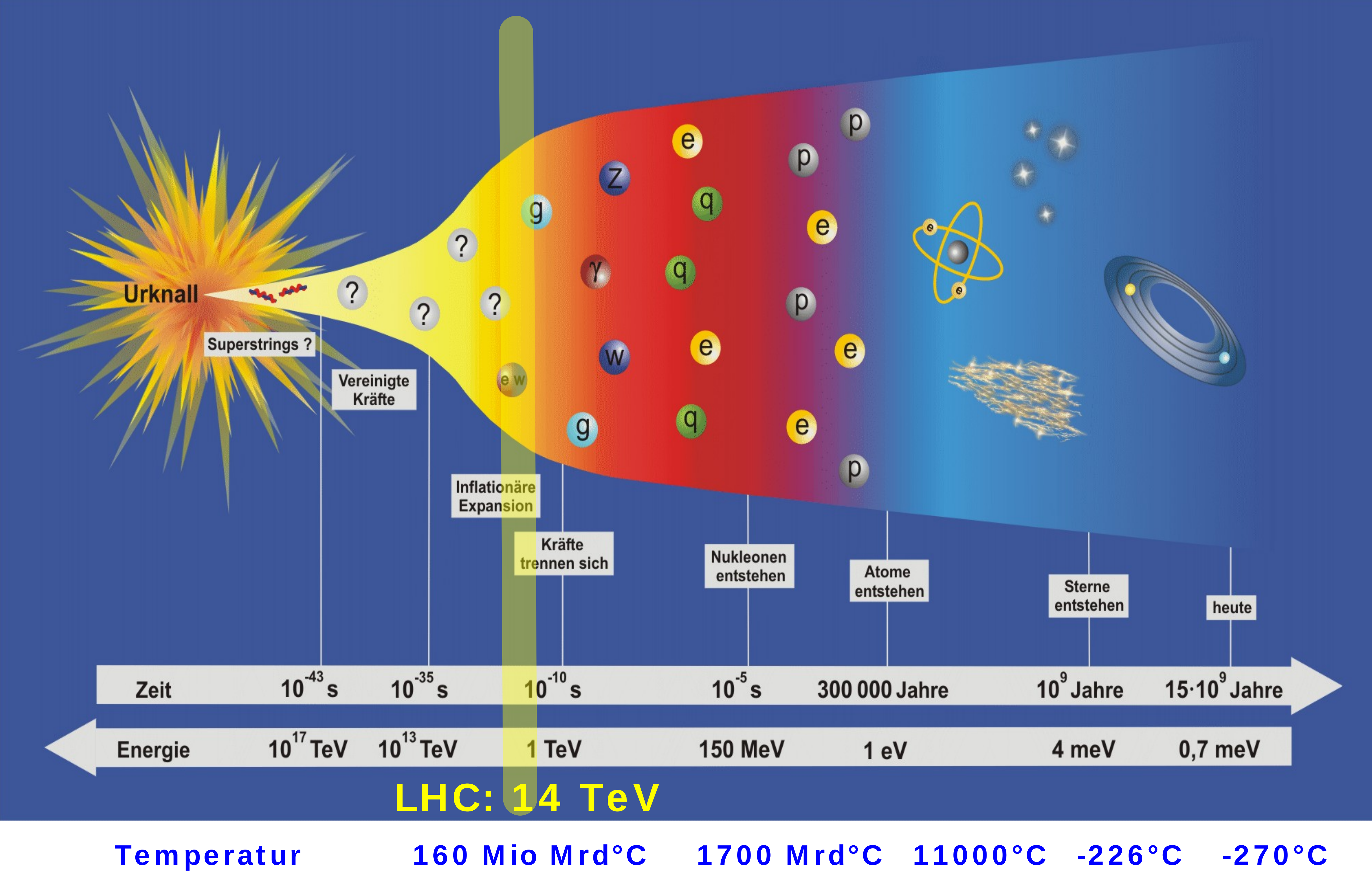
LHC und der Urknall im Labor

Prof. Dr. O.Biebel

LMU München

22. Mai 2013


DER UHRKNALL UNTER
LABORBEDINGUNGEN


Urknall
Superstrings ?
Vereinigte Kräfte
Inflationäre Expansion
Kräfte trennen sich
Nukleonen entstehen
Atome entstehen
Sterne entstehen
heute
Zeit
10^{-43} s
10^{-35} s
10^{-10} s
10^{-5} s
300 000 Jahre
10^{9} Jahre
$15 \cdot 10^{9}$ Jahre
Energie
10^{17} TeV
10^{13} TeV
1 TeV
150 MeV
1 eV
4 meV
0,7 meV
LHC: 14 TeV
Temperatur
160 Mio Mrd°C
1700 Mrd°C
11000°C
-226°C
-270°C

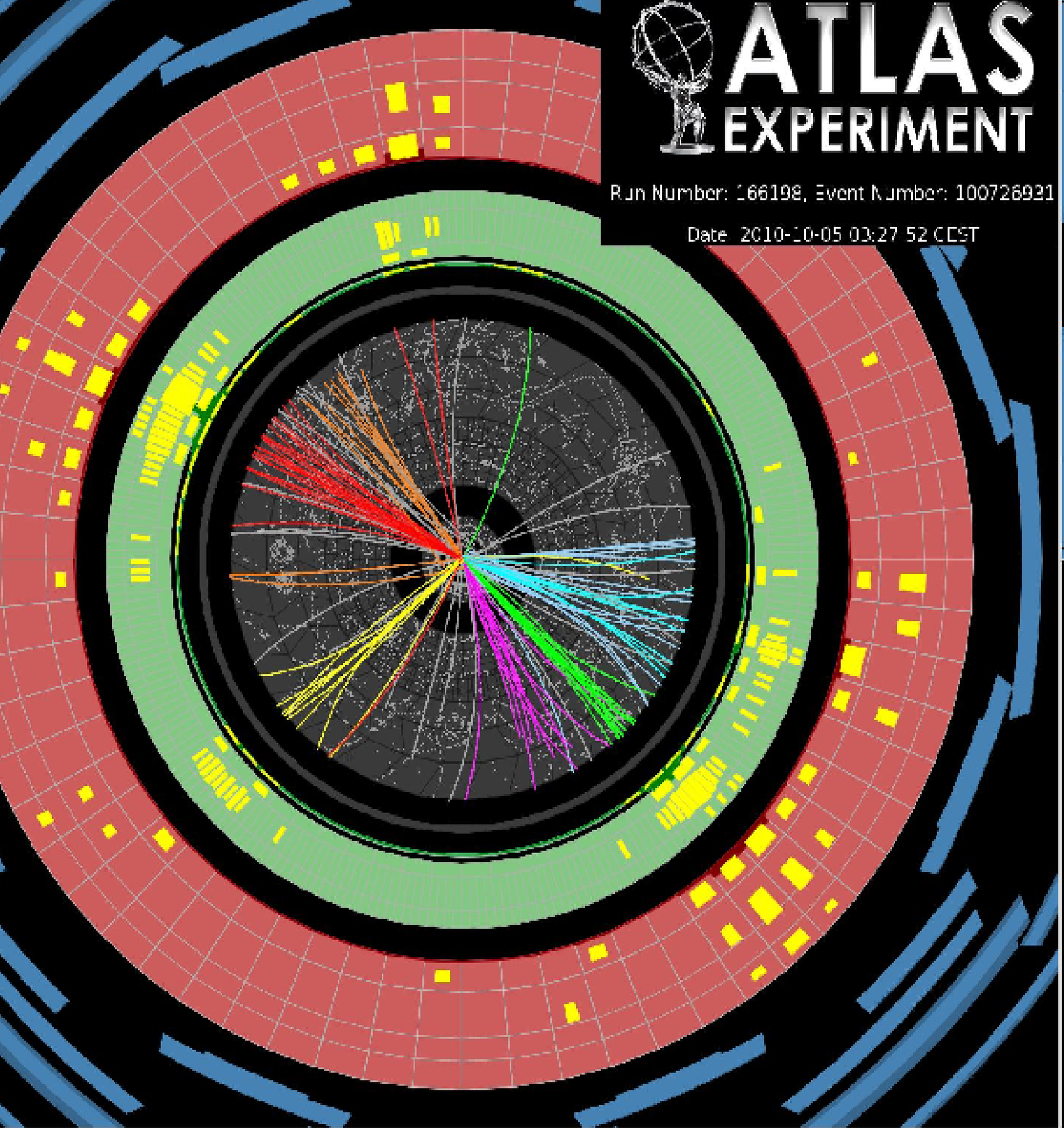

Genfer
See
CMS
Jura
LHC
SPS
ATLAS
CERN

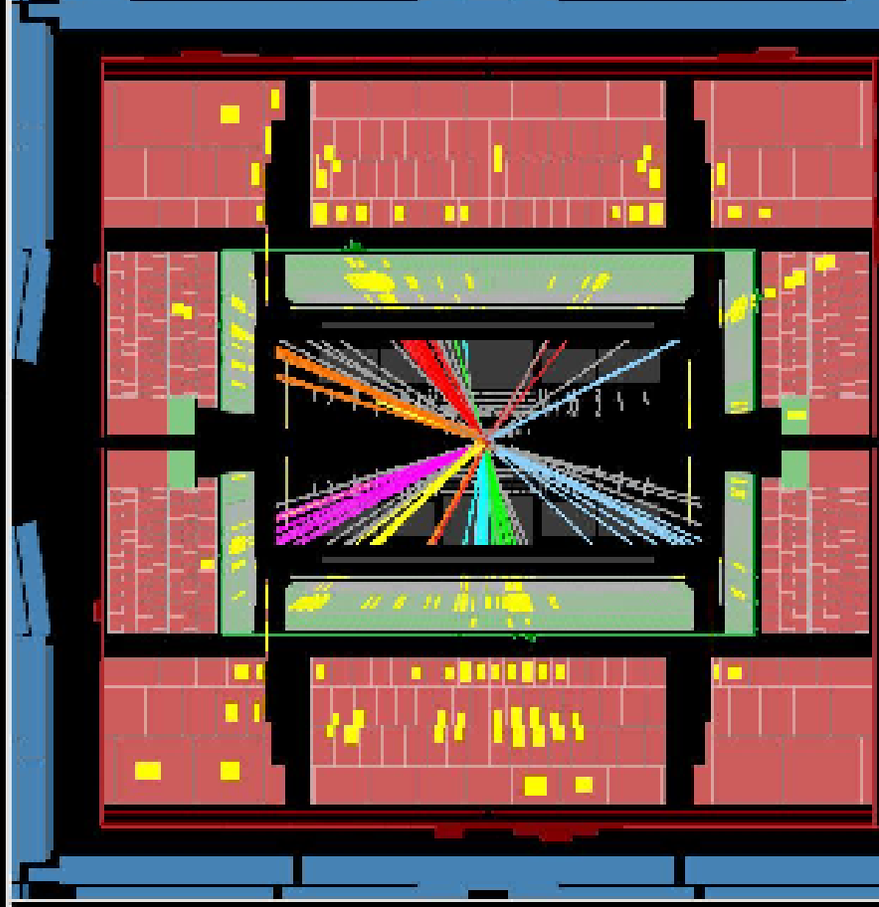
ATLAS Teilchendetektor

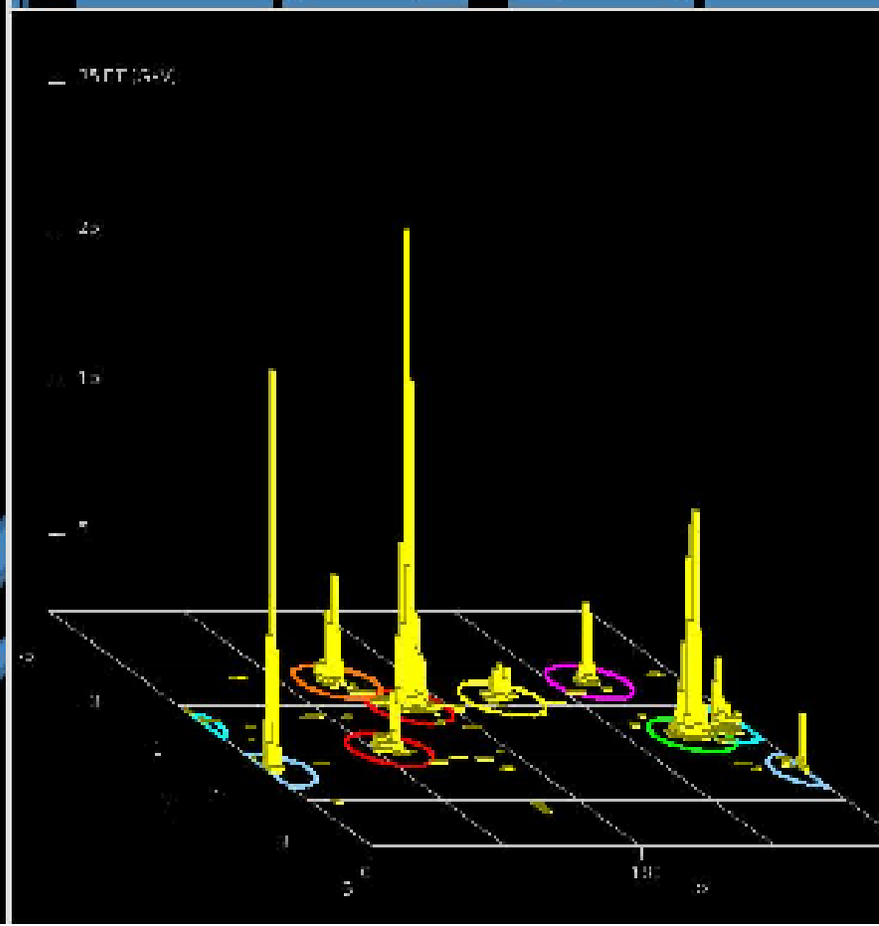
ATLAS EXPERIMENT

Run Number: 166198, Event Number: 100726921

Date: 2010-10-05 03:27:52 CEST

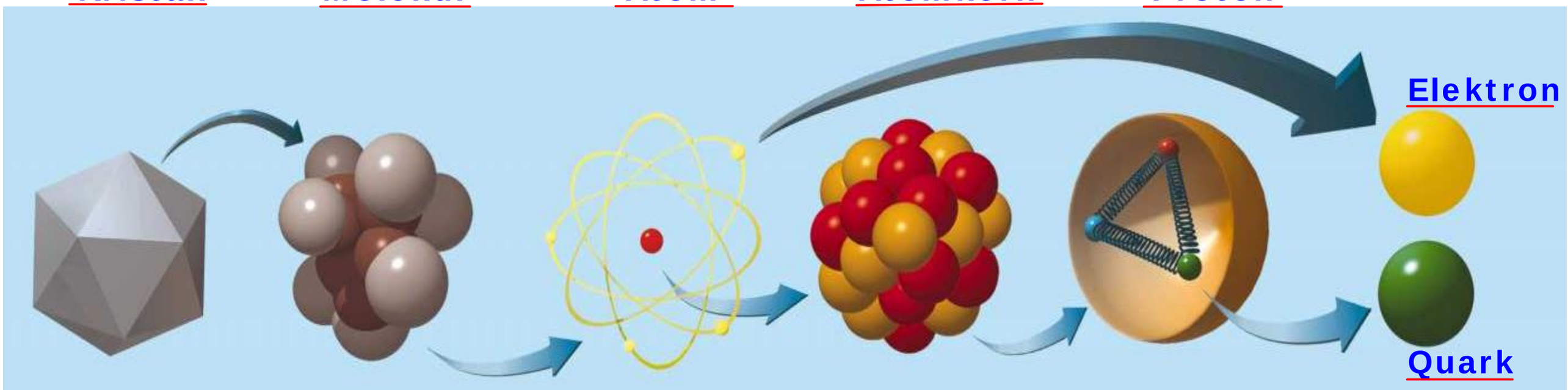






Struktur der Materie

Kristall Molekül Atom Atomkern Proton



Größenverhältnisse:

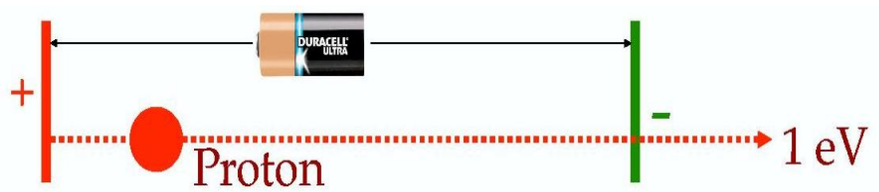
1/1.000.000 1/10 1/10.000 1/10 1/1000

typ. Größe:

0,001m 10^{-9}m 10^{-10}m 10^{-14}m 10^{-15}m $<10^{-21}$m

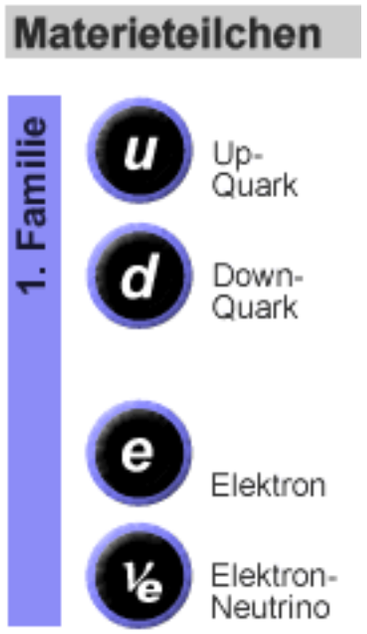
typ. Energie für experimentelle Untersuchung:

0,0001eV 0,1eV 1eV 10 MeV 1 GeV >1 TeV



Überblick

aller Elementar=teilchen



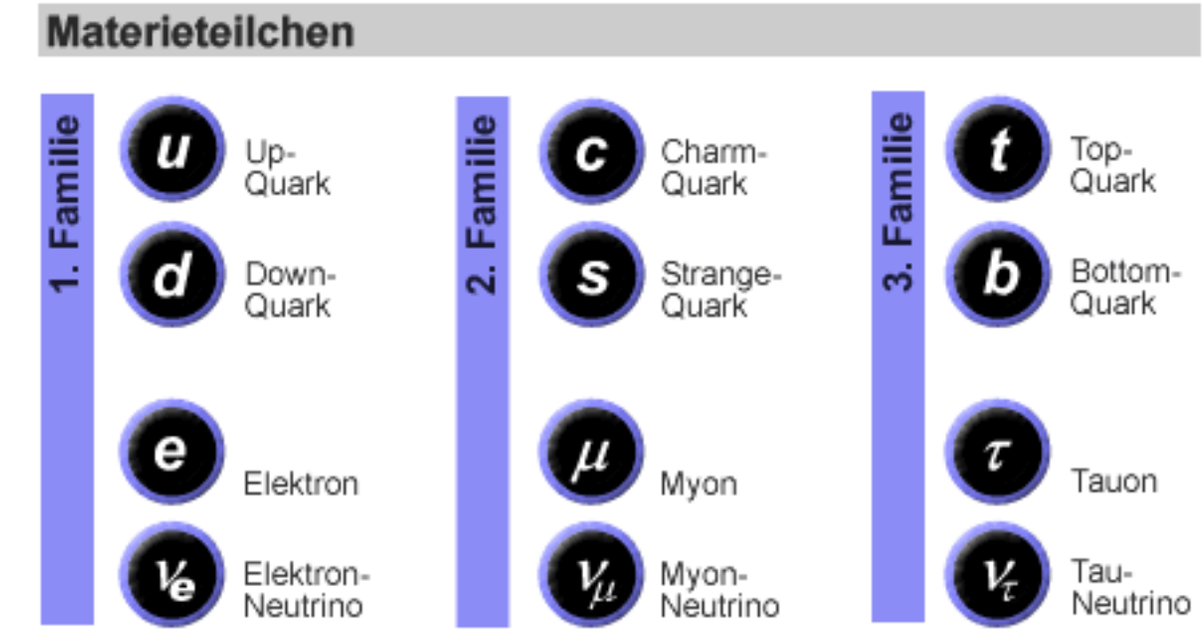
Bausteine für Proton & Neutron -> Atomkerne

