European Organization for Nuclear Research
Über 50 Jahre Grundlagenforschung in Physik

CERN

... das Labor ... die Beschleuniger ... die Experimente ... ... die Physik ...

Dr. Sascha Marc Schmeling
CERN PH

Eine Einführung

– die Organisation “CERN”

– das Labor des CERN

– Hochenergiephysik

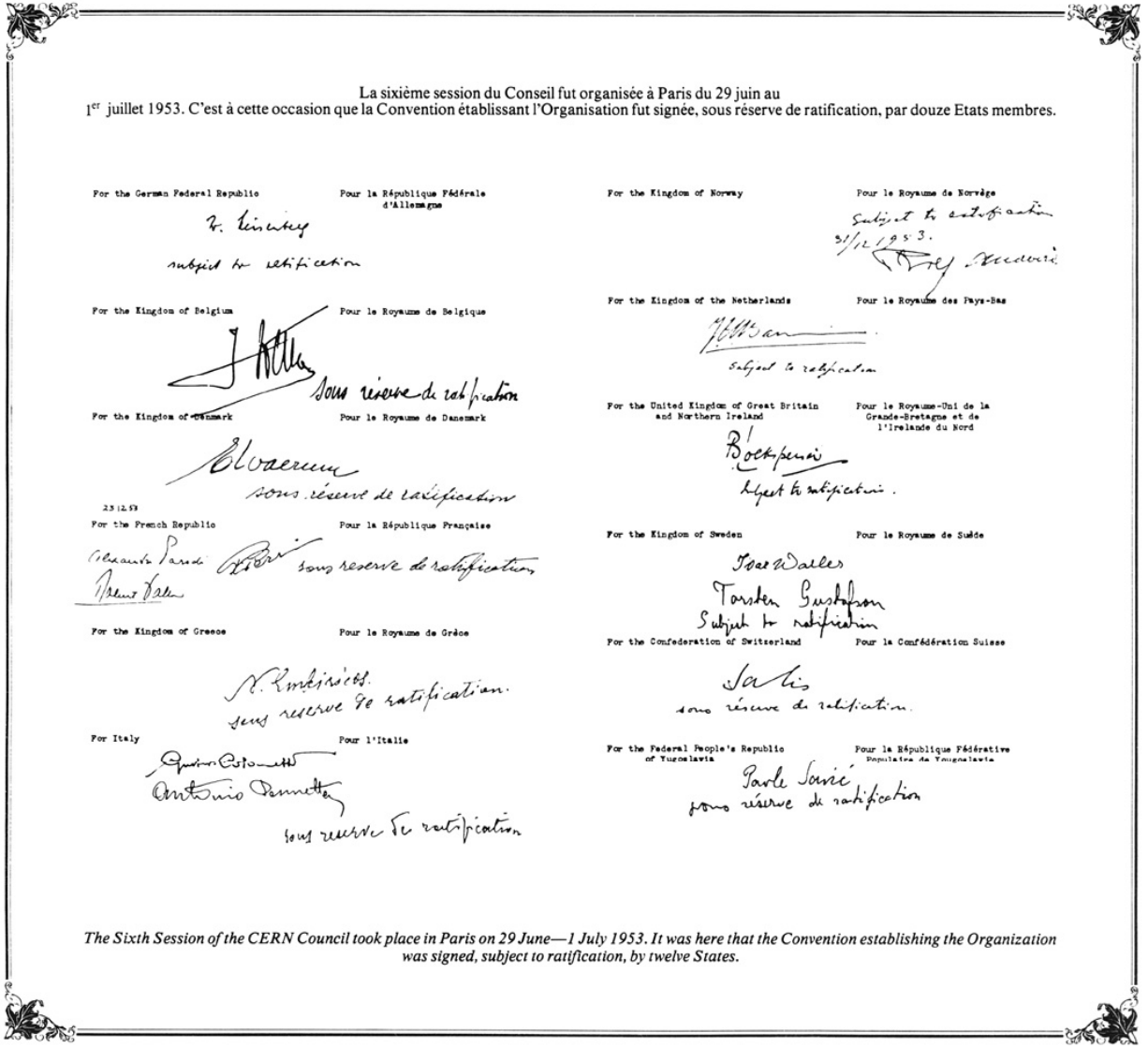
– Beschleunigeranlagen

– Experimente

– Spin-Offs

1949
Er
N
1952
G
C
ur
Oktober
Sta
1. Juli 1953
Unterzeichnur
29. September 1954
Abschluß des
ursprüngliche

Belgien,
Frar
Gr
Jugo
Norweg



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.

For the German Federal Republic — Pour la République Fédérale d'Allemagne
subject to ratification

For the Kingdom of Belgium — Pour le Royaume de Belgique
sous réserve de ratification

For the Kingdom of Denmark — Pour le Royaume de Danemark
sous réserve de ratification
23.12.53

For the French Republic — Pour la République Française
sous reserve de ratification

For the Kingdom of Greece — Pour le Royaume de Grèce
sous reserve de ratification.

For Italy — Pour l'Italie
sous reserve de ratification

For the Kingdom of Norway — Pour le Royaume de Norvège
Subject to ratification
31/12/1953.

For the Kingdom of the Netherlands — Pour le Royaume des Pays-Bas
Subject to ratification

For the United Kingdom of Great Britain and Northern Ireland — Pour le Royaume-Uni de la Grande-Bretagne et de l'Irlande du Nord
Subject to ratification.

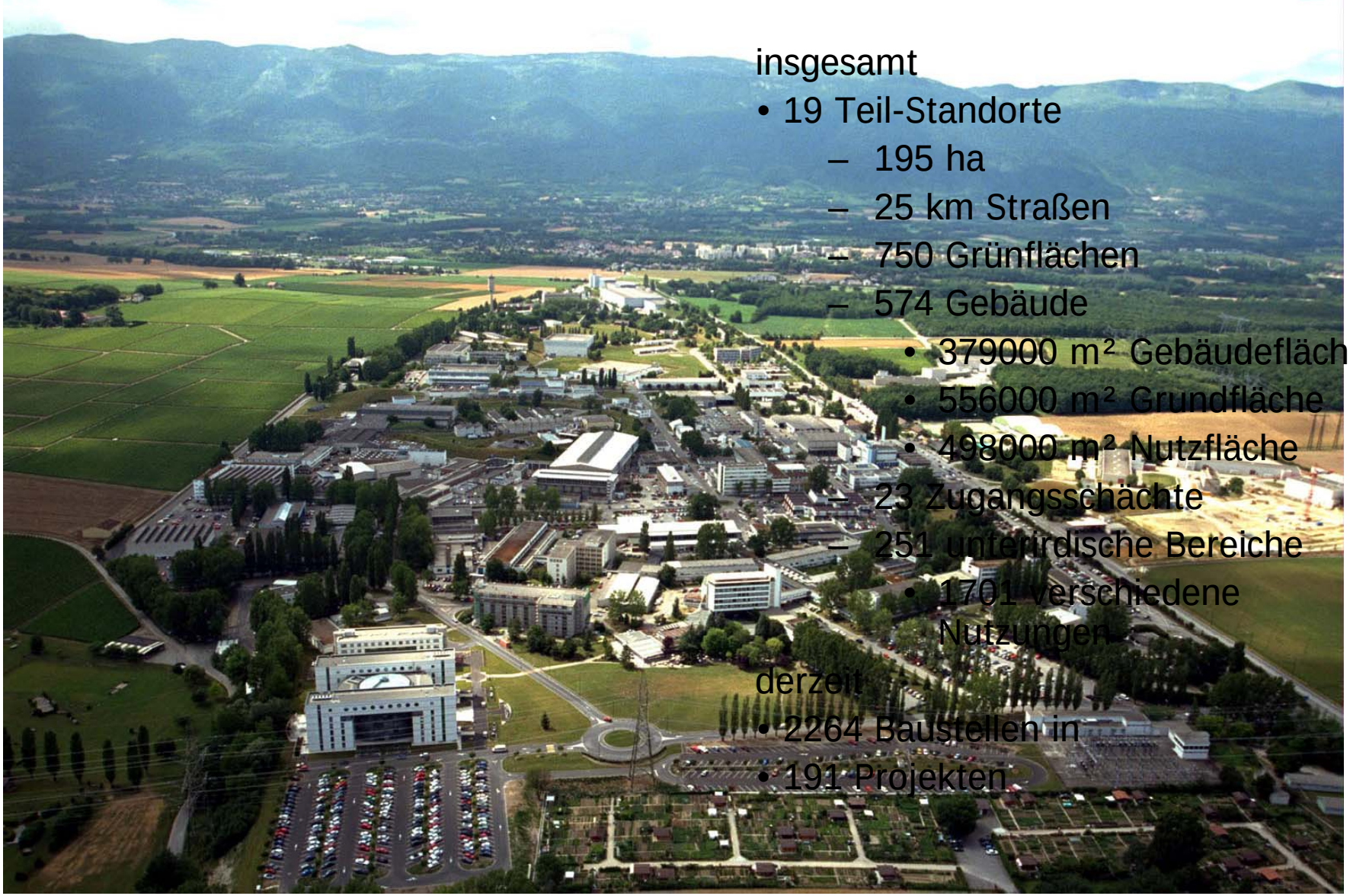
For the Kingdom of Sweden — Pour le Royaume de Suède
Subject to ratification

For the Confederation of Switzerland — Pour la Confédération Suisse
sous réserve de ratification.

For the Federal People's Republic of Yugoslavia — Pour la République Fédérative Populaire de Yougoslavie
sous réserve de ratification

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 – Das Laboratorium

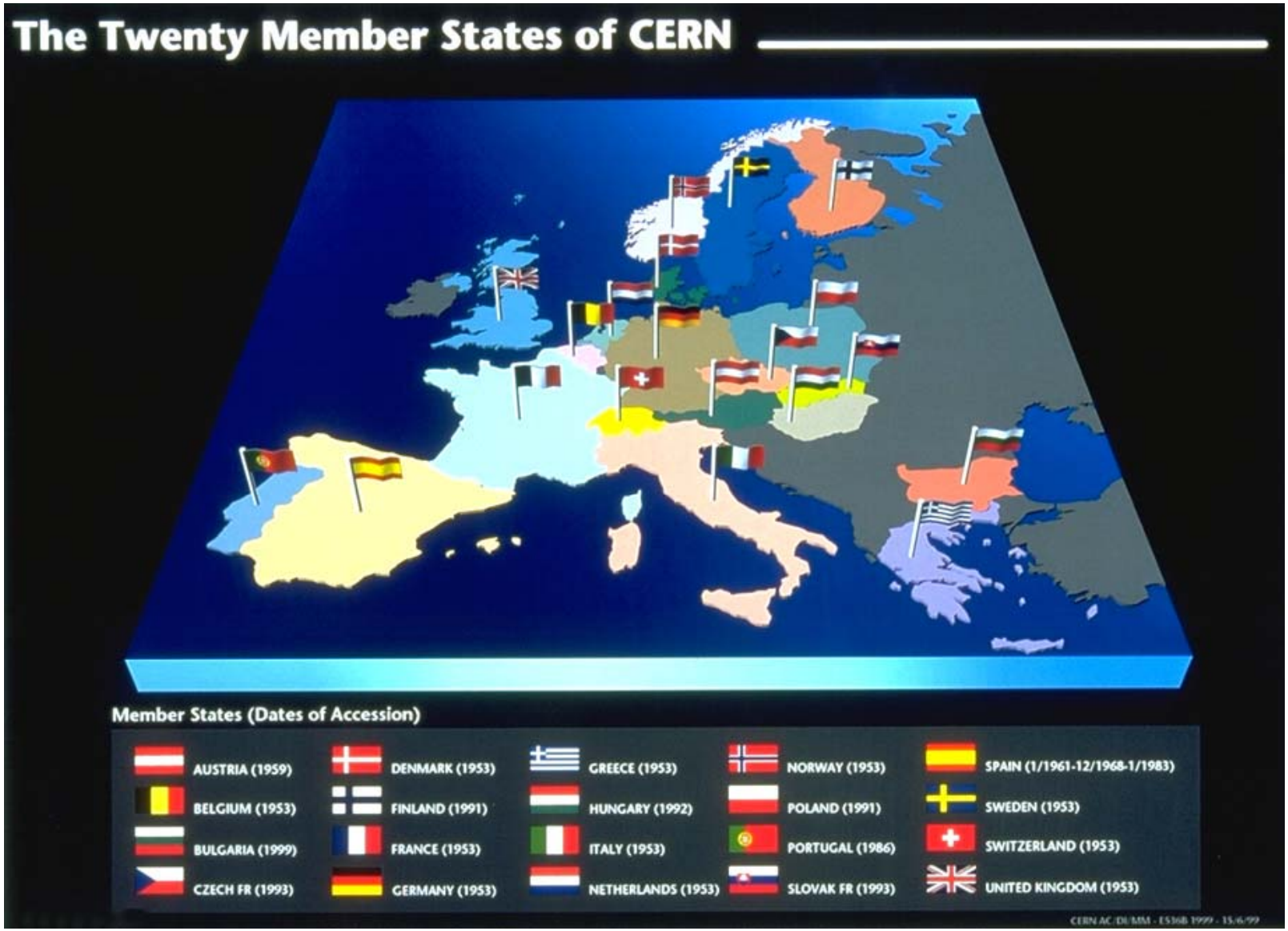


insgesamt

- 19 Teil-Standorte
  - 195 ha
  - 25 km Straßen
  - 750 Grünflächen
  - 574 Gebäude
    - 379000 m² Gebäudefläche
    - 556000 m² Grundfläche
    - 498000 m² Nutzfläche
  - 23 Zugangsschächte
  - 251 unterirdische Bereiche
    - 1701 verschiedene Nutzungen

derzeit

- 2264 Baustellen in
- 191 Projekten


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 Organisation

CERN Rat

CERN Finanzkomitee

CERN SPC

DG
CEO
Robert Aymar

FI/HR
CFO
Sigurd Lettow

DDG
CSO
Jos Engelen

Director-General's Services

SG to DG
Maximilian Metzger

Relations with…
- EU Institutions
- HEP Laboratories
- International Organizations
- Member States & Council Delegates
- Non-Member States
- Host States

- Administrative Support
- Internal Audit
- Communication
- Council Secretariat
- Education
- Legal Service
- Scientific Information
- Translations & Minutes
- Technology Transfer
- VIP Office
- Safety Commission

