The MICE/MUCOOL rf R&D Program

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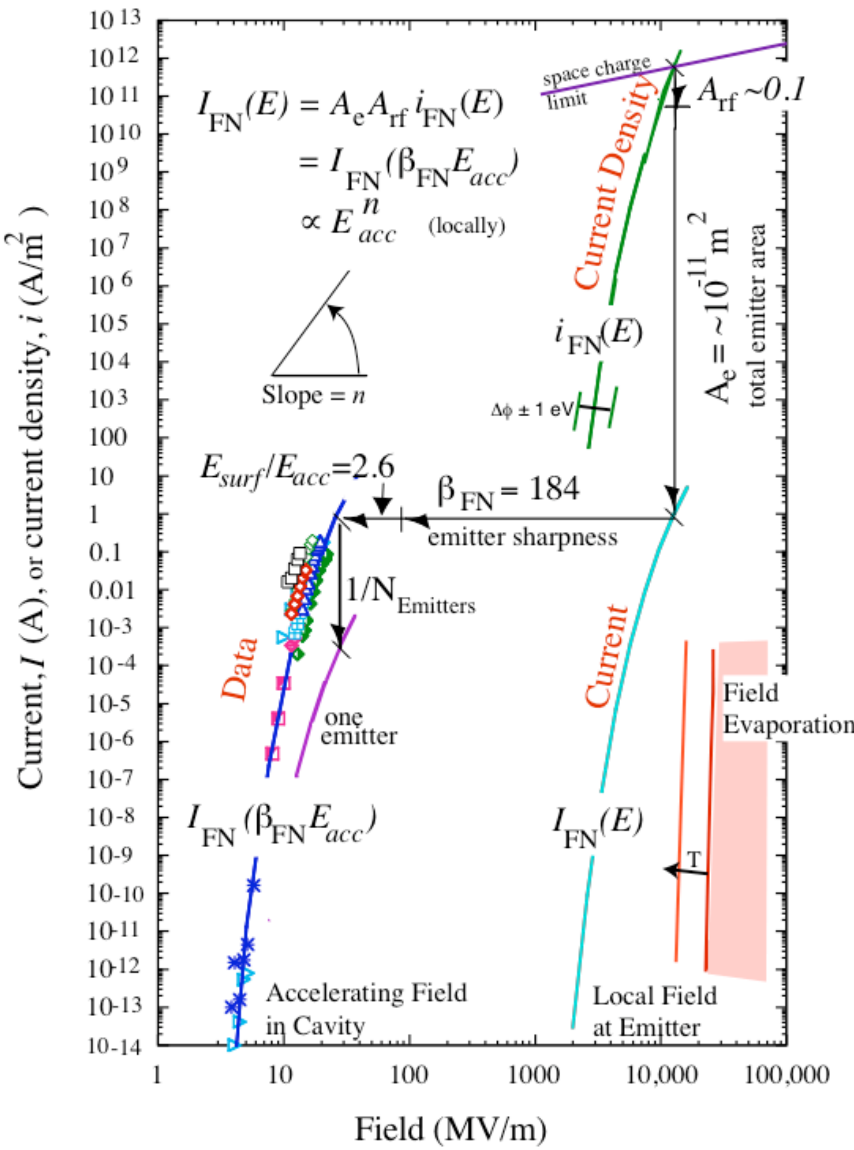
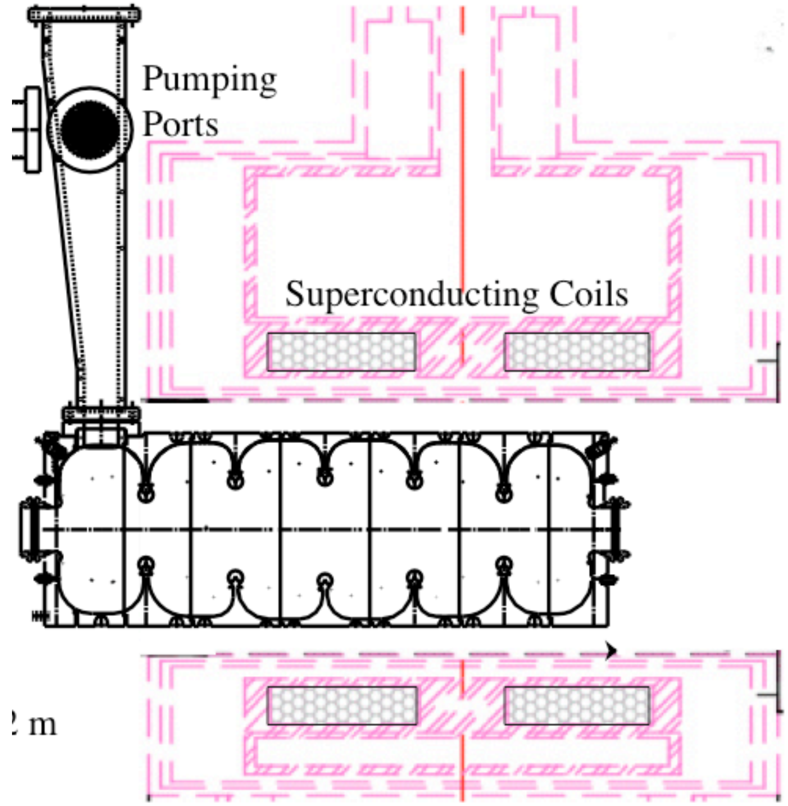
MICE/MUCOOL
Jan. 13, '05

