

Z-Factory Potential

J. Hewett - synthesis

SLAC Site LC Options

Tor R.

- SLAC site options discussed

- Small upgrades and refurbishings to the SLC
- A multi-bunch version of the SLC using new S-band structures
- A high gradient X-band Z-factory using the SLC tunnels
- A high gradient X-band $\gamma\text{-}\gamma$ Higgs shop using the SLC tunnels
- A new X-band low energy linear collider
- None of these have been developed beyond a sketch

• Could be part of LC design program

	SLC Upgrade	Multibunch S-band linac	X-band Linac in SLC tunnel	X-band $\gamma\gamma$ HS in SLC tunnel	New X-band LC
Energy	Z	Z	Z	180 GeV	300 GeV
Sources	none	New e+ source	New e+ source	Pol. e- rf guns	New e+ source
Damping Rings	upgrade	larger rings	larger rings	none	New
Linac	none	structures	X-band	X-band	X-band
Beam Delivery	upgrade	upgrade	New BDS	New BDS	New
Conventional Fac.	small	new DR vault	extensive	extensive	All new
Luminosity	2.00E+31	2.00E+32	4.00E+33	2.00E+33	1.00E+34
Cost Guess M\$	20	150	800	1000	3000
Z's/yr	8 m	80 m	1600 m		[$\sigma(e^+e^- \rightarrow Z)$ corrected for ISR]

