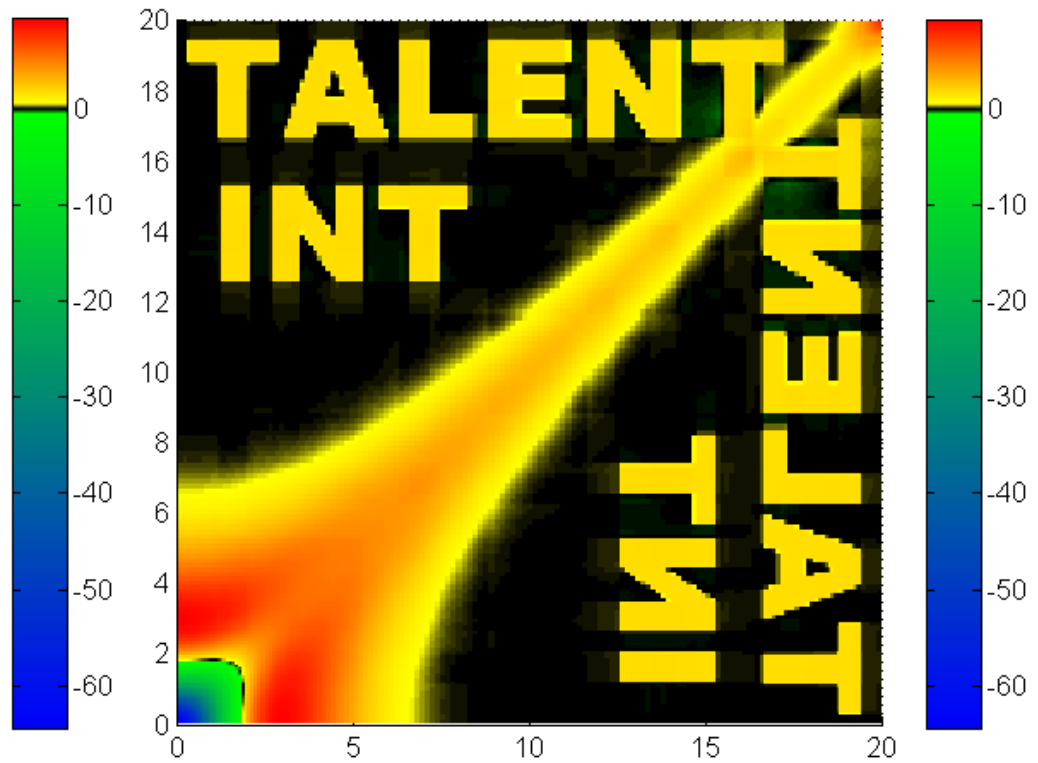
