MIRKO POJER on behalf of Hardware Commissioning Coordination

'POWERING TESTS AND SAFETY' WORKSHOP

POWERING TESTS

SAFETY AND POWERING

- Before September 19, a limit to access of people in the tunnel had been defined, which considered 1 kA as a safe current threshold.

- The incident of sector 3-4 and further investigations demonstrated that not only 1 kA was a too arbitrary value, but, above all, that also the service areas and the experimental caverns are not safe in case of an electromechanical fault, associated to a massive helium release.

- Already at the end of October last year, to investigate other sectors at the quest of a similar precursor as the one responsible for sector 3-4 event, the underground areas were massively limited.

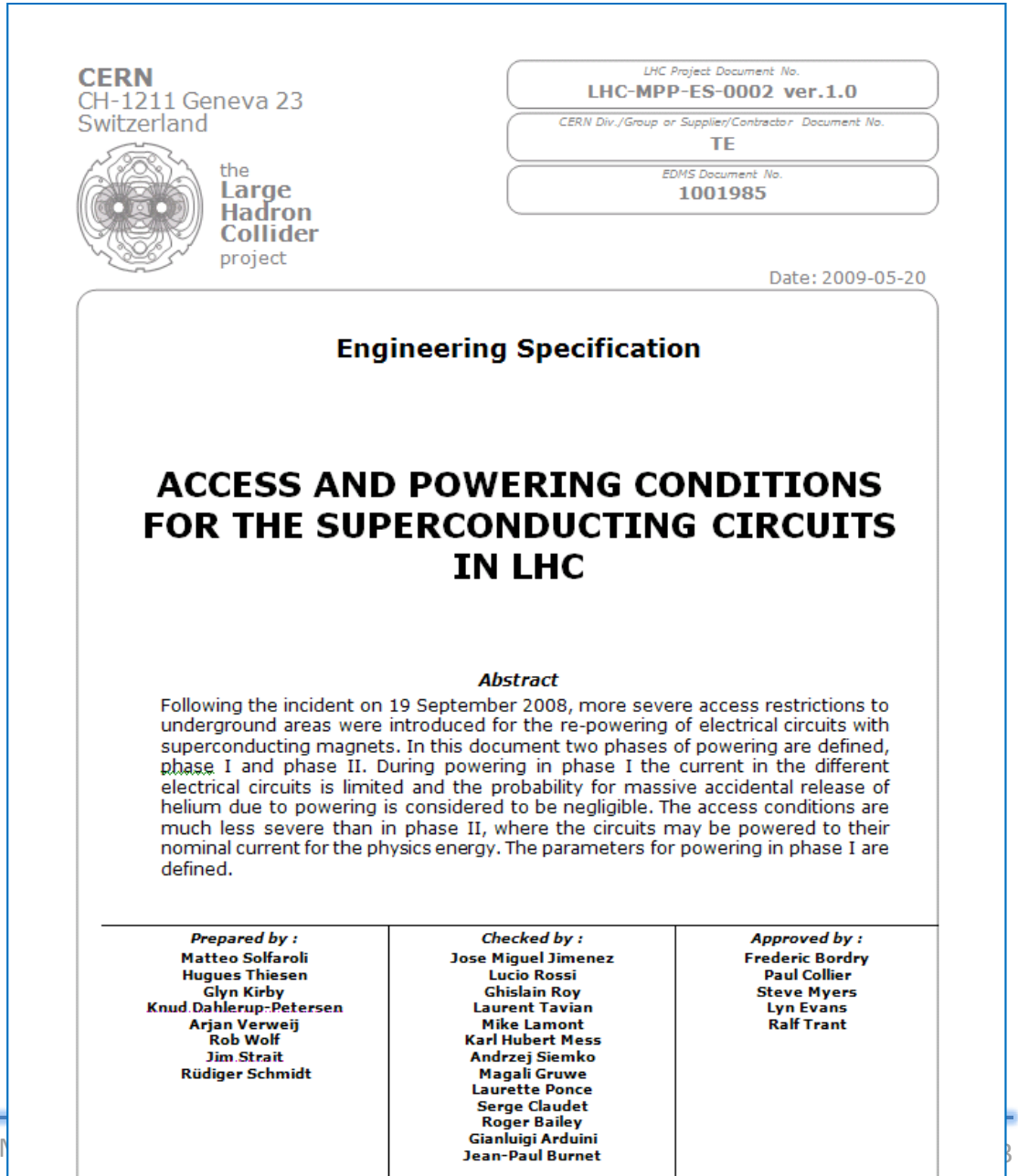
- A Safety Task Force was also constituted with the aim of defining conditions for access during powering and defining as well compensatory measures to mitigate the effects of a similar incident.

ACCESS CONDITIONS DURING POWERING TESTS

After September 19 event, strict access conditions were defined when powering the superconducting circuits in the LHC tunnel.

