Some Thoughts About Measuring

$\Gamma_{H\to\gamma\gamma}$

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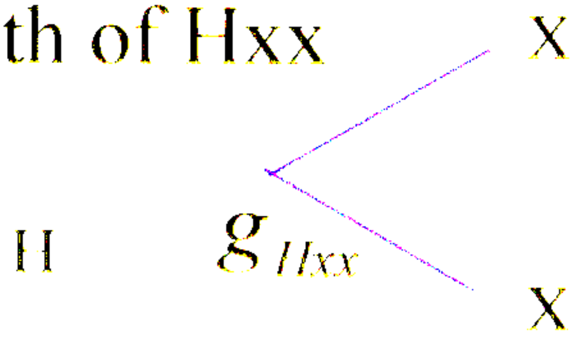
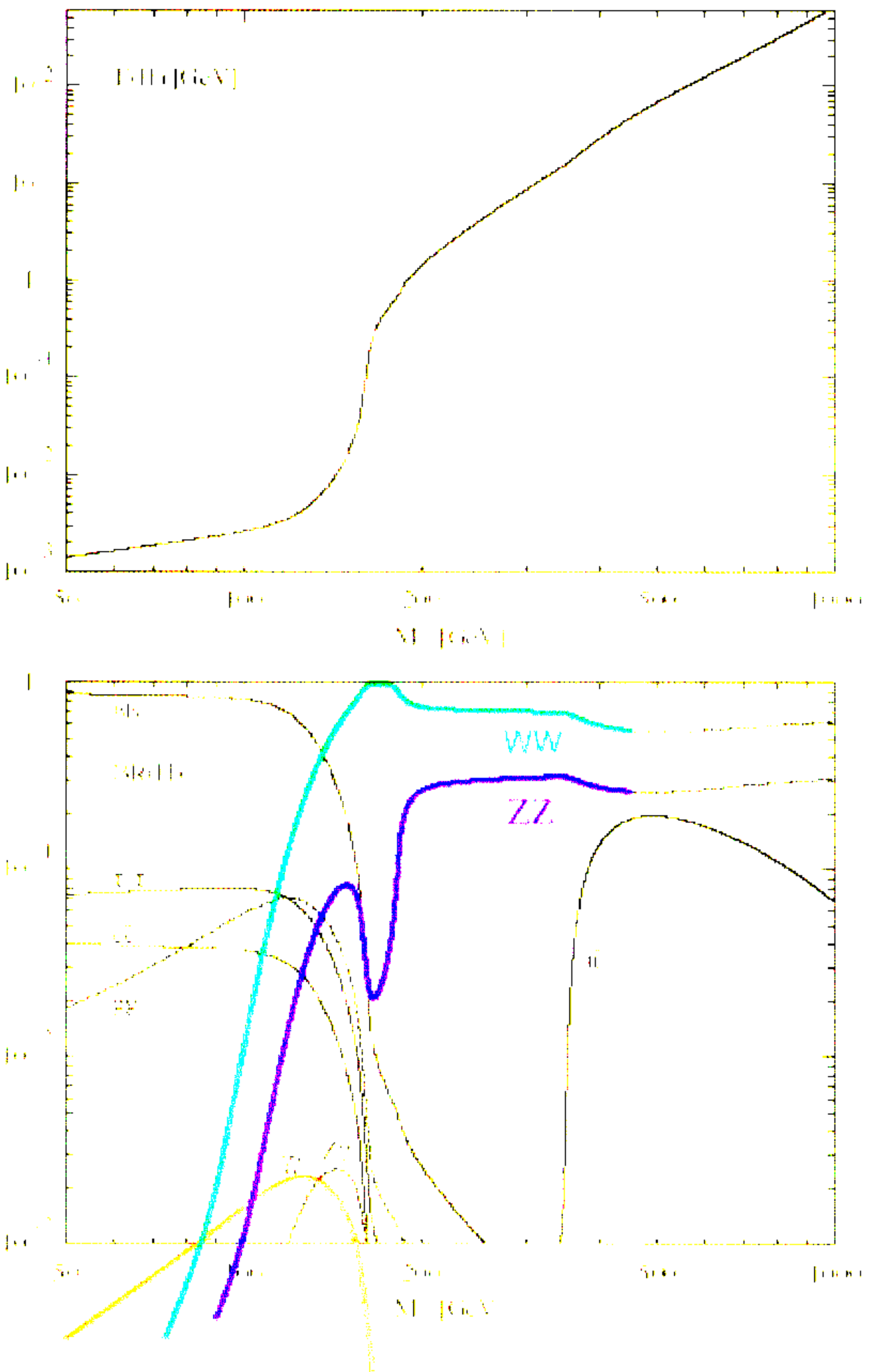
- Is $\gamma\gamma \to H$ the only way?
- Alternatives: HWW,HZZ

