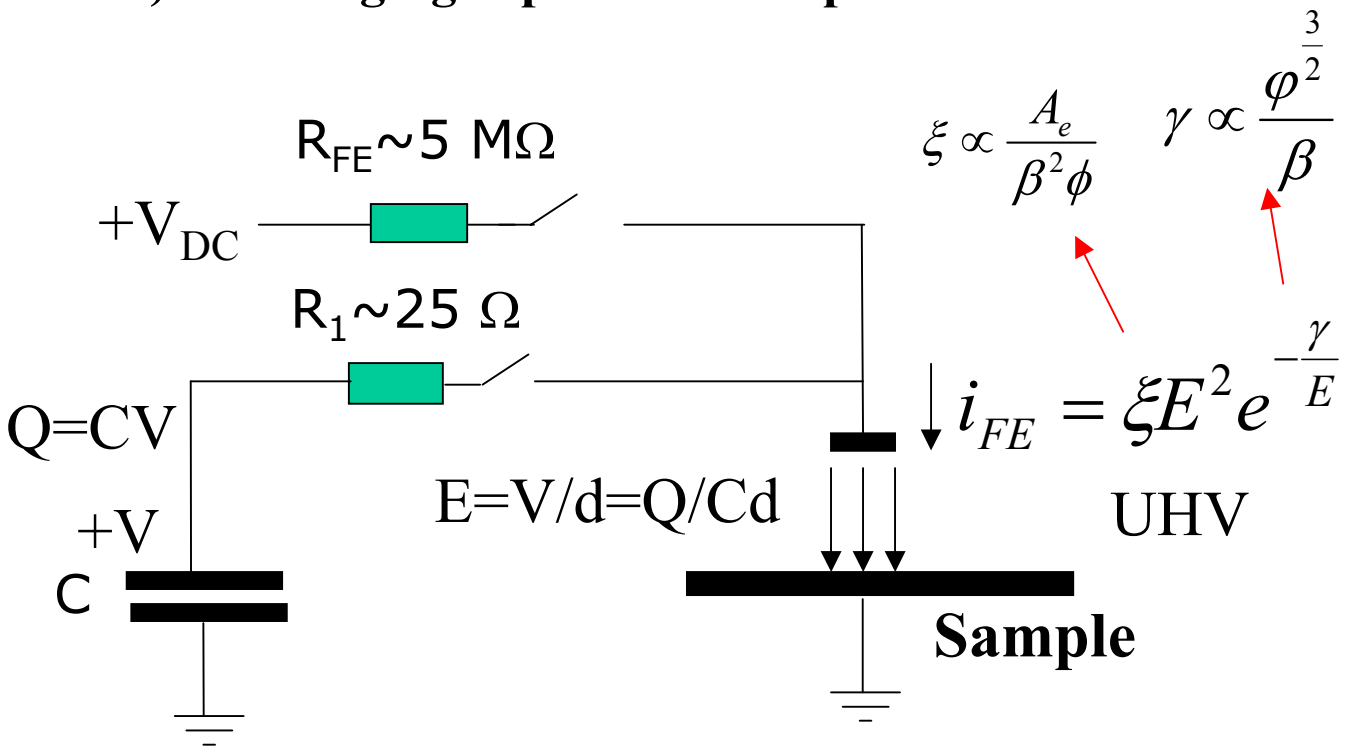
Spark-Test experiment :

1) Field emission current measurements

and

2) Discharging capacitor FE /Spark measurements



Procedure :

* Charge capacitor (C) to V_i , expose gap to init. E_i=V/d,
* The gap field will be described by :

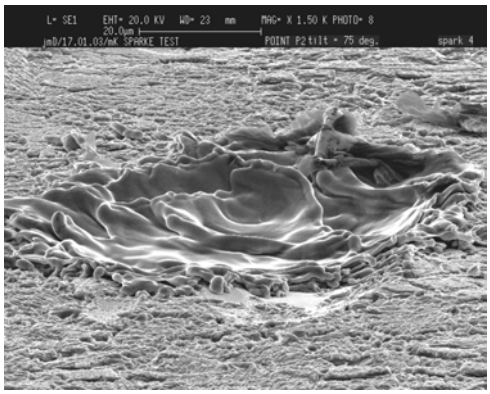
$$\dot{E} = -\hat{\xi} E^2 \exp(-\gamma / E)$$

