

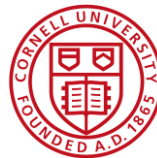


FE limits Comparison for Pulsed vs. CW Module Tests

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Field Emission Limits at **Module** Tests

1. Impact of duty cycle
2. X-Ray detection in cave

Comparing X-Rays dose-rates between Eu-XFEL (1% pulsed) and LCLS-II (CW)

'Usable gradient' limits on X-Rays dose-rates:

- LCLS-II (FNAL-CMTS): 50 mrd/h = 8.3×10^{-3} mGy/min
- Eu-XFEL (DESY-AMTF) : 10^{-2} mGy/min

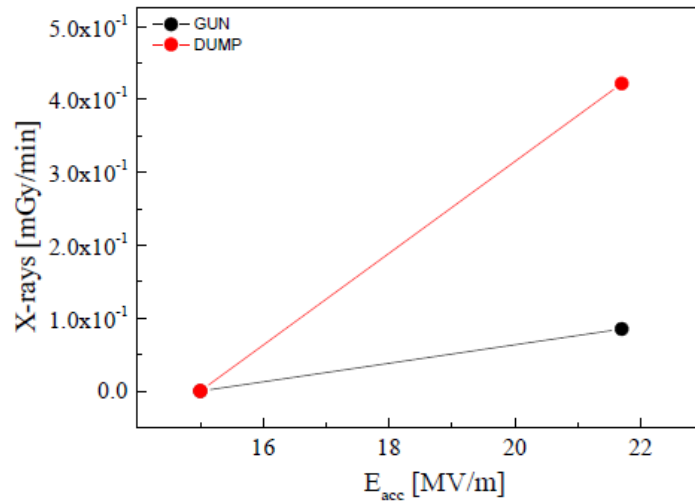
These two limits are almost identical, but is AMTF measuring the peak (during 1 ms) or the integrated (> 1s) dose rate ?

Although the 1-liter spherical chamber (type 32002) used at AMTF has integration time of 39 ms at 400 V, the most likely assumption, checked with DESY, is that the **AMTF dose-rate is integrated**: hence the 1 ms-peak **dose-rate is 1 mGy/min, 120 times higher than at CMTS.**

XFEL XM40 Module Test X-Rays Measurement

X-rays vs E_{acc}

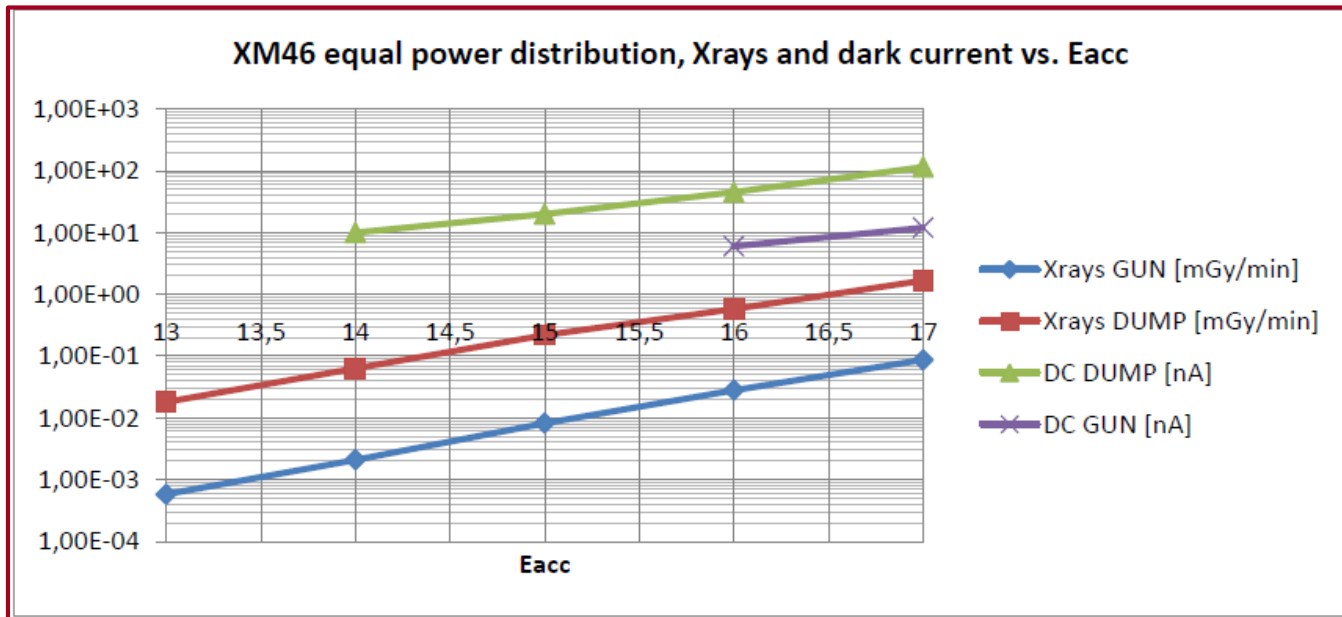
Power E_{acc} [$\frac{MV}{m}$]	Avg P_{forw} [kW]	X-rays [$\frac{mGy}{min}$]		Comment
		GUN	DUMP	
15	60.0	4.9E-5	1.59E-4	
21.7	113.9	8.51E-2	4.22E-1	



	GUN	DUMP		
MV/m	mGy/min	mGy/min		
15	4,90E-05	1,59E-04		
21,7	8,51E-02	4,22E-01		
	2,07	1,96	(MV/m)/decade	

