Adam Bartnik:

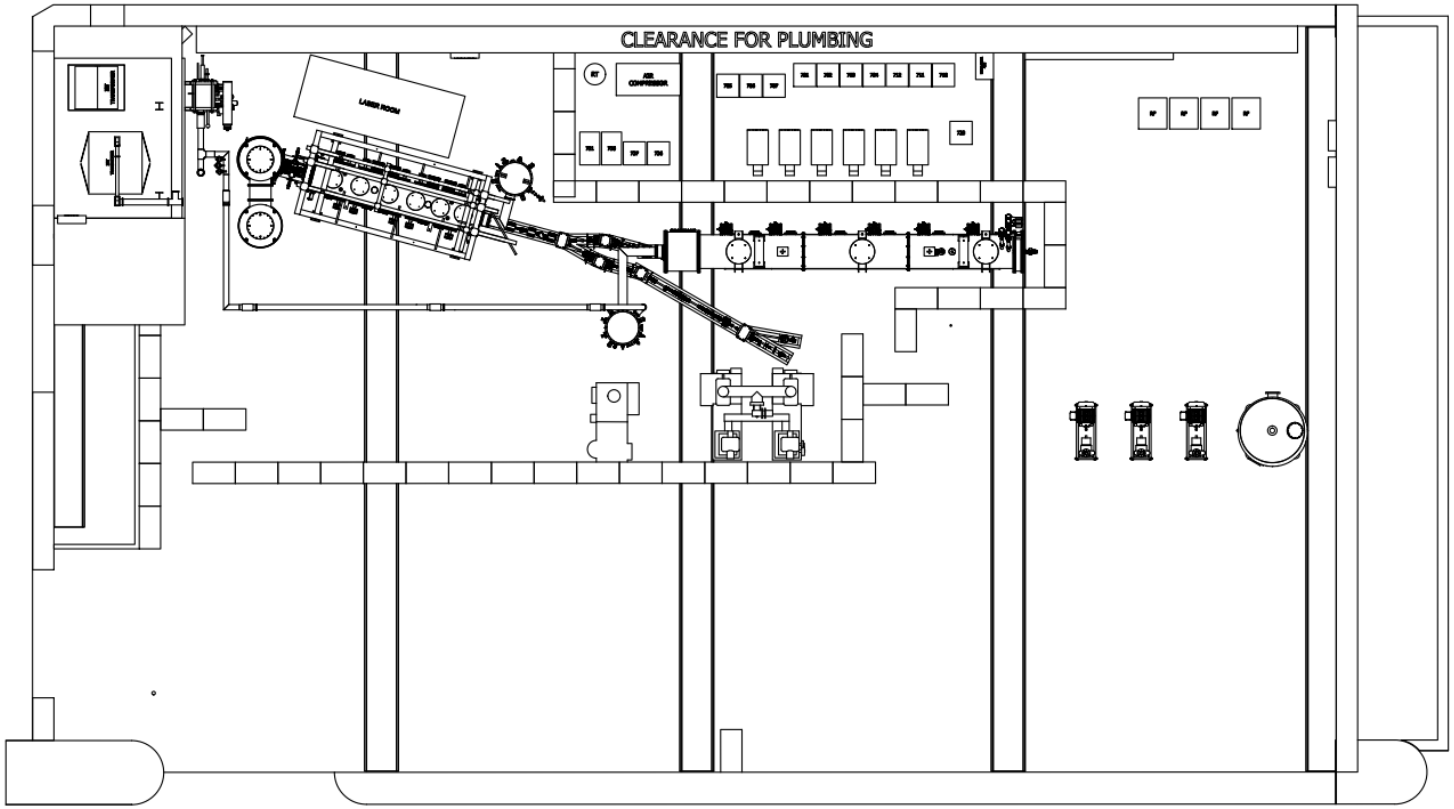
Injector Plans and Preparations for Fall Operations

Injector Preparation

These items are needed before operation can continue

- Change shielding layout
- Move laser to new room
- Replace gun resistor
- New cathode(s)

