MuCool Program Overview

Muon Cooling R&D
Alan Bross

Outline

- MuCool Overview — AB
  - Collaboration
  - MuCool Test Area
  - Program Synopsis
  - MuCool Phase II

- 201 MHz RF Program — D. Li
- 805 MHz RF Program — D. Huang
- LiH Absorber Program — AB
- Coupling Coil — M. Green
- MTA Beam Line (MCTF) — C. Johnstone

MuCool

- **Mission**
  - Design, prototype and test all cooling channel **components**
    - 201 MHz RF Cavities, LH_2 absorbers, SC solenoids
  - Support MICE (cooling demonstration experiment)
  - Perform high beam-power engineering test of cooling section components

- Consists of 10 institutions from the US, UK and Japan

RF Development
ANL
Cockcroft Institute
Fermilab
IIT
JLAB
LBNL
Mississippi

Solenoids
LBNL
Mississippi

Absorber R&D
Fermilab
IIT
KEK
NIU
Mississippi
Osaka

MuCool Test Area

- Fa… test of ion…

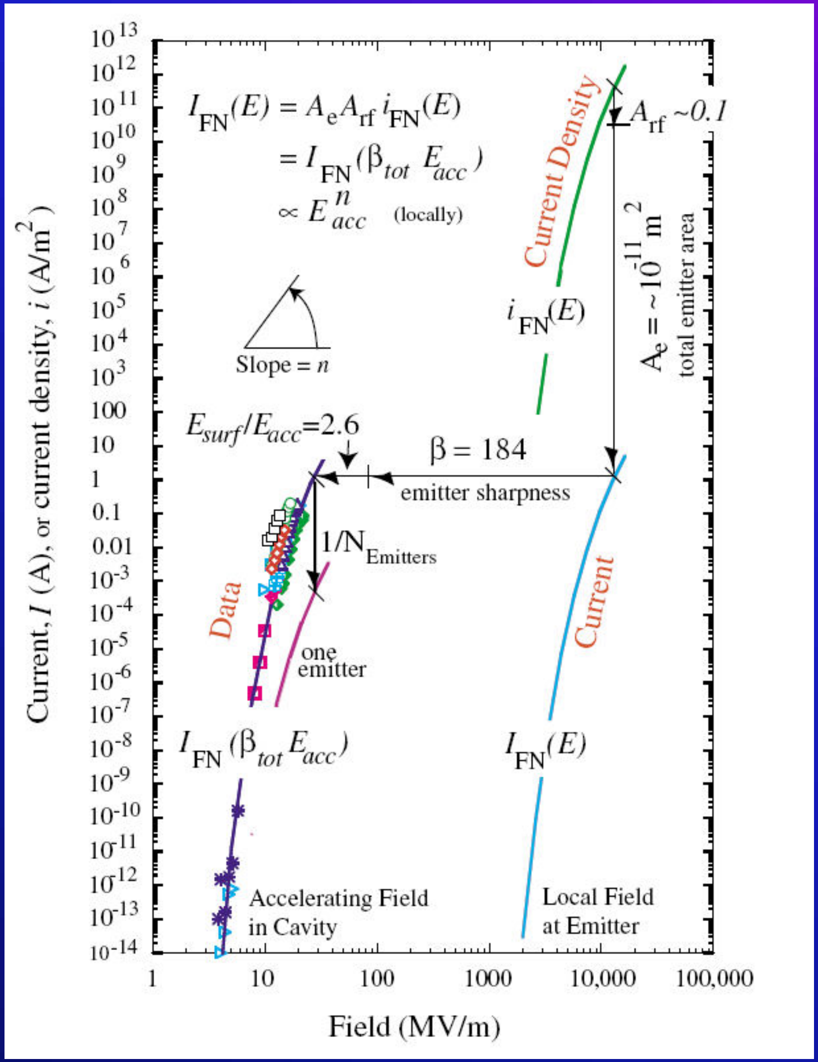
MTA Hall

RF Cavity R and D

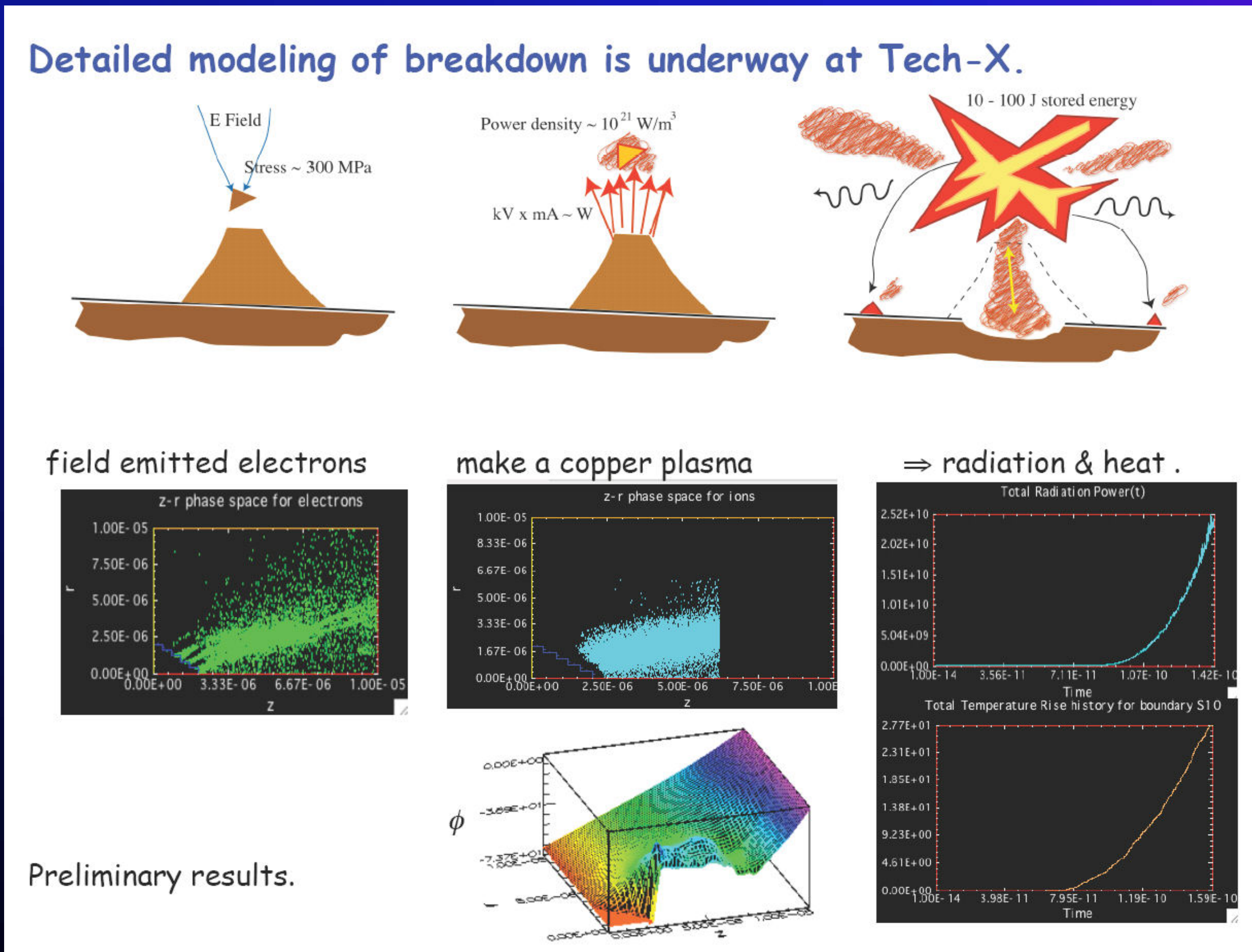
ANL/FNAL/IIT/LBNL/UMiss

Fundamental Focus Of RF R&D

- Study the limits on Accelerating Gradient in NCRF cavities in magnetic field
- It has been proposed that the behavior of RF systems in general can be accurately described (predicted) by universal curves
    - Electric Tensile Stresses are important in RF Breakdown events
- This applies to all accelerating structures



Detailed Modeling Code Now Available



Must define experiments to vet this code

NCRF Model Extended to SCRF

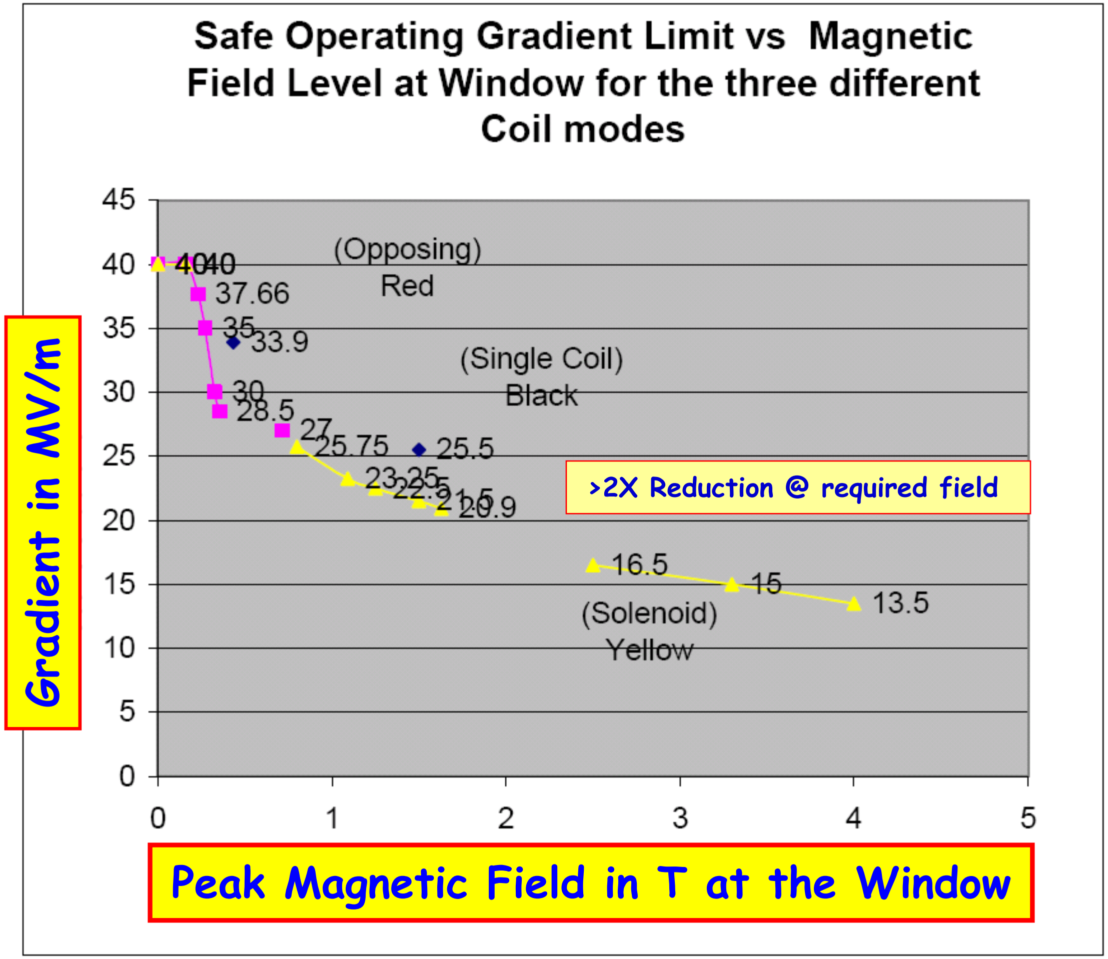
- We have extended this model to SCRF and high frequency problems.
- We are working with the Argonne Materials Science Division to develop:
  - A materials science program to understand chemical, morphology and electronic properties of rf SCRF and NC materials
  - Cavity tests to determine optimum procedures and performance.
- This program is underway and, using Argonne internal funding, and has produced important results:
  - We have developed a model of High Field Q-Slope based on magnetic oxides, that seems to explain SCRF cavity data.
  - We have developed a new procedure to produce niobium surfaces without complex oxides.
  - We are beginning a program of cavity testing with JLab.
- Using Atomic Layer Deposition and other newly developed materials science techniques we can synthesize and analyze surfaces with unprecedented precision.
    - Limits maximum gradient

Extension To SCRF

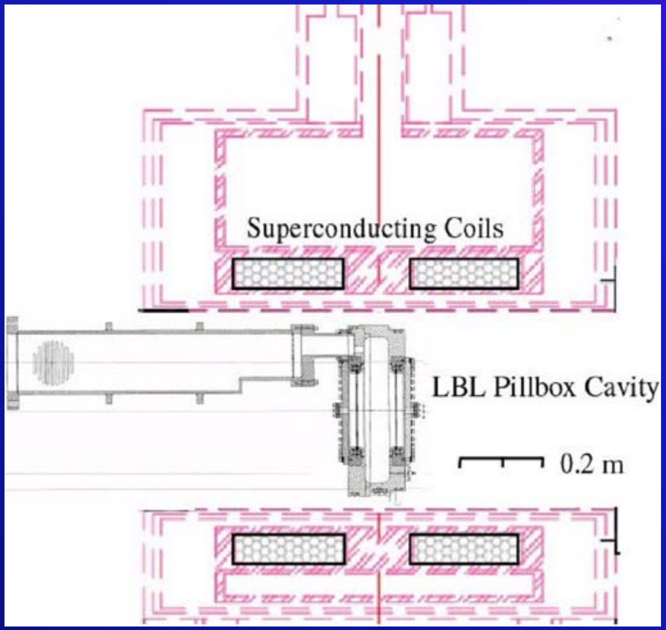
- We are extending our experimental program to explore the ultimate gradient limits of "perfect" surfaces, which have the properties that (ATOMIC LAYER DEPOSITION):
  - They are smooth at the nanometer level, so local fields (~1/r) cannot be high enough to produce field emission or breakdown events
  - They are layered, with thin superconducting layers that are expected to be resistant to B field quenches.
  - They are homogeneous, so local "hot spots" should not exist.
  - They can be applied "in-situ" so they are not subject to assembly defects.
  - They allow almost complete freedom to choose substrate for conductivity, rigidity, etc. to avoid thermal, Lorentz and microphonics effects.
- We expect we should be able to address known failure modes and produce structures that reach significantly higher gradients in both normal and superconducting systems.

