3.6. Predicting Type of Decay

Radioactive nuclides tend to decay in a way that results in a daughter nuclide that lies closer to the line of stability. Due to this, it is possible to predict the type of decay that a nuclide will undergo based on its location relative to the line of stability on the Chart of the Nuclides.

Fig. 3.6 illustrates the type of decay nuclides in different regions of the chart will typically undergo. Nuclides that are below and to the right of the line of stability will usually undergo β^- decay. Nuclides that are above and to the left of the line of stability will usually undergo either β^+ decay or electron capture. Most nuclides that will undergo α decay are found in the upper right hand region of the chart. These are general rules that have many exceptions, especially in the region of heavy nuclides.

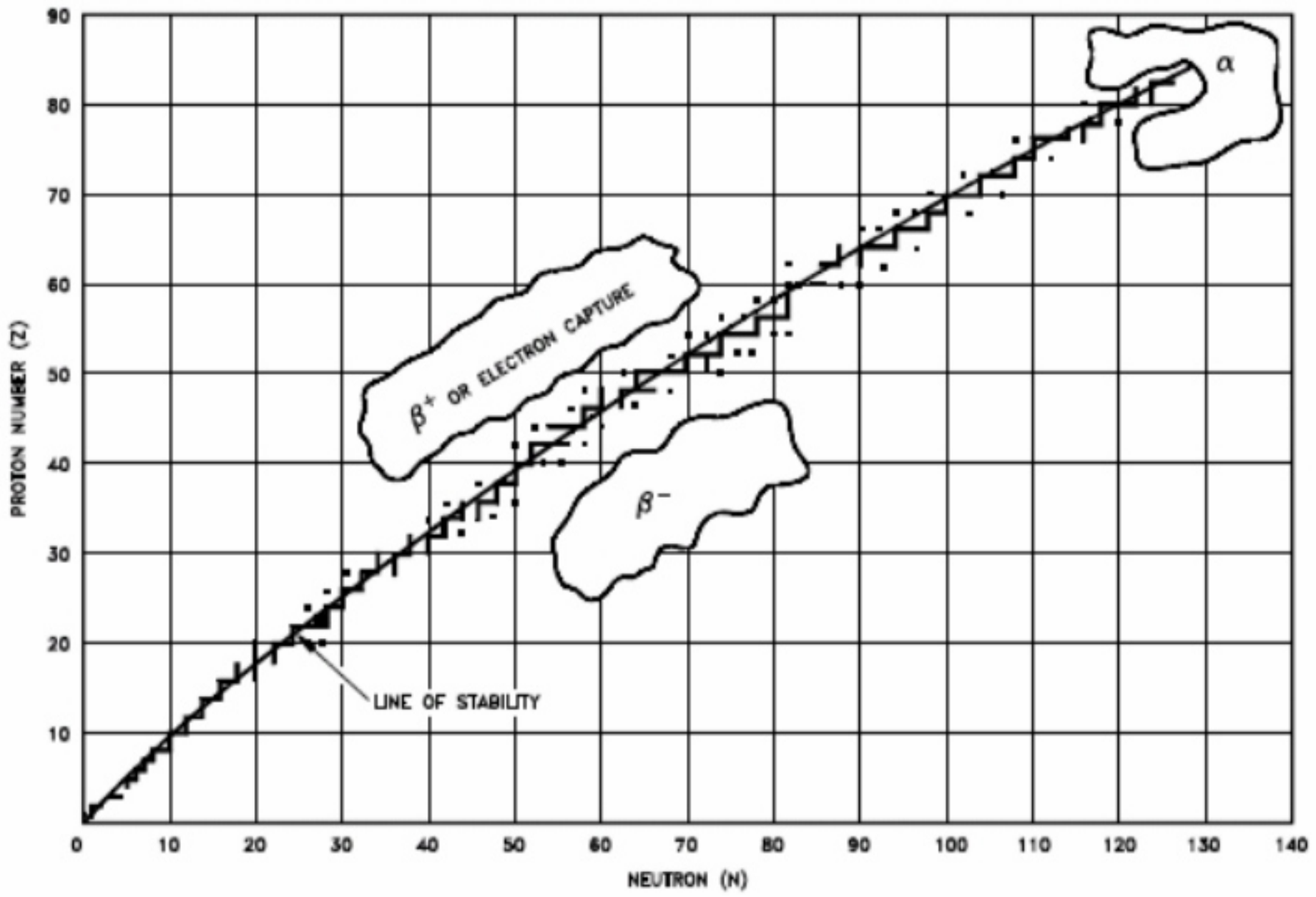

Figure 3.6. Types of radioactive decay relative to the line of stability.

