Pbar Note 621
Steve Werkema
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Procedures for Deceleration Studies

A. Overview

The purpose of deceleration studies is to construct the deceleration ramp files that are used to decelerate antiproton beam for experiment E835. A deceleration ramp file is a set of ramp tables that are downloaded to PAUX (a part of the Pbar front end) prior to a deceleration. There is a ramp table for each device that is changed during a deceleration. These tables determine how PAUX changes each device setting during a deceleration. Appendix 1 gives a table of all ramped devices.

A deceleration to the lowest energy allowed by the ramps currently in use requires the use of three ramp files: the first decelerates the beam from 8801 MeV/c to 6367 MeV/c, the second from 6367 MeV/c to 4858 MeV/c, and the third from 4858 MeV/c to 3900 MeV/c. At the time of this writing the third ramp file is incomplete.

An important new feature of the deceleration ramp files is that the value of γ_t is decreased as the beam is decelerated so that the Accumulator is always above transition.

B. Initial Conditions:

1. These conditions should be established at the beginning of the studies period. These steps do not have to be performed for each deceleration (with the exception of step 4).
2. The Antiproton source is set up for reverse protons (accumulator receives Main Injector protons on $2D/$93 cycles via AP3).
3. Debuncher, AP2 line, and D-A line buses are off (P64 aggregate <u>Debuncher and AP2 OFF</u> does this). **Caution:** Avoid needlessly cycling D:IB. Do not turn on these buses unless it is necessary to circulate beam in the Debuncher.
4. Prior to each deceleration ensure that the Accumulator buses have been cycled using either the sequencer or P102 (PBAR CYCLE BUSES).

C. Decelerate the Beam:

1. Set the Accumulator bend bus (A:IB) to get the nominal 8 GeV bend field (A:BFIELD = 16714.4 ± 0.2 Gauss).
2. Set up for the RF frequency source that will be used for the deceleration.
   - To use the Siteq set A:BUNCH to 1
   - To use the DDS set A:BUNCH to 11
3. From P64 (SEQUENCER), run the <u>Build a Decelerator</u> aggregate. This sequencer aggregate will get beam, move it to the central orbit, bunch the beam and launch the PAUX RAMP DEVELOPMENT application (P81).
4. During this part of the process, the sequencer will prompt you to provide the revolution frequency of the beam on the Accumulator injection and central orbits, as well as the ARF3 voltage to be used to move the beam. This information is obtained as follows:
   - <u>Initial frequency</u> (injection orbit frequency) -- Measure from the Accumulator 79 MHz Longitudinal Schottky with the VSA or a spectrum analyzer.
   - <u>Target frequency</u> (central orbit) -- use 628837.4 Hz.

- ARF3 Voltage -- use 2200 Volts

5. *This step is normally skipped.* Scrape the beam to the desired transverse and longitudinal beam size. The table below gives horizontal and vertical scraper positions for various beam sizes:

ε (π mm-mrad)	**Δx[1] (mm)**	**Δy[2] (mm)**	**A:RJ500 Position[3] (mm)**	**A:TJ307 Position[4] (mm)**
2.0	5.81	7.56	13.63	7.53
3.0	7.11	9.26	14.93	9.26
4.0	8.22	10.69	16.04	10.86

1. β_x = 16.88 m/rad
2. β_y = 28.58 m/rad
3. Horizontal beam centroid corresponds to A:RJ500 = 7.82 mm
4. Vertical beam centroid corresponds to A:TJ307 = -0.03 mm

CAUTION: Do not use RJ500 or LJ500 unless it is necessary. These scrapers are upstream of the A50 experimental area (for reverse protons). Scraping the beam at this location may cause a harmful radiation dose to the E835 central calorimeter.

