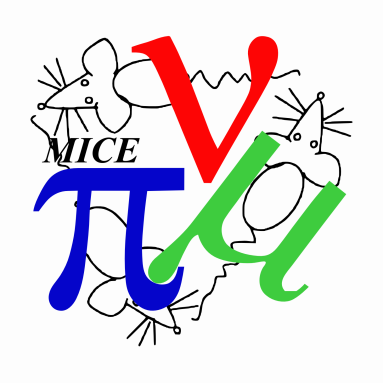
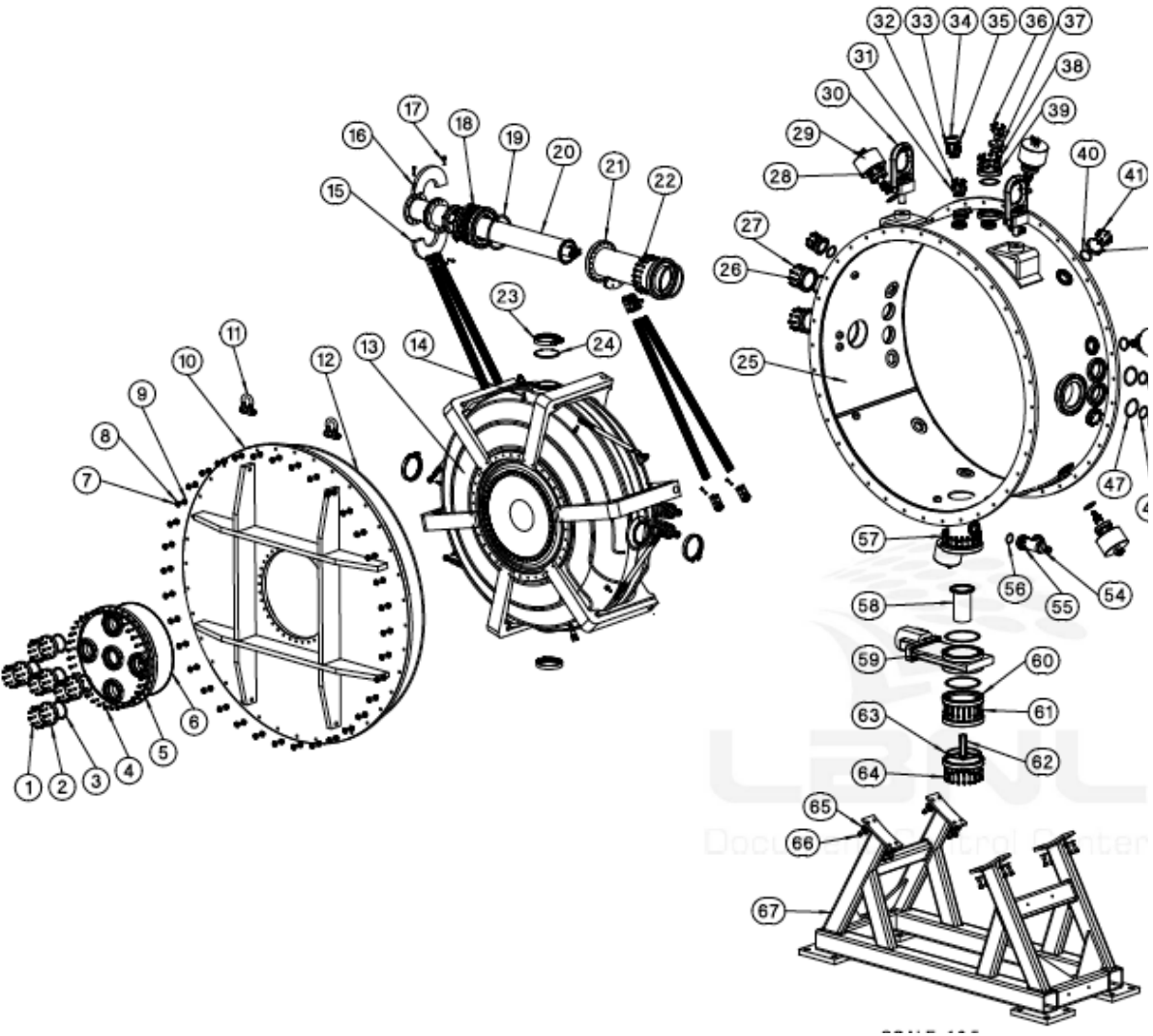


@

Yağmur Torun
Illinois Institute of Technology

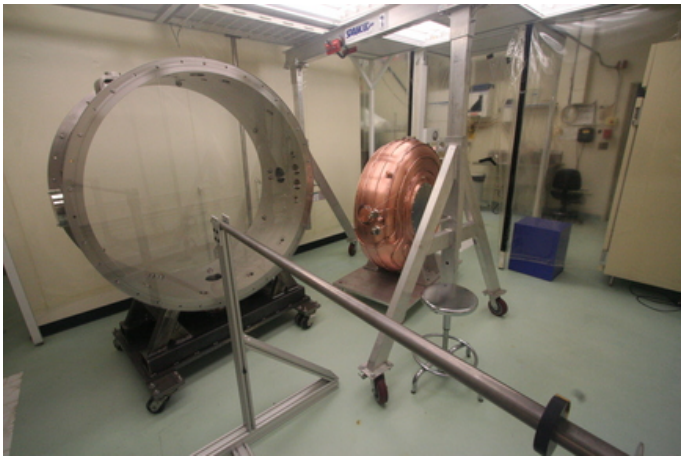
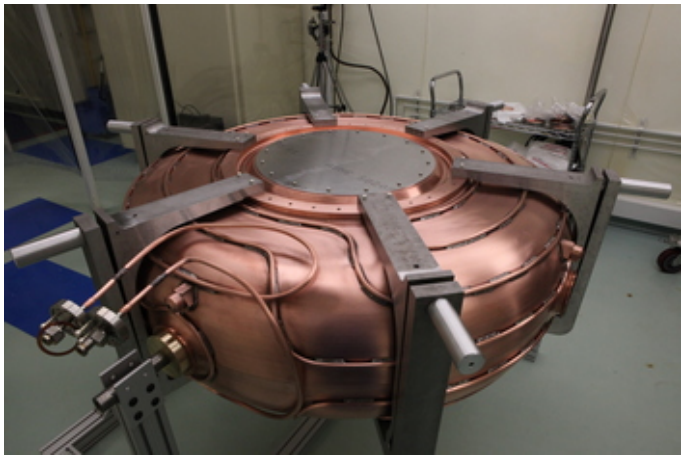
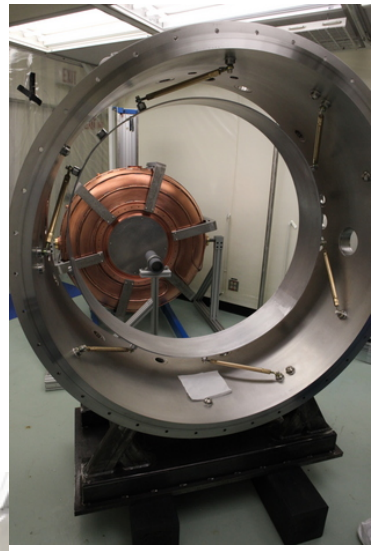
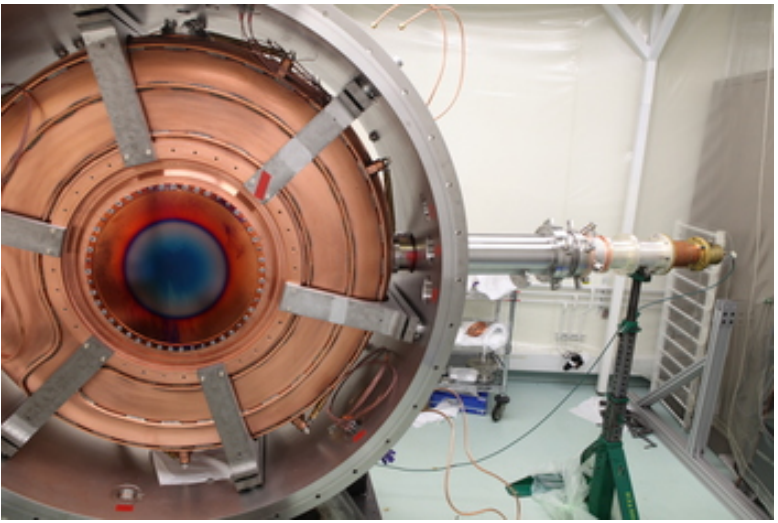
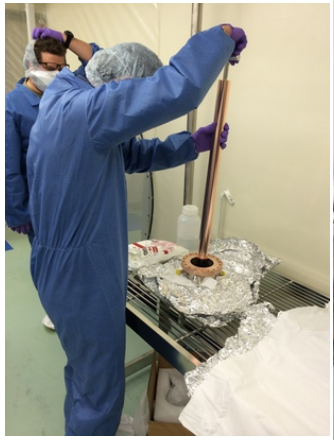
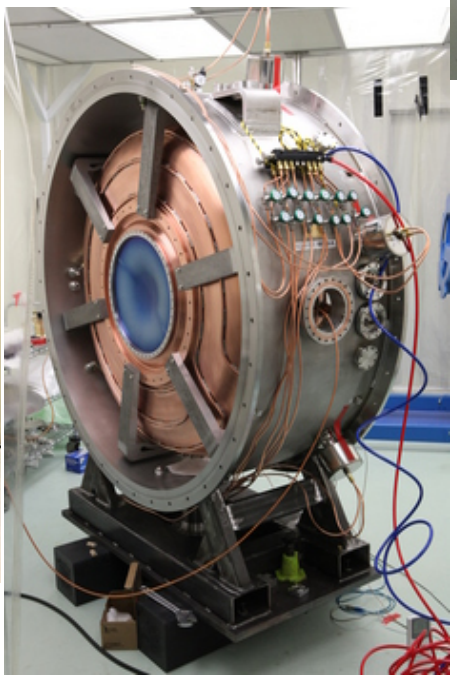
MAP 2015 Spring Meeting
FNAL – May 21, 2015

