

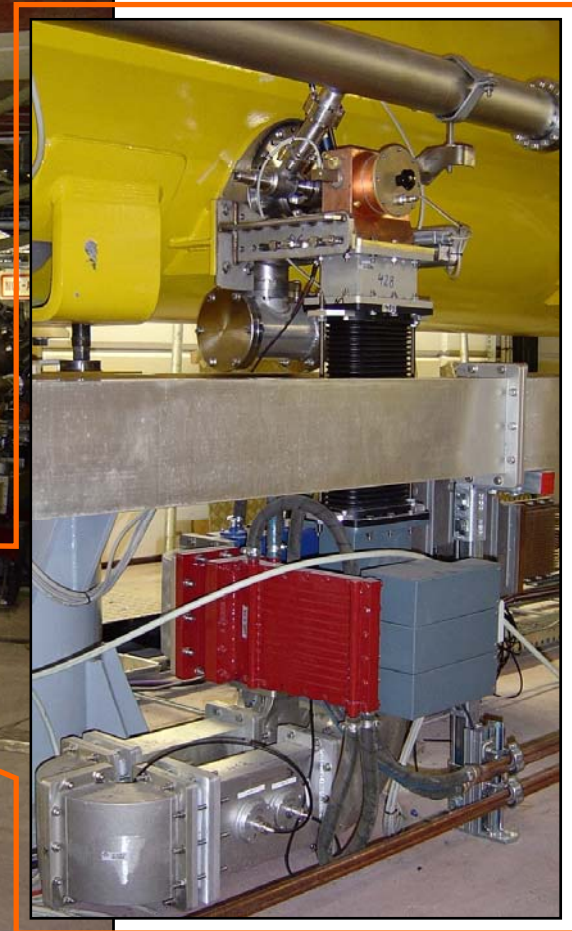
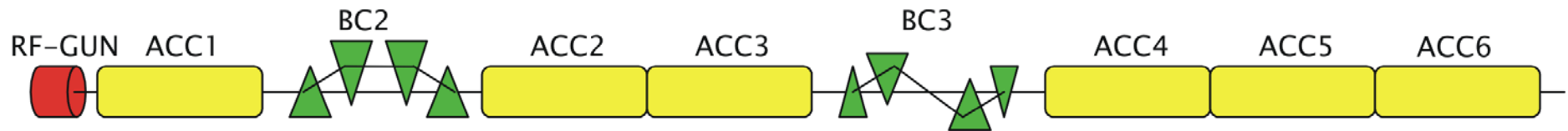
FLASH LINAC Modules

Denis Kostin, MHF-sl, DESY



HELMHOLTZ
| GEMEINSCHAFT

FLASH LINAC



FLASH LINAC

	Unit	FLASH	XFEL
Beam Energy	GeV	0.4..1.0 (1.2)	10..20
Emittance (norm.)	mm×mrad	4	1.4
Bunch Charge	nC	0.5..1	1
Peak Current	kA	1..2	5
Bunch Length	fs	120	80
Energy Spread	MeV	0.3	<2.5
Accelerating Gradient	MV/m	12..35	23.5
Repetition Rate	Hz	5	10
Average Beam Power	kW	10..15	325..650
Number of Modules		6 (7)	100 (120)
Accelerator Length	km	0.3	1.5

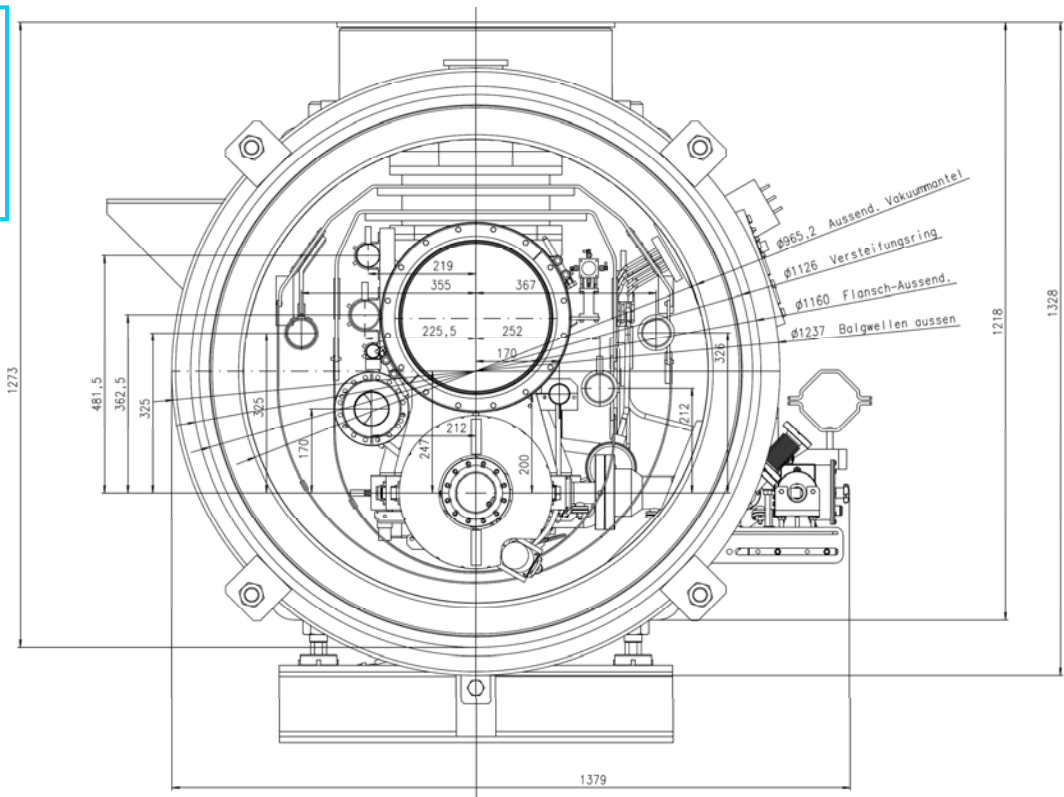
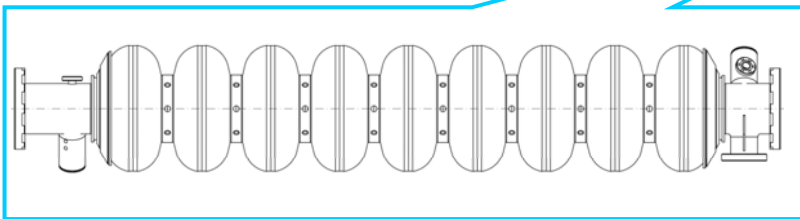
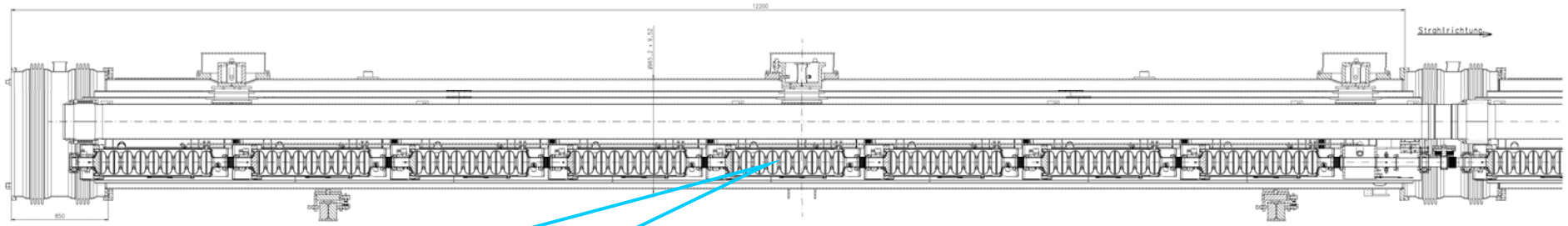
Accelerating Modules

Six accelerating modules were installed into the TTF tunnel as a part of the FLASH Linac
Each module has 8 superconducting cavities and RF power input couplers

position	module	type	assembled	coupler type	cold window	warm window
ACC1	2*	II	Jan. 2004	FNAL/TTF III	Conical/Cyl.	Planar/Cyl
ACC2	1*		Mar. 2000	FNAL/TTF II	Conical/Cyl.	Planar
ACC3	7		Dec. 2006	TTF III	Cylindrical	Cylindrical
ACC4	4	III	Jul. 2001	TTF II	Cylindrical	Plane, WG
ACC5	5		Jun. 2007	TTF III	Cylindrical	Cylindrical
ACC6	6		May. 2006	TTF III	Cylindrical	Cylindrical
ACC7	8		upgrade	TTF III	Cylindrical	Cylindrical

