



# *The Control System for the LHC tunnel cryogenics*

*Controlling Cool Accelerators*

*Controle da Criogenia de Aceleradores de Partículas*

**Dr. Paulo Gomes**

on behalf of the team CERN – TE – CRG

with the precious contributions of the colleagues:

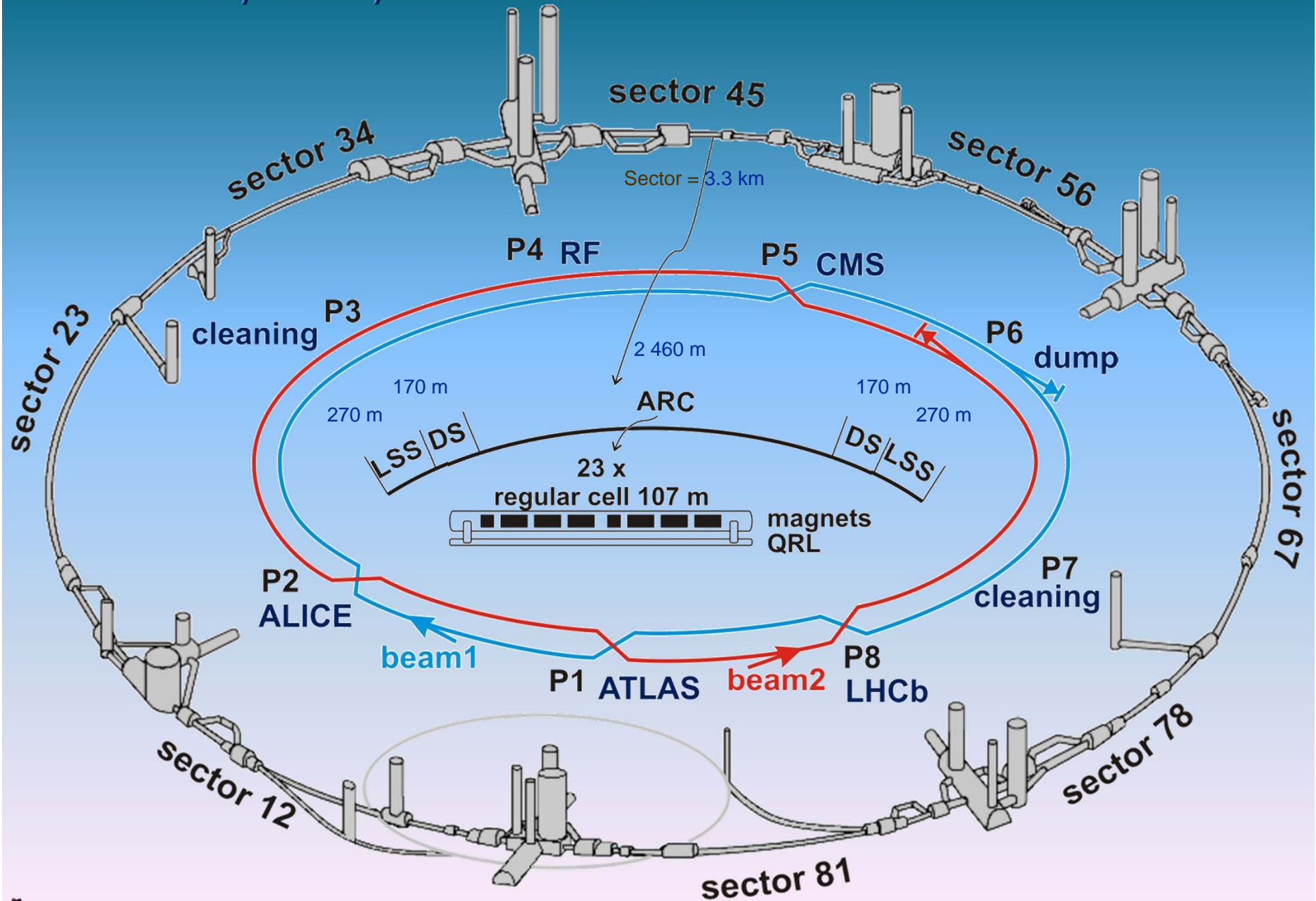
Project Associates (NTU-Athens, AGH-Krakow)

