Jefferson Lab
E94010 Technical Note
March 14, 2001

Spectrometer Mispointing for E94010 v 1.0

K. Slifer
Temple University, Philadelphia, PA 19122

E-mail
slifer@jlab.org

We determine the magnitude of the Hall A spectrometer mispointings and its effect on the analysis for experiment E94010. We examine the possibility of extracting the central scattering angle from elastic scattering data.

Contents

1 Introduction

Data taking for experiment E94010 can be split into two periods before and after the spectrometer arms were moved to take elastic data on December 12th and 13th of 1998. There is some ambiguity regarding the surveys conducted during E94010 to determine the central scattering angle and the spectrometer mispointing. To illustrate, we include an excerpt from the minutes of the 8/11/1999 GDH analysis meeting by J.P.Chen

> *"About the H-arm spectrometer angle and offset: After discussion with Javier and the survey group, we found that the only survey done before the experiment was the 9/12 survey when the spectrometer was at 12.2 degree and the spectrometer was moved to 37 degree and moved back to 15.5 degree before the GDH data taking start. So the only information on the angle and the pointing (from the start to 11/, when the spectrometer moved) is from the encoders.There are two encoders for each spectrometer. Unfortunately one of the h-arm encoders was (and still is) not working reliably. However, this will be our only information. The encoder readings give the spectrometer angle and pointings which are displayed in the spectrometer EPICS window. Following is a summary of the spectrometer angles and pointings during the GDH experiment:"*

Table 1: Survey Results for E94010

	9/25-10/6	10/6-12/12	12/12-12/13	12/13-12/24
E-Spectrometer angle	15.485	15.503	17.492	15.495
E-Horizontal Pointing	2.67	-0.36	xxxx	0.48
E-Vertical Pointing	xxxx	0.62	xxxx	0.58
H-Spectrometer angle	15.528	15.528	12.526	15.508
H-Horizontal Pointing	-3.8	-3.8	xxxx	-1.11
H-Vertical Pointing	xxxx	xxxx	xxxx	0.82
Good until run:	1621	3216/20550	20580	20607/3480

Note: Beamline upstream is positive for the horizontal pointing. Up is positive for the vertical pointing. All lengths are in mm. All angles are in degrees. Error on survey values are of the order of 0.5mm [3]

Even if the survey information was 100% complete, it is still beneficial to verify the results independently by examining the data. To this end, we analyzed scattering from carbon foils taken for optics studies.

2 Spectrometer Mispointing

E94910 devoted beamtime to scattering from seven thin carbon foils for two spectrometer energies: 862 MeV (before the move) and 2591 MeV (after the move). The foils were evenly spaced over a length of 40 cm. Foil # 4 was positioned at the origin of the target coordinate Z_{beam}. This coincides with the geometric center of Hall A [1]. From this data we can clarify the picture considerably. Fig. 1 is a schematic of the beamline showing the placement of the carbon foils and the pointing of the arms. Note that the mispointing is greatly exaggerated in the figure.

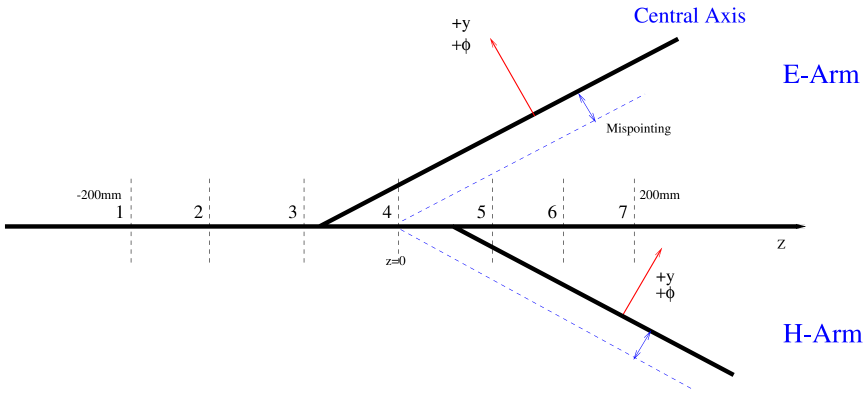

Figure 1: Spectrometer and Beam Line.

