High Gradient RF: Plans

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MNFMCC Meeting
Fermilab
May 11, 2007

MTA Program

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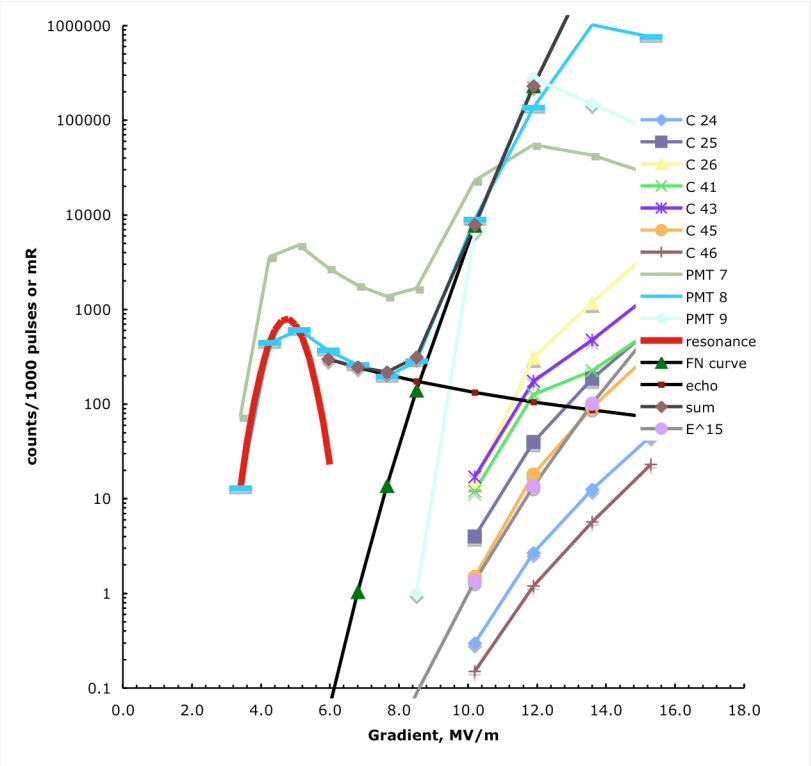
- We see a multipactor resonance.
- We need to see if we can condition thru these effects.



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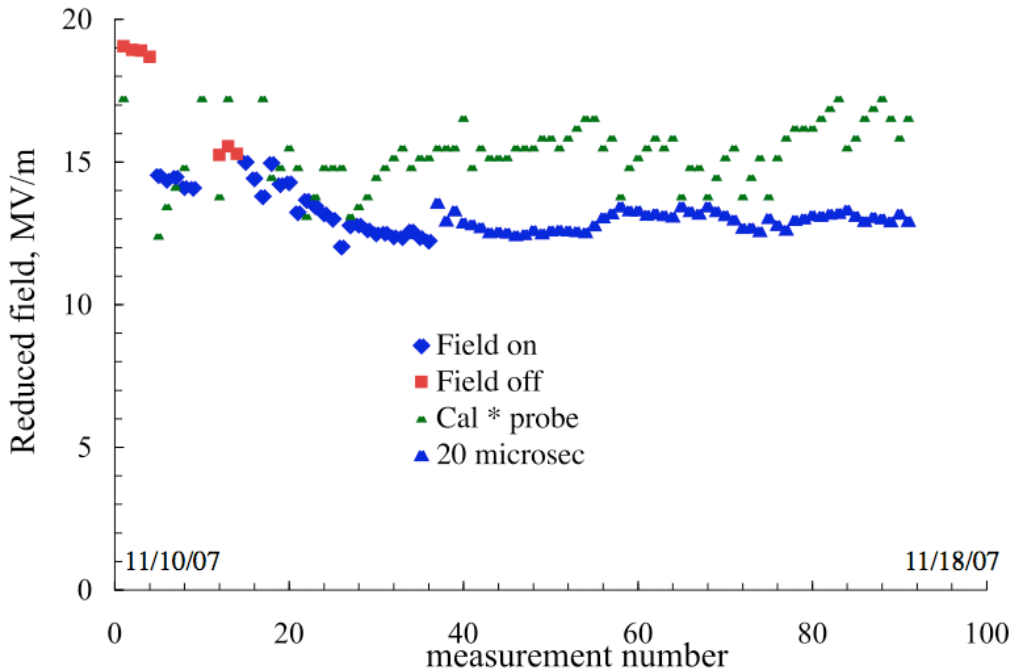
- Conditioning does not work with magnetic fields.
- We need to understand this.
- **Button studies are starting.**



Consider new initiatives:

1) E X B effects are important.

