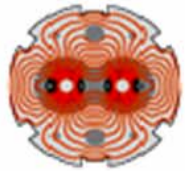
Accelerator
Technology
Department



LHC MAGNET TESTS: OPERATIONAL TECHNIQUES & EMPOWERMENT FOR SUCCESSFUL COMPLETION

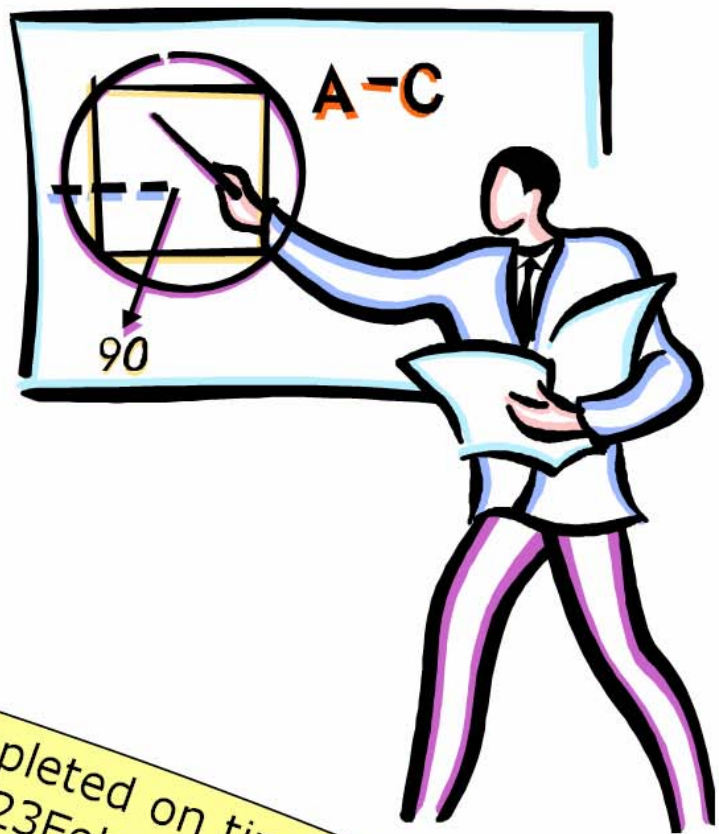
V. Chohan

CERN, Geneva, Switzerland

US Particle Accelerator Conference
Albuquerque, USA
29 June 2007

Outline

- **Introduction & *Achievements***
- **Operational Techniques**
  - ***SMTMS & E-Traveller***
  - ***Magnet Training Criteria***
  - ***Overall & Cryo Priority Handling***
  - ***ROBTC***
  - ***MAPS***
- **Concluding Remarks**

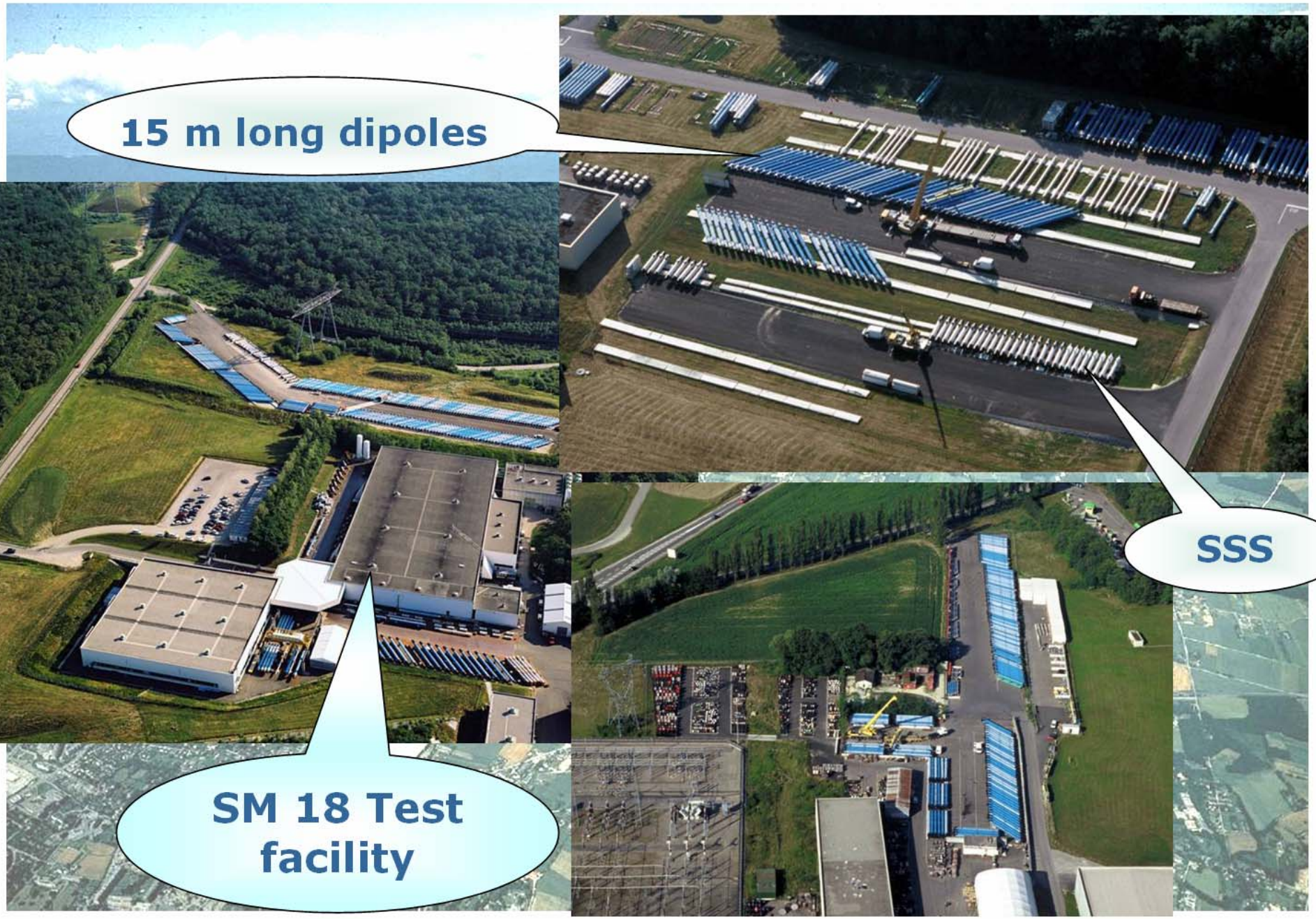


Magnet Tests Completed on time & in budget: 23Feb 07

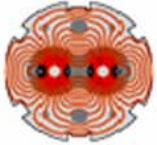
Massive Tests Effort !

Massive Tests Effort !

Massive Tests Effort !



Project Objective

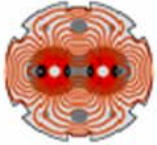


With Limited Infrastructure

& Various Operational Issues, Staffing, etc

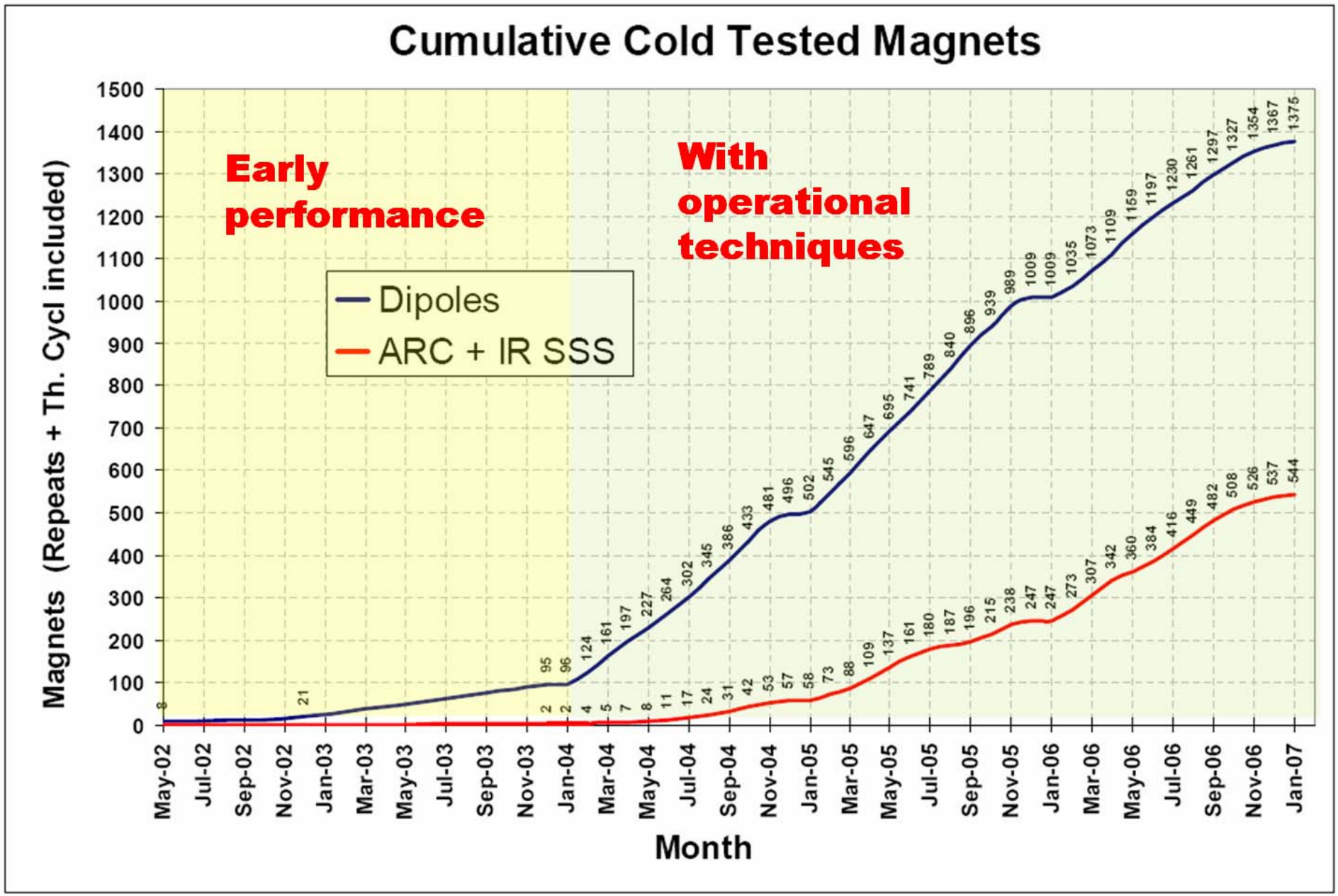
1706 magnets (~1900 *incl. spares & repeats) to be tested before early 2007 !*

Massive, Time Bound Objective!



Magnet testing completed by Feb 2007, within schedule !!!

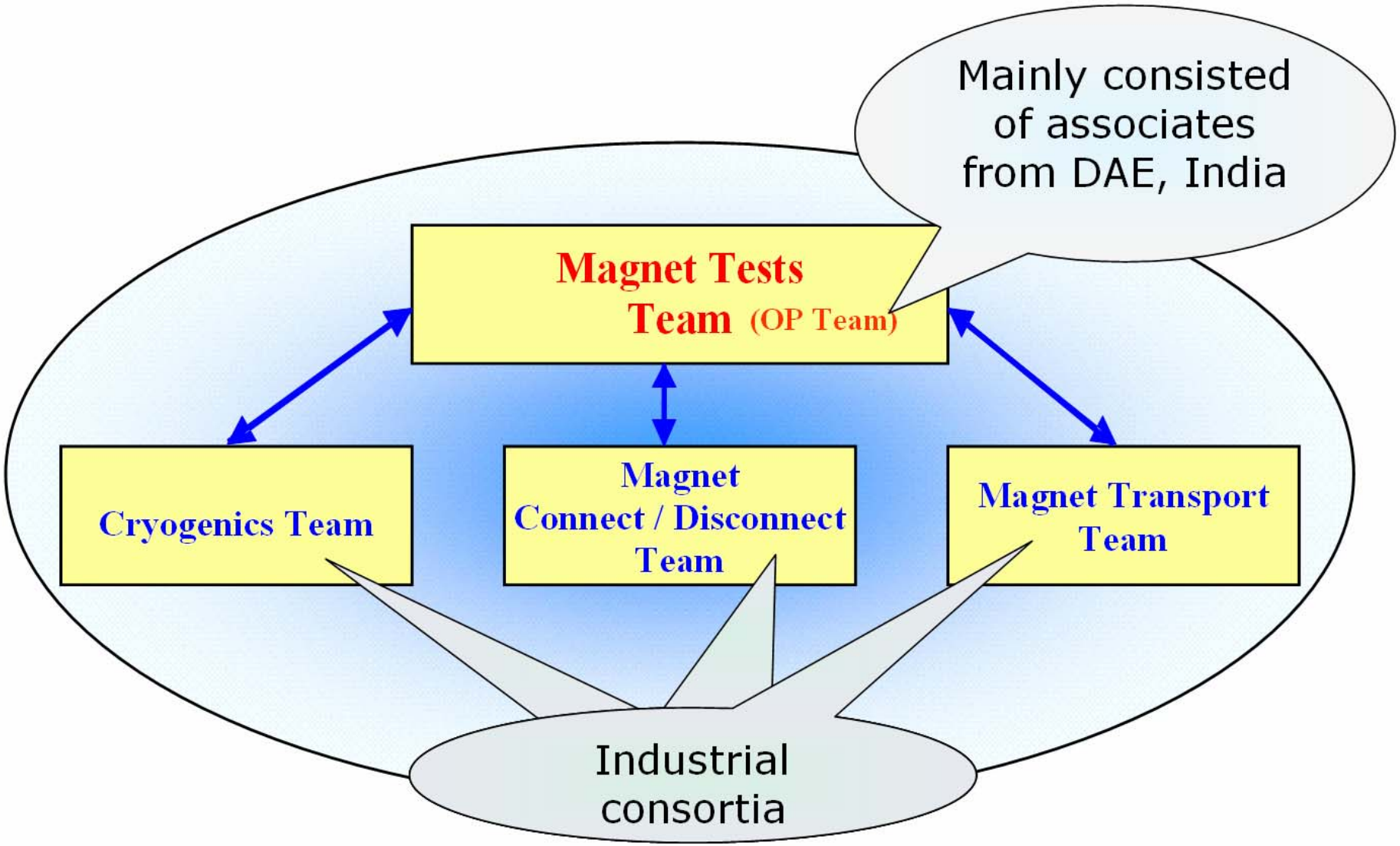
	Required for LHC	*Total tested (incl. spare + repeat)*
Dipoles	**1232**	**1375**
SSS + 5xx	**392**	**450**
IR-SSS	**82**	**94**
Total Magnets tested		**1919**


Cumulative Cold Tested Magnets
Early performance
With operational techniques
Dipoles
ARC + IR SSS
Magnets (Repeats + Th. Cycl included)
Month
0
100
200
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
May-02
Jul-02
Sep-02
Nov-02
Jan-03
Mar-03
May-03
Jul-03
Sep-03
Nov-03
Jan-04
Mar-04
May-04
Jul-04
Sep-04
Nov-04
Jan-05
Mar-05
May-05
Jul-05
Sep-05
Nov-05
Jan-06
Mar-06
May-06
Jul-06
Sep-06
Nov-06
Jan-07
8
21
95
96
124
161
197
227
264
302
345
386
433
481
496
502
545
596
647
695
741
789
840
896
939
989
1009
1009
1035
1073
1109
1159
1197
1230
1261
1297
1327
1354
1367
1375
2
2
4
5
7
8
11
17
24
31
42
53
57
58
73
88
109
137
161
180
187
196
215
238
247
247
273
307
342
360
384
416
449
482
508
526
537
544

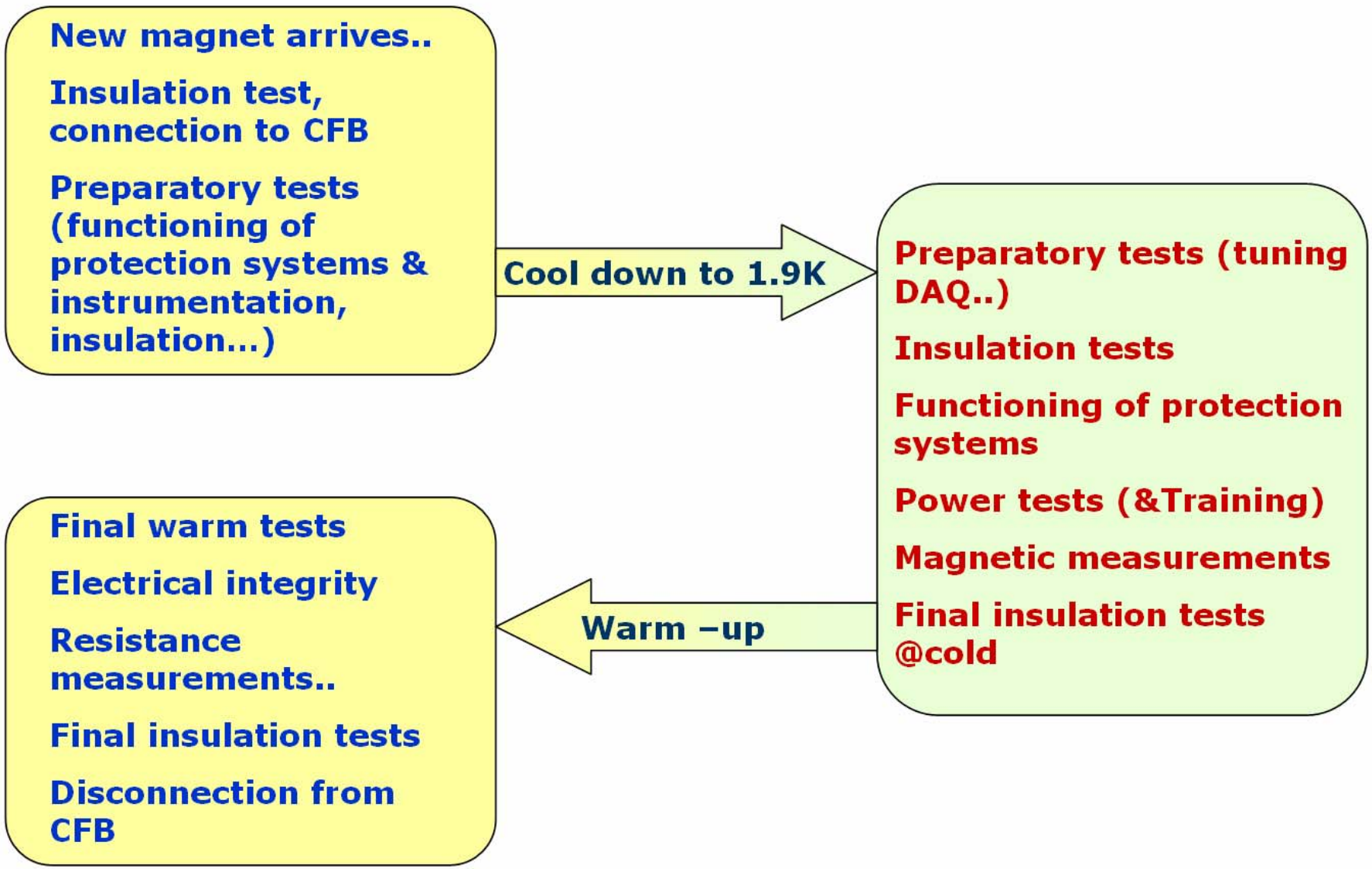
SM18 Test Facility

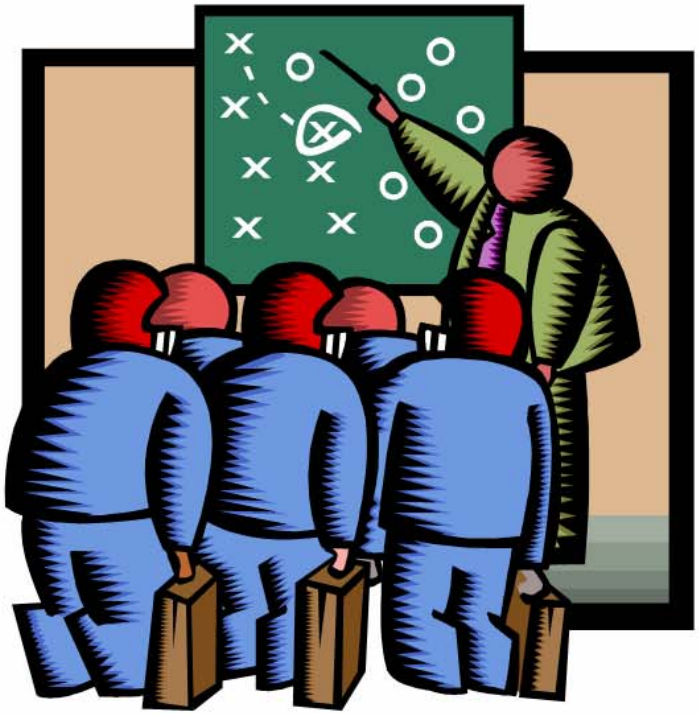
- With 12 test benches, shared resources & Limited Cryogenic infrastructure
- Testing of first series magnets: early 2001 – with only 2 test benches
- All 12 benches ready only by June 2004 !

Staffing: Various Teams of SM18



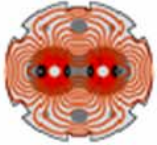
Magnet Tests.. What do we do ?





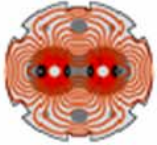
Operational Techniques & Empowerment

Operational Techniques



1. **SM18 Test Management System (SMTMS)**
   - Links electronic repository of tests results with other management tools
2. **E-traveller**
   - Web based, electronic signature based information exchange tool
3. **Modified Magnet Training Criteria**
   - Two-Quench Rule
   - Three Quench Rule
4. **Overall & Cryo priority handling**
   - 24 hour priority decision by OP team for effective & clash-free utilization of ALL resources (Cryo, Power, bench etc)
5. **Rapid On-Bench Thermal Cycle (ROBTC)**
   - Thermal cycle of a poor magnet without disconnection from test bench

Overall & Cryo Priority



- **Limited Cryogenics capacity:**
  - **3 to 5** Magnets @ 1.9K and under cold tests,
  - **Up to 2** magnets in 300K to 80 K phase,
  - **Up to 2** magnets in warm up phase,
  - **2 magnets** in 80K to 4K phase
  - **Max. 3** magnets in cool-down + warm-up together,
  - **Min. 20 minutes** delay between quenches

- **Overall & Cryo Priority allocation for maximising throughput!**

- **OP Team empowered for deciding & setting priorities…**

Overall & Cryo Priority

- **Priority setting based on time requirement for cooling-down/warming-up, forecasted future situation, cryo constraints..**

  { OP Team Empowerment was a Must... }

Warming up magnets

Magnets at 1.9 K

Cooling-down magnets in 80 K ~ 4.4 K

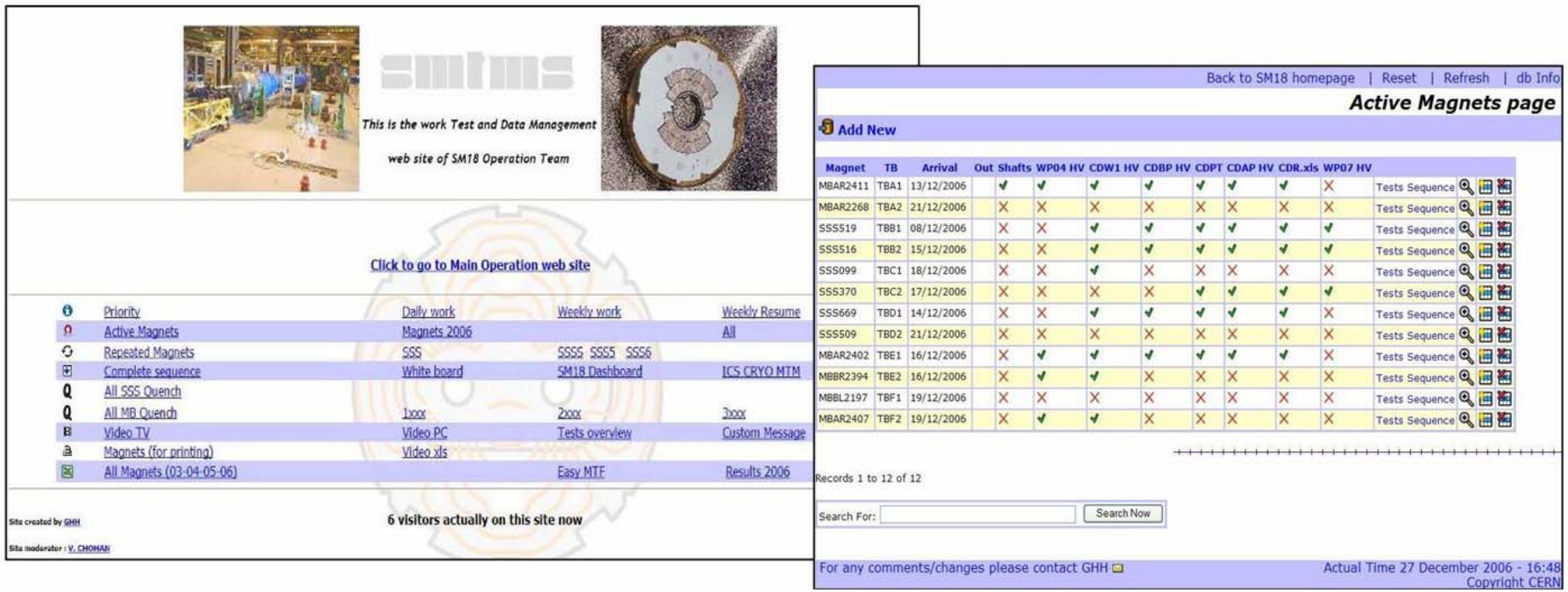
Newly arrived / finished magnets

SM18 Test Management System (SMTMS)

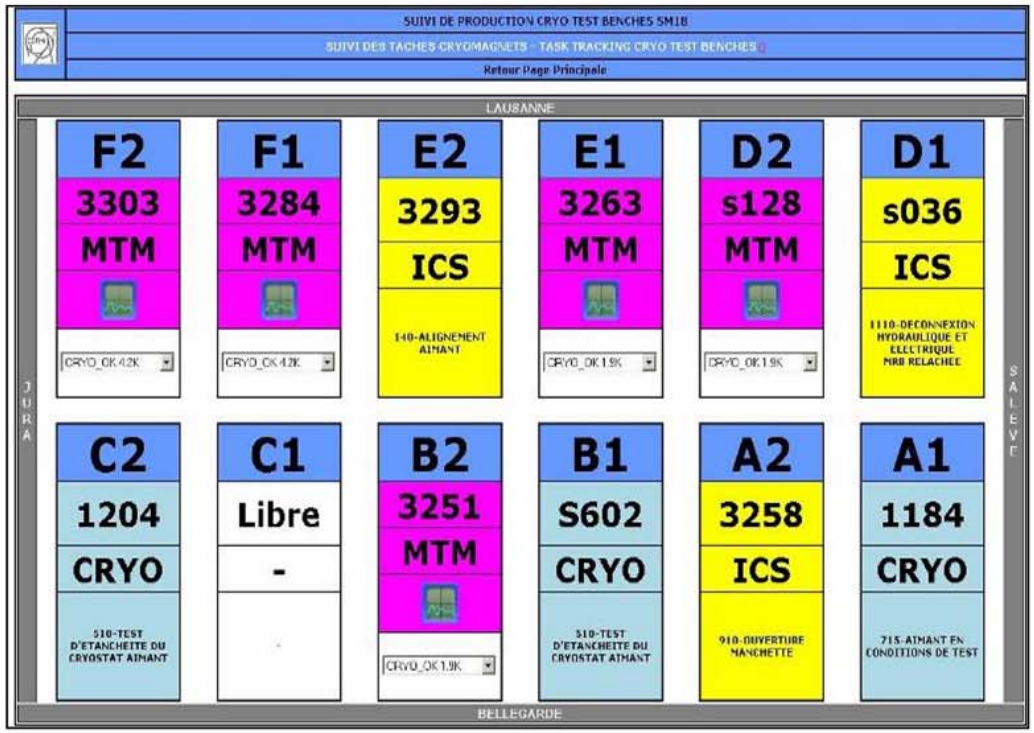
... used Web based form-filling ..

see ICALEPCS 2005 paper

SM18 Test Management System (SMTMS)



- Maintains electronic repository of tests results
- Links tests results with management tools
- Tracks test progress & test statistics
- Automatic generation of test reports

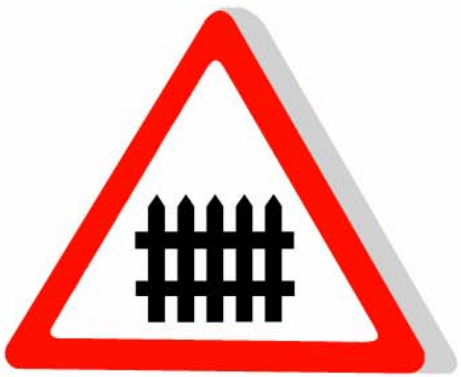


E-Traveller

Mashed web system with SMTMS

What for E-Traveller ?