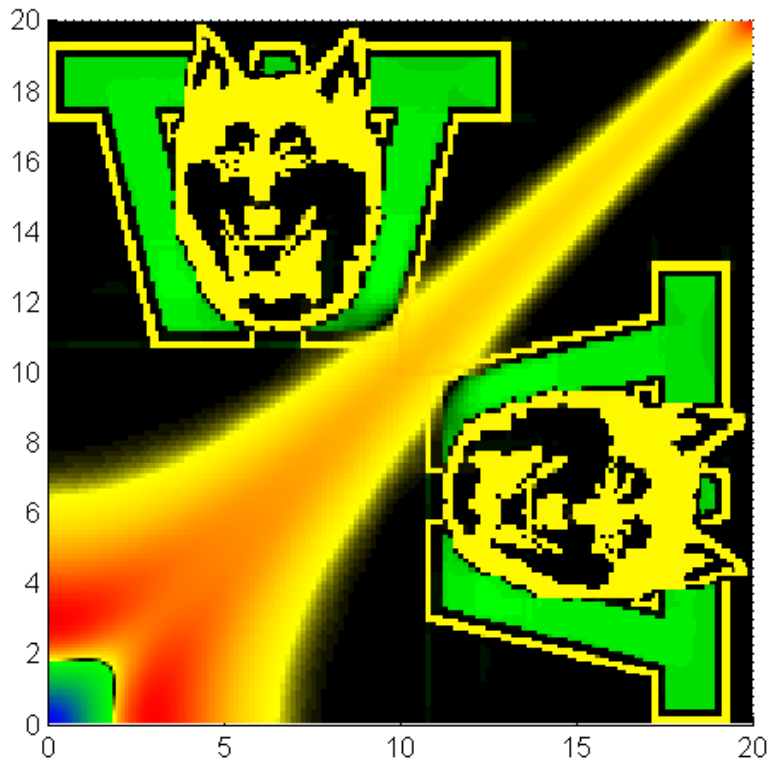
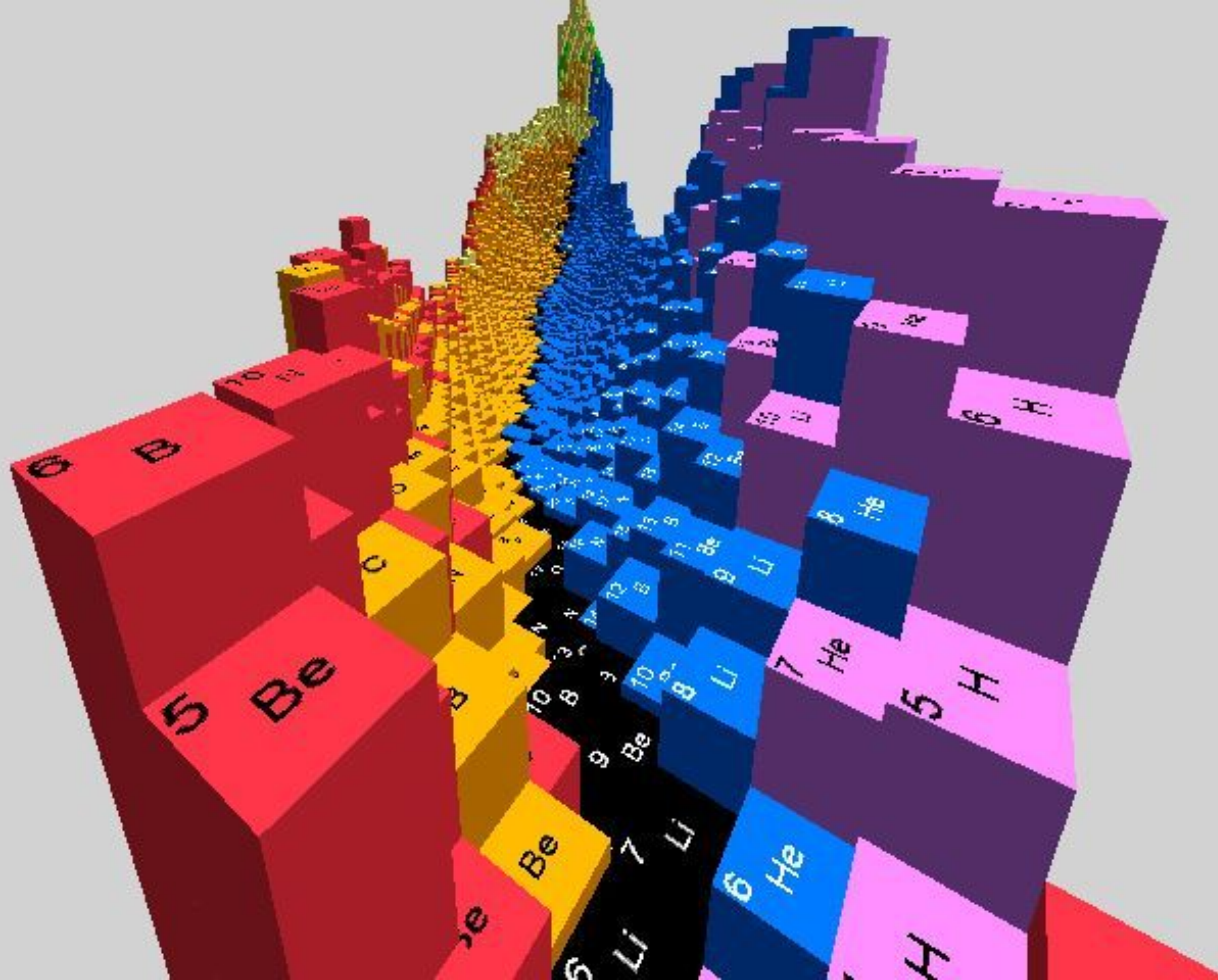
