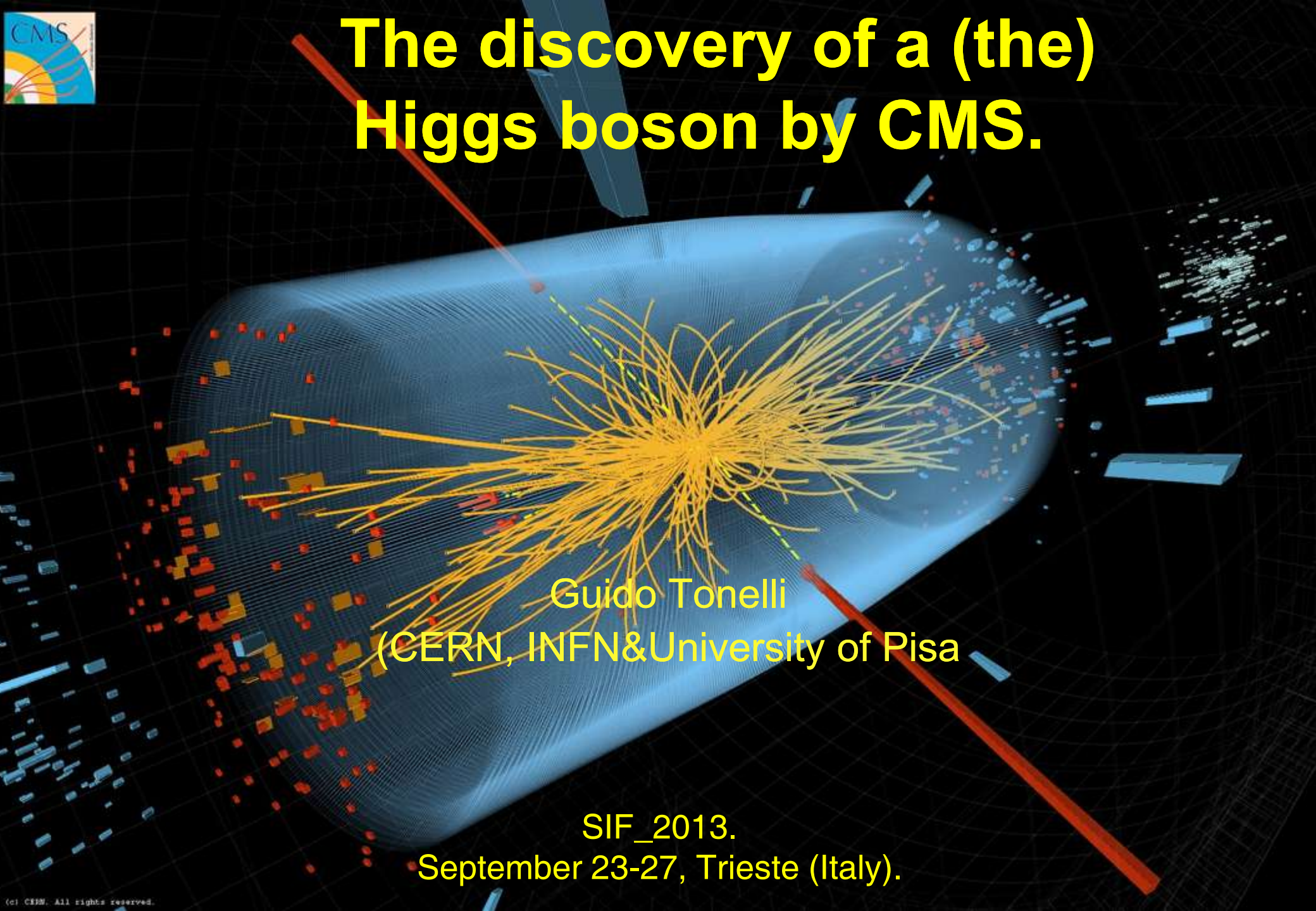
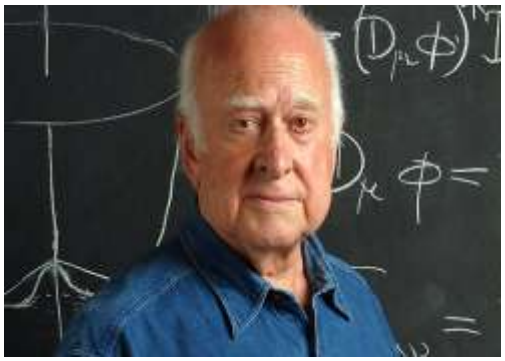


The discovery of a (the) Higgs boson by CMS.

