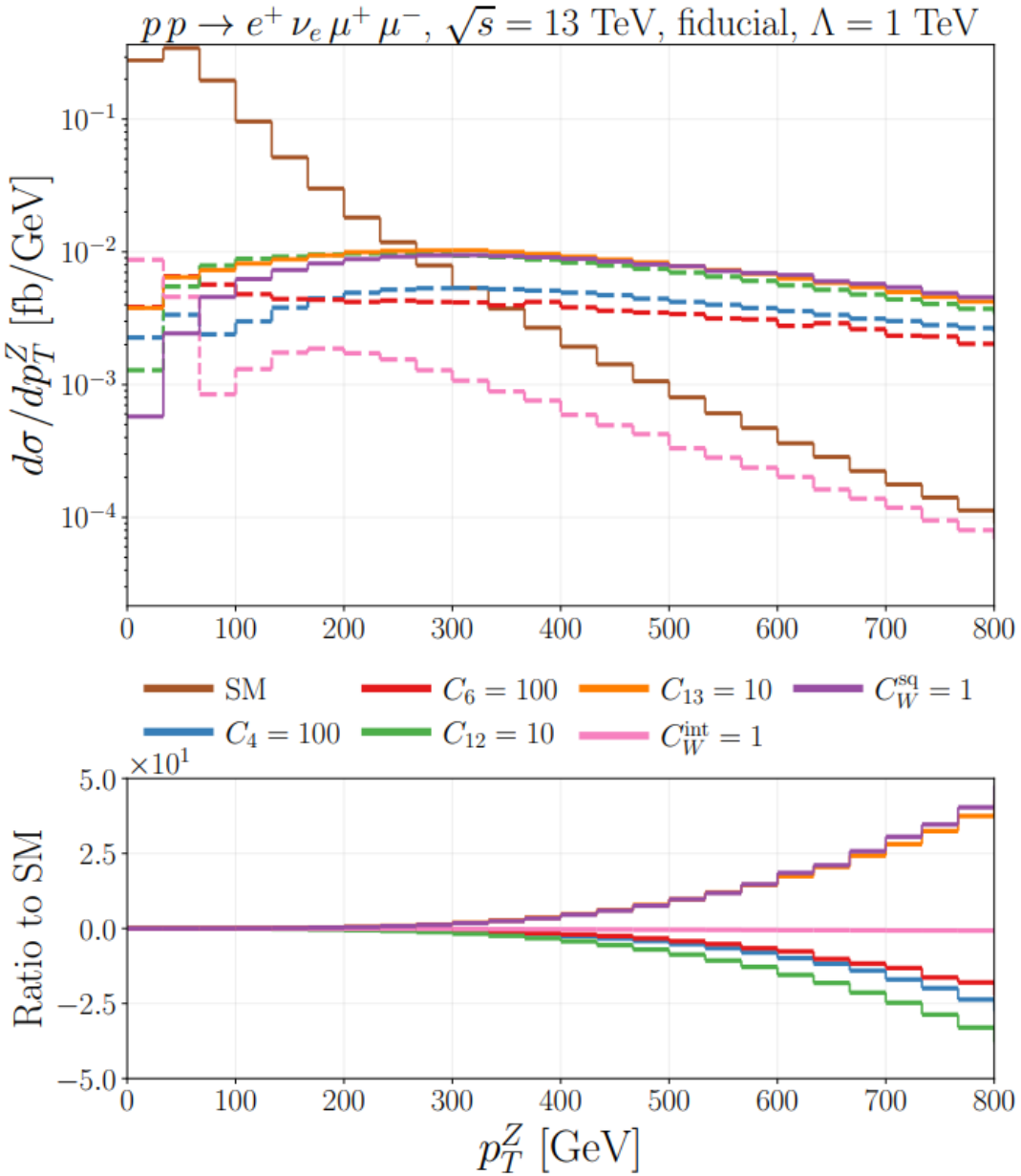
- Energy growth induced by dimension-eight operators same as $\sigma_{W,sq}$.
- $c_4 = c_6 = 100$ and $c_{12} = c_{13} = 10$ to compete with $c_W = 1$
- c_4 and c_6 suppressed by cancellations

