European Organization for Nuclear Research
50 years of research in physics

CERN

The Laboratory

Dr. Sascha Marc Schmeling
CERN PH

Introduction to CERN and HEP

- The Organization
- The Laboratory
- **H**igh **E**nergy **P**hysics
- The Accelerators
- The Experiments
- Spin-Offs

Available Tours

The Large Hadron Collider (LHC) – accelerator of the future

See behind the scenes at the sites where huge particle detectors are being assembled for installation at the collision points of the LHC's two proton beams.

- ATLAS experiment worksite
- CMS experiment assembly hall
- Test beam halls (TBH)

The Antiproton Decelerator (AD) – CERN's antimatter factory

Visit the only place in the world where antiatoms are produced in production-line fashion.

- The deceleration machine
- The experimental hall

The Proton Synchrotron (PS) – heart of CERN's accelerator complex

Here particles start their journey to the other accelerators (Super Proton Synchrotron, AD and LHC) Visit:

- LINAC 2, one of CERN's linear accelerators
- LEAR, the machine that produced the very first 9 atoms of antihydrogen in 1995

The LHC, AD, and PS tours include visits to the control rooms where experts control the injection, focusing and acceleration of particle beams.

After your tour...

Don't forget to visit CERN's on-site exhibition, Microcosm, and admire the Laboratory's collection of historic research equipment on display in Square VAN HOVE.

Visiting CERN

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1. Juli 1953

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29. September 1954

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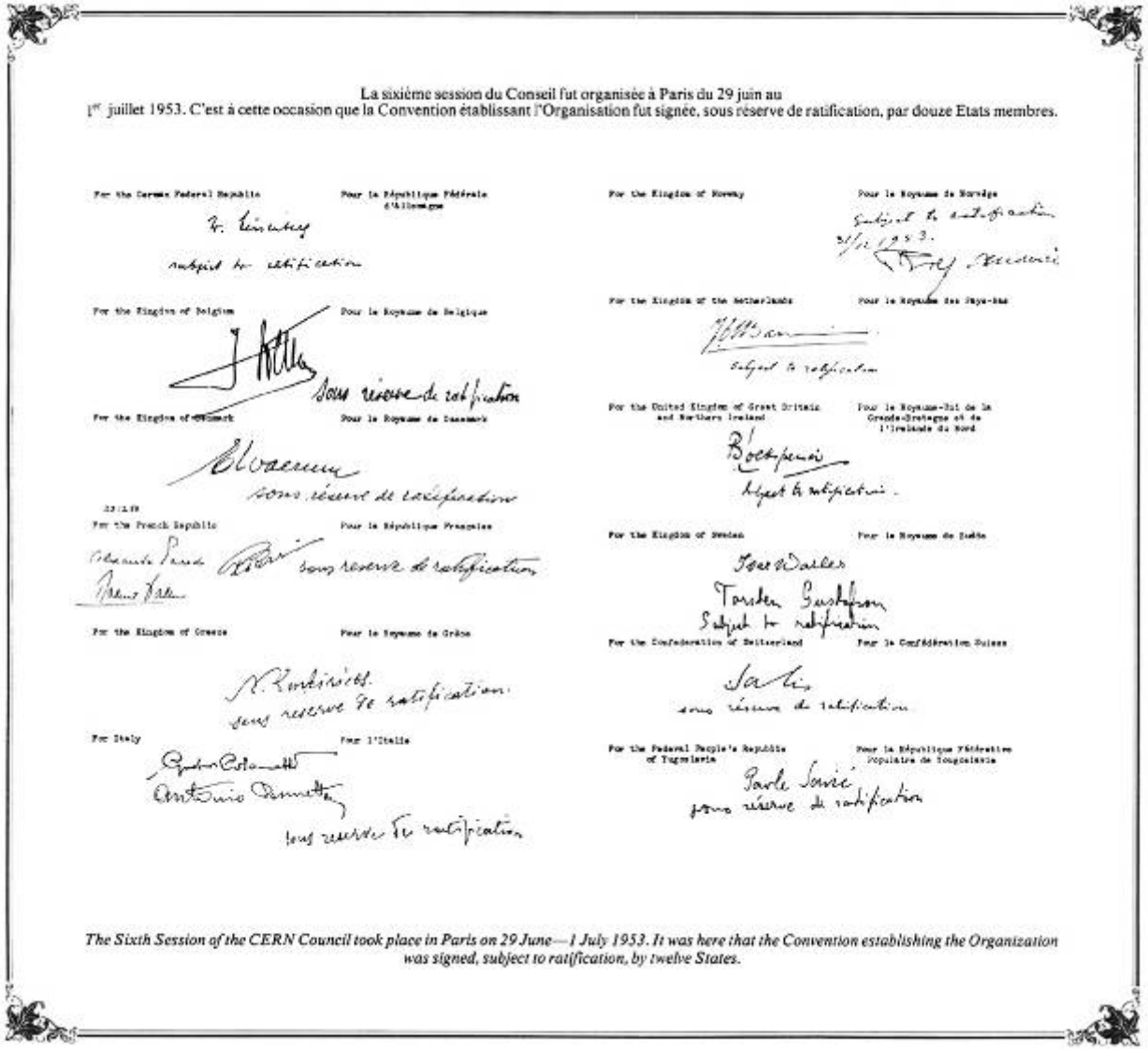
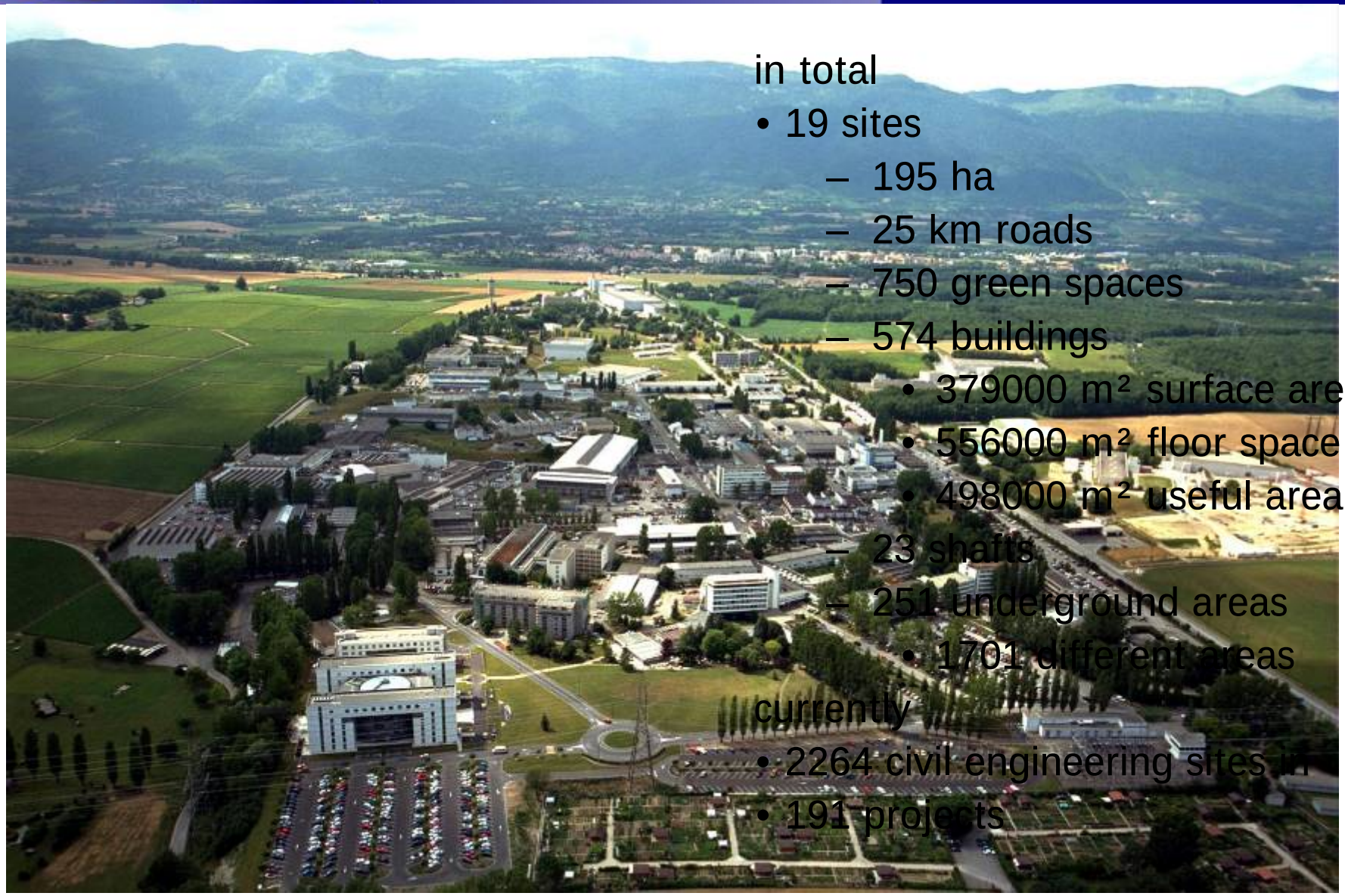
member state



La sixième session du Conseil fut organisée à Paris du 29 juin au 1er juillet 1953. C'est à cette occasion que la Convention établissant l'Organisation fut signée, sous réserve de ratification, par douze Etats membres.

The Sixth Session of the CERN Council took place in Paris on 29 June—1 July 1953. It was here that the Convention establishing the Organization was signed, subject to ratification, by twelve States.

CERN – The Laboratory



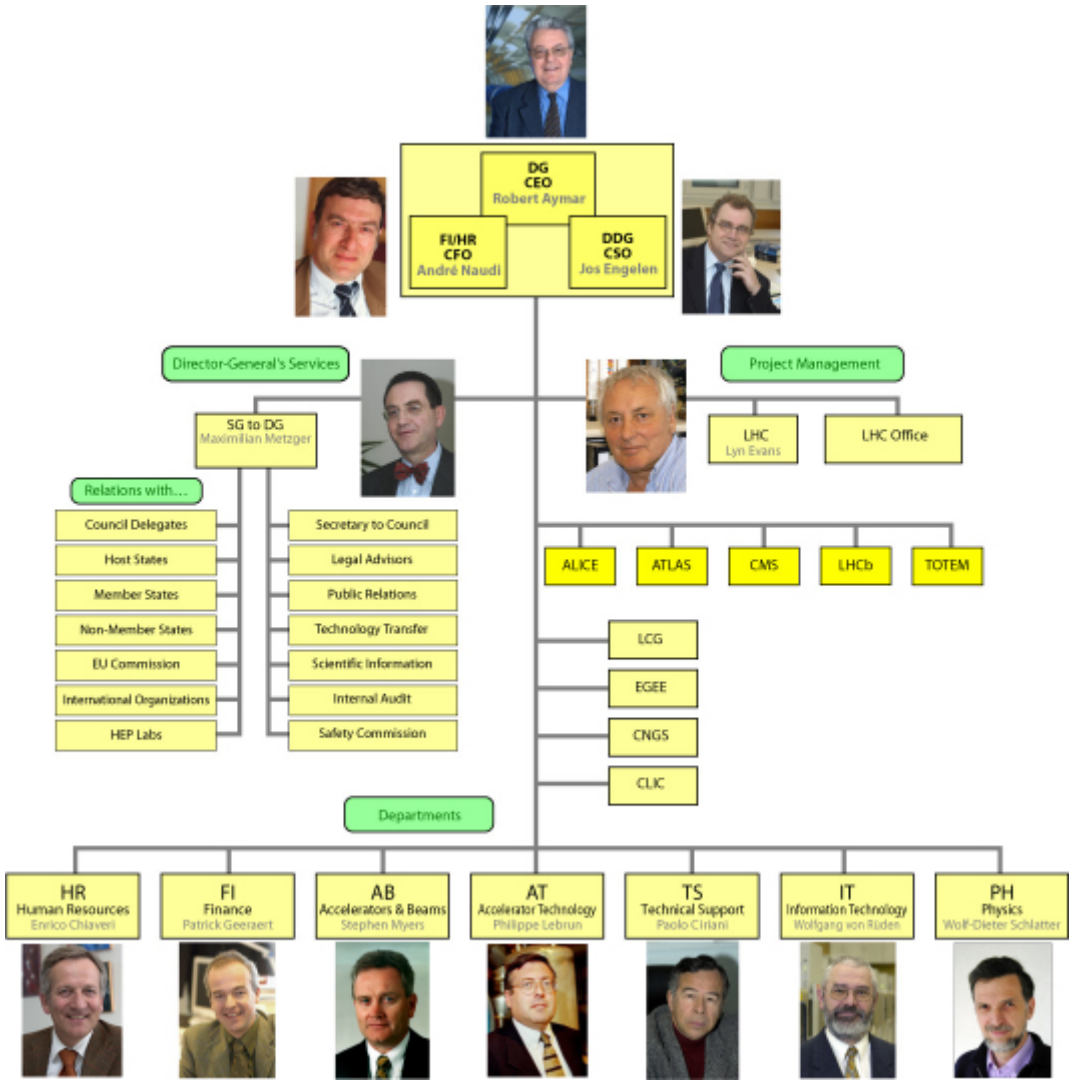
in total

- 19 sites
  - 195 ha
  - 25 km roads
  - 750 green spaces
  - 574 buildings
    - 379000 m² surface area
    - 556000 m² floor space
    - 498000 m² useful area
  - 23 shafts
  - 251 underground areas
    - 1701 different areas