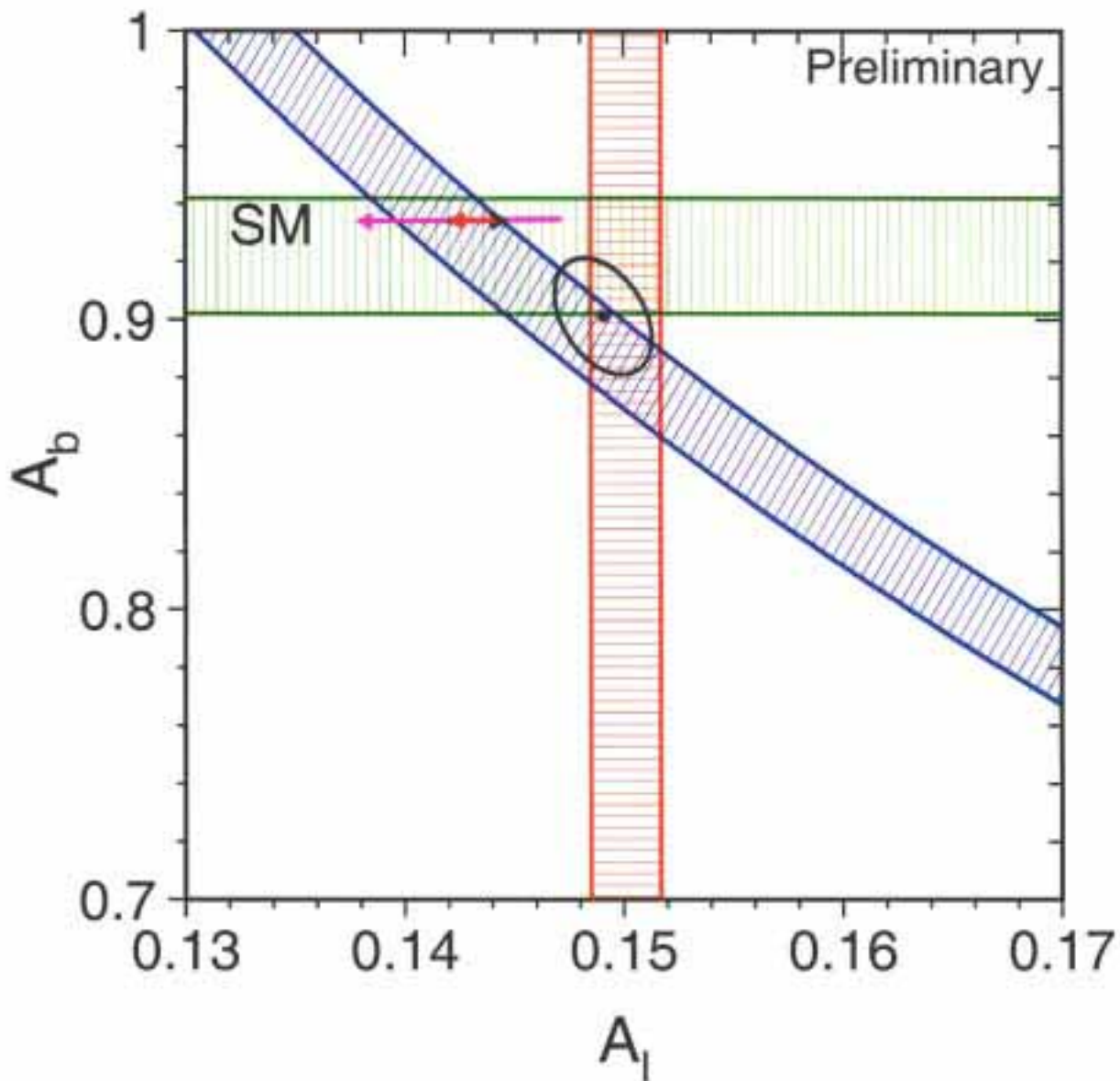
EW Fits: Issues / Questions

- Do we need this in LHC-era?
 - consistency check
 - what if LHC only discovers the Higgs...
 - LC Giga-Z is widely popular
Broad international support
- Do we need P_{e^+} ?
Tor: Need 1250 GeV of linear
But... other ideas??
- Do we also need to reduce ΔM_W , Δm_t
to gain substantial knowledge?

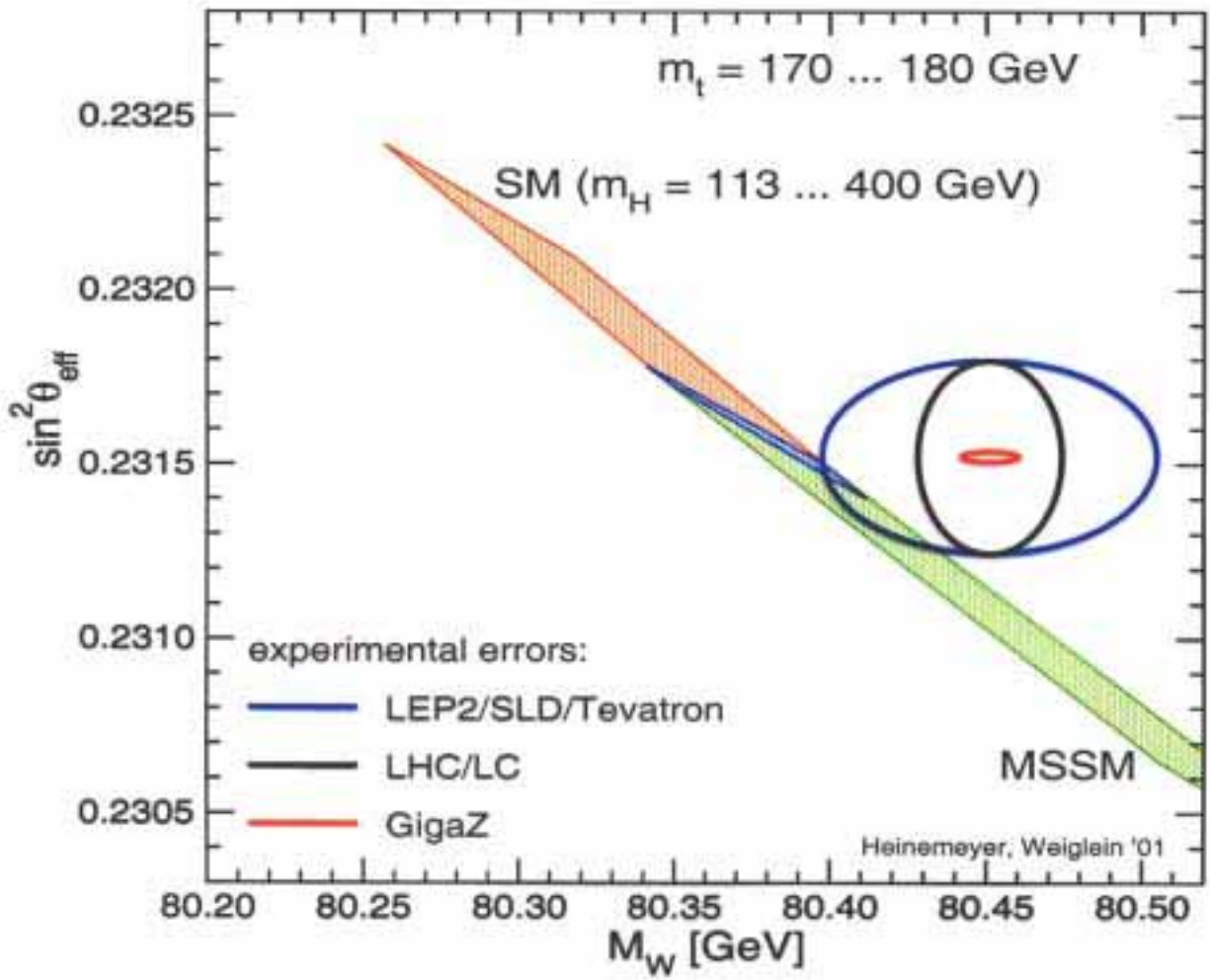
EW Fits : Outstanding Issues

SM inconsistent at 3σ - level

Peskin: It would be useful to repeat these measurements w/ LEP stats, P_e , SLD VXD-2