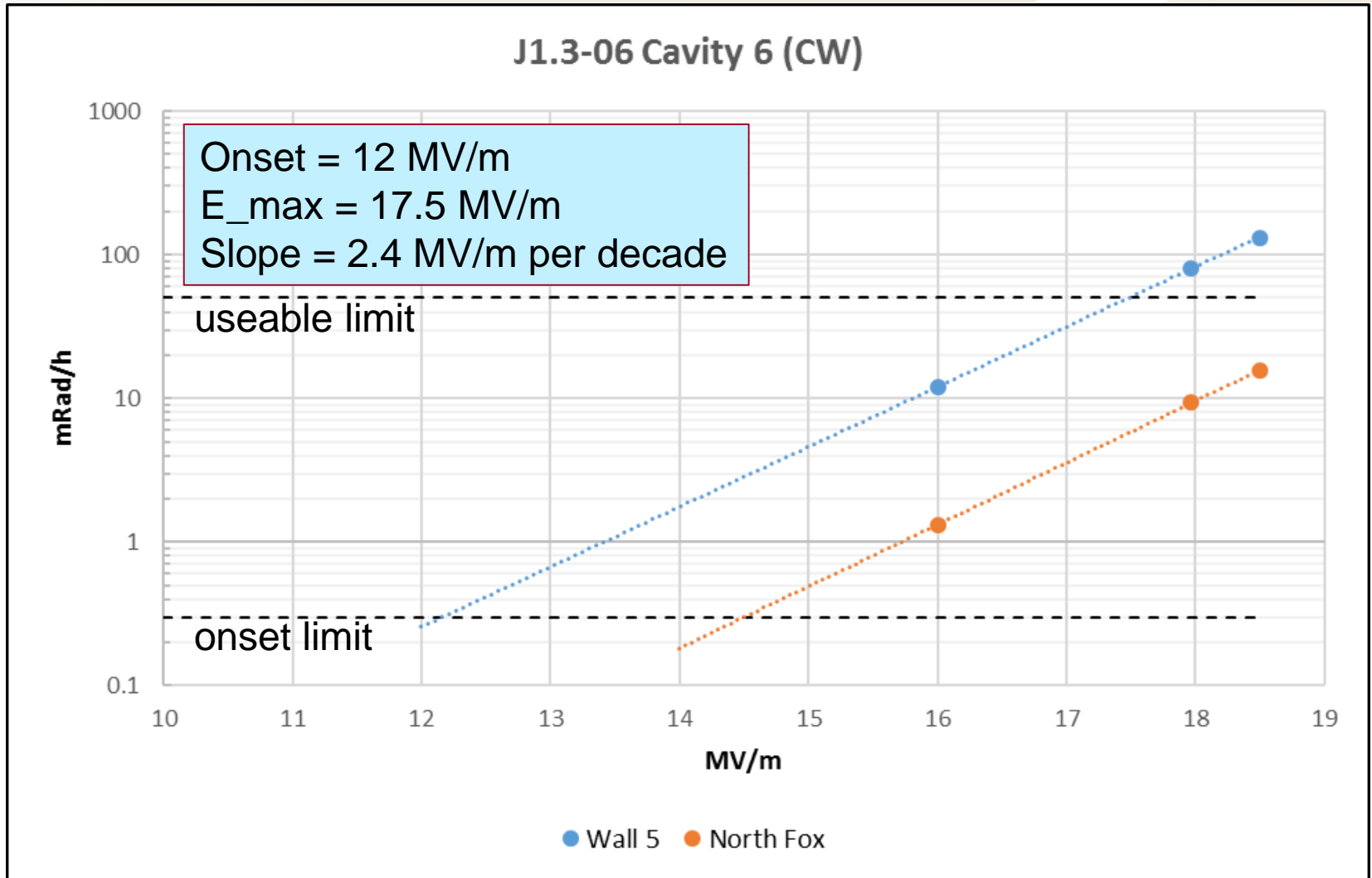
XFEL XM46 Module Test X-Rays Measurement

“XM46 is one of our dark current ‘light bulbs’ ” (N. Walker)



	GUN	DUMP	
MV/m	mGy/min	mGy/min	
13	5,80E-04	8,70E-02	
17	1,80E-02	1,68E+00	
	2,68	3,11	(MV/m)/decade

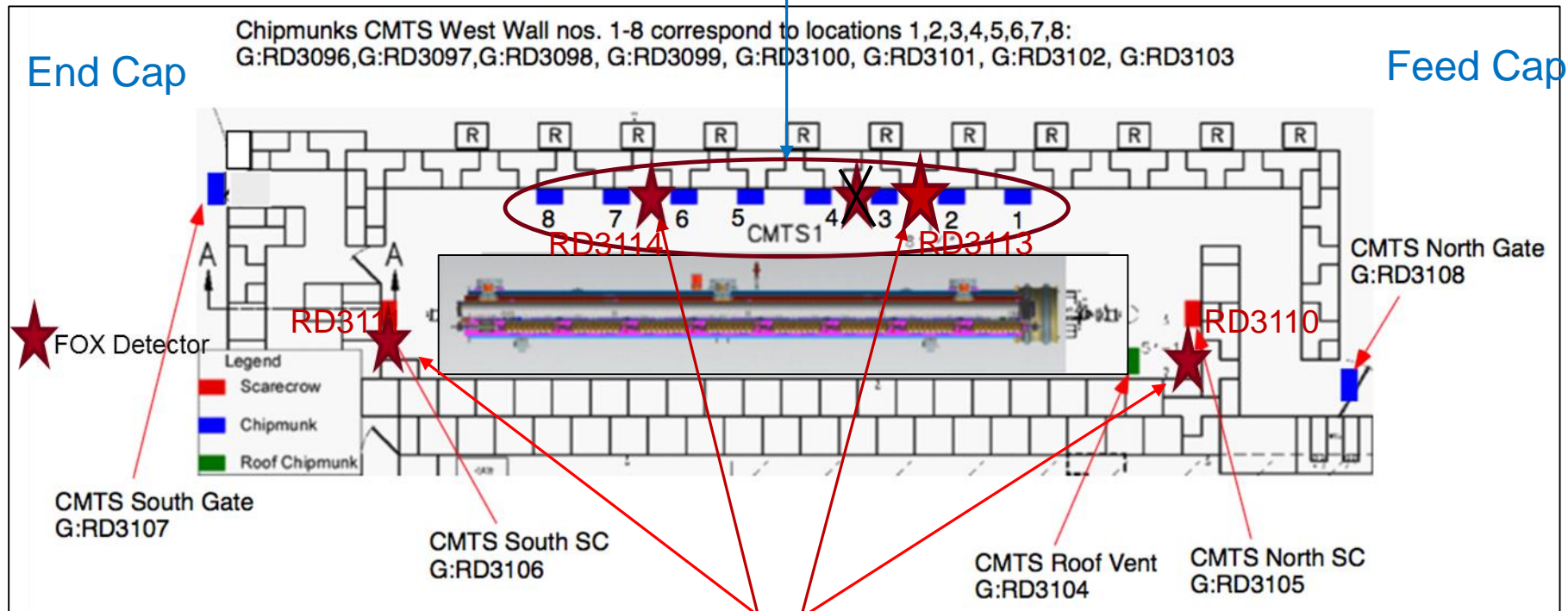
J1.3-01 Cavity 6 : FE onset and Limits



X-Ray monitor setups: CMTS@Fermilab

G:RD3096-3103: 8 detectors along module coupler-side, for measurement (mrad/h)

