Report
from the ILC Parameters WG

on parameters for ILC staging

2014/09/07

Keisuke Fujii

LCC/LCB creates Joint WG

- Charge:
  - The ILC parameter working group reports to the LCC Directorate. It consists of members from both the ILC accelerator and the physics & detector groups where each team selects a co-convener for this working group.
  - This working group prepares information on ILC machine parameters and staging scenarios as well as potential upgrade paths in a form readily usable by the LCC. In doing so, the WG will take into account technical machine constraints and physics and detector needs regarding the fundamental ILC machine parameters such as energy, luminosity, crossing angles, etc.
  - The first task for the working group is to prepare multiple scenarios for staging up to about 500 GeV. The report should contain the pros and cons of each scenario as well as luminosities needed at each energy to produce corresponding physics results.

LCC/LCB creates Joint WG

- Membership:
  - machine: Jie Gao, N. Walker (co-convener), K. Yokoya,
  - physics & detectors: T. Barklow, J. Brau (co-convener), K. Fujii, J. List

Considerations

- Start at 250 GeV
- Optimize early physics production
- Optimize overall physics reach
- Consider realistic ramp-up and upgrade timeframes
- Operations at 75% for 8 months/calendar year
  - 1.6 x 10^7 seconds/year
- These ~ 25 calendar year programs will be revised by discoveries

Development of study

- Considered about ten scenarios with variants
- Emphasized Higgs precision
- Found high energy running very important to Higgs precision
  - ttH threshold near 500 GeV argues for pushing ~ 500 GeV machine design to ~ 550 GeV
    - 550 GeV NOT explicitly in our scenario studies
  - Reduced number of scenarios to make message clear
    - chose 3 with variants

Physics Goals vs. Energy

250 Gev

- precision Higgs couplings, in particular **g**HZZ
- precision Higgs mass

350 Gev

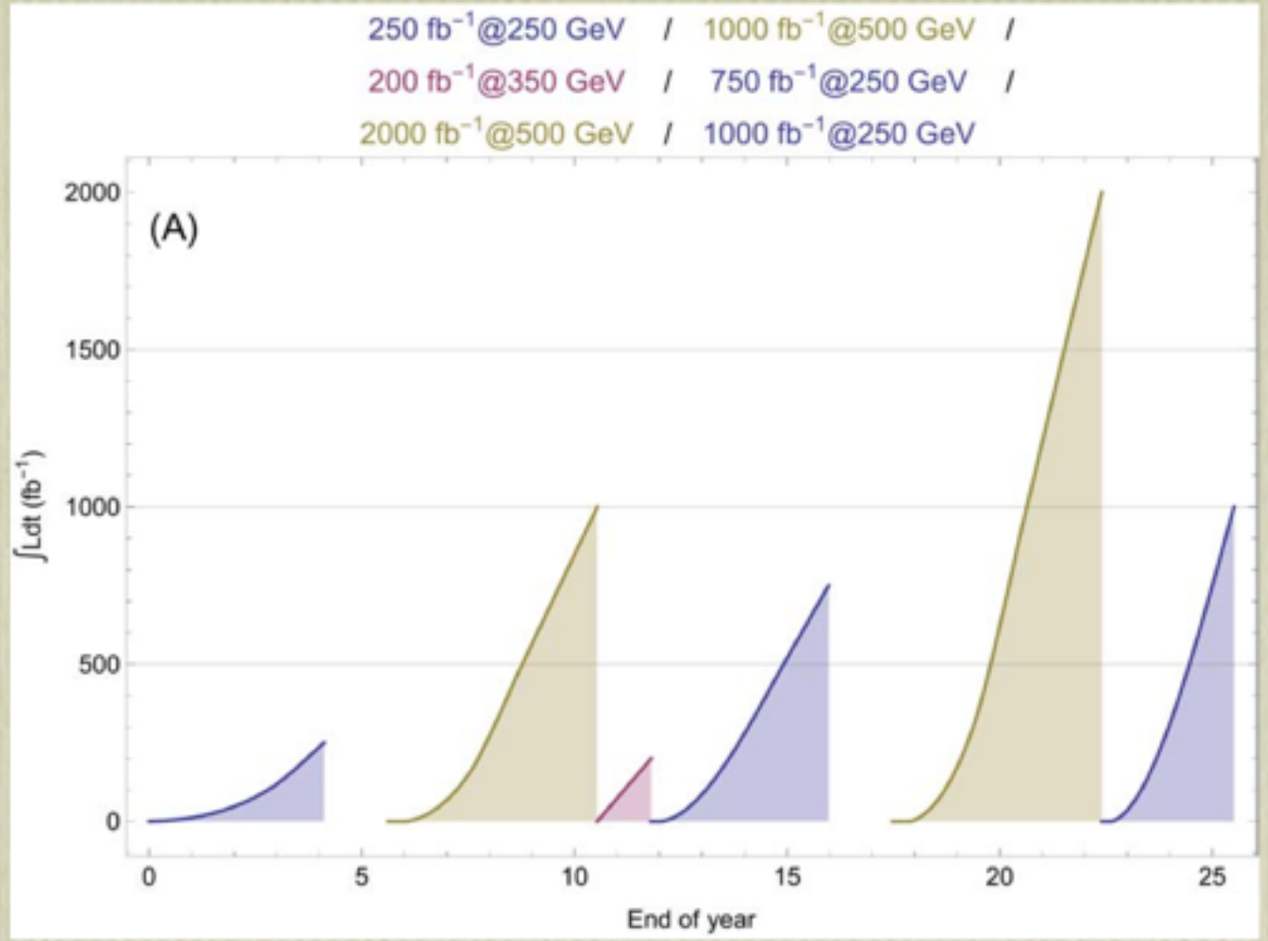
- top quark mass from threshold scan
- precision **W** couplings
- precision Higgs couplings, in particular **g**HWW

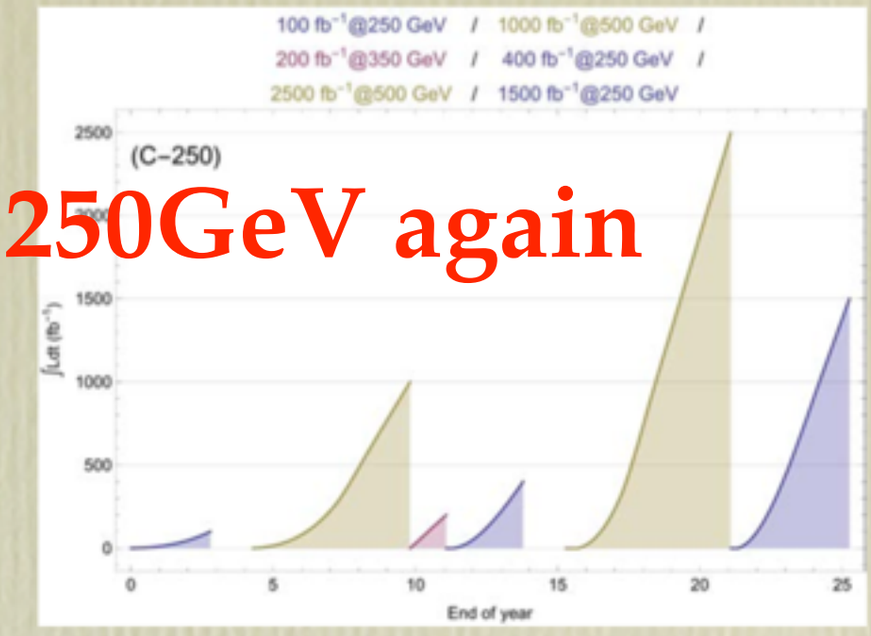
500 Gev

- precision Higgs couplings
- precision electroweak couplings of the top quark
- Higgs couplings to top
- Higgs self-coupling
- precision **W** couplings
- precision search for **Z′**
- search for supersymmetry
- search for Dark Matter
- search for extended Higgs states

