Higgs Group Report

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FCC-ee (TLEP)-Workshop at SNS, Pisa

February 5th, 2015

Objectives for year one

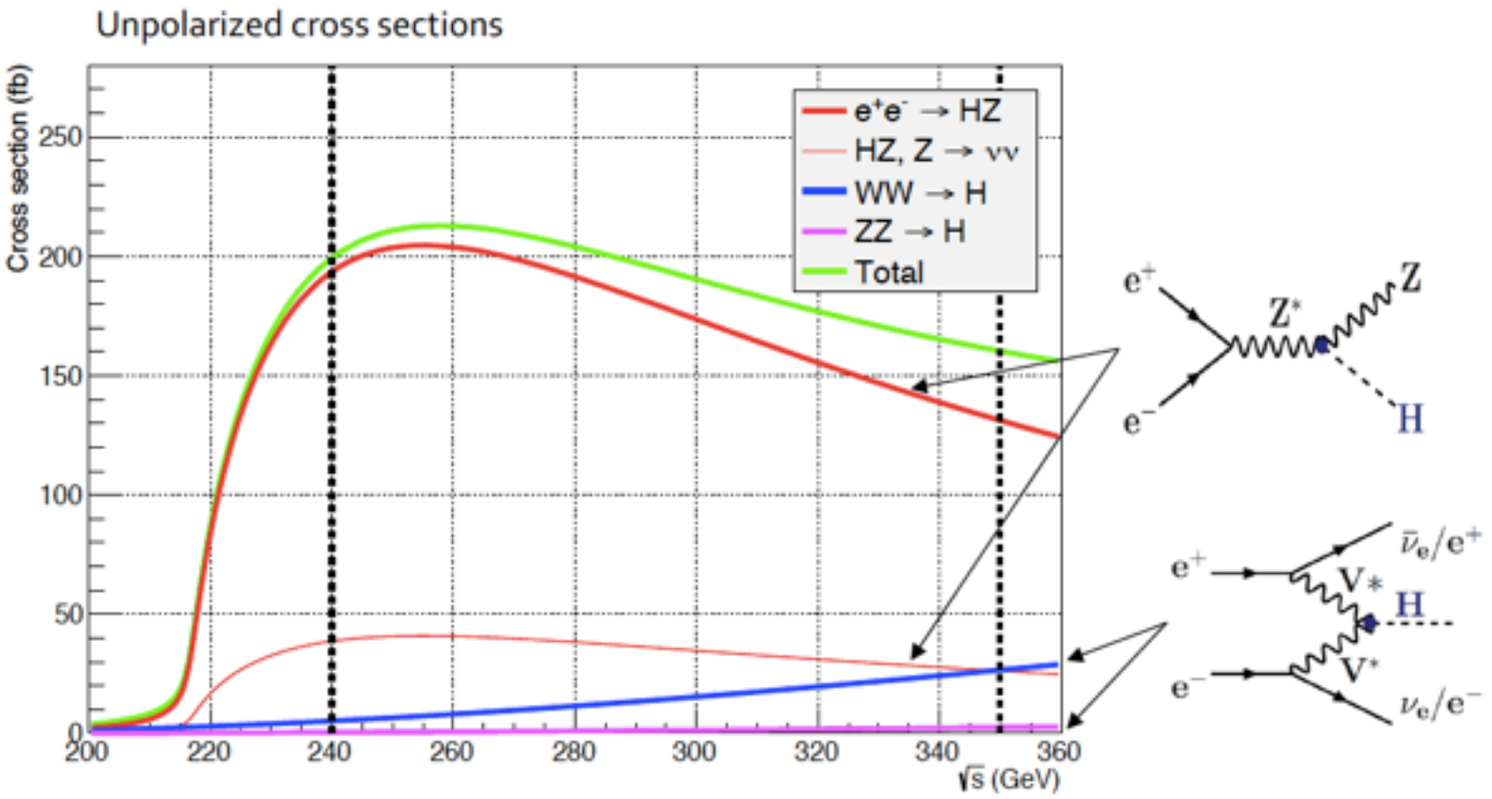
- Refine and expand FCC-ee Higgs physics program
- Identify dependencies in detector design and machine requirements
- Form a collaborative effort
- Moving from **exploration** mode to **study** mode

