Cavity Productions at DESY

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-MPY-

FNAL

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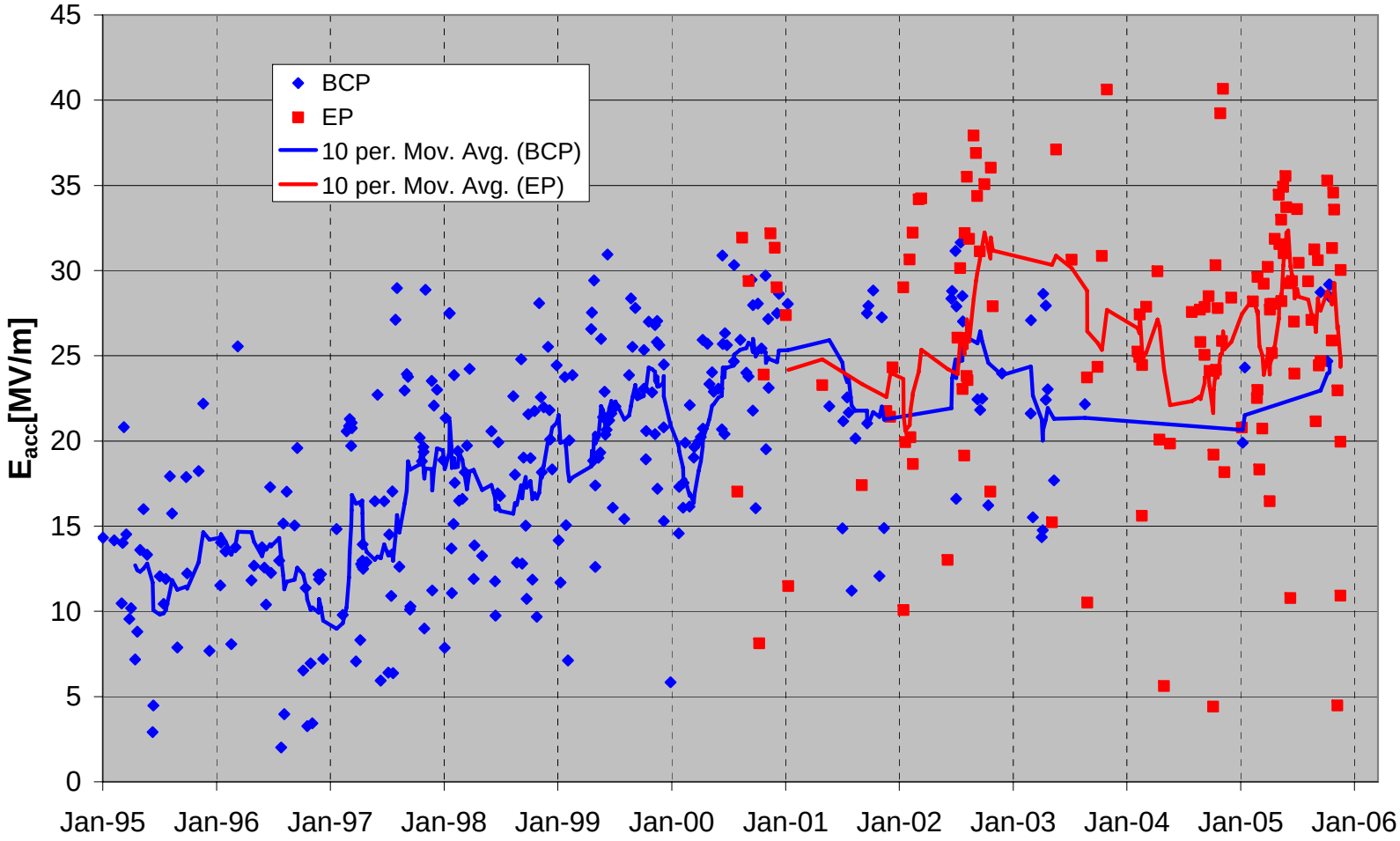
- Overview on the cavity productions
- Review of cavity performance
- Some conclusions from the TTF cavity program

Main Question:

- Was it an error to present this plot???? **NO!**



TTF Cavity Production History

- But there is a caveat:
  - The plot shown before needs a good deal of explanation
- Several parameters have changed over the time of 10 years e.g.
  - Niobium material
  - Cavity manufacturer
  - Cavity design
    - Flange system
    - French HOM
  - Surface preparation
- I will take you on a short tour!

TTF Cavity productions

- Since 1995 TTF 4 cavity productions have been made
  - 27-30 cavities each
  - 5th Production is being ordered
  - Two other batches: Alan Schwettman (5) and FZ Rossendorf (6)
  - Not tested yet: Large grain cavities (AC112-AC114)
- Total of more than 100 cavities has been tested
- Preparation facility was laid out for something like 30 cavities
- Several improvements/changes were made

Analysis

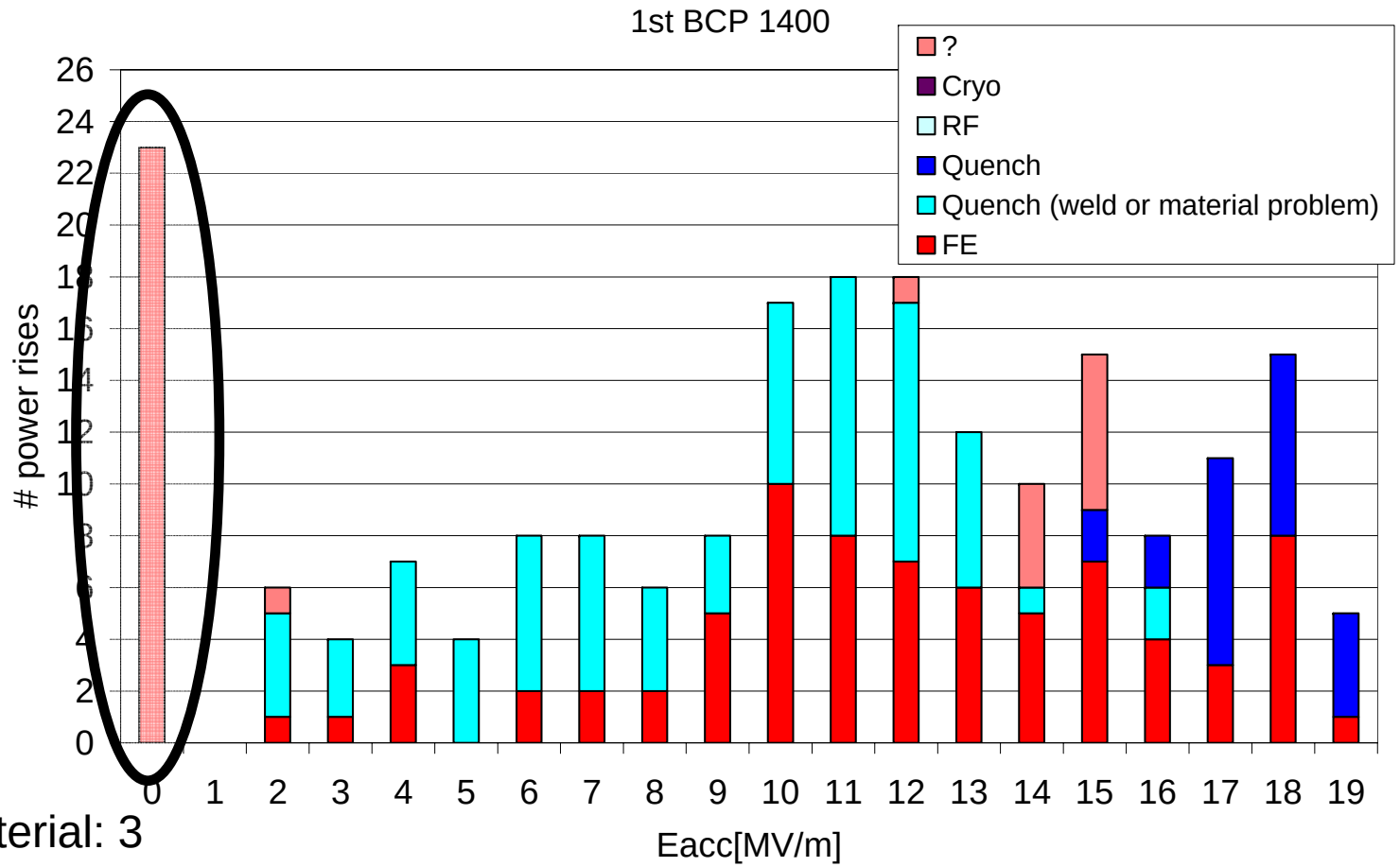
1st Production

- Cavities: 26
- Manufacturer(s):
  - Dornier: D1-D6
  - Accel (Ex-Siemens): S7-S12
  - Ansaldo/Zanon: A13-A18
  - CERCA (Framatome): C19,C21-C27
- Niobium Material:
  - Not eddy-current scanned
- Main Production/Preparation Steps:
  - Etching (BCP) + 1400° C Titanisation

1st Production - Main Problems:

Needs more evaluation:

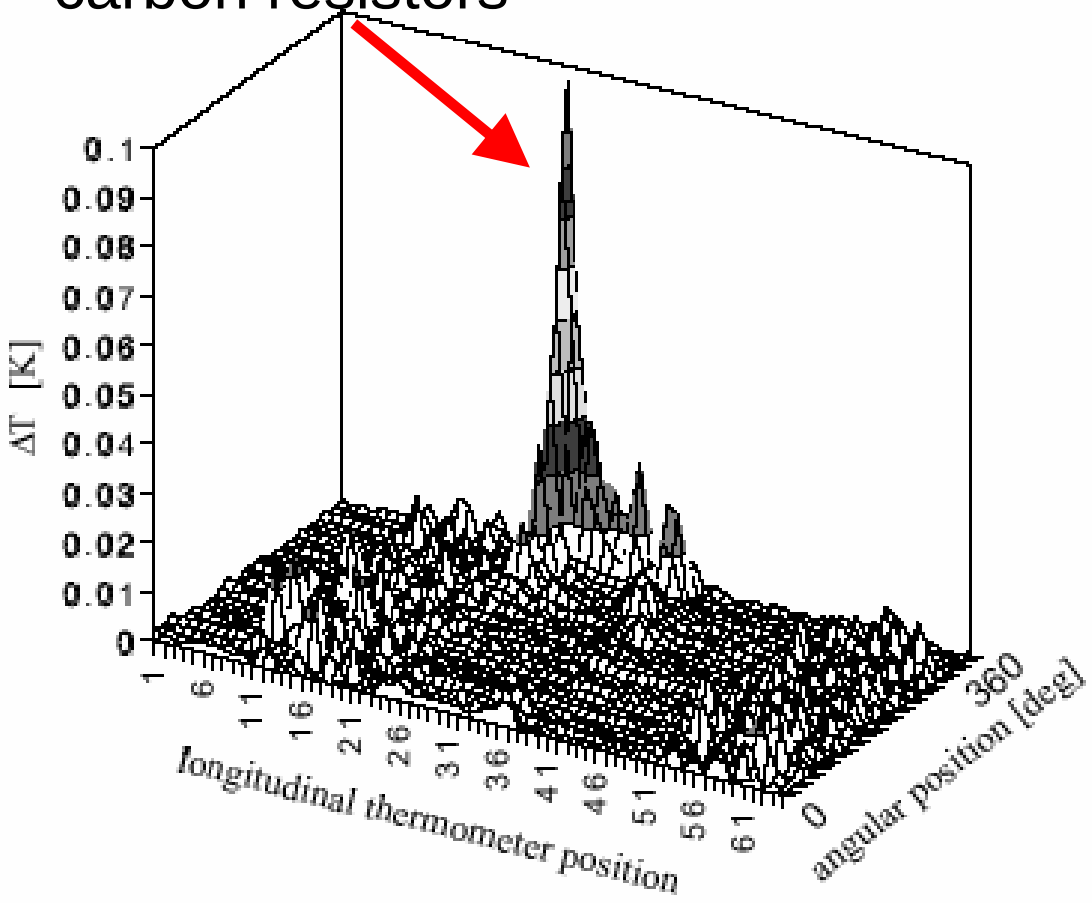
Defintely a lot of test stand problems(RF)!



