ALCPG07 meeting: Higgs to jets and photons

Patrick Fox
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Bogdanino
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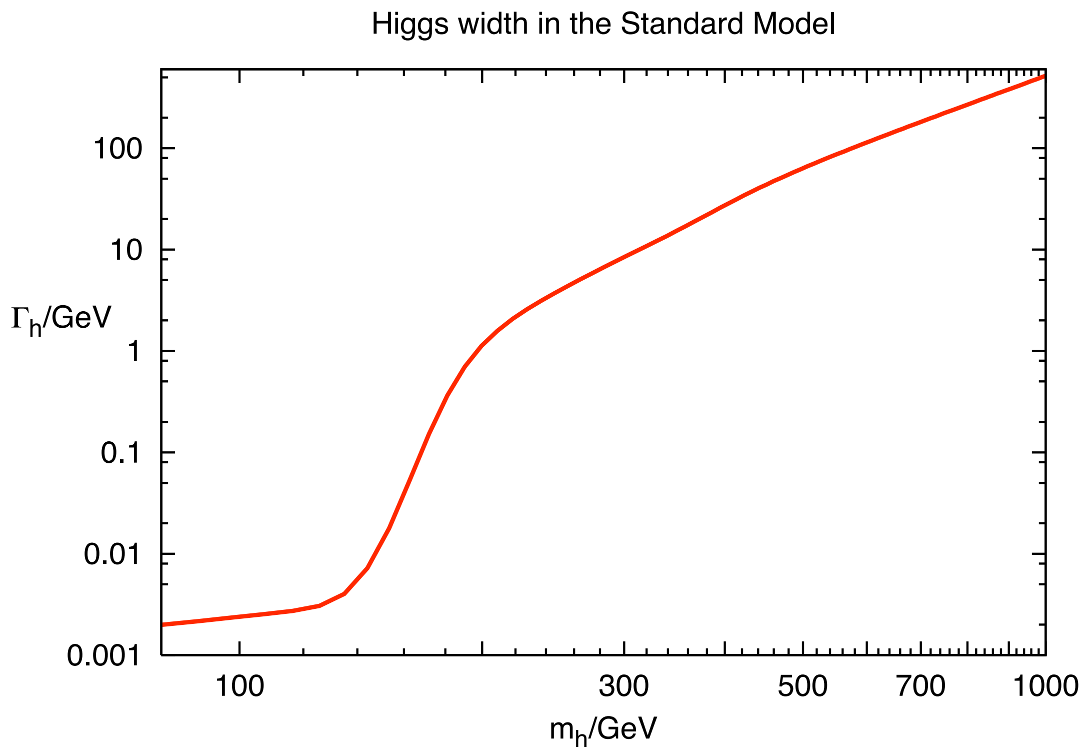
Non-standard Higgs decays



- CP violating MSSM — Carena et al.
- $h \to 2a \to 4\gamma$ at the Tevatron — Dobrescu at al.
- $h \to 4\tau$ in the NMSSM — Gunion and Dermisek
- $h \to 4b$ in the NMSSM — Ellwanger et al.
- $h \to 6j$ in the MSSM with R-parity violation — Carpeneter et al.
- $h \to 2j$ in the MSSM — Berger et al.

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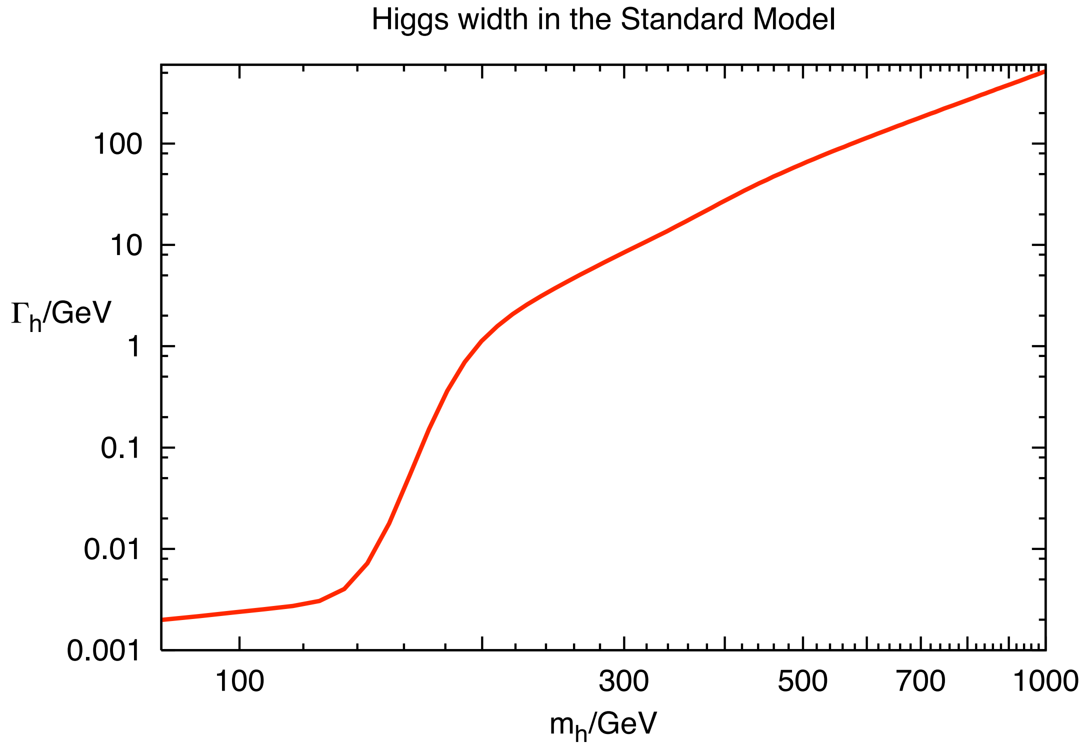
Non-standard Higgs decays

$$\mathcal{L} = \frac{c}{2} a^2 |H|^2$$



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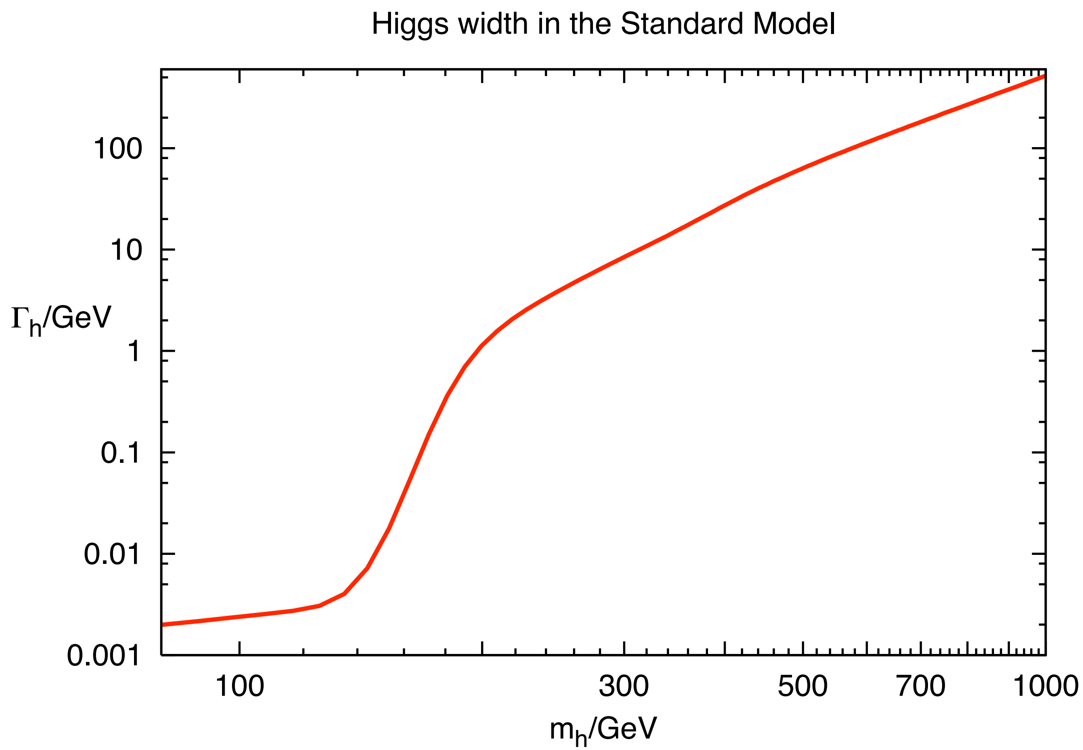
$c > 0.02$



