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C-A OPERATIONS PROCEDURES MANUAL

12.28 TtB Startup

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Hand Processed Changes

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Approved: \_\_\_\_\_ *Signature on File* \_\_\_\_\_  
Collider-Accelerator Department Chairman Date

C. Carlson

## 12.28 TtB Startup

### 1. Purpose

The purpose of this procedure is to define the sequence of activities required to set up the TtB line.

### 2. Responsibilities

It is the responsibility of the person or persons executing this procedure to observe all safety rules.

### 3. Prerequisites

The person or persons executing this procedure shall have all formal training required of a TVDG Operator.

### 4. Precautions

4.1 No beam of mass lower than 12 may be delivered to TtB.

### 5. Procedure

Refer to C-A-OPM 12.26 "TtB Fire Alarm Response", for a statement of TVDG policy with regard to TtB runs.

5.1 Prior to setting up a beam line in any target room or in TtB, determine the status of the previously used beam line. If the previously used beam line is not to be used in the near future, shut down all unnecessary systems related to that beam line.

#### 5.2 **Safety Requirements**

5.2.1 The 11DH02 Magnet shall be locked out and tagged prior to source start up any time the facility is not set up for Pulse or TtB Mode. See [C-A-OPM 12.20 "11DH02 Lockout Tagout Form"](#). This tag can only be removed after completing the form and only with supervisor approval.

5.2.2 Set all TtB radiation zones as per the procedures outlined in [C-A-OPM 12.24 "Setting TtB Radiation Zones"](#).

5.2.3 Insure that the HE MP-7 Neutron and Gamma Monitors are in the vicinity of the 11DH01 Object Slits.

5.3 **Beam Verification** - The beam to be delivered to TtB should first be verified according to the following procedure:

- 5.3.1 Set up the Ion Source according to the procedures outlined in [C-A-OPM 12.22 “Pulsed 860 or PSX-120 Source Wiring”](#), for the beam to be delivered.
- 5.3.2 Verify the beam in the 11-030 faraday cup.
- 5.3.3 Verify 3 charge states.

**Note:**

All setups described above should be fully documented with control settings, supply currents and voltages as well as beam currents at strategic faraday cups.

**5.4 TtB Equipment and Device Setup**

- 5.4.1 **Safety Requirement** - Complete the Lockout-Tagout form attached to the 11DH02 magnet power supply (see [C-A-OPM 12.20 “11DH02 Lockout Tagout Form”](#)), and obtain the authorized signatures prior to activating 11DH02.

- 5.5 **DC Tuning** - Beam tuning is done section by section. A section is defined by the elements between two consecutive foci. The sections are typically delimited by a diagnostic box at each end which contains a Beam Profile Monitor (Multi-Wire harp), and a Faraday cup for intensity measurement. Within a section is a quadrupole doublet at the center, x-y steerer at the start, and x-y steerer before the quadrupole. Section 11 contains the two 90° bending magnets (D1 & D2) and two quadrupole singlets. Section 12 is the matching (zoom) section with two quadrupoles. Section 17 contains the two 24° bending magnets (D2 & D3) and two quadrupole doublets at the center. Section 22 contains the two 69° bending magnets (D5 & D6) and two quadrupole doublets at the center.

**Note:**

Care should be taken when using multiwires with DC beams.  
DO NOT EXCEED 10 nA DC Beam on harp.

- 5.5.1 Focus the beam coming out of the accelerator onto the harp at D1 object. Using the HE quadrupole, observe two peaks on the MW. Focus is achieved when the two peaks reach maximum height simultaneously.
- 5.5.2 Remove steering from the HE quad. Vary the HE quad strength while observing the two peaks. There should be no horizontal motion on either peak. Only vertical size should change. If any horizontal motion is observed, it can be removed by adjusting the terminal steerers.
- 5.5.3 Position the beam at the entrance of the D1 magnet. Place the beam in the center of the MW at the object of D1 using the HE steerers.

- 5.5.4 Position the beam at the entrance of D2 magnet. D1 is preset to a value that will bend the desired beam  $90^\circ$  into the regulating slits at D1 image.
  - 5.5.4.1 Adjust terminal voltage until the desired beam appears on the regulating slits at D1 image and the slits are balanced.
  - 5.5.4.2 Adjust vertical position with the object steerer while observing beam on the MW at D1 image. The horizontal setting should be zero.
  - 5.5.4.3 The two quadrupole singlets are preset and should not be changed.
- 5.5.5 Position beam at the end of section 11.
  - 5.5.5.1 Adjust D2 magnet to horizontally center the beam on the MW at the end of section 11.
  - 5.5.5.2 Use the second x-y steerer to center the beam vertically on the MW at the end of section 11. The horizontal setting should be zero.
  - 5.5.5.3 The two quadrupole singlets are preset and should not be adjusted to preserve achromaticity in this section.
  - 5.5.5.4 Check the current ratio of the two singlets. It should be the inverse of the charge state ratio.
- 5.5.6 Tune the matching section (12).
  - 5.5.6.1 Using the first x-y steerer in section 12, center the beam in the first quadrupole by eliminating quadrupole steering.
  - 5.5.6.2 Using the second x-y steerer in section 12, center the beam in the second quadrupole by eliminating quadrupole steering.
  - 5.5.6.3 Leave the quadrupole strengths near the archive values.
  - 5.5.6.4 Focus the beam on the MW at the end of section 12 using the second quadrupole.
  - 5.5.6.5 Use the third steerer to position the beam in the center of the MW at the end of section 12.

