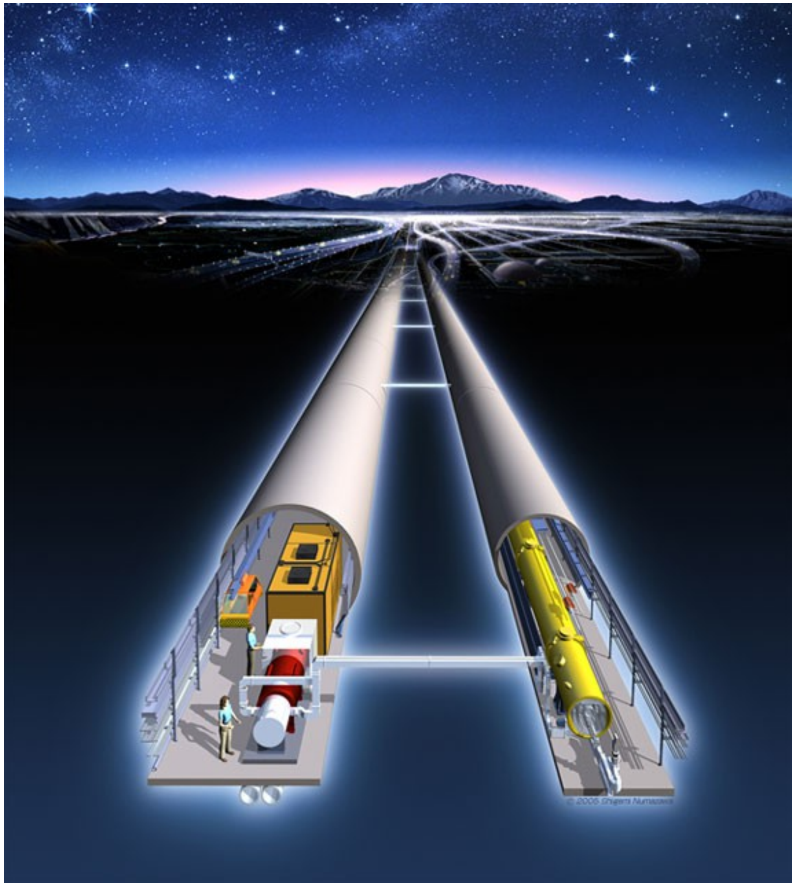
ILC Staging Scenarios



Roman Pöschl

All slides stolen from
Jim Brau@LCWS14

All faults are mine

Complete talk added to agenda of JCL

3rd Journées Collisionneur Linéaire – LPSC/Grenoble Dec. 2014

LCC 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 creates Joint WG

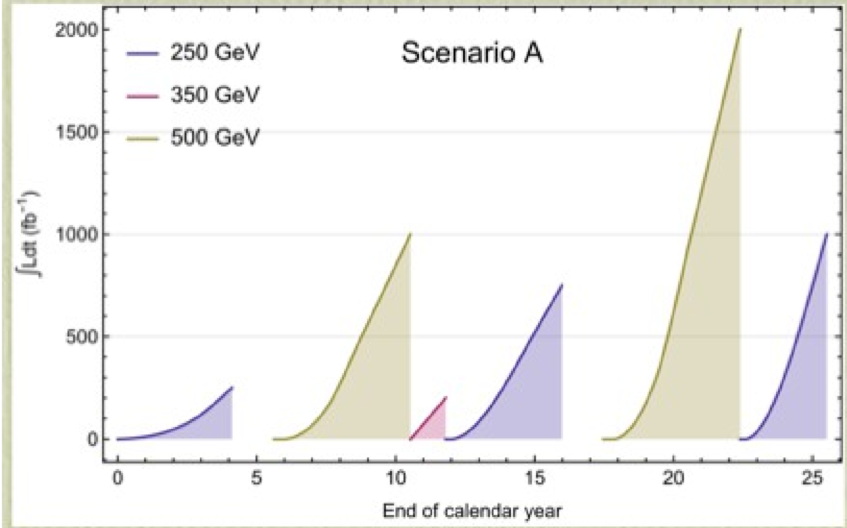
- Joint WG Membership:
  - machine: Jie Gao, N. Walker (co-convener), K. Yokoya,
  - physics & detectors: T. Barklow, J. Brau (co-convener), K. Fujii, J. List

