DC Field Emission Scanning

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- **New LabVIEW Automation of the Field Emission Scanning Microscope (FESM)**

- **FE Results on Electropolished Nb and Cu Samples**

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New Automation of FESM

- **GPIB computer control of:**
  - Motion controller MM4006 for stepper motor driven xyz stages
  - Fast rate (1kHz) Keithley 6485 Picoamperemeter
  - FUG 5kV Power Supply (Pulsable and PID regulated)

- **Programming with LabVIEW completed for :**
  - Automized Scans :
    - PID-Regulated voltage scan [V(x,y) for given I = const.]
    - Current scan [I(x,y) for a given V = const.]
  - Local measurements
    - Local field calibration [V(z) plot]
    - I/V measurements
  - Data analysis
    - FN plots to determine field enhancement factor β

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Voltage-scan

needle size (microns)

10 microns

no. of points in a line

50

no. of lines to scan

50

Position and Voltage

Position x

4,79619

Position y

0,499873

Position z

1,33295

Voltage (volts)

999,74

file path:

D:\MyData\u-scan-slow.txt
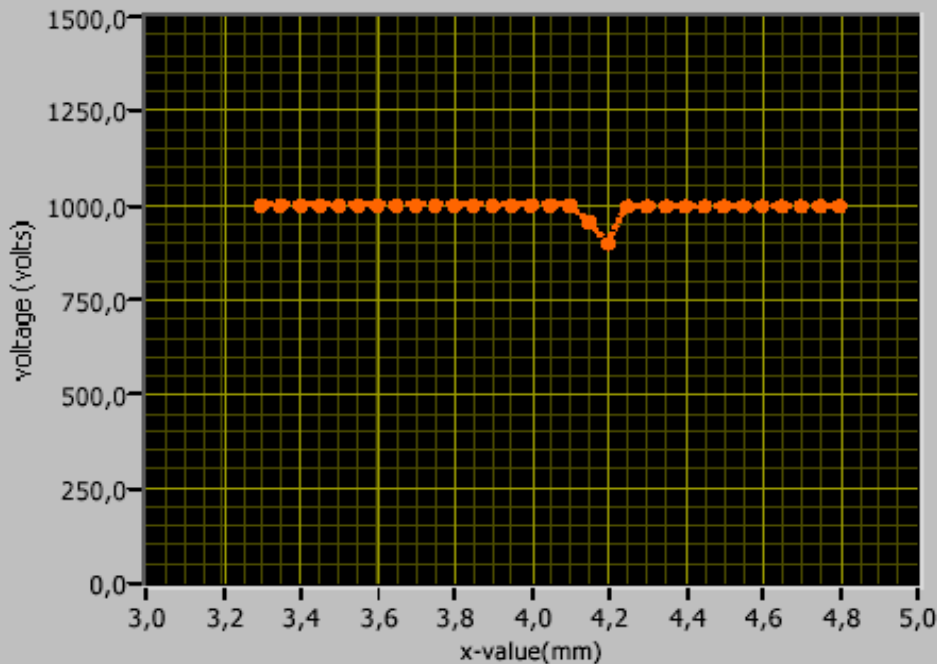
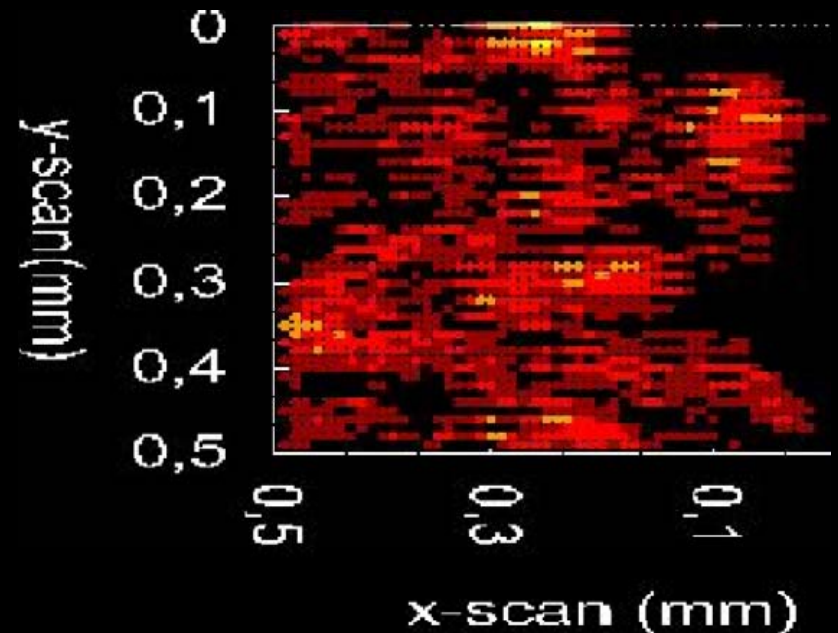**scan started at:**