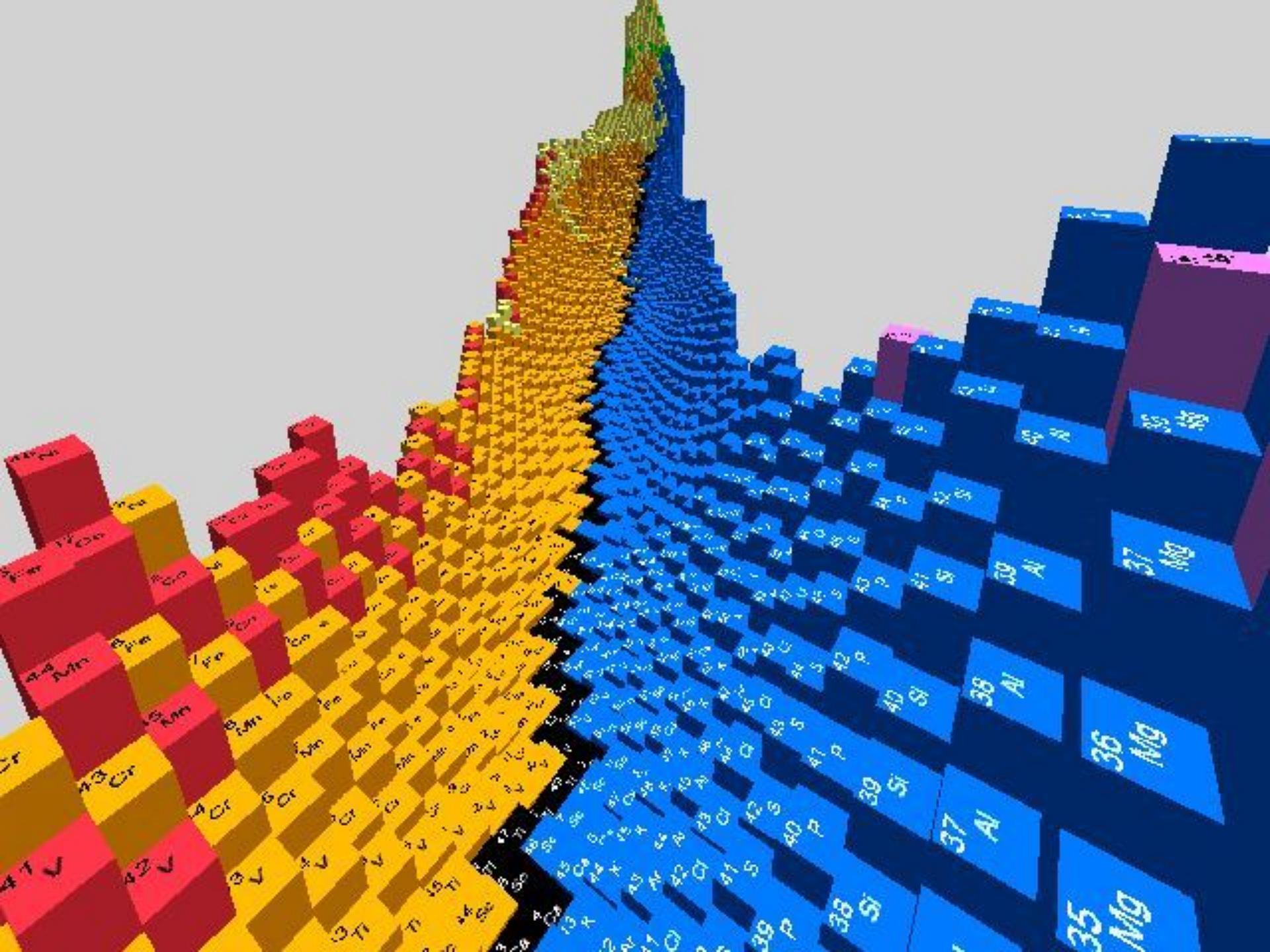


