Bremsstrahlung photon In eeH and $\mu\mu H$ processes

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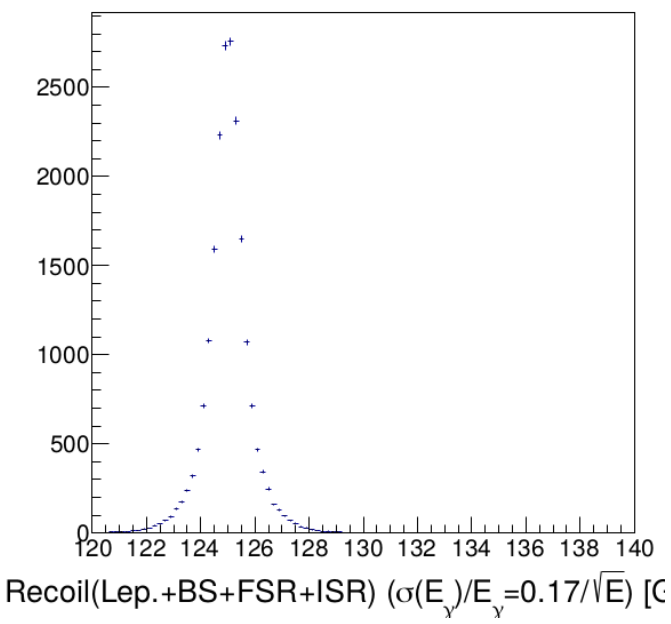
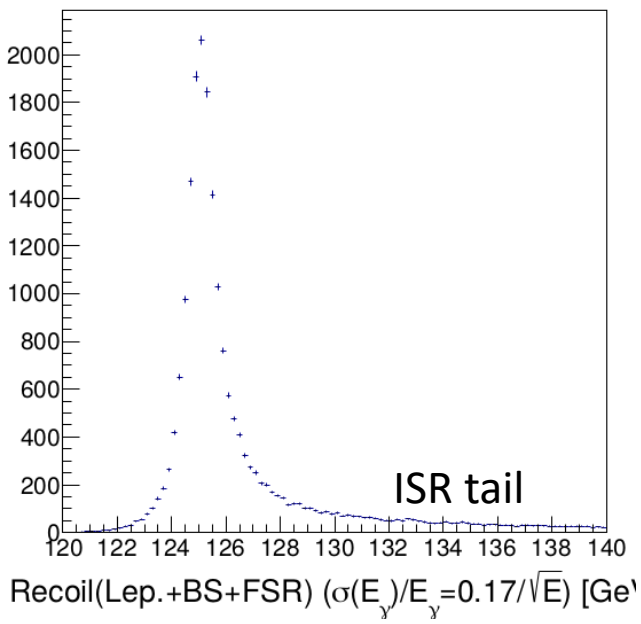
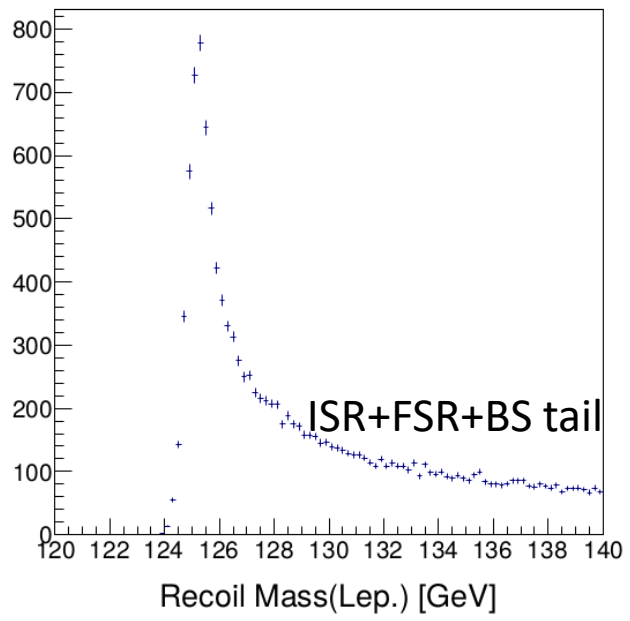
Motivation

- The recoil mass against $ee/\mu\mu$ for $eeH/\mu\mu H$ process is essential to determine the Higgs boson mass
- The precision is most sensitive to the width/statistics of peak
- Final states includes $ee/\mu\mu$ + ISR + FSR + BS; BS exists only for eeH
- Bremsstrahlung made BIG effect on the width/statistics of peak