6. Once beam is on the central orbit, knob A:R3LLAM (the ARF3 voltage control DAC) so that its setting matches its top of the ramp setting. This can be checked by looking at device 86 from P81 and verifying that the "Cal" and "Set" values are the same. *This step must be completed prior to step 7.e below.*

   NOTE: if the A:R3LLAM ramp is disabled, the deceleration will proceed with the RF voltage constant at whatever value you've set it to prior to starting the deceleration. To determine if a ramp is enabled, enter the device's ramp index (from Appendix 1) into the < > brackets on the third line of P81's main screen and interrupt on DISPLAY RAMP TABLE. The ramp is enabled if the word "YES" is present after the word ENABLE on the top line of the ramp table display.

7. Once P81 is running, execute the following steps to decelerate beam:

   a. Interrupt on the READ button. Select the appropriate deceleration ramp file from the menu -- this causes that file to be read into console memory.

   b. Load the ramps to PAUX by interrupting on the LOAD ENTIRE RAMP button.

   c. Enter the value of X:POFTT to which you intend to decelerate in the PFSTOP window. X:POFTT functions as the ramp table index. Its value is approximately equal to the beam momentum at that point in the ramp.

   d. Verify that X:POFTT is set to 8801 MeV/c.

   e. Do a SINGLE POINT retable of ALL DEVICES (bottom part of the P81 page). This matches the ramp table values corresponding to the present value of X:POFTT to the current device settings.

   f. Make sure that any measurements you want made while the beam is being decelerated are setup and ready to go. Some possibilities are:

      - Fast time plots of A:IBEAM, A:R3HLFB (RF voltage), A:R3H2AI and A:R3H2BI (ARF3 Cavity #2 anode currents), A:R3PPOS (Radial position error) versus X:POFTT.

      - Fast time plots of beam loss monitors versus X:POFTT.

- x-y plots (P106) of various BPMs versus X:POFTT.
- Tune tracker setup on the VSA.
- BPM closed orbit (i.e. verify that P51 is alive and errors have been cleared).

g. Review the Pbar alarm screen. Investigate any Accumulator alarms that you don't understand.

h. When you are satisfied that all of the above steps are complete, interrupt on the P81 START button to initiate deceleration to the target momentum.

i. Be careful to note and document (with figures in the logbook if possible) all errors that occur during the setup and deceleration.

8. When the deceleration is complete, the beam will be bunched at the target beam momentum. If you tell the sequencer to continue at this point, the beam will be debunched.
9. At this time you may make whatever measurements and corrections are necessary for this beam momentum (see Ramp Corrections and Measurements section below). If you make corrections to ramped devices, and you want the ramp tables to reflect those corrections, you must update the ramp tables by using one of the RETABLE options and then write the result to a file using the WRITE button.
10. Once corrections have been made at one energy, you have the option of continuing the deceleration to a lower energy to make additional corrections lower in the ramp. To do this, perform the following:
    - Enter the value of the new target POFTT into the PFSTOP box on P81
    - Verify that everything is ready for deceleration (cf. Step 7.f above).
    - Interrupt on the P81 CONTINUE button. The beam will be decelerated to the new target momentum.
11. When all changes have been saved into the working deceleration file, allow the sequencer to continue. All ramped devices will be restored in accordance with a D1 save/restore file that you specify. The sequencer will then cycle the buses.

D. Ramp Corrections and Measurements:

The following is a list of the measurements and corrections that should be made at various locations in the ramps. Most corrections to the ramp tables need only be made at the primary ramp points. *Copies of the most recent iteration of any of these measurements should be placed in the Pbar Electronic Log Book.*

NOTE: All closed orbit measurements referred to here are difference orbits using a closed orbit measurement of the 8 GeV central orbit (Archive File 9) as the reference orbit.

