

# An Alternative View of Tables of Isotopes

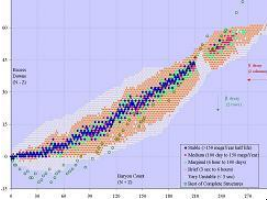
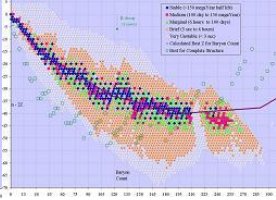
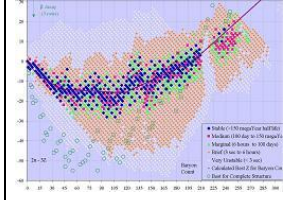
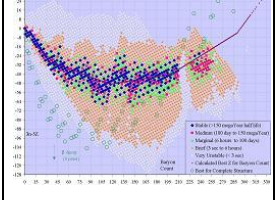
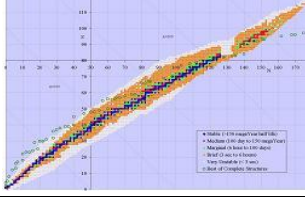
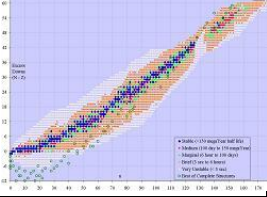
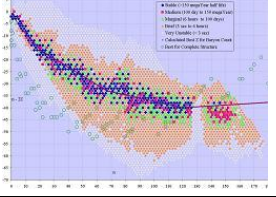
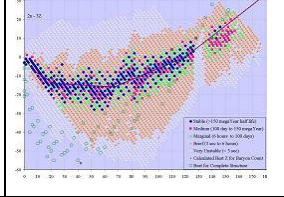
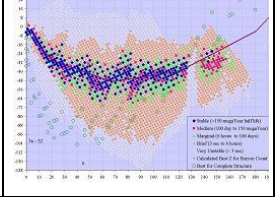
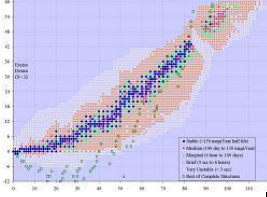
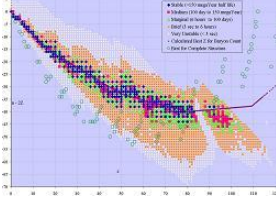
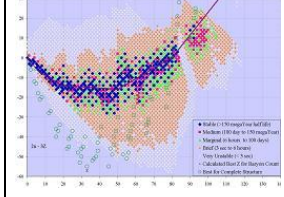
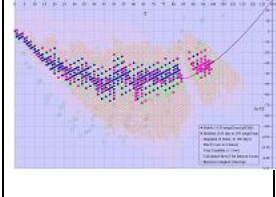
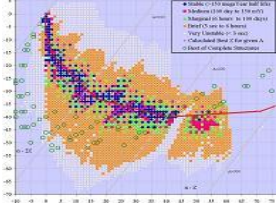
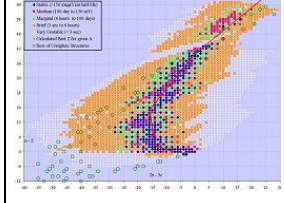
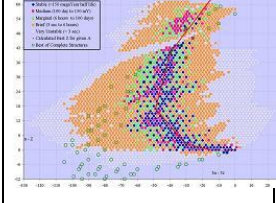
Aran David Stubbs

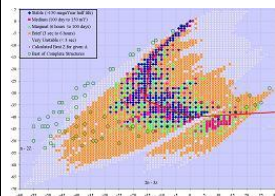
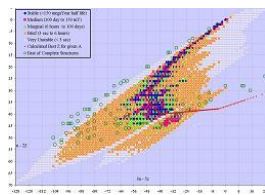
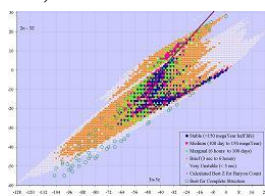
Ever since the discovery of the Neutron by Chadwick in 1932, tables of isotopes based on the atomic number  $z$  and the neutron count  $n$  have been possible. The Italian Giorgio Fea got into print in February 1935<sup>1</sup>, probably first. Many other lists followed<sup>2,3,4,5,6</sup>. A common arrangement of the table of Isotopes is the  $n * z$  arrangement, with neutron count on 1 axis and proton count on another. This is an obvious, intuitive arrangement. This does have some downsides. While only about 3200<sup>7,8</sup> isotopes are known, this arrangement requires a 180\*120 matrix for the known isotopes. All the known isotopes are in a thin strip along a diagonal. A standard work-around is to slice the table up and display these side by side. This makes it difficult to see long term patterns.

Several alternates exist, some better than the standard and some worse. To judge what are good or bad arrangements, some criteria are needed. The simplest is display area: the number of cells the matrix occupies. Another choice is the size of the longer axis. By the first criteria, the standard form is 21600 cells, by the second its long dimension is 180.

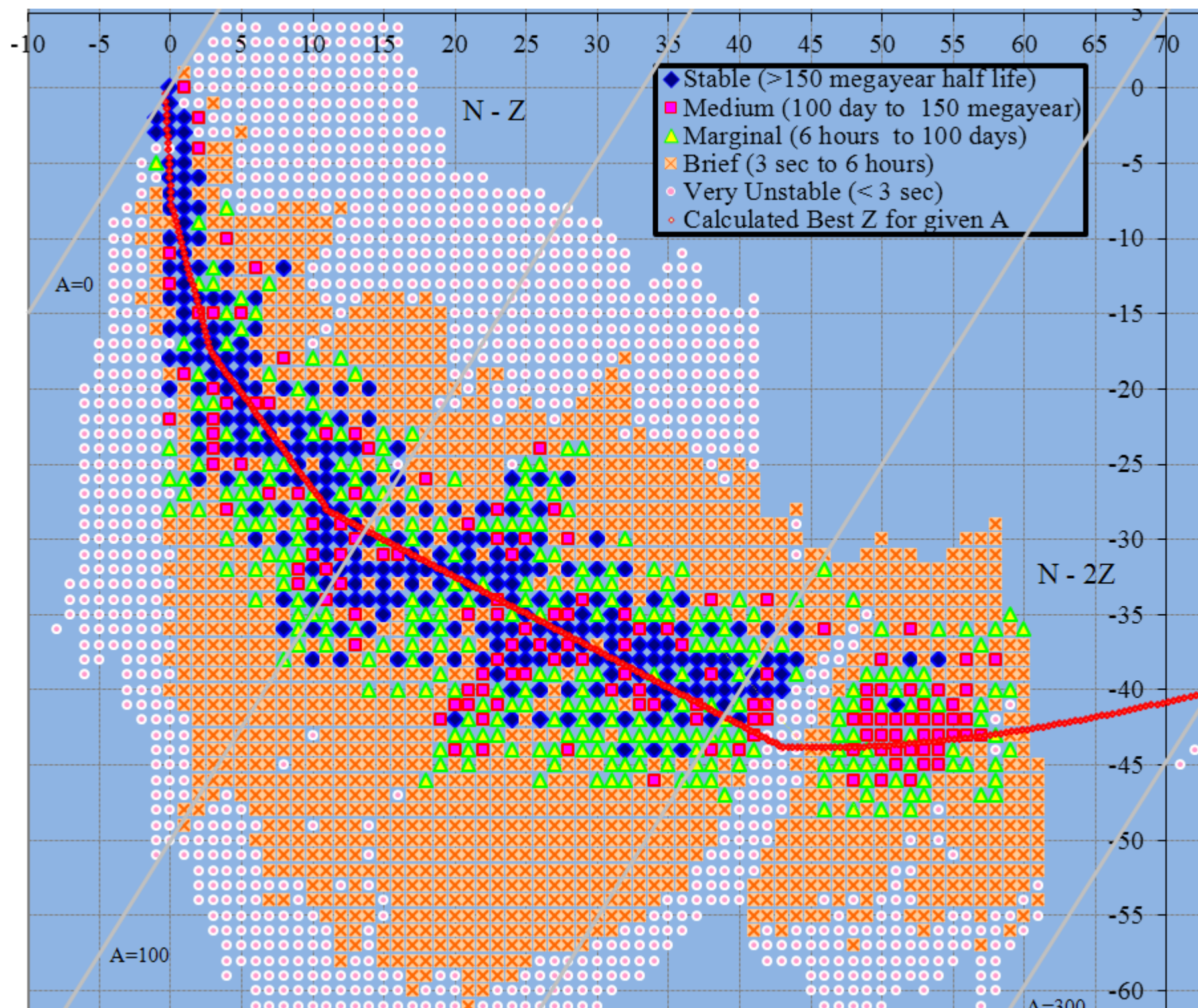
From number theory, a vector with small numbers produces the smallest range of values. Since  $n$  has a larger range, differences from  $n$  give a good start. The obvious choices are:  $n$ ,  $z$ ,  $n+z$ ,  $n-z$ ,  $n-2z$ ,  $2n-3z$ , and  $3n-5z$ . The later two were chosen by virtue of closely following the center of the data. A cross product of any disjoint pair of these vectors produces a possible display space. Some of these pairs yield skew sets, for instance  $n-z$  vs  $n+z$  where odd in one and even in the other produces an empty product set. So the size of the cross product is half the product of the vectors range ( $120*300/2$  in this case).

Several choices are less than 30% of the display area of the standard form, with the best ( $n-z * n-2z$ ) using less than 25% of the area. It is also tied for lowest maximum dimension with 74. Here is a table summarizing the available layouts. The data displayed is half life, with dark longest and white shortest. The standard and the best also have links to actual isotope tables.