Hülle der Atome

Radioaktivität; Fusion in Sonne

Überblick

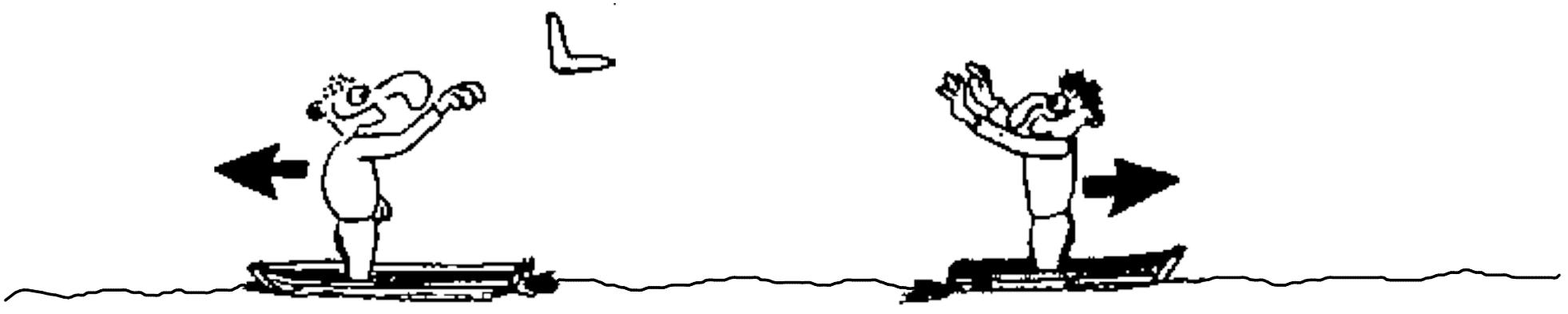
aller Elementar=teilchen



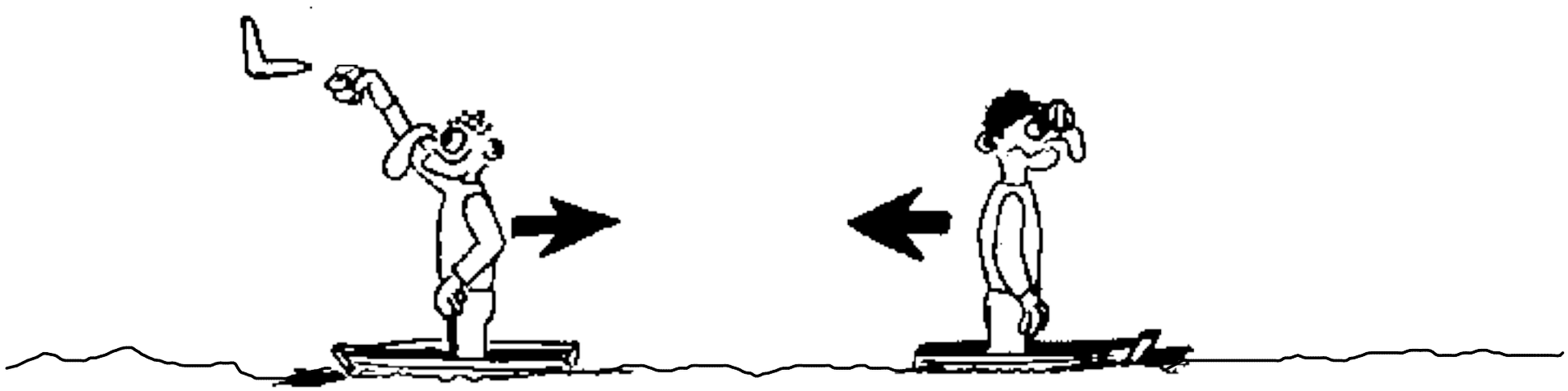
zunehmend massiver

Kräfte durch Kraftteilchen

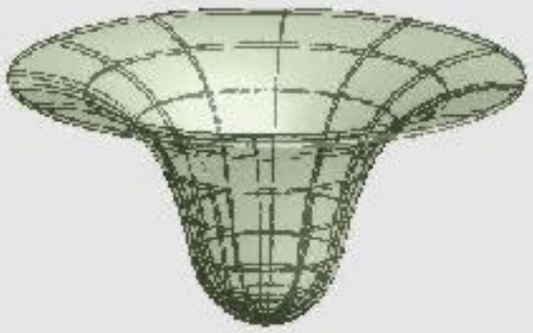
abstoßend:

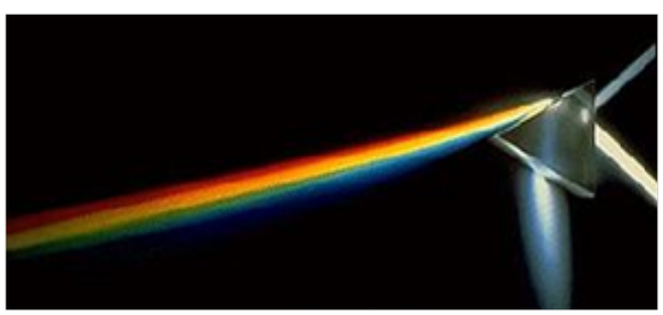


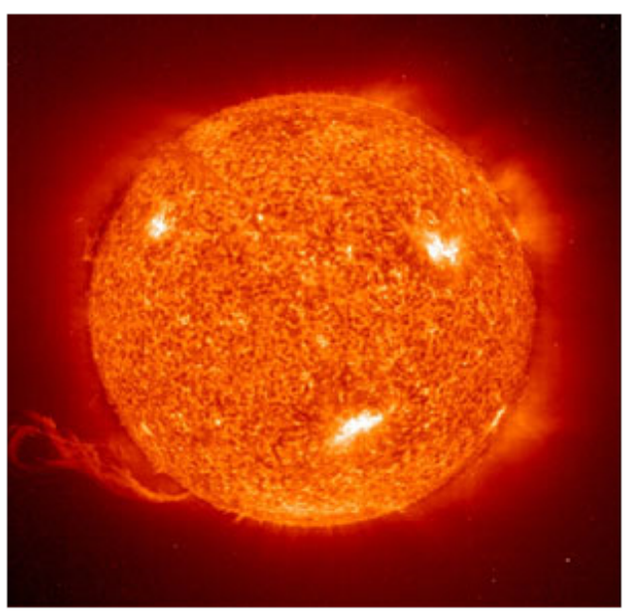
anziehend:

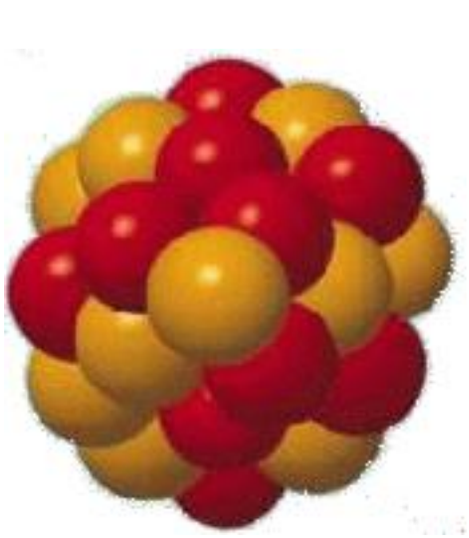


Vier bekannte Kräfte

Gravitation	elektromag. Kraft	schwache Kraft	starke Kraft
	1 Photon 	3 Bosonen 	8 Gluonen 



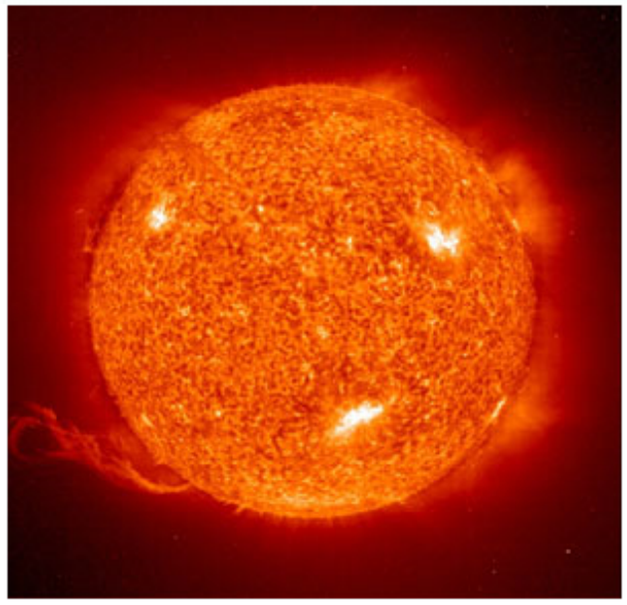


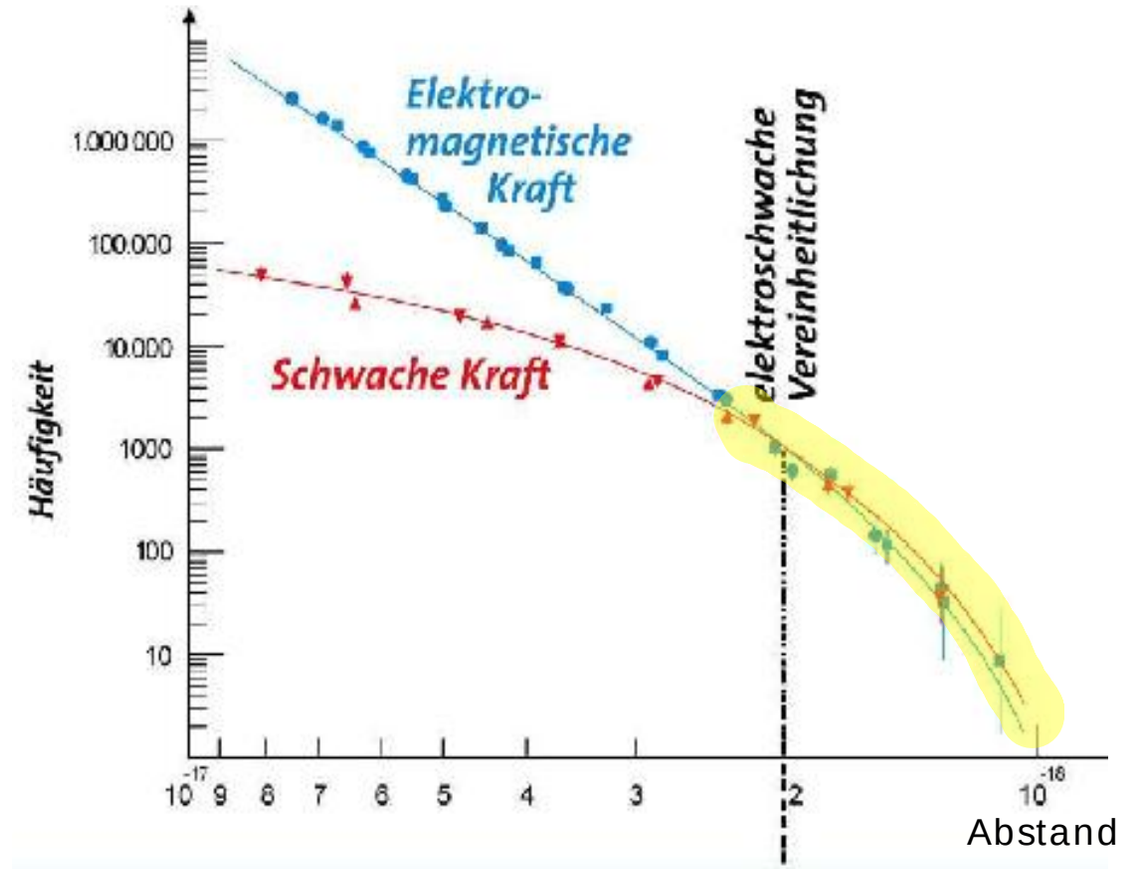


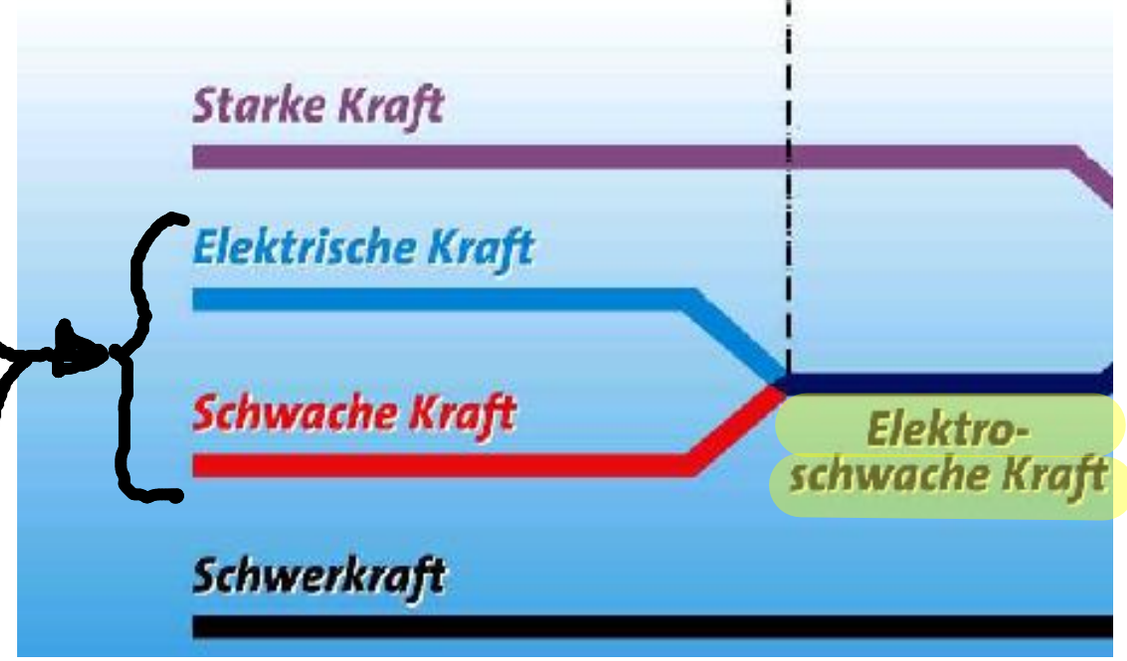
Vereinigung elektromag.&schwache Kräfte

---> Standardmodell der Teilchenphysik !

