Status of Module 6

Lutz.Lilje@desy.de
DESY -MPY-

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- What is Module 6?
- Cavity Performance in TTF modules
- Current R&D program
  - Electropolishing
- Status of components
  - Active tuner

What is Module 6?

- During the International Linear Collider Review Committee (ILC-TRC) in 2002/2003 several discussions where about what needs to be demonstrated for a technology to be a candidate for the ILC

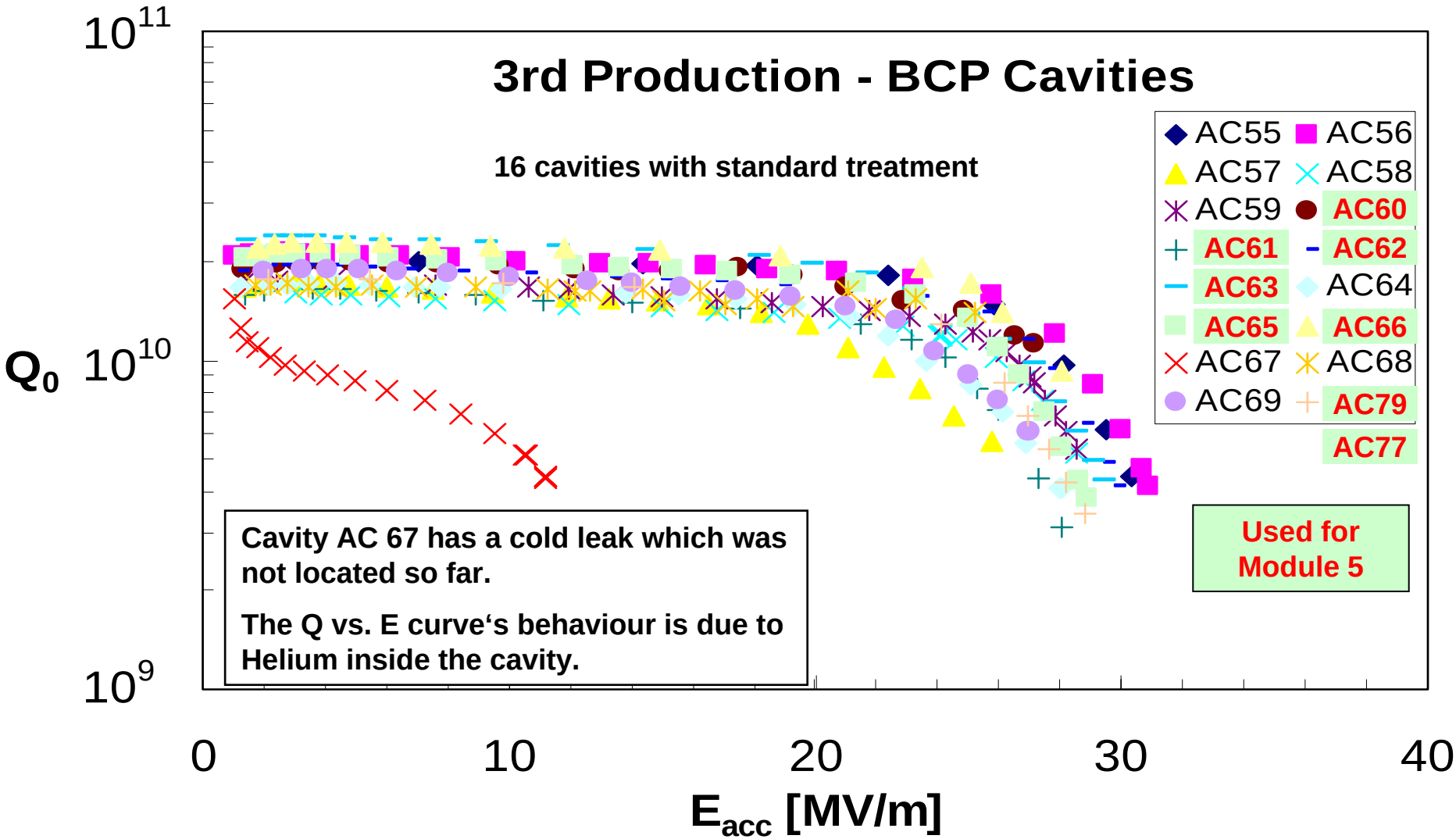
- Therefore each technology got some R&D objectives including a ranking for their criticality (R1: most critical)

- For TESLA in the energy reach category the R1 was:

R1 (TESLA Upgrade to 800 GeV c.m.)

- Quote from ILC-TRC report:
  - "The Energy Working Group considers that a feasibility demonstration of the machine requires the proof of existence of the basic building blocks of the linacs.
  - In the case of TESLA at 500 GeV, such demonstration requires in particular that s.c. cavities installed in a cryomodule be running at the design gradient of 23.8 MV/m. This has been *practically* demonstrated at TTF1 with cavities treated by chemical processing.[…] "
- This is done now.

High Gradient Performance (Etched Cavities)



Performance of Accelerator Module 5

A State-of-the-art module

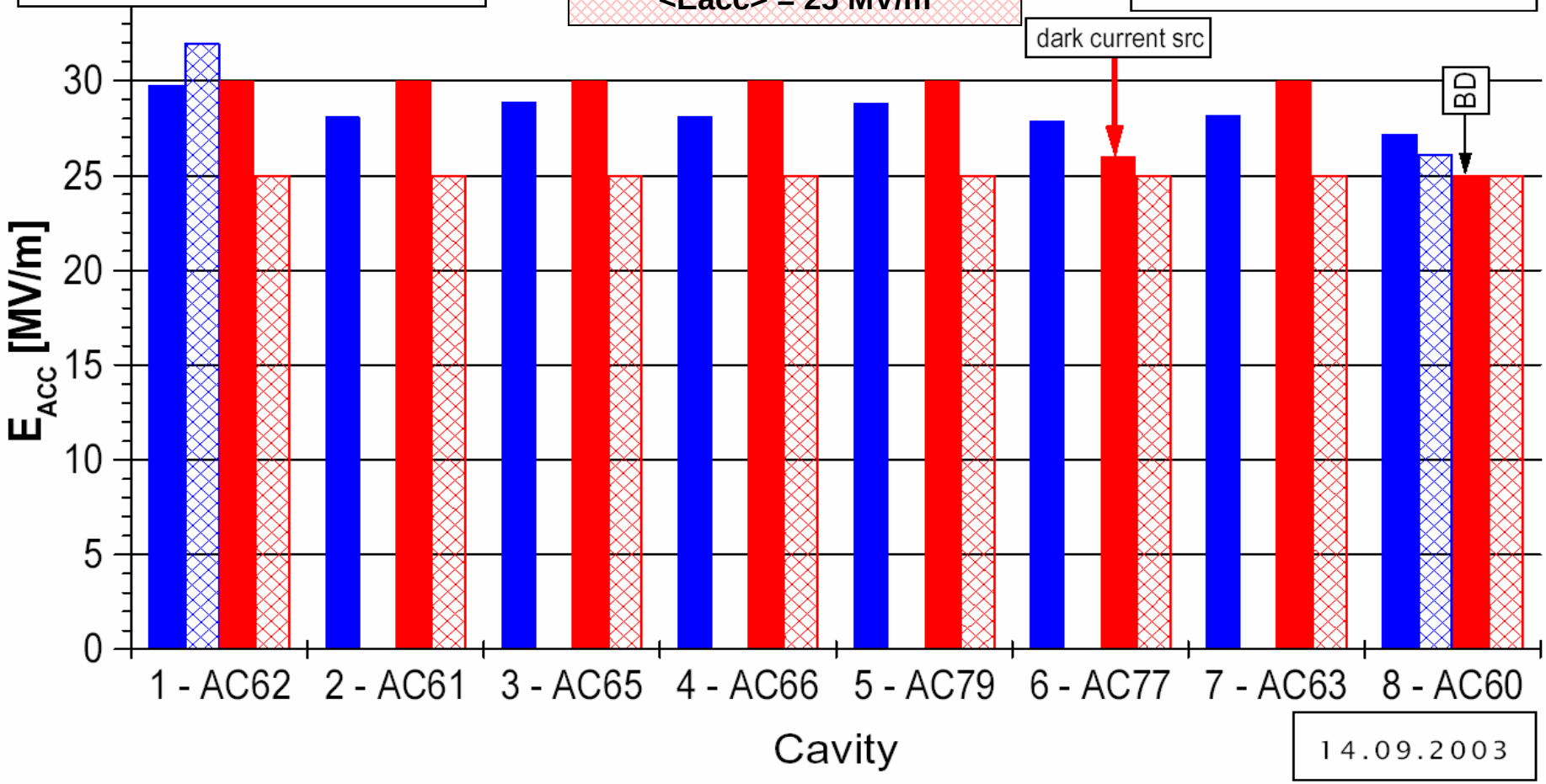
- **cryogenic type III**
- **latest coupler generation**
- **BCP cavities**

