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Marcel Demarteau

Summary 2° and Higgs Working Group

- Fruitful 3 days of presentations and discussions
- Appropriate for first muon collicler
  More detailed work needed

Summary of 2-pole physics

- Energy calibration
- Precision electroweak measurements
- Some experimental issues
- Triple, quartic gauge boson couplings

Summary of Higgs physics → Tao Han

Apologies to speakers whose topic not included

Beam Energy Calibration

(Raja)

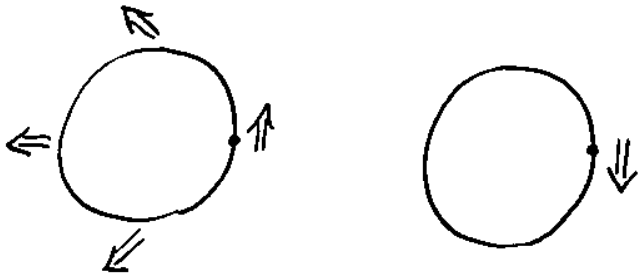
Use spin precession of μ's and energy distribution of the decay electrons

BMT equation : $\frac{d\vec{S}}{dt} = \vec{\Omega} \times \vec{S}$

$$\vec{\Omega} = -\frac{e}{m\gamma}\left[(1+a\gamma)\vec{B}_\perp + \cancel{\vec{B}_\parallel} + \cancel{\vec{E}}\right]$$

Spin tune : $\nu = \frac{El}{m_\mu}\frac{g-2}{2} \approx 0.500 \quad @ M_Z$

- Half a turn of spin / one turn of muon
- There is one place on ring w/ maximum P
- At that place, P flips every turn



Thus, $\langle E \rangle$ of decay electrons will vary in time

$$E(n) = e^{-\alpha n}\left(c_1(1 + c_2(P\cos\omega n + \varphi))\right)$$

$e^{-\alpha n}$: decay

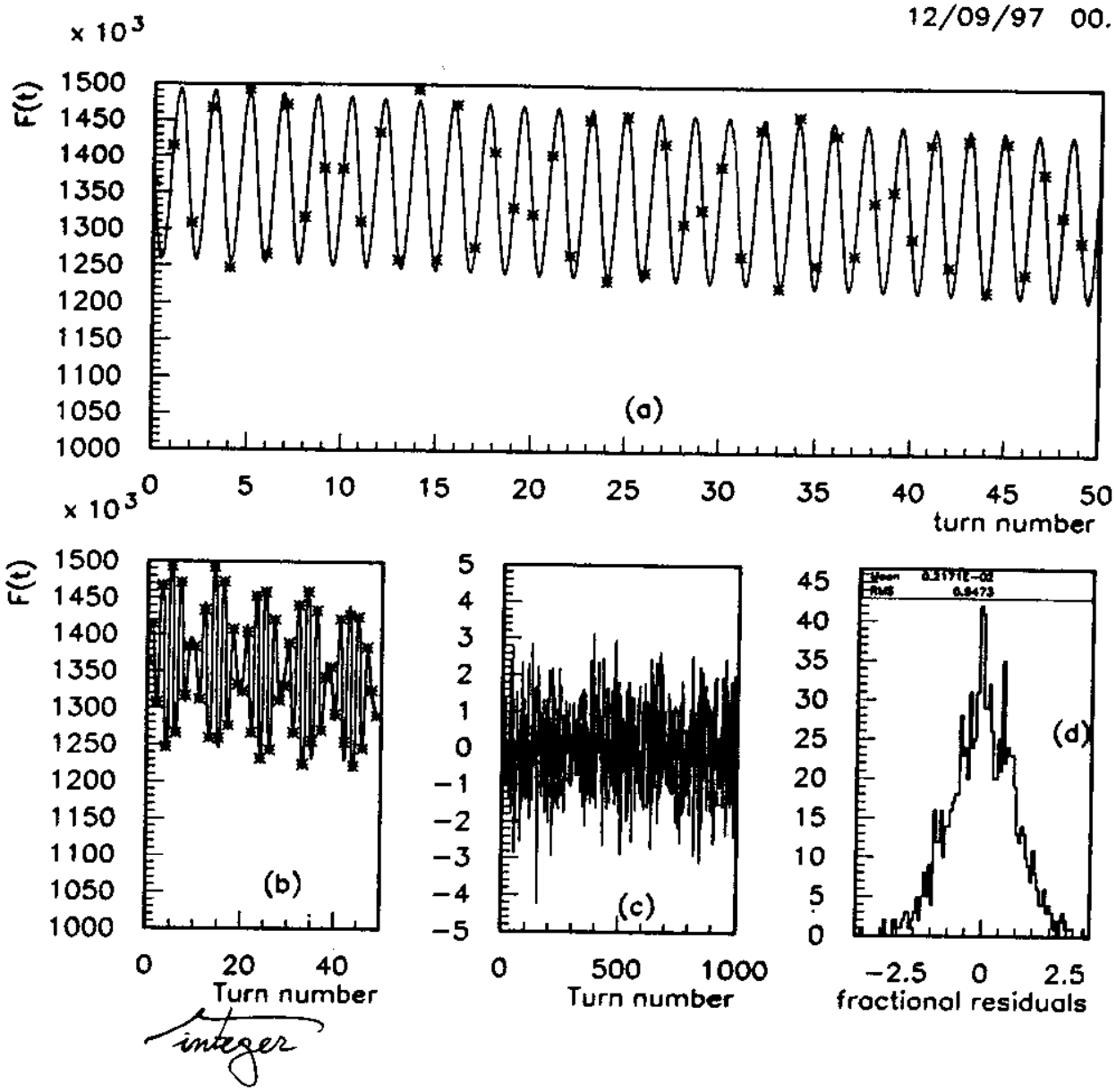
$(1 + c_2(P\cos\omega n + \varphi))$: Polarization

