MICE RF System

Andrew Moss
ASTeC

Collaboration meeting CM29

15th - 18th February 2011

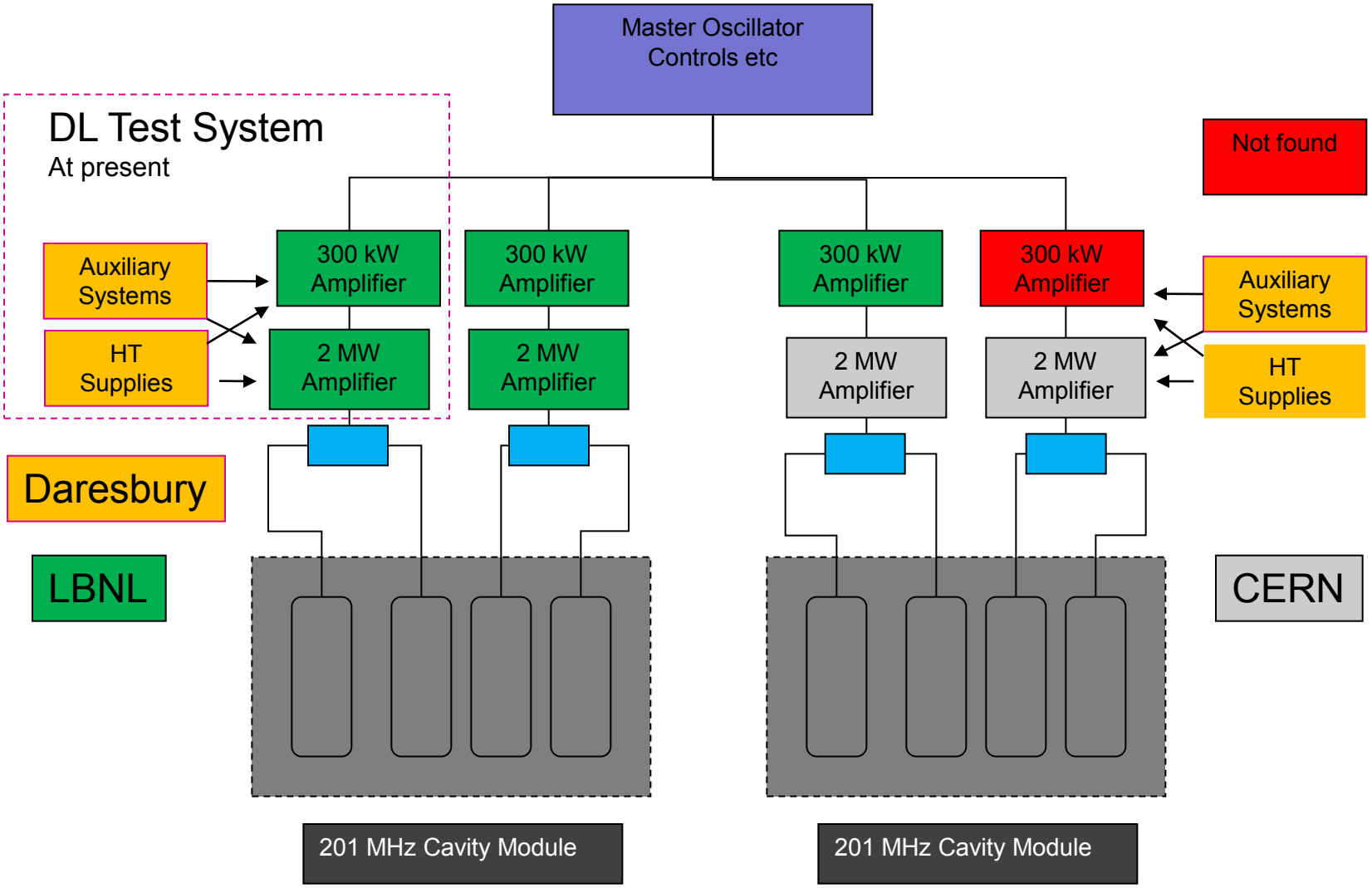
contents

- High power amplifier testing
  - Results so far
  - Next steps
  - Plan
- Hall layout
  - First attempts of CAD modelling
  - Optimisation
  - plan