[S. Heinemeyer, G. W. '01]



⇒ High sensitivity to deviations both from the SM and the MSSM

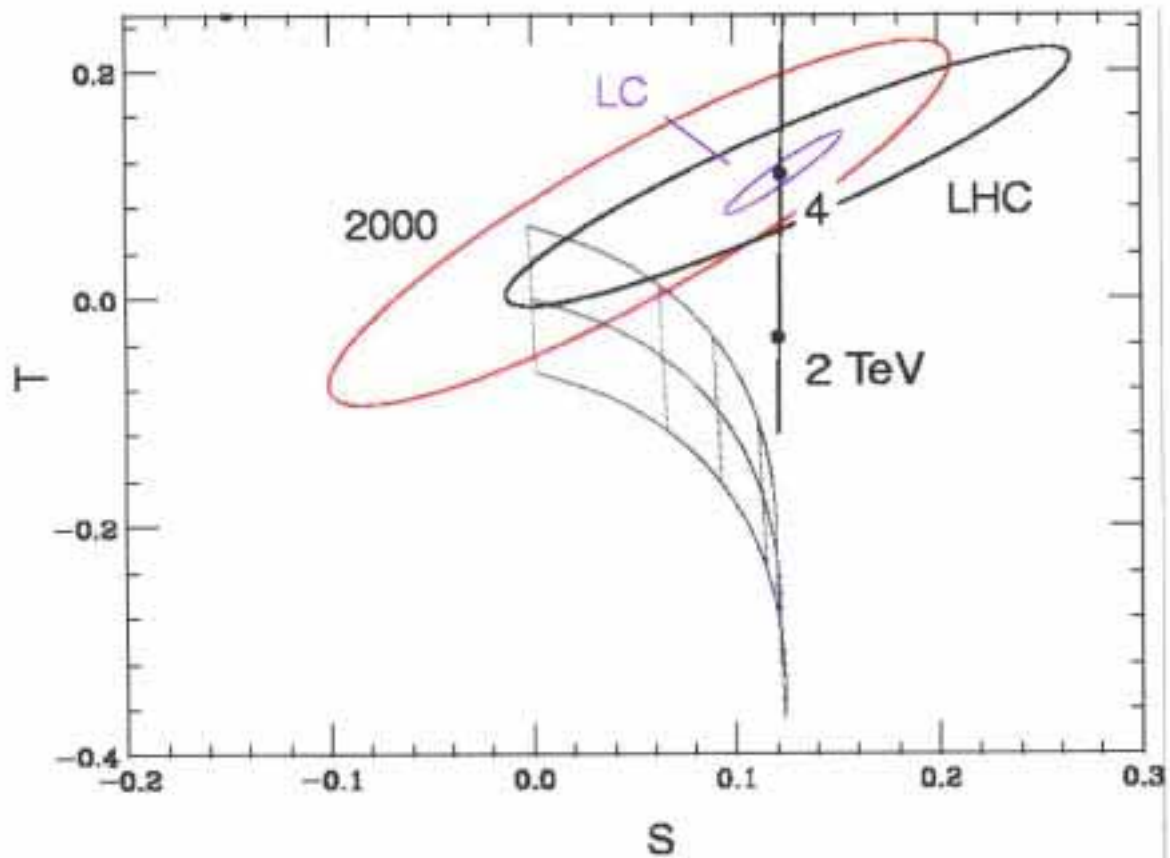
Technicolor + Extra Dimensions:

Example 2: Topcolor Seesaw

Dobrescu – Hill

Higgs at \sim TeV $H = \langle \bar{F}_{KK} | F_{KK} \rangle$

New singlet quark \sim 5 TeV



Peskin Wells

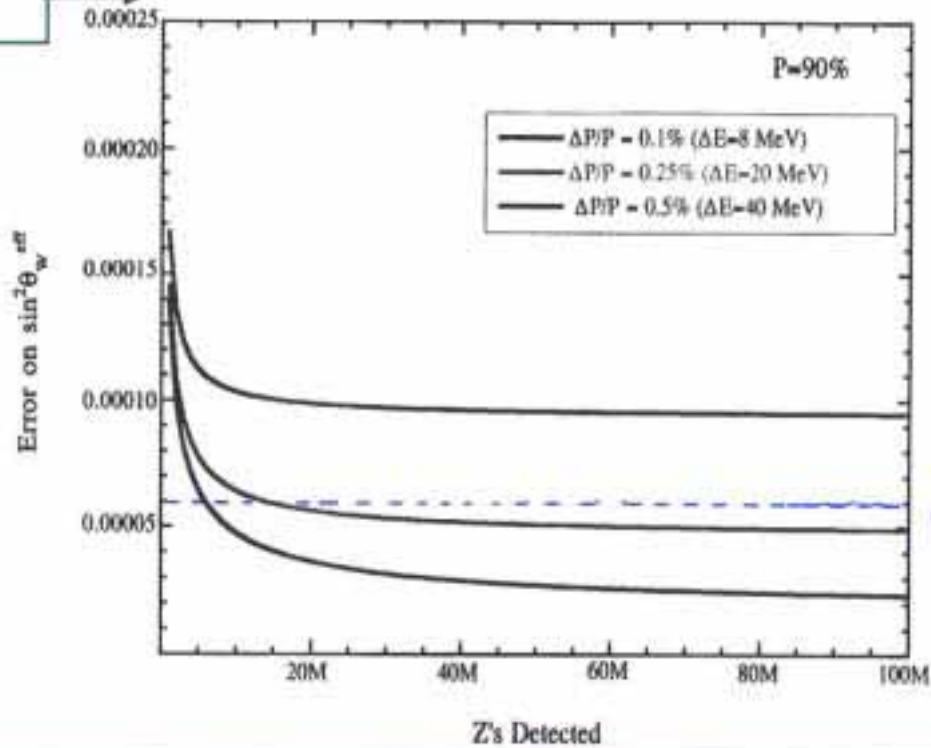
- LHC sees no new physics
- Giga-Z sees significant shifts in precision EW

Improved Weak Mixing Angle Measurement

SLD precision
0.00026

Error on $\sin^2\theta_W^{eff}$ vs. Zs Detected

M. Woods

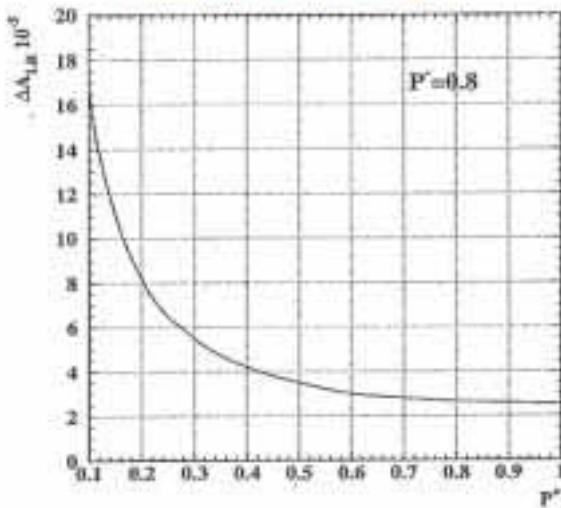


Flattens out quickly!

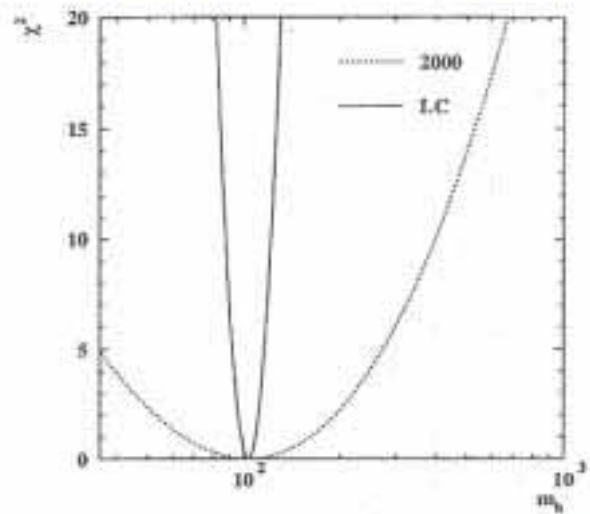
GOALS: 100M Zs
 0.25% $\Delta P/P \Rightarrow$ Feasible $\longrightarrow \delta(\sin^2\theta_W^{eff}) \sim 0.00006$
 100 ppm $\Delta E_{CM}/E_{CM}$ (10 MeV) \Rightarrow Requires further study

\rightsquigarrow this is best achievable w/o P_{e^+} .

