Status of Beam Energy Calibration with Polarization and the Spectrometer

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Content

- **Statistical error:** $\delta M_W \sim 25$ **MeV** $\Rightarrow \Delta E_{beam} = 10$ **MeV or** $\Delta E/E = 1 \cdot 10^{-4}$
- **Magnetic Extrapolation Method**
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- Not Discussed: Radiative Returns and the Energy Loss Method

Resonant Depolarization Calibrations

1996 to 1999

Date	41 GeV	45 GeV	50 GeV	55 GeV	61 GeV
19/08/96			•		
31/10/96		•			
03/11/96		•	•		
17/08/97		•			
06/09/97		•	•		
30/09/97		•	•		
02/10/97	•	•	•	•	
10/10/97		•			
11/10/97	•	•	•	•	
29/10/97	•	•			
14/06/98		•	•	•	
18/06/98		•			
15/07/98		•		•	
06/09/98		•			
07/09/98	•	•	•		
20/09/98	•	•	•	•	•
29/09/98		•			
18/10/98	•	•	•	•	•
07/06/99	•	•			
25/06/99	•	•	•		
22/07/99	•				
22/07/99		•	•		
08/08/99				•	

- The polarization calibrations are used to calibrate the NMR based magnetic field measurement system
- Extending the energy calibration lever arm from 15 to 20 GeV
- More calibrations are expected in 1999

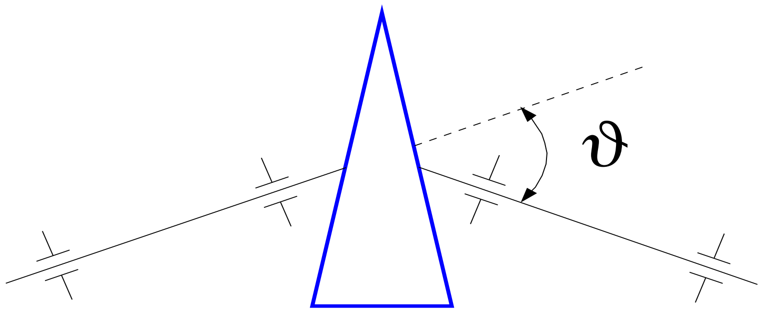
Present Beam Energy Errors

Main errors in 1997 and 1998

Source	Error [MeV] 1997	Error [MeV] 1998
Extrapolation from NMR–polarisation:		
NMR rms/$\sqrt{N}$ at physics energy	10	8
Different E_{pol} fills	5	4
Flux-loop test of extrapolation:		
NMR flux-loop difference at physics energy	20	15
Field not measured by flux loop	5	5
Optics difference	4	6
Corrector effects	3	4
IP specific corrections ($\delta E_{CM}/2$):		
RF model	4	4
Total	25	20

- LEP II beam energy calibration error dominated by NMR flux-loop difference at physics energy
- Similar error expected in 1999
- The NMR flux-loop measurement method is based on the total bending field determination

Spectrometer Method (I)



