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## 2. Introduction

The purpose of this document is to outline the procedural steps required to enter various Reverse Proton Studies modes. When we are stacking, the P1, P2 and AP1 lines are all configured for 120 GeV protons. When switching to Reverse Protons, we must stop stacking and setup the lines for 8 GeV protons. The 8 GeV protons then are sent down the AP3 line, where they are injected onto the injection orbit in the Accumulator. From there, we can extract the 8 GeV beam down the D/A line to the Debuncher. We can either circulate the reverse protons in the Debuncher or extract them up the AP2 line. We will outline how to configure the Antiproton Source in a number of different Reverse Proton studies configurations.

First, we will outline how to establish Reverse Protons circulating in the Debuncher from either dedicated TLG events or “one shots.” We will then outline how to extract the Reverse Protons from the Debuncher down the AP2 line either from circulating Debuncher beam or using partial turn Debuncher extraction. We will then cover how to setup for up D/A line studies. Lastly, we will cover how to return Pbar to normal stacking.

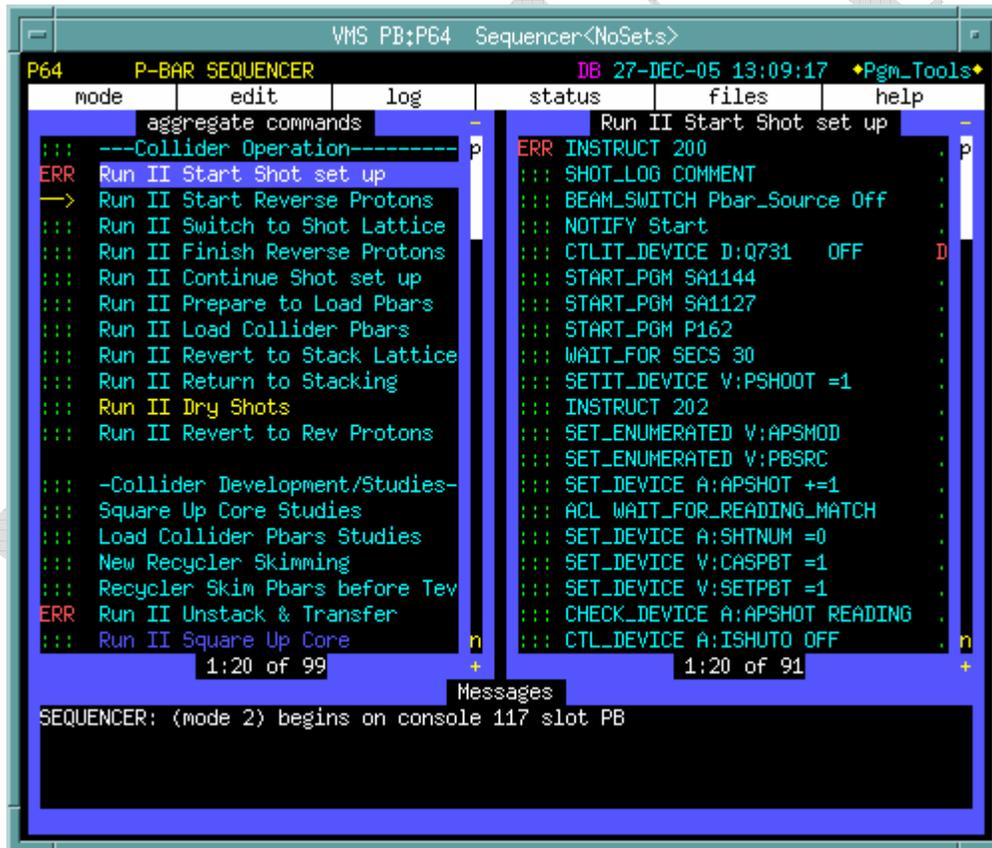
## Reverse Proton Setup Procedures

Many of the steps needed to enter and exit these study modes are consolidated into two Pbar sequencers called the Pbar Sequencer and Pbar Annex Sequencer. Other steps require manual intervention. We will assume that we are starting with the Pbar source configured in stacking mode.

### 3. Setup for Reverse Protons

From stacking mode, our first goal is to configure the Antiproton Source for reverse protons. To do so, we will run the first three aggregates in the Pbar Annex sequencer, followed by the first portion of the Pbar Sequencer “Reverse Protons to Debuncher” aggregate.

