GEn01 Beam Polarization

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1 $Q^2 = 0.5(GeV/c)^2$

The results cover the period from July 29, 2000 (run 40307) until September 14, 2000 (run 41611).

All Halls were running on one laser. The polarization was in the high 70's except for the period between run 40514 and 40804 when Hall A was at 3-pass and no Wien Angle setting was available for high polarization to all Halls. The epics history in detail can be found in table 1. The beam current asymmetry was about $1 \cdot 10^{-3}$ and got worse ($6 \cdot 10^{-3}$) after run 41000. This coincides with Hall A turning on the charge asymmetry feedback control. Later it was discovered that Hall C electrons were sampled far off the maximum in the tail of the laser pulse. Further studies by the injector group after the run period indicated that the Hall C slit was misaligned.

For the average beam polarization of each moller session (figure 2) only runs with beam current of 100±30 nA were taken into account. All the production data was taken at 100 nA and below 50 nA and above 150 nA the linearity of the beam current monitors is not guaranteed anymore. The average values for each moller session are listed in figure 2. From figure 3 one can see that the polarization is constant within statistics for the high polarization period as well as for the low polarization period. For the parametrization the whole run was divided into 4 periods defined by Wien Angle settings and averages were calculated for each period and for each half wave plate setting seperately as summarized in figure 4.

2 $Q^2 = 1(GeV/c)^2$

The results cover the period from October 27, 2001 (run 41843) until December 21, 2001 (run 43026).

The injector was running on three lasers, one for each Hall, and slits were swapped between Hall A and Hall C due to the misalignement of the Hall C slit. Hall A was running high beam current with low beam polarization. Thus a special emphasis was put on recording and minimizing the bleed through of the Hall A beam.

Epics history is given in table 5.

The beam current asymmetry was reduced with help of a feedback system down to a typical level of $5 \cdot 10^{-4}$. For the moller averages (figure 6) again only runs with beam currents between 70 and 130 nA were used.

	Date	rnum	hwp	wien	Cenergy	Aenergy
first:	Sun Jul 29 17:59:01 2001	40307	1	2.4	2336.3	5738.4
old:	Mon Jul 30 02:07:01 2001	40319	1			
new:	Mon Jul 30 02:47:59 2001	40320	0			
old:	Thu Aug 02 12:02:39 2001	40403				5738.4
new:	Fri Aug 03 02:23:15 2001	40420				1197.9
old:	Sat Aug 04 02:31:05 2001	40463	0			
new:	Sat Aug 04 20:16:39 2001	40473	1			
old:	Sat Aug 04 22:25:40 2001	40478	1			
new:	Sat Aug 04 22:33:10 2001	40479	0			
old:	Sun Aug 05 04:41:47 2001	40489	0			
new:	Sun Aug 05 05:28:21 2001	40491	1			
old:	Sun Aug 05 16:31:58 2001	40512		2.4		1197.9
new:	Mon Aug 06 02:21:04 2001	40514		25.5		3469.3
old:	Mon Aug 06 21:13:02 2001	40554	1			
new:	Mon Aug 06 21:30:25 2001	40555	0			
old:	Thu Aug 09 12:11:42 2001	40660	0			
new:	Thu Aug 09 12:56:43 2001	40661	1			
old:	Mon Aug 13 03:53:58 2001	40804		25.5		3469.3
new:	Thu Aug 16 19:44:32 2001	40848		−24.0		4606.5
old:	Thu Aug 16 19:44:32 2001	40848	1			
new:	Fri Aug 17 00:08:27 2001	40849	0			
old:	Fri Aug 17 08:22:59 2001	40864		−24.0		
new:	Fri Aug 17 18:22:42 2001	40868		−23.0		
old:	Mon Aug 20 12:38:16 2001	40976	0			
new:	Mon Aug 20 13:13:56 2001	40977	1			
old:	Thu Aug 23 07:55:39 2001	41048	1			
new:	Thu Aug 23 08:57:31 2001	41049	0			
old:	Sat Aug 25 00:31:23 2001	41106	0			
new:	Sat Aug 25 01:23:04 2001	41107	1			
old:	Fri Aug 24 06:14:45 2001	41075			2336.3	
new:	Fri Aug 24 15:01:19 2001	41091			2338.3	
old:	Sat Aug 25 01:23:04 2001	41107			2338.3	
new:	Sat Aug 25 02:02:23 2001	41108			2336.7	
old:	Sun Aug 26 05:47:35 2001	41146		−23.0	2336.7	4606.5
new:	Sun Aug 26 19:03:57 2001	41160		4.4	2335.9	5738.8
old:	Mon Aug 27 00:06:08 2001	41169	1			
new:	Mon Aug 27 10:08:14 2001	41177	0			
old:	Wed Aug 29 08:40:27 2001	41231	0			
new:	Wed Aug 29 09:40:59 2001	41232	1			
old:	Fri Aug 31 04:45:13 2001	41303	1			
new:	Fri Aug 31 05:31:11 2001	41304	0			
old:	Fri Aug 31 06:24:45 2001	41305	0	4.4		
new:	Wed Sep 05 20:48:49 2001	41332	1	6.2		
old:	Thu Sep 06 13:47:11 2001	41369		6.2		
new:	Thu Sep 06 15:55:36 2001	41373		4.9		
old:	Sun Sep 09 18:36:21 2001	41473	1			
new:	Sun Sep 09 19:00:08 2001	41474	0			
last:	Fri Sep 14 23:27:25 2001	41611	0	4.9	2335.9	5738.8