n = turn number

Measure total energy of decay electrons per turn

$E_\mu = 50$ GeV $\delta p/p = 0.03\ 10^{-2}$

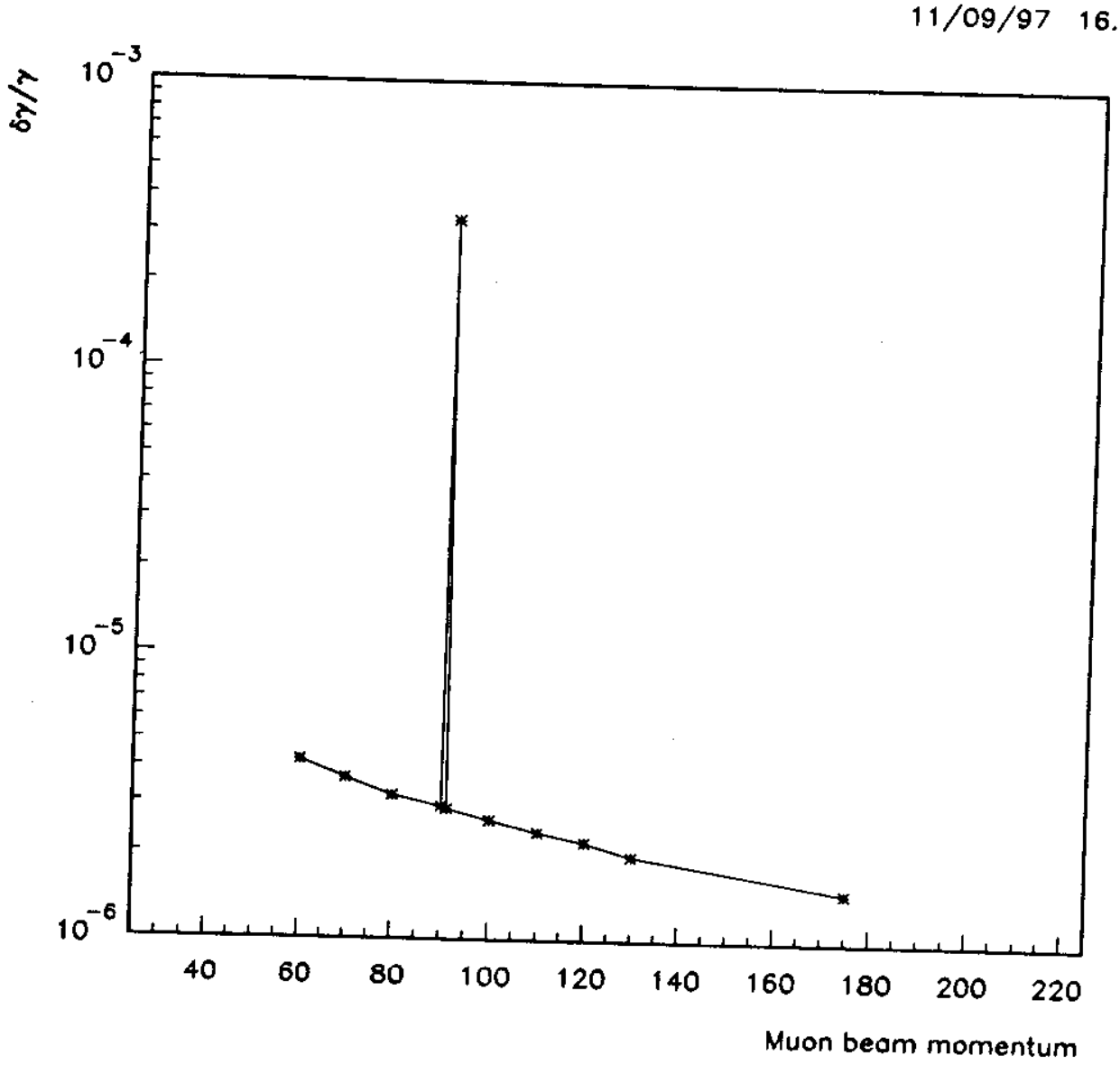
$P = -0.26$ $\Delta = 0.15\ \sqrt{\text{GeV}}$



