MICE RF System

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  - Results so far
- Hall layout
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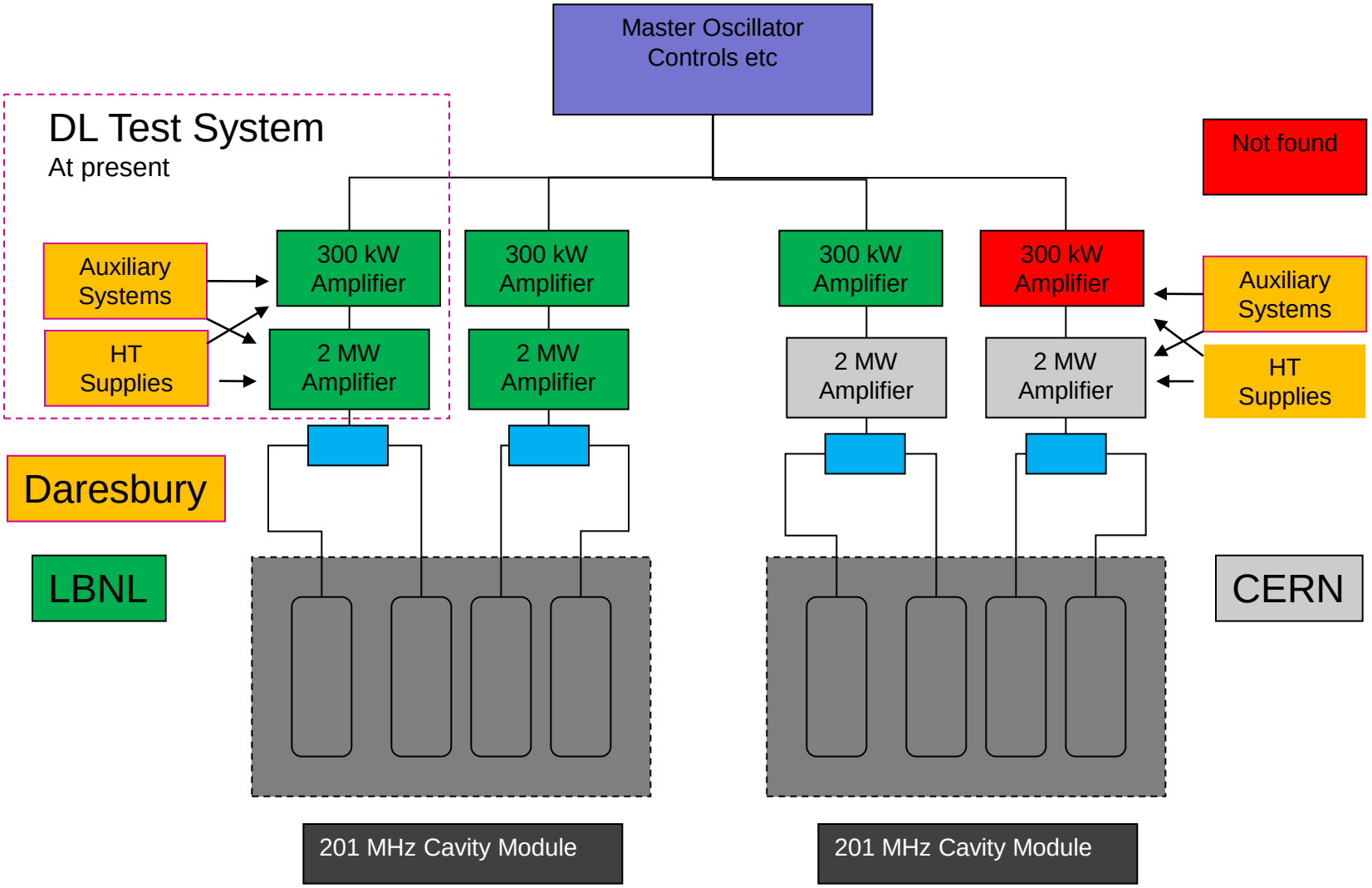
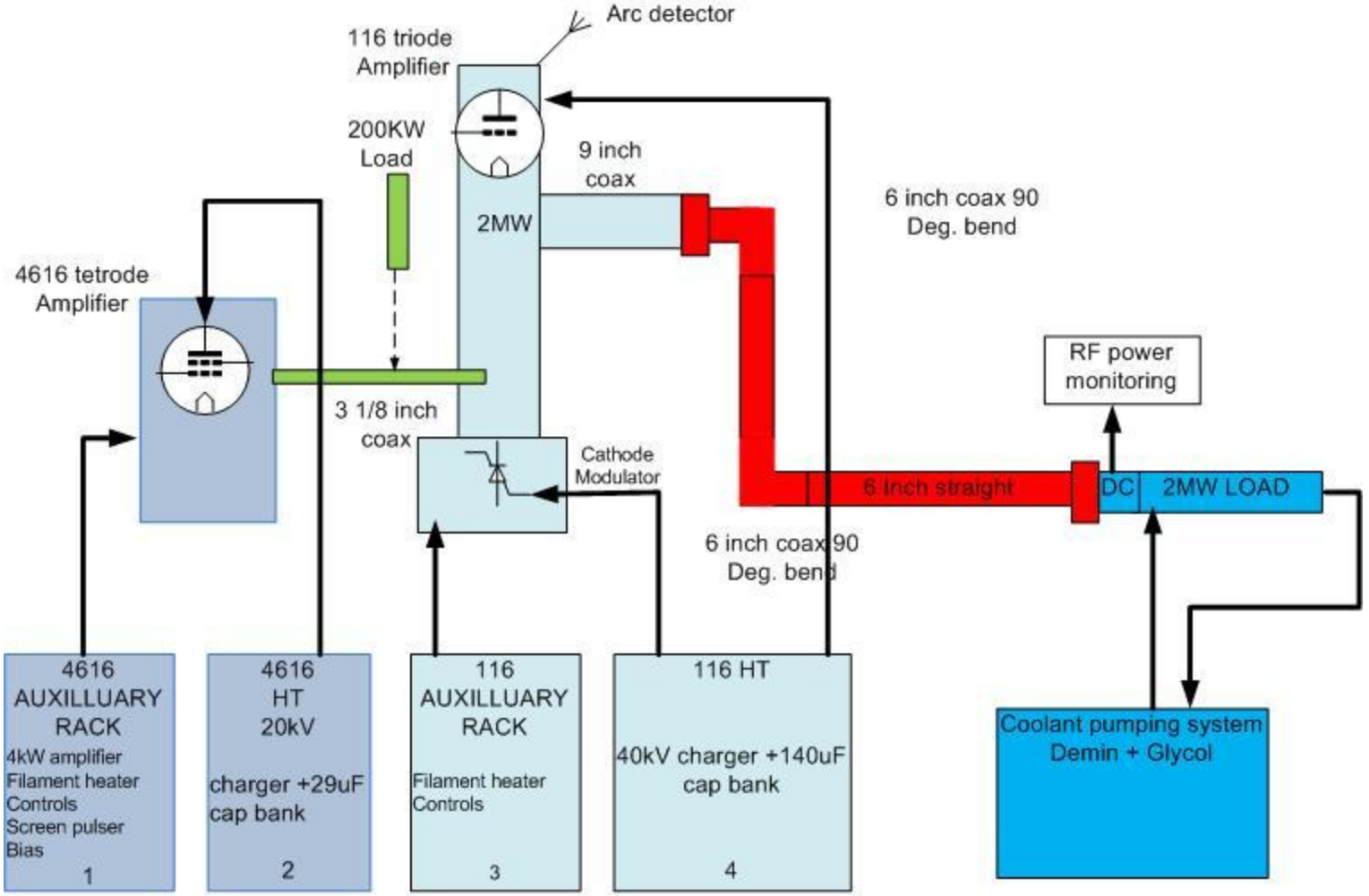
Amplifier status