Figure 1: $Q^2 = 0.5$ epics history. rnum is the ND_3 production run number (based on first-pass runlist), hwp = 1 (0) means half wave plate out (in), wien is the Wien Angle setting in degrees and Cenergy and Aenergy are nominal Hall C and A beam energies in MeV.

```
rnum = first run number in moller session
bpol = average beam polarization in percent
stat = statistical error

    rnum  bpol   stat

    40408  79.33 1.34
    40529 -67.71 0.58
    40616  65.86 0.95
    40673 -66.36 1.02
    40680  65.52 1.20
    40792 -67.65 0.95
    40904  79.53 0.84
    40955  78.47 0.57
    41082  78.05 0.72
    41148 -77.89 0.43
    41239 -78.05 0.45
    41405 -78.79 0.45
    41566  77.65 0.45
```

Figure 2: Average beam polarization values for each $Q^2 = 0.5$ moller session

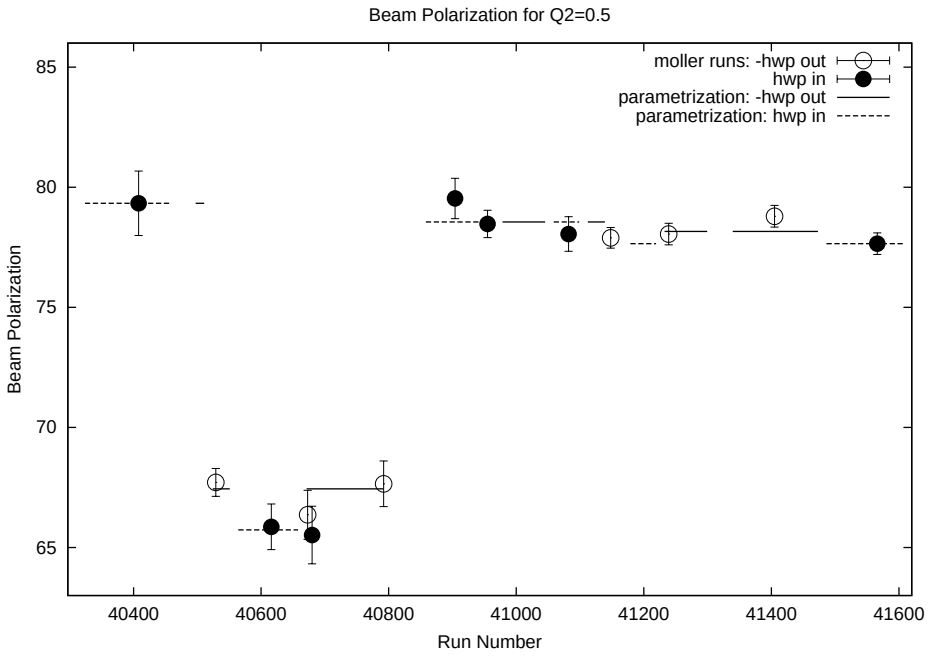

Figure 3: $Q^2 = 0.5$ beam polarization. The markers represent averaged results from moller sessions for half wave plate (hwp) in and out. Lines represent the parametrized final polarization values.

```
rnum-range = range of production run numbers
hwp = half wave plate setting, 0 = hwp in, 1 = hwp out
m = at least one moller for that rnum-range
Q = accumulated charge in microCoulomb
Q_sums = charge sums for hwp=1 and hwp=0 and both
bpol = average beam polarization in percent for hwp=1 and hwp=0
stat = statistical error

rnum-range  hwp m  Q              Q_sums    bpol  stat

40307-40319  1     1798.7    hwp=1: 4230.0  -79.33 1.34
40320-40463  0  m  7198.2    hwp=0: 8588.8   79.33 1.34
40473-40478  1      589.6          12818.8
40479-40489  0     1390.6
40491-40512  1     1841.7

40514-40554  1  m  1544.4    hwp=1:12432.5  -67.44 0.45
40555-40660  0  m  7593.9    hwp=0: 7593.9   65.73 0.75
40661-40804  1  m 10888.1          20026.4

40848-40848  1      129.2    hwp=1:16983.8  -78.55 0.39