MICE RF Module Prototype

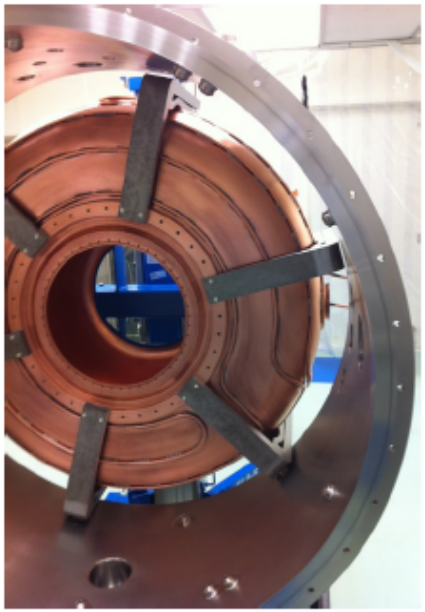
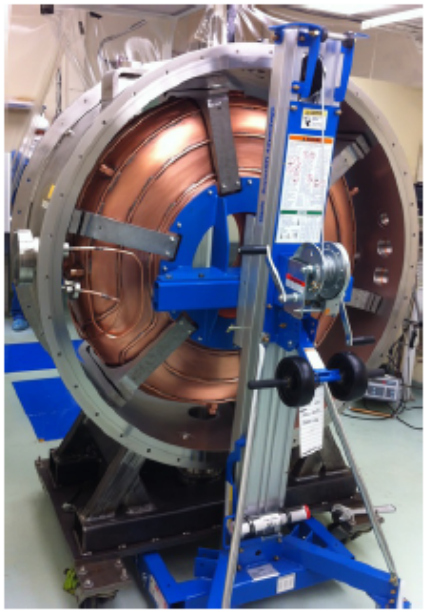
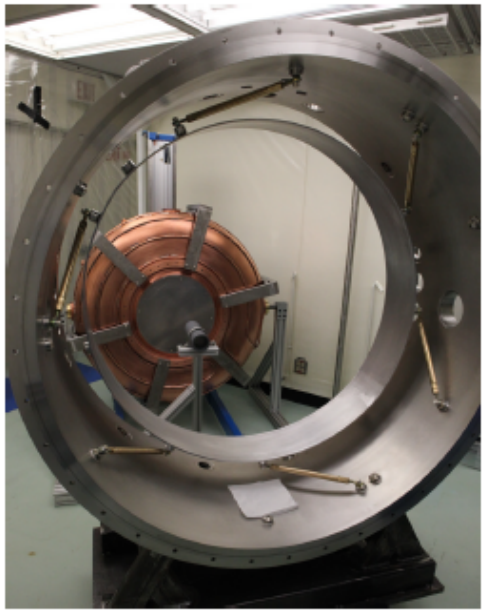


- Special vacuum vessel housing the 1st EP'd MICE cavity
- Aka SCTS, SCM, #@$*!
- Assembled in Lab-6
- Moved to MTA Hall May 2014

Assembly in Lab-6

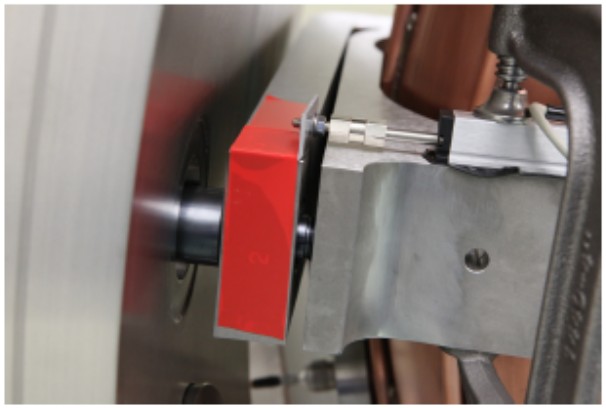







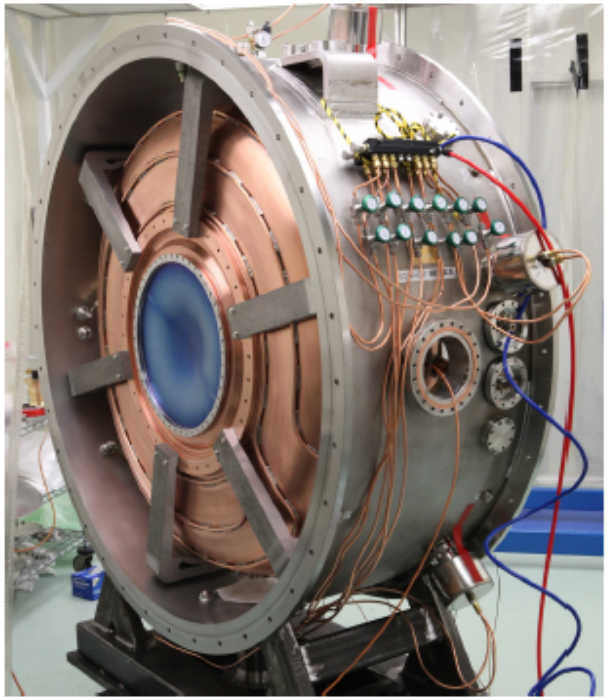

Cavity insertion

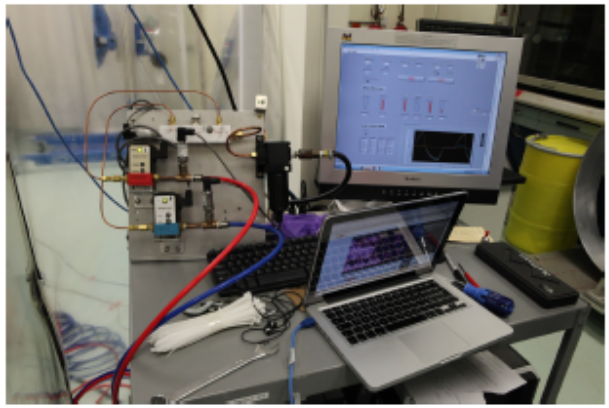





- Fixtures, alignment tools in hand
- Struts rebuilt

Tuner tests (Lab-6)

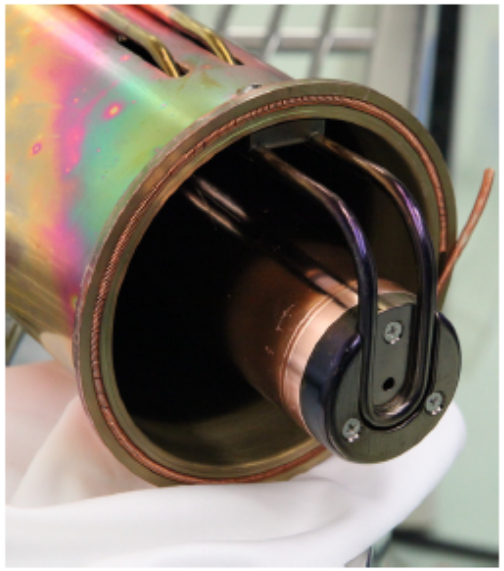


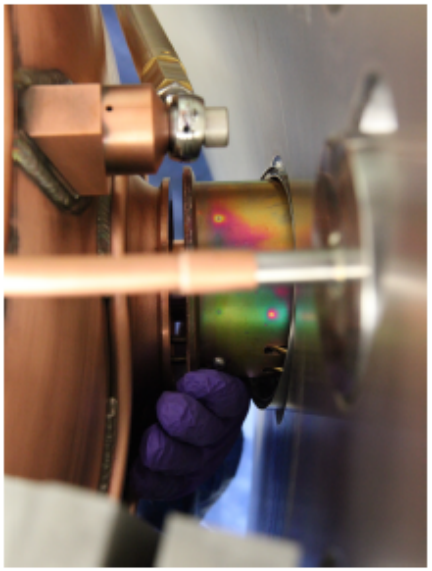
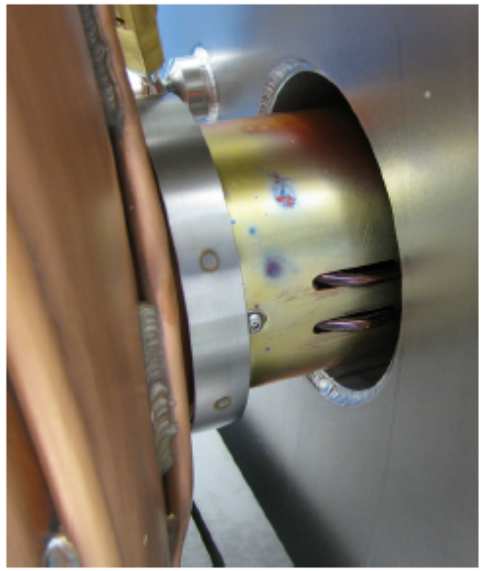




L. Somaschini, M. Sc. thesis

Couplers



- Leak check fixture built
- Design updated
  - Modified flanges and support for easier installation/adjustment
  - Holes plugges

