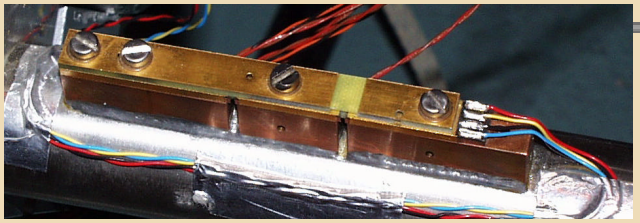
experience with the
Cryogenic Instrumentation and Controls
of String 2

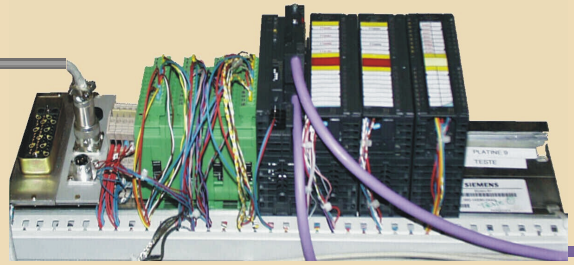
Paulo Gomes
for the ACR-IN team

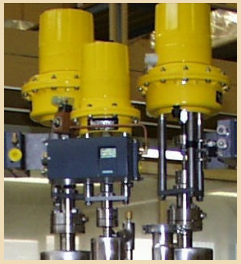
with the precious contributions of
D. Bozzini, L. Serio, his Operators team, IAS, BARC, and many others…

- String2 layout
- LHC regular cell
- commissioning check points
- the commissioning
- the thermometers issue
- other instruments
- LHC

