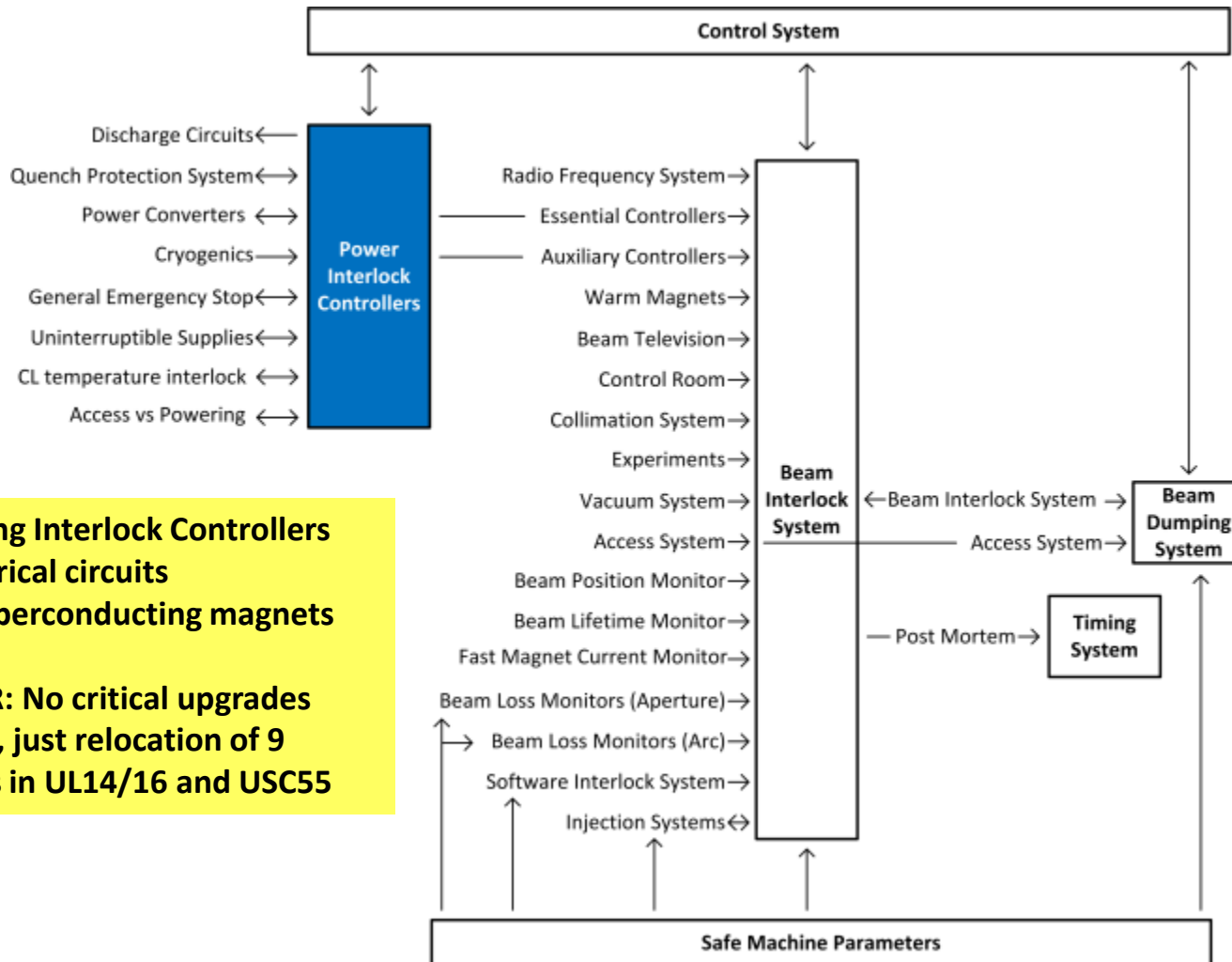# MPP Workshop
Status of Powering Interlocks

I. Romera on behalf of MPE-MS

MPS – Powering interlocks

- **37 Powering Interlock Controllers**
- **1600 electrical circuits**
- **~10000 superconducting magnets**

- **REMINDER: No critical upgrades during LS1, just relocation of 9 controllers in UL14/16 and USC55**

# Commissioning status of magnet interlocks

- **Powering test campaign**
  - 5000 interlock tests executed during the Powering Tests to commission the SC circuits
  - Clients involved in the test: QPS, PC, CRYO, UPS, AUG and LASS
  - Most of the commissioning steps integrated in ACC_TESTING and validated using automated analysis tools in PMEA framework