Assembly in Lab-6

Transport to MTA

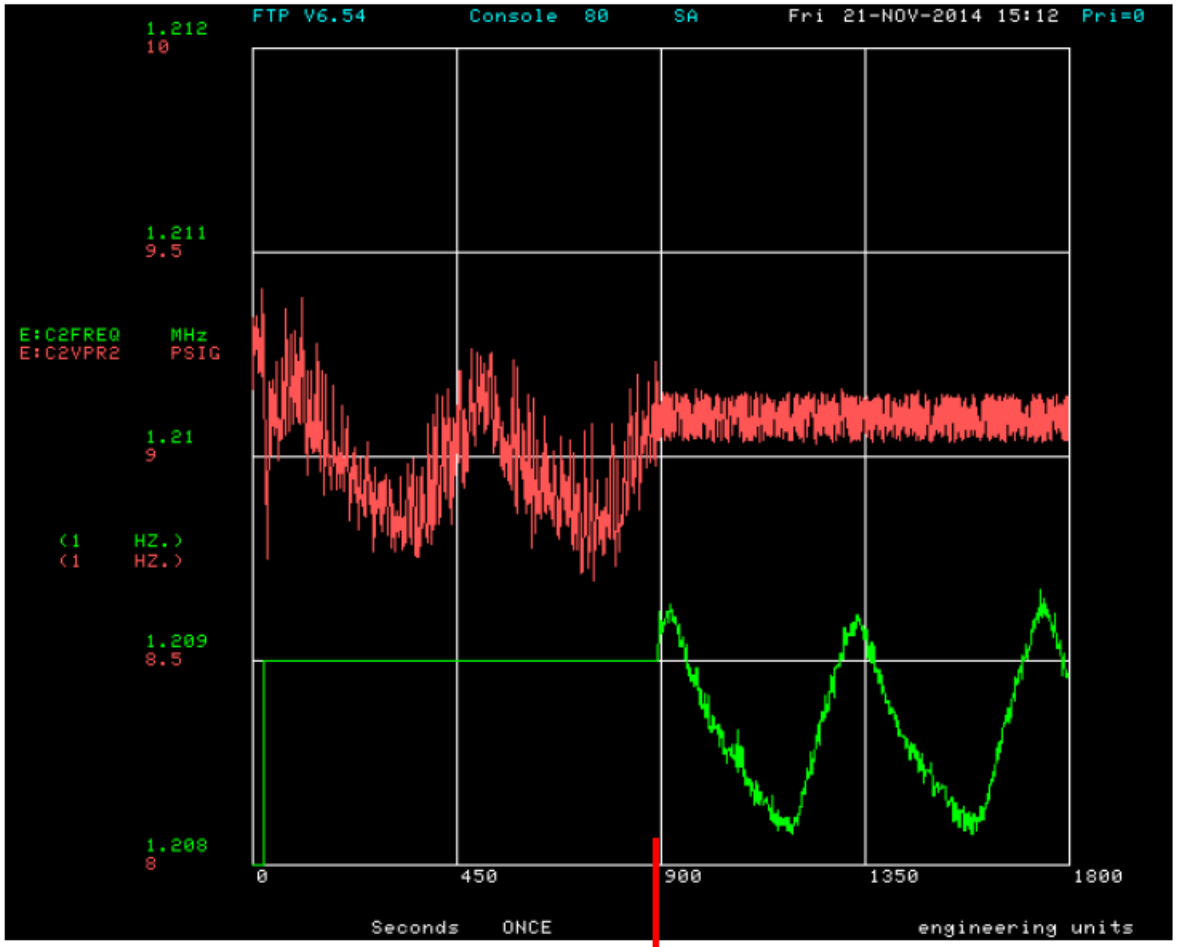
Instrumentation

- The most heavily instrumented cavity system in MTA history
  - water pressure, flow, temperature
  - RF coax N2 pressure
  - tuner actuator N2 pressure
  - external plastic scintillator counters
  - radiation dose rate monitors
  - temperature sensors on cavity body
  - acoustic sensors on cavity body
  - fibers for light inside cavity and near RF windows
  - cavity field pickup probes
  - cavity, vessel, manifold vacuum pressures

Run History

- MICE cavity powered Aug 4, 2014
  - 1 MW (old baseline) Aug 7
- Shifts starting Sep 2014, 24x7 coverage
- Operated until Nov 26, 2014
  - during Fermilab accelerator complex shutdown
  - 61% uptime, 74% shift coverage
- B=0, Cu windows
- Demonstrated
  - operation at power (3.5+ MW) well beyond new baseline
  - frequency control with (5) tuners
- Next step: reconfiguration for B-field
  - also Be windows & full tuner system

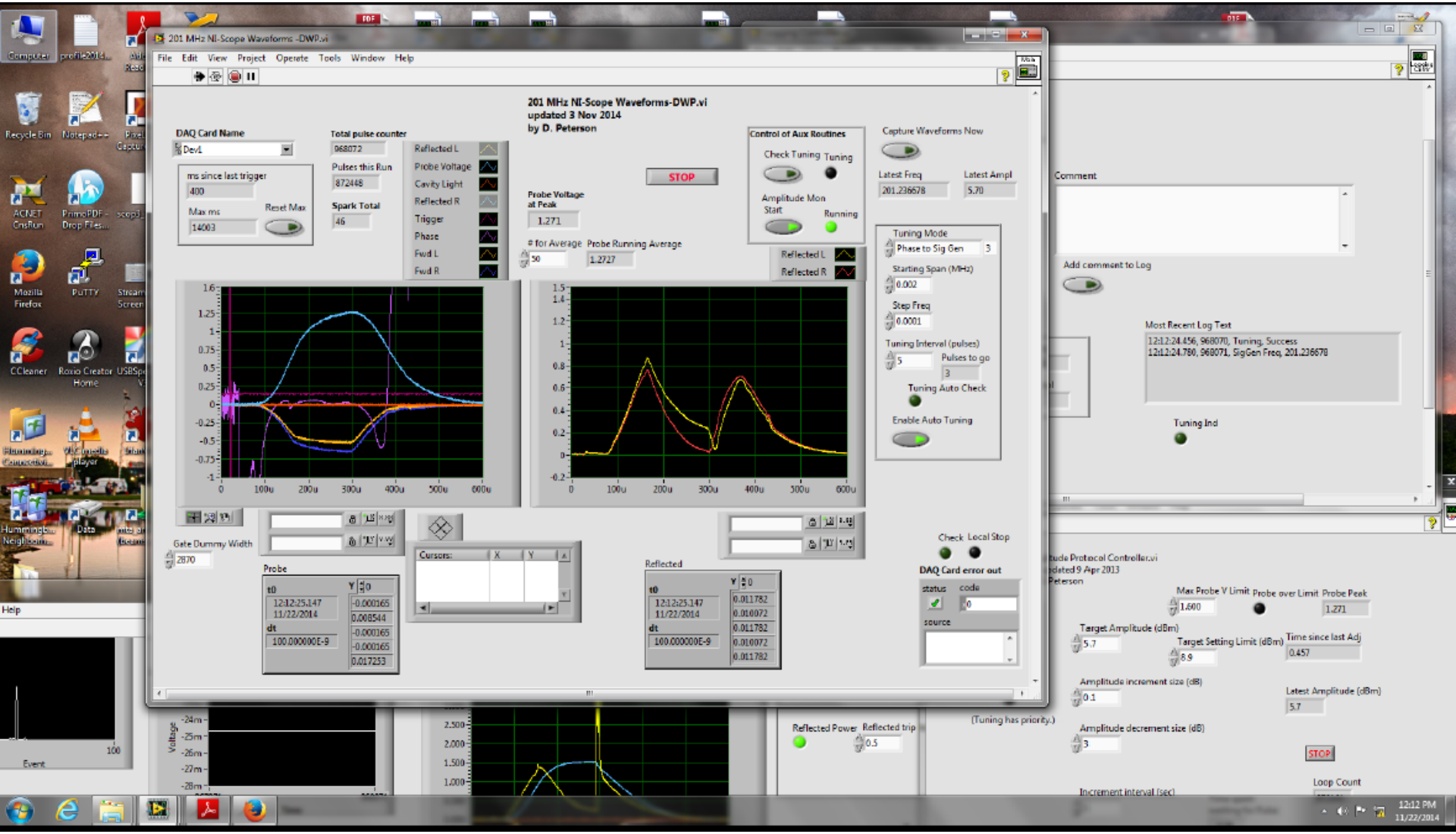
Tuning tests (5/6)



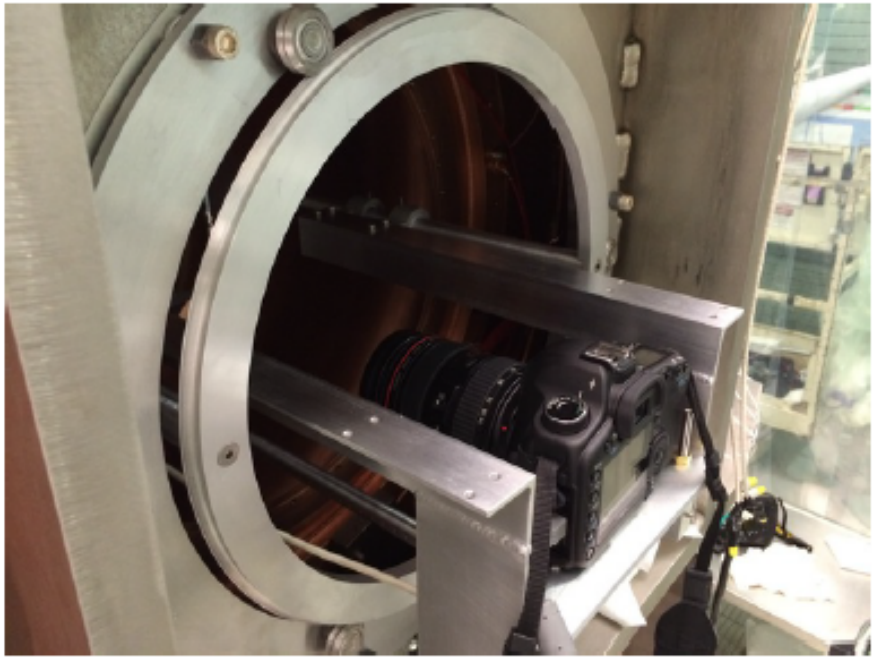
Constant Frequency with pressure tracking

