



#askCERN

# **Hangout with CERN: Latest news on the new boson**

**7 March 2013**



## Global Effort → Global Success

Results today only possible due to  
extraordinary performance of  
accelerators – experiments – Grid computing

Observation of a new particle consistent with  
a Higgs Boson (but which one...?)

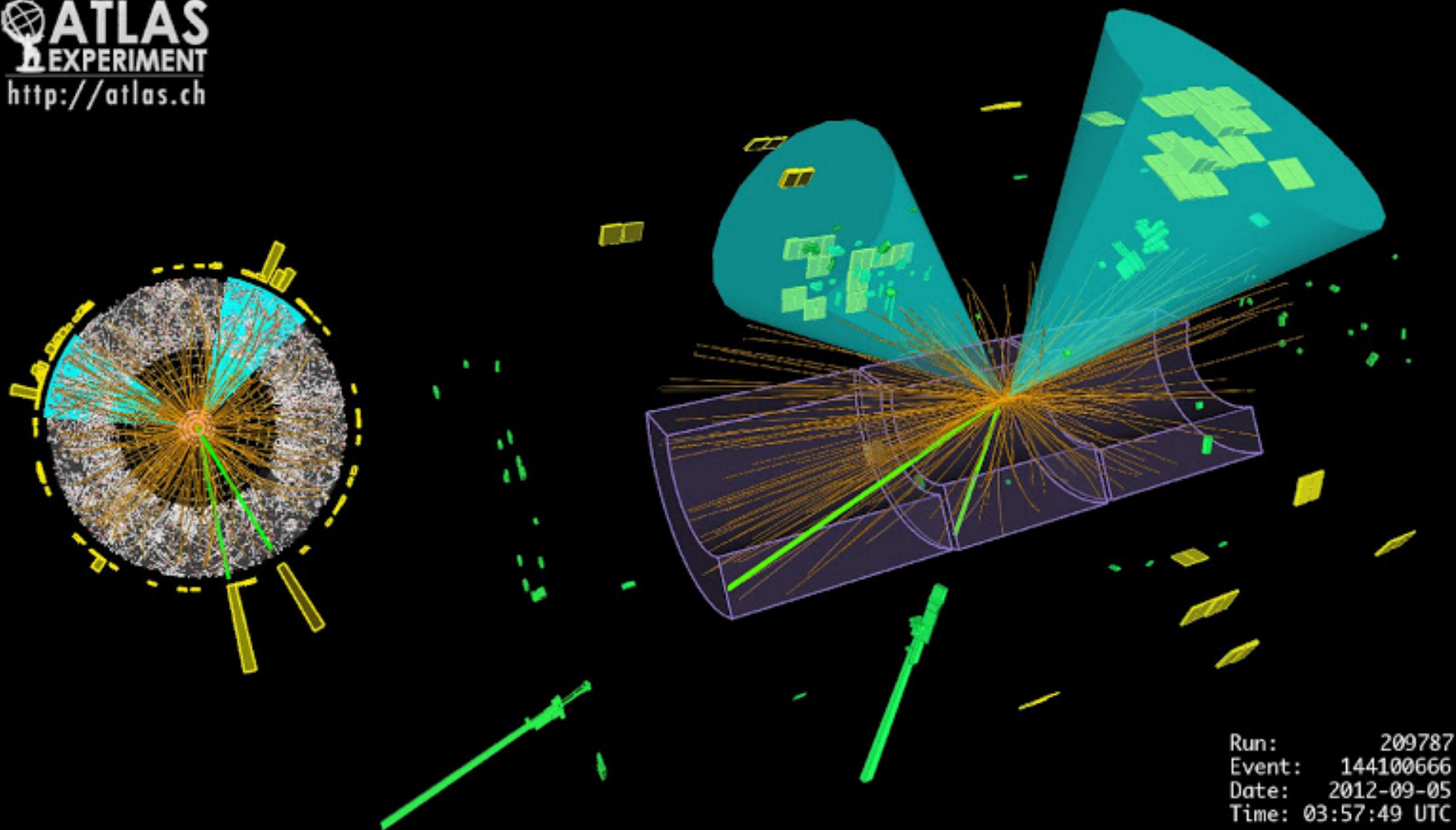
Historic Milestone but only the beginning

