Comparing Open-Cell, Pillbox and Muons Inc. Data

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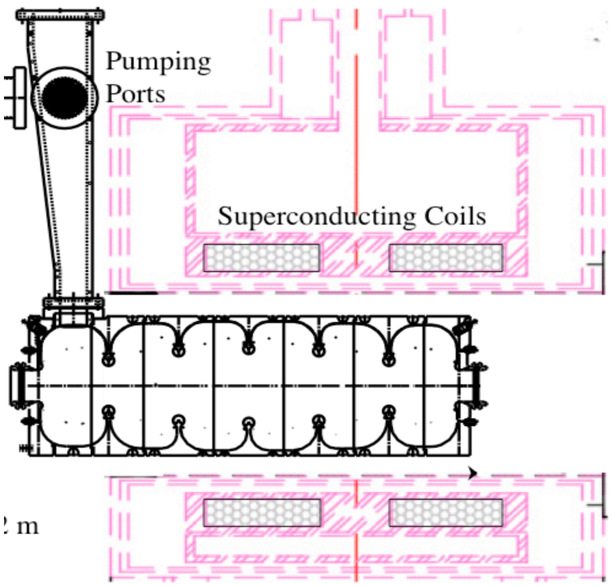
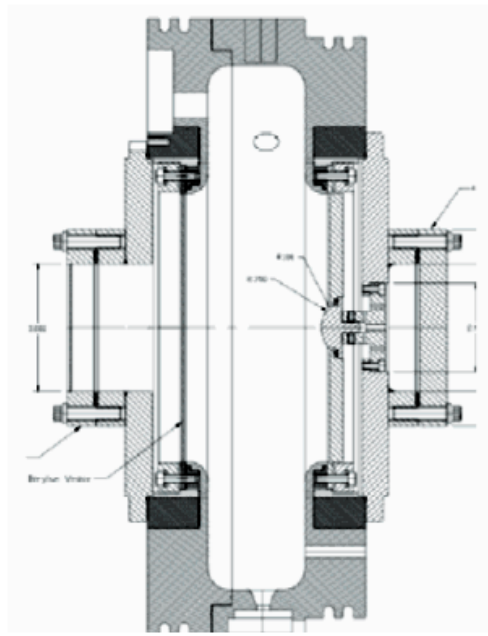
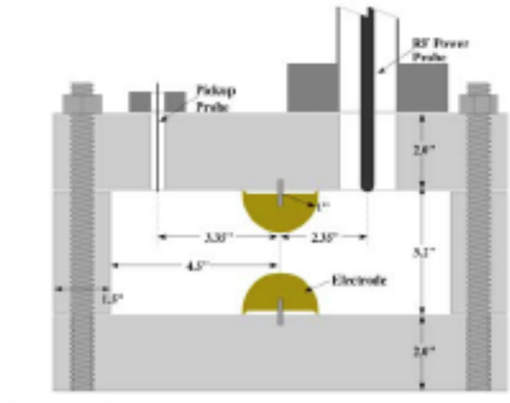
How do the Open-Cell, Pillbox and Muons Inc. data compare?

Open Cell Cavity	Pillbox Cavity	Muons Inc.
7/01 - 12/01	1/02 – present	11/03 - present







There are some inconsistencies in the results

Magnetic field:

High pressure gas:

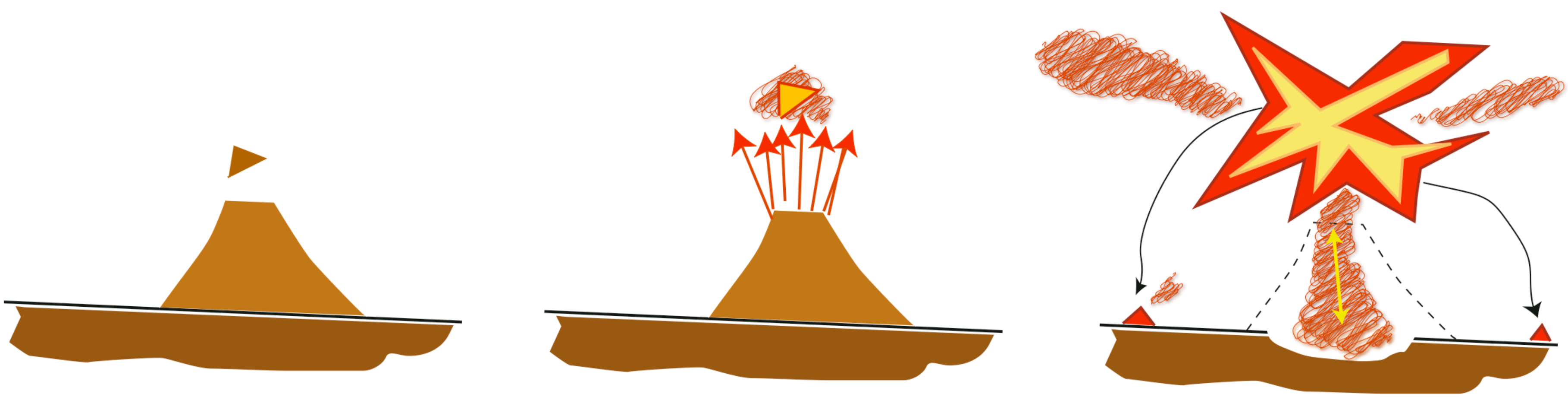
We use the electric stress model.