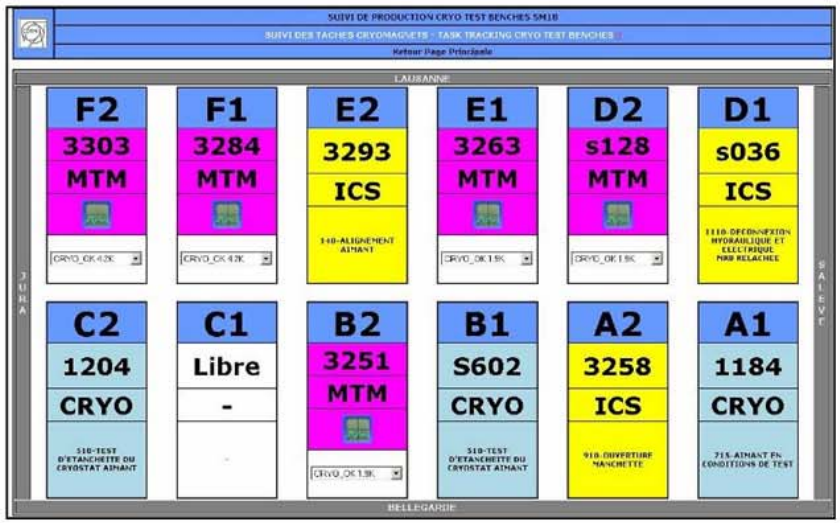
Operation Team consists of mainly Indian associates , other teams exclusively French..

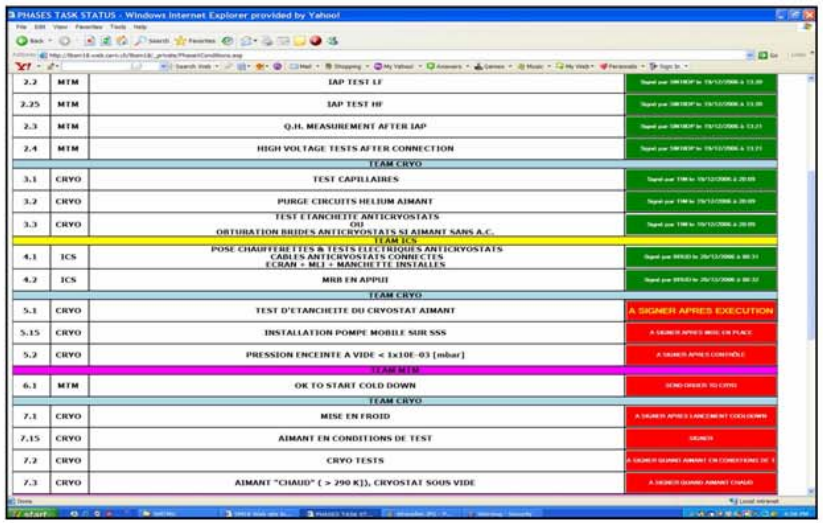


Language Barrier !!

DIFFICULT communication & co-ordination between teams

E-Traveller





- **Web based tool with mobile phone interface and video display – alert teams**
- **Keeps track of electronic, signature based information exchange**
- **Automatic time stamped log of tests activities**

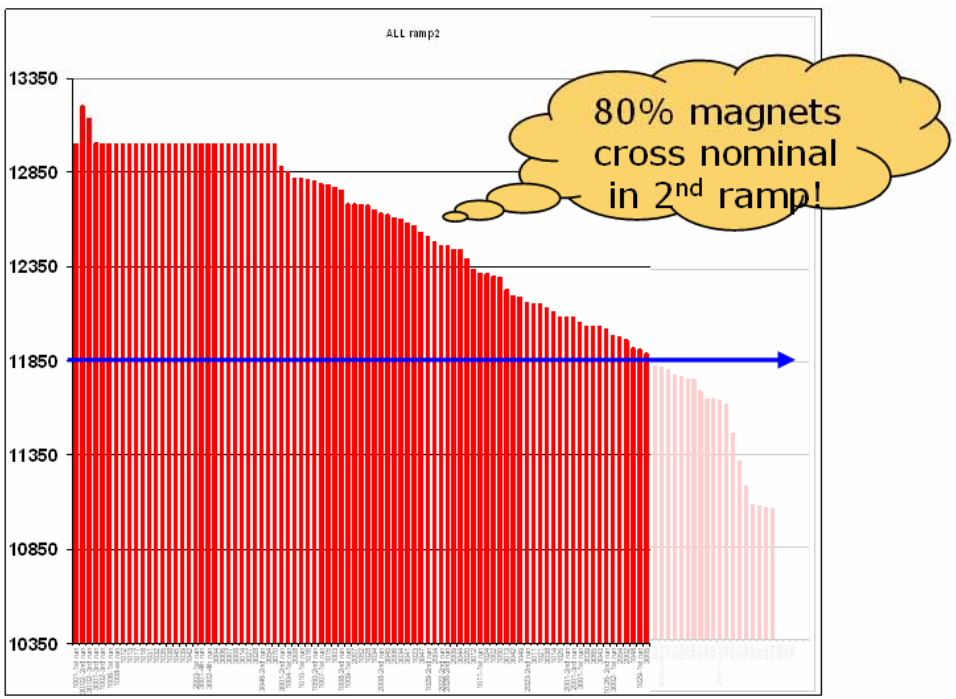
Modified Training Criteria

Training Rules

- Earlier, all magnets were trained to ultimate field (12850A ~9T)
- 3-4 hours recovery time between quenches, Time consuming…

But… Most of the 'good magnets' cross nominal field (11850A ~ 8.33T) in the second training ramp..

[year 2003 Observation by OP Team]

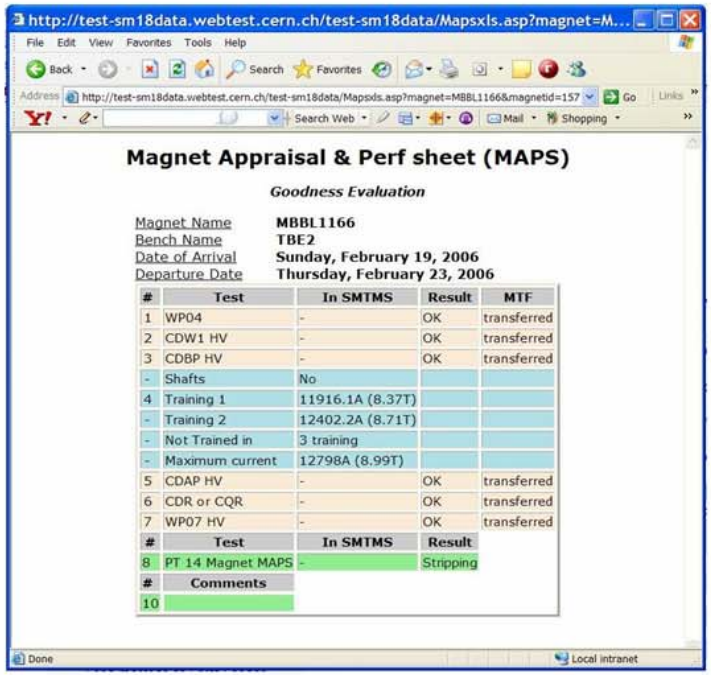


—Two-Quench Rule: Accept the magnet if it crosses nominal field in Second training with small margin!

—Three-Quench Rule: Accept the magnet if it crosses 12250 A (~8.66 T) in third training, even if it had not passed the preceding rule..

Magnet Appraisal & Performance Sheet (MAPS)

for Op Empowerment in Decision-taking on a 24 hr basis



- ***Single page report : rule based magnet goodness evaluation***

Rrapid, round the clock decision taking on first level of goodness evaluation

- ***Mitigated issues of magnet storage logistics***

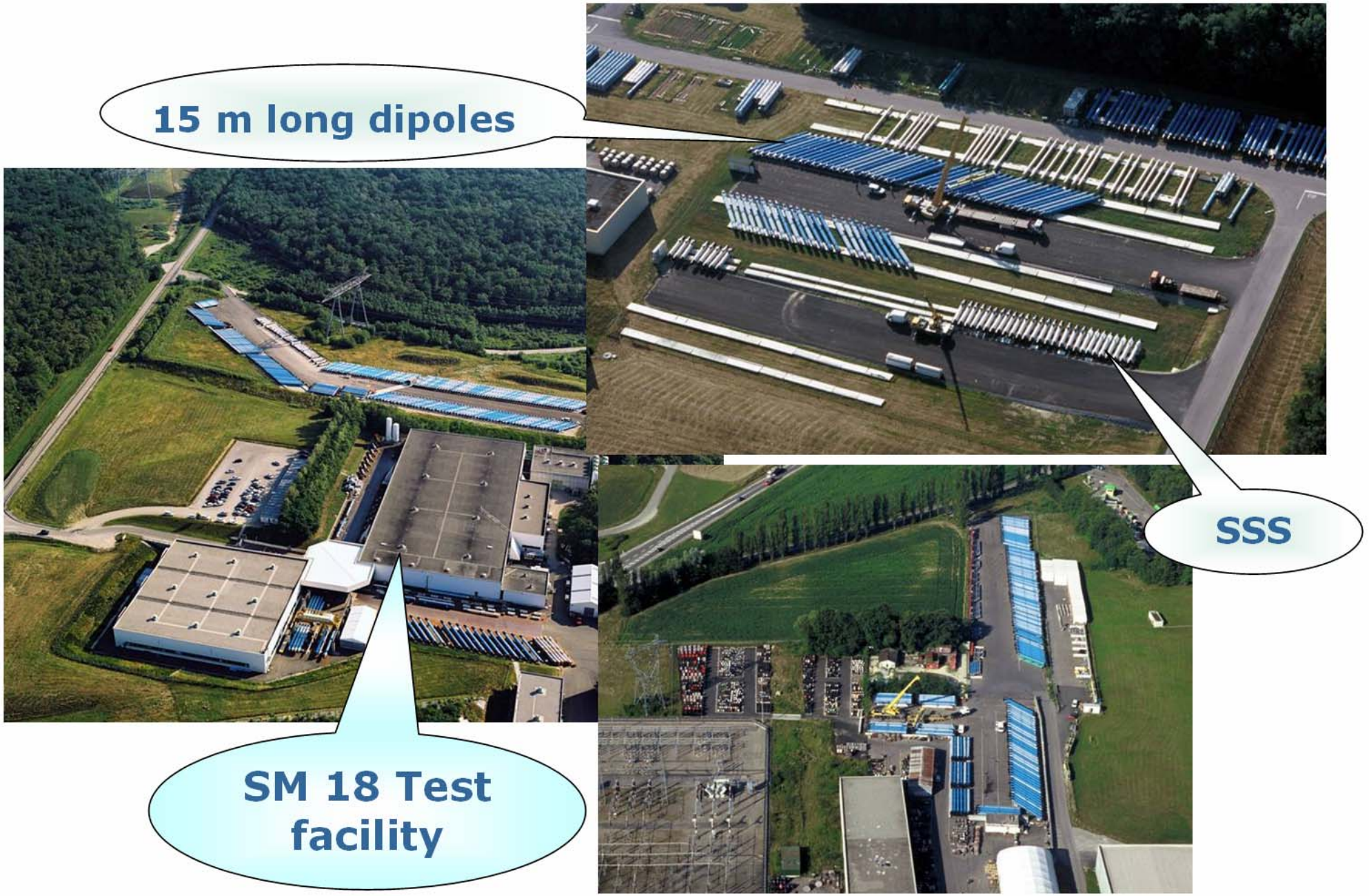
What for ?

- Earlier, all tested magnets sent to standby buffer

- Decision on acceptance for installation in LHC taken at a later date by magnet experts

- Large storage of magnets in SM18.. Hampered the throughput..

Logistics of tests & store: 24 hr basis !



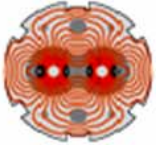
Rapid On Bench Thermal Cycle (ROBTC)

Rapid On Bench Thermal Cycle (ROBTC)

- Earlier, 'poor magnets' were disconnected from bench, fitted with anticryostats, tested again at a later date…
- Additional disconnection, connection, preparatory tests… time consuming..

- But.. Quench performance improves after thermal cycle
- Rapid On-Bench Thermal Cycle (ROBTC): Rapid thermal cycle of a poor magnet without disconnection from test bench

Concluding Remarks



1. Magnet tests completed in Feb 2007
2. Major factors behind the success:
   - Dedicated efforts of operating staff
   - Effective operator empowerment
   - Innovative operational techniques

Read Article in June '07 issue of CERN Courier

Contributors to this paper at PAC '07

(on behalf of SM18 Operation: 2002 – 2006)

Collaborators from CERN, Geneva:

G.H. Hemelsoet, E. Veyrunes, K. Priestnall, F.Pirotte

Collaborators from Dept of Atomic Energy, India:

M.Mascarenhas, S.Sridhar, A.Pagare, S.Shimjith, S.Padmakumar, A.Laddha, S.Rao, J.Gore, J. John, J.Mishra, D.Roy,P.Awale, D.Peruppayikkad ,P.Motiwala, A.Kasbekar, P.Surendran, A.Tikaria, M.Patil, Sampthkumar R.,Naushad Ali,V. Chauhan, A.Kasliwal, S.Malhotra, Ramkumar N., S.Sonnis, K.Nair, Sudheer S., C.Kulkarni, P.Kashyap, S.Bahuguna, U.Bhunia, E.Kandaswamy, M.Dixit

Indian Associates in SM18
(2002 – 2006)

Collaborators from Bhabha Atomic Research Centre (BARC), Mumbai, India:

Clement Verghese, Prem Kumar Kavalan, Laddha Anand, Maurya Beachai, Malhotra Sanjay, Perupayikkad Daniel Babu, Shetty Satish Shankar, Narayanan Ramkumar, Satyanarayana Arunkumar, Nair Kesavan, Awale Prashant Kamalakar, Patil Mahesh Balasaheb, Dubey Krishna, Roy Amitava, Thota Venkatesulu Shyam, Gupta Rakesh Kumar, Mascarenhas Martin Lucio, Surendran Puthiyedath, A Kasbekar, J Mishra, P Motiwala, P Adibabu, P Joshi, P Kashyap, Naushad Ali, D Roy, Jacob John, K Ambastha, Jaydeep Gore, Vasu Kakkat, Sanjeev Sharma, D Bhattacharjee, Sudheer Singh, Surajit Sen, Manna, Swagat Mukherjee, Vikas Chauhan, Mukesh Sharma, Vikas Telang, Subrat Kaushik, Sumeet Maity, Sampath Kumar, Charudatta Kulkarni, S. Padmakumar, P. K. Panda, N.S. Dalal, Sunil G Kulkarni, Sreyas R Shimjith, Sushil K Bahuguna, Vijendra Sinha, Kuldeep Joshi, E Kandaswamy, M Y Dixit, Amit Tikaria, R I Bhaktsingh, B V Rama Rao, S T Sonnis, N G Tayade, Vivek Yadav

G Aravamuthan, S. Gomu, Gangoor, Vineet Sinha, M Naskar,Y Chaudhari, A Basu, P Behere

Collaborators from Centre for Advanced Technology (CAT), Indore, India:

Gandhi Manoj, Marathe Ravindra G, M Jathar, Radheshyam Pramod, A Kasliwal, Khare Krishna Mohan, Pareek Prashant, Jain Akhilesh, Pagare Anand, Yash Pal Singh, Mandar Joshi, Praveen Deshpande, Jitendra Patil, Rajkumar Gupta, Seshnath Singh

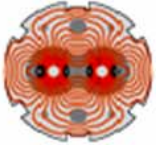
S Kane, S Pralod, Vimal Bhatnagar

Collaborators from Indira Gandhi Centre for Atomic Research (IGCAR), Kalpakkam, India:

T S Selvakumaran, R Dhandapani, Sethumadhavan Sridhar, B Rao, K Palanisami

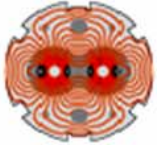
Collaborators from Variable Energy Cyclotron Centre (VECC), Kolkata, India:

Bhunia Uttam, Bhole R, Sandip Pal, J Debnath



Extra Slides

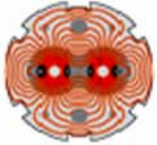
Achievements



Magnet testing completed by Feb 2007, within schedule !!!

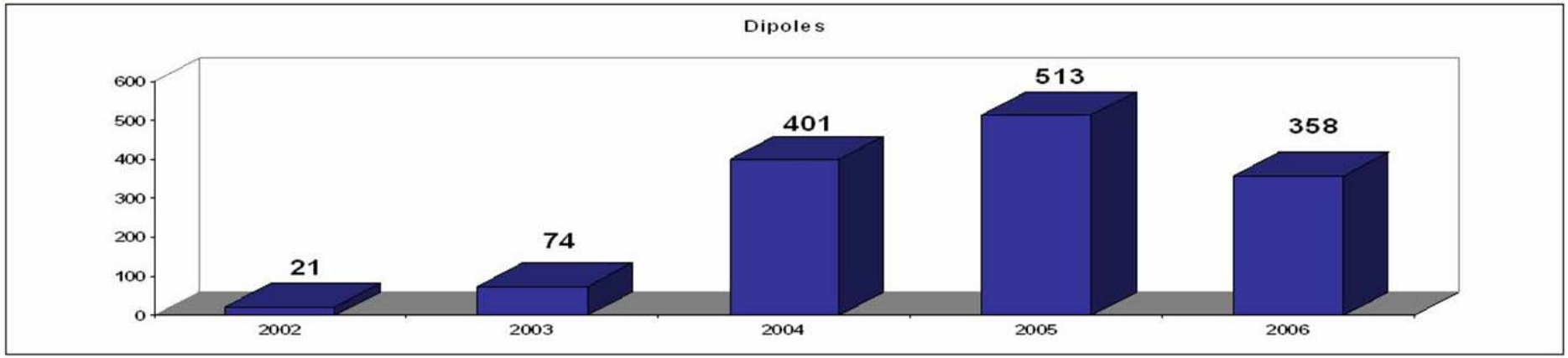
	Required for LHC	*Total tested (incl. spare + repeat)*
Dipoles	**1232**	**1375**
SSS + 5xx	**392**	**450**
IR-SSS	**82**	**94**
Total Magnets tested		**1919**

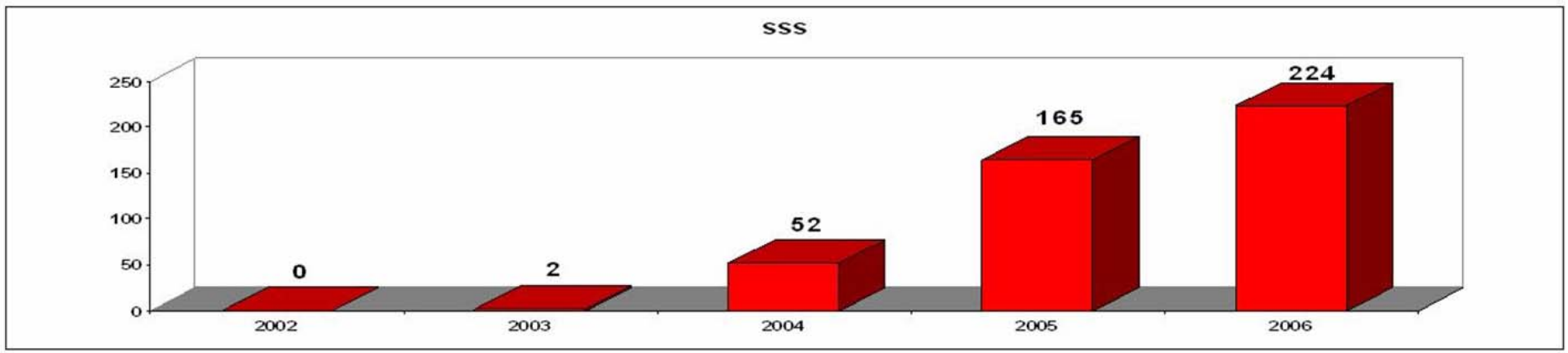
Repeat Rates & Magnetic Measurements

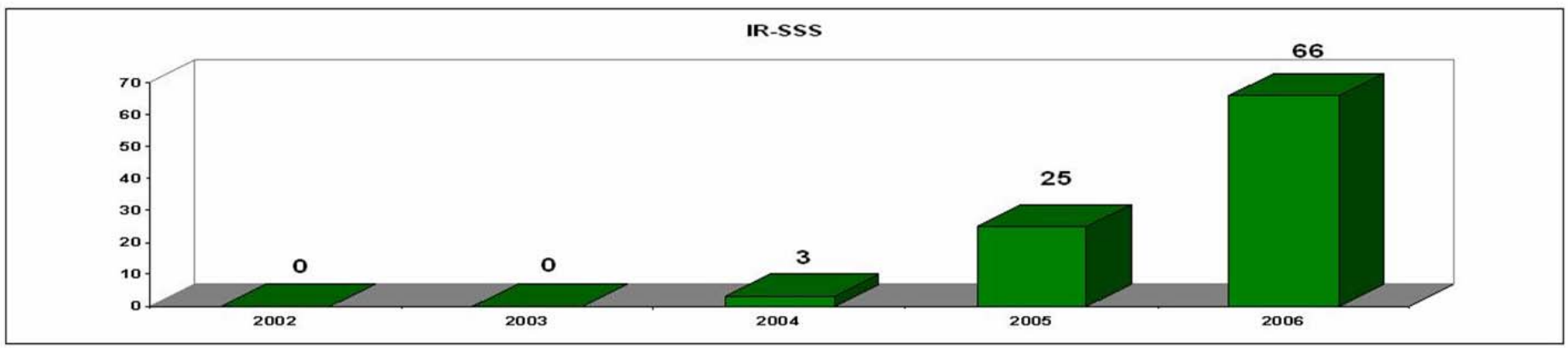


	Repeat Rate %	*Mag. Meas. (MM) %*	*Repair/ Rejection %*
Dipoles	**9**	**18.36**	**~ 3**
SSS	**12.5**	**13.32**	**~ 6**
IR-SSS	**12.8**	**30.85**	**--**

