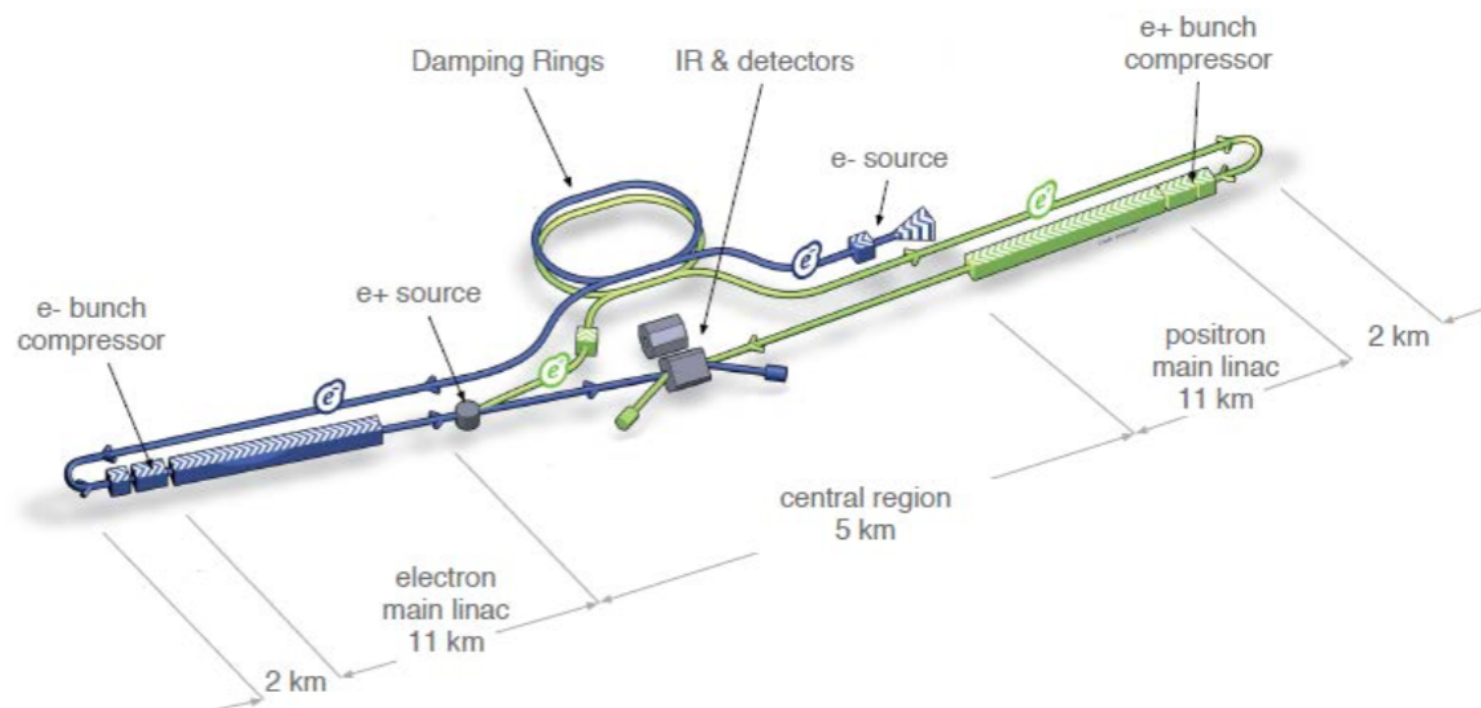


e^+e^- Higgs factories and ILC



M. E. Peskin
SLACmass summary
May 2022

The next 3 talks concern “Higgs factories”, accelerators based on e^+e^- colliders to measure the properties of the Higgs boson with high precision.

Higgs factories are expensive projects, with cost comparable to the LHC. Like the LHC, a Higgs factory should be a global project, involving physicists from all regions of the world.

Like the LHC, a Higgs factory would take about 10 years to construct, plus pre-construction design and R&D.

