Mass of Higgs→4 leptons at LHC

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A very simple and transparent way is presented for the mass definition of a new boson, observed at LHC, probably Higgs (H), decaying into 4 leptons

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- In the resent publications on H→ 4 leptons the ATLAS [1] and CMS [2] collaborations give the following values for the measured mass of H in this decay channel:
  – ATLAS - 124.3 ± 0.5(st) ± 0.6(syst) GeV
  – CMS - 125.8 ± 0.5(st) ± 0.2(syst) GeV

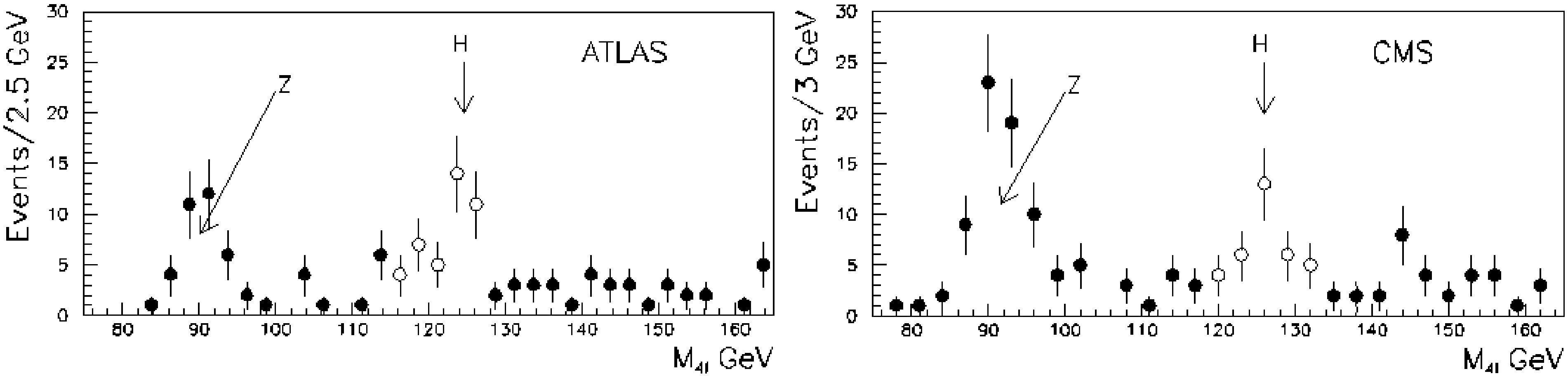
- The difference between this two experiments is about 1.5 GeV

First I will show that this difference can be substantially reduced and next how the data of ATLAS and CMS can be combined.

[1] The ATLAS Collaboration, "Measurements of the properties of the Higgs-like boson in the four lepton decay channel with the ATLAS detector using 25 fb^{-1} of proton-proton collision data", ATLAS-CONF-2013-013, March 6, 2013, http://cds.cern.ch/record/1523699

[2] The CMS Collaboration, "Properties of the Higgs-like boson in the decay H to ZZ to 4l in pp collisions at $s^{1/2}$=7 and 8 TeV", CMS-PAS-HIG-13-002, March 7, 2013, http://cds.cern.ch/record/1523767

- The 4-lepton samples have the advantage that they contain two signals:
  - one from H under the study
  - another from the very well known Z boson



The data extracted from the corresponding figures in [1,2]

- The Z signal can be used to obtain in the selected samples
  - the experimental resolution
  - a possible systematic shift of the 4-lepton effective mass scale

(without MC simulations!)

