Locating the Higgs Peak at the Muon Collider

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"Needle in a Haystack"

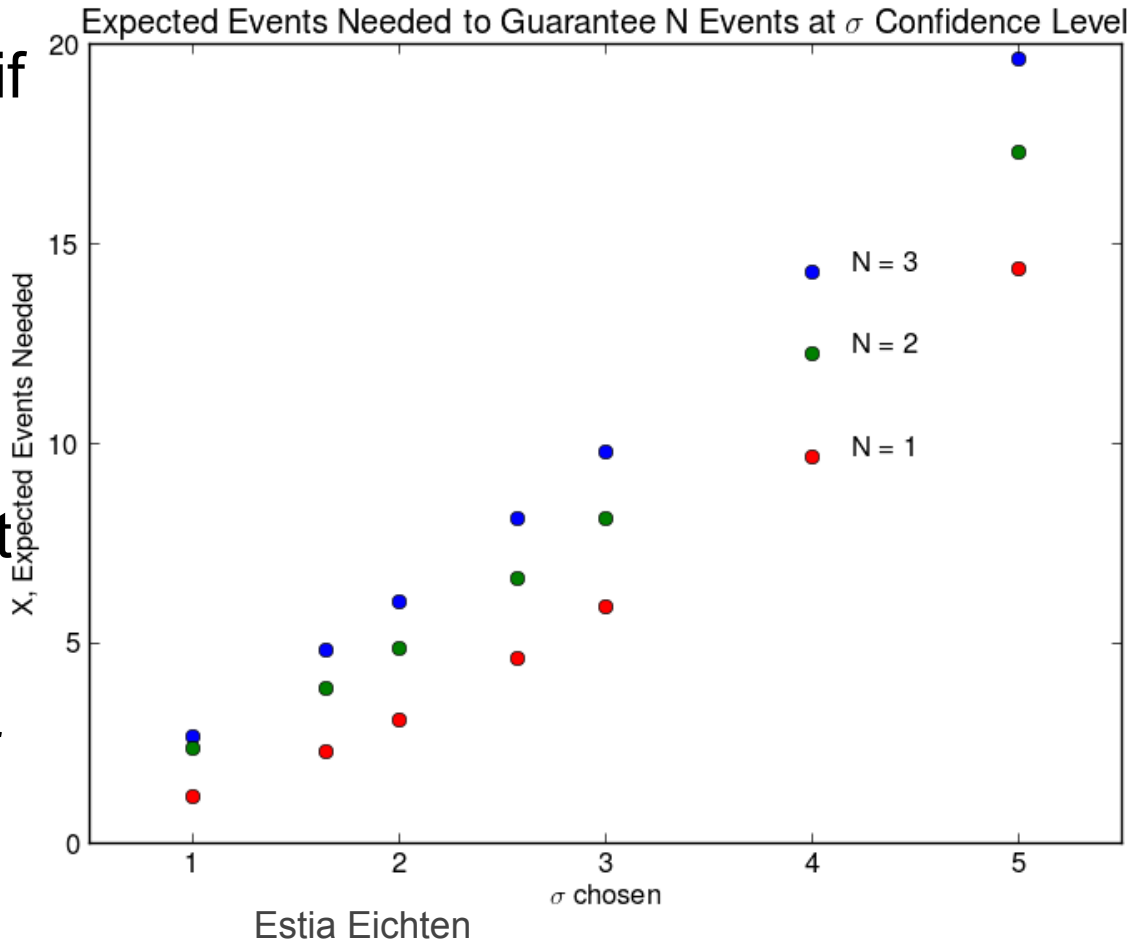
- Estimated future minimum uncertainty on Higgs mass from the LHC is on the order of 100MeV.
  - Muon collider beam energy resolution likely in the 2-5MeV range.
  - SM Higgs peak is only ~4MeV wide.
    - Finding a needle with a needle!
- Need a 'search' strategy that will minimize the luminosity required to find the Higgs peak.
  - Estimate effects of parameters such as beam width.

