Higgs Physics – input to EPPSU

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- European Particle Physics Strategy Update process
- Should the Higgs sector drive the strategy?
- What will it take to make the right decision?

Why European Particle Physics Strategy?

- Relation between ESFRI and CERN had to be clarified within the European Commission
  - ESFRI, the European Strategy Forum on Research Infrastructures, is a strategic instrument to develop the scientific integration of Europe and to strengthen its international outreach.
  - CERN's convention mandates coordination of infrastructure of particle physics for Member States

- First ESFRI roadmap published in 2006, with 35 projects, the Roadmap was updated in 2008 bringing the number of RIs of pan-European relevance to 44. Later updates 2008, 2010, 2016, 2018

- First European Particle Physics Strategy (EPPS) called by CERN Council in 2005 and endorsed in 2006, latest update in 2013… next in 2020.

Strategy Group Remit for the 2006 EPPS

The Strategy Group shall aim:

- to enhance the visibility of existing European particle physics programs;
- to foster increased collaboration among Europe's particle physics laboratories and institutes;
- to promote a coordinated European participation in world-wide projects;
- (to reiterate the CERN Council's 2004 position on the European strategy for the International Linear Collider;)
- to encourage knowledge transfer to other disciplines, industries, and society;
- to outline priorities, at least implicitly;
- to consider time scales;
- to follow a thematic or project approach, whichever is more appropriate.

European Strategy 2013 – next update 2020

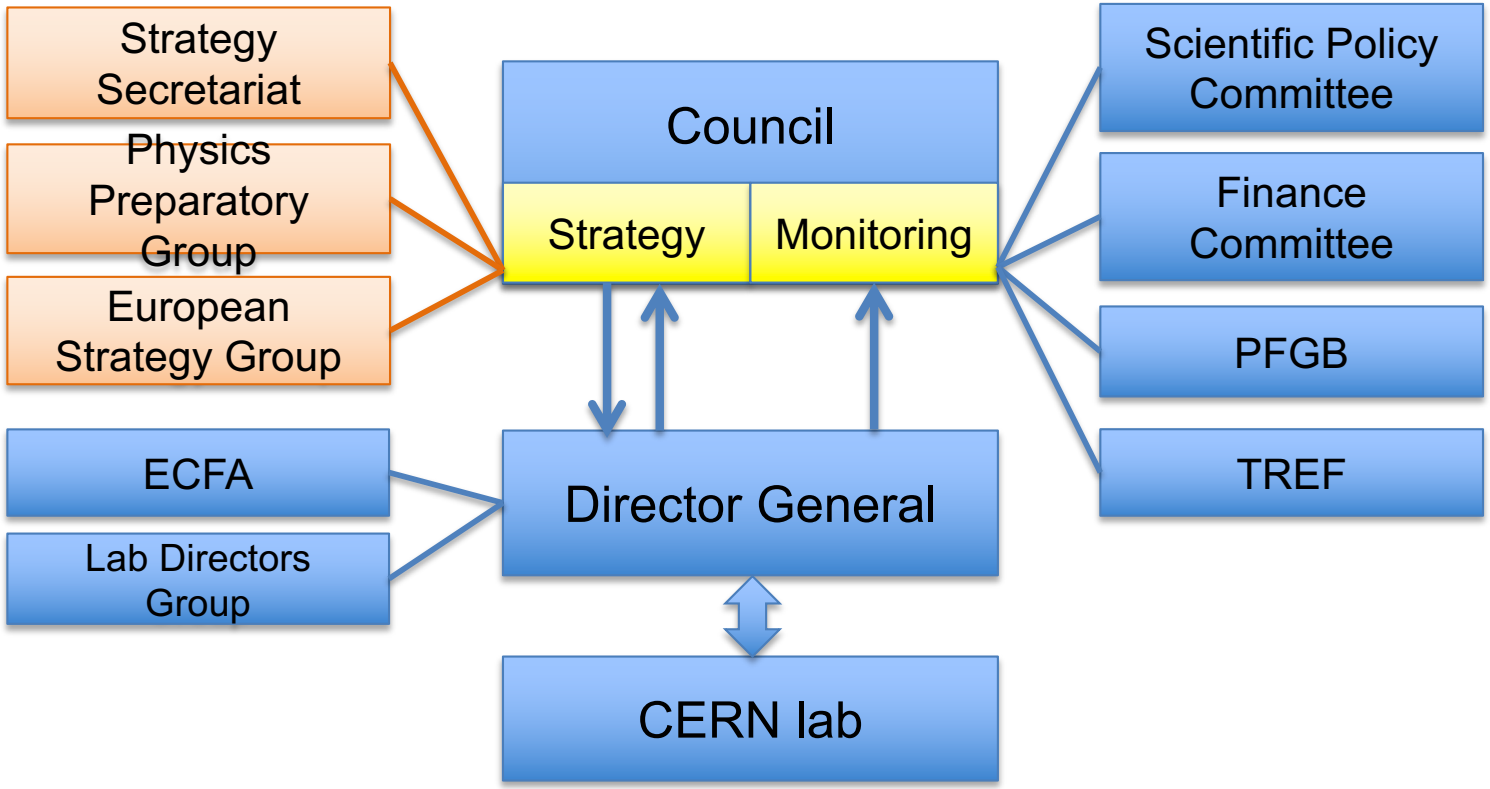
- Europe's top priority should be the exploitation of the full potential of the LHC, including the high-luminosity upgrade of the machine and detectors with a view to collecting ten times more data than in the initial design, by around 2030. (HL-LHC)

