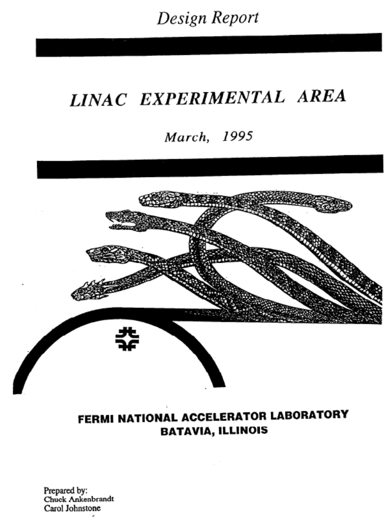
Debut of the MTA beamline

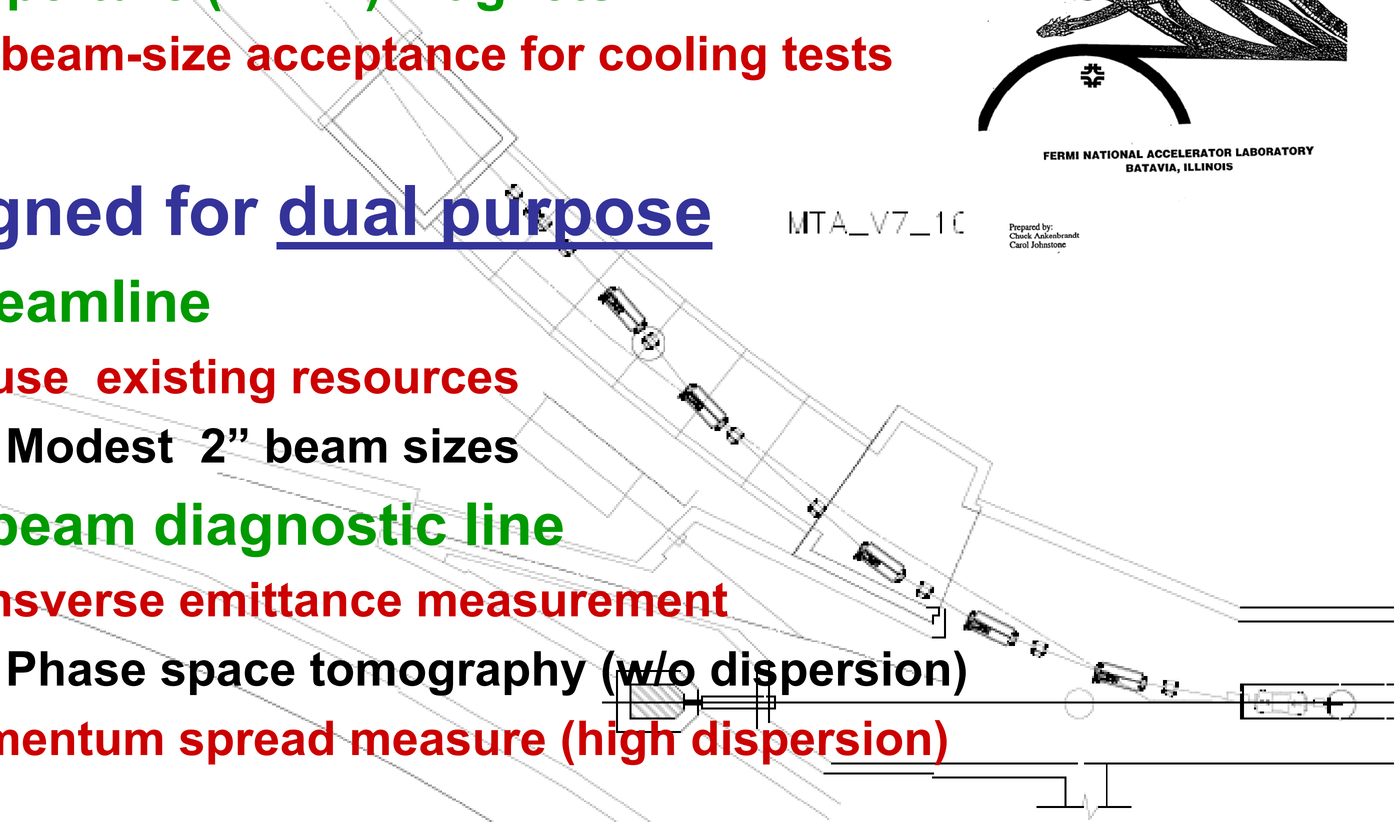
Description, status and commissioning plans

Background/Recent History, MTA Beamline

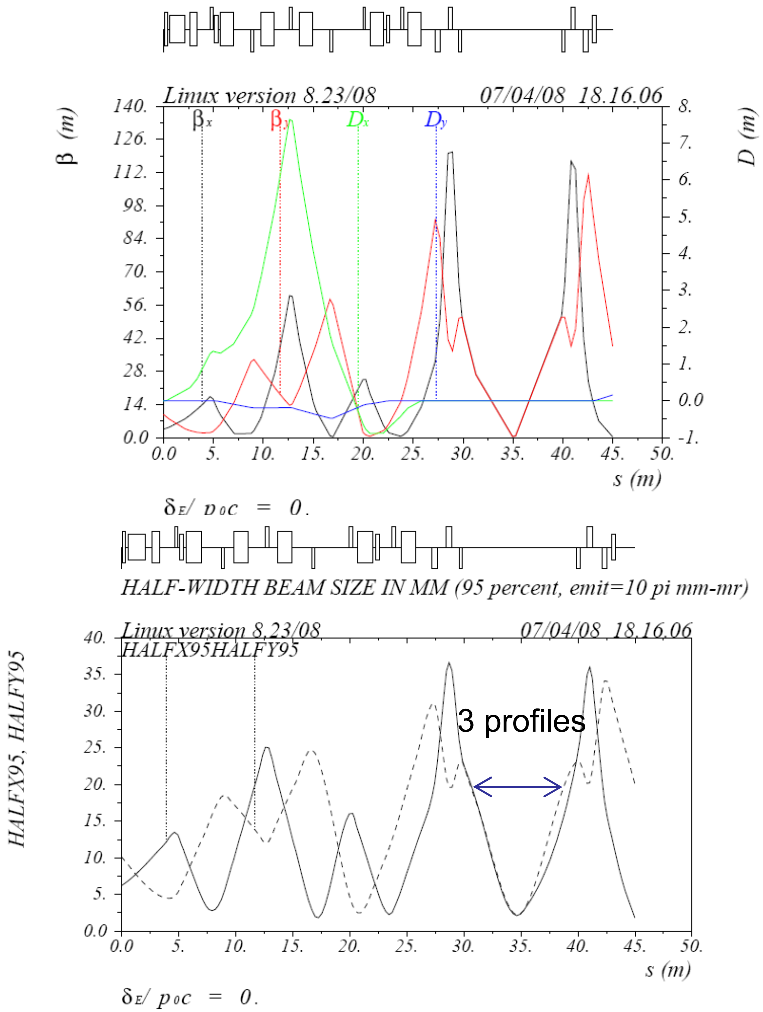
- **Original proposal 1995**
  - **Re-proposed for MuCool Test Area**
    - **Large-aperture (LANL) magnets**
      - **12” beam-size acceptance for cooling tests**



