

# The arrangement of the fundamental particles on mass levels derived from the Planck Mass

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The most recent evaluations of the Particle Data Group have made it possible to discern with precision the arrangement of the fundamental massive particles of the Standard Model on the mass levels of a network derived from the Planck Mass.

## 1 Introduction

The fundamental massive particles of the Standard Model will be shown to be arranged within a network comprising three geometric sequences of mass levels that descend from the Planck Mass ( $1.220932 \times 10^{19}$  GeV [1]). Sequence 1 is of common ratio  $1/\pi$ , Sequence 2 is of common ratio  $2/\pi$  and Sequence 3 is of common ratio  $1/e$ . A level of number  $n$  in a sequence of common ratio  $r$  is of mass  $m_n = m_{Planck} r^n$ . Particle Data Group evaluations of particle mass [2] have been used. Particle locations are shown within more than one sequence. A two-dimensional representation of the mass level structure is used so that the occupation by particles of coincident levels is highlighted. In such a representation the particles are constrained to lie on a diagonal line. The error bars would lie along the diagonal line but their lengths are no longer than the diameters of the markers.

## 2 The charged leptons

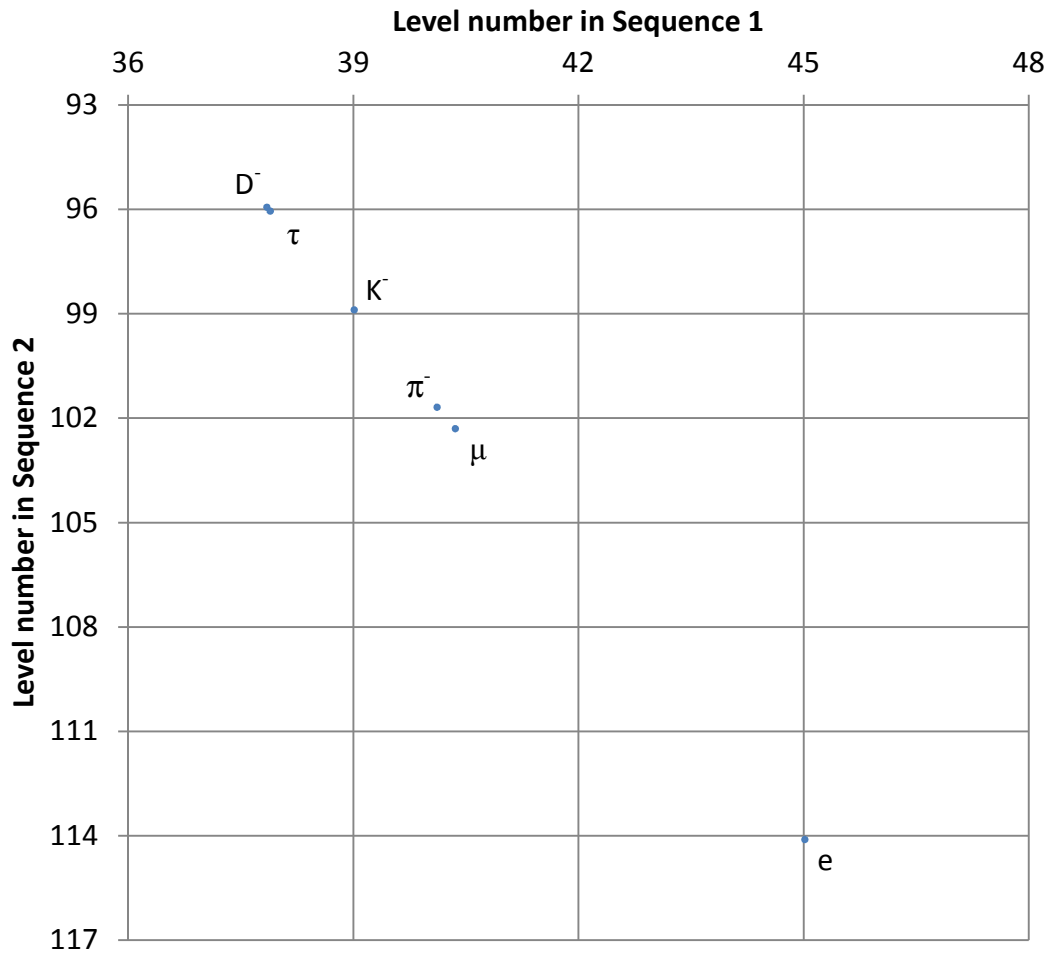
The charged leptons occupy mass levels within Sequences 1 and 2, as shown in Figure 1. The muon lies in symmetrical arrangement with the pseudoscalar meson  $\pi^-$  about level 102 in Sequence 2. The tau lepton lies in symmetrical arrangement with the pseudoscalar meson  $D^-$  about level 96 within Sequence 2. The electron lies close to level 45 in Sequence 1 and level 114 in Sequence 2. The pseudoscalar meson  $K^-$  lies close to level 39 in Sequence 1 and level 99 in Sequence 2. All occupied level numbers are multiples of 3.