20.03.2005 15:19:30

start scan

skip scan

no. of lines scanned:

11

scan completed1

ABORT??

Online data

Coloured scan plot after complete scanning

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Local field calibration [V(z) plot]

data from user? 🟢

voltage

`+2.6428E+03VN`

new file path (Not A Path if cancelled)

`D:\MyData\U(z)readings.txt` 📁

fixed current
`1` **nA**

Pos.1
-0.00200

Pos.2
0.00000

Pos.3
0.44700

needle size (microns) 2
`2 micron`

direction of motion
`z`

U(z) PLOT
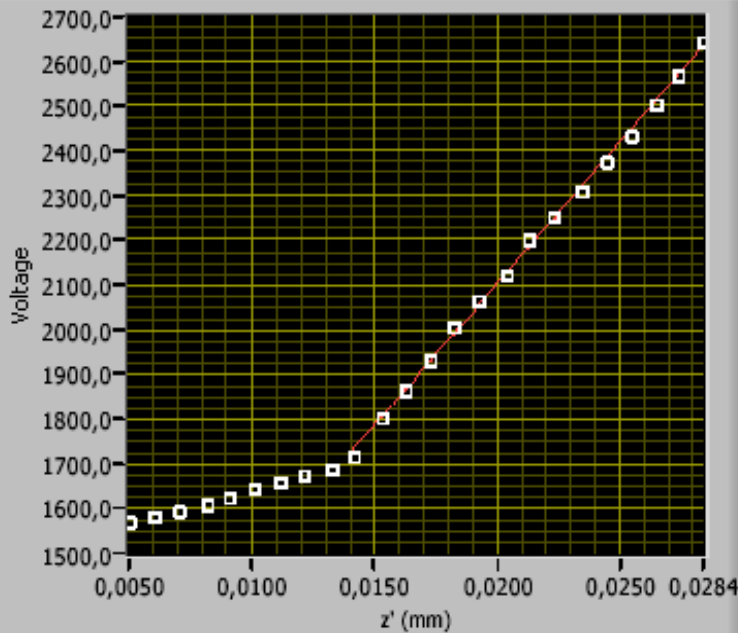
graph1
graph 2

Activation Field for emitter
`63,19` **MV/m**

Zo
`-13,2566` **micro meter**

x	y
0,00095:	1671
0,00209!	1610,6
0,00298<	1617
0,00412(	1633,8
0,00501!	1569,9
0,00603:	1581,9
0,00704:	1593,6
0,008190	1608,4
0,00907!	1624,1
0,01009!	1644,6
0,01117<	1659,3
0,01212:	1674,3
0,01326!	1687,5