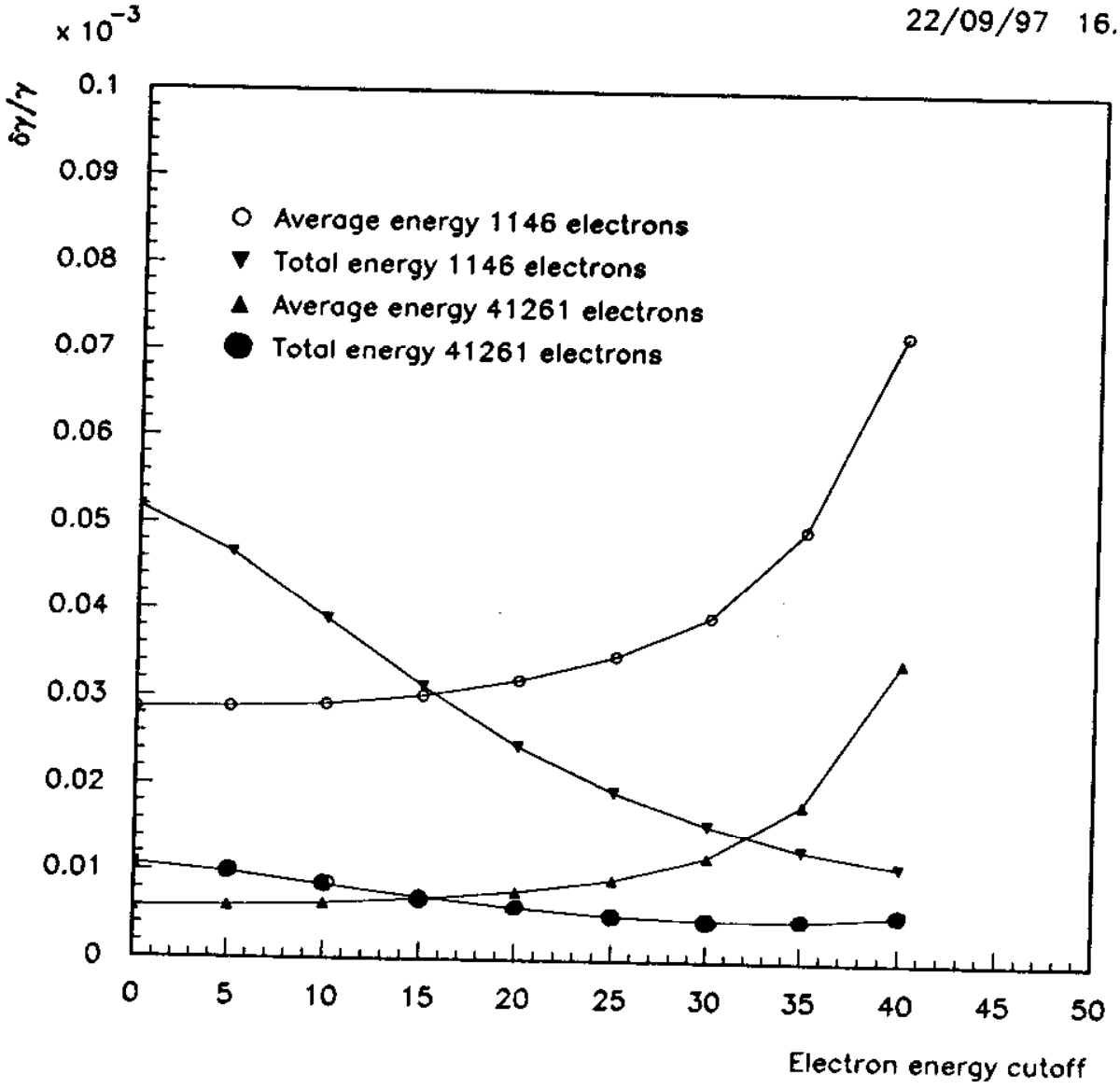
Based on ~ 40,000 decay electrons measured

Note: Amplitude gives direct measure of polarization!