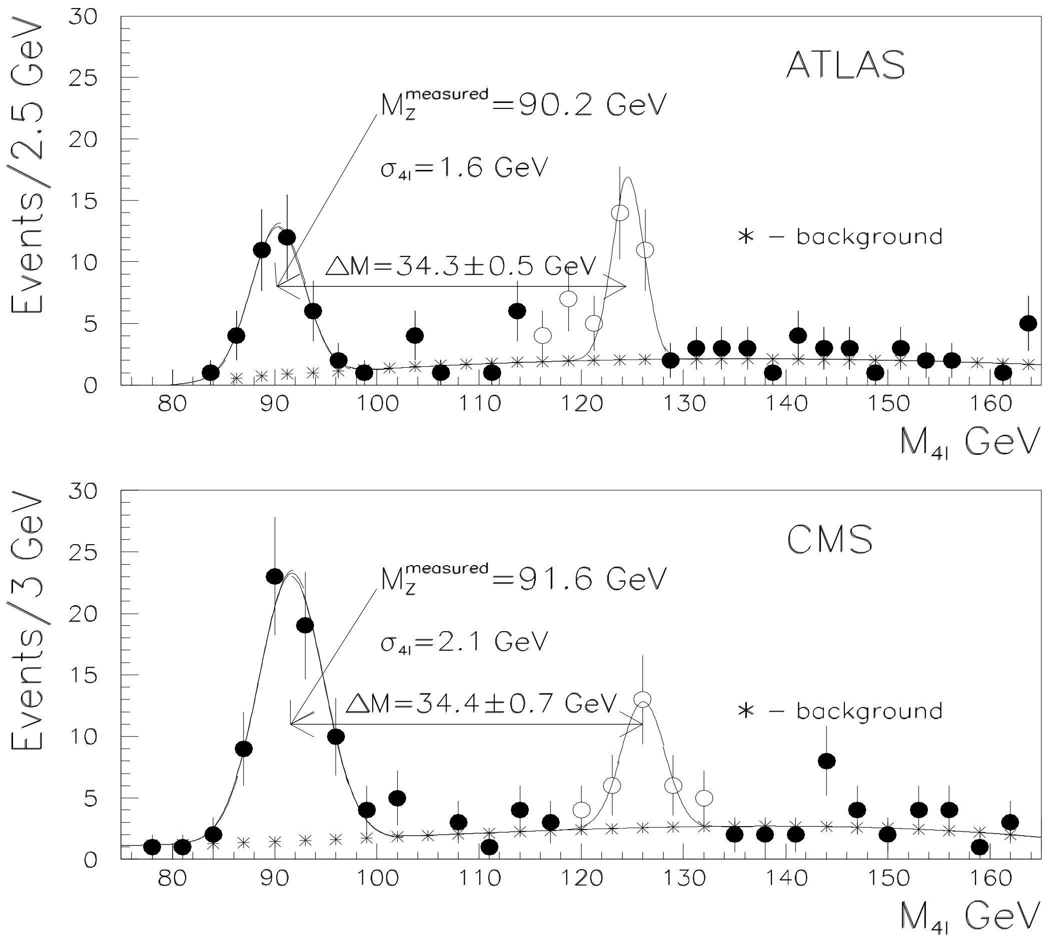
- The main idea of the present approach is
  - to determine experimentally the mass difference between H and Z
    - ΔM
  - to define the mass of H as the sum of ΔM and the table value of the Z mass
    - $M_H = M_z^{table} + \Delta M$

In this case :

the constant systematic shifts of the mass scale will be canceled

and

the results will not depend on the particles mass definition(central value of Gaussian or Breit-Wigner, or ...)



The distributions on the figures were fitted first without white points:

by one Gaussian(Z) + polynomial to define experimentally backgrounds, measured Z mass $M_z^{measured}$ and effective mass resolutions $\sigma_{4l} = \sigma_z^{measured} - \sigma_z^{table}$

and then full spectrum:

by two Gaussians +polynomial with fixed background, $\sigma_H \equiv \sigma_{4l}$ and $M_z^{measured}$ but free mass difference between Z and H - ΔM

Results

- The obtained ΔM are
  - ATLAS: $\Delta M = 34.3 \pm 0.5$ GeV
  - CMS: $\Delta M = 34.4 \pm 0.7$ GeV

- Giving the following values for the mass of H defined as $M_H = M_Z^{table} + \Delta M$
  - ATLAS: $M_H = 125.5 \pm 0.5$ GeV
  - CMS: $M_H = 125.6 \pm 0.7$ GeV

These values are much closer to each other than the published ones.