In single cavity measurements

6 out of 8 cavities reach 30 MV/m!

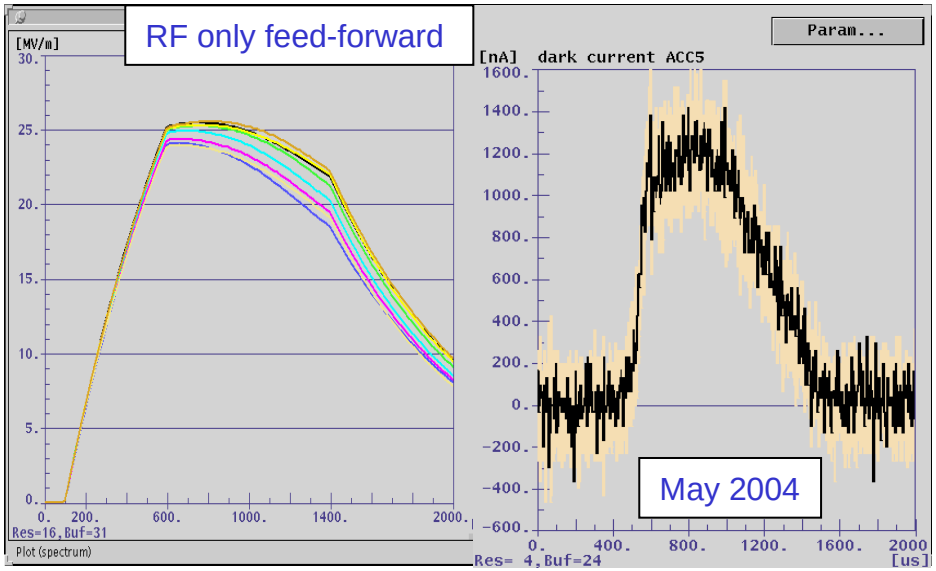
Equal power feeding

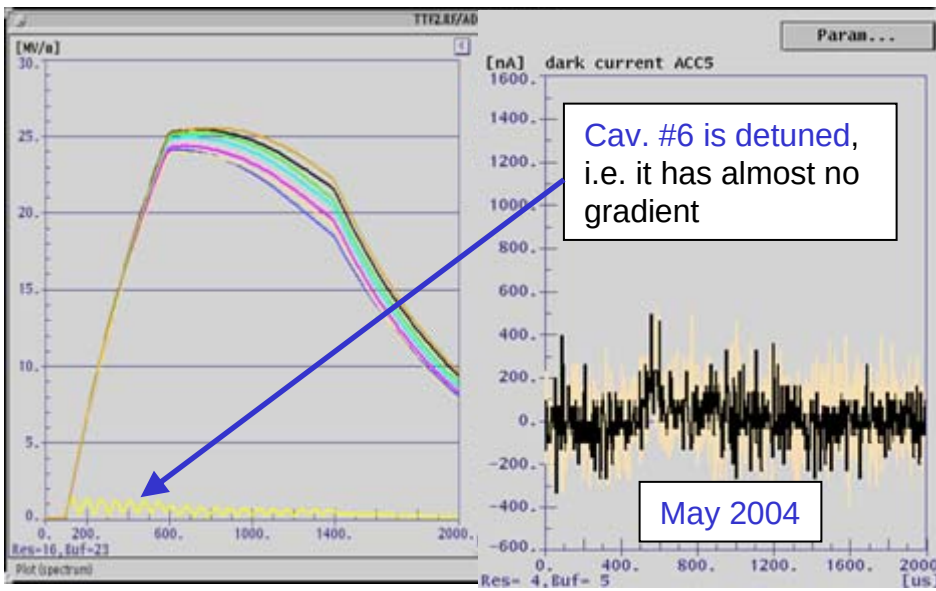
<Eacc> = 25 MV/m



Dark Current Measurements

- The on-axis dark current (d.c.) was measured for modules ACC4 / ACC5.
- Only one cavity in module ACC5 produced a mentionable dark current.
  - Captured dark current measured only at exit ACC5
  - No d.c. observable from this cavity at entrance ACC4
- The ***d.c. decreased as a function of time***
  - after module commissioning in August 2003
    - 100 nA at 16 MV/m
    - increasing by a factor 10 for each 4.4 MV/m gradient step
    - i.e. approx. 10 µA at 25 MV/m
  - May 2004
    - 100 nA at 20 MV/m
    - increasing by a factor 10 for each 3.7 MV/m gradient step,
    - i.e. 1.2 µA at 25 MV/m
  - September 2004 (extended operation at 20-25 MV/m)
    - 250 nA at 25 MV/m
- Detuning of cavity no. 6 left over an integrated dark current of the order of 20 to 25 nA at 25 MV/m average gradient
- ***Reminder:***
  - The TESLA limit is defined by additional cryogenic losses:
  - The captured d.c. has to stay below 50 nA per cavity (see TESLA Report 2003-10).



