Energy Spectrometry Experience at LEP2

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SLAC

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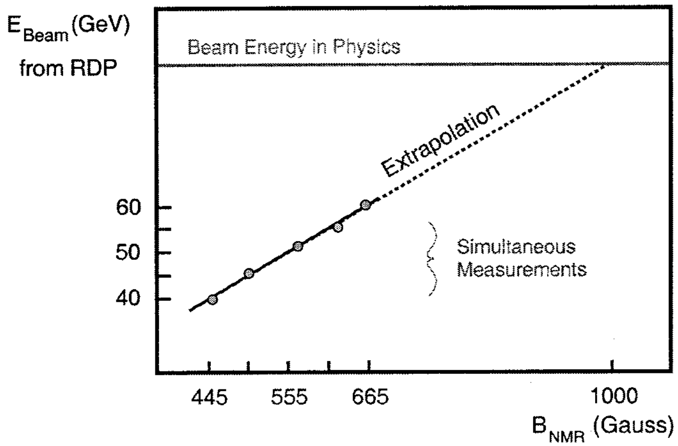
- LEPII Beam Energy Experience
- Future LC Beam Energy Prospects

http://physics.uoregon.edu/~torrence/talks/LC02

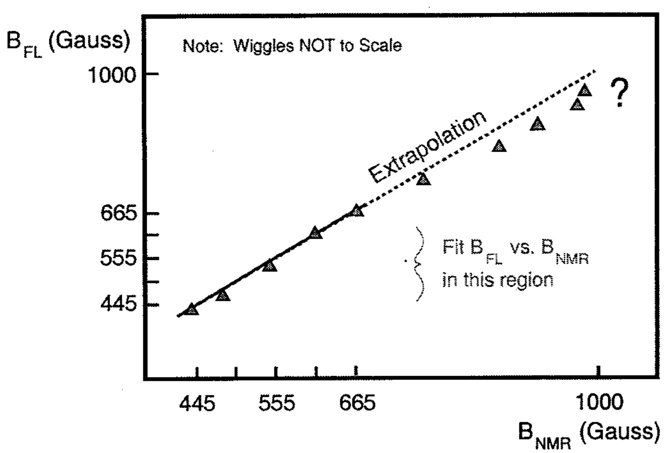
LEP II Beam Energy Experience

Magnetic Extrapolation

