Control Systems in the LHC

Controle da Criogenia e do Vácuo em Aceleradores de Partículas

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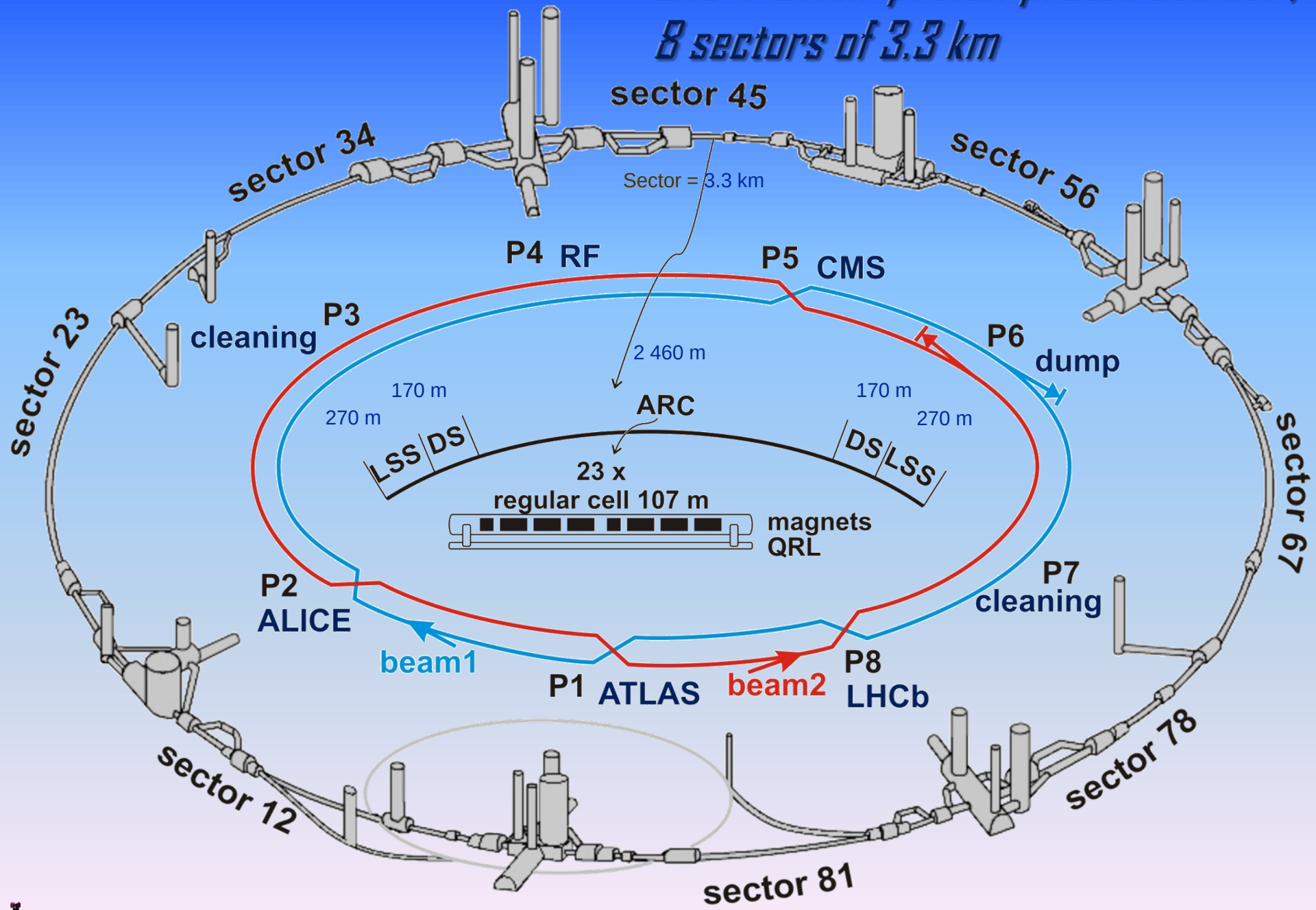
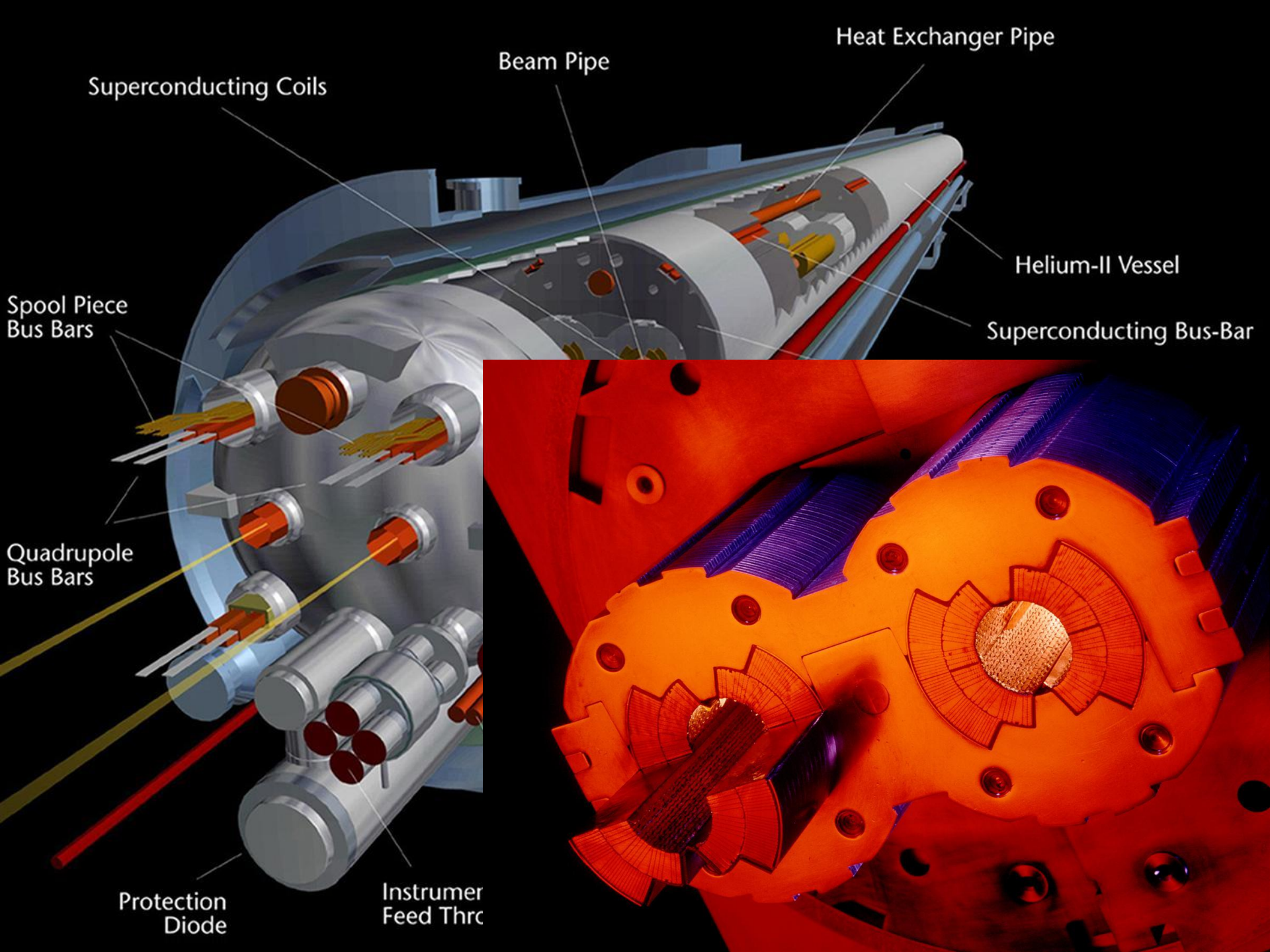
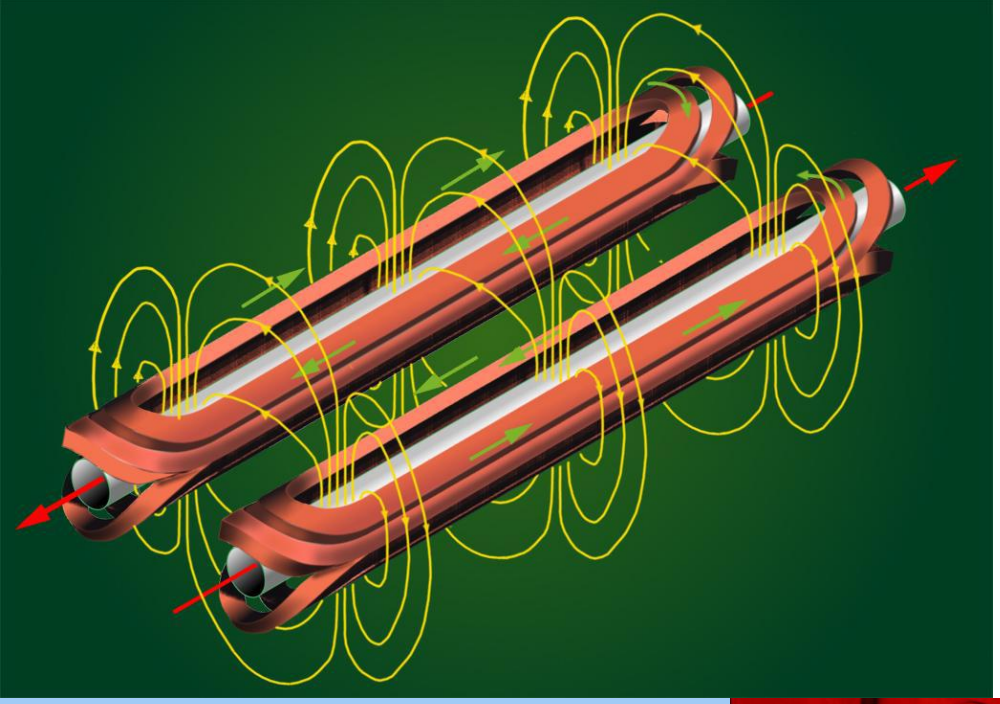
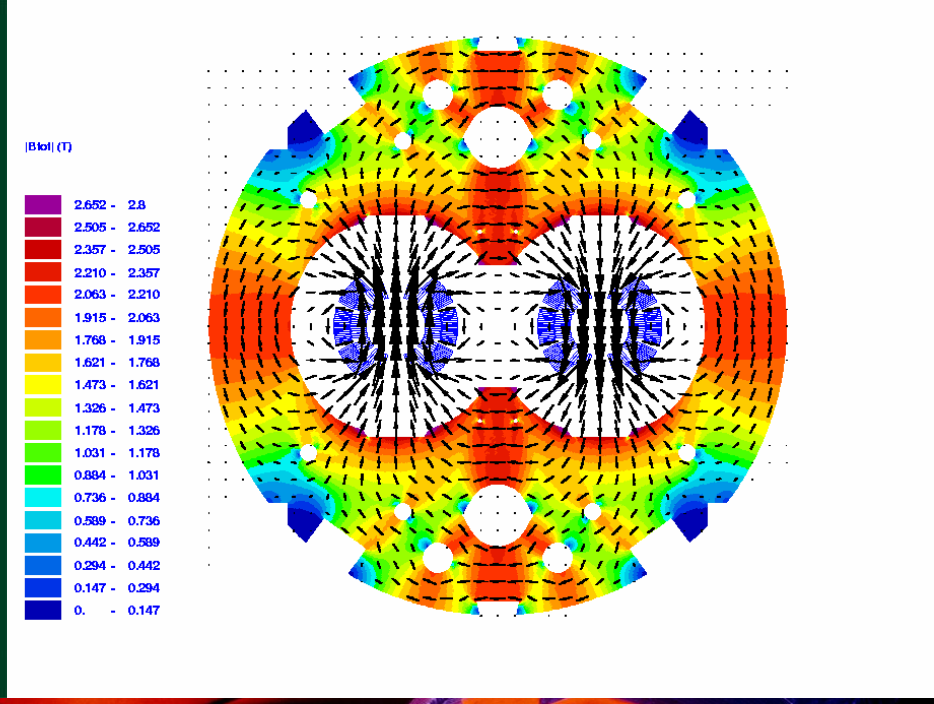
TE
VSC
Interlocks
Controls
Monitoring