$\delta\gamma/\gamma$ vs muon beam momentum



Precision on E_f measurement



$\delta E/E \sim 10^{-5}$ easily obtainable; 10^{-6} possible

First look at correction elements in lattice seem not to spoil conclusion.

(Blondel)

Z-Pole Precision Electroweak Parameters

LEP Z-pole era is over

$\sin^2\theta^{eff}_W$ discrepancy likely to remain SLD / LEP

Assume $\mathcal{L} = 2.10^{32}\ cm^{-2}s^{-1}$

$\Rightarrow \sim 100\ MZ$ / year

Choice of observables given by their sensitivity to various parameters

Observables:

$$\Gamma_l = \frac{G_F M_Z^3}{24\pi\sqrt{2}} (1+\Delta_l)\left(1+\left(\frac{g_V^l}{g_A^l}\right)^2\right)\left(1+\frac{3}{4}\frac{\alpha_s}{\pi}\right)$$

$$R_l = \frac{\Gamma_{had}}{\Gamma_l}$$

$$\sin^2\theta_W^{eff}\cdot\cos^2\theta_W^{eff} = \frac{\pi\alpha(M_Z^2)}{\sqrt{2}\,G_F M_Z^2}\,\frac{1}{1+\Delta\xi}$$

$$R_b = \frac{\Gamma_b}{\Gamma_{had}} \qquad \Gamma_b = \Gamma_d(1+\delta)$$

δm_{top} : 175 ± 6 $\qquad$ $\Delta\alpha_s$: 0.118 ± 0.003

$\Delta\alpha(M_Z^2)$: 128.896 ± 0.090

		Δm_t	$\Delta\alpha$	$\Delta\alpha_s$	Exp	m_* 60↓1000
Γ_l	83.89 ±	0.06	—	.02	0.11	0.25
$10^3 * R_l$	20775 ±	1.8	4.0	21	25	28
$10^4 * \sin^2\theta_W^{eff}$	2315.1 ±	2.0	2.3	.05	2.2	15.4
$10^4 * R_b$	2177 ±	2.0	0.2	.05	11	0.4

- Currently $\sin^2\theta_W^{eff}$ dominates Higgs mass limit
- R_l very sensitive to α_s

For high luminosity:

- $R_l = \Gamma_{had}/\Gamma_l$

  Present: 20.775 ± 0.0025
  Physics: $\alpha_S = 0.124 \pm 0.004 \pm 0.002$ (theory, MH)

  Errors dominated by lepton statistics
  Improvement of statistics of factor 10
  $\Rightarrow \quad \delta(\alpha_S) < 0.001$

- $\Gamma_Z = \Gamma_l \left(3 + N_\nu \frac{\Gamma_\nu}{\Gamma_l} + R\right)$

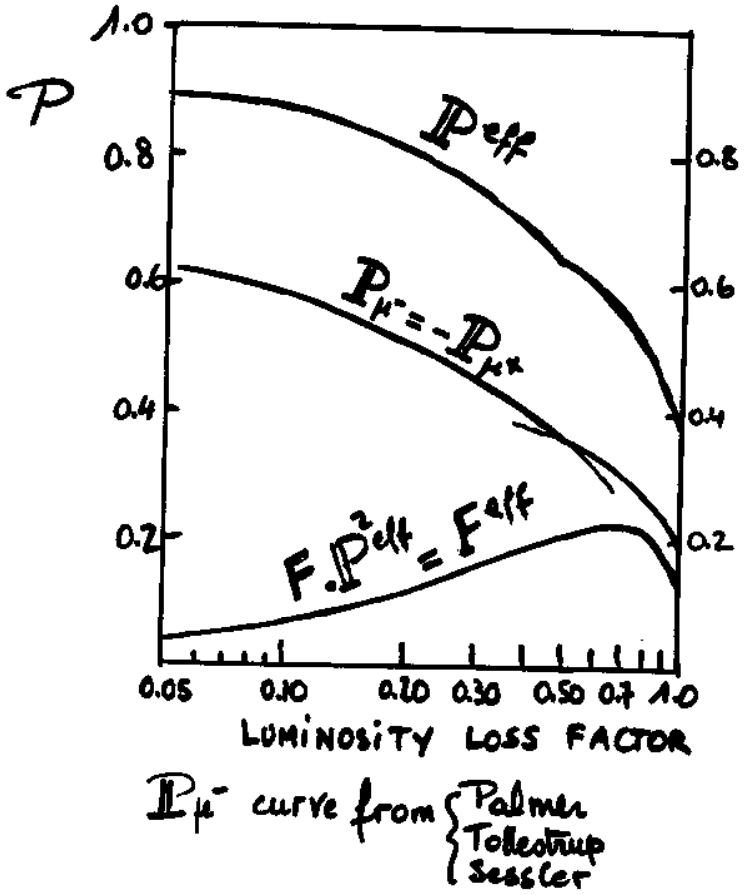
  Present: $\Gamma_Z = 2.4948 \pm 0.0020 \pm 0.0015$ (energy)
  Energy calibration interpolated
  Can be improved by continuous E-calibration
  $\Rightarrow \quad \delta(\Delta p) < 0.0003$

