- 08:30 Closed Session
- 09:00 Introduction to R&D Board Task Forces (Bill Willis)

- Part I - Gathering information for S0 (Chair: L. Lilje) ---------------------------------------
- 09:20 How to assess the experience on cavity production? (Hasan Padamsee)
- - First assessment of recent cavity productions
- - Explain the basic evaluations needed (e.g. number of cavities in the sample, average results, number of re-treatments, etc.)
- 09:40 What are the available multi-cell cavities in the US in year 2006/7? (Harry Carter)
- 09:55 Current planning and status of infrastructure esp. ANL EP (Claire Antoine,) (Ken Shepart)
- 10:25 What would be the cavity preparation rate with EP (incl. Cornell, ANL and (Shekhar Mishra)
- 10:40 Coffee Break
- 10:55 What would be the model for cavity testing ? (Shekhar Mishra (FNAL))

- Part II - Working towards a best recipe (Chair: M. Ross) -- - 11:10 - Adressing contamination issues on multi-cells - 20 min – Discussion - 5um EP a la K. Saito - Alcohol rinse - Other rinses?
- 11:30 Possibilities of integrating this into the existing/planned facilities - (Shekhar Mishra)
- 11:45 Use of DESY facilities for part of this program (Lutz Lilje (DESY))
- 12:00 Lunch
- Part III - Statistics for integration into modules (Chair: H. Padamsee)
- 13:00 Assessment of the experience at TTF (Lutz Lilje (DESY))
- 13:20 Module assembly tests at FNAL - How many on which time line? (Tom Peterson (FNAL)) 13:40 S1 Work Plan (Lutz Lilje (DESY))
- 14:00 S2 Workplan (Hasan Padamsee) --- 14:30 Closed session 15:30 FNAL Facilities Tour

Part I - Gathering information for S0

- How to assess the experience on cavity productions?
  - First assessment of recent cavity productions
  - Explain the basic evaluations needed (e.g. number of cavities in the sample, average results, number of re-treatments, etc.)
  - Lessons learned?
- - First assessment of recent cavity productions (e.g. number of cavities in the sample, average results, number of re-treatments, etc.)
- Task force should assemble a coherent report on existing statistics of cavities

Data Sets to Evaluate

- Jlab – SNS
- Jlab – Upgrade/FEL
- Daresbury ERLP
- DESY – TTF (Lutz will talk about it later)
- KEK (starting, Higo)

Jlab SNS: 3rd largest production

1st: LEP-II (Nb-Cu), 2nd: CEBAF (not relevant here)

- 23 cryomodules, 81 cavities, 2 year production testing
- 35 medium beta cavities tested 73 times
  - Field emision was a frequent limitation in early stages
- 48 High beta cavities tested 72 times
  - More multipacting in this geometry
    - (not fully understood, not expected from cell geometry)

SNS Cavity Properties

Table I : Cavity Parameters

f = 800 MHz

Parameter	Cavity Type $\beta = 0.61$	$\beta = 0.81$
Operating Gradient (MV/m)	10.2	15.6
Q_o spec at Operating Gradient	$\geq 5 \times 10^9$	$\geq 5 \times 10^9$
E_{peak} (MV/m)	27.6	34.2
H_{peak} (mT)	58.0	73.2
E_{peak}/E_{acc}	2.71	2.19
B_{peak}/E_{acc} (mT/(MV/m))	5.72	4.72
Operating Temperature (K)	2.1	2.1

Test Results of β<1 Superconducting Elliptical Cavities : Experience and Lessons Learned

Joseph Ozelis

for the SNS Cavity Team at

Institute for SRF Science and Technology

Jefferson Lab

Important Learning Experience

Table II : Medium β Cavity Average Performance

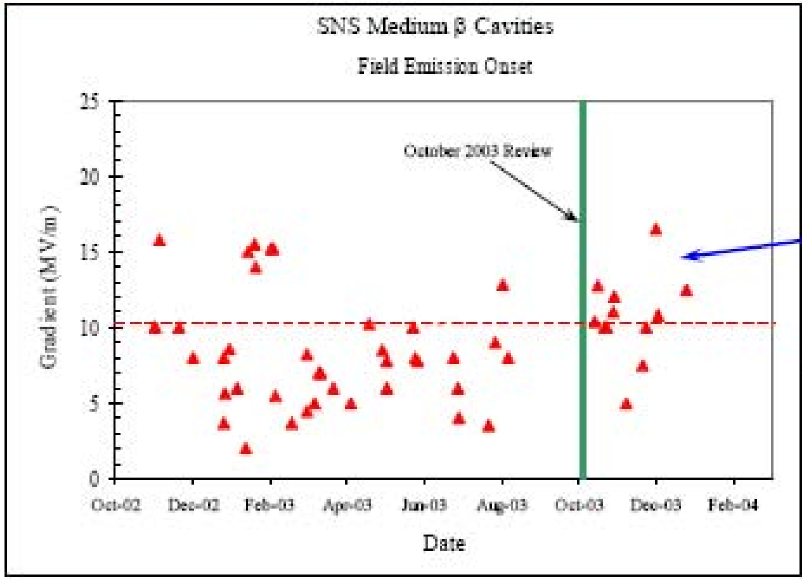
Parameter	Processing Procedures	
	Original	Improved
Gradient at Q_o spec (MV/m)	11.0	15.5
Maximum Gradient (MV/m)	12.0	16.4
Q_o at Operating Gradient	6×10^9	1.2×10^{10}
Field Emission Onset (MV/m)	8.3	10.7
Number of Tests to Qualify	1.9	1.1

Improved Cavity Processing - Reduce FE

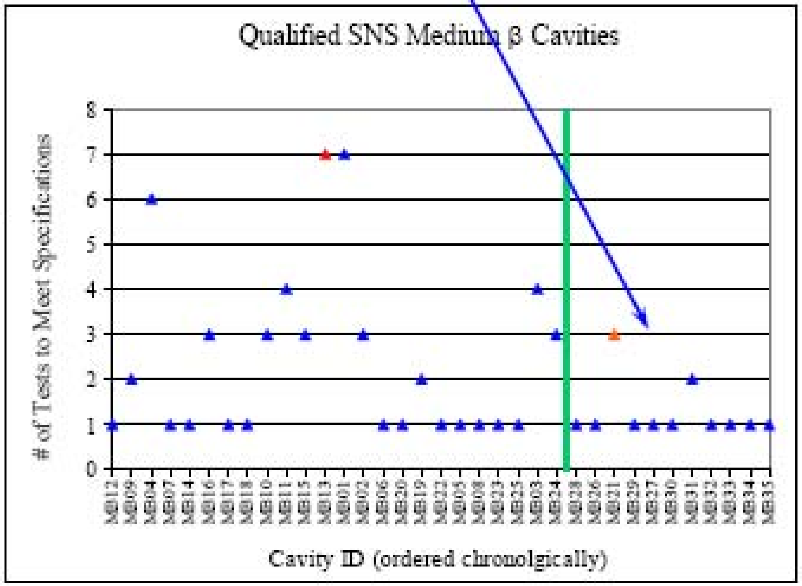
- Two reviews (Sep & Oct 2003) to identify process improvements
  - An internal review (S&T and assembly staff)
  - An external review, including management, cavity and process experts (4 involved directly in DESY effort)

- Identified process changes
  - Additional rinsing after chemistry and for HP rinsing
  - Keeping the cavity surface wet between chemistry and HPR steps
  - Allowing the cavity surface to dry between HPR steps
  - Adjust HPR head to increase the number of nozzles and reduce the nozzle diameter to increase impact force
  - Isolate cavities from test stand by evacuation in the cleanroom
  - Add flow thru rinsing during degreasing steps
  - Use fresh acid for all final processing (<10g/L Nb)
  - Remove more material after furnace treatment (100µm)

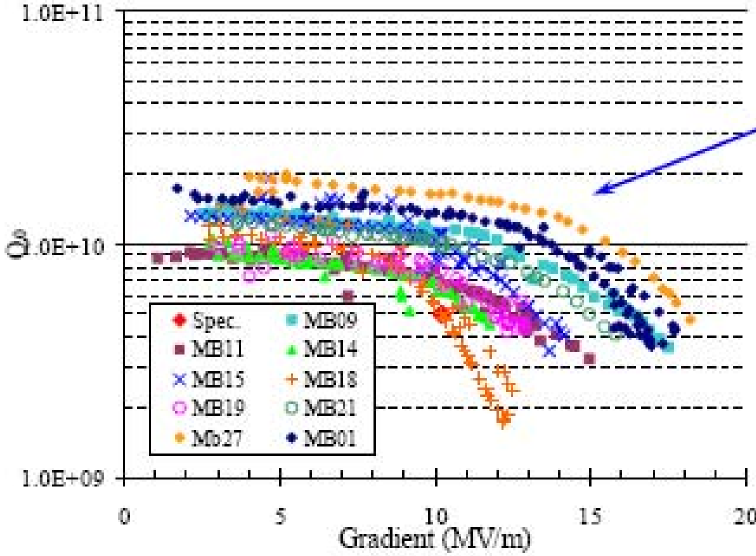
Medium β Cavity Results – Revised Procedures



Results after
new procedures
adopted

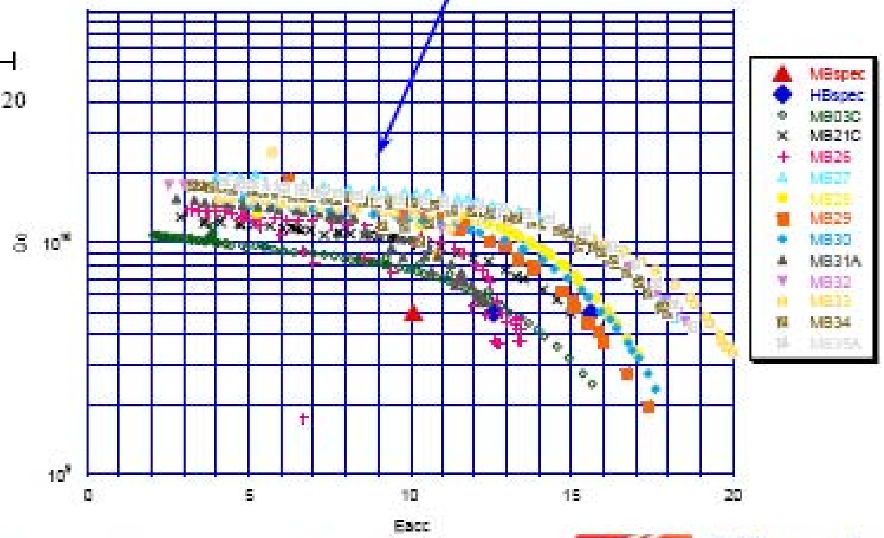


Medium β Cavity Results – Revised Procedures



Results **before** new procedures adopted

Results **after** new procedures adopted



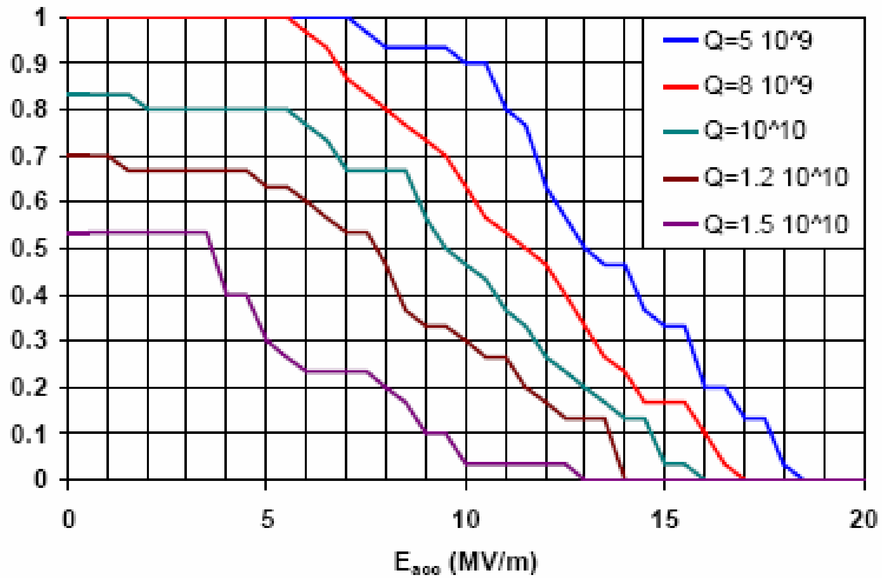


Figure 6. Fraction of 30 VTA tests of β=0.61 cavities exceeding a gradient at various Q_0.

Medium β Cavity Results – Revised Procedures

Production testing resumed in October 2003, after revised processing and assembly procedures were implemented.

Performance was measurably improved!

Onset of FE delayed (but still large variability)… RF pulse-processing used to "destroy" early emitters, before "burn-in".

Average performance for remainder (11) of medium β cavities :

Gradient at Q_o spec (MV/m) 15.5 (!)	Q_o at Operating Gradient 1.1 x 10^{10} (!)
Maximum Gradient (MV/m) 16.4 (!)	Field Emission Onset (MV/m) 10.7(Better)
Number of Tests to Qualify 1.1 (Nice!)	

Almost high β spec!

High β Cavity Results

Production testing of the bulk of high β cavities began at the end of '03/beginning of '04, upon completion of medium β cavity production testing. Identical (improved) processing/assembly procedures were used for high β as for medium β.

Field emission onset earlier… even with improved processes. Pulse-processing (developed in medium β testing) helped improve cavity test yield.

A new problem - Multipacting

Average performance for 48 medium β cavities

Gradient at Q_o spec (MV/m) 15.8 (OK) Q_o at Operating Gradient 7×10^9 (~OK)

Maximum Gradient (MV/m) 15.9 (OK)   Field Emission Onset (MV/m) 5.9 (Bad)

Number of Tests to Qualify 1.4 (Tolerable…)

Table III : High β Cavity Average Performance

Parameter	All Tests	Passed Tests
Gradient at Q_o spec (MV/m)	15.8	17.7
Maximum Gradient (MV/m)	15.9	18.7
Q_o at Operating Gradient	6.7×10^9	9.9×10^9
Field Emission Onset	5.9	6.2

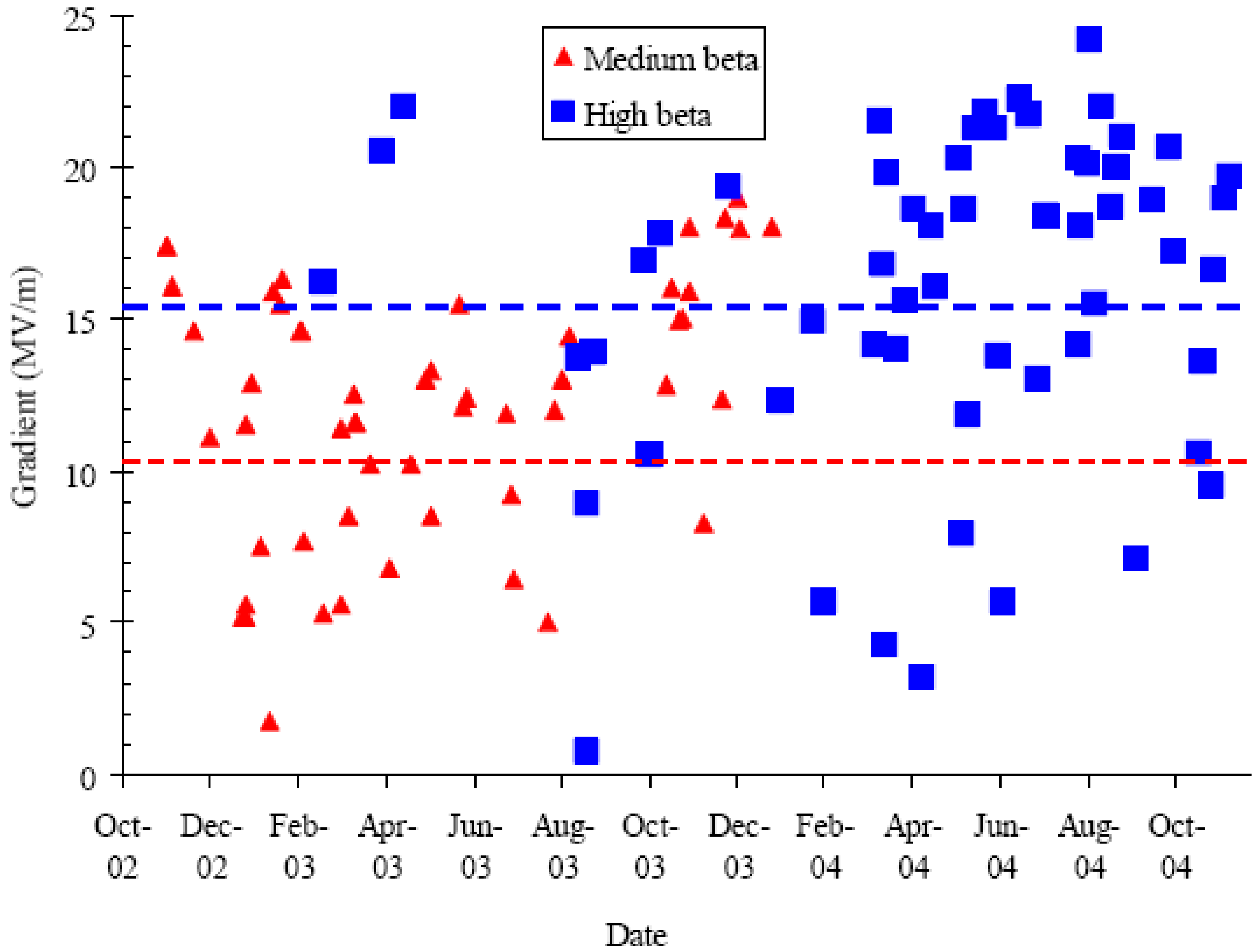
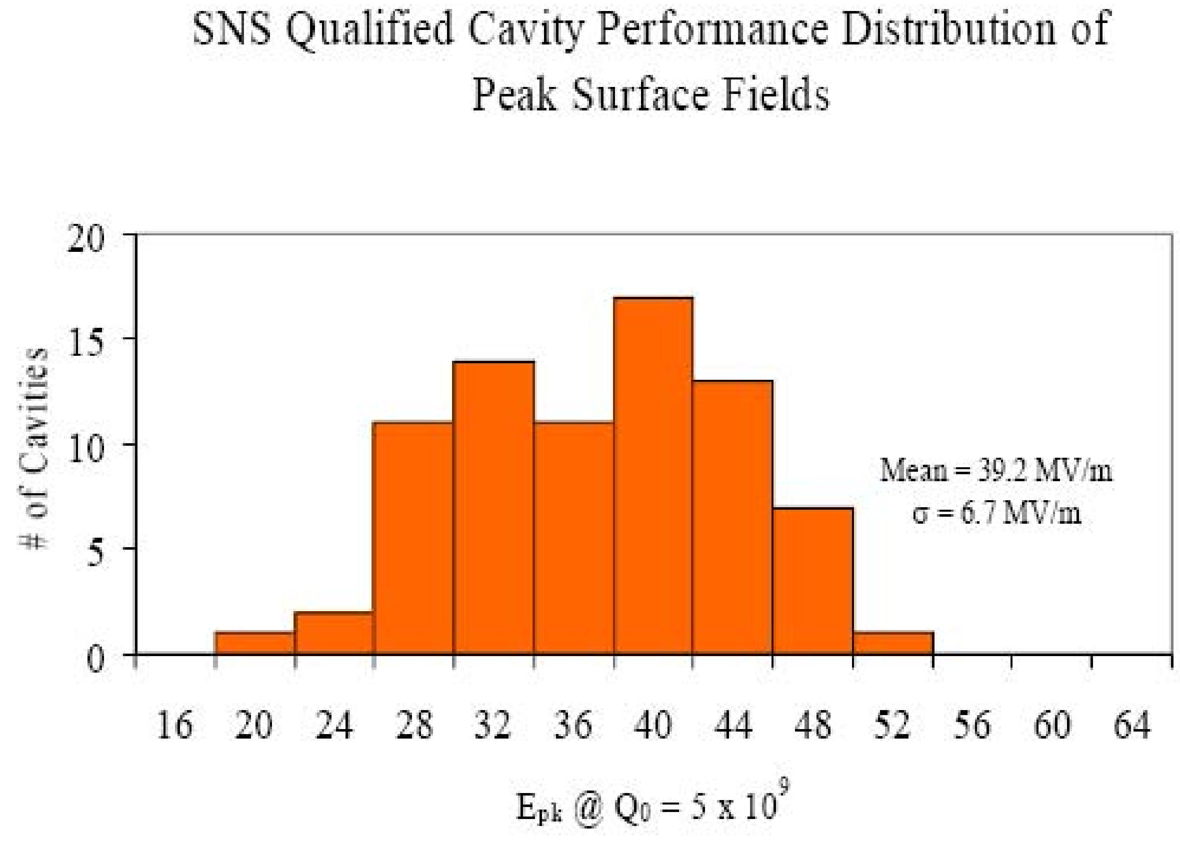


Figure 1. Gradient at $Q_o = 5 \times 10^9$. The gradient spec for the medium (high)–β cavities is indicated with the dashed red (blue) line.