- **MPS commissioning during machine checkout phase**
  - Commissioning steps described on the MPS procedure (EDMS 896390)
  - Verification that faults on the powering system are propagated to the BIS
  - Validation that each individual circuit can trigger a beam dump request to the BIS (through automated sequence to verify correct configuration, redundancy and timing delays)
  - All 32 BIS user interface boxes (CIBUs) have been electrically tested (in situ with BIS team)

- **Powering interlock controllers reconfigured for RUN2 requirements**
  - ESSENTIAL-UNMASKABLE: RB, RQD, RQF, RQX, RD1-4, RQ4-RQ10
  - AUXILIARY-MASKABLE: RCS, RQT%, RSD%, RSF%, **RQSX3, ROD, ROF**, RCBXH/V and RCB%
 - NONE-NO_IMPACT: RCD, RCO, RQS%, RSS

Non-conformities on electrical circuits

- **Circuits superlocked and removed from the PIC configuration:**
  - **RCOSX3.L2**: Open circuit (EDMS 1203477)
  - **RCOX3.L2**: Open circuit (EDMS 1203478)
  - **RCSSX3.L3**: Open circuit (EDMS 1203479)
  - **RCOSX3.L1**: Open circuit (EDMS 948545)
  - **RSS.A34B1**: Short to ground in DSLC (LHC-MP3-EN-0005)

- **Circuits repaired during LS1 and put back as AUXILIARY/MASKABLE:**
  - **RCBCHS5.L8B1**

- **Circuits repaired but still having no impact...**
  - **RCO.A12B2**
  - **RCO.A81B2**
  - **RQS.R3B1**

- **Faulty quench heaters => RQ4.R2 and RQ4.L8 are operating with 7 out of 8 heaters**

Powering-related interlocks via software (1/2)

- **Redundant opening of the 13kA EE switches through SIS**
  - Implementation to request the opening of the 13kA EE switches via software to increase the reliability of the EE system
  - Exploits the existing interlock signals on PIC to monitor the status of the Quench Interlock Loop and force the opening of the EE switches
  - ECR which describes the motivation and details of the implementation (EDMS 1460332)
  - Implementation ready and to be commissioned during TS1

Quench interlock loop – Main dipole circuits

Powering-related interlocks via software (2/2)