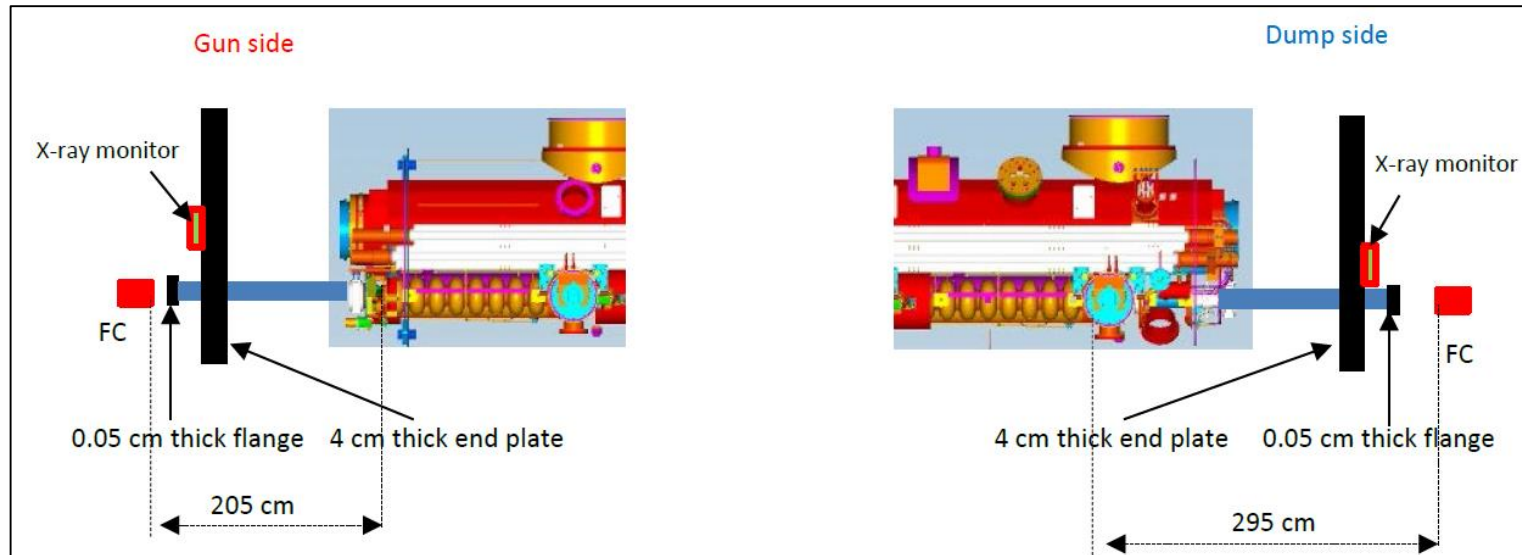
G:RD3104-3108: 5 detectors on module ends, for safety



G:RD3110-3111: 2 detectors on module ends, for measurement (in mrad/h)

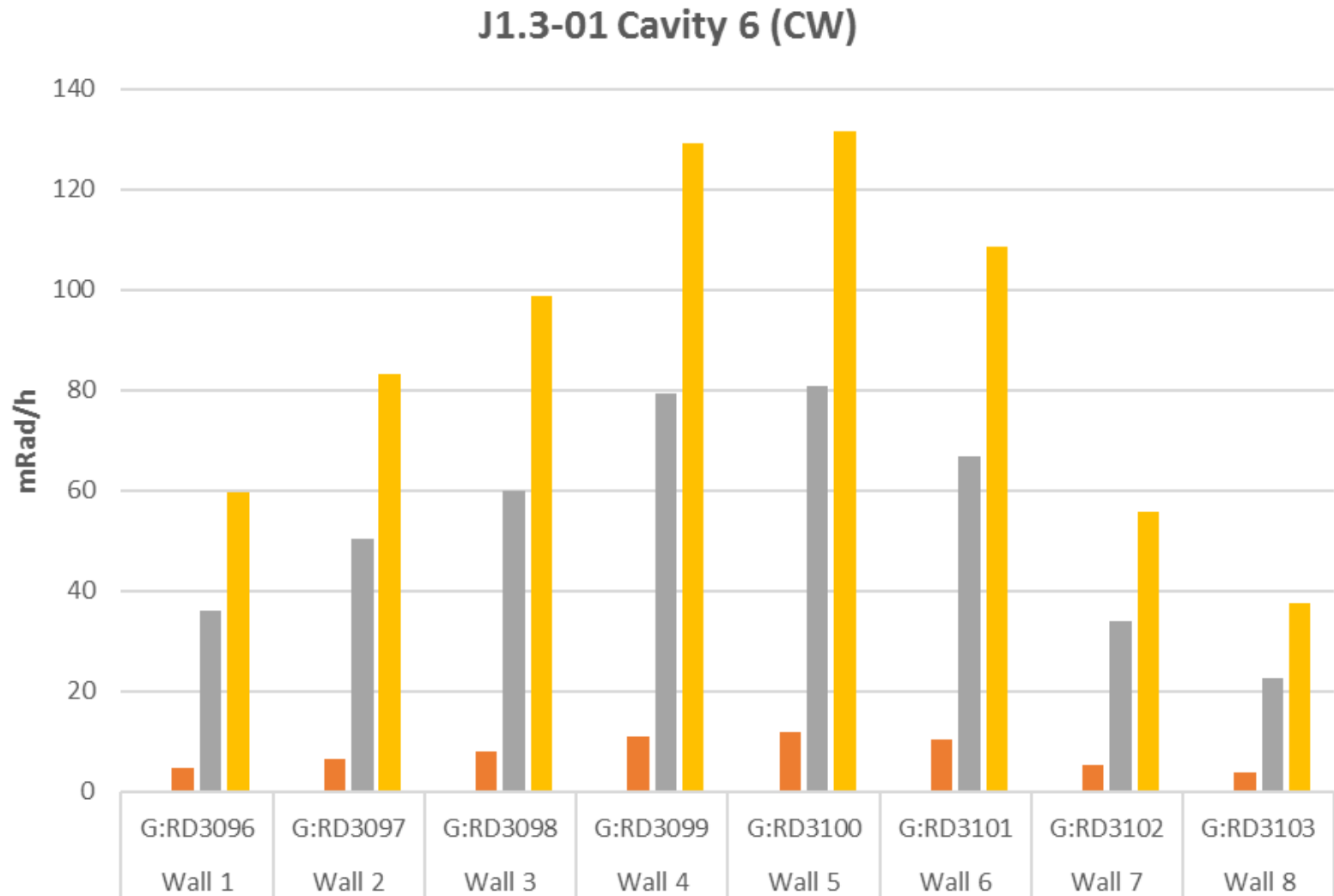
G:RD3113-3114: 2 detectors on module coupler-side, for measurement (in mrad/h)