Project Management
- LHC — Lyn Evans
- LHC Office

- ALICE
- ATLAS
- CMS
- LHCb
- LHCf
- TOTEM
- LCG
- EGEE
- CNGS
- CLIC

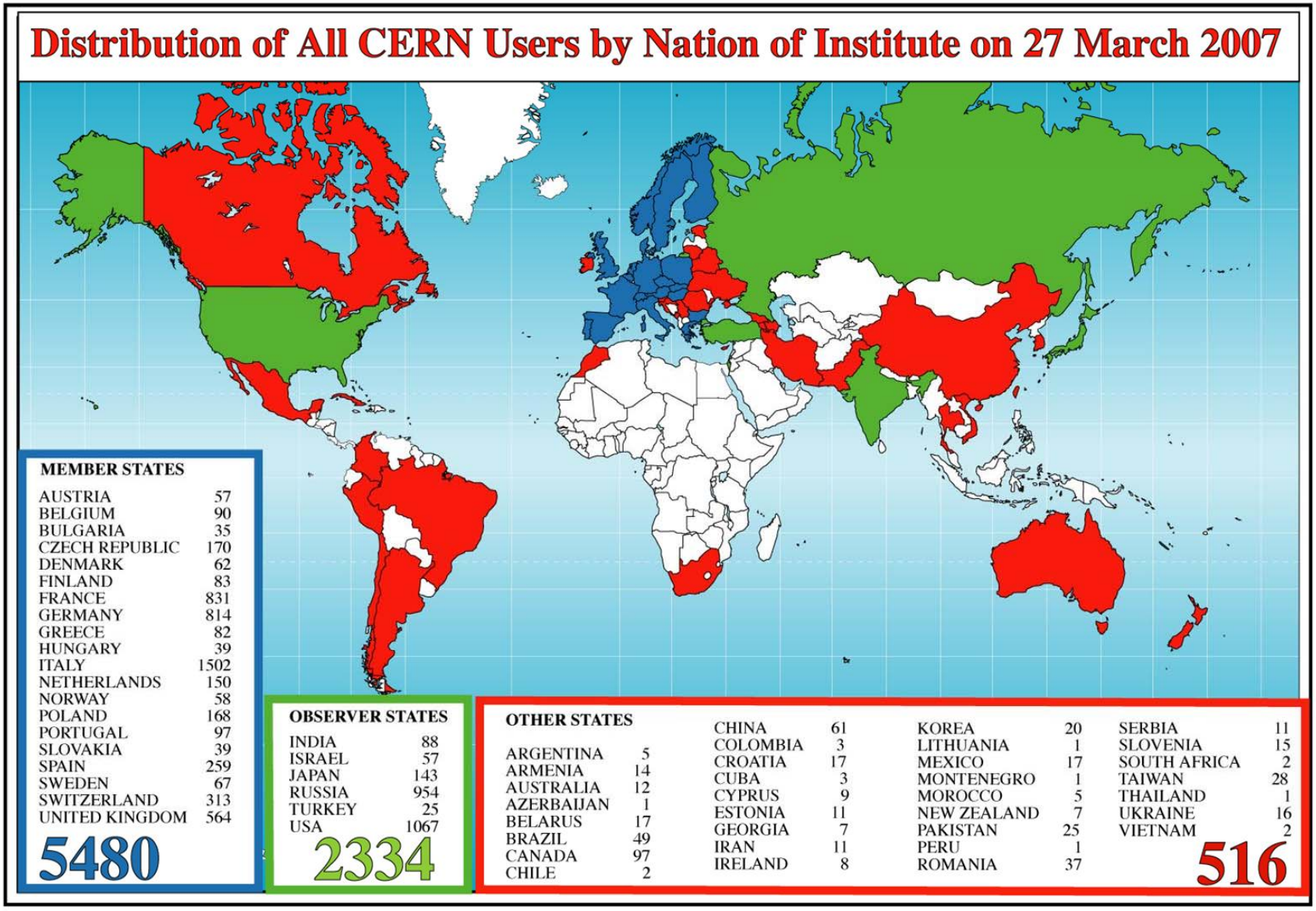
Departments

HR	FI	AB	AT	TS	IT	PH
Human Resources	Finance	Accelerators & Beams	Accelerator Technology	Technical Support	Information Technology	Physics
Enrico Chiaveri	Patrick Geeraert	Stephen Myers	Philippe Lebrun	Paolo Ciriani	Wolfgang von Rüden	Jean-Jacques Blaising







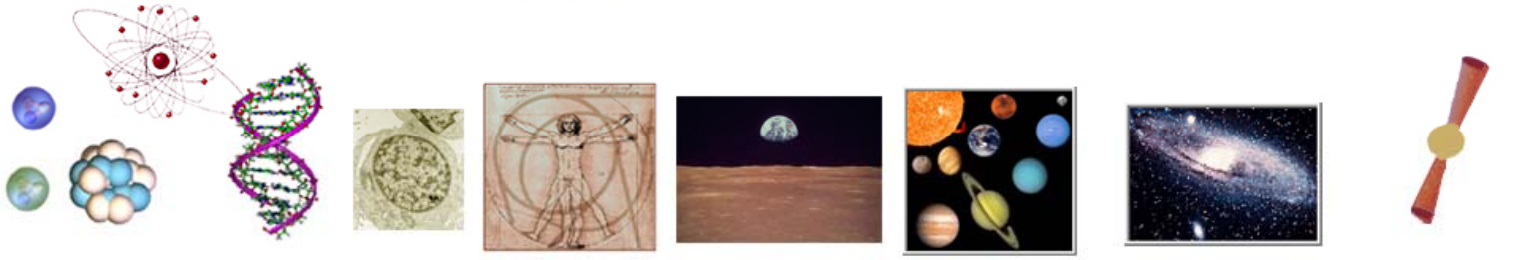

Distribution of All CERN Users by Nation of Institute on 27 March 2007
MEMBER STATES
AUSTRIA 57
BELGIUM 90
BULGARIA 35
CZECH REPUBLIC 170
DENMARK 62
FINLAND 83
FRANCE 831
GERMANY 814
GREECE 82
HUNGARY 39
ITALY 1502
NETHERLANDS 150
NORWAY 58
POLAND 168
PORTUGAL 97
SLOVAKIA 39
SPAIN 259
SWEDEN 67
SWITZERLAND 313
UNITED KINGDOM 564
5480
OBSERVER STATES
INDIA 88
ISRAEL 57
JAPAN 143
RUSSIA 954
TURKEY 25
USA 1067
2334
OTHER STATES
ARGENTINA 5
ARMENIA 14
AUSTRALIA 12
AZERBAIJAN 1
BELARUS 17
BRAZIL 49
CANADA 97
CHILE 2
CHINA 61
COLOMBIA 3
CROATIA 17
CUBA 3
CYPRUS 9
ESTONIA 11
GEORGIA 7
IRAN 11
IRELAND 8
KOREA 20
LITHUANIA 1
MEXICO 17
MONTENEGRO 1
MOROCCO 5
NEW ZEALAND 7
PAKISTAN 25
PERU 1
ROMANIA 37
SERBIA 11
SLOVENIA 15
SOUTH AFRICA 2
TAIWAN 28
THAILAND 1
UKRAINE 16
VIETNAM 2
516

Auf der Suche nach dem,
“Was die Welt im Innersten zusammenhält”

Suche nach

- elementaren Teilchen
- Kräften
- Symmetrien

Physique des Particules
Physique Nucléaire
Physique du Solide
Chimie - Biologie
Mécanique
Cosmologie
Astrophysique
Astronomie
Géophysique



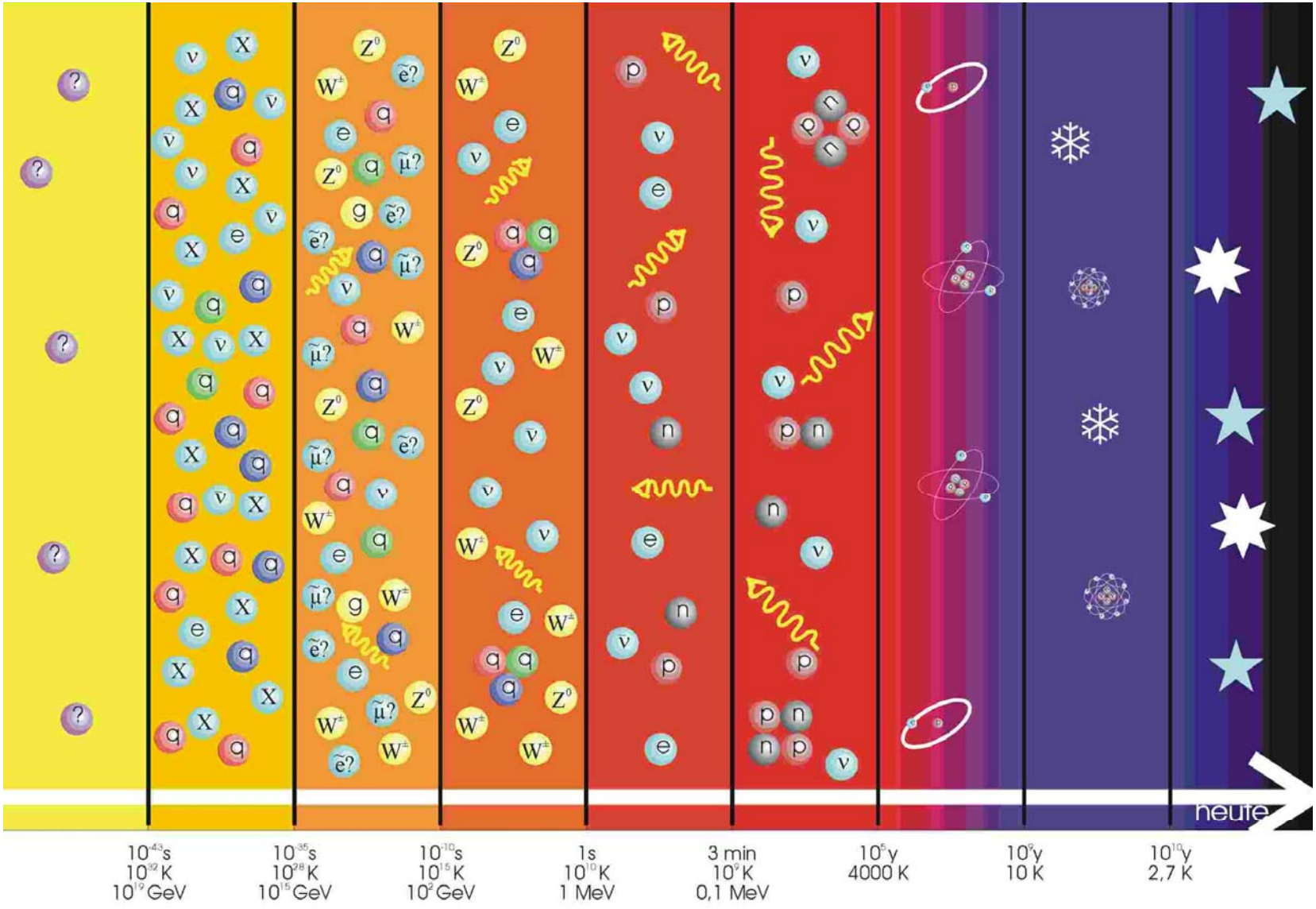
10^{-15} 10^{-12} 10^{-9} 10^{-6} 10^{-3} 1 10^{3} 10^{6} 10^{9} 10^{12} 10^{15} 10^{18} 10^{21} 10^{24}

fm pm nm μm mm m km Mm Gm Tm Pm Em

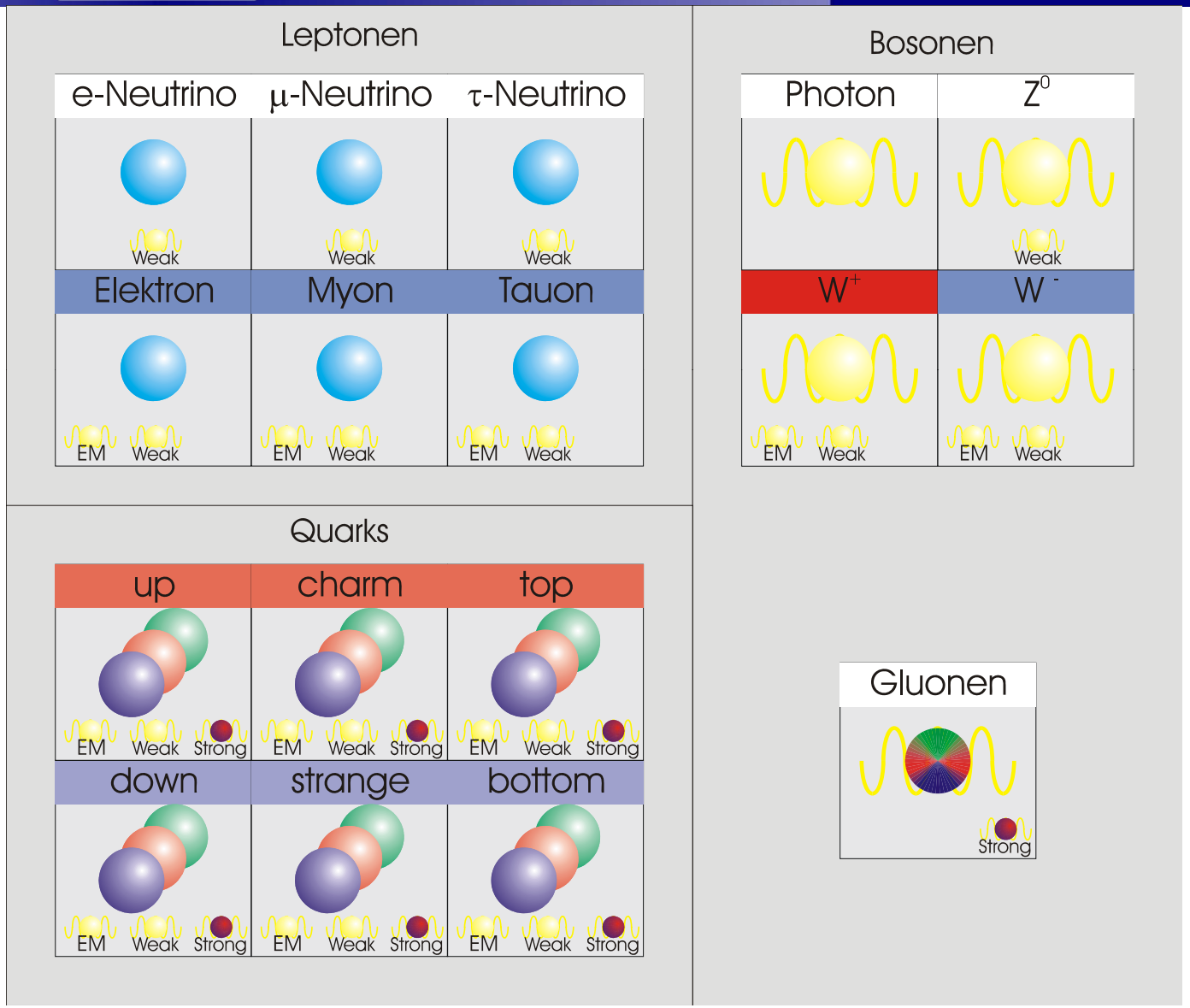
10^{-15} m = 0,000 000 000 000 001 m

D.Bertola/CERN

Geschichte des Universums



Standardmodell

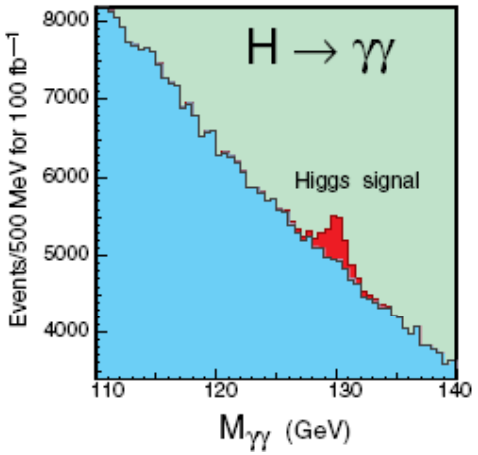


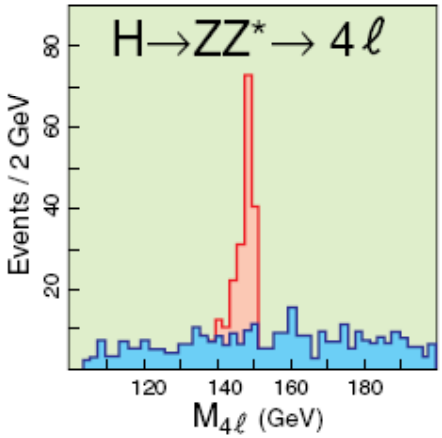
Higgs the mystery of mass

What causes particles to have mass? Why do the masses of fundamental particles differ so enormously - the top quark is more than 200,000 times heavier than the electron?

