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Extraction and Transport of Protons to Emulate 1 GeV/c/nucleon Iron Ions

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DISCLAIMER

AGS Complex Machine Studies (AGS Studies Report No. 338) **Extraction and Transport of Protons to Emulate 1 GeV/c/nucleon Iron Ions**
Study Period: June 7, 1995 (Midnight Shift)
Participants: L. Ahrens, J.W. Glenn, N. Williams
Reported by: J.W. Glenn
Machine: Booster/AGS/SEB
Beam: 8 TP Protons
Tools: Booster/AGS CBMs
Aim: To establish an initial operating setup for NASA run in A3 Line. (Data taken in HEP [SEB] Book II pp. 51-57.)

Introduction/Procedure: Protons were extracted and transported to the A target at the same rigidity as planned for the 1 GeV/c/nucleon run for the NASA biology groups this fall.

Results: In a nutshell; see the COUT print-out (fig 1).

1. Extraction efficiency was only ~50%, not inconsistent with the unexpectedly large losses seen between F12 to F16 [fig 2].

   These high F14 losses were not changed by changing F10 current or position, thus: beam loss is upstream of F10 OR the problem is a vertical - Though not checked, this is not likely as F10 has only a 1.1" of vertical aperture and the loss area 3".

   The "expected" reason for these losses was rotation of the extraction trajectory in phase space because there were many bad sextupoles in the horizontal (and vertical) chromaticity correction strings. These are being replaced with rebuilt ones this summer.

   Multiplying the total ring losses or "inefficiency" by 9 (the ratio of proton energy for the standard 24.1 GeV/c operation and this run), gives about 4 % x 9 or about 36%, a bit low. The loss monitors are shielded by the ring magnets so low energy losses probably read low. Multiplying by 12 makes eff + ineff (x 12) = 100% over 50% variation in inefficiency (fig 3). The 50% indicated extraction efficiency is probably correct.

2. Transport between C10 and the A target cave was only 13% efficient. The reason for this was not actively pursued as time was short and the priority was to extract then establish dipole currents, a lack of working flags made transport optimization difficult.

   The long loss of 10% (x 9 due to low energy [here a factor of 9 is reasonable as the line has few magnets that shield the detectors]), 90% loss is consistent with 13% transported to A station. Calibrations in '95 show the A Sec should be good to ~10%.

   The quad currents for this run were scaled from 24.1 GeV/c operation, spot sizes were not checked as most flags or their associated TVs were not working. Later calculations indicate that multiple scattering from the C10 SEC and the window at C075 would increase beam size 60% horizontally and 25% vertically. This may also have affected transport efficiency.

   The bad sextupoles in the AGS ring would have changed the alignment of the separatrix, thus changing the apparent alpha and beta of the beam; another possible cause for poor transport.

3. Settings, see print-outs (fig. 4). Others:
   F10 650 A, (Power supply initially oscillated at this current.)

Dsex 35 A	H Quad	-1.3 A
Qskew 10 A	V Quad	-4.5 A
F PBLW 33 A	H Sex	9.6 A
Main Mag 666-637 A	V Sex	15.0 A

4. Other problems and needed fixes:
   A. F PBLW had to be reduced 10 Amps [25%] to have reasonable efficiency. Again this is probably an artifact of the bad sextupoles in the ring.
   B. When debunching before transition, one uses "transition time" for debunching, but the rf off controls are not coupled to this. Please change timing so "Debunch" time causes phase shift and delays for radial loop stop and rf off.
   C. As the "invert" portion of the Main Magnet cycle uses the F bank, there is no "End of Flat Top" trigger generated. This trigger is necessary for turning off the spill servo before the next cycle. A replacement trigger is needed.
   D. There was over 100% spill modulation (mostly Siemens synched). The tolerance for voltage ripple is ~5 times as tight for this run, some extra setup time may be necessary.

