

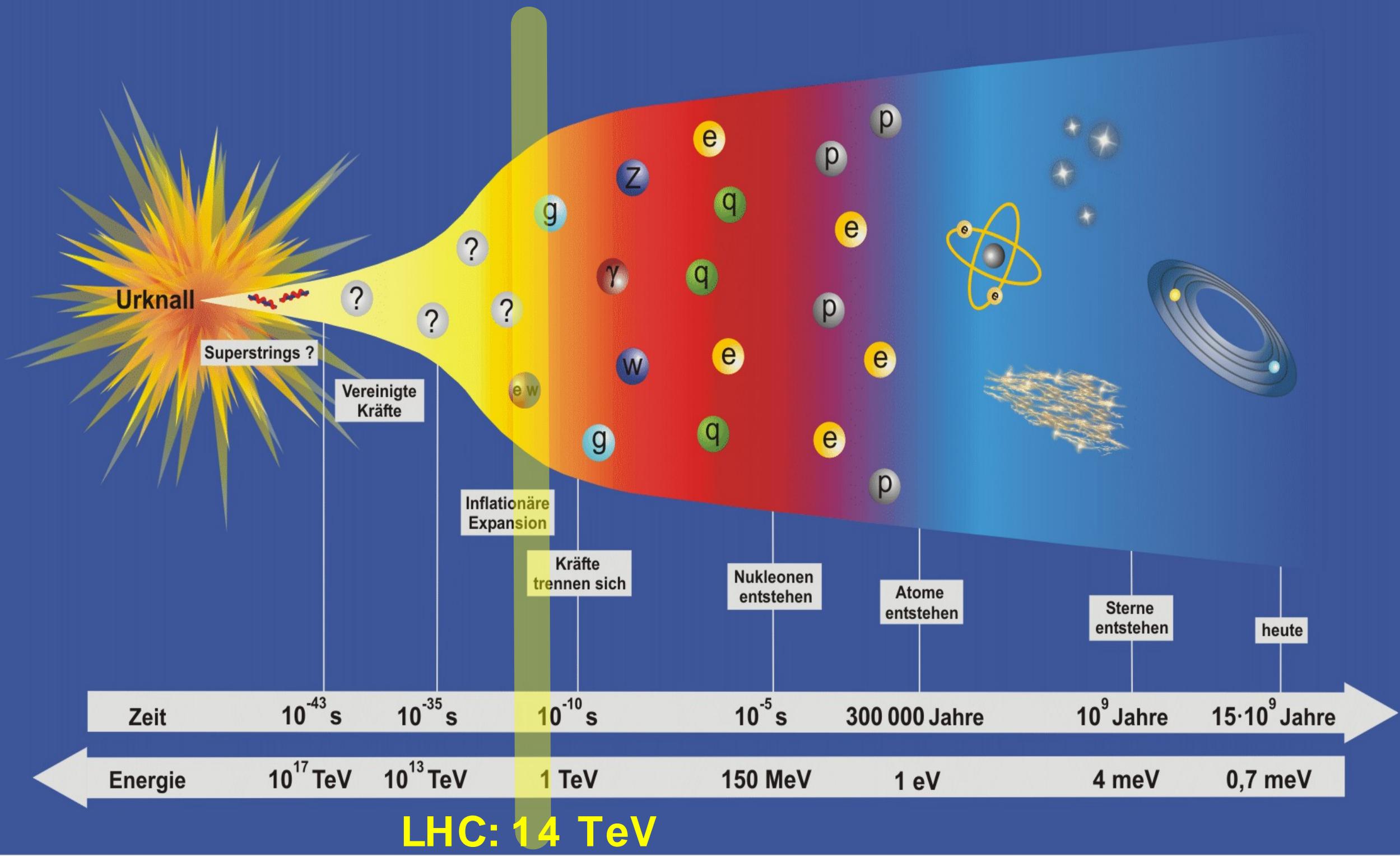
LHC und der Urknall im Labor

Über das größte Physikexperiment der Menschheit

Prof. Dr. O.Biebel

LMU München

08.Okt.2010



LHC: 14 TeV

Temperatur

160 Mio Mrd°C

1700 Mrd°C

11000°C

-226°C

-270°C



Genfer
See

GMS

Jura

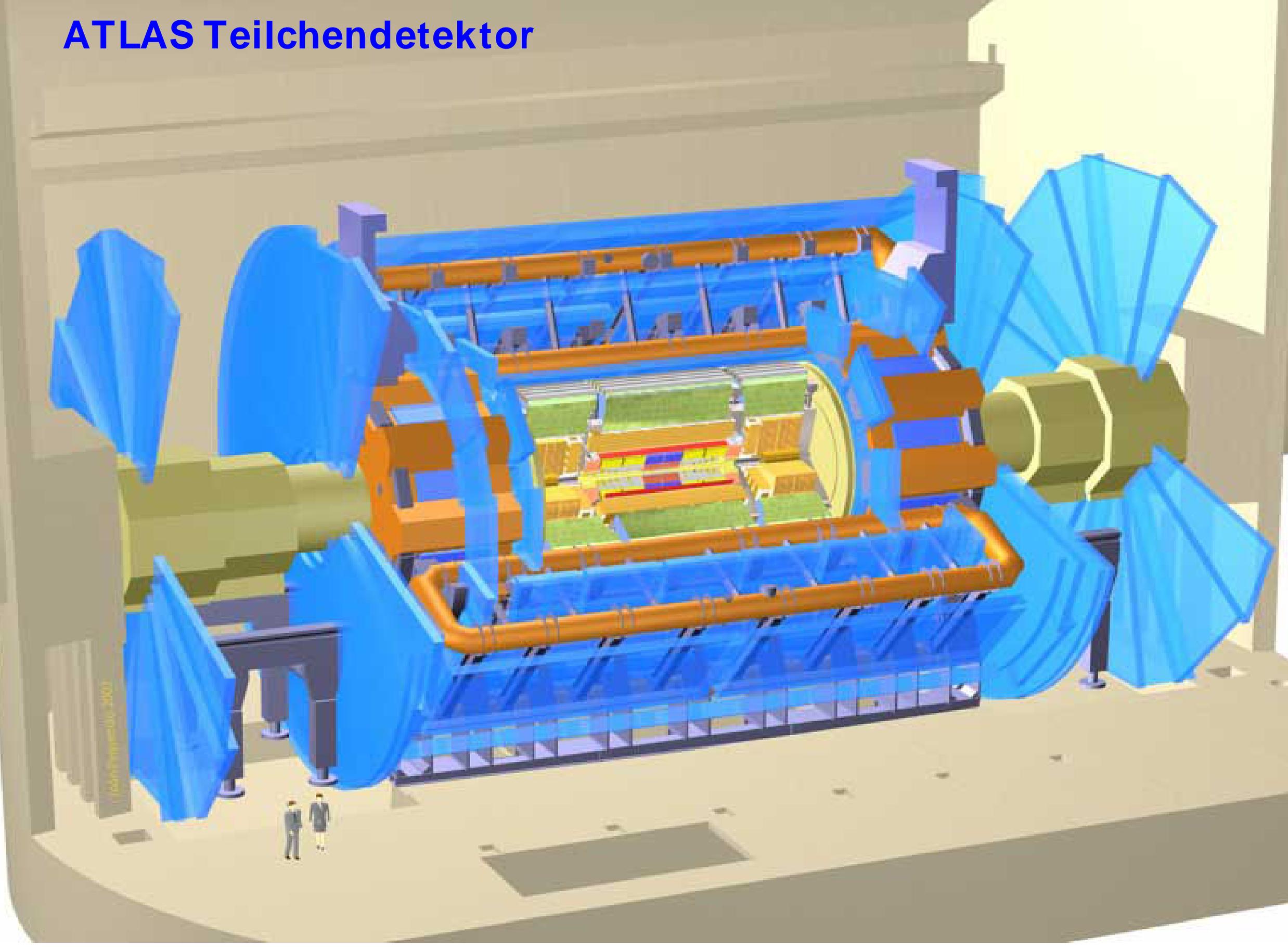
LHC

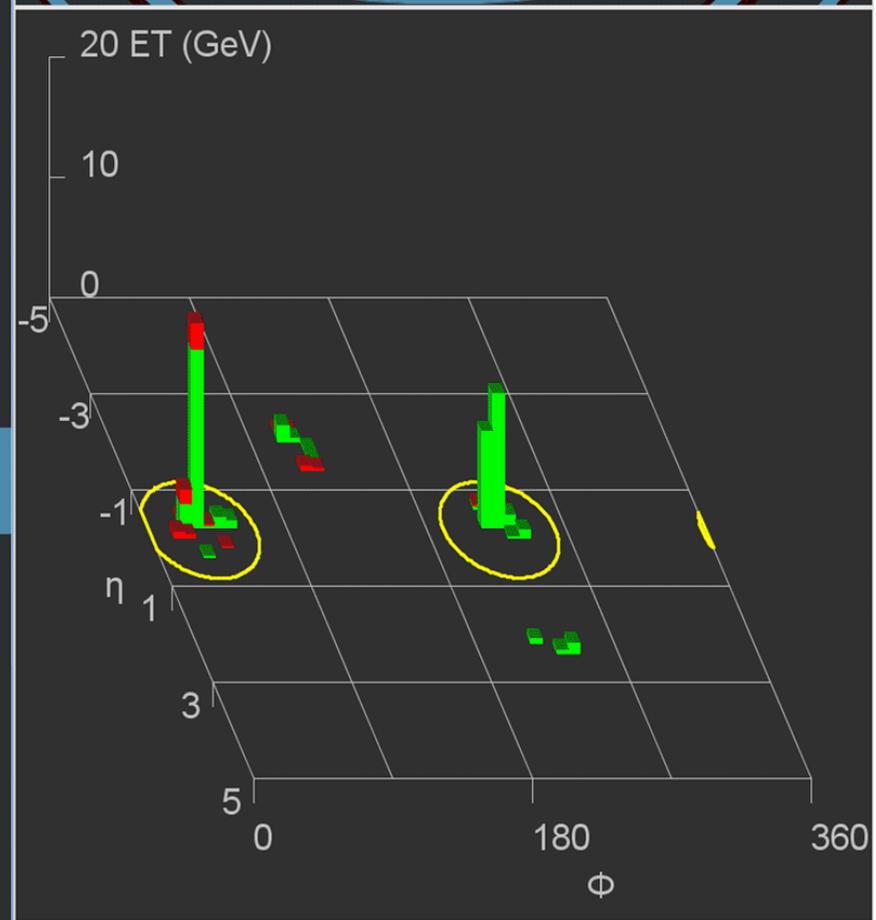
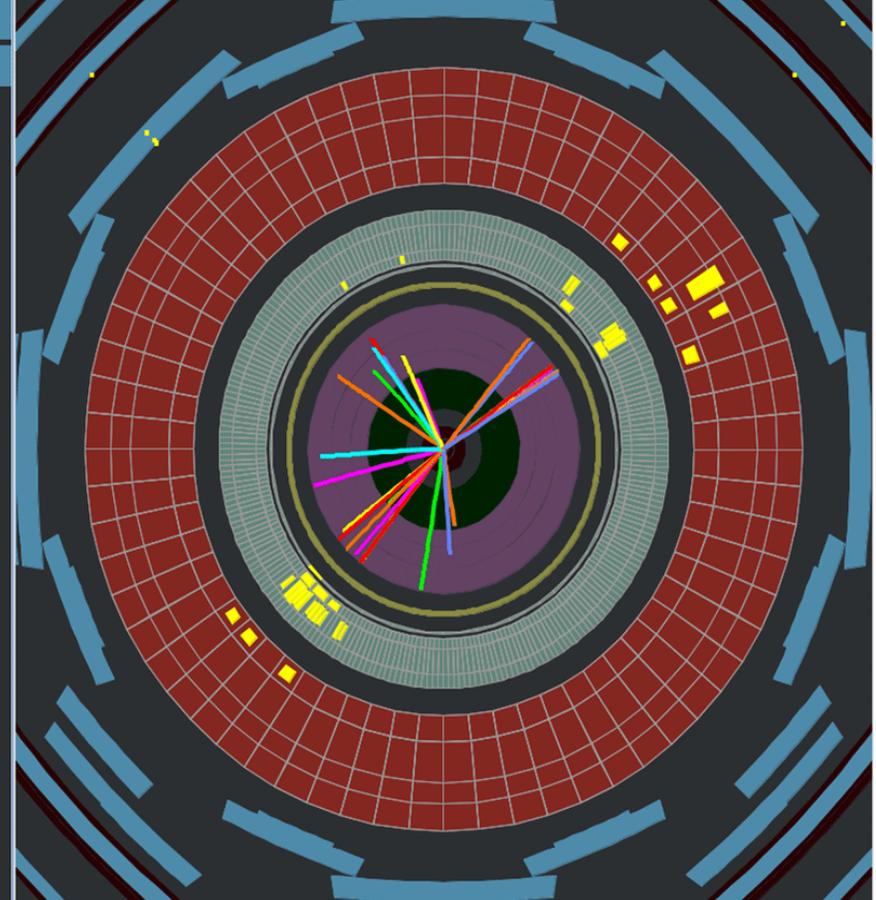
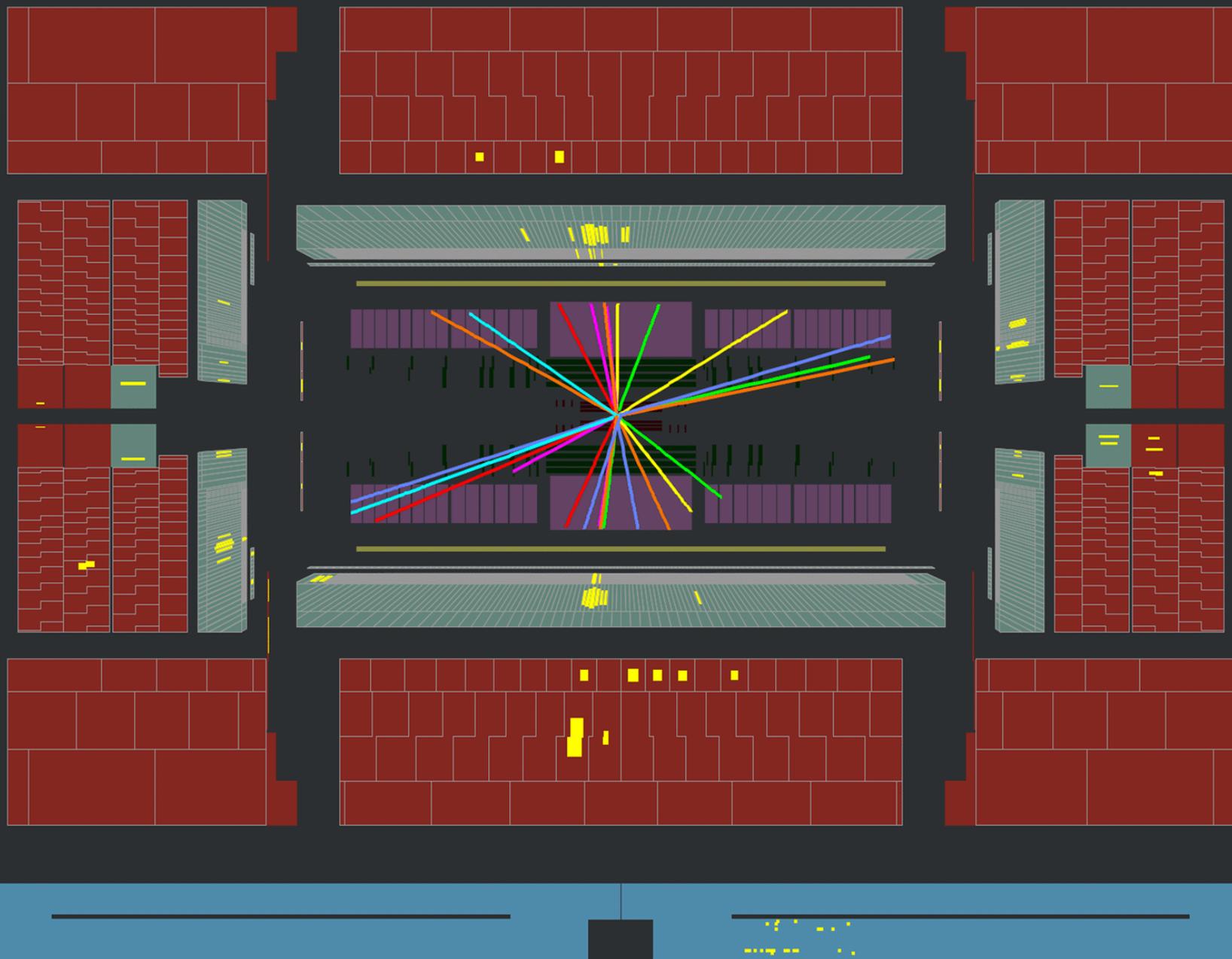
SPS

ATLAS

CERN

ATLAS Teilchendetektor





 **ATLAS**
EXPERIMENT

2009-12-08, 03:45 CET
Run 141994, Event 566308

Collision Event
with 2 Jets

Struktur der Materie

Kristall

Molekül

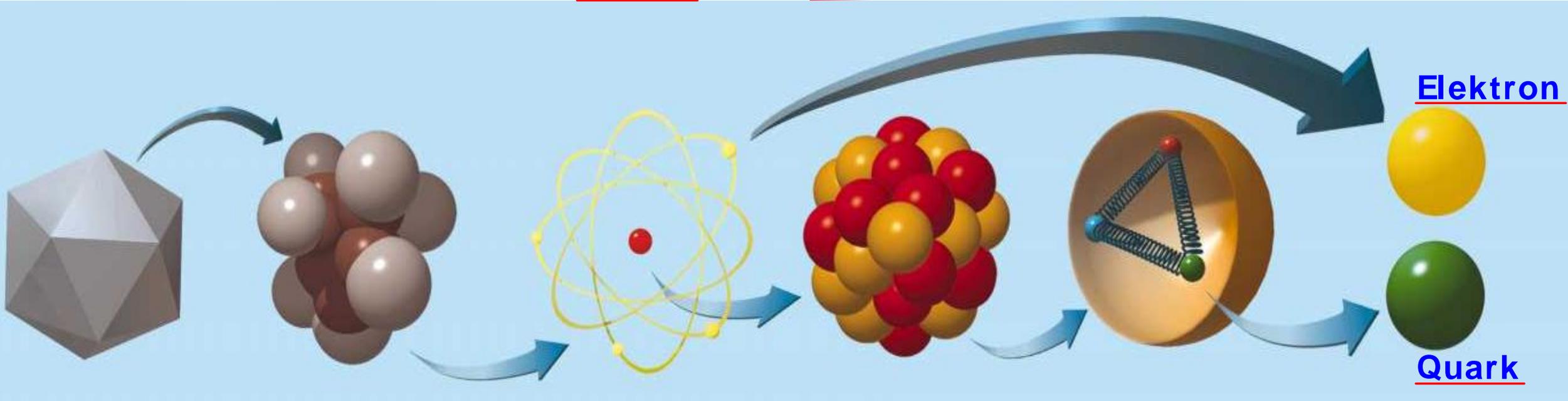
Atom

Atomkern

Proton

Elektron

Quark



Größenverhältnisse:

1/10.000.000

1/10

1/10.000

1/10

1/1000

typ. Größe:

0,01m

10^{-9} m

10^{-10} m

10^{-14} m

10^{-15} m

$<10^{-21}$ m

typ. Energie für experimentelle Untersuchung:

0,001eV

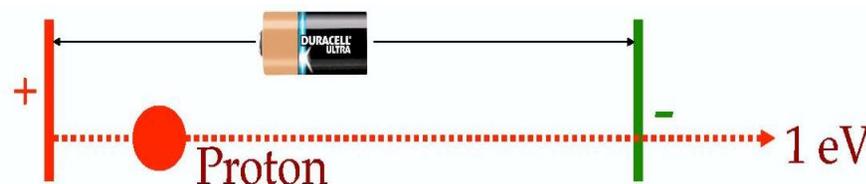
0,1eV

1eV

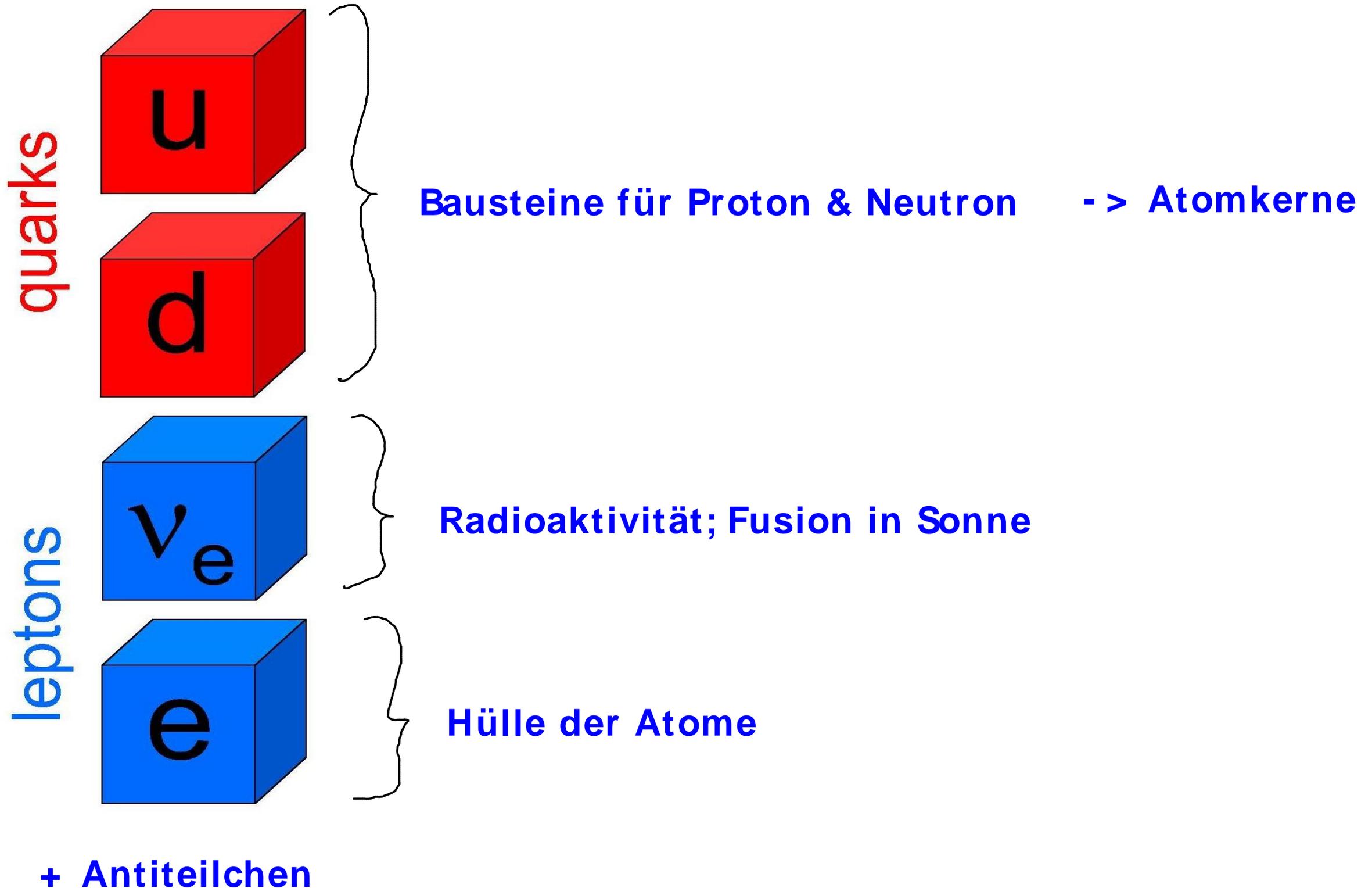
1 MeV

1 GeV

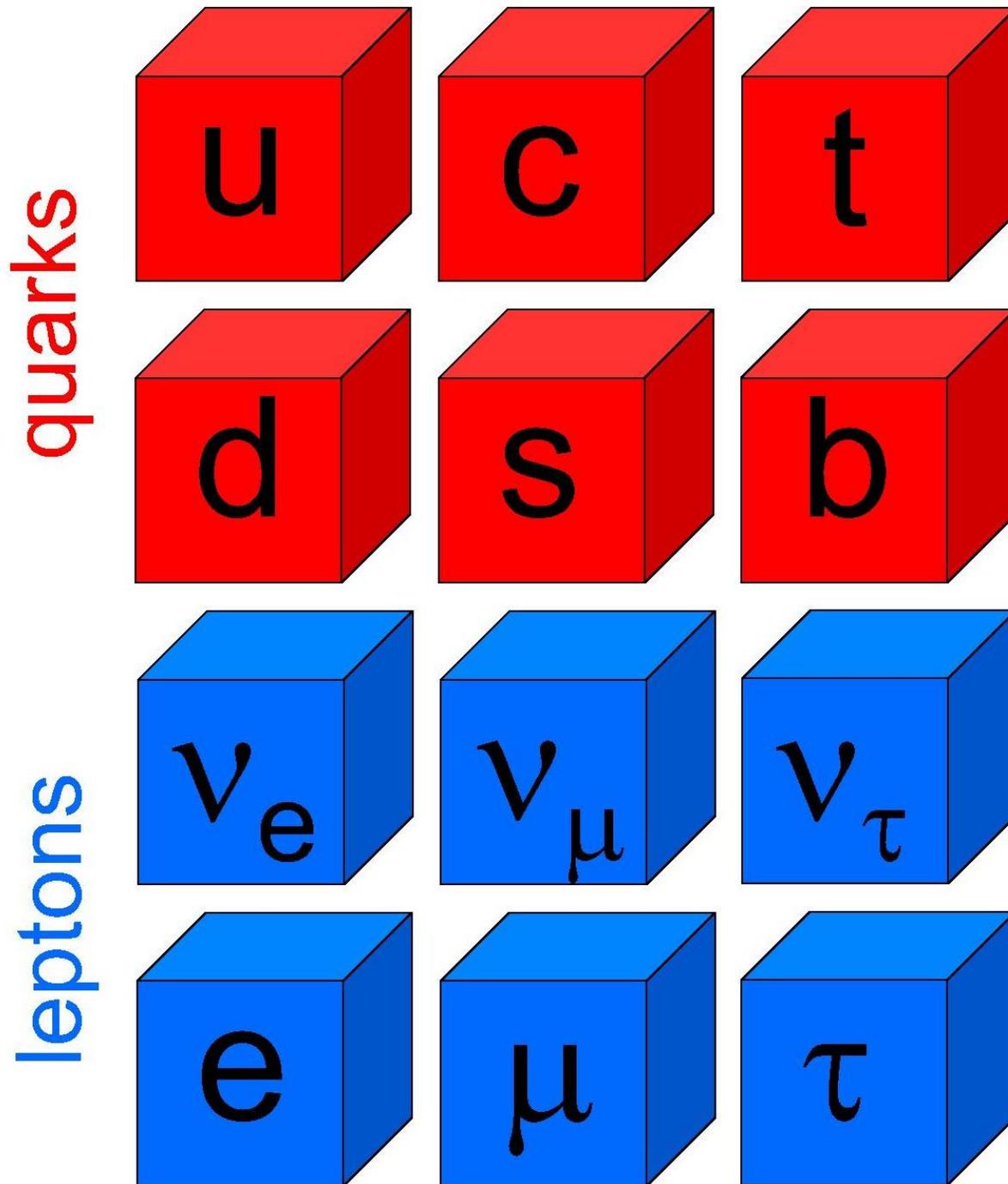
>1 TeV



Notwendige Materiebausteine



Bekannte Materiebausteine



1.