Our Lab G data at Fermilab measured the environment.





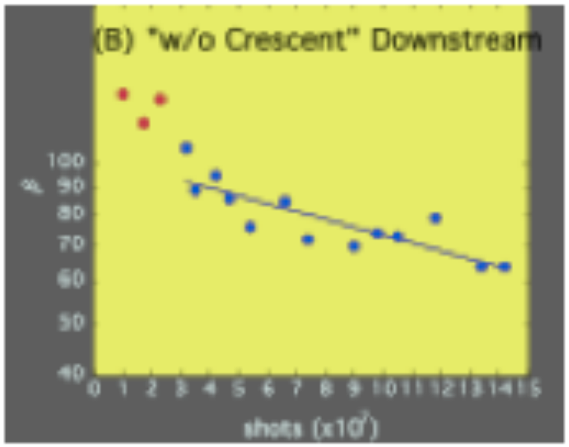
Emitter dimensions ~ 0.1 μ
Surface field ~ 10 GV/m

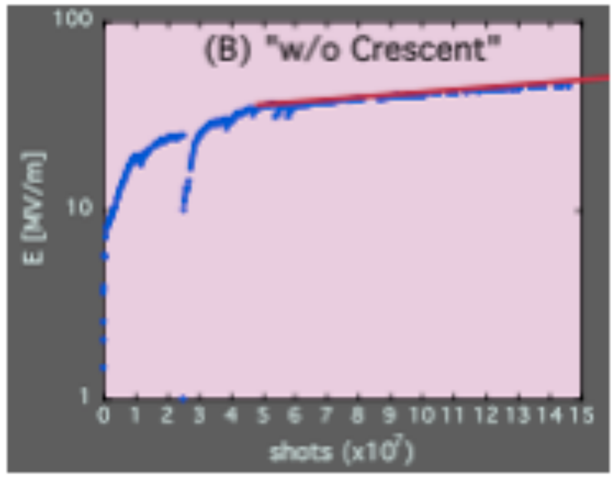
. . an active scientific field

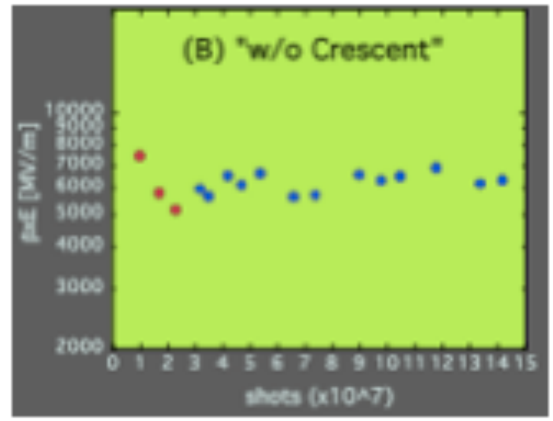
We have made major progress understanding breakdown.