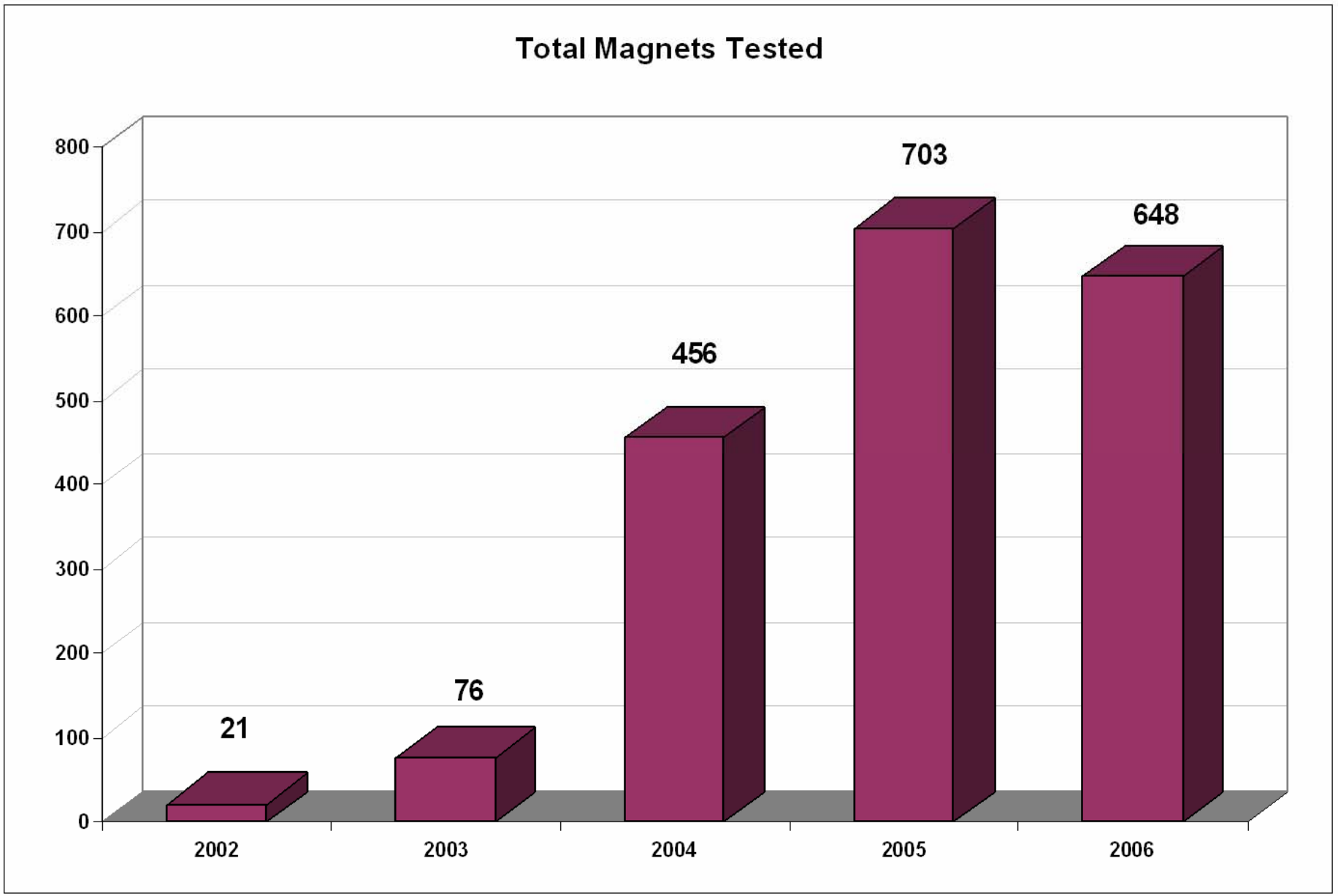
Annual Statistics



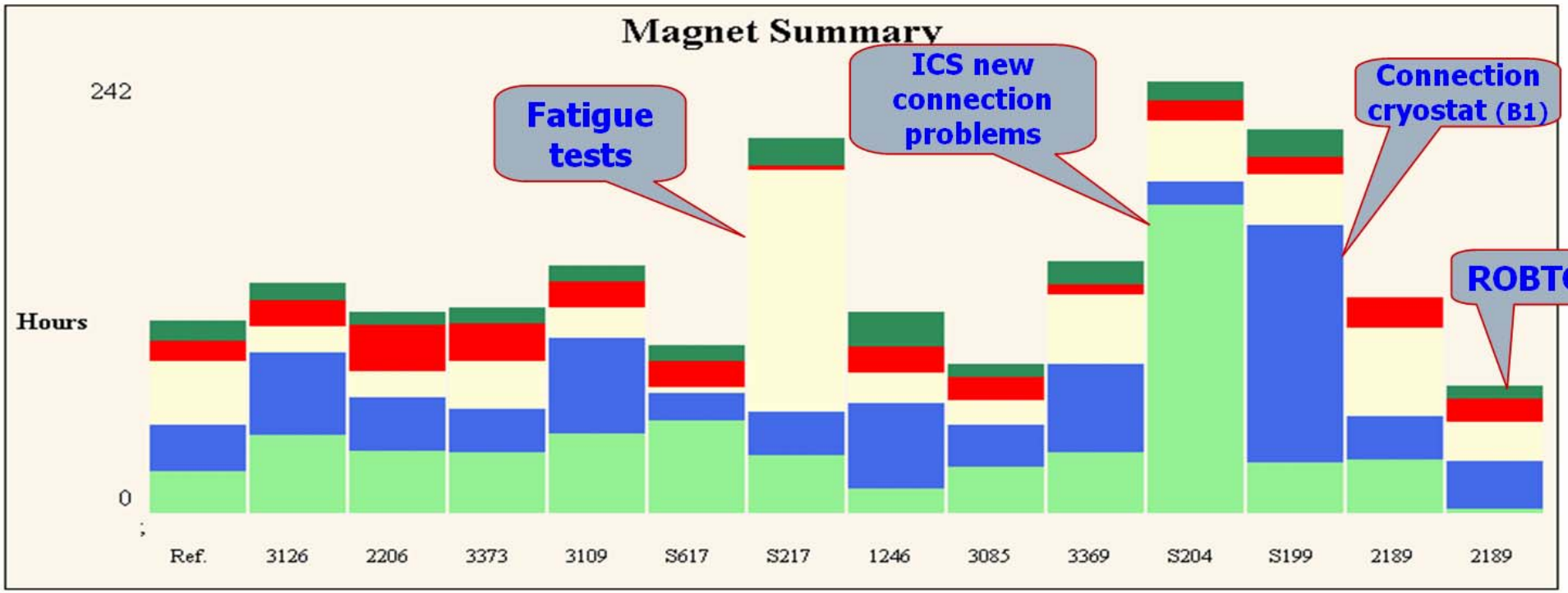




Annual Statistics

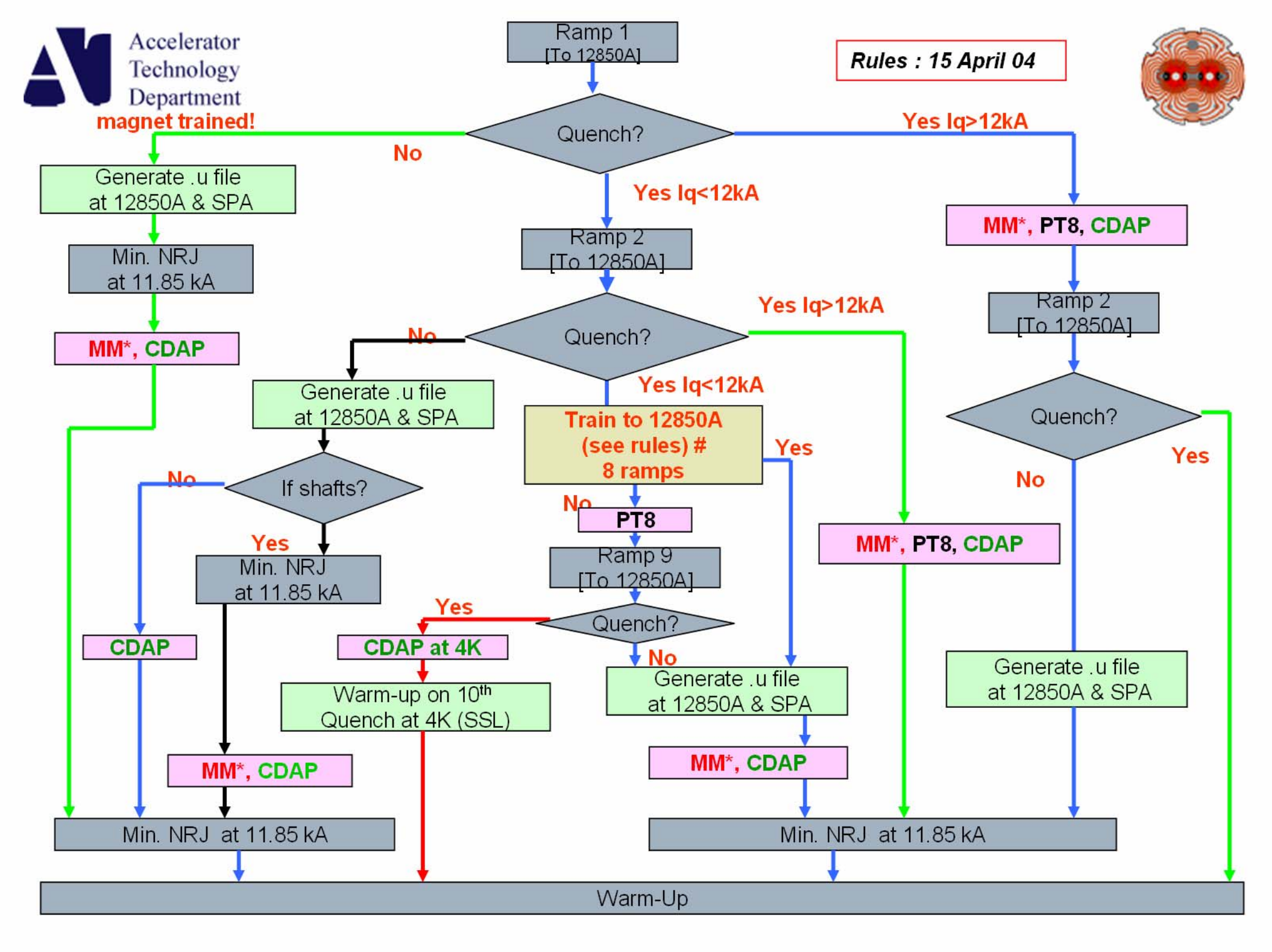


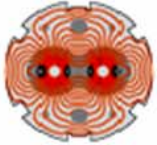
Typical magnet test times
(For the week starting 26th July 2005)



Reference Times

- Light green : Connect (up to Cryo pump down) **24 h**
- Blue : Wait + Cool down **26 h**
- Ivory: Tests at Cold **36 h**
- Red : Wait + Warm up **12 h**
- Dark Green: Disconnect **12 h**


Accelerator Technology Department
Ramp 1 [To 12850A]
Rules : 15 April 04
magnet trained!
Quench?
No
Yes Iq>12kA
Yes Iq<12kA
Generate .u file at 12850A & SPA
Min. NRJ at 11.85 kA
MM*, CDAP
Ramp 2 [To 12850A]
MM*, PT8, CDAP
Quench?
No
Yes Iq>12kA
Yes Iq<12kA
Generate .u file at 12850A & SPA
Train to 12850A (see rules) # 8 ramps
Yes
No
PT8
Ramp 9 [To 12850A]
Quench?
Yes
CDAP at 4K
Warm-up on 10th Quench at 4K (SSL)
No
Generate .u file at 12850A & SPA
MM*, CDAP
Ramp 2 [To 12850A]
Quench?
Yes
No
MM*, PT8, CDAP
Generate .u file at 12850A & SPA
If shafts?
No
Yes
Min. NRJ at 11.85 kA
CDAP
MM*, CDAP
Min. NRJ at 11.85 kA
Min. NRJ at 11.85 kA
Warm-Up



- # Max 9 Ramps to 12850A; If this terminated in <= 9 ramps
- Then follow flowchart , else:
- magnet is poor & do warmup on 10th with 4K quench
- Instead of PT10
- THEN: Thermal Cycle if AntiC exist & so put in shafts
- ELSE((if no AntiC) – Magnet removed & Standby

MM* If Shafts Are Present!

PT8 = Ramp to 12 kA & SPA

Min NRJ = Quench provoked
FPA Disabled

Thermal Cycle Rules with Shafts Inserted :

In the 2nd Run:

if 1st Q above (8.4 T) 12000A then MB accepted

if 2st Q above (8.6 T) 12350A then MB accepted

ELSE MAGNET REJECTED WITH poor perf non-conformity but with the rules :

if Quenches are localised only in 2nd run (with shafts inserted only in the 2nd run): perform 5 quenches only

And END the Tests

.

if Quenches were localised in first RUN :

then perform max 2 localized quenches only in 2nd run

Making it possible ..

It is pretty cool...

With a little workout..

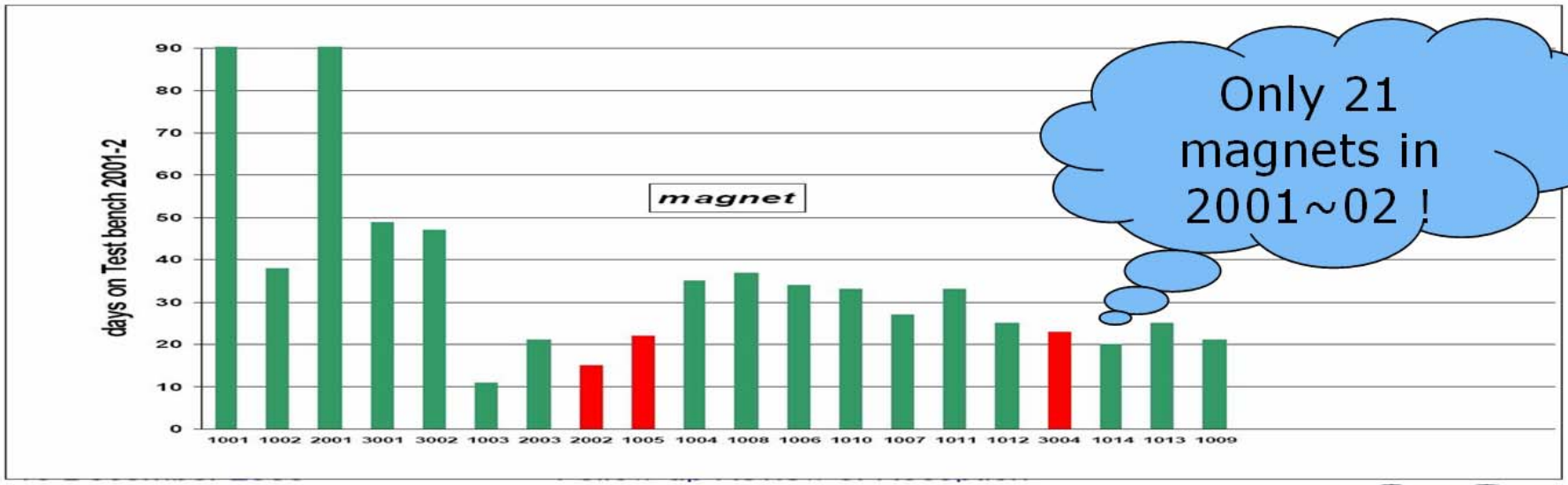
With food for thought..

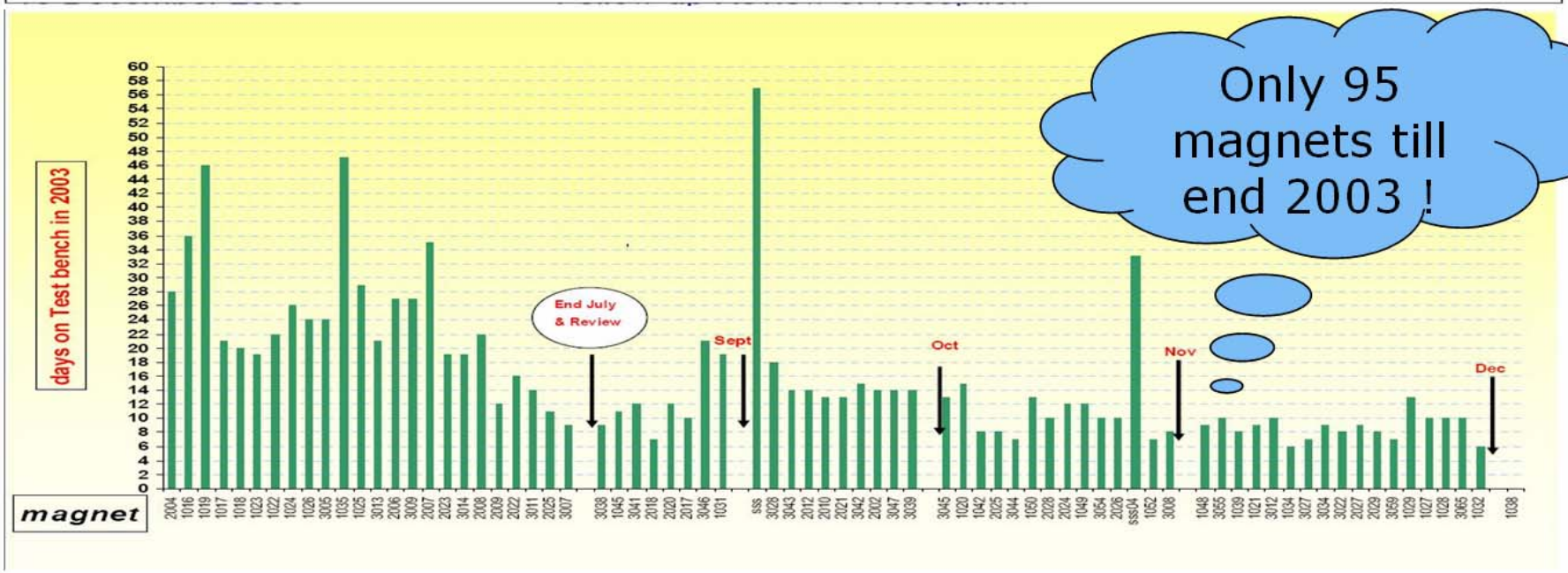

Thank You !

& Bit of aerobics for health !

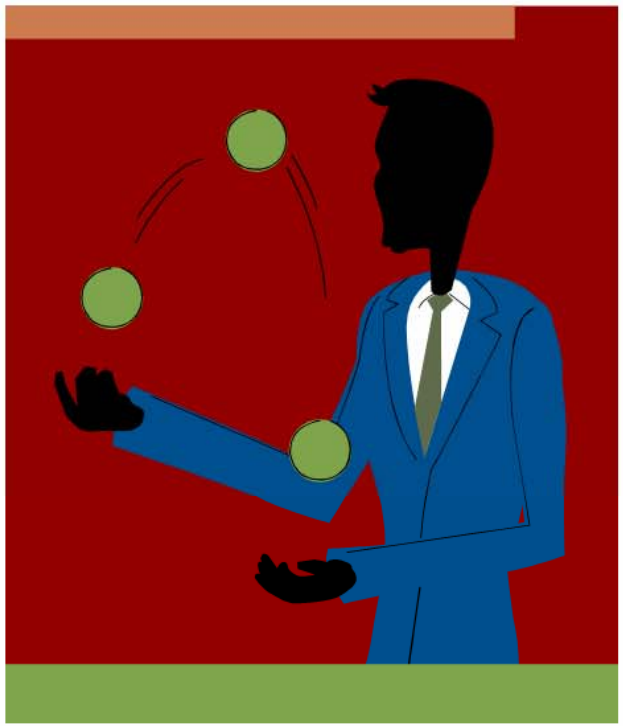
Early Performance

Early Performance





Finish testing of remaining ~1800 magnets by early 2007 ???



Overall & Cryo Priority Handling

Overall & Cryo Priority Setting

Cold Tests	Bench	Temp.	Priority
10 - 1.9 [K] since 8h 56' (PT 3 QH Measure)	TBC1	1.90	5
Warming up or Cooling Down	**Bench**	**Temp.**	**Priority**
6 - COOLDOWN TO 80 [K] since 9h 36' (Prep 5 Cool Down)			
13 - WARM UP TO 300 [K] since 10h 31' (PT 12 Warm Up)			
13 - WARM UP TO 300 [K] since 58' (PT 12 Warm Up)			
Cooling 80 K to 4K			
Warm			
2 - CONNECTING MAGNET since 8h 10' (ICS 2 Connect Magnet (ICS))			
52 - OVC PURGE since 23' (ICS 4 Final connection)			
2 - CONNECTING MAGNET since 56h 6' (_)			
2 - CONNECTING MAGNET since 10h 47' (ICS 1 WP04 HV Test Warm)			
52 - OVC PURGE since 2h 33' (ICS 4 Final connection)			
16 - OVC AT ATM. since 13h 29' (PT 13.2 Resist. Meas.)			
Other			
9 - LHe FILLING since 2h 26' (PT 11 4 K Quench SSL)			
15 - MAGNET AT 300 [K] since 10h 27' (PT 13.2 Resist. Meas.)			

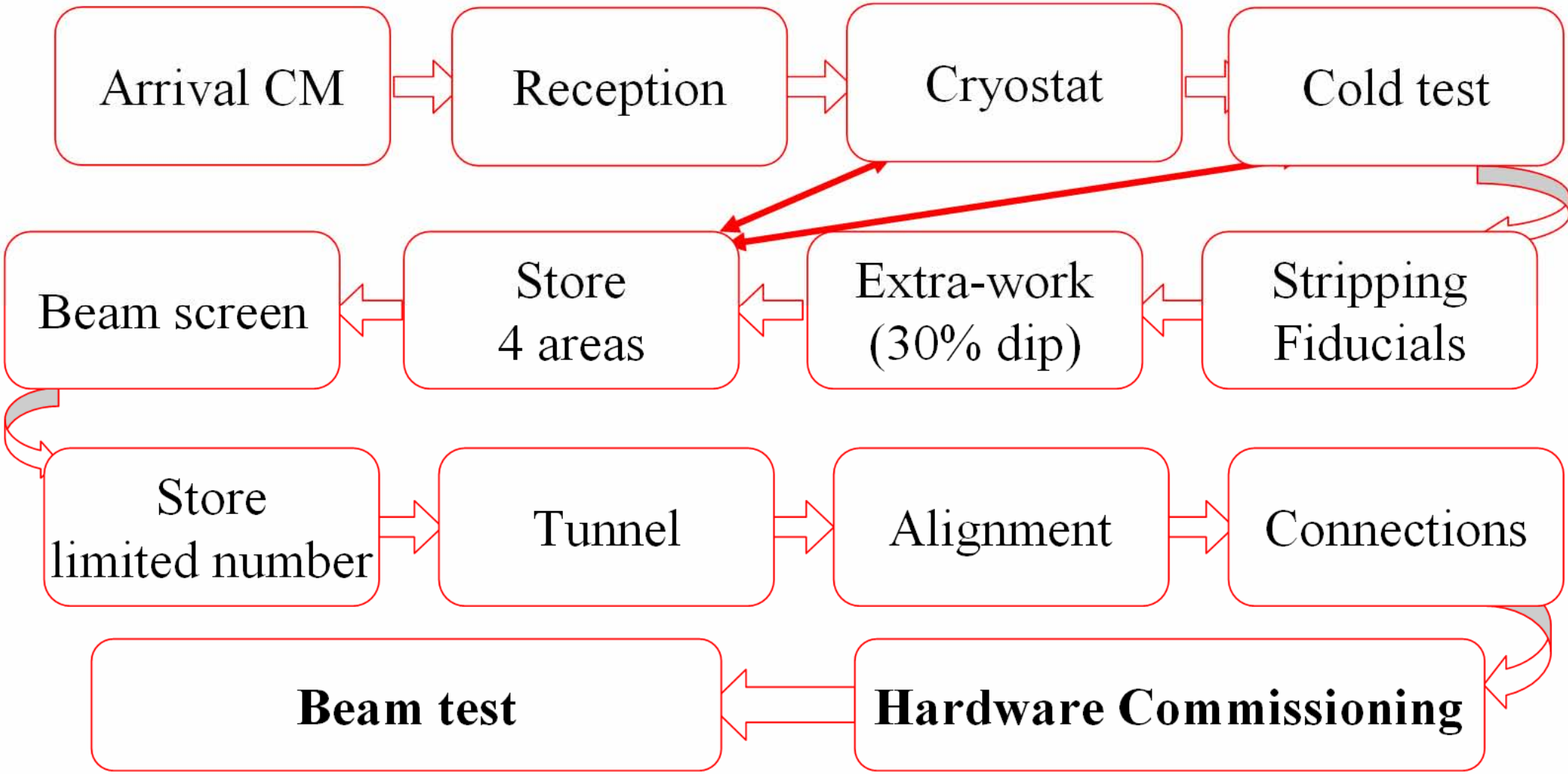
CRYOGENICS PRIORITIES & RESOURCES USAGE ON Thursday 12 October 2006 5:41:17 AM

MAIN PRIORITY				CWS [g/s]		PRIORITIES			COMMON RESOURCES
LEVEL	MAIN	MAGNET	T Mag[K]	COOL	WARM	CWS	LHe	1.9 [K]	
1	A2	2393	285		90	A2	C1	C1	LHe DEWAR LEVEL: 71 %
2	D1	S317	276			F2	C2	A2	LN2 DEWAR LEVEL: 72 %
3	F2	2374	104		88	A1	A2	D1	BALLON VOLUME: 72 m^3
4	C2	s339	4.6			D1	D1	F2	1.9 [K] Pumping Resources: 1(WPU1) + 4(WPU2) = 5 [g/s]
5	C1	s360	1.9			C2	F2	C2	
6	E2	2357	297			C1	E2	E2	TOTAL HELIUM FLOW THRU CWS: 274 [g/s]
7	B2	s353	297			E2	B2	B2	
8	A1	1373	107	83		B2	A1	A1	
9	E1	2389	298			E1	E1	E1	
10	F1	2381	296			F1	F1	F1	
11	B1	s518	297			B1	D2	D2	
12	D2	S515	296			D2	B1	B1	