A solution has been developed by several physicists and takes the name of Peter Higgs. According to this, the whole of space is permeated by a field, similar in some ways to the electromagnetic field. As particles move through space they travel through this field. The interaction between the particles and the field is similar to the action of a viscous force felt by a particle moving through a thick liquid. The stronger the interaction of the particles with the Higgs field, the more mass they appear to have.

We know from quantum theory that fields have particles associated with them, so if the Higgs idea is right, there must be a Higgs particle. Finding it is the key to verifying whether our best hypothesis for the origin of mass is indeed correct.





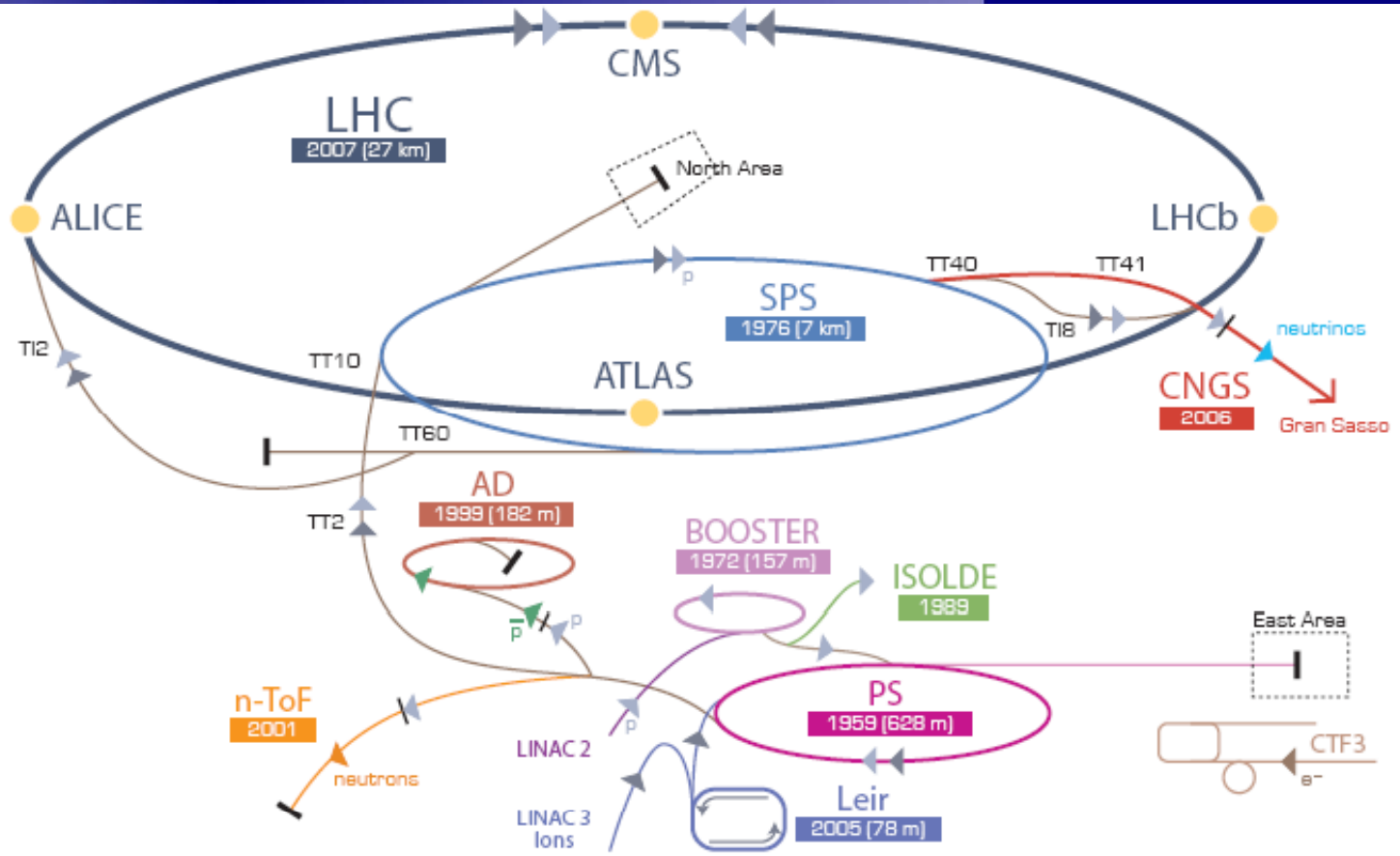
Methoden der Hochenergiephysik

Erreichen hoher Energien mit Beschleunigern:

- natürliche Beschleuniger
  - Astroteilchenphysik
- künstliche Beschleuniger
  - Teilchenphysik

Untersuchung der Wechselwirkungen von Materie und Antimaterie mit Detektoren

Beschleuniger bei CERN



1982 : Erste Projektstudien

1983 : Z^0-Ereignis am S_pS

1985 : Nobelpreis für S. van der Meer und C. Rubbia

1989 : Beginn des LEP-Betriebs (Z Factory)

1994 : Zustimmung zum LHC durch das Council

1996 : Endgültige Entscheidung zum Baubeginn

1996 : LEP Betrieb bei 100 GeV (W Factory)