We will start by entering the Pbar Sequencer, which can be found on Acnet page P64.



The screenshot displays the Pbar Sequencer interface with the following content:

```
VMS PB:P64 Sequencer<NoSets>
P64 P-BAR SEQUENCER DB 27-DEC-05 13:09:17 Pgm_Tools
mode edit log status files help
aggregate commands Run II Start Shot set up
ERR Run II Start Shot set up
Run II Start Reverse Protons
Run II Switch to Shot Lattice
Run II Finish Reverse Protons
Run II Continue Shot set up
Run II Prepare to Load Pbars
Run II Load Collider Pbars
Run II Revert to Stack Lattice
Run II Return to Stacking
Run II Dry Shots
Run II Revert to Rev Protons
-Collider Development/Studies-
Square Up Core Studies
Load Collider Pbars Studies
New Recycler Skimming
Recycler Skim Pbars before Tev
ERR Run II Unstack & Transfer
Run II Square Up Core
1:20 of 99
Messages
SEQUENCER: (mode 2) begins on console 117 slot PB
Run II Start Shot set up
ERR INSTRUCT 200
SHOT_LOG COMMENT
BEAM_SWITCH Pbar_Source Off
NOTIFY Start
CTLIT_DEVICE D:Q731 OFF
START_PGM SA1144
START_PGM SA1127
START_PGM P162
WAIT_FOR SECS 30
SETIT_DEVICE V:PSHOOT =1
INSTRUCT 202
SET_ENUMERATED V:APSMOD
SET_ENUMERATED V:PBSRC
SET_DEVICE A:APSHOT +=1
ACL_WAIT_FOR_READING_MATCH
SET_DEVICE A:SHTNUM =0
SET_DEVICE V:CASPBT =1
SET_DEVICE V:SETPBT =1
CHECK_DEVICE A:APSHOT READING
CTL_DEVICE A:ISHUTO OFF
1:20 of 91
```

Figure 3-1: The Pbar Sequencer.

After entering the Pbar Sequencer, click on the menu bar item “mode” in the upper left corner of the screen. Select the Pbar Annex (Mode 17) from the selection menu.

## Reverse Proton Setup Procedures

The screenshot shows a VMS terminal window titled "VMS PB:P64 Sequencer<NoSets>". The window is divided into two main panes. The left pane, titled "aggregate commands", lists various commands for the "Fast Recycler Start" aggregate. The right pane, titled "Fast Recycler Start", shows the execution details for the selected command. At the bottom, a "Messages" pane displays system messages.

```
VMS PB:P64 Sequencer<NoSets>
P64 PBAR ANNEX DB 27-DEC-05 13:11:50 Pgm_Tools
mode edit log status files help
aggregate commands Fast Recycler Start
::: Fast Recycler Start
::: Fast Recycler Reverse Protons
::: Fast Recycler Finish Rev Prot
::: Fast Recycler Prepare to Shoot
ERR Fast Recycler Shoot
::: Recycler 'Express Lane' Shots
ERR Fast Recycler Back to Stacking
::: Crew Chief's Aggregate
::: Mixed Pbars Unstack&Transfer
::: Reverse Protons to Debuncher
::: Fast Recycler Start Old!
::: Recycler Prepare to Shoot old
ERR Momentum Cooling band 4
ERR Momentum Cooling band 3
1:20 of 26
Fast Recycler Start
::: SHOT_LOG CHAPTER
::: START_PGM P162
::: WAIT_FOR SECS 30
::: SETIT_DEVICE V:PSHOOT =1
::: SET_DEVICE A:APSHOT +=1
::: ACL WAIT_FOR_READING_MATCH
::: SET_DEVICE A:SHTNUM =0
::: SET_DEVICE V:CASPBT =1
::: SET_DEVICE V:SETPBT =1
::: CHECK_DEVICE A:APSHOT READING
::: CTLIT_DEVICE D:BSC925 OFF
::: INSTRUCT 327
::: SET_SEQ FILE_SR 87
::: SET_SEQ FILE 47
::: SET_SEQ FILE 48
::: ACL COMPARE_10_DEVICES
::: ACL COMPARE_10_DEVICES
::: ACL COMPARE_10_DEVICES
::: ACL COMPARE_10_DEVICES
::: BOOST_INTENSITY EVT16 2
1:20 of 91
Messages
SEQUENCER: (mode 17) begins on console 117 slot PB
SEQUENCER: (mode 2) ends on console 117 slot PB
SEQUENCER: (mode 2) begins on console 117 slot PB
```

Figure 3-2: The Pbar Annex Sequencer.

