FEL Driver Recovery Procedure/Optimization Test Plan

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A. Purpose

1) Restore FEL CW operation at high powers

2) Improve FEL CW operation

B. Overview

1) Restoration of FEL CW operation
   a) System restore
   b) Injector setup
   c) Module phasing
   d) Verification of beam thread
   e) Restore FEL lasing
   f) Energy recovery setup
   g) Check Thread into dump – do with trim quads/sextupoles on
   h) Longitudinal matching
   i) Dump setup for CW running
   j) Go CW

2) Check nature of transmission limitation – Change ILM0F062 head voltage by –100 V and see if current limit increases (scraping or instability)
   a) If scraping, proceed as follows
      i) Aperture scans
      ii) Lattice Certification/correction – betatron and dispersion (difference orbits)
      iii) Resteering
      iv) Halo Management
   b) If instability, initiate employment search

3) Aperture Scans

4) Lattice certification/correction

5) Resteer system to eliminate halo and alleviate scraping
   a) Unit – downstream of solenoid, upstream of unit (helps with halo)
   b) Downstream of unit
   c) FELINJ string/1F01H correction
   d) Resteer through wiggler
   e) Recheck centering in 3F, 4F, 5F (particularly 5F – check DY5F02 shunt excitation (may need to increase field in magnet to move beam to the right at reinjection); match FELmain excitation to electron beam central energy while lasing
   f) Resteer reinjected beam to "center" of ITV1F00
   g) Find beam on ITV1F02
   h) Check FELEXT excitation when beam "properly centered" through module

6) Implement halo management and suppression schemes
   a) Close 3F scraper jaws
   b) Implement "vertical halo suppression optics" in 5F

7) Commission and implement procedures using new BCM cavities to improve longitudinal matching

C. Prerequisites

1) Stray field survey 0F/5F

2) New diagnostics – viewers, BCMs, BLMs

3) Gun restored

D. Restoration of FEL CW Operation

The purpose of this procedure is to restore the machine to high current/high power FEL operation thereby recovering the running configuration of December 1998. It is an abbreviated version of the "High Power Setup Procedure Revision 2.2" intended to take advantage of system reproducibility. Should it fail, simply repeat the High Power Setup Procedure.

1) System restore
   a) All-save 190

2) Injector setup
   a) *Check to see if orbit is okay and previous phases work – if so, record them and use in the following*
      i) Shift drive laser phase to 0^o
      ii) Shift all other phases in correlated fashion
      iii) Verify beam behavior is unchanged
   b) *If the phases and orbit are not okay, set the injector up again as follows:*
      i) Shift drive laser phase to 0^o
      ii) transient phase buncher
      iii) Steer into/out of unit using "standard" method
      iv) Phase unit using standard procedure
   c) *If the phases are okay but the orbit is hosed, fix the orbit then shift the phases as Step a) above.*

3) Module phasing
   a) Individual cavity phasing
   b) Adjust gang phase to maximize Happek output

4) Verification of beam thread
   a) Through hole in ITV1F02
   b) Through wiggler viewer holes
   c) Through recirculator trim quads
   d) To 1G dump

5) Restore FEL lasing in pulsed mode
   a) Clean up spots at 2F03, 3A, 3B by messing with buncher phase (so much for configuration control!). Call Court before doing so, but only if it's the middle of the night.
   b) Optimize bunch length by adjusting module gang phase to maximize Happek signal output
   c) Initiate lasing by performing cavity length scan.
   d) Set laser cavity length 1/3 of the way back from the peak of the detuning curve (Figure 1)

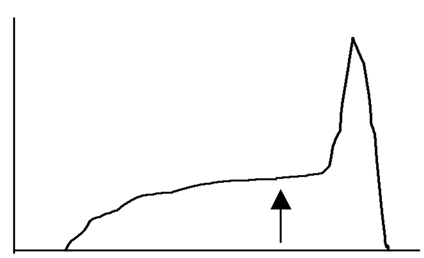

Figure 1: Detuning curve showing nominal setpoint for optical cavity length.