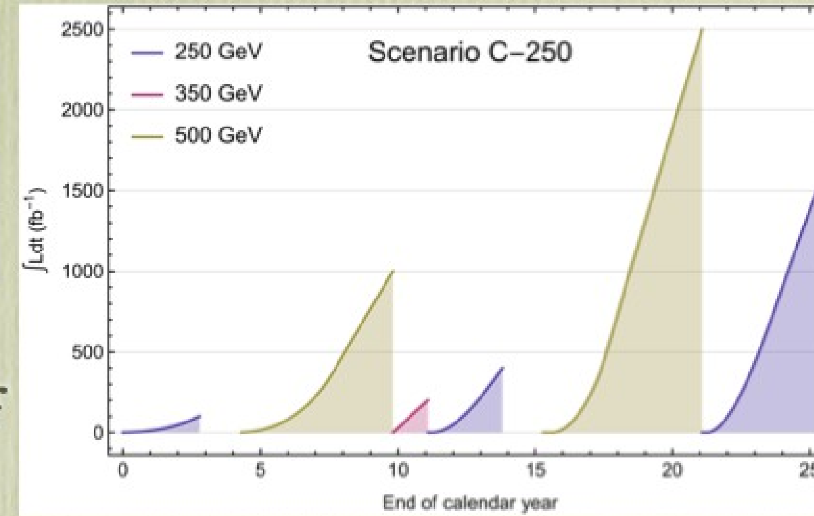
contributions to study from
Mikael Berggren, Roberto Contino, Christophe Grojean, Benno List, Maxim Perelstein, Michael Peskin, Roman Pöschl, Juergen Reuter, Tomohiko Tanabe, Mark Thomson, Junping Tian, Graham Wilson and all members of the ILC Physics Working Group.

Scenarios

Remark: Start at 250 GeV is JAHEP recommendation

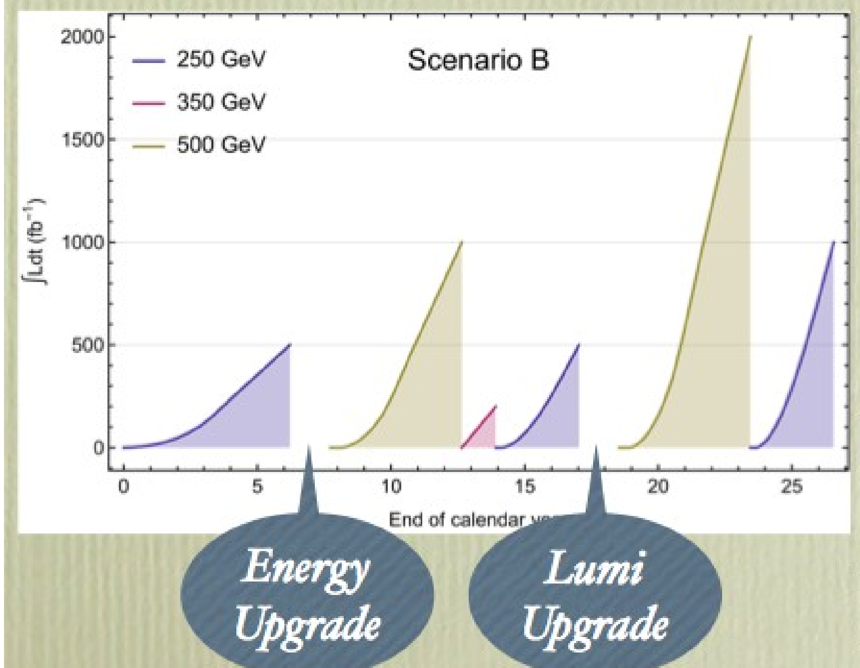
- A: run for 250 fb^{-1} during initial 250 GeV phase (4.1 calendar years) then upgrade to 500 GeV
- B: run for 500 fb^{-1} @ 250 GeV before beginning 500 GeV upgrade (6.2 calendar years)
- C: run for 100 fb^{-1} @ 250 GeV (2.8 calendar years, minimum time required to produce all cryomodules) and then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