- **Ensure that magnets follow the desired cryogenic phase distribution, within the limits of possibilities due to the varying training performance (a priori not known)**

Magnet work flow at CERN before beam test

Courtesy: L.Rossi



Magnet work flow at CERN before beam test

Courtesy: L.Rossi

Arrival C

Reception

st

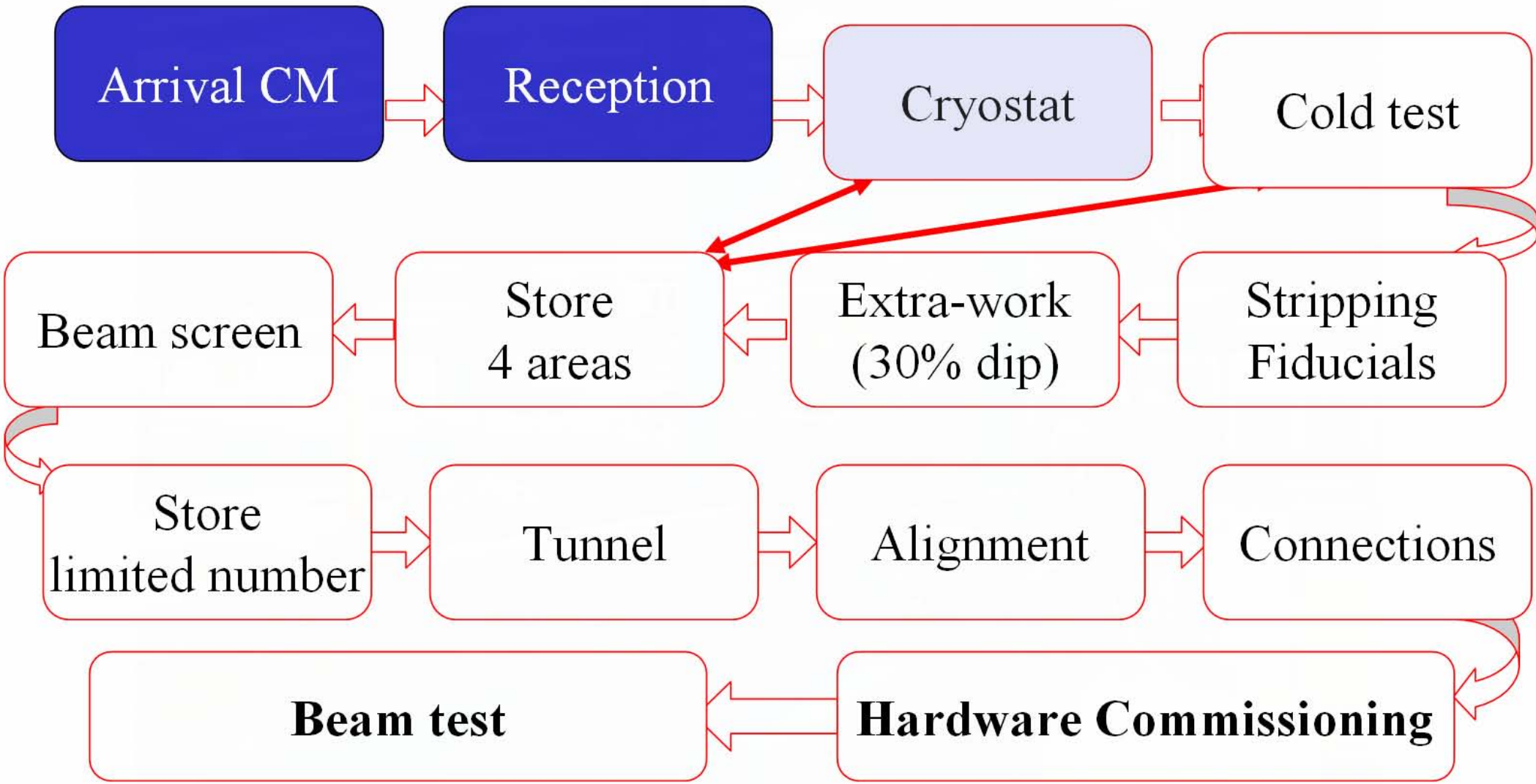
Beam screen

Store
limited num

ons

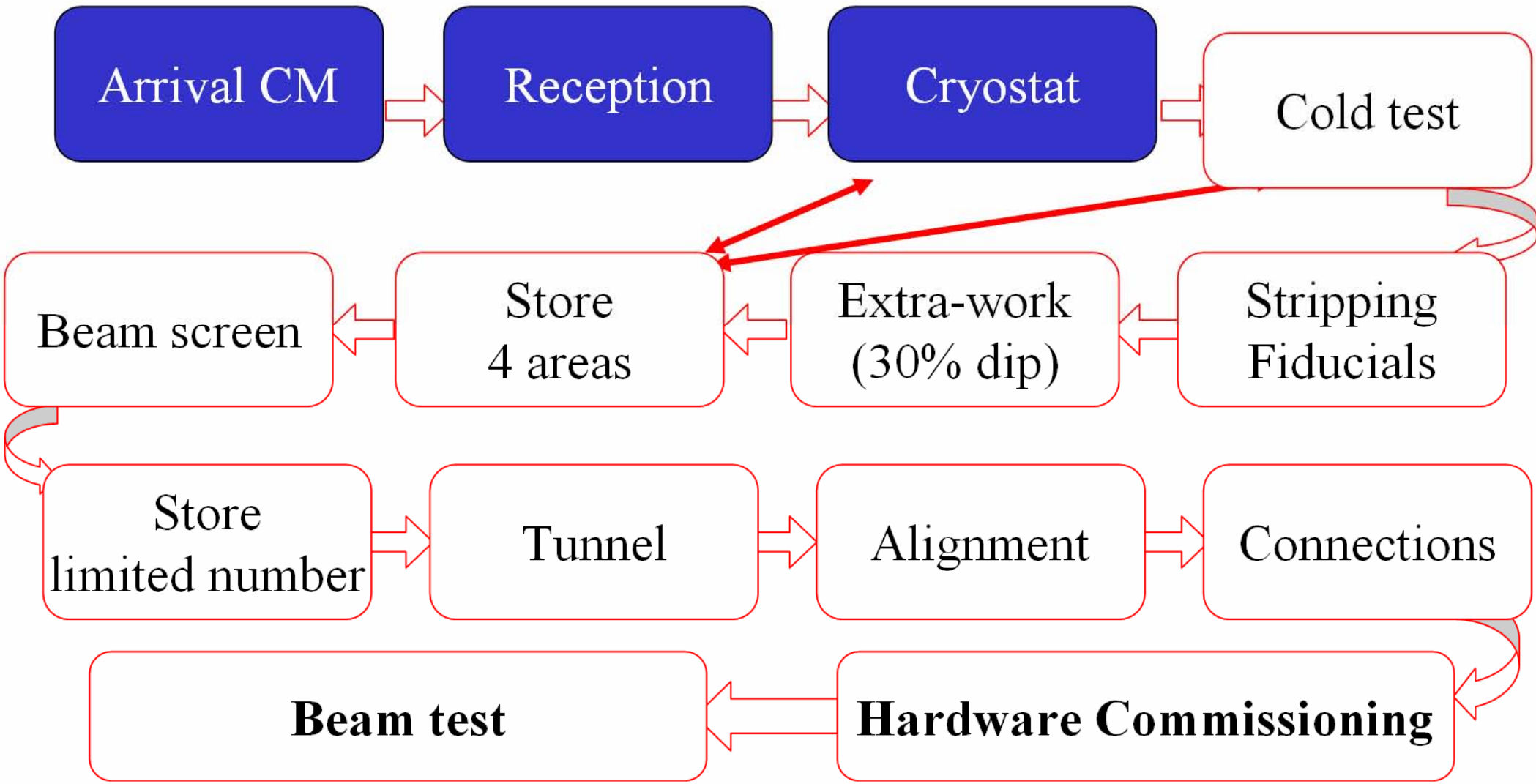
Magnet work flow at CERN before beam test

Courtesy: L.Rossi



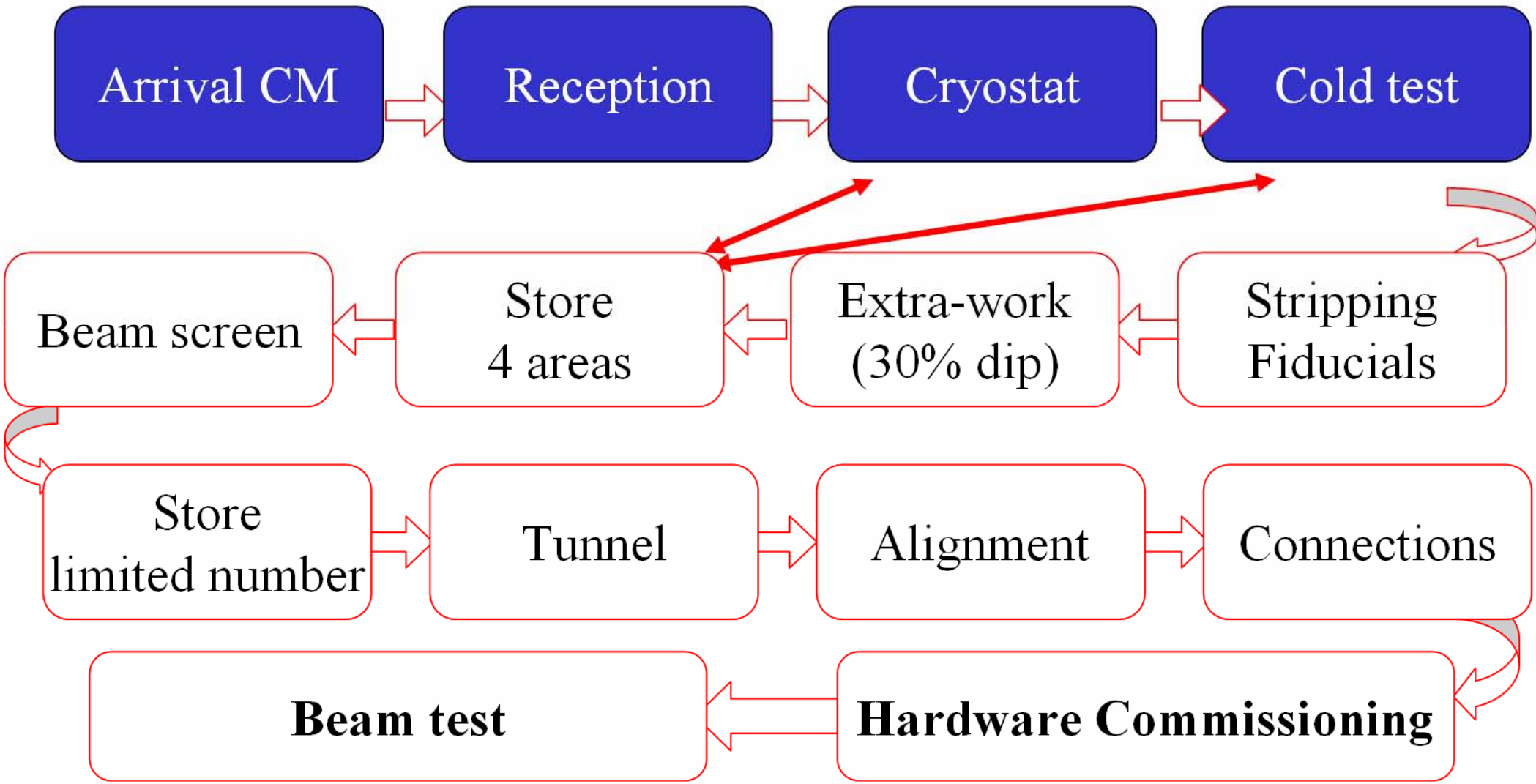
Magnet work flow at CERN before beam test

Courtesy: L.Rossi



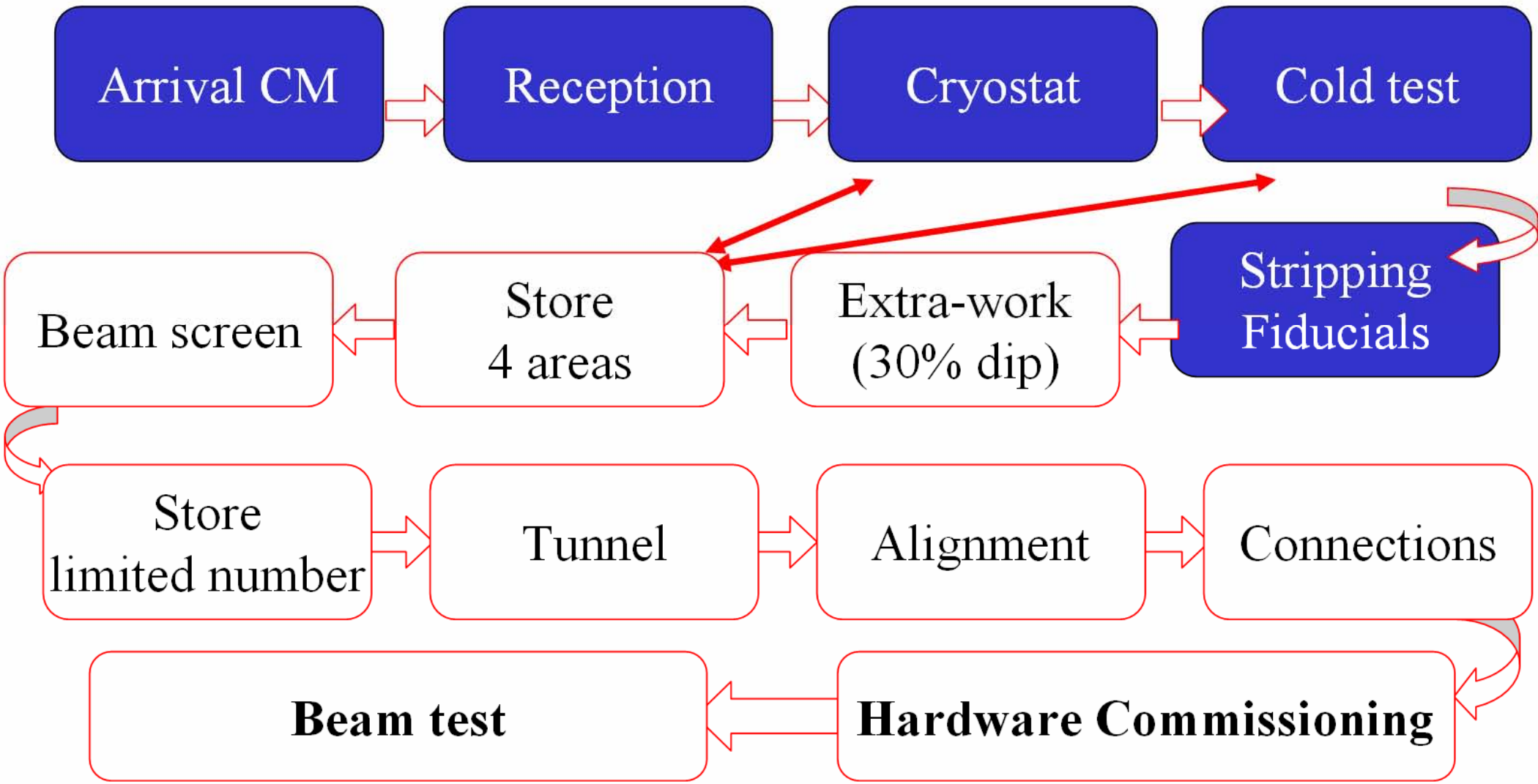
Magnet work flow at CERN before beam test

Courtesy: L.Rossi



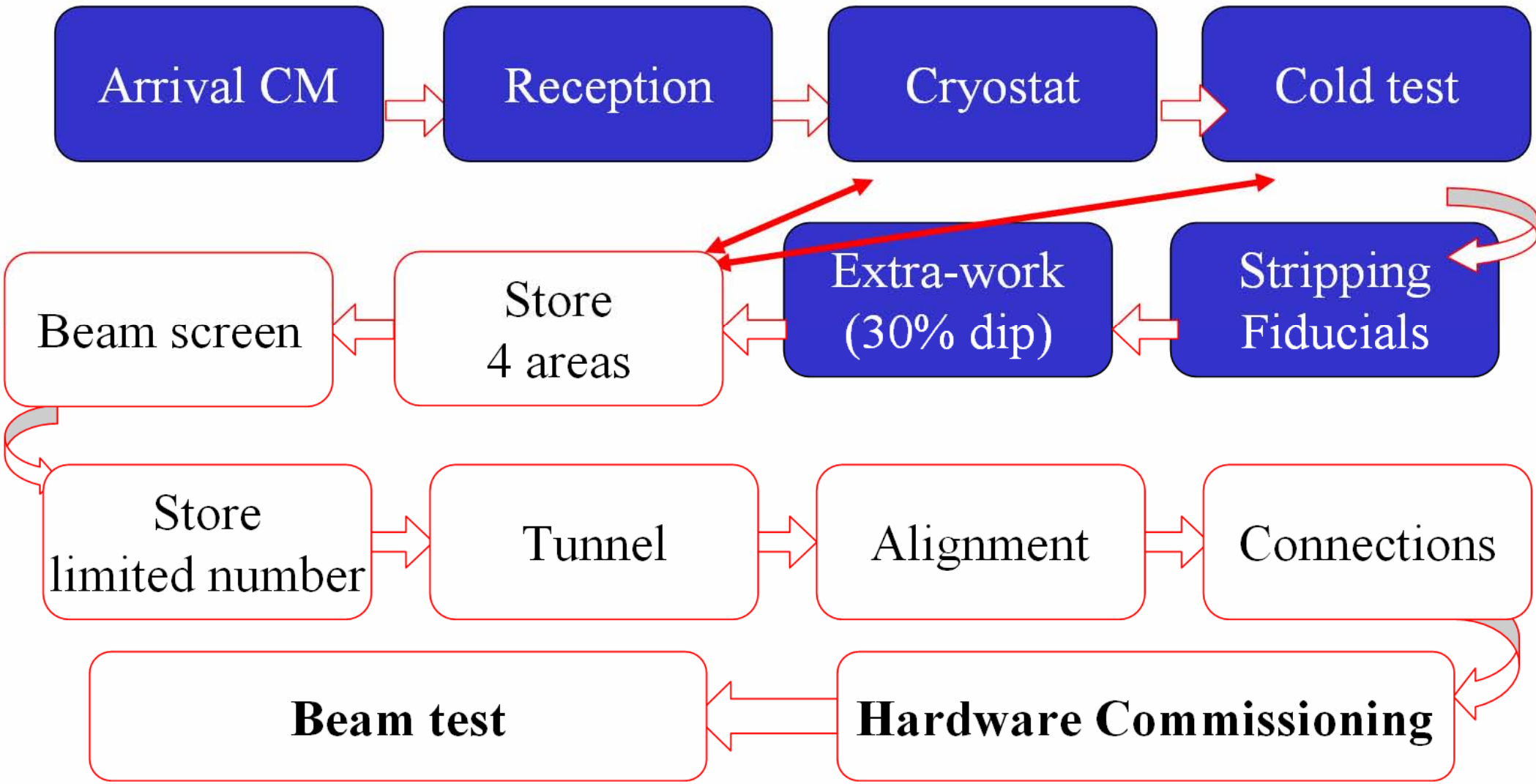
Magnet work flow at CERN before beam test

Courtesy: L.Rossi



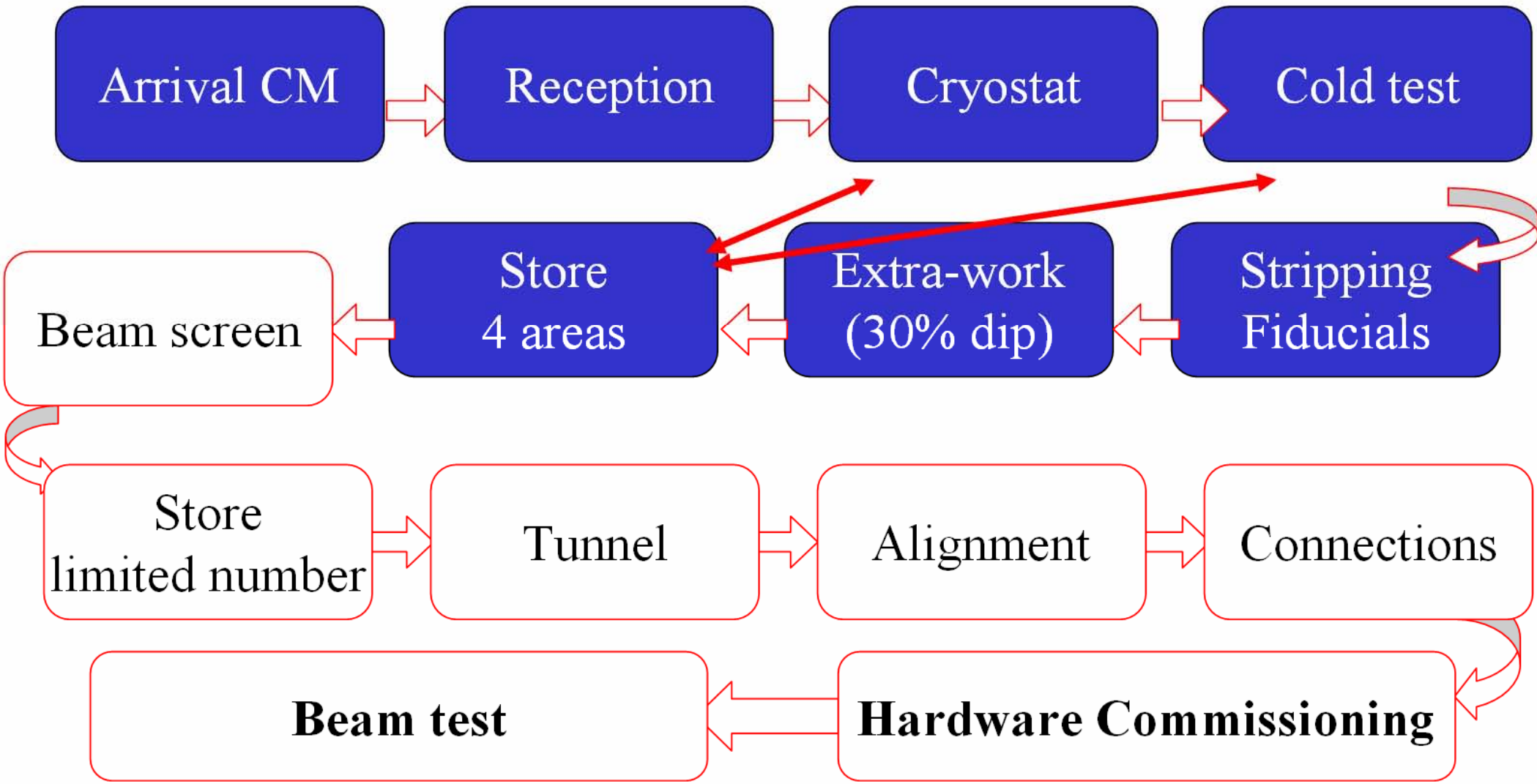
Magnet work flow at CERN before beam test

Courtesy: L.Rossi



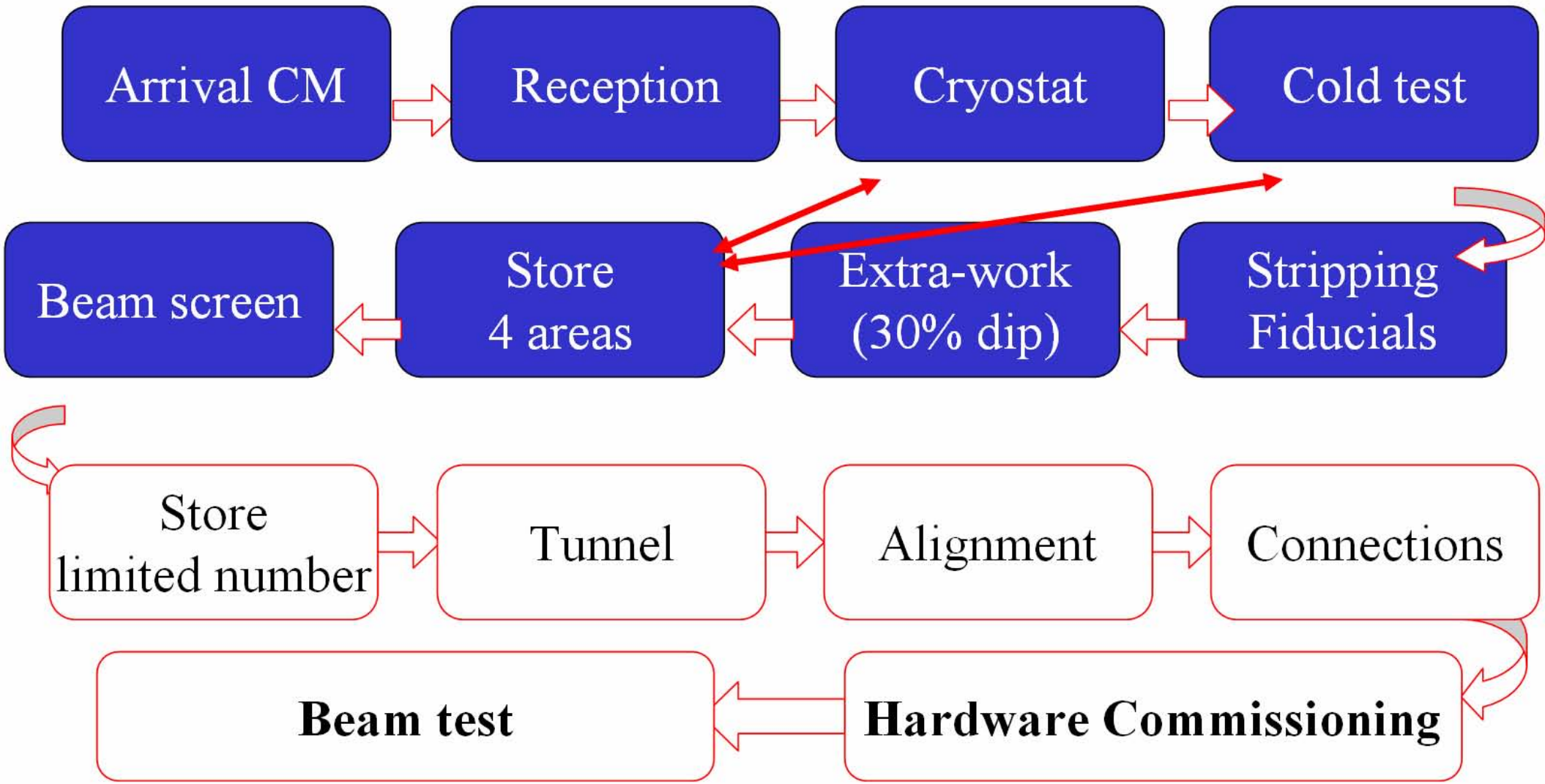
Magnet work flow at CERN before beam test

