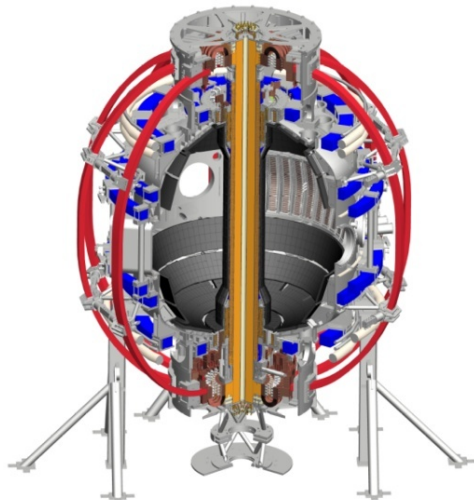


Automatic Rampdowns

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X Science LLC

Meeting name
Location
Date



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Kyushu U
Kyushu Tokai U
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ENEA, Frascati
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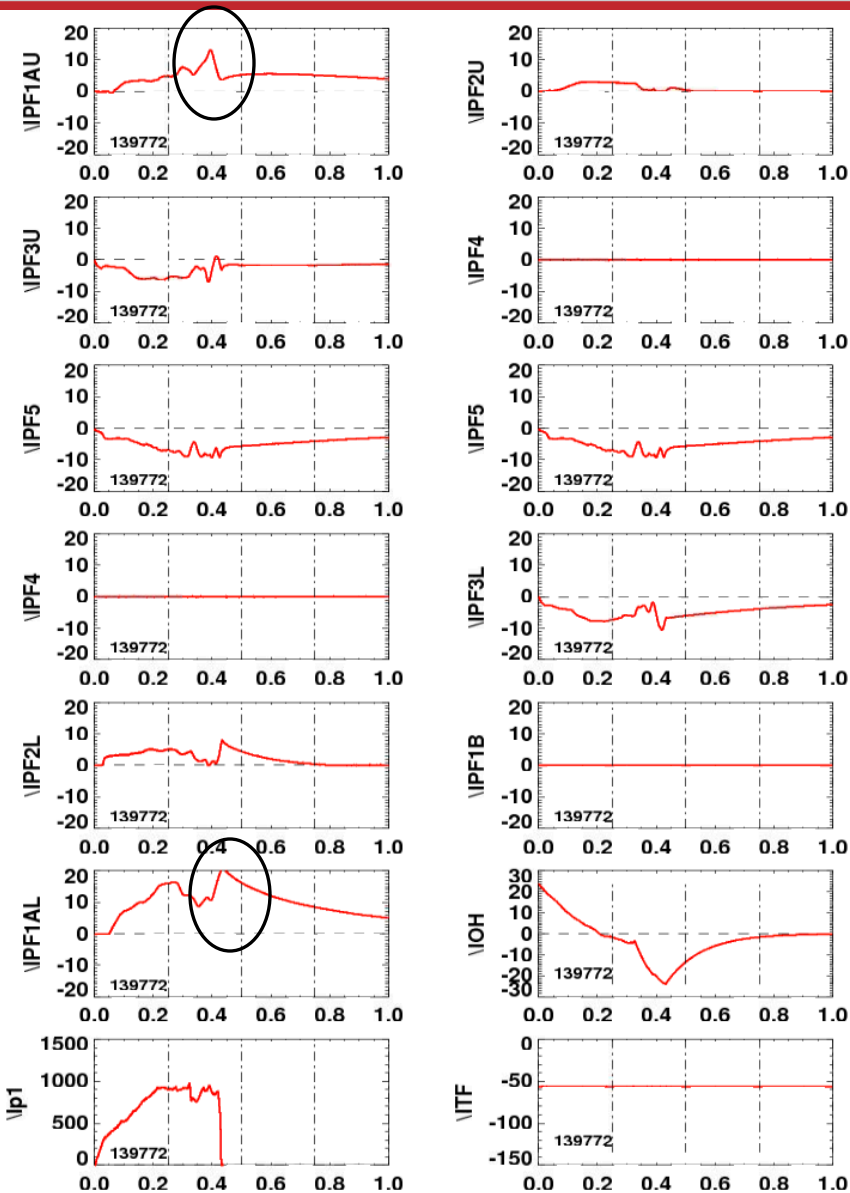
You Must Carefully Identify Your Goals for a Rampdown XP

- With pre-programmed rampdowns:
 - You can:
 - Study transport and MHD physics in great detail.
 - Like Steve is proposing.
 - Make nice “trophy” examples
 - And this does have value moving forward.
 - Support specific XPs.
 - Like Charle’s particle retention XP in the past
 - You can’t:
 - Reduce the number of disruptions
 - Because you will be deciding ahead of time when to program the rampdown.
 - Transfer the capability from shot to shot
 - Or at least, it will take a lot of work.
 - Limit forces on the machine
- With automated rampdowns:
 - You can:
 - Limit forces
 - Reduce disruption rate
 - assuming that you are willing to count rampdown disruptions separately from those where no action is taken.
 - You can’t:
 - Guarantee that the rampdowns will be clean
 - Ensure that they will be scientifically interesting.