40849-40976  0  m  9603.4    hwp=0:17351.9   78.55 0.39
40977-41048  1    11228.0          34335.7
41049-41106  0  m  7748.5
41107-41146  1     5626.6

41160-41169  1  m  1263.9    hwp=1:25290.6  -78.16 0.26
41177-41231  0     8145.0    hwp=0:26246.4   77.65 0.45
41232-41303  1  m  9739.5          51537.0
41304-41305  0      463.7
41332-41473  1  m 14287.2
41474-41611  0  m 17637.7
```

Figure 4: Beam polarization summary for $Q^2 = 0.5$

```
       Date                          rnum  hwp Wien

first: Sat Oct 27 20:21:37 2001   41843 1   96.2

  old: Tue Oct 30 05:48:05 2001   41920     96.2
  new: Wed Oct 31 10:54:45 2001   41934     95.7

  old: Thu Nov 08 05:33:37 2001   42148 1
  new: Thu Nov 08 15:38:59 2001   42171 0

  old: Wed Nov 21 06:58:17 2001   42519 0
  new: Sat Dec 01 01:41:55 2001   42591 1

  old: Mon Dec 17 16:05:25 2001   42945 1
  new: Mon Dec 17 19:24:27 2001   42953 0

 last: Fri Dec 21 06:23:36 2001   43026 0   95.7
```

Figure 5: Relevant epics history for $Q^2 = 1$. Same nomenclature as figure 1.

```
rnum = first run number in moller session
bpol = average beam polarization in percent
stat = statistical error

    rnum  bpol   stat

    41989  68.03 0.56
    42062  74.20 1.37
    42162  67.59 0.67
    42167 -73.99 0.71
    42281 -73.40 0.49
    42353 -71.99 0.47
    42501 -72.39 0.60
    42547 -68.77 0.68
    42550  68.51 0.26
    42657  72.61 0.59
    42723  70.14 0.46
    42789  74.48 0.96
    42864  72.70 0.31
    42947  75.02 0.70
    42950 -75.66 0.65
    42989 -74.05 0.69
```

Figure 6: Average beam polarization values for each $Q^2 = 1$ moller session

Figure 7 shows that there are trends in the beam polarization and that the variations even go beyond statistics. For the parametrization linear fits were done for those periods. A summary is given in figure 8.