3.7. Decay Schemes

Decay schemes are widely used to give a visual representation of radioactive decay. A scheme for relatively straightforward decay is shown in Fig. 3.7 below:

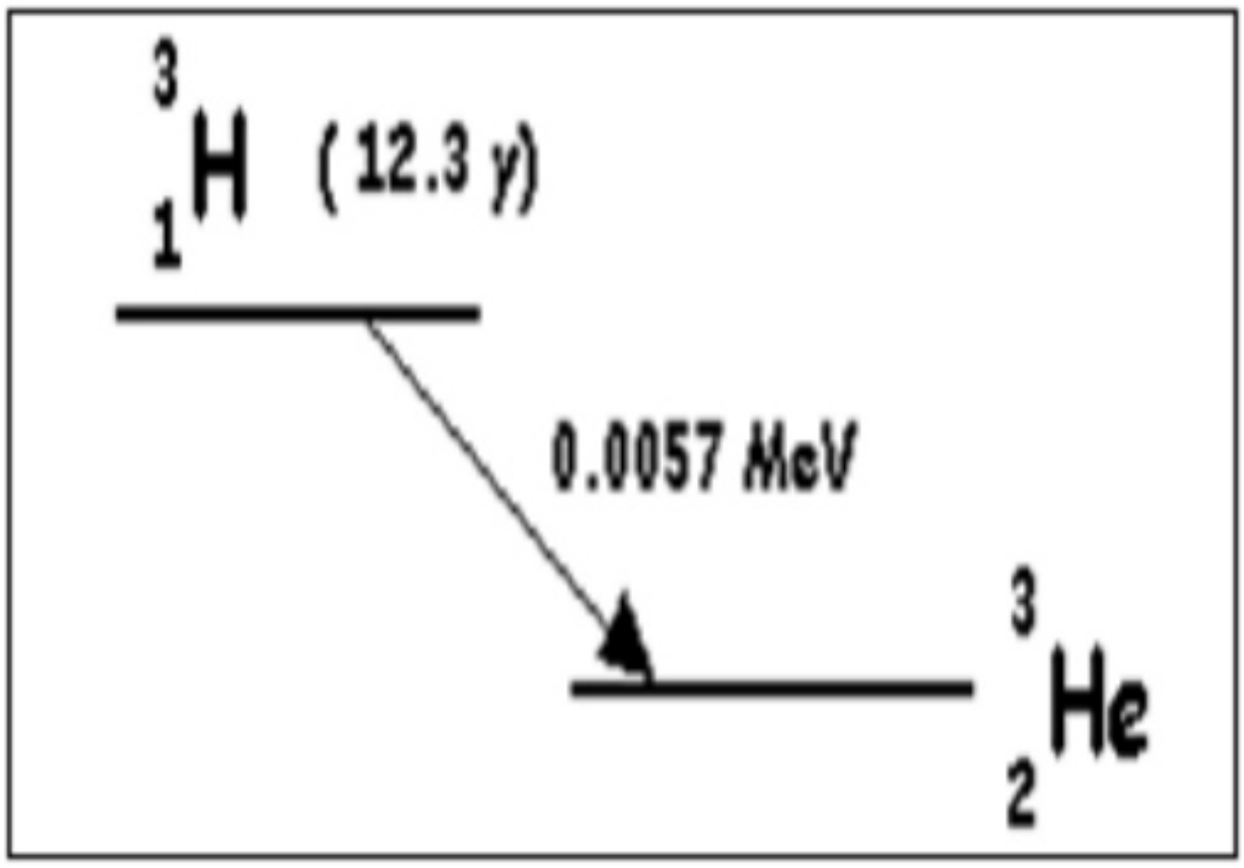

Figure 3.7. Decay scheme of ^{3}H to the ground state of ^{3}He.

This scheme is for ^{3}H, which decays to ^{3}He with a half-life of 12.3 years through the emission of a beta-minus particle with an energy of 0.0057 MeV.

A scheme for a more complicated decay is that of ^{137}Cs, Fig. 3.8. This isotope can decay through two beta-minus processes. In one, which occurs in 5% of disintegrations a beta-minus particle is emitted with energy of 1.17 MeV to produce ^{137}Ba. In the second which occurs more frequently (in the remaining 95% of disintegrations), a beta-minus particle of energy 0.51 MeV is emitted to produce $^{137}Ba^{*}$; in other words a barium-137 nucleus in a meta-stable state or excited state. The $^{137}Ba^{*}$ then decays via isomeric transition with the emission of a gamma ray of energy 0.662 MeV.