Global Implications for the future









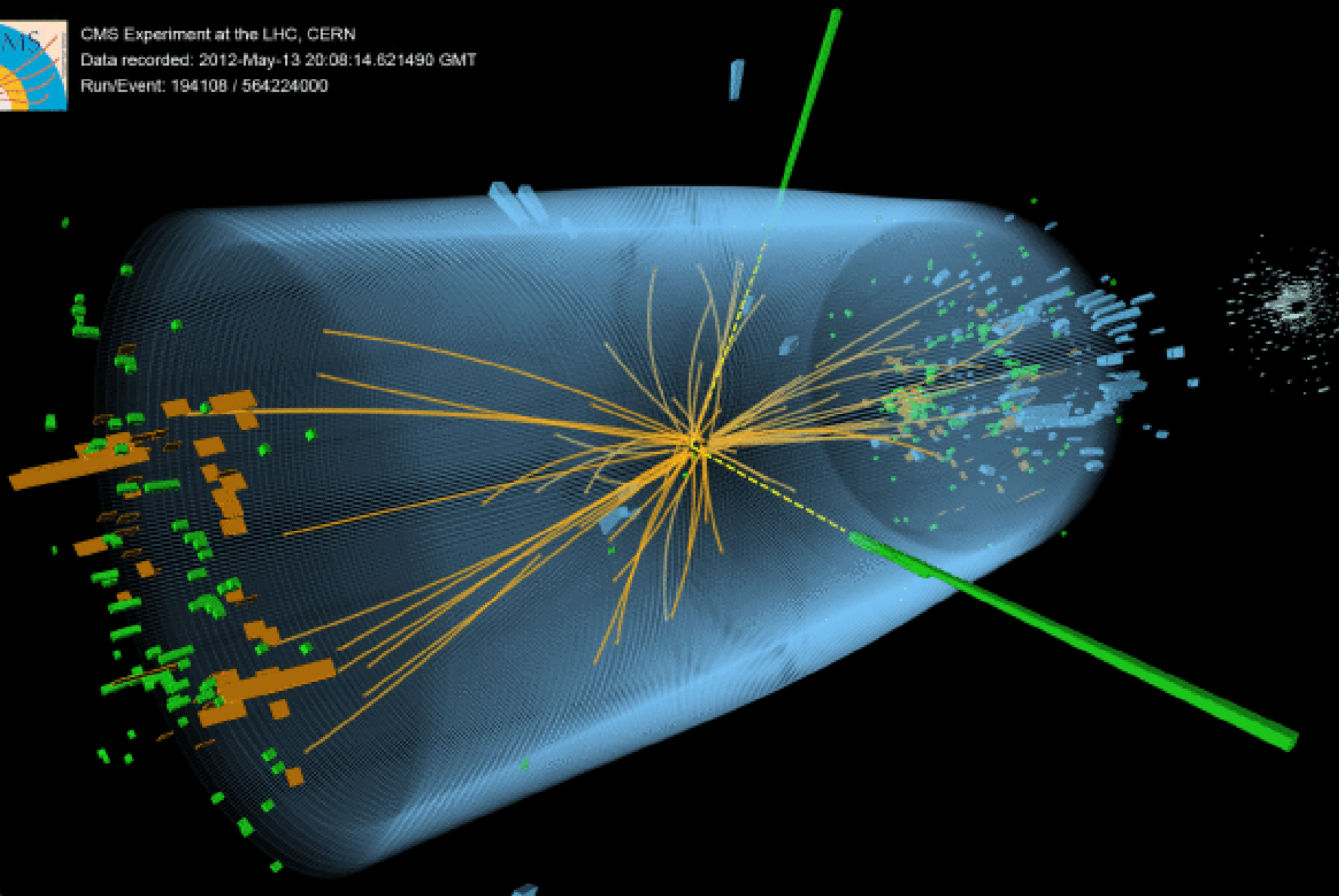
Run: 209787  
Event: 144100666  
Date: 2012-09-05  
Time: 03:57:49 UTC