Conclusion: At least 5% of the beam in the AGS beam to the target is expected. With rebuilt sextupoles and instrumentation, there are reasons to expect better efficiencies for the actual iron run.

```
*****************************************
*SEB   3.9TP        T/I    6.%      LLS     9.9*
*ASEC  0.5TP  13.%        A3SEC  0.0TP     1.%*
*AION  4.1TP 801.%        A3ION  0.0TP     0.%*
*ATEL     69   0.%        A3TEL      0     0.%*
*ATMP -2040'C             A3TMP     0'C       *
*                                             *
*AD45 0.1  AQ79 4.2  A1Q214.6                 *
*AD67 0.2  ACV -0.8  A1D314.6                 *
*AD89 0.2            A1D4 0.3                 *
*AQ6  1.3            A1D5 0.0                 *
*                                             *
*                                             *
* EXP 865       0     0.00%  ON               *
* EXP 852       0     0.00%  ON               *
*****************************************
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```
*****************************************
*SEB   3.9TP        T/I    6.%      LLS   9.9*
*BSEC  0.0TP    0.%        B5SEC  0.0TP 109.%*
*BION  0.0TP   92.%        B5ION  2.0TP*****%*
*BTEL      0    0.%        B5TEL      0   0.%*
*BTMP  1997'C              B5TMP   888'C     *
*                                            *
*BQ9   0.1  BCV   0.0  B1Q126.8  B5U 14.6    *
*BD58  0.1             B1D116.7  B5D 49.8    *
*BQ10-0.0              B5Q 29.0              *
*BQ13 0.0                                    *
*                                            *
*                                            *
* EXP TST       0     0.00%  AD              *
* EXP 871       0     0.00%  ON              *
*****************************************
```

```
*****************************************
*SEB   3.9TP        T/I    6.%      LLS     9.9*
*CSEC  0.0TP    0.%        C3SEC  0.0TP 498.%*
*CION  0.1TP1483.%         C3ION  0.0TP    0.%*
*CTEL      0    0.%        C3TEL      0    0.%*
*CTMP  1790'C              C3TMP -2026'C      *
*                                             *
*CQ9   0.1                 C1D1 1.0  C3Q9 0.1 *
*CQ10  0.1                 C3D1 1.2           *
*CQ12  0.0                 C3F1 0.0           *
*CCV   0.2                 C3P2 0.0           *
*                                             *
* EXP 787       0     0.12%  ON               *
* EXP 909       0     0.00%  ON               *
* EXP 850      10   ******%  AD               *
*****************************************
```

```
*****************************************
*SEB   3.9TP        T/I    6.%      LLS   9.9*
*DSEC   0.0TP   0.%                          *
*DION -0.0TP -0.%                            *
*DTEL      0   0.%                           *
*DTMP -2005'C                                *
*                                            *
*DD6   0.1  DQ6   0.0  DD15-0.0  DCVU-0.0    *
*DD9   0.2  D233  0.0  DQ9  0.0  DCVD 0.2    *
*DD11  0.1  D1D3  0.0  DQ10 0.0              *
*DD13  0.0  DQ7  -0.0  DQ11-0.0              *
*                                            *
* EXP 813       0     0.00%  ON              *
*                                            *
*                                            *
*                                            *
*****************************************
```

```
*****************************************
*SEB EXTRACTION            9-MAY-95 16:23 08*
*                  SPECIE: PROTN             *
*MOM   3.745 GEV/C : SWP    1.899 %/SEC      *
*EFSP  0.000 SEC   : SPLRF  0.000            *
*                                            *
