********** DRAFT ***********

Set Up Procedure for the 10 MeV Injector Test Stand

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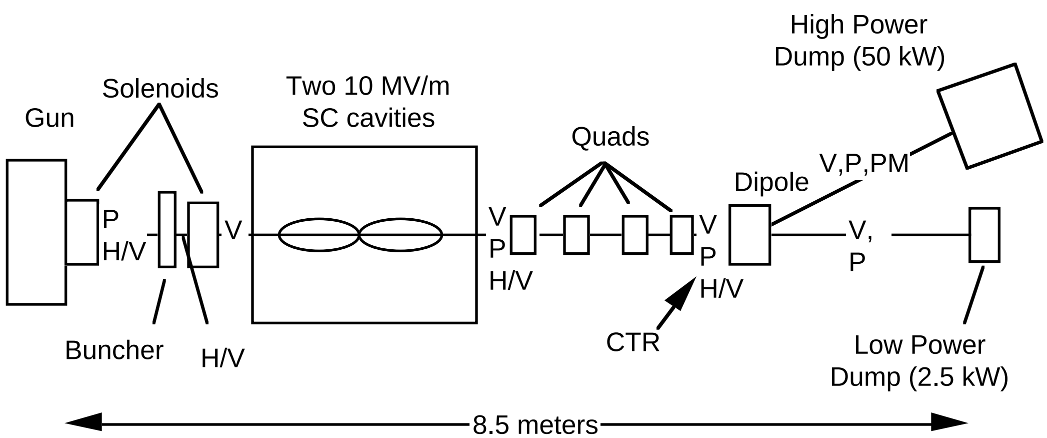
Last modified: 6/22/96



V = Viewer, flourescent at 500 keV, OTR at 10 MeV

PM = Stripline beam position monitor

P = profile diagnostic, wire scanner at 500 keV, OTR at 10 MeV

CTR = Coherent Transition Radiation Bunch length diagnostic

H/V = Corrector pair

I. Prerequisites to turning on beam

A. **PSS in tact and activated**

B. **MPS in tact and activated**

1. **All injector valves open**
2. **Vacuum OK**

C. **Set all magnets to nominal and cycle hysteresis**

D. **Stable operation of all RF at nominal gradients**

E. **Beam parameters for set up mode**

1. **Micropulse frequency = 2.339 MHz**
2. **Macropulse frequency = 10-60 Hz**

4. **≈135 pC/bunch**
5. **Average current ≈600 namps.(30 μ sec macropulse length, 60 Hz)**

F. **Is there a good diagnostic to detect low levels of beam scraping near the gun? During PAC95, J. Clendenin indicated that this was critical to their success with long cathode life at SLAC. Is pressure rise good enough? CKS comment on 2/8/96 was that pressure rise will be relied on; he also noted that the SLAC system has significantly smaller apertures at valves and bend dipoles. In addtition, there is a high pumping speed at the**

cathode itself due to NEG inside the gun. If lifetime is shorter than expected, possibility of mounting photomultiplier tubes on pipe to detect scraping. Hopefully, this will not be necessary.

<u>II. Gun turn on</u>

- **A. Set predetermined optics for low charge/bunch**
- **B. Turn off buncher and cryounit RF**
- **C. Insert <u>viewer</u> at before cryounit**
- **D. "Turn on" beam**
- **E. If CARM trips beam off, radiation limit was exceeded; or viewer limit reached(precalculated)**
- **F. Run <u>HARP</u> at light box (remove viewer if necessary) to verify presence of beam.**
- **G. If beam is not at harp:**
  1. **Watch for pressure increase near gun; this is one indication that the beam is being generated.**
  2. **Adjust steering until buncher transient signal appears or look for signal on current monitor(is there a ceramic break planned in the 500 keV region for the final injector config?;**
  3. **Run harp to verify presence of beam and axisymmetry.**

