Higgs Mass Scan at a $\gamma\gamma$-Collider

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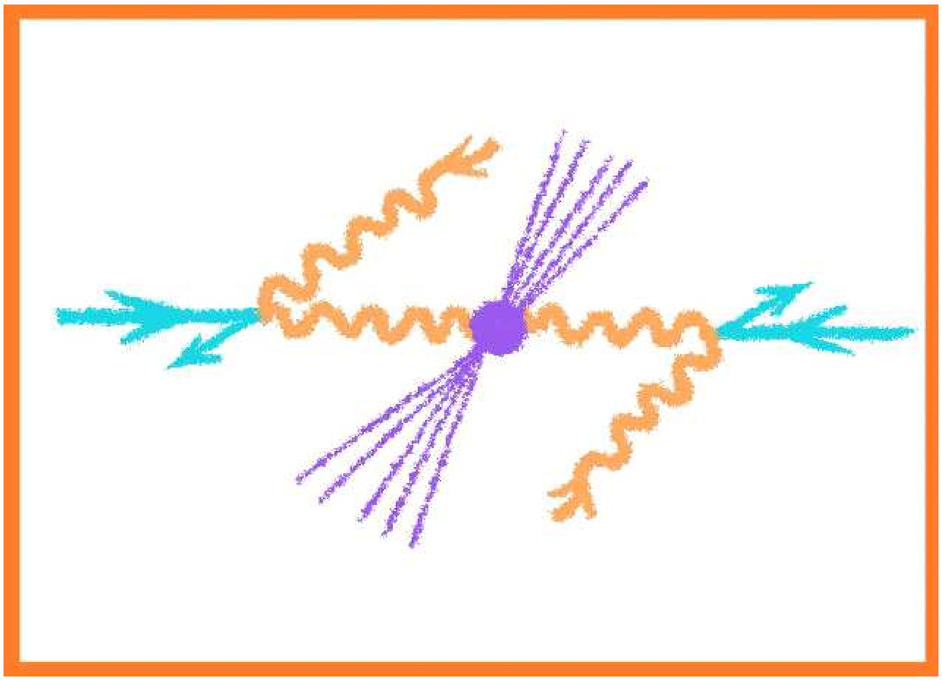
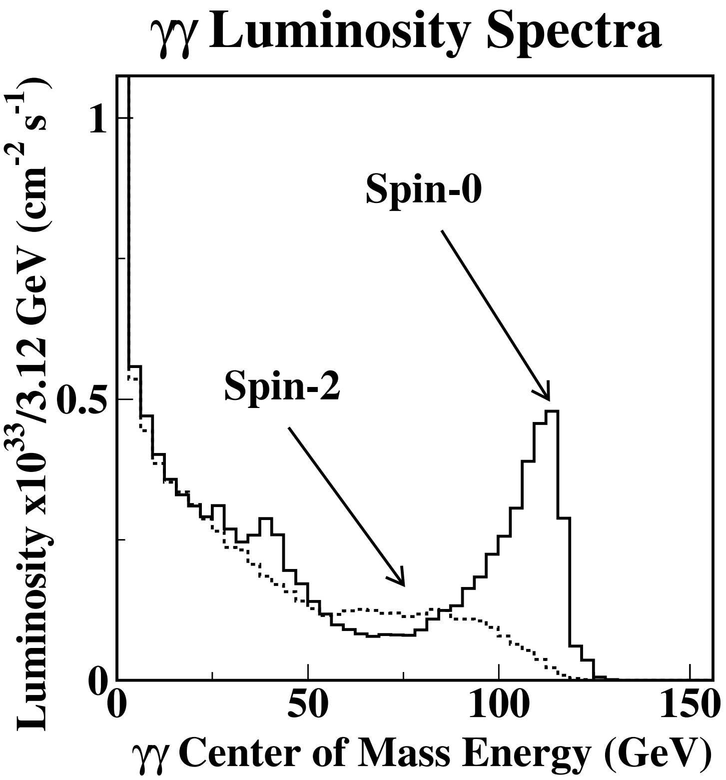