In particular, two powering phases are identified: powering Phase I and powering Phase II, with different access limitations according to the energy stored in the circuits and to the effect of electro-mechanical failure and helium release (MCI).

This is taking into account the recommendations of the Safety Working Group, organized after sector 3-4 incident.



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Engineering Specification

ACCESS AND POWERING CONDITIONS FOR THE SUPERCONDUCTING CIRCUITS IN LHC

Abstract

Following the incident on 19 September 2008, more severe access restrictions to underground areas were introduced for the re-powering of electrical circuits with superconducting magnets. In this document two phases of powering are defined, phase I and phase II. During powering in phase I the current in the different electrical circuits is limited and the probability for massive accidental release of helium due to powering is considered to be negligible. The access conditions are much less severe than in phase II, where the circuits may be powered to their nominal current for the physics energy. The parameters for powering in phase I are defined.

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A SAFE LIMIT IN ELECTROMAGNETIC ENERGY

"…the risk of massive accidental helium release due to powering is negligible if the stored energy in the circuit is below 100 kJ"

Circuit type	Maximum energy stored [J] at nominal current	L [H]	Maximum current level	Energy [J]	Corresponding powering test step
main dipoles	1.13E+09	15.708	0A	0.0E+00	PIC1
main quadrupoles	3.79E+07*	0.263	760A	7.6E+04	PLI1
arc individually powered quadrupoles	8.70E+05 (RQ7)	0.06	900A	2.4E+04	PLI2
600A circuits	6.50E+04** (RSD1)	0.432 (400A)	400A / 550A	3.5E+04	PNO
120A orbit correctors	1.42E+04 (RCBCH7)	2.84	120A	1.4E+04	PNO
60A orbit correctors	9.10E+03	6.02	60A	9.1E+03	PNO
Stand alone quadrupole	1.90E+06 (RQ4.L2)	0.296	600A	5.3E+04	PLI2
Stand alone dipoles	9.40E+05 (RD2.R2)	0.052	1000A	2.6E+04	PLI2
inner triplet quadrupoles (Q1+Q3/Q2a+ Q2b)	7.55E+06	L1 = 0.09 L2 = 0.038 L3 = 0.09	n.a.	5.9E+03	PCC

* Energy stored in both circuits, since at a current above 2000A the RQF and RQD circuits are always powered together

** The current in a few 600A circuits (RQ6) in point 3 and point 7 is limited to 400A, to respect the limit for the stored energy of 100kJ

A SAFE LIMIT IN ELECTROMAGNETIC ENERGY

The 100 kJ energy level has been taken as the boundary between Phase I and Phase II, between which tests are permitted with people in the tunnel and which are not, when we have to close and when we have to really patrol a sector.

(*For access conditions related to the different powering phases see Matteo's presentation*)

In this case the powering conditions during phase I are as follows:

- No tests on the RB in Phase I, apart PIC1, done in simulation mode
- In the same cryostat, no more than one main circuit (RQF/D, IPD, IPQ) powered simultaneously
- In the arc, it is possible to power one individual powered quadrupole from an even point and one individual powered quadrupole from an odd point at the same time
- No restriction for powering the 60A, 80A, 120A and 600A circuits

(*Refer to Laurette's presentation for current limits etc.*)

Circuit type	Maximum current level
main dipoles	0A
main quadrupoles	760A
arc individually powered quadrupoles	900A
600A circuits	400A / 550A
120A orbit correctors	120A
60A orbit correctors	60A
Stand alone quadrupole	600A
Stand alone dipoles	1000A
inner triplet quadrupoles (Q1+Q3/Q2a+ Q2b)	I_PCC