LHC : 27km proton-proton collider , 8 sectors of 3.3 km




Heat Exchanger Pipe
Beam Pipe
Superconducting Coils
Helium-II Vessel
Spool Piece
Bus Bars
Superconducting Bus-Bar
Quadrupole
Bus Bars
Protection
Diode
Instrumer
Feed Thro





energy per beam: 7 TeV

luminosity: 10^{34} $cm^{-2}s^{-1}$

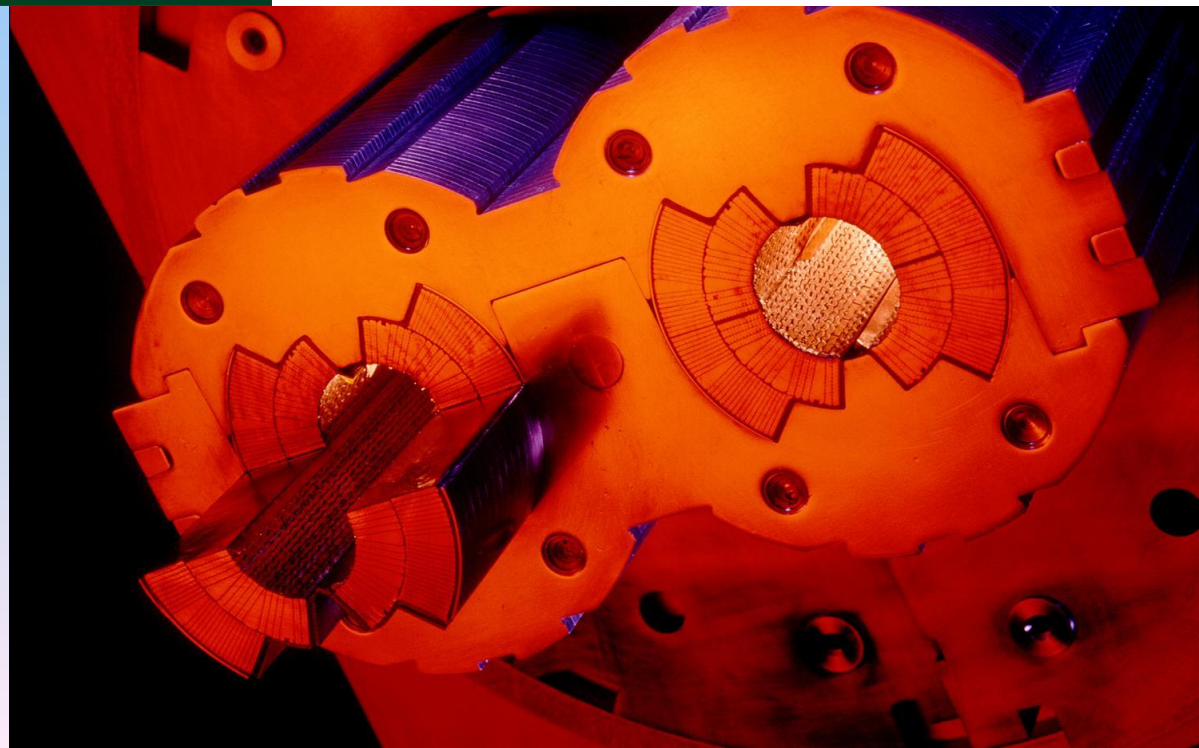
main dipoles field: 8 T

current: 12 kA

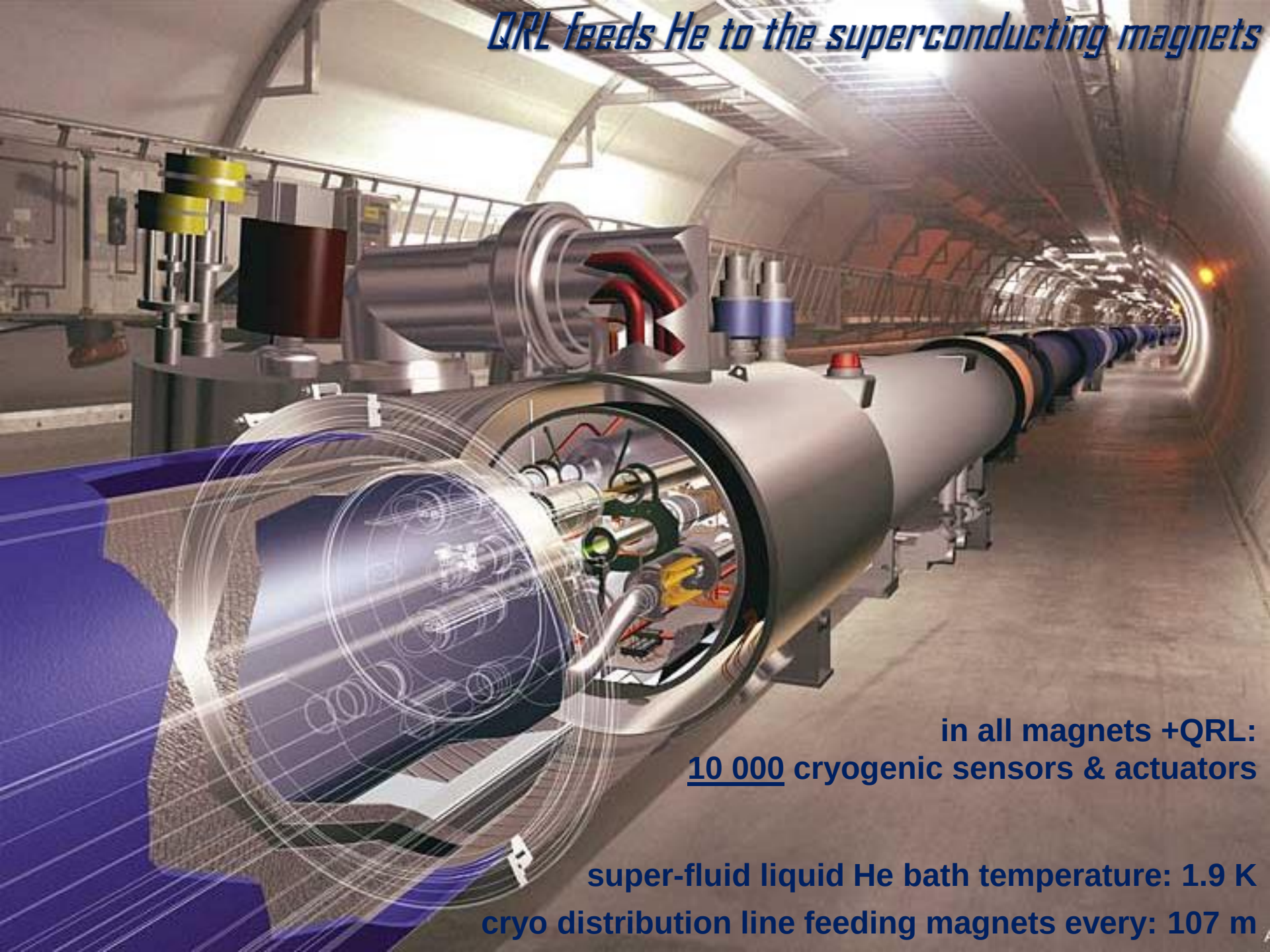
 # main magnets

superconducting at 1.9K

1200 D + 400 Q



QRL feeds He to the superconducting magnets



in all magnets +QRL:
<u>10 000</u> cryogenic sensors & actuators

super-fluid liquid He bath temperature: 1.9 K

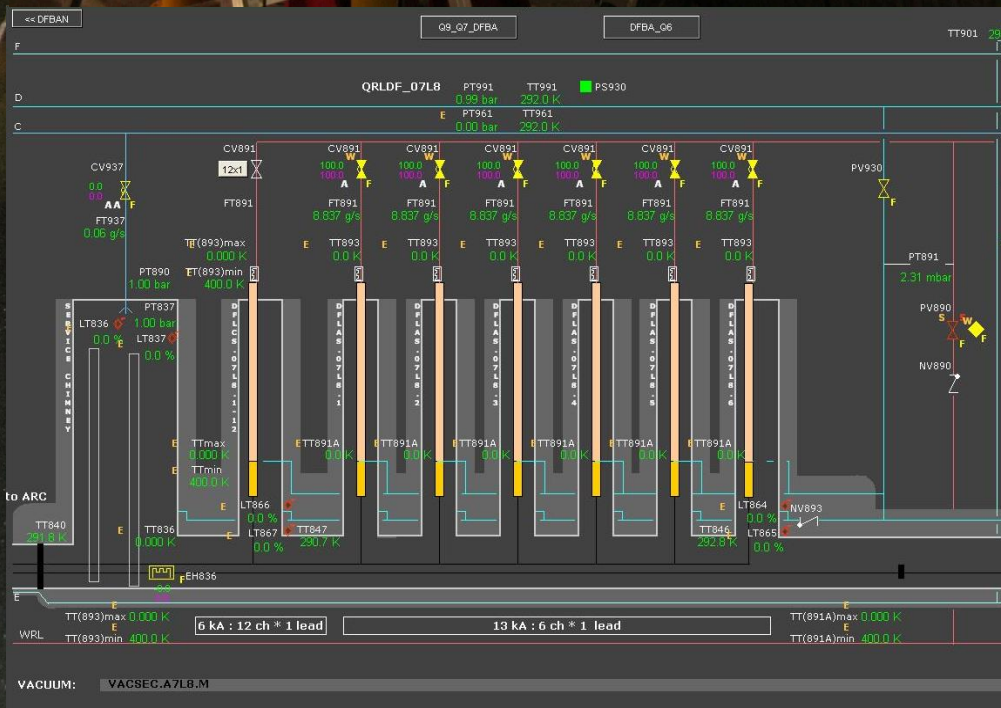
cryo distribution line feeding magnets every: 107 m

