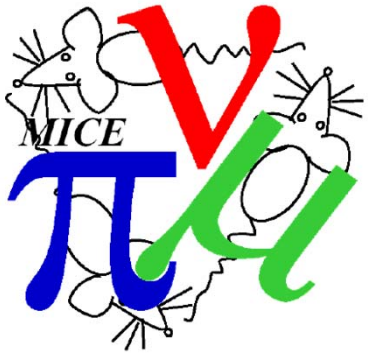


CM 35 RF Session Summary

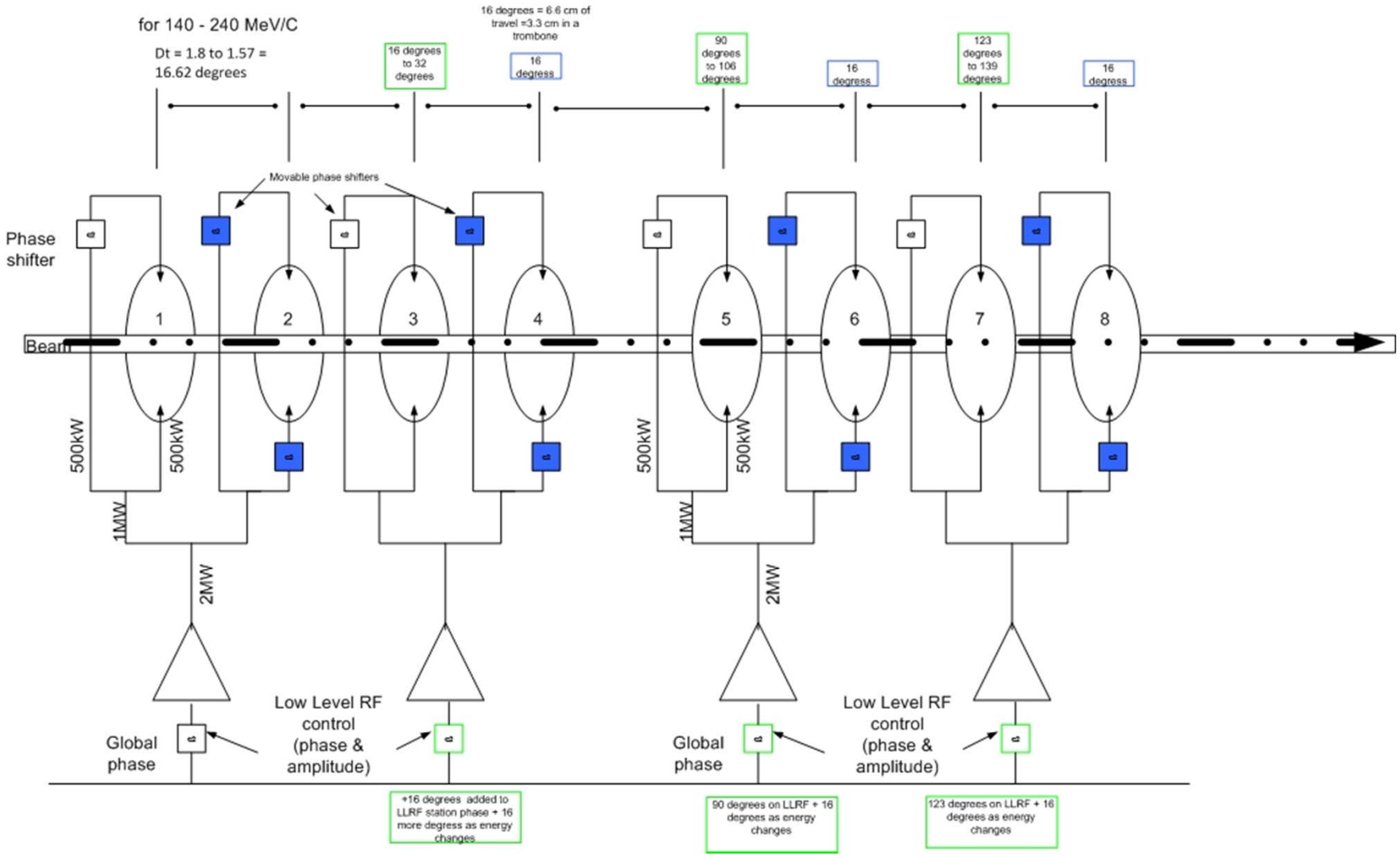
Kevin Ronald for

The MICE RF Group

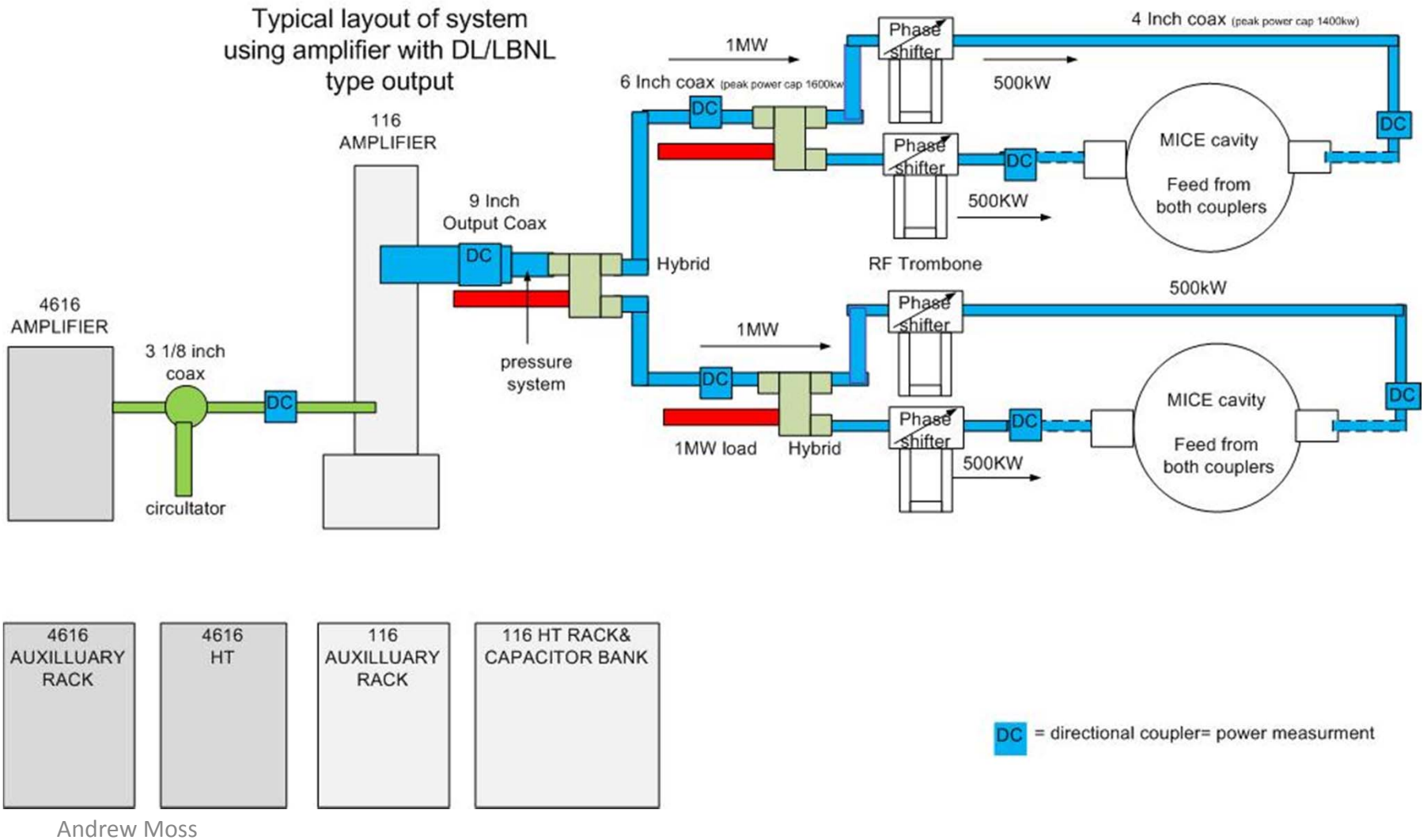
Contents

- Report from Andy Moss on the progress on the HP tests
  - Power limitation traced to arc'ing problem on anode
  - Mitigation
- Report from Alan Grant on the progress on the distribution network and TIARA test station
  - Design finished
  - Procurement in progress
- Report from Yagmur Torun on Cavity Test Plan at MTA
  - Detailed plans for assembly and installation of 1st cavity in Single Cavity Test Stand
  - Schedules for tests
- Report from Derun Li on progress on RFCC
  - Resolution of cooling pipe problem
  - 1st coil at FNAL for testing in FSU cryostat
  - RFCC cryostat design complete