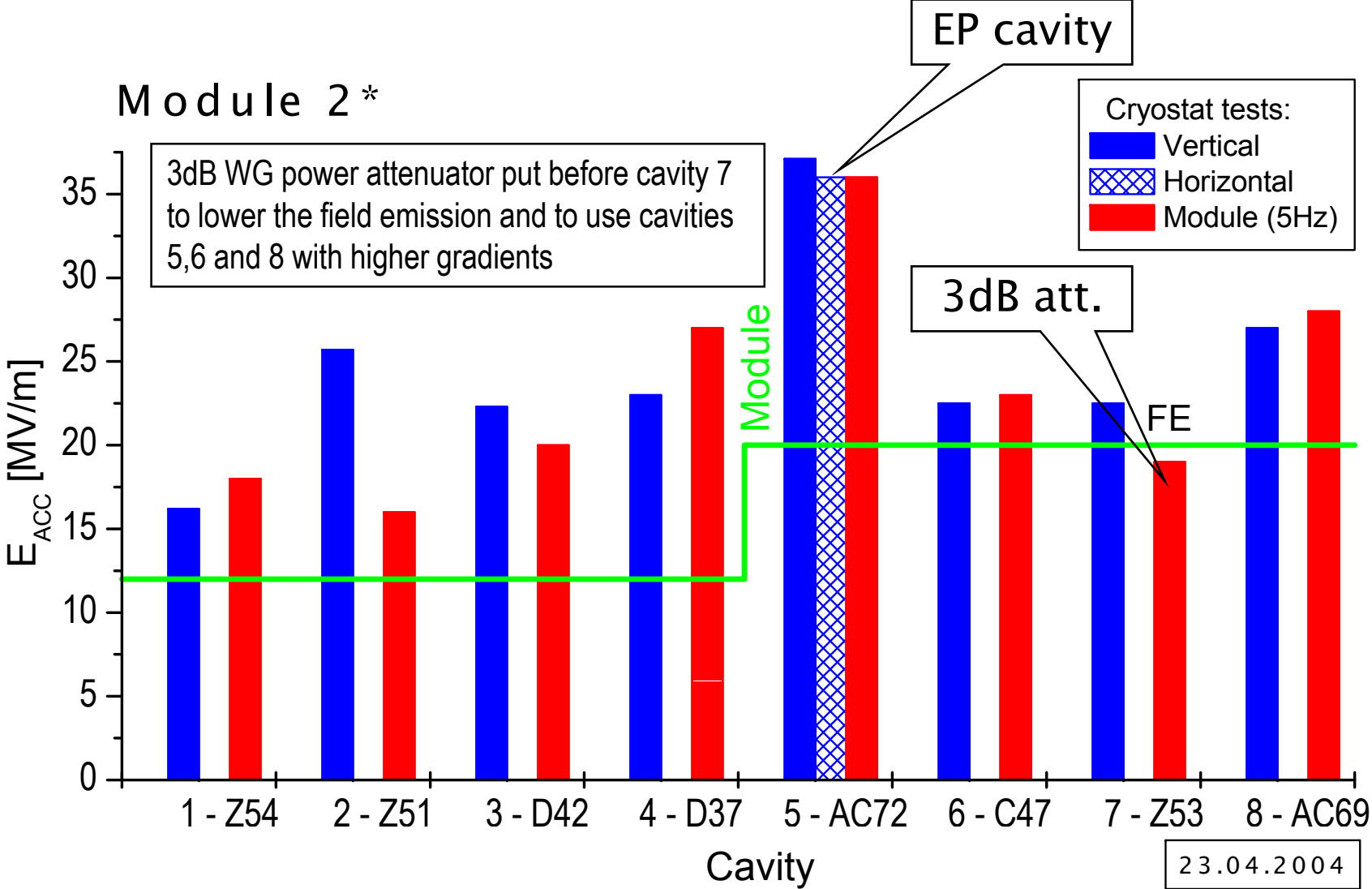
After upgrade ACC1 will be module 3** (Typ II, TTF III couplers), ACC7 will be added.

FLASH LINAC Cavities

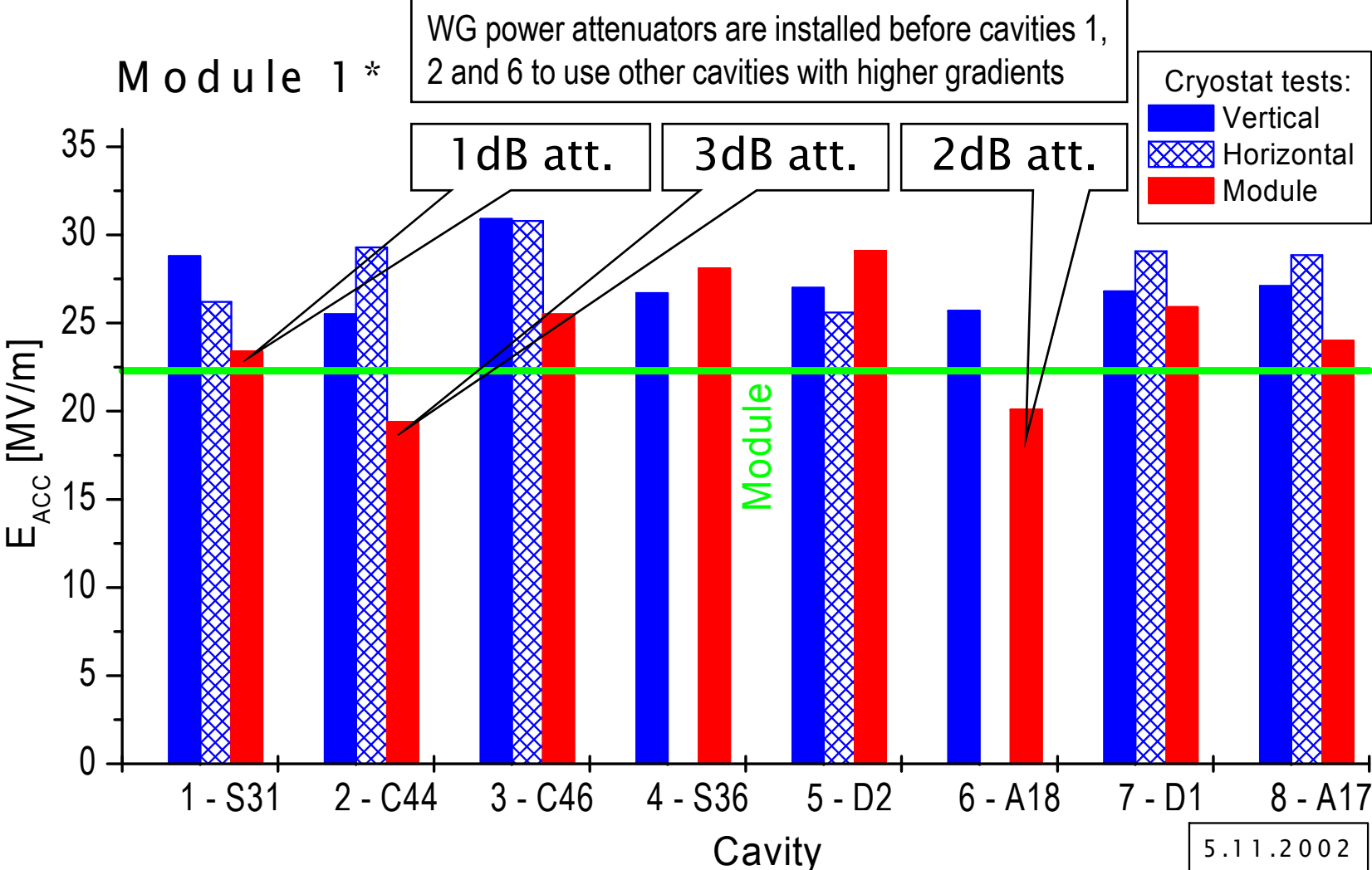


Number of cavities	8
Cavity length	1.038 m
Operating frequency	1.3 GHz
R/Q	1036 Ω
Operating temperature	2 K
Accelerating Gradient	23..35 MV/m
Quality factor	10^{10}
Q_{ext} (input coupler)	3×10^6