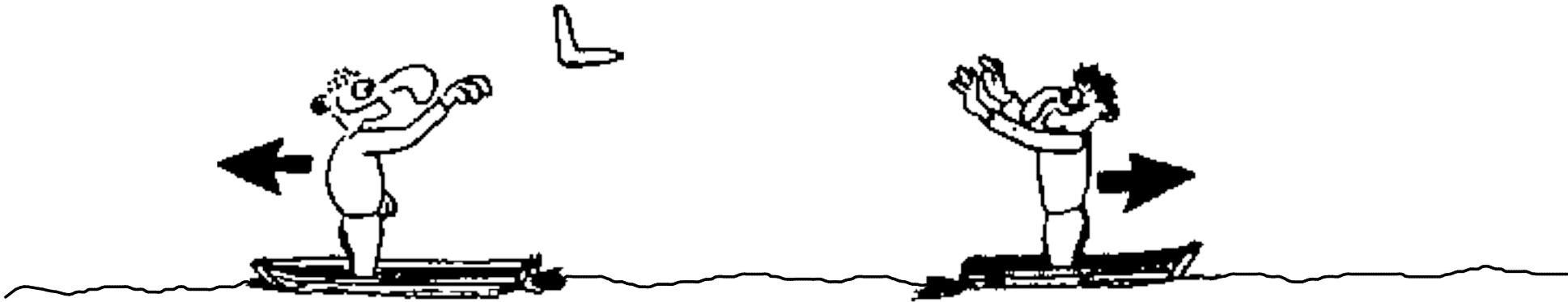
2.

3.

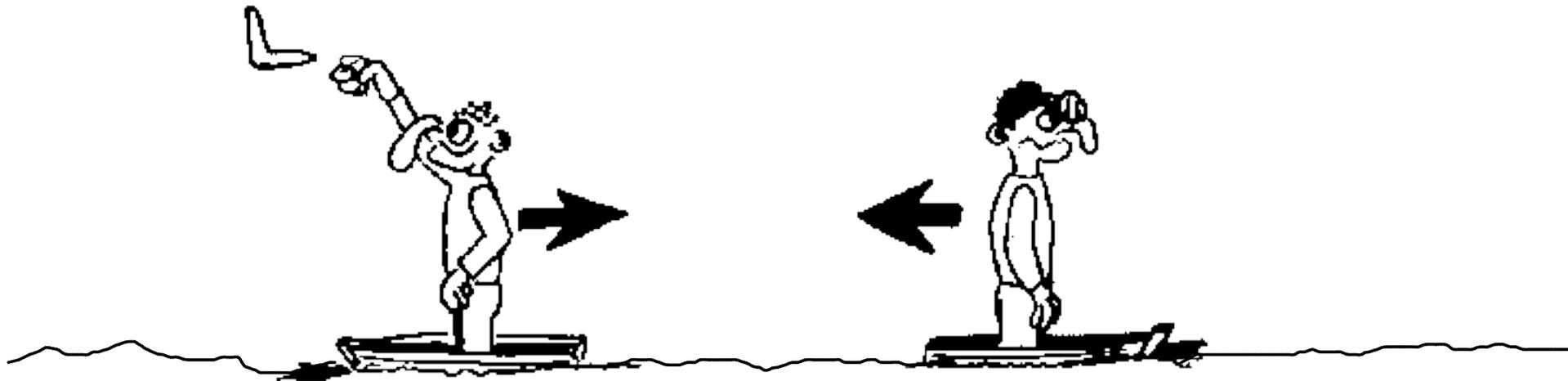
Familie; zunehmend massiver

Kräfte durch Kraftteilchen

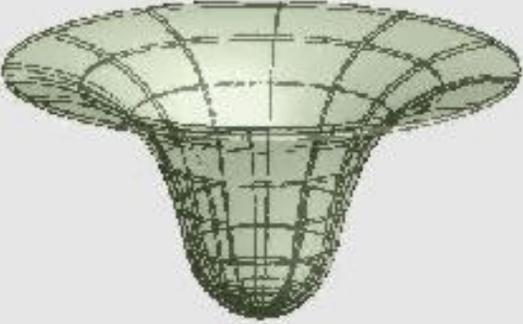
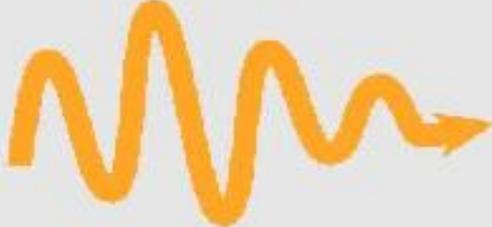
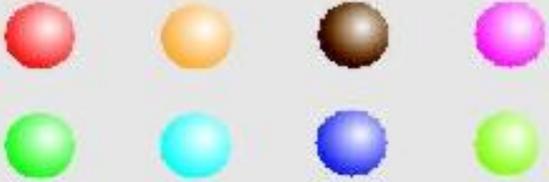
abstoßend:



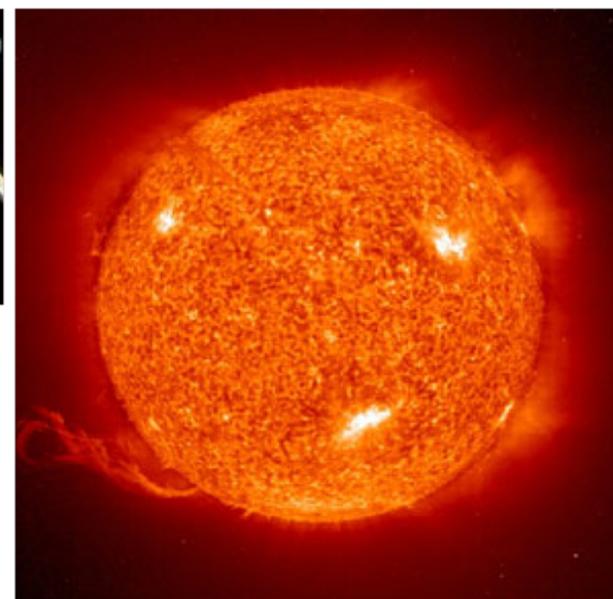
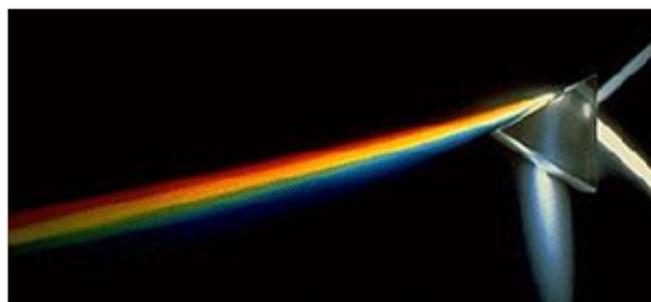
anziehend:



Vier bekannte Kräfte

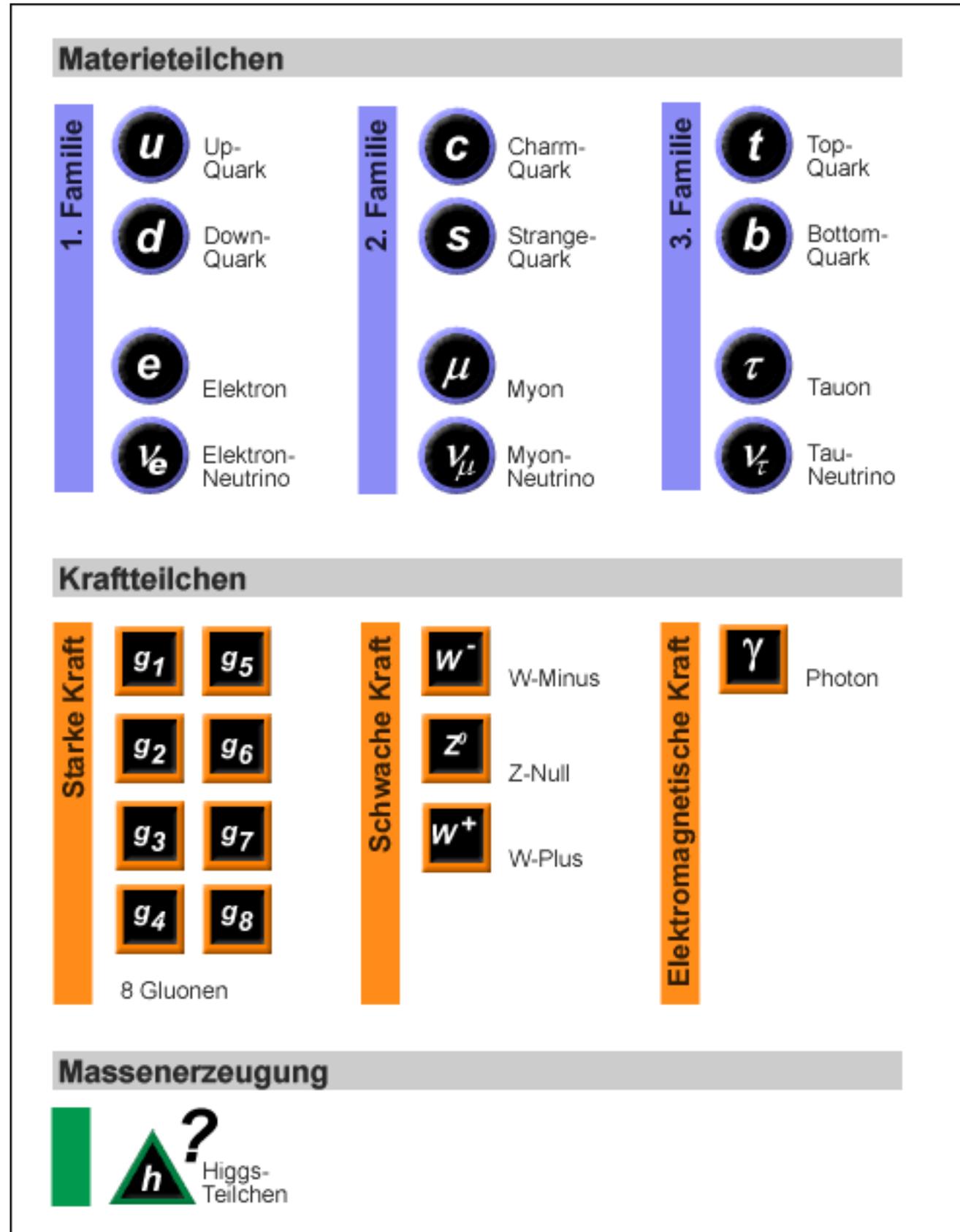
Gravitation	elektromag. Kraft	schwache Kraft	starke Kraft
	<p>1 Photon</p> 	<p>3 Bosonen</p> 	<p>8 Gluonen</p> 

© Exzellenzcluster Universe - www.universe-cluster.de



Überblick

aller Elementar=
teilchen



< - noch zu entdecken

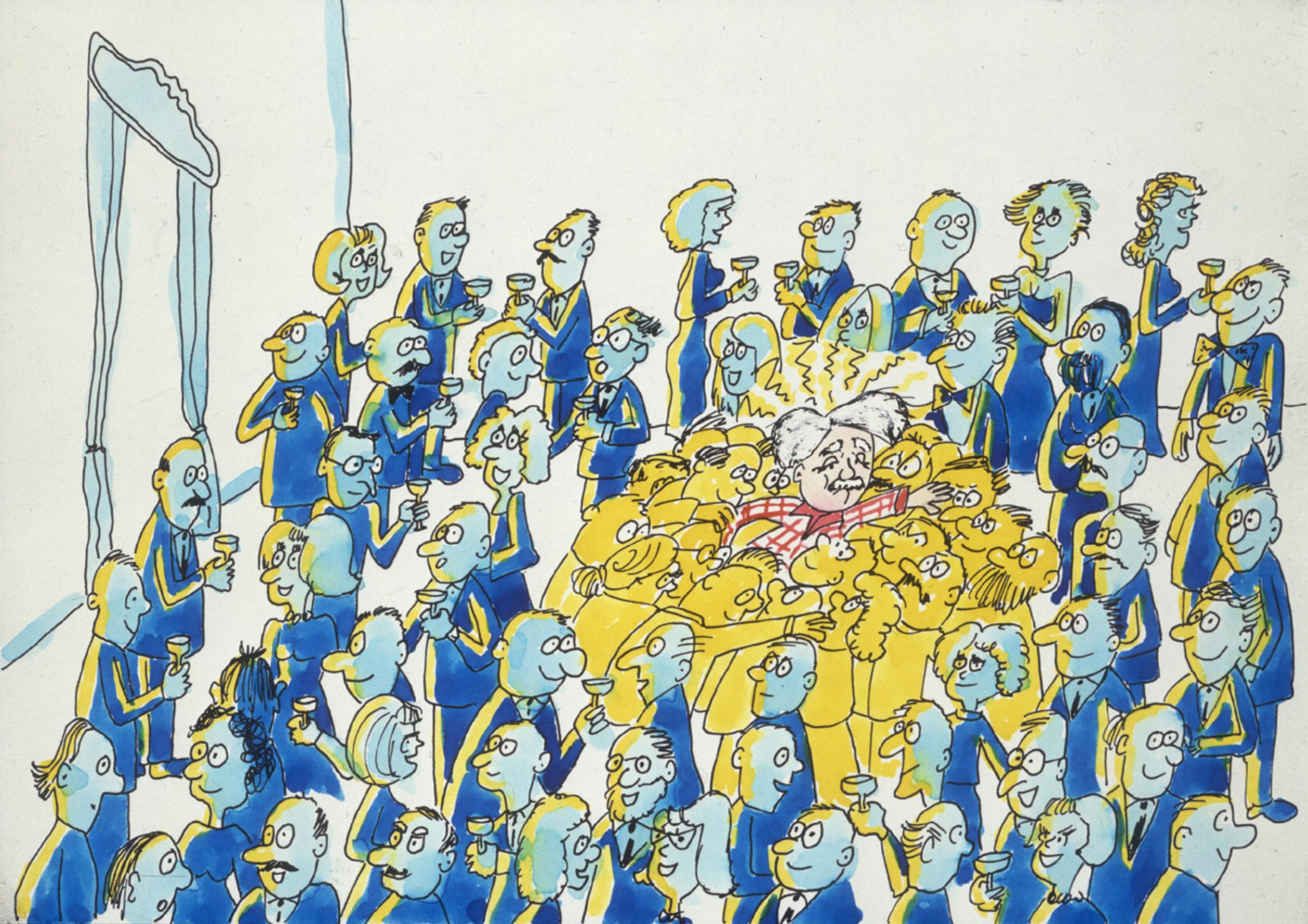
Massenerzeugung durch Higgs-Teilchen



© Original Artist
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www.CartoonStock.com



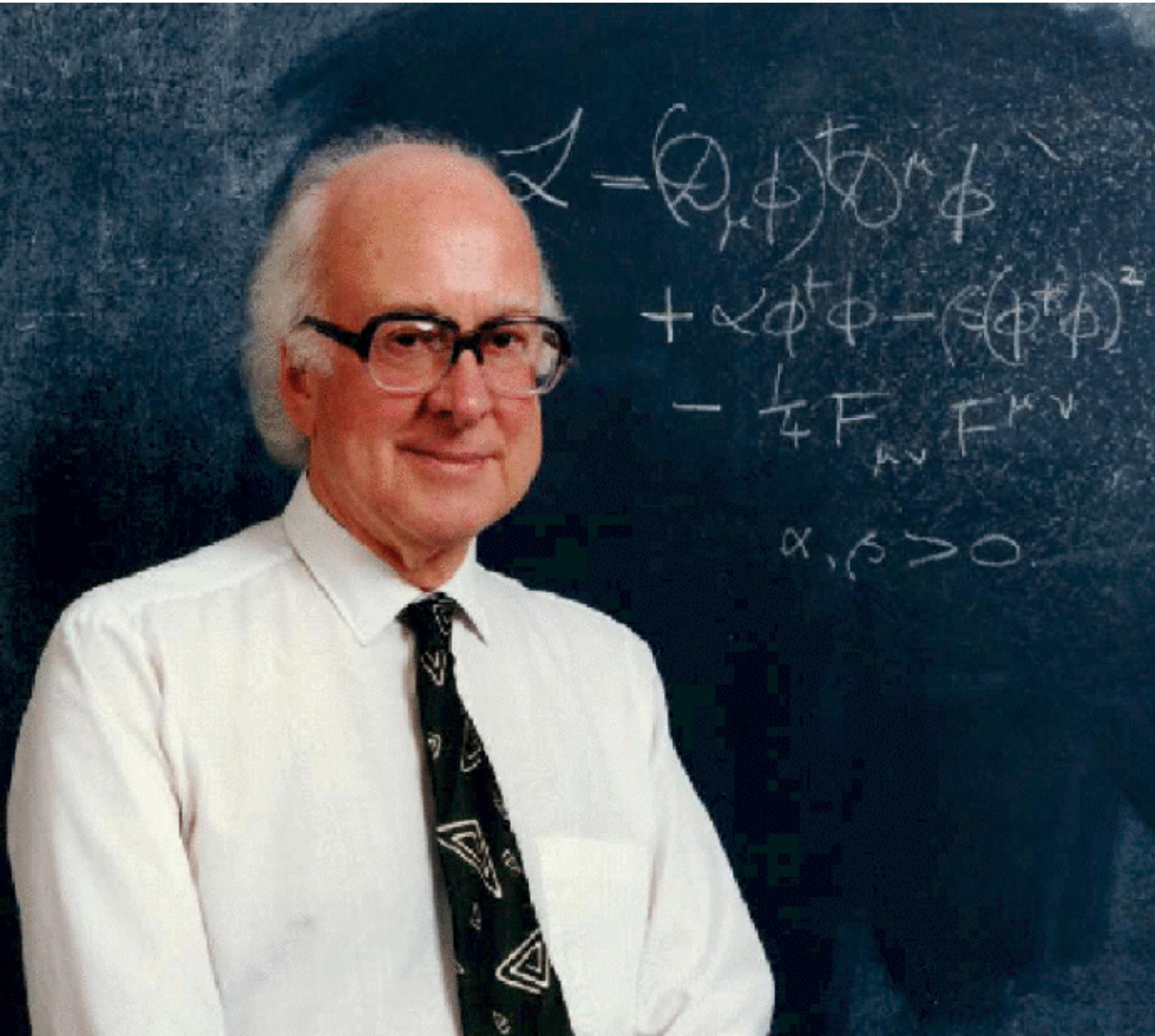








Einzig gefundenes Higgs



Peter Higgs



Genfer
See

CMS

Jura

LHC

ATLAS

SPS

CERN

Der LHC- Beschleuniger

Mikroskop:

höchste Energie - > kleinste Strukturen

$E=mc^2$:

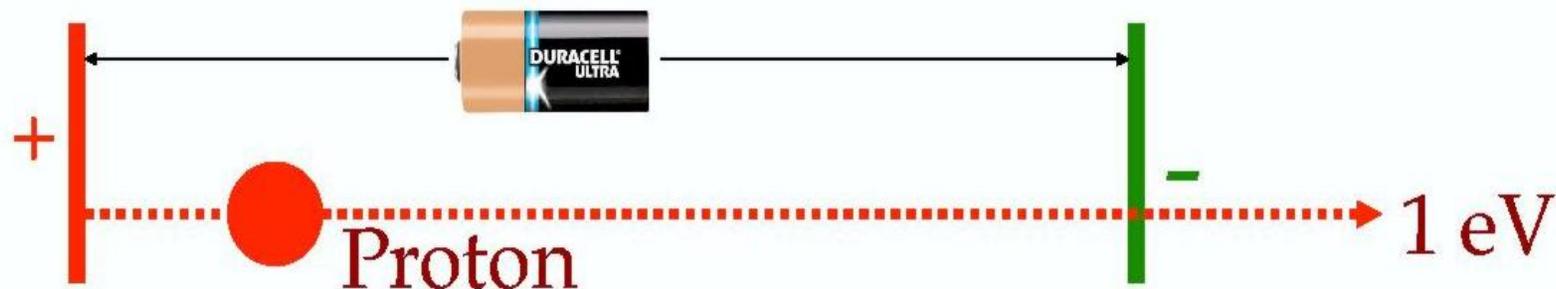
höchste Energie - > schwerste Teilchen

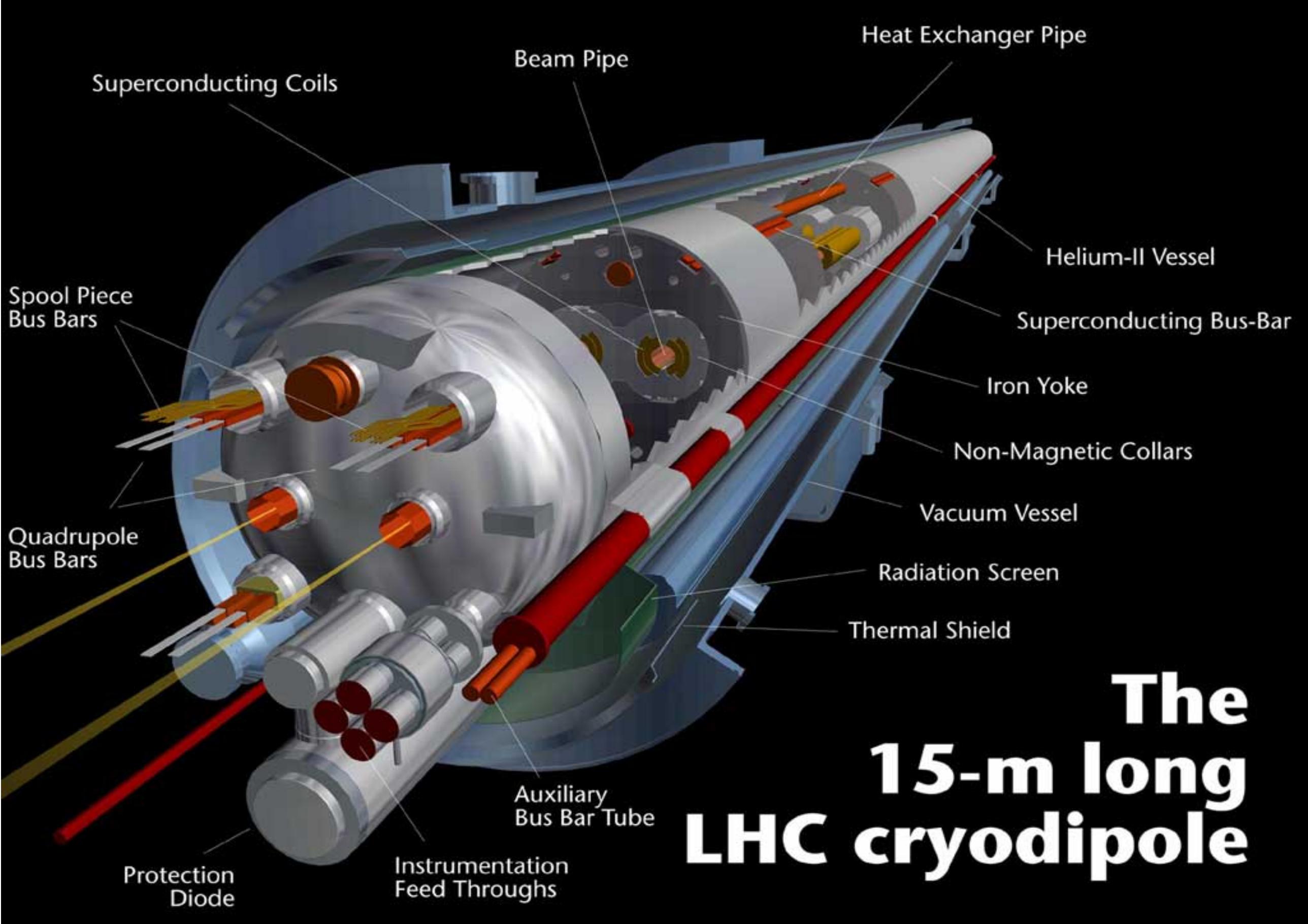
Physik&Technologie:

hohe Energie

- > großer Umfang

- > starke Magnetfelder





Superconducting Coils

Beam Pipe

Heat Exchanger Pipe

Helium-II Vessel

Superconducting Bus-Bar

Iron Yoke

Non-Magnetic Collars

Vacuum Vessel

Radiation Screen

Thermal Shield

Spool Piece Bus Bars

Quadrupole Bus Bars

Auxiliary Bus Bar Tube

Protection Diode

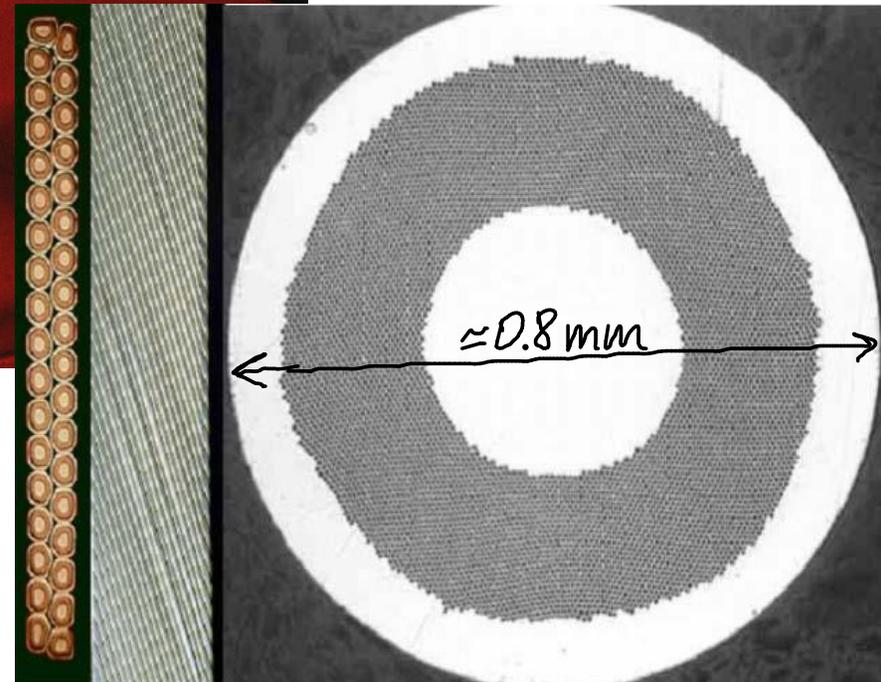
Instrumentation Feed Throughs

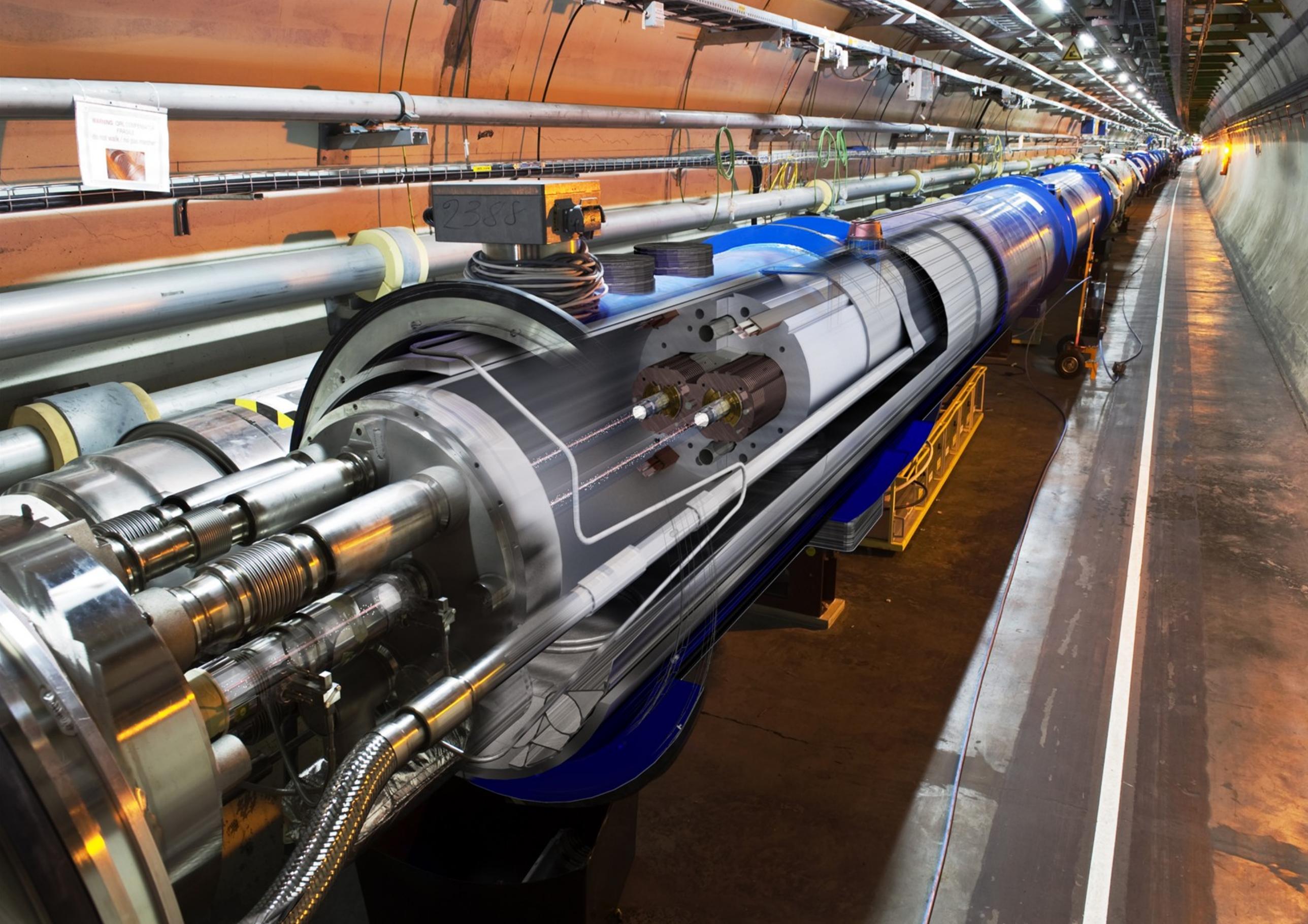
The 15-m long LHC cryodipole

Supraleitende
Ablenkmagnete



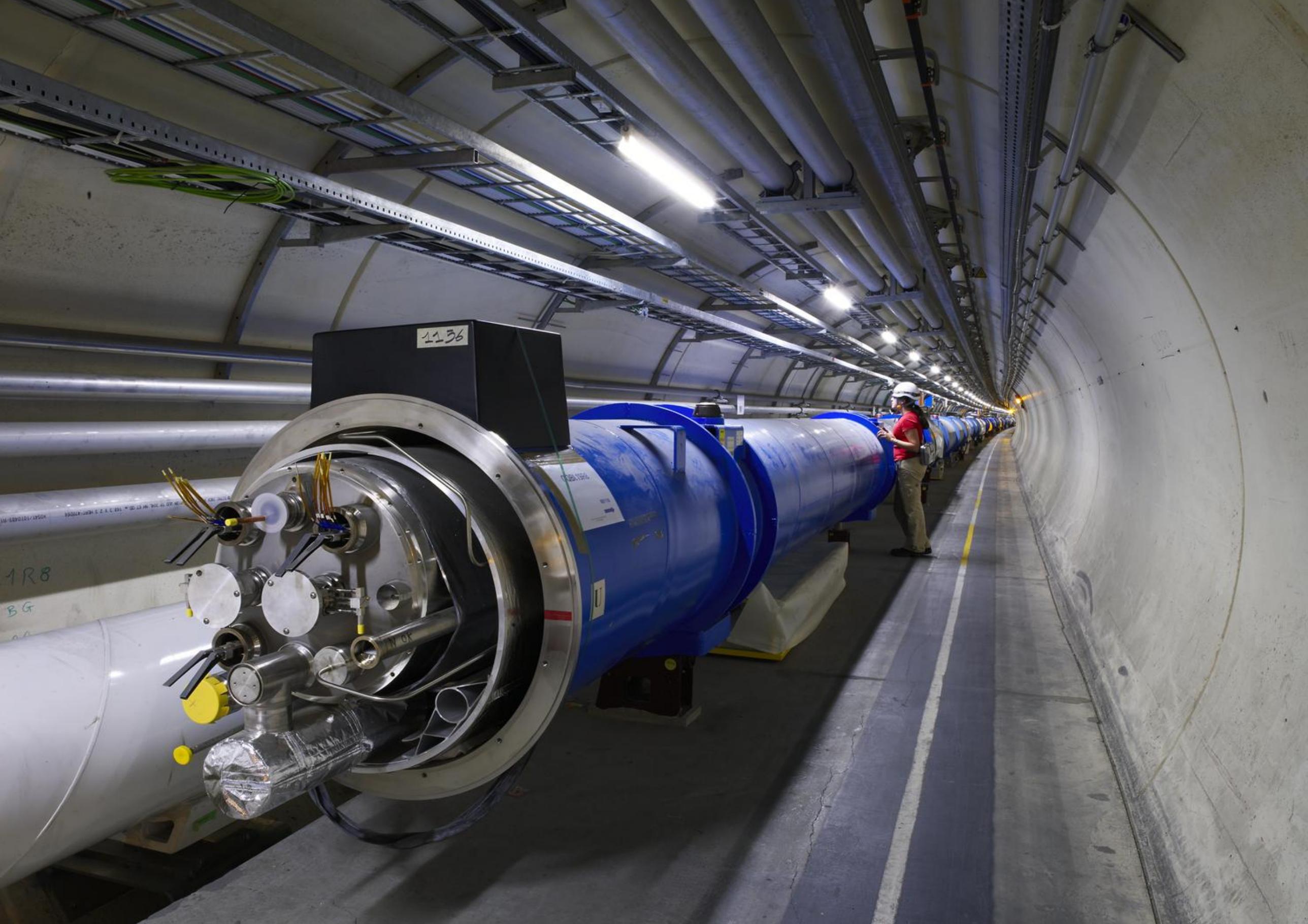
Supraleitender
Draht





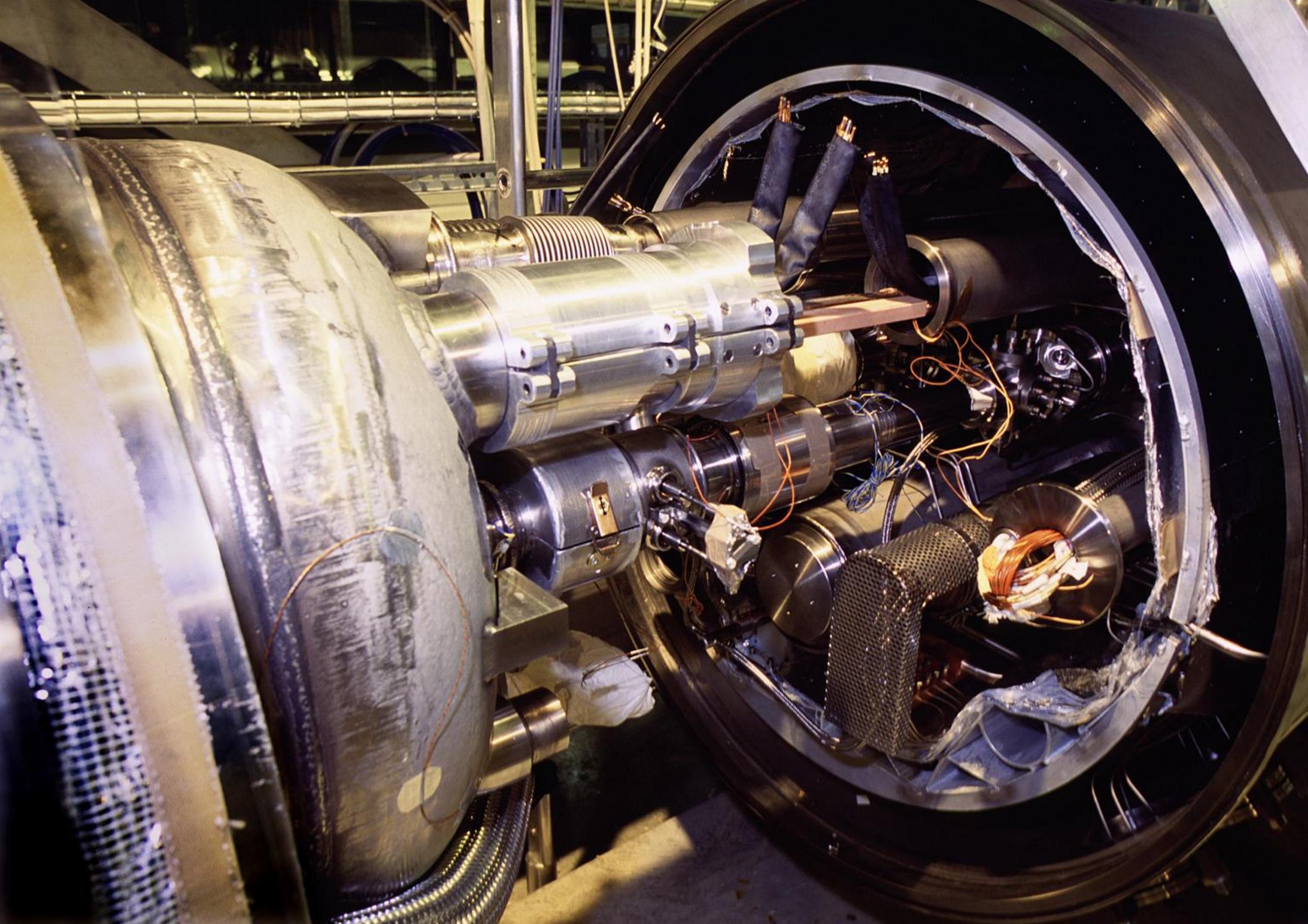
WARNING OIL CONTAMINATION
FRAGILE
DO NOT WORK / DO NOT REPAIR

2388



1136

1R8
BG



LHC: Daten & Fakten

- Strahl:

Energie der Protonen	7 TeV
Strom der Protonen	0,58 A
- > gespeicherte Strahlenergie	100 kWh

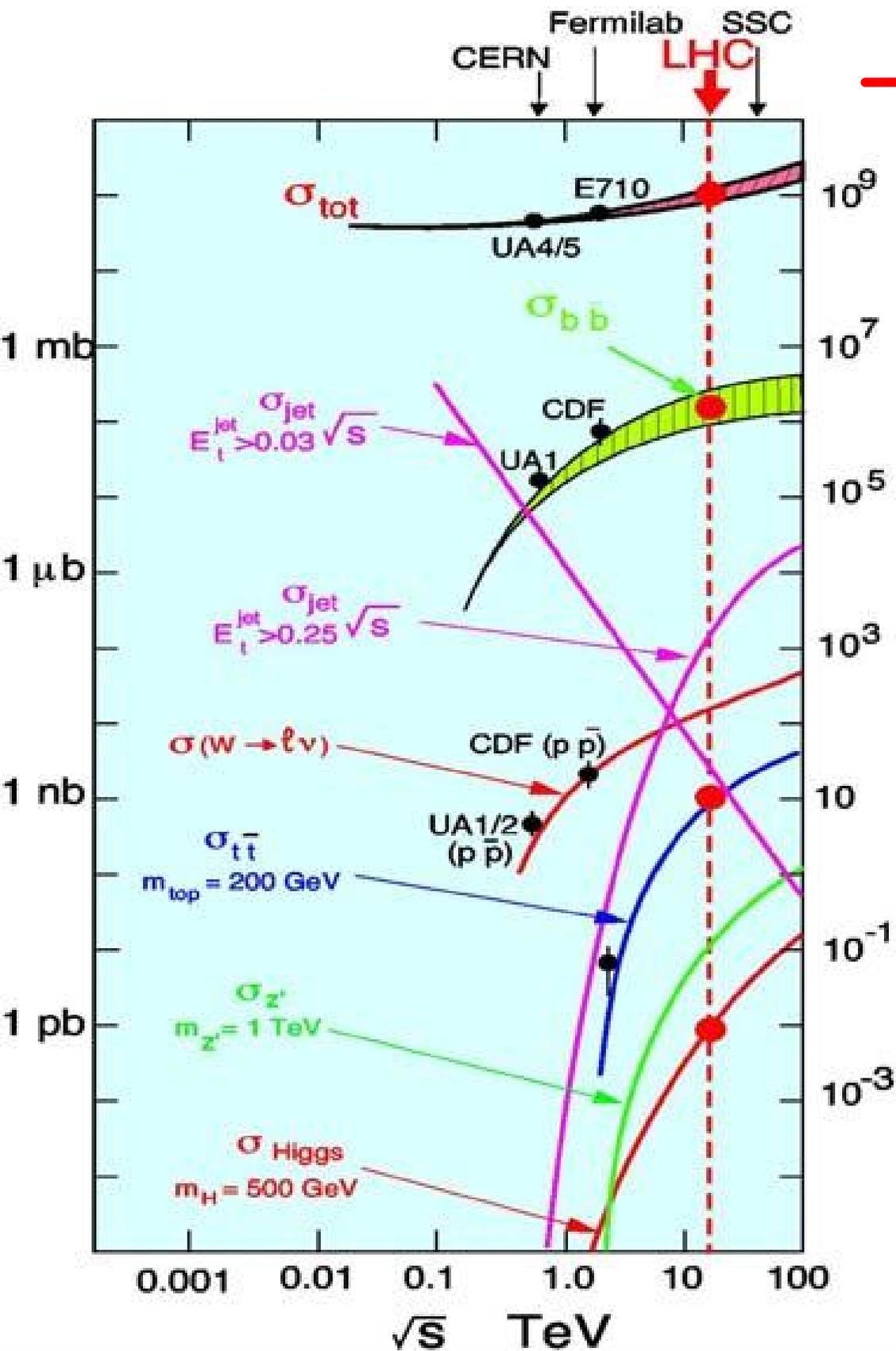
- Magnete:

max. Magnetfeld	8,33 Tesla
Betriebstemperatur	- 271 °C
Anzahl d. Ablenkmagnete	1232
Länge eines Ablenkmagnets	ca. 14 m
gespeicherte Energie	ca. 3000 kWh

- Tunnel:

Umfang	ca. 27 km
Kollisionszonen für	4 Teilchendetektoren
Tunnellage	100- 170m unterirdisch