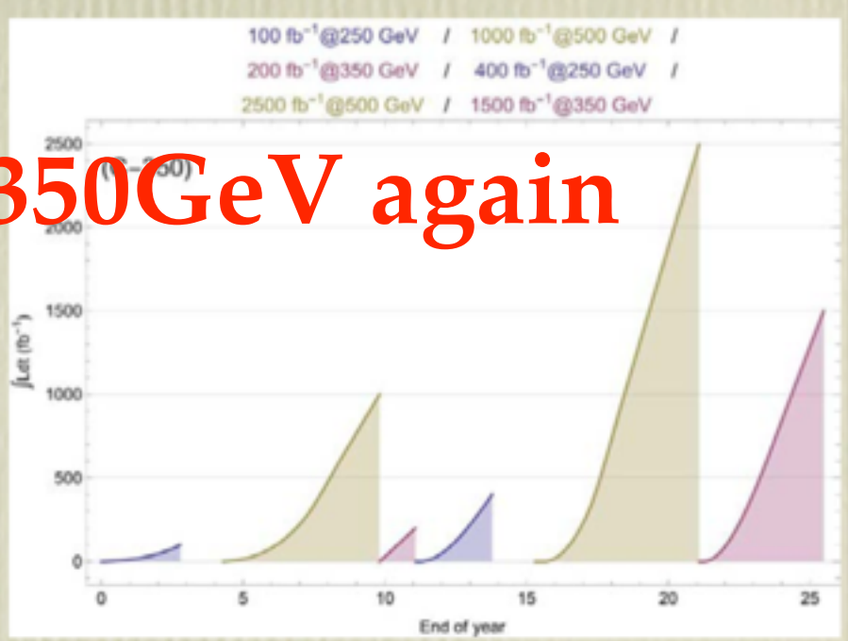
Scenarios

- A: run for 250 fb^{-1} during initial 250 GeV phase (4.1 calendar years)
- B: run for 500 fb^{-1} @ 250 GeV before beginning 500 GeV upgrade (6.2 calendar years)
- C: run for 100 fb^{-1} @ 250 GeV (2.8 calendar years) and then upgrade to 500 GeV
  - 3 variants of C: 250 GeV, 350 GeV, or 500 GeV emphasis in last phase





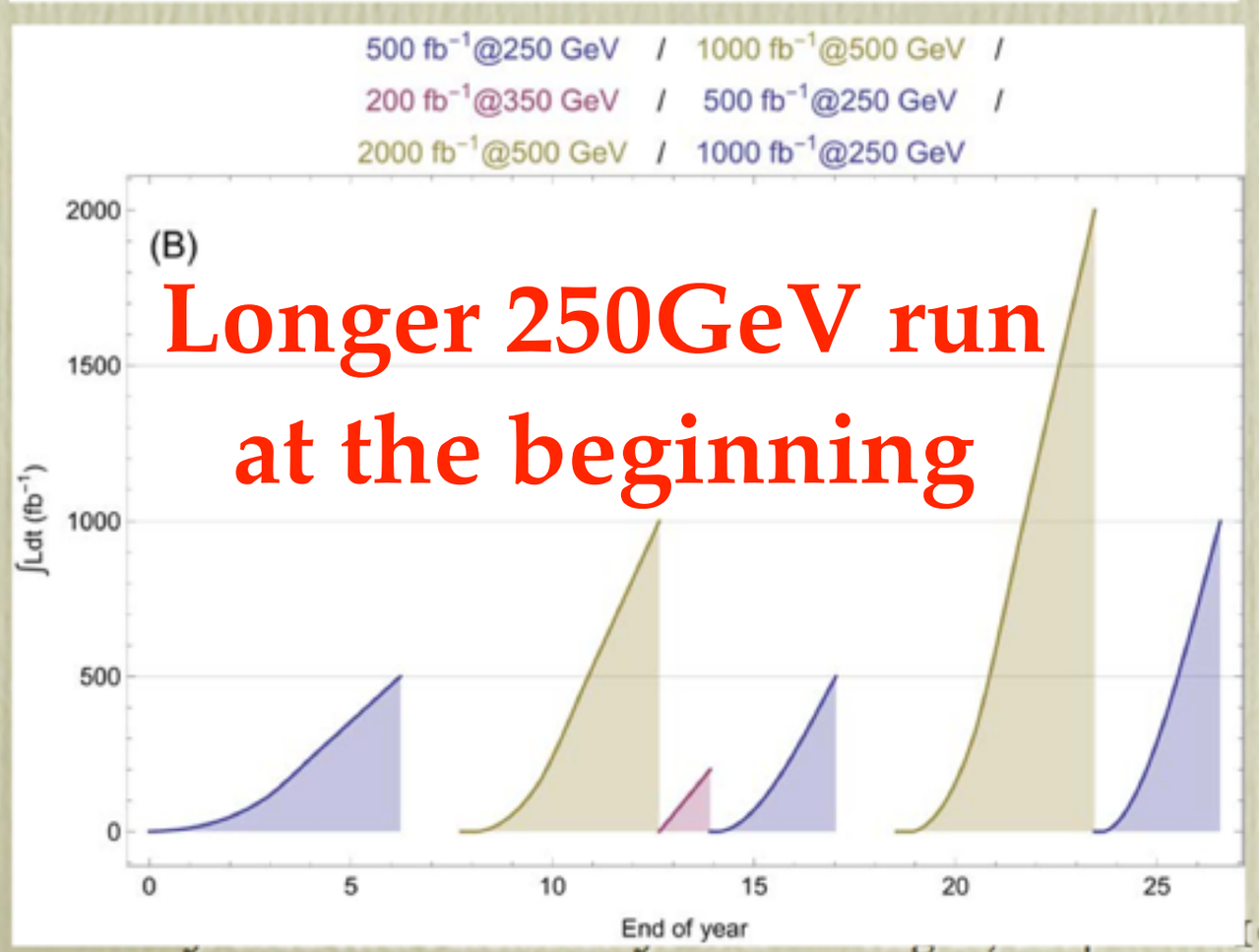
250GeV again



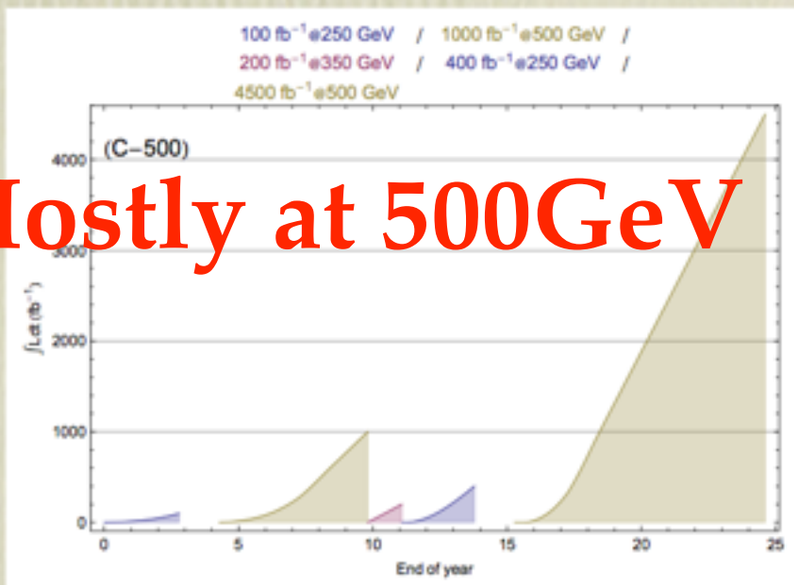
350GeV again

Projected evolution of integrated luminosity with realistic ramp-up and upgrade timelines

