Calculating precise electroweak predictions

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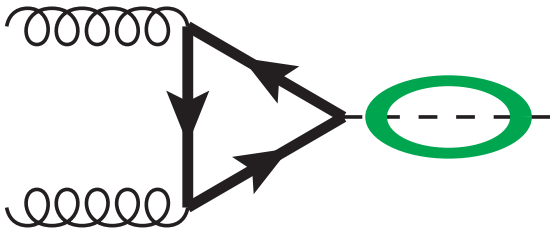
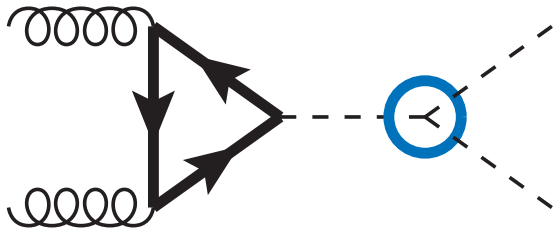
YETI 2026: Precision $\times$ Collider

Higgs boson production



- m_H, s_H, Y_f
- LHC
- Discovery



- λ_{HHH}
- HL-LHC
- Precision

Theory-uncertainty budget

- *ggH* 2017

δ(scale)	δ(trunc)	δ(PDF-TH)	δ(EW)	$\delta(t, b, c)$	$\delta(1/m_t)$
$^{+0.21\%}_{-2.37\%}$	$\pm 0.37\%$	$\pm 1.16\%$	± 1	$\pm 0.83\%$	$\pm 1\%$

- *ggHH* 2025

δ(NLO QCD)	δ(NNLO QCD)	δ(aN3LO QCD)	$\delta(m_t)$
$\pm 13\%$	$\pm 2.6\%$	± 0.9	$\pm 20\%$

