Polish involvment in the LHC construction at CERN

- At least three polish institution have been involved in the LHC construction
- Namely:

Wroclaw University

Universilty of Science and Technology (AGH) Krakow

Last but least

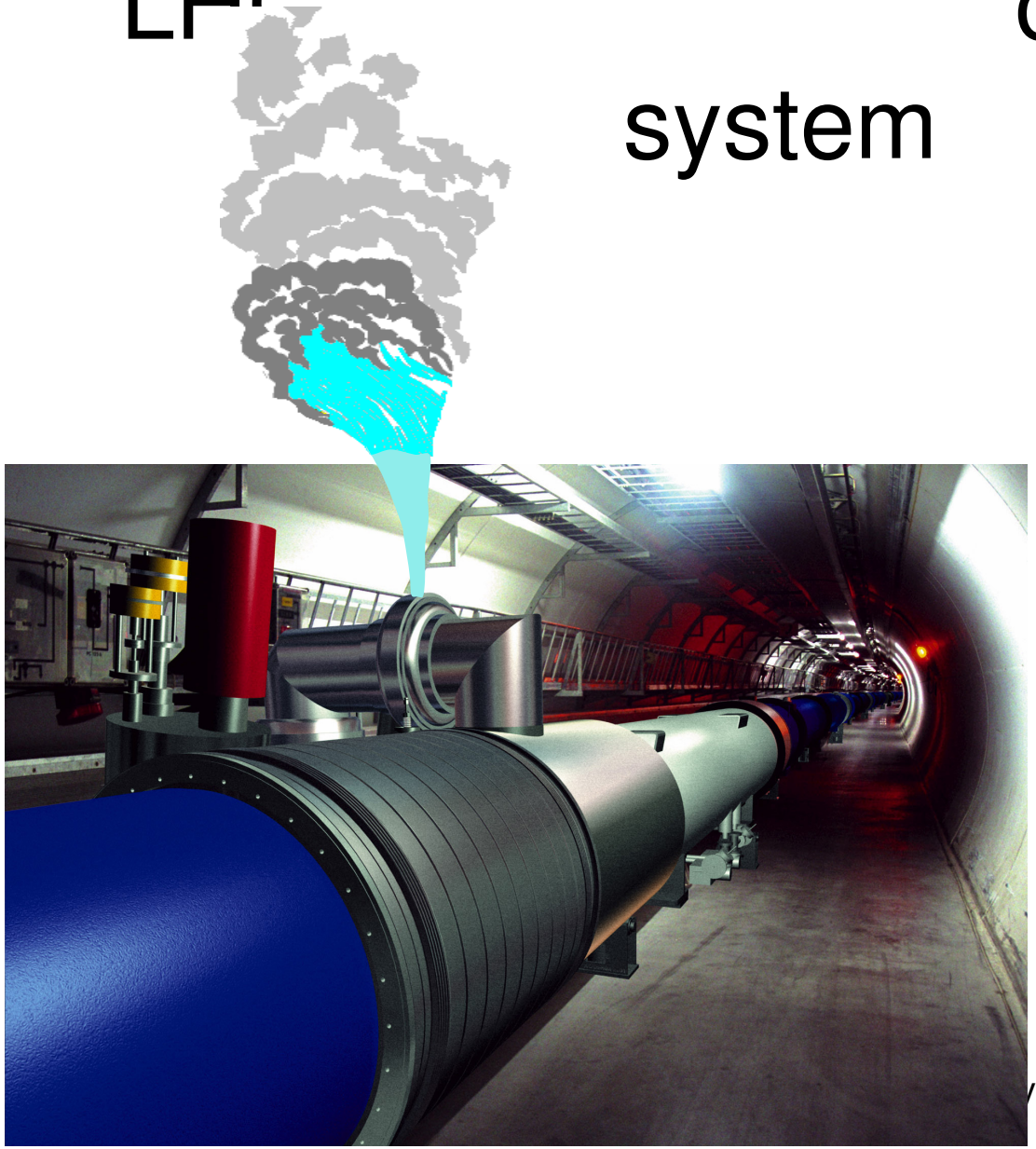
H. Niewodniczanski Institute of Nuclear Physics
Polish Academy od Sciences - Krakow

Wroclaw University Technology input to the LHC construction

Content

- Magnet resistive transition (quench) thermohydraulics
- Risk analysis of the LHC cryogenic system
- Thermal reception tests of the QRL
- Pressure and leak tightness tests of the DFB boxes

Risk analysis of the LHC cryogenic system



Questions that were to be answered

- Thermohydraulics of magnet resistive transitions
- Pressure evolution in magnet cryostat following quench
- Sector quench and helium relief
- Helium potential flow to the LHC tunnel
- And many others

Stability tests of the cryogenic distribution line (QRL) compensators

Stability tests of some bellows types for Cryognic Distribution Line were performed at WUT in 2006

Thermal reception tests of cryogenic distribution line QRL

CERN and Wroclaw UT engineers in the LHC tunnel

The LHC Cryogenic Distribution Line during the reception tests in sector 8-1

AGH – University of Science and Technology, Kraków

Participation in LHC hardware commissioning

Letter of Intent - 17th May 2005

Collaboration Agreements:

Computer Control and Instrumentation for Cryogenic Supply - K/1208/AT/LHC

Quench Protection and Energy Extraction Systems - K/1231/AT/LHC

Technical Support for LHC - K/1258/TS/LHC

Instrumentation and Controls for the LHC Tunnel Cryogenics – K/1397/AT/LHC

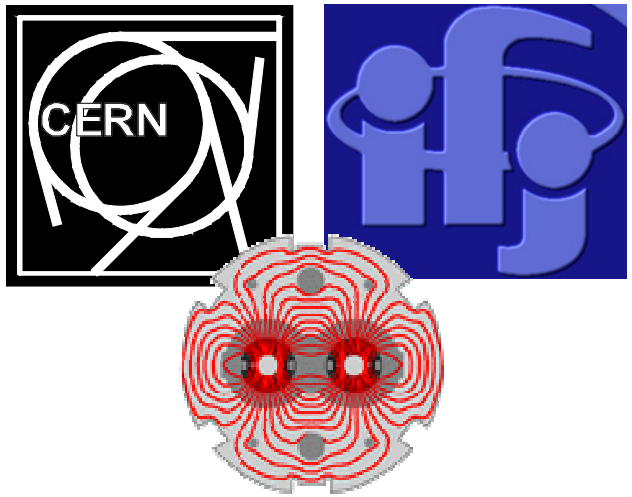
Inventory of Cooling and Ventilation LHC Systems – K/1424/TS/LHC