Note
- time is in calendar years



Longer 250GeV run at the beginning



Mostly at 500GeV

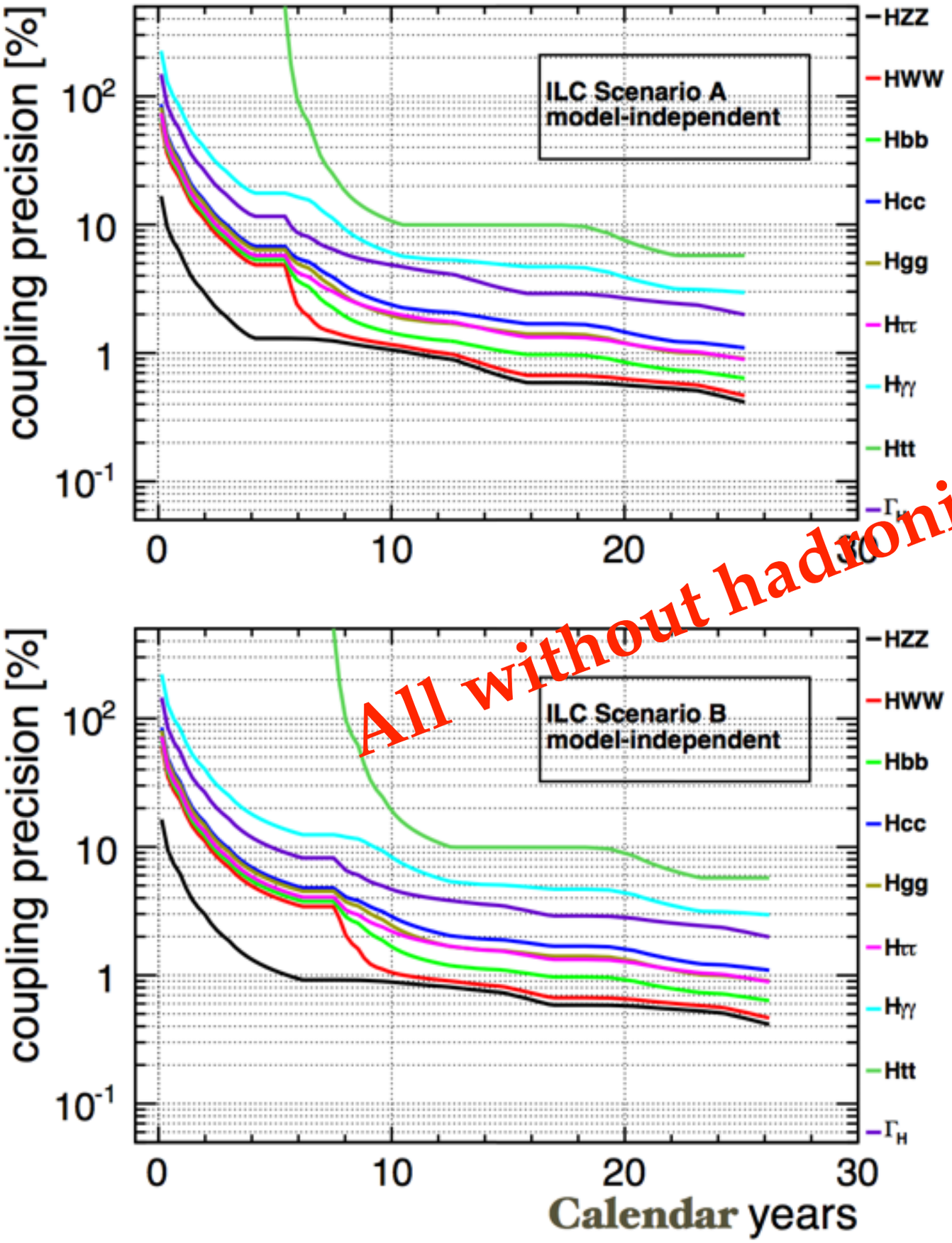
Summary of scenarios

	$\int \mathcal{L}dt$ [fb^{-1}]				
$\sqrt{s}$	A	B	C-250	C-350	C-500
250 GeV	2000	2000	2000	500	500
350 GeV	200	200	200	1700	200
500 GeV	3000	3000	3500	3500	5500

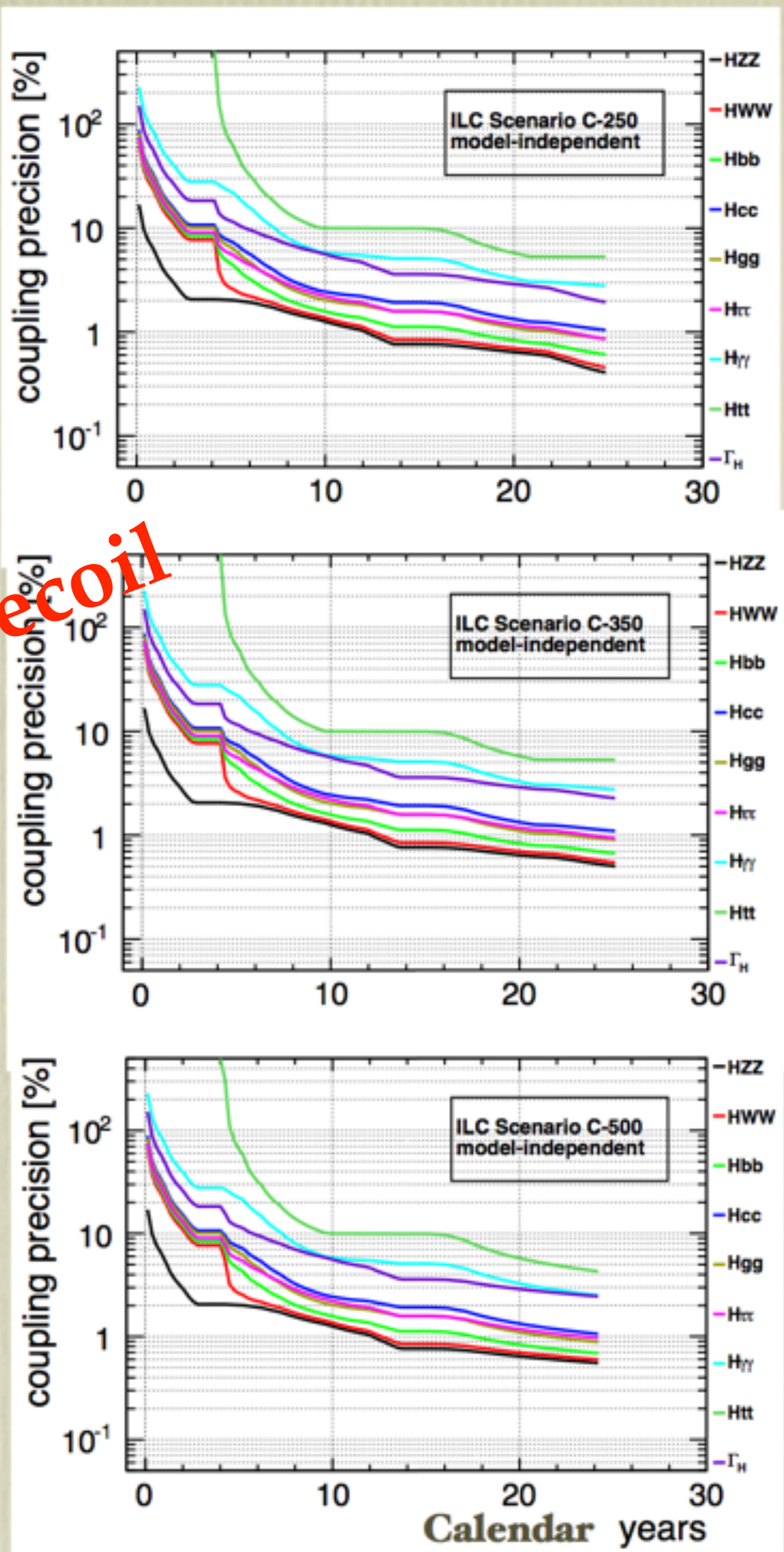
Table 1: Proposed total target integrated luminosities for $\sqrt{s} = 250, 350, 500$ GeV.