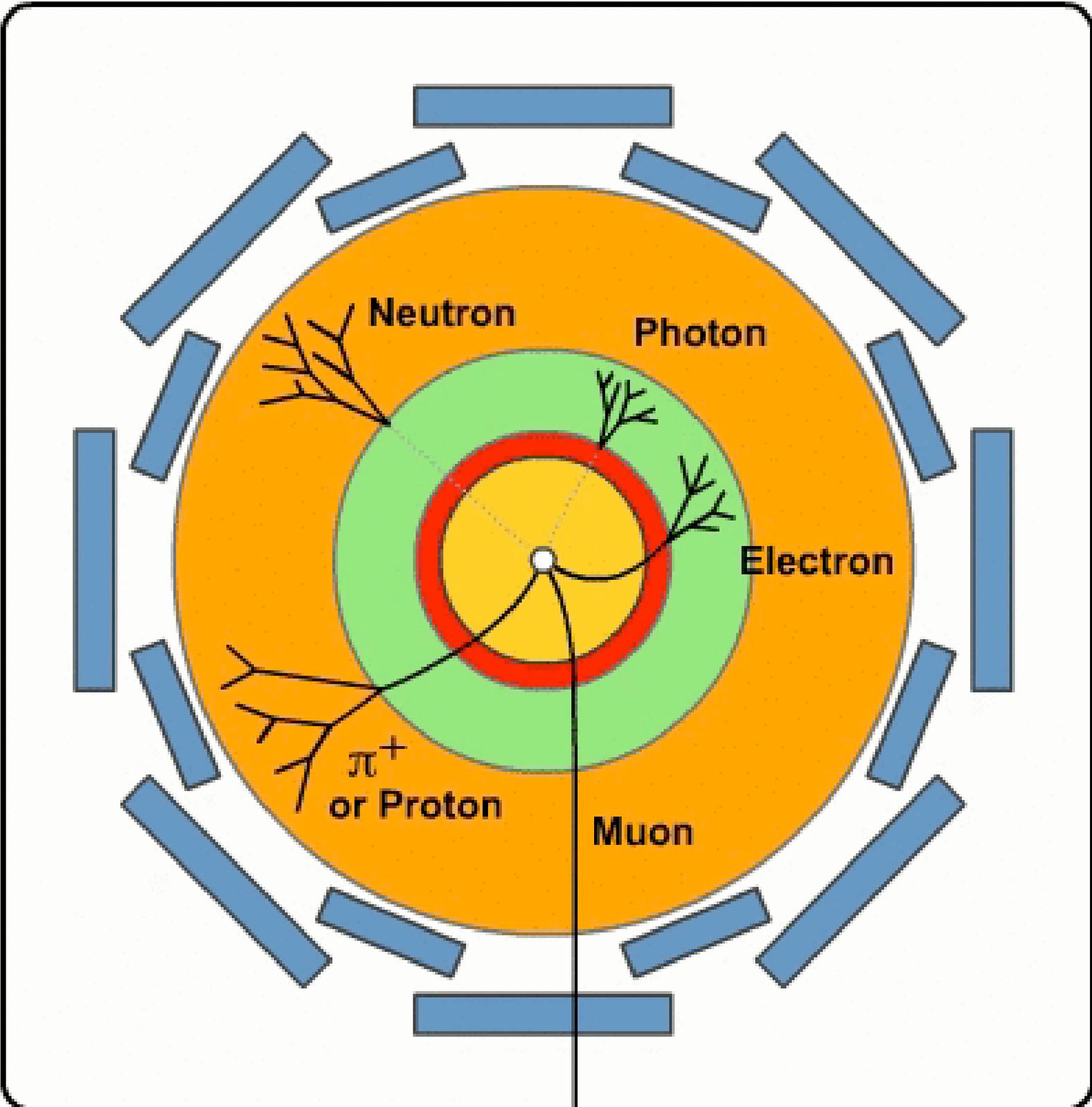
Proton-Proton-Kollisionen



< - 1 Mrd Kollisionen / Sekunde
meist bekannte Reaktionen

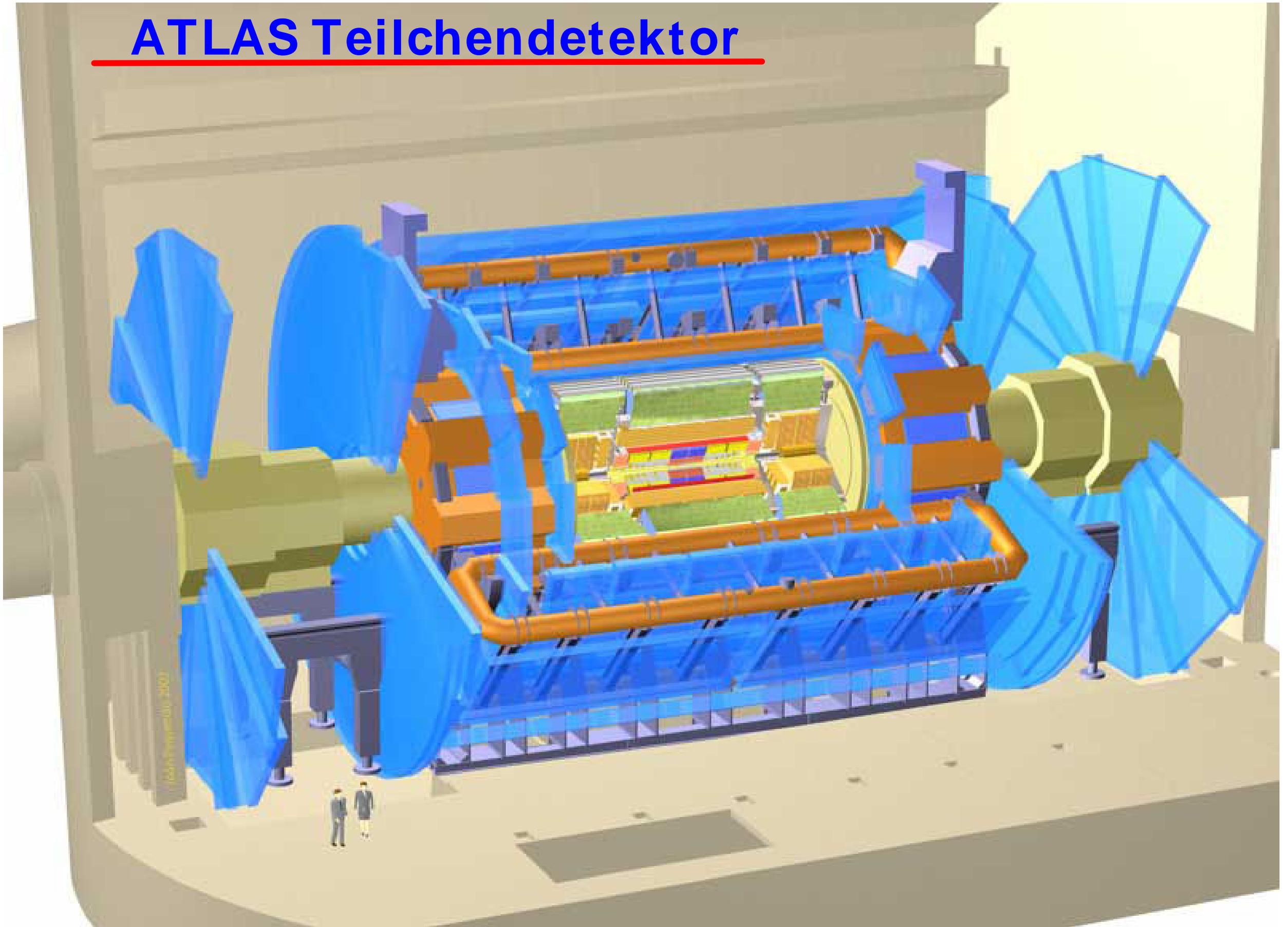
< - Erwartung für Higgs-Teilchen
1 Higgs-Teilchen / Minute

Prinzipieller Aufbau des ATLAS- Detektors (Querschnitt)

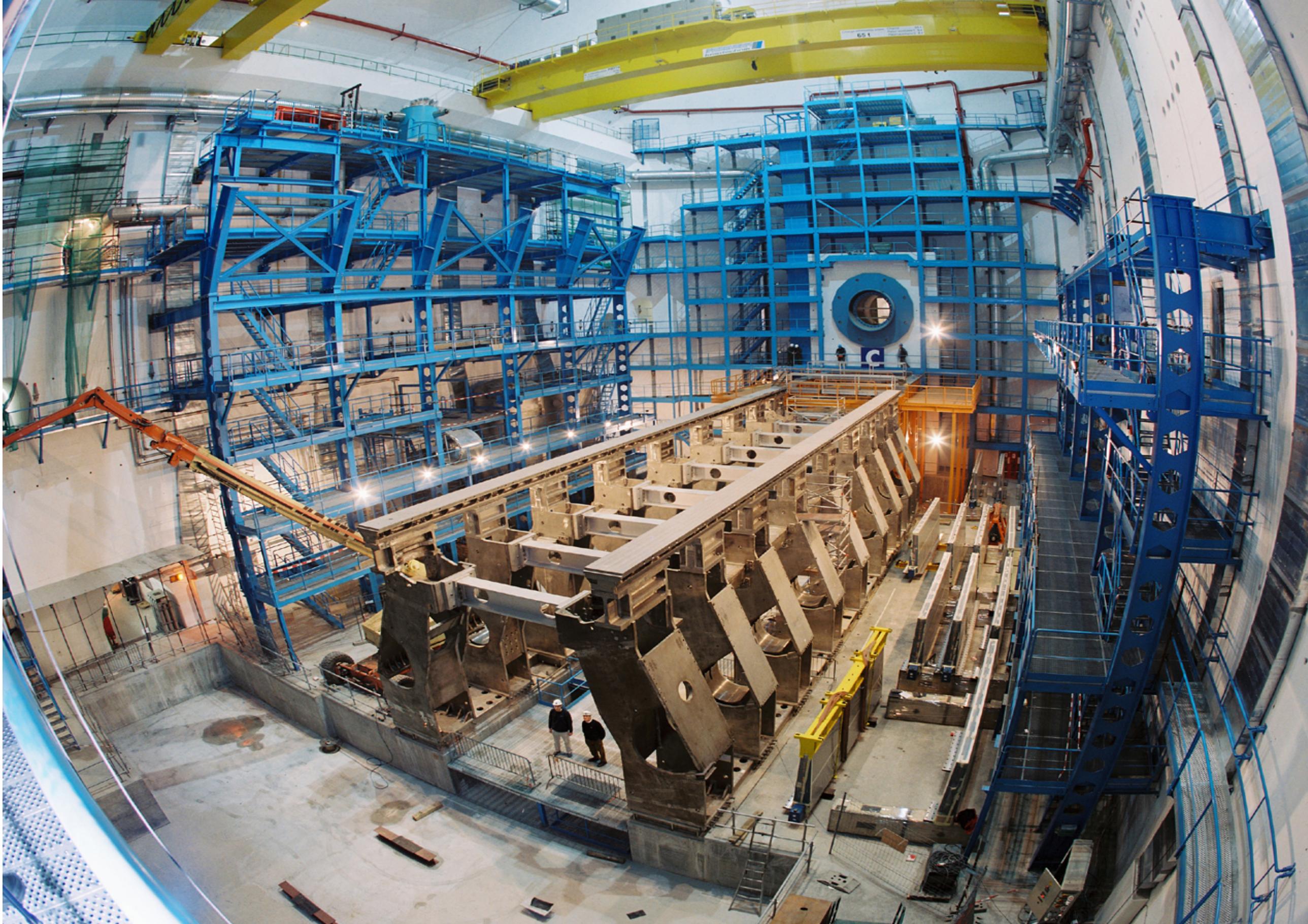


-  Myon- Detektor
-  Energiesmessung für Hadronen
-  Energiesmessung für Elektron & Photon
-  Magnet zur Spurkrümmung
-  Spurdetektor
-  Strahlröhre

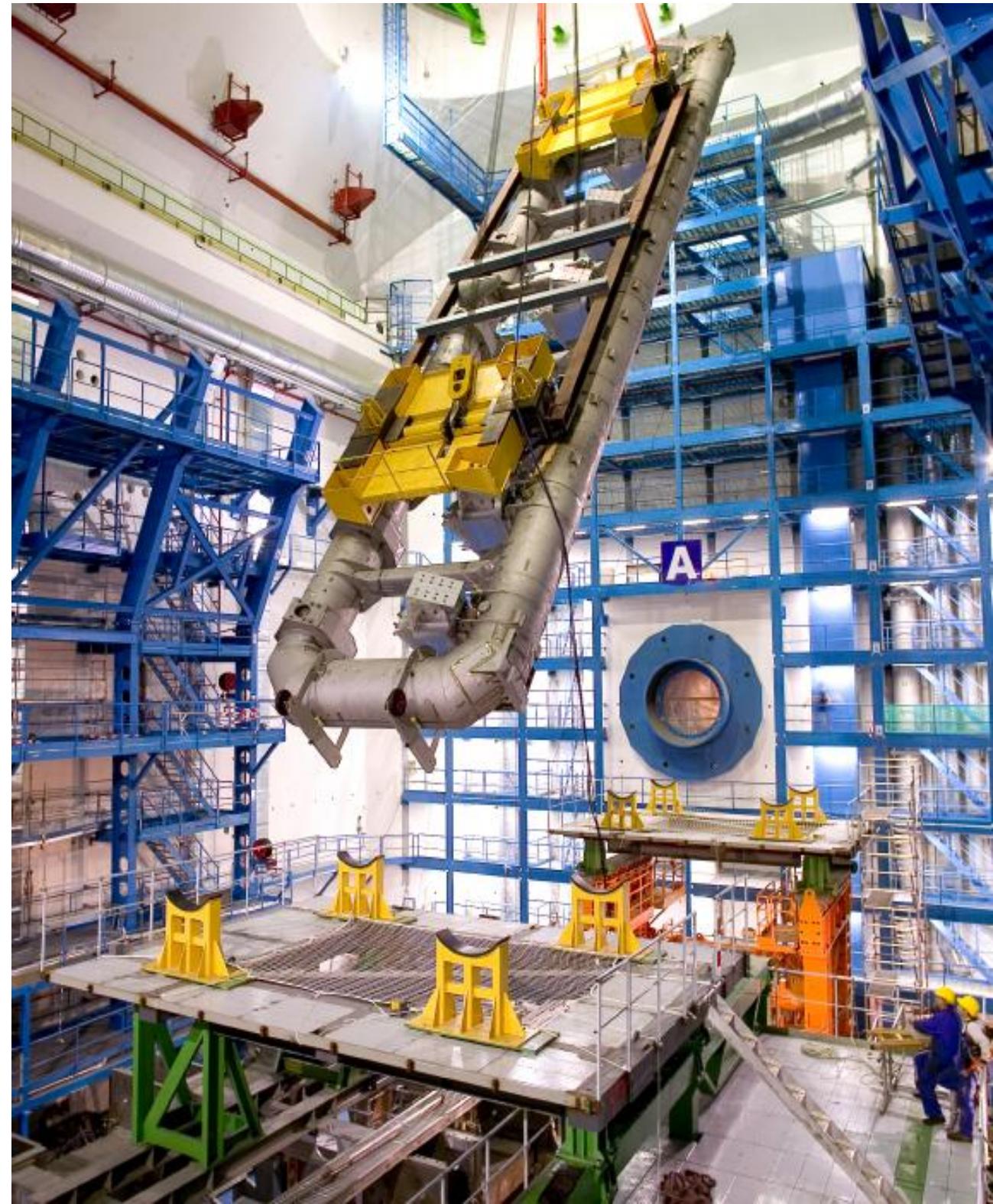
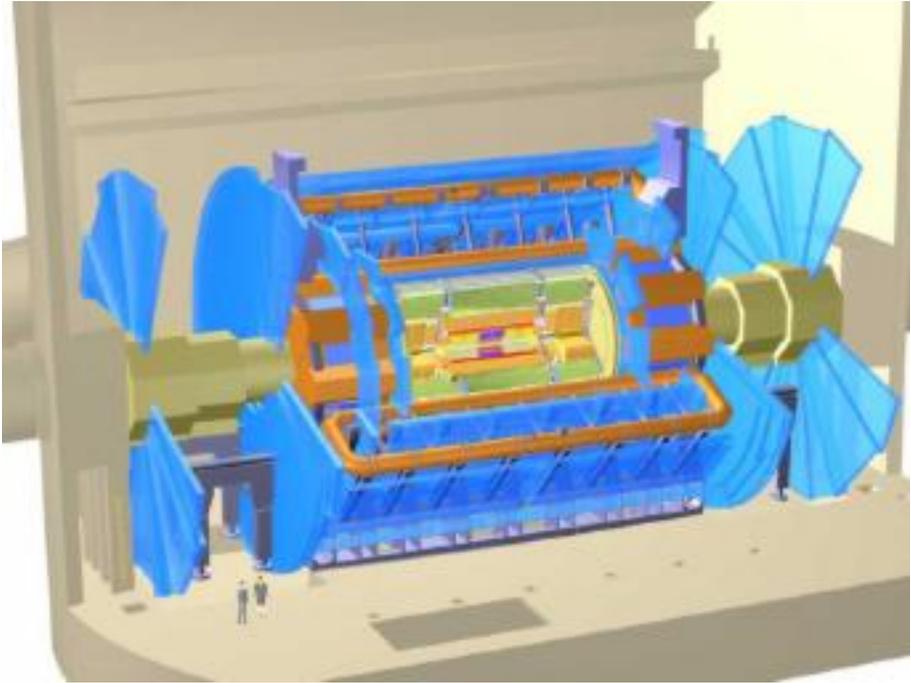
ATLAS Teilchendetektor





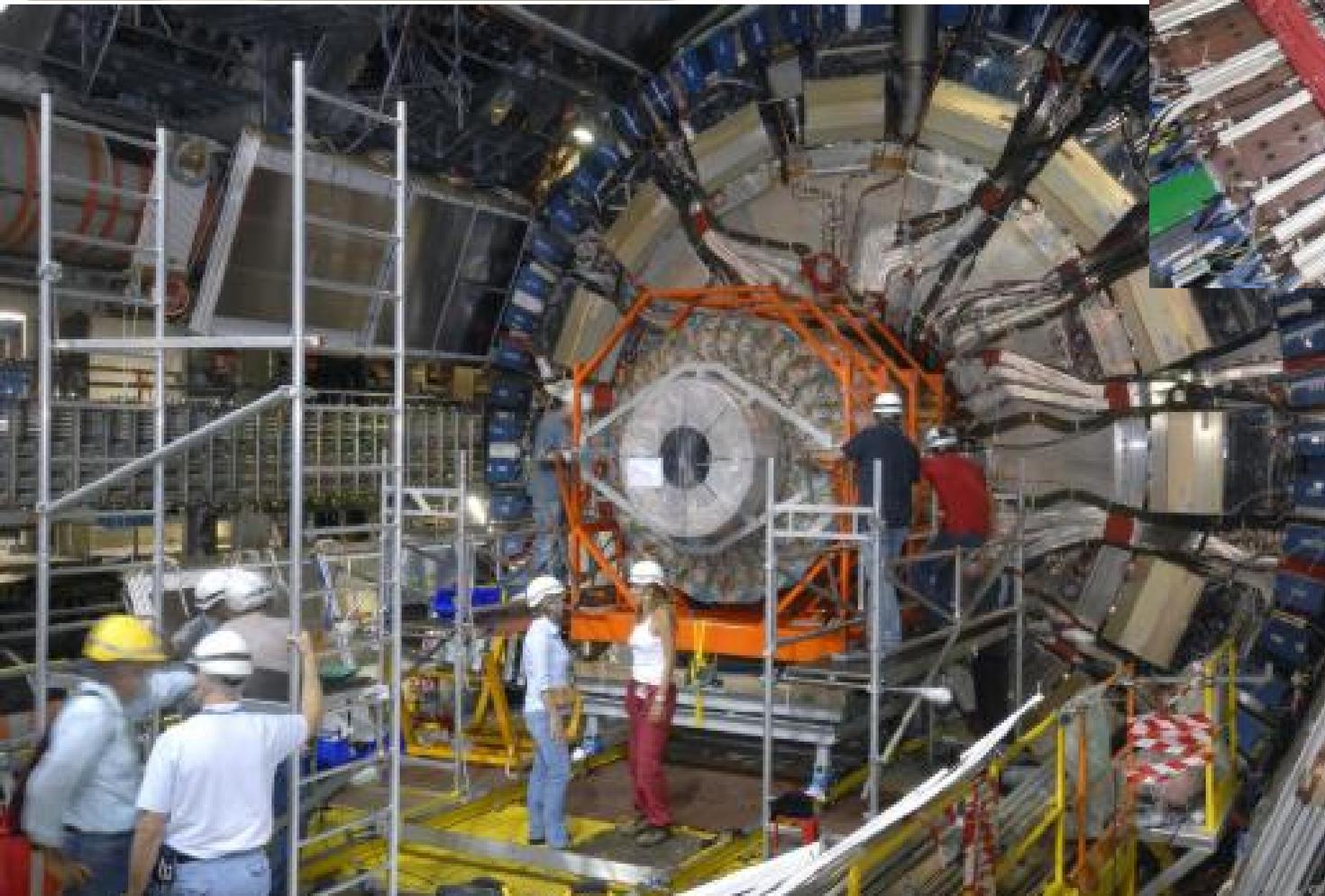
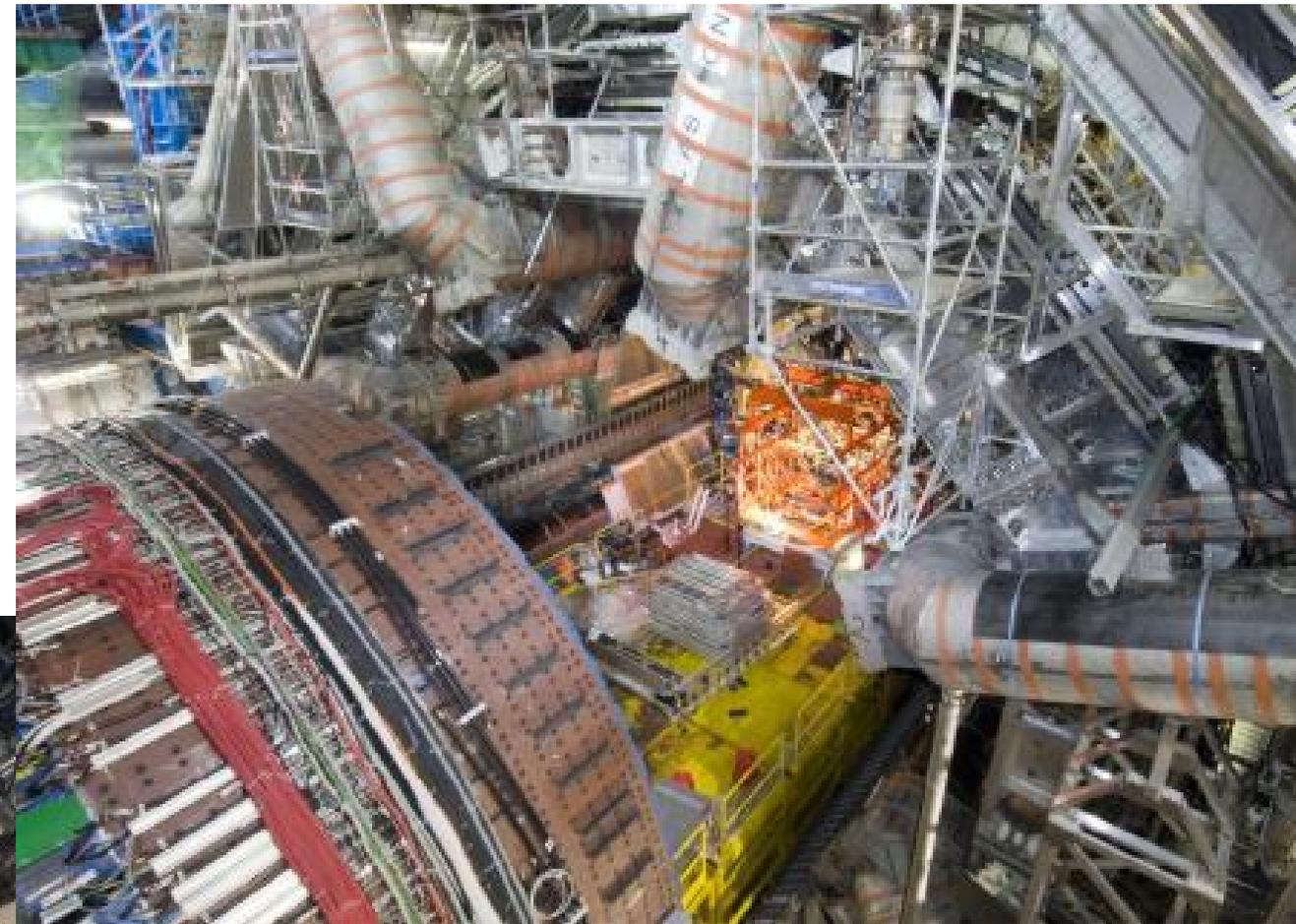
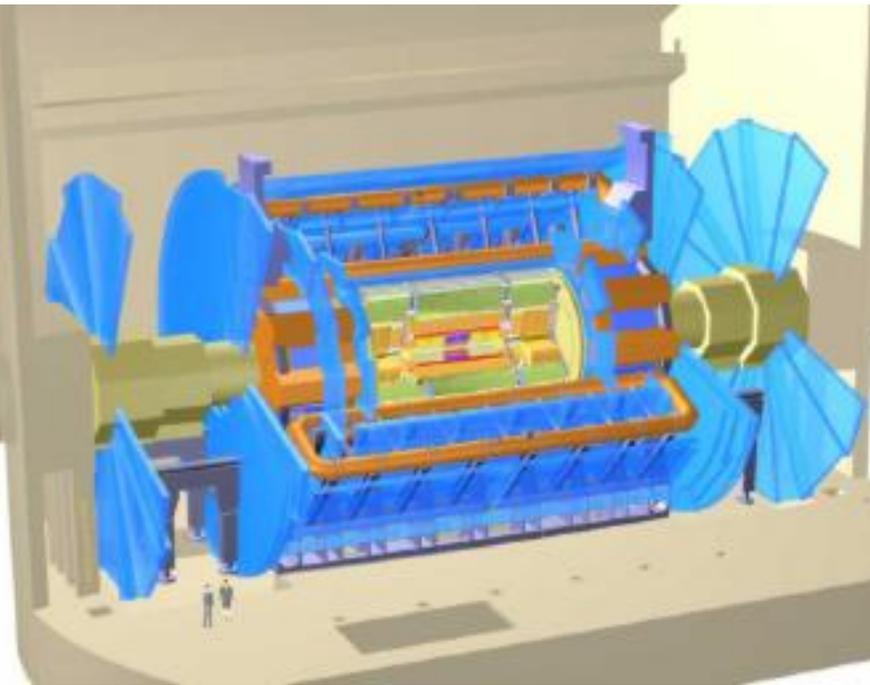