- **QPS checks before beam injection through SIS**
  - Mechanism to verify the healthy state of the QPS systems before beam injection
  - Observed during operation that QPS_OK signals can toggle and inhibit injection
  - Temporary solution was to mask the interlock on the SIS
  - QPS experts are investigating the problem and a possible solution
- **Quench heater power supply monitoring through LHC Circuit SCADA (WinCC)**
  - Monitors the status of the quench heater power supplies and removes the QPS_OK in case of circuit protection risk
  - Automatic mail notification warning about degraded situation does not work anymore
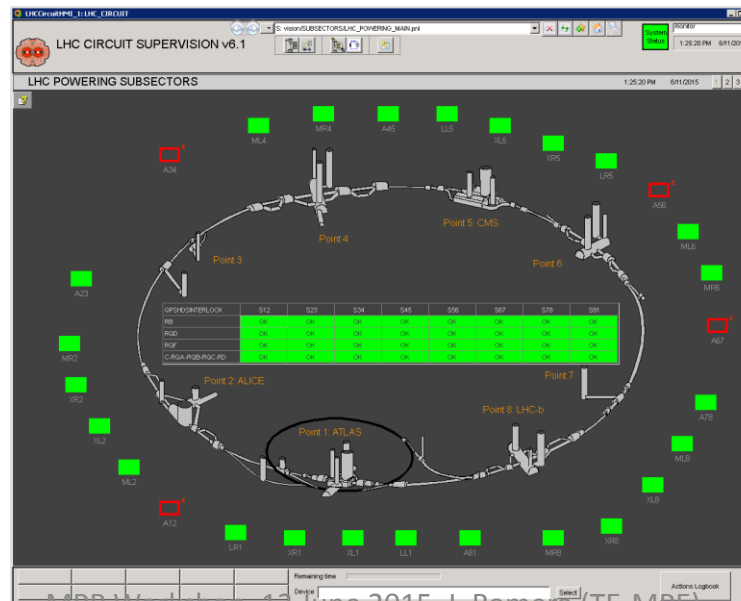
MPS – Fast Magnet Current Change Monitors
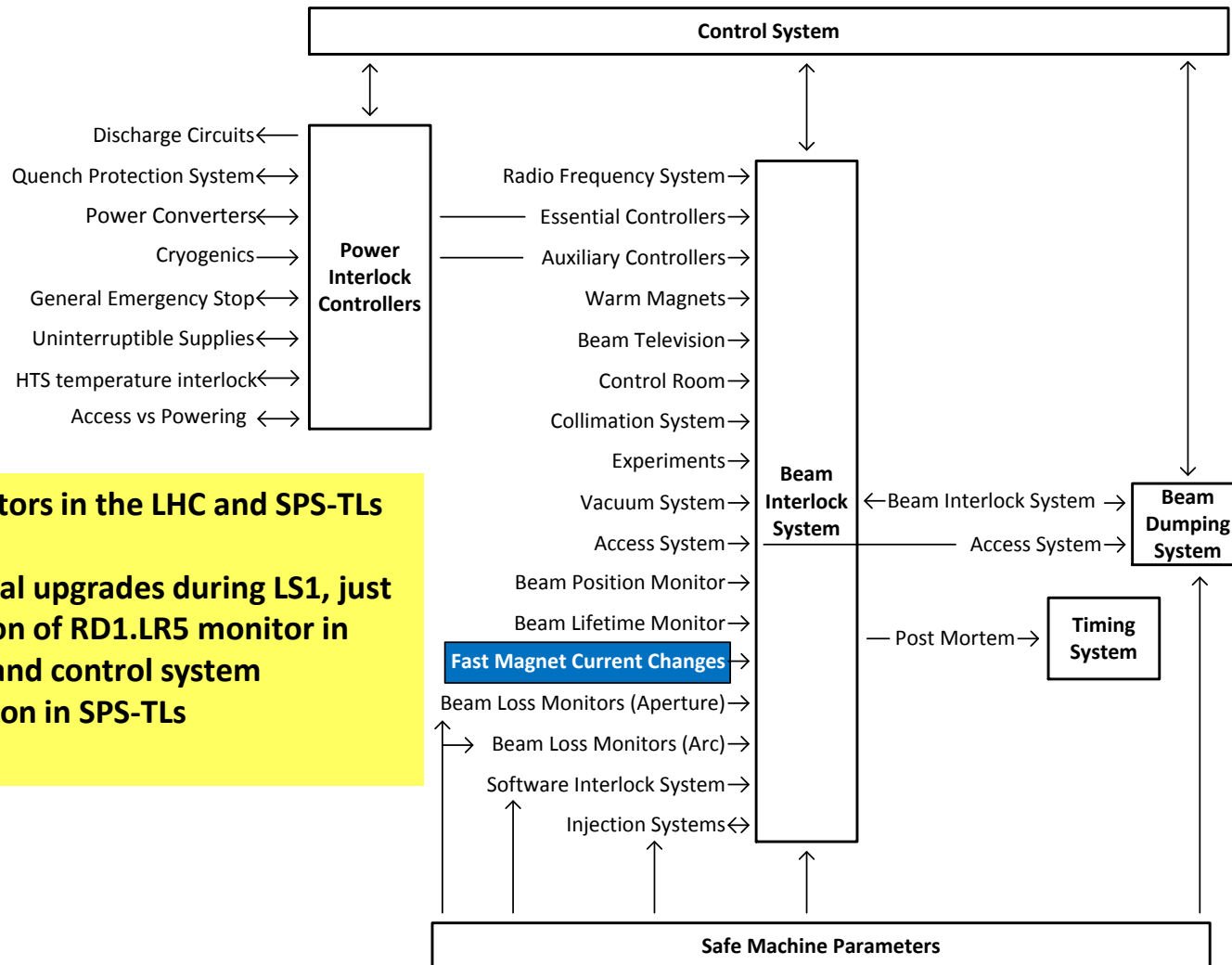
- **26 monitors in the LHC and SPS-TLs**

- **No critical upgrades during LS1, just relocation of RD1.LR5 monitor in point 5 and control system renovation in SPS-TLs**

FMCM commissioning (1/2)

- **Commissioning steps described on the MPS procedure (EDMS 896393)**
  - All 26 user interface boxes (CIBUs) have been electrically tested (with BIS team)
  - Validation of dump thresholds at nominal current with no beam
  - Commissioning steps integrated in ACC_TEST for status tracking

FMCM	2015 (6.5TeV equivalent)			2012 (4TeV equivalent)			ΔI/I (%) limit	Conformity
	Inom (A)	Itrip (A)	ΔI/I (%)	Inom (A)	Itrip (A)	ΔI/I (%)		
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

- FMCMs thresholds have been set for 7TeV operation (for max ΔV scenario)
- Therefore sensitivity at 6.5TeV equivalent current is higher than at 4TeV

