TTF Cavity Preparation

Lutz Lilje
DESY -MPY-
Lutz.Lilje@desy.de

TESLA Technology Collaboration Meeting March 2005

- Review of the standard preparation

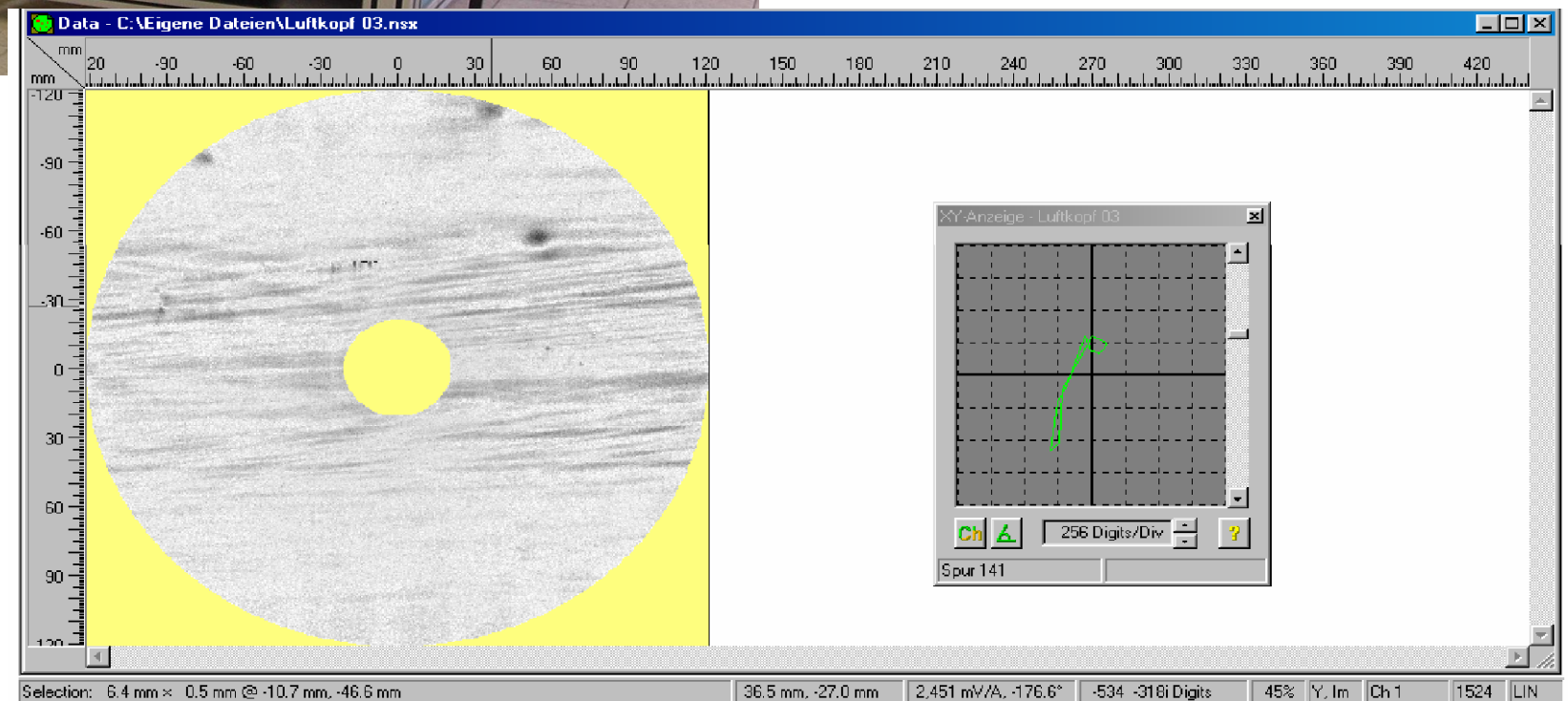
Preparation of TESLA Cavities

- High purity niobium sheets of Residual Resistivity Ratio RRR=300 are scanned by eddy-currents to exclude foreign material inclusions like tantalum and iron
- Industrial production of full nine-cell cavities:
  - Deep-drawing of subunits (half-cells, etc.) from niobium sheets
  - Chemical preparation for welding, cleanroom preparation
  - Electron-beam welding according to detailed specification
- 800 °C stress annealing of the full cavity removes hydrogen from the Nb
- Option: 1400 °C high temperature heat treatment with titanium getter layer to increase the thermal conductivity (RRR=500) further
- Cleanroom handling:
  - Chemical etching (or electropolishing) to remove damage layer and titanium getter layer
  - High pressure water rinsing as final treatment to avoid particle contamination