- Breakdown involves three processes:

  1) Fracture
     dominated by material tensile strength

  2) Field emission heating
     Gas can snub breakdown

  3) Discharge of energy in cavity
     related to stored energy and surface area

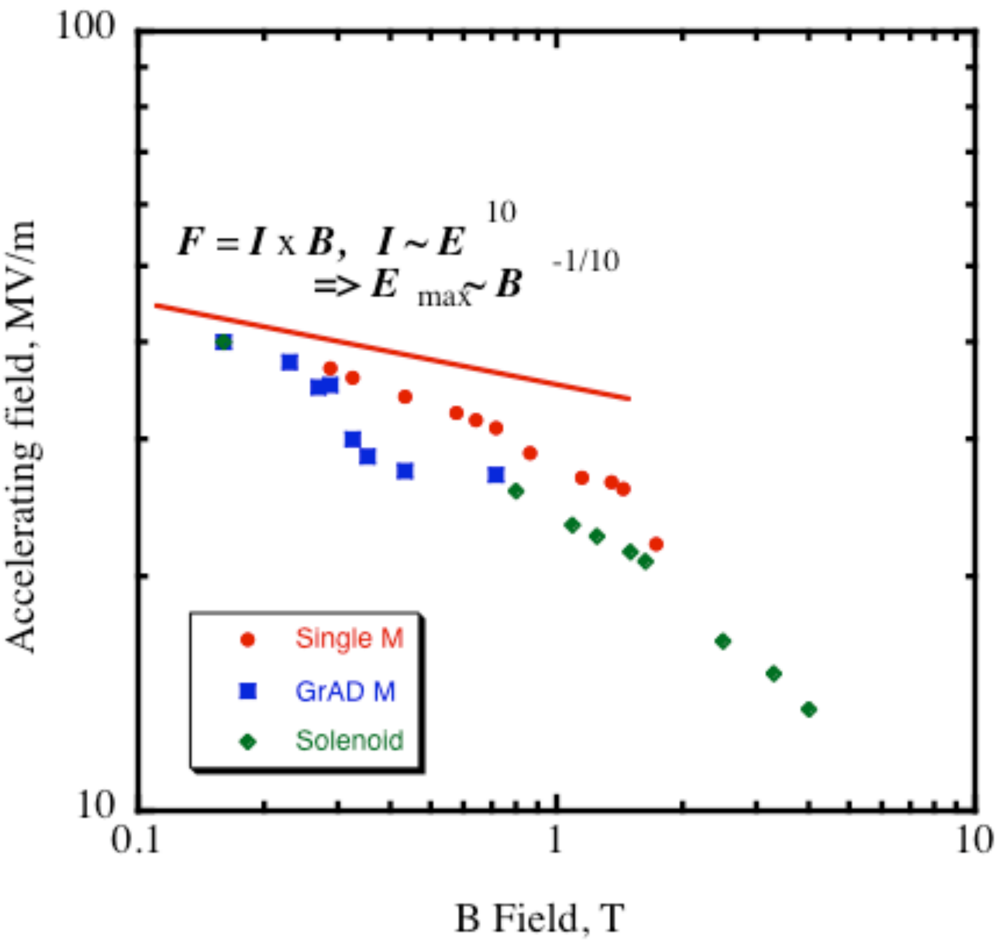


Fracture | Field emission heating | Discharge

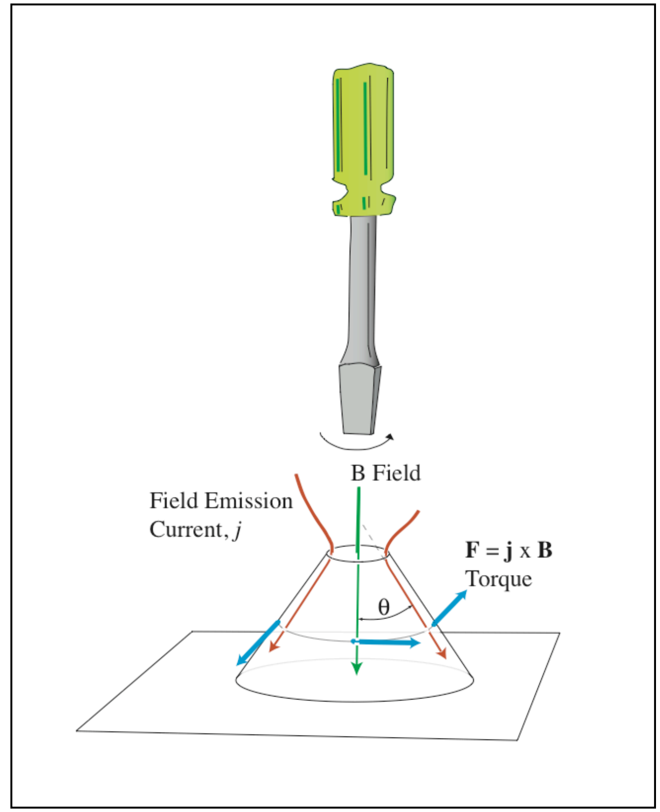
The Pillbox data seemed to imply j x B forces.