In Figure 2, the geometric mean of the muon mass and  $\pi^-$  mass is shown to coincide with level 102 in Sequence 2, which lies adjacent to a sublevel in Sequence 1. The geometric mean of the tau lepton mass and  $D^-$  mass is shown to coincide with level 96 in Sequence 2, which lies adjacent to a sublevel in Sequence 1. The geometric mean of the electron mass and  $K^-$  mass

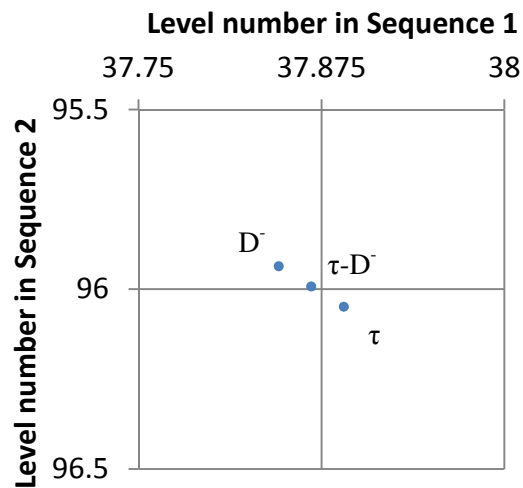
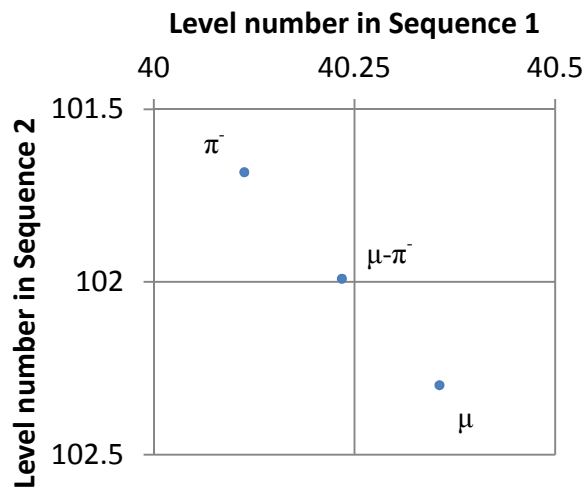
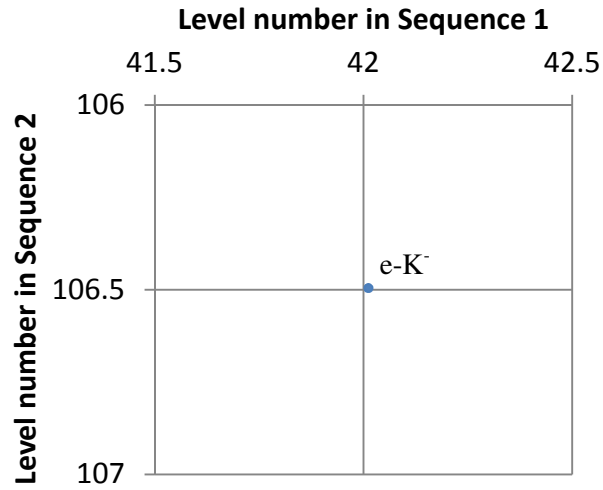
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coincides with level 106.5 in Sequence 2, which lies adjacent to a level of integer number in Sequence 1. The evident  $e$ - $K^-$ ,  $\mu$ - $\pi^-$  and  $\tau$ - $D^-$  partnerships may arise as the result of broken symmetry. The partnerships are characterised by  $\Delta J=1/2$ .