Total calendar time (years) for each scenario

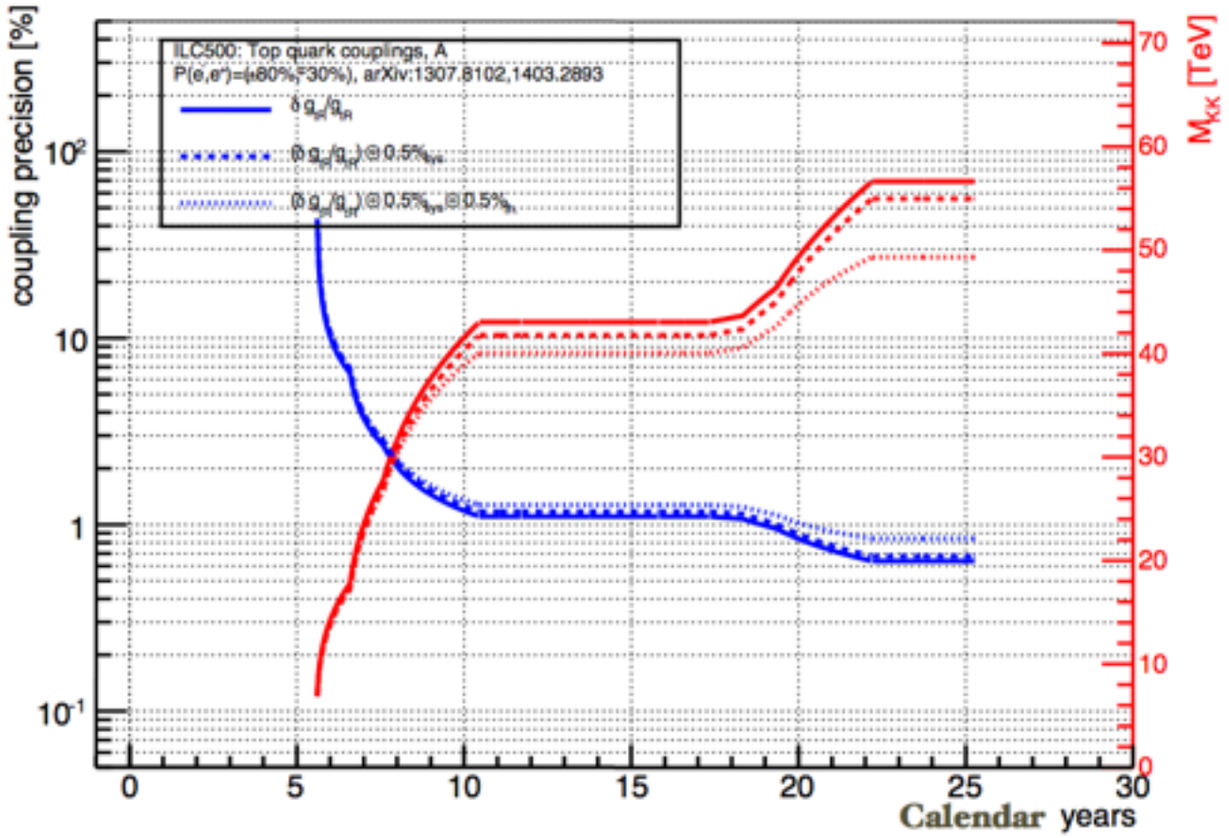
25.5 26.6 25.3 25.5 24.6

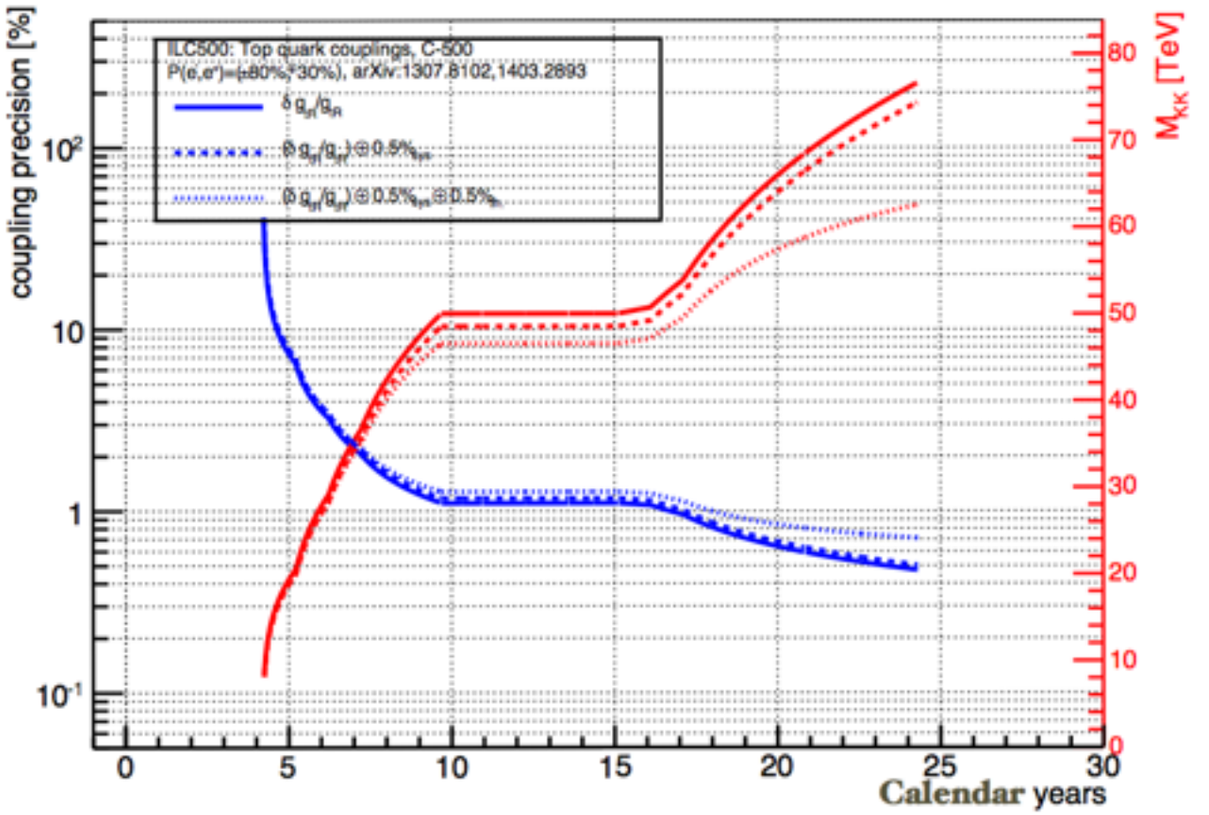


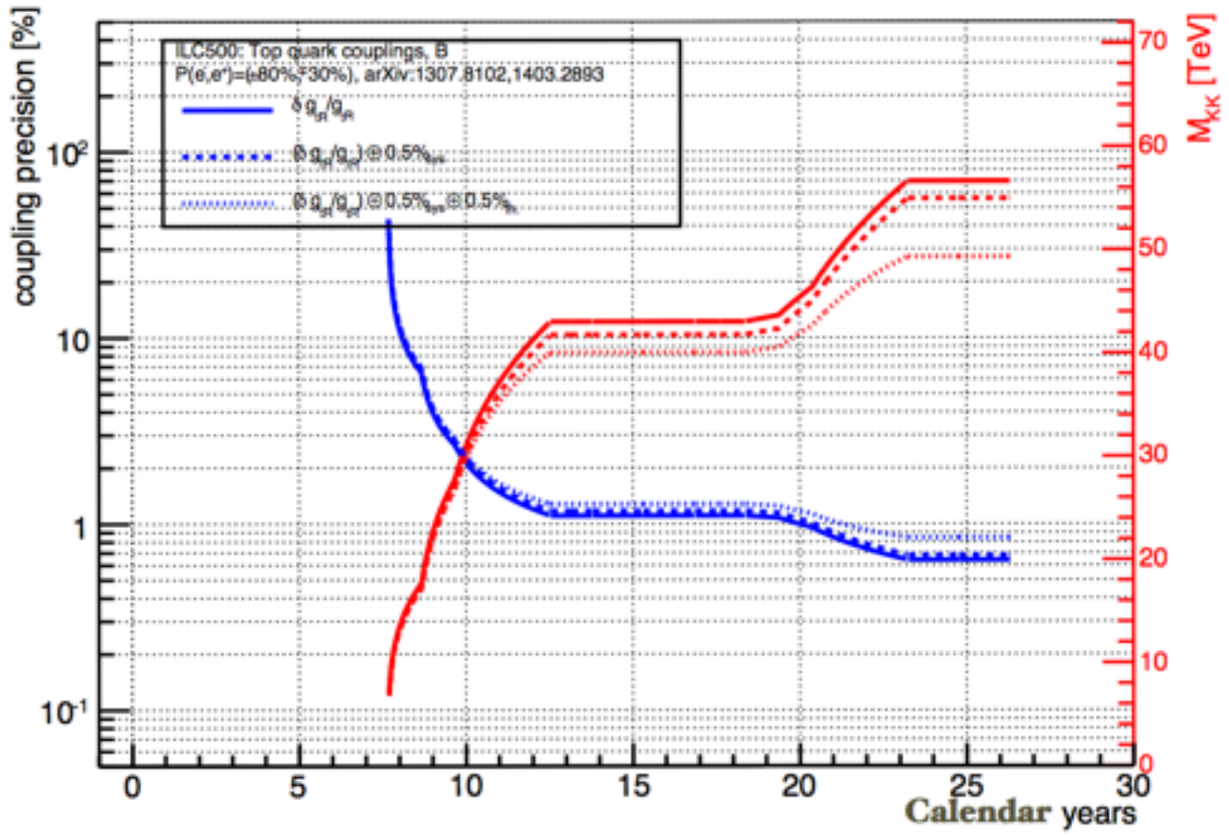
All without hadronic recoil

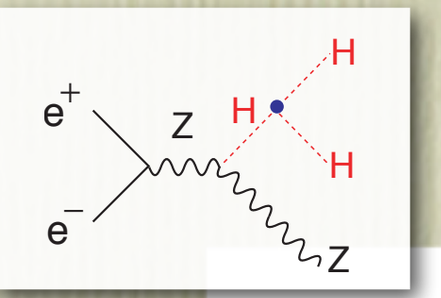


Top RH coupling & sensitivity of KK mass scale

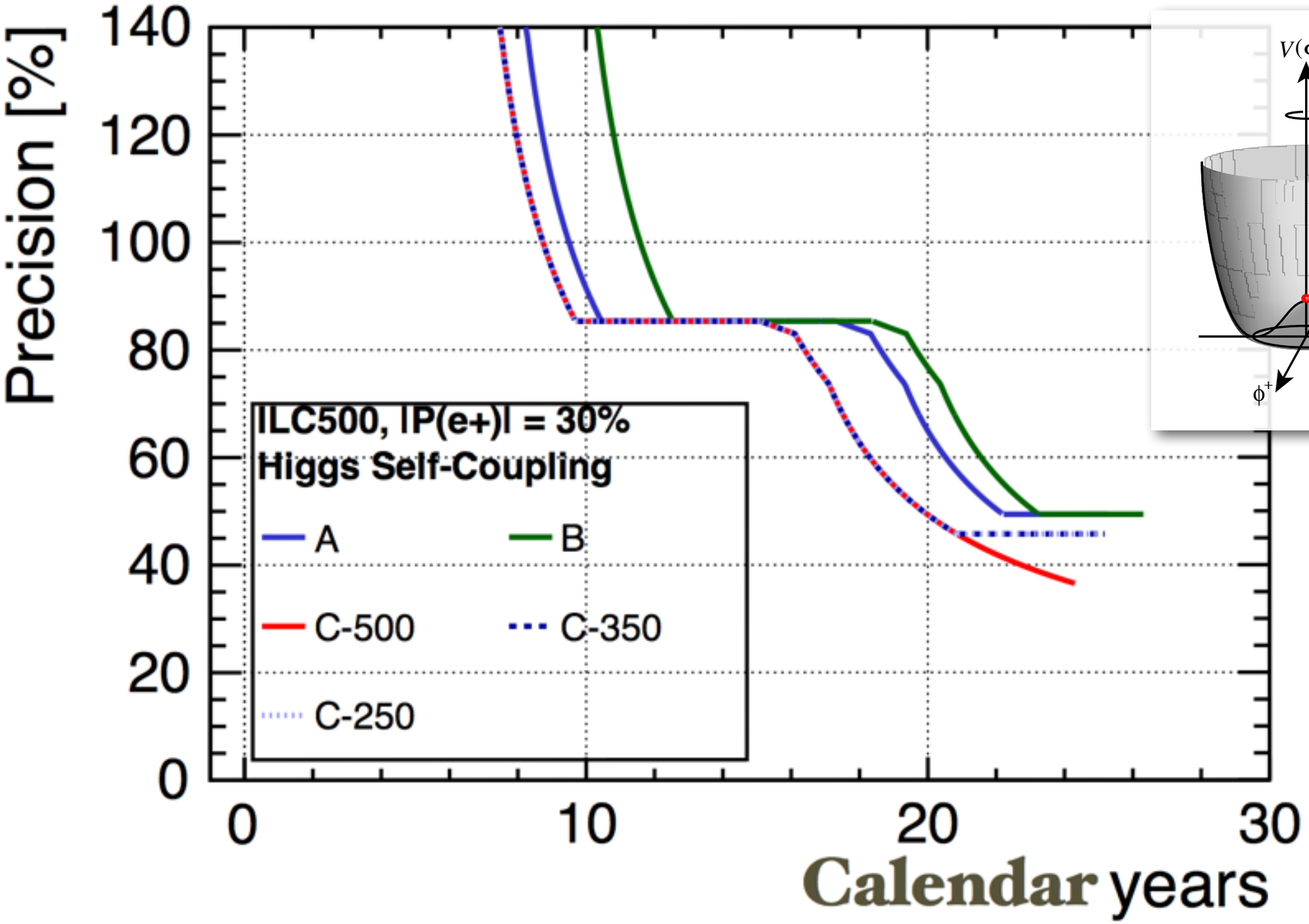


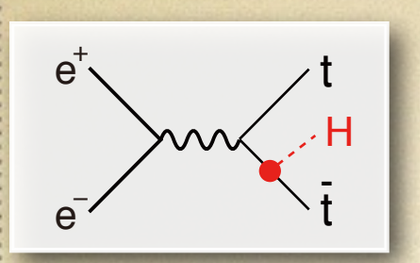