- ***j*** x ***B*** forces are driven by field emission currents <u>in</u> the emitter.

Pillbox data



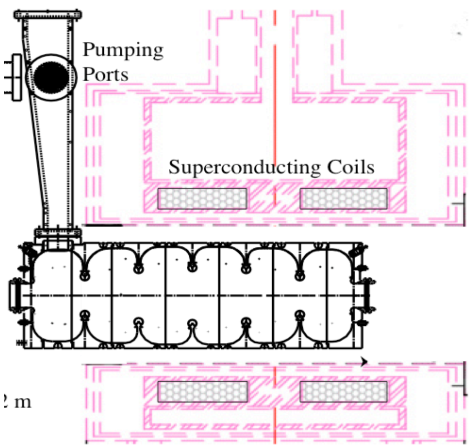
The model

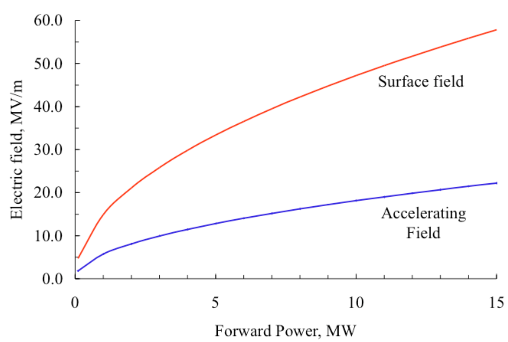


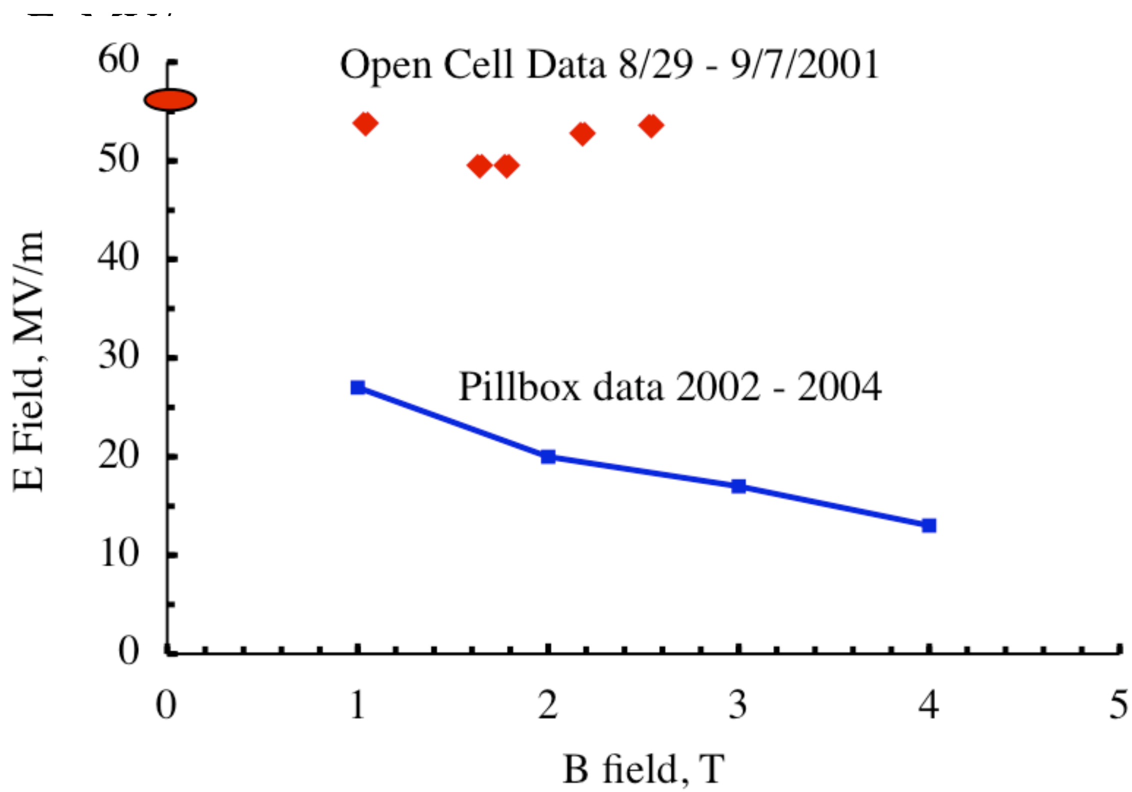
The open cell data from 2001 (with B field) did not.

