

# **Analysis of e1c Beam Charge Asymmetries**

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## **Abstract**

This note describes an analysis of beam charge asymmetries for the e1c running period which ran January to April, 1999. This analysis was undertaken to investigate possible beam asymmetries which would influence extracted analyzing powers. Elastic e-p scattering has no asymmetry and thus serves as an excellent monitor of beam charge asymmetry. 2.567 GeV, 4.247 GeV, and 4.462 GeV data were analyzed. The majority of asymmetries are less than 1% for a single run, averaging to  $0.348\text{E-}03 \pm 0.149\text{E-}03$  for the complete set of analyzed runs.

# 1 Procedure

The analysis was performed on the elc ntuples. Spin-sorted  $W$  projections were made, elastic peaks were summed, and beam charge asymmetries were formed from the elastic sums. A sample  $W$  spectrum is shown in Figure 1 with summing gate. Asymmetries were calculated as:

$$A = \frac{Y_+ - Y_-}{Y_+ + Y_-}$$

with statistical uncertainties given by:

$$\Delta A = \sqrt{\frac{4Y_+Y_-}{(Y_+ + Y_-)^3}}$$

where  $Y_+$  ( $Y_-$ ) is the yield for the positive (negative) helicity state.

Helicity information was taken from the ntuple variable *evntclas* which includes both helicity and trigger bit information. For the 2.567 and 4.247 GeV runs, *evntclas* = 1 & 2 was taken to be helicity state 1 and *evntclas* = 4 & 5 was taken to be helicity state 2. The level 2 trigger was introduced during the elc running. As a result the trigger bits changed and the *evntclas* states changed. *Evntclas* = 11 & 12 was taken to be helicity state 1 and *evntclas* = 14 & 15 was taken to be helicity state 2 for the 4.462 GeV runs. Sometimes it takes a while to get used to new things. This was true for the level 2 trigger. For runs 17591 to 17664, the wrong trigger file was loaded and *evntclas* changed again creating a sequence of values. We took helicity state 1 to be when *evntclas* = 1, 2, 11, 12, 21, & 22 and the helicity state 2 to be when *evntclas* = 4, 5, 14, 15, 24, & 25 for these runs. This is consistent with other helicity-dependent analyses.

Determining the sign of the asymmetry involves correlating the helicity states with positive and negative values. This depends both upon the status of the half-wave plate at the polarized ion source and the spin precession of the electrons in the accelerator. For the 2.567 and 4.247 GeV running, when the half-wave plate was IN (OUT) helicity state 1 (2) was positive. For the 4.462 GeV running, when the half-wave plate was OUT (IN) helicity state 1 (2) was positive. These effects were included in the analysis.

## 2 Results and Discussion

Gold runs for the 2.567 GeV, 4.247 GeV, and 4.462 GeV data sets were analyzed. The 4.056 GeV data were not analyzed as there was significant beam polarization contamination due to leak through from Hall C. Run 17708 and those following were