CMS Experiment at the LHC, CERN

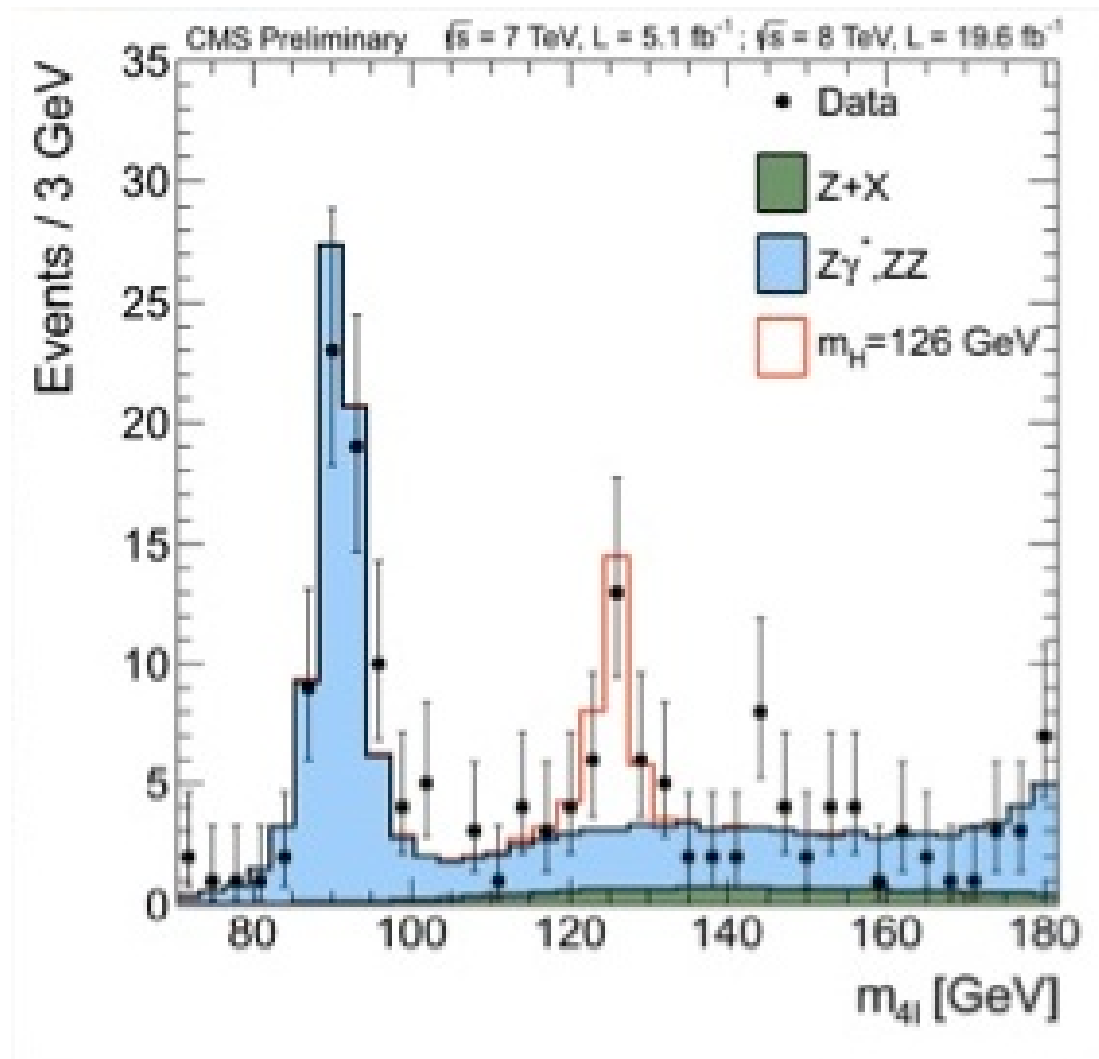
Data recorded: 2012-May-13 20:08:14.621490 GMT