- People are confirming our predictions.

KEK







Enhancement factor * Surface field = 6 - 7 GV/m

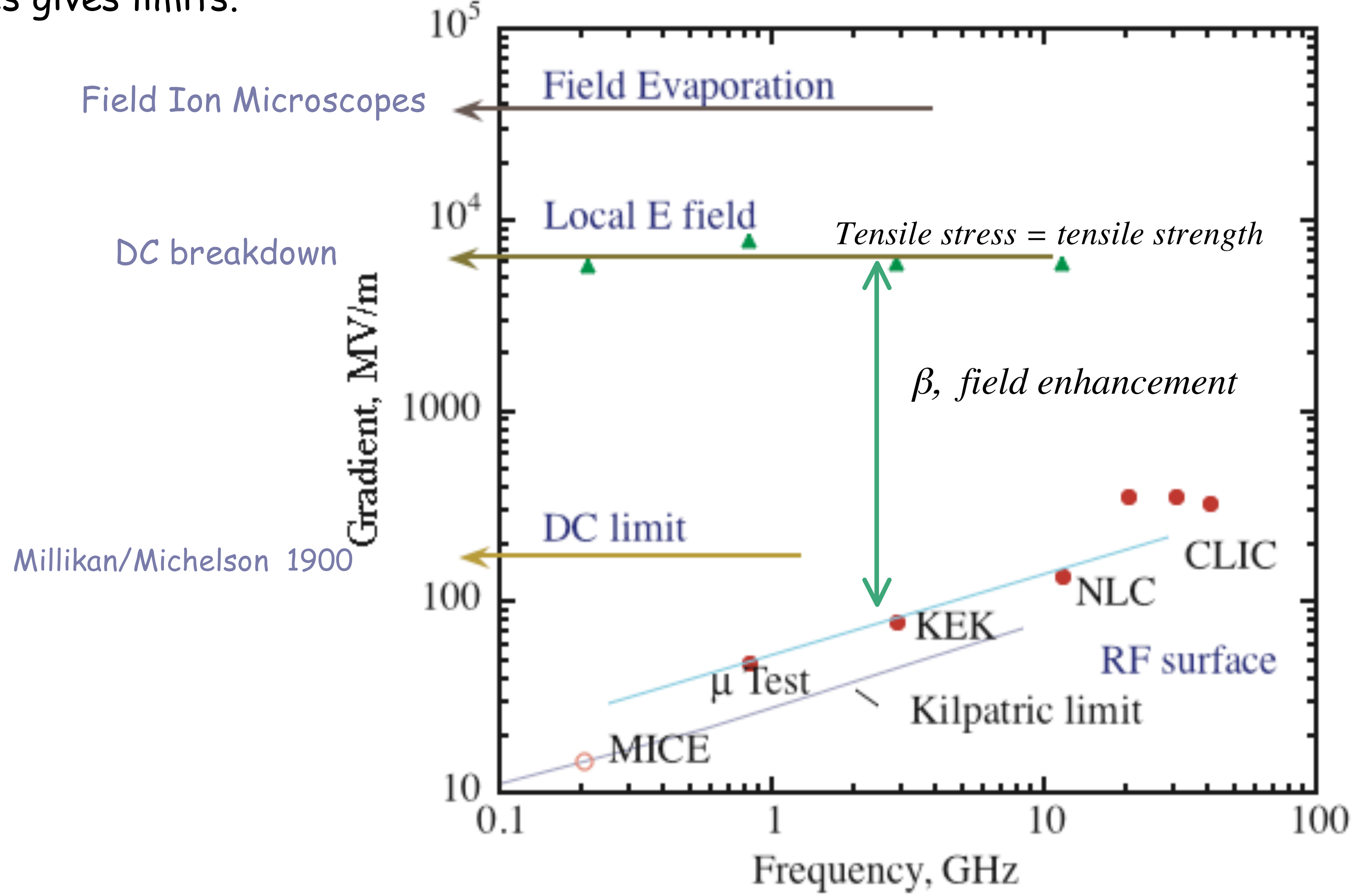
SLAC

(Fowler-Nordheim: $E_{eff} = Es * \beta$ -> 7 GV/m = 170 *40)

- No other model predicts breakdown thresholds.