- Magnetically insulated transmission lines work.
- We need the MICE coupling coil.
- A rotatable cavity would be very useful, and give basic data.
- The design is tricky,
  Moretti needs a challenge.

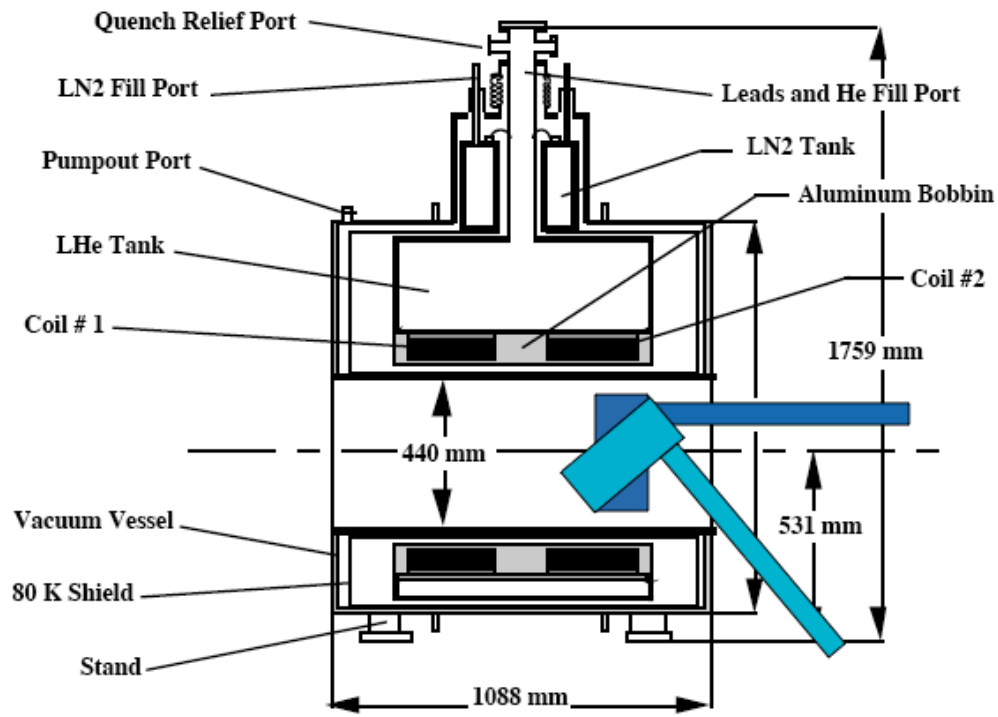


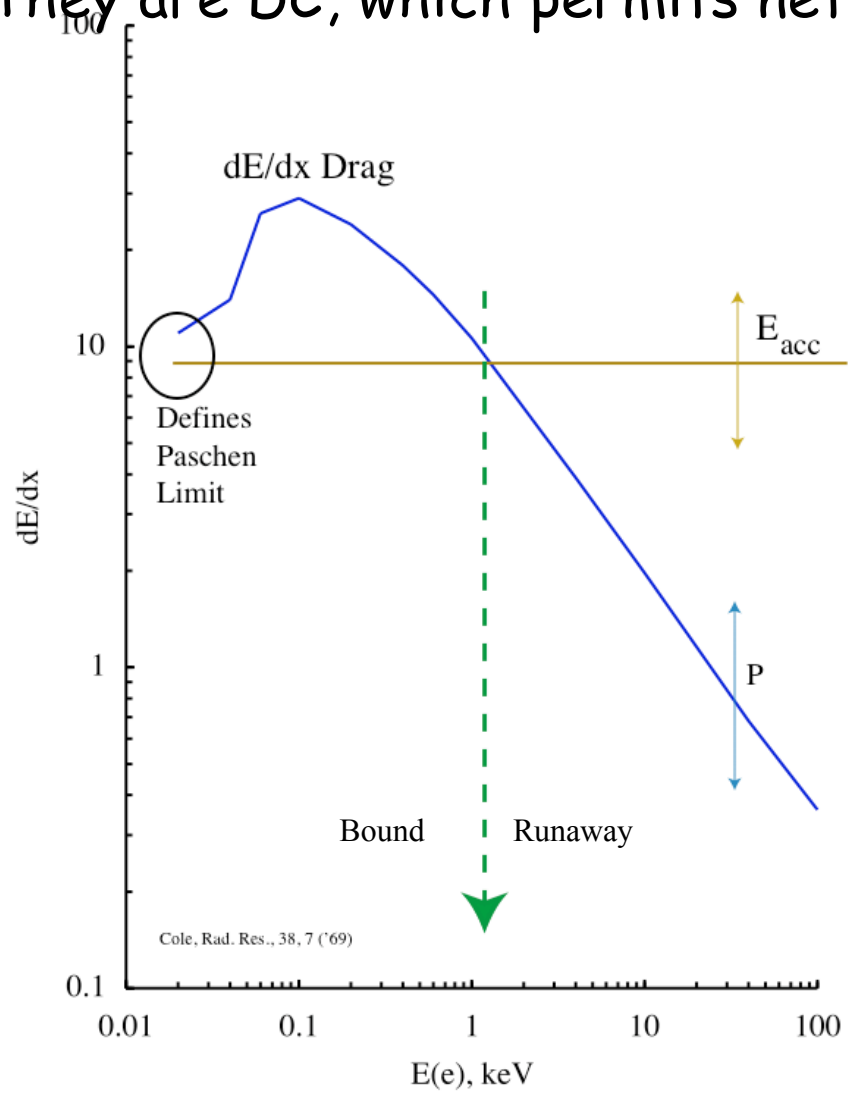
Figure 1. A Cross-section View of the RF Solenoid from the Side