Basic Strategy

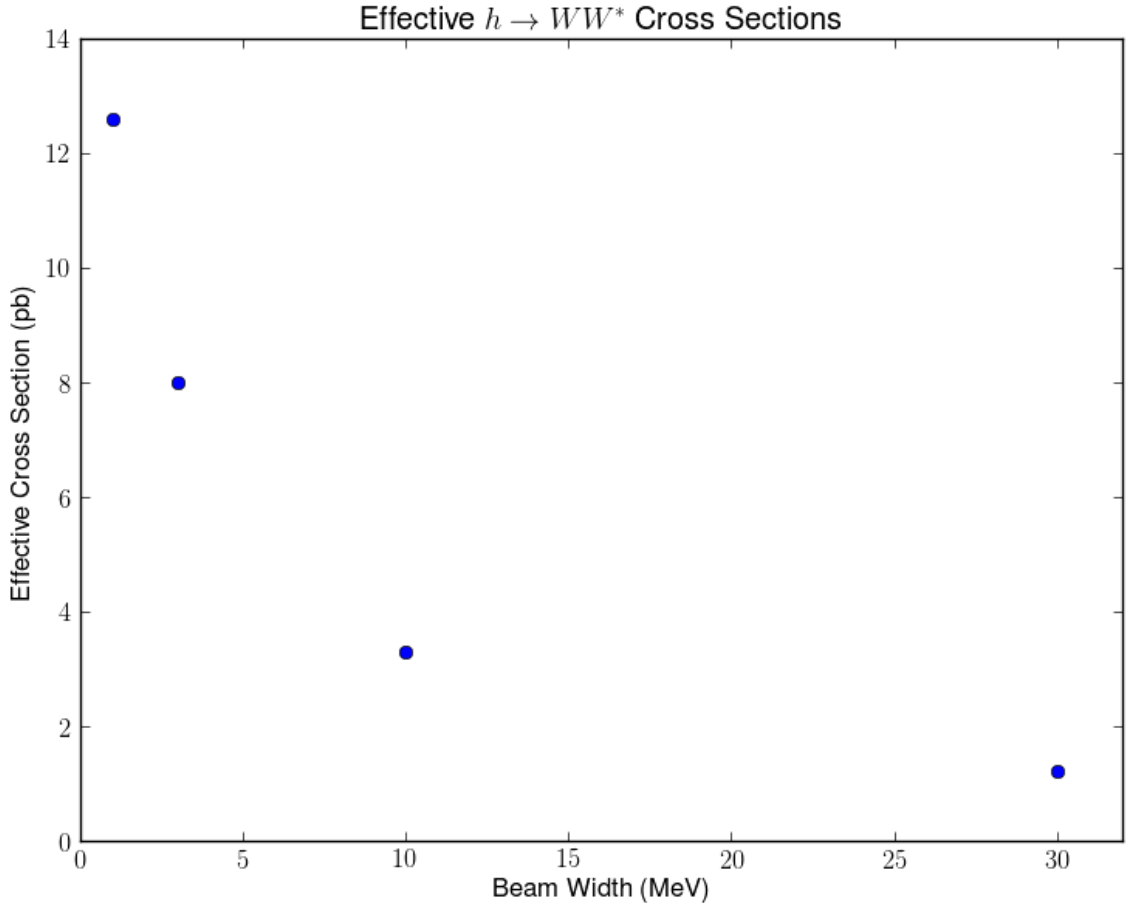
- Use *a priori* information from LHC measurements to guide search.
  - 126.0GeV mean, 100MeV width.
- Divide search space into bins of width equal to beam gaussian width (+/- 1σ)
- Take data in bins ordered by the probability of finding Higgs.
  - Probability calculated from
    - LHC peak
    - Chance of seeing at least N events if beam is centered on peak.

Probability of Observation Requirement

- Choose the number of events N we want to guarantee observing if the beam is centered on the peak.
- Use Poissonian statistics. To ***guarantee*** observing at least N=2 events at a 3σ confidence level (99.73%), ***expected*** value of X, number of observed events, must be 8.13