Courtesy: L.Rossi



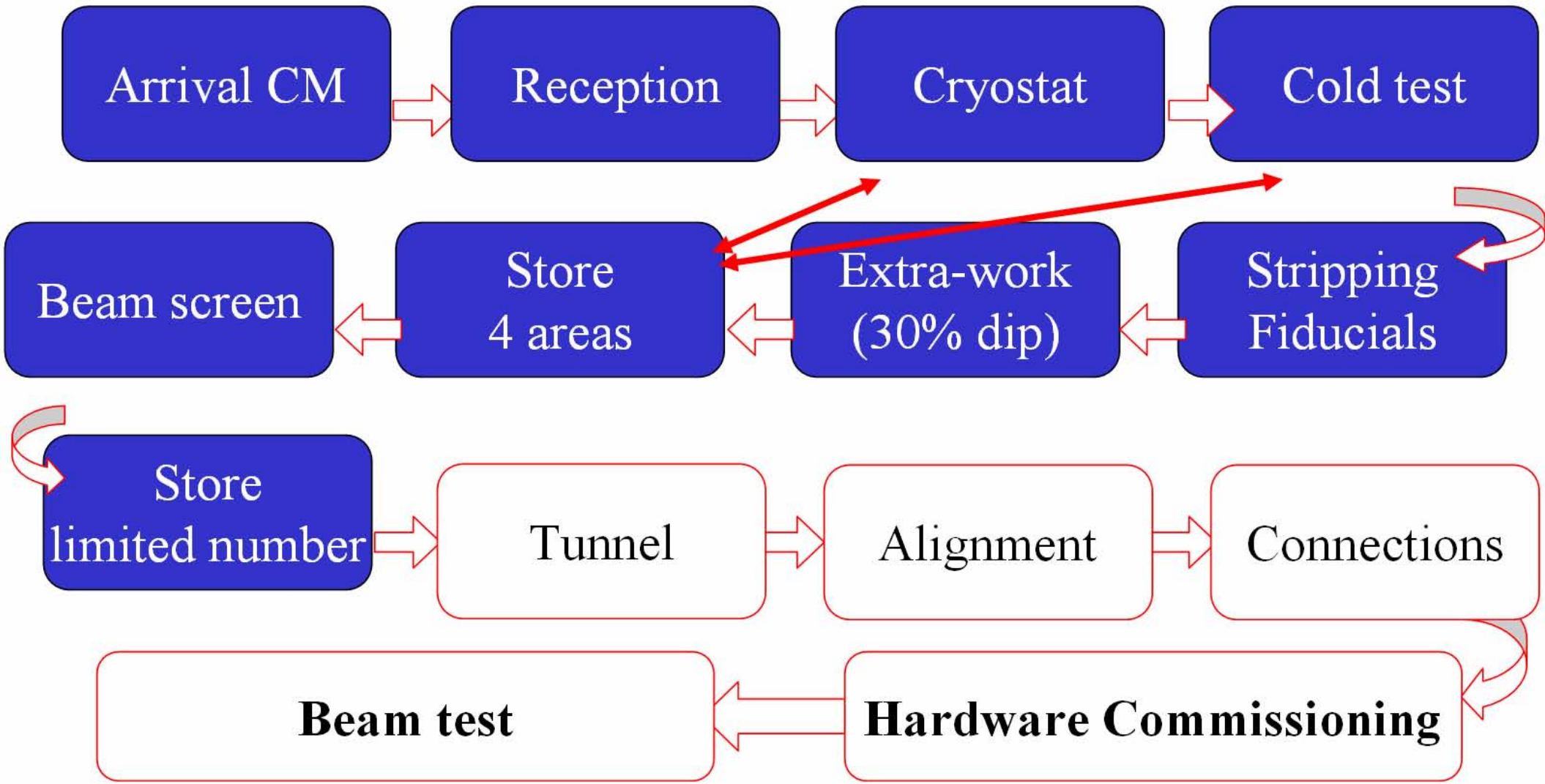
Magnet work flow at CERN before beam test

Courtesy: L.Rossi



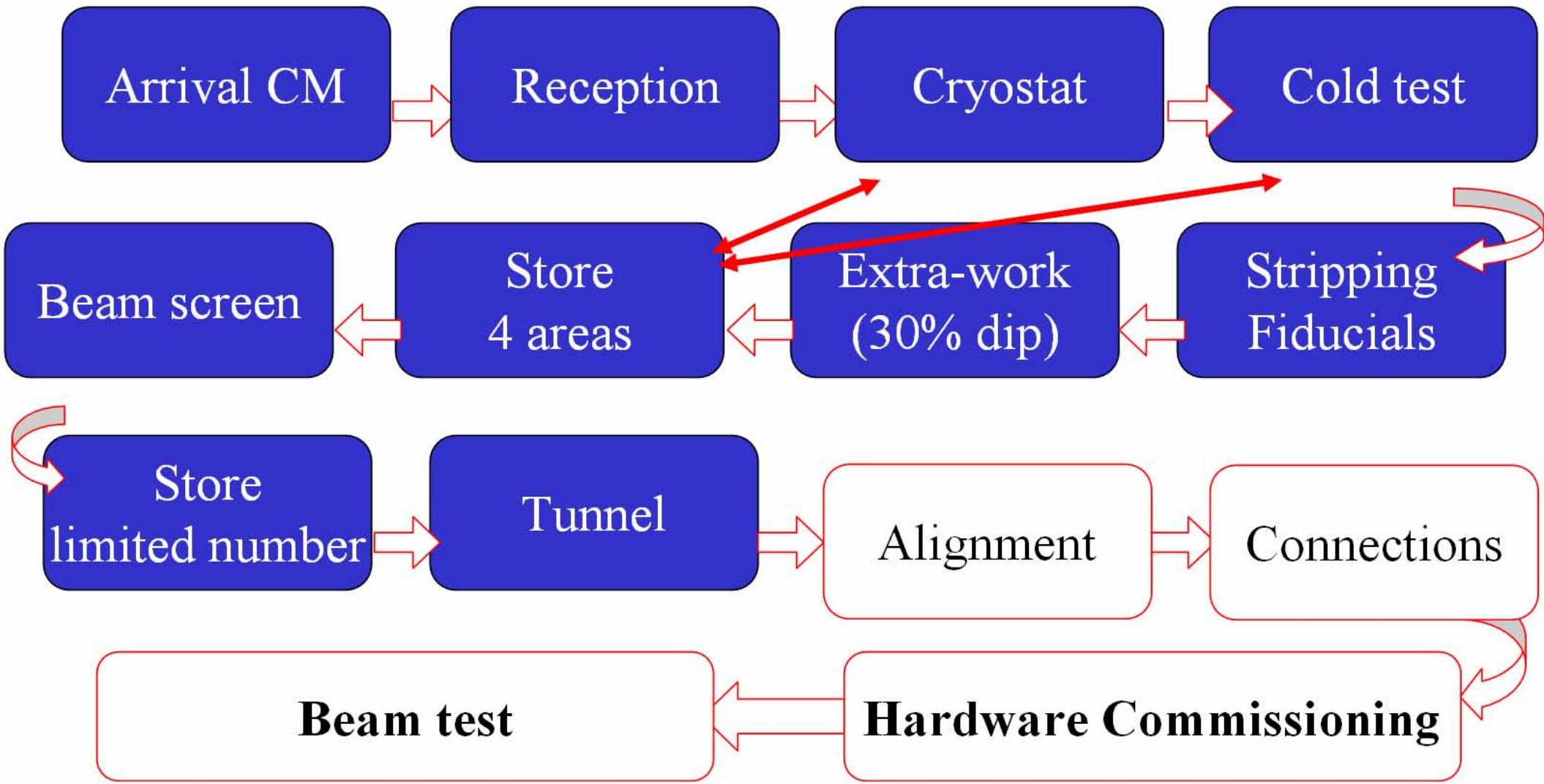
Magnet work flow at CERN before beam test

Courtesy: L.Rossi



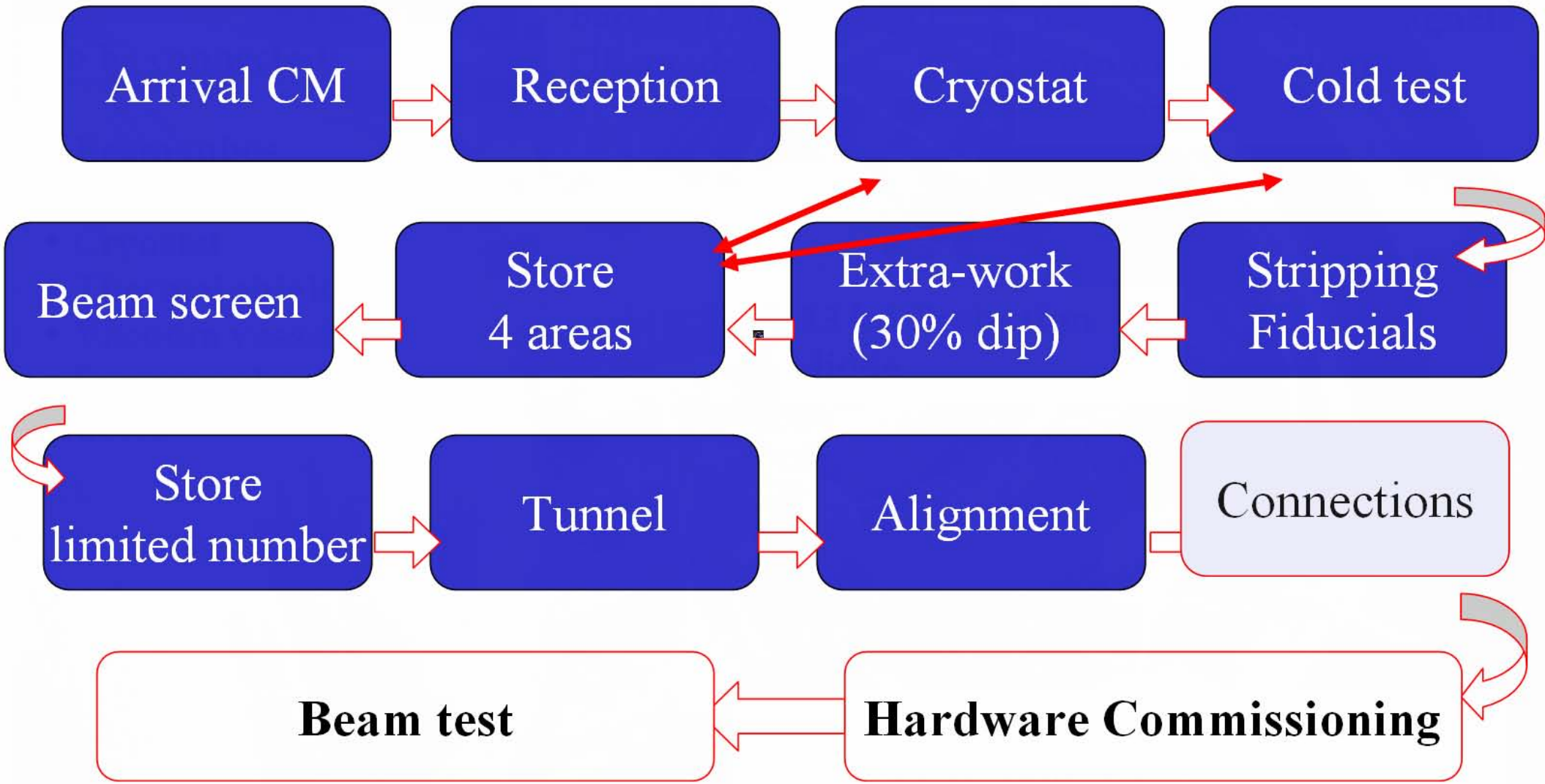
Magnet work flow at CERN before beam test

Courtesy: L.Rossi



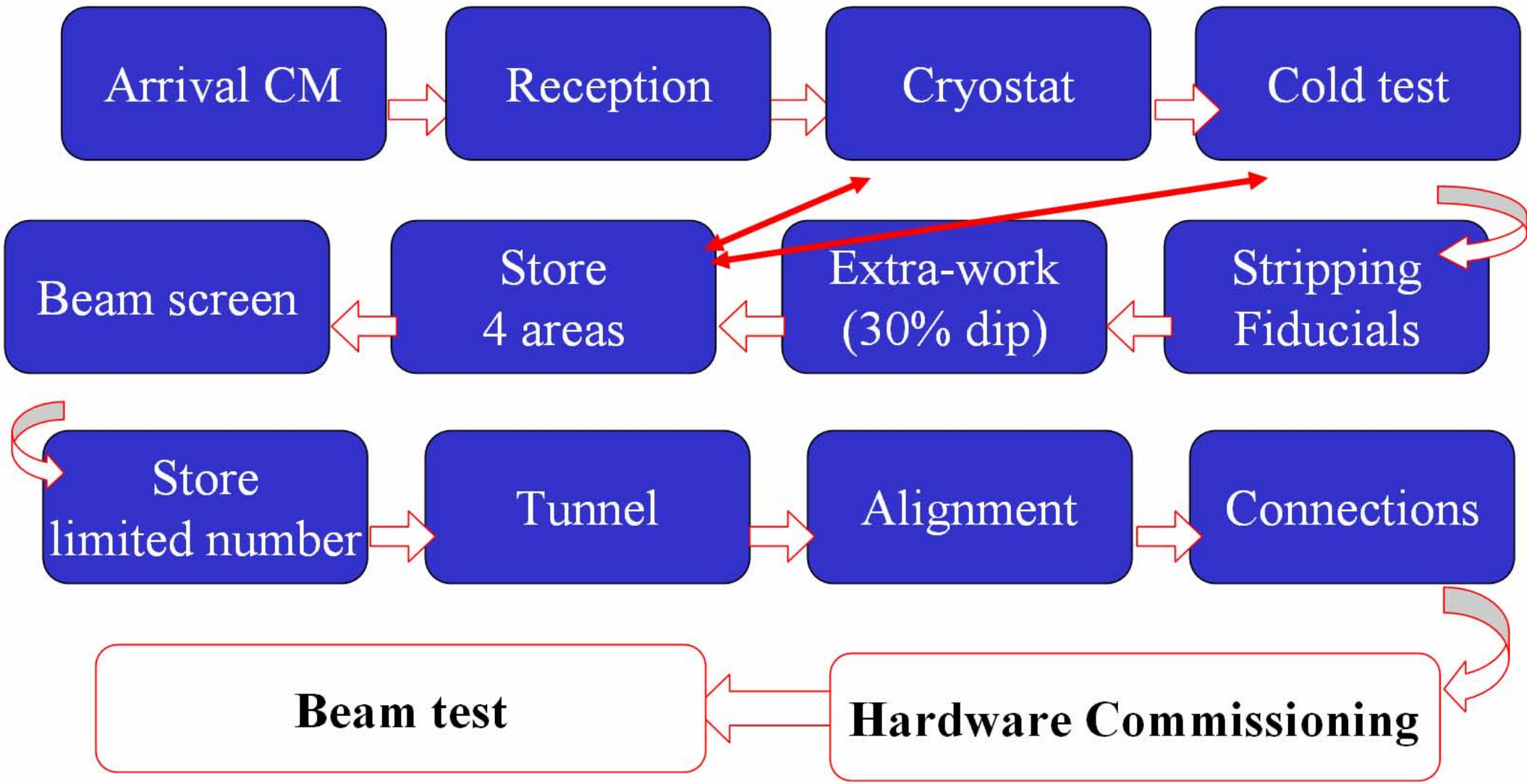
Magnet work flow at CERN before beam test

Courtesy: L.Rossi



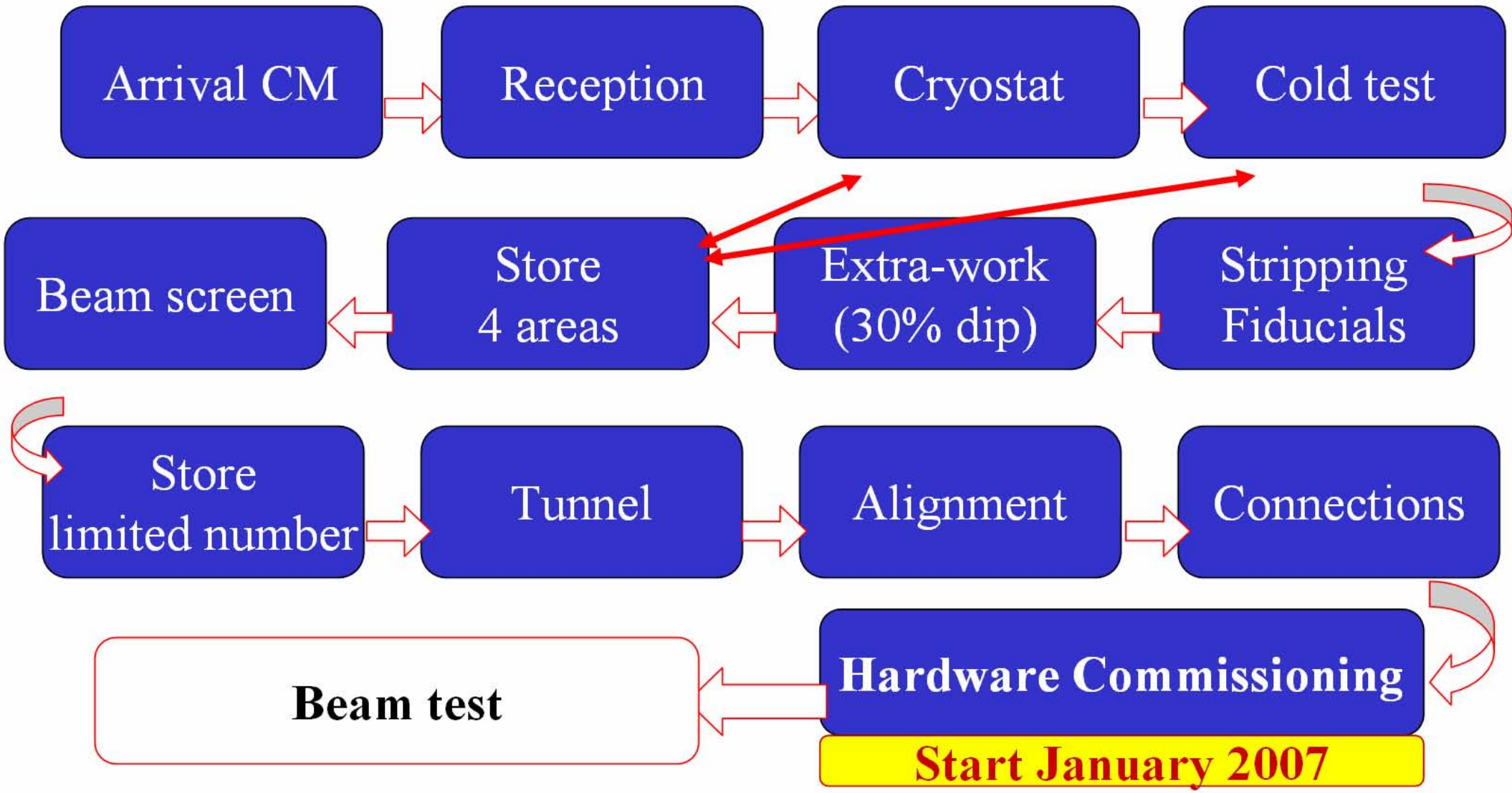
Magnet work flow at CERN before beam test

Courtesy: L.Rossi



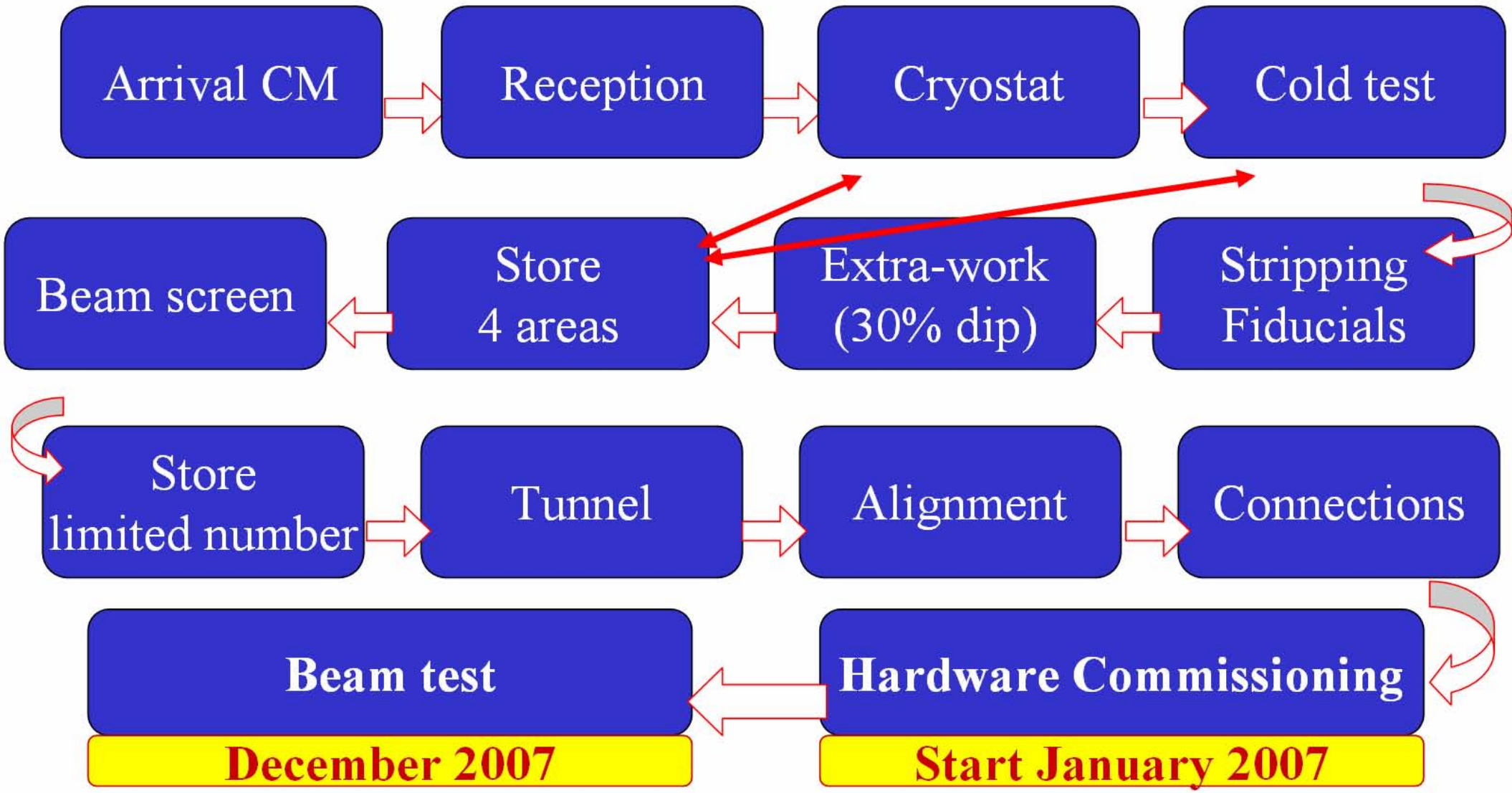
Magnet work flow at CERN before beam test