- Background & Basis
- Method & Results

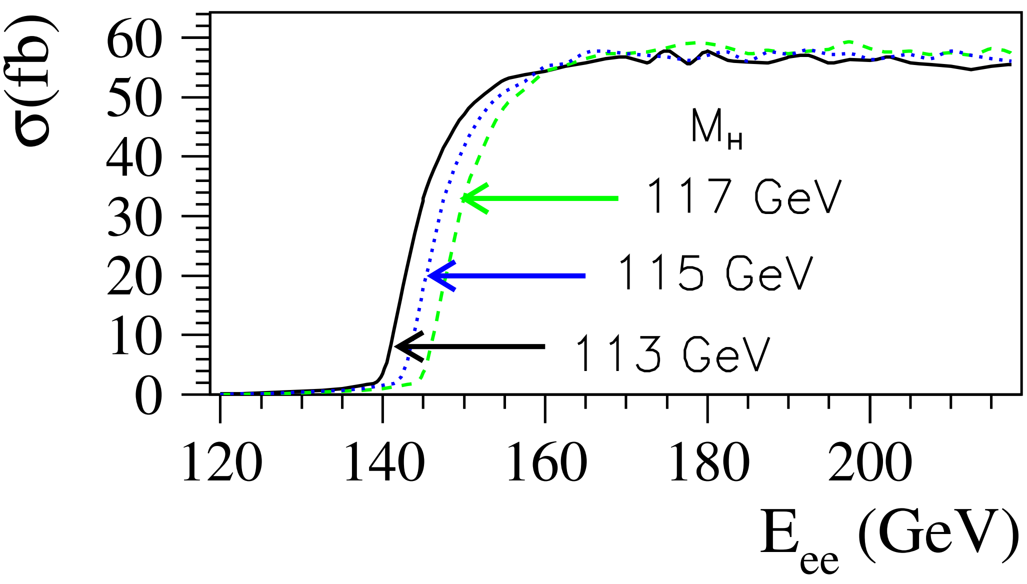
ref: `hep-ex/0111056`

Concept

The upper edge of the photon energy spectrum is sharp:

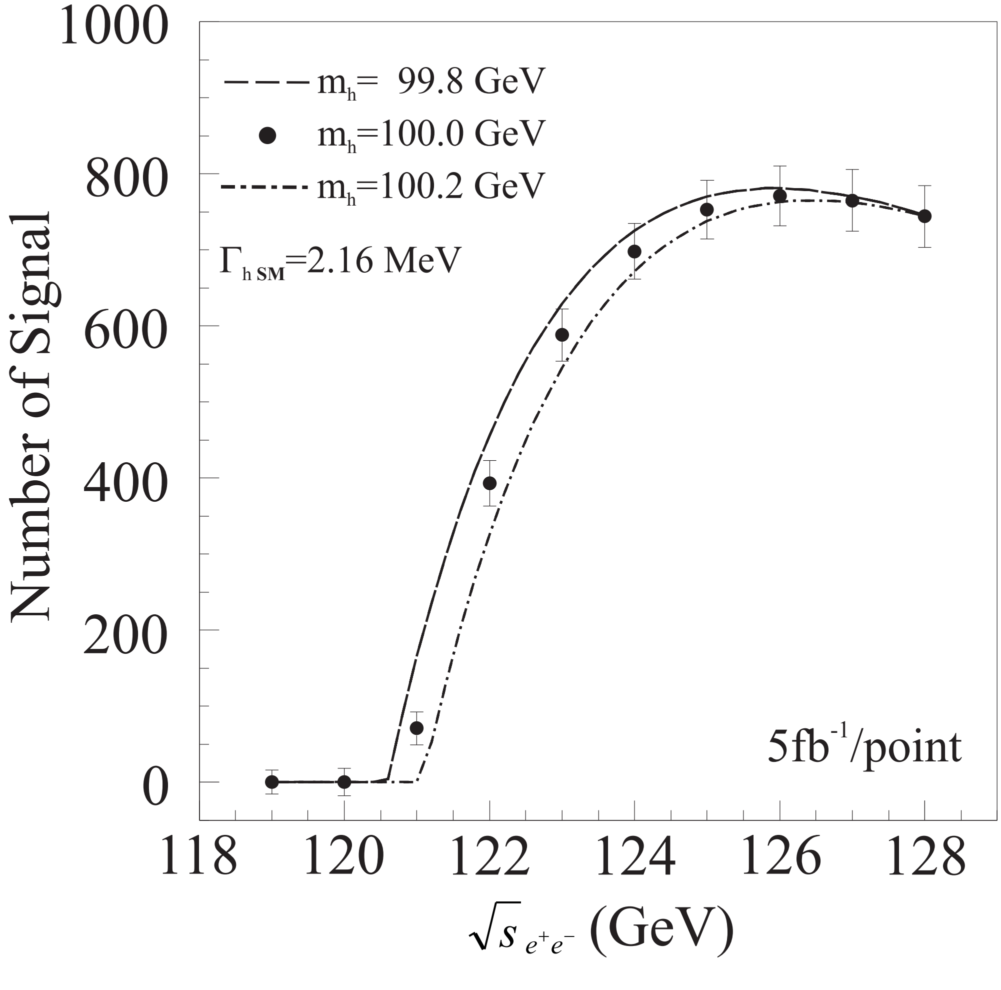


$\Rightarrow$ excitation curve is sensitive to the Higgs mass:



Threshold Scan

Tomomi Ohgaki proposed measuring the cross section at a series of energy points $\sqrt{s_{ee}}$.



(`hep-ph/0002083`)

We have looked into optimizing the selection of energy points.

Concept

Choose a particular $\sqrt{s_{ee}}$.

Does the cross section depend a lot or a little on m_h?

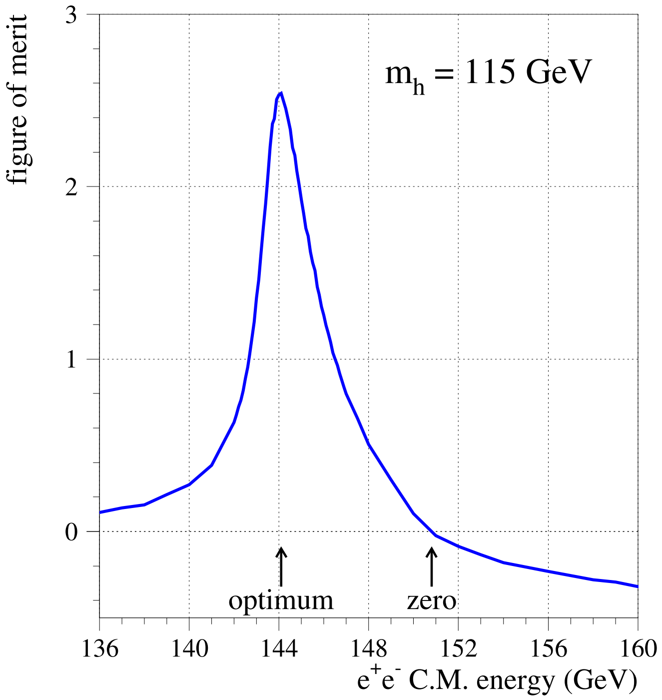
Define a FOM based on statistical sensitivity (no systematics at this point).

- For a fixed $\sqrt{s_{ee}}$, consider two hypothetical Higgs masses leading to two different yields, N_1 and N_2.
- We want to chose $\sqrt{s_{ee}}$ which makes it easiest to distinguish the two hypotheses.
- This means we want to maximize our ability to differentiate between N_1 and N_2 as measurements.
- The appropriate figure-of-merit is

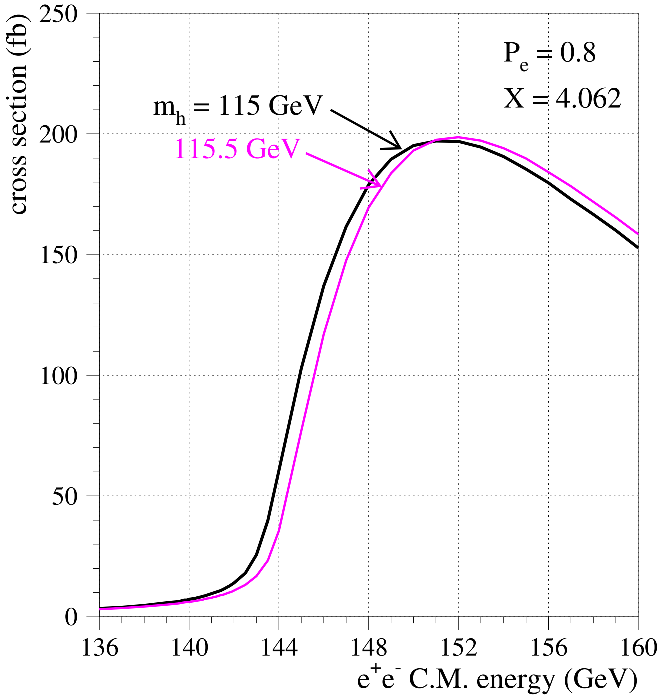
$$FOM = \frac{|N_1 - N_2|}{\sqrt{\sigma_{N_1}^2 + \sigma_{N_2}^2}} = \frac{|N_1 - N_2|}{\sqrt{N_1 + N_2}}.$$