Numbers:

- 806 man-months at CERN
- 36 persons of AGH-UST staff members deployed in the different Groups at CERN
  - 5 Ph.D's
  - 28 Engineers
  - 3 Technicans

June 2003 – director IFJ PAN prof. A.Budzanowski (from left) and leader of the project LHC L.Evans after signater of collaboration agreement

April 2005 y - director IFJ PAN prof. M.Jeżabek (from left) and director of the LHC projct L.Evans during signaters of new agreements



Thousands reasons LESS for LHC not working ?

Zenon SUŁEK, on behalf of ICIT

CERN - HNINP Symposium, 14th November 2007

beginning

- June 2003 – first agreement of cooperation;
- September 2003 – first working visit;
- February 2005 – core team, preparation of procedures and equipment;
- April 2005 – start of inspection, QRL_7-8 (PA6 and tunnel) and LHC (first welds 3rd May);
- ICIT → I see it!

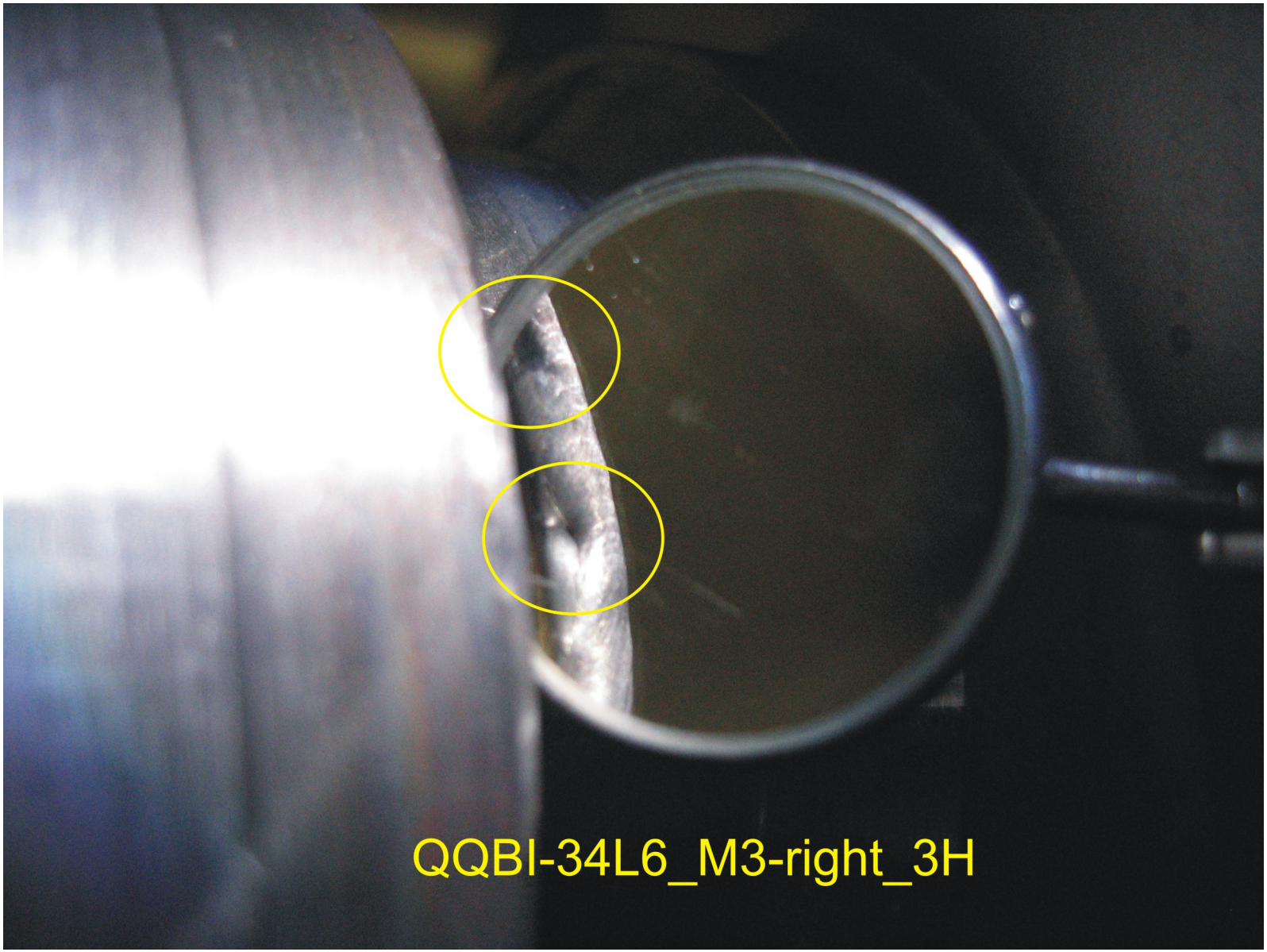
and the end (by November 2007)?