Effect of P_{e^+}



Effect on Blue-Band plot



$\Delta A_{LR} = 38 \times 10^{-5}$ w/ $P_{e^+} = 0$
[taking $\Delta P/P = 0.25\%$]

Erlar et al

Giga-Z
claimed
errors

	LEP/SLC/Tev [19]	TESLA
$\sin^2 \theta_{\text{eff}}^Z$	0.23146 ± 0.00017	± 0.000013
lineshape observables:		
M_Z	$91.1875 \pm 0.0021 \text{ GeV}$	$\pm 0.0021 \text{ GeV}$
$\alpha_s(M_Z^2)$	0.1183 ± 0.0027	± 0.0009
$\Delta \rho_L$	$(0.55 \pm 0.10) \cdot 10^{-2}$	$\pm 0.05 \cdot 10^{-2}$
N_ν	2.984 ± 0.008	± 0.004
heavy flavours:		
A_b	0.898 ± 0.015	± 0.001
R_b^0	0.21653 ± 0.00069	± 0.00014
M_W	$80.436 \pm 0.036 \text{ GeV}$	$\pm 0.006 \text{ GeV}$

Tesla TDR

so, explore S T contours for various levels of precision on the inputs:

Status of Theory Errors

$\Delta \Gamma_l$ is already systematics limited at LEP

Missing 2-loop calcs

Δs_*^2 can be improved as $1/\sqrt{N}$:

$\Delta s_{\text{eff}}^{\text{eff}}|_{\text{Th}} \sim 8 \times 10^{-5}$

current SLD	26×10^{-5}	
20 M	5×10^{-5}	
200 M	1×10^{-5}	(if still $1/\sqrt{N}$)

Complete to 2nd order!

Δm_W

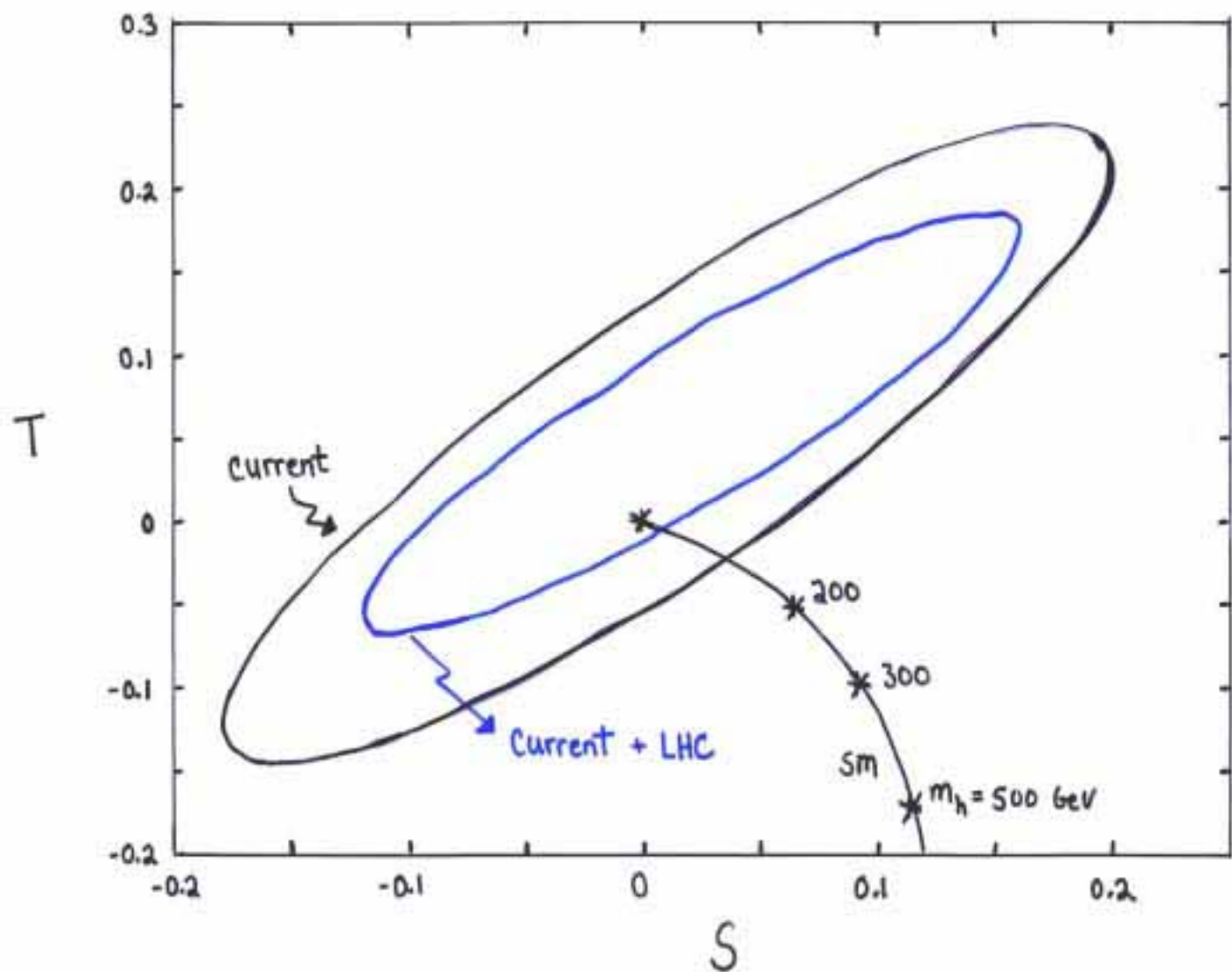
$\Delta m_W|_{\text{Th}} \sim 5 \text{ MeV}$