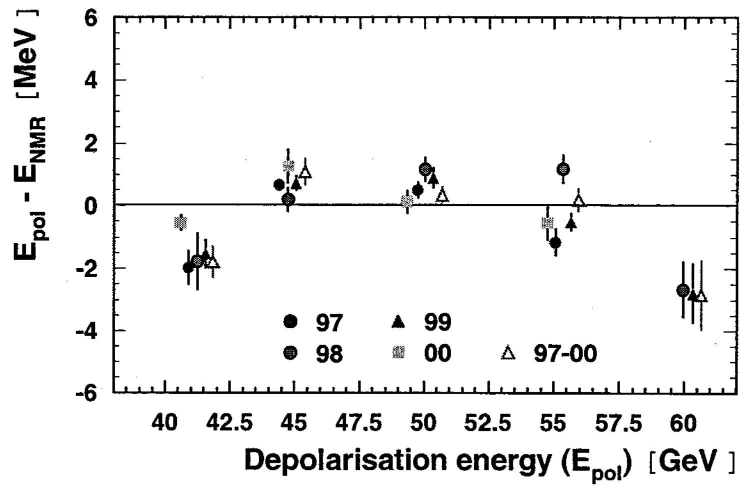
Step 1: Calibrate NMRs with RDP

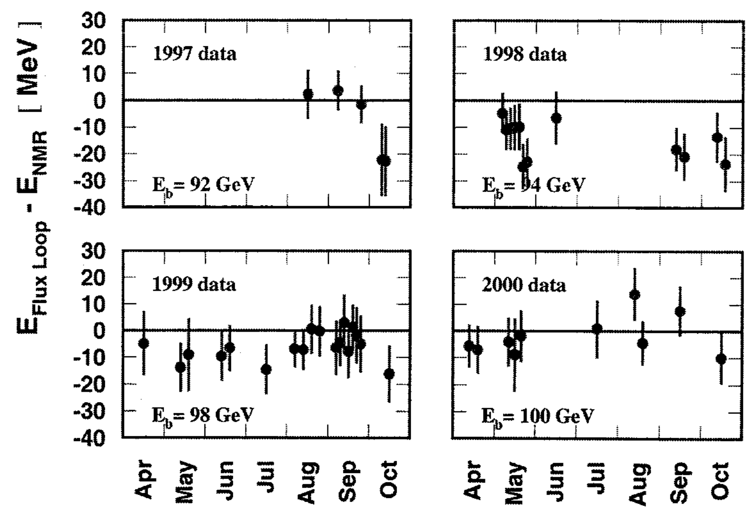


Step 2: Cross Check Linearity with Flux Loop

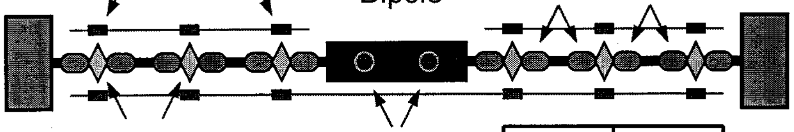


Extrapolation Data





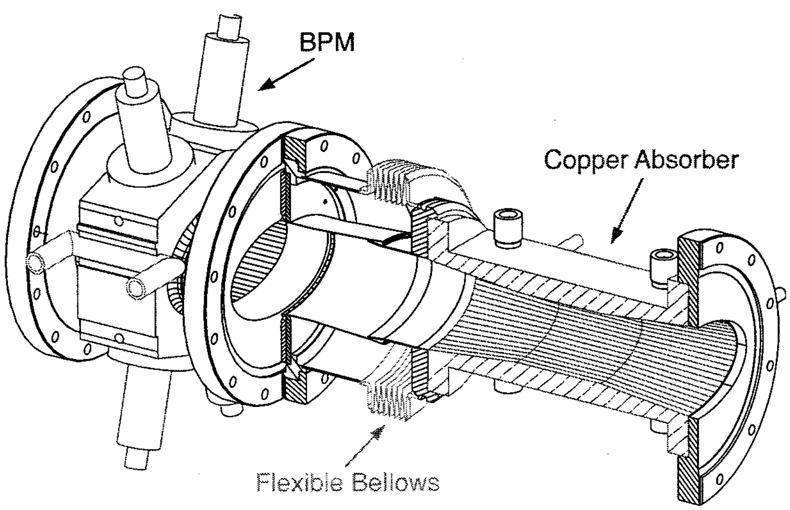
LEP Spectrometer



1 micron stability required for a few hours only!

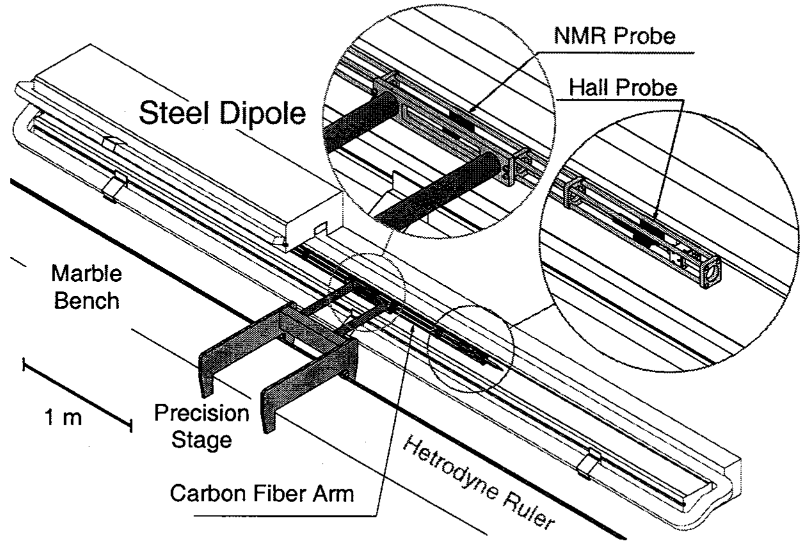
⇛ Must be stable as machine energy doubles...