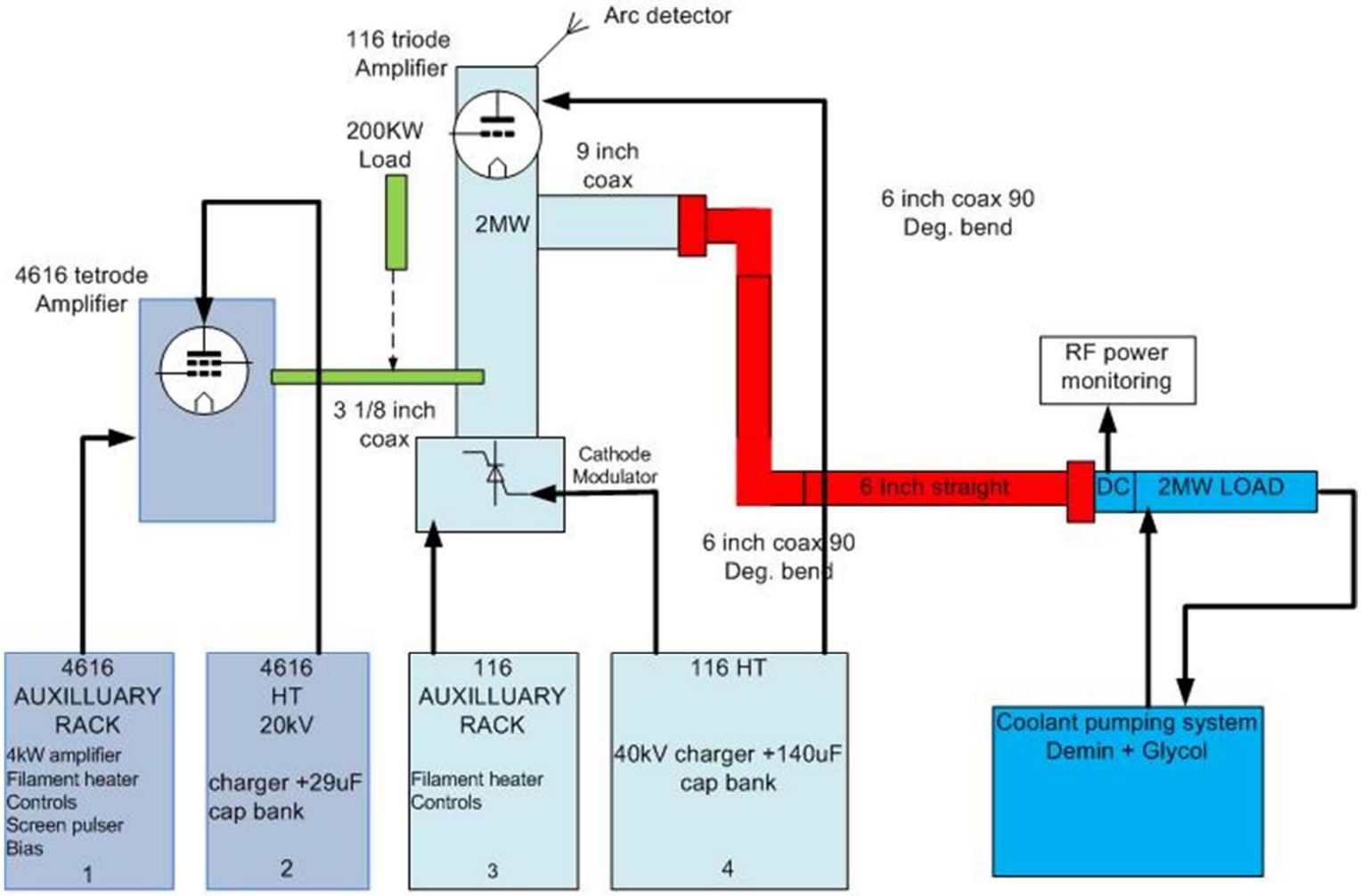
Schematic of System



Amplifier layout

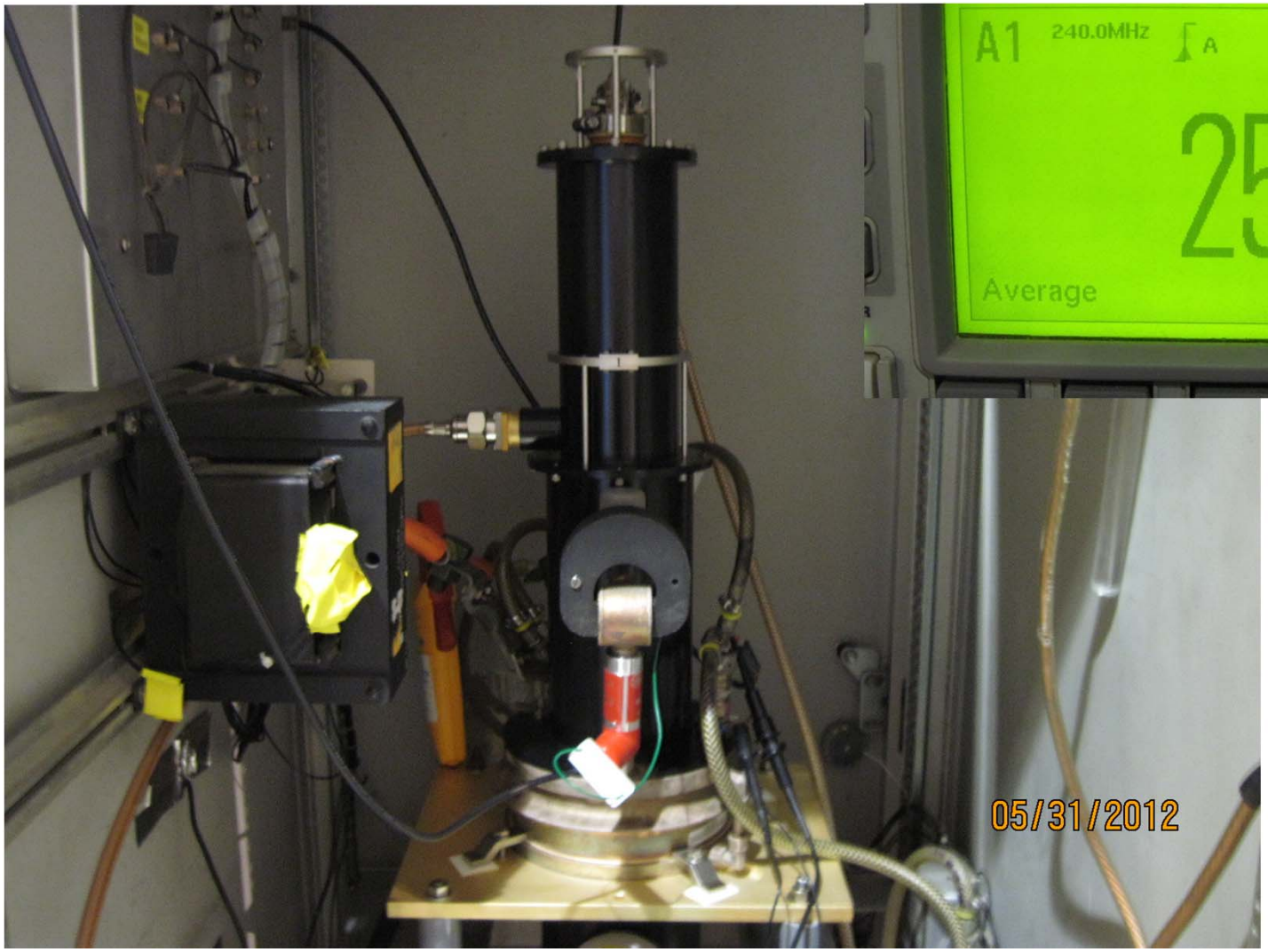


Test system at Daresbury



Daresbury test setup for proving amplifiers/power supplies

New 250kW amplifier enclosure



New amplifier operating at 240MHz (driver low on gain at 201MHz)

Delivered to Mississippi on 8th June 2012

New tetrode tube in DL test amplifier number 1

- Tube needed to be conditioned after spending 3 years on shelf
- Input matching required careful tuning as new valve presents different RF load eventually this was optimised at around 20dB
- After 20 hours running, with a lot of adjustments to amplifier and electrical parameters, system is stable and predictable with linear response
- Still some issues with screen power supply to sort out – loading of screen is moving with beam current and output loading

Drive (dBm)	ct 100mv per amp	HT (kV)	Electric power in tube (kW)	Grid 1 (V)	Screen Grid (V)	Drive (W)	Forward power (kW)	Reflected power (W)	Reflected Power Percentage (%)	Gain (dB)	Efficiency (%)	Ion Pump Current (µA)
0	8.1	19	153.9	170	1740	1086	48	243	0.5	16.5	31.2	0.11
1	9.9	19	188.1	170	1740	1376	69.2	320	0.5	17.0	36.8	0.17
2	12	19	228	170	1740	1740	102	307	0.3	17.7	44.7	0.3
3	14.9	19	283.1	170	1740	2200	158	311	0.2	18.6	55.8	0.39
3.5	17	19	323	170	1740	2480	208	314	0.2	19.2	64.4	0.55
3.7	17.7	19	336.3	170	1740	2580	236	364	0.2	19.6	70.2	0.98
3.5	17.5	19	332.5	170	1740	2480	234	287	0.1	19.7	70.4	0.64

RF and power supply testing

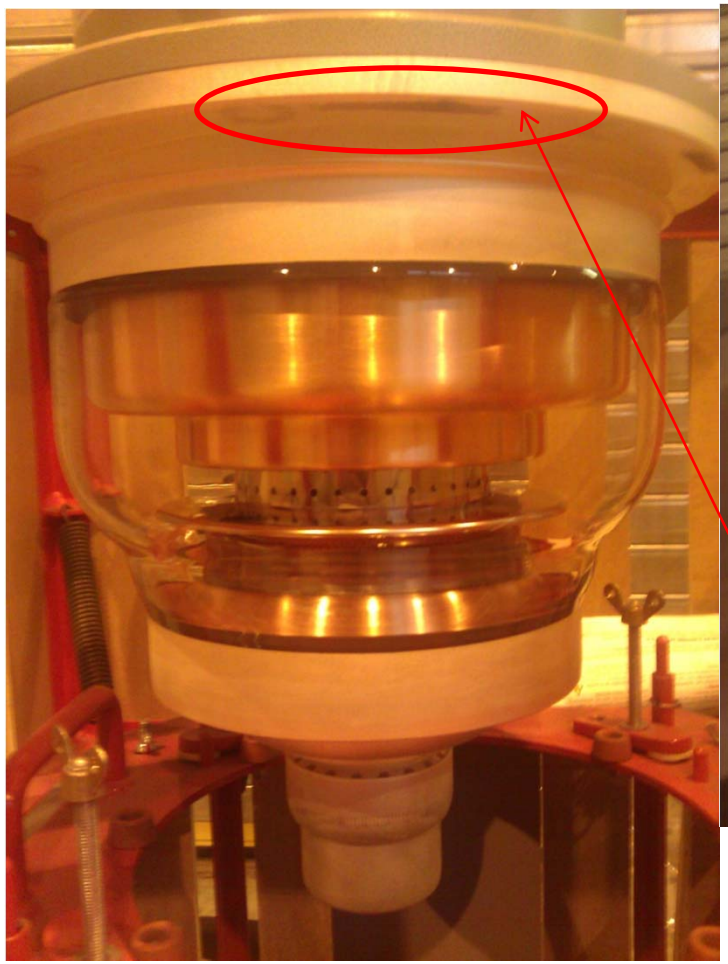
- Operation at 1.2MW with good conversion efficiency and gain
- Overload of power supply resistors during a crowbar caused system stop, replaced with higher power units, testing underway, but now problematic – repeated crowbar events