on the machine | distributed racks | central rack | control room

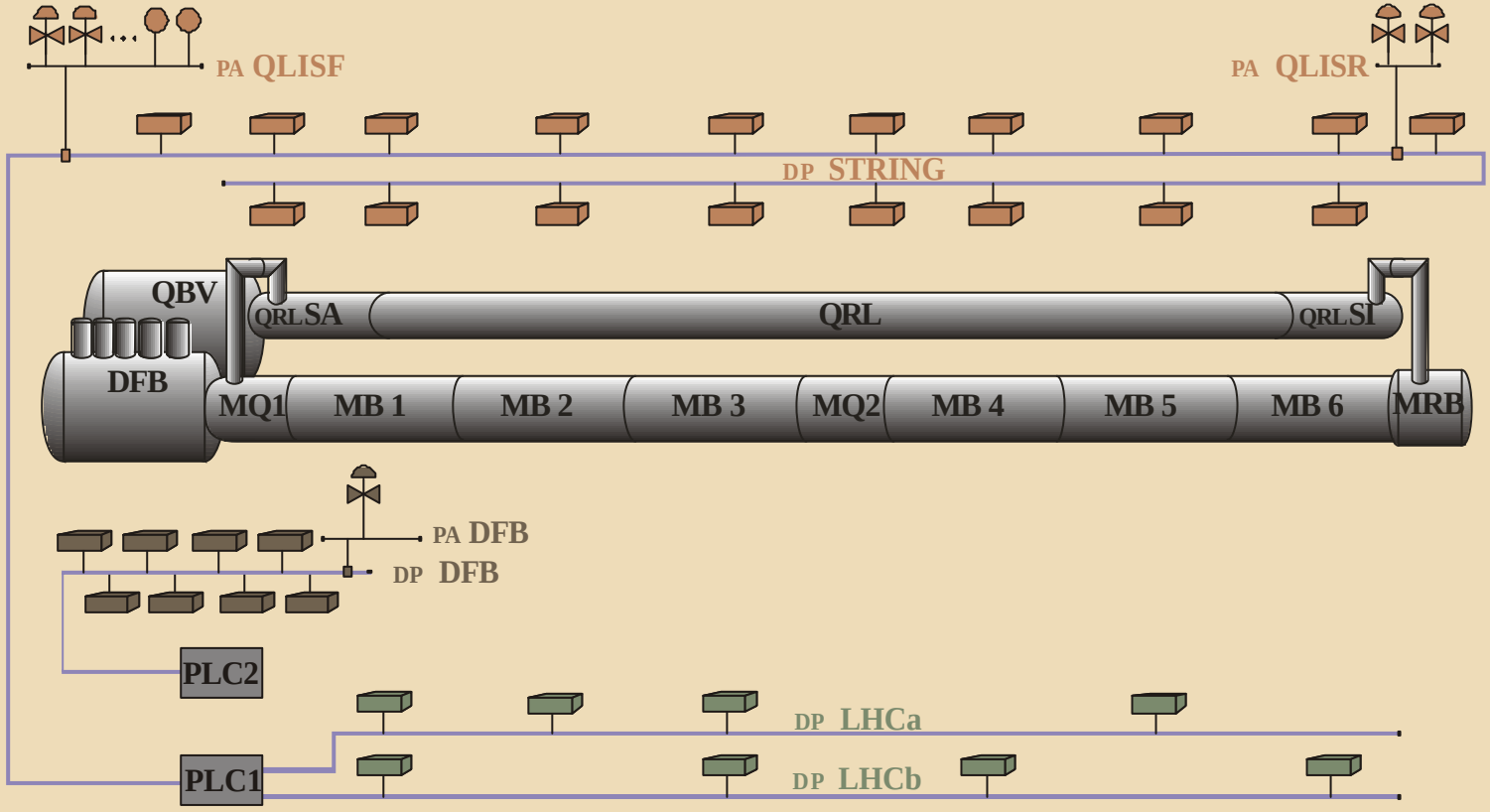




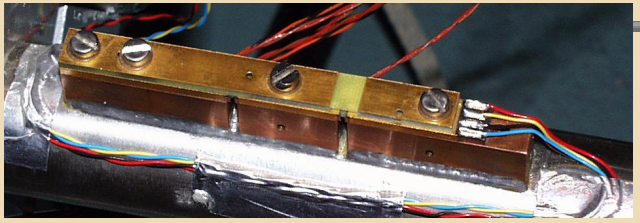


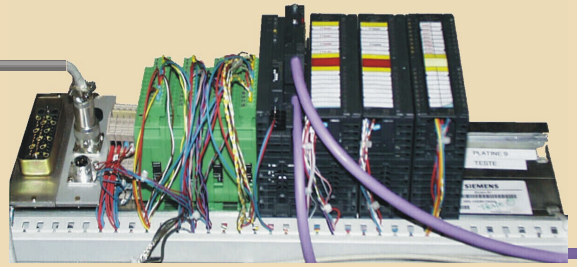
actuators	sensors	signal cables	signal conditioners	remote I/O stations	fieldbus segments	PLC	Ethernet	OWS
80	620	300	350	40	7 Profibus	2		3

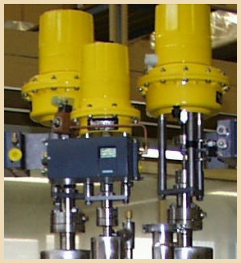
full String 2



intelligent instruments dumb rad-tol instruments	industrial + custom + Siemens ET200M custom ACR/IN rad-tol	Siemens S7-400 UNICOS - Schneider	PCVue32 UNICOS - PVSS







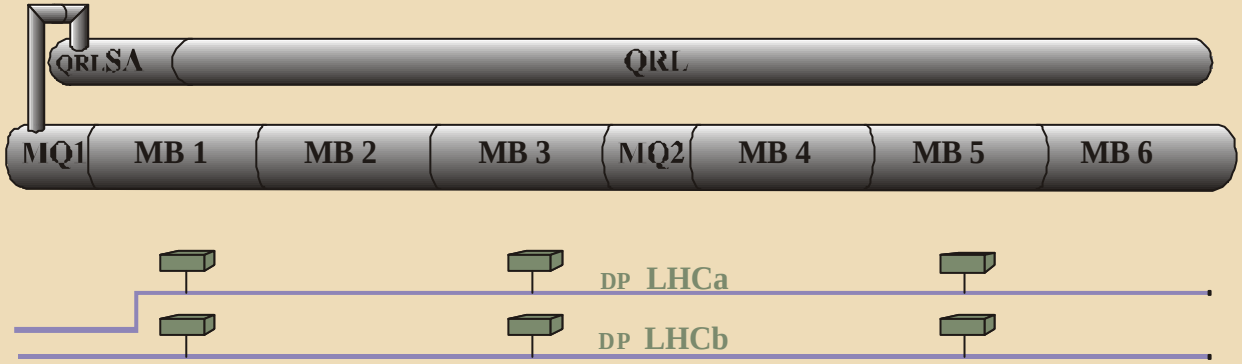
actuators	sensors	signal cables	signal conditioners	remote I/O stations	fieldbus segments	PLC	Ethernet	OWS
80	620	300	350	40	7 Profibus	2		3
16	**23**	**30**	**18**	**6**	**2 WorldFip**			