AN HELP IN DISTINGUISHING THE TWO PHASES

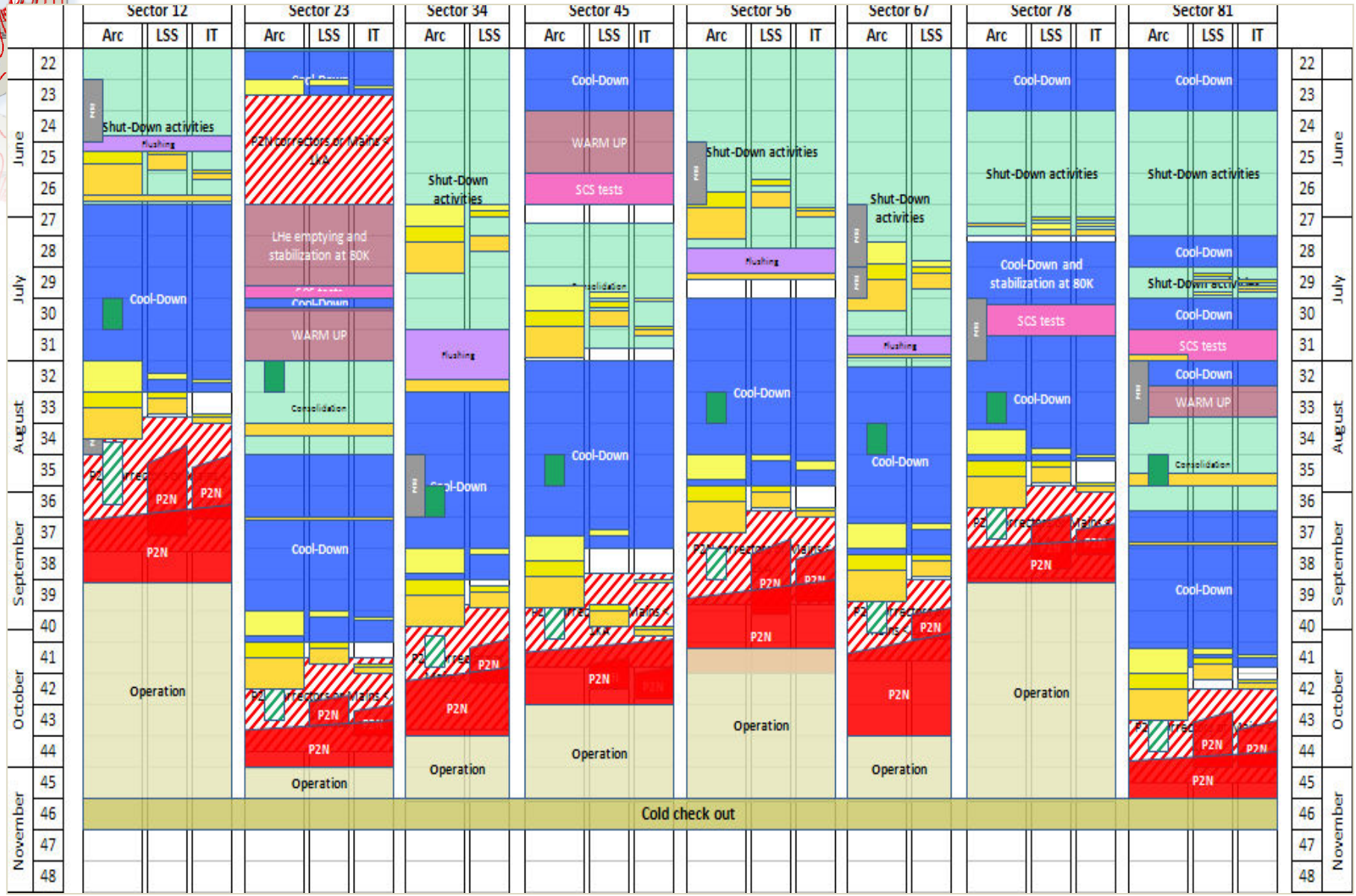
- The Powering to Nominal web page has been adapted:

RCOX3.L8	24 HOUR HEAT RUN	0 / 8 (0%)	-	-	-	PCL	PCC.1	PIC2	PNO.a1	PNO.d1	PNO.e1	PIC2 GPM																					
RCSSX3.L8	24 HOUR HEAT RUN	0 / 8 (0%)	-	-	-	PCL	PCC.1	PIC2	PNO.a1	PNO.d1	PNO.e1	PIC2 GPM																					
RCSX3.L8	24 HOUR HEAT RUN	0 / 8 (0%)	-	-	-	PCL	PCC.1	PIC2	PNO.a1	PNO.d1	PNO.e1	PIC2 GPM																					
RCTX3.L8	24 HOUR HEAT RUN	0 / 8 (0%)	-	-	-	PCL	PCC.1	PIC2	PNO.a1	PNO.d1	PNO.e1	PIC2 GPM																					
RD1.L8	24 HOUR HEAT RUN	0 / 11 (0%)	-	-	-	PCL	PCC.3	PIC2	PLI1.e2	PLI2.f2	PNO.e2	PIC2 GPM																					
RD2.L8	24 HOUR HEAT RUN	0 / 11 (0%)	-	-	-	PCL	PCC.3	PIC2	PLI1.e2	PLI2.f2	PNO.e2	PIC2 GPM																					
RQ10.L8	24 HOUR HEAT RUN	0 / 13 (0%)	-	-	-	PCL	PCC.4	PIC2	PLI1.e3	PLI2.f3	PLI2.e3	PNO.e3	PNO.e4	PIC2 GPM																			
RQ4.L8	24 HOUR HEAT RUN	0 / 13 (0%)	-	-	-	PCL	PCC.4	PIC2	PLI1.e3	PLI2.f3	PLI2.e3	PNO.e3	PNO.e4	PIC2 GPM																			
RQ5.L8	24 HOUR HEAT RUN	0 / 13 (0%)	-	-	-	PCL	PCC.4	PIC2	PLI1.e3	PLI2.f3	PLI2.e3	PNO.e3	PNO.e4	PIC2 GPM																			
RQ6.L8	24 HOUR HEAT RUN	0 / 13 (0%)	-	-	-	PCL	PCC.4	PIC2	PLI1.e3	PLI2.f3	PLI2.e3	PNO.e3	PNO.e4	PIC2 GPM																			
RQ7.L8	24 HOUR HEAT RUN	0 / 13 (0%)	-	-	-	PCL	PCC.4	PIC2	PLI1.e3	PLI2.f3	PLI2.e3	PNO.e3	PNO.e4	PIC2 GPM																			