Cavities @ ACC1

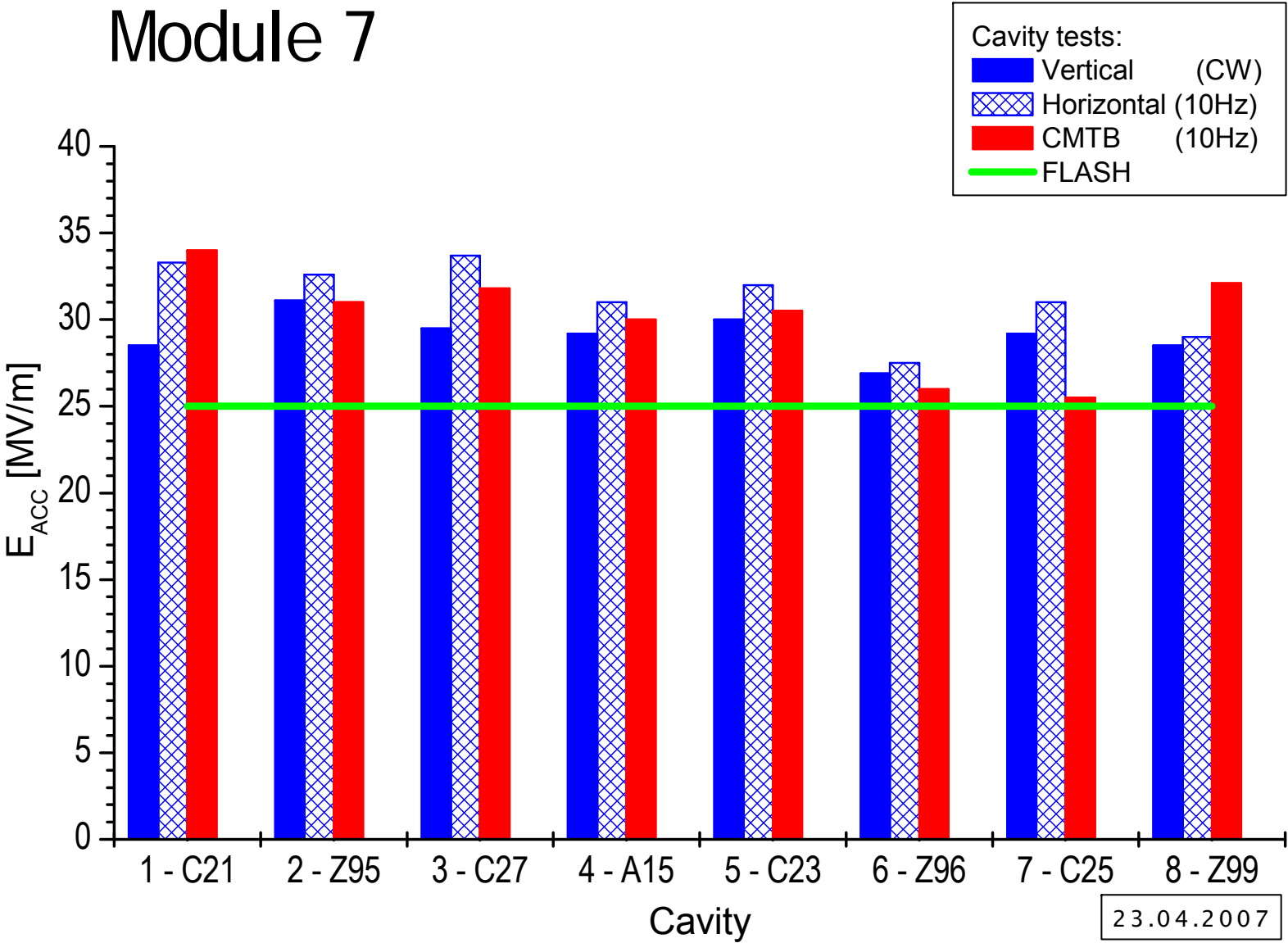


Cavities @ ACC2

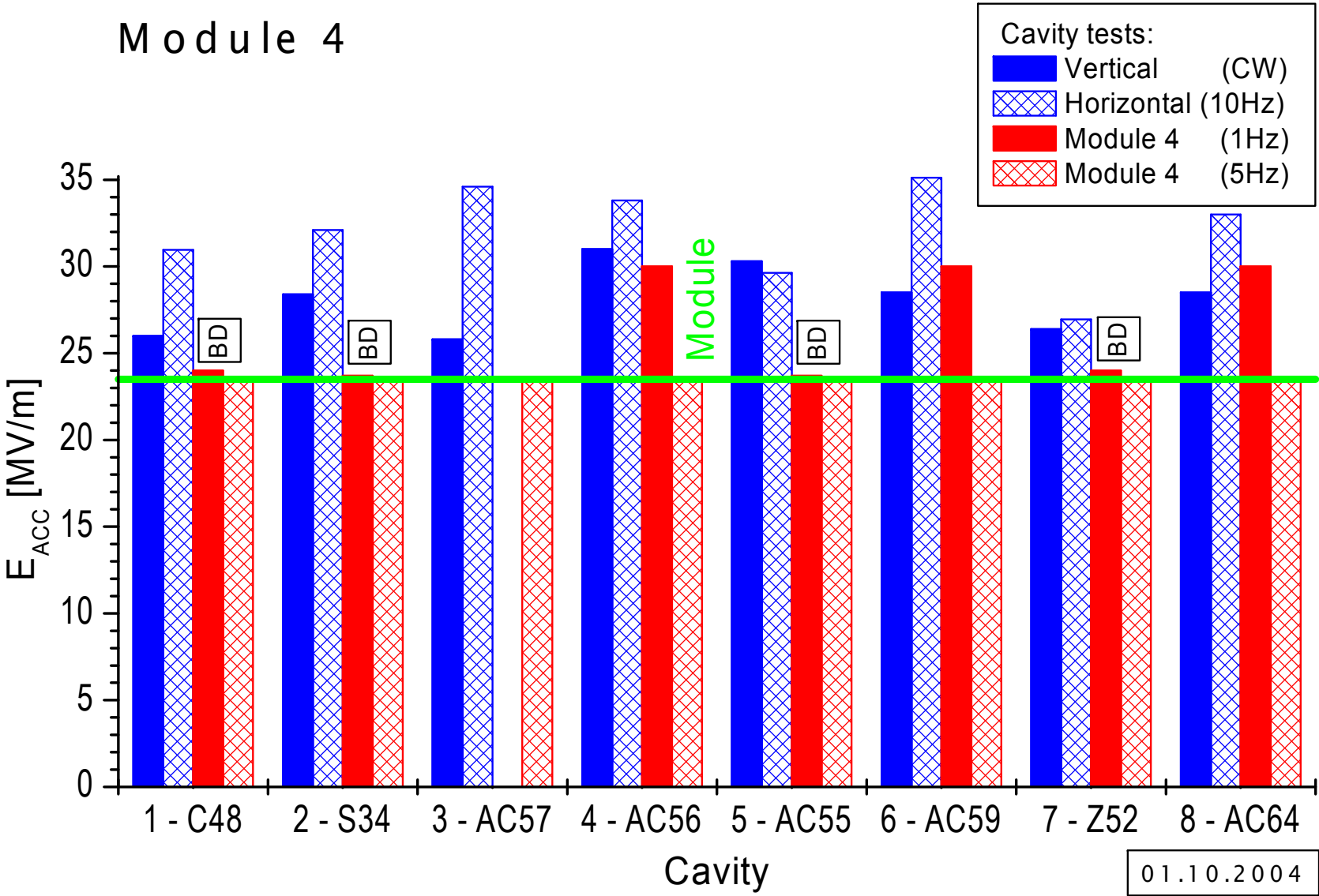


Cavities @ ACC3

Module 7

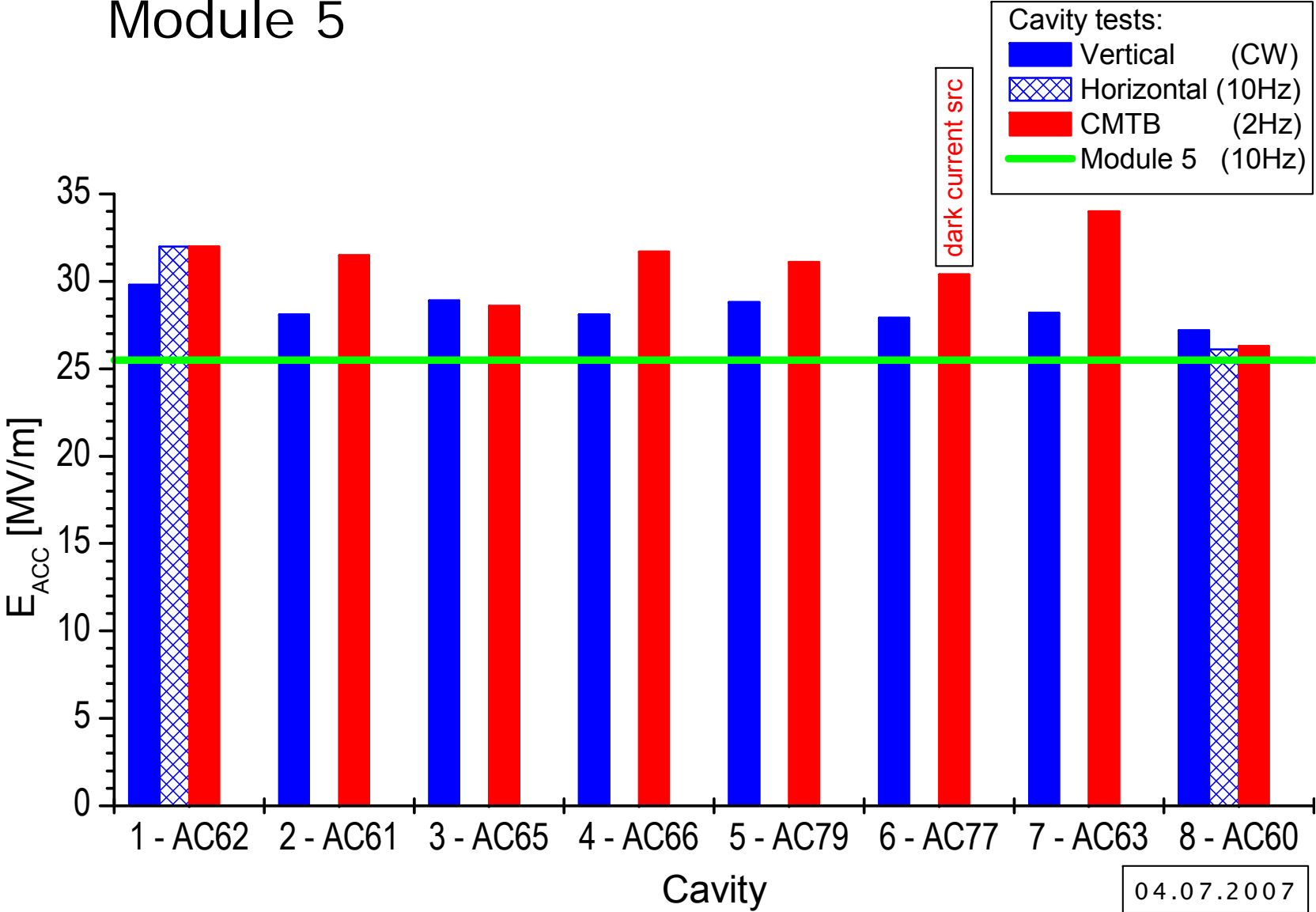


Cavities @ ACC4



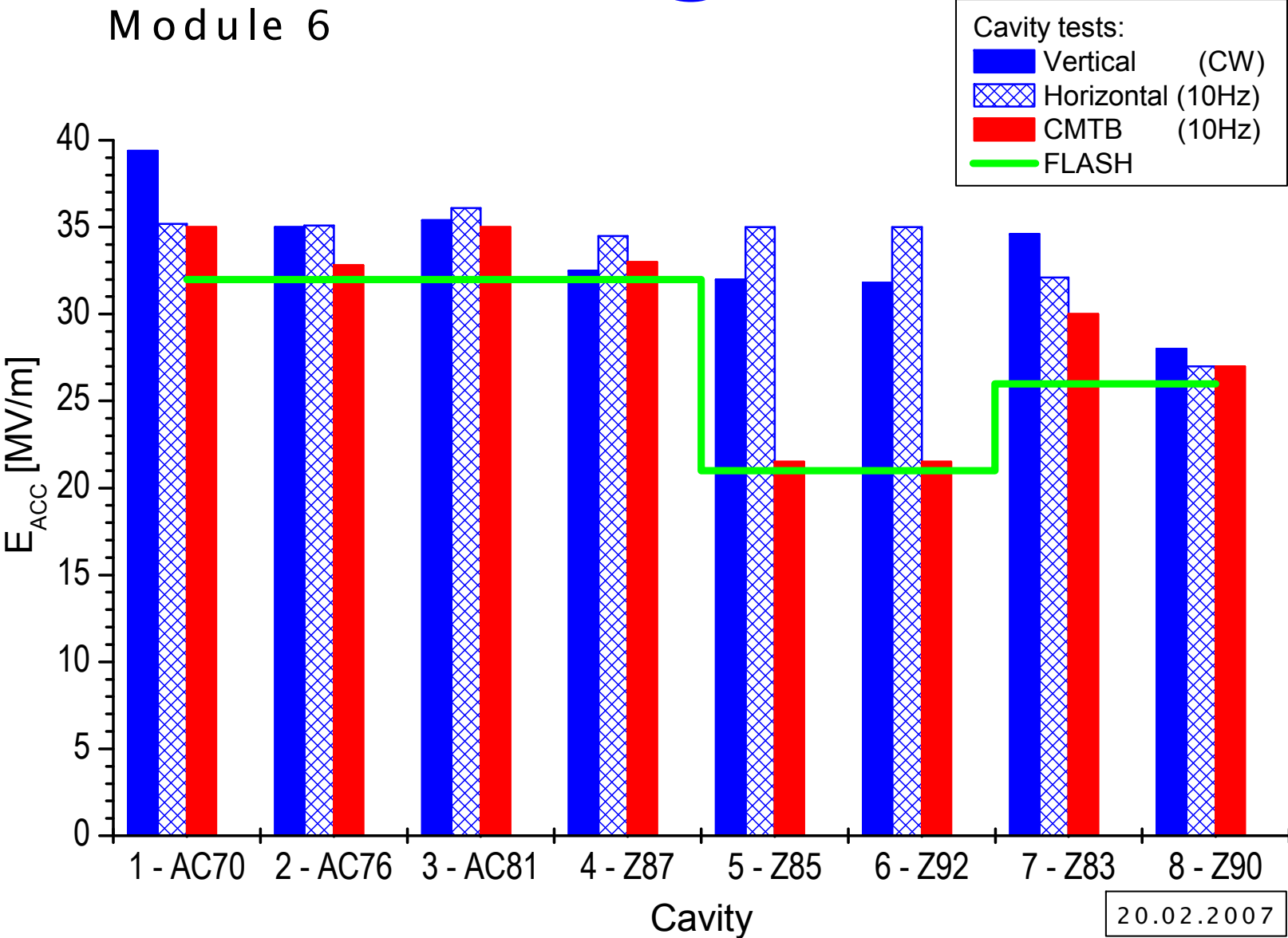
