500 GeV ILC Operating Scenarios†

ILC Parameters Joint Working Group

formed and charged by the Linear Collider Collaboration

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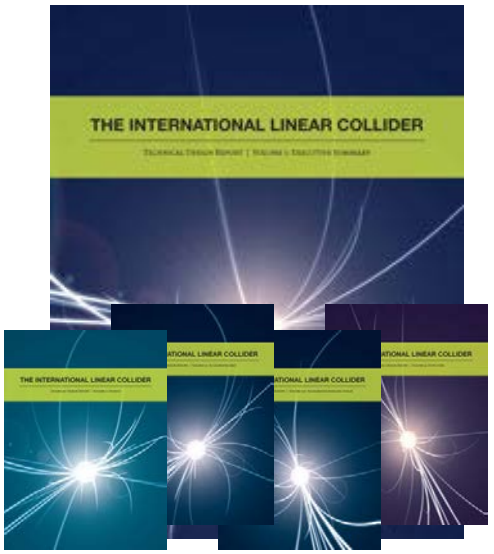
† arXiv:1506.07830 [hep-ph]

Optimized ILC Operating Scenario



- Based on five-volume blueprint for ILC after many years of globally coordinated R&D driven by physics goals (TDR published 12 June 2013)
  - Realistic technical design and implementation plan, optimized for performance, cost and risk
- TDR followed successful R&D program:
  - construction and commissioning of world-wide superconducting RF accelerator test facilities,
  - improvement in accelerating cavity production processes,
  - plans for mass production of 16,000 superconducting cavities needed to drive the ILC's particle beams.
- TDR includes details of the two state-of-the-art detectors
- Extensive outline of geological and civil engineering studies conducted for ILC siting
- TDR plans initial $E_{CMS} = 500$ GeV $\Rightarrow$ upgrade to 1 TeV

ILC Physics Goals	***500 GeV***
• precision Higgs couplings	✔
• **g**HWW and overall normalization of Higgs couplings	✔
• search for invisible and exotic Higgs decay modes	✔
• Higgs couplings to top	✔
• Higgs self-coupling	✔
• search for extended Higgs states	✔
• precision electroweak couplings of the top quark	✔
• precision **W** couplings	✔
• precision search for **Z′**	✔
• search for supersymmetry	✔
• search for Dark Matter	✔

ILC Physics Goals	*500 GeV*	*350 GeV*
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• search for supersymmetry	✔	
• search for Dark Matter	✔	
• top quark mass from threshold scan		✔

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• precision search for **Z′**	✔		
• search for supersymmetry	✔		
• search for Dark Matter	✔		
• top quark mass from threshold scan		✔	
• precision Higgs mass			✔

Operating scenarios

Flexibility in operating energy up to maximum (initial max ≥ 500 GeV) – this is one strength of the ILC.

Polarization: $|P(e^-)| = 80\%$, $|P(e^+)| = 30\%$

Optimize for machine and physics, with emphasis on higher operating energy. (of course, actual scenario will depend on future factors.)

Assume 20 years of operation, compared many scenarios, including: G20, **H20 (preferred)**, I20, Snowmass study* (< 15 yr).

NOTE – centre-of-mass energy scans of interest (e.g. new particle thresholds, and 1 TeV upgrade, important capabilities.