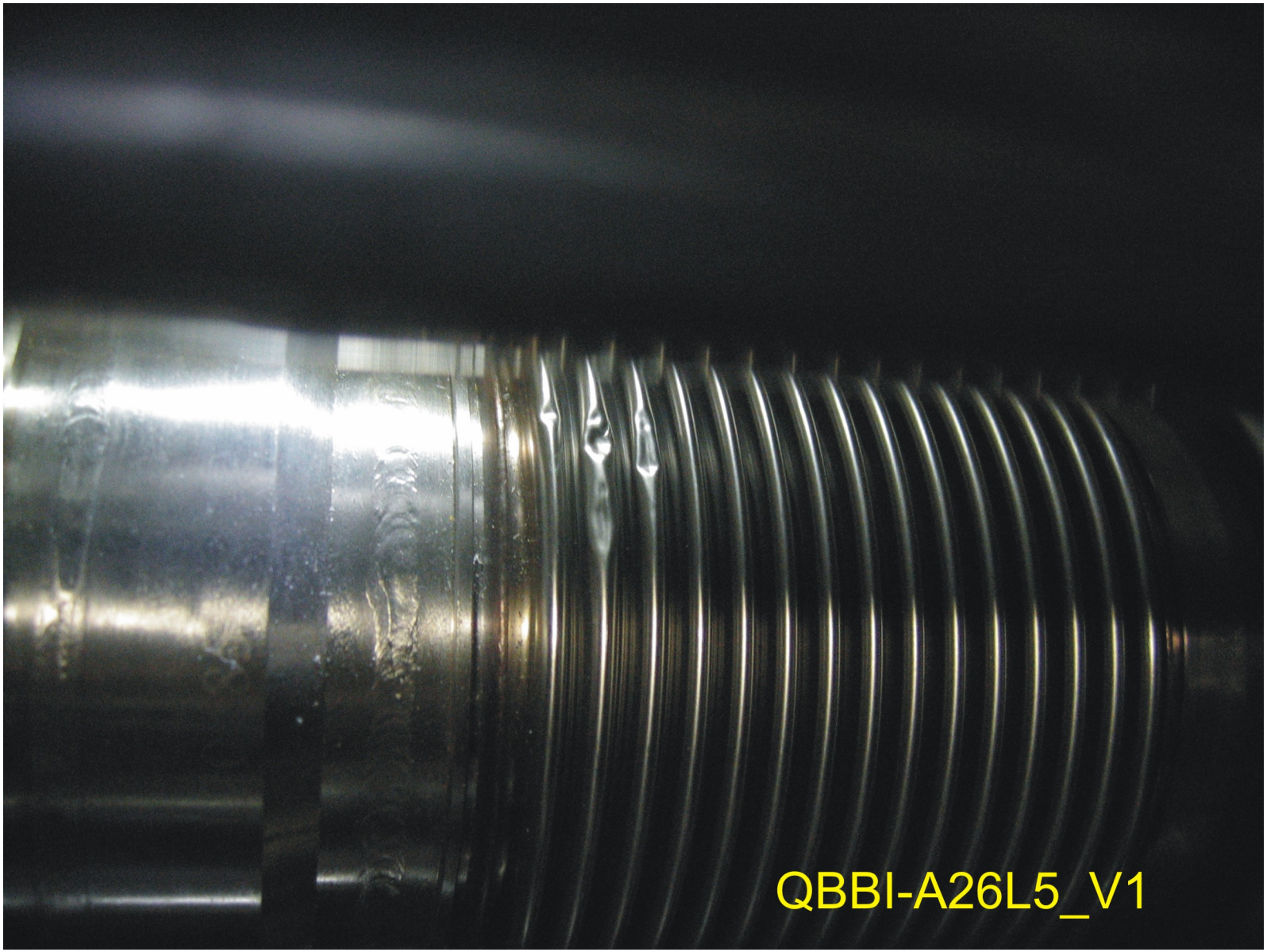
- 363 man*month, 20 persons in peak;
- 42 persons involved;
- 3222 raports of non-conformity;
- 32 thick files of paper raports (pre-inspection tunnel and surface, welds);
- 12 GB of reflectometry data (still growing rapidly) and 1GB images from endoscopy;
- 8GB+ of images from weld (and other) inspections