Cavities @ ACC5

Module 5



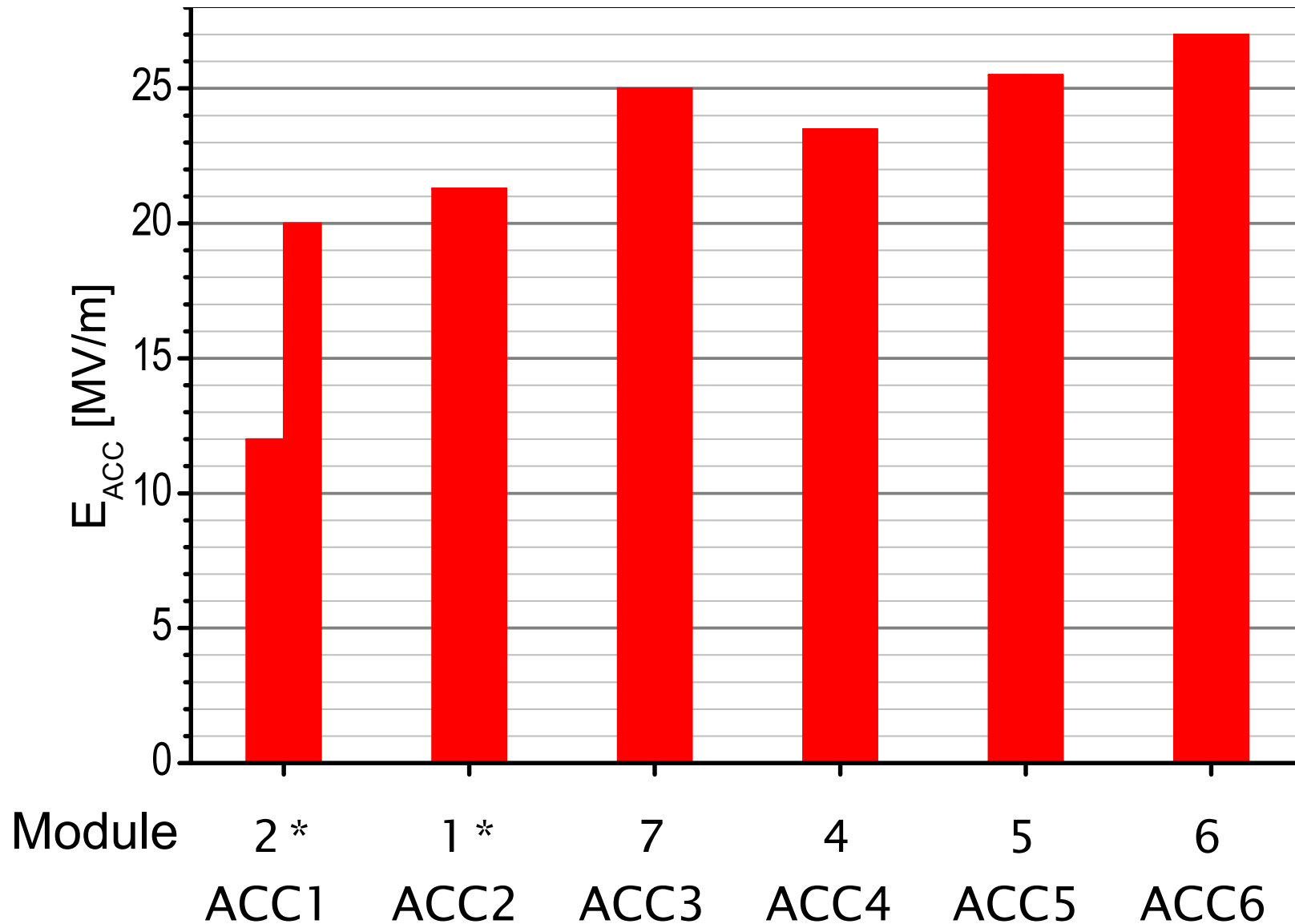
Cavities @ ACC6

Module 6



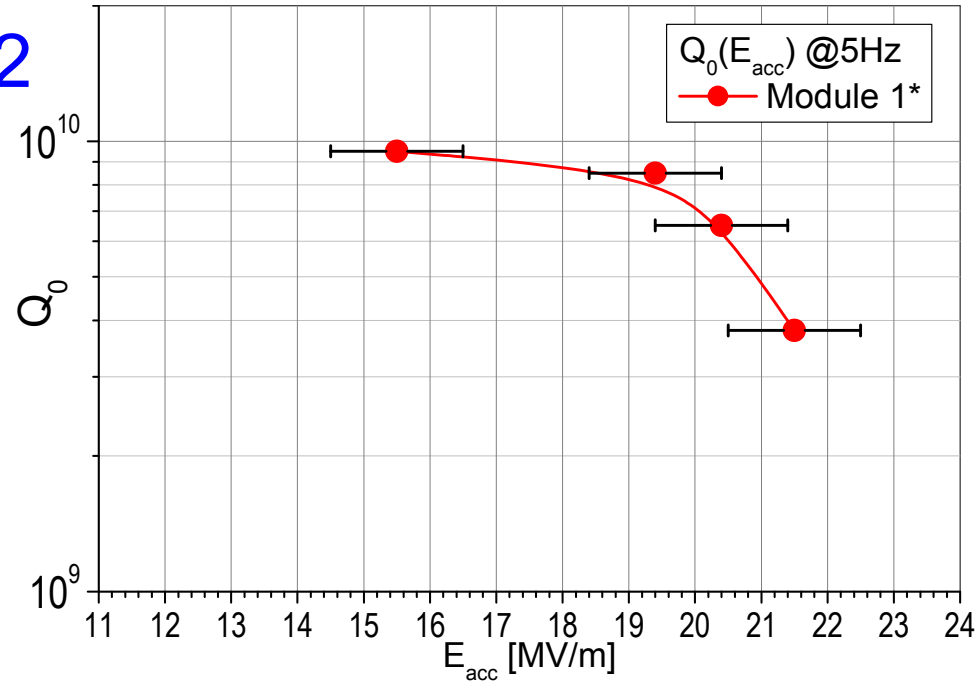
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Modules Operating Gradients