- CERN should undertake design studies for accelerator projects in a global context, with emphasis on proton-proton and electron-positron high-energy frontier machines. These design studies should be coupled to a vigorous accelerator R&D programme (CLIC, FCC hh,ee,ep … AWAKE)

- There is a strong scientific case for an electron-positron collider… The Technical Design Report of the International Linear Collider (ILC) has been completed, with large European participation… Europe looks forward to a proposal from Japan to discuss a possible participation. (Waiting for Japanese Gov. decision)

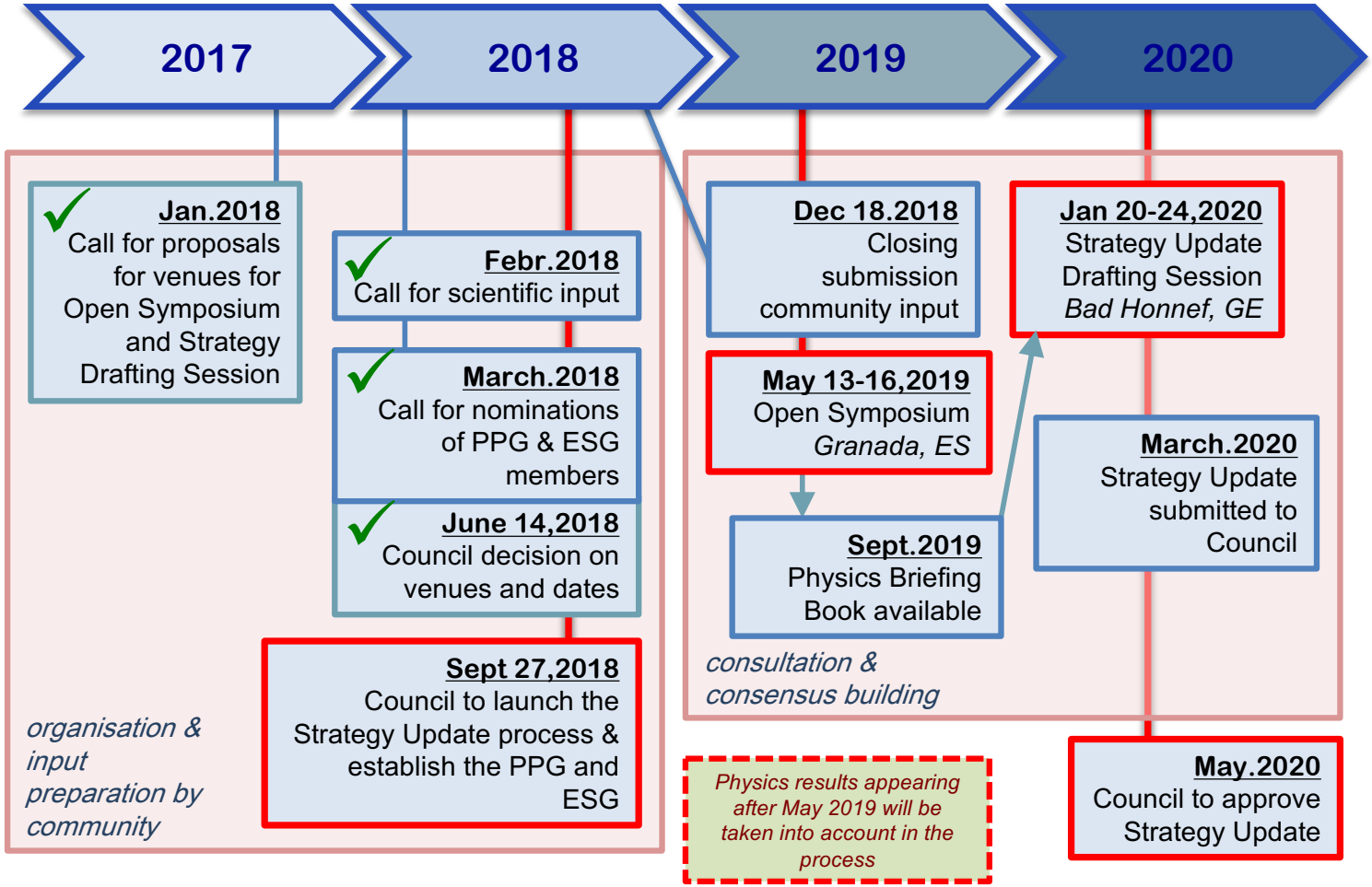
- CERN should develop a neutrino programme to pave the way for a substantial European role in future long-baseline experiments. Europe should explore the possibility of major participation in leading long-baseline neutrino projects in the US and Japan. (LBNF in FNAL – DUNE in S. Dakota)