Eddy Current Scanner for Niobium Sheets

Real and imaginary part of conductivity at defect, typical Fe signal

Global view, rolling marks and defect areas can be seen



Lutz Lilje DESY

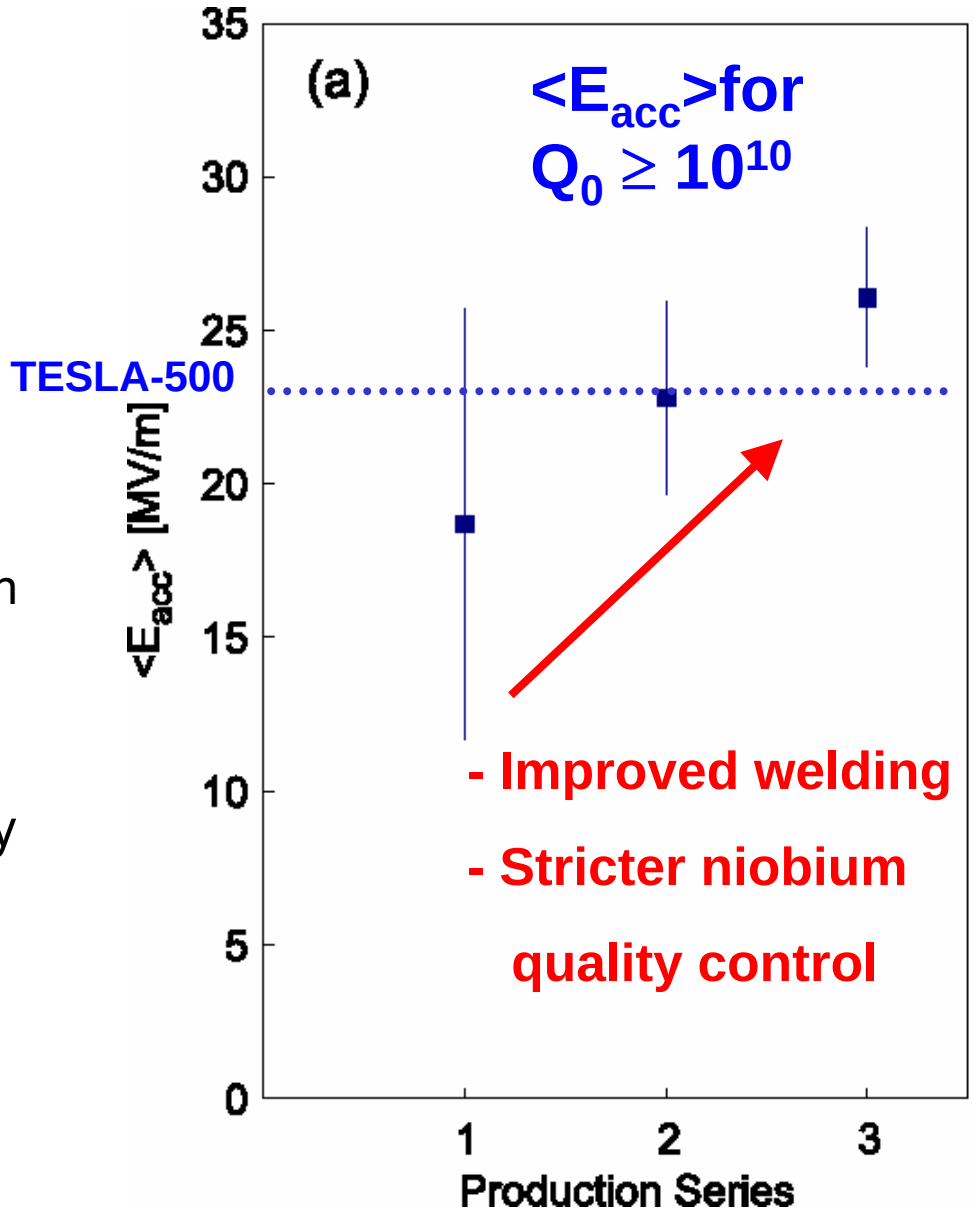
Standard Cavity Production

(e.g. EB welding at CERCA)

Preparation of TESLA Cavities

Results of Cavity Production

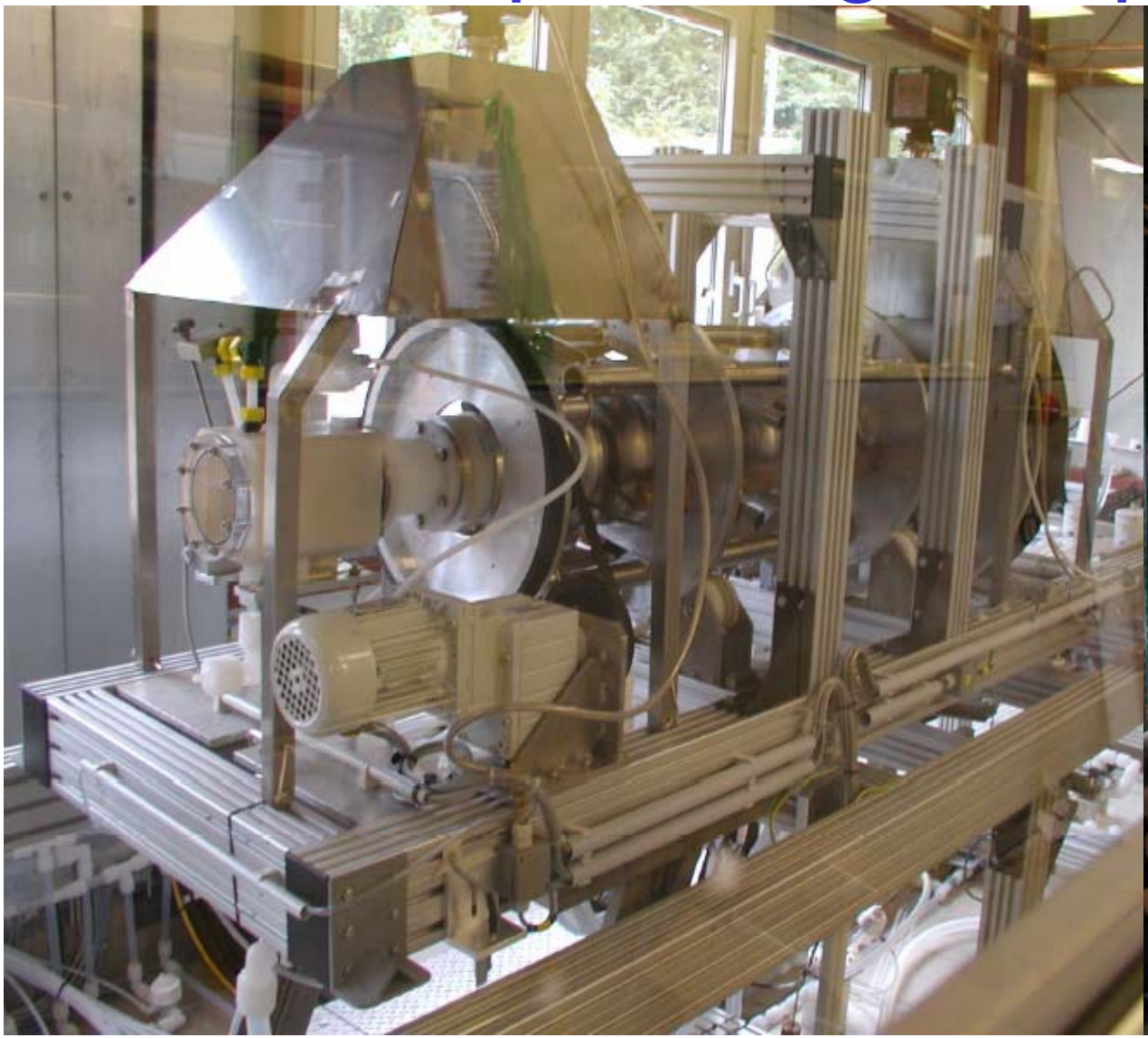
- Cavity shape is optimal (no change since 10 years)
- Three production series of cavities were tested to:
  - qualify companies for cavity production
  - improve performance by precise specification
- Gradient has increased to 25 MV/m in the 3rd production series of cavities by 2001 (TESLA-500 specification)
- At the same time the spread of the performance became smaller
- An improved surface treatment became available: Electropolishing (EP)