* The capacitor is partly discharged by field emission, until field emission cuts off. [A spark is a total discharge]
* For initial FE emission levels of >100 nA, the remaining field (charge) is then calculated by (asymptotic solution):

$$E(\tau = 2s) = \frac{\gamma}{\ln(\hat{\xi}\tau\gamma)} \approx \frac{\gamma_0}{\ln(\hat{\xi}_0\tau\gamma_0)} \left\{ 1 - a1 * \frac{\Delta\beta}{\beta_0} - a2 * \frac{\Delta A}{A_{e0}} + a3 * \frac{\Delta\phi}{\phi_0^{3/2}} + a4 \right\}$$

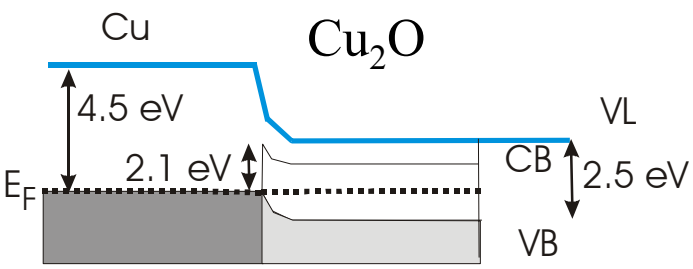
Morten Kildemo; EST-SM; CERN; (2003)

Discharging capacitor –spark scans on electrochemically roughened Cu

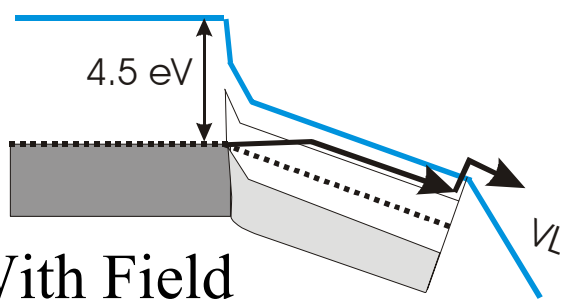


$$E(\tau = 2s) = \frac{\gamma}{\ln(\hat{\xi}\tau\gamma)} \approx \frac{\gamma_0}{\ln(\hat{\xi}_0\tau\gamma_0)}\left\{1 - a1*\frac{\Delta\beta}{\beta_0} - a2*\frac{\Delta A}{A_{e0}} + a3*\frac{\Delta\phi}{\phi_0^{3/2}} + a4\right\}$$

Oxide and adsorbate ΔΦ, different phenomenas (charge transfer vs band)