2) High pressures and dielectrics.

- Beam effects may be easier to study in synchrotron beams.

- They are DC, which permits network analyzer measurements.

kinematics don't give E> 1KeV

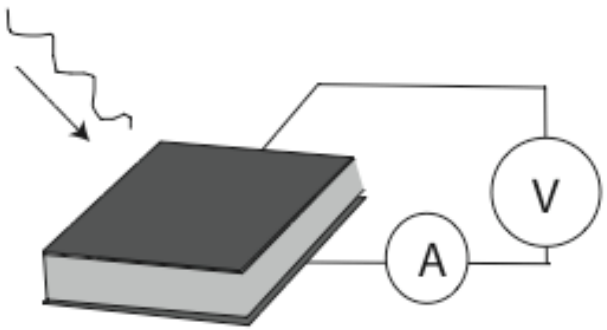


3) Gas/dielectric breakdown theory

- Drift chamber physics and breakdown mechanisms have a lot in commom.

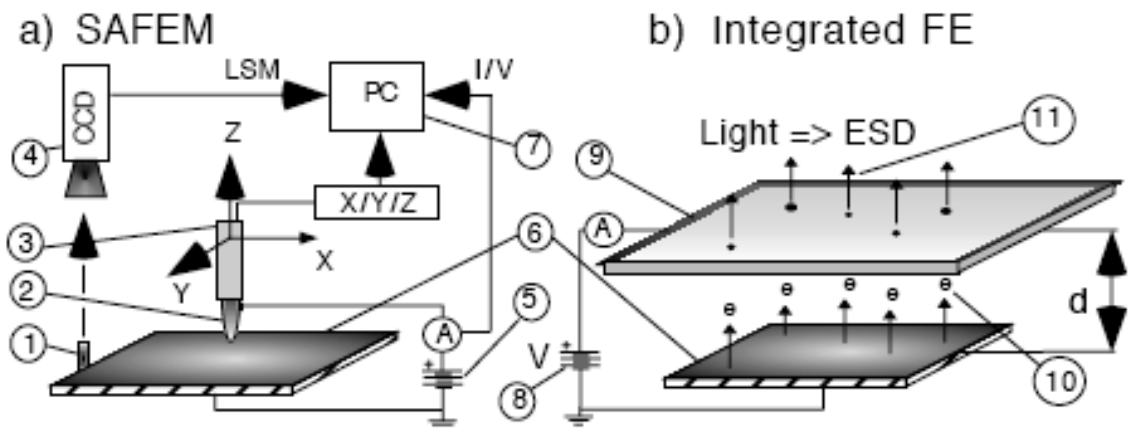
- Much of this is in standard programs and references.

- Are tests with solids relevant?



4) Field emission Microscopy

- This seems to be the best way to study emitters/breakdown sites.