Guido Tonelli
(CERN, INFN&University of Pisa

SIF_2013.
September 23-27, Trieste (Italy).

A ~50 year old elegant conjecture…



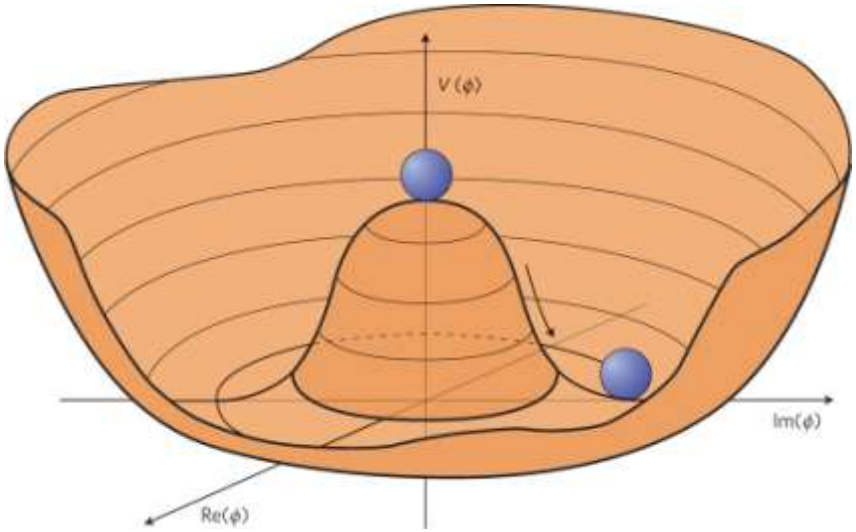
[1] F. Englert and R. Brout, "Broken symmetry and the mass of gauge vector mesons", *Phys. Rev. Lett.* **13** (1964) 321, doi:10.1103/PhysRevLett.13.321.

[2] P. W. Higgs, "Broken symmetries, massless particles and gauge fields", *Phys. Lett.* **12** (1964) 132, doi:10.1016/0031-9163(64)91136-9.

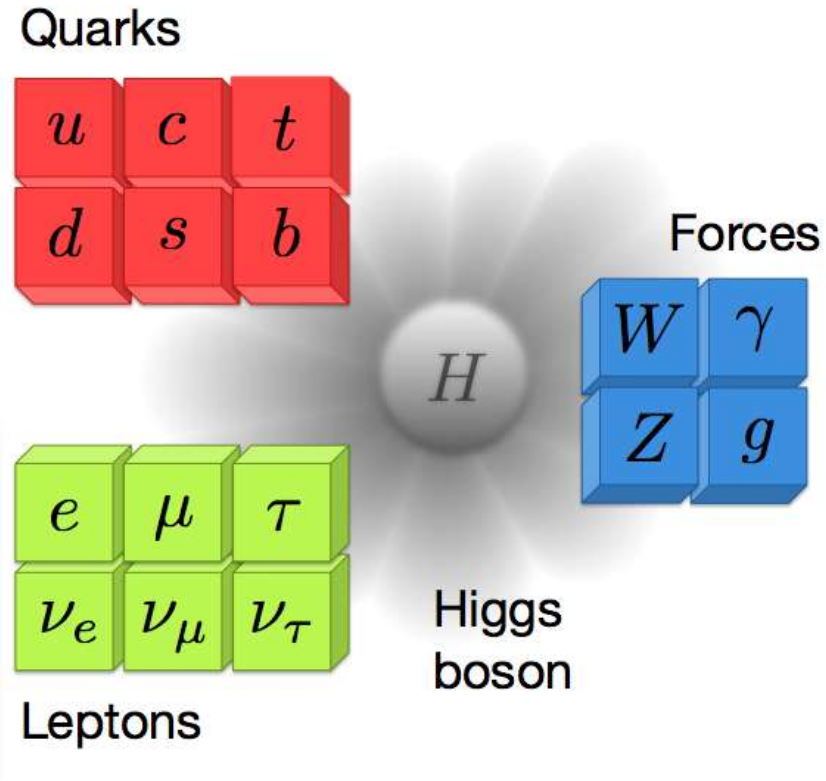
[3] P. W. Higgs, "Broken symmetries and the masses of gauge bosons", *Phys. Rev. Lett.* **13** (1964) 508, doi:10.1103/PhysRevLett.13.508.