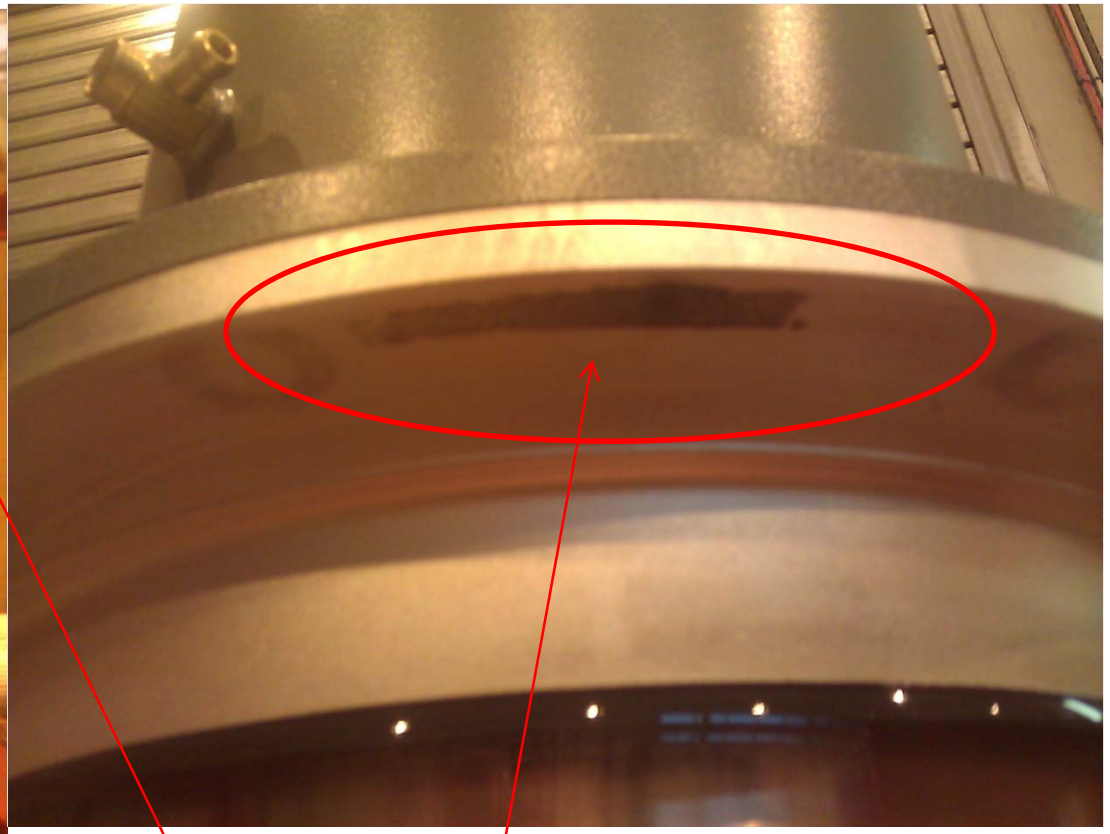
Forward power into load

Current status of HP Tests

- Testing of the amplifier system continued into late 2012
  - However performance above 300kW proved to be very difficult
- After a period of diagnosis on the power supply and amplifiers it was decided to remove the new tube and revert back to the old used tube to re-establish settings on the amplifier system
- As the power tube was removed it became clear that sparking had occurred around the valve which clearly indicated the source of the problems we had experienced
  - This would have triggered the initial crowbar event
  - Would have inhibited further increases in output power

116 triode removal





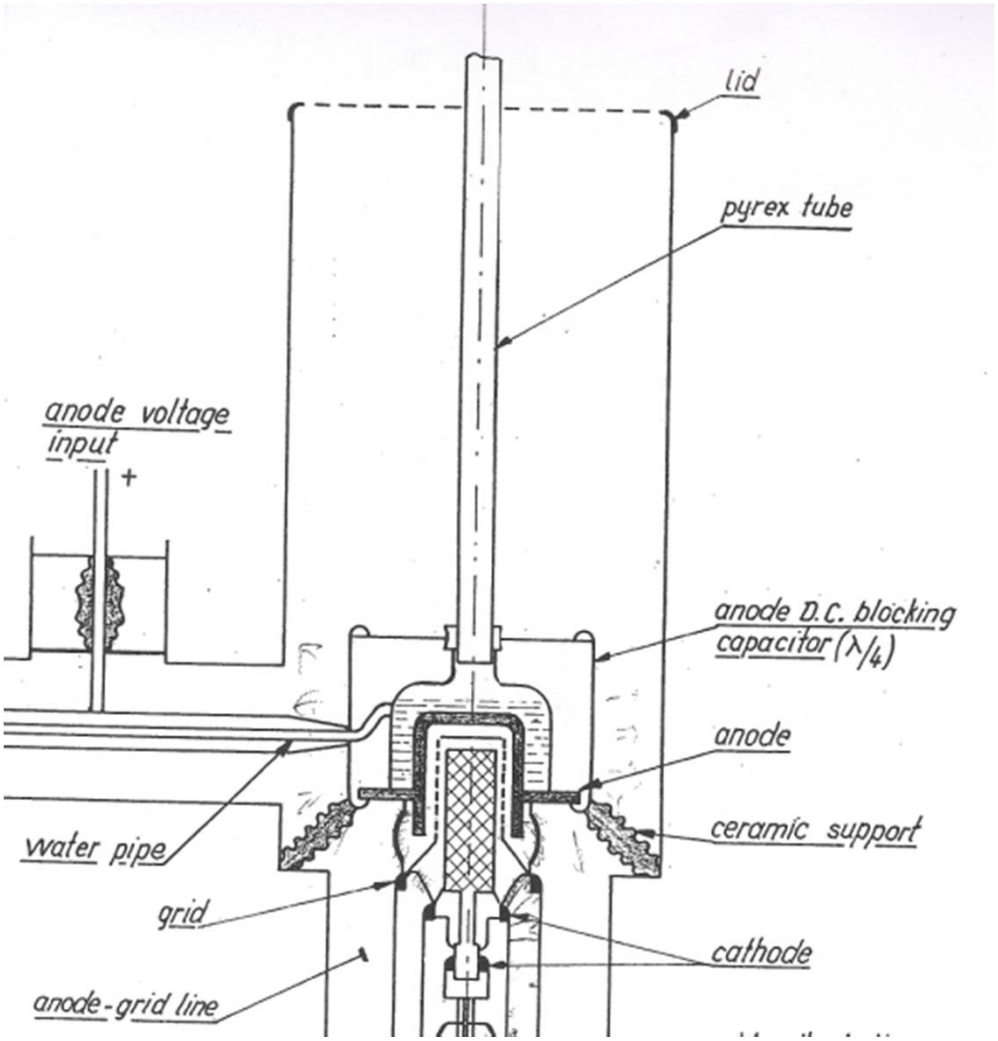
Evidence of arcing on HT connection

HT top box

- HT top box is where high voltage is applied to the anode
- Water coolant is supplied to the valve using insulating glass rods
- On the original LBNL amplifier, coolant passed out of the system as steam
- CERN HT top box with ability to pass both coolant flow and return pipes, which is why it was used
- Original LBNL HT top box with small inlet for only one coolant pipe
- HT box to tube interface is slightly different and is where fault is created
- LBNL HT top box is being converted to two water pipes and with correct spacing should remove issue that created arcing

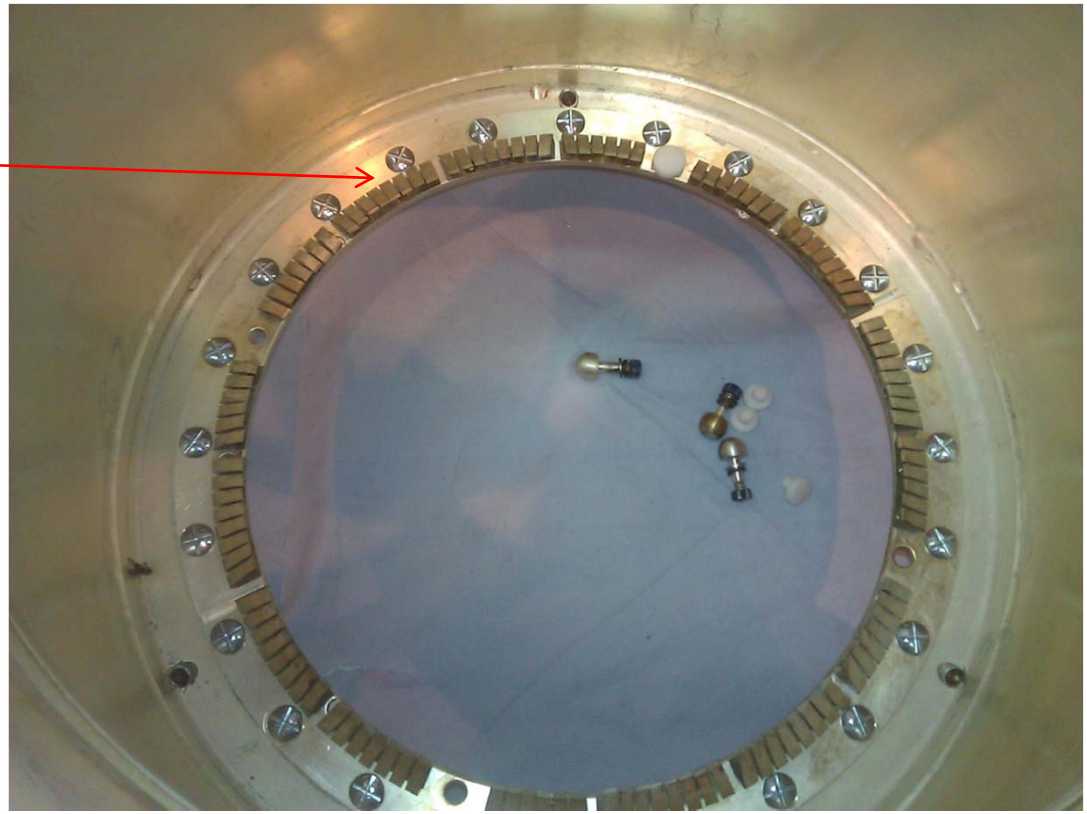
HT Top Box

- The seating of the valve in the HT top box has caused the arcing
- The HT box actually belongs to another amplifier and was swapped in to speed up the commissioning process
- However there are some dimensional and location differences that obviously have caused the issues that we can see when the tube is removed