currently

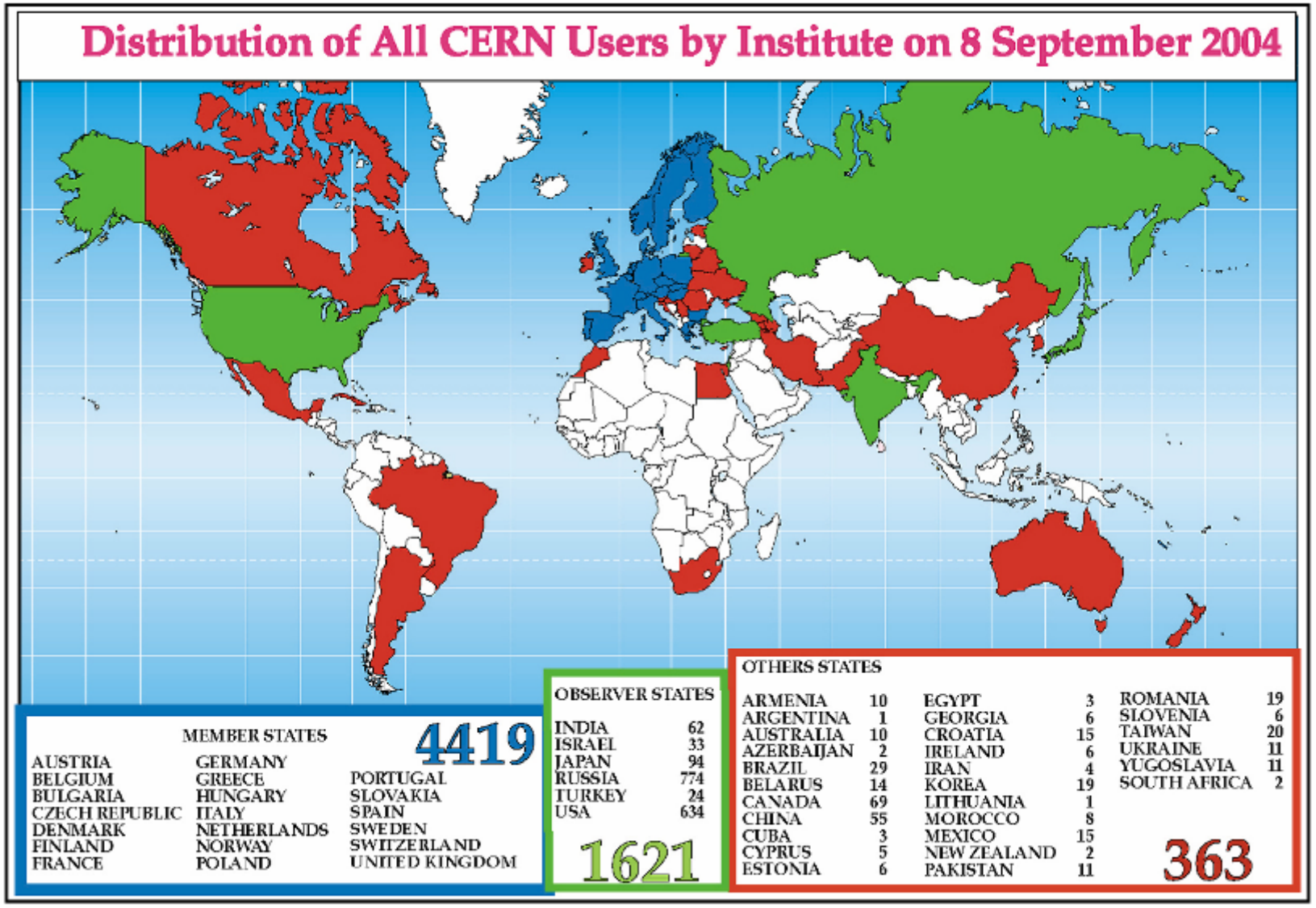
- 2264 civil engineering sites in
- 191 projects

CERN Organisation




The Twenty Member States of CERN
Member States (Dates of Accession)
AUSTRIA (1959)
BELGIUM (1953)
BULGARIA (1999)
CZECH FR (1993)
DENMARK (1953)
FINLAND (1991)
FRANCE (1953)
GERMANY (1953)
GREECE (1953)
HUNGARY (1992)
ITALY (1953)
NETHERLANDS (1953)
NORWAY (1953)
POLAND (1991)
PORTUGAL (1986)
SLOVAK FR (1993)
SPAIN (1/1961-12/1968-1/1983)
SWEDEN (1953)
SWITZERLAND (1953)
UNITED KINGDOM (1953)

CERN Users


Distribution of All CERN Users by Institute on 8 September 2004
MEMBER STATES
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ITALY
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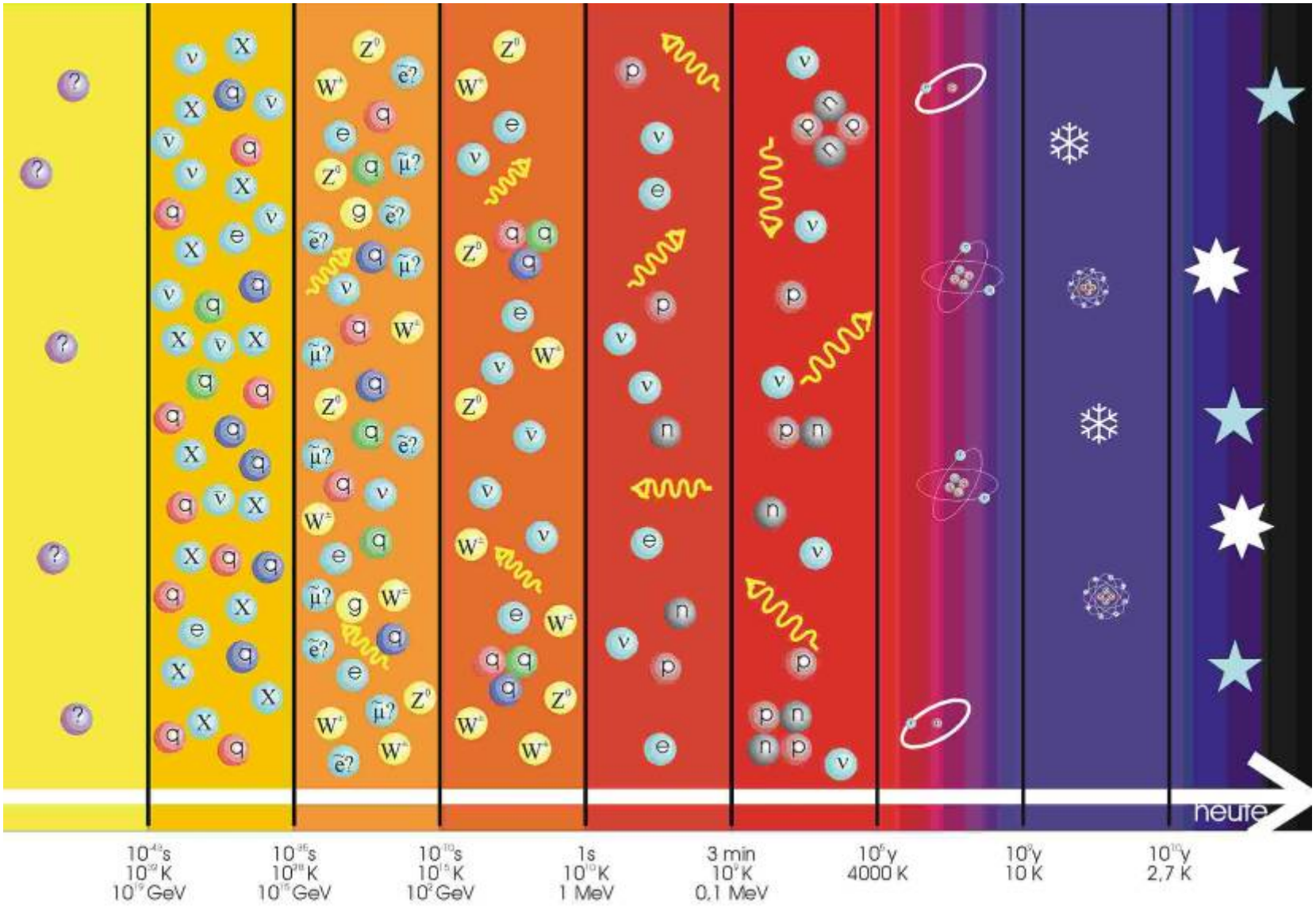
NORWAY
POLAND
PORTUGAL
SLOVAKIA
SPAIN
SWEDEN
SWITZERLAND
UNITED KINGDOM
OBSERVER STATES
INDIA 62
ISRAEL 33
JAPAN 94
RUSSIA 774
TURKEY 24
USA 634
1621
OTHERS STATES
ARMENIA 10
ARGENTINA 1
AUSTRALIA 10
AZERBAIJAN 2
BRAZIL 29
BELARUS 14
CANADA 69
CHINA 55
CUBA 3
CYPRUS 5
ESTONIA 6
EGYPT 3
GEORGIA 6
CROATIA 15
IRELAND 6
IRAN 4
KOREA 19
LITHUANIA 1
MOROCCO 8
MEXICO 15
NEW ZEALAND 2
PAKISTAN 11
ROMANIA 19
SLOVENIA 6
TAIWAN 20
UKRAINE 11
YUGOSLAVIA 11
SOUTH AFRICA 2
363

Research to discover the principles that keep the world together.