[4] G. S. Guralnik, C. R. Hagen, and T. W. B. Kibble, "Global conservation laws and massless particles", *Phys. Rev. Lett.* **13** (1964) 585, doi:10.1103/PhysRevLett.13.585.

…with profound implications.



$$V(\Phi) = \mu^2 \Phi^\dagger \Phi + \lambda^2 \left(\Phi^\dagger \Phi\right)^2$$



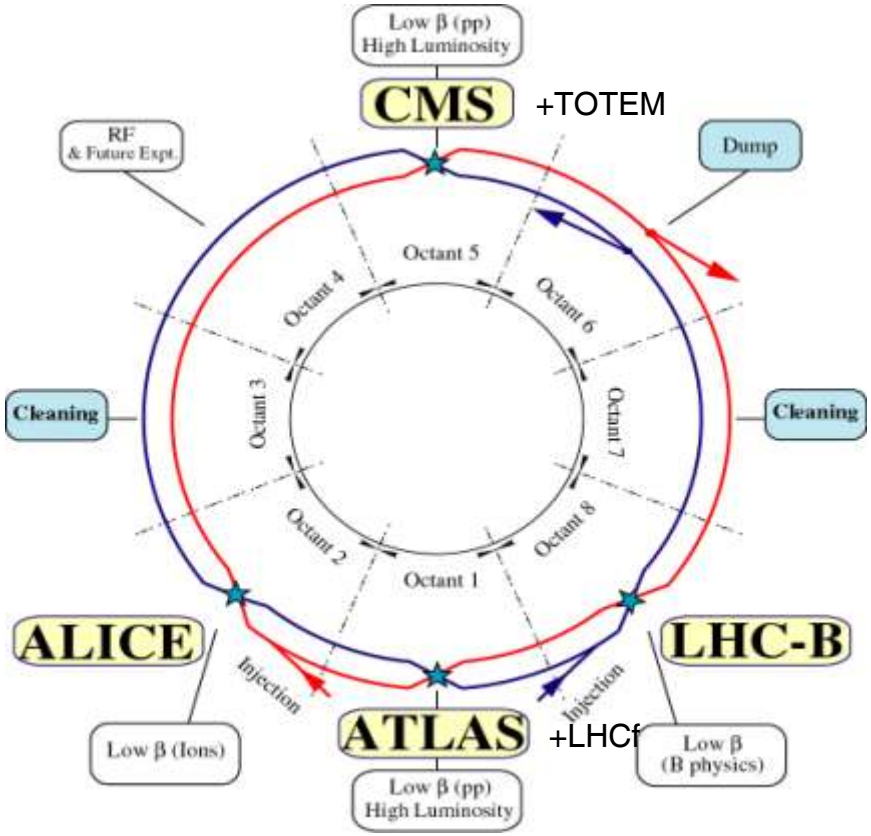
The exact symmetries of the Lagrangian relating the weak and electromagnetic interactions are broken by the vacuum: the photon remains massless while the W and Z boson becomes massive. A mechanism " a la Yukawa" gives mass to fermions.
A new scalar field pervades every corner of our universe.

LHC: a beautiful machine

1232 superconducting dipoles
15m long at 1.9 K, B=8.33 T
Inner coil diameter = 56 mm

Max. beam-energy	**7 TeV**	(7xTEVATRON)
Design Luminosity	**10^{34} cm^{-2}s^{-1}**	(>100x TEVATRON)
Bunch spacing	**24.95 ns**	
Particles/bunch	1.1 10^{11}	
Stored E/beam	362 MJ	

Also : Lead Ions operation
Energy/nucleon 2.76 TeV / u
Total initial lumi 10^{27} cm^{-2} s^{-1}



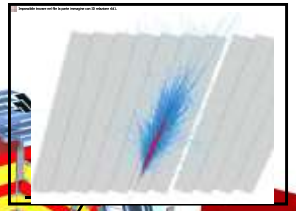
After the incident on the splices in 2008
3.5-4 TeV max beam energy
50ns bunch spacing, high "pile-up"
Max L~5-7x10^{33} cm^{-2}s^{-1}