Motivation for My Proposal

- NSTX Experience:
 - There was no automated rampdown of the plasma current, or any even semi-controlled termination of the discharge.
 - If the solenoid reached the current limit, then it brutally took the OH current back to zero
 - Steve Jardin is looking at one of these cases I believe.
 - Beams only turned off when I_p dropped beneath 200(?) kA.
 - There were a handful of shots with painstakingly hand-tuned rampdowns for the particle retention JRT.
 - Coil protection was essentially limited to overcurrent/overheat/overtime.
- Why is NSTX-U different?
 - We now have a digital coil protection system, which will compute all sorts of forces & stresses in realtime.
 - And if any limit values are exceeded, it results in an immediate shutdown of the coil systems.
 - The passive plates are approaching their limit of strength for current quenches following a 2MA VDE.
 - So we should learn how not to have VDEs.
 - If we run NSTX-U the same as we ran NSTX, we will be tripping the DCPS on a large fraction of our shots.
 - And then have to beg for resets after each one...
- Goal of this XP:
 - Define a very basic rampdown scenario that can be appended to ALL of our shots.
 - Includes both the disruption detection and the rampdown response
 - My priorities:
 - Limit PF transients from shape, S.P., and vertical position control (#1)
 - Eliminate VDEs (#2)
 - Ramp down the magnetic stored energy (#3)
 - Ramp down the thermal stored energy (#4)
 - I do not care if these rampdowns are not ITER/FNSF relevant.
 - This would complement any XPs dedicated to rampdown physics.

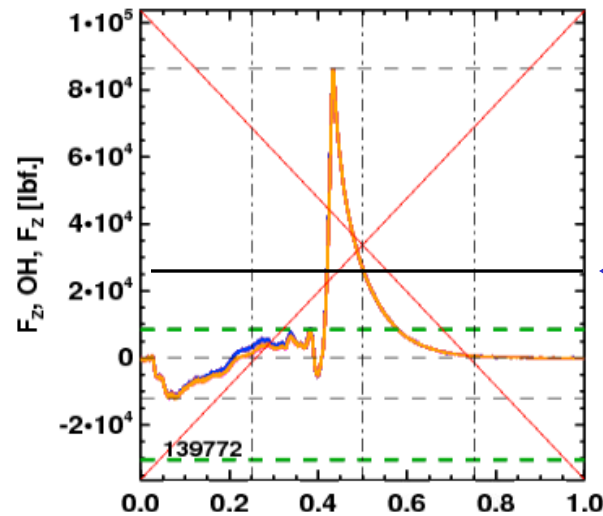
Semi Random Example #1: F_z on OH Coil



Shot with strike-point control on.

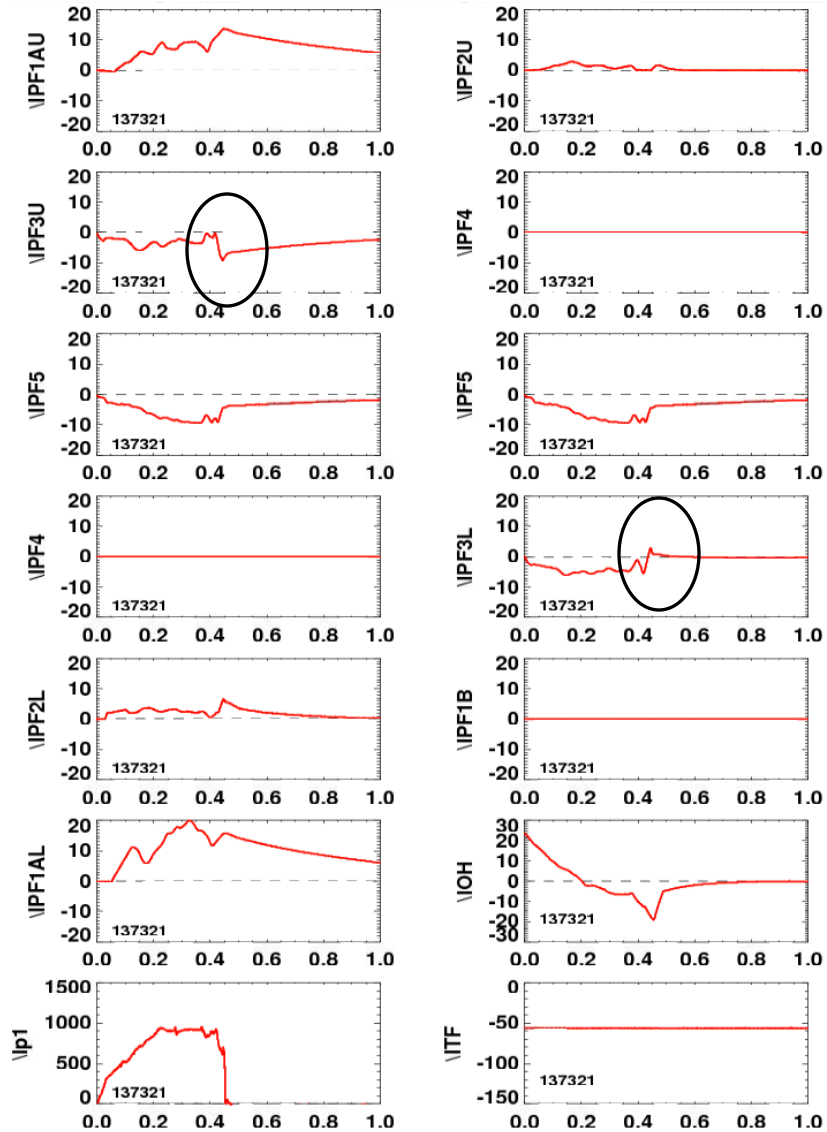
Large asymmetry in the PF-1a currents.