FINISH 🟢

I/V measurements

Anode to sample distance

33   µm

MV/m

Electric Field

55,3182

Voltage Control

0

PROCEED

VOLTAGE SUPPLIED

+3.7682E+00VN

KEITHLEY CURRENT READING

-8.532681E-13A,+8.154108E+03,+0.000000E+00

file path

D:\MyData\23 marchCurrent1.txt

Plot 0
Plot 1

i-v curve
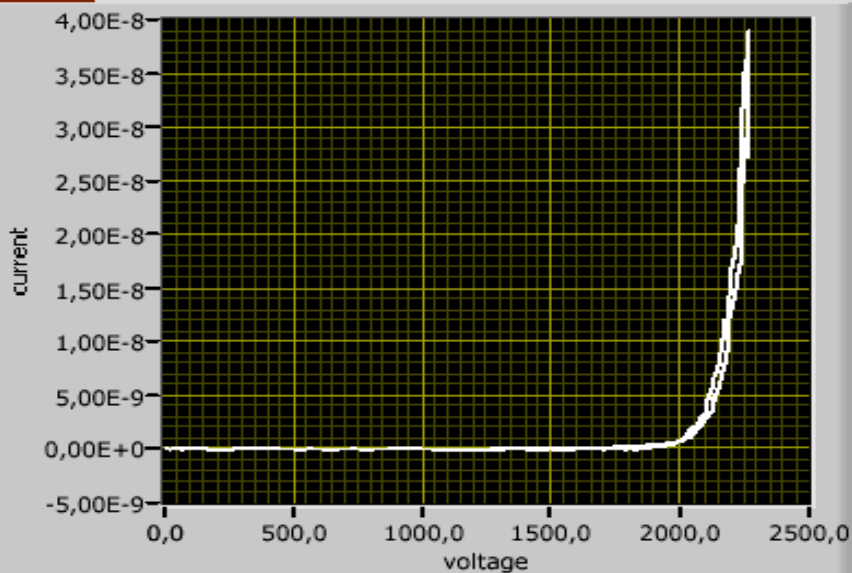
FN plot
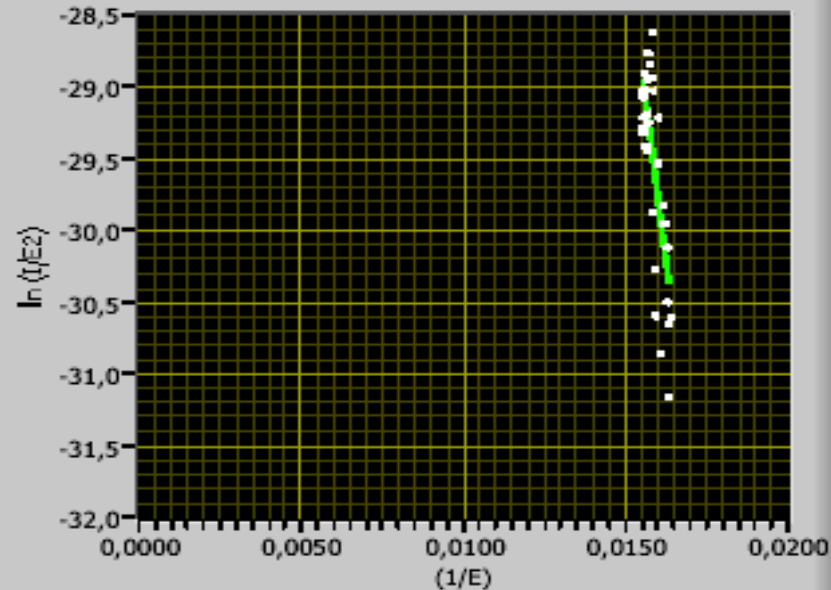
slope of FN curve

-1794,38

s- factor(cm)^2

7,64964E-15

intercept of FN curve

-1,06

beta value

36,335

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Results on Nb Samples:

- **2 EP-Nb samples from DESY** (# 10, #11)
  - Surface observed NOT FLAT
  - CONCAVE CURVATURE
    (Δh > 100 µm, 70 µm)
  - Scanning at fixed distance Δz < 100 µm is not possible yet
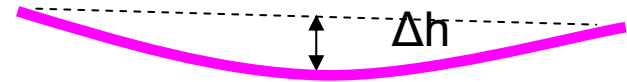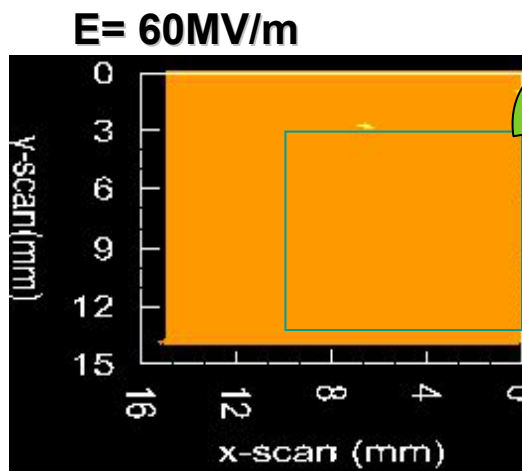
- **Probable causes**
  - Inhomogeneous electric field distribution during EP
  - Mechanical pressure on sample in FM coupler port