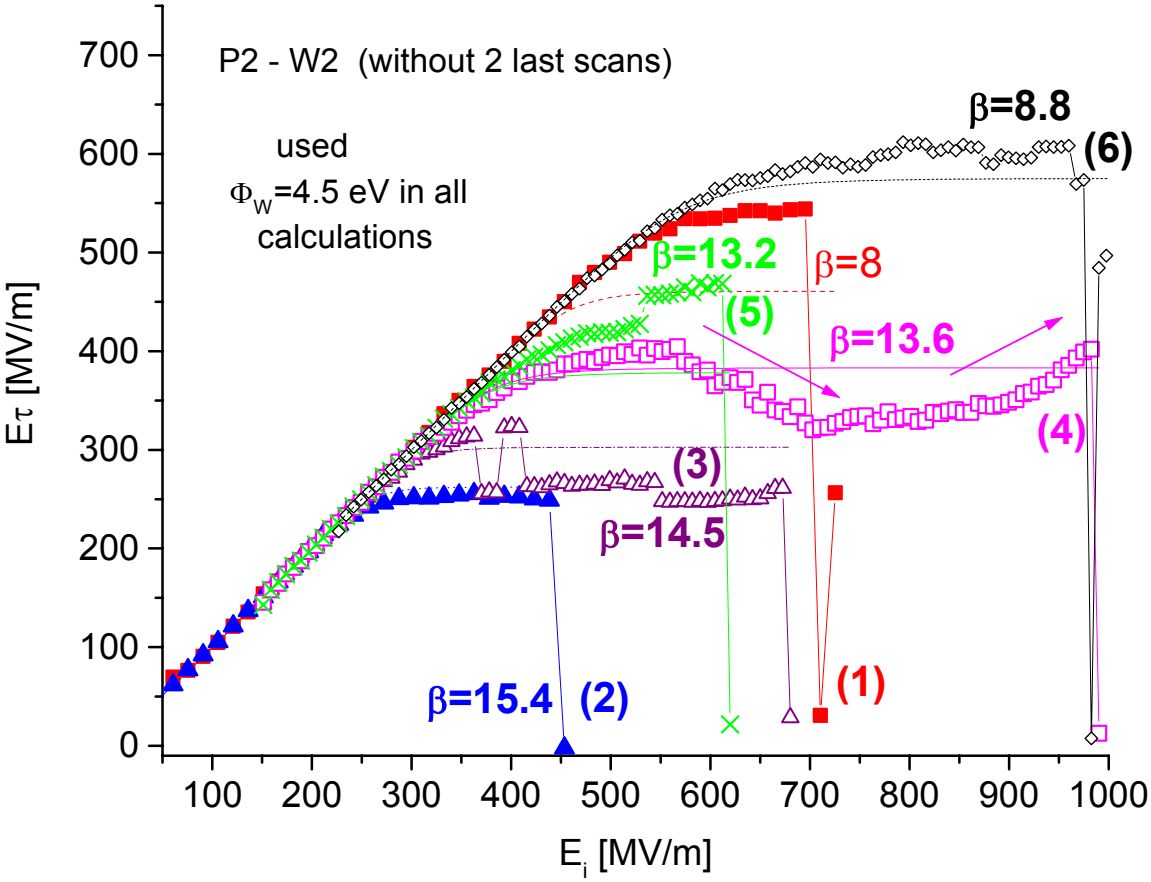
No Field



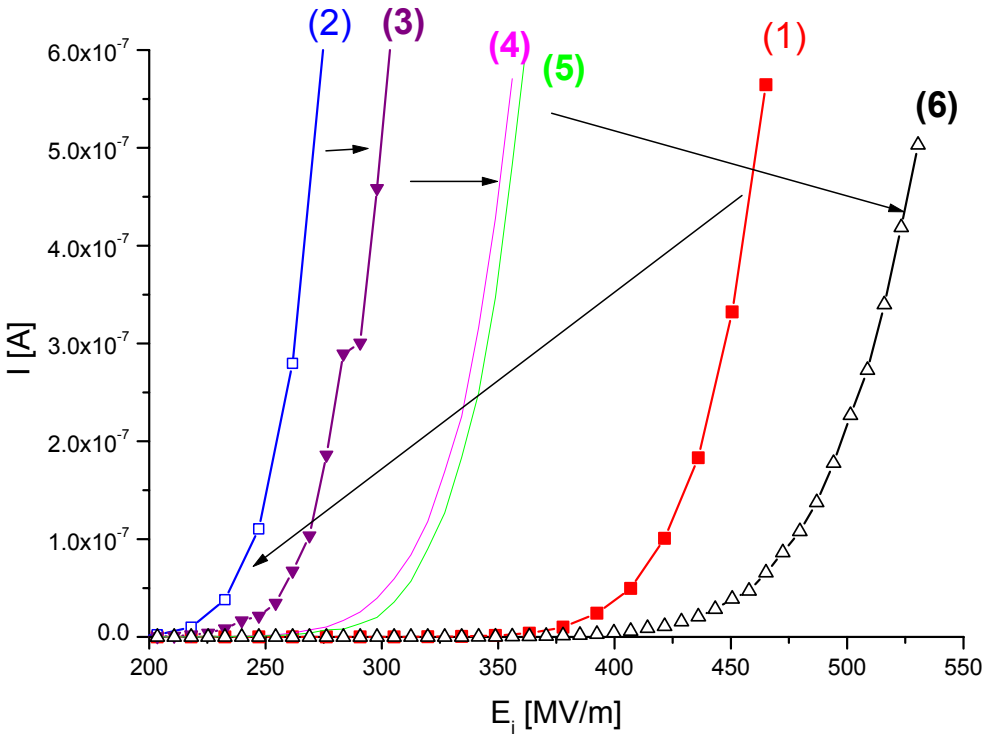
With Field

Morten Kildemo; EST-SM; CERN; (2003)