SRG with the husky and TALENT generators!

Thanks to Boris Carlsson

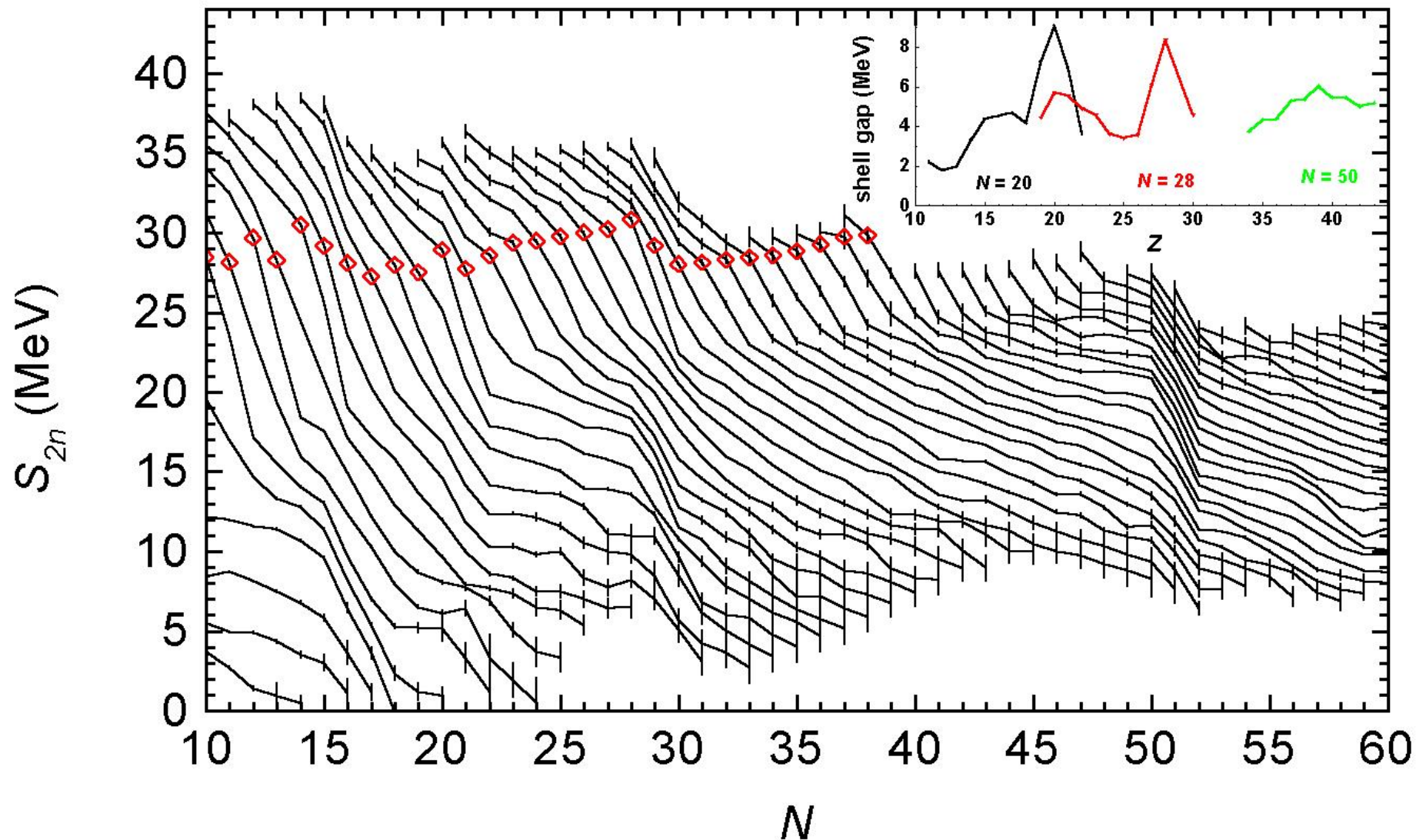




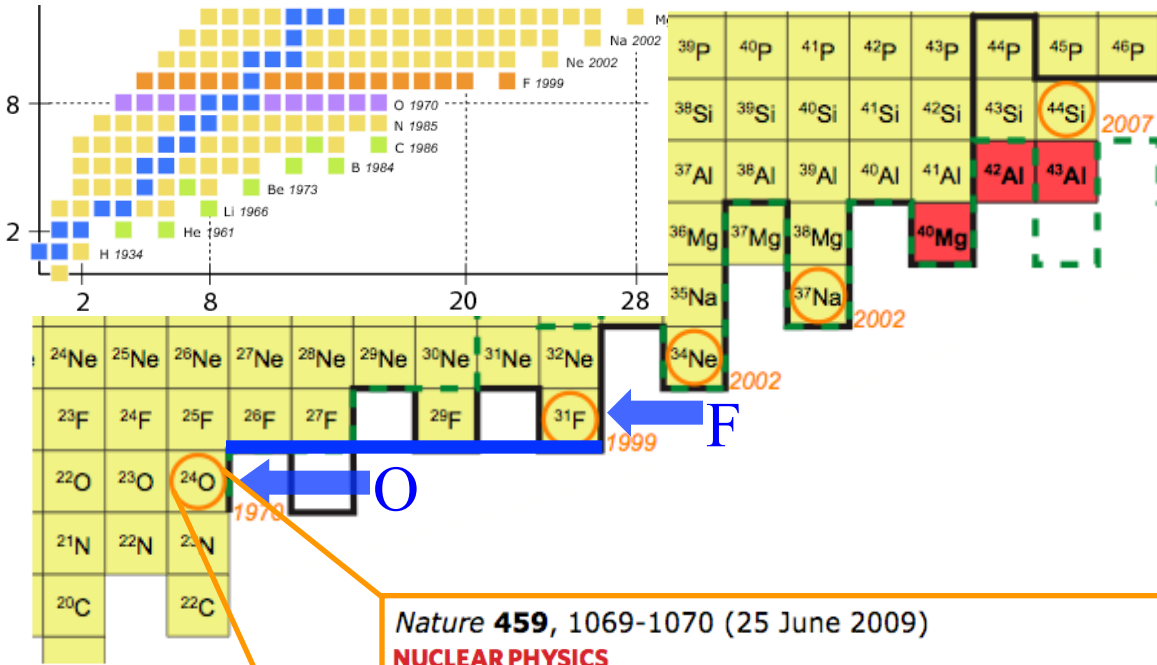


Shell closures from masses

$2n$ ($2p$) separation energy decreases rapidly following shell closure:
 N (Z)=2, 8, 20, 28, 50, 82,... (peak in shell gap = difference of S_{2n})



The oxygen anomaly



Nature **459**, 1069-1070 (25 June 2009)