- We have not included background in this FOM. Presumably it does not alter the picture radically.

PANDORA: $m_h = 115$ GeV, $P_{e^-} = -0.8$ & $P_{\text{laser}} = 1$.



Maximum sensitivity is well below the peak!



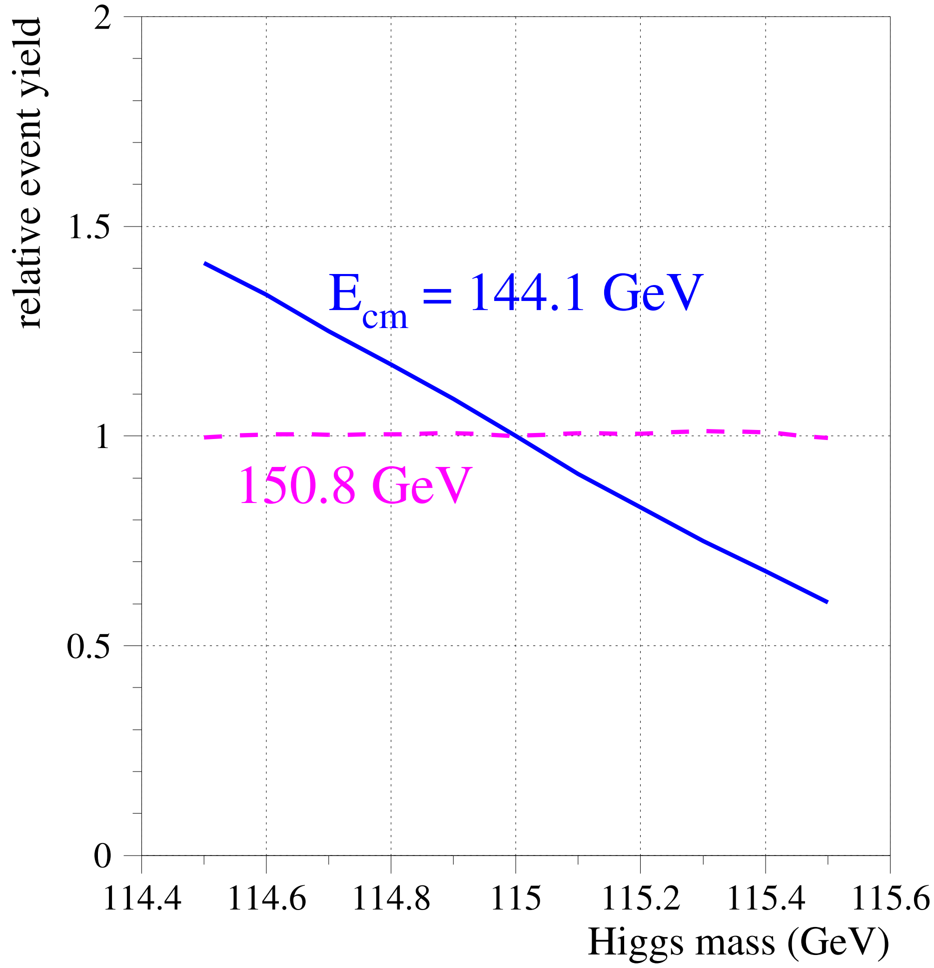
Note also there is a point of *zero sensitivity*.

Distinguishing m_h and $\Gamma_{\gamma\gamma}$

Problem: At a given $\sqrt{s_{ee}}$, an increase in signal could be due to the Higgs mass **or** to $\Gamma_{\gamma\gamma}$.