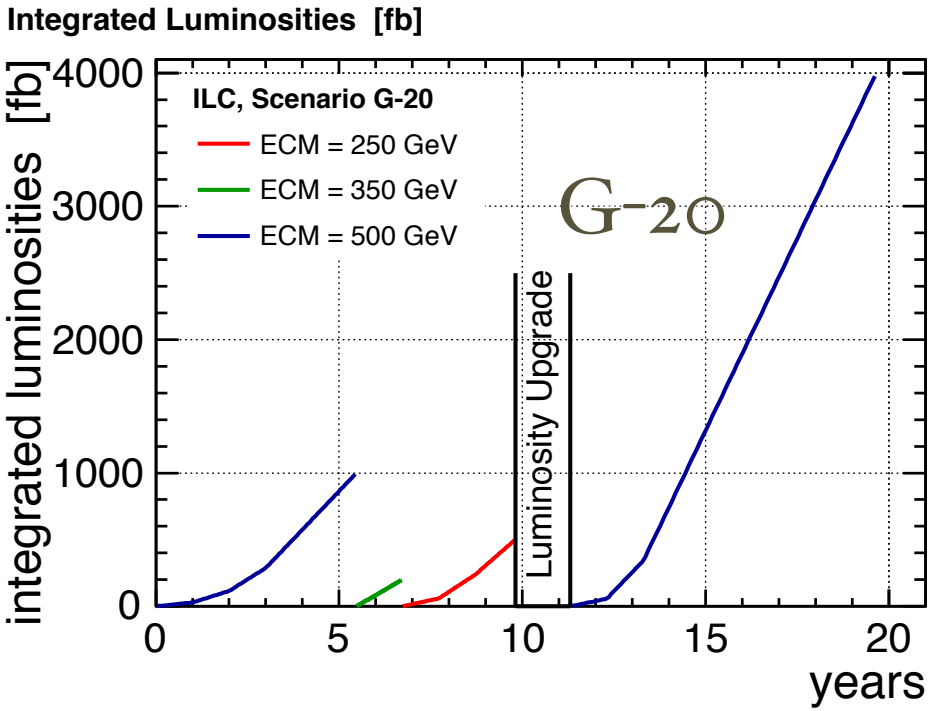
Study assumptions

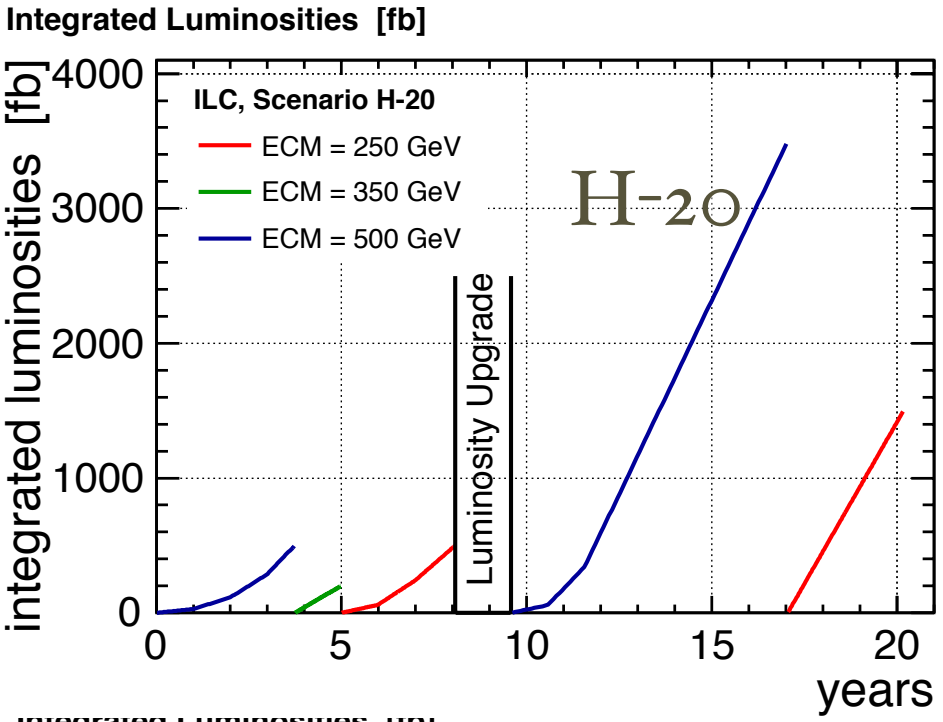
8 months/yr at 75% efficiency with ramp-ups of luminosity performance
= 1.6×10^7 sec/year

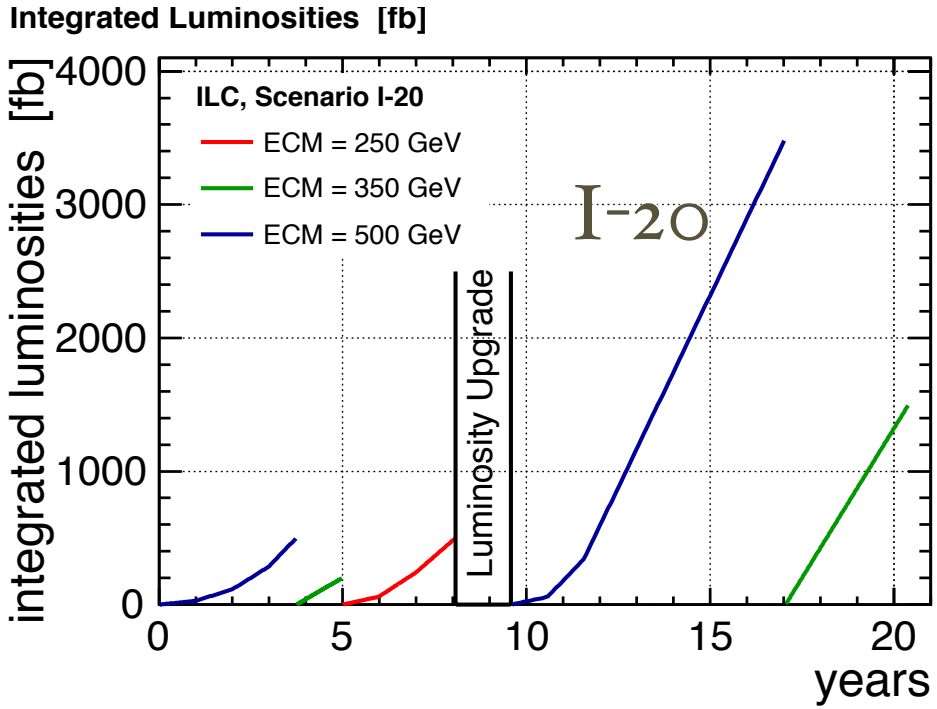
18-mo. shutdown for luminosity upgrade after ~8 years.

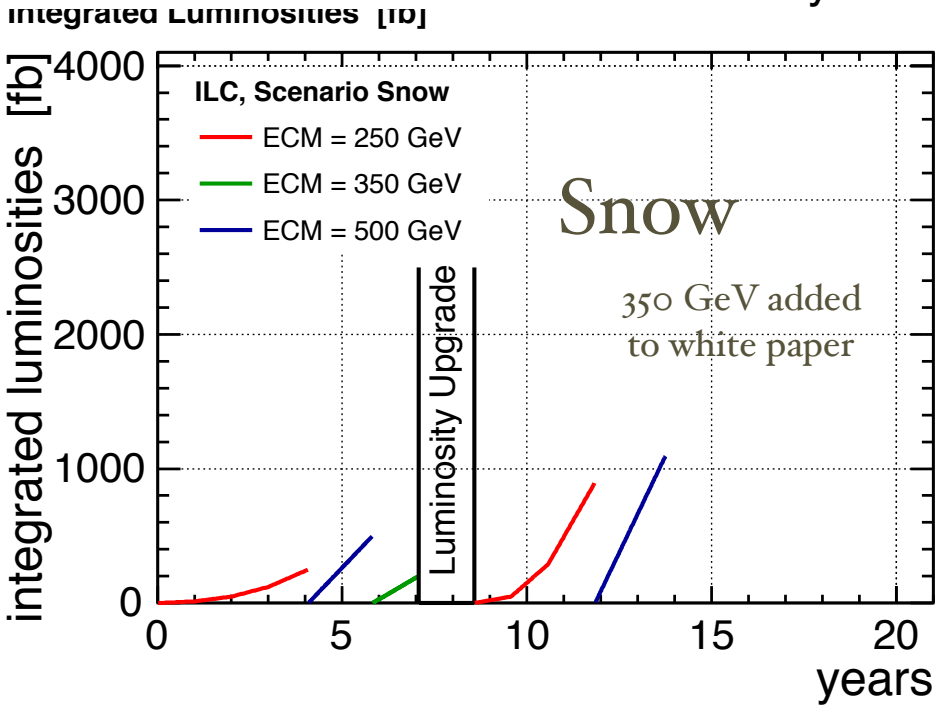
10-Hz and 7-Hz operation assumed for 250 GeV and 350 GeV