52 DFBs

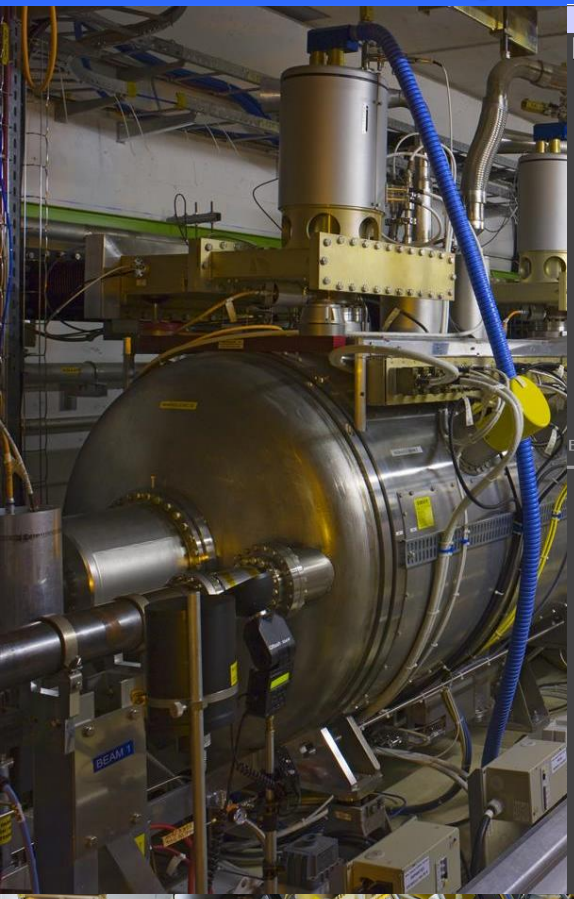
5 000 instruments

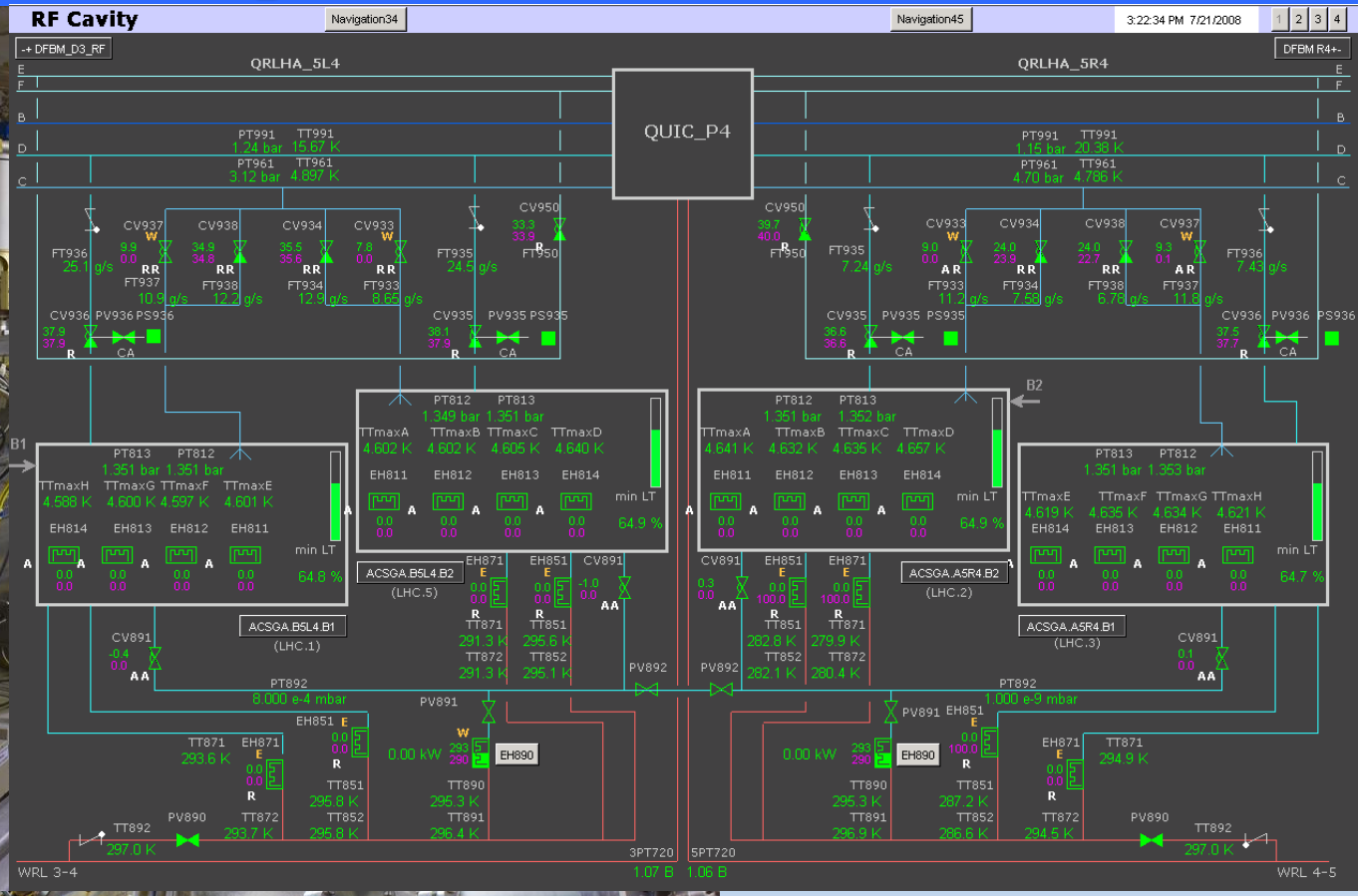
support and cool

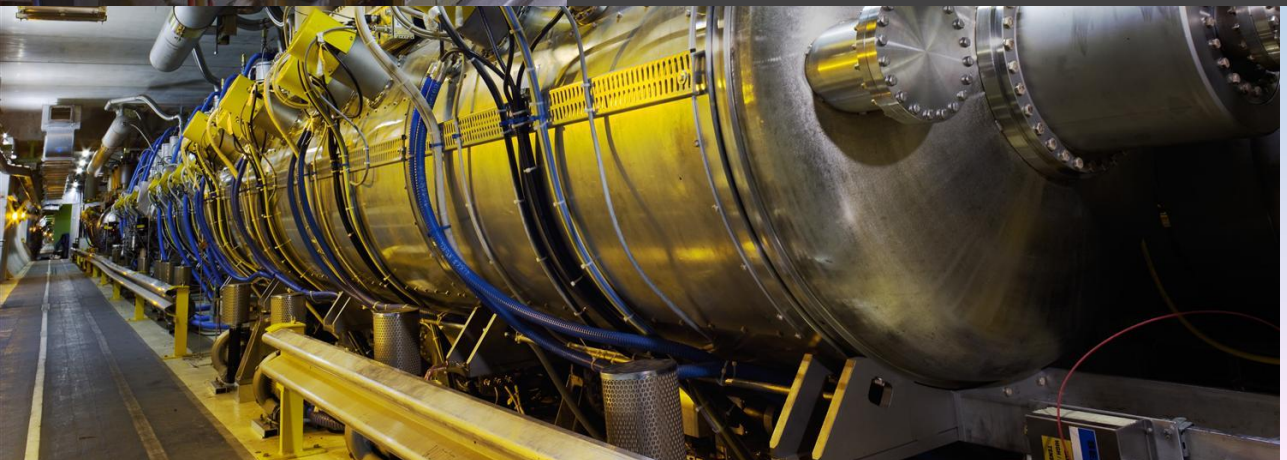
Current Leads that power the magnets



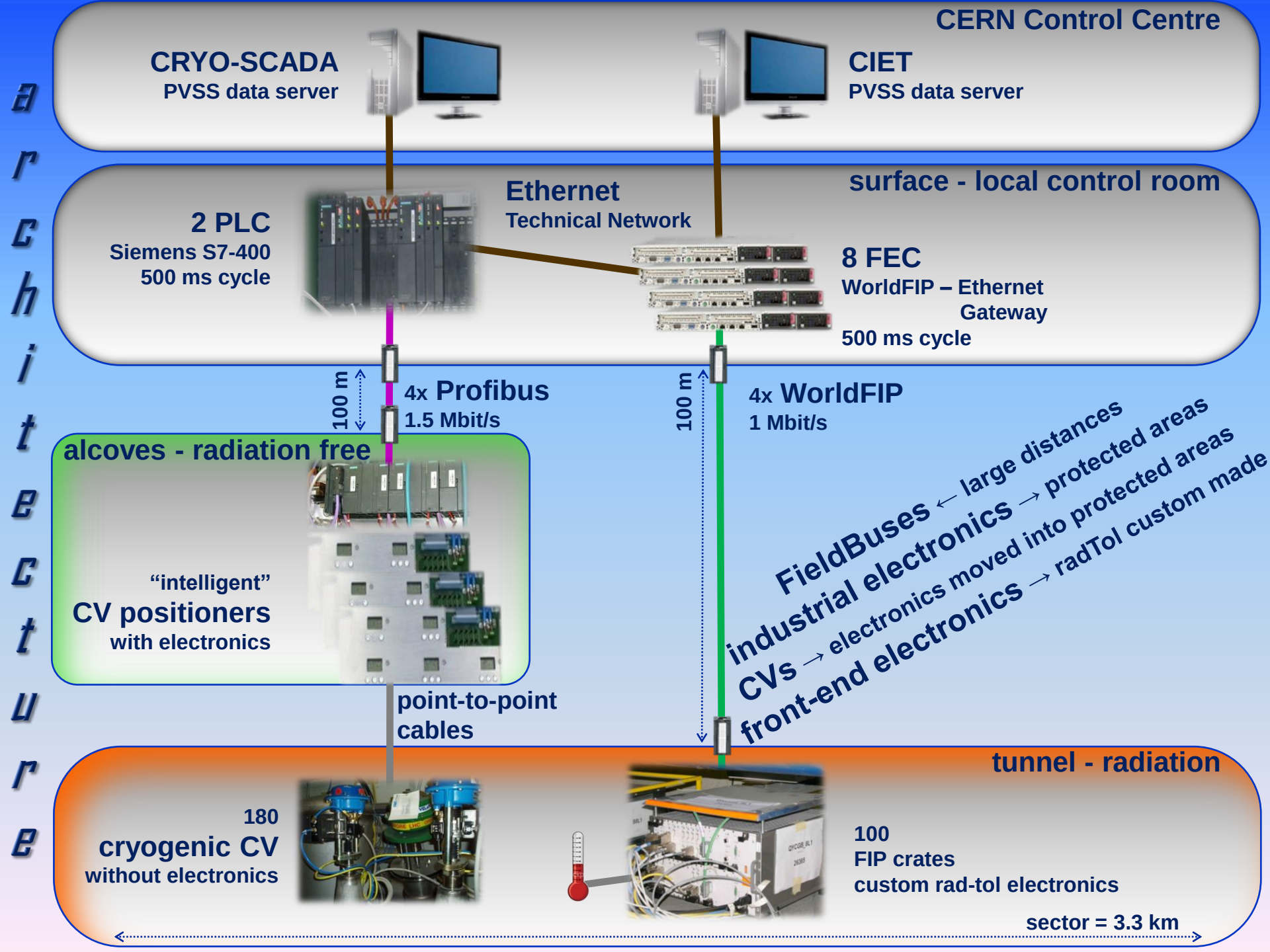
RF superconducting accelerator cavities @ 4.5 K







16 cavities
grouped on 4 modules, on IP4
200 cryo instruments


architecture
CERN Control Centre
CRYO-SCADA
PVSS data server
CIET
PVSS data server
surface - local control room
Ethernet
Technical Network
2 PLC
Siemens S7-400
500 ms cycle
8 FEC
WorldFIP – Ethernet
Gateway
500 ms cycle
100 m
4x Profibus
1.5 Mbit/s
100 m
4x WorldFIP
1 Mbit/s
alcoves - radiation free
"intelligent"
CV positioners
with electronics
FieldBuses ← large distances
industrial electronics → protected areas
CVs → electronics moved into protected areas
front-end electronics → radTol custom made
point-to-point
cables
tunnel - radiation
180
cryogenic CV
without electronics
100
FIP crates