To check the pointing values shown in Table 1, we plot the Z_{beam} distribution*

$$Z_{beam} = \frac{-y_t \cos(\phi_t)}{\sin(\phi_0 + \phi)} \tag{1}$$

Fig. 2 shows electron arm carbon data before the move (run 20271) and Fig. 3 shows electron arm data after the move (run 20587). Foil #7 lies outside of the acceptance for the Electron spectrometer. Figs. 4 and 5 show that foil #1 is beyond the acceptance for the Hadron arm. If there was no mispointing, the central foil would be located at z_{beam}=0. From the position of the central foil ΔZ, we can determine the spectrometer horizontal mispointing M

$$M = \Delta Z \sin\theta \tag{2}$$

To reduce the error, we take the weighted average of the mispointing determination for six† foils. These results are shown in Tables 2 to 5.

2.1 Conclusion

Table 6 summarizes the results for both spectrometers. The Electron arm results for the mispointing are consistent with zero and agree with the survey within error. The Electron arm mispointing should have very little effect on the analysis. The Hadron arm results, on the other hand, differ quite strongly from the survey/encoder values. This discrepancy will need to be resolved if the Hadron Arm data is to be used for an absolute Cross-section measurement.

*No shift is applied to ϕ_t, y_t,or Z_{beam} in this study.

†Only the central five foils can be fit reliably for the Hadron Arm.

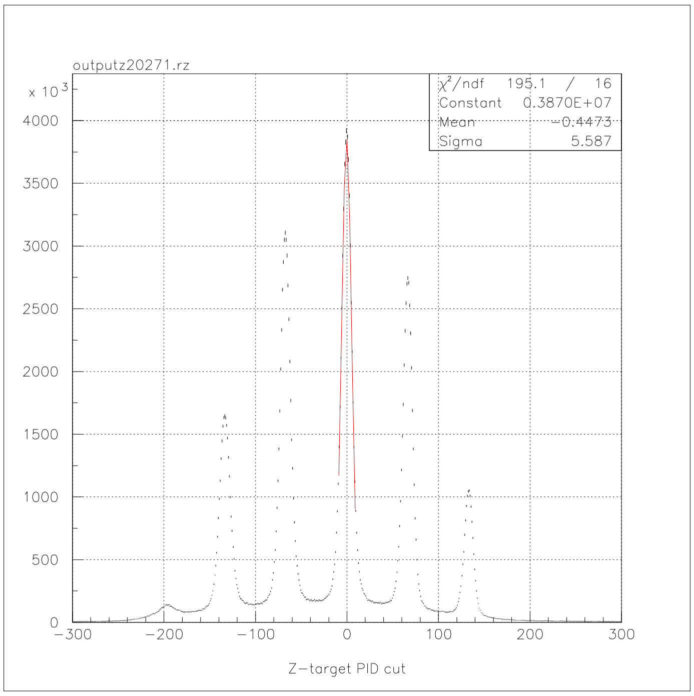

Figure 2: Electron Arm carbon foil data before move.

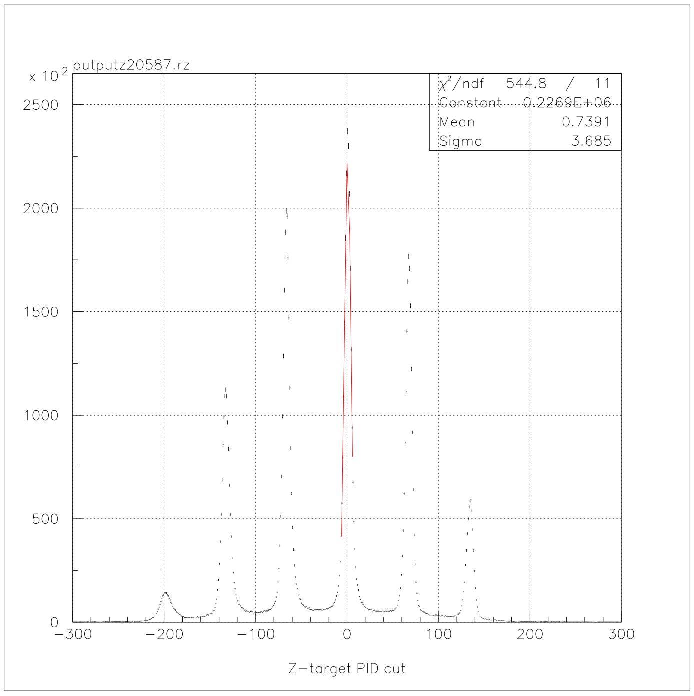

Figure 3: Electron Arm carbon foil data after move.