Maximum Gradients in copper cavities.

- Physics gives limits.



MICE/MuCool need to know:

- Can we operate reliably at 8 – 16 MV/m with a ~5 T field ?
- Can we reduce field emission backgrounds with high work function materials ?
- Will coatings of these materials stick to the copper ?
- Can they be applied to a large, expensive cavity ?
- Can we defeat the magnetic field effects by reducing field emission ?

- Will high intensity beams change things ?
- Can high pressure gas reduce breakdown ?
- Can Materials Science techniques reduce breakdown ?

The Muon Collaboration rf program

Experimental

- Muon Test Area at Fermilab

  Tests of cavities at 805 and 201 MHz with magnetic field

- Atom probe experiments at Northwestern

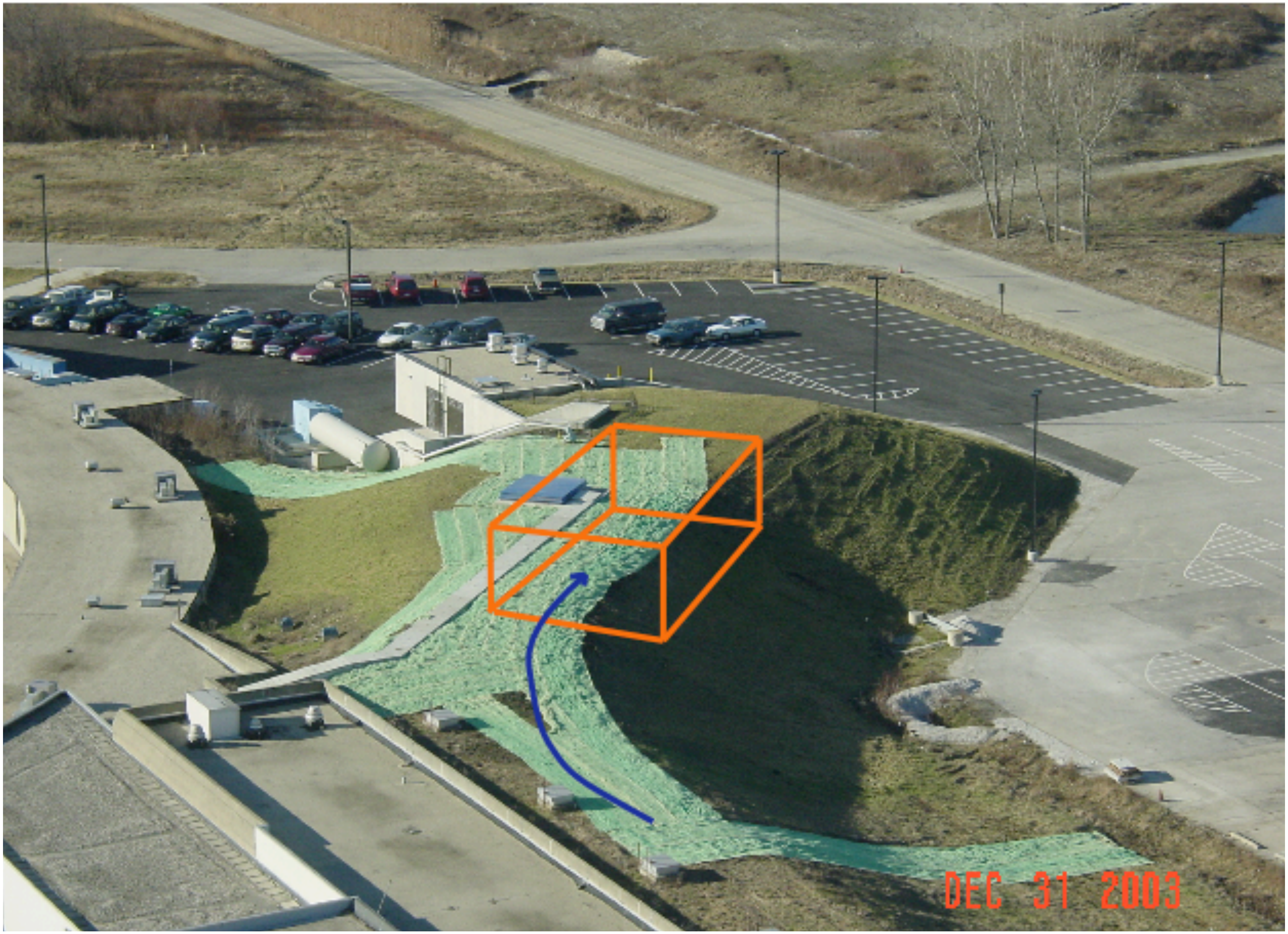
  Materials studies relevant to Muon cooling, breakdown and SCRF