RQ8.L8	24 HOUR HEAT RUN	0 / 13 (0%)	-	-	-	PCL	PCC.4	PIC2	PLI1.e3	PLI2.f3	PLI2.e3	PNO.e3	PNO.e4	PIC2 GPM																			
RQ9.L8	24 HOUR HEAT RUN	0 / 13 (0%)	-	-	-	PCL	PCC.4	PIC2	PLI1.e3	PLI2.f3	PLI2.e3	PNO.e3	PNO.e4	PIC2 GPM																			
RQX.L8	24 HOUR HEAT RUN	0 / 23 (0%)	-	-	-	PCC.T1	PCC.T2	PCC.T3	PIC2	PLI2.e5	PLI3.d8	PLI2.e6	PLI3.d10	PLI3.f6	PCC.T4	PNO.d12	PNO.d11	PNO.d13	PNO.d14	PNO.d15	PNO.d16	PNO.d17	PIC2 GPM									
RB.A78	24 HOUR HEAT RUN	0 / 23 (0%)	-	-	-	PCL	PQC	PCC.2	PIC2	PLI1.a2	PLI1.b2	PLI2.a1	PLI1.d2	PLI2.b2	PLI2.e2	PLI3.a2	PLI3.a5	PLI3.f1	PLI3.d2	PNO.a6	PNO.b2	PIC2 GPM	PNO.TRAIN									
RQD.A78	24 HOUR HEAT RUN	0 / 23 (0%)	-	-	-	PCL	PQC	PCC.3	PIC2	PLI2.a1	PLI1.b3	PLI1.d2	PLI2.b3	PLI2.f1	PLI2.e2	PLI3.a2	PLI3.a5	PLI3.b3	PNO.a6	PNO.b3	PIC2 QPM	PNO.TRAIN										
RQF.A78	24 HOUR HEAT RUN	0 / 23 (0%)	-	-	-	PCL	PQC	PCC.3	PIC2	PLI2.a1	PLI1.b3	PLI1.d2	PLI2.b3	PLI2.f1	PLI2.e2	PLI3.a2	PLI3.a5	PLI3.b3	PNO.a6	PNO.b3	PIC2 QPM	PNO.TRAIN										

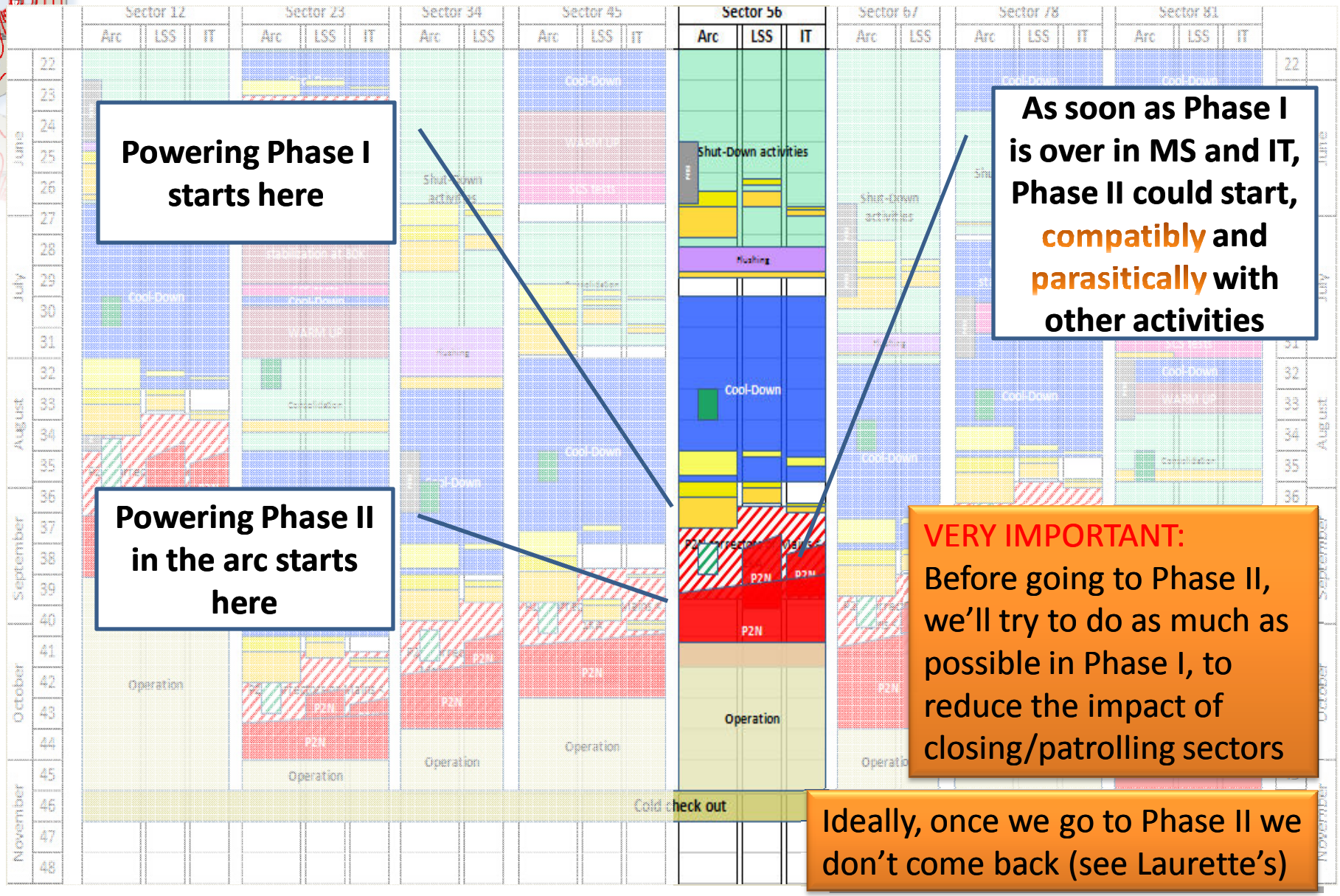
Circuit type	Maximum current level
main dipoles	0A
main quadrupoles	760A
arc individually powered quadrupoles	900A
600A circuits	400A / 550A
120A orbit correctors	120A
60A orbit correctors	60A
Stand alone quadrupole	600A
Stand alone dipoles	1000A
inner triplet quadrupoles (Q1+Q3/Q2a+ Q2b)	I_PCC