- Measuring the total Higgs Width requires a precise independent measurements of the Branching Ratio and partial width of Hxx

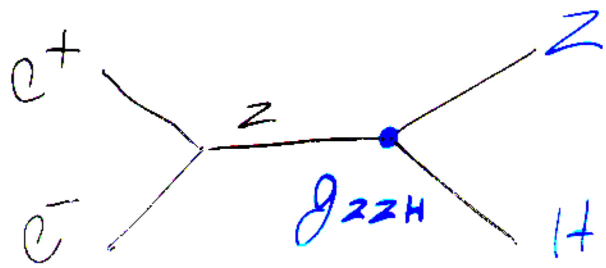


$$\Gamma_H = \frac{\Gamma_{Hxx}}{BR(H \rightarrow xx)} \propto \frac{g^2_{Hxx}}{BR(H \rightarrow xx)}$$

Higgs Width and Branching Ratios

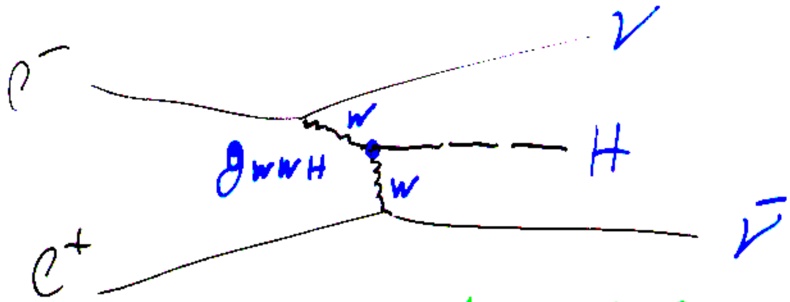


For $m_H > 140$ GeV the WW and ZZ decay modes are the most relevant ones



$$\sigma(e^+e^- \to ZH) = \frac{G_F^2 M_Z^4}{96\pi s}\left[v_e^2 + a_e^2\right]\lambda^{1/2}\frac{\lambda + 12M_Z^2/s}{\left[1 - M_Z^2/s\right]^2}\ .$$

where $v_e = -1 + 4\sin^2\theta_W$ and $a_e = -1$ are the vector and axial-vector Z charges of the electron and $\lambda = [1 - (M_H + M_Z)^2/s][1 - (M_H - M_Z)^2/s]$ is the usual two-particle phase-space function. The cross section is of the size $\sigma \sim \alpha_W^2/s$, i.e. of second order in the weak coupling, and it scales in the squared energy.



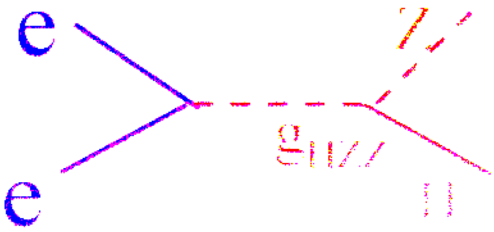
Kilian, Kramer, Zerwas hep-ph 9512355 (program by K. Desch)
Spira, Zerwas hep-ph 9803257

$$\sigma(e^+e^- \to \bar\nu_e\nu_e H) = \frac{G_F^3 M_W^4}{4\sqrt{2}\pi^3}\int_{\kappa_H}^1\int_x^1 \frac{dx\,dy}{[1+(y-x)/\kappa_W]^2} f(x,y)$$