Change shielding layout

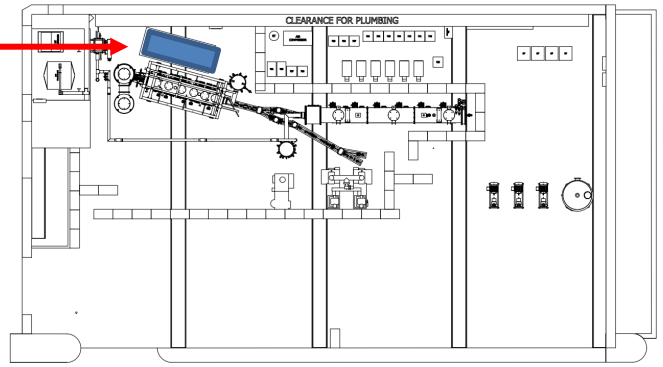


- Now has access to east RF area / electronics racks **during operation**
- Shielding changes are complete, but still needs an interlock checkout, and evening radiation surveys before daytime operation can occur

Move laser to new room

New room,
1 m away

Old room, 60 m away



The Good

- Reduces time consuming alignment
- Improves stability / reproducibility

The Bad

- New room is significantly smaller
- No AC (two HEPA filters on roof instead)
- Cannot (manually) tweak laser during operation

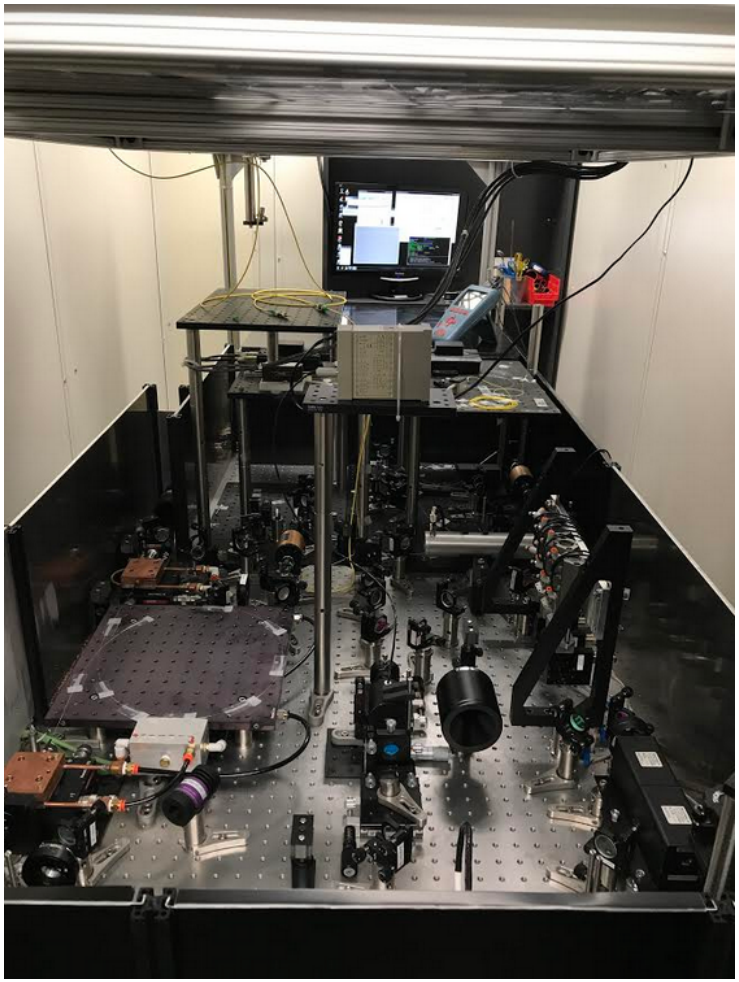
Move laser to new room

New laser design

- No (250 W) high power amplifier
  - Simpler and smaller design, still good for ~100s of pC
- New EO Modulator
  - Capable of arbitrary pulse picking (TTL)
  - Has worse “extinction ratio” than previous modulator (10^5, previous = 10^6), but seems tolerable

Unfinished modifications needed for CBETA

- New oscillator, 42 MHz
- Redo synchronization hardware / software
- Hardware to generate pilot bunch pulse train