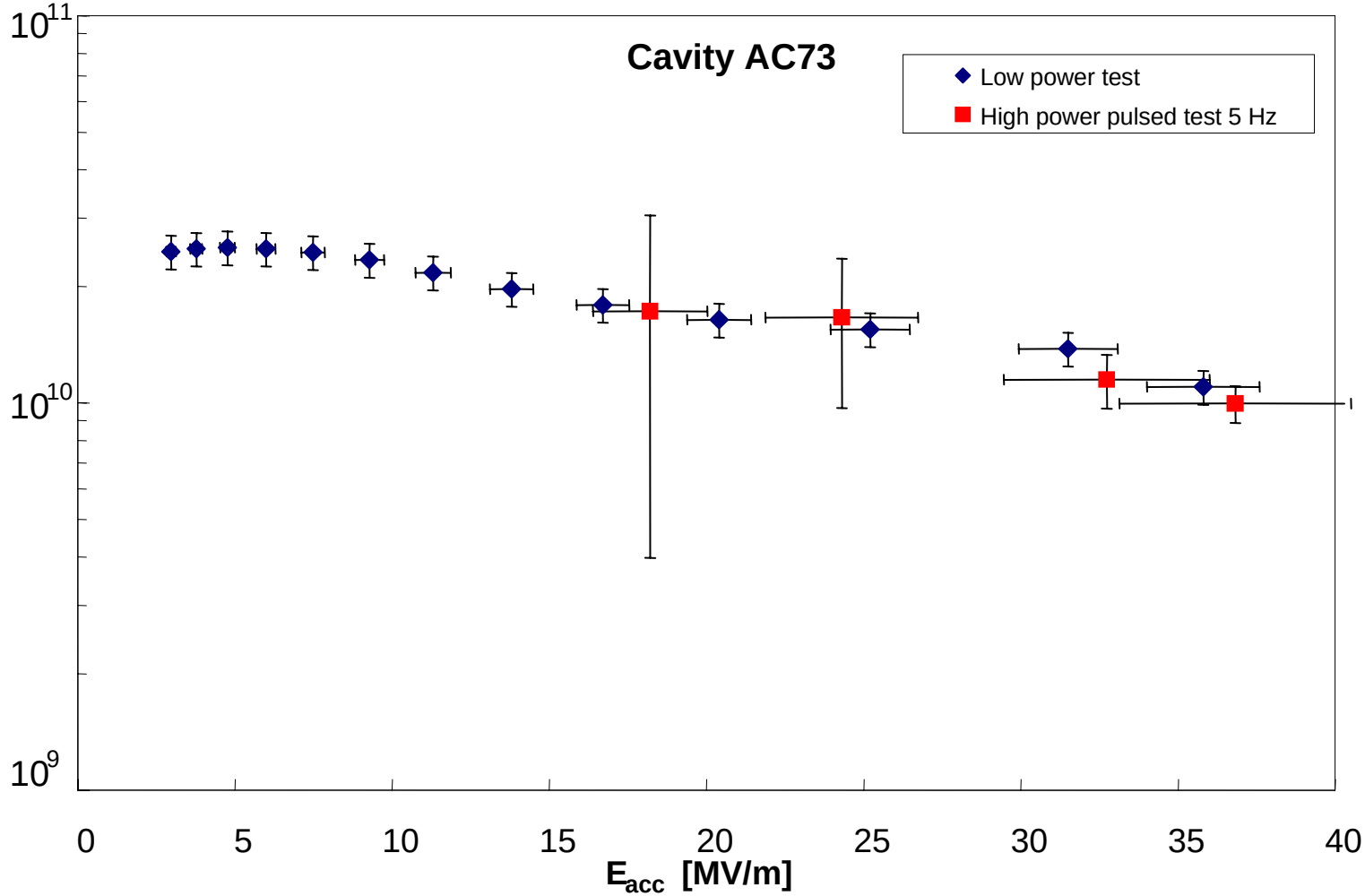


R1 (TESLA Upgrade to 800 GeV c.m.) ctd.

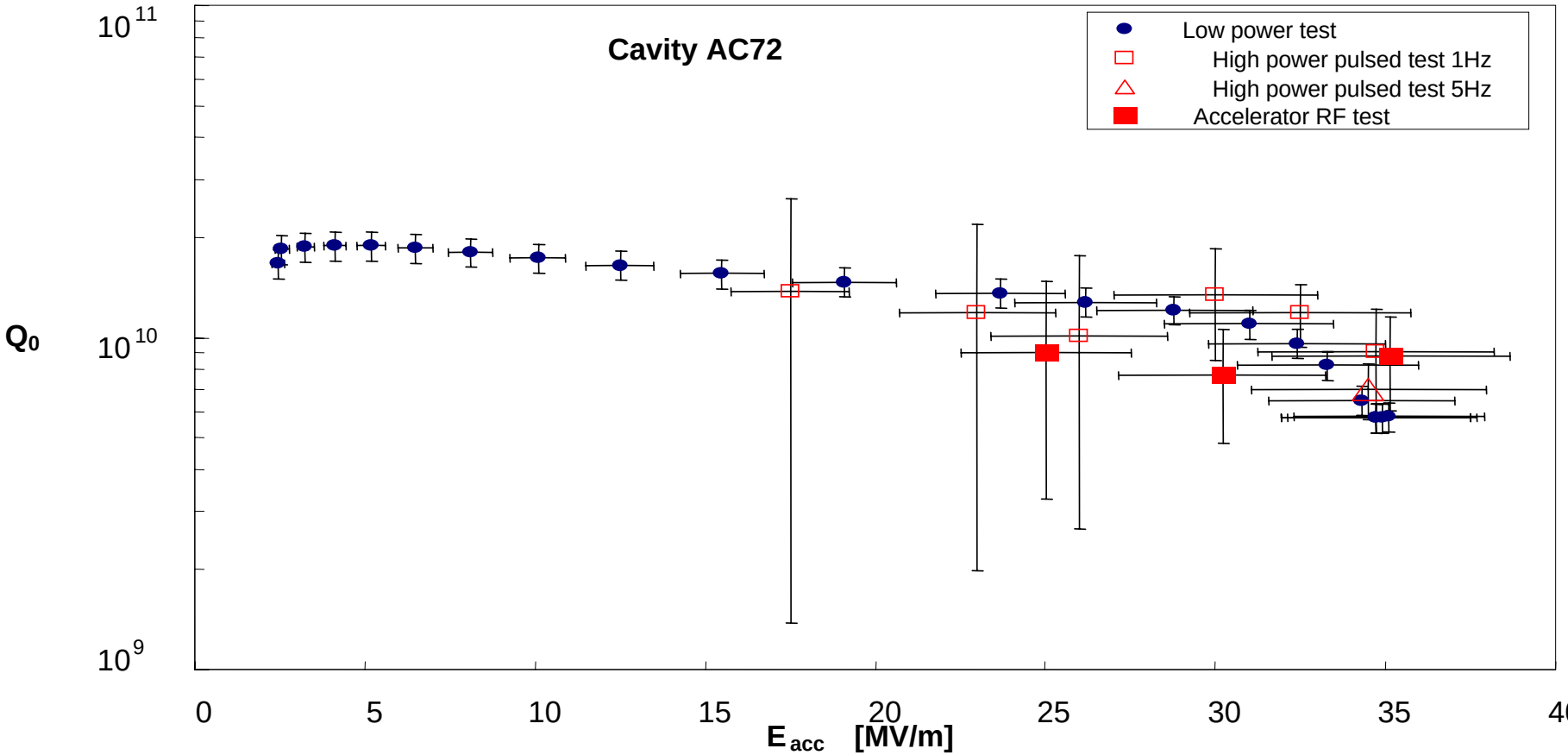
- Quote from ILC-TRC report:
  - "The feasibility demonstration of the TESLA energy upgrade to about 800 GeV requires that a cryomodule be assembled and tested at the design gradient of 35 MV/m.
  - The test should prove that quench rates and breakdowns, including couplers, are commensurate with the operational expectations.
  - It should also show that dark currents at the design gradient are manageable, which means that several cavities should be assembled together in the cryomodule.
  - Tests with electropolished cavities assembled in a cryomodule are foreseen in 2003."
- This is module 6 – and not yet done…
- Important
  - This does not necessarily mean a test with beam!
- The module was promised for installation in the TTF Linac by spring/mid 2006 (next big shutdown)