$$f(x,y) = \left(\frac{2x}{y^3} - \frac{1+3x}{y^2} + \frac{2+x}{y} - 1\right)\left[\frac{z}{1+z} - \log(1+z)\right] + \frac{x}{y^3}\frac{z^2(1-y)}{1+z}\ .$$

with $\kappa_H = M_H^2/s$, $\kappa_W = M_W^2/s$ and $z = y(x - \kappa_H)/(\kappa_W x)$.

The HZ Option



$$\sigma(ee \to HZ) \approx \frac{G_F^2 m_Z^4}{96\pi s} f(m_H, m_Z, s)$$

$$g_{HZZ} = 2\left[\sqrt{2}G_F\right]^{\frac{1}{2}} m_Z^2$$

$$\sigma(ee \to HZ) \prec g_{HZZ}^2$$

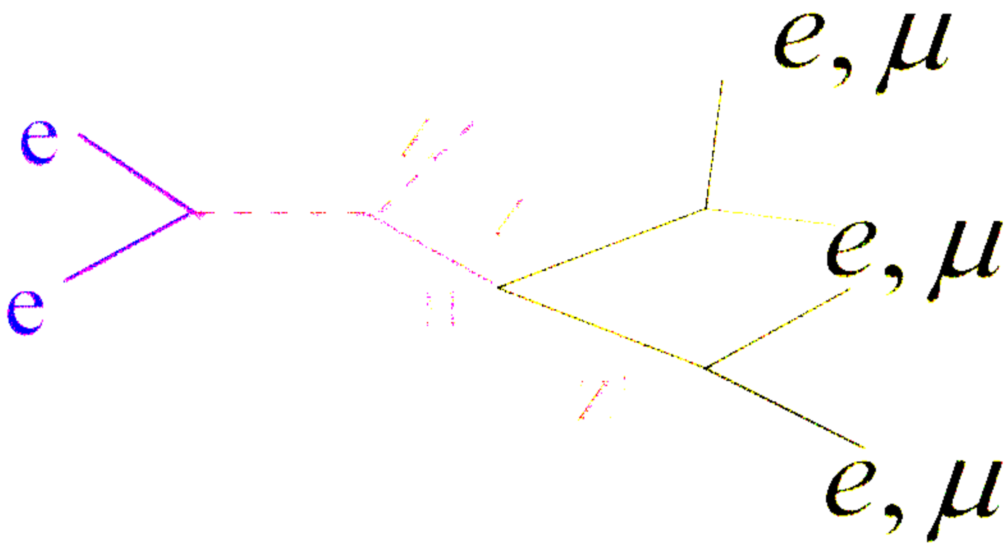
:For 500/fb one expects

$$\frac{\Delta\sigma_{HZ}}{\sigma_{HZ}} \quad \frac{\Delta g_{HZZ}^2}{g_{HZZ}^2} \quad \frac{\Delta\Gamma_{HZZ}}{\Gamma_{HZZ}} \approx 3\%$$

