Recent Progress in RF

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RF in MICE is central and crucial
MICE is Approved, Funded* and construction is underway.

- Weak links: 1) We need to reach full E field with 5 T solenoid.
  2) We need low backgrounds in spectrometers.

*not fully
High Gradients in Cavities

- Failure of atomic bonds in metal
- Failure at defects
- Failure of large, dirty samples

Graph showing the relationship between frequency and gradient, with key points labeled for Field Evaporation, Local E field, DC limit, and enhancement factor, $\beta$. Points are marked for different projects and experiments, including SCRF, KEK, NLC, CLIC, RF surface, and Kilpatrick limit.
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
  Prof. David Seidman, Jason Sebastian (Northwestern)
  P. Bauer, C. Boffo (FNAL)

**Modeling**

- **Model breakdown process, at Argonne.**
Magnetic field data is consistent with $J \times B$ effects.

- $j \times B$ forces are driven by field emission currents in the emitter.
Muon Test Area: RF Tests

- Cabling is almost complete.
- Tests of 805 and 201 MHz windows
  magnetic field effects
  coatings, high pressure
The LEAP Microscope
Imago Scientific Instruments

Imago LEAP Microscope
Evaporation fields: 10 - 50 GV/m
Pulse rate: 200 kHz
Data rate: 20 kHz
Field of view < 100 nm
Atom Probe: Coating Tests

Typical experimental sequence (simplified)

1. Move tip into main chamber
2. Develop tip to smooth end-form via field-evaporation
   - Positive high voltage
3. Measure I-E response (field-emission; Fowler-Nordheim plot)
   - Negative high voltage
4. Move tip into evaporation ante-chamber
5. Evaporate onto developed tip surface
   - Other tip treatments
6. Move tip back into main chamber
7. Re-measure I-E response (field-emission; Fowler-Nordheim plot)
   - Negative high voltage
8. Remove coating via field evaporation
   - Positive high voltage
   - Information about coating adhesion, bonding, interdiffusion, etc.
Atom Probe Data: Fluorine Contamination on Niobium

- Ions are identified by time of flight (over ~10 cm).

w/ P. Bauer, C. Boffo, FNAL
Atom Probe Data: Room Temp. Cu

(Very preliminary)

- We see discontinuities. Are these breakdown triggers?
More Data: Are these Breakdown Triggers?
Summary

• We are getting atom probe data relevant to:
  Breakdown
  Surface microstructure
  Surface contamination (oxides etc.)

• We see “flashes” at about the surface fields we might expect rf breakdown.

• After the surface “cleans up”, the tips support much higher fields.

• We don’t understand all of this yet.