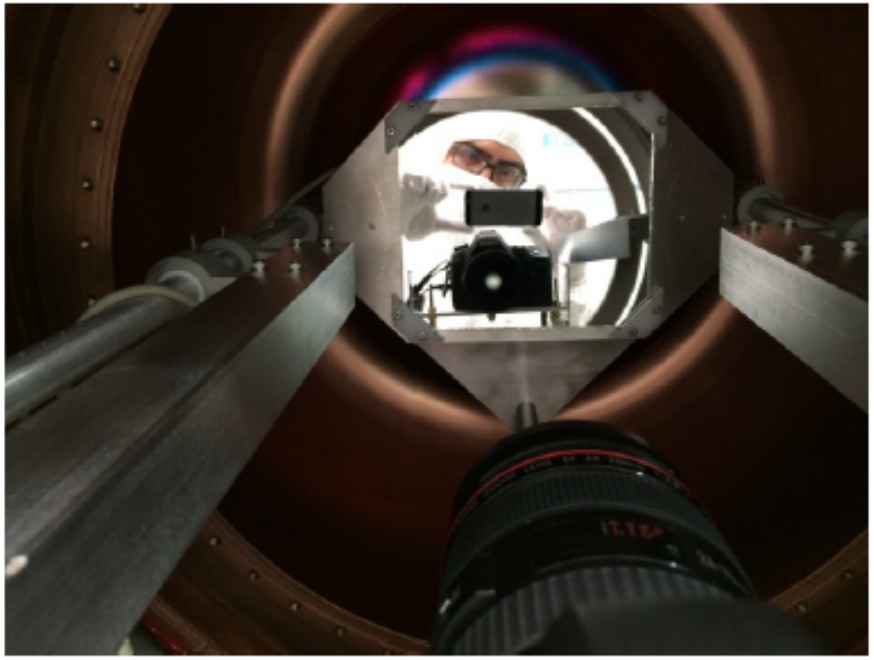
Constant Pressure with frequency tracking

RF Controls (D. Peterson)



Interior Inspection

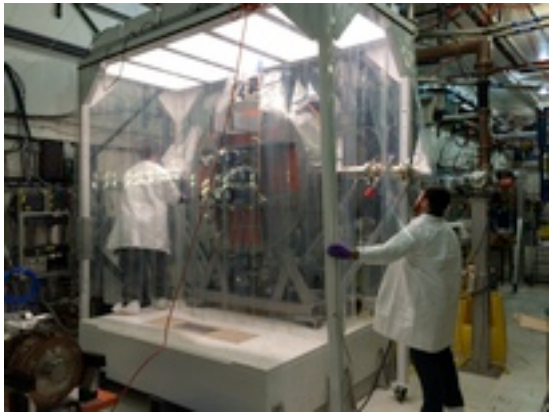


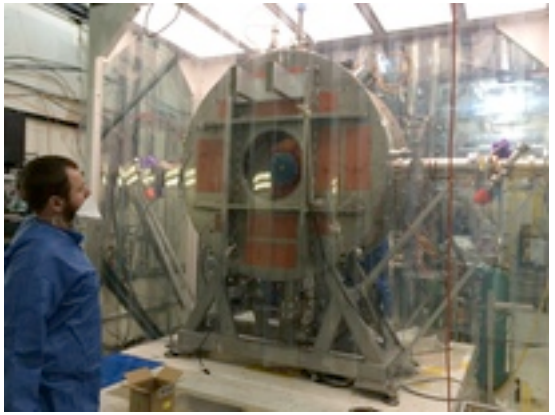
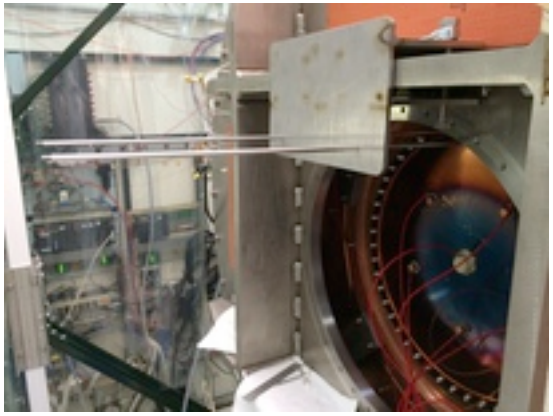
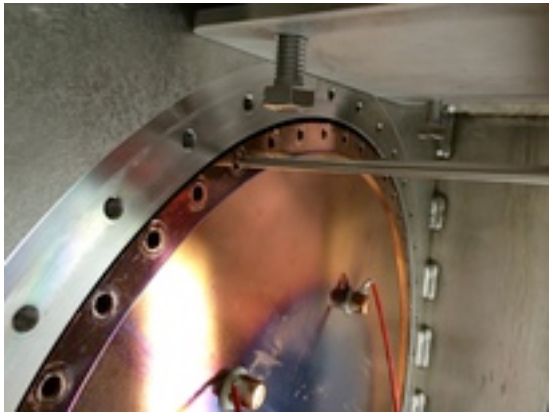


Reconfiguration (Jan-Feb 2015)

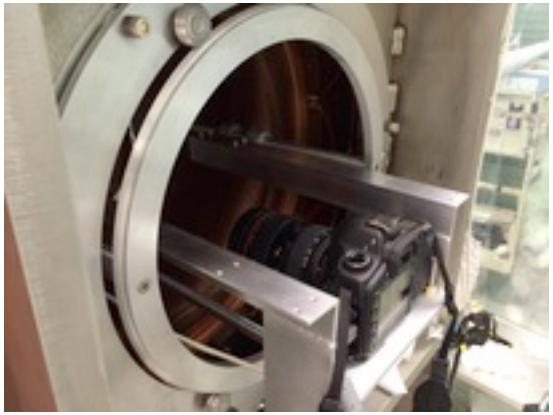
- Interior inspection
  - no damage seen in cavity or near coupler windows
- Be windows installed
- Frequency measurements with spacers under window
  - Matches Tianhuan's prediction
- Missing actuator installed
  - Another leaky one replaced with spare
- Succesful pump-down
  - Vacuum leak at RF window instrumentation port

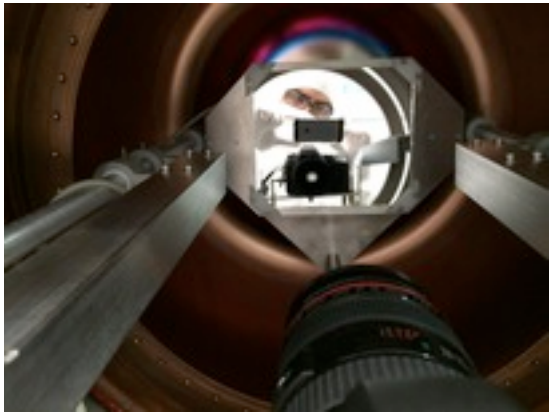
Reconfiguration

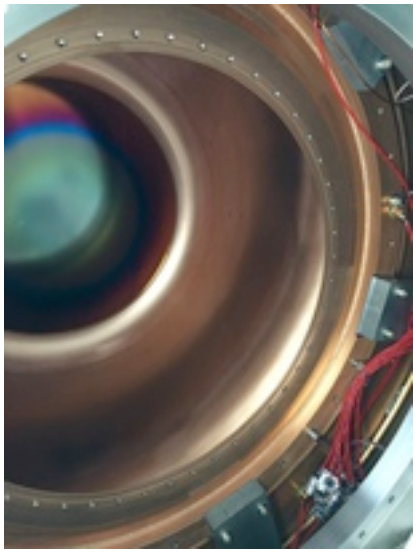


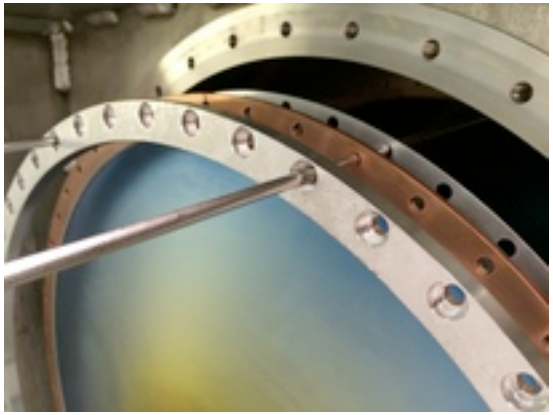




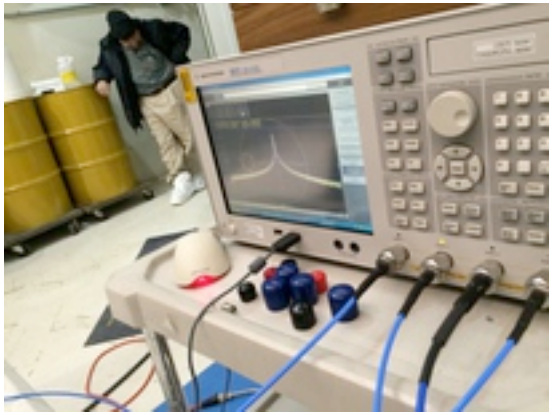

Reconfiguration

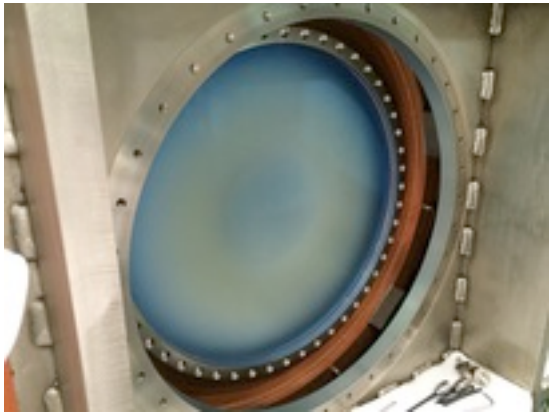








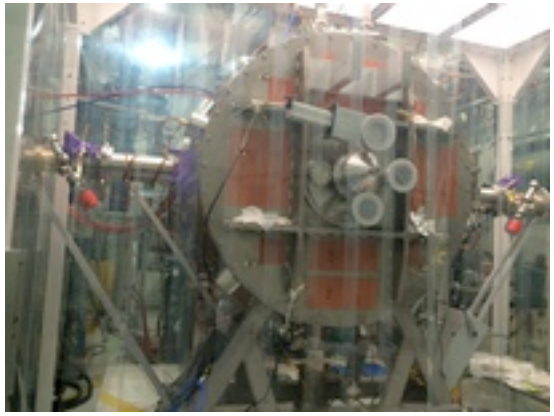
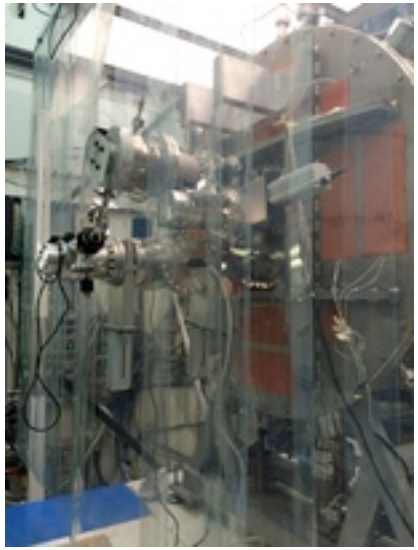




