European XFEL

TTC Meeting, July 5-8 2016, Saclay, France.

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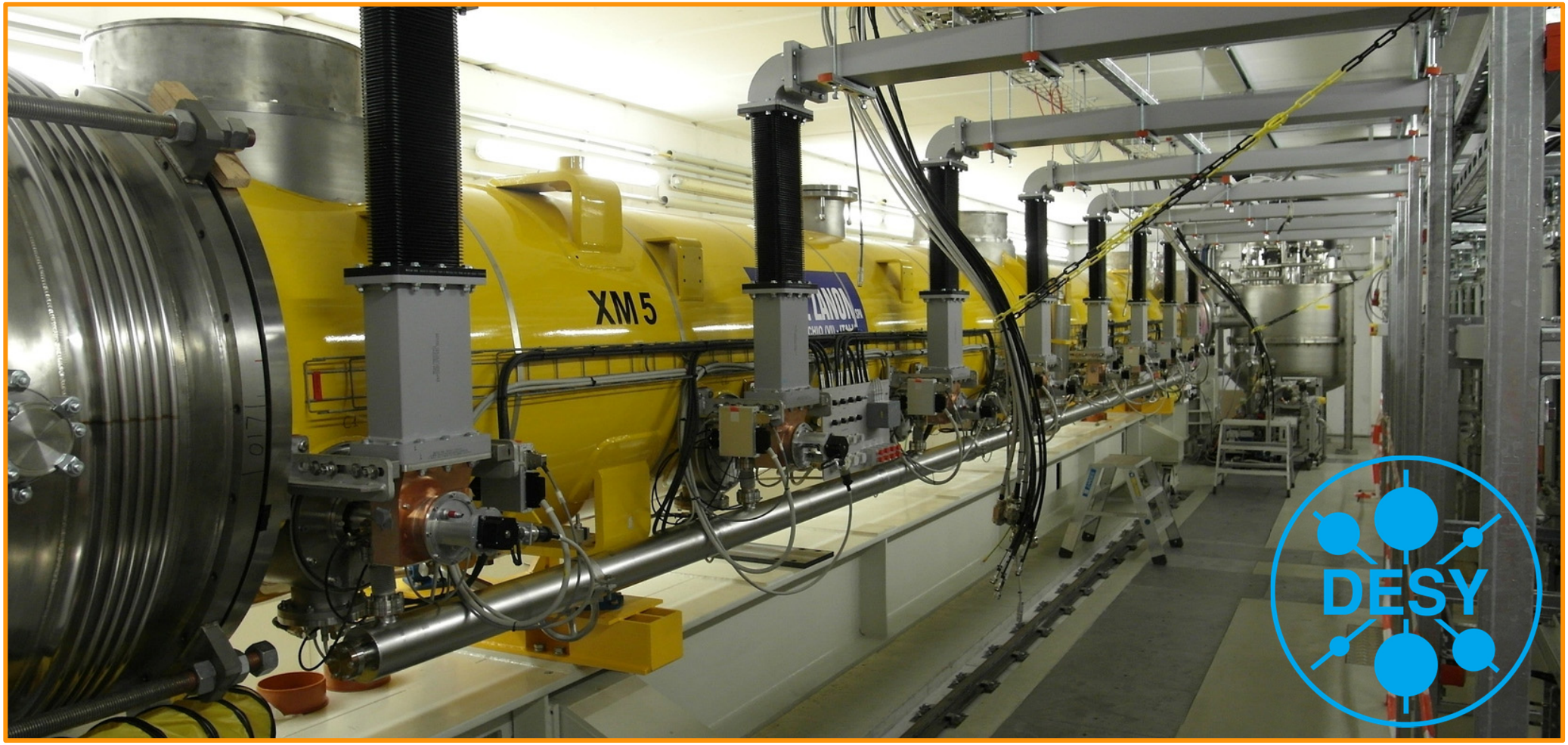
Improvement / Deterioration of Module Performance due to RF Conditioning at AMTF



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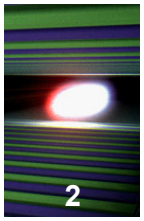
Outline