… also see Krisztian's talk at FCC-ee workshop in Paris

Exploiting very large Higgs sample

- Precision Higgs studies (TLEP Physics case)
- Higgs self coupling through loop corrections
- 1st and 2nd fermion generation couplings
- Rare and exotic decays (e.g. DM decays)
- Extra Higgs bosons
- Tensor structure

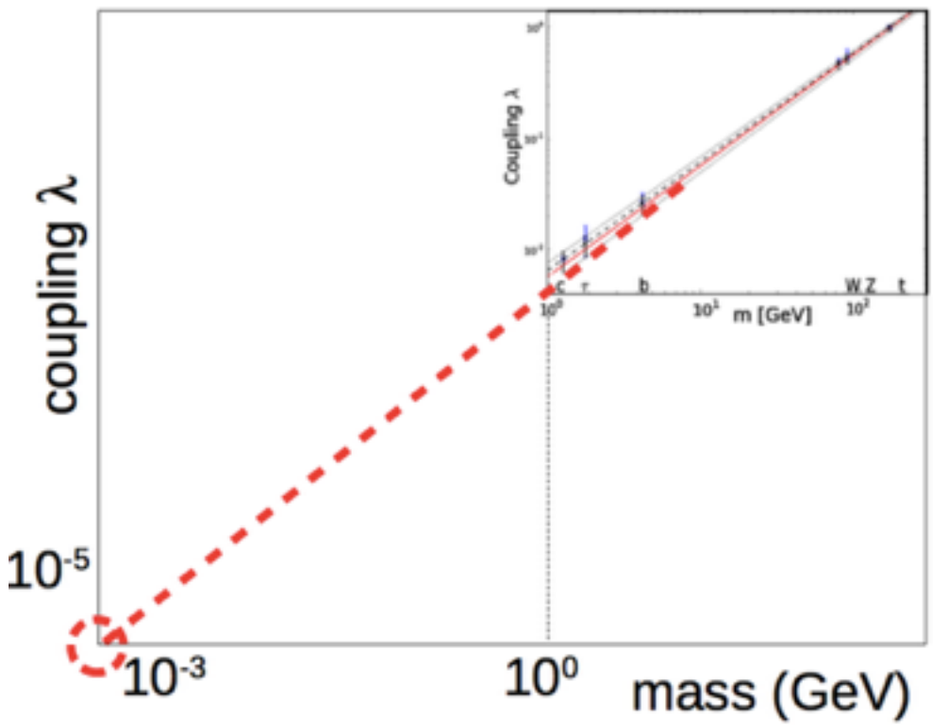
	TLEP 240
Total Integrated Luminosity (ab^{-1})	**10**
Number of Higgs bosons from $e^+e^- \to HZ$	**2,000,000**
Number of Higgs bosons from boson fusion	**50,000**

