FE limits Comparison for Pulsed vs. CW Module Tests

O. Napoly

TTC Meeting, Milano

7 February 2018

SLAC NATIONAL ACCELERATOR LABORATORY
BERKELEY LAB Lawrence Berkeley National Laboratory
Argonne NATIONAL LABORATORY
CORNELL UNIVERSITY FOUNDED A.D. 1865
Fermilab
Jefferson Lab

U.S. DEPARTMENT OF ENERGY
Office of Science

Outline

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

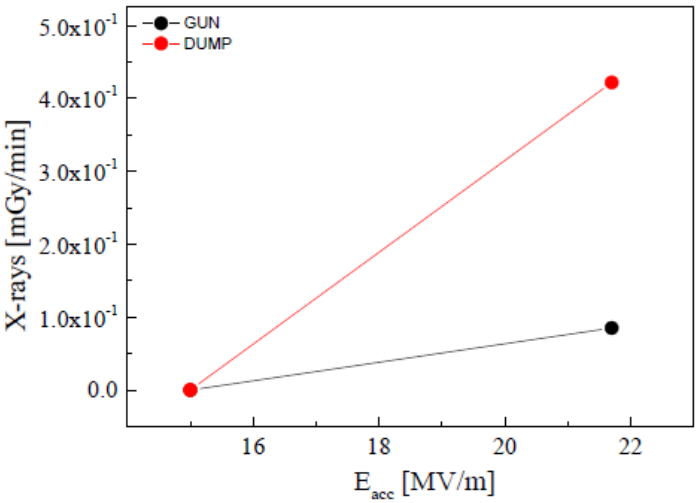
These two limits are almost identical, but is AMTF measuring the peak (during 1 ms) or the integrated (> 1s) dose rate ?

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}

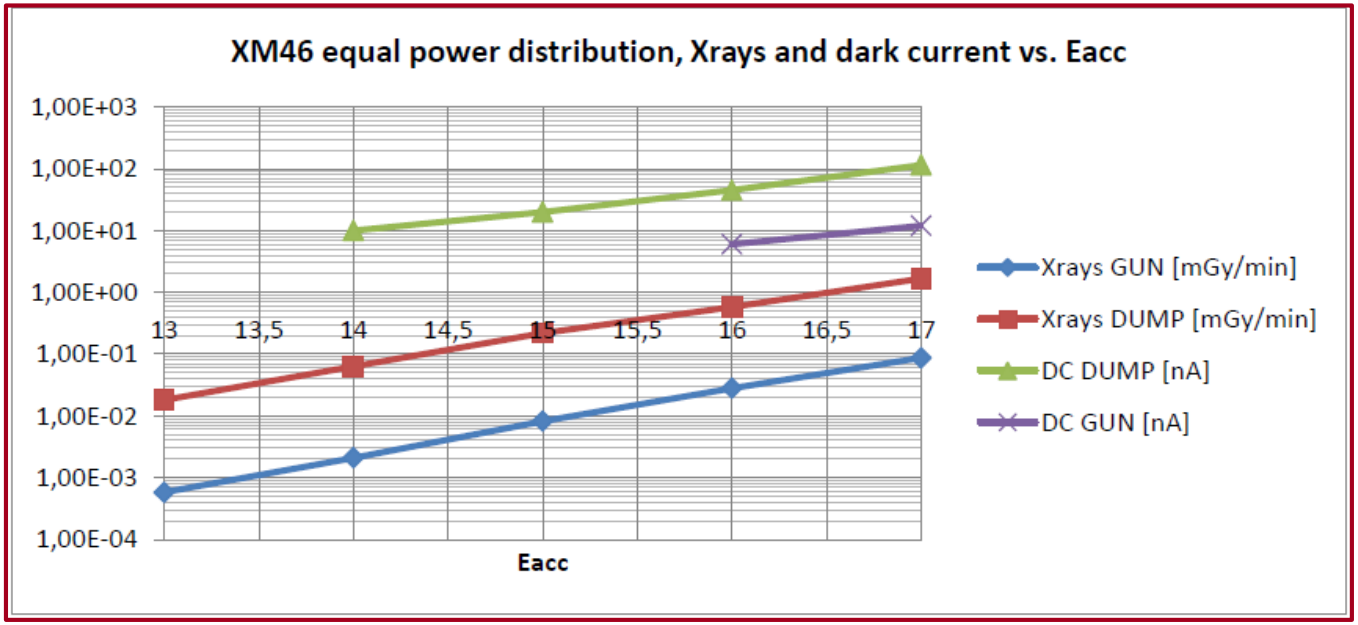
Power E_{acc} $\left[\frac{MV}{m}\right]$	Avg P_{forw} [kW]	X-rays $\left[\frac{mGy}{min}\right]$		Comment
		GUN	DUMP	
15	60.0	4.9E-5	1.59E-4	
21.7	113.9	8.51E-2	4.22E-1	