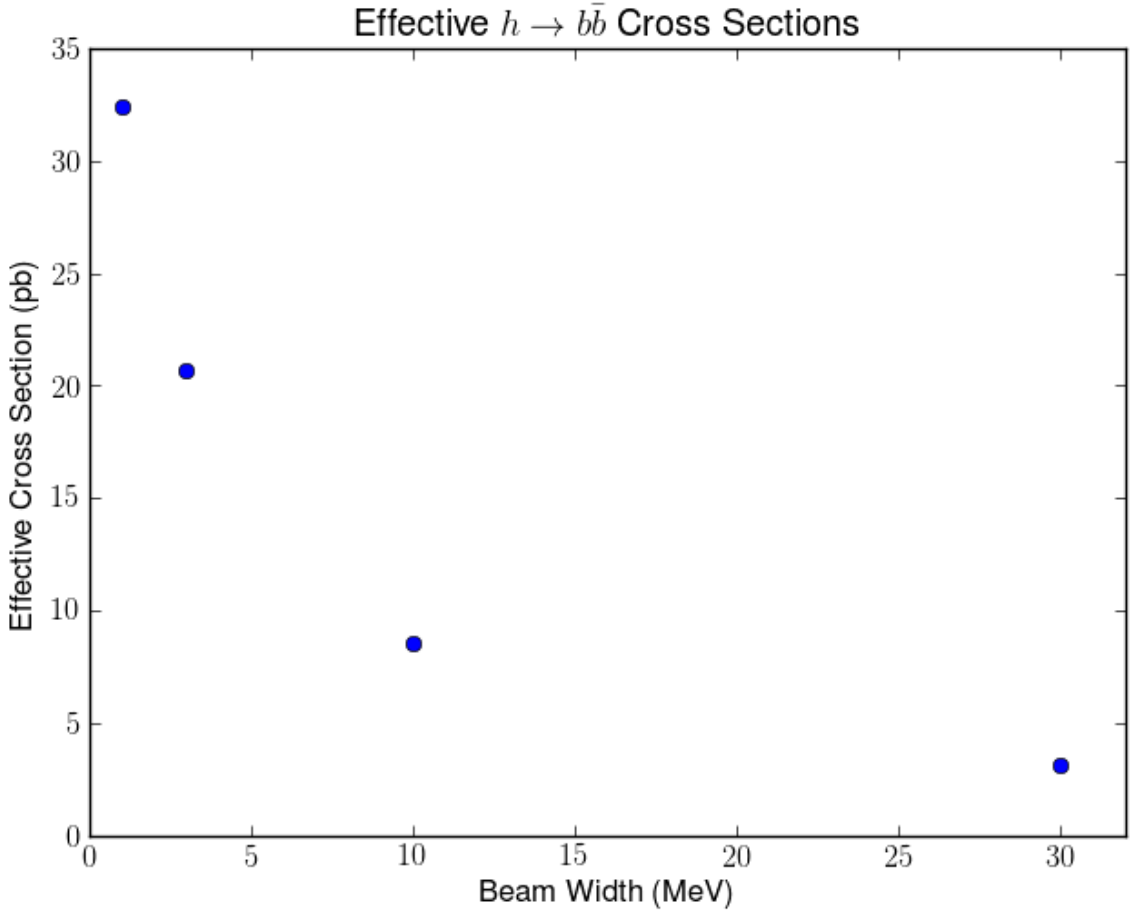


Effects of Beam Width



- Cross sections given beam is centered on Higgs 4.2MeV wide Higgs peak and **no background**
- Wider beams reduce effective Higgs cross section but can search a wider space.
- Minimal physics background in WW* channel

