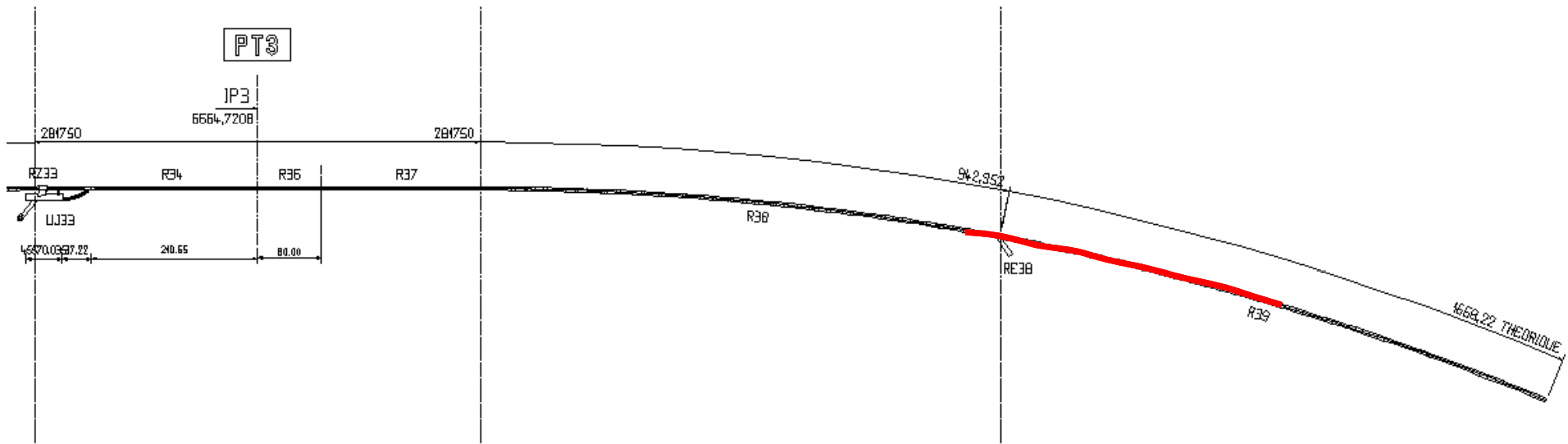


Update on Sector 34

R.Saban
LEMIC - October 28th 2008





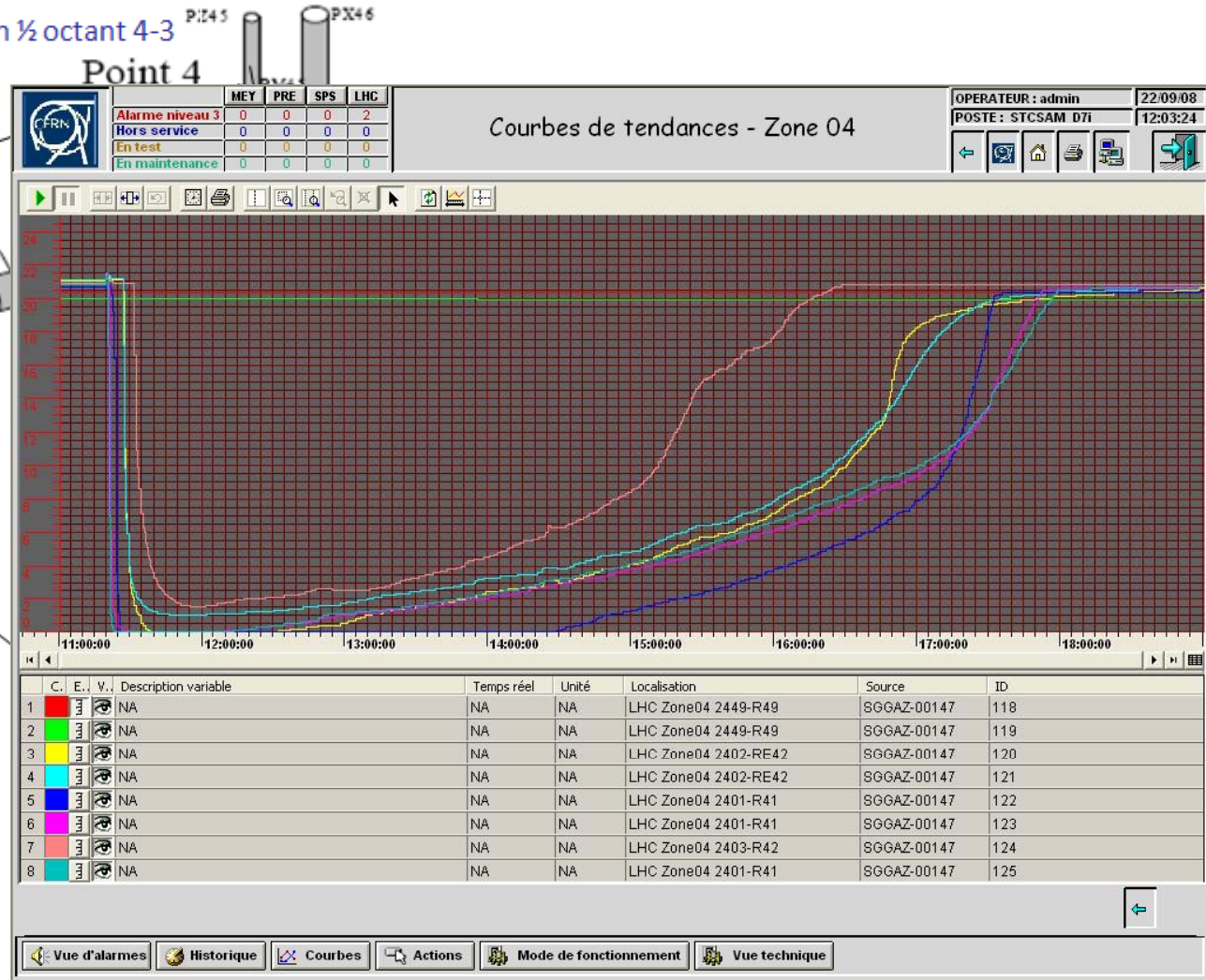
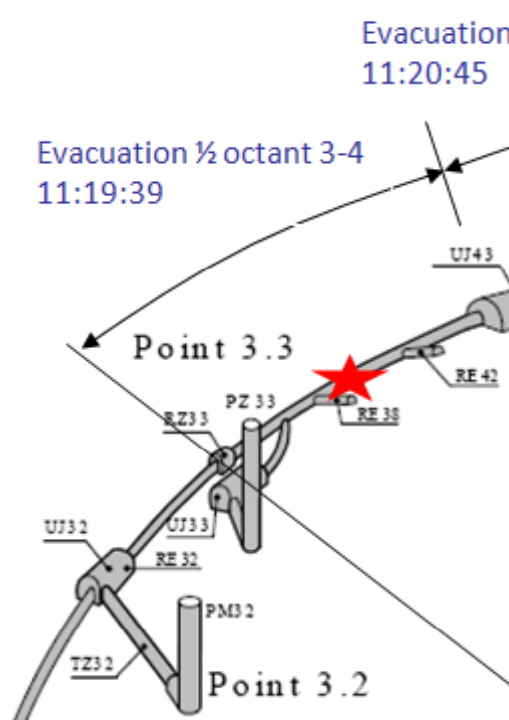
Summary of the analysis

On 19 September 2008, during powering tests of the main dipole circuit in Sector 34 of the LHC, a fault occurred in the electrical bus connection in the region between a dipole and a quadrupole, resulting in mechanical damage and release of helium from the magnet cold mass into the tunnel. Proper safety procedures were in force, the safety systems performed as expected, and no-one was put at risk.

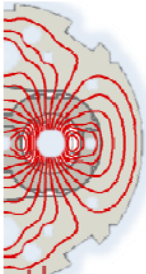
After a period during which the temperature of the magnets in question was allowed to rise close to room temperature, inspections started and a number of clear findings have now been established. Investigations are continuing and the complete findings will be reported at a later date.

