

The Large Hadron Collider control room at CERN (Geneva)



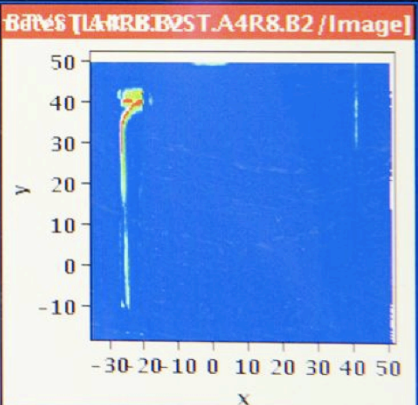
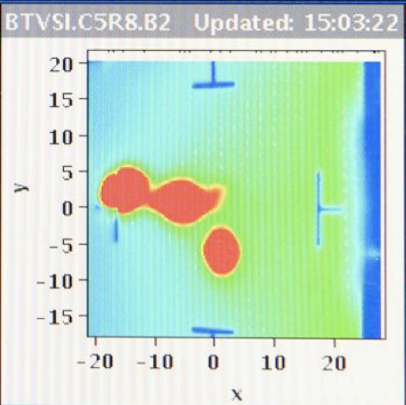
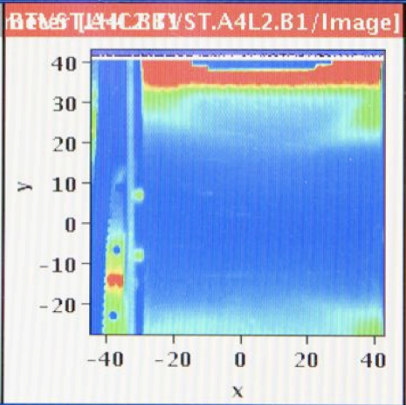
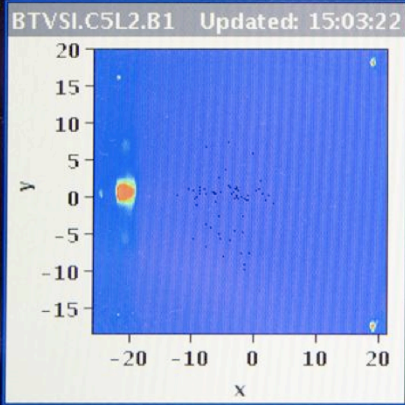
10th of September 2008 at CERN (Geneva): start of the LHC experiment

10-09-2008 15:03:39

BEAM SETUP: INJECTION PROBE BEAM

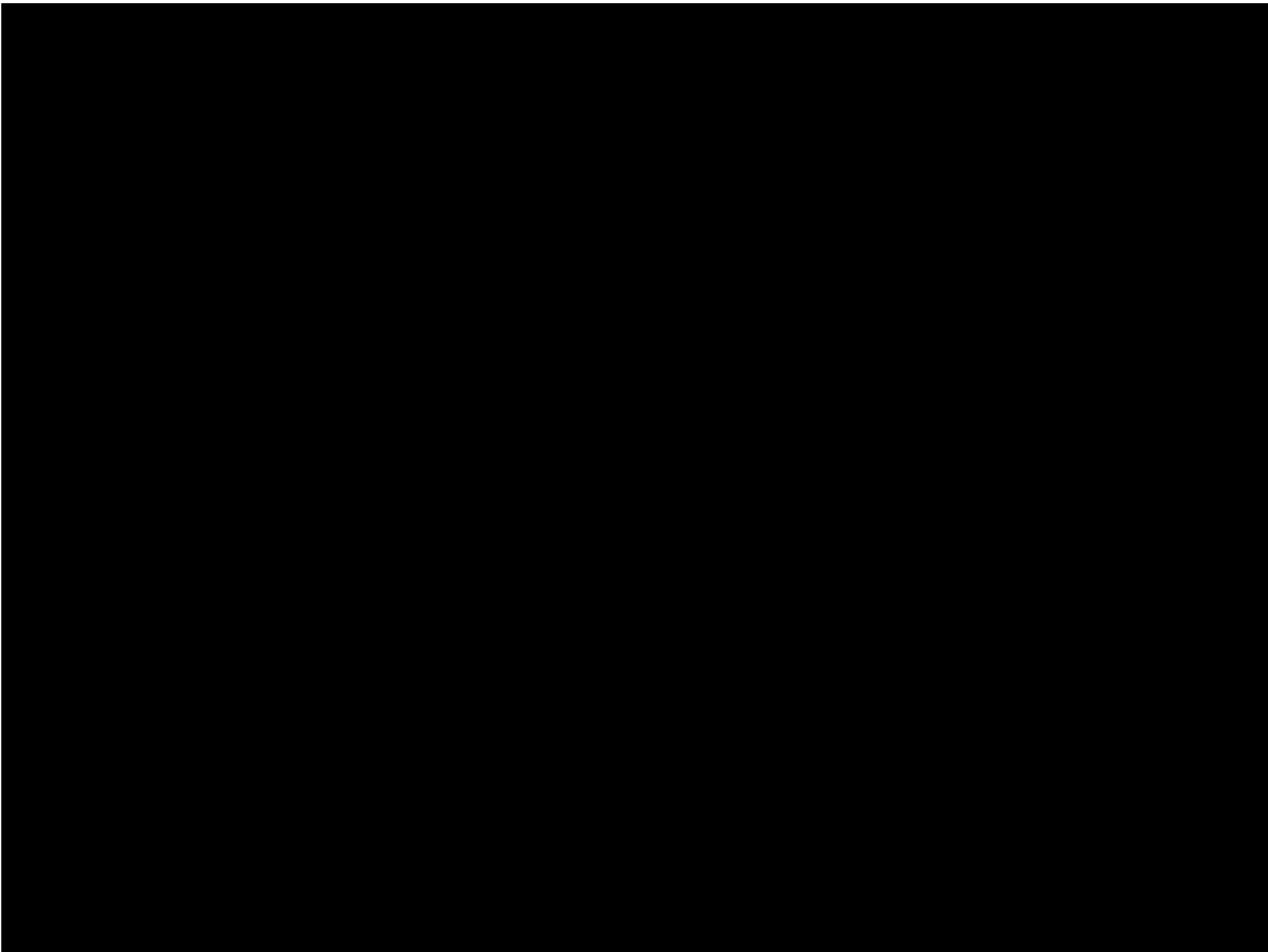
TED T12 position:	BEAM	TED T18 position:	BEAM
TDI P2 gaps/mm	upstream: 29.83	downstream: 30.16	
TDI P8 gaps/mm	upstream: 29.98	downstream: 30.00	

BCT T12:	0.00e+00	BCT T18:	0.00e+00
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Comments 10-09-2008 15:03:08 :

10th of September 2008 at CERN (Geneva): start of the LHC experiment

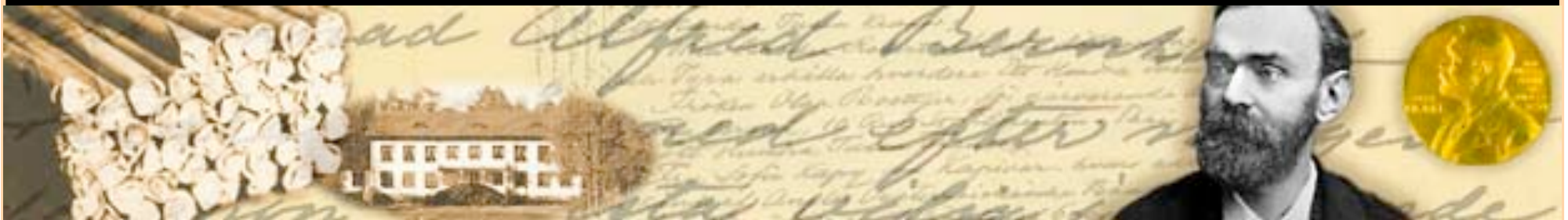




What is physics ?