Summary of SNS Cavity Performance



Lessons Learned

Evaluate & optimize facilities for applicability to particular design or process

- Reduced effectiveness of HPR system
  - ✓ Larger cavity equator and iris radii – reduced impact energy
  - ✓ Larger cavity surface area – reduced coverage
  - ✓ Cell shape (β<1) - lower momentum transfer as $\theta_{norm} \neq 0$
  - ✓ Cavity weight → component wear and failures

- HPR pump failures
  - ✓ Original pump not designed for continuous use
  - ✓ Additional rinsing → motor lifetime impact, H_2O capacity limitations
  - ✓ Replacement (spare) pumps not identical (grease)

- Additional process monitoring
  - ✓ Particle counts (air, HPR water)
  - ✓ TOC monitoring
  - ✓ RGA scan for hydrocarbons during cavity pumpdown

Lessons Learned

Guiding Principles for production-scale SRF implementations…

- Prototype program must be comprehensive.
- Consider a pre-production phase.
- Personnel continuity, discipline, and training key to performance.
- Facilities must be matched to design/process specifics.
- Module performance may only be weakly coupled to vertical cavity performance if significant handling occurs in between… so minimize it, or control & monitor it explicitly.
- Quality control measures are important throughout every dimension of the process, with timely and frequent feedback required. Everything matters… this is difficult work!

Renascence Cavity Fabrication

- Production set
  - —5 HG and 4 LL 7-cell cavities
  - —RRR 347 Nb
  - —$Nb_{55}Ti$ flanges and helium vessel transition plate
  - —Endgroups on HG and LL are identical
  - —Developed standard production drawings and procedures
  - —Refined assembly sequence details for efficiency and QA
  - —Mix of internal/external shop machining
  - —All in-house chemistry and EBW

Compare Properties

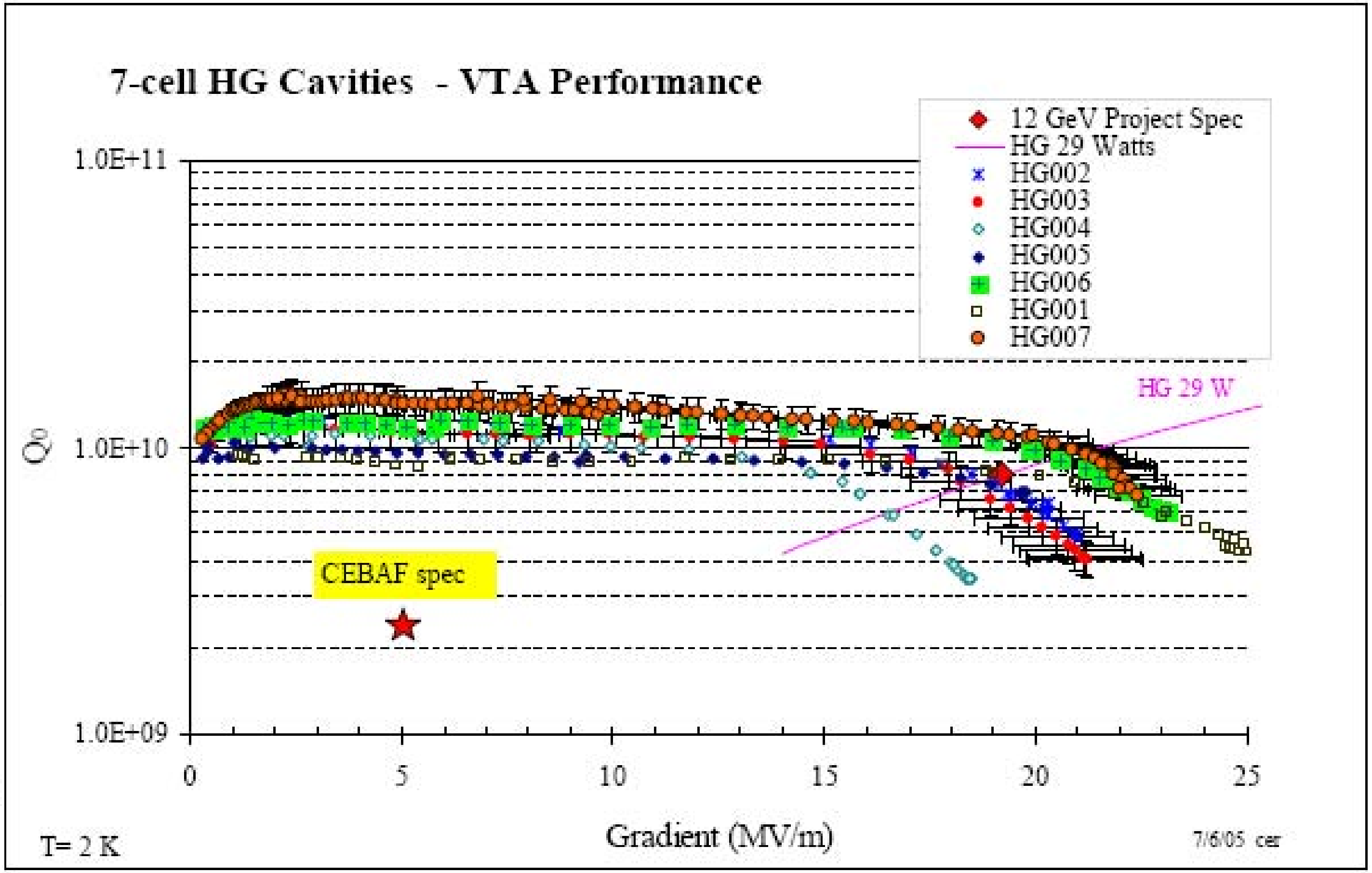
		CEBAF Original Cornell ß=1	CEBAF -12 High Gradient ß=1	CEBAF -12 Low Loss ß=1	TESLA ß=1	SNS ß=0.61	SNS ß=0.81
f_o	[MHz]	1448.3	1468.9	1475.1	1278.0	792.8	792.8
f_π	[MHz]	1497.0	1497.0	1497.0	1300.0	805.0	805.0
k_{cc}	[%]	3.29	1.89	1.49	1.9	1.52	1.52
E_{peak}/E_{acc}	-	2.56	1.96	2.17	1.98	2.66	2.14
B_{peak}/E_{acc}	[mT/(MV/m)]	4.56	4.15	3.74	4.15	5.44	4.58

Cavity Testing - HG

- Planned 12 GeV cavity temp:
  - 2.07 K
- Allocated dynamic heat budget:
  - 29 W

<u>HG design</u>

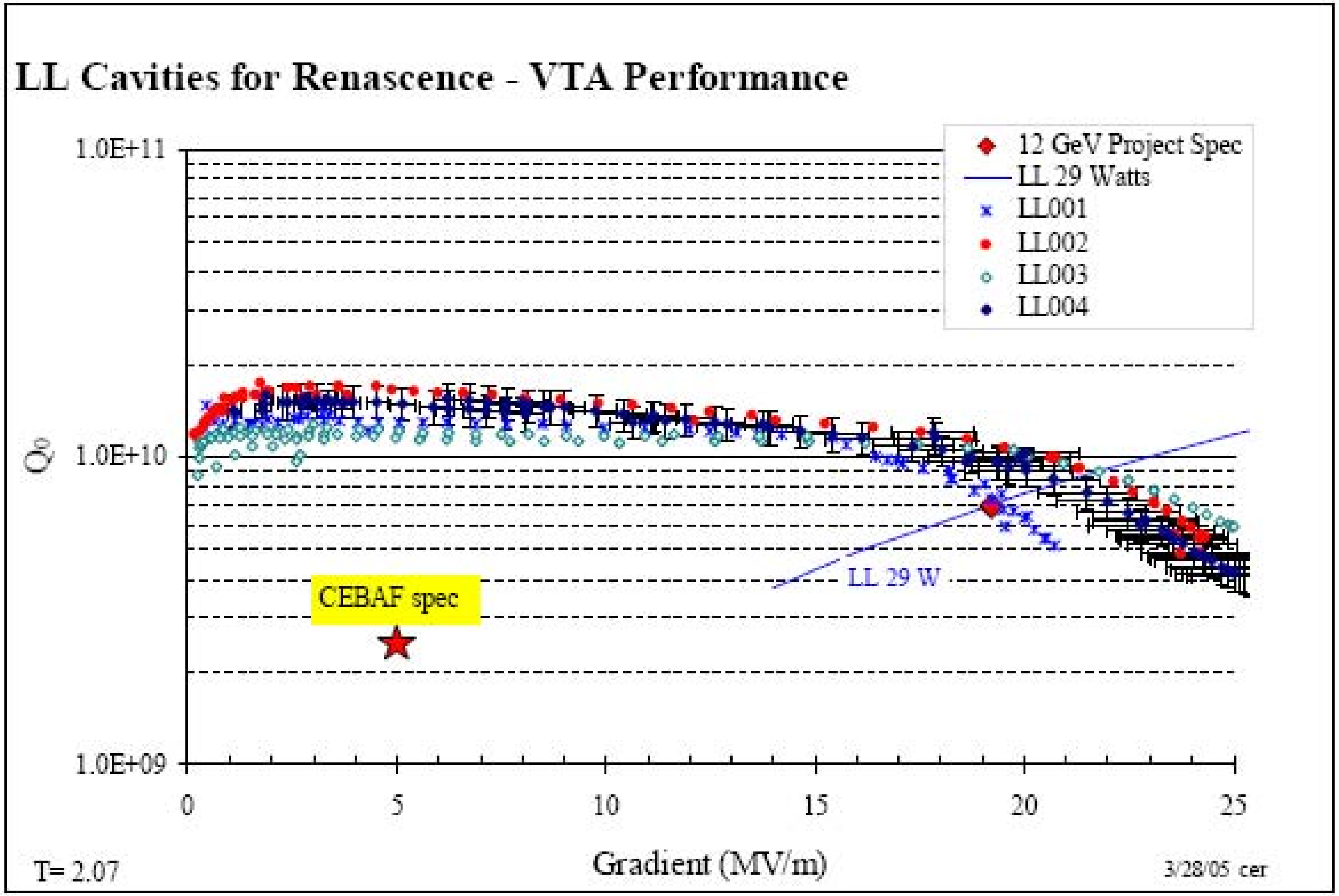
- No MP encountered
- Only HG004 was FE-limited
- Q-drop 18-20 MV/m observed without radiation



Cavity Testing - LL

LL design

- No MP encountered
- No FE-limited cavities
- Q-drop 17-21 MV/m observed without radiation
- 120 C bake improved Q_0 < 15 MV/m only (Input coupler heating suspected)



Summary of basic evaluations needed

- Cavity properties, Epk/Eacc, Hpk/Eacc
- number of cavities in the sample,
- average results, spread
- number of re-treatments,
- field emission onset levels, spread
- Q vs E curve,
- nature of highest field limitation
  - quench, Q-slope, field emission, H- contamination
- Number of cavities with fabrication defects (e.g weld)
- Number of cavities with material defects (needs thermometry)
- fraction of cavities reaching design Q at design field,
- Procedure variations
- Recipe variations
- Lessons learned

Addressing contamination issues on multi-cells

Sources of Reproducibility Problems

- Thermal breakdown of superconductivity from material or manufacturing defects
  - Weld Problems at new industry
    - Deviation from specification
    - Insufficient quality control
  - Industry is improving welding procedures to avoid problems
- Imperfections in final surface treatment,
  - e.g electropolishing (EP)
  - Final rinsing
- Field Emission from particle contamination

Electro-polishing (EP) Studies

- Field emission onset levels vary strongly
  - Sulphur contamination of EP ?
  - Efforts on better contamination control (e.g. H_2O_2 rinse, better filtering acids, cleanliness for EP)
  - Measure Nb, F, S contents of acids during EP
  - Control EP parameters, V, I, acid temp…
- Series of control studies on EP underway at DESY, KEK, Jlab, and other places
- World collaboration effort to document procedures, parameters & problems (after SMTF and TTC meetings)
  - Aim: to assemble the best recipe
  - First draft of reports available
  - Active exchange of information - through website set up after collaboration meetings

Other Studies

- Final High Pressure Rinsing (HPR) rinsing anomalies?
  - Accidental dust…
- Water quality
  - Resistivity, Particle Count, Bacteria, TOC
  - Monitor and improve
- Final pump down anomalies
  - e.g pump oil contamination in line
  - see later for KEK results
- Need excellent control of facilities
- H absorption => Q-disease in some cases
- Higher RRR material more prone to H pick-up
  - Need good temperature control
  - Uniform RRR selection

Task Force to Digest Existing EP Study and Proposal

- Tajima, Boffa Review Paper on EP
- Kneisel, Reschke Plan for EP Studies

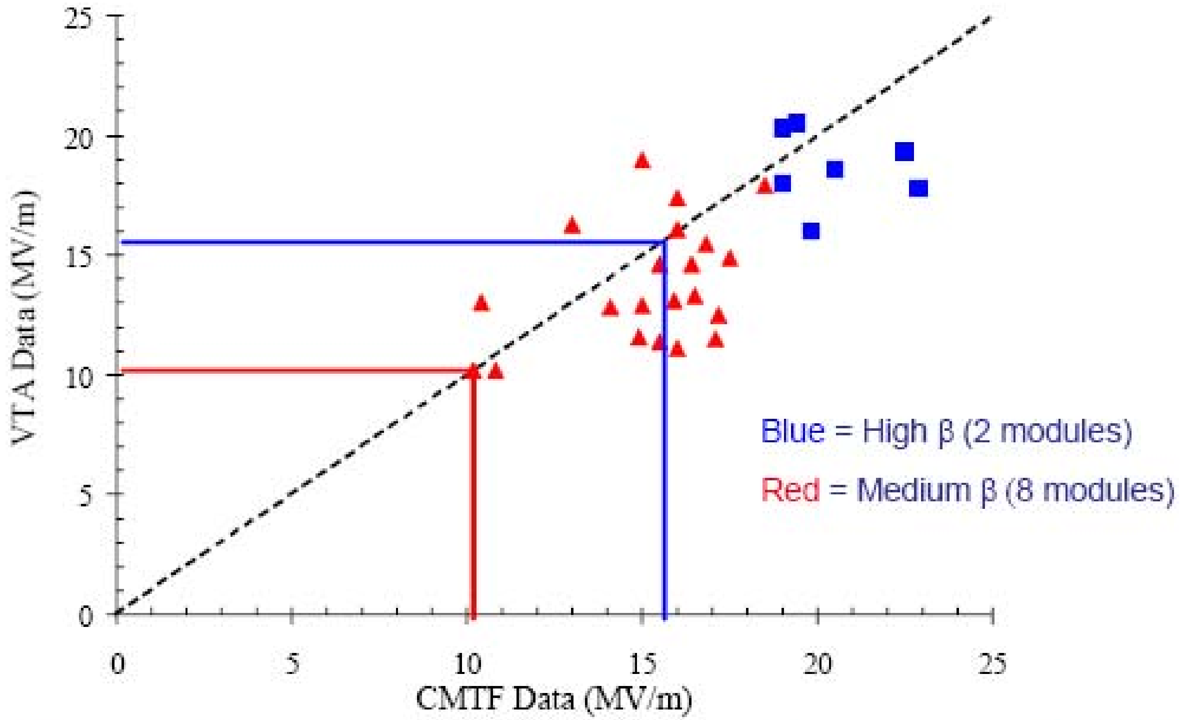
<u>Goal</u>: S1 should address the successful gradient yield of cryomodules.
The goal should also include Q, dark current (or Xray), alignment

- At minimum, S1 is a proof-of-principle demonstration, needed soon
- DESY cryomodule#6 has a good chance of reaching 31.5 MV/m.
- <u>Gathering information</u>
  - We need to bring together existing statistics on TTF cryomodule performance “vertical test results vs cryomodule test results”, to see what is the expected yield of cryomodule gradients.
-

Comparison w/ Cryomodule Performance

Gradient at $Q_0 = 5 \times 10^9$

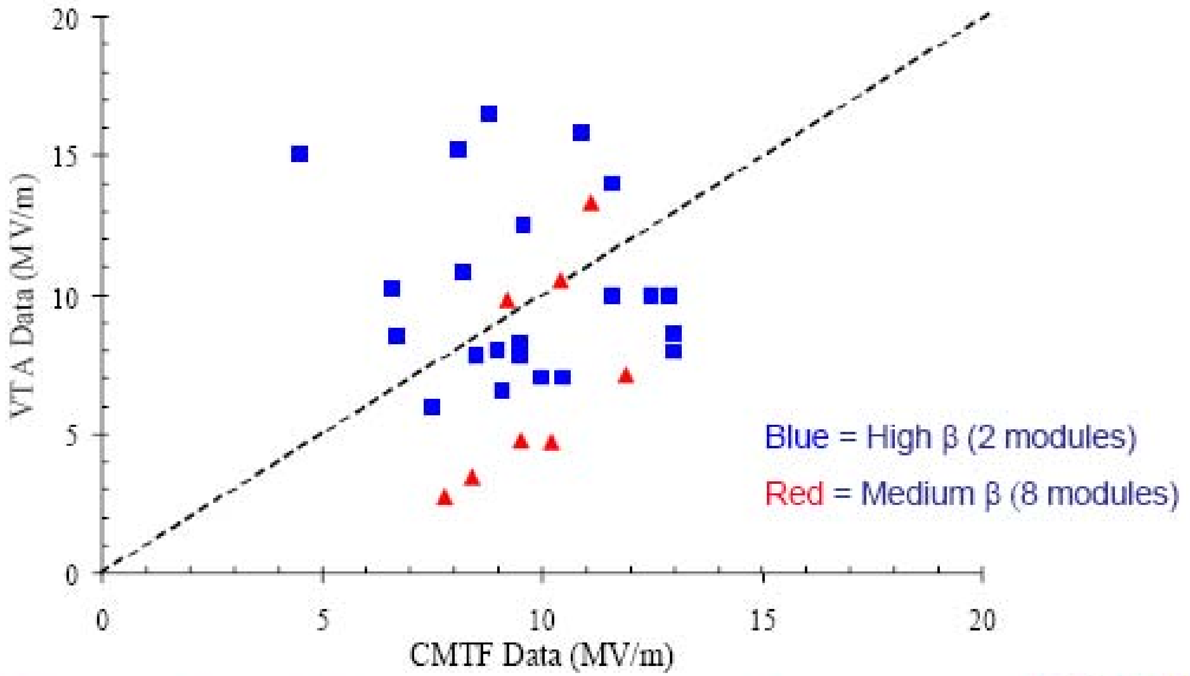
Cavity gradients in the CMTF were found to be ~35% higher than those measured in the VTA. This increase is perhaps due to the much lower RF duty factor (6-7%) employed during module testing. Note – no MP was ever observed in CM testing.



