Progress in Understanding High Gradients

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11/4/05

A new experimental program will look at high gradient rf.

- Ron Ruth has been appointed PI, his thrust seems to be towards “CLIC”.

- Many groups involved

  Labs: ANL, LBNL, NRL, SLAC
  Univ: Md, MIT
  SBIR: Calabazas Creek Research, Tech-X, Omega-P

  Different frequencies: 11.4 GHz, 17GHz, 34 GHz, 90 GHz , Lower

  Thrust: Source development (gyrotrons, . .), Theory, Simulations, Search expts

  No agreement on what to do yet.

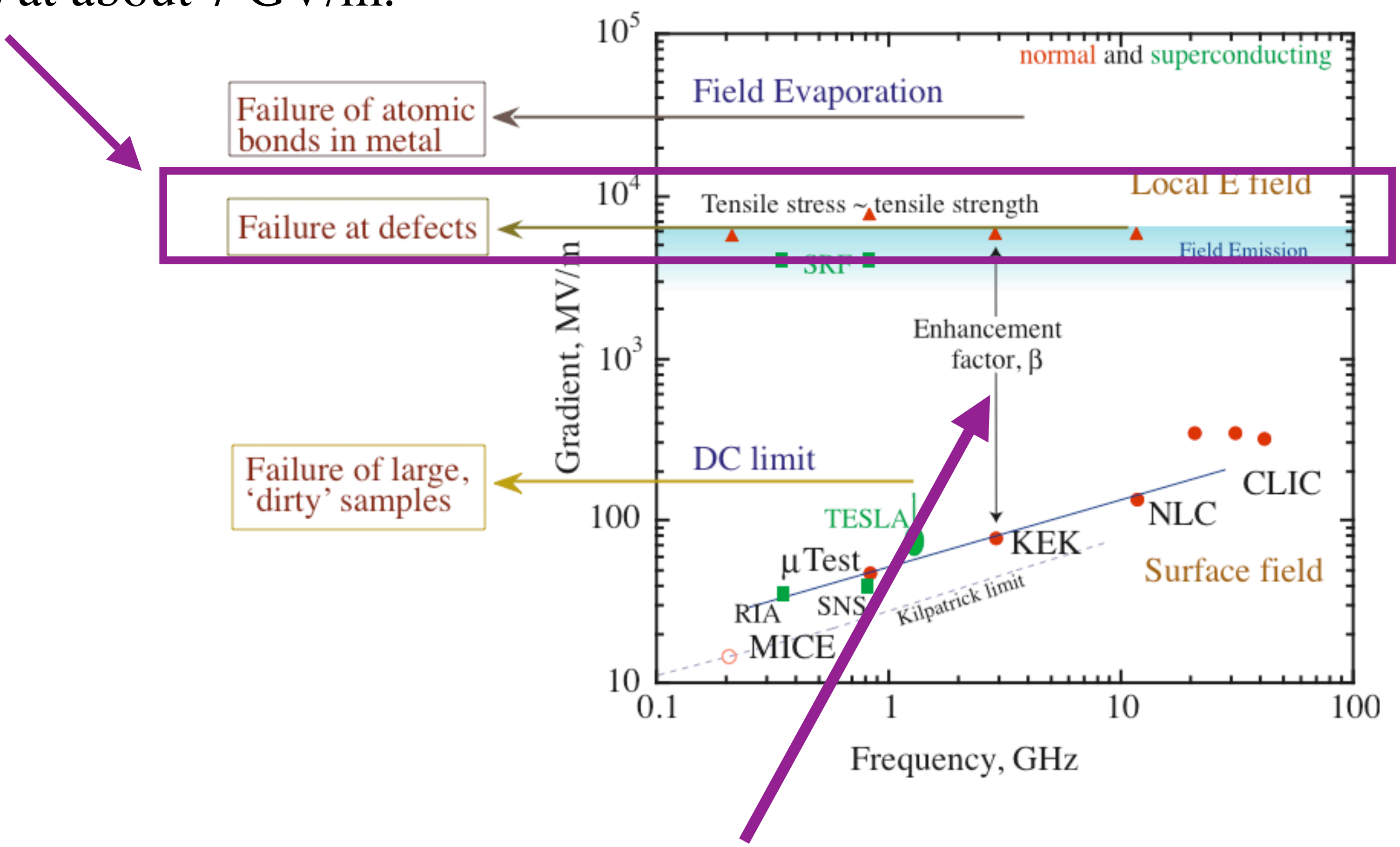
- Will these contributions be refereed separately?