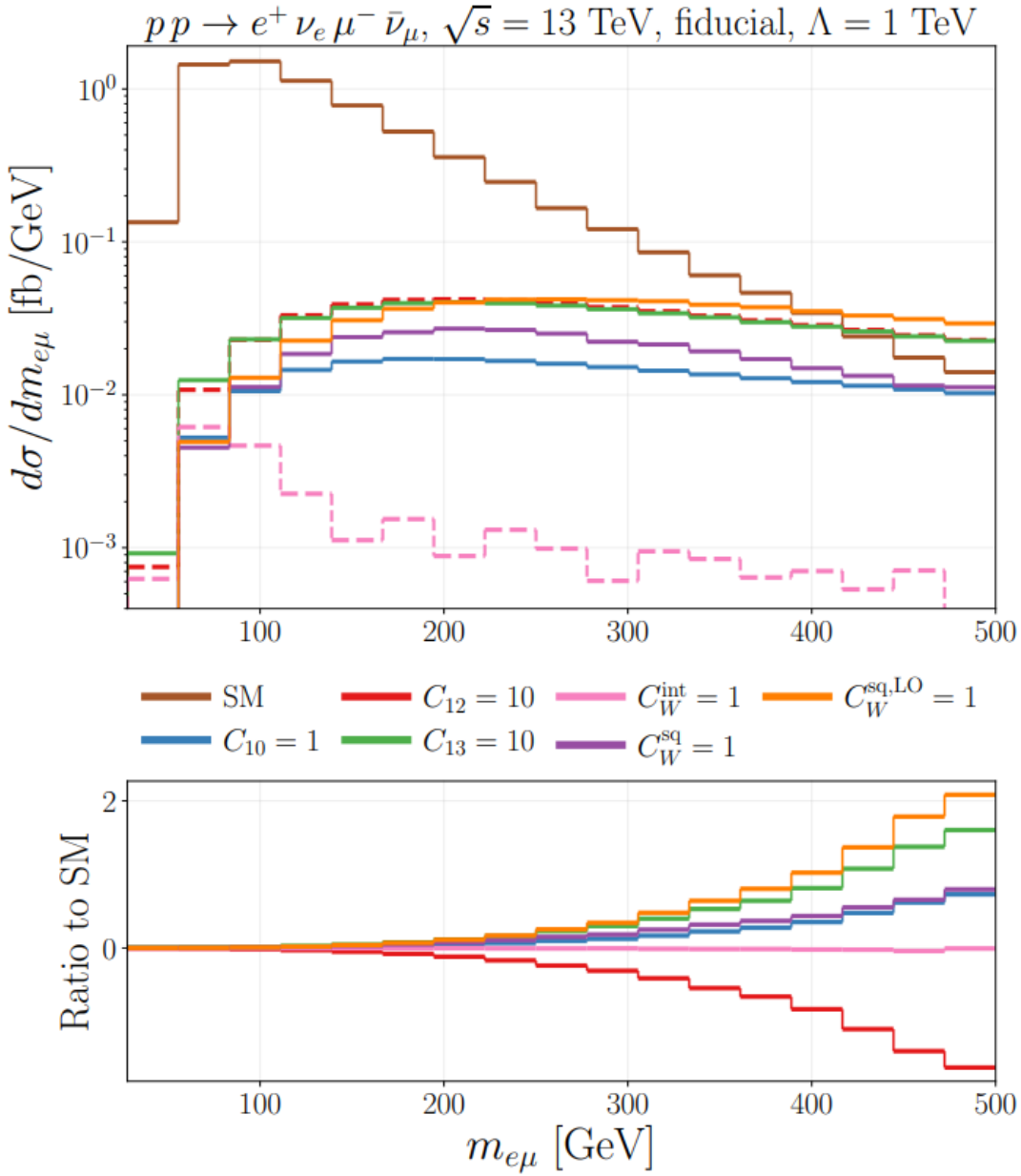




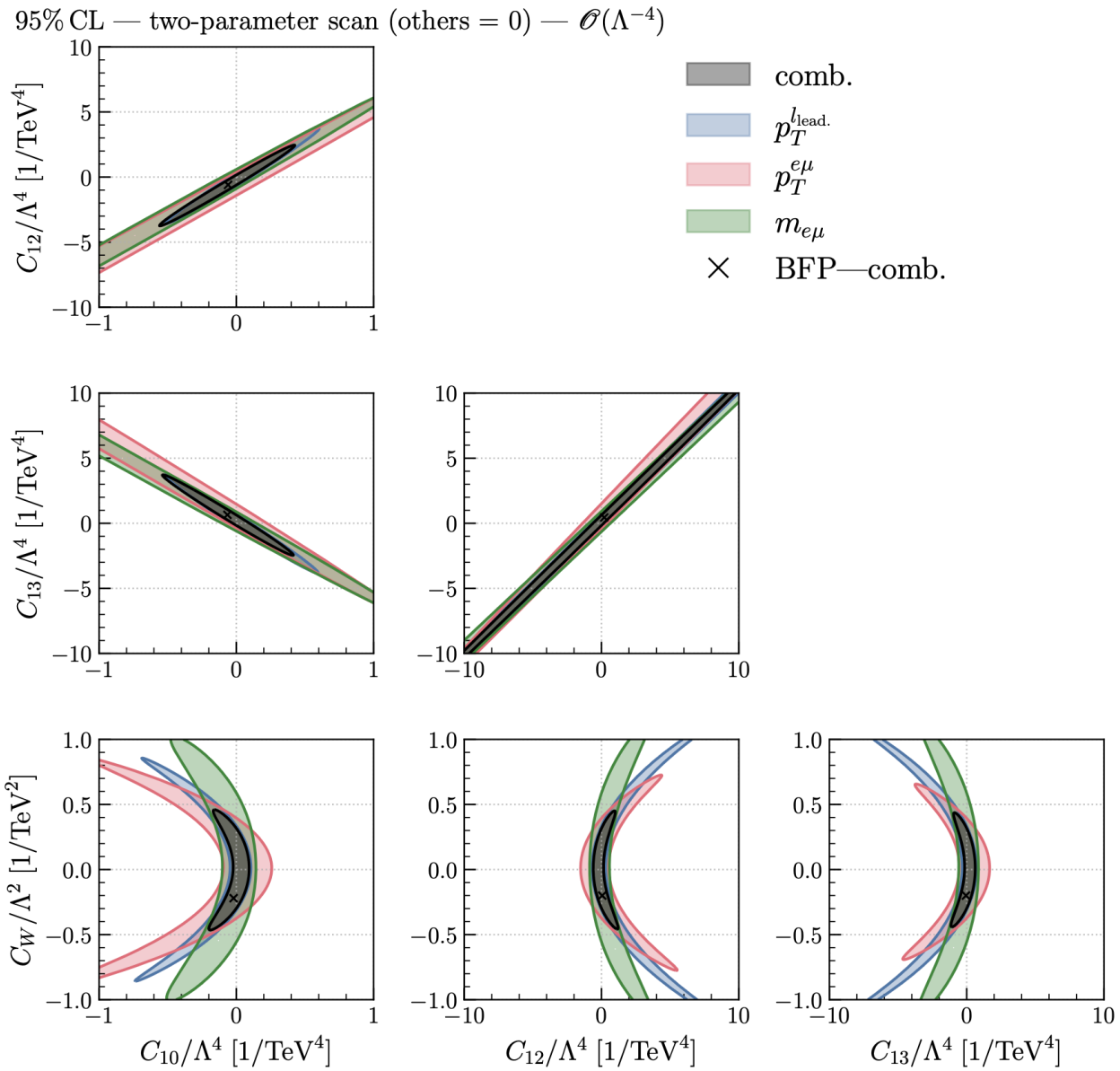
Differential distributions: WW

- Energy growth of dimension-eight operators same as $\mathcal{O}_W$
- $c_{12} = c_{13} = 10$ to compete with $c_W = 1$

σ_{10} contributes at $O(\Lambda^{-4})$ with (kind of) the same size as $\sigma_{W,sq}$.