current	34 MeV	
LHC	15 MeV	
threshold	5 MeV	dedicated e+e- run

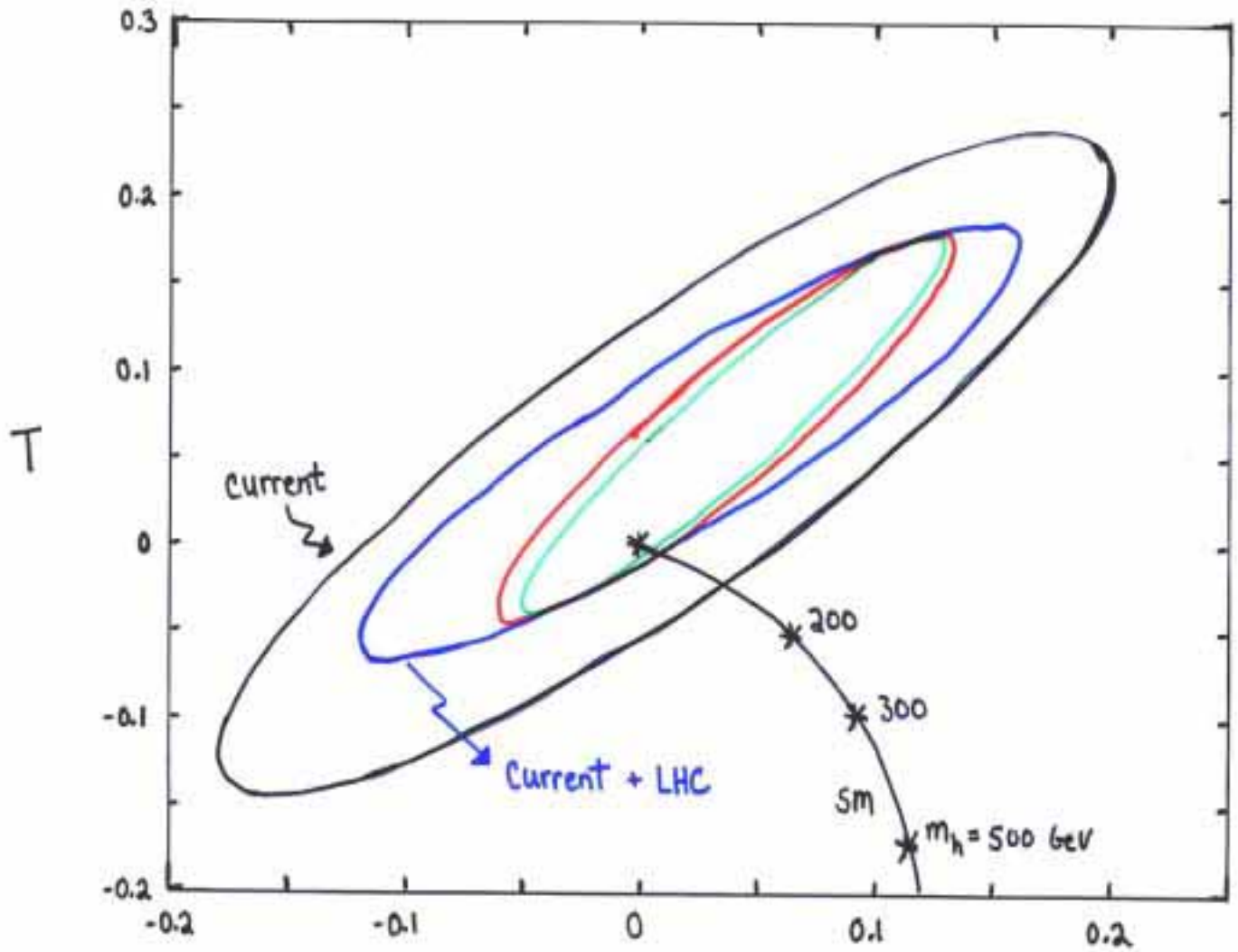
Δm_t

current	5.1 GeV
LHC	2 GeV (theor. syst. limit)
LC	0.1 GeV

and error on $\alpha^{-1}(m_Z)$ at 21 or 7×10^{-3}



Improve $\sin^2 \theta_{\text{eff}}^l$ $5, 1 \times 10^{-5}$

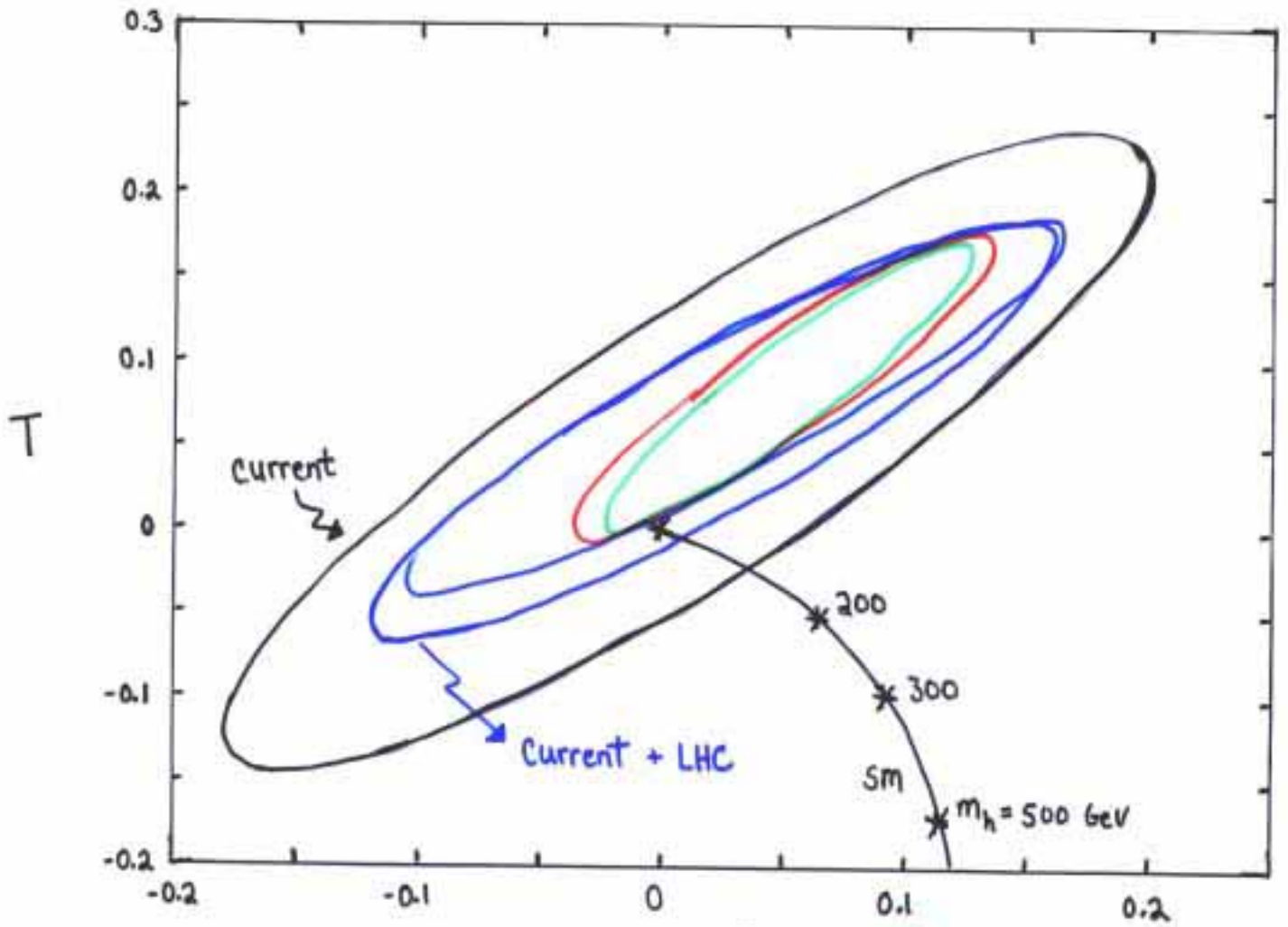


optimistic $\Delta \alpha^{-1} = 7 \times 10^{-3}$

S

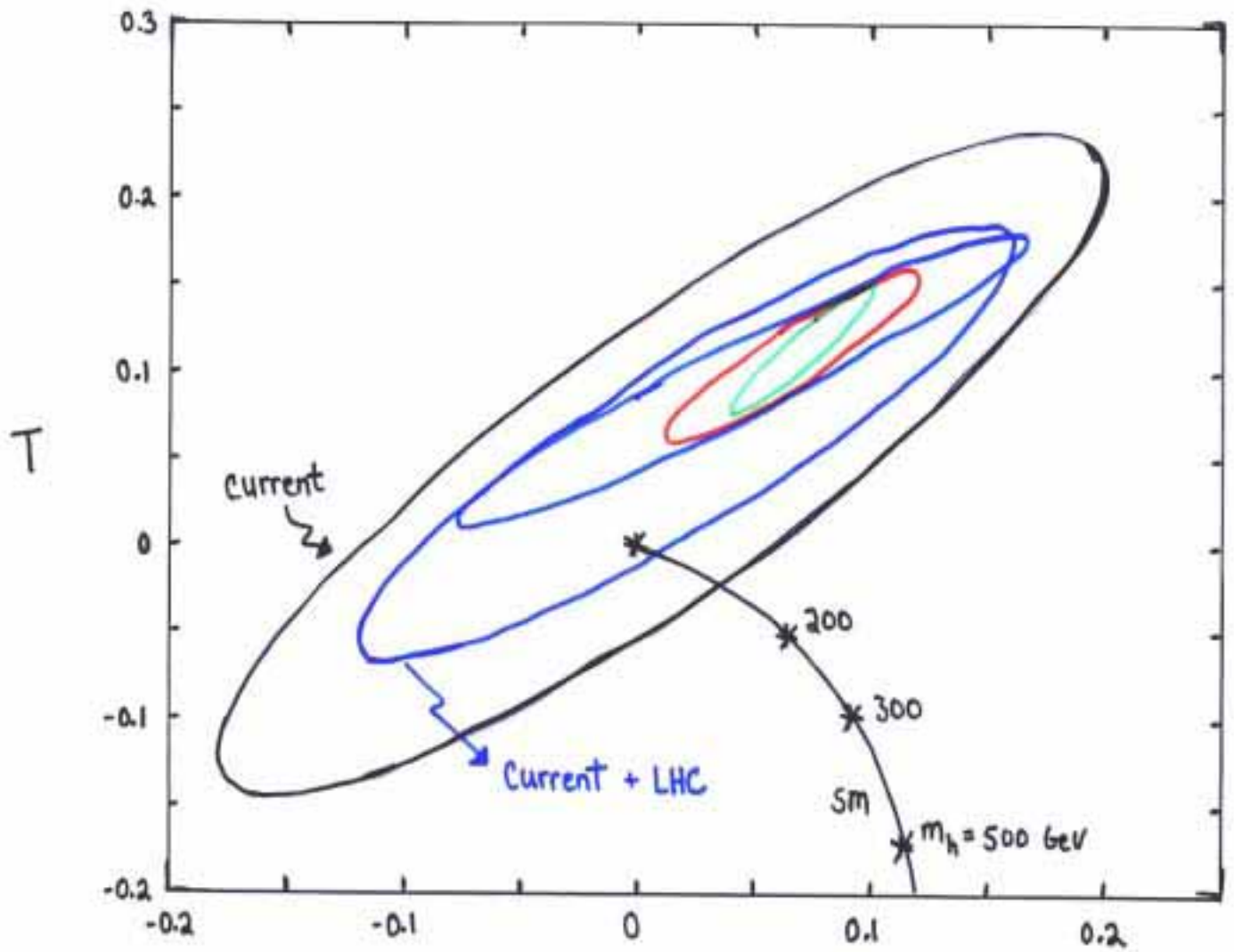
not much difference between $5, 1 \times 10^{-5}$.

$$\Delta m_W = 6 \text{ MeV}$$



$$\Delta \sin^2 \theta_{\text{eff}}^p \approx 5.1 \times 10^{-5}$$