   e) Optimize lasing by steering mirrors and e-beam

6) Energy recovery setup– *the italicized comments in the following apply to recovering the setup of All-save 190 – other all save sets may not have these features. See further comments in Step 8 on longitudinal matching*
   a) Minimize GASKs (not all zero/equal)
      i) *Use ~1400 g-cm on DG3F02H string*
   b) *Steer hard right into module to avoid ILM0F062 trips*
   c) Aperture scan module using GASKs (cavity 1 particulary useful, as may be the BCM signal if you can find and use it – see comments in Step 8 below, though) as diagnostic and 5F05/7H,V as variables

7) Steering into dump – do with trim quads/sextupoles on
   a) Keep FELEXT at ~11500 g-cm or whatever All-save 190 value is
   b) If beam not visible on ITV1G01, proceed as follows:
      i) Record dump quads QI1G01,2, and 3 turn off
      ii) Record 1G01H, V and turn off
      iii) Rail QI1G01 to find beam on ITV1G01
      iv) Move QI1G01 toward zero, move QI1G02 away from zero in opposite direction and steer with 1G01H,V to keep beam on ITV1G01
      v) When beam steered to center on ITV1G01 and QI1G01,2 back to All-save 190 doublet values, proceed.
   c) Seek beam on ITV1G0* (the new dump face viewer) by cycling QI1G03 around zero; steer with 1G01H,V, focus with QI1G01/2 as doublet to get well defined, well steered beam on this viewer.

8) Longitudinal matching – the comments of Step 6 above apply in this context and should be reviewed. Some are All-save 190 specific.
   a) Trace out trough of RF waveform on ITV1G01 by varying recirculator path length, verify that we are on “long” side (around 1400 g-cm) of trough
   b) With sextupoles off optimize spot at ITV1G01 using QH(3,5)F0(2,3) as a single family. This will typically appear as a two-lobed spot or even two spots without sextupoles.
   c) Optimize spot at ITV1G01 using SC(3,5)F0(2,3). This will typically cause the two lobes or two spots to coalesce.
   d) Verify spot is acceptable at ITV1G0*

   In setting up longitudinal matching, be aware of the following:
   a) The DG3F02H string value of ~1400 g-cm is All-save 190 specific and appears to be “long” – that is, on the “far” side of trough or more than 180 degrees away from the accelerating phase. This may account for the apparent sign reversal in momentum compaction required to get good momentum spread at this path length

b) *Phillipe Piot has ascertained that a setting of ~1000 g-cm seems to put the energy recovered and accelerated beams in phase at the BCM downstream of the module. The momentum spread is not so good at this setting, but might be amenable to improvement by changing the sign of the trim quads and reoptimizing the sextupoles. Note well that the magnitudes of any of these should not change drastically (by an order of magitude or even factors of 2 or 3) when performing such optimizations*

9) Dump Setup for CW running
   a) Center up on ITV1G0* using 1G01H,V
   b) Pull viewers, bring up BLMs
   c) Aperture scan dump using 1G01H,V; verify "center position" is the same as from steering to viewer. Note: you should rotate the phase of the drive laser timing w.r.t. the 60 Hz line phase to trace out the dump raster pattern while doing this!

10) Go CW
   a) Verify all insertion devices are retracted
   b) Verify BLM HV is on, load default CW BLM settings
   c) Unmask BLMs
   d) Go CW
   e) Ramp frequency and charge/bunch
   f) Steer away from scraping (right and up at reinjection, left at dump)
   g) Contact L. Merminga, J. Preble, I. Campisi, and R. Walker to monitor SRF cavity IR trip behavior while pushing CW current beyond 1 mA.
      i) It should not be necessary IR trip levels if needed to allow running at currents above 1 mA. If it appears to be, convene a meeting of the aforementioned and the commissioning coordinator to decide on a course of action.