(Brodie Spindt JAP 90 (01) 768)

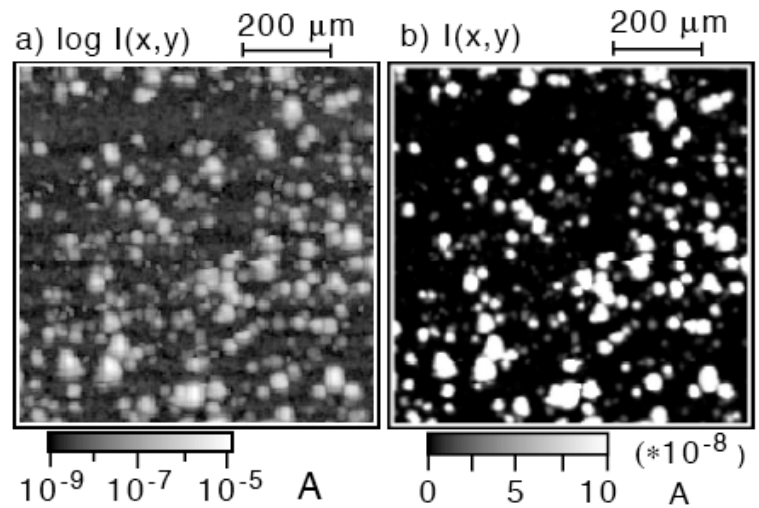


FIG. 4. FE apparatuses: (a) Scanning anode field emission microscope and (b) integral field emission with a phosphor screen. (1) Reference light source for sample positioning. (2) *x/y/z*-movable scanning FE Pt–Ir tip (radius ~5 μm). (3) *x/y/z* piezo step motors. (4) Charge coupled device camera for motion monitoring. (5) Source-measure device (1100 V/10 mA). (6) Carbon thin film emitter. (7) Computer controlled sample motion, current (*A*) and voltage (*V*) monitoring. (8) High voltage supply 3000 V. (9) Phosphor screen with variable separation *d*. (10) Spotwise electron emission. (11) Electron stimulated fluorescence of the phosphor screen ⇒ emission site density.

5) Atom Probe Tomography

- This is the ideal way to study high fields + materials.

- 21st century technology.

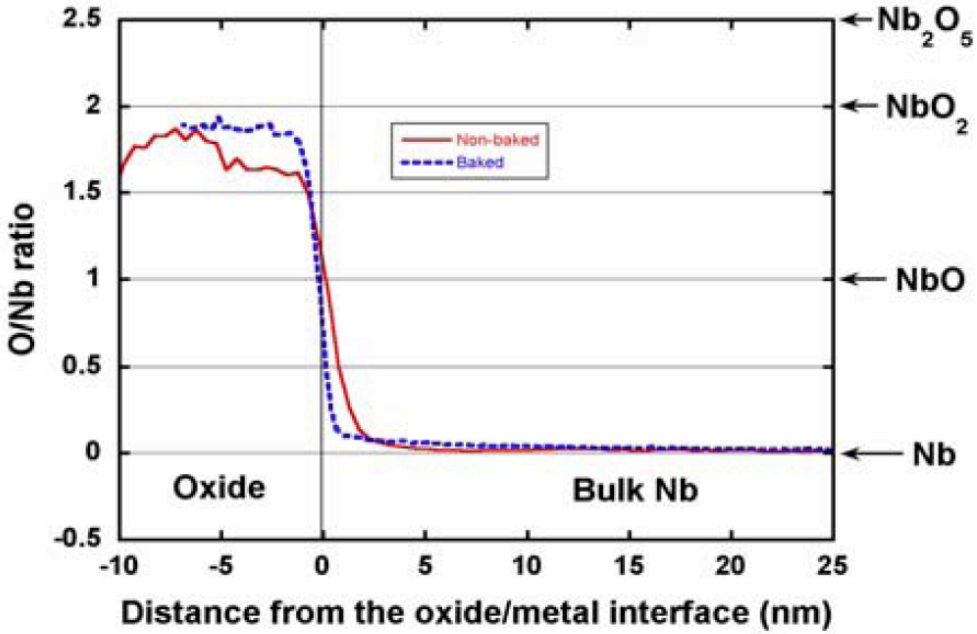


Fig. 5. O/Nb ratio from the 3D reconstructions of unbaked and baked niobium tips. The stoichiometry of the oxide is deduced from the profile. The profile clearly demonstrates that the thickness of the oxide decreases after baking. The chemistry of the oxide, however, does not change.