The sensitivity will be dominated by the resolution $BR(H \to ZZ)$

The HZ Option

Measuring the HZZ BR

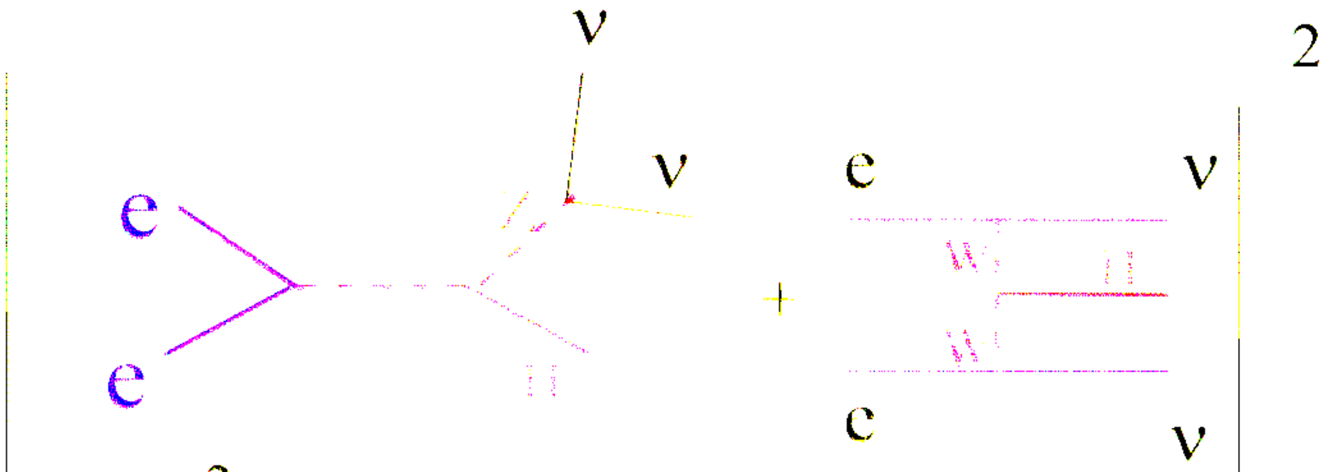


- A clean signature costs a drop of $(0.06)^2 \sim 3.6 \cdot 10^{-3}$ in the observed cross section!
- However for m_H>140 GeV the $\gamma\gamma$ Branching Ratio is too small!
- But numbers are SMALL!

$$\int L \cdot \sigma \cdot BR(H \to ZZ^* \to 4l) \approx 500\, fb^{-1} \cdot 100\, fb \cdot 0.1 \cdot 3.6 \cdot 10^{-4} = 1.8$$

- Need to use other Z decay channels! (Why Not? Remember LEP)

The WW Alternative



$$g_{HZZ}^{2} \qquad g_{HWW}\, g_{HZZ} \qquad g_{HWW}^{2}$$

- Assuming HVV universality

$$g_{HZZ} = g_{HWW}$$

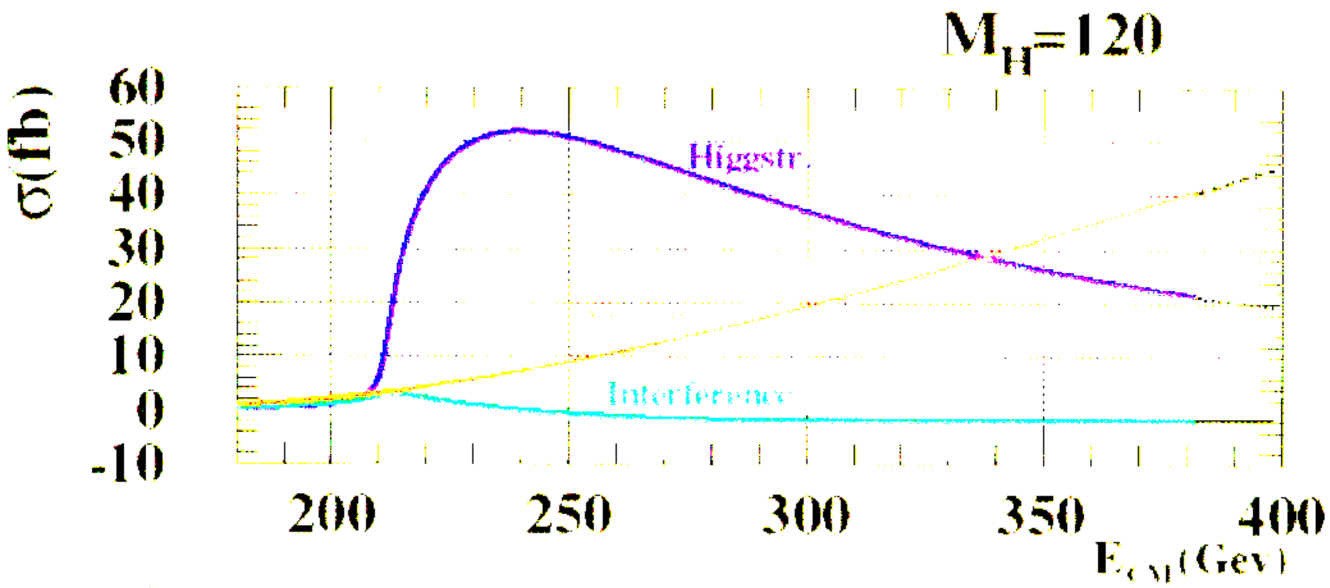
$$\frac{\Delta\sigma_{tot}}{\sigma_{tot}} = \frac{\Delta g_{HWW}^{2}}{g_{HWW}^{2}} = \frac{\Delta\Gamma_{HWW}}{\Gamma_{HWW}}$$