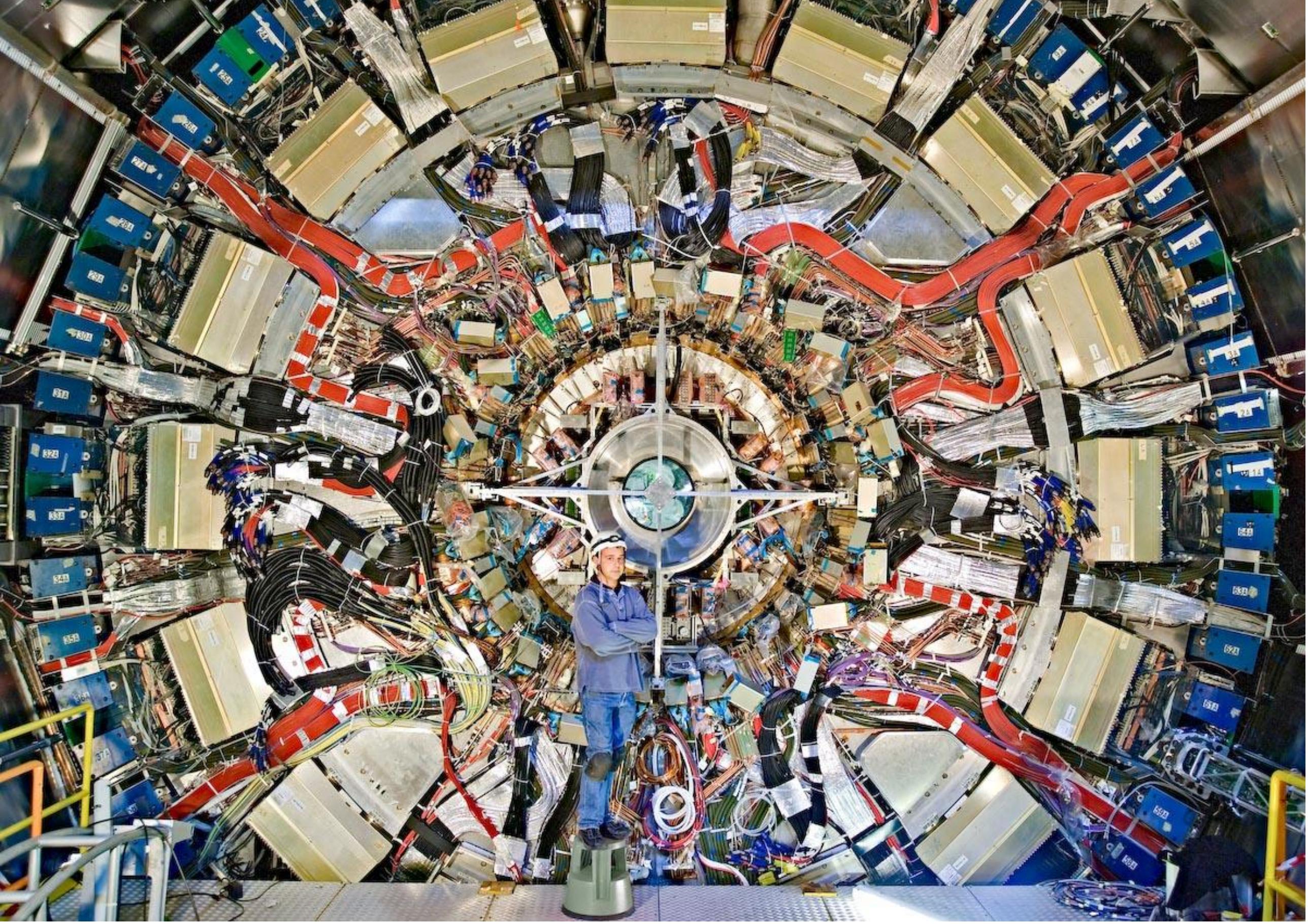
Magnetspulen des Toriodmagneten



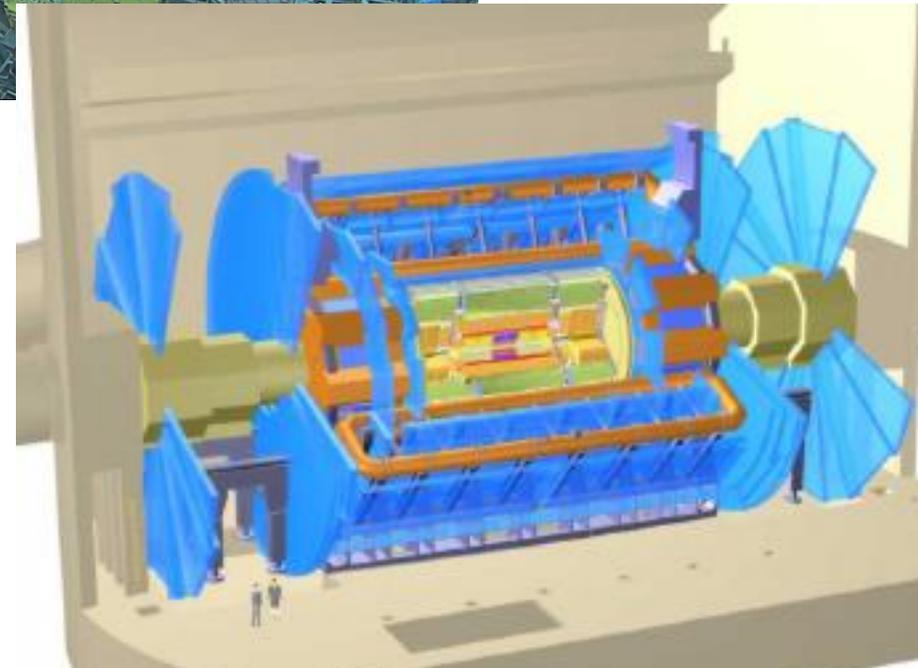
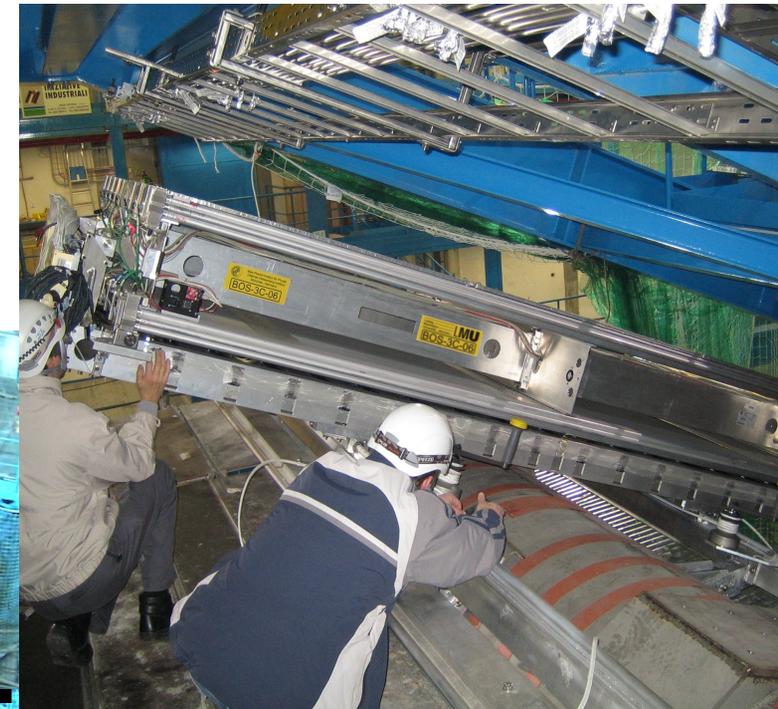
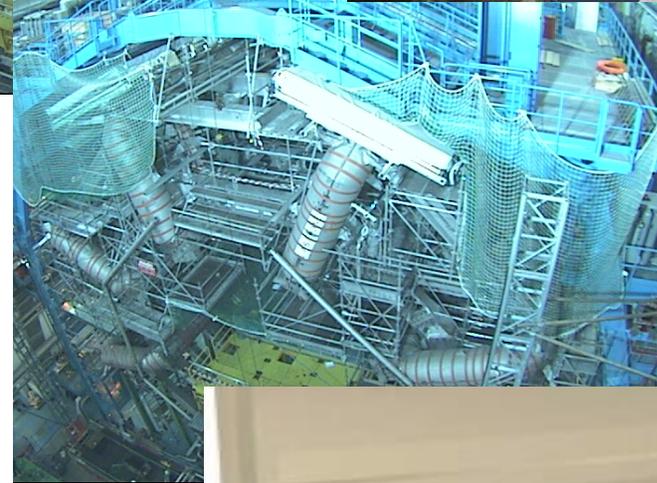
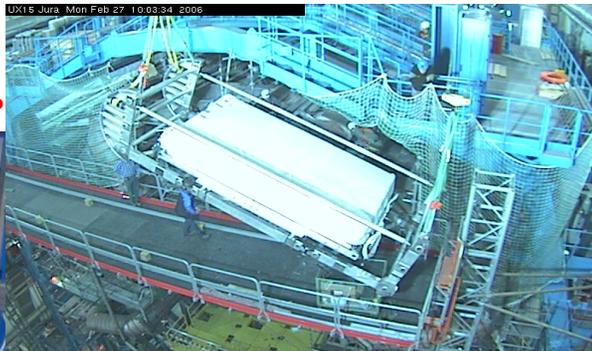
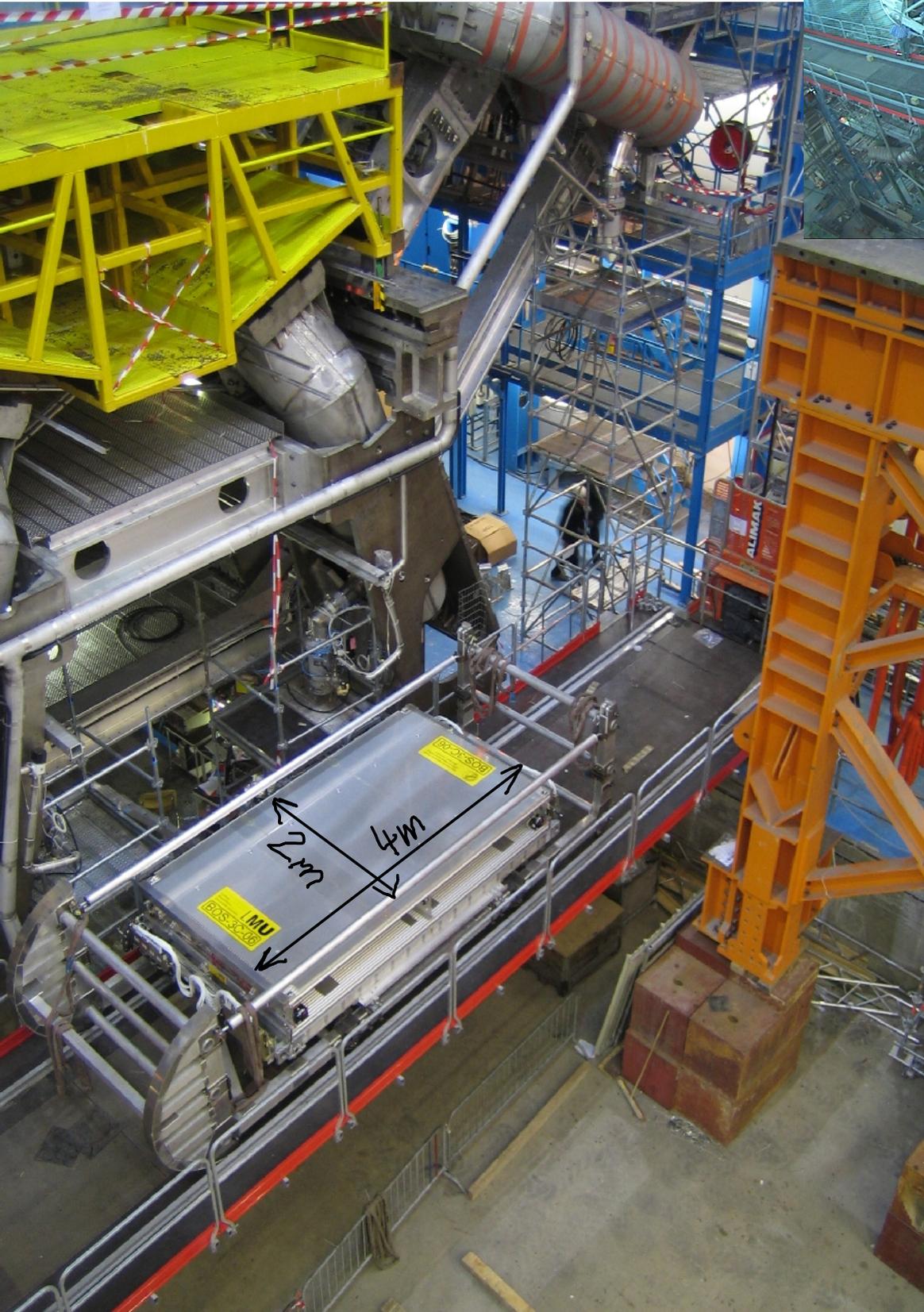


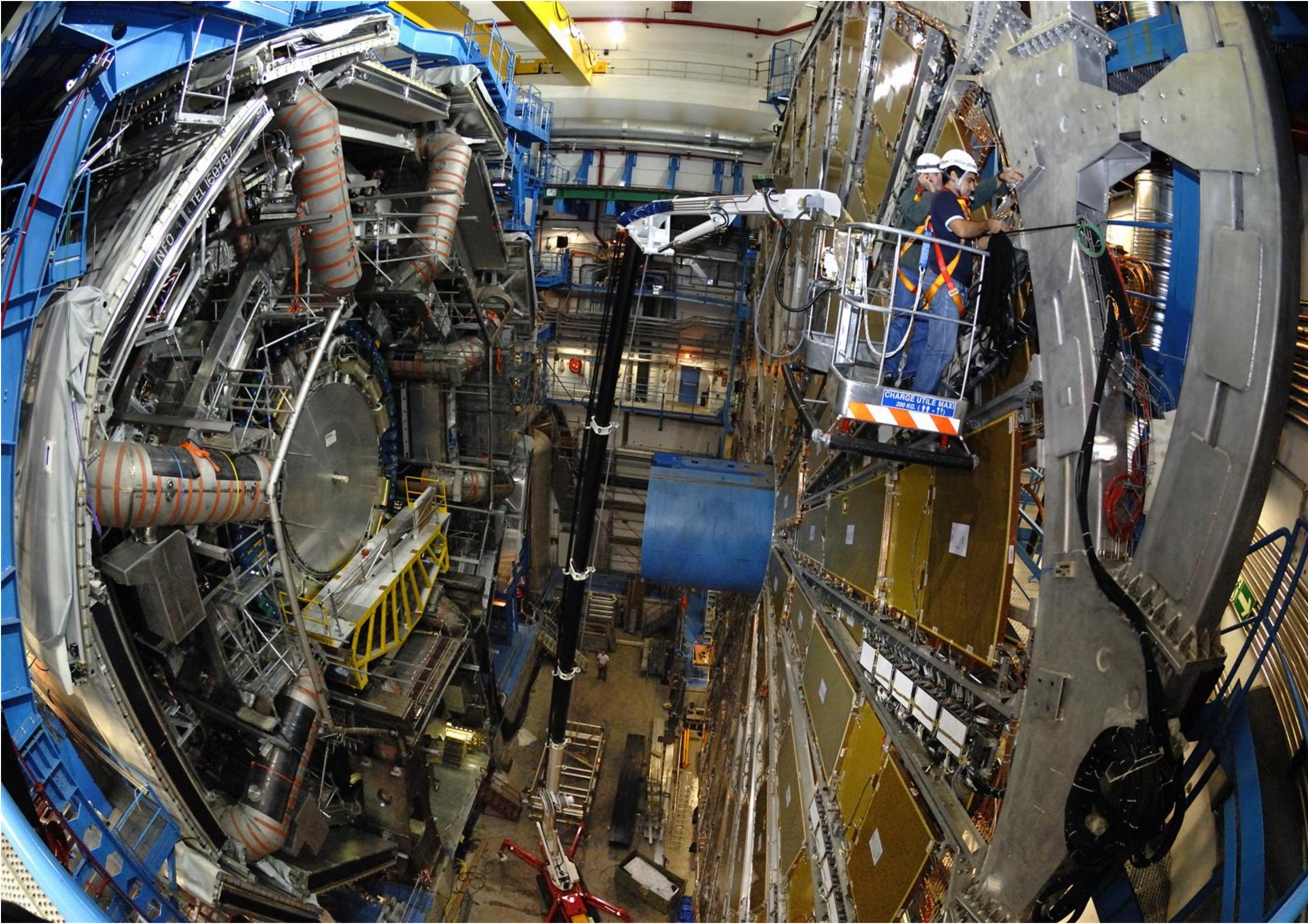
Spurdetektor & Energiemessdetektoren





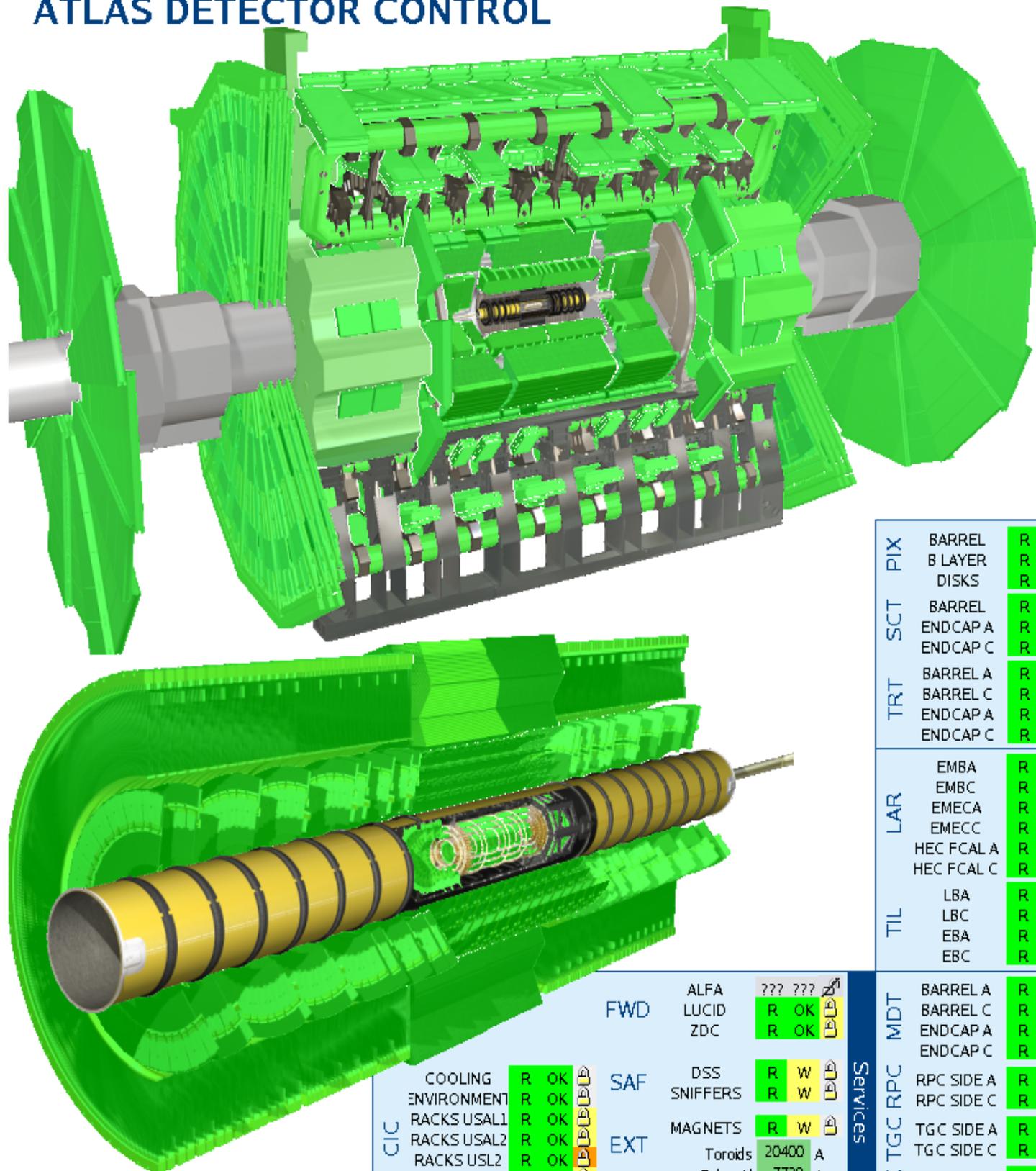
Myondetektormodul





INFO TEL 168787

CHARGE UTILE MAXI
200 KG. (440 LBS.)



ATLAS- Detektorstatus

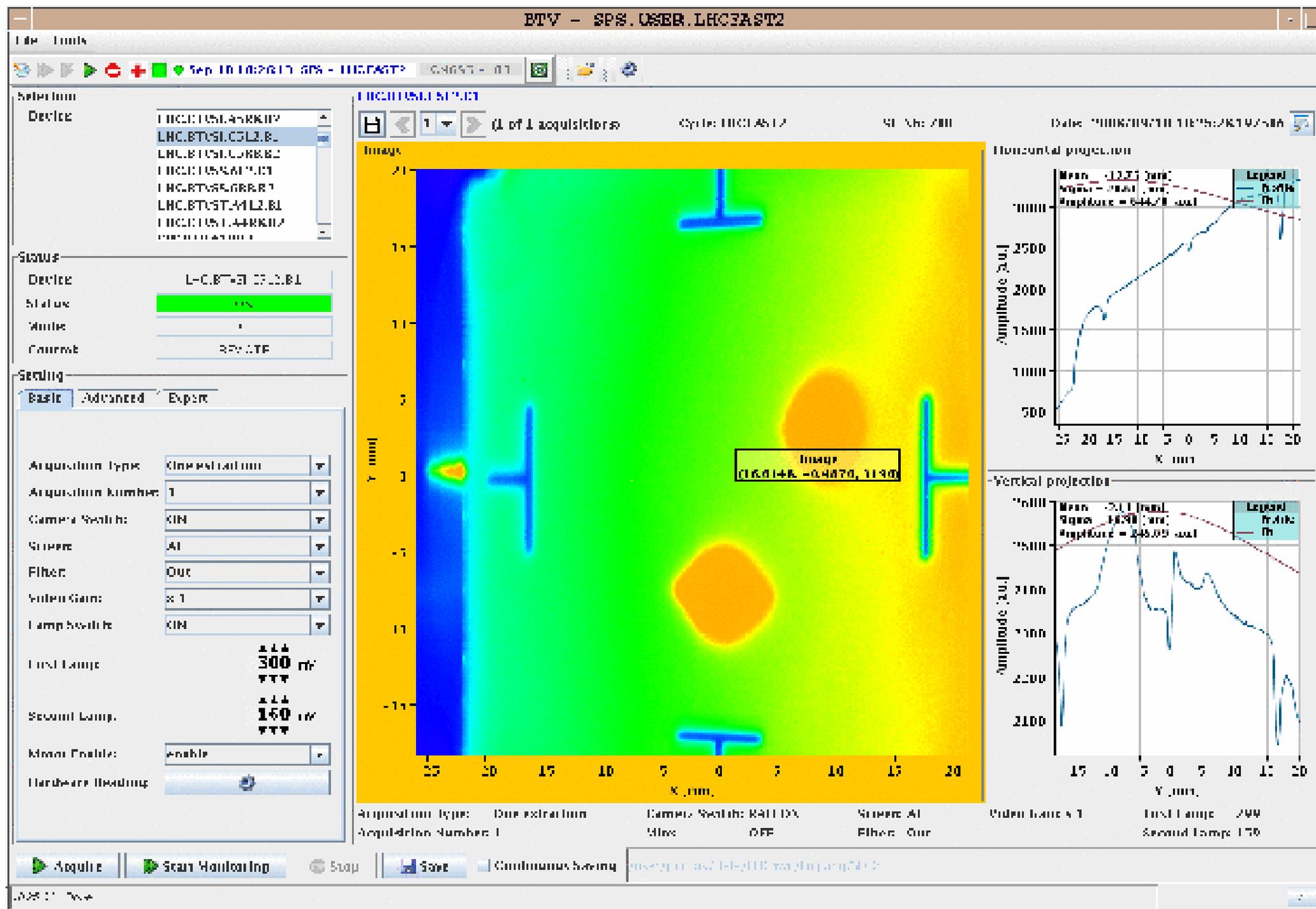
im November 2009

= > alles bereit !