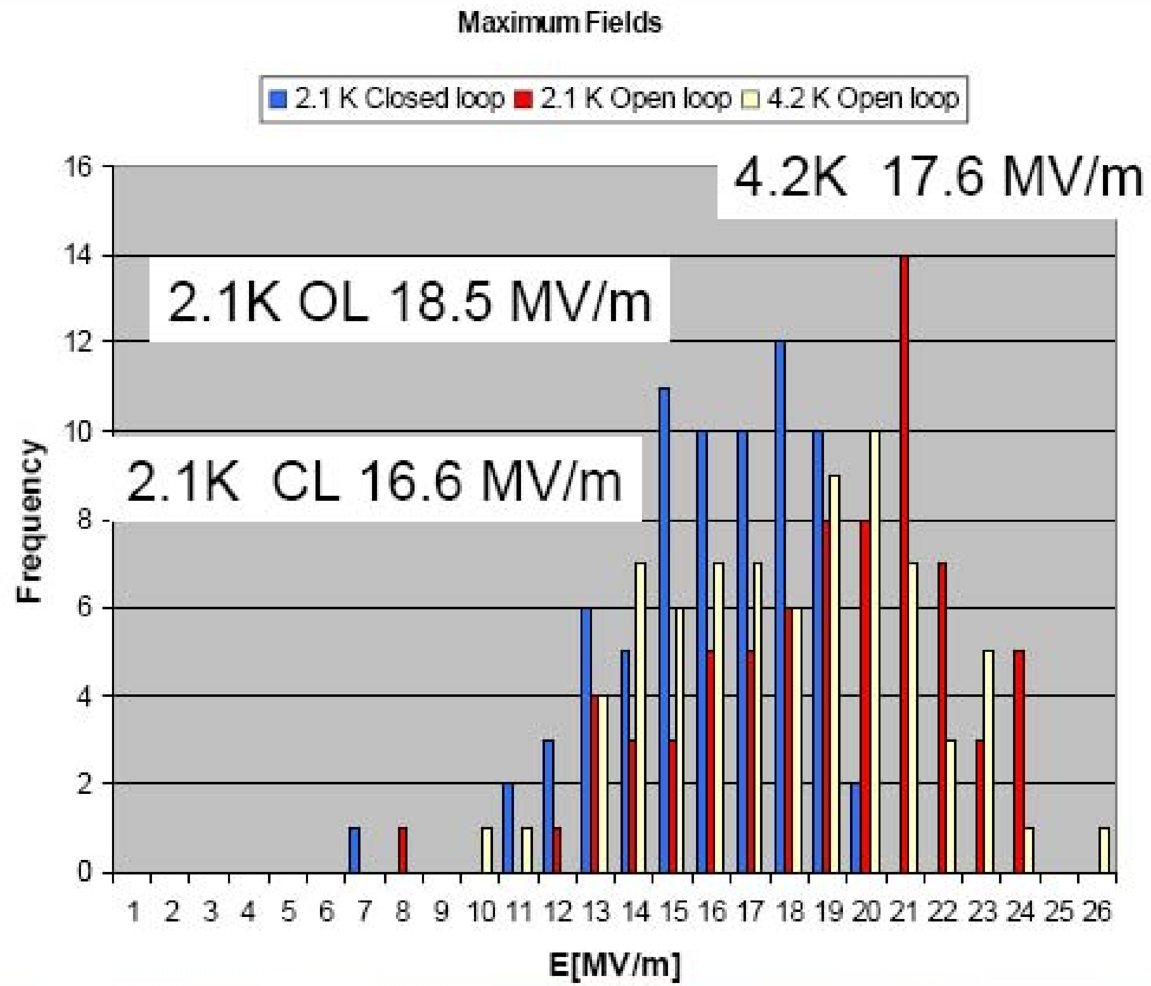
Comparison w/ Cryomodule Performance

Onset of Field Emission

No strong correlation exists. As FE onset is largely determined by environmental factors, and the cavities were re-processed before sting assembly, it is reasonable to conclude that vertical test FE onset is not a good predictor of onset of FE in a completed cryomodule.



Operation at 2.1 K vs. 4.2 K

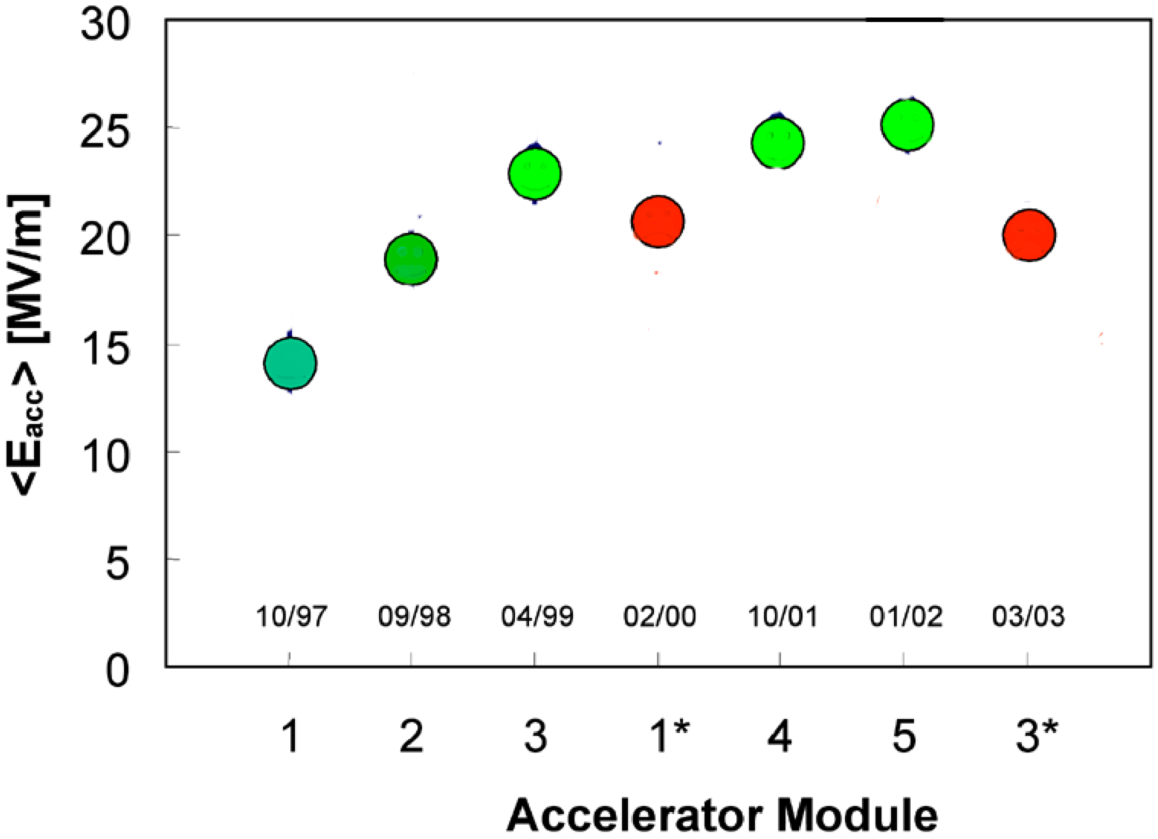


Assemblies, Installations and Cold Operation

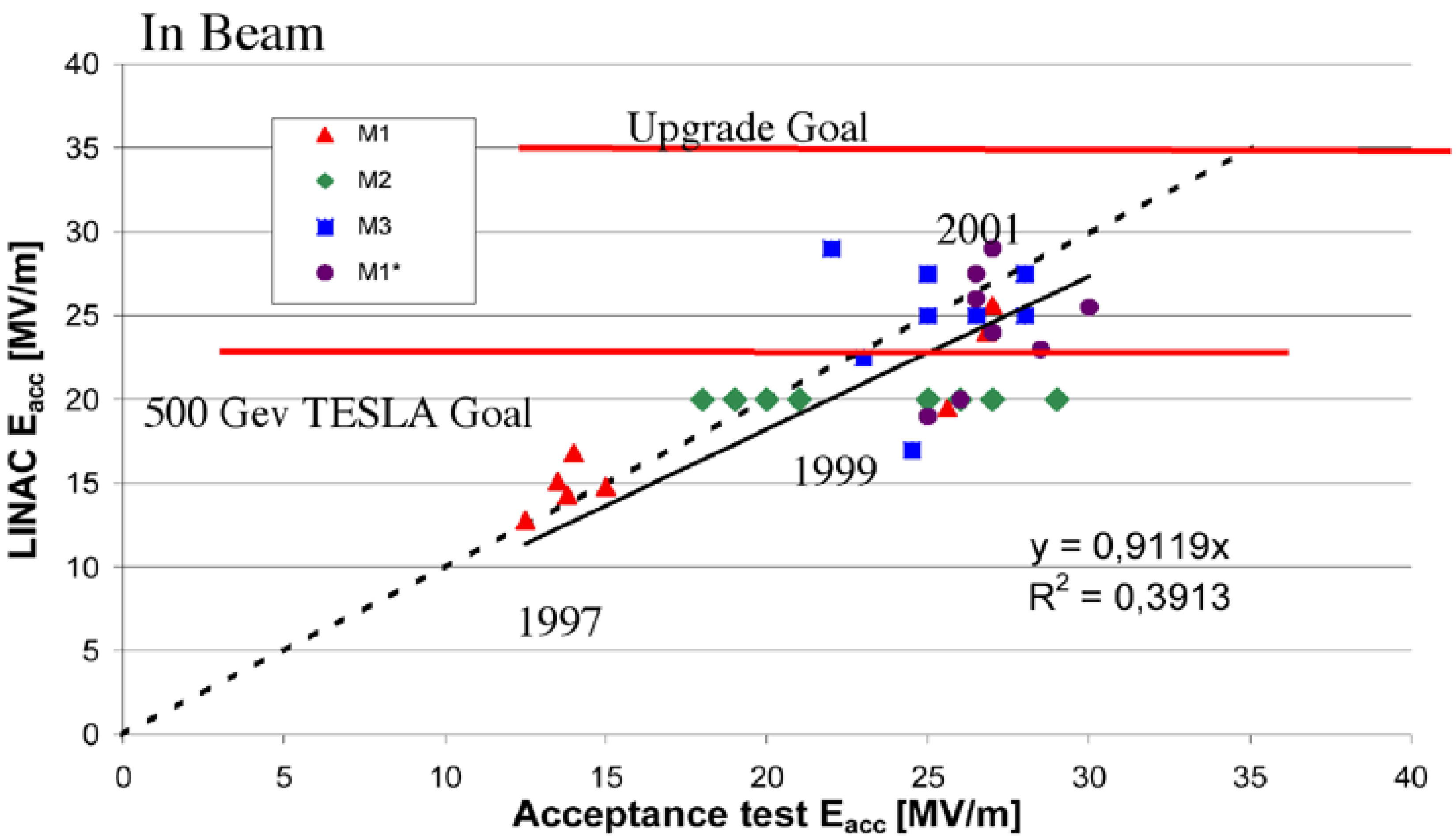
Overview Assemblies and Cold Tests TTF-Cryomodules

Status: 15-Feb-05 R. Lange DESY -MKS1-

Module	Type	Assembly		Installation and Test		Therm. Cycles
		Year	Days	in TTF-Linac		cold/warm
Capture	Spec.	Saclay 1996		Oct-96	96-->Sep-03	c/w 13
M1	I	1997	>>	Mar-97	97-->Sep-97	c/w 2
M1 rep.	I	1997/98	>>	Jan-98	98-->Mar-99	c/w 3
M2	II	1998	>>	Sep-98	98-->May-02	c/w 3
M3	II	1999	35+15	Jun-99	99-->May-02	c/w 1
M1*	II	2000	24	Jun-02	02-->	c/w 3 +1
M4	III	2001	18+10	Apr-03	03-->	c/w 1 +1
M5	III	2002	30	Apr-03	03-->	c/w 1 +1
MSS	Spec.	2002	36	Jun-02	02-->Sep-03	c/w 3
M3*	II	2003	18+6	Apr-03	03-->	c/w 1 +1
M2*	II	2004	20	Feb-04	04-->	c/w 1



<E_{acc}> [MV/m]
30
25
20
15
10
5
0
10/97
09/98
04/99
02/00
10/01
01/02
03/03
1
2
3
1*
4
5
3*
Accelerator Module



In Beam
Upgrade Goal
500 Gev TESLA Goal
M1
M2
M3
M1*
2001
1999
1997
y = 0,9119x
R2 = 0,3913
LINAC Eacc [MV/m]
Acceptance test Eacc [MV/m]
0
5
10
15
20
25
30
35
40

Performance of Accelerator Module 5

A State-of-the-art module

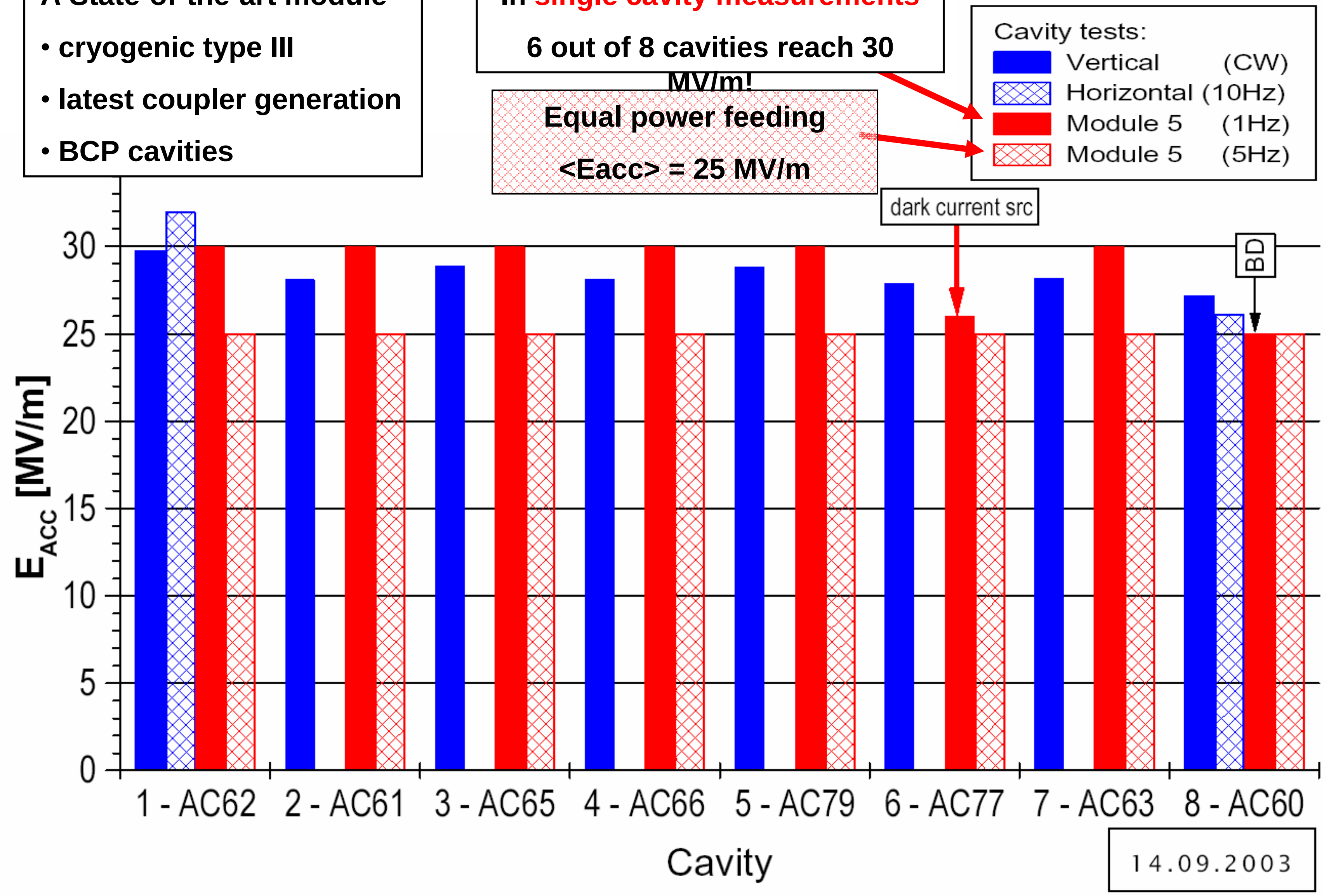
- cryogenic type III
- latest coupler generation
- BCP cavities

In single cavity measurements

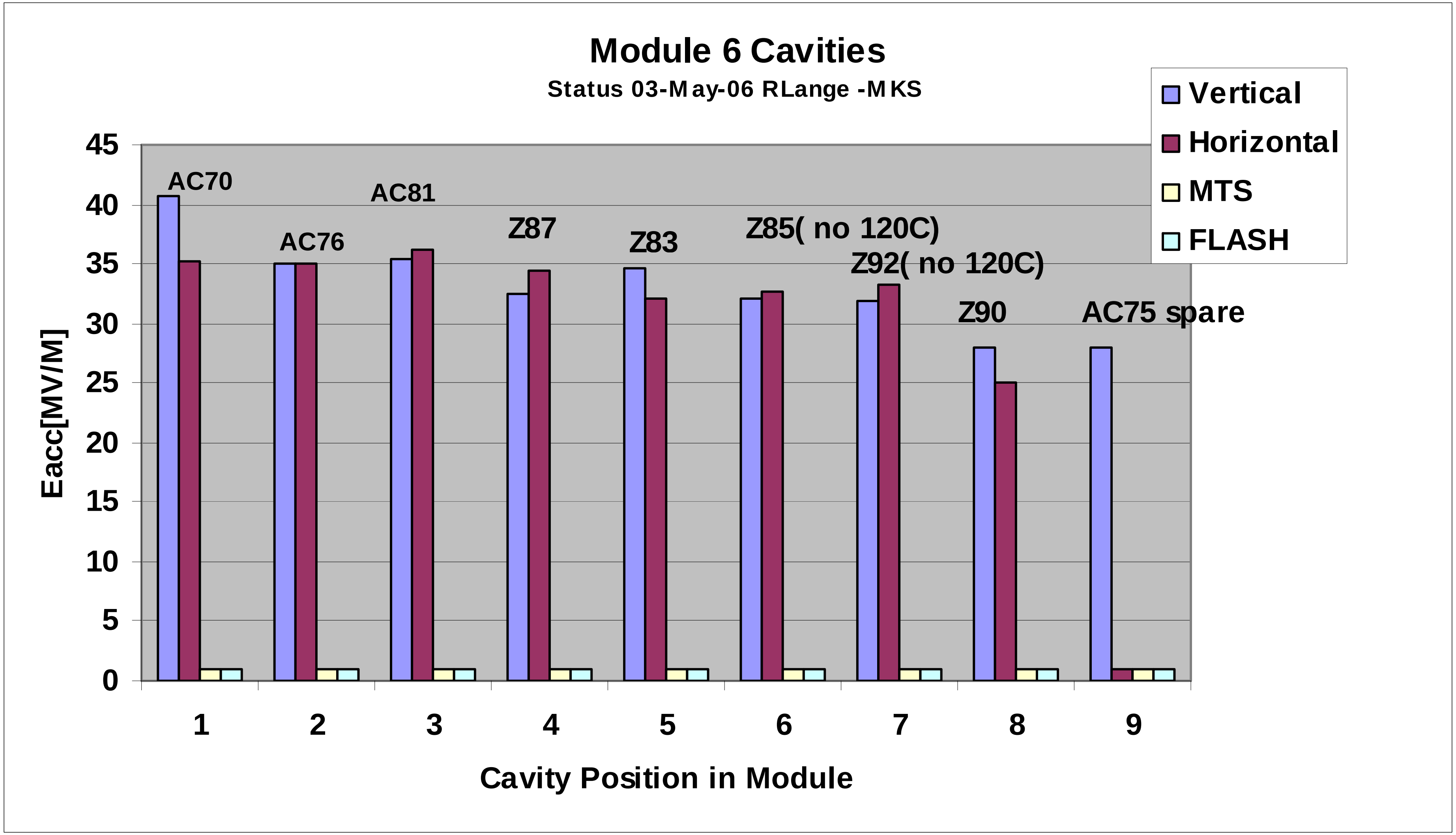
6 out of 8 cavities reach 30 MV/m!