- The first results with B field:
  Conditioning **with** B field required as much time as conditioning **without** field.
  We saw higher radiation levels.

- The radiation levels were hard to measure – our primary worry.







Why don't the Pillbox and Open-Cell Data Agree?

- The geometry is different.
  Comparatively small fraction of internal area at high E fields in open-cell.

- The pillbox surfaces are more damaged.
  Repeated scotchbrite treatments?

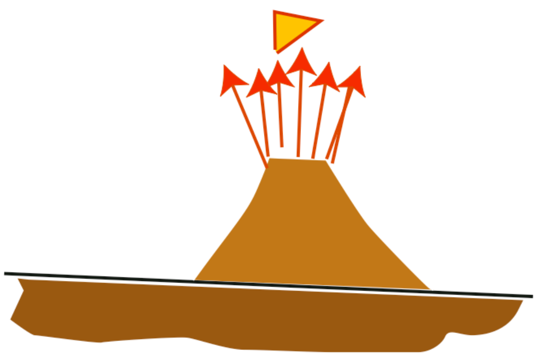
- The electric and magnetic fields are parallel.
  Magnetic confinement of discharge between parallel, high surface fields

- Conditioning was not as thorough for the pillbox data.

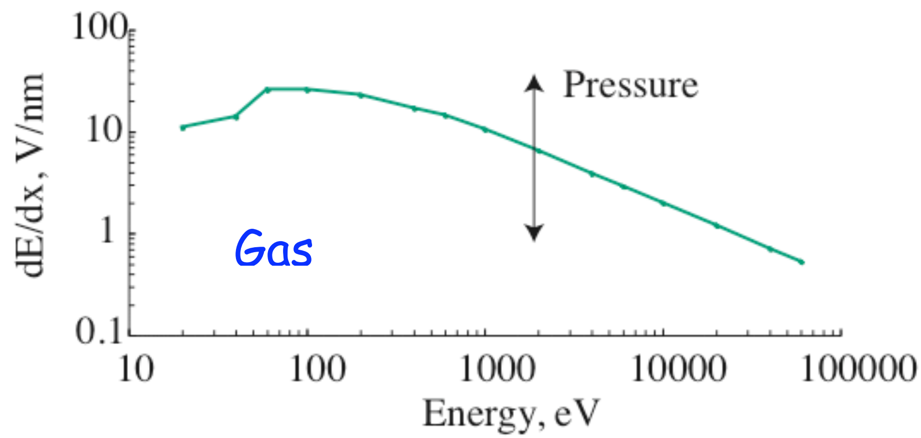
- Open cell fields were overestimated because of dark current power losses.

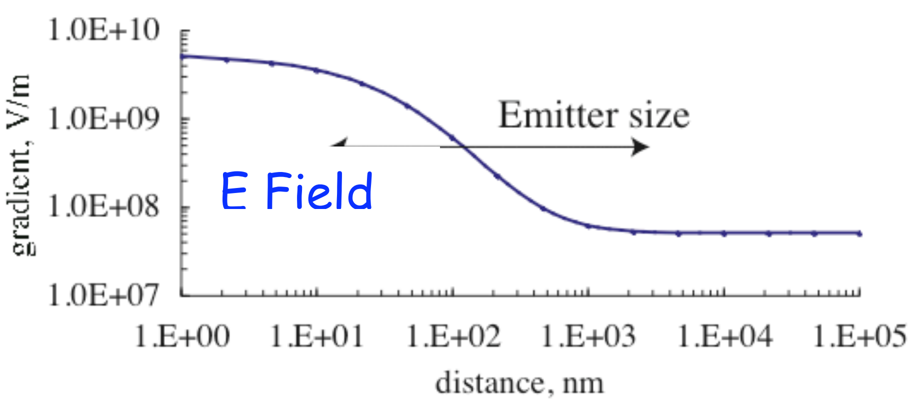
High Gas Pressure data are controversial.