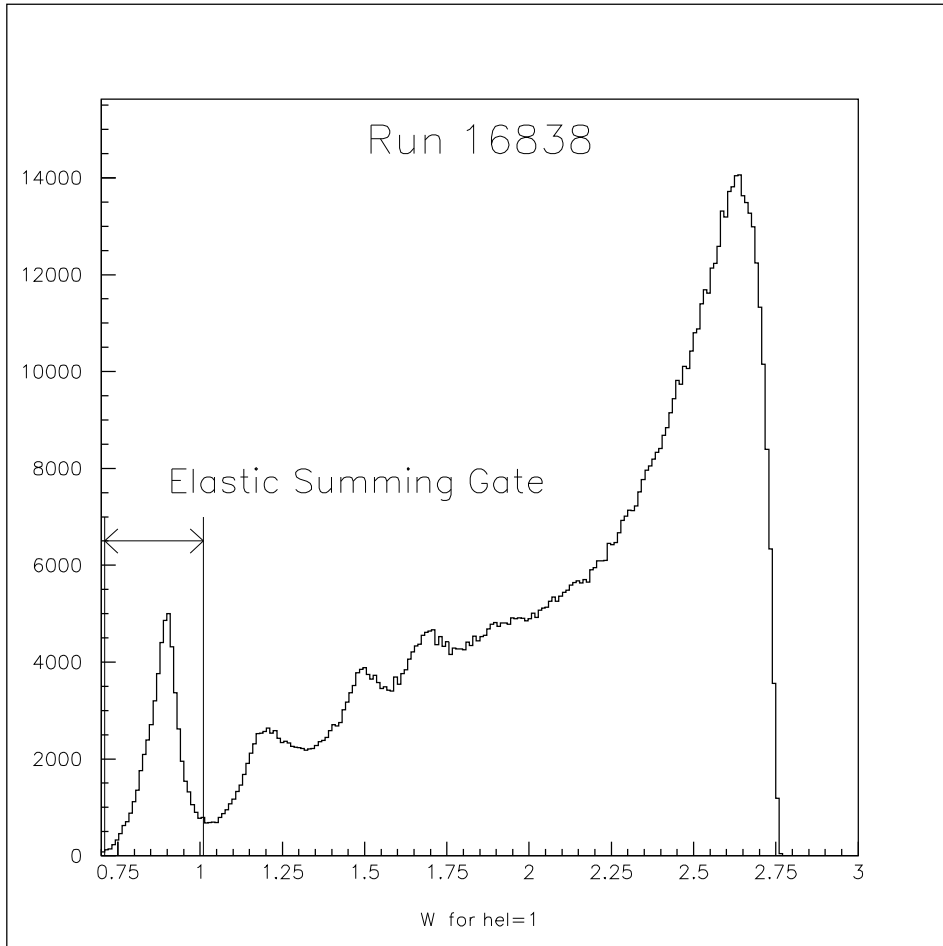


Figure 1: Typical  $W$  spectrum used in analysis. Summing region is indicated.

taken in delayed-polarization reporting mode and are not included in this report. This includes all of the 4.462 GeV / 2250 A running and part of the 4.462 GeV / 3375 A running. Complete sets of data for several runs was not available due to corruption of the tape media in the mass storage silo. These include runs 16704, 16705, 16707 16708 from the 2.567 GeV / 2250 A running and runs 16961 and 16976 from the 4.247 GeV / 3375 A running. These runs have not been included in this report. The averages for each kinematic setting are summarized in Table 2. Complete results for the remaining data sets are shown in Figures 2, 3, and 4 and presented in Tables 2, 3, 4, 5, and 6.

The majority of beam charge asymmetries are less than 1%, with an average asymmetry of less than 0.4% for each of the five kinematic settings, as can be seen in the tables. When averaged over the complete set of runs the asymmetry is  $0.348\text{E-}03 \pm 0.149\text{E-}03$ . While not all of the results are consistent with zero, they are small enough to ignore at the current level of precision in CLAS. However, one trend may be of concern. There may be a correlation between half-wave plates and sign of the asymmetry in the 2.567 GeV data set. Most runs with half-wave plate IN are negative and most runs with half-wave plate OUT are positive at 2.567 GeV. This trend is not as apparent at the other energies.

Energy (GeV)	Torus (A)	Asymmetry	Statistical Uncertainty
2.567	1500	0.433E-03	0.178E-03
2.567	2250	0.113E-03	0.249E-03
4.247	2250	0.199E-02	0.522E-03
4.247	3375	0.296E-02	0.129E-02
4.462	3375	-0.340E-02	0.957E-03
Average		0.348E-03	0.149E-03

Table 1: Beam charge asymmetry for each kinematic setting.

