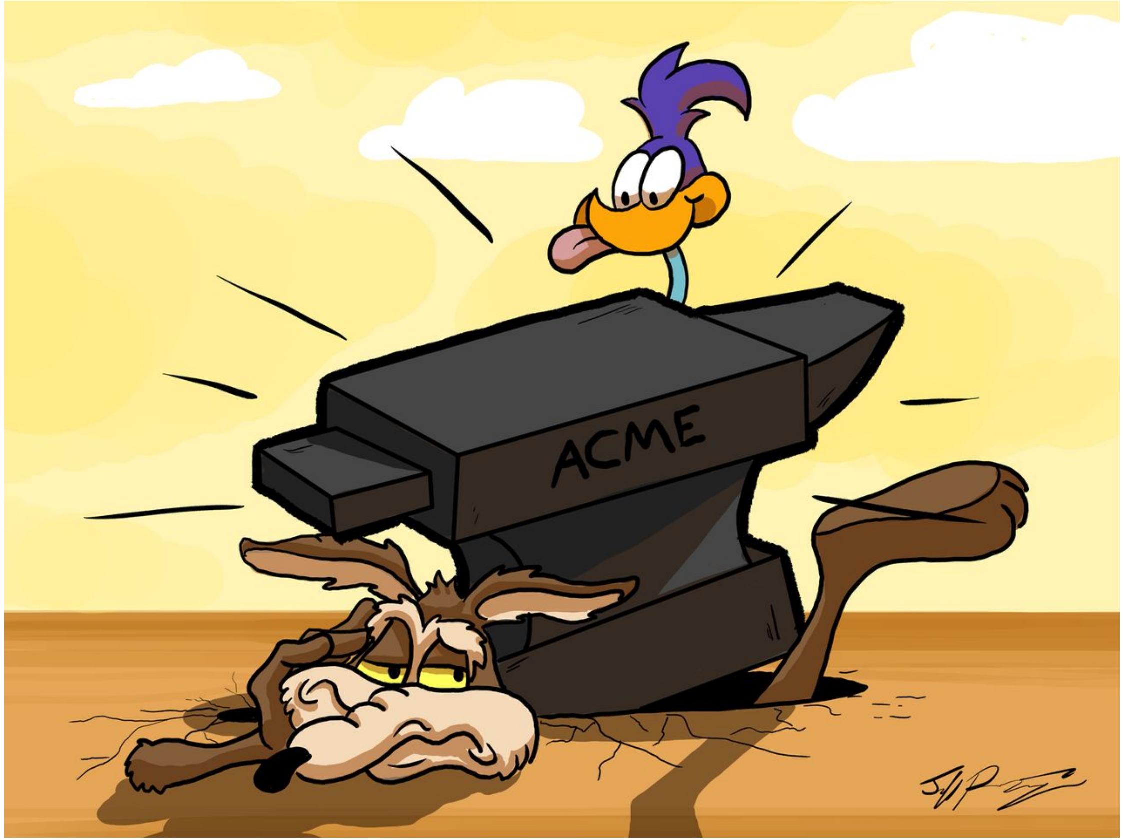
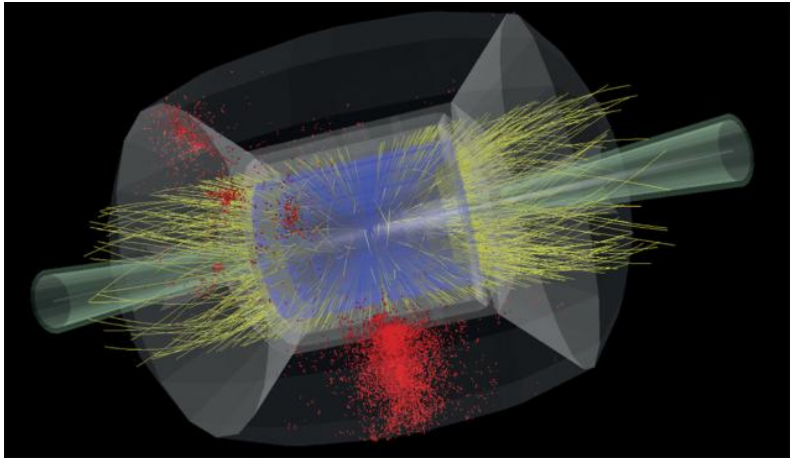
ACME - A Colliding Muon Experiment