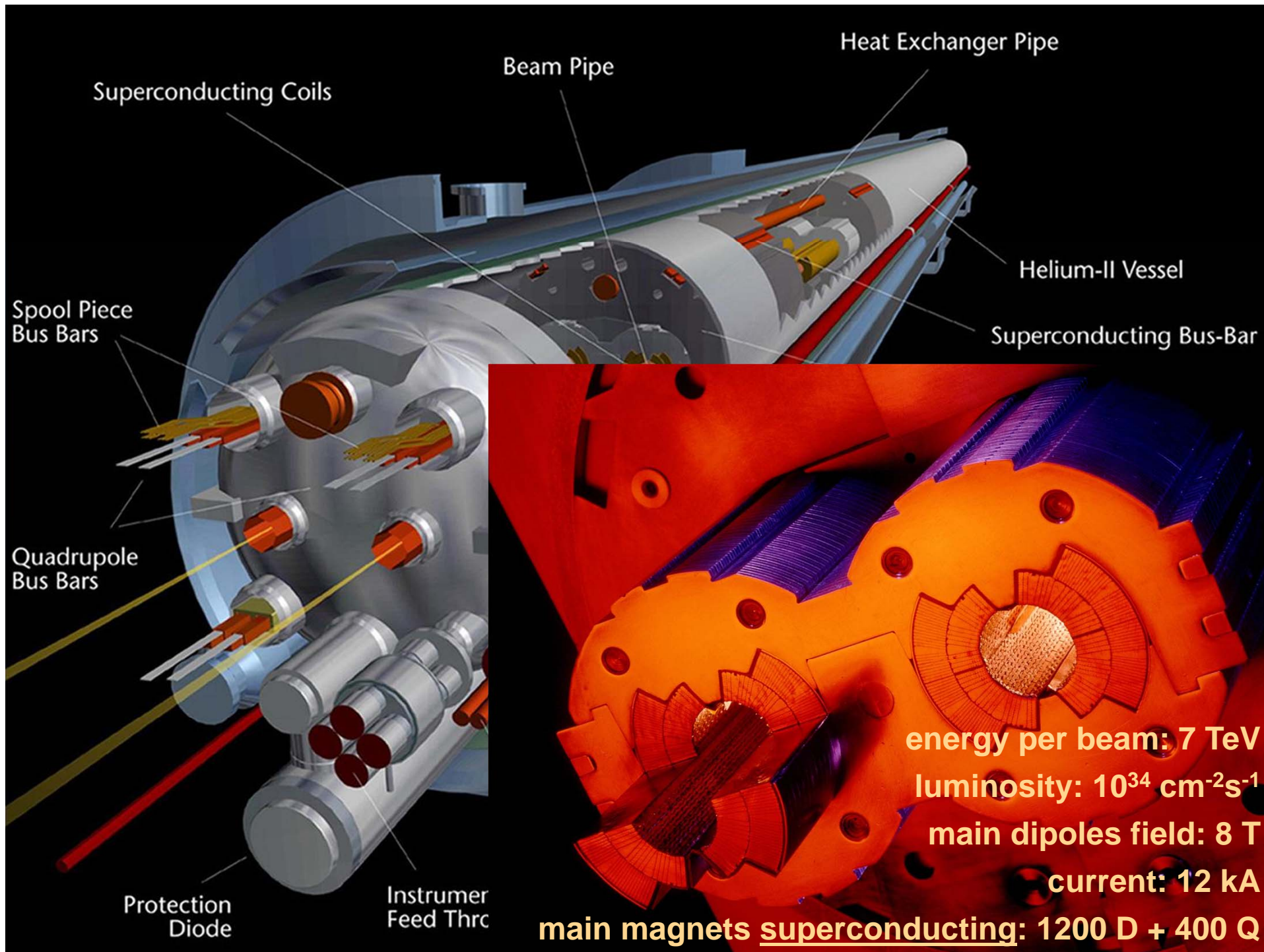
Industrial Support

Cryogenic Operation

AB – CO