LHC regular cell

- **one order of magnitude less instruments**
- **more regular topology**

- **custom rad-tol front-end**
- **UNICOS, Schneider, WorldFip**

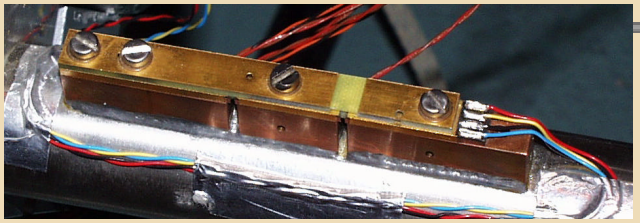
→ **NEED to be validated on the String in 2003**

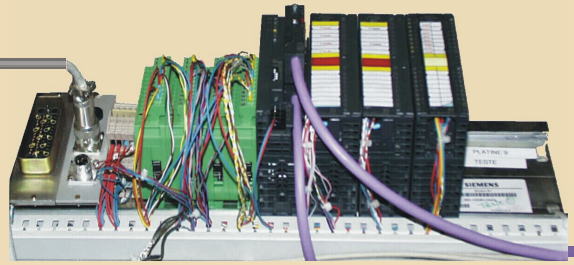


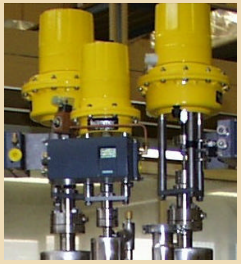
ACR / IN

others

IAS







signal cables
wire damaged
swapped sensors
pin-out

signal conditioners
choice of conditioner type / range
calibration of conditioner
pin-out

remote I/O stations
Profibus address
I/O module type
pin-out

PLC
Profibus addresses
I/O-mem mapping addresses
communication with ABB
logic of interlocks, alarms, process
sensor calibration functions
- correspondence SN --Tag
- mathematical function integrity

OWS
synoptic layout
mapping of
- PLC addresses
- interlocks, alarms, process

sensors
choice of sensor type / range
wrong info on TT type (CX, Pt100, CRT)
correspondence SN --Tag
- swapped SN
- unknown SN
- unreported change of SN
- late info on SN

mechanical mounting
- wire/ block thermalisation

electrical mounting
- electromagnetic noise
- sensor / wire damaged
- pin-out

commissioning checkpoints

Profibus networks
bus terminations
contacts inside connectors

Ethernet
IP addresses, routers

the commissioning

1. Ethernet 2 PLC / EWS / OWS

2. Profibus all remote I/O stations accessible (cable continuity, Profibus address)
all I/O modules well configured, in each station

3. databases PLC & OWS synchronised (by forcing values on PLC)
all parameters & values for sensors / actuators
all parameters & thresholds for interlocks / alarms / process

4. once SPV application on the OWS is reliable,
qualitative inspection of sensor values (@ room T, P) → identification of completely wrong values
wrong pinout / broken sensor, wire, conditioner
CX / Pt100 identification error
wrong range settings

➔ **instrumentation commissioning needs PLC / OWS / ethernet running**

NEED access to LAN in LHC tunnel

5. first set of simple/obvious corrections

6. quantitative/fine inspection of values (@ nominal T, P, dT_gradients)
swapped, inaccurate, non-identified sensors

7. if problem follow signal chain (hardware + software)
connector on machine / connector on rack / connector on I/O module
PLC physical value / PLC engineering value / OWS database

the thermometers issue - identification (440 TT)

SIEMENS S7
R-T-I table
IMGC / To / D Ichim
LHC / ACR / IN / PGomes, ChBalle

CX (Cernox Resistance Thermometer)
R at Room Temperature : 53.37 Ohm
Environement: Vacuum
Current: 0
Temperature Range: 1.6K...295.7K