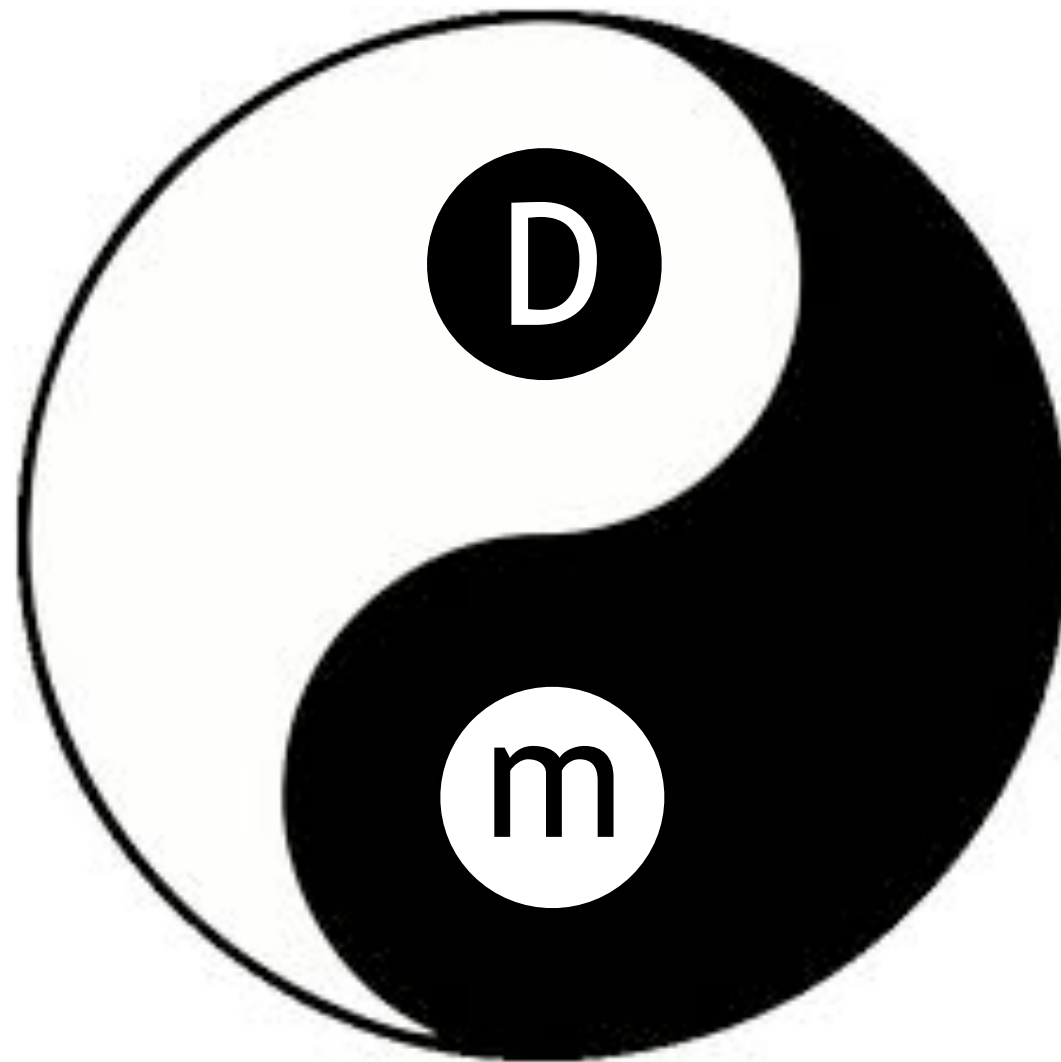
So, the biggest decision to be made at this Snowmass and P5 is whether the US will participate in a Higgs factory. If one will happen, we need to get started now.

Why is the Higgs so important ?

It has a central role in the Standard Model, and its physics dictates the form of any BSM theory.

Lev Okun's this metaphor for the Standard Model Lagrangian, and, by extension, for all of our knowledge of particle physics:

Gauge
side



Higgs
side

Gauge side / Higgs side

Maxwell's equations

Quantum numbers

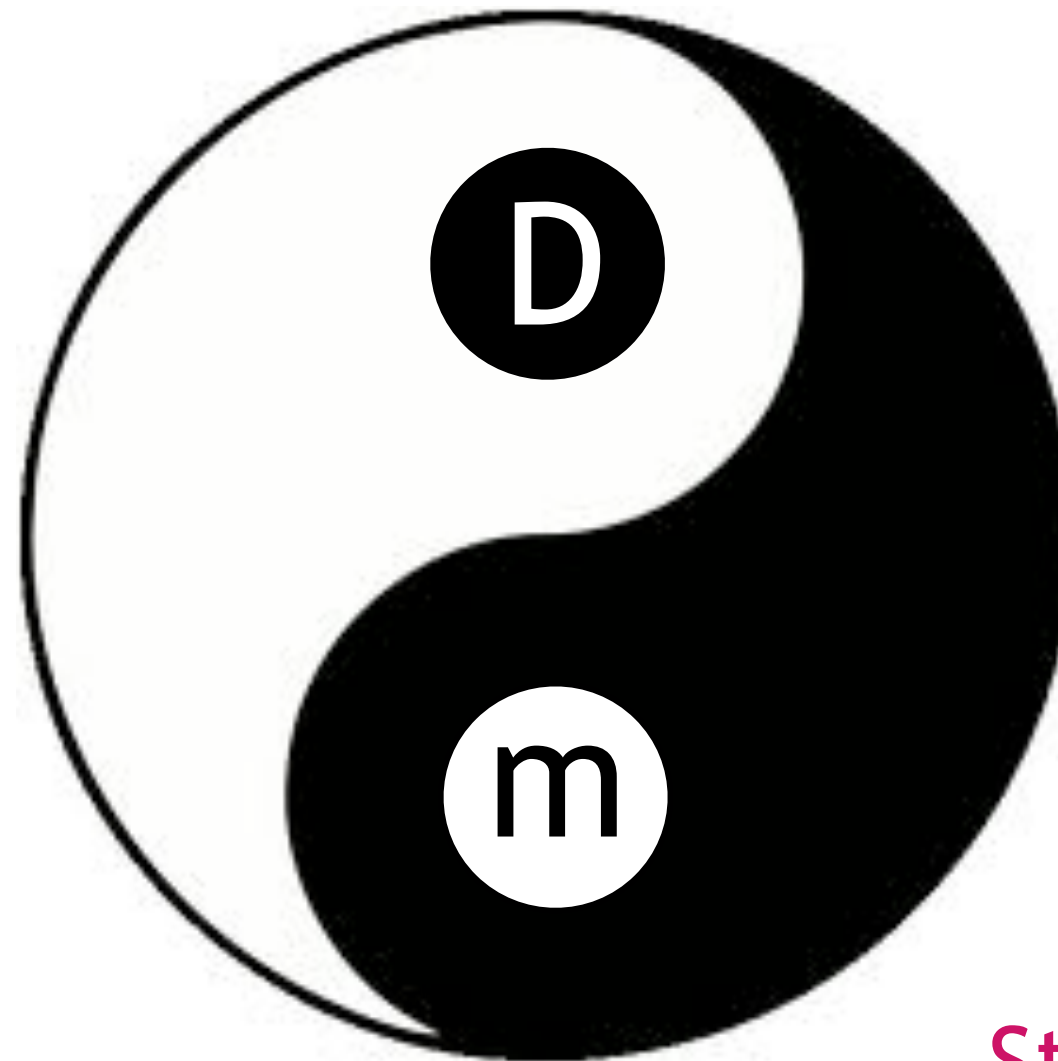
Parity violation

W, Z boson

Proton structure

Asymptotic freedom

Standard Model
all-powerful



W, Z masses

Quark masses and mixings

Neutrino masses

CP violation

L, B violation

Standard Model
impotent

Dark matter? It depends on the model.
WIMP dark matter is firmly on the Higgs side.