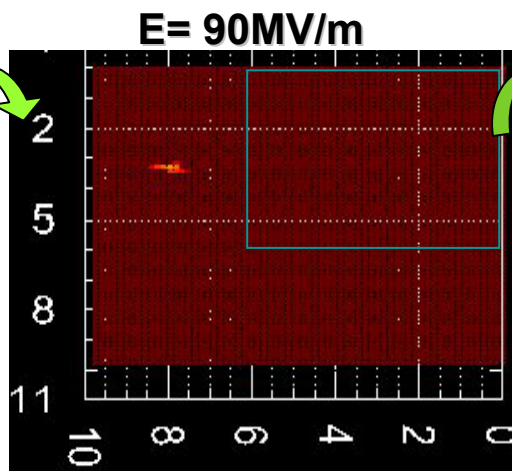$\Rightarrow$ **Modification of sample position during EP is required!**
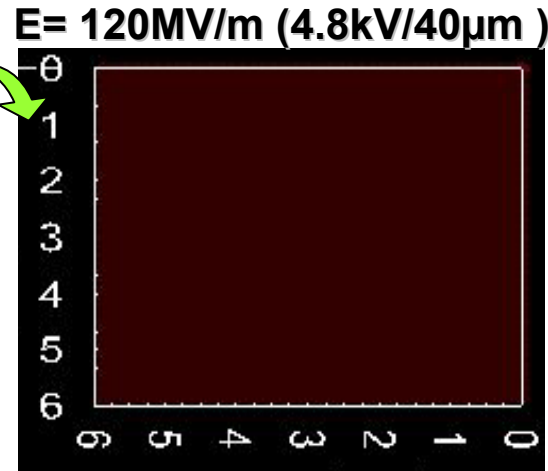
Regulated V-scans on EP-Nb sample from Saclay (SEP1)
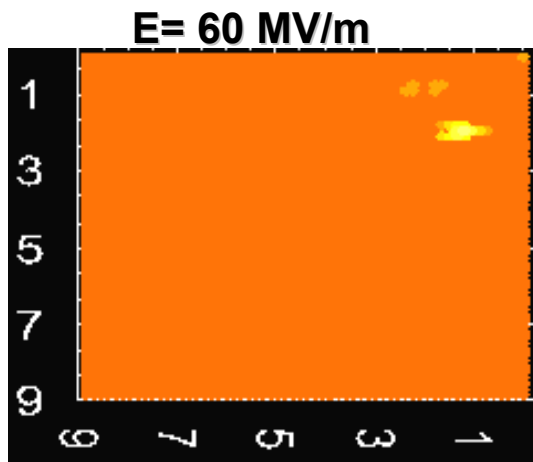
Anode diameter = 300μm, Δz = 50 μm (±5μm)

E= 60MV/m

N ~ 1emitter/cm^2

E= 90MV/m

N > 1 emitter/cm^2

E= 120MV/m (4.8kV/40μm)