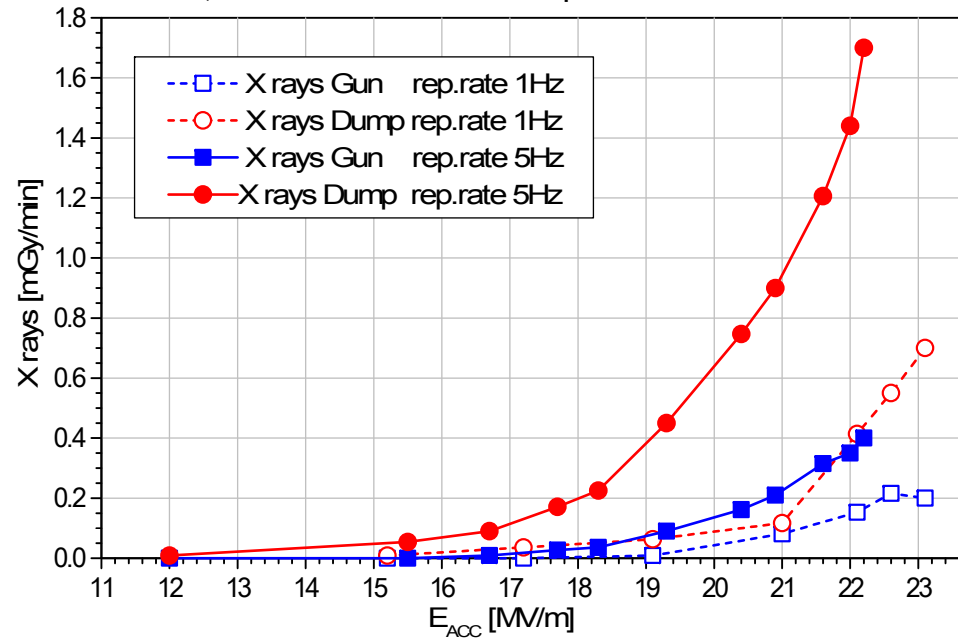
Module 1* / ACC2

$Q_0(E_{acc})$



ACC2 / Module 1* radiation profile measurement

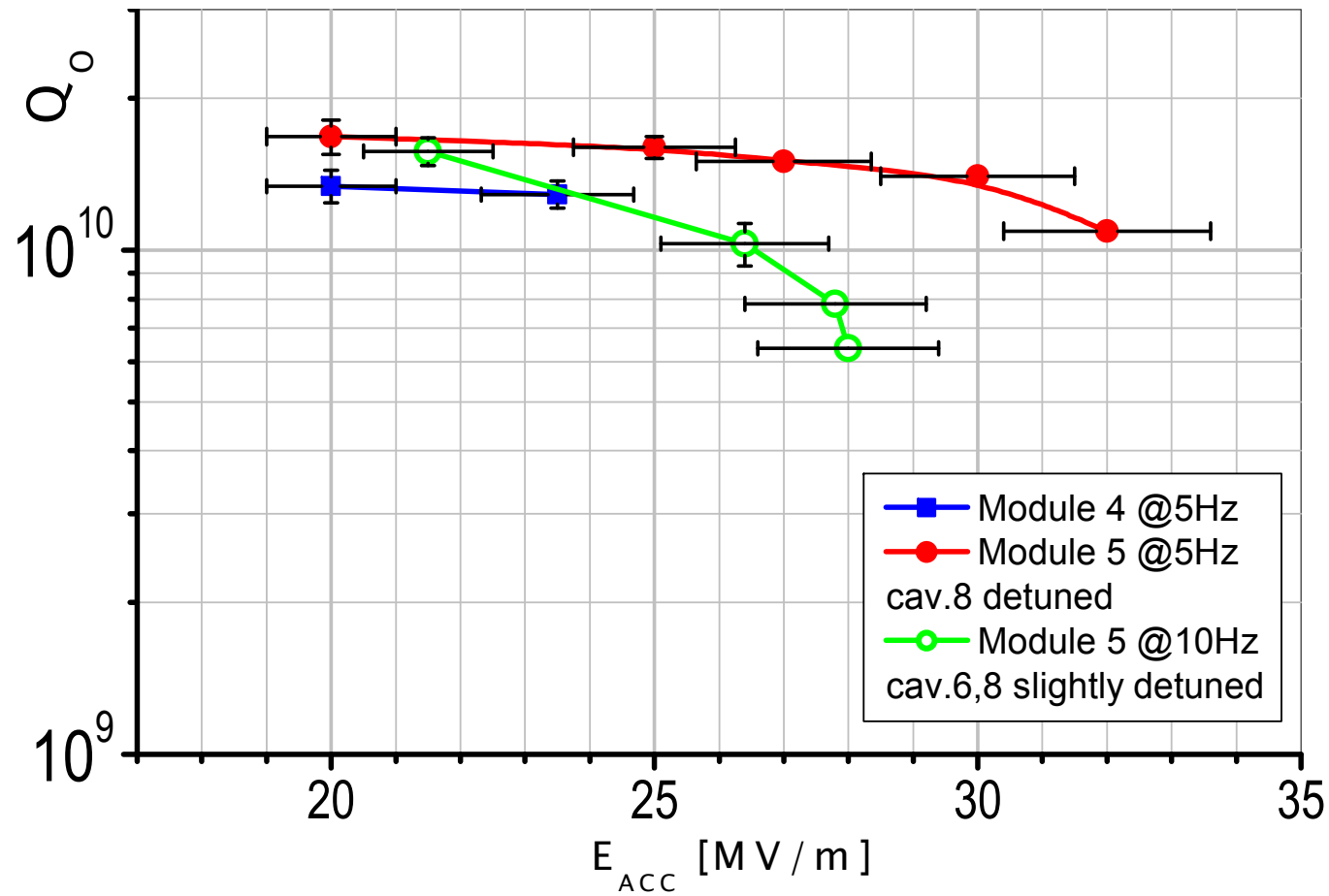
X-rays



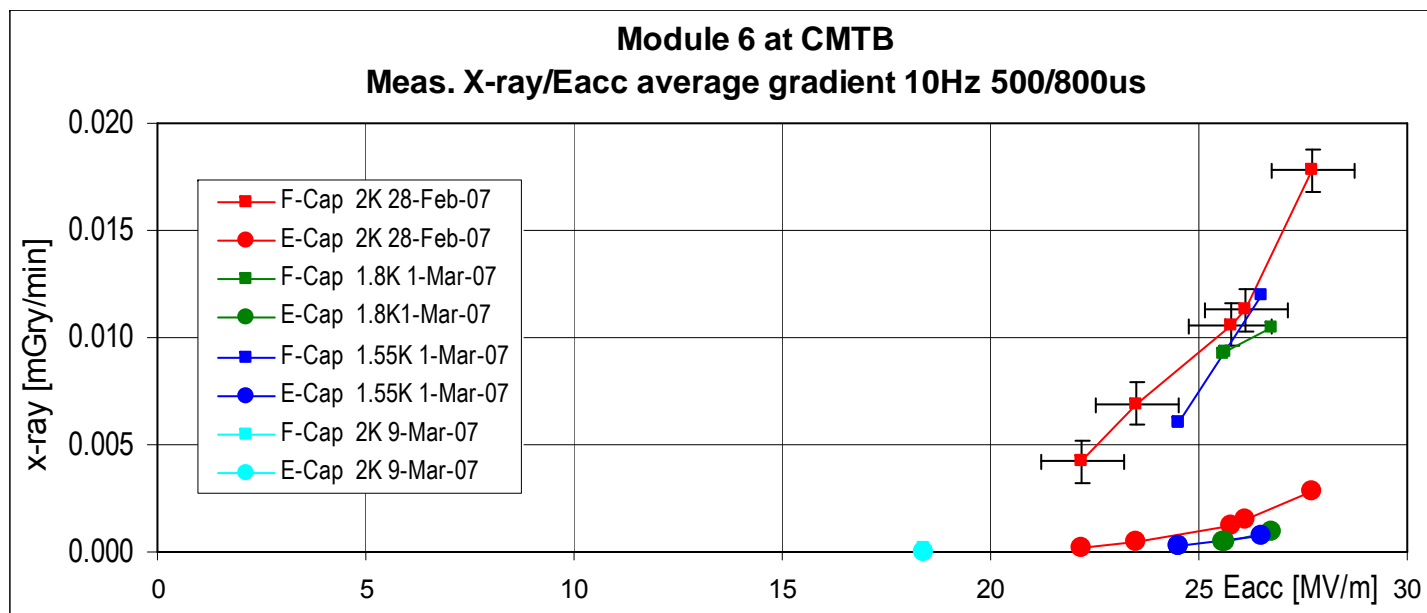
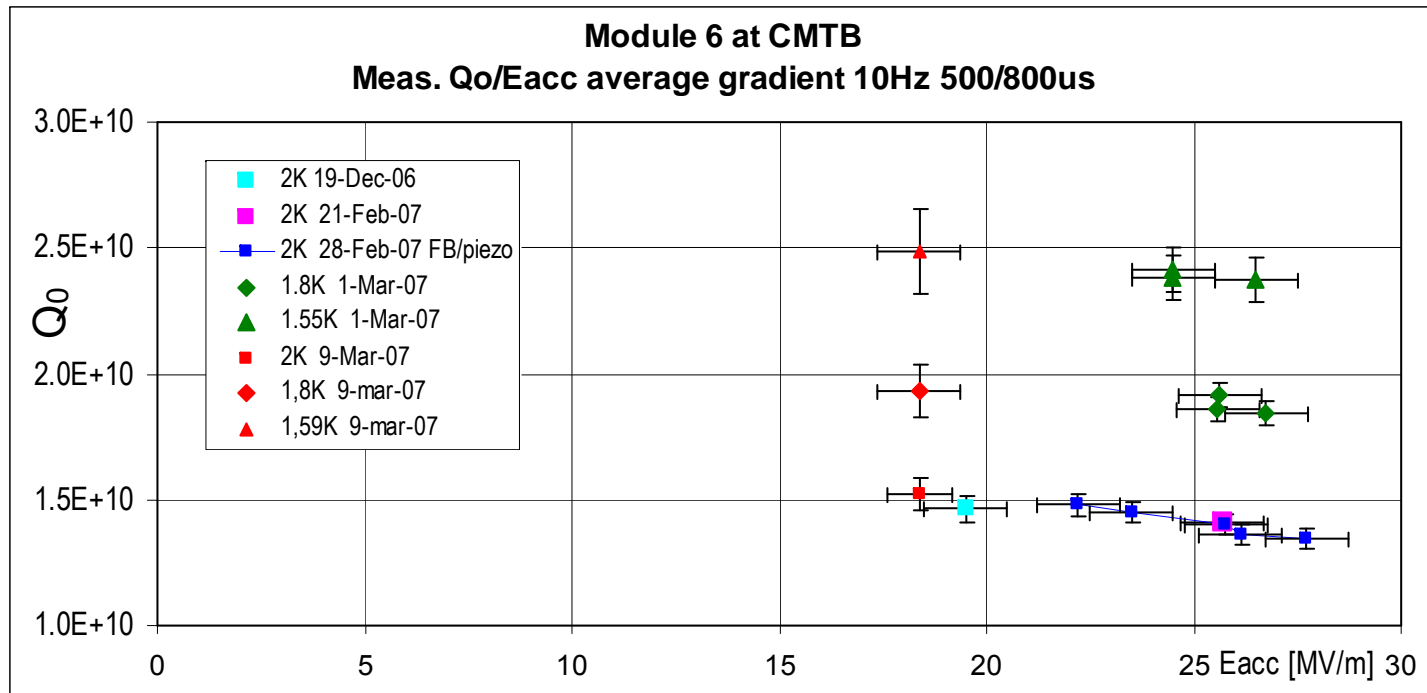
Q_0 Measurements

