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Physics at a Z Pole Factory

Studies with 10^8, 10^9, 10^{10} ... Z Decays (with polarization)

Outline

1. Motivation
2. Z Pole Statistics
3. Z Physics Studies
   - i) $\sin^2\theta_W^{eff}$ to ± 0.000020! Must Do!
   - ii) $Zb\bar{b}$ Coupling (R_b, A_b anomaly) 2.5σ deviation? $10\times 30 \times$ Imp
   - iii) Γ_Z, $\Gamma(Z\to \ell^+\ell^-)$, $\Gamma(Z\to \nu\bar{\nu})$ (systematics)?
   - iv) Rare + Forbidden Z Decays (Not Compelling)? ($Z\to b\bar{s}$ or $\tau\bar{\mu}$?)
4. b Physics (Unique Features) LRFB tag!
   - i) CP Violation (B_d^0, $B^\pm$, B_s^0, Λ_b, B_c, bcq) } "New Physics" or α, β, γ
   - ii) Rare Decays, FCNC ...
5. τ Physics (Unique Features)
   - i) Precision Measurements: τ_τ, $B(\tau\to \ell\nu\bar{\nu})$, $\tau\to \nu_\tau K\pi$ ... QCD
   - ii) FCNC (eg $\tau\to\mu\gamma$), $g\!\!\!/$, ...
6. Comments + Conclusions

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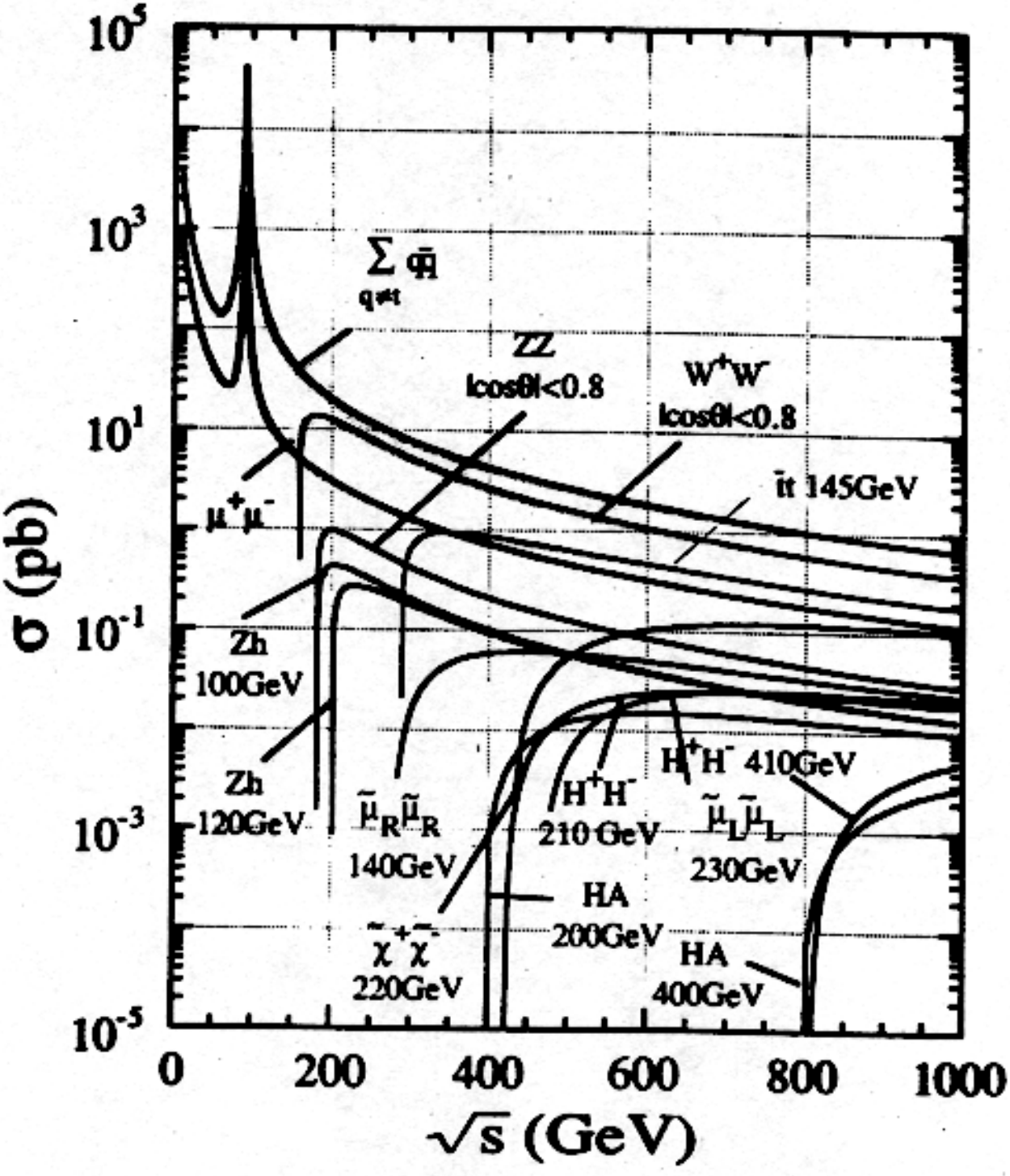
From JLC Group



