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Higgs Group Report

FCC-ee / TLEP workshop
CERN
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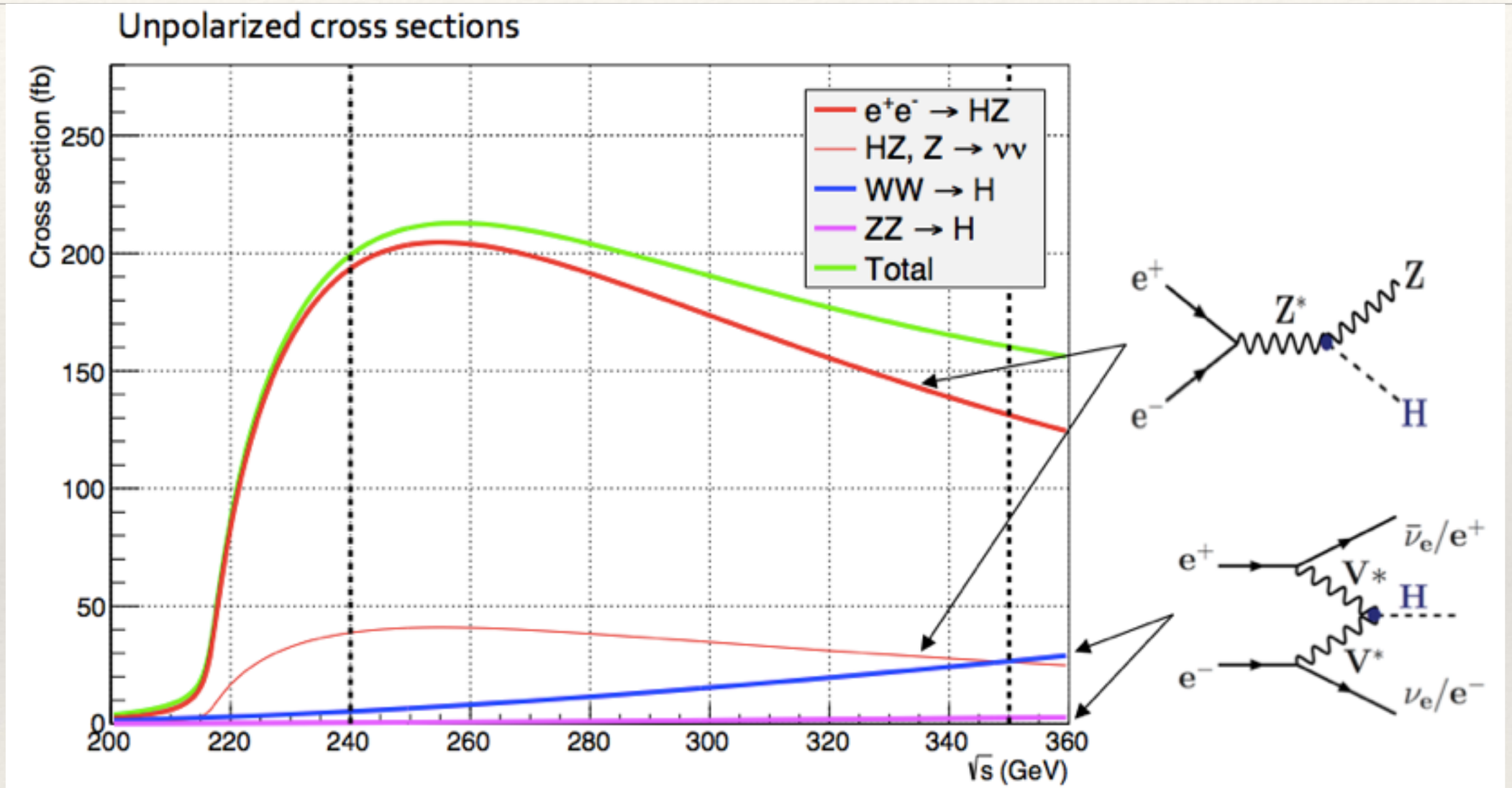
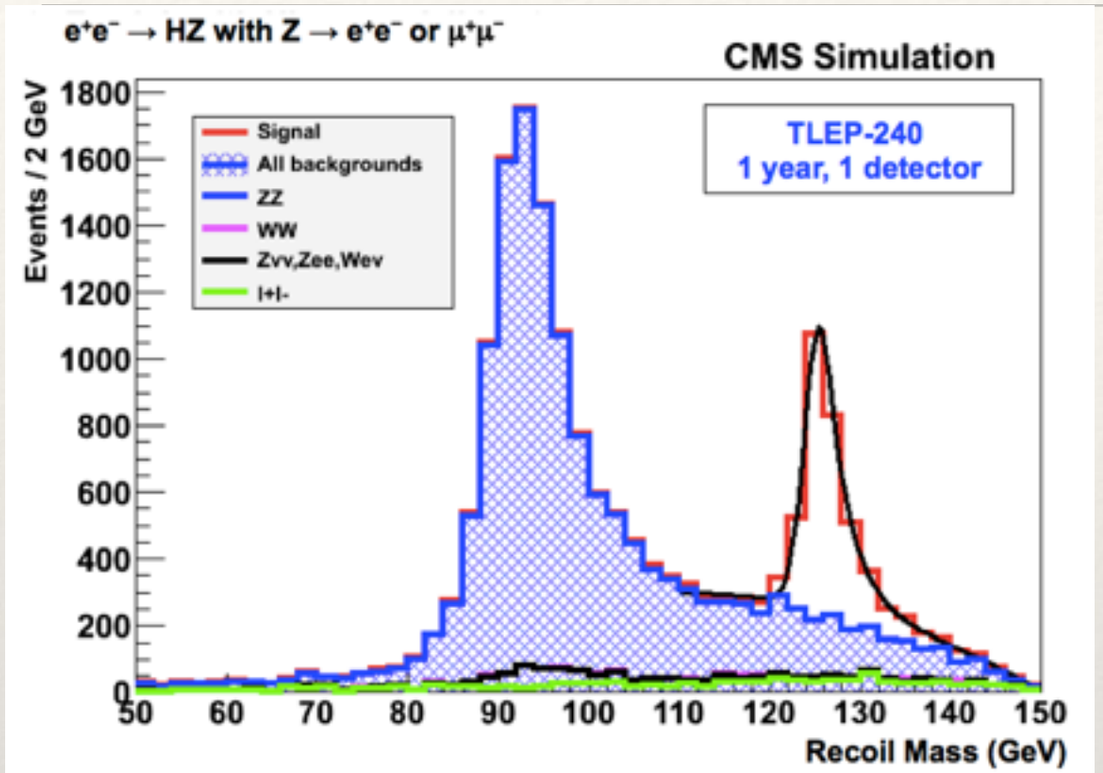
Higgs Production