elektromag. Kraft	schwache Kraft
1 Photon	3 Bosonen
	Z^0 W^+ W^-

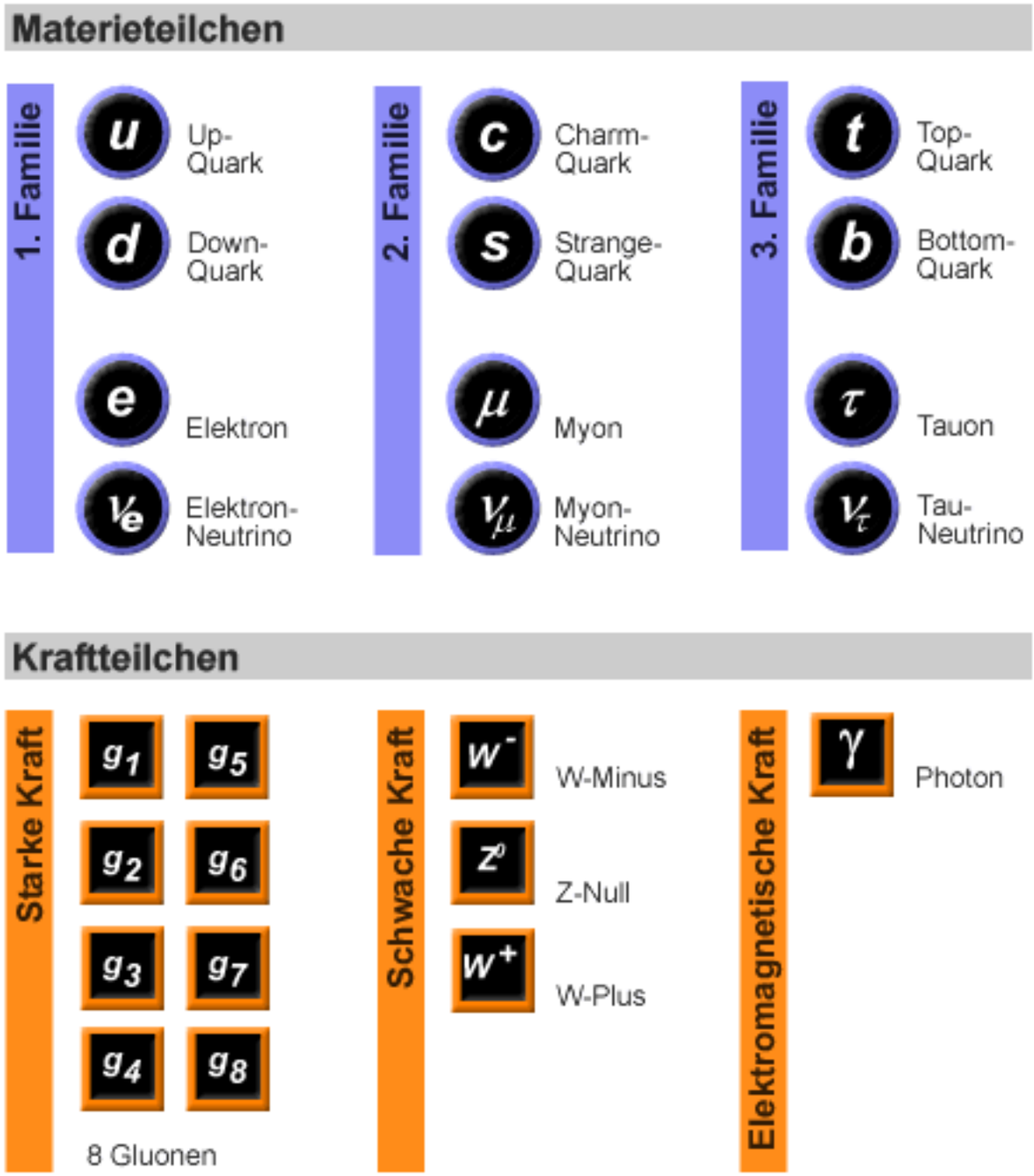






Überblick

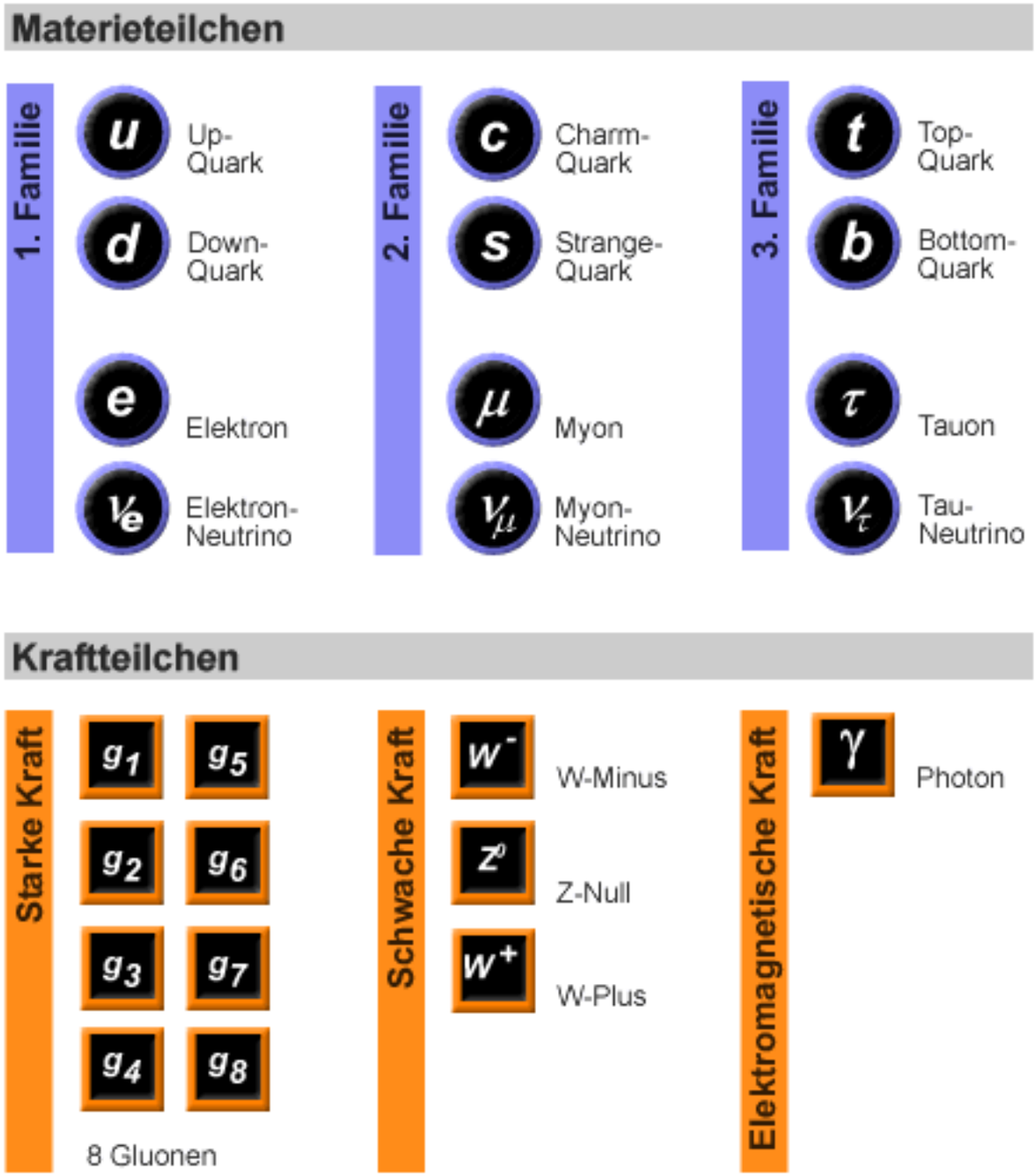
aller Elementar=teilchen



Problem: Standardmodell erwartet masselose W & Z-Teilchen
Experimente beobachten sehr massive W & Z-Teilchen

Überblick

aller Elementar=teilchen



Lösung: spontane Aufteilung der elektroschwachen Kraft + ----> < ---- ??????


Genfer
See
CMS
Jura
LHC
SPS
ATLAS
CERN

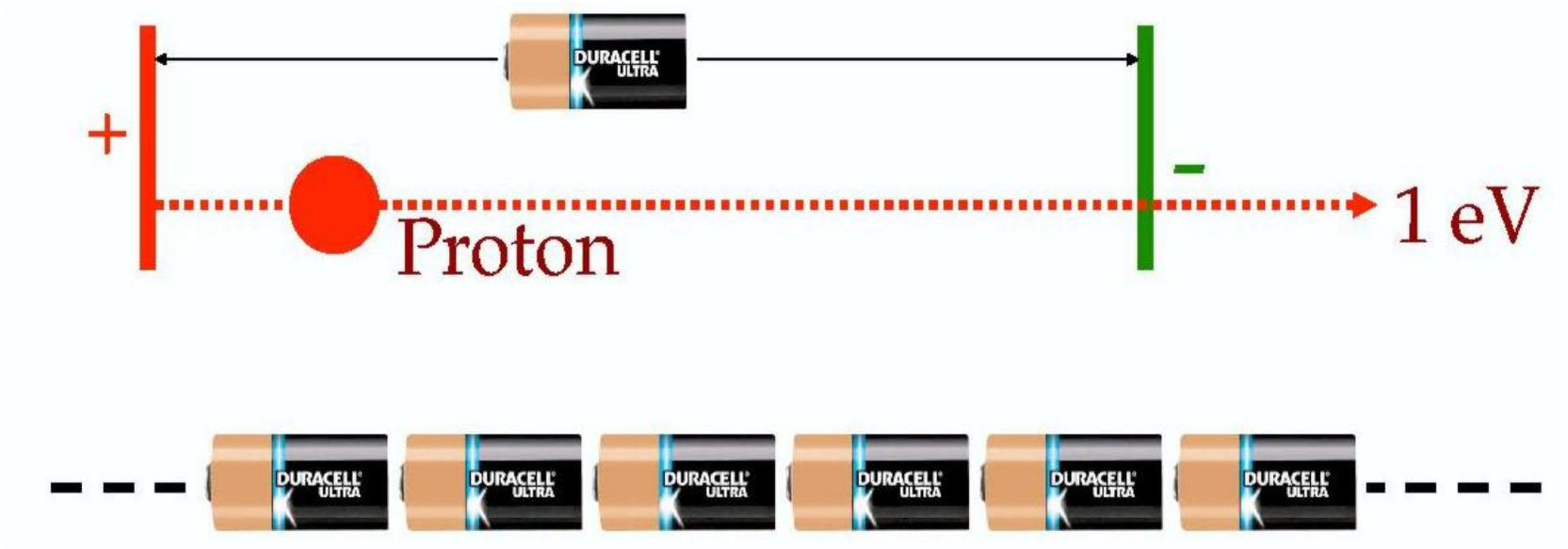
Der LHC-Beschleuniger

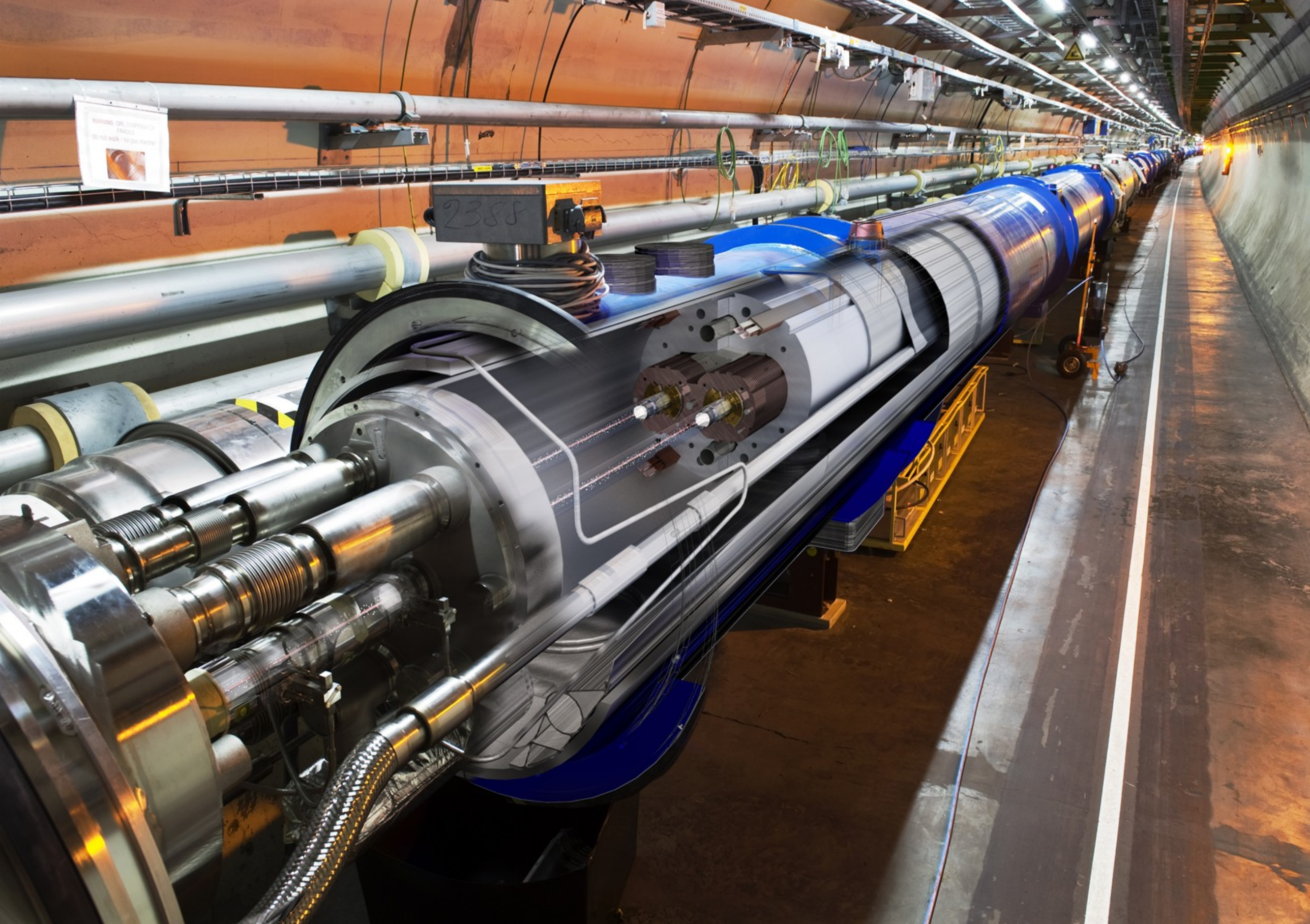
Mikroskop: höchste Energie -> kleinste Strukturen

$E=mc^2$: höchste Energie -> schwerste Teilchen

Physik&Technologie: hohe Energie -> großer Umfang

-> starke Magnetfelder




2388

LHC: Daten & Fakten

- **Strahl:**

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

- **Magnete:**

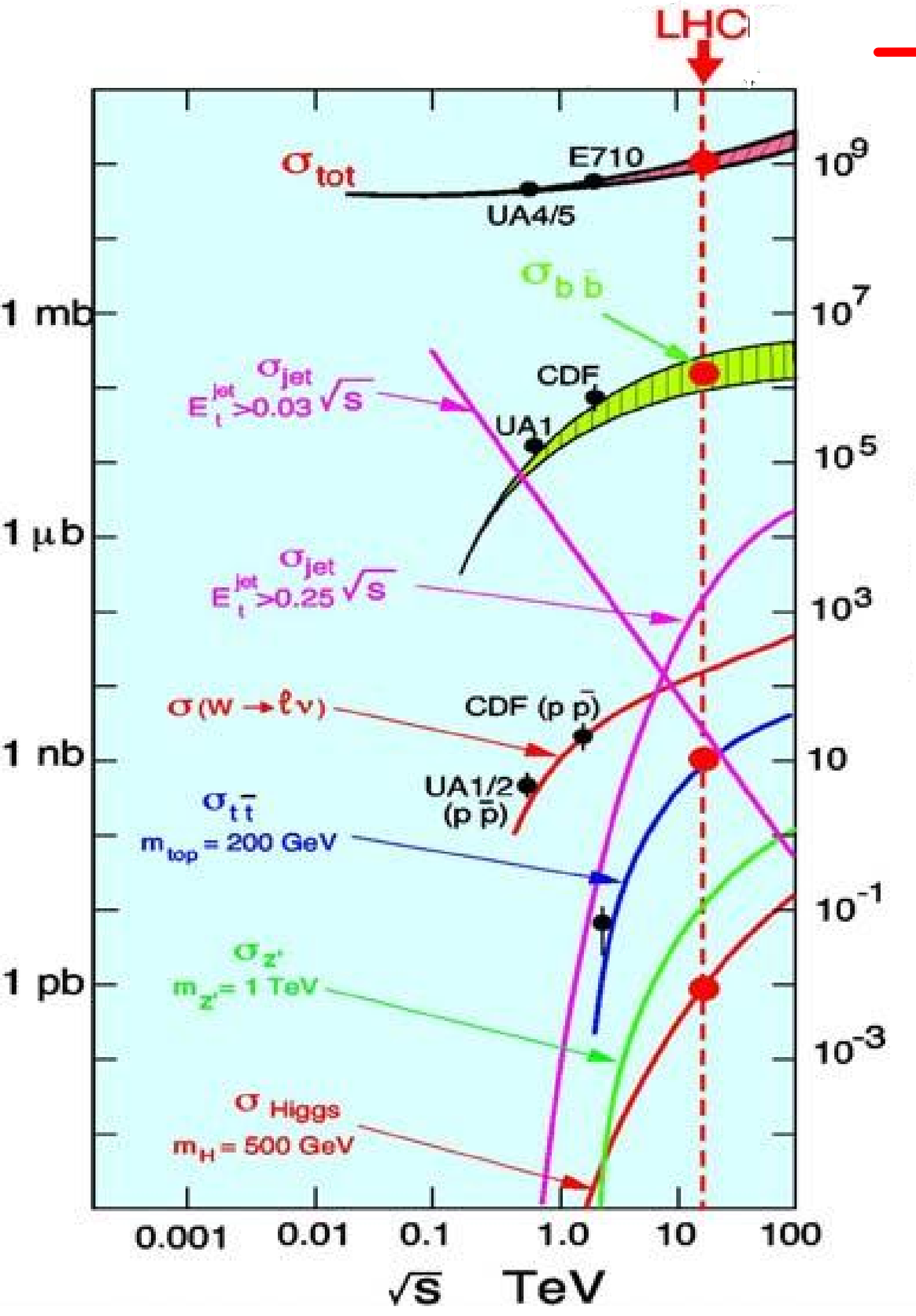
max. Magnetfeld	8,33 Tesla
Betriebstemperatur	-271°C
Anzahl d. Ablenkmagnete	1232
Länge eines Ablenkmagnets	ca. 14 m
gespeicherte Energie	ca. 3000 kWh