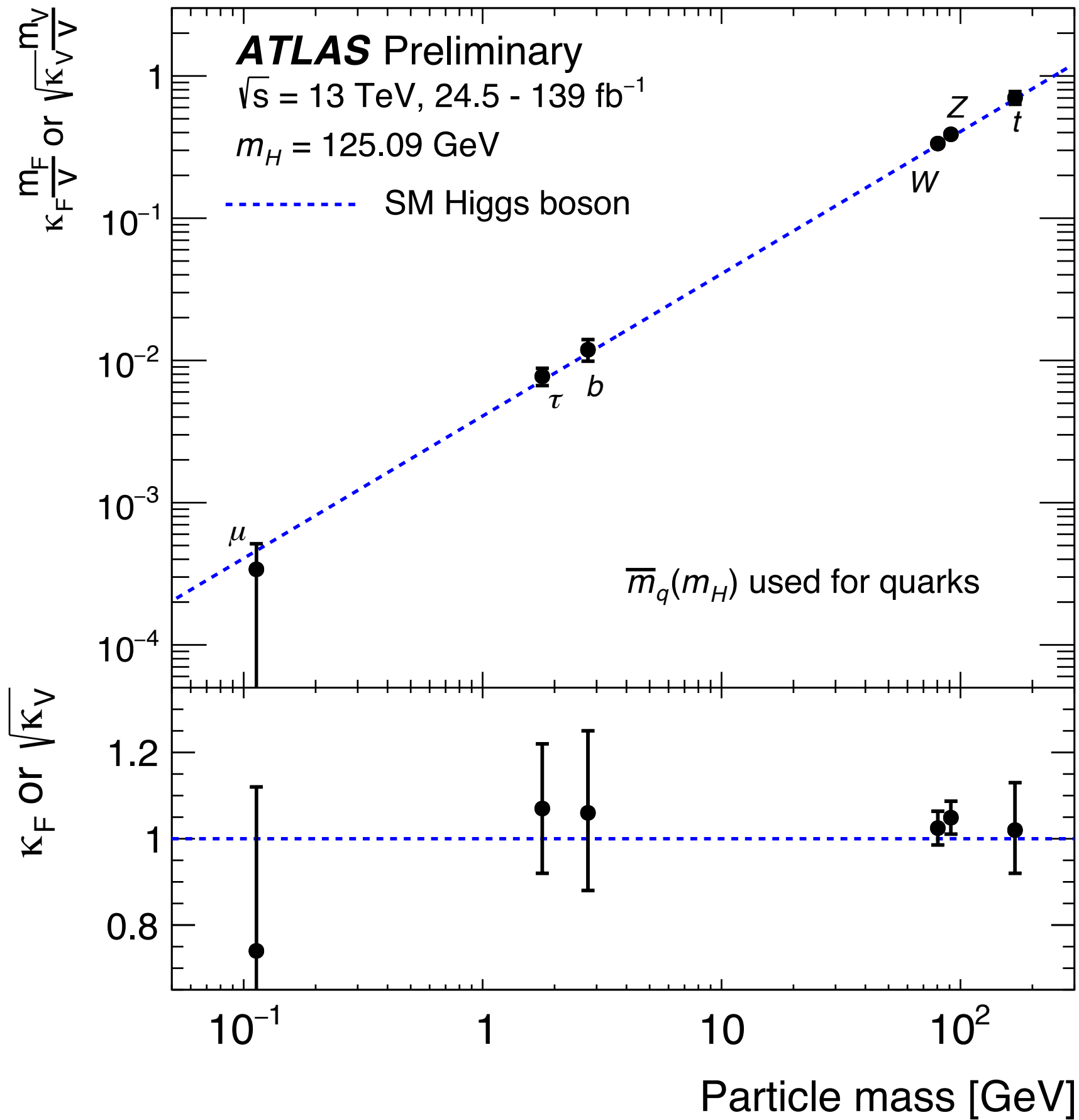
Every model of **neutrino mass, quark mixings, CP violation, baryogenesis** begins with a specific assumption about the nature of the Higgs boson.

Typically, models assume that the Higgs boson is an elementary scalar with no a priori constraints on its couplings.

We cannot make progress on any of the “Higgs side” questions until we understand the principles that cause the Higgs boson to act as it does.

Why do we need to explore the Higgs boson with higher precision ? Doesn't LHC do extremely well already?

What is the target precision for a Higgs factory? Is it only that we should advance beyond LHC/HL-LHC ?



Haven't we
 already proved
 that Higgs is the
 origin of mass ?