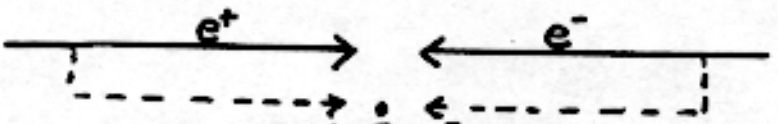
1. Motivation (Part of NLC Physics Program)

e^+e^- at $\sqrt{s} \rightarrow$ 500, 1,000, 1,500 GeV with polarization

$\sqrt{s}$ =	90 - 500 GeV	500 - 1500 GeV	2-4 TeV ?
	Z Pole	$t\bar{t}H$	Destiny ?
	W^+W^-	SUSY	
	$t\bar{t}$	Z', Z^*	?
	ZH (probably)	Extra Dim.	
	SUSY ?		
	Crisp	Less Crisp	Not Crisp
	Clear	Very Compelling	Most Compelling
	Compelling	Clearer - Post LHC	Discovery Potential
	+		
	Some Discovery Potential		

* High Statistics Z Pole Studies

Gold Mine or Detector Calibration ?



Dedicated Effort ? (Second Int. Region ?)

Z pole
W^+W^-
ZH
$\gamma\gamma \rightarrow H$

* Studies: K. Mönig, Sitges 1999

Heinemeyer, Mannel, Weiglein, Sitges 1999

W. Marciano, Berkeley 2000

2. Z Pole Statistics

~1980 Z Pole Facilities (Proposed)

	LEP	SLC	CESR II	
Design Luminosity $cm^{-2}s^{-1}$	10^{32}	10^{30}	3×10^{31}	New Physics? (Precision)
Polarization	?	Yes	?	

Achievements: LEP I $4\times4\times10^6$ Z Decays, No Pol.

SLC 5.5×10^5 Z Decays, $P_{e^-} \sim 75\%$ (stat. limited)

Future Facilities (?)

NLC: $\mathcal{L} \simeq 2\times10^{33} cm^{-2}s^{-1} \rightarrow 10^9 Z / 10^7 sec$ (~ 1 LEP/day)

TESLA: $\mathcal{L} \simeq 7\times10^{33} cm^{-2}s^{-1} \rightarrow 3.5\times10^9 Z / 10^7 sec$

Dedicated Facility $\mathcal{L} \simeq 10^{34} cm^{-2}s^{-1} \times 5yrs \rightarrow 2.5\times10^{10}$ Z decays !!

What can be done with $10^8, 10^9, 10^{10} \ldots$ Z decays?

High Polarization: $P_{e^-} + P_{e^+}$ (Both Polarized?)

$P_{eff} = \dfrac{P_{e^-} - P_{e^+}}{1 - P_{e^-}P_{e^+}}$ eg $|P_{e^-}| = 0.80$, $|P_{e^+}| = 0.60 \rightarrow P_{eff} = 0.950$ small unc.

Alternative $P_{e^-} = 0.90$ $P_{e^+} = 0$, $P_{eff} = P_{e^-} = 0.90$ unc.?

Effective Polarization P_{e^-} = electron pol. P_{e^+} = positron pol.

$$P_{eff} = \frac{P_{e^-} - P_{e^+}}{1 - P_{e^-} P_{e^+}}$$ Add like rel. velocities $-1 \le P_{eff} \le 1$

$$\frac{\Delta P_{eff}}{P_{eff}} = \frac{(1 - P_{e^+}^2) P_{e^-}}{(P_{e^-} - P_{e^+})(1 - P_{e^-} P_{e^+})} \frac{\Delta P_{e^-}}{P_{e^-}} - \frac{(1 - P_{e^-}^2) P_{e^+}}{(P_{e^-} - P_{e^+})(1 - P_{e^-} P_{e^+})} \frac{\Delta P_{e^+}}{P_{e^+}}$$

↖ Error Suppression Factors ↗

Eg. $P_{e^-} = 0.90$ $P_{e^+} = -0.50 \pm 0.05$ → $P_{eff} = 0.966 \pm 0.005$!