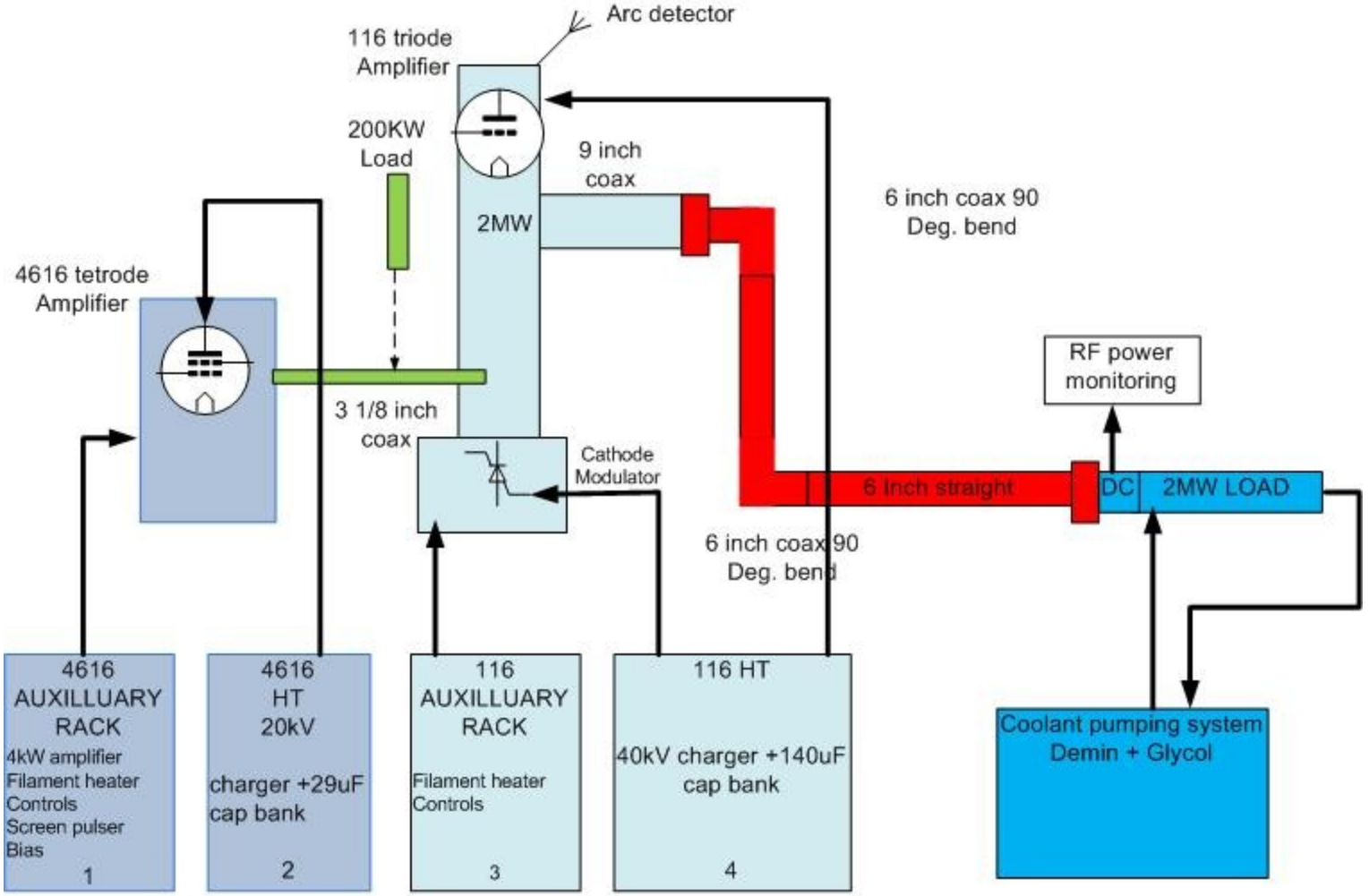
Amplifier status

- First medium power (300kW) amplifier and power supply system tested 2008
- Refurbishment and rebuild of first high power (2MW) amplifier complete October 2009
- Power supplies for first 2MW amp operational
- Two further 300kW amplifiers awaiting repair
- Two refurbished 2MW CERN amplifiers partly tested, awaiting assembly and high power test
- Still need to build 3 more sets of power supplies
- One more 300kW amplifier to buy/acquire

RF system components



Test system at Daresbury

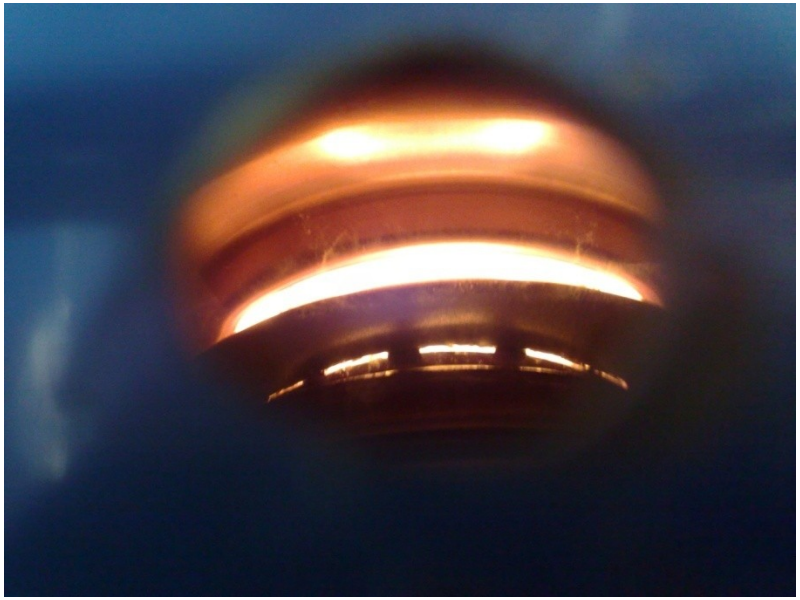


Daresbury test setup for proving amplifiers/power supplies

Andrew Moss

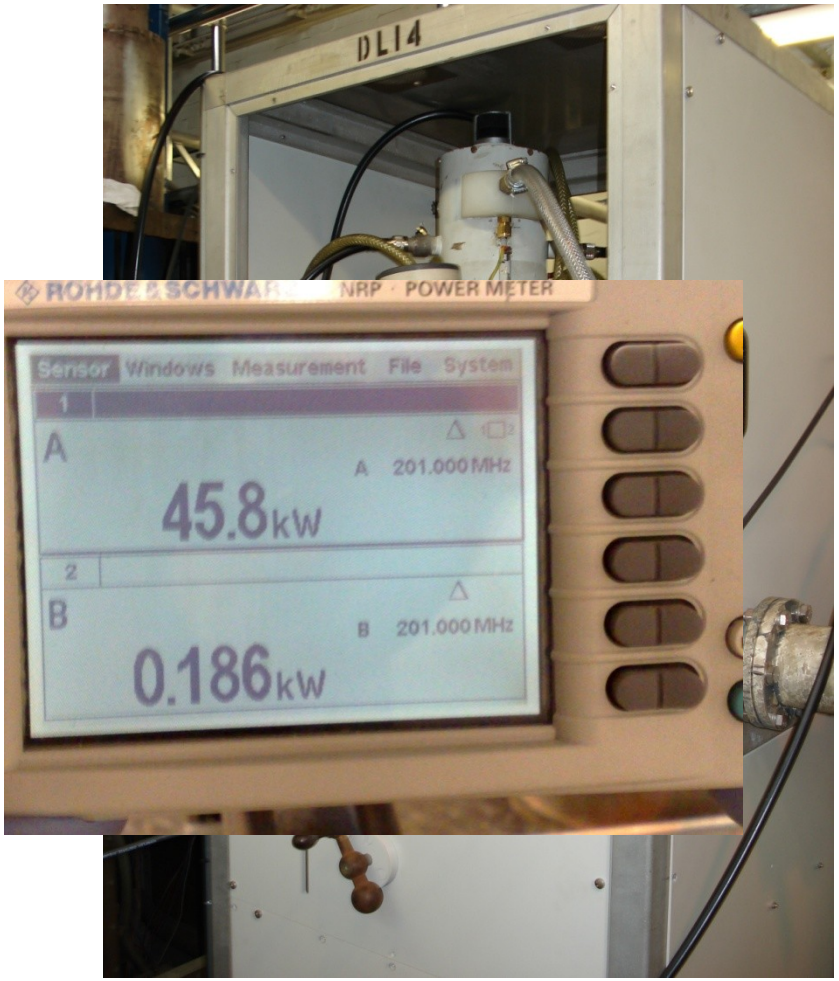
High power amplifier status

- Final electrical checks September 2010 – crowbar/cathode modulator systems
- Amplifier connected to test load via coax
- Filament test to 500A on tube



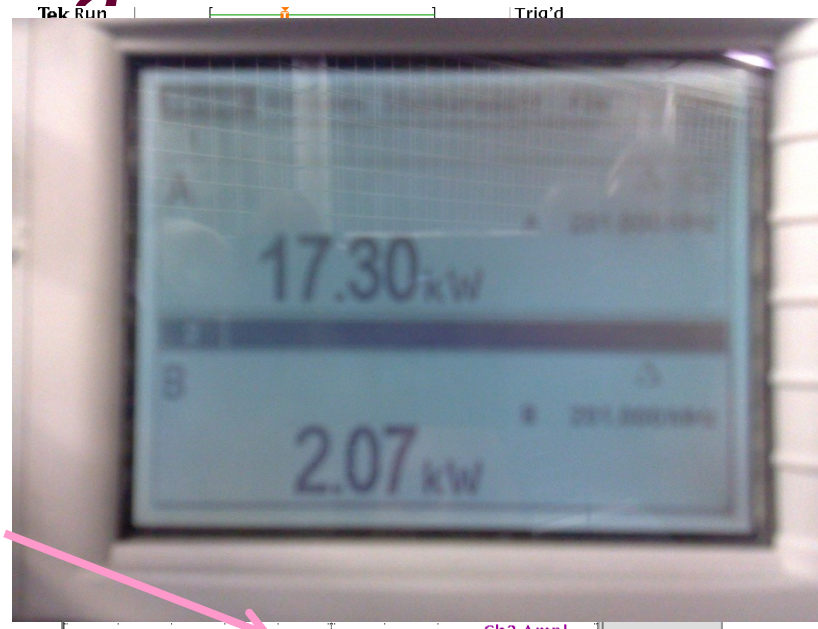
4616 medium power amplifier

- 4616 pre amplifier set up on matched test load
- system has old LBNL tube installed, new ones in stock
- System operated at 70kW into load, gives us a known starting point to run into the 2MW amplifier system