- Gas can suppress BD by stopping Field Emission heating.
  Paschen breakdown occurs when electron friction is insufficient.
  Pressure and type: H_2, SF_6
- Larger emitter ➔ field goes farther
- $E_{electron} = \int (acc - loss)\, dx$,
  Electric fields accelerate e^-.
  Gas slows down e^-



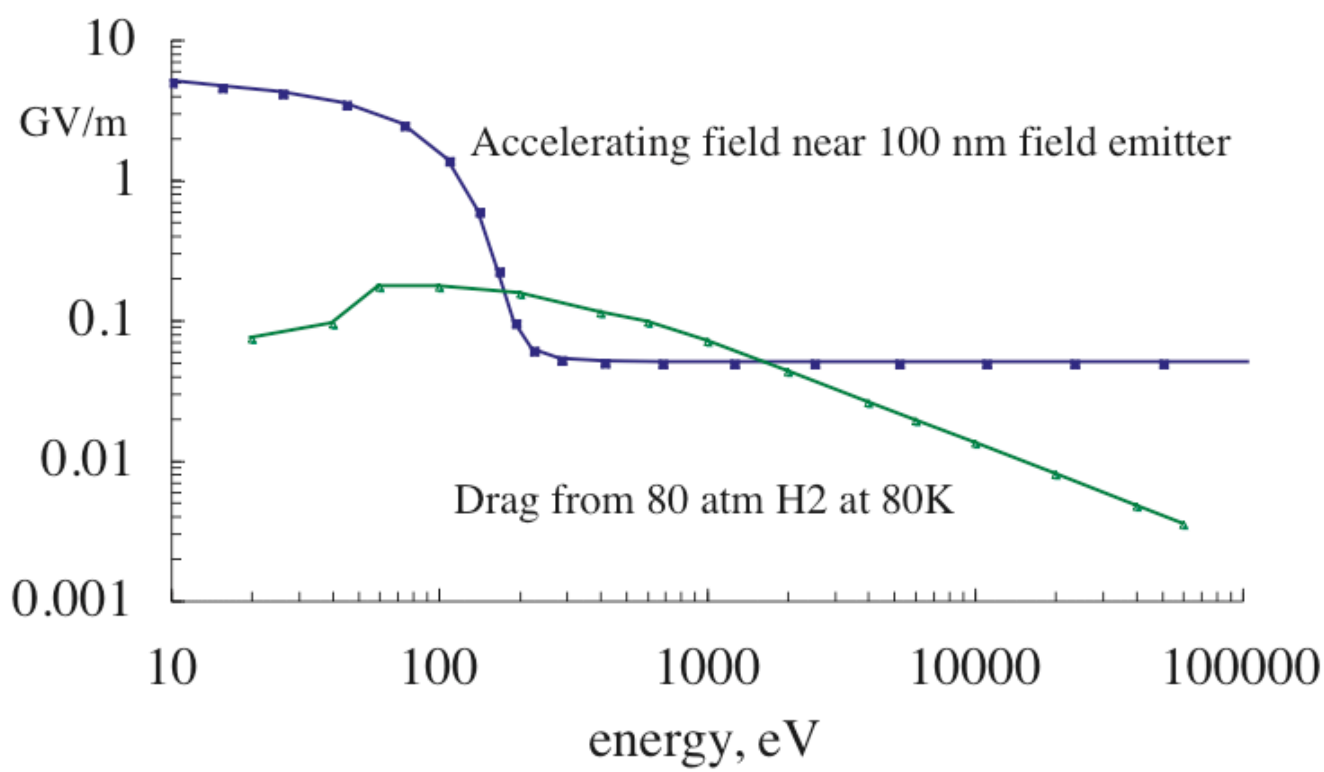
Field emission heating





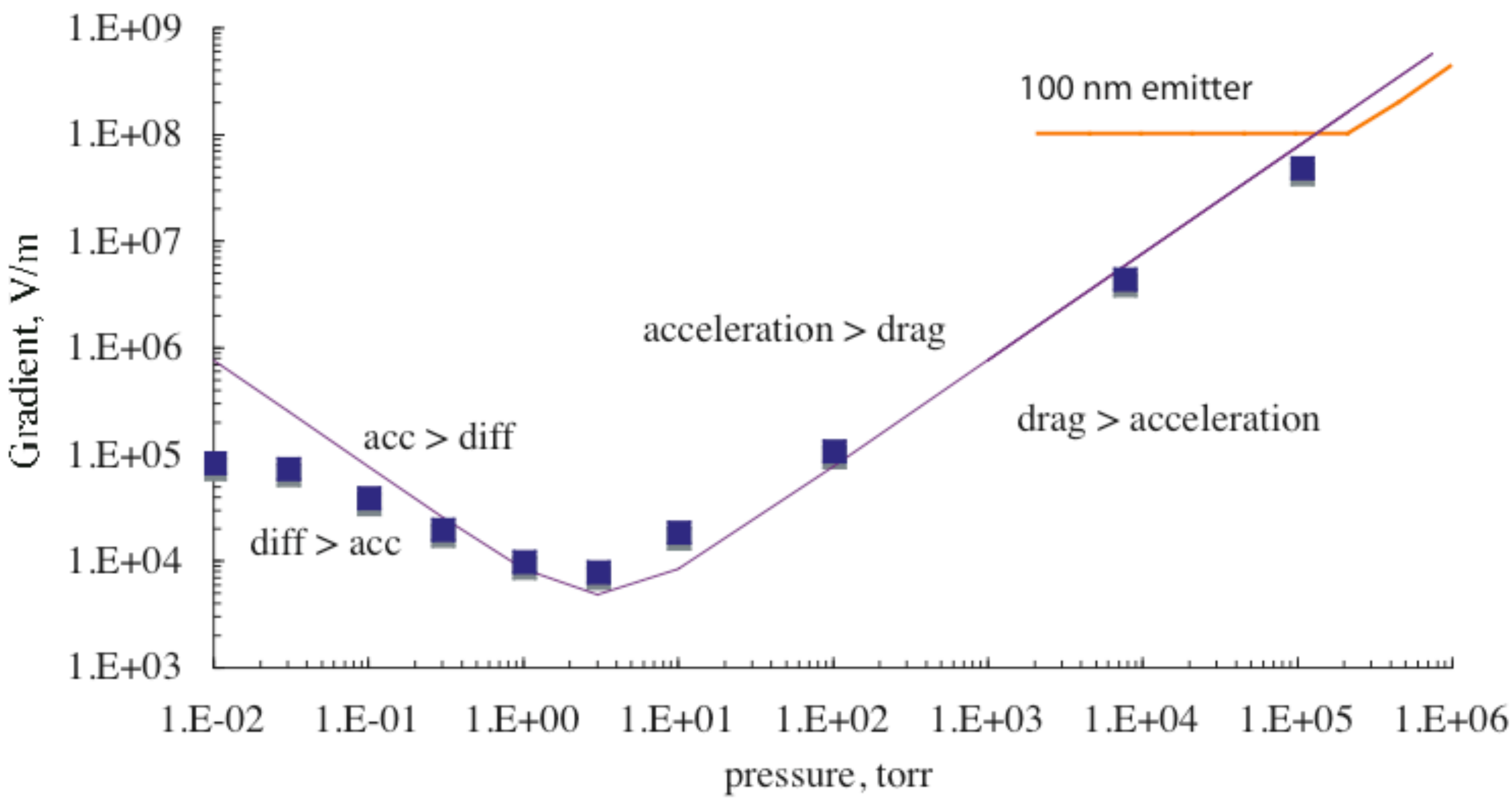