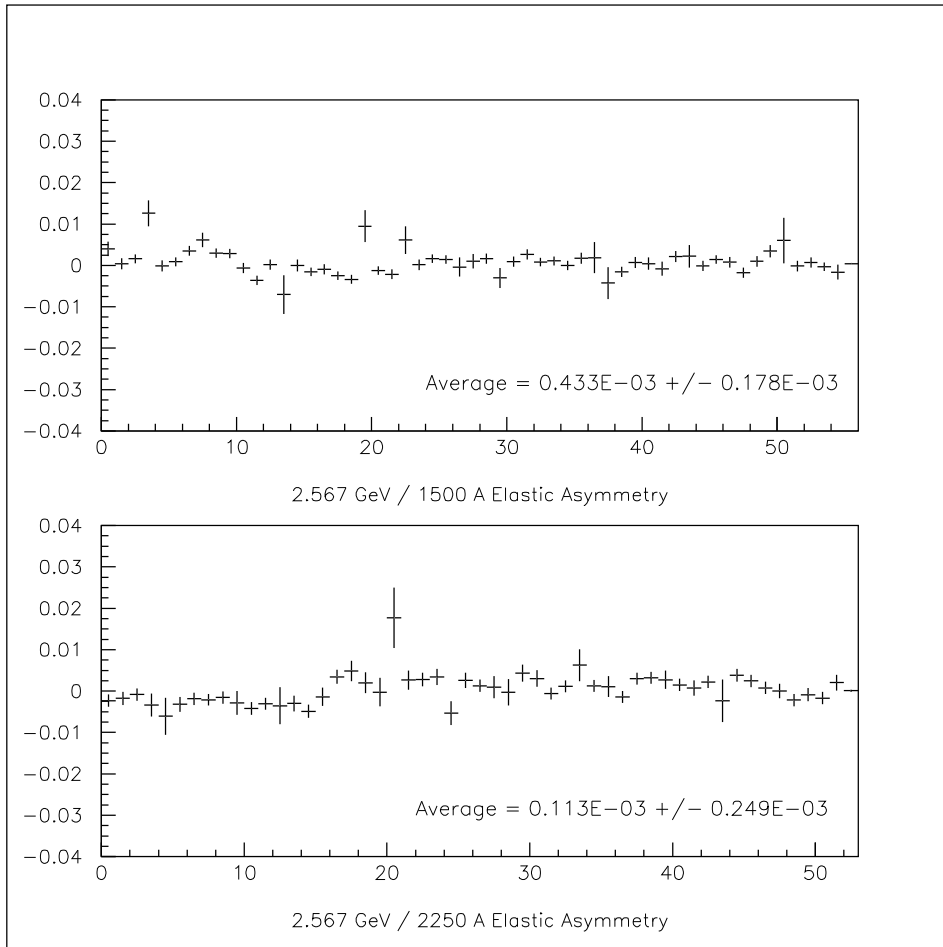


Figure 2: Beam charge asymmetry for 2.567 GeV data, 1500 A torus setting above, 2250 A below. The right-most point indicates the average asymmetry.