Alternative: Measure $N_{LR}, N_{RL}, N_{LL}, N_{RR}$ → $P_{e^+}, P_{e^-}, \sin^2\theta_W^{eff}$
(A. Blondel)

10^9 Z Decays → $1.5\times10^8\ b\bar{b}$ $\quad 3.3\times10^7\ \tau^+\tau^-$

80% → $6\times10^7\ B_d^0, \bar{B}_d^0, B^+, B^-$

12% → $1.8\times10^7\ B_s^0, \bar{B}_s^0$

8% → $1.2\times10^7\ \Lambda_b, \bar{\Lambda}_b$ pol.

$\sim10^4\ B_c, \bar{B}_c$

$\sim 2\times10^3\ b\bar{c}q$

} Probably want $\gtrsim 10^{10}$ Z → $> 10^9\ b\bar{b}$ Dedicated Effort

SLAC B Factory → $3\times10^7\ B\bar{B}$/yr $\xrightarrow{\text{upgrade}}$ $10^8\ B\bar{B}$/yr competition?

$5\times10^7\ \tau^+\tau^-$/yr (Backgrounds, charm)

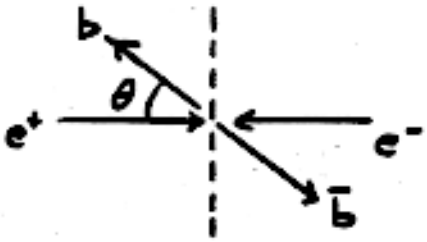
LHCB, BTeV → $10^{12}\sim10^{13}\ b\bar{b}$/yr! ($\sim10^{11}\ \tau$/yr) usable?

Z Pole Advantages: $\tau^+\tau^-$ low mult. very clean c.d.
high energy, vertex (eg. lifetime)

$b\bar{b}$ Clean, Small Bkrd, H.E., High Efficiency

sym. $^*B^0 = {}^*\bar{B}^0$, $^*\Lambda_b = {}^*\bar{\Lambda}_b$ etc

* Most Important: LRFB Flavor Tag (qP Asym.) Cf LHCB



$$\frac{dN(e^+e^-\to b\bar{b})}{dx} = \frac{3}{8}N\left(1-P_{e^-}P_{e^+}+(P_{e^+}-P_{e^-})A_{LR}\right)\cdot\left(1+x^2+\frac{8}{3}xA_{eff}\right)$$

$-1 \le x = \cos\theta \le 1$

$$A_{eff} = \frac{A_{FB}+P_{eff}A_{LR}^{FB}}{1+P_{eff}A_{LR}} \simeq \frac{3}{4}P_{eff} \text{ for } b\bar{b}$$

(b forward vs. b backward (same hemisphere))

3. Z Physics Studies: $> 10^9$ Z Decays $\Delta P_{eff}/P_{eff} = \pm 0.001$?

i) $\sin^2\theta_W^{eff}$ Most Important EW Parameter, "A Standard" Window to "New Physics"

e^+e^-: Cleanest Method $A_{LR} \Rightarrow \frac{N_{LR} - N_{RL}}{N_{LR} + N_{RL}} = P_{eff} \frac{2(1-4\sin^2\theta_W)}{1+(1-4\sin^2\theta_W)^2} \simeq 0.15$

$$\frac{\Delta s^2}{s^2} \simeq \frac{1}{10} \frac{\delta A_{LR}}{A_{LR}}$$ very sensitive

α, G_μ, m_Z vs $\sin^2\theta_W^{eff} \longrightarrow m_H$ Higgs Mass

$$\sin^2\theta_W^{eff} = (0.23158 \pm 0.00016 \pm 0.00006)(1 + 0.00226 \ln(\frac{m_H}{100\,GeV}))$$

$A_{LR} \longrightarrow \sin^2\theta_W^{eff} = 0.23101(28) \longrightarrow m_H \simeq 47\,GeV$

$A_{LR} + A_{FB}(l^+l^-) \rightarrow \sin^2\theta_W^{eff} = 0.23119(21) \longrightarrow m_H \simeq 67^{+45}_{-27}\,GeV$

$A_{FB}(had) \rightarrow \sin^2\theta_W^{eff} = 0.23236(32) \longrightarrow m_H \simeq 630\,GeV$

Average $\rightarrow \sin^2\theta_W^{eff} = 0.23153(17) \longrightarrow m_H \simeq 128^{+70}_{-42}\,GeV$

Current Situation Unacceptable What is $\sin^2\theta_W^{eff}$?