- Our modeling and experimental program are almost to the point where we will be able to make predictions of all breakdown phenomena.

- MICE needs results - fast.

The Problem

- It is possible to understand the breakdown as mechanical failure that occurs on tiny emitters at about 7 GV/m.



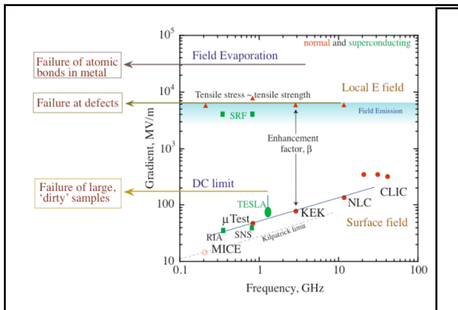
- We want to know what determines the value of β, which determines E_{acc}.

- There are lots of variables: *f*, *P*, *U*, *mat'l*, *τ*, *geom.*, *vac.*, *conditioning* . . .

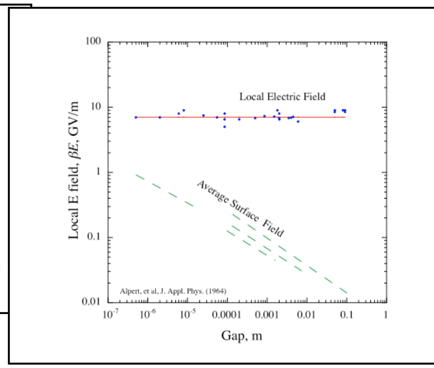
There are a number of mechanisms at work during breakdown.

- We think mechanical stress triggers breakdown events,
- Parameters that **are not** involved in breakdown triggers:

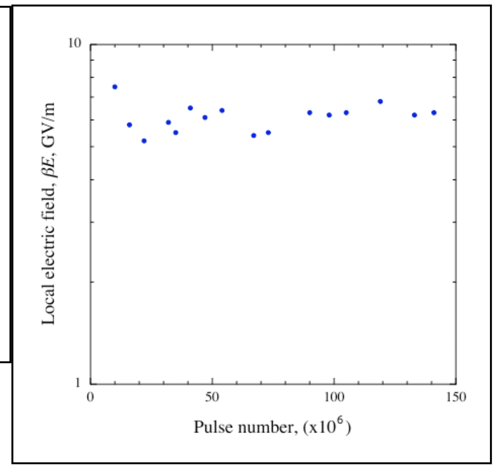
Frequency



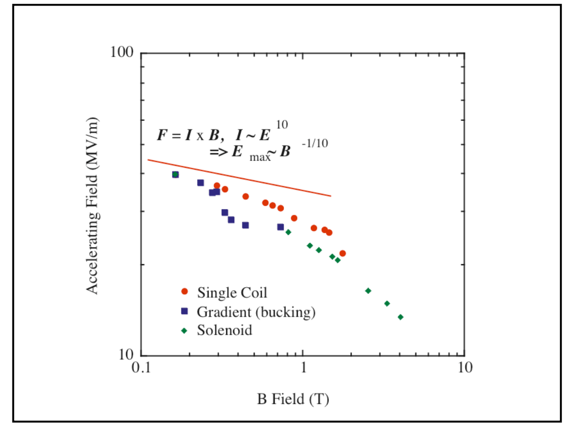
DC gap



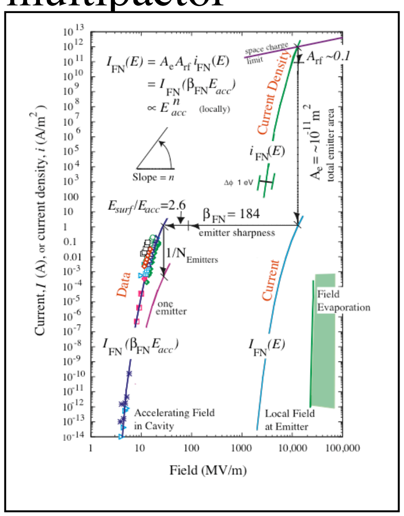
state of conditioning



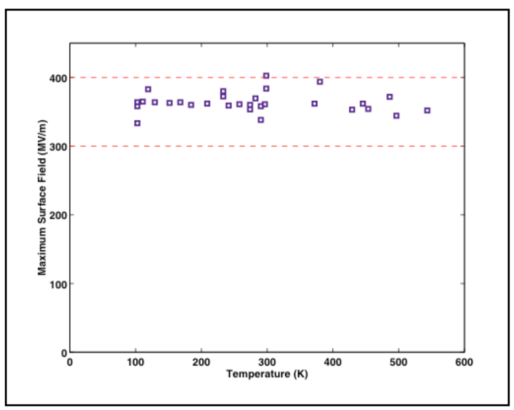
small B fields



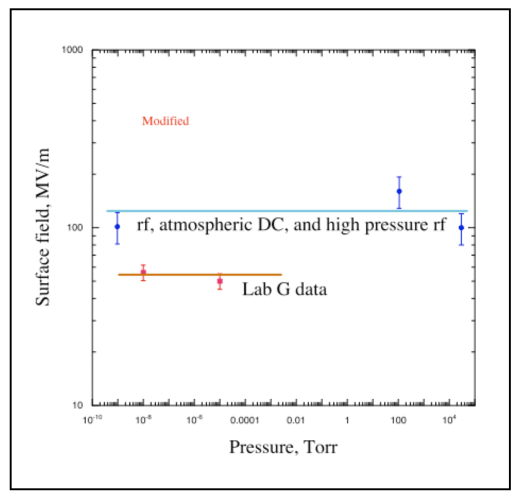
multipactor



temperature

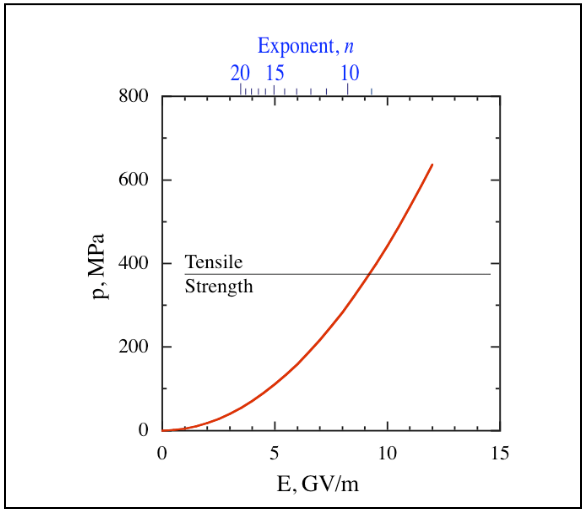


pressure*

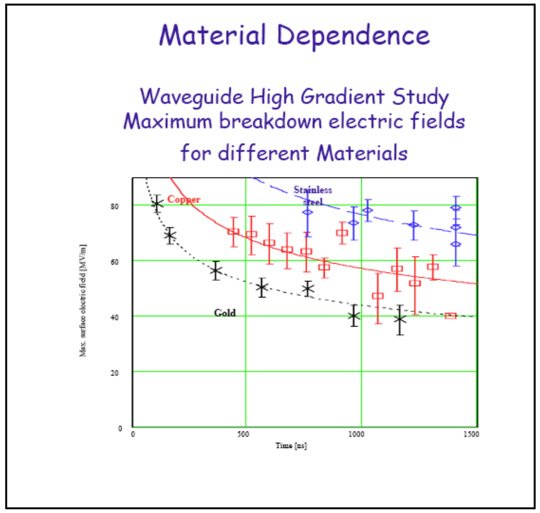


- Things that **do** matter.