- No breakdown in 1100 hours at 35 MV/m (neither the Cavity nor the Coupler)
- No degradation was observed when breakdowns were forced (thermal quenches and coupler breakdowns)
- Standard X-ray radiation measurement indicates that both tested cavities are radiation-free up to 34 and 35 MV/m respectively

High Power Test Results



Cavity Test Inside a Module (ctd.)



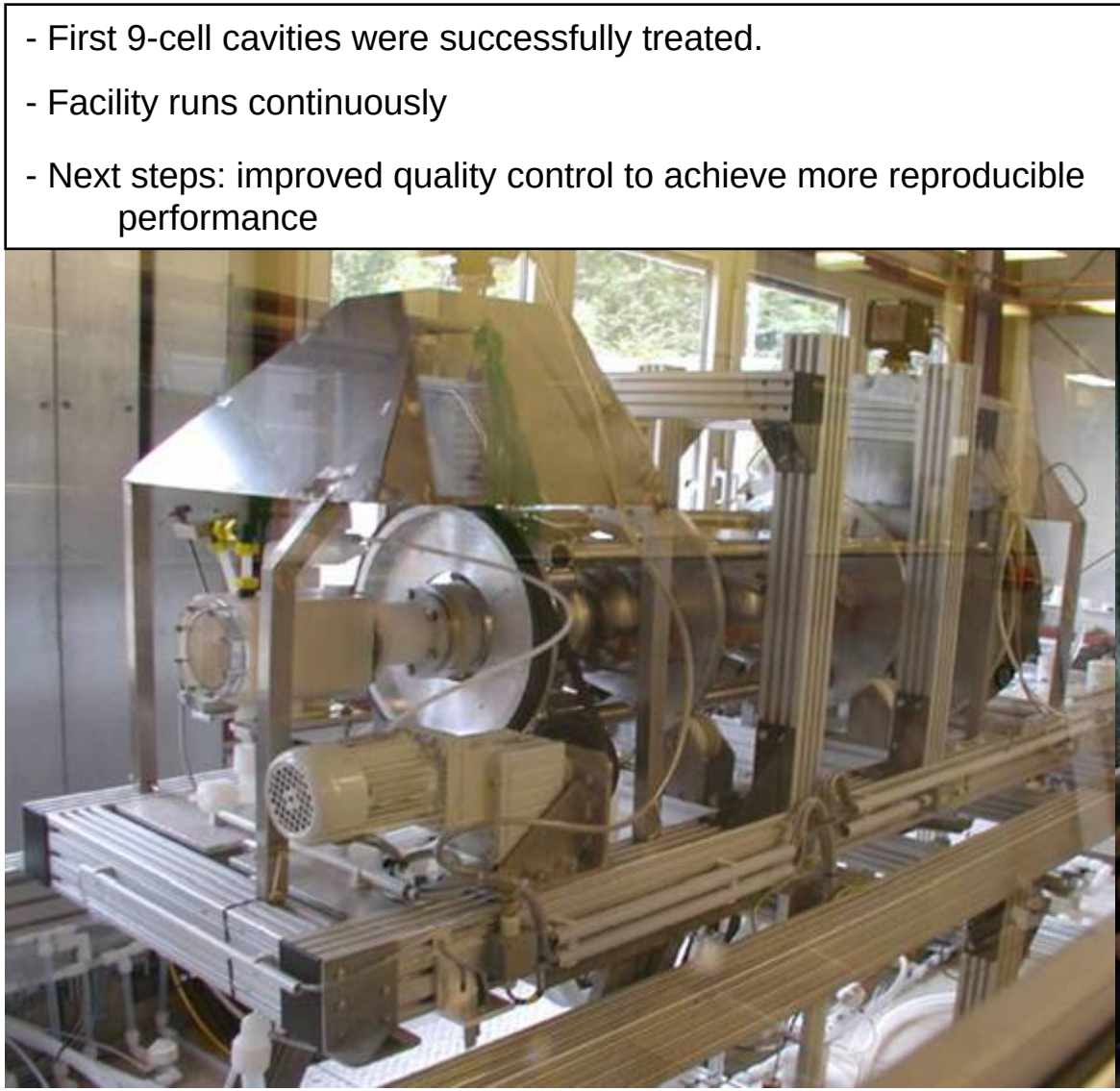
- One electropolished cavities (AC72) was installed into an accelerating module for the VUV-FEL
- Very low cryogenic losses as in high power tests
- Standard X-ray radiation measurement indicates no radiation up to 35 MV/m