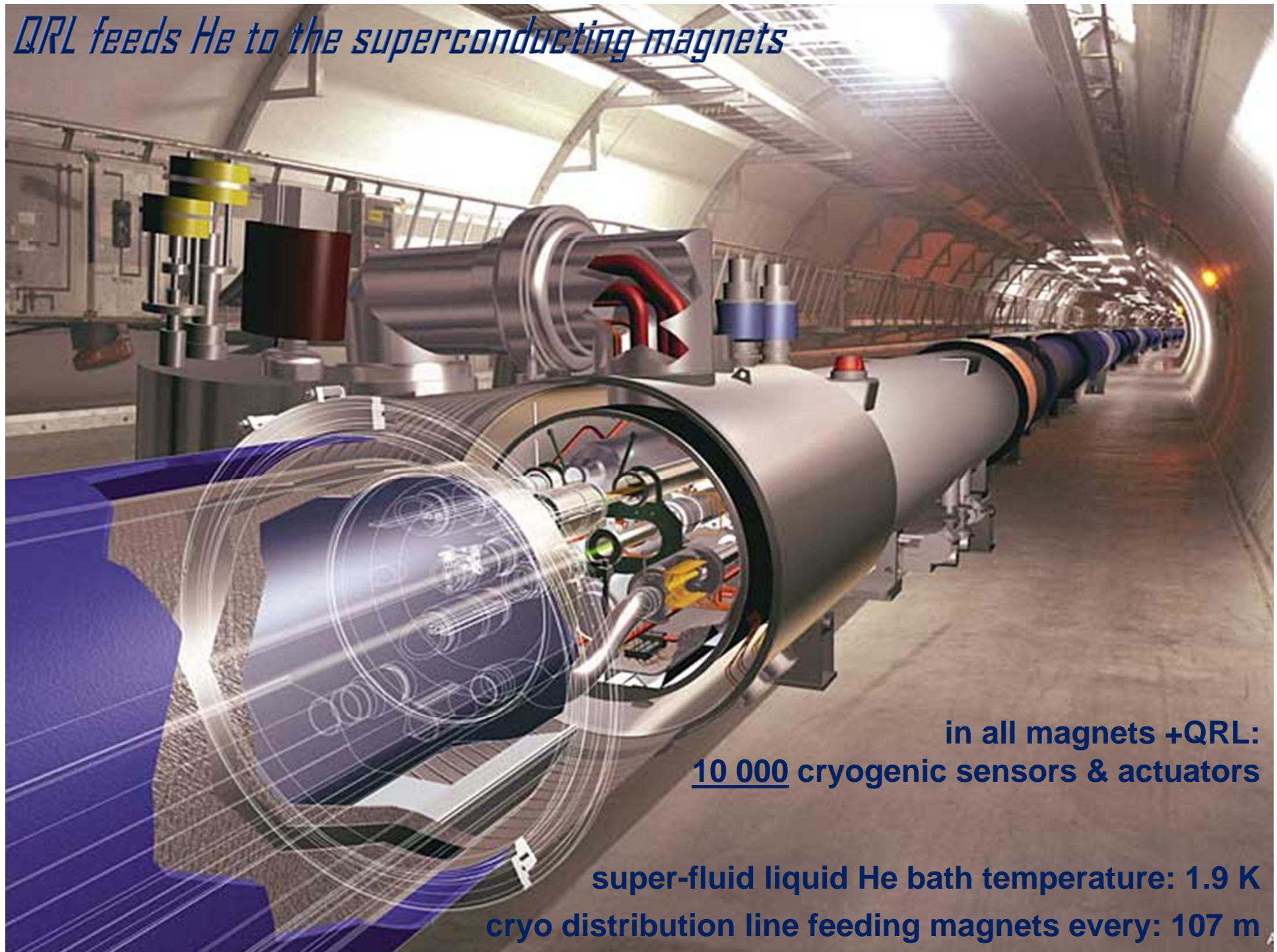
# LHC : 27km proton-proton collider, 8 sectors of 3.3 km