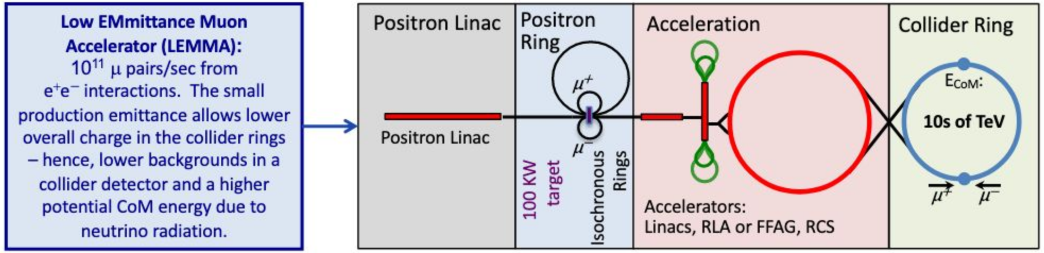
Why are muon accelerators so cool?

- Full beam energy available for hard collision
- 14TeV Muon collider has effective energy reach of 100TeV FCC-pp
- Higher mass suppresses synchrotron radiation by factor 10^9 compared to electron collider, allows for smaller detector
- 10 TeV+ muon collider has the potential to directly discover many TeV-scale particles, and ones below the TeV scale which elude the LHC.
- Super clean environment compared to p-p collisions
- Offer tests of Lepton Flavour Violation, anomalous magnetic moment
- A chance to explore novel ideas and technologies



Difficulties on muon colliders

- Producing many muons in bunches
- Short muon lifetime
- Decaying muons to eνν in beampipe create background from electrons producing EM shower → need shielding from these electrons
  - Readily available, high intensity beams for long-baseline neutrino factory
- Radioactive hazard from neutrinos



Quartic self-coupling is interesting!

$$V(H) = \frac{1}{2} m_H^2 H^2 + \lambda_3 v H^3 + \frac{1}{4} \lambda_4 H^4$$

- Higher point Higgs self-interaction are not allowed by the renormalizability of the SM
- Better understanding of the Higgs potential and the electroweak symmetry breaking
- Knowledge about the SM nature of the Higgs mechanism

Quartic self-coupling is interesting!

$$V(H) = \frac{1}{2}m_H^2 H^2 + \lambda_3 v H^3 + \frac{1}{4}\lambda_4 H^4$$

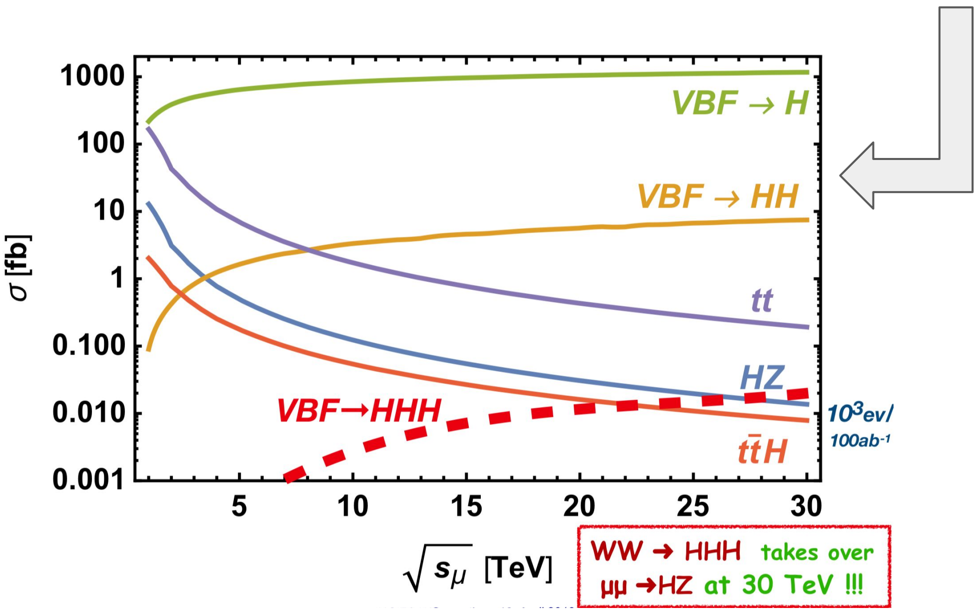
- Standard Model prediction: $\lambda_3 = \lambda_4$
- Measure λ_3 and λ_4 independently, if different then new physics!