R&D on Cavity Preparation

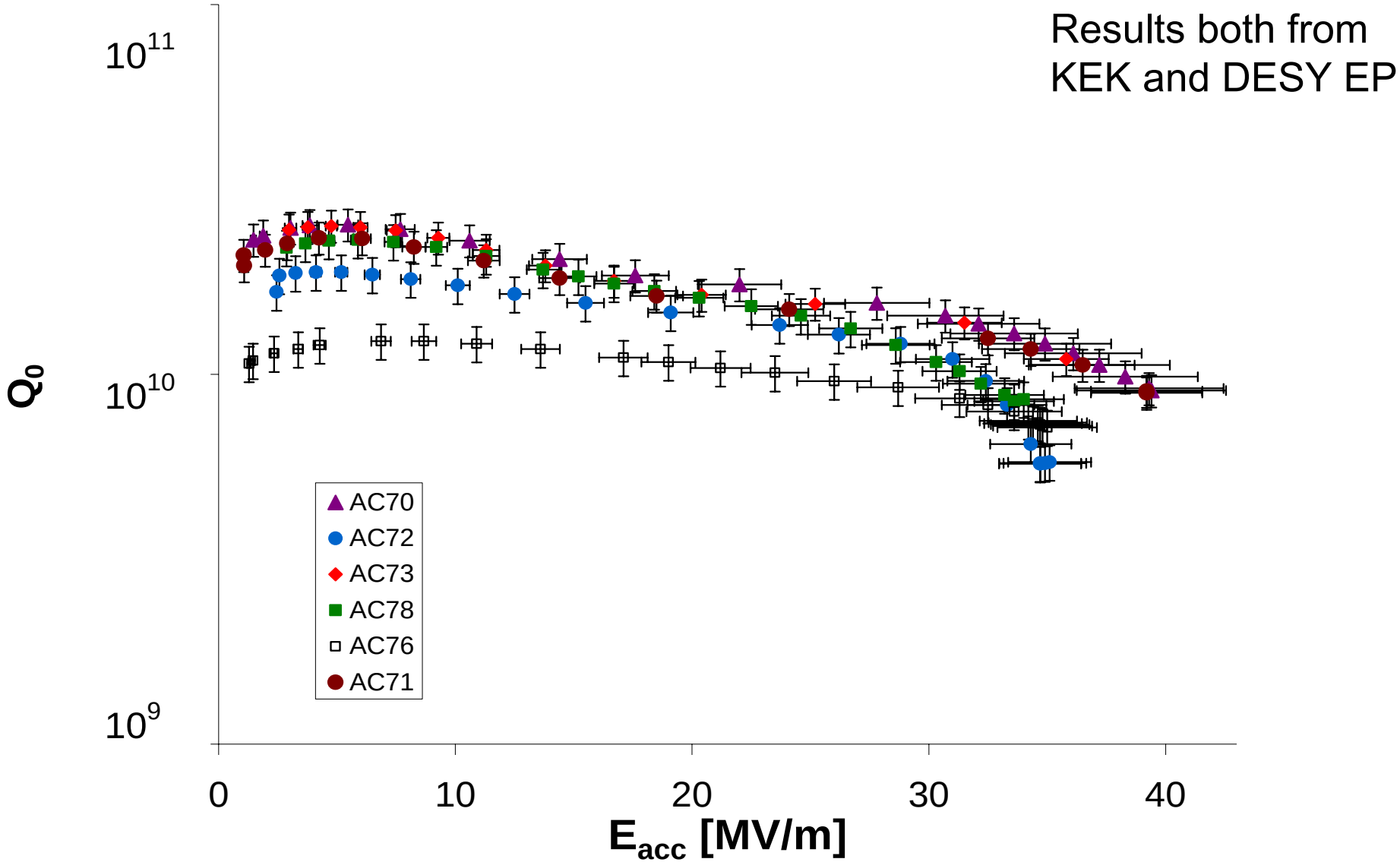
- Electropolishing (EP) is the most promising surface preparation technique for superconducting cavities
  - Is baseline also for the XFEL
    - Try to avoid 1400°C furnace treatment for postpurification
  - DESY EP setup accumulated a lot of operational experience
    - Important for a new industrial study on cavity preparation
      - For TESLA cost etimates have been based on etching (+1400°C furnace) treatment
    - Recently problems with field emission
      - Investigations are ongoing to improve quality control
      - There exists hints of sulphur contamination of the EP system

Electropolishing setup at DESY

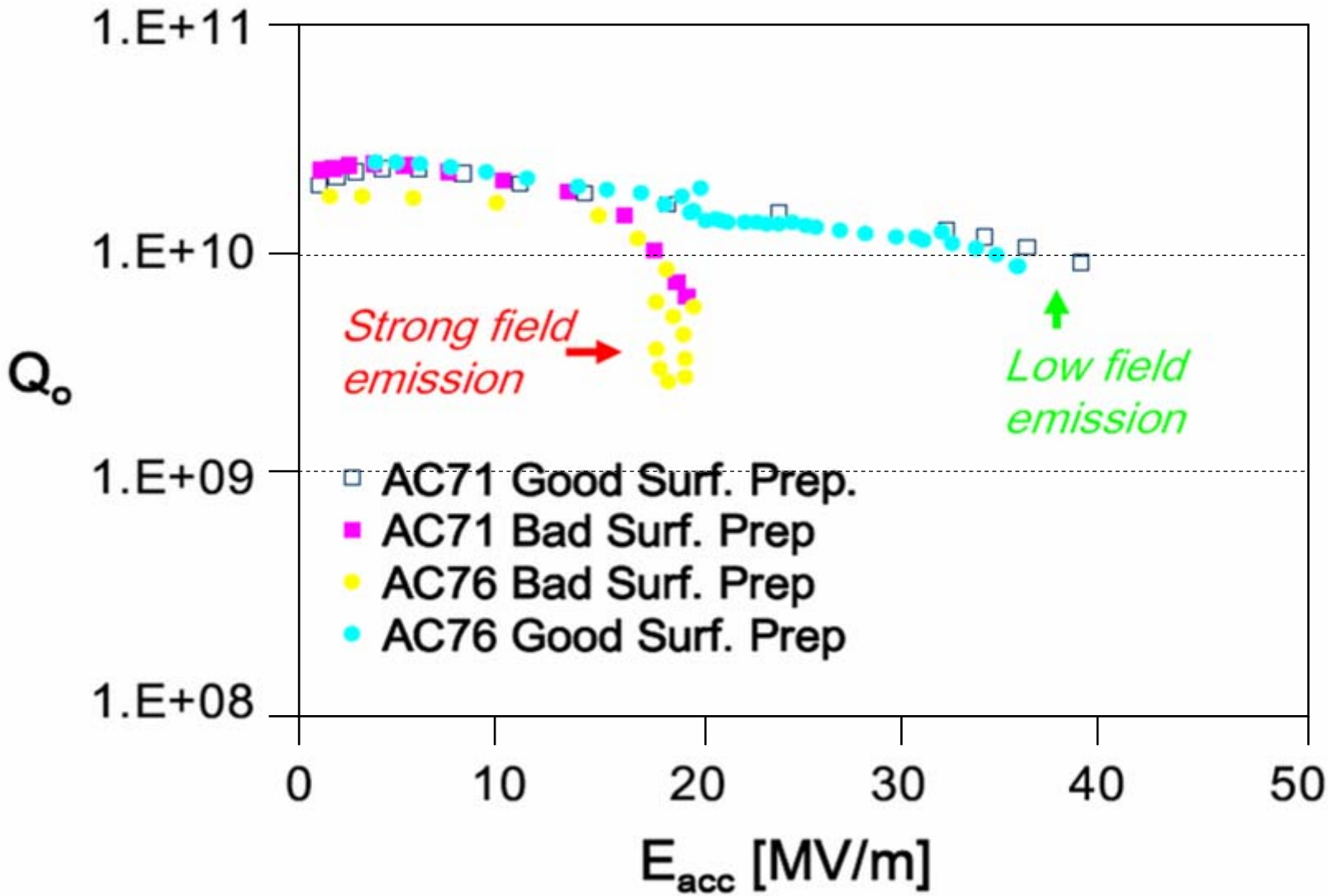
- First 9-cell cavities were successfully treated.
- Facility runs continuously
- Next steps: improved quality control to achieve more reproducible performance