$$\Delta m_W = 6 \text{ MeV} + \Delta m_t = 100 \text{ MeV} \text{ [Full LC]}$$



$$\Delta \sin^2 \theta_{\text{eff}}^{\text{SI}} = 5, 1 \times 10^{-5}$$

B Physics Opportunities: Not well-studied!

Z-Factory advantages:

- Polarization - tags B vs \bar{B} [Could double tag Quality factor]
 - Λ_b highly polarized
- Boost of the Z - helps w/ missing energy modes
 $B \rightarrow \tau \nu, s \nu \bar{\nu}$
- Produce B_d, B_s, Λ_b
- Direct CP asymmetries in rare decays
- Inclusive final states
- $Z \rightarrow b\bar{s} + \bar{b}s$

Studies based on \mathcal{L} only:

(Snowmass)

	$e^+e^- ('05)$	BTeV/LHCb	10^{36}	$10^9 Z$	$10^{10} Z$
$\Delta \sin 2\beta$	0.037	0.014/0.02	0.008	0.04	0.013
$\Delta \sin 2\alpha$	0.26	0.05	0.032	0.07	

JoAnne's take on Z-Factory Potential

- EW fits need $\Delta M_w, \Delta m_t$ reduction to gain significant improvement $\left[+ P_{e^+} \text{ for high lumi} \right]$
- Improved R_b/A_b
- B-Physics potential could be BIG!
Needs a good study + α_{lumi}
- Possible to incorporate machine as part of LC Design study - test LC components
- International community is interested in Giga-Z

This option deserves serious consideration
[with high α_{lumi}]

- ★ Local community seems reluctant to return to the Z.
- ★ Conflicts w/ LC