Status of the $g-2$ EDM Analysis

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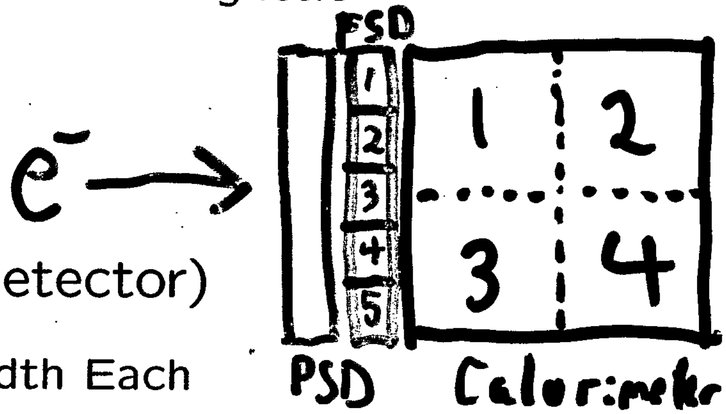
Detectors

Calorimeter

- 24 Lead/Scintillating Fiber Electromagnetic Calorimeters
- Readout Through 4 PMTs



FSD (Front Scintillator Detector)

- 5 Tiles, 2.8 cm Vertical Width Each
- 1999: 6 Stations 2000-2001: 12 Stations

PSD (Position Sensitive Detector)

- Tile-Fiber Hodoscopes on 5 Stations
- 7mm Width Tiles
- 20 Vertical × 32 Horizontal Segments
- Systematic Studies

Traceback

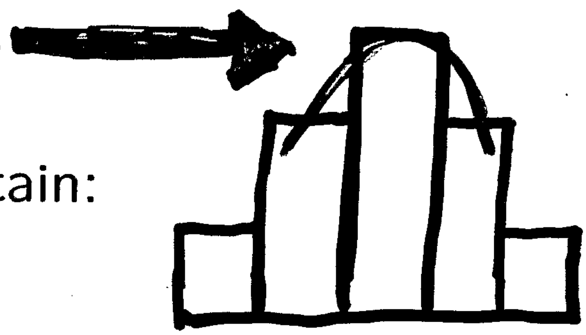
- 4 Planes of Horizontal and Vertical Straw Tubes
- Direct Sensitivity to Electron Decay Angle

$\Delta\bar{y}$ Method

An EDM causes a vertical oscillation of the profile with the g-2 frequency, but 90° out of phase. This effect is greatest for electrons of energy 1.2-2.4 GeV. The simplest analysis method is to look at the mean of the distribution vs time in the g-2 cycle. We can use 3 tiles or all 5.

Parabolic Method

Using tiles 2-4 assume the profile is a parabola $N(y) = A(y - y_\circ)^2 + C$.



Solving for the peak ($y_\circ$) we obtain:

$$y_\circ = \frac{\Delta}{2}\frac{N_2 - N_4}{2N_3 - N_2 - N_4}$$

$\Delta\phi$ Method

An EDM would cause a difference in the phase of the g-2 oscillation from the top to the bottom of the detector.