- 5.5.7 Tune sections 13 - 16.
  - 5.5.7.1 Use the first steerer in each section to position the beam in the center of the quadrupole as observed by quadrupole steering elimination.
  - 5.5.7.2 Focus the beam with the quadrupole onto the MW at the end of each section.
  - 5.5.7.3 Position the beam in the center of the MW at the end of each section using the second steerer in the section.
- 5.5.8 Tune section 17 containing D3 & D4.
  - 5.5.8.1 D3 & D4 are set at the archive values.
  - 5.5.8.2 Use D3 to center the beam horizontally on the MW before D4.
  - 5.5.8.3 Use the first x-y steerer to center the beam vertically on the MW before D4.
  - 5.5.8.4 The quadrupoles are preset and should not be adjusted in order to preserve achromaticity in this section.
  - 5.5.8.5 Use D4 to center the beam horizontally on the MW at the end of section 17.
  - 5.5.8.6 Use the second x-y steerer to center the beam vertically on the MW at the end of section 17. D3 & D4 should run at the same magnetic field.
- 5.5.9 Tune sections 18-21. These are tuned in a similar way as sections 13-16.
- 5.5.10 Improving transmission in sections 13-16.
  - 5.5.10.1 Carefully adjust section 13 quadrupole while measuring beam current at the end of section 14. Maintain the A/B ratios as close as possible to original. Do not adjust any steerer values. Repeat the same for 14 & 15 quadrupoles. Do not adjust any steerer values.
- 5.5.11 Improving transmission in section 17.
  - 5.5.11.1 Adjust section 16 quadrupole while measuring beam current at the end of section 17. Do not adjust section 17 quadrupoles. Do not adjust any steerer values.

- 5.5.12 Improving transmission in sections 18-21.
    - 5.5.12.1 Use same method as for sections 13 - 16.
  - 5.5.13 Repeat above transmission improvement starting with quadrupole in section 12. Do not adjust any steerer values.
  - 5.5.14 Try adjusting steerers starting with the last x-y steerer in Section 12. Measure beam current at the end of the next section. Observe vacuum levels in each section and try to keep at minimum.
  - 5.5.15 Insure that quadrupoles in sections 20 & 21 do not steer even at the risk of a slight loss in transmission.
- 5.6 Achromatic Tuning
- 5.6.1 Adjusting Sections 11, 12, 13
    - 5.6.1.1 Eliminate steering of HEQ looking at 10MW020.
    - 5.6.1.2 Produce waist at 11MW030 between D1 and D2.
    - 5.6.1.3 Open regulating slits (D1 image).
    - 5.6.1.4 Vary GVM and observe beam motion on 11MW060. Measure chromaticity ( $\Delta X / \Delta GVM$ ).
    - 5.6.1.5 Change 11QH1 and 11QH2 maintaining their ratio.
    - 5.6.1.6 Repeat 5.6.1.4 and 5. Plot chromaticity as a function of quadrupole setting.
    - 5.6.1.7 Adjust 11QH1 and 11QH2 for no chromaticity.
    - 5.6.1.8 Measure chromaticity at 12MW030. If not 0, adjust by changing strength of 11QH1 and 11QH2 maintaining the ratio of 11QH1 to 11QH2 constant.
    - 5.6.1.9 Check chromaticity at 11M060 again, and if necessary iterate steps 5.6.1.4 through 9.

- 5.6.2. Adjusting Sections 16, 17, 18
  - 5.6.2.1 Obtain waist in front of 17DH1 at 16MW155 by adjusting 16QH1 and 16QV1.
  - 5.6.2.2 Weaken 16QH1 and 16QV1 by the same calculated fraction to move waist into center of 17DH1.
  - 5.6.2.3 Look at 17MW58 and obtain waist adjusting 17QH1, 17QV1, 17QH2, 17QV2. ( $H1=H2$ ,  $V1=V2$ )
  - 5.6.2.4 Verify that waist is in the center of 17DH1 by varying 17DH1 while looking at 17MW58. The beam should not move. If it moves, repeat steps 5.6.2.2 and 5.6.2.3, after changing 16QH1 and 16QV1 slightly until no motion is observed.
  - 5.6.2.5 Weaken all 17Qs by the same calculated fraction to move waist into the center of 17DH2.
  - 5.6.2.6 Adjust 18QH1 and 18QH2 to obtain a waist at 18MW153.
  - 5.6.2.7 Verify that waist is in the center of 18DH1 by varying 18DH1 while looking at 18MW153. The beam should not move. If it moves, repeat steps 6 and 7 after changing all 17Qs by the same small fraction. Repeat until no motion is observed.
  - 5.6.2.8 Measure position chromaticity at 18MW153 by changing GVM with wide open regulating slits. If not 0, change the "17" quadrupoles by the same small fraction until no further motion is observed.
- 5.6.3. Compare final settings with last TtB run.
- 5.6.4 Verify achromaticity with pulsed beam.
- 5.6.5 Zoom Lens Matching Section Tuning
- 5.6.6 Tuning A Typical Straight Section
- 5.6.7 Tuning Around Bending Magnets

## 6. **Documentation**

None

**7. References**

- 7.1 [C-A-OPM 12.26 “TtB Fire Alarm Response”](#).
- 7.2 [C-A-OPM 12.20 “11DH02 Lockout Tagout Form”](#).
- 7.3 [C-A-OPM 12.24 “Setting TtB Radiation Zones”](#).
- 7.4 [C-A-OPM 12.22 “Pulsed 860 or PSX-120 Source Wiring”](#)

**8. Attachments**

None