- **Tunnel:**

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

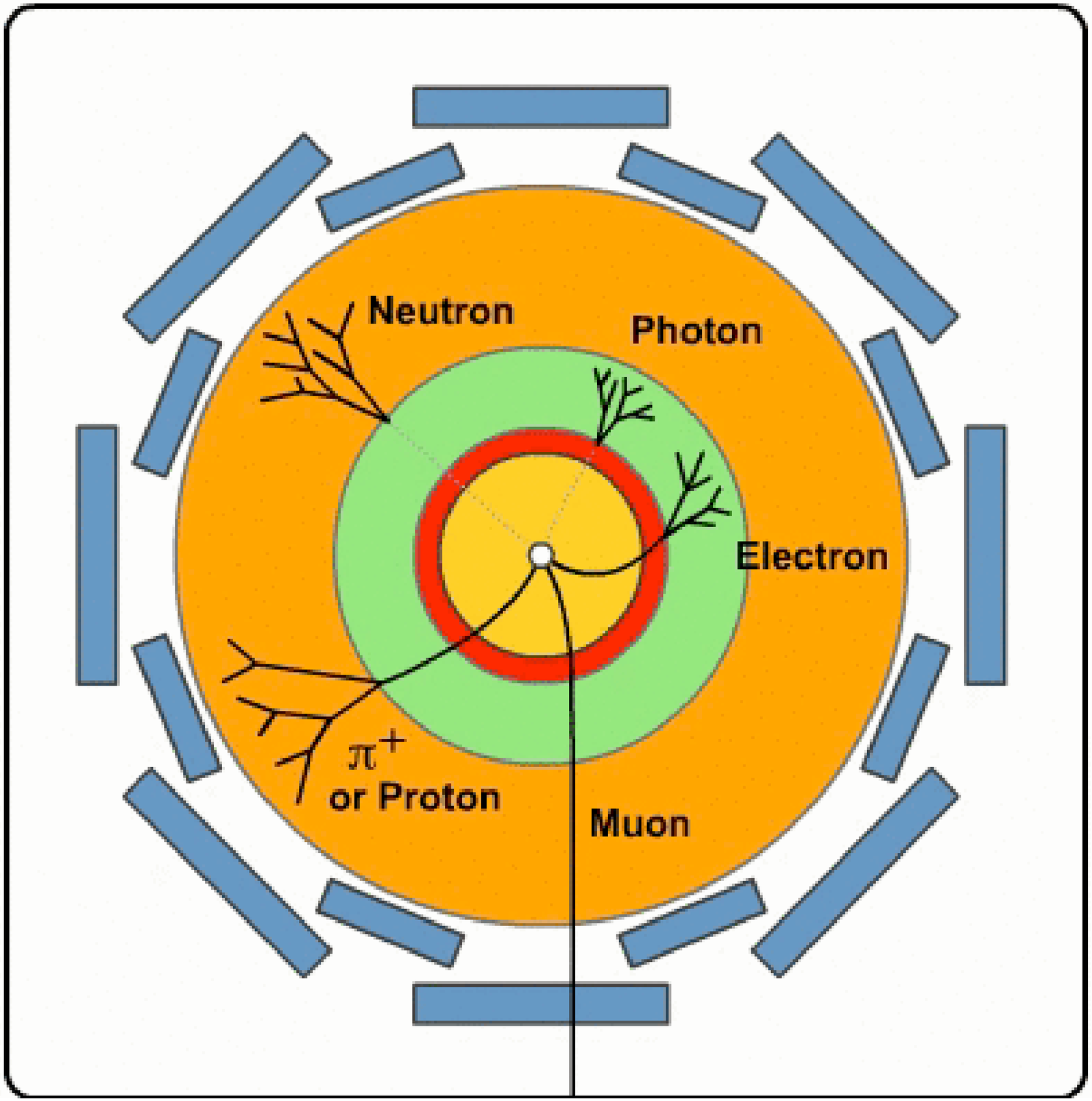
Proton-Proton-Kollisionen

<- 1 Mrd Kollisionen / Sekunde



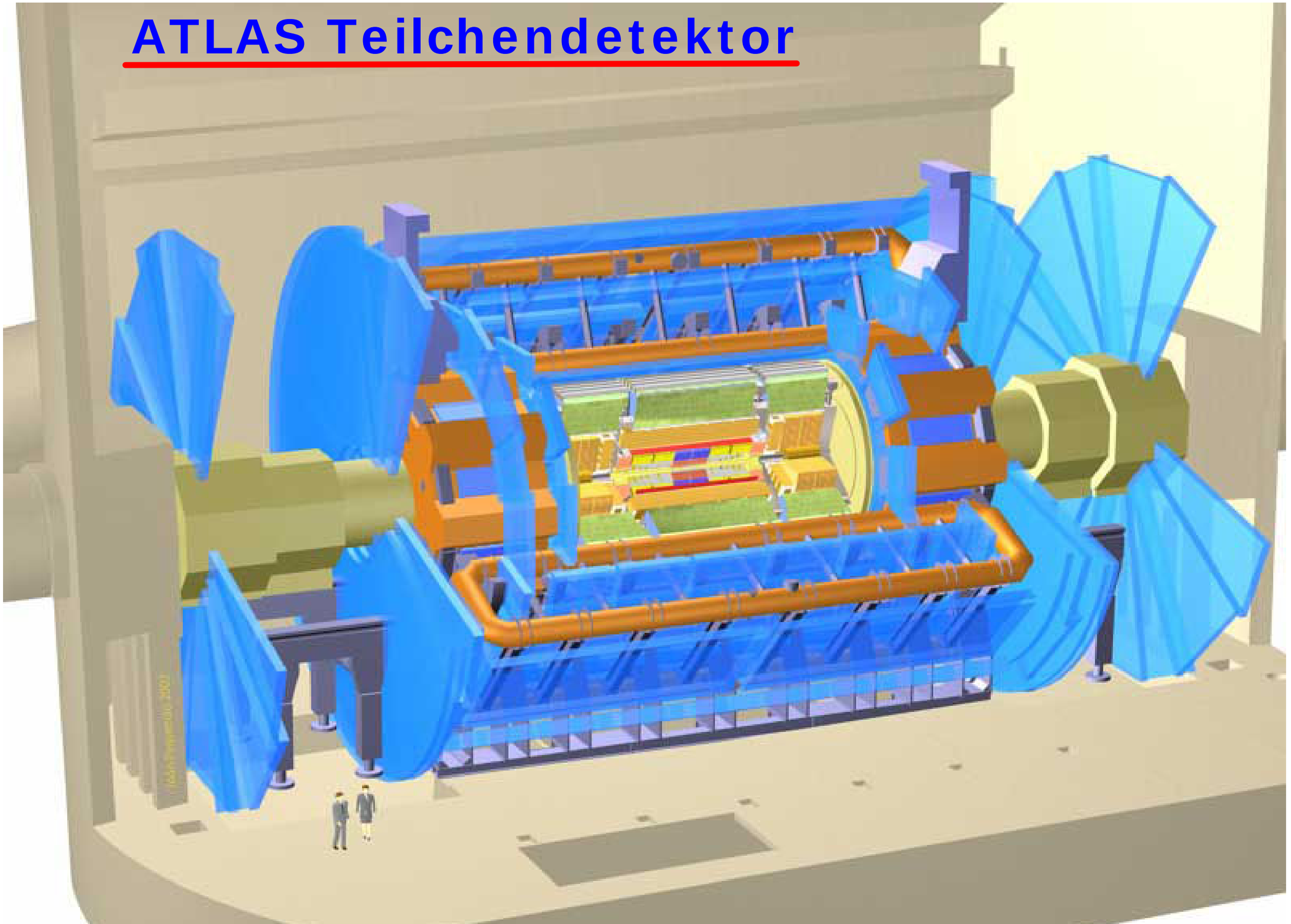
Prinzipieller Aufbau des ATLAS-Detektors

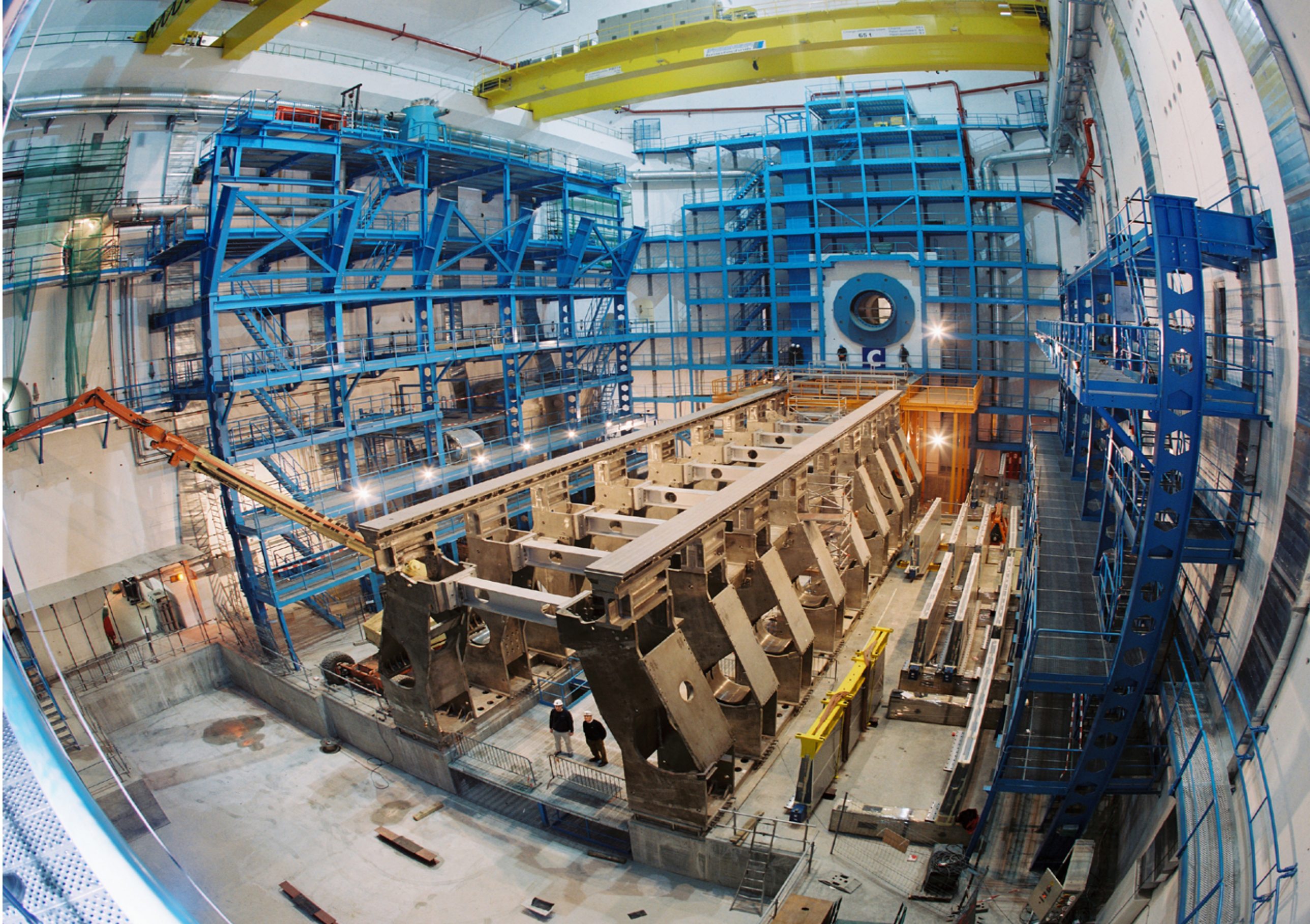
(Querschnitt)



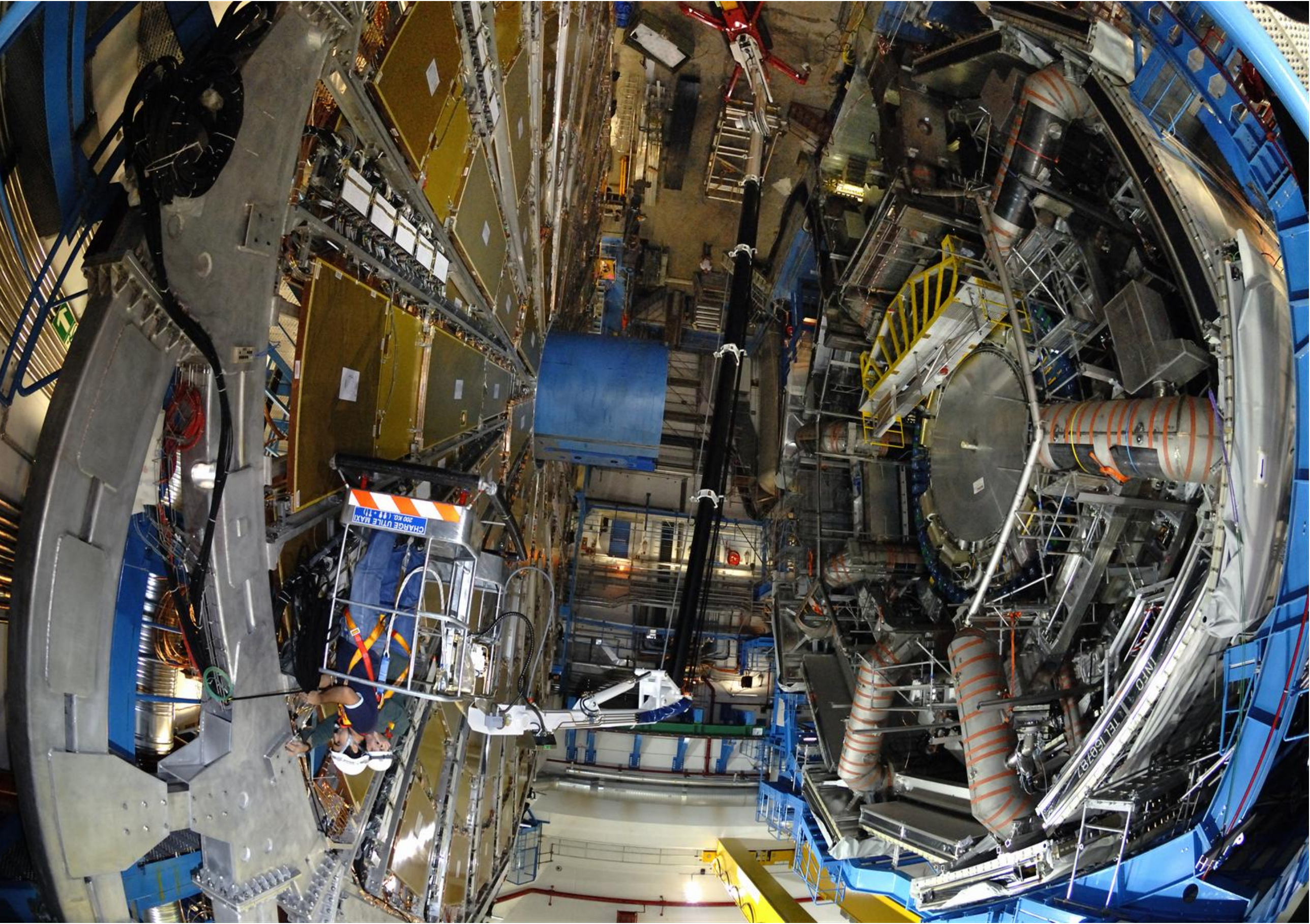
- Myon-Detektor
- Energiemessung für Hadronen
- Energiemessung für Elektron&Photon
- Magnet zur Spur= krümmung
- Spurdetektor
- Strahlröhre

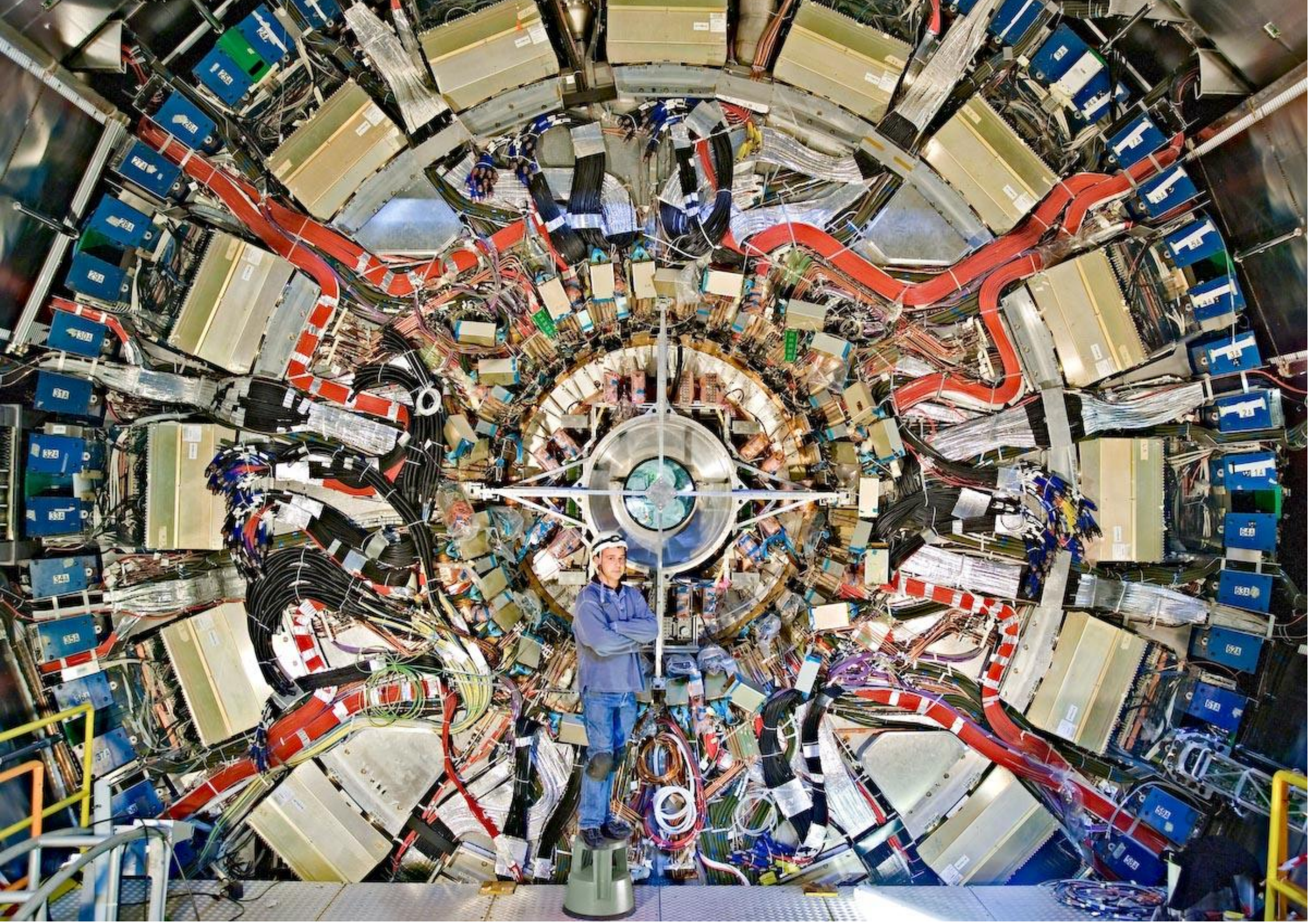
ATLAS Teilchendetektor






LASTONE


CHARGE UTILE MAXI
200 KG

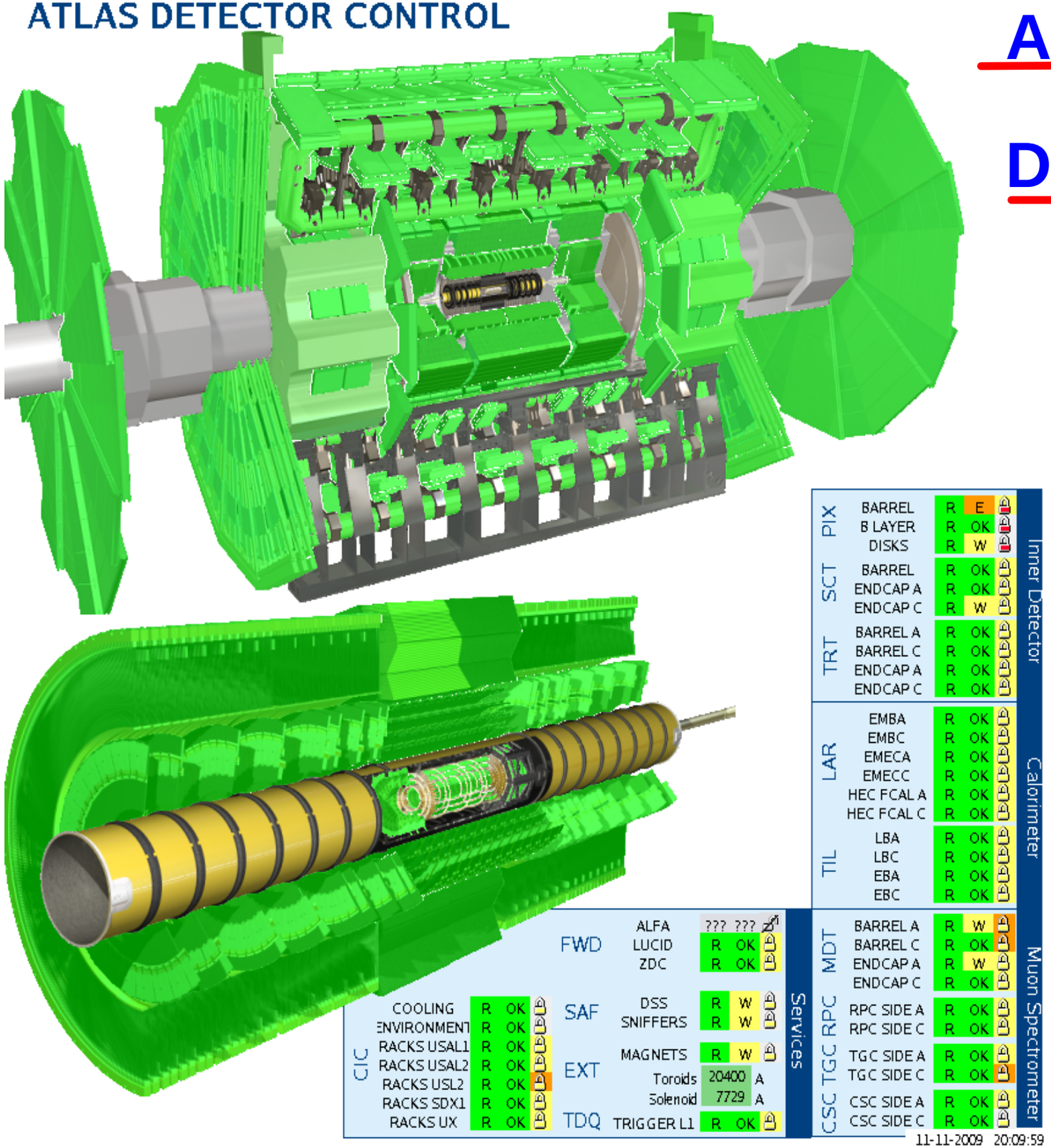


ATLAS-

Detektorstatus

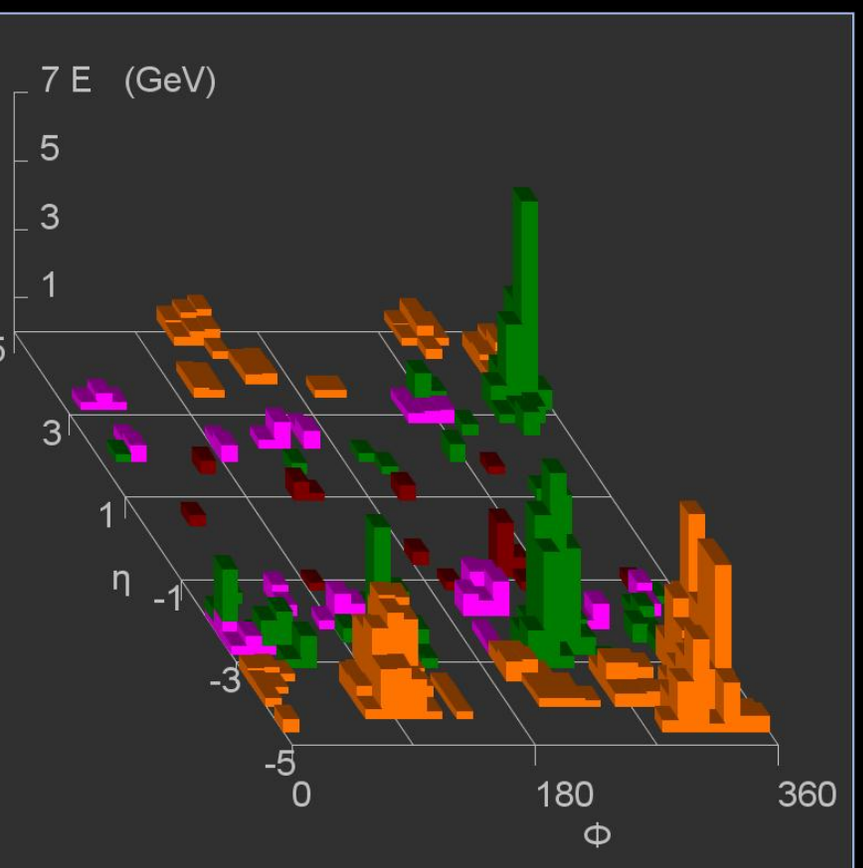
seit November 2009

=> alles bereit !