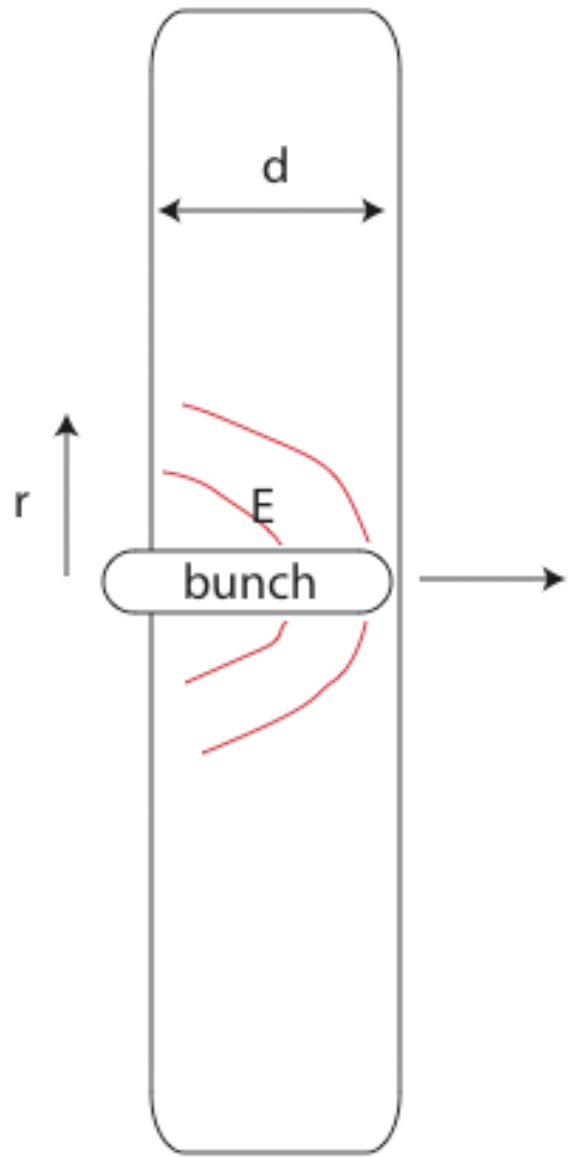
6) Beam loading

- This could be an issue for the small beams required by colliders.

- The bunch can only take energy from the part of the cavity that causally communicates with it, r ~ d.

- Trailing edges of the bunch can see reduced accelerating fields.

- This is effectively beam heating.



7) Nanofabricated SCRF Composites

- **How structures fail**

Field emission

Field emitted electrons heat and quenches the superconductor.

Multipactor

Resonant amplification of low energy electrons.