Synchrotron Shielding

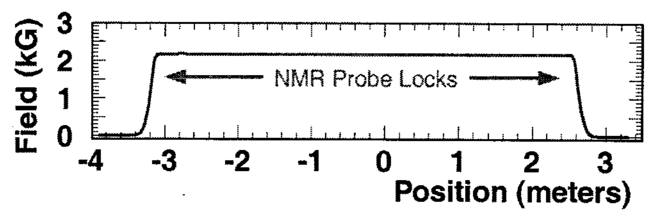


⇛ Temperature Regulation of BPMs to ~ $0.2°C$

Magnet Mapping



Need $\oint Bdl$ as $f(B_{Ref})$



NMR Probe: $\delta B/B \sim 10^{-6}$ over 90%

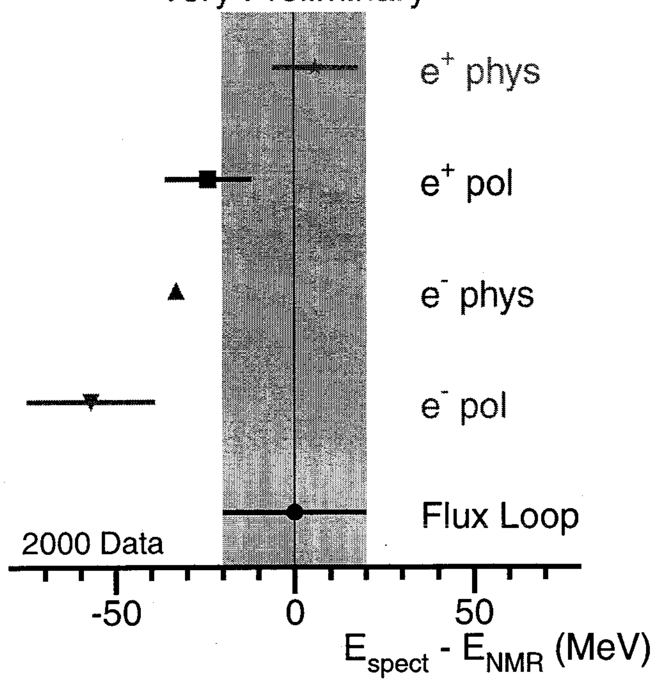
Hall Probe: $\delta B/B \sim 10^{-4}$ over 10%

Precision of ~ 3 x 10^{-5} achieved from 1999 - 2001

Magnet has recently been re-mapped!

Spectrometer Results

Very Preliminary

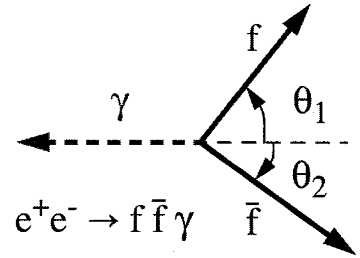


Error Bars indicate RMS of measurements

⇛ No disagreement with Flux Loop

Significant systematics still to be understood...

Radiative Returns



$e^+e^- \to f\,\bar{f}\,\gamma$

$$\frac{s'}{s} = \frac{\sin\theta_1 + \sin\theta_2 - |\sin(\theta_1+\theta_2)|}{\sin\theta_1 + \sin\theta_2 + |\sin(\theta_1+\theta_2)|}$$

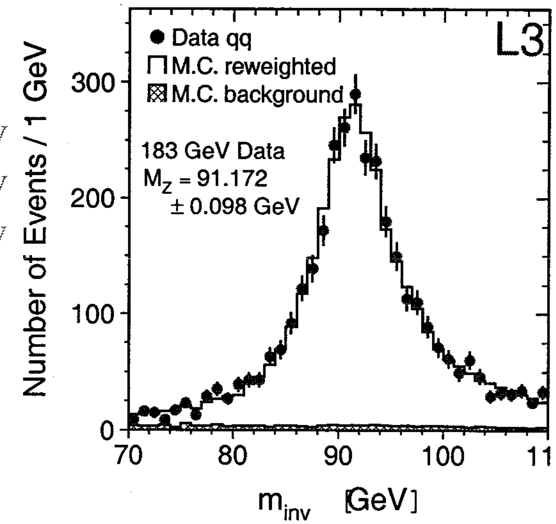
Statistics

Channel	ΔE_{beam}
$q\bar{q}\gamma$	~ 18 MeV
$\mu\mu\gamma$	~ 40 MeV
$ee\gamma$	~ 70 MeV

LEP Potential

Statistics Only

2.7 fb^{-1}



Systematics

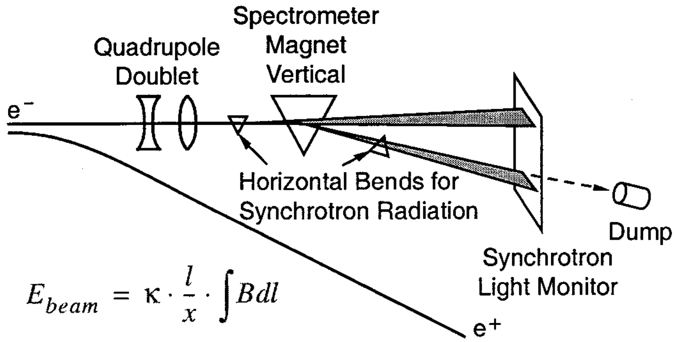
- Theoretical Description
- Hadronization Uncertainties
- Detector Understanding

Need absolute θ measurement!