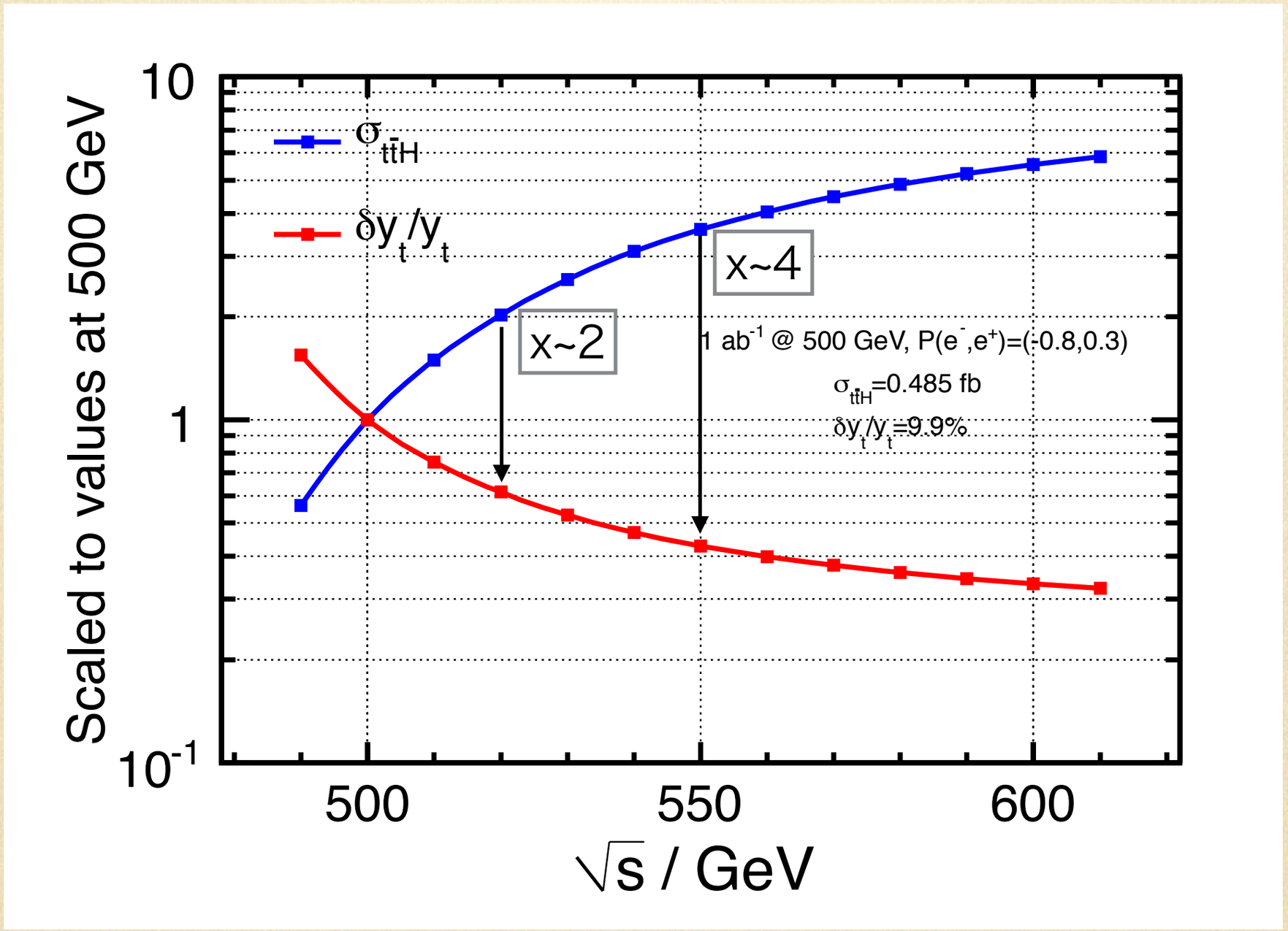


Precision of Higgs self-coupling





Top Yukawa coupling



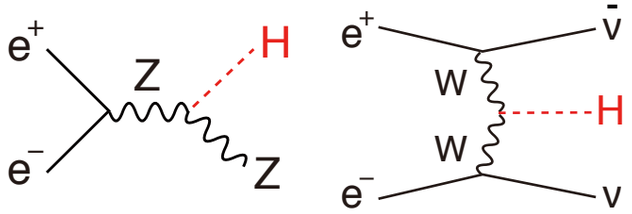
Y. Sudo

Slight increase of E_{max} is very beneficial!

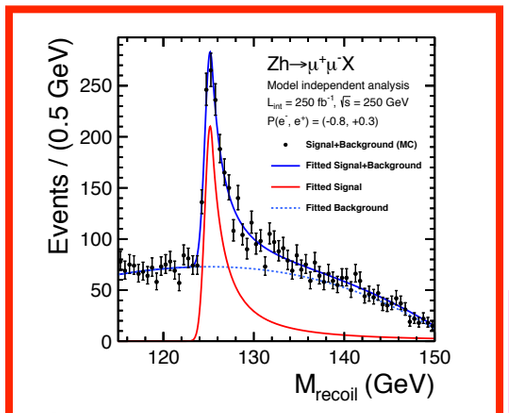
Key Point

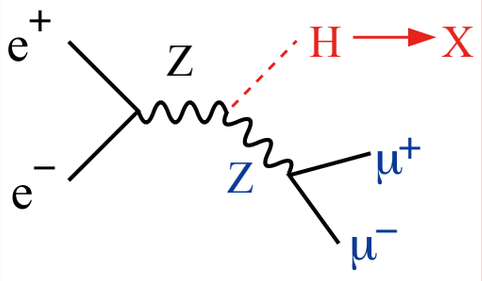
At LHC all the measurements are σ×BR measurements.

At ILC all but the σ measurement using recoil mass technique is σ×BR measurements.