European Particle Physics organisation & governance



Based on a slide from the President of Council, at the FALC meeting, Cambridge (UK), March 8, 2018

European Particle Physics Strategy *Update*



Input from LHC results

- The Standard Model is doing amazingly well
- The Higgs scalar is very much like expected in the Standard Model
- There is no indication of physics BSM up to scales of the order of TeVs
- Lepton/flavor conservation – hints from LHCb in c/b-decays???

Input from outside LHC

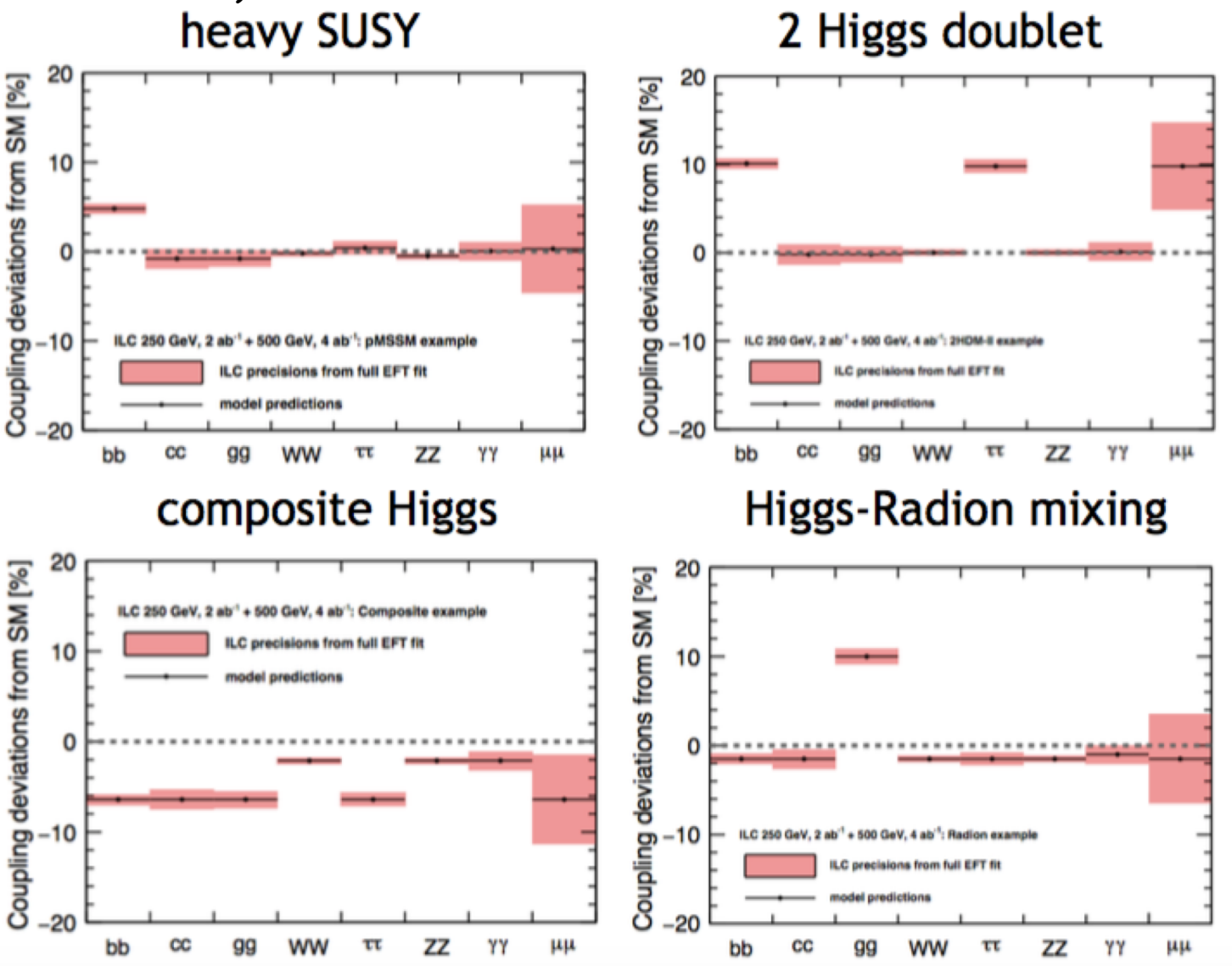
- Neutrinos have masses (oscillations) – not acquired in the SM
- There is dark matter in the Universe with no candidates within the SM (axions???)
- Prevalence of matter over anti-matter
- Theorist believe that the theory is not complete