*QRL feeds He to the superconducting magnets*



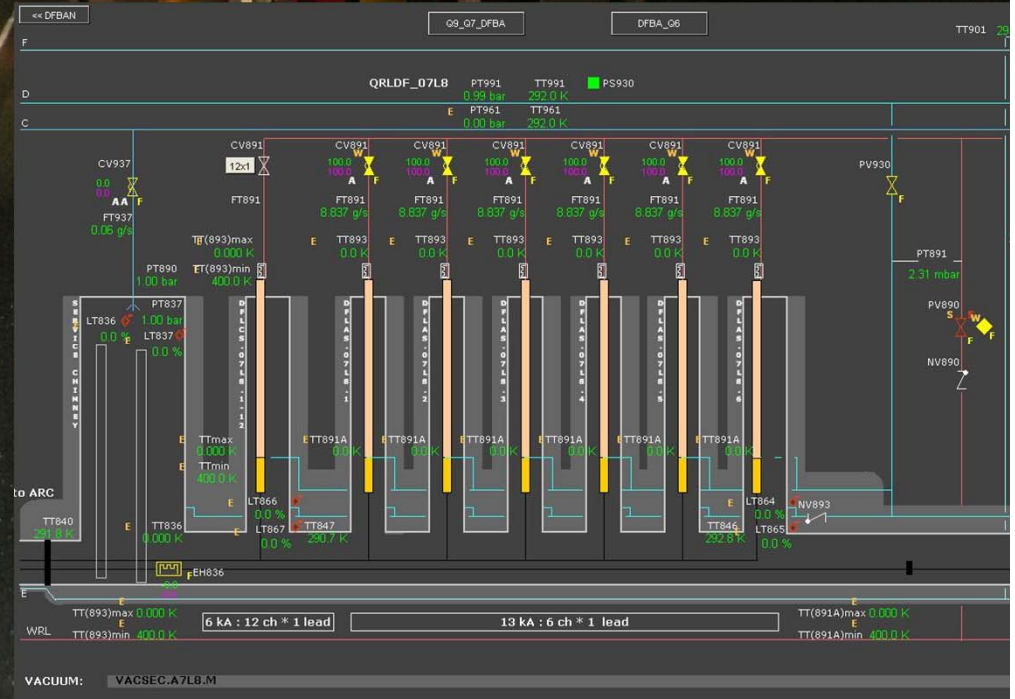
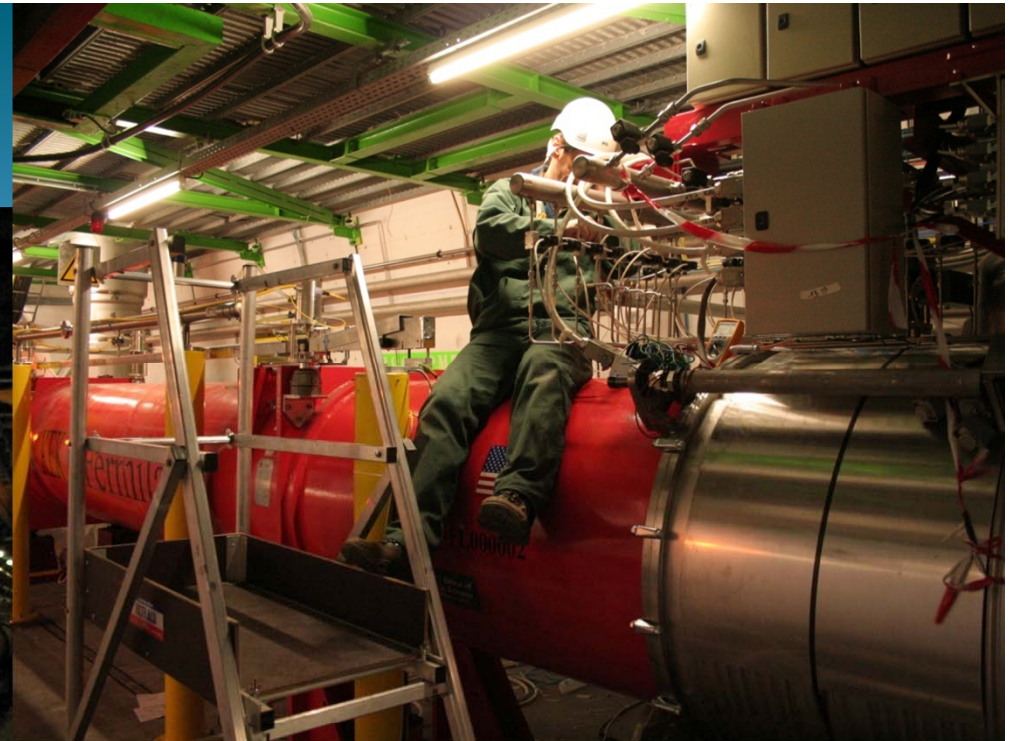
in all magnets +QRL:  
10 000 cryogenic sensors & actuators

super-fluid liquid He bath temperature: 1.9 K  
cryo distribution line feeding magnets every: 107 m