	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	

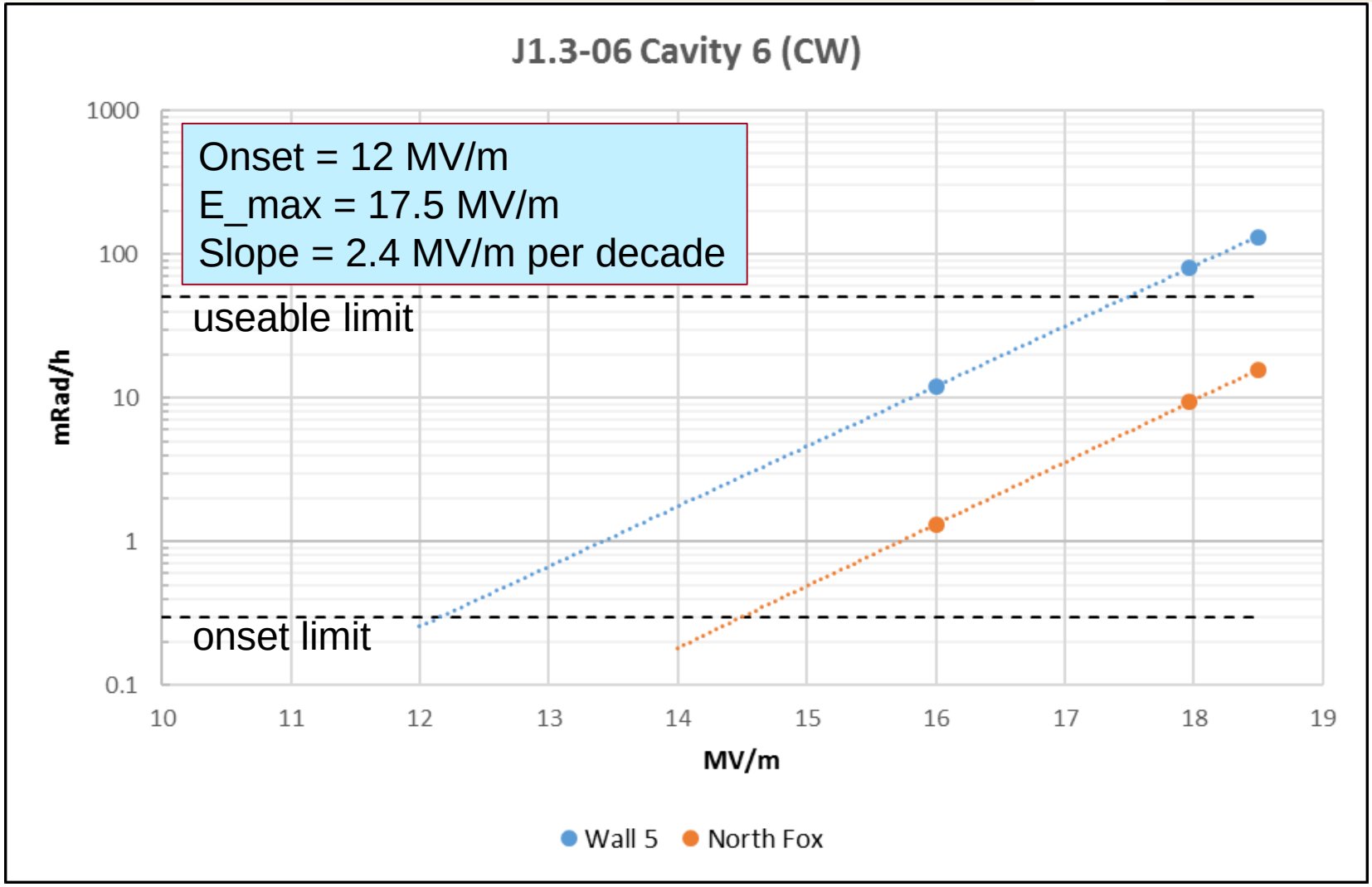
XFEL XM46 Module Test X-Rays Measurement