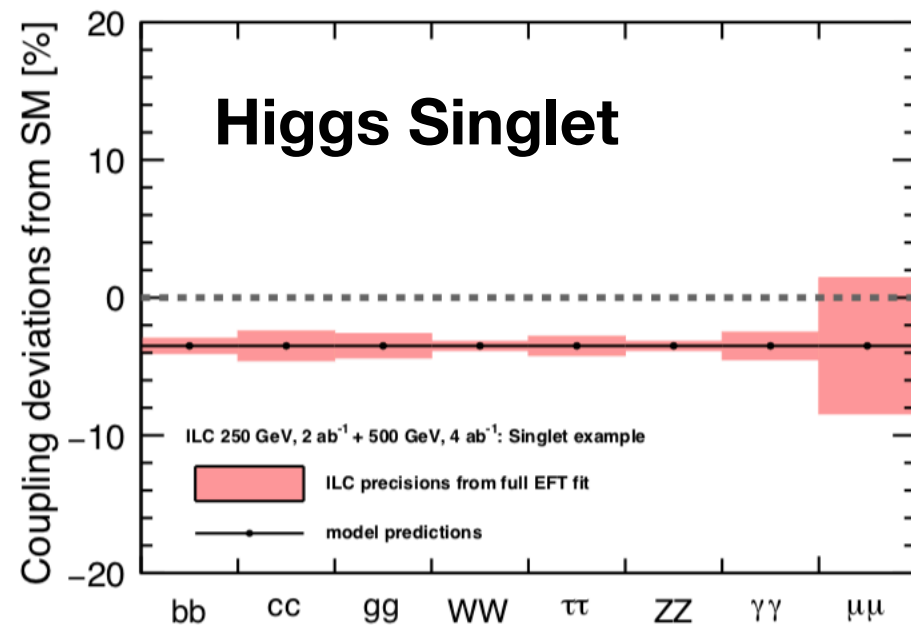
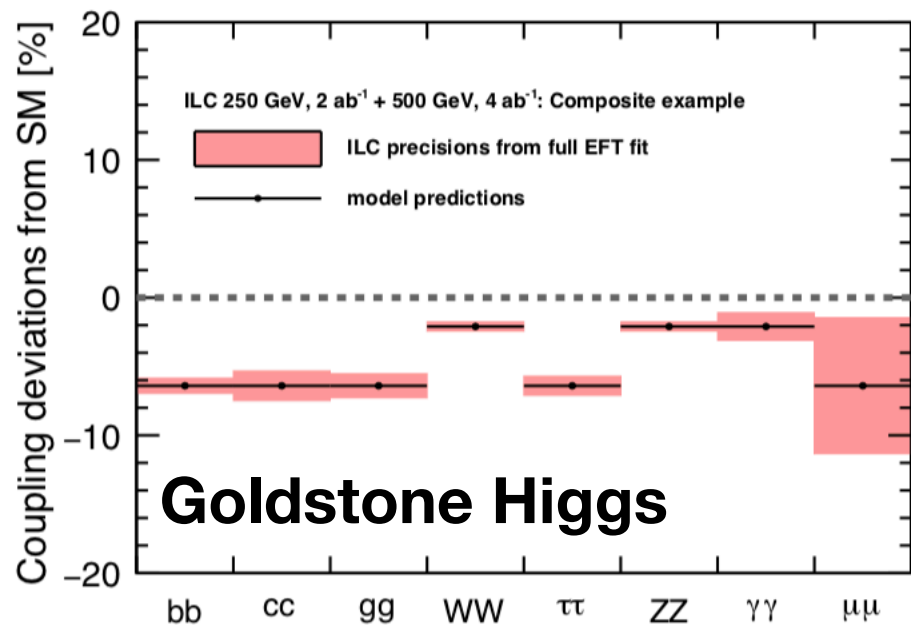
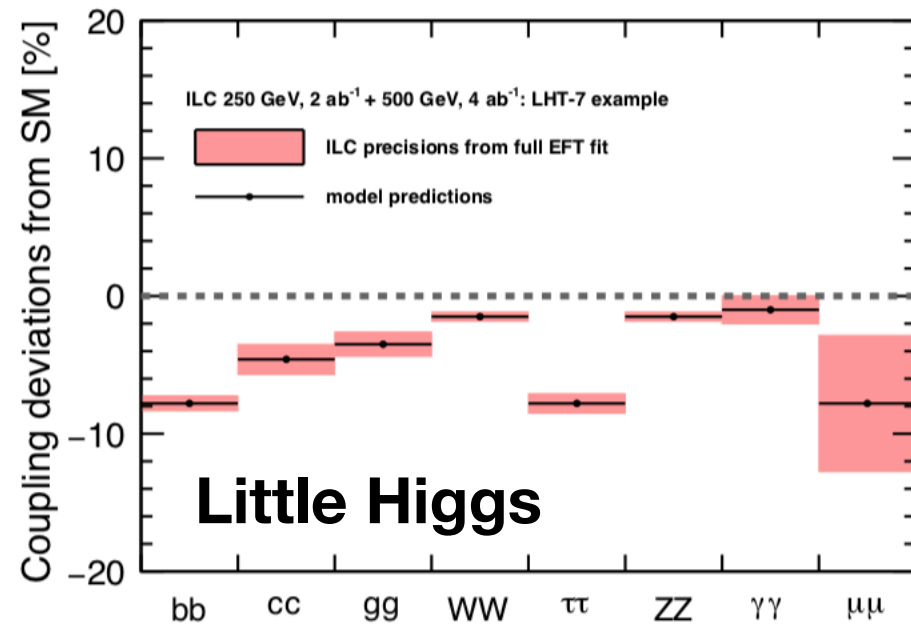