- First medium power (250kW) 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

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4616 medium power amplifier

- 4616 pre amplifier set up on 50 Ohm test load
- System operated at 70kW into load using an old Berkeley tube, gave us a known starting point to run into the 2MW amplifier system
- Tube has now been replaced with a new one and testing has been done up to 120kW

High power amplifier status

- During refurbishment plastic material replaced around heater terminal, now understood to be capacitive material that allows RF to penetrate into amplifier circuit
- When testing commenced, RF drive could not match correctly – higher drive reducing the output power
- Now replaced with original plastic material used at LBNL
- System responded instantly with much high output powers for the same drive input

RF and power supply testing

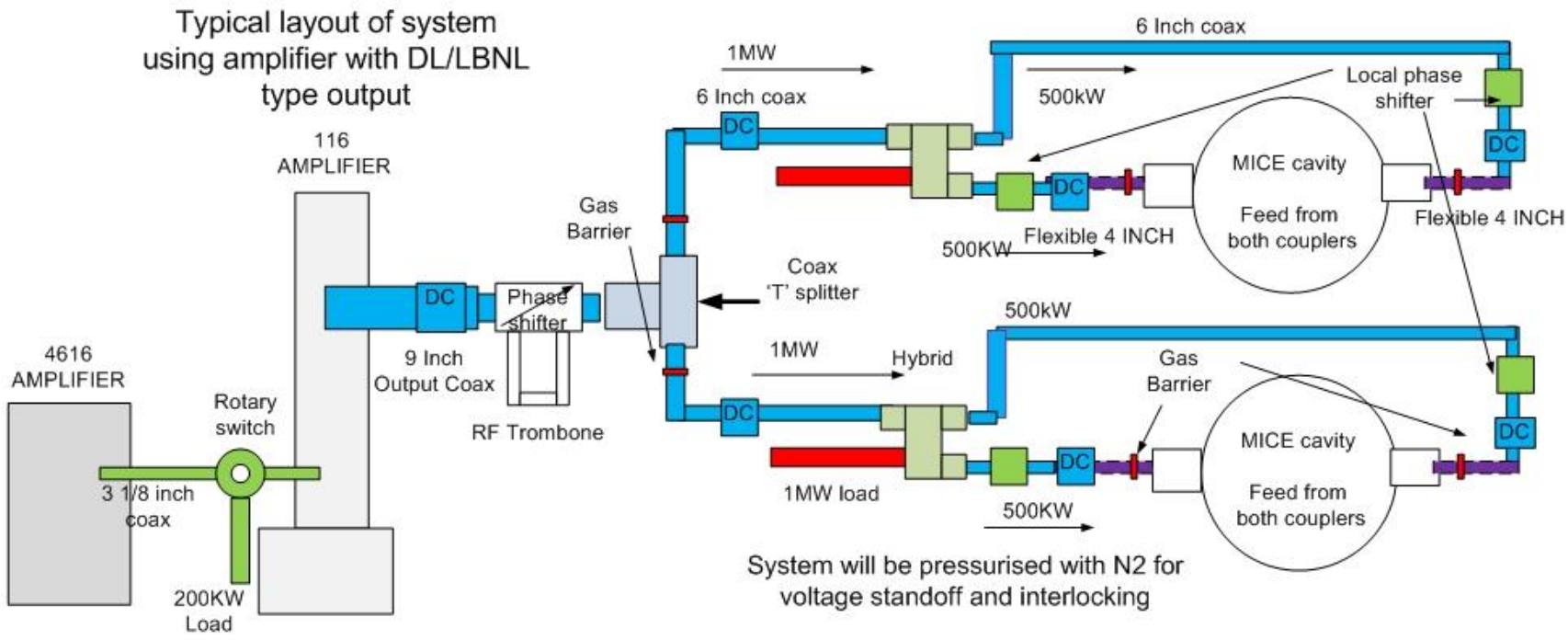
- System pushed to 1MW RF output
- Relatively quiet:
  - No evidence of significant X-ray production or microwave radiation

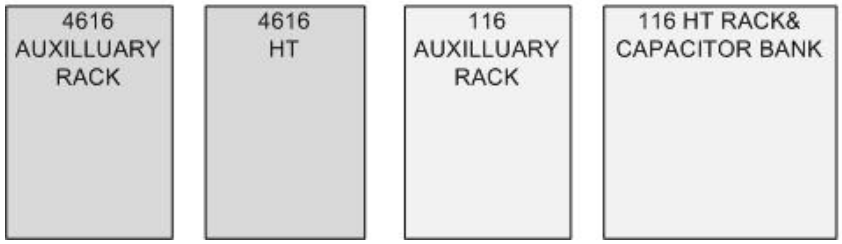
Forward power into load

Further 116 testing

- Old ISIS tube showing gain of 10 which is to be expected, has allowed test of amplifier up to 1MW
- So far the amplifier system seams very well behaved at up to 30kV and 1MW
- Now plan to swap to a new 4616 and new 116 to push system harder
- New 4616 tube has proved to be more difficult to set up, lots of oscillation, currently still investigating using test load however 120kW at 15kV with 16dB gain