1. E-XFEL CryoModule Tests Statistics
2. CM Test / RF Conditioning
3. Summary

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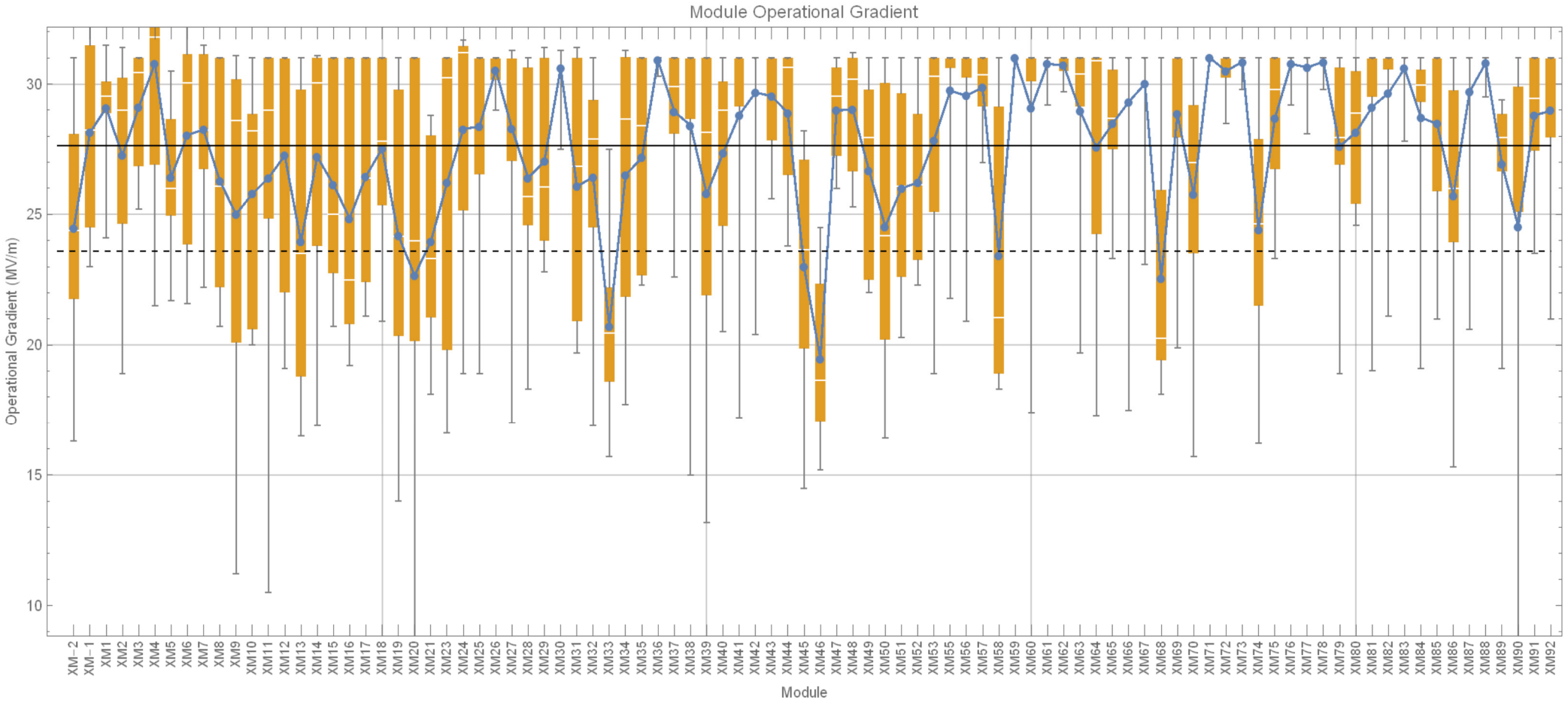
1.1 E-XFEL CryoModule Test Statistics