2D parameter fit: WW



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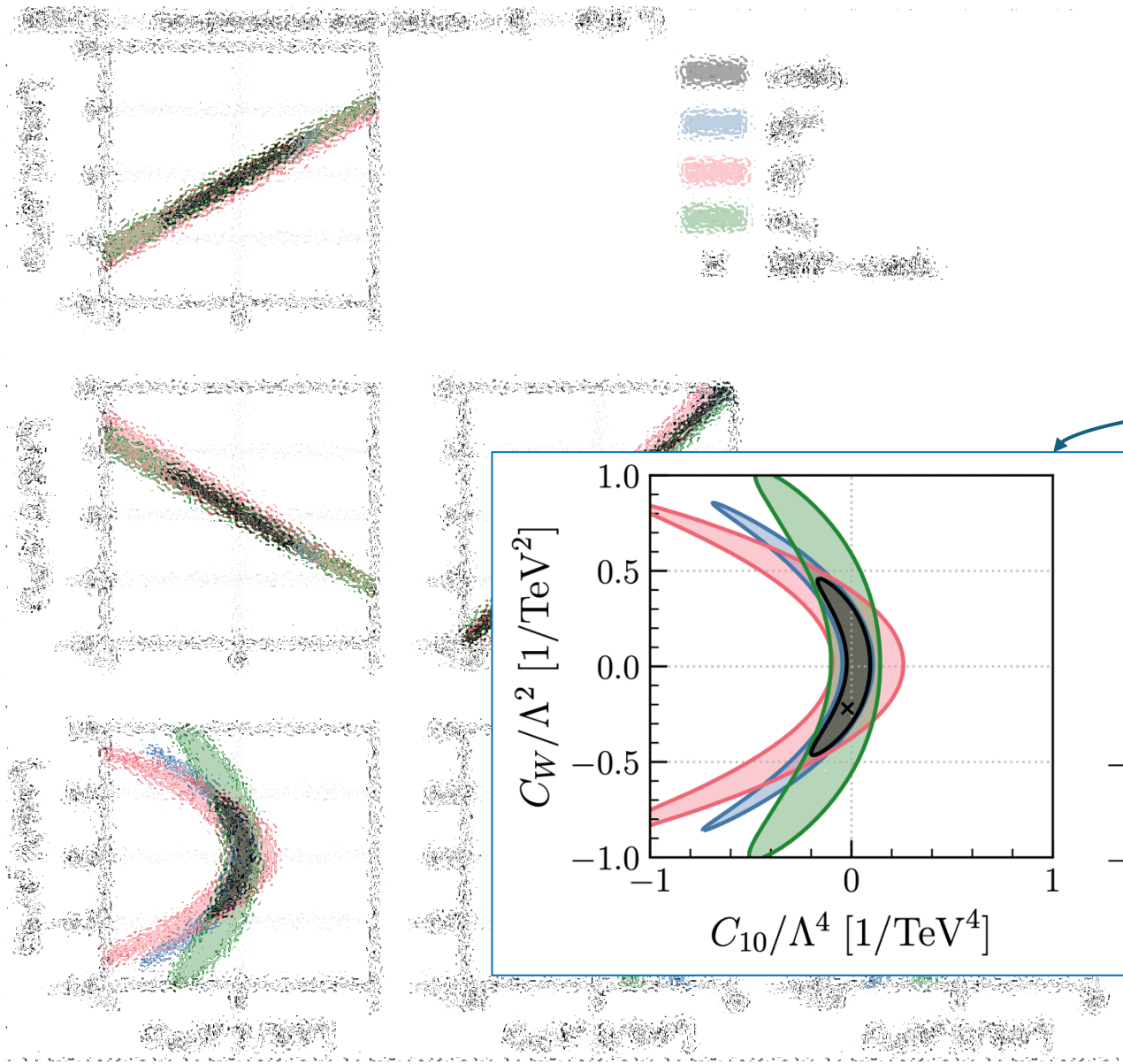