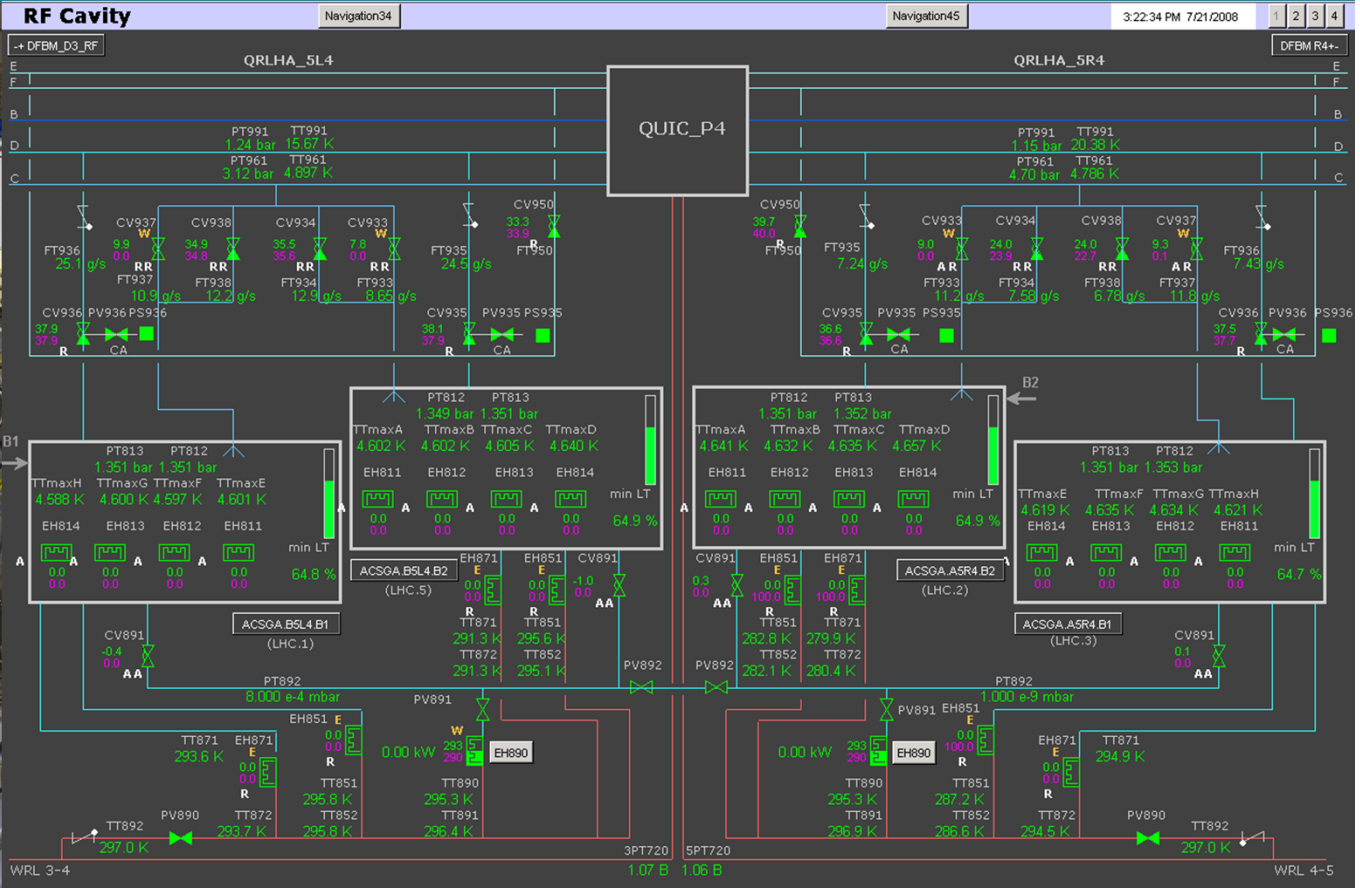
52 DFBs

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

CERN Control Centre

CRYO-SCADA  
PVSS data server

CIET  
PVSS data server

2 PLC  
Siemens S7-400  
500 ms cycle

Ethernet  
Technical Network

surface - local control room

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

point-to-point  
cables

FieldBuses ← large distances  
industrial electronics → protected areas  
CVs → electronics moved into protected areas  
front-end electronics → radTol custom made

180  
cryogenic CV  
without electronics

100  
FIP crates  
custom rad-tol electronics

tunnel - radiation

sector = 3.3 km

E  
P  
C  
h  
i  
t  
E  
C  
t  
U  
P  
E

# 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



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

Channel ID	Name	Status
Q101F-0101.01	Q101F-0101.01	CONNECTED
Q101F-0101.02	Q101F-0101.02	CONNECTED
Q101F-0101.03	Q101F-0101.03	CONNECTED
Q101F-0101.04	Q101F-0101.04	CONNECTED
Q101F-0101.05	Q101F-0101.05	CONNECTED
Q101F-0101.06	Q101F-0101.06	CONNECTED
Q101F-0101.07	Q101F-0101.07	CONNECTED
Q101F-0101.08	Q101F-0101.08	CONNECTED
Q101F-0101.09	Q101F-0101.09	CONNECTED
Q101F-0101.10	Q101F-0101.10	CONNECTED