The results depend on pressure and emitter size.

- Field emitted electrons are a hot, intense beam
- Drag can slow them down eventually.
- Paschen's Law governs breakdown of gas (at ~0 energy).



Paschen's Law (with surfaces)

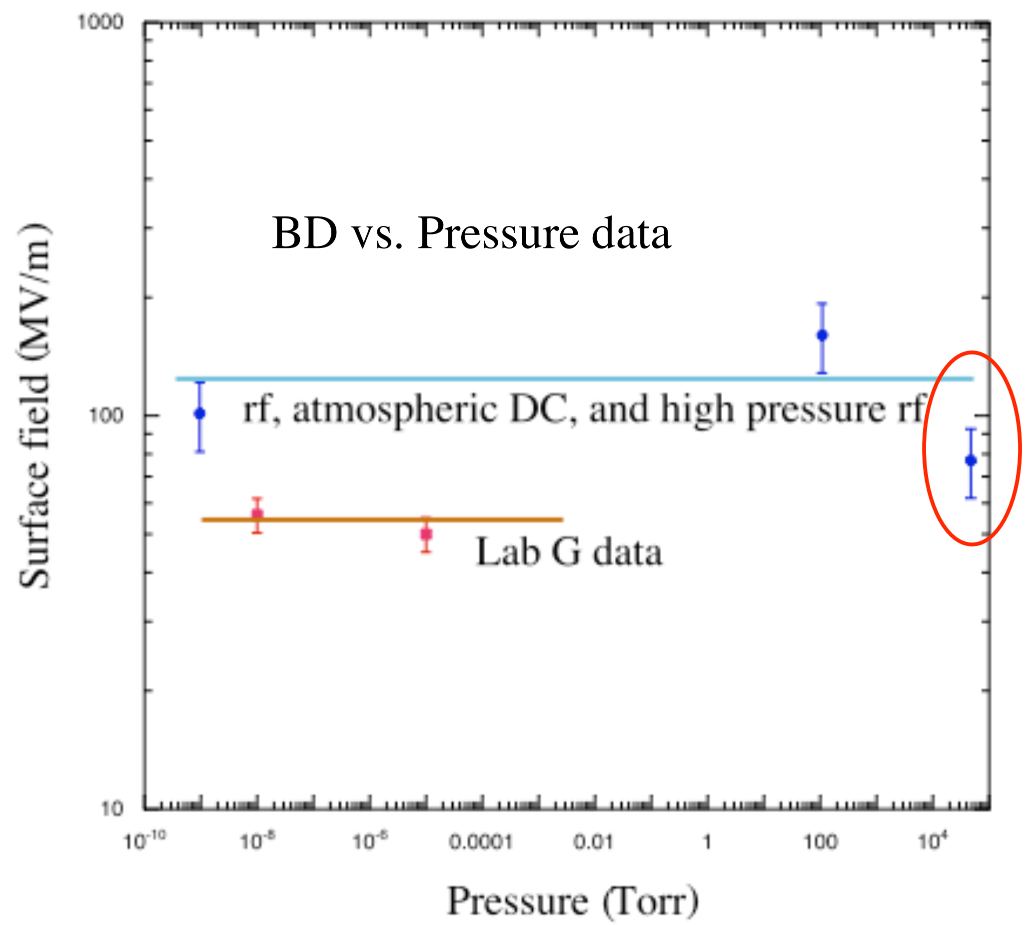
- Gas variables
  - Electric field / pressure
  - Transverse size of tube
- Surface variables
  - Size of asperity
  - Pressure and type of gas