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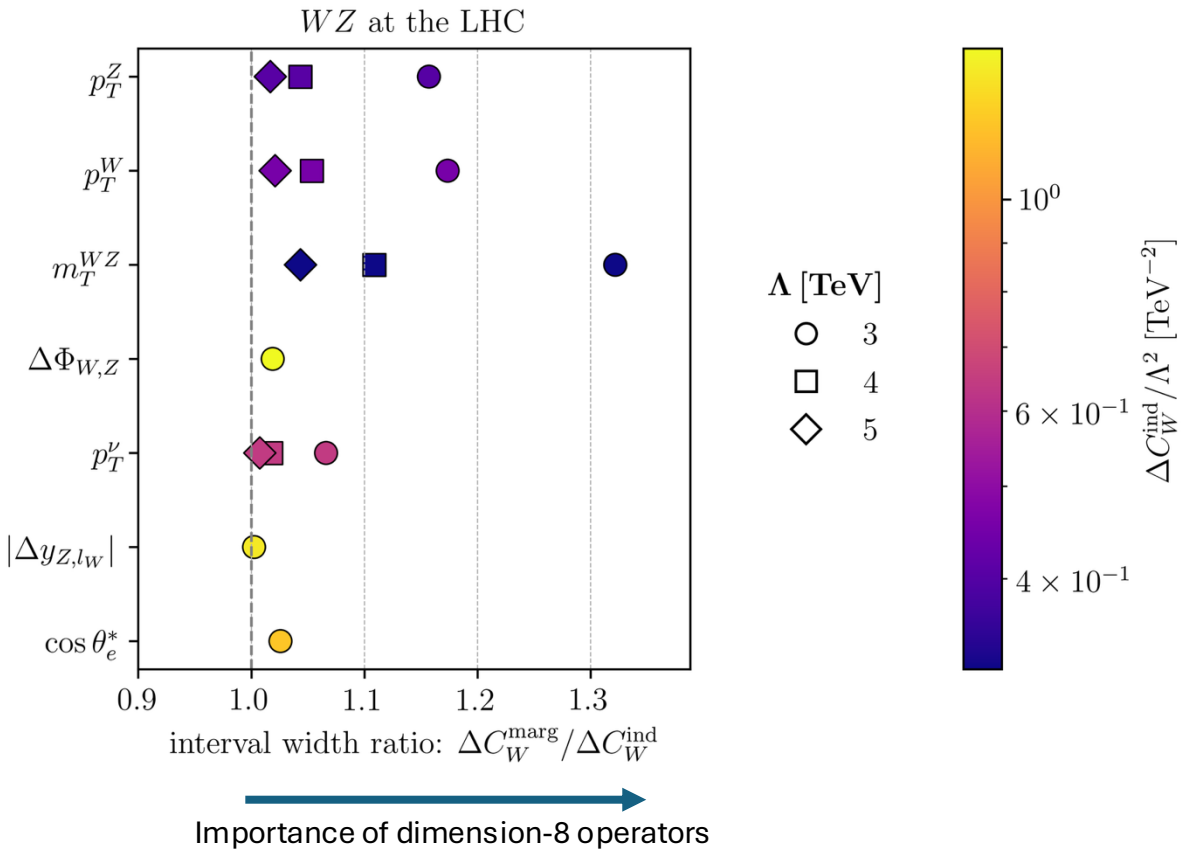
c_{10} allowed parameter space is similar to c_W space

Impact of dimension-8 operators on c_W

- We estimate the effects of including dimension-8 operators on the bounds for c_W



- ➢ Energy observables are the most affected by dimension-8 operators, up to 30%
- ➢ Angular observables in WZ can be used to constrain c_W reliably ignoring dimension-8 operators