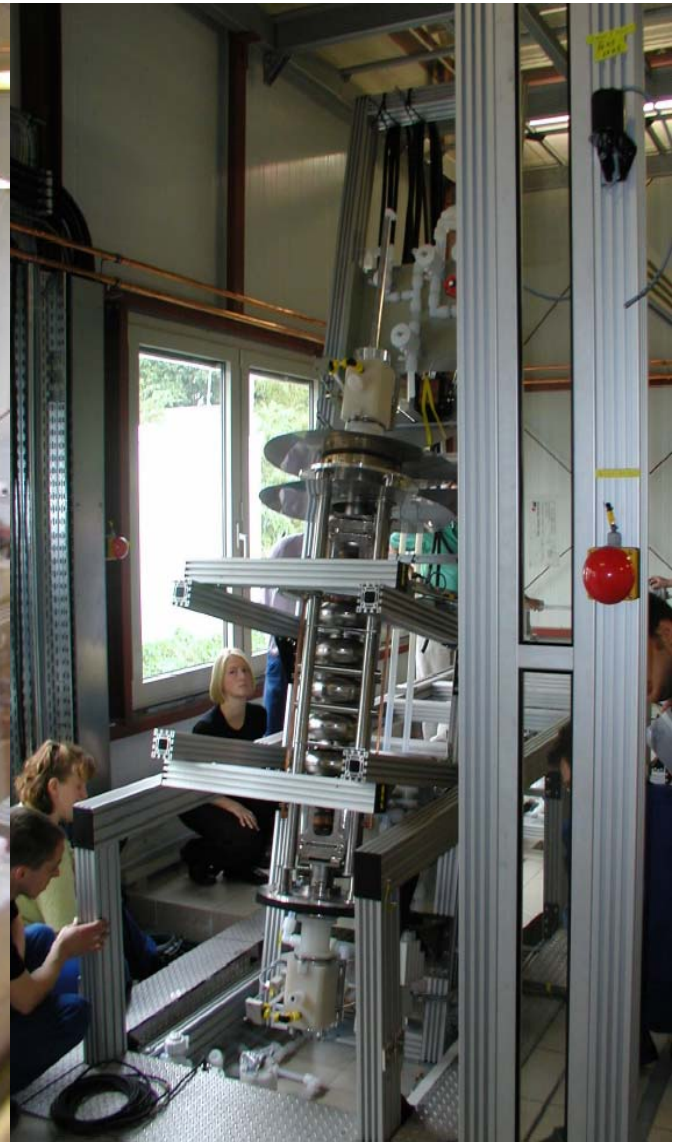


Comments to the Standard Preparation

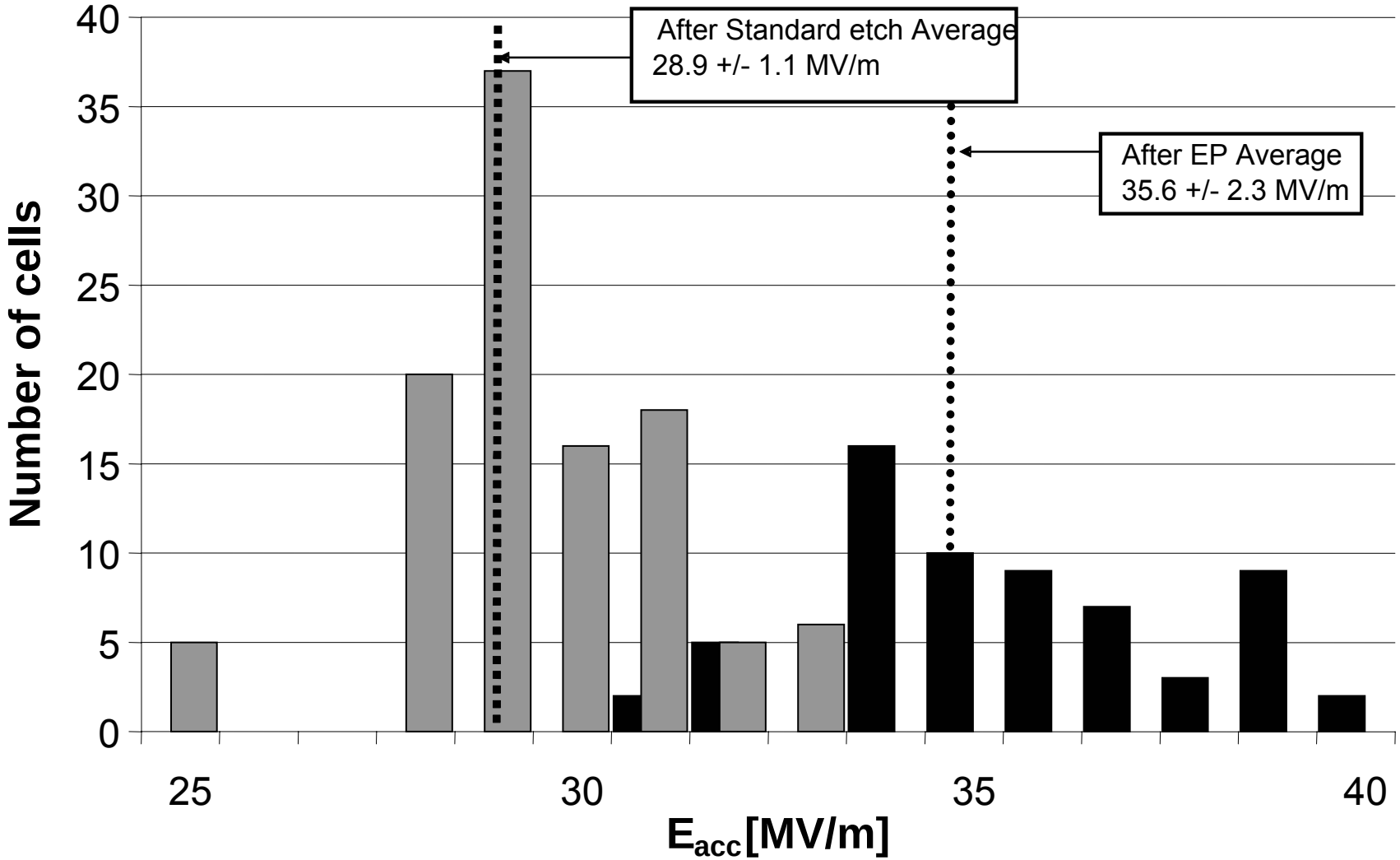
- Eddy-current scanning has proven to be crucial to improve niobium sheet quality
  - Is there a better quality control available?
  - Or can the scanning be done on sub-units like dumb-bells?
- Electron-beam welding
  - Can deliver reproducible results if necessary pre-cleaning of parts is done
  - Are other fabrication techniques really superior (better performance/ more reliable/ reproducible/ cost effective)?
- Etching
  - could be performed with reasonable reproducibility
  - Can readily performed by industry
  - Concern:
    - Etching limits the cavity performance to 30 MV/m even when using post-purification with titanium
- Field emission
  - Continuous struggle
  - Very difficult to pin-down reasons

