$h \to \gamma\gamma$: mini-review

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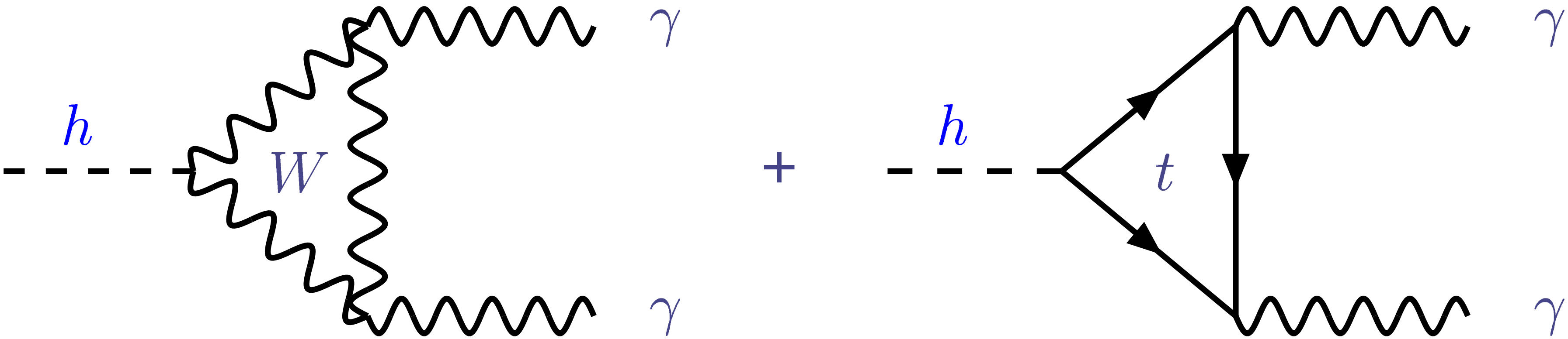
Outline

- Physics motivation for $h \to \gamma\gamma$ measurement
- Theoretical uncertainty in $BR(\gamma\gamma)$ calculation
- How well can the LHC measure $BR(\gamma\gamma)$?
- How well can the ILC measure $BR(\gamma\gamma)$?
- ILC experimental issues
- Effect of EM calorimeter energy resolution