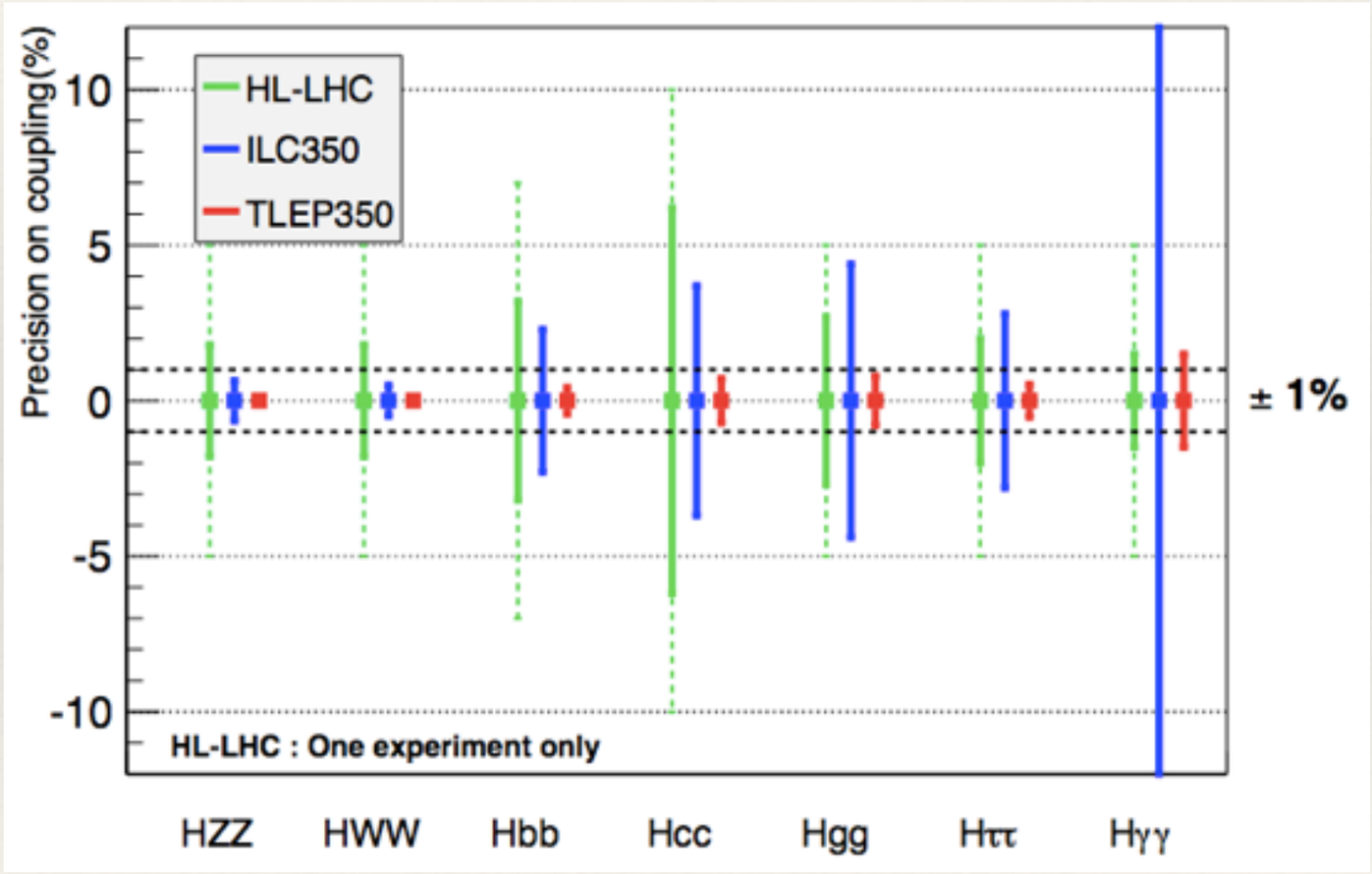


	TLEP 240
Total Integrated Luminosity (ab^{-1})	**10**
Number of Higgs bosons from $e^+e^- \to HZ$	**2,000,000**
Number of Higgs bosons from boson fusion	**50,000**

Coupling Measurements



	TLEP 240
σ_{HZ}	**0.4%**
$\sigma_{HZ} \times BR(H \to b\bar{b})$	**0.2%**
$\sigma_{HZ} \times BR(H \to c\bar{c})$	**1.2%**
$\sigma_{HZ} \times BR(H \to gg)$	**1.4%**
$\sigma_{HZ} \times BR(H \to WW)$	**0.9%**
$\sigma_{HZ} \times BR(H \to \tau\tau)$	**0.7%**
$\sigma_{HZ} \times BR(H \to ZZ)$	**3.1%**
$\sigma_{HZ} \times BR(H \to \gamma\gamma)$	**3.0%**
$\sigma_{HZ} \times BR(H \to \mu\mu)$	**13%**



Program of Work

- TLEP Physics Case, JHEP 1401 (2014) 164 gives a good starting point for the Higgs Physics potential of a circular e^+e^- machine.
- Huge amount of work done at LEP and for ILC and CLIC
- To prepare the FCC-ee/TLEP conceptual design report, progress is needed on a number areas, e.g.
  - Full simulation using a electron-positron detector
  - Theoretical uncertainties need detailed discussion
  - Expanded Higgs program
- Areas or work
  - Infrastructure and Tools
  - Experimental studies
  - Phenomenology
  - Theoretical prediction

Infrastructure and Tools

- TLEP Physics Case studies performed using CMS full simulation, in some case with additional assumptions. Reminder, CMS is not an electron-position collider detector :).
- How can Higgs measurements be improved with an optimized detector (and collider)?
- Examples:
  - vertex detector to discriminate Higgs to bb, cc, and gg
  - effect of jet angular and energy resolution on mass resolution

Infrastructure and Tools

- **To facilitate the studies we need to invest in tools**
  - development and validation of software framework
  - development (implementation) of reconstruction and identification tool
  - further development of Higgs combination tool
  - comprehensive review of Monte Carlo generators
  - review and implementation of theoretical uncertainties

Experimental Studies

Experimental studies have the goal to assess the performance of Higgs boson measurements using the FCC-ee and to qualify the detector design. Studies should be performed at √s = 240 GeV and 350 GeV unless otherwise stated.