Electropolishing Setup at DESY





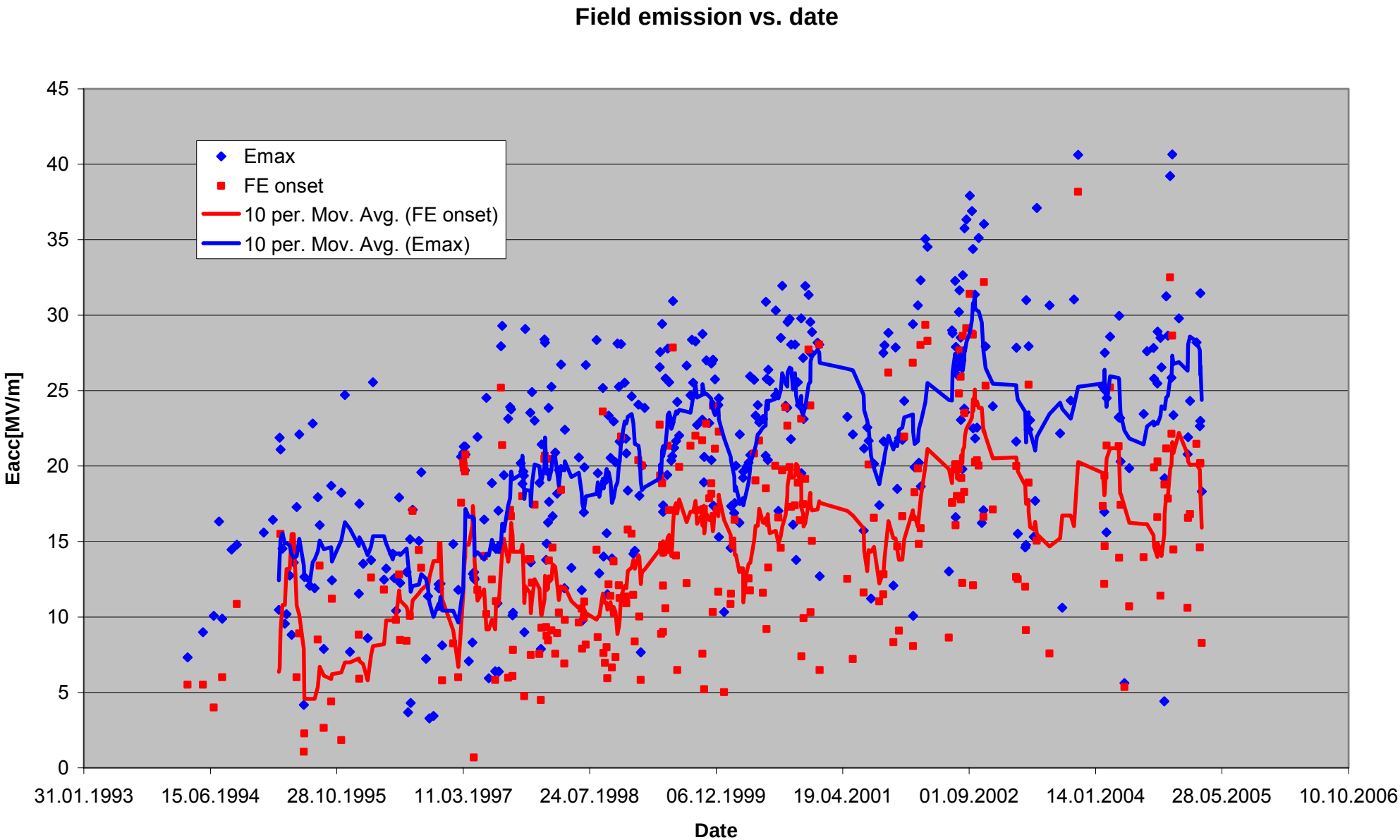
Comparison of EP to Standard Etch



- EP offers systematically higher gradient than standard etch (single cell results from mode analysis of multi-cells)