"Physics is considered to be the most basic of the natural sciences. It deals with the fundamental constituents of matter and their interactions as well as the nature of atoms and the build-up of molecules and condensed matter. It tries to give unified descriptions of the behavior of matter as well as of radiation, covering as many types of phenomena as possible. In some of its applications, it comes close to the classical areas of chemistry, and in others there is a clear connection to the phenomena traditionally studied by astronomers. Present trends are even pointing toward a close approach of some areas of physics and microbiology."

By Erik B. Karlsson, "The Nobel Prize: The First 100 Years", 2001



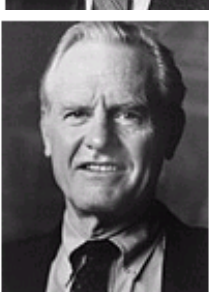
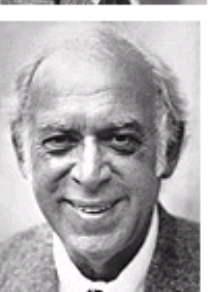
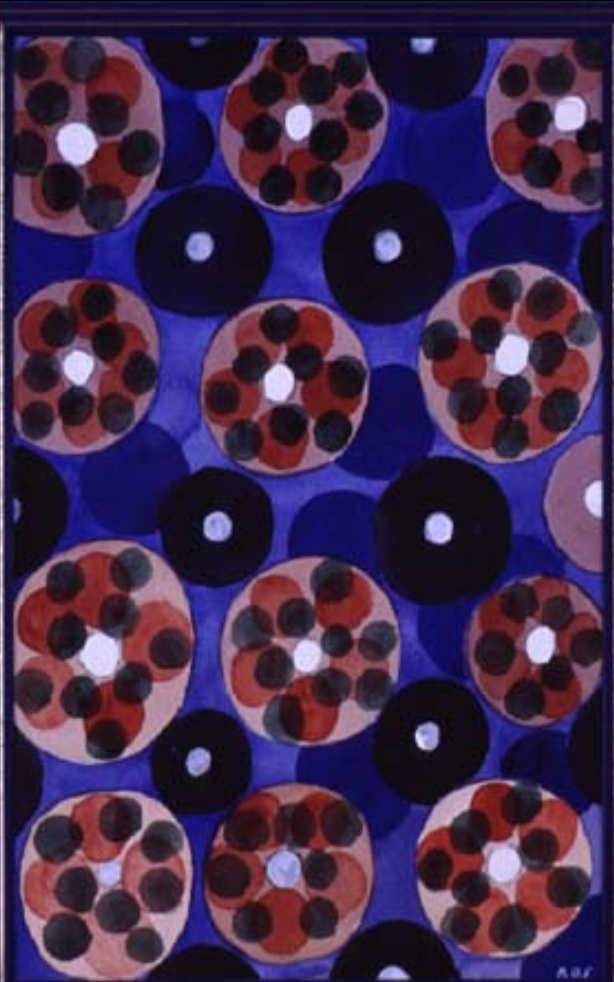


photo PRB

photo PRB

photo PRB



Kungliga
Svenska Vetenskapsakademien
har den 12 oktober 1999 beslutat
att med det

NOBELPRIS

som detta är tillerkännes den
som inom fysikens område gjort
den viktigaste upptäckten eller
uppfinnningen gemensamt belöna

Gerardus 't Hooft

och *Martinus J G Veltman*

för deras avgörande insatser
rörande kvantstrukturen hos teorin
för elektrosvag växelverkan i fysiken

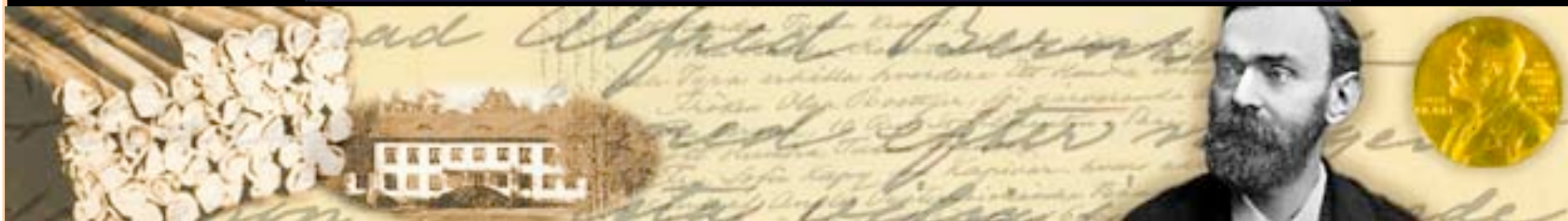
• STOCKHOLM DEN 10 DECEMBER 1999 •

Tan S. Ni hon



Erling Norrby

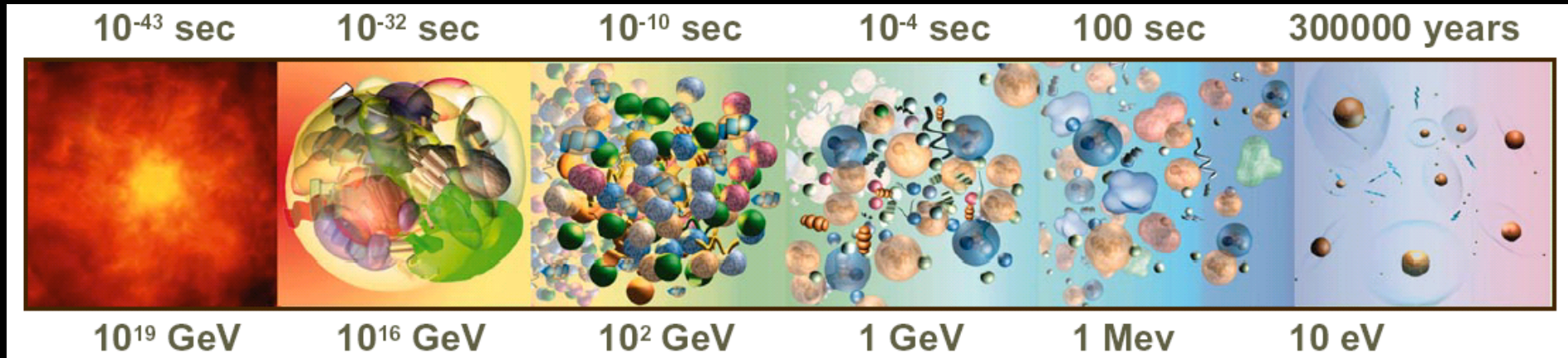
26



Nature : the story from the Big Bang until today

symmetry

“chaos”