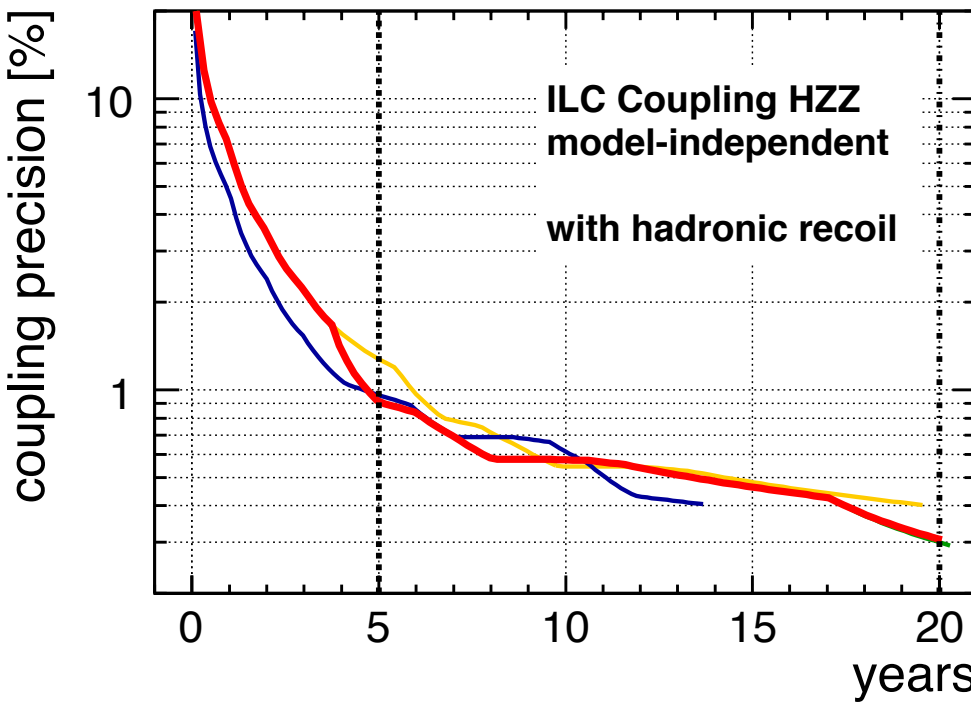
* - arXiv:1310.0763 [hep-ph]

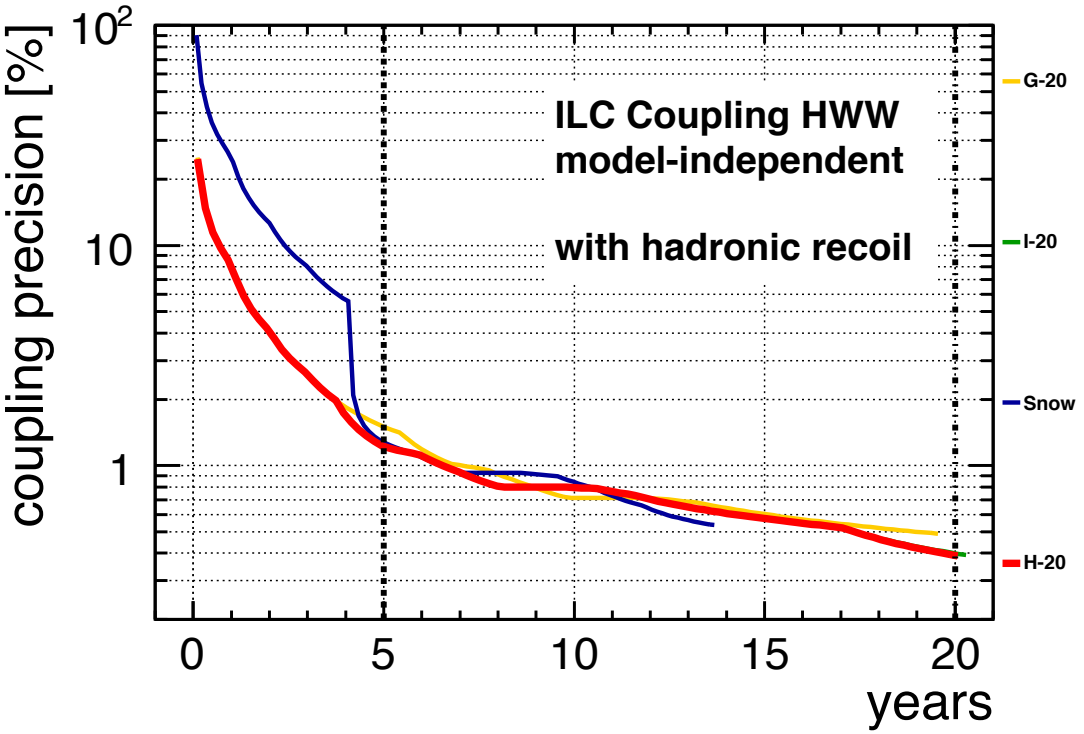

Integrated Luminosities [fb]
ILC, Scenario G-20
ECM = 250 GeV
ECM = 350 GeV
ECM = 500 GeV
G-20
Luminosity Upgrade
integrated luminosities [fb]
years
0
1000
2000
3000
4000
0
5
10
15
20