	<b>n</b> 0 to 179	<b>z</b> 0 to 119	<b>n-z</b> -8 to +61	<b>n-2z</b> -69 to +4	<b>2n-3z</b> -58 to +29	<b>3n-5z</b> -127 to +24
<b>n+z</b> 0 to 299	300*180 54,000 cells	300*120 36,000 cells	300/2*70 10,500 cells 	300/3*74 7400 cells 	300/3*88 8800 cells 	300/5*152 9120 cells 
<b>n</b> 0 to 179	N/A	180*120 <a href="#">21,600 cells</a> 	180*70 12,600 cells 	180/2*74 6660 cells 	180/3*88 5280 cells 	180/5*152 5472 cells 
<b>z</b> 0 to 119	120*180 21,600 cells	N/A	120*70 8400 cells 	120*74 8880 cells 	120/2*88 5280 cells 	120/3*152 6080 cells 
<b>n-z</b> -8 to +61	70*180 12,600 cells	70*120 8400 cells	N/A	70*74 <a href="#">5180 cells</a> 	70*88 6160 cells 	70*152/2 5320 cells 

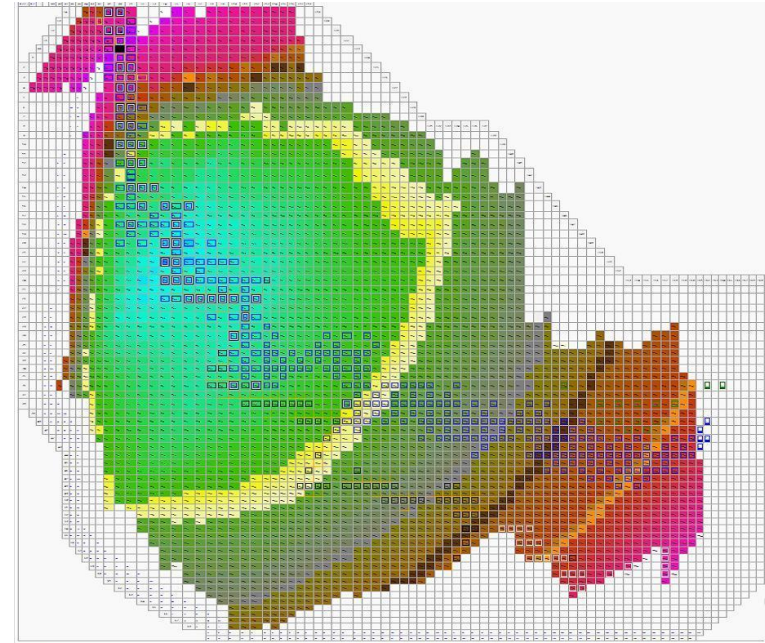
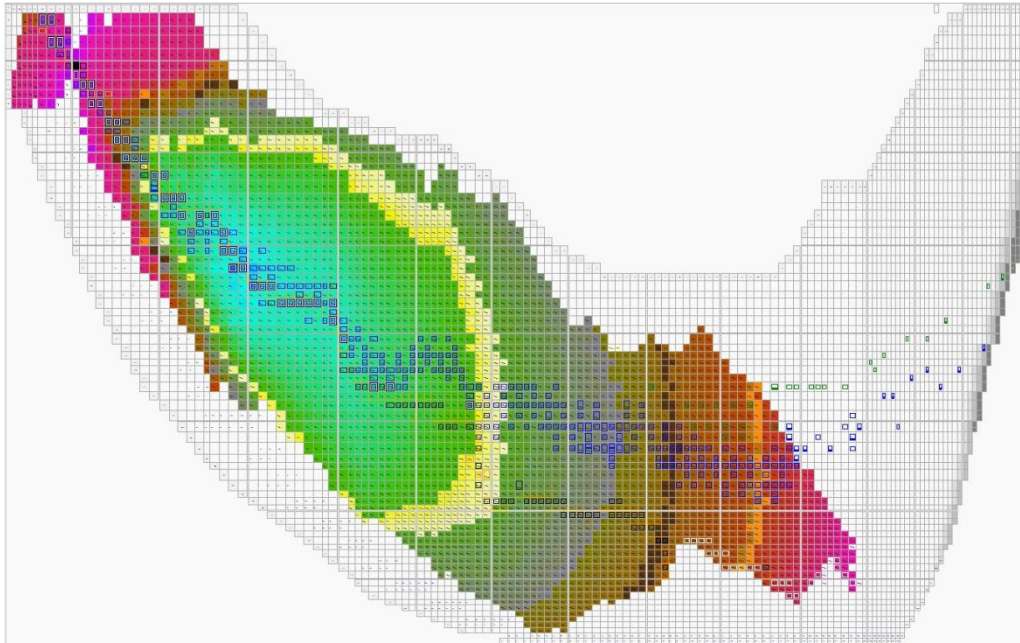
<b>n-2z</b> -69 to +4	74*180/2 6660 cells	74*120 8880 cells	74*70 5180 cells	N/A	74*88 6512 cells 	74*152 11,248 cells 
<b>2n-3z</b> -58 to +29	88*180/3 5280 cells	88*120/2 5280 cells	88*70 6160 cells	88*74 6512 cells	N/A	88*152 13,376 cells 

While the n-z by n-2z is clearly best for the known isotopes, it fades a bit for the likely extensions. With z ranging 0:137 and A (n+z) ranging 0:390 (which is likely), n-z ranges -8 to +116, for 9250 cells. The n-2z vs A/3 is the next best for that space with n-2z retaining its -69 to +4 range, and A/3 ranging 0:130, for about 9700 cells. Here is a blowup of the best fit:





Many of the arrangements may be valuable for a particular use. For instance the energy per baryon looks like this in  $A/3 * n - 2z$ , and  $n - z * n - 2z$ , respectively. A blue outline surrounds the cell with the lowest energy per baryon for a baryon count, and green for the stablest when that is not least energy.



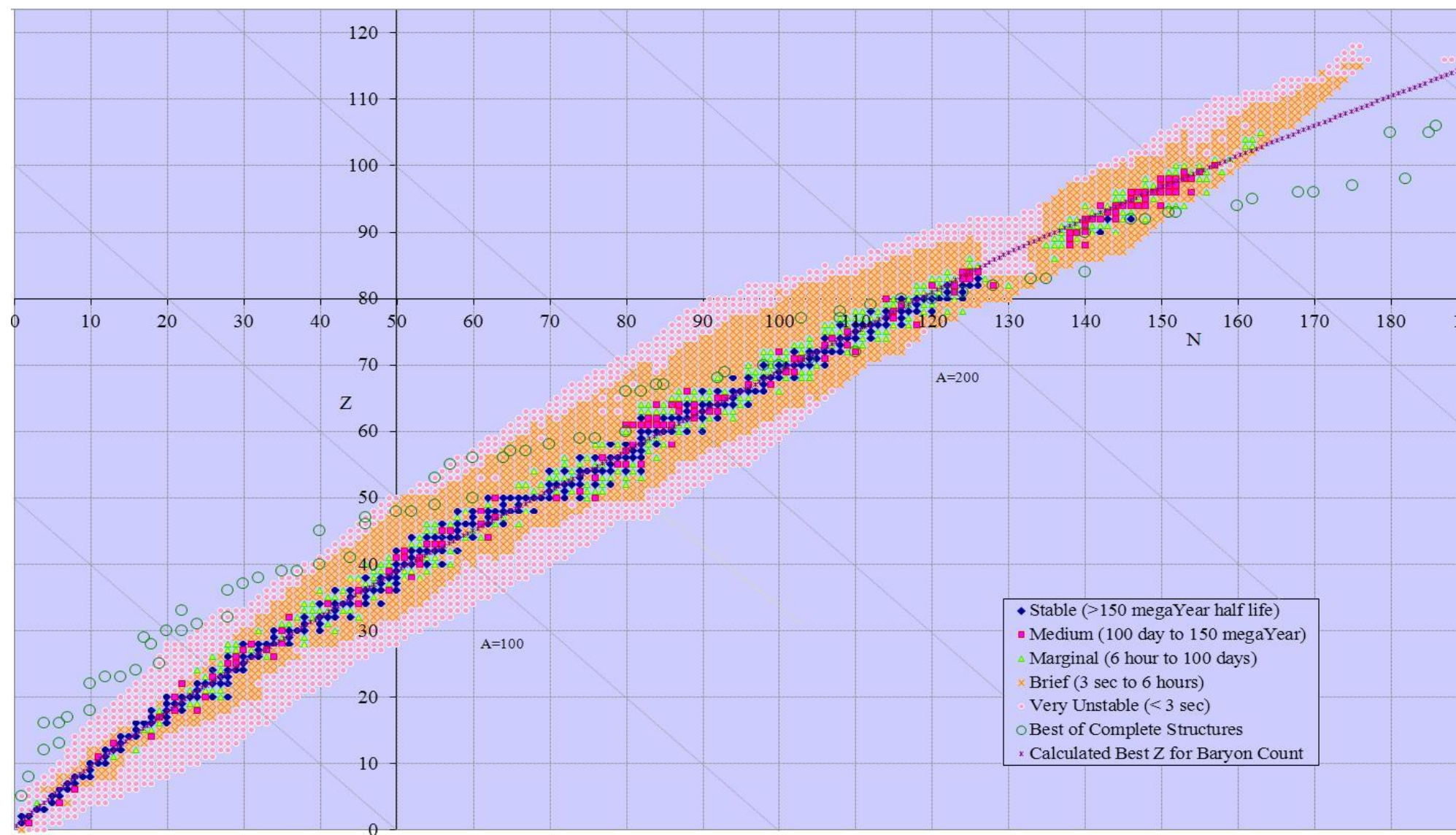
## References

- 1) "Tabelle Raissuntive E Bibliografia delle Transmutazioni Artificiali" Georgio Fea. Il Nuovo Cimento 2 (1935) 368
- 2) Amaldi, D'Agostino, Fermi, Pontecorvo, Rasetti, and Segrè, Proc. Roy. Soc. London A149, 522 (1935)
- 3) Alichanian, Alichanow, and Dzelepov, Physik. Zeits. Sowjetunion 10, 78 (1936)
- 4) "Table of Isotopes" [G. T. Seaborg](#) and [I. Perlman](#) Rev Mod Phys 20 585-667 (1948)
- 5) "Table of Isotopes" [Strominger, D.](#) ; [Hollander, J.M.](#) ; [Seaborg, G.T.](#) Rev Mod Phys 30 585-904 (1958)
- 6) "Table of Isotopes" [Browne, E.](#) ; [Dairiki, J.M.](#) ; [Doebler, R.E.](#) ; [Shihab-Eldin, A.A.](#) ; [Jardine, L.J.](#) ; [Tuli, J.K.](#) ; [Buyrn, A.B.](#) book: Stanford press, Fireside, John Wiley & sons (1978) revised (1996)
- 7) "[What We Do: The Chart of Nuclides](#)". Knolls Atomic Power Laboratory. <http://www.knollslab.com/nuclides.html> Retrieved 14 May 2009

8) Nudata from Centre de Spectrométrie Nucléaire et de Spectrométrie de Masse CSNSM, IN2P3-CNRS. Retrieved 15 September 2009.