custom rad-tol electronics
sector = 3.3 km

a few numbers (per sector)

	TT	CV	PV QV	PT	LT	EH	total
average / sector	1 000	325	90	90	65	310	1 880
total all-sectors	8 000	2 600	720	720	520	2 480	15 040

	FIP crates	FIP segments	Profibus segments	PLC	CCL	alarms interlocks
average / sector	100	8	5	2	2x250	600+500
total all-sectors	800	68	42	16	4 000	8 800

2 000 sensors and actuators

100 FIP crates

2 Siemens S7-400 PLCs

500 Closed Control Loops

1 100 alarms & interlocks

PLC cycle 500 ms

5 600 objects of 16 types

250 000 lines of SCL source code

>3 Mbytes of machine code

AND...

the last 5 sectors were to be deployed at a rate of 1 new sector every 2 weeks

Databases are intensively used (LHC Controls Layout DB)

17 055 instrumentation channels

798 FIP crates 855 cards

1 738 Profibus components

5 000 cable numbers

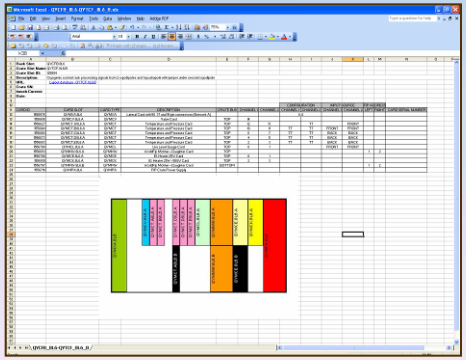
LHC Layout Database

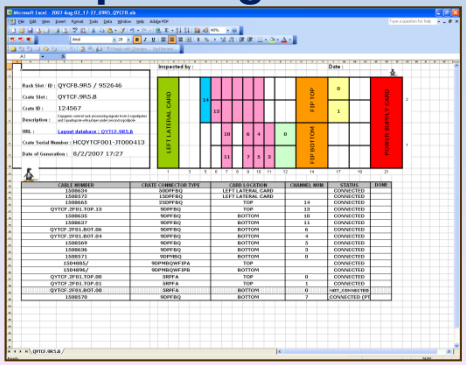
specification files for manufacturing FIP Crates

