MICE RF System

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ASTeC

CM32

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RAL

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- Results of RF review and changes
  - Amplifier system
  - Hall layout
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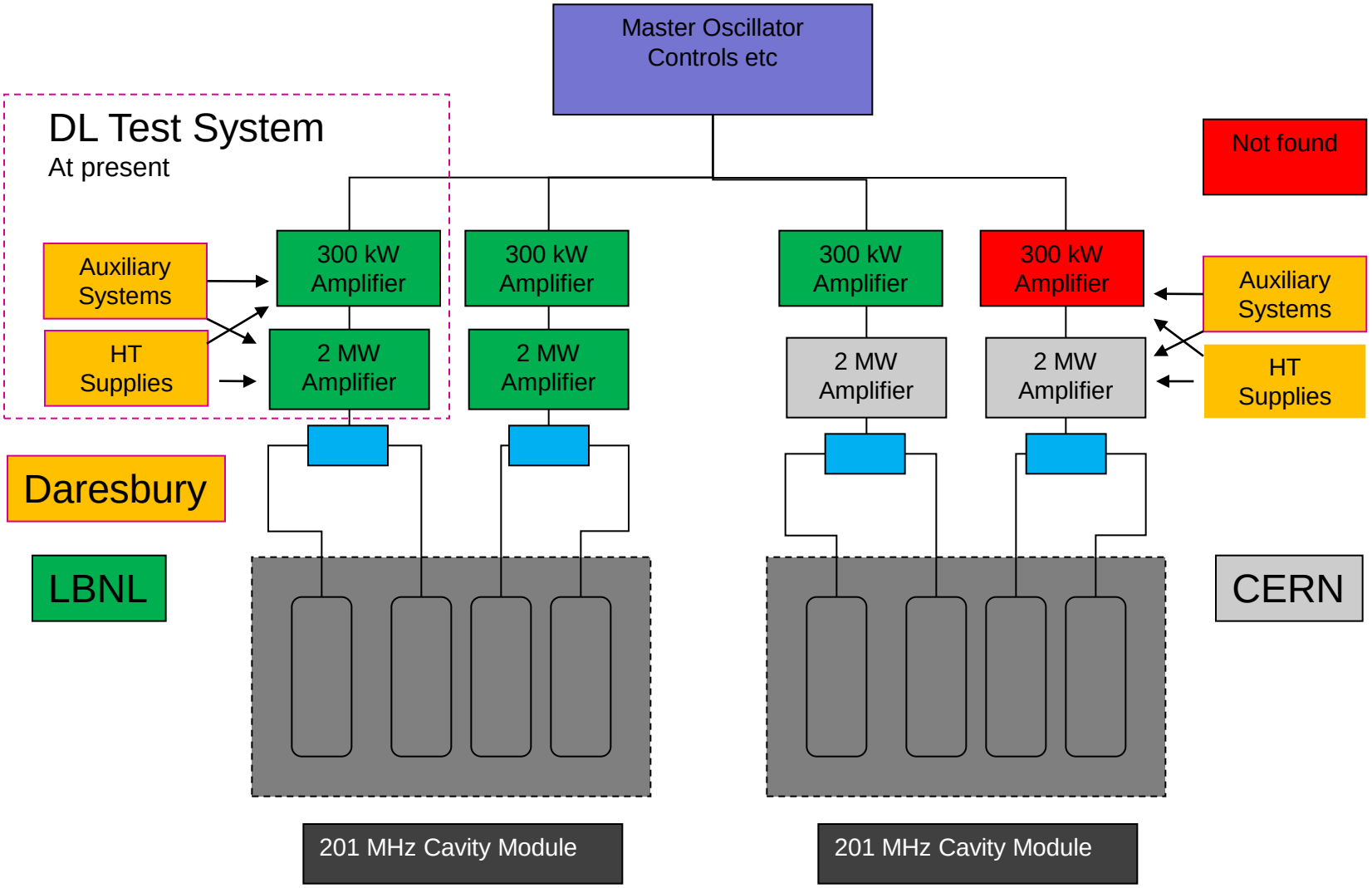
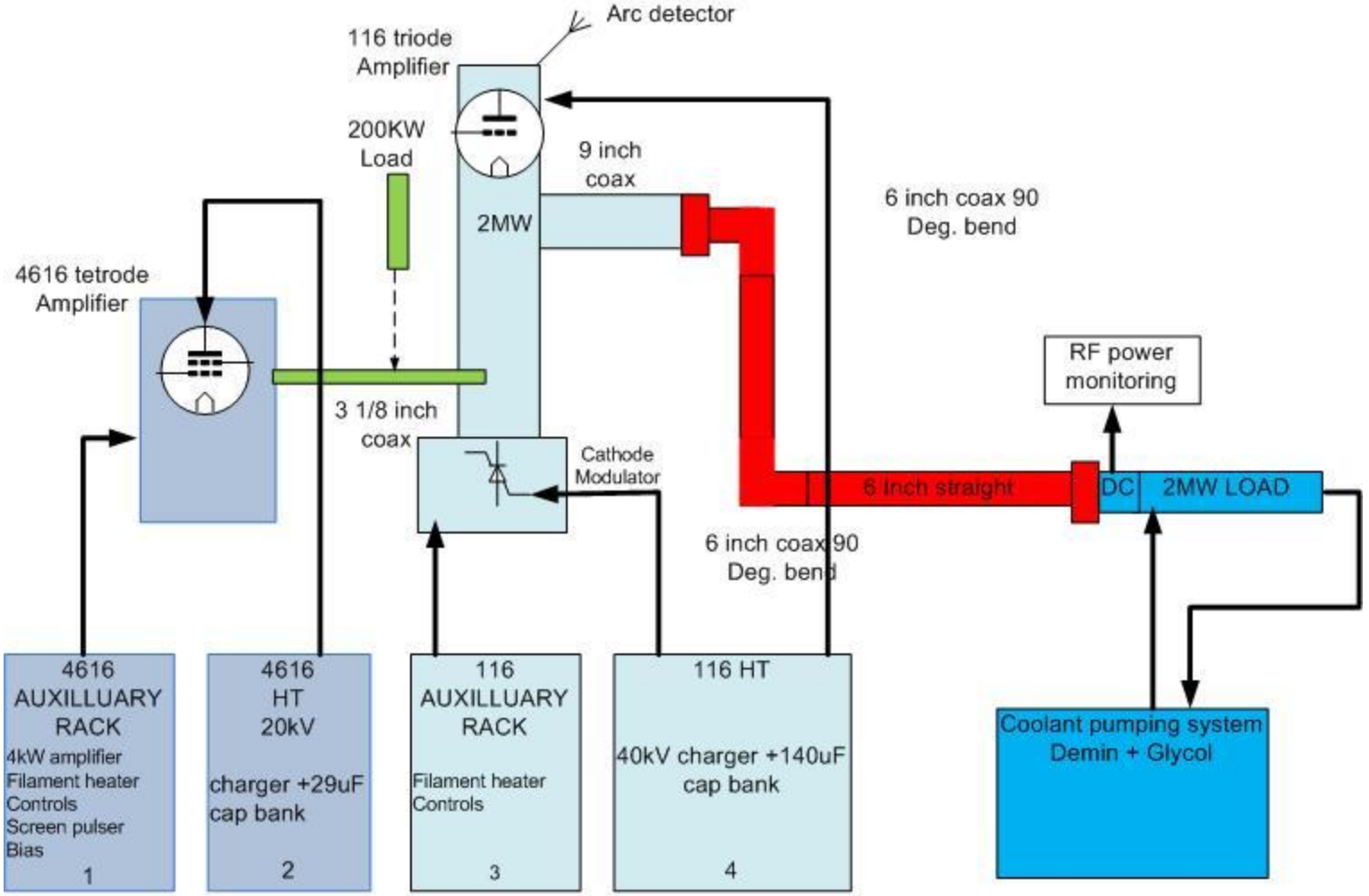
RF system components