1. Correct the ARF3 frequency ramp so that $\Delta p/p = 0 \pm 0.5\times10^{-4}$ as measured by P51 using the horizontal BPMs. This correction must be performed at all ramp POFTT values. If you used the Siteq for the deceleration, adjust A:RLLFS0 to correct $\Delta p/p$. If the DDS was used, the correction must be done with A:RLLFS1. Update the value of the frequency device that was not used for this correction so that RLLFS0 = RLLFS1. Do a SINGLE POINT retable of A:R1LLFS (device 79) and A:RLLFS1 (device 141).
2. After checking that the Accumulator NMR is locked on, record the value of A:BFIELD at each primary point. Retable A:NMRD0 to adjacent points (if you are at a primary point) if you had to make a change to it to get the NMR to re-lock.

3. At each primary point correct the tunes to $Q_x = 6.695$ and $Q_y = 8.685$ (±0.003). Generally one can use A:QSF1 to adjust the horizontal tune and A:QSD for the vertical tune. Retable A:QSF1 (device 4) and A:QSD (device 77) to adjacent points.
4. At each primary point, correct the closed orbit (using P137) to the standard 8 GeV central orbit (Archive file 9). The corrected orbit should match the reference orbit to within ±2 mm at all BPMs in both planes. Retable TRIMS/SHUNTS to adjacent points when this correction is complete.
5. At each primary point, correct the chromaticity in each plane such that $0.4 < \xi < 0.8$ as measured by P43. The horizontal chromaticity is primarily corrected by A:SEX10 and the vertical by A:SEX12. Retable the changed devices (devices 10 and 11) to adjacent points.
6. *This correction is not normally performed.* At each primary point minimize dispersion at A10, A30, and A50.
7. Measure h and g_t at each primary point.
8. Measure the horizontal and vertical aperture at each primary point. *Note the caution given in C.5 above regarding the use of the A50 scrapers.*
9. Measure the lattice (take one bump BPM data) at energies near where E835 will be operating.

After retabling, save the corrected ramp to your working deceleration ramp file.

Avoid overwriting ramp files that were recently written (i.e. within the last 24 hours).

Appendix 1
Deceleration Ramp Devices

Device Index	PAUX Device	ACNET Device	Description
0	X:POFTR	X:POFTT	Ramp index (~ Beam momentum)
1	X:IBR	A:IB	Bend Bus
2	X:LQR	A:LQ	Large Quad Bus
3	X:QDFR	A:QDF	Focusing/Defocusing Bus
4	X:QSF1R	A:QSF1	Focusing Shunt on Foc./Defoc. Bus
5	X:SQ100R	A:SQ100	Skew Quad
6	X:SQ607R	A:SQ607	Skew Quad
7	X:SEX3R	A:SEX3	Sextupole
8	X:SEX7R	A:SEX7	Sextupole
9	X:SEX9R	A:SEX9	Sextupole
10	X:SEX10R	A:SEX10	Sextupole
11	X:SEX12R	A:SEX12	Sextupole
12	X:OCT10R	A:OCT10	Octupole
13	X:OCT12R	A:OCT12	Octupole
14	X:NMRD0R	A:NMRD0	NMR Probe parameter
15	X:BS110R	A:BS110	Dipole Shunt
16	X:BS109R	A:BS109	Dipole Shunt
17	X:BS108R	A:BS108	Dipole Shunt
18	X:BS107R	A:BS107	Dipole Shunt
19	X:BS103R	A:BS103	Dipole Shunt
20	X:BS210R	A:BS210	Dipole Shunt
21	X:BS209R	A:BS209	Dipole Shunt
22	X:BS208R	A:BS208	Dipole Shunt
23	X:BS207R	A:BS207	Dipole Shunt
24	X:BS203R	A:BS203	Dipole Shunt
25	X:BS310R	A:BS310	Dipole Shunt
26	X:BS309R	A:BS309	Dipole Shunt
27	X:BS308R	A:BS308	Dipole Shunt
28	X:BS307R	A:BS307	Dipole Shunt
29	X:BS303R	A:BS303	Dipole Shunt
30	X:BS410R	A:BS410	Dipole Shunt
31	X:BS409R	A:BS409	Dipole Shunt
32	X:BS408R	A:BS408	Dipole Shunt
33	X:BS407R	A:BS407	Dipole Shunt
34	X:BS403R	A:BS403	Dipole Shunt
35	X:BS510R	A:BS510	Dipole Shunt
36	X:BS509R	A:BS509	Dipole Shunt
37	X:BS508R	A:BS508	Dipole Shunt
38	X:BS507R	A:BS507	Dipole Shunt
39	X:BS503R	A:BS503	Dipole Shunt
40	X:BS610R	A:BS610	Dipole Shunt
41	X:BS609R	A:BS609	Dipole Shunt
42	X:BS608R	A:BS608	Dipole Shunt
43	X:BS607R	A:BS607	Dipole Shunt
44	X:BS603R	A:BS603	Dipole Shunt
45	X:H100R	A:H100	Horizontal Dipole Trim
46	X:H105R	A:H105	Horizontal Dipole Trim
47	X:H205R	A:H205	Horizontal Dipole Trim
48	X:H305R	A:H305	Horizontal Dipole Trim