Initial testing

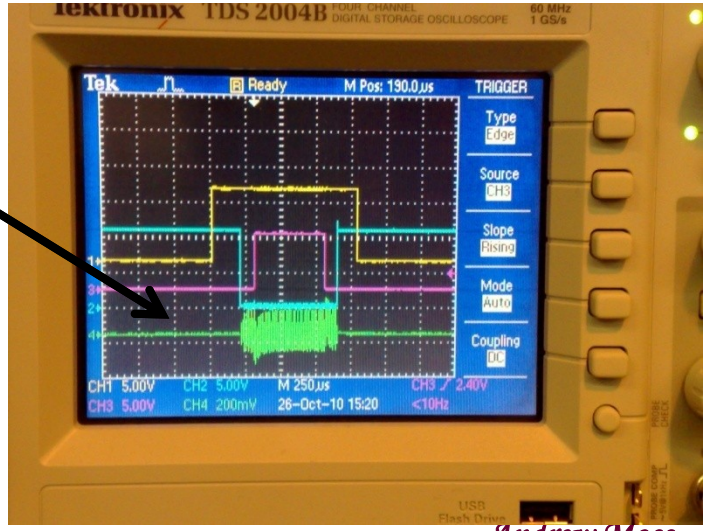
- 4616 connected into input of main 116 amplifier
- High reflected power issues immediately, looked to be reflecting 50 % of power
- However match of input changes with heating, RF drive level, HT applied and cathode modulator switching on, after playing with the system tuning match got much better (10th reflected power)
- RF diode traces a great diagnostic to see immediate changes in response (1Hz) operation as power meters slow to update at low rep rate



Andrew Moss

116 amplifier testing

- So far testing has been relatively un dramatic and system very quickly up to 100kW
- Old ISIS tube installed while we learn how to operate the system
- Sudden oscillation possible, can see diode traces change dramatically when this happens
- lots of RF noise on all earth systems causing interlocks to fire at 160kW, gradually going around the power supply fixing these issues
- Discussions with ISIS linac team have indicated that the amplifier looks to be working correctly, suggested a method for tuning up the system. HV bypass capacitors have been fitted on main cap bank to aid in noise reduction



Andrew Moss

RF and power supply testing this week

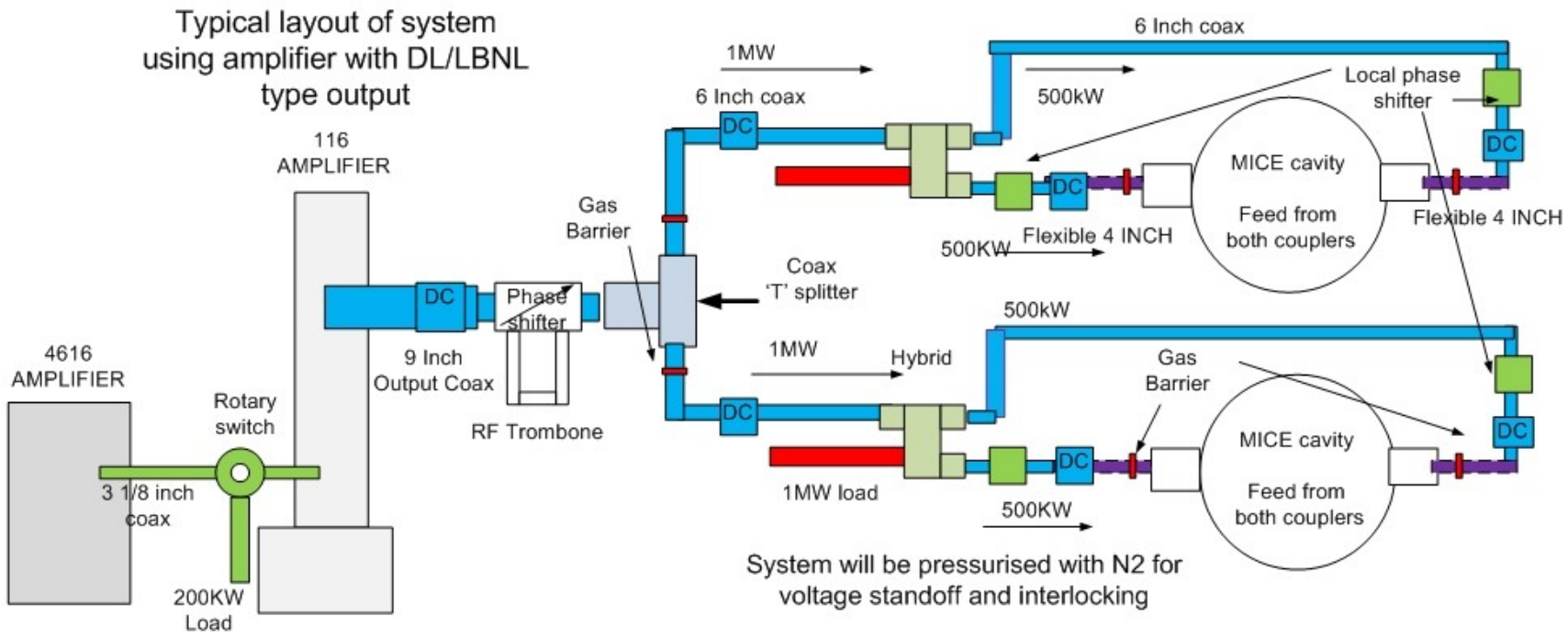
- System pushed to 200kW RF output by driving input very hard
- Tests on crowbar circuit have revealed that at HV level of 23kV system starts to have breakdown issues inside power supply
- Testing with a current limited (1mA) power supply to find cause of breakdown will commence

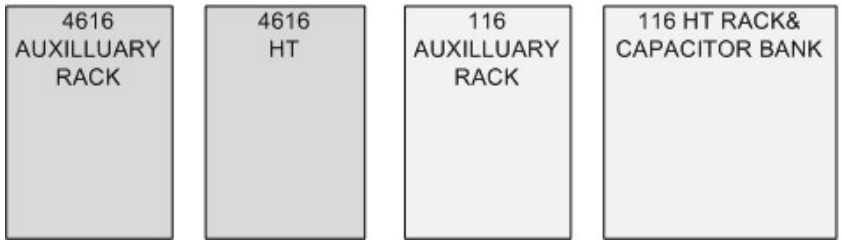
Forward power into load

Further 116 testing

- HV issues are the are the major obstacle to reaching high power in this system at the moment, could also be some self oscillation in the circuit, lots more to understand
- Old ISIS tube showing gain of 10 which is to be expected, should be useful up to 1MW
- Will then swap to a new 4616 and new 116 to push system harder
- So far the amplifier system seams very well behaved at up to 22kV and 200kW, however a long way to go yet !