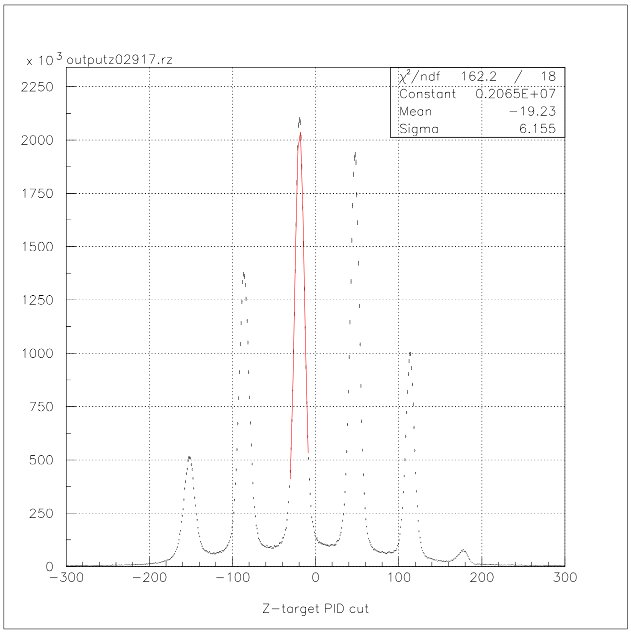

Figure 4: Hadron Arm carbon foil data before move

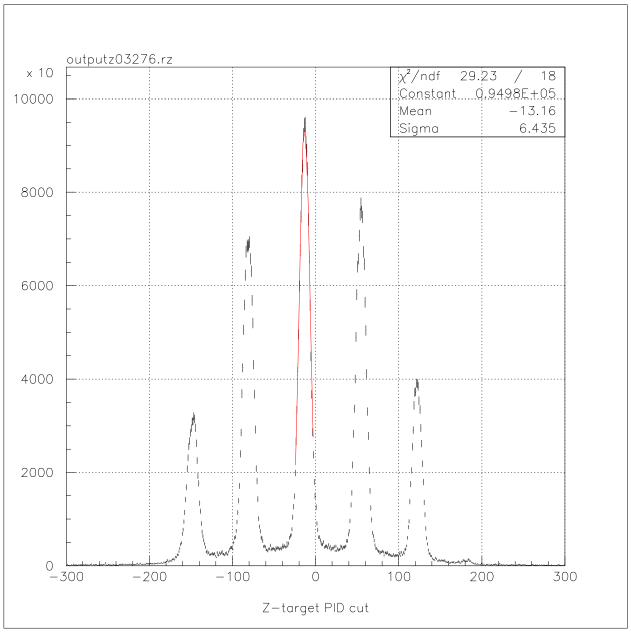

Figure 5: Hadron Arm carbon foil data after move

Table 2: Electron arm Mispointing Before move

Foil #	Mispointing (mm)	σ(mm)
1	1.06	2.96
2	-0.02	1.64
3	-0.18	1.51
4	-0.11	1.50
5	-0.09	1.44
6	-0.11	1.33
Weighted Average	-0.05	0.64

Table 3: Electron arm Mispointing after move

Foil #	Mispointing (mm)	σ(mm)
1	0.45	1.71
2	0.21	1.11
3	0.11	0.98
4	0.21	0.96
5	0.00	0.93
6	0.33	1.00
Weighted Average	0.18	0.43

Table 4: Hadron arm Mispointing before move

Foil #	Mispointing (mm)	σ(mm)
2	-4.96	1.97
3	-5.18	1.72
4	-5.15	1.65
5	-5.23	1.58
6	-5.27	1.46
Weighted Average	-5.18	0.74

Table 5: Hadron arm Mispointing after move

Foil #	Mispointing (mm)	σ(mm)
2	-3.91	1.81
3	-3.83	1.69
4	-3.52	1.72
5	-3.25	1.68
6	-3.01	1.56
Weighted Average	-3.48	0.75