Too Big A Range ($\sim 0.2307 \rightarrow 0.2327$)

Aim for $\frac{\Delta s^2}{s^2} \simeq \pm 0.01\%$ (Need $\frac{\delta A_{LR}}{A_{LR}} \simeq \pm 0.1\%$)

Requires $\simeq 6\times10^7$ Z decays, $\frac{\Delta P_{eff}}{P_{eff}} \simeq \pm 0.1\%$ (Hard) SLD $\pm 0.5\%$

A_{LR} Systematics at SLD

1.) $\delta P_{e^-}/P_{e^-} = \pm 0.5\% \rightarrow \Delta \sin^2\theta_W^{eff} \simeq \pm 0.0001$

2.) $\Delta E_{c.m.} \simeq \pm 25\,MeV \rightarrow \delta A_{LR}/A_{LR} \simeq \pm 0.4\%$

3.) $P_{e^+} = -0.02 \pm 0.07\%$

$$A_{LR}^{eff} = \frac{P_{e^-}(A_{LR} - P_{e^+})}{1 - P_{e^+} A_{LR}} \rightarrow \delta A_{LR}/A_{LR} \simeq \pm 0.5\%$$

Reduce each by factor 5-10! $\rightarrow \Delta \sin^2\theta_W^{eff} \simeq \pm 0.00002$!

Use $P_{e^+} + P_{e^-} \rightarrow P_{eff}$

or

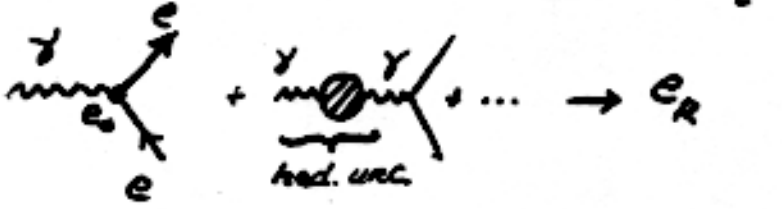
Measure $N_{LR}, N_{RL}, N_{LL}, N_{RR}$ (A. Blondel)

Precision EW Measurements

$$\sin^2\theta_W^\circ = \frac{e_0^2}{g_{Z_0}^2} = 1-(m_W^\circ/m_Z^\circ)^2 \qquad \text{Bare Natural Relation}$$

$$\sin^2\theta_W = \frac{e^2}{g_Z^2}(1+\text{finite R.C.}) = \left(1-\frac{m_W^2}{m_Z^2}\right)(1+\text{finite R.C.})$$

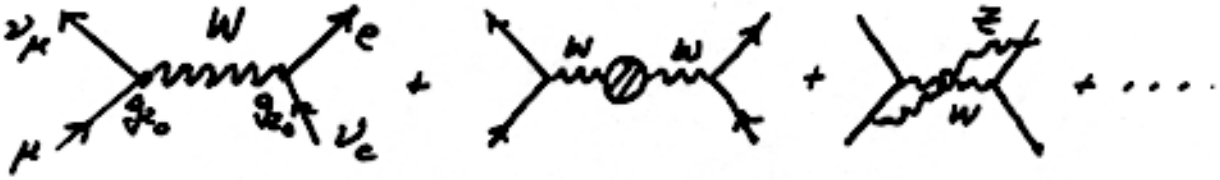
Window to m_t, m_H, "new physics"



$\to e_R \qquad \alpha = \dfrac{e^2(q^2=0)}{4\pi}$

$\alpha^{-1} = 137.03599959(40)$ from g_e-2 T. Kinoshita

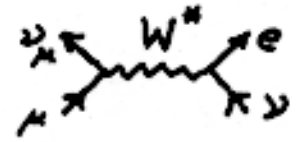
g_{Z_R} from muon lifetime $\mu^+ \to e^+\nu_e\bar{\nu}_\mu(\gamma)$



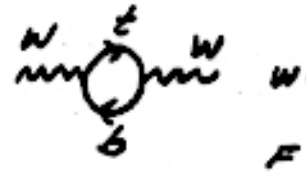
$\tau_\mu = 2.197035(40)\times 10^{-6}\,s$

$$\to \quad G_\mu = \frac{g_{Z_R}^2}{4\sqrt{2}\,m_W^2} = 1.16637(1)\times 10^{-5}\,GeV^{-2}$$

