Electron Yukawa from resonant s-channel Higgs production at FCC-ee

ICHEP-2020

Prague/Virtual, July-August 2020

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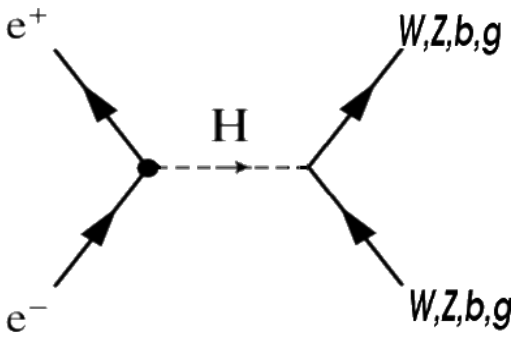
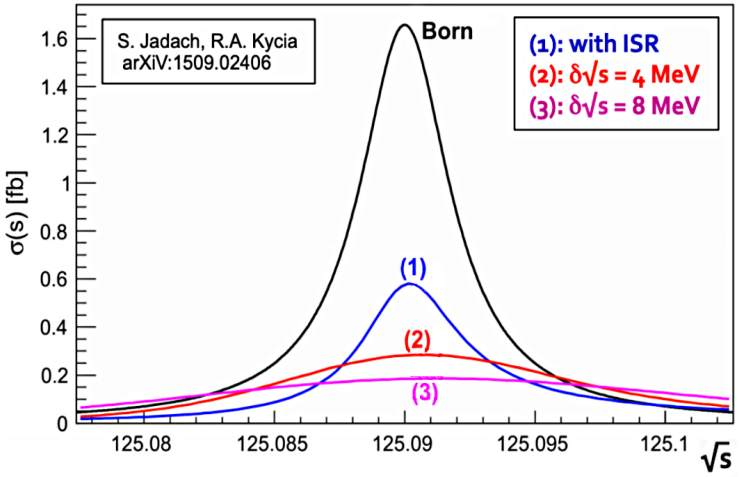


e Yukawa via s-channel $e^+e^- \to H$ production

- Higgs decay to e^+e^- is unobservable: $BR(H \to e^+e^-) \propto m_e^2 \approx 5 \cdot 10^{-9}$
- Resonant Higgs production considered so far only for muon collider: $\sigma(\mu\mu \to H) \approx 70$ pb. Tiny κ_e Yukawa coupling ⇒ Tiny $\sigma(ee \to H)$:

$$\sigma(e^+e^- \to H) = \frac{4\pi\Gamma_H^2 Br(H \to e^+e^-)}{(\hat{s} - M_H^2)^2 + \Gamma_H^2 M_H^2} = 1.64 \text{ fb}$$

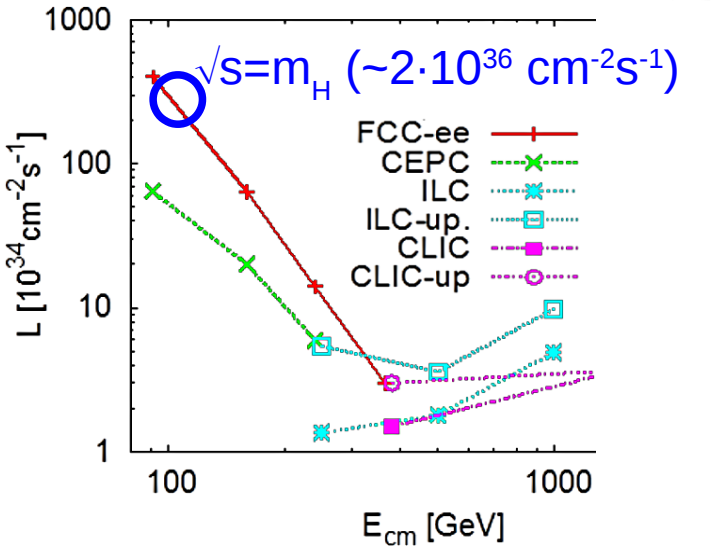


- ISR & beam energy spread further reduce resonant $e^+e^- \to H$ cross section:

$\sigma(ee \to H) = 290$ ab ($\delta\sqrt{s} \approx \Gamma_H = 4.2$ MeV)

- Can we exploit the huge luminosities expected at FCC-ee to carry out the measurement?