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

Candidate Collision Event



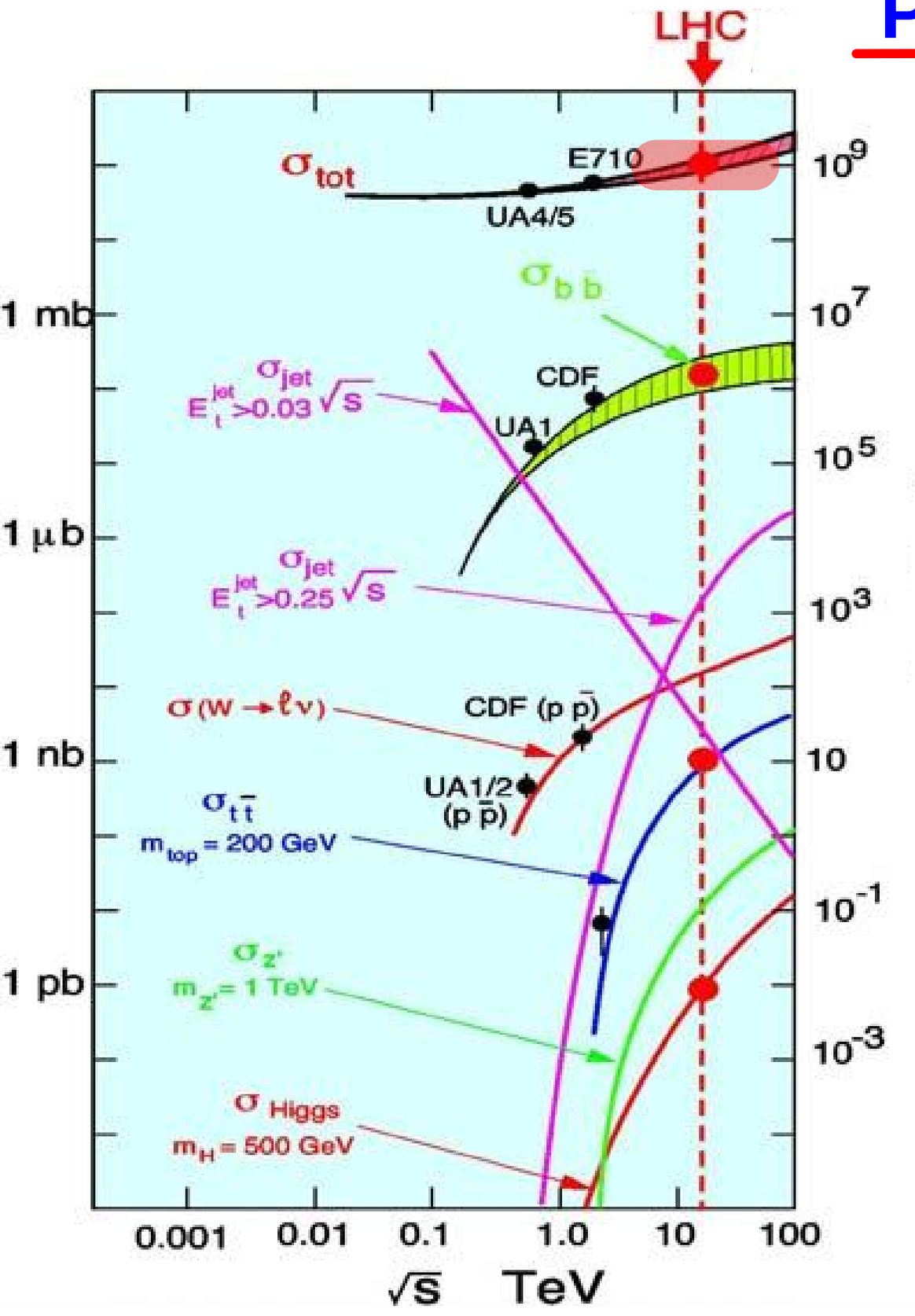
ATLAS EXPERIMENT

2009-11-23, 14:22 CET

Run 140541, Event 171897

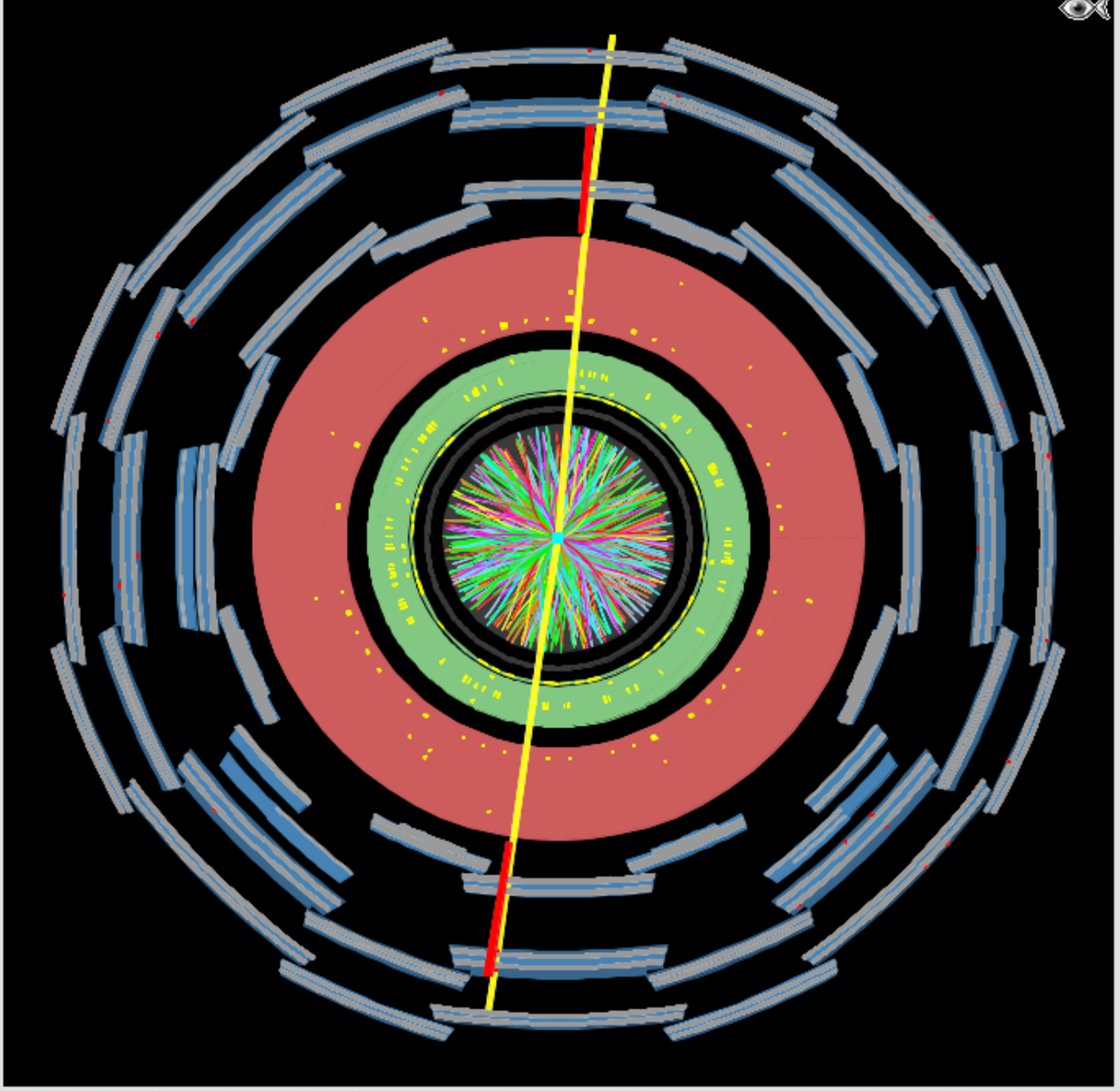
http://atlas.web.cern.ch/Atlas/public/EVTDISPLAY/events.html