Test system at Daresbury



Daresbury test setup for proving amplifiers/power supplies

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RF and power supply testing

- System pushed to 1MW RF output
- Relatively quiet:
  - No evidence of significant X-ray production or microwave radiation

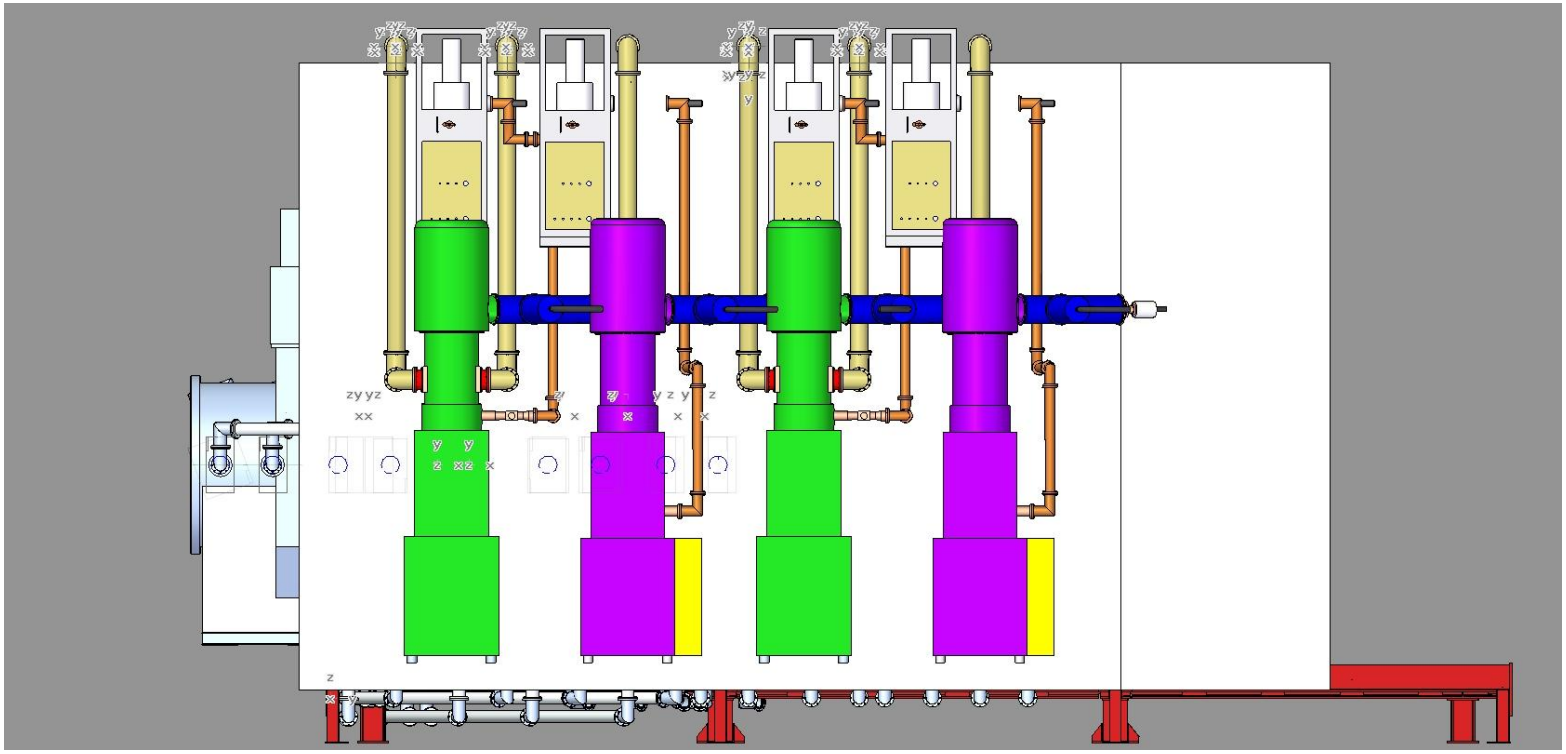
Forward power into load

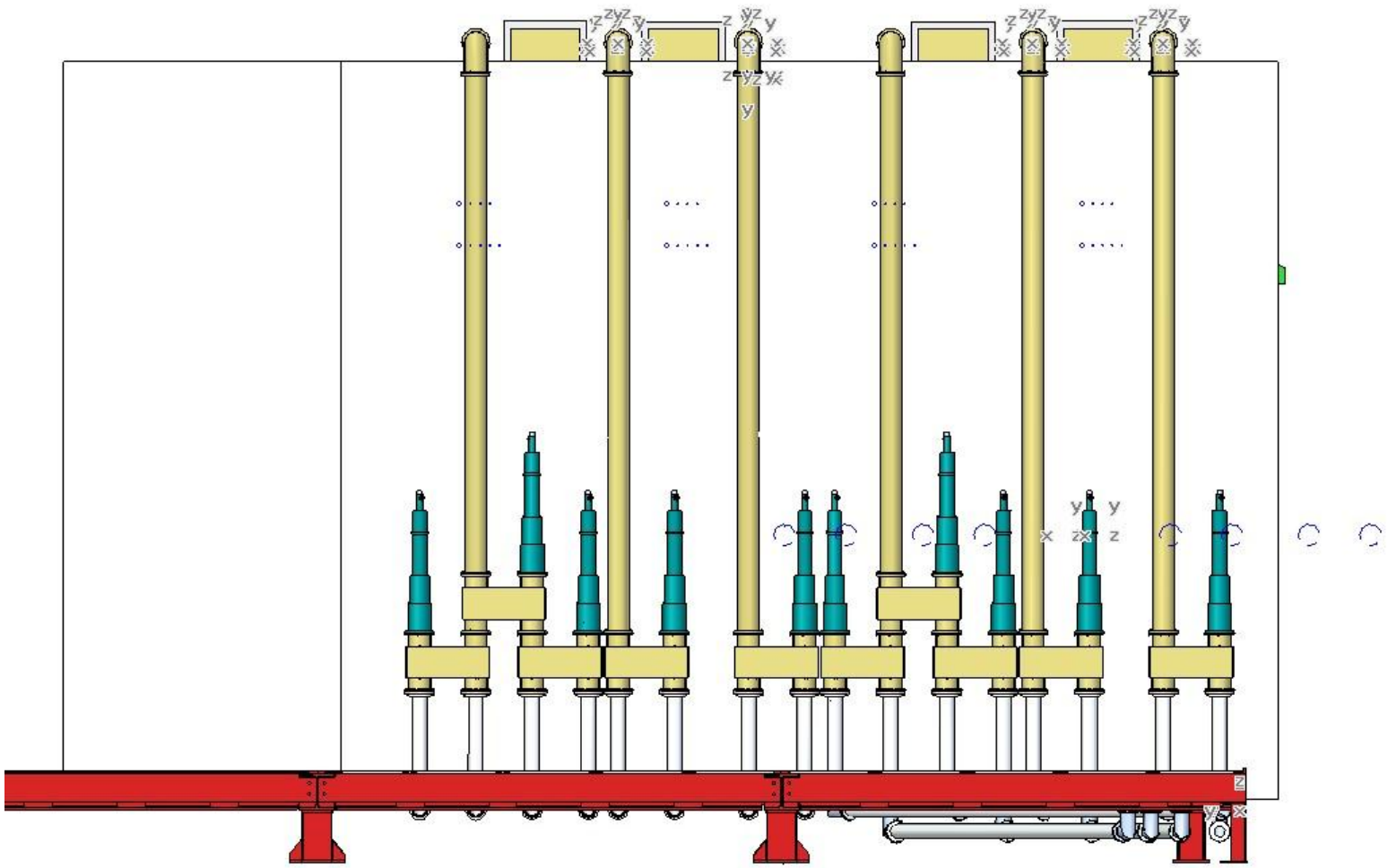
Review panel concerns over amplifiers

- Tube lifetime is around 15,000 hours on ISIS at 50 Hz ~ 4MW, MICE will run at 1Hz and 2MW so lifetime should be extended
- Power output will degrade over time to around 50% of initial level, therefore the effective cavity gradient will also degrade over time
- Currently no spare tubes, option to purchase 2 more TH116 tubes, however there will be no more, production of glass assemblies has ended, ISIS tubes are removed from service at power level of ~1MW
- Amplifiers will be difficult to maintain behind shield wall, layout changes suggested to allow access to work on systems
- 4616 amplifier currently appears above shield wall and may see some magnetic field – no information found on what level is acceptable from manufactures or other lab experiments, however as the tube has a very small electron drift gap - not that concerned at the moment, will have to fix what goes wrong in the hall. Power supplies include many transformers, circuit breakers, PLCs and many other magnetic components