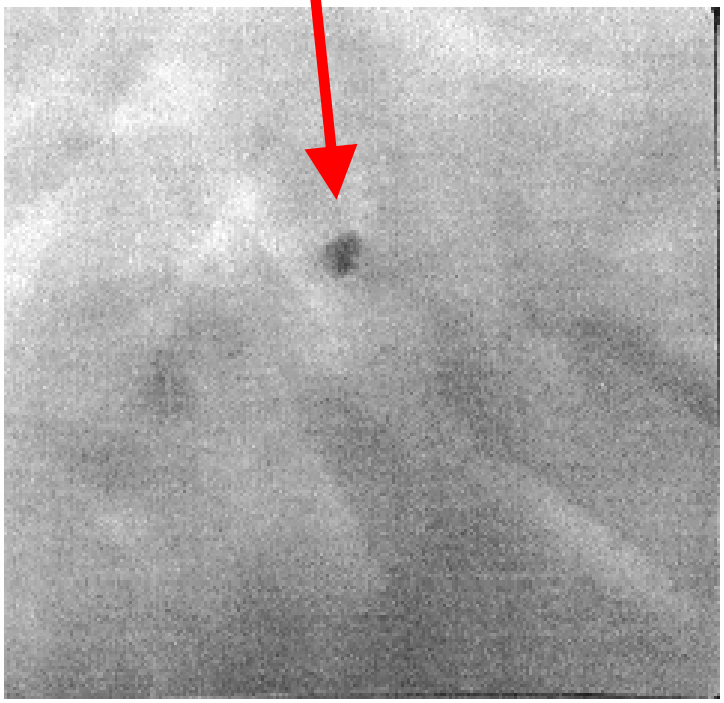
- Field emission
- Defects
  - Niobium material: 3
    - D6 (Tantalum detected)
    - D4, D5 similar RF behaviour
  - Welding: 9
    - S7-S12 (weld preparation)
    - A13,A14 (weld procedure)
    - C22 (hole reparired)
    - (C20 never really existe, massive weld problem)

Example Of A Material Defect

Heating on the outside surface measured with carbon resistors

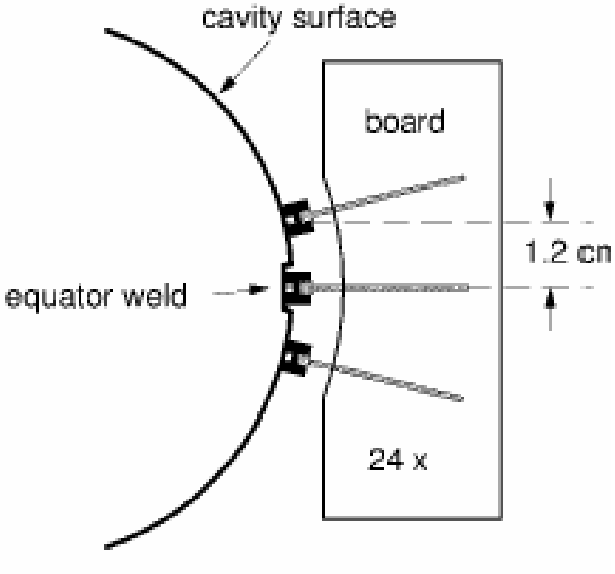


Defect found with X-ray technique: Tantalum



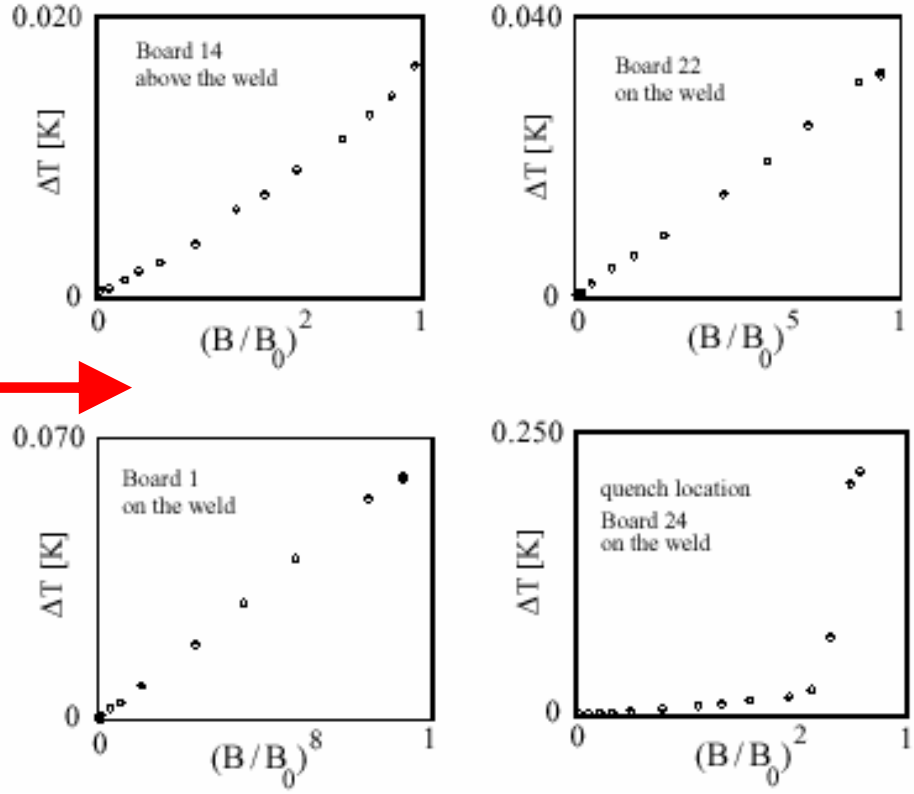
Imperfect Equator Welds

Temperature mapping of the equator region

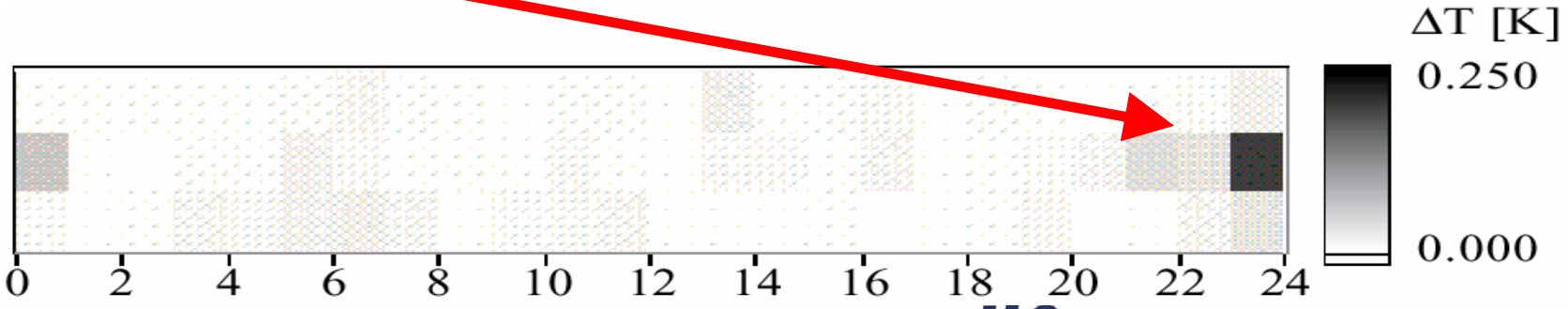


Thermometer response:

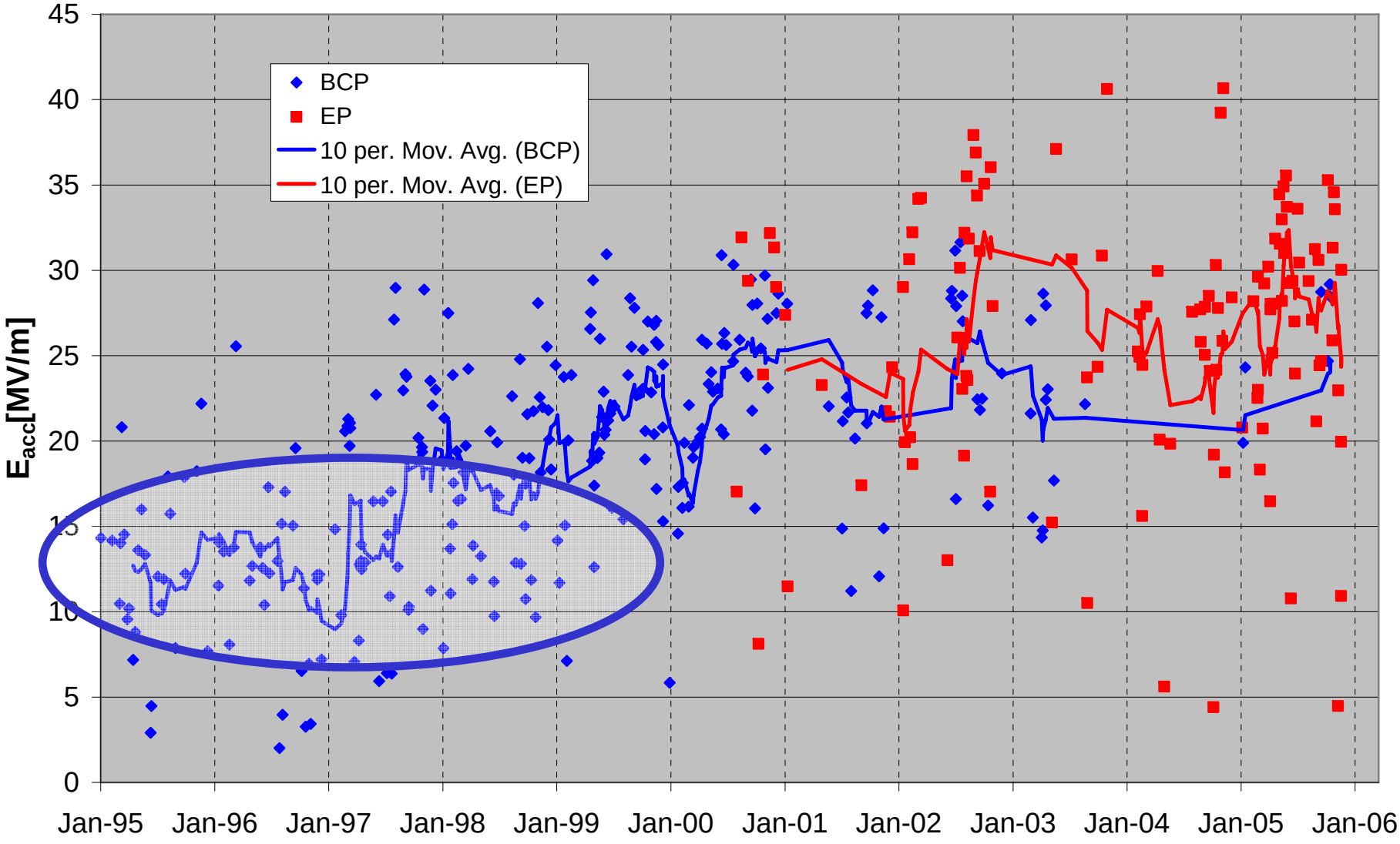
$\Delta T \sim B^2 - B^8$



Heating on the equator

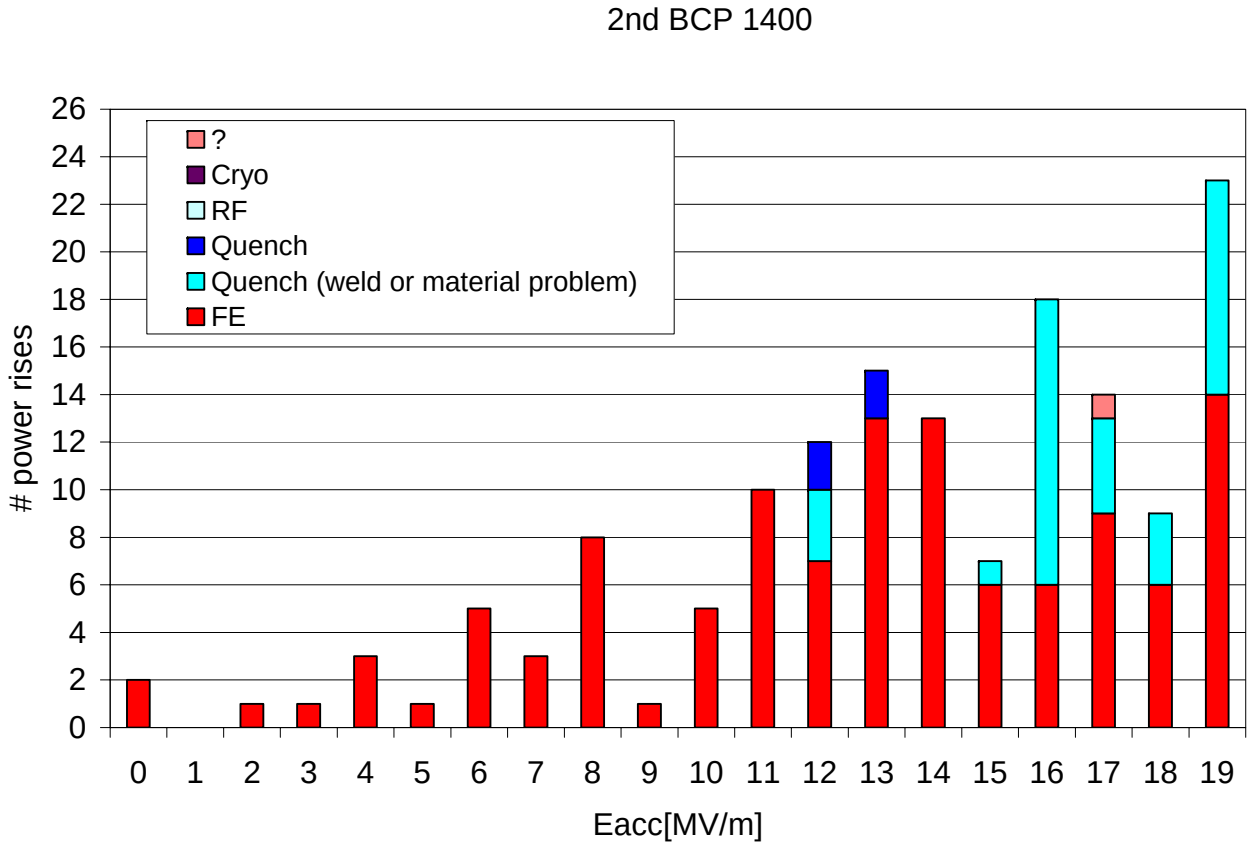


You are here!


