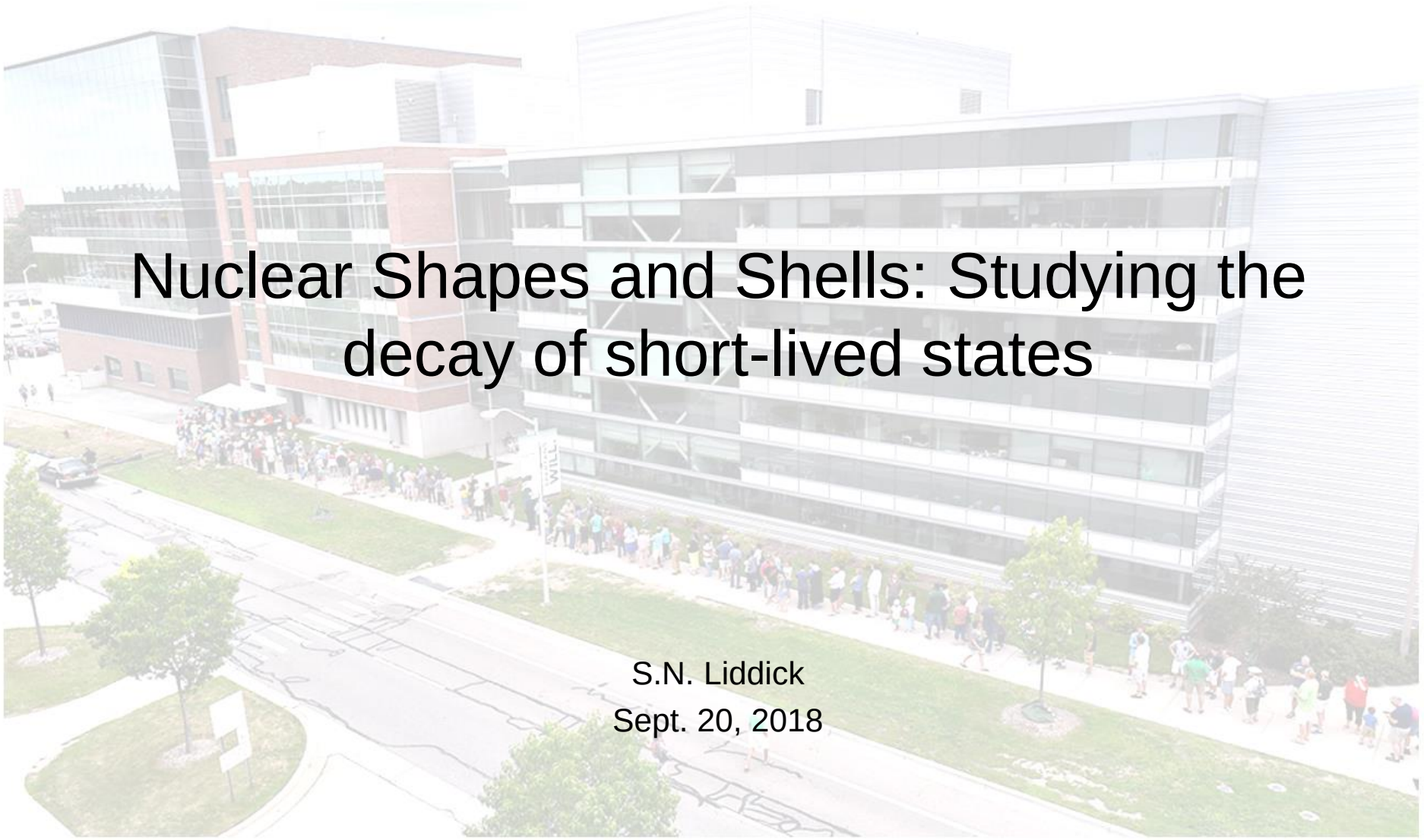
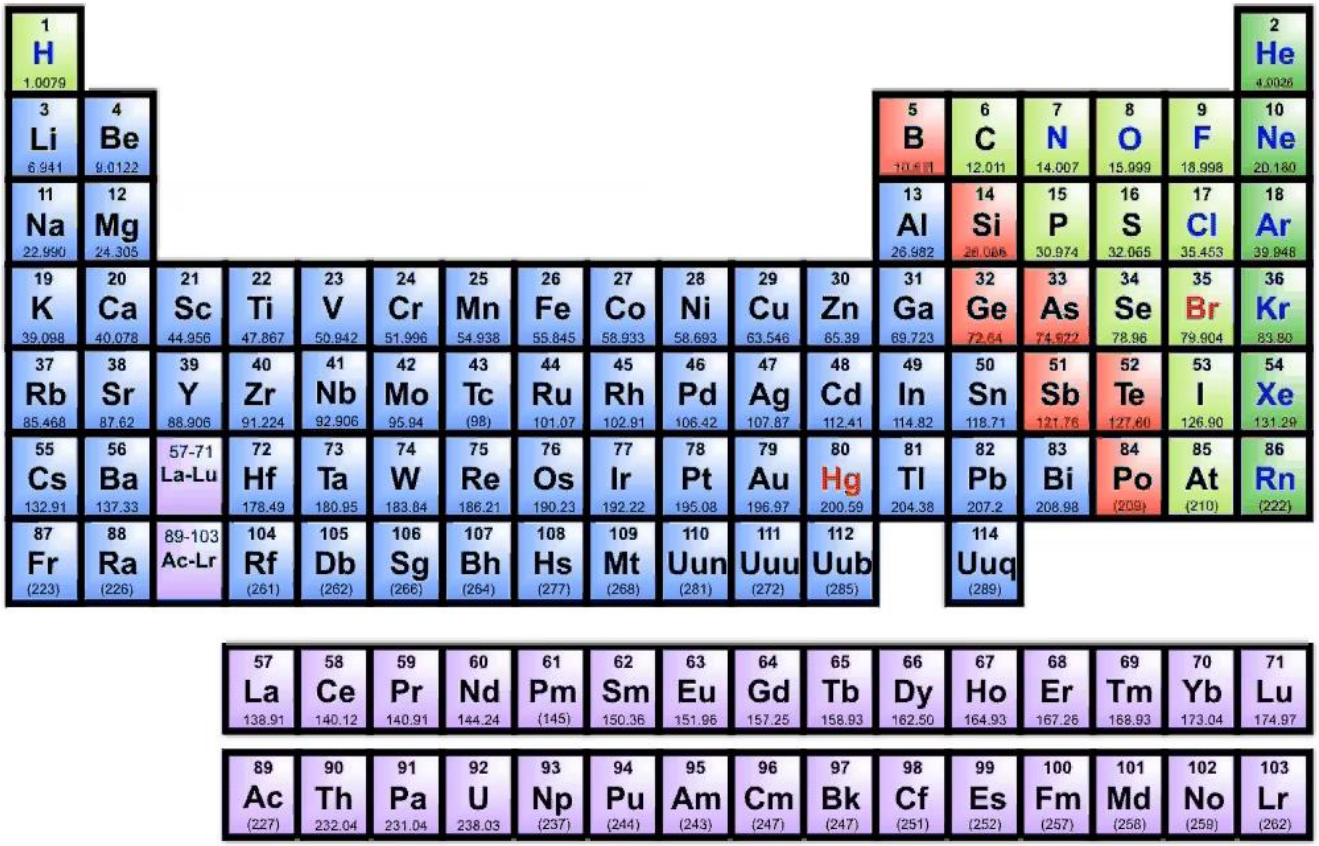


