FMCM: Summary of changes and re-commissioning after EYETS

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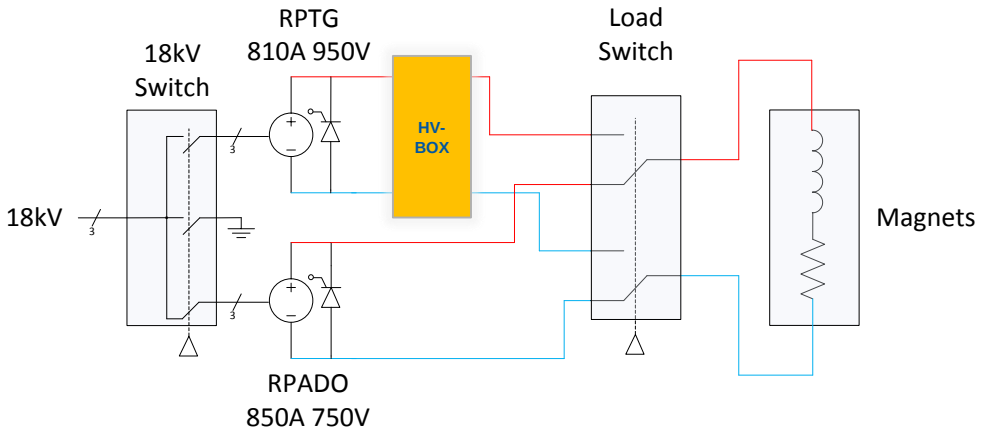
Summary of changes

- **No changes** at the level of the FMCM firmware but two HV-box interfaces (RD34.LR3/7) relocated following PC replacement + related changes on the FMCM IPOC
- RPTG power converters on **RD1.LR1/5 and RD34.LR3/7 replaced by new SATURN power converters** aiming at reducing the sensitivity of FMCMs against electrical network perturbations



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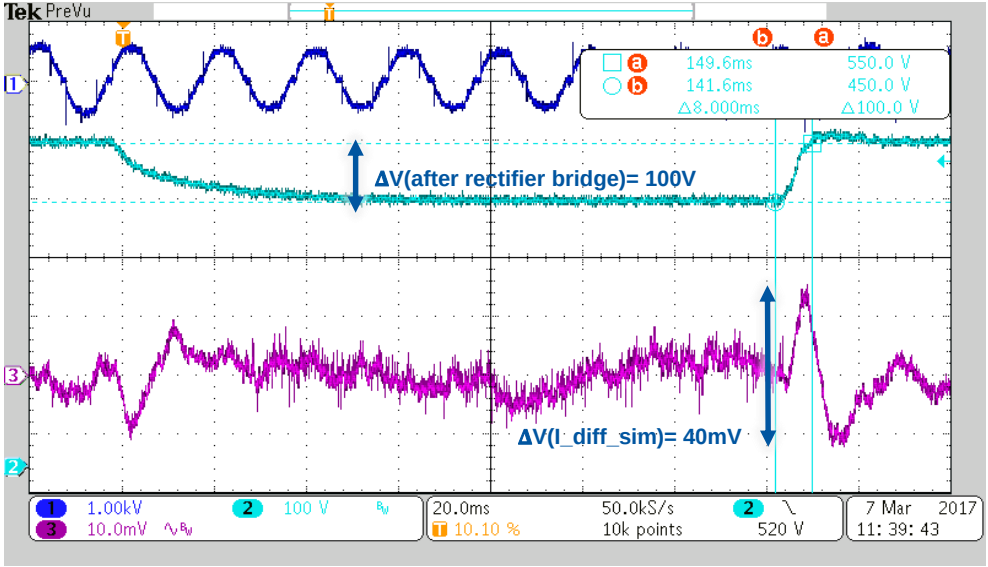
- In 2016, **22 beam dumps at stable beams provoked by electrical disturbances and followed by FMCM trips**

  (40% could have been avoided with SATURN)

SATURN testbed: Injection of electrical perturbations



- **18% voltage dip on 3** phases during 160ms
- **Test load** (L=41mH, R=0.9Ω, tau=L/R=0.045s) vs **RD1.LR5 load** (L=1.74H, R=0.79, tau=2.2s)
- **ΔV(I_diff_sim) = 40mV =>** At present, FMCM threshold on RD1 = 400mV
- https://edms.cern.ch/ui/file/1764200/1/VTG_test.mp4 (Thanks to I. Josifovic)

Re-commissioning without beam

1) Participate to the **dry-run of new PCs** (RD1.LR1/5 & RD34.LR3/7)

2) Validation of connection to **UPS electrical network**

3) For all FMCMs (12 in LHC and 14 in SPS-TLs): **Trigger, threshold validation (dI/I) and propagation to BIS**, as described on the MPS document - EDMS 896393

4	S	For each FMCM, **program a current step into the powering cycle (TL devices) or create an FGC_STATE fault on the power converter (LHC) and validate the correct triggering of the FMCM with the BIS**; optimize threshold if required with increasing beam intensity/energy (Note: The threshold is not dependent on the beam intensity/energy, but may for safety reasons be further decreased for high beam intensity).	BE/OP, TE/MPE