**Figure 1** Charged leptons and their evident pseudoscalar partners on the mass levels of Sequences 1 and 2. Sequences 1 and 2 descend in geometric sequence from the Planck Mass with common ratios  $1/\pi$  and  $2/\pi$ , respectively. All occupied level numbers are multiples of 3.



**Figure 2** The symmetrical arrangement of charged leptons and charged pseudoscalar mesons on the mass levels of Sequences 1 and 2. Lepton-meson partnerships are represented by the geometric mean of the particle masses.

### 3 The quarks

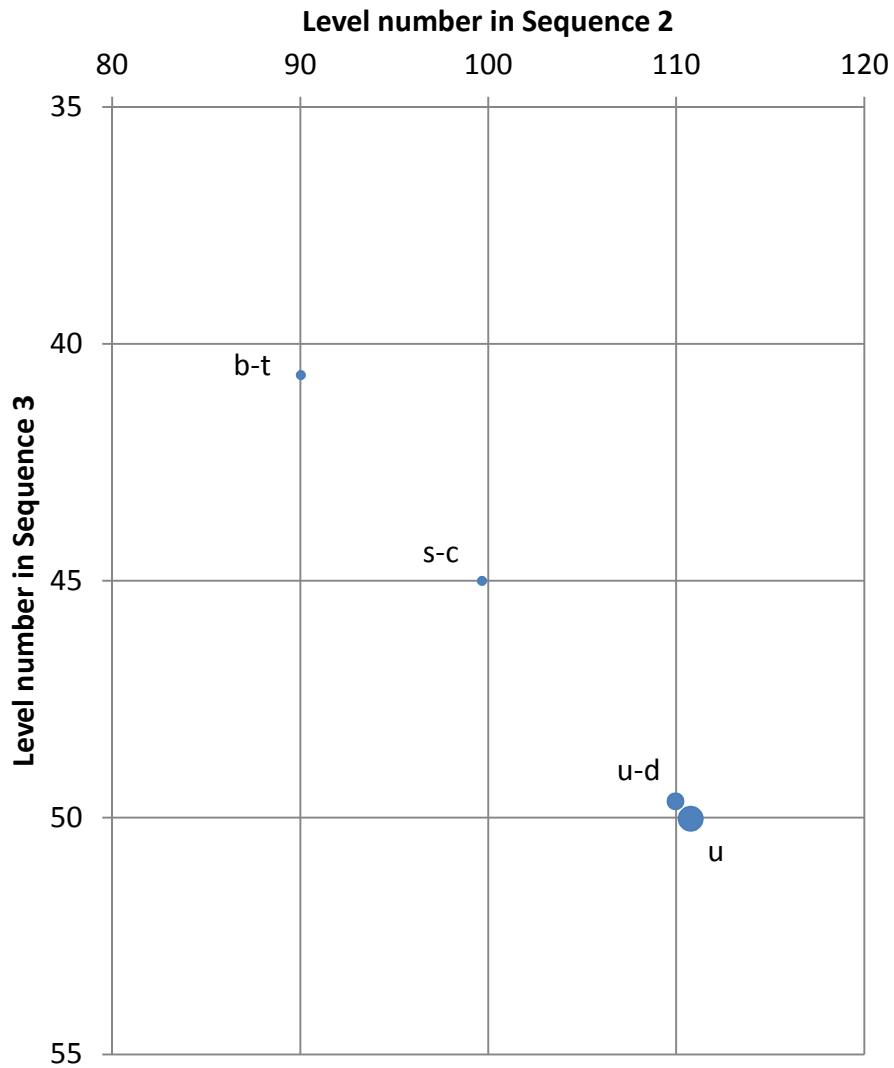
The quarks of each generation take up a symmetrical arrangement about a mass level within either Sequence 2 or Sequence 3, close to near-coincident levels in the two sequences. The symmetrical arrangement has been deduced from the observation that, for each generation, the geometric mean of the two quark masses coincides with a mass level, as shown in Figure 3. For each quark doublet, the ‘experimental evaluation’ of doublet mass has been calculated as the geometric mean of the Particle Data Group’s quark mass evaluations (mean values) and compared, in Table 1, with the masses of levels derived from the Planck Mass. The mean value of the up quark mass evaluation is included as it coincides with the mass of level 50 in Sequence 3. All occupied level numbers are multiples of 5.