Device Index	PAUX Device	ACNET Device	Description
49	X:H405R	A:H405	Horizontal Dipole Trim
50	X:H505R	A:H505	Horizontal Dipole Trim
51	X:H605R	A:H605	Horizontal Dipole Trim
52	X:V102R	A:V102	Vertical Dipole Trim
53	X:V104R	A:V104	Vertical Dipole Trim
54	X:V106R	A:V106	Vertical Dipole Trim
55	X:V109R	A:V109	Vertical Dipole Trim
56	X:V202R	A:V202	Vertical Dipole Trim
57	X:V204R	A:V204	Vertical Dipole Trim
58	X:V206R	A:V206	Vertical Dipole Trim
59	X:V209R	A:V209	Vertical Dipole Trim
60	X:V302R	A:V302	Vertical Dipole Trim
61	X:V304R	A:V304	Vertical Dipole Trim
62	X:V306R	A:V306	Vertical Dipole Trim
63	X:V309R	A:V309	Vertical Dipole Trim
64	X:V402R	A:V402	Vertical Dipole Trim
65	X:V404R	A:V404	Vertical Dipole Trim
66	X:V406R	A:V406	Vertical Dipole Trim
67	X:V409R	A:V409	Vertical Dipole Trim
68	X:V502R	A:V502	Vertical Dipole Trim
69	X:V504R	A:V504	Vertical Dipole Trim
70	X:V506R	A:V506	Vertical Dipole Trim
71	X:V509R	A:V509	Vertical Dipole Trim
72	X:V602R	A:V602	Vertical Dipole Trim
73	X:V604R	A:V604	Vertical Dipole Trim
74	X:V606R	A:V606	Vertical Dipole Trim
75	X:V609R	A:V609	Vertical Dipole Trim
76	X:QTR	A:QT	Quad triplet bus
77	X:QSDR	A:QSD	Defocusing Shunt on Foc./Defoc. Bus
78	X:NMRD1R	A:NMRD1	NMR Probe parameter
79	X:1LLFSR	A:R1LLFS	Sciteq Frequency (ARF3)
80	X:H201R	A:H201	Horizontal Dipole Trim
81	X:H204R	A:H204	Horizontal Dipole Trim
82	X:DVND1R	A:DPVND1	Vertical Damper notch delay
83	X:DHND1R	A:DPHND1	Horizontal Damper notch delay
84	X:DVSD1R	A:DPVSD1	Vertical Damper system delay
85	X:DHSD1R	A:DPHSD1	Horizontal Damper system delay
86	X:3LLAMR	A:R3LLAM	ARF3 Amplitude DAC
87	X:Q100RR	A:SQ100R	Skew Quad Polarity reversing switch
88	X:Q607RR	A:SQ607R	Skew Quad Polarity reversing switch
89	X:EMITHR	A:EMITHS	Horiz. 79 MHz Emit. Mon. synthesizer freq.
90	X:EMITVR	A:EMITVS	Vert. 79 MHz Emit. Mon. synthesizer freq.
91	X:EMT5HR	A:EMT5HS	Horiz. 500 MHz Emit. Mon. synthesizer freq.
92	X:EMT5VR	A:EMT5VS	Vert. 500 MHz Emit. Mon. synthesizer freq.
93	X:PT101R	X:PT101T	2-4 GHz Δp cooling trombone correction
94	X:HT101R	X:HT101T	Horizontal cooling trombone correction
95	X:VT101R	X:VT101T	Vertical cooling trombone correction
96	X:MT101R	X:MT101T	4-8 GHz Δp cooling trombone correction
97	X:QS103R	A:QS103	Shunt current in quad A1Q3
98	X:QS104R	A:QS104	Shunt current in quad A1Q4
99	X:QS105R	A:QS105	Shunt current in quad A1Q5
100	X:QS106R	A:QS106	Shunt current in quad A1Q6