System	Component	Status	Icon	
Inner Detector	PIX	BARREL	R E	
		B LAYER	R OK	
		DISKS	R W	
	SCT	BARREL	R OK	
		ENDCAP A	R OK	
		ENDCAP C	R W	
	TRT	BARREL A	R OK	
		BARREL C	R OK	
		ENDCAP A	R OK	
		ENDCAP C	R OK	
	Calorimeter	LAR	EMBA	R OK
			EMBC	R OK
EMECA			R OK	
EMECC			R OK	
HEC FCAL A			R OK	
HEC FCAL C			R OK	
TIL	LBA	R OK		
	LBC	R OK		
	EBA	R OK		
	EBC	R OK		
Muon Spectrometer	MDT	BARREL A	R W	
		BARREL C	R OK	
		ENDCAP A	R W	
		ENDCAP C	R OK	
	RPC	RPC SIDE A	R OK	
		RPC SIDE C	R OK	
		TGC SIDE A	R OK	
		TGC SIDE C	R OK	
	CSC	CSC SIDE A	R OK	
		CSC SIDE C	R OK	
		Services		
		FWD	ALFA	??? ???
LUCID	R OK			
ZDC	R OK			
SAF	DSS	R W		
	SNIFFERS	R W		
EXT	MAGNETS	R W		
	Toroids	20400 A		
	Solenoid	7729 A		
TDQ	TRIGGER L1	R OK		
CIC	COOLING	R OK		
	ENVIRONMENT	R OK		
	RACKS USAL1	R OK		
	RACKS USAL2	R OK		
	RACKS USL2	R OK		
	RACKS SDX1	R OK		
RACKS UX	R OK			



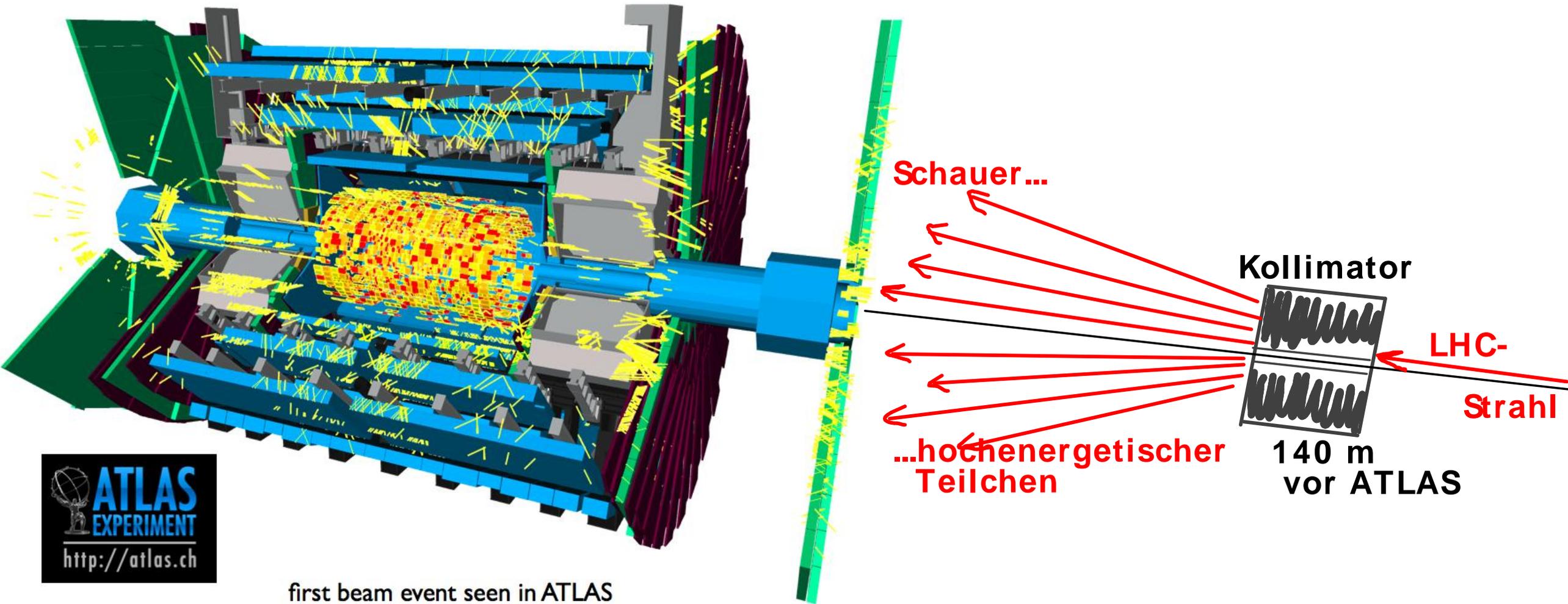
LHC: Beam on turns 1 and 2





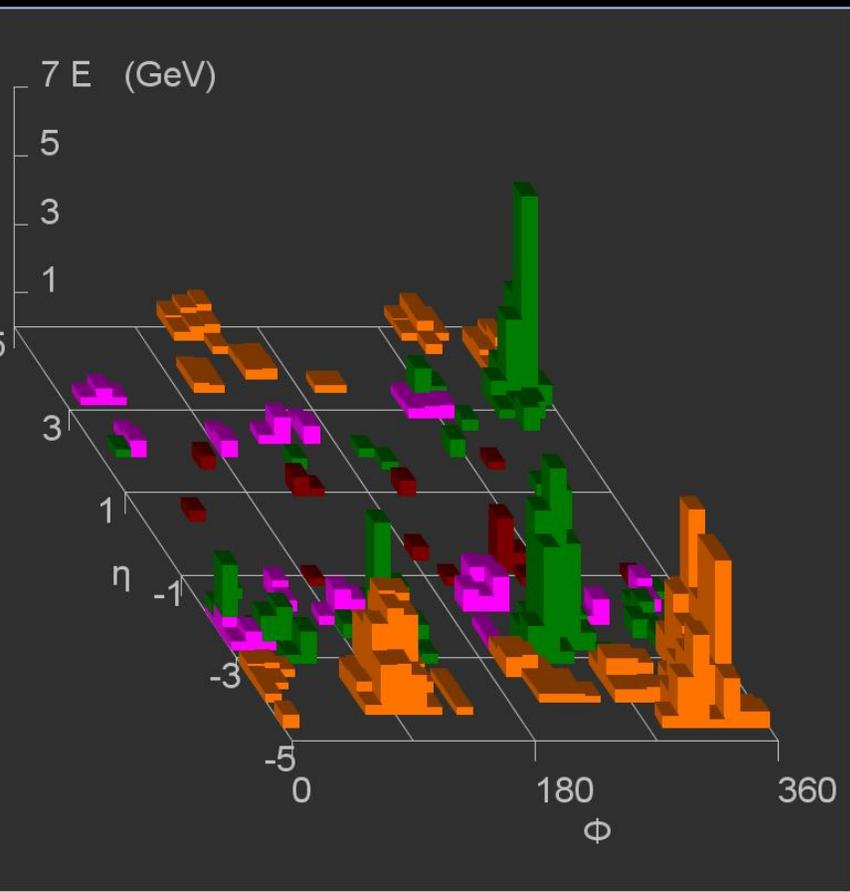
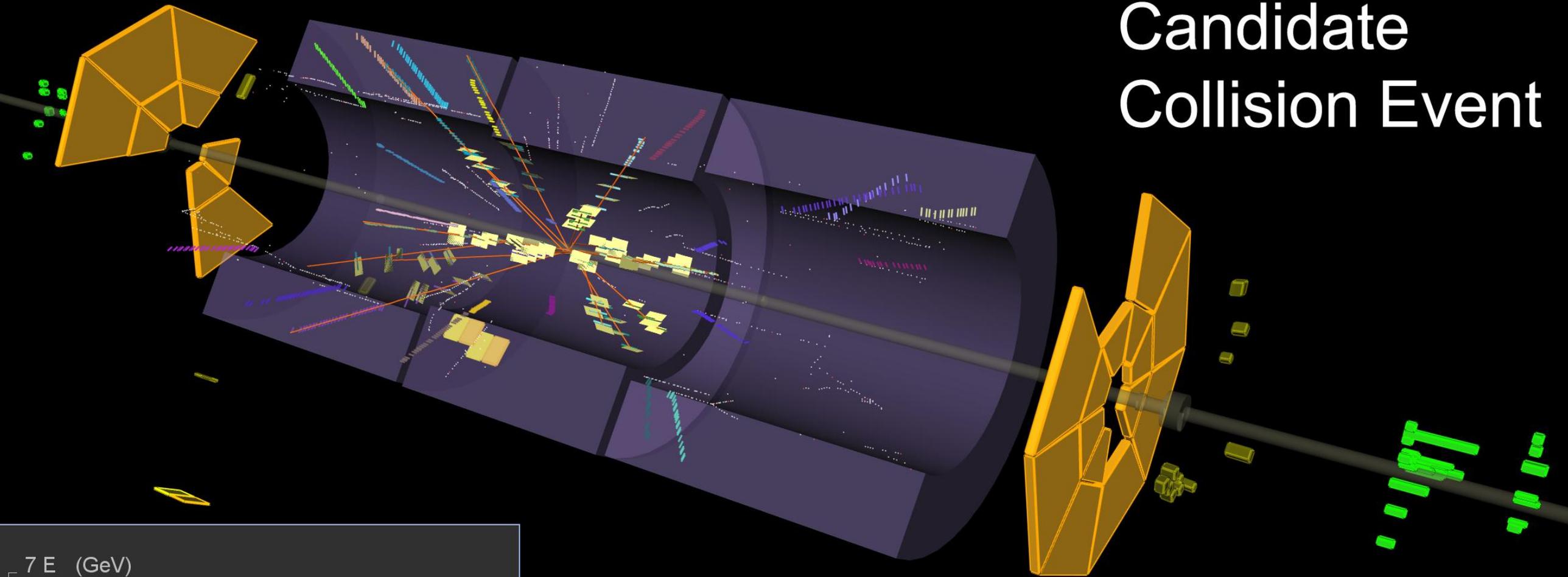
!!! BEAM AT ATLAS !!!
20-11-09 20:53

LHC: Strahl- Kollimation Reaktionen



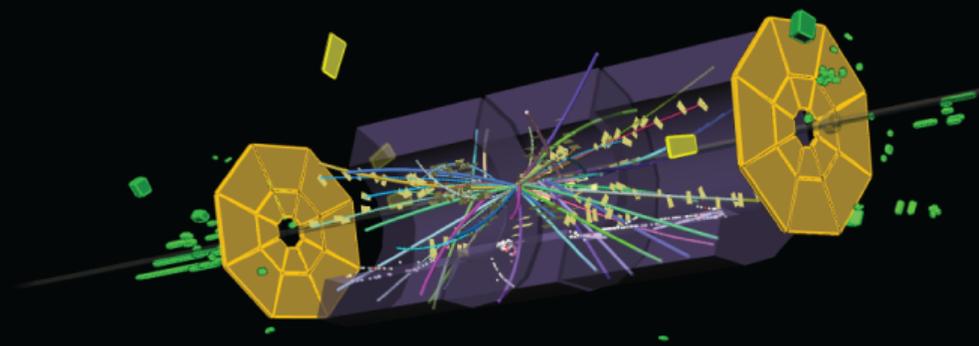


Candidate Collision Event



ATLAS
EXPERIMENT

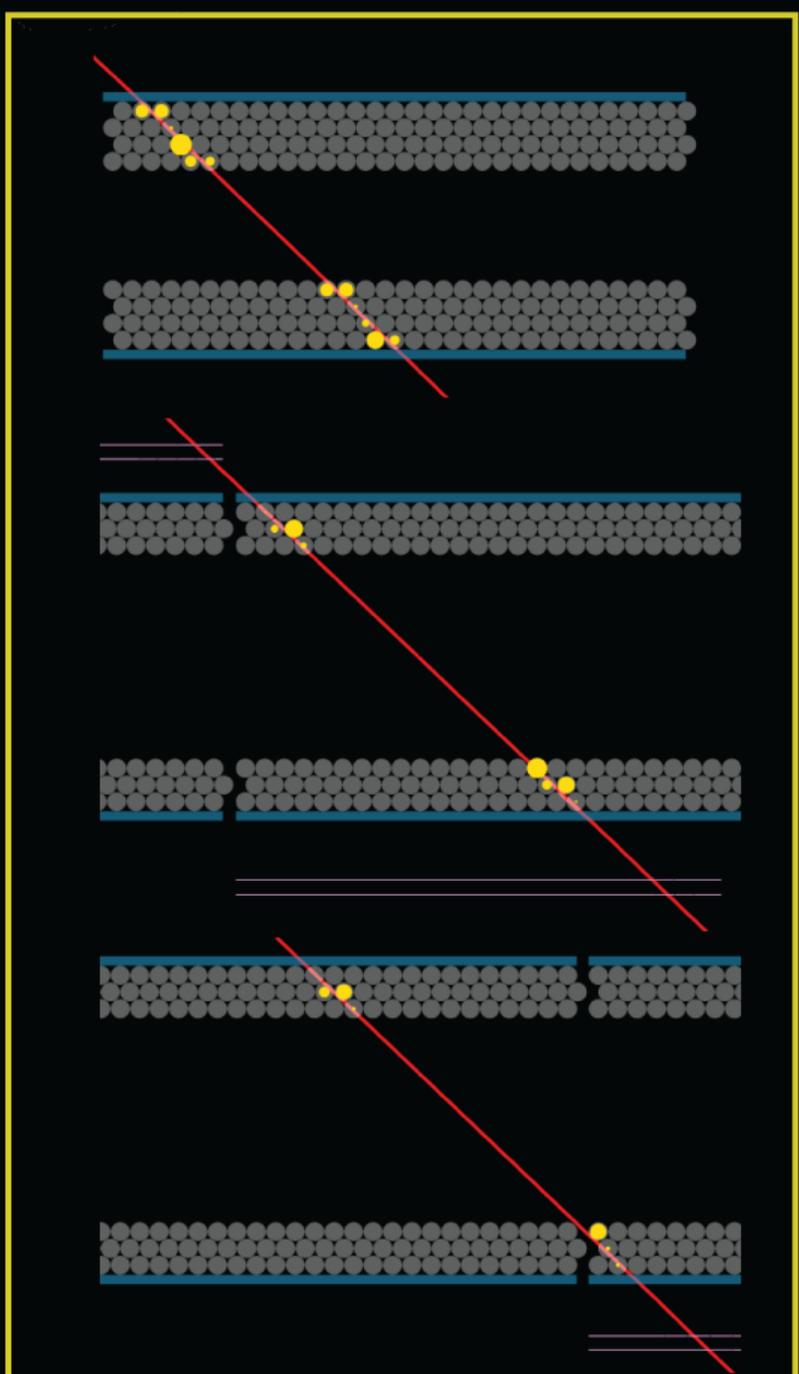
2009-11-23, 14:22 CET
Run 140541, Event 171897

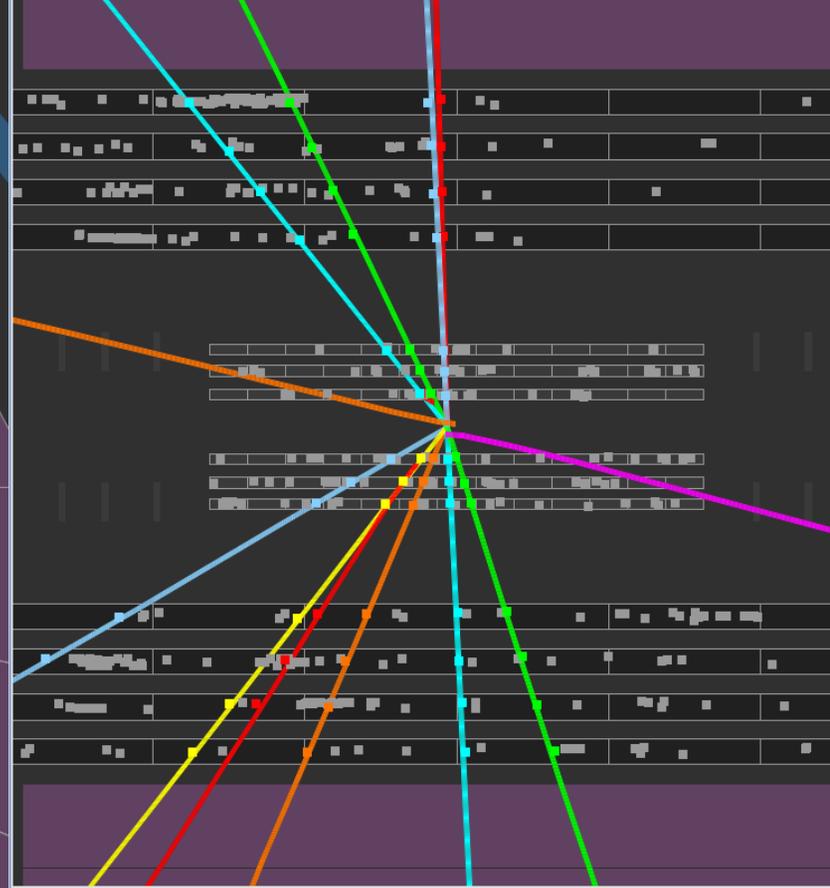
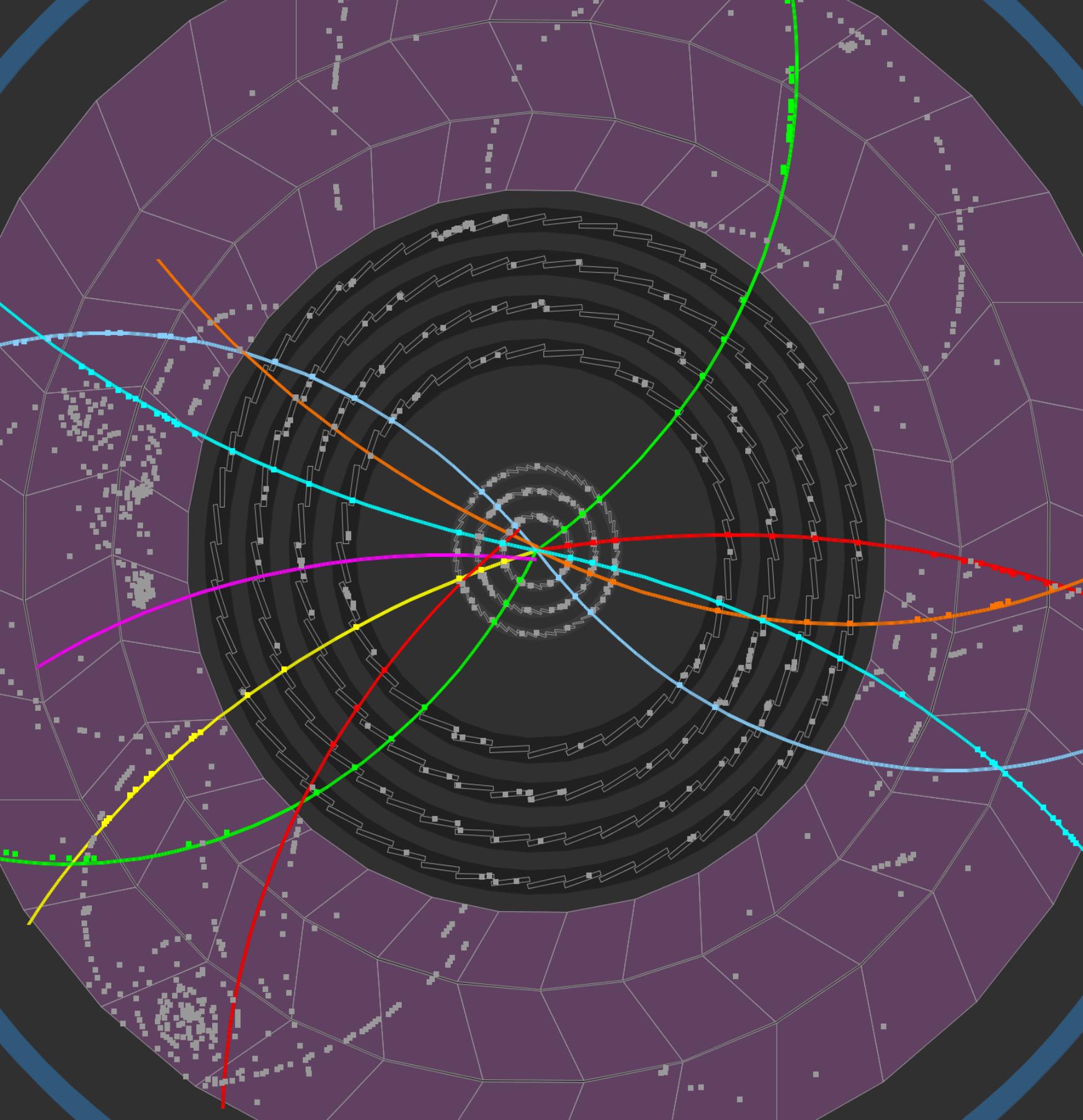