"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	

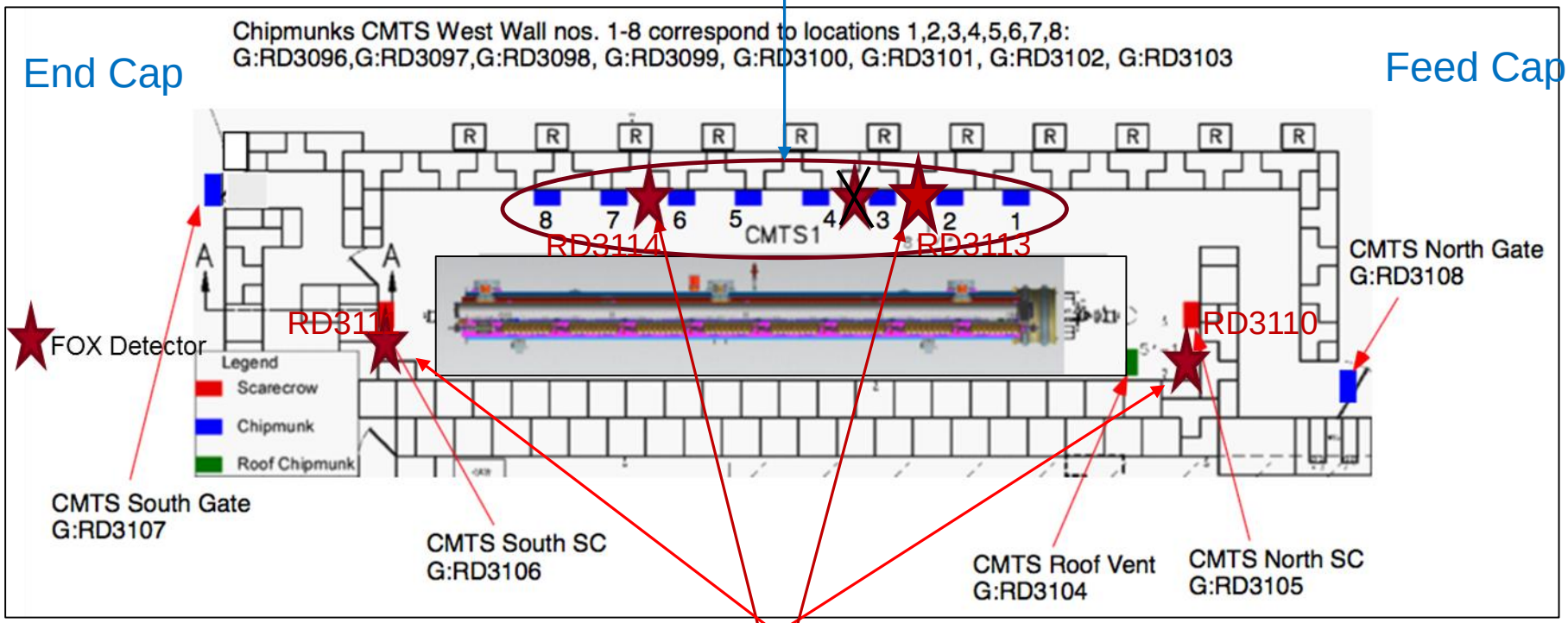
J1.3-01 Cavity 6 : FE onset and Limits



X-Ray monitor setups: CMTS@Fermilab

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

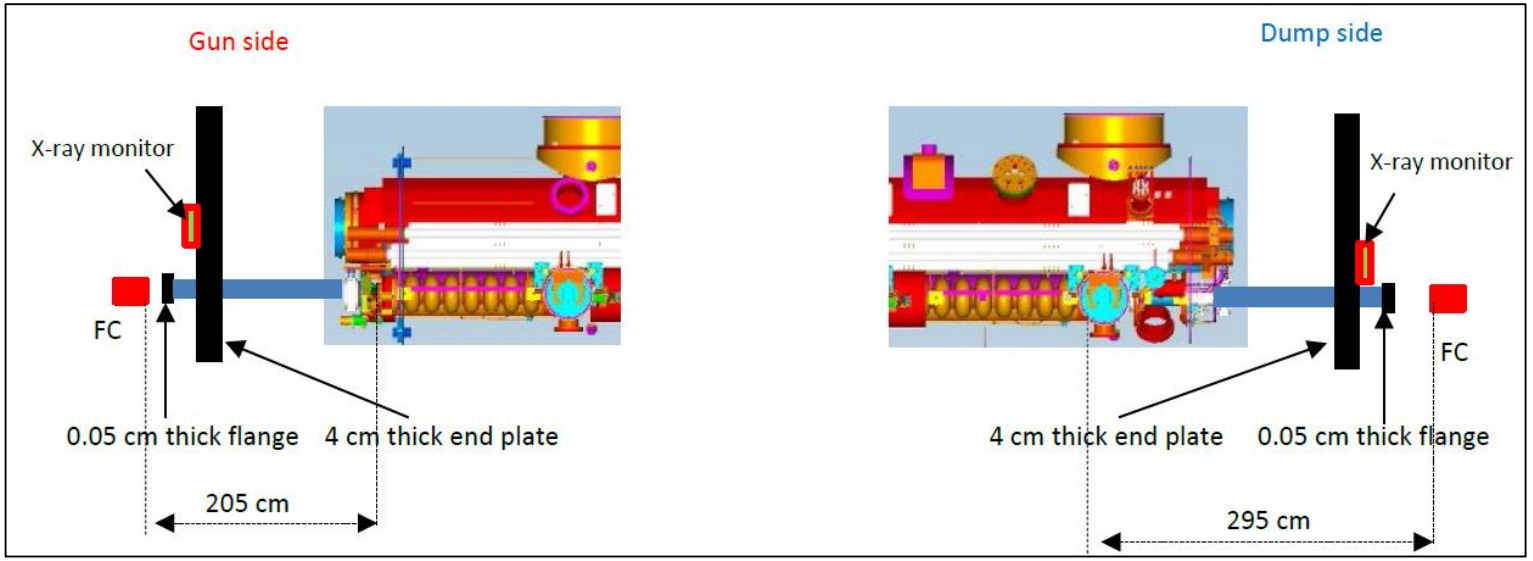
G:RD3104-3108: 5 detectors on module ends, for safety



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

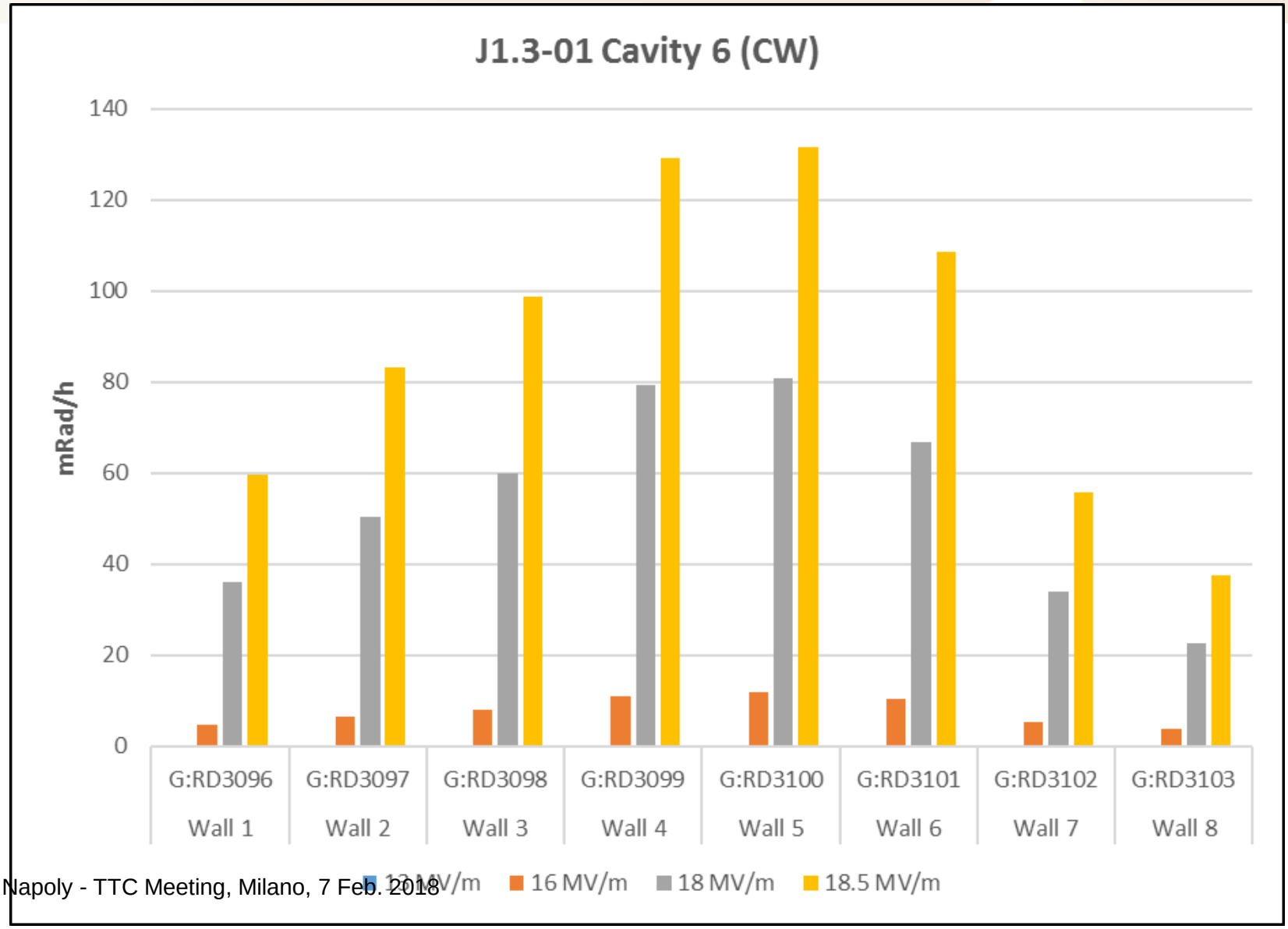
G:RD3113-3114: 2 detectors on module coupler-side, for measurement (in mrad/h)