Device Index	PAUX Device	ACNET Device	Description
101	X:QS108R	A:QS108	Shunt current in quad A1Q8
102	X:QS110R	A:QS110	Shunt current in quad A1Q10
103	X:QS111R	A:QS111	Shunt current in quad A1Q11
104	X:QS114R	A:QS114	Shunt current in quad A1Q14
105	X:QS203R	A:QS203	Shunt current in quad A2Q3
106	X:QS204R	A:QS204	Shunt current in quad A2Q4
107	X:QS205R	A:QS205	Shunt current in quad A2Q5
108	X:QS206R	A:QS206	Shunt current in quad A2Q6
109	X:QS208R	A:QS208	Shunt current in quad A2Q8
110	X:QS210R	A:QS210	Shunt current in quad A2Q10
111	X:QS211R	A:QS211	Shunt current in quad A2Q11
112	X:QS214R	A:QS214	Shunt current in quad A2Q14
113	X:QS303R	A:QS303	Shunt current in quad A3Q3
114	X:QS306R	A:QS306	Shunt current in quad A3Q6
115	X:QS307R	A:QS307	Shunt current in quad A3Q7
116	X:QS308R	A:QS308	Shunt current in quad A3Q8
117	X:QS310R	A:QS310	Shunt current in quad A3Q10
118	X:QS311R	A:QS311	Shunt current in quad A3Q11
119	X:QS314R	A:QS314	Shunt current in quad A3Q14
120	X:QS401R	A:QS401	Shunt current in quad A4Q1
121	X:QS403R	A:QS403	Shunt current in quad A4Q3
122	X:QS406R	A:QS406	Shunt current in quad A4Q6
123	X:QS408R	A:QS408	Shunt current in quad A4Q8
124	X:QS410R	A:QS410	Shunt current in quad A4Q10
125	X:QS411R	A:QS411	Shunt current in quad A4Q11
126	X:QS414R	A:QS414	Shunt current in quad A4Q14
127	X:QS501R	A:QS501	Shunt current in quad A5Q1
128	X:QS503R	A:QS503	Shunt current in quad A5Q3
129	X:QS506R	A:QS506	Shunt current in quad A5Q6
130	X:QS508R	A:QS508	Shunt current in quad A5Q8
131	X:QS510R	A:QS510	Shunt current in quad A5Q10
132	X:QS511R	A:QS511	Shunt current in quad A5Q11
133	X:QS514R	A:QS514	Shunt current in quad A5Q14
134	X:QS603R	A:QS603	Shunt current in quad A6Q3
135	X:QS606R	A:QS606	Shunt current in quad A6Q6
136	X:QS608R	A:QS608	Shunt current in quad A6Q8
137	X:QS610R	A:QS610	Shunt current in quad A6Q10
138	X:QS611R	A:QS611	Shunt current in quad A6Q11
139	X:QS614R	A:QS614	Shunt current in quad A6Q14
140	X:ELAMR	D:ELAM	Accumulator extraction lambertson
141	X:RLFS1R	A:RLLFS1	ARF3 DDS frequency