Predicted hall layout for RF components





DC = directional coupler= power measurment

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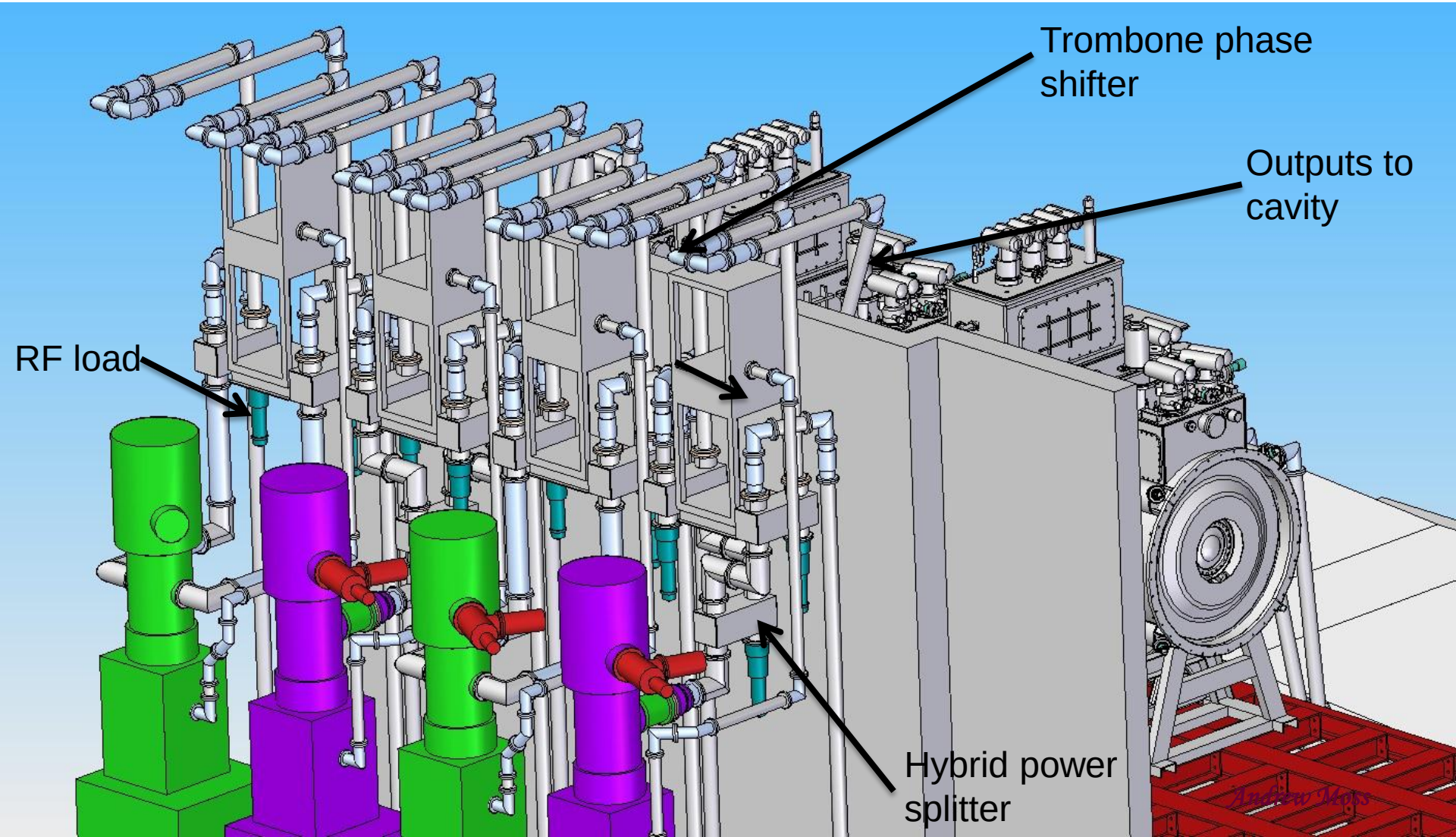
Coax design

- Hybrid power splitters to divide power before each cavity with a rejection load, however the reject load will only see reflected power from unbalanced conditions which will be small, this load could be limited to a 50kW device, this should provide a robust reliable system
- Local phase shifters in each cavity coupler, small range available only due to physical size of phase trombones, 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