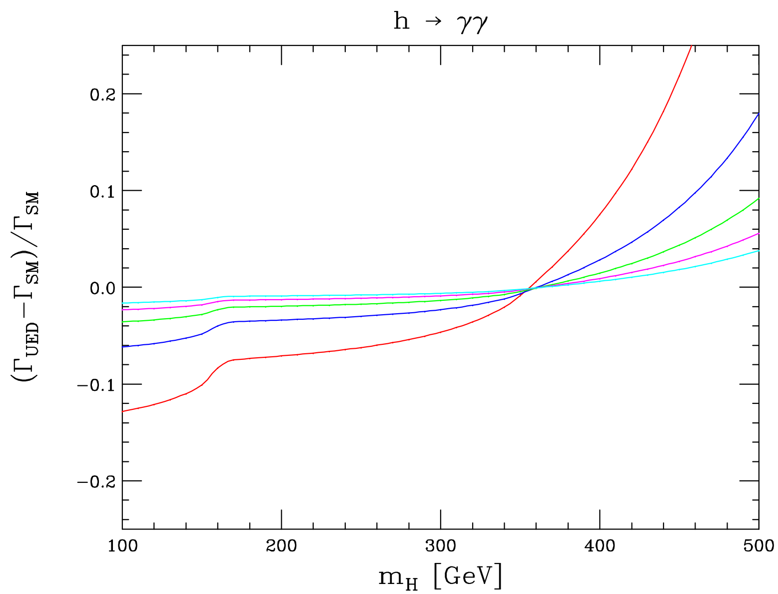
$h \to \gamma\gamma$ in the SM



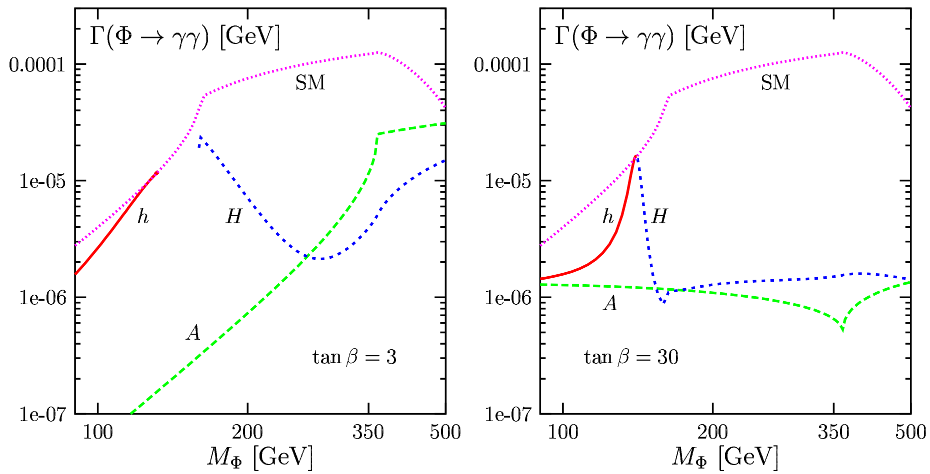
- Produced via W, t loops $\Rightarrow$ these interfere destructively
- At $m_h = 120$ GeV, $BR(\gamma\gamma) \approx 2 \times 10^{-3}$

New physics effects

- Because it is loop-induced, especially sensitive to new physics



Universal Extra Dimensions
(FP, hep-ph/0204067)



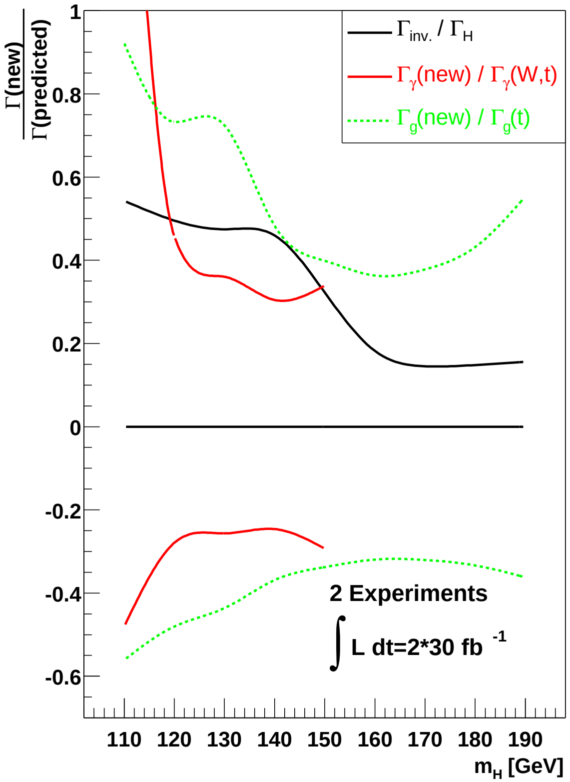
MSSM
(Djouadi, hep-ph/0503173)

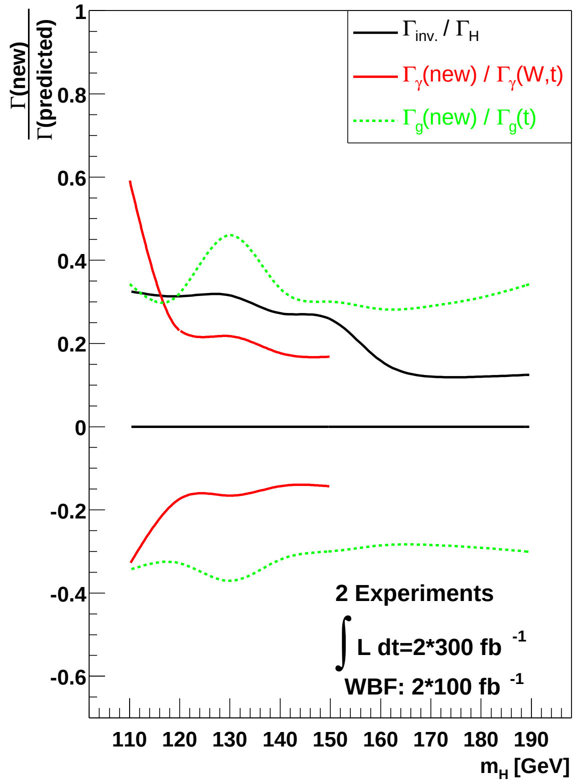
- Shifts of 10% $\to$ factors of a few possible