Cable ID	Name	Status
Q101F-0101.01	Q101F-0101.01	CONNECTED
Q101F-0101.02	Q101F-0101.02	CONNECTED
Q101F-0101.03	Q101F-0101.03	CONNECTED
Q101F-0101.04	Q101F-0101.04	CONNECTED
Q101F-0101.05	Q101F-0101.05	CONNECTED
Q101F-0101.06	Q101F-0101.06	CONNECTED
Q101F-0101.07	Q101F-0101.07	CONNECTED
Q101F-0101.08	Q101F-0101.08	CONNECTED
Q101F-0101.09	Q101F-0101.09	CONNECTED
Q101F-0101.10	Q101F-0101.10	CONNECTED

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

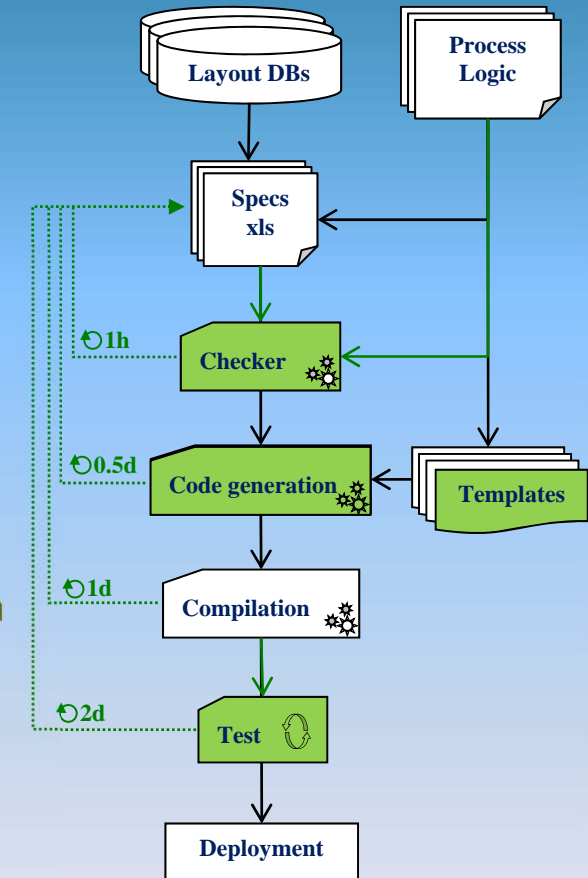
code compilation with UNICOS libraries

(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





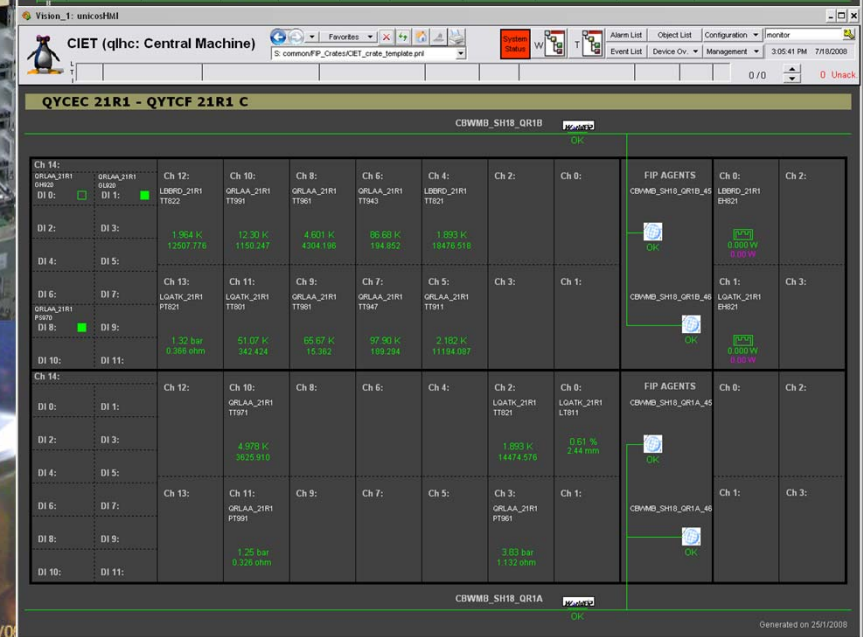