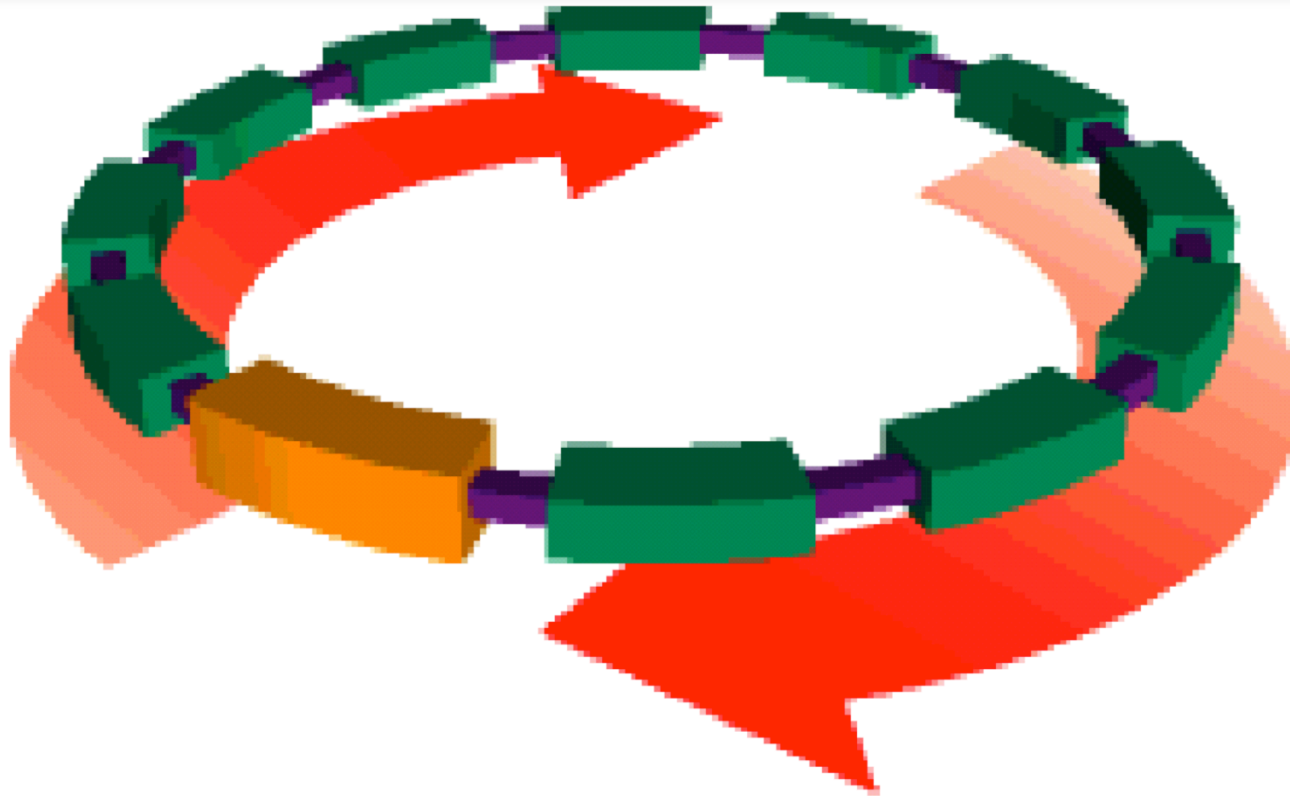
Elementary particle physics or high energy physics

Astro-physics
Chemistry
Biology ...

One single theory describing everything

Different theories describe several aspects of Nature

General principle of a circular accelerator

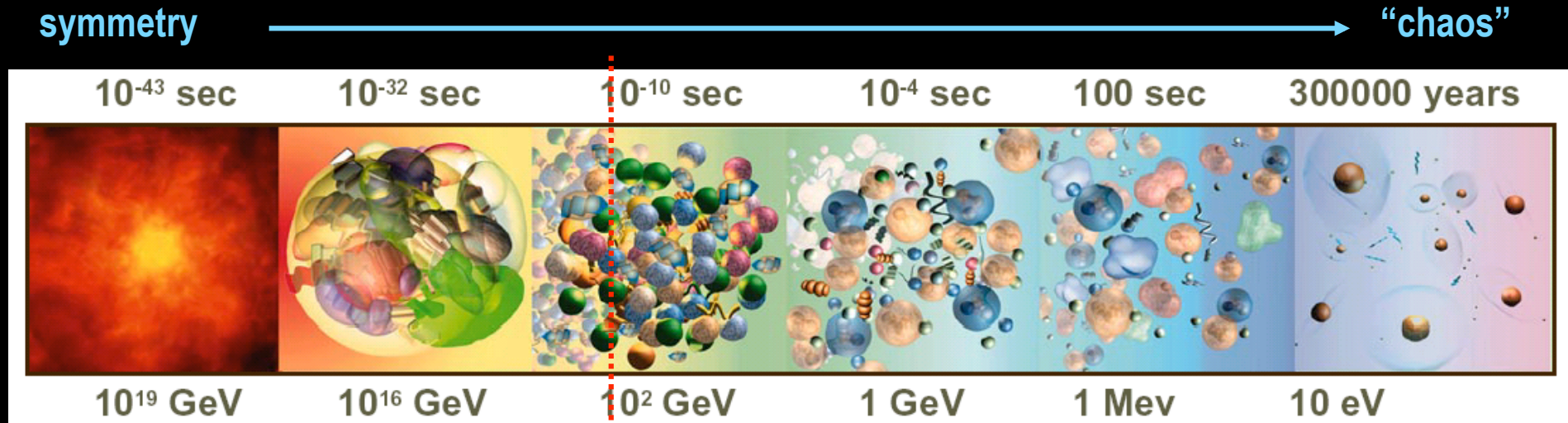


bend particles with a magnet



accelerate particles with electric fields

Nature : the story from the Big Bang until today



Experimental not accessible today : other theories aim to describe this period but today they cannot be verified yet !!


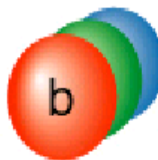


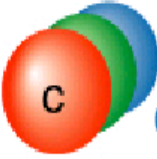
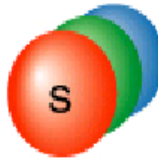






today

One theory describing everything up to ~ 1000 GeV :

The Standard Model

What do we know today : the Standard Model *matter particles* → *fermions*

Increasing mass ↑

Quarks		Leptons	
 t Top	 b Bottom	 τ Tau	 ν_τ Tau-neutrino
 c Charm	 s Strange	 μ Muon	 ν_μ Muon-neutrino
 u Up	 d Down	 e Electron	 ν_e Electron-neutrino

massive
electrical charged

small or no mass ??
no electric charge

The Tevatron Collider at Fermilab (Chicago)



2 TeV collisions



AZ U. of Arizona
 CA U. of California, Berkeley
 U. of California, Riverside
 Cal. State U., Fresno
 Lawrence Berkeley Nat. Lab.
 FL Florida State U.
 IL Fermilab
 U. of Illinois, Chicago
 Northern Illinois U.
 Northwestern U.
 IN Indiana U.
 U. of Notre Dame
 Purdue U. Calumet
 IA Iowa State U.
 KS U. of Kansas
 Kansas State U.
 LA Louisiana Tech U.
 MD U. of Maryland
 MA Boston U.
 Northeastern U.
 MI U. of Michigan
 Michigan State U.
 MS U. of Mississippi
 NE U. of Nebraska
 NJ Princeton U.
 NY Columbia U.
 U. of Rochester
 SUNY, Buffalo
 SUNY, Stony Brook
 Brookhaven Nat. Lab.
 OK Langston U.
 U. of Oklahoma
 Oklahoma State U.
 RI Brown U.
 TX Southern Methodist U.
 U. of Texas at Arlington
 Rice U.
 VA U. of Virginia
 WA U. of Washington



U. de Buenos Aires



LAFEX, CBPF, Rio de Janeiro
 State U. do Rio de Janeiro
 U. Federal do ABC, São Paulo
 State U. Paulista, São Paulo



U. of Alberta
 McGill U.
 Simon Fraser U.
 York U.



U. of Science and Technology
 of China, Hefei



U. de los Andes, Bogotá



Charles U., Prague
 Czech Tech. U., Prague
 Academy of Sciences, Prague



U. San Francisco de Quito



LPC, Clermont-Ferrand
 ISN, IN2P3, Grenoble
 CPPM, IN2P3, Marseille
 LAL, IN2P3, Orsay
 LPNHE, IN2P3, Paris
 DAPNIA/SPP, CEA, Saclay
 IReS, Strasbourg
 IPN, IN2P3, Villeurbanne