CM Operational (usable) Gradient

reaching the 27.7 MV/m average operating gradient



- CM Test is limited to 31 MV/m

up to XM92

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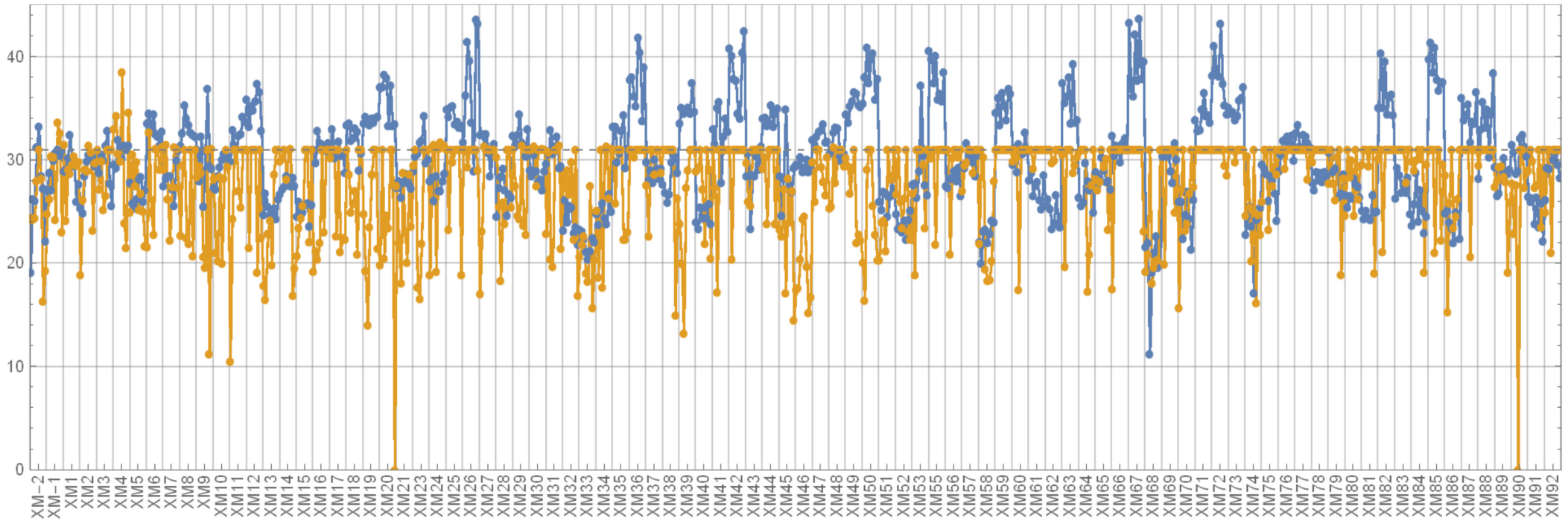
1.2 E-XFEL CryoModule Test Statistics