Theoretical uncertainties

- Can be computed with high precision
- $\Delta_{th}[\sigma \times BR(\gamma\gamma)] = 1 - 2\%$
- 0.1% from missing higher order calculations, remainder from parametric uncertainties in $\bar{m}_b, \bar{m}_c$ (Droll and Logan, hep-ph/0612317)
- Production modes:
  - ILC $e^+e^- \to v\bar{v}h$ uncertainty: 0.5% (from Droll and Logan)
  - LHC $gg \to h$: $5\%^*$ at (almost) N^3LO (Vogt et al., hep-ph/0608307)
  - LHC WBF: 4% (from Dührssen et al., hep-ph/0406323)

Measurement at the LHC





Dührssen et al., hep-ph/0406323

- 20% precision for $m_h = 120$ GeV at high luminosity
- Caveat! Uses 20% uncertainty for $gg \to h$, needs updating

Measurement at the ILC

- Studies done with $1\,\mathrm{ab}^{-1}$ at $\sqrt{s} = 350, 500, 1000$ GeV

  Boos et al., hep-ph/0011366; Barklow, hep-ph/0312268

- For $m_h = 120$ GeV:

$$\sqrt{s} = 350\,\mathrm{GeV} \quad \Rightarrow \quad \Delta BR(\gamma\gamma) = 12.1\%$$
$$\sqrt{s} = 500\,\mathrm{GeV} \quad \Rightarrow \quad \Delta BR(\gamma\gamma) = 9.6\%$$
$$\sqrt{s} = 1000\,\mathrm{GeV} \quad \Rightarrow \quad \Delta BR(\gamma\gamma) = 5.4\%$$

- First two use $e^+_{pol} = 60\%$, last $e^+_{pol} = 50\%$; both use $e^-_{pol} = 80\%$

$\Rightarrow$ ILC can do quite well at all stages!

Experimental issues

- Beam polarization is an important issue; without it:

$$\sqrt{s} = 350\,\mathrm{GeV}: \qquad \Delta BR(\gamma\gamma) = 12.1\% \Rightarrow 17.9\%$$

$$\sqrt{s} = 500\,\mathrm{GeV}: \qquad \Delta BR(\gamma\gamma) = 9.6\% \Rightarrow 16.4\%$$

- Energy resolution of EM calorimeter?
- $BR(\gamma\gamma)$ an ILC calorimeter benchmark (Battaglia et al., hep-ex/060301)