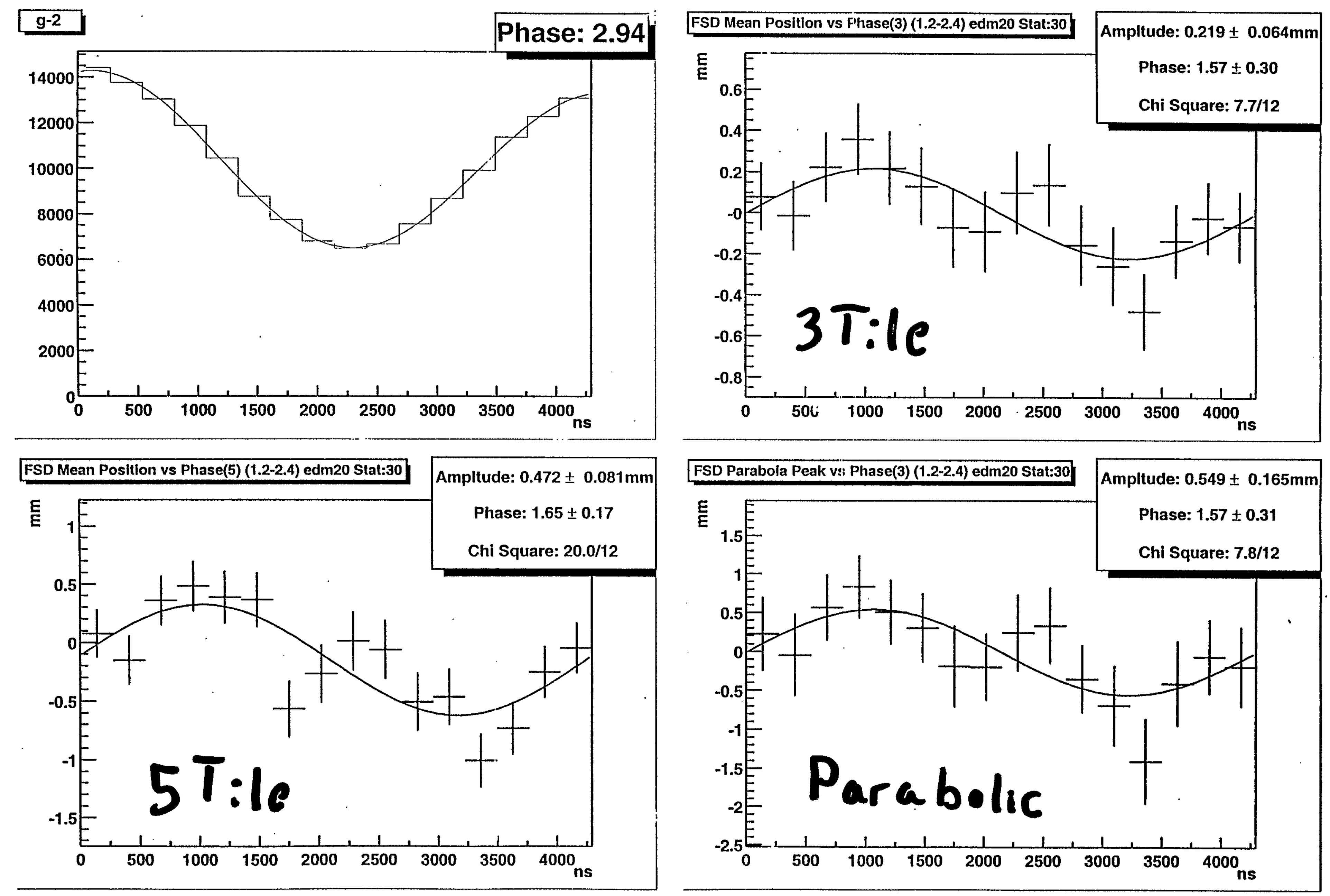
$\Delta\omega$ Method

In addition to tilting the plane of precession an EDM will also change the g-2 frequency.

A CERN level EDM would cause a 6ppm shift in the g-2 frequency. The change in frequency scales as the square of the EDM.

Based on the 1999 g-2 result we can place a 95% confidence level limit of 3.9×10^{-19} e-cm on the muon EDM.