Modeling

- Model breakdown process, at Argonne.

We have a new experimental area at Fermilab

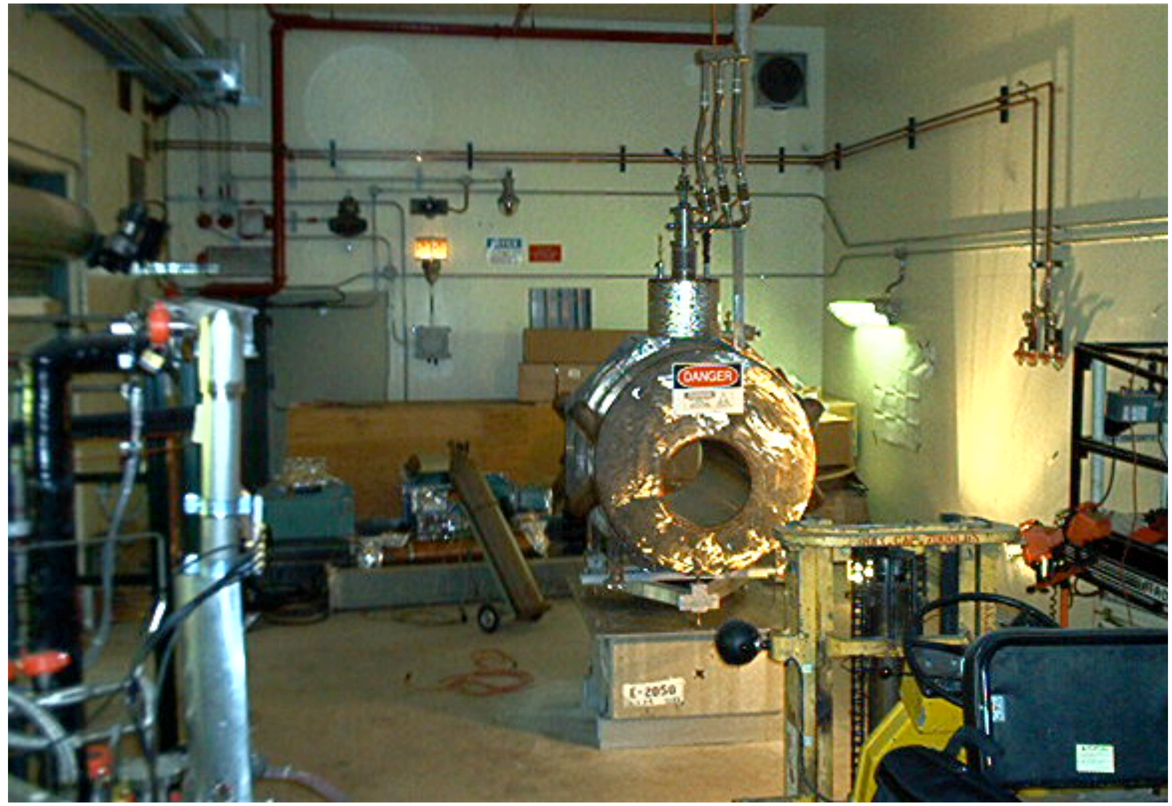
The Muon Test Area (MTA)



The MTA.