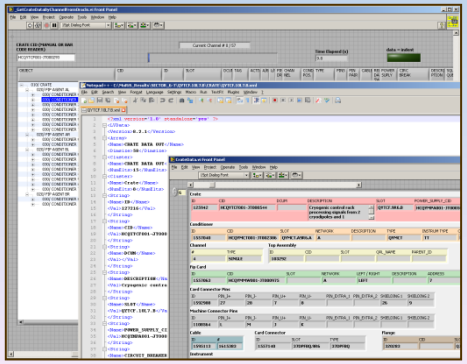
cabling files for connecting & inspecting cables

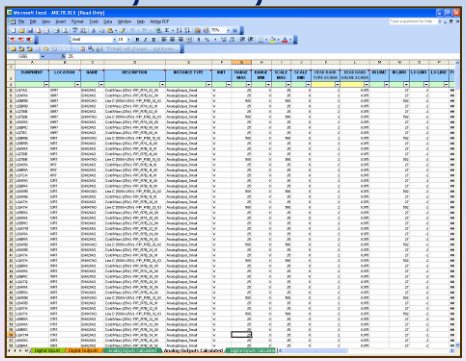
XML files for Mobile Test Bench

specifications for control software PLC , FEC, SCADA









software production cycle

(existing) UNICOS framework (Unified Industrial Control System)

provides methodology & baseline tools to program industrial control systems @ CERN

(developed) generator of process specifications

extracts from DBs the list of all objects, parameters, logical relations

(new) checker of specifications

(written) logic templates

similar code for objects of same family

(new) external function with common logic

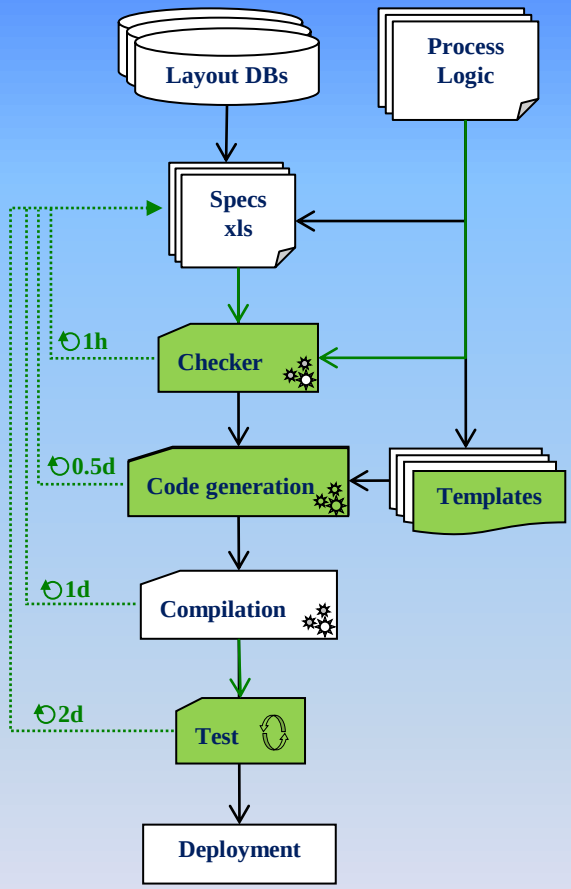
(existing) UNICOS source code generator for PLC & SCADA

(new) generator for specificities not covered by UNICOS gen

code compilation with UNICOS libraries

(new) run/check code on test PLC with simulated inputs

project deployment on field machines



(new) last 5 LHC sectors to be deployed at a rate of 1 new sector every 2 weeks

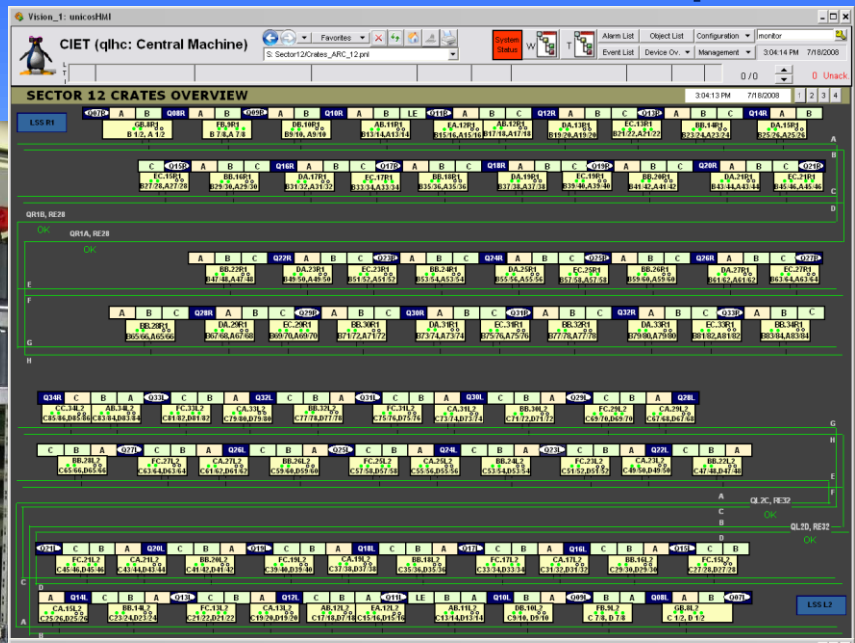
In the end, the full sector code generation took only 2 days

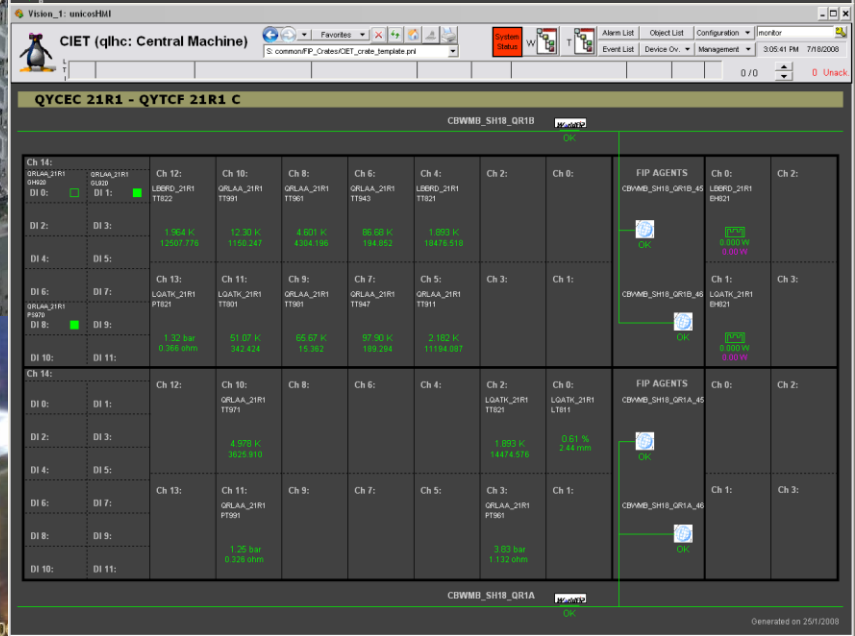
SCADA : Supervisory Control & Data Acquisition

200 panels / sector
40 synoptics, 35 bar-graphs, 60 alarms & interlocks

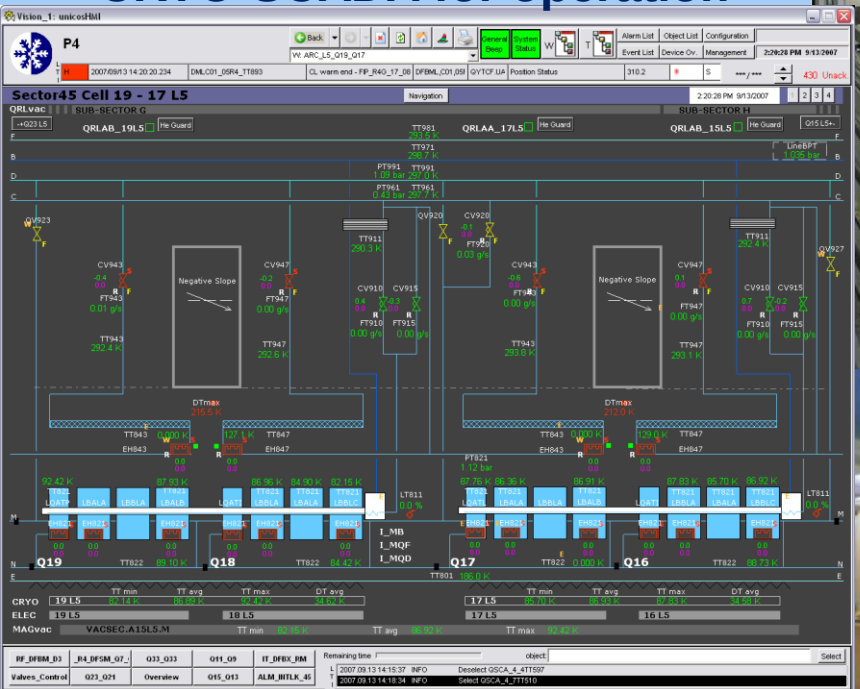
Repetitive panels use parameterized templates
Parameters generator, directly from DB