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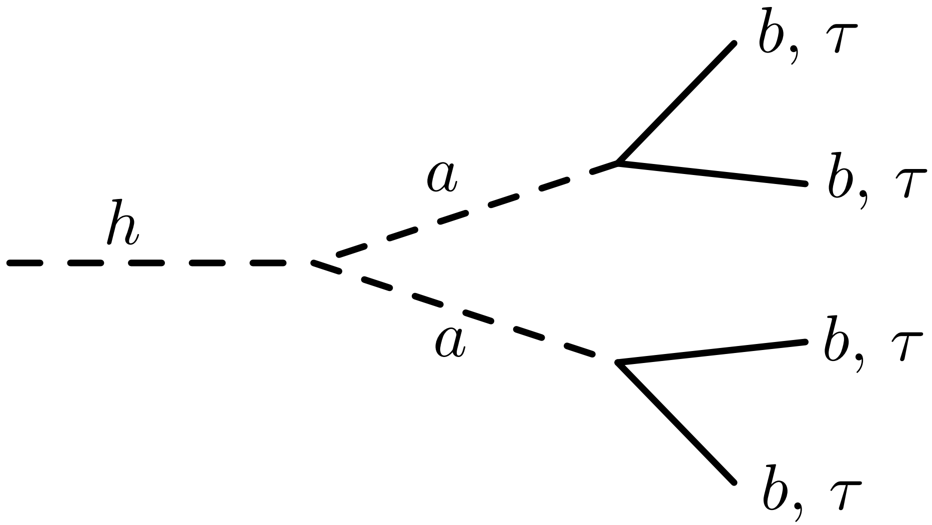
Phenomenology

NMSSM



$$\xi^2_{2b+4b} \equiv \frac{\xi^2_{4b}}{\xi^2_{4b,bd}} + \frac{\xi^2_{2b}}{\xi^2_{2b,bd}} < \sqrt{2}$$

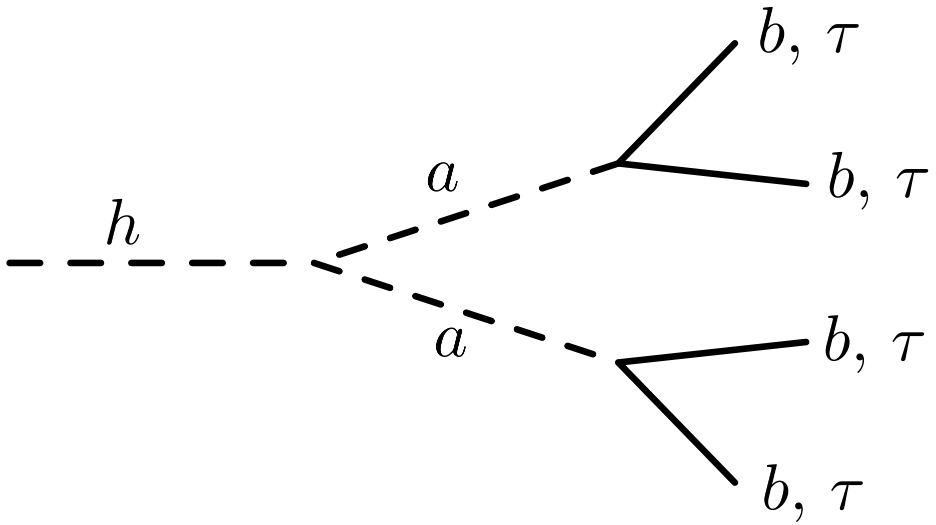
Bounds

$m_H \gtrsim 110\,\mathrm{GeV}$ (b final state)

$m_H \gtrsim 86\,\mathrm{GeV}$ (τ final state)

Phenomenology

NMSSM



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Bounds

$m_H \gtrsim 110\,\mathrm{GeV}$ (b final state)

$m_H \gtrsim 86\,\mathrm{GeV}$ (τ final state) ← Requires $m_a \lesssim 12\,\mathrm{GeV}$

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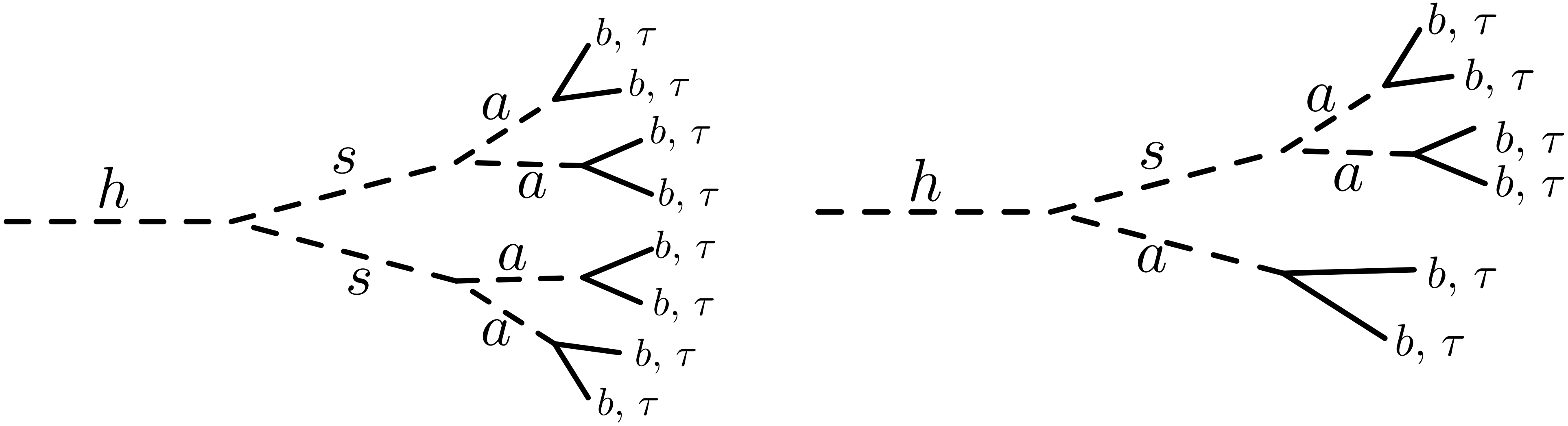
Phenomenology