BCP
EP
10 per. Mov. Avg. (BCP)
10 per. Mov. Avg. (EP)
E_{acc}[MV/m]
45
40
35
30
25
20
15
10
5
0
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06

2nd Production

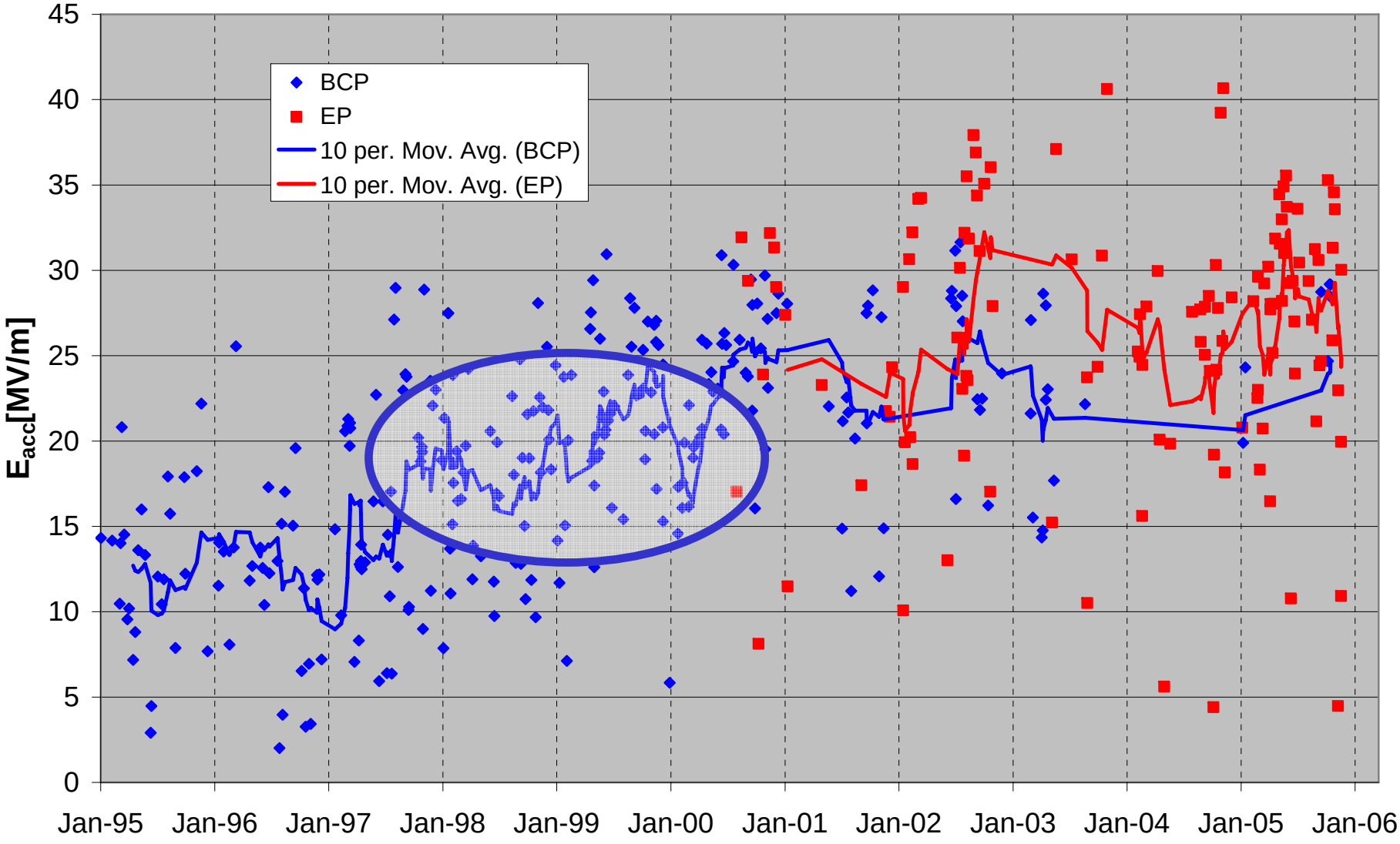
- Cavities: 27
- Manufacturer(s):
  - Accel (Ex-Siemens): S28-S36
  - Dornier: D37-D42
  - CERCA (Framatome): C43-C48
  - Zanon: Z49-Z54
- Niobium Material:
  - Eddy-current scanned
    - 2nd gen. scanning XY-table
  - Tokio Denkai (RRR=200) without protection of rollers from Iron particles
  - Cabot not qualified with cavities
- Main Production/Preparation Steps:
  - Etching (BCP) + 1400°C Titanisation



- Field emission
- Defects
  - Niobium material: 6
    - Cabot: Z49-Z52, Z54
    - Tokio Denkai: Z53?
  - Repaired Weld: 1
    - C43
    - No cleanroom for weld preparation: Z cavities

2nd Production - Main Problems:

You are here!


BCP
EP
10 per. Mov. Avg. (BCP)
10 per. Mov. Avg. (EP)
E_{acc}[MV/m]
0
5
10
15
20
25
30
35
40
45
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06

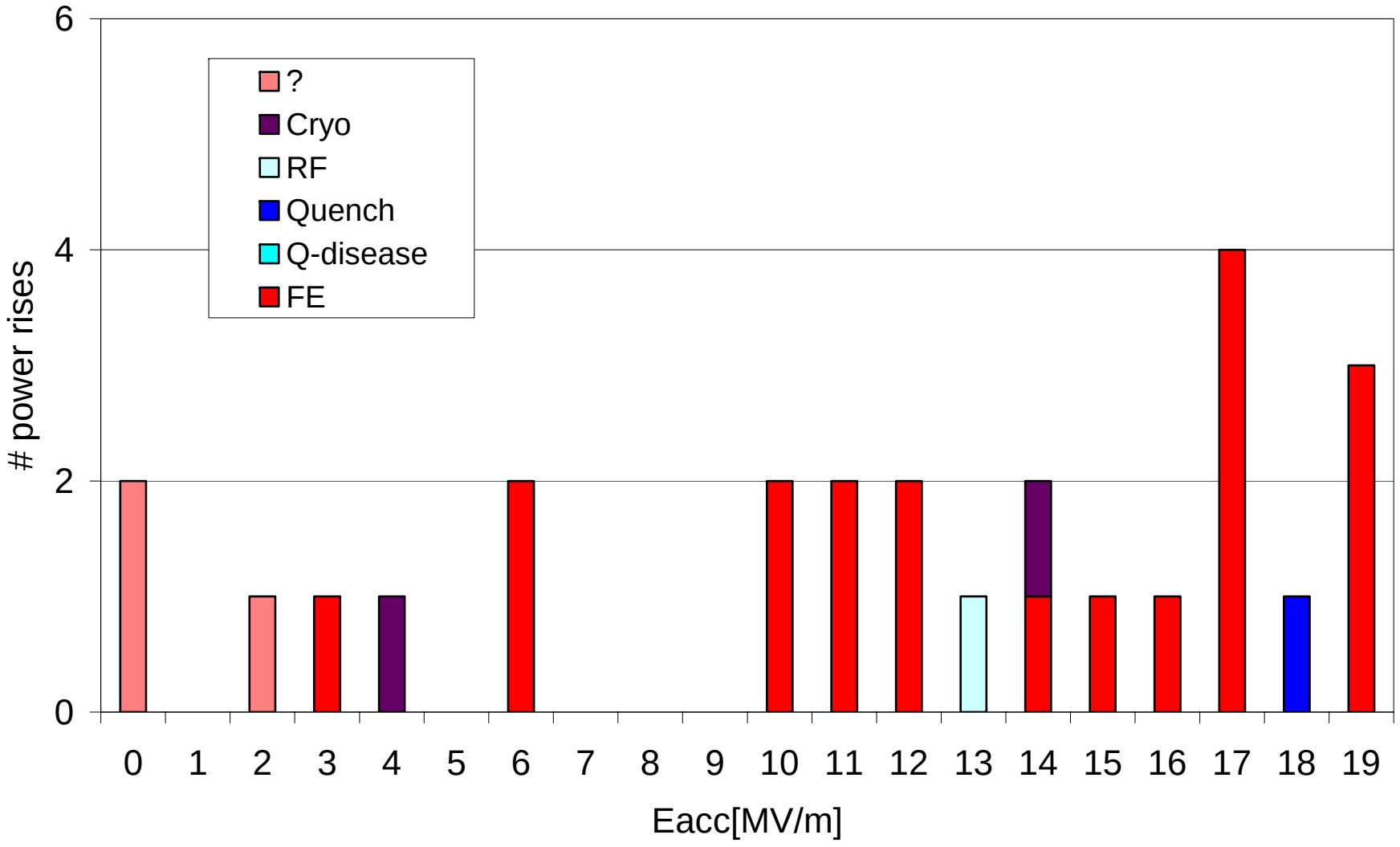
3rd Production

- Cavities: 27 (+6)
- Manufacturer(s):
  - Accel : AC55-AC81 (+ R1-R6)
- Niobium Material:
  - Heraeus + Wah Chang
  - (R: Heraeus+ Wah Chang different batch, material was sorted out from DESY production)
  - Eddy-current scanned
    - 3rd generation turntable
- Main Production/Preparation Steps:
  - BCP batch: 16 (+ 6) cavities
    - Etching (BCP) + 1400°C
  - EP batch: 11 cavities
    - EP at KEK: mix of 1400C and 800C cavities
    - As most (not alll) cavities have shown fieldemssion several steps were done:
      - Short etch, A lot of HPR, eventually DESY-EP, re-etch

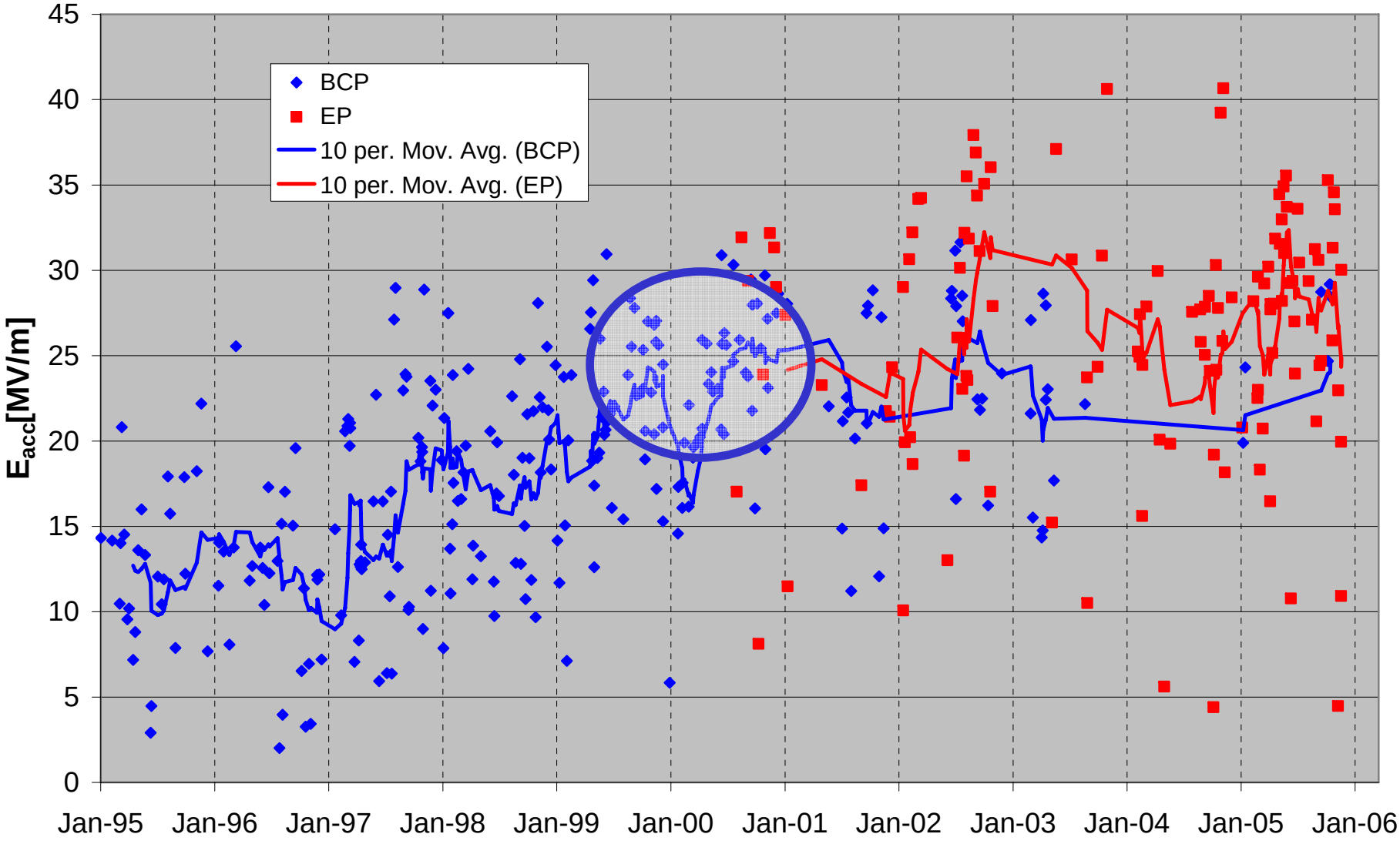
3rd Production -Main Problems:

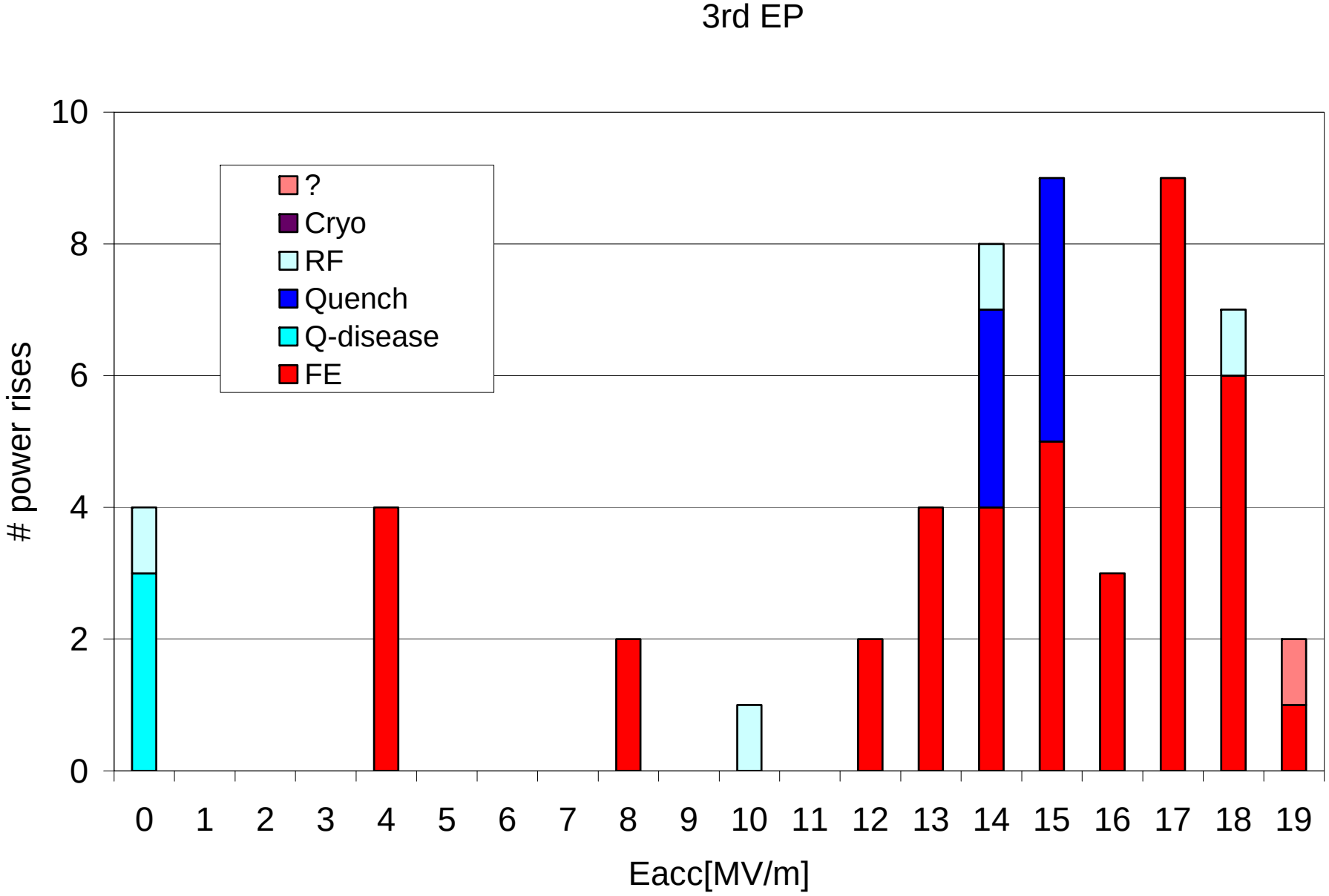
- Field emission
  - Both batches suffered from this
- Defects
  - BCP Batch
    - Cold leak
      - » AC63
  - EP batch
    - Q-disease
      - » AC71, AC80
    - Accidents:
      - » newly revised tank welding procedure was implemented
    - Used to setup DESY EP facility

3rd BCP 1400

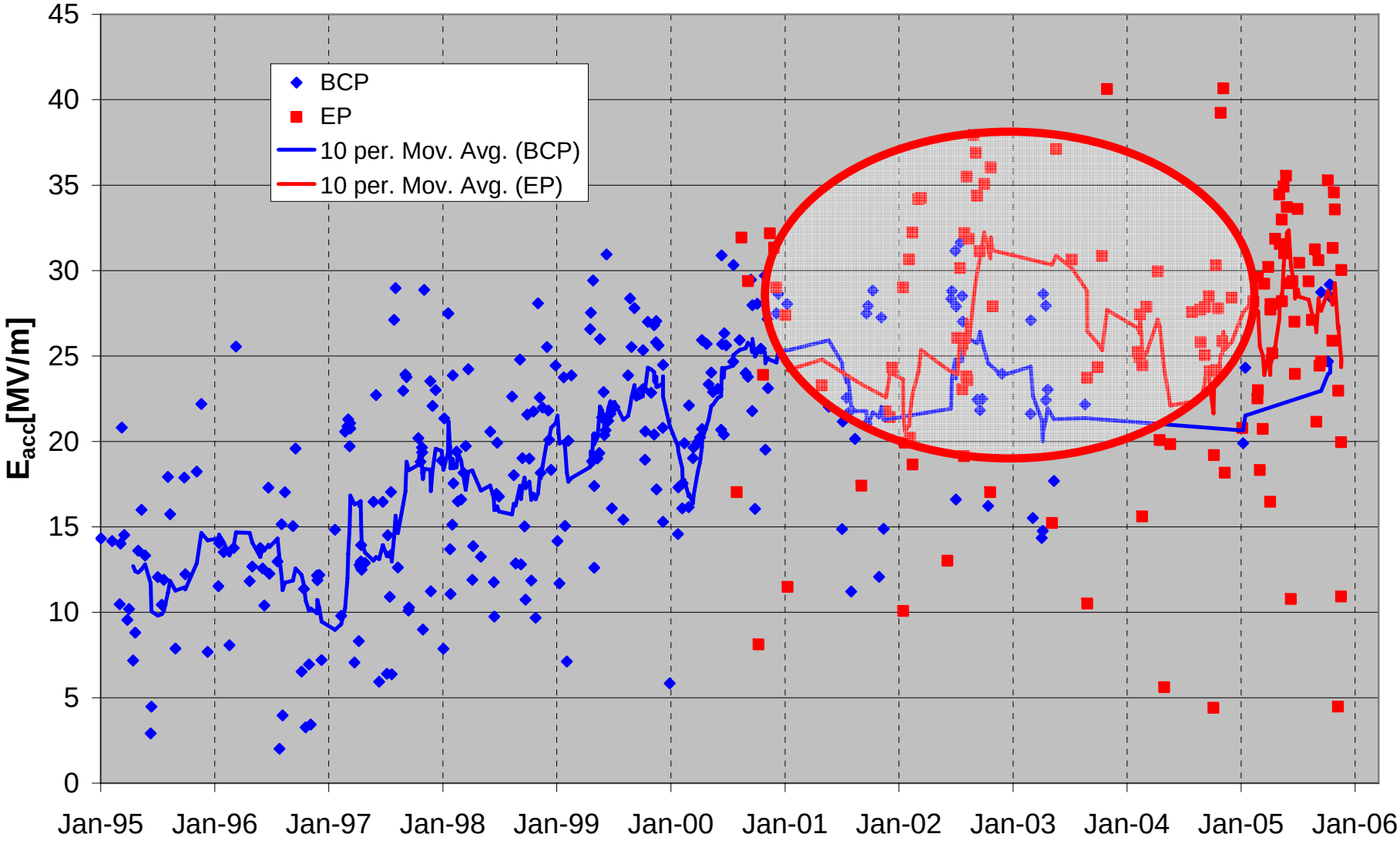

6
4
2
0
power rises
?
Cryo
RF
Quench
Q-disease
FE
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
Eacc[MV/m]

You are here …


BCP
EP
10 per. Mov. Avg. (BCP)
10 per. Mov. Avg. (EP)
E_{acc}[MV/m]
0
5
10
15
20
25
30
35
40
45
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06


3rd EP
power rises
Eacc[MV/m]
?
Cryo
RF
Quench
Q-disease
FE
0
2
4
6
8
10
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19

… and here!


BCP
EP
10 per. Mov. Avg. (BCP)
10 per. Mov. Avg. (EP)
E_{acc}[MV/m]
0
5
10
15
20
25
30
35
40
45
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06

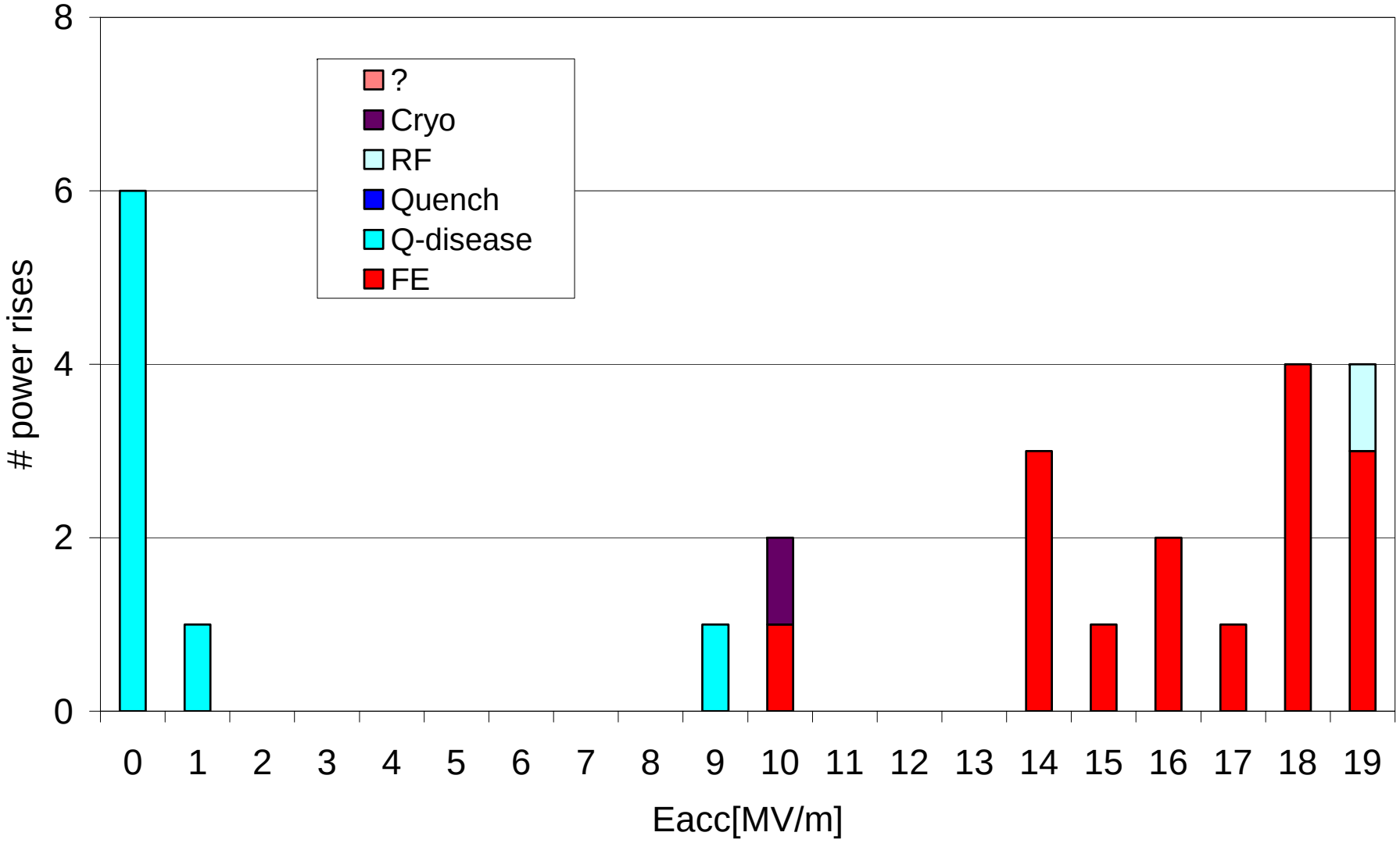
4th Production

- Cavities: 30
- Manufacturer(s):
  - Zanon: Z82-Z111
- Niobium Material:
  - WC,TD
  - Eddy-current scanned
- Main Production/Preparation Steps:
  - EP
  - Only 800C