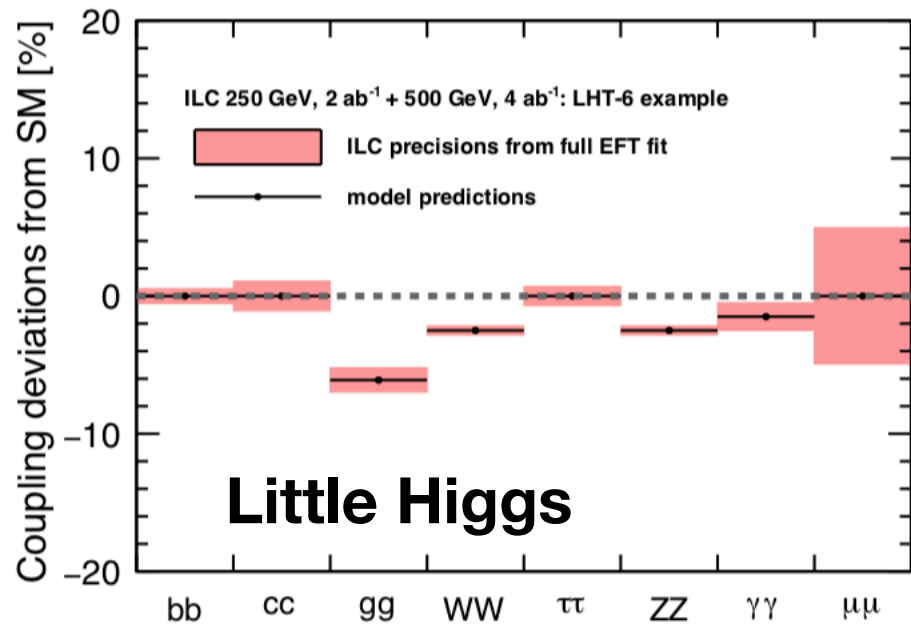
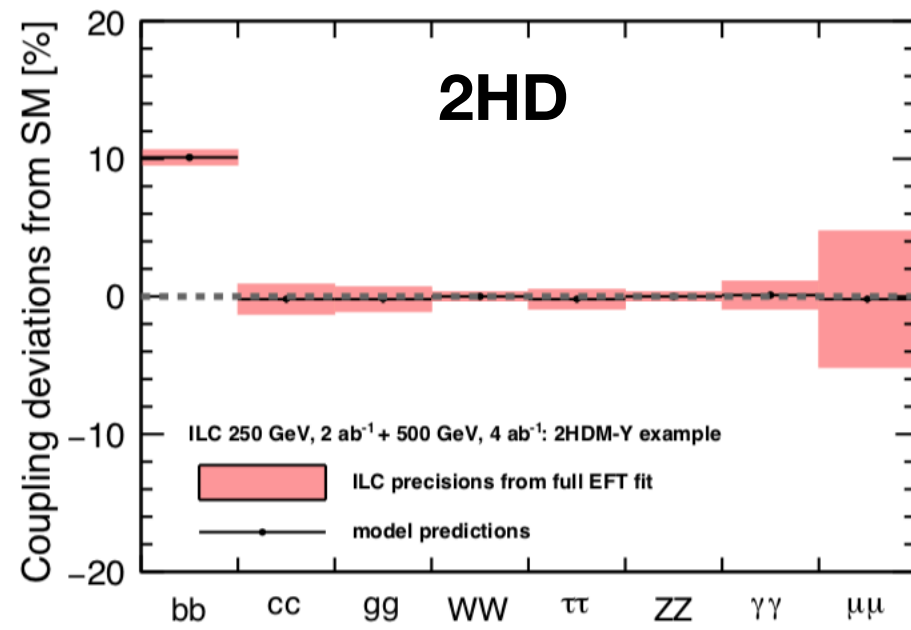
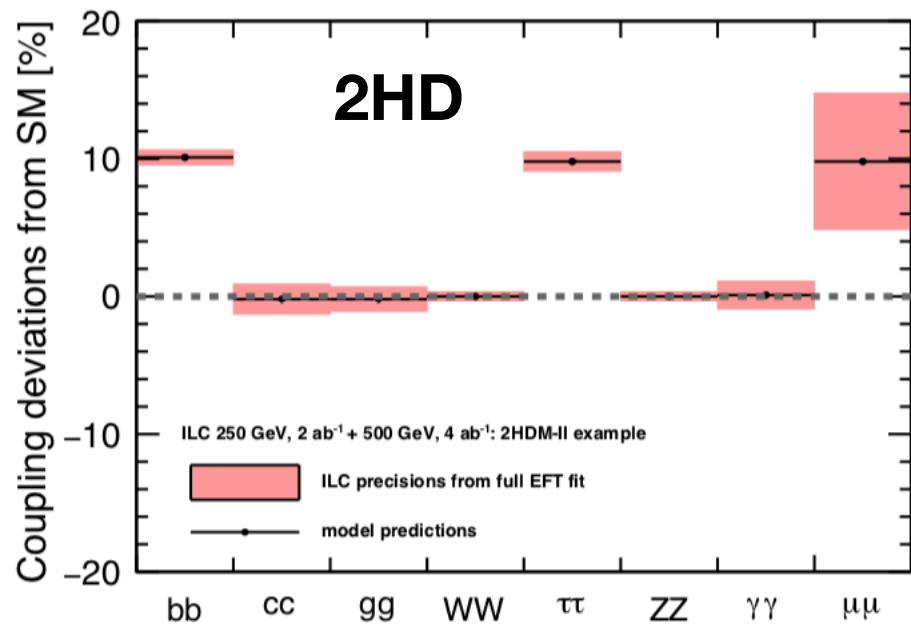
In BSM models with an effective Higgs field and new particles at a much higher mass M , corrections to the SM Higgs properties are of order