X-Ray monitor setups: CMTB@DESY

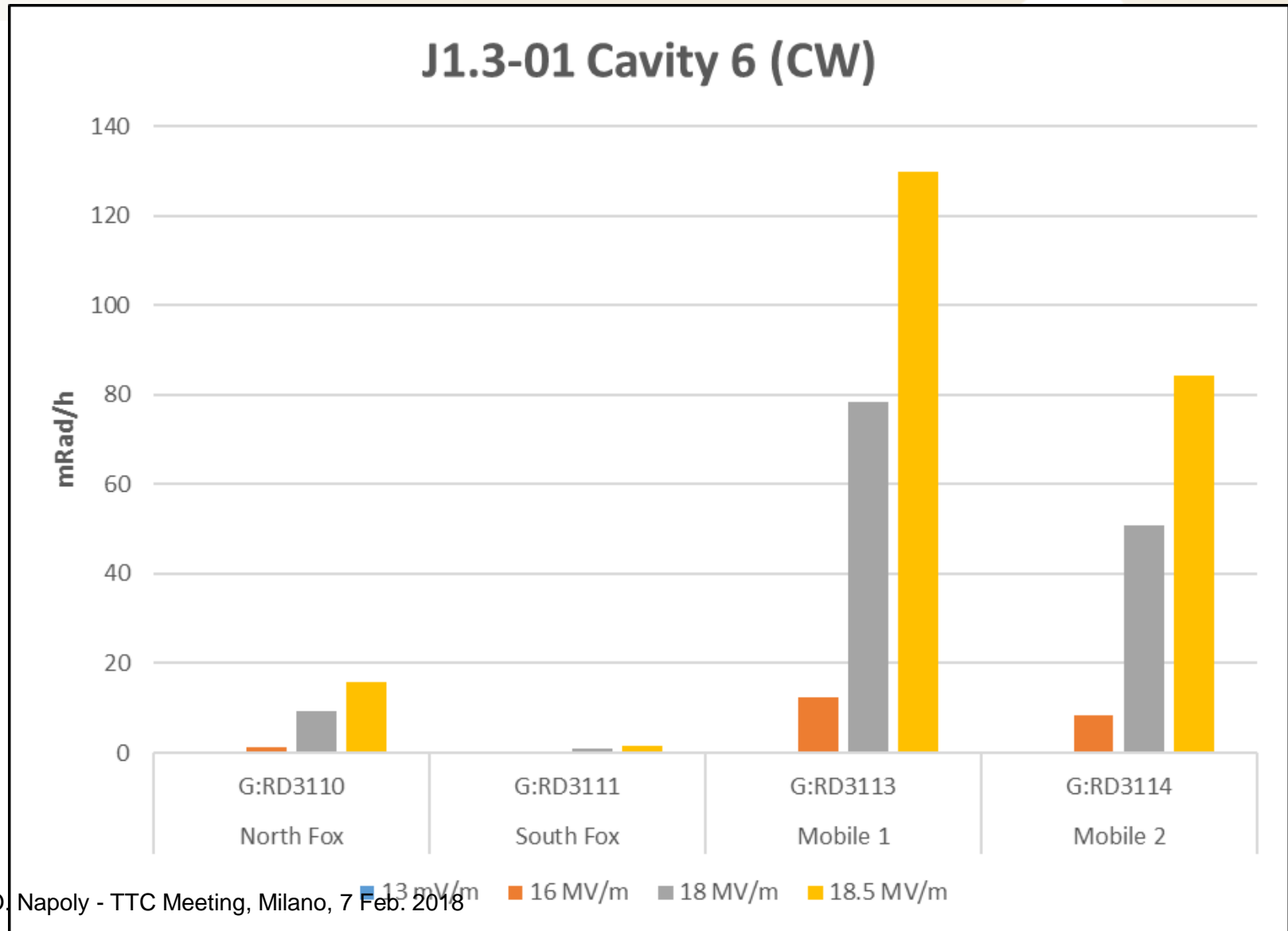


CMTB and AMTF have only two X-Ray detectors located at both ends of cryomodule: 'GUN side' and 'DUMP side'.