Run/Event: 194108 / 564224000



# Today's trivia question

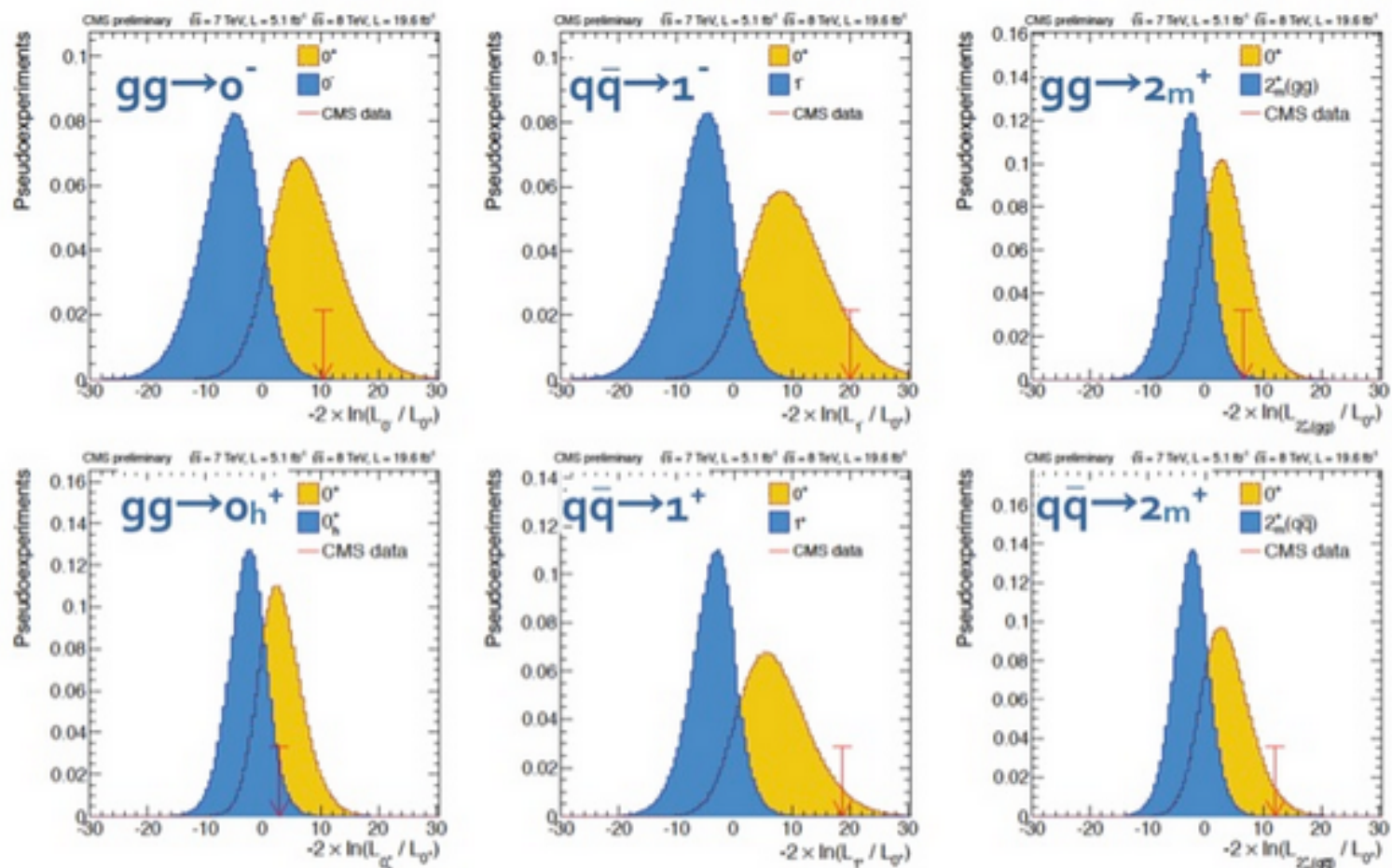
- When results were presented on 4 July 2012, which two channels when combined gave both CMS and ATLAS a 5 sigma significance?