Electropolishing: Test Results



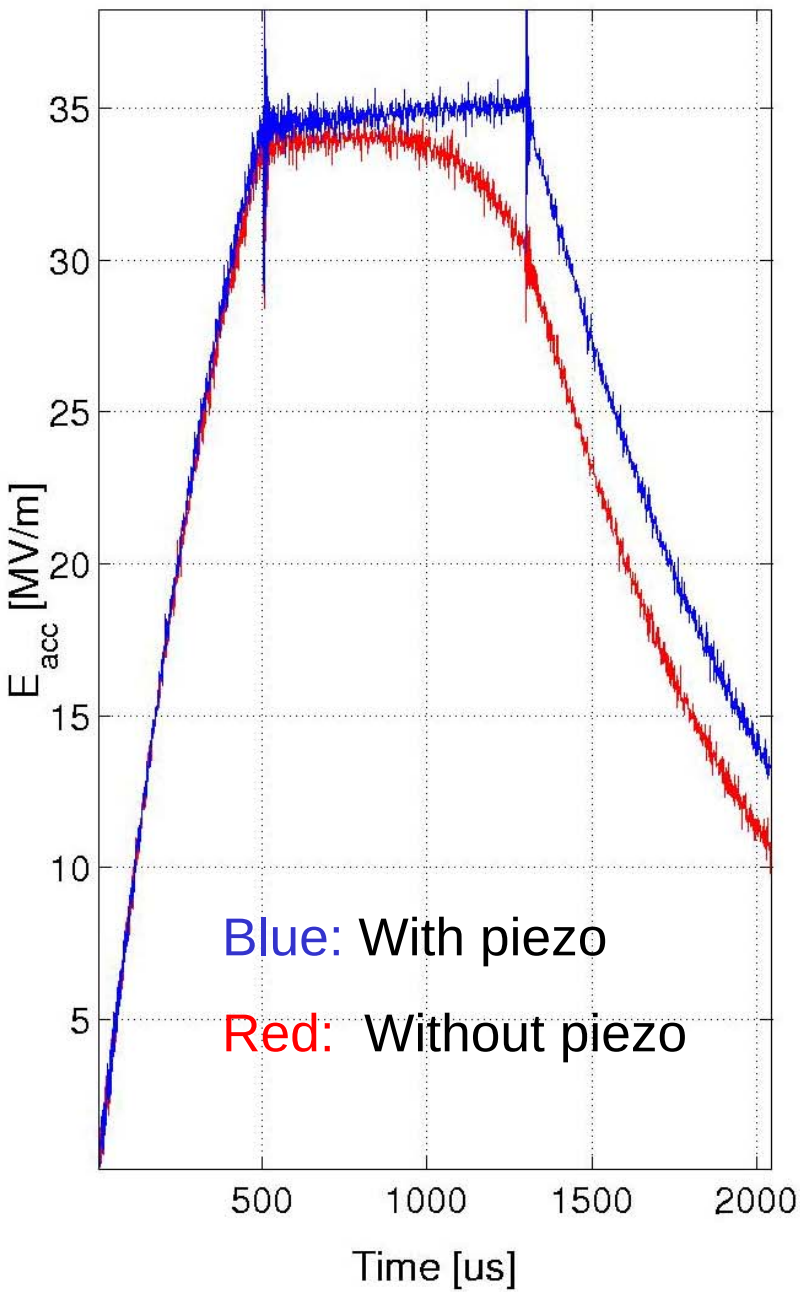
Problem: Reproducibility in the EP Process