Equal power feeding

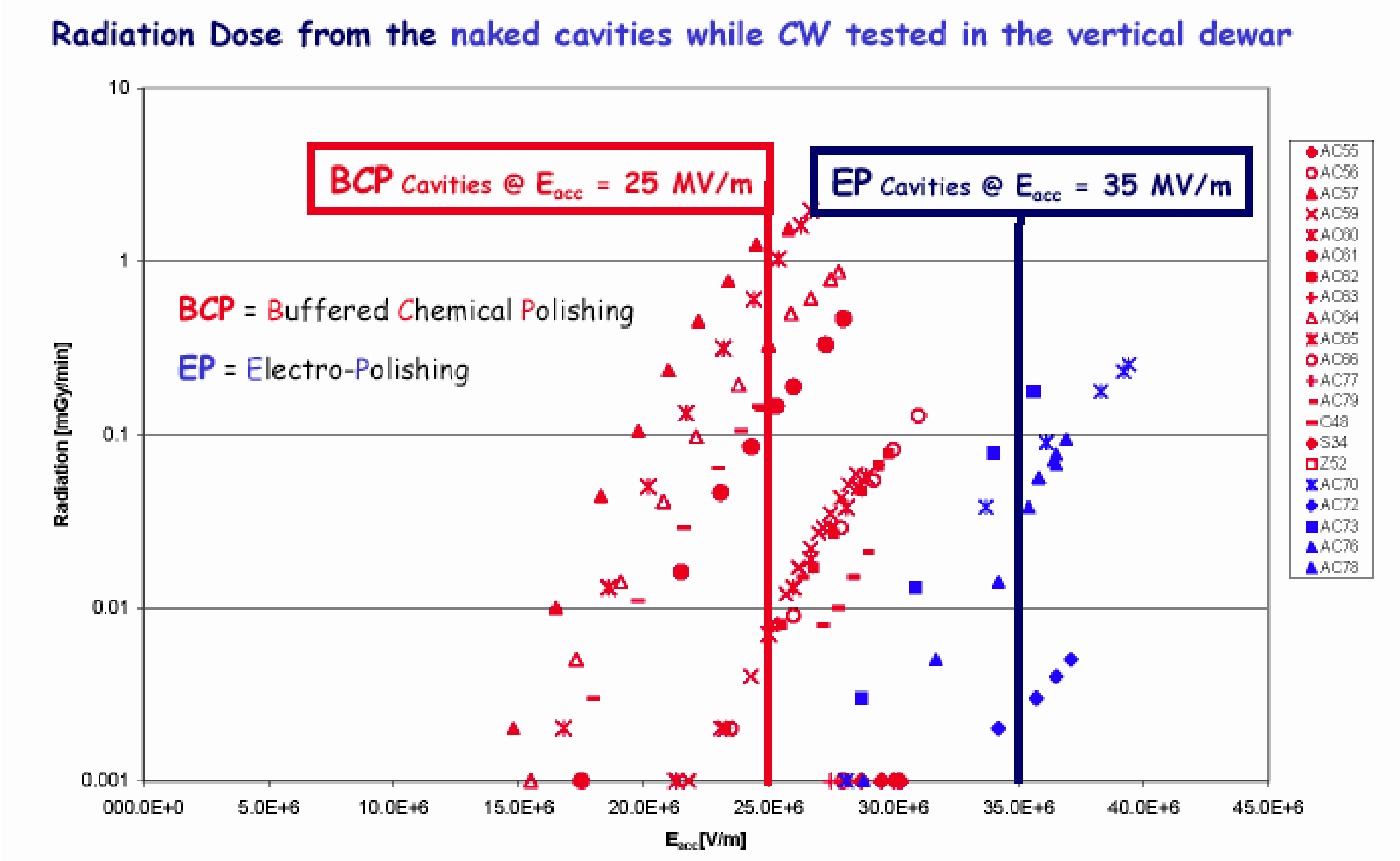
<Eacc> = 25 MV/m



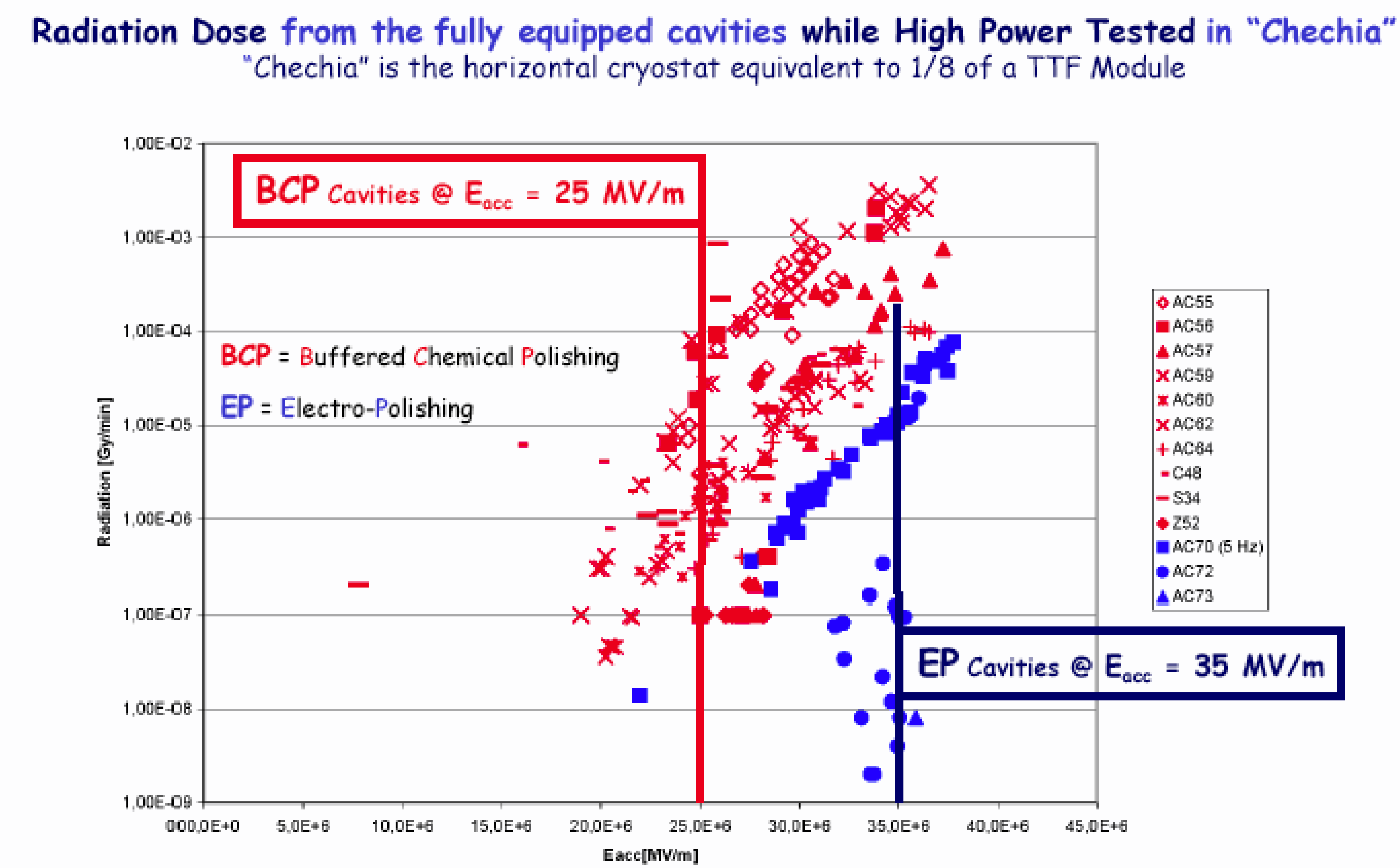
Module 6 expectations…



All 5 Electropolished Cavities at 35 MV/m show less radiation than BCP cavities at 25 MV/m



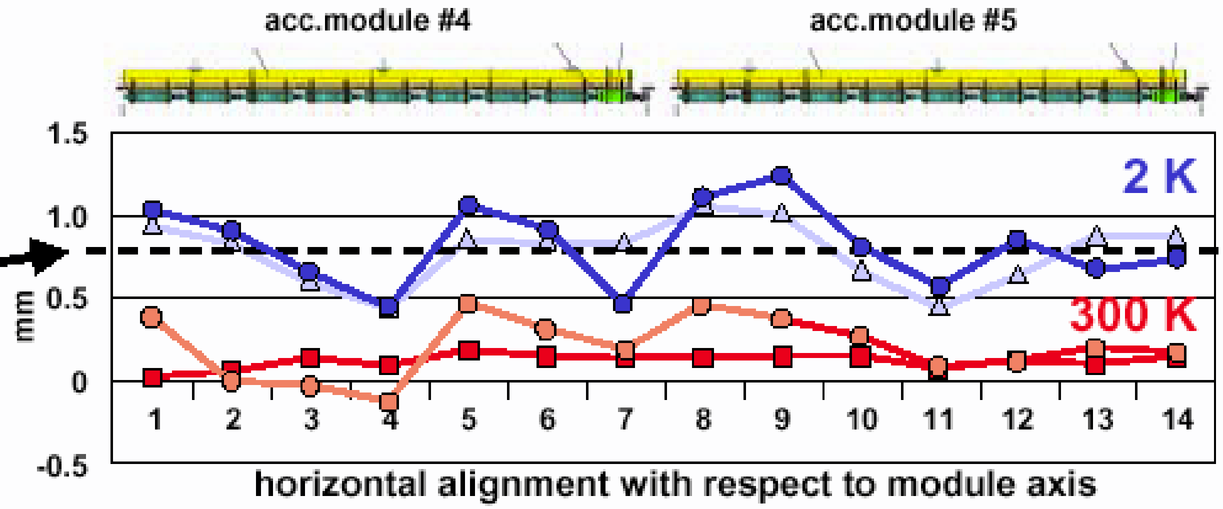
Again, Electropolished cavities at 35 MV/m show less radiation than BCP cavities at 25 MV/m



cavity / quad string alignment is measured using a stretched wire system

at warm and at cold temperature

corresponds to a perfectly aligned cavity / quad string



■ 20-Jun-03	300 K
△ 22-Jul-03	2 K
● 06-Oct-03	300 K
● 31-Mar-04	2 K

TDR specifications (RMS):

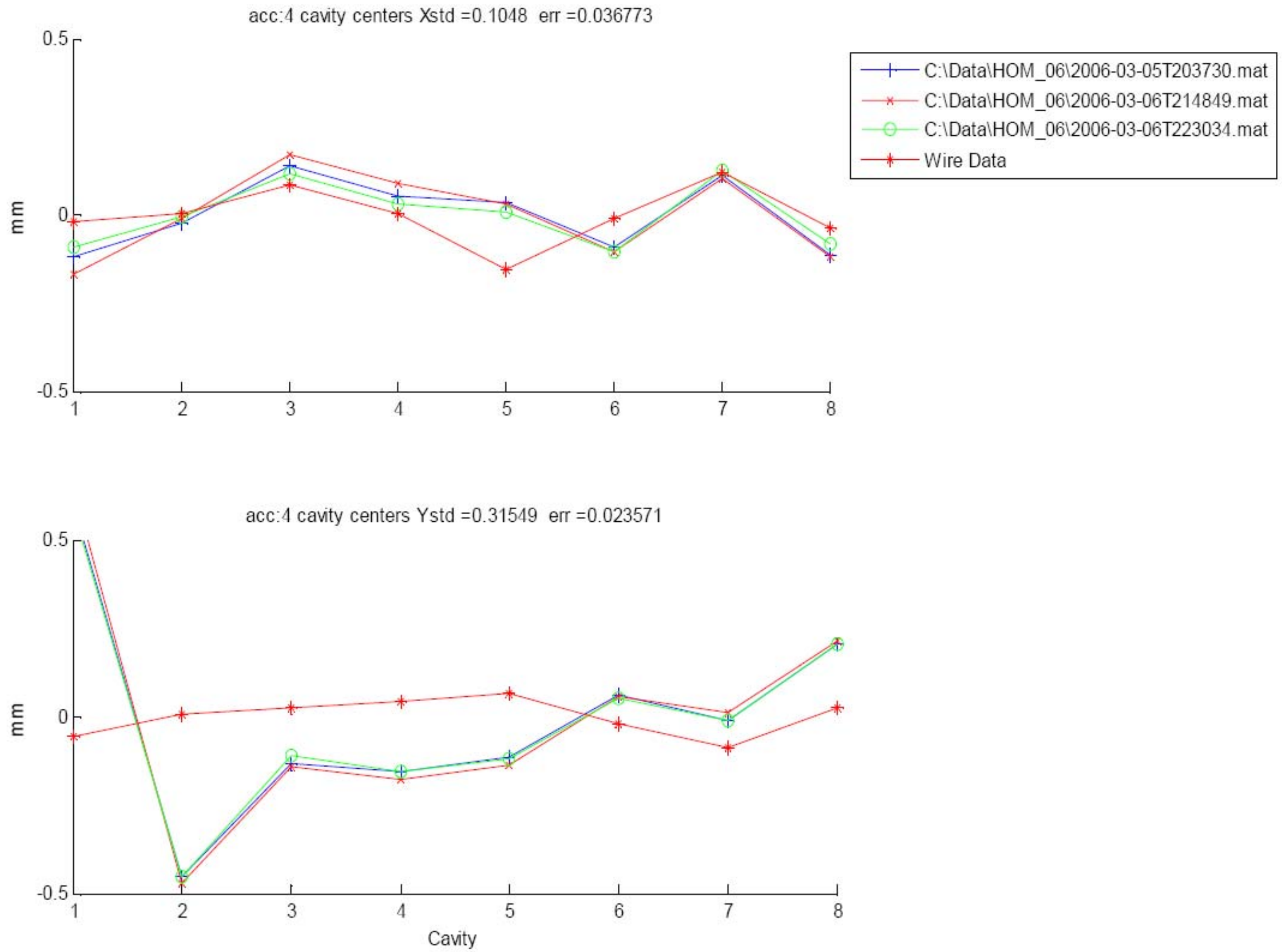
cavities	x/y:	+/- 0.5 mm
	z:	+/- 1 mm
quad/dip	x/y:	+/- 0.3 mm
	z:	+/- 1 mm
	roll:	+/- 0.1 mrad

Results (peak):

cavities	x:	+/- 0.35 mm
	y:	+/- 0.25 mm
quad/dip	x:	+ 0.1 / - 0.4 mm
	y:	+ 0.2 / - 0.5 mm

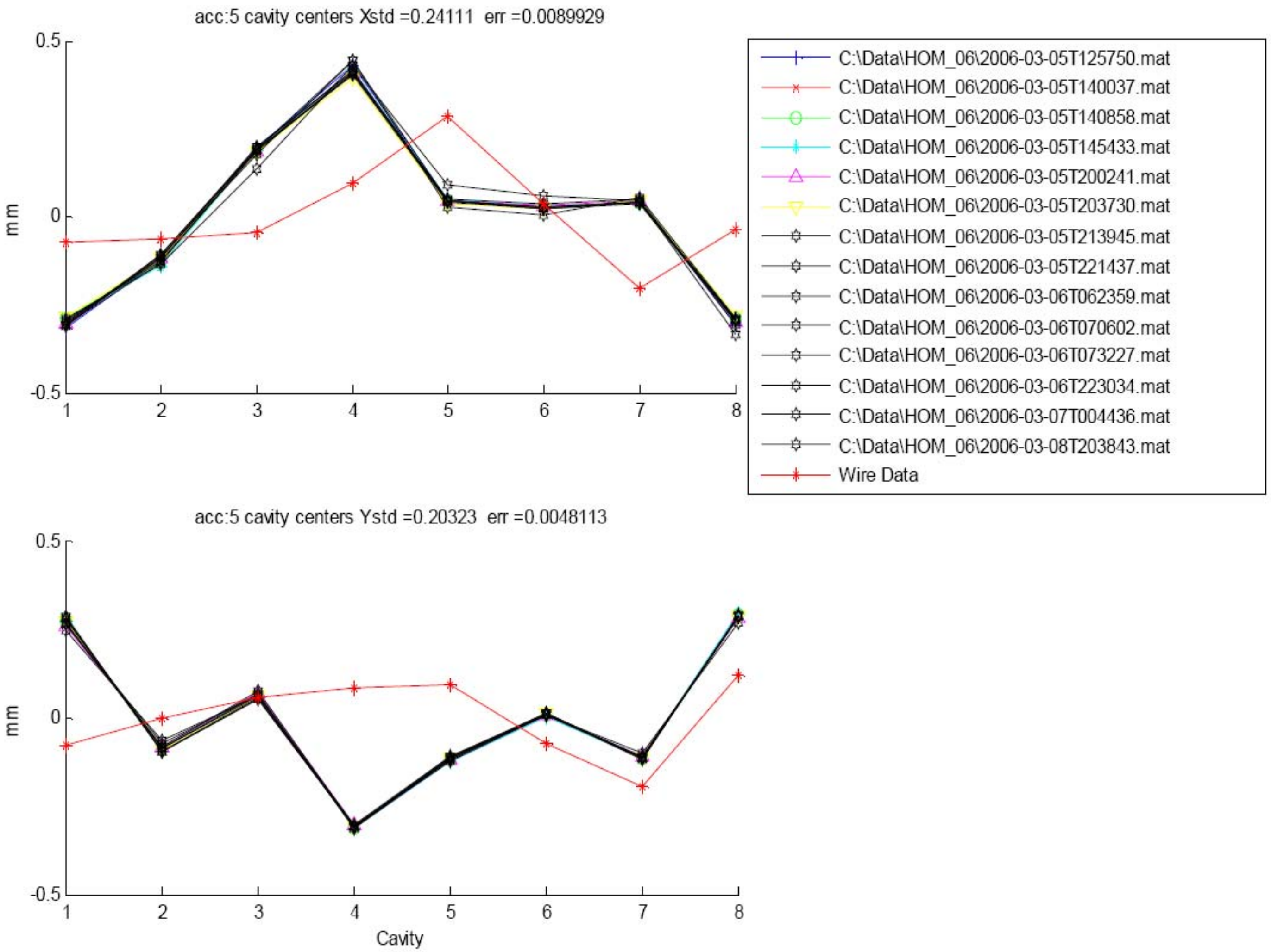
overall module tilt ≈ 0.1 mrad

HOM Messungen
(J. Frisch, M. Ross, N. Baboi et al.)