1. Size of EW corrections
2. Form of EW corrections
3. Tips for EW corrections

The Size of EW Corrections

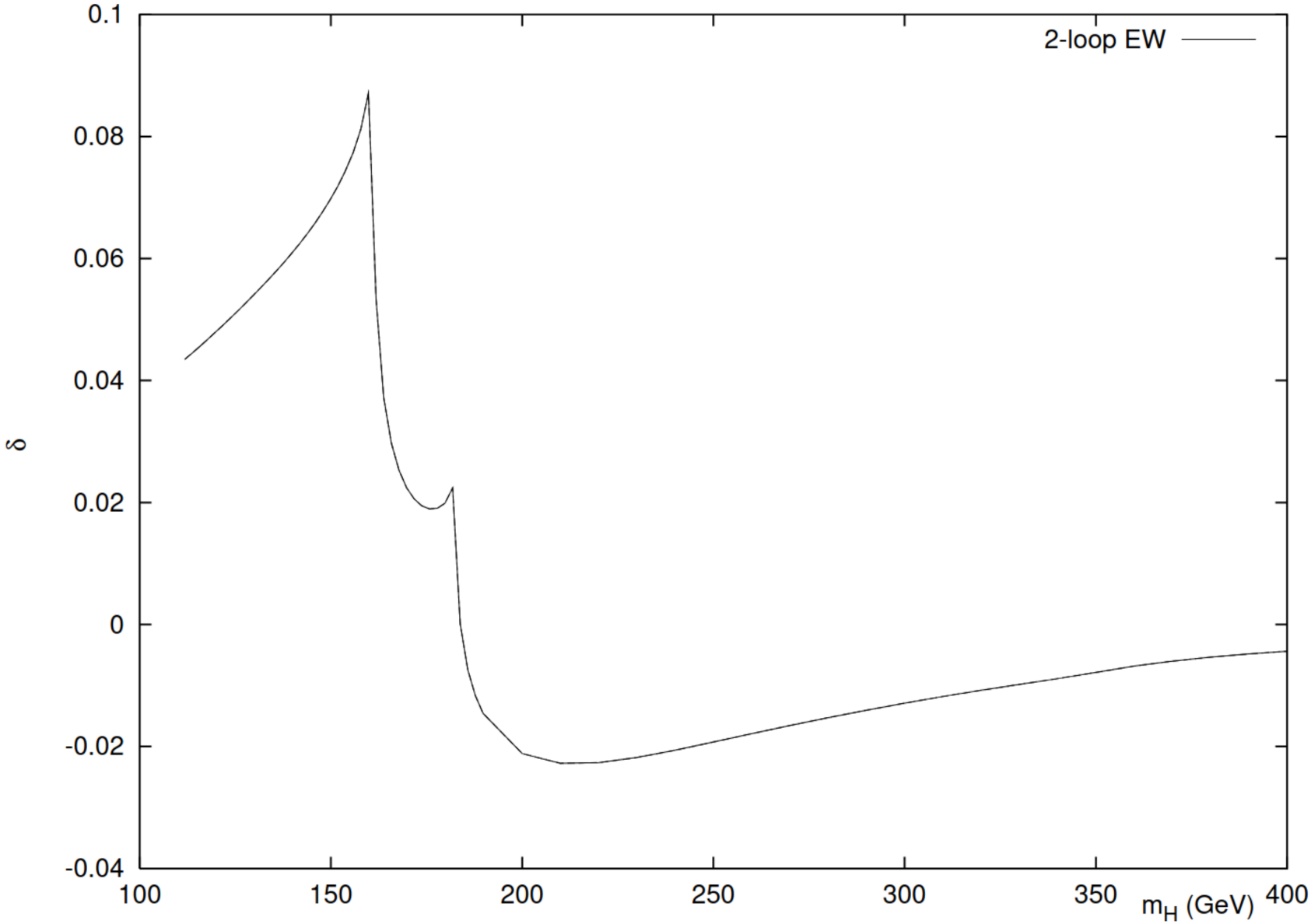
ggH: theory predictions

$$\sigma_{ggH} = 48.0\,\text{pb} =$$