The flavoured quarks are shown individually on the mass levels of Sequences 2 and 3 in Figure 4. The quarks can be seen to occupy levels and prominent sublevels.

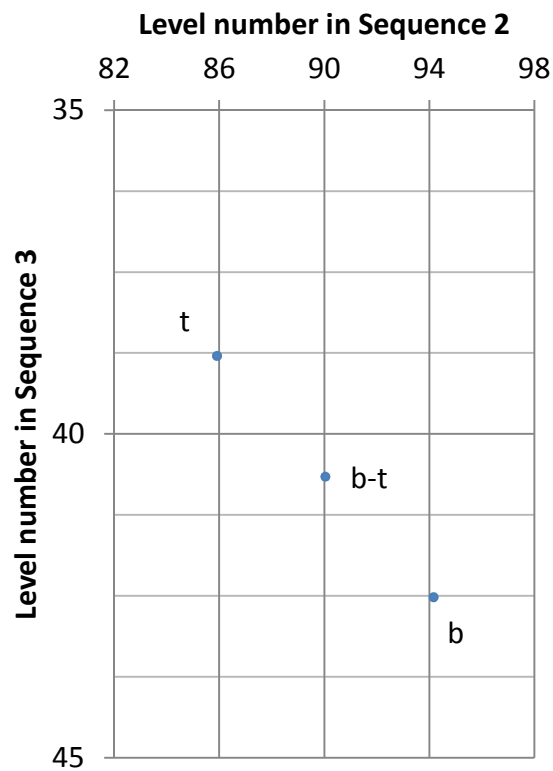
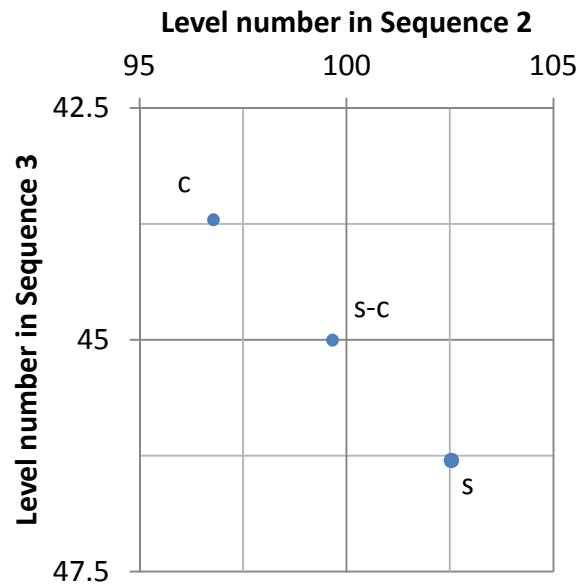
Quark(s)	Experimental evaluation based on PDG values [2]	Level number	Level mass
up	2.3 MeV	50, Sequence 3	2.35 MeV
up-down	3.3 MeV	110, Sequence 2	3.26 MeV
strange-charm	350 MeV	45, Sequence 3	349 MeV
bottom-top	27 GeV*	90, Sequence 2	27.3 GeV

**Table 1** Mass level occupation by the quarks.

\*  $m_b = 4.18 \text{ GeV}$ ;  $m_t = 173.5 \text{ GeV}$



**Figure 3** Quark doublets on the mass levels of Sequences 2 and 3. Sequences 2 and 3 descend in geometric sequence from the Planck Mass with common ratios  $2/\pi$  and  $1/e$ , respectively. Each doublet is represented by the geometric mean of the two values of quark mass evaluation (Particle Data Group mean values [2]). The up quark (mean value 2.3 MeV) appears to occupy level 50, of mass 2.35 MeV, in Sequence 3.



**Figure 4** The flavoured quarks on the mass levels of Sequences 2 and 3. Each doublet is represented by the geometric mean of the two quark masses.

## 4 The weak gauge bosons and the Higgs boson

The W and Z bosons are shown on the mass levels of Sequences 1, 2 and 3 in Figure 5. The bosons take up the configuration of a doublet or partnership:  $W^\pm$  and  $Z^0$  are symmetrically arranged about a half-level in Sequence 3, adjacent to half-levels in both Sequence 1 and Sequence 2. The individual particles lie close to sublevels in all three sequences.