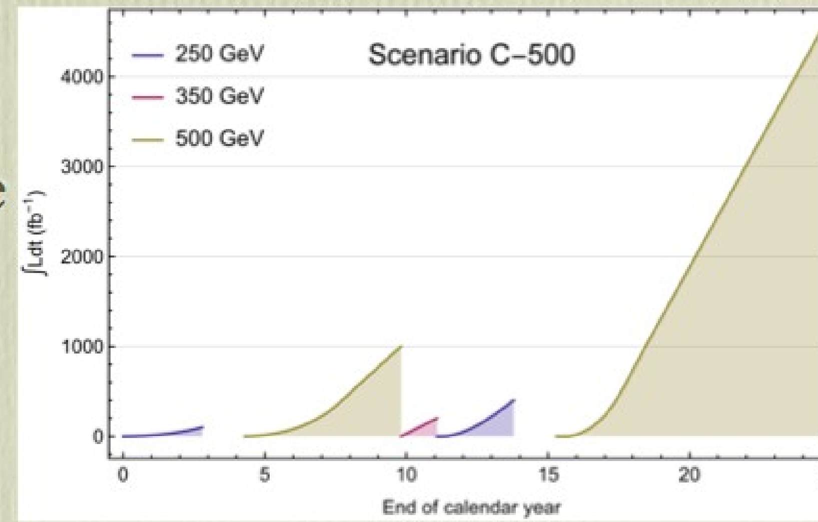




Projected evolution of integrated luminosity with realistic ramp-up and upgrade timelines