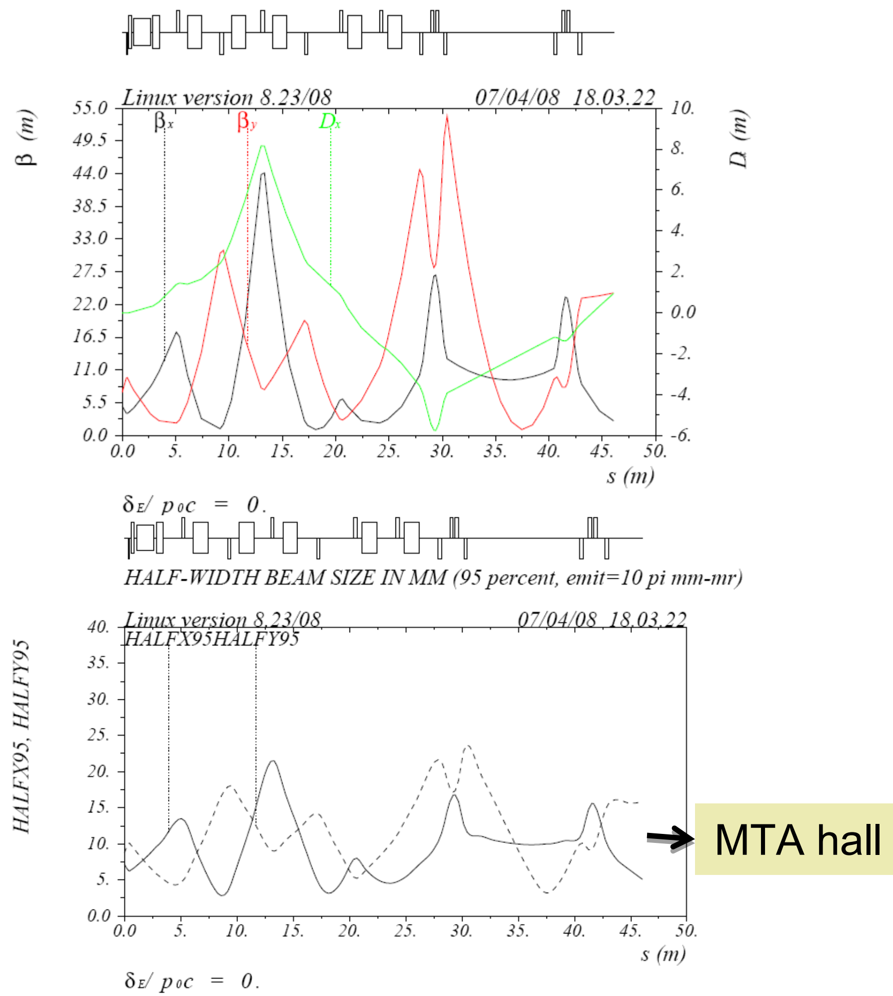
  - **Re-designed for dual purpose**
    - **MTA beamline**
      - **Re-use existing resources**
        - » **Modest 2” beam sizes**
    - **Linac beam diagnostic line**
      - **Transverse emittance measurement**
        - » **Phase space tomography (w/o dispersion)**
      - **Momentum spread measure (high dispersion)**



Emittance vs. Operational Tunes



Emittance measurement



Low-loss operation

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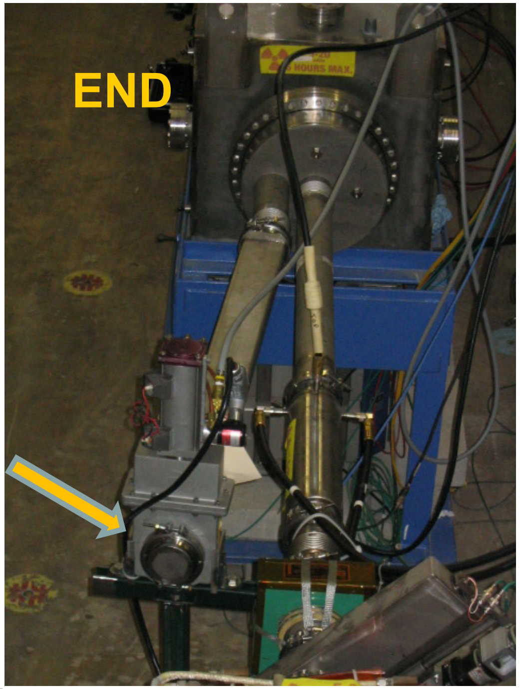
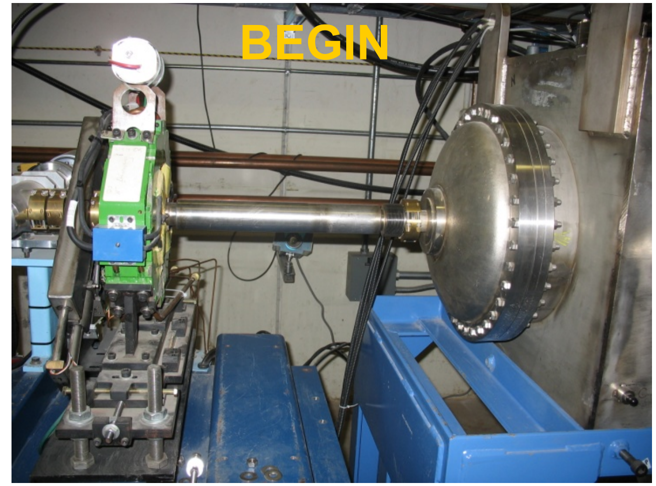
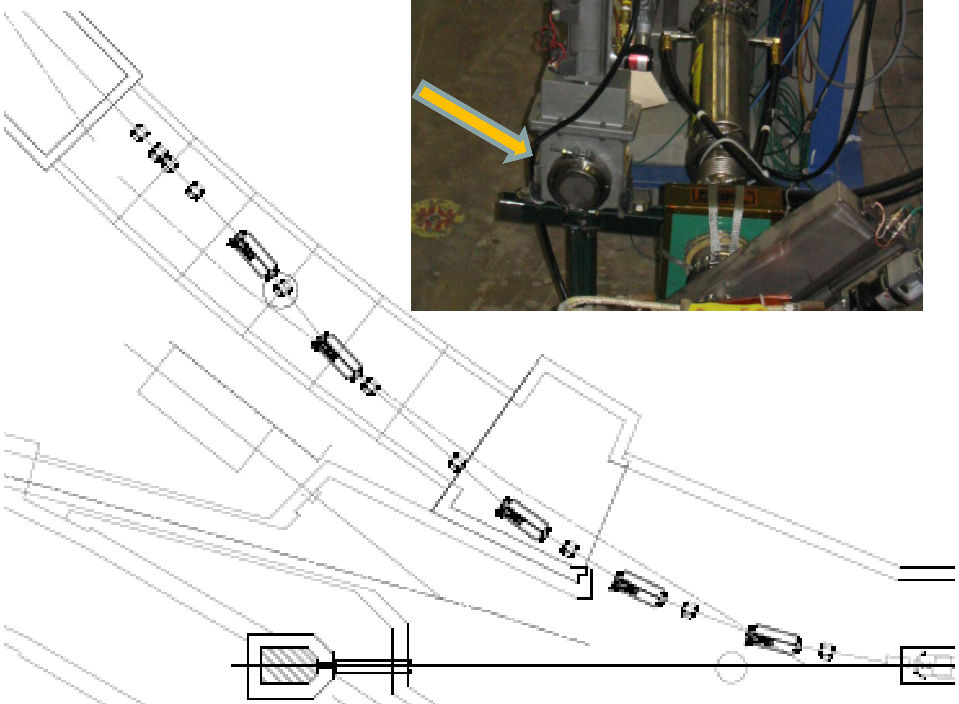
MTA Beamline status, March 2007







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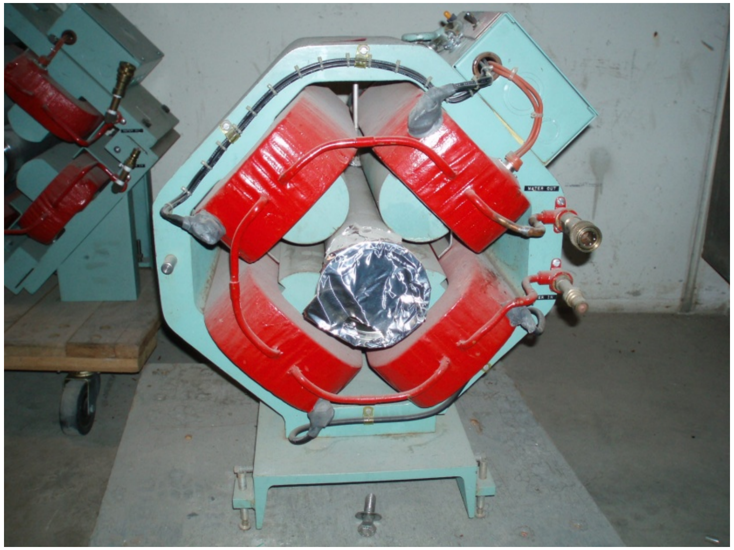
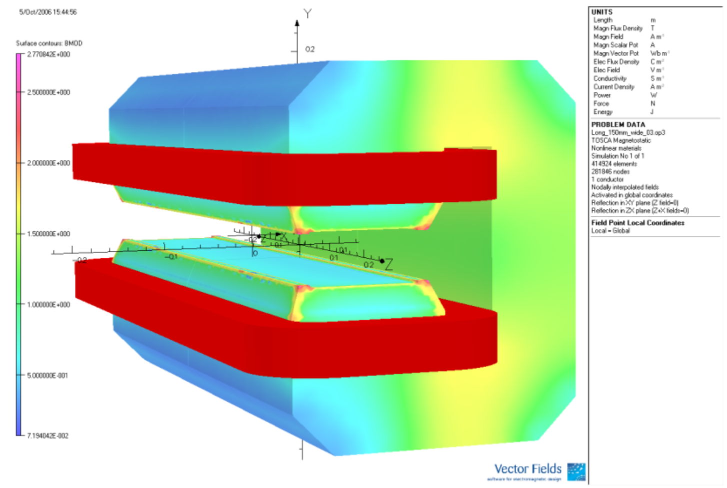
Before/After Technical Division