N.B. It is not a safety measure, but just a "guideline". For the HW/SW tools, refer to Laurette's.

THE ACTUAL PLANNING



THE ACTUAL PLANNING



Powering Phase I starts here

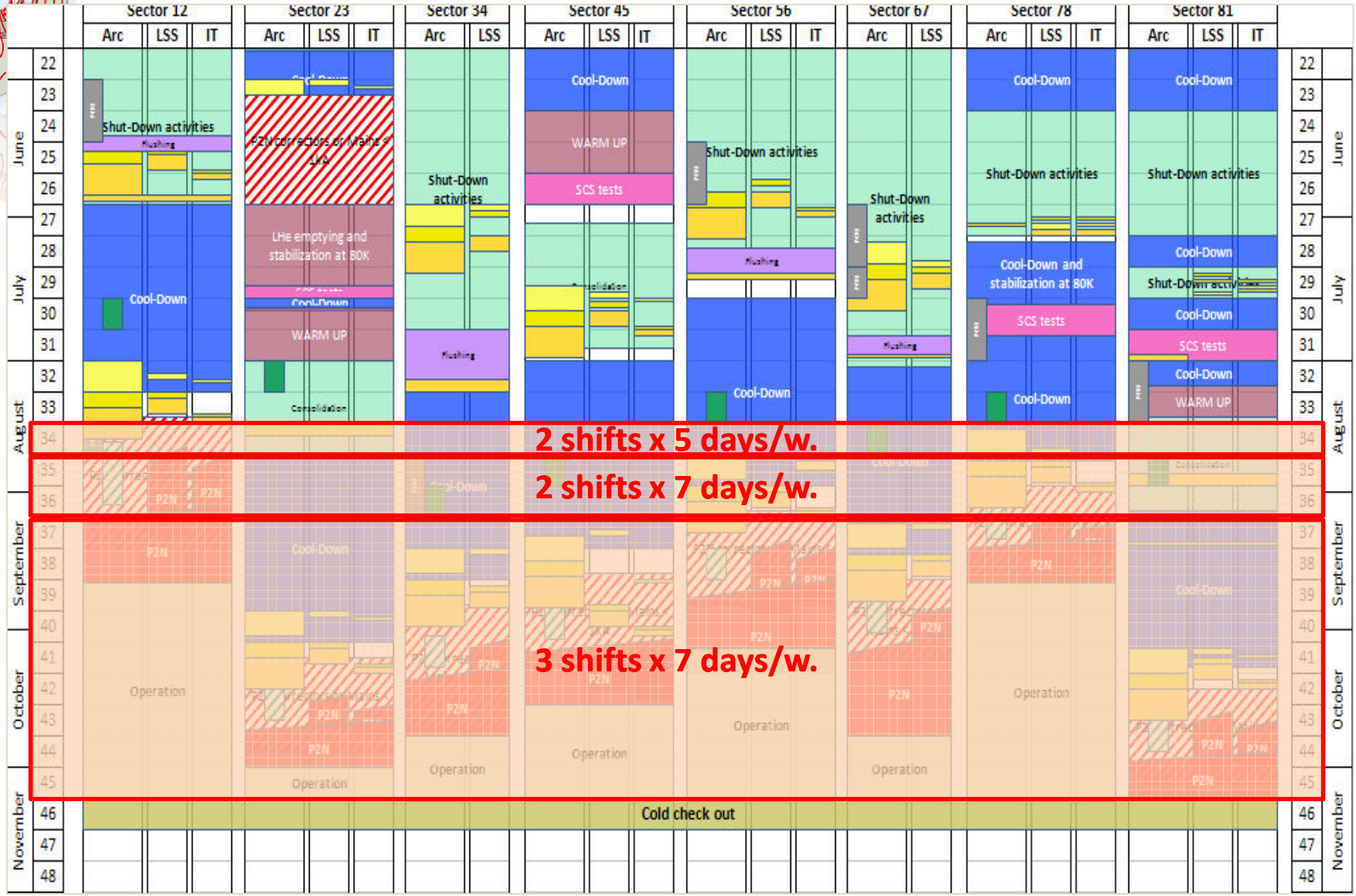
Powering Phase II in the arc starts here