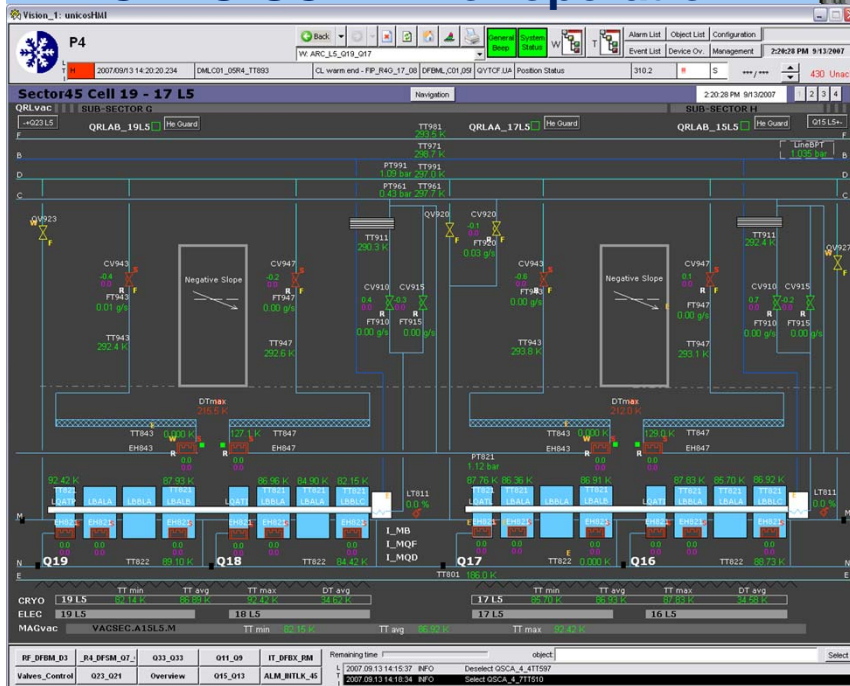
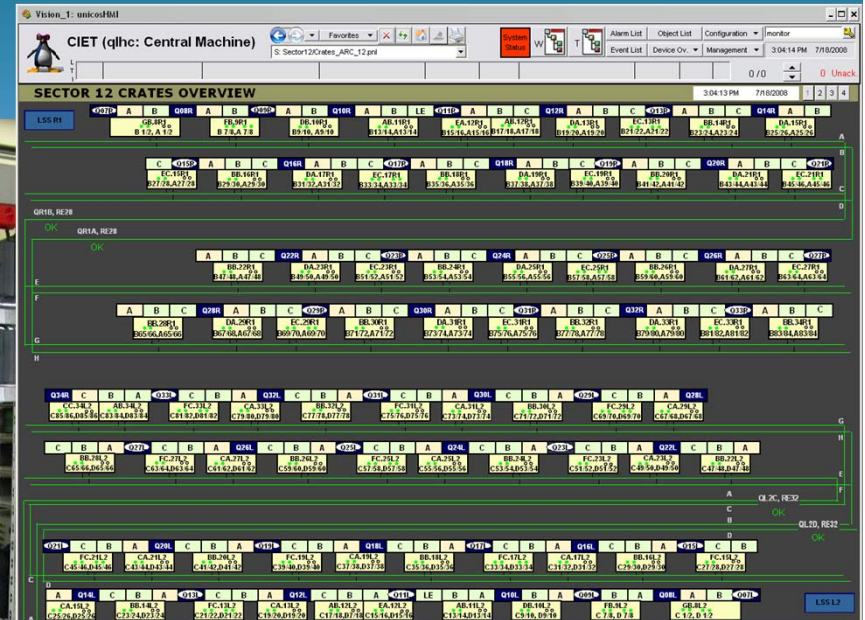
# SCADA : Supervisory Control & Data Acquisition

200 panels / sector  
 40 synoptics, 35 bar-graphs, 60 alarms & interlocks  
 Repetitive panels use parameterized templates  
 Parameters generator, directly from DB

## CRYO-SCADA for operation



## CIET for Instrumentation Experts



## *Conclusions*

**The control software production relies strongly on  
a set of databases and on  
a package of automatic generation tools,  
which have been developed to create code  
in several steps,  
according to a well established methodology**