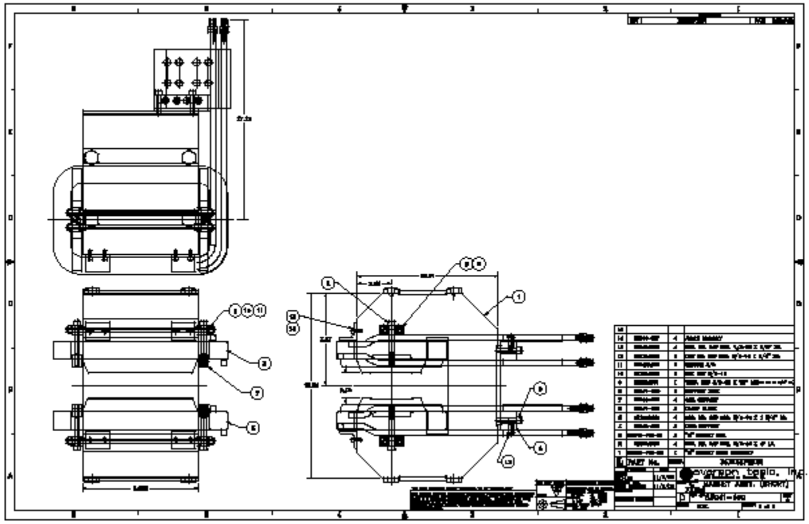


Design of the C magnet

C. Johnstone, F. Mills, D. Harding

General	Value
B_{peak}, range	6.0 - 6.5 kG
Repetition Rate	15 Hz
Pulse Length (half sine wave)	8.33 msec
Integrated strength, error	
1st magnet	0.1668 T-m, ±1% at peak
2nd magnet	2.5 × 1st magnet strength, ±1% at peak
Good Field Region	
Width, field error	0.0600 m (2.36"), 10^{-3} at peak
Gap	0.05100 m (2.008")
Beam tube (elliptical) ~width x height	0.1173 m (4.618"), 0.0508 m (2")
Beam tube thickness	1.59×10^{-3} m (0.0625")
2nd magnet:	
Tube diameter, thickness, outside beamline	0.08255 m(3.25"), 1.59×10^{-3} m (0.0625")
Center to center spacing - beam tubes @upstream magnet entrance	0.1126 m ± 0.0003 m (4.433± 0.006")
Physical Dimensions	
Minimum spacing between coils (top to bottom)	0.1080 ± 0.0064 (4.25 ± 0.125")
Maximum slot length	
1st magnet	0.4254 m ± 0.0064 (16.75 ±0.25")
Maximum steel Length	
1st magnet	0.2604 m (10.25")
Required Mechanical Properties	
Operational flexing or fatiguing of coil+core	≤0.1 mil
Coil or Core temperature rise, at any point	<10° C , for
Cooling water available	~1 gal/min @60psi and 95°F
Connections, water and power	Standard Fermilab connections





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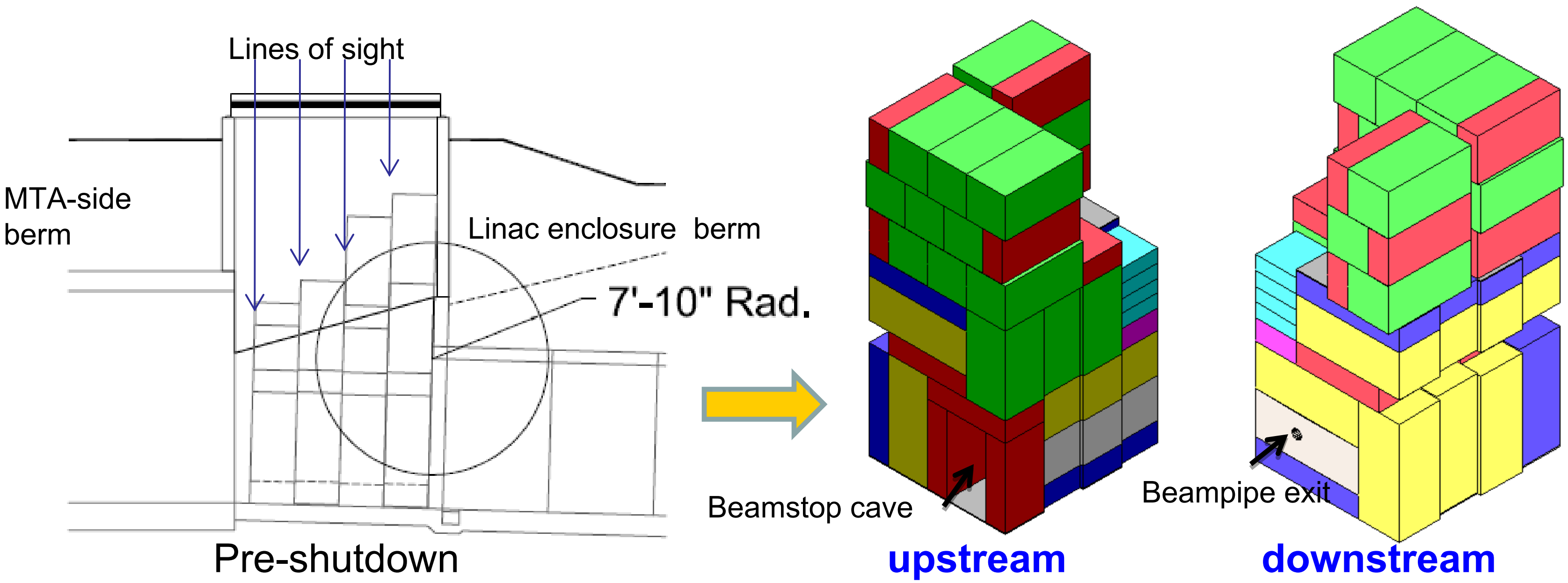
The C magnet – TD, October, 2007

Shutdown '07, Installation of Beamline

- Hatch shielding reconfiguration for beam
  - Eliminate vertical "lines of sight", floor leveled
  - Required crane + riggers
  - Allowed staging and rough installation via same crane/riggers
    - Addressed shutdown manpower shortages
    - Critical for successful installation of beamline during '07 shutdown