No emission in selected area!
$\Rightarrow$ **EP is effective up to E=120MV/m**

E= 60 MV/m

N ~ 5 emitters/cm^2
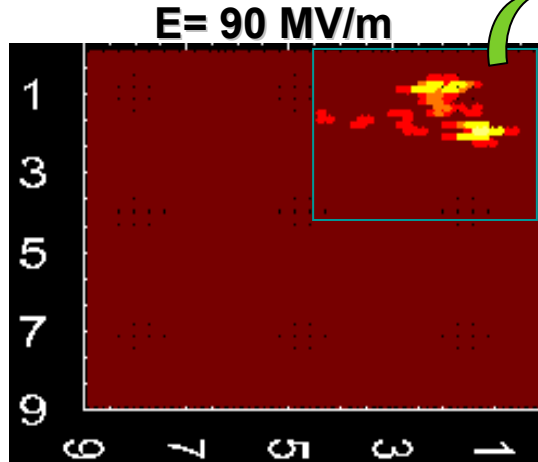
E= 90 MV/m

N ~ 11 emitters/cm^2
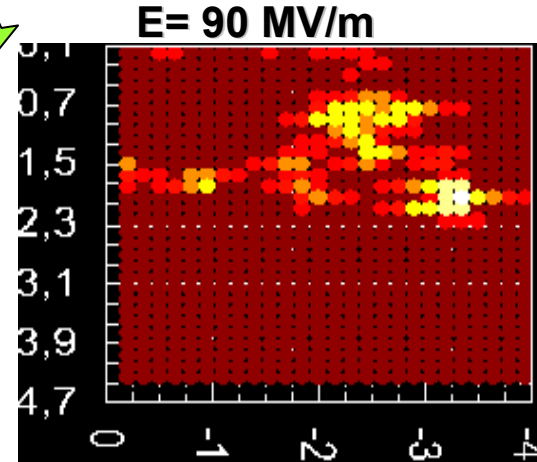
E= 90 MV/m

N ~ 13 emitters/cm^2 $\Rightarrow$ 70/cm^2

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Regulated voltage scans on Cu Sample from DESY (DCu1)

Anode diameter $\varnothing_{Anode}$=300μm
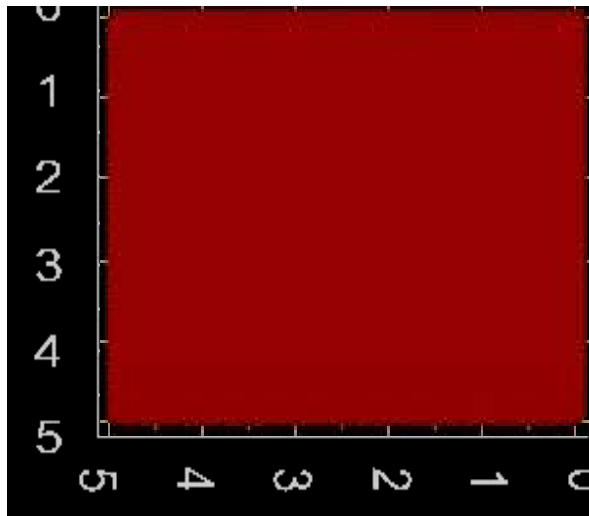
$\varnothing_{Anode}$= 100μm
(higher resolution scan)

E= 60MV/m
$\triangle z$ = 75 μm (±5μm)

E= 90MV/m
$\triangle z$ = 50 μm (±5μm)

No emission
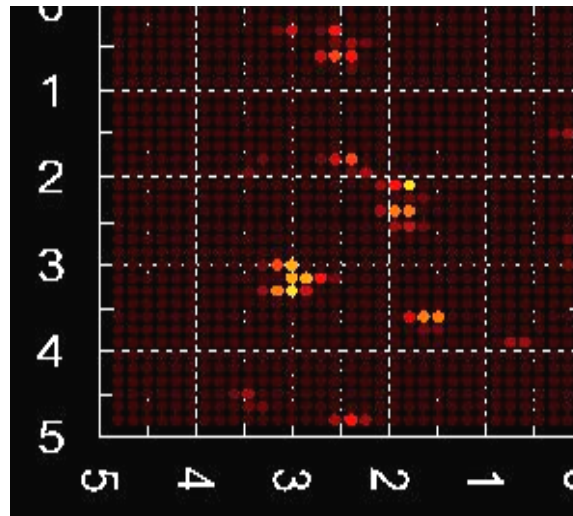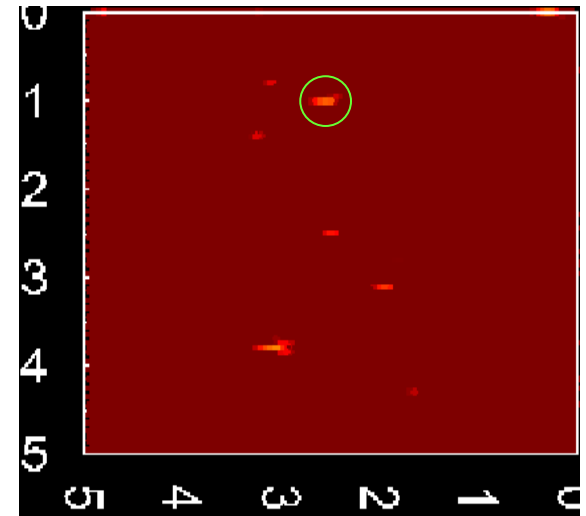
N ~ 48 emitters /cm^2

N ~ 32 emitters/cm^2
Circled emitter chosen for
local measurements

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Local measurements of a strong emitter on DCu 1