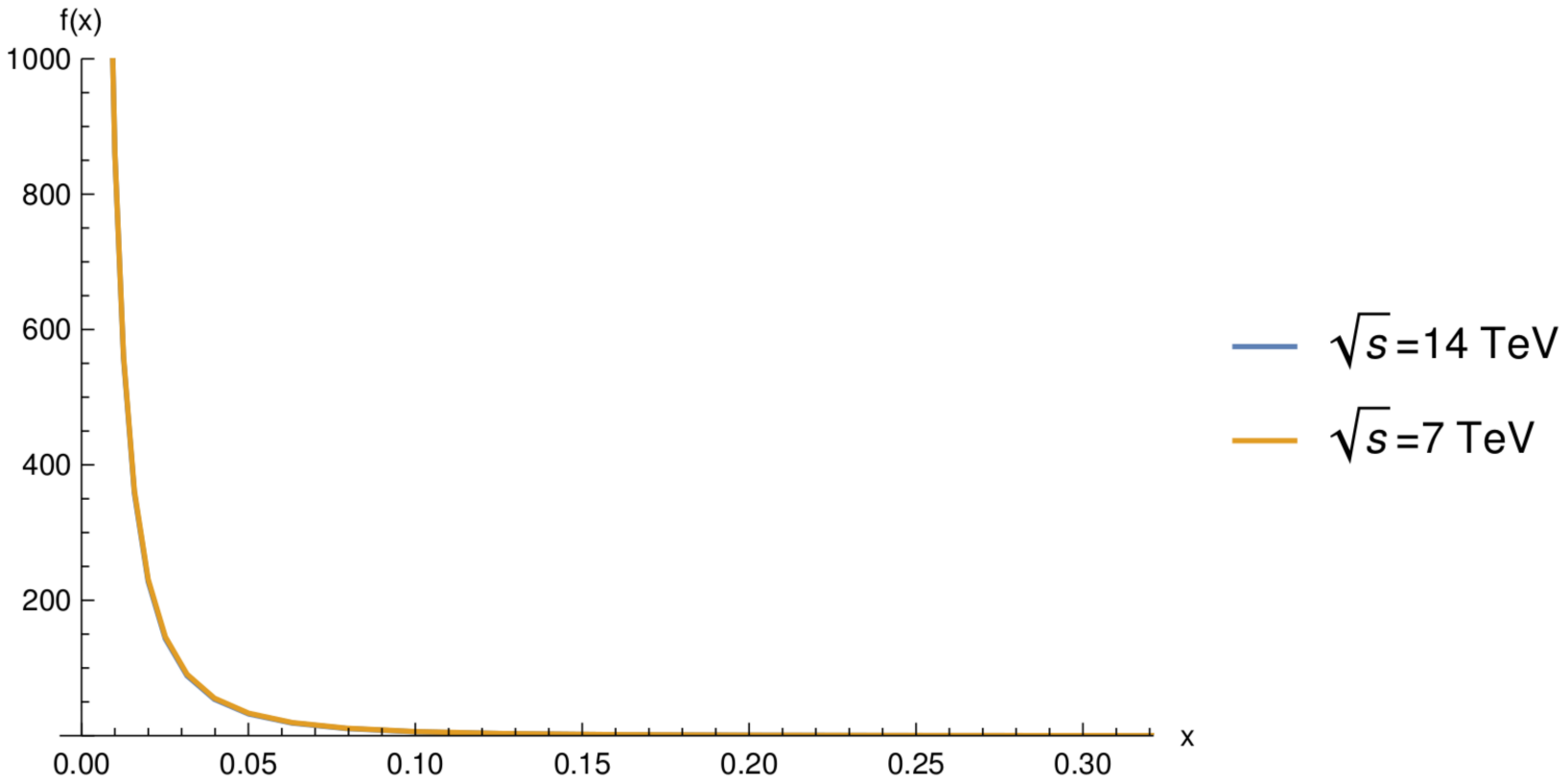
$+16.0\,\text{pb}$	LO
$+18.8\,\text{pb}$	NLO QCD
$+9.9\,\text{pb}$	NNLO QCD
$+1.5\,\text{pb}$	NNNLO QCD
$+1.1\,\text{pb}$	NLO EW
$+0.7\,\text{pb}$	NLO EW $\times$ NLO QCD

ggH: light quarks

[hep-ph/0404071]