As soon as Phase I is over in MS and IT, Phase II could start, compatibly and parasitically with other activities

VERY IMPORTANT:
Before going to Phase II, we'll try to do as much as possible in Phase I, to reduce the impact of closing/patrolling sectors

Ideally, once we go to Phase II we don't come back (see Laurette's)

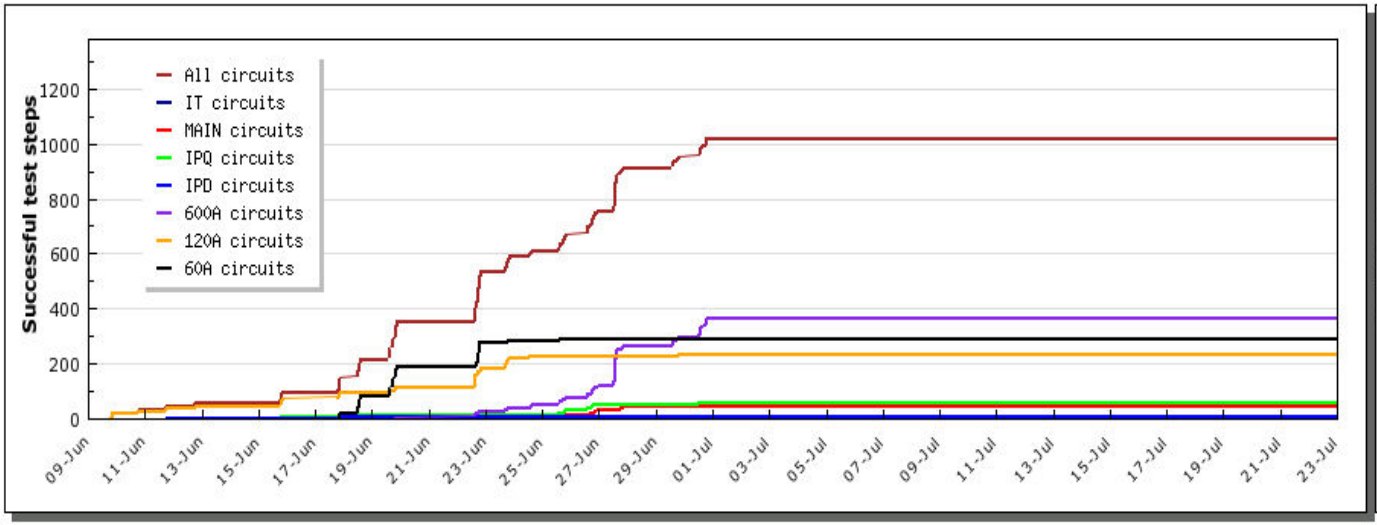
THE ACTUAL PLANNING

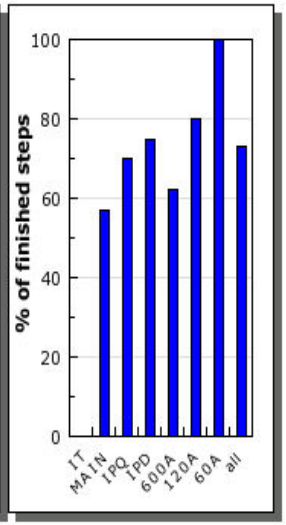


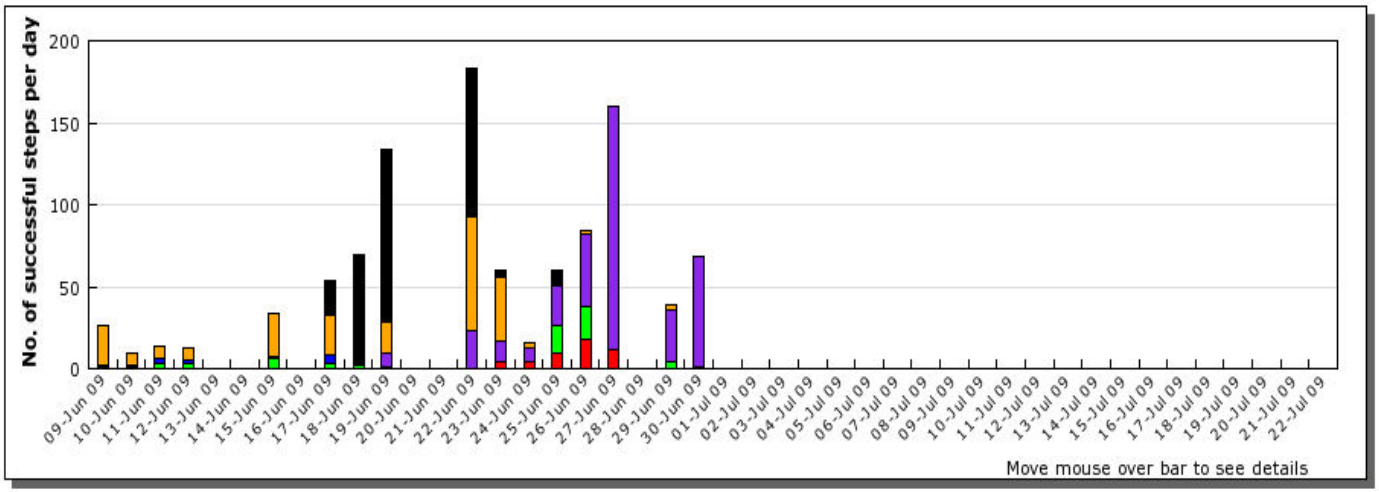
WHICH IS THE IMPACT OF ACCESS RESTRICTIONS ON THE POWERING TESTS

684/11000 test steps are done in Phase II (about 6% of total)

Summary of executed test steps in sector 23



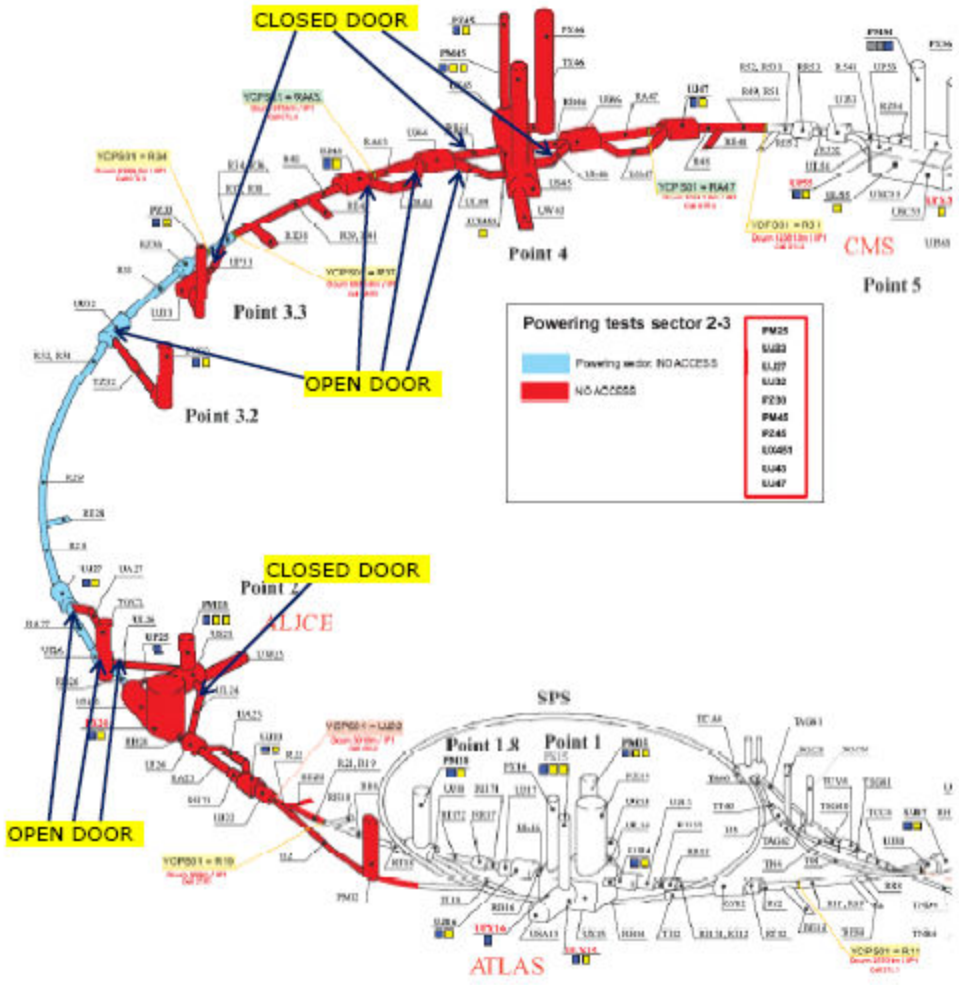




Summary (repeated steps included)