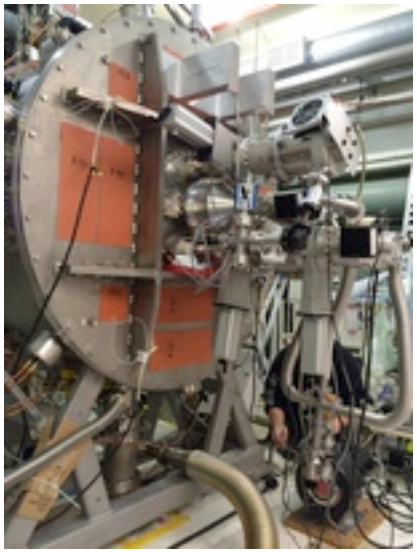
Reconfiguration

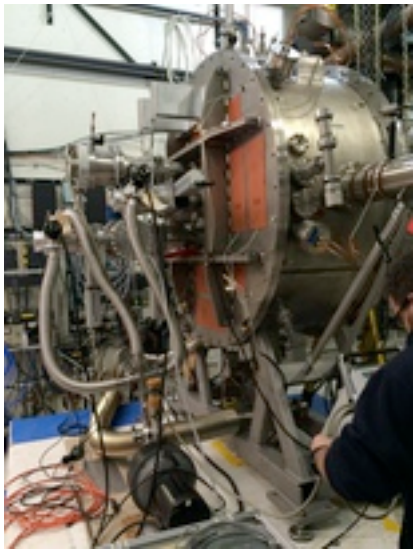


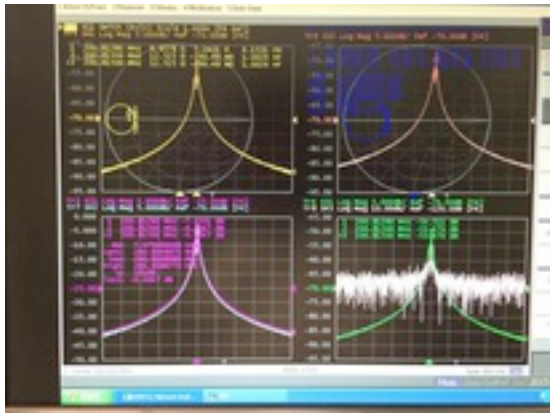



Reconfiguration







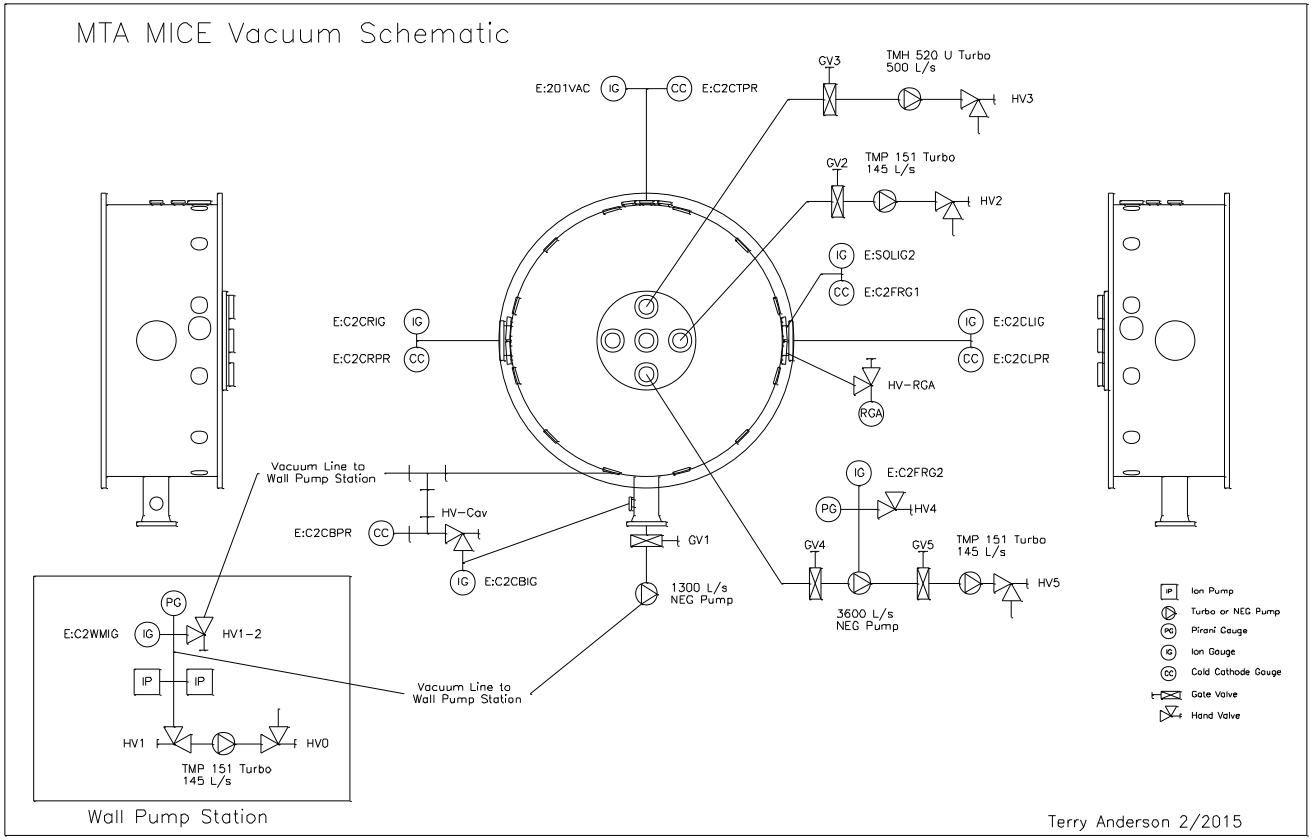
Services

- Water cooling
  - Average power/cavity up by 60% in new MICE baseline (1.6 MW)
    - increased temperature differential across the 2 faces
  - Flow through cavity circuit limited by pressure drop
  - MTA RF pulse has 10-20% of flattop but can run at up to 10 Hz
    - ran at same/higher average power
- Actuator gas
  - Tuners measured to 100 psi, 80 psi available in hall
    - Much less needed for operation
      - Transfer function +3/-4 kHz/psi
      - Cavity bandwidth is ~4 kHz
      - Expected temperature dependence -3.4 kHz/C

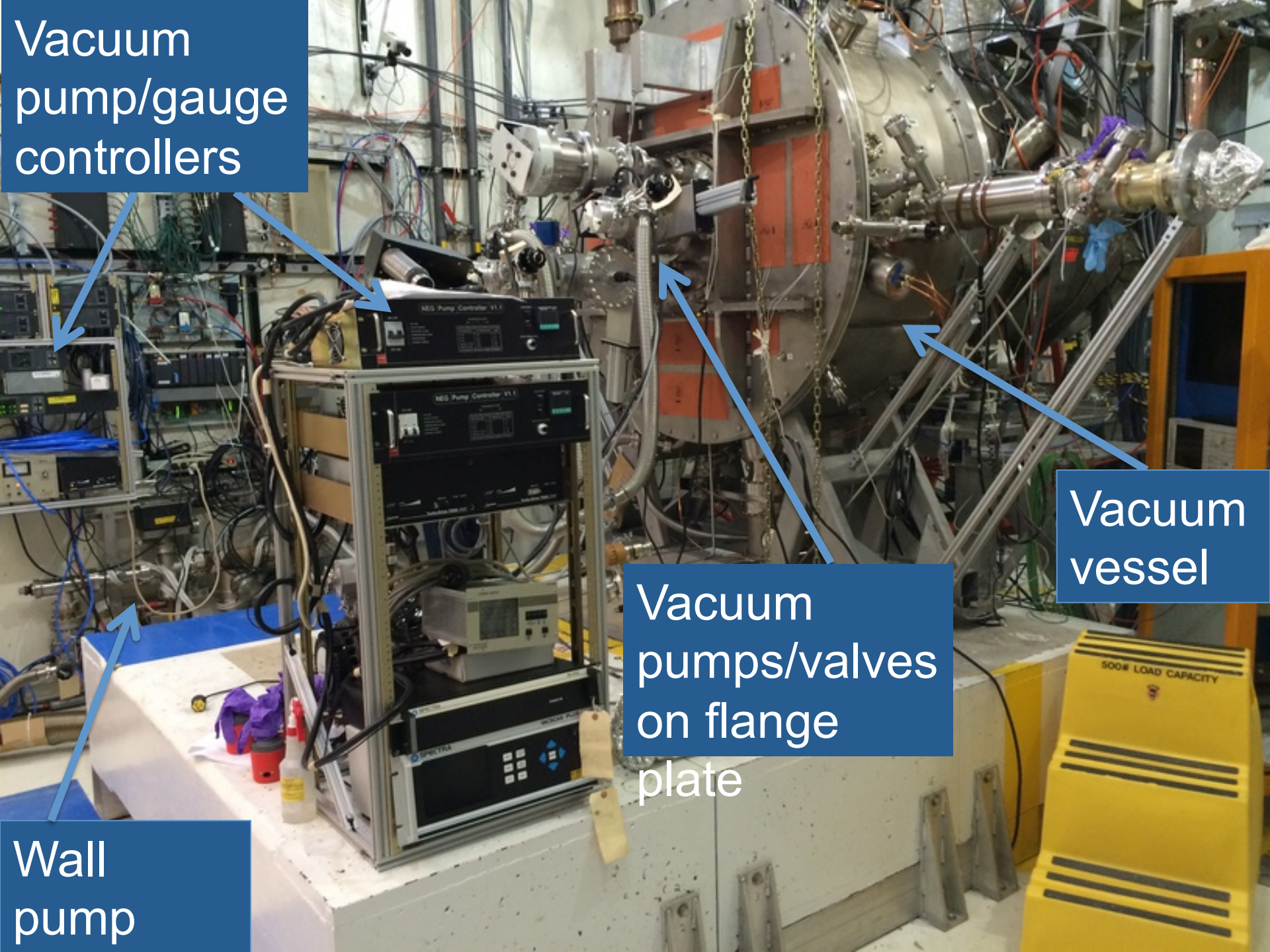
Vacuum system

- Original layout (single getter pump at bottom of cavity) did not have enough pumping speed or capacity for cavity+vessel
- Blocked space between cavity bottom tube and vessel
- Added turbo pumps on flange plate to handle vessel load
  - not an option in magnetic field
- Large leak path still present through coupler holes
  - addressed in latest design changes
- New configuration with HV getter pump on flange plate
- Retrofit resulting in complex system
  - 9 pumps, 17 valves, 135+ flanges, 14 gauges
- Be window safety considerations limit allowable differential pressure between inside & outside of cavity
  - Inside should be <0.1 uTorr
  - Outside shared by rest of cooling channel (few uTorr)
  - Need (at all times)
    - Large conductance for viscous flow
    - Small conductance for molecular flow