The Higgs boson is shown on the mass levels of Sequences 2 and 3 in Figure 6. The boson may have been found with a mass around 125-126 GeV [3, 4], and is shown here with a mass of 125.5 MeV. The adjacent sublevel in Sequence 2, which it might occupy, is of mass 125.3 GeV.

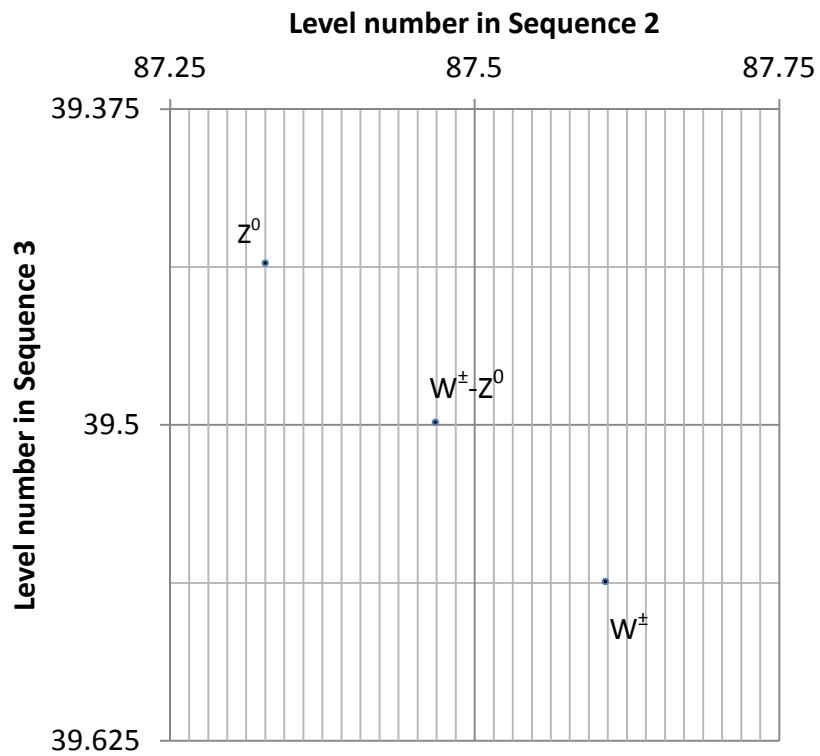
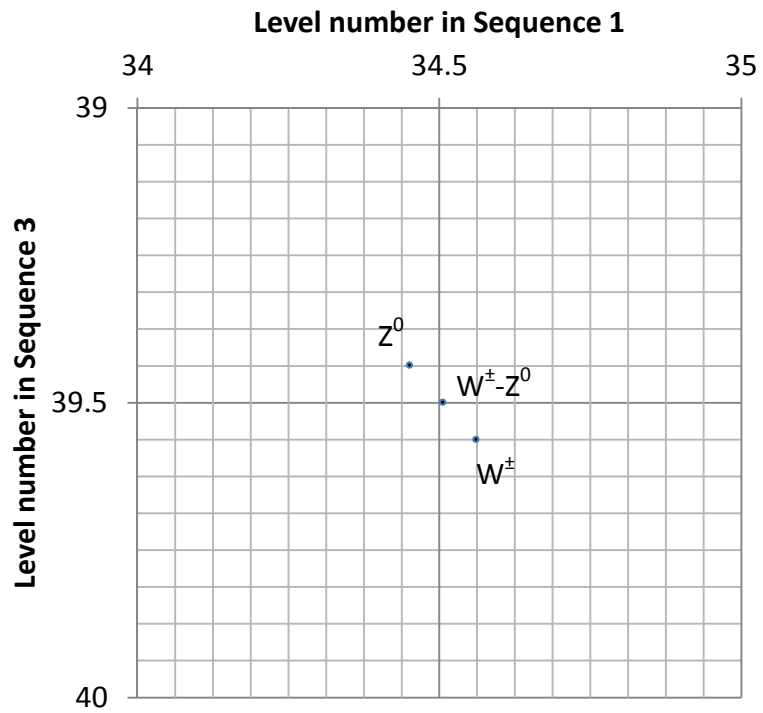
In Figure 7, the weak gauge bosons and the Higgs boson are shown to occupy levels within Higgs Sequences 2 and 3, which descend from the Higgs field vacuum expectation value (246.22 GeV) with common ratios  $2/\pi$  and  $1/e$ , respectively, and are incorporated into Sequences 2 and 3. The Z boson mass is related to the Higgs field VEV by a factor  $e^{-1}$ ; the Higgs field VEV itself is related to the GUT scale of  $2 \times 10^{16}$  GeV by a factor  $e^{-32}$ .

