

# Beam Induced Gas Breakdown

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MCTF meeting  
Fermilab  
March 8, '07



## High pressure cavities

- High pressure gas cavities have different problems than vacuum cavities.
- Both the gas and the surface can break down.
  - Surface breakdown behavior seems better
  - Beam/gas induced breakdown and loading may be a serious problem
- How do vacuum and gas filled cavities compare?

## We expect vacuum cavities will be lightly loaded.

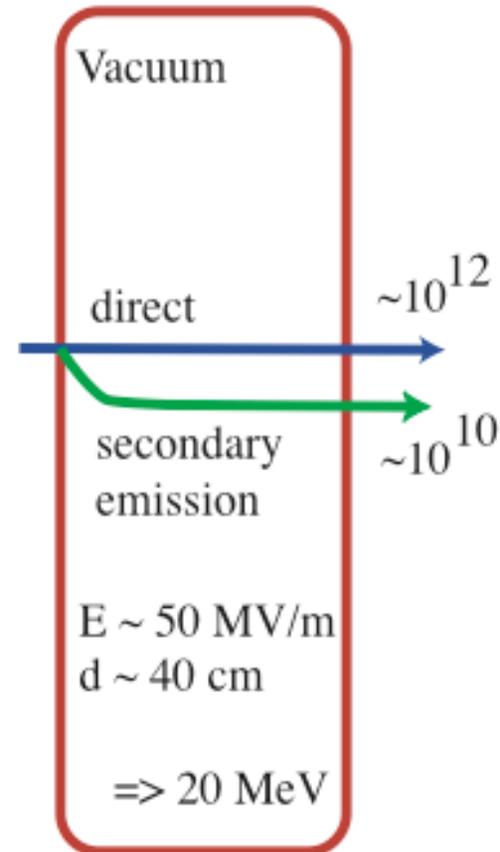
- Perhaps  $10^{12}$  muons, some electrons, K's, protons pass through.
- Secondary emission does not contribute.
- At 50 MV/m,  $10^{12}$  particles remove  $\sim 0.6\%$  of the stored energy/pulse.

$1.5 \times 10^{14}$  would remove all the energy.

lower gradients  $\Leftrightarrow$  more % loading

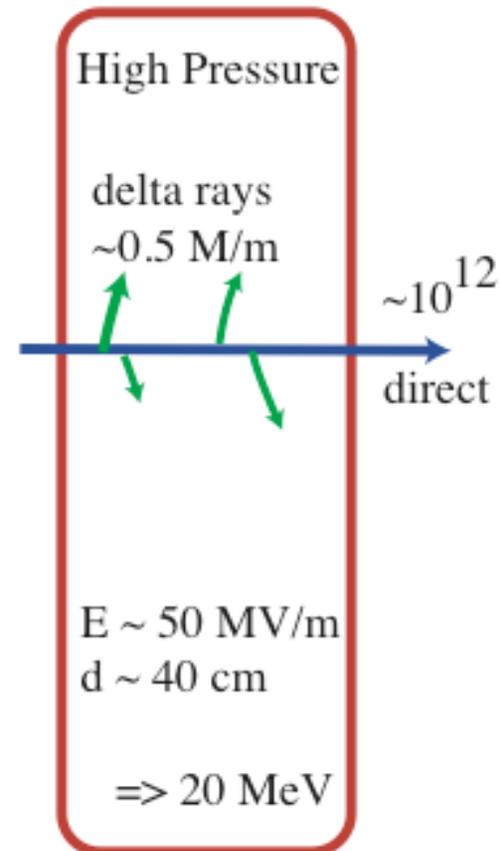
$$U \sim E^2$$

$$dE \sim E.$$



## High pressure gas produces many secondaries.

- At  $0.05 \text{ g/cm}^3$ ,  $\sim 1 \text{ M/m}$  secondary electrons are produced per MIP.
- While most of these will recombine, some won't.
- Two bad things can happen:
  - The beam takes all stored energy ( $\sim 10^{14}$ ).
  - The beam takes a lot of it ( $\gg 10^{12}$ ).