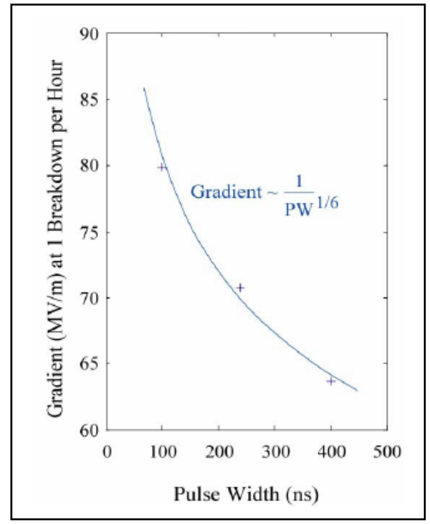
Local electric field



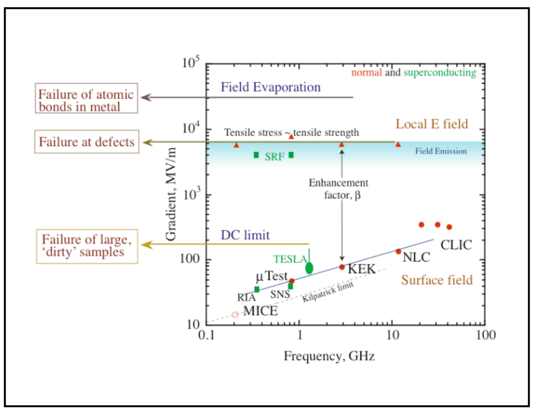
material



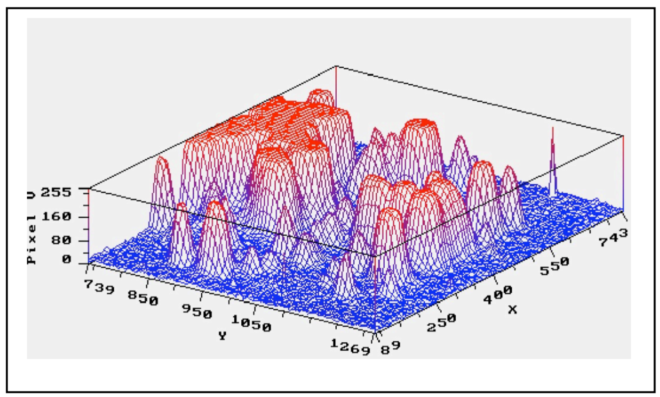
pulse length



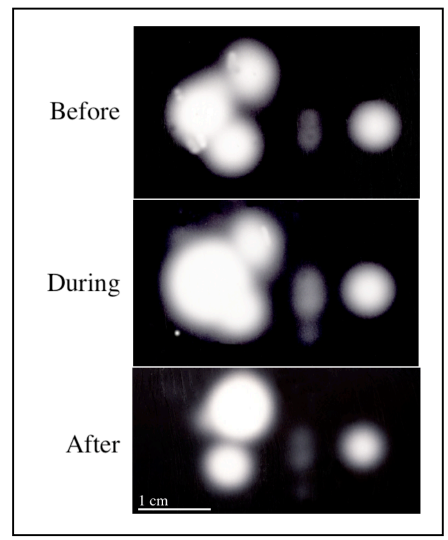