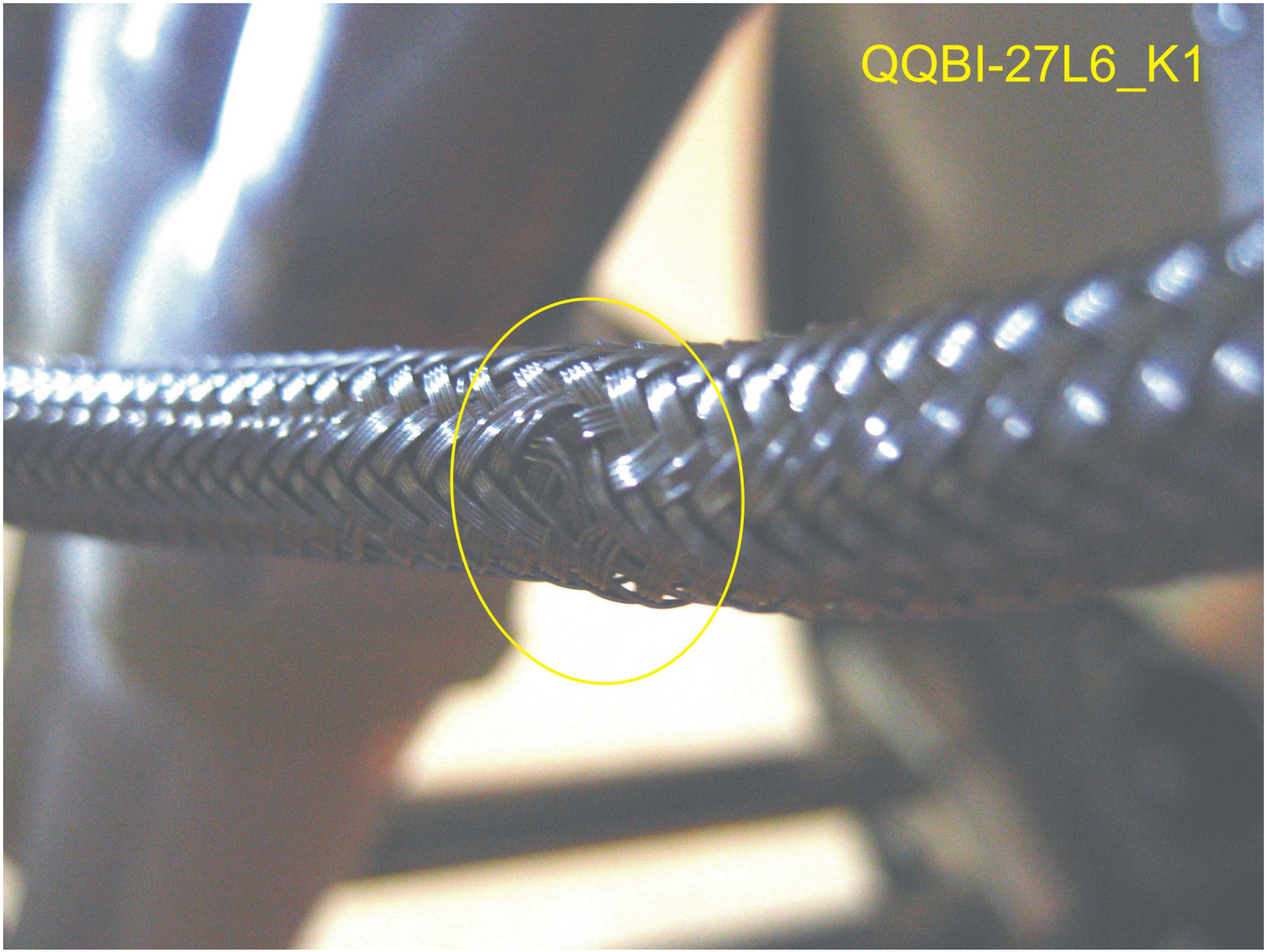
routine

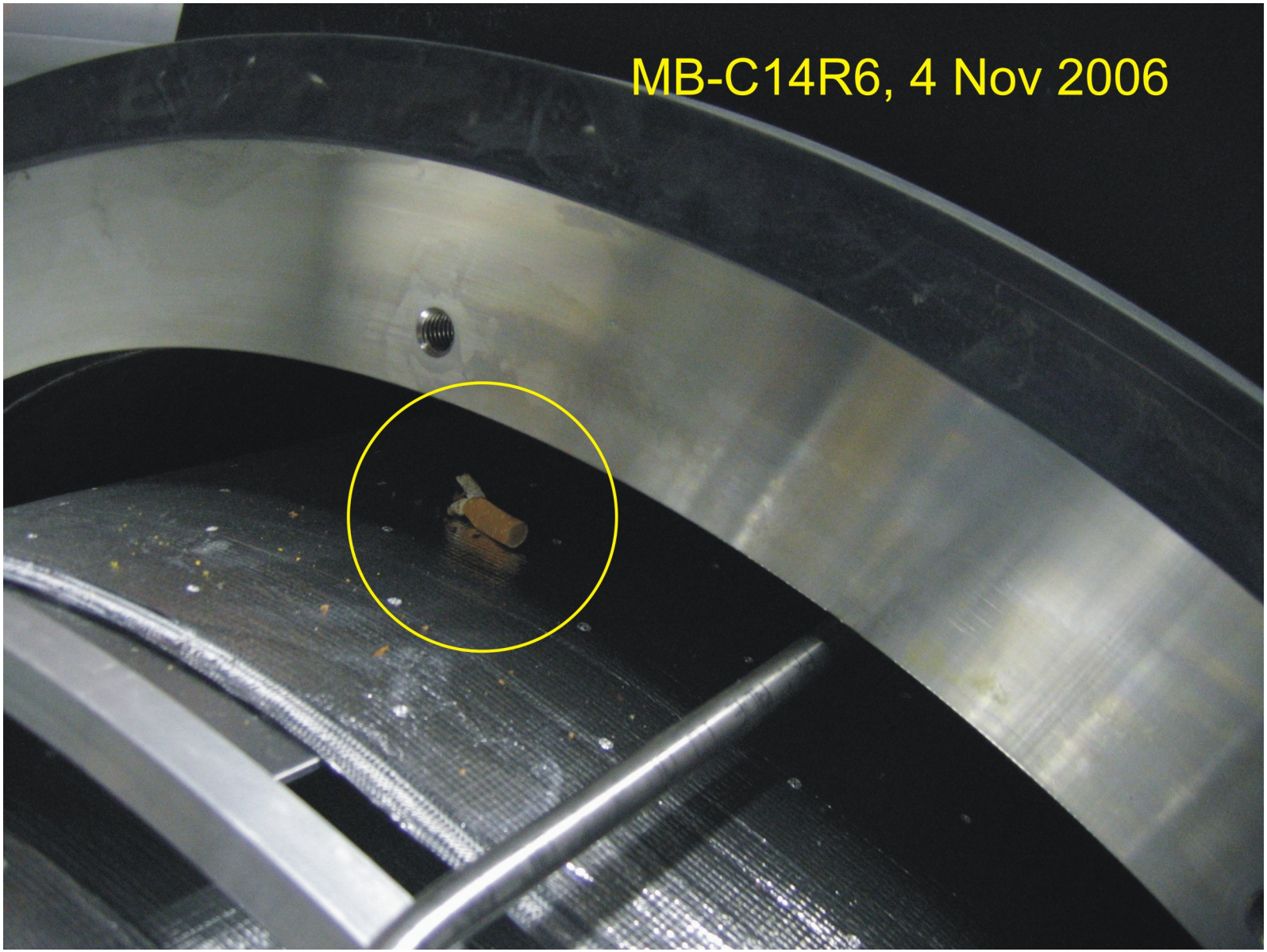
- Pre-inspection;
- Inspection of welds and other operations;
- Final inspection before closure;
- Bellows of PIM (and others);
- W bellows;
- US of main bus bars;
- ... and as requested