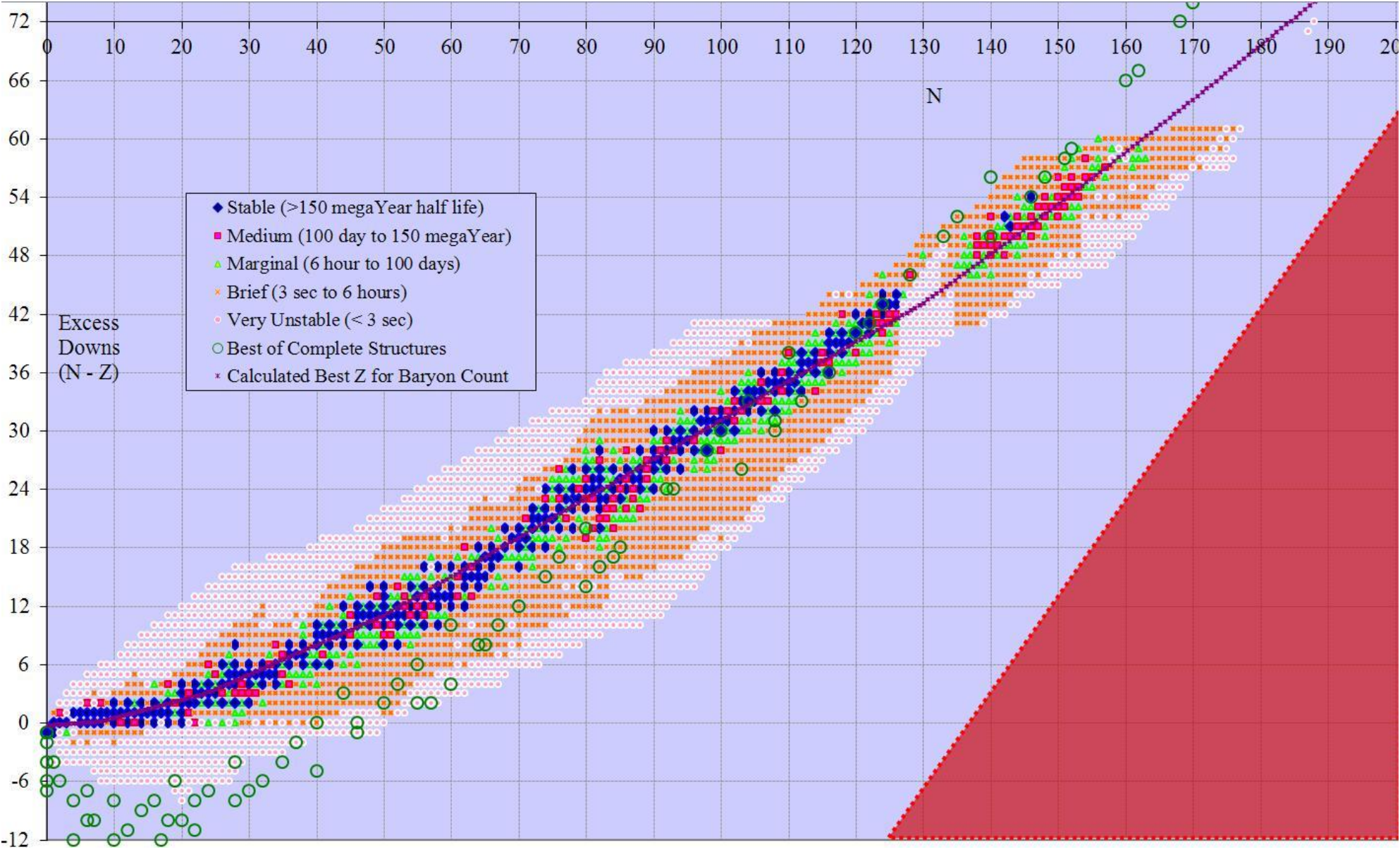
## Illustrations:

N x Z



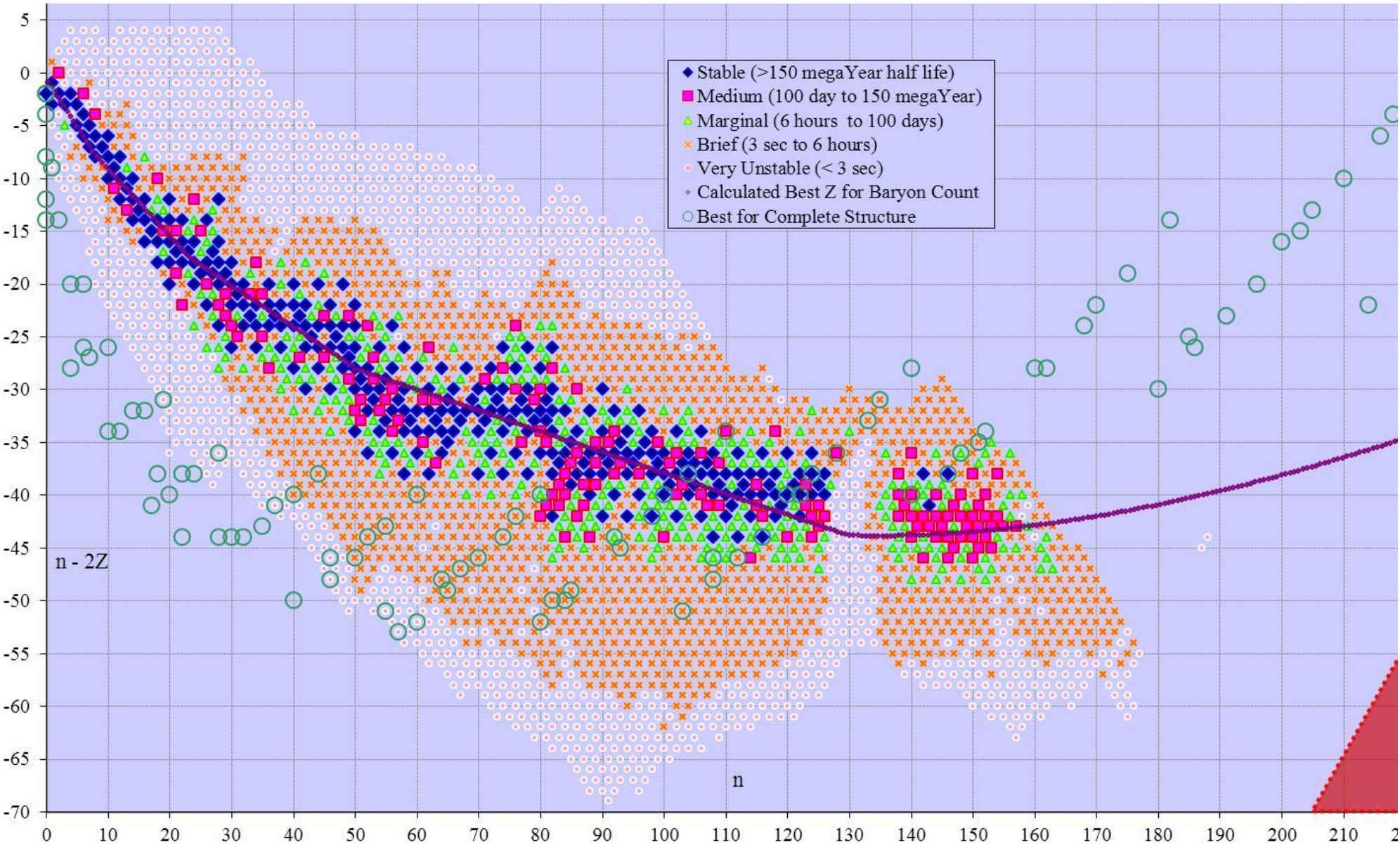


$N \times N-Z$



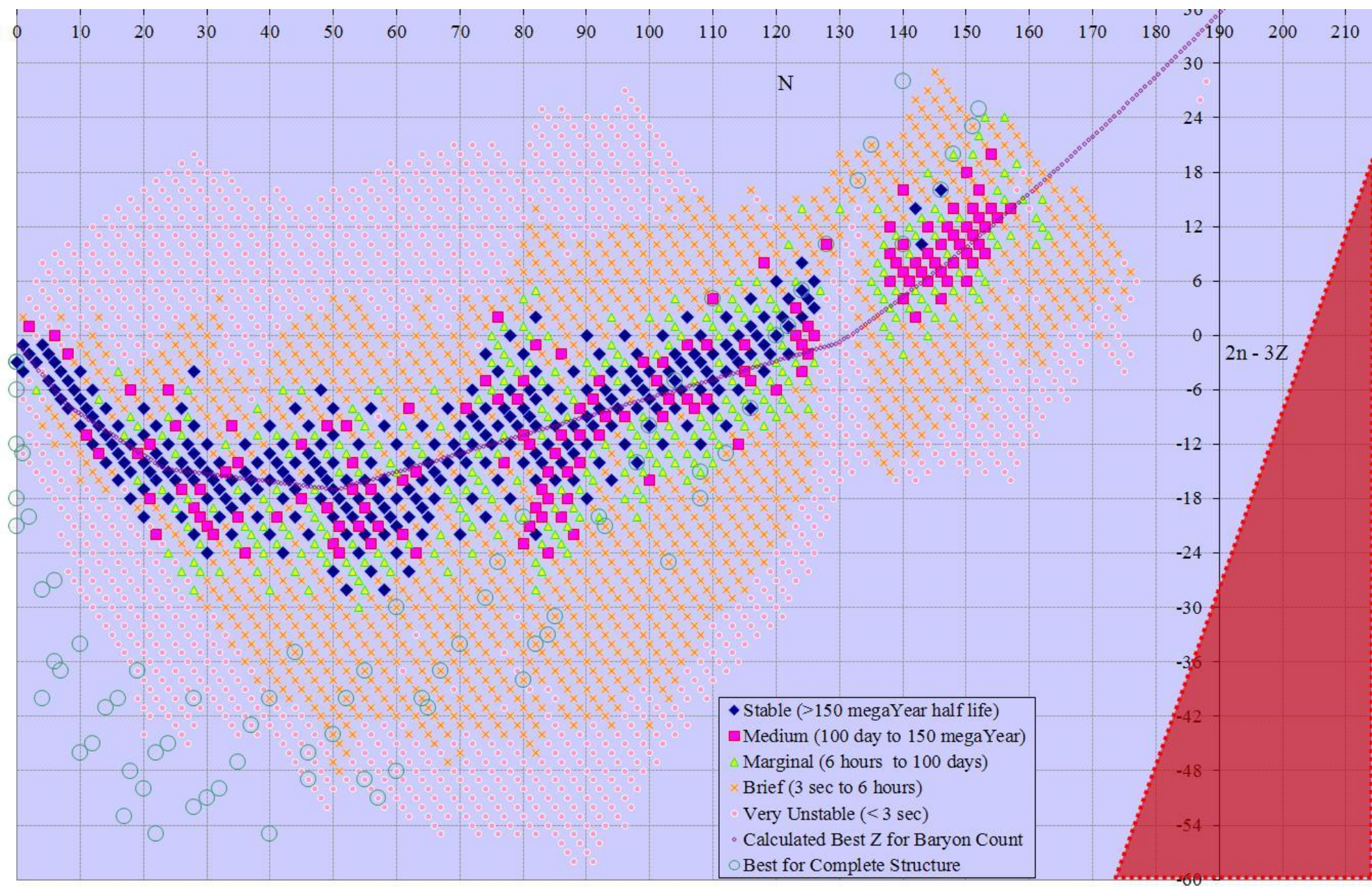


$N \times N-2Z$



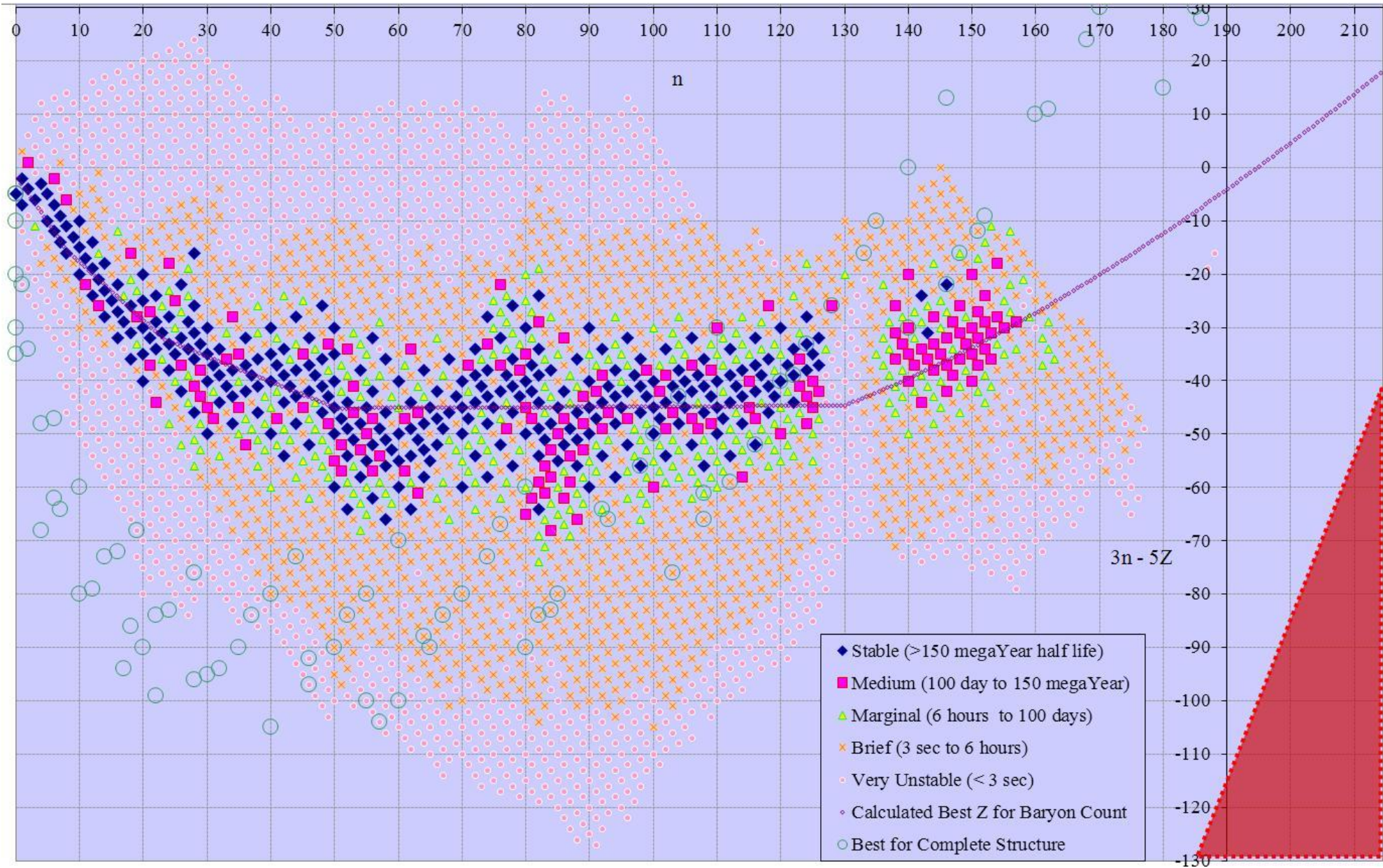


$N \times 2N-3Z$



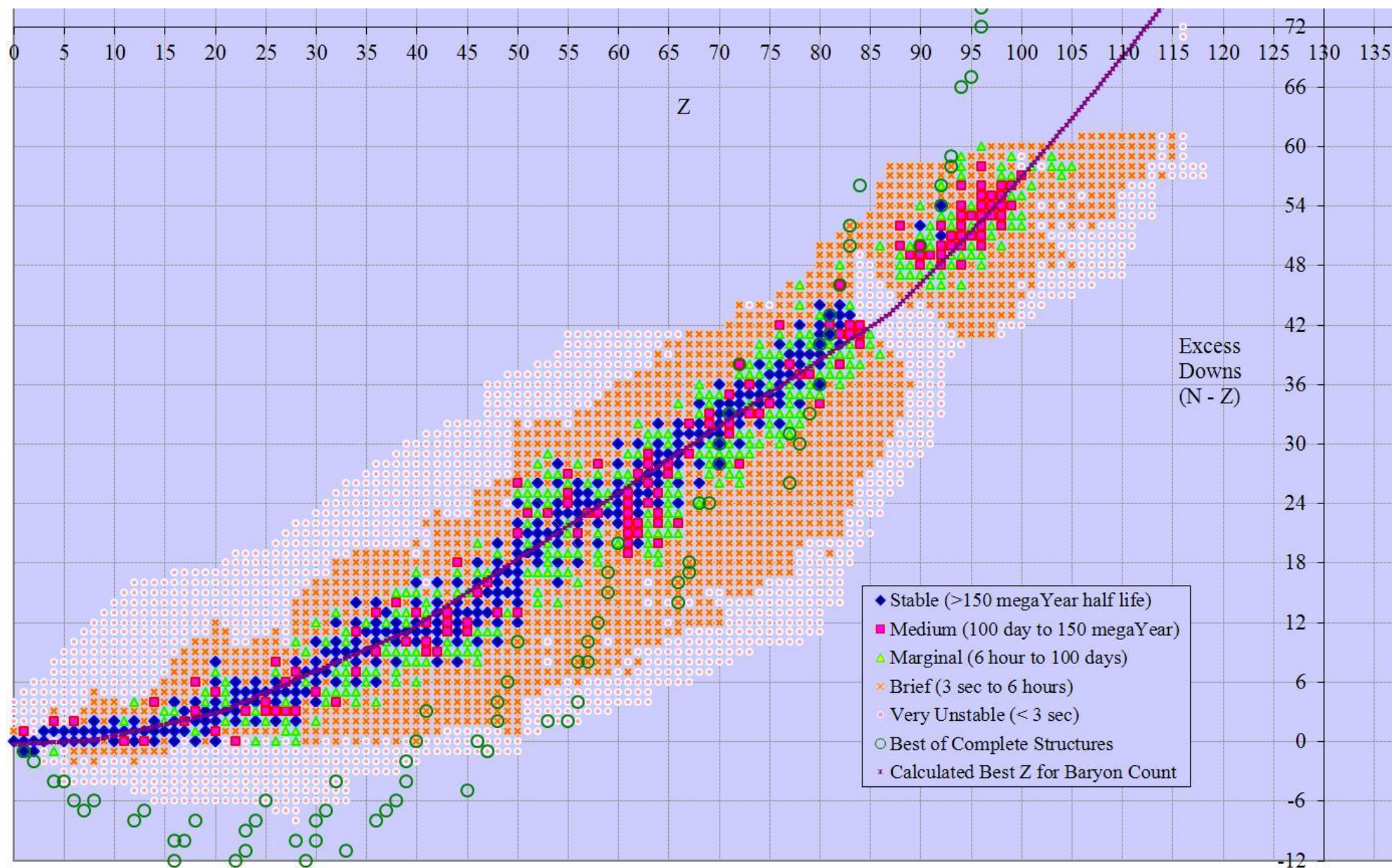