Trombone phase shifter
Outputs to cavity
RF load
Hybrid power splitter
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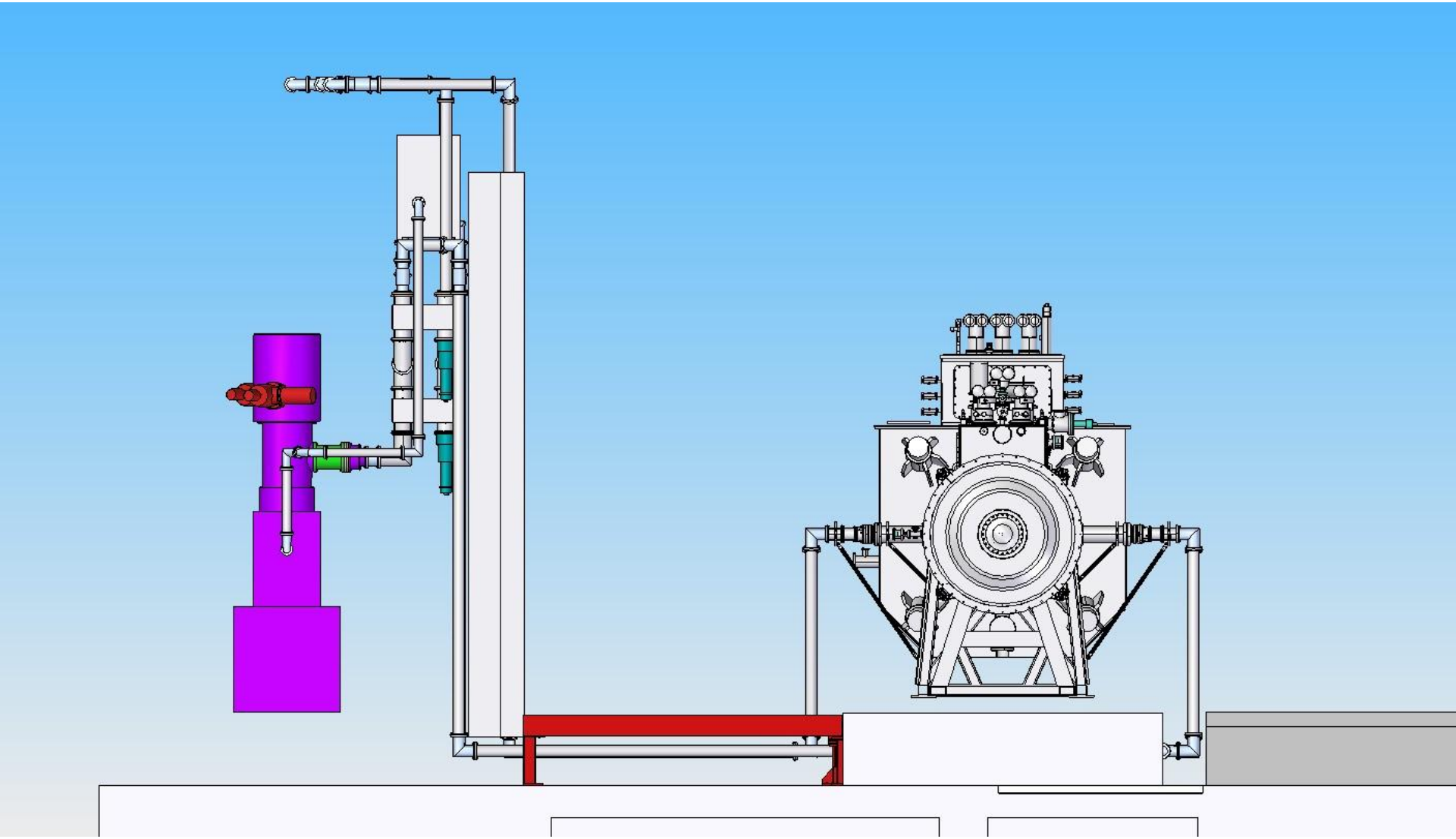
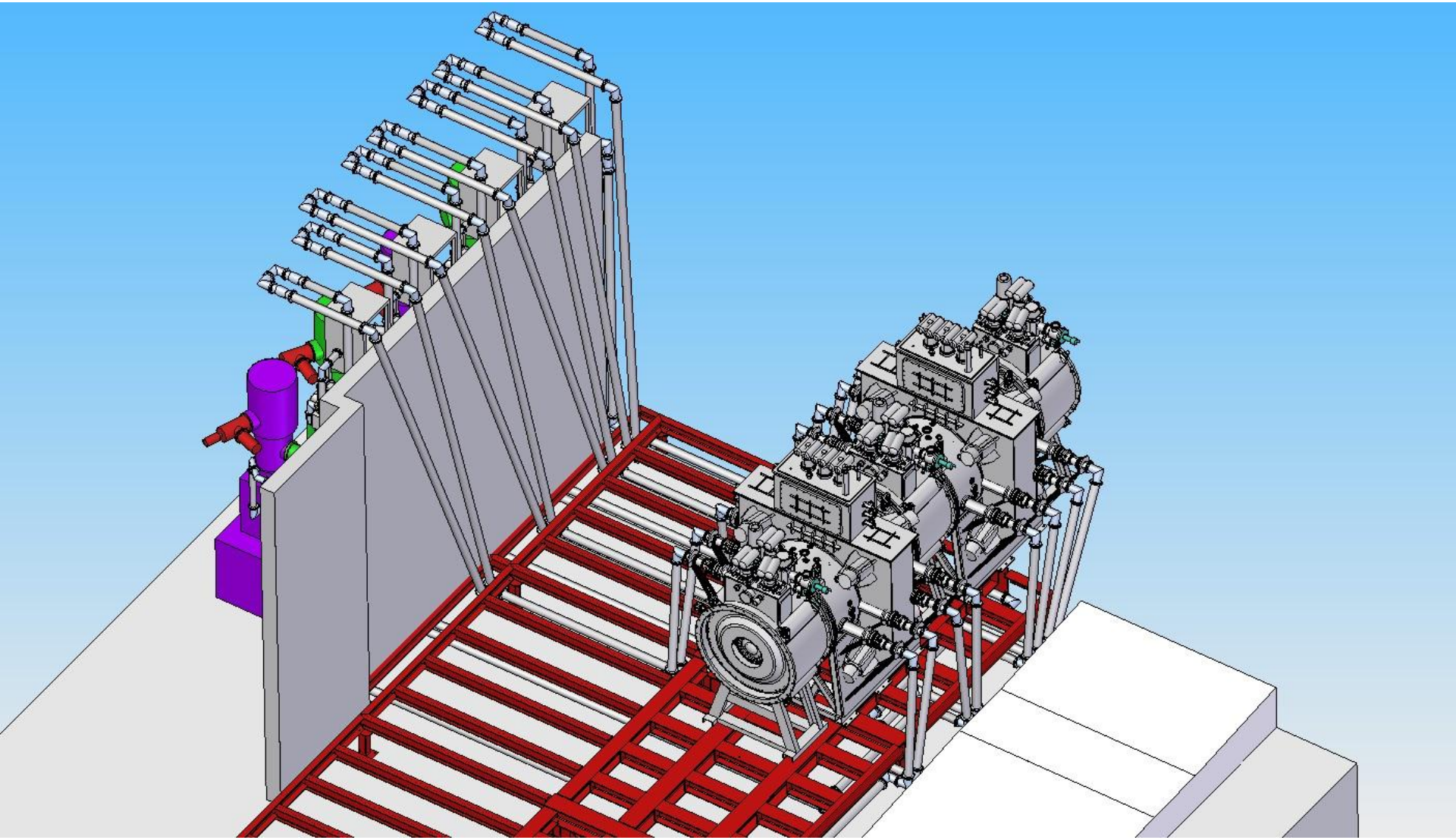
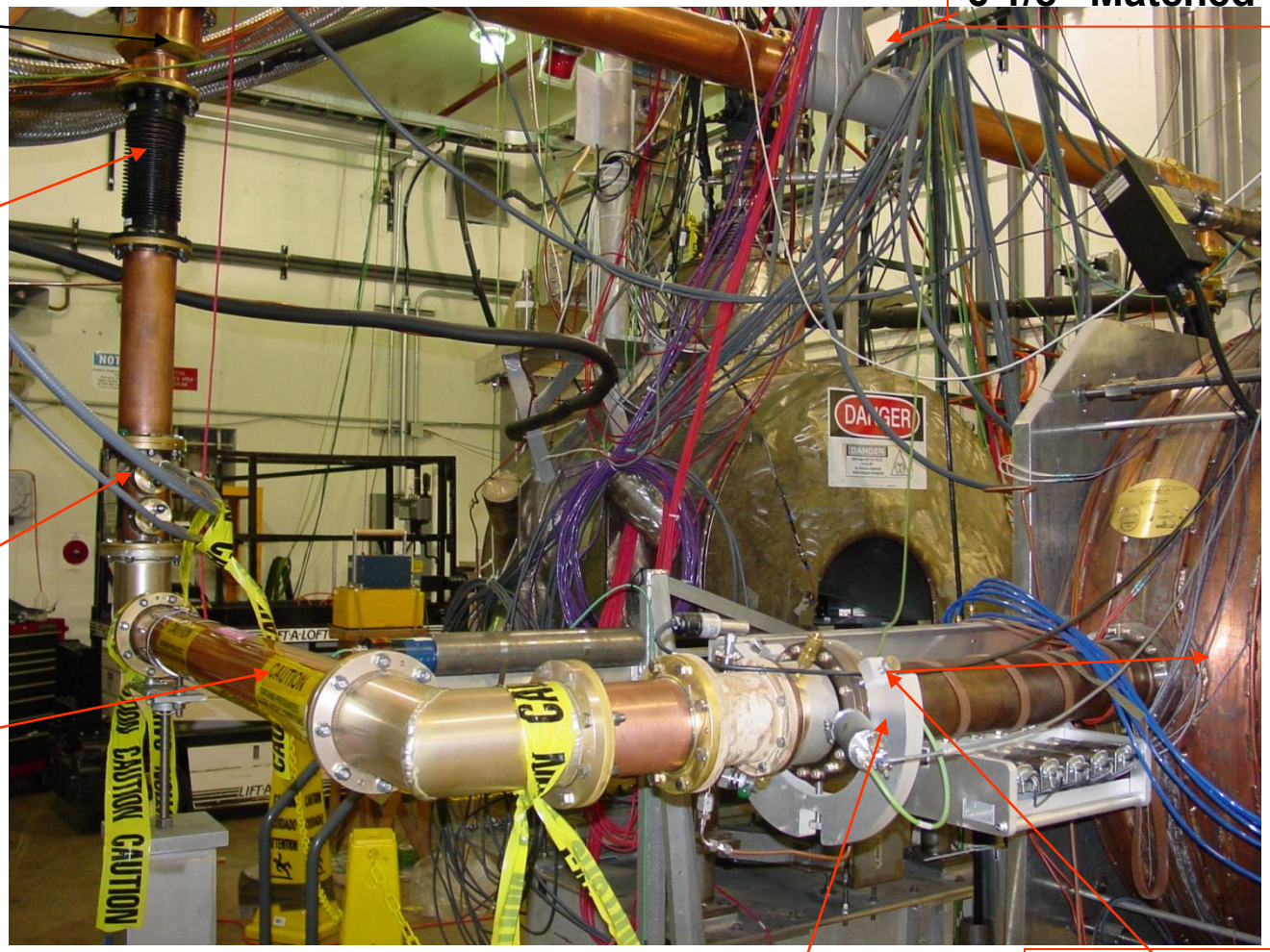