The Basic Problem – B Field Effect

805 MHz Studies



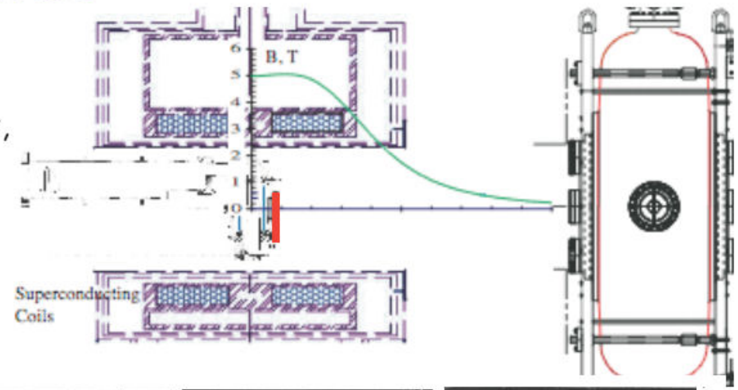
- Data seem to follow universal curve
  - Max stable gradient degrades quickly with B field
- Remeasured
  - Same results



805 MHz Imaging

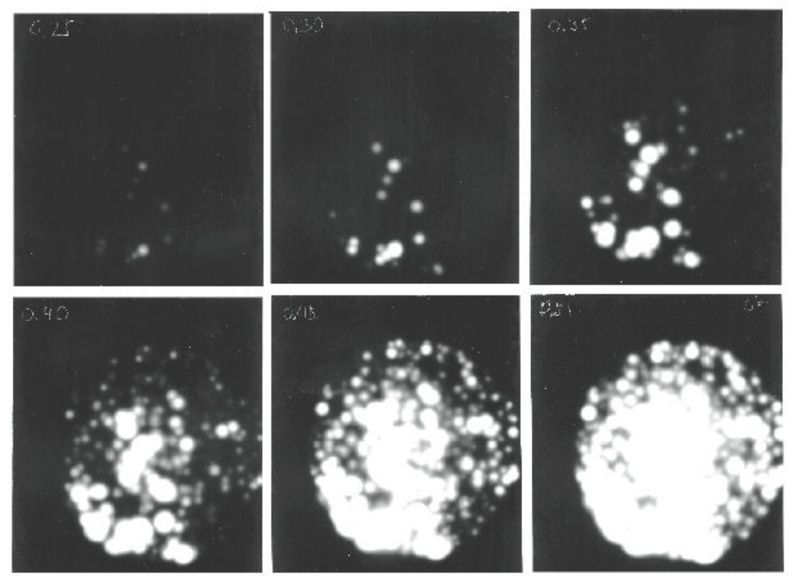
Polaroid Pictures of Field emitters

- Inserting polaroids near the window,



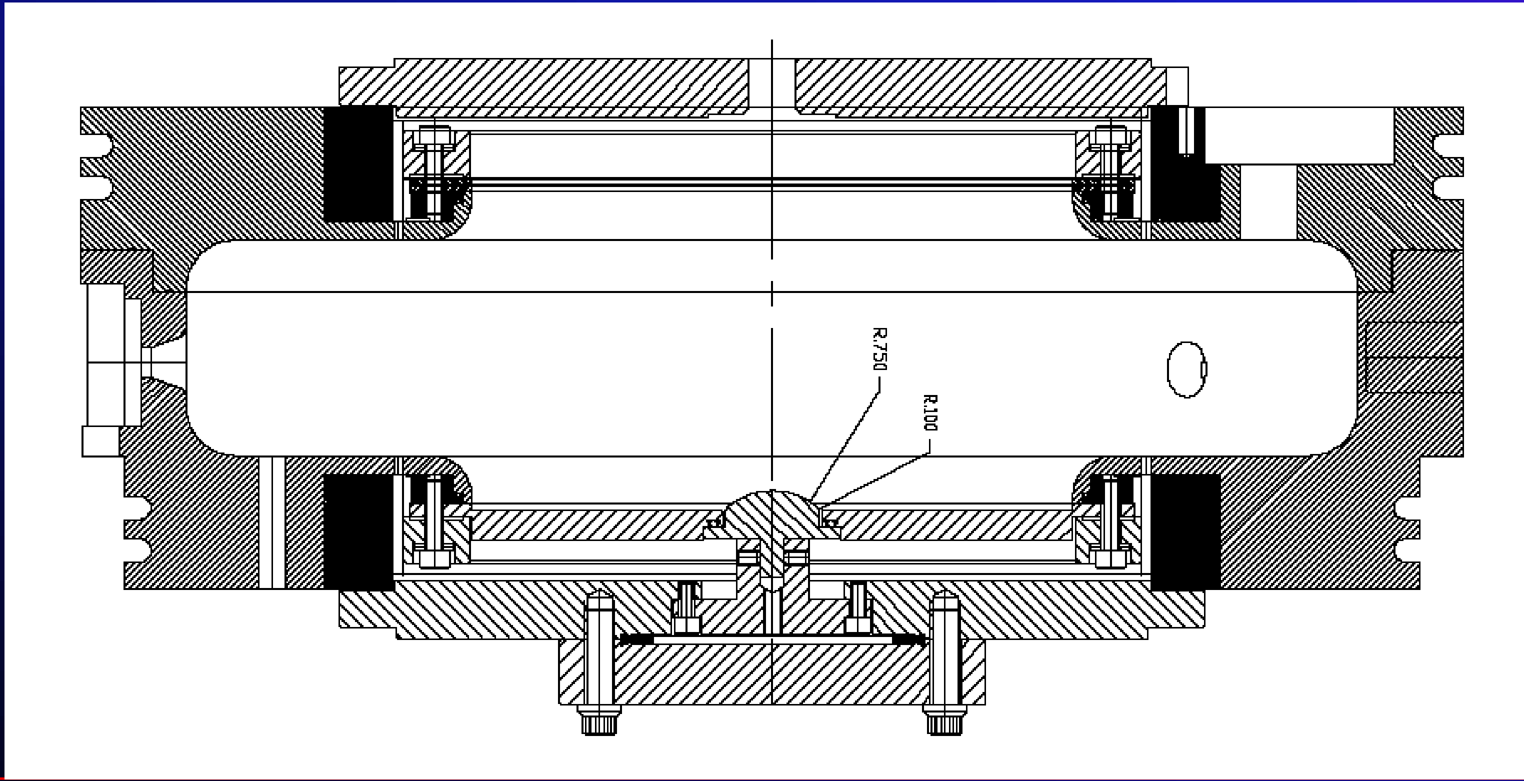
- Gives a picture of how the field emitters change with rf field.