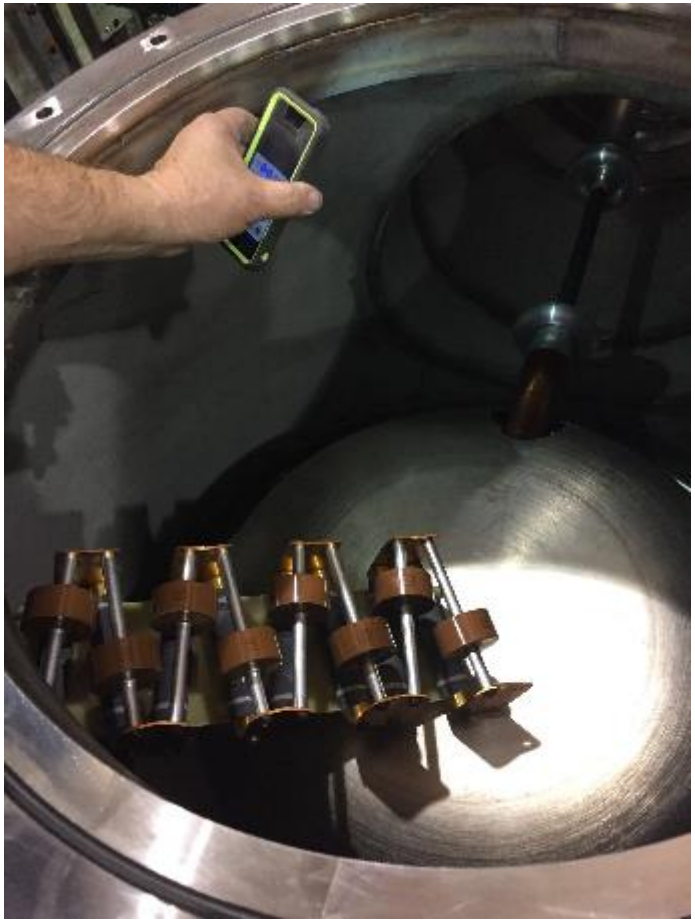
Replace gun resistor

In Dec. 2016, stable gun voltage dropped from 350 kV to 300 kV.

We want 350+ kV for CBETA.

In order to process the gun

- Replace 1 kOhm “running” resistor with 66 MOhm “processing” resistor
- Need a blank cathode with no active area for processing

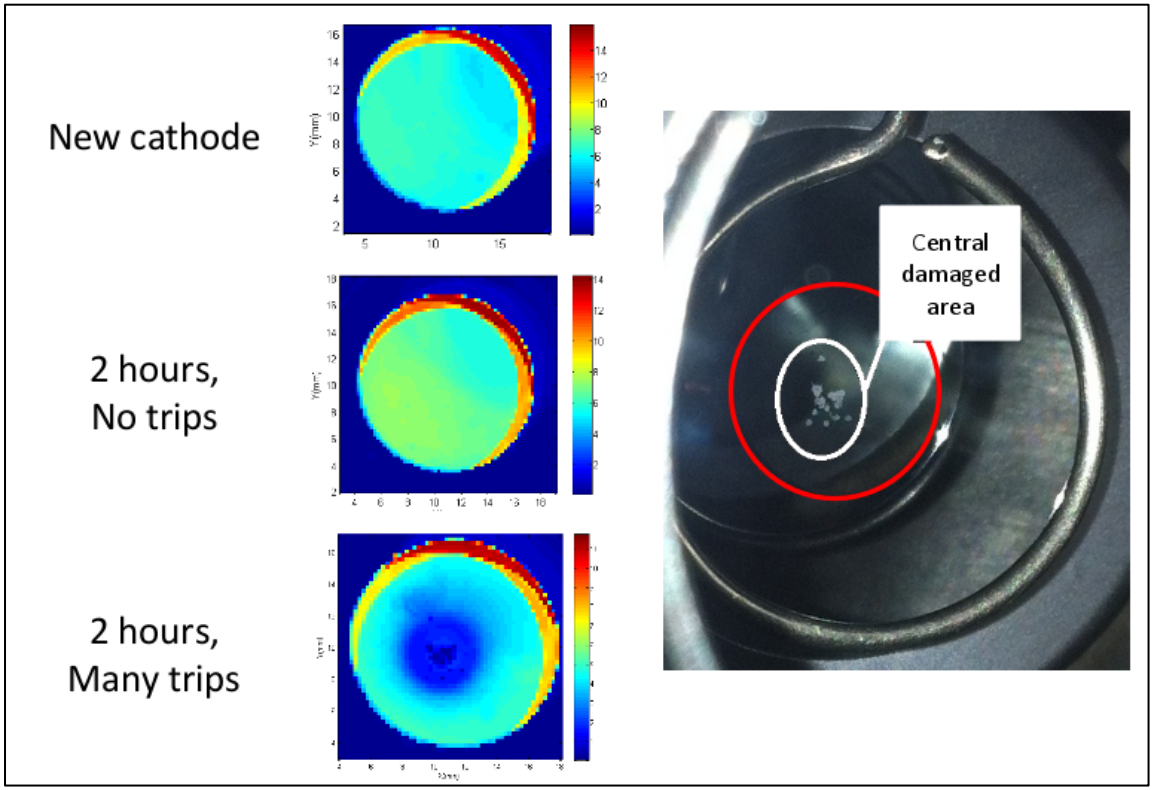


New cathode(s)