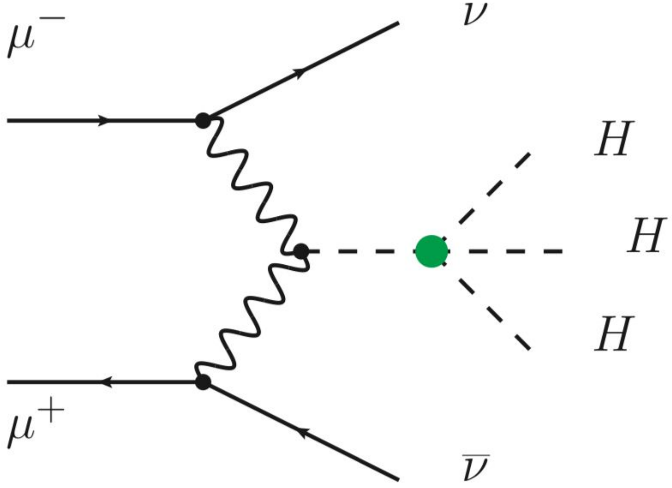
How to measure it?

Best estimate from μμ->WWvv-> HHHvv production to 6b +2v in the final state

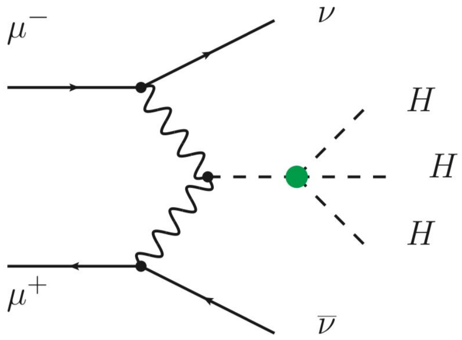
Indirect bounds from one-loop contributions in HH final states