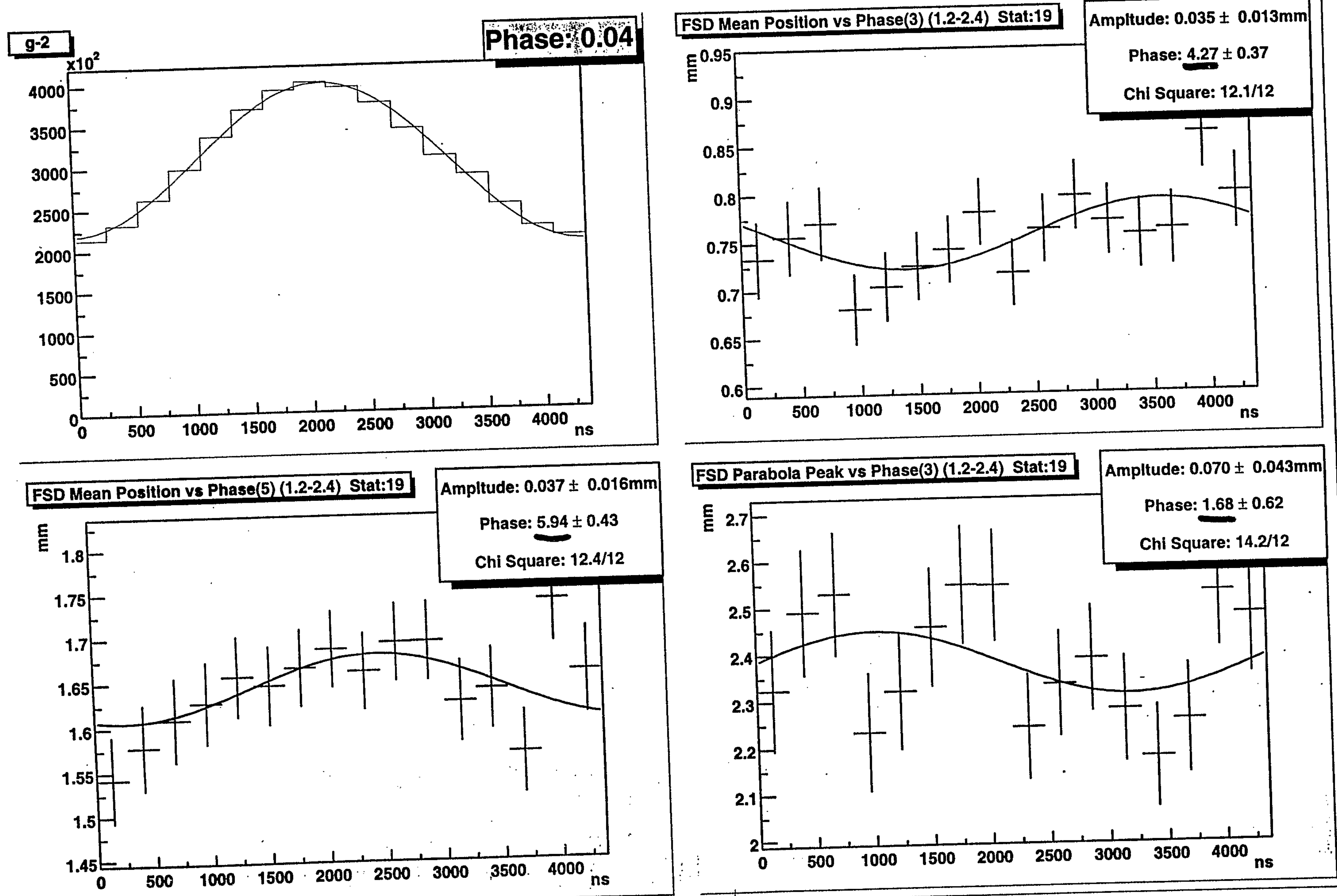
GEANT Simulation: 7.4×10^{-18} e·cm EDM

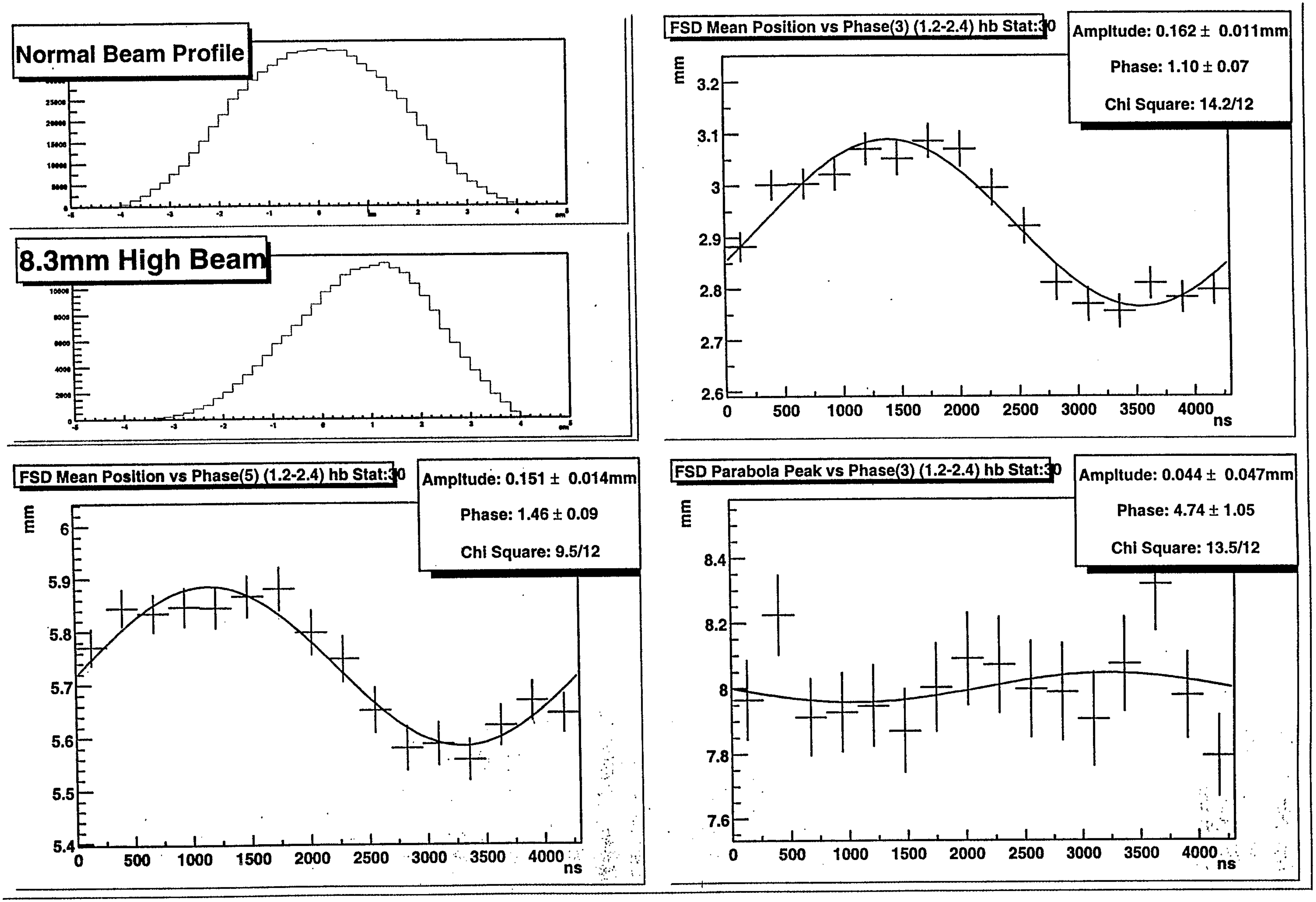


EDM Statistical Errors

	3 Tile Mean	5 Tile Mean	Parabolic
CERN EDM	$11\mu m$	$30\mu m$	$35\mu m$
1999 Statistics	$5.5\mu m$	$6.9\mu m$	$19\mu m$
1999/CERN	1/2	1/4	1/2
2000/CERN	1/6	1/12	1/6