- Best measurement of $\sin^2\vartheta_W^{eff}$ from A_{LR}
  Both beams polarised:

$$\sigma = \sigma_\mu \left(1 - P_{\mu^-} P_{\mu^+} + A_{LR}\left(P_{\mu^+} - P_{\mu^-}\right)\right)$$

$$P_{eff} = \frac{P_{\mu^+} - P_{\mu^-}}{1 - P_{\mu^+} P_{\mu^-}}$$

e.g. $P_{\mu^+} = 50\%$, $P_{\mu^-} = -50\%$ $\quad P_{eff} = 80\%$ $\quad \sigma/\sigma_\mu = 1.25$



$\mathbb{P}_{\mu^-}$ curve from { Palmer, Tolleotrup, Sessler }

$$\mathbb{P}_{eff} = \frac{P_{\mu^+} - P_{\mu^-}}{1 - P_{\mu^+} \cdot P_{\mu^-}}$$

Convolute with loss in Luminosity:

$$F^{eff} = (P^{eff})^2 * L$$

optimum ~ 0.7

Bonuses Polarisation:

- Cross check of both P_{μ^+} and P_{μ^-}
- Cross section measurement gives measurement of P: $\frac{1}{2}(\sigma^{\Rightarrow\Rightarrow} + \sigma^{\Leftarrow\Leftarrow}) = \sigma(1 - P_{\mu^+} \cdot P_{\mu^-})$
- Signal / background optimization
- Precision optimization

From A_{LR} for 40 M2, $P_\mu = 0.45$

$$\Rightarrow \delta(\sin^2\vartheta_W^{eff}) < 10^{-4}$$

- R_b : measurement currently systematics limited. Given SLD, will be tough to improve.
- Michel parameters in τ-decays
- B_s - oscillations
- Rare b-decays

⋮

Tagging Issues

(King)
(Willocq)

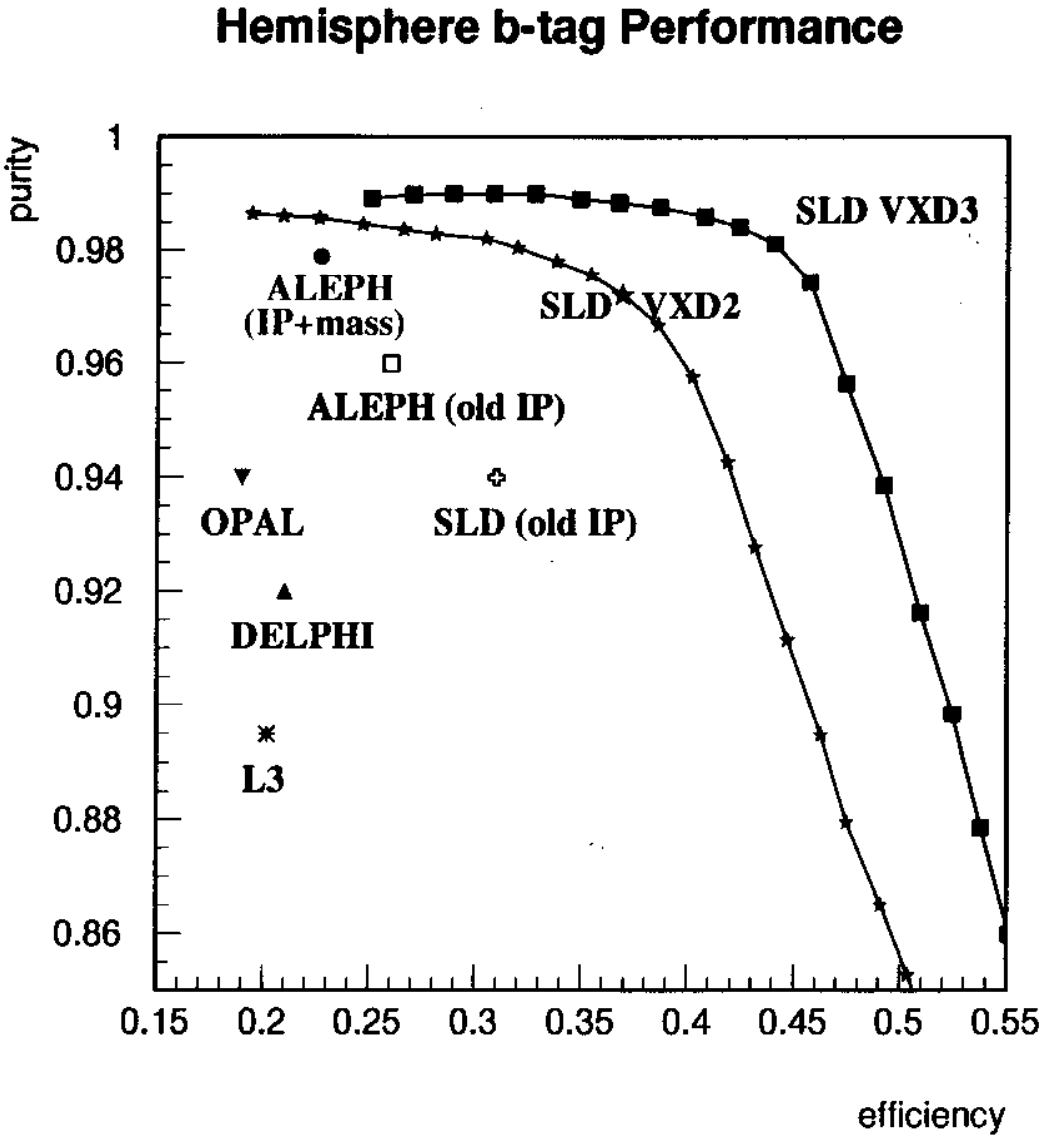
b-quarks and tagging of b's is the central issue for the FNC, both on Z-pole and for Higgs studies