CM Operational (usable) Gradient VT / CM

loosing some performance compared to VT



- CM Test is limited to 31 MV/m

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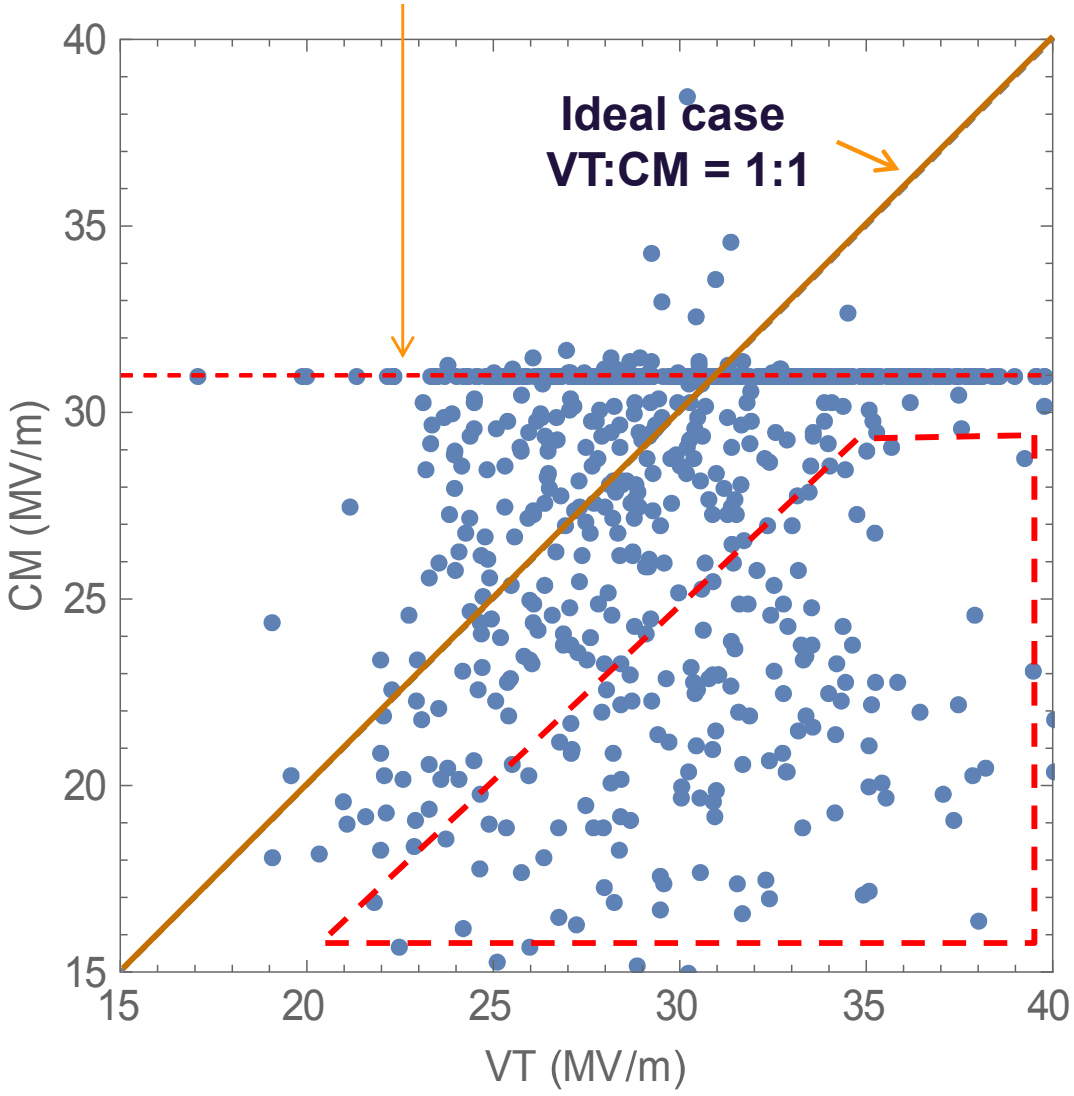
1.3 CM / VT comparison: usable Gradient

individual cavity comparison

(upper limit due to 31 MV/m limit in module test)



- **we lose between vertical and cryomodule test**
- average VT: (33.8) **30.2 MV/m**
  (clipped at 31 MV/m)
  average CT: **27.7 MV/m**
  (includes limit at 31MV/m)