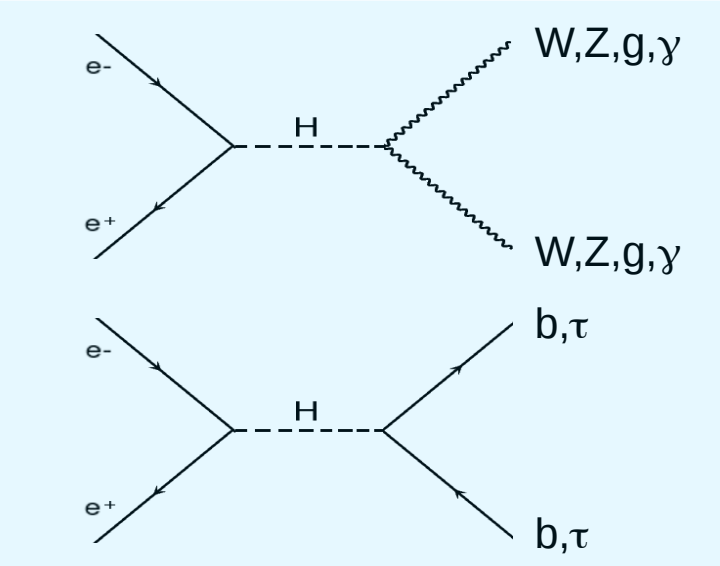
  IFF we can monochromatize the beams to reach $\delta\sqrt{s} \approx 4$ MeV (natural Higgs width), and know m_H within few MeV, FCC-ee running at H pole mass would produce 300 Higgs bosons per 1 ab^{-1}.



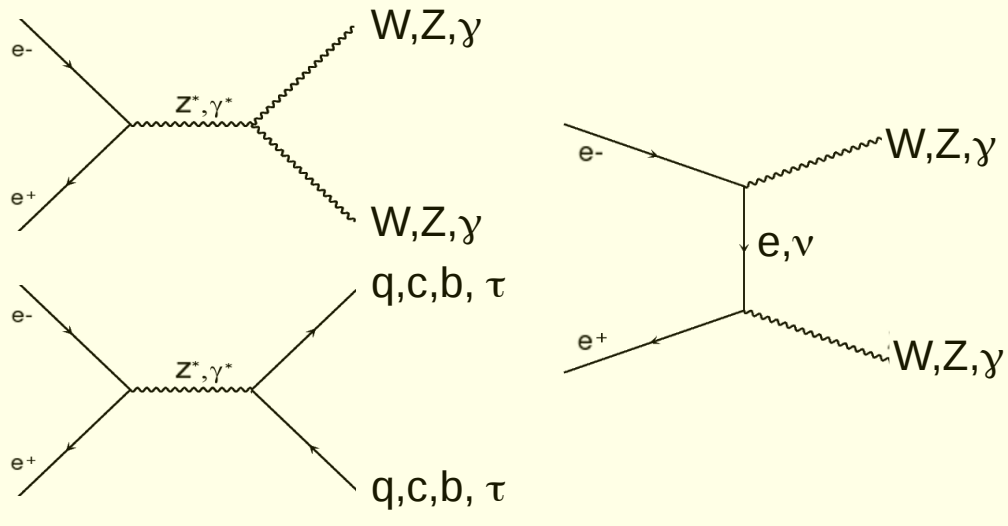
Signal & backgrounds simulation

- PYTHIA8 e^+e^- at $\sqrt{s} = m_H = 125$ GeV to generate 10 final-states for Higgs signal plus backgrounds (s-channel Z/γ*, plus all t-channels):

SIGNAL



BACKGROUNDS (10^2–10^8 larger, before cuts)



- Very-rare counting experiment. Most significant channel $H \rightarrow WW^* \rightarrow l\nu jj$:

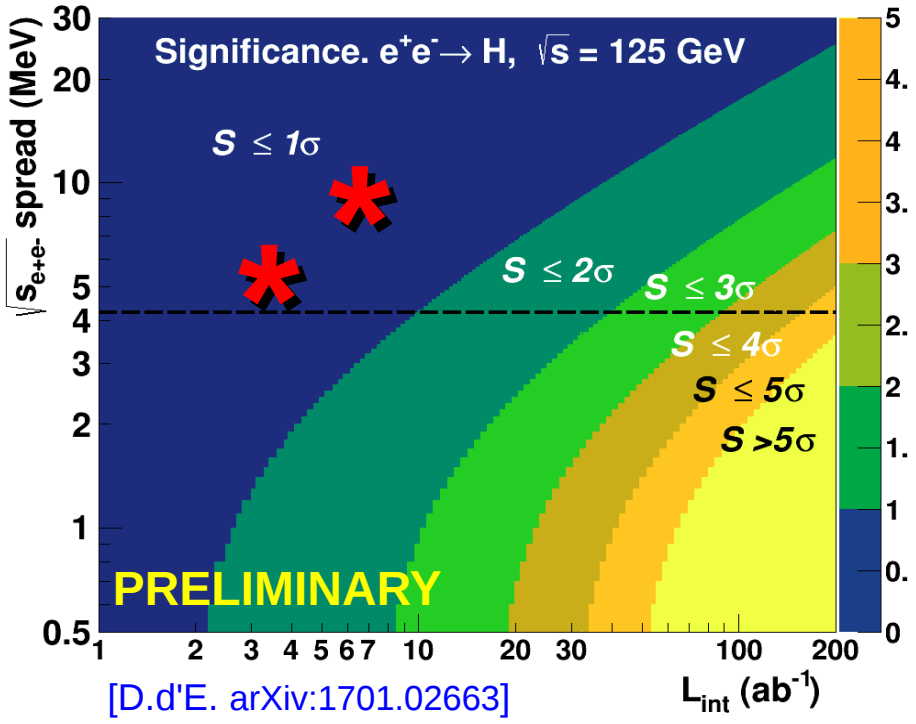
$E_{j1,j2} < 52{,}45$ GeV ← Kills $e^+e^- \rightarrow q\bar{q}$
$m_{w(l\nu)} > 12$ GeV/c^2 ← Kills $e^+e^- \rightarrow q\bar{q}$
$E_{lepton} > 10$ GeV ← Kills $e^+e^- \rightarrow q\bar{q}$
ME > 20 GeV ← Kills $e^+e^- \rightarrow q\bar{q}$
$m_{ME} < 3$ GeV/c^2 ← Kills $e^+e^- \rightarrow \tau\tau$
BDT MVA ← Kills $e^+e^- \rightarrow WW^*$ continuum
(exploits opposite $W^\pm$ polarizations in H decay)

$q\bar{q}$:	σ = 22 pb	⇒	σ(after) = 4 ab
$\tau\ \tau$:	σ = 1 pb	⇒	σ(after) = 2.6 ab
WW*:	σ = 16.3 fb	⇒	σ(after) = 2.7 fb
H(WW*):	σ = 23 ab	⇒	σ(after) = 8 ab

For L_{int}=10 ab^{-1}
$S/\sqrt{B} = 80/\sqrt{27000} \approx 0.5$
Significance ≈ 0.5

$e^{\pm}$ Yukawa coupling at FCC-ee(125)

- Counting experiment combining signal+backgds in 10 Higgs decay channels:



[D.d'E. arXiv:1701.02663]

- Monochromatization working points:

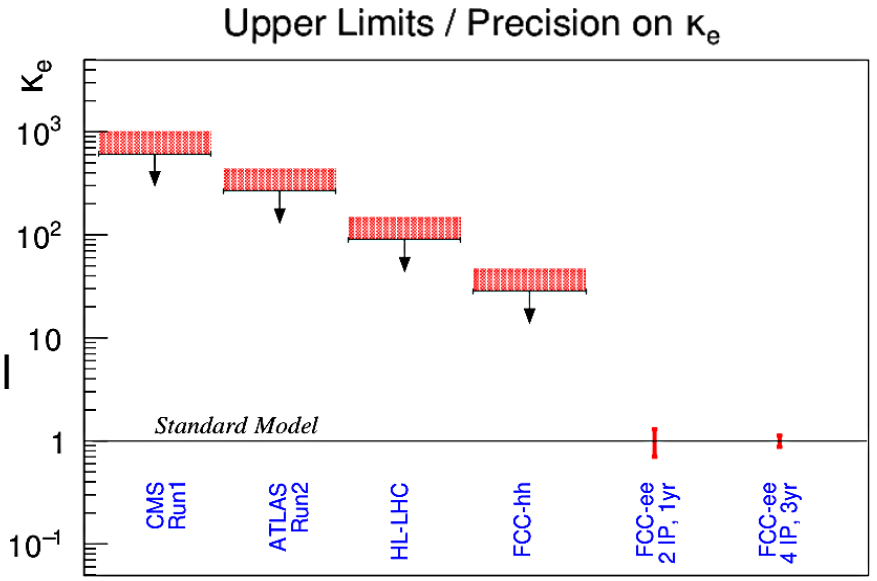
$\delta\sqrt{s}$ = 6 MeV, L_{int} = 3 ab^{-1} (baseline)
$\delta\sqrt{s}$= 10 MeV, L_{int} =7 ab^{-1} (optimized)

3σ evidence of ee→H would require 4 exps. running ~2 years at Higgs pole

- Preliminary upper limits on electron Yukawa κ_e coupling expected at SM-level

Limits on κ_e are X100 (X30) better than at HL-LHC (FCC-hh).

- Unique opportunity to constrain κ_e Yukawa!



N.B.: *Upper limits in this plot derived with a more optimistic working point (work in progress)*