HOM Messungen

(J. Frisch, M. Ross, N. Baboi et al.)



Propose to develop the S2 Task Force R&D work plan in three stages:

- Stage 1
- A plan to answer R2 issues in TRC report. These issues may be expanded to include further tests

- Stage 2
- Determine the number of RF units (or string length) needed for demonstration of ILC readiness, i.e. a sufficient technology demonstration to launch ILC.
  - One approach is to work backwards from the ILC construction scenario (construction period 5 years) to determine the level of industrial/laboratory preparedness necessary between now and ILC approval (2007 – 2010).
- Define a plan to realize the desired number of RF units.
- Define the goals of system tests to be carried out with the RF units.
- Stage 3
- Determine if a Test Linac needs to be assembled from the RF units.
- Define the properties of the beam and the beam-related studies that need to be carried out with the linac.
- Define a plan to assemble the Test Linac including cost estimate and time line.
- Work to be done in consultation with S3 (Damping Rings Task Force)

Tentative list of Members of Task Force S2

- Padamsee (Chair), Himel, Kephart, Hayano, Nobu, Weise (no answer yet)
- Consultants: Nagaitsev, Solyak, Lutz, Ross, Schulte

Tentative Charge for S2 Task Force (to be approved by EC)

The conceptual plan for the R&D for the ILC includes the building and testing of a string of cryomodules after the proof of principle milestone of reliable production of cavities and single cryomodules has been achieved. As the basic building block of the linac, the minimal string is one RF Unit containing three cryomodules with full RF power controlled substantially as in the final linac. The desired string for the ILC R&D plan may consist of many RF units. The definition of the details of this milestone, which we call S2, needs to be defined by GDE, along with a timeline for its realization. Some of the crucial specifications of the string have been defined in the R2 ranking of the R&D issues in the TRC report (2003). More specifications may be necessary. The full scope and goals should be well-established and accepted soon, since the they will constitute an important milestone on the road to final construction approval. The R&D Board is asked to set up a Task Force to propose a Plan with a set of goals and specifications and a time scale for accomplishing them, which will be submitted to the GDE for action. Examples of the parameters to be determined are the number of modules needed in the string, the performance specifications, the nature and duration of the tests, the rules for the deviations from the final production specifications and final environmental conditions. The Task Force should take care that the whole project is as well-defined as possible, interacting with the Area communities involved. Without anticipating the result of the Task Force analysis of the number of modules required, it is likely to be large enough so that industrialization is required to render their production practical. The Plan should contain the practical information to show how the transitions from proof-of-principle to the S2 Milestone and start of main linac production should be accomplished.

- There is no GDE specification dealing with a Test Linac, and the Task Force proposal should address the question of whether there should be a Test Linac, and with what parameters. Such a linac would imply the injection of a beam into the string defined in S2. The Task Force should establish the relationships between the functions of the string, the operation of the string in realistic conditions, and the use of a Test Linac as a facility for beam measurements.

Next Steps

- Task Force to prepare a more detailed work plan
- I can circulate a draft-plan for comments
- Set up phone meetings, emails…

Next Modules 2005-2008

<u>Order at Zanon Oct-05</u>
2 cryostats
cold mass/vac-vessel
Delivery Oct-06

M8

M9

<u>Order at A, B,(C) Nov-06</u>
2(3) x 2 cryostats
cold mass/vac-vessel
Delivery July-07

M A1

M B1

M C1

Delivery Dec-07

M A2

M B2

M C3

<u>Order at ? Jul-08</u>
3 Pre-cryostats
complete module
Delivery Jun-09

<u>Goal:</u>
Modify for Type3+
Must:Compatible with
Type3(spare TTF)
Learn specification
EN13445/without authority
M8 assembly by industry?

<u>Goal:</u>
Qualify
2(3) vendors for
improved design
XFEL prototype
AD2000/TÜV joined
assembly by industry

<u>Goal:</u>
Qualify
2(3) vendors for
XFEL prototype
Best/cheap solution

<u>Goal:</u>
Production and
Test of 3 XFEL
complete preseries
modules delivered
by industry

END

Preparation: First ACCEL Cavity at Cornell

BCP Complete

HPR Complete

KEK: Check Reproducibility of final rinsing procedure: HPR

Reproducibility @ 2K and Error

Re-HPR, Re-evacuation

Low Loss @ 2K

Eacc,max	Qo @ Eacc,max
46.5	1.20E10
47.3	1.13E10
46.6	1.50E10
45.0	1.03E10
44.0	1.20E10

45.9±1.3 MV/m , Q0 = (1.21±0.18) E10

Reentrant@ 2k

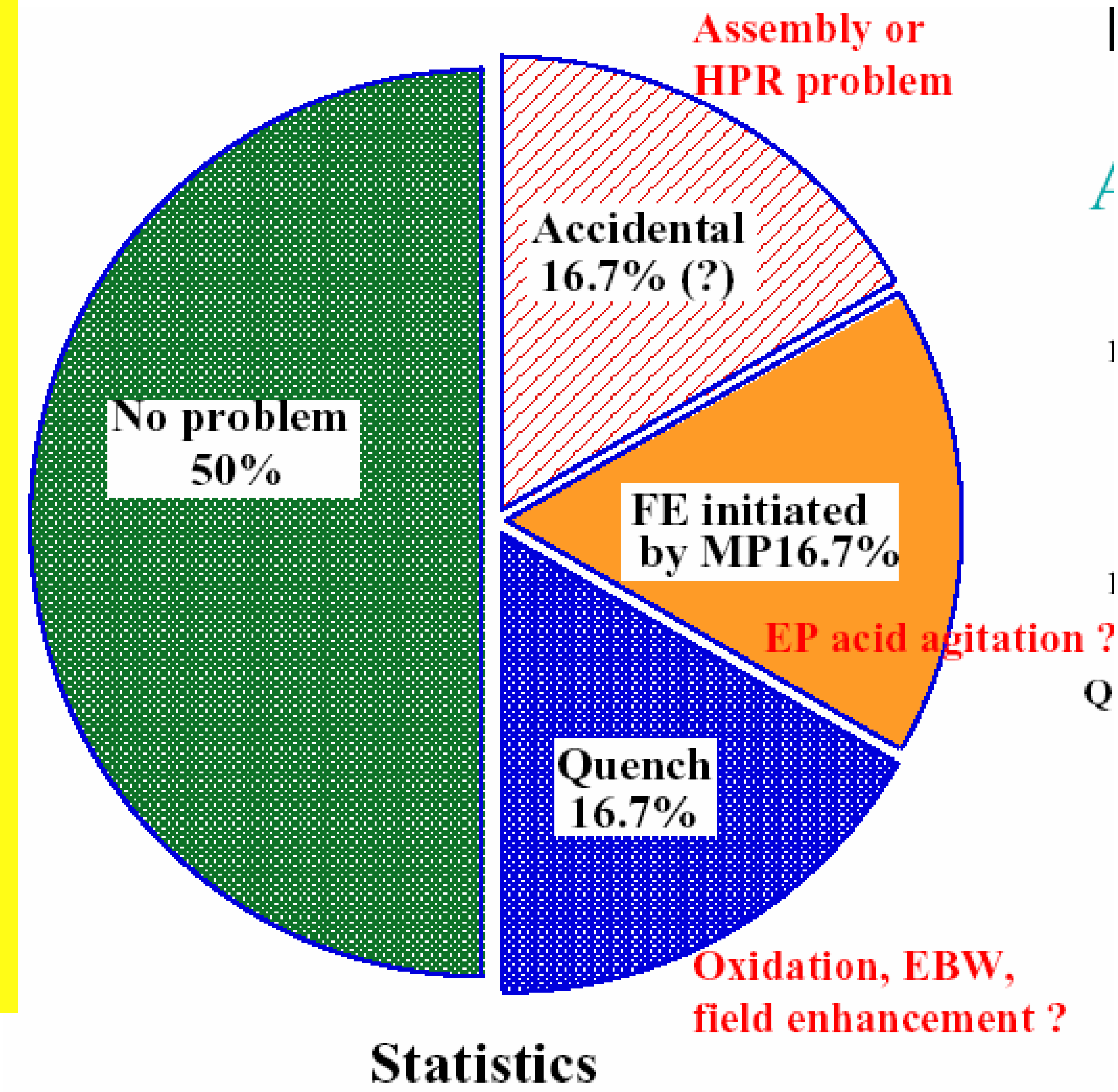
Eacc,max	Qo @ Eacc,max
51.2	0.59E10
52.3	0.97E10
51.9	1.11E10
52.4	1.21E10
50.0	0.98E10

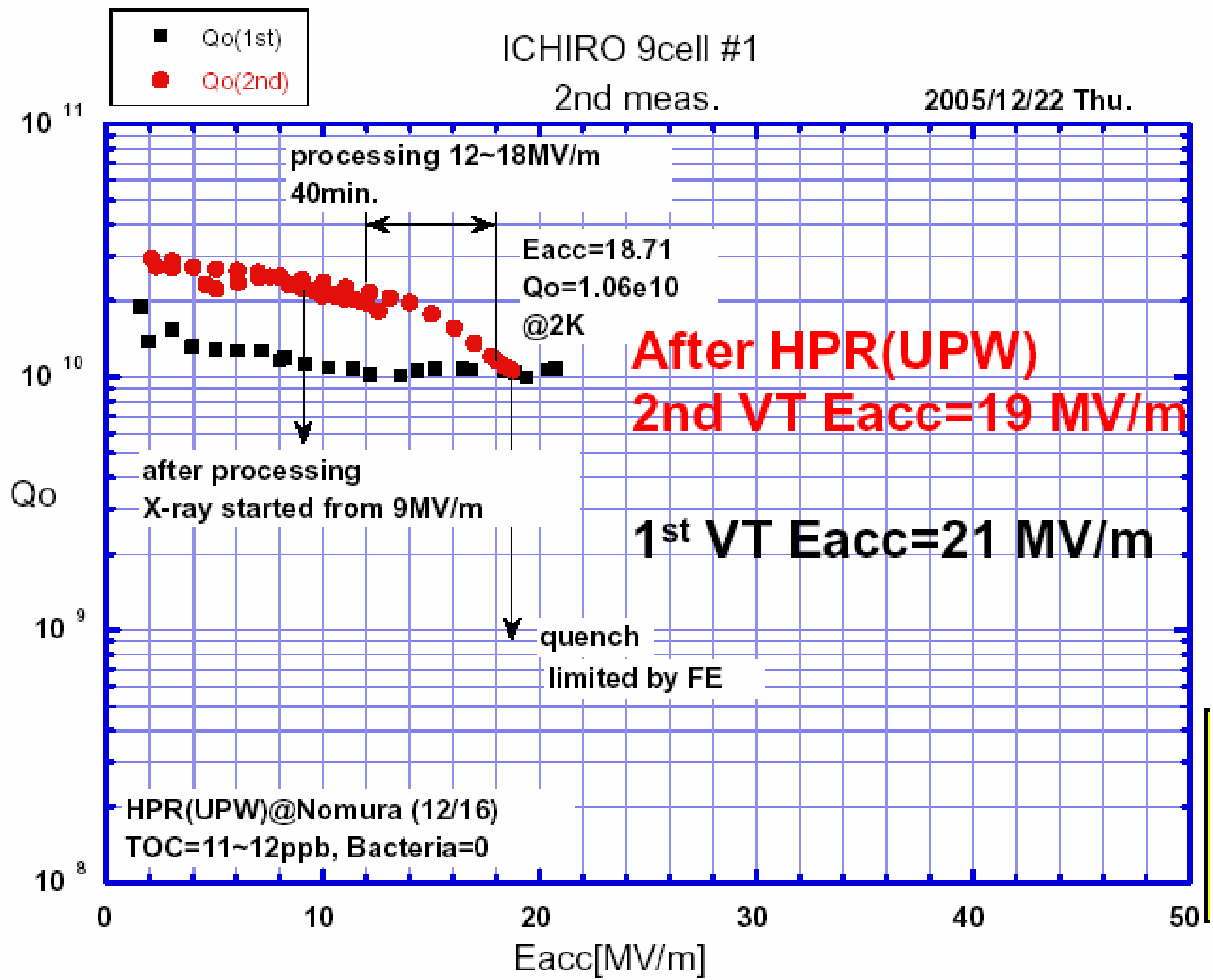
51.6 ±1.0 MV/m, Q0 = (0.97±0.24) E10

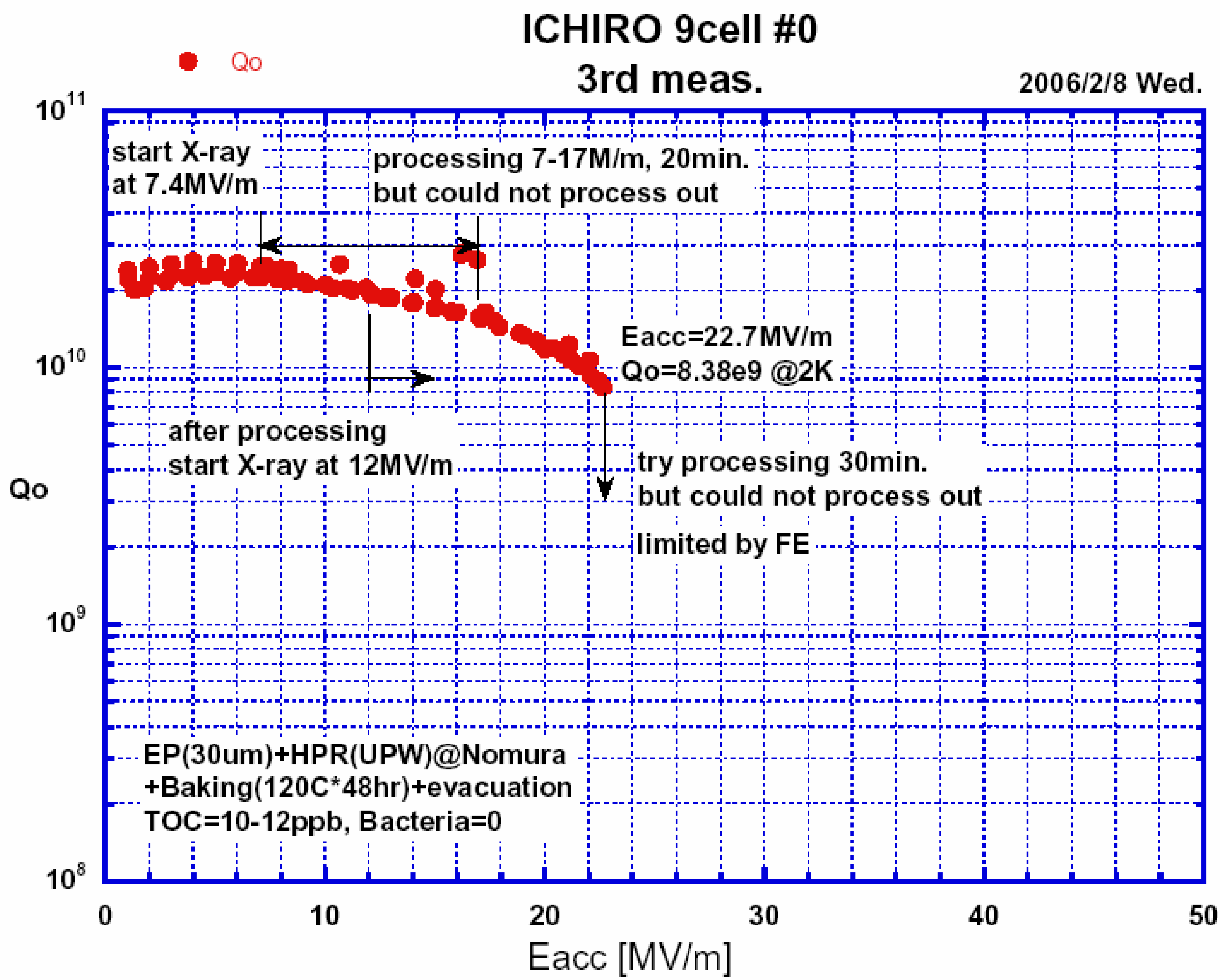
Seven Single Cell Cavities, Search for Best Preparation Procedures, Example :

cavity	date	meas.	treatment	Eacc	Qo
IS-#2	11月18日	1st	KEK recipe	−	−
	11月29日	2nd	HPR(KEK)	37	1.53E+10
	12月5日	3rd	HPR(Nomura)	37.6	1.42E+10
	12月19日	4th	HF rins+HPR(Nomura)	28	4.56E+09
	12月27日	5th	warm-up + Baking(120C*48hr)	25	5.77E+09
	1月11日	6th	HPR(KEK)	37.1	1.64E+10
	1月12日	7th	keep 100K*12hr	35.8	1.57E+10
	3月20日	8th	EP(3um, closed)+HPR(UPW)+Baking	39.3	9.69E+09
	3月21日	9th	100K*12hrs	41.6	1.00E+10
	4月4日	10th	EP(20+3um, closed)+HPR(UPW)+Baking	47.07	1.06E+10
cavity	date	meas.	treatment	Eacc	Qo
IS-#3	11月21日	1st	KEK recipe	31.4	8.66E+09
	11月30日	2nd	HPR(Nomura)	32.7	7.27E+09
	12月28日	3rd	HF rins+HPR(Nomura)	36.7	1.43E+10
	3月23日	4th	EP(3um, closed)+HPR(UPW)+Baking	39.4	1.32E+10
	3月25日	5th	100K*38hrs	40.3	1.28E+10
cavity	date	meas.	treatment	Eacc	Qo
IS-#4	11月22日	1st	KEK recipe	45.1	9.07E+09
	1月6日	2nd	HPR(KEK)	42.7	5.66E+09
	1月18日	3rd	HPR(Nomura)	43.7	6.07E+09
	1月19日	4th	add L.He	40	6.06E+09
	3月13日	5th	HF rins +HPR(UPW)	50.4	9.97E+09
	3月15日	6th	100K*12hrs	47.3	1.12E+10
	3月28日	7th	EP(3um, closed)+HPR(UPW)+Baking	41.13	1.17E+10
	3月30日	8th	100K*40hrs	40.12	1.20E+10