  8.8 - 17.6 MV/m



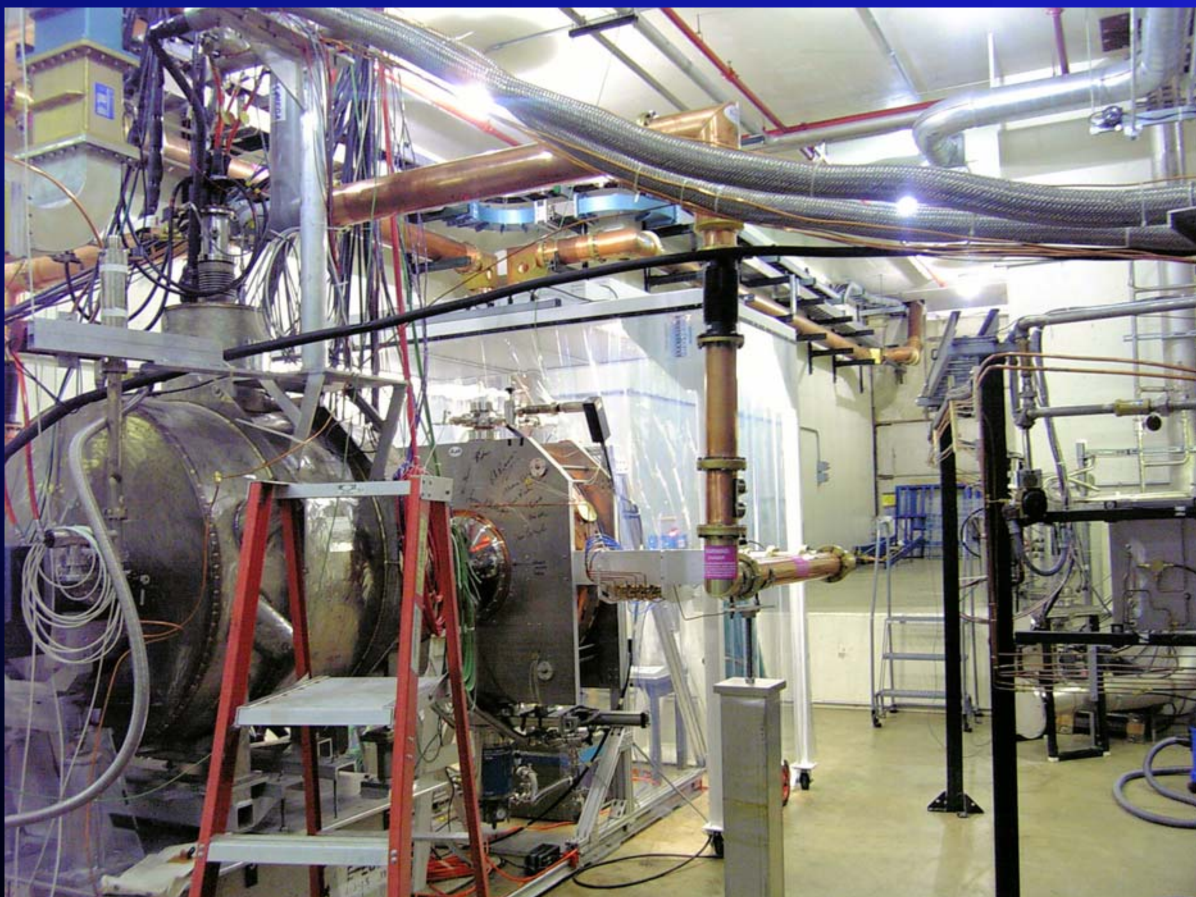
Next 805 MHz study - Buttons

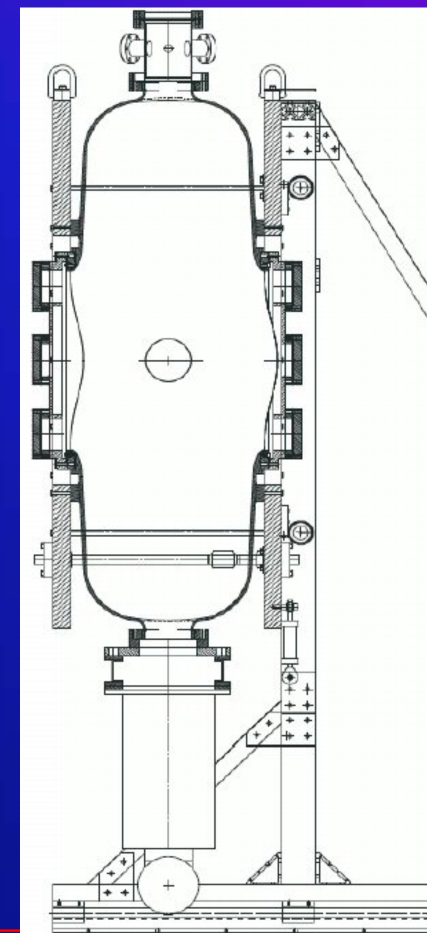
- Button test
  - Evaluate various materials and coatings
  - Quick Change over