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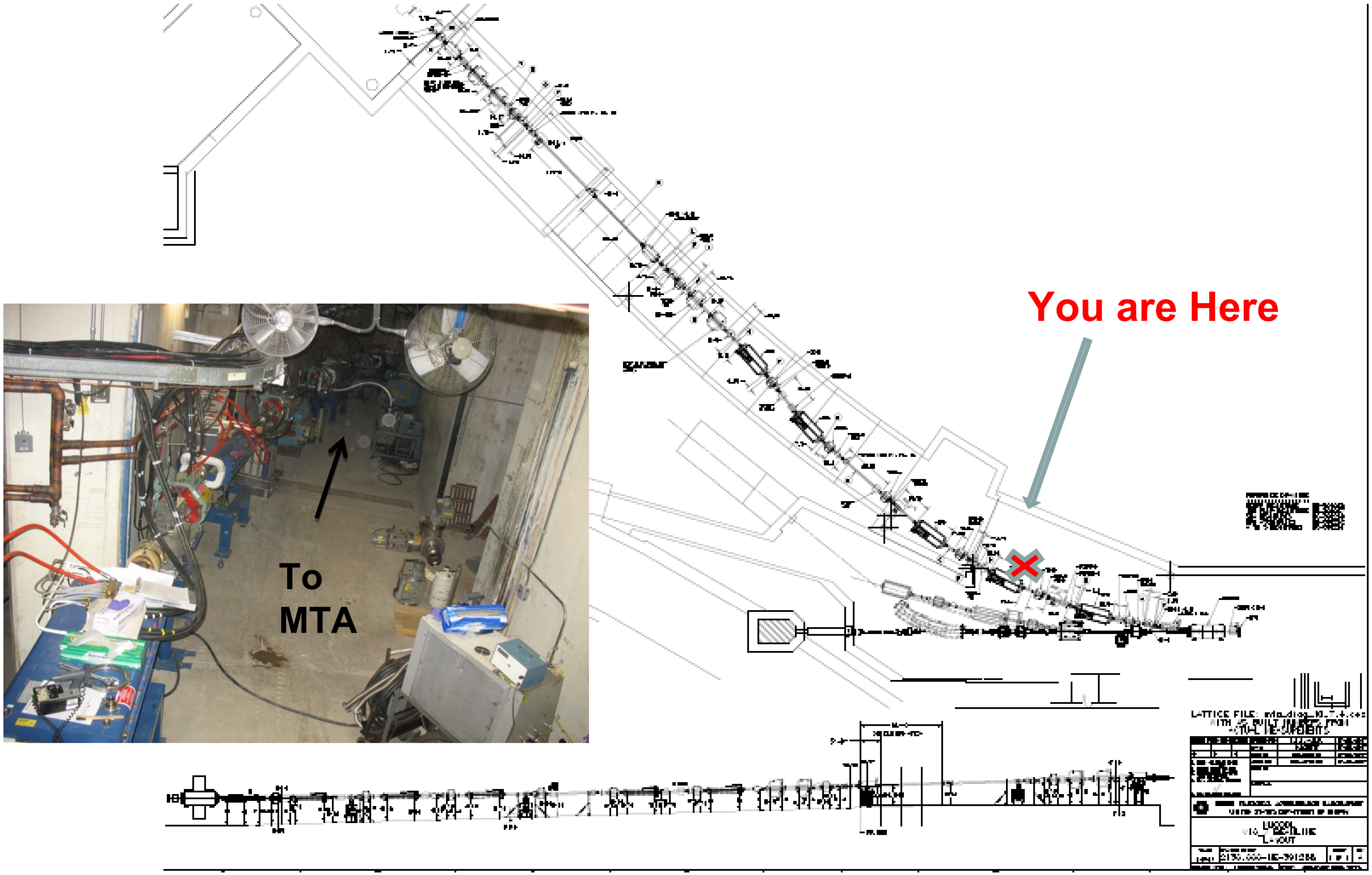
As-built MTA Beamline, Nov., 2007



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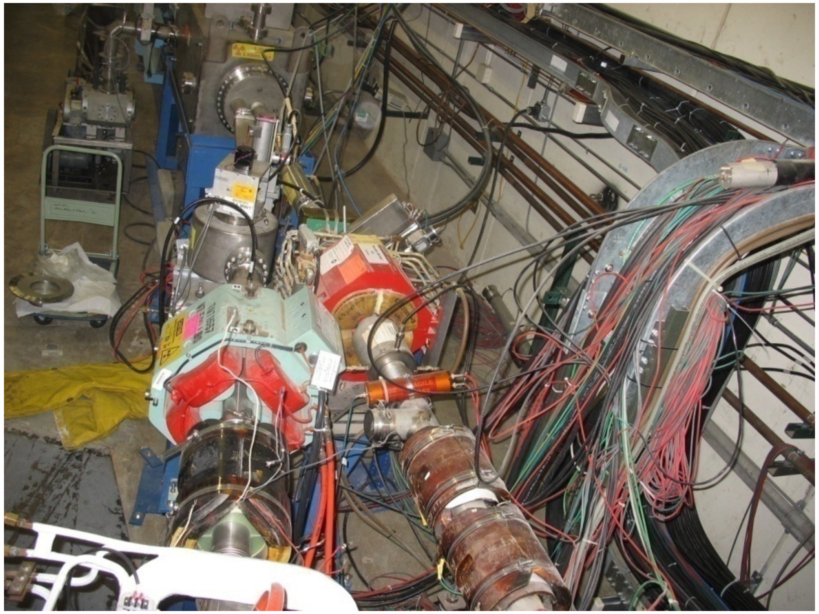
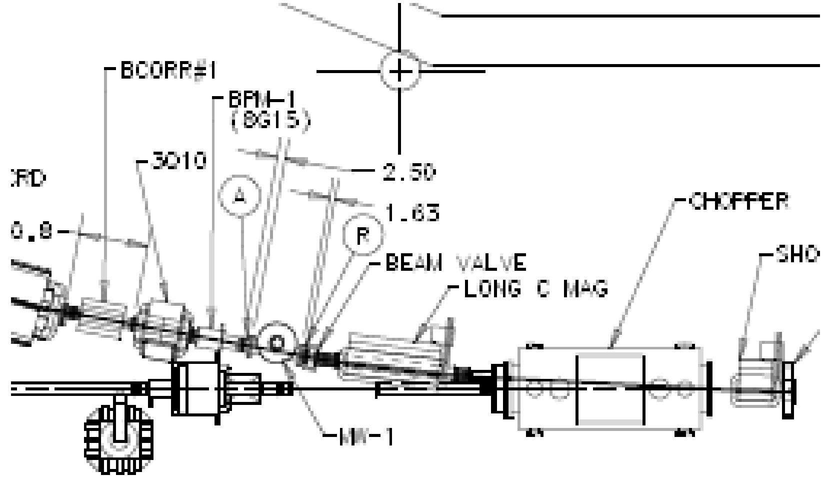
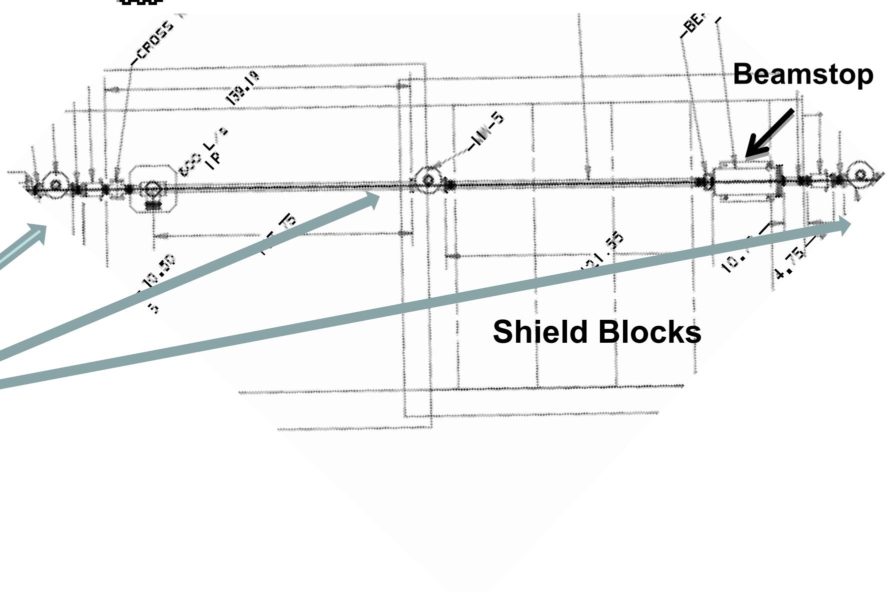
Extraction Area and Emittance Measurement







Extraction from Linac

10 m straight between quads
3 MW profile monitors for tomography

General Shielding Requirements

- Radiological limits:
  - Normal operation losses
    - Unlimited occupancy *
      - ≤0.25 mrem/hr
    - Controlled Area: postings**
      - 0.25 - 5 mrem/hr
    - Radiation Area: fencing, posted**
      - 5 – 100 mrem/hr
  - Accident
      - 500 mrem/accident; 1 sec to stop beam**
  - Max 15 Hz repetition rate