stored energy/power/geom



secondary emitters



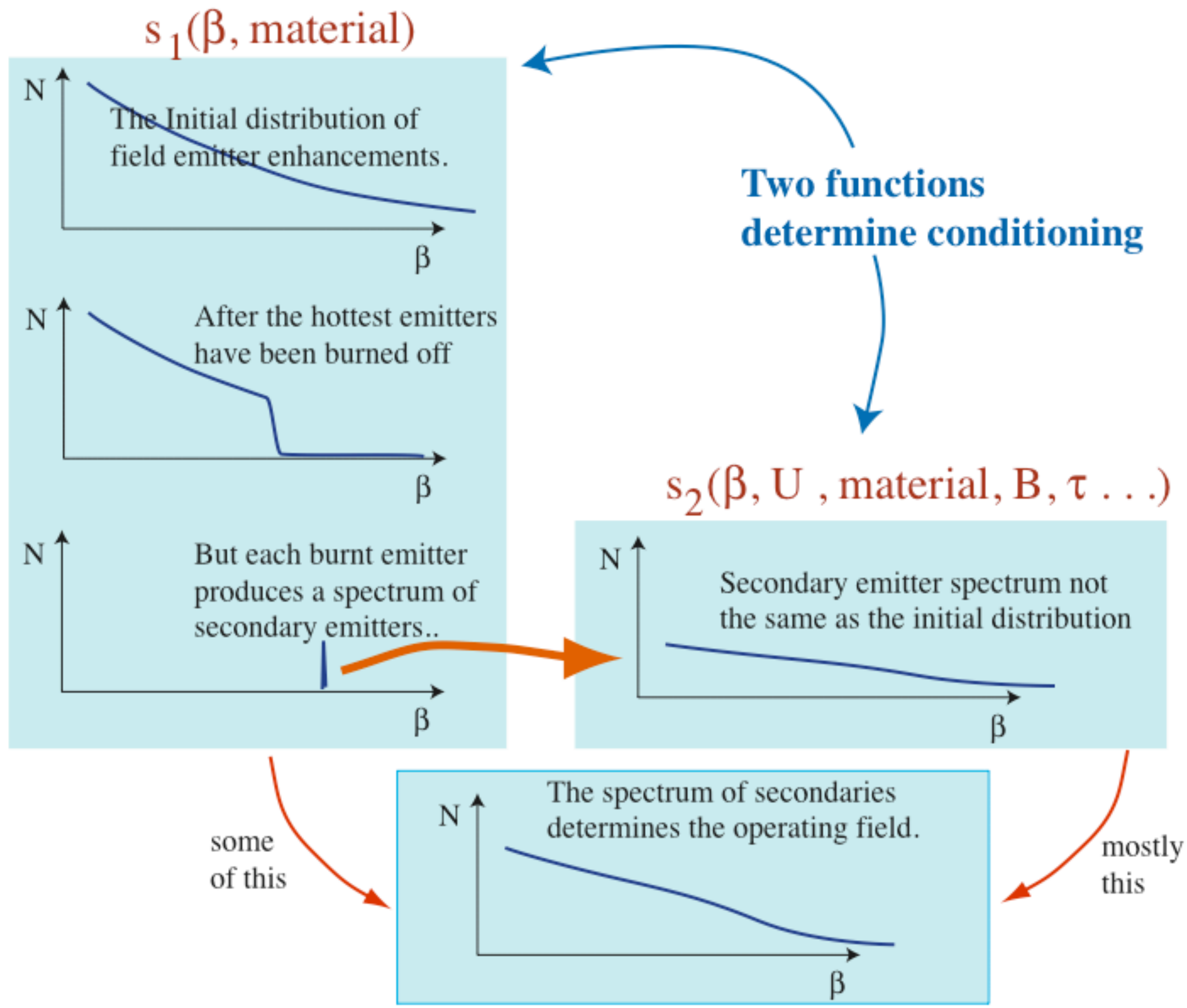
high β asperities



- Field emission is not required, but may be there at some level.