Discharging capacitor –spark scans on electro-chemically roughened W

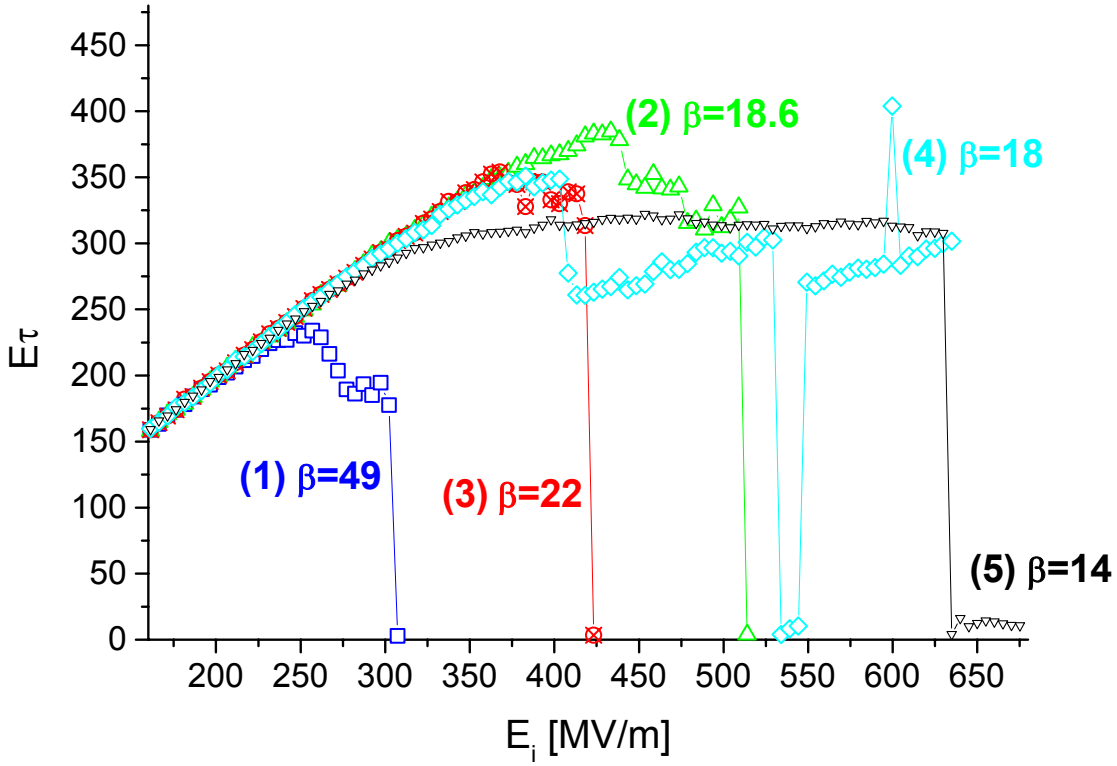


Field emission recorded prior to the spark scans

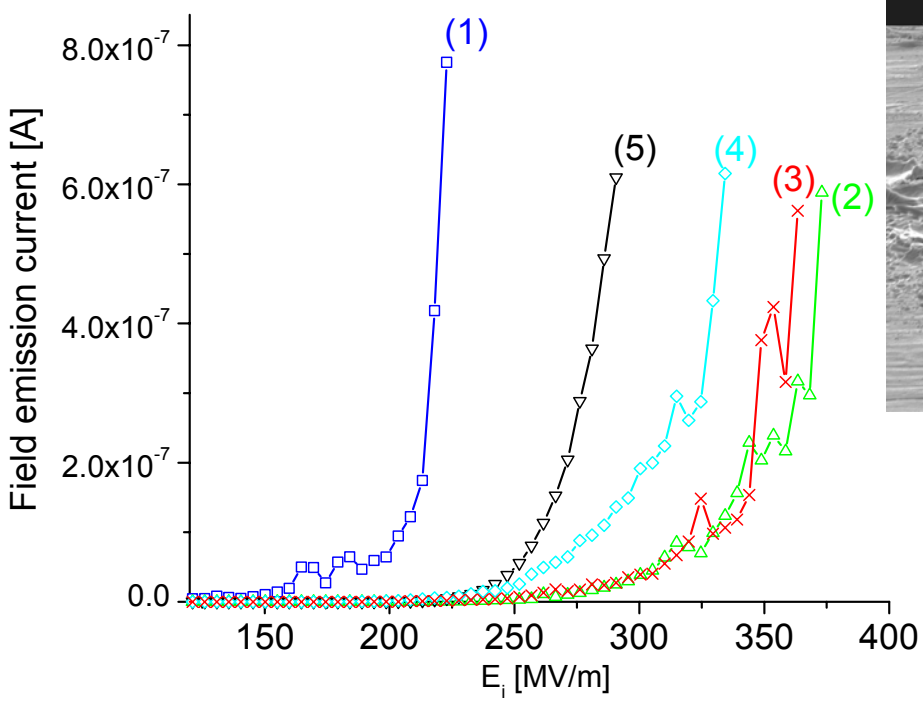


Morten Kildemo; EST-SM; CERN; (2003)