2000 : Ende des LEP Betriebs

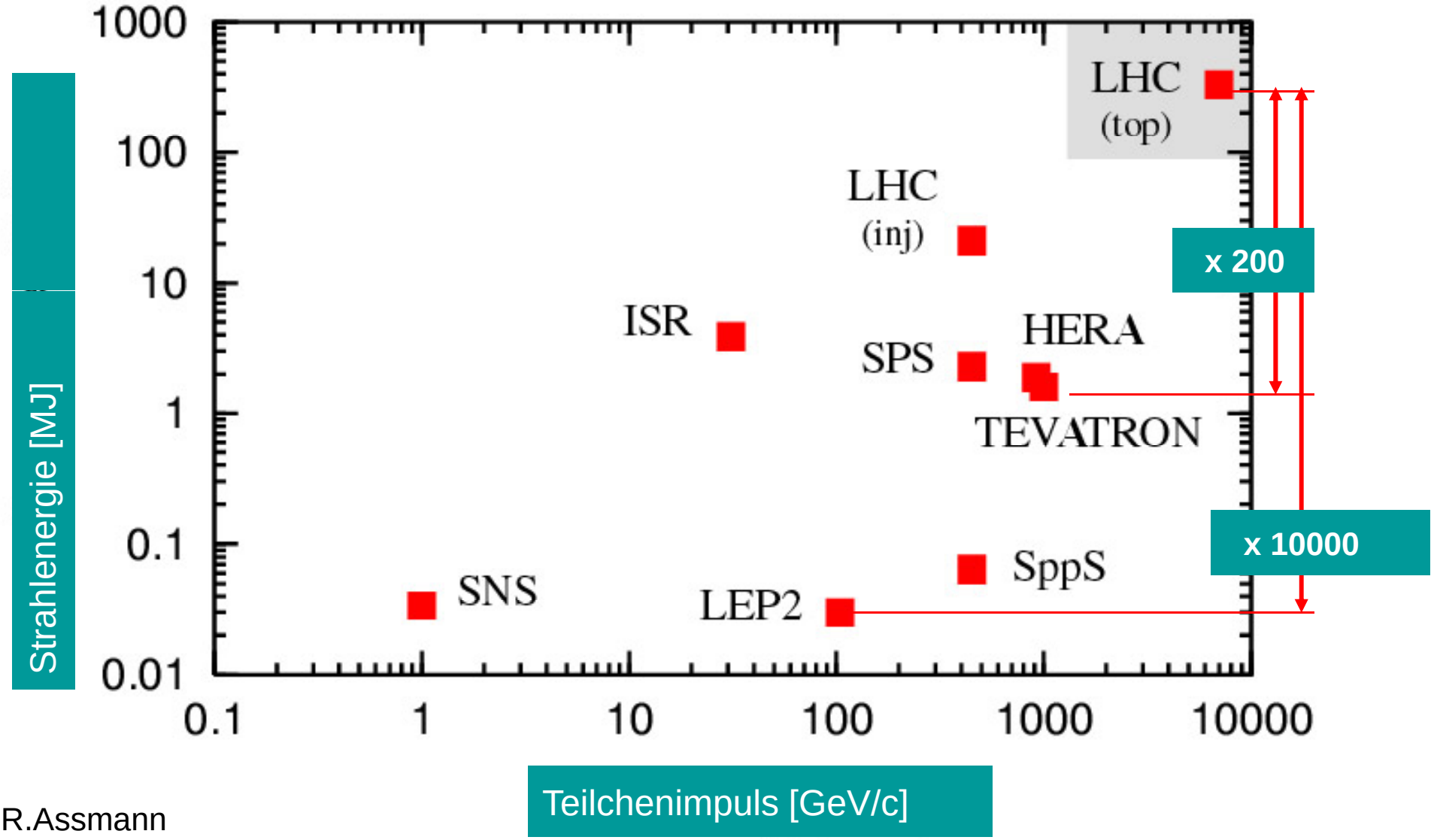
2002 : Abschluß des LEP Abbaus

2003 : Beginn der LHC Installation

2005 : Beginn der LHC Tests

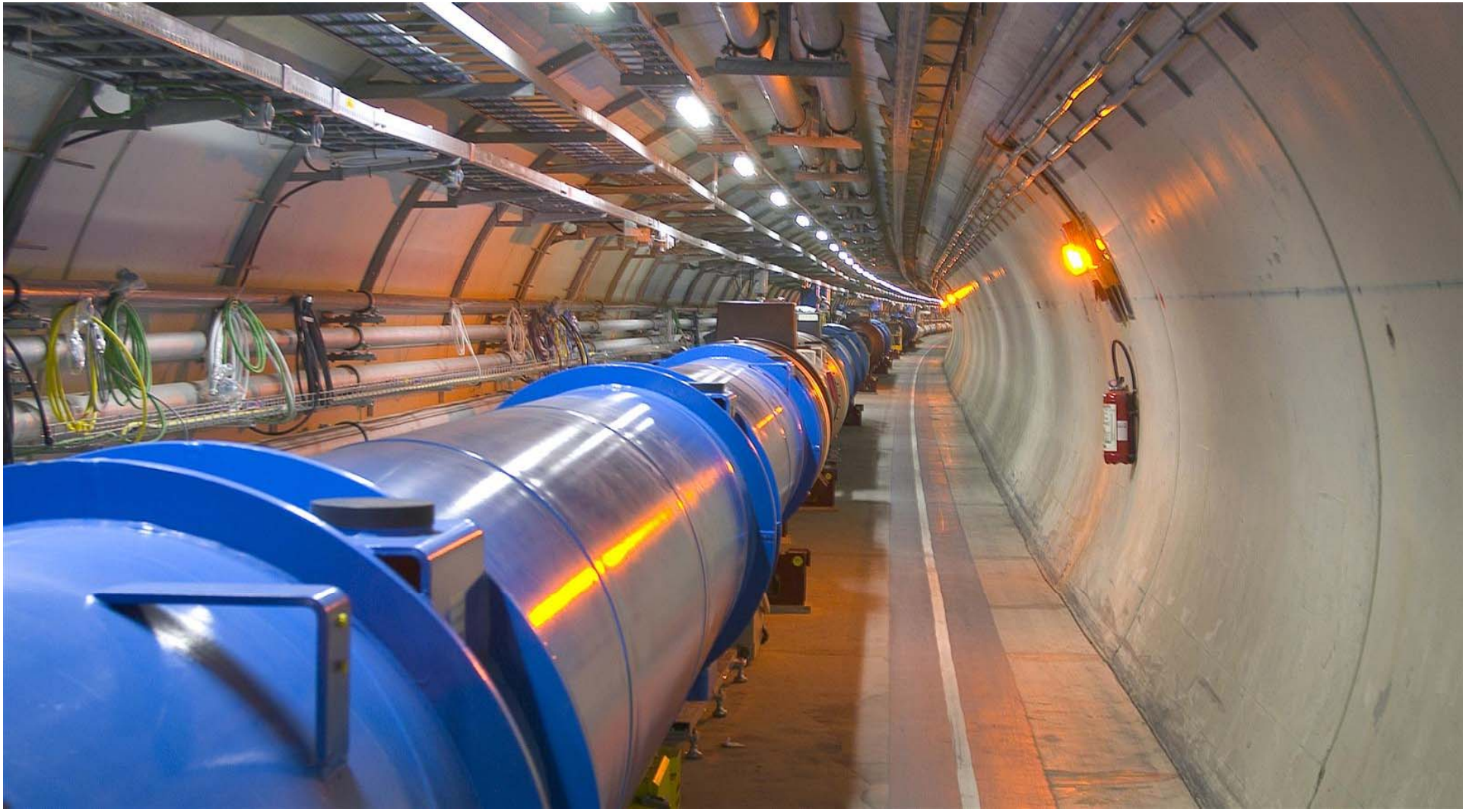
2008 : Betriebsaufnahme LHC

Herausforderung: Strahlenergie

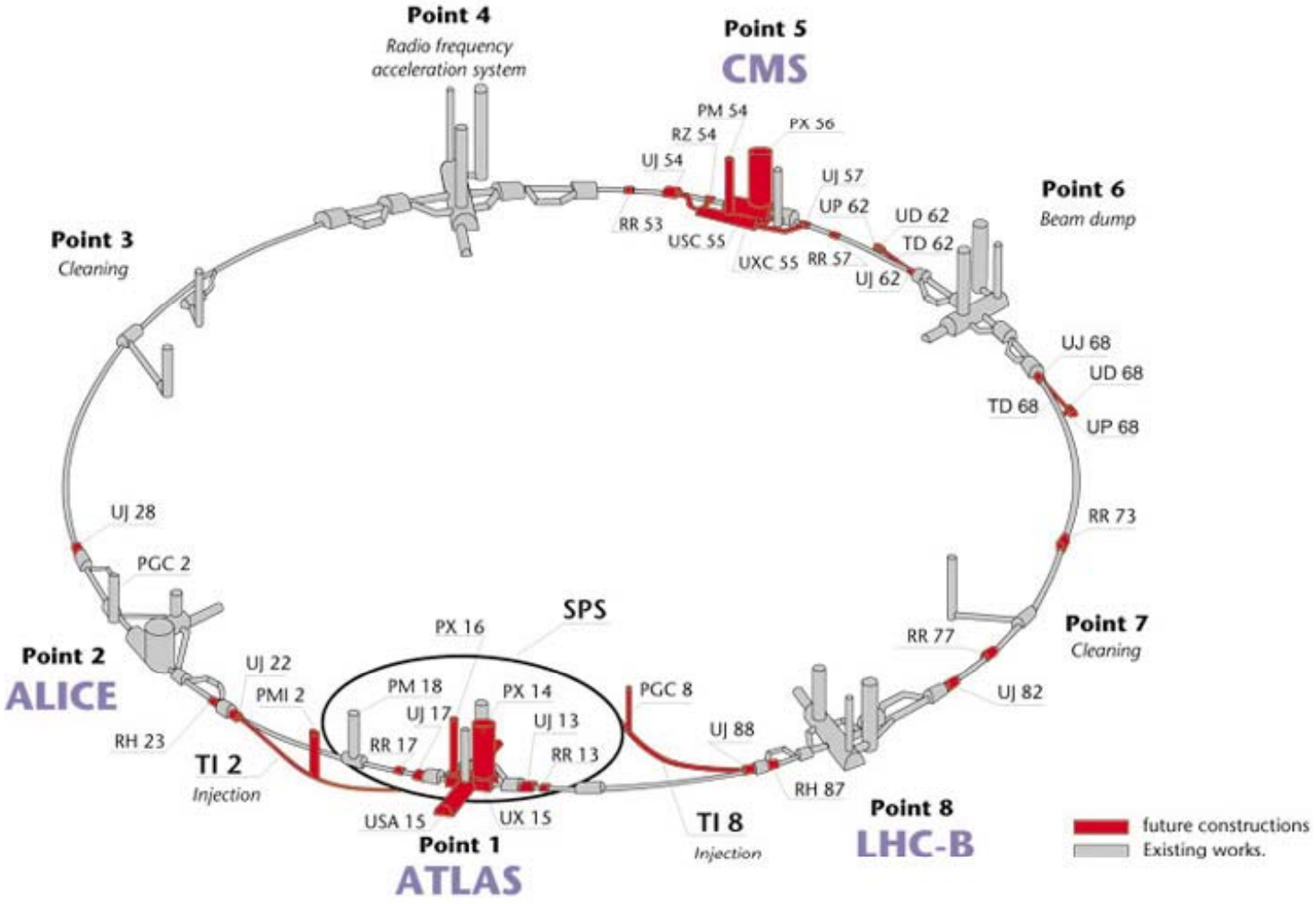


R.Assmann

LHC Tunnel



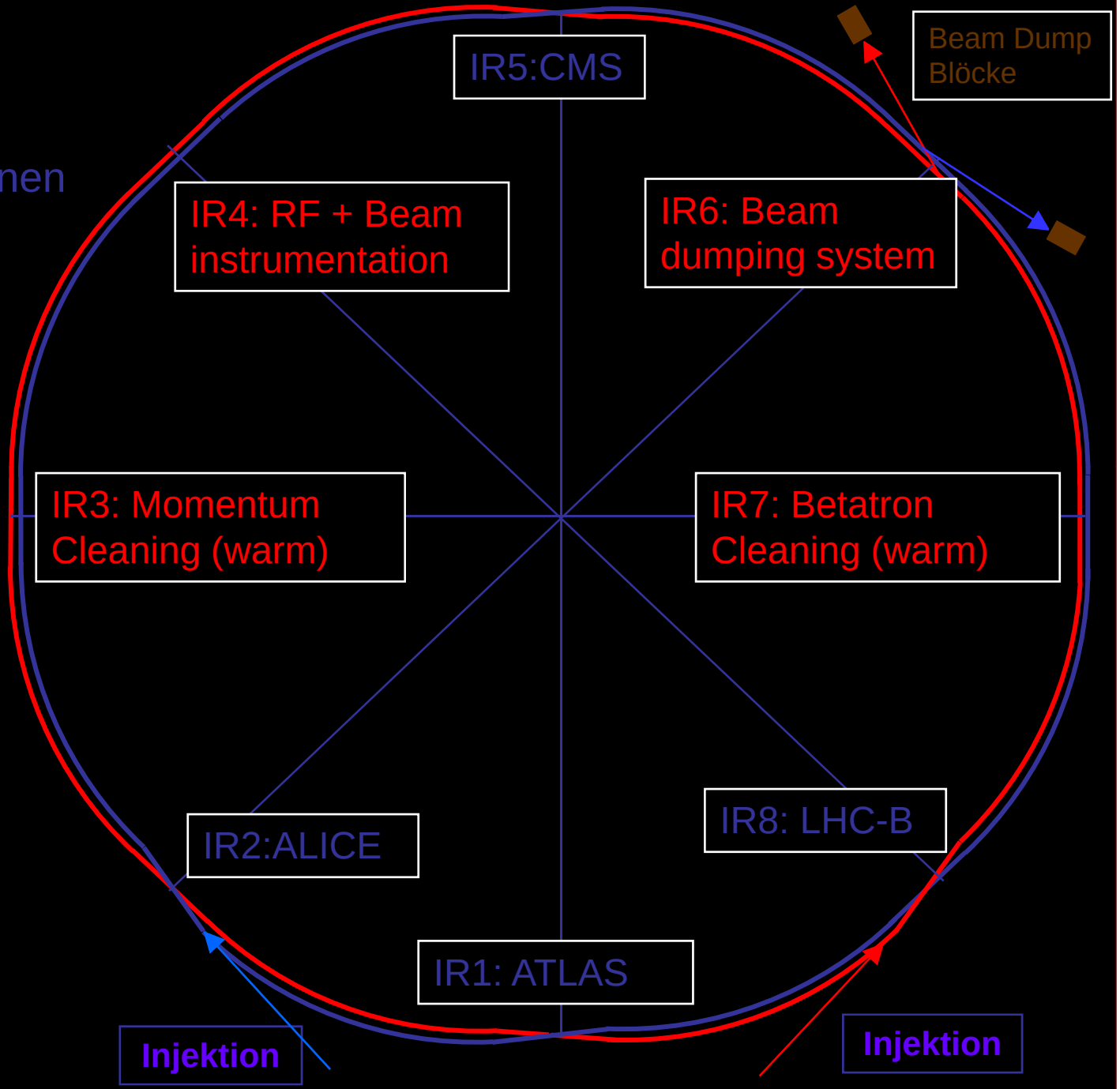
LEP/LHC Tunnel

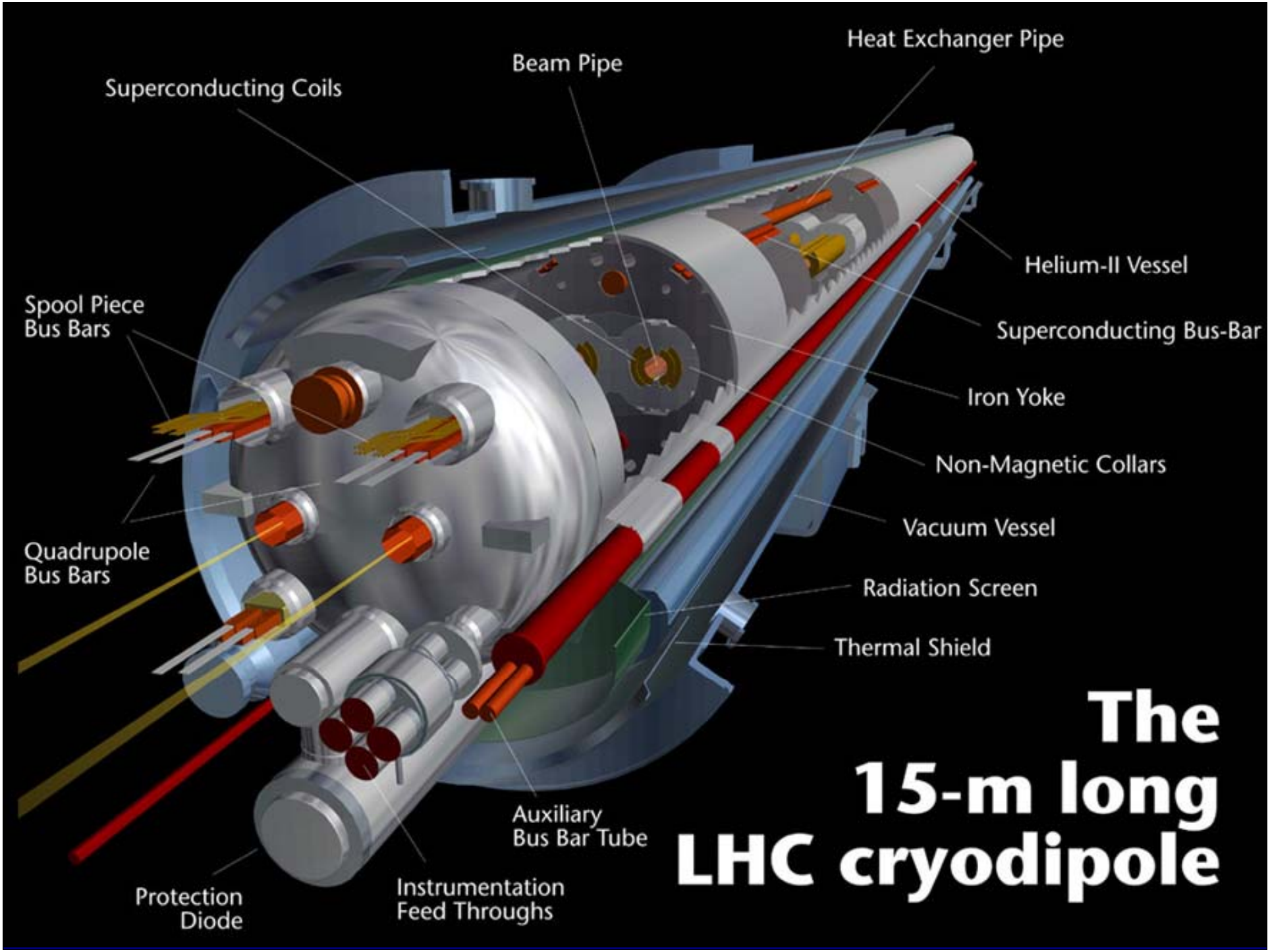


LHC Layout

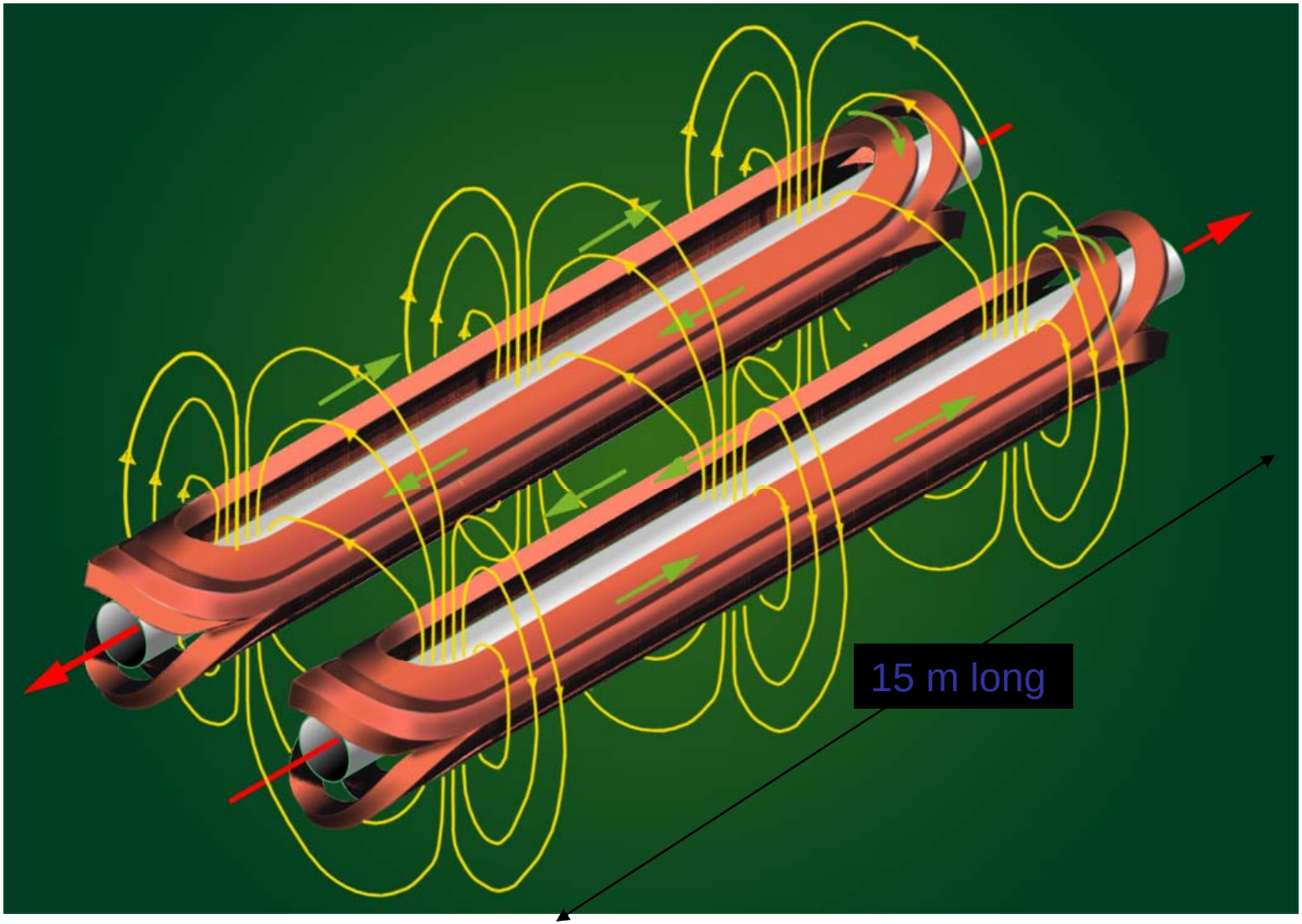
acht Bögen

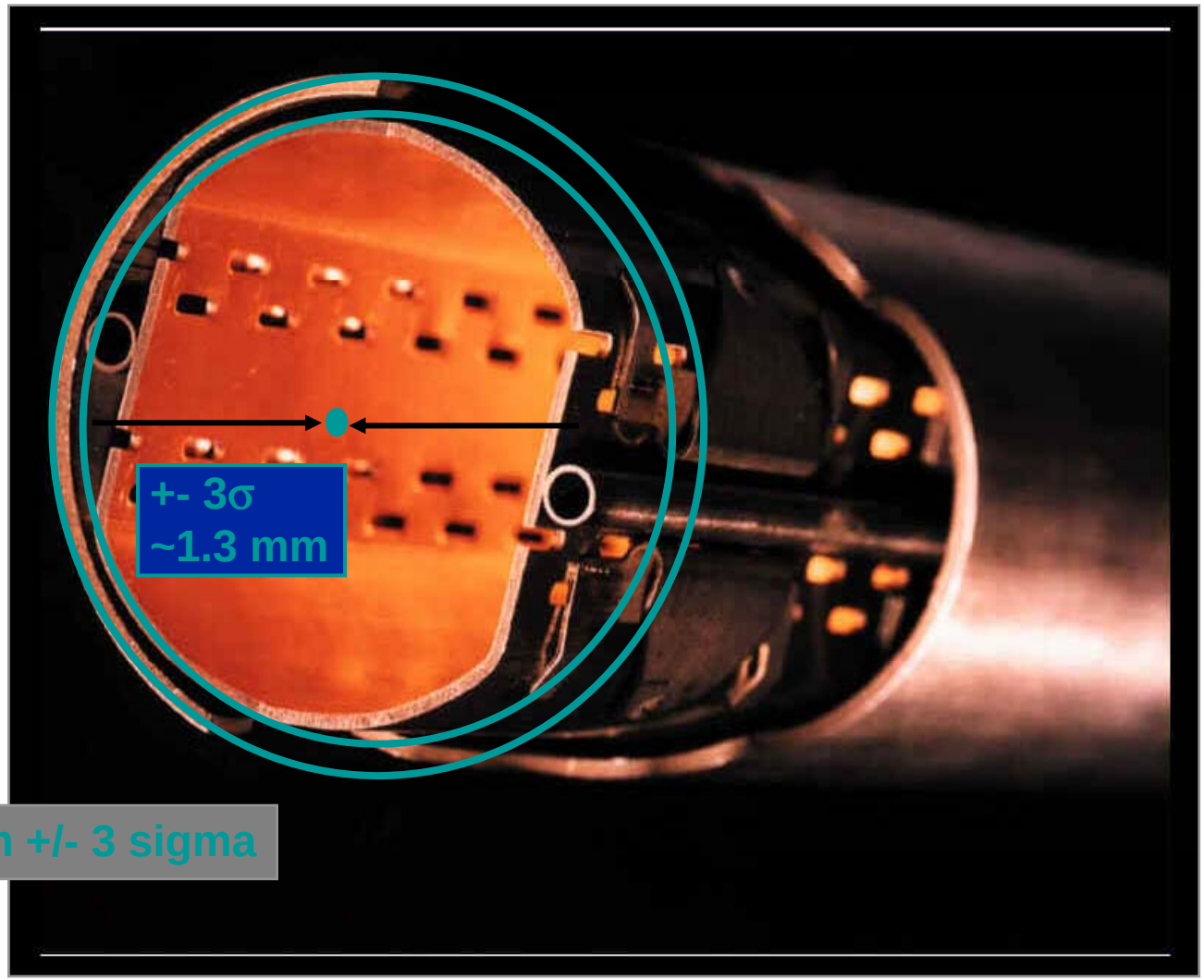
acht gerade Sektionen



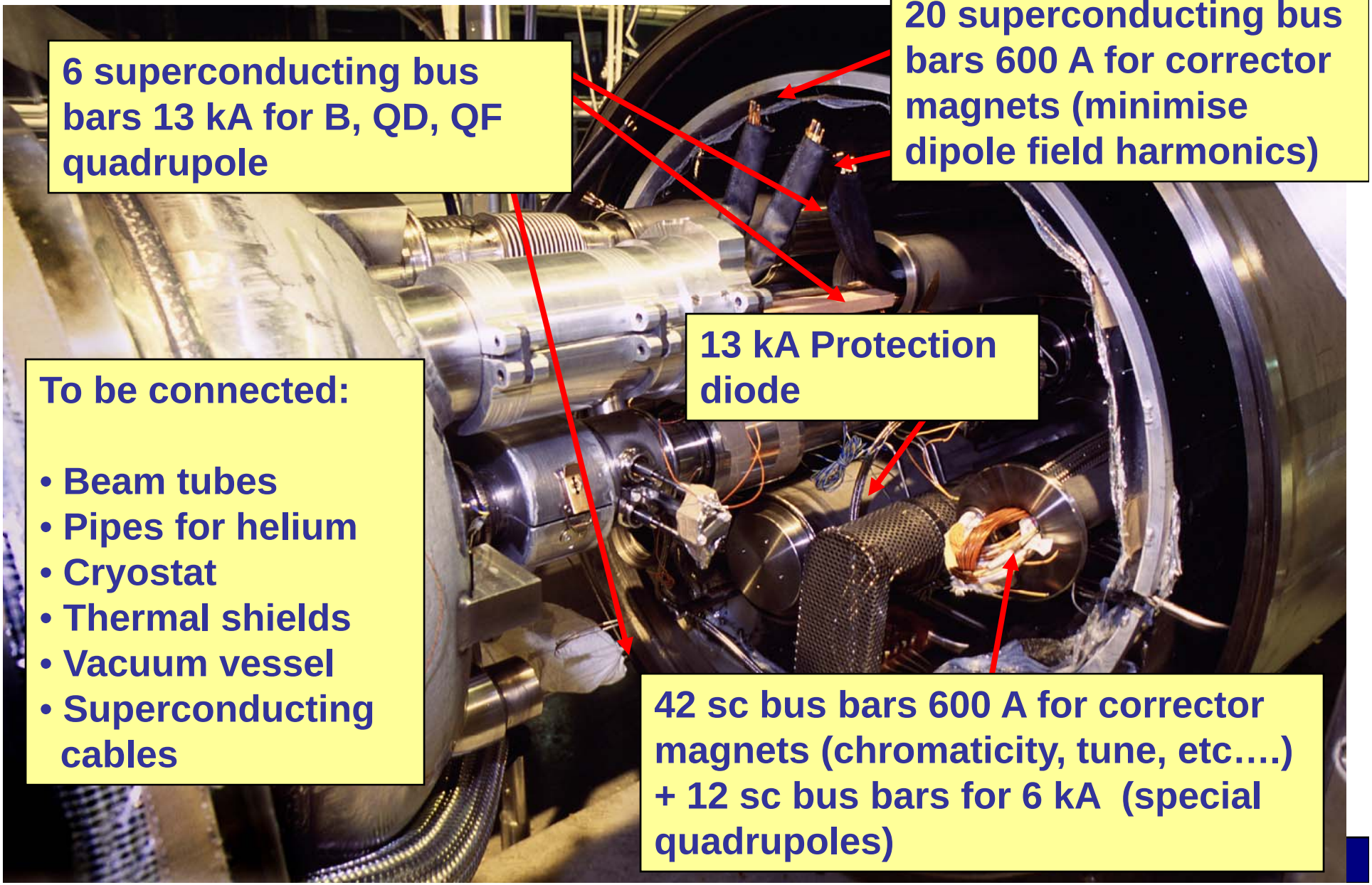

Heat Exchanger Pipe
Beam Pipe
Superconducting Coils
Helium-II Vessel
Spool Piece
Bus Bars
Superconducting Bus-Bar
Iron Yoke
Non-Magnetic Collars
Quadrupole
Bus Bars
Vacuum Vessel
Radiation Screen
Thermal Shield
The
15-m long
LHC cryodipole
Auxiliary
Bus Bar Tube
Protection
Diode
Instrumentation
Feed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

Spulenanordnung in den „Dipolen“




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

Eine von 1800 Verbindungen zwischen supraleitenden Magneten im LHC



6 superconducting bus bars 13 kA for B, QD, QF quadrupole