4) **IPOC** validation (following changes on converter controls)

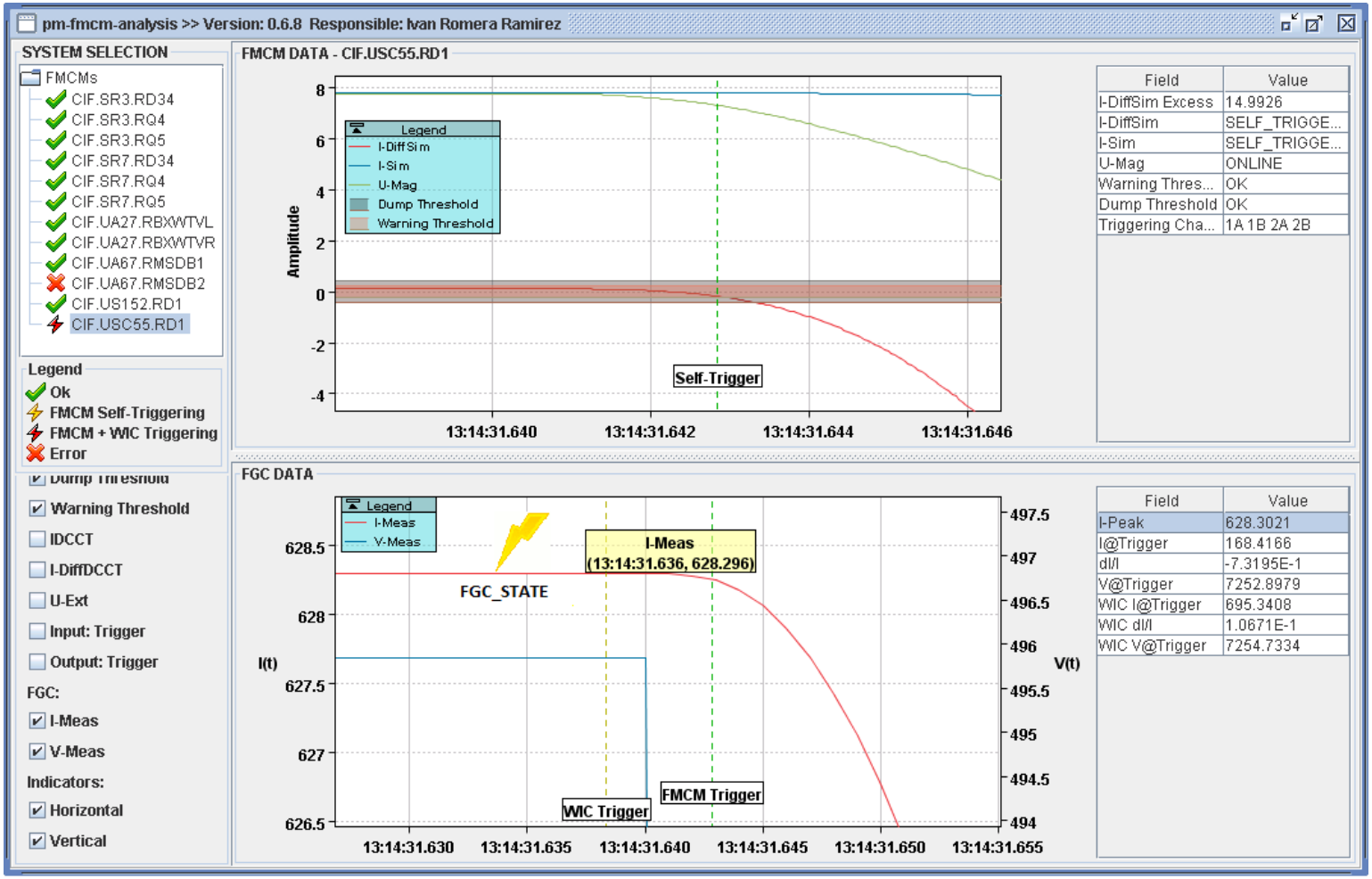
Re-commissioning with beam

1) For RD1.LR1/5 and RD34.LR3/7: **Trigger, threshold validation, propagation to BIS and verification of beam excursion and losses with pilot beams** at 450 GeV and 6.5 TeV (EOF tests)

	Rep.	Action	Group(s) Responsible
1	S	For each FMCM (or a selection in case of a short winter-stop; **), program a current step into the powering cycle (or provoke an FGC_STATE fault) and validate the correct triggering of the FMCM with the BIS** **Determine the maximum beam excursion observed in the vacuum chambers of the TL/LHC and possible beam losses before the beam was dumped**. These tests can be done as an end of fill (EOF) test.	BE/OP, TE/MPE
2 **NEW**	N	**In case of relevant changes of optics or powering configurations** potentially affecting the protection timescales and thresholds, **the abovementioned test shall be repeated with the FMCM masked in order to establish a new reference and to confirm the beam dump to happen via BLMs in IR7.** **Determine the maximum beam excursion observed in the vacuum chambers of the TL/LHC and the reaction time of the BLM system** (which ideally should trigger in IR7). These tests can be done as an end of fill (EOF) test, the interlocked BPMs in IR6 should be masked and the monitoring factor of a selected set of primary collimators in IR7 decreased in order to trigger the BLMs with the used pilot beam.	BE/OP, TE/MPE