Note
- time is in <u>calendar years</u>





Summary of scenarios

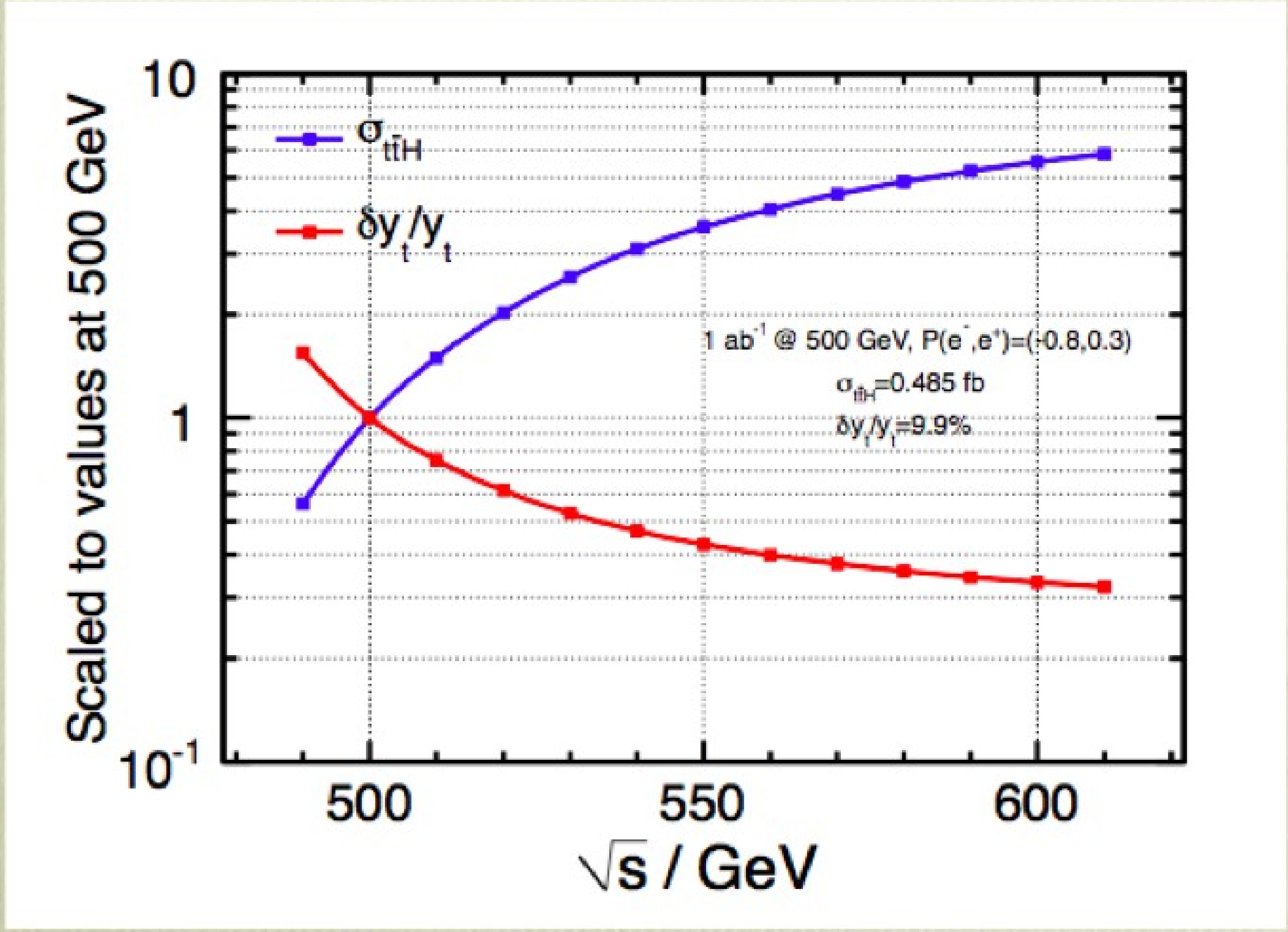
	$\int \mathcal{L}dt$ [fb^{-1}]			
$\sqrt{s}$	A	B	C-250	C-500
250 GeV	2000	2000	2000	500
350 GeV	200	200	200	200
500 GeV	3000	3000	3500	5500

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

	total run time *before*		
	500 GeV	Lumi upgrade	TeV upgrade
Scenario	[years]	[years]	[years]
A	4.1	16.0	25.5
B	6.2	17.1	26.6
C-250	2.8	13.8	25.3
C-500	2.8	13.8	24.6

Table 5: Cumulative running times for the four scenarios, including ramp-up and installation of upgrades. Not included: calibration and physics runs at Z pole and WW-threshold or scanning of new physics thresholds.

$t\bar{t}H$ & $\sqrt{s} \sim 500 - 550$ GeV

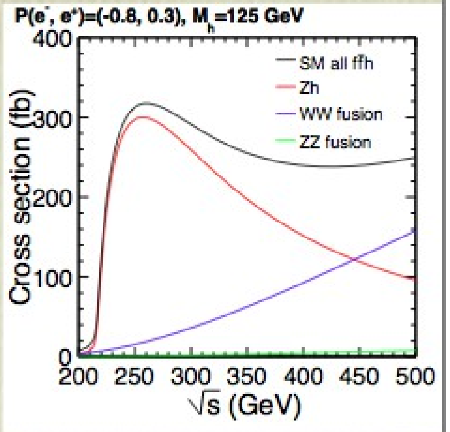


550 GeV is 2.4 improvement over 500 GeV

Scenario D:

Start at 350 GeV?

- If staging is necessary, starting at 350 GeV presents scientific advantages over 250 GeV. Therefore, we discuss this possibility.
- At 350 GeV, Higgs production comes largely from the Higgsstrahlung process, but the important WW-fusion process is rising, increasing three-fold from 250 GeV to 350 GeV.
- This increase enables precise measurements of both the Z-Higgs coupling (g_{HZZ}) and the W-Higgs coupling (g_{HWW}) at 350 GeV.