CIET for Instrumentation Experts





CRYO-SCADA for operation

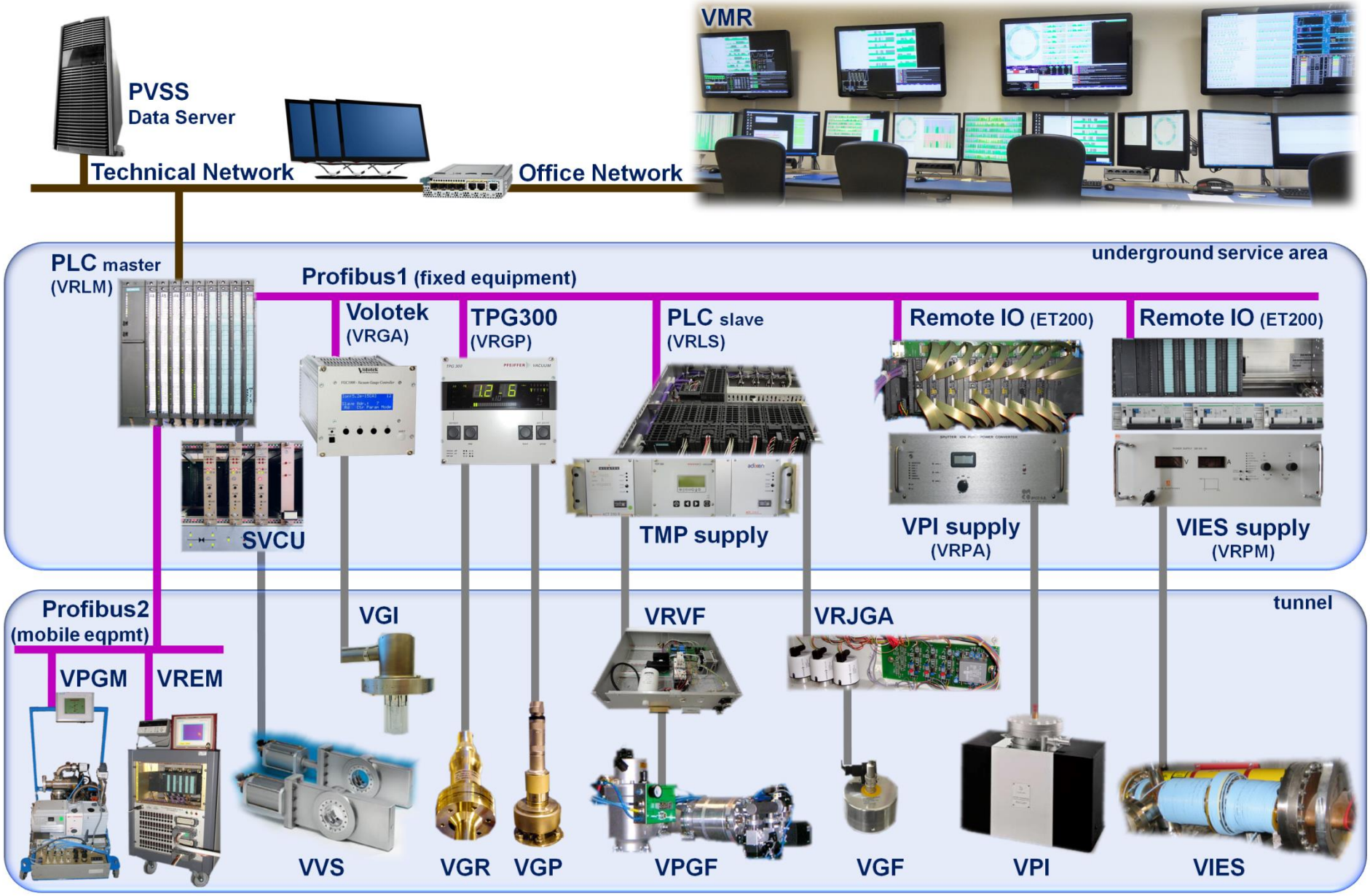


10 Sep 08 – the first proton beams in the LHC

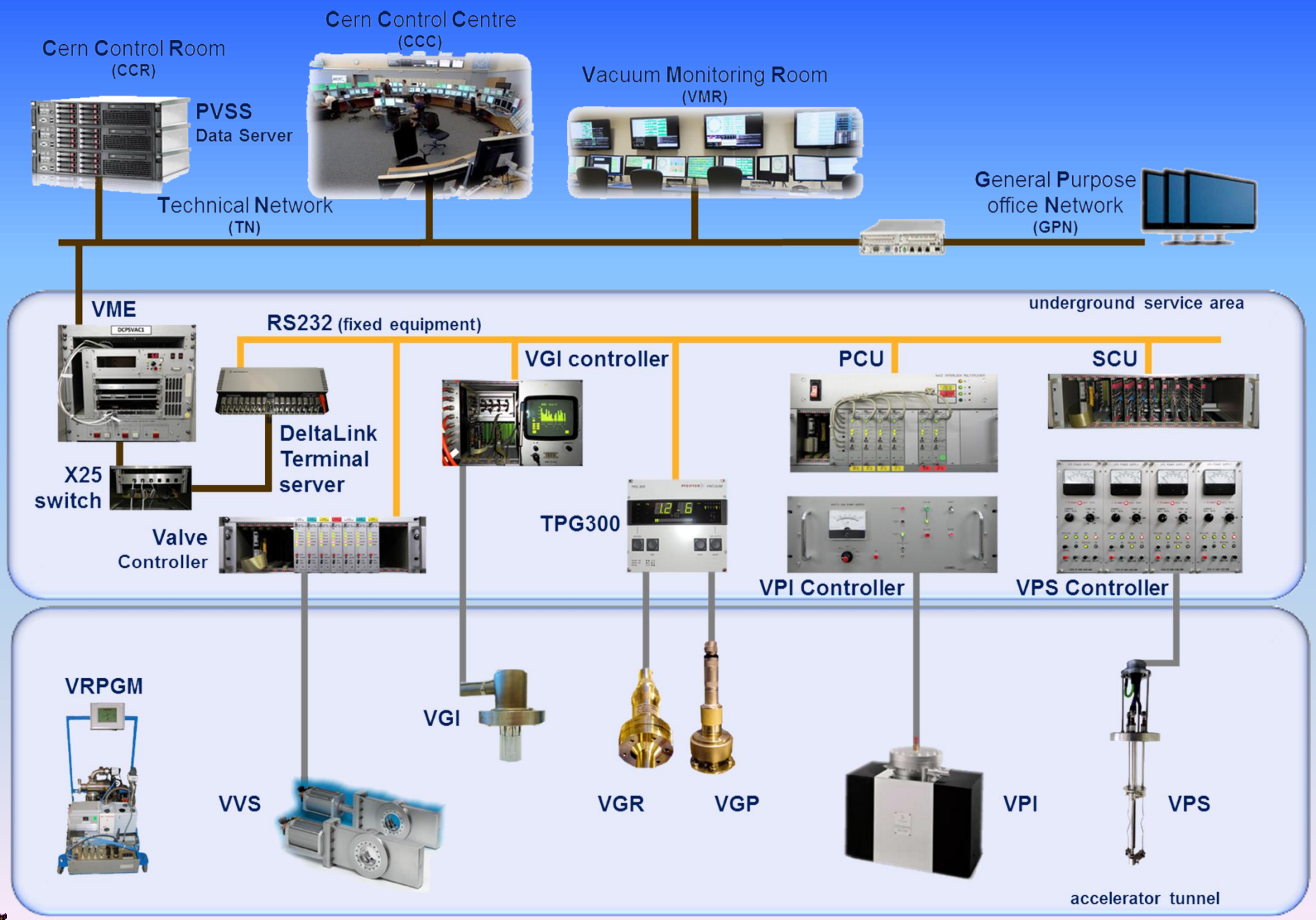
At 10:28, one beam of protons was steered around the machine for the 1st time