Courtesy: L.Rossi



Magnet work flow at CERN before beam test

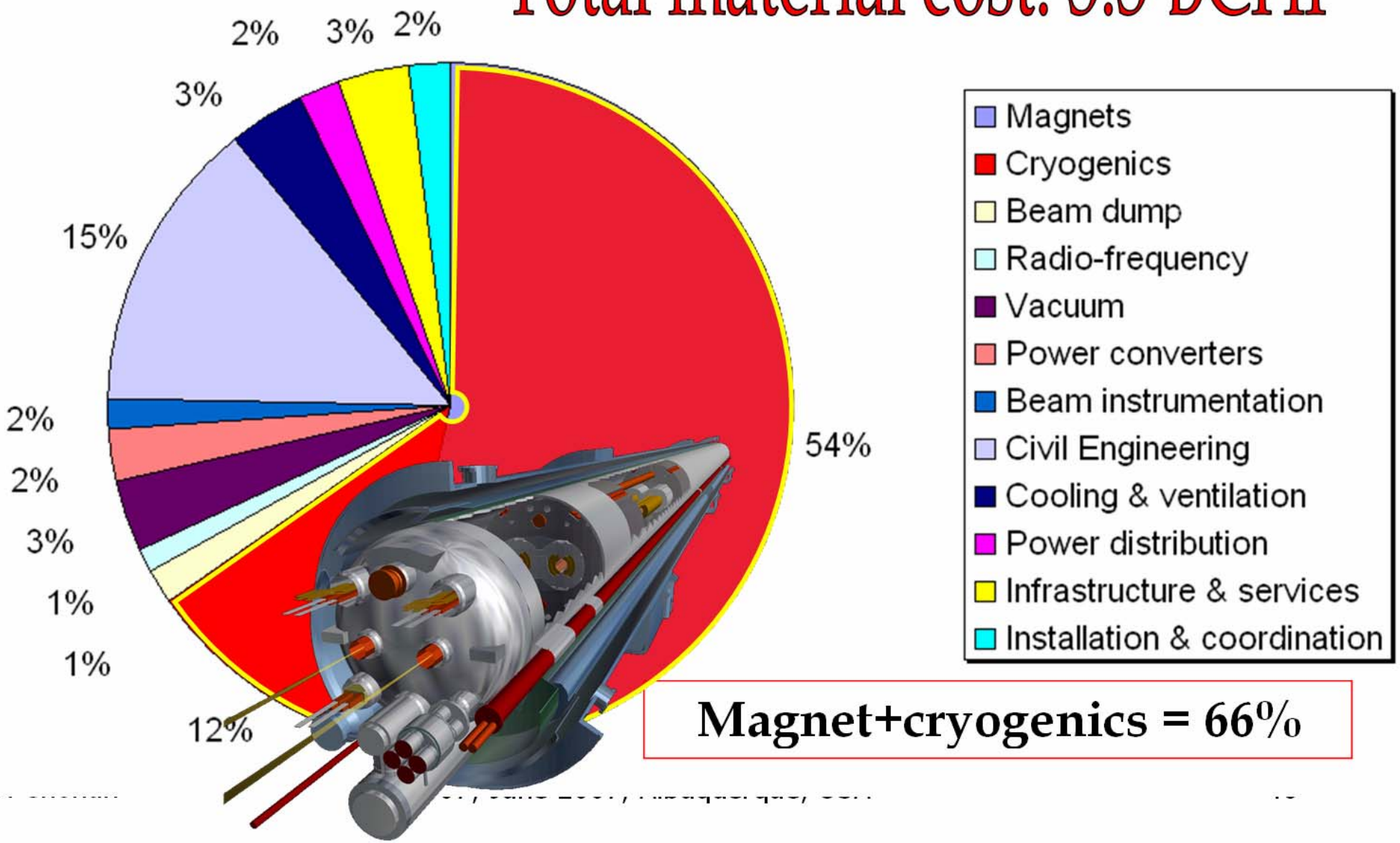
Courtesy: L.Rossi



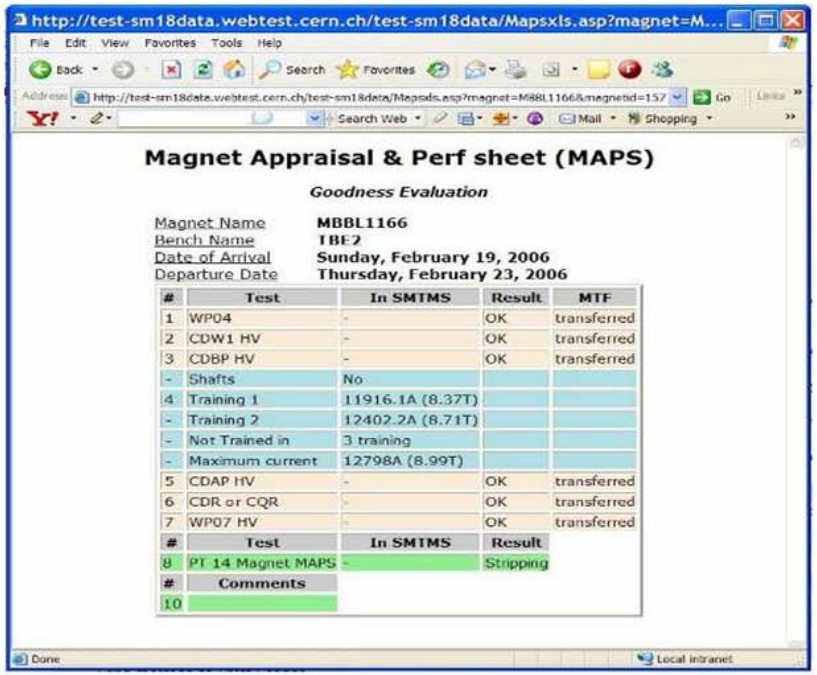
Cost structure of the LHC

Courtesy: L.Rossi

Total material cost: 3.3 BCHF



Magnet+cryogenics = 66%



Magnet Appraisal & Performance Sheet (MAPS)

for Op Empowerment in Decision-taking on a 24 hr basis

Why SM18 Test Management System : SMTMS?

All tests results were entered in
Magnet Test Report (MTR – paper log)

Verification & Analysis of results ??

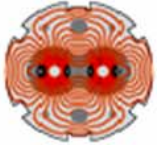
Execution of MAPS

- Enter the test results in template based reports

- Parameters beyond thresholds: Generate non-conformity (NC)

- MAPS: Check for NCs, sign E-traveller, generate MAPS sheet from SMTMS

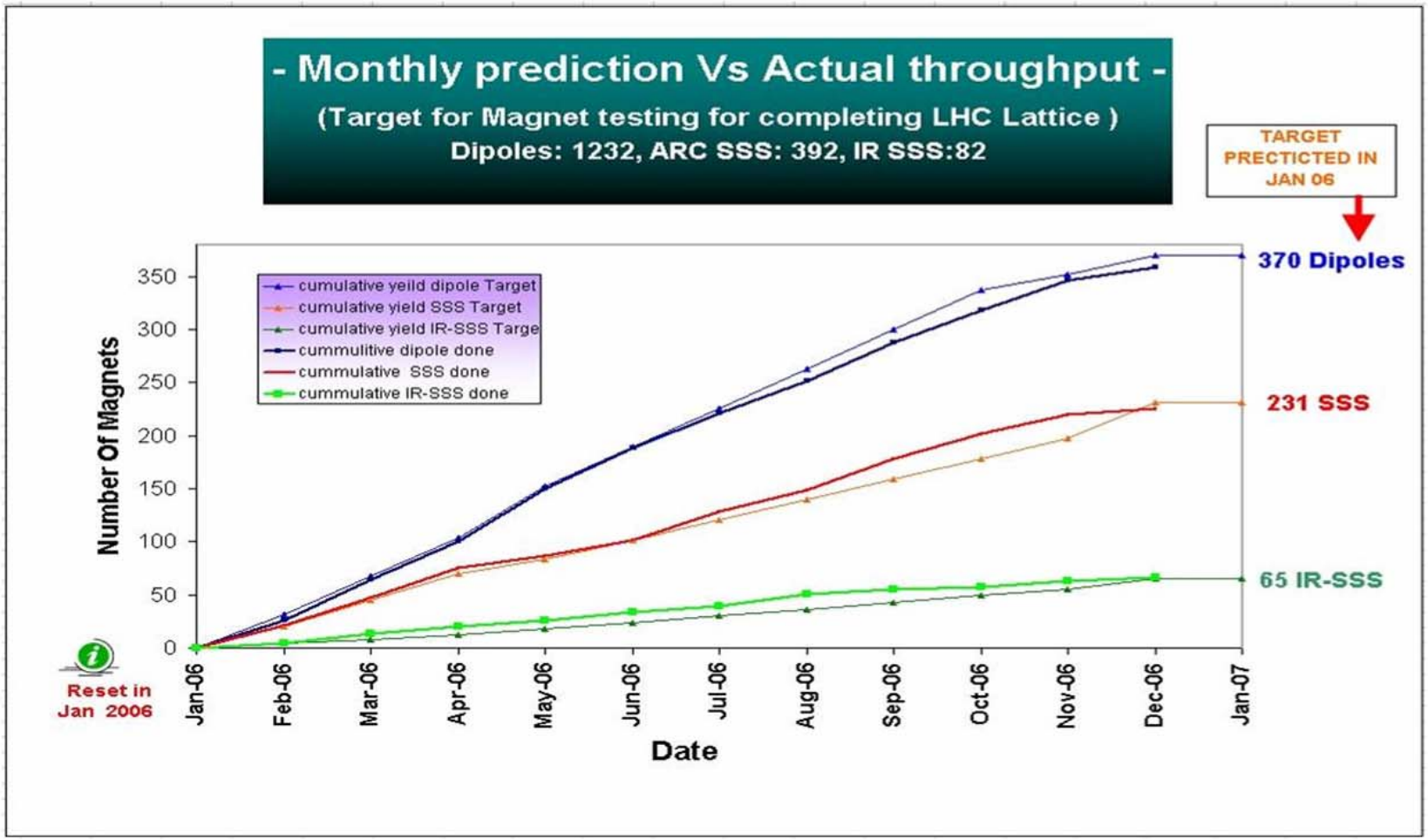
Introduction



- **LHC Requires:**
  - **1232 Dipoles (~19 km out of 27 km ring)**
  - **360 Short Straight Sections (MQ - SSS)**
  - **114 Insertion Region SSS (IR-SSS)**

- **Testing & Qualification (& Training!) of each of them for:**
  - **Cryo, mechanical & electrical insulation**
  - **Quench performance**
  - **Field Quality**

Statistics: Actual Vs. Predicted Throughput



- For the dipoles actual throughput has coincided with the prediction.
- For the special SSS and arc SSS the actual throughput is better then the prediction.

SM18 Test Operation

Available Resources

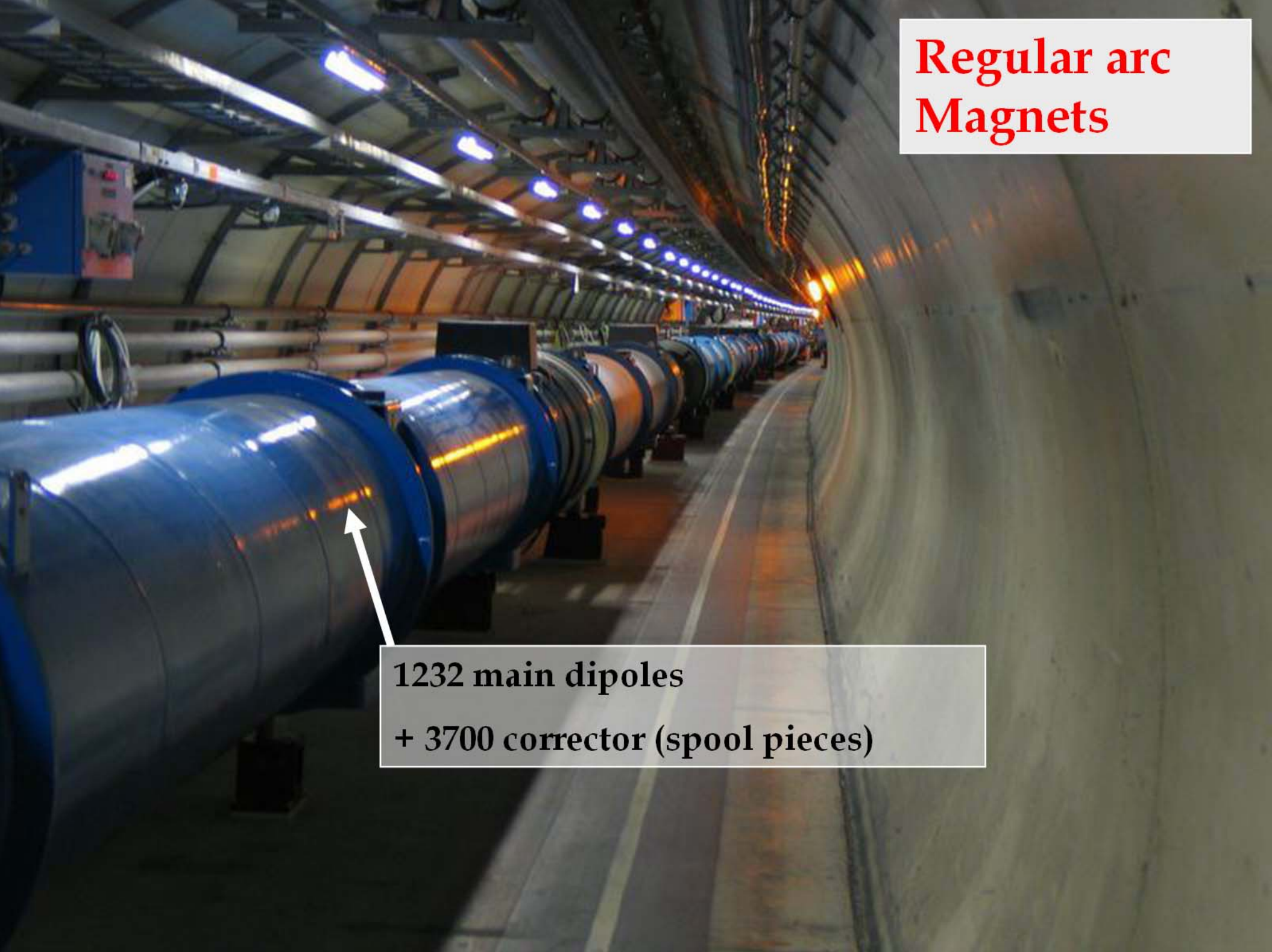
SM18 Test Operation

Available Resources

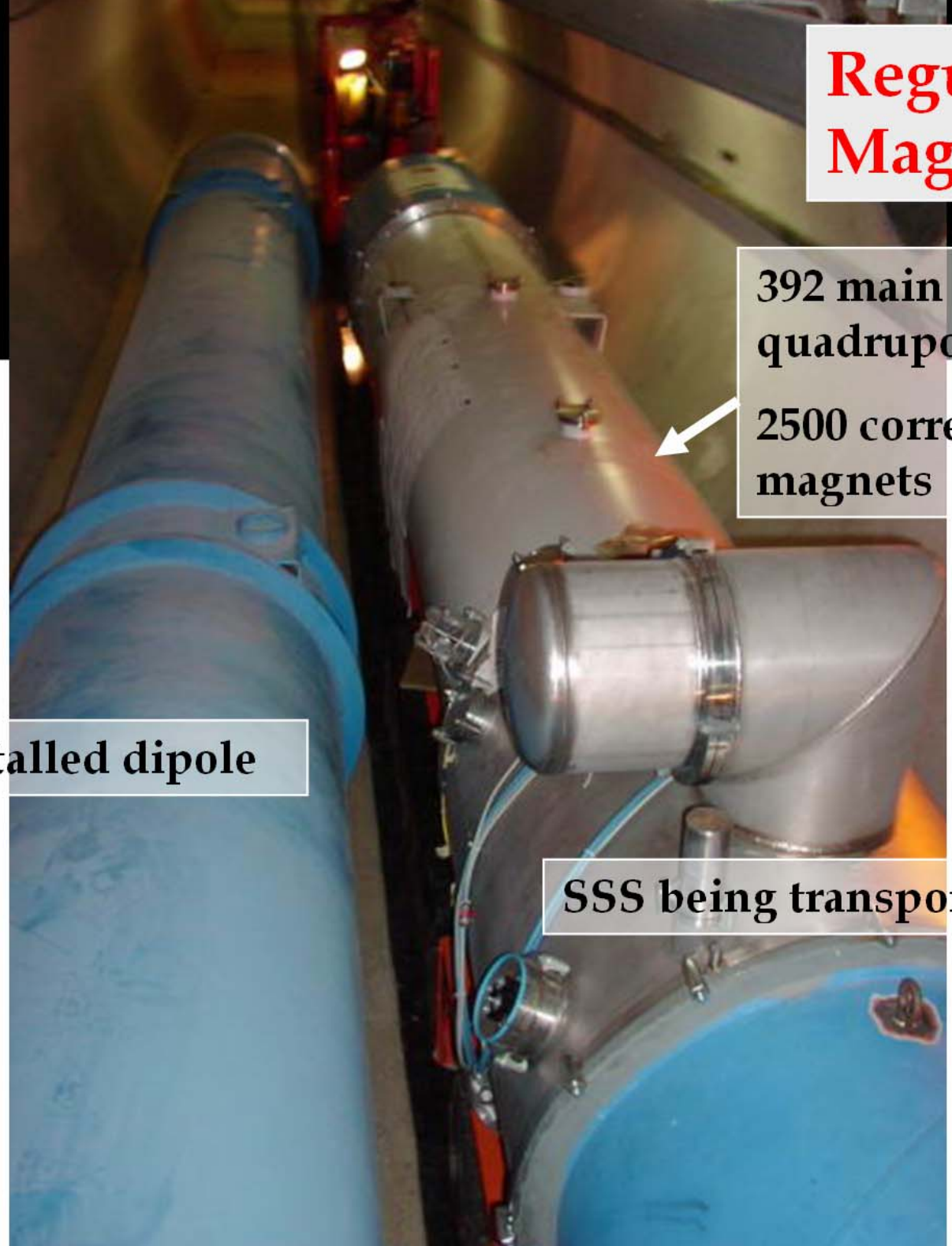
- **Test Equipment**
  - **Fixed**
    - 12 Test Benches arranged in pairs so, 6 clusters(A to F)
    - 6 Main Power Converters
    - 6 sets of Electronics for testing 1 per cluster
  - **Mobile**
    - For Q-location & MM special 15 m Shafts to be installed in magnets
    - Mobile Racks for HV insulation tests & Magnetic Measurements
    - SSW Units
- **Shared Utilities**
  - Water for 4 magnet powering at the same time
  - Cryogenics capacity and limits
- **Manpower [24 hr Tests Operation Staff] in 2005**
  - 14 CERN staff (~12 FTE) on loan from CERN Accelerator Operation (some only part-time)
  - 20-25 persons on exact 1 year contracts from India & constantly rotating, so (~16 FTE)
  - ICS "Magnet connectors/disconnectors" working 24 hours (but ROCLA not)
  - Cryogenic Support staff
- **Technical Support**
  - Equipment support for magnet test equipment and electronics


LHC tunnel 2002


LHC tunnel 2006


Regular arc Magnets
1232 main dipoles
+ 3700 corrector (spool pieces)