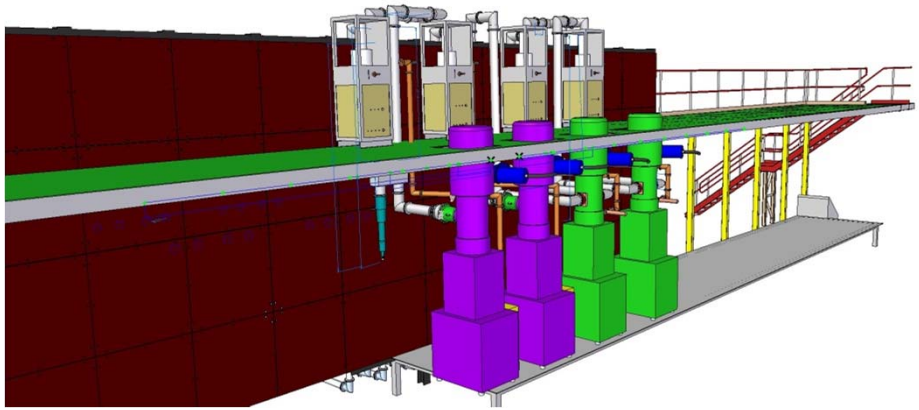
HT connection

- Picture shows the correct spring finger arrangement that is required for the LBNL amplifier
- Using the CERN top box allowed the valve to be pressed too far down into the socket causing the incorrect alignment
- All parts are being machined now ready for fitment to the amplifier in the next 5 weeks
- Amplifier testing will then proceed again with the old Triode tube first to 1MW
- The Triode tube will then be swapped for the new device and tested to 2MW

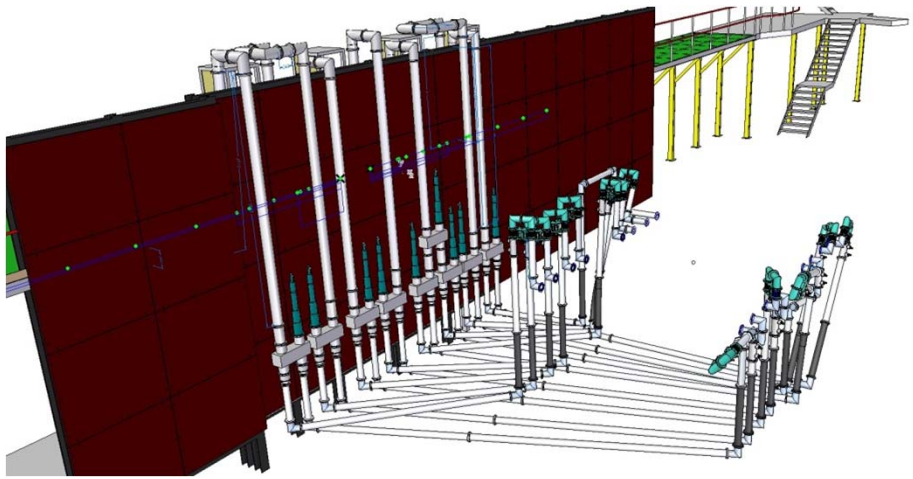


RF Distribution – Final Installation

Amplifiers behind Shield Wall



Distribution Network to MICE

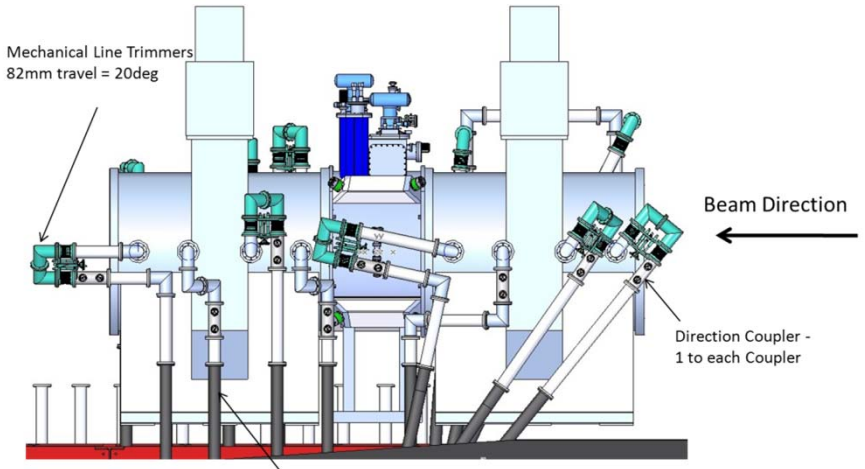


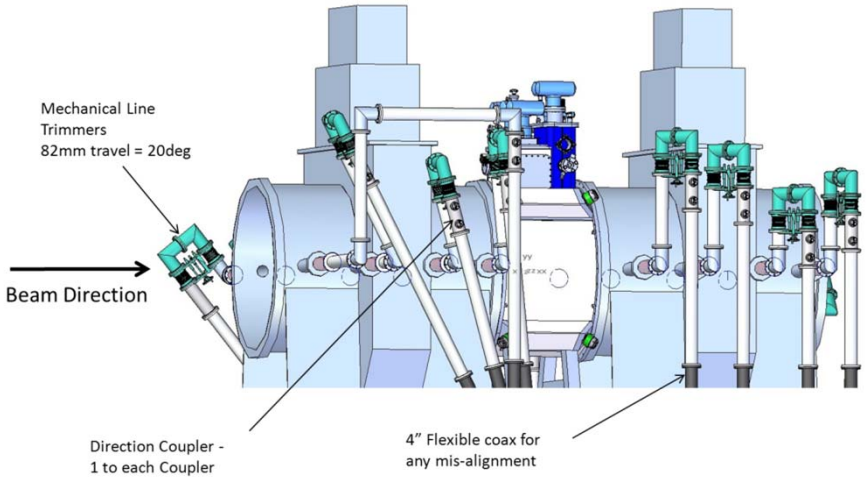
- Amplifiers installed behind shield wall
  - Triodes on main floor, Tetrodes on Mezzanine
  - Impact of B-fields currently being analysed
  - Shielding requirements assessed
- High power dynamic phase shifters removed.
- 4 off 6 inch coax lines over wall
  - Pressurised to increase power handling
- Hybrid splitters moved - more accessible
  - Minimises clutter and increases service access to the amplifier stations
- Line lengths matched using 3D CAD
- Manually adjustable line trimmers installed at cavity to take up assembly errors in coax length
- Easier to assemble – introduced flexible coax
  - Allows for small misalignments
- 2 Hybrids split output from the Berkeley Amplifiers on amplifier side of wall
- CERN amplifiers have two outputs
- 4 hybrids on MICE side of shield wall
  - Split power for the opposed couplers of each cavity
- Lines will be pressurised with 2Bar Nitrogen

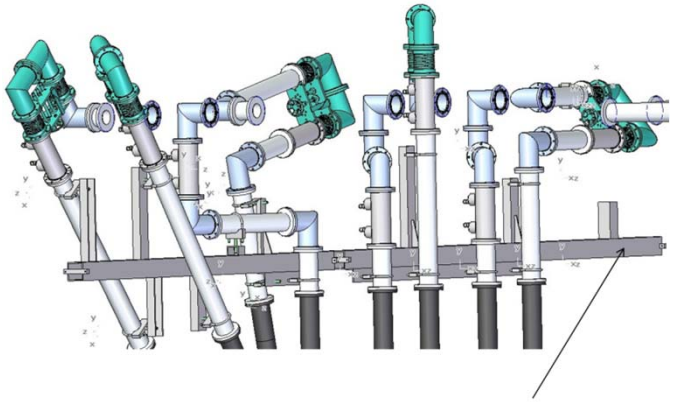
Revised Co-Axial Distribution Network

- Co-axial line length calculated: procurement in progress
- Most other components already being procured
- Hanger and Mounting designs completed and testing in hand

Line Trimmer Arrangement to South Side RF Couplers

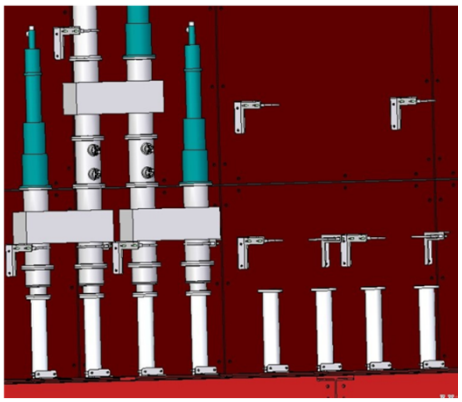






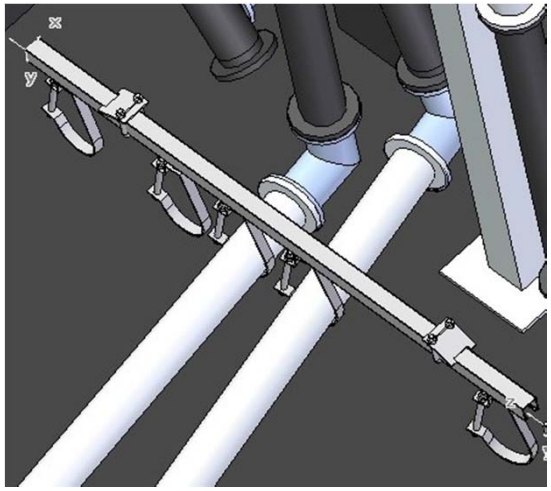
Support frame fixed to South Mezzanine support structure
Coax fixed (2 positions) to relieve stress on cavity couplers