ATLAS EXPERIMENT

2009-12-06, 08:38 CET
Run 141749, Event 171059

Collision Event with Muon Track



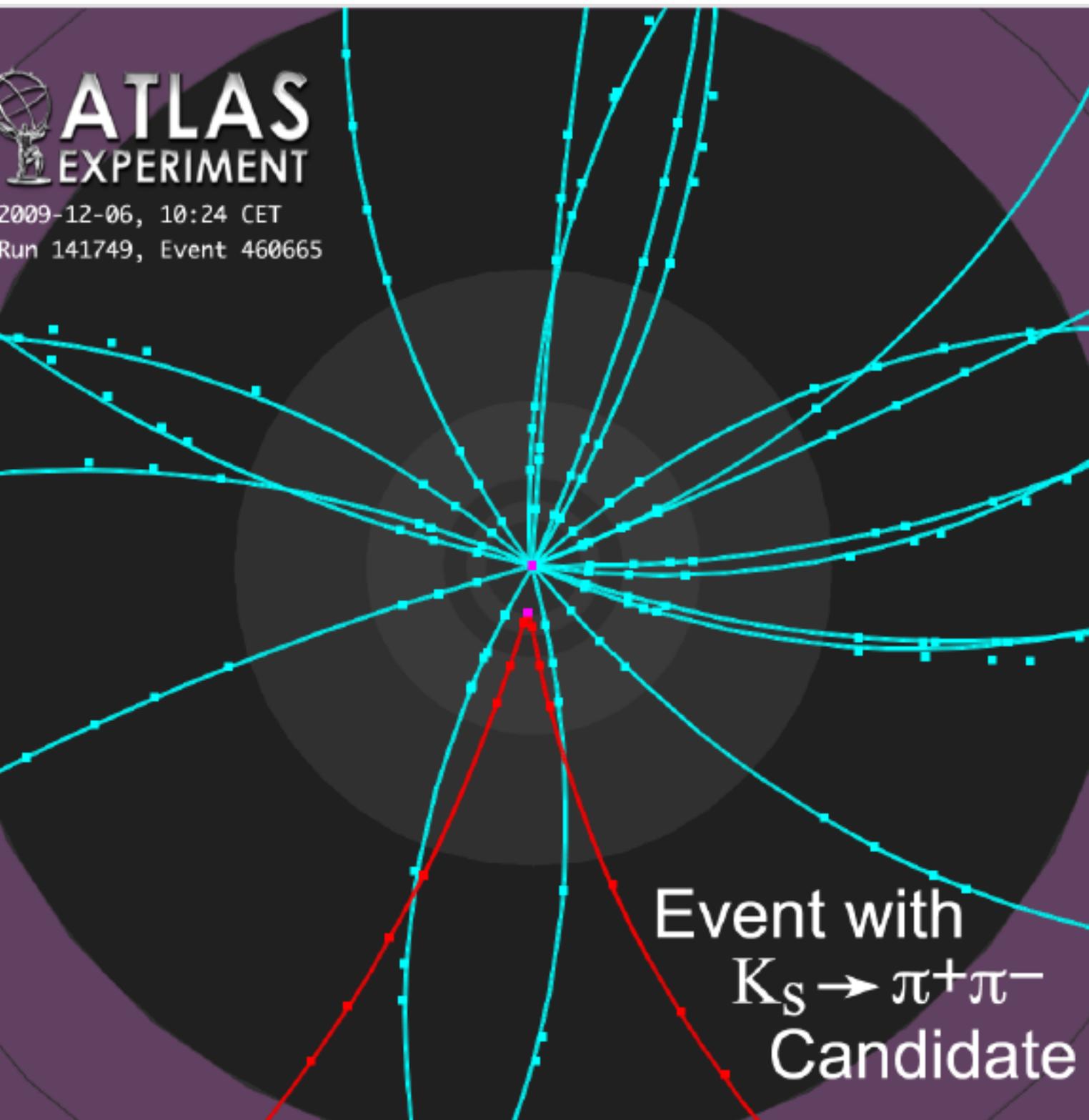


ATLAS
EXPERIMENT

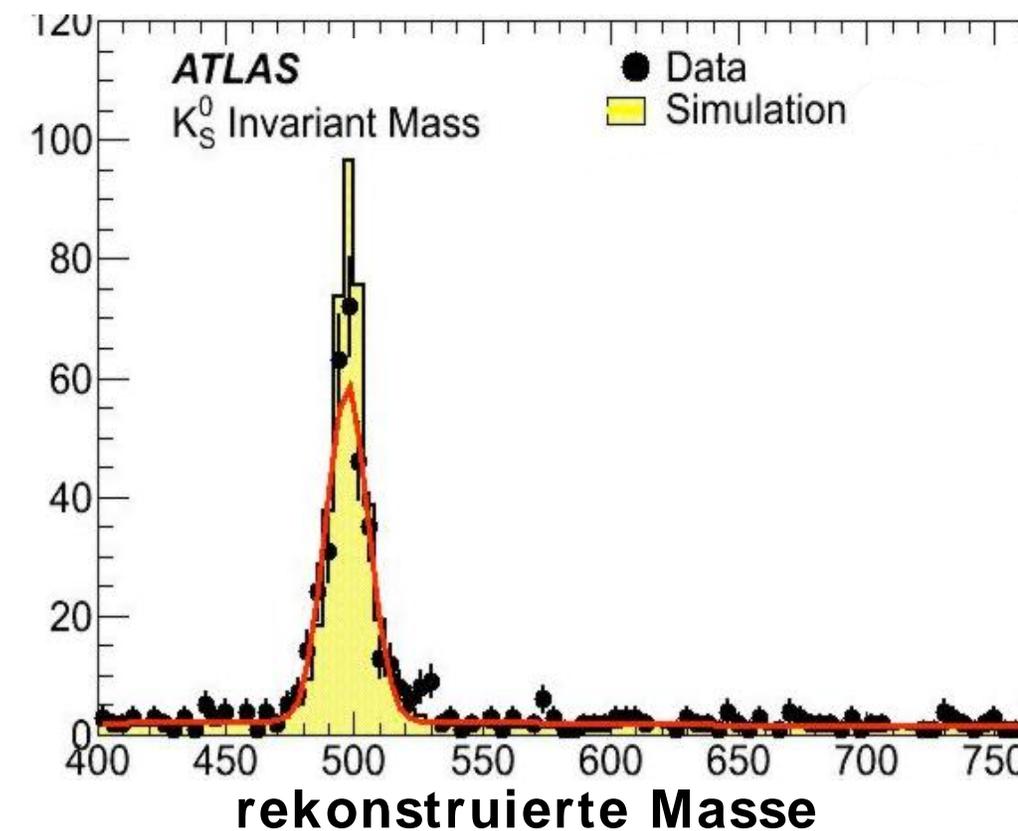
2009-12-06, 10:03 CET

Run 141749, Event 405315

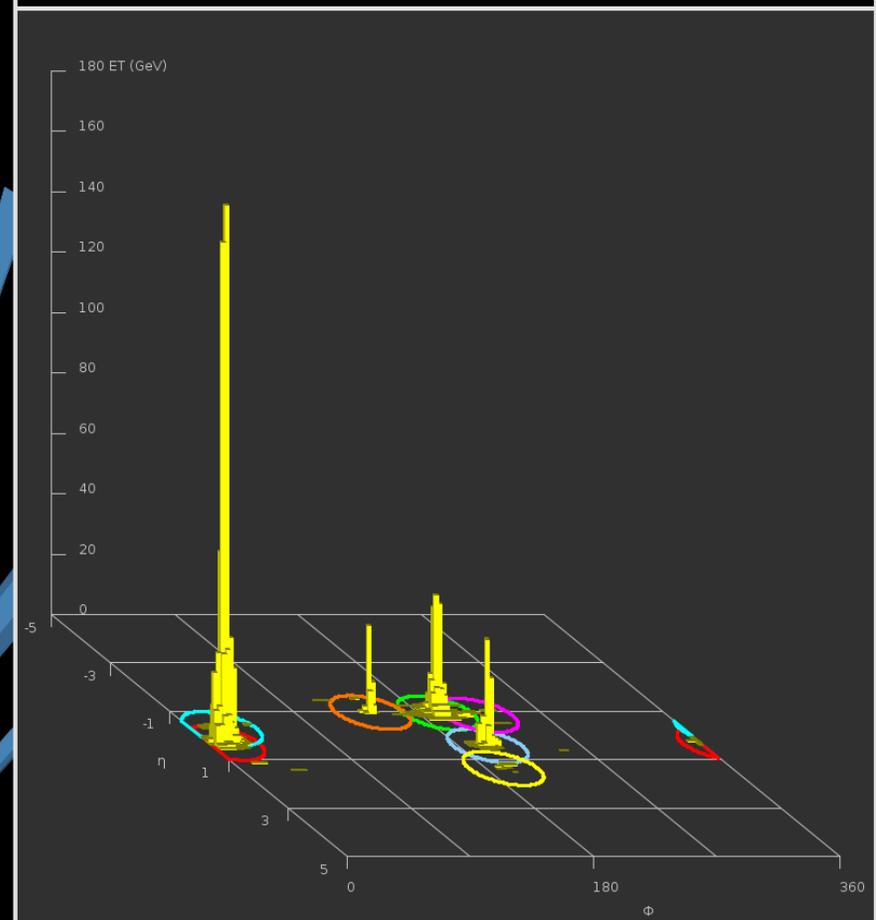
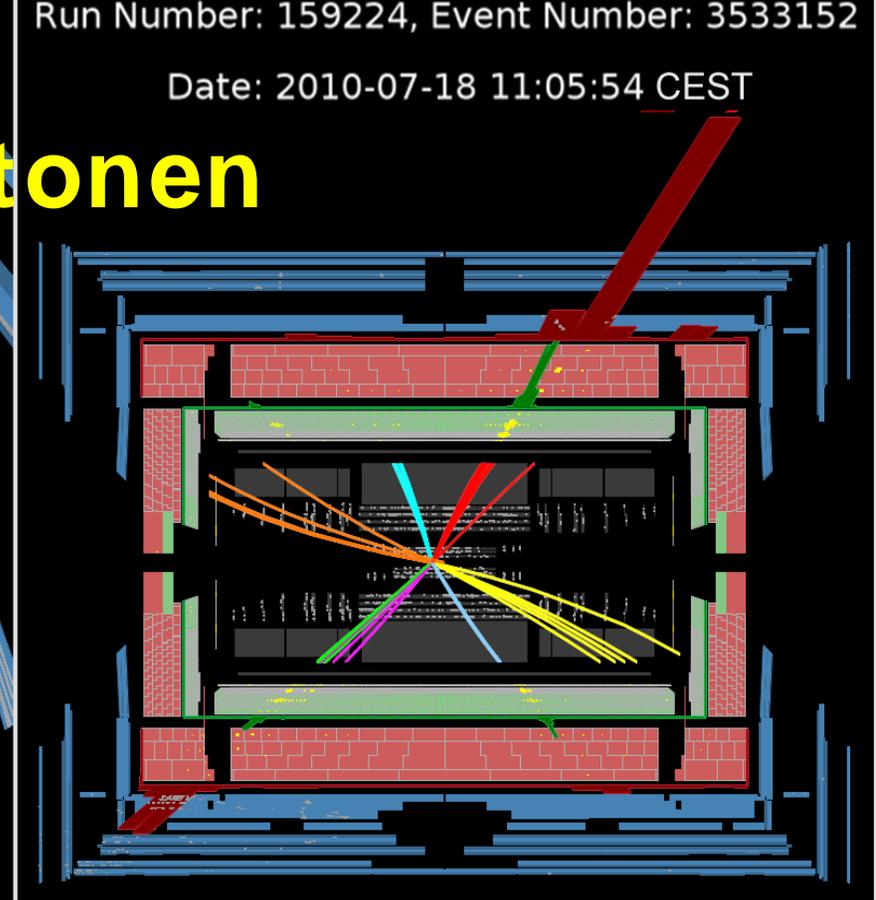
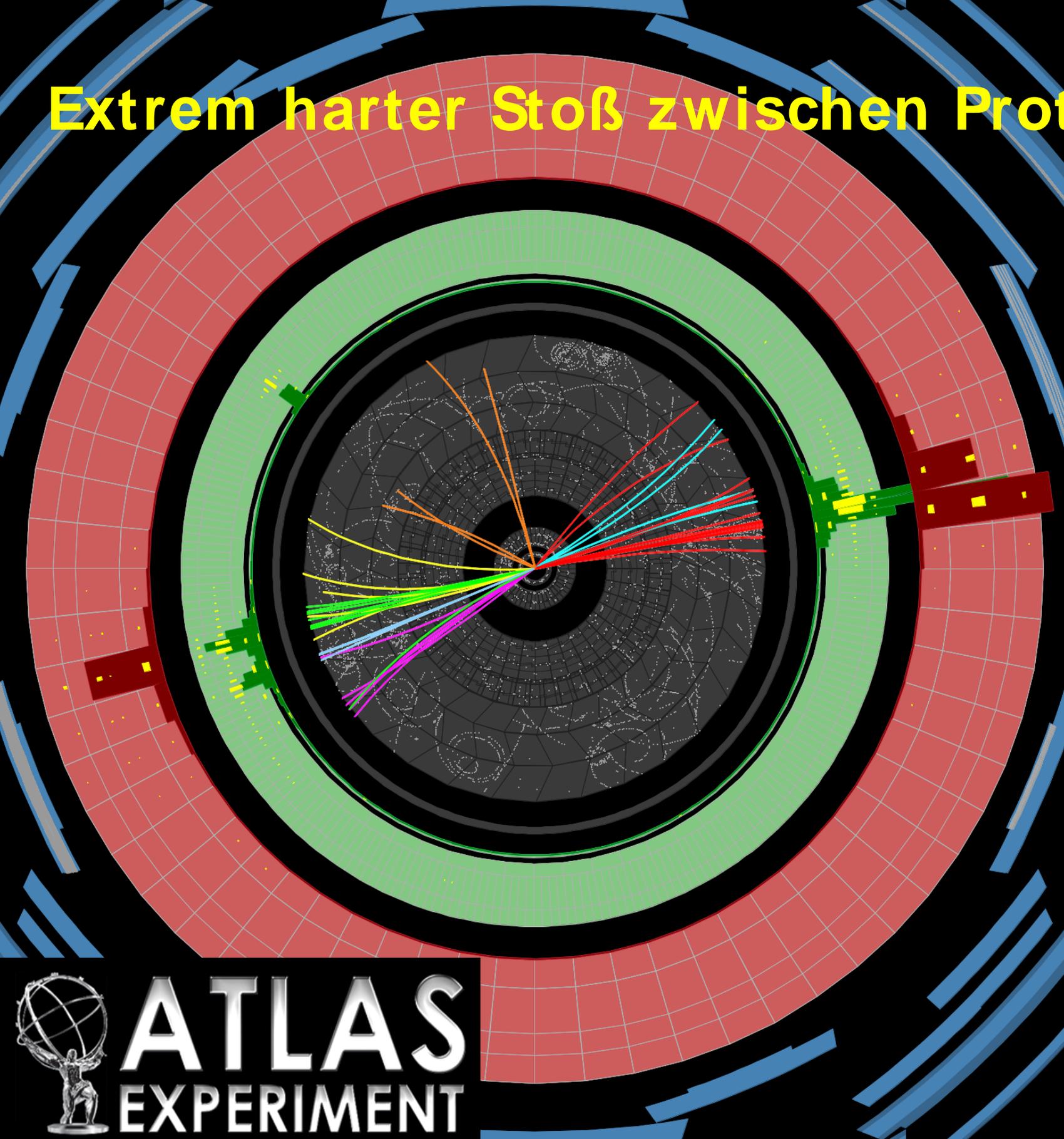
Collision Event



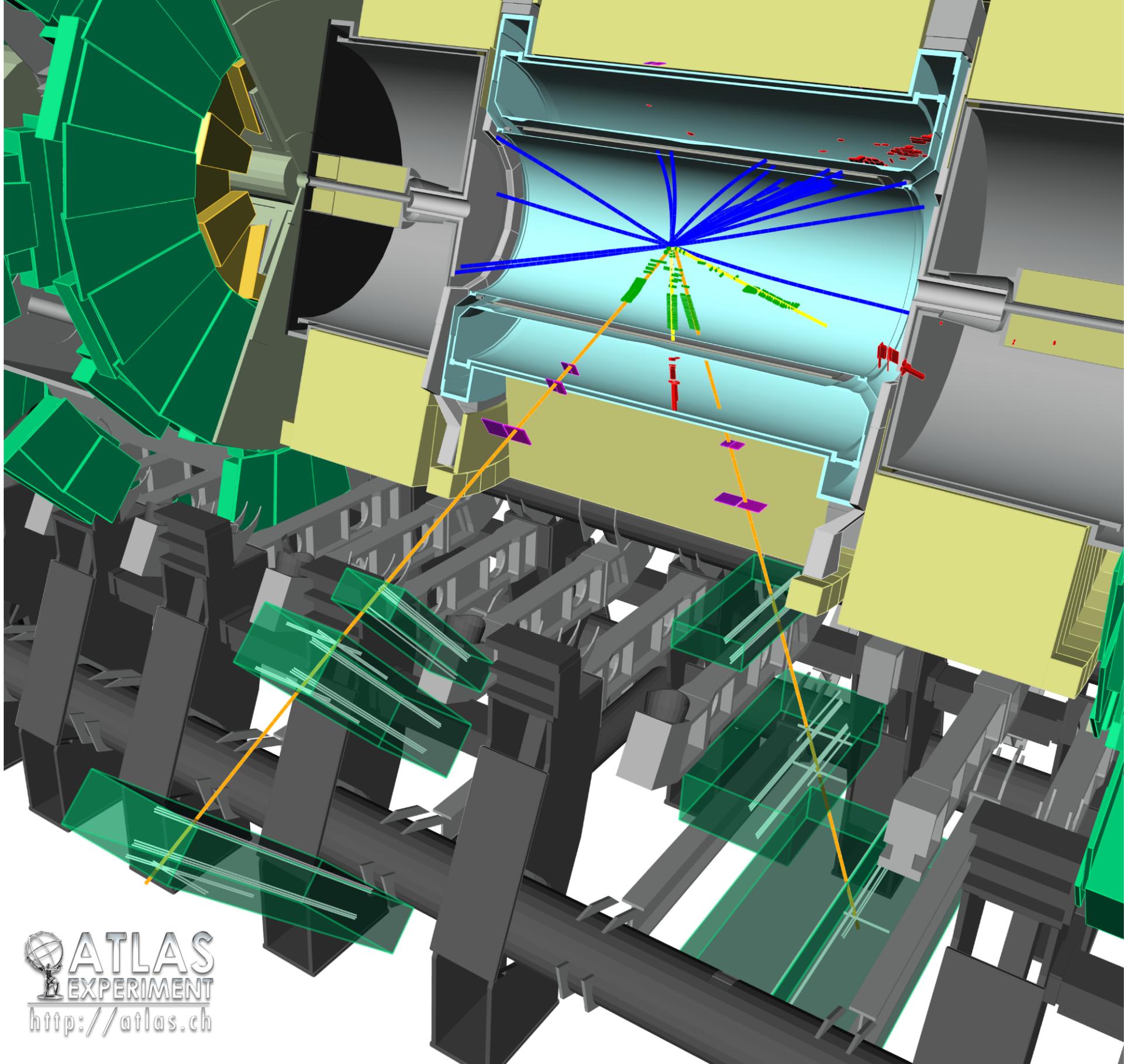
Rekonstruktion kurzlebiger Teilchen



Extrem harter Stoß zwischen Protonen



Ein Higgs- Teilchen ...



...
leider nur
Computer-
Simulation

Teilchenphysik komplett, wenn Higgs gefunden ?

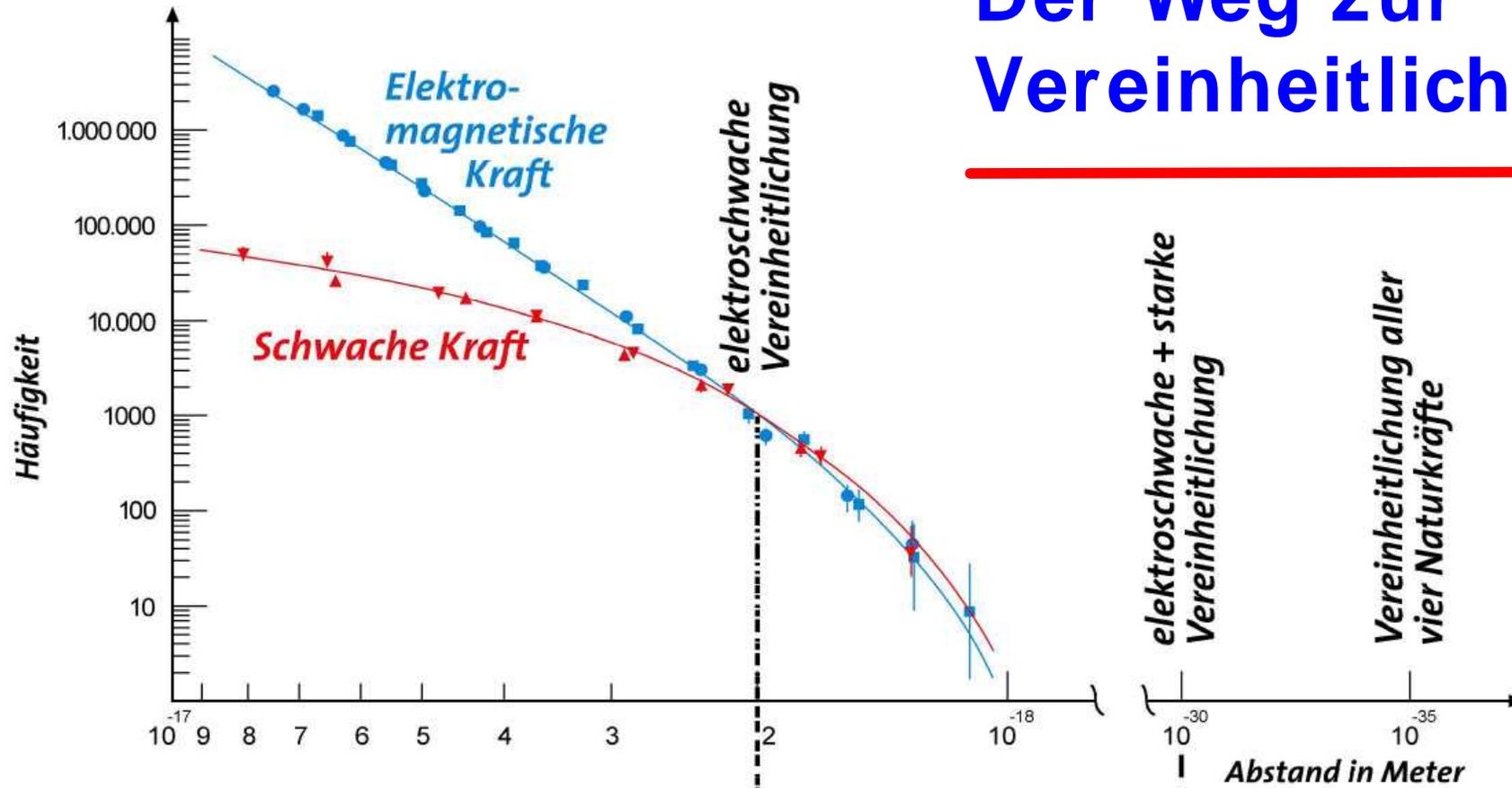
Antwort: **Nein !**

Viele offene Fragen:

- (1) Ist Higgs wirklich Ursprung der Teilchenmassen ?
- (2) Gibt es eine Vereinheitlichung der vier Kräfte ?
- (3) Gibt es weitere Teilchenfamilien ?
- (4) Was ist die Natur der "Dunklen Materie" im Universum ?
- (5) Gibt es weitere Raumdimensionen ?

...

Der Weg zur Vereinheitlichung aller Kräfte ?