X-Ray monitor setups: CMTB@DESY

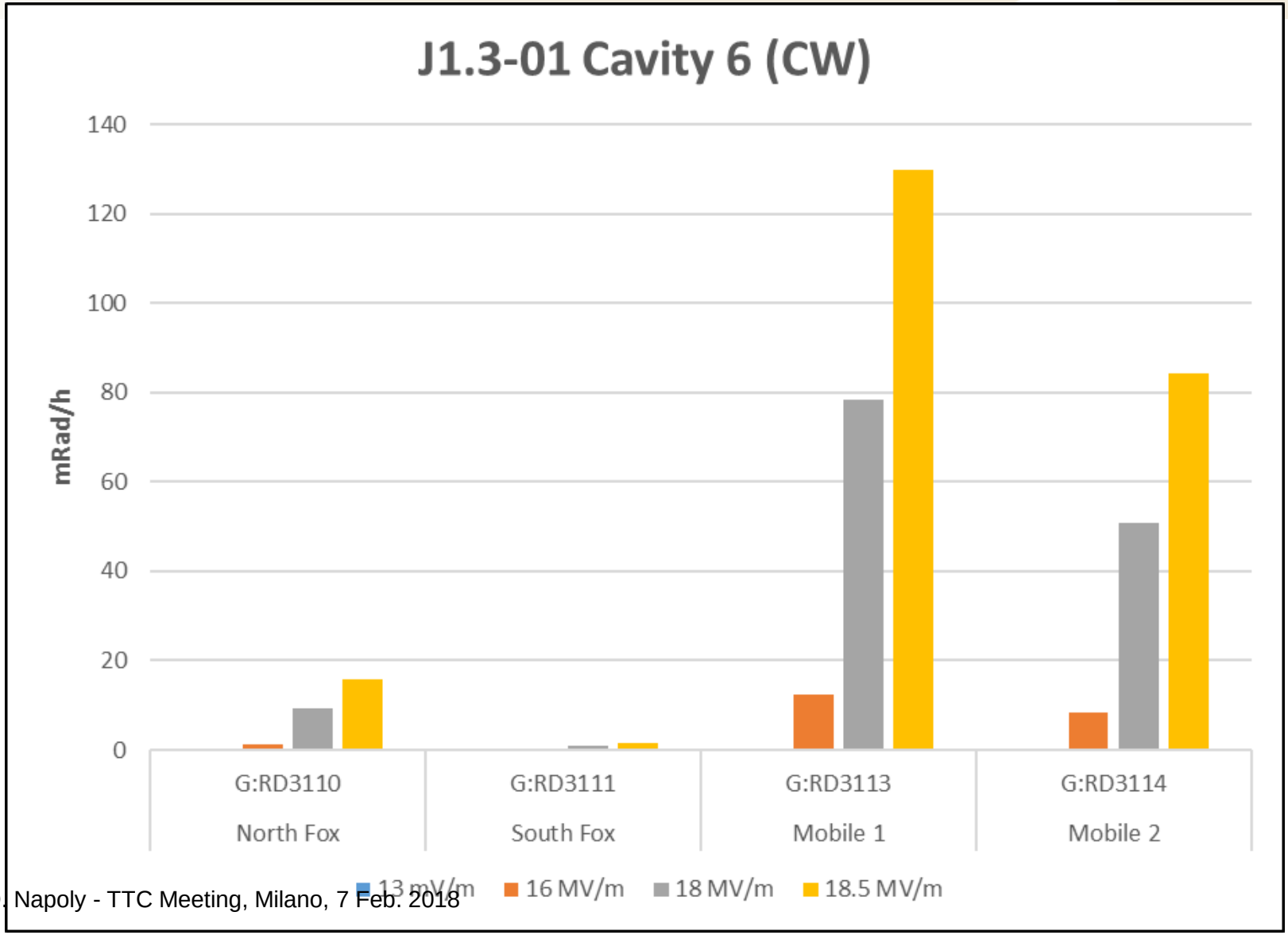


CMTB and AMTF have only two X-Ray detectors located at both ends of cryomodule: ‘GUN side’ and ‘DUMP side’.