20 superconducting bus bars 600 A for corrector magnets (minimise dipole field harmonics)

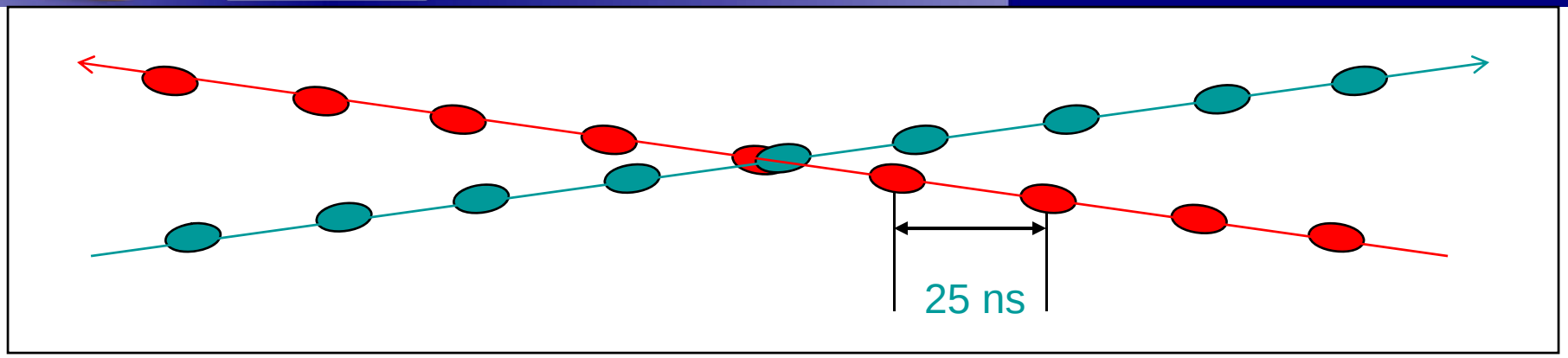
13 kA Protection diode

To be connected:

- **Beam tubes**
- **Pipes for helium**
- **Cryostat**
- **Thermal shields**
- **Vacuum vessel**
- **Superconducting cables**

42 sc bus bars 600 A for corrector magnets (chromaticity, tune, etc….) + 12 sc bus bars for 6 kA (special quadrupoles)

Strahlenergie



Strahlenergie = Protonenenergie • Anzahl der Wolken • Anzahl der Protonen pro Wolke

Protonenenergie: 7 TeV

bei höchster Intensität:

Anzahl der Wolken pro Richtung: 2808

Anzahl der Protonen je Wolke: $1.05 \bullet 10^{11}$

Strahlenergie (pro Richtung): 346 MJoule

Magnetenergie

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

gespeicherte Energie in einem Dipol: 7.6 MJ

Gesamt für alle 1232 Dipole im LHC: 9.4 GJ

10 GJoule……

entsprechen der freiwerdenden Energie von 1900 kg TNT

entsprechen der “Energie” von 400 kg Schokolade

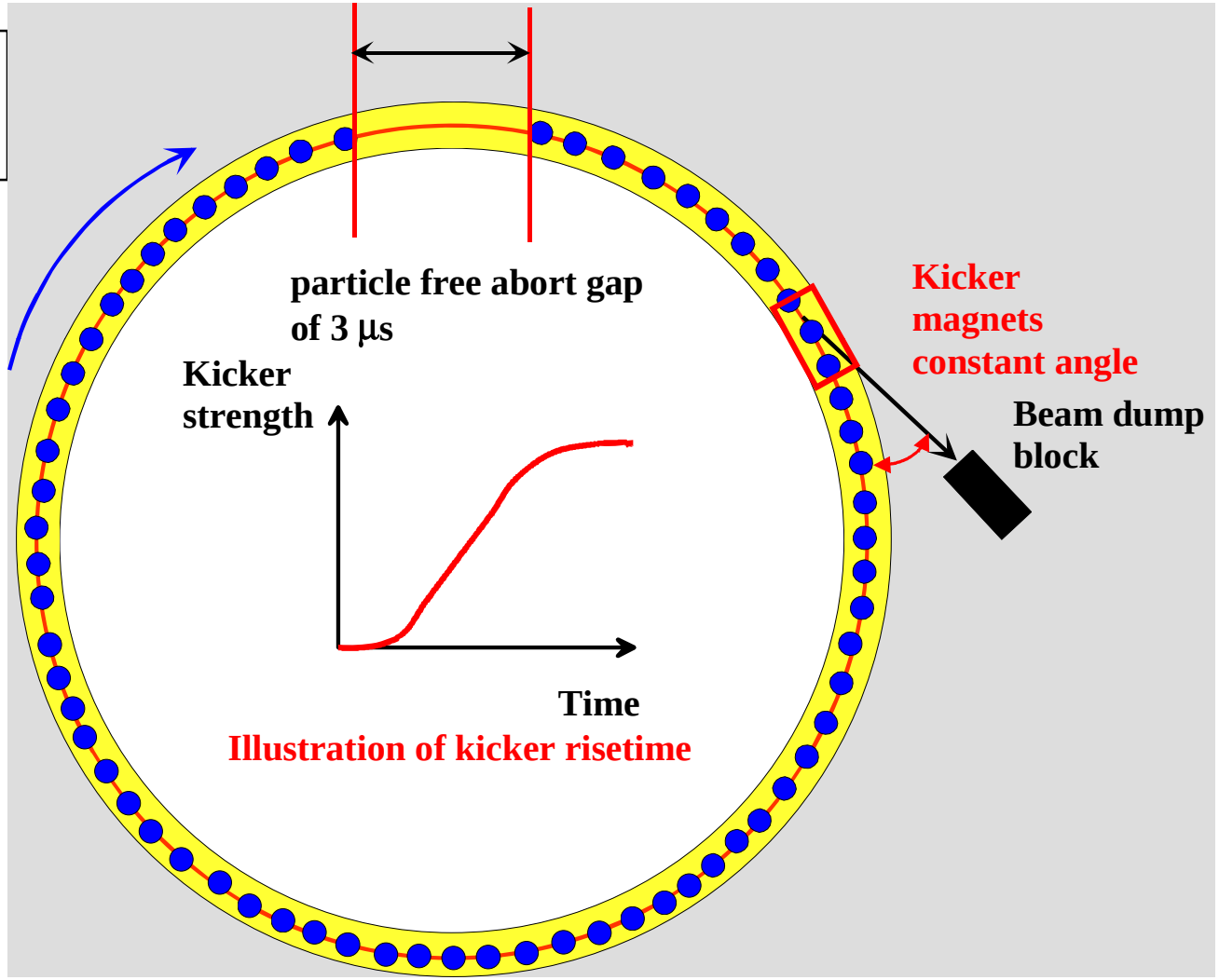
damit kann man 12000 kg Kupfer schmelzen

Kann eine solche Energie eine Einrichtung zerstören?

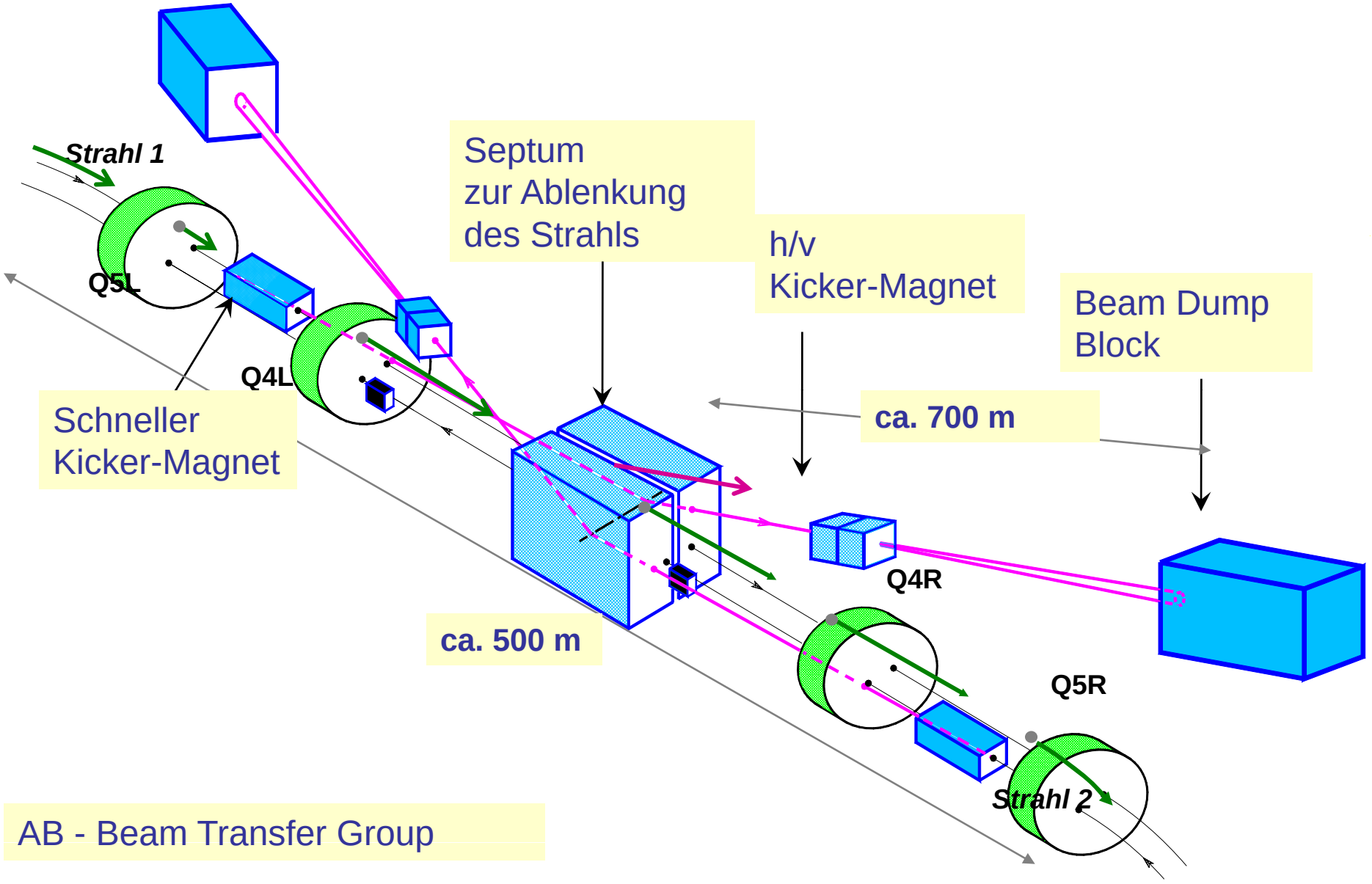
Wie schnell kann man diese Energie ableiten?