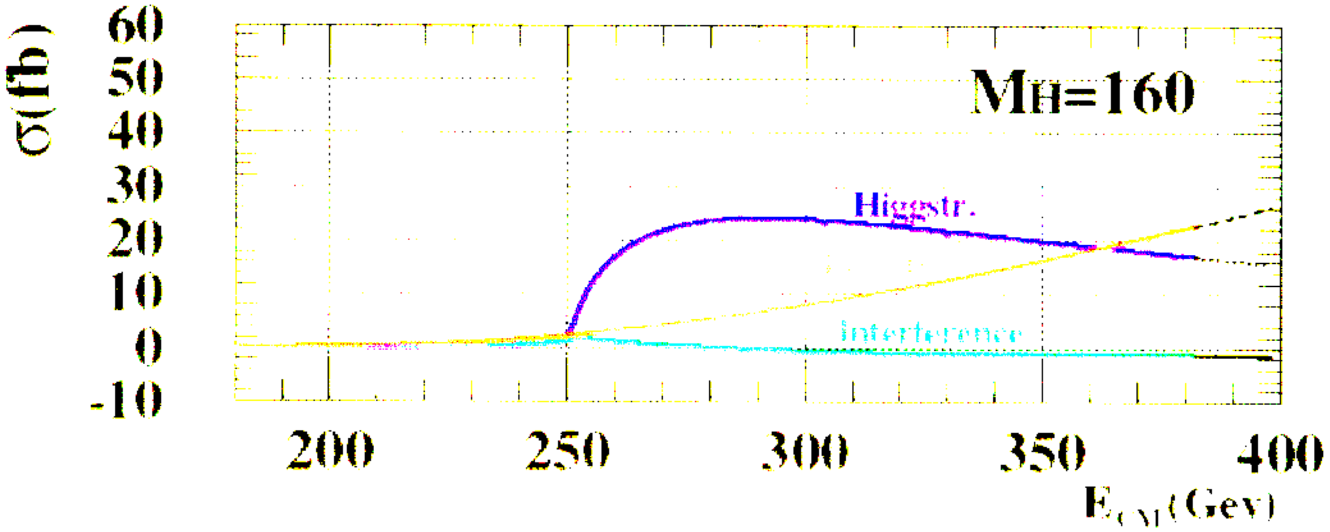
- Alternatively one can subtract the HZ contribution however, interference is too big

Fusion dominates only for very high $\sqrt{s}$
For $\sqrt{s} \sim 350$ Fusion $\sim$ Higgstr