σ×BR → **BR** → **g coupling**

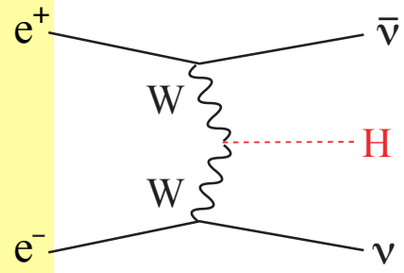




The Key

σ
from recoil mass

Γ$_H$
total width



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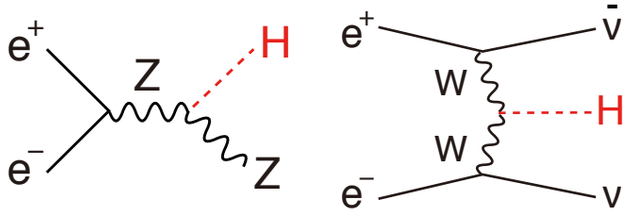
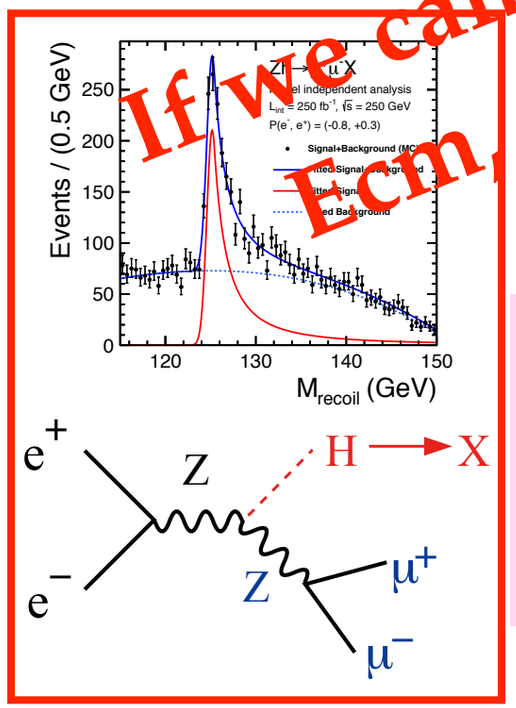


σ×BR → **BR** → **g coupling**

If we can use hadronic recoil mass method at higher Ecm, say at 500GeV, the importance of 250GeV diminishes significantly!



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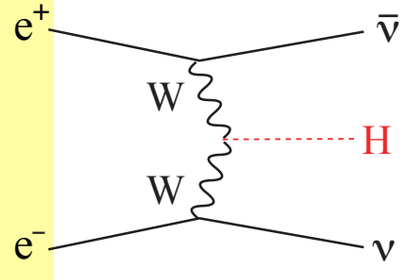

Other issues

- Polarization mix
  - importance of positron polarization
- Model independency of $ZH \to q\bar{q}H$
- WW threshold
- Z-pole for physics
- Z-pole for calibration

Next steps

- Comments on DRAFT from Physics WG **Done!**
- Meet in Tokyo on September 4 **Done!**
- Present updated DRAFT to LCC & LCB
- Respond to LCC/LCB comments
- Prepare DRAFT for comment at LCWS14
  - plenary session
- Finish report by ICFA Seminar

Sep. 4 Meeting in Tokyo

Jim Brau, Tim Barklow, Jenny List, KF, and Hitoshi Yamamoto met in Tokyo

We will include the hadronic recoil measurements at 500 GeV to be consistent with the Snowmass studies. This fact should be added in the text to make clear what is included.

We also plan to add ***the Higgs coupling precision that is obtained by assuming the sum of the BRs = 1*** and ***by applying the LHC style fit***.

We need to prepare some information on ***what is achieved in the first 5 years***.

Add the presentation of ***the physics motivation for each scenario***.

We plan to prepare a chapter on ***what could be achieved by starting at 350 GeV***.
We can assume we run at 350 GeV for 500 fb-1 and then accumulate 200 fb-1 at 250 GeV before upgrading to 500 GeV. The machine side plan for this scenario will be prepared and it will be referred to in the text and presented in a later chapter.

We discussed the disadvantages of 350 GeV. It is thought that ***the mass measurement suffers relative to the measurement at 250 GeV***. It may be possible to nearly match the 250 GeV precision using ***the direct measurement of H -> b bar*** (as Roman studied for TESLA) or H -> W W*

We will prepare a ***plot for the report of the evolution of the Higgs mass measurement through the 25 year program***.

The search for WIMP pair production using ISR, being worked on.
This favors the highest possible energy, which we will describe in the report.

Our studies favors C-500 over the other scenarios based on what we know today.
We will put this into the summary statement for review by the LCC/LCB.
We will propose that ***the ~25 year integrated luminosities for this scenario be taken as the convention for future statements on ILC performance***.
Need to check consistency with the Snowmass white paper for the end-point precisions.
(systematic uncertainties in hadronic recoil should be investigated)

Emphasize the flexibility of the ILC. For example, discoveries at the LHC or in the early phases of the ILC could significant influence on the preferred operating energy, even for an energy other than 250 GeV, 350 GeV or 500 GeV.

Timeline (tentative, needs approval from LCC&LCB):
we will prepare a draft for the LCC/LCB by September 18th and ask them for comments within 1 week (Sep 25) so we can revise and circulate to the community on Sep 29, one week before the start of LCWS in Belgrade (Oct 6)

Summary table of Higgs measurements @ ILC

Nominal

newly added: H—>μμ at other than 1 TeV

ECM	@ 250 GeV		@ 350 GeV		@ 500 GeV		@ 1 TeV
luminosity · fb	250		330		500		1000
polarization (e-,e+)	(-0.8, +0.3)		(-0.8, +0.3)		(-0.8, +0.3)		(-0.8, +0.2)
process	ZH	νν̄H	ZH	νν̄H	ZH	νν̄H	νν̄H
cross section	2.6%	-	3.5%		*3%*	-	-
	σ·Br	σ·Br	σ·Br	σ·Br	σ·Br	σ·Br	σ·Br
H-->bb	1.2%	10.5%	1.3%	1.3%	1.8%	0.66%	0.32%
H-->cc	8.3%		9.9%	13%	13%	6.2%	3.1%
H-->gg	7%		7.3%	8.6%	11%	4.1%	2.3%
H-->WW*	6.4%		6.8%	5.0%	9.2%	2.4%	1.6%
H-->ττ	4.2%		4.6%	19%	5.4%	9%	3.1%
H-->ZZ*	19%		22%	17%	25%	8.2%	4.1%
H-->γγ	29-38%		29-38%	39%	29-38%	19%	7.4%
H-->μμ	72%		76%	142%	88%	72%	31%
H-->Inv. (95% C.L.)	< 0.95%		< 1.5%		< 3.2%		
ttH, H-->bb	-				28%		6%

mostly from White Paper; being updated by new studies with mH = 125 GeV (see backup)