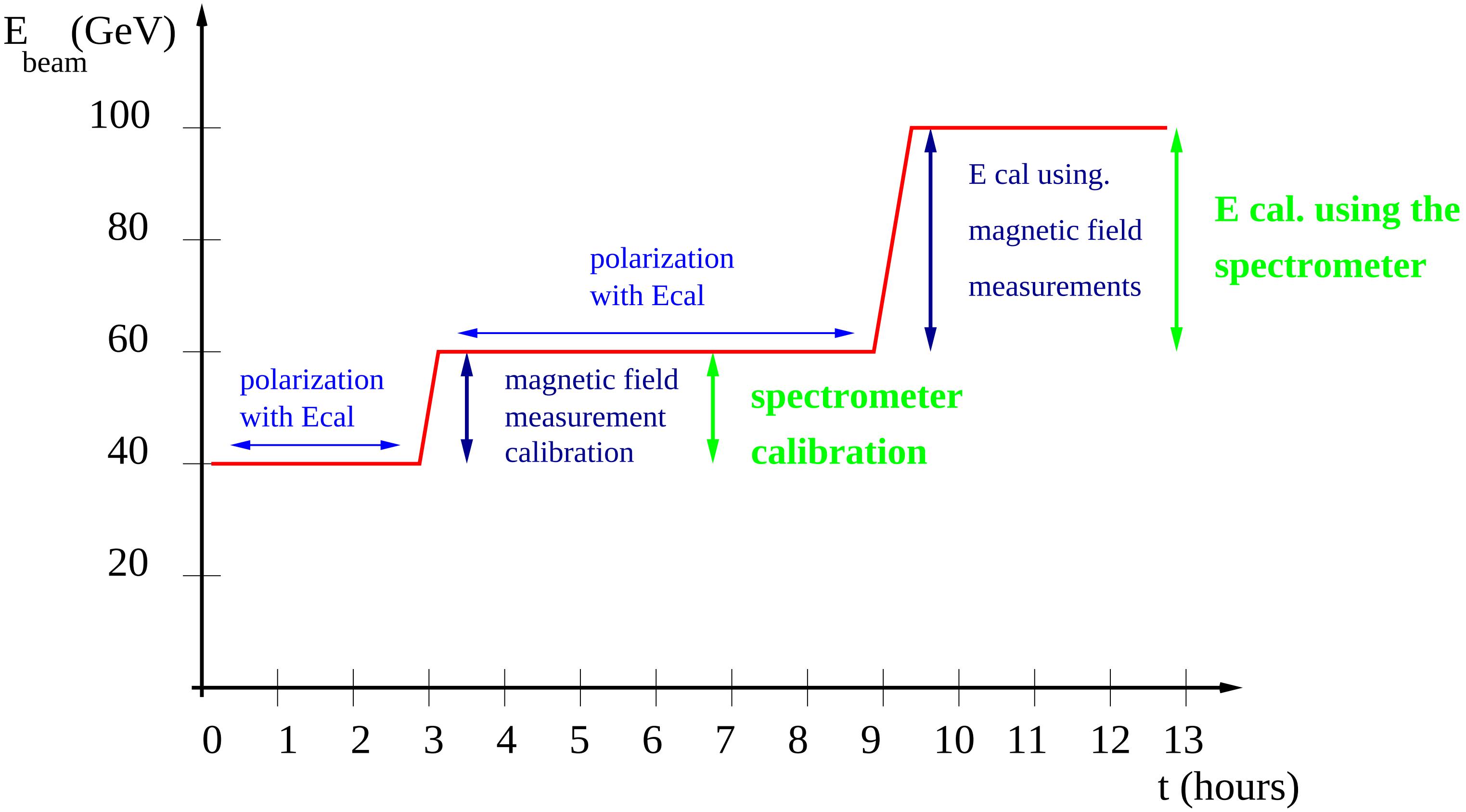
$$\vartheta \propto \frac{\int B dl}{E_{beam}}$$