V(z) at 1 nA for field calibration
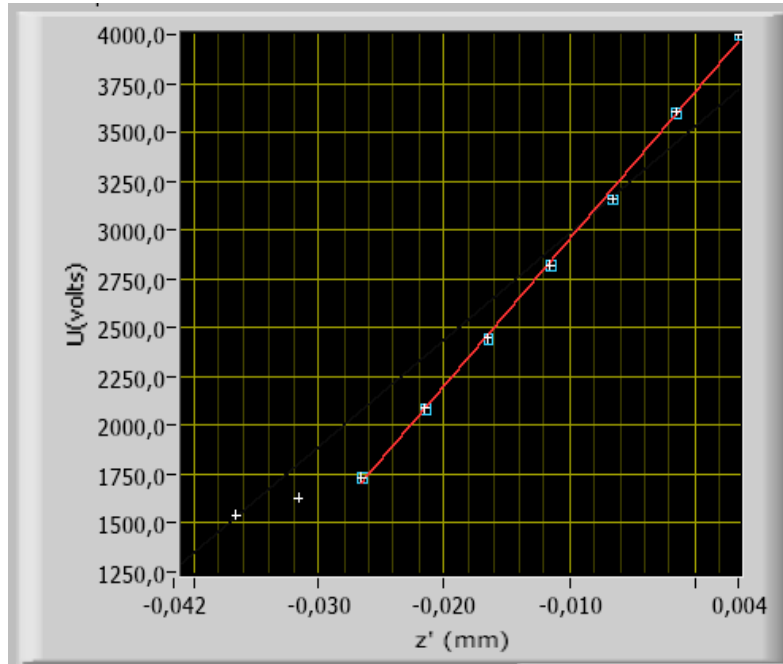
FN plot

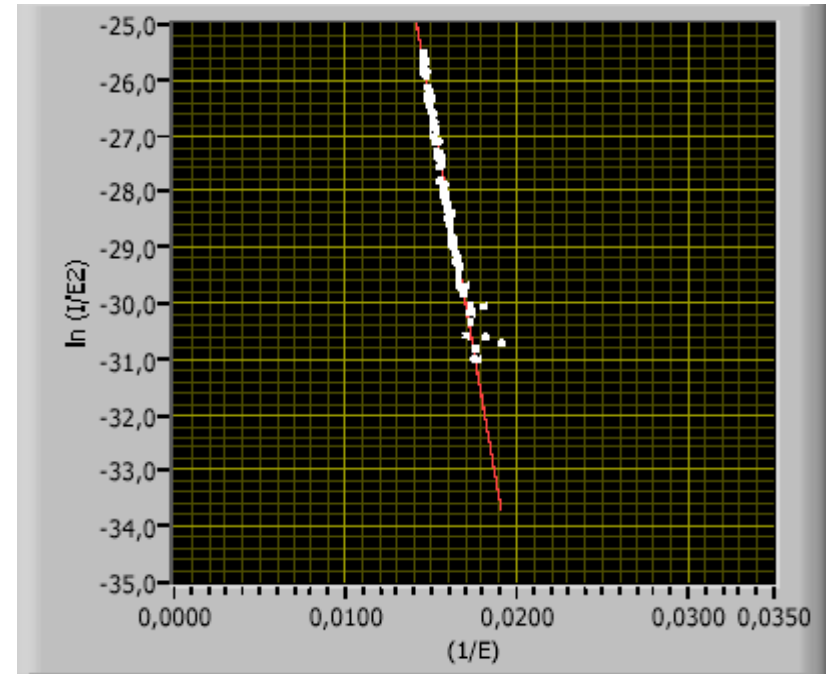**Absolute distance between anode and sample:** $\Delta z = z' + z_0$, where $z_0 = 49$ μm

Activation field for the selected emitter:

$E_0 = 74.86$ MV/m

For the chosen emitter:
β factor = 37.03
S factor = 2.03 E-14 cm^2

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Outlook

- **Further automation:**
  - Programming of xyz-piezostages for higher resolution
  - Autotilting of samples
  - Computerised data analysis (e.g. N(E))

- **Systematic measurements**
  - Quality control scans of EP-Nb samples
  - Comparision of HPR and DIC methods
  - Improvement of Cu surface treatment
  - Field emitter identification by ex-situ SEM and EDAX

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