MSSM + S + new operators



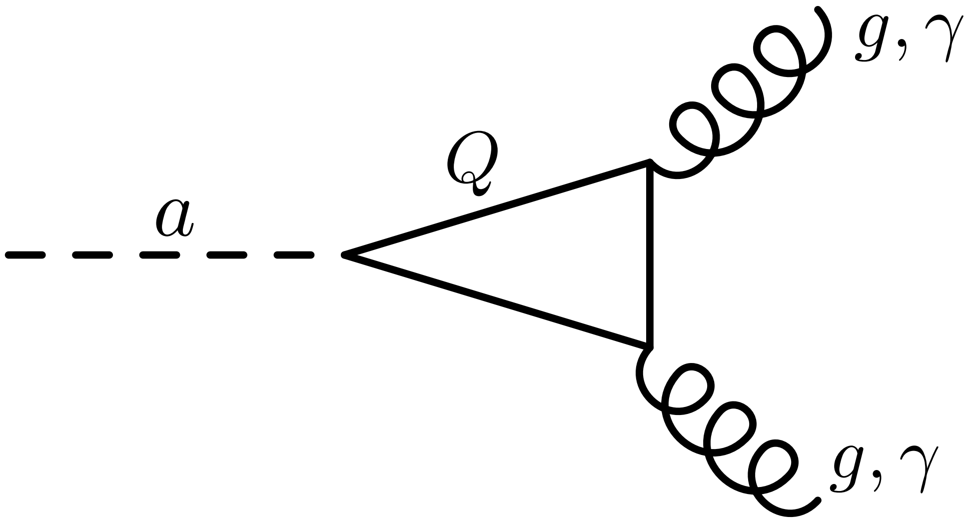
Bounds

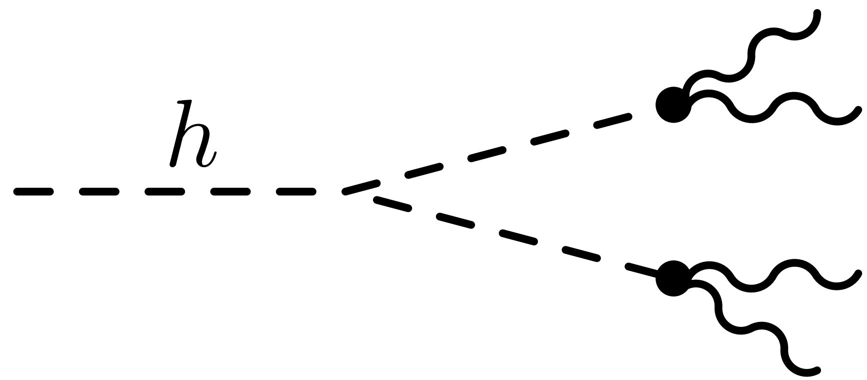
Only model independent bound applies

- Very hard to see at hadronic machines
- Similar to hidden valley models
- Displaced vertices?

Phenomenology

MSSM + S + new operators





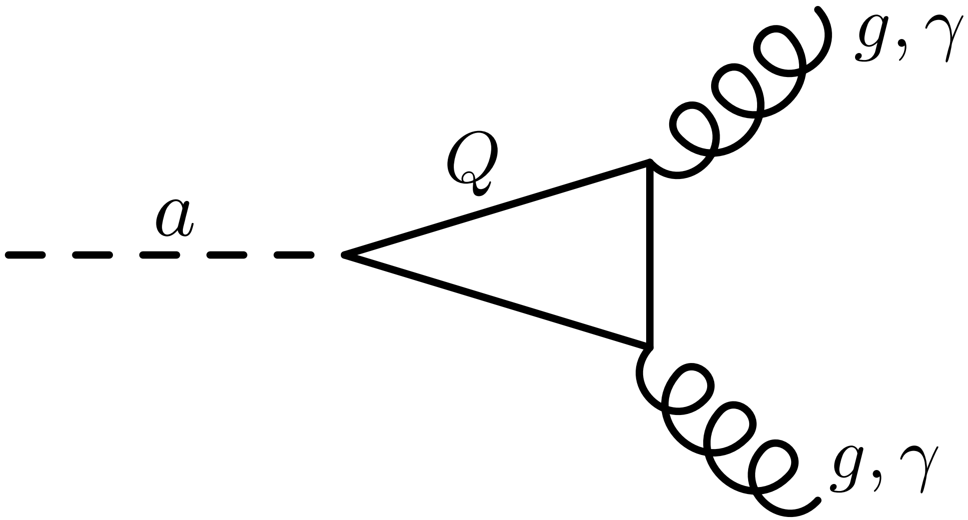
Bounds

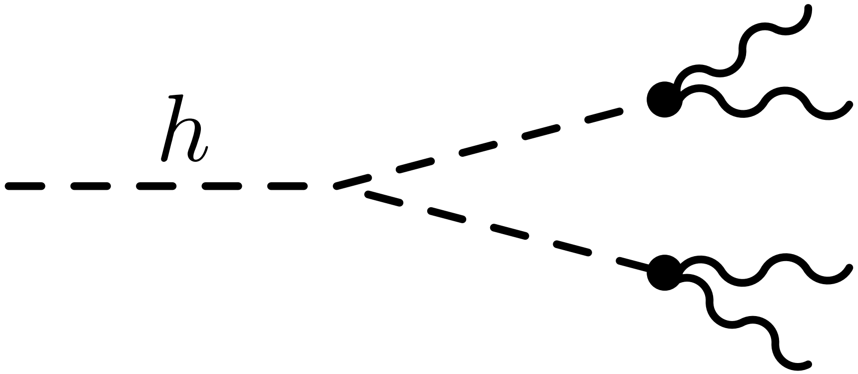
Only model independent LEP bound applies: $m_h > 82\ \mathrm{GeV}$

- Very hard to see at hadronic machines
- Hope for 4 photon channel?

Phenomenology

MSSM + S + new operators





Bounds

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- Very hard to see at hadronic machines
- Hope for 4 photon channel?

$$\frac{\Gamma_{a\to 2\gamma}}{\Gamma_{a\to 2g}} \sim \frac{\alpha^2}{\alpha_s^2} \sim 10^{-3} - 10^{-5}$$