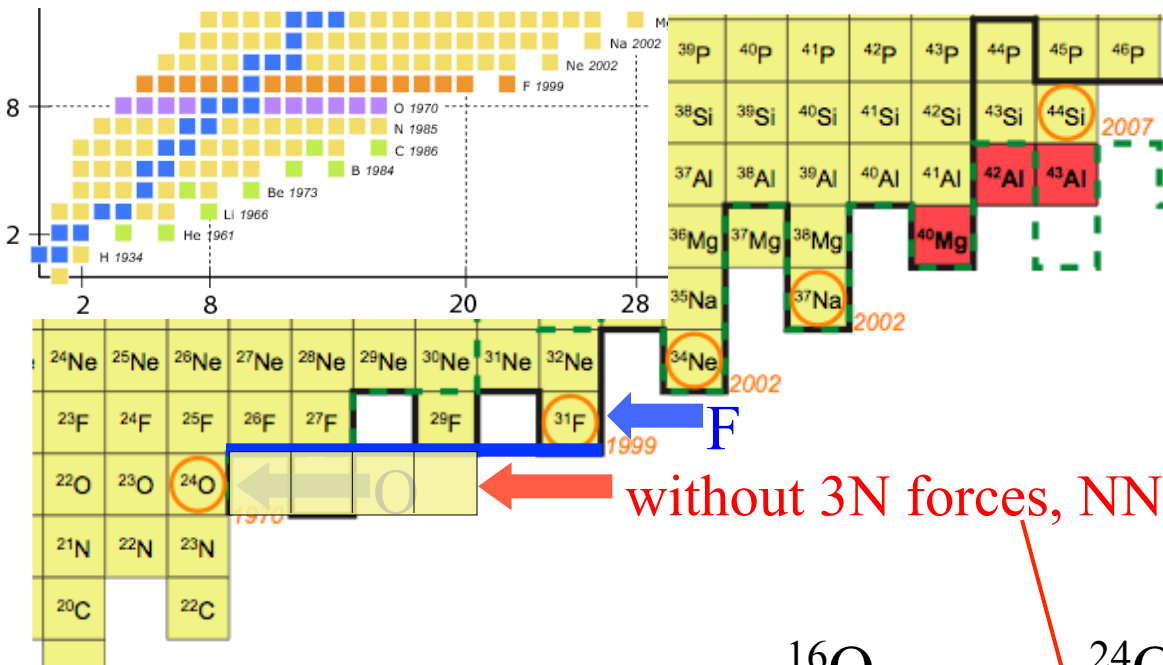
NUCLEAR PHYSICS

Unexpected doubly magic nucleus

Robert V. F. Janssens

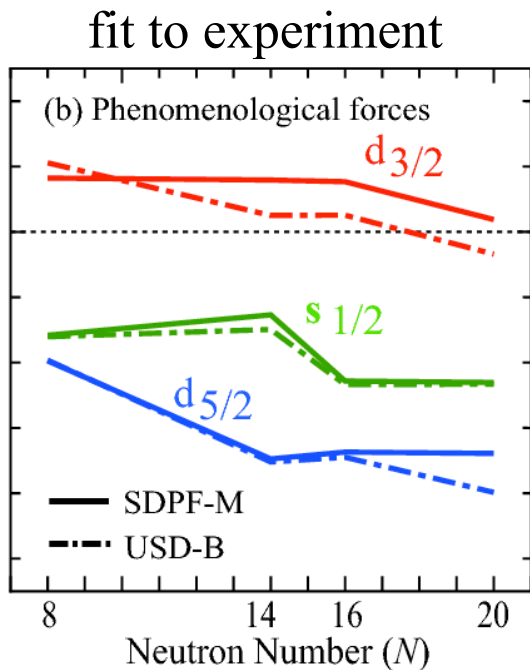
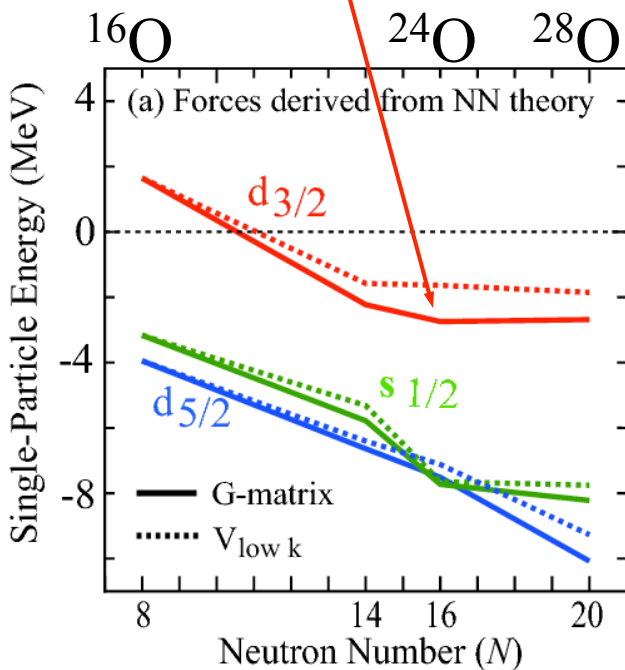
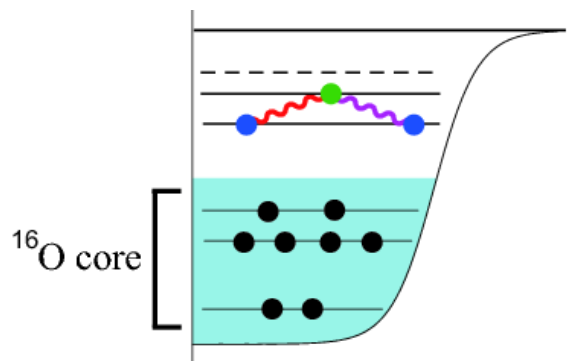
Nuclei with a 'magic' number of both protons and neutrons, dubbed doubly magic, are particularly stable. The oxygen isotope ^{24}O has been found to be one such nucleus — yet it lies just at the limit of stability.