	N_{cavs}	Average	RMS	min	max
VT	735.	30.2	4.6	11.2	43.7
CM	735.	27.7	4.6	0.	38.5

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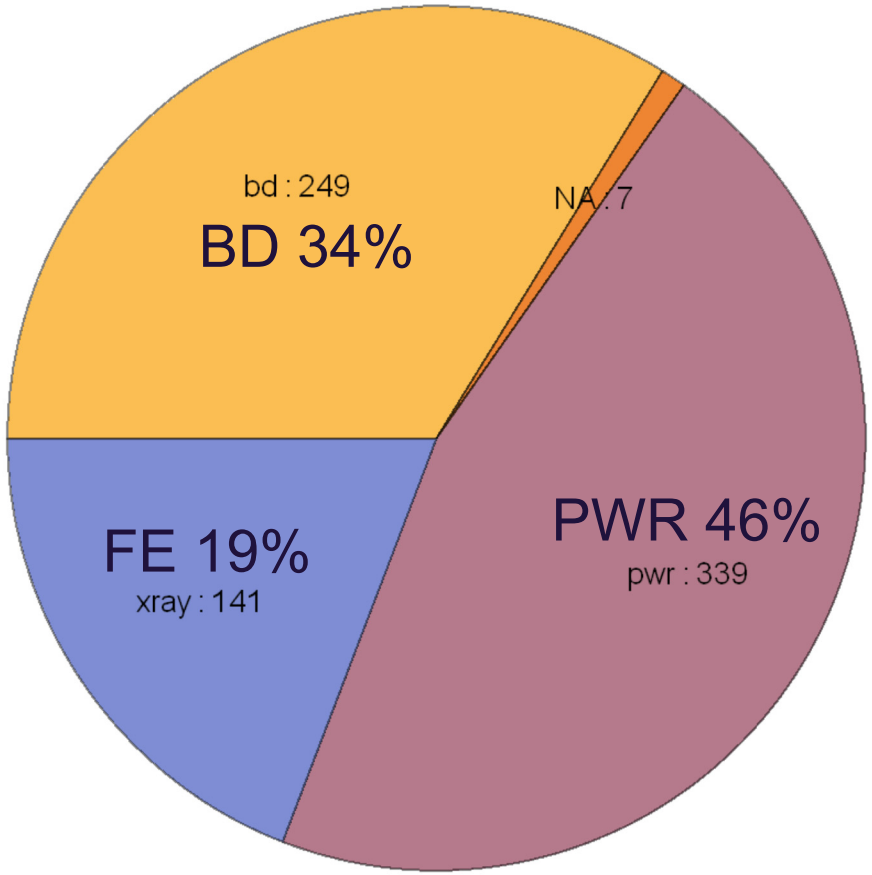
1.4 CM Operating Gradient Limits

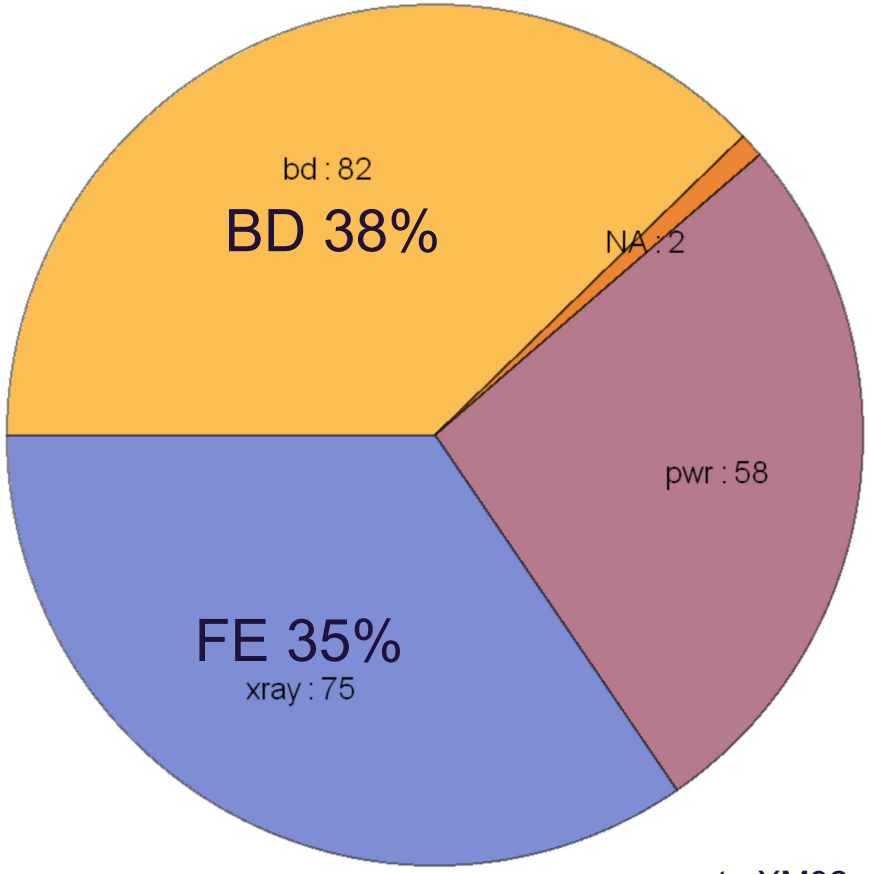
CM Limits breakdown

Op. Gradient



Limits with CM/VT Difference

Op. Gradient Δ>5 MV/m



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- CM Test is limited to 31 MV/m