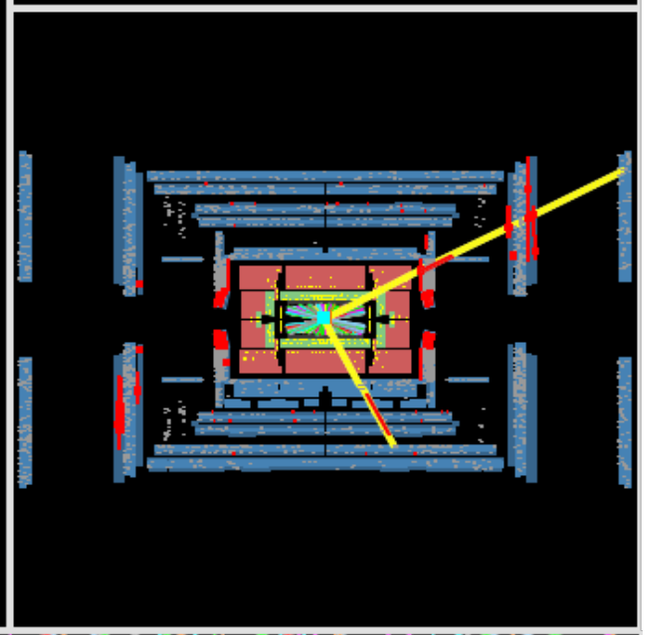
Proton-Proton-Kollisionen



<- 1 Mrd Kollisionen / Sekunde

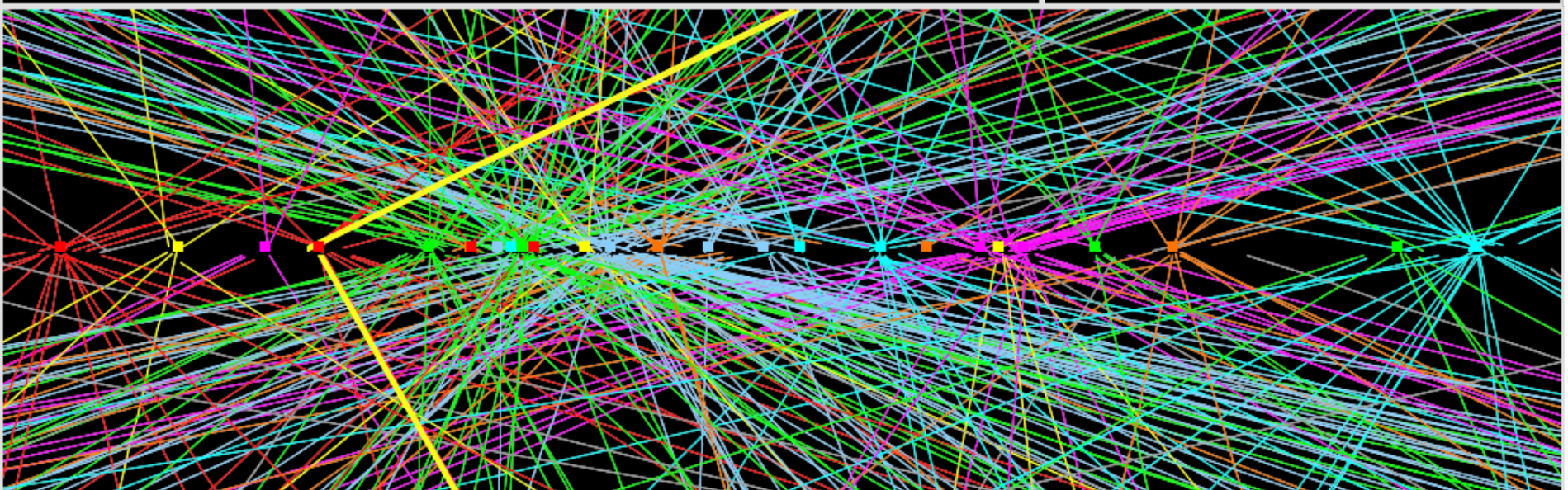
meist bekannte Reaktionen





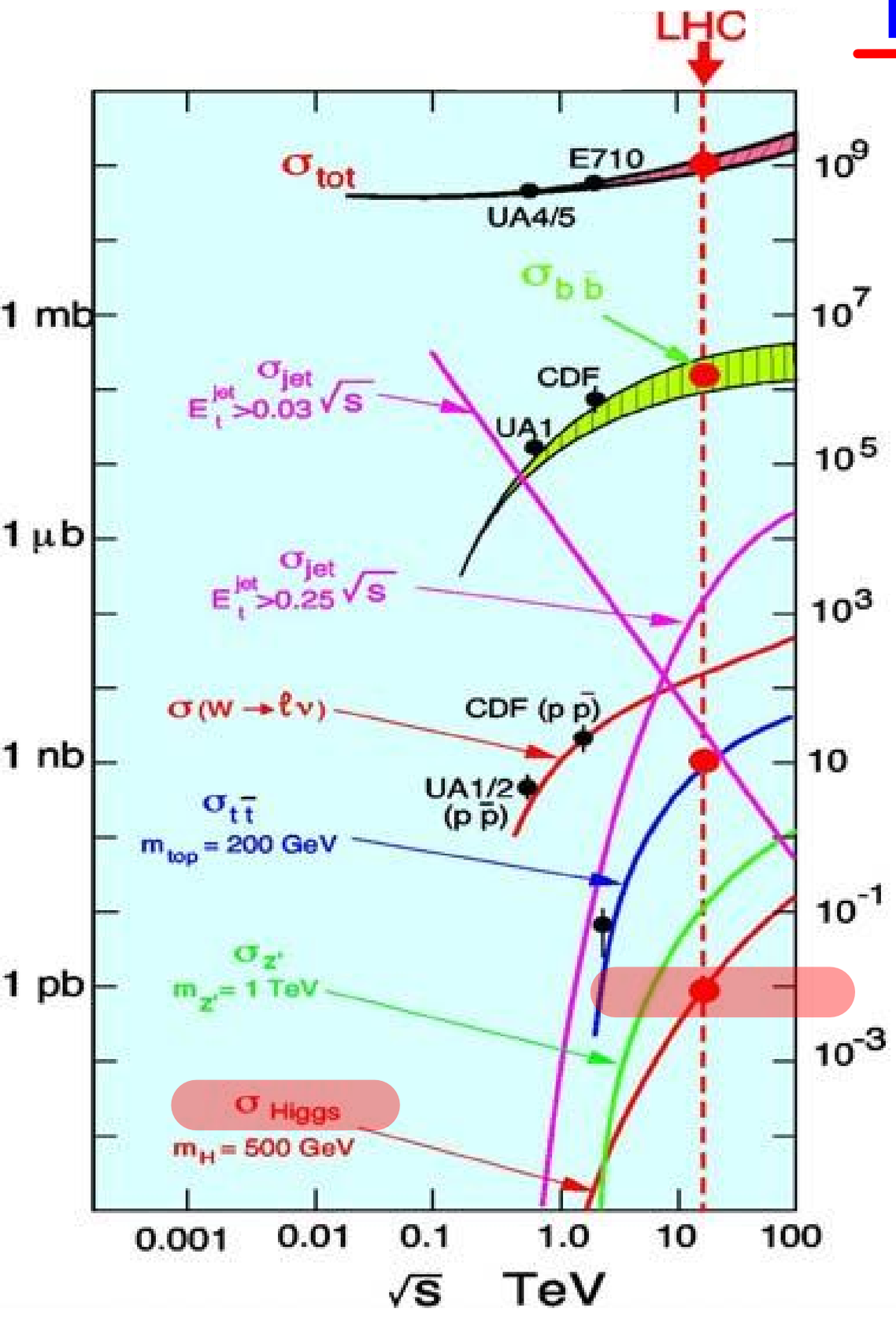
typische Reaktion

beim Auf= einandertreffen der Proton-Teilchenstrahlen



im Mittel ca. 25 Kollisionen zugleich

Proton-Proton-Kollisionen



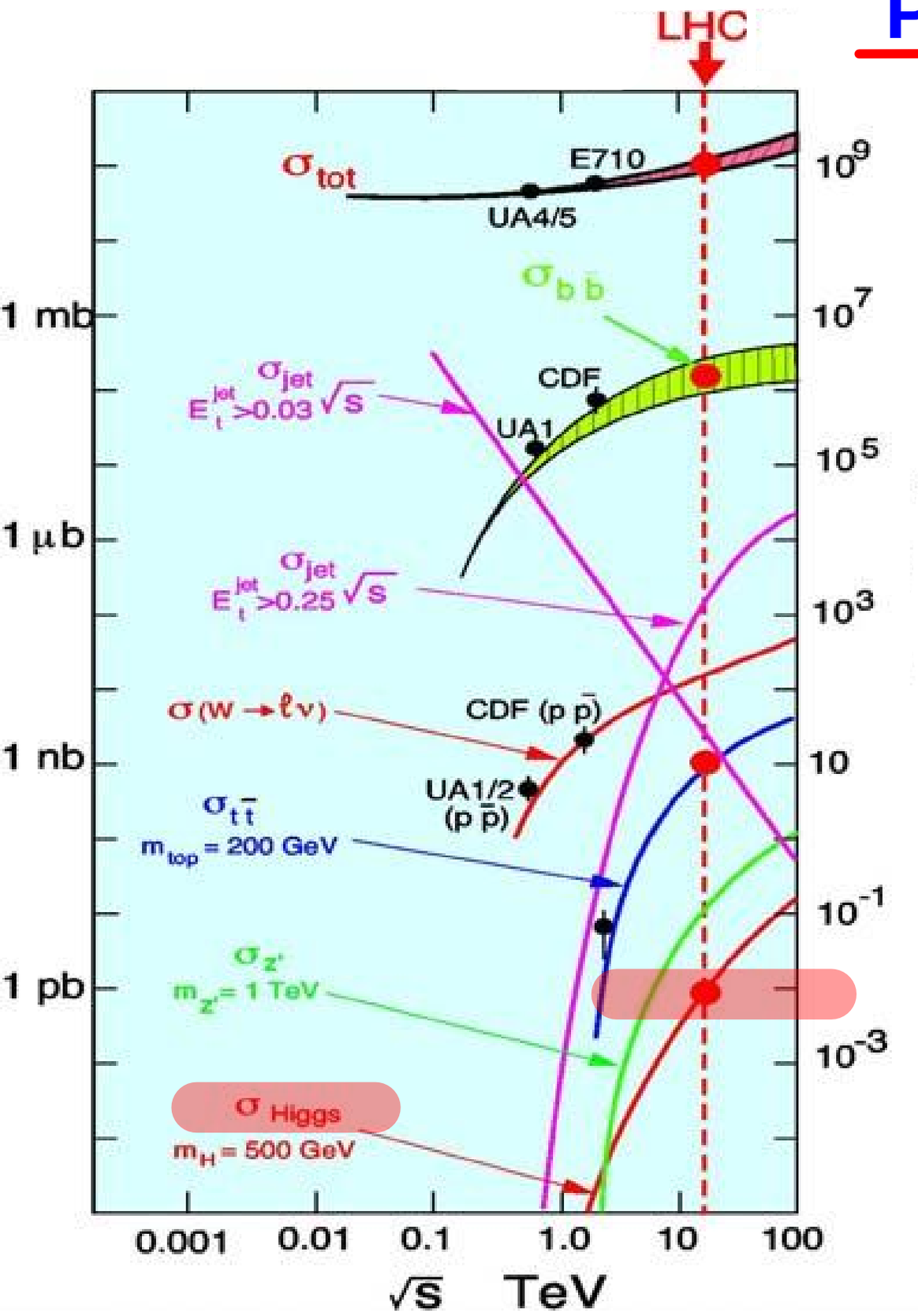
<- 1 Mrd Kollisionen / Sekunde

meist bekannte Reaktionen

<- Erwartung für Higgs-Teilchen

1 Higgs-Teilchen / Minute

Proton-Proton-Kollisionen



<- 1 Mrd Kollisionen / Sekunde

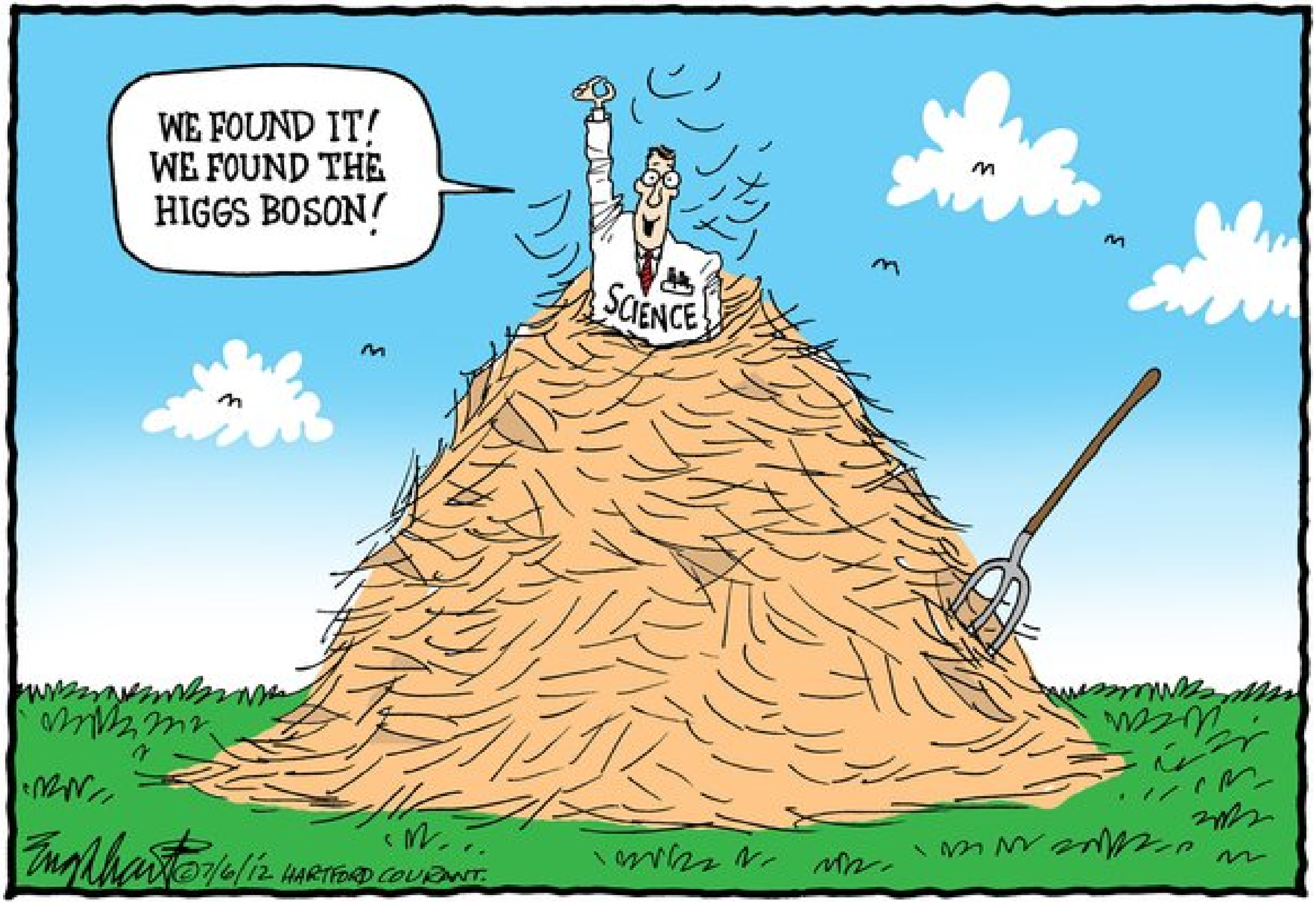
meist bekannte Reaktionen

<- Erwartung für Higgs-Teilchen

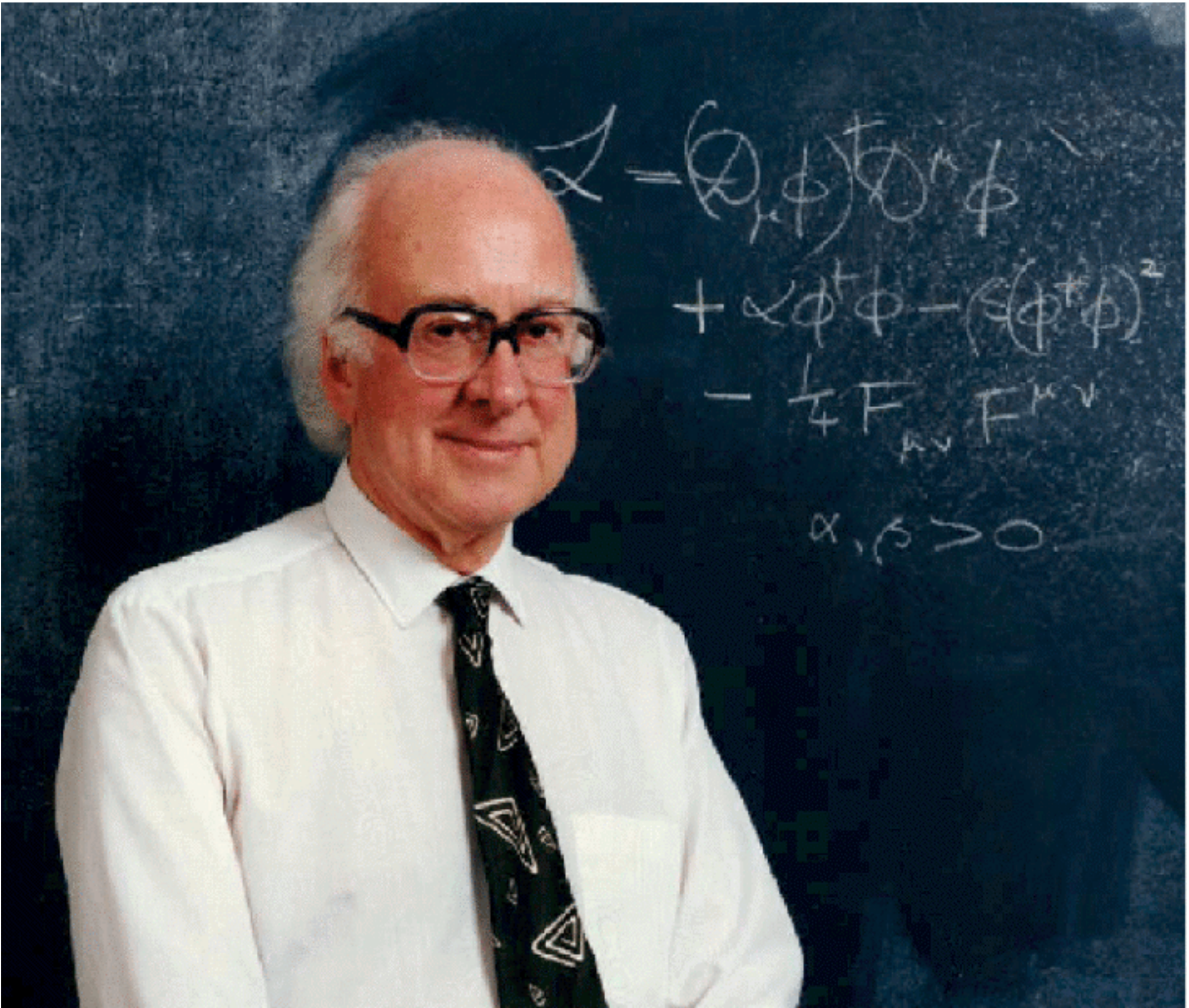
1 Higgs-Teilchen / Minute

Massenerzeugung

h ? Higgs-Teilchen

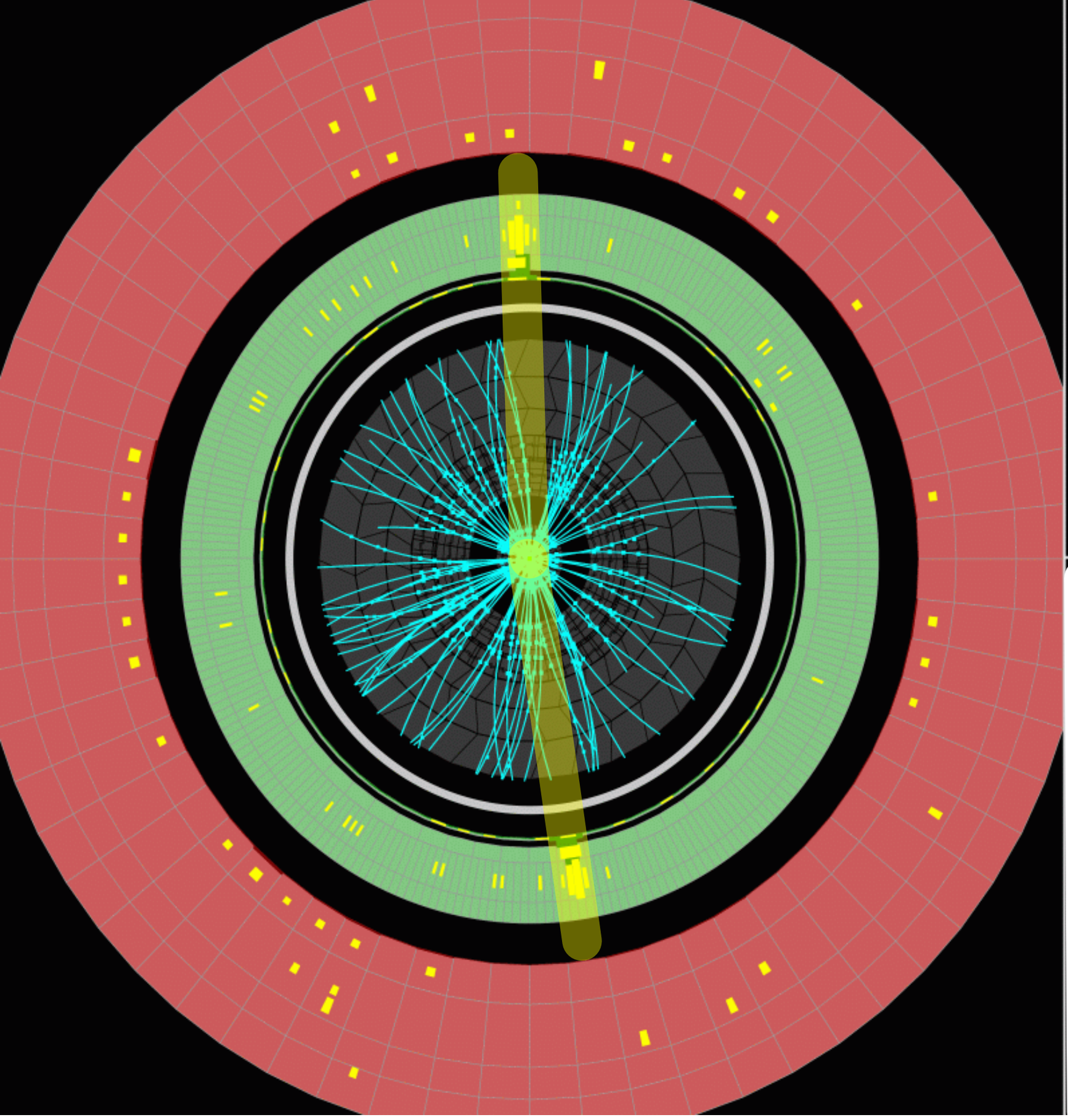

WE FOUND IT!
WE FOUND THE HIGGS BOSON!
SCIENCE
©7/6/12 HARTFORD COURANT.

Lang bekanntes Higgs



Peter Higgs

(*29.Mai 1929)