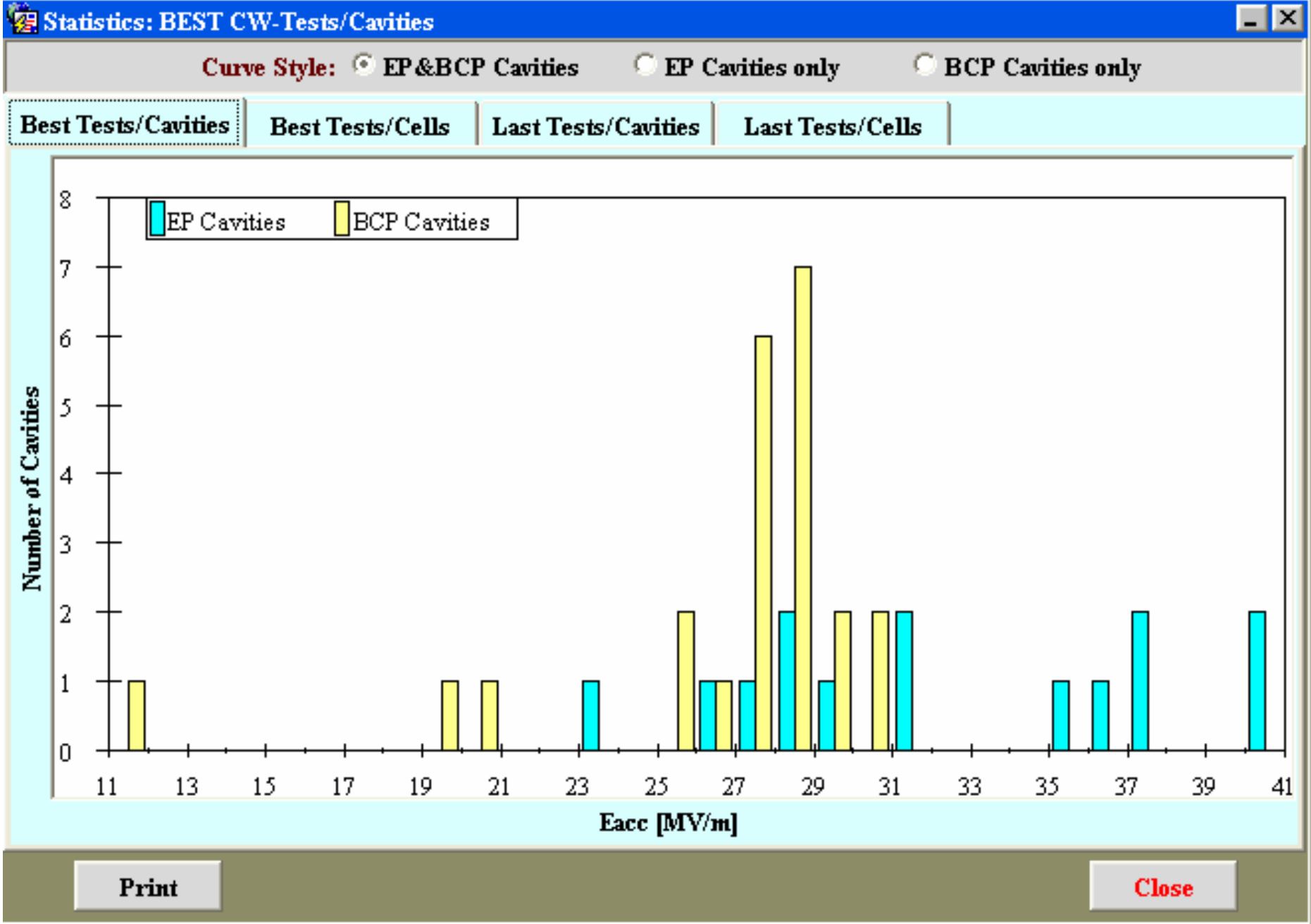
But:

- Field emission is a major concern


Field emission vs. date
Emax
FE onset
10 per. Mov. Avg. (FE onset)
10 per. Mov. Avg. (Emax)
Eacc[MV/m]
0
5
10
15
20
25
30
35
40
45
31.01.1993
15.06.1994
28.10.1995
11.03.1997
24.07.1998
06.12.1999
19.04.2001
01.09.2002
14.01.2004
28.05.2005
10.10.2006
Date