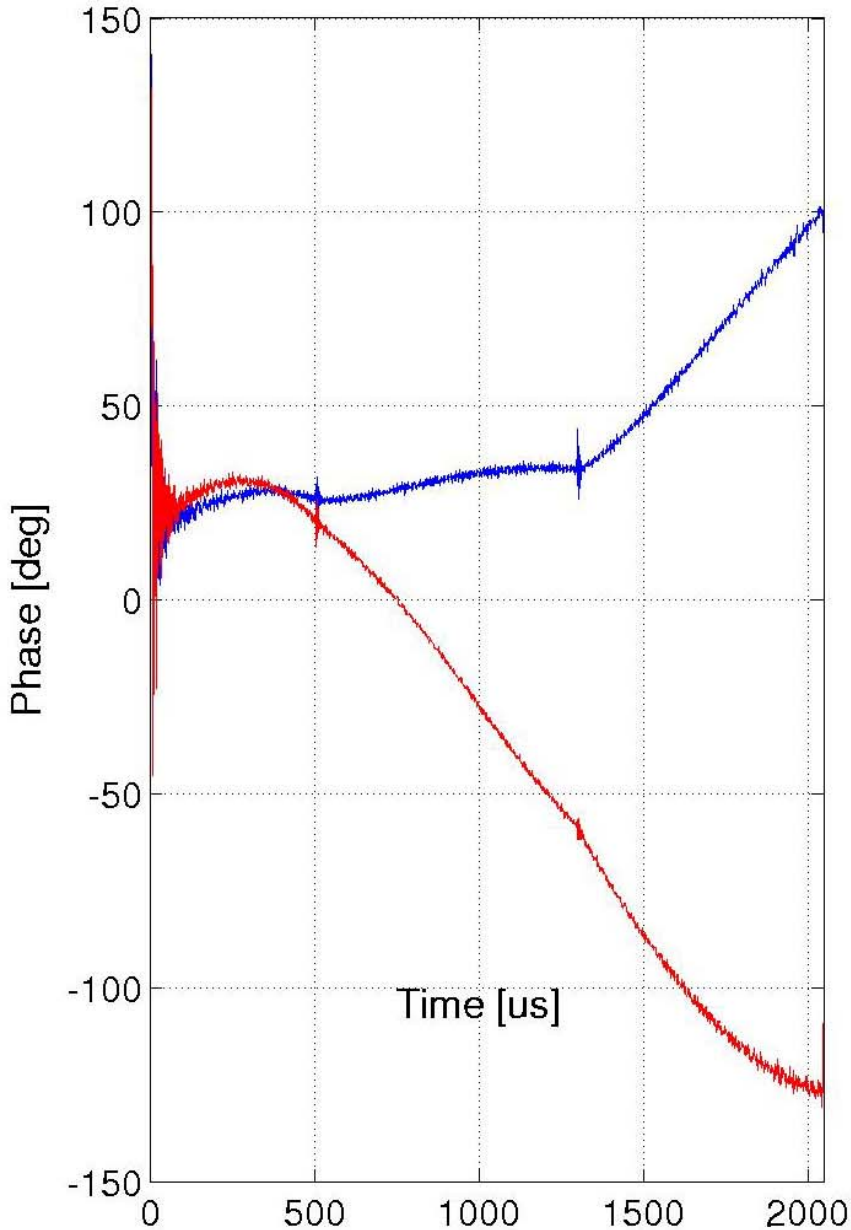


Module 6 – Status of Parts

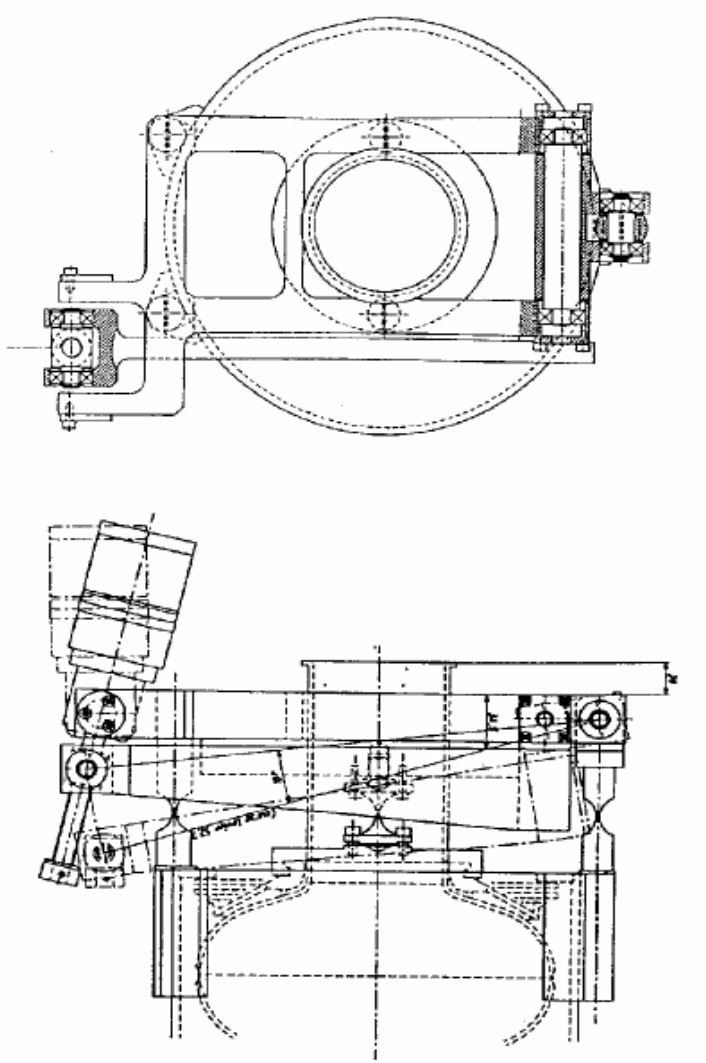
- Nearly everything is available, except for:
- Cavities
  - 2 Cavities have been high power tested, but need a new test due to mechanical problems with the coupler
    - AC73, AC70
  - 1 (maybe 2) Cavities have been qualified in the low power test
    - Need tank welding etc
    - AC76, AC81 (?)
  - Need 5 (4) more good cavities
    - Candidate cavities which have had 35 MV/m or a close to that gradient: AC71, AC78, Z85
      - New surface preparation needed
    - 2 (1) from the new cavity production
- Tuner
  - A fixture for the active compensation with piezo-electric elements is needed.
  - Stiffness of existing fixture not sufficient
  - A backup solution exists
- All cavities should go into high power test before installation into the module

Active tuning: RF Signals at 35 MV/m

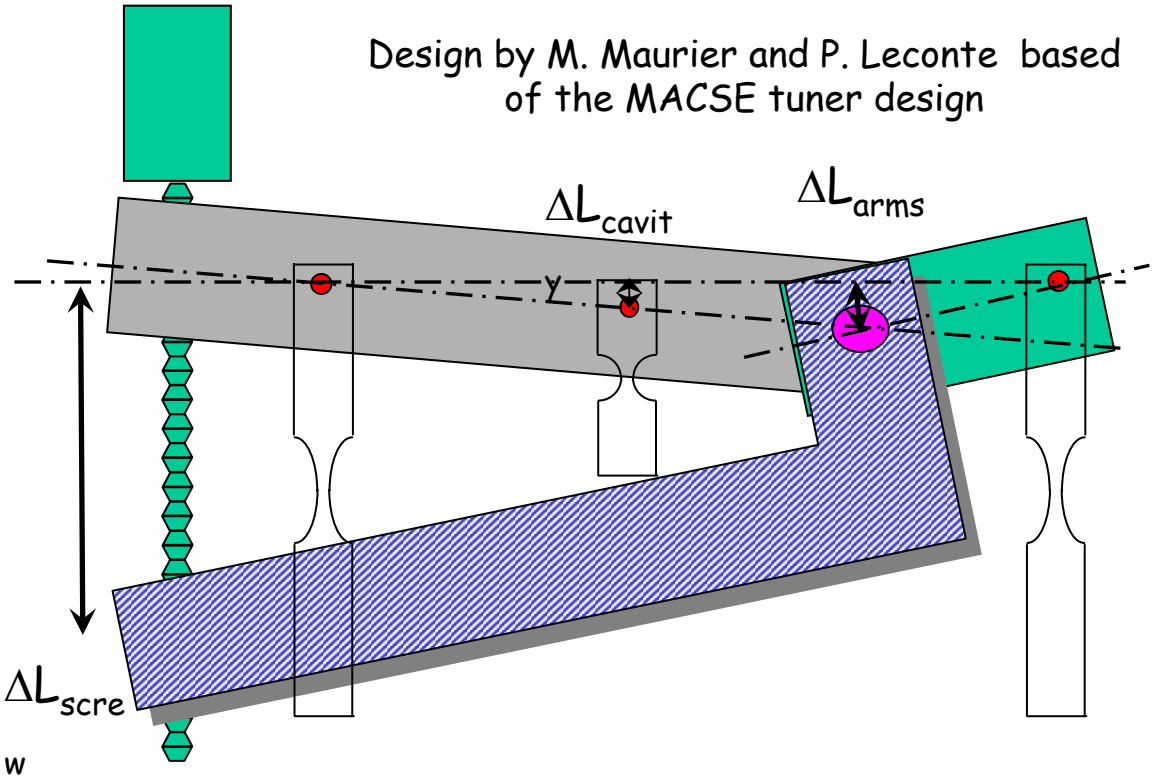




Lateral Tuner (Saclay)