CX_LS_X08573 DFBS_TT400 22-Aug-01 DB 512

index	R [Ohm]	T [K]	I [mA]	range_bits	index	R [Ohm]	T [K]	I [mA]	range_bits
0	53.637	295.154	7.433	11	32	2355.072	6.041	19.072	10
1	56.989	276.199	7.647	11	33	2461.088	5.763	19.751	10
2	60.341	258.324	7.862	11	34	2673.121	5.425	5.711	00
3	67.046	229.408	8.291	11	35	2885.154	5.132	5.846	00
4	70.398	217.903	8.505	11	36	3097.187	4.880	5.982	00
5	73.751	206.877	8.720	11	37	3309.219	4.661	6.118	00
6	80.455	188.391	9.149	11	38	3521.252	4.470	6.254	00
7	87.160	173.030	9.578	11	39	3733.285	4.298	6.389	00
8	93.864	159.837	10.007	11	40	3945.318	4.148	6.525	00
9	100.569	148.486	10.436	11	41	4157.350	4.010	6.661	00
10	107.273	138.268	10.866	11	42	4369.383	3.885	6.796	00
11	120.683	121.573	11.724	11	43	4793.449	3.670	7.068	00
12	128.728	113.590	12.239	11	44	5005.481	3.575	7.204	00
13	134.092	108.436	12.582	11	45	5111.498	3.542	7.271	00
14	135.364	107.518	12.663	11	46	5217.514	3.482	7.339	00
15	147.501	97.728	13.440	11	47	6065.645	3.194	7.882	00
16	160.910	88.900	14.298	11	48	6913.776	2.973	8.425	00
17	234.745	59.251	19.024	11	49	7761.907	2.797	8.968	00
18	340.761	33.175	6.181	10	50	8185.973	2.723	9.239	00
19	446.777	32.901	6.859	10	51	8398.005	2.686	9.375	00
20	552.794	22.633	7.538	10	52	8504.022	2.672	9.443	00
21	764.826	16.187	8.895	10	53	8610.038	2.652	9.510	00
22	870.843	14.940	9.573	10	54	9458.169	2.530	10.053	00
23	976.859	12.766	10.252	10	55	10306.300	2.426	10.596	00
24	1188.892	10.697	11.609	10	56	11154.431	2.336	11.139	00
25	1400.925	9.177	12.966	10	57	12002.562	2.257	11.682	00
26	1506.941	8.641	13.644	10	58	12850.693	2.188	12.224	00
27	1612.957	8.134	14.323	10	59	13698.824	2.124	12.767	00
28	1824.990	7.301	15.680	10	60	15395.086	2.017	13.853	00
29	2037.023	6.695	17.037	10	61	17091.348	1.927	14.938	00
30	2249.056	6.171	18.394	10	62	20483.872	1.787	17.110	00
31	2302.064	6.064	18.733	10	63	23876.396	1.682	19.281	00
					64	27268.920	1.599	21.452	00

TT with SAME transfer function **300 Pt100**

TT with INDIVIDUAL transfer function **140 Cernox**

each and every Cernox must be :

UNAMBIGUOUSLY identified

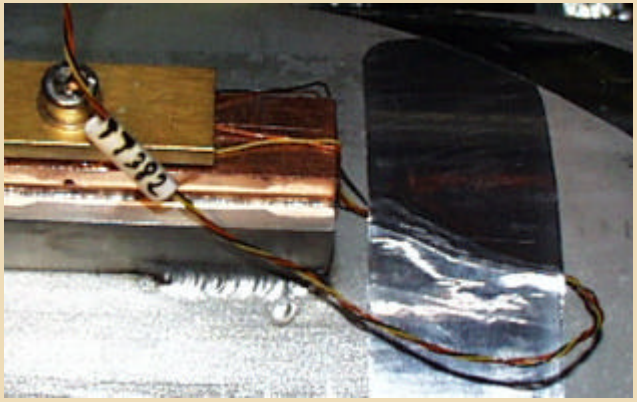
IN TIME for producing the corresponding PLC interpolation table

enormous effort to get IDs from the responsibles of every system

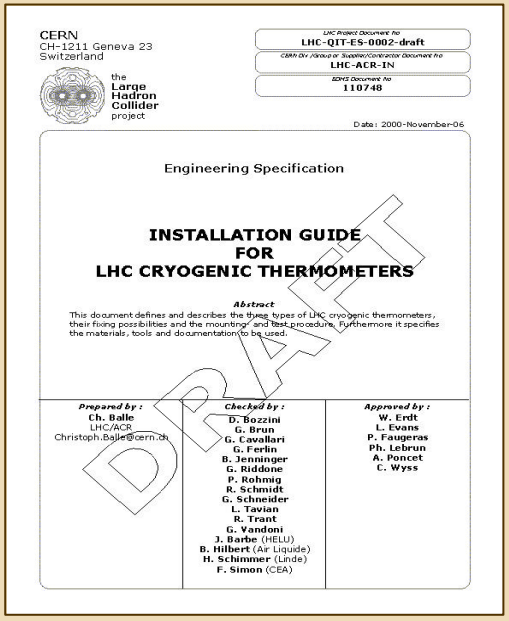
not always correct at the first iteration !!!

NEED much more DISCIPLINE from the TT users

the thermometers issue - installation



wires not protected against sharp edge



CERN
CH-1211 Geneva 23
Switzerland

the Large Hadron Collider project

LHC Project Document No: LHC-QIT-ES-0002-draft
CERN Div /Group or Supplier/Contractor Document No: LHC-ACR-IN
EDMS Document No: 110748

Date: 2000-November-06

Engineering Specification

INSTALLATION GUIDE FOR LHC CRYOGENIC THERMOMETERS

Abstract

This document defines and describes the three types of LHC cryogenic thermometers, their fixing possibilities and the mounting and test procedure. Furthermore it specifies the materials, tools and documentation to be used.