From NLC extrapolation:

b-tag eff: ~ 055
c-tag eff: ~ 0.38

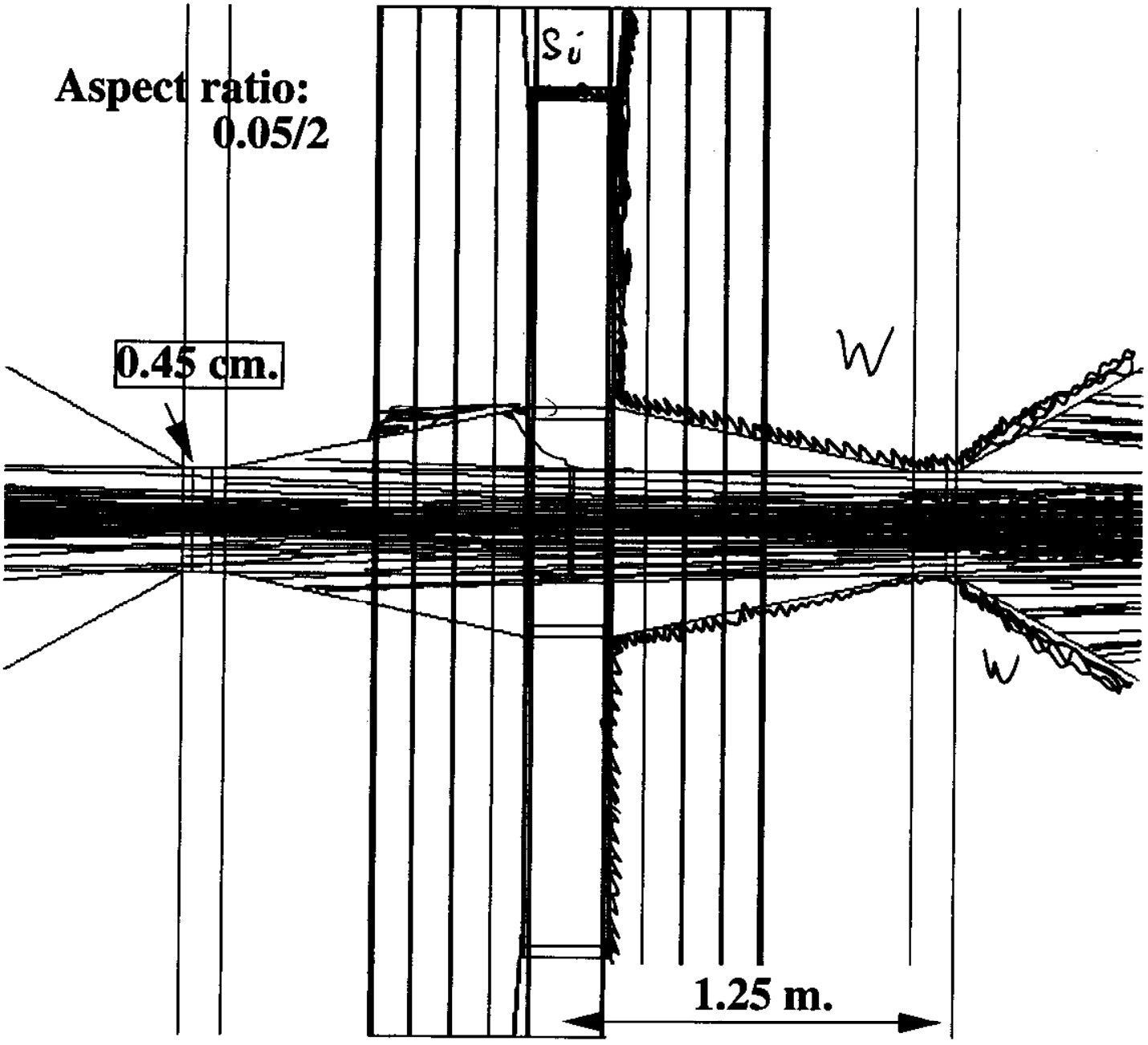
SLD VXD3: inner radius 2.5 cm
outer radius ~ 5.0 cm
σ_y beam ~ 1 μ
σ_x beam ~ 1.5 μ
extremely low occupancy