We will now run the first three aggregates in the Pbar Annex Sequencer. The same three aggregates are used in the initial stages of the Accumulator to Recycler transfers so there are some commands that may not be necessary for our Reverse Proton studies. We will attempt to point these out as we go along.

### a. Pbar Annex Sequencer: Fast Recycler Start

Click on “Fast Recycler Start” in the left column of the sequencer. The right column now shows the commands in this sequencer. To start this aggregate, click on the green “:::” on the first command in the sequence. We will now step through each command in the sequencer.

**::: SHOT\_LOG CHAPTER**

This command starts a new shot log chapter in the Recycler shot scrapbook at <http://www-bd.fnal.gov/cgi-mach/machlog.pl?nb=rscrap03&load=no>. Since we are not completing a Recycler shot, we can actually skip this command and start the aggregate at the next command.

## Reverse Proton Setup Procedures

### ::: START\_PGM P162

Starts the Accumulator BPM TBT Page P162 (keeper is Keith Gollwitzer). This page, as shown below, checks the status of the Accumulator BPM houses and issues resets to any house that is not online. This allows plenty of time for the BPM houses to reboot before they are need in the beam line tune-up. Upon completion, this application self terminates and the window will close on its own.

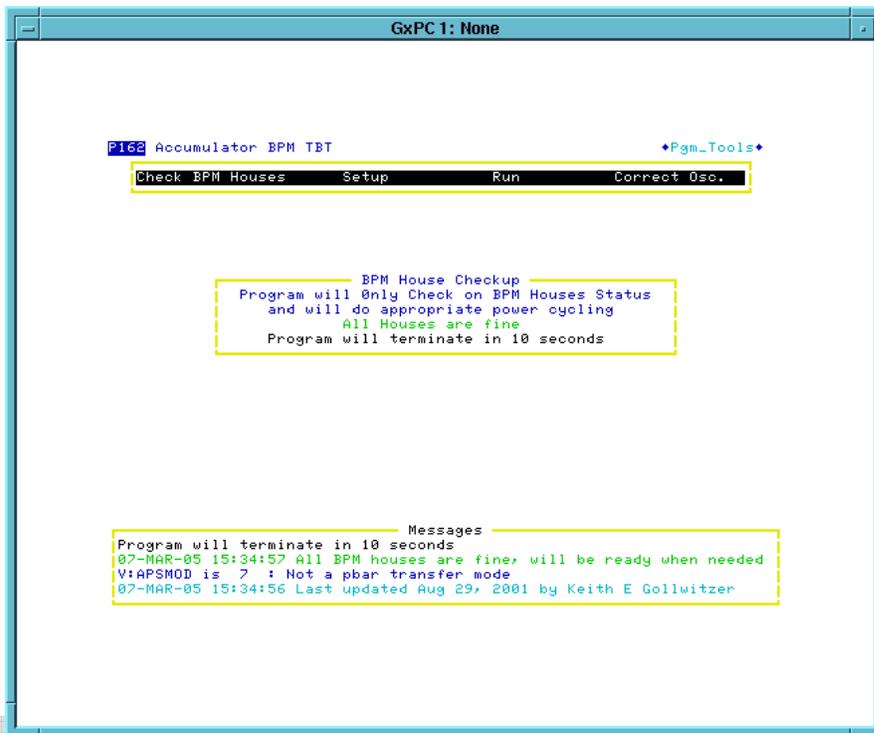


Figure 3-3:

### ::: WAIT\_FOR SECS 30

This command waits 30 seconds for the previous command to complete.

### ::: SETIT\_DEVICE V:PSHOOT =1

Sets the state parameter V:PSHOOT to 1, then pauses long enough to verify that the setting was completed successfully.

Devices that start with V: are called state parameters. State parameters define the operational state of a device or accelerator, allow the sequencers to be more automated, and prevent the different sequencers from getting out of sequence with each other. Often one sequencer waits at a certain spot until another sequencer changes a state parameter.