The oxygen anomaly - not reproduced without 3N forces



without 3N forces, NN interactions too attractive

many-body theory based on two-nucleon forces:
drip-line incorrect at ^{28}O



The shell model - impact of 3N forces

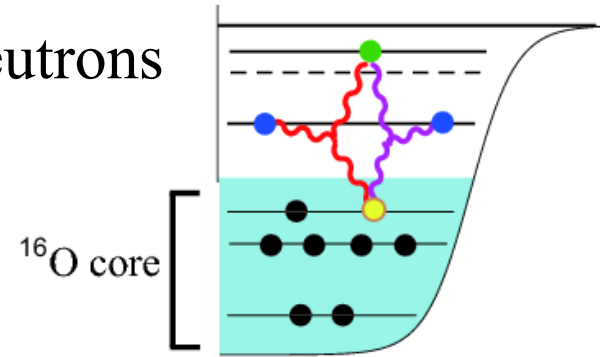
include 'normal-ordered' 2-body part of 3N forces (enhanced by core A)

leads to repulsive interactions between valence neutrons

contributions from residual three valence-nucleon interactions suppressed by $E_{\text{ex}}/E_{\text{F}} \sim N_{\text{valence}}/N_{\text{core}}$

Friman, AS (2011)

residual 3N amplified in most neutron-rich nuclei



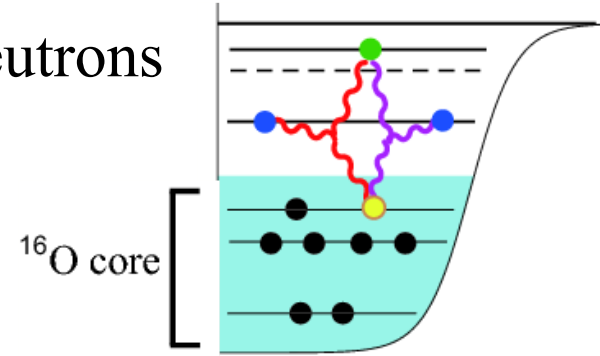
Oxygen isotopes - impact of 3N forces

include ‘normal-ordered’ 2-body part of 3N forces (enhanced by core A)