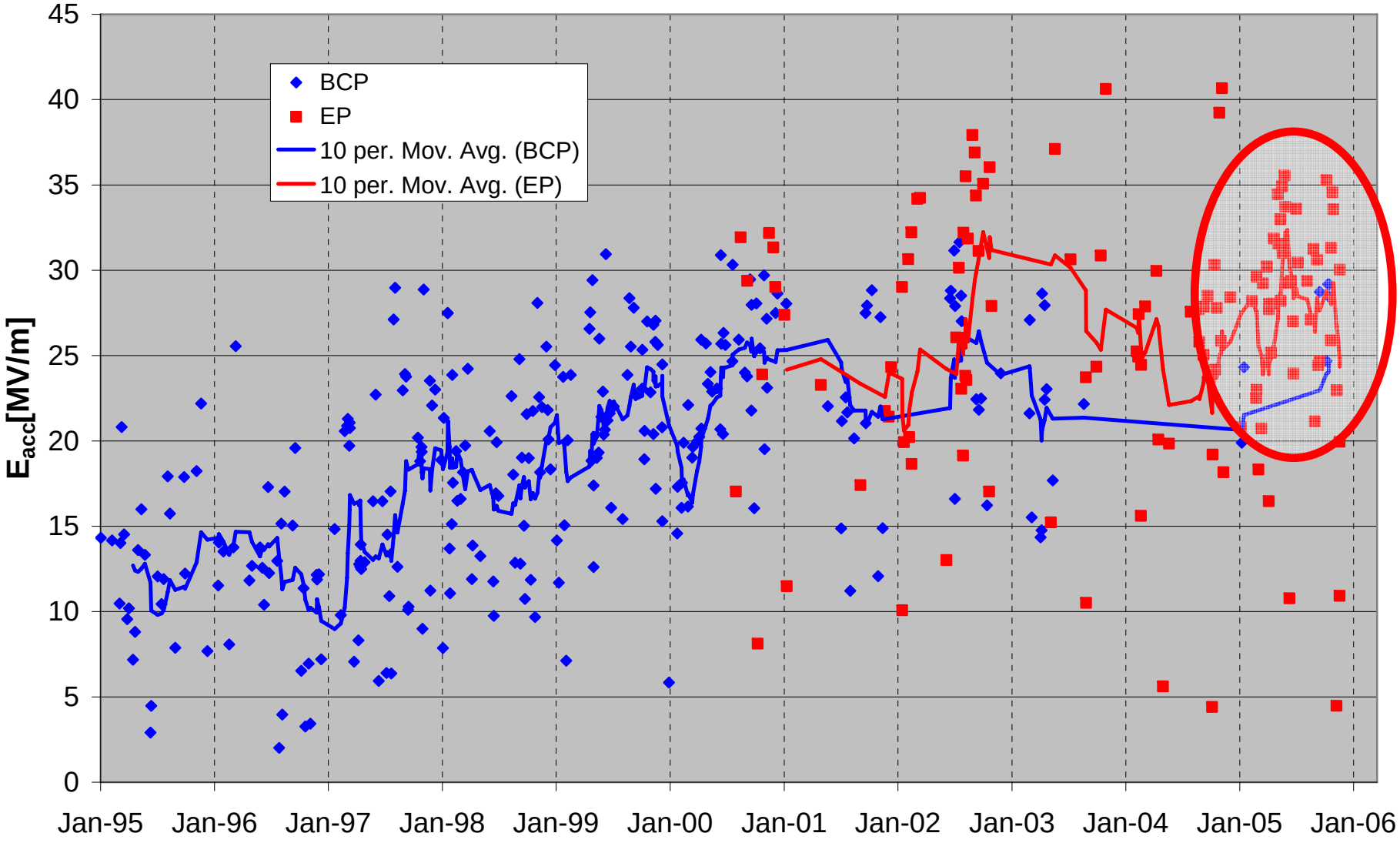
4th Production: Main Problems:

- Weld repaired
  - Z85 (T-map shows no quench at equator)
- Defects
  - Niobium material
  - Welding
    - Z82-Z84
- Q-disease
  - 2 cavities

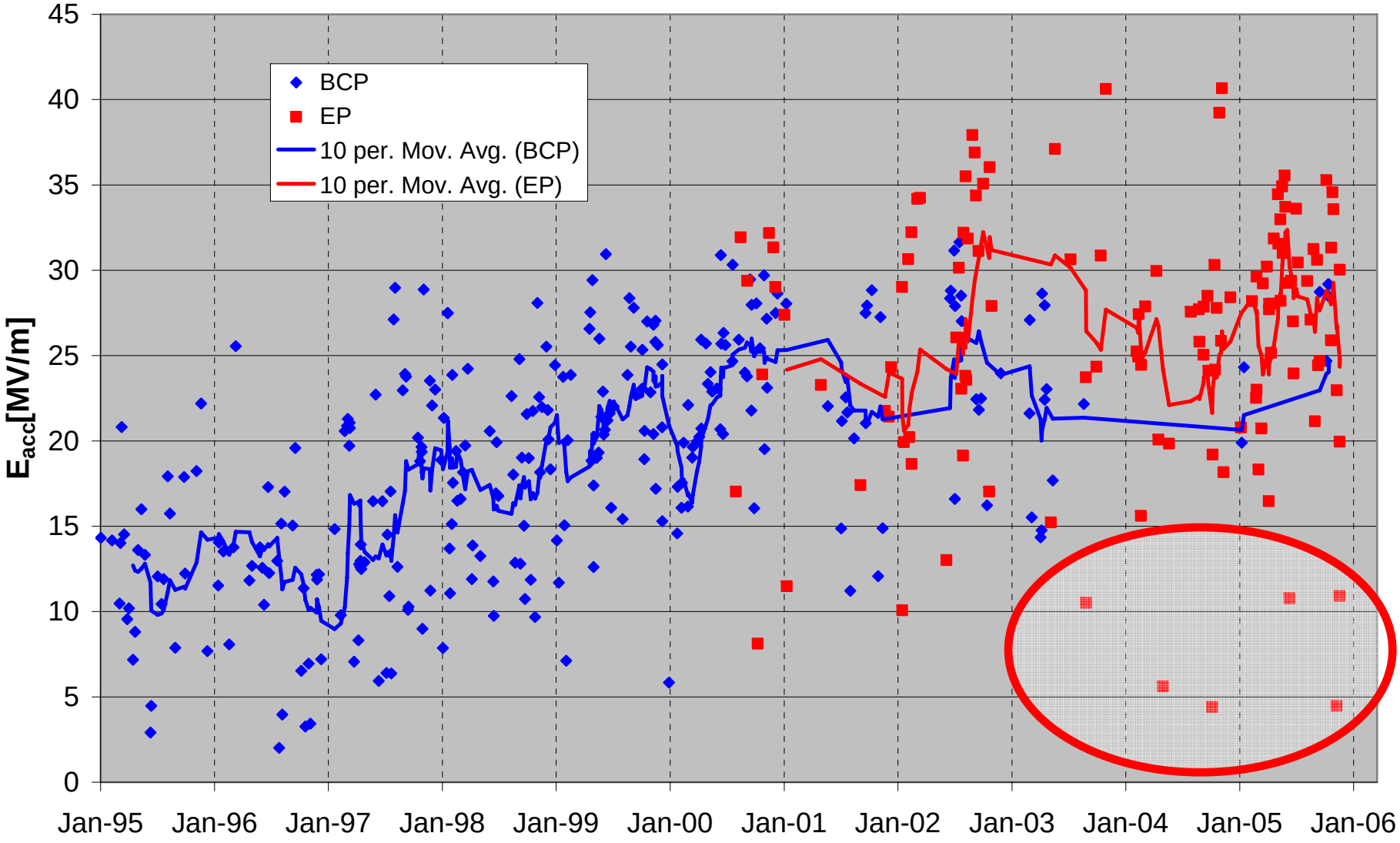
4th EP


8
6
4
2
0
power rises
?
Cryo
RF
Quench
Q-disease
FE
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
Eacc[MV/m]

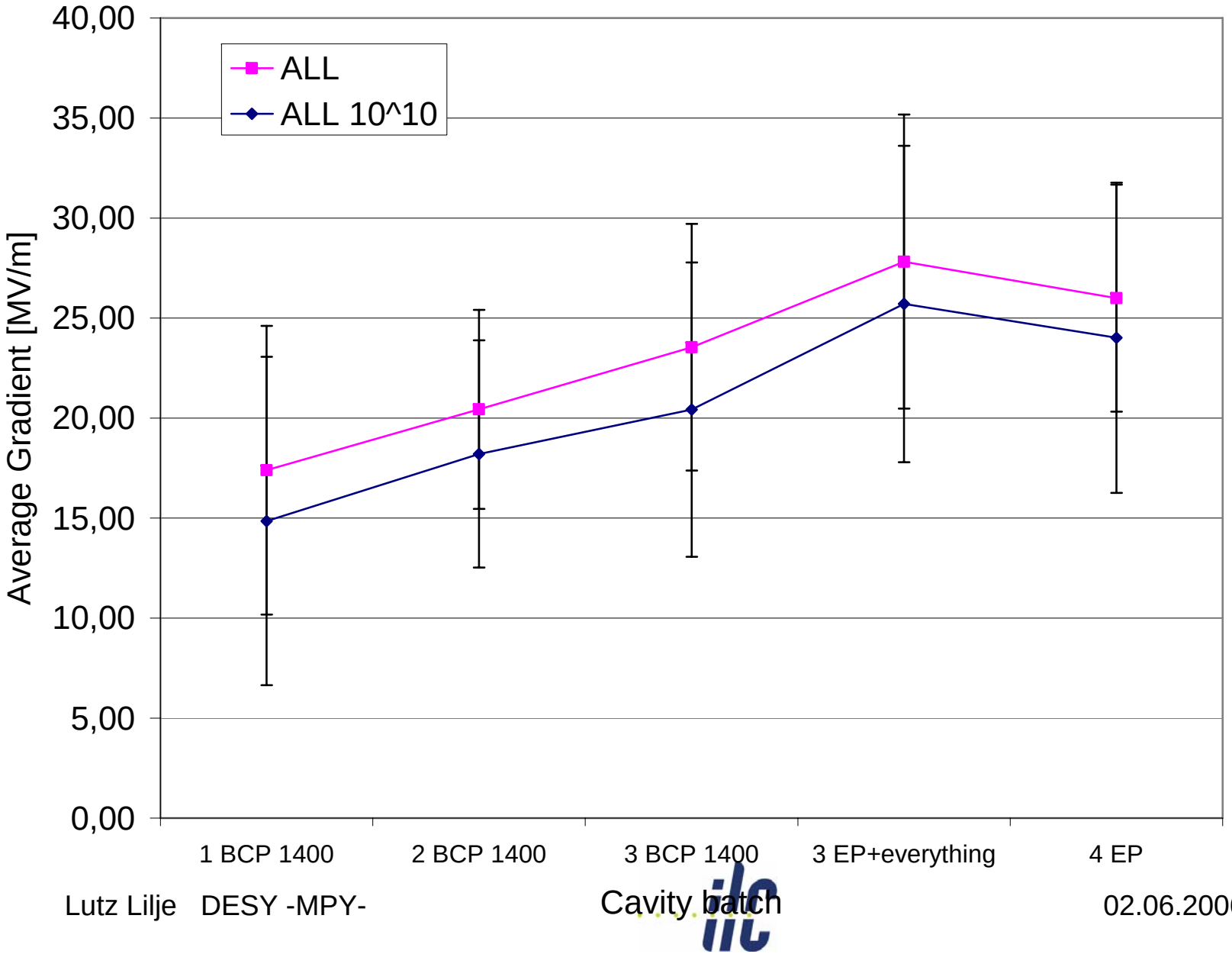
You are here!