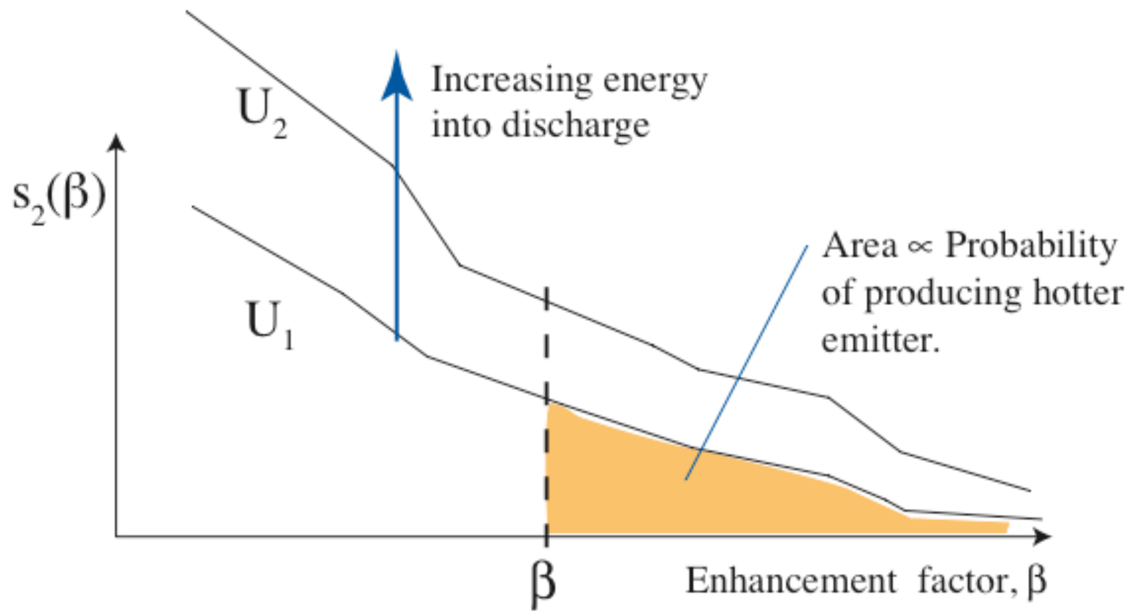
Secondary emitters seem to determine E_{max}.

- The maximum field is determined from $s_2(\beta.\ mat'l,\ \tau,\ ..)$, the spectrum of secondary emitters



Stable operation cannot generate high field enhancements.

- The cavity cannot operate at fields where a breakdown event produces higher β's than the one which was destroyed.
- Stable operation requires lower β's be produced at breakdown.
- E_{max} is defined by the constraint that the probability for producing higher β's is ~ 1.
- This is simple and reasonable.



$$\int_{\beta}^{\infty} d\beta \; s_2(\beta, material, \tau) \approx c$$

solve for β_{max},

$E_{max} = 7$ GV/m/β_{max}

The secondary emitter spectrum, $s_2(\beta)$, is not well measured.