## Reverse Proton Setup Procedures

---

V:PSHOOT is a state parameter for the Pbar transfer state. V:PSHOOT state 1 means “not ready for transfer.” Later in this aggregate, V:PSHOOT is set to 4 (“Ready for Main Injector Tune up”). The **Main Injector Shot Transfer Line Tuneup** aggregate waits for PSHOOT to be set to 4 (“Ready for Main Injector Tune up”) before starting its beam line tune-up.

```
::: SET_DEVICE A:APSHOT +=1
```

Increments A:APSHOT by 1. This is the Pbar transfer series number, which is incremented before and after any Pbar transfer from the Accumulator to the Tevatron or Accumulator to the Recycler. This command is not necessary for Reverse Proton Studies.

```
::: ACL_WAIT_FOR_READING_MATCH
```

A Runs an Accelerator Command Language (ACL) script called WAIT\_FOR\_READING\_MATCH that waits for "SDA Shot/Store #" (A:FILE) to read the same value as the Pbar transfer series number (A:APSHOT). More information on ACL scripts can be found at [http://adcon.fnal.gov/userb/www/controls/clib/intro\\_acl.html](http://adcon.fnal.gov/userb/www/controls/clib/intro_acl.html).

```
::: SET_DEVICE A:SHTNUM =0
```

Sets the “Pbar transfer series Shot #” parameter (A:SHTNUM) to zero. Later on A:SHTNUM is incremented by one for every Pbar transfer. This is not used during Reverse Proton Studies.

```
::: SET_DEVICE V:CASPBT =1
::: SET_DEVICE V:SETPBT =1
::: CHECK_DEVICE A:APSSHOT READING
::: CTLIT_DEVICE D:BSC925 OFF
::: INSTRUCT 327
::: SET_SEQ FIEL_SR 87
::: SET_SEQ FILE 47
::: SET_SEQ FILE 48
::: ACL_COMPARE_10_DEVICES
::: ACL_COMPARE_10_DEVICES
::: ACL_COMPARE_10_DEVICES
::: ACL_COMPARE_10_DEVICES
::: BOOST_INTENSITY EVT16 2
::: CHECK_DEVICE A:R2DDS1 SAVE_SET
::: CHECK_DEVICE A:R2LLAM SAVE_SET
::: CHECK_DEVICE D:DPHATT SAVE_SET
::: CHECK_DEVICE A:SCRES SAVE_SET
:::
```

**D**  
**D**

## Reverse Proton Setup Procedures

---

```

::: WAIT_DEVICE V:MSHOOT
::: SPECTRUM_LOAD 2 7
::: SEQ_PGM REQUEST Unstack SA
::: SEQ_PGM REQUEST AP0 Scope
::: SEQ_PGM REQUEST Acc Gap Mon
::: ACKNOWLEDGE
::: AUTO_PLOT Core Emittances
::: START_PGM SA1127
::: BEAM_SWITCH Pbar_Source Off
::: NOTIFY Start
::: SET_ENUMERATED V:APSMOD
::: SHOT_LOG COMMENT
::: ABORT_MASK PBAR_SOFT ENABLED
::: ABORT_MASK AP1_120_PS ENABLED
::: INSTRUCT 206
::: ALARM_LIST PBAR 2
::: SET_SEQ FILE 37
::: INSTRUCT 307
::: SET_SEQ FILE_SR 79
::: SET_SEQ FILE 41
::: SET_SEQ FILE 42
::: ALARM_LIST PBAR 12
::: EVENT 91 DISABLE
::: WAIT_FOR SECS 10
::: CTL_DEVICE M:Q102 RESET
::: CTLIT_DEVICE M:Q202 ON
::: ALARM_LIST PBAR 3
::: SET_ENUMERATED V:APSMOD
::: LOAD_TLG 101 REPEAT
::: ABORT_MASK AP1_8_PS DISABLED
::: EVENT 88 TRIGGER
:::
::: SETIT_DEVICE V:SHOOT =4
::: BEAM_SWITCH Pbar_Source On
::: ALARM_LIST PBAR 52
::: WAIT_FOR SECS 3
::: ALARM_LIST PBAR 23
::: SET_SEQ FILE 1
::: SET_SEQ FILE 83
::: SET_SEQ FILE 85
::: CTL_DEVICE A:ISHUTO OFF
::: CTL_DEVICE A:ESHUTO OFF
::: CTL_DEVICE A:ISHUTC ON
::: CTL_DEVICE A:ESHUTC ON
::: START_PGM SA1144
::: START_PGM SA1144