Search for

- elementary particles
- forces
- symmetries

History of the Universe



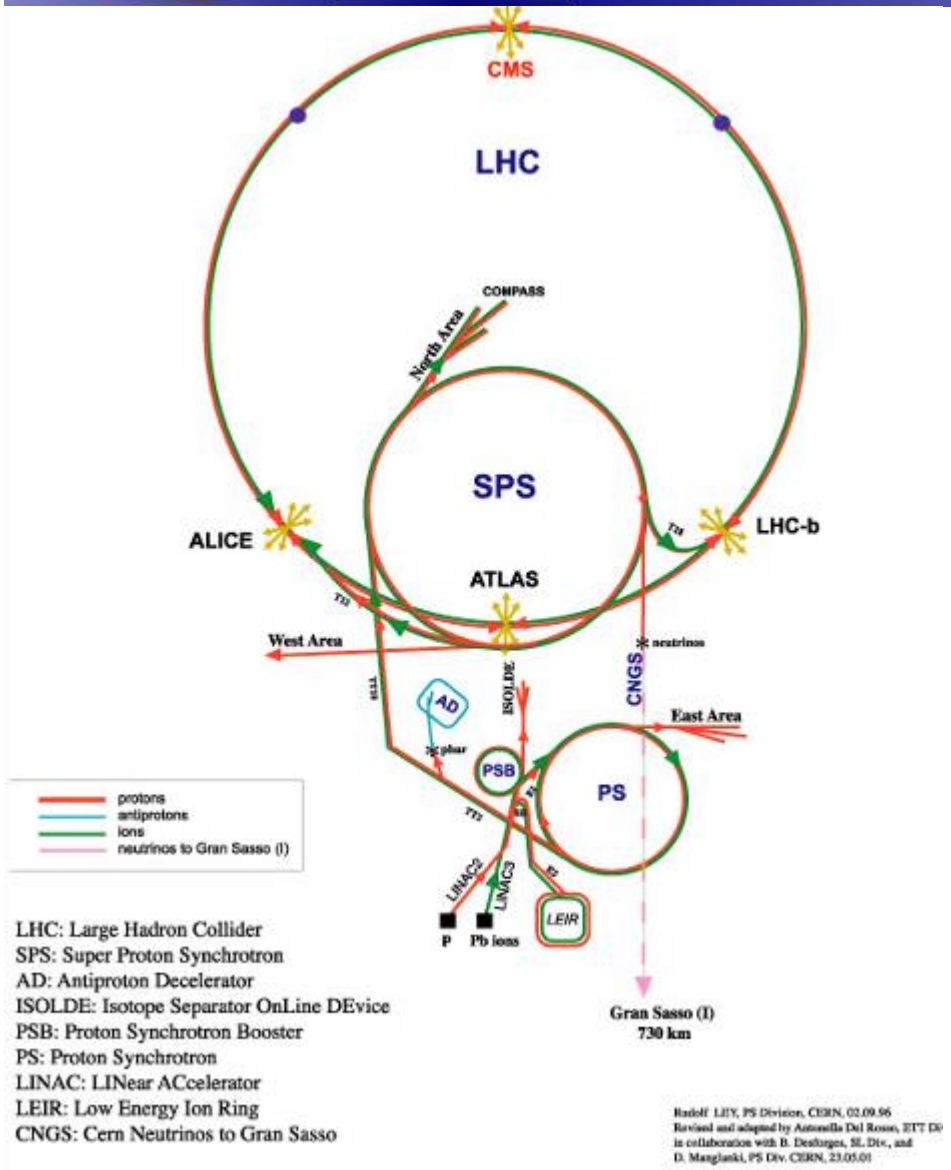
Standard Model

Reach high energies with accelerators

- natural accelerators
  - Astroparticle Physics
- artificial accelerators
  - Particle Physics

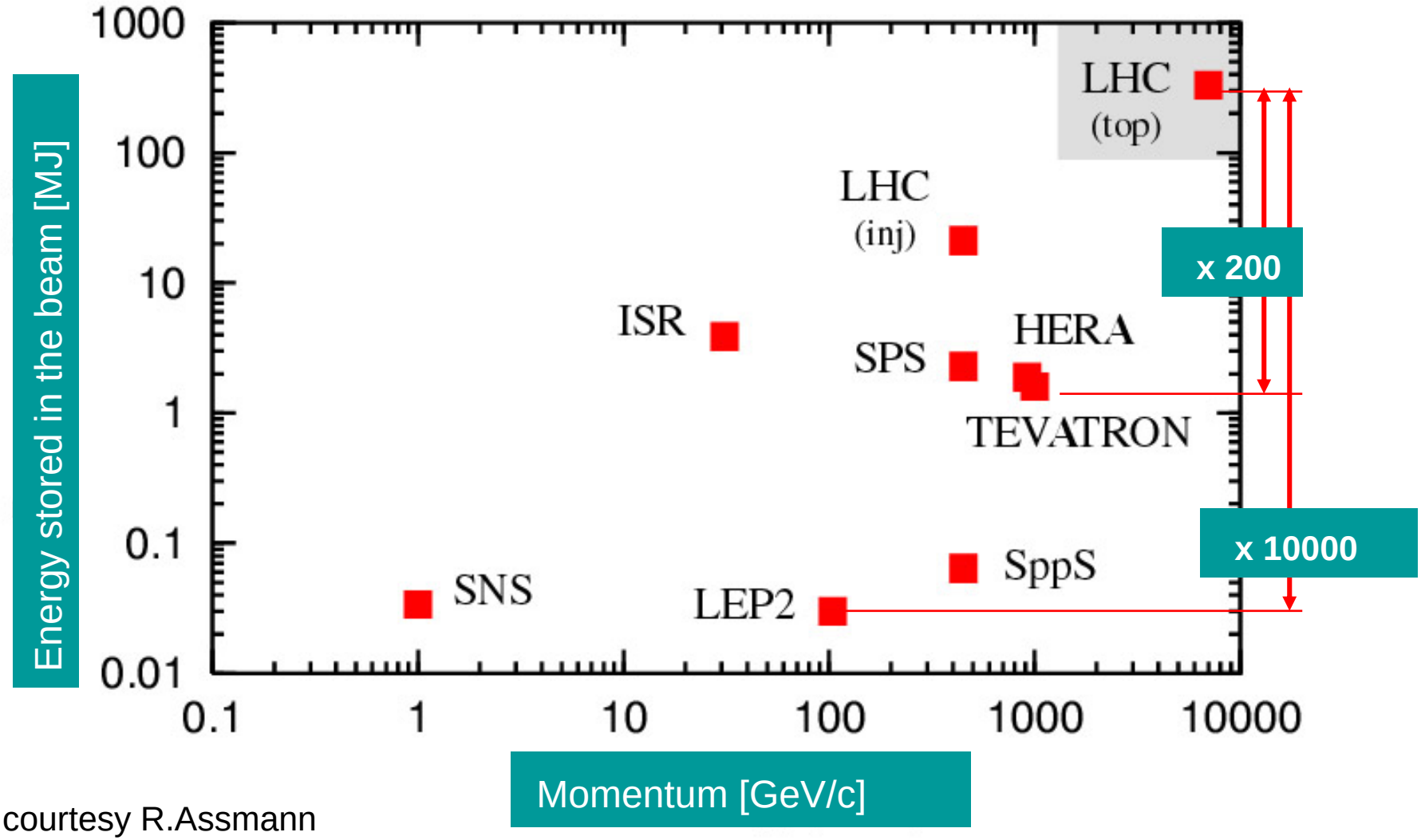
Probing of interactions of matter and antimatter with detectors

Accelerators at CERN



- Decommissioned Accelerators
  - SC
  - ISR
- "Operational" Accelerators
  - PS
    - AD complex
  - SPS
    - fix target experiments
- Future Accelerators
  - LHC
  - CNGS
  - CLIC study

Challenges: Energy stored in the beam



courtesy R.Assmann

LHC: From first ideas to realisation

1982 : First studies for the LHC project

1983 : Z0 detected at SPS proton antiproton collider

1985 : Nobel Price for S. van der Meer and C. Rubbia

1989 : Start of LEP operation (Z-factory)

1994 : Approval of the LHC by the CERN Council

1996 : Final decision to start the LHC construction

1996 : LEP operation at 100 GeV (W-factory)