Table 6: Summary. Electron and Hadron Arm Mispointing

ARM	Before 12/12/98	After 12/13/98
EARM Horizontal Pointing	-0.05$\pm$0.64	0.18$\pm$0.43
HARM Horizontal Pointing	-5.18$\pm$0.74	-3.48$\pm$0.75

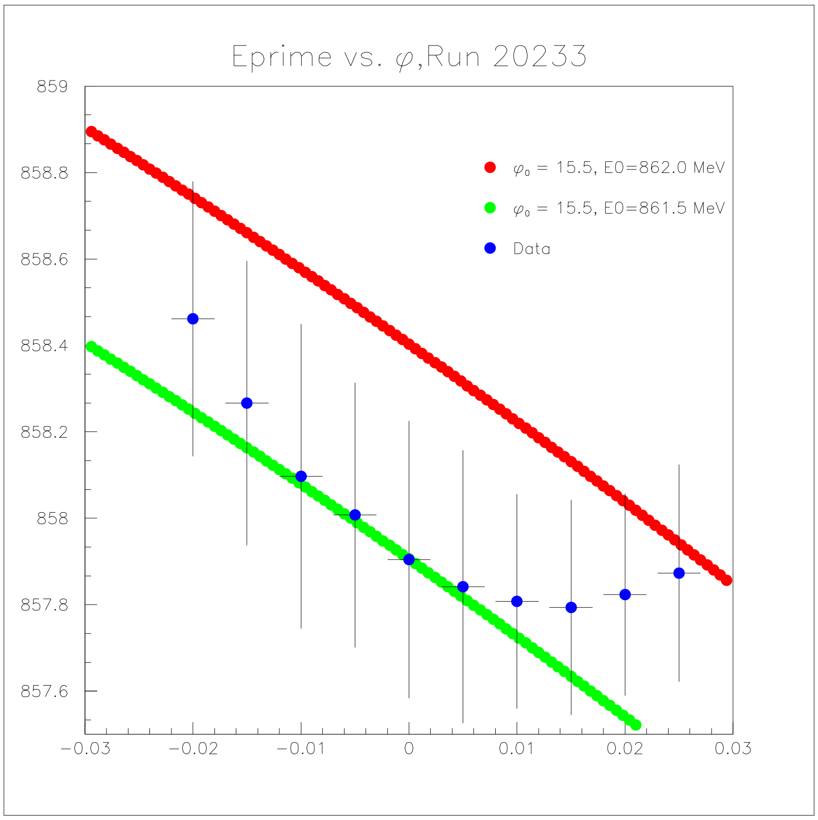

Figure 6: E' vs. ϕ_t. Run 20233

3 The Scattering Angle

From the carbon data we can, in principle, make a determination of the central scattering angle ϕ_0 using the relation for elastic scattering:

$$E' = \frac{E}{1 + \frac{2E}{M}\sin^2(\frac{\phi_0+\phi}{2})} \tag{3}$$

Fig. 6 shows the predicted E' behaviour as a function of ϕ_t, for two slightly different values of the incident energy, as well as experimental data from run 20233. The predictions take into account the energy loss due to passage through the carbon foils and surrounding target materials. Run 20233 was an electron arm run with E_{beam} = 862.0 MeV and P_0 = 857.5 MeV/c. The elastic peak was positioned at the center of the momentum acceptance.

Unfortunately, the result is very sensitive to the value of the incident energy and to the central scattered momentum. A half MeV change in E_{beam} results in the deviation shown for the predicted curves. We simply do not know the energy and momentum well enough for this measurement to be useful.

Notice that the data deviates from the expected monotonically decreasing behaviour. When ϕ_t is far from 0, the results are systematically larger than expected.

4 Acknowledgements

Seonho Choi provided the code to calculate the energy loss due to passage through target materials (along with alot of valuable advice).

References

[1] Nilanga Liyanage, private communication.7 Mar 2001

[2] 314159265

[3] M. Liang *Survey Summary Report* E89-003,E89-033 technical note. 17 Feb 1998. **hallaweb.jlab.org/publications/technotes.html** The surveys discussed in this report do not pertain to E94010, but give a sense of the error associated with such a measurement.