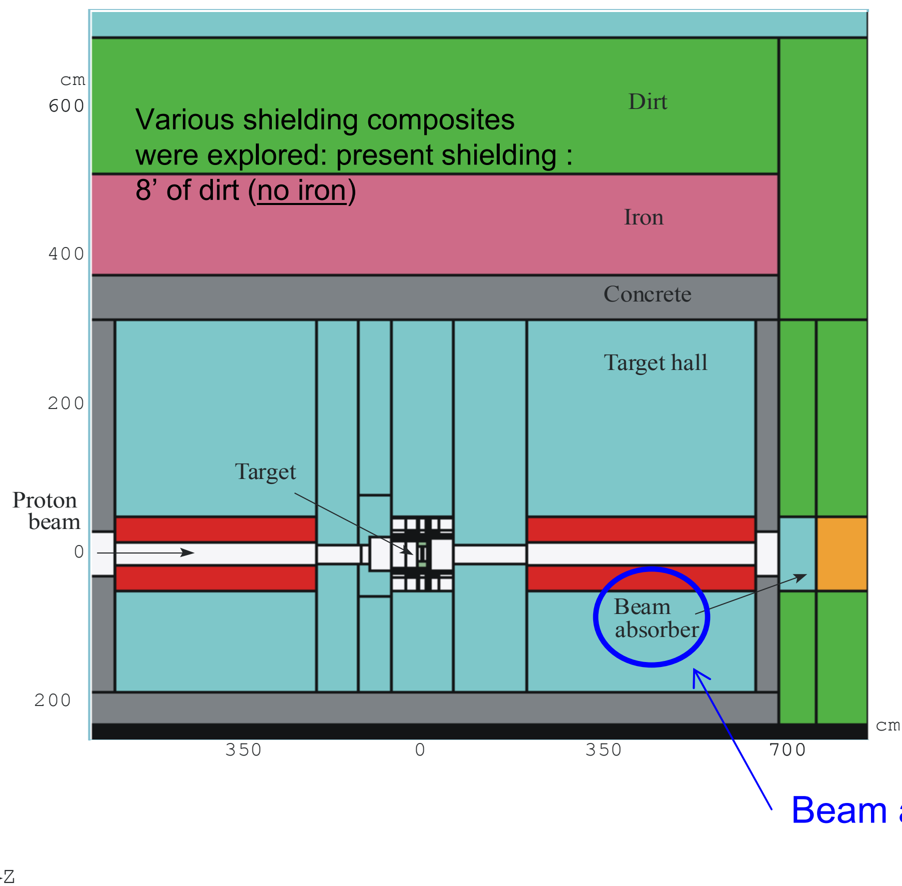
*parking lot ** berm

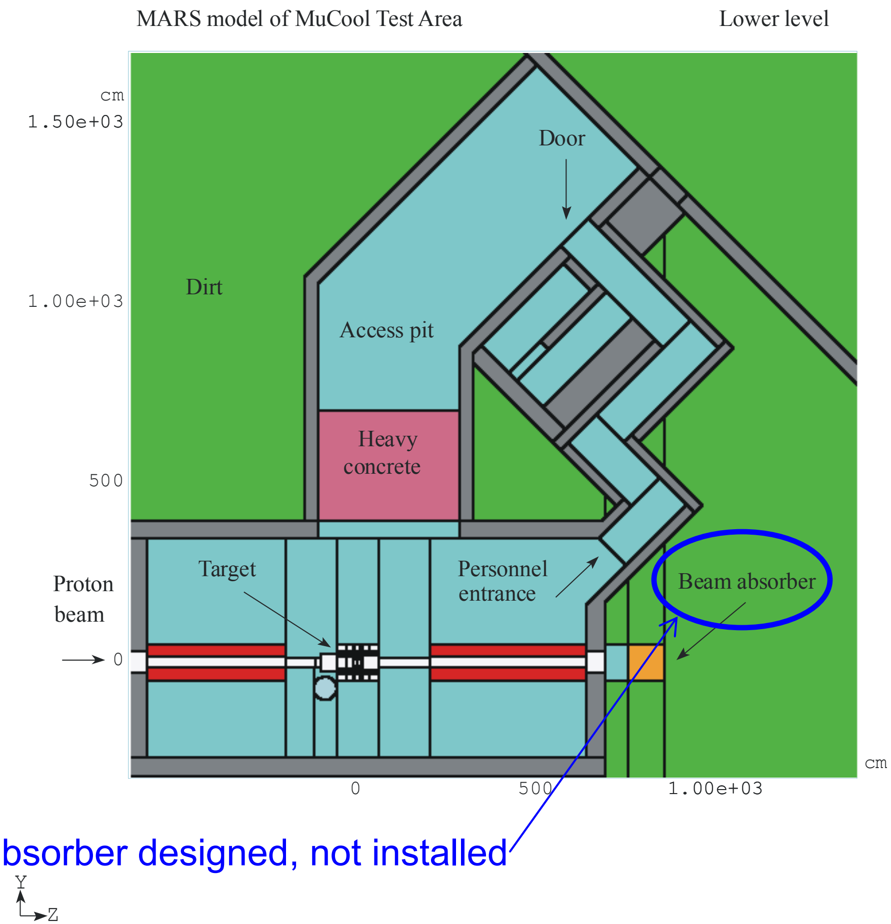
Beam Conditions and External Shielding

- Fermilab Linac beam:
  - 400-MeV protons
    - σ_r = 1cm for loss calculations
      - Defines beam tail (normal losses), size (accidents)
  - 2×10^{14} p/s or 1.3×10^{13} p/pulse
  - Max 15 Hz repetition rate
- External shielding:
  - 18” concrete ceiling
    - Load bearing: up to19’ of dirt
  - 8’ of berm

MARS model of Experimental Hall + Targets

Target Models: hydrogen absorber (2% λ), 1 cm thick Cu disk (10% λ), Muons Inc. gas cavity (150% λ) – I. Rakhno

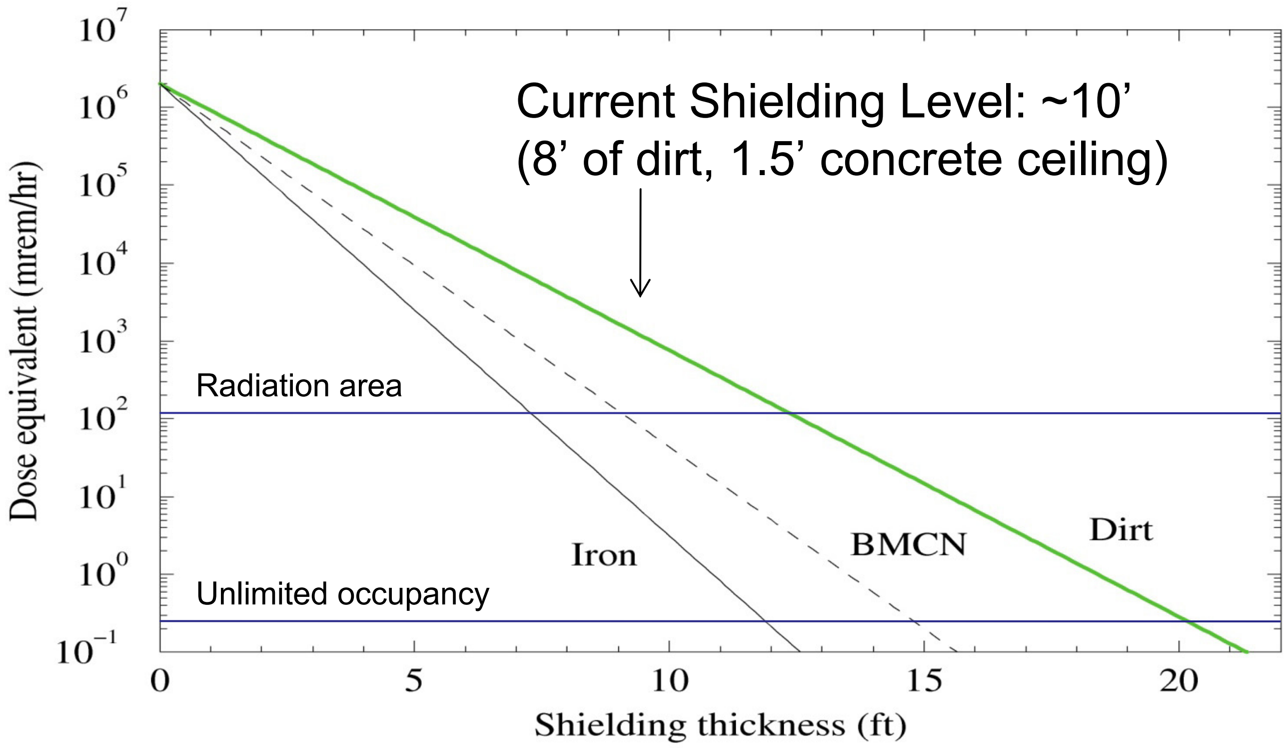




Beam absorber designed, not installed

Results of MARS Simulations

- Generic Target: 1 cm, 10% λ Cu disk:
  - Results for full Linac intensity @15Hz, dirt
  - replacing 8' berm with iron, BMCN (heavy concrete)