U. of Aachen
 Bonn U.
 U. of Freiburg
 U. of Mainz
 Ludwig-Maximilians U., Munich
 U. of Wuppertal

The DØ Collaboration



Panjab U. Chandigarh
 Delhi U., Delhi
 Tata Institute, Mumbai



University College, Dublin



KDL, Korea U., Seoul
 SungKyunKwan U., Suwan



CINVESTAV, Mexico City



FOM-NIKHEF, Amsterdam
 U. of Amsterdam / NIKHEF
 U. of Nijmegen / NIKHEF



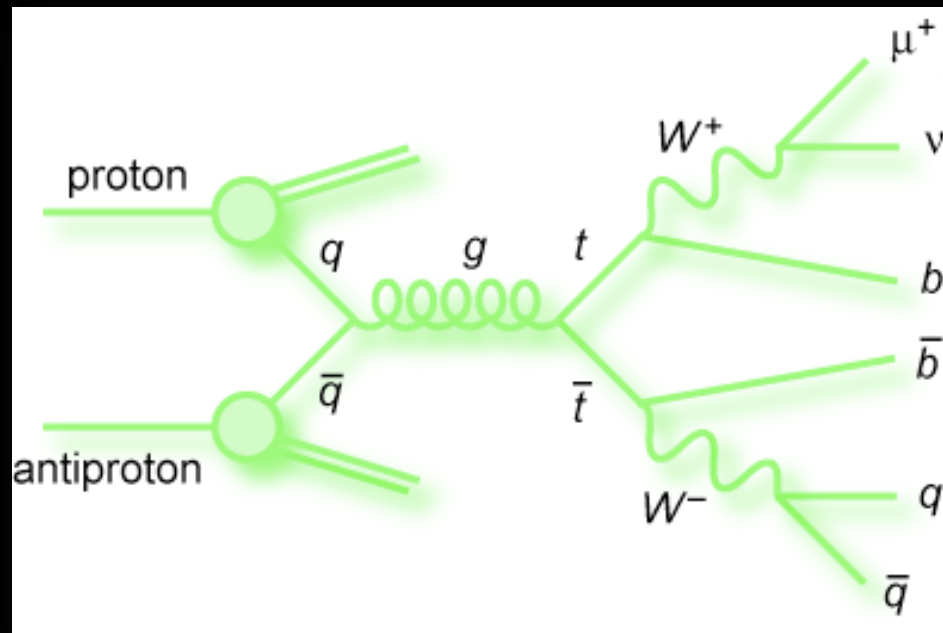
JINR, Dubna
 ITEP, Moscow
 Moscow State U.
 IHEP, Protvino
 PNPI, St. Petersburg



Lund U.
 RIT, Stockholm
 Stockholm U.
 Uppsala U.



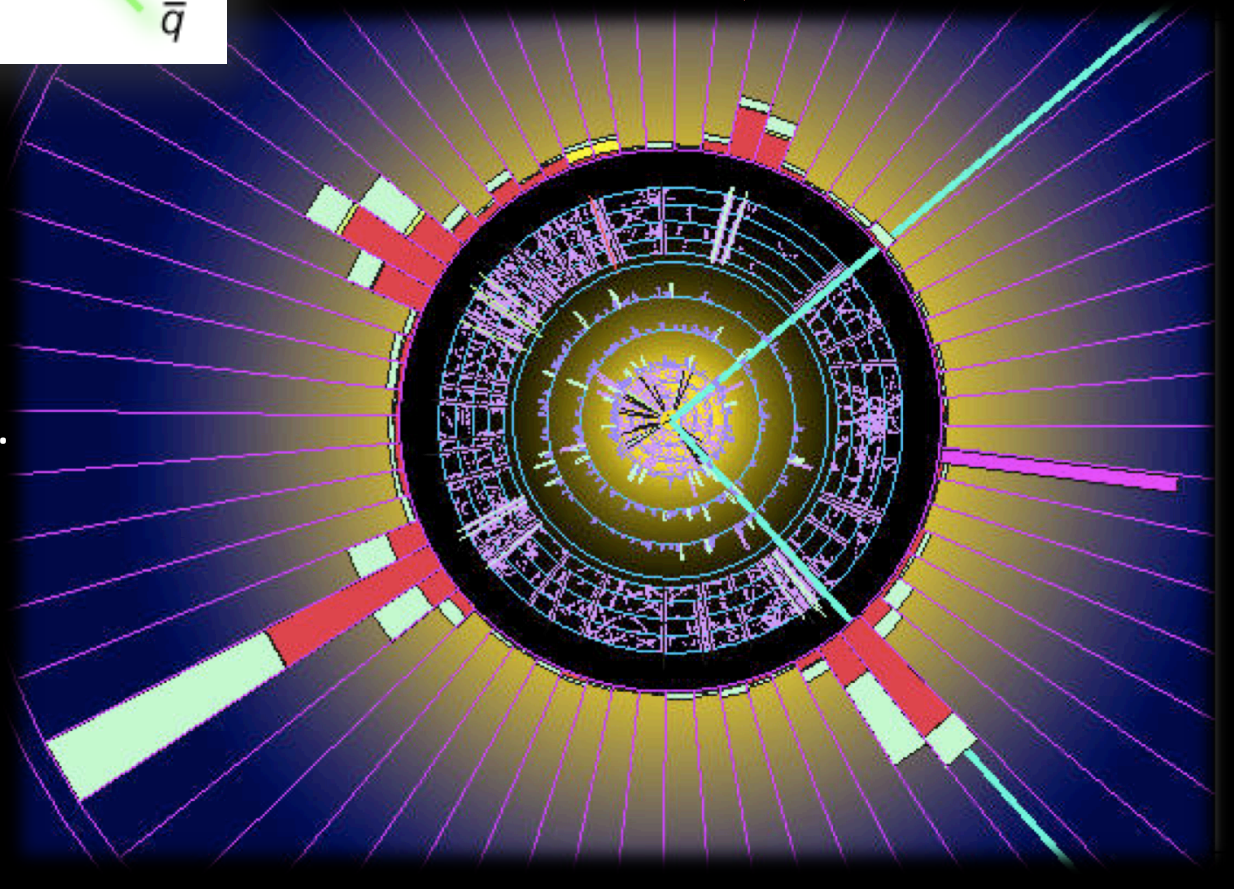
Lancaster U.
 Imperial College, London
 U. of Manchester



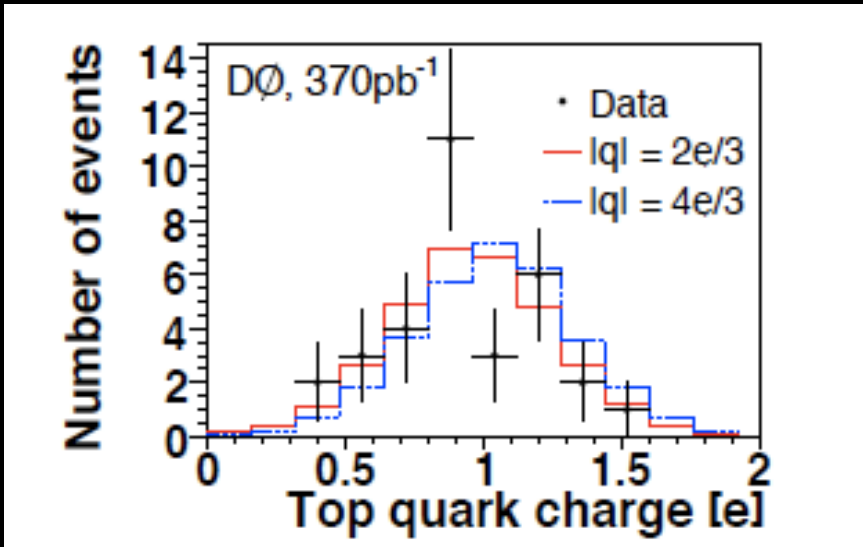
simulation

analysis

In the real collisions taken by the D0 experiment and after the event selection 21 of these events remain to measure the electric charge of the top quark.