DRAFT

Prepared by :	Checked by :	Approved by :
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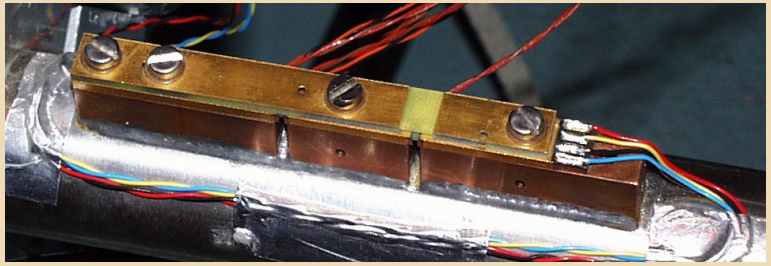
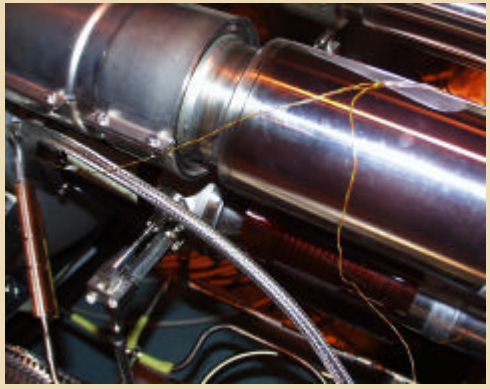
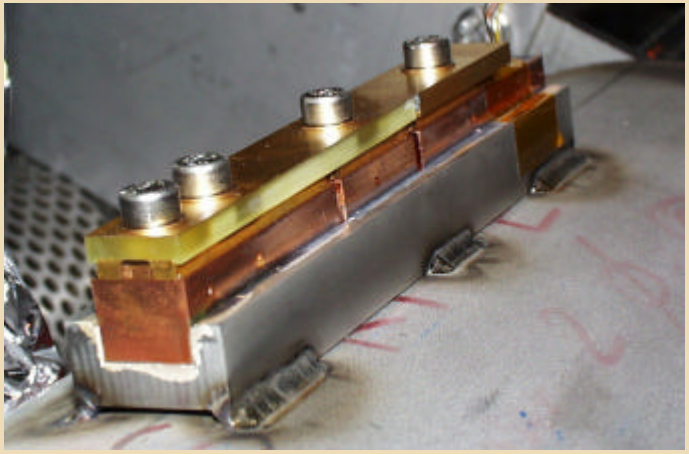
the specs were not respected
(materials, mounting, wiring)