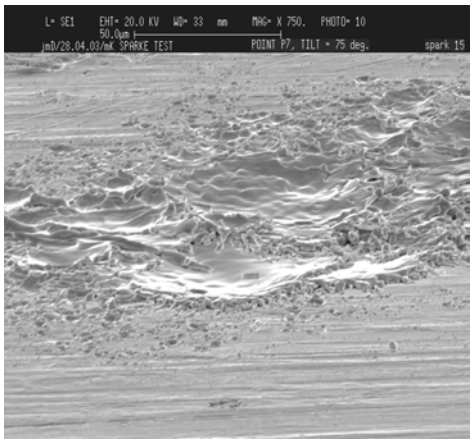
Discharging capacitor –spark scans on Nb, only degreased and ultrasonic cleaned



Field emission traces prior to spark scans



SEM

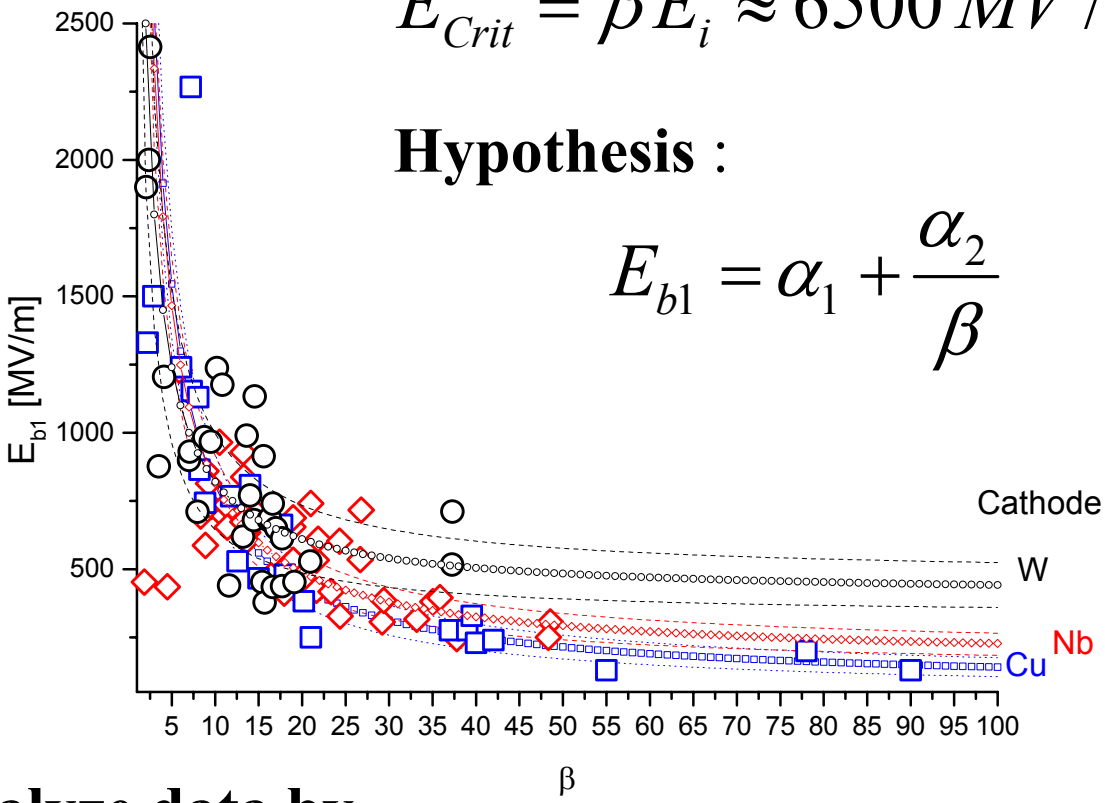


First break down field (E_{b1}) versus field enhancement factor β

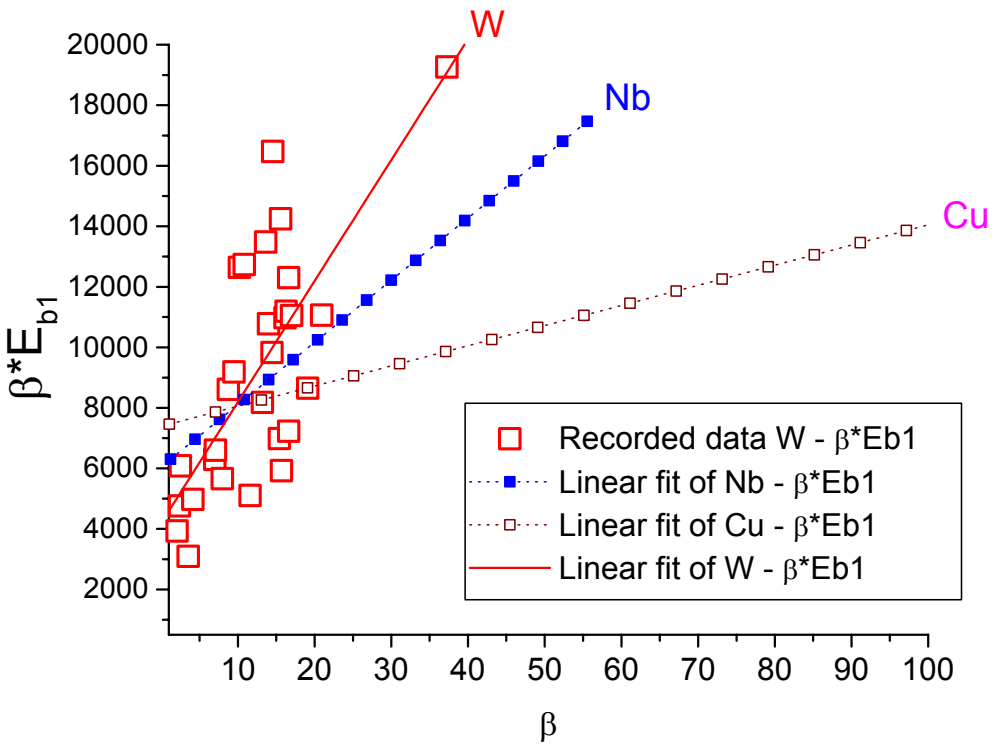
$$E_{Crit} = \beta E_i \approx 6500\, MV/m$$

Hypothesis :