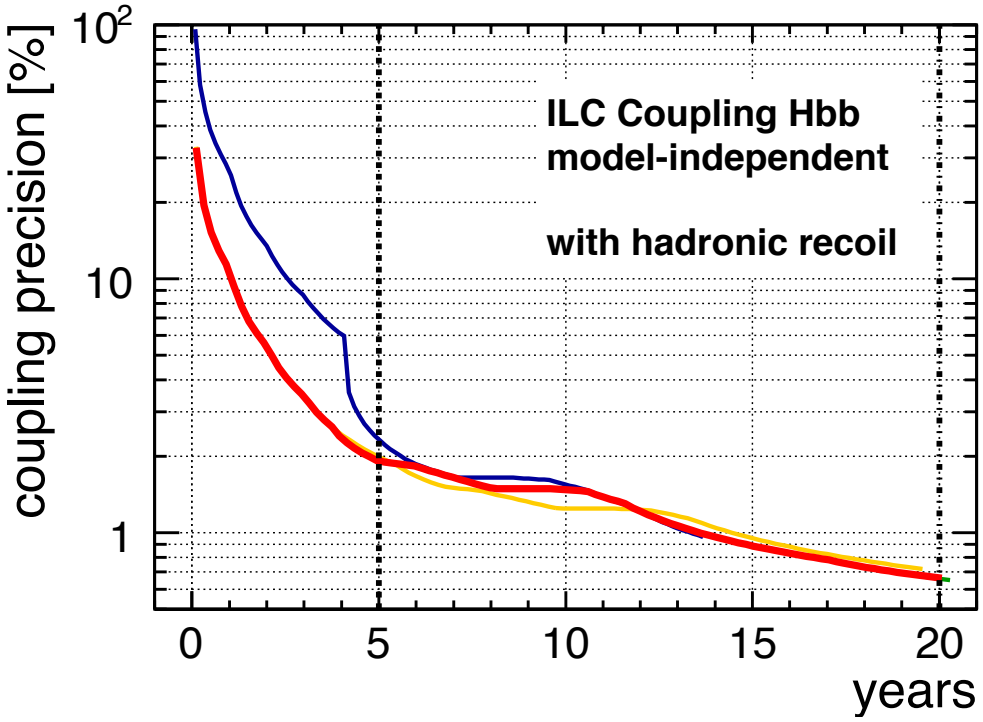

Integrated Luminosities [fb]
ILC, Scenario H-20
ECM = 250 GeV
ECM = 350 GeV
ECM = 500 GeV
H-20
Luminosity Upgrade
integrated luminosities [fb]
years
0
1000
2000
3000
4000
0
5
10
15
20

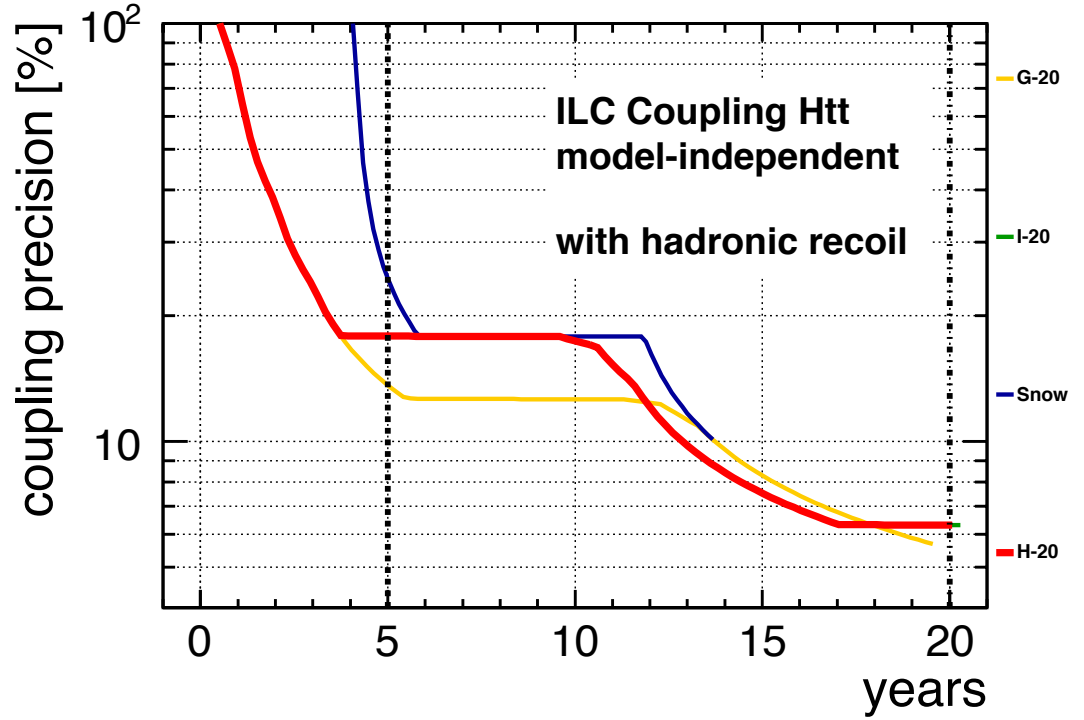

Integrated Luminosities [fb]
ILC, Scenario I-20
ECM = 250 GeV
ECM = 350 GeV
ECM = 500 GeV
I-20
Luminosity Upgrade
integrated luminosities [fb]
years
0
1000
2000
3000
4000
0
5
10
15
20


Integrated Luminosities [fb]
ILC, Scenario Snow
ECM = 250 GeV
ECM = 350 GeV
ECM = 500 GeV
Snow
350 GeV added
to white paper
Luminosity Upgrade
integrated luminosities [fb]
years
0
1000
2000
3000
4000
0
5
10
15
20


ILC Coupling HZZ
model-independent
with hadronic recoil
coupling precision [%]
10
1
0
5
10
15
20
years

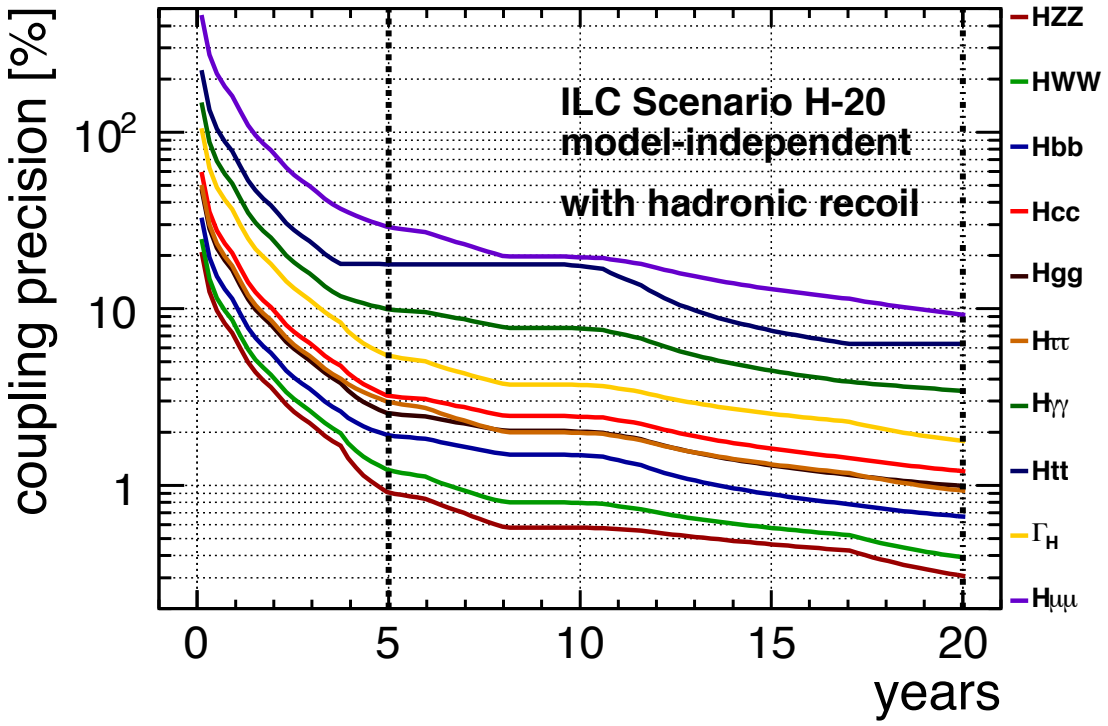

ILC Coupling HWW
model-independent
with hadronic recoil
coupling precision [%]
10^2
10
1
0
5
10
15
20
years
G-20
I-20
Snow
H-20