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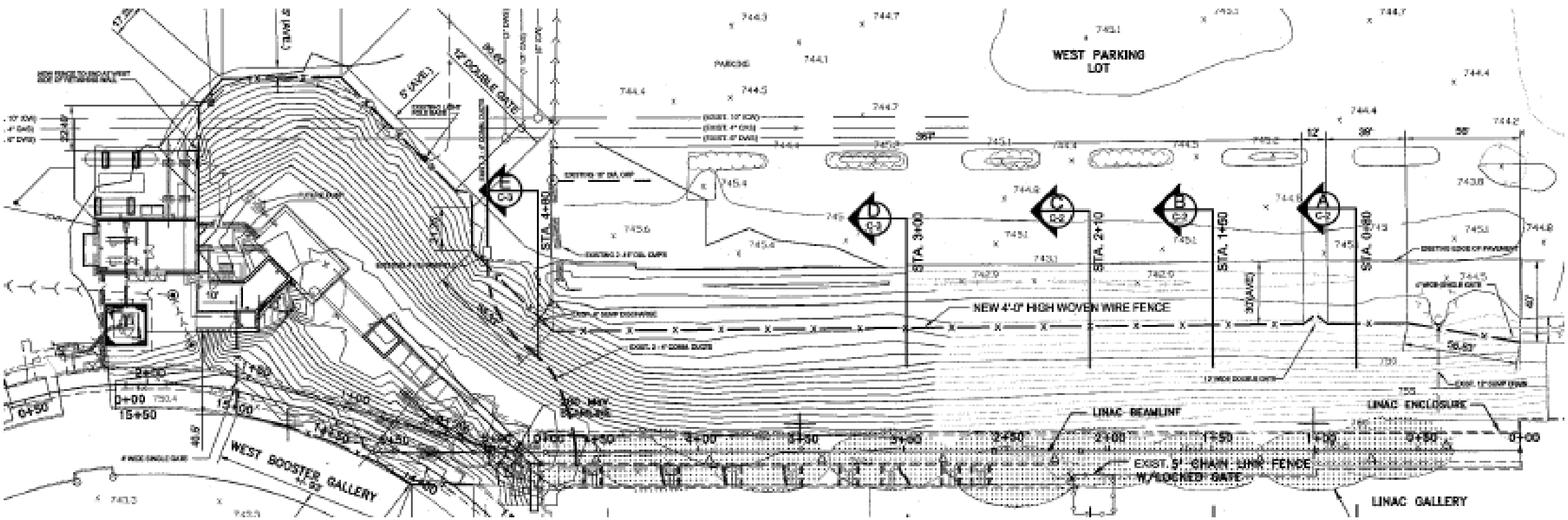
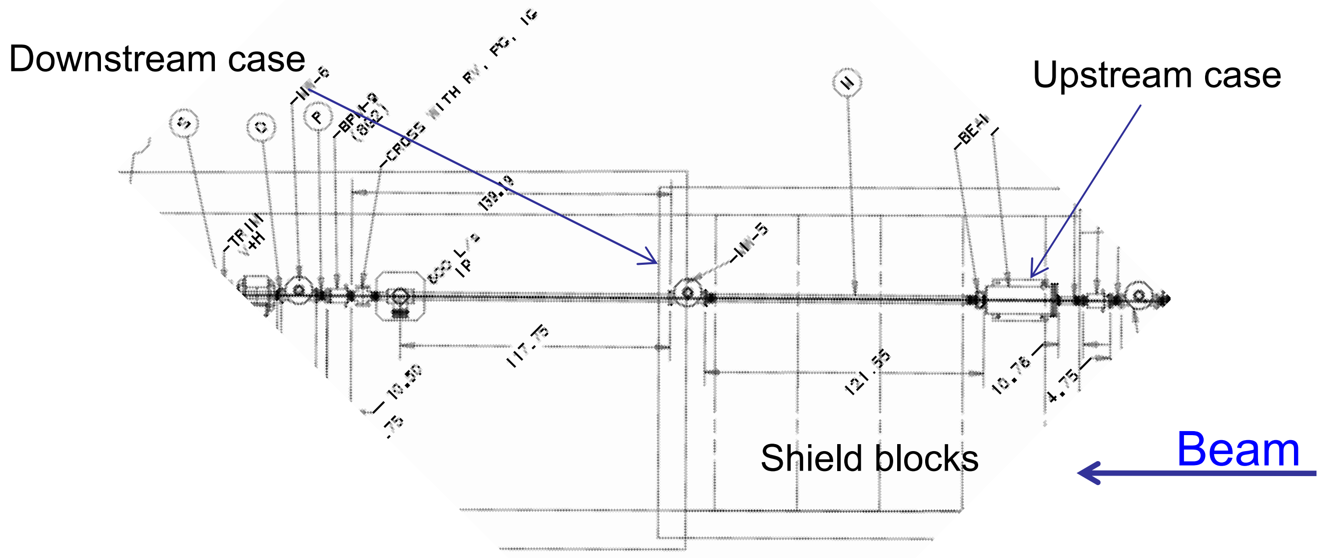
Present Beamline Operational Limits

- Implementation of fence + postings
  - Achieves 1 Hz operation @ full Linac intensity
  - 1 Hz hardwired into C magnet power supply
    - Can be reversed for full 15 Hz operation



Present Accident Limitations

- Worst-case accidents:
  - Two pulse beam loss, full Linac intensity
    - Component downstream of hatch shielding
    - 1st beam stop, partially inside shielding



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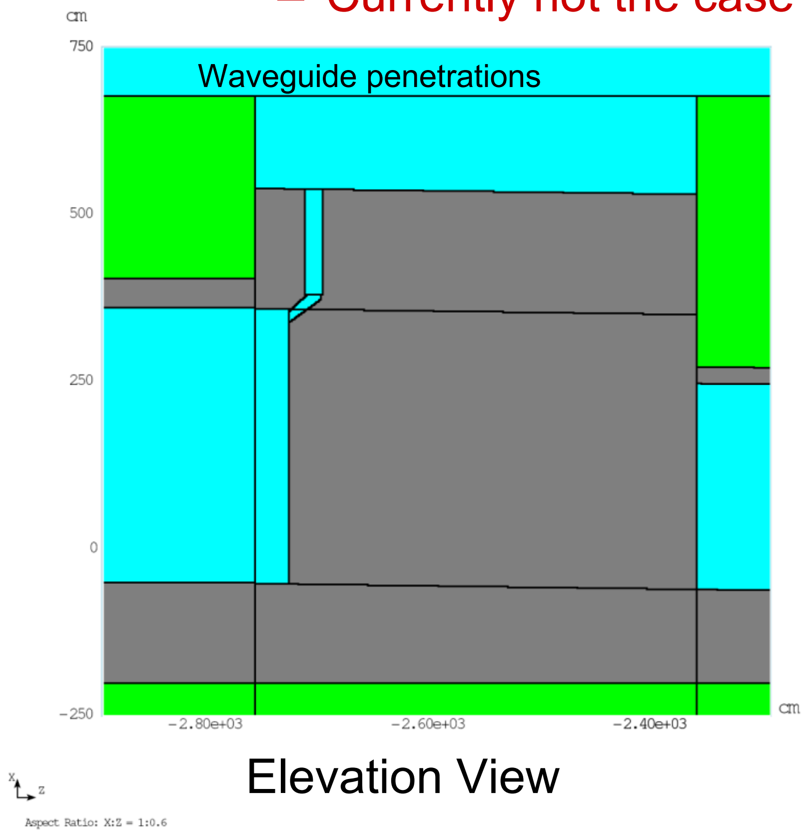
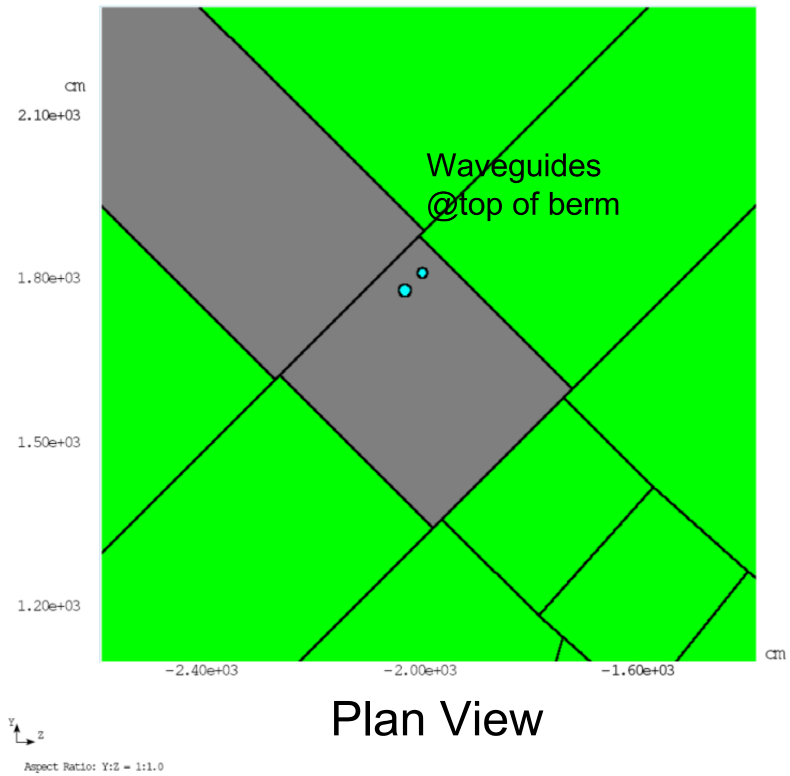
Worst Case Accident MTA Stub