The Compact Muon Solenoid (CMS)

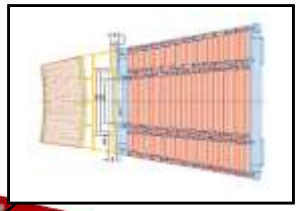
SUPERCONDUCTING COIL

CALORIMETERS

ECAL Scintillating $PbWO_4$ Crystals



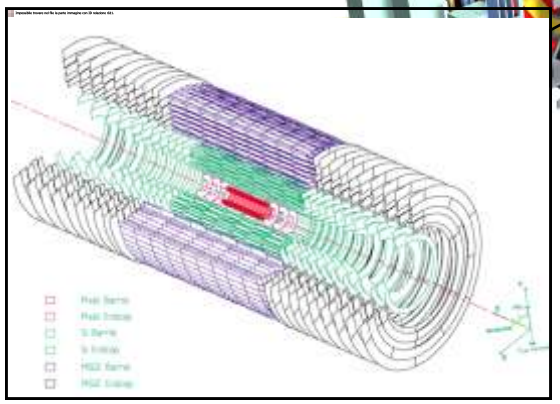
HCAL Plastic scintillator copper sandwich



Total weight : 12,500 t
Overall diameter : 14.6 m
Overall length : 21.6 m
Magnetic field : 3.8 Tesla

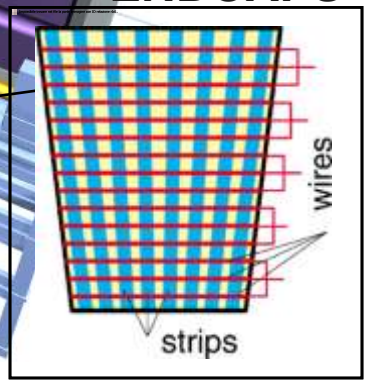
IRON YOKE

TRACKERs



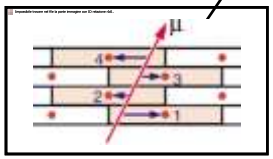
Silicon Microstrips
Pixels

MUON ENDCAPS

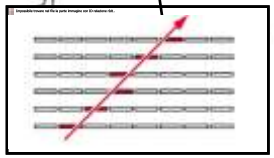


Cathode Strip Chambers (**CSC**)
Resistive Plate Chambers (**RPC**)