CERN Press Release October 16, 2008

Helium in the tunnel



timeline



the event

the valves in the D-area become available again

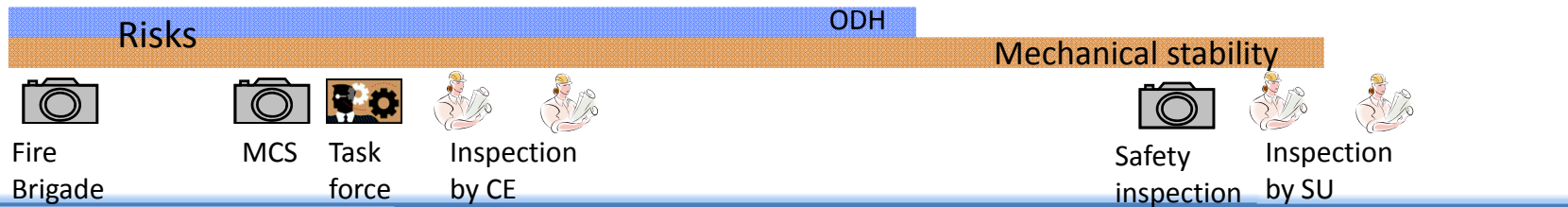
cold masses depressurized

switching off the quench heater power supplies

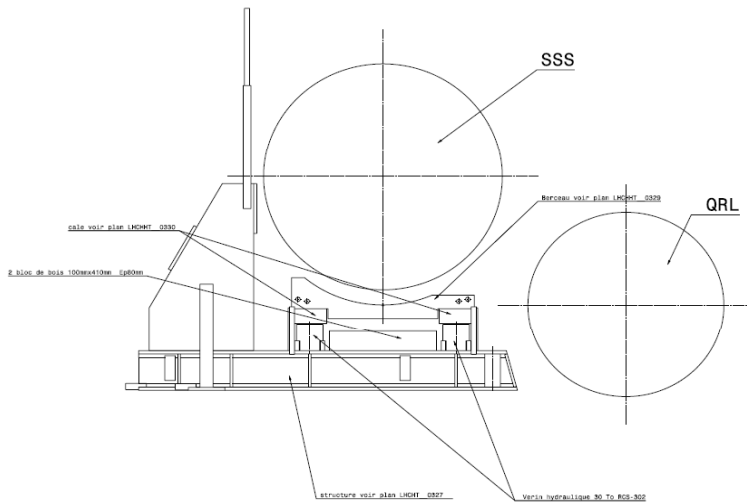
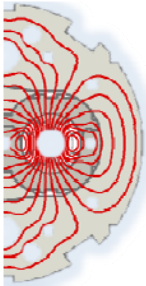
lighting becomes available

some electronics is turned on or off, other is removed from the tunnel

The warm-up of the sector starts with the breaking of the insulation vacuum

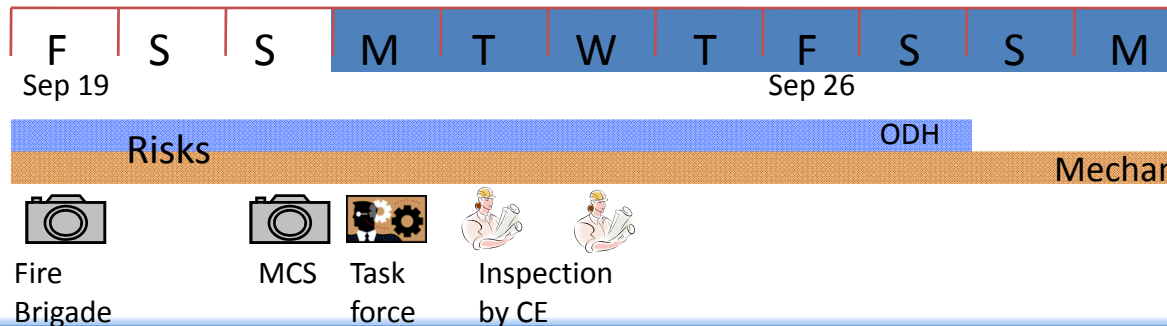


timeline

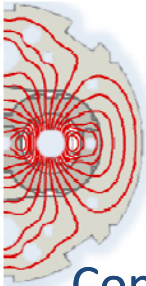


Since then, the following activities have been going in parallel:

1. Opening of the interconnects
2. Measurements of the displacement of the cold masses with respect to the cryostat
3. Opening of the beam tubes
4. Opening of the bus bar tubes
5. Analysis of the material found in the beam tubes
6. Endoscopic inspections of the beam tubes
7. Removal of electronics
8. Preparation for transport



report from Civil Engineering

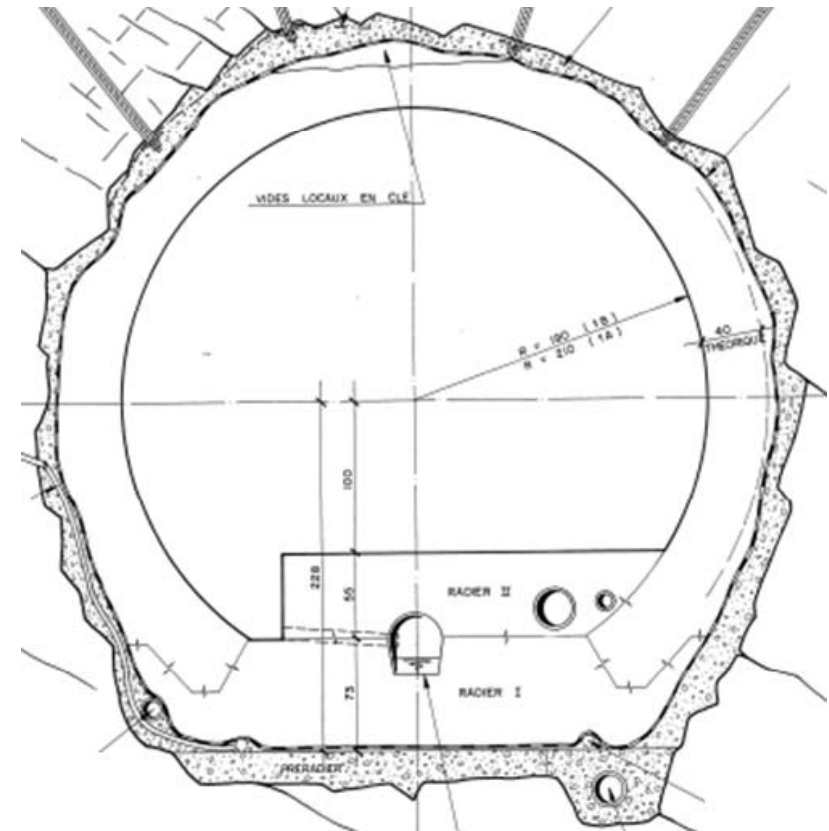


Constats

- ▶ Rupture du radier à l'emplacement du pied de jack arraché et détériorations diverses autour des socles de certains pieds de jack
- ▶ Quelques nouvelles fissures mineures décelées
- ▶ Pas des nouvelles fuites d'eau, mais une légère recrudescence des fuites déjà existantes
- ▶ Pas d'éclats de béton provenant de la voute
- ▶ Pas de modification perceptible dans l'écoulement d'eau
- ▶ Pas des zones sonnant le creux

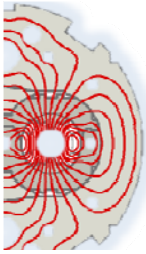
Conclusions

- ▶ Pas des signes apparents de désordre structurel de l'ouvrage dans la zone de l'incident.
- ▶ Les ruptures en radier concernent seulement le radier secondaire (donc pas d'incidence sur la structure).