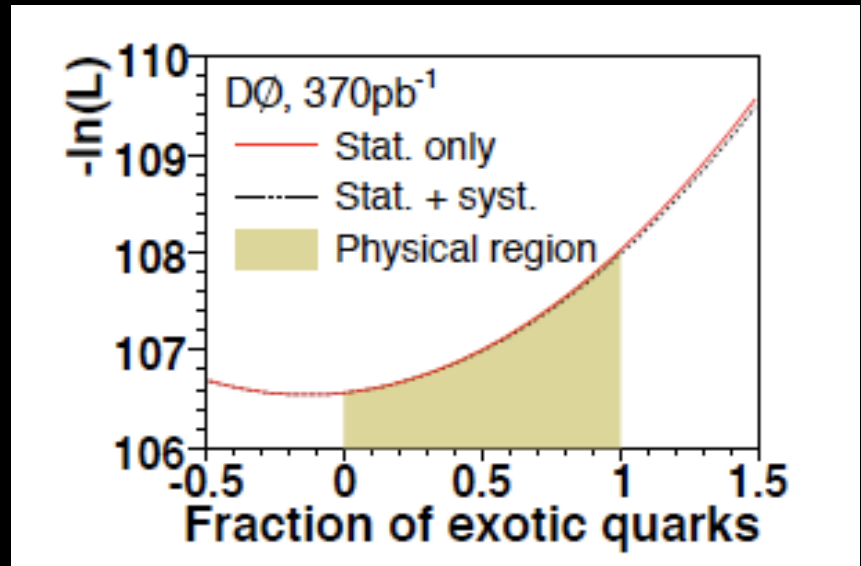
Reconstructed top quark charge



The probability of the observation assuming that 100% of the selected events are exotic quarks with electric charge $4e/3$ is 8%.

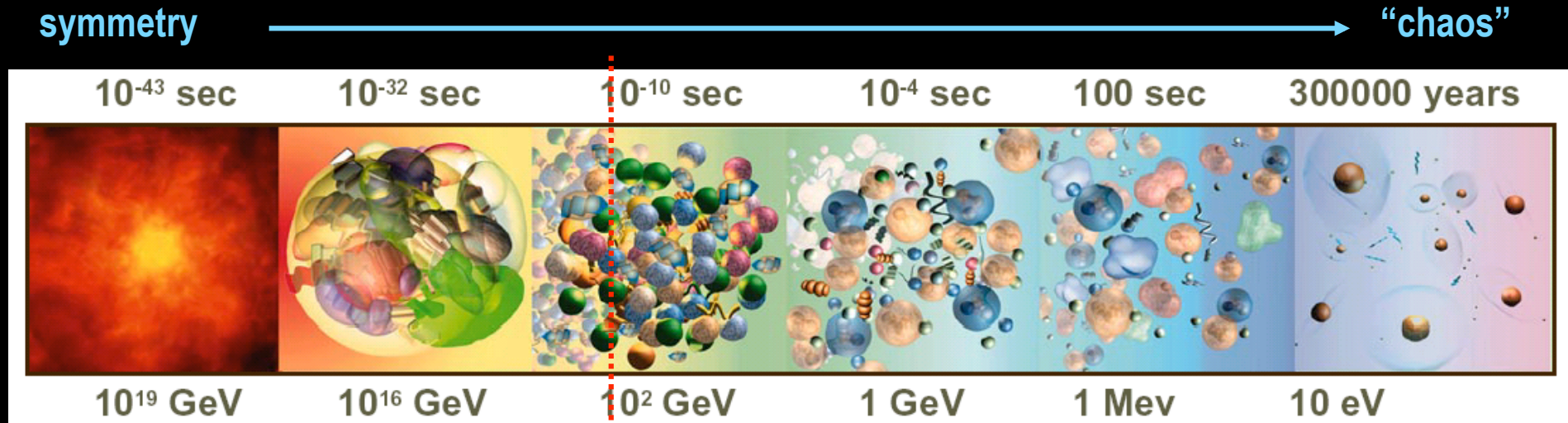
First time ever this is measured!!

$$p(Q; \rho) = \rho \times p^{\text{ex}}(Q) + (1 - \rho) \times p^{\text{sm}}(Q)$$



Probability	ρ	ρ (Bayesian)
68%	$-0.80 < \rho < 0.54$	$0 < \rho < 0.52$
90%	$-1.24 < \rho < 0.97$	$0 < \rho < 0.80$

Nature : the story from the Big Bang until today



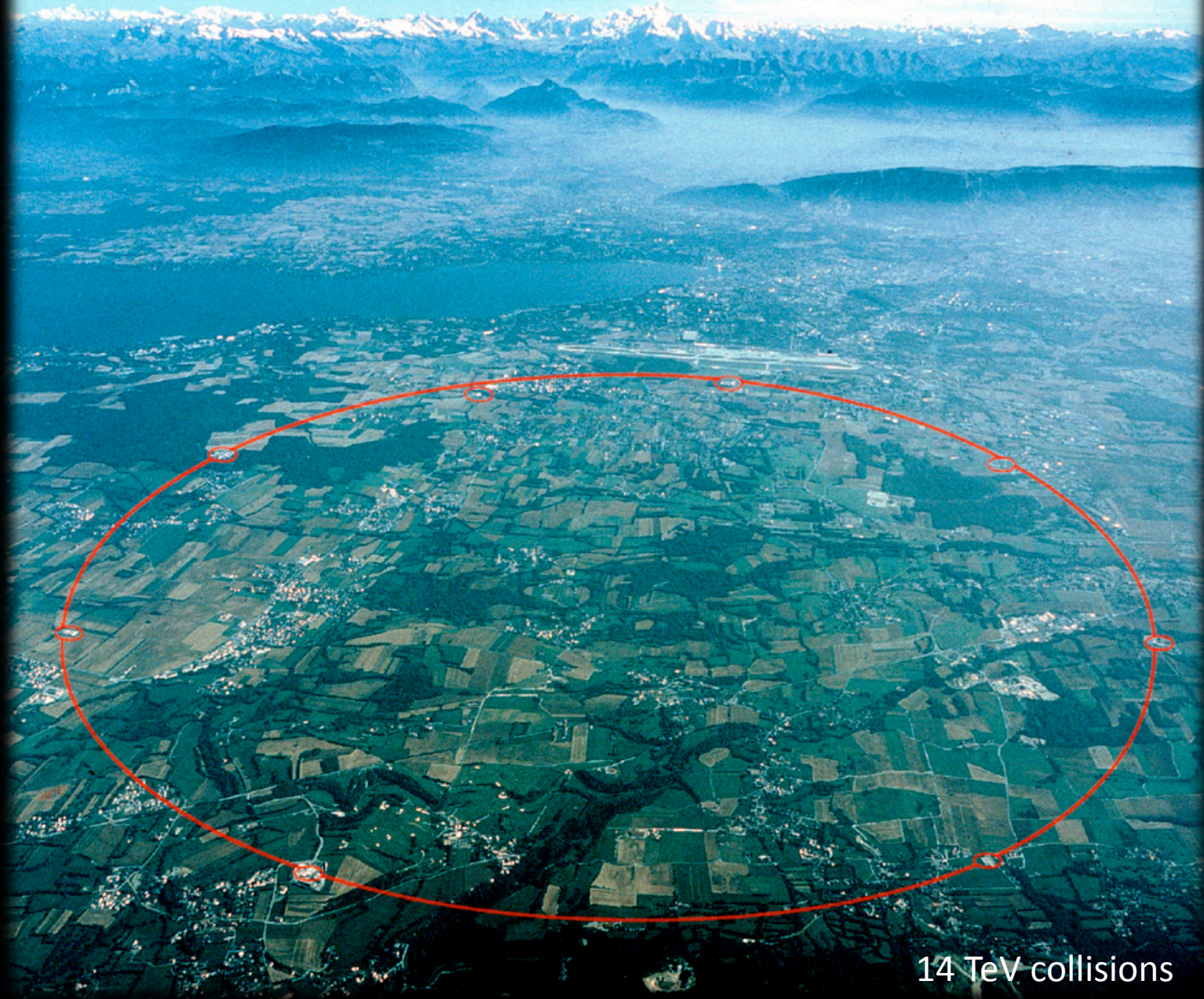
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today