$$E_{b1} = \alpha_1 + \frac{\alpha_2}{\beta}$$

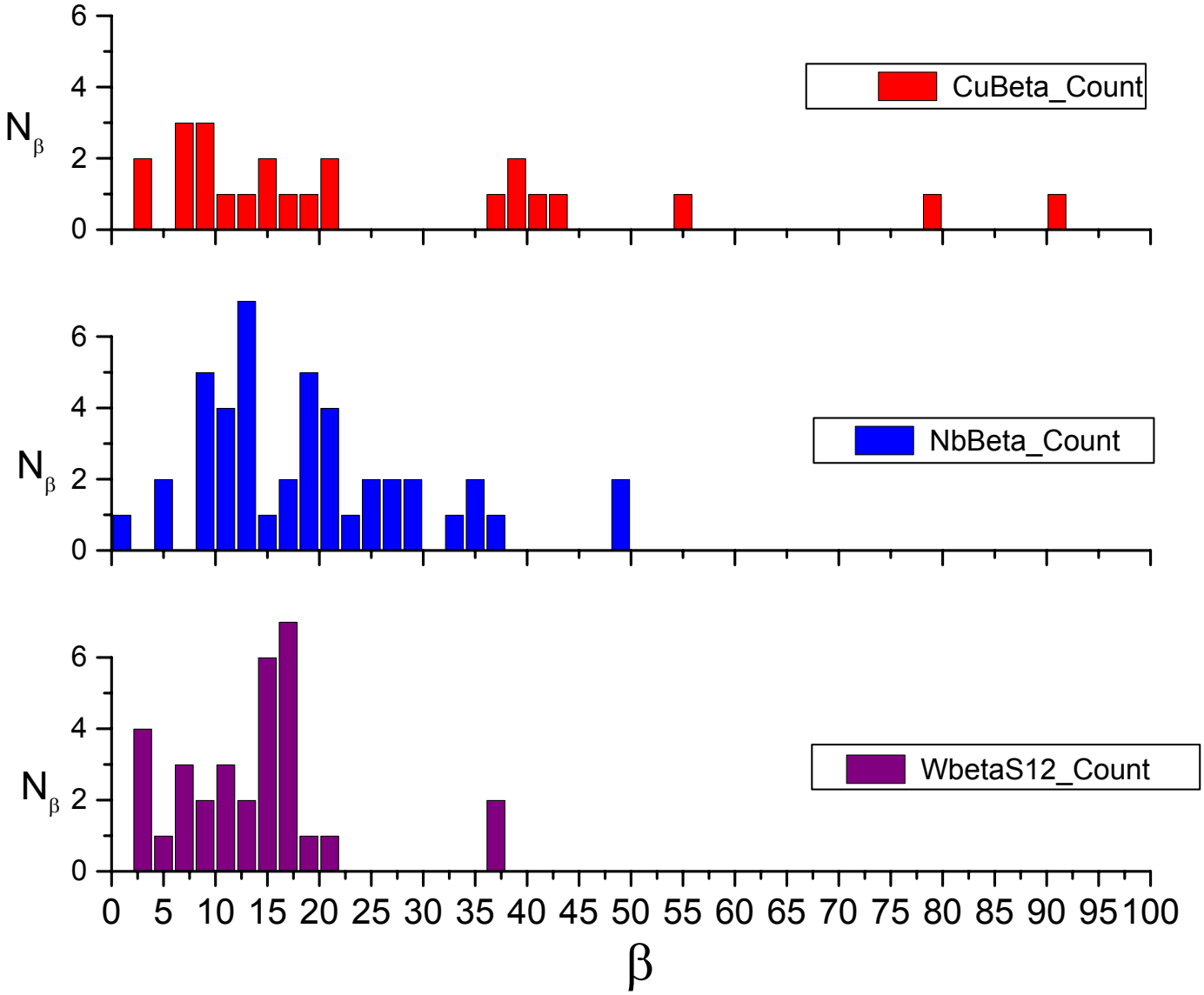