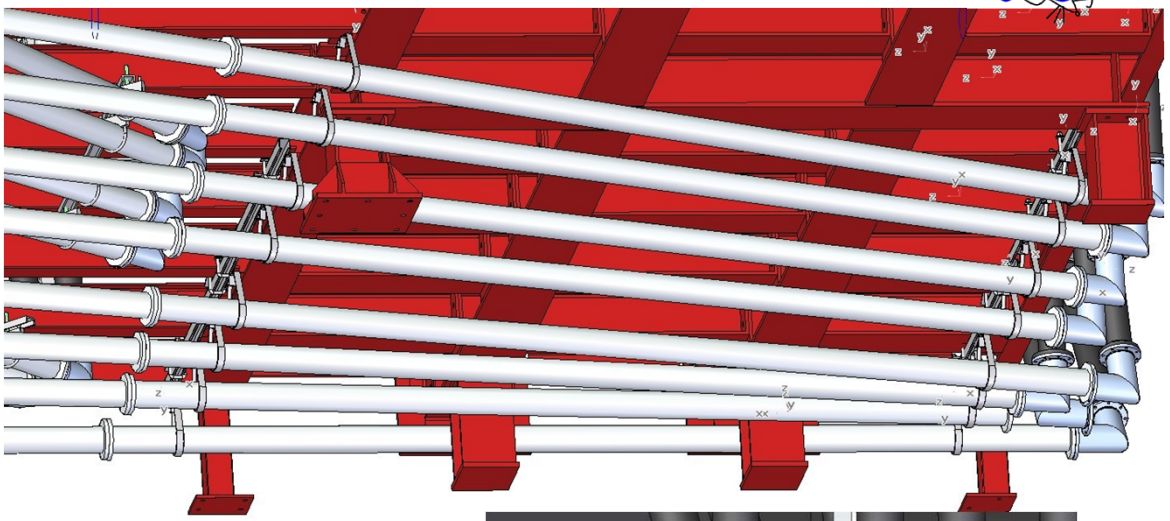
Common bracket & clamp design for
coax and hybrid splitter support
On shield wall



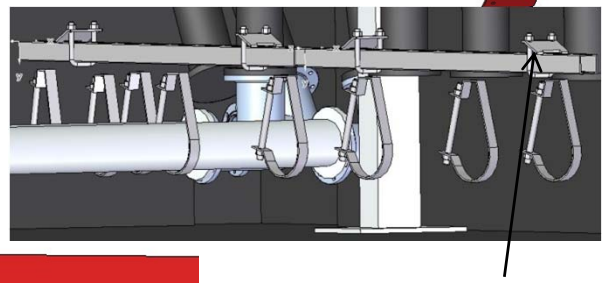
2 off Unistrut frames for coax support
RFCC's - North side

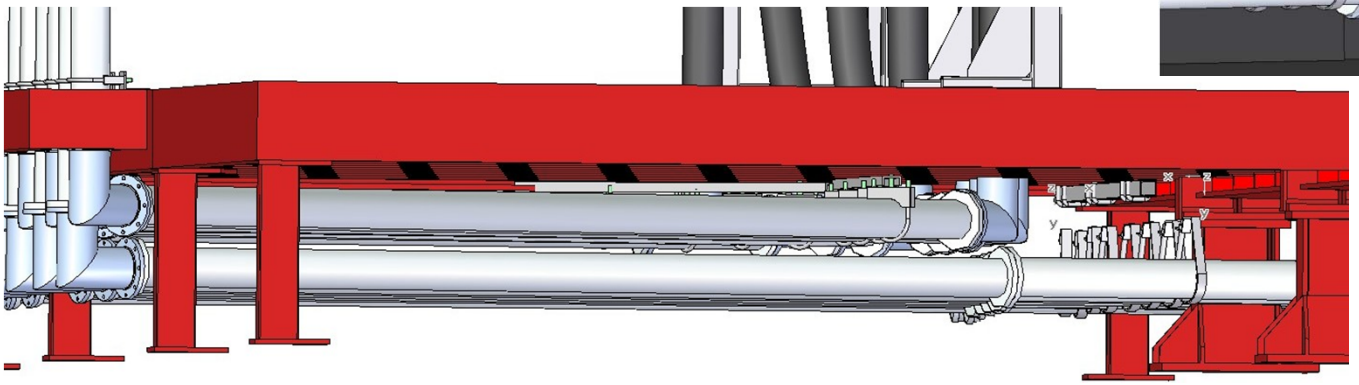
Designs of the RF Coax Support





Coax held in position on ‘hangers’ suspended from floor steelwork.
Flexible system

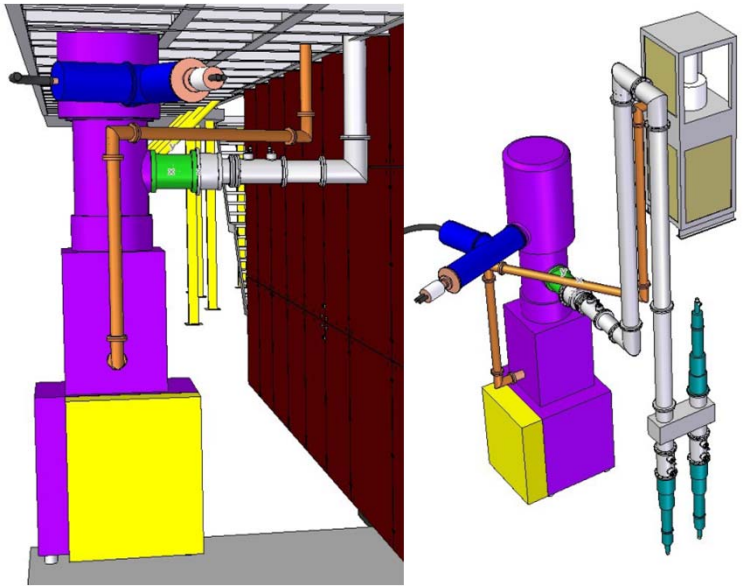




Hangers suspend on Unistrut fixed to steelwork with adjustable clamps.

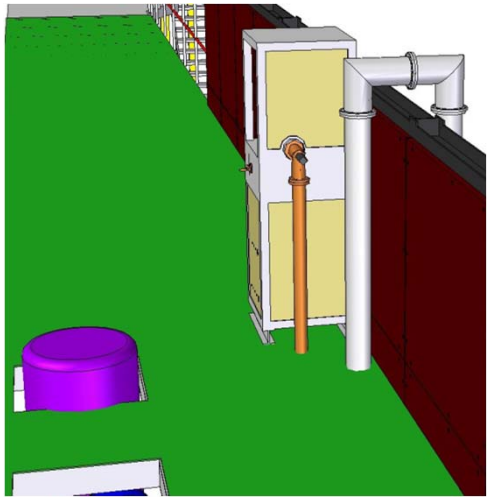
No support structure on floor. Clear access for cable trays and water pipes.

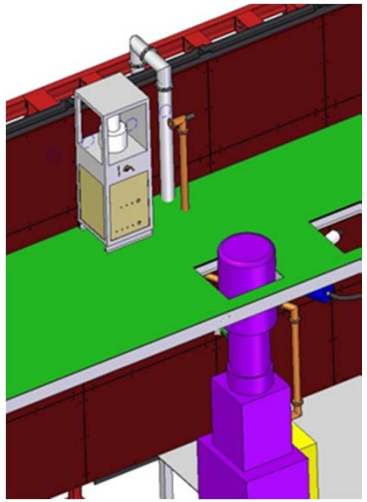
MICE Hall RF system for TIARA Test

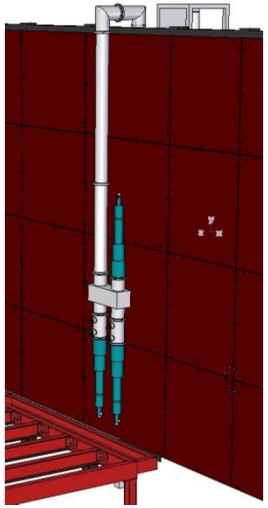


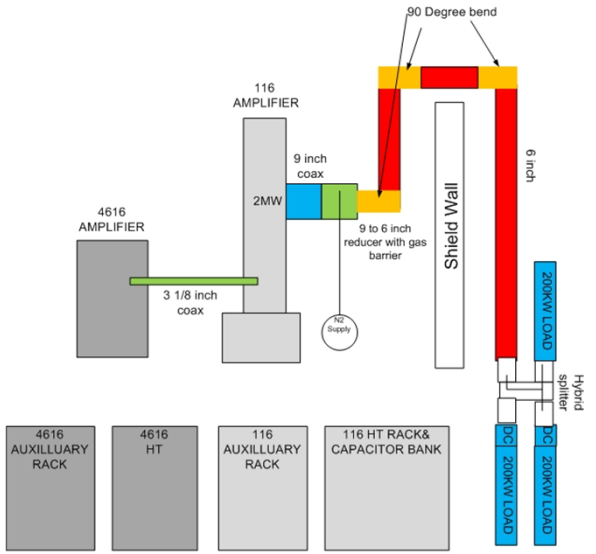
- One amplifier set installed in operational position
  - Installed in the first amplifier station
  - Tetrode on Mezzanine, Triodes deep behind the shield wall
  - Opportunity to test the impact of B-fields during STEP IV
- One hybrid installed on MICE side of shield
- 3 loads, two will share the output power of the amplifier
- Procurement of all components under way