Could also contain new tree level physics

eg 

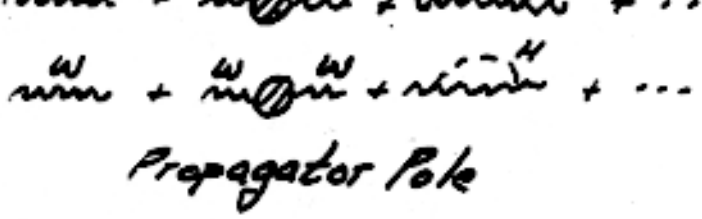
excited W^* $\quad m_{W^*} \gtrsim 3\,TeV$

loops depend on $m_t + m_H$ 

New heavy fermions 

S+T Parameters

Z + W Masses



Propagator Pole

LEP → $m_Z = 91.1871(21)$ GeV Very Precise

CDF, DØ.. → $m_W = 80.448(62)$ GeV

LEP II → $m_W = 80.401(48)$ GeV

Ade **$m_W = 80.419(38)$ GeV** LHC → ±15 MeV

NLC → ±6 MeV!?

$$\left(1 - \frac{m_W^2}{m_Z^2}\right)\left(1 + \text{R.C.}\right) = \frac{\pi\alpha}{\sqrt{2}\, m_W^2 G_\mu}$$

↑ depend on m_H + $m_t = 174.3 \pm 5.1$ GeV

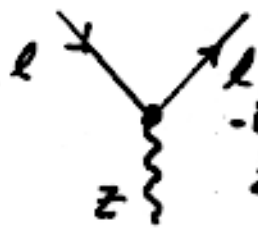
→ **$m_H = 53^{+77}_{-40}$ GeV** LEP II $m_H > 108$ GeV

Standard Model
No New Physics
to $M_{Pl} \simeq 10^{19}$ GeV

$135\text{ GeV} < m_H < 140\text{ GeV}$ (~ 170 GeV)

vac. stability pert unitarity (Pert. th.)

Weak Mixing Angle $\sin^2\theta_W$ (Even better constraint)



$$-i\frac{g_{Z_0}}{2\sqrt{2}}\gamma_\mu\,(\text{Z couplings})\left(1 - 4\sin^2\theta_W^{\circ} - \gamma_5\right)$$

$$+\text{R.C.} \rightarrow \frac{-ig_Z}{2\sqrt{2}}\gamma_\mu\left(1 - 4\sin^2\theta_W^{\text{eff}} - \gamma_5\right)$$ defined at Z pole

$\sin^2\theta_W^{eff}$ best measured at Z Pole

A_{LR}, A_{FB}, $A_{\tau pol.}$ $\propto (1-4\sin^2\theta_W^{eff})$

$$\frac{\delta A}{A} \sim \frac{4}{(1-4s^2)}\,\delta s^2$$

very sensitive $s^2 \simeq 0.231$

$\sin^2\theta_W^{eff} = 0.23119 \pm 0.00021$ (leptons)

$\sin^2\theta_W^{eff} = 0.23236 \pm 0.00032$ (hadrons)

} discrepency

Ave $\sin^2\theta_W^{eff} = 0.23153 \pm 0.00017$ $\rightarrow$ $m_H \simeq 128^{+70}_{-42}$ GeV

What is $\sin^2\theta_W^{eff}$? Need a credible standard!

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m_H prediction $m_H = (140 \pm \underbrace{50}_{\Delta m_t} \pm \underbrace{17\,\text{GeV}}_{\Delta\alpha(m_Z)}) \exp\{1911\,(\sin^2\theta_W^{eff} - 0.23158)\}$

$\Delta s^2/s^2 \simeq \pm 0.01\%$ $\rightarrow$ $\Delta m_H/m_H \simeq \pm 4\%$

GUTS, S, T, U, SUSY, High Energy Comparison ...