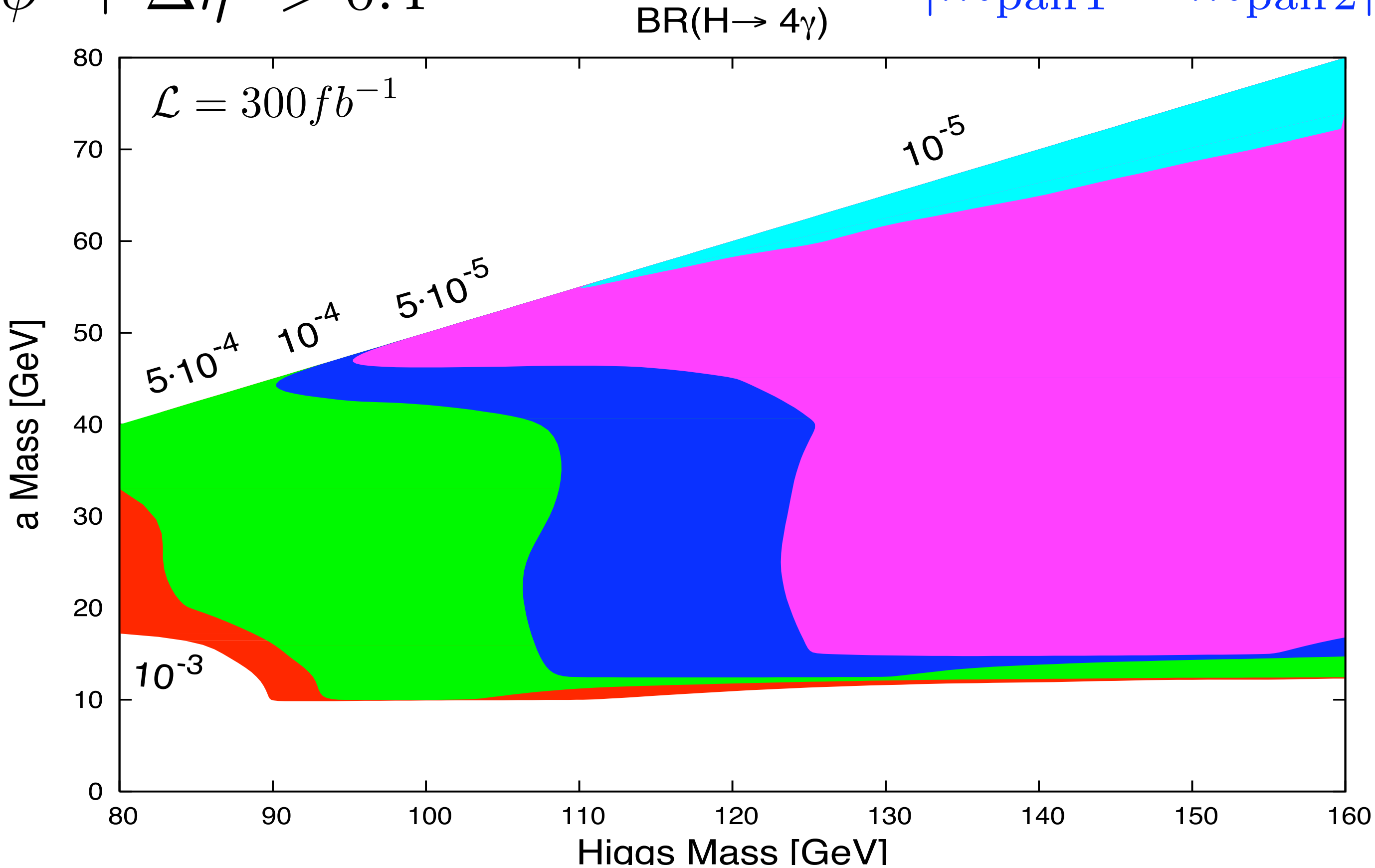
$h \to 4\gamma$ at the LHC

Chang, PF, Weiner

- Potentially allows discovery of h and a
- "Theorists" simulation: minimal detector effects

$p_T^\gamma > 20\,\mathrm{GeV}$ $|\eta| < 2.5$

$\Delta R = \sqrt{\Delta\phi^2 + \Delta\eta^2} > 0.4$ $|m_{\mathrm{pair1}} - m_{\mathrm{pair2}}| < 5\,\mathrm{GeV}$



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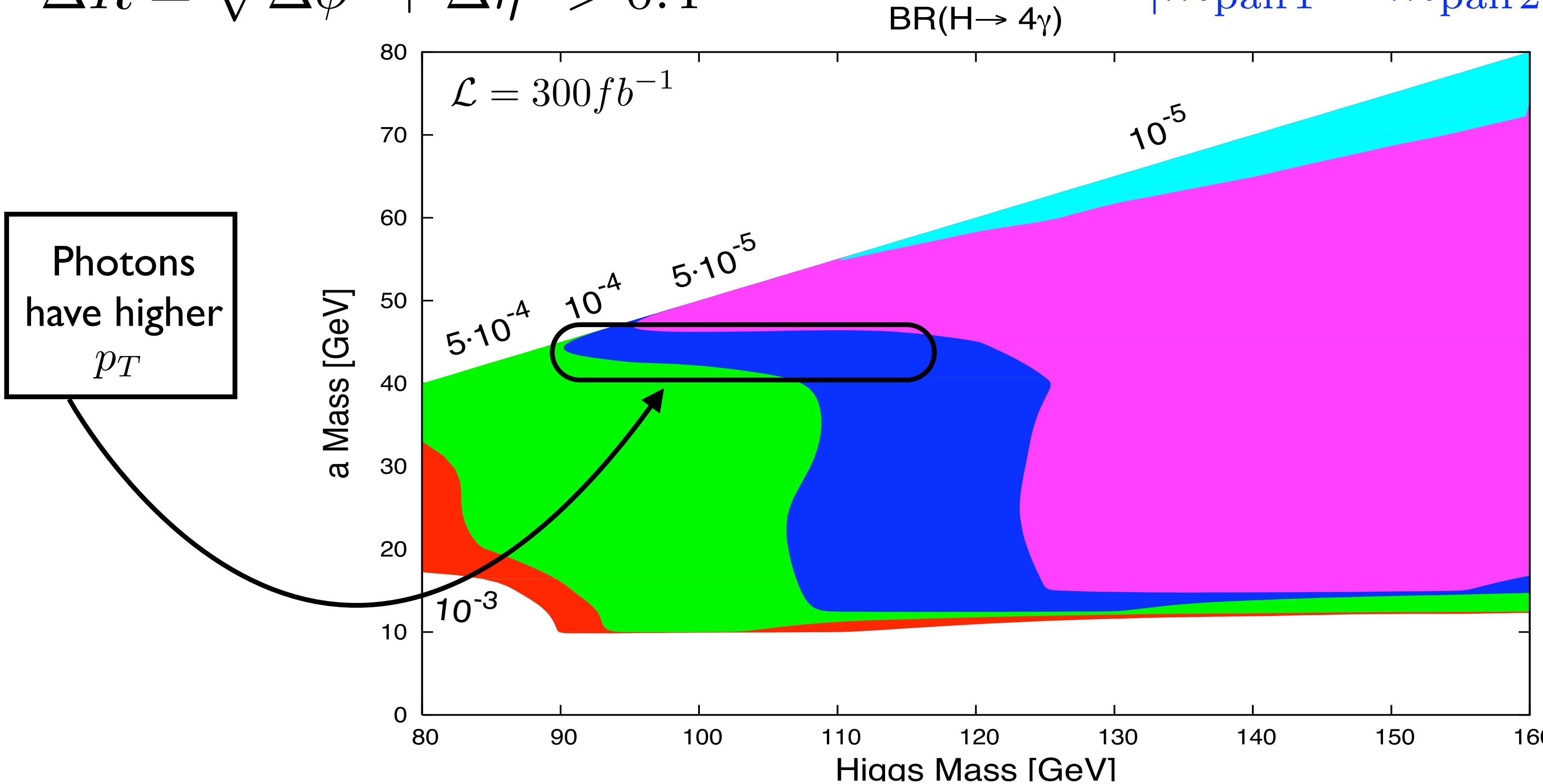

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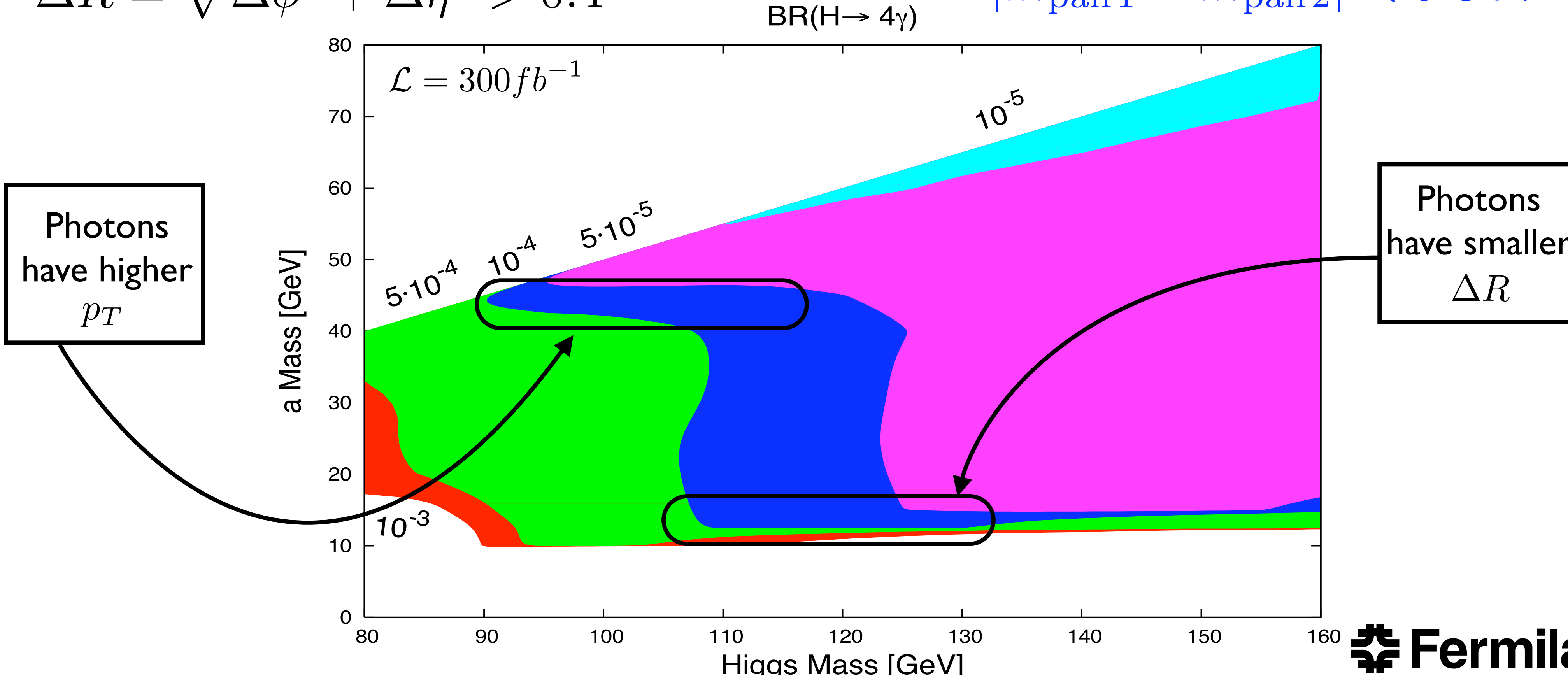