QBBI-A32R5_V2-left_6-7H


QQBI-34L6_M3-right_3H


QBBI-A26L5_V1

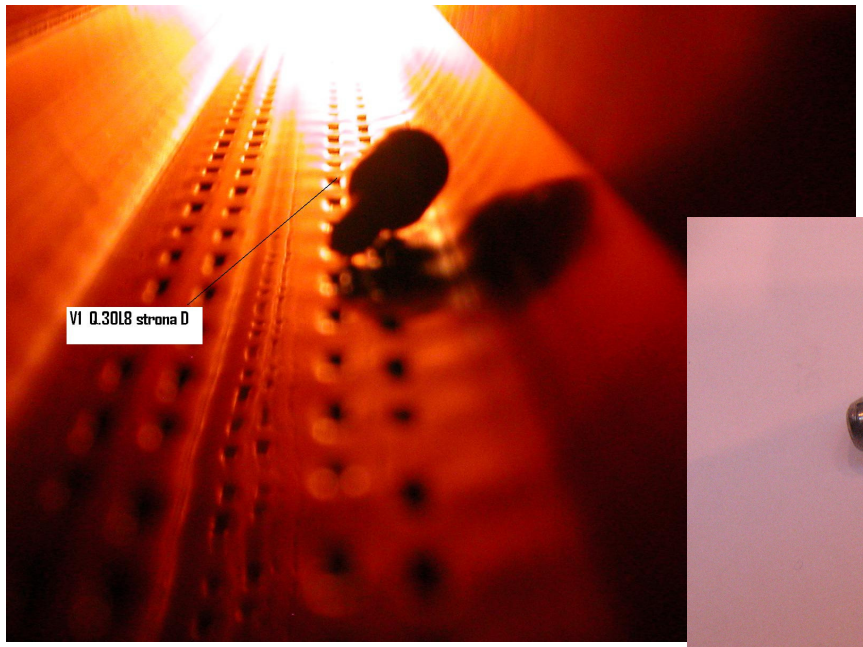

QQBI-27L6_K1


MB-C14R6, 4 Nov 2006

Milestone I: reflectometry

- Introduced November 2005;
- At the beginning as a method for inspection of PIM installation (chain of 8 magnets) → problem with interpretation of some cases → evolution to measurement of single magnet rf signature

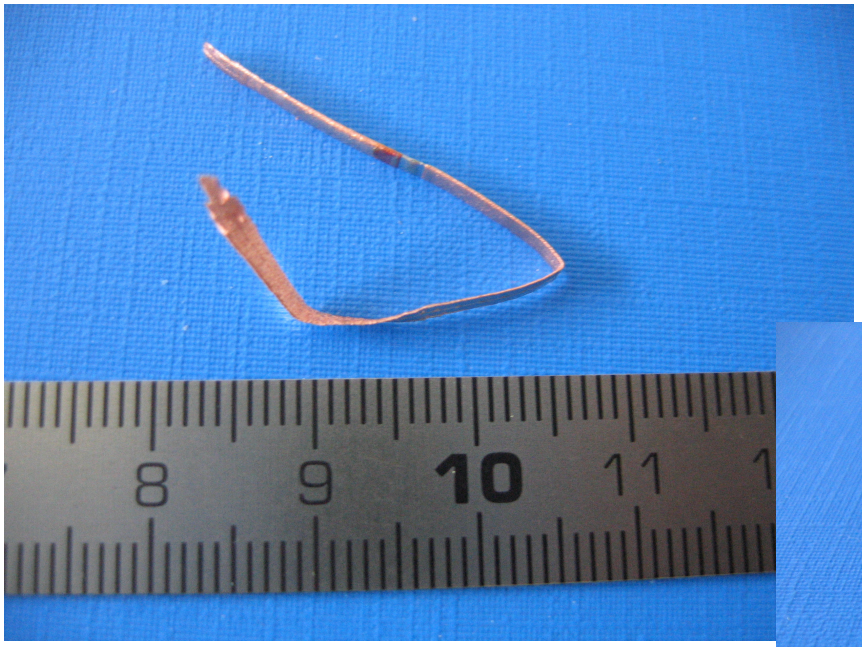
MQ.30L8, 31.01.2006



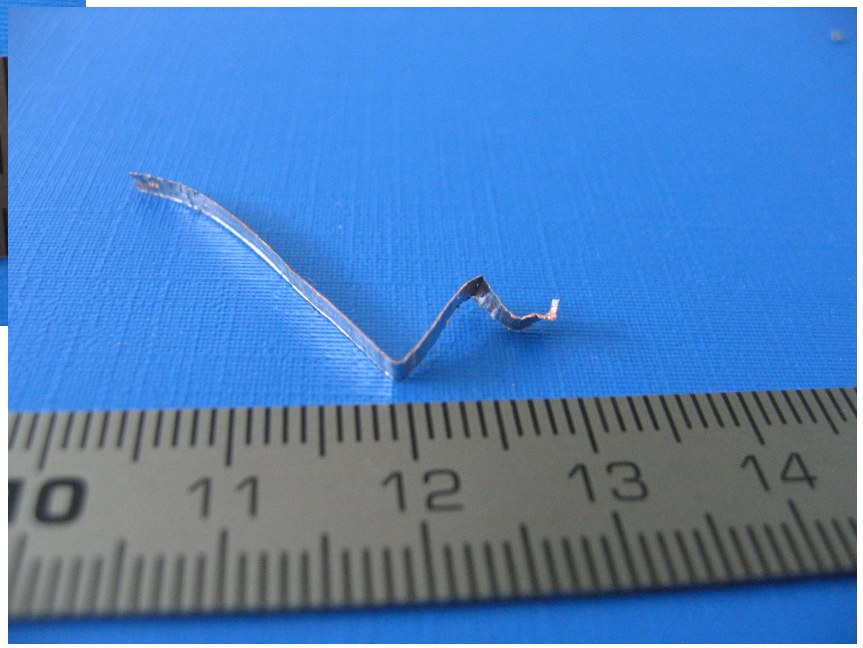
echo -22 dB

Milestone II, inspection on surface

- Introduced as early detection of non-perpendicular flanges;
- Soon covering full pre-inspection, especially of beam lines – much better conditions!!
- ‘eagle eye’ of Andrzej;
- ... → then interventions with blowing and endoscopy