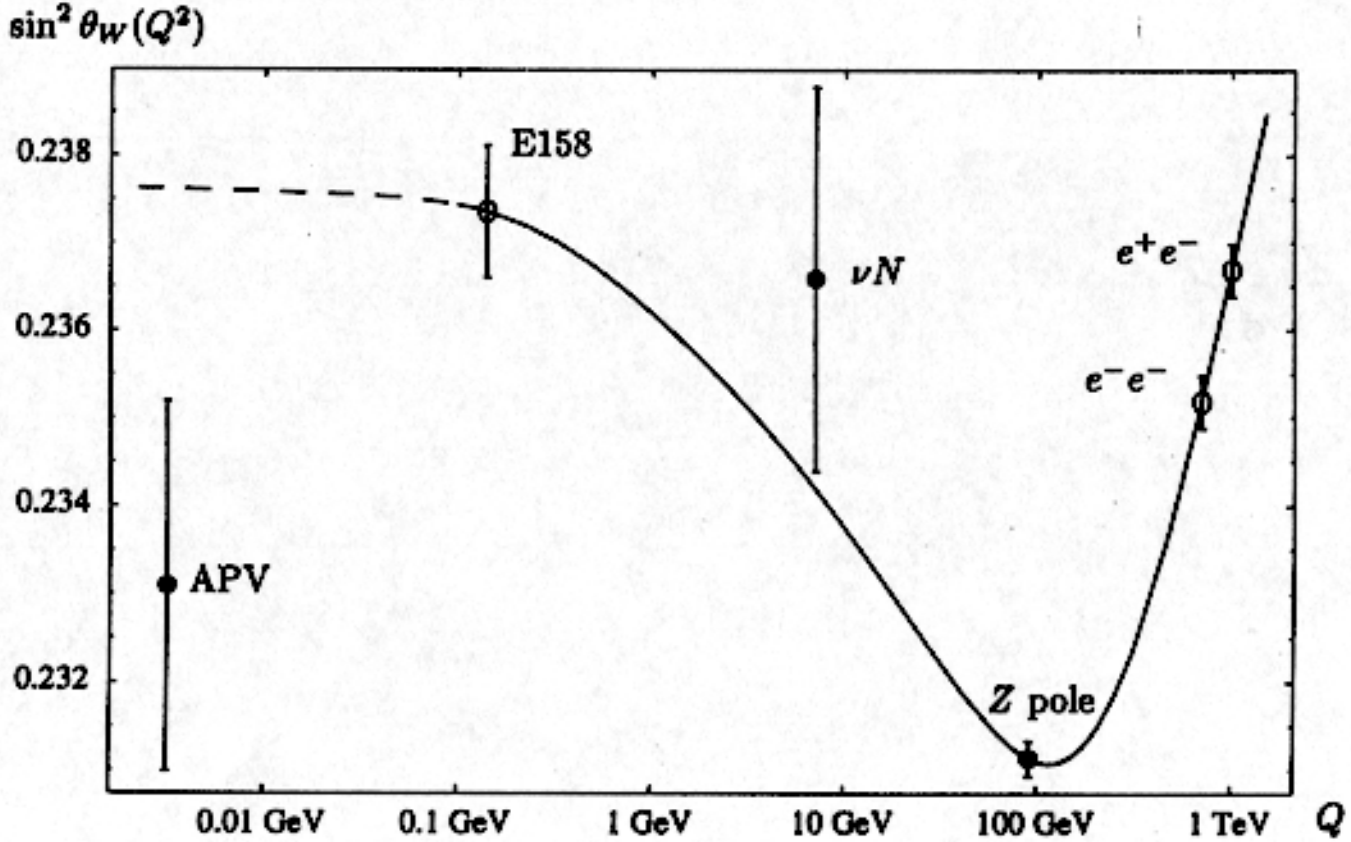

Fig. 1. Predicted running of $\sin^2\theta_W(Q^2)$ and evidence from existing experiments (dark circles) along with expectations from potential future Møller and e^+e^- asymmetry measurements at $\sqrt{s} =$ 1 TeV.

Other Methods: $e^+e^- \to \tau^+\tau^-$ (tau pol) } Currently Stat. limited!
$e^+e^- \to \ell^+\ell^-$ FB Asy. } (Ultimate systematics?)

Collectively (10^9 Z decays) → $\Delta\sin^2\theta_W = \pm 0.000020$ Powerful

Implications $\Delta s^2/s^2 = \pm 0.01\%$ → $\frac{\Delta m_W}{m_W}$ to $\pm 4\%$!

S+T Parameters to ± 0.02 (± 0.01)
$m_{W'} \sim 10\text{-}20$ TeV, $m_{Z'} \sim 10$TeV } compare with e^+e^- at
$\Lambda_{comp} \sim 100$TeV } $\sqrt{s} \simeq 500\text{-}1000$GeV

Expect to find a deviation (Also push $\Delta m_W \simeq \pm 6$ MeV)

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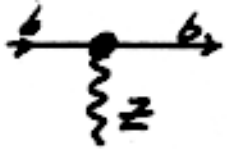
ii) **$Zb\bar{b}$ Coupling**



FB + LRFB Asy.
$A_b^{exp}/A_b^{th} \simeq 0.958 \pm 0.017$ 2.5σ
$R_b = \Gamma(Z \to b\bar{b})/\Gamma(Z \to \text{hadrons})$
$R_b^{exp}/R_b^{th} = 1.0029 \pm 0.0035$

Anomalous $g_R(b)$?
$g_R(b)^{exp} \simeq +0.10$ $g_R(b)^{th} \simeq 0.077$

Could be improved $\Delta R_b/R_b \lesssim 10^{-3}$ $\Delta R_b/R_b \lesssim 10^{-3}$!
Sensitive To "New Physics"

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iii) **Z Width** (line shape)

$\Gamma_{had} = 1743.9 \pm 2.0$ MeV → $\alpha_s(M_Z)$ Very Clean

$\Gamma(Z \to \ell^+\ell^-) = 83.96 \pm 0.09$ MeV → T → ± 0.05 (current ± 0.14)

$\Gamma(Z \to \nu\bar{\nu}) = 499.8 \pm 1.5$ MeV → $N_\nu = 2.9835(83)$ small discrepancy

Table 1: Current values of some important electroweak parameters and the potential uncertainty obtainable at the NLC with high statistics ($\gtrsim 10^9 Z$'s) running at the Z pole, W^+W^- and $t\bar{t}$.