How should we go about understanding all these issues ?

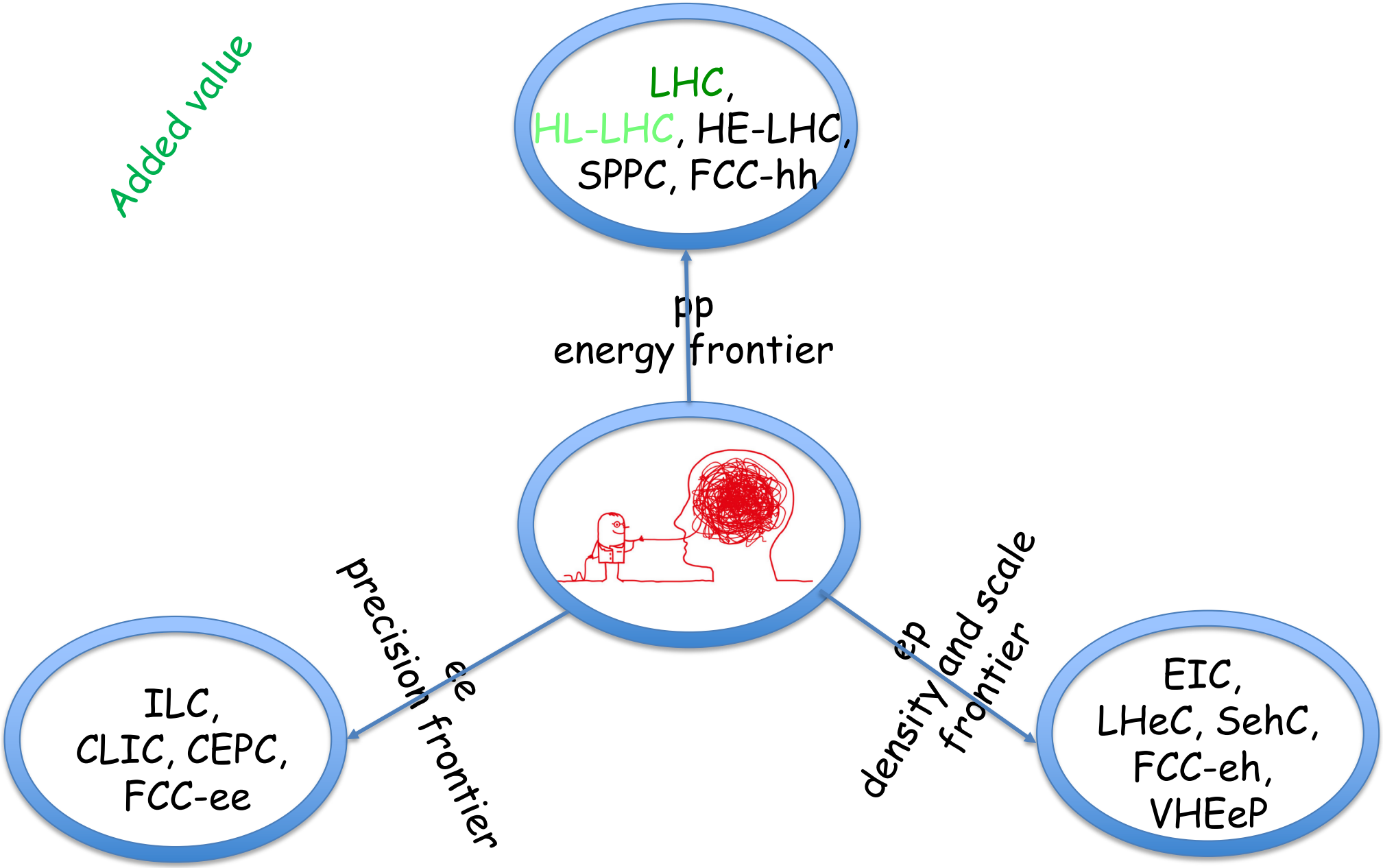
Can precision studies of the Higgs sector lead to a break-through?
Define precision