MUON BARREL

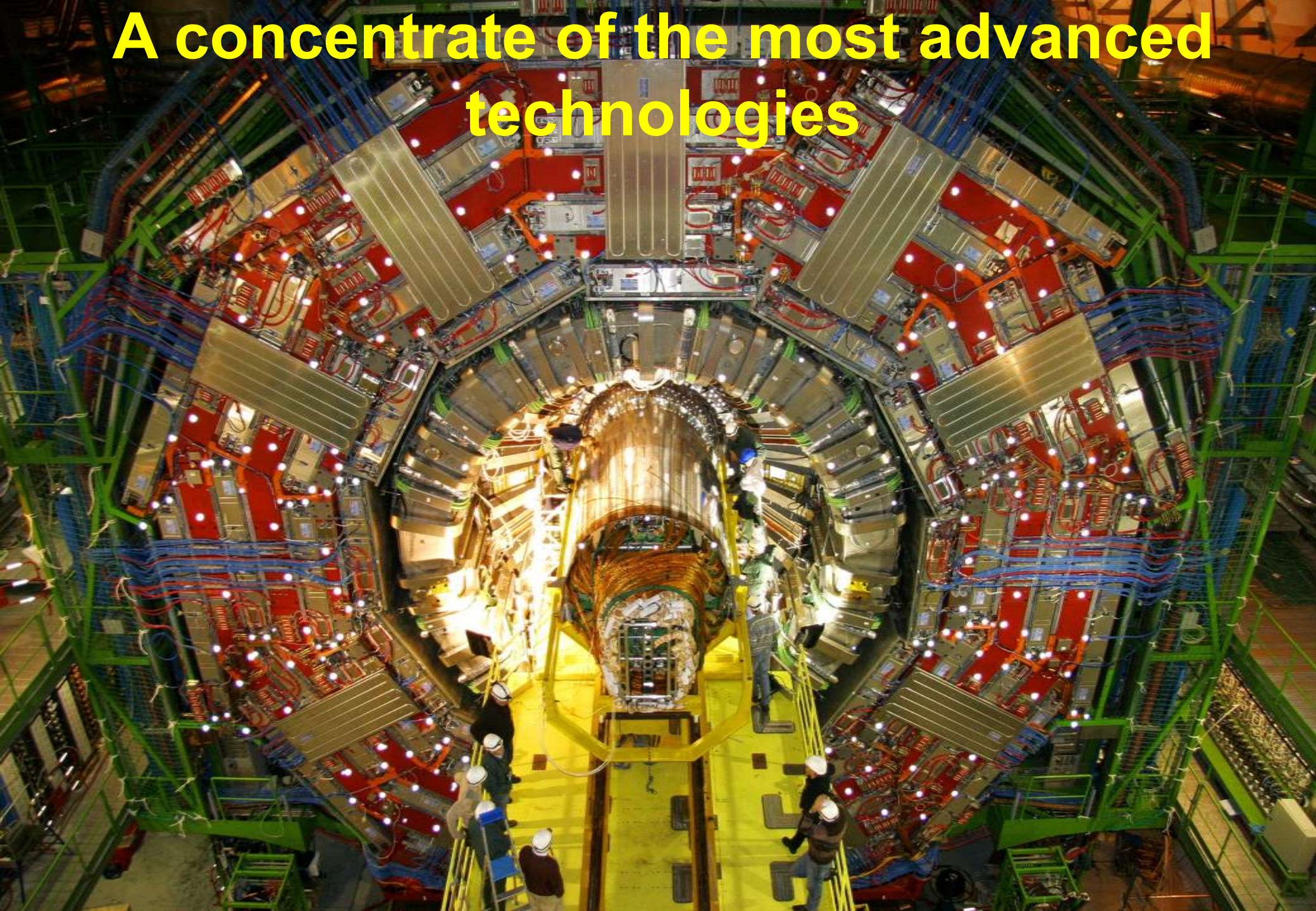


Drift Tube Chambers (**DT**)



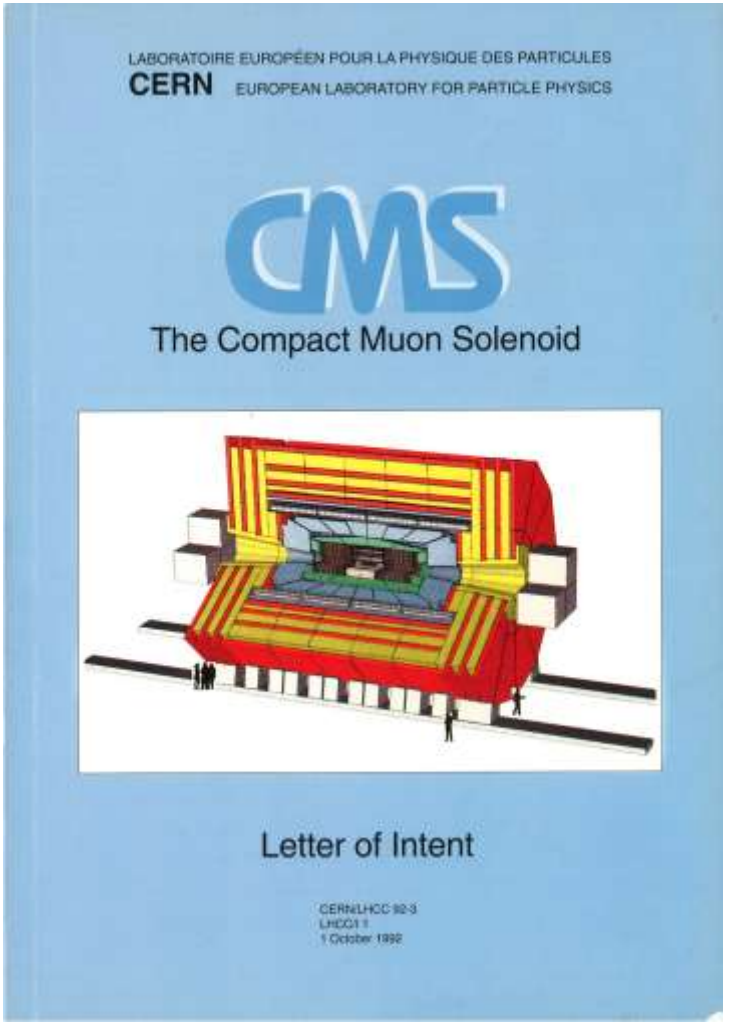
Resistive Plate Chambers (**RPC**)