```

D  
D

## Reverse Proton Setup Procedures

---

```
::: INSTRUCT 302
:::
::: SET_DEVICE A:VSARST =9
::: WAIT_DEVICE A:VSARST
::: START_PGM SA1156
::: START_PGM SA1136
::: WAIT_FRO SECS 15
::: ACL_SET_FROM_READING
::: SET_DEVICE A:VSAFWD =5
::: SETIT_DEVICE A:DTMHVE =.5
::: SETIT_DEVICE A:VSARST =5
::: CHECK_DEVICE A:VSAFWS READING
::: INSTRUCT 303
::: CUSTOM COOL_GAIN
::: SET_DECICE A:DPHATT =5
::: SET_DEIVCE A:SCRES +-1.8
::: ALARM_LIST PBAR 76
::: SET_SEQ FILE 92
```

### ***b. Pbar Annex Sequencer: Fast Recycler Reverse Protons***

```
::: ACKNOWLEDGE
::: CTLIT_DEVICE A:SPPS01 OFF
::: SET_SEQ FILE 28
::: SET_SEQ FILE 94
::: SET_SEQ FILE 30
::: CTLIT_DEVICE A:CMTW01 ON
::: CTLIT_DEVICE A:CMTW02 ON
:::
::: CHECK_DEVICE A:ISHTST READING
::: CHECK_DEVICE A:ESHTST READING
::: CHECK_DEVICE A:R2HLSC ON
::: CHECK_DEVICE A:R2HLGS ON
::: ALARM_LIST PBAR 38
::: CHECK_DEVICE A:FRWDTH READING
:::
:::
::: SETIT_DEVICE A:VSARST =3
::: ACKNOWLEDGE
::: WAIT_FOR SECS 20
::: WAIT_DEVICE A:VSARST
::: SETIT_DEVICE A:VSARST =7
::: ACKNOWLEDGE
```

### ***c. Pbar Annex Sequencer: Fast Recycler Finish Reverse Protons***

```
::: SHOT_LOG COMMENT
:::
::: EVENT 9C DISABLE
::: BEAM_SWITCH Pbar_Source Off
::: BOOST_INTENSITY EVT16 1
::: CTLIT_DEVICE D:BSC925 ON
:::
::: CTLIT_DEVICE D:ESEPV ON
::: CTLIT_DEVICE A:ISEP1V ON
::: CTLIT_DEVICE A:ISEP2V ON
:::
::: CTLIT_DEVICE A:EKIK ON
::: CTLIT_DEVICE A:EKIKQ ON
:::
::: EVENT 88 TRIGGER
::: AUTO_PLOT Beamline tuneup
::: BEAM_SWITCH Pbar_Source On
::: INSTRUCT 231
::: START_PGM P150
::: INSTRUCT 214
::: BEAM_SWITCH PBAR_SOURCE OFF
::: SETIT_DEVICE V:PSHOOT =7
::: ACKNOWLEDGE
::: BOOST_INTENSITY EVT16 1
::: BEAM_SWITCH Pbar_Source On
::: INSTRUCT 316
::: AUTO_PLOT TBT eff
::: START_PGM P162
::: BEAM_SWITCH Pbar_Source On
::: INSTRUCT 215
::: ACKNOWLEDGE
::: COPY_SCREEN LCL MY SLOT
::: COPY_SCREEN LCL MY SLOT
::: SHOT_LOG IMAGE
::: SHOT_LOG Comment
::: BEAM_SWITCH Pbar_Source Off
:::
::: CHECK_DEVICE A:CENFRQ READING
::: CHECK_DEVICE A:VFACCM READING
::: SET_DEVICE A:RLLEXF =628767.50
:::
::: CTLIT_DEVICE A:EKIK ON
::: CTLIT_DEVICE A:EKIKQ ON
```