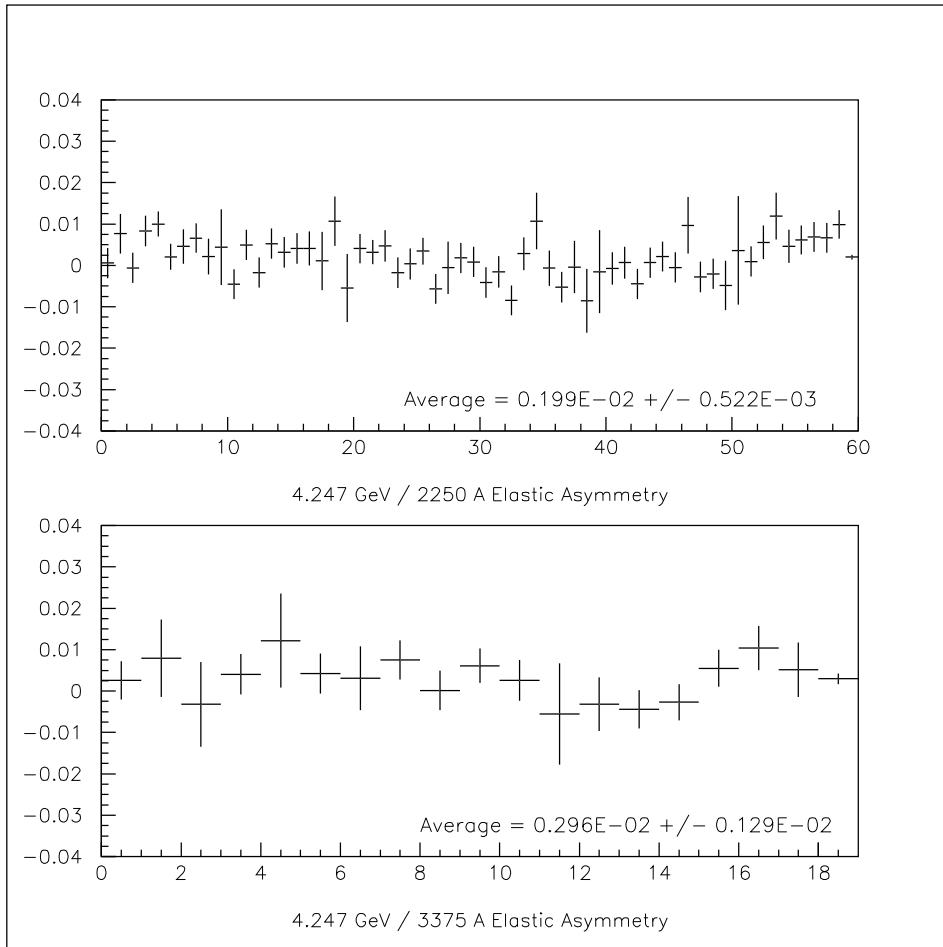


Figure 3: Beam charge asymmetry for 4.247 GeV data, 2250 A torus setting above, 3375 A below. The right-most point indicates the average asymmetry.