Fermilab Vacuum System (T. Anderson)



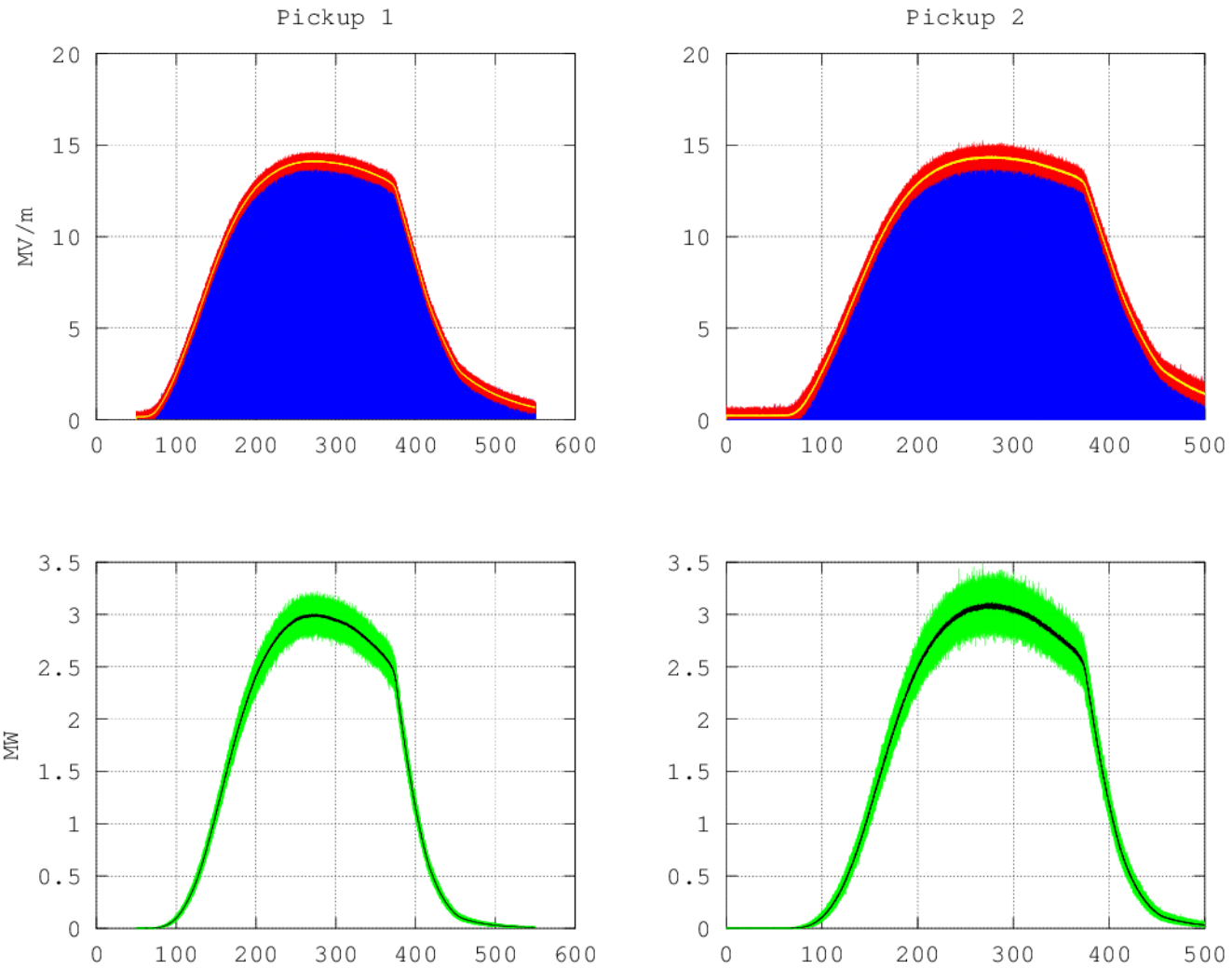
- Detailed procedures prepared
- Measurements made in different configurations to
  - confirm outgassing loads, conductances, gas composition
  - provide data to be incorporated into final vacuum system design


Vacuum pump/gauge controllers
Vacuum vessel
Vacuum pumps/valves on flange plate
Wall pump
500# LOAD CAPACITY

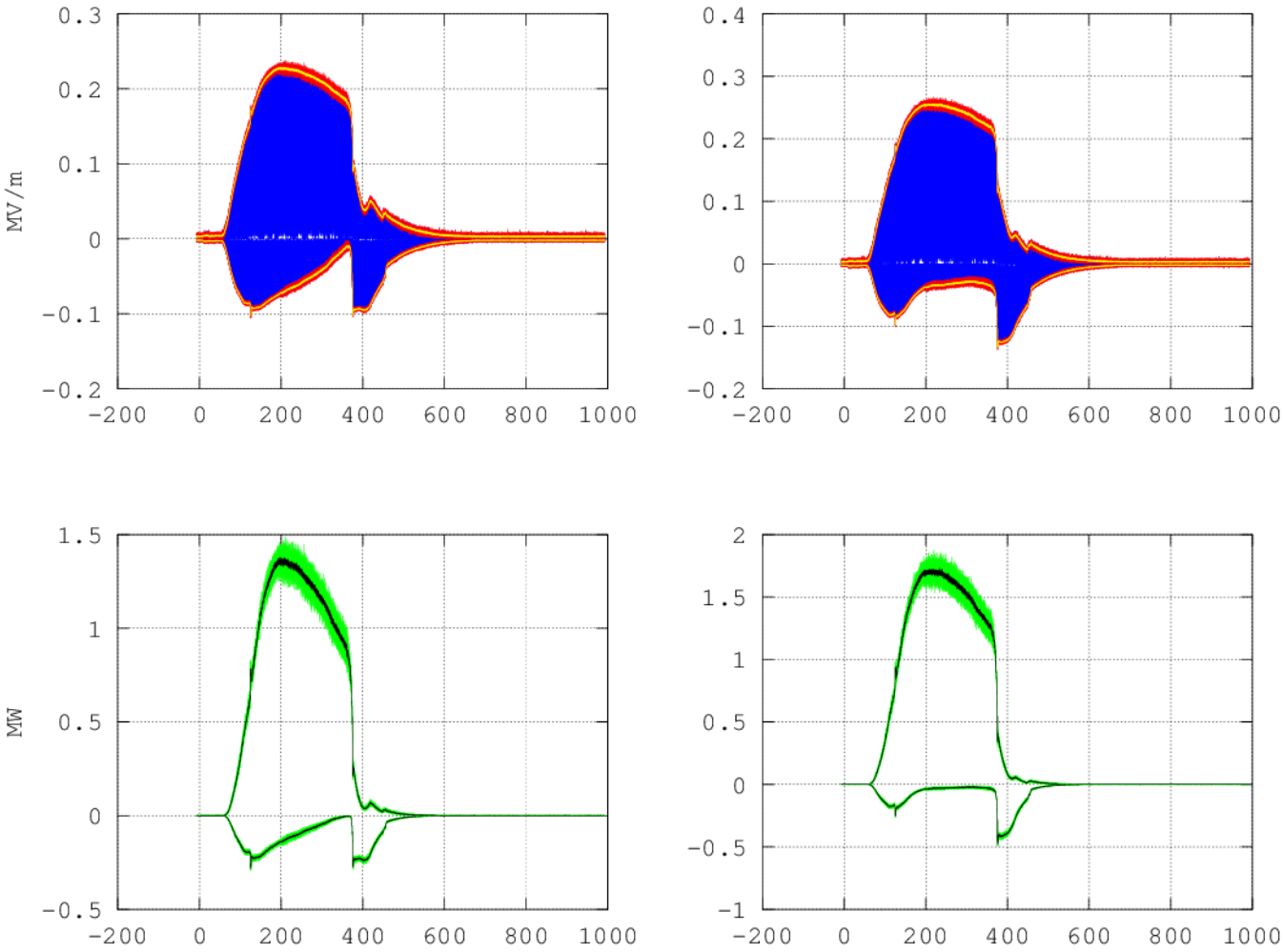
Recent Progress

- Ran with Be windows (B=0) Mar 18-Apr 6, 24x7 shifts with some breaks
  - 11 MV/m to confirm all is OK
- B=5T run Apr 24-May 20
  - Demonstrated/exceeded MICE operating parameters in 3M pulse stretch
    - Gradient (~11 MV/m), peak power (~1.8 MW)
    - With 0.8M pulses at MICE average power
  - Also pushed higher
    - 14.5 MV/m, limited by amplifier power