FMCM commissioning (2/2)

- **Verification of orbit deviations and beam losses (at injection and flat-top) with pilot beams**
  - All FMCMs have been commissioned at injection (no need to precycle the magnets)
  - Most critical circuits (RD1s and RD34s) tested as well at flat-top as EOF test
  - Test consists in verifying the trajectory evolution after switching OFF the PC
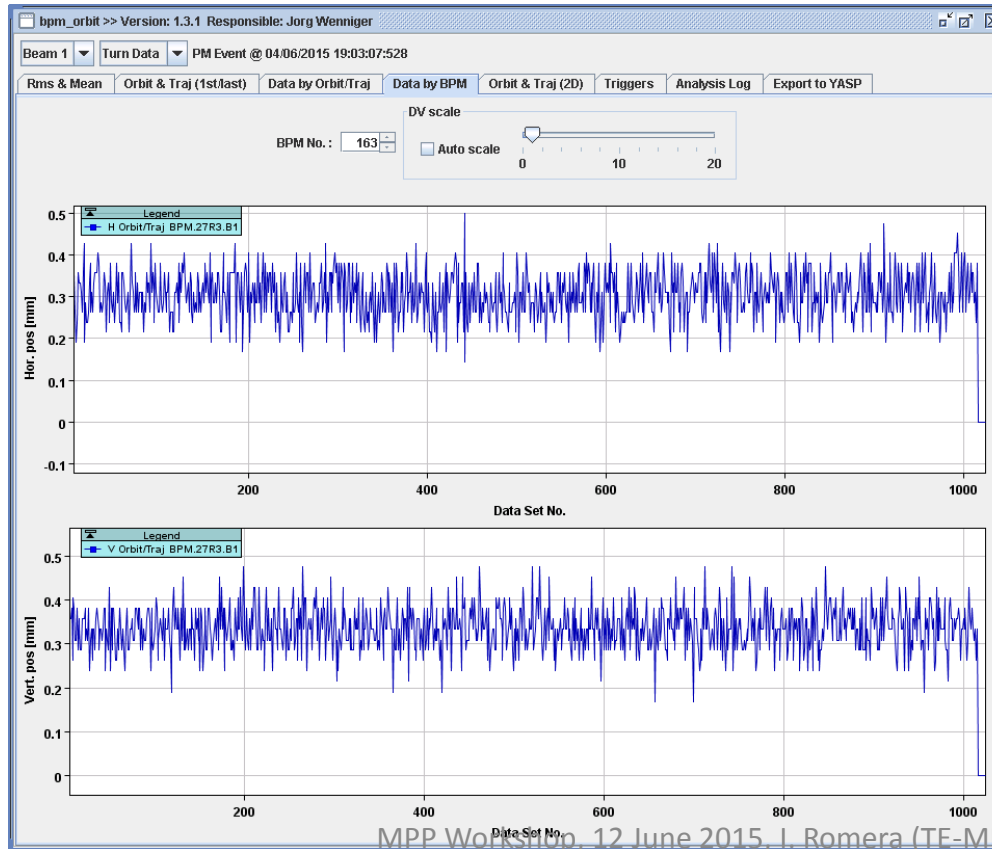
Test on RD34.LR3 @ 04.06.2015
- Trajectory over 1024 turns at the same BPM with no visible changes on the beam orbit