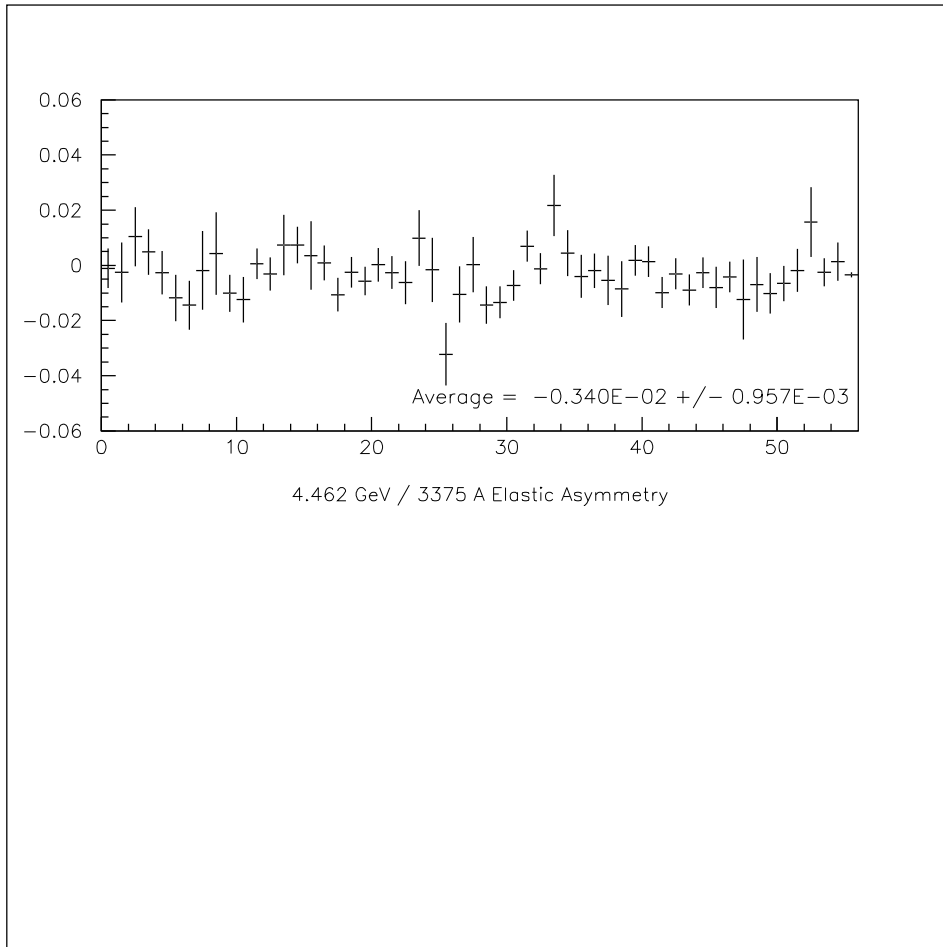


Figure 4: Beam charge asymmetry for 4.462 GeV data, 3375 A torus. The right-most point indicates the average asymmetry.

Run Number	$\frac{1}{2}$ Wave Plate	Asymmetry	Statistical Uncertainty	Run Number	$\frac{1}{2}$ Wave Plate	Asymmetry	Statistical Uncertainty
16507	OUT	0.396E-02	0.173E-02	16567	OUT	0.160E-02	0.123E-02
16508	OUT	0.407E-03	0.130E-02	16569	OUT	-0.303E-02	0.239E-02
16509	OUT	0.159E-02	0.107E-02	16576	OUT	0.875E-03	0.122E-02
16510	OUT	0.126E-01	0.311E-02	16577	OUT	0.266E-02	0.121E-02
16513	OUT	-0.775E-04	0.133E-02	16581	OUT	0.820E-03	0.104E-02
16514	OUT	0.897E-03	0.108E-02	16582	OUT	0.108E-02	0.108E-02
16515	OUT	0.351E-02	0.116E-02	16584	OUT	0.124E-05	0.112E-02
16516	OUT	0.616E-02	0.178E-02	16585	OUT	0.173E-02	0.131E-02
16517	OUT	0.298E-02	0.111E-02	16586	OUT	0.184E-02	0.376E-02
16518	OUT	0.285E-02	0.113E-02	16587	OUT	-0.425E-02	0.387E-02
16519	OUT	-0.605E-03	0.125E-02	16588	OUT	-0.157E-02	0.127E-02
16527	IN	-0.365E-02	0.114E-02	16589	OUT	0.687E-03	0.130E-02
16528	IN	0.220E-03	0.122E-02	16590	OUT	0.412E-03	0.150E-02
16529	IN	-0.705E-02	0.467E-02	16595	OUT	-0.794E-03	0.165E-02
16530	IN	-0.427E-05	0.146E-02	16597	OUT	0.213E-02	0.131E-02
16531	IN	-0.158E-02	0.103E-02	16598	OUT	0.222E-02	0.273E-02
16532	IN	-0.950E-03	0.122E-02	16600	OUT	-0.107E-03	0.125E-02
16543	IN	-0.252E-02	0.103E-02	16601	OUT	0.140E-02	0.104E-02
16544	IN	-0.337E-02	0.104E-02	16602	OUT	0.784E-03	0.128E-02
16545	IN	0.947E-02	0.386E-02	16604	OUT	-0.175E-02	0.125E-02
16546	IN	-0.123E-02	0.102E-02	16605	OUT	0.971E-03	0.125E-02
16547	IN	-0.217E-02	0.119E-02	16606	OUT	0.344E-02	0.147E-02
16558	OUT	0.611E-02	0.333E-02	16607	OUT	0.601E-02	0.552E-02
16559	OUT	0.153E-03	0.129E-02	16608	IN	-0.151E-03	0.128E-02
16560	OUT	0.159E-02	0.104E-02	16609	IN	0.683E-03	0.126E-02
16561	OUT	0.142E-02	0.104E-02	16610	IN	-0.356E-03	0.105E-02
16565	OUT	-0.386E-03	0.232E-02	16611	IN	-0.162E-02	0.180E-02
16566	OUT	0.105E-02	0.175E-02	<b>Average</b>		<b>0.433E-03</b>	<b>0.178E-03</b>