Sensitivity of Higgs couplings to BSM – is this convincing enough

(arXiV:1506.05392)



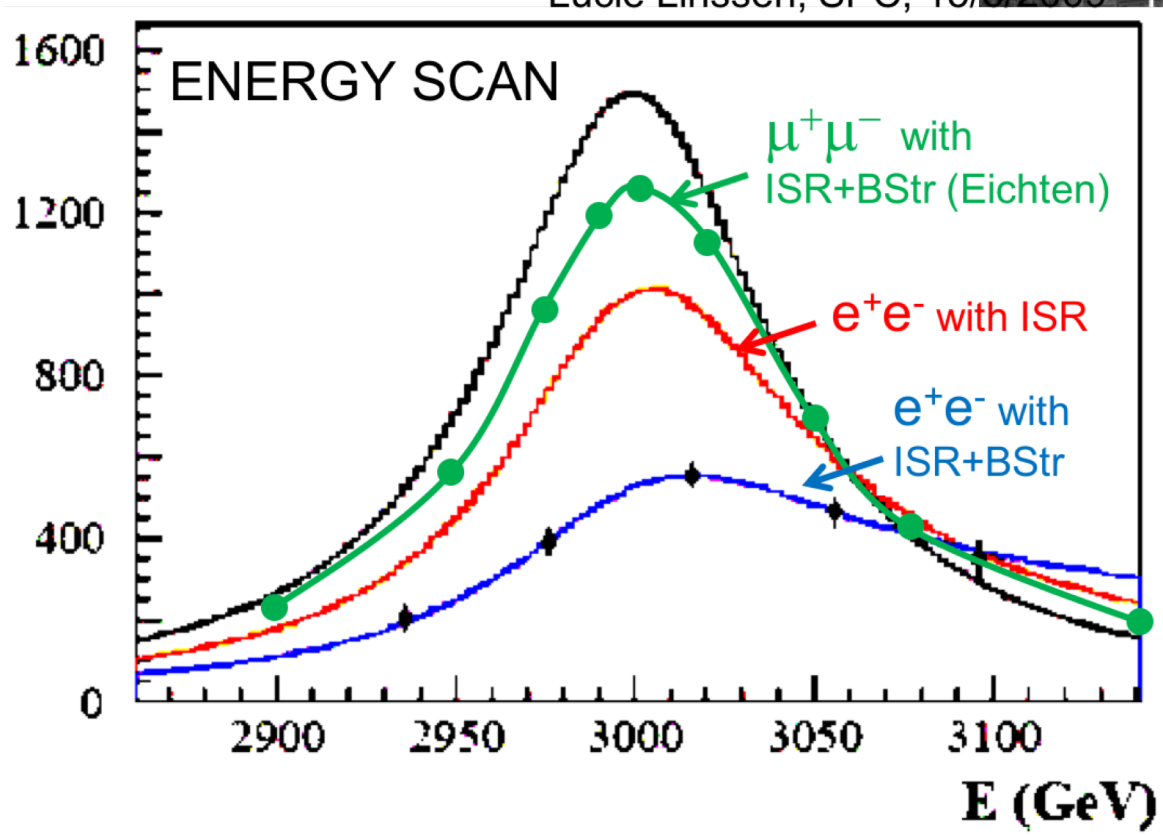
Controlled experiments at accelerators

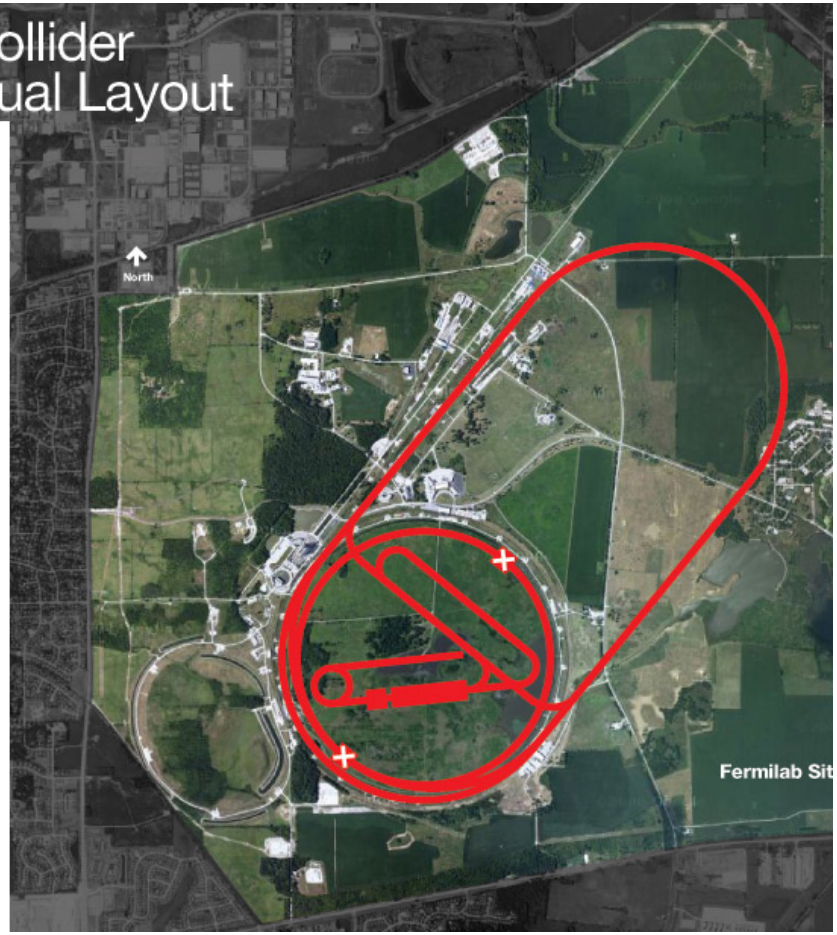


Prescision Frontier – muon collider

- Muon collider – Higgs factory and energy frontier

Circular collider – 120 GeV to 5 TeV, 300 m long (neutrino factory as added bonus)