eeH && $\sqrt{s}$ = 240GeV && w/o energy spreading && w/o cuts

Smearing for energy spreading

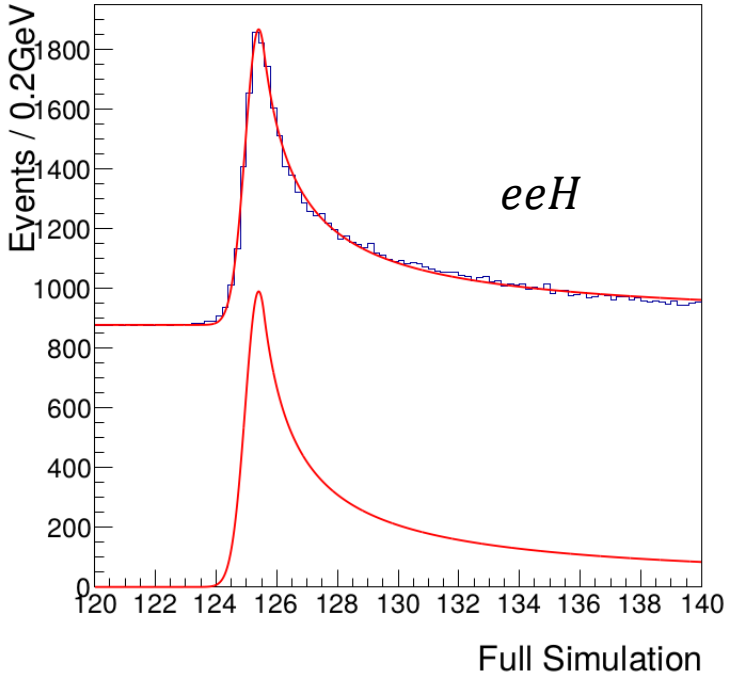
- Uncertainty of Energy of incident electron/position: 0.134% (CDR)
- The recoil mass spreading due to energy spreading:
  - 0.134%*240GeV = 320MeV ~ the smearing due to finite lepton energy resolution
  - NOT negligible
- Ideal smearing
  - Generate events in c.m.s energy $\sqrt{s^*} = \sqrt{s}\left(1 + \frac{\delta_1+\delta_2}{2}\right)$
  - Boost the events with $\beta = \frac{\delta_1-\delta_2}{2}$

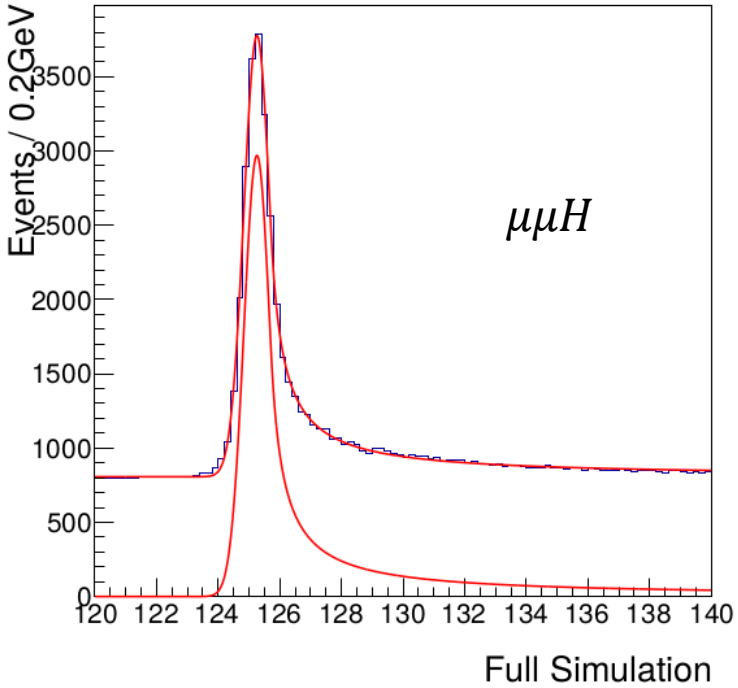
Smearing for energy spreading

- Correction
  - $m_{rec}^2 = (\sqrt{s} - E)^2 - p^2$
  - $m_{rec}^2 = \left(\sqrt{s^*} - \frac{(\delta_1+\delta_2)\sqrt{s}}{2} - E^* - \beta p_z^*\right)^2 - (p_z^* + \beta E^*)^2 - p_T^2$ // boost along z axis
  - $m_{rec}^2 = \left(\sqrt{s^*} - E^*\right)^2 - p^{*2} + \delta_1(\dots) + \delta_2(\dots)$
  - The term $\left(\sqrt{s^*} - E^*\right)^2 - p^{*2}$ is indeed independent to $\sqrt{s^*}$
- Approximation method
  - $E = E^* + \beta p_z^* + \frac{(\delta_1+\delta_2)\sqrt{s}}{2}$
  - $p_z = p_z^* + \beta E^*$
  - $p_{x(y)} = p_{x(y)}^*$
  - Now $something^*$ means variable generated at $\sqrt{s}$
  - $m_{rec}^2 = \left(\sqrt{s^*} - E^* - \frac{(\delta_1+\delta_2)\sqrt{s}}{2}\right)^2 - p^{*2} + \delta_1(\dots) + \delta_2(\dots)$
  - $m_{rec}^2 = (\sqrt{s} - E^*)^2 - p^{*2} + \delta_1(\dots) + \delta_2(\dots)$

Full Simulation

- Cuts (following zhenxing's paper except the BDT cut)
  - Eff(eeH) = 51%. Eff($\mu\mu H$)=70%
- Smearing for energy spreading
- Adding fake backgrounds
- Fit recoil mass against $ee/\mu\mu$ with crystalball function
  - eeH $\sigma(m_H) = 15\text{MeV}$
  - $\mu\mu H$ $\sigma(m_H) = 6\text{MeV}$





Fast Simulation Calibration

- Scaling weight for matching the eff.
- Tuning the energy resolution of lepton for matching the $\sigma(m_H)$
  - $\frac{\sigma(E_e)}{E_e} = 3.3 \times 10^{-3}$
  - $\frac{\sigma(E_\mu)}{E_\mu} = 2.7 \times 10^{-3}$

Fast simulation taking into BS&FSR