Der Beam Dump

Synchronisierung mit der Abbruchlücke

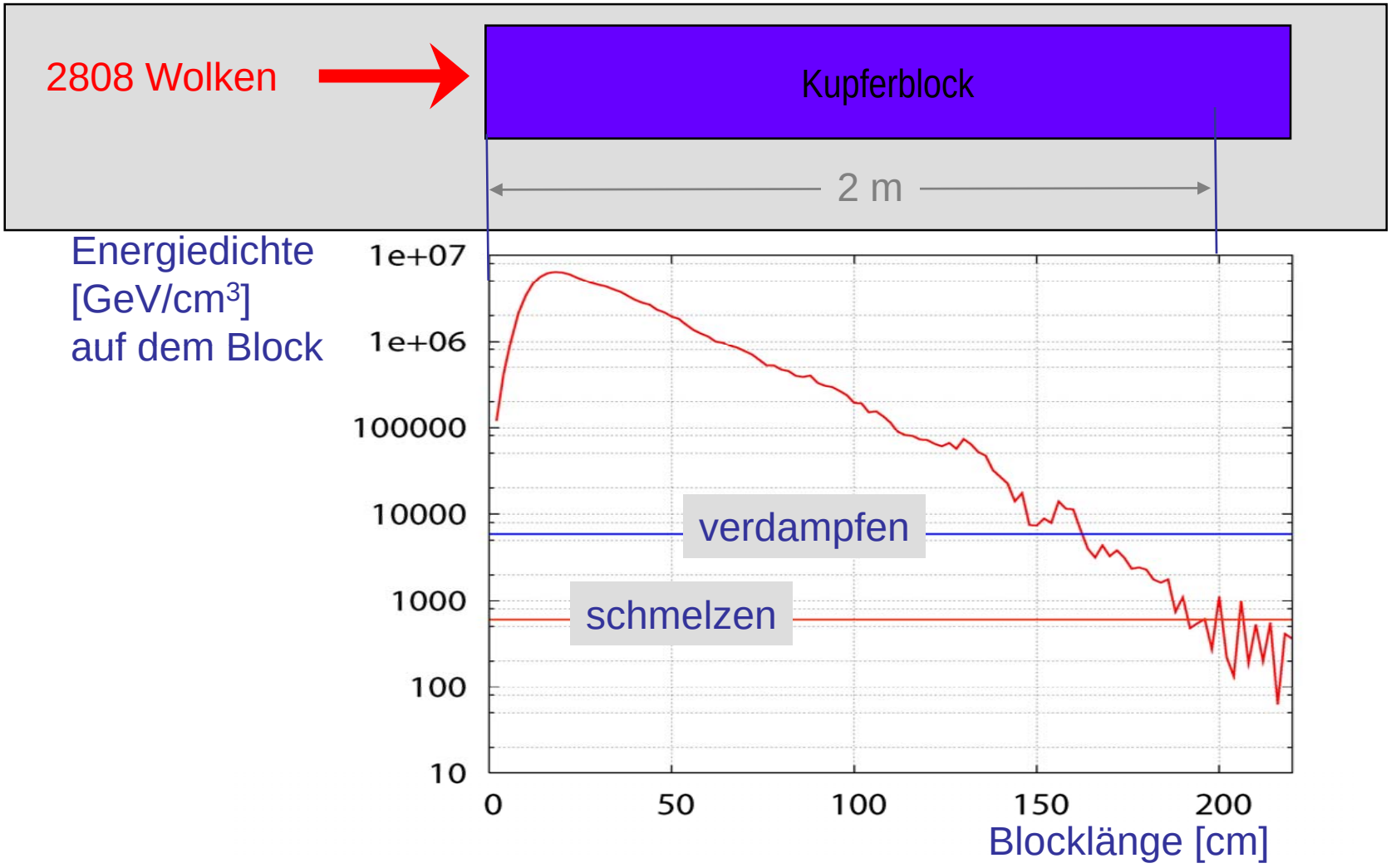


Die Abbruchlücke muß wirklich leer sein


Strahl 1
Septum
zur Ablenkung
des Strahls
h/v
Kicker-Magnet
Beam Dump
Block
Q5L
Q4L
Schneller
Kicker-Magnet
ca. 700 m
Q4R
ca. 500 m
Q5R
Strahl 2
AB - Beam Transfer Group

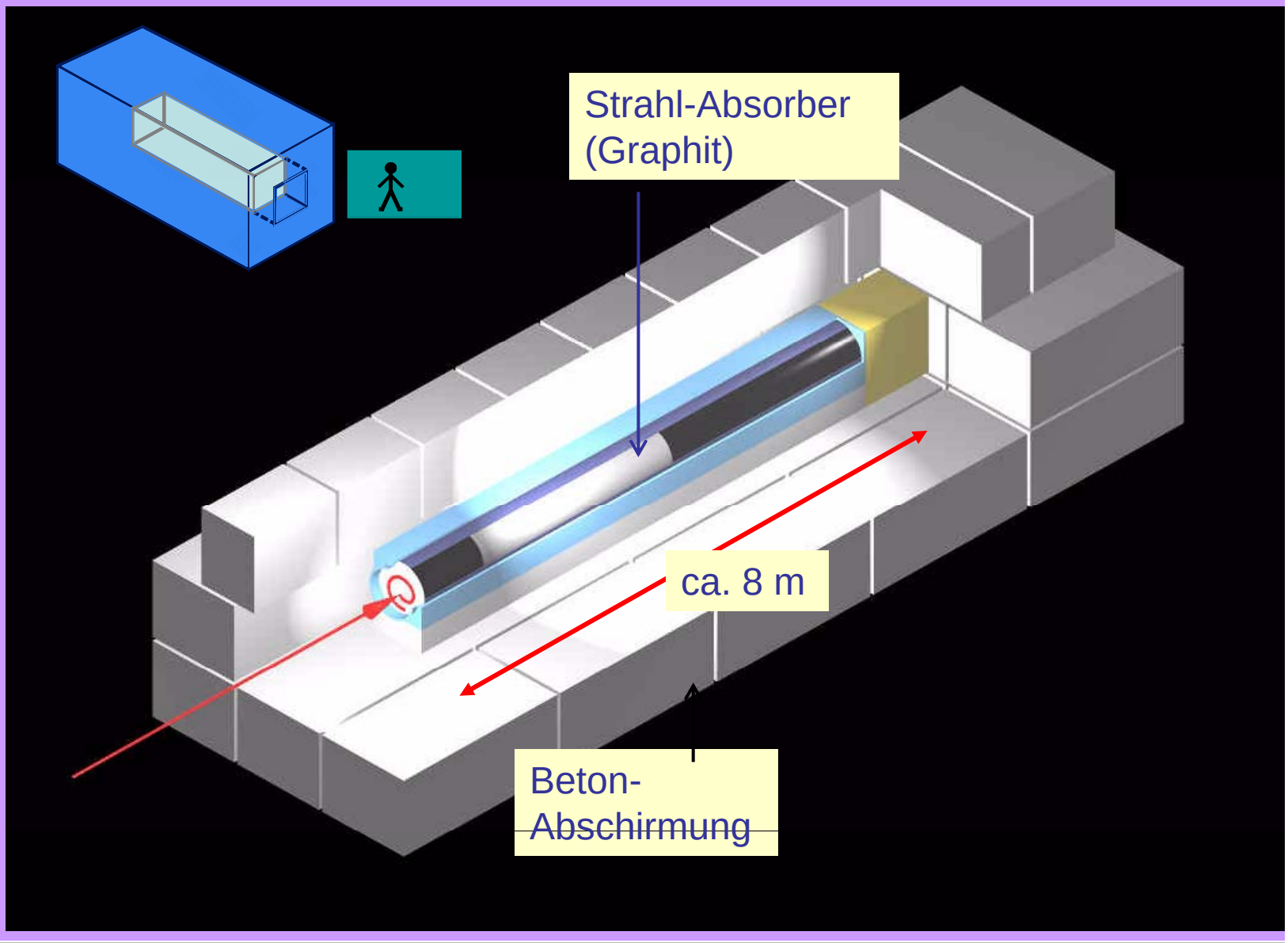

R622
TD62
UJ62
R623

Gesamtstrahl auf einen Kupferblock



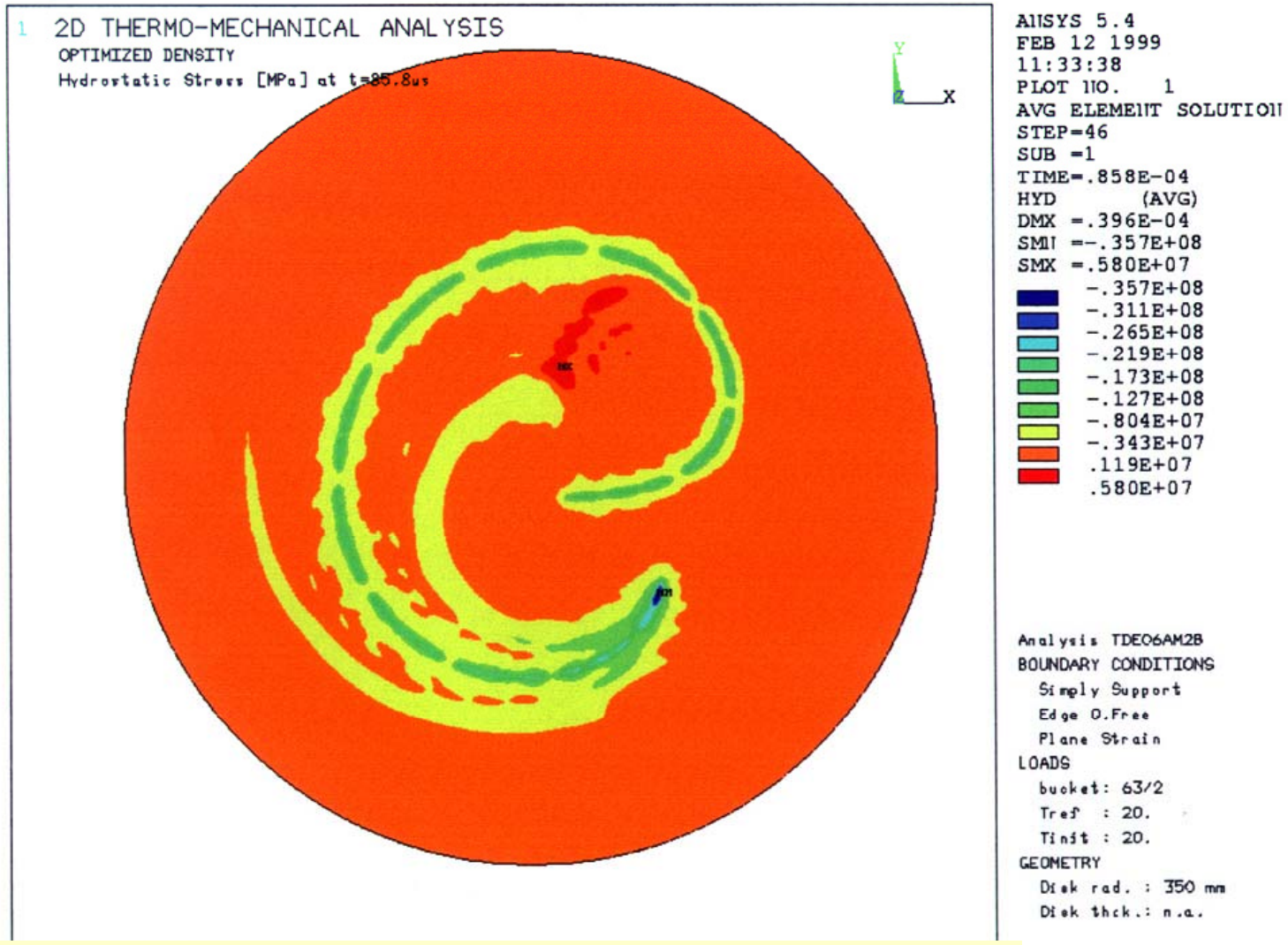
N.Tahir (GSI) et al.