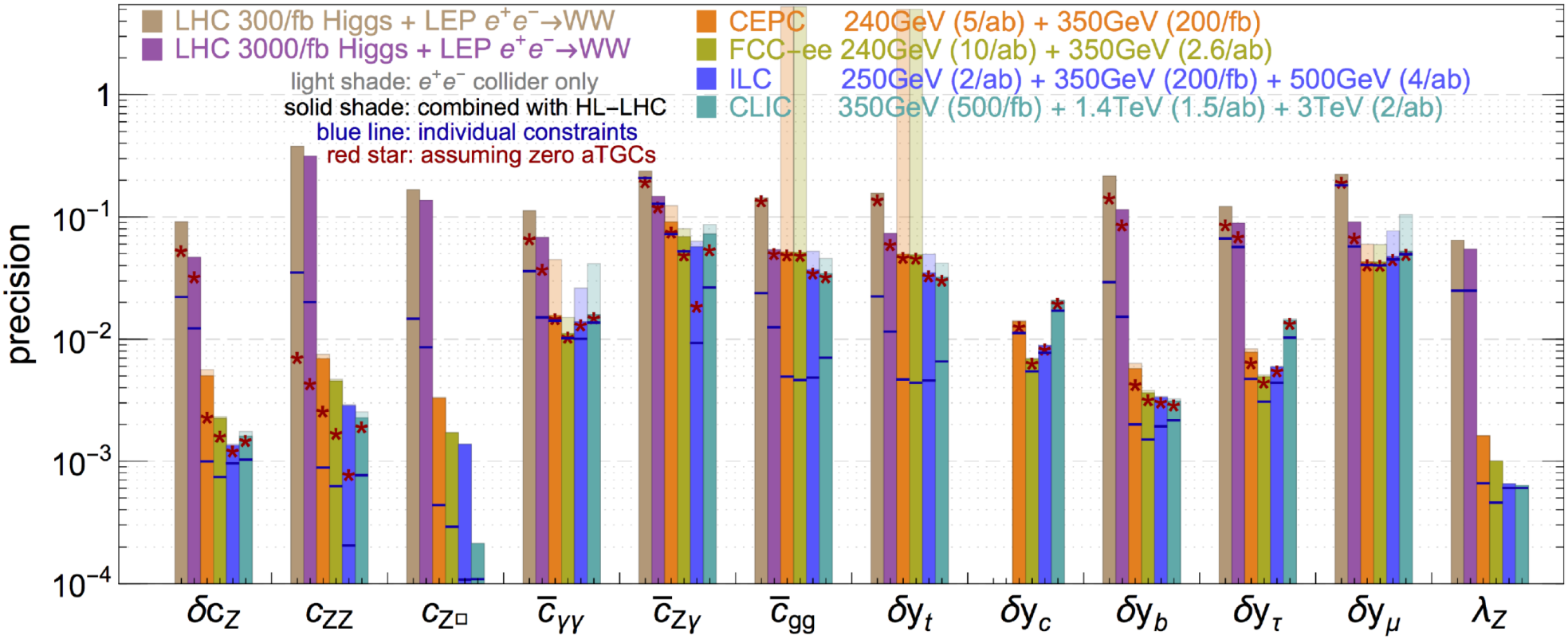




Challenges: to produce enough muons, cool them and compress the beam and all very fast