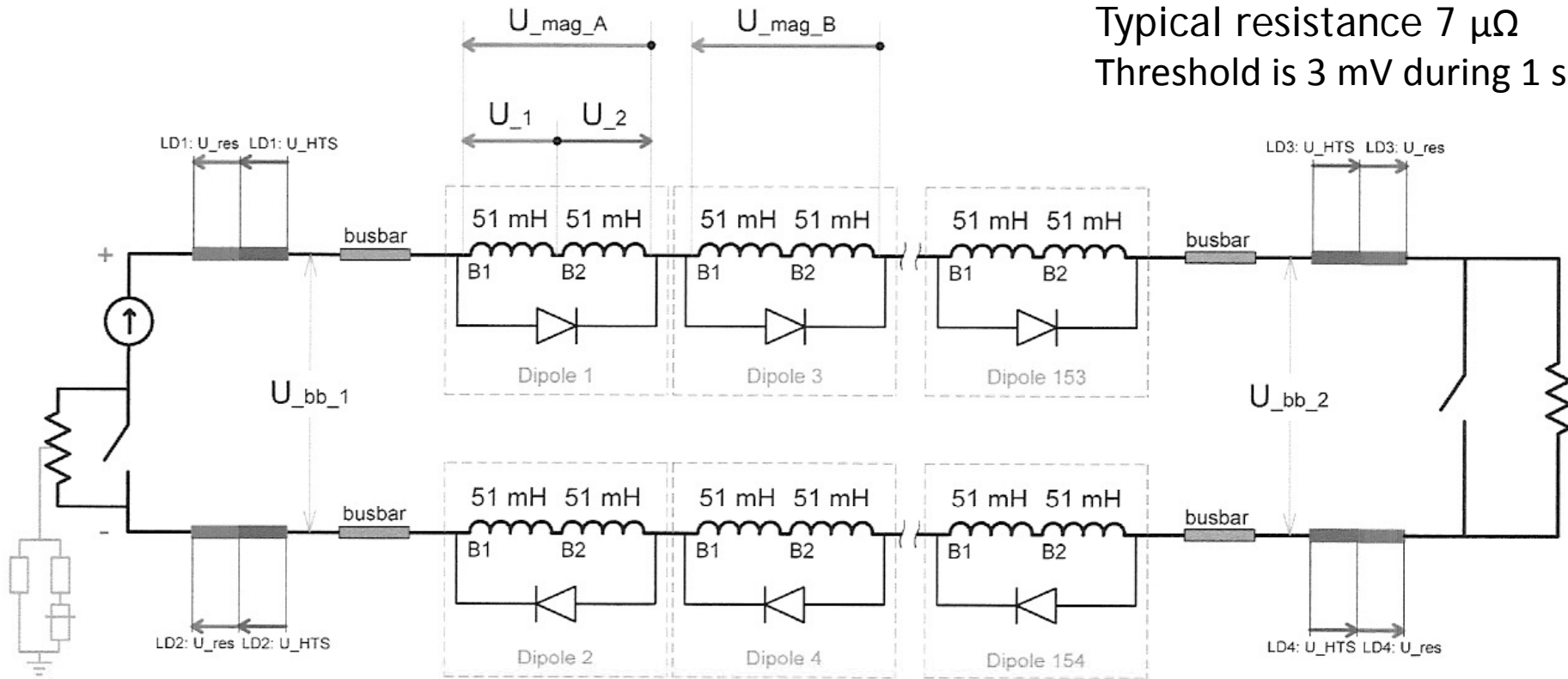
report from Survey

Elément	Pt	Alésage				Dtilt (mrad)	Faisceau moyen			
		Cumul théo. (m)	Dr/bump (mm)	DI/bump (mm)	Dv/bump (mm)		Cumul théo. (m)	Dr/bump (mm)	Dv/bump (mm)	
MQ	19R3	E	7527.951	0.2	-3.0	0.7	-0.15	7527.817	0.3	0.8
		S	7530.796	-0.5	-3.4	1.0		7530.917	-0.5	1.1
MQ	22R3	E	7688.302	-0.3	-6.5	0.2	-0.45	7688.167	-0.1	0.2
		S	7691.147	-0.8	-7.2	1.9		7691.267	-0.6	2.1
MQ	23R3	E	7741.752	-6.3	-187.1	-0.3	-2.96	7741.617	-4.5	0.2
		S	7744.595	-19.1	-187.4	6.1		7744.717	-18.4	7.2
MQ	27R3	E	7955.551	-17.9	475.8	-3.5	-29.12	7955.417	-8.4	-0.7
		S	7958.396	34.7	472.4	108.8		7958.517	49.0	121.7
MB	A28R3	E	7962.633	-1.7	-3.6	-0.4	-1.65	7960.882	-0.4	0.5
		M	7968.033	-1.4	-3.7	0.6				
		S	7973.432	-1.7	-4.2	0.5		7975.182	-0.3	1.6
		T	7973.432	-1.6	-4.2	1.4				
MQ	28R3	E	8009.000	-1.8	11.7	1.1	-2.62	8008.867	-0.8	1.8
		S	8011.845	-0.7	11.2	2.4		8011.967	0.4	3.1
MQ	31R3	E	8169.351	-26.0	188.2	-0.2	-11.71	8169.217	-21.9	2.0
		S	8172.196	-9.4	187.6	19.9		8172.317	-3.8	23.9
MQ	32R3	E	8222.800	-0.2	5.1	0.3	-0.85	8222.667	0.1	0.6
		S	8225.646	0.3	4.6	0.2		8225.767	0.7	0.4