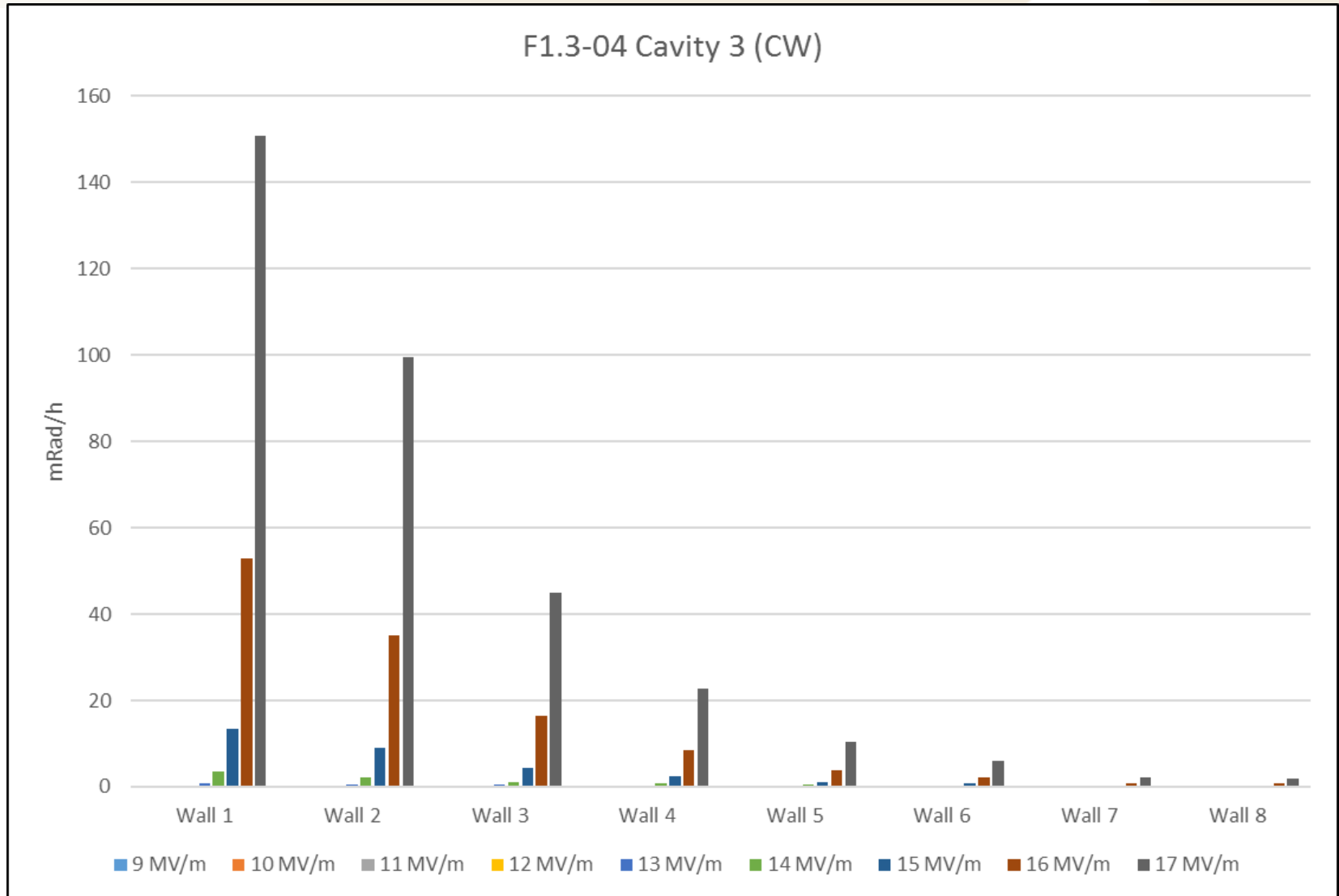
J1.3-01 Cavity 6 : Coupler-side detectors



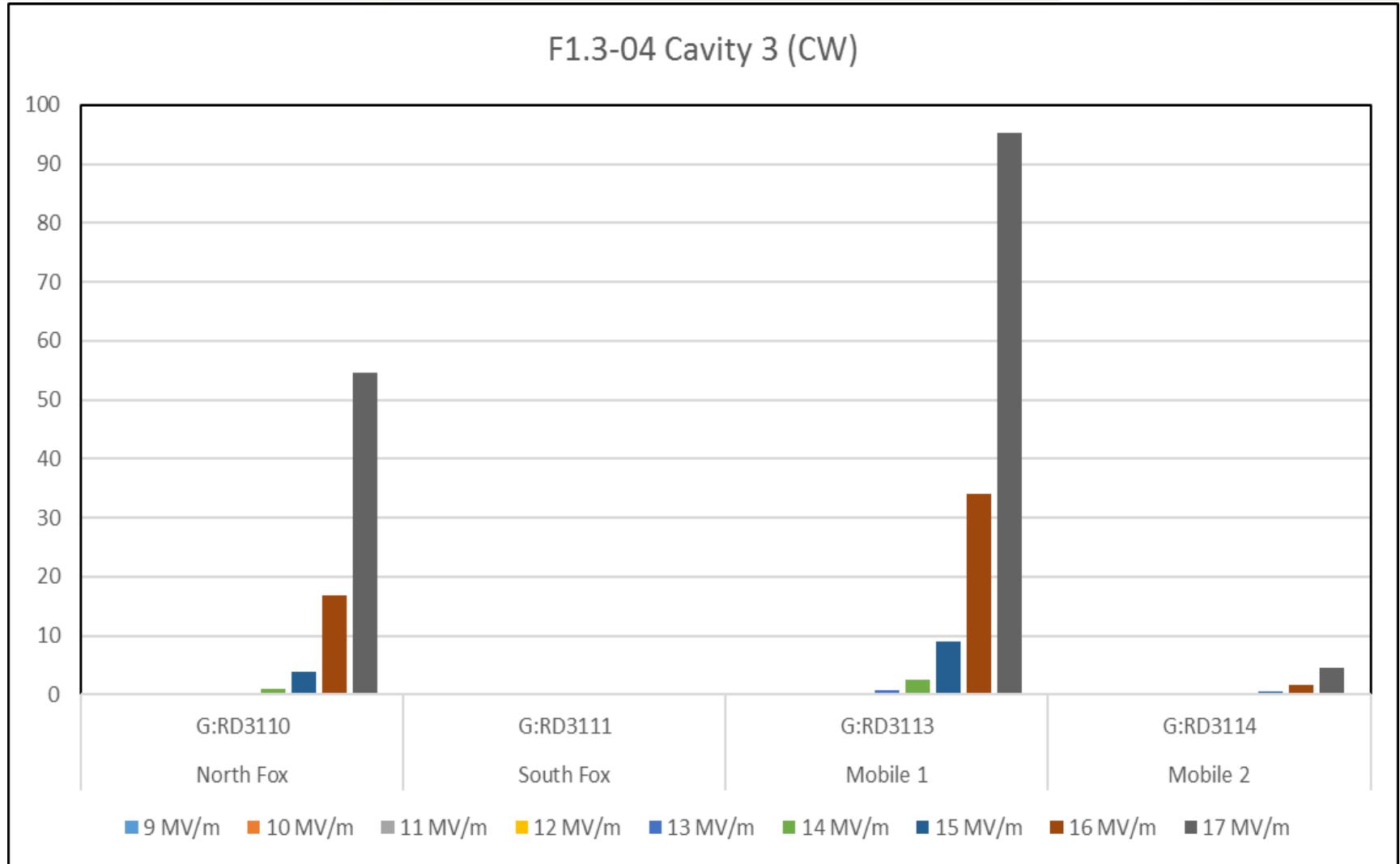
J1.3-01 Cavity 6 : Mobile Coupler-side and US/DS detectors