$c_i \in [-10,10]$

Missing points → c_W unconstrained within prior

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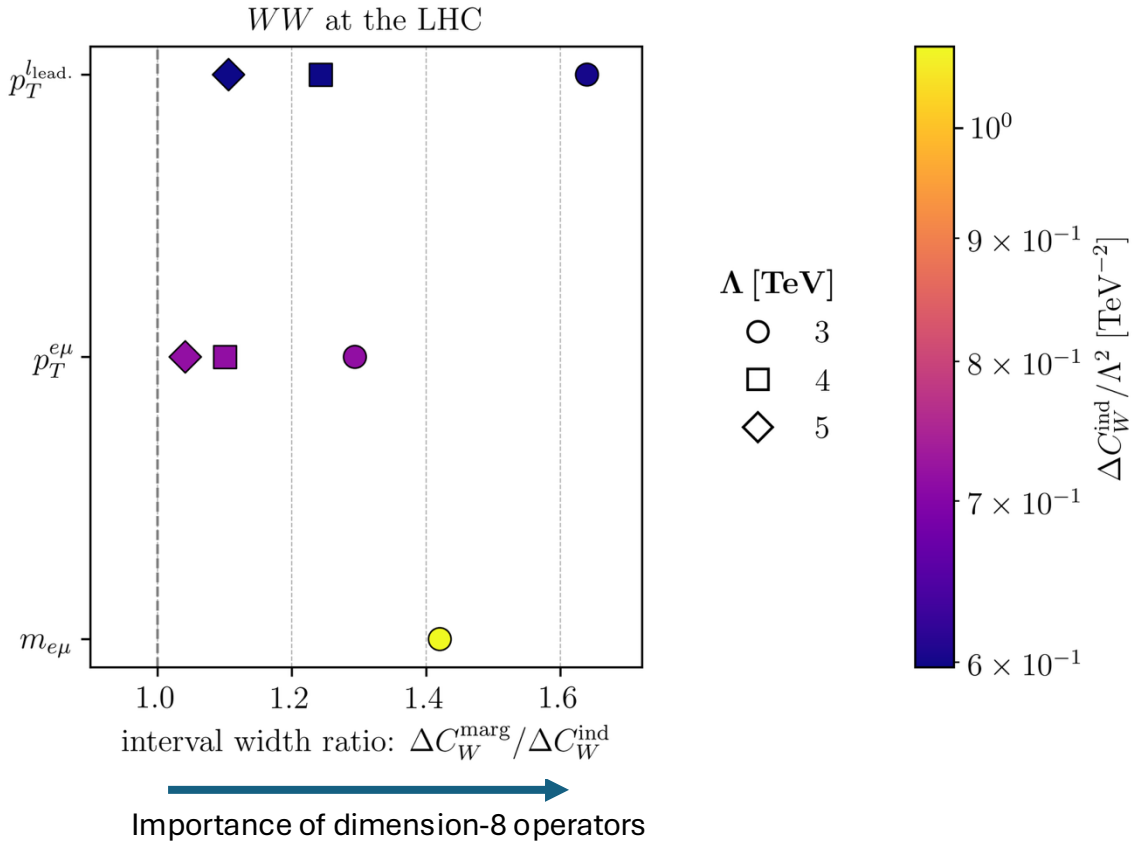

- ➢ Energy observables are the most affected by dimension-8 operators, up to 30%
- ➢ Angular observables in WZ can be used to constrain c_W reliably ignoring dimension-8 operators
- ➢ In WW the effects are bigger due to c_{10}, and dimension-8 operators modify the c_W interval up to 60%

$c_i \in [-10,10]$

Missing points → c_W unconstrained within prior

Conclusions

- We studied diboson production at the LHC with the inclusion of dimension-8 operators
- The strongest contributions are from $\mathcal{O}_{10}$ for WW and $\mathcal{O}_{12}, \mathcal{O}_{13}$ for WW and WZ
- We estimated the impact of dimension-8 operators on the constraints for c_W
  - Up to 30% in WZ
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- Effects of dimension-8 operators can be non-negligible

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Thank you!