*EBM     8.72TP: LBM    8.65TP:RAD    0.06'*
*SEB     3.90TP:XEFF    45.20 %:             *
*DLY 6552.6 MS:XINEF    3.96 %:T/I    6.25%*
*LOSSES:                                     *
*LLS     9.9    :F5     2.18 %:RLME   0.17 %*
*H20     0.05 %:F10     0.54 %:RLML   0.53 %*
*                                            *
*                                            *
*                                            *
*                                            *
*****************************************
```

```
*****************************************
*SEB     3.90TP      SHARING                 *
*T/I   6.3 ALL    0.54TP 13.84% RNSW   7.09%*
*PLS 20.4 A       0.51TP 13.07% SWCV   3.19%*
*LLS   9.9 B      0.01TP  0.28% ACV   -0.78%*
*MPA 76.3 C       0.01TP  0.14% BCV    0.02%*
*          D      0.01TP  0.35% CCV    0.21%*
*                               DCV    0.17%*
*                                            *
*Q1-4-0.52 AD23 0.56 BD4   0.04 AQ6    1.26 *
*AB1   0.31 CD23 0.59 BD58 0.15 DD4    2.36 *
*DB2   0.20 CQ58 0.33 BQ9  0.10 DD45   0.33 *
*BB3   2.15 CP2 -0.01 BQ10-0.04 DD6    0.15 *
*AP1  -0.14 CD4  0.02 AD45 0.06 DD9    0.22 *
*CP1   0.32 CQ9  0.12 AD67 0.20 DD11   0.11 *
*D101  6.77 CQ10 0.08 AD89 0.17 DD13   0.03 *
*****************************************
```

```
*****************************************
*SEB     3.90TP      LONG LOSS               *
*T/I   6.3 ALL    0.54TP 13.84% RNSW   7.09%*
*PLS 20.4 A       0.51TP 13.07% SWCV   3.19%*
*LLS   9.9 B      0.01TP  0.28% ACV   -0.78%*
*MPA 76.3 C       0.01TP  0.14% BCV    0.02%*
*          D      0.01TP  0.35% CCV    0.21%*
*                               DCV    0.17%*
*                                            *
*CL03 3.73 CL25 0.13 AL24 0.69 CL47 0.27 *
*CL06 0.96 CL28 0.02 DL17 0.08 DL24-0.02 *
*CL09 2.40 CL31 0.00 DL20 0.03 DL27 0.00 *
*CL13 0.63 CL34 0.00 AL28 3.30 DL30-0.01 *
*CL16 0.47 CL37 0.00 BL44 0.01 DL33-0.03 *
*CL19 0.48 CL39 0.01 BL46 0.01 DL39 0.24 *
*CL22 0.26 AL22 0.39 CL44 0.01           *
*****************************************
```

```
*****************************************
*SEB GENERAL PAGE          9-MAY-95 16:23 08*
*FTBM      8.6 TP     ECBM      8.7 TP    *
*SEB       3.9 TP      MOM   3.745 GEV/C*
*EFF     45.20 %       REP    3.60  SEC   *
*DEL     13.84  LOSS   8.11 MPA  76.26 %*
*                                         *
*A    0.5TP:B    0.0TP:C    0.0TP:D    0.0TP:*
*TL      69:TL       0:TL       0:TL       0:*
*A3 0.00TP:B5 0.01TP:C3 0.03TP:           :*
*                                         *
*          :          :787       0:813    0:*
*865      0:TST      0:909       0:        :*
*852      0:871      0:850      10:        :*
*                                         *
*                                         *
*****************************************
```

```
*****************************************
*SEB POWER & STATUS        9-MAY-95 16:23 08*
*                                            *
* A2 865 0.00 MW ON :   TOT EXP    0.00 MW*
* A1 852 0.00 MW ON :     XPORT    1.57 MW*
* B2 TST 0.00 MW AD :   SIEMENS    0.00 MW*
* B5 871 0.00 MW ON :  TOTAL PWR   1.57 MW*
* C4 787 0.00 MW ON :                      *
* C8 909 0.00 MW ON :                      *
* C1 850 0.00 MW AD :                      *
* D6 813 0.00 MW ON :                      *
*                                            *
*                                            *
*                                            *
*                                            *
*                                            *
*****************************************
```