cooper wires instead of manganin wires



dangling and stretched wires



point welding of support

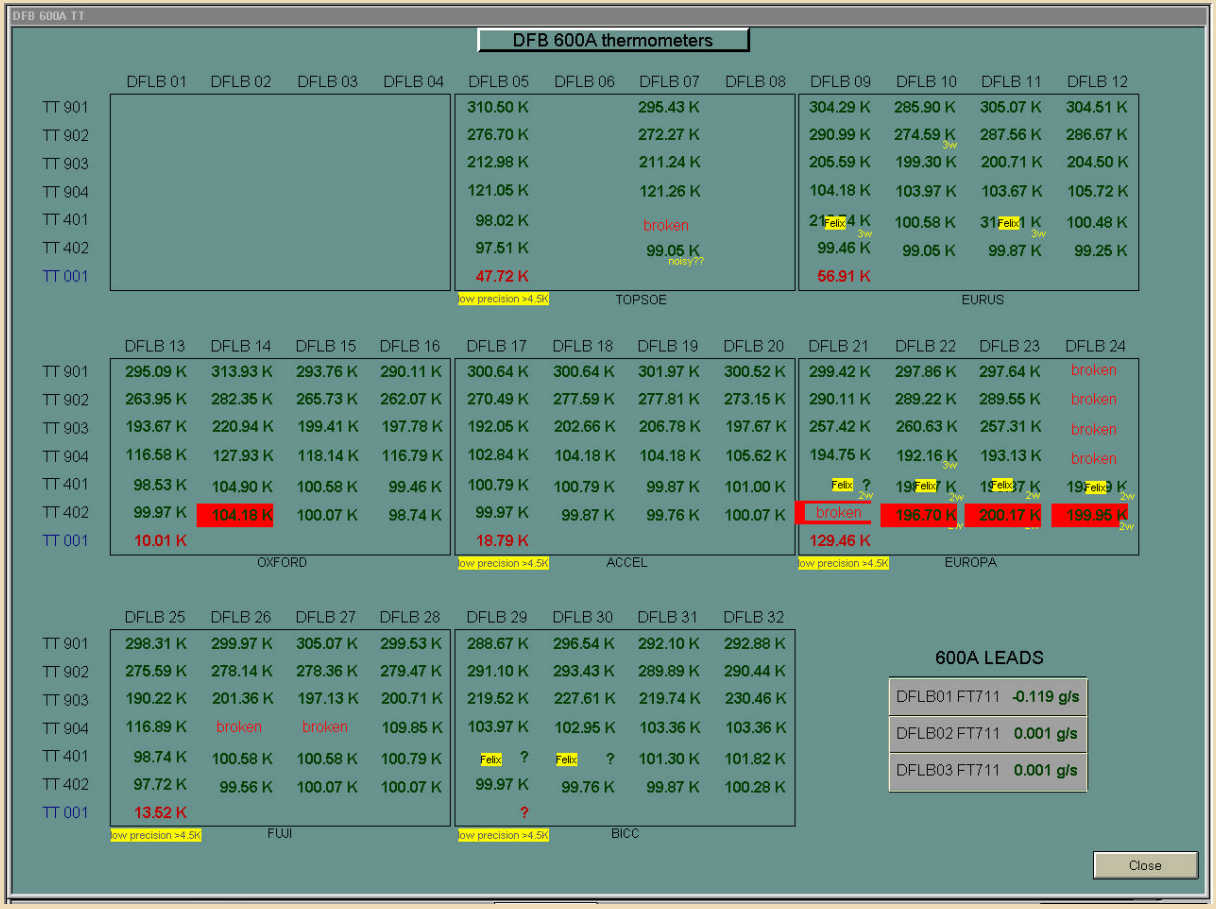
SOME have been repaired

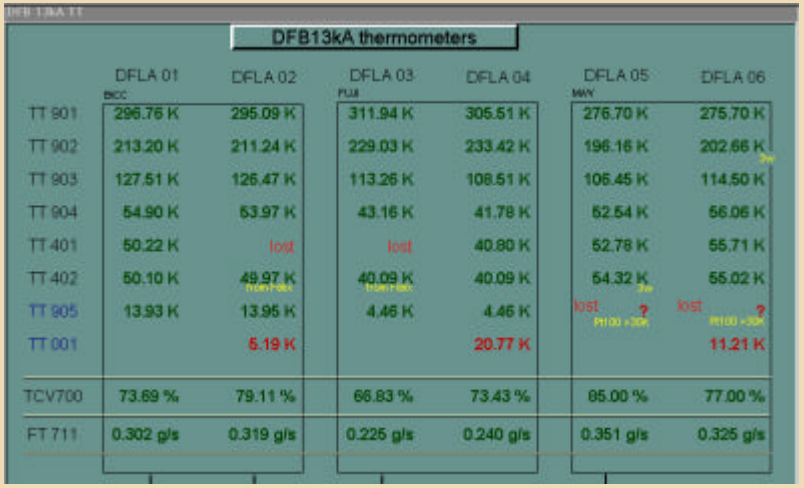
others … nobody has a clue on how they are mounted !!!

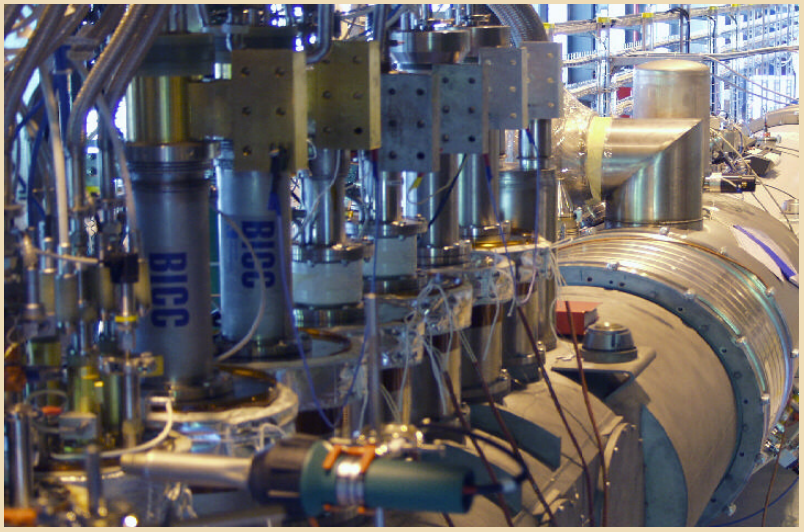
MUST users take photos of every TT ?

the thermometers issue - Current Leads (200 TT)