Tagging Performance



What's left to be done @ 2 Tev.

1. Optimize the nose cone..



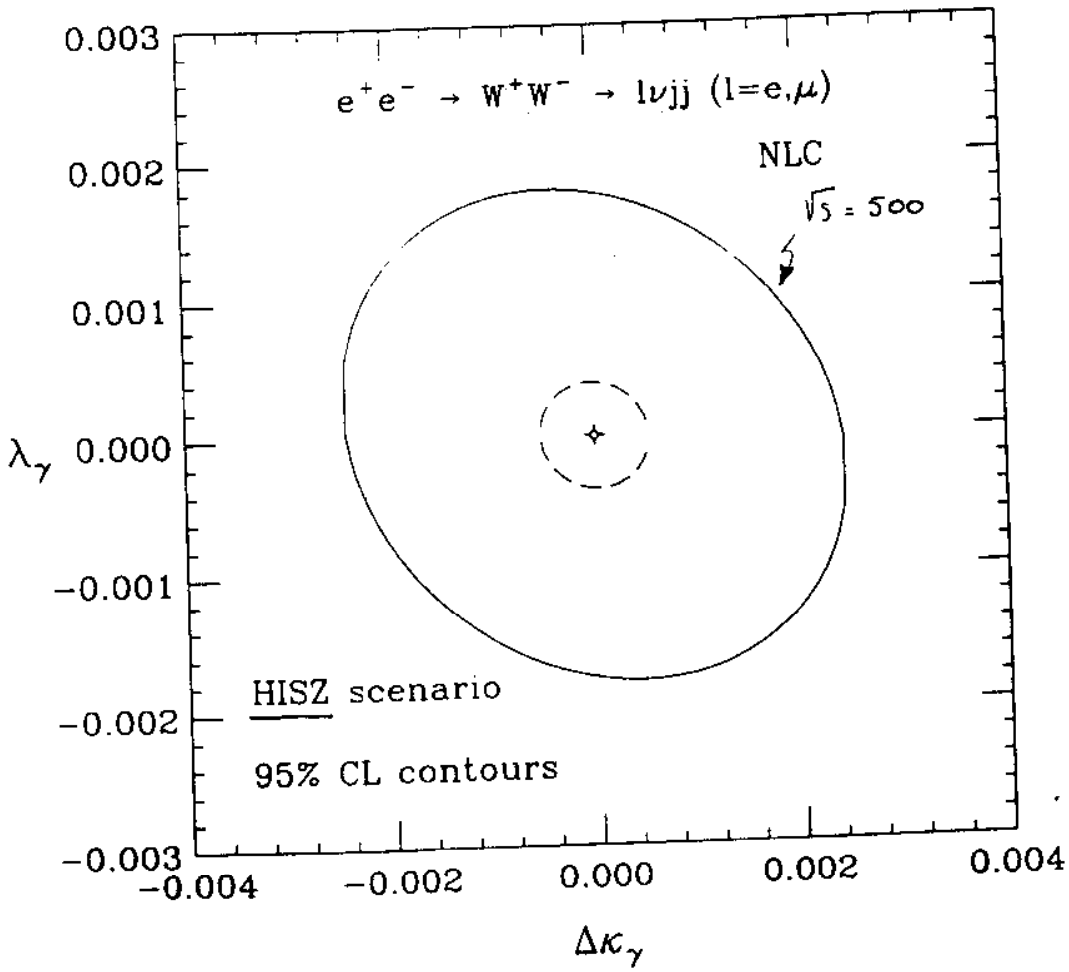
With respect tot the solenoidal field..