Measure $\int B dl$ and ϑ to determine E_{beam} with an accuracy of

$$\frac{\Delta E}{E} = 1 \cdot 10^{-4}$$

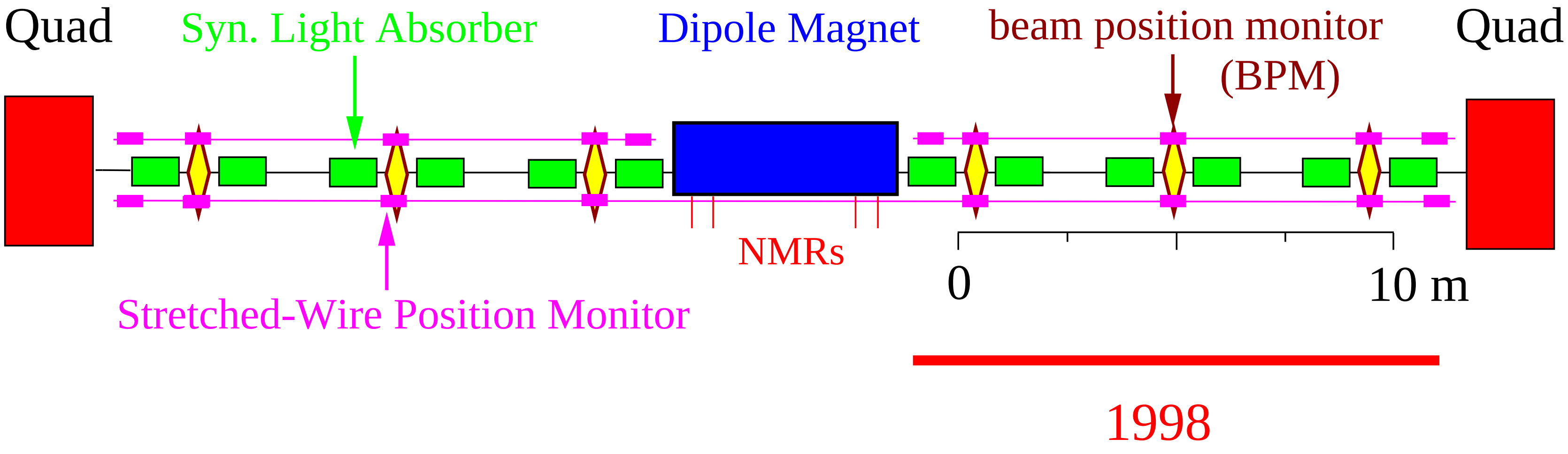
- Maximal error of the position monitors (BPM): **1 μm**
- Maximal error on integral magnetic field prediction: $\Delta B/B = 3 \cdot 10^{-5}$
- Errors must be valid for a period of **2 hours**

Spectrometer Method (II)



- **A relative calibration method:** $$\frac{E^{100GeV}}{E^{60GeV}} = \frac{\Theta^{60GeV}}{\Theta^{100GeV}} \cdot \frac{\int B^{100GeV} dl}{\int B^{60GeV} dl}$$

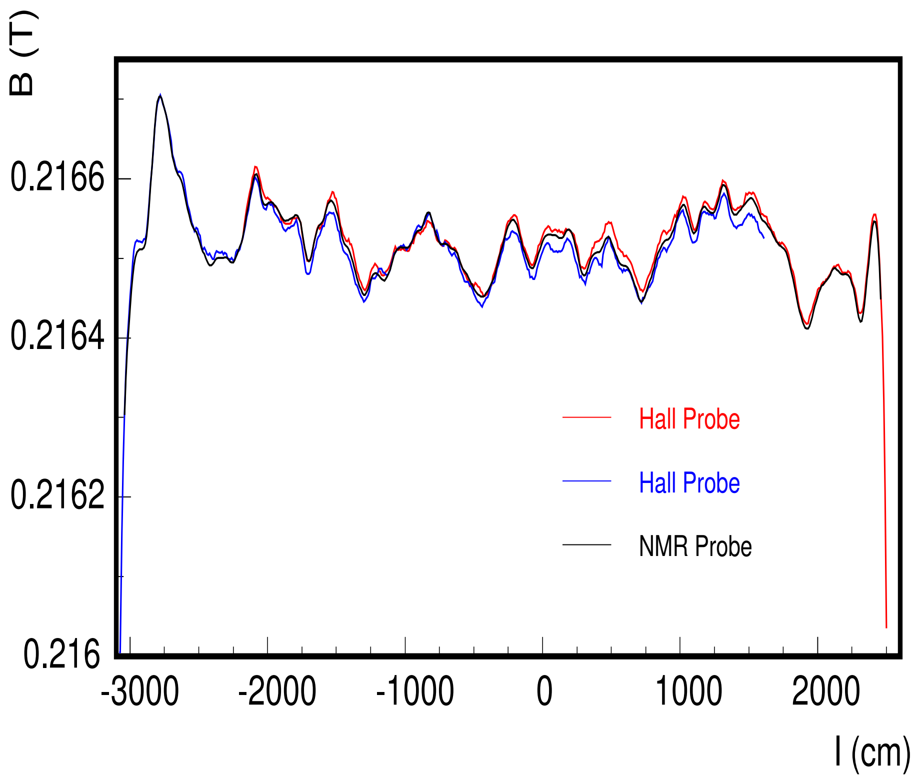
Spectrometer Method (III)