- For high current operation, we use an off-center cathode, because
- But for machine alignment and tuning, it's much easier to use a centered cathode
- Currently, we have only an off-center cathode

Needed cathodes:

1. Processing cathode
2. Large area, centered



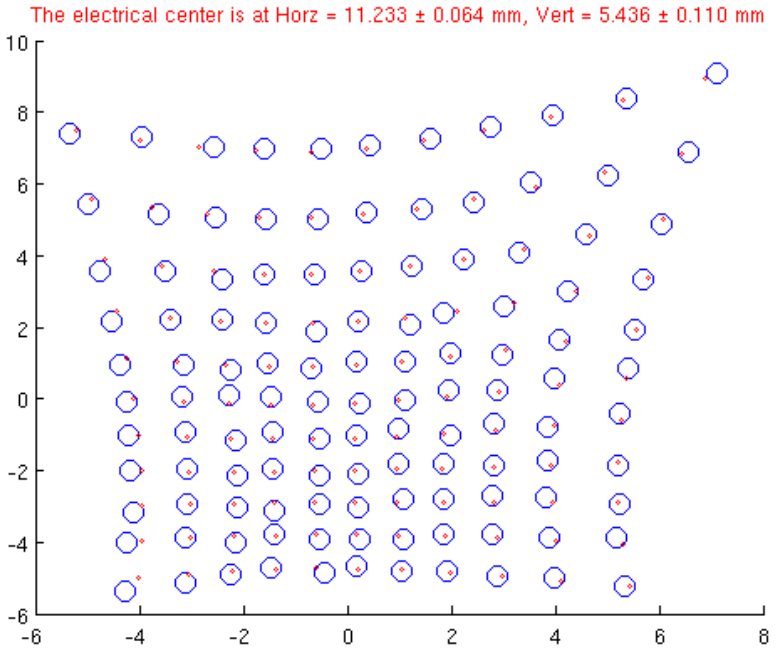
Goals for Fall Operation

- Align the low energy section
- Measure emittance, beta functions, adjust optics to optimize
- Additional BPM tests
- Continue testing MLC without beam (not discussed here)

Align the low energy section

Laser alignment onto the gun / cathode

1. Raster laser in square grid on ~10 mm x 10 mm area
2. With optics turned off, monitor downstream beam position at s ~ 1 m on view screen
3. Fit observed position to simple cubic nonlinearity (from the gun field)
4. Center of the gun is at the center of the nonlinearity



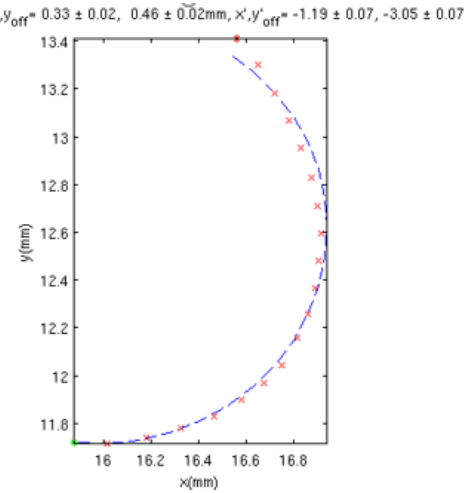
This is all done automatically with a Matlab script that takes and analyzes the data:

- /nfs/erl/online/ops/matlab_scripts/alignment/center_laser_in_gun.m

Align the low energy section

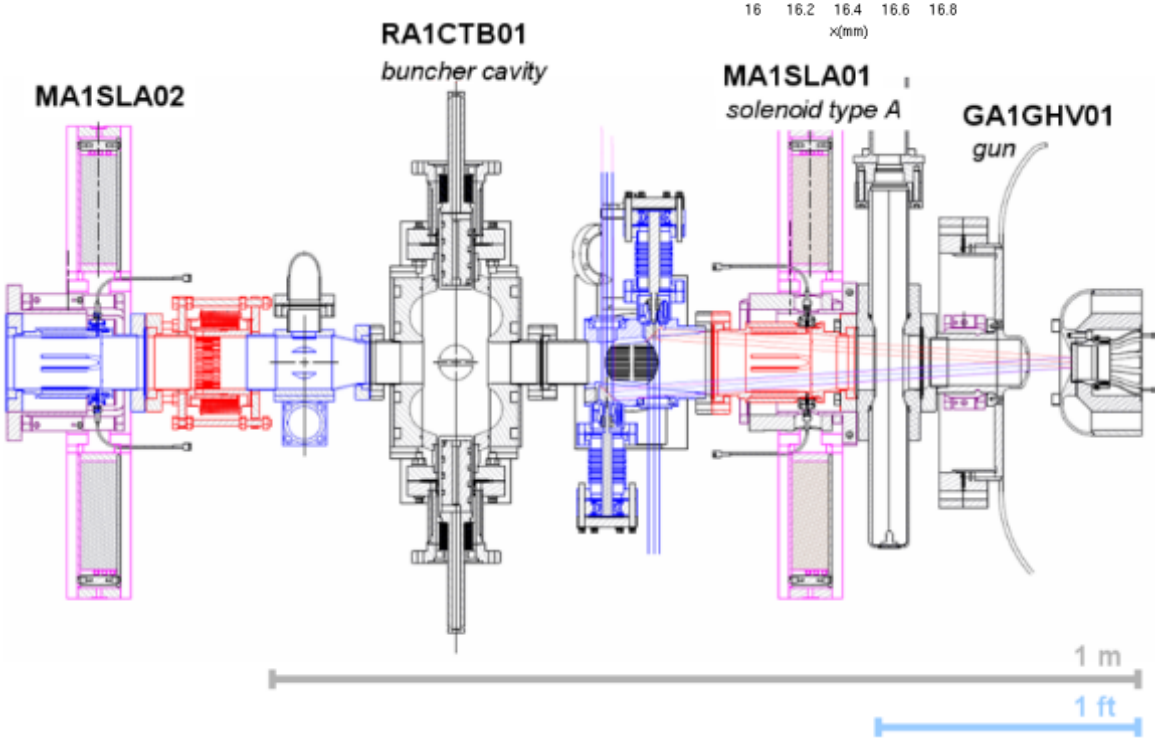
1. With gun correctors, align the beam through the buncher
2. With 2nd solenoid and ICM correctors, align 1st and 3rd ICM cavities (2nd is off)
3. Move solenoids (motorized) so that they are aligned to the beam
4. Repeat as needed

Scripts exist to align RF cavities, but in practice it is simpler/faster to toggle cavities on/off or adjust RF phase while observing downstream position.



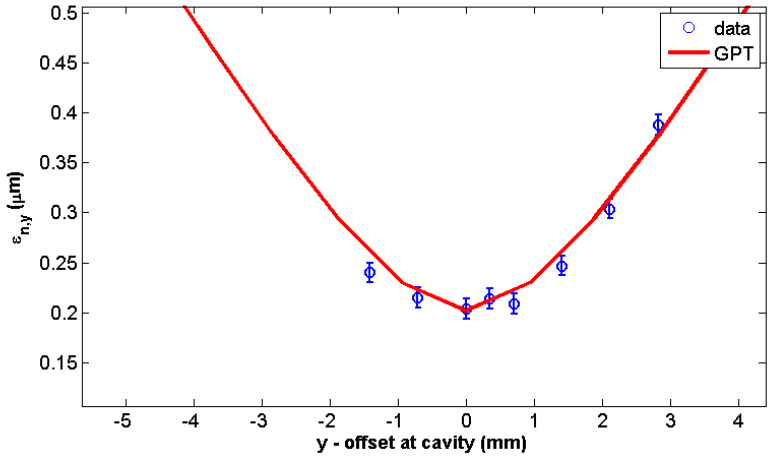
Solenoid alignment script:

1. Scan solenoid current
2. Monitor beam position on viewscreen
3. Fit observed position changes to prediction using 1D gun/solenoid field maps with misalignment
4. Move motors to correct this predicted misalignment