ILC Coupling Hbb
model-independent
with hadronic recoil
coupling precision [%]
10^2
10
1
0
5
10
15
20
years

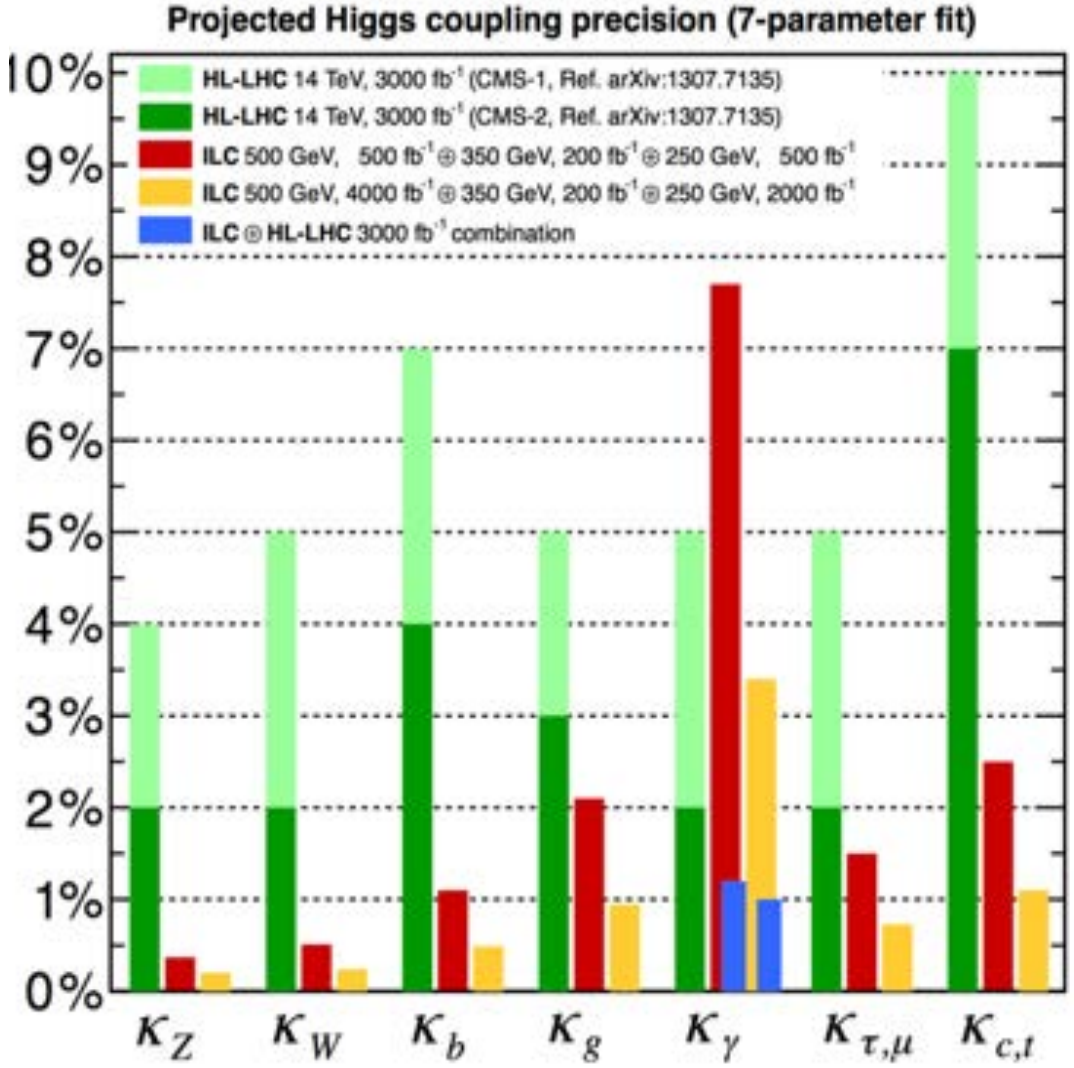

ILC Coupling Htt
model-independent
with hadronic recoil
coupling precision [%]
10^2
10
0
5
10
15
20
years
G-20
I-20
Snow
H-20

Higgs couplings (H-20)

- H-20 preferred for
  - slightly better early precision (compared to G-20)
  - current best reliability of m_h and $\sigma(e^+e^- \rightarrow Zh)$ measurements when done at 250 GeV
- Model independent
  - Higgs recoil from hadronic decaying Z is nearly model independent
- H-20 approved (June 2015) by Linear Collider Board

