Higgs Bosons at Future Lepton Colliders

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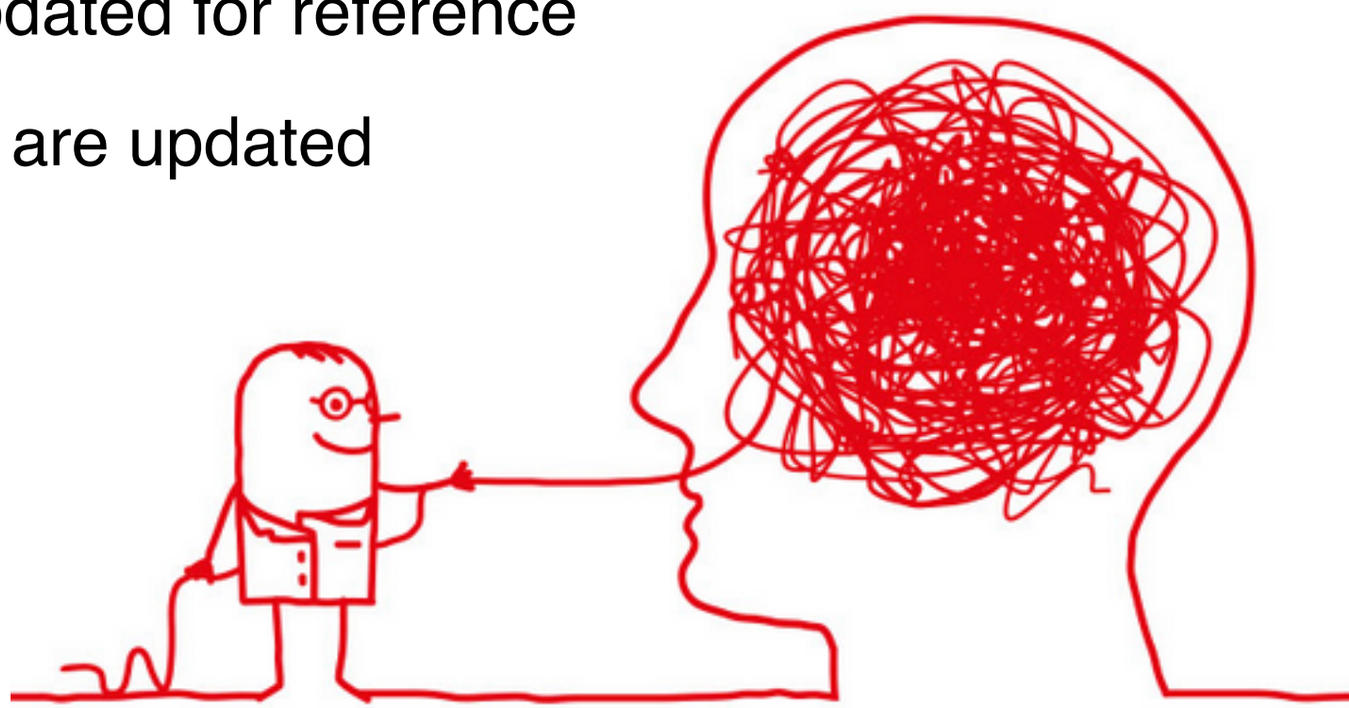
January 30th, 2017
FCC-ee Physics Meeting - CERN

Introduction

- **Comparing the Higgs physics potential between collider options is constant source for criticism and debate**
  - Hadron collider Higgs coupling measurement are model dependent
  - Lepton collider options are compared with varying assumptions on energy, luminosity, polarization, and run time of the machines, etc
- **These slides are based on a talk at Higgs Couplings 2015**
  - Attempt to update and keep updated for reference
  - So far, only the summary table are updated



Future Lepton Collider Projects

- ➡ International Linear Collider (ILC)
- ➡ **Compact Linear Collider (CLIC)**
- ➡ Circular Electron Positron Collider (CEPC)
- ➡ Future Circular Collider (FCC-ee)
- ➡ Muon Collider

CDR Vol 2: Physics and Detectors - arXiv:1203.5940
CDR Vol 3: The CLIC Programme - arXiv: 1209.2543
CLIC Snowmass White Paper - arXiv: 1307.5288

CLIC
50km, 100V/m
3000 GeV

- ➡ Normal conducting accelerator structures operated at room temperature
- ➡ Two beam acceleration technique provides 100MV/m gradient
- ➡ Implementation in energy stages, driven by physics and technical considerations
- ➡ Each stage correspond to 4-5 years of data taking