the circuit

The current leads
 Typical resistance $7 \mu\Omega$
 Threshold is 3 mV during 1 s



Bus

$$U_{res} = U_{bb_1} + U_{bb_2} - N (U_{mag_A} + U_{mag_B}) / 2$$

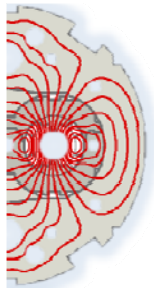
Threshold is 1V during 1 s

Magnets

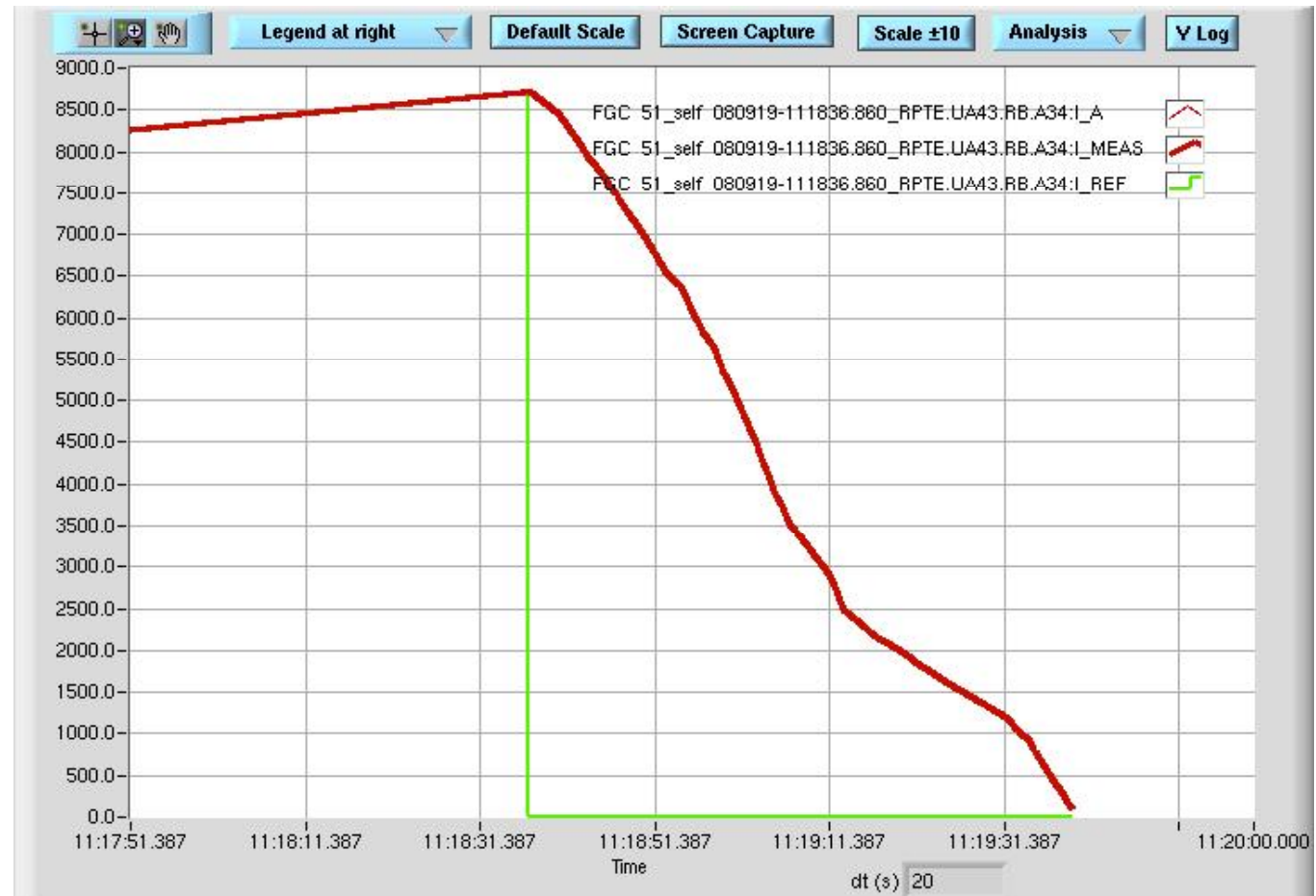
$$U_{res} = U_{1} + U_{2}$$

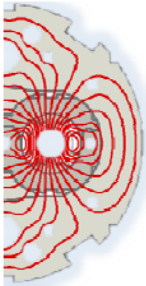
Threshold is 100 mV during 10 ms

the discharge



- ▶ Anomalous shape far from exponential
- ▶ It takes about 60 s (normal time constant is 104 s)
- ▶ More than 100 dipoles quenched





opening of the interconnects

	Q17	A18	B18	C18	Q18	A19	B19	C19	Q19	A20	B20	C20	Q20	A21	B21	C21	Q21
Cryostat	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Cold mass	?	?	?	?	?	?	?	?	?	?	?	?	<5	<5	<5	<5	<5

	Q21	A22	B22	C22	Q22	A23	B23	C23	Q23	A24	B24	C24	Q24	A25	B25	C25	Q25