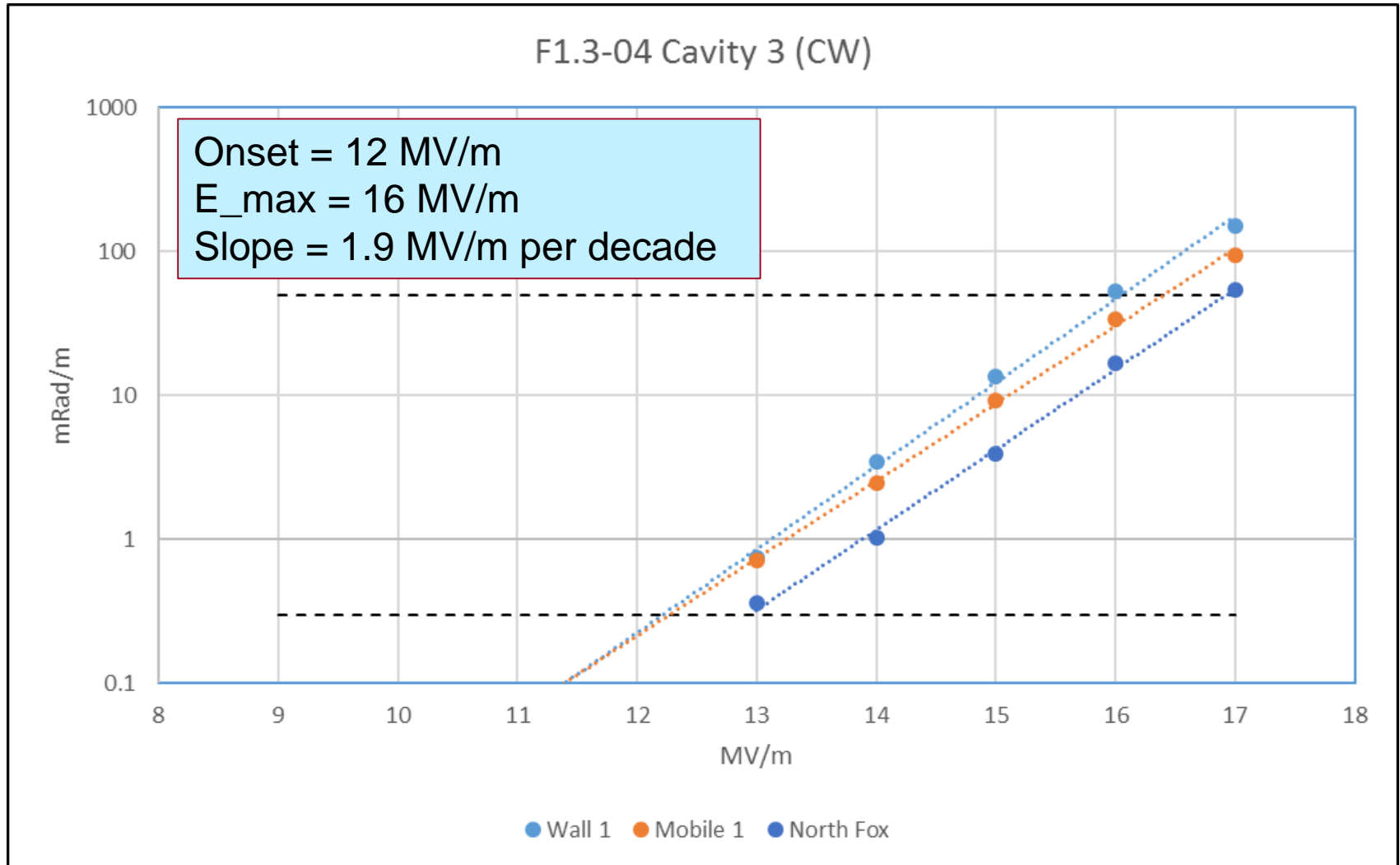
F1.3-04 Cavity 3 : Coupler-side detectors