$h \rightarrow 2j\ 2\gamma$ at the LHC

A Martin

Too much background in $gg \rightarrow h$ channel, for typical BR

Can use associated production.
W helps lower background.

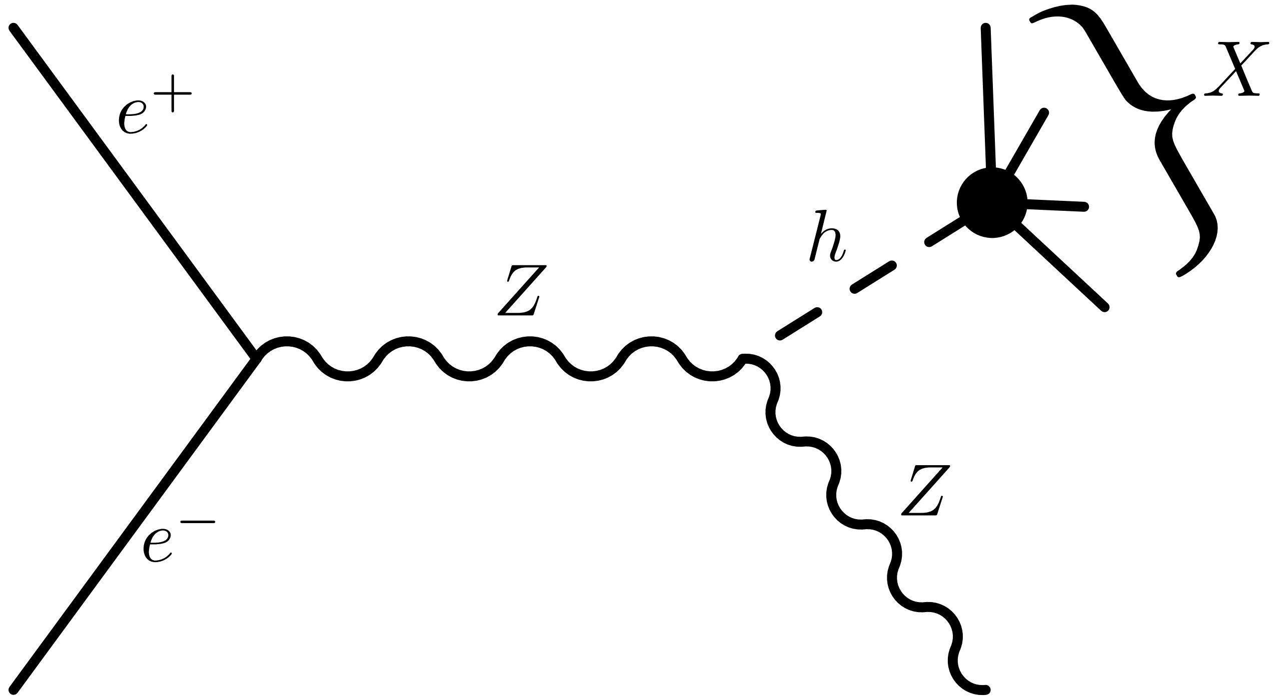
Needs $Br > 0.04$ for discovery at LHC

$h \to 2j \; 2\gamma$ at the Tevatron

Dobrescu et al.

- The integrated luminosity is $\mathcal{O}(8fb^{-1})$ and the Higgs production is smaller by an order of magnitude
- Backgrounds are better understood, and cuts can be weaker
- $\gamma\gamma + X$ searches exist, may be extended
- Possible to use $h \to 2g2\gamma$ channel with $M_{jj} \approx M_{\gamma\gamma}$ requirement?
- If $m_a < 5$ GeV jets look like photons
- For $m_a > 5$ GeV doesn't look good

Higgs searches



$$\xi^2 = \frac{\sigma(e^+e^-\to hZ)}{\sigma_{SM}(e^+e^-\to hZ)} \times BR(h \to X)$$

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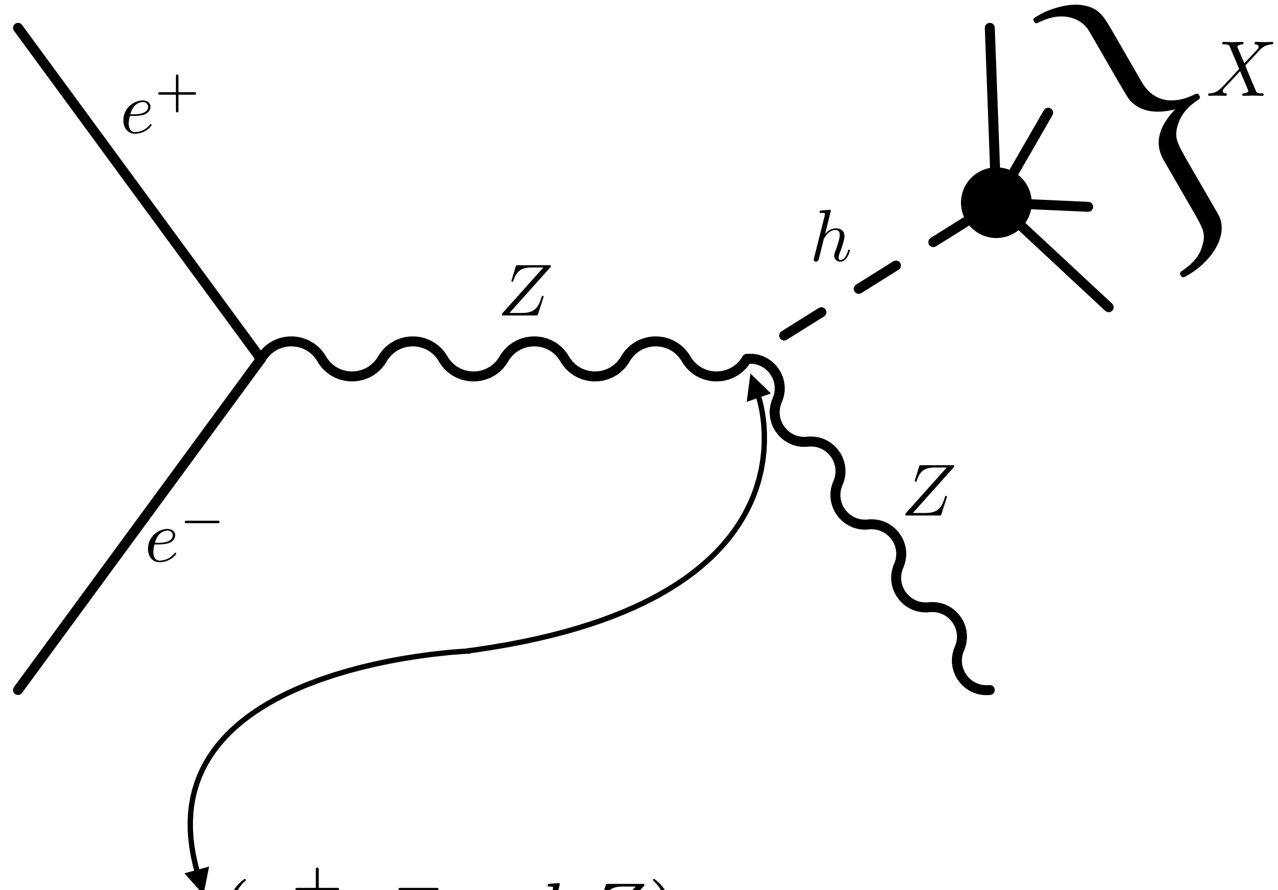
Higgs searches