Cryostat	<2	<2	<2	<2	-7	<2	<2	<2	-187	<2	<2	<2	<2	<2	<2	<2	<2
Cold mass	<5	<5	<5	<5	-25	-67	-102	-144	<5	-190	-130	-60	<5	<5	<5	<5	<5

	Q25	A26	B26	C26	Q26	A27	B27	C27	Q27	A28	B28	C28	Q28	A29	B29	C29	Q29
Cryostat	<2	<2	<2	<2	<2	<2	<2	<2	474	-4	<2	<2	11	<2	<2	<2	<2
Cold mass	<5	<5	<5	<5	<5	57	114	150?	-45	230	189	144	92? Vert	50	35	<5	<5

	Q29	A30	B30	C30	Q30	A31	B31	C31	Q31	A32	B32	C32	Q32	A33	B33	C33	Q33
Cryostat	<2	<2	<2	<2	<2	<2	<2	<2	188	<2	<2	<2	5	<2	<2	<2	<2
Cold mass	<5	<5	<5	<5	<5	19	77	148	<5?	140	105	60	?	?	?	?	?

- SSS with vacuum barrier
- >0 Towards P4
- Values are in mm
- Electrical interruptions
- Dipole in short circuit
- Not measured yet
- Electrically damaged IC or CM
- Cold mass displacement
- Cryostat displacement
- Buffer zones