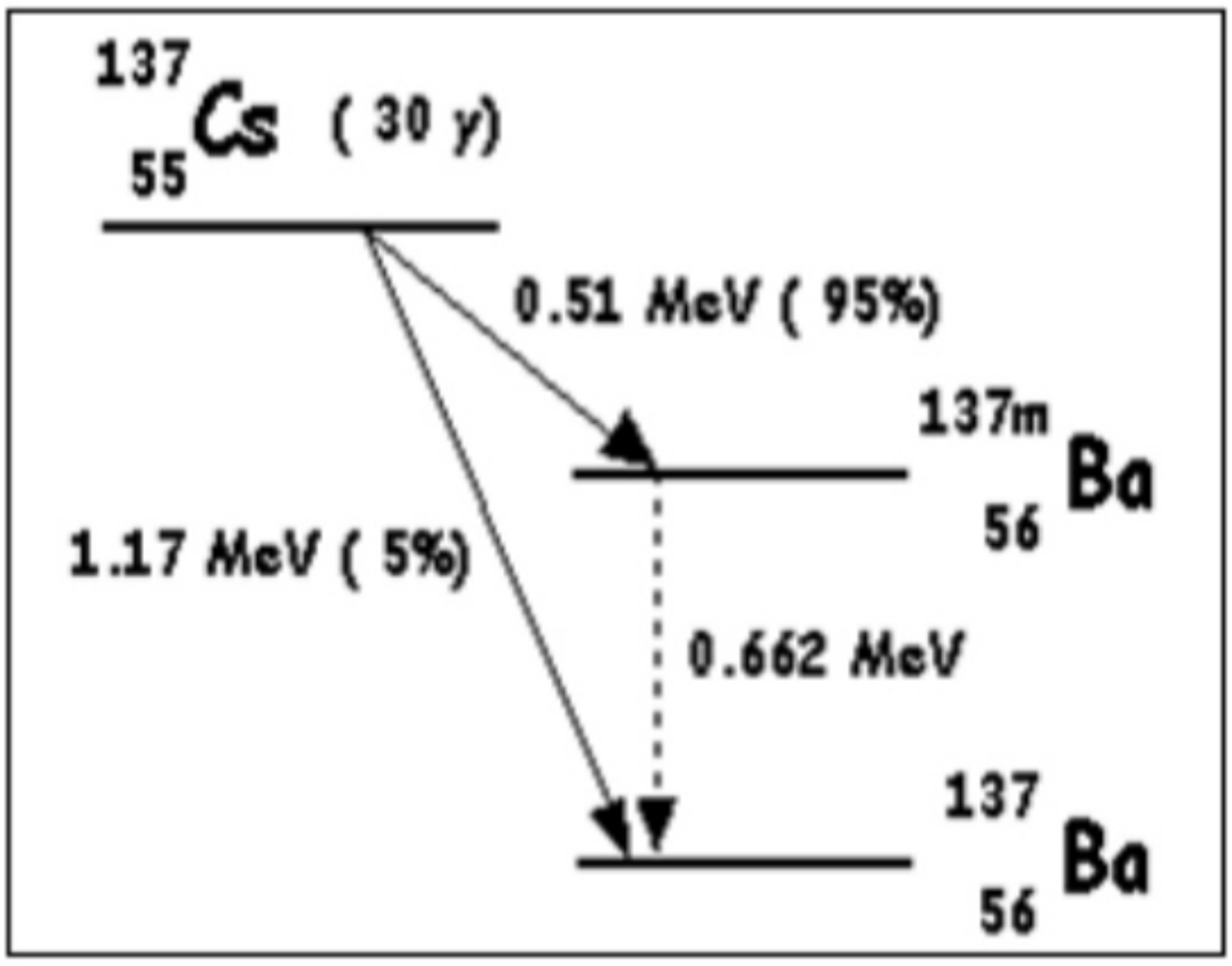

Figure 3.8. Decay of ^{137}Cs showing the fraction of β^- decays to the ground state and to the excited state of ^{137}Ba, which in turn decays by γ-emission.

The general method used for decay schemes is illustrated in Fig. 3.9. The energy is plotted on the vertical axis and atomic number on the horizontal axis - although these axes are rarely displayed in actual schemes. The isotope from which the scheme originates is displayed at the top **X** in the case above. This isotope is referred to as the parent. The parent looses energy when it decays and hence the products of the decay referred to as daughter**s** are plotted at a lower energy level.