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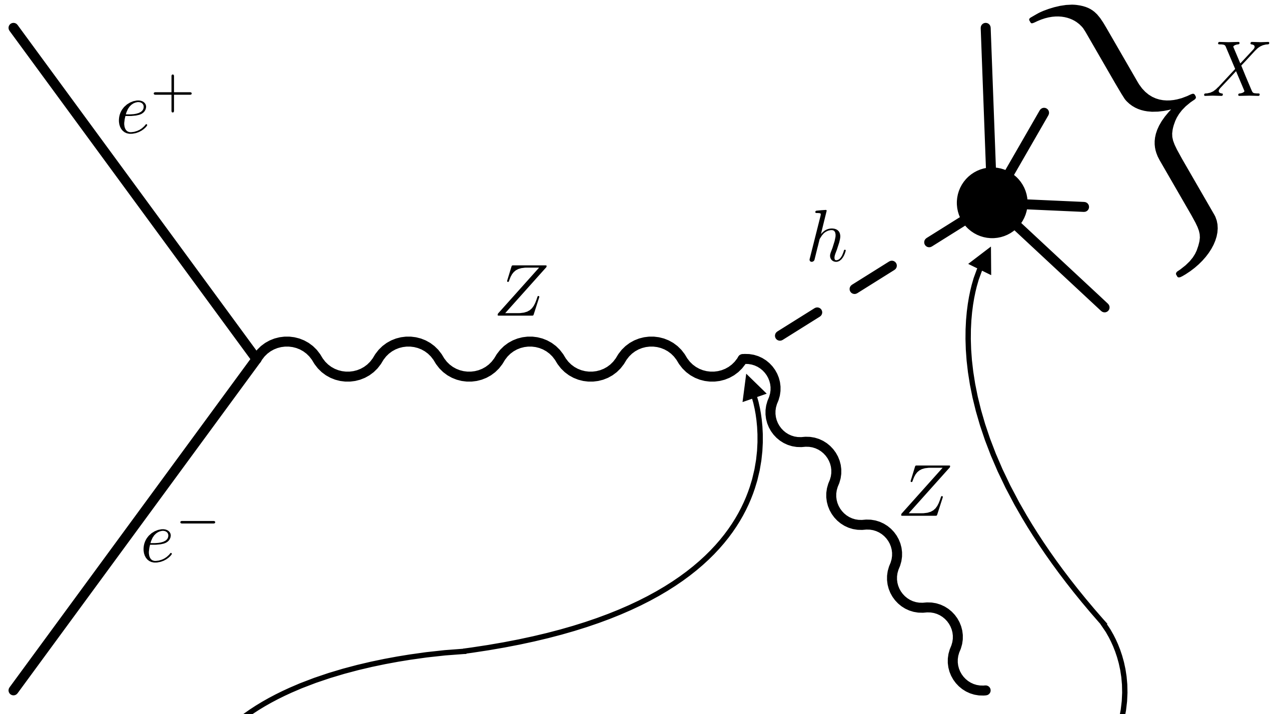

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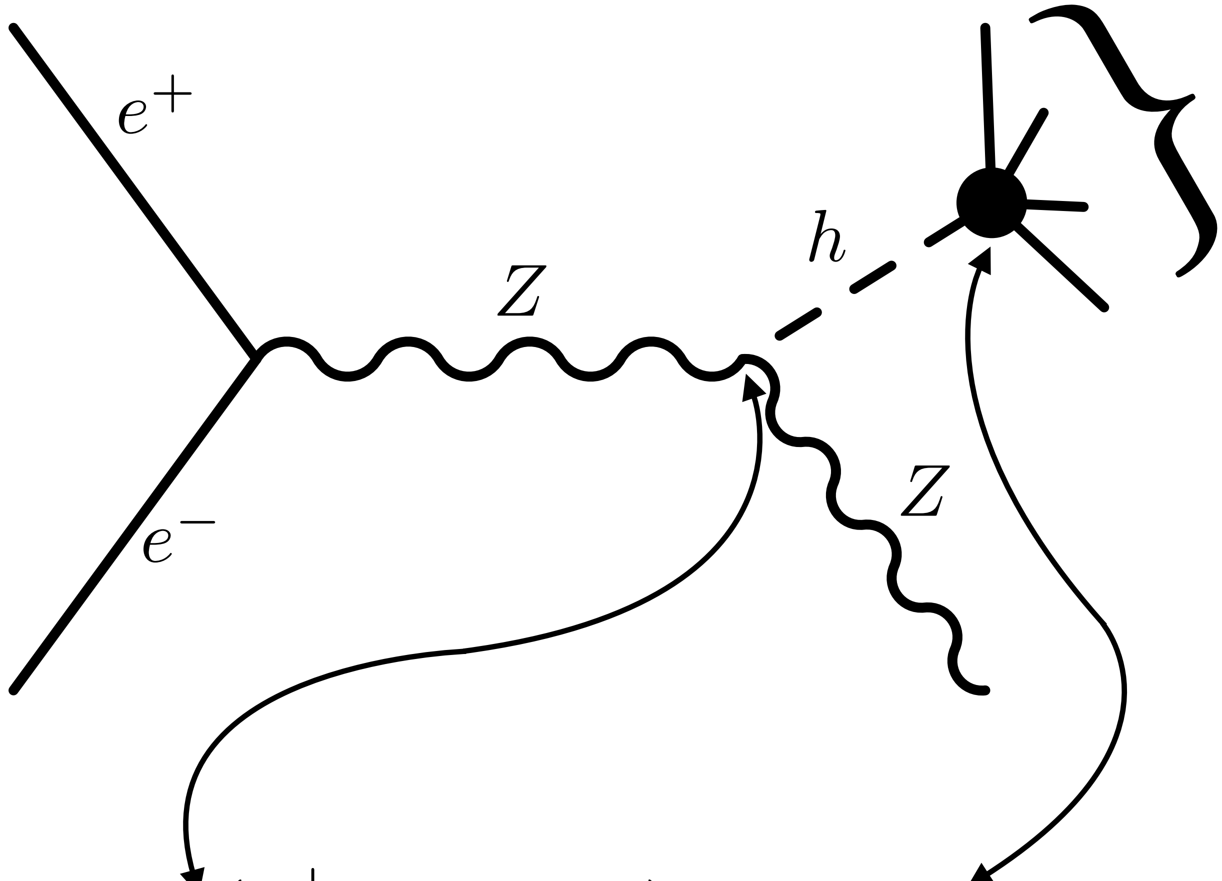