BCP
EP
10 per. Mov. Avg. (BCP)
10 per. Mov. Avg. (EP)
E_{acc}[MV/m]
0
5
10
15
20
25
30
35
40
45
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
Jan-06

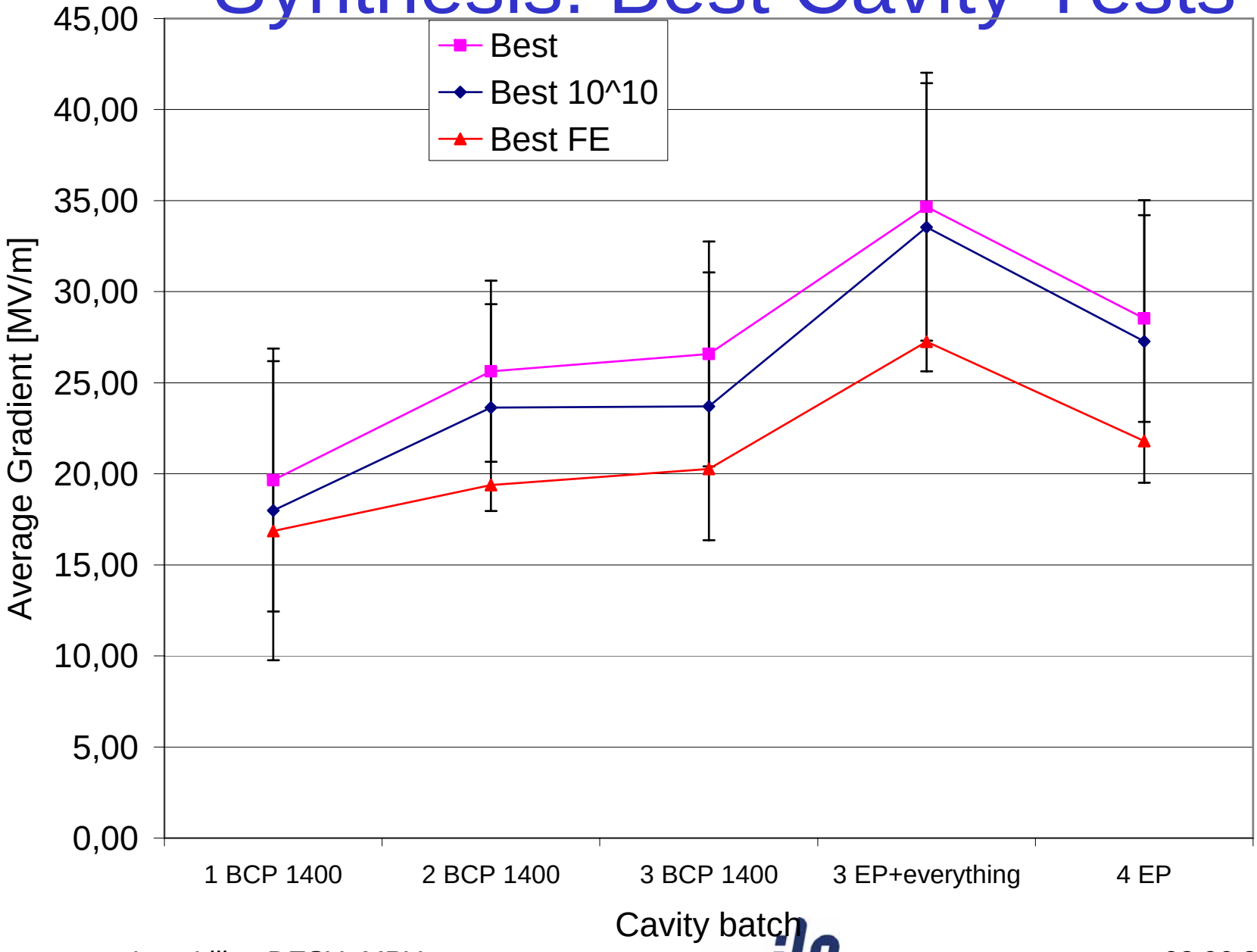
Q-disease is here!



Synthesis: All Cavity Tests



Synthesis: Best Cavity Tests



Synthesis

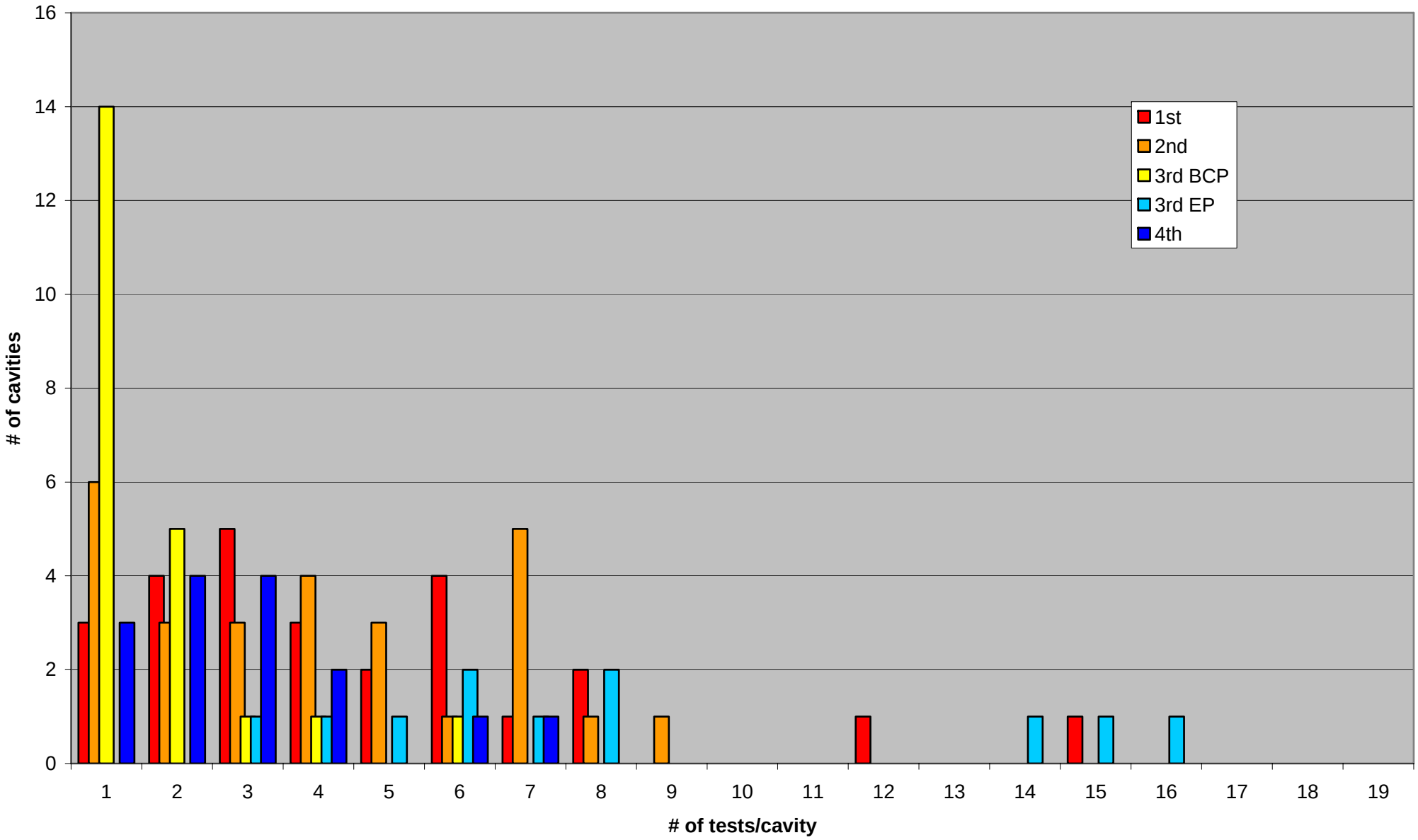
- Field emission is a major problem
  - It is a statistical effect and a large sample needs to looked at
    - this is due to what ever distribution of particles is in your system
  - Single-cell tests do not help here too much
    - You have to work on the real cavity
  - Other effects are shadowed by FE
    - e.g. is the material a problem above say 30 MV/m? Maybe not..
- Q-disease is so far a DESY problem but….
  - … other people have not looked systematically.
    - Some tests (~10) at KEK: all negative.
    - Tests at DESY: ~ 10 % have shown Q-disease
      - One cavity
      - One batch of acid
      - 1-2 tests cannot be explained

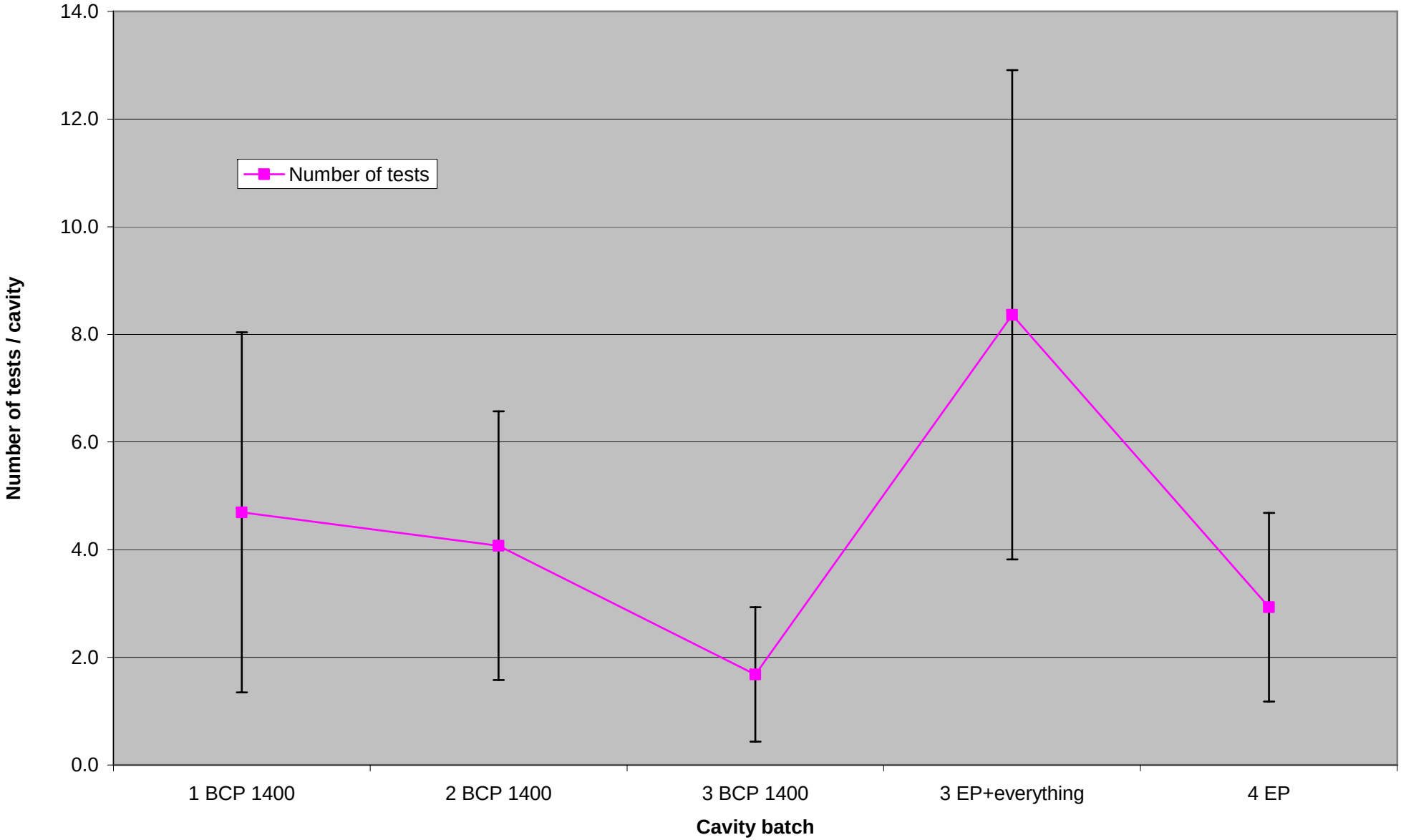
Cavity testing

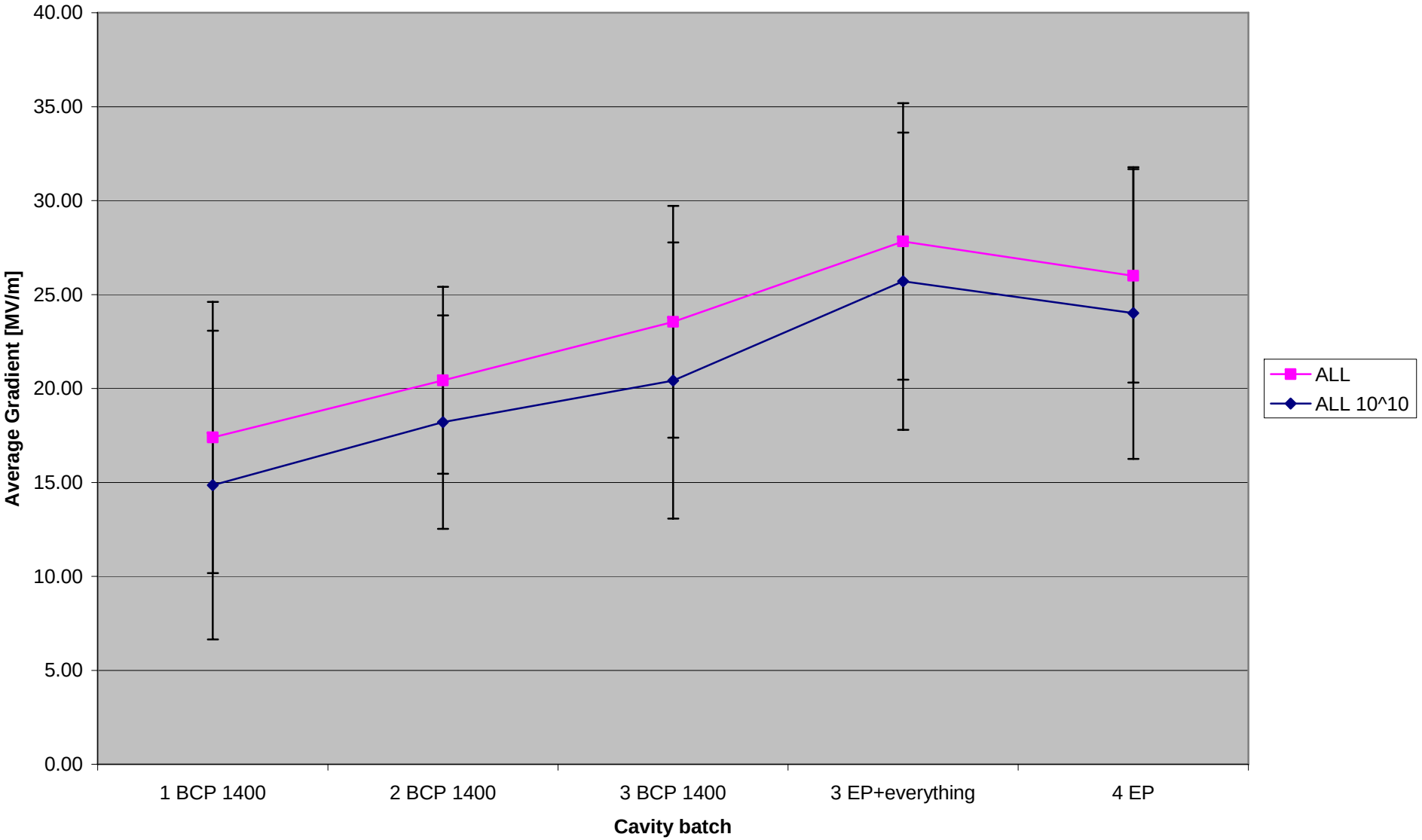
- To find put this information out of a cavity batch systematic testing of multi-cells is needed
  - Diagnostics needed to qualify vendors (Temperature mapping)
    - This also needs to be improved at DESY….
  - Tests on Q-disease are needed on each EP cavity
    - Need to understand whether this is a local problem (I fear not)
  - Tests of the full passband are useful to enhance statistics
    - …provided the field flatness of the cavity is correctly tuned!
  - For ILC a minimum requirement for a multi-cell test should be defined