Table 2: Beam Charge Asymmetry 2.567 GeV / 1500 A



Run Number	$\frac{1}{2}$ Wave Plate	Asymmetry	Statistical Uncertainty	Run Number	$\frac{1}{2}$ Wave Plate	Asymmetry	Statistical Uncertainty
16634	IN	-0.230E-02	0.149E-02	16688	OUT	0.129E-02	0.152E-02
16635	IN	-0.178E-02	0.157E-02	16689	OUT	0.914E-03	0.269E-02
16637	IN	-0.841E-03	0.149E-02	16690	OUT	-0.301E-03	0.317E-02
16647	IN	-0.335E-02	0.278E-02	16691	OUT	0.435E-02	0.209E-02
16648	IN	-0.609E-02	0.445E-02	16692	OUT	0.305E-02	0.205E-02
16649	IN	-0.322E-02	0.181E-02	16693	OUT	-0.606E-03	0.142E-02
16651	IN	-0.188E-02	0.146E-02	16694	OUT	0.117E-02	0.145E-02
16652	IN	-0.210E-02	0.137E-02	16695	OUT	0.626E-02	0.383E-02
16653	IN	-0.157E-02	0.146E-02	16696	OUT	0.126E-02	0.144E-02
16654	IN	-0.286E-02	0.284E-02	16697	OUT	0.109E-02	0.253E-02
16655	IN	-0.422E-02	0.155E-02	16698	OUT	-0.141E-02	0.147E-02
16656	IN	-0.308E-02	0.145E-02	16699	OUT	0.304E-02	0.145E-02
16657	IN	-0.355E-02	0.445E-02	16701	OUT	0.322E-02	0.144E-02
16668	IN	-0.299E-02	0.192E-02	16703	OUT	0.273E-02	0.224E-02
16669	IN	-0.487E-02	0.162E-02	16706	OUT	0.148E-02	0.151E-02
16670	IN	-0.140E-02	0.219E-02	16709	OUT	0.751E-03	0.186E-02
16673	OUT	0.346E-02	0.172E-02	16711	OUT	0.220E-02	0.151E-02
16675	OUT	0.488E-02	0.247E-02	16712	OUT	-0.233E-02	0.512E-02
16676	OUT	0.202E-02	0.251E-02	16715	OUT	0.382E-02	0.153E-02
16677	OUT	-0.245E-03	0.341E-02	16716	OUT	0.245E-02	0.148E-02
16679	OUT	0.177E-01	0.727E-02	16718	OUT	0.743E-03	0.149E-02
16680	OUT	0.265E-02	0.231E-02	16719	OUT	0.579E-04	0.175E-02
16684	OUT	0.283E-02	0.163E-02	16720	IN	-0.218E-02	0.146E-02
16685	OUT	0.340E-02	0.199E-02	16726	IN	-0.863E-03	0.158E-02
16686	OUT	-0.530E-02	0.286E-02	16731	IN	-0.168E-02	0.145E-02
16687	OUT	0.257E-02	0.183E-02	16732	IN	0.203E-02	0.190E-02
<b>Average</b>						<b>0.113E-03</b>	<b>0.249E-03</b>