- BPM button shielded by synchrotron light absorber
- BPM support temperature stabilised and position monitored
- Mild iron magnet (10 times lower variations with temperature)
- Last year: prototype, this year: full setup (including new magnet)

Magnetic Measurements (I)

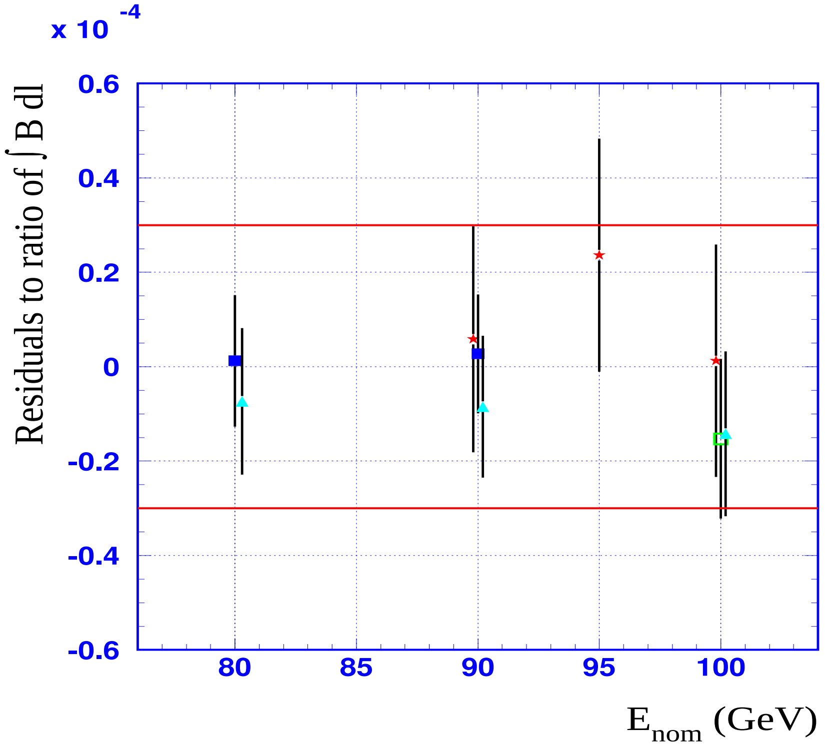
Aim of measurements: $\int Bdl = f(B_{ref})$



- **Magnet mapping 1998 / 1999**
- B_{ref} **determined with four fixed installed NMR probes**
- $\int Bdl$ **determined with movable probes**

Magnetic Measurements (II)

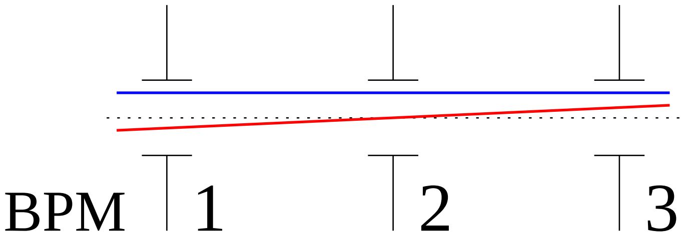
The variation of: $$\frac{\int B^{100} dl}{\int B^{44} dl} - \frac{f(B^{100}_{ref})}{f(B^{44}_{ref})}$$ leads to error estimate