Predicted hall layout for RF components





DC = directional coupler= power measurment

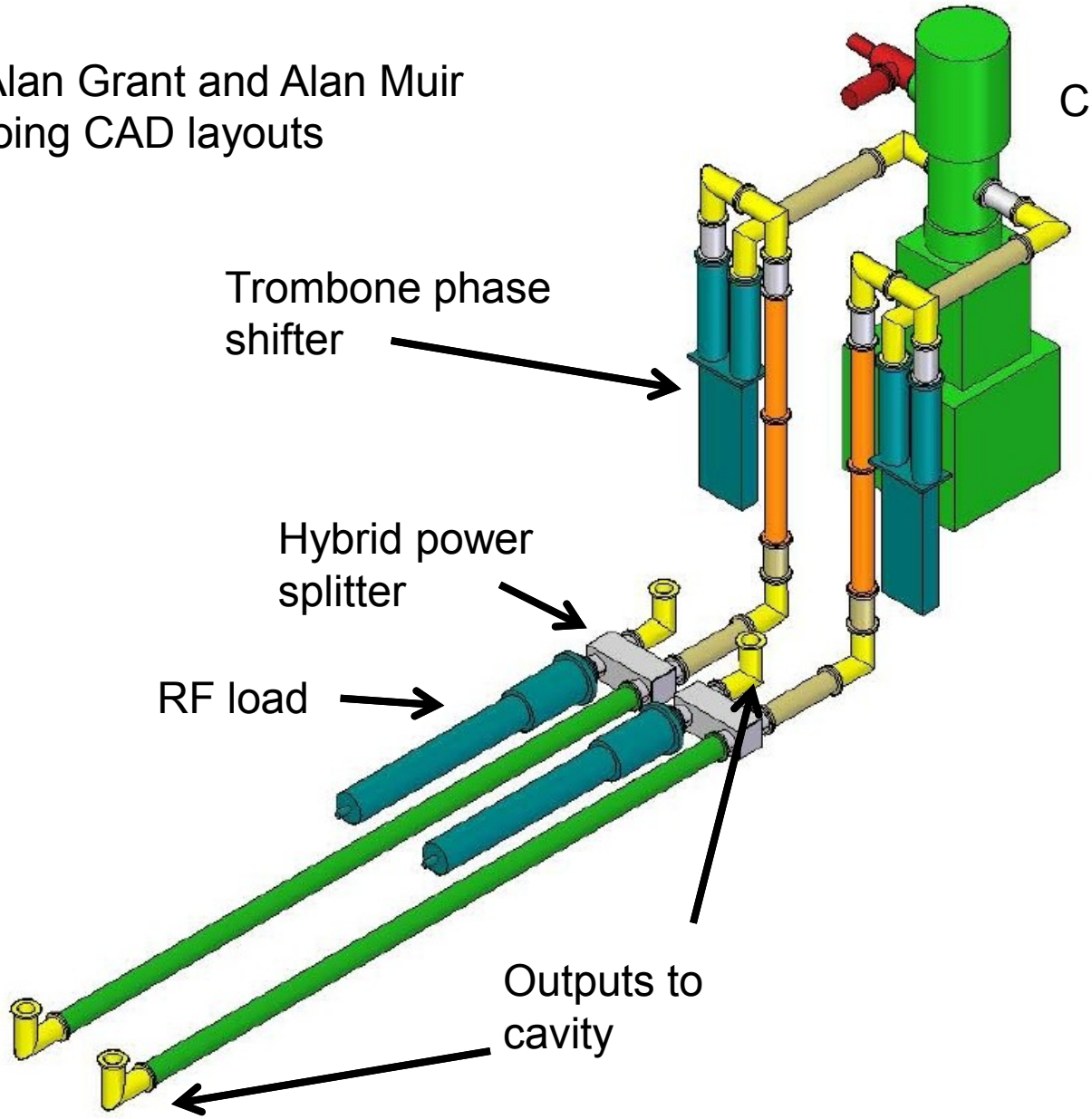
Andrew Moss

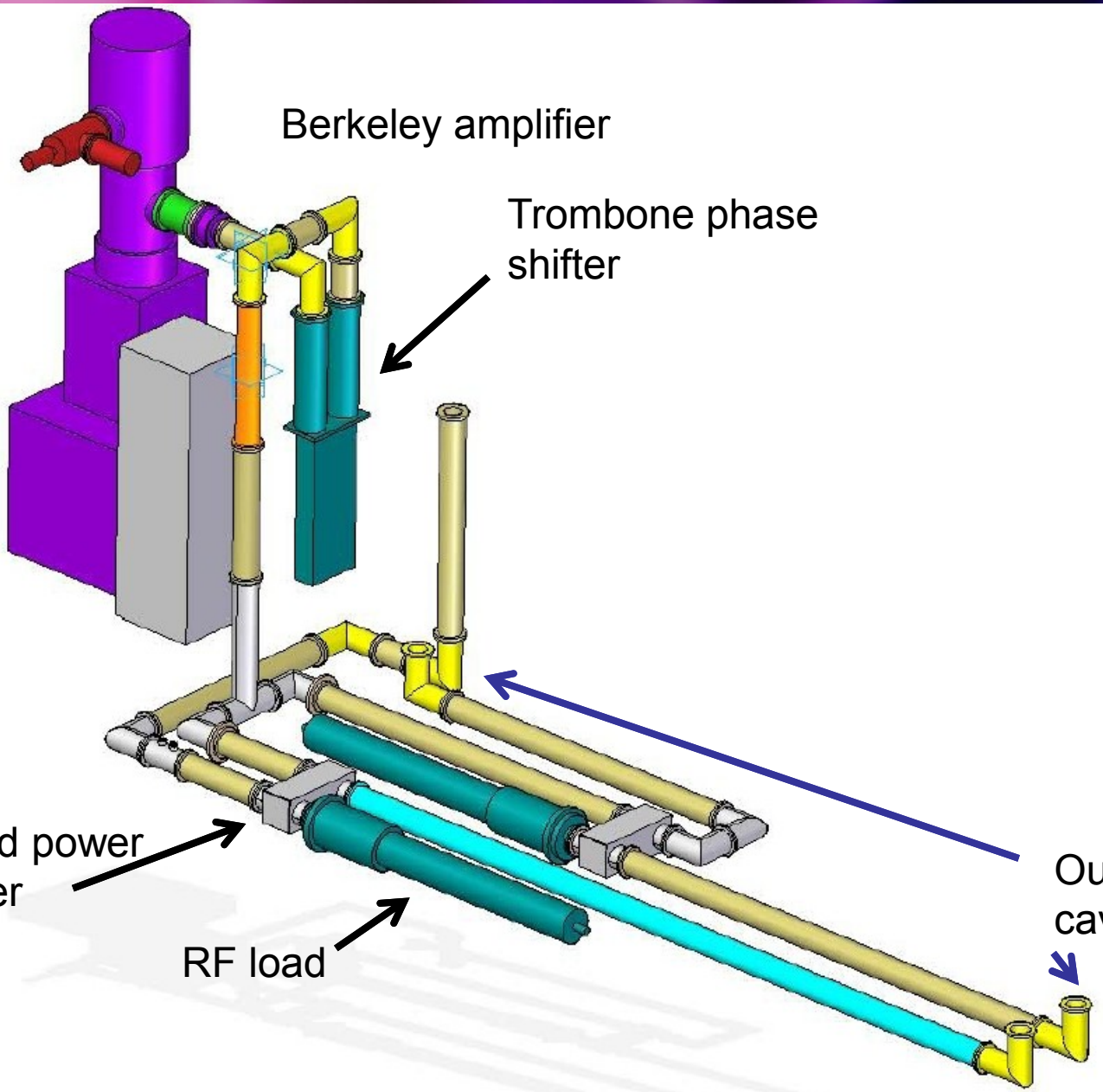
Coax design

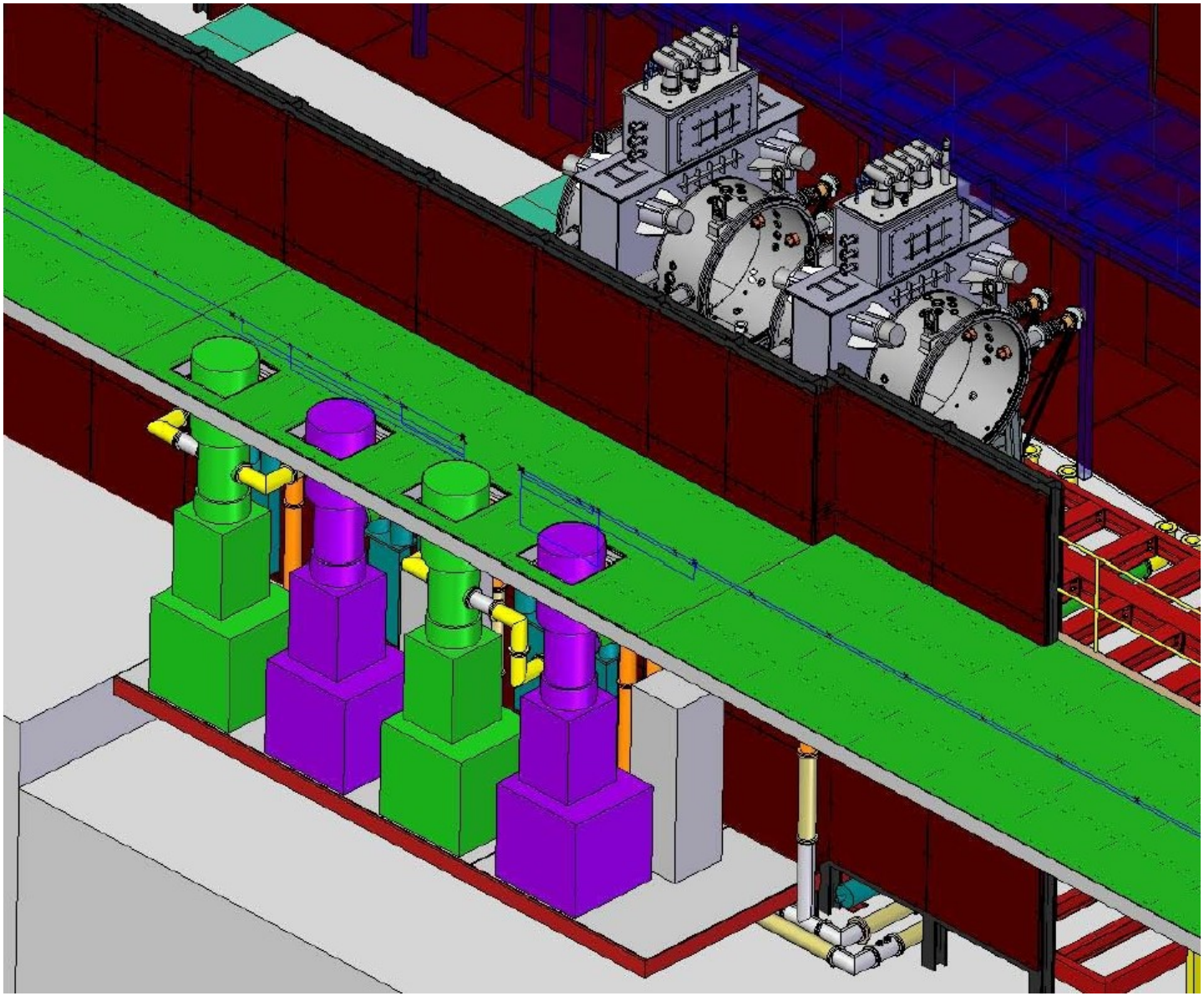
- Coax system will use large phase shifter to make amplifier immune to reflected power issues
- Hybrid power splitters to divide power before each cavity with a rejection load, this should provide a robust reliable system
- Local phase shifters in each cavity coupler, small range available only, so need