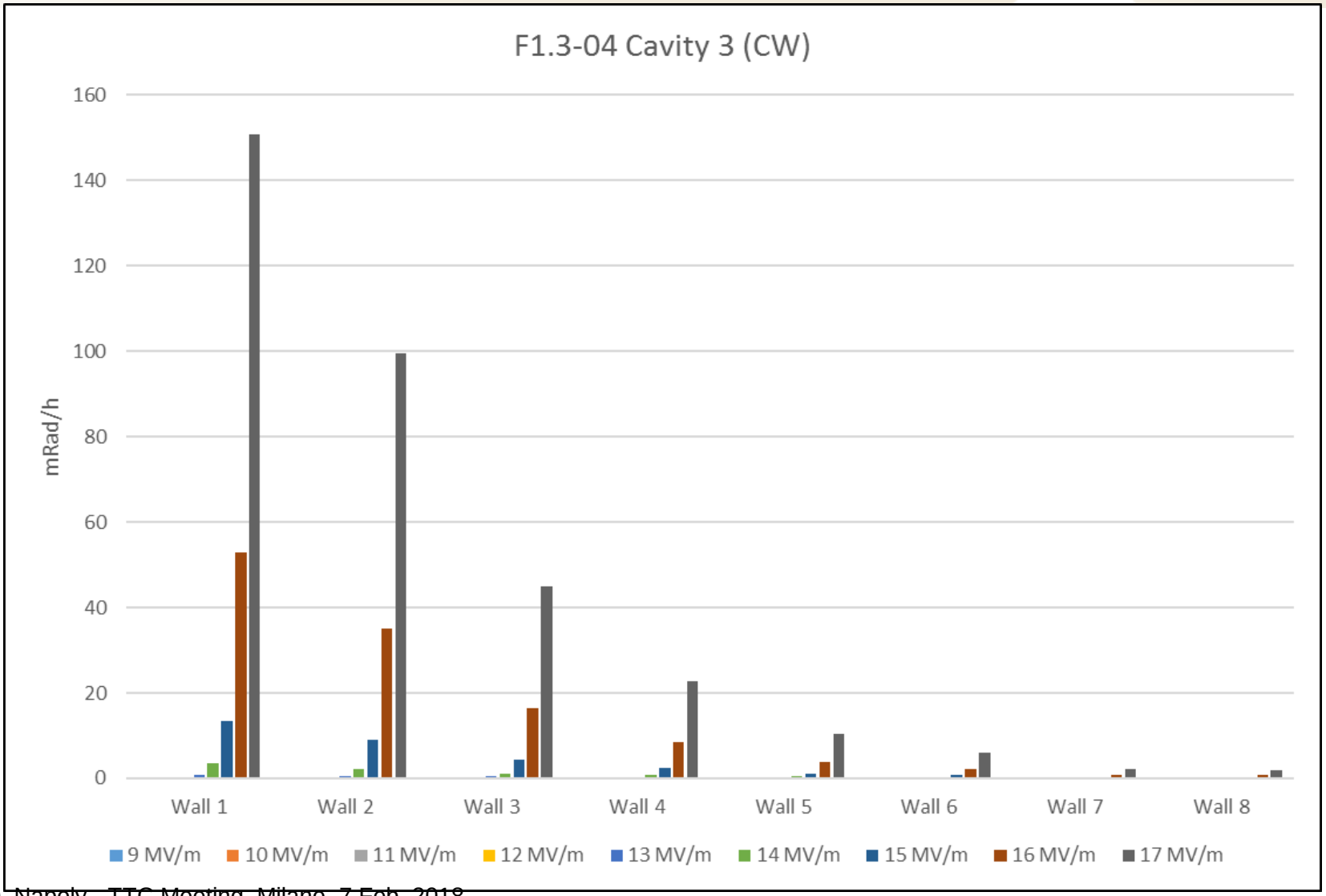
J1.3-01 Cavity 6 : Coupler-side detectors



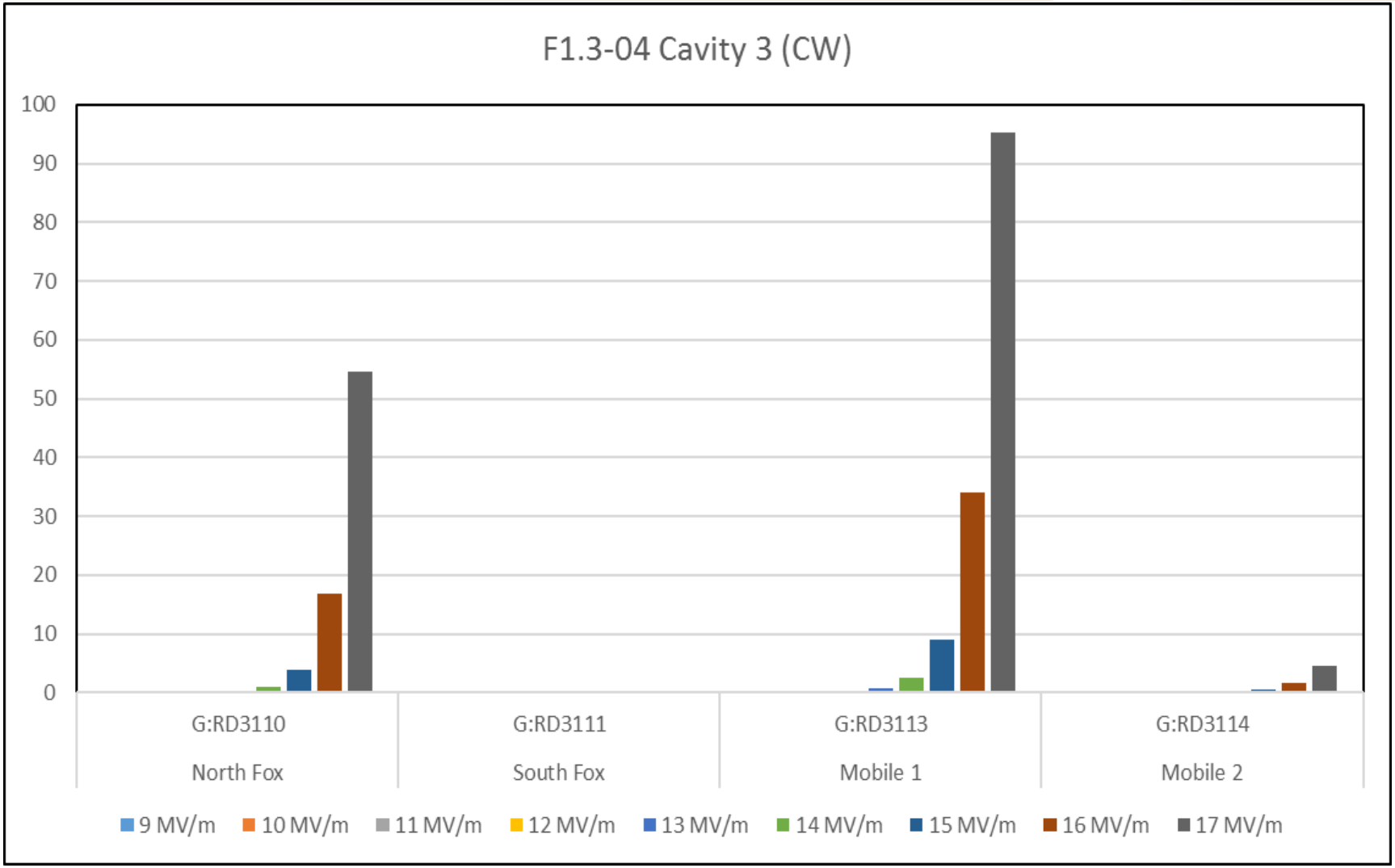
J1.3-01 Cavity 6 : Mobile Coupler-side and US/DS detectors