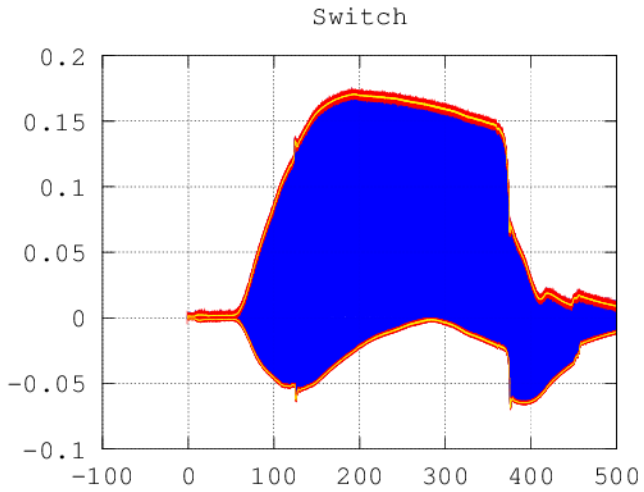
Pulse 6849000

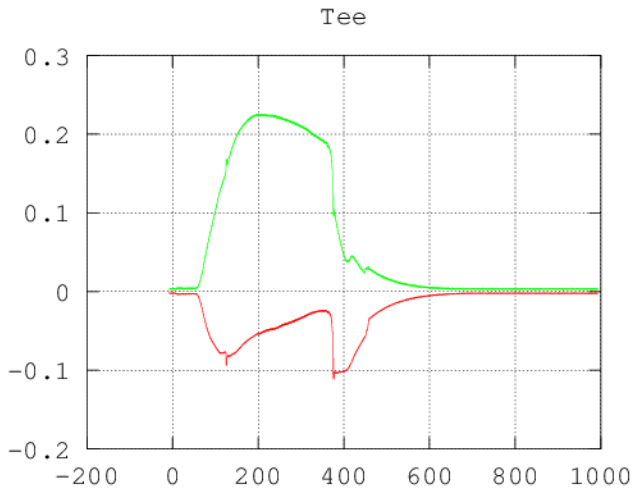


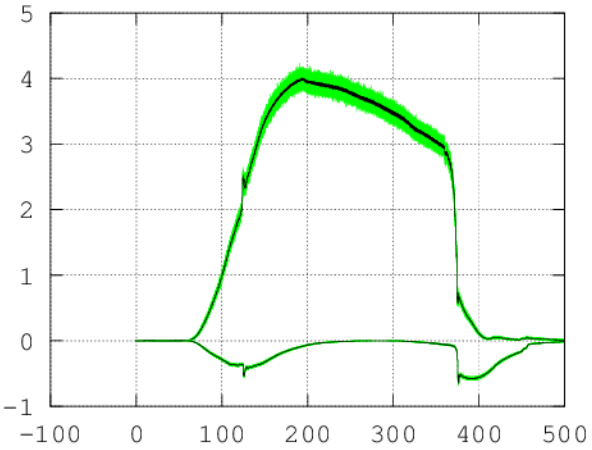
Pulse 6849000

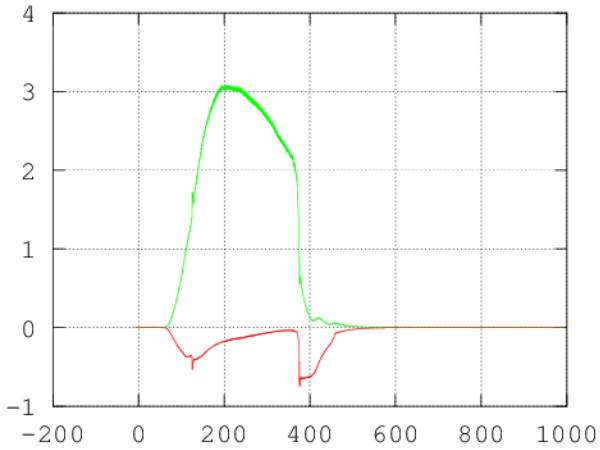


Pulse 6849000

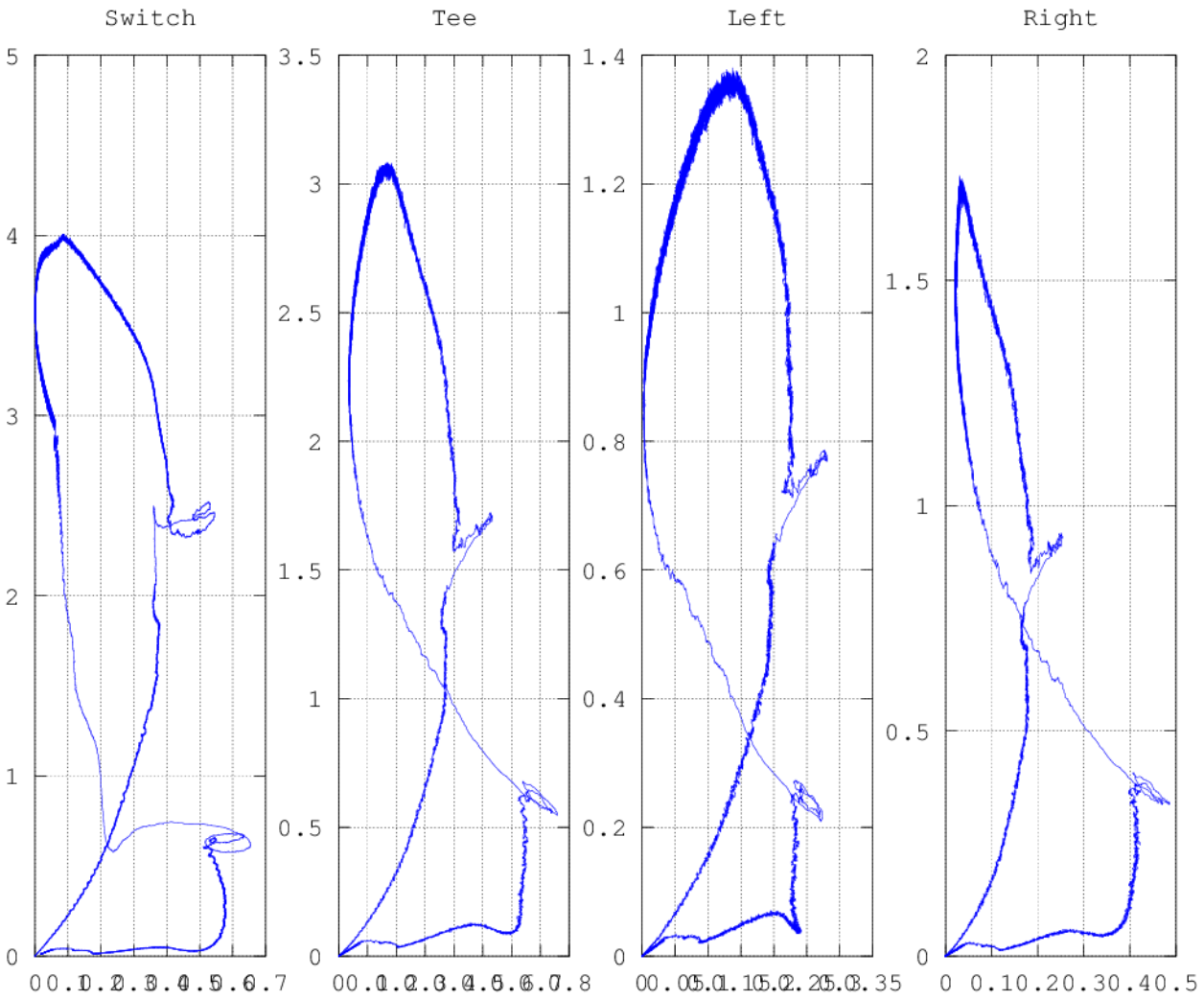








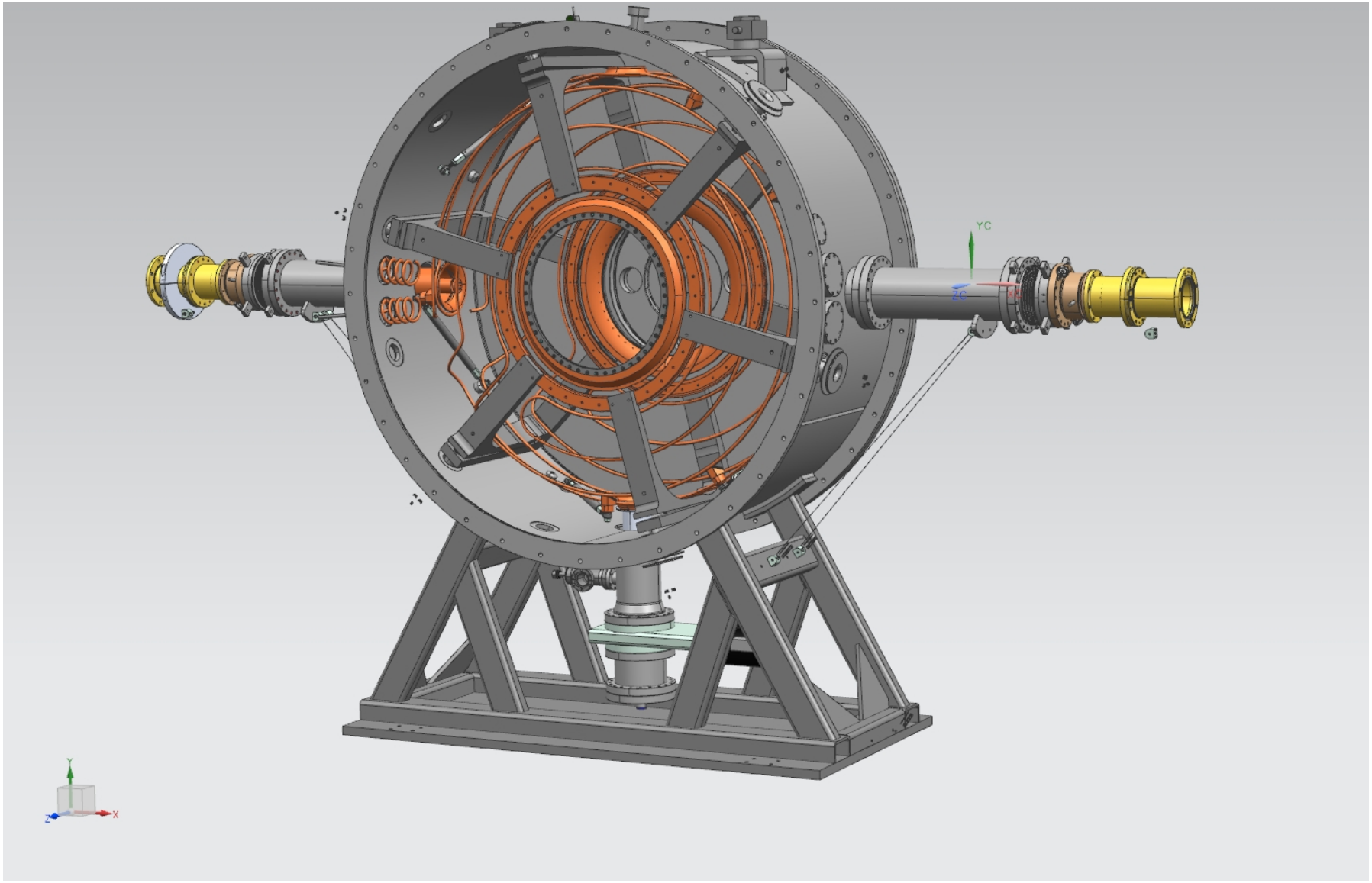
Pulse 6849000



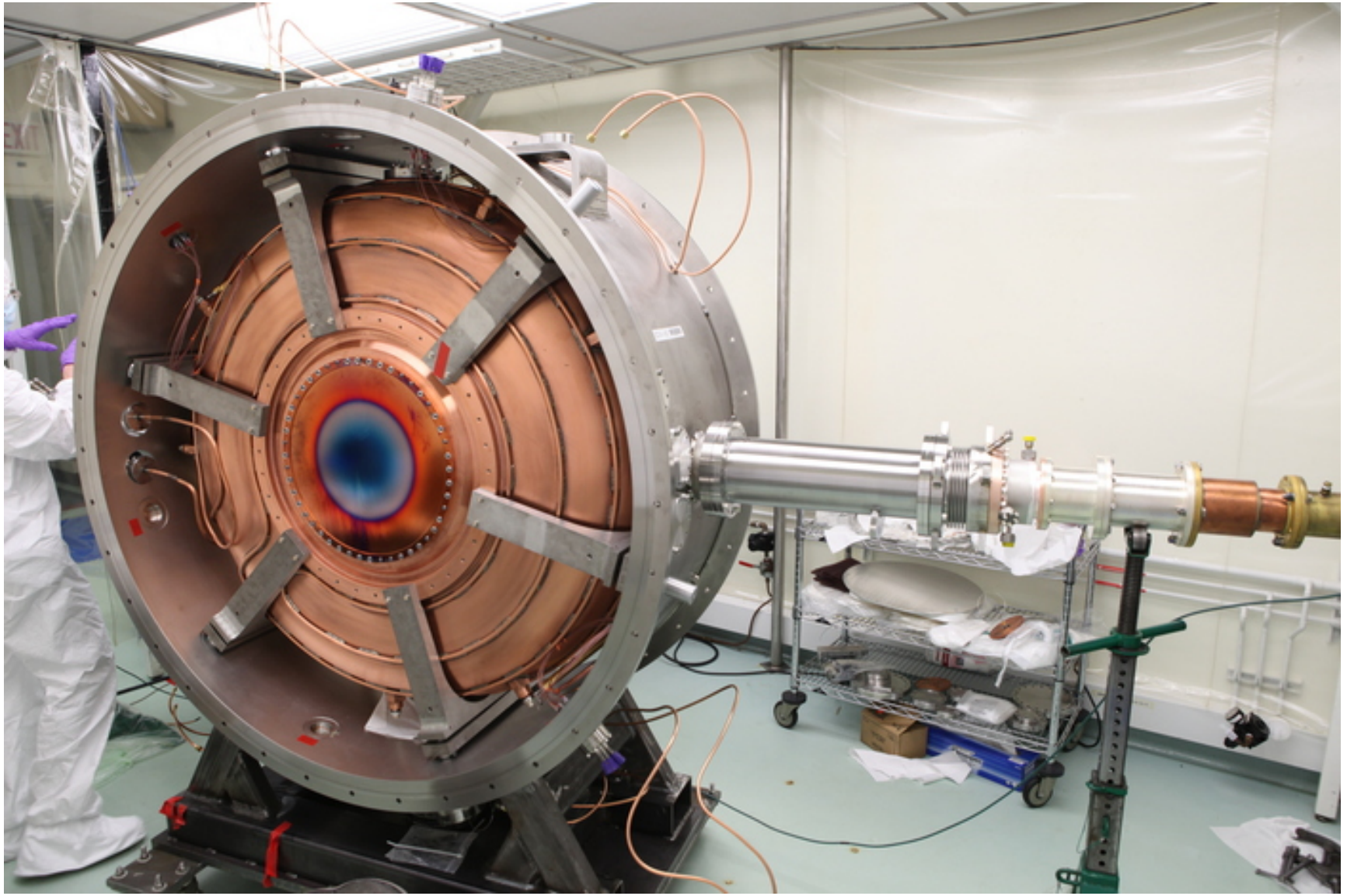
Status & Schedule

- High-power run (B=5T, Be) finished yesterday
- Intend to complete rest of the present run plan next week
  - B-field and gradient sweeps to investigate
    - Radiation rates
    - Dark current
  - Full tuner system test under power
- Shifters welcome
- Possible future tests
  - Inspect cavity interior and couplers
  - Measure Be window temperature
  - Run with a new coupler
  - Install/test new actuators