6 1/8" t0 4 1/16" Coax Transition

6 1/8" Matched Tee

Flexible line section



Dual Directional Coupler

4 1/16" Coax Section

Photo-Multiplier

Vacuum RF Coupler Loop

MTA with 201MHz MICE cavity on test

Slides courtesy of Al Moretti, Fermilab

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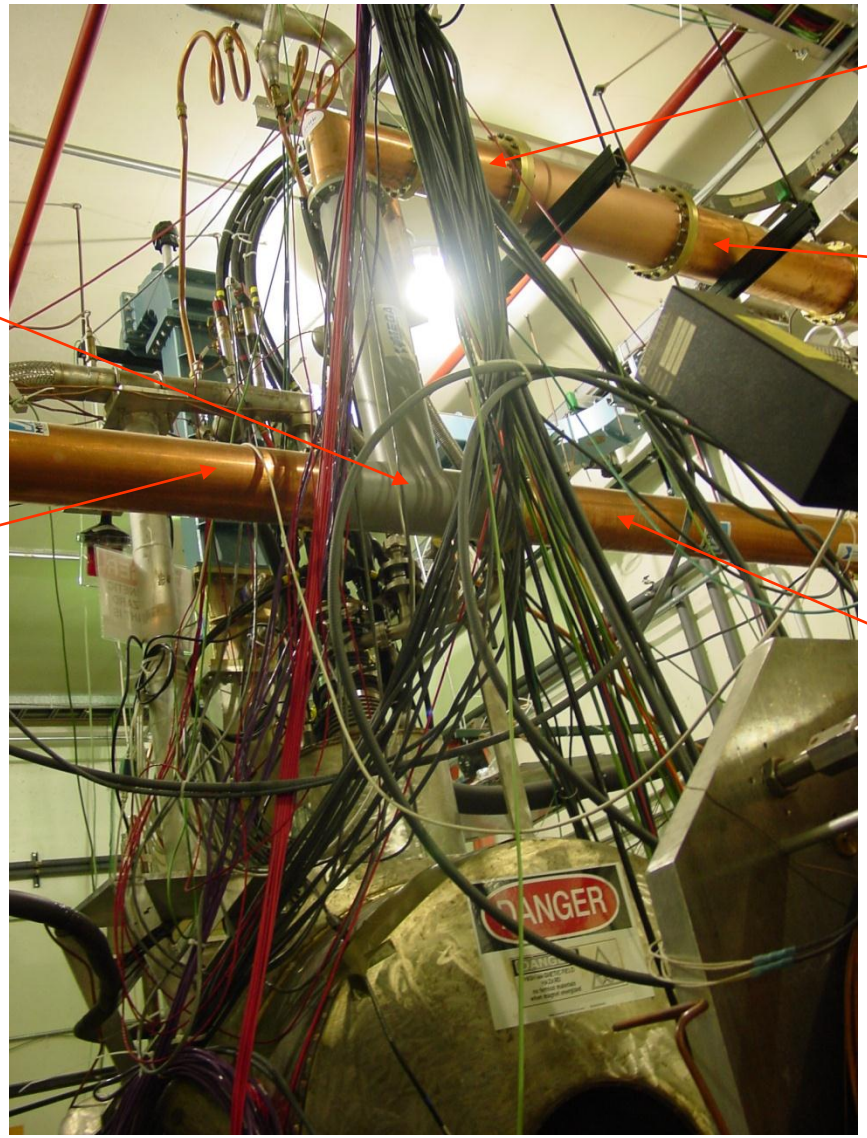