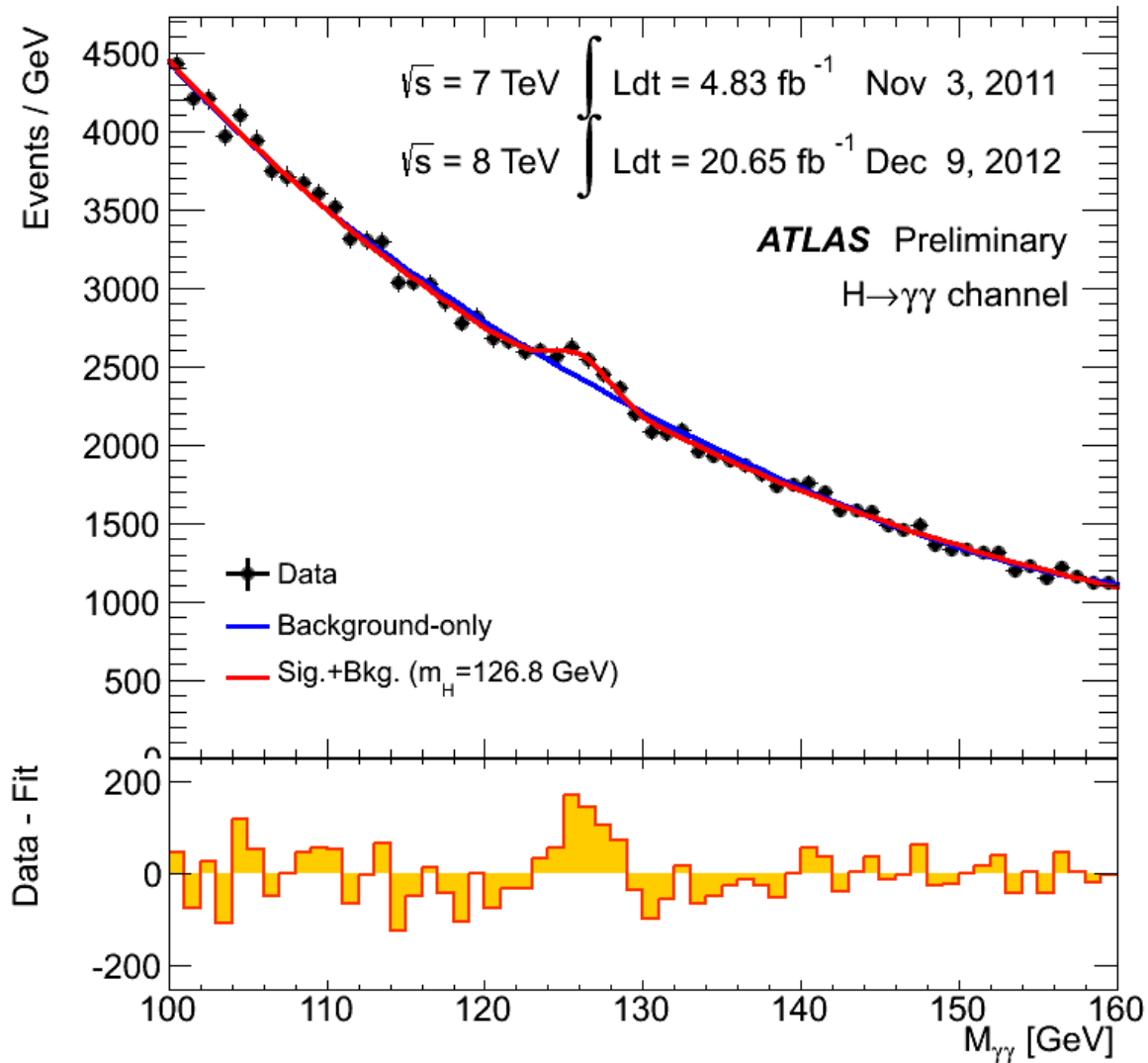
*Boson  $\rightarrow$  4 leptons*

*Data (black dots)  
match simulation of a  
Higgs boson (red line)*





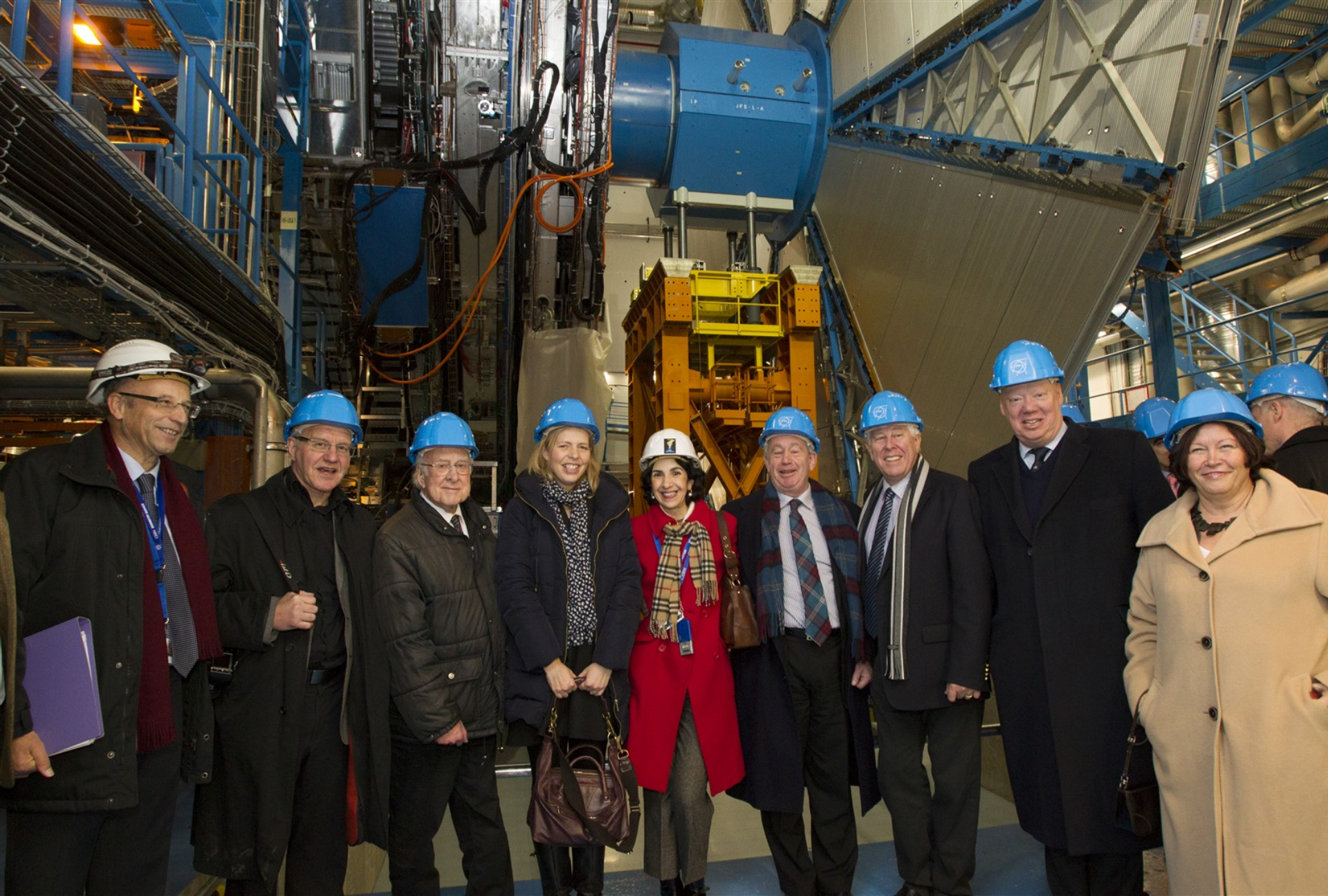
CMS checks to see if the new particle is more likely to have a spin-parity of  $0^+$  (in yellow) as expected for a Higgs boson than other hypotheses (all shown in blue). The red arrow shows the value obtained for the new boson. The compatibility with each hypothesis is measured by the amount of the curve lying to the right of the arrow. There is always more yellow remaining than blue, meaning in all cases, the new boson is more likely to have spin  $0^+$  than any other values.



Check out the animations:

<https://twiki.cern.ch/twiki/bin/view/AtlasPublic/HiggsPublicResults#Animations>






# Today's trivia answer

ZZ and gammagamma

# cern.ch/LHCathome

CERN Accelerating science


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LHC@home

LHC@home is a platform for volunteers to help physicists develop and exploit particle accelerators like CERN's [Large Hadron Collider](#), and to compare theory with experiment in the search for new fundamental particles.

By contributing spare processing capacity on their home and laptop computers, volunteers may run simulations of beam dynamics and particle collisions in the [LHC's giant detectors](#).



**The Sixtrack project**


Help us to study the LHC machine and its upgrade to understand the fundamental laws of the universe.

[View details »](#)

**The Test4Theory project**

Help us on the research about the elusive Higgs particle with our virtual atom smasher.