Date 26/10/2008

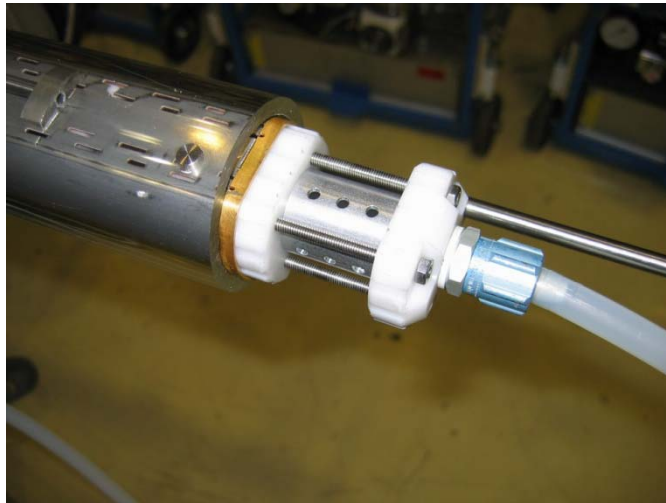
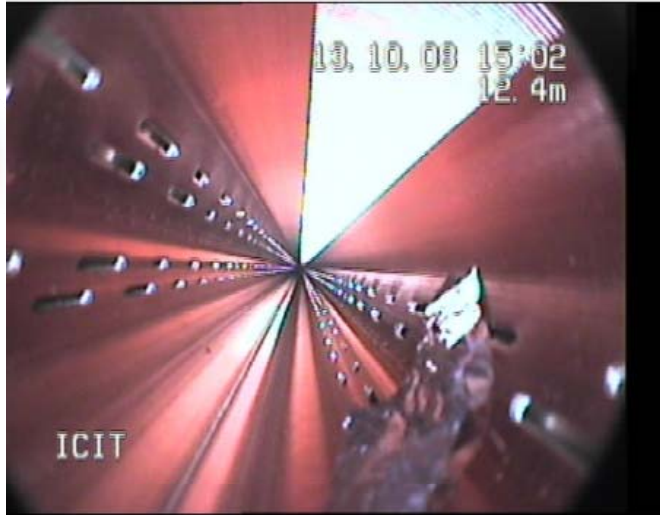
JPh Tock



opening of the interconnects

- Systematic inspections of the opened interconnects show
 - Damaged super insulation in more than half of the magnets
 - Damaged support posts due to the big displacement of the cold mass with respect to the cryostat
- The first magnet will be available for transport at the end of this week
- Qualified personnel who participated in the interconnects and cryostating has been identified and is being made available to CERN
- The last assessment indicates that more dipoles and SSSs than initially anticipated will have to be brought to the surface for repair, cleaning and exchange of multilayer insulation
- Enough spare magnets and spare components are available

opening of the beam tubes



The first test of in-situ cleaning of the beam vacuum tube in sector 3-4 was done last Friday.

The test revealed that the soot cannot be simply sucked by a vacuum cleaner but a combined action with a brush is required.

Only MLI could be sucked with the current device. However, a preliminary test was done with a brush, but without sucking.

This test was conclusive to remove the soot from the beam screen surface. AT-VAC is now building a new prototype with a brush incorporated with the pumping device.



measurements to confirm or rule-out the existence of a bad splice in Sector 12

- Gradual powering of Sector 12 started last week to investigate suspect heating in cells 15 and 16 (and maybe 17) R1 during the nominal powering tests of Sector 12 in late August.
- Starting from very low current levels and assessing each step before passing to the next one. So far, calorimetric and electrical measurements have been carried out at three current levels 350, 760 and 1250 A.
- The procedure, the risk, the access conditions are clearly detailed in an EDMS document which is regularly updated and circulated for approval.



lessons learnt

1. An improvement of the quench detection system is under way, to generate both early warnings and interlocks, and to encompass magnets, bus bars and interconnects. It will be implemented before any further powering of the LHC circuits at higher current.
2. The relief devices on the cryostat vacuum vessels will be increased in discharge capacity and in number, so as to contain a possible pressure rise to below 0.15 MPa absolute even in presence of an electrical arc.
3. The external anchoring of the cryostats at the locations of the vacuum barriers will be reinforced to guarantee mechanical stability.
4. The personnel access rules during powering will also be reexamined, to further exclude human presence not only in the machine tunnel, but also in the neighboring caverns and technical areas underground.

- All the interconnects will be opened by the end of this week
- One beam vacuum interconnect in five towards Point 3 will be opened and an endoscopic inspection will be made to
 - Identify damaged PIMs
 - Rule-out contamination with soot
- We are aiming at bringing to the surface all the magnets needing repair before the X-mas shutdown
- Consolidation actions (quench protection system, relief valves, anchoring of the external supports) will be carried out during the shutdown