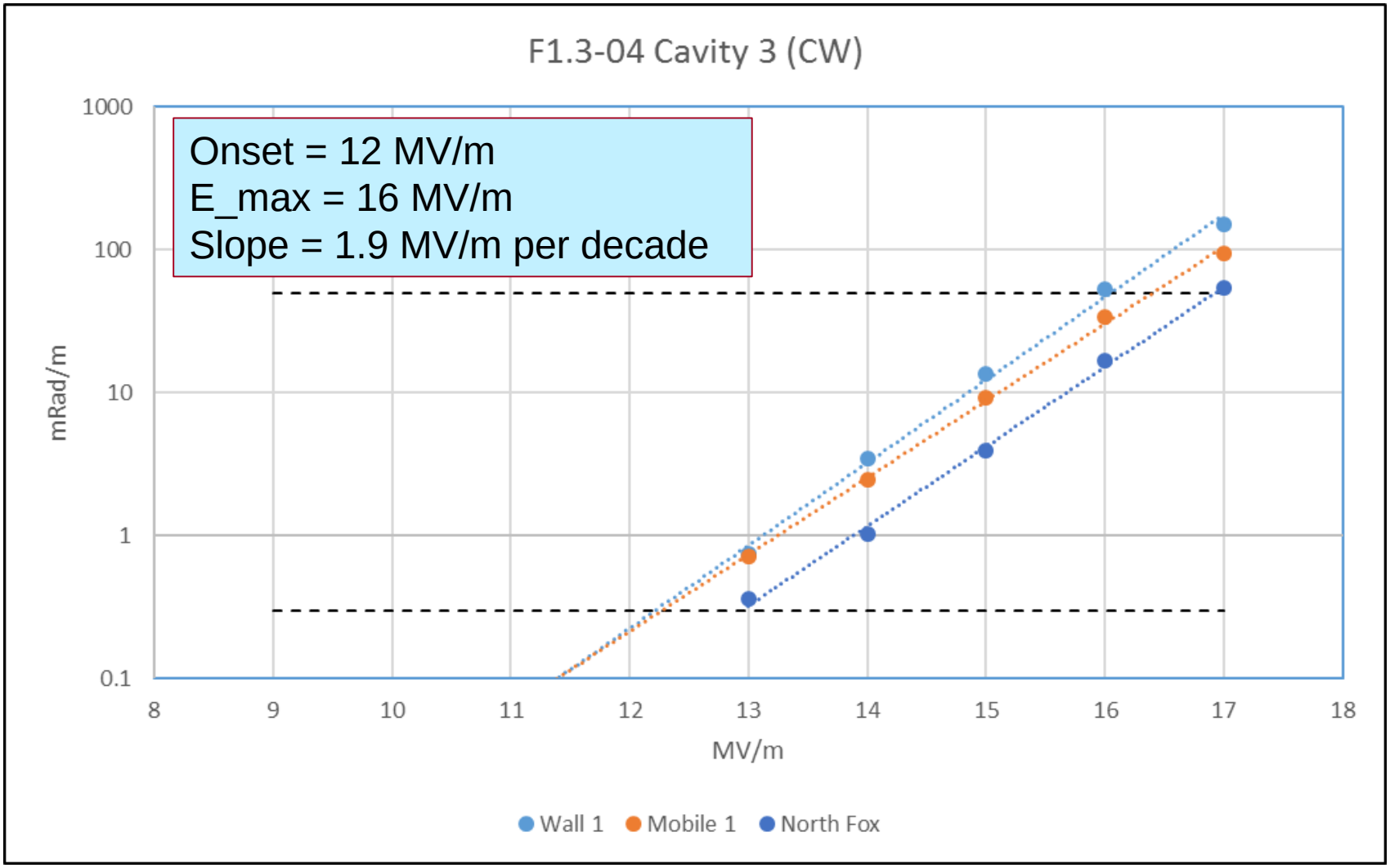
F1.3-04 Cavity 3 : Coupler-side detectors