Beam Dump Block - Layout



L.Bruno

Hydrostatischer Druck



L.Bruno: Thermo-Mechanical Analysis with ANSYS

Energieableitung – Magnete

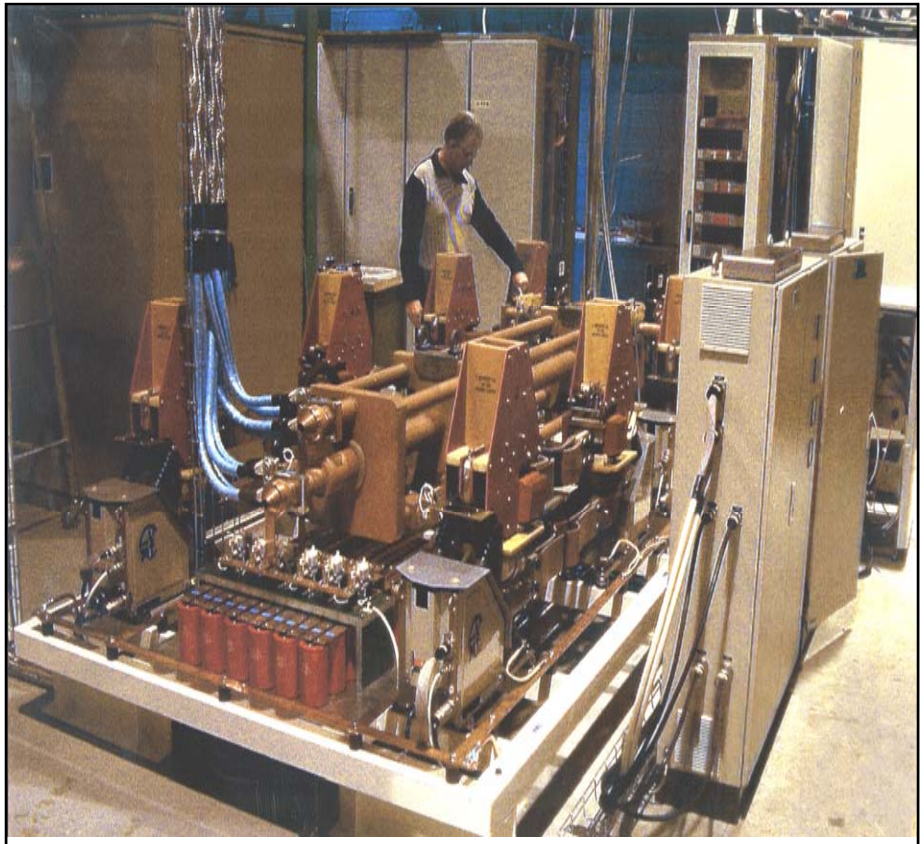
Energie in allen Dipolen: 10 GJoule

… pro Sektor: 1.3 GJoule

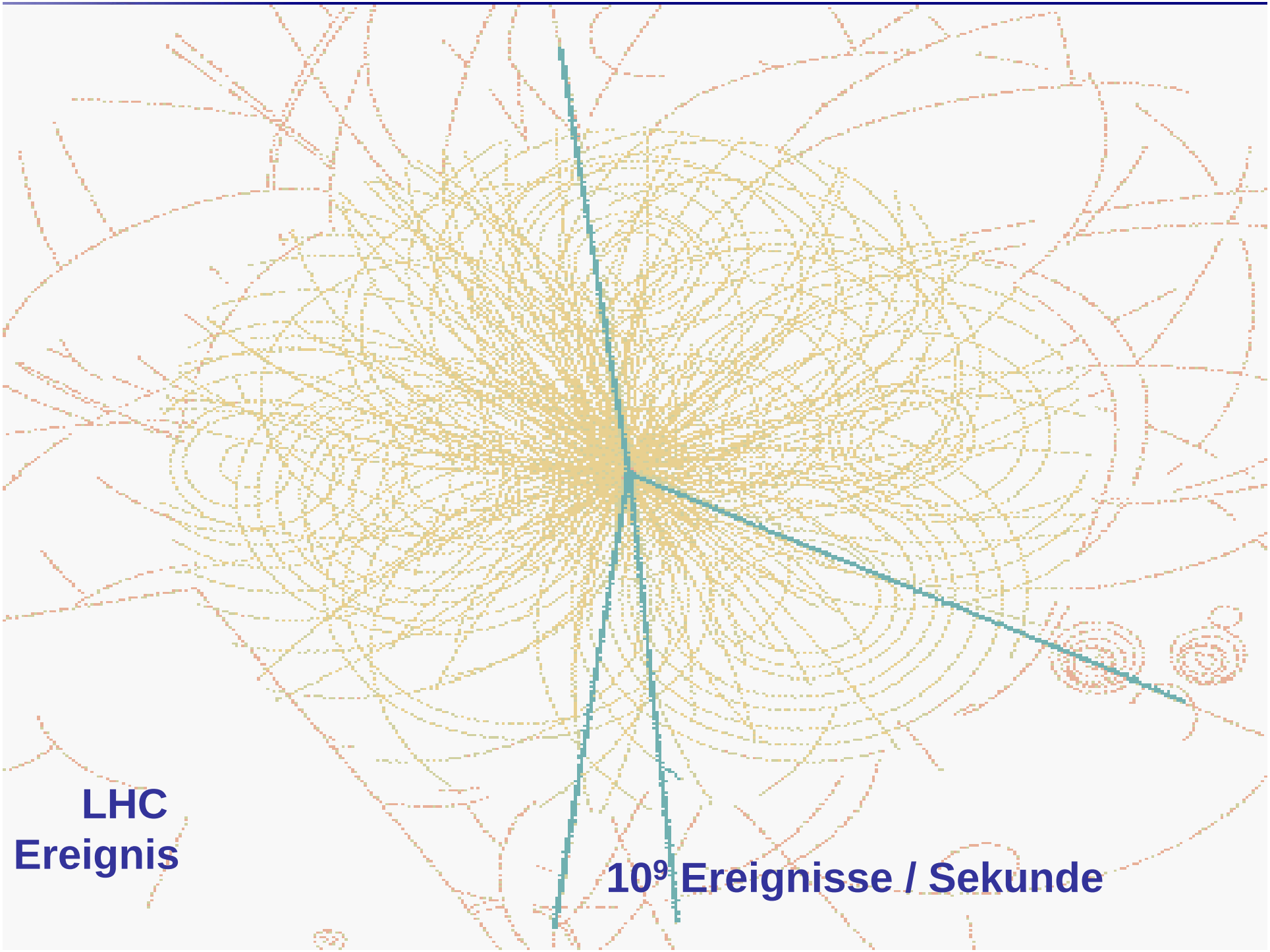
Unkontrollierte Energieableitung wird verhindert durch

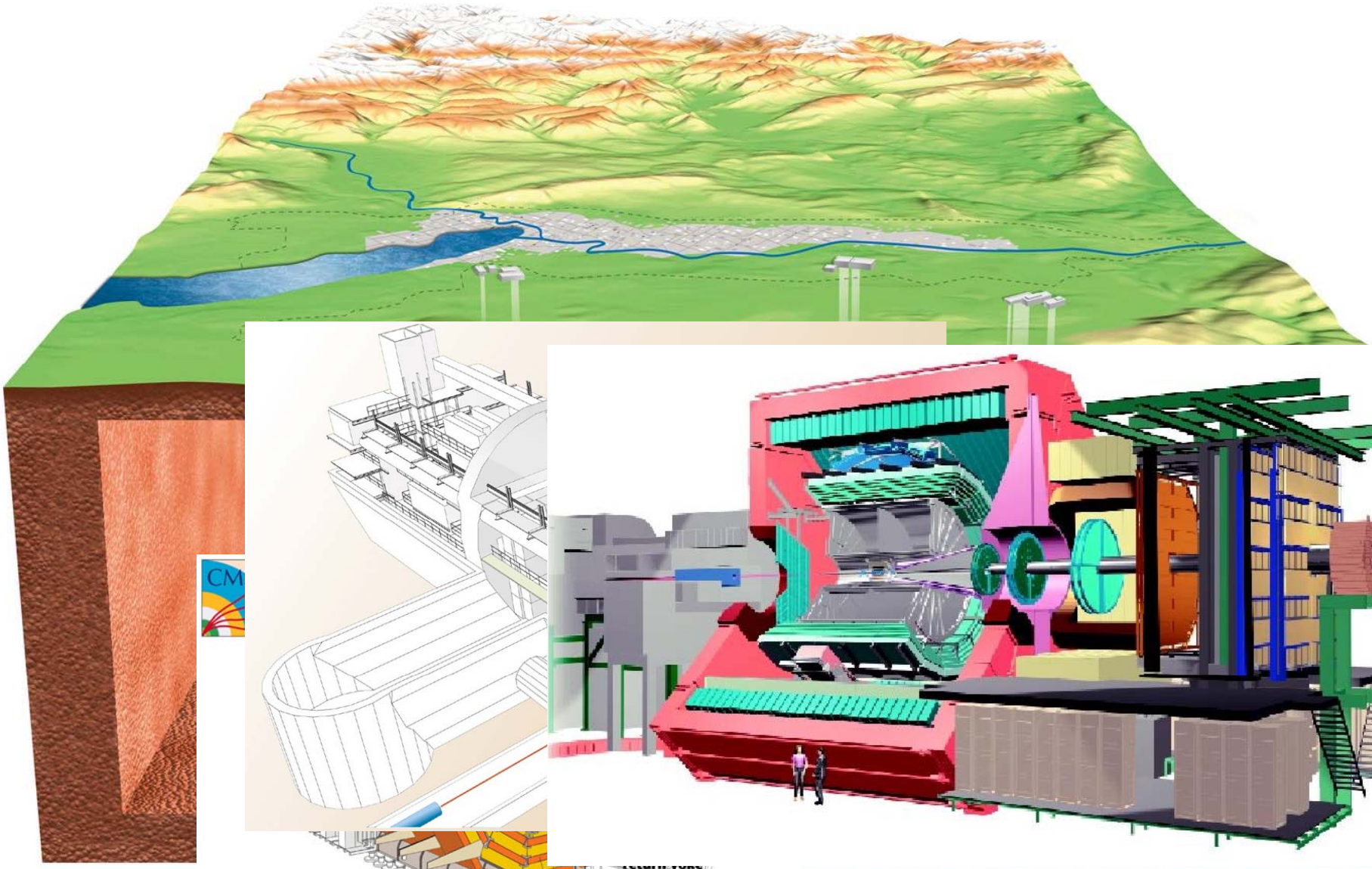
Strom-um-leitung durch Bypass-Dioden

Energie wird durch einen Schalter auf eine Widerstandsbank geleitet, die sich auf 300 ºC aufheizt