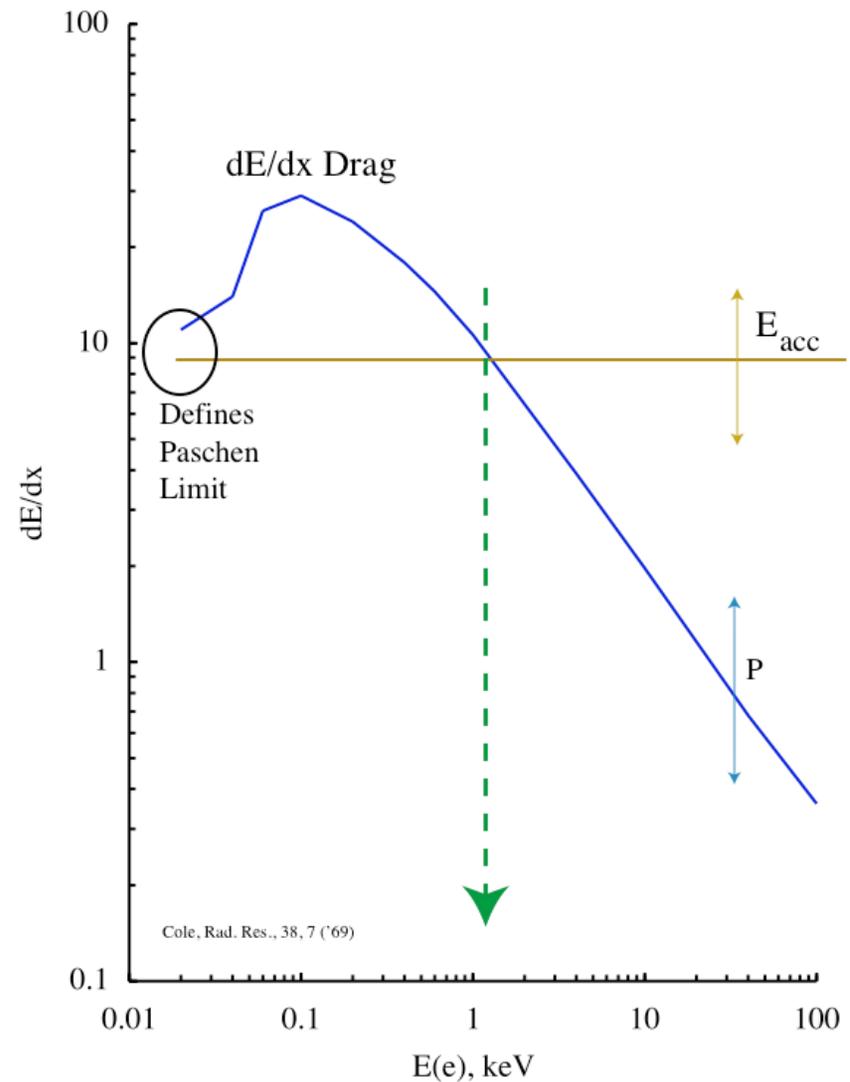
- The beam loading is position dependent.
- Loading heats the muon beam.
  - How much loading is tolerable?

# Drag and Acceleration

- Gas breakdown is a function of  $E/p$ .
- Normal avalanches have no high energy particles.
- $\delta$  rays can be quite energetic, however.

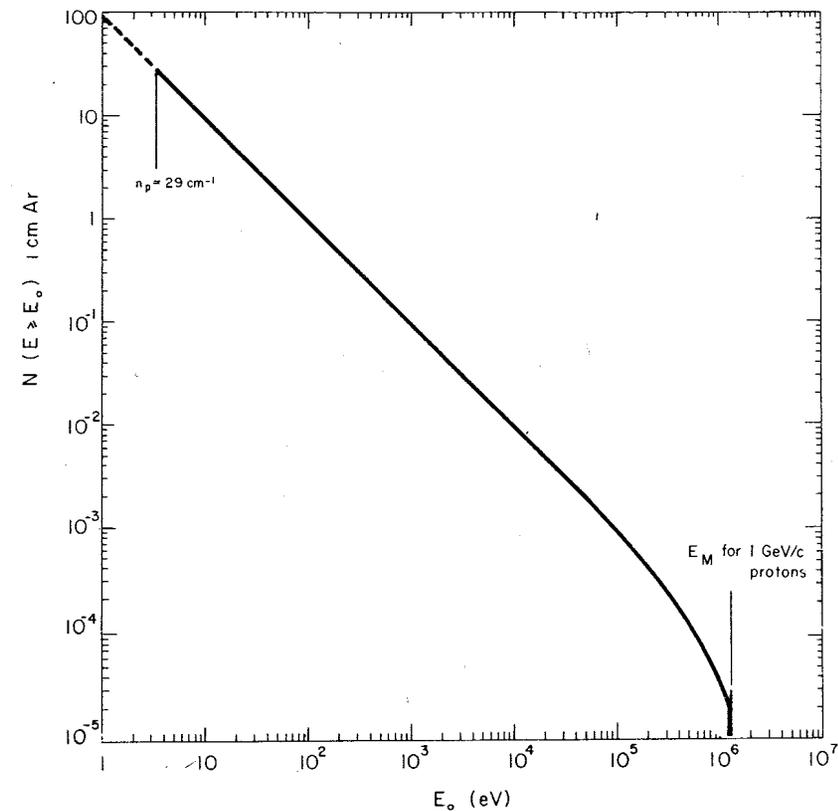
Above  $\sim 1$  keV there is little drag.

These particles may be accelerated



## This is a problem that detector designers understand.

- Sauli, CERN 77-09, gives the population of fast electrons.
- About  $10^{-3}$  delta rays have  $E > 1$  keV.



- Secondaries could short or unevenly load down the cavity.

## Summary

- High pressure cavities may be vulnerable to beam loading and discharge.
- Simple arguments show the general parameter ranges involved.
- Experimental options:
  - Intense beams thru cavities
  - Q measurements with X ray beams
- Modeling
  - G4BL
  - Loading vs. 3D bunch shape
  - Nonlinear beam loading vs. bunch heating