Table 3: Beam Charge Asymmetry 2.567 GeV / 2250 A

Run Number	$\frac{1}{2}$ Wave Plate	Asymmetry	Statistical Uncertainty	Run Number	$\frac{1}{2}$ Wave Plate	Asymmetry	Statistical Uncertainty
16833	OUT	0.571E-03	0.364E-02	16894	OUT	-0.415E-02	0.373E-02
16834	OUT	0.765E-02	0.474E-02	16897	OUT	-0.157E-02	0.384E-02
16835	IN	-0.590E-03	0.366E-02	16898	OUT	-0.844E-02	0.364E-02
16836	IN	0.831E-02	0.366E-02	16899	OUT	0.283E-02	0.396E-02
16838	IN	0.100E-01	0.302E-02	16900	OUT	0.107E-01	0.683E-02
16841	IN	0.207E-02	0.316E-02	16905	OUT	-0.658E-03	0.427E-02
16842	IN	0.456E-02	0.414E-02	16910	OUT	-0.527E-02	0.370E-02
16845	IN	0.659E-02	0.356E-02	16911	OUT	-0.402E-03	0.634E-02
16846	IN	0.216E-02	0.432E-02	16913	OUT	-0.853E-02	0.772E-02
16849	IN	0.441E-02	0.912E-02	16914	OUT	-0.151E-02	0.100E-01
16851	IN	-0.459E-02	0.360E-02	16916	OUT	-0.711E-03	0.389E-02
16854	IN	0.496E-02	0.366E-02	16917	OUT	0.675E-03	0.387E-02
16855	IN	-0.172E-02	0.369E-02	16918	OUT	-0.446E-02	0.364E-02
16856	IN	0.525E-02	0.364E-02	16920	OUT	0.651E-03	0.361E-02
16857	IN	0.320E-02	0.372E-02	16921	OUT	0.213E-02	0.362E-02
16858	IN	0.413E-02	0.369E-02	16922	OUT	-0.483E-03	0.366E-02
16864	IN	0.408E-02	0.412E-02	16923	OUT	0.969E-02	0.684E-02
16869	IN	0.109E-02	0.703E-02	16925	OUT	-0.283E-02	0.371E-02
16871	IN	0.107E-01	0.598E-02	16926	OUT	-0.203E-02	0.368E-02
16872	IN	-0.545E-02	0.820E-02	16927	OUT	-0.486E-02	0.593E-02
16873	IN	0.407E-02	0.353E-02	16928	IN	0.363E-02	0.131E-01
16874	OUT	0.322E-02	0.291E-02	16929	IN	0.949E-03	0.368E-02
16875	OUT	0.475E-02	0.381E-02	16930	IN	0.557E-02	0.404E-02
16876	OUT	-0.178E-02	0.369E-02	16933	IN	0.119E-01	0.566E-02
16877	OUT	0.342E-03	0.378E-02	16934	IN	0.461E-02	0.405E-02
16878	OUT	0.343E-02	0.325E-02	16937	IN	0.611E-02	0.349E-02
16879	OUT	-0.567E-02	0.359E-02	16938	IN	0.685E-02	0.361E-02
16881	OUT	-0.564E-03	0.635E-02	16939	IN	0.663E-02	0.360E-02
16882	OUT	0.182E-02	0.366E-02	16940	IN	0.989E-02	0.346E-02
16883	OUT	0.833E-03	0.367E-02	<b>Average</b>		<b>0.199E-02</b>	<b>0.522E-03</b>

Table 4: Beam Charge Asymmetry 4.247 GeV / 2250 A

Run Number	$\frac{1}{2}$ Wave Plate	Asymmetry	Statistical Uncertainty	Run Number	$\frac{1}{2}$ Wave Plate	Asymmetry	Statistical Uncertainty
16941	IN	0.258E-02	0.466E-02	16956	IN	0.612E-02	0.416E-02
16942	IN	0.797E-02	0.936E-02	16957	IN	0.259E-02	0.490E-02
16944	IN	-0.321E-02	0.102E-01	16958	IN	-0.552E-02	0.122E-01
16945	IN	0.406E-02	0.489E-02	16962	IN	-0.317E-02	0.646E-02
16946	IN	0.122E-01	0.114E-01	16975	OUT	-0.442E-02	0.462E-02
16947	IN	0.425E-02	0.482E-02	16985	OUT	-0.268E-02	0.437E-02
16948	IN	0.308E-02	0.769E-02	16986	OUT	0.549E-02	0.446E-02
16950	IN	0.755E-02	0.474E-02	16987	OUT	0.104E-01	0.536E-02
16955	IN	0.162E-03	0.480E-02	16988	OUT	0.518E-02	0.660E-02
				<b>Average</b>		<b>0.296E-02</b>	<b>0.129E-02</b>