13 kA Schalter aus Protvino, Russia

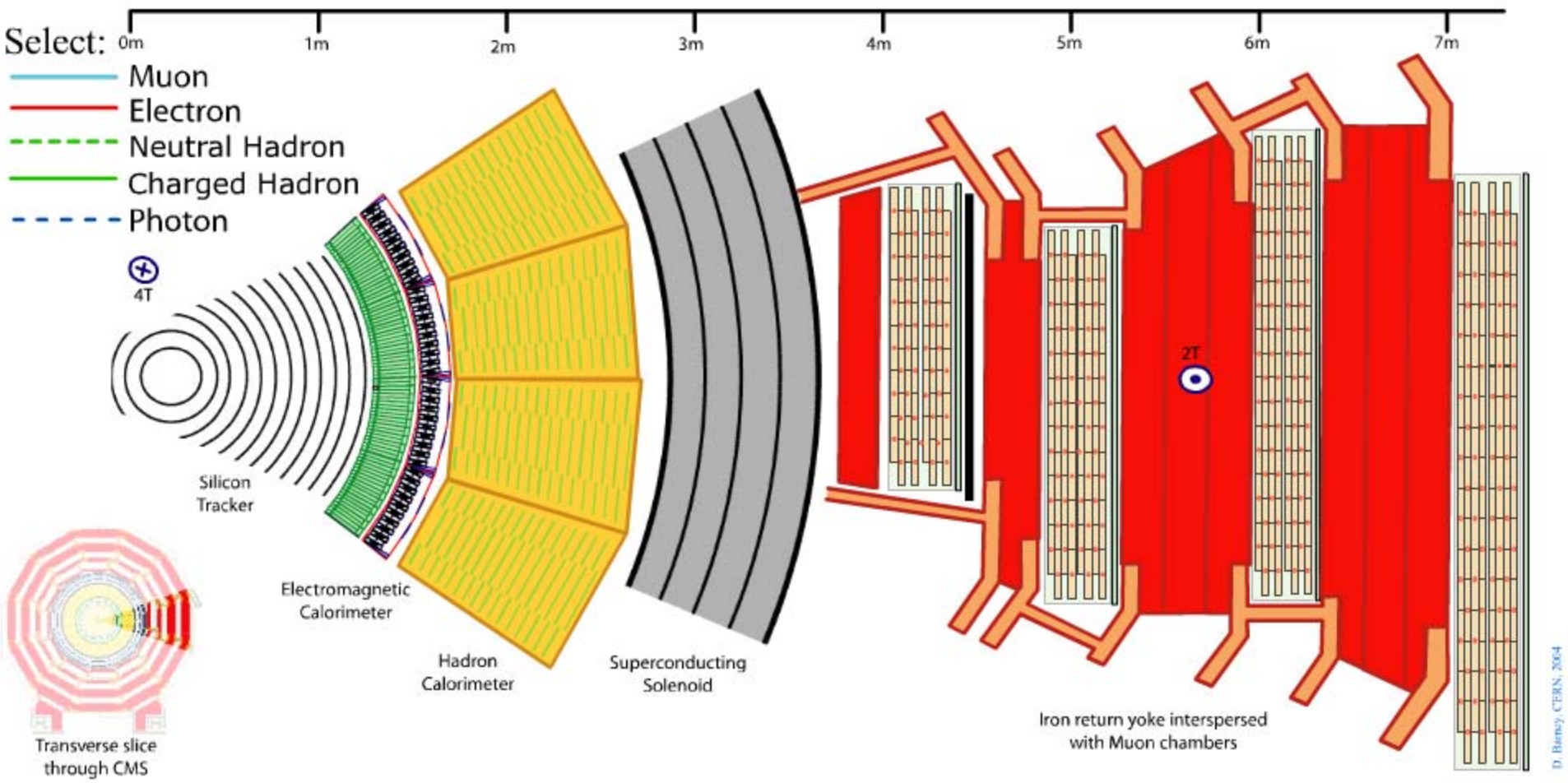

LHC
Ereignis
10^9 Ereignisse / Sekunde



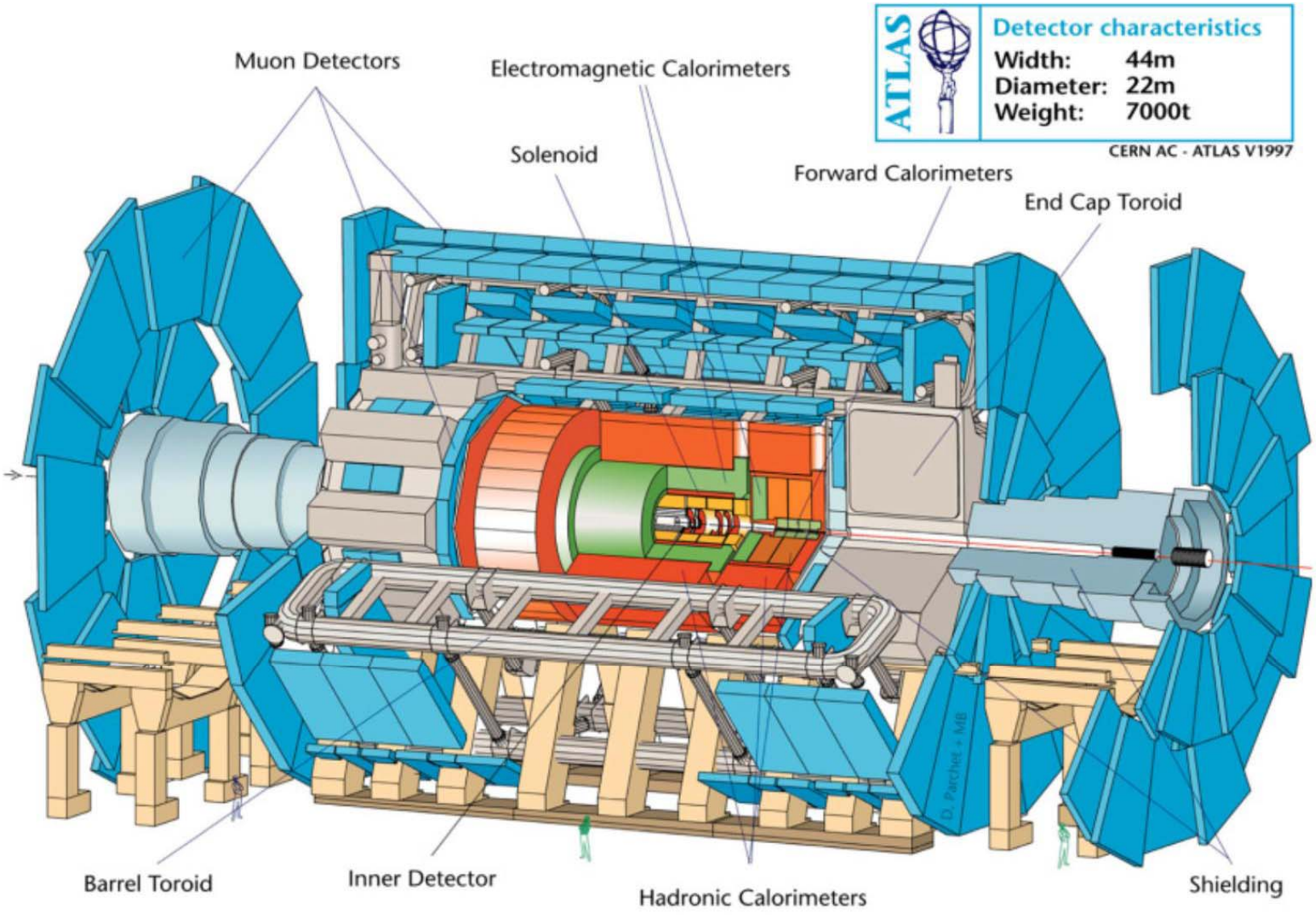
Detector characteristics

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

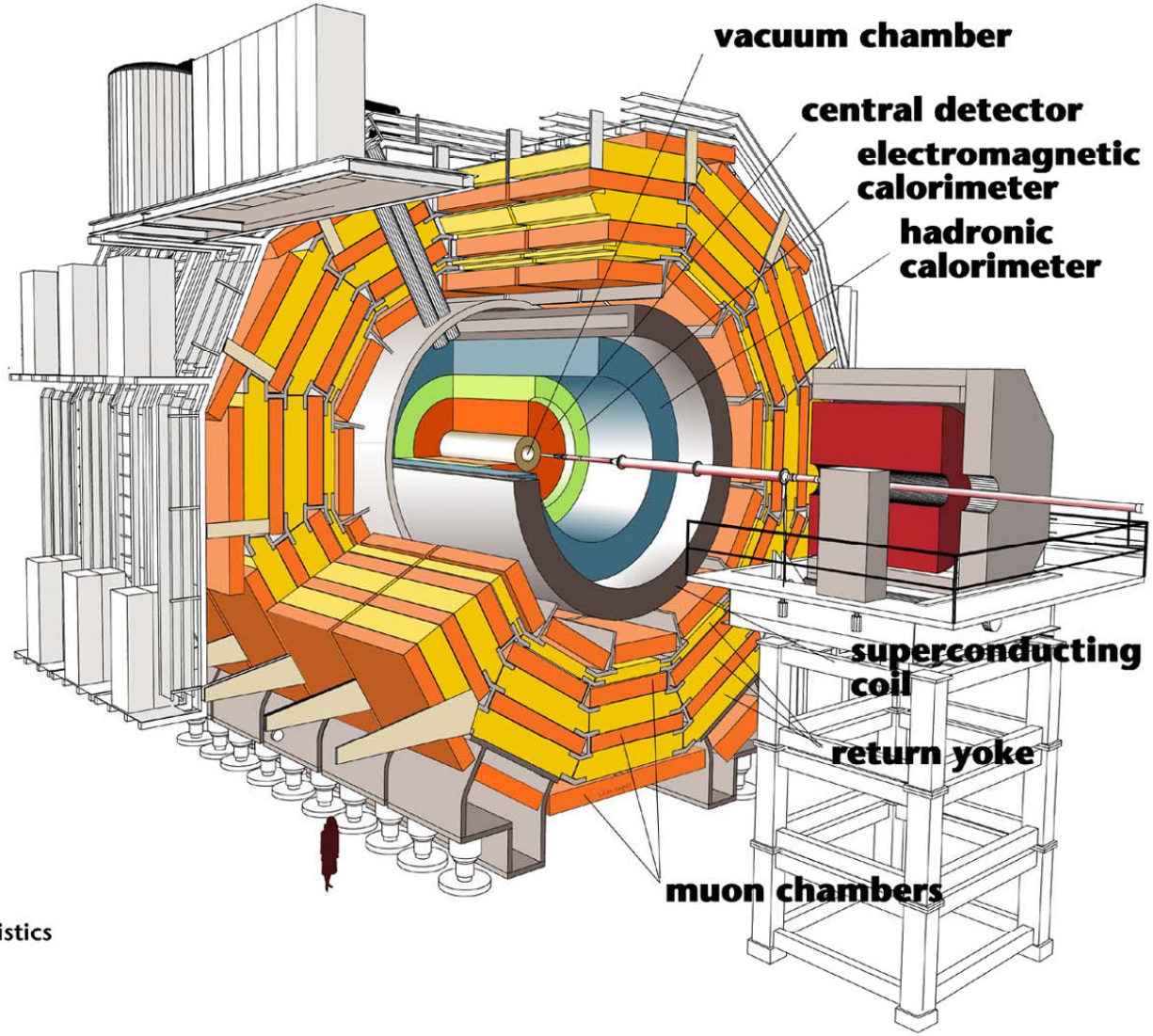
CMS Event


Select:
Muon
Electron
Neutral Hadron
Charged Hadron
Photon
0m
1m
2m
3m
4m
5m
6m
7m
4T
2T
Silicon Tracker
Electromagnetic Calorimeter
Hadron Calorimeter
Superconducting Solenoid
Iron return yoke interspersed with Muon chambers
Transverse slice through CMS
D. Barney, CERN, 2004

ATLAS Experiment



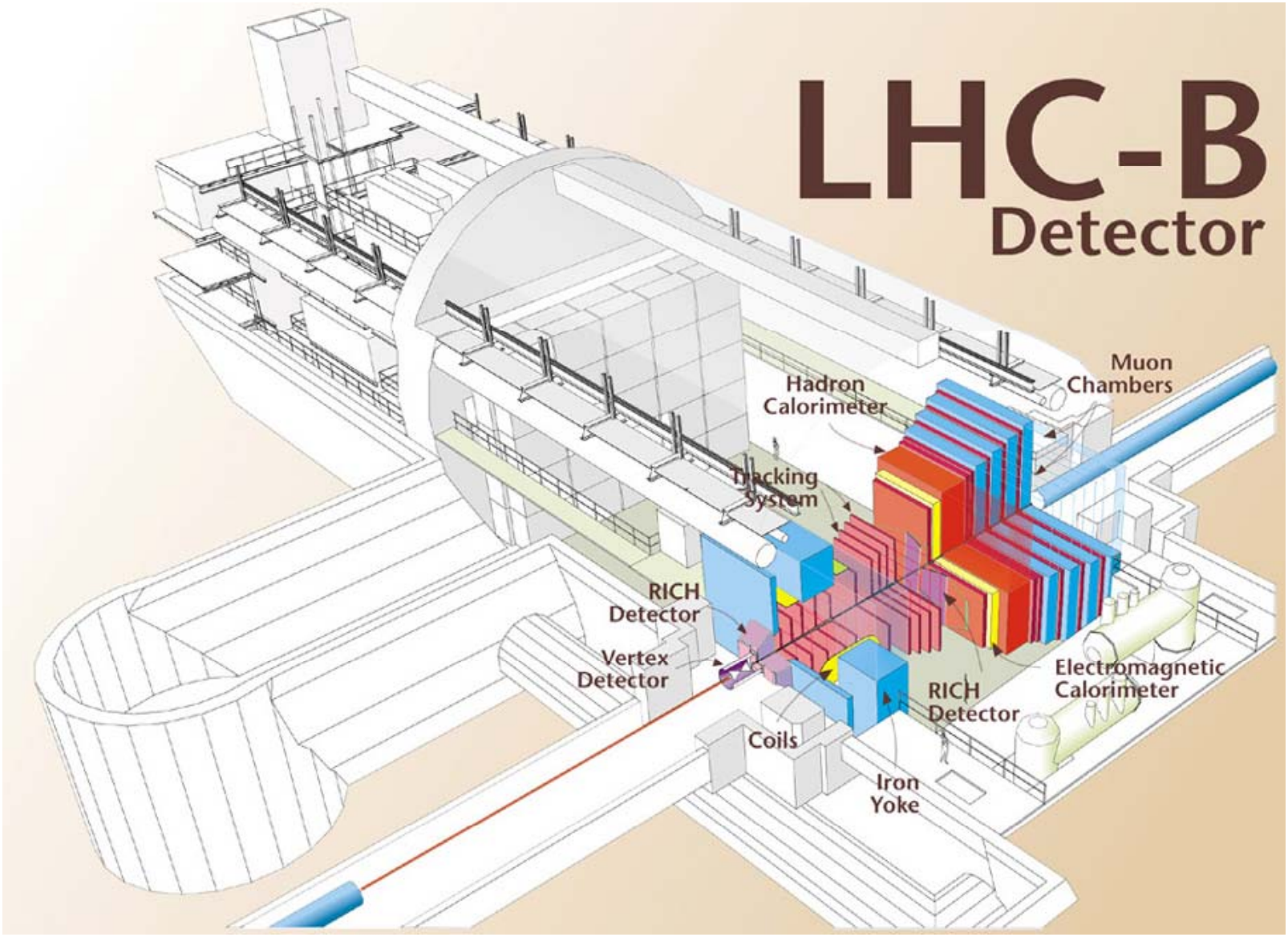
CMS Experiment



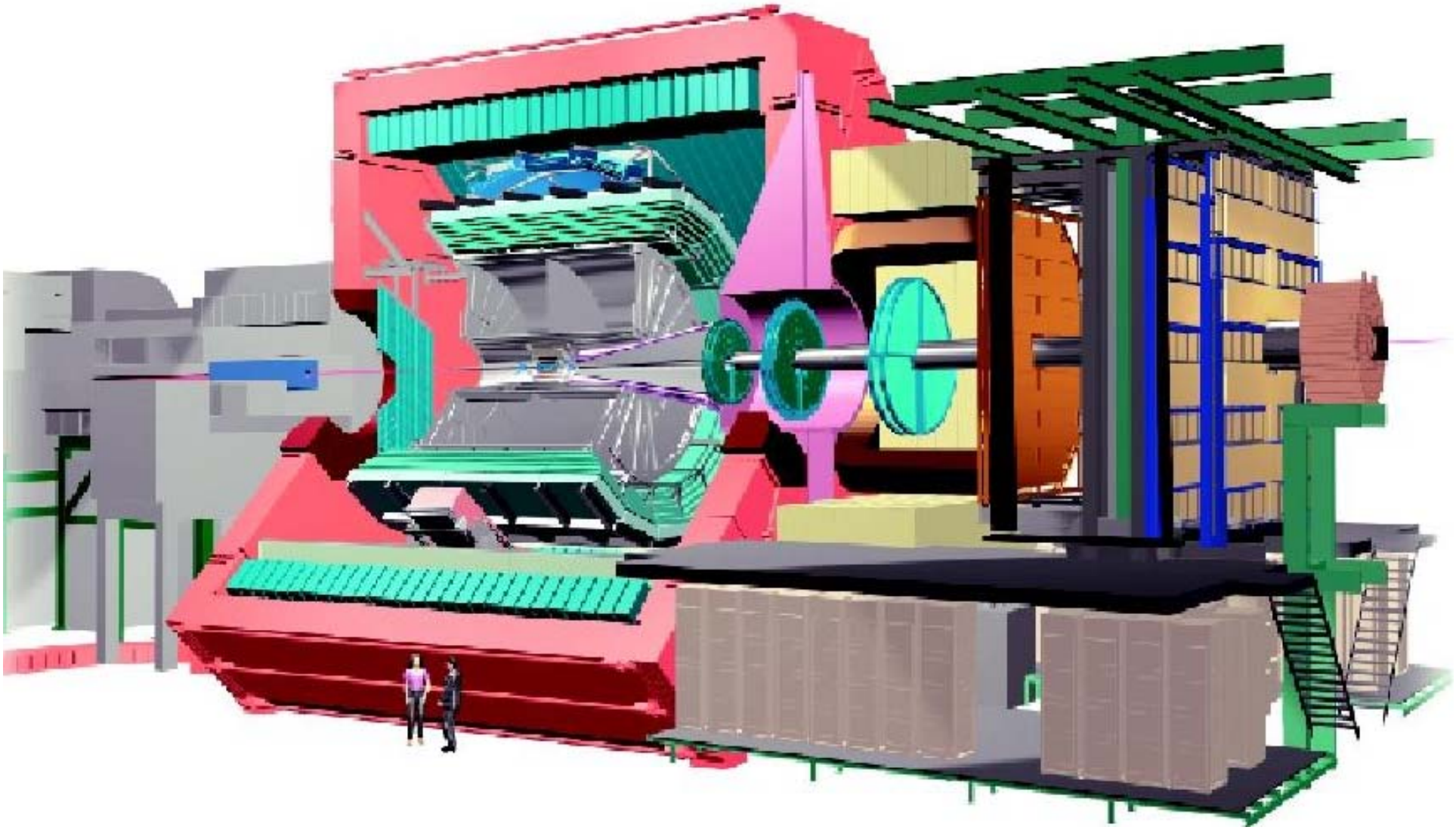
Detector characteristics

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

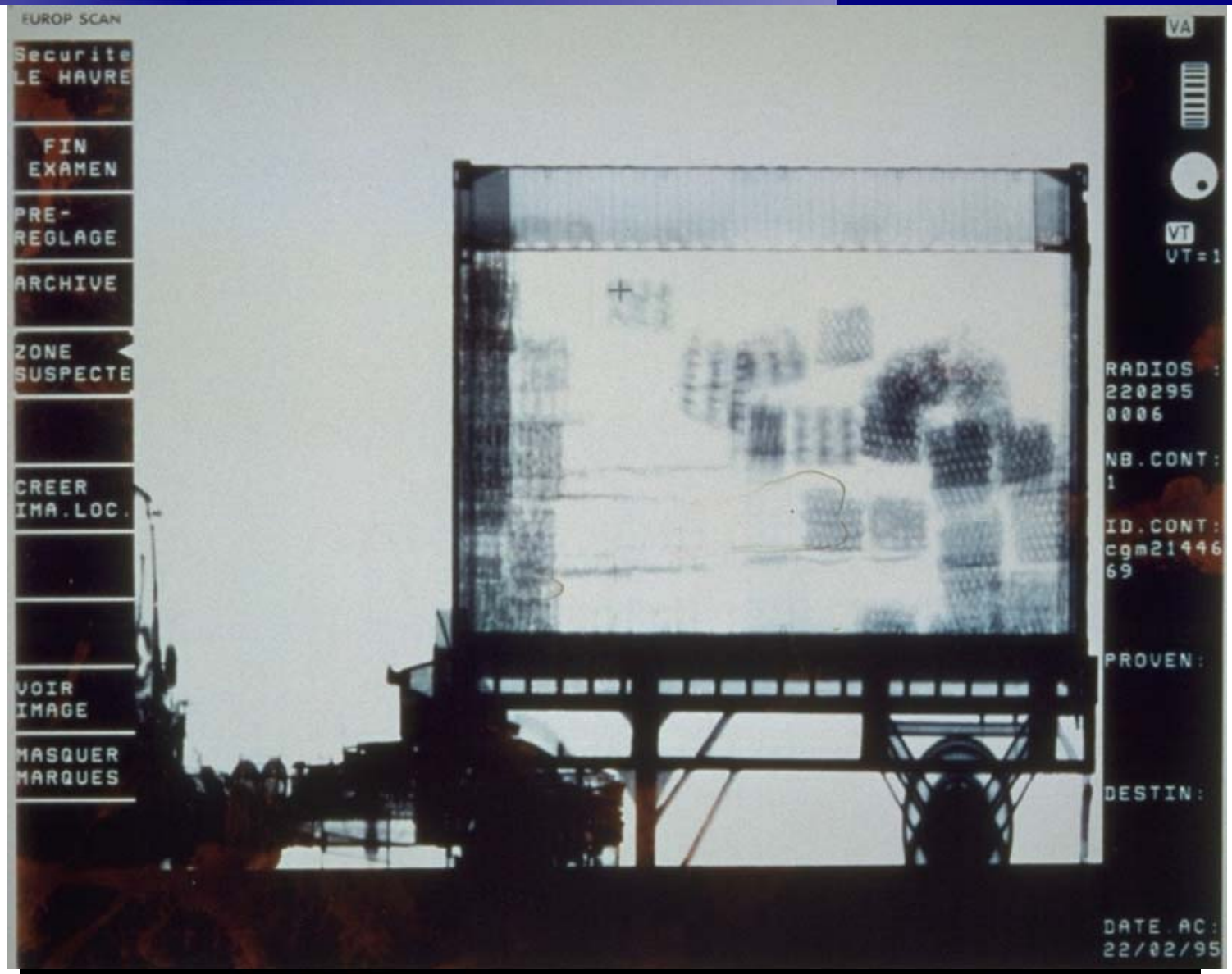
LHCb Experiment



ALICE Experiment



Spin-Offs


EUROP SCAN
Securite
LE HAVRE
FIN
EXAMEN
PRE-
REGLAGE
ARCHIVE
ZONE
SUSPECTE
CREER
IMA.LOC.
VOIR
IMAGE
MASQUER
MARQUES
VA
VT
VT=1
RADIOS :
220295
0006
NB.CONT:
1
ID.CONT:
cgm21446
69
PROVEN:
DESTIN:
DATE.AC:
22/02/95

Fragen ?