to plan coax system carefully to get phase lengths within range at the cavity input couplers
- Power monitoring in each section of coax will be linked in to RF control system so that issues can be flagged before faults occur
- Nitrogen gas pressure system with the coax for voltage stand off and interlock
- Plan to have the ability to connect test loads in place of cavity to test amplifier/coax system in its complete configuration

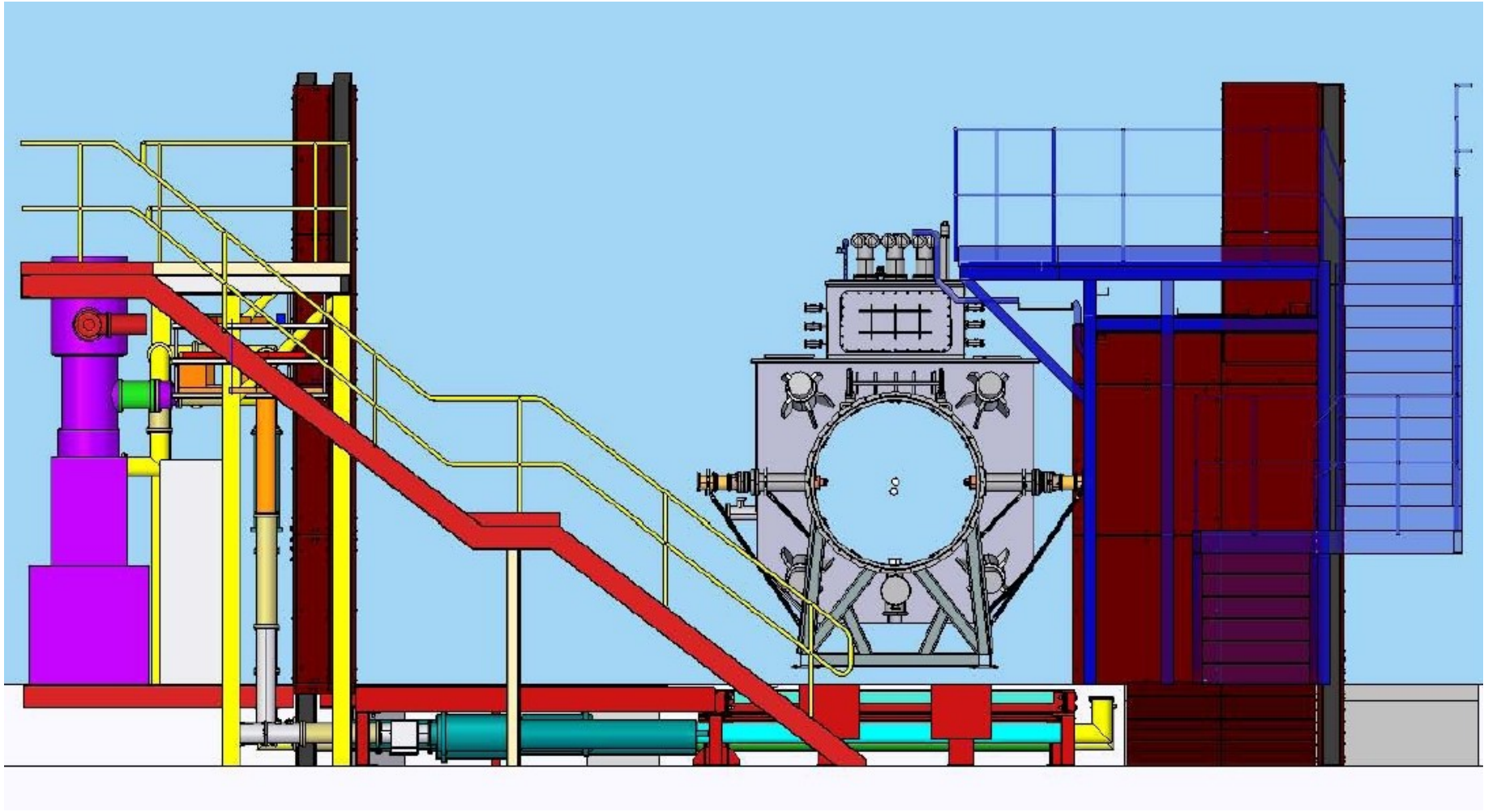
Tim Hayler, Alan Grant and Alan Muir have been doing CAD layouts