1999 Data ~ Station 19   preliminary

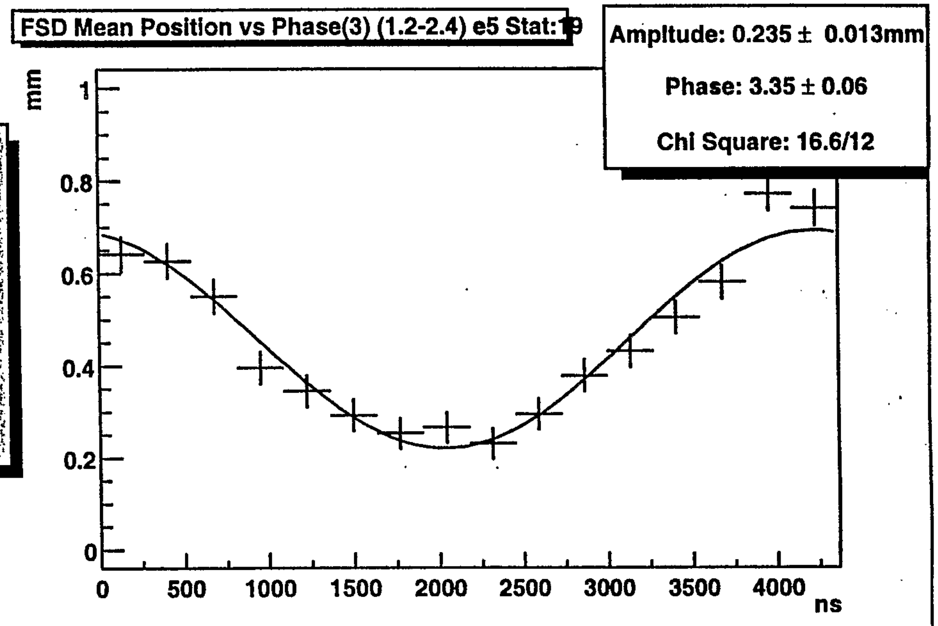


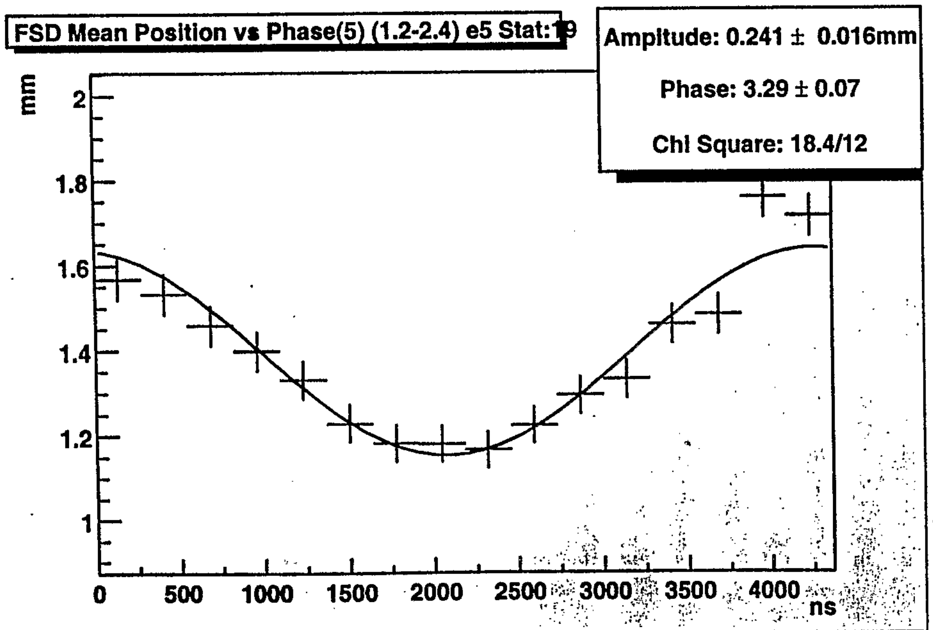


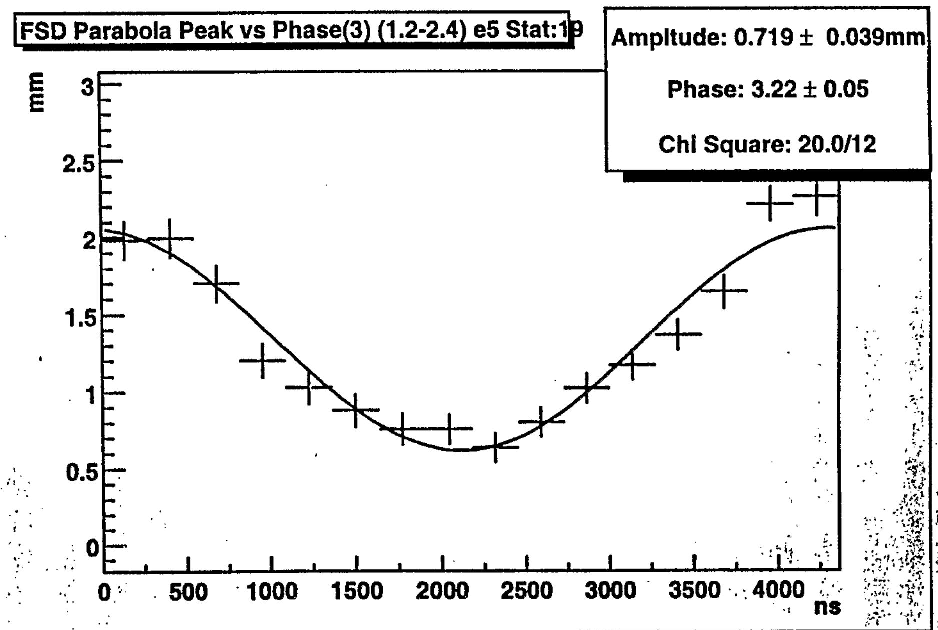
Normal Beam Profile
8.3mm High Beam
FSD Mean Position vs Phase(3) (1.2-2.4) hb Stat:30
Amplitude: 0.162 ± 0.011mm
Phase: 1.10 ± 0.07
Chi Square: 14.2/12
mm
ns
FSD Mean Position vs Phase(5) (1.2-2.4) hb Stat:30
Amplitude: 0.151 ± 0.014mm
Phase: 1.46 ± 0.09
Chi Square: 9.5/12
mm
ns
FSD Parabola Peak vs Phase(3) (1.2-2.4) hb Stat:30
Amplitude: 0.044 ± 0.047mm
Phase: 4.74 ± 1.05
Chi Square: 13.5/12
mm
ns

Top/Bottom 5% Energy Miscalibration

Systematic Study on Data







Effect on Muons

A radial magnetic field can cause a tilt in the muon precession plane in the same way that an EDM would. An EDM of 3.7^{-19} e-cm causes a 3.4mrad tilt in the precession plane. We know that the average radial field in the ring is less than 40ppm of the total field. This is therefore a negligible systematic error.

Effect on Positrons

The change in the vertical position of the profile due to a radial field is approximately equal to the change in trajectory length times the angle of the field. In simulation we see a change in average trajectory length of 54mm within the g-2 cycle. From measurements the maximum radial field sampled by electrons is less than 100ppm. So maximally we have a 5.4μm systematic.

Current Levels of Systematic Errors