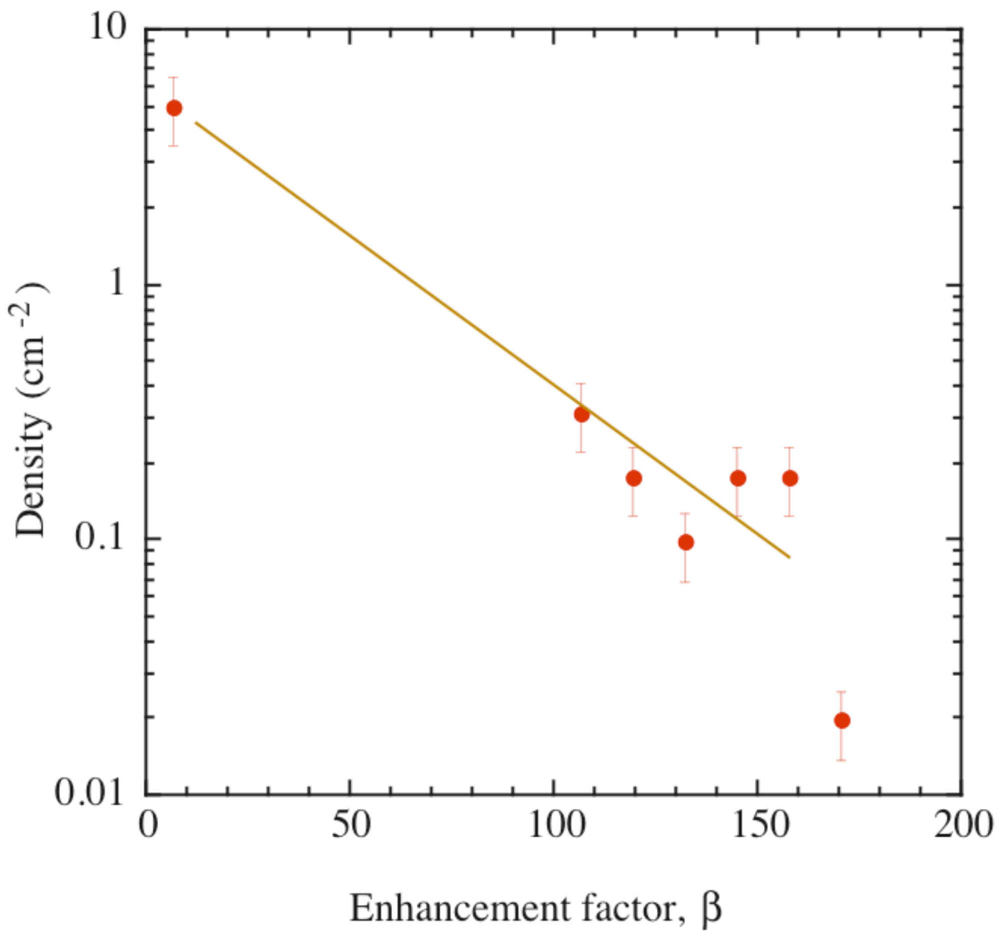
- We made the only measurement.

- Others have "sort of" measured $s_1(\beta)$

  Results don't agree
  and are badly interpreted

- This can, and should, be done better.

  .



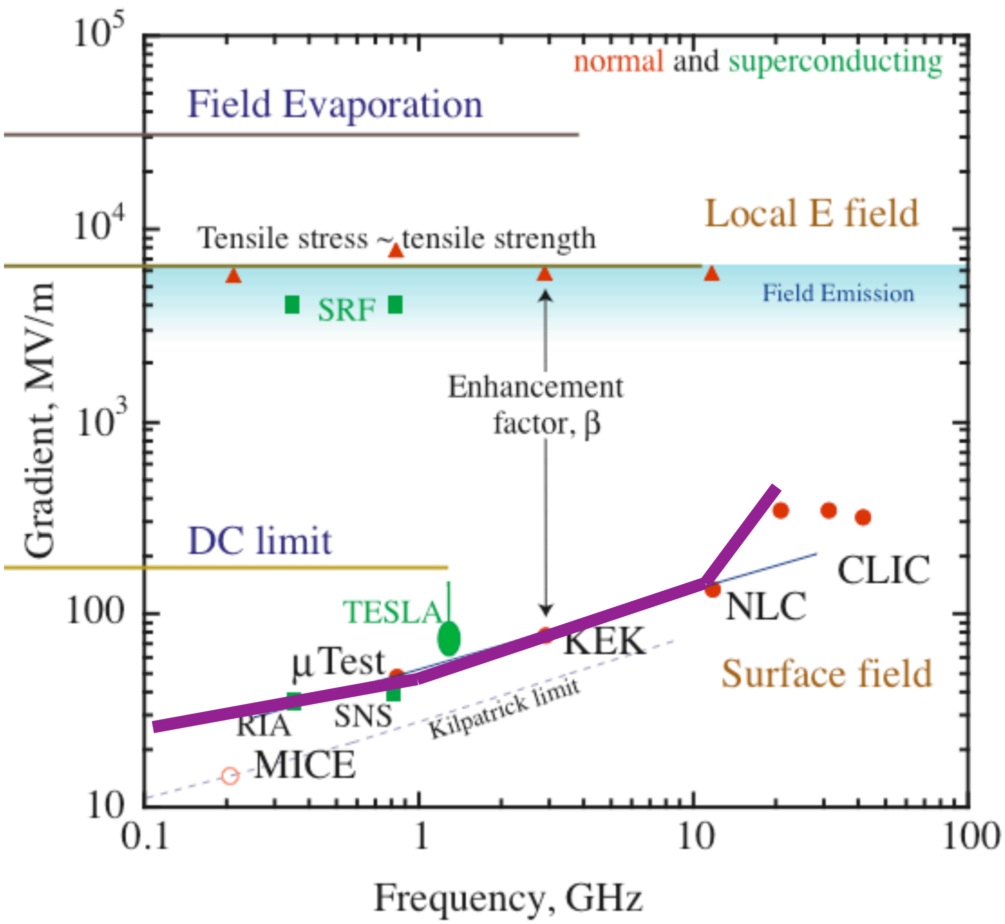
- How to parameterize $s_2(\beta)$ from the data?