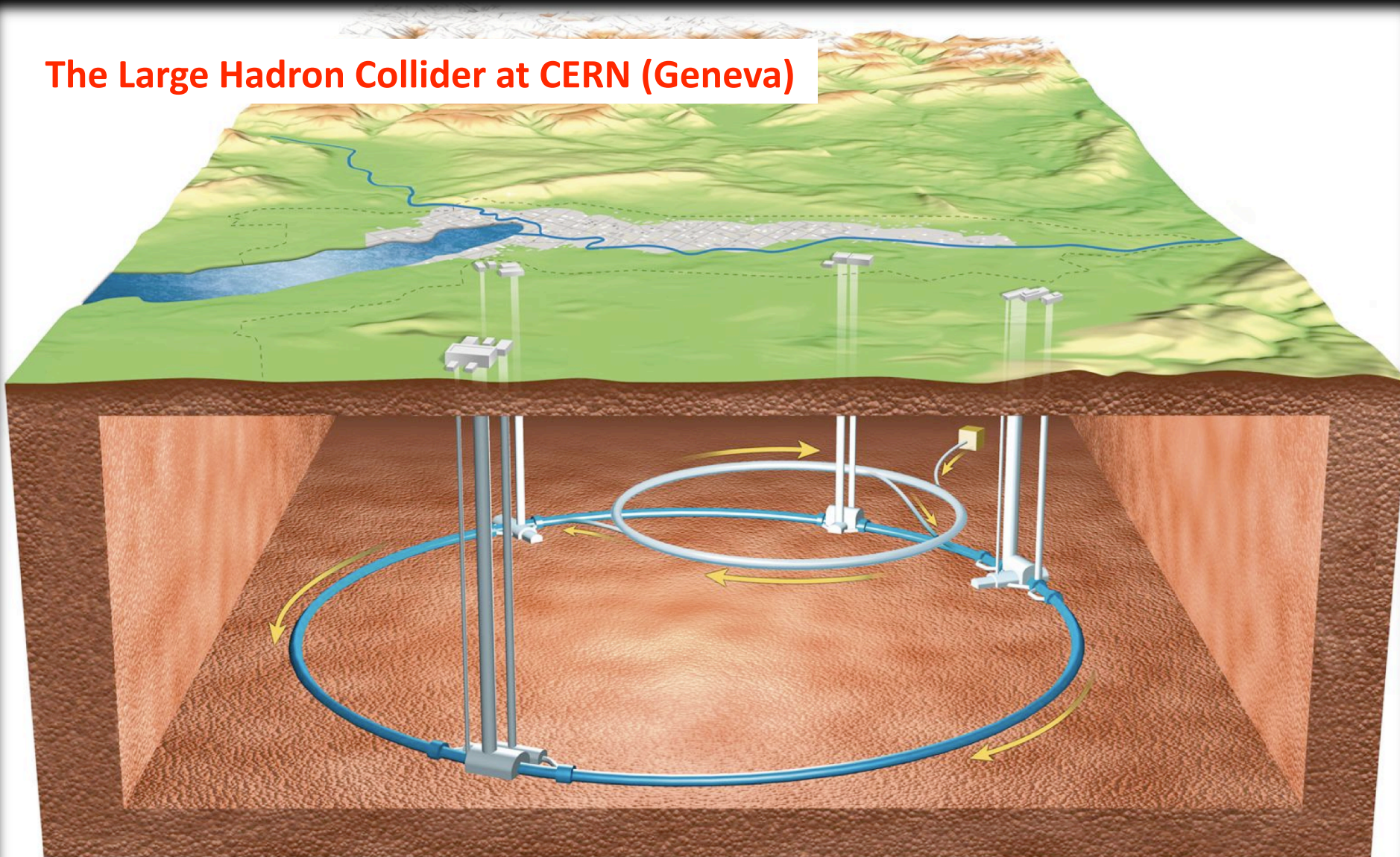
One theory describing everything up to ~ 1000 GeV :
The Standard Model

The Large Hadron Collider at CERN (Geneva)

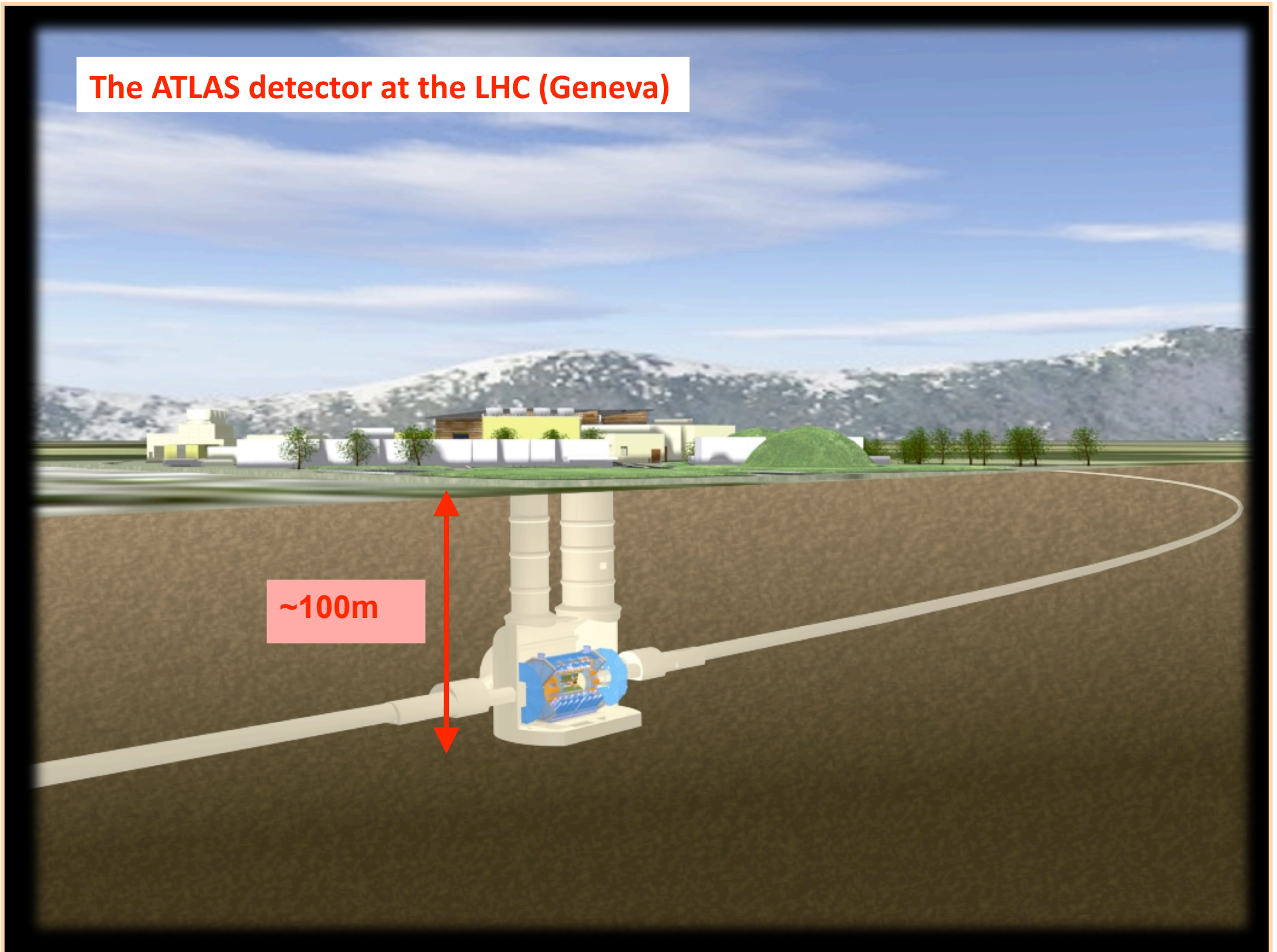


14 TeV collisions

The Large Hadron Collider at CERN (Geneva)