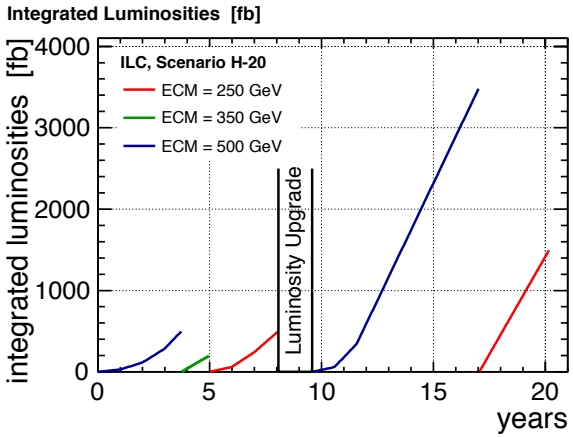


Model-dependent H20 Higgs couplings and LHC



Summary of Optimized H20 Scenario

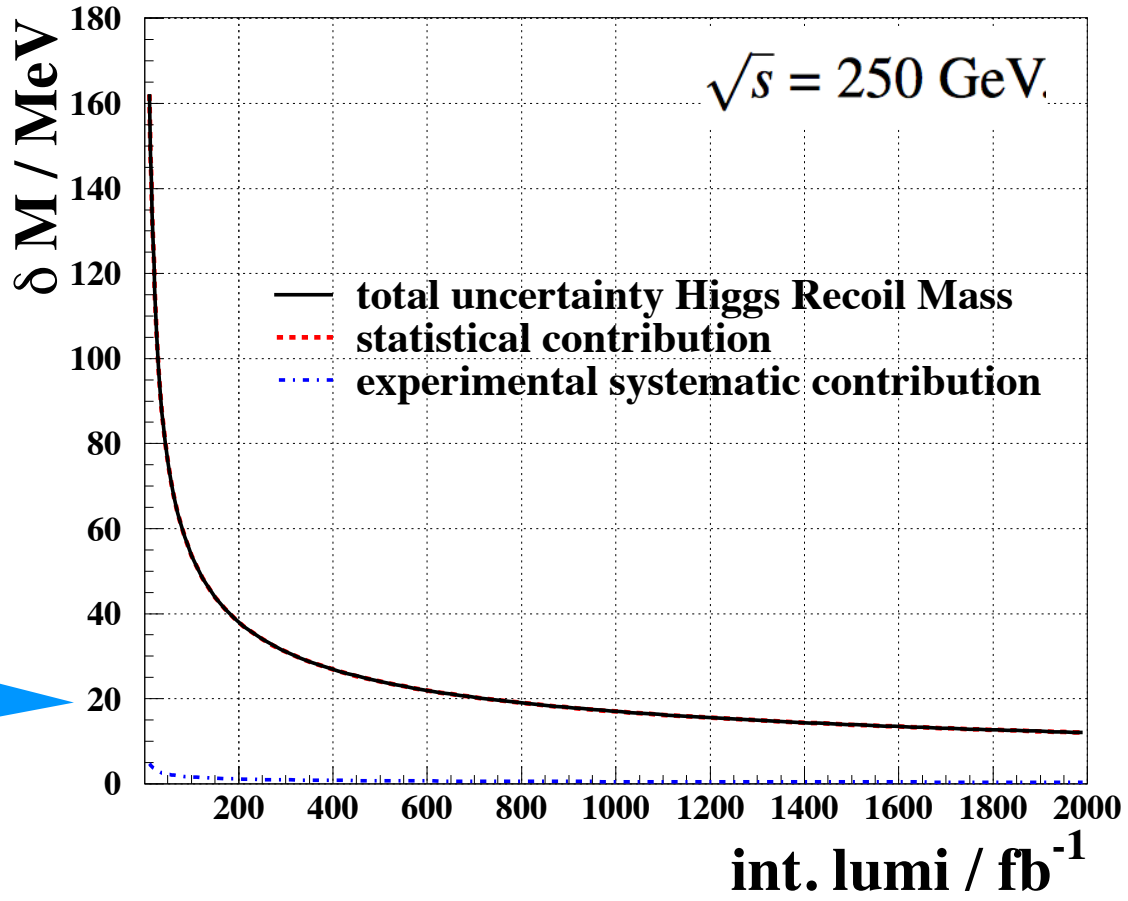
	first phase	lumi upgrade	total
250 GeV	500 fb^{-1}	1500 fb^{-1}	2 ab^{-1}
350 GeV	200 fb^{-1}		0.2 ab^{-1}
500 GeV	500 fb^{-1}	3500 fb^{-1}	4 ab^{-1}
time	8.1 yrs	10.6 yrs	20.2 yrs*



* includes 1.5 years for luminosity upgrade

Higgs mass

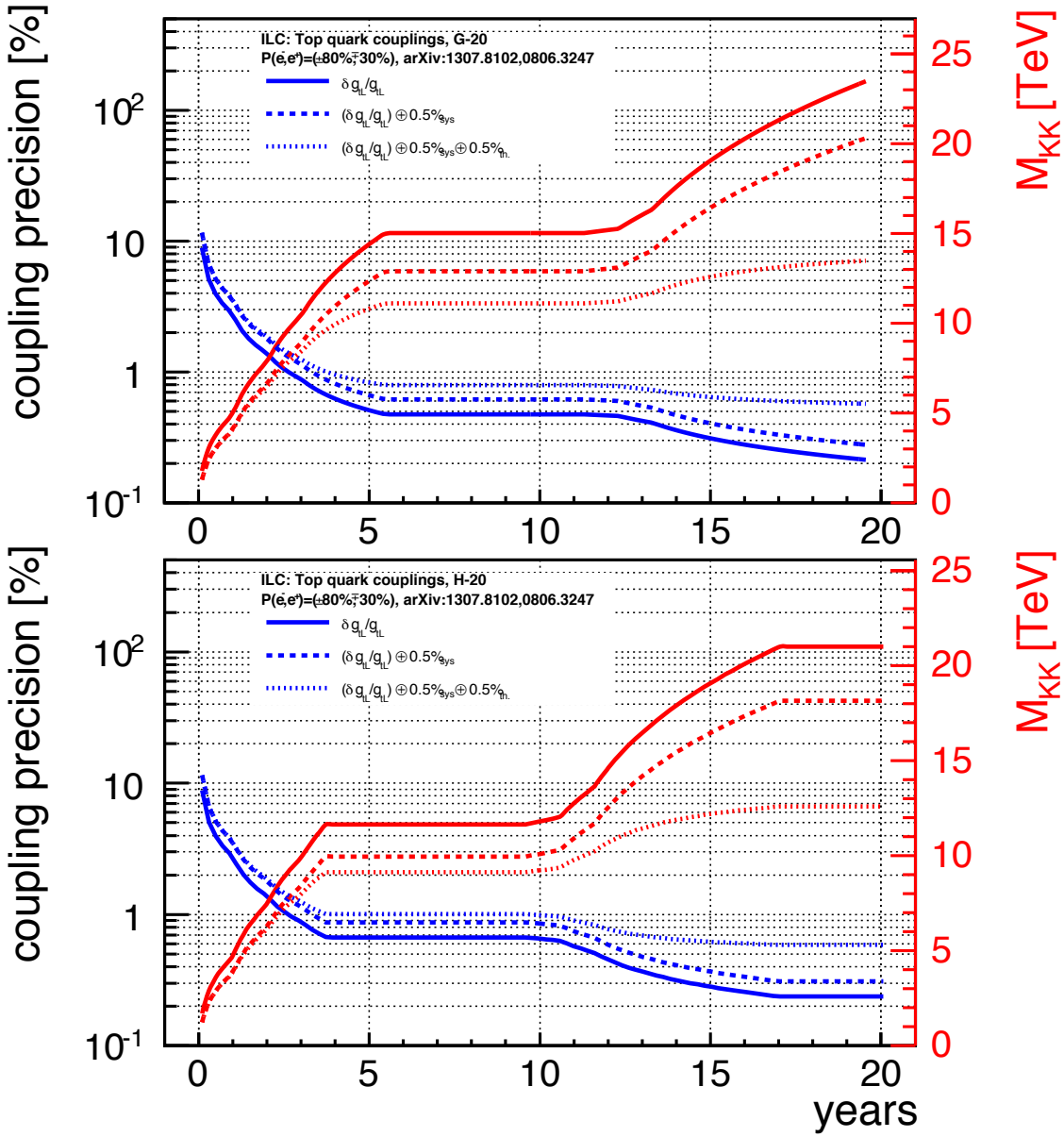
- Fundamental parameter of SM, important to know in own right
- Higgs decay partial width dependence on m_h requires 20 MeV m_h precision to achieve desired 0.2% on partial widths