TIARA Installation Detail







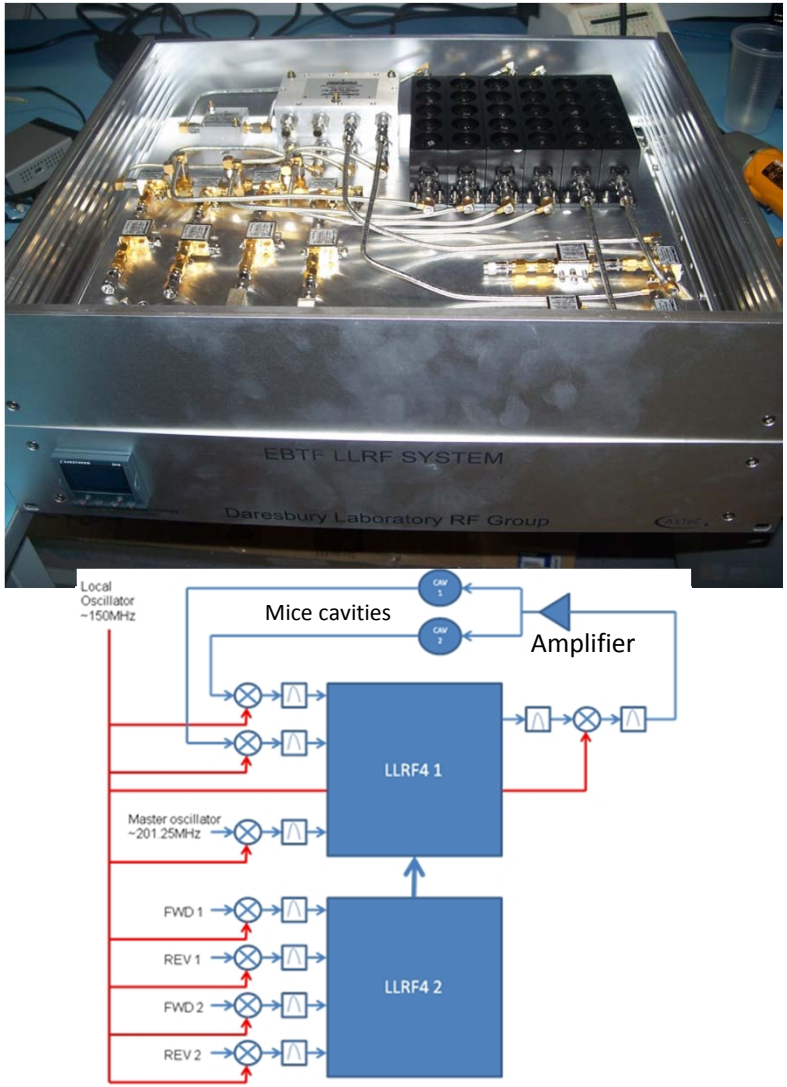


Procurement

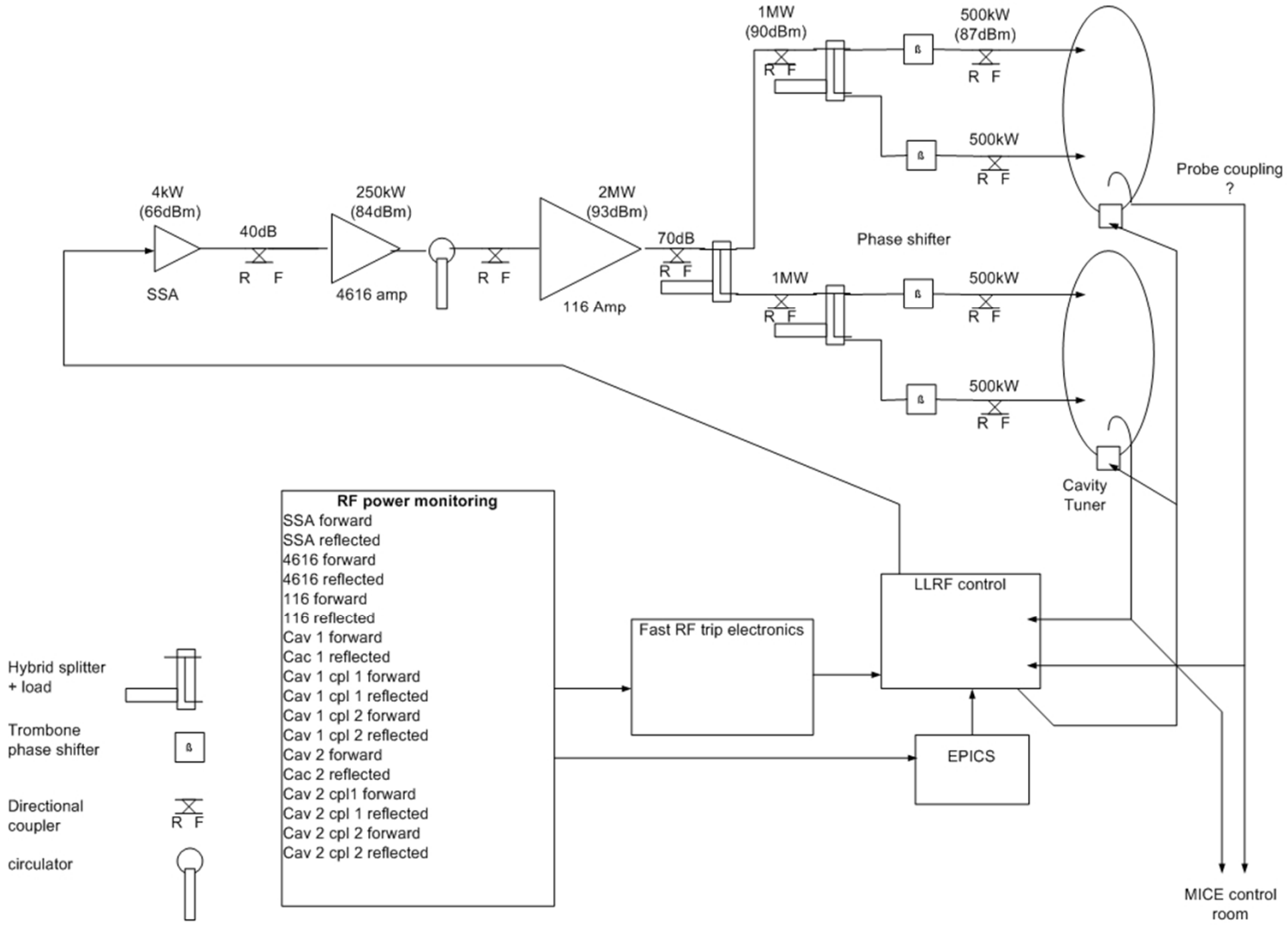
- Substantial procurement of RF components through University of Mississippi
  - New Tetrode amplifier set delivered to University of Mississippi from Photonis
  - Loads on order from Altronics
- Distribution Network
  - RF 4” elbows delivered to U. Mississippi
  - Quotes obtained for all other required components
  - Don Summers (and colleagues) working on procurement
  - Lead time of ~10 Weeks seems possible
- All components required for TIARA deliverables part of quote
  - Indication of flexibility from potential supplier on schedule flexibility of important components

Digital low level RF Control

- To **control** and regulate cavity amplitude and phase angle during the RF pulse
- DL able to build up hardware ~ 3months
- Systems in use already with EPICS control, feedback, feedforward, resonance control etc
- Ramped pulse structure to limit reflected power tested on bench with 1.3GHz cavity