  - Beam test

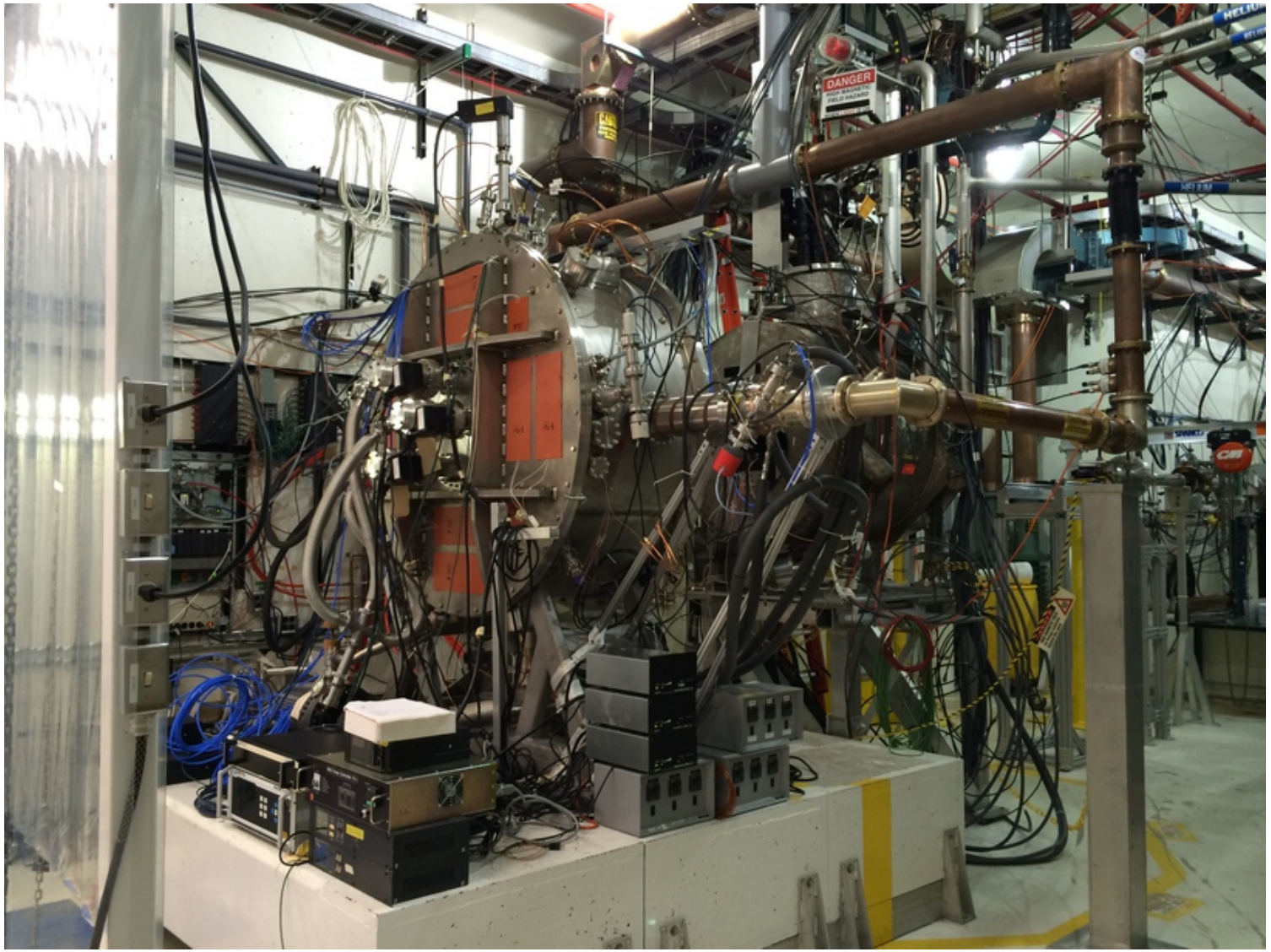
Design



Assembly



Installation



Experience => MICE

- The prototype under test in the MTA has mostly the same components and interfaces as the MICE RF modules
  - Module assembly
    - fixtures, procedures
  - Services and instrumentation
    - vacuum system
    - cooling, thermal response
  - RF system
    - cavity instrumentation and calibration
    - DAQ, signal analysis
  - Tuning system
  - Controls, monitoring, interlocks

Acknowledgement

Shift crew

- Michael Backfish, Daniel Bowring, Ben Freemire, Terry Hart, Chris Hunt, Alexey Kochemirovskiy, Peter Lane, Maria Leonova, Tianhuan Luo, Al Moretti, Dave Peterson, Milorad Popovic, David Speirs, Tim Stanley, YT, Colin Whyte, Katsuya Yonehara