E. Check Nature of Transmission Limitation

The purpose of this test is to establish a value for current limitations. It is expected that the machine will trip off on ILM0F062 at about 1.6 mA while lasing; the following procedure will be used to determine if this limit is lasing specific, if it is due to scraping or a gross beam instability, and to characterize beam loss behavior near the limiting current.

1) Bring up some selection of BLM signals for ILM0F062 and the four "floater" BLMs (spare 1 – at reinjection point, spare 2 on beamline on 2nd reverse bend of 5F region, spare 3 on cryomodule top center, and spare4 on beamline at 4F01) on a Tech Scope (K. Jordan will usefully assist this).

2) Search for current limitation while lasing, while monitoring the BLM signals for any unusual signatures.

3) If a limiting current value under 5 mA with laser power under 1 kW is encountered, go out of lasing and recheck for the current limitation to ascertain if it is momentum spread/lasing/recirculator related.

4) With and without lasing, change ILM0F062 head voltage by –100 V and see if current limit increases (scraping or instability?).

5) Decide on course of action
   a) If instability, initiate job search
   b) If scraping limited either/both nonlasing/lasing, proceed with any/all of the following in whatever order is deemed appropriate by the commissioning coordinator
      i) Aperture Scans
      ii) Lattice certification/correction using difference orbits
      iii) Resteering system
      iv) Halo management/suppression

6) You may wish to investigate potential instabilities/scraping at other combinations of current/repetition rate, such as full charge/bunch and 30 Hz or 60 Hz with longer or shorter pulse lengths

F. Aperture Scans

The purpose of this test is to search for scraping that leads to cw current limitations. This may be done with

- *Pulsed beam*
- *30 Hz beam*
- *60 Hz beam*
- *cw beam*

so as to provide increasing sensitivity to suspected halo. Extreme caution should be exercised if high rep rate or cw beam is used in this test.

The test described below is specifically designed to search for scraping in the 5F and reinjection regions, which was where current-limiting BLM trips (on ILM0F062) were encountered in December 1998.

1) Set up beam operations to 1G with lasing in the desired beam mode (pulsed, 30 Hz, 60 Hz, cw). All BLMs should be clear.

2) Bring up ILM0F062, and floater BLMs “spare1” (at the reinjection point) and “spare 2” (at the center of the 2nd reverse bend in the 5F region) on the AMS and on the MPS operations screen.

3) Scan aperture horizontally:
   a) Record settings of MDH4F10H and MDH4F12H
   b) Launch a sine-like horizontal orbit into 5F region by simultaneously incrementing MDH4F10H and MDH4F12H B*L values by offsets equal in magnitude but opposite in sign. Start by incrementing MDH4F10H positively and decrementing MDH4F12H.
   c) Increase the steering amplitude of MDH4F10H (simultaneously decrease the magnitude of MDH4F12H by the same amount) until a BLM response is observed on the AMS signals of the BLMs under consideration. Record this value.
   d) Record the maximum positive increment in MDH4F10H (decrement in MDH4F12H) to which you can go before BLMs fault; record which BLMs fault.
   e) Restore correctors to their initial values.
   f) Repeat the process of Steps 3) b)-e) steering to the opposite direction (decreasing MDH4F10H and increasing MDH4F12H by equal magnitudes)
   g) Repeat the search of steps 3) b)-f) using a cosine-like horizontal orbit launched into 5F. This is generated by incrementing MDH4F12H with an offset the same in sign but 2.4 times the magnitude of the offset used in MDH4F10H.

4) Scan aperture vertically using the above process.
   a) The sine-like orbit is generated using MDH4F13V
   b) The cosine-like orbit is generated using MDH4F11V

5) If scraping is observed,
   a) localize the source based on the aperture scans
   b) resteer the affected region
   c) repeat aperture scans to verify the available aperture has increased.