Matched
Tee 6 1/8”

To Side #1
Coupler

9 3/16’ to 6 1/8
“ Transition

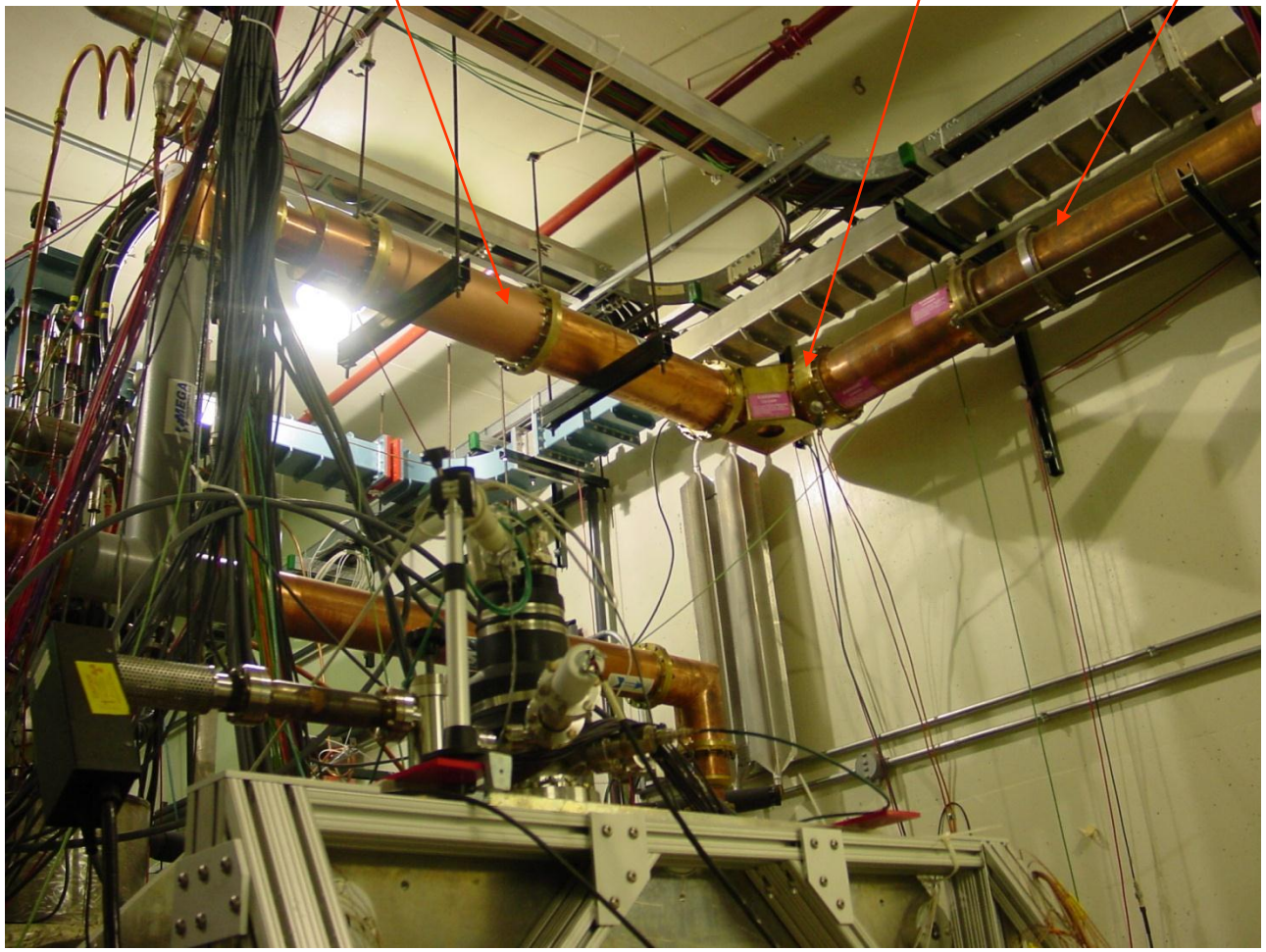
9 3/16” line

To Side # 2
Coupler

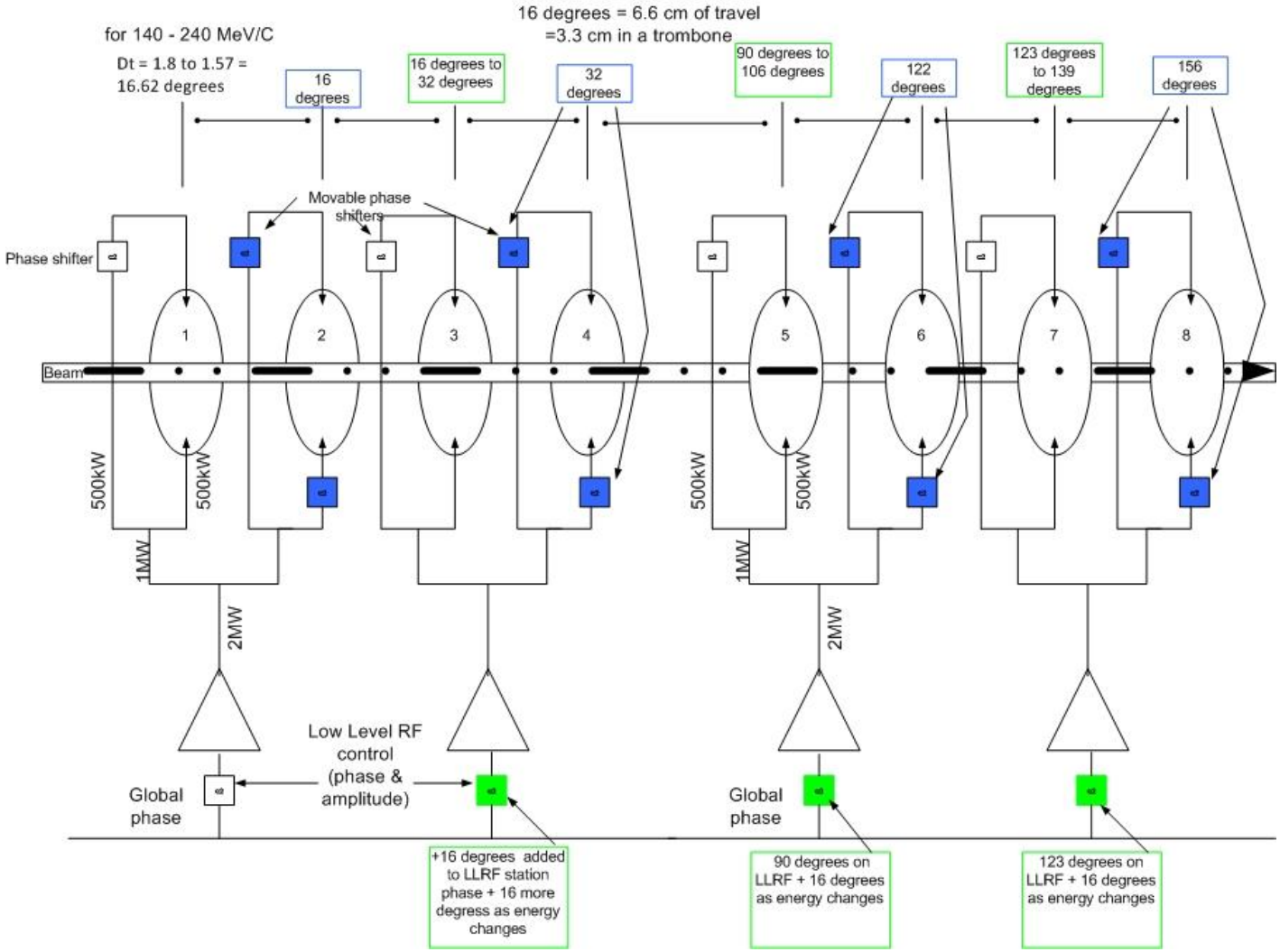
9 3/16” Dual Directional coupler

