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2/27/92
PBAR NOTE 528

Measurement of D->A momentum aperture and test of D->A field qualities

The data presented here were taken during two shifts dedicated to D->A studies. The goal during both of these study periods was a test of the field quality of the D->A channel devices, but for the first study period on 10/21/91 the TBT system was not operational so we simply measured the transfer efficiency as a function of momentum. The conclusion from these measurements is as follows: 1) The momentum aperture of the D->A channel is smaller than expected. 2) The restriction in physical space is somewhere near A:IKIK. 3) The field quality of the injection channel devices is adequate.

MOMENTUM APERTURE LIMITS

Figure 1 shows the measured efficiency with both shutters open using the standard reverse proton magnet settings. The efficiency is about 100% from the very edge of the momentum aperture, 628700, to a point close to the first shutter. At this point the efficiency takes a sharp dive. The full range with good efficiency is about 0.3% dp/p. The shutter location was derived from the energy spectrum of reverse protons injected with the injection shutter closed shown in Figure 2. The dispersion at A:IKIK is 9.8 meters, therefore the effective horizontal aperture near the injection kicker is about 27 mm. Figure 3 shows a drawing of the the ferrite and beam gap in the kicker with the beam size derived from these measurements. The measured aperture is almost a factor of two smaller than the physical aperture. The gap between the shutter and the edge of the gap is 0.21% in dp/p, or 20 mm; which was verified by an examination of the design drawings.

Local bumps at the A:IKIK will change the location of the injection kicker in revolution frequency. To identify the source of the losses we used a local bump that caused an orbit distortion shown in Figure 4. The bump we found on the parameter page was not

local, but we only had a few minutes to complete the measurement and had to make do with what we had. With the bump in place we measured good transfer efficiency well past the endpoint of the earlier measurements, see Figure 1. The high momentum aperture limit, however, moved in by the same amount.

FIELD QUALITY MEASUREMENTS

During the second study period on 1/12/92 we tested the field quality of A:IKIK by measuring injection oscillations in the debuncher as a function of momentum. About 10 bunches of reverse protons were captured at 628724 HZ in a bucket to bucket transfer using ARF1. These were either accelerated or decelerated to the desired energy and then transferred to the debuncher through the D->A line. These measurements were made more difficult by the fact that the some beam was lost as ARF1 changed it's energy, leaving too little beam to trigger the BPM system. We often transferred about 1×10^{10} protons, but waited for as many as 20 pulses for a TBT trigger.

The debuncher TBT system was used to detect injection oscillations that would arise if the off momentum beam encountered different fields than the central momentum beam. The dispersion through most of the D->A line is about 1 meter, so this test was most sensitive to field variations in A:IKIK where the dispersion is 9.8 meters.

Figures 5-8 show the sensitivity of the TBT measurements to changes in the strength of several D->A channel devices. A change of 10% in A:IKIK or D:EKIK gives about 6 mm injection oscillations. A change of about 1.5% in any of the septa gives about 10 mm injection oscillations. During stacking a change of about 4 volts on any one septa is visible in the D->A efficiency, i.e. we start to be sensitive to oscillations of about 4 mm. In the A->D direction 4 mm oscillations should be insignificant.

Figures 9-14 show the TBT measurements taken at different transfer momenta. The bulls eye plot has been blown up to show more detail. There is some evidence in Figures 9-14 of dispersive

mismatching. At 628717 there is a clear 2 mm oscillation not present at 628724. At 628740 there is an oscillation of about the same size in the opposite direction. Although visible, this small mismatch is most likely not the cause of the momentum restriction in the D->A channel. In addition, if the mismatch is caused by field non-uniformity it must be a combination of one of the kickers and one of the septa since the observed oscillations are at an angle of 45 degrees to either device. Oscillations of a few millimeters are in fact expected due to the fact that the D->A line is not dispersion matched.

CONCLUSION

The momentum aperture of the D->A channel is restricted by a physical limitation somewhere near the injection kicker. The effective beam size in the injection kicker is much smaller than the good field region of about 50 mm. Some effects of dispersion mis-matching are visible, but are not large enough to explain the aperture restriction.

FIGURE 1

A → D EFFICIENCY

● = NORMAL SETTINGS
X = WITH BUMP, SEE FIGURE 3

REVOLUTION FREQUENCY

FIGURE 2

BEAM ON EXTRACTION ORBIT - SHOWS OUTLINE OF SHUTTER

Start Freq 79.21000001 MHz

Stop Freq 79.23000001 MHz

01/17/92 0251

Scale 10 dB/div

Atten 10 dB

Swp 1.5 sec

Vid BW 100 Hz

Res BW 300 Hz

Ref Lvl -30 dB

VID AVG

CONSOLE LOCATION 04, MCR-E2
Pbar SA Plot
18-FEB-1992 10:20

1-19 VTR S

THIS UNIT WILL BE USED IN A HIGH VACUUM, 10^{-10} TORR.,
 ALL COOLANTS AND GRINDING FLUIDS USED
 IN MANUFACTURE MUST BE FULLY WATER SOLUBLE.
 SOLUBLE WAXES OR COMPOUNDS MAY BE USED,
 BUT BE DIFFICULT OR IMPOSSIBLE TO REMOVE.