Upstream (last year)

Downstream (last week)

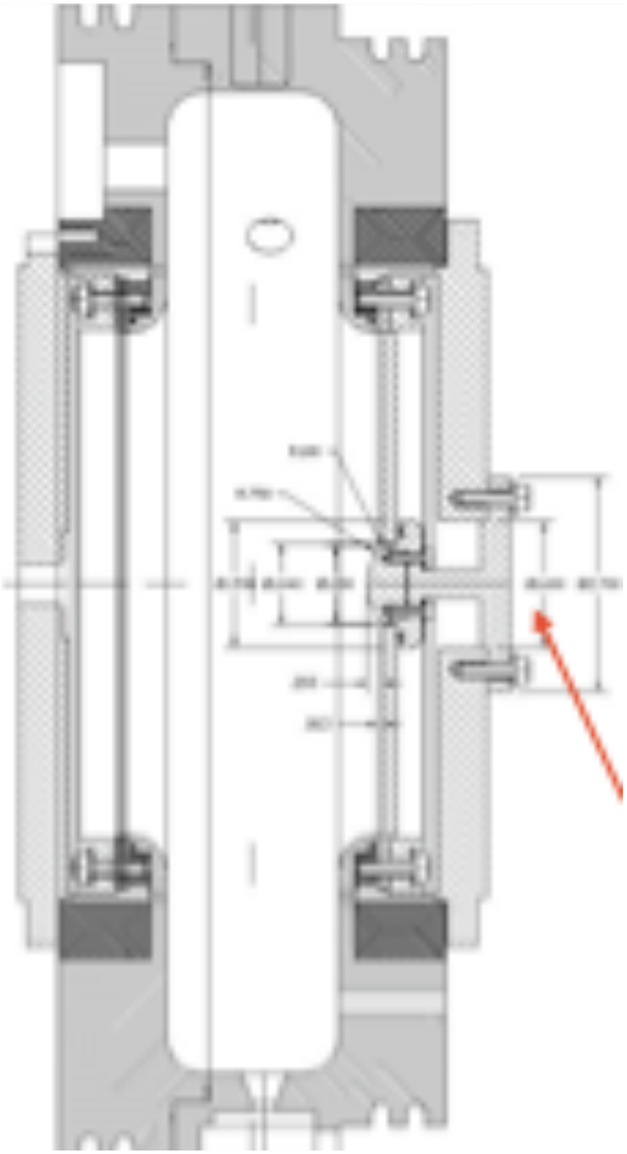


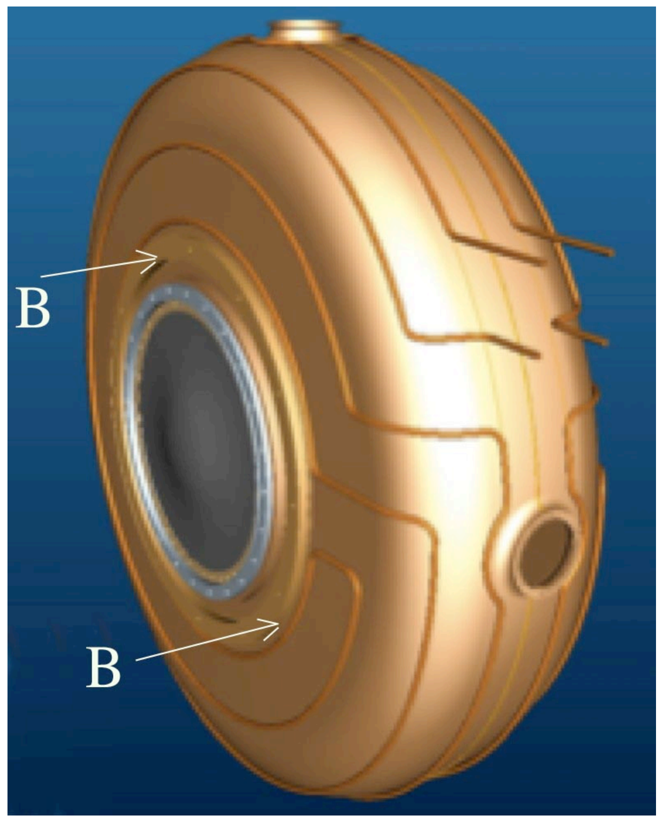
We expect to be taking data in March.