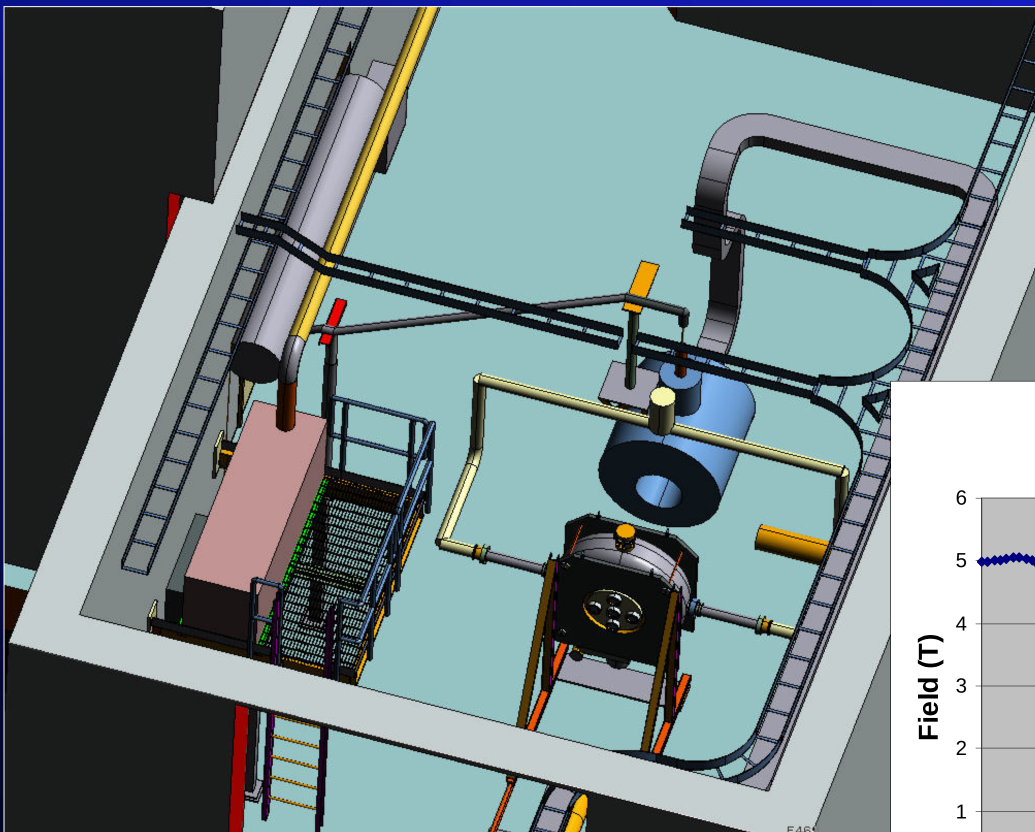
RF R&D – 201 MHz Cavity Design

- **The 201 MHz Cavity – *19 MV/m Gradient Achieved*** (Design – 16MV/m)
  - In low (few hundred G) B field. Still no breakdown. Limited by available power