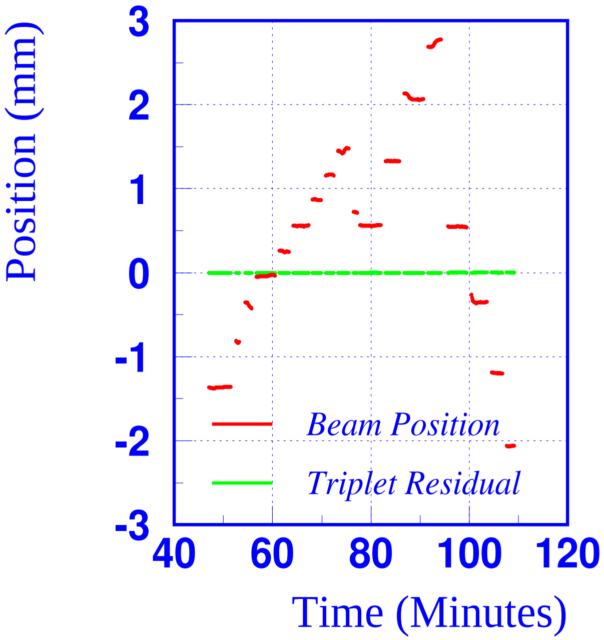


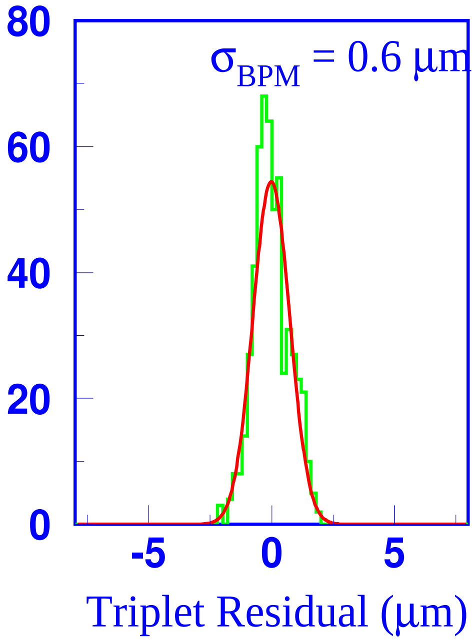
- The variation between field integrals and the predictions is smaller than $3 \cdot 10^{-5}$
- The measurements include tests in the lab., in the LEP tunnel, different power converter and with and without vacuum chamber