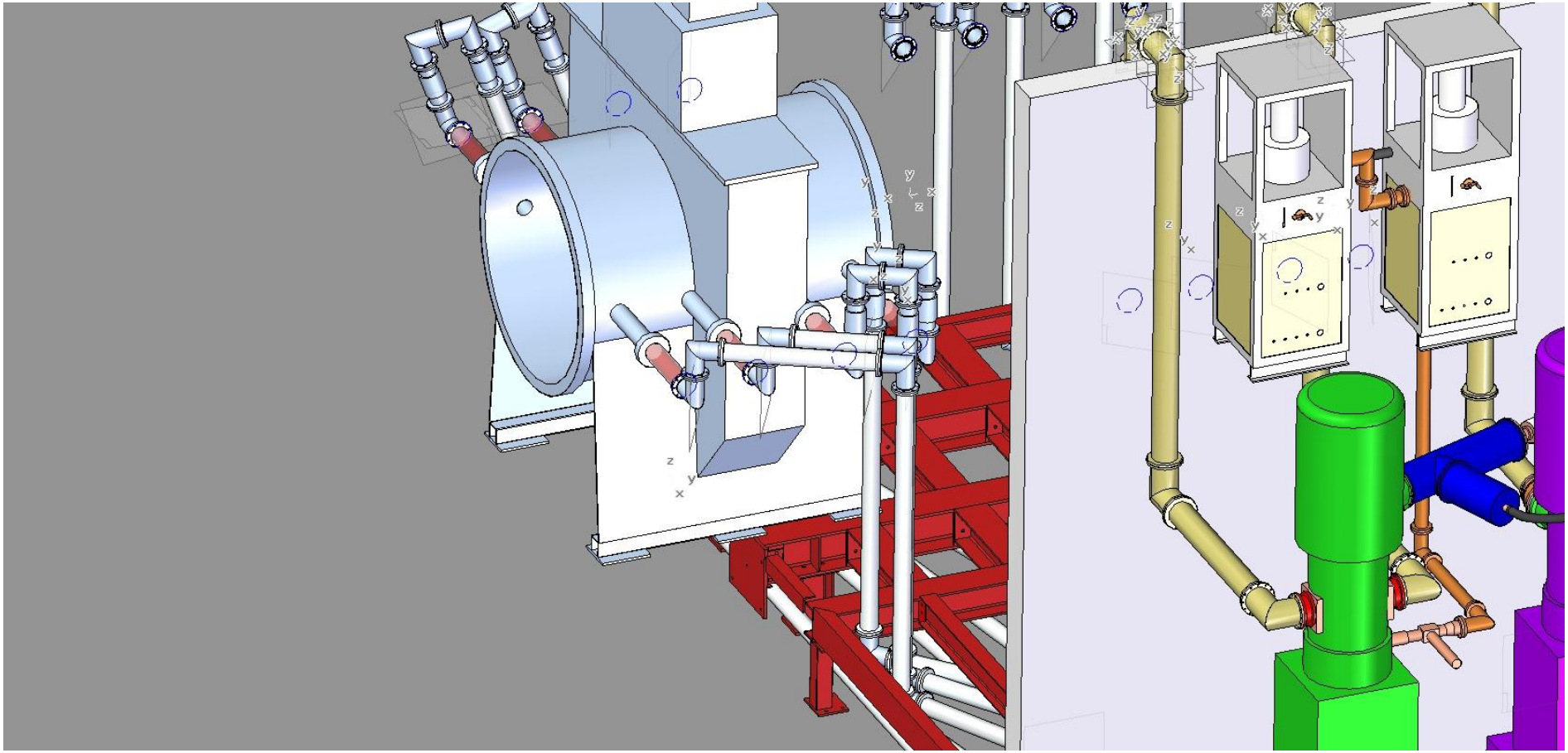
Review on the coax layout

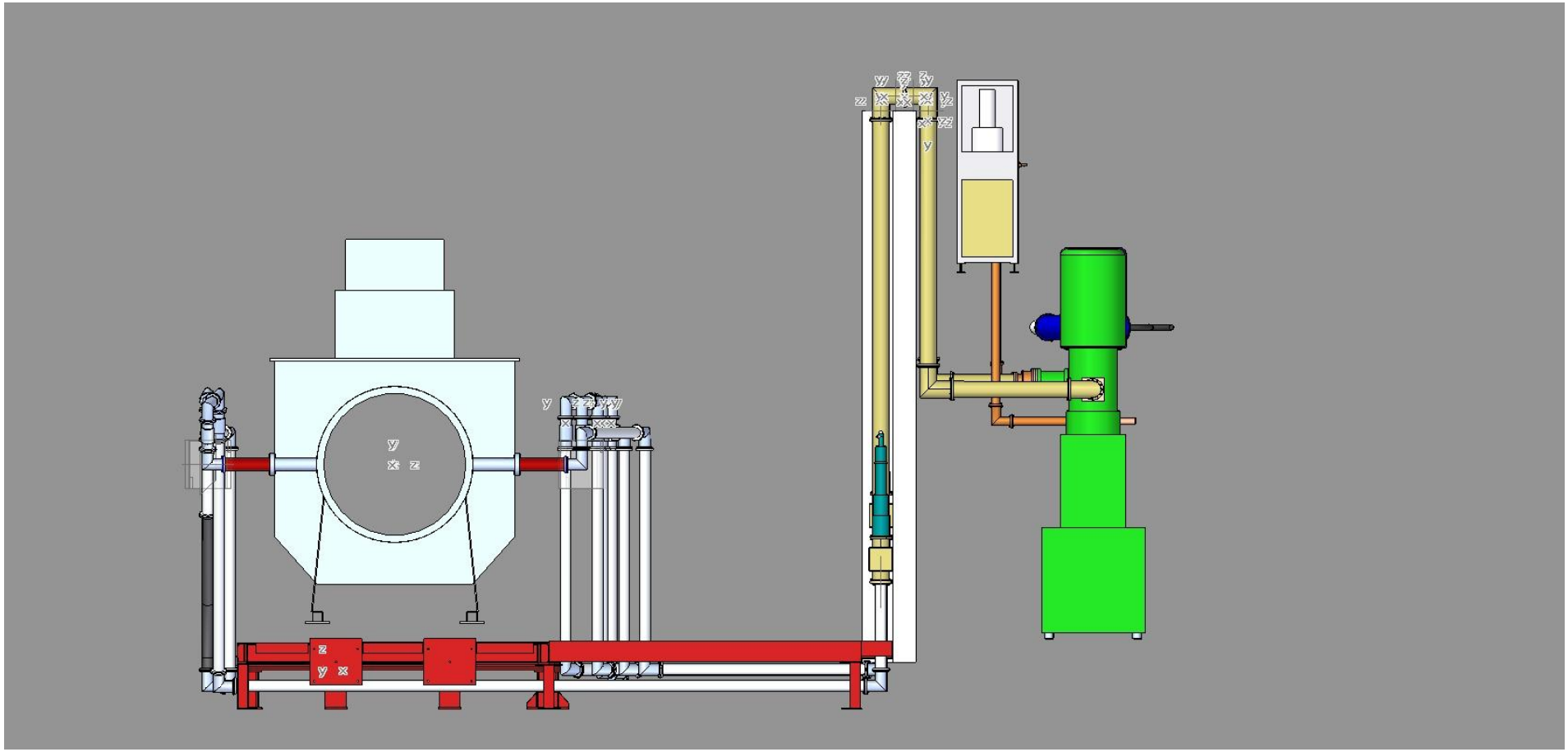
- Different layouts of coax were suggested that would improve access to the amplifiers and simplify the coax runs. Equipment to be hung on the inside of shield wall
- The uses of movable coax phase shifters would cause reliability issues, during the meeting a fixed cavity phase offset was agreed that provided 98% of acceleration for all momentum
- Fixed phase shifters would be used to make up for any phase imbalance in coax lines to the cavity