We are moving into the downstream end of the Linac Gallery.

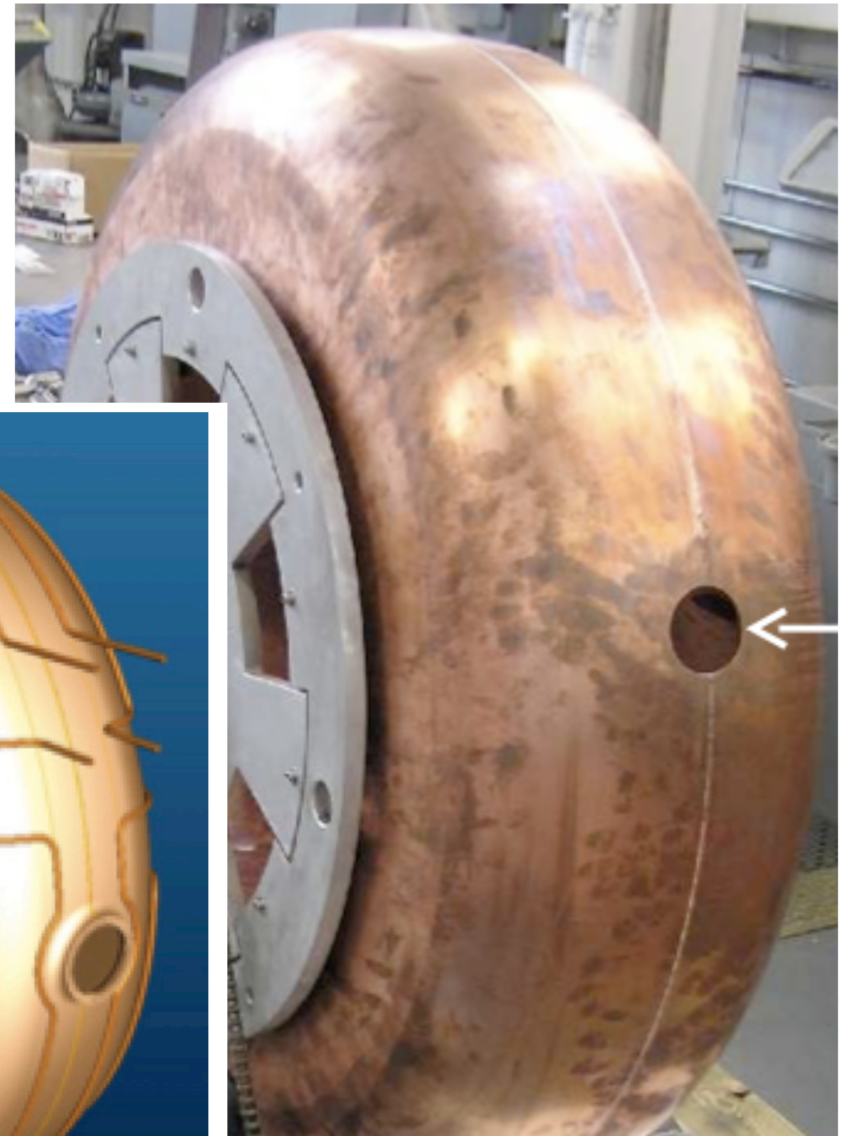
We will be studying two cavities

805 MHz





201 MHz



Muon Test Area Experimental Program

- 805 MHz cavity
  - Curved windows (the flat ones were unstable)
  - Button tests of different materials (damage in different materials)
  - Magnetic field studies (we need to operate at 5T)
  - High pressure cavities (high pressures may be good)

- 201 MHz cavity
  - Conditioning and breakdown studies (needed for MICE)
  - Magnetic field studies (Can we reach 16 MV/m?)