Solution: Use the point of zero sensitivity to m_h to detect a change in $\Gamma_{\gamma\gamma}$ alone.

For quite a wide range in m_h, these two $\sqrt{s_{ee}}$ points retain their distinctive roles.



Pure m_h Dependence

We define a new observable, Y, which depends only on m_h and not on $\Gamma_{\gamma\gamma}$. At the same time, it automatically subtracts the background under the signal, *all in a model-independent way.*

Define

$$\begin{aligned} N_{\text{thresh}} &= N \text{ events at optimal point} \\ N_{\text{peak}} &= N \text{ events at insensitive point} \\ N_{\text{below}} &= N \text{ events below threshold.} \end{aligned}$$

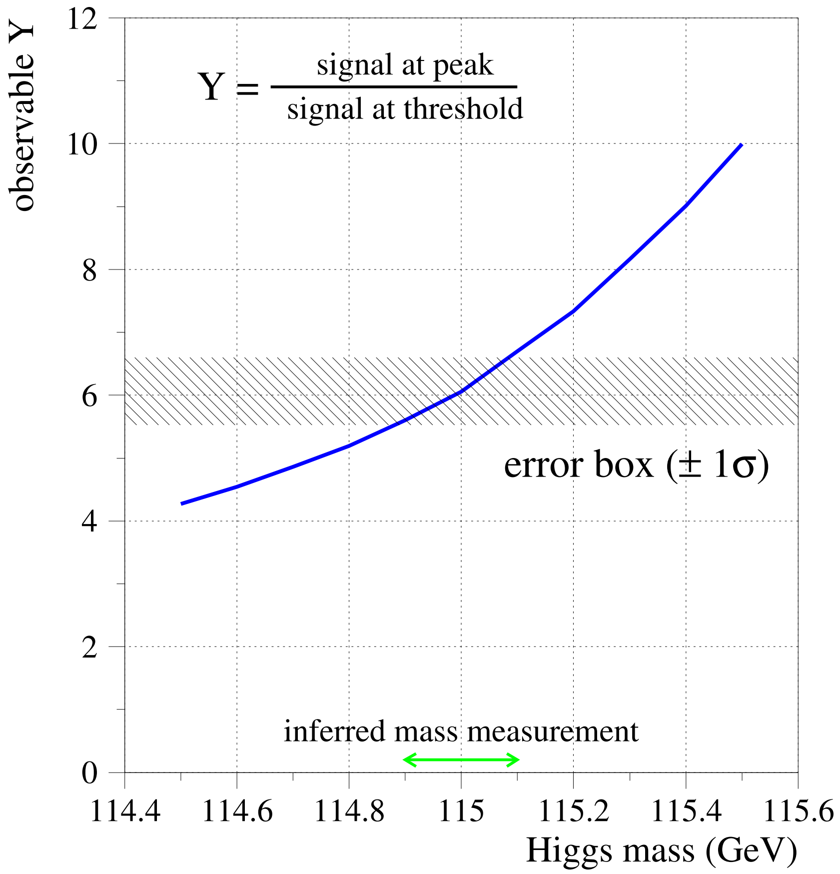
The the new observable is the ratio of background-subtracted yields:

$$Y = \frac{N_{\text{peak}} - N_{\text{below}} \cdot r_p}{N_{\text{thresh}} - N_{\text{below}} \cdot r_t}$$

where r_p and r_t are scale factors which relate the background data taken below threshold to the expectation at threshold and at peak.

Result

For expected yields at TESLA or CLICHE, we estimate $\sigma_Y/Y = 0.09$ assuming one year running on peak, a half year at threshold, and a half year below threshold.



This translates into an error $\boxed{\sigma(m_h) \cong 100 \text{ MeV}}$.

- no systematics from uncertainty on $P(e^-)$
- We need to check spectrum uncertainties.

Conclusions

- The point of optimal sensitivity has been found.
- A point of zero sensitivity can be used to distinguish m_h and $\Gamma_{\gamma\gamma}$.
- The ratio of background-subtracted yields could be used to infer m_h to about 100 MeV.

- This analysis could (should?) be repeated for the NLC scenario.
- Uncertainties in the luminosity function need to be taken into account.
- Would a more refined variable improve the result?