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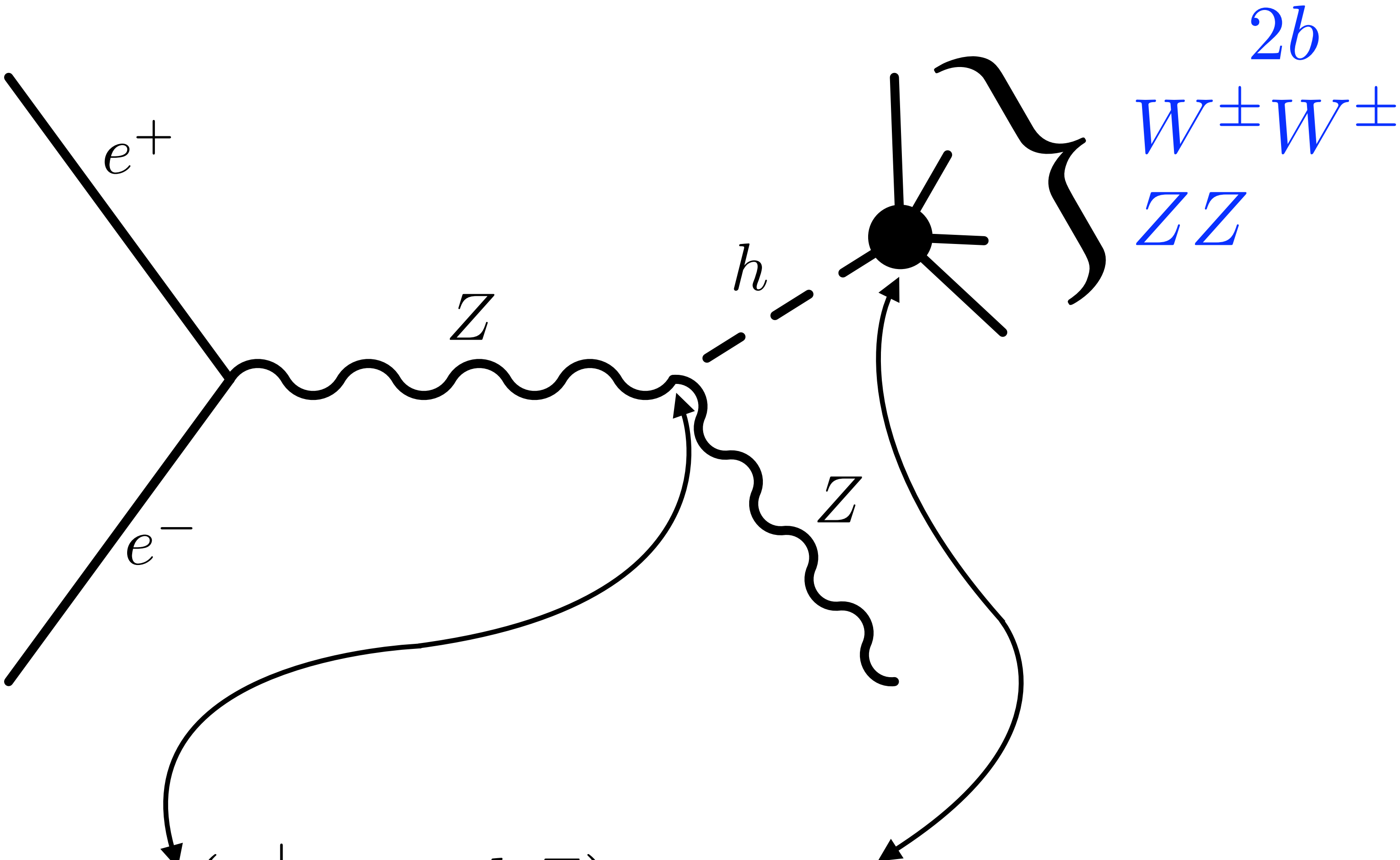

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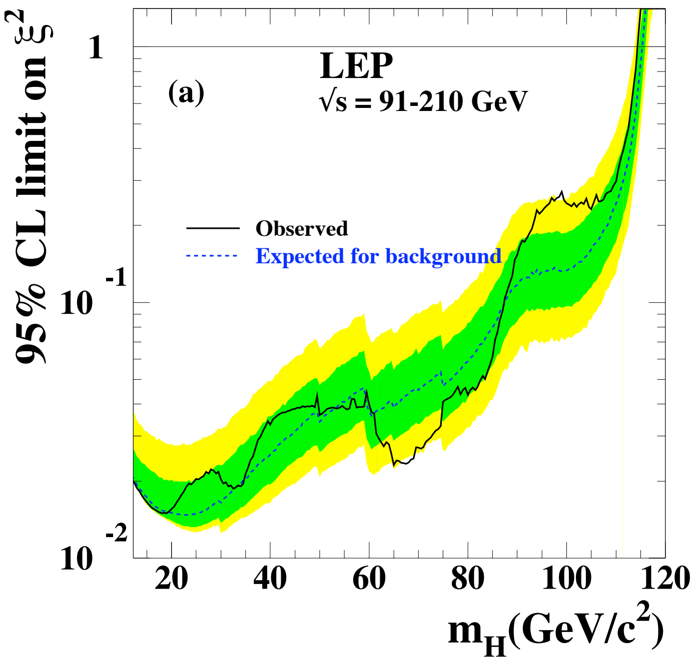
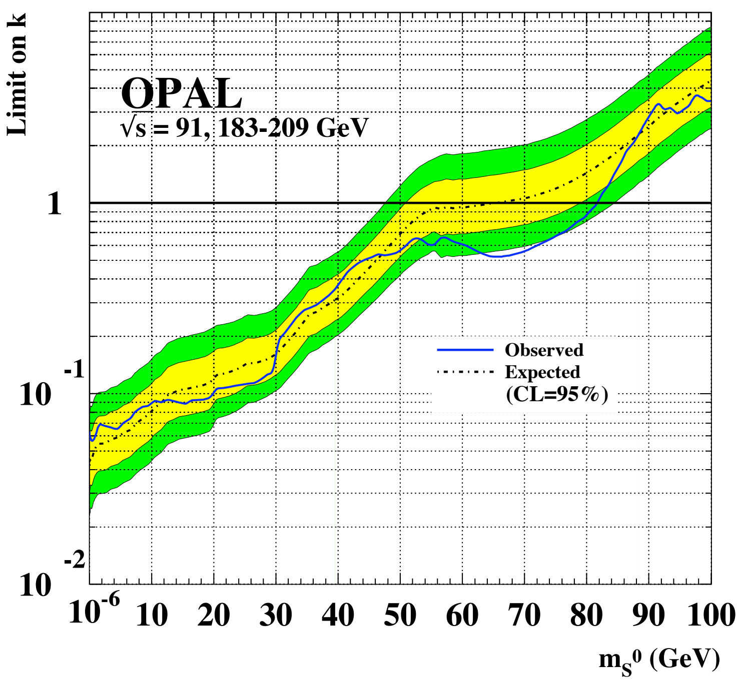
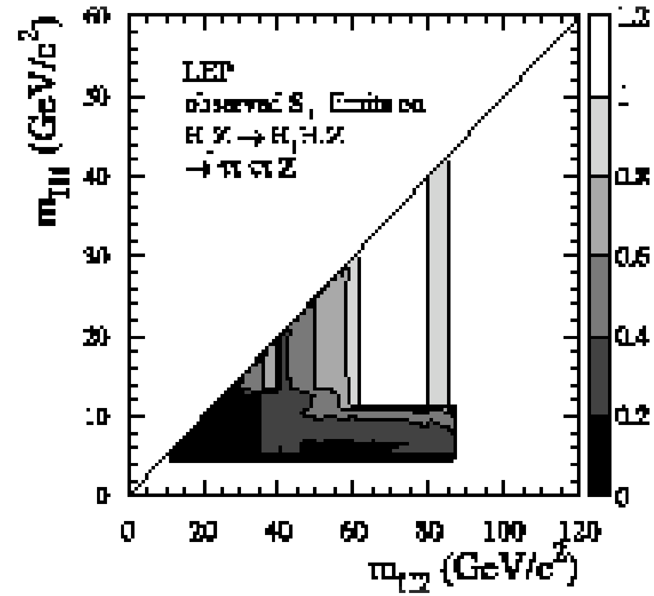
LEP Higgs searches