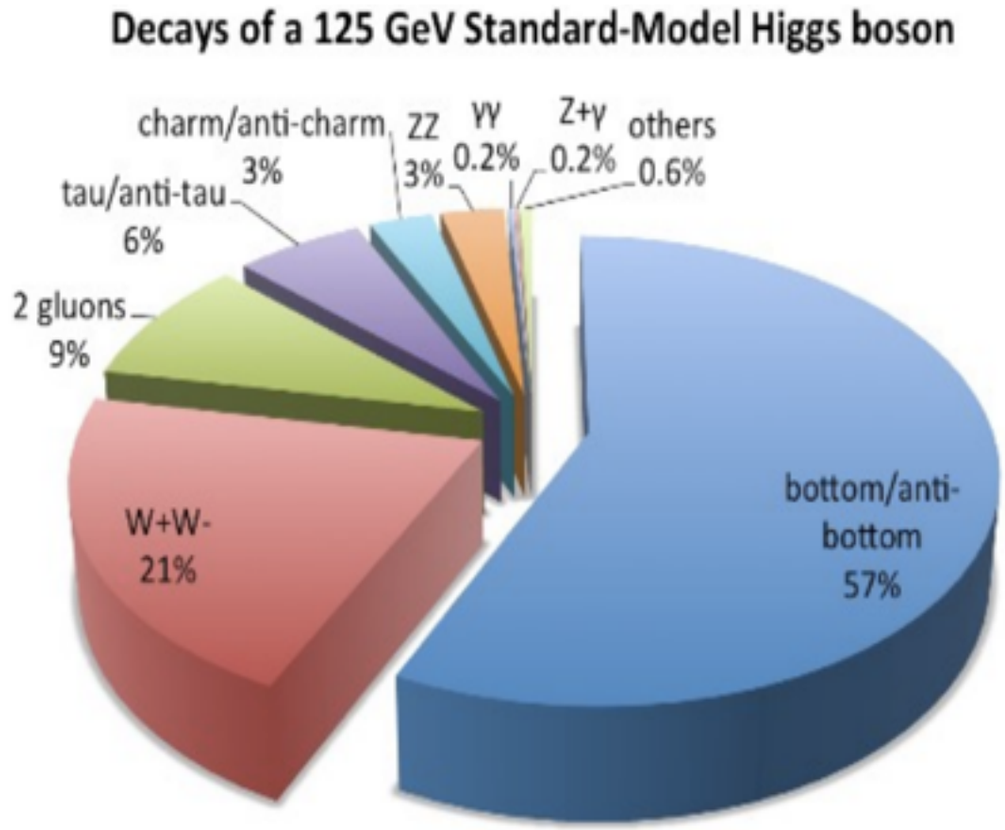


	TLEP 240
σ_{HZ}	**0.4%**
$\sigma_{HZ} \times BR(H \to b\bar{b})$	**0.2%**
$\sigma_{HZ} \times BR(H \to c\bar{c})$	**1.2%**
$\sigma_{HZ} \times BR(H \to gg)$	**1.4%**
$\sigma_{HZ} \times BR(H \to WW)$	**0.9%**
$\sigma_{HZ} \times BR(H \to \tau\tau)$	**0.7%**
$\sigma_{HZ} \times BR(H \to ZZ)$	**3.1%**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

First generation couplings

- **s-channel Higgs production** (d'Enterria, Aleksan, Wojcik)
- **Unique opportunity for measurement close to SM sensitivity**