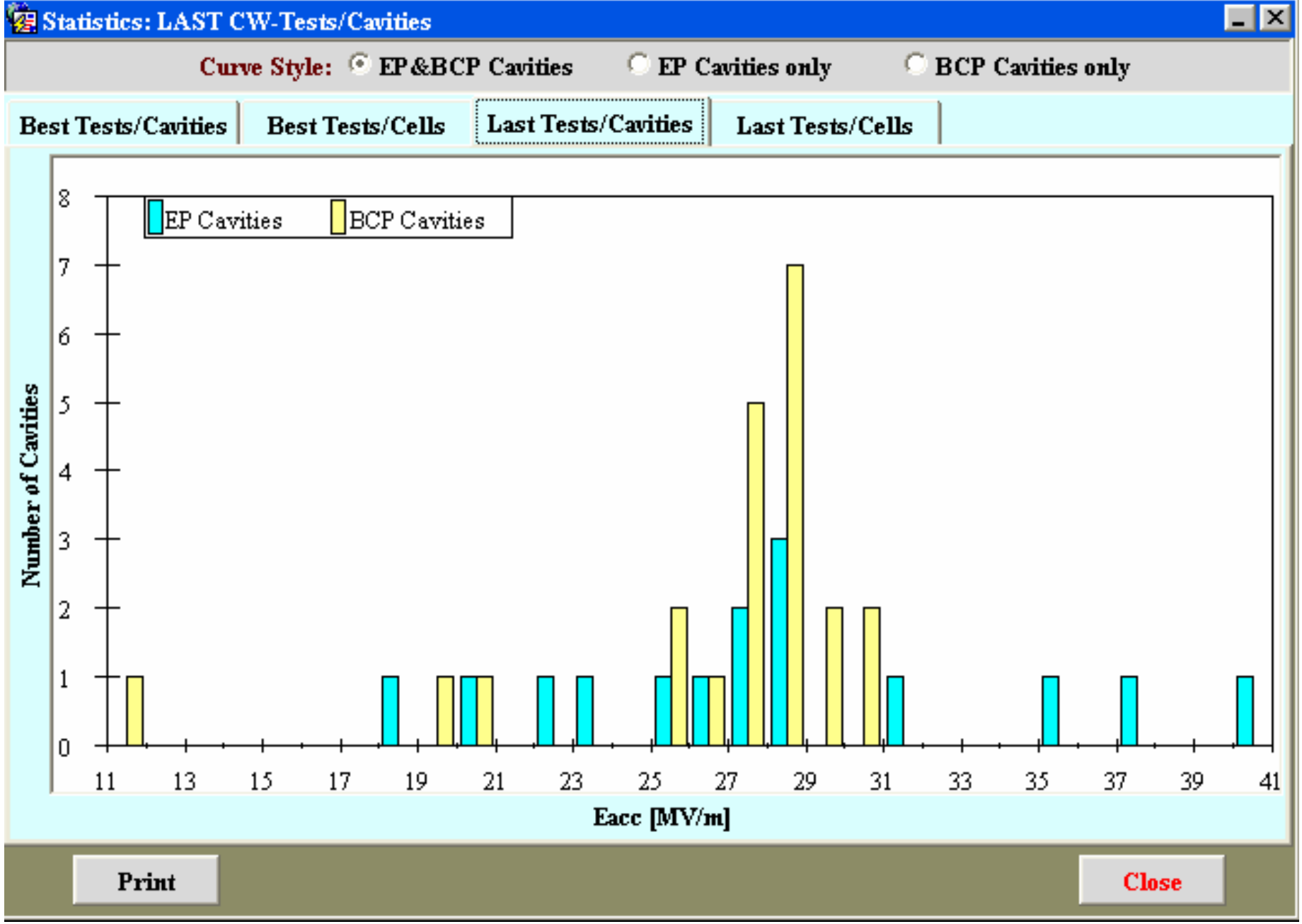
Comparison of best test: EP vs. BCP

- Best test on cavity selected (pi-mode)
- Mixture of 800°C and 1400°C cavities


Statistics: BEST CW-Tests/Cavities
Curve Style:
EP &BCP Cavities
EP Cavities only
BCP Cavities only
Best Tests/Cavities
Best Tests/Cells
Last Tests/Cavities
Last Tests/Cells
EP Cavities
BCP Cavities
Number of Cavities
0
1
2
3
4
5
6
7
8
11
13
15
17
19
21
23
25
27
29
31
33
35
37
39
41
Eacc [MV/m]
Print
Close

Comparison of last test: EP vs. BCP

- Includes new surface preparations due to problems during handling, accidents etc.


Statistics: LAST CW-Tests/Cavities
Curve Style:
EP &BCP Cavities
EP Cavities only
BCP Cavities only
Best Tests/Cavities
Best Tests/Cells
Last Tests/Cavities
Last Tests/Cells
EP Cavities
BCP Cavities
Number of Cavities
0
1
2
3
4
5
6
7
8
11
13
15
17
19
21
23
25
27
29
31
33
35
37
39
41
Eacc [MV/m]
Print
Close

Comments for EP

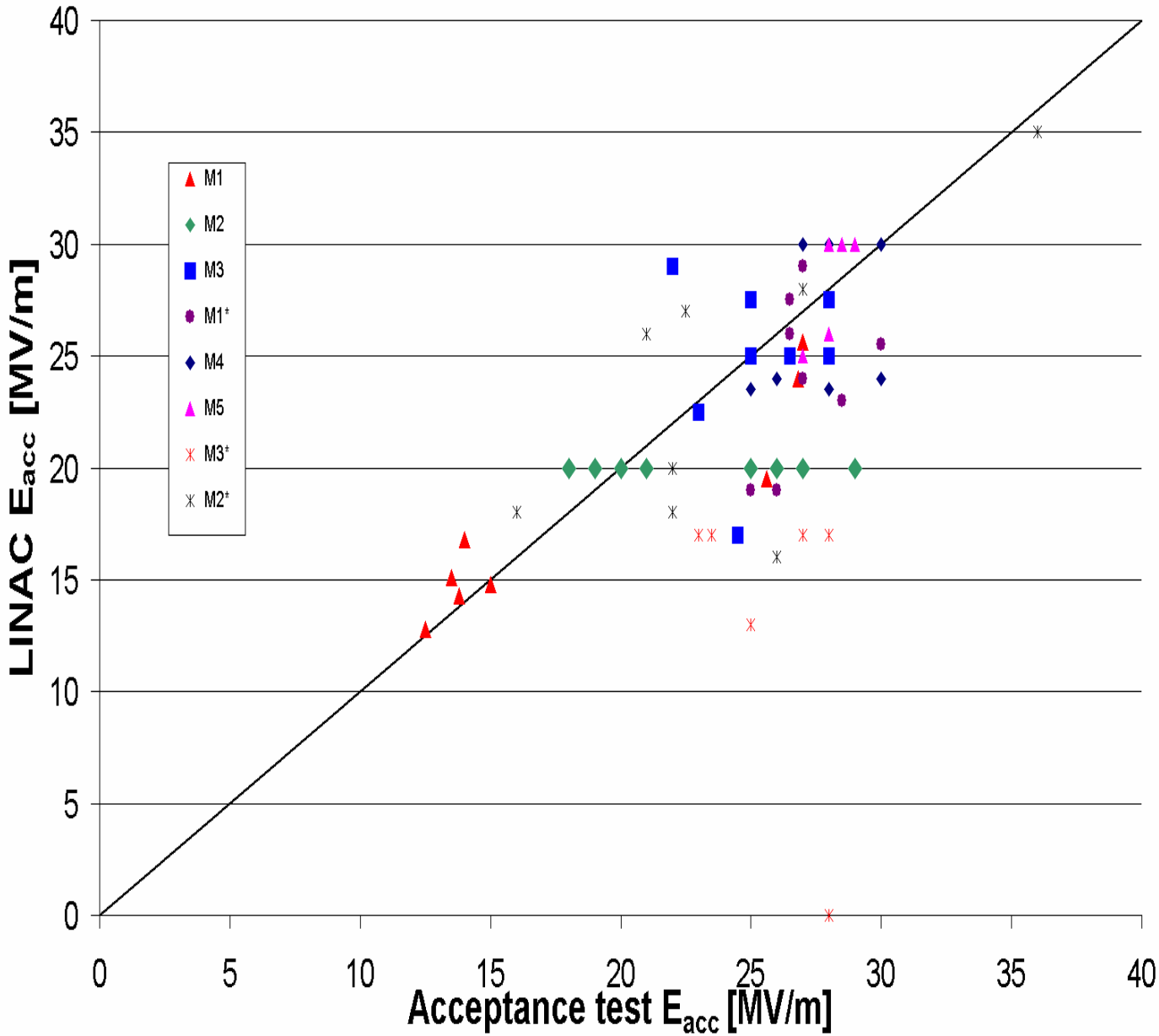
- Electropolishing delivers higher gradients
  - Potentially can avoid 1400°C treatment
- DESY EP system runs smoothly
  - After start-up problems (sensors, wear on rotary seals, etc)
- A full process is not yet as reproducible as etching (to achieve 35 MV/m)
  - Need for example different way for tank welding to avoid new surface preparation after weld
  - Mainly field emission problems
    - Last year several problems with HPR system