High Pressure Results

- Open Cell
  Conditioning with high pressure (10^{-5}) N_2 went OK.

- Muons Inc.
  High Pressure data obtained with W electrodes
  Little degredation with B field.
  Cavity conditions faster.
    Small asperities suppressed ?



Conclusions

- The Muons Inc. data with magnetic field is consistent with old, open cell data.

  Both structures produced >50 MV/m surface fields

    Tungsten surfaces expected to be better than copper.

  Somewhat similar geometries, (high fields on small fraction of interior)

- Pillbox data seems to have anomalous magnetic field dependence.

  Could be due to

    cavity geometry

    E and B parallel

    surface damage etc

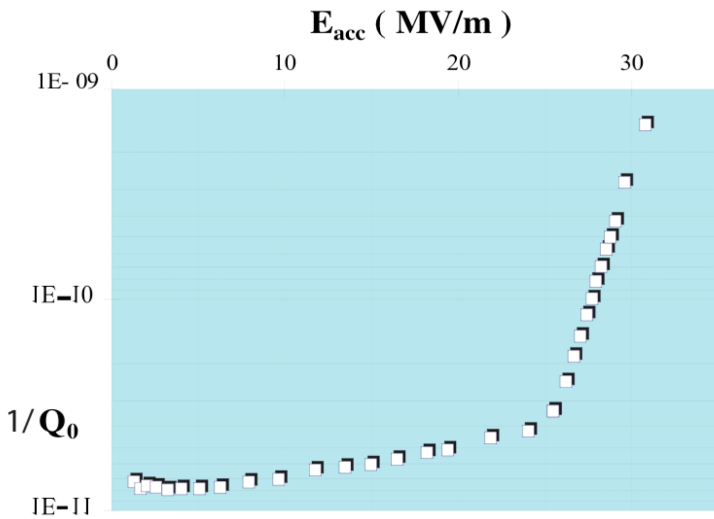
    Conditioning

      ? ?

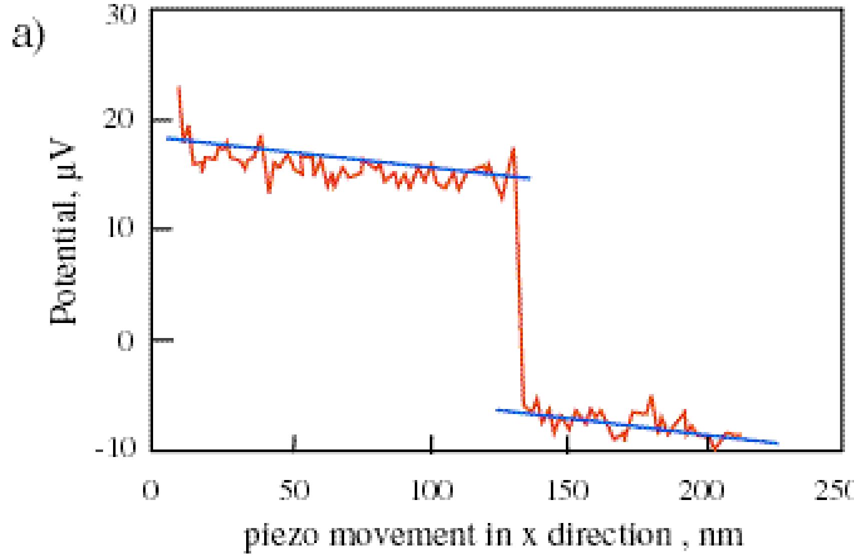
- Improvements due to High Pressure gas are somewhat controversial.

P.S., Q slope in SCRF

Q slope = field emission between grains?