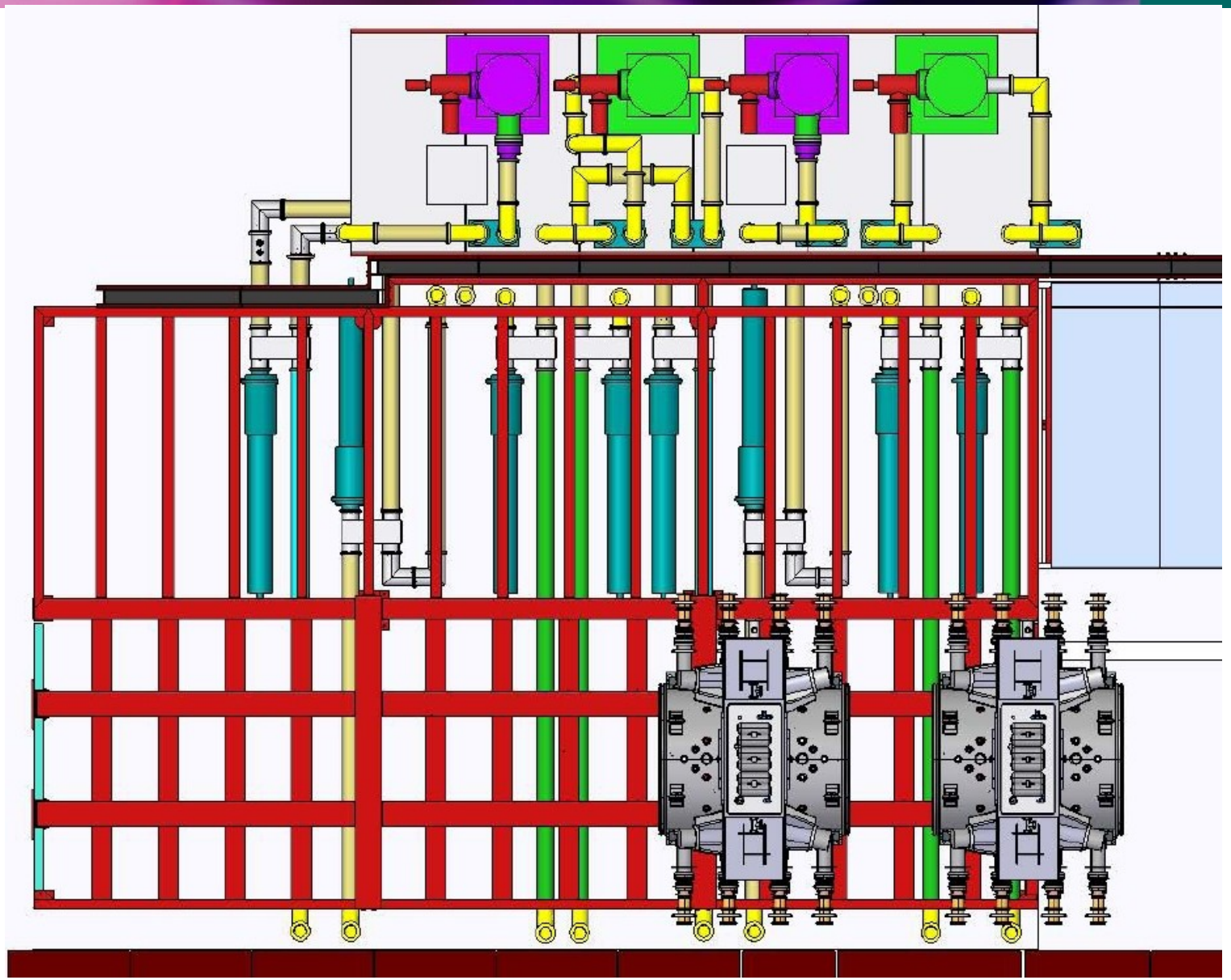
CERN amplifier




Berkeley amplifier
Trombone phase shifter
Hybrid power splitter
RF load
Outputs to cavity