  It seems factorizable.

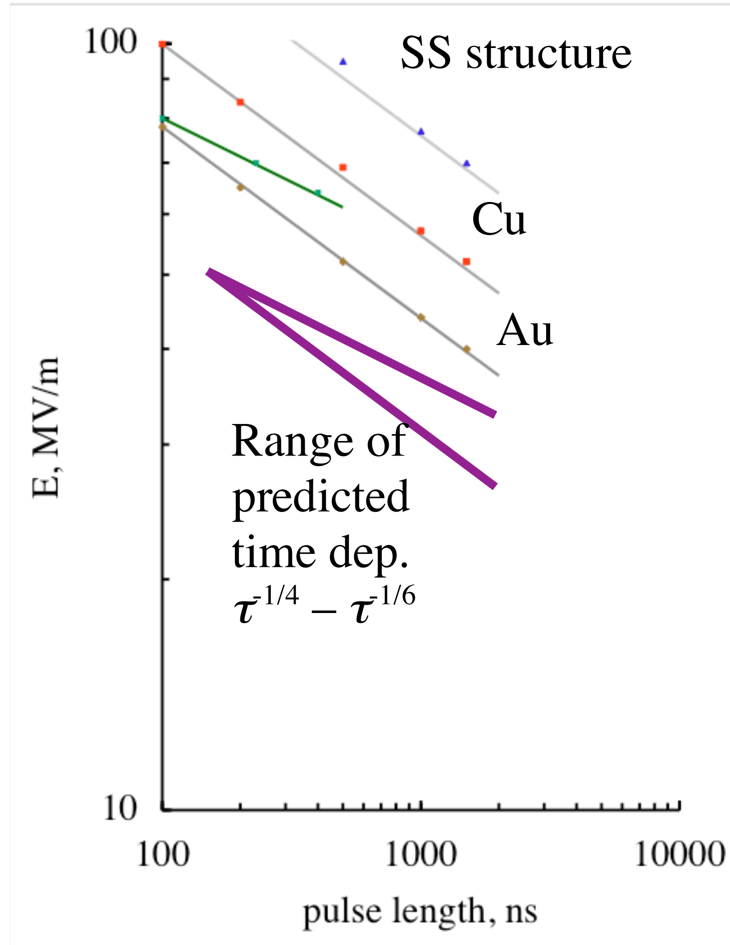
  $s_2(\beta, \tau, mat'l, U, A \ldots) = c\ \tau\ U\ A\ f(mat'l)\ s_2'(\beta \ldots)$

Simple Examples

Frequency dependence
(every cavity is different)



Pulse length dependence



- We need a variety of data to factor out the contributions of different parameters.
- Pulse length data are the easiest to understand.

Conclusions

- It seems possible to predict operating fields from secondary emitter spectra.

- A new High Gradient RF study is starting.

  The work should not get frozen into unproductive directions.

  The Muon Program can benefit from this work.

- Our low frequency cavities give essential and unique data.

- A paper is underway – needs 805 MHz data.

- A 105 year old Physics Problem solved. (?)