- Two-pulse beam accident near waveguides I. Rakhno
  - Note! waveguides assumed encased in shielding
    - Currently not the case



Elevation View



Plan View

MARS Results: Worst Case, MTA Stub*

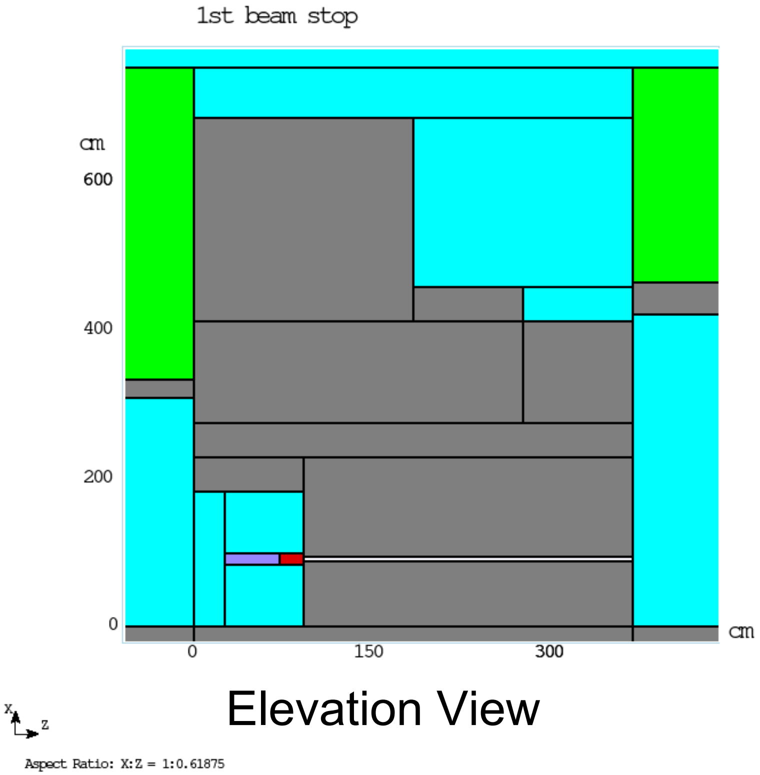
Location	Dose (mrem/pulse)
Beam pipe 5 m US the 12-ft sh.block	1
Beam pipe 2.5m US the 12-ft sh.block	1
Beam stop itself	1
Beam pipe inside the 12-ft sh.block	25
Quad 5 m DS the 12-ft sh.block	240

There is no cross-talk between the penetrations, so that we have **two spots** 240 mrem/pulse each, not one spot 480 mrem/pulse.

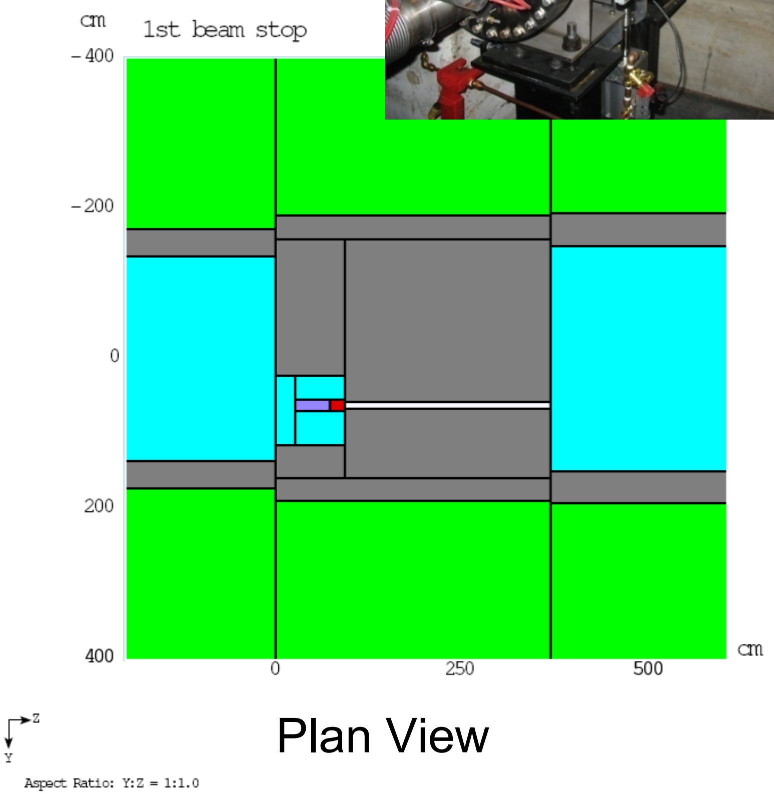
*MARS simulations by I. Rakhno

Worst Case Accident Linac Enclosure

- Two-pulse accident on 1st beam stop.



Elevation View



Plan View

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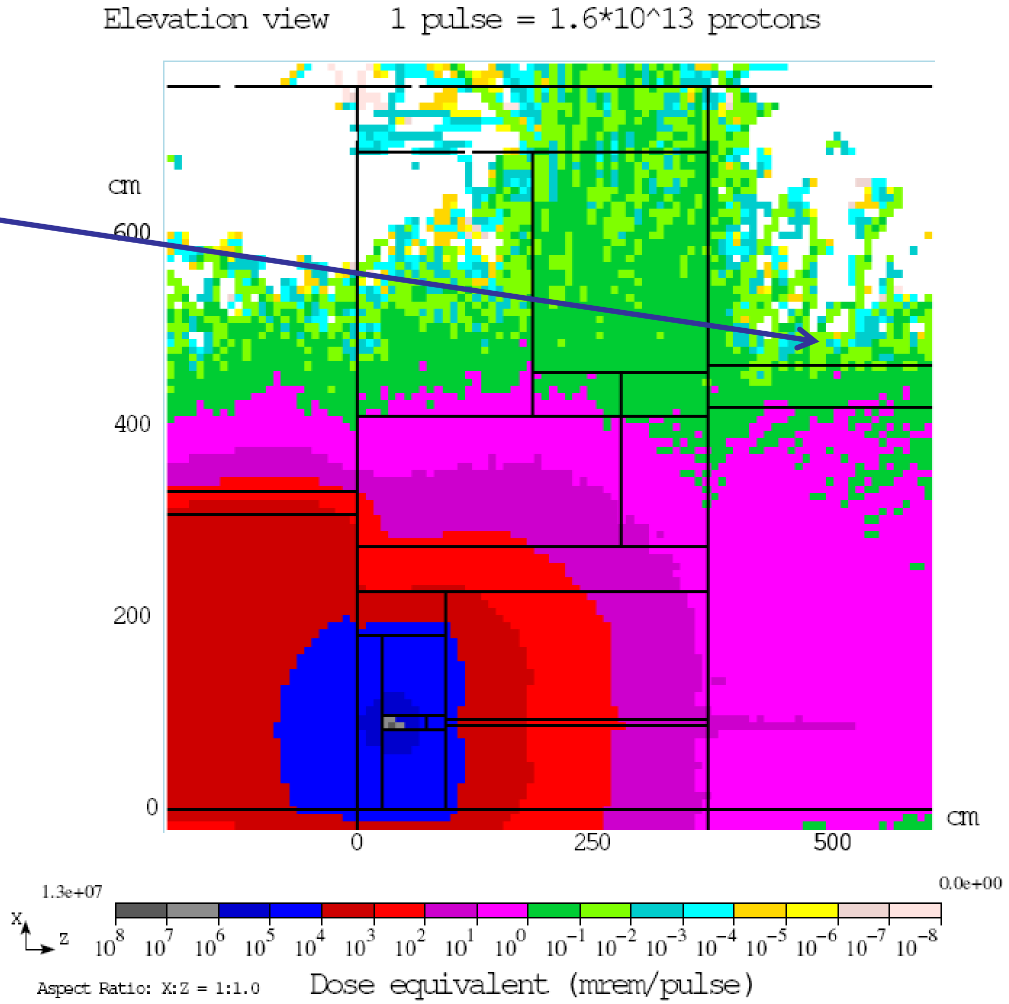
Operational losses, 1st beam stop