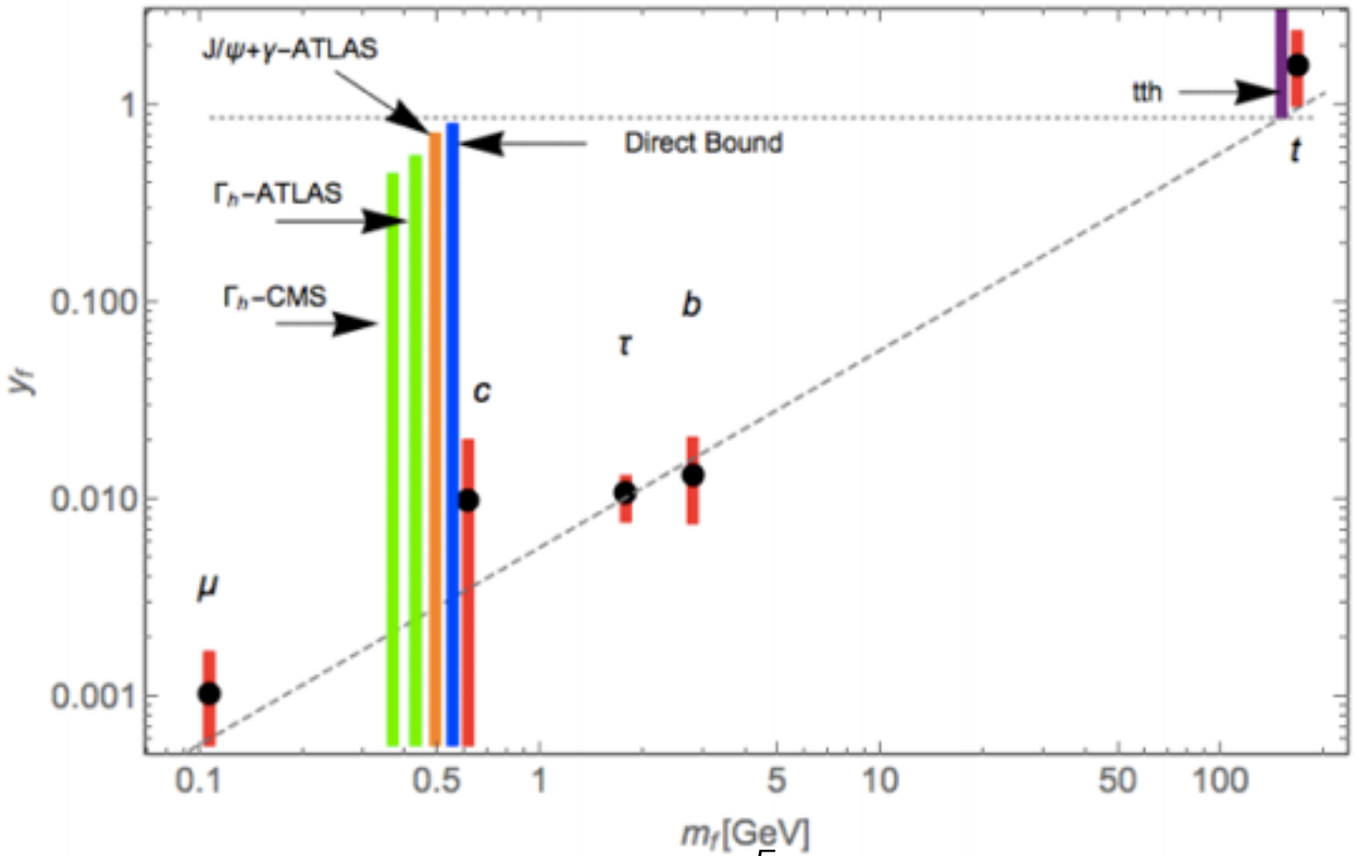




- **Questions to follow up**
  - how large are loop induced corrections? how large are BSM effects?
  - do we need an energy scan to find the Higgs?
  - how much luminosity will be available for this measurement? By how much is the luminosity reduced by monochromators?
  - can polarization increase sensitivity?

Light quark couplings

- Detailed talk by Yotam Soreq
- **Inclusive analysis jet-flavor tagging**
  - set requirement for FCC-ee detector
- **Exclusive analysis using vector mesons**
  - **ργ** channel most promising



Rare and exotic decays

- 2,000,000 ZH events allow for detailed studies of rare and exotic decays
  - requires hadronic and invisible Z decays
  - set requirements for FCC-ee detector
- Coupling measurements have sensitivity to BSM decays
- Dedicated studies using specific final states improve sensitivity
- Example: Higgs to invisible; flavor violating Higgs; VP and VP* modes; and many more
- Potential at the LHC (and HL-LHC) currently not fully explored
- Modes with of limited LHC sensitivity are of particular importance
  - Currently under study
- Detailed discussion of exotic Higgs decays at Phys. Rev. D 90, 075004 (2014)
- Next step: study a selected number of final states