## 5 Conclusions

1. The fundamental massive particles of the Standard Model are arranged on mass levels within three geometric sequences that descend from the Planck Mass.
2. Coincident mass levels are favoured locations for particles.
3. The charged leptons partner the charged pseudoscalar mesons.
4. The lepton-meson partnerships are centred on mass levels within Sequences 1 and 2. The level numbers are multiples of 3.
5. The quark doublets are centred on mass levels within Sequences 2 and 3. The level numbers are multiples of 5.
6. The weak gauge bosons are centred on a half-level in Sequence 3, adjacent to half-levels in Sequences 1 and 2.
7. The Higgs field coupling constants of the weak gauge bosons and the Higgs boson are equal to integer and half-integer powers of the mass sequence common ratios.

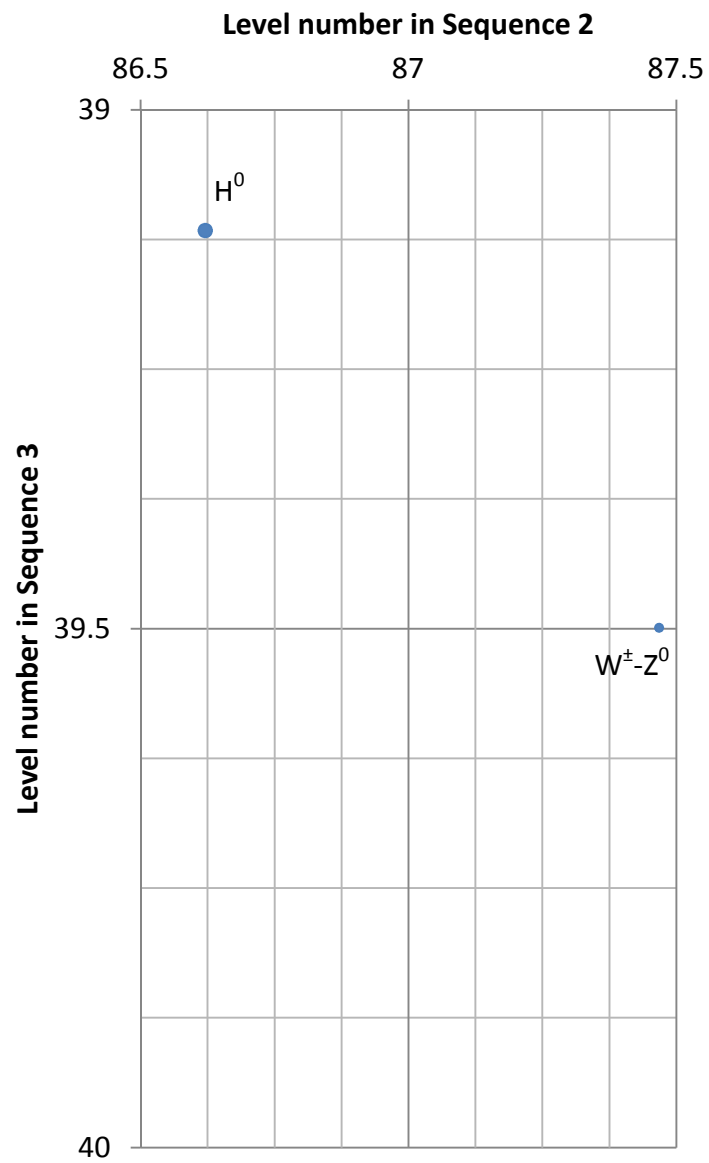