fig 1

fig 2

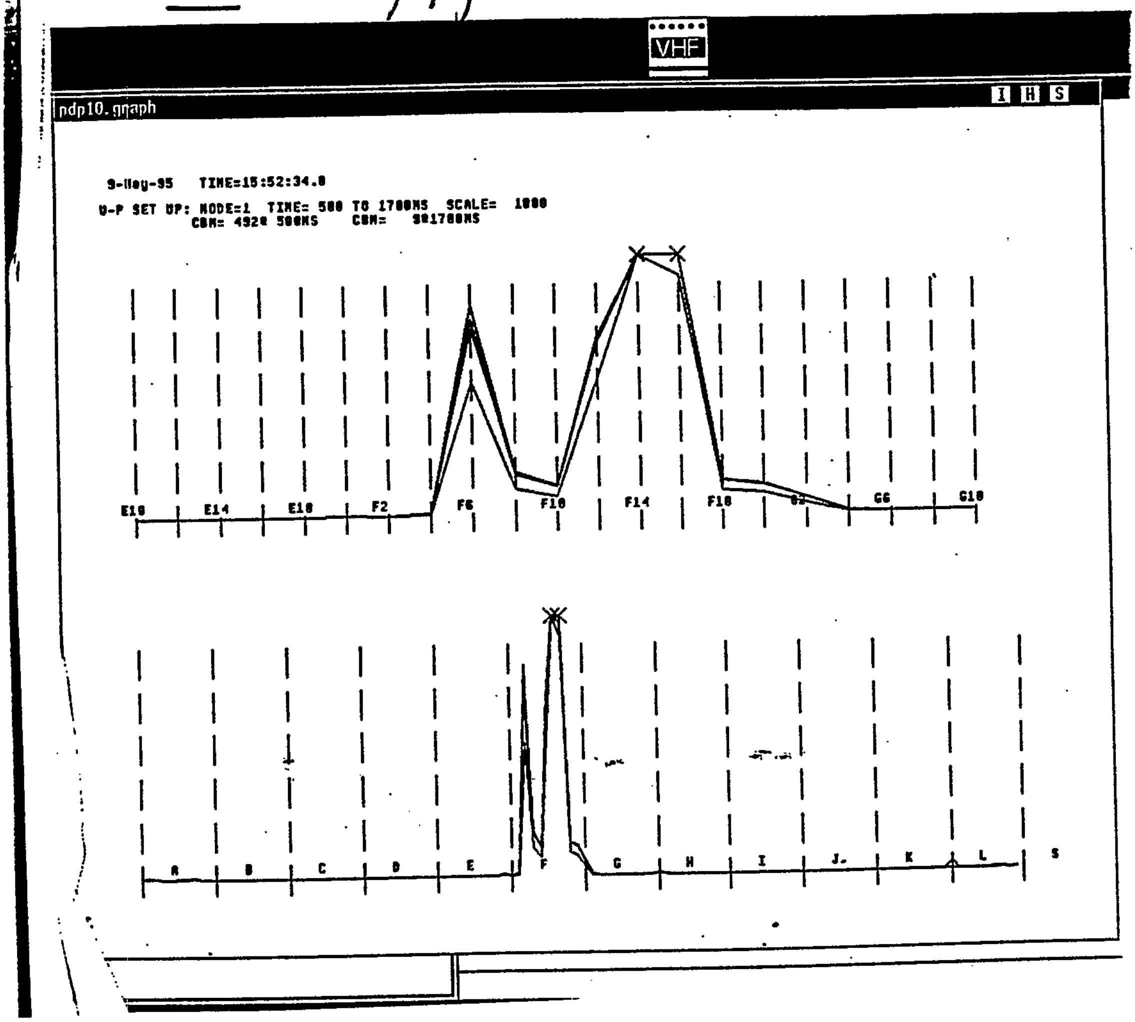
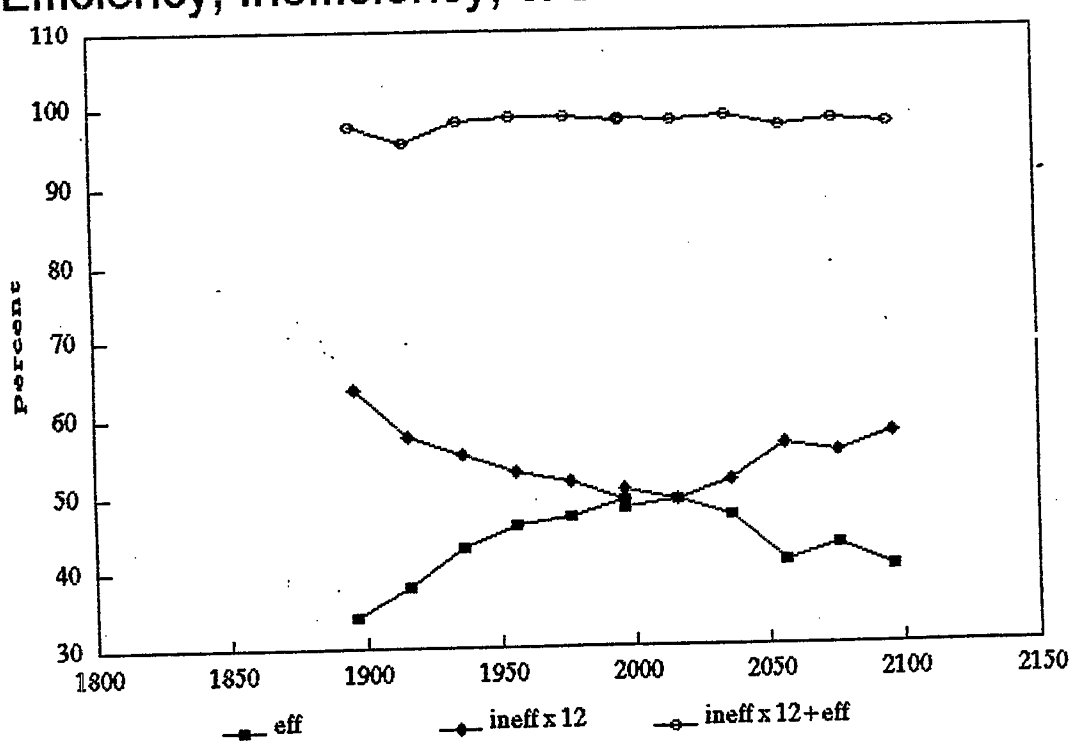