- The weighted mean from the two experiments is

$$M_H = 125.5 \pm 0.4 \text{ GeV}$$

Some speculations

- Obviously one day the data from ATLAS and CMS will be combined for analysis

- But even now it can be done by:

  a) choosing the appropriate abscissa for both experiments in the form of:

$$M_{4l}^{corrected} = M_{4l}^{measured} + M_Z^{table} - M_z^{measured}$$

  (in order to take into account the systematic constant shift of measured mass of 4 leptons in the used samples), and

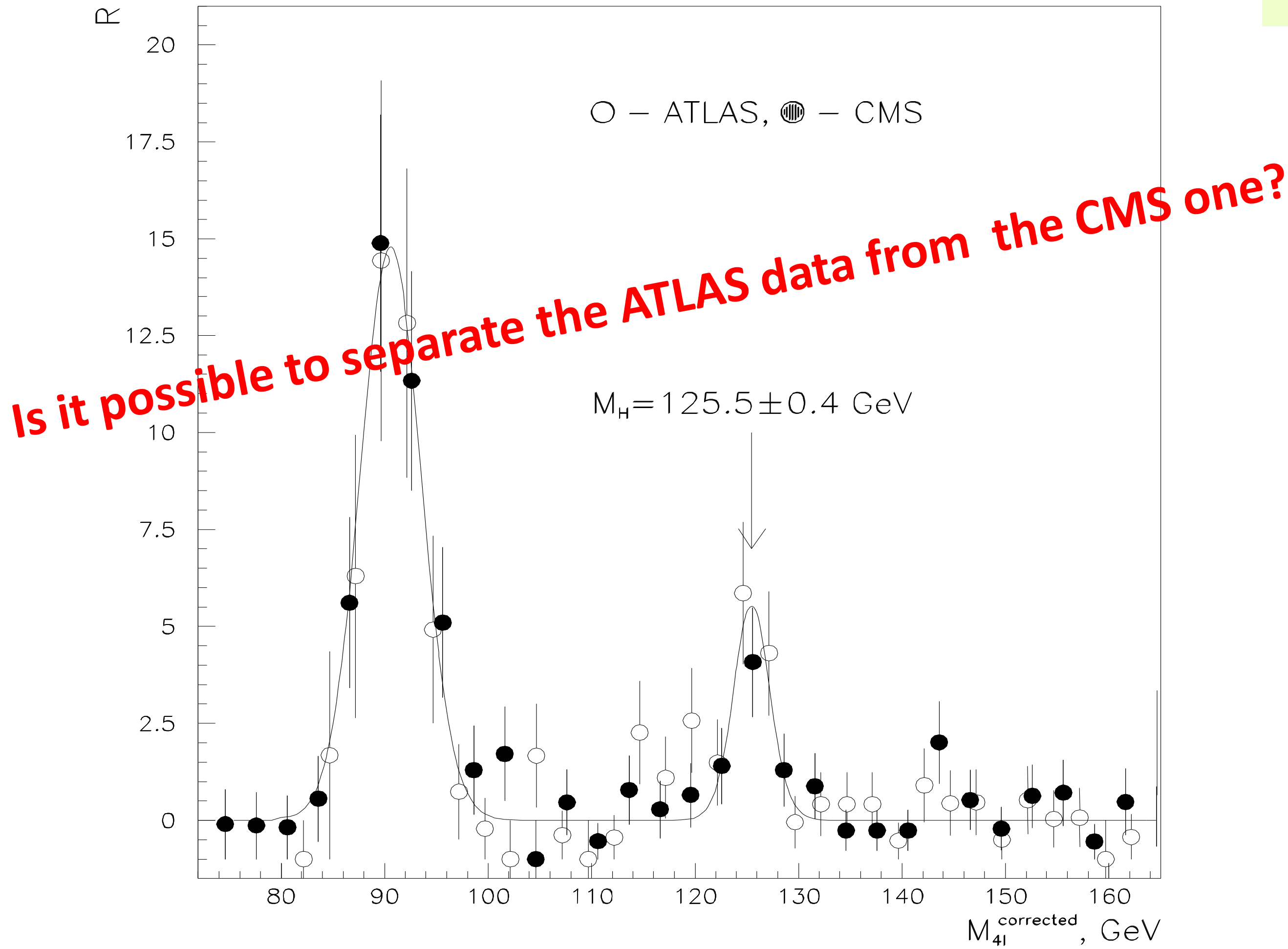
  b) choosing as an ordinate the ratio of signal to the background:

$$R = Signal / Background = Nevents / BKG\text{-}1$$

  (in order to take into account the difference of the ATLAS and CMS acceptances)

Such a plot is presented on the next figure

Some speculations (cont.)