## Reverse Proton Setup Procedures

---

```
::: ACKNOWLEDGE
::: CTLIT_DEVICE A:EKIK OFF
::: CTLIT_DEVICE A:EKIK OFF
::: CTLIT_DEVICE A:IKIK OFF
::: CTLIT_DEVICE A:ISEP1V OFF
::: CTLIT_DEVICE A:ISEP2V OFF
::: CTLIT_DEVICE D:IKIK OFF
::: CTLIT_DEVICE D:ESEPV OFF
::: CHECK_DEVICES A:SCRES RESTORE
::: SET_DEVICE D:H926PB D:H9267RP
::: SET_DEVICE M:V105PB M:V105RP
::: SET_DEVICE M:H100PB M:H100RP
::: SET_DEVICE M:V101PB M:V101RP
::: SET_DEVICE M:V11APB M:V11ARP
::: SET_DEVICE M:H105PB M:H105RP
::: SET_DEVICE M:H107PB M:H107RP
::: ACKNOWLEDGE
::: LOAD_TLG 103 REPEAT
```

After completing the above three aggregates, we will switch to the Pbar Sequencer to establish the Reverse Proton Beam to the Debuncher.

### ***d. Pbar Sequencer: Reverse Protons to the Debuncher***

```
::: ACKNOWLEDGE
::: SET_SEQ FILE 90
::: CHECK_DEVICE D:R1HT02 SAVE_SET
::: CHECK_DEVICE D:R1HT03 SAVE_SET
::: CHECK_DEVICE D:R1HT04 SAVE_SET
::: CHECK_DEVICE D:R1HT05 SAVE_SET
::: CHECK_DEVICE D:R1HT06 SAVE_SET
::: CHECK_DEVICE D:R1HT07 SAVE_SET
::: SET_DEVICE D:R1HT02
::: SET_DEVICE D:R1HT03
::: SET_DEVICE D:R1HT04
::: SET_DEVICE D:R1HT05
::: SET_DEVICE D:R1HT06
::: SET_DEVICE D:R1HT07
::: ACKNOWLEDGE
::: BOOST_INTENSITY EVT16 1
::: ALARM_LIST PBAR 72
::: WAIT_FRO SECS 5
::: ALARM_LIST PBAR 76
::: ACL SET_FROM_READING
::: SETIT_DEVICE A:VSARST =5
```

## Reverse Proton Setup Procedures

---

```
::: CTL_DEVICE A:R1HLSC RESET
::: CTLIT_DEVICE A:R1HLSC ON
::: SETIT_DEVICE A:EKIKTG =13.8365
::: CHECK_DEIVCE D:IKIKP SAVE_SET
::: CHECK_DEVICE D:AP10T0 SAVE_SET
::: CHECK_DEVICE D:DAP2X SAVE_SET
::: CHECK_DEVICE D:R1LLT4 SAVE_SET
::: CTLIT_DEVICE A:ISHUTO OFF
::: CTLIT_DEVICE A:ESHUTO OFF
::: CTLIT_DEVICE A:ISHUTC ON
::: CTLIT_DEVICE A:ESHUTC ON
::: WAIT_DEVICE A:ISHTST
::: WAIT_DEVICE A:ESHTST
::: CTL_DEVICE A:EKIK ON
::: CTL_DEIVE A:IKIK ON
::: CTL_DEVICE A:ISEP1V ON
::: CTL_DEVICE A:ISEP2V ON
::: CTL_DEVICE D:EKIK ON
::: CTL_DEVICE D:ESEPV ON
::: CTL_DEVICE D:Q731 RESET
::: CTL_DEVICE D:Q731 ON
::: ACKNOWLEDGE
::: CTLIT_DEVICE D:VAREVT ON
::: CHECK_DEVICE A:SCRES SAVE_SET
::: SET_DEVICE A:SCRES +=2
::: FTP beam 0
::: AUTO_PLOT Deb/AP2 rev prot
::: ACKNOWLEDGE
::: ACKNOWLEDGE
```

We can now circulate beam in the AP2 line.

### 4. Circulating Beam in the Debuncher

#### *a. Beam Modes*

i. \$16/\$2D in the TLG

ii. One Shots

#### *b. Debuncher Admittance Measurement*

i. Aggregate

- ii. **Manual Lumberjack Method**
- iii. **Using Java code to do the calculation**

**5. Beam up AP2**

*a. Establishing beam up the AP2 line*

*b. Beam Modes*

- i. **Partial Debuncher Turn to AP2**
- ii. **Circulating Debuncher beam to AP2**

**6. D/A Orbit Studies**

**7. Return to Stacking**

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