Opal Estimates

$q\bar{q}\gamma$	ΔE_{beam} ~ 70 MeV
$\mu\mu\gamma$	ΔE_{beam} ~ 20 MeV
$ee\gamma$	ΔE_{beam} ~ 80 MeV

Meet the WISRD



$$E_{beam} = \kappa \cdot \frac{l}{x} \cdot \int B dl$$

SLC Parameters at 50 GeV

$$\int B dl = 3.05 \text{ Tesla meters}$$

l = 15 meters $\qquad x$ = 27 cm at 50 GeV

Systematic Errors per Beam

$\Delta\int B dl$:	100 ppm
Alignment:	190 ppm
Detector - IP:	135 ppm
Total:	250 ppm ⇛ 12.5 MeV at 50 GeV

⇛ Can probably improve below 200 ppm up to 200 GeV

WISRD Limits

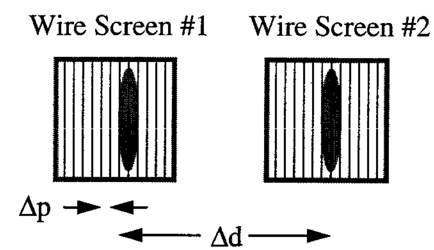
Magnetic Field

- $\Delta\int B dl$: 100 ppm achieved at SLC
- Error is relative: Not affected by increasing $\sqrt{s}$
- Dominated by absolute scale error

⇛ Relative accuracy of ~ 30 ppm achieved at LEP

Detector Alignment

- Magnet to Detector distance irrelevant: dl/l = 17 ppm
- Transverse detector precision dominates:



Pitch Error: Δp = 10 μm

Relative detector distance: Δd = 25 μm

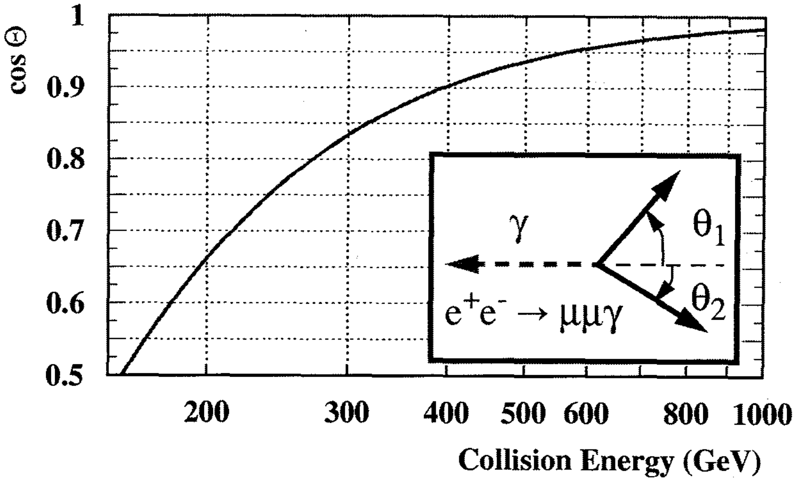
⇛ 93 ppm at 50 GeV (d=27 cm)

⇛ 370 ppm at 500 GeV! (assuming single screen)

Better detector possible for high energy/small d?

Intrinsic Synchrotron stripe width ~1mm at SLC...

Radiative Returns



Symmetric production: $s' = m_Z^2, \Theta_1 = \Theta_2$

Collision Energy	$\cos\Theta$	Θ (mRad)
2 m_W	0.522	1000
2 m_t	0.875	500
500 GeV	0.937	360
1 TeV	0.984	180

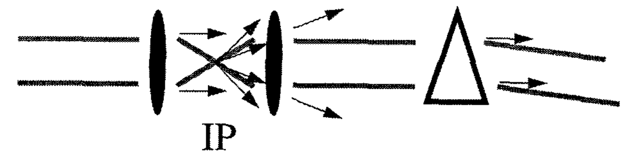
Need precision and accuracy at small Θ

$\delta\Theta \approx 0.1\%$ per event (Γ_Z limit)

Luminosity Spectrum

Need E_{beam} at IP

- Synchrotron energy loss
- Beamstrahlung
- Luminosity-weighted energy



Typical values (2 E_{beam} - $\langle E_{Lum} \rangle$)

SLD	40 MeV
NLC-90	125 MeV
Tesla-90	44 MeV
GigaZ	~1 MeV

⇛ Low dispersion settings needed for high precision

Lumi-weighted energy spectrum

- Precise determination of collision parameters
- Best to measure directly from data

⇛ Comparable to radiative returns...