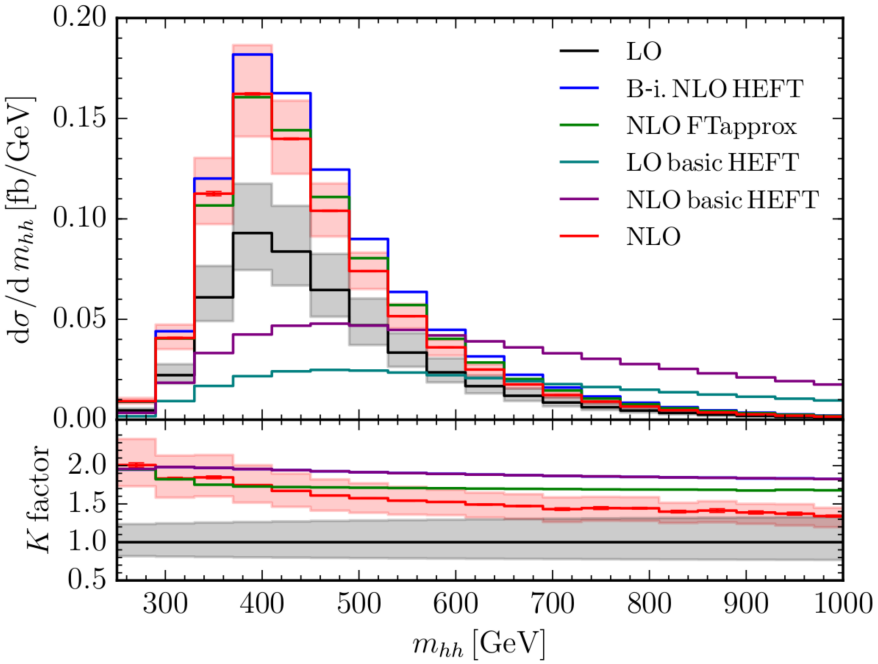
Gluon PDF

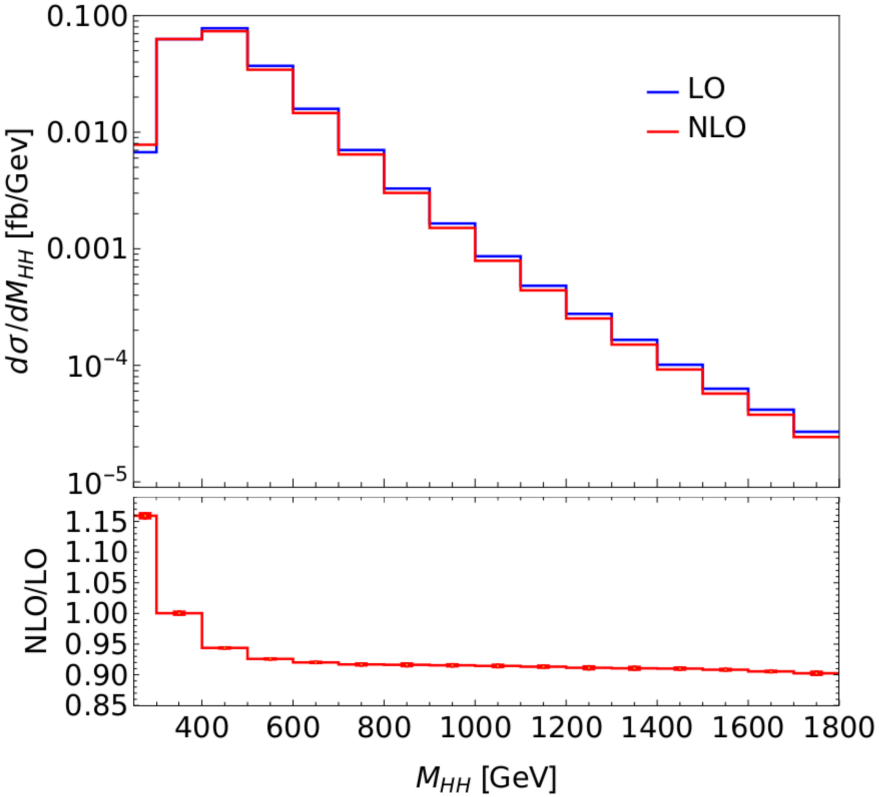

f(x)
1000
800
600
400
200
0.00
0.05
0.10
0.15
0.20
0.25
0.30
x
$\sqrt{s}$=14 TeV
$\sqrt{s}$=7 TeV

ggHH: theory predictions

$$\sigma_{ggHH} = 33.62\,\text{fb} = \begin{array}{rl} +17.46\,\text{fb} & \text{LO} \\ +11.35\,\text{fb} & \text{NLO QCD} \\ +4.54\,\text{fb} & \text{aNNLO QCD} \\ +1.05\,\text{fb} & \text{aN3LO QCD} \\ -0.79\,\text{fb} & \text{NLO EW} \end{array}$$