<u>III. Center beam in first solenoid -- Actually, since the laser spot will be moved around on the GaAs wafer as sections electron emission from a spot drops, it may not be possible to keep the beam centered in the solenoid. (6/23/96)</u>

- **A. Establish beam on viewer at cryounit**

<u>COMMENT ON CAMERAS: CKS WARNS THAT CCDs HAVE ATENDENCCY TO FAIL IN RADIATION AREAS. EXPERIENCE IN 500 KEV TEST STAND EXPERIMENTS HOULD DETERMINE LIFETIME AT THAT ENERGY. CID cameras are more rad resistant; we may have to go this way eventually.</u>

- **B. Adjust lens focusing and observe beam motion**
- **C. Move laser spot in logical direction**
- **D. Repeat steps B and C until no motion is evident while changing solenoid current.**
- **E. Note: CKS commented 2/8/96 that there is room inside the solenoid for a Haimson coil if necessary.**

<u>IV. Buncher set up</u>

- **A. Turn on buncher RF**
- **B. Thread beam at least to BPM past buncher(Note: this BPM will not be here most likely; may have a ceramic gap current monitor to measure pulse charge. This will be tested in 500 keV experiments. However, impedance estimate and measurement is required.**
- **C. Transient phase buncher**
  1. **Observe buncher gradient feedback drive signal (GASK) on oscilloscope**
  2. **Adjust buncher phase so that signal reads zero**
  3. **This should be near the zero crossing of the buncher**
  4. **Nominal gradient probably depends on charge/bunch; need to measure charge per bunch early in setup. Where is the earliest location? BPM? Ceramic break?**

5. **Should be able to set phase to within 5-10 degrees with care.**

D. Center beam in buncher

1. **Thread beam to viewer prior to cryounit**
2. **Vary buncher phase +/-45° (automated) and observe motion; if spot centroid moves, beam is not centered in buncher**
3. **If beam not centered, adjust corrector upstream of buncher until motion stops.**
4. **Since this will probably need to be checked and adjusted fairly regularly(whenever the laser spot is moved), it should be automated.**

E. Calibrate buncher amplitude (This section needs to be reviewed carefully. Also, this section needs to be done infrequently)

1. **Measure Buncher Q and determine necessary power to set up nominal buncher gradient; this should get setting within 20-30%**

2. **Calibration of Buncher gradient using time of arrival at unit**
    - a. Setup 5 MeV beam(one cavity only) to spectrometer viewer with shortest bunch length out of gun as possible(NEED VALUE HERE)
    - b. Crest cyrounit cavity
    - c. Find buncher zero crossing
        - **i. Turn off buncher**
        - **ii. If spot on spectrometer viewer moves adjust buncher phase**
        - **iii. Turn on buncher**
        - **iv. Repeat steps i-iii til spot does not move. This sets zero crossing to higher precision than step C.**
    - d. Crest buncher (add or subtract 90 degrees to zero crossing phase)
    - e. Recenter beam in spectrometer viewer
    - f. Record spectrometer change
    - g. Calculate how far off crest beam in the unit the beam needs to be to cause change.
    - h. Calculate buncher amplitude from this.
    - i. Repeat for several buncher gradients

3. **Calibration of buncher gradient using Spectrometer--ONLY WORKS IF FLUORESCENT VIEWER IS ON SPEC. LEG. CURRENT PLAN IS TO HAVE ALL 10 MEV VIEWERS OTR TYPE!!! Otherwise would have to rely on BPM. Ugh!**
    - a. Set macropulse rep. rate to low charge/bunch set up mode
        - **i. Micropulse frequency = 2.339 MHz**
        - **ii. Macropulse frequency = 10-60 Hz**
        - **iii. Macroulse length = 30 μ sec (Note: At 2.339 MHz, 135 pC/bunch, 8 μ sec macropulse length gives the CEBAF 2500 microamp*microsecond burn through limit; we can exceed this, however)**
        - **iv. ≈ 10 pC/bunch**
    - b. Set precalculated optics for low charge/bunch
    - c. Thread beam through cryounit to **viewer or BPM** at high dispersion point in spectrometer leg; I'm assuming this is possible, for low space charge, I think it is doable.
    - d. Set buncher to crest; verify at high dispersion point
    - e. Record buncher gradient vs observed energy to get rough calibration

f. Make sure that spots on

f. 6/23/96 Note: The spectrometer dipole planned is a BM magnet. This is a 3.5 A max magnet. At 3.5 Amp it will bend a 12 MeV beam. Thus, ≈ 0.25 Amps should bend a 500 keV beam.