6) If scraping is not observed, consider moving to the next higher power beam mode and repeating the exercise.

G. Lattice Certification/Correction Using Difference Orbits

Contact D. Douglas for details of a more thorough procedure; the following simply checks phase advances and overall dispersive behavior. Be sure to turn off trim quads and sextupoles before making measurements and to restore them after.

1) Certify betatron and dispersion behavior using difference orbit measurements
   a) Betatron behavior check using difference orbits – trim quads and sextupoles should be OFF! Bring up and zero relative BPM screens.
      i) Steer across 3F using 2F08 steerers:
         (1) 2F08H should steer to nodes at 4F03, 7, 11, 5F05
         (2) 2F08V should steer to nodes at 4F01, 5, 9, 13, 5F05
      ii) Steer across 4F using 4F01 steers
         (1) 4F01H should steer to nodes at 4F05, 9, 13
         (2) 4F01V should steer to nodes at 4F05, 9, 13, 5F05
         (3) pattern should repeat as you move down the backleg
      iii) Steer across 5F using 4F13 steerers:
         (1) 4F13H should produce about 4 mm motion at ITV5F05/mrad of steering (~130 g-cm)
         (2) 4F13V should steer to a node at 5F05.
   b) Dispersion measurements – lasing, trim quads and sextupoles should be off; change module cavities 1 and 2 by 0.5 MV gradient each to give 1.25% momentum shift to check linear momentum dependence.
      i) Without lasing, dispersion should be suppressed in backleg and in reinjection line (IPM5F05, 7, ITV5F05, ITV5F05, ITV1F00).

2) Develop compensatory settings or devise corrections for lattice errors
   a) *Dispersion correction at reinjection:*
      i) Create dispersion at ITV5F05 by incrementing QH5F03
      ii) Create dispersive slope at ITV5F05 by incrementing QH5F03 and decrementing QH5F04 by an equal amount (change in 5F03 + change in 5F04=0)
      iii) Create dispersive slope in the center of the reinjection chicane by incrementing QH5F03
      iv) Create dispersion in the center of the reinjection chicane by incrementing QH5F03 and decrementing QH5F04 by twice the amount by which QH5F03 was incremented (2*change in 5F03 + change in 5F04=0)
   b) *Spot size modification at reinjection* – see discussion of Halo Management, Section I.

H. Systemic Resteer

This is an overview of a resteering procedure intended to steer the system away from any scraping observed in Sections E. and F. The commissioning coordinator can pick and choose from the various steps in an effort to expedite progress

1) Unit – *the next two steps are a stand-alone test that may require mechanical changes to the system and thus should be allocated at least a full shift of run time. It will require the support of mechanical technicians as well. Be sure to get help from George Biallas for this* – This is to move the steering at the unit front end to downstream of solenoid, upstream of unit (helps with halo):
   a) Save golden orbits using new BPM features and save/restore
   b) Restore 2nd solenoid to proper location from its present (low) position
   c) Zero correctors immediately upstream of solenoid
   d) Center in solenoid by varying its excitation and steering with correctors adjacent to buncher until beam is stationary on 0F02 viewer. If the solenoid is in the "correct" position, the beam should be about at center on this viewer
   e) Steer through unit using correctors downstream of solenoid, looking for beam on 0F04 viewer. When aquired, turn off all 0F quads, and steer to center of viewer. This should more or less center the beam in at least QJ0F03; verify that this is so
   f) Reactivate the injector quads, and steer beam through to ITV0F06 using 0F04H,V (and 0F06H,V if needed).
   g) Continue with the next step to recover steering through the rest of the machine.