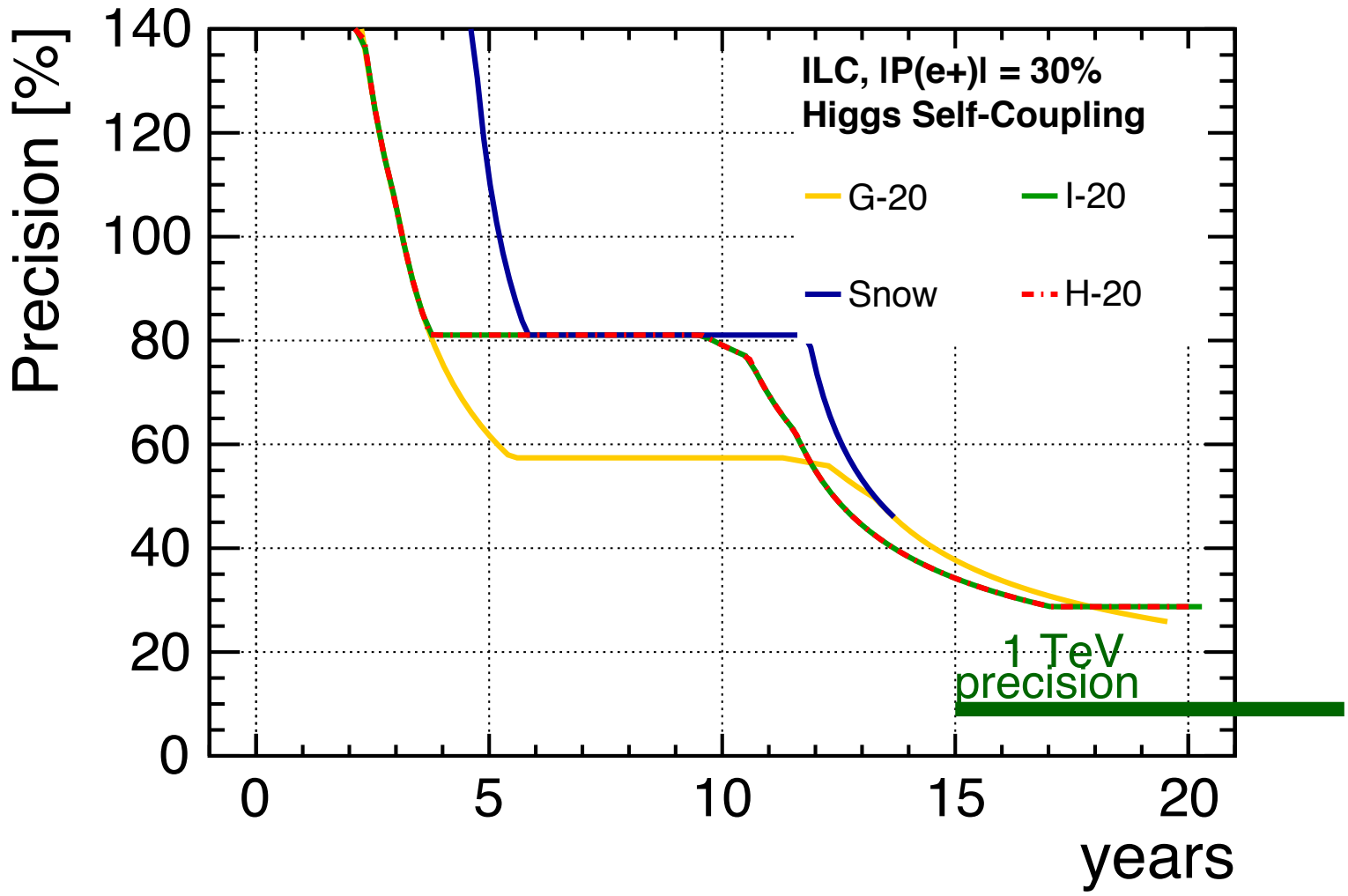
- Higgs recoil from Z → μμ (expect 1 MeV systematic uncertainty)
- Note - direct reconstruction at 500 GeV in h → bb and → WW shows similar level of promise