Q_0 Measurements

august 2006

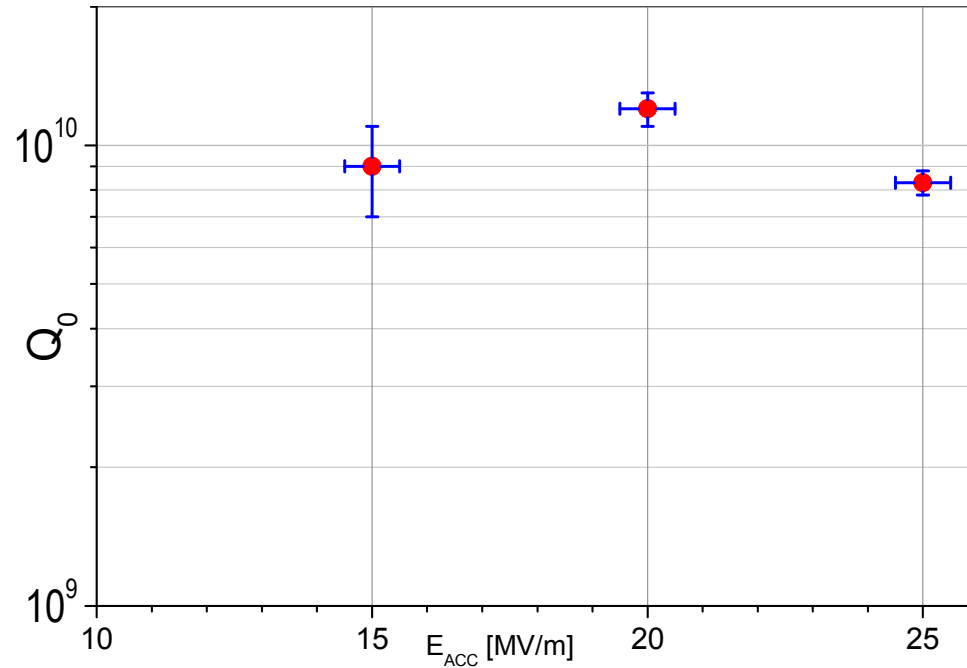


Q₀ Measurements

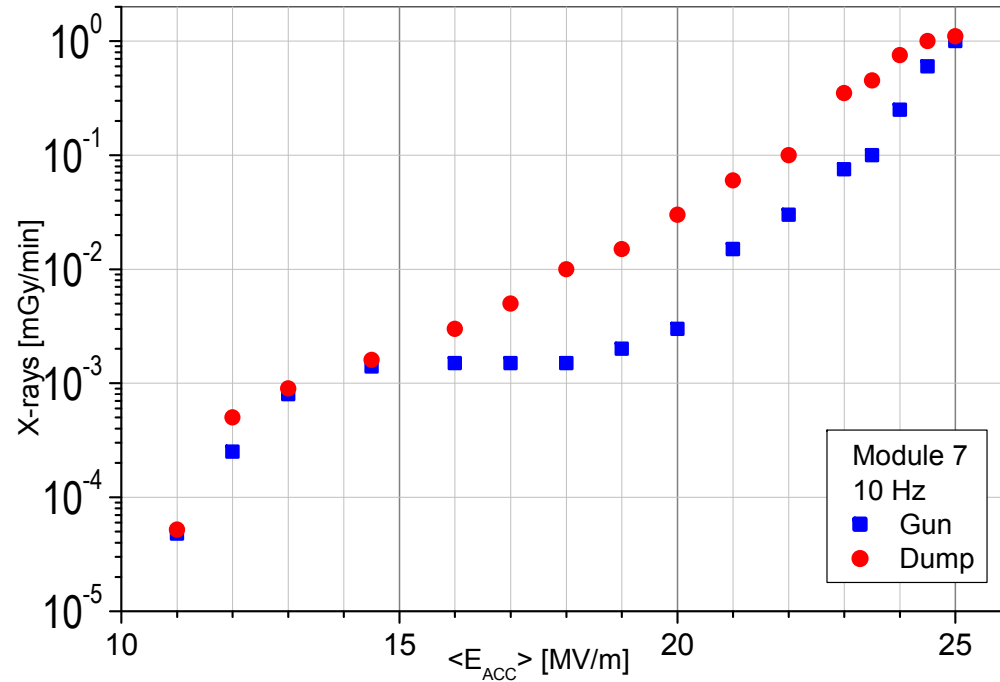


Module 7 / ACC3

$Q_0 (E_{acc})$



X-rays

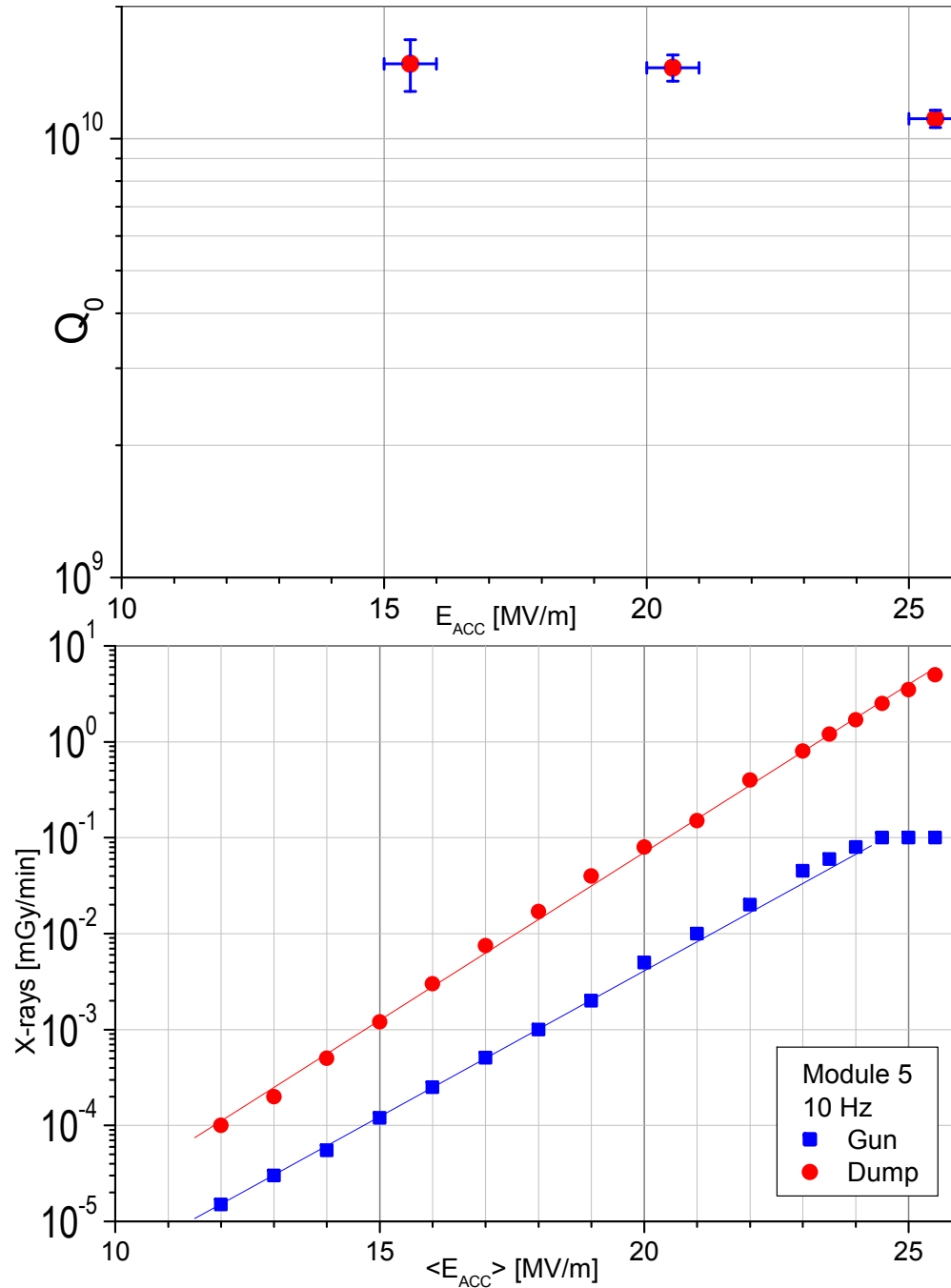


Q_0 Measurements

Module 5 / ACC5

$Q_0(E_{acc})$

X-rays

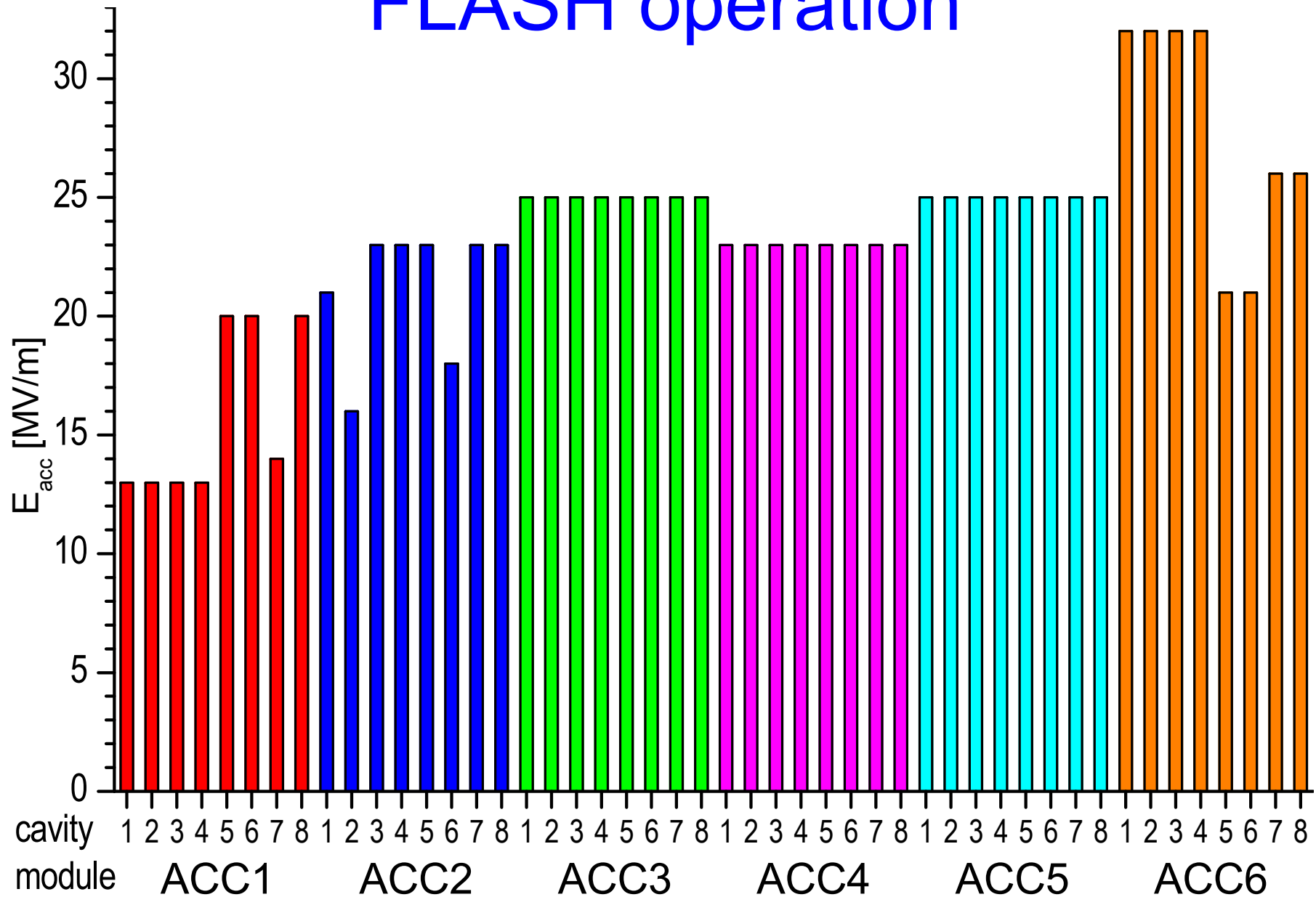


Q_0 Measurements

FLASH operation

module	cavity	E_{acc} [MV/m]	attenuator [dB]	comment
ACC1	1, 2, 3, 4	13	—	capture section, lower gradient
	5, 6, 8	20	—	
	7	14	3	too high FE
ACC2	3, 4, 5, 7, 8	23	—	limited at 24 .. 25 MV/m
	1	21	1	quench
	2	16	3	quench
	6	18	2	quench
ACC3	1 ... 8	25	—	limited at 25.5 MV/m
ACC4	1 ... 8	23	—	limited at 23.5 MV/m
ACC5	1 ... 8	25	—	limited at 26.0 MV/m
ACC6	1 ... 4	32	XFEL type RF power distribution	limited at 33.0 MV/m
	5, 6	21		limited at 22.0 MV/m
	7, 8	26		limited at 27.0 MV/m