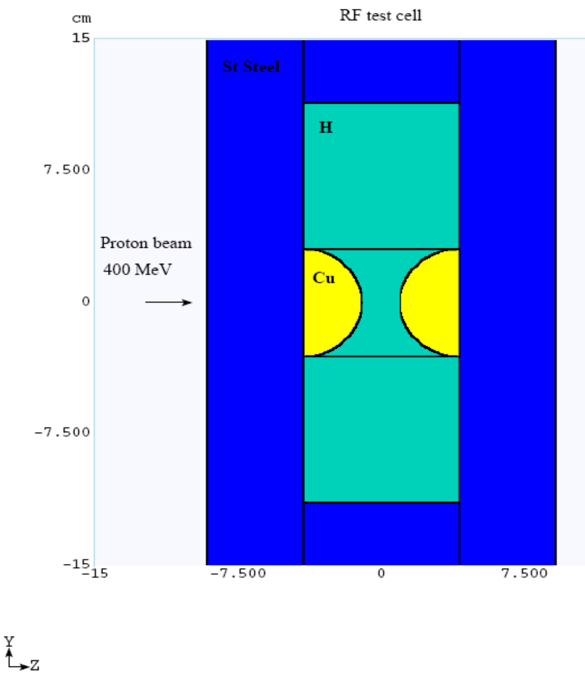
- Dose in shielding gap
  - Just under 1 mrem/hour
  - With fence in place
    - Radiation Area:
      - **Limit 100 mrem/hr**
    - ~1 pulse/minute



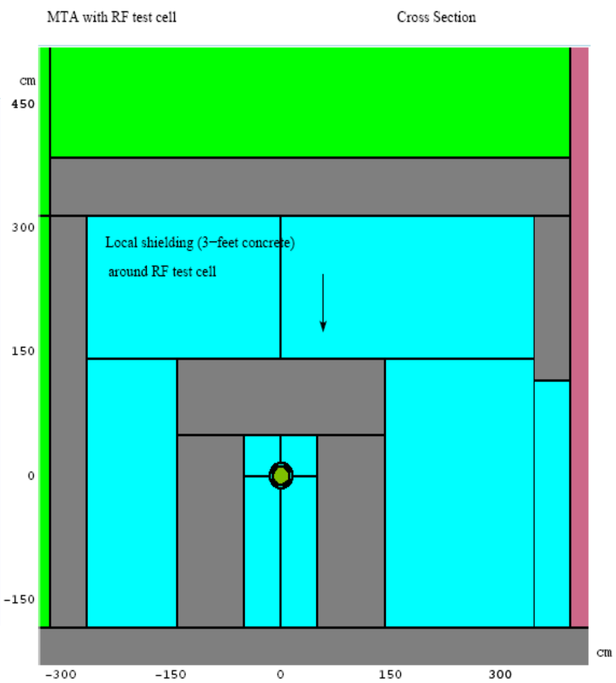
Beamline commissioning

- 1/per minute to 1st beam stop approved
  - Estimated readiness for beam – June, 2008
    - Contingent on Linac downtime (enclosure access) for
      - C magnet installation
      - Final beamline alignment
- Beam to 2nd beamstop, end of MTA stub requires
  - Relocation of waveguides – plan in progress
  - Gap in hatch shielding filled
- Beam to Muon’s Inc. gas-filled cavity
  - Modeled in MARS (I. Rakhno)
  - Specific, local shielding required

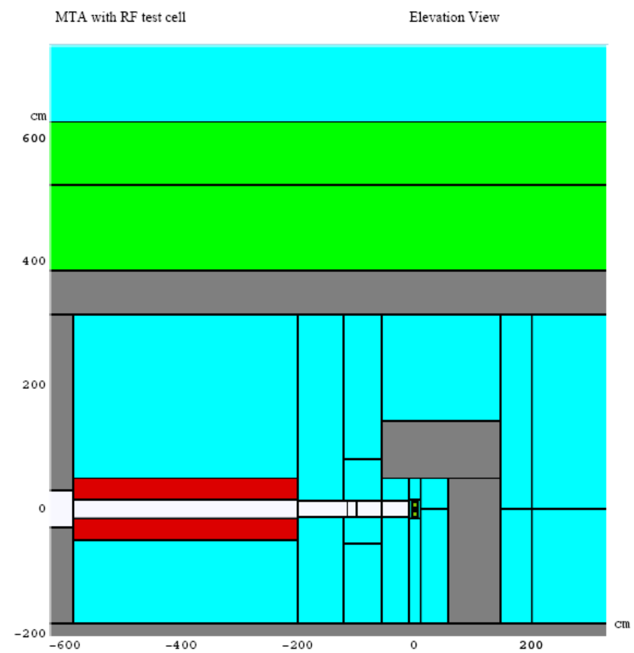
Beam Experiment, Muons Inc Cavity



Rf Cavity



Looking Downstream elevation view

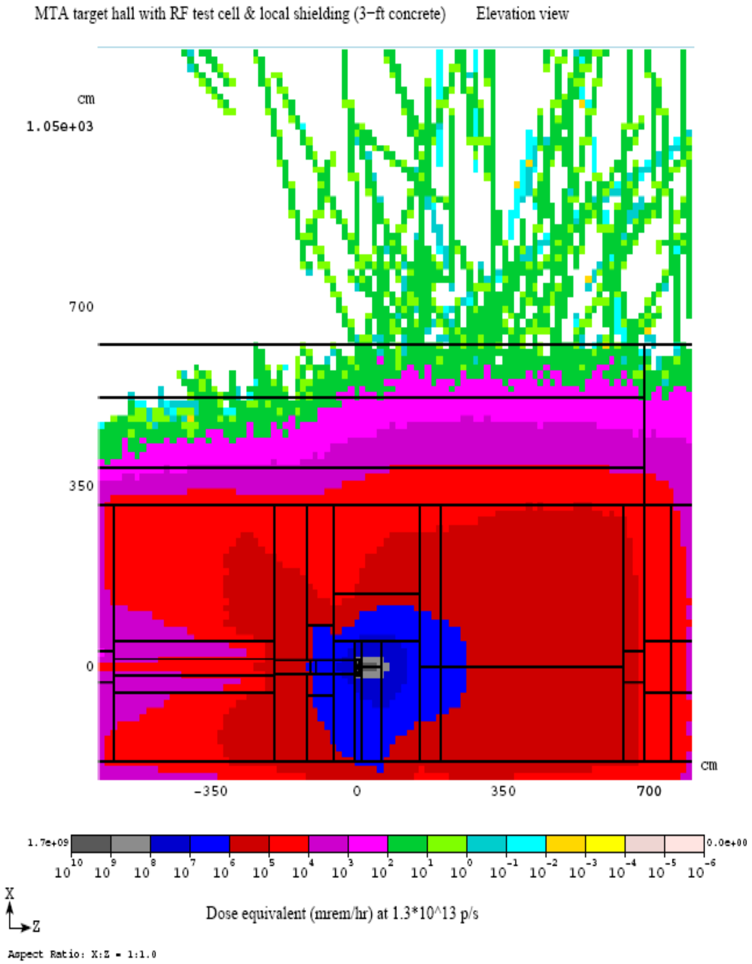


Profile View

MARS Results Muons Inc. Cavity

- At 1 Hz full Linac intensity
  - Without local shielding
    - Dose exceeds 100 mrem/hr on top of berm
  - With 3' local shielding
    - The dose ~ 20 mrem/hr @hottest spot
  - Cavity is the beamstop

(I. Rakhno)



Elevation View, Exp. Hall

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Summary

- With Fence and postings. No additional shielding:
  - Beamline operation is presently limited to 1 Hz
    - 1 Hz operation has been implemented in pulsed extraction magnets
  - Configuration control (local shielding) will be required for Muons Inc rf cavity – 2-3' of concrete
  - Experiments which are not "beam stops" require a beam absorber

Acknowledgements: Proton source dept, F. Garcia, in particular, and Ext. Beams, C. Moore, dept head.