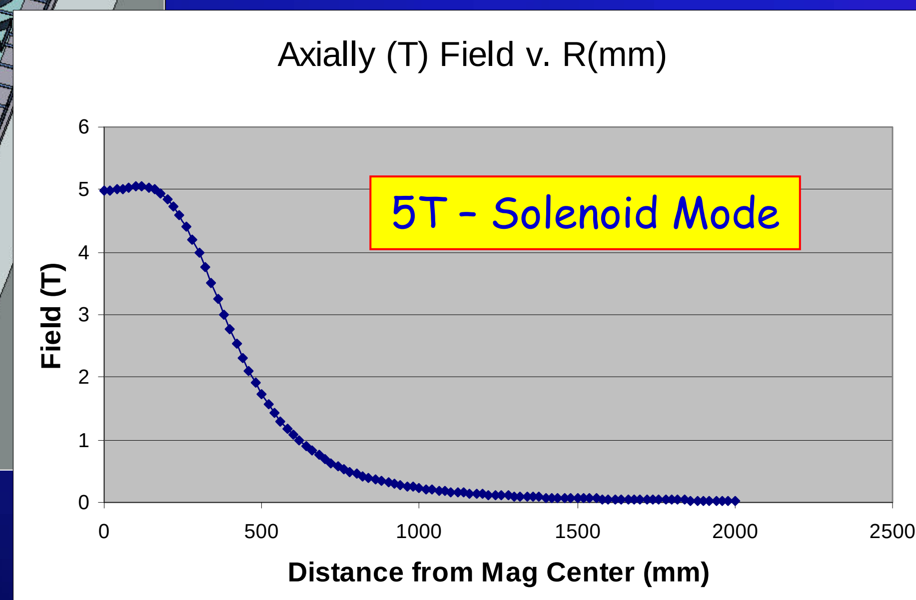




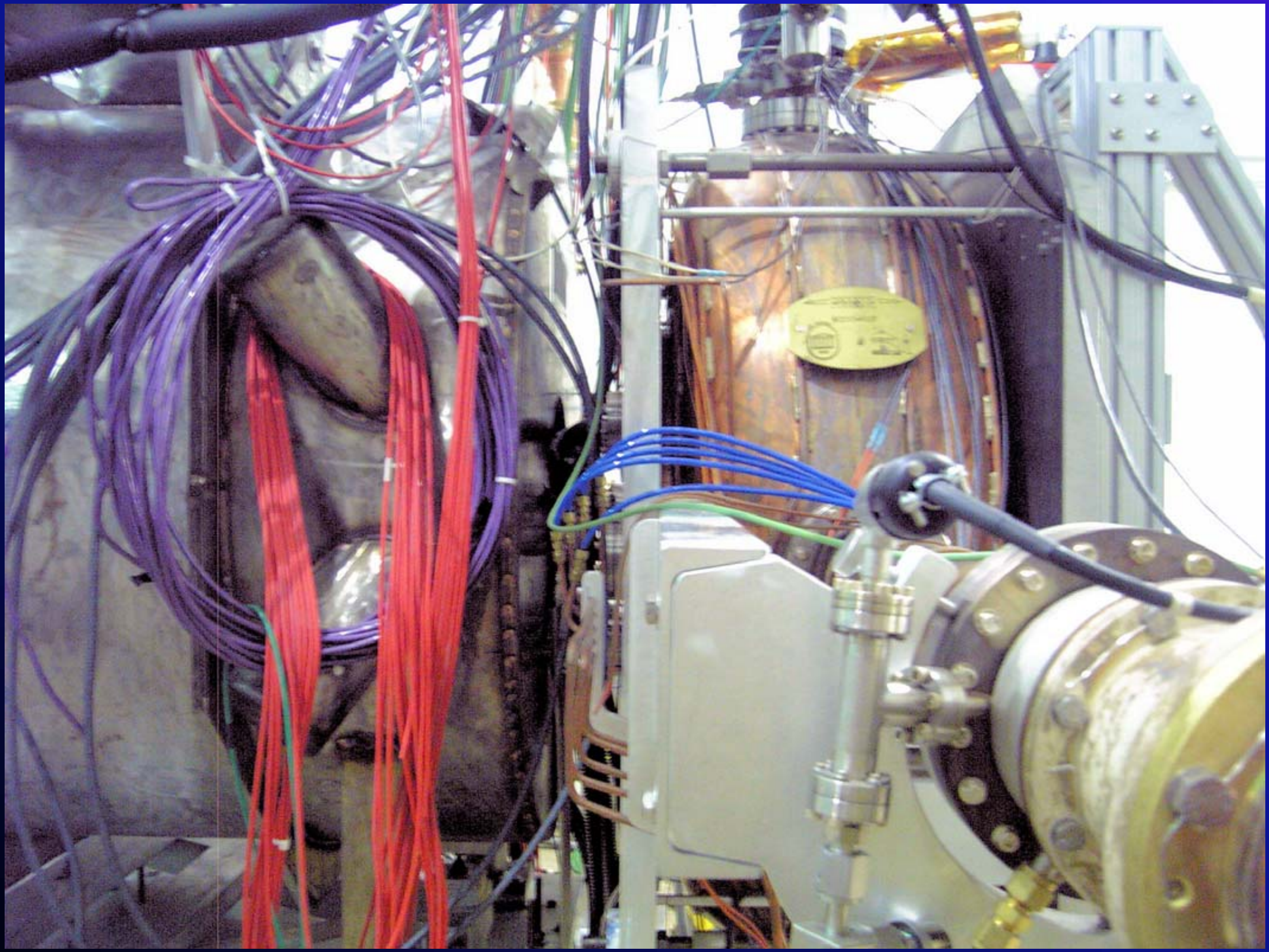
201 MHz Cavity Operation in B Field



- Initial 201 MHz operation in B Field
  - Limited to few hundred Gauss
    - Using Fringe Field of 4T magnet (in blue)



201 in Position



- We have now moved 201 as close as possible to 5T solenoid
- Can obtain ≈ 1.5T on near window of 201

LiH Absorber R&D

Production of LiH Disks

- Only 1 vendor was found that would cast LiH
  - After some reflection (and some input from Chemists from Argonne Lab), the vendor decided casting LiH was too dangerous (production of H_2 gas)
- Working with Y12 (Oakridge)
  - Found the engineer in charge of their LiH work and he suggested that they press (Hot 150C, Isostatic (30,000 psi) a "loaf" and machine parts to our specification from the loaf
    - They have achieved 98% theoretical density using this technique
    - They are doing R&D on casting LiH for their internal programs, but do not recommend it for our application.
      - It is very tricky due to the high temperature (700C +) and the large (30%) shrinkage on cooling
- We are in the process of setting up a contract with them to make a disk for temperature studies and 1 or 2 disks for MICE
  - Note: The Li in their LiH is ^{6}Li
    - For the mass we will receive, our parts will be considered Nuclear Material
      - This will require additional proceedures/paperwork for shipment, but Y12 personnel see no inherent problem

MuCool Phase II

Cryo-Infrastructure Installation/Commission
Beam Line Installation/Commission

MTA Cryo-Infrastructure

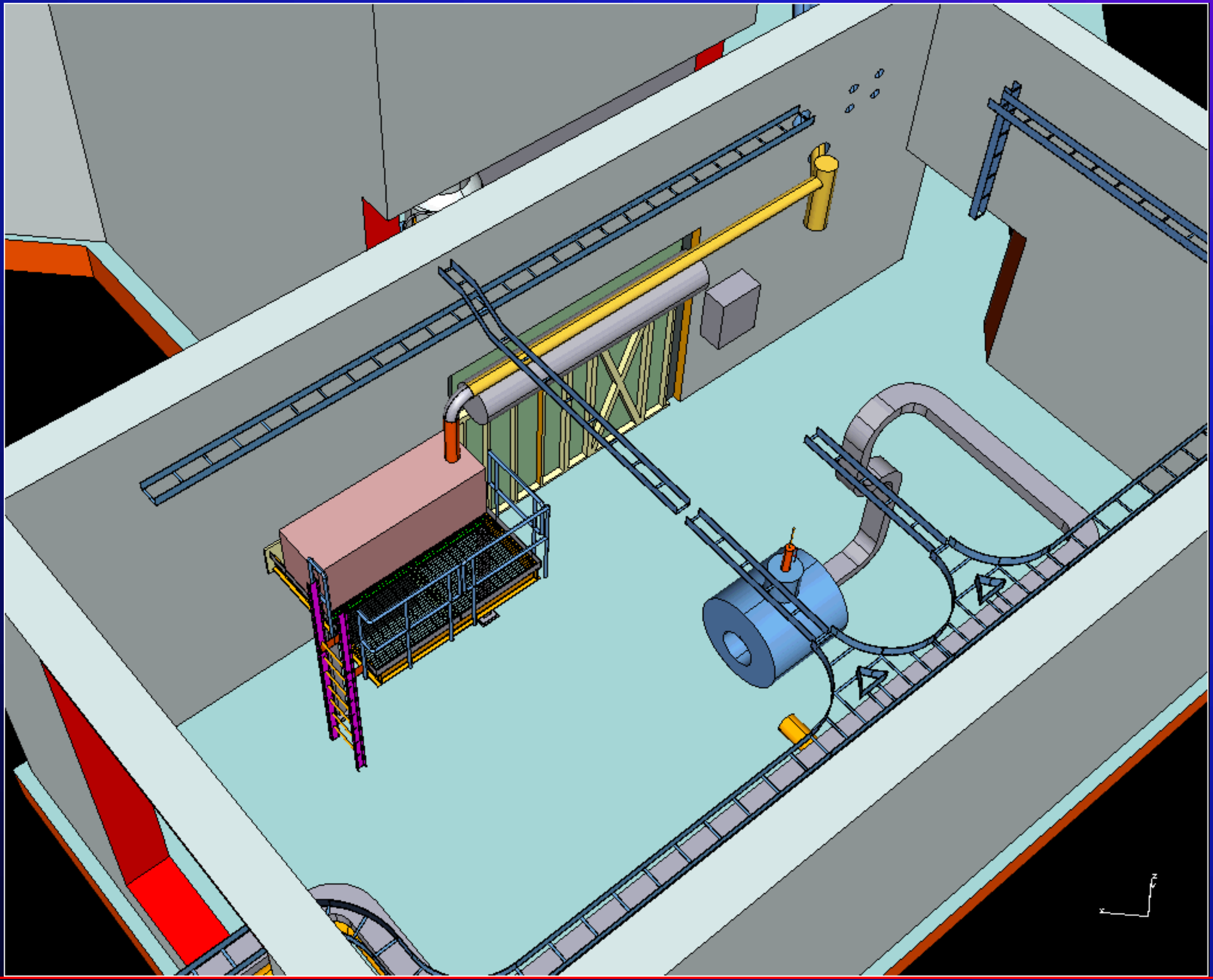
- MTA Reconfiguration
  - Commission Cryo-Plant (June 2008)
  - Install Transfer Line system
  - Raise Equipment to beam height
  - New shield wall
- Working on Project Plan
  - ≈ 3 month effort with adequate technician resources
    - Need 5 technicians full time (estimate is about 2000 hours)
    - Plus 5 weeks of a welder
    - Plus $50k in M&S (Does not include rerouting of RF power)
- Need to complete before the 2009 (March) Accelerator Shutdown