Beam Position Measurements

BPM triplet residual: $$T = \frac{x_1 + x_3}{2} - x_2$$

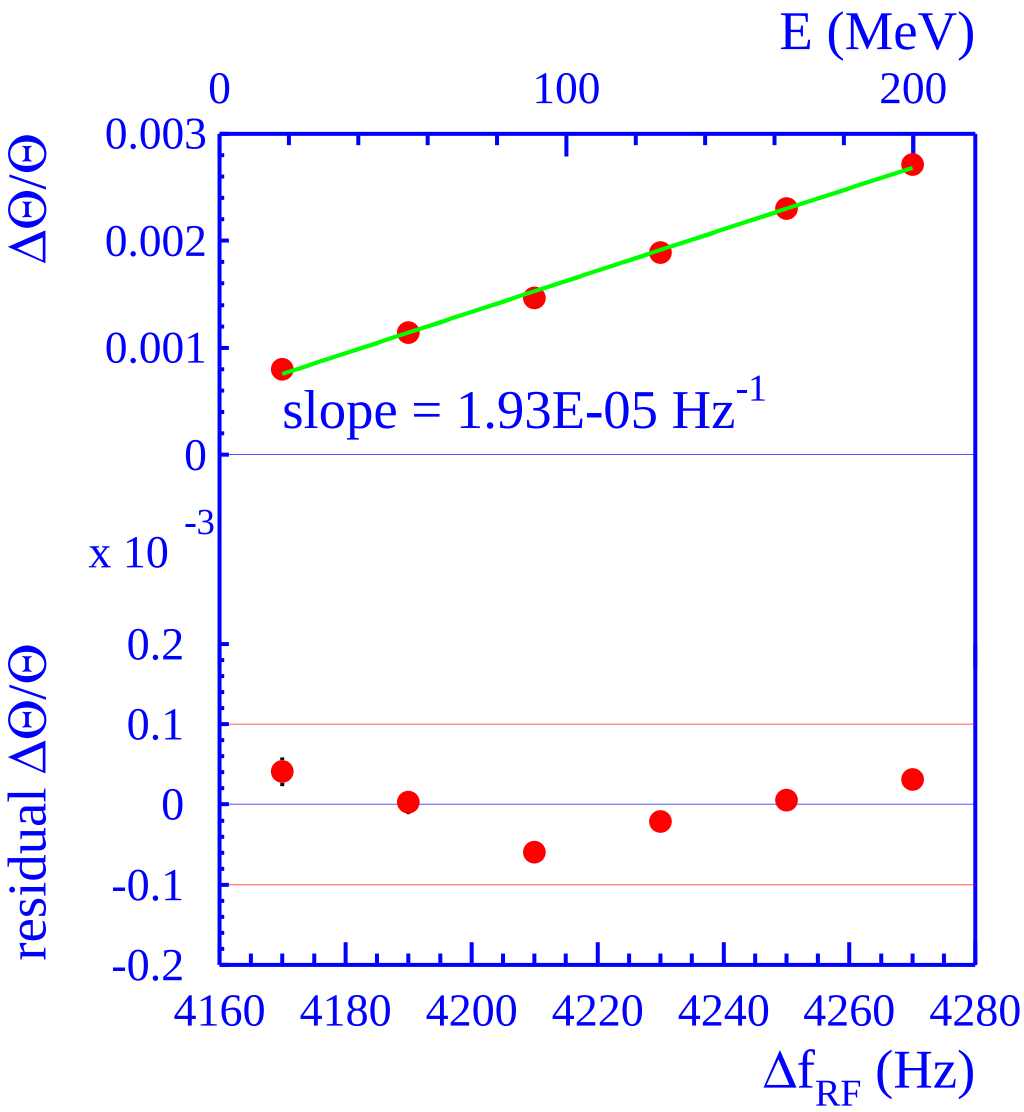






- Final electronic available in July
- The triplet residual is sensitive to relative changes of the beam position measurement system comparing 3 BPMs
- Suppression of the beam movements by a factor of almost 10^4
- The triplet residuals allow a continuous and direct determination of the BPM measurements error

Proof of Principle



- Bending angle variation is linear with energy change
- Residual variation smaller than $1 \cdot 10^{-4}$
- Slope depends on BPM absolute scale calibration (expected: 1.81 Hz^{-1}), to be done

Summary and Outlook (LEP II Calibrations)

- **Resonant Depolarization extended to 61 GeV**
- **1997:** $\dfrac{\Delta E}{E} = 3 \cdot 10^{-4}$
- **1998:** $\dfrac{\Delta E}{E} = 2 \cdot 10^{-4}$
- **1999: More calibrations have to be done**

Summary and Outlook (Spectrometer)

- Reached Integral magnetic field prediction accuracy of: $\frac{\Delta \int Bdl}{\int Bdl} = 3 \cdot 10^{-5}$
- Linearity and stability of BPMs better than 1μm
- Relative bending angle variation below $1 \cdot 10^{-4}$ during a beam energy change of 180 MeV
- To do: cross checks
- Ready to make beam energy measurements with the spectrometer