4. **Can a time of flight diagnostic be used to measure gradient? Cryounit cavity as pickup? This was tried on main machine but was not accurate.**

F. Set buncher amplitude to nominal amplitude and nominal phase.

G. Verify that spot on viewer prior to cryounit is round, and ≈ 1 cm (4σ) diameter (Do we need a harp to do this? Comments from diagnostic group to the effect that viewer blooming is mainly due to the camera and to a lesser extent, the phosphor. Low bloom phosphor should be used and nonblooming cameras[CCD or CID])

V. Cryounit set up

A. Turn on cryounit RF(nominal gradients); [experience has shown that gradient values determined during commissioning are within 10-20% of actual]

B. Thread beam onto viewer prior to cyrounit

C. If necessary, adjust correctors up stream of cyrounit until transient signal appears in cavity 1 of cryounit.

D. Transient phase cavity 1 of cyrounit

1. **Observe unit-1 GASK signal on oscilloscope**
2. **Adjust unit-1 phase so that signal reads zero**
3. **This should be near the zero crossing of cavity unit 1**
4. **Set phase to nominal value (note that this is highly dependent on charge per bunch; Probably want to crest initially for low bunch charge, simulations are required)**

E. If beam does not appear on viewer downstream of cryounit, adjust correctors upstream of cyrounit until transient signal appears in cavity 2 of cyrounit.

F. Transient phase cavity 2 of cryounit

1. **Observe unit-2 GASK signal on oscilloscope**
2. **Adjust unit-2 phase so that signal reads zero**
3. **This should be near the zero crossing of cavity unit 2**
4. **Set phase to nominal valuenote that this is highly dependent on charge per bunch; Probably want to crest initially for low bunch charge)**

G. Center beam in cryounit

1. **Thread beam to** viewer **after cryounit**
2. **Vary cryounit phase +/-25˚ (automated) and observe motion; if spot centroid moves, beam is not centered in cryounit**
3. **If beam not centered, adjust corrector upstream of cryounit until motion stops.**

H. Calibrate cryounit gradients

1. **Thread beam to high dispersion point of spectrometer using corrector pairs after unit and and prior to spec. magnet.**
2. **Crest cryounit using viewer or BPM at high dispersion point**
3. **Plot gradient vs measured energy (to more accurately set energy, zero spectrometer and steer to zero positions immediately before spectrometer and on straight ahead leg, then turn on spectrometer.**

G. **Set cryounit to nominal gradient and phase**

VI. Set Energy and Calibrate cavity gradients

A. **Thread to spectrometer dump**

1. **Might want to center in quads? Insufficient corrector to center in each quad; however, should be able to get close since quads are fairly close together.**
3. **Beam size at 2 viewers on straight section should be close to the same size so verify parallel envelope; if necessary, use slit to check beam size between viewers.**
    a. If envelope not parallel?
        i. **Adjust solenoitd per some recipe**
        ii. **Adjust unit phase per some recipe.**
    b. Parallel envelope only calculated for 135 pC bunch at this time (6/6/95) Low bunch charge cases need to be calculated.