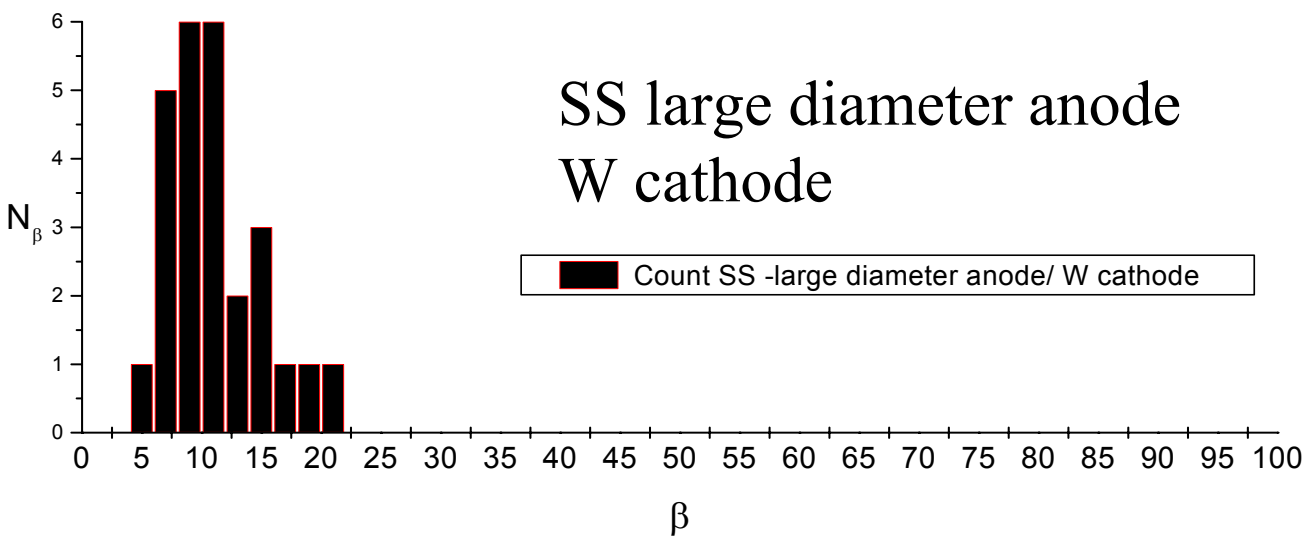
Analyze data by linear fit to : $y(\beta) = E_{b1}\beta = \alpha_2 + \alpha_1\beta$