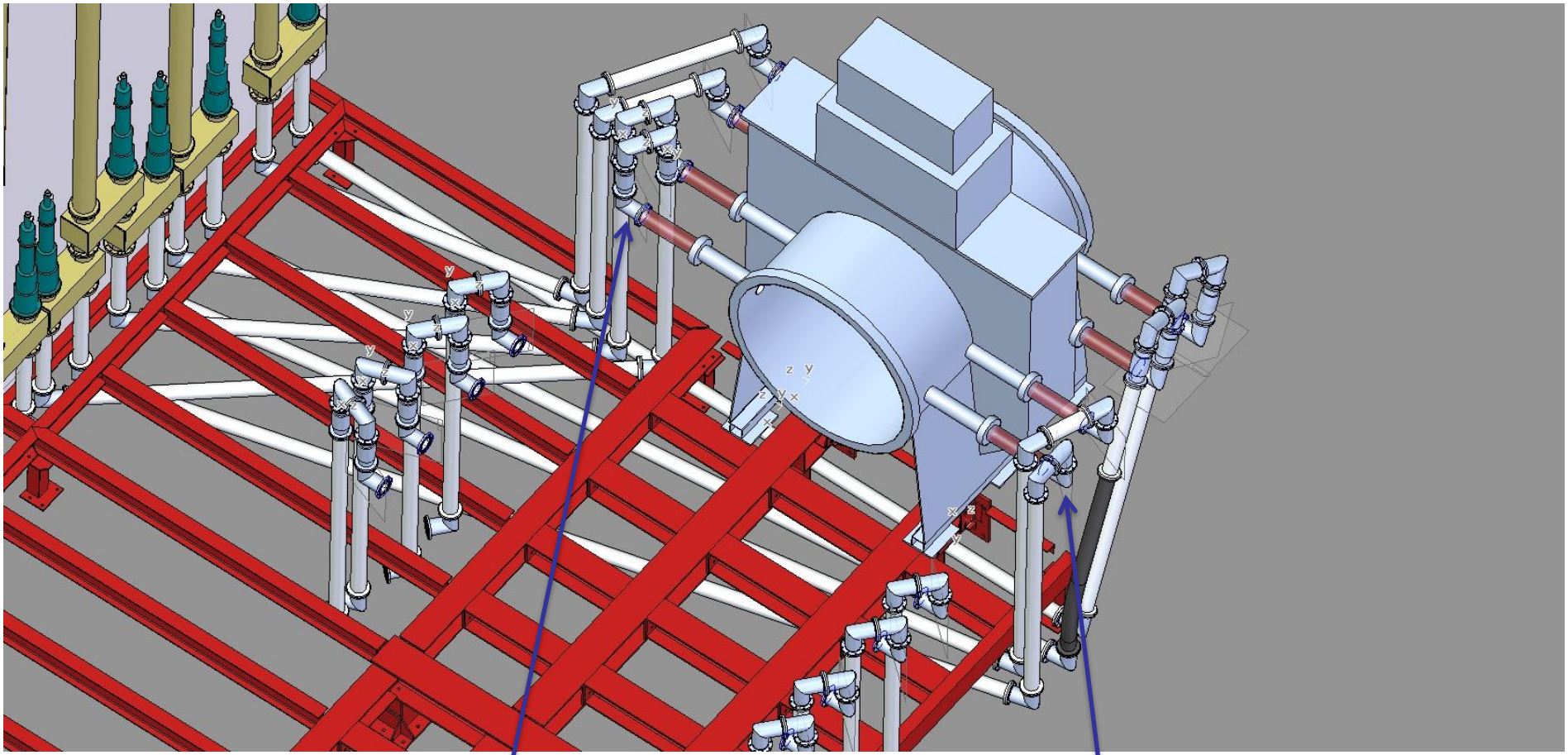




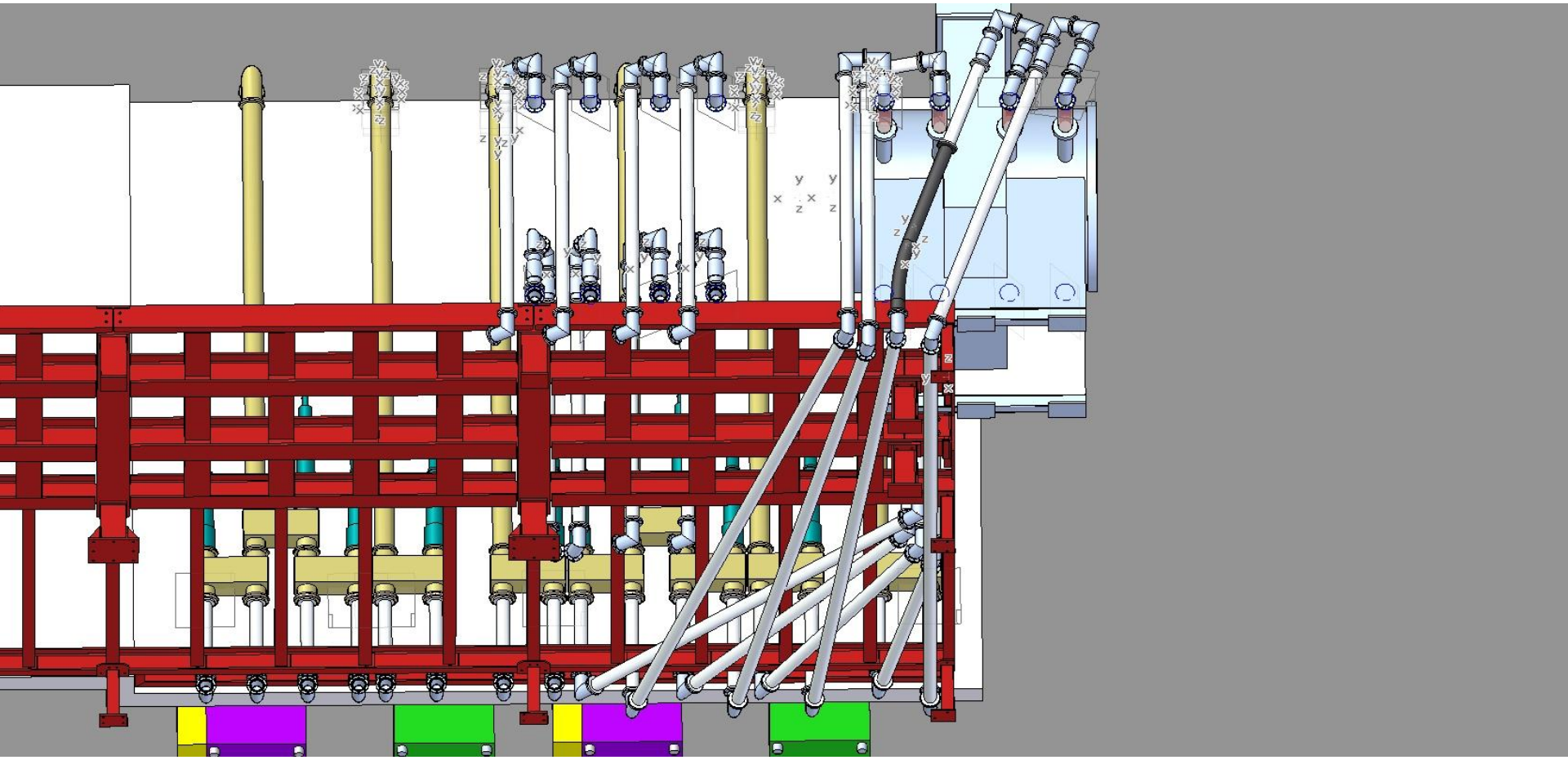
Alternative coax distribution