Effects of Beam Width

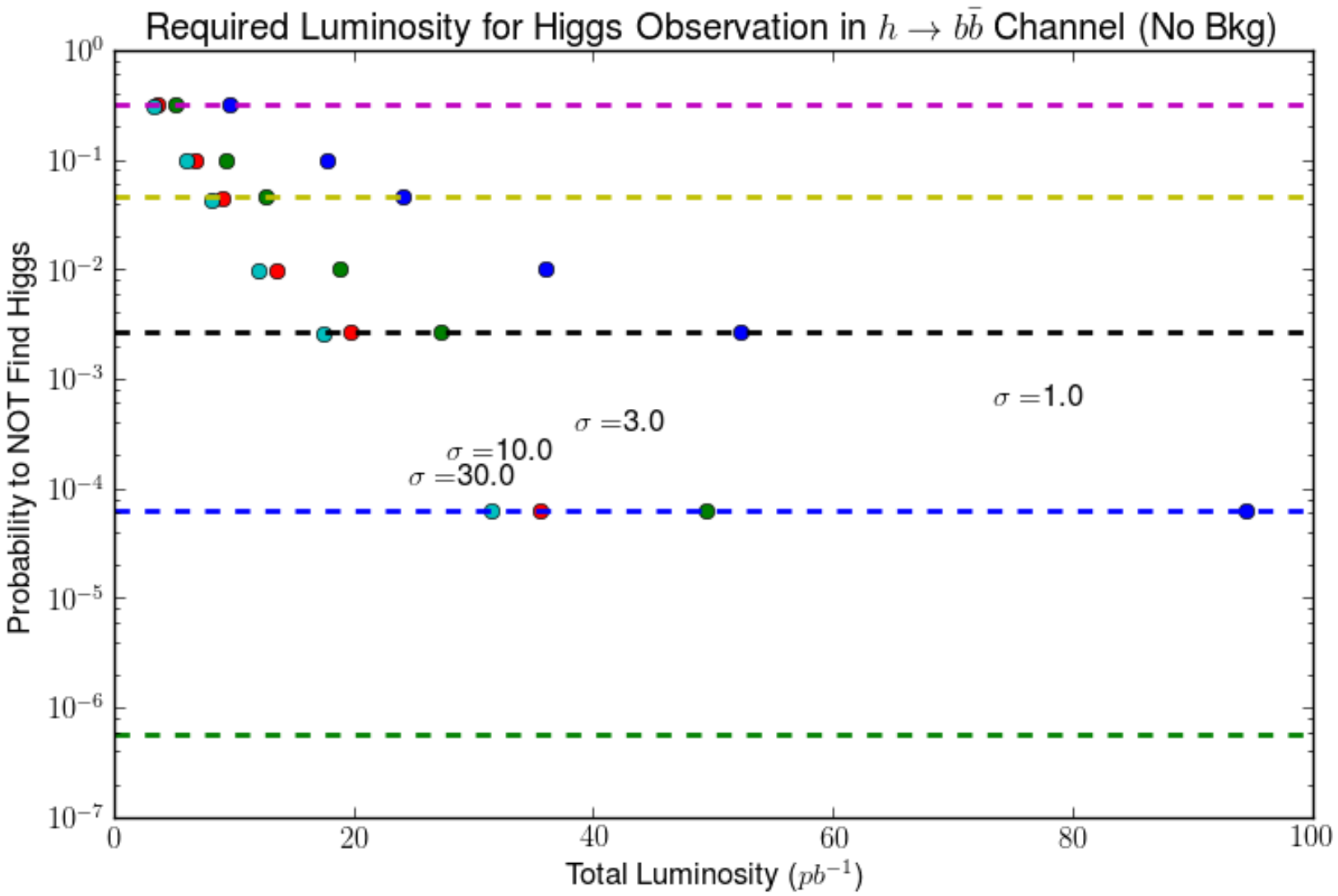


- Higher cross section in b-bbar channel, but also larger physics background (not yet included in calculations).

Search Method

- For each bin, calculate amount of luminosity required to achieve each confidence level.
- Rank bins at each interval in confidence level by *a priori* probability given by the LHC multiplied by the change in confidence level.
- Search bins in order according to this ranking.
  - Fanning out pattern:
    - Starts at center of LHC peak and fans out to either side
    - Returns to center when ranking is higher there than on the tails.
  - Sum the luminosity taken at each point.