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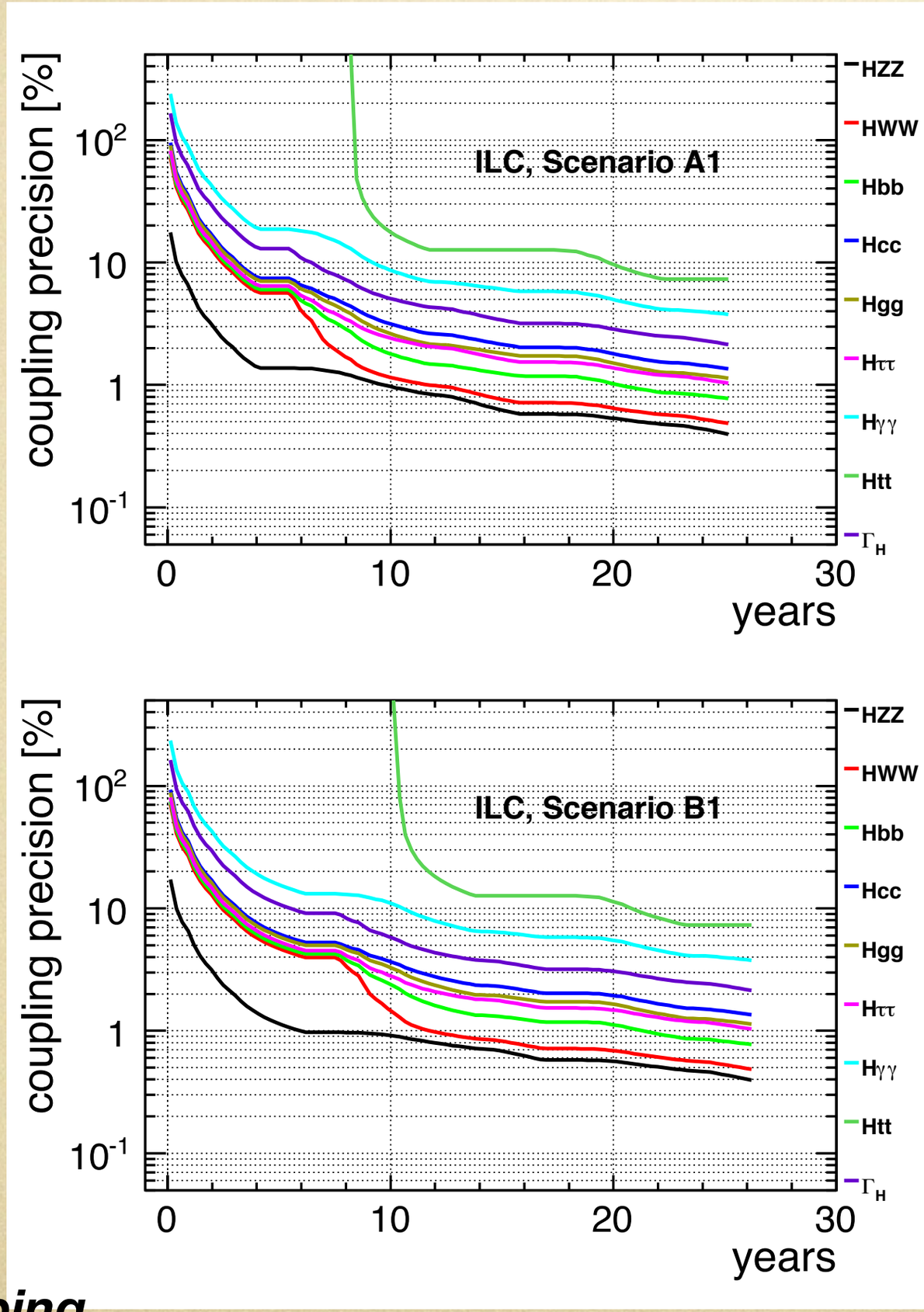