SPARE SLIDES

FMCM trigger and BIS verification



Thresholds on LHC monitors

- FMCMs thresholds have been set for 7TeV operation (for max ΔV scenario)
- Therefore sensitivity at 6.5TeV equivalent current is higher than at injection

	2015 (6.5TeV equivalent)			2012 (4TeV equivalent)				
FMCM	Inom (A)	Itrip (A)	ΔI/I (%)	Inom (A)	Itrip (A)	ΔI/I (%)	ΔI/I (%) limit	Conformity
SR3.RD34	40.9200	40.84	0.195503421	40.93	40.83	0.24431957	0.035	OUT OF RANGE
SR3.RD34	594.0040	593.85	0.025925751	363.8013	363.7	0.02784487	0.035	IN RANGE
SR3.RQ4	518.3500	518.258	0.017748625	320.01	319.94	0.021874316	0.035	IN RANGE
SR3.RQ5	546.1710	546.07	0.018492377	320	319.93	0.021875	0.035	IN RANGE
SR7.RD34	40.9300	40.83	0.24431957	40.93	40.85	0.19545565	0.035	OUT OF RANGE
SR7.RD34	594.0010	593.82	0.030471329	363.84	363.75	0.024736148	0.035	IN RANGE
SR7.RQ4	550.4800	550.415	0.011807877	337	336.95	0.014836795	0.035	IN RANGE
SR7.RQ5	560.5660	560.5	0.011773814	343	342.95	0.014577259	0.035	IN RANGE
UA23.RBXWTVL	574.4280	574.32	0.018801312	577.049	576.92	0.022355121	0.035	IN RANGE
UA23.RBXWTVR	503.0220	502.93	0.018289459	503.024	502.92	0.020674958	0.035	IN RANGE
UA67.RMSD1	753.7700	753.64	0.01724664	463	462.9	0.021598272	0.035	IN RANGE
UA67.RMSD2	753.7700	753.65	0.015919976	463	462.89	0.023758099	0.035	IN RANGE
RD1.LR1	628.558	628.525	0.005250112	383	382.96	0.010443864	0.035	IN RANGE
RD1.LR5	628.2970	628.25	0.007480539	383	382.962	0.009921671	0.035	IN RANGE

Thresholds on SPS TL monitors

	2015 (6.5TeV equivalent)			2012 (4TeV equivalent)				
FMCM	**Inom (A)**	**Itrip (A)**	**ΔI/I (%)**	**Inom (A)**	**Itrip (A)**	**ΔI/I (%)**	**ΔI/I (%) limit**	**Conformity**
RBI.410147	CNGS not used			3968.1	3967.45	0.016380636	0.1	IN RANGE
RBI.410010	CNGS not used			840.3748	840.3412	0.003998216	0.1	IN RANGE
RBIH.400309	984.27	984.0767	0.01963892	674.0723	673.9502	0.018113784	0.1	IN RANGE
RBIH.400107	768.297	768.3029	-0.000767932	5275.9094	5275.0855	0.015616265	0.5	IN RANGE
RBI.81607	5274.8794	5274.3853	0.009367039	20271.9727	20256.5918	0.075872734	0.1	IN RANGE
MSE6183M	18598.6406	18589.416	0.049598249	5673.2941	5664.8254	0.149273065	0.5	IN RANGE
MST6177M	5673.6948	5669.5747	0.072617582	3743.1152	3742.5781	0.014349011	0.5	IN RANGE
RBIH.20150	3743.3701	3742.2759	0.029230345	3087.8418	3087.0361	0.026092658	0.3	IN RANGE
MSE4183M	21572.5703	21560.8516	0.054322224	20079.3457	20061.7676	0.087543191	0.2	IN RANGE
MBB.6608M	HiradMat not tested yet						0.1	
MBS.6600M	HiradMat not tested yet						0.1	
RBI.22134	5164.9614	5164.4668	0.009576064	5165.332	5165.0024	0.006381003	0.3	IN RANGE
RBIH.29314	724.0219	723.9609	0.00842516	724.2516	724.0906	0.022229844	0.3	IN RANGE
RMSI.L2B1	945.538	945.5346	0.000353238	945.5566	945.4556	0.010681539	0.35	IN RANGE
RBIH.87833	895.2255	895.1645	0.006813926	893.8599	893.8293	0.003423355	0.1	IN RANGE
RMSI.R8B2	947.889	947.84161	0.004999531	947.987	947.81065	0.018602576	0.1	IN RANGE