N x 3N-5Z



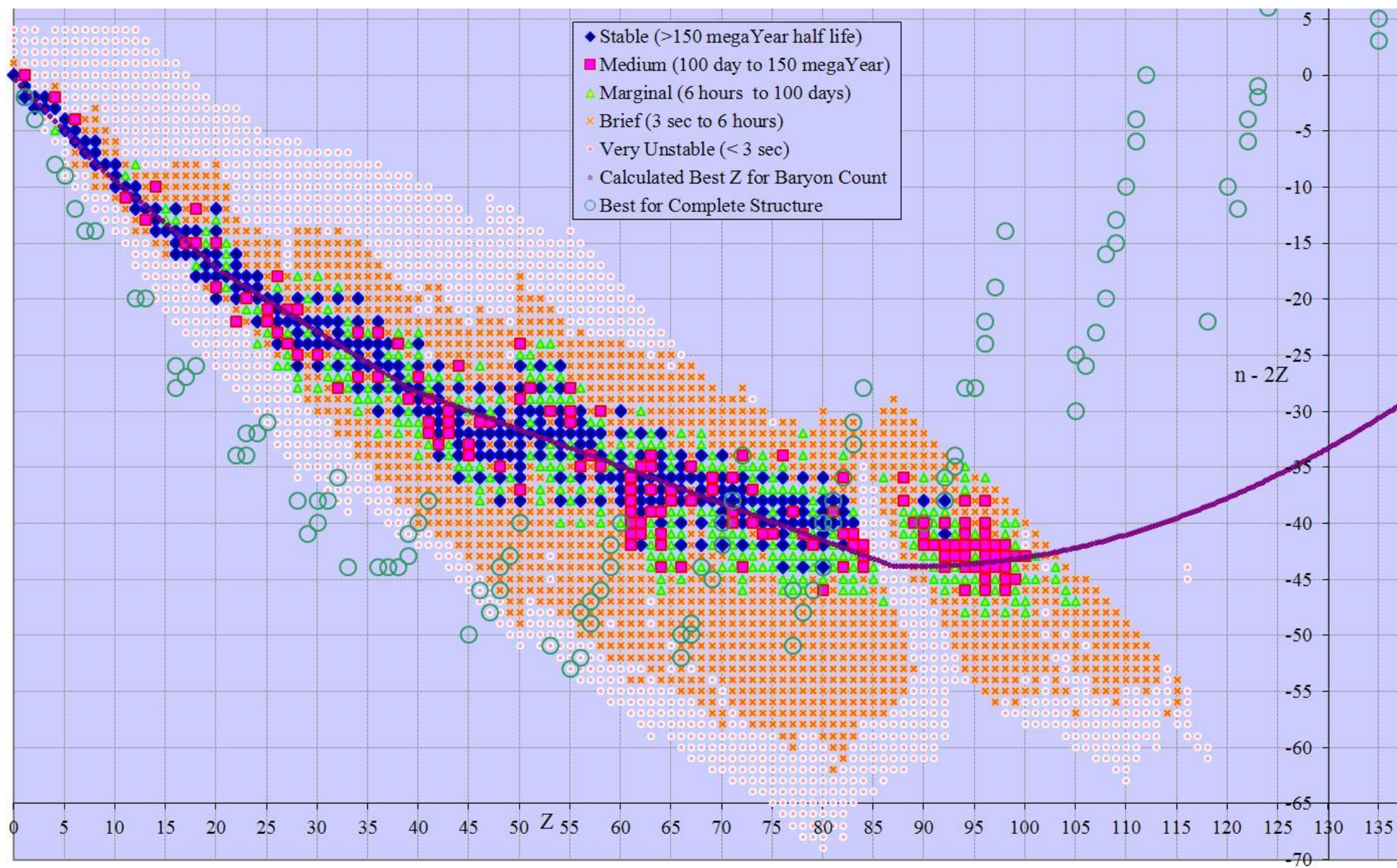


$Z \times N-Z$



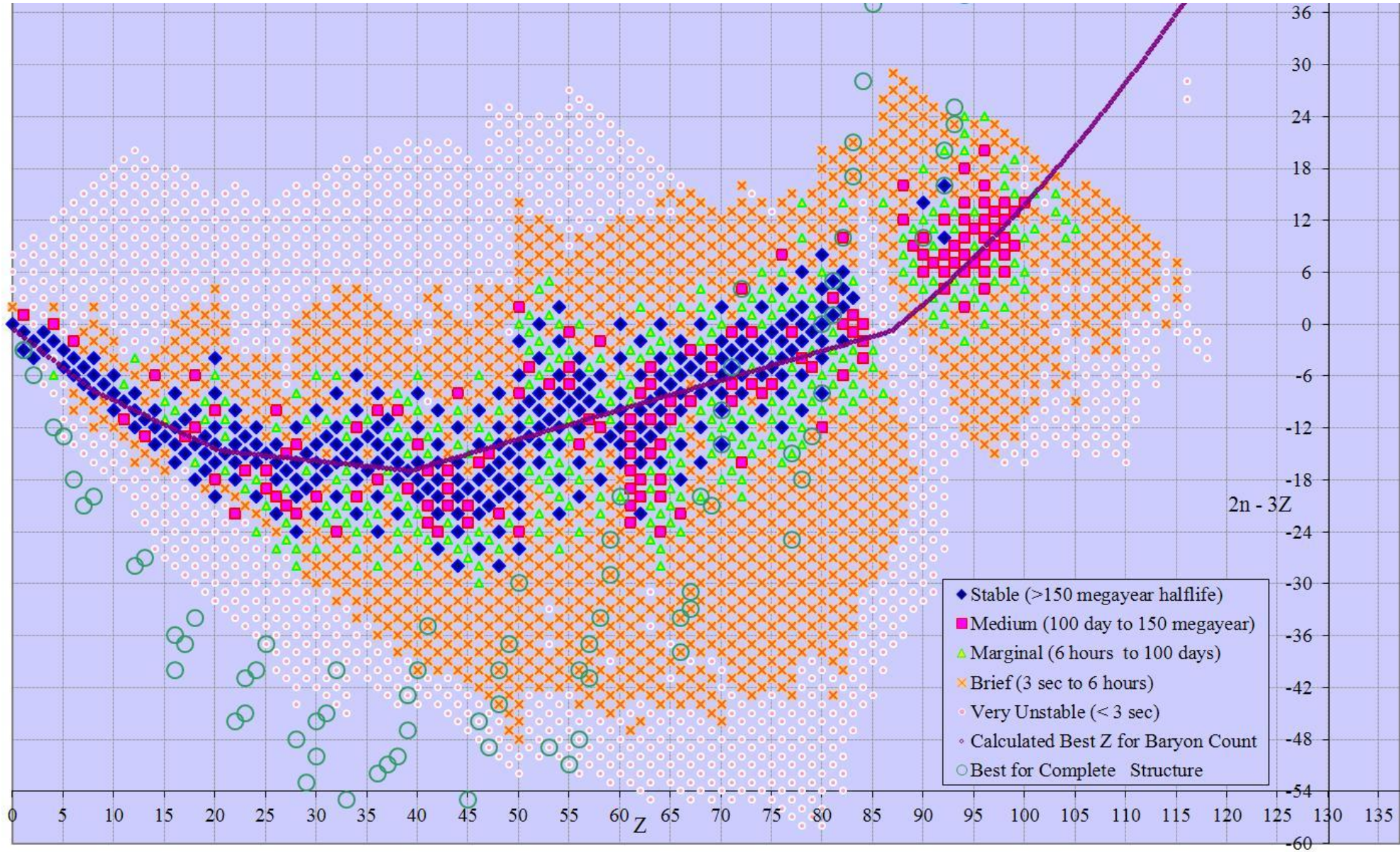


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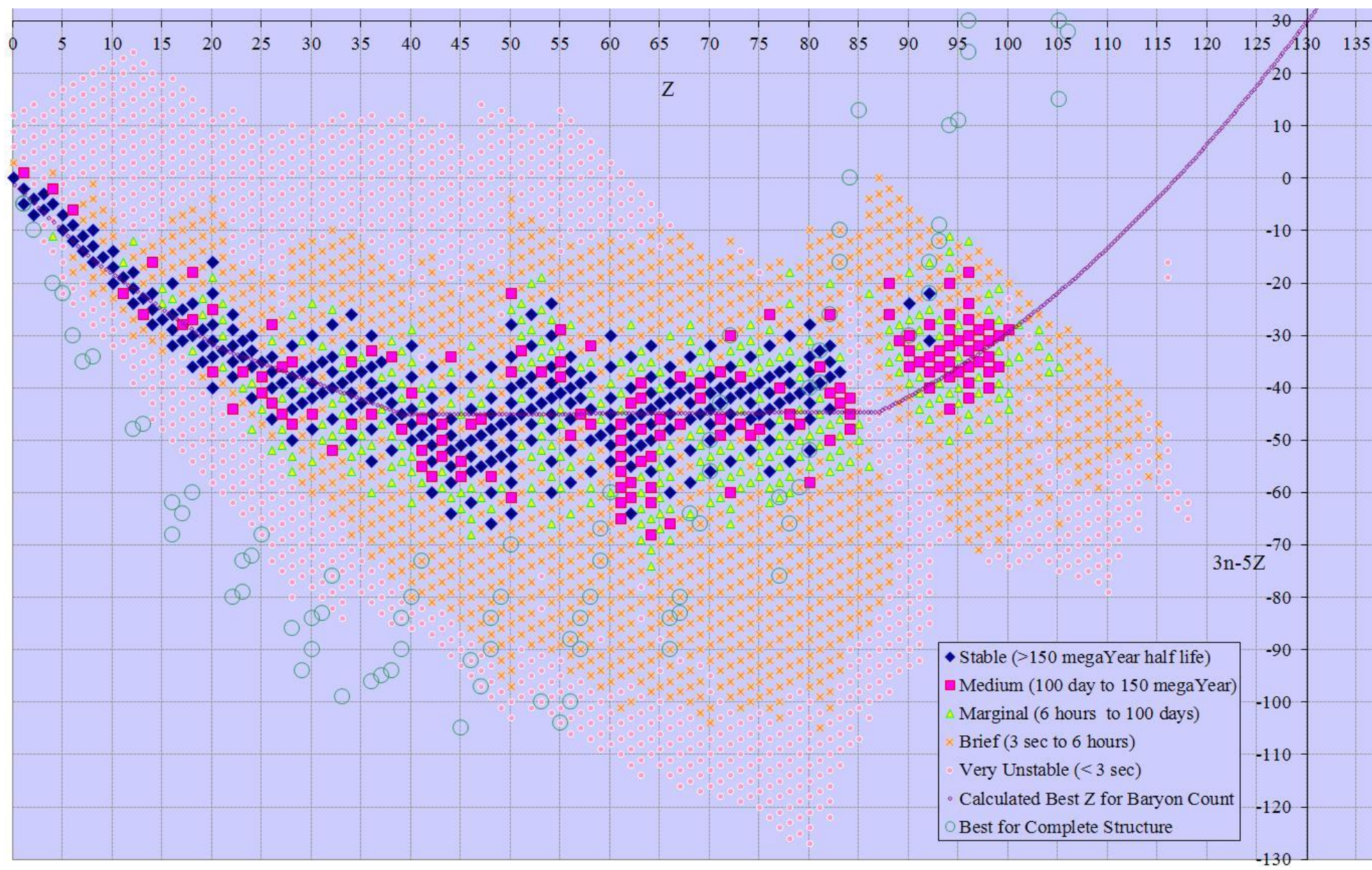