1. Higgs-strahlung production (ee -> HZ)
    - Inclusive Z -> ll measurements
        - Measurement of the ZH cross section
    - Exclusive Z -> ll measurements
        - Hadronic Higgs decays (H -> bb, cc, gg, WW, ZZ)
        - Higgs to ZZ (Essential for the total width determination at √s = 240 GeV)
        - Higgs to WW (with lepton decays)
        - Higgs to tau tau
    - Inclusive Z -> qq measurements
        - Measurement of the ZH cross section
    - Exclusive Z -> qq measurements
        - Four jet final state (H -> bb, cc, gg, WW, ZZ)
        - Six jet final state (H -> WW, ZZ, bb, cc, gg)
        - Jets plus leptons final states (H -> WW,ZZ,mumu)
        - Higgs to tau tau
    - Exclusive Z -> νν measurements
        - Higgs to bb
    - Invisible Higgs decays
    - Exotic Higgs decays (e.g. flavour changing decays)
2. Vector boson fusion production
3. Exclusive H-> γγ or H -> μμ (ee) production
4. Exclusive H -> Zγ production
5. ee -> Hγ production
6. ee -> H direct production
7. Other production processes
    - SM Higgs: bbH production, tau tau H production
    - 2HDM: hA production, bbH, tau tau production (enhanced with tan beta), and specific decays h -> AA, etc.

Channel need to be investigate wrt the detector performance

Phenomenology

- Extraction of Higgs boson couplings
- Extraction of total width from precision measurements
- Measurements of Higgs boson mass
- Study of tensor structure
- Extraction of Higgs self coupling from precision measurements
- Interplay of Higgs precision measurements with SM precision observables
- Rare decays
- Beyond standard model interpretations

Theoretical Predictions

- Cross sections for signal and backgrounds
- Decay width and Branching ratios

Table 1-5. *Uncertainties on $M_H = 126$ GeV Standard Model widths arising from the parametric uncertainties on α_s, m_b, and m_c and from theory uncertainties [16]. For the total uncertainty, parametric uncertainties are added in quadrature and the result is added linearly to the theory uncertainty.*

Channel	$\Delta\alpha_s$	Δm_b	Δm_c	Theory Uncertainty	Total Uncertainty
$H \to \gamma\gamma$	0%	0%	0%	±1%	±1%
$H \to b\bar{b}$	$\mp 2.3\%$	$^{+3.3\%}_{-3.2\%}$	0%	±2%	±6%
$H \to c\bar{c}$	$^{-7.1\%}_{+7.0\%}$	$\mp 0.1\%$	$^{+6.2\%}_{-6.1\%}$	±2%	±11%
$H \to gg$	$^{+4.2\%}_{-4.1\%}$	$\mp 0.1\%$	0%	±3%	±7%
$H \to \tau^+\tau^-$	0%	0%	0%	±2%	±2%
$H \to WW^*$	0%	0%	0%	±0.5%	±0.5%
$H \to ZZ^*$	0%	0%	0%	±0.5%	±0.5%

- Snowmass Higgs report or YR3 or Peskin et al

Conclusion

- **At the beginning of a long term coordinated FCC-ee/TLEP Higgs effort**
- **Large amount of work / results are already available**
- **Plenty interesting work ahead: infrastructure and tools, experimental studies, phenomenology and theory**

- Pointer:
  - Convener: Krisztian Peter (CERN), Markus Klute (MIT)
  - FCC-ee Higgs twiki: https://twiki.cern.ch/twiki/bin/view/FCC/FCCeeH126Properties
  - FCC-ee Higgs e-group: fcc-ee-H126Properties@cern.ch