A concentrate of the most advanced technologies

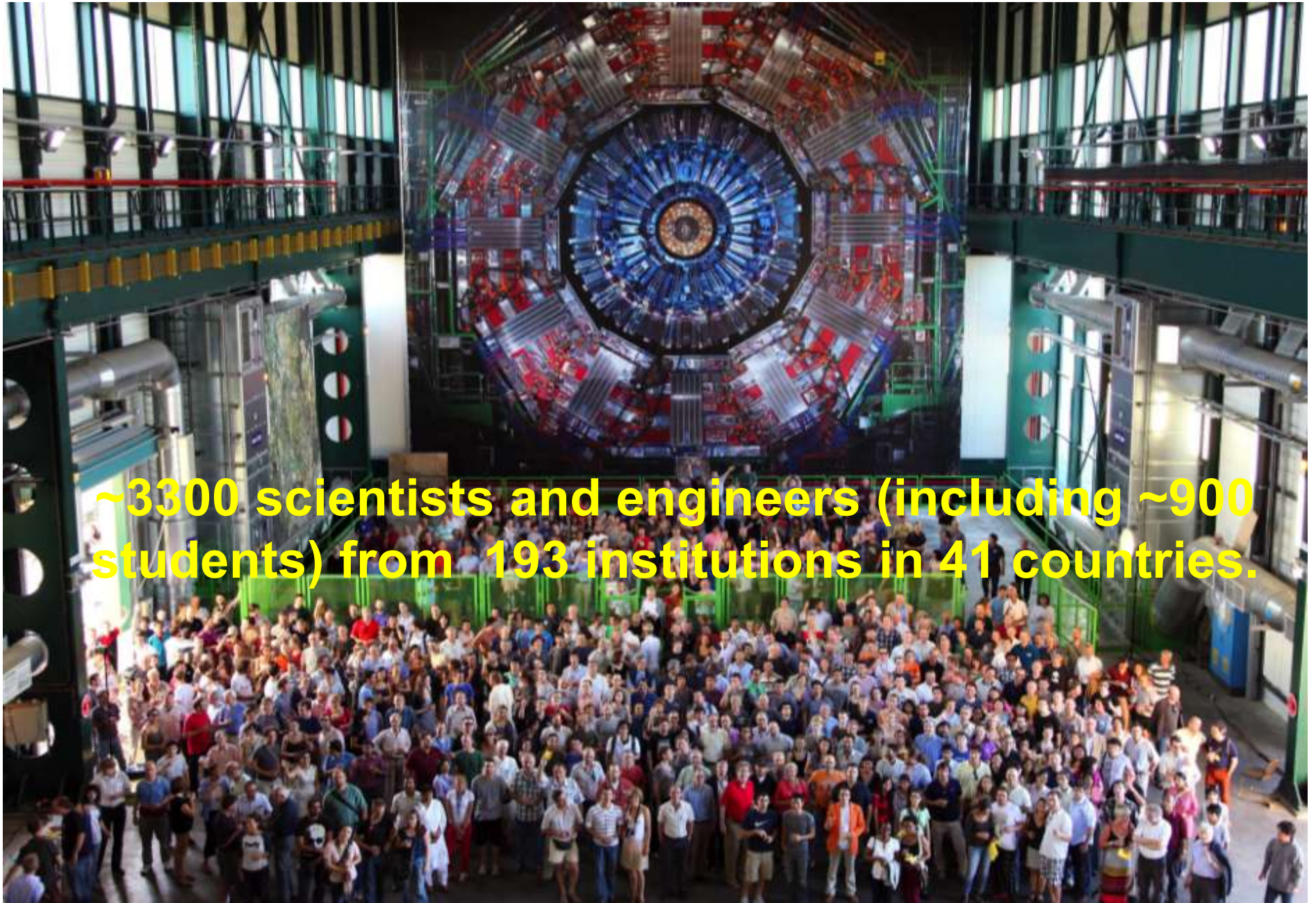


Many years of tough work

- The Letters of Intent for CMS dates back to 1992. The LHCC gave the green light on June 1993.
- The accelerator was approved in 1994.
- It took many years of tough work by thousand of people facing un-precented challenges to complete the construction of LHC and of its complex detectors.