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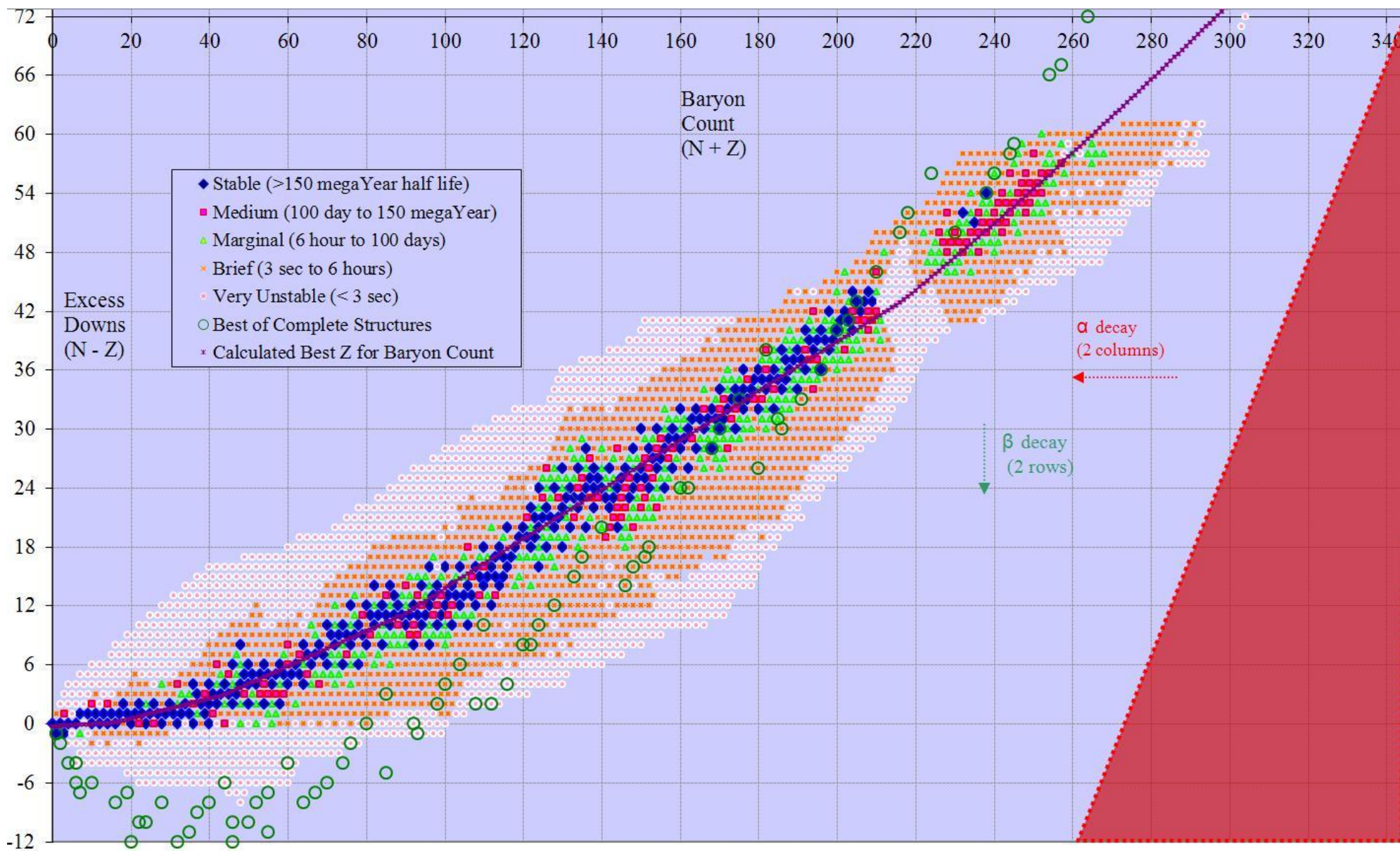