Parameter	Current Value	Potential NLC Unc.
$\sin^2\theta_W^{\rm eff}$	0.23119 ± 0.00021	± 0.00002
m_W	80.448 ± 0.038 GeV	± 0.006 GeV
m_t	174.3 ± 5.1 GeV	± 0.2 GeV
$\Gamma(Z \to \ell^+\ell^-)$	83.96 ± 0.09 MeV	± 0.04 MeV
$R_b^{\rm exp}/R_b^{\rm th}$	1.0029 ± 0.0035	± 0.0007
$A_b^{\rm exp}/A_b^{\rm th}$	0.958 ± 0.017	± 0.001

$m_H = (140 \pm 5\,\text{GeV}) \exp[191 (\sin^2\theta_W^{\rm eff} - 0.23158)]$

vs direct $e^+e^- \to ZH \to \Delta m_H < 200$ MeV

or $S = 118\left(2\left(\frac{m_W - 80.372}{80.372}\right) + \frac{\sin^2\theta_W^{\rm eff} - 0.23152}{0.23152}\right) = \underbrace{-0.030 \pm 0.112 \pm 0.107}_{\text{current}}$

$\xrightarrow[\text{NLC}]{}$ ± 0.018 ± 0.010 similar ΔT

1 Chiral Doublet (Heavy) $\Delta S = +0.05 - 0.10$

G_μ vs $\alpha, m_Z, m_t, m_H, \sin^2\theta_W^{\rm eff}$

$m_{W^*} > 8 \underbrace{\sqrt{c}\,(g_i^*/g_2)}_{>1}$ TeV extra dim, $\Delta S < 0.01$, susy loops ...

iv) Rare + Forbidden Z Decays

$Z \to \mu\bar{e}$ Ruled out by $\mu^- N \to e^- N < 6\times10^{-13} \to B(Z\to\mu\bar{e}) < 10^{-13}$

$Z \to \mu\tau$ (Better) $B(\tau\to\mu e^+e^-) \simeq \frac{1}{6} B(Z\to\mu\tau)$ $10^{-8}\sim10^{-9}$ goal

$Z \to WX$ $BR \sim 1.5\times10^{-7}$  ZWW coupling

$Z \to P^0\gamma$ P^0 = pseudo-Goldstone Boson $\sim10^{-7}$ if light

Not Compelling in my opinion (But interesting) $Z\to\mu\tau$

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4. b Physics $>10^9 b\bar{b}$ pairs!

Study many decay modes with high stats. (q/p Asym. $\lesssim \pm 1\%$)

egs.	$B_s \to \phi\gamma$	$\sim 5\times10^{-5}$
(theory)	$\Lambda_b \to \Lambda\gamma$	$\sim 2.75\times10^{-7}$
	$B_s \to \gamma\gamma$	$\sim 3\times10^{-7}$
	$B_s \to \tau^+\tau^-$	$\sim 7\times10^{-7}$
	$B_s \to \mu^+\mu^-$	$\sim 4\times10^{-9}$ (New Physics) LHC Discovery
*	$B_s \to \phi\mu^+\mu^-$	$\sim 10^{-6}$

$B_s \to J/\psi\,\phi \sim 10^{-3}$ Golden

$B_s \to D_s^- +$ anything 0.999

Use LRFB, High Energy tag b flavor

i) CP Violation $\overleftarrow{b}\ \overrightarrow{\bar{b}}$ Flavor Tag - Powerful!

$$A = \frac{(B^0\to f) - (\bar{B}^0\to f)}{(B^0\to f) + (\bar{B}^0\to f)}$$ time dep + integrated

$B_d^{(-)0} \to J/\psi K_S,\ \pi^+\pi^- \ldots \to$ CKM κ, β, γ very precise

$B^\pm \to J/\psi K^\pm \ldots$

(Better than LHC ?)
At least comparable!
(Different Systematics)

CP violation in $b \to s\gamma$ vs $\bar{b} \to \bar{s}\gamma$ "New Physics" eg SUSY
$B_s \to K^*\gamma$ $|\delta A/A| \lesssim 0.01$! Cf. Neubert
$B_s \to \phi\gamma$

$B_s \to J/\psi\,\phi$ (Golden Mode), $B_s^0 \to D_s X \cdots$ (Semi-Inclusive)

Measure B_s^0-$\bar{B}_s^0$ osc $\Delta\Gamma(B)$ $CP = +1$ vs -1 } Rich Extensive Program
Pol. $\Lambda_b \to \Lambda e\nu$ etc, $B_c \to \tau\nu$, ...