on shield wall







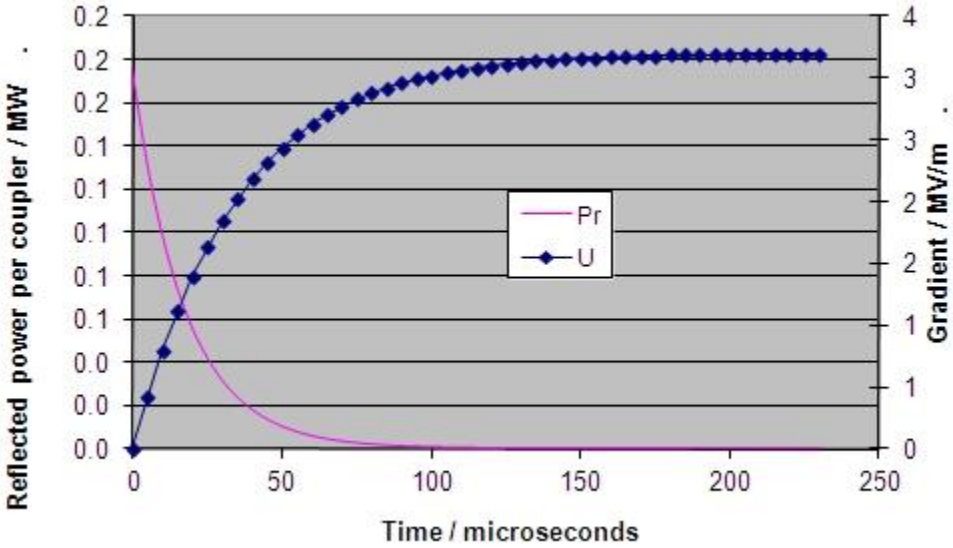
These sections can be used to adjust phase length