$Z \times 3N-5Z$



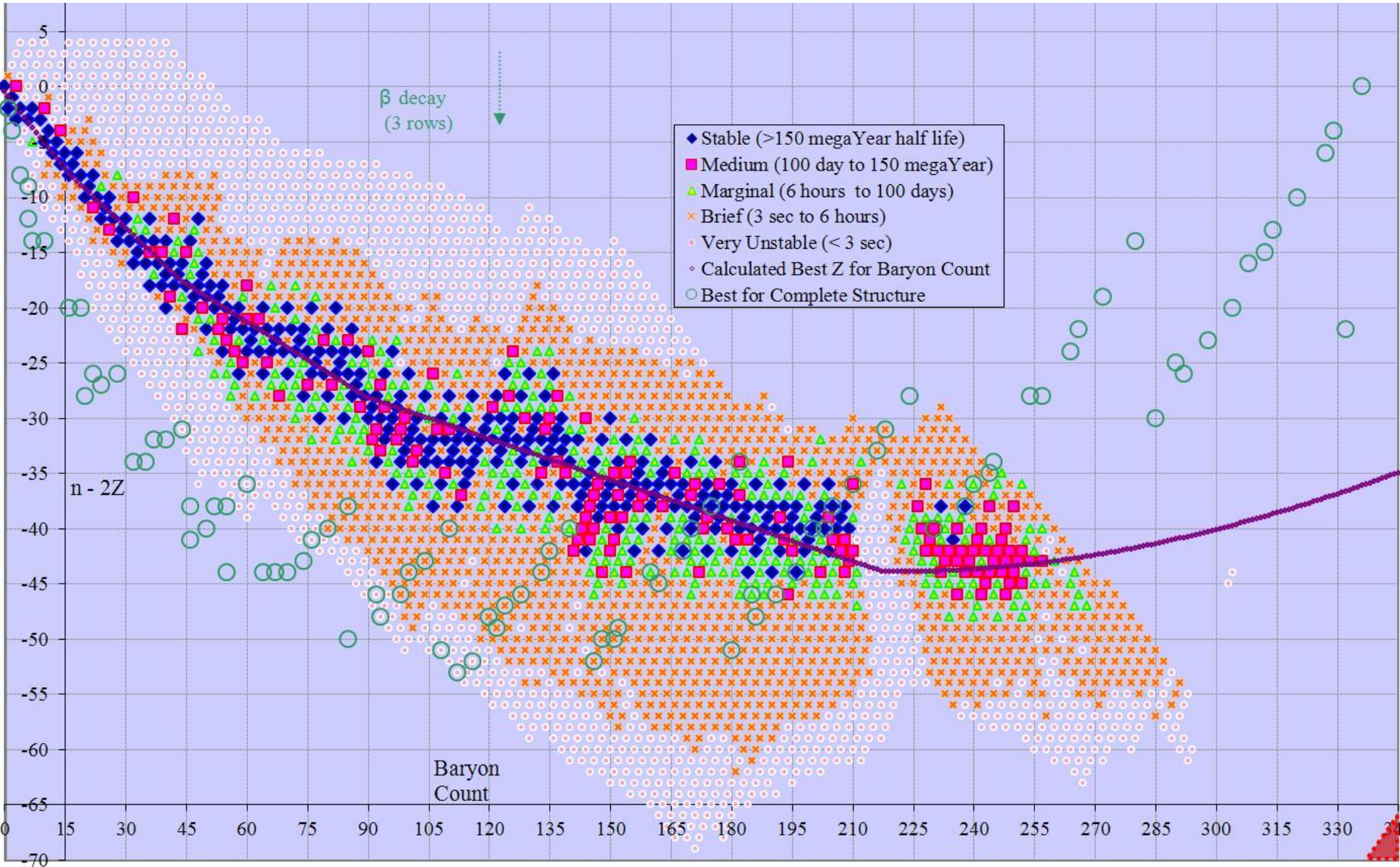


$N+Z \times N-Z$



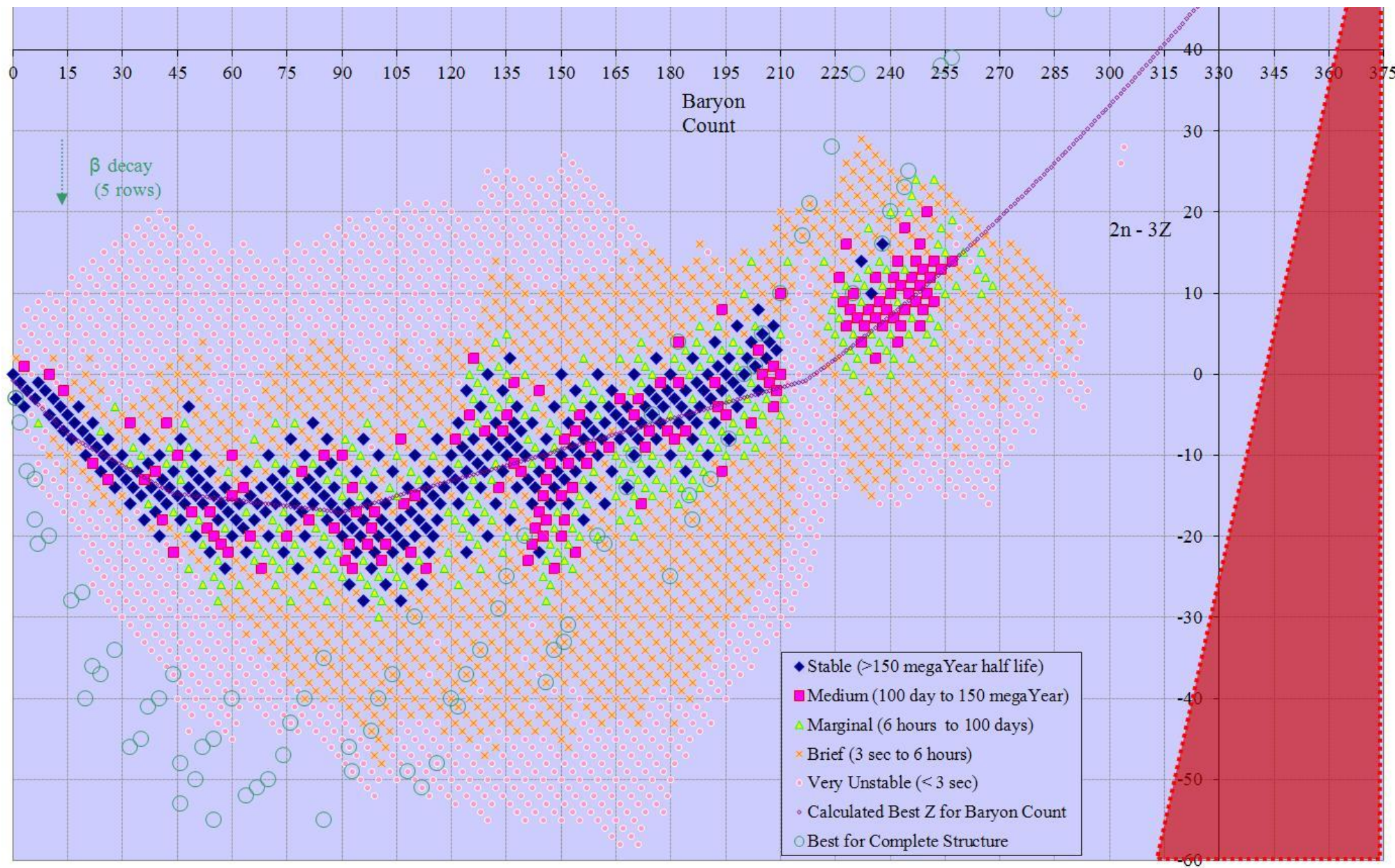


$N+Z \times N-2Z$



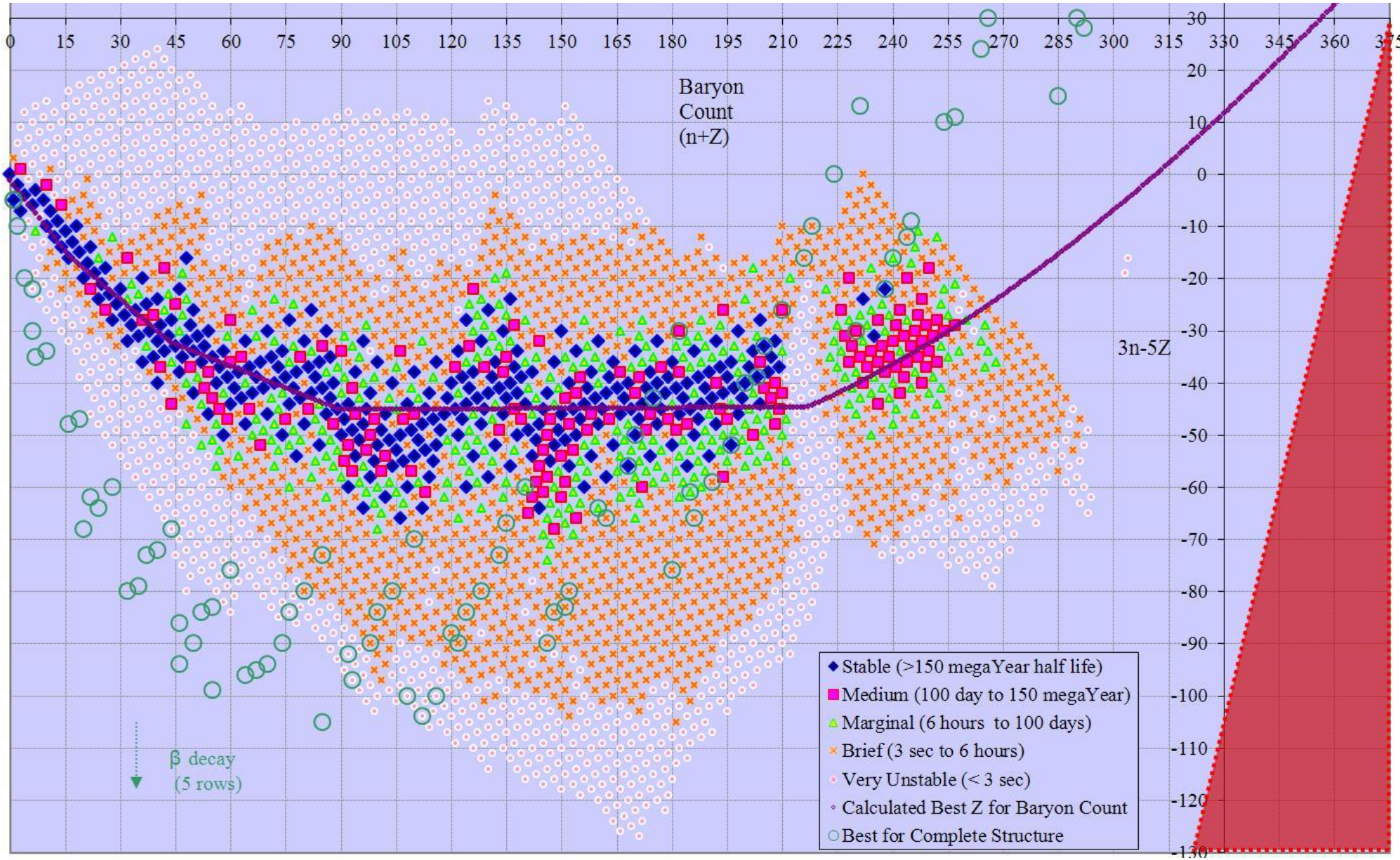


$N+Z \times 2N-3Z$



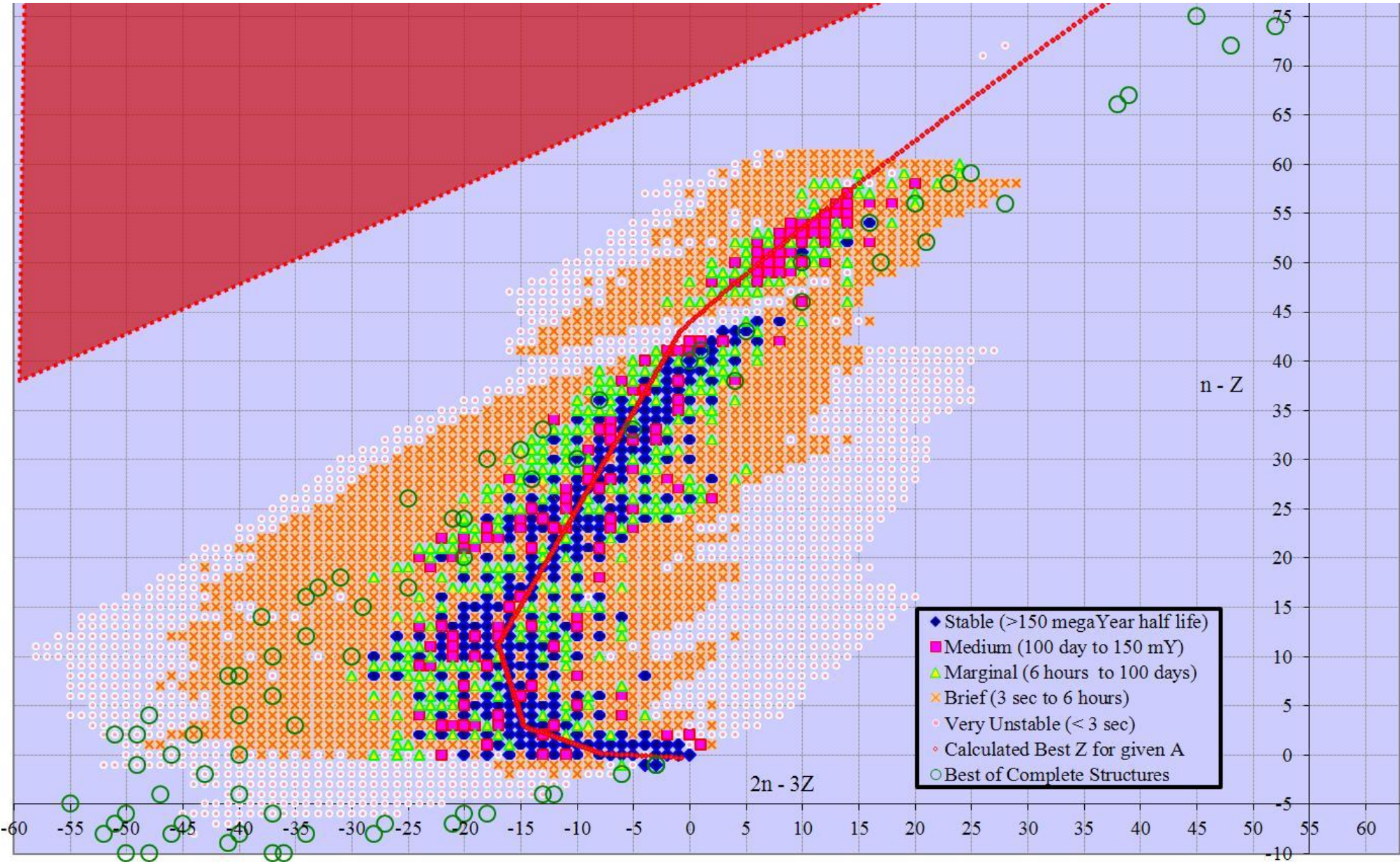