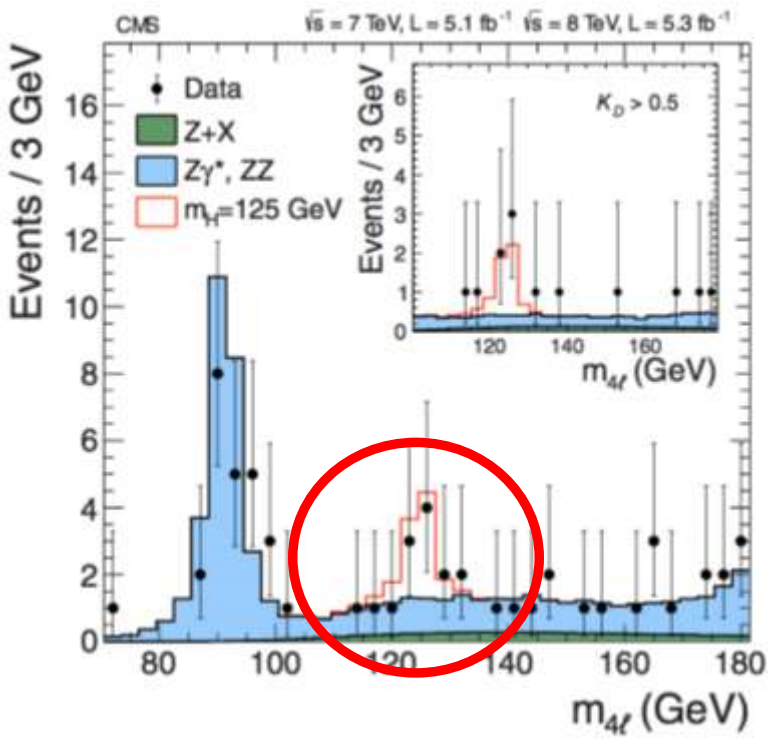


The CMS Collaboration



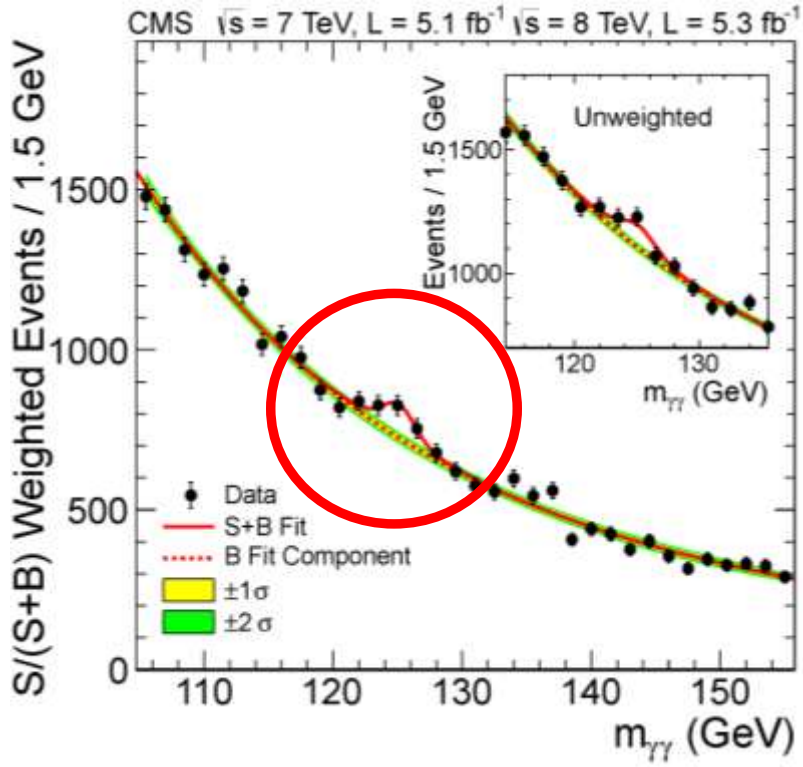
A coincidence of signals in the two high resolution channels.

H→ZZ→4leptons



3.2σ excess (3.8 exp.)@ 125.6 GeV

H→γγ



4.1σ excess (2.8exp.) @ 125GeV

A new boson discovered by ATLAS and CMS at the Large Hadron Collider.