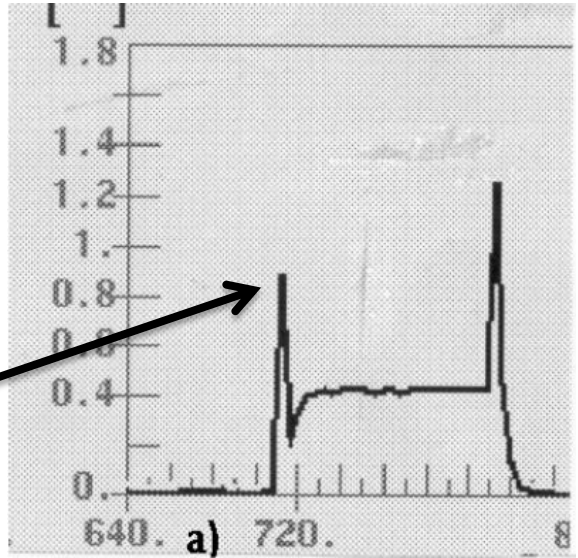


View from underneath the false floor
showing coax distribution

Reflected power due to cavity filling

- Cavity filling is done by switching on forward power at maximum to fill the cavity as quickly as possible
- Cavity reflects forward power during filling for a short time ~50uS
- This leads to a doubling of effective RF power (at the start of the pulse) in the coax guide = 4 times the voltage
- In the 4 inch coax and cavity couplers this passes the 700kW breakdown limit (in air)





Reflected power

Inputs	
Q0	44000
Prf	3.50E+05
Qe	88000
f	2.00E+08
R/L	2.20E+07
Calculation	
Qematch	88000
U0	1.23E+01
QL	22000
Beta	1
TL	1.75E-05
L	7.50E-01
R	1.65E+07
Power per coupler	1.75E+05

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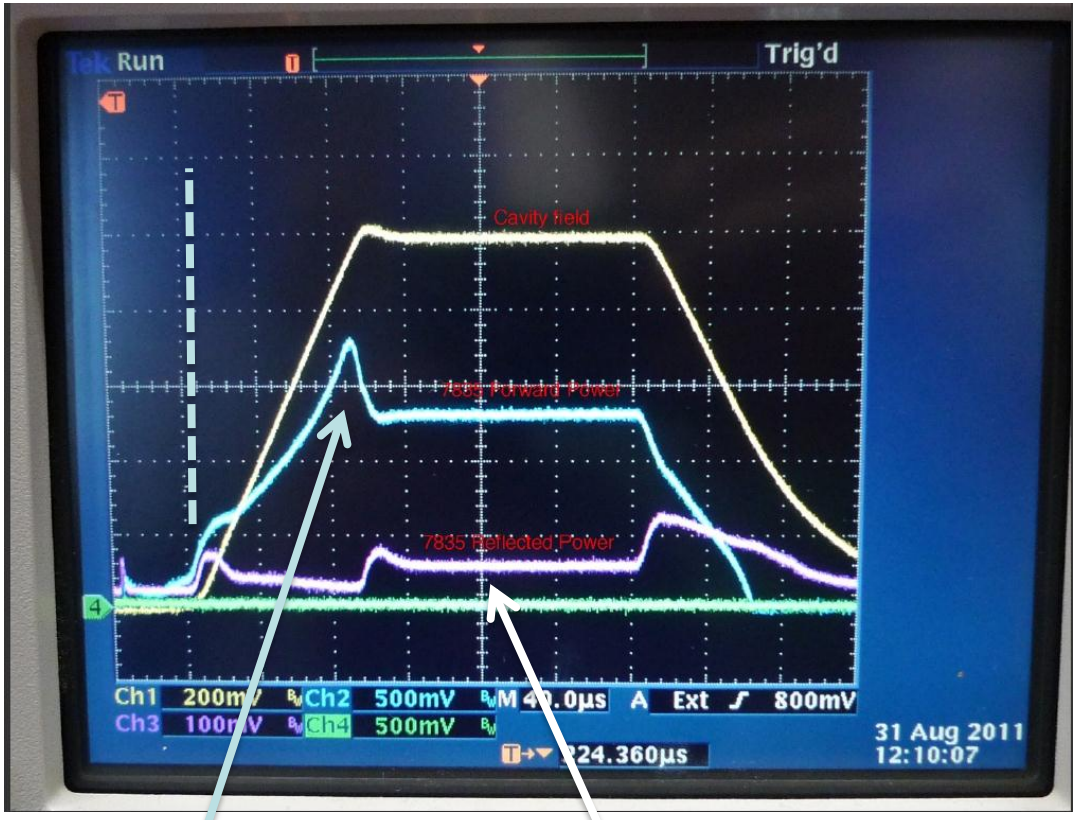
Cavity filling solution

- Using a slow fill approach, the forward power is switched on in a ramped way to reduce reflected power effect
- Can reduce reflected power to a tenth of forward wave
- Example from FNAL
- Using digital LLRF this is simple to achieve
- Nitrogen will be used in the coax guides



Amplitude loop activates

Reflected power

Cavity phasing

- With two cavities being driven by one amplifier, a fixed phase angle will set between the two cavities, there is still some question over the exact number of degrees this should be ~124 degrees, this can be accommodated by putting additional lengths of coax in the distribution system for each second cavity attached to the amplifier
- The phase angle will change by 16 degrees (for perfect acceleration) for each cavity from 140- 240MeV/C, however this will have to be a fixed value at the best compromise ~ 8 degrees