Top electroweak couplings

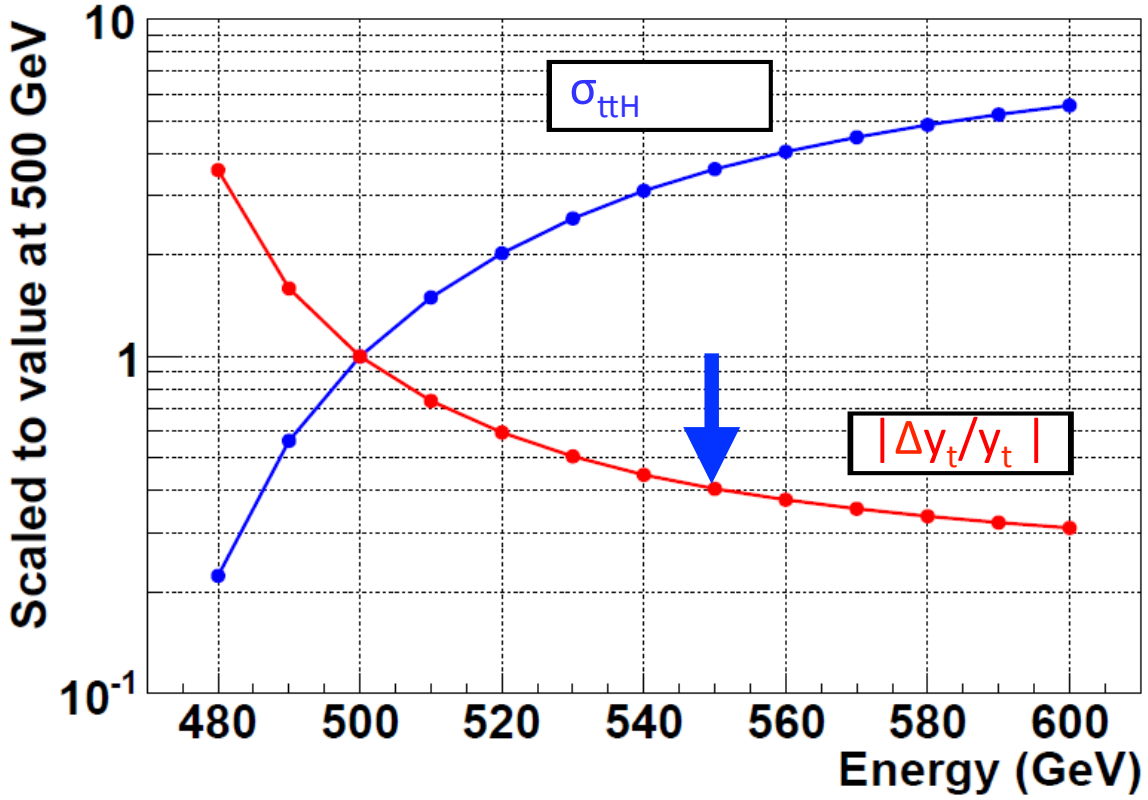
- Left-handed top coupling, and derived mass scale sensitivity for Kaluza-Klein excitations in an extra-dimensions model



Higgs self-coupling

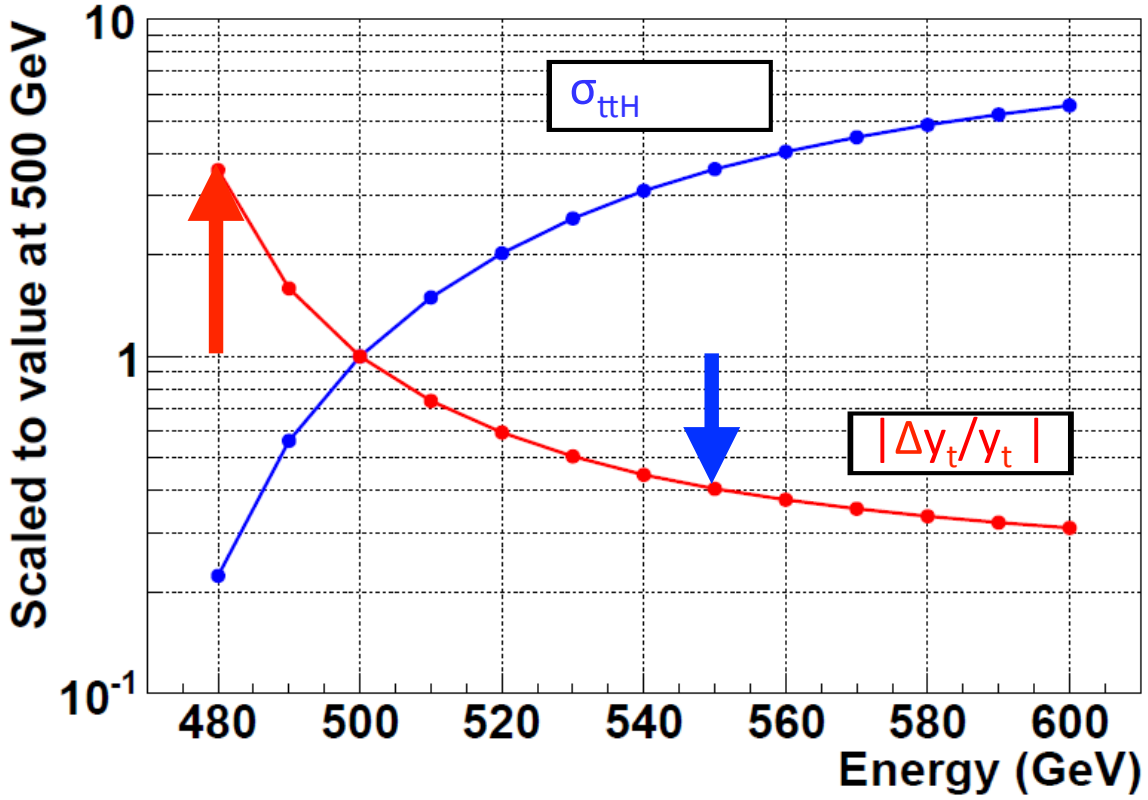


500 GeV vs. 550 GeV & ttH



550 GeV is 2.4 precision improvement over 500 GeV

500 GeV vs. 550 GeV & ttH



550 GeV is 2.4 precision improvement over 500 GeV
- Failing to achieve 500 GeV loses reach quickly

Linear Collider Collaboration striving for ≥ 550 GeV

Conclusions: Optimized ILC running scenario

- After considering various running scenarios for 500 GeV ILC, the preferred scenario based on current knowledge: H-20
  - 500 GeV startup, 20 yr duration (run at 500, 350 & 250 GeV)
  - luminosity upgrade after 8 years
  - after several years of 500 GeV operation with upgraded luminosity, return to 250 GeV
- tth benefits from stretching to 550 GeV capability
- Actual running scenario will depend on physics results of LHC and early ILC (eg. other energy in 250-500 GeV range)
  - http://arxiv.org/abs/1506.07830

- Acknowlegements

contributions to study from
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please refer to http://arxiv.org/abs/1506.07830 for specific references (not listed in this talk)