Assembly of cavities into modules

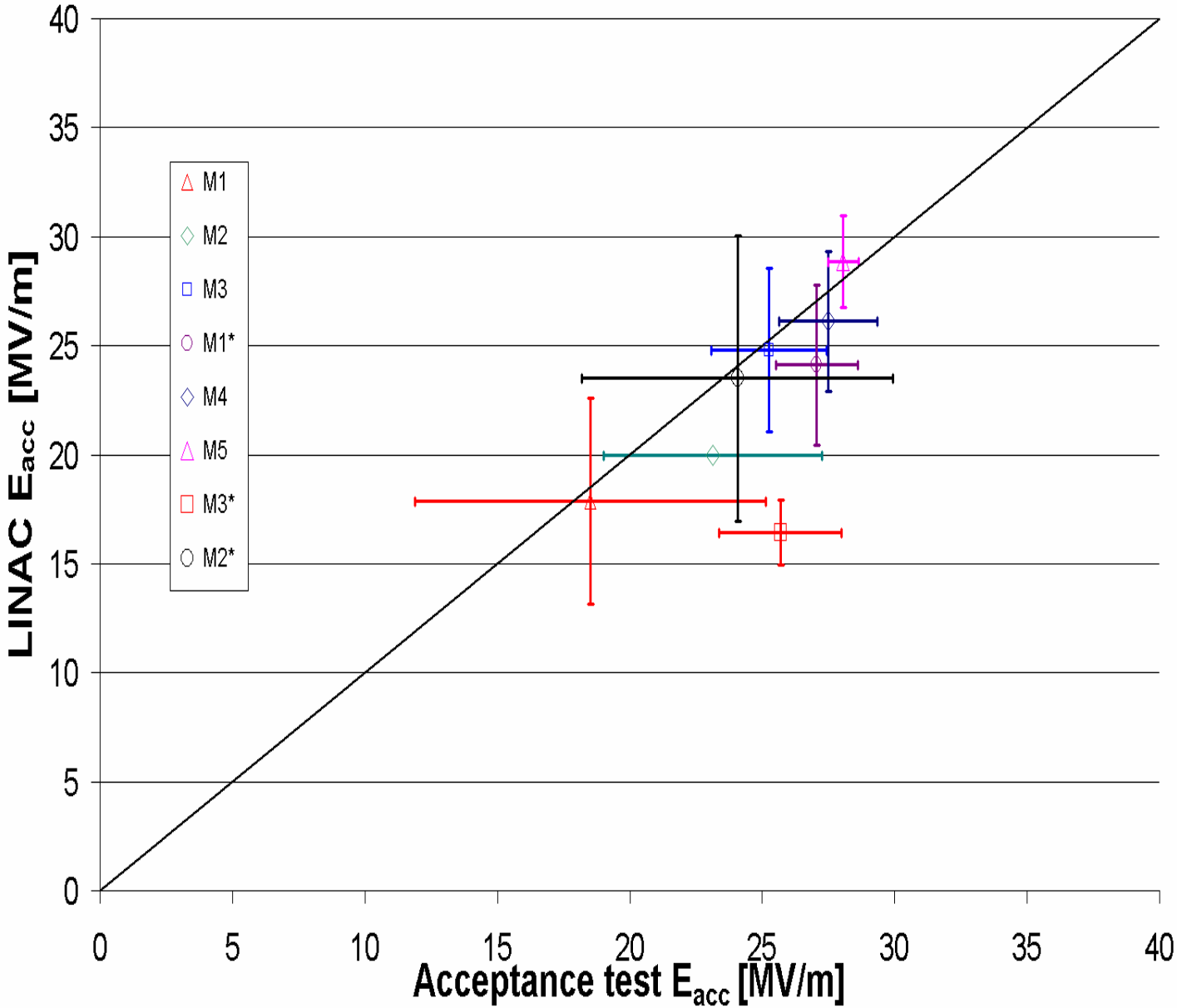
- Slightly off-topic, see WG3
- Results from best performance vertical test vs. Quench/Power limit in the machine

LINAC vs. Vertical (Individual Cavities)

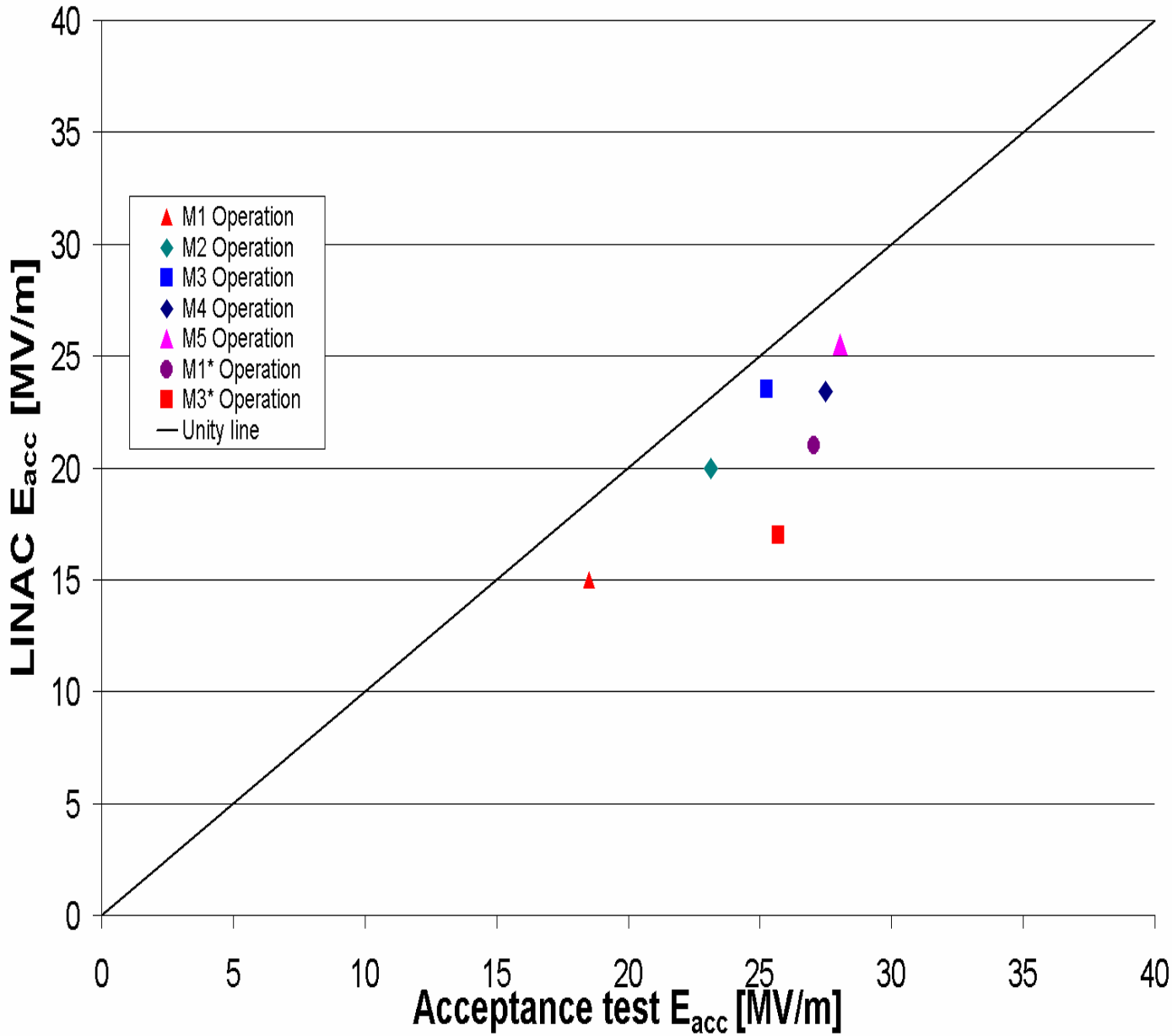
- Some cavities power limited
  - Esp. M5
- Coupler limited
  - M2
  - M4/C3
- Only module measurement available
  - M2