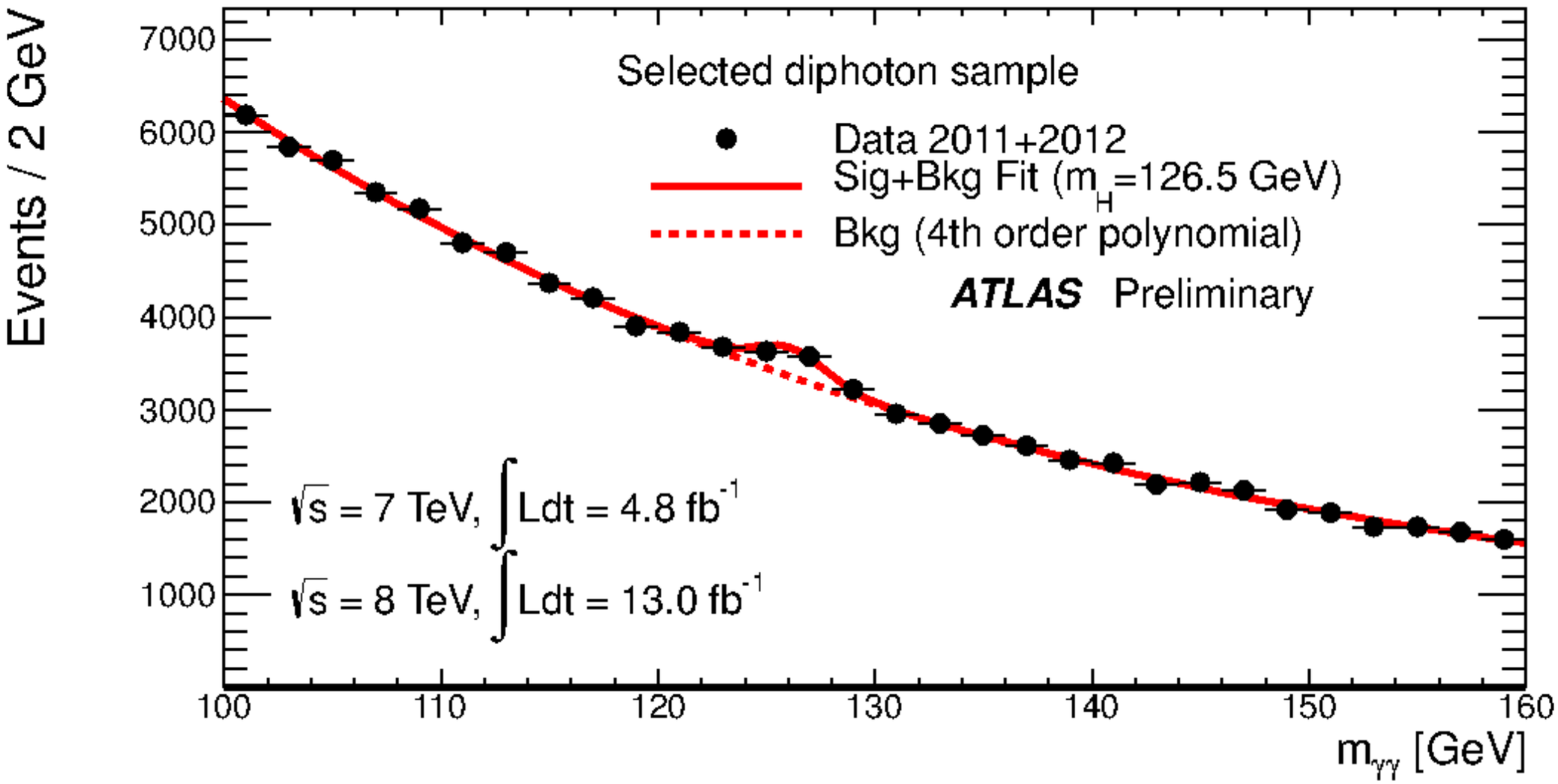
ATLAS EXPERIMENT

Run Number: 203779, Event Number: 56662314

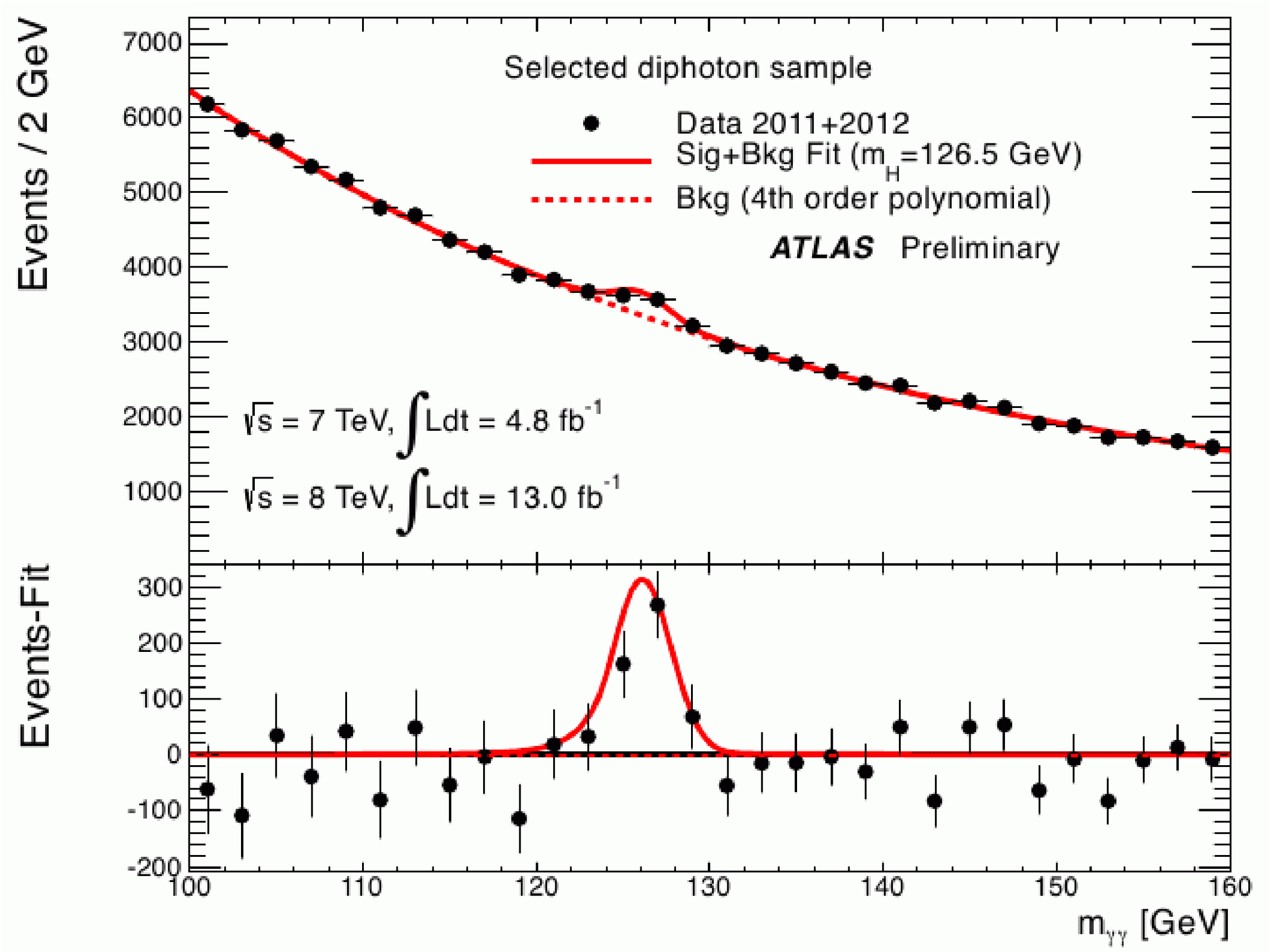
Date: 2012-05-23 22:19:29 CEST

Kandidat für Higgs-Teilchen-reaktion mit zwei Photonen

Paarmasse der beiden Photonen



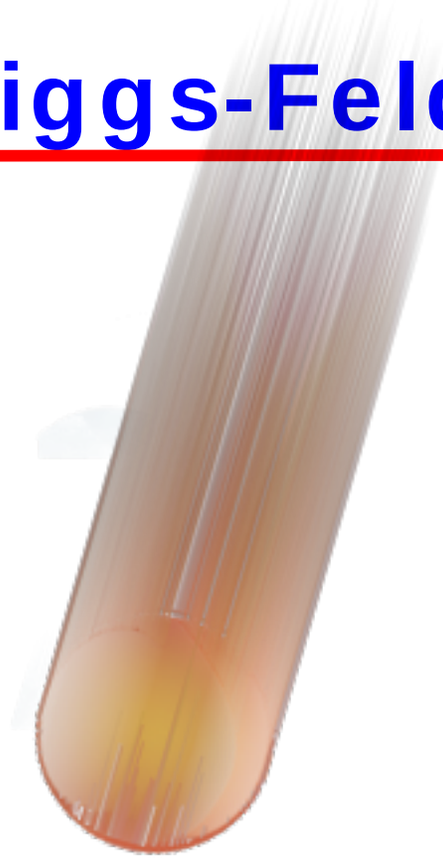
Paarmasse der beiden Photonen



Massenerzeugung durch Higgs-Feld

ohne Higgs-Feld:

immer so schnell wie Licht



Massenerzeugung durch Higgs-Feld

ohne Higgs-Feld:

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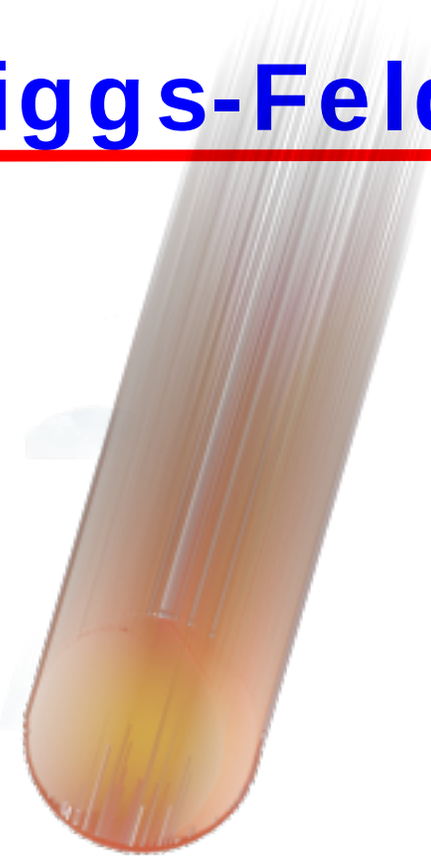
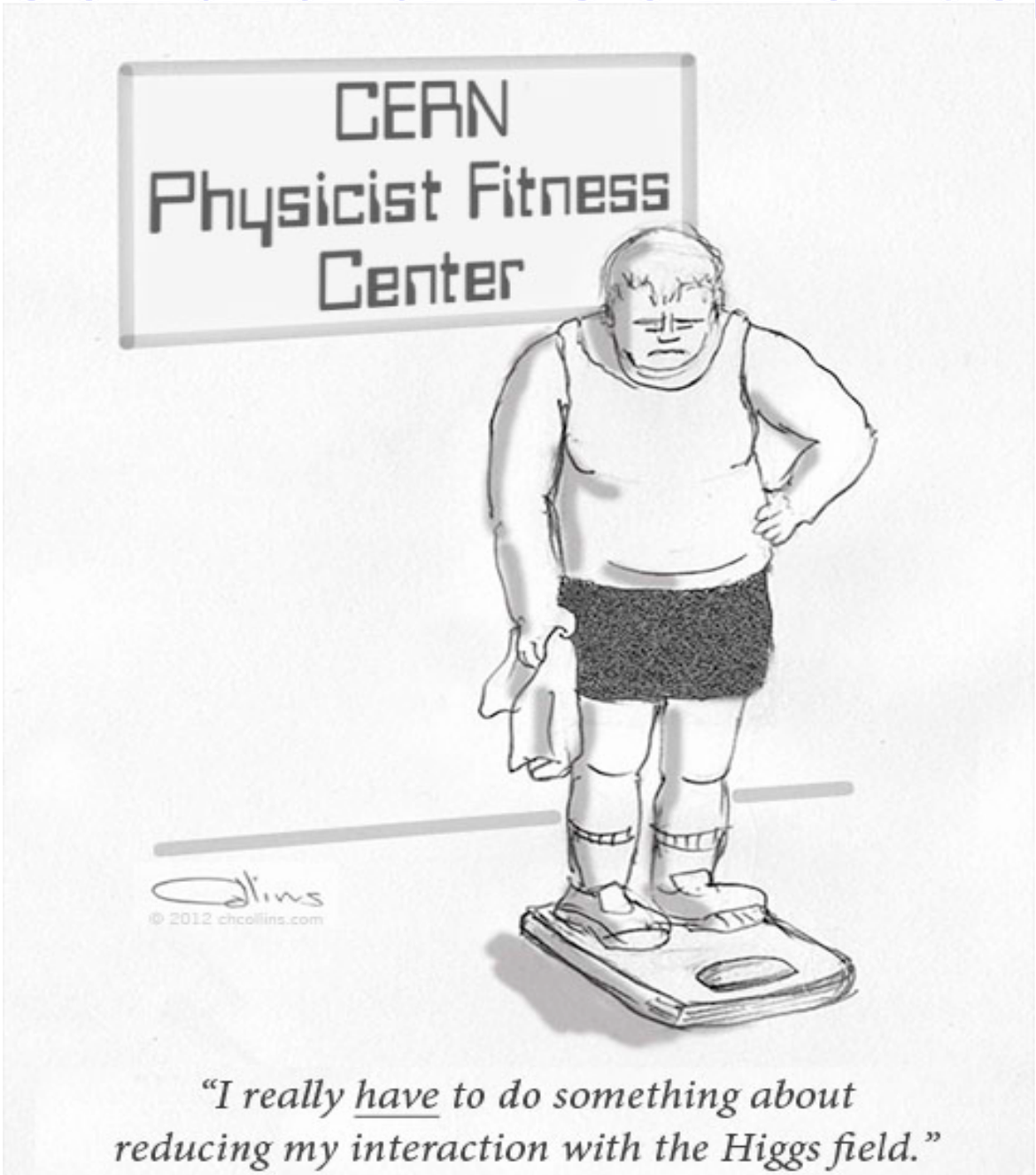


mit Higgs-Feld:

langsamer als Licht

Was bedeutet das Higgs-Teilchen?

nicht schuld an Gewichtsproblemen

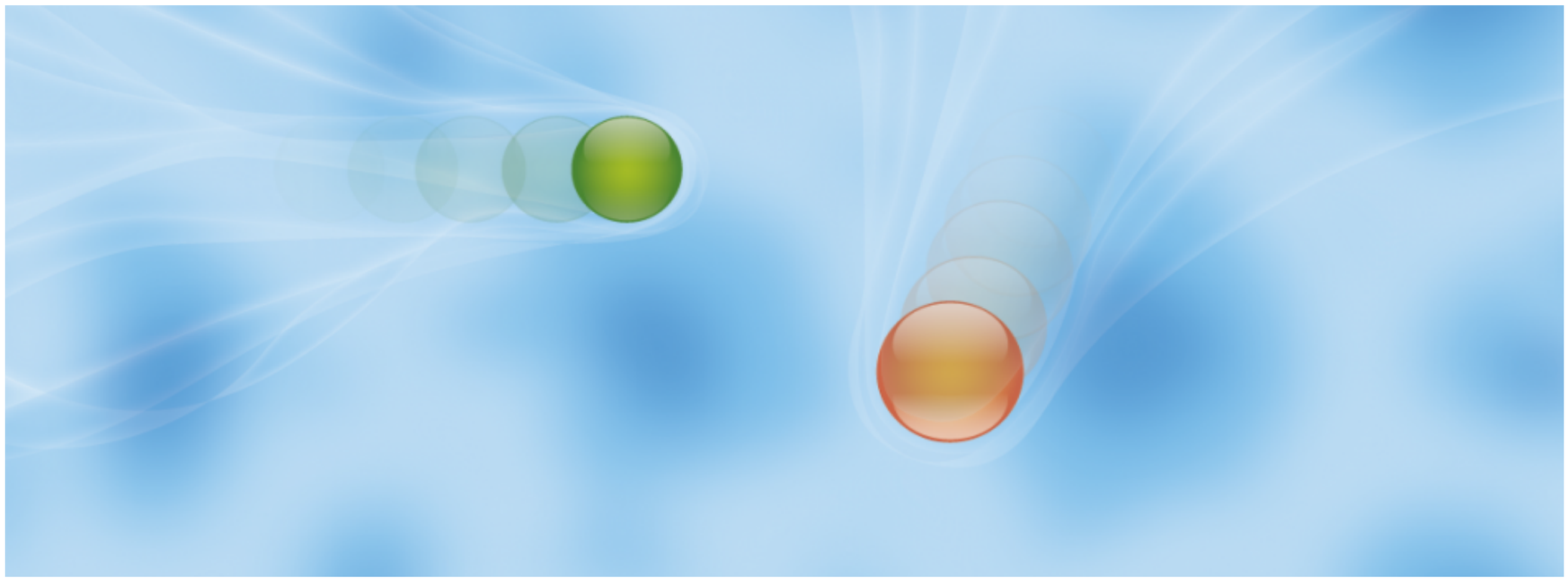


"I really have to do something about reducing my interaction with the Higgs field."

Was bedeutet das Higgs-Teilchen?

nicht schuld an Gewichtsproblemen

erklärt nur, dass fundamentale Elementarteilchen Masse haben, wie zum Beispiel das Elektron

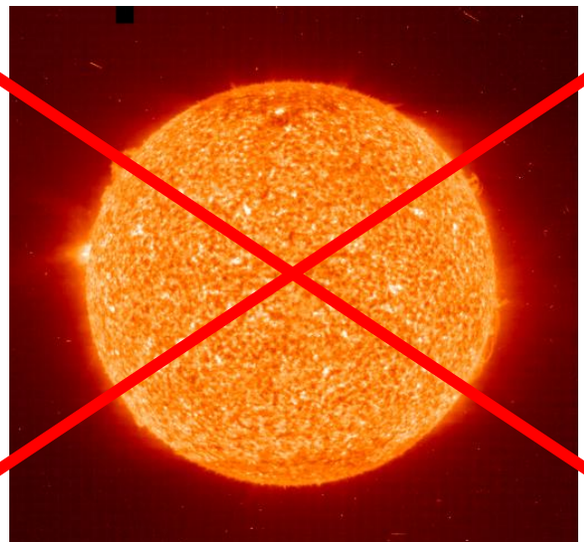


Was bedeutet das Higgs-Teilchen?

nicht schuld an Gewichtsproblemen

erklärt nur, dass fundamentale Elementarteilchen Masse haben, wie zum Beispiel das Elektron

Wären Elektronen masselos, gäbe es keine Sterne, keine Sonne, keine Erde und uns natürlich auch nicht.



Was bedeutet das Higgs-Teilchen?

nicht schuld an Gewichtsproblemen

erklärt nur, dass fundamentale Elementarteilchen Masse haben, wie zum Beispiel das Elektron

Wären Elektronen masselos, gäbe es keine Sterne, keine Sonne, keine Erde und uns natürlich auch nicht.

Mit dem Higgs-Teilchen verstehen wir, dass Teilchen massiv sind! Leider nicht, welche Masse :-(

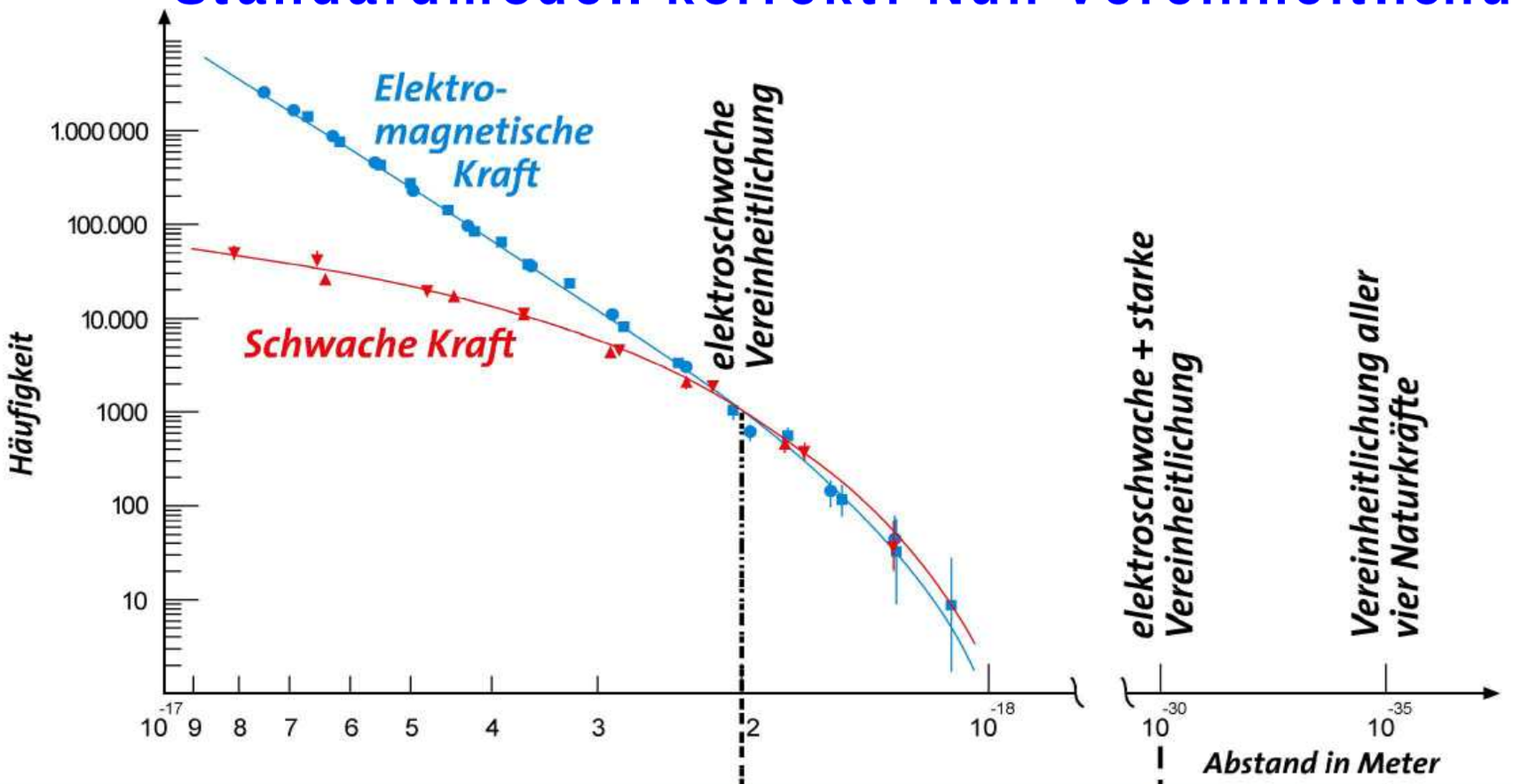
Was bedeutet das Higgs-Teilchen?

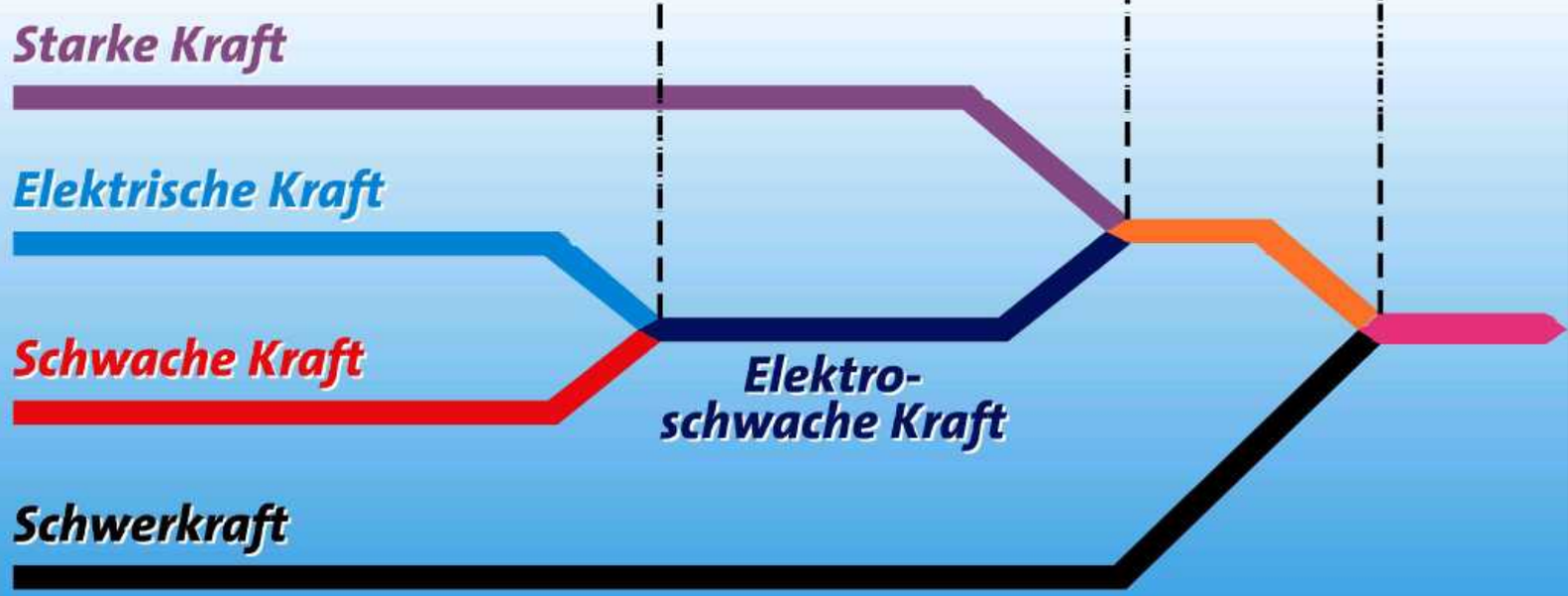
Teilchenphysik komplett, nachdem Higgs-Teilchen gefunden ?