ISMA
Centre

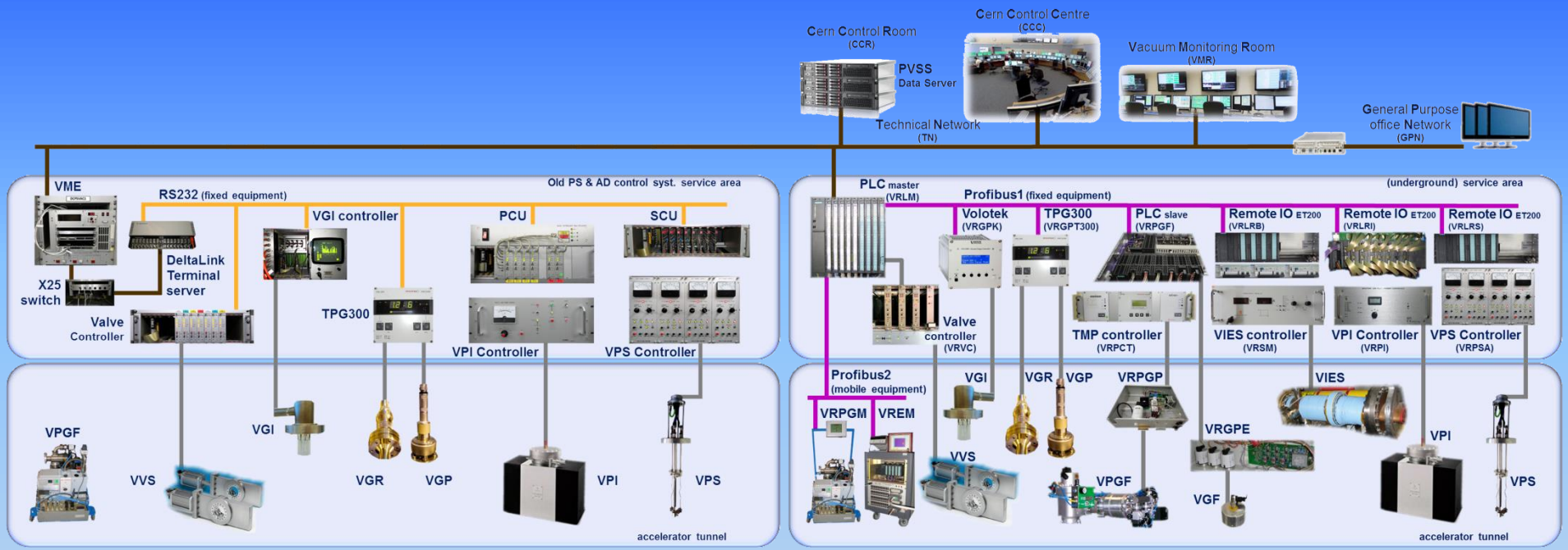
VACUUM : architecture



VACUUM : architecture (old)



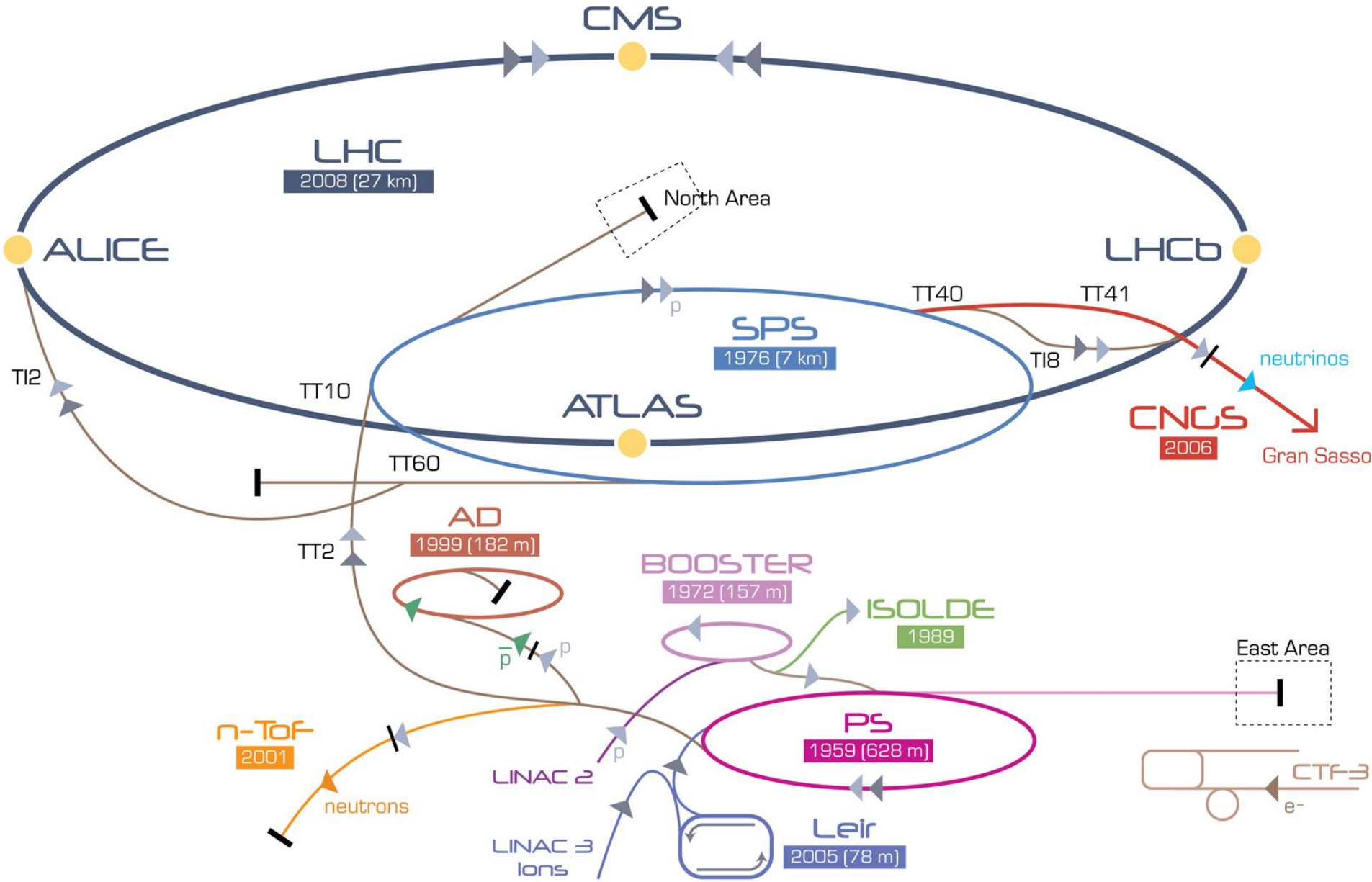
VACUUM : architecture (old -> new)



VACUUM
for all CERN accelerator complex

Instrument count

6 000 instruments to be controlled and monitored,
distributed along 128 km of vacuum, in the range of $10^{-4}..10^{-11}$ mbar