Regular arc Magnets

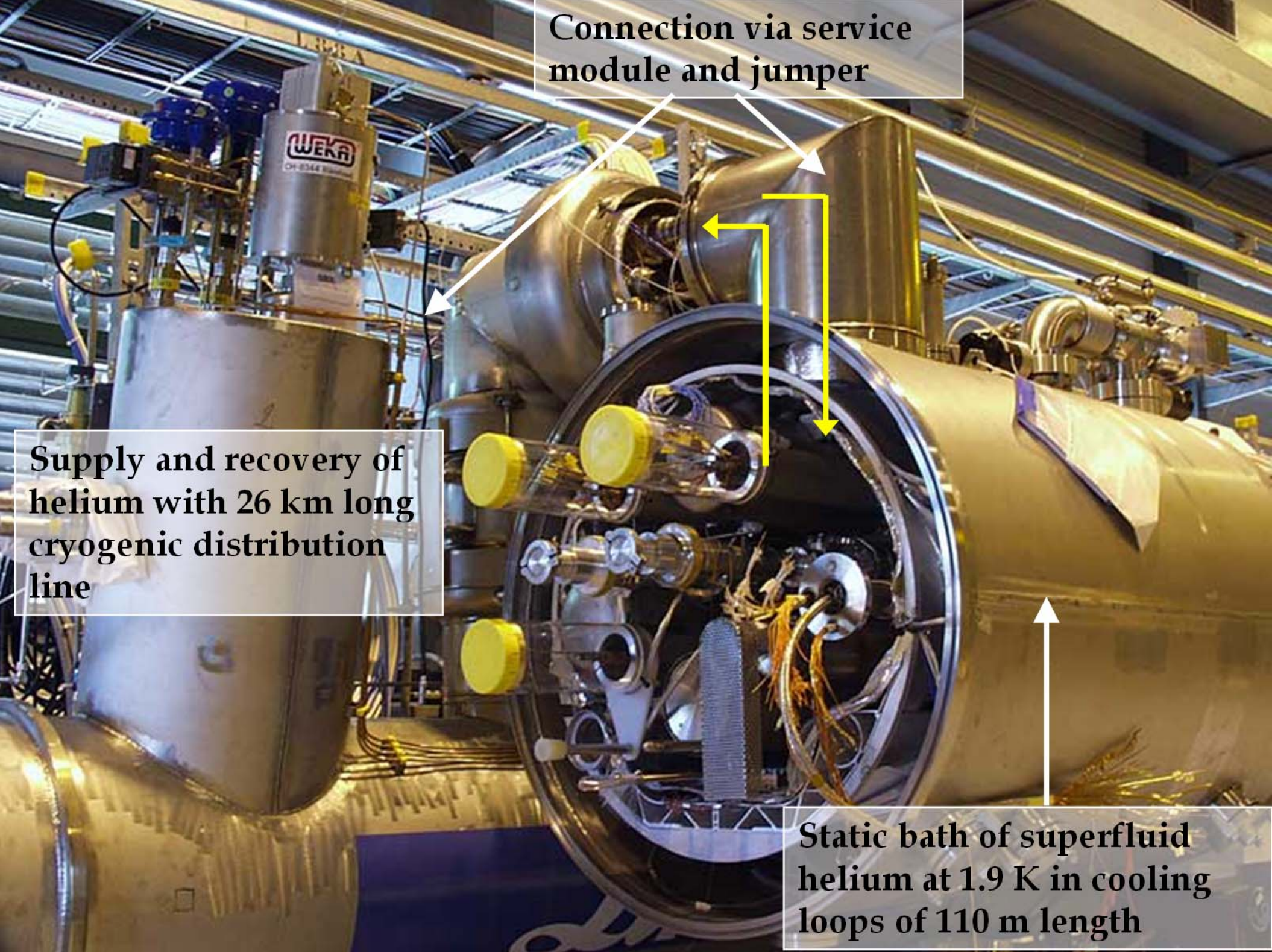


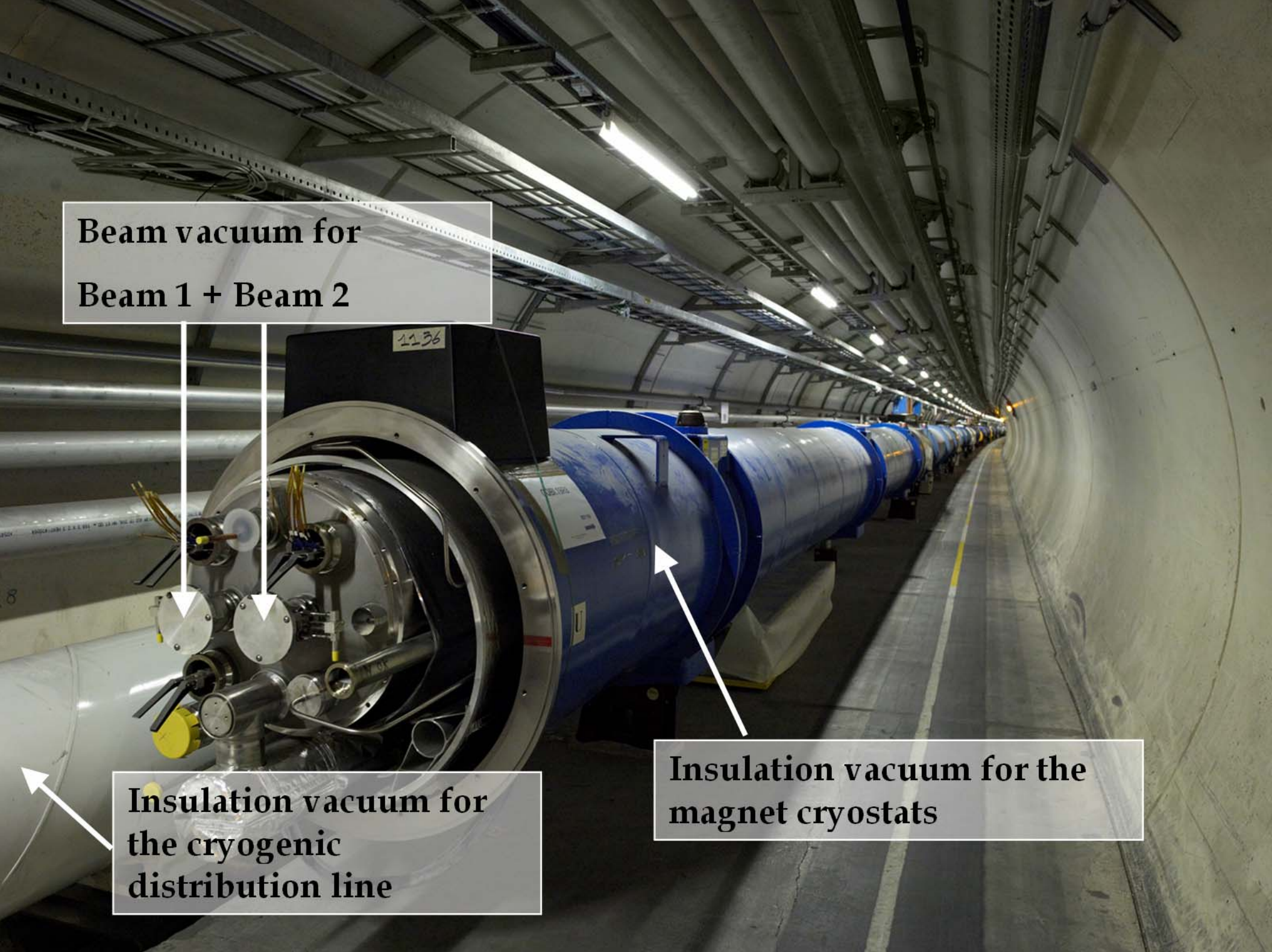
392 main quadrupoles +

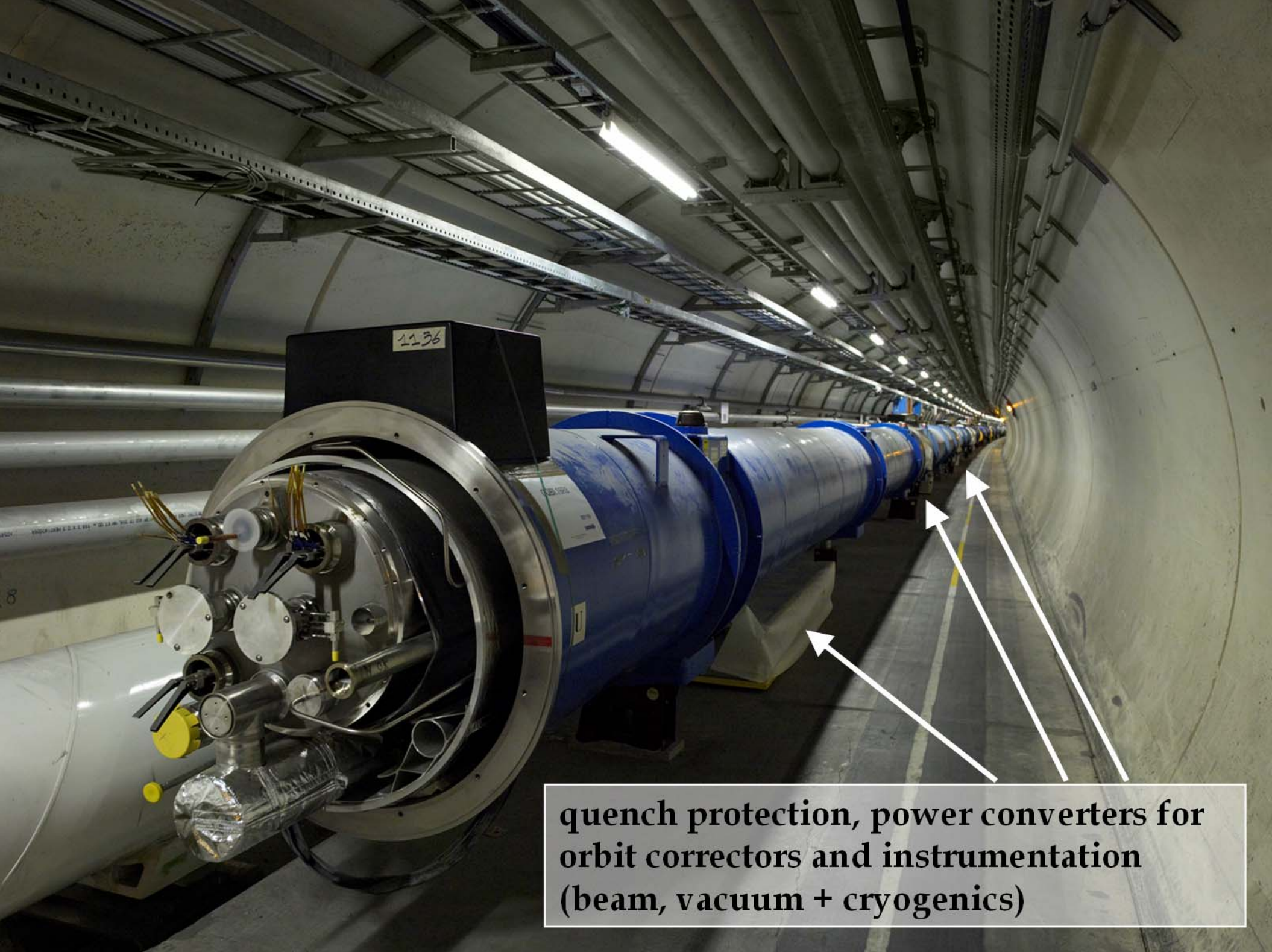
2500 corrector magnets

Installed dipole

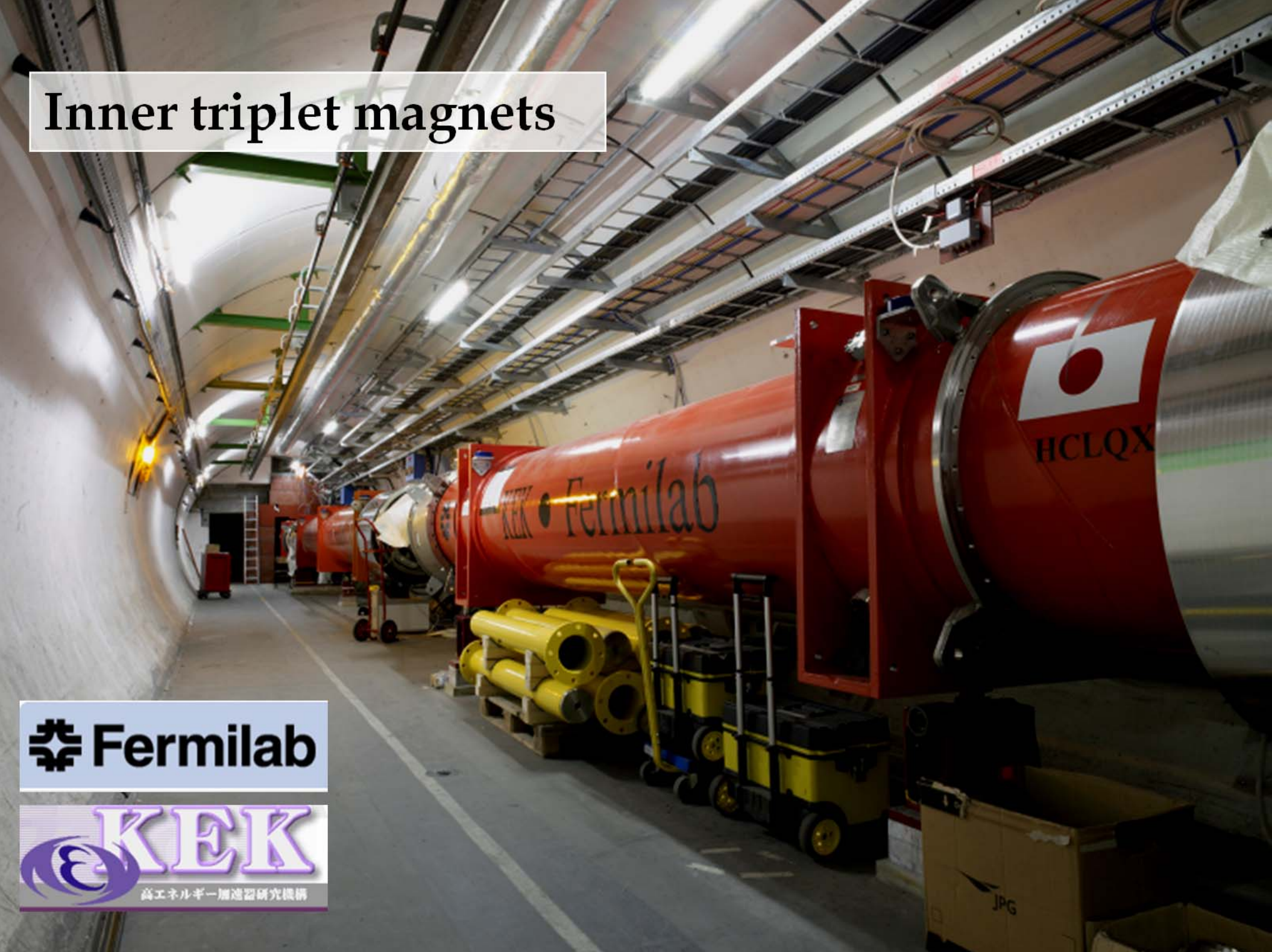
SSS being transported


Connection via service module and jumper
Supply and recovery of helium with 26 km long cryogenic distribution line
Static bath of superfluid helium at 1.9 K in cooling loops of 110 m length


Beam vacuum for
Beam 1 + Beam 2
Insulation vacuum for the magnet cryostats
Insulation vacuum for the cryogenic distribution line


1136
quench protection, power converters for
orbit correctors and instrumentation
(beam, vacuum + cryogenics)

Inner triplet magnets



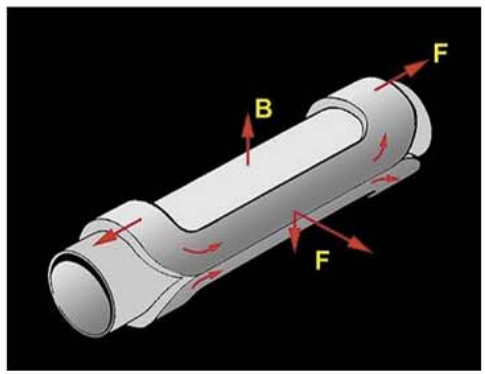
Fermilab

KEK
高エネルギー加速器研究機構

Accelerator magnets issues

Courtesy: L.Rossi

- In iron dominated magnets the pole shape dictates field quality
- In superconducting magnets the conductor position dictates the accuracy of the field.
- Coils not self-supporting
- Beam will circulate 500 Millions times in the LHC
- Field accuracy: 10-100 ppm
- Necessity to have all dipoles equal in length within ~ 100 ppm (1.5 mm over 15 m of the LH(dipole length !)

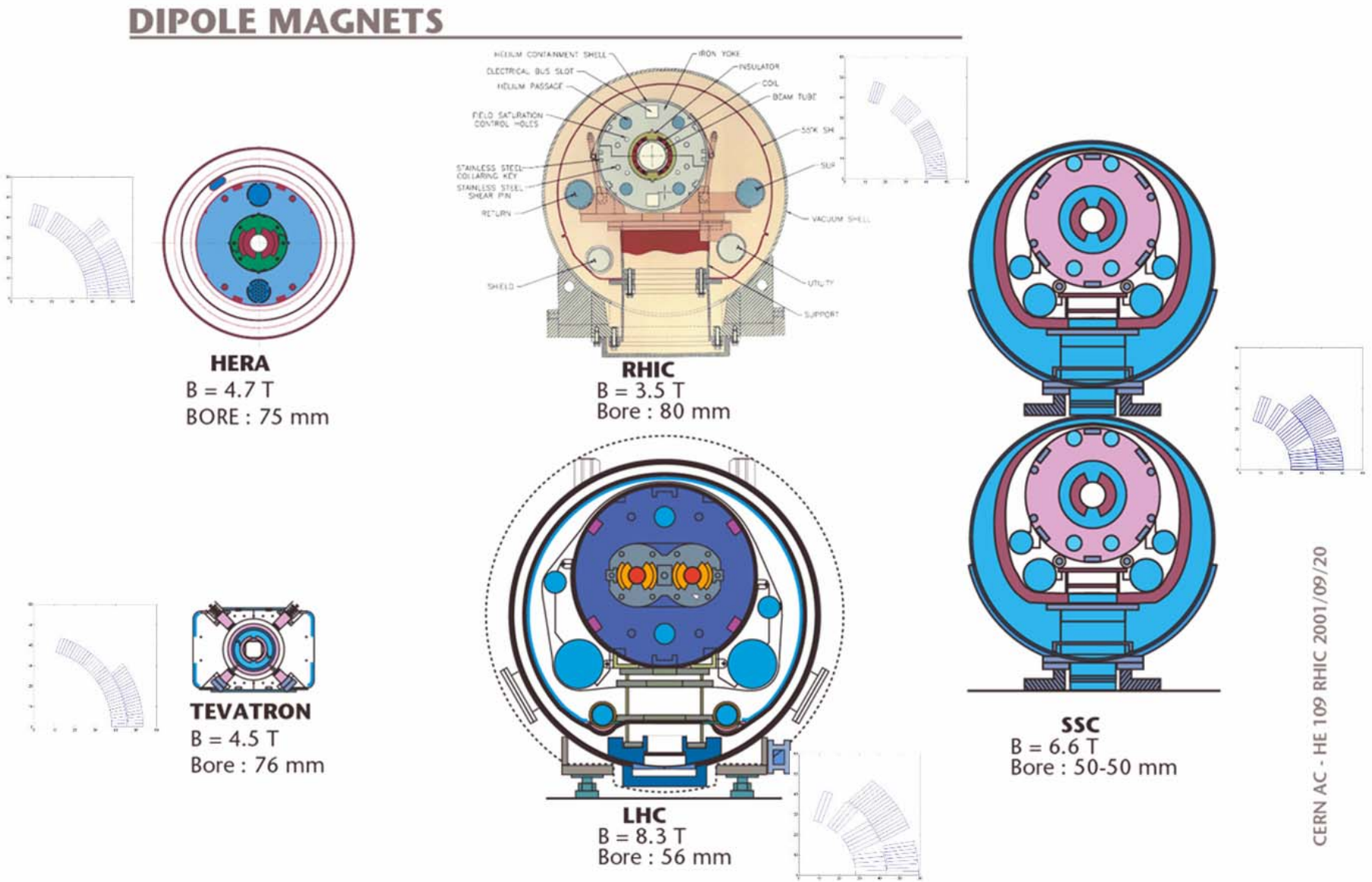


LHC main dipoles

- Quantity: 1232 dipoles ×15 m = 18.5 km
- Operated at same current: 154 circuits
- Extremely high current density: operation 85% of Ic (on load line), little stabilizer to increase J⇒ Training. BUT we cannot train them at long (it costs too much) and **they should not re-training.**
- After the cool down the **worst magnet will determine the energy of the accelerator.**

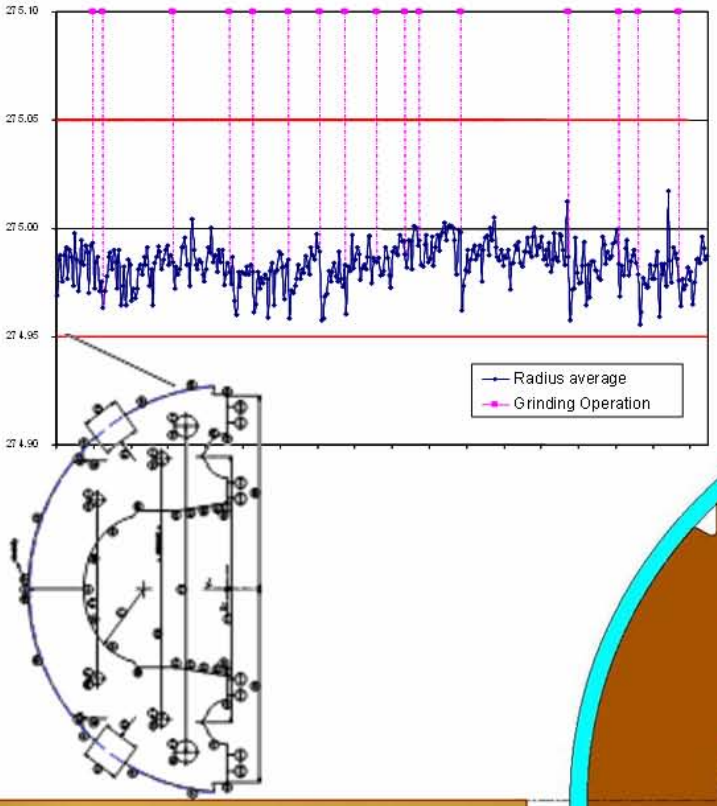
The historical look…

Courtesy: L.Rossi



Accelerator Technology Department

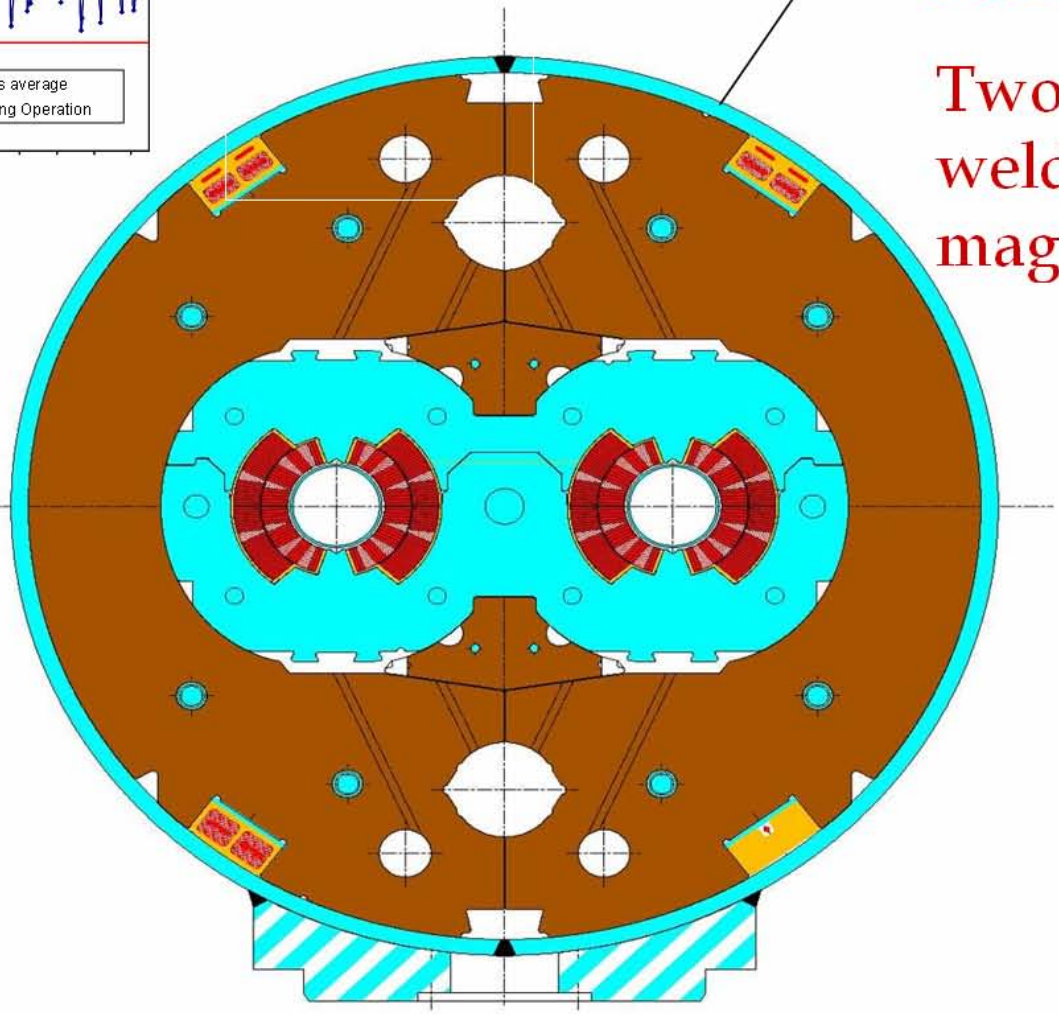
Dipole cross section: yoke & shrinking cylinder



Curvature released from ± 1 to ± 2.5 mm:

Solution: pairing

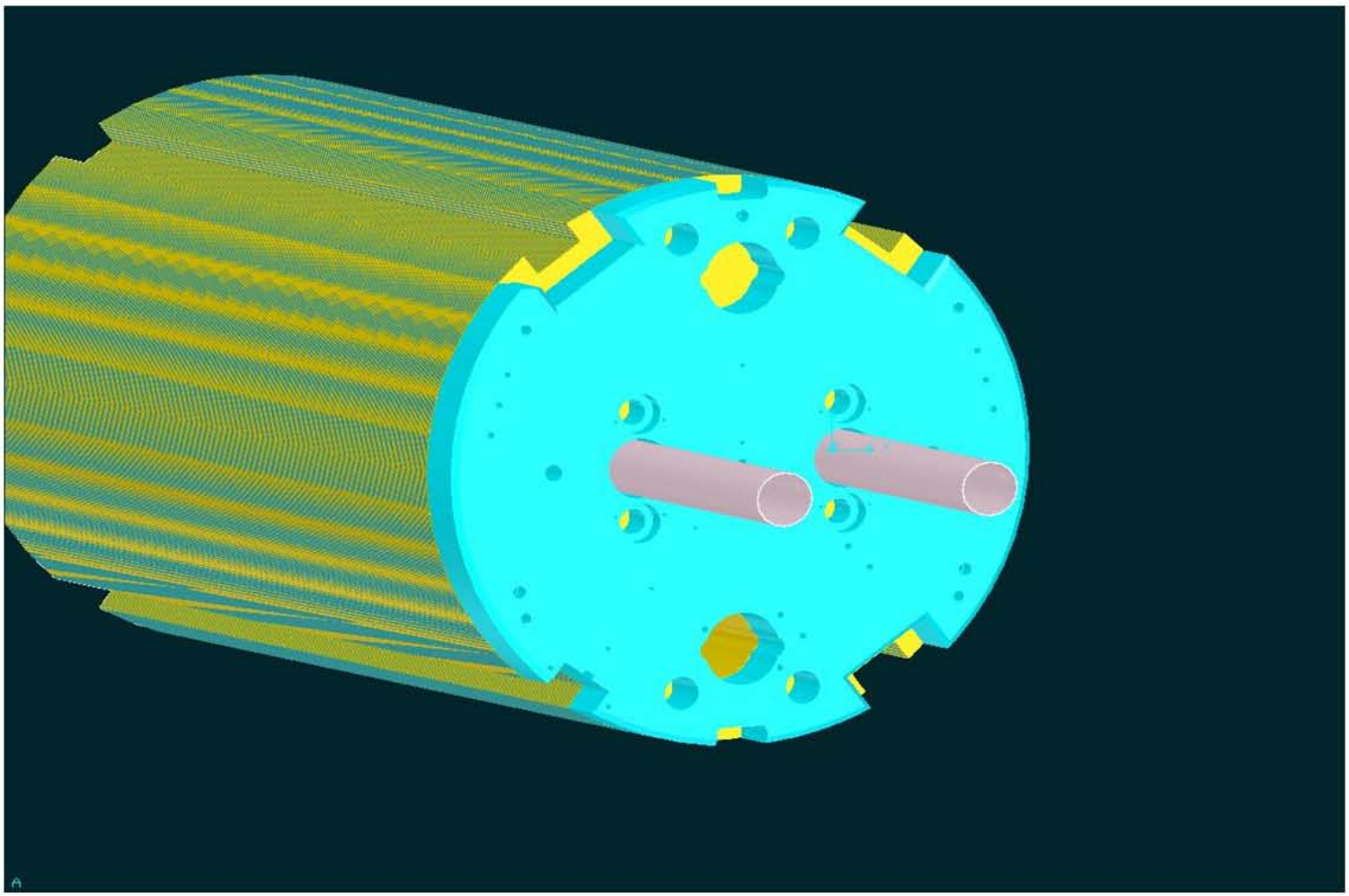
Two half shells, welded on the magnet



Courtesy: L.Rossi

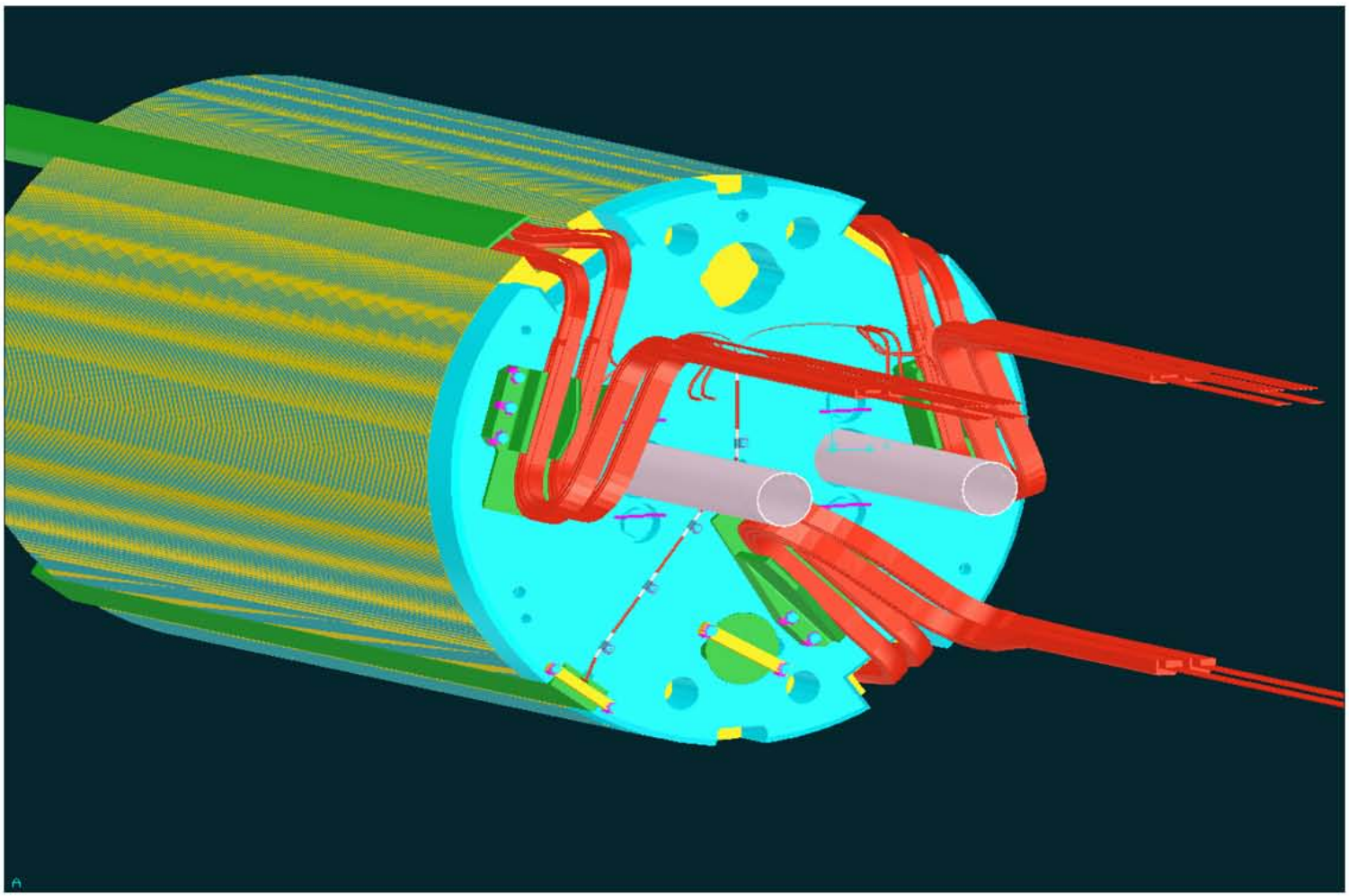
Dipole -end part end plate

Courtesy: L.Rossi



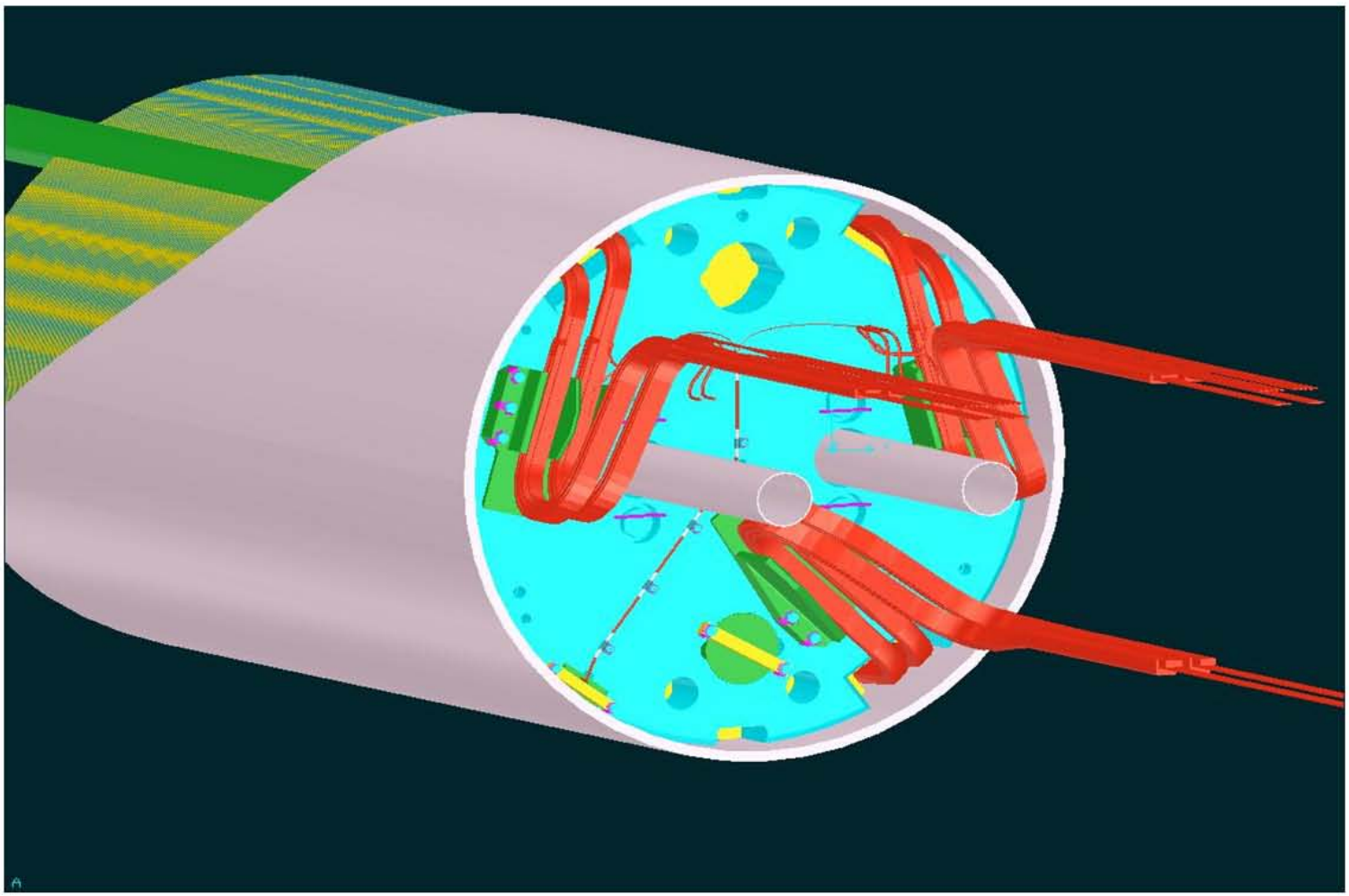
Dipole-end part Bus Bars

Courtesy: L.Rossi



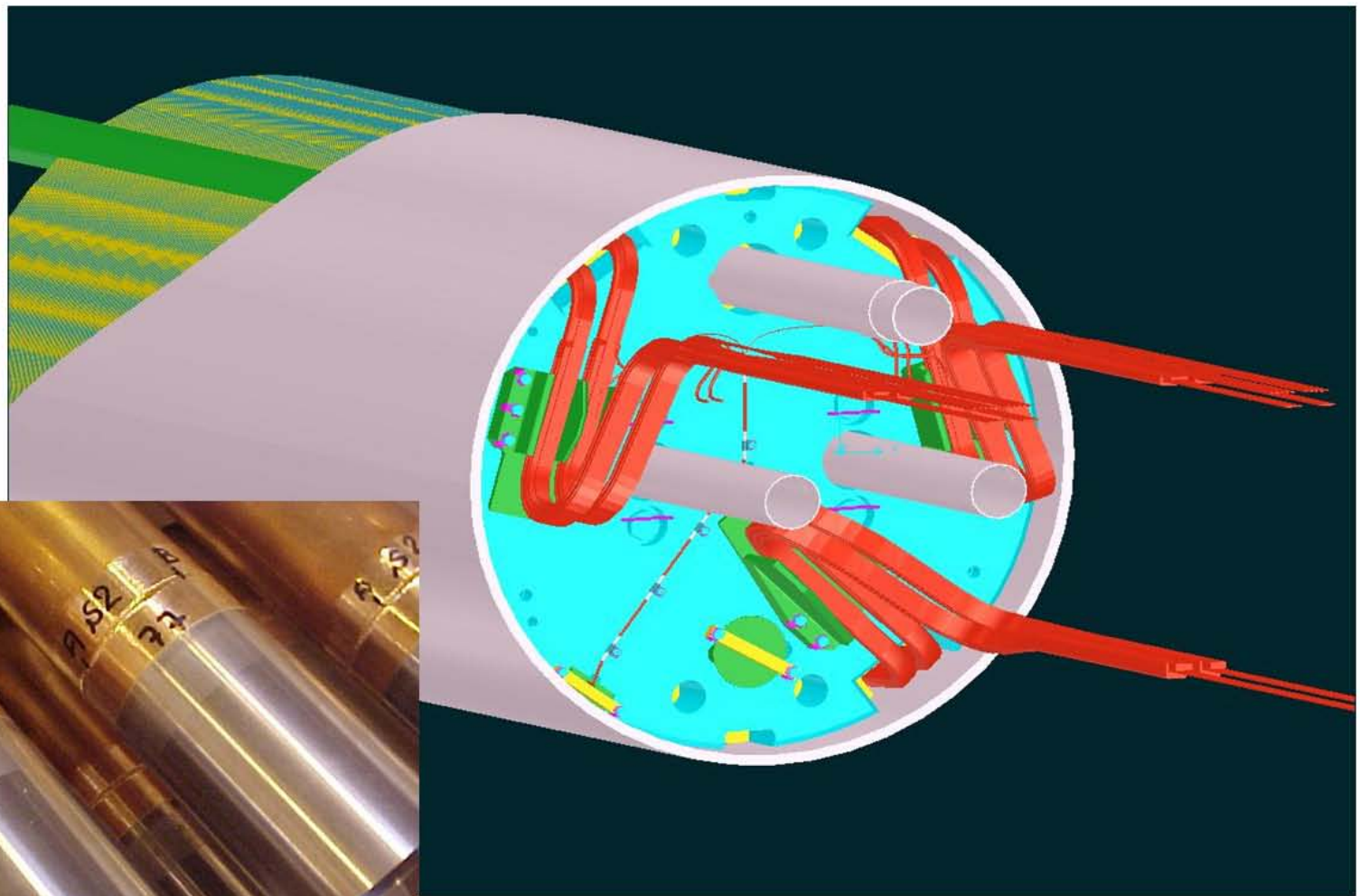
Courtesy: L.Rossi

Dipole -end part Shrinking cyilinder



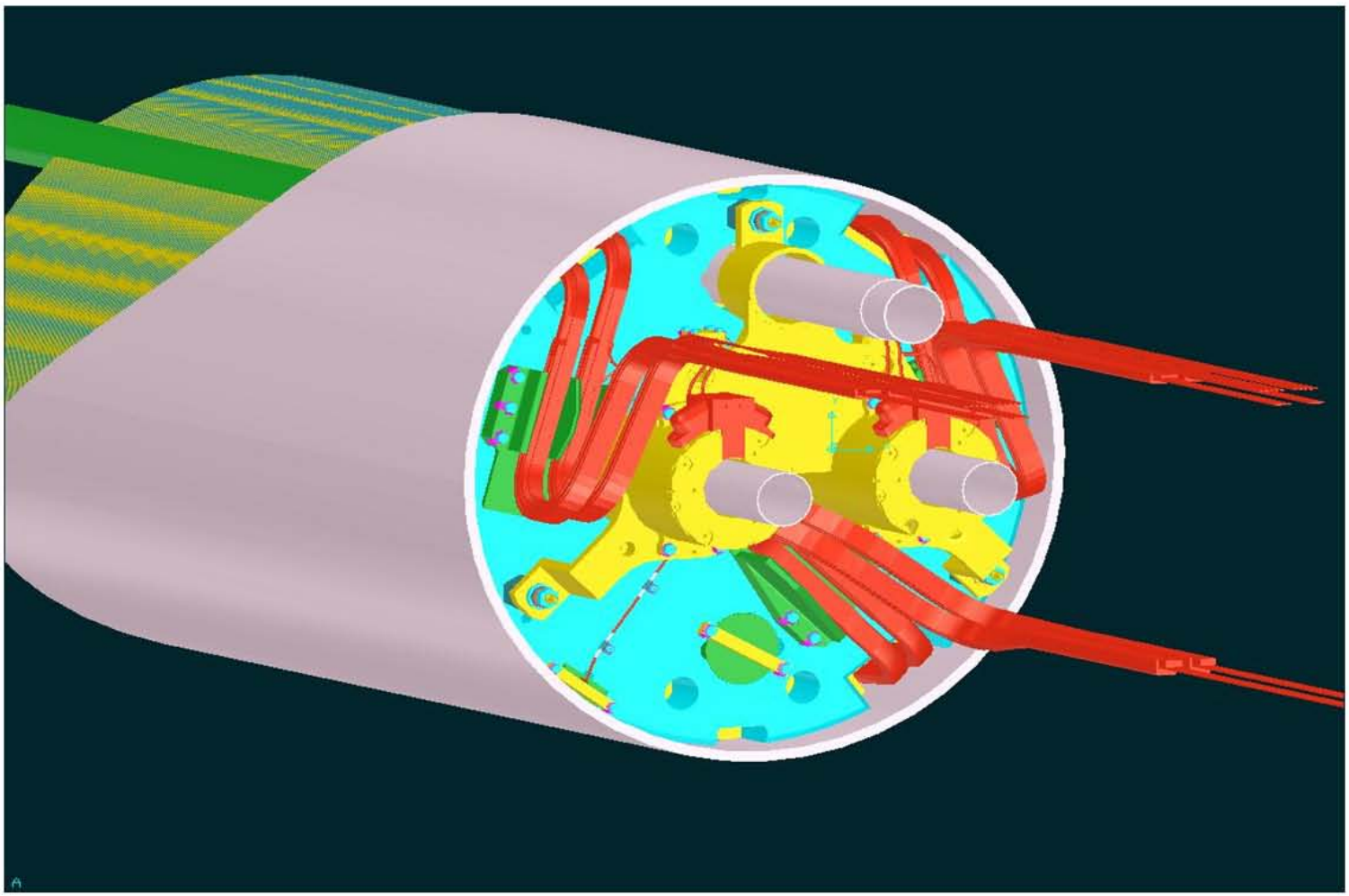
Dipole -end part Cu HXT

Courtesy: L.Rossi



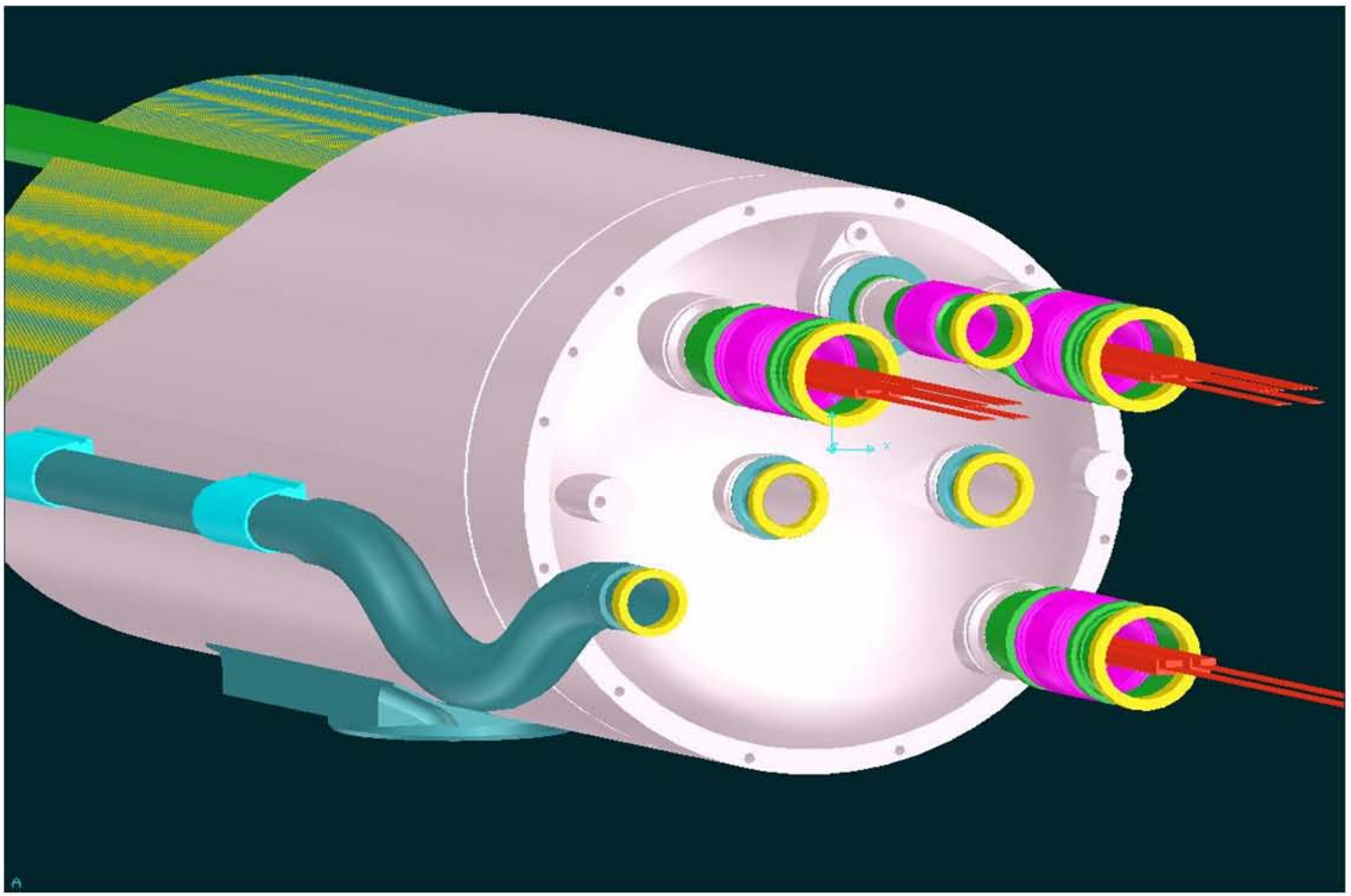
Dipole -end part Corrector Magnets

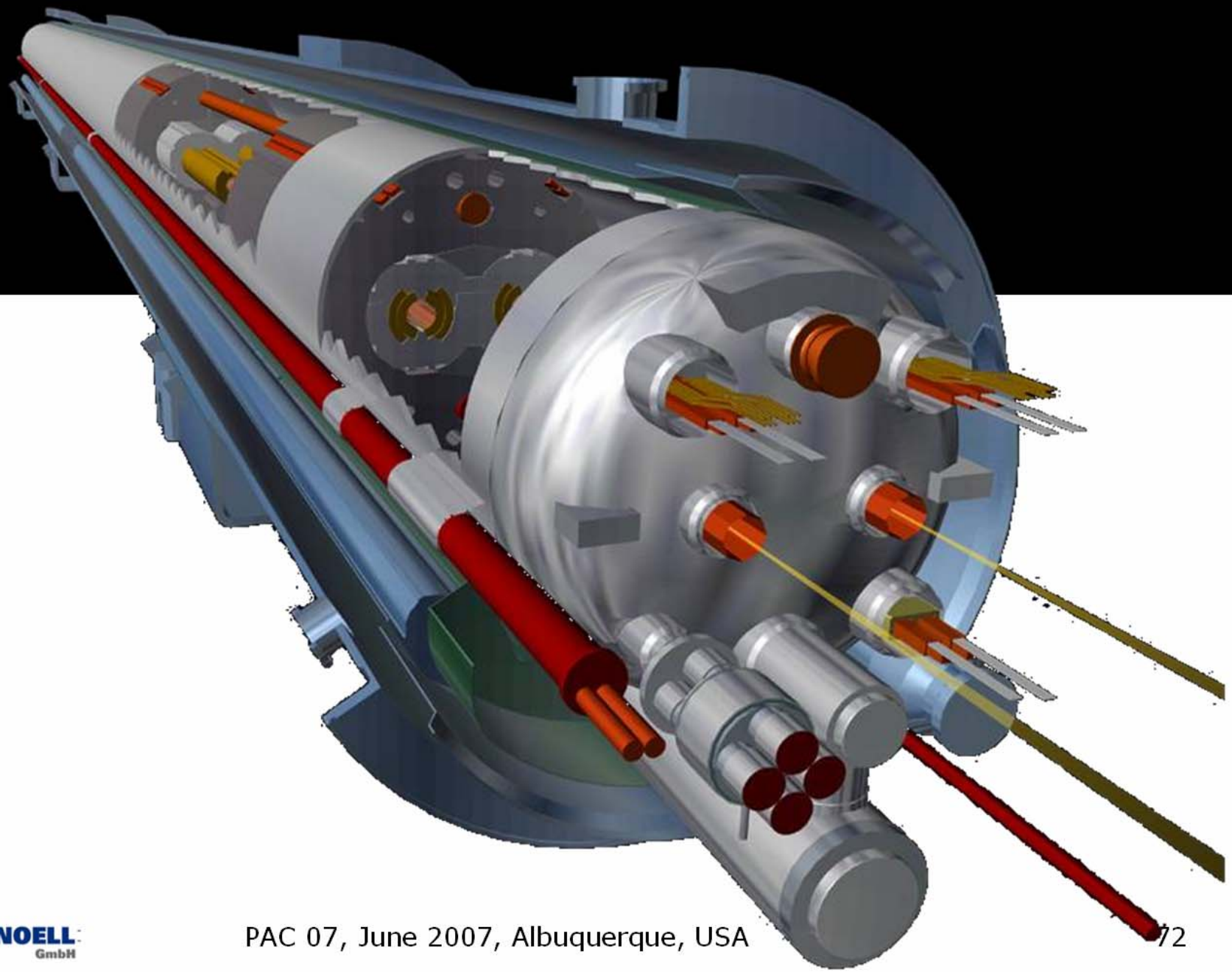
Courtesy: L.Rossi



Dipole -end part
Cold foot, Bellows and N-line

Courtesy: L.Rossi





CERN

ALSTOM

FRAMATOME ANP

JEUMONT S.A.

ASG Superconductors

GRUPPO MALACALZA

BABCOCK NOELL GmbH

To-Do List & MTR

Tests numbered sequentially

Prefixes define type of test

		LIST OF TESTS FOR A NEW DIPOLE With Magnetic Measurements - No Thermal Cycle	Estimated Time	estimate count [hours]	Documents
Preparatory tests at Warm					
	IC91	HV Test performed by ICS. "Warm initial before bolting"			
	IC92	Electrical Connection to CFB (ICS - BOLTING).			
	SCAN1	Scan Dewar, Magnet Name, Gauntlet and Anticryostats (or the MDB end plates if no anticryostats are installed) or Enter the magnet Name in TEMA if MTF & Isovac are not active.	0.15	0:15	
Prep	1	Lyre Test. (With ICS)	0.30	0:45	
	2.1	IAP @ warm. LF heater discharge	0.30	1:15	
	2.2	IAP @ warm. HF heater discharge	0.30	1:45	
	2.3	Resistance Measurement. (Quench Heaters after discharge)	0.30	2:15	CDW1 Resistance
	SCAN2	Scan the HV mobile rack. Check Gauntlet entry in MTF.	0.15	2:30	
	3	HV Insulation Test. "Warm initial after bolting to CFB"	1.30	4:00	CDW1 HV
	IC93	SIGN TRAVELLER.			WP04.1.3.2.3.3 Page 8/10
	CR1	Cryo Team Leak test	0.30	4:30	
	IC94	Final Connection to CFB /CFE (ICS)			
	SCAN3	Scan the Shafts, TBU and Mobile Rack, or Quench Antennae.	0.15	4:45	
	4	Connect the TBU with the mobile rack if shafts are available. Start T-COIL if the bench is active.	0.30	5:15	
	5	Cool Down. Put 2A in the magnet and launch Thermal Cycle in TEMA.	30.00	35:15	
Cold tests at 1.9K					
	SCAN4	Scan the HV Mobile Rack	0.15	35:30	
PT	2	HV Insulation test. "Cold initial before test connected to CFB"	1.45	37:15	CDBP HV
PT	1	IAP @cold. (Check of T-Coil, tuning of offset and compensation for Potain cards and Qloc)	1.30	38:45	
PT	3	Resistance Measurement. (Quench Heaters)	0.15	39:00	CDBP Resistance
PT	4	Slow Power Abort Check @ 1000A.	0.30	39:30	
MM	1	Shaft alignment and MMP Checks @ 1500A.	0.45	40:15	
PT	5.1	HALF LF. (Provoked Quench at 1.5 kA. Triggered by one card and protected by the other)	1.00	41:15	
	5.2	HALF HF. (Provoked Quench at 1.5 kA. Triggered by one card and protected by the other)	1.00	42:15	
PTE		Minimum Energy Quench @ 8kA (fast PA disabled) for Diode Test.	2.30	44:45	
PT	6	Training Quenches. According to the current training flowchart.	20.00	64:45	
MM	2	LHC cycle.	2.30	67:15	
MM	3	Full load Iloc. (+ Joints Measurements)	3.00	70:15	
PT	8	De-excitation. Ramp to 12000A and Slow PA. (If Slow PA was not done at ultimate)	0.30	70:45	
MM	4	Single Stretched Wire.	6.00	76:45	
	SCAN5	Scan the HV Mobile Rack	0.15	77:00	CDPT
PT	9	HV Insulation Tests: "Cold final after test connected to CFB"	1.45	78:45	CDAP HV
PT	10	Minimum Energy Quench @ 11850A (fast PA disabled) to warm up the magnet	0.30	79:15	
		Make sure Quench Heaters are discharged before starting Thermal Cycle.		79:15	
PT	12	Warm Up. Put 2A in the magnet and launch Thermal Cycle in TEMA.	0.15	79:30	
		Electrical disconnection of the cables between TBU and mobile rack.			
Warm-up					
PT	13.1	IAP @warm. No Quench Heater Discharge Test.	1.00	80:30	
	13.2	Resistance Measurement. (Quench Heaters, Voltage taps, Correctors, Cryo Heater and Temp. sensor)	0.30	81:00	CDW2 Resistance
	IC95	SIGN TRAVELLER.			WP07
	SCAN6	After disconnection, scan the EMPTY label on the CFB.			
		Total Duration without Thermal Cycle : all Prep + Cooldown(80hrs)+ Power + MM tests + SSW		81:00	

Obeys To-Do List

Checklists & notes appended

MBAF136 MBAL1136 on TBF1

PREP 1	**LYRE TEST** (carried out with ICS personnel, put 2A at 15 V, in the magnet)	
Carried out By:	TEAM MEMBER(S)	SHIFT LEADER
Date and Time:		
Voltmeter Reading (Max. Value during Test.)		Voltmeter Reading (Min. Value during Test.)
Results		
Note	The convalescence voltage expected ~ 11.5 V	
IMPORTANT	Sign ELECTRONIC traveller as soon as the test is performed	

PREP 2.1	**IAP AT WARM** (LF HEATER DISCHARGE) (put 2.5 A at 18 V, in the magnet)	
Carried out By:	TEAM MEMBER(S)	SHIFT LEADER
Date and Time:		
File Name(s)		
Results	Quench Heaters	
	Voltage Taps	
	Temperature sensor Reading	

PREP 2.2	**IAP AT WARM** (HF HEATER DISCHARGE) (put 2.5 A at 18 V, in the magnet)	
Carried out By:	TEAM MEMBER(S)	SHIFT LEADER
Date and Time:		
File Name(s)		
Results	Quench Heaters	
	Voltage Taps	

SM18 Magnet Tests : What it's all about