Total Required Luminosity



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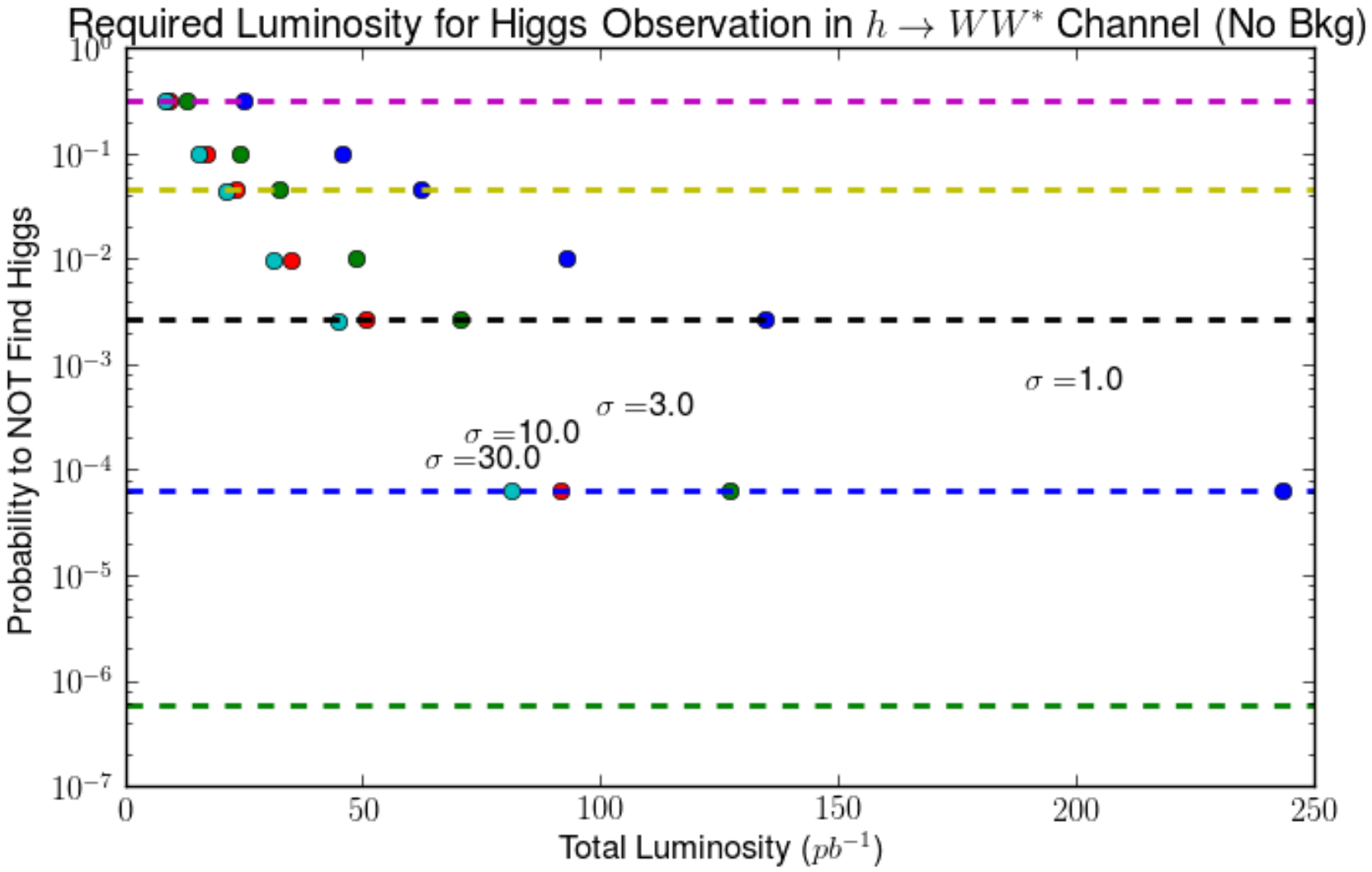

Thoughts

- Physics backgrounds are not (yet!) taken into account.
  - WW* background is very low.
    - Tracking important for measurement via lepton + missing E_T
    - Calorimetry important for 4-jet reconstruction
    - What is reasonable fake rate?
  - b-bbar physics background is higher than signal.
    - b-tagging study to estimate fake rate, purity, efficiency
    - Try reconstructing jets to separate Z's from h's
- Still ignoring machine backgrounds.

Thoughts

- Search method is still naive.
  - Eventually do a simulated search where probabilities are periodically recalculated based on observed events.
    - *ie.* zero in on observed peaks
- Search method depends on easy adjustment of beam energy.
- Will want ability to change beam width for searching vs measuring.
- Total required luminosity currently minimized at around 30MeV beam width.
  - Should change with backgrounds.

Looking Forward

- b-bbar
  - flavor tagging with LCFIPlus
  - Event topology to remove Z/gamma -> b-bbar background, eg:
    - Thrust, Oblateness, Number of jets, 2-jet invariant mass, b-momentum
    - Straight from Pythia data
  - Potential huge reduction in physics background
- WW* channel
  - Fake rate
  - Jet reconstruction
- More realistic calculations of physics measurement potential.