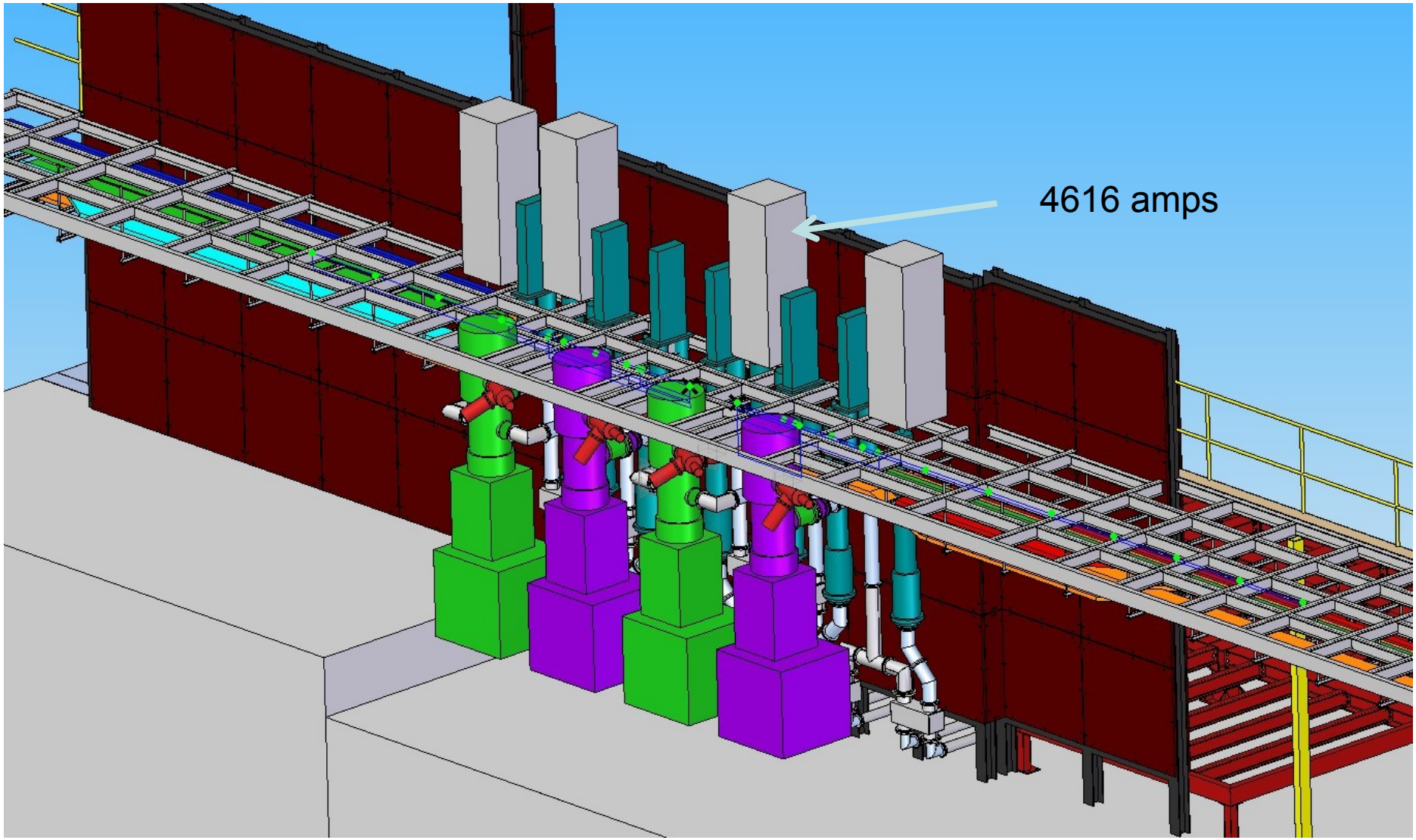


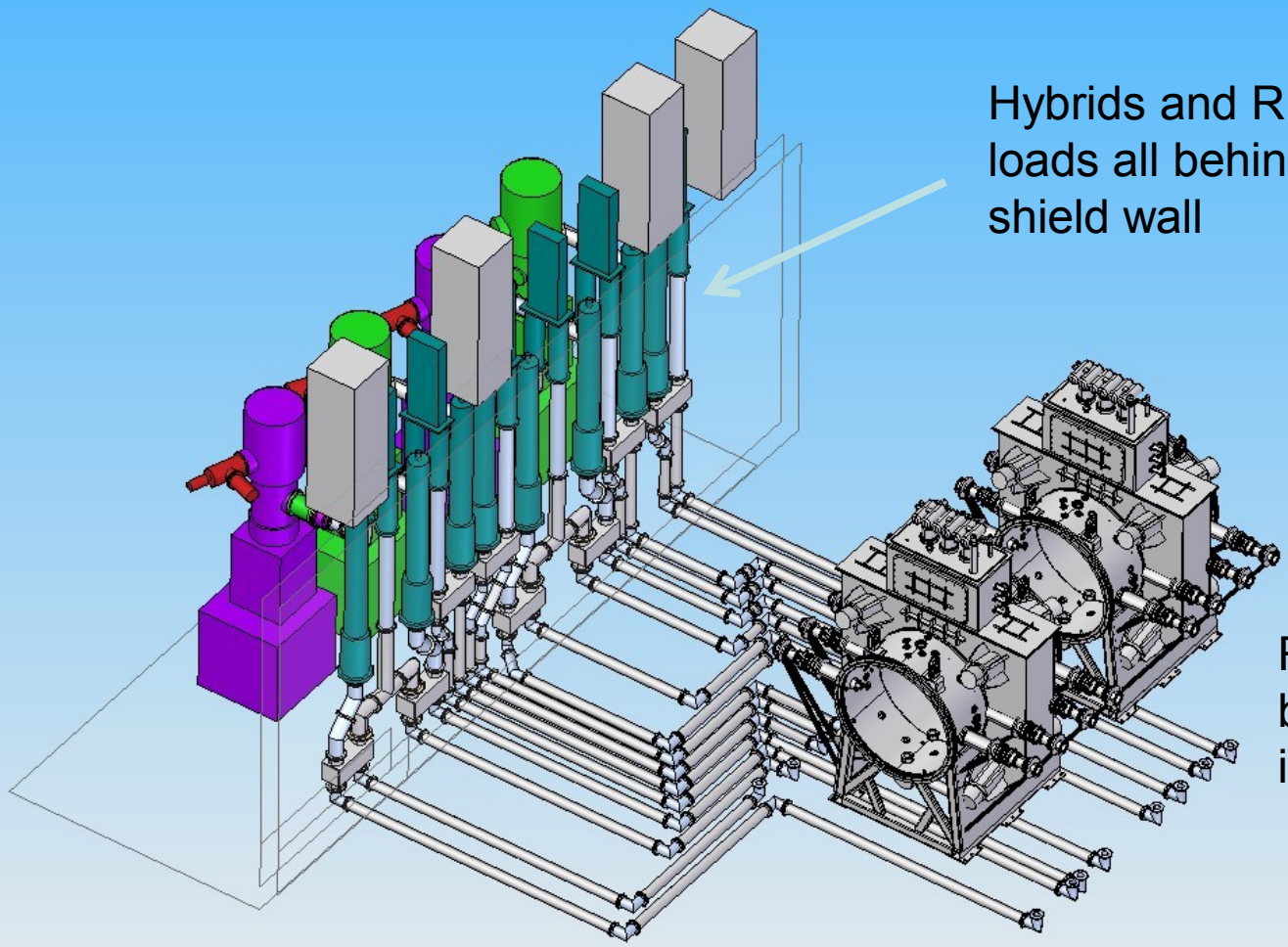


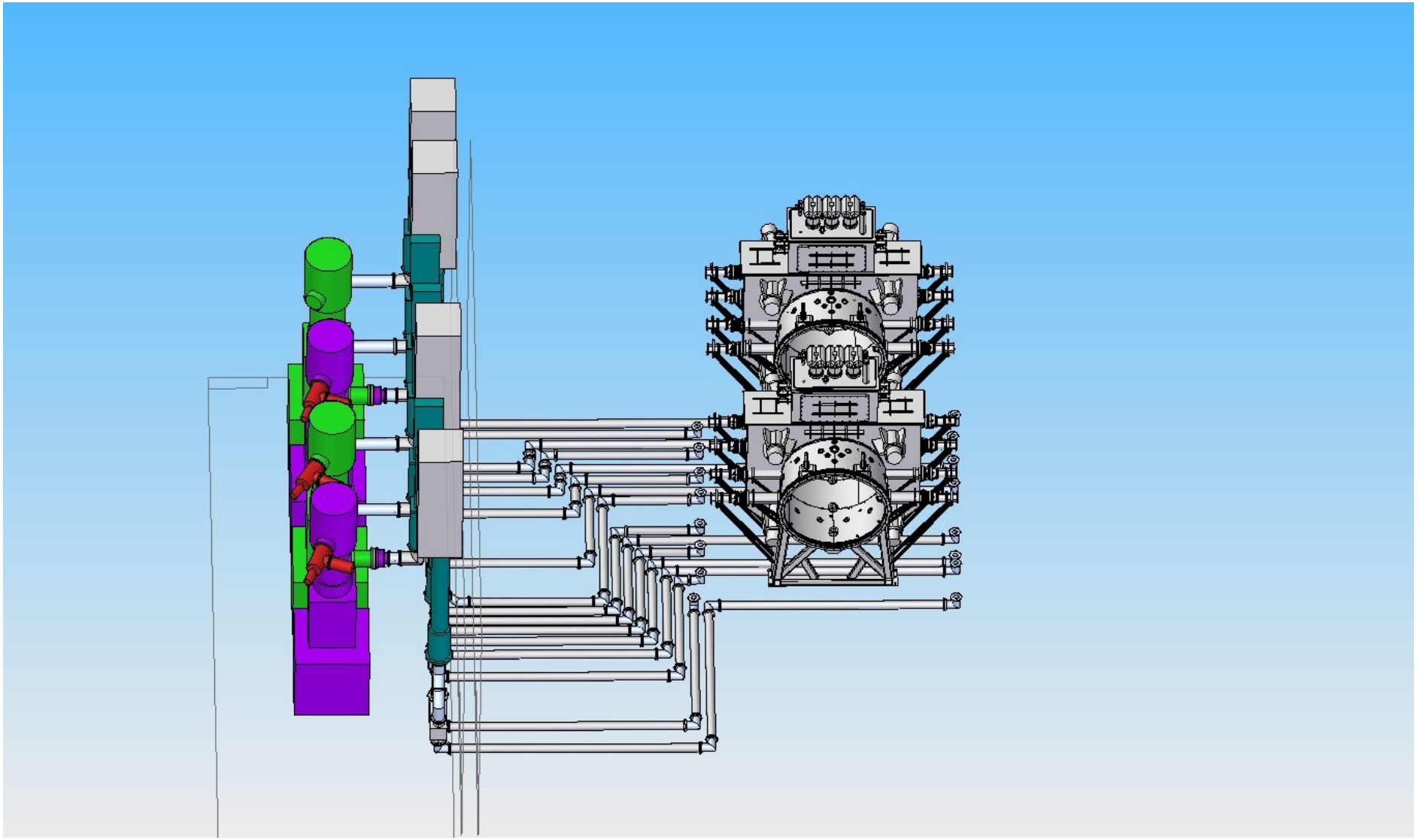


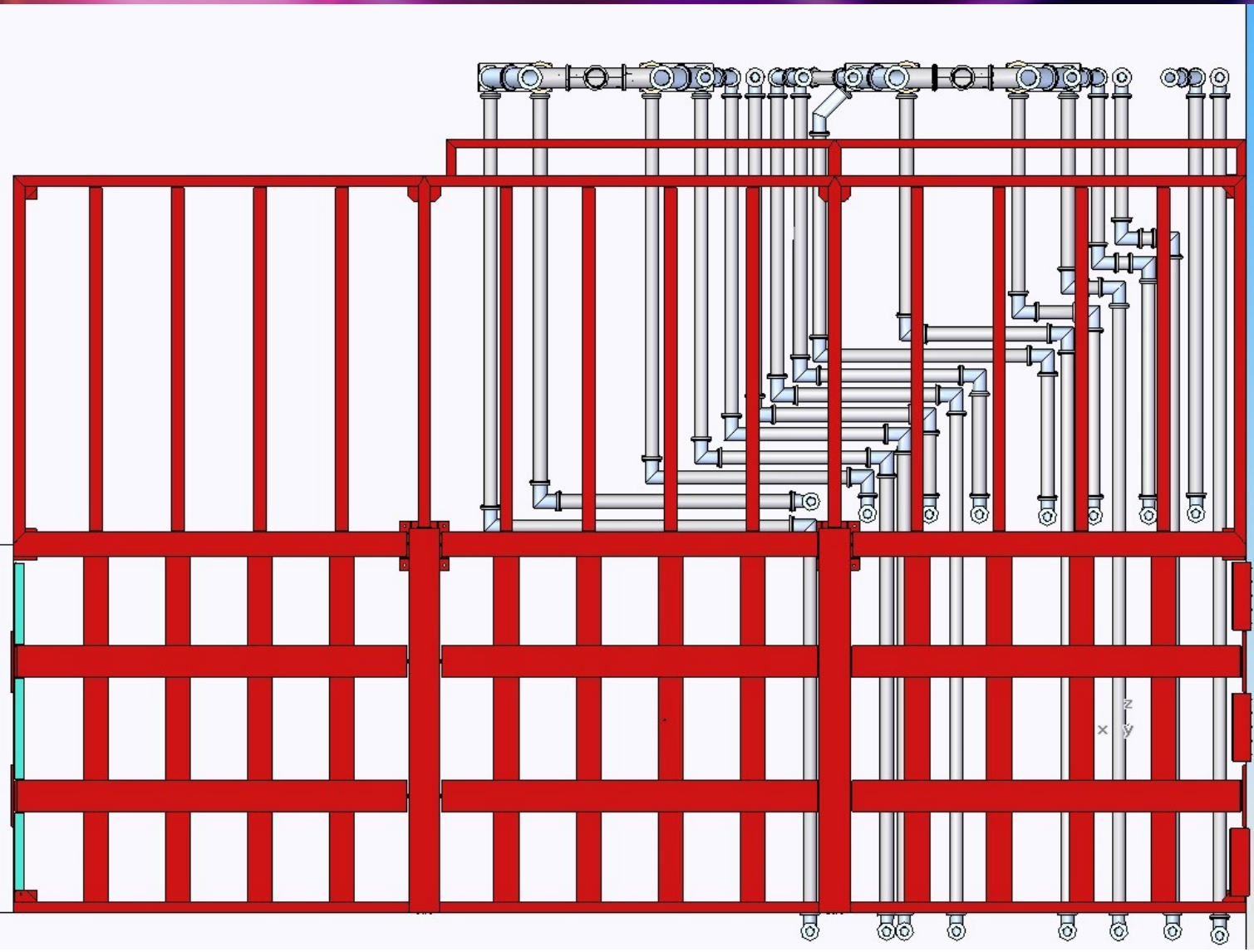
Layout optimisation

- Try to get as much of the complex RF devices out from under the floor so that floor does not need to be lifted if there is a problem
- Still need space around amplifiers to work on them
- trombone phase shifters behind shield wall freed up a lot of space
- move feeds to cavity couplers as close as possible to under the required port
- ‘flexible’s’ up from floor to cavity couplers will be able to be removed so RFCC can be moved


4616 amps


Hybrids and RF loads all behind shield wall
RF outputs below RFCC inputs





Layout further work

- Need to match lengths of coax from hybrid splitters to cavity inputs for phase addition
- These can be in 4 inch coax to save space
- Smaller RF loads found, can be designed to our specification
- Will add small phase shifters into these lines to take out small errors
- N2 pressurisation to be discussed, cavity inputs may need this anyway for voltage standoff, interlock if something goes wrong in the couplers/coax
- Write specification for coax system to purchase

Plan

- Complete tests on current amplifier and then ship to MICE
- Build up first CERN amplifier to working system and begin tests early 2011
- Test digital LLRF on amplifier system
- Build up next set of power supplies and transfer into test system, send current power supplies to be installed in MICE hall
- Complete design of RF components from amplifier to cavities and procure

Thanks to

- Tim Hayler, Alan Grant, Alan Muir for their work on the layout
- Mark Keelan and Alan Letchford for help with the amplifier systems