- These critical measurements are important to the determination of the total Higgs width (Γ_H), and the most precise model independent determination of all the couplings, testing the standard model, and measuring invisible or exotic decays of the Higgs boson.
- Top pair production is open, enabling measurements of top mass (≲ 100 MeV) and top Electroweak couplings.
- Furthermore, the main advantage of 250 GeV (the Higgs mass measurement) might be comparably achieved with measurements at 350 GeV using hadronic decays

J. Brau/ILC Parameters Jt WG - Oct. 8, 2014 18

Accuracies in First 5 Years

Note:
For LHC
not couplings
but κ's!

Γ_H derived
from
couplings

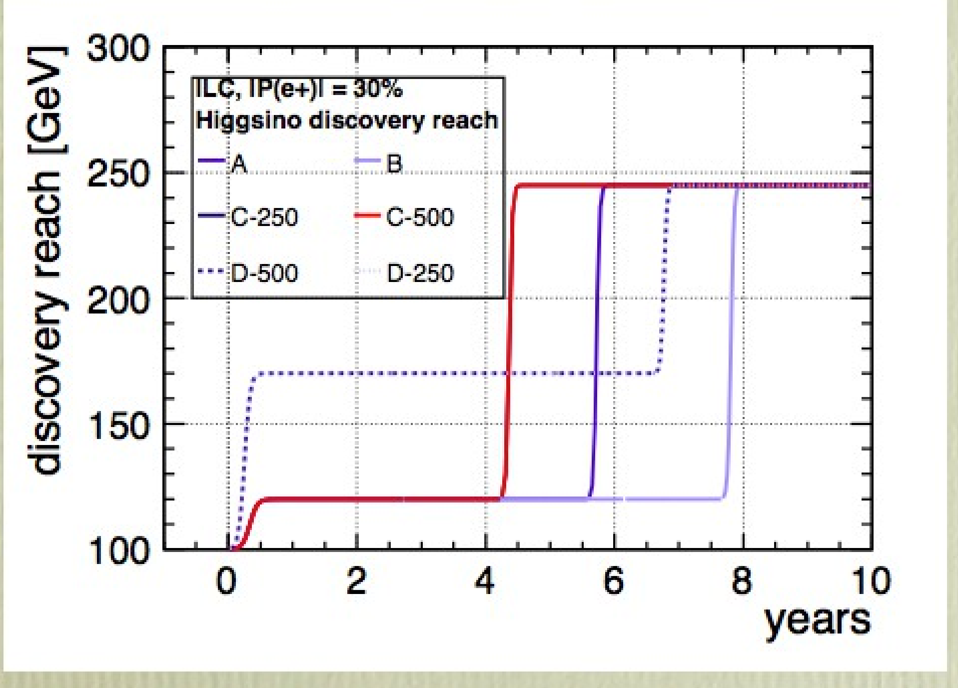
See:
1310.8361

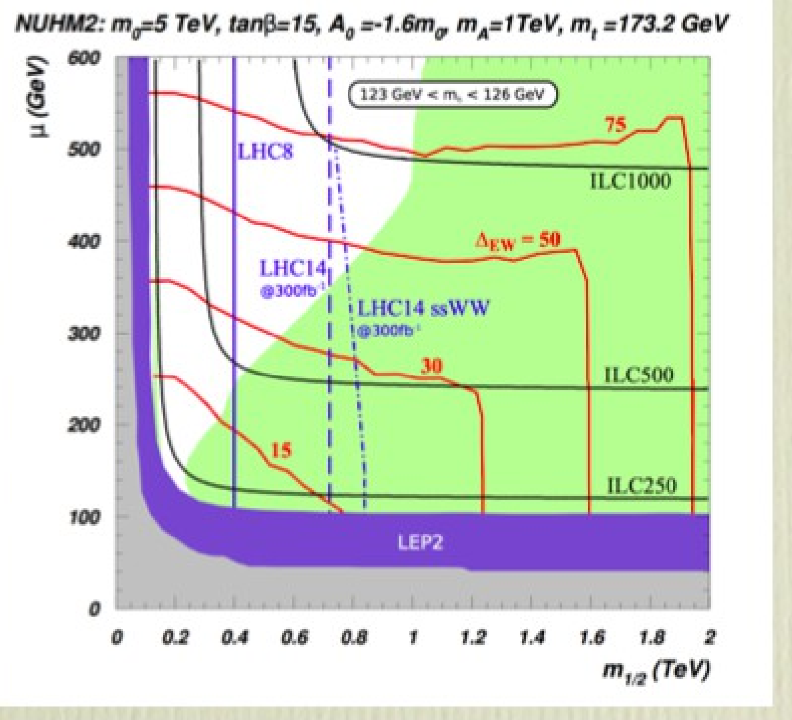
	HL-LHC	ILC Scenario B	ILC Scenario D-500
$\sqrt{s}$ (GeV)	1400	250	350
L (fb^{-1})	3000	360	470
$\gamma\gamma$	2-5 %	14.8 %	10.9 %
gg	3-5 %	4.8 %	2.9 %
WW	2-5 %	3.9 %	0.63 %
ZZ	2-4 %	0.63 %	0.49 %
$t\bar{t}$ (c$\bar{c}$)	7-10 %	5.3 %	3.7 %
$b\bar{b}$	4-7 %	3.8 %	1.3 %
$\tau^+\tau^-$	2-5 %	4.3 %	2.4 %
$\Gamma_T(h)$	5-8 %	7.3 %	2.1 %

Table 7: Expected accuracies $\Delta g_i/g_i$ of Higgs boson couplings for the end of the HL-LHC program and for the first five years of ILC running assuming either Scenario B or Scenario D-500. The couplings are derived from a seven parameter fit of $g_g, g_\gamma, g_W, g_Z, g_b, g_t, g_\tau$ using the model dependent constraints described in Section 10.3.7 of the first report of the LHC Higgs Cross Section Working Group [26]. The HL-LHC coupling errors are taken from the 2013 Snowmass Higgs Working Group Report [15].

Discoveries

- The ILC physics program could be significantly enhanced by discoveries with the LHC or the early ILC running
- Early higher energy running increases the probability for this to happen early at the ILC
- Example: Higgsino





Conclusions on Staging

- For 250 GeV start optimal physics scenario is C-500, with the largest fraction of lifetime operating at the highest possible energy, optimizing the possibility of discoveries of new physics & making the earliest measurements of important Higgs properties.

- Improved early physics reach by starting at 350 GeV, rather than 250 GeV. This would optimize the Higgs measurements, open up early measurements of the top mass and electroweak couplings, and increase discovery reach for new particles.

- The physics impact of the ILC is significantly improved if the maximum energy of the 500 GeV ILC is stretched to 550 GeV where the top Yukawa precision is more than a factor of two times better than at 500 GeV.

- Report emphasizes physics that we are absolutely certain will be done with the ILC and the operational accelerator plans for achieving the best outcomes for that physics.
  - precision measurements of the Higgs boson, the top quark, and possibly measurements of the W and Z gauge bosons.