RF system monitoring and protection

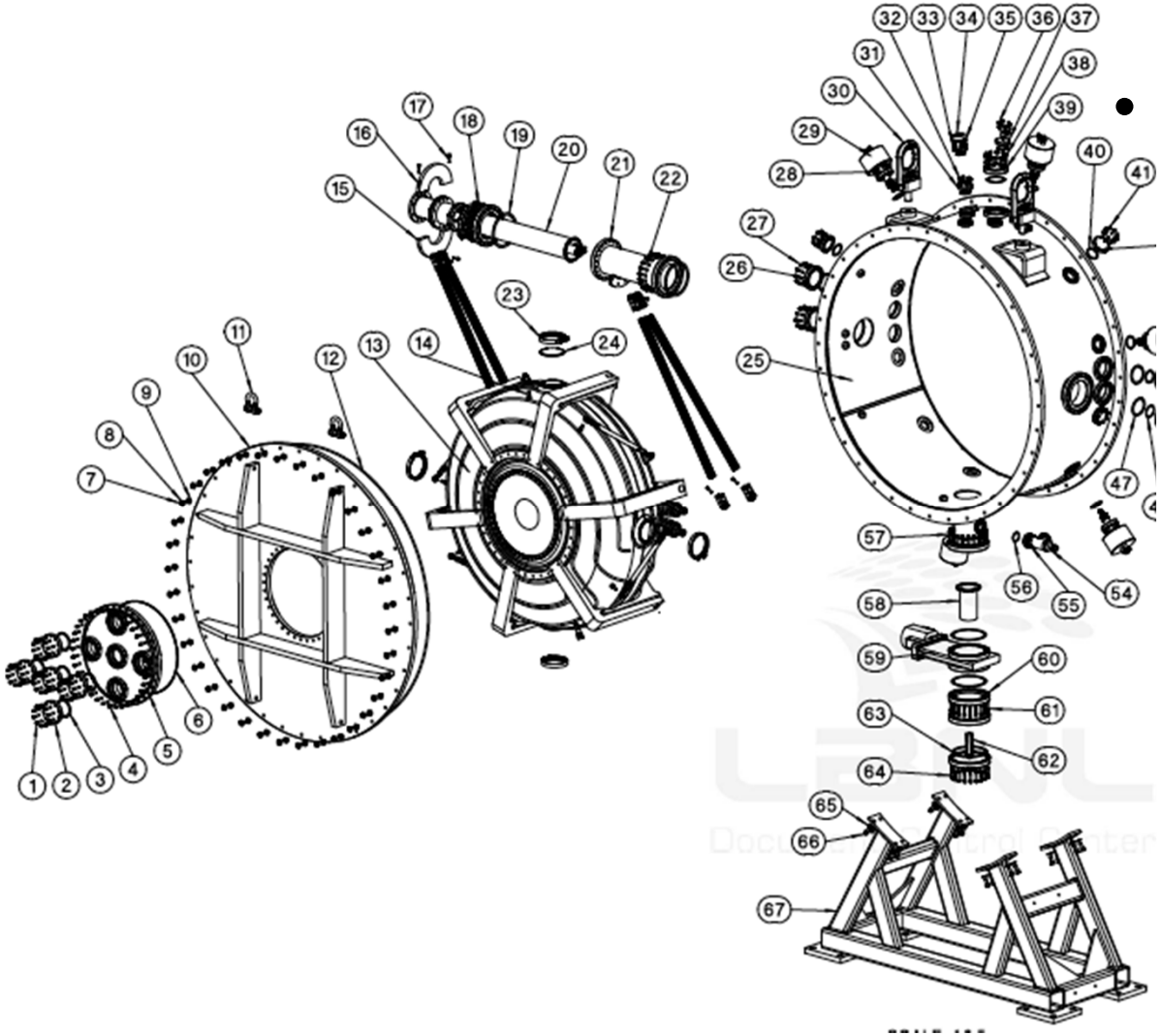


Cavities

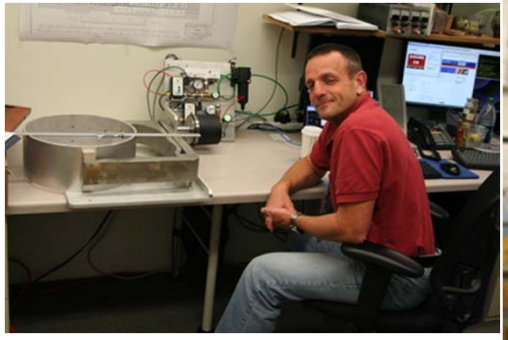
- Cavity dimensions mechanically measured
- First cavity electropolished
  - 9 cavities to be polished imminently
- Beryllium windows fabricated
- New coupler design nearing fabrication
- After polishing, cavities subject to RF measurement and tuning
- Single cavity test stand completed at MTA
  - First cavity moved to FermiLab for testing
  - Awaiting couplers, other components in place at FermiLab
  - Apr 2013 planned for tests
    - In fringing magnetic field, up to 1T
- Automated actuator driver to tune cavity being developed
  - Will interface to LLRF

201-MHz Single-Cavity Module

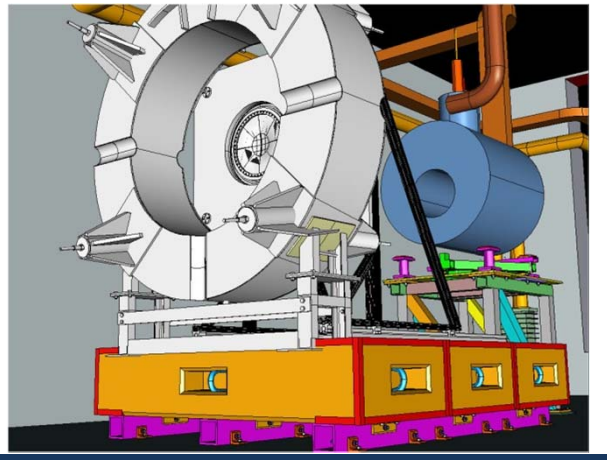
- MICE cavity in vacuum vessel for MTA test
- Components
  - 1st MICE cavity EP'ed and now at Fermilab
  - Be windows ready
  - Tuner forks built
  - Ready for fabrication of new couplers



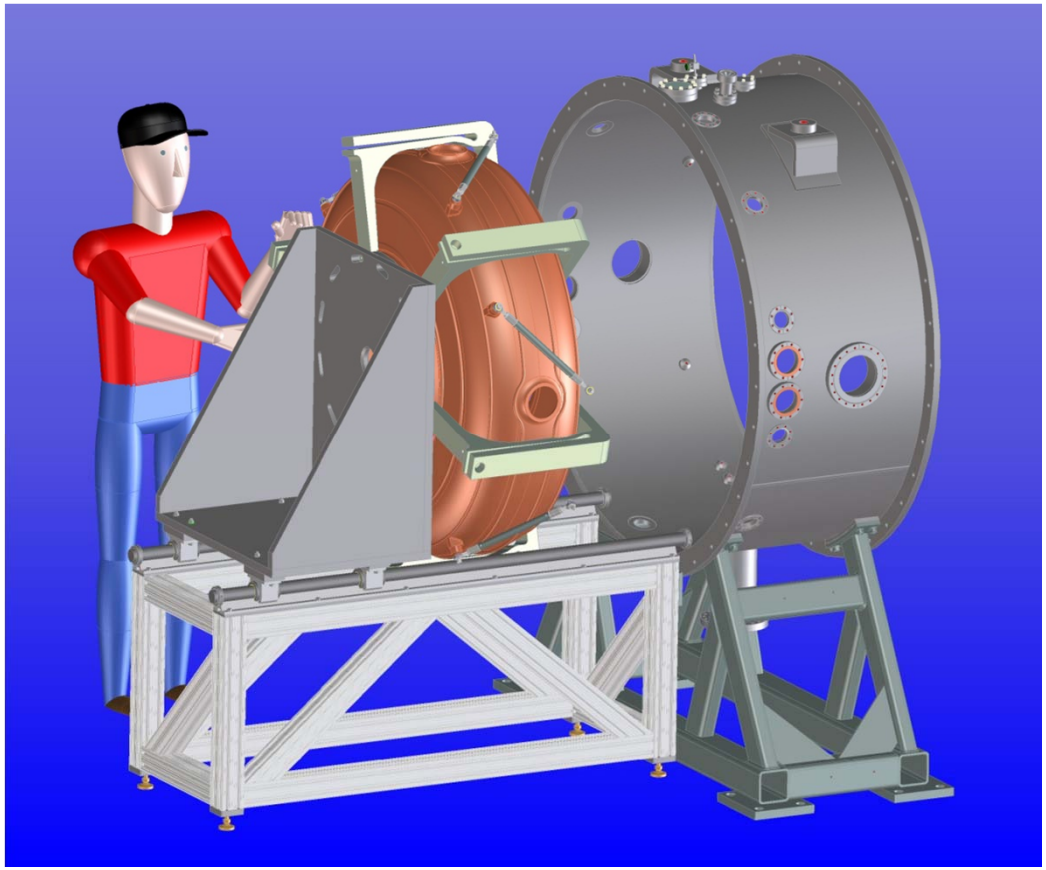
201-MHz Single-Cavity Module



- Assembly/integration
  - Cavity and vessel at Lab-6
  - Clean room prepared
  - Plan in place for handling and transport (R. Schultz, J. Volk)
  - Assembly fixture designed (A. DeMello)
  - Tuner control bench tested (P. Hanlet)
- Expect operation Summer 2013
  - beam test also under consideration
- Ultimately will be tested with the first Coupling Coil Magnet
  - Requires 6-month MTA shutdown