2) Downstream of unit:
   a) With beam steered as above, steer with correctors 0F04H,V immediately after the unit to center beam in QJ0F06.
   b) Steer beam back to ITV0F06 center using 0F06H,V correctors.
   c) Steer beam back to ITV1F01 center using 0F06AH, V
   d) Steer beam back to ITV1F02 center using 1F01H,V
   e) Verify that the machine steering has recovered to the golden orbit saved in step 1) a). If not, resteer to this orbit using 0F06AH, V and 1F01H, V

3) FELINJ string/1F01H correction
   a) Record the setting of 1F01H
   b) Check the beam location on ITV1F01 and ITV1F02
   c) Bring up relative BPMs and zero
   d) Zero 1F01H

e) Increment FELEXT by the initial B*L of 1F01H
f) Increment 0F06AH by the initial B*L of 1F01H (ADD the value to the excitation)
g) Decrement 0F06H by the initial B*L of 1F01H (SUBTRACT the value)
h) Verify the beam has remained fixed by checking relative BPMs. If it has not
   i) Call David Douglas and yell at him
   ii) Resteer the system to zero the relative BPMs using 0F06H and 0F06AH
i) Check to verify the beam is at its initial location on ITV1F01 and ITV1F02.

4) Resteer through wiggler – this should not generally be required if the upstream steering is “properly” done, but if it is,
   a) Steer in position at ITV2F03, 3A and 3B using 2F00H and V
   b) Steer in angle at ITV2F03, 3A and 3B using 2F02H and V.

5) Recheck centering in 3F, 4F, 5F (particularly 5F – check DY5F02 shunt excitation (may need to increase field in magnet to move beam to the right at reinjection); match FEL main dipole buss excitation to electron beam central energy while lasing
   a) *Steering check in 3F* – examine spots on new ITV3F01 and ITV3F02 to see there is evidence of gross missteering or beam energy mismatch. If so, resteer as in High Power Setup Procedure, Revision 2.2. Otherwise:
      i) Verify beam in centered in QH3F02 and observable on ITV3F02. If not, proceed with steering as in High Power Setup Procedure Revision 2.2
      ii) Insert 3F02 scraper jaws while lasing and monitor beam spot on ITV3F01. Verify beam is centered in scraper when jaws are symmetrically inserted.
      iii) Repeat above process using BLMs as the diagnostic to improve sensitivity and ascertain if there is evidence of halo.
      iv) When arc buss excitation is set and results of i), ii) and iii) are reconciled, insert scraper jaws until beam begins to eclipse on ITV3F01 and/or significant loss is observed on BLMs (e.g., the 3F02 BLM latches). Back each scraper out 5 mm.
      v) With beam so steered to center of scraper and QH3F02, record the value of and de-excite MDG3F02H string and verify beam is centered on ITV3F02 and in QH3F03. If it is not, adjust shunt excitation, MDF3F01H, and MDC3F02V to put beam on center at ITF3F02 and in QH3F03.
      vi) With beam so steered to DQ3F03, verify beam is centered downstream at QH3F04. If not, adjust MDF3F01H, shunt

excitation, and MDC3F01V to simultaneously center in ITV3F02, QH3F03 and QH3F04.

vii) With beam so steered, center vertically in QG4F01 using MDC3F03 and horizontally in QG4F02 using MDF3F04.

b) *Steering check in 4F* – proceed as in the High Power Setup Procedure Revision 2.2 to verify centering in all backleg quads – this will opportunely provide BPM offsets which can now be profitably used and recorded with an all-save.

c) *Steering check in 5F* – verify steering as appropriate though the 5F region using a procedure similar to that employed in the 3F region. This procedure is heavily overconstrained by the fact you have already set the dipole buss excitation and that the dipoles are known to match fairly closely (with the possible exception of the Dys) – so the main trick is probably to get the MDY5F02 shunt set correctly.

i) Check beam images on ITV5F01, ITV5F02, ITV5F04 and ITV5F05 to verify no gross steering errors are present.

ii) Verify that beam is centered on ITV5F01; if not, put it there with 4F13H corrector

iii) Verify beam is centered in QH5F01 and QH5F02. If not, center in both using 4F13H and V. If you cannot simultaneously center in both, it is probably because you are not coming in straight; you should review the centering in the 4F region quads.