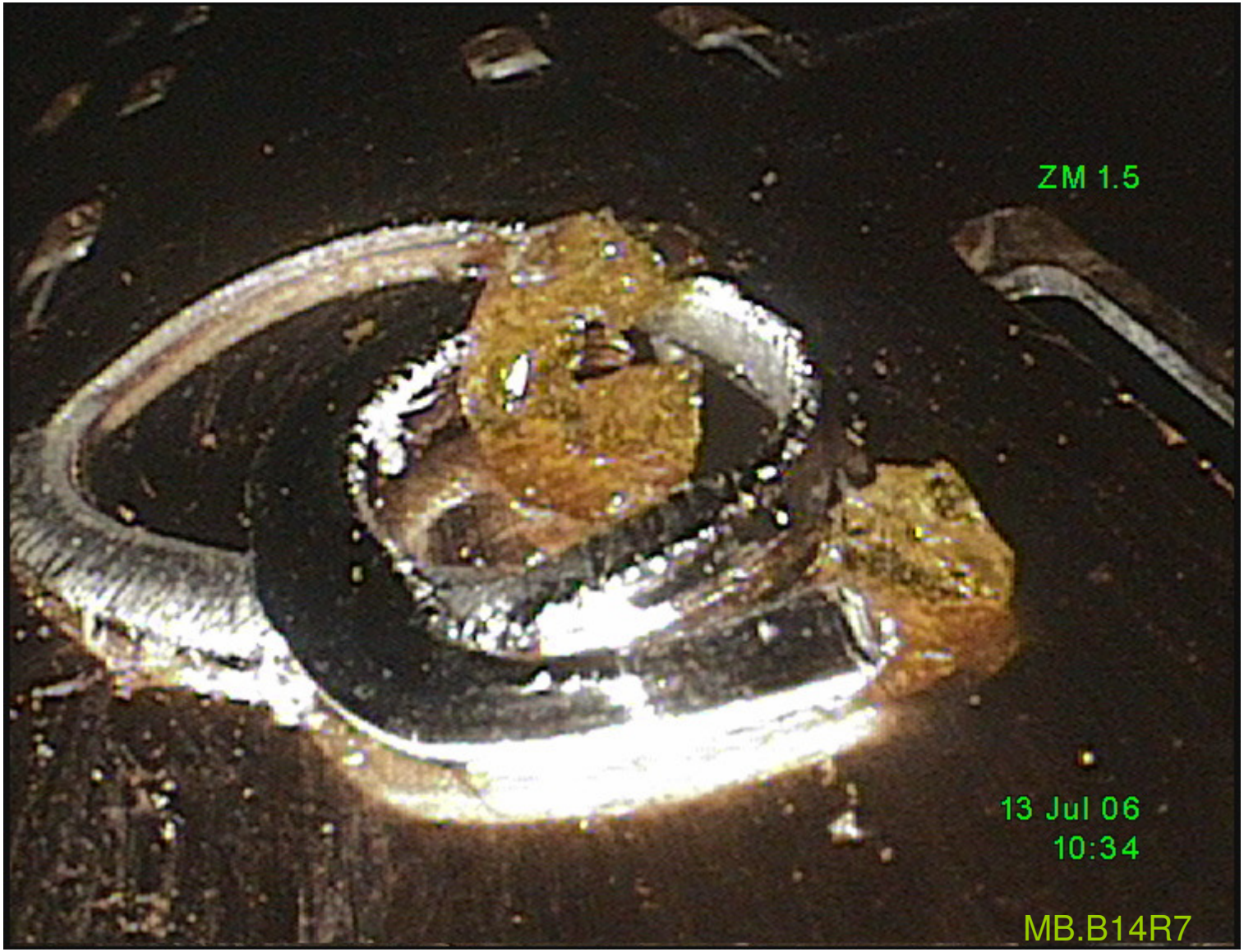
MB.A10R8, -15 dB



MQ.12R8, -43 dB

Milestone III, revision of approach

- More discovered cases;
- Revision of all known suspicious cases from the past → successful interventions;
- LTC and MARIC meetings, June 2006;
- Reflectometry of individual magnets and chains used as routine;
- New advanced endoscope GE Everest;
- Development of new tools


ZM 1.5
13 Jul 06
10:34
MB.B14R7


MB-B14R7

Milestone IV, s. 7-8, buckled PIMs

- After warm-up, replacement of non-conform PIMs, one with buckled springs;
- Reflectometry and consequently endoscopy from QBQI.25R7 → in QQBI.26R7 buckled springs detected;
- Campaigne of checking all PIMs along sector, radiography, reflectometry, endoscopy, 'magic ball' etc → more cases!

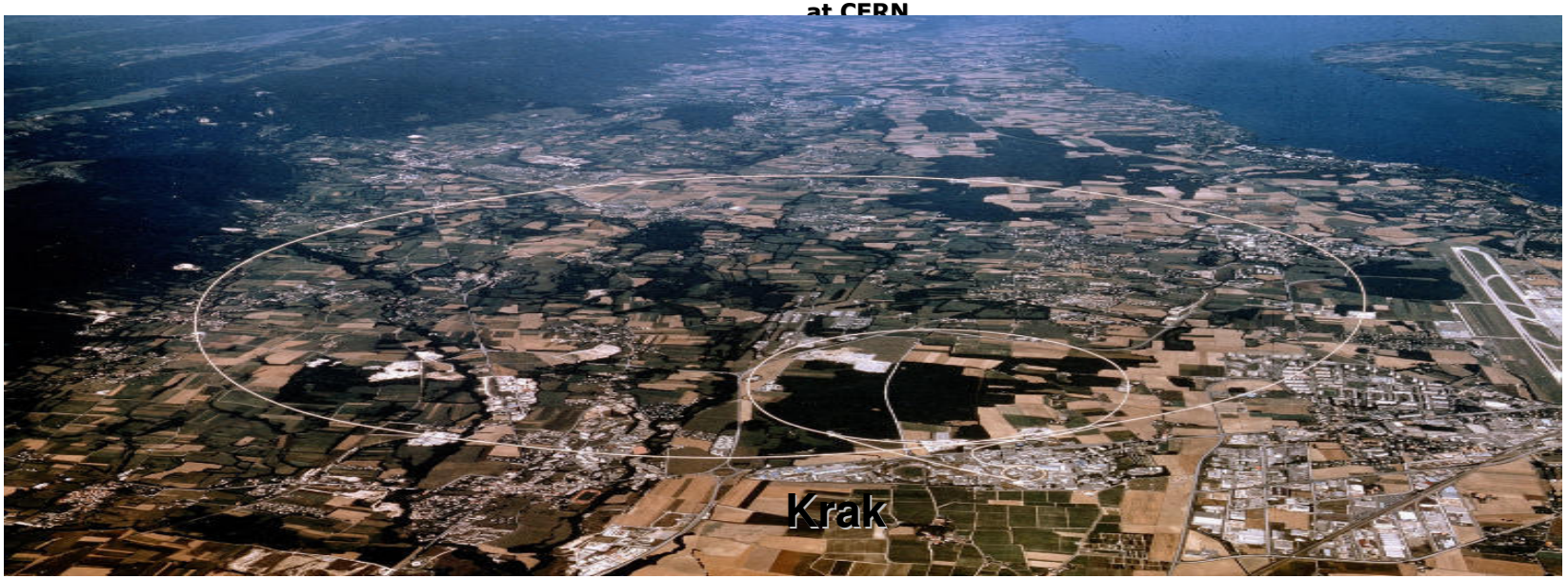
Consequences
for scheduling, commissioning
and operation of LHC??