fig 3

Efficiency, Inefficiency, & Sum vs F5DS Position



5	SEB	CD1	311A	ON
6	SEB	CQ1	238A	ON
7	SEB	CP020	51A	ON
8	SEB	CQ2	197B	ON
9	SEB	CQ3	321A	ON
10	SEB	CQ4	294B	ON
12	SEB	AB1	60	ON
15	SEB	DB2	55	ON
18	SEB	BB3	60	ON
21	SEB	CP075	351A	ON
22	SEB	AP1	379A	ON
25	SEB	CP1	293B	ON
29	SEB	CD101	1A	STBY
30	SEB	CP103	201A	ON
31	SEB	AD283	328A	ON
32	SEB	AD2T	318A	ON
33	SEB	AF124	1702	ON
34	SEB	DD485	1A	ON
35	SEB	AS155	1A	ON
36	SEB	AP105	405A	ON
37	SEB	AQ5	1B	STBY
39	SEB	AD489	384A	ON
40	SEB	AD9T	20A	ON
41	SEB	AD5-8	340A	ON
42	SEB	AD5T	431A	ON
43	SEB	AD6T	1A	ON
45	SEB	AQ6	60B	ON
46	SEB	AP244	180B	ON
47	SEB	AD247	2000A	STBY
48	SEB	AQ788	199A	ON
49	SEB	AP285	45A	ON
50	SEB	AQ9	340B	ON

8	SEB	F20VB	2000	OFF
11	SEB	G20VB	2000	OFF
21	SEB	F5SPS	800	ON
22	SEB	F5ON	350	ON
23	SEB	F5OF	1700	ON
24	SEB	F5US	1664	NORM
25	SEB	F5DS	1986	NORM
42	SEB	F10ON	700	ON
43	SEB	F10OF	1700	ON
44	SEB	F10US	1799	NORM
45	SEB	F10DS	1320	NORM
51	SEB	H20US	4031	NORM
52	SEB	H20DS	4050	NORM
86	SEB	HSRON	500	ON
87	SEB	HSROF	1700	ON
88	INS	1ERD	1800	ON
89	INS	1ERST	500	ON
90	INS	D2RD	1800	ON
91	INS	D2RST	0	ON
82	SEB	INTRS	500	ON

fig 4