iv) With the beam centered in QH5F02, verify the beam is centered on ITV5F02 (you may have to steer around until it disappears and then "split the difference") and in QH5F03. If it is not centered in QH5F03,

(1) Adjust the shunt on the DY5F02 and DC5F02V to center in QH5F03. NOTE WELL: this is possibly the crux of the scraping problem at the reinjection point. If this DY is mis-excited, the orbit error propagates to the downstream DU where it goes to large amplitude – in the opposite direction. The 400 g-cm steer needed on 5F05H to avoid lighting ILM0F062 is, in the machine model, a compensation for a ½% over-excitation of the DY. This in itself leads to ~1 cm orbit offsets. Caution is therefore advised. You might want to

(a) set up for a cw run,

(b) go to pulsed mode,

(c) resteer – a first guess says to increase the shunt by maybe ½% – and then reduce 5F05 and resteer to the dump

(d) go cw again to see if the aperture is better.

You should have as a goal getting the beam on center on ITV5F02 and in the center of QH5F03. This is to be done by adjusting the shunt, DF5F01H and DC5F02V.

v) With the beam centered in QH5F03, verify the beam is properly steered on ITV5F04, and that it is centered in QH5F04 – as viewed from ITV5F05, NOT ITV5F04 (which is next to the quad). If it is not so centered, you probably still do not have the shunt set correctly, and the previous task should be reviewed and repeated.

vi) With the beam centered in QH5F04, center in QB5F05 using DF5F03 and DC5F02)

vii) With the beam centered in QH5F04, center on ITV5F05 using 5F05H and V. This should also center the beam in QB5F07 and 8, more or less; touch the QB5F08 centering up as needed by looking at ITV1F00 and steering with 5F05H and V.

The 5F region is now essentially resteered and the beam is headed "straight" at reinjection (up to but not including 5F07H and V).

d) Restore MDH3F02H string to the value zeroed out in Step 5) a) v).

6) Steer reinjected beam to "center" of ITV1F00 using 5F07H and V.

7) Find beam on ITV1F02:
   a) Vary MDG3F02H string to minimize GASK signals
   b) Aperture scan module using GASK and BLM signals as diagnostics
      i) A sine-like horizontal reinjection orbit can be made incrementing 5F05H and decrementing 5F07H by the same magnitude
      ii) A cosine-like horizontal reinjection orbit can be made by varying 5F07H
      iii) A sine-like vertical reinjection orbit can be made by incrementing 5F03V and decrementing 5F05V by the same magnitude
      iv) A cosine-like vertical reinjection orbit can be made by varying 5F05V
   c) Center the beam in the module using the results of the above aperture scan
   d) Steer with 5F07H and V to locate beam on viewer ITV1F02. Center the recirculated beam in the viewer hole.

8) With the beam centered though the module, steer to dump
   a) Bring up relative BPM spikes and zero them
   b) Insert ITV1G01. If beam is on viewer, proceed to c). If not, search for beam:
      i) Steer with 1G01H and V to locate beam on ITV1G01. If not evident,
      ii) Cycle QI1G01 and look for beam. When it is acquired, set the quad so it is visible on ITV1G01. If this cannot be done,
      iii) As a last resort, grid search with QI1G01 excitation, and 1G01H, V values until beam is acquired on ITV1G01.