[View details »](#)



**Do you want to help?**  
You can! Become a volunteer scientist donating some CPU cycles.

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## Huge impact from a tiny decay

The [Hadron Collider Physics Symposium](#) opened on November 12 in Kyoto on a grand note. For the first time, the [LHCb](#) collaboration operating at the [Large Hadron Collider](#) (LHC) at [CERN](#) showed evidence for an extremely rare type of events, namely the decay of a  $B_s$  meson into a pair of muons (a particle very similar to the electron but 200 times heavier). A meson is a composite class of particles formed from a quark and an antiquark. The  $B_s$  meson is made of a bottom [quark](#)  $b$  and a strange quark  $s$ . This particle is very unstable and decays in about a picosecond (a millionth of a millionth of a second) into lighter particles.

Decays into two muons are predicted by the theory, the [Standard Model of particle physics](#), that states it should occur only about 3 times in a billionth of decays. In scientific notation, we write  $(3.54 \pm 0.30) \times 10^{-9}$  where the value of 0.30 represents the error margin on this theoretical calculation. Now, the LHCb collaboration proudly announced that they observed it at a rate of  $(3.2^{+1.5}_{-1.2}) \times 10^{-9}$ , a value very close to the theoretically predicted value, at least within the experimental error.

LHCb  
 $1.0 \text{ fb}^{-1} (7\text{TeV}) + 1.1 \text{ fb}^{-1} (8\text{TeV})$   
 $\text{BDT} > 0.7$

Candidates / (50 MeV/c<sup>2</sup>)

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Thoughts on work and life from particle physicists from around the world.

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[Le mystère plane toujours sur le boson de Higgs](#) ▶

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## The mystery remains on the Higgs boson

Ever since the discovery of what might be the [Higgs boson last July](#), physicists from the [CMS](#) and [ATLAS](#) experiments have been trying to pinpoint its true identity. Is this the Higgs boson expected by the [Standard Model of particle physics](#) or some "Higgs-like boson" befitting a different theoretical model?

To tell the difference, we must check all its properties, like how often this boson decays into different types of particles, and determine its spin and parity, two properties of fundamental particles.

Since the new boson has a short lifetime, it breaks apart immediately after being created. There are five ways a Standard Model Higgs boson should decay that we can study at the [Large Hadron Collider \(LHC\)](#): breaking into two photons, two W or two Z bosons, two b quarks or two tau leptons in well defined proportions. We must check both the presence of and the rate at which each decay mode occurs.

Last summer, just after the discovery of the new boson, both experiments reported unambiguous observations in only three channels. Unfortunately, the data sample was still too small to really be able to check if the new boson could decay into a pair of b quarks or tau leptons.

With more data available, the two experiments have just shown results for all channels today at a [conference](#) held in Kyoto as shown on the two figures below.

CMS Preliminary  $\sqrt{s} = 7 \text{ TeV, } L = 3.1 \text{ fb}^{-1}, \sqrt{s} = 8 \text{ TeV, } L = 12.9 \text{ fb}^{-1}$   
 $\tau_1 = 125.8 \text{ GeV}$

Decay Channel	Best fit $\sigma/\sigma_{SM}$
$H \rightarrow b\bar{b}$	~1.0
$H \rightarrow \tau\tau$	~1.0
$H \rightarrow \gamma\gamma$	~1.5
$H \rightarrow W\bar{W}$	~0.8
$H \rightarrow Z\bar{Z}$	~0.8

Best fit  $\sigma/\sigma_{SM}$

ATLAS Preliminary  $\sqrt{s} = 7 \text{ TeV, } L = 3.1 \text{ fb}^{-1}, \sqrt{s} = 8 \text{ TeV, } L = 12.9 \text{ fb}^{-1}$   
 $\tau_1 = 125 \text{ GeV}$

Decay Channel	Signal strength ( $\mu$ )
$WZ H \rightarrow b\bar{b}$	~0.0
$H \rightarrow \tau\tau$	~0.5
$H \rightarrow \gamma\gamma$	~0.5
$H \rightarrow WW$	~0.5
$H \rightarrow ZZ$	~0.5
Combined	~1.3

Signal strength ( $\mu$ )

# cern.ch/hangouts

- Live streams
- Archives
- Schedule
- Resources

# Participants

Nazila Mahmoudi, CERN theorist

Heather Gray, ATLAS physicist

Pauline Gagnon, ATLAS physicist and CERN blogger

Victoria Martin, ATLAS physicist, University of Edinburgh

# Credits

Tara Shears — Host

Kelly Izlar — Q&A from Social Media

Kate Kahle and Achintya Rao — Production

Thank you for watching!



[www.cern.ch](http://www.cern.ch)