Combining Fusion & Higgstr

The WW Option

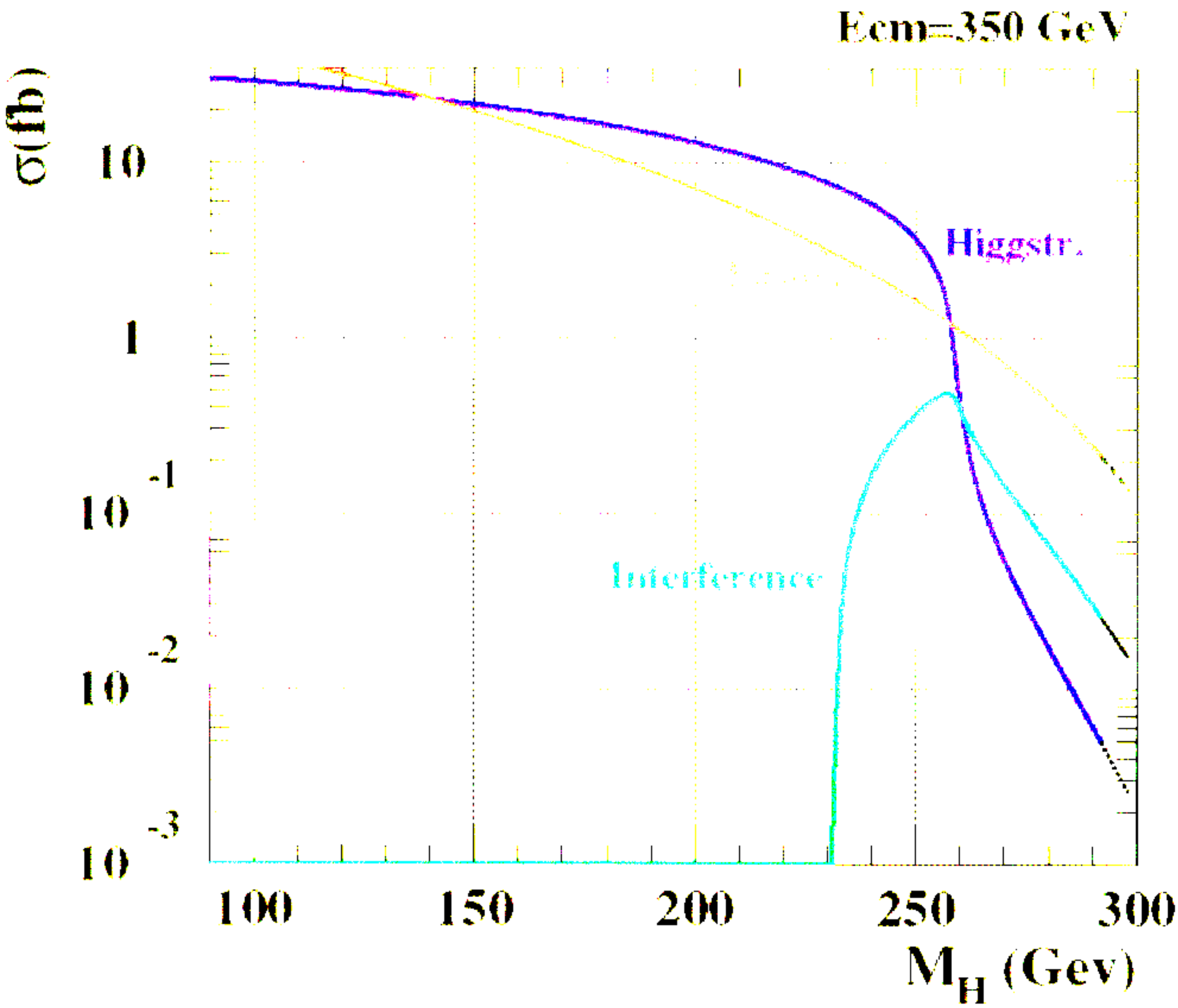




$$\int L \cdot \sigma_{H\nu\nu} \approx 500\, fb^{-1} \cdot 50\, fb = 25000$$

Huge!!!