Gas Stop

Line stretcher



Cavity phasing



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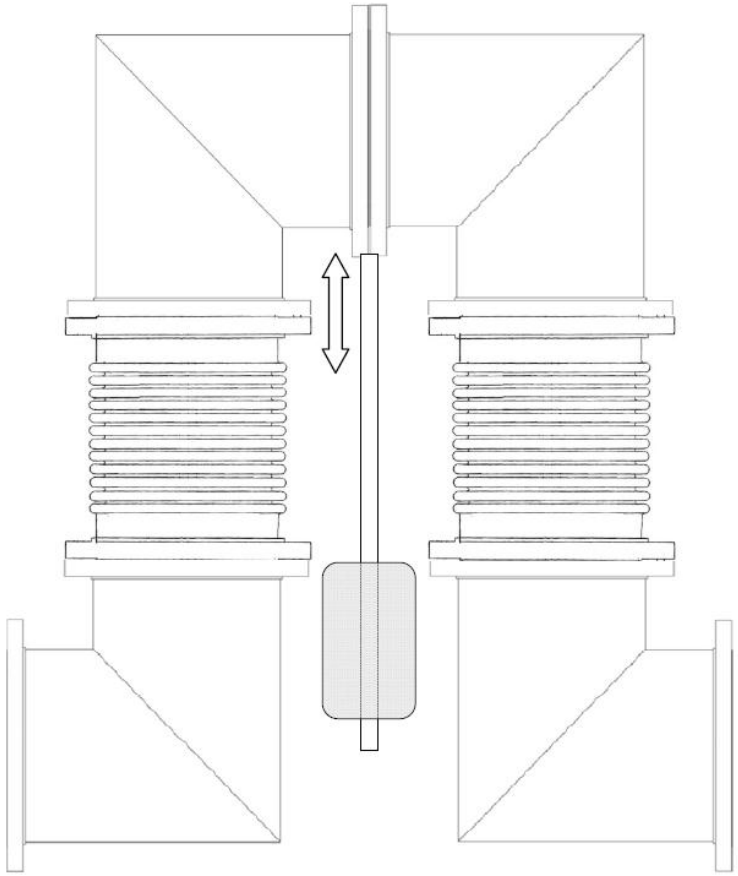
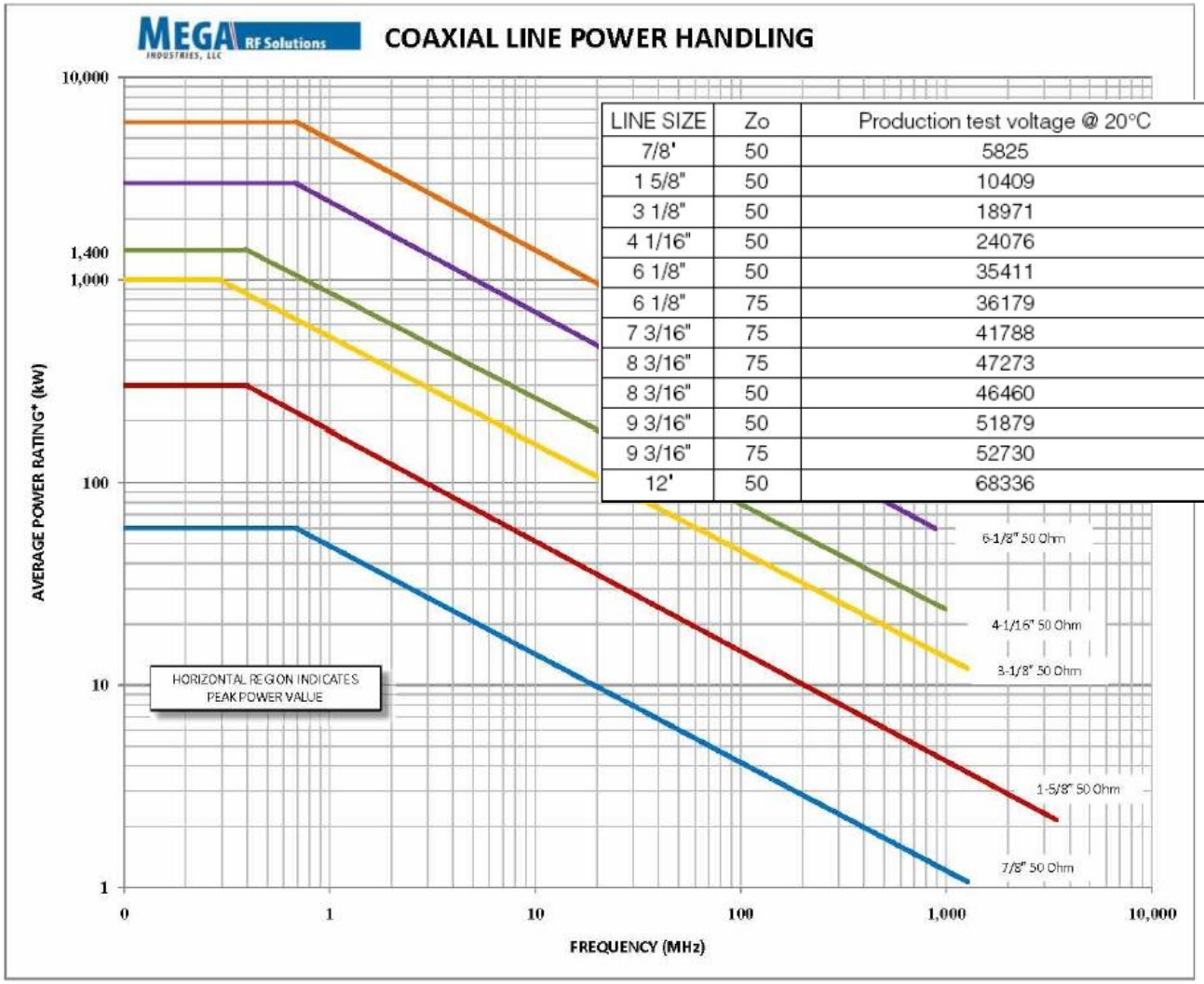
High power phase shifters