FLASH operation

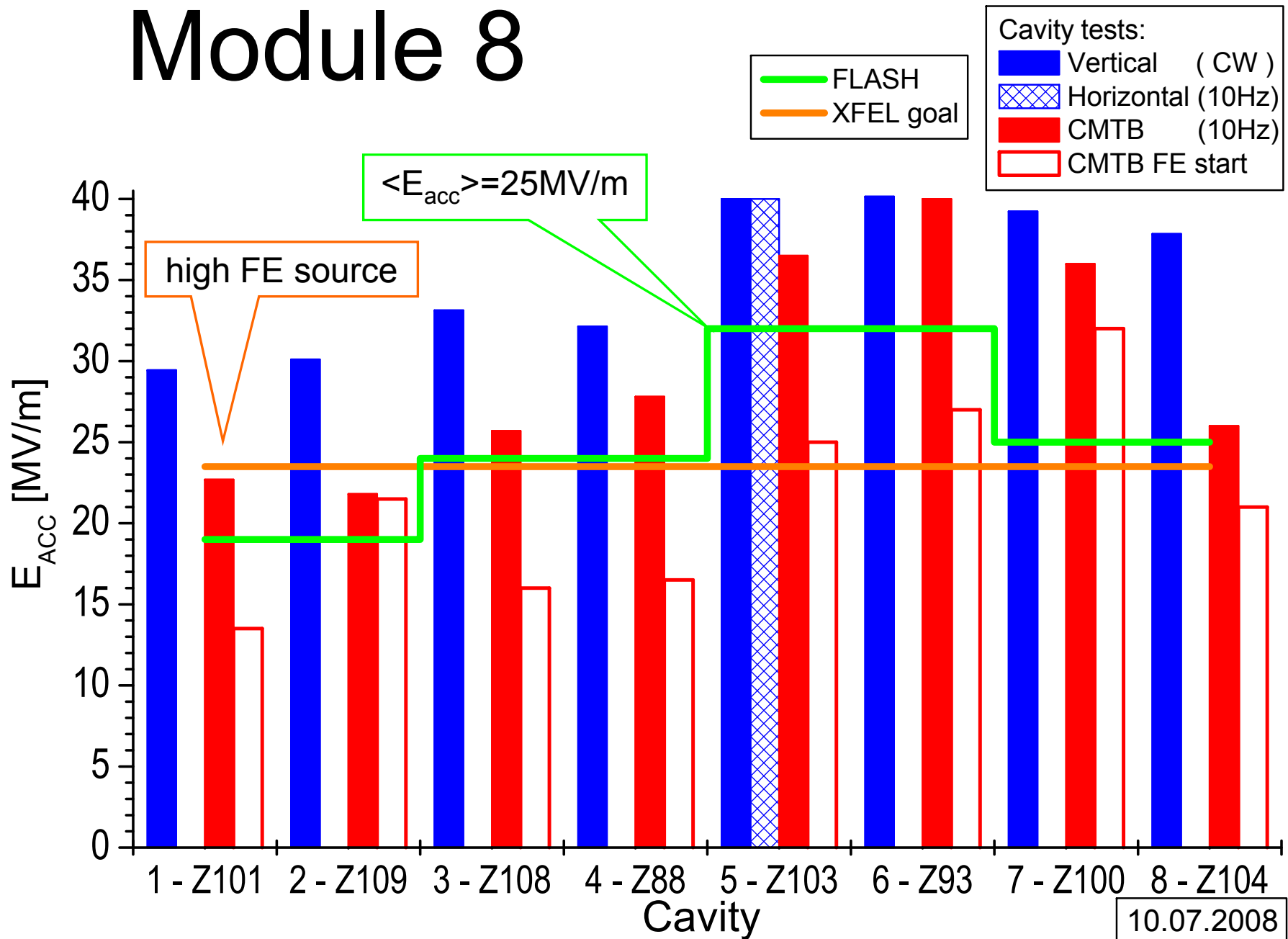


Module Test Stand (CMTB)

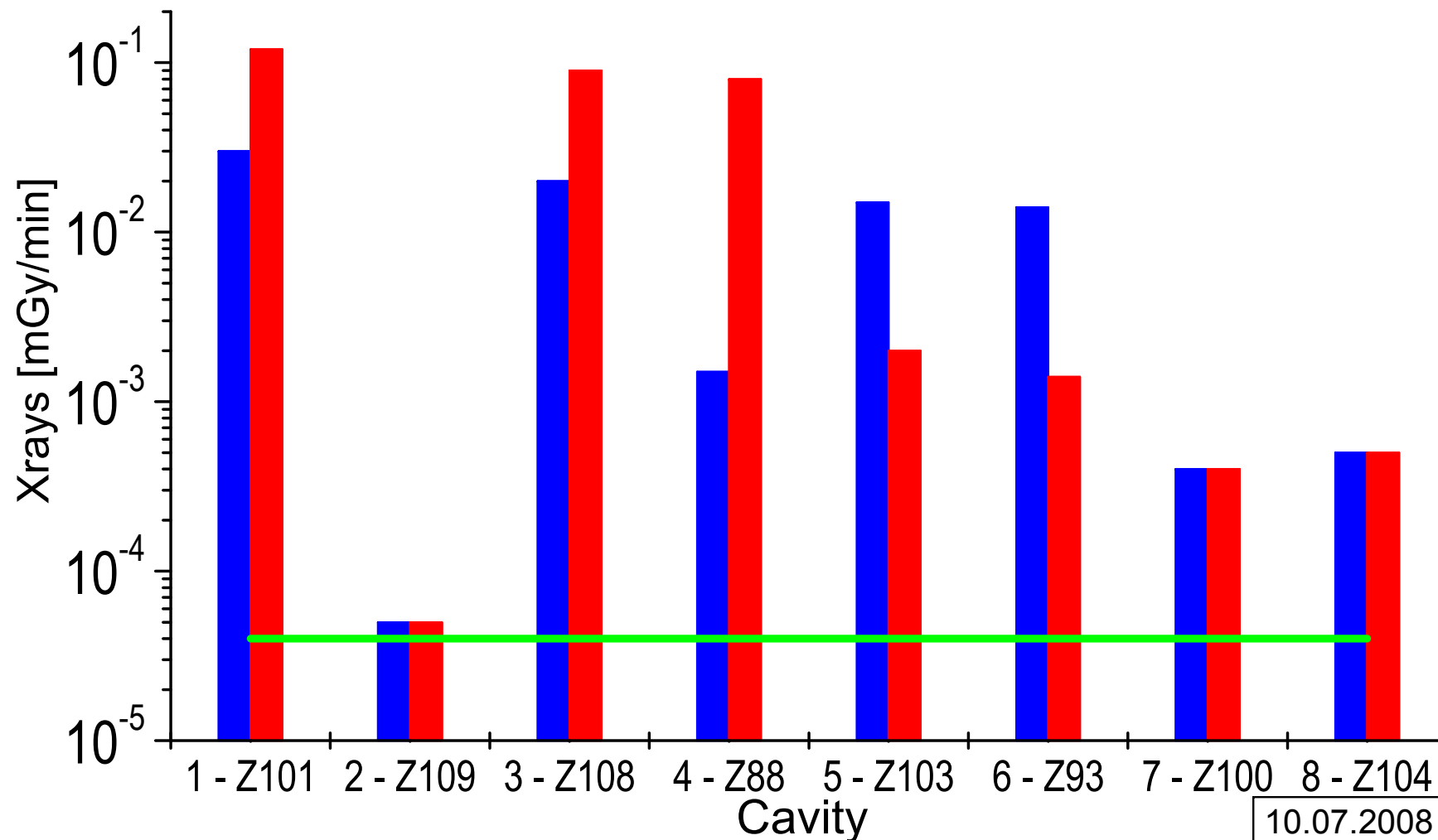
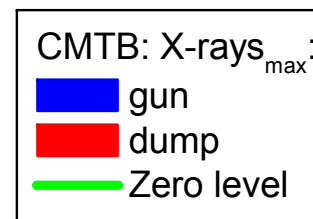