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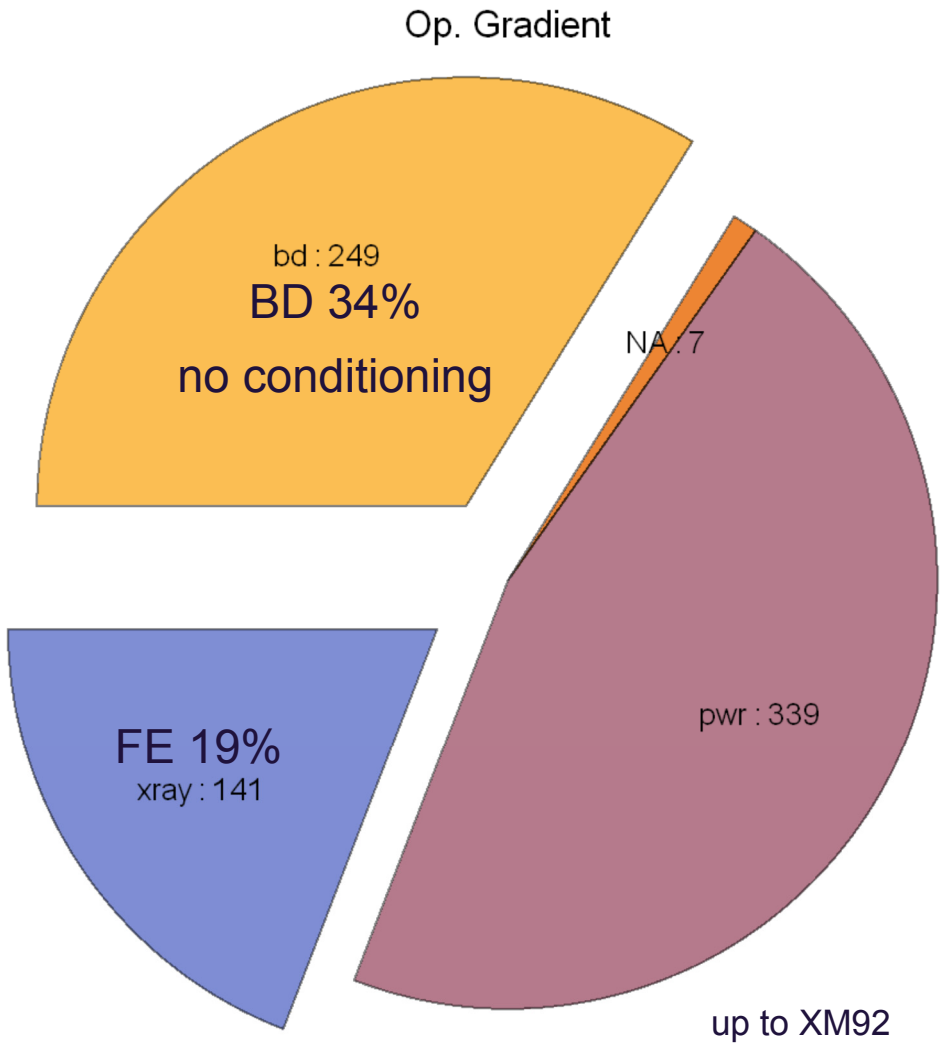
2.1 CM Test / RF Conditioning: Limits

1. The Cavity CM Performance Limits: Quench/Breakdown and FE/X-rays;
2. RF Conditioning is attempted to cure (increase) the limits;
3. Cavity Breakdown (without FE) is hard to improve/cure, RF conditioning was unsuccessful. Some MP caused BDs were cured;
4. FE/X-rays Limit (10^{-2} mGy/min) was improved in some cases by attempted RF conditioning. Initial (1st power rise) Gamma Radiation was decreased from 2..10 times up to full conditioning (no FE);
5. The FE degradation was observed as well during the CM tests;