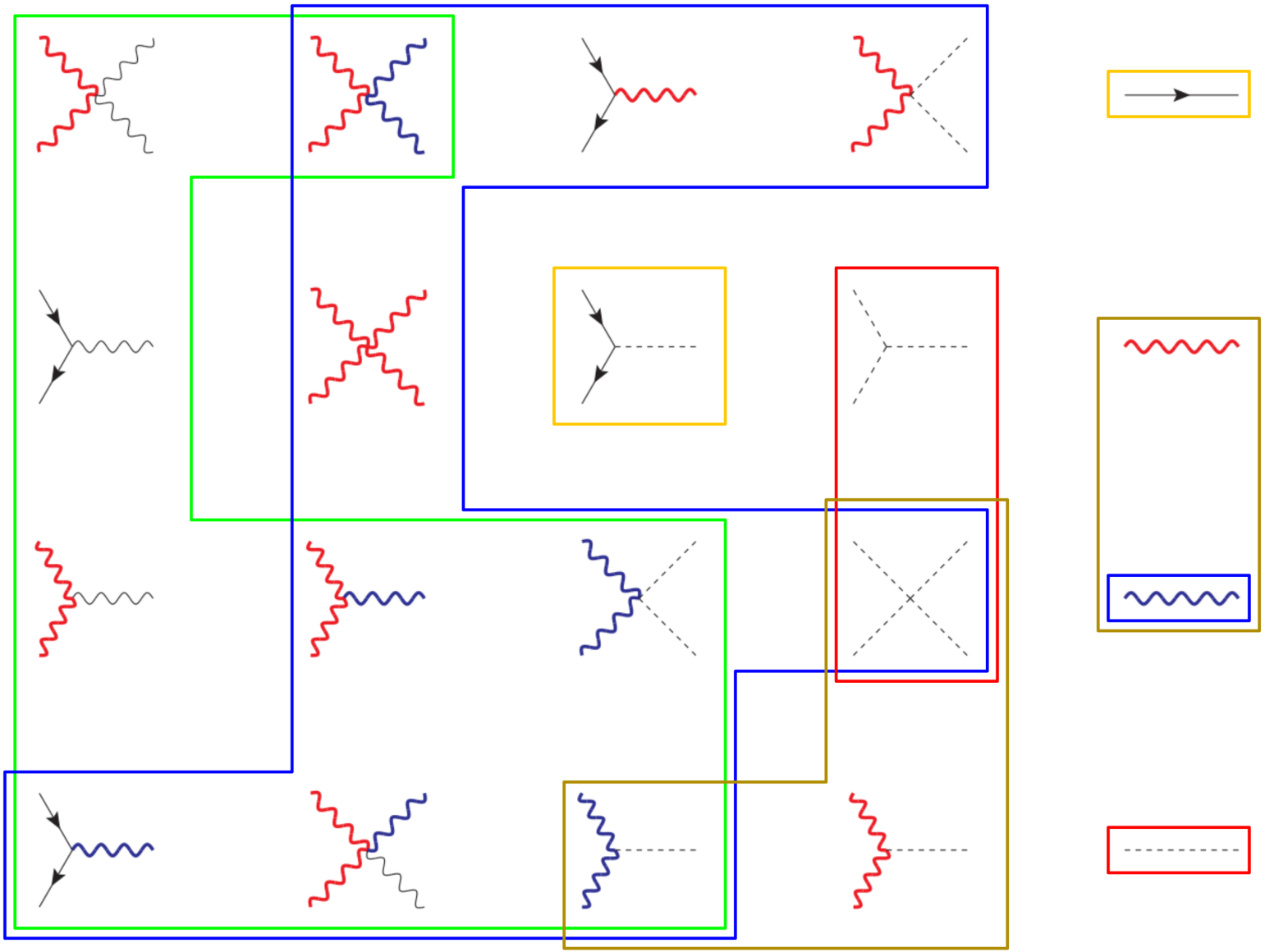
ggHH: NLO QCD vs. NLO EW





The Form of EW Corrections

EW vertices



$(g-2)_\mu$ amplitude

$\mathcal{M}$		$\mathcal{L}$
$\bar{u}\,\gamma^\mu\,u$	$\Longleftrightarrow$	$\bar{\psi}\,\not{A}\,\psi$
$\dfrac{\mathrm{i}}{2m}\,\bar{u}\,\sigma^{\mu\nu}\,q_\nu\,u$	$\Longleftrightarrow$	$\bar{\psi}\,F^{\mu\nu}\sigma_{\mu\nu}\,\psi$
$\mathrm{i}E^{\mu\nu\rho\sigma}\,\bar{u}\,q_\nu\sigma_{\rho\sigma}\,u$	$\Longleftrightarrow$	$\bar{\psi}\,\tilde{F}^{\mu\nu}\sigma_{\mu\nu}\,\psi$
$\dfrac{1}{2m}\,\bar{u}\left(q^\mu-\dfrac{q^2}{2m}\gamma^\mu\right)\gamma_5\,u$	$\Longleftrightarrow$	$\bar{\psi}\,\not{\partial}\gamma_5\,\psi$

γ_5 schemes

- Larin scheme
  - $\gamma^\mu\gamma_5 = (\gamma^\mu\gamma_5 - \gamma_5\gamma^\mu)/2$
  - $\mathrm{Tr}[\ldots\gamma_5\ldots\gamma_\mu\gamma_5\ldots] = -\mathrm{Tr}[\ldots\gamma_5\ldots\gamma_5\gamma_\mu\ldots]$
  - $\gamma_5 = E^{\mu\nu\rho\sigma}\gamma_\mu\gamma_\nu\gamma_\rho\gamma_\sigma/24$
  - $E^{\mu\nu\rho\sigma}E_{\alpha\beta\gamma\delta} = \tilde{g}^{\mu\nu\rho\sigma}_{\alpha\beta\gamma\delta}$
  - $\overline{\alpha}_B = \overline{\alpha}(1 + \delta Z_5\,\overline{\alpha})$
- Kreimer scheme
  - $\{\gamma^\mu, \gamma_5\} = 0$