Access Powering Interlocks

- Interlock that allows for short access with magnets powered at low current
- During LS1 a **new PLC-based system** has been installed in the CCR aiming to increase the dependability of the **interface between the LASS and SIS**
- System deployed and **fully operational since May 2014**
- **New Kontron computer** installed in the CCR and **FESA class to be deployed in TS1**
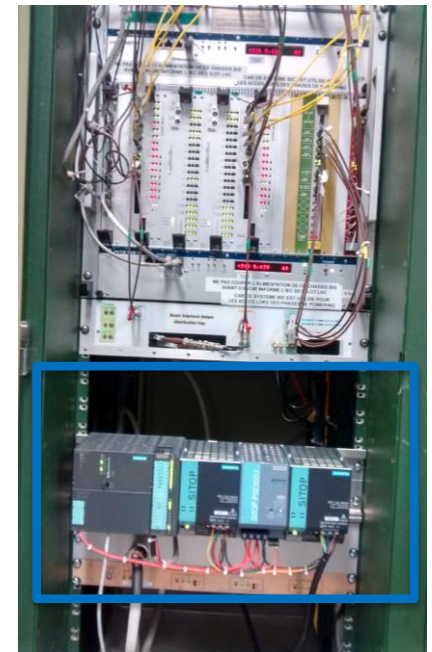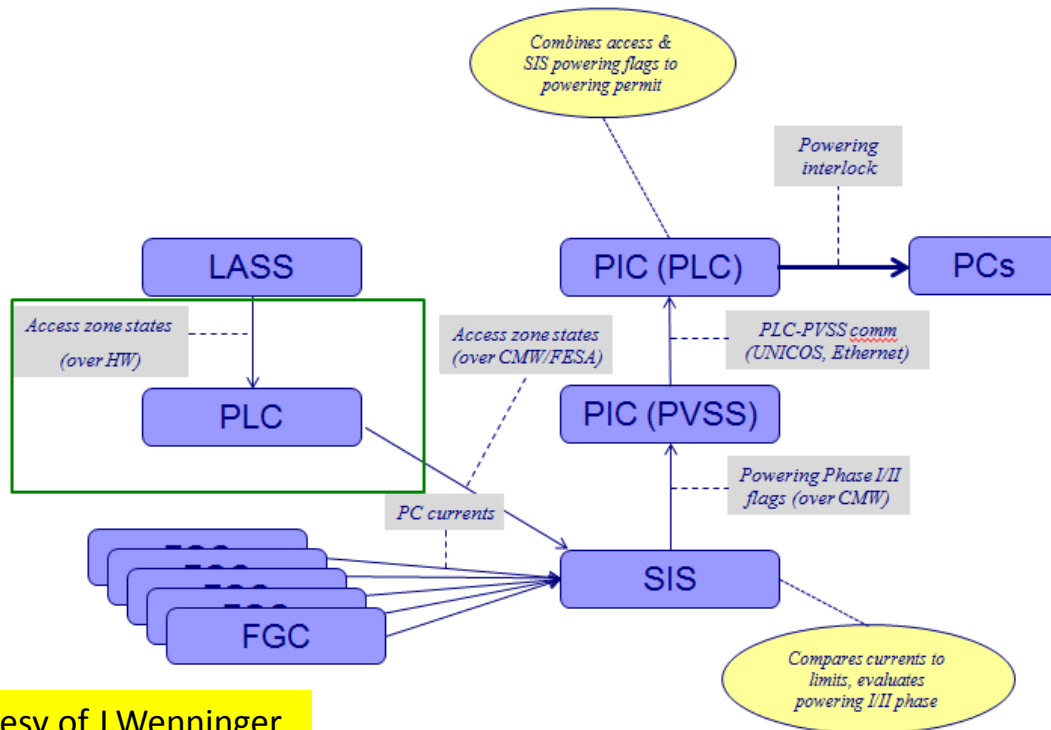
Courtesy of J.Wenninger

Validation of UPS distribution network

- **Test campaign to validate the redundant UPS power distribution network** for the LHC equipment systems (joint effort between EN-EL and TE-MPE)

- Tests carried out during the Powering Tests in all 8 LHC sectors including tunnel and service areas

- Important **non-conformities on Machine Protection Systems**
  - **QPS**: Some quench heater power supplies on same UPS (FIXED)
  - **LBDS**: LBDS2 Re-trigger crates connected to the same UPS (FIXED)
  - **BPMs**: Some BPM racks powered by normal network (PENDING)
  - .....

- Full **report available** on EDMS 1505860

- Some **tests already organised during TS1** to validate conformity of powering (e.g. LBDS1)

Summary

- **MPS commissioning** on powering interlocks **successfully completed**

- Experience during **first weeks of operation was very positive** and magnet interlock systems were successfully running with **no major problems**

- **Interventions/tests scheduled during TS1:**
  - Test of redundant opening of the 13kA EE switches through the SIS
  - Deployment of new FMCM FESA class to solve an issue with timestamping of PM buffers
  - Deployment of FESA class on a dedicated machine for the Access Powering Interlocks

- With regard to the UPS tests => **It is highly recommended to follow the recommendations written in the test report** and we urge equipment owners to follow with EN-EL the non-conformities related to powering

THANKS FOR YOUR ATTENTION!

FMCM thresholds on SPS-TLs

FMCM	2015 (6.5TeV equivalent)			2012 (4TeV equivalent)			ΔI/I (%) limit	Conformity
	Inom (A)	Itrip (A)	ΔI/I (%)	Inom (A)	Itrip (A)	ΔI/I (%)		
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	3641.702	3641.165	0.014745852				0.1	IN RANGE
MBS.6600M	3188.5161	3188.784	-0.008402028				0.1	IN RANGE
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