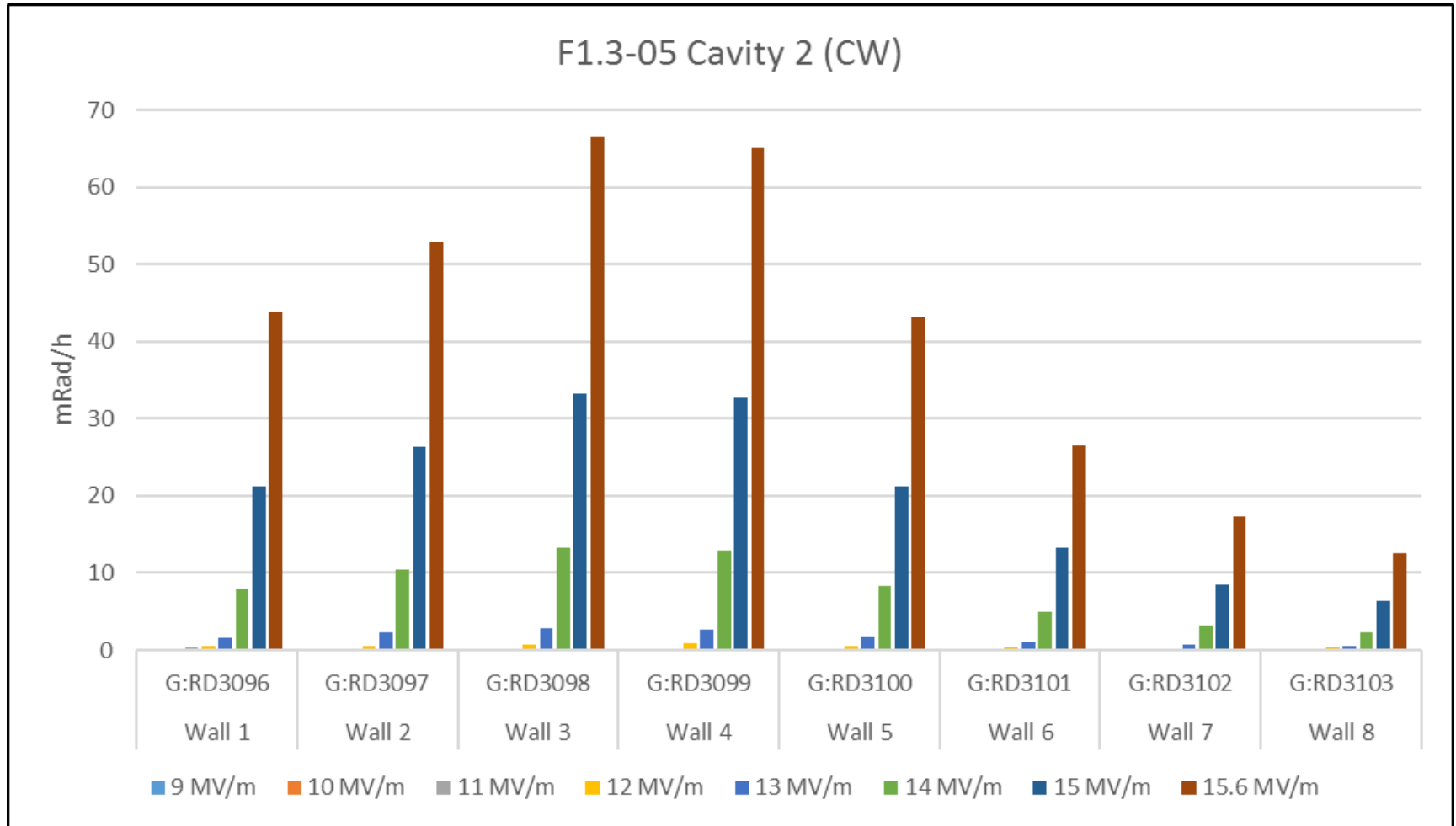
F1.3-04 Cavity 3 : Mobile Coupler-side and US/DS detectors