Amplitude of vertical oscillation expected based on estimates of various sources of systematic error. This does not account for the phase of the oscillation.

Systematic	3 Tile Mean μm	5 Tile Mean μm	Parabolic μm
Energy Calibration (1%)	47	48	143
Tilt (1°)	5.7	8.7	20
Detector/Beam Alignment (2mm)	40	38	<12
Tile Eff. (1%)	<1	<1	19
Timing Offset ($1ns$)	2.0	2.7	5.4
Radial B Field ($100ppm$)	1.9	5.4	5.4
CERN EDM	11	30	35

Outlook for Improving Systematics

Top/Bottom Energy Scale

- 12 independent detectors.
- Out of phase with EDM.
- Instead of linear fit to spectrum, fit to Asymmetry vs Energy.

Detector/Beam Alignment

- Parabolic method much less sensitive than mean.
- CBO causes similar effect.

Tile Efficiencies

- 12 independent detectors.
- Better estimate using the calorimeter top/bottom segmentation.
- Tiles were in WFDs for part of the run in 2000 and 2001
- Mean much less sensitive than parabolic method.

Outlook for Improving Systematics

Detector Tilt

- 12 independent detectors.
- Use high energy electrons (insensitive to EDM).
- Partially out of phase with EDM.

Timing Difference

- Use cyclotron motion of early beam (before debunching) to get better relative timing.

Radial Magnetic Field

- Use high energy electrons (insensitive to EDM).
- Use CBO, which also causes changes in drift distance.
- MC studies.

Conclusions

- Several large sources of systematic error to be dealt with.
- Not statistics limited.
- I believe that a Muon EDM measurement 3-4 times better than CERN is possible.