The ATLAS detector at the LHC (Geneva)



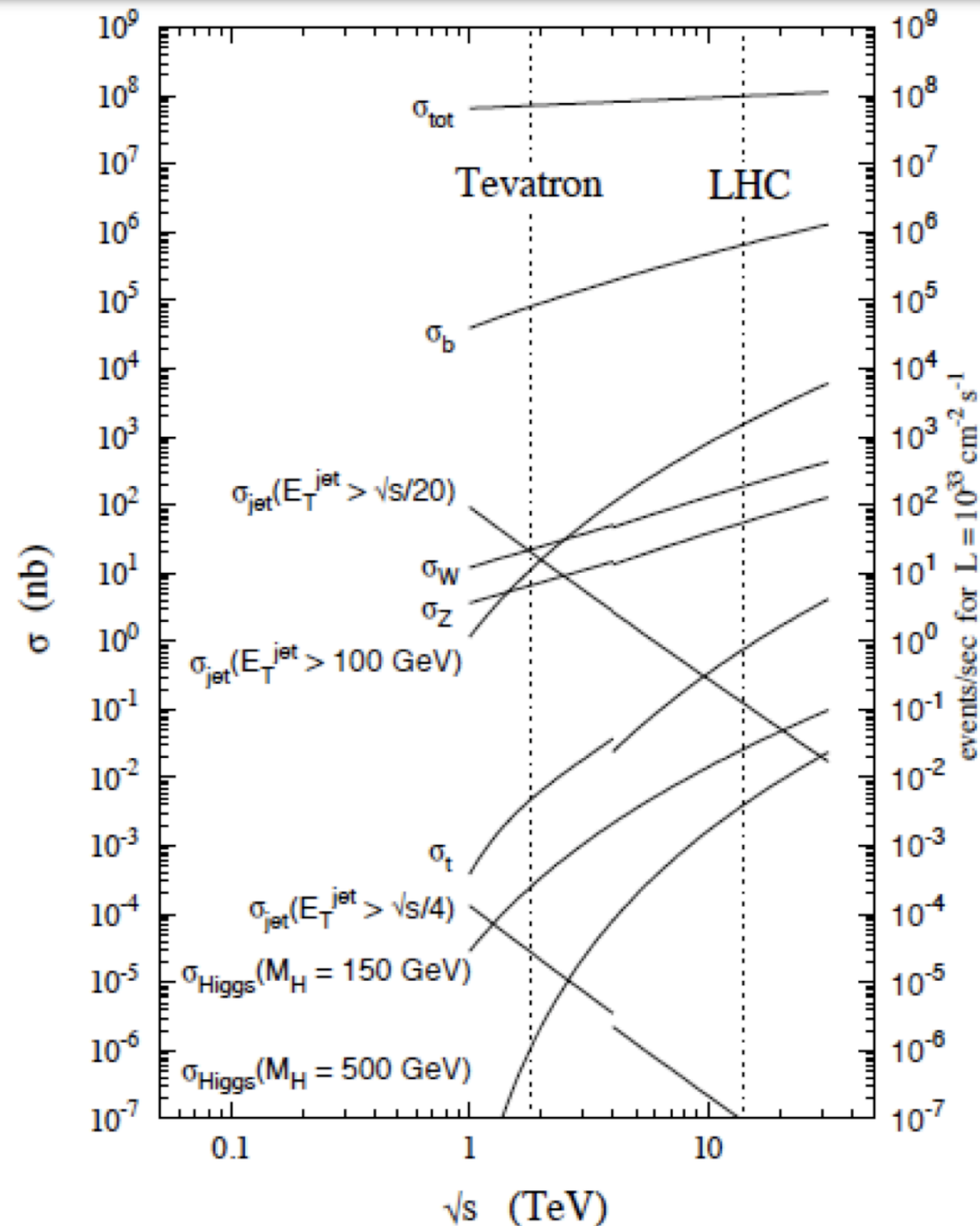
Tevatron:

Top quarks are a field for exciting physics

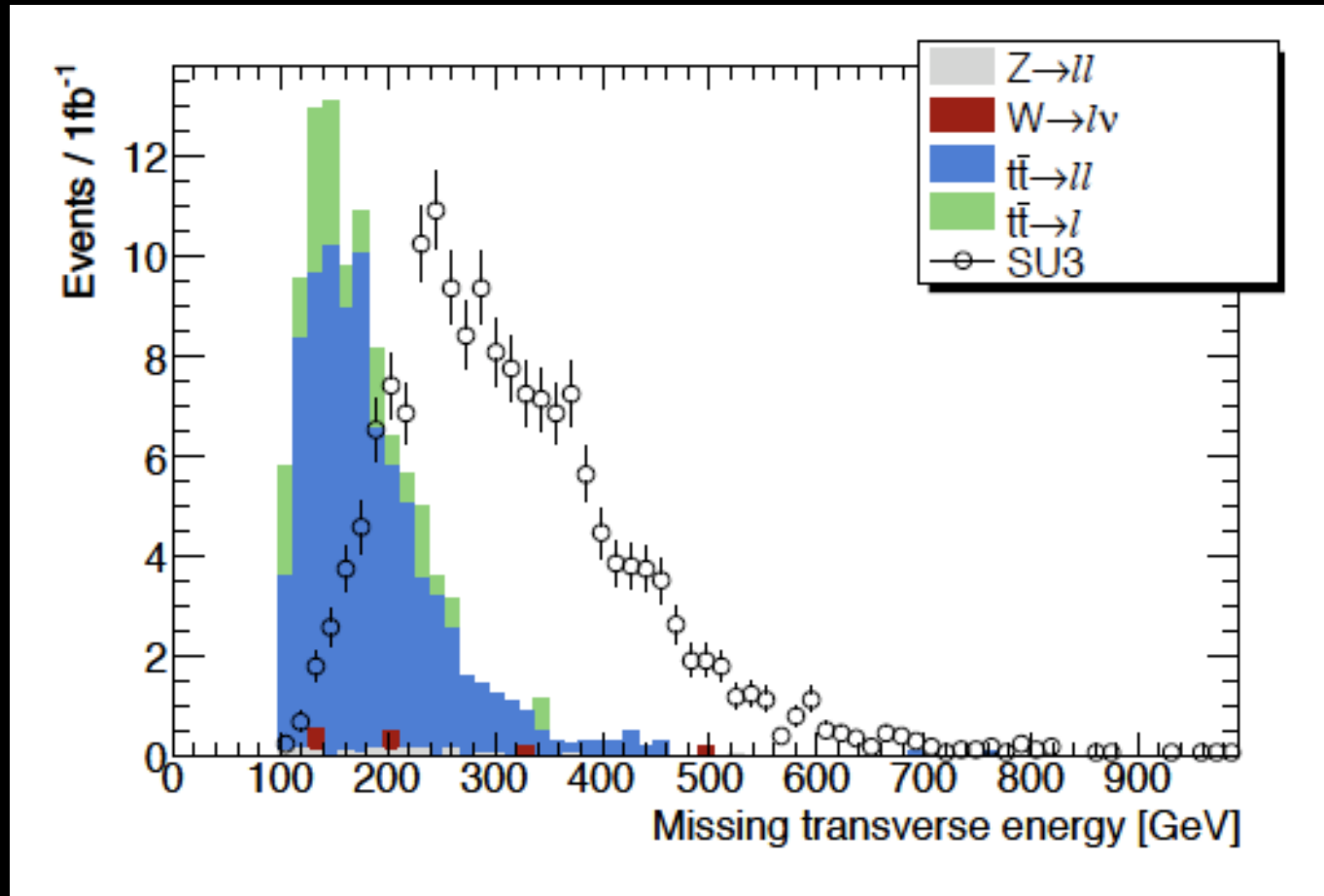
LHC:

Top quarks become background events for the new particles we search

In the search for new particles we need to measure the level/shape of the background from the data itself.