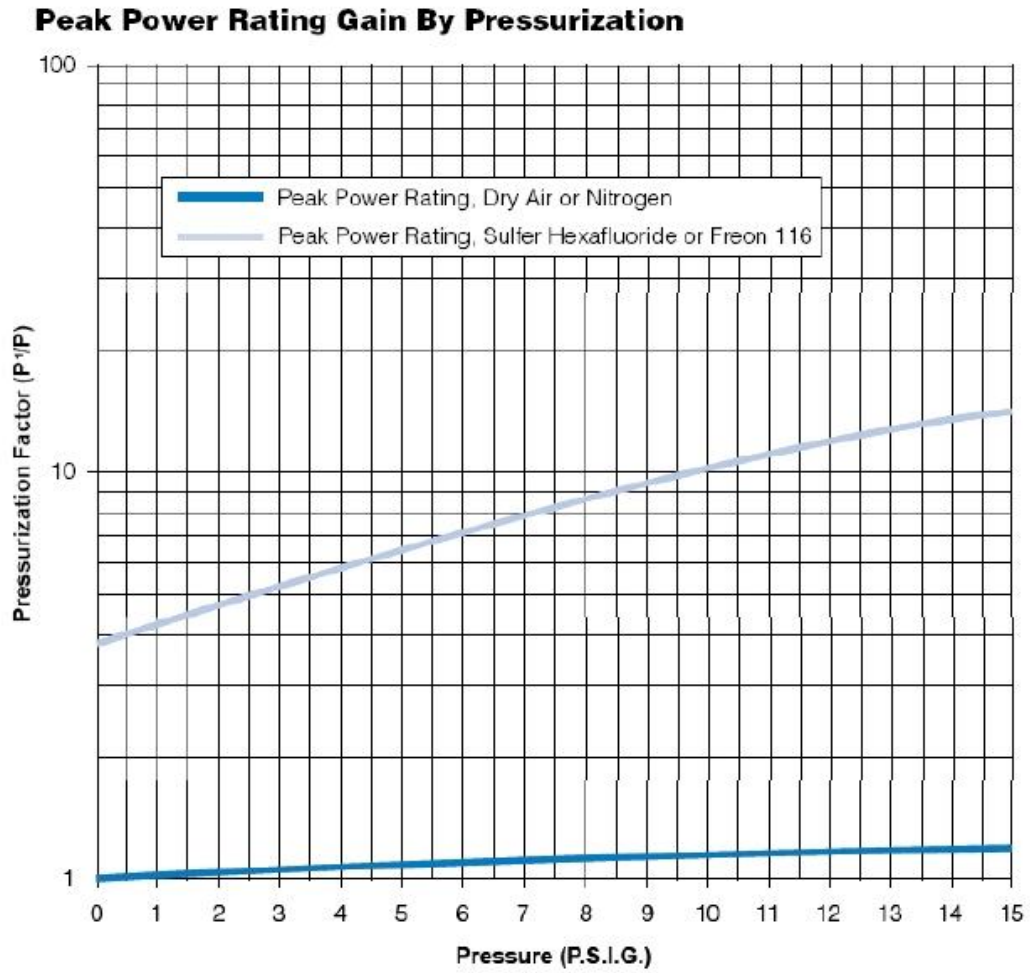
- Discussions with manufacturers may mean further work to be done looking for options
- Decision depending on the range of movement and the requirements on frequency of movement
- LLRF can be used to move drive to amplifiers very easily

Peak power handling for coax guides



LINE SIZE	Zo	Production test voltage @ 20°C	RF Voltage Limit	Peak Power (watts)
7/8'	50	5825	1442	41600
1 5/8"	50	10409	2576	132700
3 1/8"	50	18971	4695	440900
4 1/16"	50	24076	5959	710100
6 1/8"	50	35411	8764	1536100
6 1/8"	75	36179	8954	1069000
7 3/16"	75	41788	10342	1426100
8 3/16"	75	47273	11699	1825000
8 3/16"	50	46460	11498	2644200
9 3/16"	50	51879	12839	3296900
9 3/16"	75	52730	13050	2270700
12'	50	68336	16912	5720500

Effect of gas pressure



Conclusion

- Amplifier test system tested to 1MW with power supplies
- Coax system designed to phase match RF into each cavity, all coax lines are the same length and have the same number of elbows
- Hybrids will be used to split RF power and give good isolation, reject load can be small as balanced reflected power will be directed back to triode, this should not present an issue
- Cavity phasing can be done using a combination of LLRF and limited range high power phase shifters
- Nitrogen gas pressure will be used to extend the peak voltage stand off of the coax guides