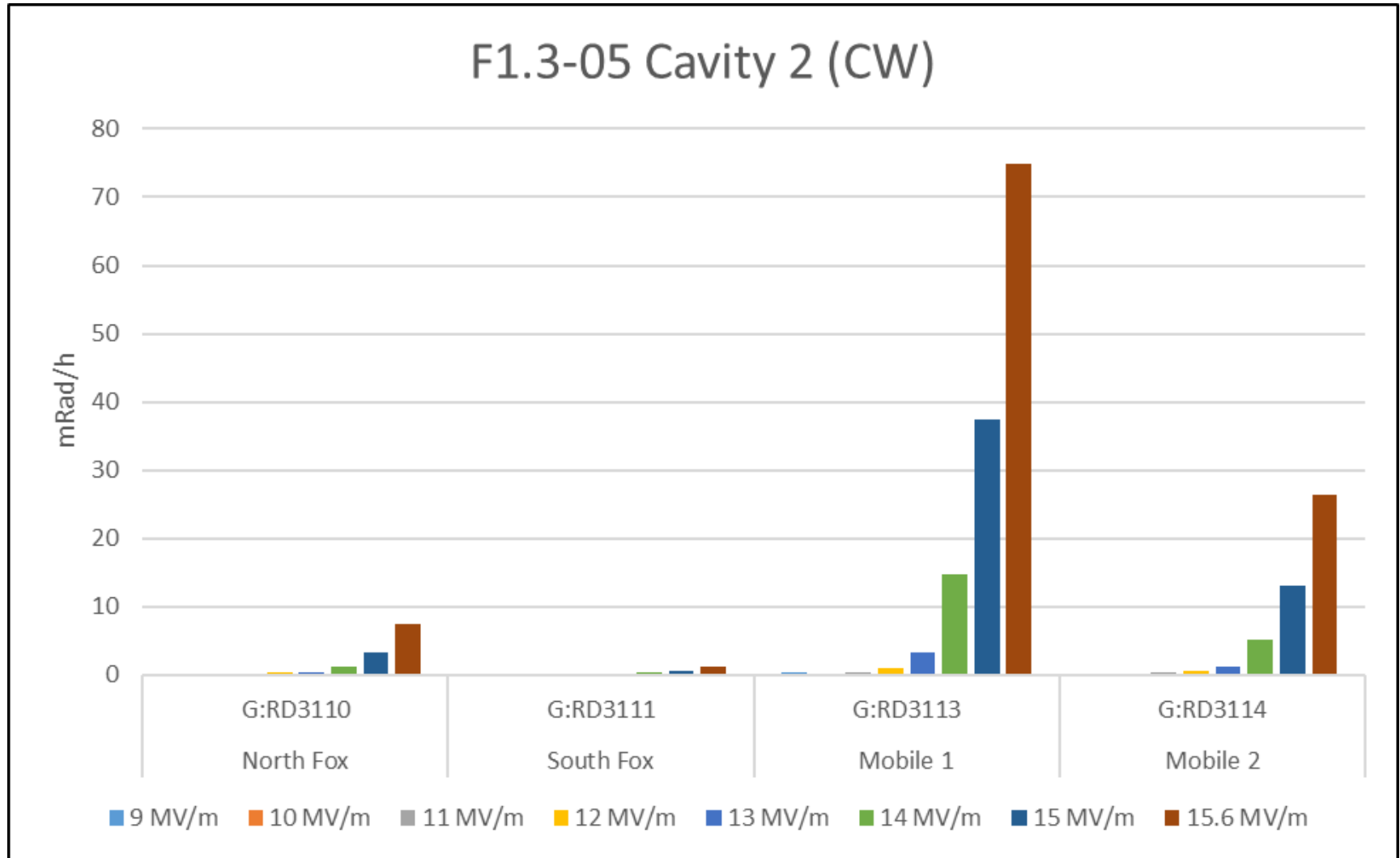
F1.3-04 Cavity 3 : FE onset and Limits



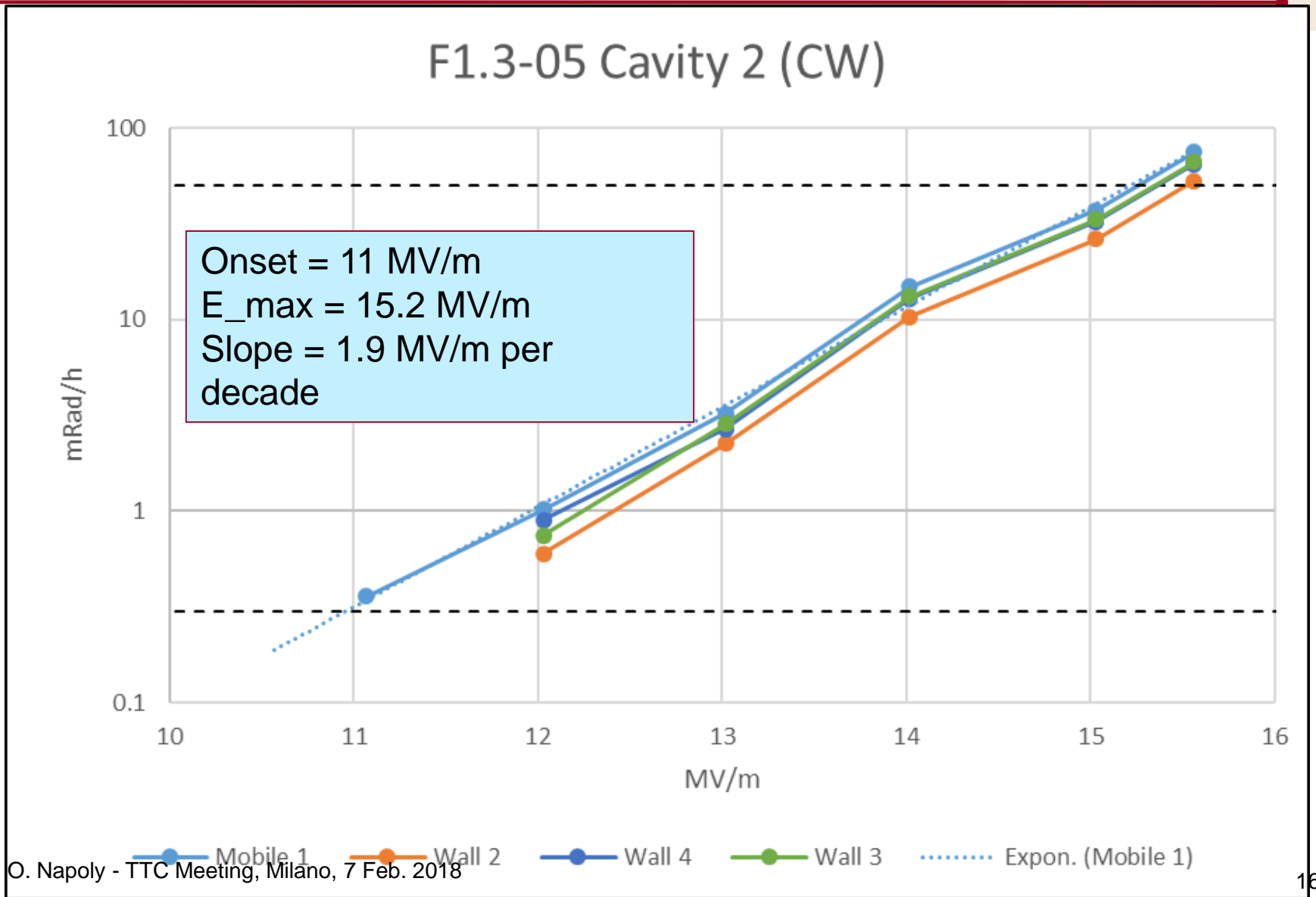
F1.3-01 Cavity 2 : Coupler-side detectors



F1.3-05 Cavity 2 : Mobile Coupler-side and US/DS detectors



F1.3-05 Cavity 2 : FE onset and Limits



CMTS Measurements at FNAL

- F1.3-02 Cavity 5 (5 May 2017) w
- F1.3-03 Cavity 4 (20 June 2017) w
- F1.3-04 Cavity 3&6 (29 Aug. 2017) s,w
- J1.3-01 Cavity 6 (2 Oct. 2017) w
- F1.3-06 Cavity 2 (31 Oct. 2017) 0
- F1.3-05 Cavity 1&2&3 (7-15 Dec. 2017) s,w,0

- Only F1.3-03 Cavity 7&8 are missing from this analysis.

- F1.3-07 is Field Emission free !

Conclusion on FE Dose Rate Limits

- 1) The 100 ratio between E-XFEL vs. LCLS-II duty cycles has an impact of 4-6 MV/m on the 'usable gradients' difference, when Field Emission is the limiting factor:
i.e. a 14 MV/m FE-limit (or onset) for LCLS-II modules corresponds to about 18-20 MV/m FE-limit (or onset) for E-XFEL modules.

- 2) Out of the 9 scrutinized cavities with field emission at FNAL/CMTS,
 - no cavity is limited by US/DS X-Ray detectors
 - 2 cavities have sizeable signals on the US/DS X-Ray detectors,
 - 5 cavities have weak signals on the US/DS X-Ray detectors,
 - the remaining 2 cavities would have been deemed 'FE free' w/o side detectors

- 3) I would like to see X-Rays detectors on the coupler opposite-side, and on top and bottom of the cryomodule.
They can only decrease the onset or maximum gradients, by how much ?