If supersymmetry is part of Nature, then new particle should exist, and some of them escape detection resulting in missing (transverse) energy.

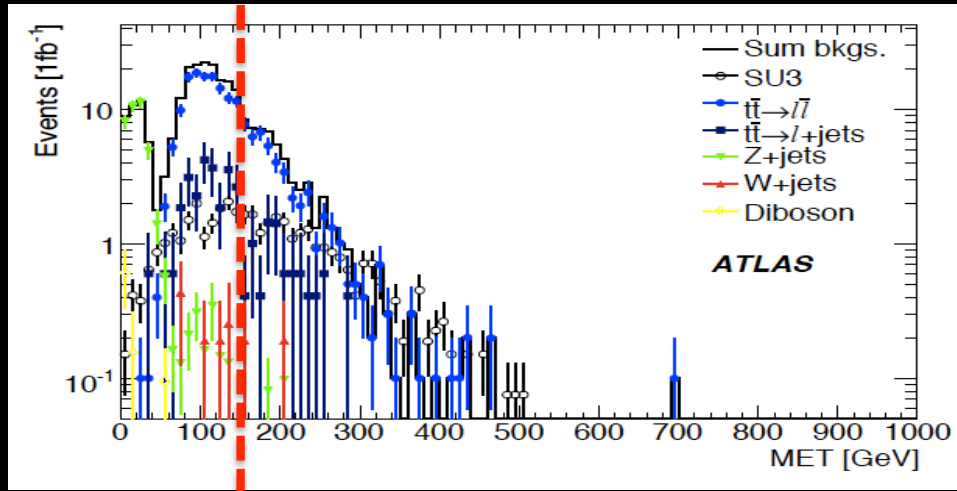


But, we cannot trust the calculation of the Standard Model processes at these high missing transverse energies.

correct
b-quark pairs

control
region

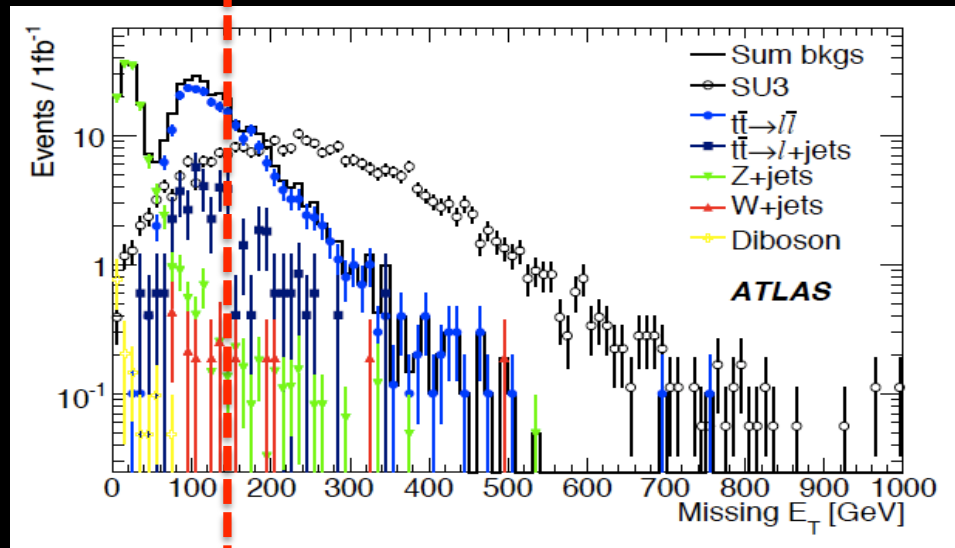
A



A'

signal
region

N



SUSY signal
region

N_{bck}

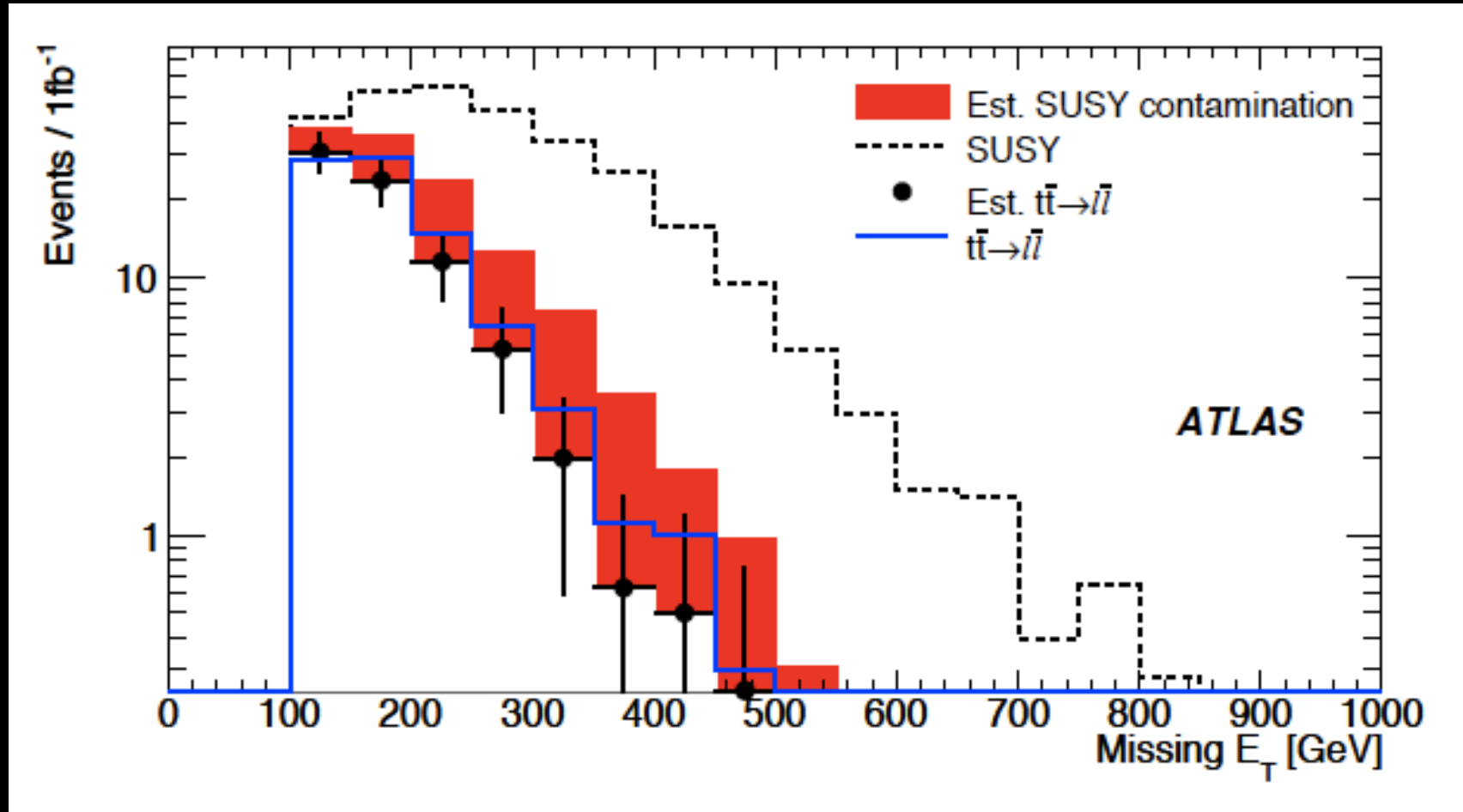
normalization
region

signal
region

MET

$$N_{\text{bck}} = N \times (A'/A)$$

Estimated background from data agrees reasonable with prediction



Basis which is needed for future searches of supersymmetric particles

Summary

A clear contribution to the research of particle physics which is an important domain in modern physics

Tevatron (Fermilab, Chicago)

First measurement of the electric charge of the top quark

Confirmation of the Standard Model prediction

LHC (CERN, Geneva)

Estimate of the background contribution in the search for new physics