## 6 References

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2. Beringer J et al (Particle Data Group) 2012, Phys. Rev. D **86**, 010001
3. The CMS collaboration, arXiv:1207.7235, J. Phys. Lett. B716 (2012) 30
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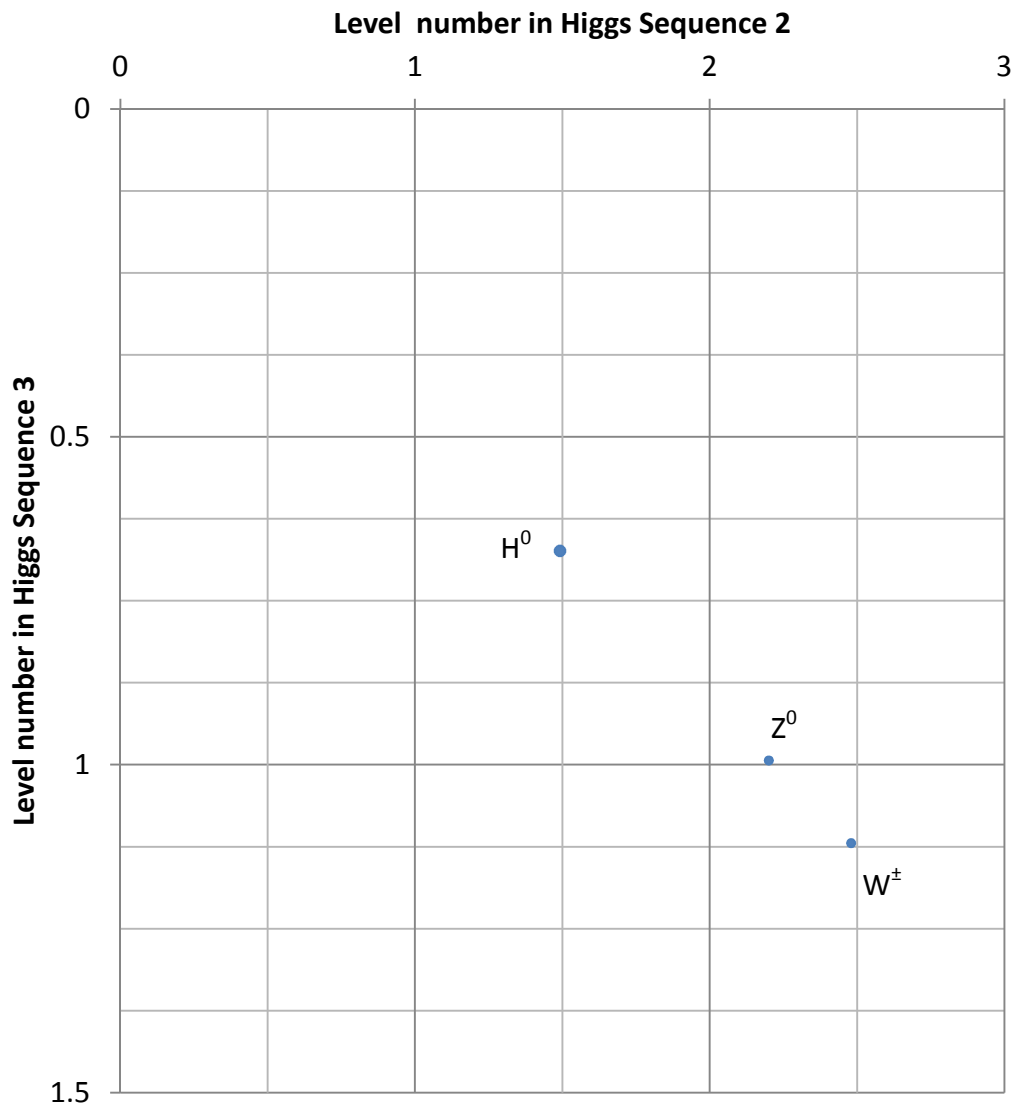


**Figure 5** The weak gauge bosons on the mass levels of Sequences 1, 2 and 3. The  $W^\pm$ - $Z$  partnership is represented by the geometric mean of the two boson masses.





**Figure 6** The Higgs boson (shown with a mass of 125.5 GeV) on the mass levels of Sequences 2 and 3.



**Figure 7** The Higgs boson (shown with a mass of 125.5 GeV) and the weak gauge bosons on the mass levels of Higgs Sequences 2 and 3, which descend from the Higgs field VEV (246.22 GeV) with common ratios  $2/\pi$  and  $1/e$ , respectively.