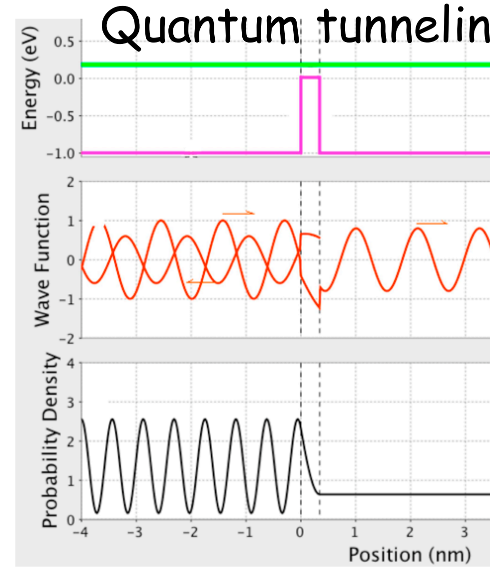
Fermi level at grain Boundaries



Superconducting losses ∝ normal conductivity

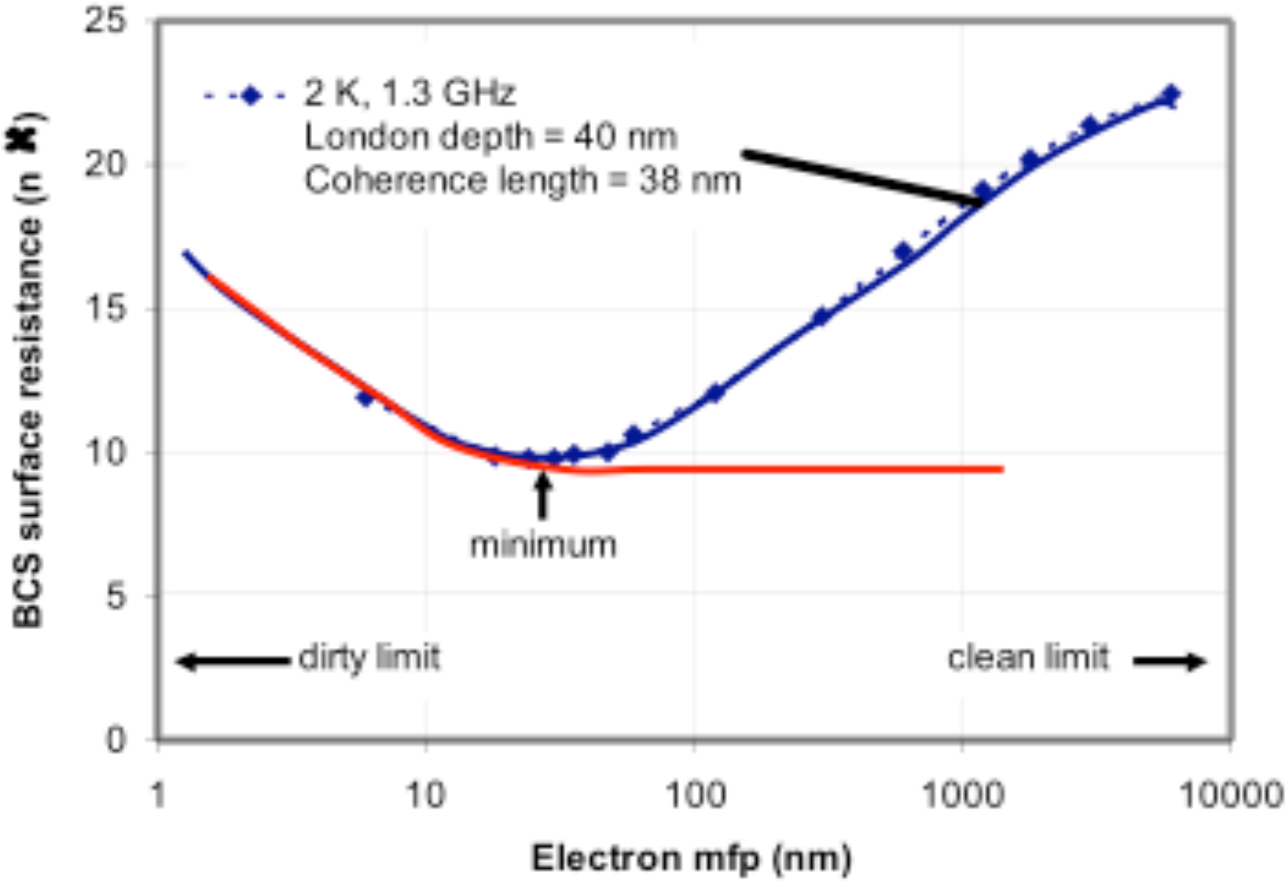
$$R_s = \frac{3\mu_0^2 \lambda^3 \Delta}{2k_B T} \sigma_{eff} \omega^2 e^{-\Delta/(k_B T)} \left[\ln \frac{1.2 k_B T \Delta \xi^2}{\hbar^2 \omega^2 \lambda^2} \right]$$

Quantum tunneling



This idea is not inconsistent with data.

- Sensitive to low temp bake, insensitive to exposure to air, no X radiation



- We are checking with experts. There aren't many.

- ANL materials scientists may be interested in pursuing this.