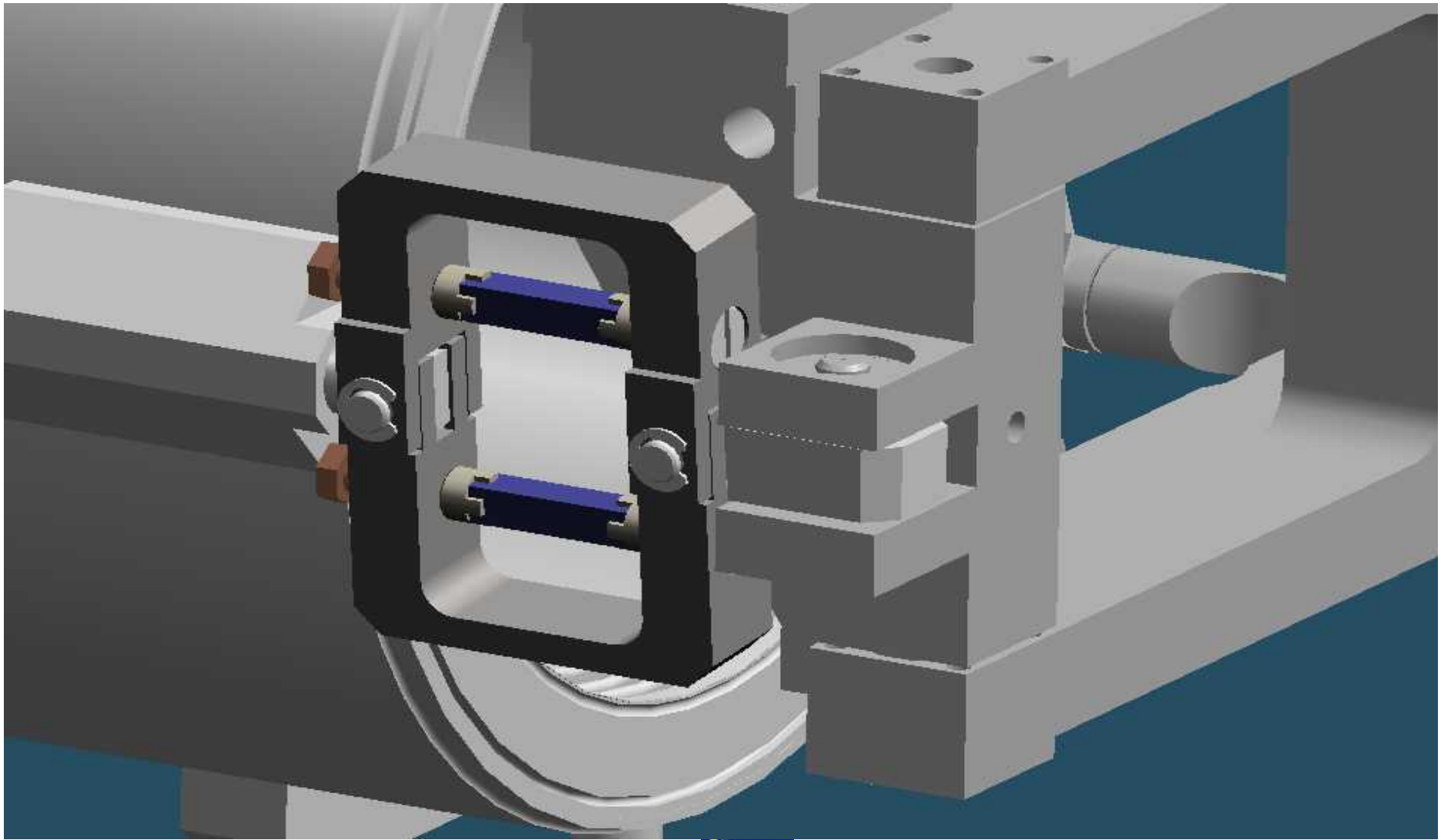


Design by M. Maurier and P. Leconte based of the MACSE tuner design



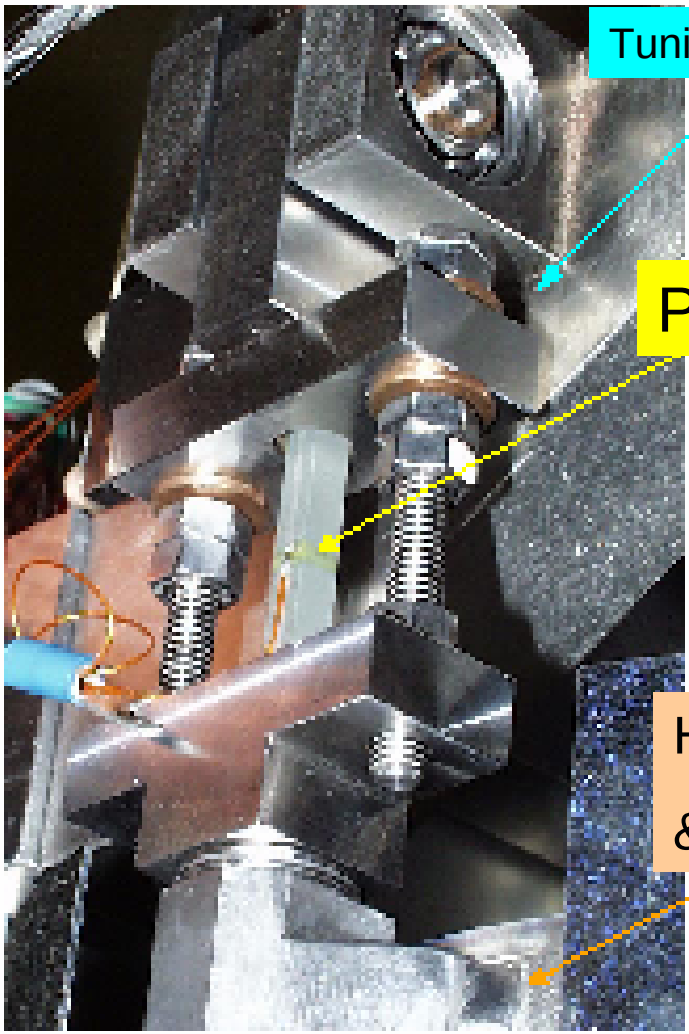
- Used in TTF
  - Double lever system: ratio ~ 1/17
  - Stepping motor with Harmonic Drive gear box
  - Screw – nut system

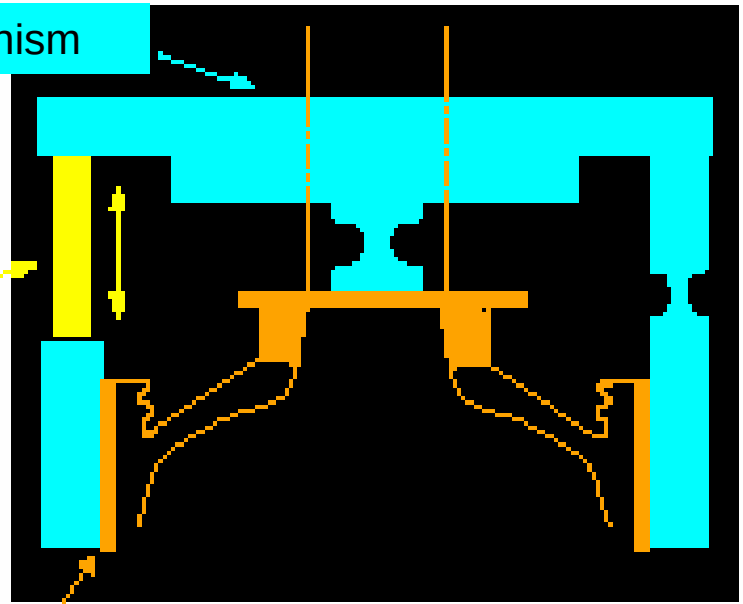
Drawing of Piezoelectric Elements in the Tuning Mechanism



Piezoelectric Tuner

M. Liepe, S. Simrock, W.D.-Moeller





Piezo-Actuator:

l=39mm

U_{max}=150V

Δ l=3μm at 2K

$\Delta f_{max,static}$=500Hz

Summary

- TESLA-800 R1 issue:
  - Has been partially demonstrated
  - Proof-of-existence for 35 MV/m in the accelerator
- Module 6
  - Reproducibility of the EP process is a problem
    - Field emission is a major performance limitation
    - The real source still needs to be understood
  - Tuner needs some work on Piezo fixture
    - Test can be done at less than 35 MV/m
    - Backup exists