If the beam cannot be found, call the commissioning coordinator for assistance.

c) With the beam on ITV1G01, “walk” 1G01H excitation to zero while centering horizontally in QI1G01 using FELEXT. NOTE WELL:
   i) as you vary FELEXT you must watch the relative BPM spikes to be sure the FELEXT string is not steering the recirculated beam! If recirculator steering downstream of FELEXT occurs, for each step in FELEXT resteer the spikes through the recirculator to zero using 2F00H,V and 2F02H,V.
      (1) Simulation suggests that antisymmetric pairing of the horizontal correctors should do the job (increment 2F00H, decrement 2F02H by the same amount).
      (2) Simulation suggests that symmetric pairing of the vertical correctors should do the job (increment 2F00V and 2F02V equally)
   ii) 1G01V is next to QI1G01 and therefore is not effective for centering. Do not attempt to center in QI1G01 vertically, just keep the beam on the viewer using 1G01V, and log any evidence that the beam is not vertically centered in the quad, as this indicates that
      (1) it is either not straight out of the module
      (2) the 1G line is sagging, or
      (3) there are vertically bending stray fields around.

d) With the beam centered in QI1G01, reduce the quad to ±300 g (whatever it was to start with) and make QI1G02 the opposite (– QI1G01). Verify the spot is more or less on center on the dump; if it is not, put it there using 1G00H and V.

e) If the spot is not “nice”, check and optimize the longitudinal match (see Section J below):
   i) The path length should have been optimized in step 7) above
   ii) The steering of step c) immediately above has set FELEXT
   iii) Only the trim quads and sextupoles remain as available knobs – optimize the spot using them.

f) With a nice spot on ITV1G01, insert the new viewer ITV1G0*, and steer the beam onto it.
   i) Be sure to have the DLPC phase cycle so that the raster pattern is evident
   ii) Steer the centroid of the beam/raster pattern using 1G00H and V
   iii) Clean up the spot as needed using QI1G01, 2 and 3.

I. Halo Management and Suppression

This is a sketchy procedure intended to either collimate away halo (horizontally) or reduce its amplitude (vertically) to avoid scraping.

1) Close 3F scraper jaws (while watching BLMs!) – review and implement procedure of Section H 5) a) wherein the beam steering through 3F is optimized and the scraper jaws shoved in to horizontally collimate the beam.

2) Implement “vertical halo suppression optics” in 5F to reduce vertical beam size in 5F and the module during energy recovery.

    a) Call D. Douglas for “rematch” values intended to reduce vertical beam size through 5F and during energy recovery.

J. Improve Longitudinal Match

This is a speculative placeholder intended to acknowledge that we really don't have a quantitative clue as to how the machine works but realize that if we get REALLY stuck, we might be able to improve things by falling back and carefully characterizing everything and doing the setup “right”, from gun to dump.

1) Commission and implement procedures using new BCM cavities to improve longitudinal matching (“then a miracle occurs…”)

2) At the time this is written, it is strongly suspected that the energy recovered beam is about 200^o out of phase with the accelerated beam, rather than the desired 180^o. This may have undesirable consequences w.r.t. instability thresholds. The situation may be rectified as follows:
    a) Insert ITV1G01
    b) Run MQH1G01 to ~1020 g while steering as needed with 1G01H to keep the beam on the viewer.
    c) Turn off trim quads and sextupoles
    d) Lower MDG3F02H string from 1400 g-cm to ~1000 g-cm, while
        i) Watching GASKs to verify they become minimal again as 1000 g-cm is approached
        ii) Watching BCM signal to zero it as the phase is taken to 180^o, and
    e) Turn trim quads back on to same magnitude but opposite sign as initially
    f) Turn trim sextupoles to same value as initially

g) Reduce MQH1G01 value to original; optimize spot by adjusting phase, FELEXT, steering, and trim magnet values.
h) Set dump transport up as in section D and try cw run for power

This will hopefully restore good quality beam to the 1G dump that is exactly out of phase with the accelerated beam. The magnitudes of the momentum compactions should be roughly the same as before, but the sign should be opposite for the linear term (quads) and the same for the quadratic (sextupole).

A guess as to the final magnitude follows – good transmission to 1.5 mA was achieved using trim quad settings of +36 g. This should be compared to the "predicted" value of –48.3 g. Moving to the "correct" energy recovery phase should, in principle, make –36 g "work". Try it and see!