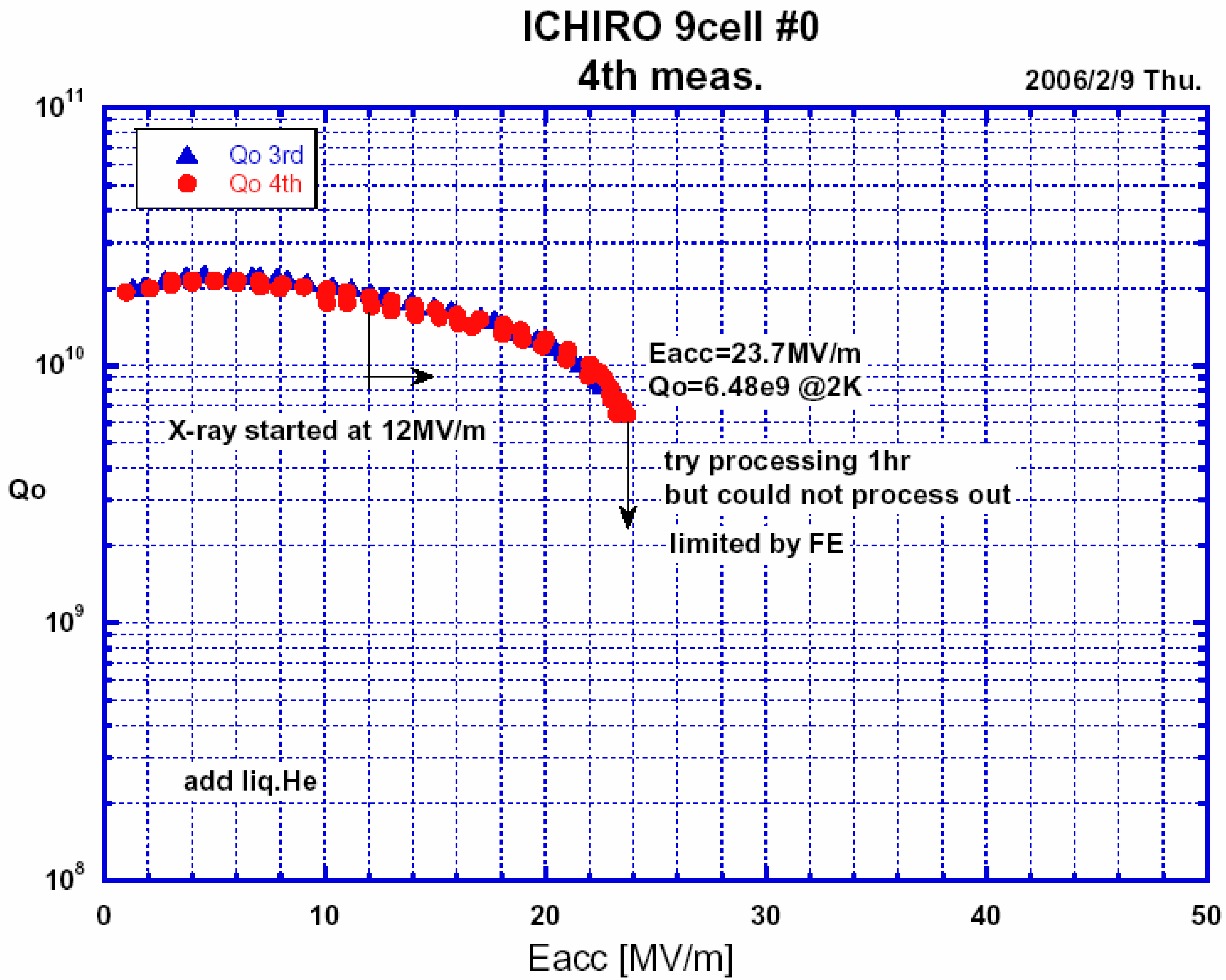
- Repeat ALL treatments with 7 single cell cavities (LL/Ichiro)
- Check success rate for 45 MV/m and limitation statistics



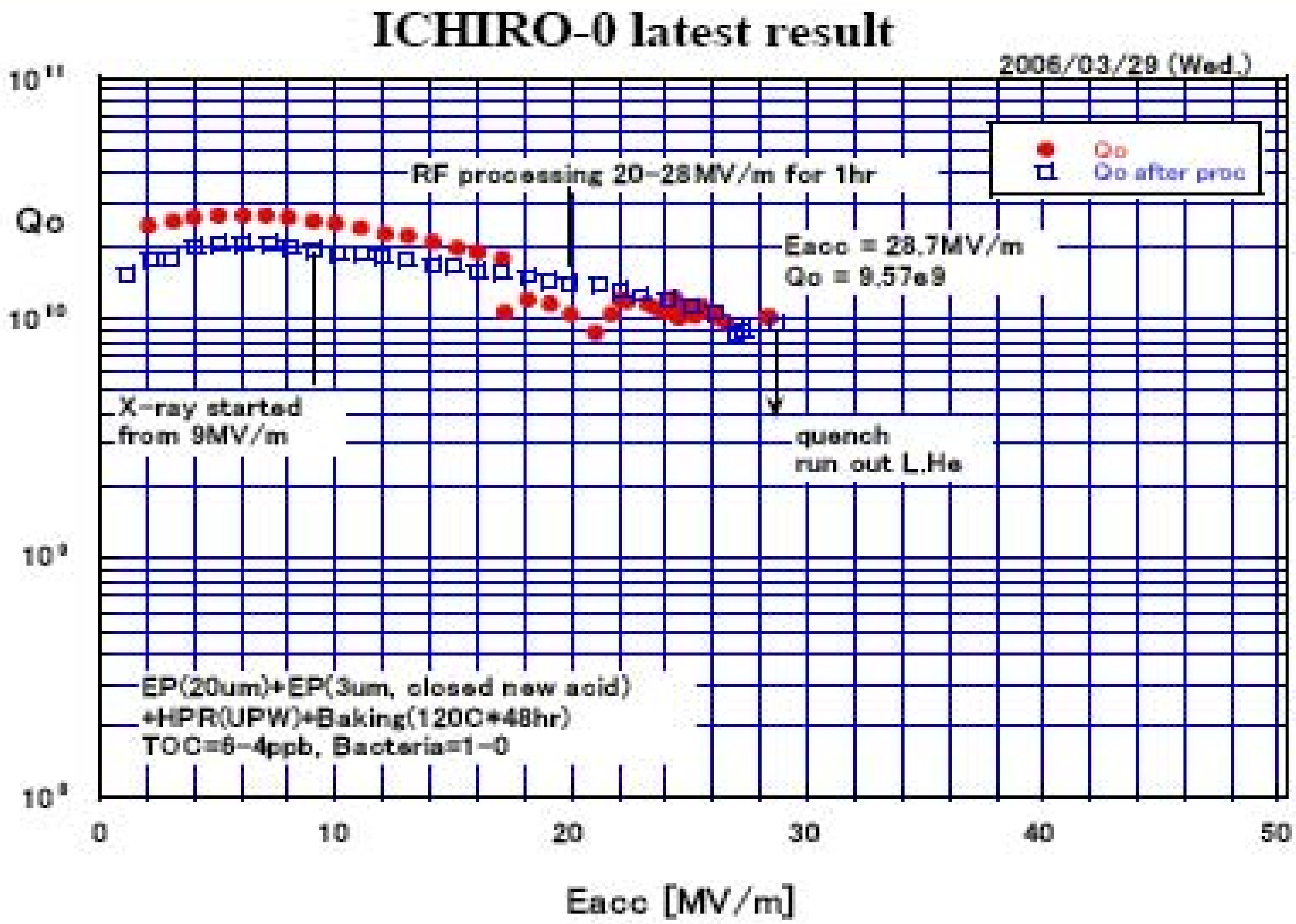

Qo(1st)
Qo(2nd)
ICHIRO 9cell #1
2nd meas.
2005/12/22 Thu.
processing 12~18MV/m
40min.
Eacc=18.71
Qo=1.06e10
@2K
After HPR(UPW)
2nd VT Eacc=19 MV/m
after processing
X-ray started from 9MV/m
1st VT Eacc=21 MV/m
quench
limited by FE
HPR(UPW)@Nomura (12/16)
TOC=11~12ppb, Bacteria=0
Qo
Eacc[MV/m]
10 11
10 10
10 9
10 8
0
10
20
30
40
50



ICHIRO 9cell #0
3rd meas.
2006/2/8 Wed.
Qo
start X-ray
at 7.4MV/m
processing 7-17M/m, 20min.
but could not process out
Eacc=22.7MV/m
Qo=8.38e9 @2K
after processing
start X-ray at 12MV/m
try processing 30min.
but could not process out
limited by FE
EP(30um)+HPR(UPW)@Nomura
+Baking(120C*48hr)+evacuation
TOC=10-12ppb, Bacteria=0
10^{11}
10^{10}
10^{9}
10^{8}
0
10
20
30
40
50
Eacc [MV/m]


ICHIRO 9cell #0
4th meas.
2006/2/9 Thu.
Qo 3rd
Qo 4th
Eacc=23.7MV/m
Qo=6.48e9 @2K
X-ray started at 12MV/m
try processing 1hr
but could not process out
limited by FE
add liq.He
Qo
Eacc [MV/m]
10^11
10^10
10^9
10^8
0
10
20
30
40
50

latest result 9-cell cavity result on ICH



- 8 medium beta and 2 high beta cryomodules were tested at Jlab
- The rest were tested at SNS

- Final preparation for cryomodule cavity string:
- • Degrease
- • 20 µm BCP 1:1:2 @ 10°C
- • 62 C UPW rinse to >17 MΩ-cm resistivity 12 7-cell 1.5 GHz cavities for 12 GeV upgrade
- 4 LL shape (lower Hpk) and 8 HG shape (lower Epk)

- • Degrease
- • 20 μm BCP 1:1:2 @ 10°C
- • 62 C UPW rinse to >17 MΩ-cm resistivity
- • HPR 2x2 hours with fan spray nozzle
- • Flange assembly (HOMs, FP, FPC tophat)
- • HPR 2x2 hours with fan spray nozzle
- • Overnight static drying in Class 10 environment
- • Assembly
- • Pumpout with clean vacuum system
- • Leak check
- • Sealed vacuum
- • VTA test with coax/waveguide tophat *Q*l ~ 7×109
- • Option for 120°C bake, 48 hours and retest
- • Final tuning
- • Helium vessel welding

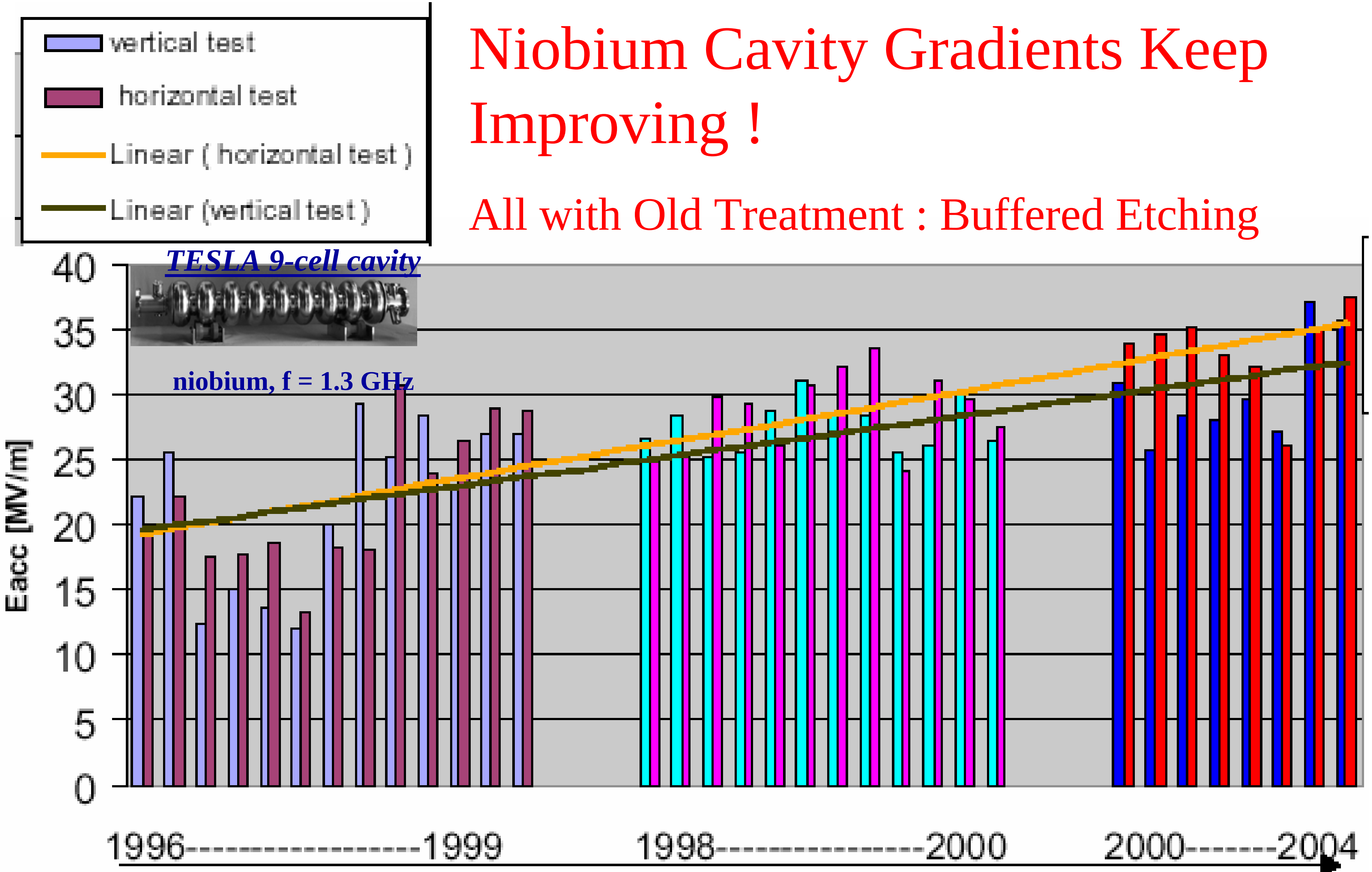
- HPR 2x2 hours with fan spray nozzle
- • Flange/feedthrough assembly (HOMs, FP)
- • HPR 2x2 hours with fan spray nozzle
- • Overnight static drying in Class 10 environment
- • Assembly on string for cryomodule

Summary of Large grain/Single Crystal Tests at Jlab

Suppl.	Ingot	RRR/Ta [ppm]	Type/ Nc	F [GHz]	Q [10^{10}] (2K, E_{max})	E_{acc} [MV/m]	Fabrication
CBMM	A	280/800	HG / 1	1.5	**1.25**	**34**	*W-EDM*
CBMM	B	280/800	HG /1	1.5	**0.93**	**32**	*W-EDM*
CBMM	C	280/1500	ILC_LL / 1	1.3	**1.4**	**34**	*S-cut / W-EDM*
CBMM	B	280/800	OC / 1	1.5	**0.5**	**25**	*S-cut (80 μm)*
CBMM	B	280/800	HG / 1	1.5	**0.48**	**27.5**	*S-cut, removal test* *~ 75 micron removal*
CBMM	A (single)	280/800	HG / 1	2.2	**0.5**	**38** *(185/165 mT)*	*W-EDM*
CBMM	A (single)	280 / 800	ILC_LL/1	2.3	**0.7**	**45**	*W-EDM*
CBMM	A	280/800	HG /7	1.5	**0.85**	**25.6** *quench*	*W-EDM*
CBMM	C	280/1500	ILC_LL /7	1.3			*S-cut / W-EDM* *fabrication completed*
Ninxia		330-360/150	OC / 1	1.5	**0.87**	**36.6** *After baking*	*S-Cut, machined*
Wah Chang	C1/C2	> 300 / < 500	HG/1	2.2	0.24	*26.5* *Q - drop*	*W-EDM*
Wah Chang	B1/B2	> 300 / < 500	HG/1	2.2	0.45 Rres ~ 0	**27**	*W-EDM*

Niobium Cavity Gradients Keep Improving !

All with Old Treatment : Buffered Etching

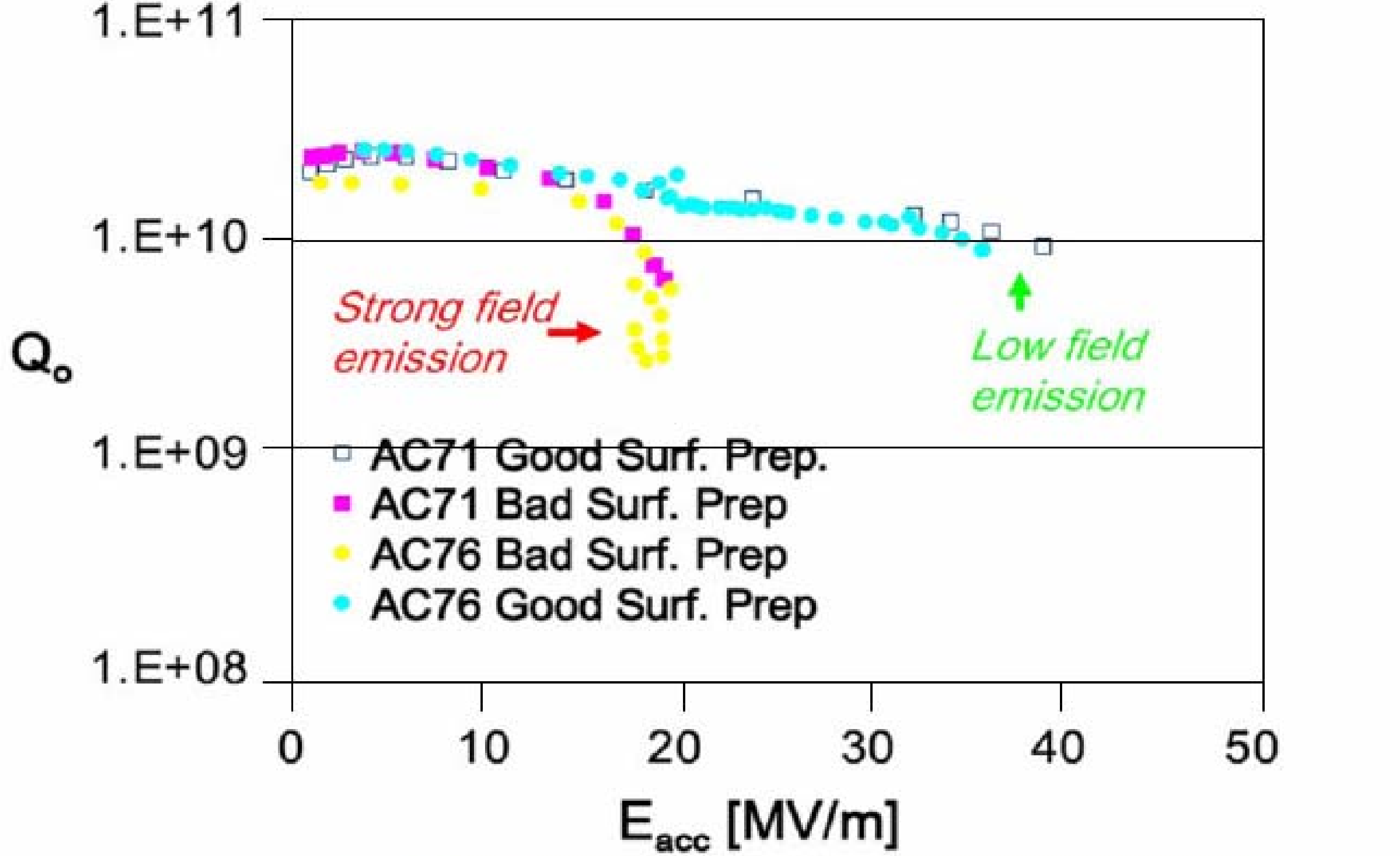


first production
average gradient
21,6 MV/m vertical
21,7 MV/m horizontal

second production
average gradient
27,5 MV/m vertical
28,7 MV/m horizontal

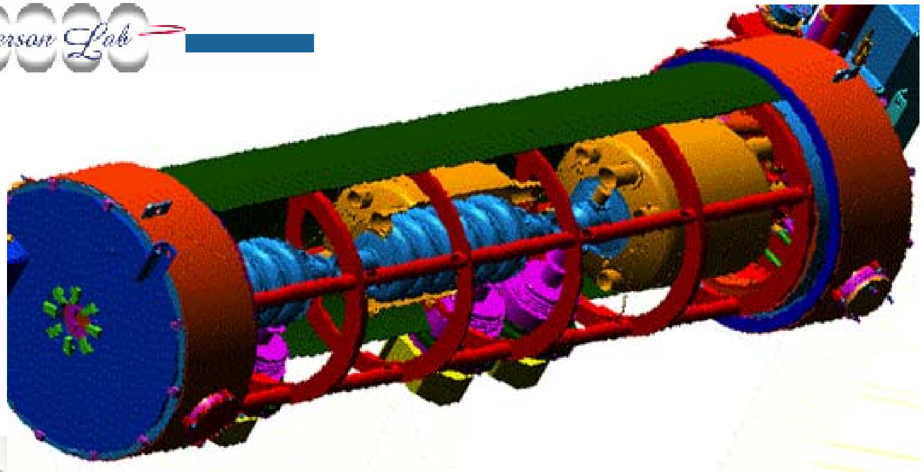
third production
average gradient
30,3 MV/m vertical
33,4 MV/m horizontal