$h \to \not{E}_T$

$h \to 4b$

$h \to 2b2\tau$

$h \to 2b2\mu$

$h \to 4\tau, 2\tau2\mu$

$h \to 4j$

$h \to 2\gamma2j$

$h \to 4\gamma$

$h \to ZZ_D, Za \to 4\ell$

$h \to Z_D Z_D \to 4\ell$

$h \to \gamma + \not{E}_T$

$h \to 2\gamma + \not{E}_T$

$h \to 4$ ISOLATED LEPTONS $+ \not{E}_T$

$h \to 2\ell + \not{E}_T$

$h \to$ ONE LEPTON-JET $+ X$

$h \to$ TWO LEPTON-JETS $+ X$

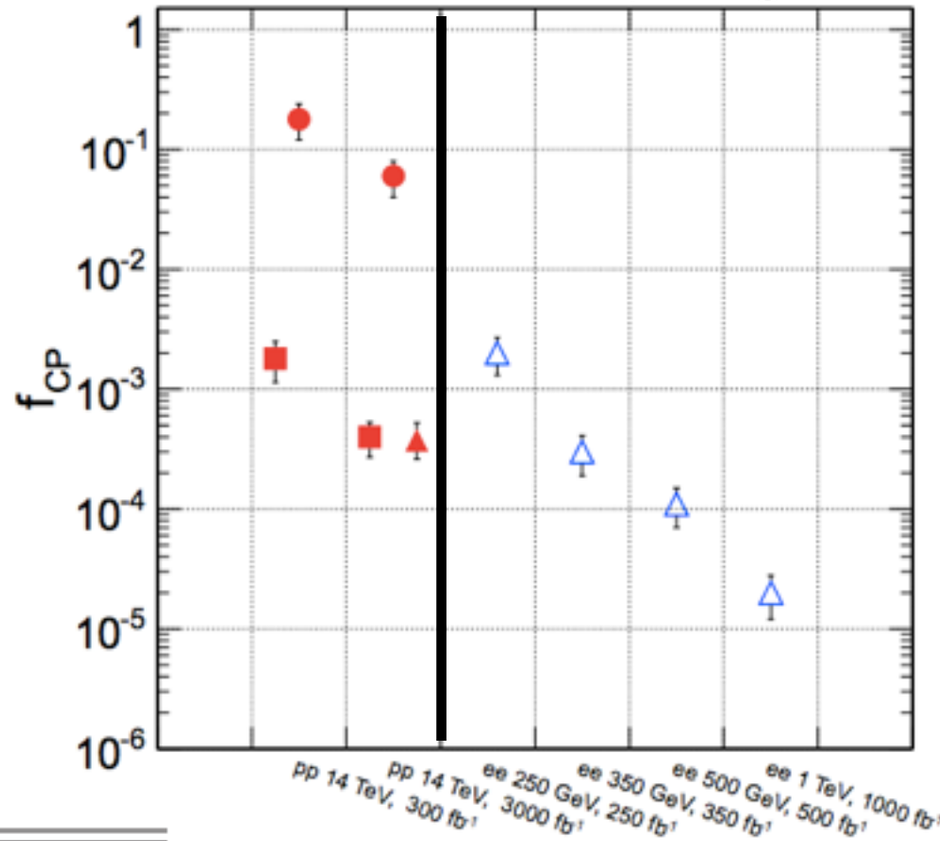
$h \to b\bar{b} + \not{E}_T$

$h \to \tau^+\tau^- + \not{E}_T$

CP Measurements

- CP violation can be studied by searching for CP-odd contributions; CP-even already established
- Snowmass Higgs paper http://arxiv.org/abs/1310.8361
- Higgs to Tau decays of interest
- Estimates available in literature, but somehow naive
- FCC-ee studies are ongoing

for HVV couplings



$$\mathcal{L}_{hff} \propto h\bar{f}(\cos\Delta + i\gamma_5 \sin\Delta)f$$

HL-LHC ~11°

http://arxiv.org/abs/1308.1094

ILC 1/ab

$\sigma_{e^+e^-\to hZ}$	0.30 pb
$\mathrm{Br}(h \to \tau^+\tau^-)$	6.1%
$\mathrm{Br}(\tau^- \to \pi^-\pi^0\nu)$	26%
$\mathrm{Br}(Z \to \mathrm{visibles})$	80%
N_{events}	990
Accuracy	4.4°

CEPC1	CEPC5	CEPC10
5.5°	2.5°	1.7°

Summary

- Exploring Higgs physics potential beyond TLEP Physics case studies
  - This talk gives some highlights, not the complete picture
- Exploring requirements / constraints on detector and machine
- Manpower needed to fully explore potential
- Details on Higgs work package in Krisztian's at in Paris