B. **Measure energy at high dispersion**

1. **If necessary, adjust first dipole til beam appears on spectrometer BPM**
2. **Perform step IV.E. Calibration of buncher amplitude if not already done**
2. **Calibrate/Set cryounit gradient**
    a. Check phasing of unit cavities 1 and 2 by finding crest
    b. Adjust cryounit gradients equally til nominal 10 MeV magnetic field is achieved in dipole and beam is centered in BPM or viewer

VII. Measure Energy Spread at high dispersion viewer

VIII. Measure bunch length

A. **CSR interferometer being built by U. Happek.**

B. **To be tested on 45 MeV injector**

C. **Will be located on test stand at foil viewer prior to spectrometer magnet.**

D. **Beam profile may be extractable from data**

XI. Measurement of emittance - THIS NEEDS MUCH WORK! HOWEVER IT IS NOT CRITICAL FOR INJECTOR TEST STAND SETUP

A. **Quad vary technique how accurate here? Estimate is that normalized rms emittance would have to be >20 mm-mrad to have an accurate measurement.**

B. **Sampling device - similar to UCLA design. Probably need two devices, one for vertical and one for horizontal; can be on same cross.**

1. **Insert slit and view beam at viewer just upstream of dipole. (This viewer is an OTR, is camera sensitive enough to detect the reduced light levels? An OTR is desireable since there are no blooming(due to screen) or phosphor burn problems.**

2. Verify that a waist is at the slit. If image of multiple sheet beams are separated by the same amount as the physical slits, then a waist occurs at the slit. Probably will have to adjust upstream quads to set waist.
3. UCLA has multiple slit design that operates at 16 MeV
4. Need to check drift- first estimates are <0.75 meter using 50 micron slits.
5. Cooling of slits is critical for us at beam setup powers. Slit dimensions can not change much due to heating. May have to investigate low rep rate measurements.

XII. Measurement of longitudinal phase space?

A. Actual value?

B. Tilt Can possibly be accomplished by sweeping beam across 1 mm slit and measuring time of arrival using pickup device such as cavity or BPM. Peak of signal would give longitudinal profile

C. Bunch length measurement would then give ε_{ϕ}.

D. Is measuring bunch length and energy spread in the spectrometer good enough?

E. This device is not planned for implementation in the Injector Test Stand. First tests will occur when injector is moved to FEL building.

G. Do we need a Yao type device to set phases as in the main machine?

XIII. Setup of High power beam to the 10 MeV dump

A. Set up pulsed mode beam to dump (nominal has all QJ's OFF)

B. Increase expander quadrupoles slowly through predetermined set points til beam size at dump reaches 5 cm in x and 8 cm in y diameters(need viewer of some kind near dump or use surface of dump)

The first expander quad(QB1) focuses to the center of the 2nd expander quad (QB2), making the horizontal beam size insensitive to QB2. Measurement of beam size with the quads off at the viewer between QB1 and QB2 and at the dump should help determine target strengths. (PARMELA nominals are 67.5 and -200 G/cm respectively. These correspond to $\approx$ 1.1 amps and $\approx$ 3.2 amps.

As the quads are increased, recentering will probaly be necessary using the dipole and corrector pair after the dipole.

The beam power may have to be increased as the beam size increases in order to see the beam spot size using the IR cameras. Great care must be taken if this is necessary. BLMs should be active.

This will be an iterative process

May need to adjust QJs to make beam smaller in x and larger in y at the entrance to the expander.

Expect considerable jitter in horizontal beam size and position

C. Observe beam jitter as quad strengths are increased and verify that beam remains on dump. If jitter is large, quads can be relaxed since jitter acts to spread beam

D. Turn on raster and adjust strength so that centroid of beam travels in ~3.5 cm diameter circle (or someting like a circle). It may be necessary to set the magnitude of the raster field with QB1 and QB2 are off.
E. Monitor vacuum and BLMs for points of beam loss prior to dump; if beam loss occurs before expander quads, resteer til there is no loss. There SHOULD be plenty of aperture up to this point.
F. Increase Pulse width from nominal setup to CW (2.339 MHz or 37 MHz, which ever is being used). Specifically watch 2"to 8" pipe transition point (beam at its closest to pipe here).