Tri-Higgs production cross-section increases with energy



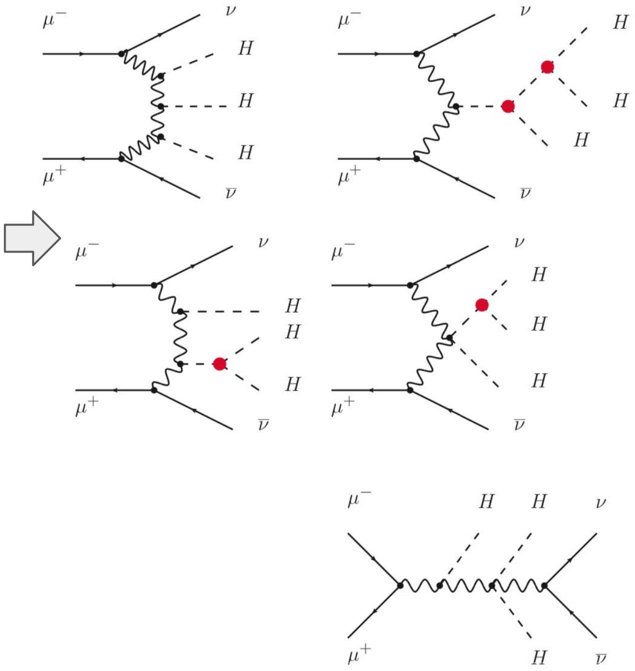


Backgrounds



Background involves trilinear Higgs couplings as well as WWH & WWHH couplings

Precise knowledge of these couplings needed to estimate background

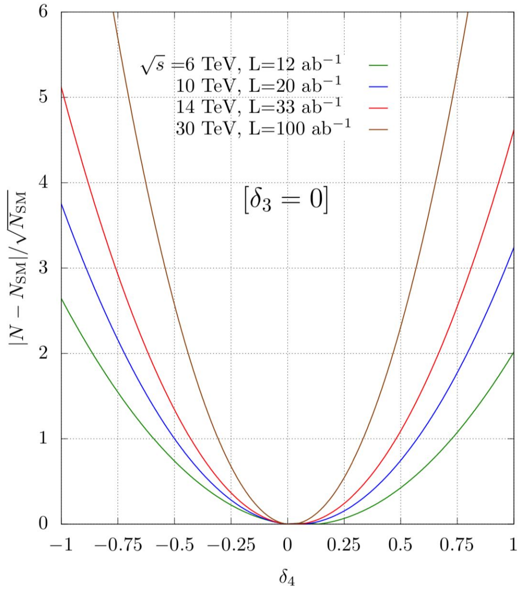


Sensitivity to deviations from SM value

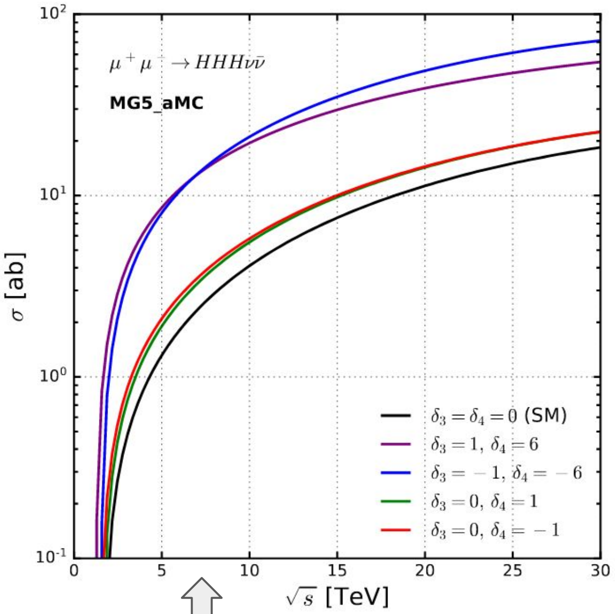
$$\lambda_3 = \lambda_{SM}(1+\delta_3) = \kappa_3\lambda_{SM} \,,$$
$$\lambda_4 = \lambda_{SM}(1+\delta_4) = \kappa_4\lambda_{SM} \,,$$

- δ3 = 0

Sensitivity to λ4 in standard deviations wrt SM configuration for different energies and luminosities



Cross-section for tri-Higgs production as a function of energy for different combinations of λ3, λ4



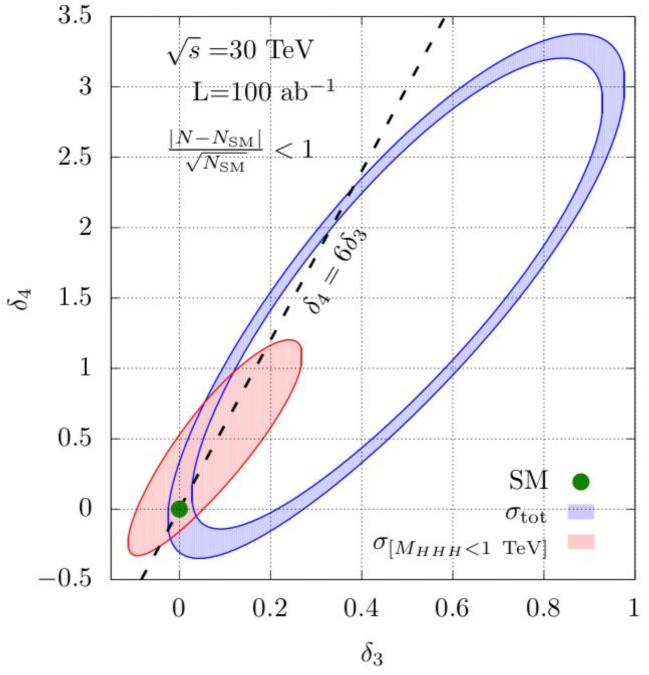
Sensitivity to deviations from SM value

- $\delta 3 \neq 0$, $\delta 4 \neq 0$

At perturbative level, one can link the deviations of the λ's to higher dimensional operators.

Simplest choice: one 6-dim SMEFT operator

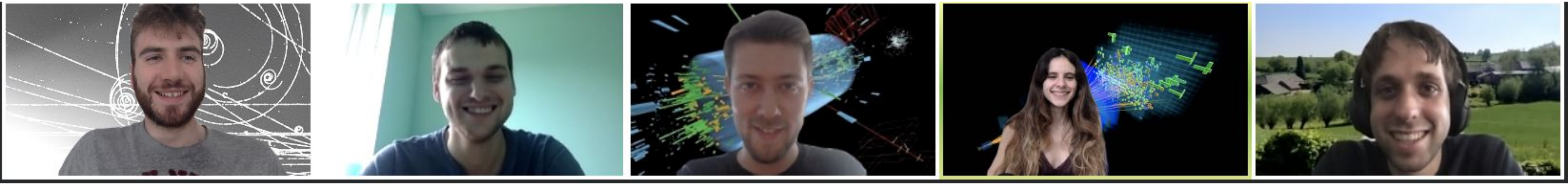
$c_6(\Phi^\dagger\Phi)^3/\Lambda^2$ ⟹ $\delta 4 = 6\, \delta 3$



Conclusions

- Can a future 30 TeV muon collider possibly measure these?

- A leptonic collider of ~ 30 TeV and with a luminosity of several tens of attobarns, should provide enough events to measure the SM Higgs quartic coupling with an accuracy of tens of percent.



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Sources

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- https://indico.cern.ch/event/765096/contributions/3295784/attachments/1785298/2906335/MuonCollider_ESPP_18dec18.pdf
- https://journals.aps.org/prd/pdf/10.1103/PhysRevD.101.075023

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