Problems: Reproducibility in the EP Process



SNS: First High Intensity
tin
to






11 completed

6 cryomodules

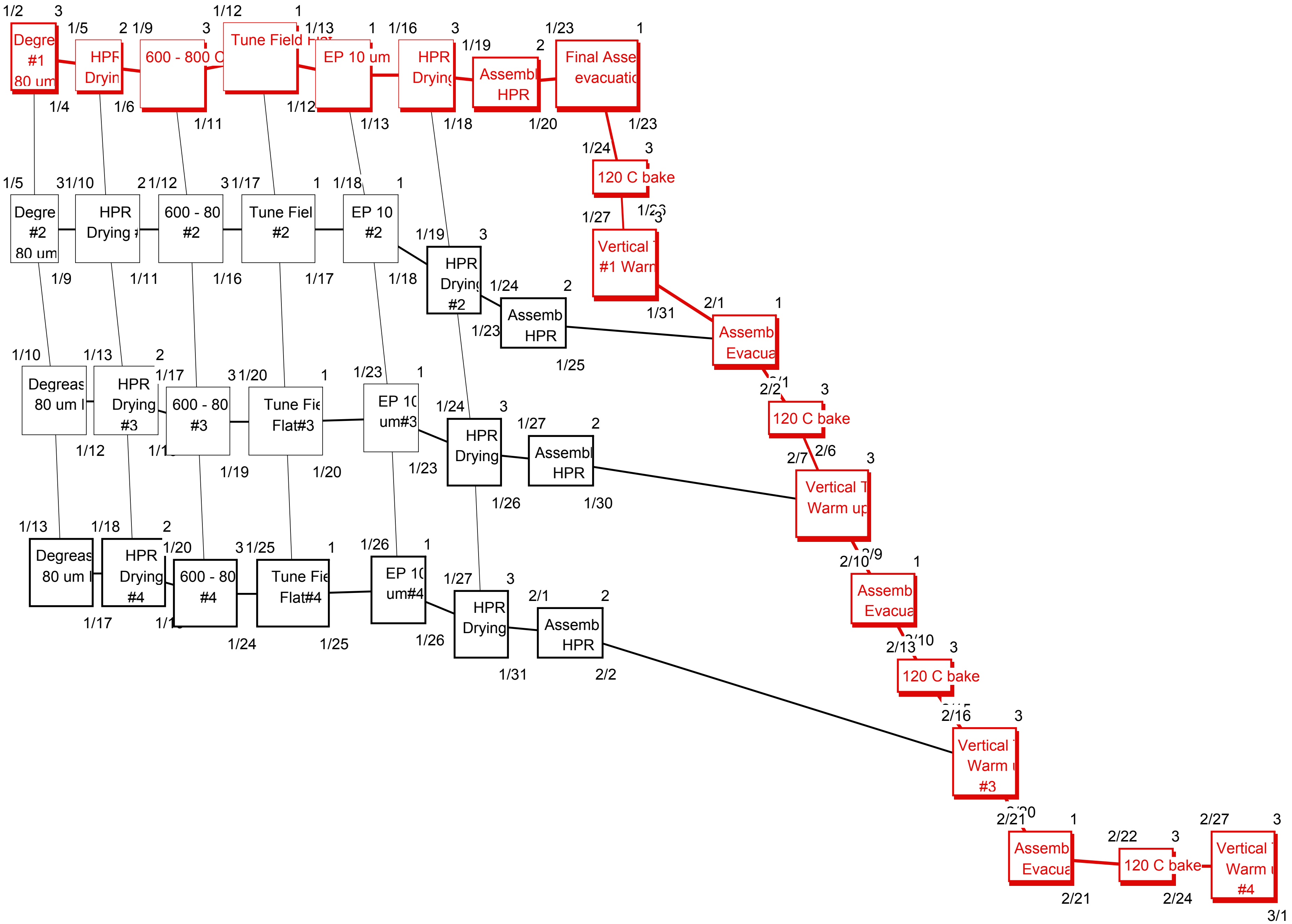
installed at SNS

Overview

- Current status
  - Type II and Type III cryostats are in use at FLASH
  - Type III nearly meets all requirements for XFEL
  - Design for improved cryostat finished: Type III+
    - XFEL features included
    - Still FLASH-compatible
- On the way
    - Module Assembly Study
    - Full fabrication drawings of Type III+ cryostat available by November 2006
    - Try to comply with EN13445 without external authorites
- Next steps and limitations
    - Qualification of cryostat vendors in one (or two) stages by mid 2007 (end 2007)
    - Include AD 2000 with german authorities (TÜV)

Next cryomodules assemblies/repairs/orders

Plan Jan-06	required performance	assembly/ disass/repair	material	Modifications (Ideas)	tests on/ usage for	comments
M6 TTF-III	31.5MV/m operational?	assembly May-06	Complete	tuner motor, piezo EP-cav. HOM-abs	CMTB/ FLASH ACC6	Industry Design/ assembly study
M7 TTF-II	23MV/m operational	assembly Sep-06 delay	Complete Wait for cav test	fast tuning (EP-cavities?)	CMTB/ FLASH ACC3	Industry Design/ assembly study?
M5 TTF-III	>25MV/m	repair tuner May-07	Complete	no Tuner repair only	CMTB/ FLASH ACC5	depends on schedule FLASH
M3*/3** TTF-II	23MV/m operational	disass. M3*? ass. M3**?	Complete New cav treatm	(fast tuning?) better performanc	CMTB crash/ spare FLASH	depends on schedule FLASH
M8 TTF-III+	28MV/m operational	Deliverery CM Oct-06 Ass. Jan-	Wait for cavities BPM/Mag Tuner	BPM/mag new and hanging like cav	CMTB/ spare FLASH	Industry Design/ assembly study



Degre #1 80 um
HPR Dryin
600 - 800 C
Tune Field
EP 10 um
HPR Drying
Assembl HPR
Final Asse evacuatio
120 C bake
Vertical #1 Warn
Assemb Evacua
Degre #2 80 um
HPR Drying
600 - 80 #2
Tune Fiel #2
EP 10 #2
HPR Drying #2
Assemb HPR
Degreas 80 um
HPR Drying #3
600 - 80 #3
Tune Fie Flat#3
EP 10 um#3
HPR Drying
Assembl HPR
120 C bake
Vertical Warm up
Degreas 80 um
HPR Drying #4
600 - 80 #4
Tune Fie Flat#4
EP 10 um#4
HPR Drying
Assemb HPR
Assemb Evacua
120 C bake
Vertical Warm #3
Assemb Evacua
120 C bake
Vertical Warm #4

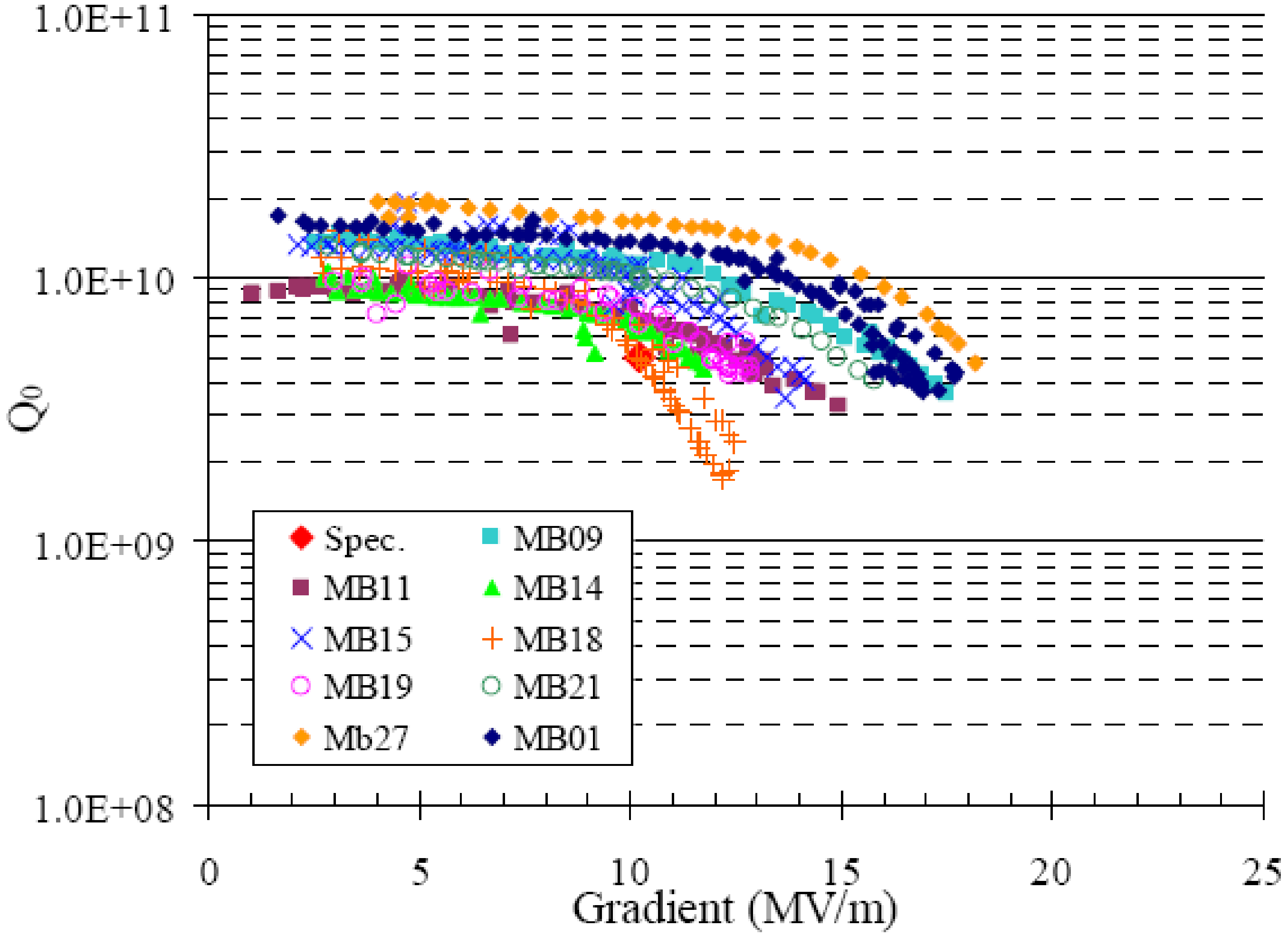


Figure 2. A set of Q_o vs E curves for the medium-β cavities, showing a typical spread in performance resulting from FE loading.

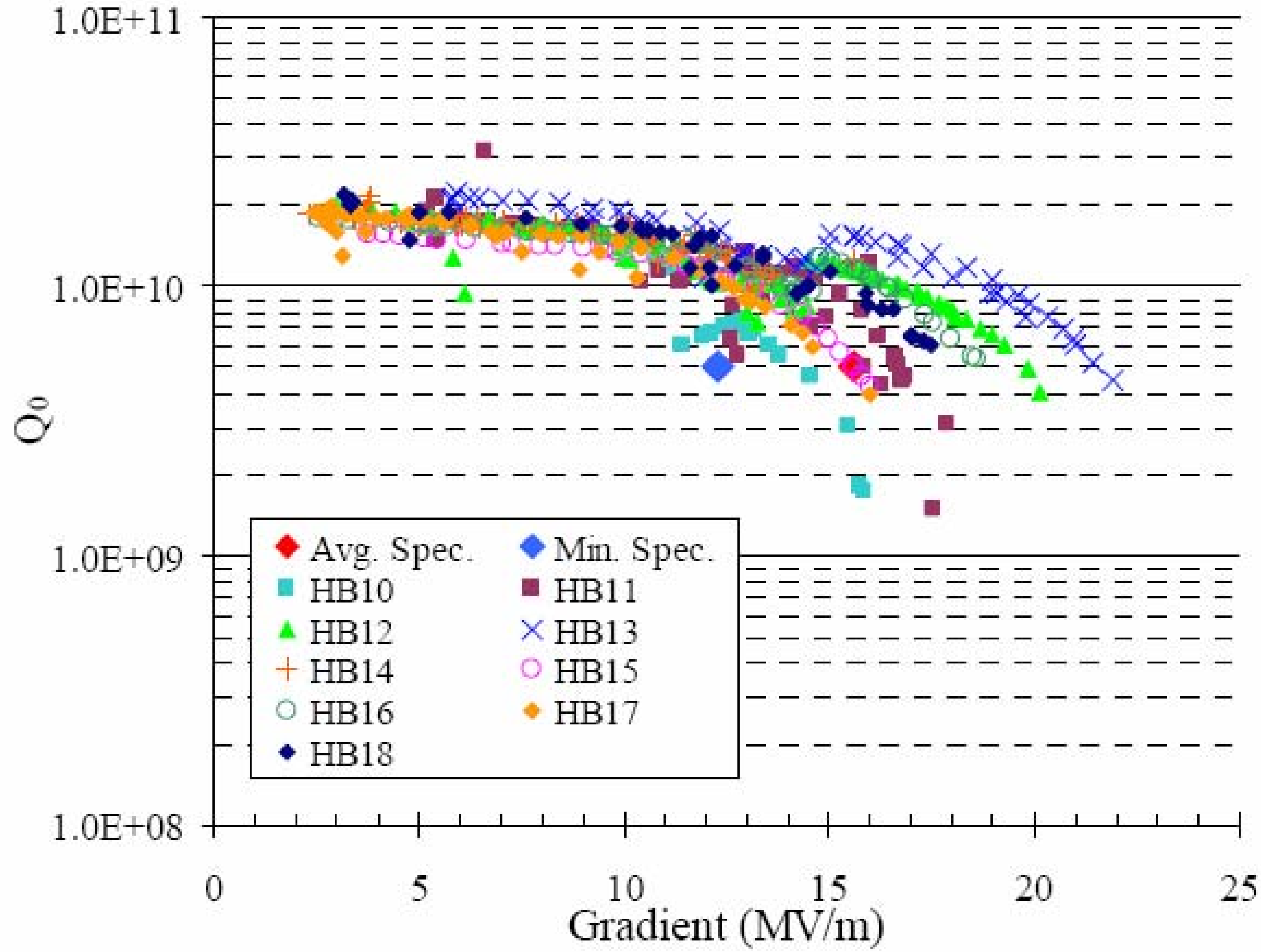


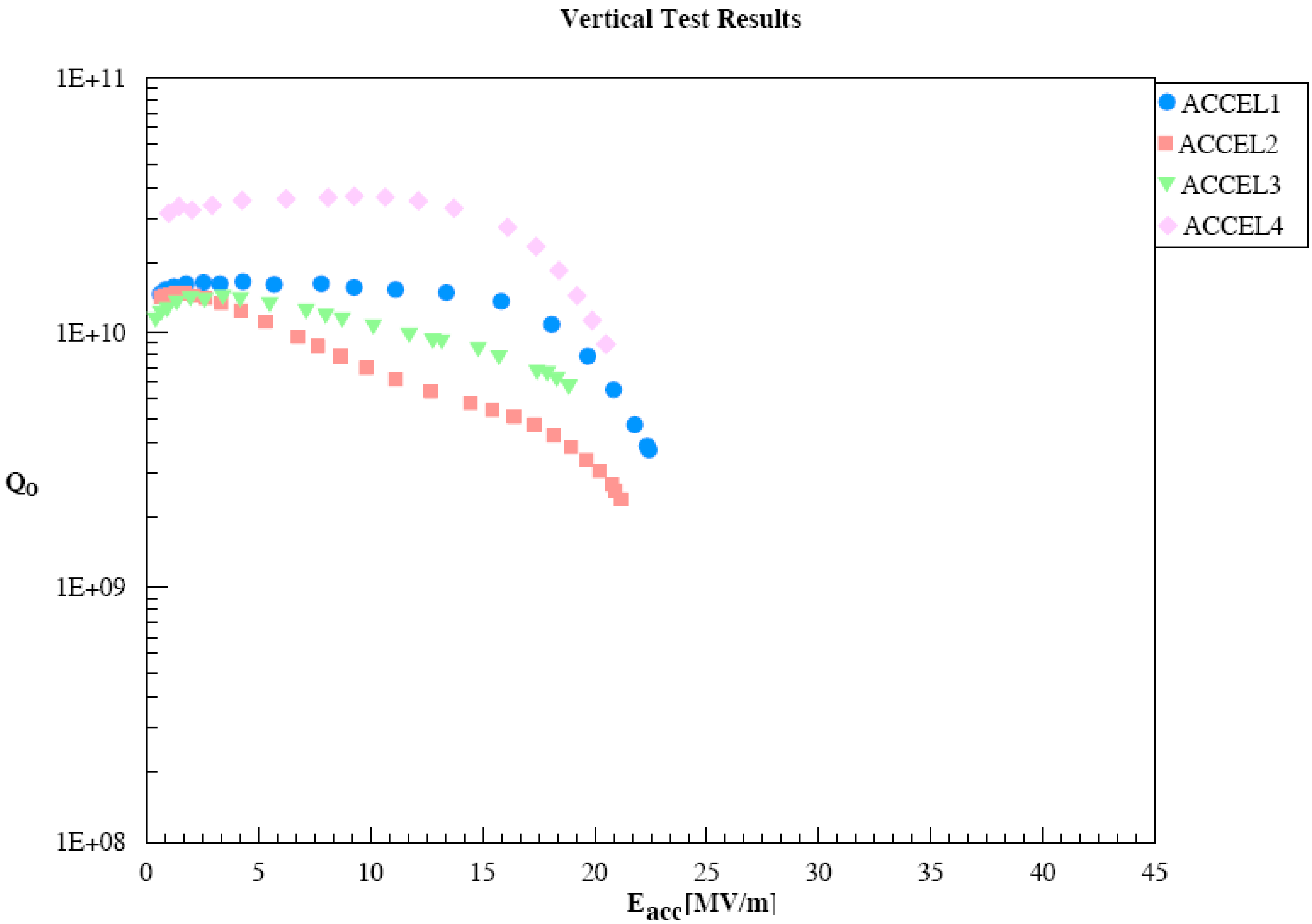
Figure 3. A set of Q_o vs E curves for the high-β cavities, showing a typical spread in performance resulting from FE loading.