Triple Gauge boson Couplings

(Baur)
(Tikhonin)

At FNC effects of ISR reduced.

Expect ~ factor 10 improvement in limits on anomalous couplings compared to LHC



$|\Delta\kappa_\gamma| < 2.4\ 10^{-3}$

$|\lambda_\gamma| < 1.8\ 10^{-3}$

(He)

Bounds on quartic gauge boson couplings
Very large integrated $\mathcal{L}$ needed

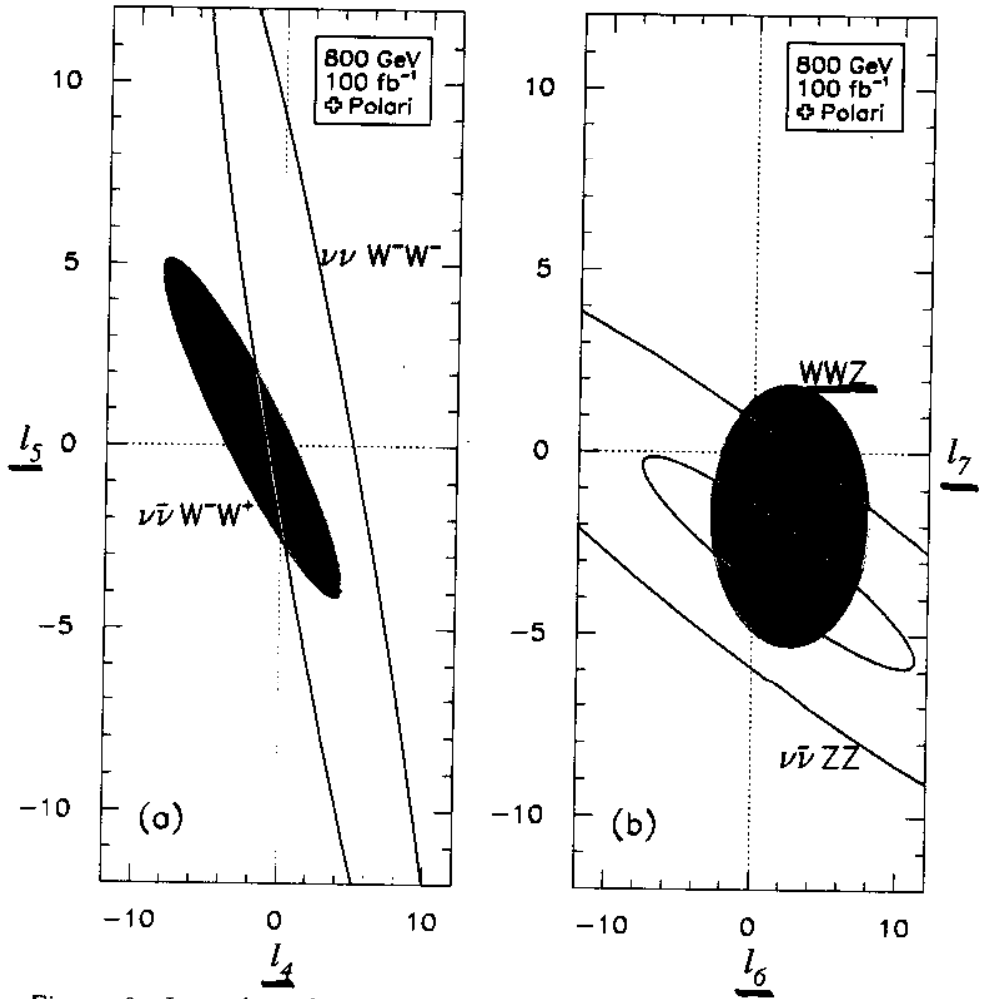


Figure 9: Interplay of the VV-fusions and VVV-productions at a 800 GeV linear collider. The polarized $e^{\mp}$ beams ($90\%e^-$ & $65\%e^+$) are used. (a). $\pm 1\sigma$ exclusion contours from $e^-e^+ \to \nu\bar{\nu}W^-W^+$ and $e^-e^+ \to \nu\bar{\nu}W^-W^-$ fusion channels for determining ℓ_4-ℓ_5 ; (b). $\pm 1\sigma$ exclusion contours from processes $e^-e^+ \to \nu\bar{\nu}ZZ$ and $e^-e^+ \to WWZ$ for determining ℓ_6-ℓ_7 . The important role of the WWZ-production is shown.

Conclusions:

- 2-Pole physics is interesting but need 100 fb^{-1}/yr to make it worth while
- Polarisation is highly desirable but not at loss of luminosity
- Small beam spot crucial for high b-tag efficiency
- Accuracy of luminosity measurement to be determined (LEP: 10^{-3})