2000 : End of LEP operation

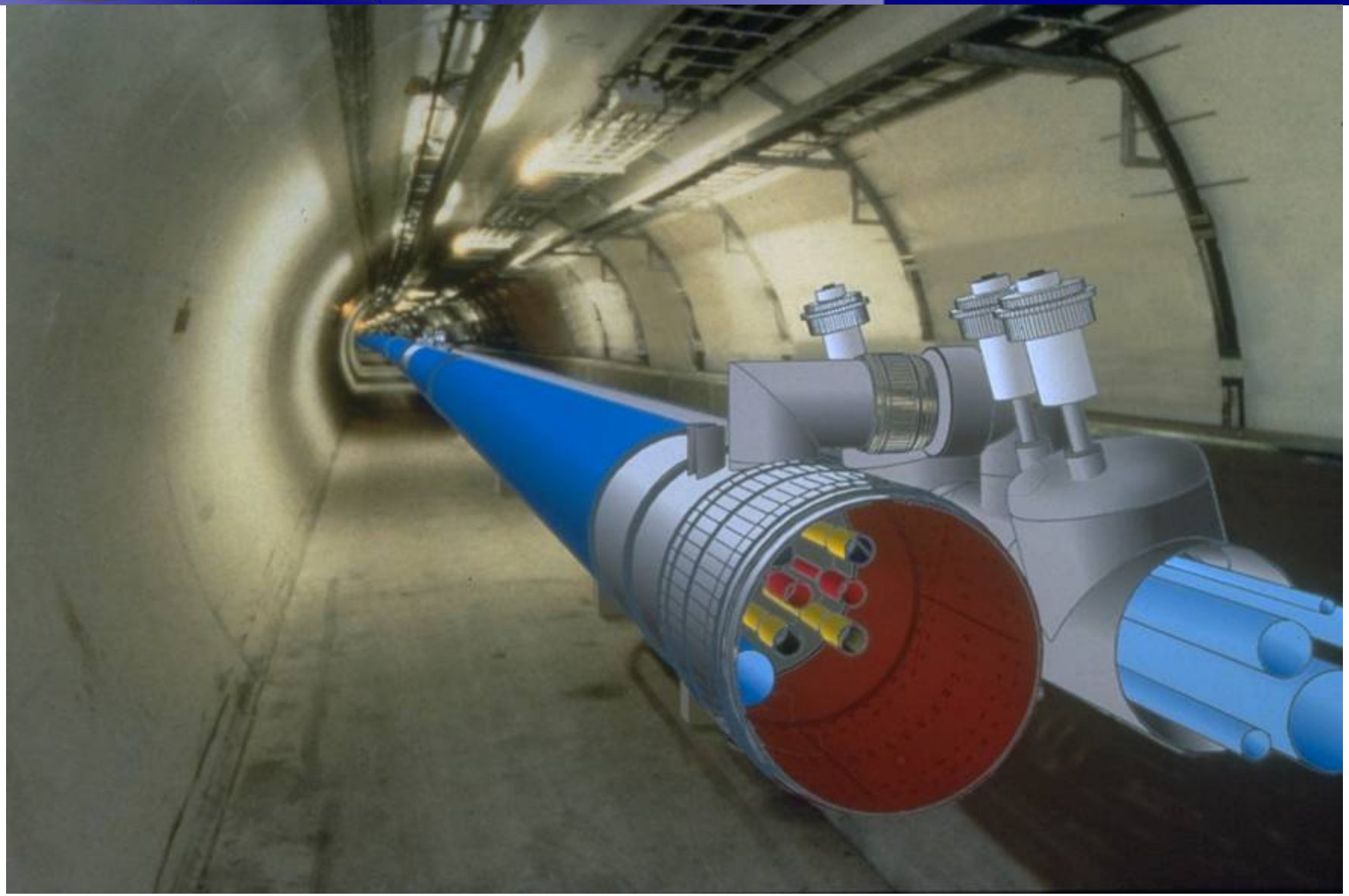
2002 : LEP equipment removed

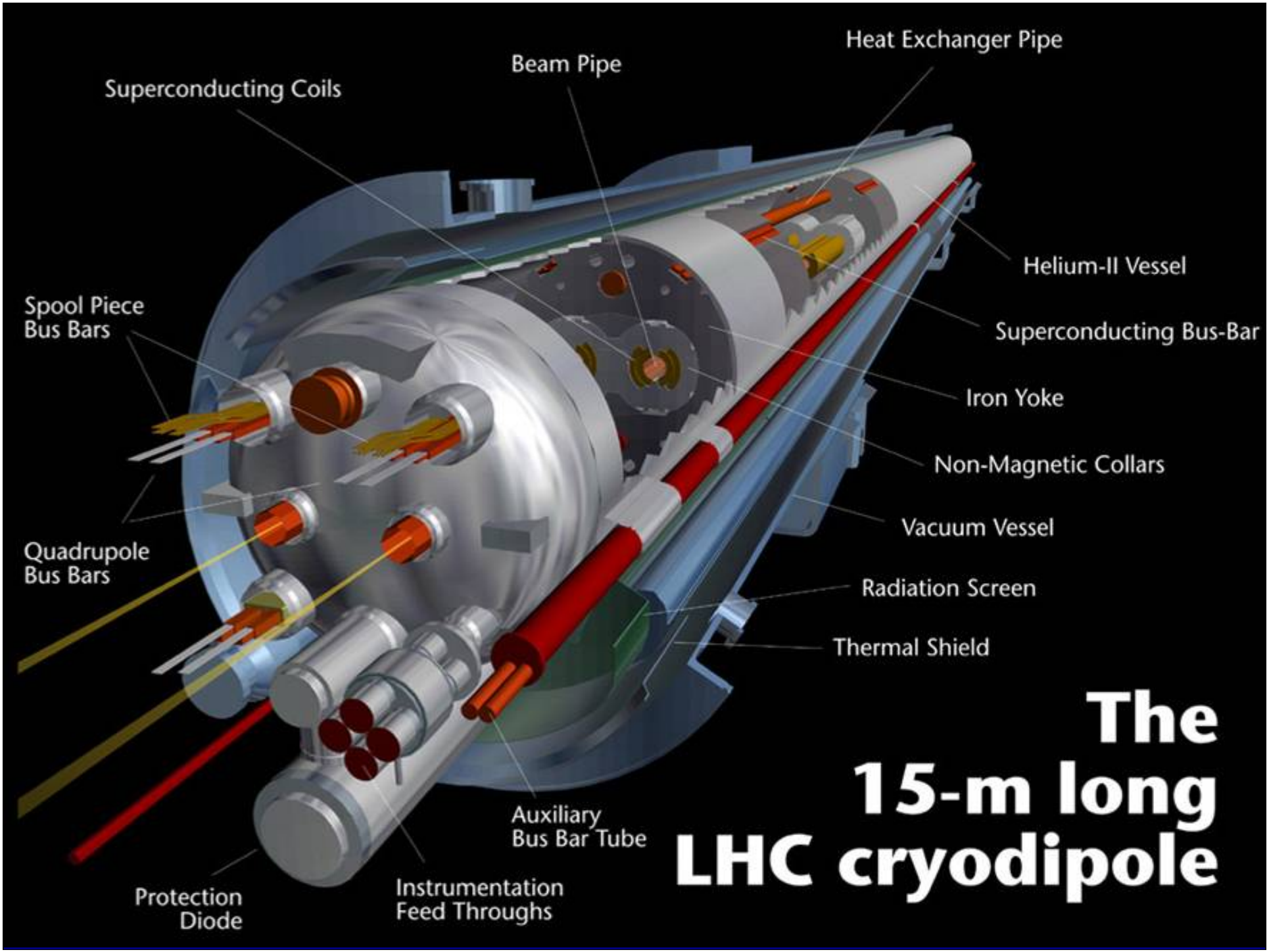
2003 : Start of the LHC installation

2005 : Start of hardware commissioning

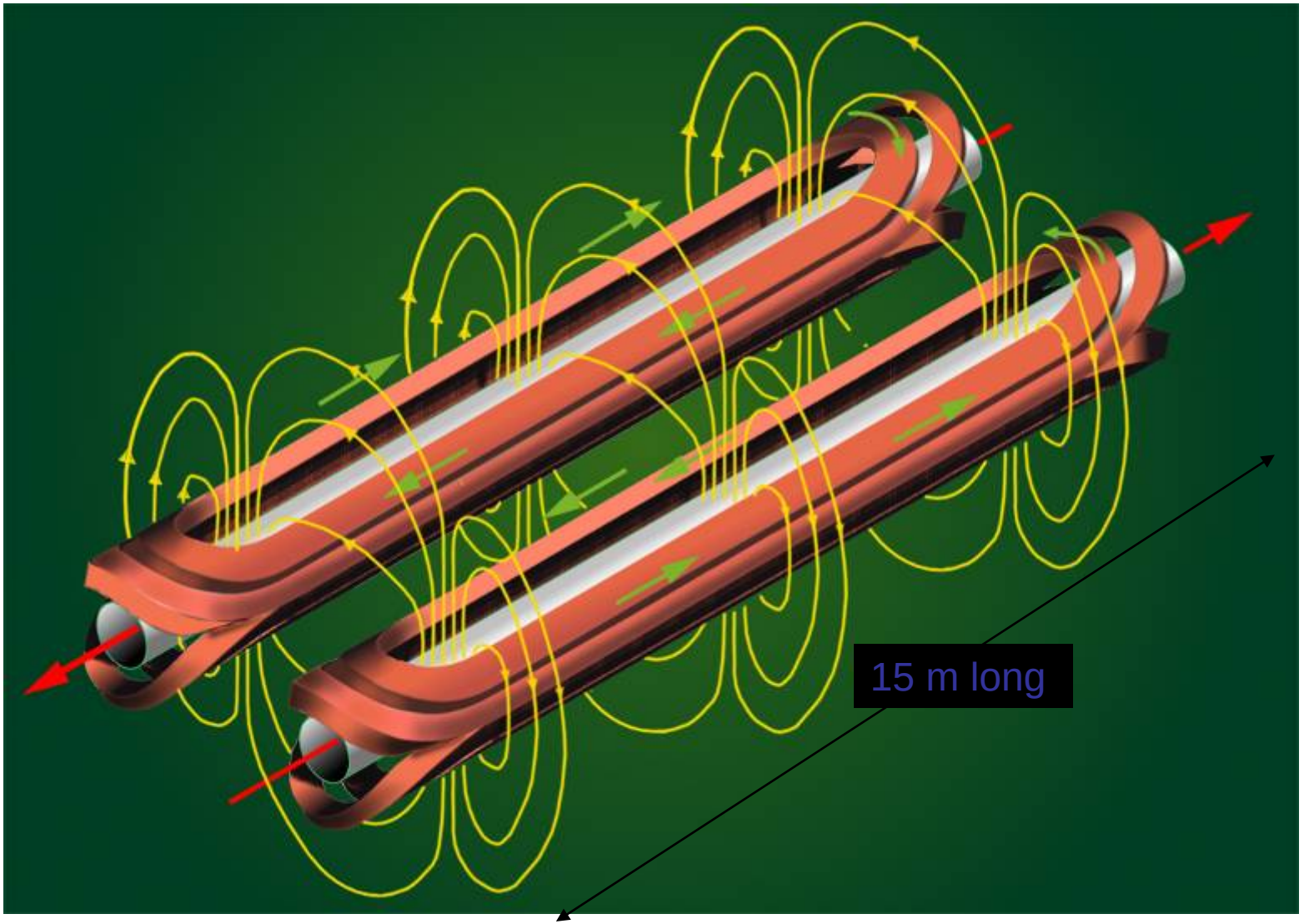
2007 : Commissioning with beam planned

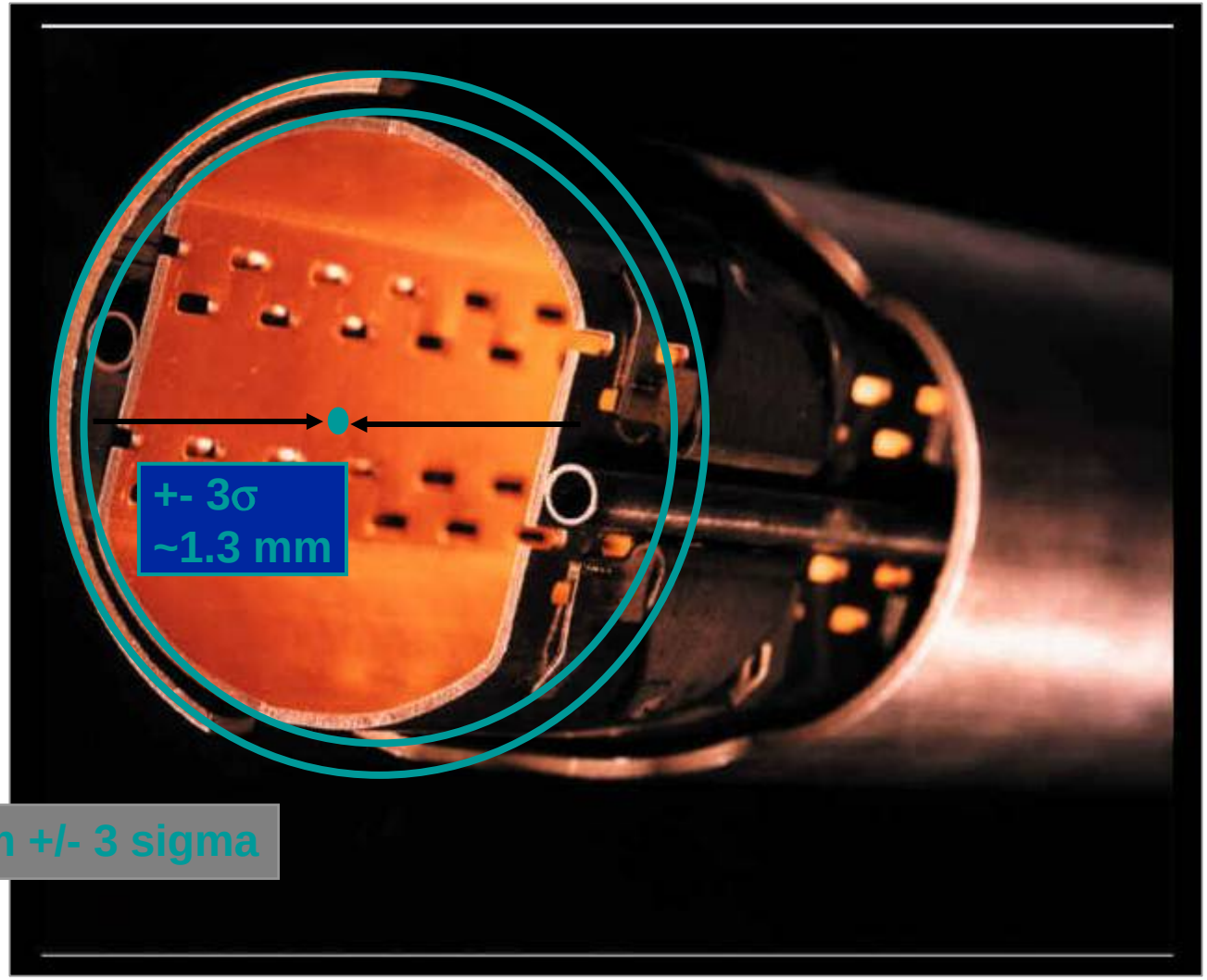
LEP/LHC Tunnel




Heat Exchanger Pipe
Beam Pipe
Superconducting Coils
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

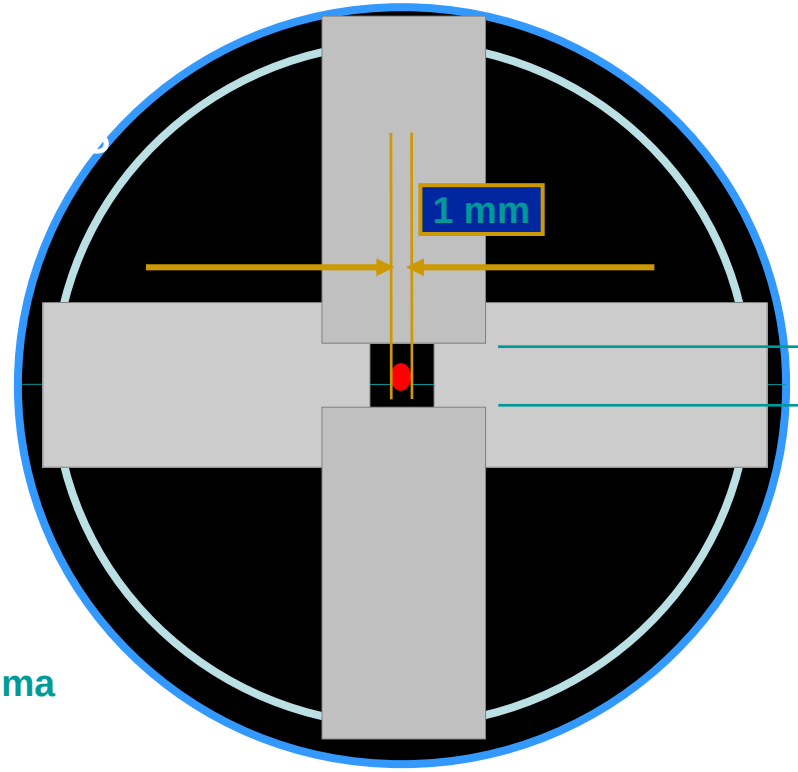
Coils for Dipolemagnets




56.0 mm
+- 3σ
~1.3 mm
Beam +/- 3 sigma

56.0 mm

Ralphs Assmanns EURO



+/- 8 sigma = 4.0 mm

Beam +/- 3 sigma


Storage of dipole cold masses
waiting for cryostating

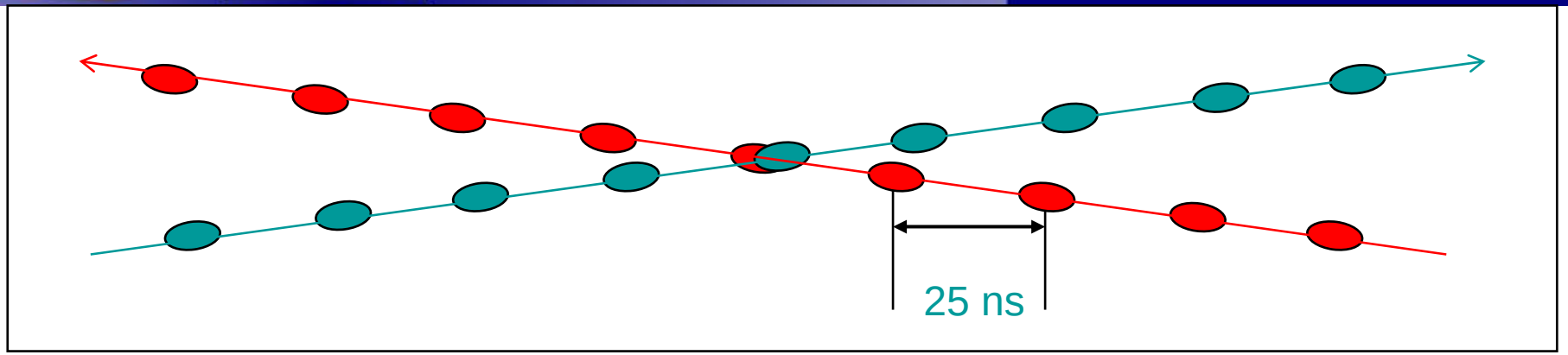
Energy stored in LHC magnets

$$E_{dipole} = 0.5 \bullet L_{dipole} \bullet I^2_{dipole}$$

Energy stored in one dipole is 7.6 MJoule

For all 1232 dipoles in the LHC: 9.4 GJ

Energy stored in the beams



Beam energy: Proton Energy • Number of Bunches • Number of protons per bunch

Proton Energy: 7 TeV

In order to achieve very high luminosity:

Number of bunches per beam: 2808

Number of protons per bunch: $1.05 \bullet 10^{11}$

Energy per beam: 346 MJoule

10 GJoule……

corresponds to the energy of 1900 kg TNT

corresponds to the energy of 400 kg Chocolate

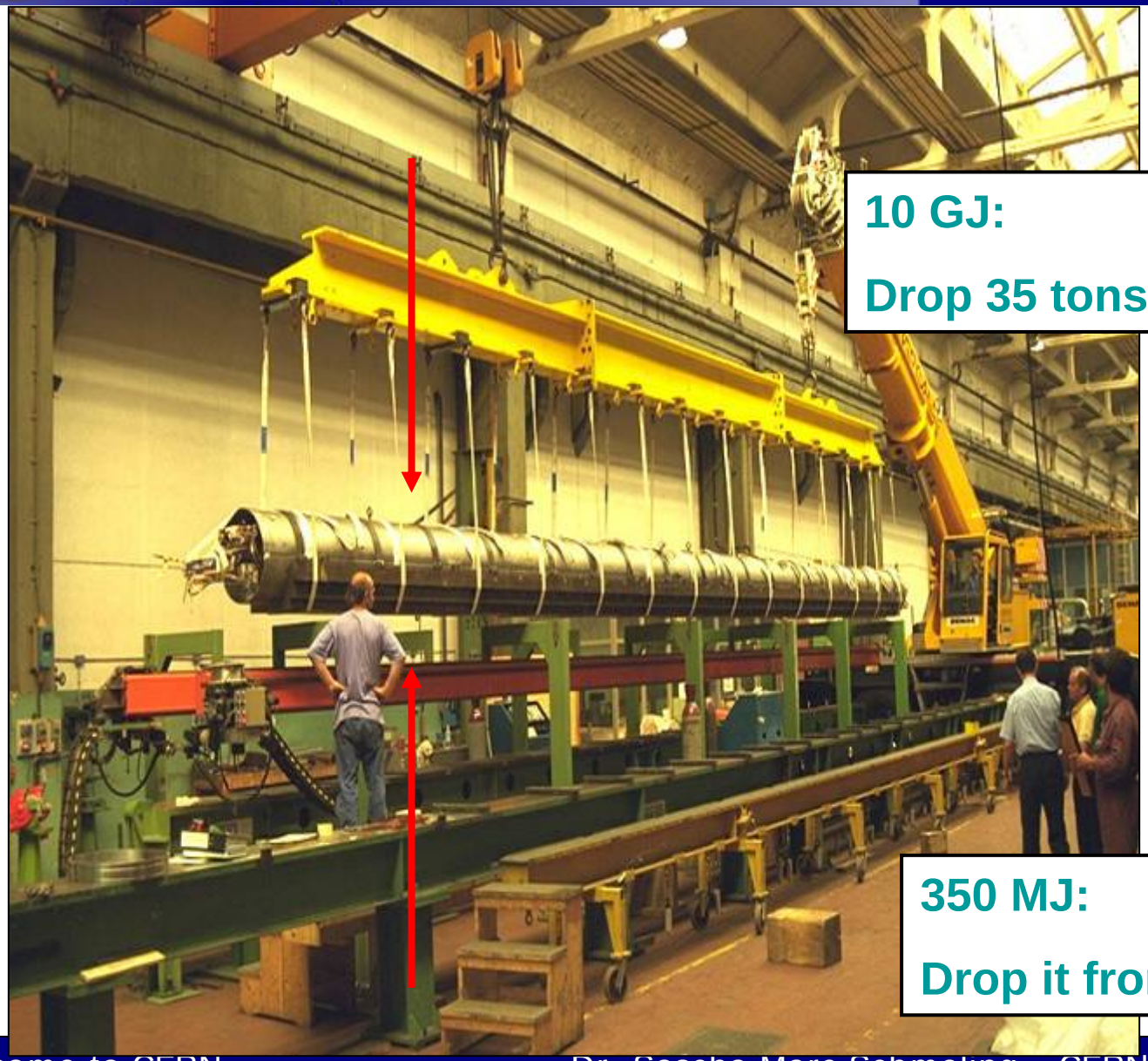
corresponds to the energy for heating and melting
12000 kg of copper

corresponds to the energy produced by of one nuclear power plant during about 10 seconds

Could this damage equipment?

How fast can this energy be released?

Energy in Magnets and Beams



10 GJ:

Drop 35 tons from 28 km

350 MJ:

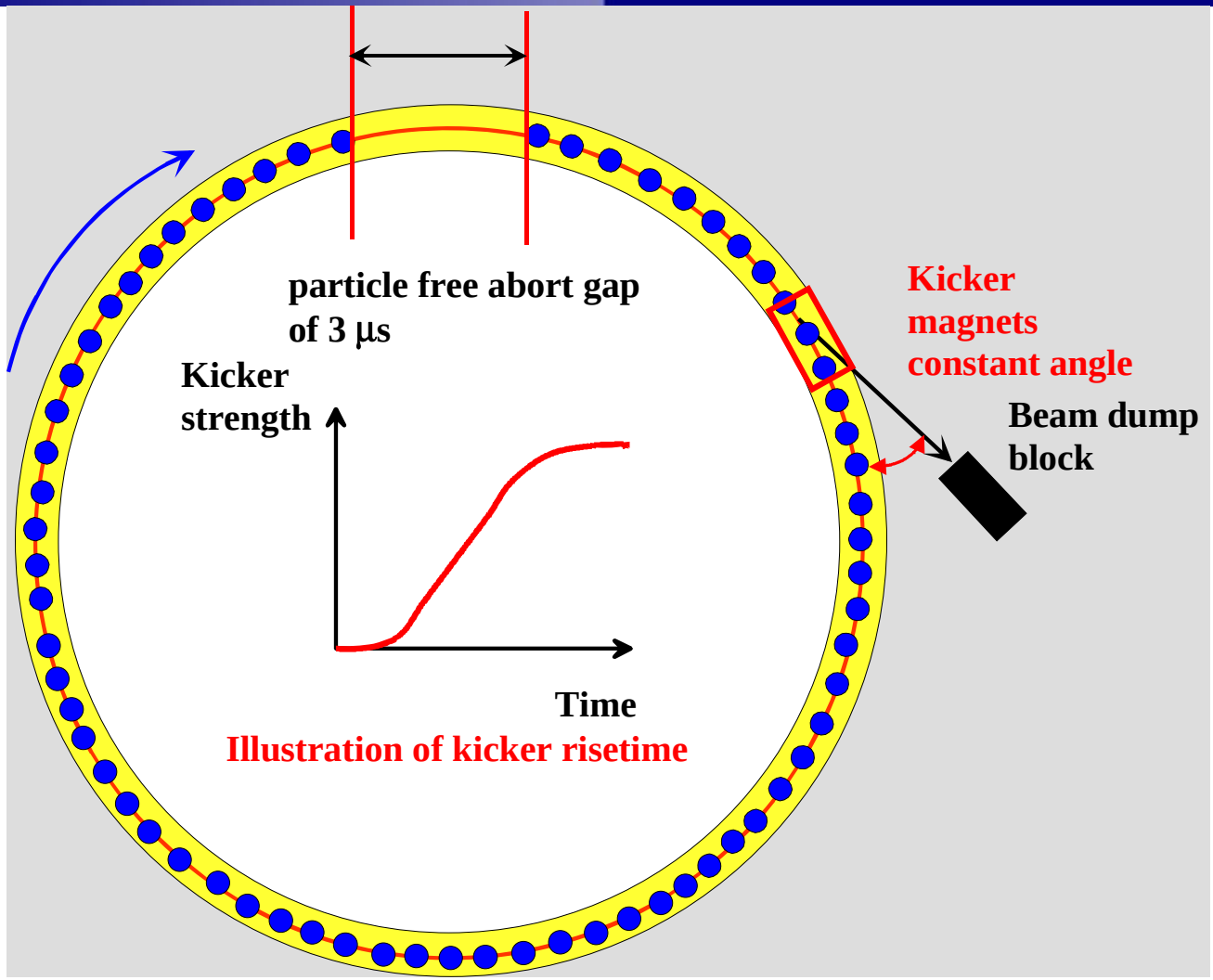
Drop it from 1 km

Requirement for clean beam dump

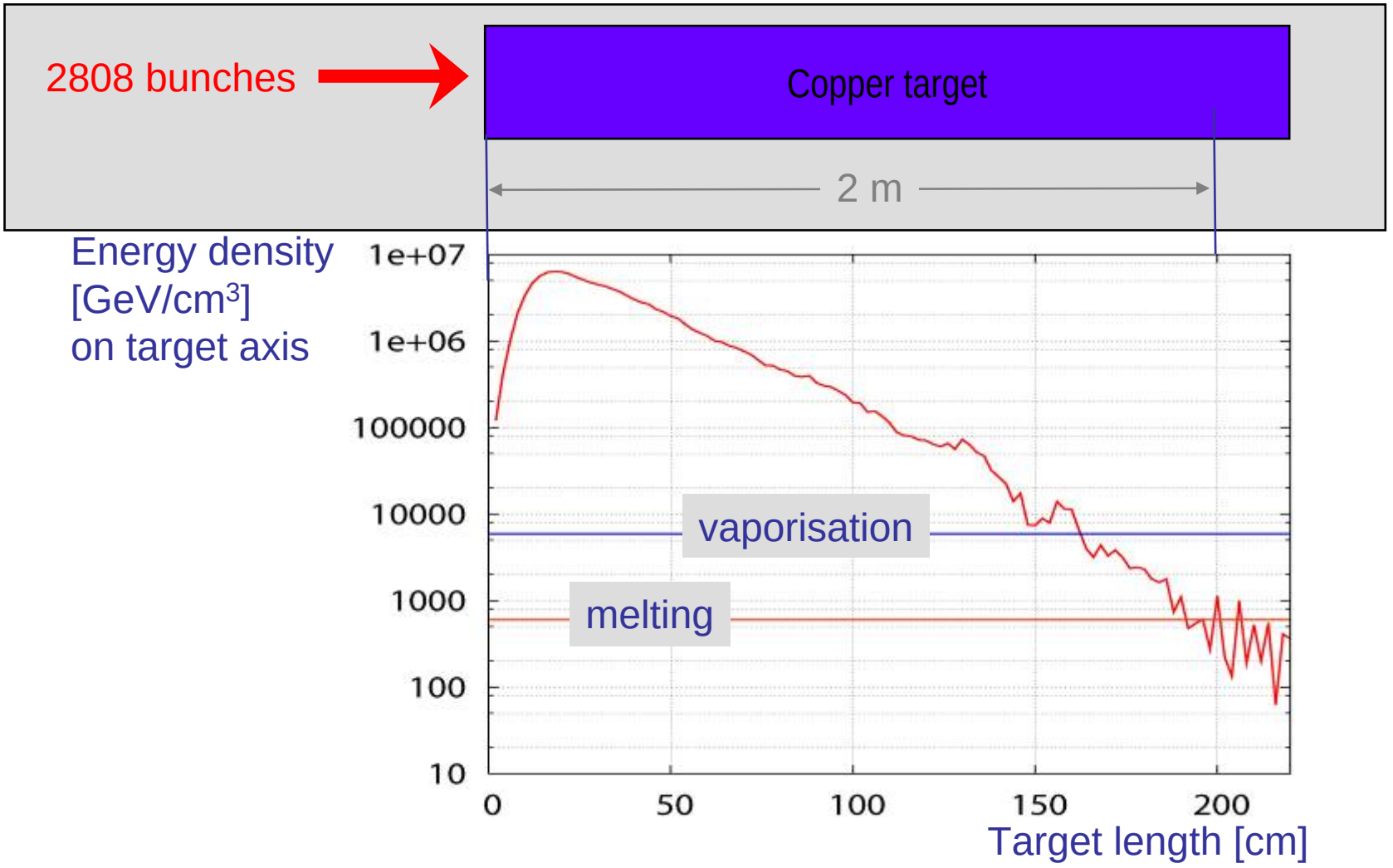
Beam dump must be synchronised with particle free gap