Comparison between collider options – how to make the comparison convincing

Precision reach of the 12-parameter fit in Higgs basis

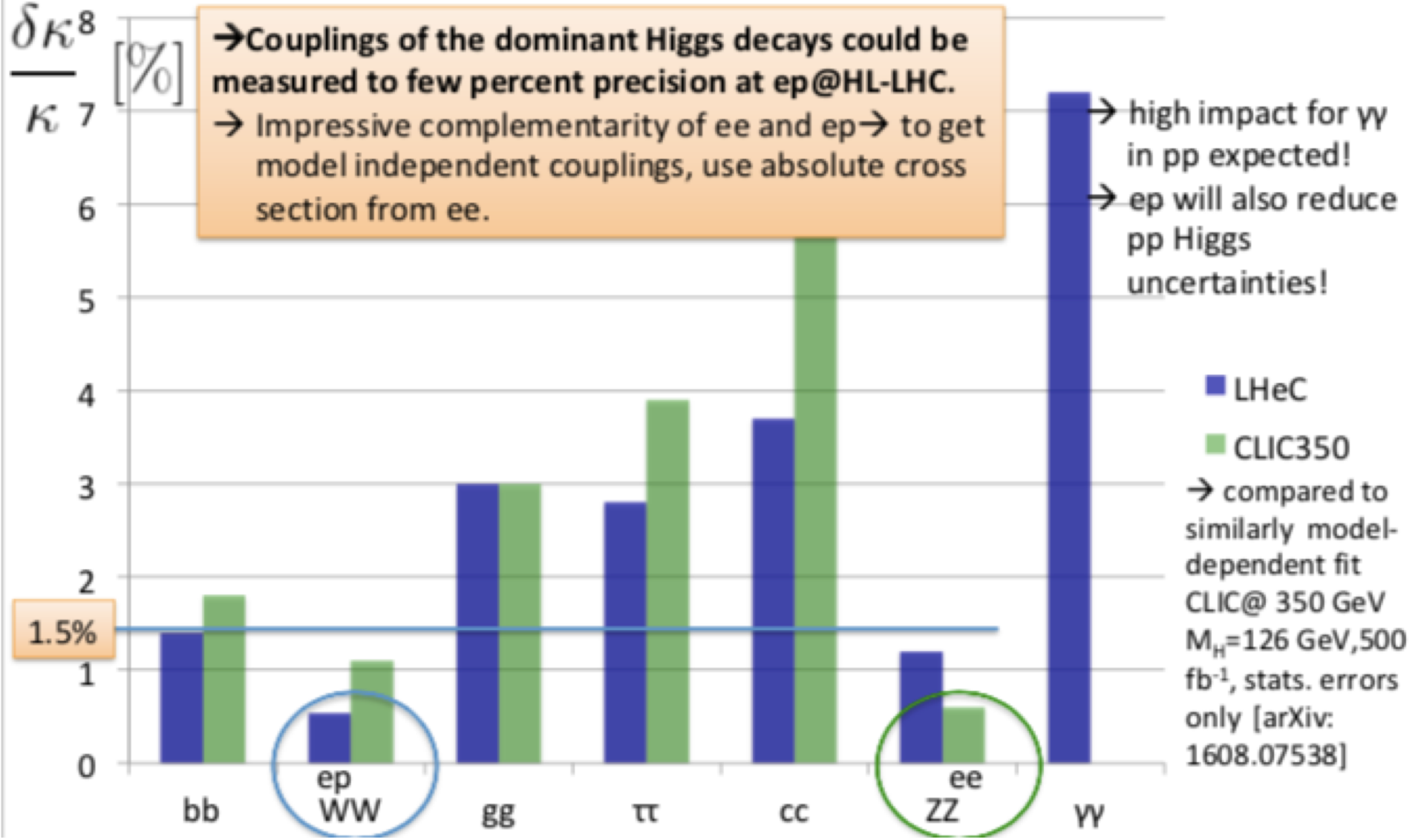


- Many EFT parameters can be measured significantly better at ee than at HL-LHC
- H➔cc only accessible at lepton colliders

arXiv:1704.02333
See also JHEP 1705, 096 (2017)

Uta & Max Klein, Contribution to HL/HE Workshop, 4.4.2018, preliminary

Model-dependent Coupling Fit @ LHeC



Unifying machine parameters and performance for physics (F. Bordry)

LHC 2017

parameter	LHC 2017
allocated physics time T [days]	160
peak luminosity $\hat{L}$ [10^{34} cm^{-2}s^{-1}]	1.5 (levelled)
availability A [%]	81
average turnaround t_{ta} [h]	5 (w/o faults)
(optimum) run time t_{run} [h]	~10
nominal luminosity / day L_{av} [fb^{-1}]	0.4
time-fraction in physics t_{phys} [%]	**50**
int. luminosity L_{int} per expt. [fb^{-1}/yr]	**50**

Draft for CERN ee machines

Summary

Machine \ Parameters	FCC-ee Z 91.2 GeV	FCC-ee WW 160 GeV	FCC-ee H (ZH) 240 GeV	FCC-ee ttbar 365 GeV	CLIC 380 GeV	CLIC 1.5 TeV	CLIC 3 TeV
Run time per year [days]	185 for all						
Nominal luminosity / IP [10^{34} cm^{-2}s^{-1}]	200	25	7	1.4	1.5	3.7	6.0
Total integrated luminosity/year [ab^{-1}] for 2 IP	48	6	1.7	0.34			
Total integrated luminosity/year [ab^{-1}] 1 IP					0.18	0.45	0.72

To conclude – up for discussion

- Do we need a new facility for Higgs studies (on top of HL-LHC)?
  - Make the case for precision measurements stronger
  - Define which precision matters?
  - Is 3H coupling more important than the rest of the couplings?
  - …
- Is theory ready to match the "required" precision?
  - Would that help in recommending the next facility?
  - Are theorists ready to spread their expertise?
  - …
- Experimental aspects
  - Come up with recommendations how to compare exp. precisions
  - Would it make sense to separate stat., syst., theory uncertainties
  - Implement accelerator parameters policing
  - …
- Think about added value
  - … technology, society, education, future…..