Starke Kraft

Elektrische Kraft

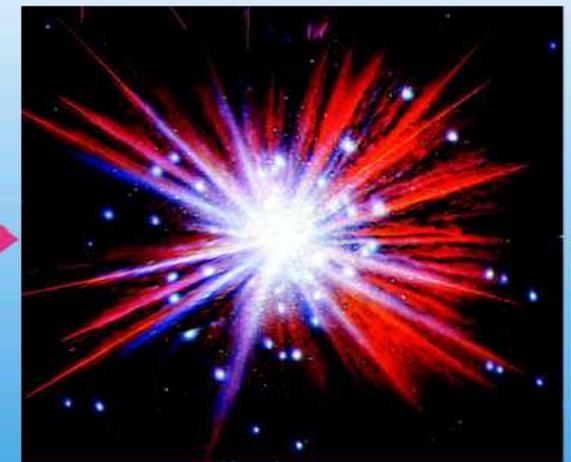
Schwache Kraft

Schwerkraft

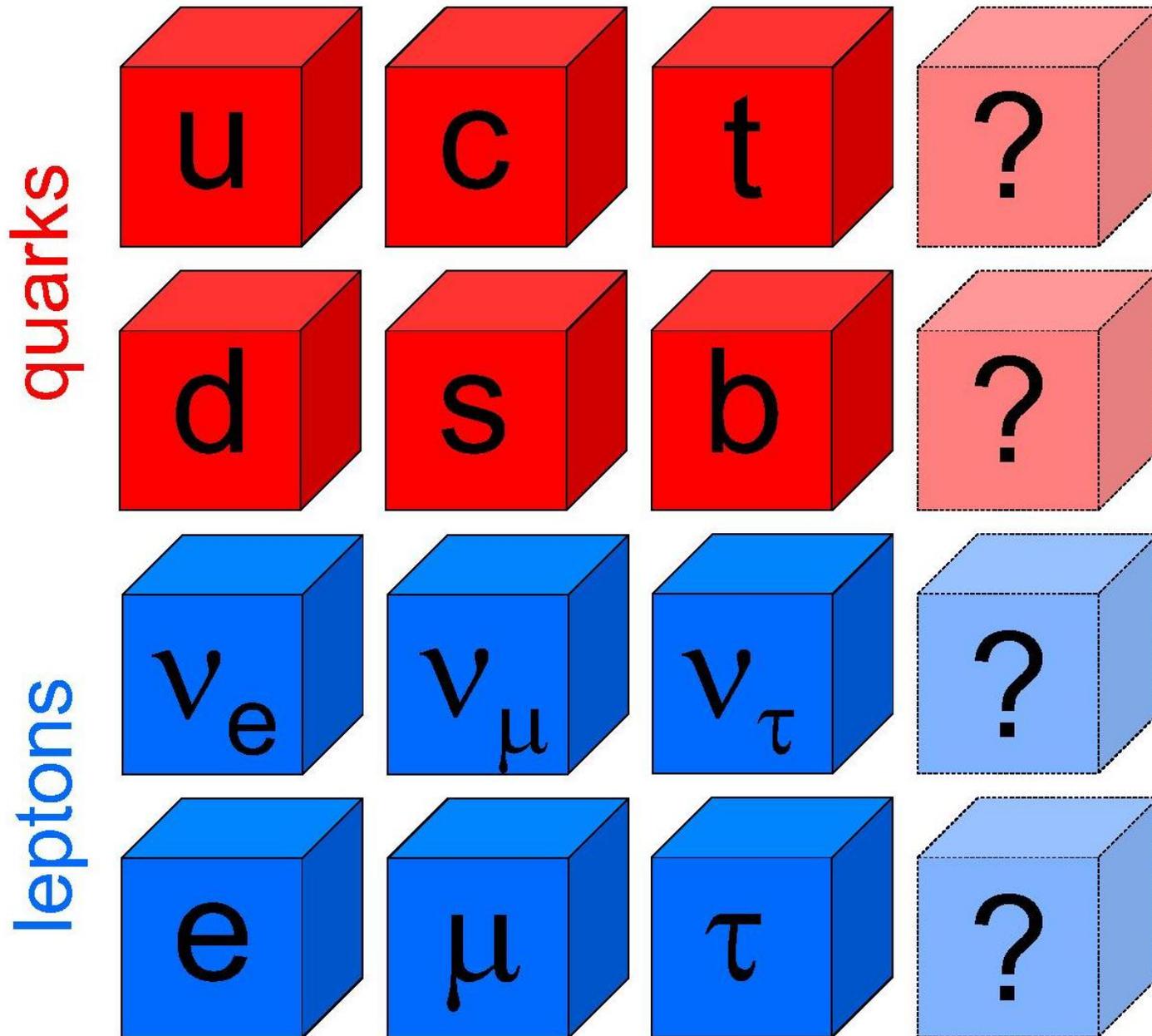
Elektroschwache Kraft

zunehmende Energie
100 GeV

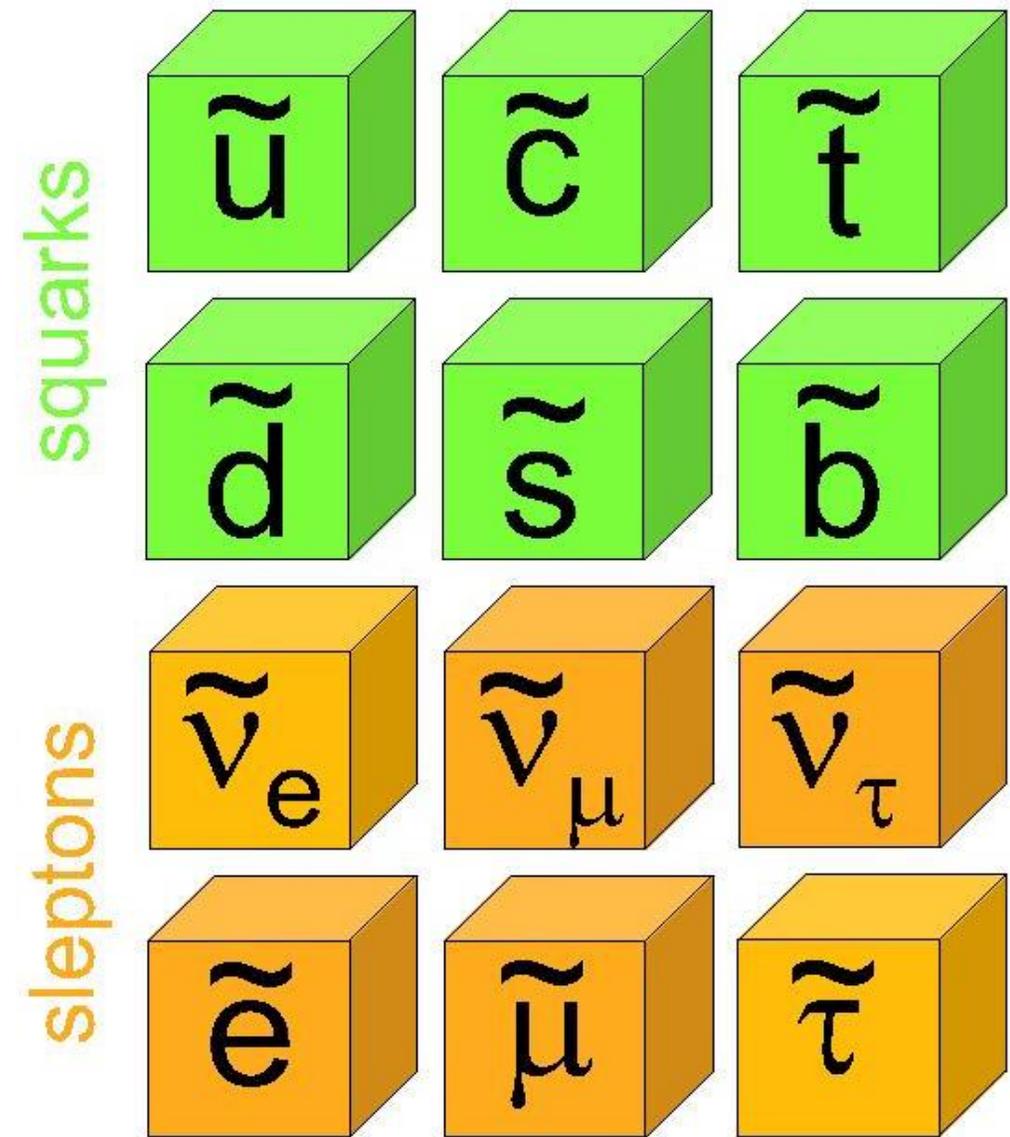
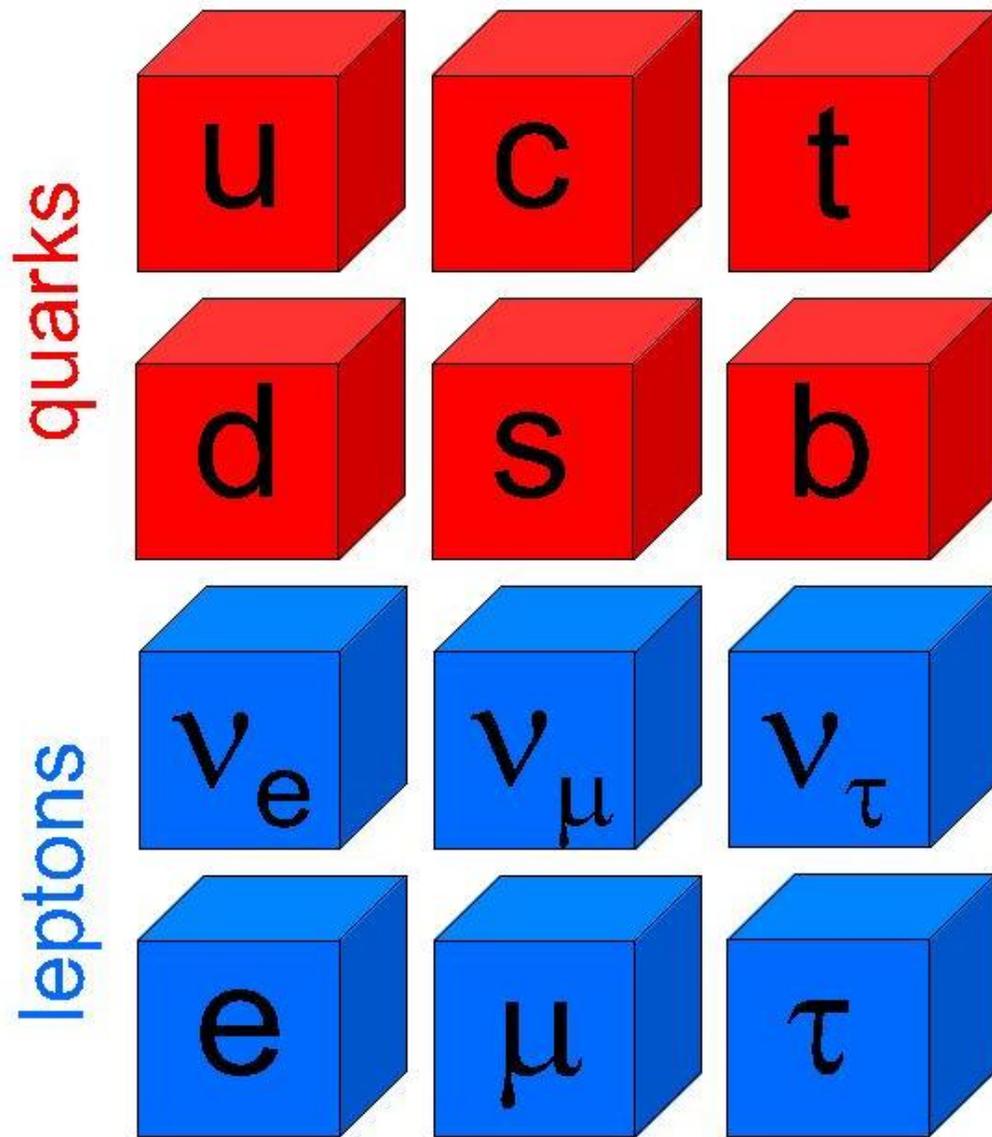
Urknall



Weitere Materiebausteine ?



SuperSymmetrie zwischen Materie- & Kraftteilchen ?

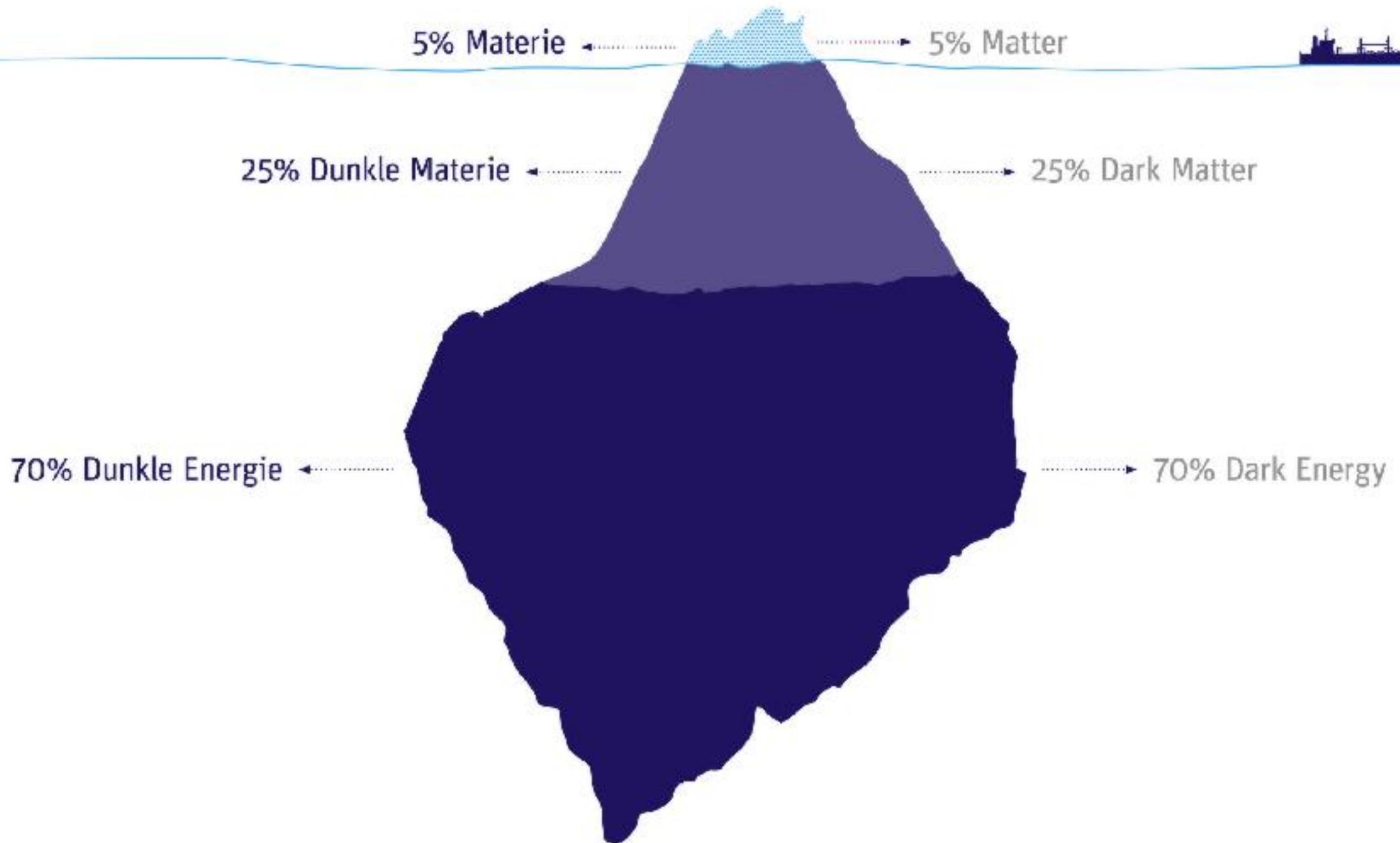


$\gamma, W^+, W^-, Z^0, g_{1..3}, H$

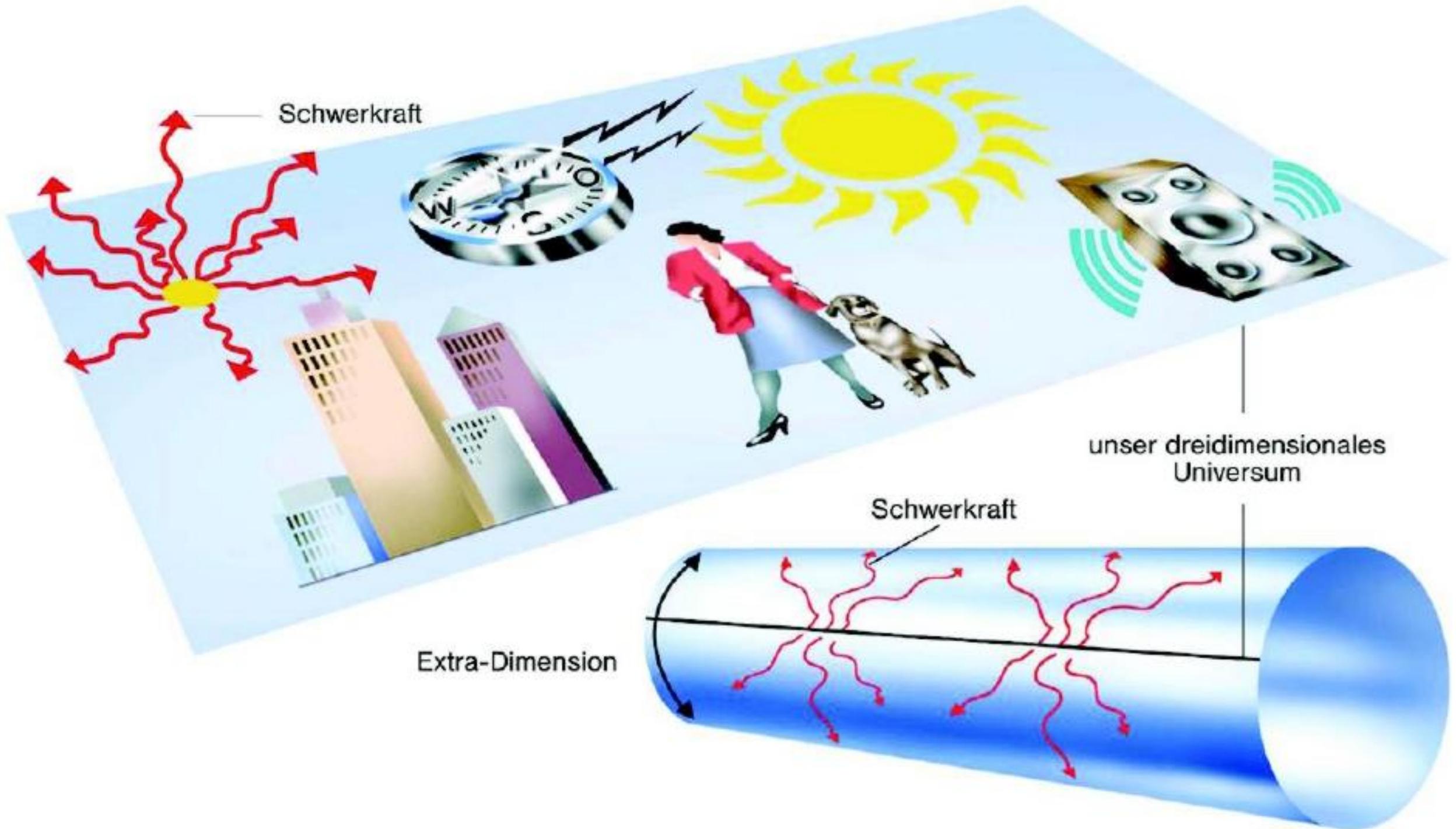
$\tilde{g}, \tilde{W}^+, \tilde{W}^-, \tilde{Z}^0, \tilde{g}_{1..3}, \hat{H}$

SuperSymmetrie- Teilchen < - ? - > Dunkle Materie

Bestandteile unseres Universums



Weitere mikroskopische Raumdimensionen ?



Antworten von LHC und den Detektoren erwartet !

Genfer See

Jura



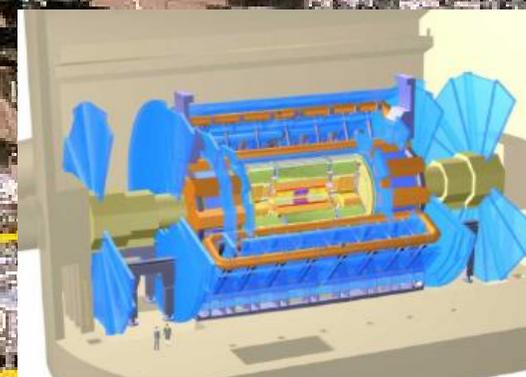
GMS

LHC

SPS

ATLAS

CERN



einige Mitarbeiter der ATLAS Arbeitsgemeinschaft



LHC- Teilchenphysik in Deutschland



gefördert durch
Bund & Länder:

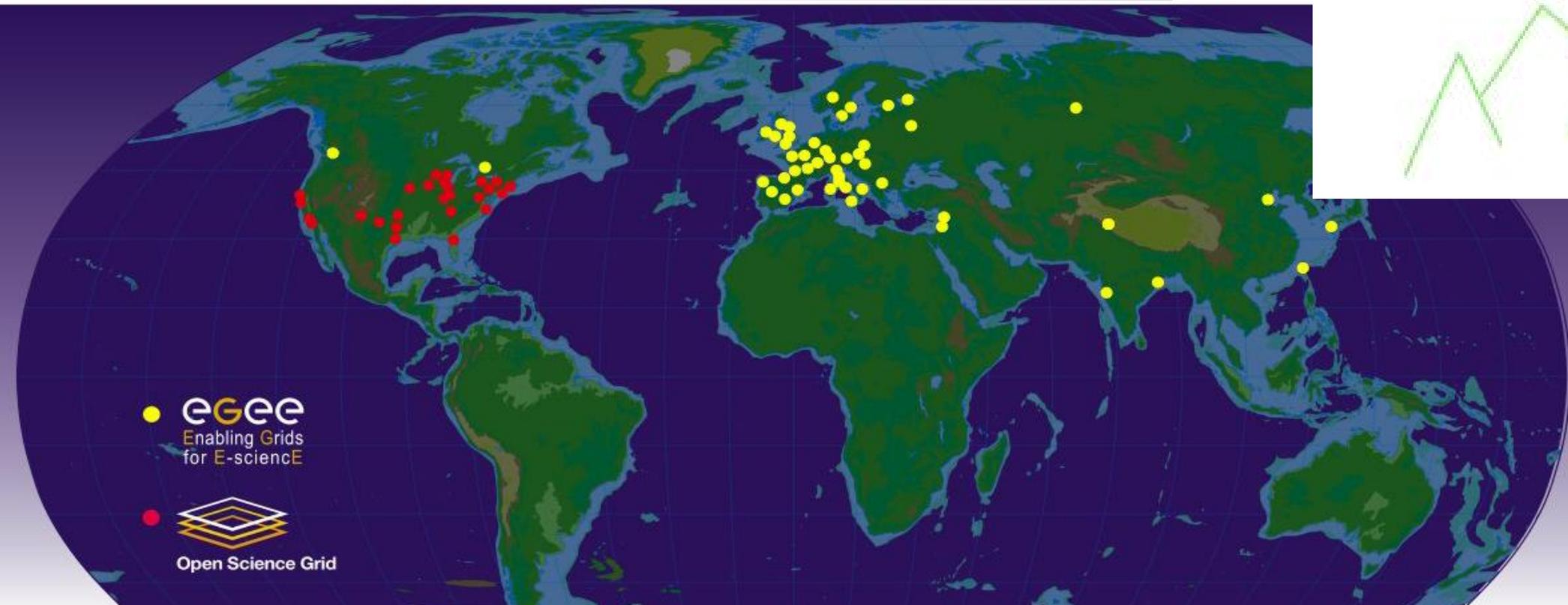
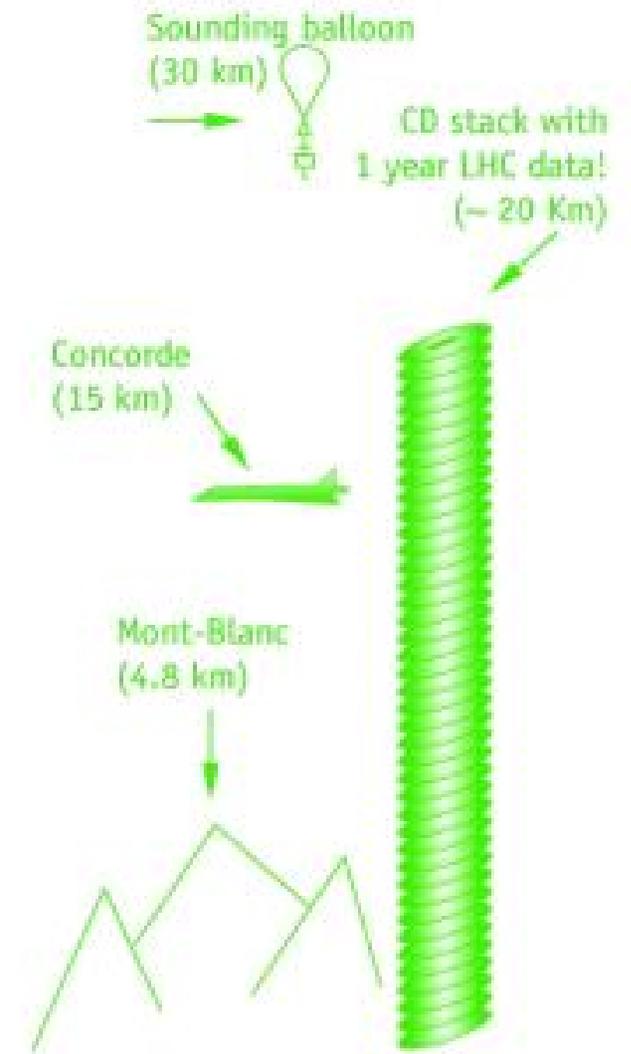
GEFÖRDERT VOM



Bundesministerium
für Bildung
und Forschung

DFG Deutsche
Forschungsgemeinschaft

LHC&Detektoren: Computing- und Daten- Grid



CERN: Geburtsplatz des WorldWideWeb !

2.

930430

ORGANISATION EUROPEENNE POUR LA RECHERCHE NUCLEAIRE
CERN EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

STATEMENT CONCERNING CERN W3 SOFTWARE RELEASE INTO PUBLIC DOMAIN

TO WHOM IT MAY CONCERN

Introduction

The World Wide Web, hereafter referred to as W3, is a global computer networked information system.

The W3 project provides a collaborative information system independent of hardware and software platform, and physical location. The project spans technical design notes, documentation, news, discussion, educational material, personal notes, publicity, bulletin boards, live status information and numerical data as a uniform continuum, seamlessly intergated with similar information in other disciplines.

The information is presented to the user as a web of interlinked documents .

Acces to information through W3 is:

- via a hypertext model;
- network based, world wide;
- information format independent;
- highly platform/operating system independent;
- scalable from local notes to distributed data bases.

Webs can be independent, subsets or supersets of each other. They can be local, regional or worldwide. The documents available on a web may reside on any computer supported by that web.

Declaration

The following CERN software is hereby put into the public domain:

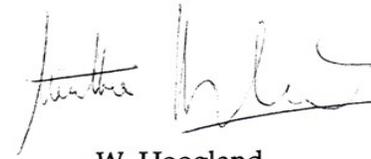
- W 3 basic ("line-mode") client
- W 3 basic server
- W 3 library of common code.

CERN's intention in this is to further compatibility, common practices, and standards in networking and computer supported collaboration. This does not constitute a precedent to be applied to any other CERN copyright software.

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Geneva, 30 April 1993



W. Hoogland
Director of Research



H. Weber
Director of Administration

Copie certifiée conforme

Fait à Genève le 03-05-93





Informationen im Web



Teilchenphysik in Deutschland

"Das Schönste, was wir erleben können, ist das Geheimnisvolle!" (A. Einstein)

*Was ist eigentlich Teilchenphysik?
An welchen Experimenten weltweit sind Teilchenphysiker beteiligt?
Und wie sind sie organisiert?*

*Wo kann man mehr über die Forschung der Teilchenphysik erfahren?
Gibt es eine Forschungsgruppe in meiner Nähe?
Wie kann man das Thema im Schulunterricht integrieren?
Und wo finde ich geeignetes Material dafür?*

Antworten auf diese und viele weitere Fragen finden Sie auf den folgenden Seiten.

- Teilchenphysik**
Eine kurze Einführung ins Thema Teilchenphysik mit Informationen zu Elementarteilchen, Experimenten und Teilchenbeschleunigern
- Multimedia**
Bilder, Fotos und Videos von verschiedenen Plattformen und Experimenten, Pressearchive und Links zu TV- und Radioendungen. Außerdem Skripte, Unterrichtsmaterialien und Lehrmaterialien für Schüler, Lehrer und Studenten.
- Teilchenphysik vor Ort**

Quarks, Elektronen & Co

Juli 2010, Dresden: das Netzwerk Teilchenwelt ist mit seinen neuen Webseiten online. [Mehr](#)