.	XR2	MR2	A23	Total
IT	0			0
MAIN			48	48
IPQ		19	41	60
IPD	7	8		15
600A	28		341	369
120A	21	84	131	236
60A			296	296
Total	56	111	857	1024

EXAMPLE OF PHASE II: 26-28 JUNE



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Date: 2009-06-26

Engineering specification

SAFETY ASPECTS OF THE QPS TESTS ON 26-28 JUNE 2009

Abstract

The early validation of the prototype for the new QPS system on the main bending and main quadrupole magnets is considered as mandatory. No space for a late discovery of errors is in fact left by a tight installation and system test planning. For this reason, powering of the main circuits in sector 2-3 up to 1 kA is proposed before the planned consolidation activity in that Sector starts, that is, at the latest, during the weekend of 26-28 June 2009.
Although the energy stored in the magnets for these tests is approximately two orders of magnitude lower than that corresponding to nominal 5 TeV operation, it falls into the agreed boundaries of Phase II powering. This requires for the evacuation of half of the machine, and demands for some compensatory measures to be put in place.

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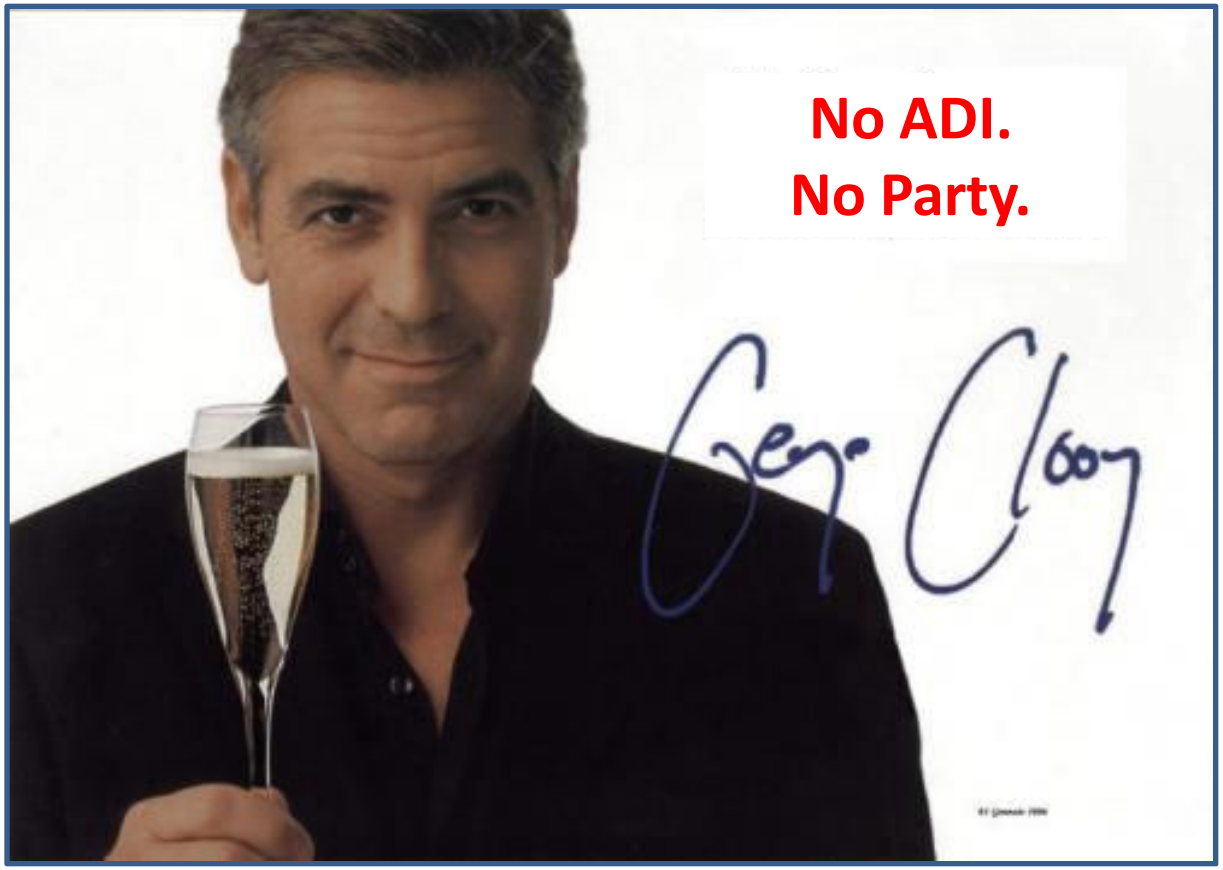
Thanks for the attention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