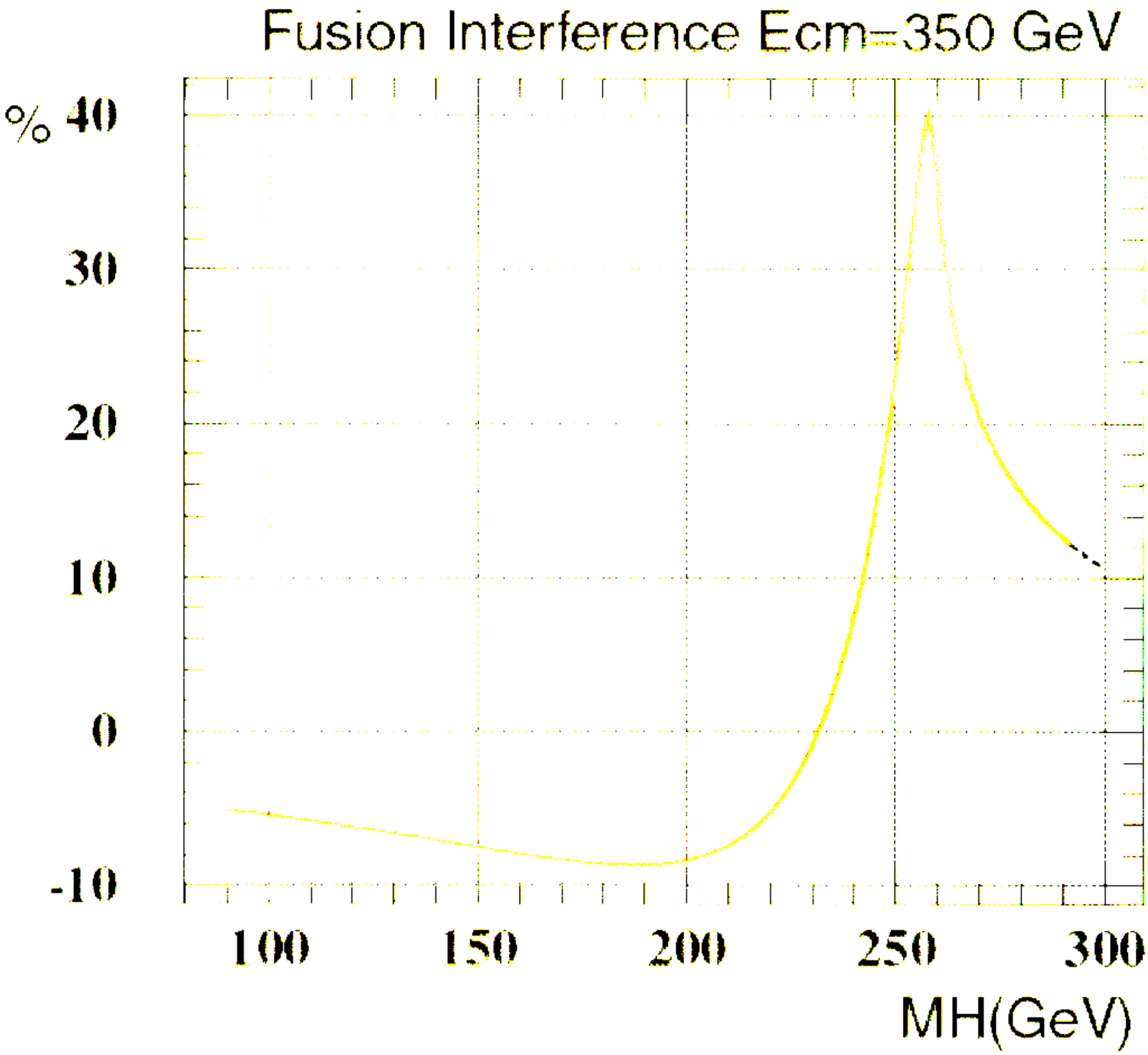
For heavy Higgs masses production cross section decreases but still total σ of the $O(20\ fb)$



Even a 200 GeV Higgs have a relatively high Cross Section!!!

Interference is too big to be neglected

$$\% \equiv \frac{\sigma_{interference}}{\sigma_{fusion}}$$



Conclusions

- It is not clear that the only way to measure the total Higgs width is via the $H\gamma\gamma$ coupling.
- The HZ and fusion processes can be used to measure the HZZ and HWW coupling.
- The total width can be deduced by measuring the Higgs decay branching ratio to ZZ and WW.
- Assuming that the HZZ and HWW couplings are identical one can measure them via the $H\nu\nu$ production process.
- For m_H<140 GeV there is no other way.