ACCUMULATOR CLOSED ORBIT

(HORIZONTAL)

A:IBEAM

16.844

A:R3HLFB

6.963655

X:POFTT

5947.142

CO Date/Time: 10/19/91 0041:55

AVG OVER 20 FRAMES (20 20 20 20 20 20) FILE 53 HAS BEEN SUBTRACTED

Deltap/p = -.0004

BEAM POSITIONS (mm)

A1Q1	1.11	A2Q14	6.09	A3Q1	.41	A4Q14	-13.44	A5Q1	-.38	A6Q14	-11.09
A1Q3	.73	A2Q11	3.99	A3Q3	-1.13	A4Q11	-9.45	A5Q3	.33	A6Q11	-7.15
A1Q4	.51	A2Q10	4.28	A3Q4	-2.15	A4Q10	-17.46	A5Q4	-1.49	A6Q10	-7.45
A1Q6	-2.58	A2Q8	-.99	A3Q6	NO BEAM	A4Q8	0	A5Q6	-2	A6Q8	.37
A1Q8	-.98	A2Q6	-1.79	A3Q8	-.37	A4Q6	-1.89	A5Q8	-.7	A6Q6	-2.44
A1Q10	9.23	A2Q4	.99	A3Q10	-4.3	A4Q4	-1.12	A5Q10	-6.4	A6Q4	-1.13
A1Q11	11.1	A2Q3	.35	A3Q11	-2.9	A4Q3	-.35	A5Q11	-7.87	A6Q3	-.39
A1Q14	10.69	A2Q1	.39	A3Q14	NO BEAM	A4Q1	-.43	A5Q14	-15.27	A6Q1	-.44

SOLE LOCATION 14; AP10

19-OCT-1991 00:43

Figure 4

Figure 5

MULTIPLE TURN DISPLAY, SECTOR 1D

Accumulator to Debuncher

1/12/92 2122:40

Ampl = 9.3 mm Phi = 78 °;

Chisq = 6.13

Ampl = 2.3 mm Phi = 37 °;

Chisq = 21.23

AIKIK -8 KVOLTS V

0

: FAILED

CONSOLE LOCATION 14; AP10
Pbar BPM Turn-by-turn display

12-JAN-1992 21:23

File 6

MULTIPLE TURN DISPLAY, SECTOR 1D

Accumulator to Debuncher

1/12/92 2129:09

Ampl = 10 mm Phi = 7.6°;

Chisq = 10.22

Ampl = 2.6 mm Phi = 13°;

Chisq = 60.44

D: FKIK
-10 KV

0

Not new time stamp

CONSOLE LOCATION 14; AP10
Pbar BPM Turn-by-turn display

12-JAN-1992 21:30

FIGURE 7

MULTIPLE TURN DISPLAY, SECTOR 1D

Accumulator to Debuncher

1/12/92 2106:40

Ampl = 5 mm Phi = 186°;

Chisq = 11.84

CONSOLE LOCATION 14; AP10
Pbar BPM Turn-by-turn display

12-JAN-1992 21:07

FIGURE 8

MULTIPLE TURN DISPLAY, SECTOR 1D

Accumulator to Debuncher

1/12/92 2114:30

Ampl = 7.2 mm Phi = 87 °;

Chisq = 4.301

Ampl = 1.9 mm Phi = 37 °;

Chisq = 13.87

94

Not new time stamp

UPDATE FAILED

86.7 D1Q2

33.7

CONSOLE LOCATION 14; AP10
Pbar BPM Turn-by-turn display

12-JAN-1992 21:15

F Rure-9

MULTIPLE TURN DISPLAY, SECTOR 1D

Accumulator to Debuncher

1/12/92 2337:59

Ampl = 1.4 mm Phi = 220°;

Chisq = 15.01

628717

0

LED

CONSOLE LOCATION 14; AP10
Pbar BPM Turn-by-turn display

12-JAN-1992 23:38
C

Figure 10

MULTIPLE TURN DISPLAY, SECTOR 1D

Accumulator to Debuncher

1/12/92 2208:42

Ampl = 2.2 mm Phi = 273°;

Chisq = 10.24

628724

0

Not new time stamp

CONSOLE LOCATION 14; AP10
Pbar BPM Turn-by-turn display

12-JAN-1992 22:09

Figure 11

MULTIPLE TURN DISPLAY, SECTOR 1D

Accumulator to Debuncher

1/12/92 2246:29

Ampl = 1.5 mm Phi = 46°;

Chisq = 3.378

Ampl = .57 mm Phi = 132°;

Chisq = 4.16

628732

0

Not new time stamp

CONSOLE LOCATION 14; AP10
Pbar BPM Turn-by-turn display

12-JAN-1992 22:51

Figure 12

MULTIPLE TURN DISPLAY, SECTOR 1D

Accumulator to Debuncher

1/12/92 2345:59

Ampl = 1.3 mm Phi = 300°;

Chisq = 46.26

Ampl = .44 mm Phi = 181°;

Chisq = 34.32

628732
REPEAT

79

Not new time stamp UPDATE FAILED

CONSOLE LOCATION 14; AP10
Pbar BPM Turn-by-turn display

12-JAN-1992 23:46

Fig 13

MULTIPLE TURN DISPLAY, SECTOR 1D

Accumulator to Debuncher

1/12/92 2305:09

Ampl = 1.2 mm Phi = 75°;

Chisq = 4.125

628746

179

Not new time stamp UPDATE FAILED

CONSOLE LOCATION 14; AP10
Pbar BPM Turn-by-turn display

12-JAN-1992 23:06

Figure 14

MULTIPLE TURN DISPLAY, SECTOR 1D

Accumulator to Debuncher

1/12/92 2313:59

Ampl = 1.9 mm Phi = 234°;

Chisq = 17.62

Ampl = .47 mm Phi = 186°;

Chisq = 12.39

628 752

32

Not new time stamp

UPDATE FAILED

CONSOLE LOCATION 14; AP10
Pbar BPM Turn-by-turn display

12-JAN-1992 23:14
9