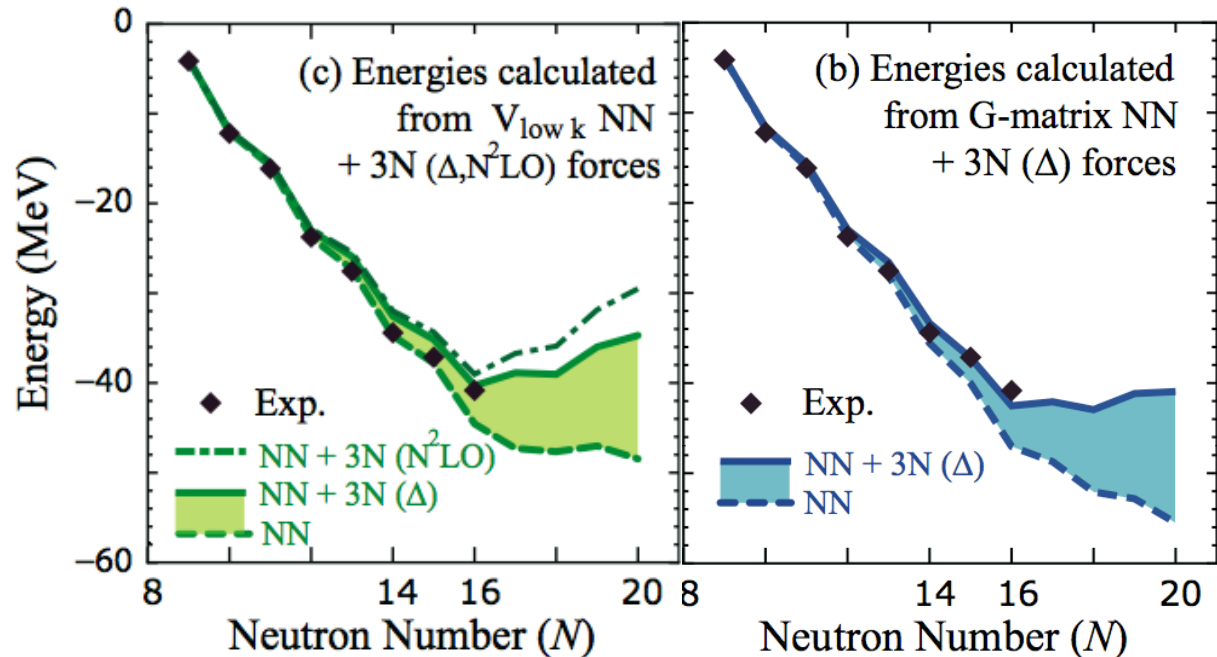
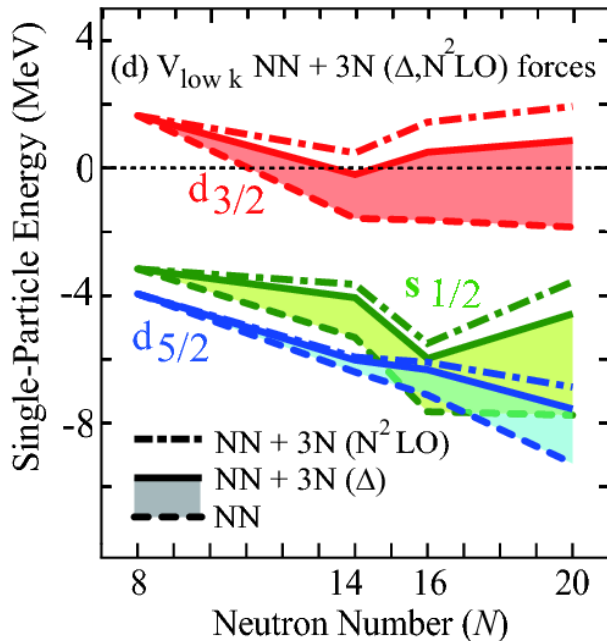
leads to repulsive interactions between valence neutrons

contributions from residual three valence-nucleon interactions suppressed by $E_{\text{ex}}/E_{\text{F}} \sim N_{\text{valence}}/N_{\text{core}}$

Friman, AS (2011)



$d_{3/2}$ orbital remains unbound from ^{16}O to ^{28}O



microscopic explanation of the oxygen anomaly Otsuka et al. (2010)

New ab-initio methods extend reach

impact of 3N forces confirmed in large-space calculations:

Coupled Cluster theory with phenomenological 3N forces [Hagen et al. \(2012\)](#)

In-Medium Similarity RG based on chiral NN+3N [Hergert et al. \(2013\)](#)

Green's function methods based on chiral NN+3N [Cipollone et al. \(2013\)](#)