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Module 8

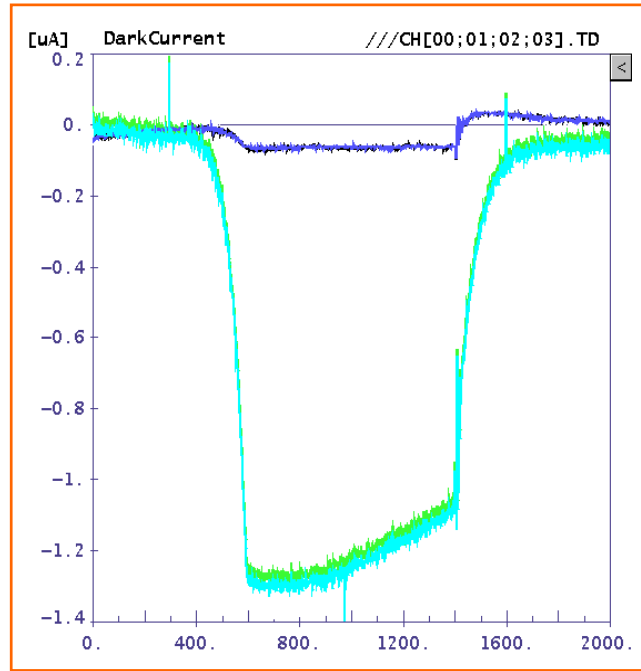


Module 8

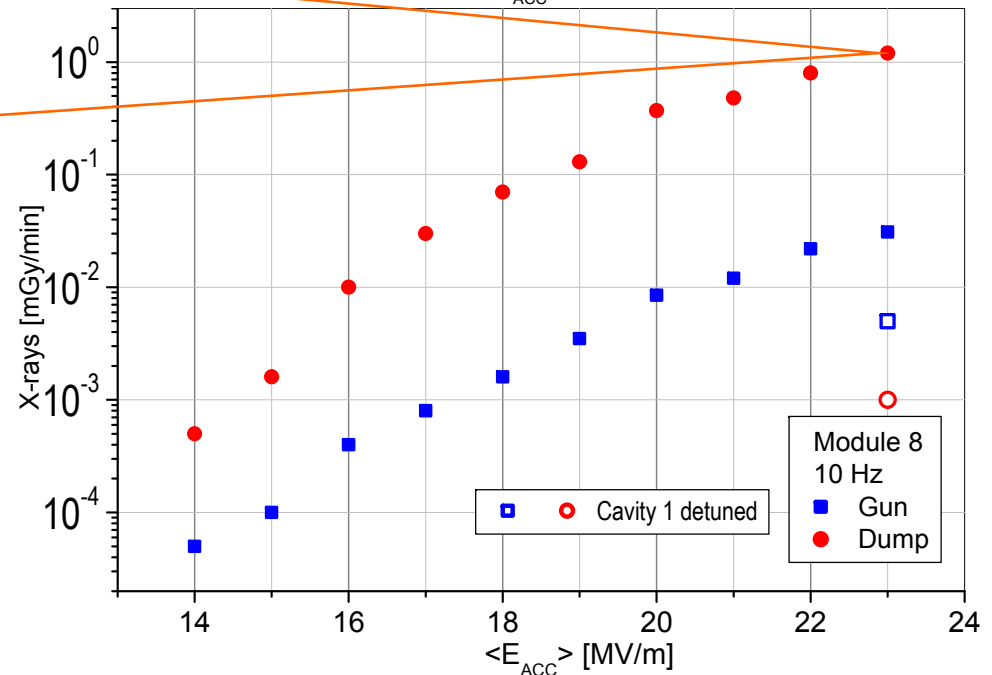
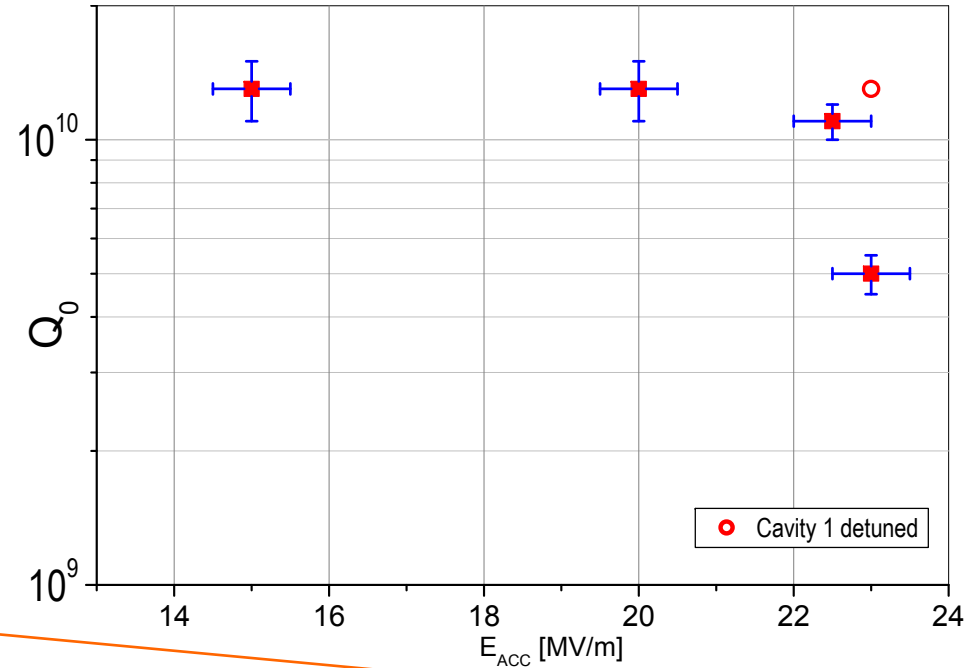


Module 8

Module test



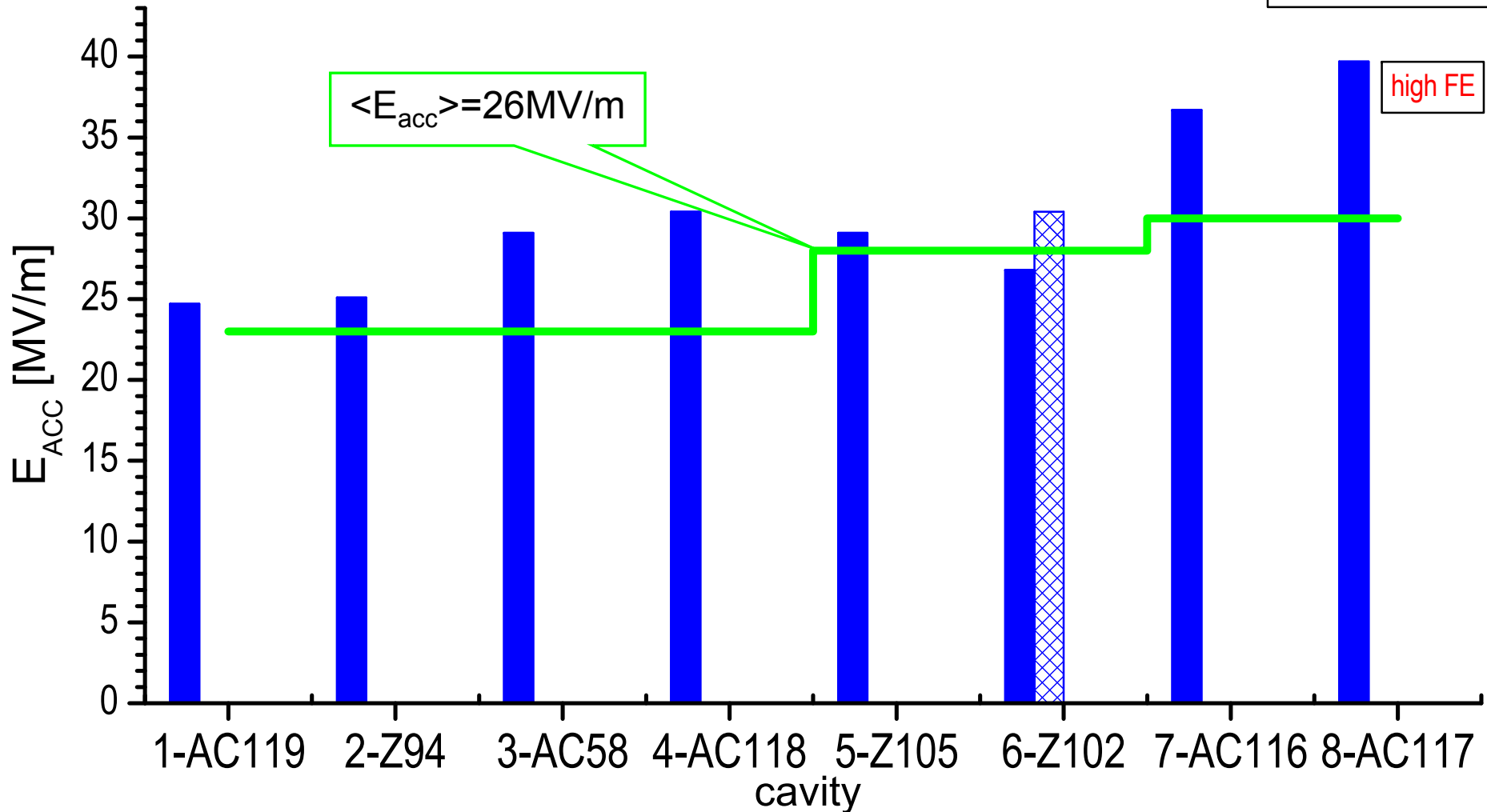
limited at $\langle E_{acc} \rangle = 23$ MV/m,
 by the Cav.1..3 quench, with
 Xrays ~ 1 mGy/min,
 dark current ~ 1.2 μ A



Module 3**

Module 3** Cavities tests:
■ Vertical (CW)
▨ Horizontal (10Hz)
▧ Module 3** CMTB (10Hz)
■ Module 3** LINAC (5Hz)

21. 10. 2008



Conclusions

- ★ All couplers in the FLASH linac could be processed and operated up to the cavity performance limits.
- ★ 4 modules: 4, 5, 6 and 7 fulfill the TESLA500 specifications.
- ★ ACC5 / module 5, tested at the repetition rate of 5 Hz was operating at the accelerating gradient of 25.5 MV/m , 500 + 800 μ s full length flat-top pulse and quality factor of 1×10^{10} . 10 Hz operation was done at 23 MV/m.
- ★ ACC1: cavity 7 is a source of a dark current, up to 10 mGy/min on axis, new module 3** planned to be installed (upgrade).
ACC3: new module 7 with $E_{acc} = 25$ MV/m is installed.
ACC5: cavity 6 is a source of a dark current of 200 nA (peak) at 25 MV/m.
module 5 was repaired and tested: $E_{acc} = 25.5$ MV/m
ACC6: new module 6 with $\langle E_{acc} \rangle = 27$ MV/m is installed.
ACC7: module 8 (tested on the CMTB) planned to be installed (upgrade).
- ★ All modules have functioned continuously during certain periods of time.
- ★ Cavity 5 (AC72, EP) tested in Module 2* / ACC1 reached 35 MV/m, confirmed with beam.