Quench fields

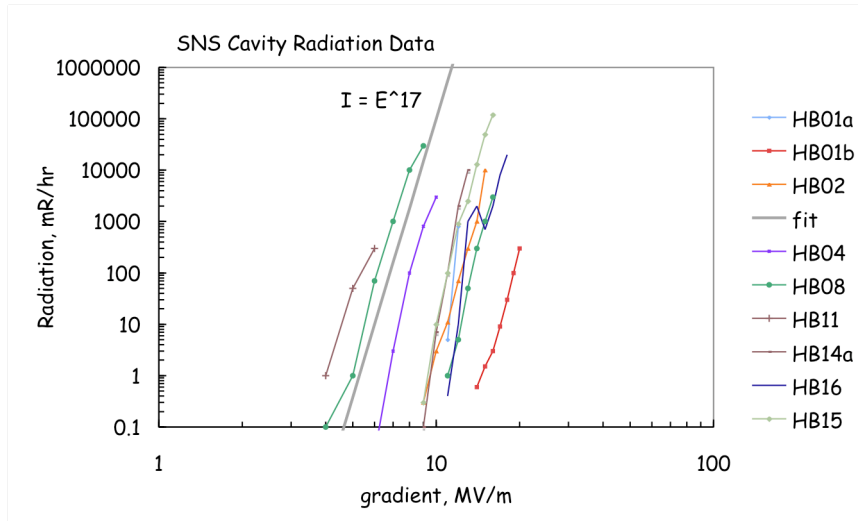
Cavities quench when
$B > 180$ mT

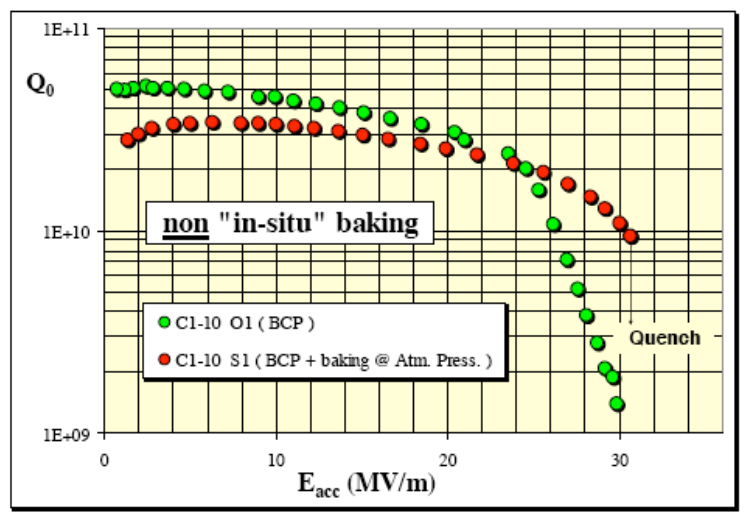
High field Q-slope

Cavity losses rise with impurities and defects.

Thermal

Increased thermal conductivity stabilizes quenches.





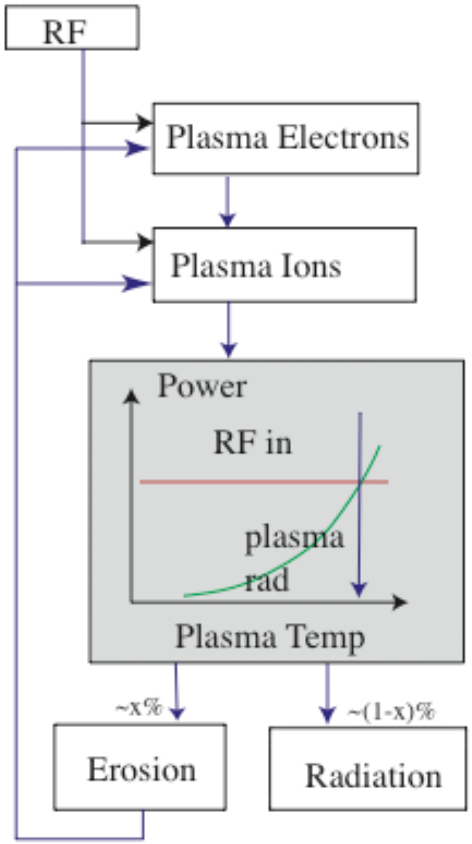
- Can one design materials that can't fail in these ways?

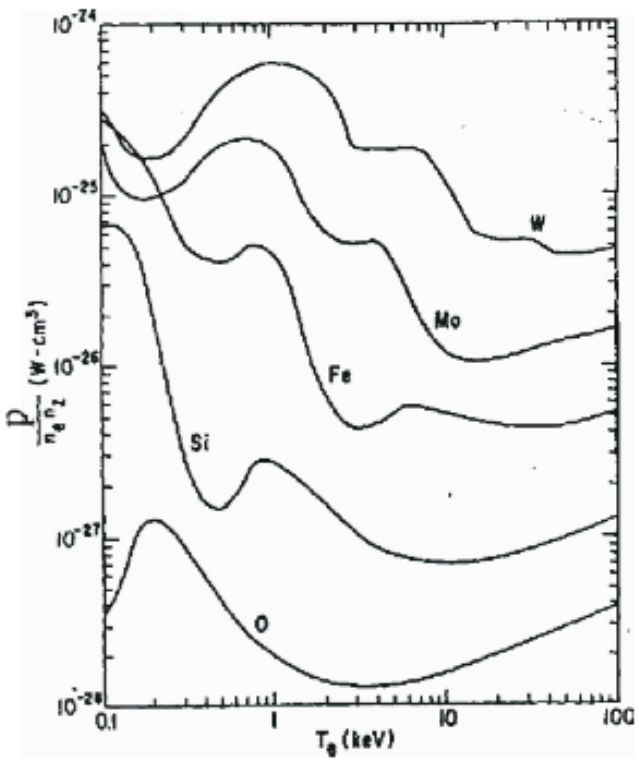
8) The plasma physics of the discharge has not been explored.

- In a dense, metallic plasma, recombination radiation (called impurity radiation in the fusion community) seems to be the dominant effect & is not well understood.

- Arcs happen fast, and ions don't drift far ⇒ very dense plasmas

- An effort to understand arcs is underway with Tech-X





Summary

- Accelerator science needs to understand rf gradient limits.
- I think the program centered at SLAC is starting in the wrong place and going in the wrong direction.
- Unlike engineering development, a research program will have little momentum, and primarily requires people interested in understanding many mangy issues.
- SCRF, High Pressure, Magnetic fields, Vacuum, High and low f are all part of the same field.