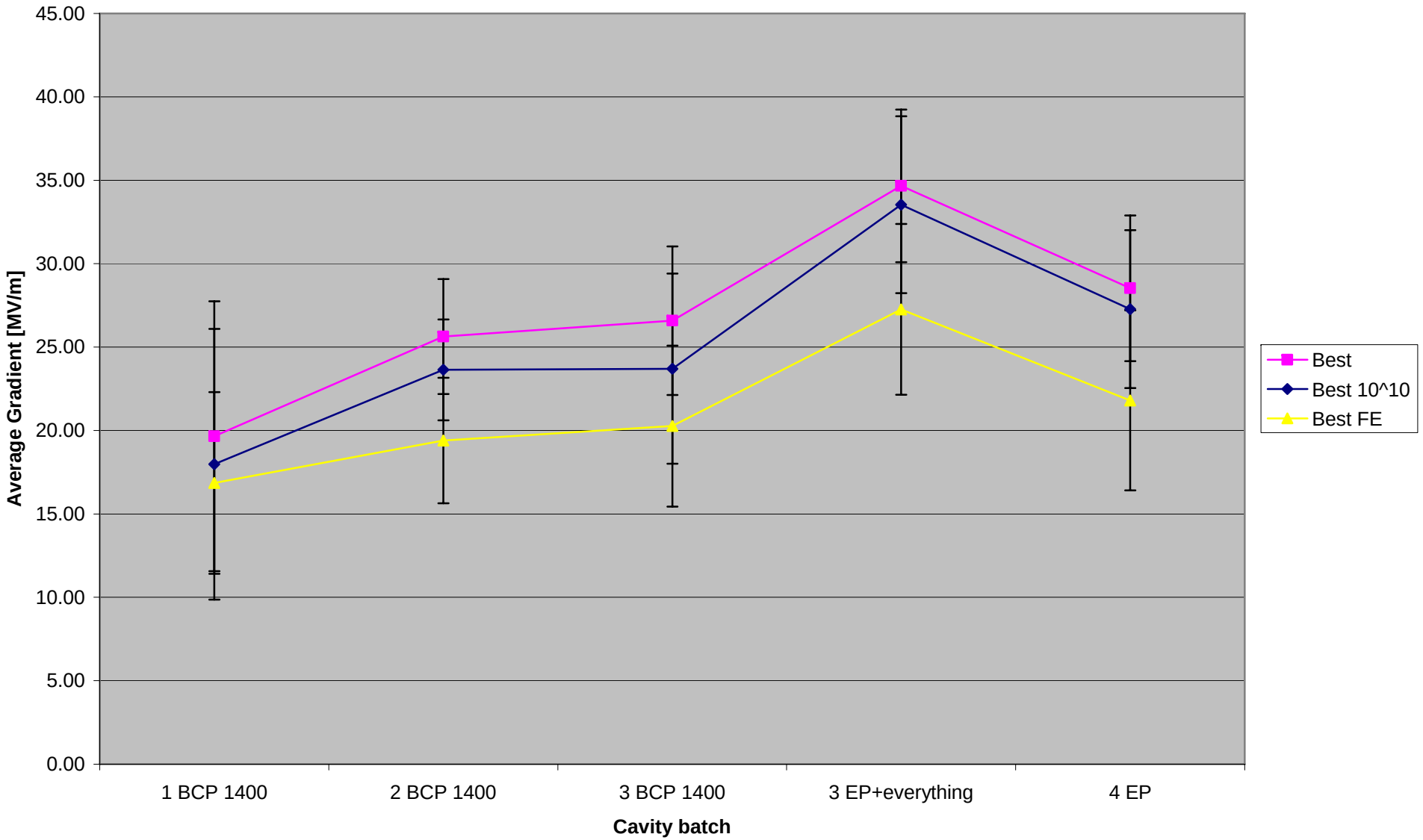
Conclusion

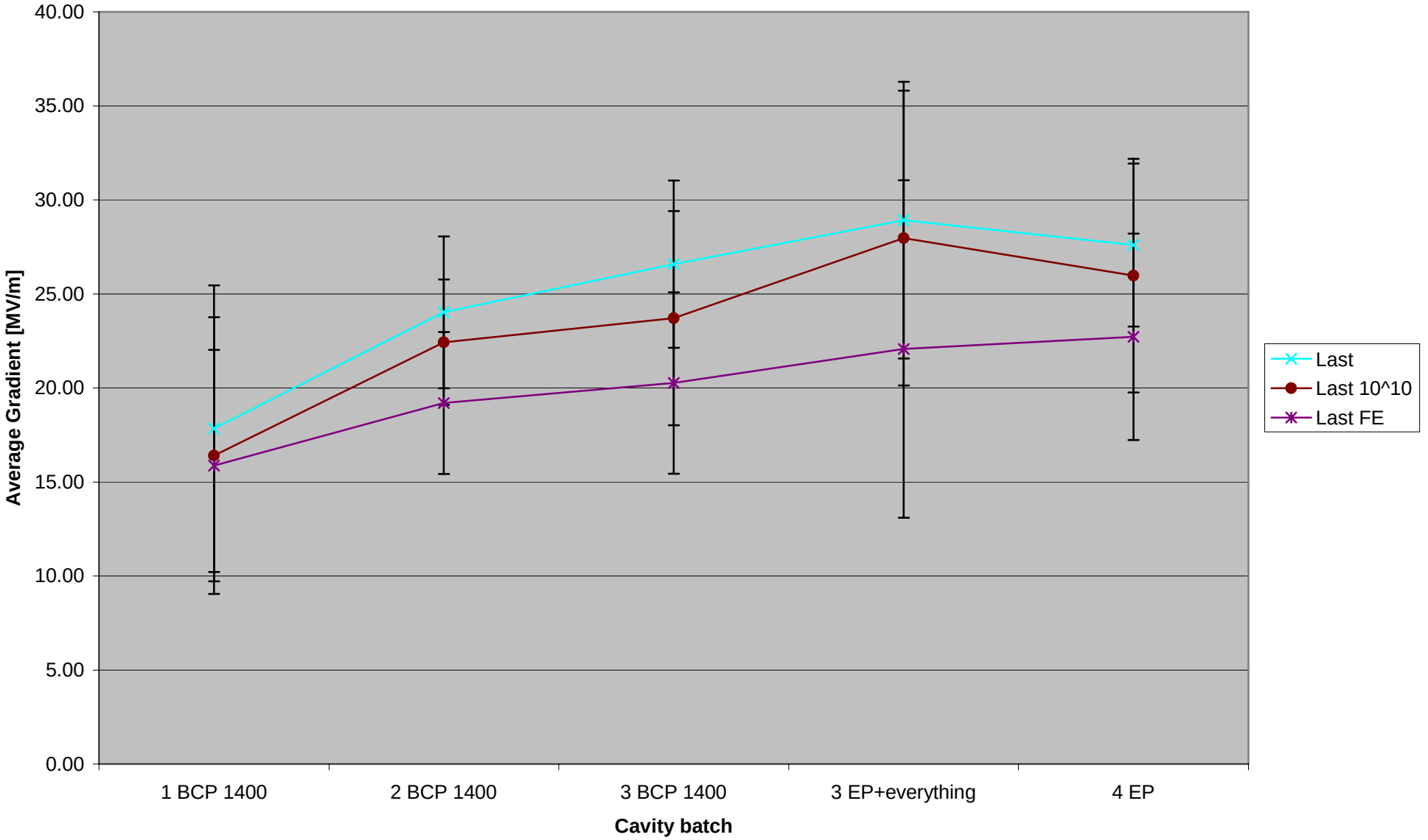
- Vertical test results scatter significantly already
  - This needs improvement!
- Although field emission levels are slowly increasing, this is the major source of scatter.
  - Unfortunately, it also shadows other effects
- It is necessary to:
  - Test a large batch of cavities
    - Field emission is a statistical problem!
    - Other parameters will inevitably vary (cavity vendors)
  - Define coherent test procedures
    - E.g passband measurement, Q-disease test
    - Diagnostics

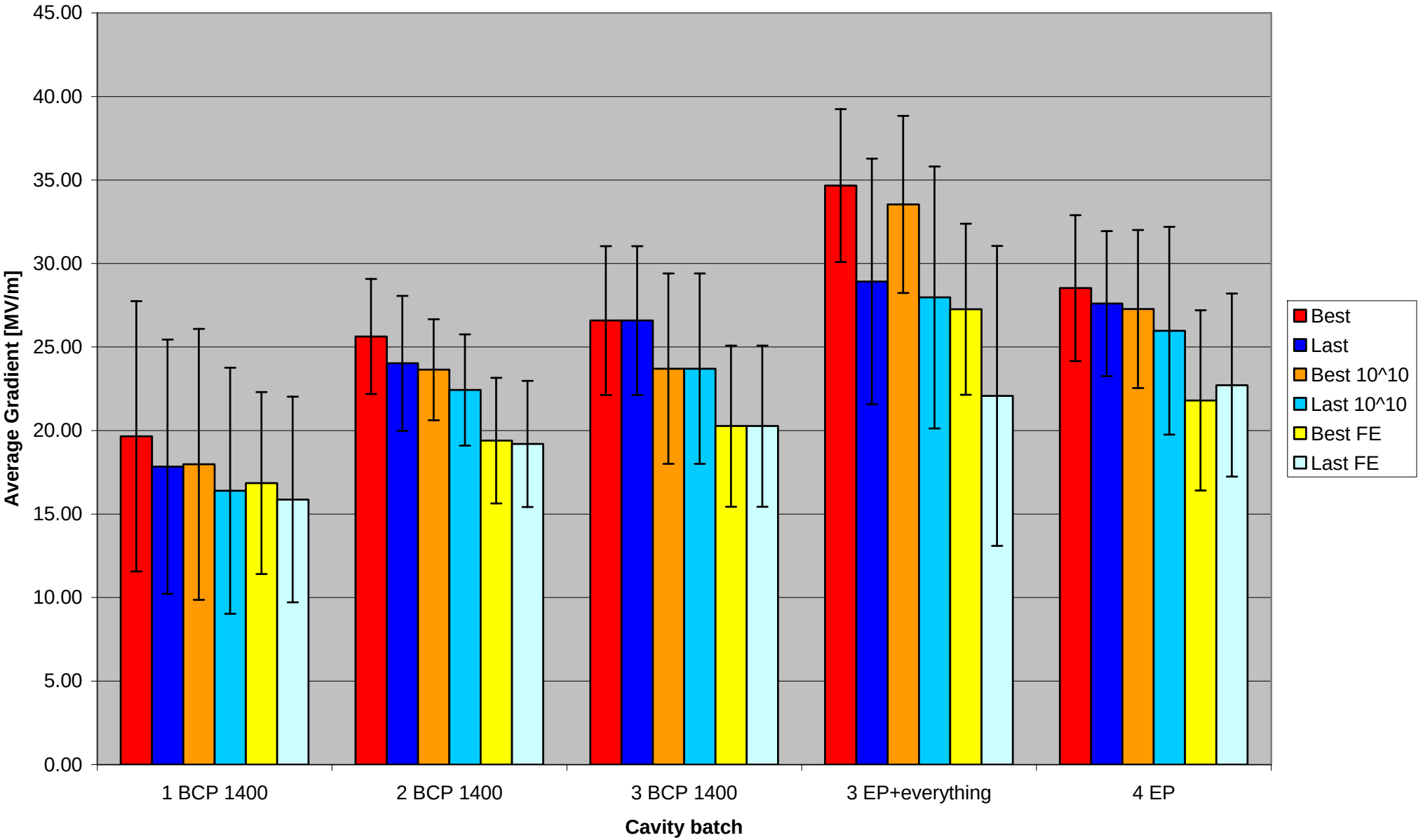

16
14
12
10
8
6
4
2
0
# of cavities
1st
2nd
3rd BCP
3rd EP
4th
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
# of tests/cavity