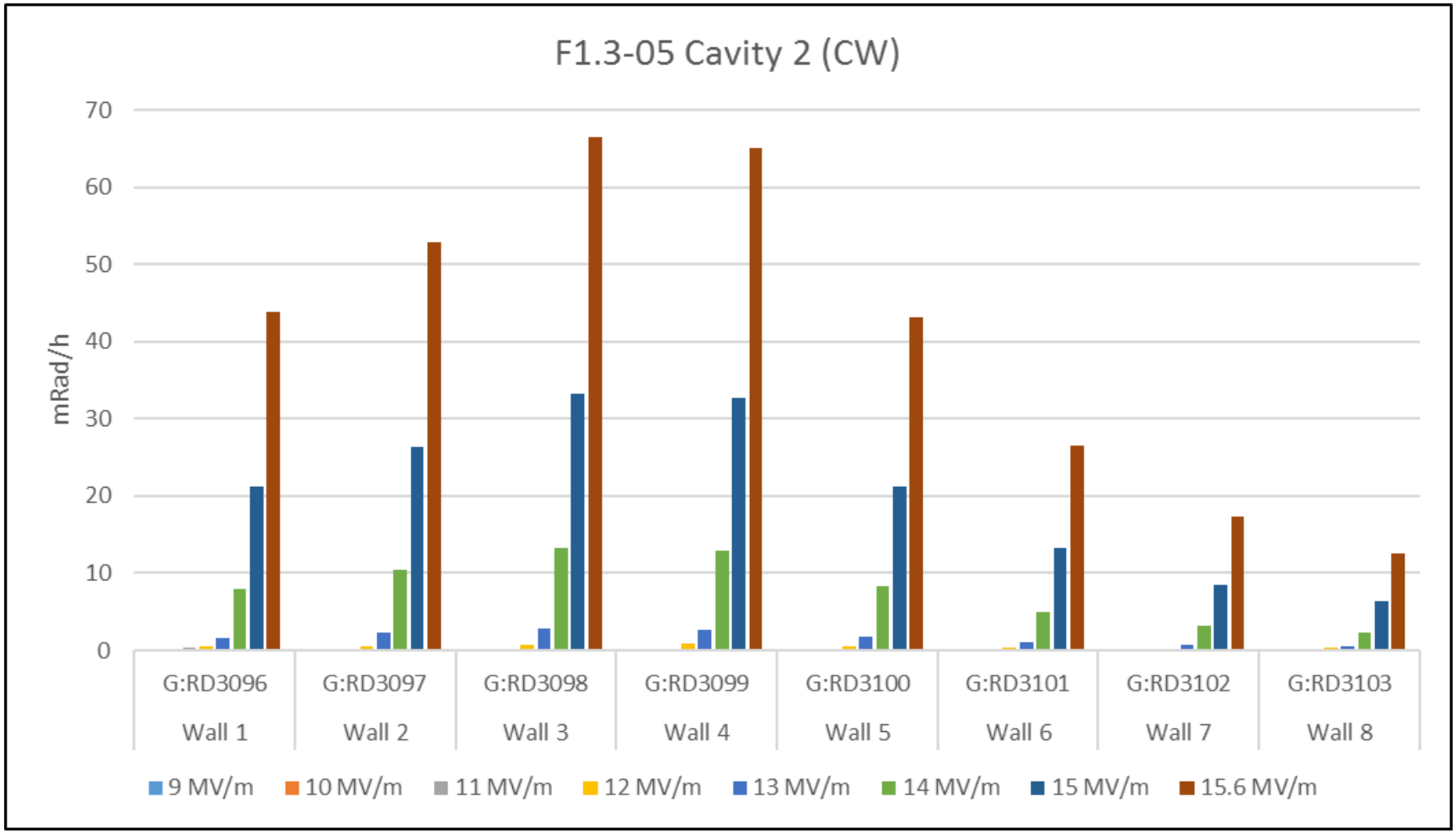
F1.3-04 Cavity 3 : Mobile Coupler-side and US/DS detectors