Easily leads to excessive vertical force on the solenoid.

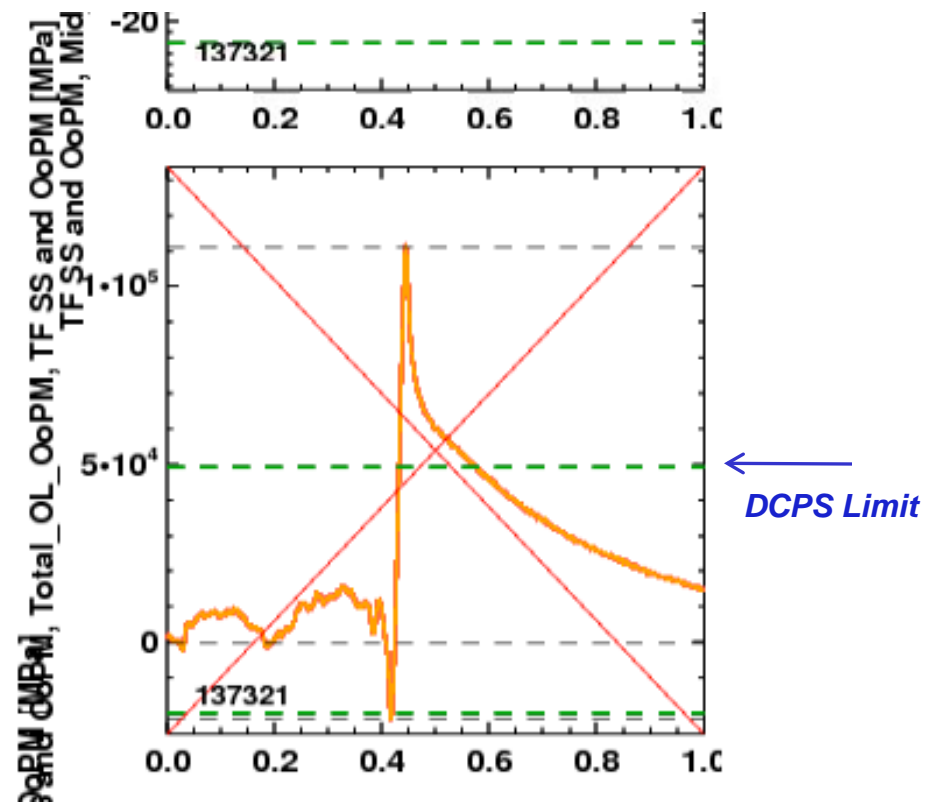


Design Limit is 20k-30k lbs.

Semi Random Example #2: Total Outer Leg (OL) Out of Plane Moment (OoPM)



SPG Comments
Again, large force set by transient response (PF-3U/L)



Software Spec. has been Drafted

- Bring a subset of highly reliable realtime signals into the system category, and use these to assess if a shutdown should be initiated.
 - I_p error, $B_{P,n=1}$ amplitude, vertical motion detector, operator trigger,...
 - This is all perfectly well defined at this point...read the spec.
- When it is initiated, make specific changes in a number of other categories (this part is less well specified at present):
 - I_p -OH: ramp down the plasma current over a predefined duration.
 - System: transition to shape category control of the PF voltage requests
 - Shape: Limit on the inner wall.
 - NBI: turn the beams off (probably just immediately off at first).
 - RWMEF: Turn the SPAs off
 - GIS: less sure...
- Note: this is NOT a general exception handling mechanism.
 - We should look into that, but I don't want to bog this down.

General Plan Towards an XP

- Need to finalize the software requirements, especially for the phase transitions.
 - I could use some practical help in assessing how the system and shape category phase transitions should be handled from a PCS specific perspective.
- Finish code.
- Run in the background: check it is alive
- Run the XMP: just to check that the most basic functions work.
- Optimization within this XP:
 - Pick an H-mode scenario of interest (probably the fiducial, whatever that ends up being).
 - Using the operator trigger, spend ~10 shots optimizing the rampdown for the allowed parameters (I_p ramp-rate, shape change timing,...).
 - Deliberately trigger disruptions ($n=1$ fields, turning off vertical control), and see system respond (5 shots).
 - Then append rampdown scenario to a second scenario of interest (5 shots).