- The curve - fit of R with free parameters - weights of the Z and H signals and the mass of H
- The background and resolution were fixed to the ones of ATLAS and CMS respectively
- The coincidence between the two experiments is so good that one can consider the result as an outcome of a common LHC experiment with the total luminosity about twice more than accepted by ATLAS and CMS separately

Conclusions

With today LHC statistic the mass of the new boson, discovered by ATLAS and CMS (published results before Nov.2013), in the

4-lepton decay channel equals to:

125.5 ± 0.4 GeV

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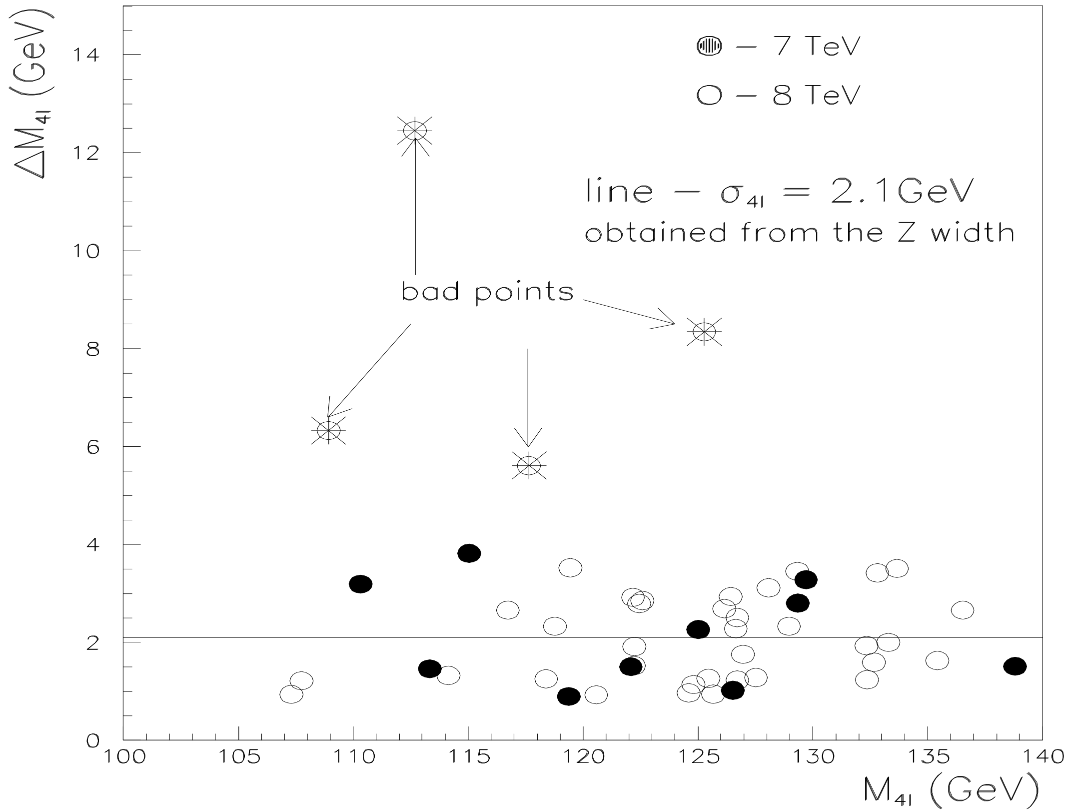

ΔM4l (GeV)
14
12
10
8
6
4
2
0
100
105
110
115
120
125
130
135
140
M4l (GeV)
– 7 TeV
– 8 TeV
line – σ4l = 2.1GeV
obtained from the Z width
bad points