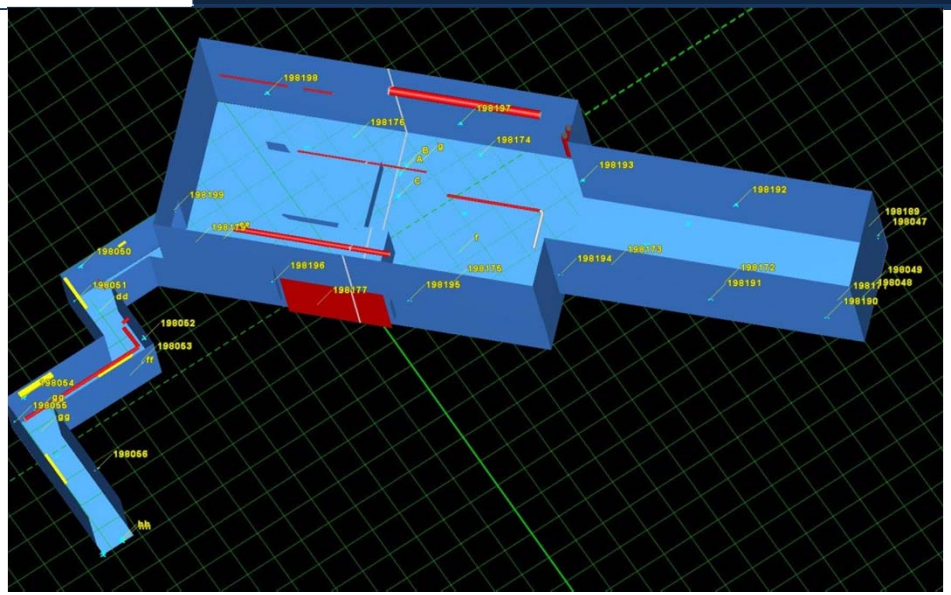
Cavity installation

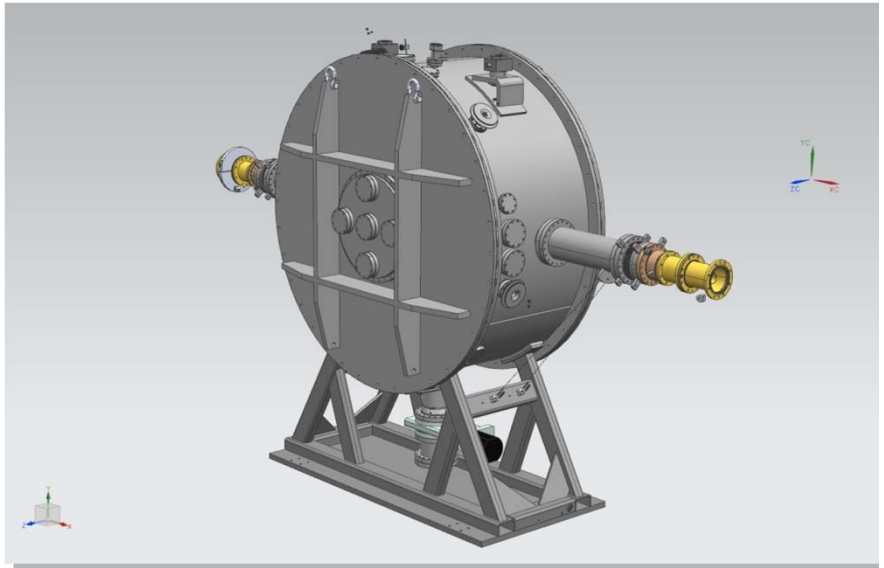


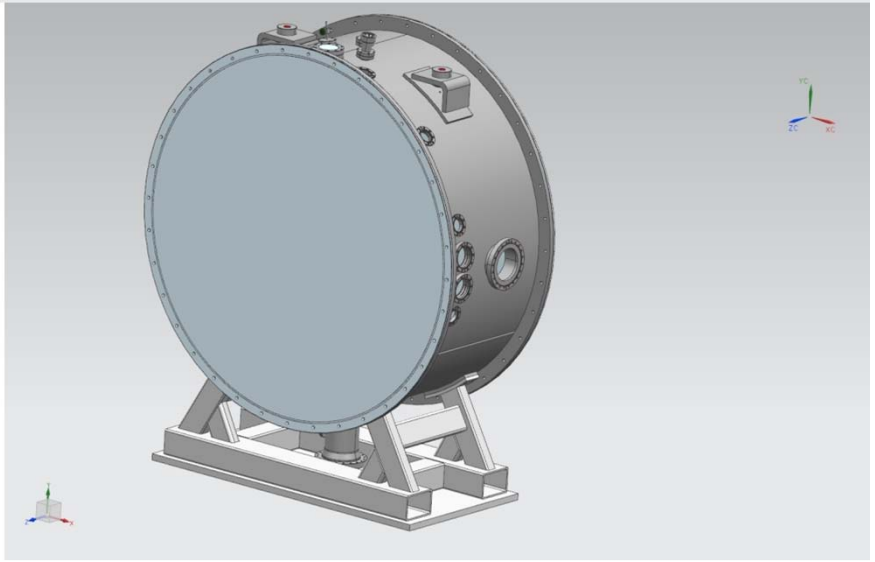
Vertical layout selected

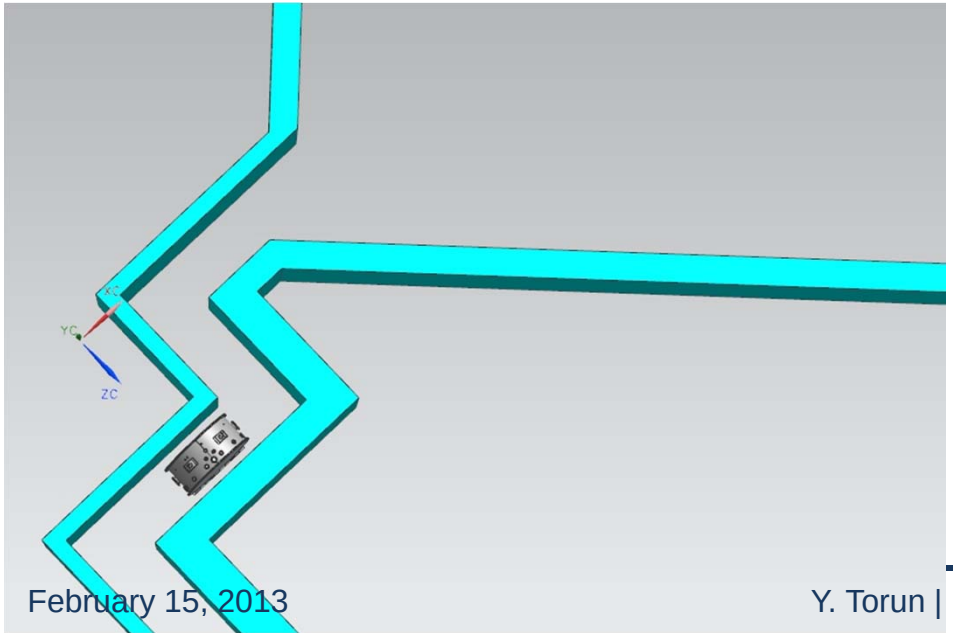
- Smaller footprint better suited to available clean room space
- Similar to MICE RFCC
- Simplified (one-sided)

MTA Installation

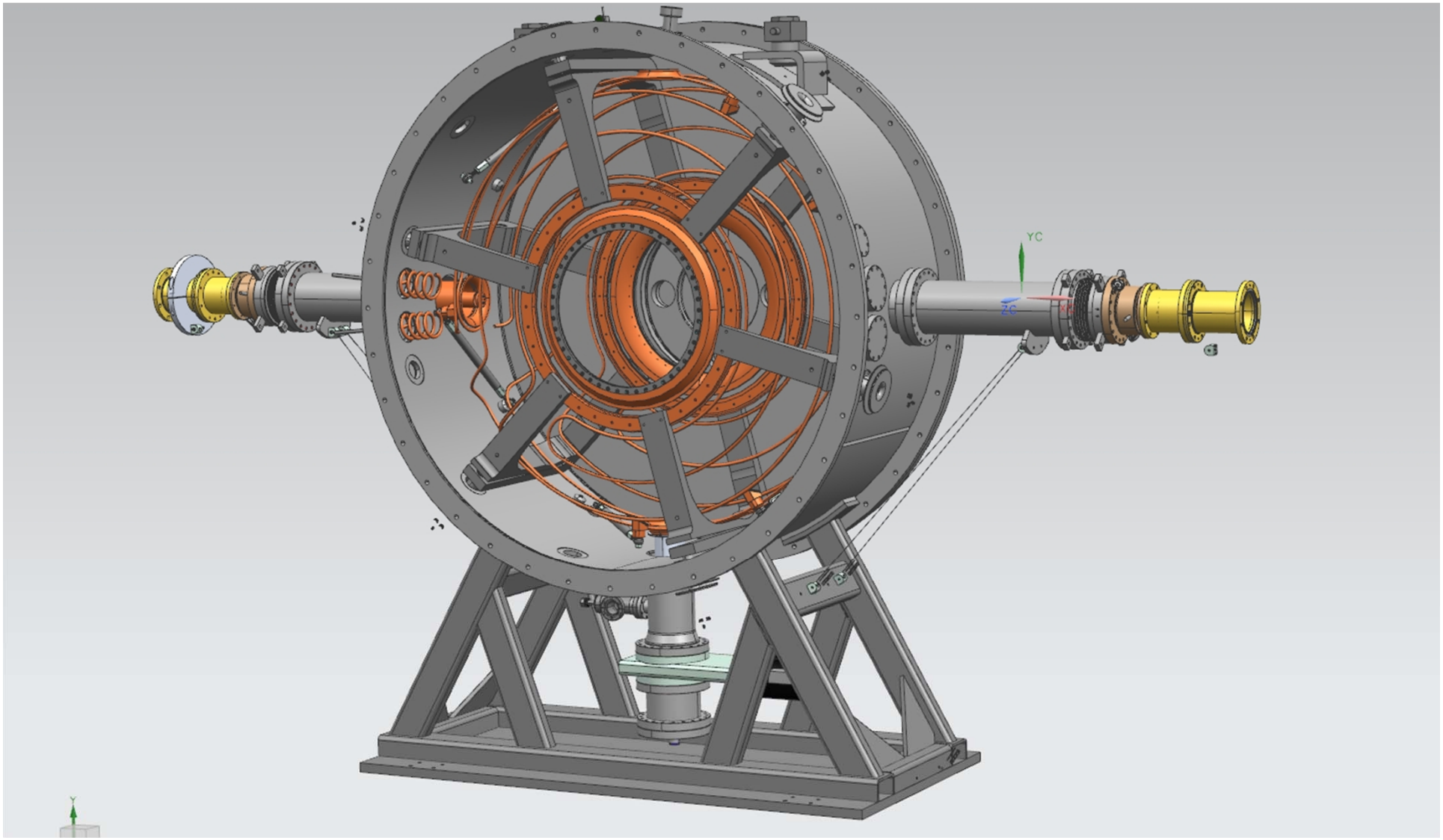








Put on doors in MTA clean room



Cavity Plan

- Cavity moved to MTA estimated late April
  - Fabrication and conditioning of revised couplers required
  - Fabrication of the transport jigs required
  - Machining and installation of tuners required
  - Tuners and cavity installed in outer frame in external clean room
  - Transport to MTA late April

- MTA continuing installation
  - Clean room installed in MTA
  - Finish cavity assembly
    - Couplers, Windows
    - Test stand end caps
  - Installation in test stand late May
    - Connection to services and RF power
    - LLRF Measurements

- Cavity power testing
  - Anticipated at zero B field, June
  - Anticipate in fringe field, July

Summary

- High Power Tests
  - Halted by air side arcing in amplifier assembly
  - Caused repeated crowbar events about 32kV bias voltage
  - Revealed issue with crowbar circuit: Now corrected
  - Arc seat located and cleaned: Valve socket redesigned to improve location accuracy
  - Assembly completed as of last week
  - Time driver is TIARA. Amplifier set in MICE hall by September. 2MW demonstrated

- Distribution Network
  - Design completed for entire step VI configuration
  - Procurement process under way for loads
  - Procurement process getting under way for all other co-axial components and lines
  - Includes components required for TIARA tests

- Cavity testing
  - Cavity and components now at FNAL
    - Some machining of the tuners still required
    - Manufacture of new couplers imminent (design completed)
  - Detailed plan worked out for its partial assembly, transport to MTA and final assembly
  - Plan aims for power tests in late Summer.