Strength of kicker and septum magnets must match energy of the beam

« Particle free gap » must be free of particles

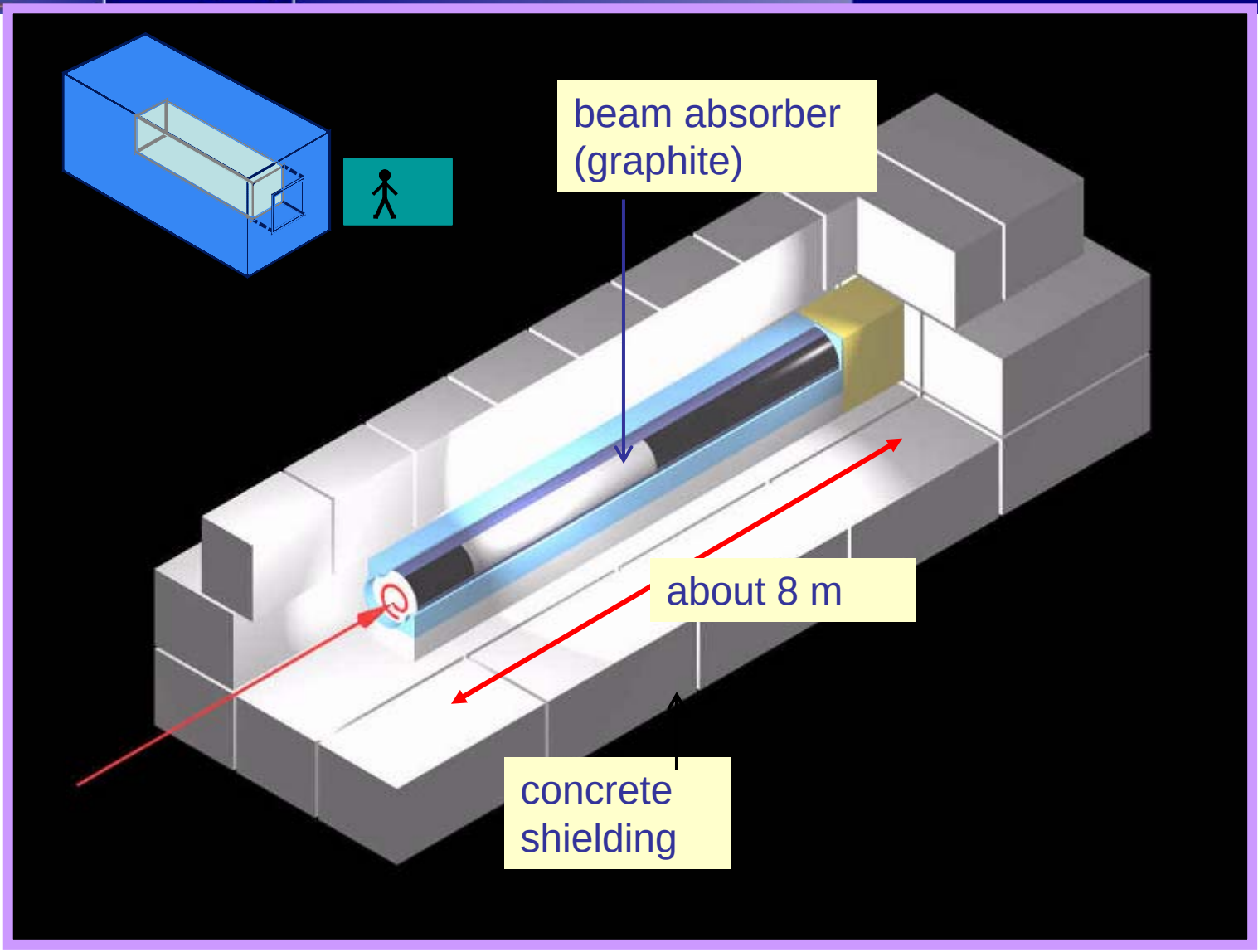


Full LHC beam deflected into copper target

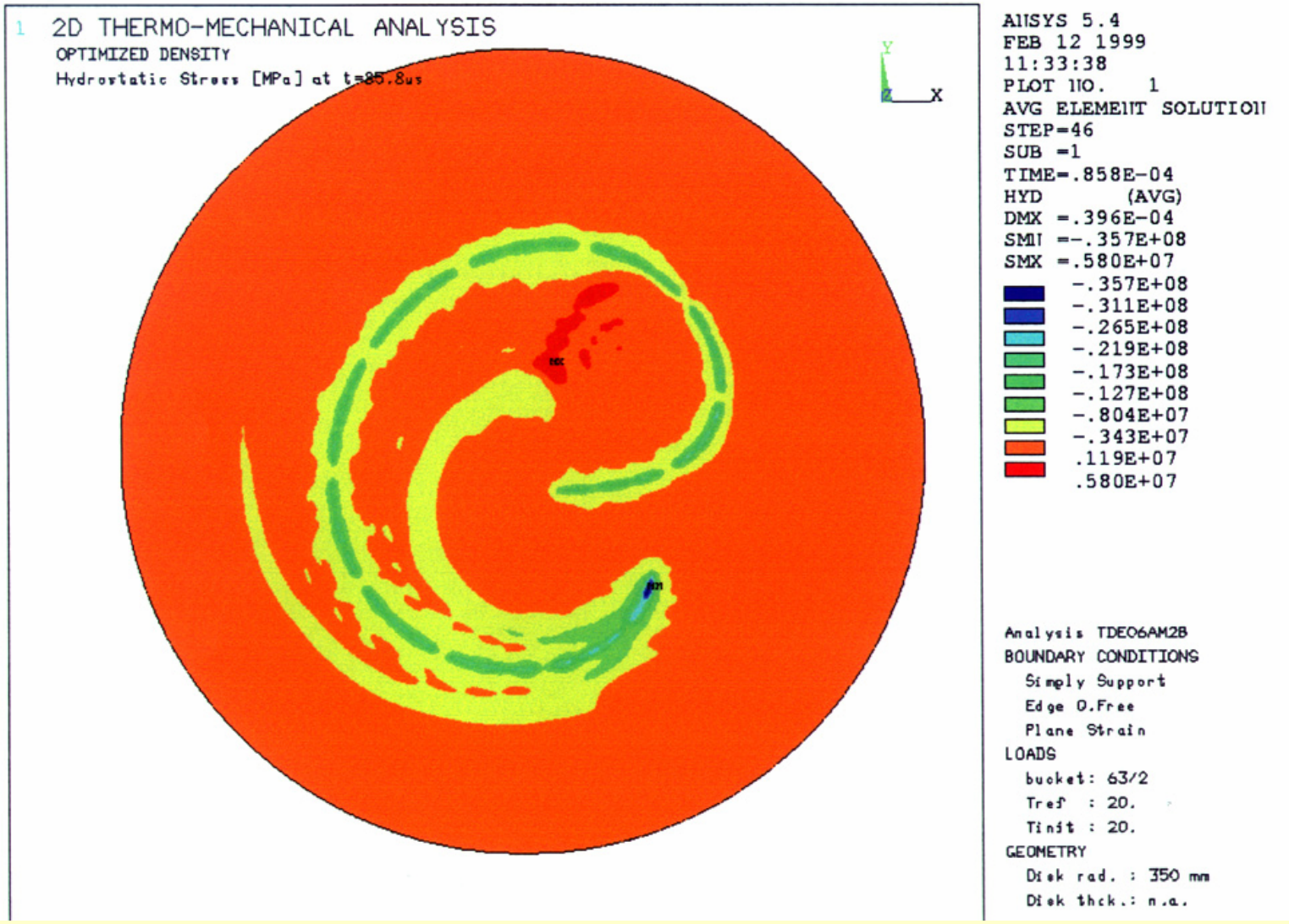


N.Tahir (GSI) et al.

Beam Dump Block - Layout



Hydrostatic stress after beam deposition



L.Bruno: Thermo-Mechanical Analysis with ANSYS

Machine protection: Magnet energy

Energy in dipole magnets: 10 GJoule

… per sector reduced to 1.3 GJoule

Uncontrolled release of energy is prevented:

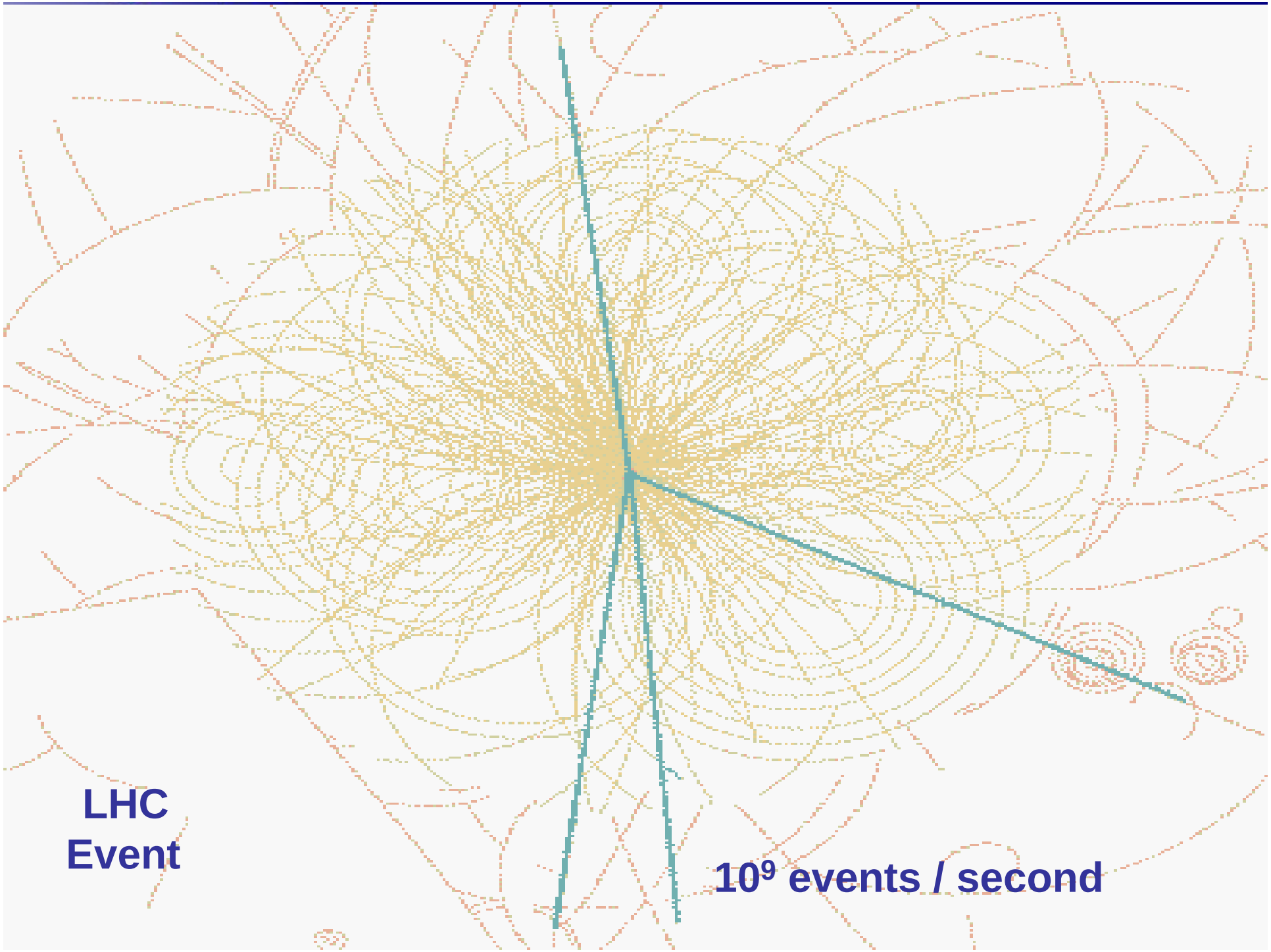
Fire quench heaters

Current by-passes magnet via power diode

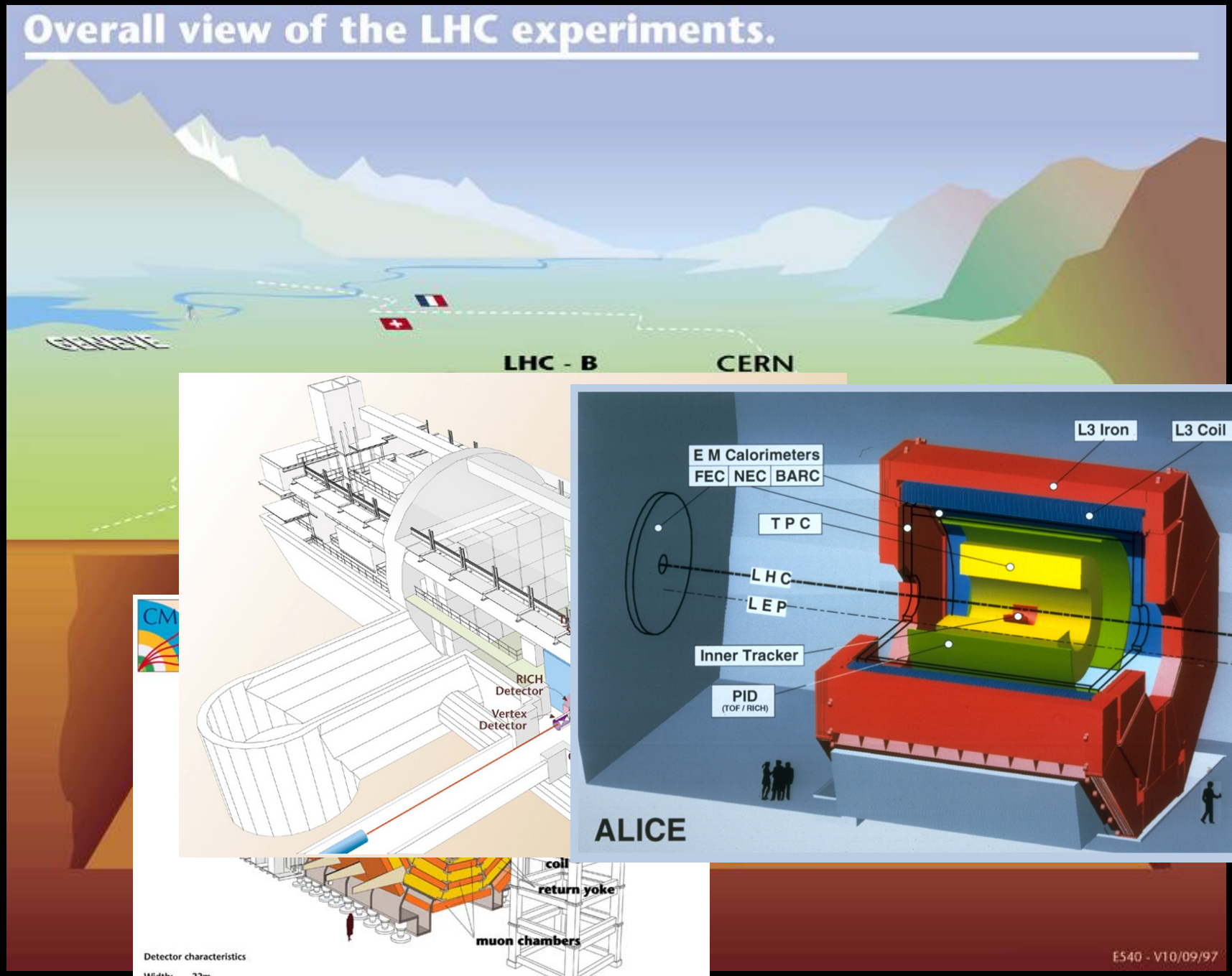
Extract energy by switching a resistor into the circuit - the resistor with a mass of eight tons is heated to 300 °C

13 kA switches from Protvino Russia

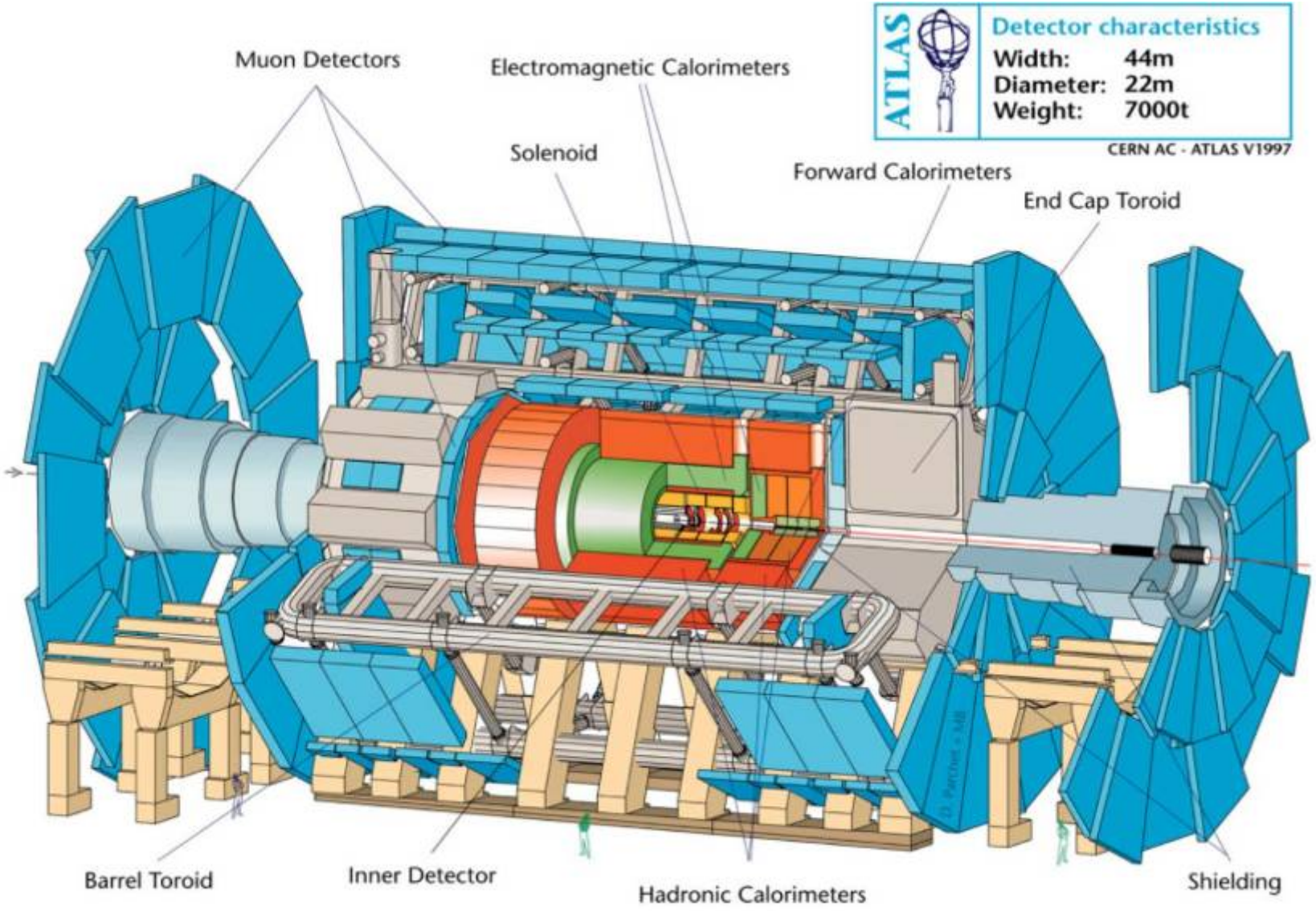
All components of the system have been validated, and production started (part in collaboration with Russia and India)

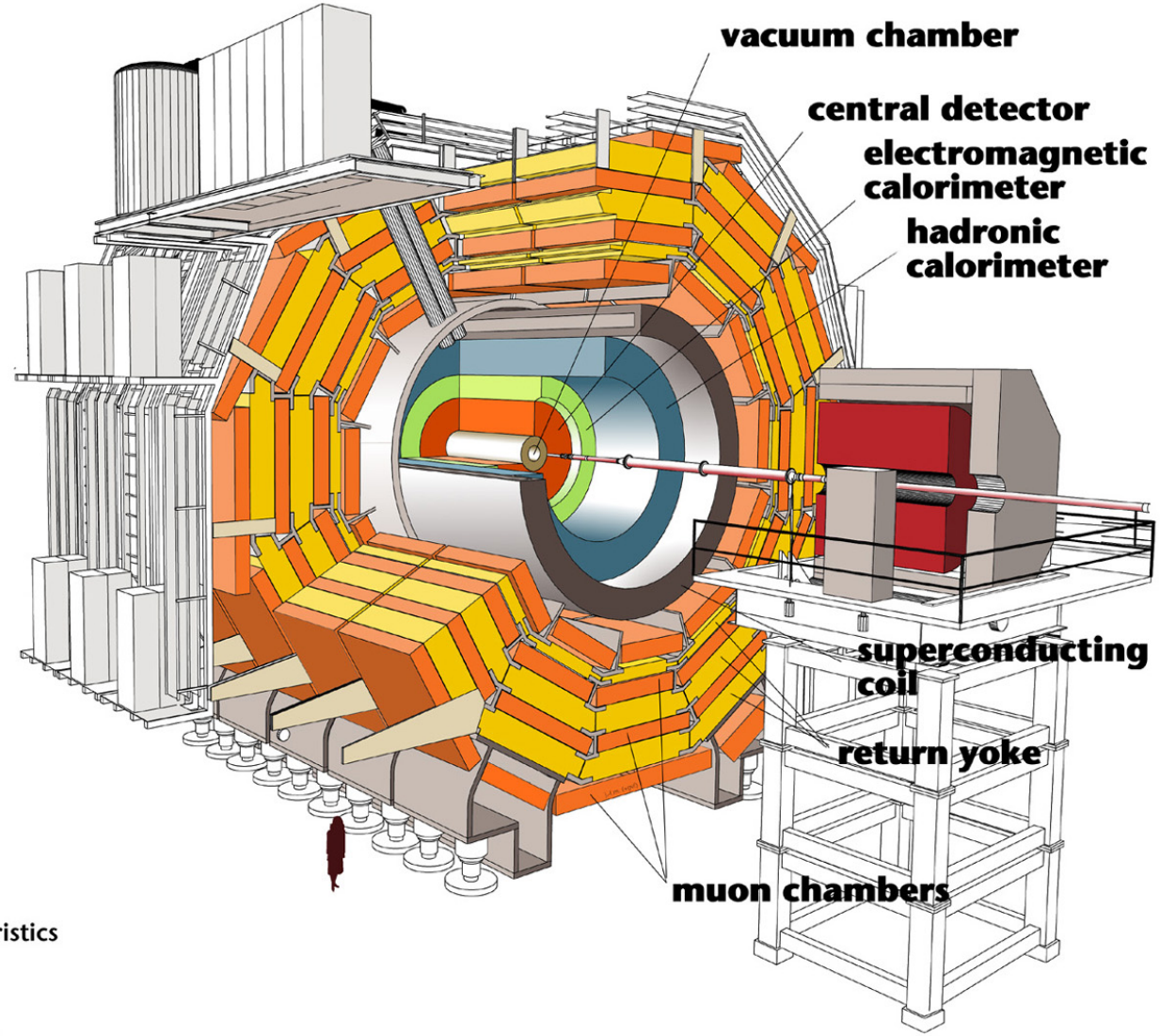

LHC
Event
10^9 events / second

Overall view of the LHC experiments.