Existing Dewar-Fed Cryogen System

- *All of this is removed*
- New (simpler) shield wall
  - Will allow for easier pit access to hall
  - More shielding needed for beam operations in MTA Hall

MTA – Refrigerator Room

Transfer Line System

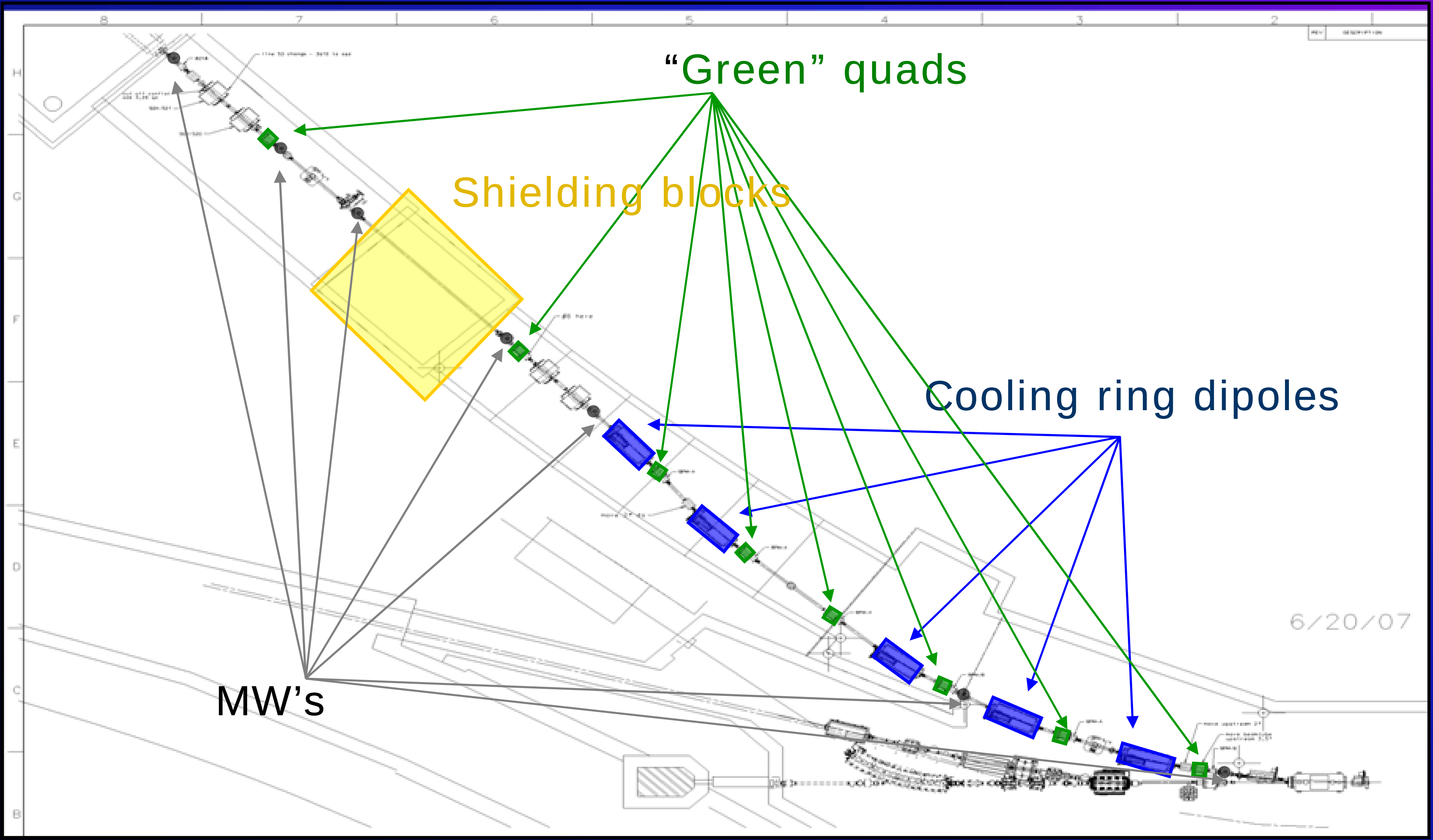


Transfer Line System

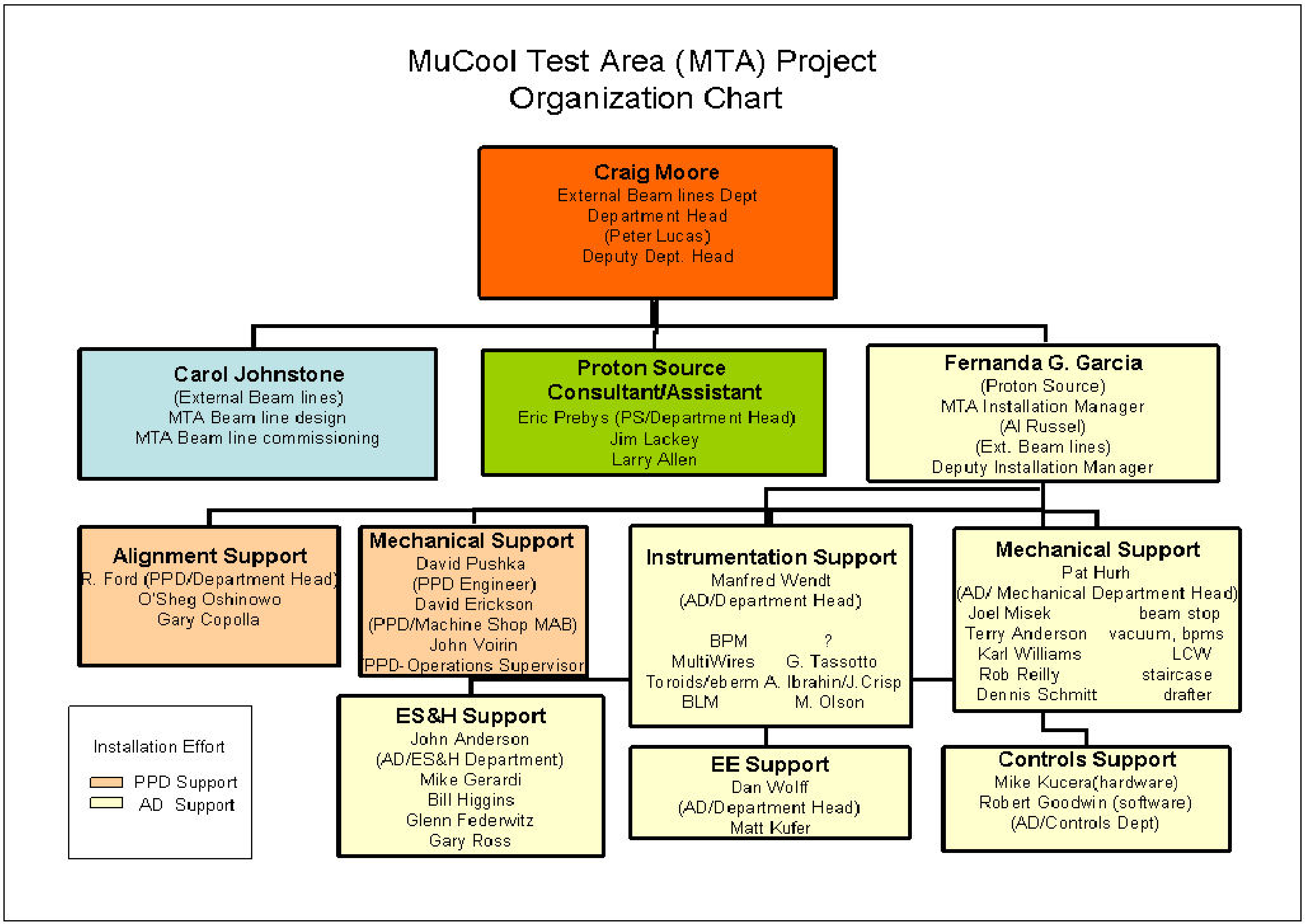
Valve Box Piping

Completed Valve Box

MTA Beam Line as Installed



MTA Beam Line Group



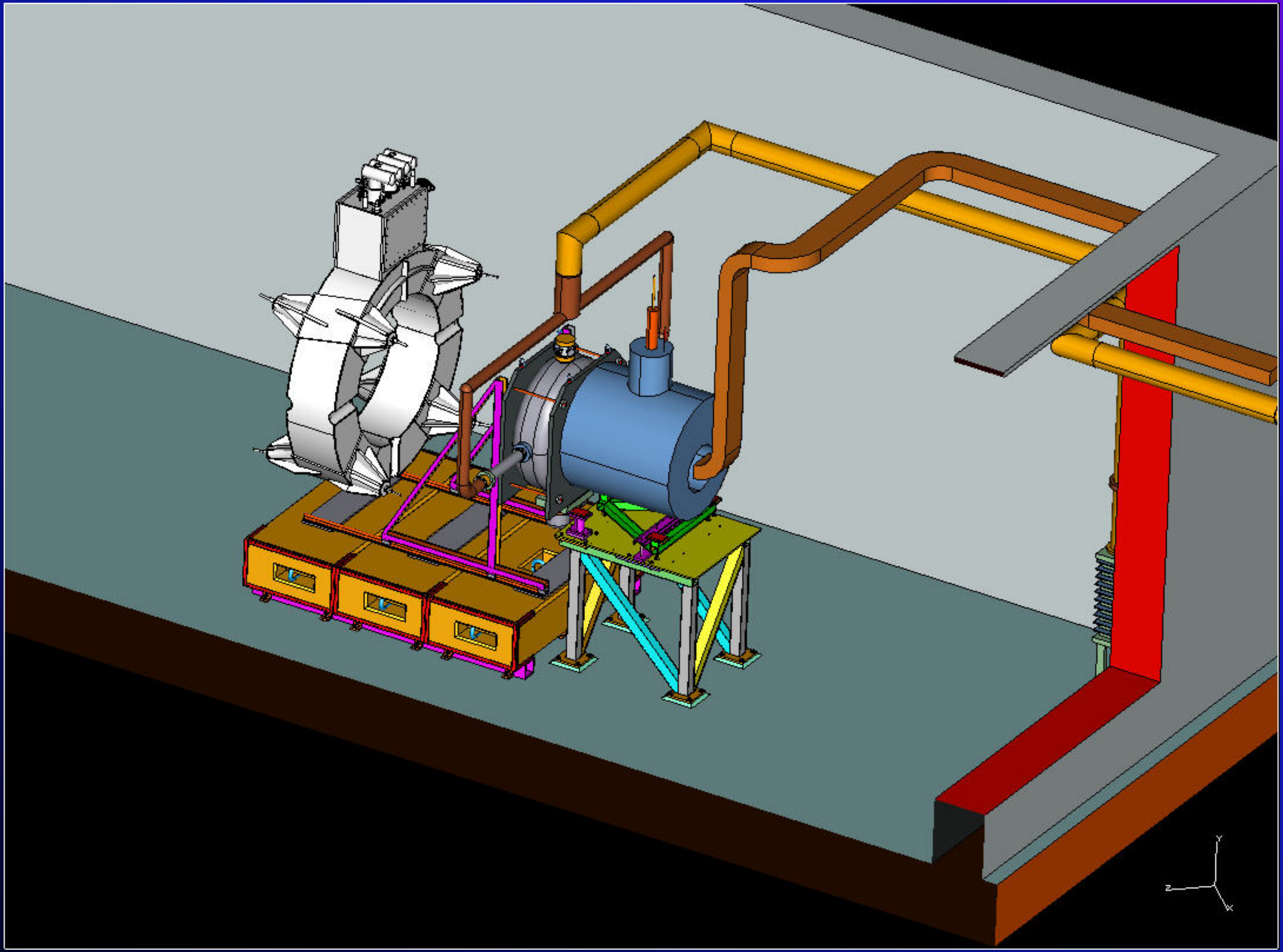
First Beam Experiments

- Currently 5T magnet and 201 cavity on floor (below beam ht.)
- We will raise equipment to beam height
  - Also flip orientation of 201 MHz cavity and magnet
- Goal
  - First Beam Experiment (Muon's Inc HP RF Test Cell) by end of 2008

MTA Beam Commissioning

- Beam Line commissioning to first beam stop (Linac side of shield wall) may start as early as June
- Still doing radiation shielding assessments
  - Rerouting RF Power required
    - Final configuration for this still being developed
- Will start at low intensity
  - Need Shielding upgrade (over-burden) for high-intensity

Phase II - Configuration



MuCool Plans for the Coming Year

- 805 MHz RF studies – Buttons (with and without B field)
  - Materials tests
  - Surface treatment (HP Wash + EP (from UK), ALD (Argonne)
  - E X B study
- 201 MHz RF
  - Continue B field studies
  - Working with Linac Group to improve operational efficiency
- Begin thermal and mechanical tests on HIP LiH absorber prototypes
- Complete MTA cryo infrastructure installation and commission system
- Commission Beam Line
- First tests with Beam Complete by January 09 (MCTF)
  - Test of Muons Inc. HP H_2 RF test cell with beam