CM Test Op.Gradient Limits



up to XM92

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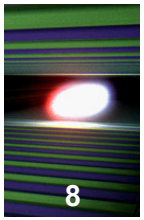
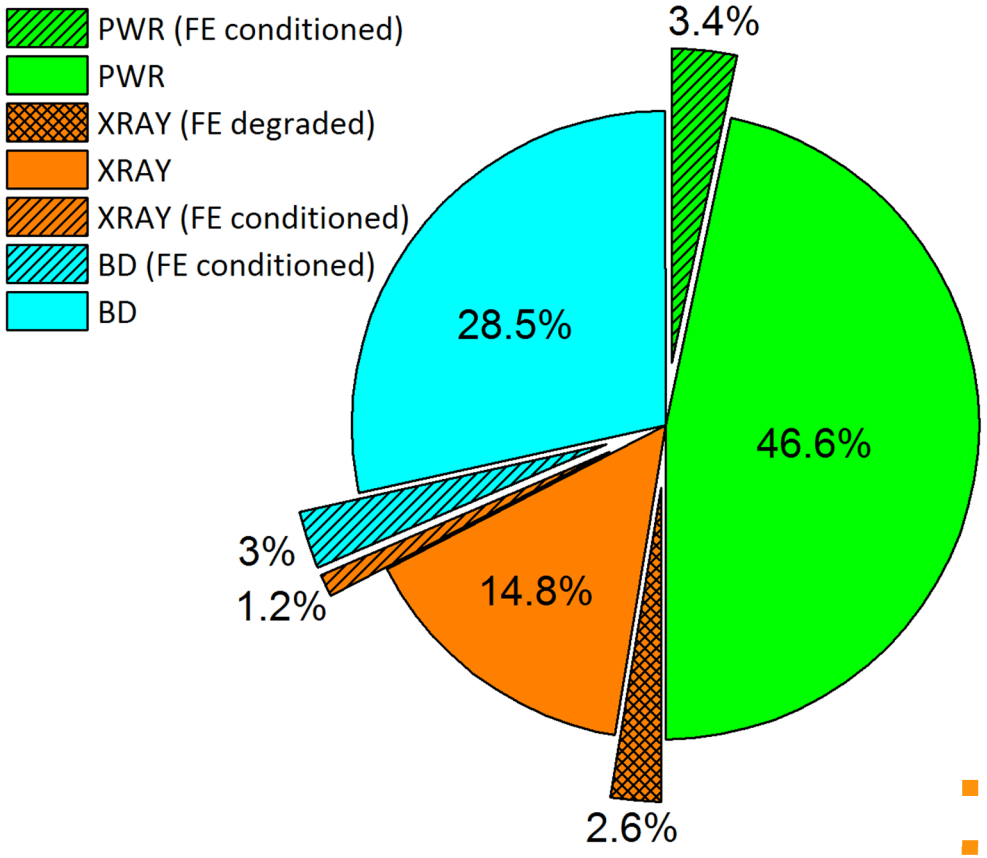
2.2 CM Test / RF Conditioning: Statistics



CM Test Op.Gradient Limits



97 Tested Modules: XM-2 .. XM95

Σ cavities	776	
BD Limited	244	31%
FE Limited	144	19%
MP Conditioned	7	1%
FE Conditioned	58	8% (~30% cavities with FE)
Conditioned Limits	PWR: 26, BD: 23, XRAY: 9	
FE Degradation	20	3% (~10% cavities with FE)

- FE Conditioning: X-rays decrease after 1st power rise / processing;
- FE Degradation: X-rays increase during the test.

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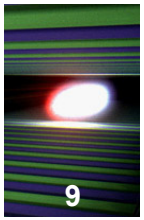
3. Summary



- Three main limiting factors for the E-XFEL cryo-module cavities tests are breakdown (31%), field emission/X-rays (19%) and available RF power;
- RF conditioning was applied to cure the breakdown and field emission cavity performance limits;
- RF conditioning of a cavity breakdown (quench) without field emission was mostly unsuccessful (no improvement), in some cases MP quenches were conditioned;
- RF conditioning did improve the performance of ~30% E-XFEL cavities with field emission, decreasing the cavities gamma radiation successfully;
- RF conditioning did degrade the performance of ~3% of E-XFEL cavities in respect to field emission, this is ~10% of cavities with FE;
- Total effect is positive, overall performance was improved: average operating gradient was increased with cured cavities and FE caused gamma radiation and dark current decreased.