$$v^2/M^2 \quad v = 246 \text{ GeV}$$

that is, **well below 10%** for $M \sim 2 \text{ TeV}$.

In such model, we would not have expected to see any deviation from the Standard Model in the current LHC data set. **In fact, today, we are not even in the game.**

On the other hand, once we reach sensitivity to v^2/M^2 effects, the corrections can be of **any form**.



In all cases, the new particles responsible for the deviations are out of reach of HL-LHC.

For a detailed discussion of these points— and much more – see the [ILC Snowmass White Paper](#)

[arXiv:2203.07622](#)

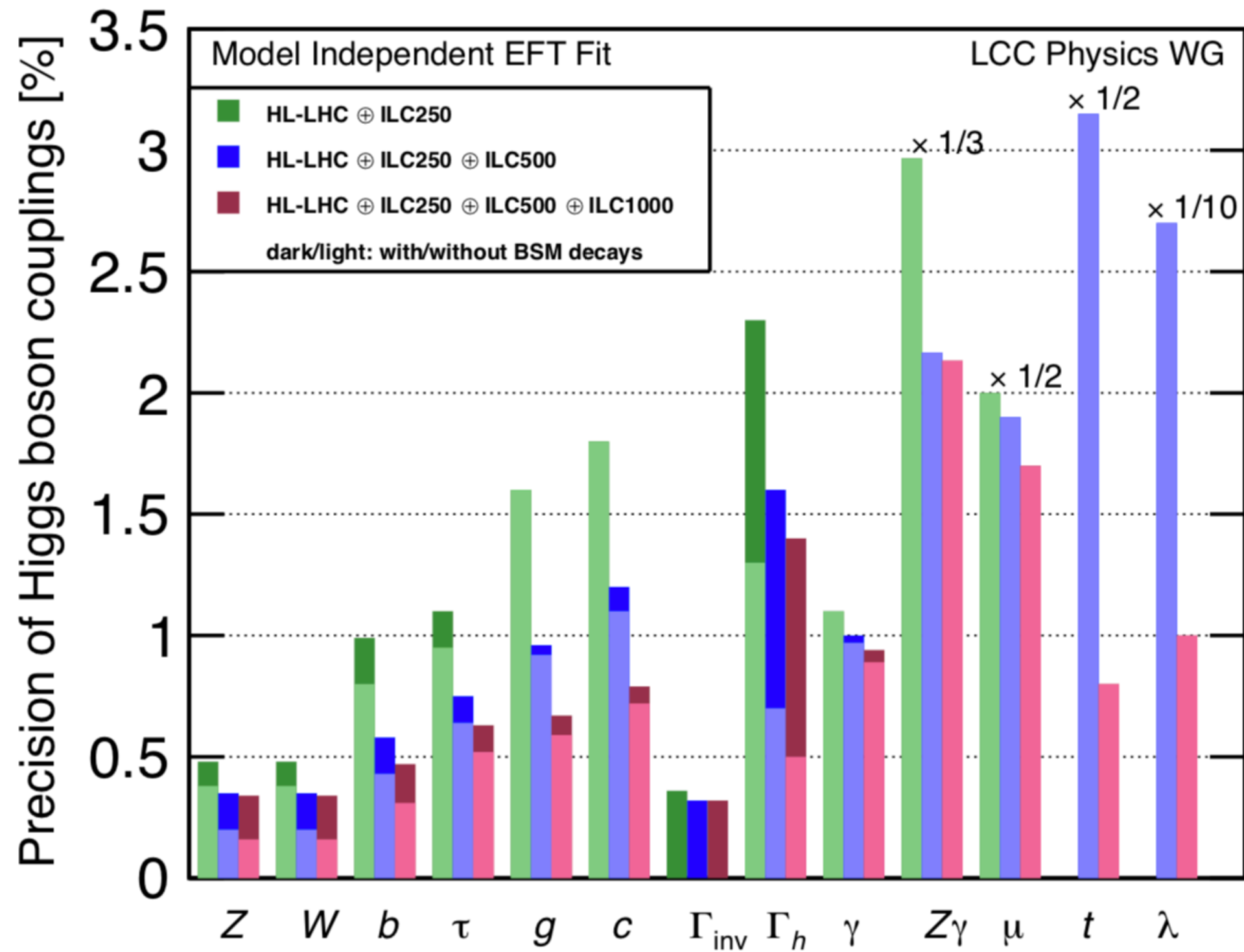
350 pages, 500 authors

This report covers the physics case for the ILC and the machine design. It also reviews the proposed detectors and simulations of the experimental program. **We demonstrate that we can reach Higgs coupling measurements of 1% and beyond, with robust control of uncertainties.**

I encourage you to endorse this report. Please visit

<https://agenda.linearcollider.org/event/9135/>

Projected uncertainties on Higgs boson couplings:



The physics and theory chapters of this report apply to all Higgs factories.

Possible realizations of a Higgs factory:

International Linear Collider in Japan (ILC)

Future Circular Collider (FCC) at CERN – ee version

DG's report in January: 7 years after HL-LHC = 2048

CLIC at CERN

seems to have lost support relative to FCC

Circular Electron Positron Collider (CEPC) in China

international politics is interfering with global support

CCC, XCC proposals – next 2 talks

current timeline of ILC:

- 2013 - submission of TDR, interest from Japan
- 2018 - conclusion of Science Council of Japan study
- 2021 - proposal of the ILC Pre-Lab , MEXT: “premature”
- 2023 - increased funding from Japan for final R&D issues
- 2024 - begin discussions on international cost sharing
- 2028 - begin tunnel construction, SRF cavity procurement
- 2039 - commissioning and first data

At this time, we are requesting funding only for the 250 GeV stage of the ILC.

ILC is the only Higgs factory proposal fully engaged with governments and negotiating funding. As of now, it is the only proposal with a path to first data before 2040.

To make progress in particle physics, we need to understand the Higgs boson. A Higgs factory can discover physics beyond the SM and give concrete evidence into its origin.

Among Higgs factory proposals, the ILC in Japan is now the leader. Snowmass should support US involvement in ILC, if it can be realized in a timely fashion.

At the same time, we should investigate other Higgs factory proposals. One way or another, it is necessary that we explore this physics.