Enormouse cummulation of knowledge,
motivation and will to solve all
problems and any problem.

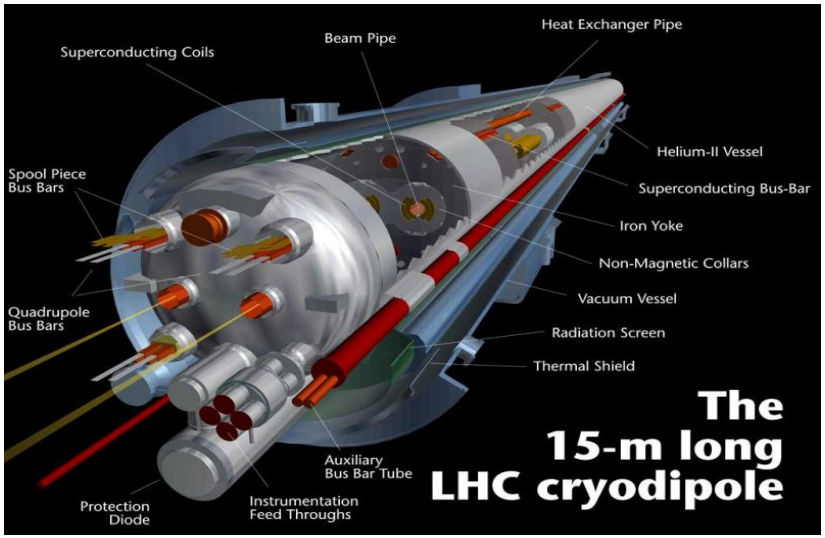
I am optimistic!

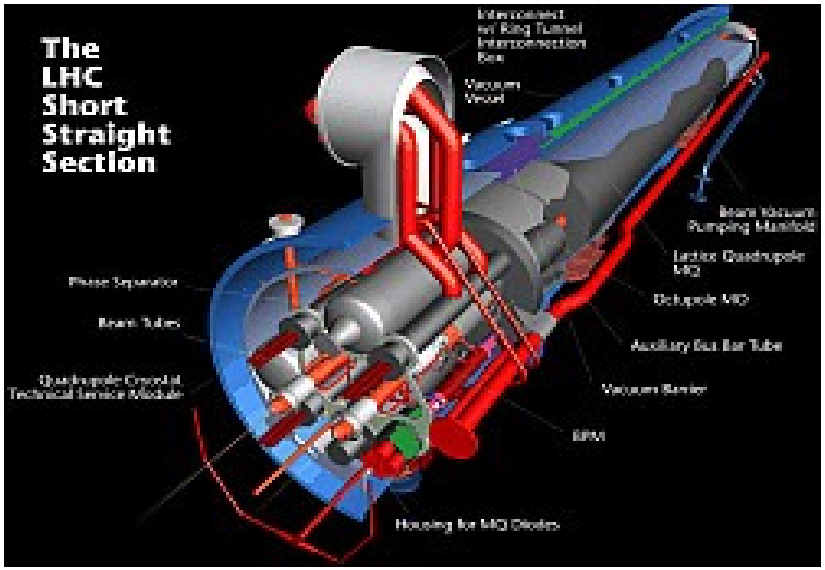
The Henryk Niewodniczański Institute of Nuclear Physics Polish Academy of Sciences, Kraków, Poland

Electronics and Electrical Section of The Equipment and Infrastructure Department at CERN



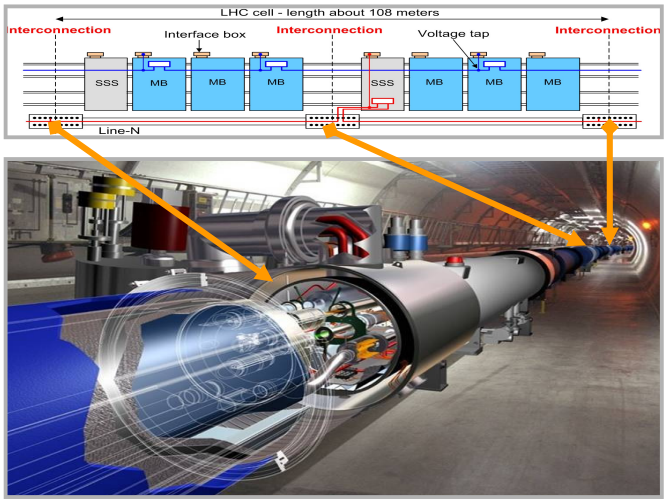
The **Large Hadron Collider** (LHC) at CERN is a two-ring, superconducting accelerator and collider installed in the tunnel of 27 km circumference. The LHC is composed of 1750 superconducting circuits powering individual or series of superconducting magnets. From the electrical assembly point of view the most complex parts are the 8 long continuous of 204 cryo-magnets mechanically and electrically interconnected.