Parameter	Symbol	Unit	Stage 1	Stage 2	Stage 3
Center-of-mass energy	$\sqrt{s}$	GeV	350	1400	3000
Integrated luminosity	$\mathscr{L}_{\text{int}}$	ab^{-1}	0.5	1.5	2.0

New CLIC Results

➡ Latest on Higgs physics from CLIC

- https://arxiv.org/abs/1608.07538
- polarization considered for 1.4 and 3 TeV

Parameter	Relative precision		
	350 GeV	+ 1.4 TeV	+ 3 TeV
	500 fb^{-1}	+ 1.5 ab^{-1}	+ 2 ab^{-1}
g_{HZZ}	0.8 %	0.8 %	0.8 %
g_{HWW}	1.3 %	0.9 %	0.9 %
g_{Hbb}	2.8 %	1.0 %	0.9 %
g_{Hcc}	6.0 %	2.3 %	1.9 %
$g_{H\tau\tau}$	4.2 %	1.7 %	1.4 %
$g_{H\mu\mu}$	–	14.1 %	7.8 %
g_{Htt}	–	4.4 %	4.4 %
$g^{\dagger}_{Hgg}$	3.6 %	1.7 %	1.4 %
$g^{\dagger}_{H\gamma\gamma}$	–	5.7 %	3.2 %
$g^{\dagger}_{HZ\gamma}$	–	15.6 %	9.1 %
Γ_H	6.4 %	3.7 %	3.6 %

Expected Precision on Higgs Parameters

Uncertainties	μ-Collider	CLIC	ILC*	CEPC	FCC-ee
m_H [MeV]	**0.06**		30	5.5	8
Γ_H [MeV]	0.17	0.15	0.16	0.12	**0.04**
g_{HZZ} [%]	-	0.8	0.6	0.25	**0.15**
g_{HWW} [%]	2.2	0.9	0.8	1.2	**0.2**
g_{Hbb} [%]	2.3	1.0	1.5	1.3	**0.4**
$g_{H\tau\tau}$ [%]	5	1.7	1.9	1.4	**0.5**
$g_{H\gamma\gamma}$ [%]	10	5.7	7.8	4.7	**1.5**
g_{Hcc} [%]	-	2.3	2.7	1.7	**0.7**
g_{Hgg} [%]	-	1.7	2.3	1.5	**0.8**
g_{Htt} [%]	-	**4.4**	18	-	-
$g_{H\mu\mu}$ [%]	**2.1**	14	20	8.6	6.2
g_{HHH} [%]	-	**24**	-	-	-

*ILC lumi upgrade improves precision by factor 2

for ~10y operation
lots of "!,*,?" in this table

Expected Precision on Higgs Parameters

Uncertainties	HL-LHC*	μ-Collider	CLIC	ILC**	CEPC	FCC-ee
m_H [MeV]	40	**0.06**		30	5.5	8
Γ_H [MeV]	-	0.17	0.15	0.16	0.12	**0.04**
g_{HZZ} [%]	2.0	-	0.8	0.6	0.25	**0.15**
g_{HWW} [%]	2.0	2.2	0.9	0.8	1.2	**0.2**
g_{Hbb} [%]	4.0	2.3	1.0	1.5	1.3	**0.4**
$g_{H\tau\tau}$ [%]	2.0	5	1.7	1.9	1.4	**0.5**
$g_{H\gamma\gamma}$ [%]	2.0	10	5.7	7.8	4.7	**1.5**
g_{Hcc} [%]	-	-	2.3	2.7	1.7	**0.7**
g_{Hgg} [%]	3.0	-	1.7	2.3	1.5	**0.8**
g_{Htt} [%]	**4.0**	-	4.4	18	-	-
$g_{H\mu\mu}$ [%]	4.0	**2.1**	14	20	8.6	6.2
g_{HHH} [%]	30	-	**24**	-	-	-

* Estimate for two HL-LHC experiments
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Proposed set of slides

- **Introduction**
  - Case for precision Higgs physics
  - Future lepton collider projects in a nutshell
- **Higgs Production at Lepton Colliders**
  - Processes
  - Energy
  - Luminosity
- **Higgs studies at lepton collider**
  - Couplings
  - Mass
  - Total width
  - BSM Higgs
- **Complementarity to hadron collider**
- **Conclusions**