The figure illustrates the situation for common forms of radioactive decay. Alpha decay is illustrated on the left where the mass number is reduced by 4 and the atomic number is reduced by 2 to produce daughter **Y**. To its right, the scheme for beta-plus decay is shown to produce daughter **B**. The situation for beta-minus decay followed by gamma

decay is shown on the right side of the diagram where a daughter **C** in the excited energy state is produced to decay to its ground state by emitting a gamma ray.

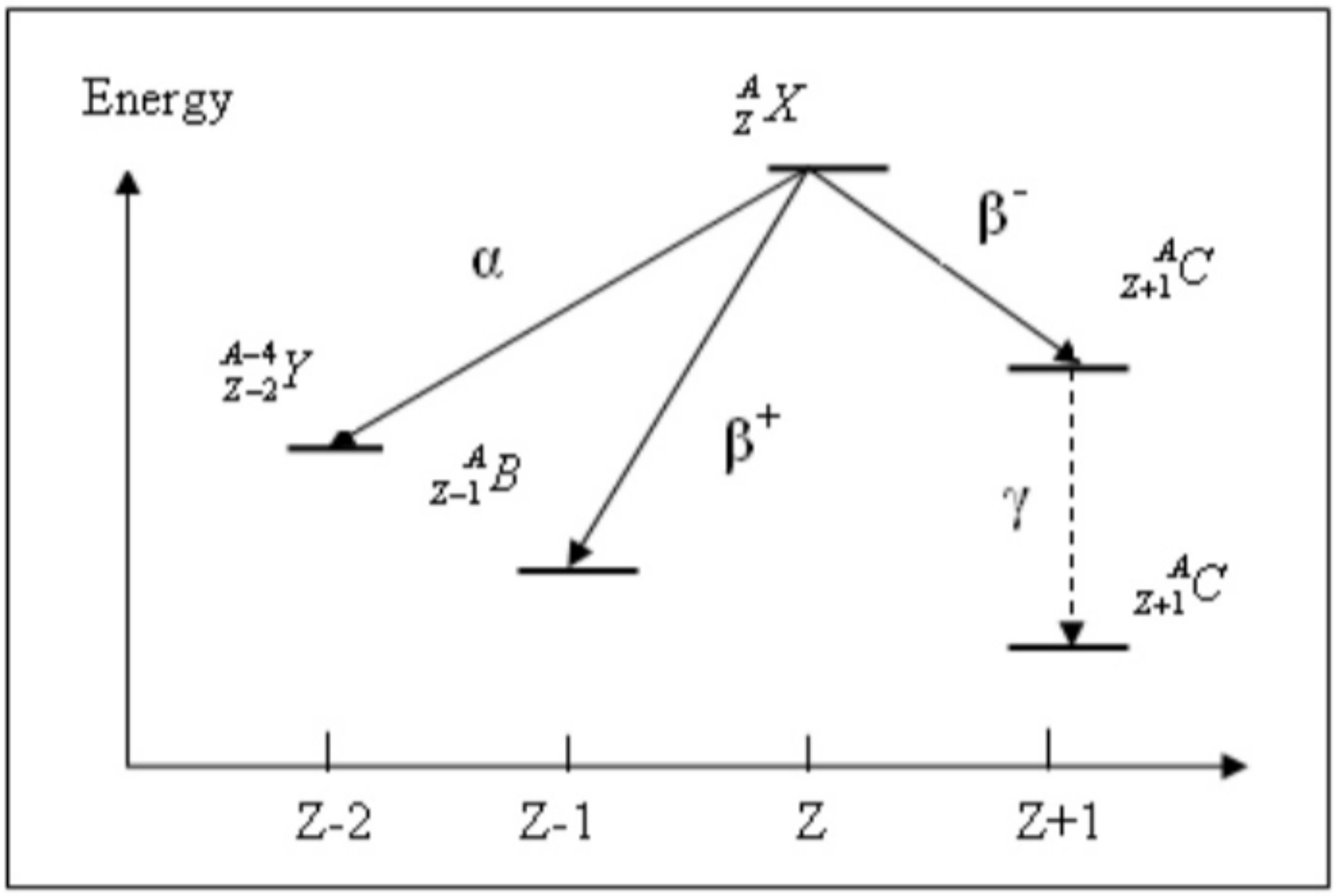

Figure 3.9. Schematic diagram describing all types of decay.