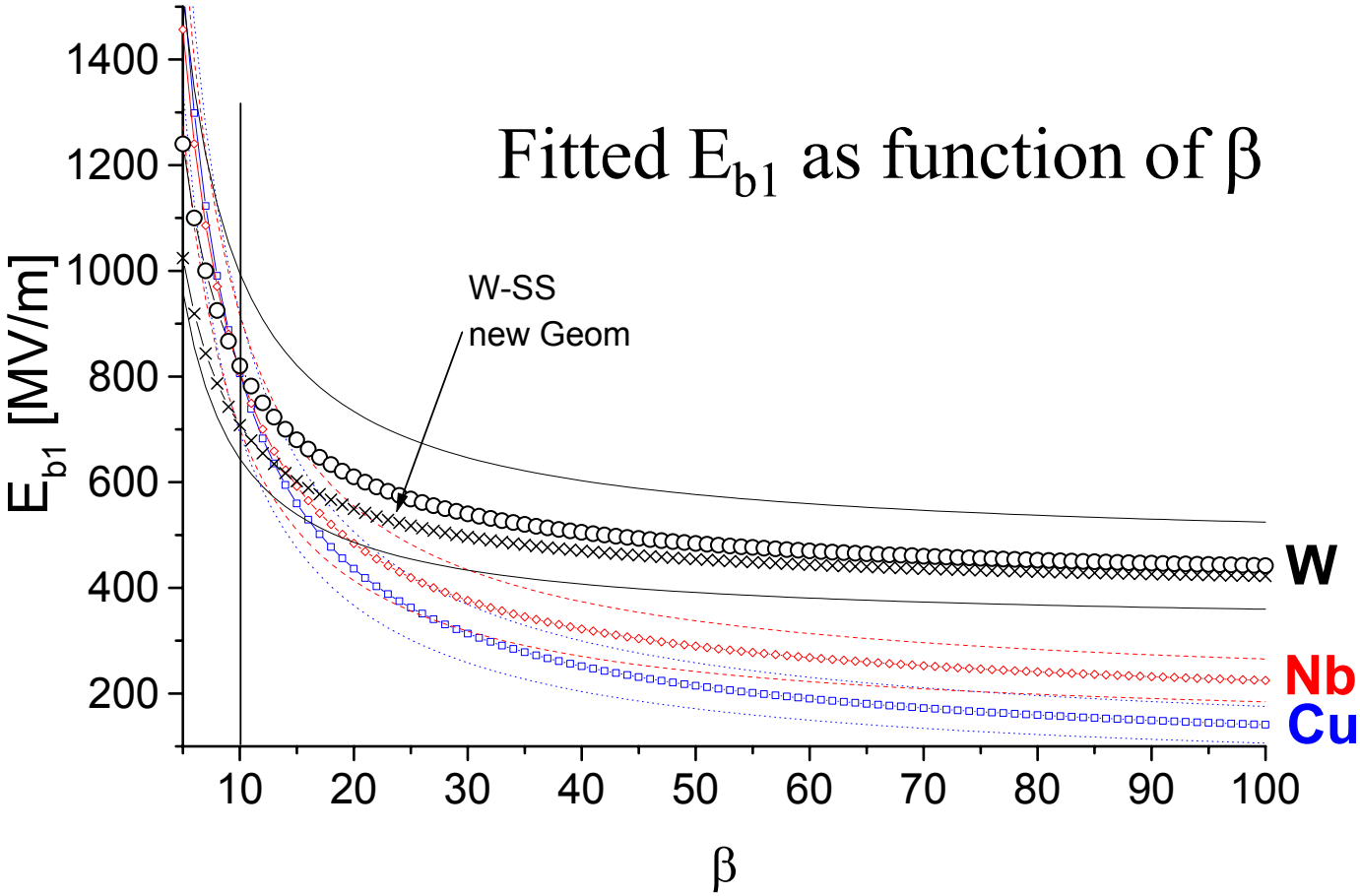
Morten Kildemo; EST-SM; CERN; (2003)

Accumulate all breakdown data and analyze distribution of β values for Cu, Nb and W





Speculative conclusion I :



Cu behaves better than W for lower β

- ***higher thermal conductivity of Cu ?***

For higher β, W behaves better than Cu

- ***heat conduction is limited by the protrusion ?***
- ***The lower vapor pressure of W dominate the first breakdown field ?***

- but what about Nb (poor thermal conductivity ?)

Speculative conclusion II

Extrapolation to/application to irises :

Higher (E_{b1}) breakdown values for Cu (than W) could in principle be reached for lower β values

However,….

* breakdown of a defect, cause larger erosion for Cu than W => **larger β values**

(recall, specific erosion 10 times higher for Cu compared to W).

* At higher β values W have more acceptable E_b, after conditioning of initial adsorbate effects.

* Oxide appears to degrade breakdown performance of Cu and Nb, while improve W.