ATLAS Experiment

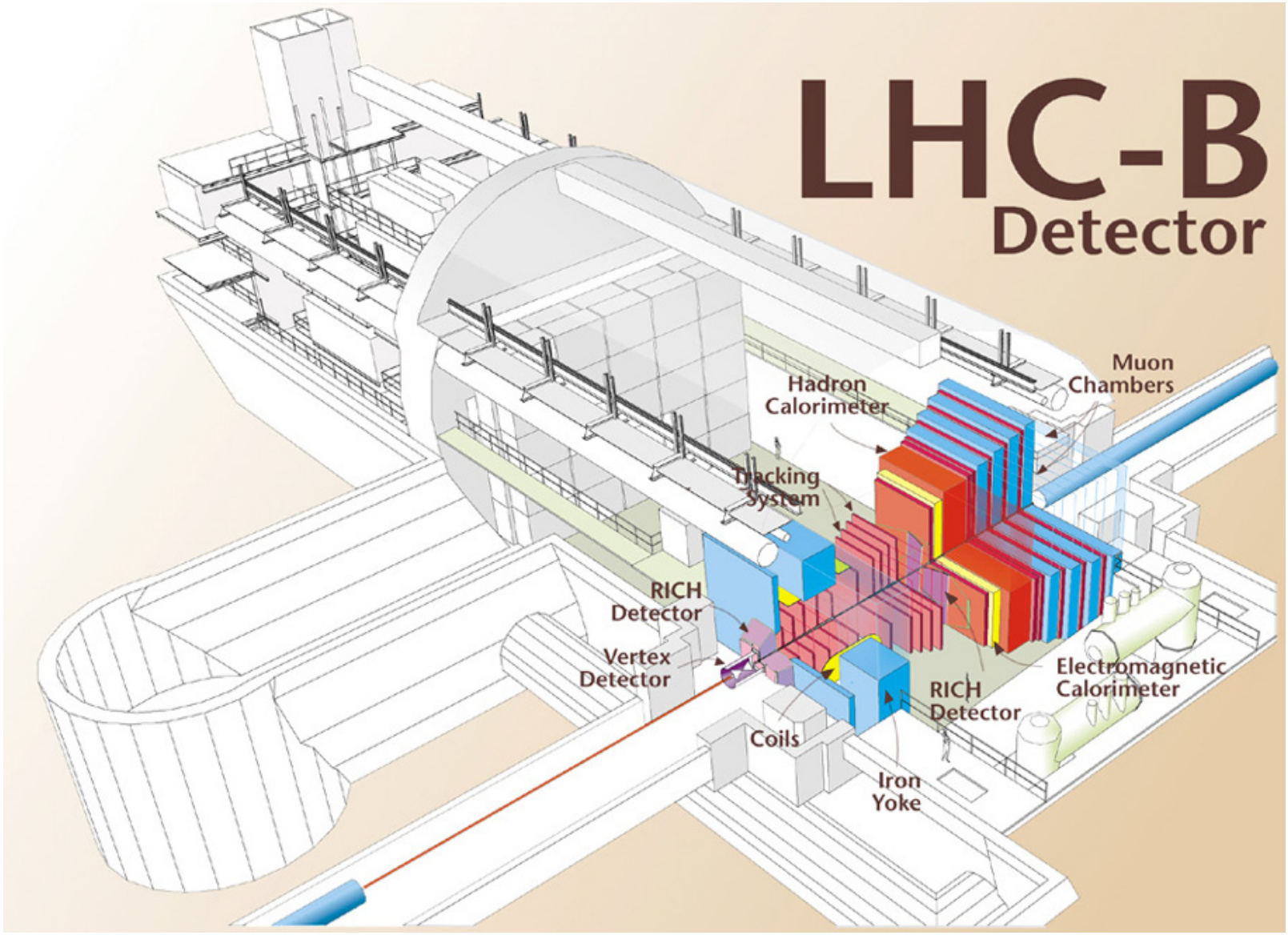




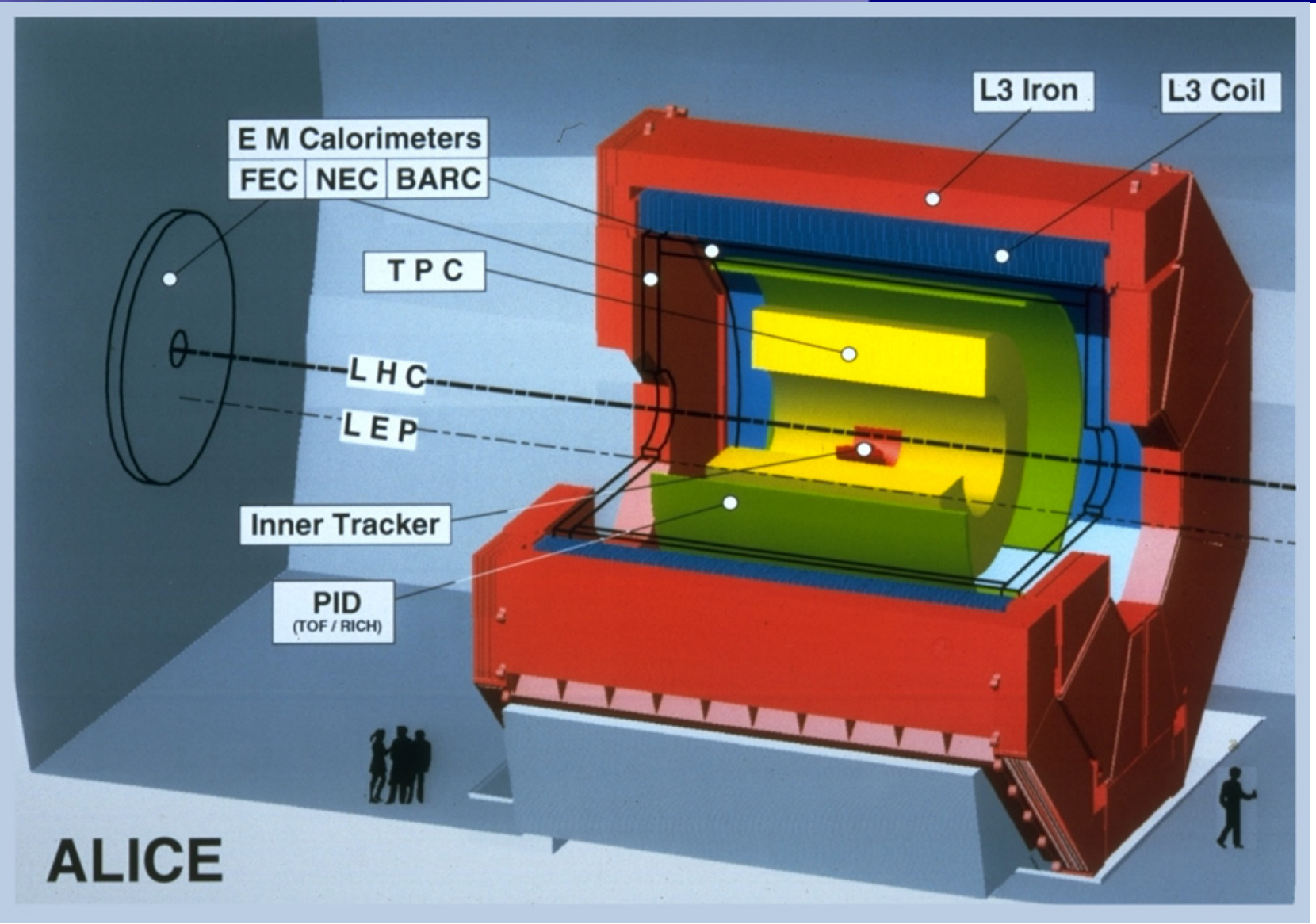
Detector characteristics

Width:	22m
Diameter:	15m
Weight:	14'500t

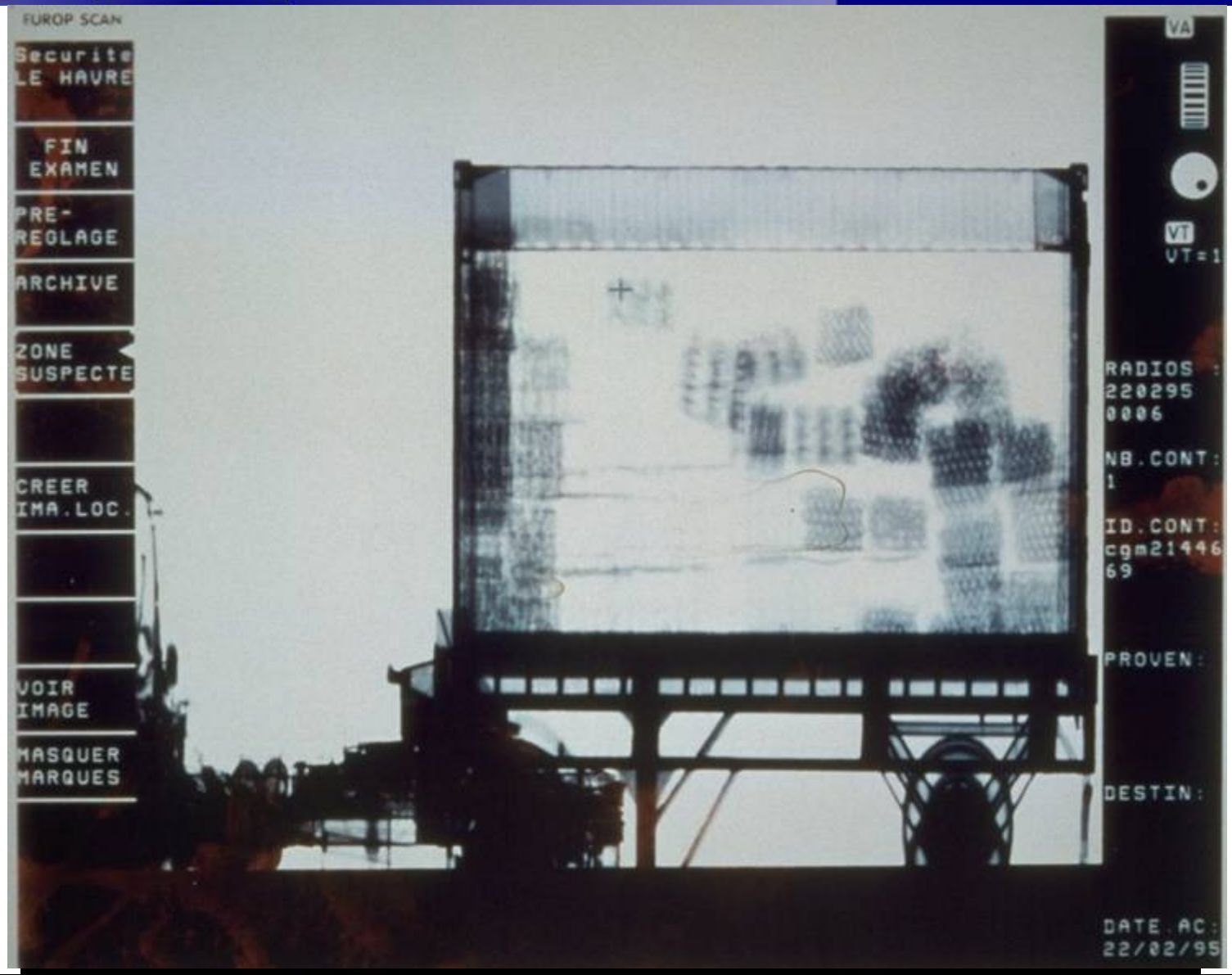
LHCb Experiment



ALICE Experiment



Spin-Offs


FUROP SCAN
Securite LE HAVRE
FIN EXAMEN
PRE-REGLAGE
ARCHIVE
ZONE SUSPECTE
CREER IMA.LOC.
VOIR IMAGE
MASQUER MARQUES
VA
VT
VT=1
RADIOS :
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NB.CONT:
1
ID.CONT:
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PROVEN:
DESTIN:
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Your Questions ?