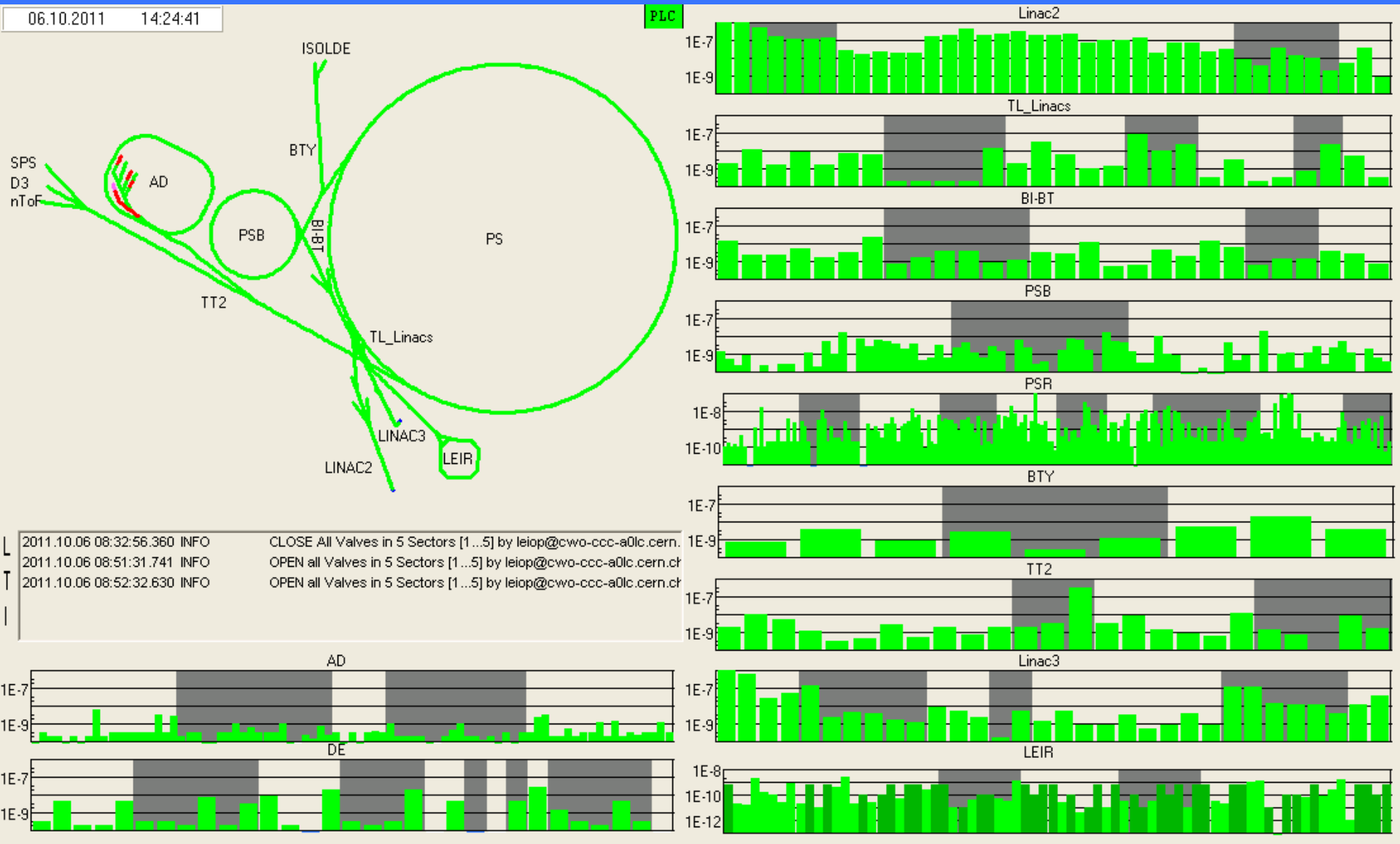
VACUUM
Instrument count

Instrument count

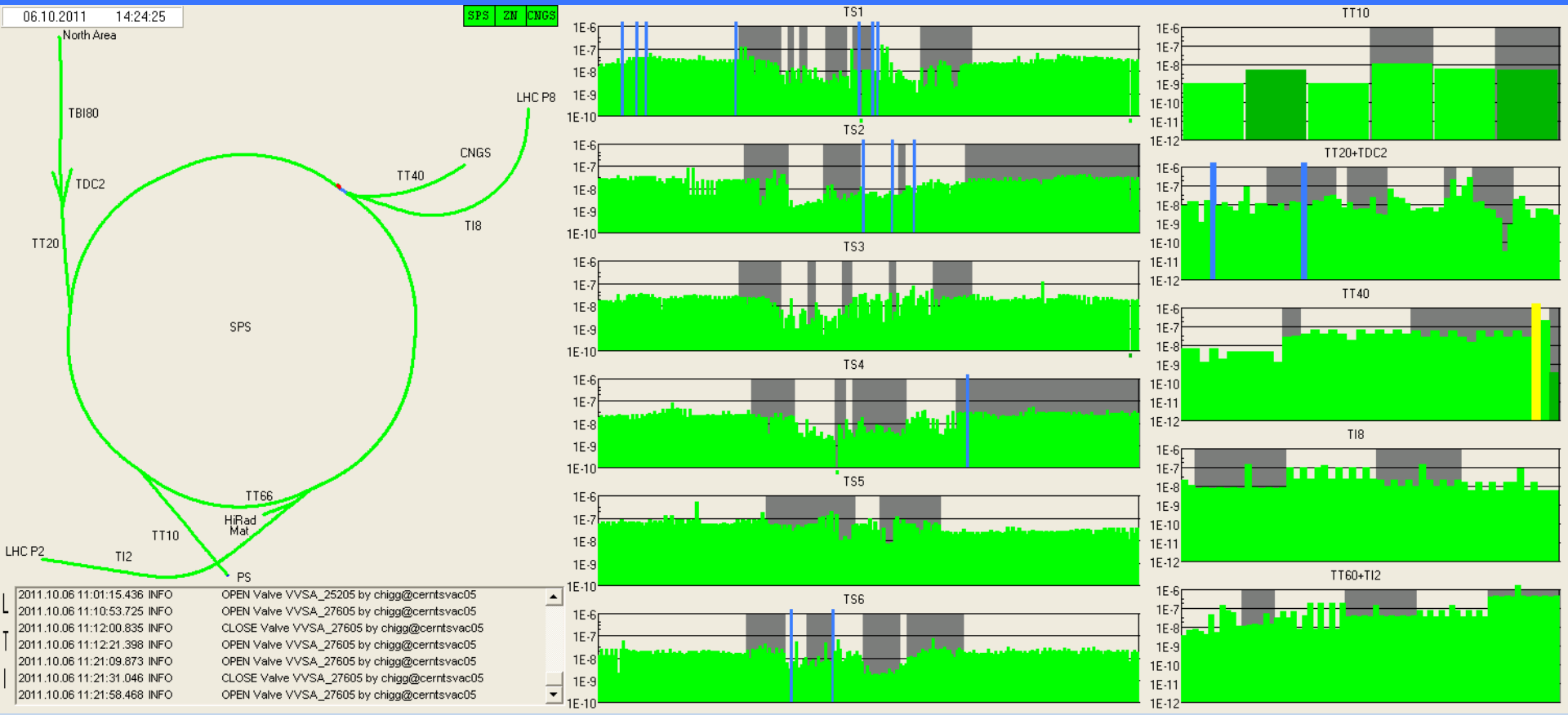
6 000 instruments to be controlled and monitored, distributed along 128 km of vacuum, in the range of $10^{-4}..10^{-11}$ mbar

	L2,L3, PSB,PS	SPS	LHC beam	LHC insul.	other facilities	total
length [km]	2	16	59	50	1	128
log (P [mb])	-7..-10	-7..-9	-8..-11	-5..-7	-4..-10	-4..-11
PLC master	5	8	28		3	44
PLC other	0	10	7		0	17
PLC slave	0	0	100		155	255
VGM	0	0	10	231	0	241
VGR	102	113	428	348	61	1052
VGP	122	128	649	364	66	1329
VGF	0	13	4	0	0	17
VGI	28	0	167	0	16	211
VPGF	7	3	14	179	51	254
VPI	370	1429	825	0	69	2693
VPS	48	0	0	0	0	48
VVS	76	87	305	39	13	520
VVF	0	11	0	0	0	11
VVW	0	5	0	0	0	5

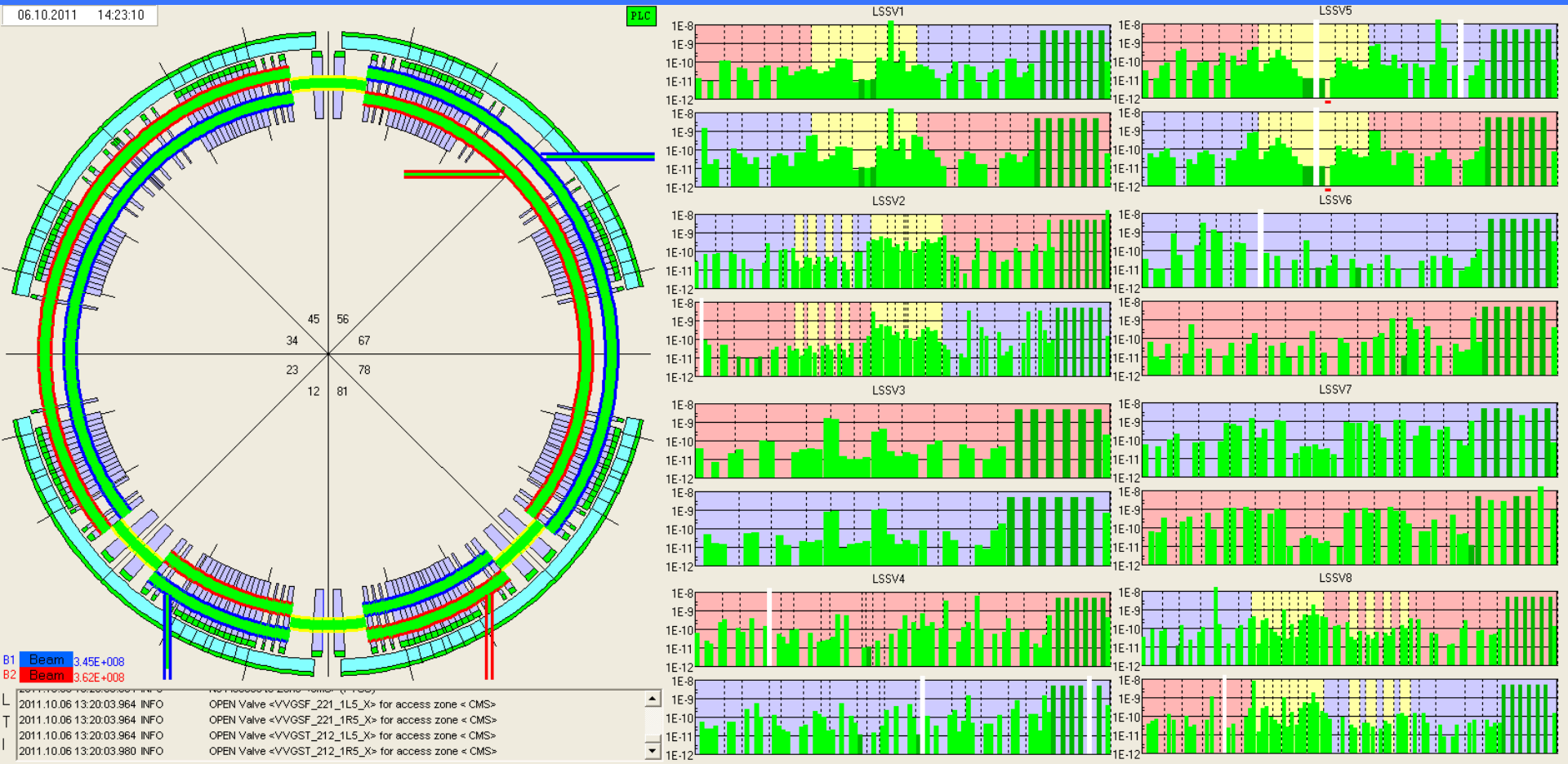
VACUUM SCADA : supervision PS



VACUUM SCADA : supervision SPS



VACUUM SCADA : supervision LHC



CM1