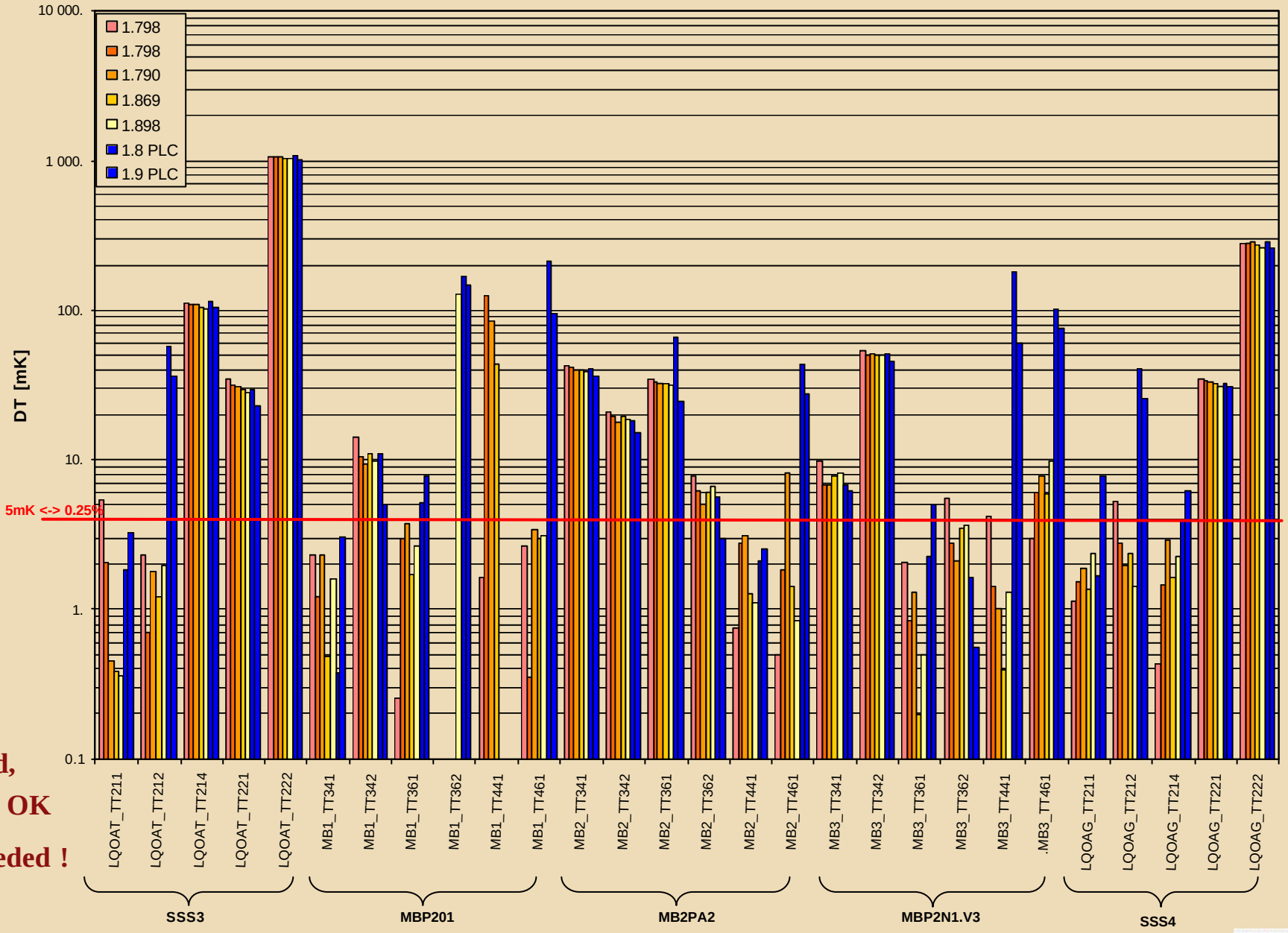
100%	all 38 CL	numbered in reverse order	bad documentation
	in every CL	circular permutation of the 6 TT	
	TT type	some changed from CX to Pt100	quality assurance ?
>10%	>10 TT	lost	
	>10 TT	broken wires	







the thermometers issue - accuracy (28 TT)



in the MAGNETS @ nominal T=1.8K,

expected accuracy is better than 10mK

all errors understood, thermometers calibs OK

no re-calibration needed !

the thermometers issue - magnets (28 TT)

MQ1 / SSS3:

1/3	1 TTcm	bad calib of unknown origin	100 mK
2/2	1 TTvac	not perfect mounting	30 mK
	1 TTvac	Cu wires + 10cm inox	1 000 mK
	1 TT	to gnd	~