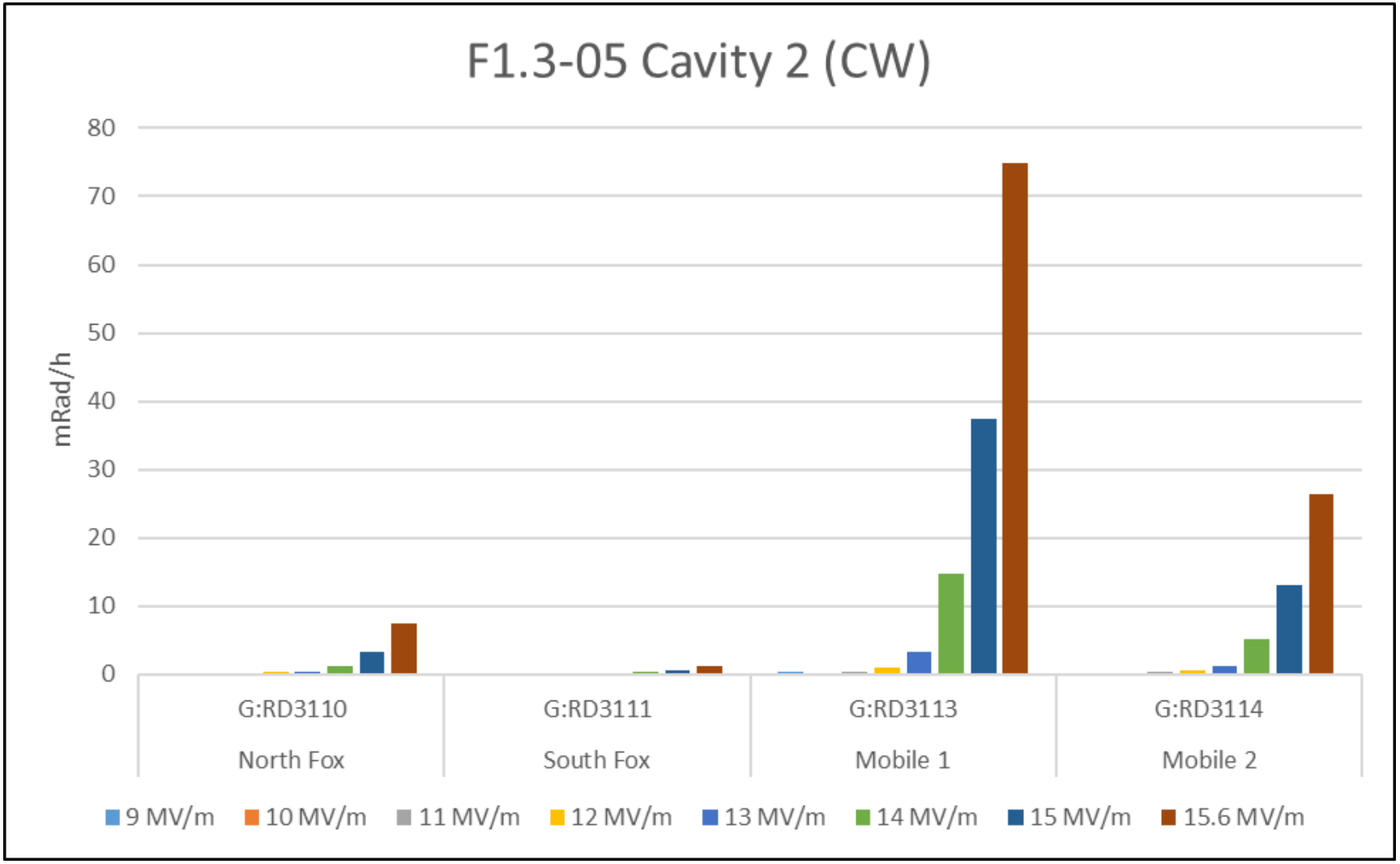
F1.3-04 Cavity 3 : FE onset and Limits



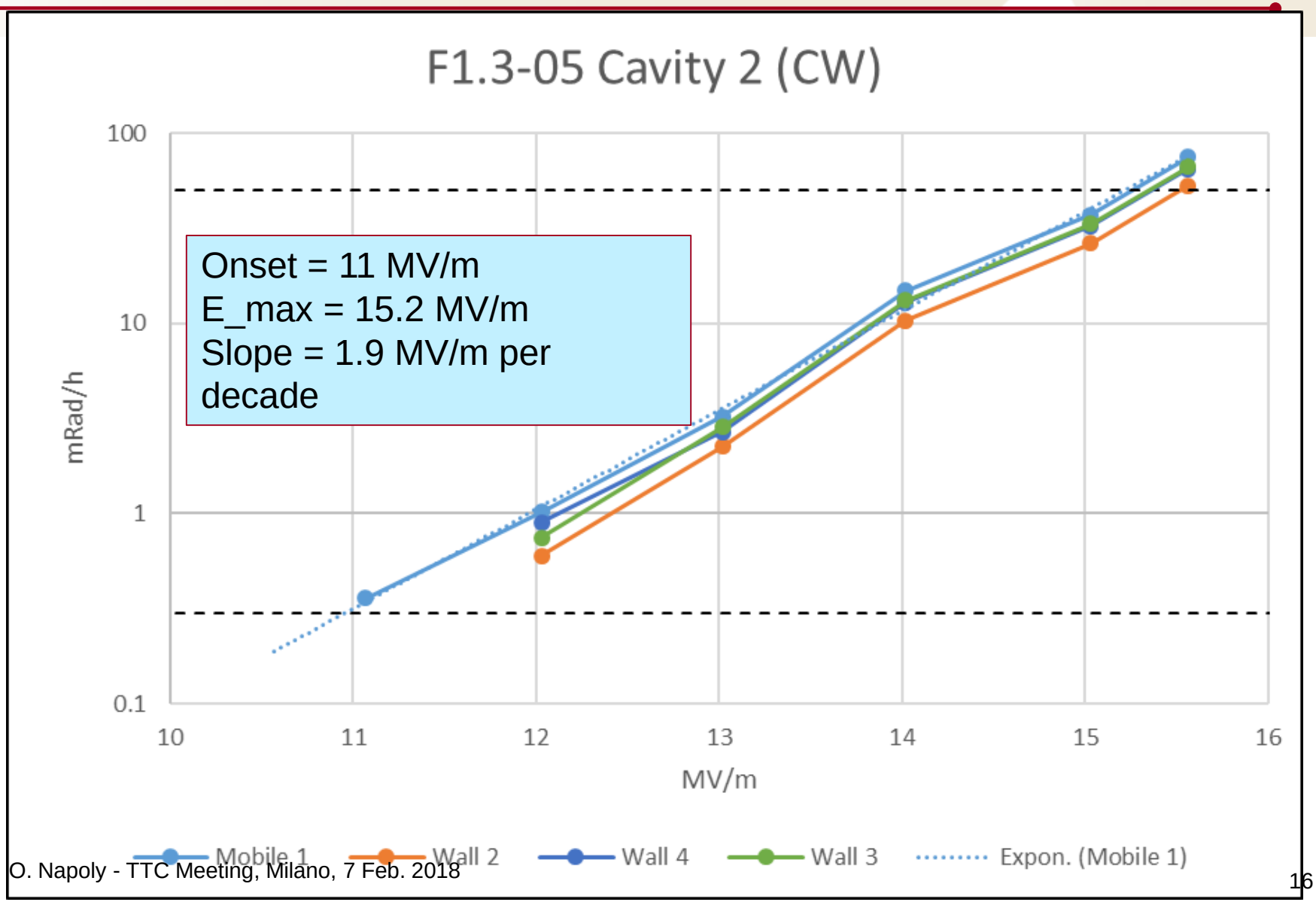
F1.3-01 Cavity 2 : Coupler-side detectors



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 ?