Summary of SNS Cavity Performance

Average CW performance of all cavities that met specifications

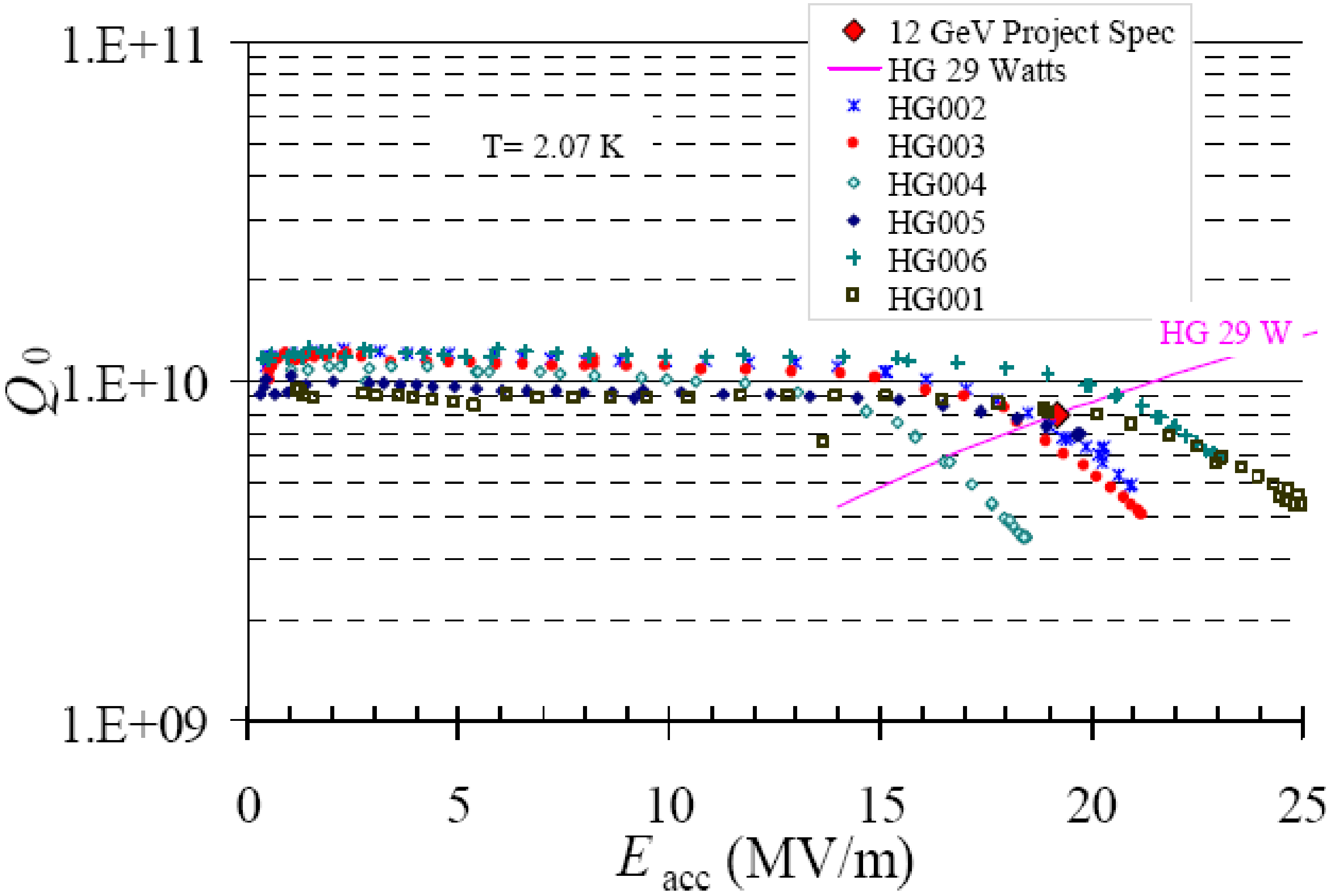
Parameter	Medium β	High β
Gradient (E_{pk}) at Q_o spec (MV/m)	13.3 (36.0)	18.2 (39.9)
Maximum Gradient (E_{pk}) (MV/m)	14.3 (38.8)	18.7 (41.0)
Q_o at Operating Gradient	8.8×10^9	9.9×10^9
Field Emission Onset (MV/m)	9.7	6.2
Total number of cavities tested	35	48
Total number of tests (incl. non-qualification tests)	73	72

The above tests were performed in the span of ~ 2 years.



Vertical Test Results
1E+11
1E+10
1E+09
1E+08
Q0
0
5
10
15
20
25
30
35
40
45
Eacc[MV/m]
ACCEL1
ACCEL2
ACCEL3
ACCEL4

t



0[9]

Figure 1. Qualification vertical tests of the High Gradient (HG) cavities.

Figure 2.)

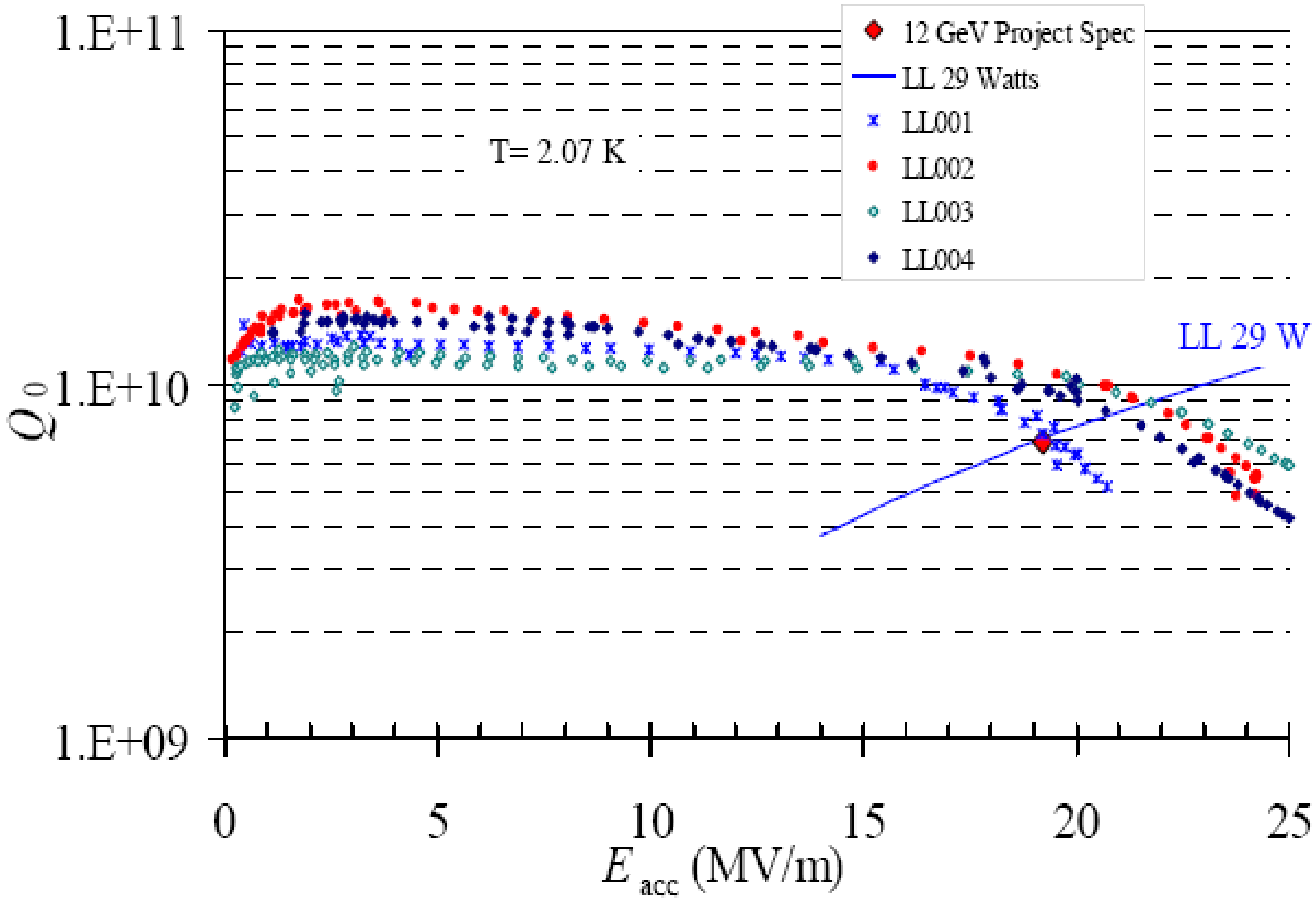


Figure 2. Qualification vertical tests of the Low Loss (LL) cavities.

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- Cryomodule design
  - Al Guerra
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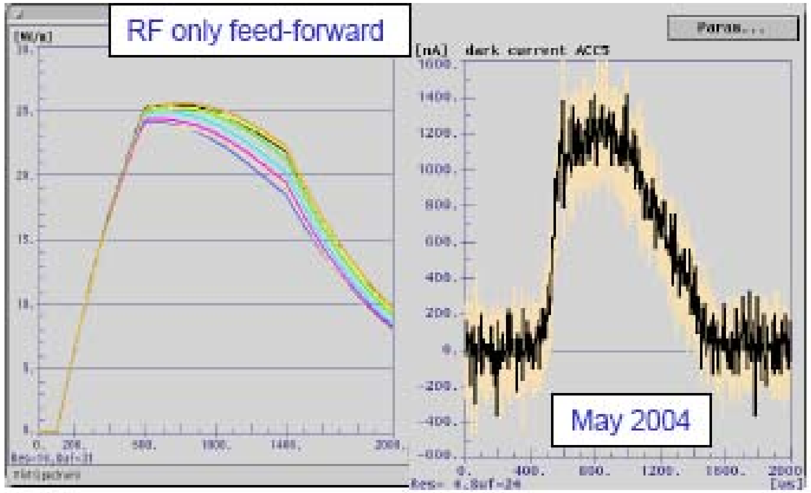
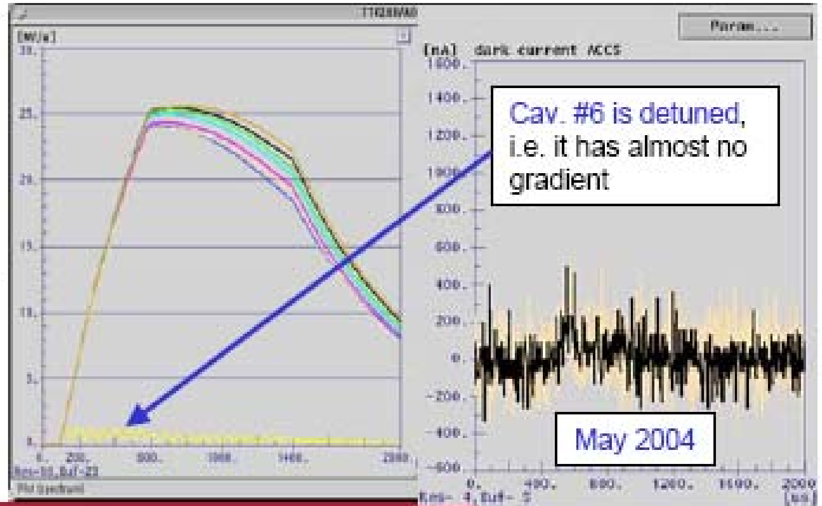
No. DE-AC05-84ER-40150

Dark Current (d.c.) Measurements

- The on-axis d.c. was measured for ACC4 / ACC5.
  - setup incompatible with accelerator operations
- 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
    - 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
  - September 2004 (extended operation at 20-25 MV/m)
    - 250 nA at 25 MV/m
  - July 2005
    - No d.c. measurement, but cavity improved further
- ***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).





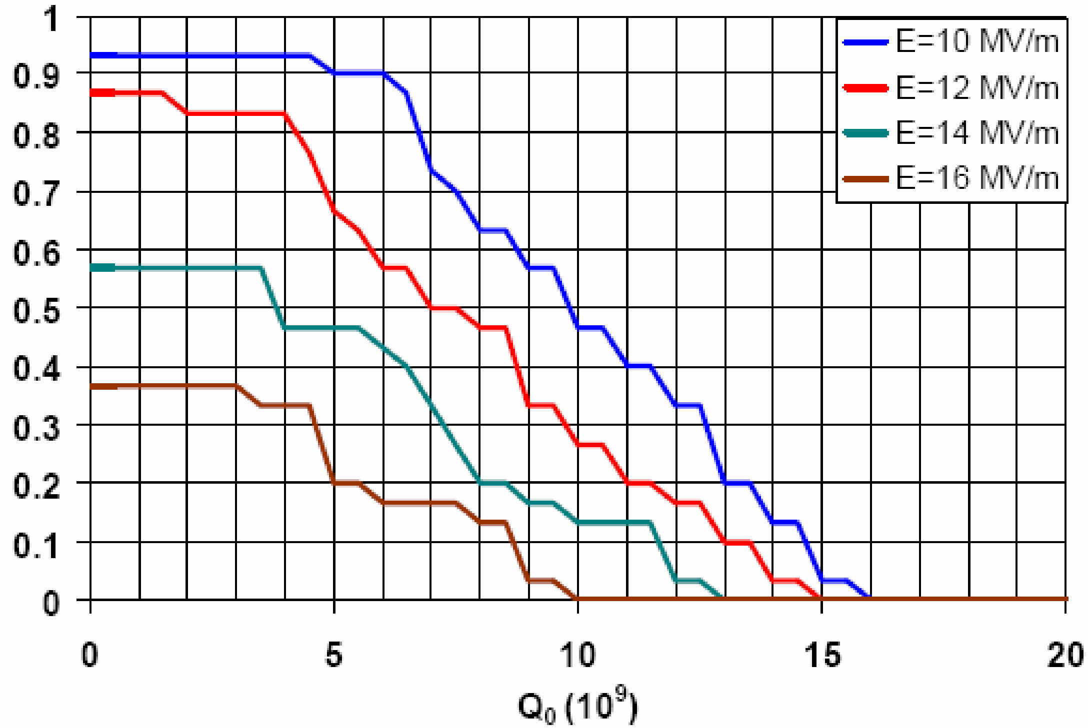


Figure 5. Fraction of 30 VTA tests of β=0.61 cavities exceeding a Q_0 at various operating gradients.

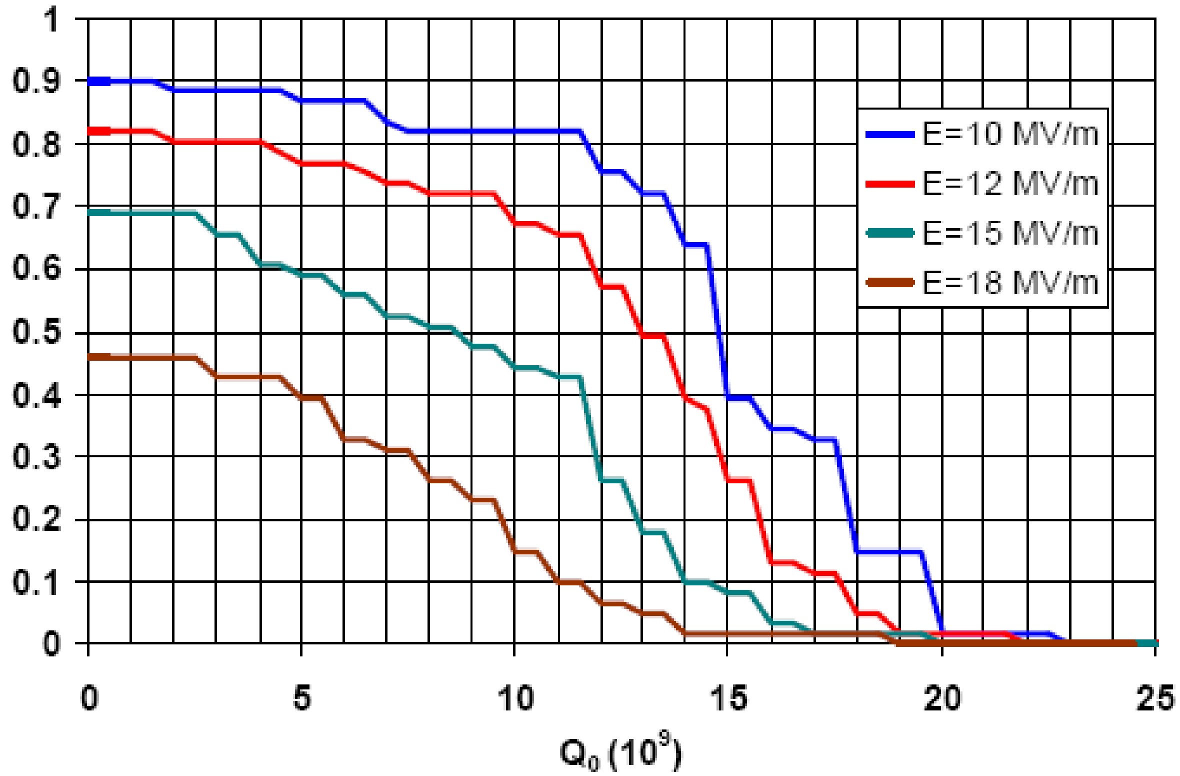


Figure 7. Fraction of 61 VTA tests of β=0.81 cavities exceeding a Q_0 at various operating gradients.

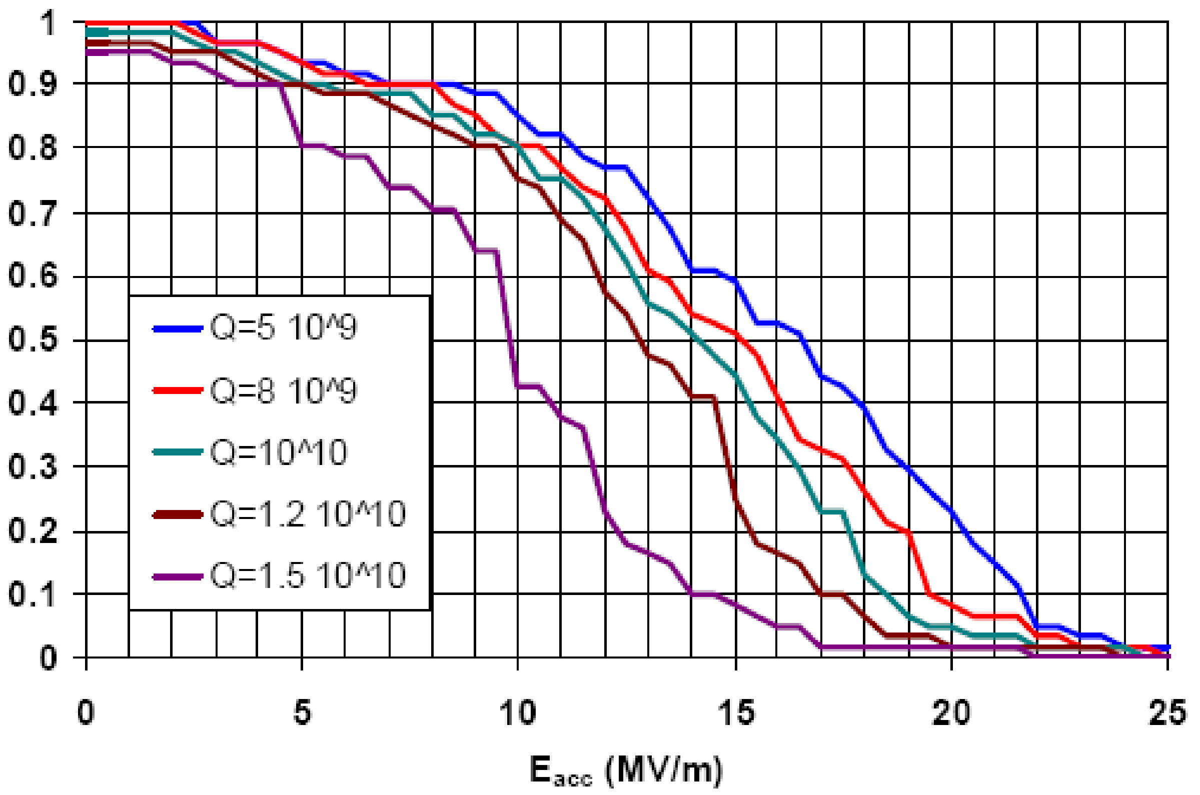


Figure 8. Fraction of 61 VTA tests of β=0.81 cavities exceeding a gradient at various Q_0.

Q vs. E curve at 2.05 K