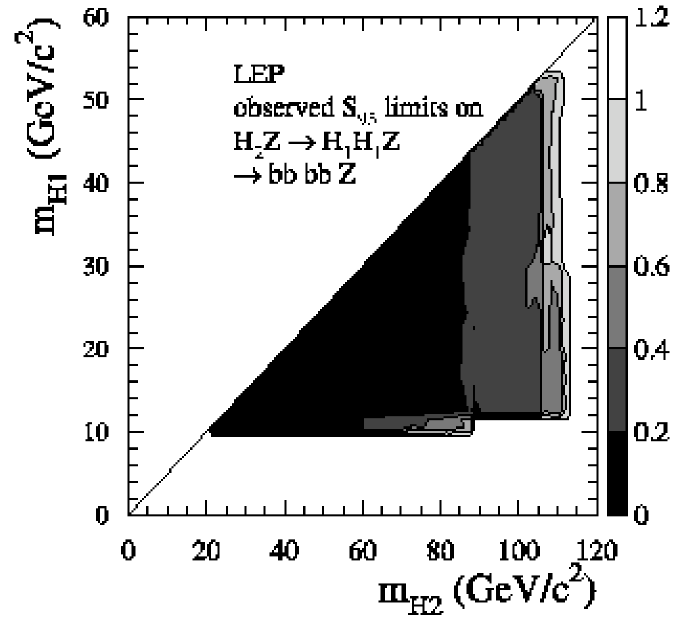




X	Bound (GeV)
SM	114.4
?	82
Invis.	114
$\not{\psi}$	109.7
2γ	117
$2j$	113
$4b$	110
4τ	86



Cascade decays



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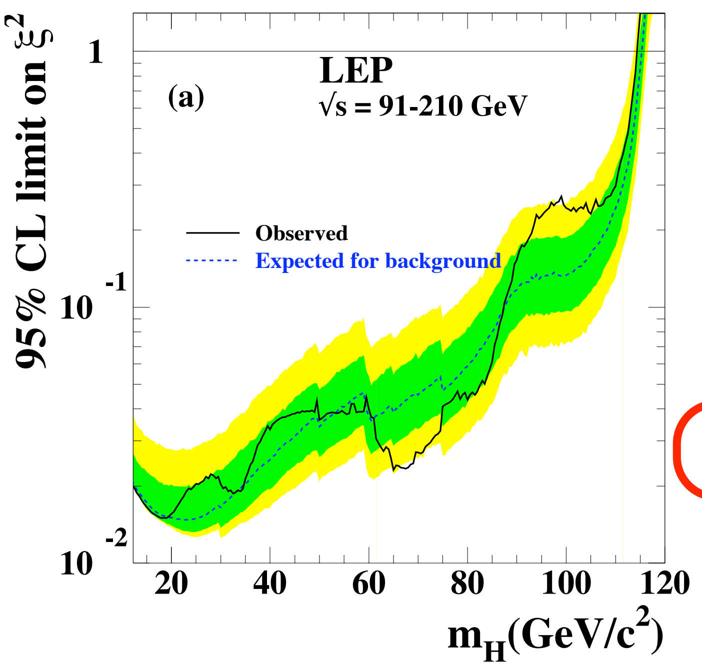
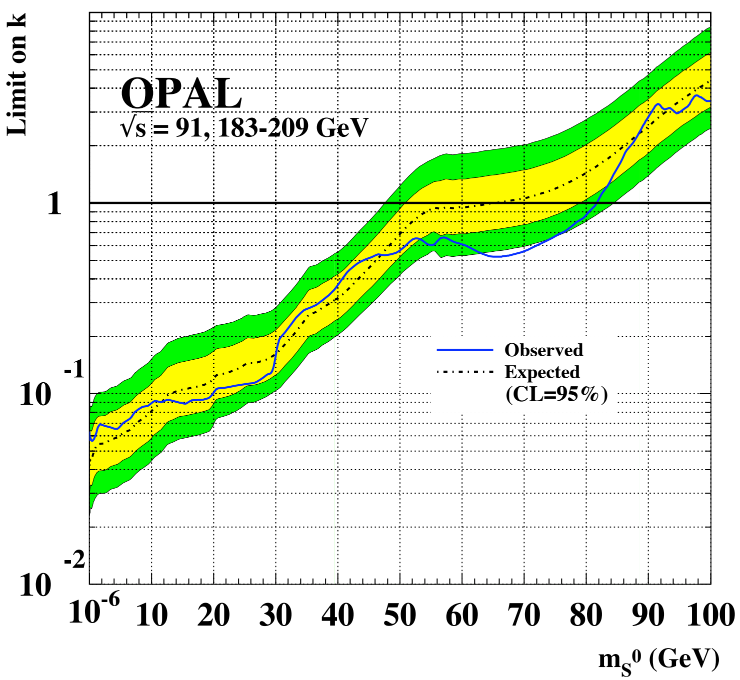
LEP Higgs searches





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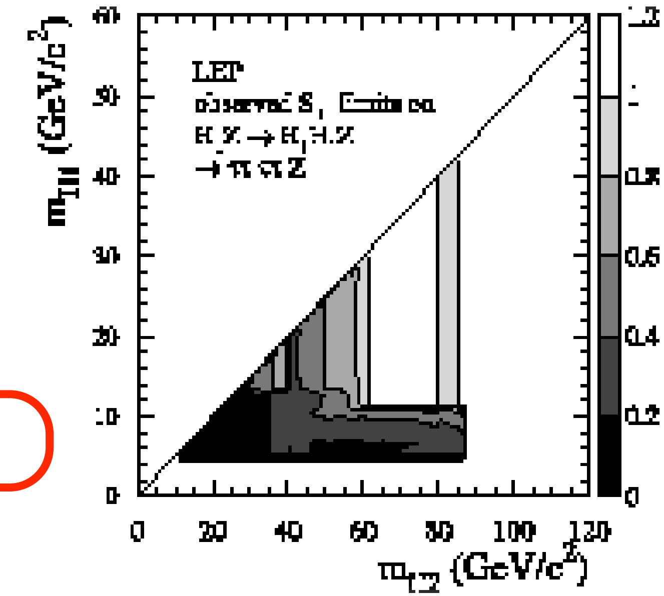

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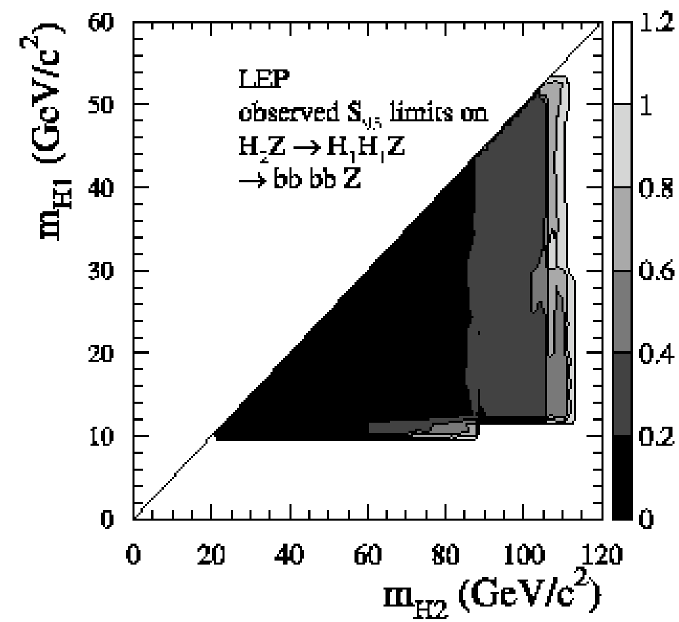

Conclusions

- Many BSM models (NMSSM, MSSM + singlet, ...) contain non-standard Higgs decays
- $h \to 2a \to 4j,\ 2j\ 2\gamma,\ 4\gamma$ all possible
- Allow for a Higgs well below SM LEP bound
- Small branching ratio or large backgrounds make these hard at hadronic machines
- Leptonic machines complimentary, allow measurement in all 3 channels