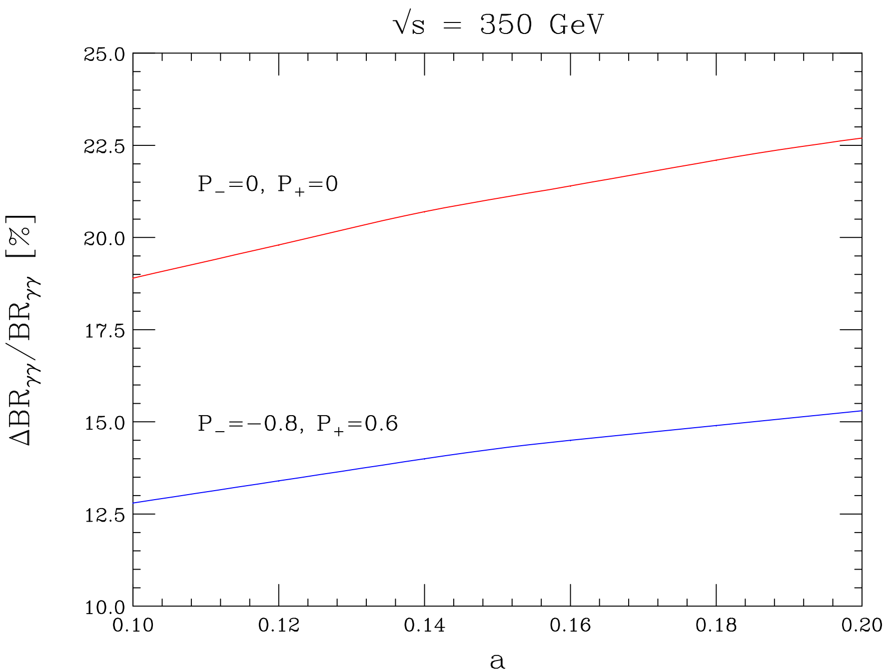
Analysis of resolution effect

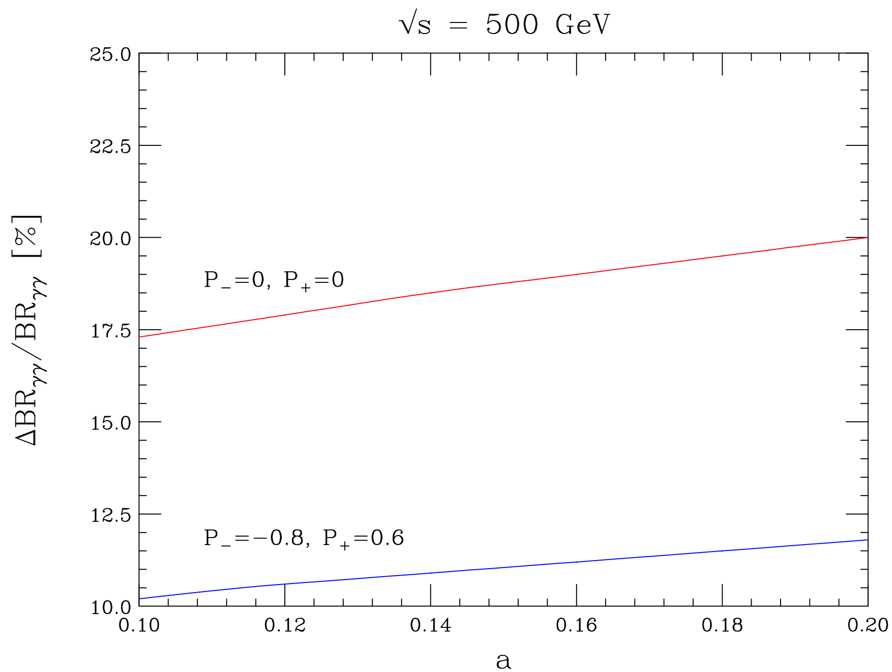
- Use analysis of Boos et al., hep-ph/0011366 and $m_h = 120$ GeV
- Relevant final states: $q\bar{q}\gamma\gamma$ at $\sqrt{s} = 350$ GeV, $\nu\bar{\nu}\gamma\gamma$ at $\sqrt{s} = 350, 500$ GeV
- Parametrize background after selection cuts as linear for $110 < m_{\gamma\gamma} < 130\,\mathrm{GeV}$
- Calorimeter resolution:

$$\frac{\sigma_E}{E} = \frac{a}{\sqrt{E(\mathrm{GeV})}}$$

- Vary a between $[10\%, 20\%]$; consistent with range in DCR
- Treat Higgs signal as Gaussian with experimental width dependent on a
- For each a minimize $\sqrt{S+B}/S$ w.r.t. size of $m_{\gamma\gamma}$ window

Results and conclusion





- $a = 0.10$ results less than 1% higher than Boos et al. $\Rightarrow$ consistent
- Optimum $m_{\gamma\gamma}$ window $\approx 1.2 \times \Gamma_{exp} \Rightarrow$ same as Boos et al.
- Precision degrades by $2 - 4\%$ taking a from $0.10 \rightarrow 0.20$

$\Rightarrow$ less important than polarization