τ Pol. $B \to K\tau\nu$, $B \to K\tau^+\tau^-$, $B \to \tau^+\tau^-$ } Triple Products Transverse Pol. } Multi-Higgs $\not{CP}$

With 10^{10} Z decays → Many $\not{CP}$ Asymmetries can be measured

Must do if "New Effects" Uncovered at B factories, CDF ... LHC

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5. τ Physics $Z \to \tau^+\tau^-$ 10^{10} Z decays → 6×10^8 τ decays

LEPI $\tau_\tau = 290.5 \pm 1 \times 10^{-15}$ s
$B_e = 0.1781(6)$ → $G_{\tau e} = 1.1666(28) \times 10^{-5}\,\text{GeV}^{-2}$
$B_\mu = 0.1736(6)$ → $G_{\tau\mu} = 1.1679(28) \times 10^{-5}\,\text{GeV}^{-2}$
$G_\mu = 1.16637(1) \times 10^{-5}\,\text{GeV}^{-2}$

Test e-μ-τ universality 10× Improvement? → ±0.03%

Constrain W_R, Heavy Neutrino Mixing, ...

$\tau \to \text{hadrons} + \nu_\tau \to \alpha_s(m_\tau) = 0.120(2)$, sum rules ... V_{us}?

$\tau \to \nu_\tau K\pi \to m_s(1\text{GeV}) = 164 \pm 33$ MeV (A. Pich)

$\tau \to \nu_\tau K\pi$ $\not{CP}$? ($K_{\nu 3}$ analog)

Rare or Forbidden Decays

eg $B(\tau \to \mu\gamma) < 1\times10^{-6}$ vs $B(\mu \to e\gamma) < 1\times10^{-11}$ MEGA $\to 10^{-14}$ (PSI)

others $\tau \to \mu\pi^0, \mu\phi, \mu^+\mu^-\mu^+ \ldots$

Model Dependent

eg. SUSY SU(5) Barbieri, Hall, + Strumia

$$B(\tau \to \mu\gamma) \simeq 3\times10^{3}\, B(\mu \to e\gamma)$$

$B(\tau \to \mu\gamma)$ interesting at $\sim 10^{-8} \to 10^{-9}$ (Most Do)

Others $\tau^- \to \mu^+\mu^-\mu^+$, $\tau \to \mu p$, etc... Many!

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6. Comments + Conclusions

NLC, TESLA $\gtrsim 10^9$ Z Decays $\to$ $\Delta\sin^2\theta_W \simeq \pm 0.000020$!
Compelling

Also, improve $A_b, R_b, \Gamma_Z, \Gamma(Z \to \ell^+\ell^-)$....

* Dedicated Facility $> 10^{10}$ Z Decays (several yrs running)

Best way to do CP LRFB $b\bar{b}$ (Major Program)

eg $b \to s\gamma$, $B_s \to J/\psi\,\phi$ ... $\mathcal{O}(10^8$ decays, asym...)
Extensive $B_s \to \phi\gamma$

τ Physics τ_τ, B_c, QCD, $\tau \to \mu\gamma$...

Well Motivated But Politics? Too Many b Facilities?

Someday it will happen (Thorough Study Needed)

Needed: 1) Thorough Physics, Machine + Detector Studies

issues e^- polarization, luminosity, systematics ..

incorporate SLD + LEP experiences (5 detectors)

fast track? Start Z pole program early?

NLC Study Group (+ Tesla Counterpart)

Questions: $\Delta \sin^2\theta_W^{eff}$, ΔR_b, ΔA_b, $\Delta \Gamma_l$, $\Delta \Gamma_Z$ ... ?

B physics: α, β, γ, Δm_{B_s}, $\Delta \Gamma_B$, FCNC } LHC
$B_s \to J/\psi\phi$, ... "New Physics" }
$\phi\mu^+\mu^-$ ... $\phi\gamma$ ...

τ Studies: lifetime, B_l, Rare Decays (eg $\tau \to \mu\gamma$)
charm, QCD ...

Document Goals + Capabilities (Advocates)