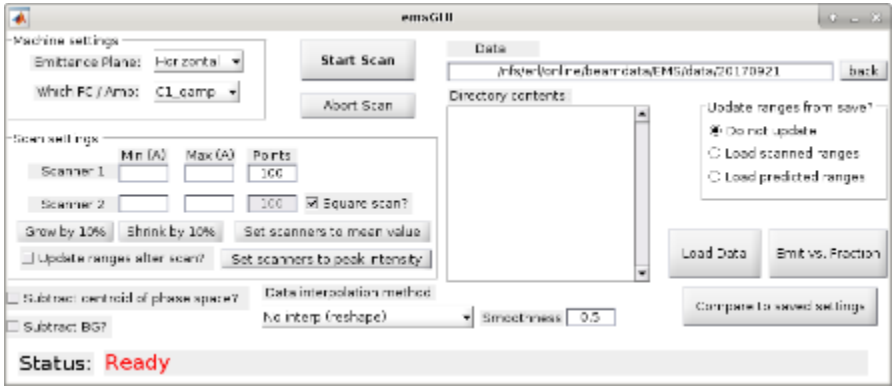


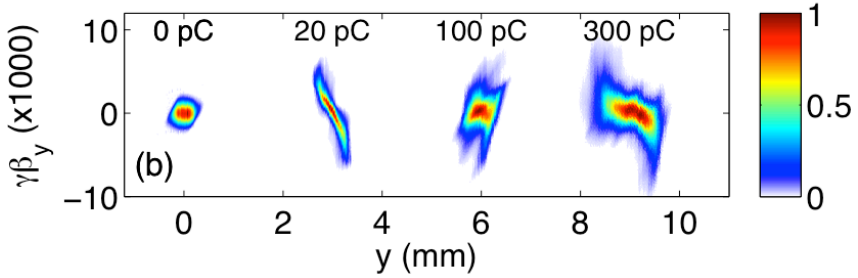
Measure emittance

Check machine alignment at 0 pC:



Optimize at 25 pC:





Matching beta functions

Minimizing emittance while matching beta functions

- Use script to calculate machine response
  - Runs in parallel in CU compute cluster (few minutes total time)
  - Uses GPT, so includes space charge
- Use pseudo-inverse to try to adjust beta functions
- Currently works well in simulation, provided one starts “close enough” to the target

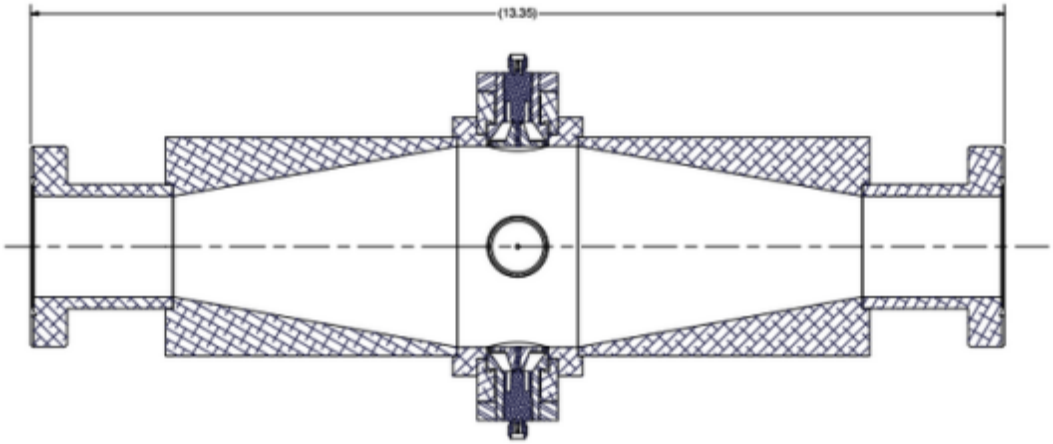
It’s expected that a lot of manual optics tweaking will be needed…

Additional BPM tests

New filtering hardware is ready to be tested here, and we hope to do that as soon as we have a stable beam.

Things to test:

- The BPM ringing was significantly reduced
- Try to get further from the center of the pipe to better test nonlinearity
- Other ideas?
  - Intentionally attenuate one button to compare effect to simulation?



Schedule

The goals shown previously are nice, but the reality is that we are competing for time with other work in that area. On a daily basis, we may or may not be able to operate the machine, depending on work occurring above our shield walls.

So, keep in mind that we will be happy to get any or all of that completed, because any work that is done now is work that will not need to be done during the FAT!