**The UNICOS automated generation & checking tools proved to be essential for flexible and robust PLC code generation**

**Thanks to extensive automatic code generation, we achieved  
reduced software-production time and effort  
increased code reliability  
minimised risk of human mistakes  
simplified long term maintenance**

**We managed to reach a deployment rate of 1 new sector every 2 weeks,  
while in parallel giving support and modifications on other operating sectors**

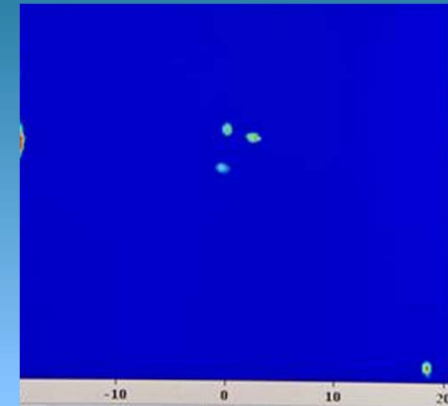
**And...**



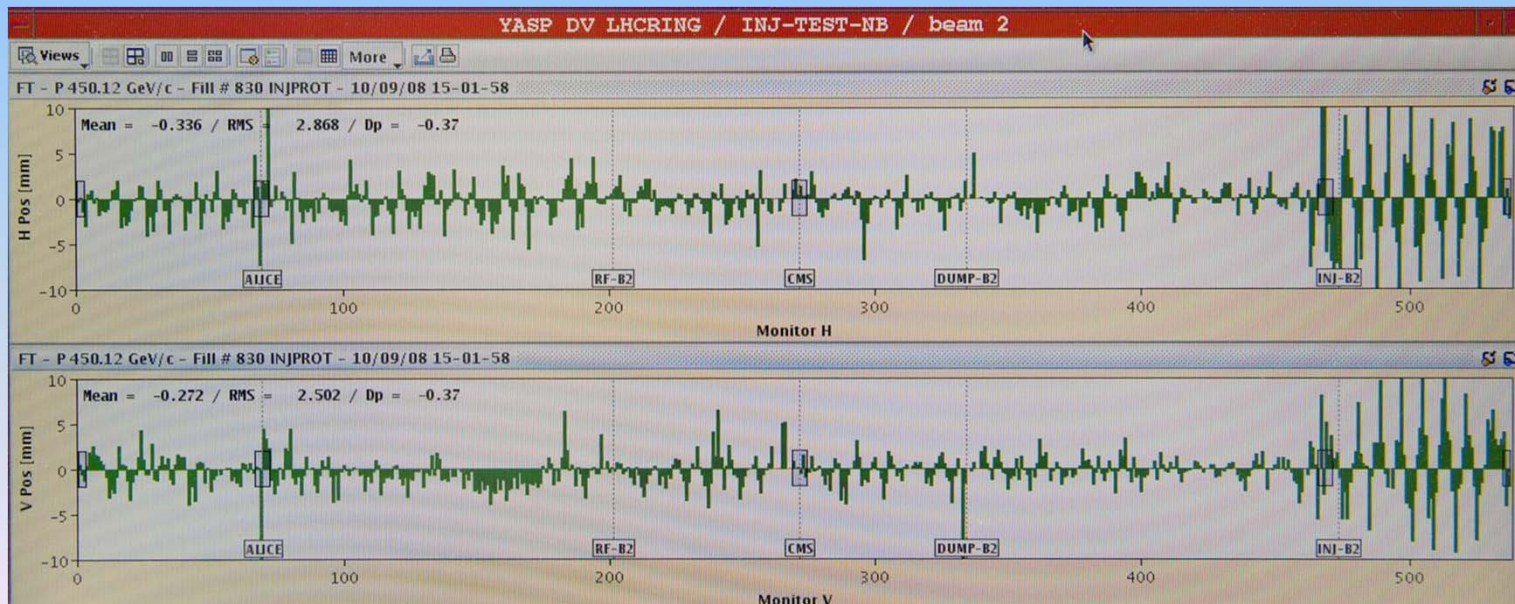


# 10 Sep 08 - the first proton beams in the LHC

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



Around 15:00 the other beam circulated in the second ring (anticlockwise)



(<http://cdsweb.cern.ch/journal/article?issue=39/2008&name=CERNBulletin&category=News%20Articles&number=1&ln=en>)