14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Number of tests / cavity
Number of tests
1 BCP 1400
2 BCP 1400
3 BCP 1400
3 EP+everything
4 EP
Cavity batch


40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
Average Gradient [MV/m]
1 BCP 1400
2 BCP 1400
3 BCP 1400
3 EP+everything
4 EP
Cavity batch
ALL
ALL 10^10

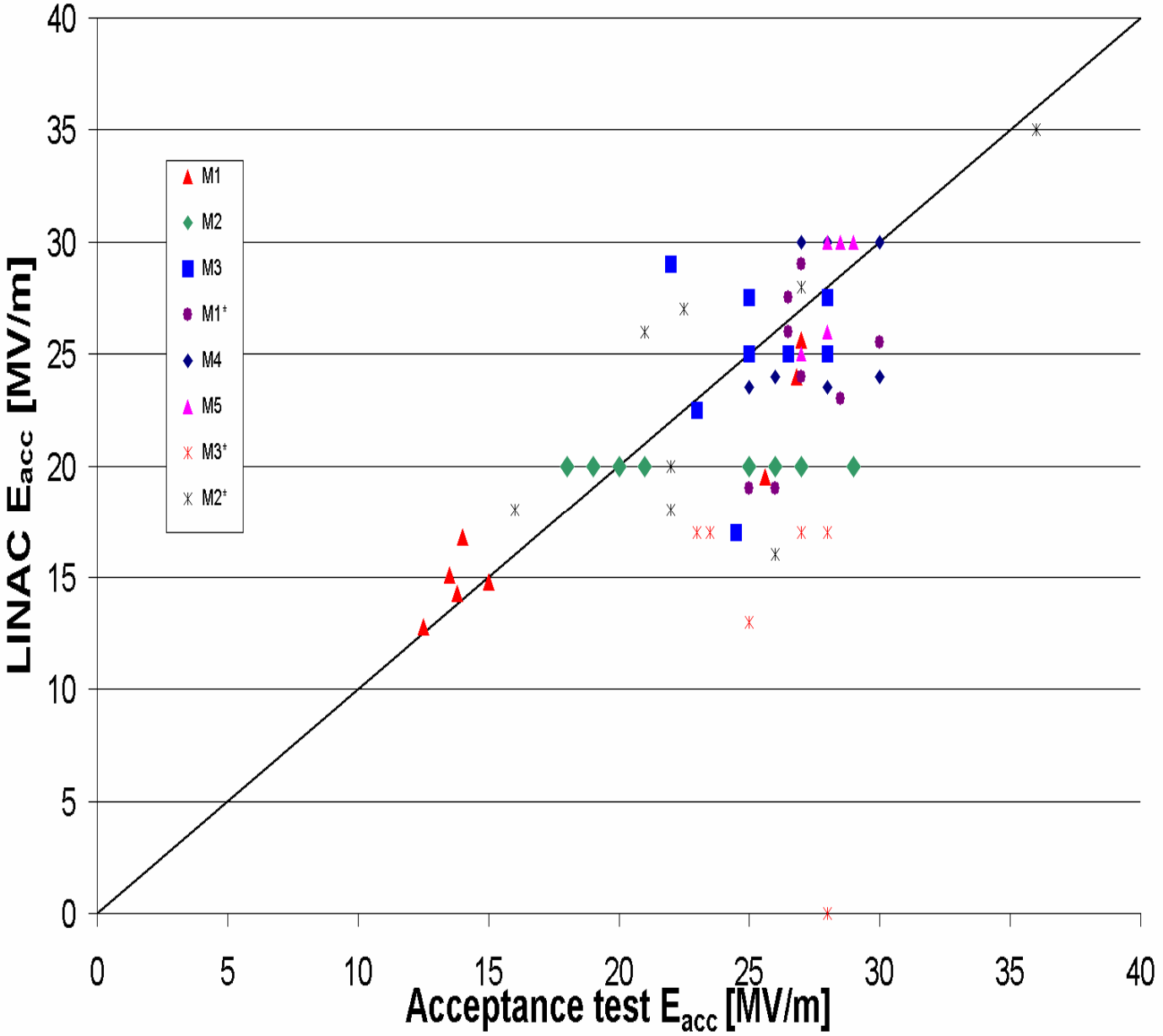

45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
Average Gradient [MV/m]
1 BCP 1400
2 BCP 1400
3 BCP 1400
3 EP+everything
4 EP
Cavity batch
Best
Best 10^10
Best FE


40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
Average Gradient [MV/m]
1 BCP 1400
2 BCP 1400
3 BCP 1400
3 EP+everything
4 EP
Cavity batch
Last
Last 10^10
Last FE

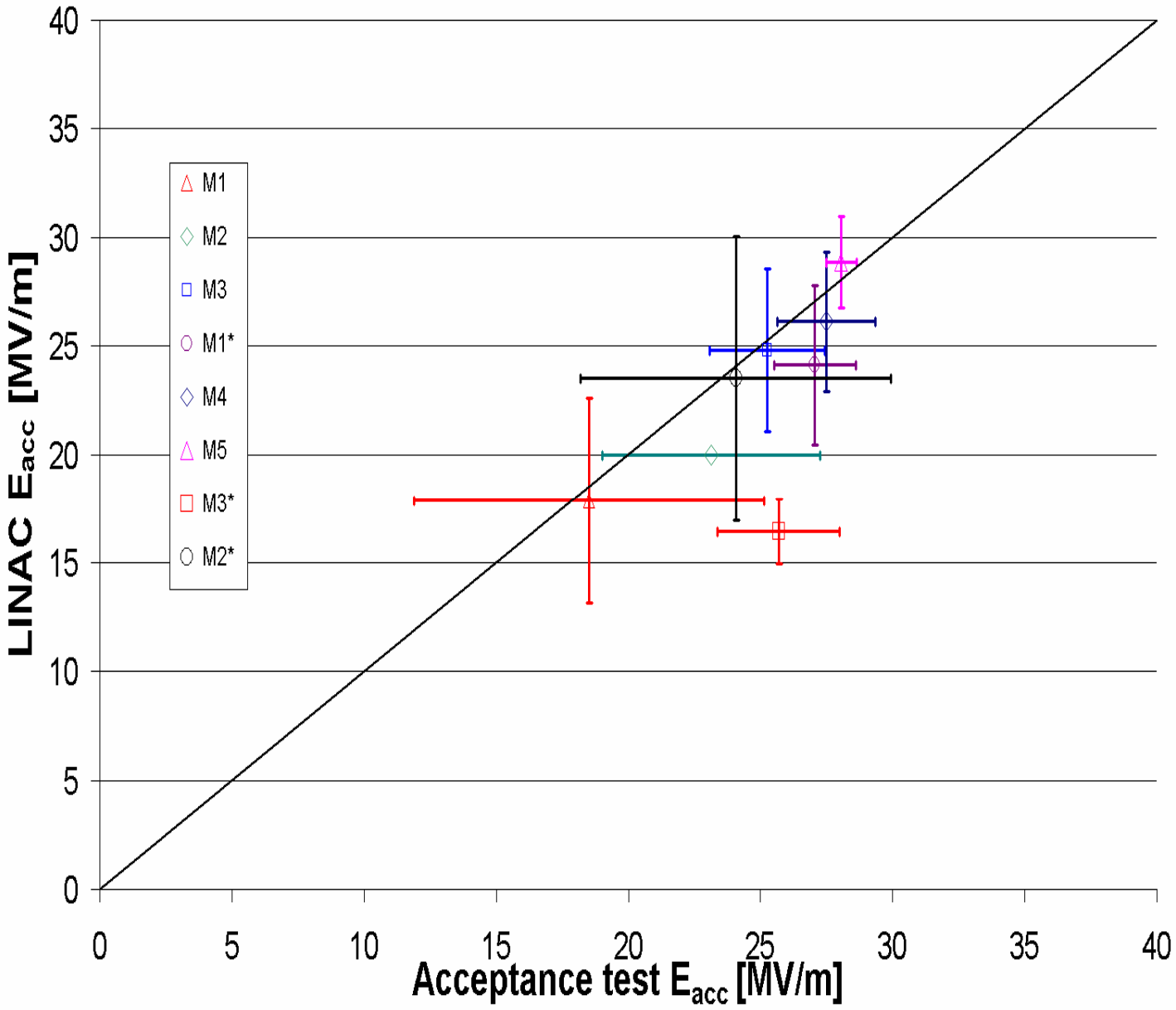

45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
Average Gradient [MV/m]
1 BCP 1400
2 BCP 1400
3 BCP 1400
3 EP+everything
4 EP
Cavity batch
Best
Last
Best 10^10
Last 10^10
Best FE
Last FE

LINAC vs. Vertical (Individual Cavities)

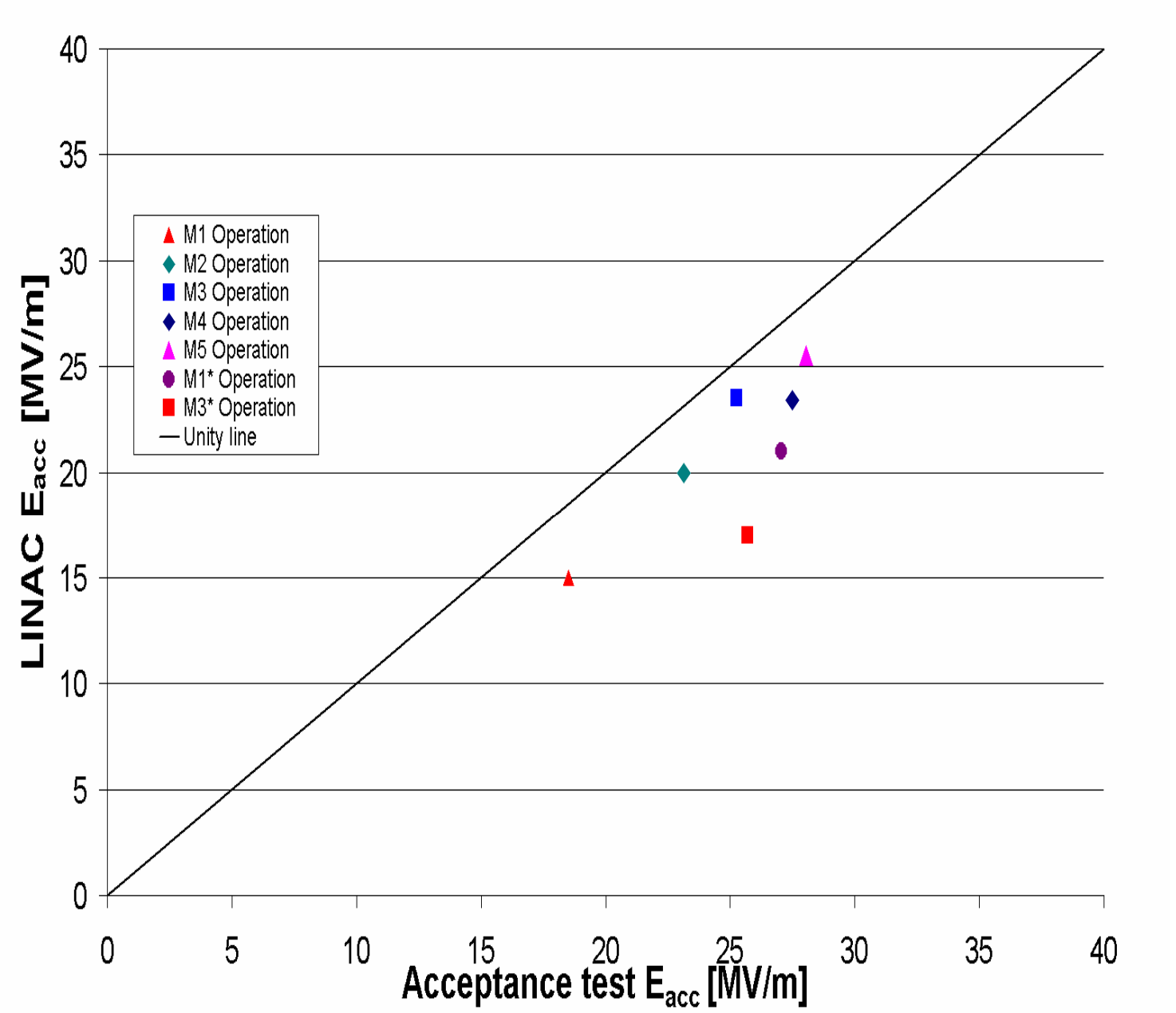
- Some cavities power limited
  - Esp. M5
- Coupler limited
  - M2
  - M4/C3
- Only module measurement available
  - M2



LINAC vs. Vertical (Cavity Average Gradients)



LINAC vs. Vertical (Module Max. Operational Gradient)



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