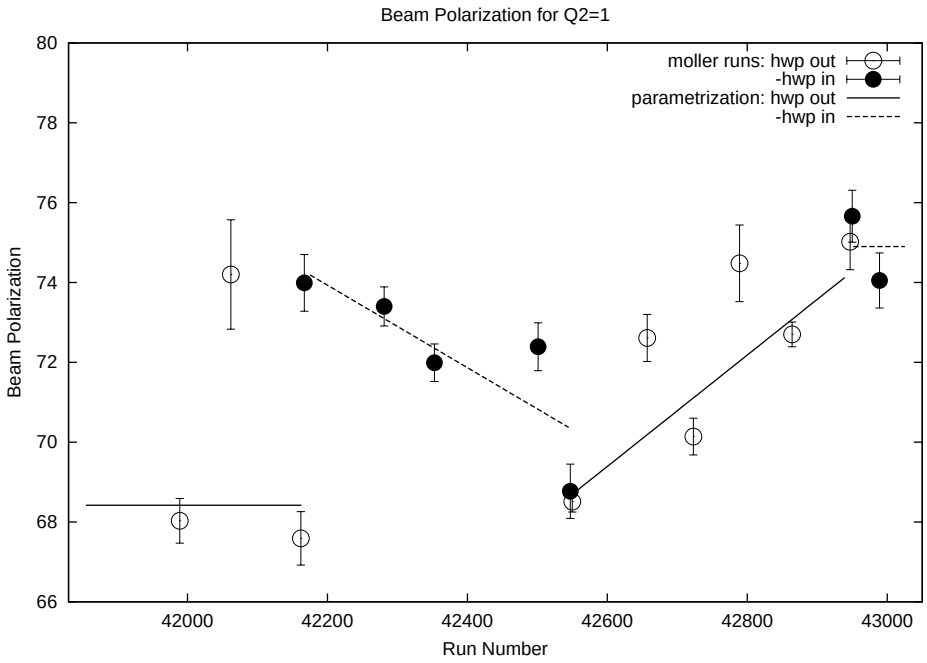

Figure 7: $Q^2 = 1$ beam polarization. The markers represent averaged results from moller sessions for half wave plate (hwp) in and out. Lines represent the parametrized final polarization values.

```
rnum-range = range of production run numbers
hwp = half wave plate setting, 0 = hwp in, 1 = hwp out
m = at least one moller for that rnum-range
Q = accumulated charge in microCoulomb
bpol = average beam polarization in percent for hwp=1 and hwp=0
stat = statistical error

rnum-range  hwp m  Q       bpol                              stat

41843-42148  1  m  3102.6  68.42                             0.41
42171-42519  0  m  5272.4  0.0103501*(rnum-42000)-76.0062    1.00
42591-42945  1  m  5684.4  0.0139484*(rnum-42500)+67.998     0.91
42953-43026  0  m  1379.6  -74.90                            0.48
```

Figure 8: Beam polarization summary for $Q^2 = 1$.

3 Errors

Source	Relative errors (%)	
	$Q^2 = 0.5$	$Q^2 = 1$
Statistics	0.70	1.20
Analyzing Power	0.47	0.47
Monte Carlo	0.70	0.70
Hall A leakage	-	1.00
Bpol scatter	-	2.82
Total	1.10	3.33

Statistics Charge weighted average of the single periods.

Analyzing Power From NIM A462 (2001) 382

Monte Carlo Statistics and Systematics of Simulation

Hall A leakage Affects only the $Q2 = 1$ period. Hall A leakage was repeatedly measured and kept below 2%. The polarization of the Hall A beam was measured to be $33.4 \pm 2.0\%$ (run 42066) with the same sign as the Hall C beam polarization. 2% leakage results in less than 1% rel impact on the beam polarization. With the repeated measurements and the knowledge of the Hall A beam polarization it is in principal possible to correct for that effect. It is however not worth the effort considering the other dominant errors and the statistical accuracy of the main experiment.

Bpol Scatter During $Q2 = 1$ the measurements of the beam polarization showed erratic behaviour. Studies (run 42723 - 42729 and run 42864 - 42880) revealed a correlation between setting of the laser phase and beam polarization. The injector group confirmed that finding with a independent measurement after the experiment. This correlation however does not explain all the scatter observed. Therefore we apply a 2% absolute error.

4 Additional Notes

Asymmetry Corrections: The raw asymmetry is corrected for accidentals, charge offset and charge asymmetry. A closer look at the magnitude of these corrections was taken for the $Q^2 = 0.5$ period. The accidental background can dilute the asymmetry for single runs as much as 5%, but averaged over all runs the correction is less than 1%. The charge offset correction is small for all runs (less than 0.5%) and in average less than 0.1%. The charge asymmetry correction is 0-8% before run 41000 and 8-15% later. (For the $Q2 = 1$ period this effect was typically less than 2% due to the feedback control).
Since the correction for charge asymmetry is rather large here some further checks:

- Charge asymmetry correction was done for both beam current monitors BCM1 and BCM2. The difference is less than 0.1%.
- Runs 42550 - 42558 were measured with a charge asymmetry of $2.5 \cdot 10^{-3}$ resulting in a larger than 100% correction, while runs 42559 - 42566 had a reduced charge asymmetry of $< 5 \cdot 10^{-4}$ resulting in a less than 1% correction. The results ($69.3 \pm 0.4_{stat}$ and $68.0 \pm 0.3_{stat}$) agree reasonably.