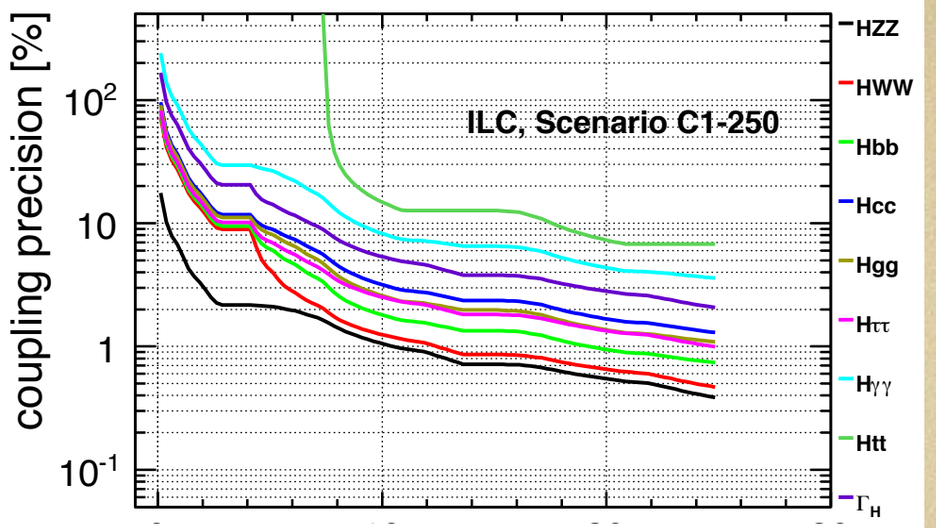

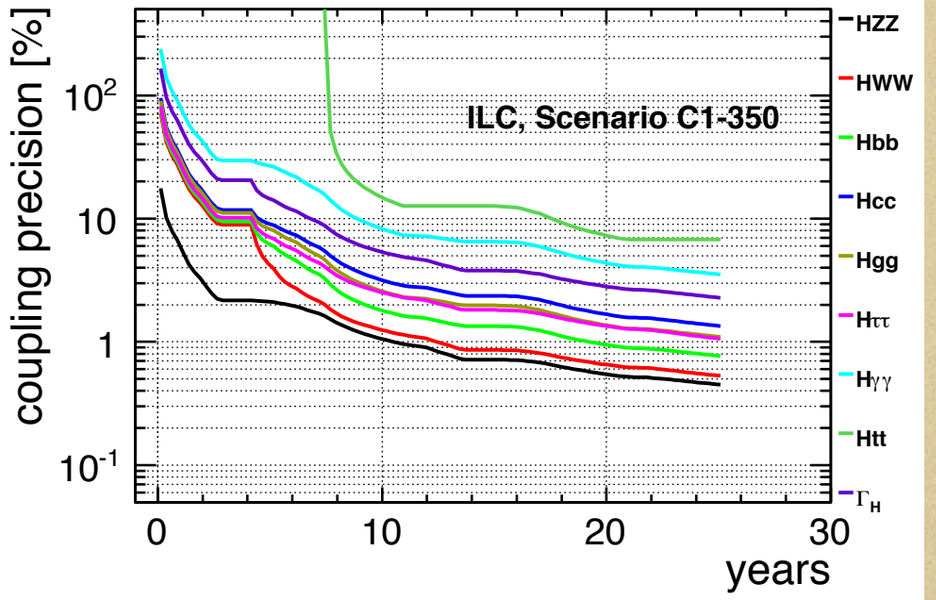

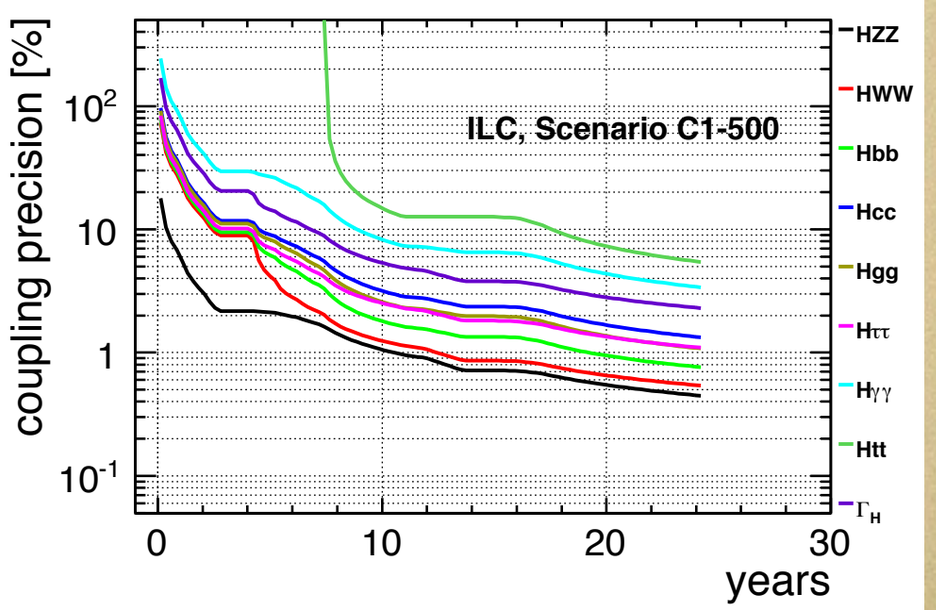

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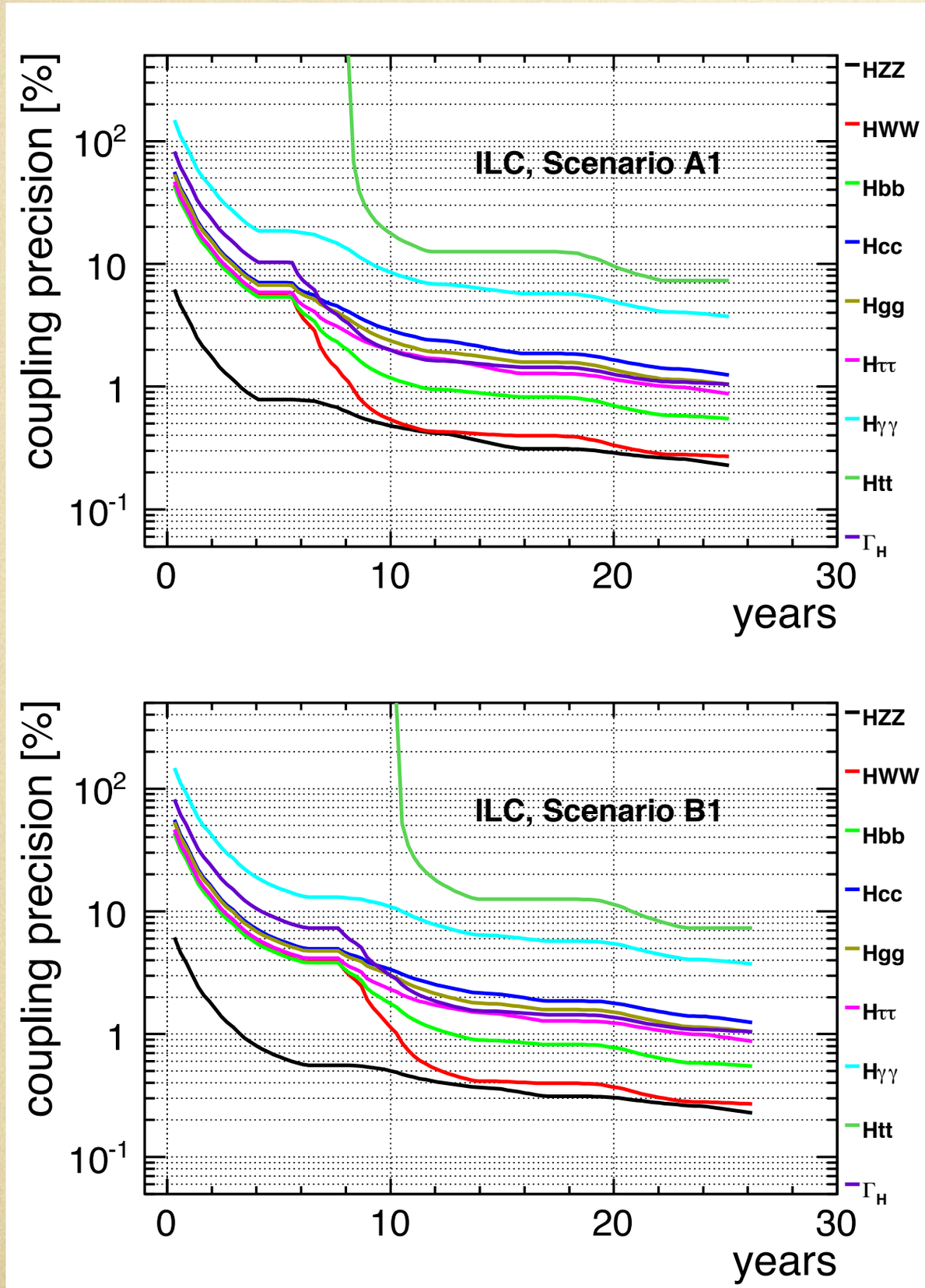

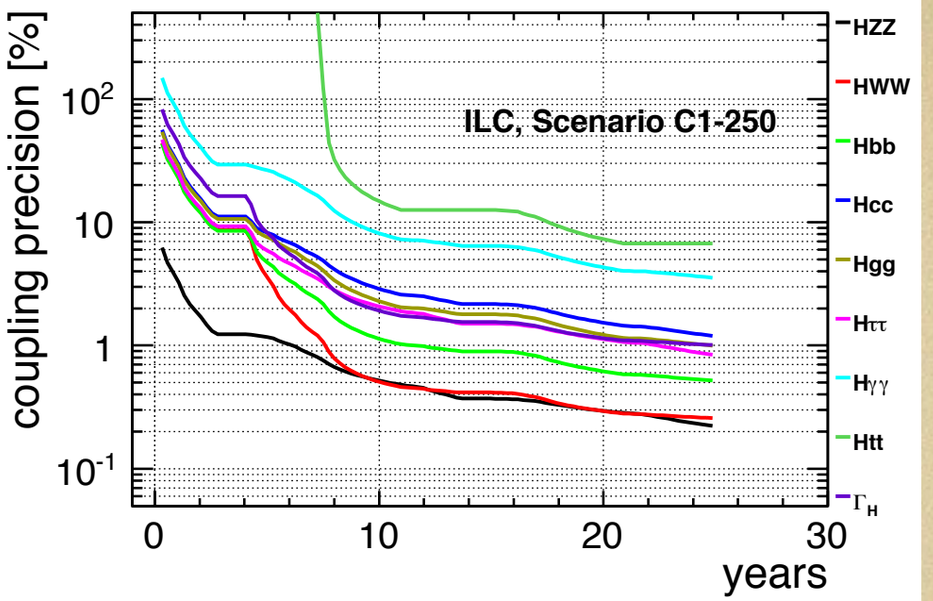

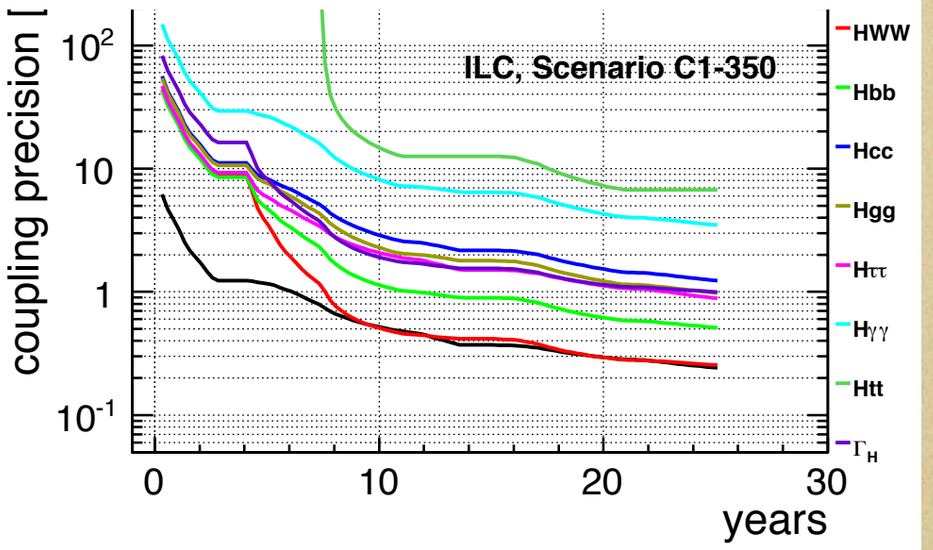

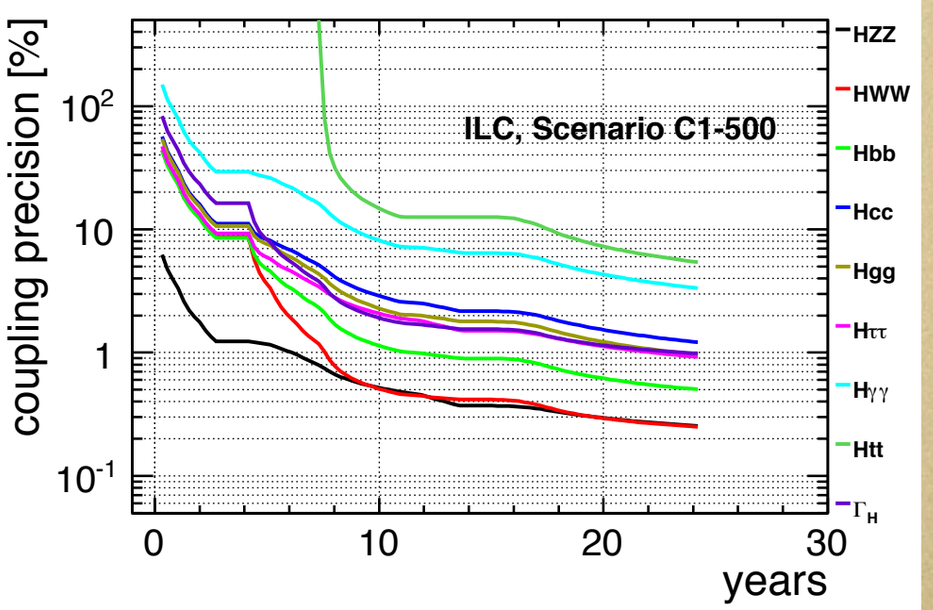

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precisions at the end of 500 GeV ILC

coupling Δg/g	C1-500		Snowmass LumiUP500	
	ΓH free	constrained	ΓH free	constrained
HZZ	0.44%	0.25%	0.55%	0.27%
HWW	0.54%	0.25%	0.63%	0.27%
Hbb	0.76%	0.5%	0.88%	0.55%
Hcc	1.3%	1.2%	1.5%	1.3%
Hgg	1.1%	0.95%	1.2%	1.1%
Hττ	1.1%	0.92%	1.2%	1.0%
Hγγ	3.4%	3.3%	4.1%	4.0%
Htt	5.4%	5.4%	7.8%	7.8%
Hμμ	10%	10%	11%	11%
Γ	2.3%	0.98%	2.7%	1.0%
Inv. (95% CL)	0.77%	0.77%	< 0.43%	< 0.43%

assumed (eLpR, eRpL, eLpL, eRpR) = (67.5%, 22.5%, 5%, 5%) @ 250, 350 GeV

assumed (eLpR, eRpL, eLpL, eRpR) = (40%, 40%, 10%, 10%) @ 500 GeV