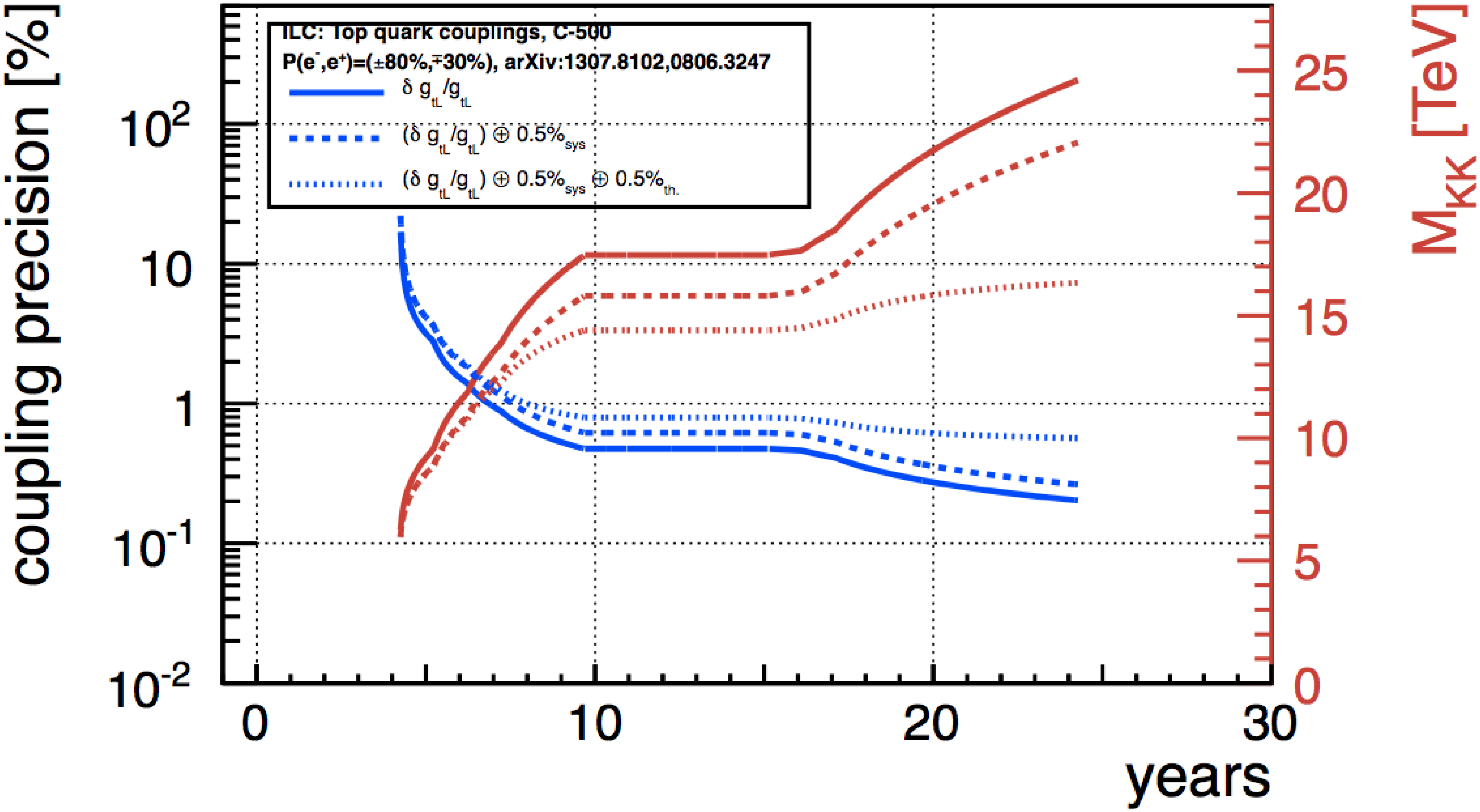
- Each scenario has compelling and impactful scientific program, but discoveries by the LHC or early running of the ILC could expand ILC's scientific impact. Discoveries of pair-produced new particles would motivation operations at or near the threshold of new physics, a capability that is one of the particular operational strengths of the ILC.

Draft of report at http://pages.uoregon.edu/jimbrau/temp/main.pdf

Backup

Example for physics reach

New physics reach for typical BSM scenarios with composite Higgs/Top
And or extra dimenssions
Based on phenomenology described in Pomerol et al. arXiv:0806.3247



Can probe scales of ~25 TeV in typical scenarios
(… and up tp 80 GeV for extreme scenarios)