High Gradients

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A: High Gradients: CLIC, Muons and the ILC

- The same physical mechanisms limit CLIC, ILC and Muon options.

- These mechanisms are not well studied or well understood.
Gradient limits in SCRF and NC: Similarities and differences.

Normal conductors

- Fracture determines gradients
- Power thru field emission
- Copper fractures @ ~8 GV/m
- Copper is pure, ~monolayer oxide
- \( s_2(\beta) \) (secondary dist.) gives limits

Superconducting rf

- Field emission determines gradients
- Stopped by FE at 4 GV/m
- Nb fractures @ ~14 GV/m when cold
- Contamination particles, oxides ??
- Initial conditions \( s_1(\beta) \) give limit
- Field emission limit can be moved.
We have a number of solutions to these problems.

- We hosted a SCRF materials at Argonne to discuss these options.
  
  Atomic Layer Deposition (ALD)
  
  Control of field emission
  
  Gas Cluster Ion Beams (GCIB)
  
  Understanding field emission
    - Common problem with CLIC, Muons, proton driver etc.
B: Conditioning with magnetic field in the MTA

- The pillbox cavity cannot reach high electric fields with magnetic field.

- The open cell cavity and high pressure cavity both could.

- Look at radiation data from chipmunk 46 during conditioning with B.
We ran for about two weeks with magnetic field.
Comparing fields that produced 1 mr/hr.

calibration: 34.5 MV/m – 1 V
How long should conditioning take?

- Lab G open cell (from new)

- Nitrogen conditioning of a damaged cavity

- Timescales of \( \sim (\Delta E/E = 10\%) / \text{ (weeks)} \)
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
What’s happening?

• When E is parallel to B, the plasma is confined, making things worse.

  We are trying to run OOPIC to describe what happens to arcs in magnetic fields. So far this is all speculation.

• The pillbox is unique in that this condition exists over a very wide area.

  The MICE experiment has E not parallel to B in the cavities, but we don’t understand enough about the 201 operation to say anything.

  Only small % areas in the open cell or high pressure cell had E parallel to B.

• What happen when E is not parallel to B?

  We should try one coil operation

• At this point the pillbox is highly damaged and it may take extensive conditioning to significantly improve operation.
C: Modeling Breakdown with B Field

- Two effects:
  - Magnetic Confinement of Plasma
  - Impurity radiation from plasmas

Ion Larmor radii ~ few mm
Ion-Ion collision time
LTE, ambipolar diffusion
cross field drifts

\[ 10^{17} \text{ cm}^3 \text{ produces } 27 \text{ GW/cm}^3 \]
EM energy gets coupled to the wall

- Need plasma code to sort this out, OOPIC has been recommended.