Antwort: **Nein !**

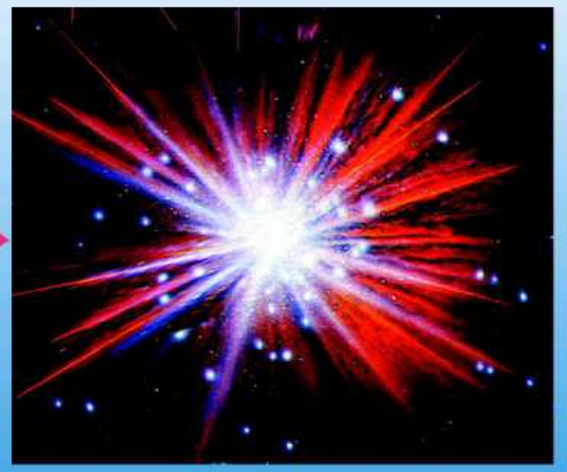
Was bedeutet das Higgs-Teilchen?

Standardmodell korrekt! Nun Vereinheitlichung aller Kräfte?



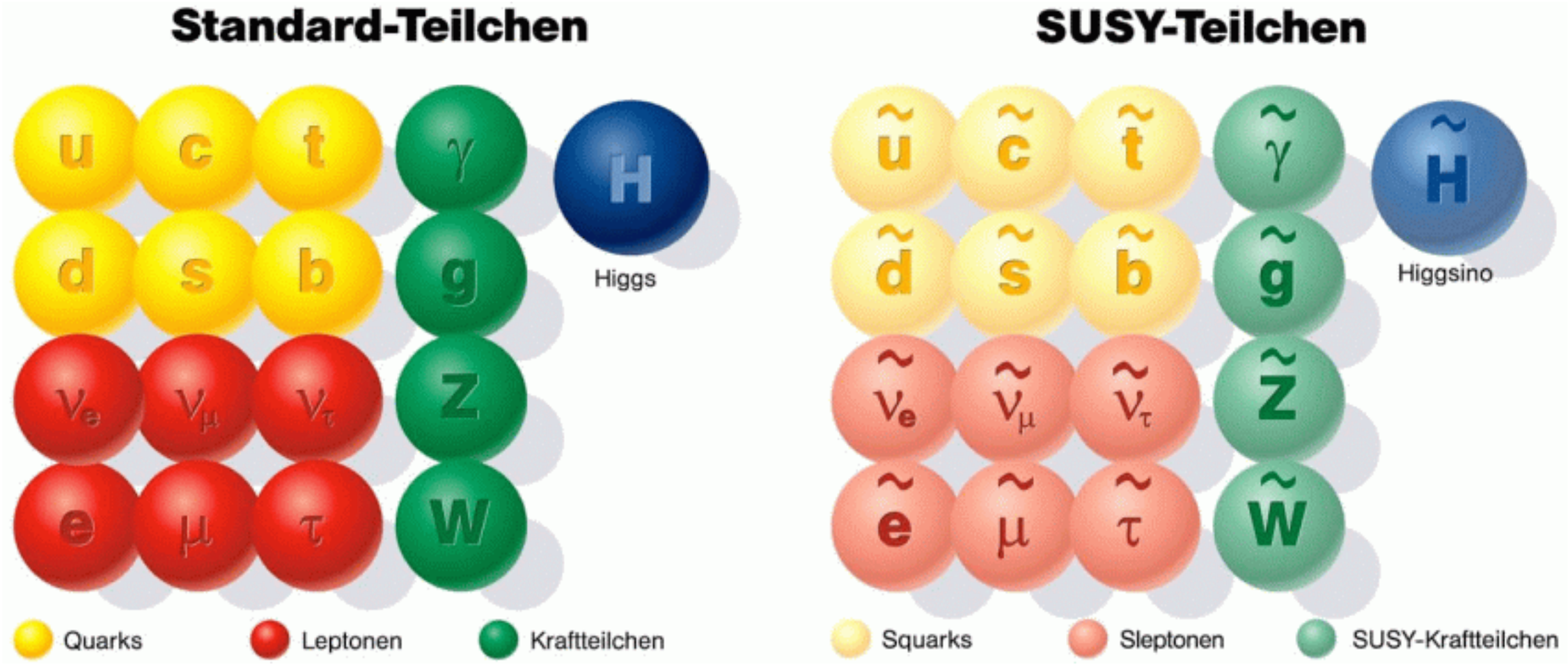


Urknall



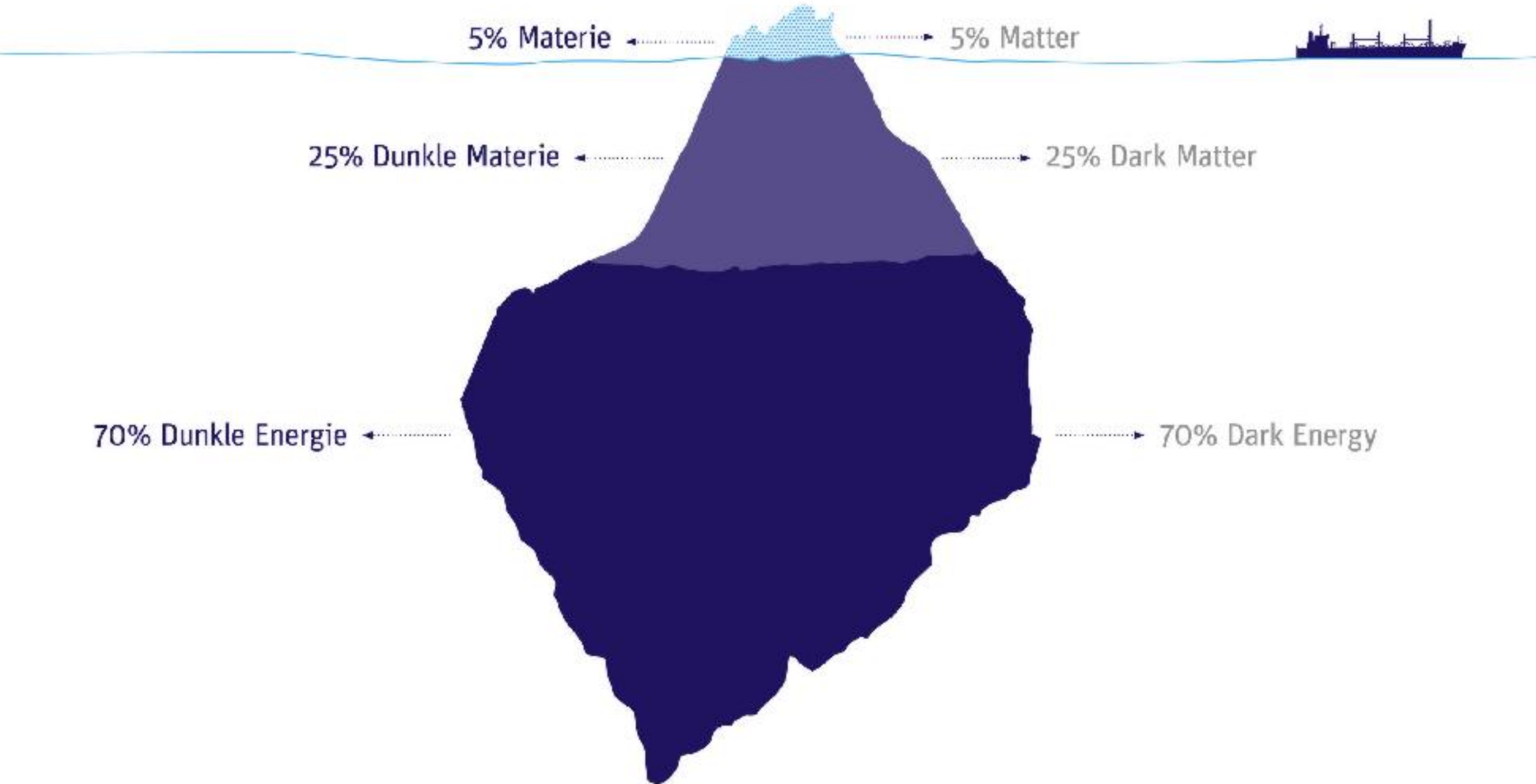
Was bedeutet das Higgs-Teilchen?

Standardmodell korrekt! Nun supersymmetrische Verdopplung?

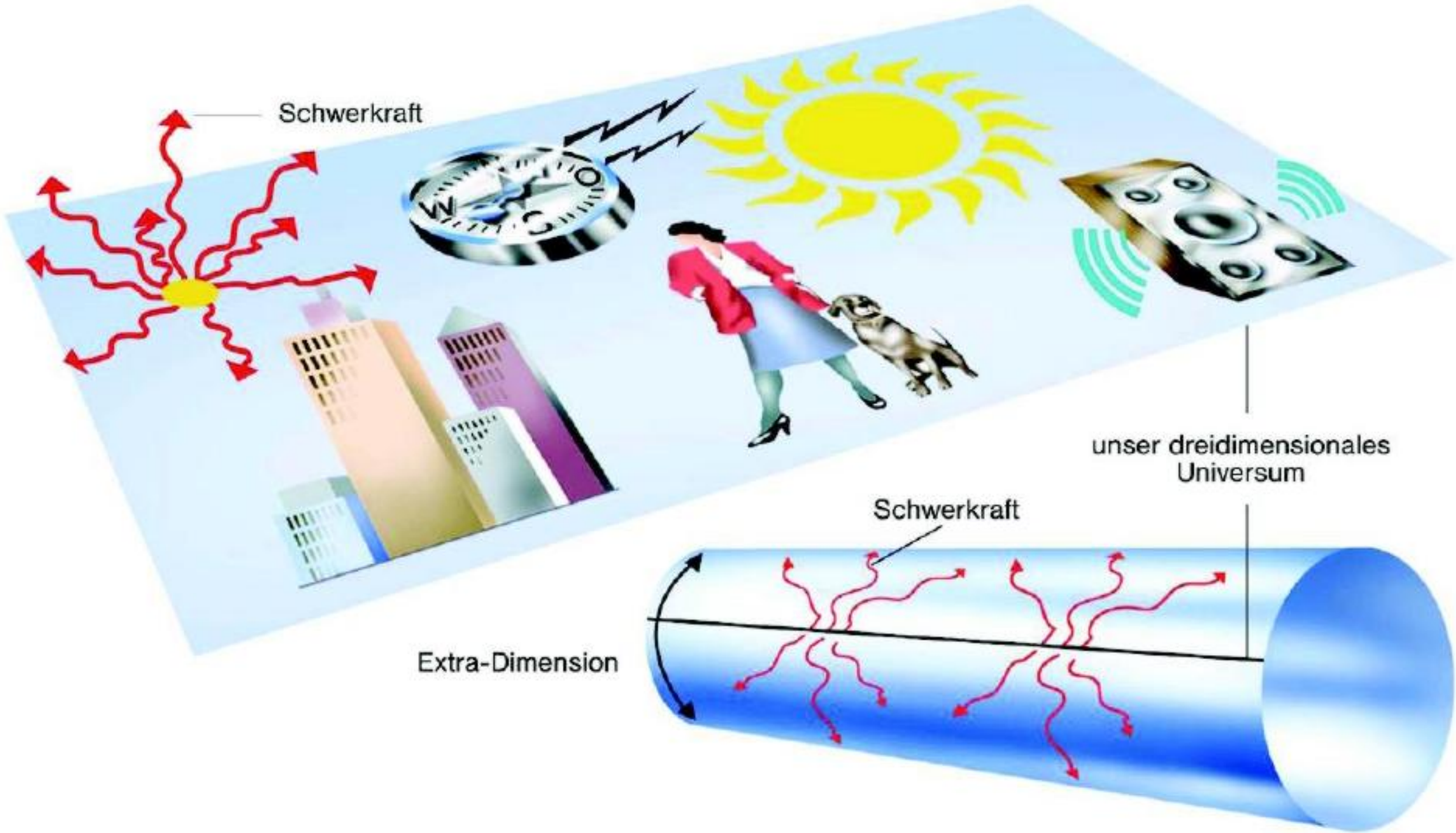


Supersymmetrische Verdopplung vs.

Woraus besteht das Universum?



Weitere mikroskopische Raumdimensionen ?




Ehrlich, meine Hausaufgaben wurden von einem Schwarzen Loch verschluckt!


Führerschein? Vom Schwarzen Loch aufgesaugt!


Mein Zugticket? Schwups – in einem Schwarzen Loch verschwunden!


Der Forderungskatalog des linken Flügels? In einem Schwarzen Loch, schätze ich.

Antworten von LHC und den Detektoren erwartet !

Genfer See

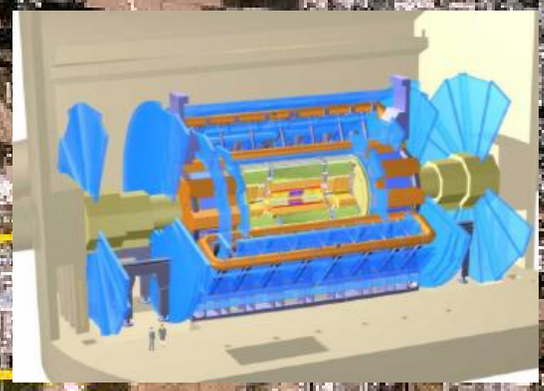
CMS

Jura

LHC

SPS

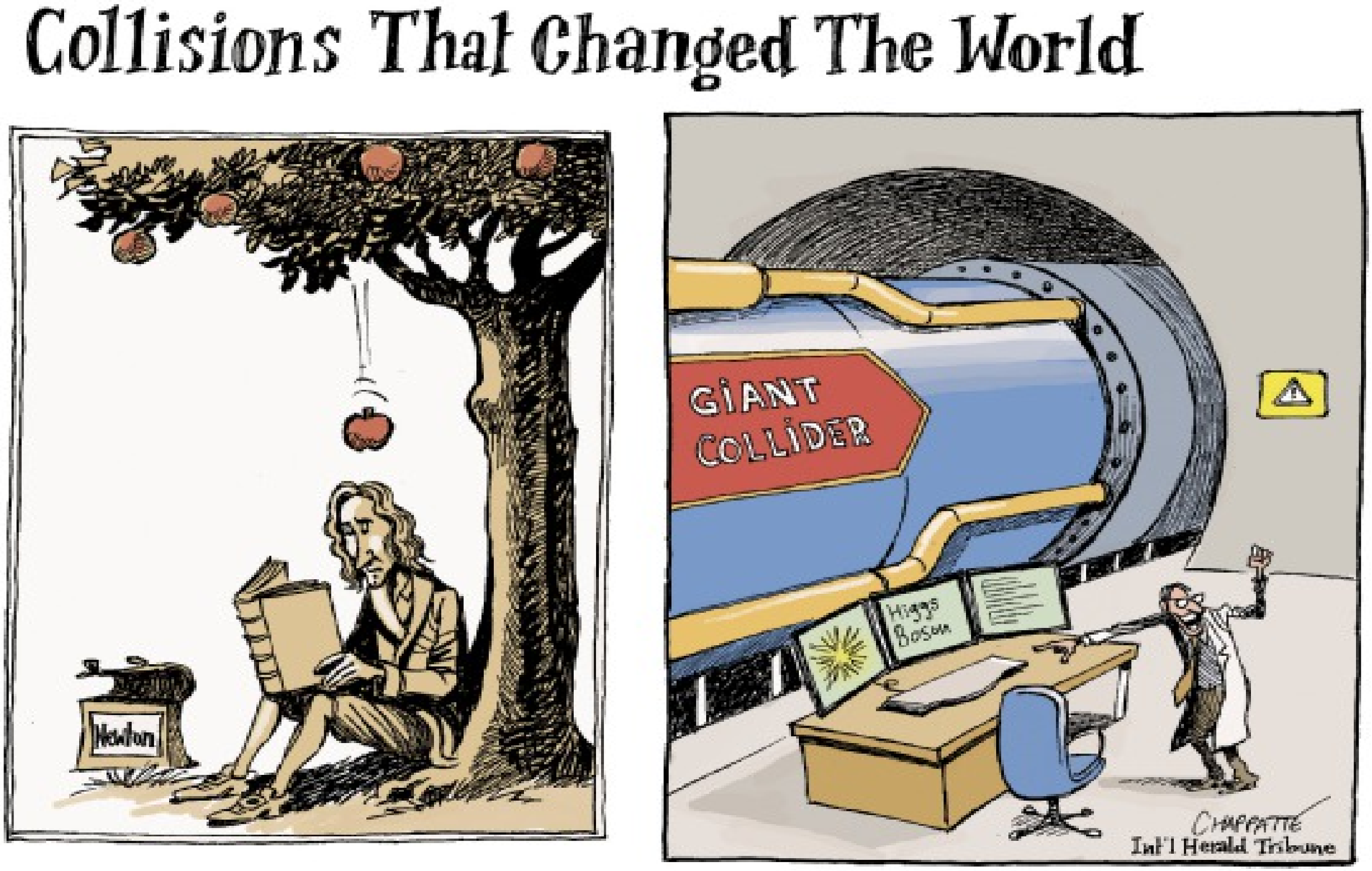
ATLAS



CERN

einige Mitarbeiter der ATLAS Arbeitsgemeinschaft

Was bedeutet dies nun für unseren Alltag?



Was bedeutet dies nun für unseren Alltag?

Was bedeutet dies nun für unseren Alltag?

Geduld, z.B.: Äthertheorie -> Relativitätstheorie -> GPS = 100 Jahre

CERN: Geburtsplatz des WorldWideWeb !

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.

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Geneva, 30 April 1993

W. Hoogland
Director of Research

H. Weber
Director of Administration

opie certifiée conforme

ait à Genève le 03-05-93

ORGANISATION EUROPÉENNE POUR LA RECHERCHE NUCLÉAIRE
DIVISION DES FINANCES
CERN

Massenerzeugung durch Higgs-Teilchen