  - $\mathrm{Tr}[\gamma^\mu\gamma_5\Gamma_a] + \mathrm{Tr}[\gamma^\mu\gamma_5\Gamma_b] + \ldots$
  - Bose symmetry among axial vertices
  - $\overline{\alpha}_B = \overline{\alpha}(1 + \delta Z_5\,\overline{\alpha})$
- Naïve γ_5 scheme
  - γ_5 as in $D = 4$
  - first occurrence of γ_5

Tips for EW Corrections

Gauges

$$\frac{\mathrm{i}\left(-g^{\mu\nu}+\frac{k^\mu k^\nu}{m^2}\right)}{k^2-m^2}+\frac{-\mathrm{i}\frac{k^\mu k^\nu}{m^2}}{k^2-\xi m^2}$$

$$\frac{\mathrm{i}}{k^2-\xi m^2}$$

Gauges

$$\frac{\mathrm{i}\left(-g^{\mu\nu}+\frac{k^\mu k^\nu}{m^2}\right)}{k^2-m^2}+\frac{-\mathrm{i}\frac{k^\mu k^\nu}{m^2}}{k^2-\xi m^2}$$

$$\frac{\mathrm{i}}{k^2-\xi m^2}$$

Unitary

$$\frac{\mathrm{i}\left(-g^{\mu\nu}+\frac{k^\mu k^\nu}{m^2}\right)}{k^2-m^2}$$

–

Feynman

$$\frac{\mathrm{i}g^{\mu\nu}}{k^2-m^2}$$

$$\frac{\mathrm{i}}{k^2-m^2}$$

1. Size of EW corrections
   - Enhancement:
     - n_l multiplicity
     - Threshold enhancement
     - Sudakov logs
   - Suppression:
     - α vs. α_S
     - No real emissions
2. Form of EW corrections
   - Many parameters but many constraints
   - γ_5: new structures, new issues
   - New channels
3. Tips for EW corrections
   - Gauges
   - Schemes
   - Partition

Thank you for your attention

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