- Surface modification and control (Can we do better?)

Materials issues relevant to breakdown.

- What is the spectrum of sample failure vs. field, temperature, material?

- What sort of
  - Clusters
  - Large fragments
  - Microflashes

    are produced at high fields?

- How does failure depend on surface or subsurface defects?

- Zeke Insepov has predictions.


PHYSICAL REVIEW SPECIAL TOPICS - ACCELERATORS AND BEAMS 7, 122001 (2004)

New mechanism of cluster-field evaporation in rf breakdown

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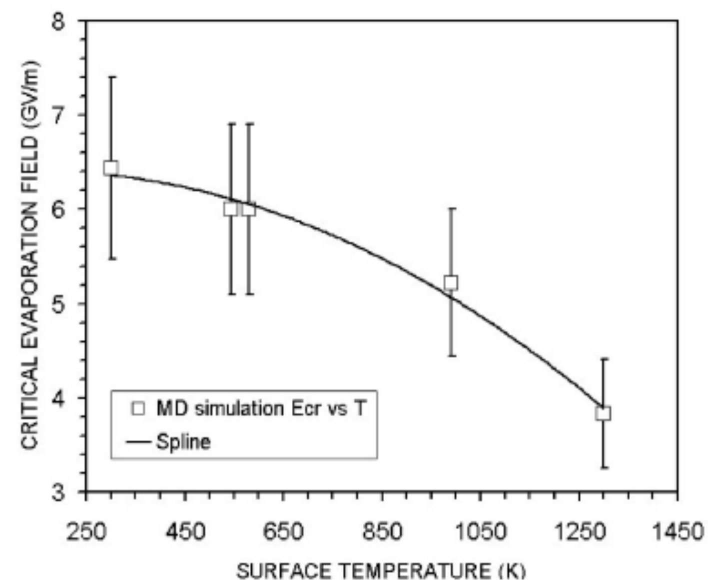
Argonne National Laboratory, 9700 South Cass Avenue, Argonne, Illinois 60439, USA
(Received 26 April 2004; published 22 December 2004)



Coating tests

- It would be enormously beneficial if coatings suppressed dark currents.
- It is not economic to test surface treatments in a big cavity.
  We could ruin the surface.
- Tests in an atom probe system can use small samples.
- Procedure:
  Clean surface
  Coat
  Measure field emission (negative voltage)
  Remove coating and measure sticking coefficient (positive voltage)
  Repeat

Atom Probe Tomography Studies

	MICE/MUCOOL	Breakdown	SCRF
Reducing dark currents	X		X
Coatings/adhesion	X	X	X
Failure vs E		X	
Oxide surfaces	X	X	X
Surface modification	X	X	X
Clusters and fragments	X	X	X
Microflashes		X	
Grain boundaries, defects		X	X
Gas in metals (temp etc)	X	X	X
New materials	X	X	X
Nanotechnology	X	X	X

to be done with D. N. Seidman and J. Sebastian at Northwestern and P. Bauer at Fermilab.

Questions where material structure would be useful for SCRF.

- Supercurrents amd (isulating) Oxides occupy the top 100 nm of the niobium.
  What happens?
  What do the surface layers look like?
  How do oxygen and hydrogen interact with the surface?
  How much control does one have of the surface?

- What do real grain boundaries look like?
  at the surface, in the bulk
  how are they affected by baking, etc?

- High field losses affected by ~100 degC baking. Why?

- Deposited coatings on copper are more lossy than bulk niobium, Why?

- Can surface modification help control field emission?

Conclusions

- The Muon Collaboration has a broad and productive program in rf R&D.

- We claim to be the first to understand breakdown triggers.

- We want to **prove** we are right and **improve** the state-of-the-art.

- There is a wide range of applications and connections.
  - Normal conducting rf
  - Superconducting rf
  - (Nanotechnology)
  - (High power density physics)

- We are trying to share costs with Superconducting rf R&D.