MQ2 / SSS4:

2/3	2 TTcm	swapped	✓
	1 TTvac	not perfect mounting	30 mK
2/2	1 TTvac	10cm inox	300 mK
	3 TT	broken wires	~
	2 TT	reversed wires	~
	1 TT	grounded wires	~

MB1 / MBP2O1:

2/2	2 TTcm	lost on the Bench	X
	1 TTcm	replaced	✓
1/4	1 TTvac	broken wires	~

MB2 / MBP2A2:

2/4	2 TTvac	not perfect mounting	40 mK

MB4 / A001_2:

100%	1 TTcm	damaged	~

MB3 / MBP2A1s:

2/2	2 TTcm	damaged on the Bench	~
1/4	1 TTvac	not perfect mounting	50 mK
	1 TT	broken wires	~
	1 TT	reversed wires	~

the thermometers issue - let's be serious!

too many	**broken / grounded wires**	] **most of them repaired** (but degraded accuracy)
	swapped sensors / wires	
	re-installed sensors	**risk of damage**
	lost sensors (during Bench tests ?)	
too long time to	**identify**	
	repair	

- **ACR/IN should not supply TT without knowing their exact destination**
- **users must strictly follow installation guide**
- **users should produce accurate documentation on location, pin-out, follow-up**
- **users should check integrity at all phases of assembly (traveler doc)**

- **ACR/IN has no resources to inspect all systems before closure !**
- **should users take photos of every TT ?**

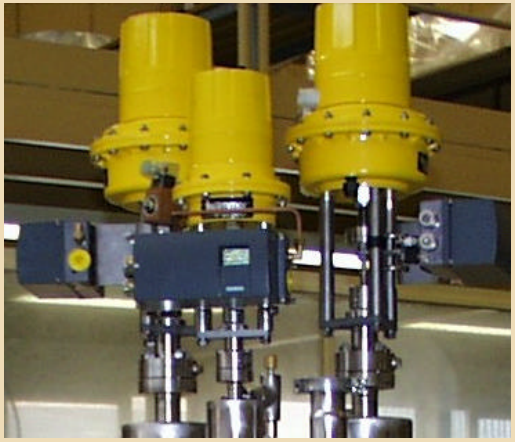
otherwise → **high risk of blindness for LHC !!**
(series magnets have only 1 TT)

other instruments

1 PT	lost in MB1 / MBP2O1
3 LT (LHe wetting indicators)	grounded wires

→ not LHC

1 EH — lost in MB1 / MBP2O1



3/10 intelligent valve positioners — lost firmware config ➔ card replacement

commissioning summary

many unexpected problems

- **3 months to commission only the cooldown related instruments**
- **Operator and Engineering WS next to the plant** → **NEED access to LAN in LHC tunnel**

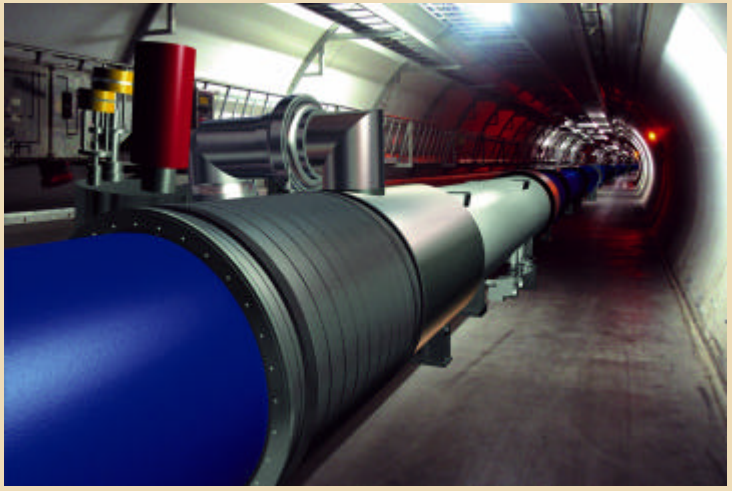
- **2 more months commissioning instruments & control for nominal conditions (T, P, I)**
- **2.5 more months still hunting for bad TT (not yet finished !)**

→ **commissioning time MUST not be neglected !!**

the positive note:

- **we managed to always be on time for the milestones**
- **(also thanks to mechanical assembly delays …)**

and for the LHC ?



- **custom rad-tol front-end, WorldFip, Schneider, UNICOS**
  NEED to be validated on the String in 2003
- **commissioning time MUST not be neglected !!**
- **NEED access to LAN in LHC tunnel for commissioning & maintenance**
- **let's be more serious about the expensive instruments we stuff into the machine !!**