$N+Z \times 3N-5Z$



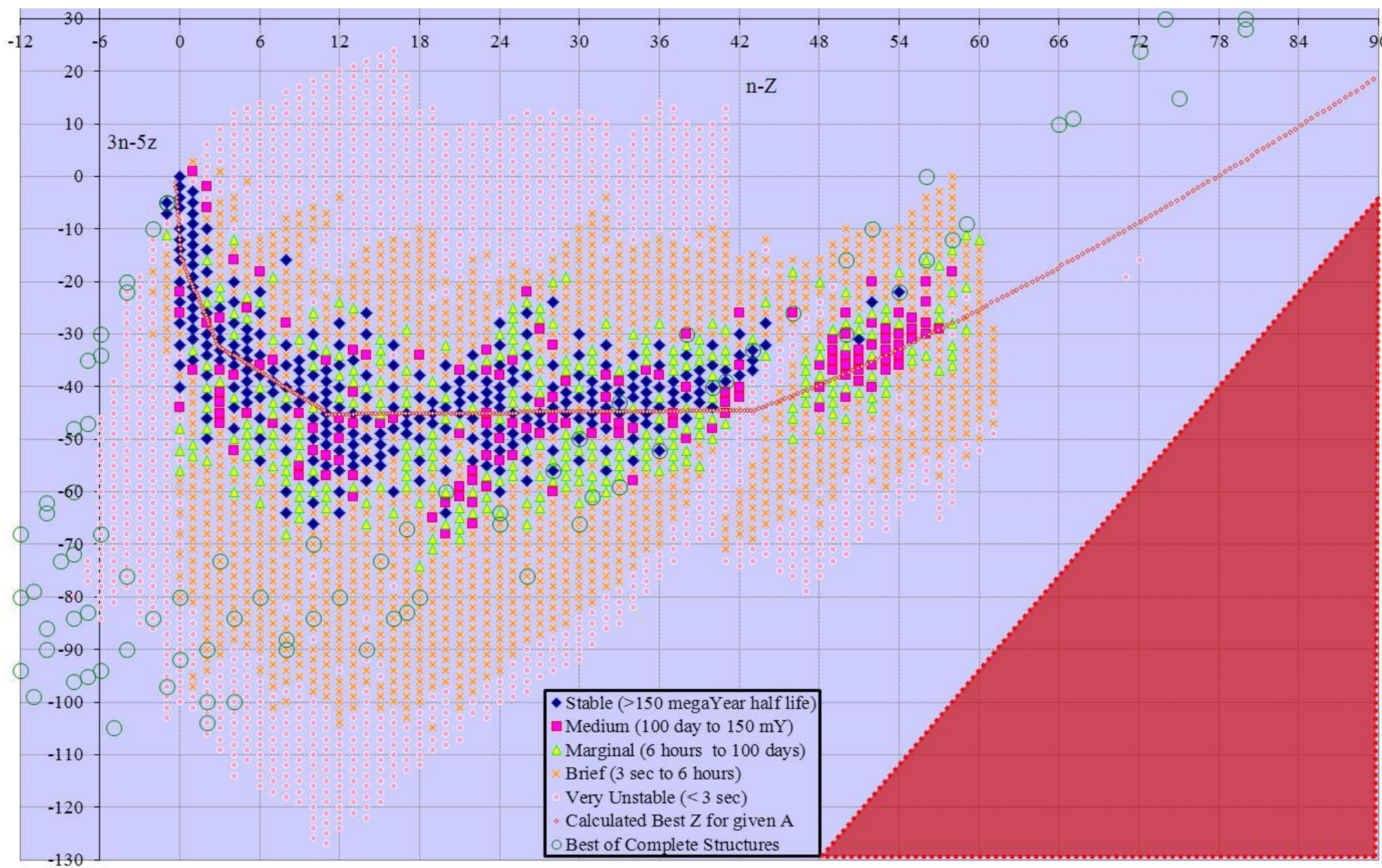


$2N-3Z$  x  $N-Z$



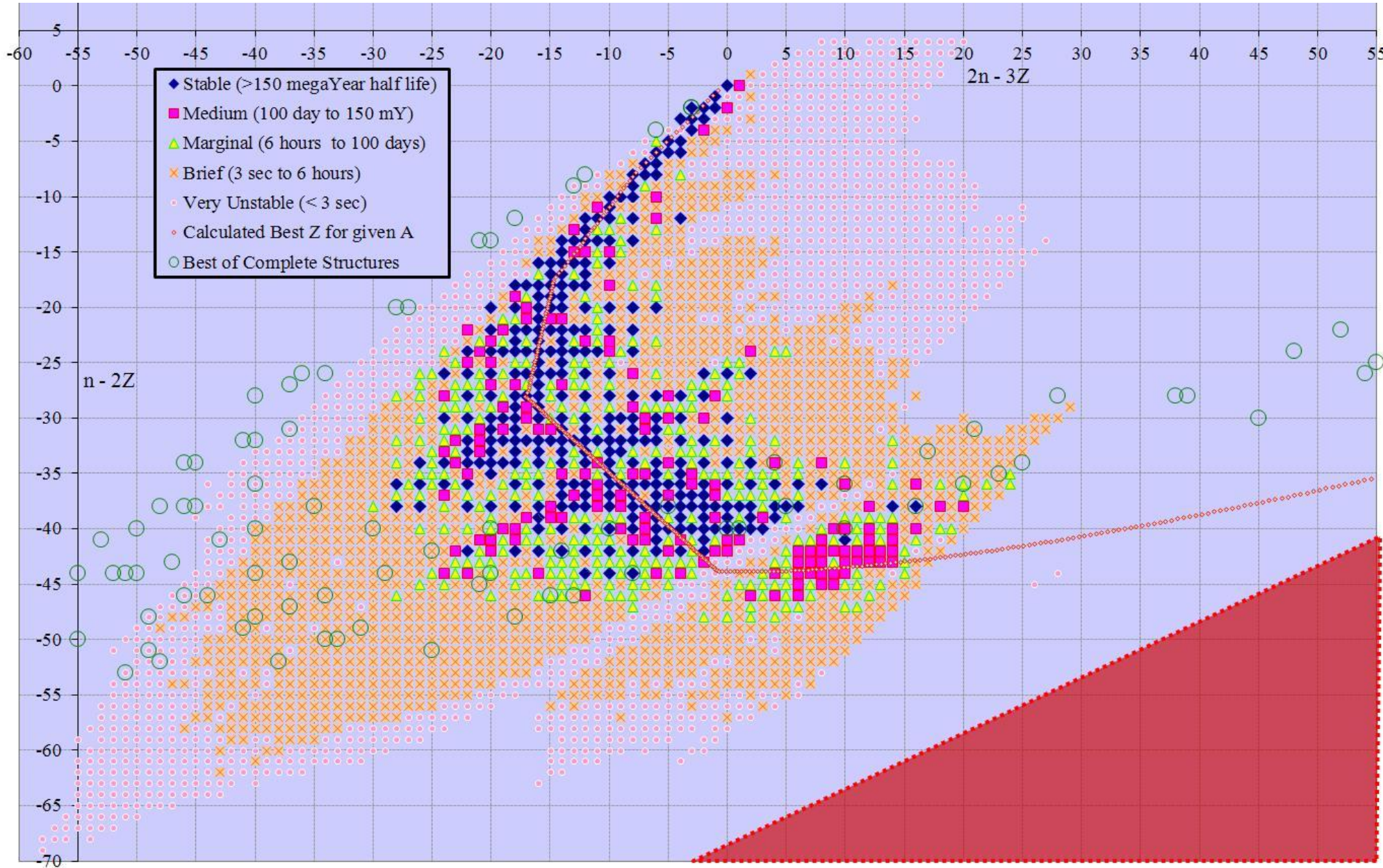


N-Z x 3N-5Z



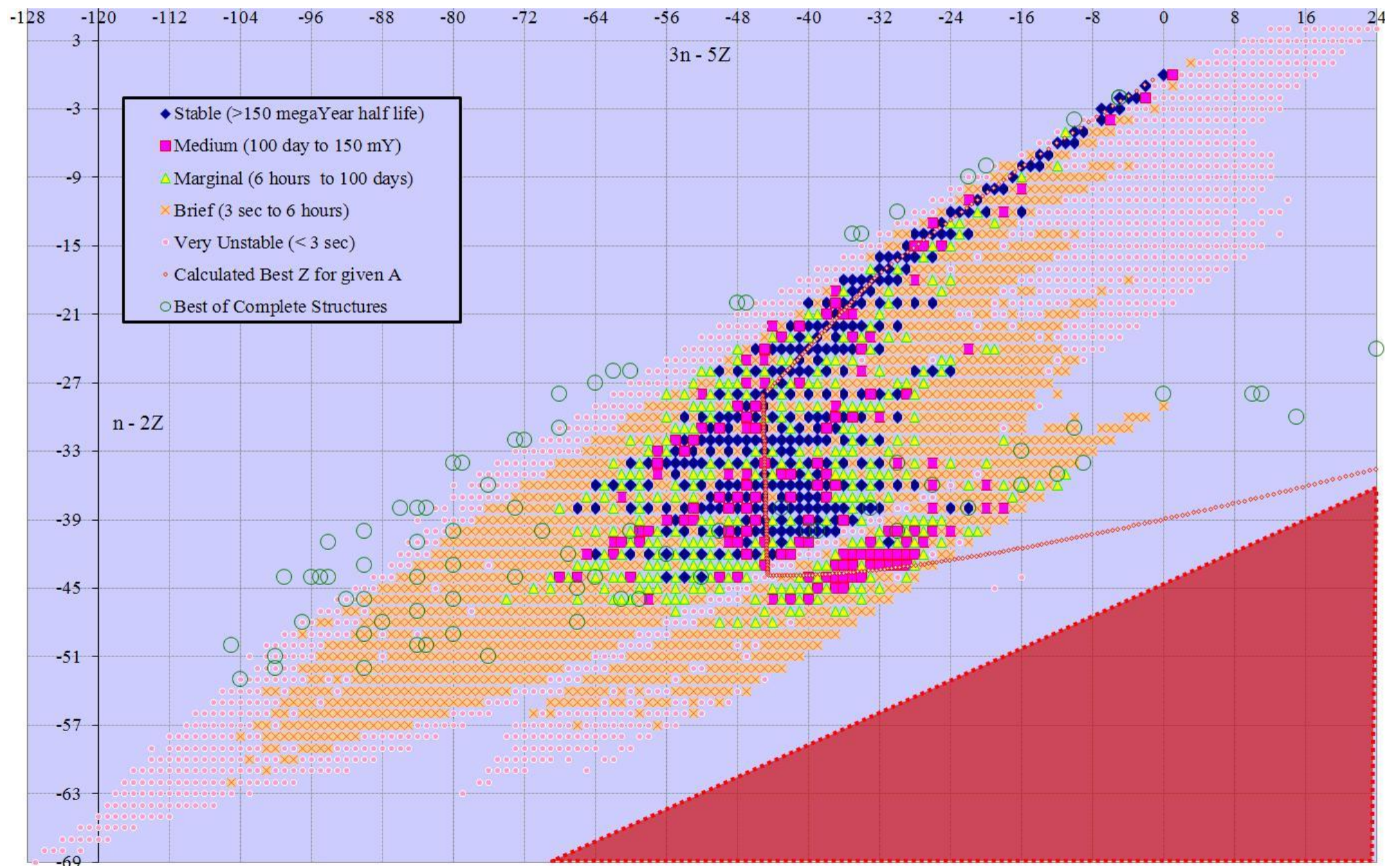


2N-3Z x N-2Z





3N-5Z x N-2Z





3N-5Z x 2N-3Z