Energy Gain in Cavity If muon travels through Crest	Momentum (MeV/c)	Total Energy (MeV/c^2)	Kinetic Energy (MeV/c^2)	**Approx** KE Gain (MeV/c^2)	**Approx** KE (MeV/c^2)	Gamma	v/c	Transit Time (ns)	Phase Shift (degrees)
	140	175.40	69.74	2.682	72.42	1.685	0.805	1.699	123.09
	160	191.74	86.08	2.730	88.81	1.841	0.840	1.629	118.02
	180	208.72	103.06	2.764	105.82	2.002	0.866	1.579	114.38
	200	226.19	120.54	2.788	123.32	2.167	0.887	1.542	111.68
	220	244.06	138.40	2.805	141.20	2.336	0.904	1.513	109.63
	240	262.23	156.57	2.819	159.39	2.509	0.917	1.491	108.04
							Max delta phase		15.05

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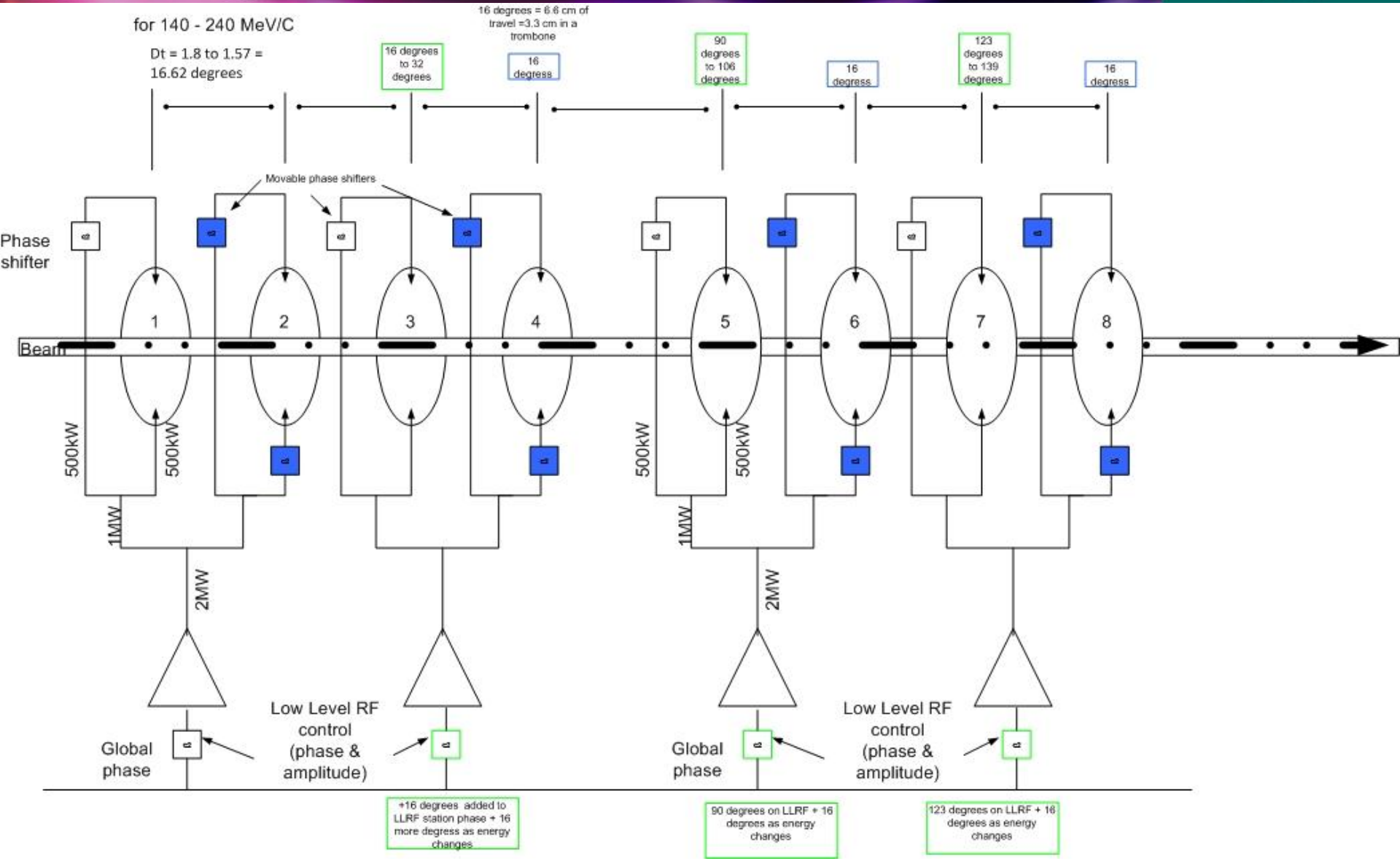

Need to check the fixed phase relationship between cavities

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Experiment timing

- Need to understand the issues for MICE experiment timing and the RF system measurements
- Timing will be generated from the target system, measurement of cavity gradient and phase as the muon passes though the cavity – need to design a system to do this, need to understand what the issues are
- Engineers at DL could work on this with help from LBNL and UK Uni effort, if we can understand and define the real tasks

Summery

- RF testing to 2MW will be done before the next CM
- RF review has prompted a new round of optimisation of coax distribution that looks to make things easier in a number of areas, space around the amplifiers, lower transmission loss, easier to install
- Coax should be filled with N2, slow cavity filling will be needed to avoid breakdown inside the guides, RF tests at the MTA are required to prove this as an acceptable design
- RF specification is being refined and needs to be approved
- Discussions about LLRF control/experiment timing need to be understood and build a team to look at solutions