Table 5: Beam Charge Asymmetry 4.247 GeV / 3375 A

Run Number	$\frac{1}{2}$ Wave Plate	Asymmetry	Statistical Uncertainty	Run Number	$\frac{1}{2}$ Wave Plate	Asymmetry	Statistical Uncertainty
17591	OUT	-0.107E-02	0.714E-02	17645	OUT	-0.144E-01	0.677E-02
17592	OUT	-0.257E-02	0.108E-01	17646	OUT	-0.134E-01	0.581E-02
17593	OUT	0.104E-01	0.107E-01	17647	OUT	-0.729E-02	0.556E-02
17594	OUT	0.485E-02	0.827E-02	17648	OUT	0.693E-02	0.564E-02
17595	OUT	-0.260E-02	0.786E-02	17649	OUT	-0.122E-02	0.566E-02
17596	OUT	-0.118E-01	0.840E-02	17651	OUT	0.217E-01	0.111E-01
17599	OUT	-0.144E-01	0.889E-02	17652	OUT	0.449E-02	0.832E-02
17600	OUT	-0.181E-02	0.142E-01	17661	OUT	-0.400E-02	0.778E-02
17607	OUT	0.428E-02	0.150E-01	17663	OUT	-0.195E-02	0.624E-02
17611	OUT	-0.101E-01	0.675E-02	17664	OUT	-0.540E-02	0.898E-02
17612	OUT	-0.124E-01	0.824E-02	17668	OUT	-0.854E-02	0.101E-01
17613	OUT	0.650E-03	0.556E-02	17672	OUT	0.184E-02	0.558E-02
17614	OUT	-0.313E-02	0.596E-02	17673	OUT	0.137E-02	0.557E-02
17617	OUT	0.737E-02	0.109E-01	17675	OUT	-0.985E-02	0.562E-02
17623	OUT	0.739E-02	0.667E-02	17676	OUT	-0.311E-02	0.563E-02
17624	OUT	0.356E-02	0.124E-01	17677	OUT	-0.893E-02	0.559E-02
17625	OUT	0.958E-03	0.632E-02	17678	OUT	-0.265E-02	0.562E-02
17626	OUT	-0.106E-01	0.605E-02	17679	OUT	-0.799E-02	0.747E-02
17628	OUT	-0.253E-02	0.556E-02	17680	OUT	-0.423E-02	0.556E-02
17629	OUT	-0.570E-02	0.518E-02	17681	OUT	-0.124E-01	0.145E-01
17630	OUT	0.219E-03	0.605E-02	17682	OUT	-0.694E-02	0.996E-02
17631	OUT	-0.263E-02	0.593E-02	17683	OUT	-0.102E-01	0.732E-02
17635	OUT	-0.626E-02	0.779E-02	17685	OUT	-0.654E-02	0.641E-02
17640	OUT	0.986E-02	0.101E-01	17689	OUT	-0.183E-02	0.782E-02
17641	OUT	-0.163E-02	0.116E-01	17690	OUT	0.157E-01	0.127E-01
17642	OUT	-0.322E-01	0.113E-01	17695	OUT	-0.251E-02	0.512E-02
17643	OUT	-0.105E-01	0.102E-01	17707	OUT	0.134E-02	0.691E-02
17644	OUT	0.300E-03	0.100E-01	<b>Average</b>		<b>-0.340E-02</b>	<b>0.957E-03</b>

Table 6: Beam Charge Asymmetry 4.462 GeV / 3375 A