Superconducting Coils
Beam Pipe
Heat Exchanger Pipe
Helium-II Vessel
Spool Piece
Bus Bars
Superconducting Bus-Bar
Iron Yoke
Non-Magnetic Collars
Quadrupole
Bus Bars
Vacuum Vessel
Radiation Screen
Thermal Shield
Auxiliary
Bus Bar Tube
Protection
Diode
Instrumentation
Feed Throughs
The
15-m long
LHC cryodipole

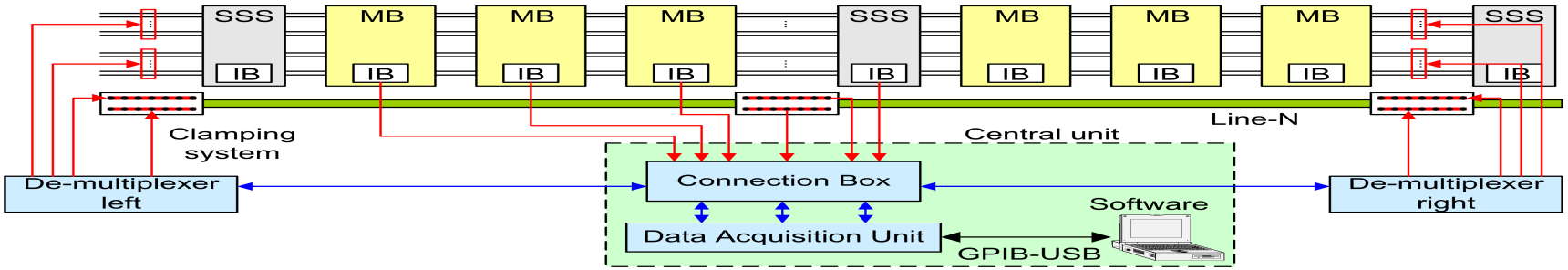

The
LHC
Short
Straight
Section

The Henryk Niewodniczański Institute of Nuclear Physics Polish Academy of Sciences,

The Electronics and Electrical Section (SEE) of The Equipment and Infrastructure Department (DAI) of The Henryk Niewodniczański Institute of Nuclear Physics Polish Academy of Sciences (HN INP PAS) is involved in assembly of the Large Hadron Collider at CERN.



Verification of the electrical circuits of the LHC superconducting magnets in the LHC tunnel of 26658 m circumference was done simultaneously on a few fronts depending on the status of the LHC installation. The complicated



The Henryk Niewodniczański Institute of Nuclear Physics Polish Academy of Sciences, Kraków, Poland

Electronics and Electrical Section of The Equipment and Infrastructure Department at CERN

Tasks in the tunnel during LHC assembly:

- Arc Interconnection Verification (AIV) – tests of the group of arc magnets
- Partial Assembly Qualification (PAQ) – this application serves to qualify the interconnection of the spool circuits of a half cell.
- Dipole Orbit Corrector (DOC) – test of continuity, polarity, insulation and transfer function measurement
- High Voltage Qualification (HVQ): an 80 channel system to perform high voltage tests up to 2 kV
- Installation of the auxiliary superconducting cables in the LHC tunnel
- Distribution Feed Box (DFB) – tests during assembly

DOC test of 120 A circuits

HVQ test of superconducting circuits

Verification of all electrical circuits of the superconducting magnets in the LHC tunnel during hardware commissioning at warm and at cold:

- Tests at warm
- Monitoring of the magnets electrical circuits during flushing and cool-down phase.
- Tests at cold (1.9 K)
- Localization and investigation of the electrical faults detected during tests.

Mobile measurement system TP4&DOC in the LHC tunnel

Krakow ELQA team has done over 1700 tests and verified almost 100 000 electrical connections between circuits of the superconducting magnets in the LHC tunnel. During these works in the LHC tunnel over 150 different nonconformities were discovered.

Kraków, Poland
The Henryk Niewodniczański Institute of Nuclear Physics Polish Academy of Sciences, Electronics and Electrical Section of The Equipment and Infrastructure Department

Tasks in a laboratory

Manufacturing and verification of 400 segments of the line-N (auxiliary superconducting 42-wires cable segment, length about 54 m)
Distribution Feed Box (DFB) automatic testing procedures for the qualification during the assembly.
Training on construction and electrical circuits of the superconducting magnets

Design and construction of the electronic automatic measurement systems (AIV - 8 systems, PAQ – 4 systems, HVQ – 20 systems, HVQN – 4 systems, TP4&DOC – 4 systems).
Maintenance, service and modification of the measurement systems
Manufacturing of the cables dedicated for all the automatic measurement systems
Manufacturing, verification and installation of special bundles superconducting cables
Manufacturing of special cables for grounding all superconducting magnet circuits in LHC tunnel.
Mechanical works during construction of the automatic measurement systems

T

Summary


Discovery machine (LHC)
the energy available for the
n is lower than the accelerator
4

Warszawa, 16 listopada 2007 r.

MINISTERSTWO
NAUKI I SZKOLNICTWA WYŻSZEGO
PODSEKRETARZ STANU
prof. Krzysztof Jan Kurzydłowski

Szanowny Pan
prof. Marek Jeżabek
Dyrektor
Instytutu Fizyki Jądrowej PAN

Szanowny Panie Dyrektorze!

Uprzejmie dziękuję za przesłanie materiałów z seminarium z okazji zakończenia przez pracowników Instytutu prac nad budową akceleratora LHC w CERN-ie. Pragnę również najserdeczniej pogratulować sukcesu Panu oraz całemu zespołowi pracującemu nad tym projektem. Cieszę się, że polscy inżynierowie i technicy znaleźli uznanie u naszych zagranicznych partnerów. Liczę, że to pozytywne doświadczenie będzie owocować podczas dalszej współpracy.

Gratulując powtórnie udanego zakończenia przedsięwzięcia, życzę kolejnych, jeszcze ambitniejszych, wyzwań.

Z wyrazami szacunku,