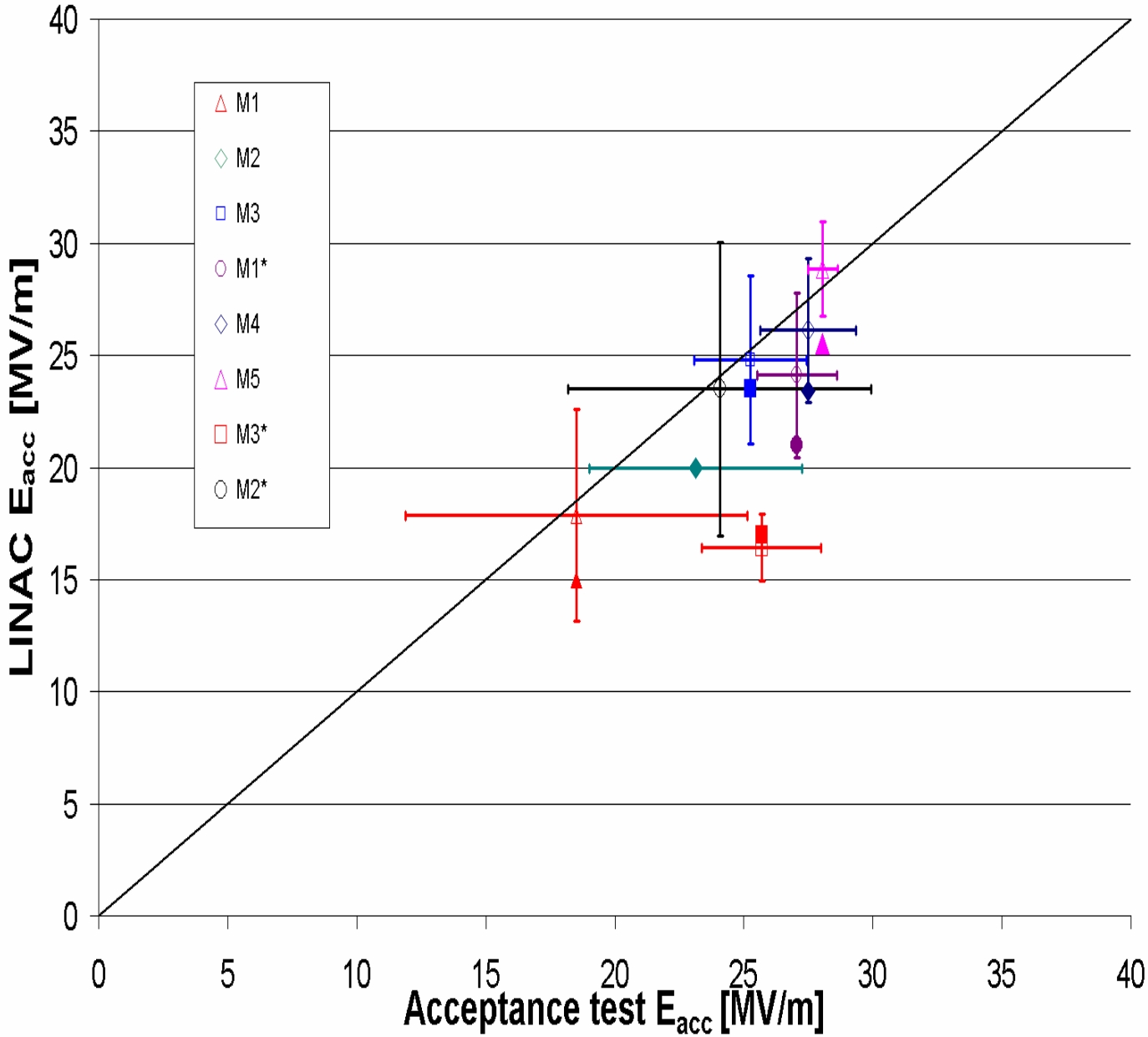
LINAC vs. Vertical (Cavity Average Gradients)



LINAC vs. Vertical (Module Max. Operational Gradient)



LINAC vs. Vertical (Cavity Average and Module Max. Operational)



Comments on module assembly

- Discussion in WG3!
- Cavity performance can detoriate
  - Sometimes this can be unterstood
- Detailed analysis of assembly protocols is underway – stay tuned!

TTF Cavity Preparation Review

- What is needed?
  - More reproducible EP results
  - How can one reduce field emission reliably?
    - Are there other, better cleaning methods?
- Development of better quality control measures for all processes
  - Further improve monitoring of process parameters (esp. High-pressure rinsing system)