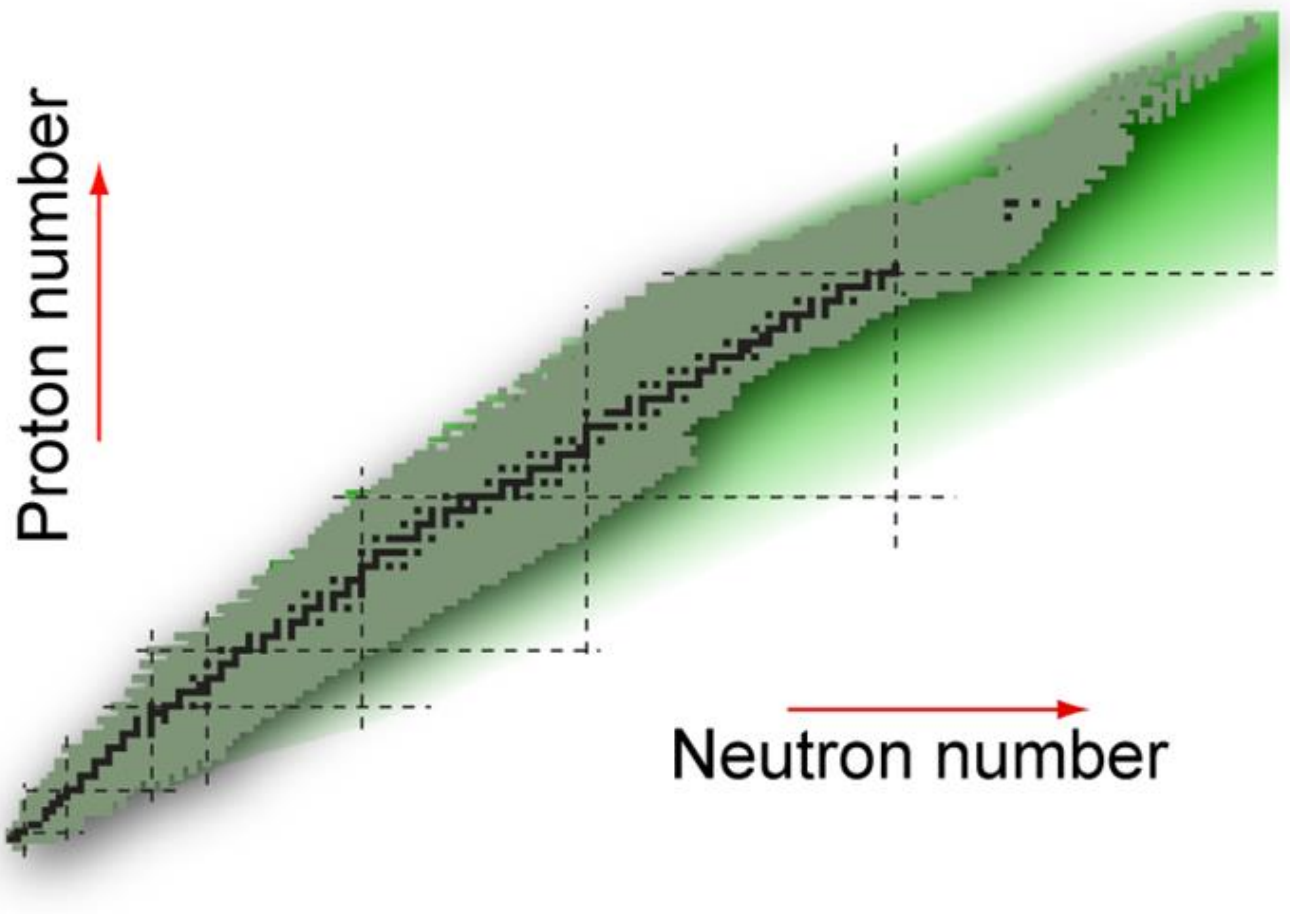
Nuclear Shapes and Shells: Studying the decay of short-lived states

S.N. Liddick

Sept. 20, 2018

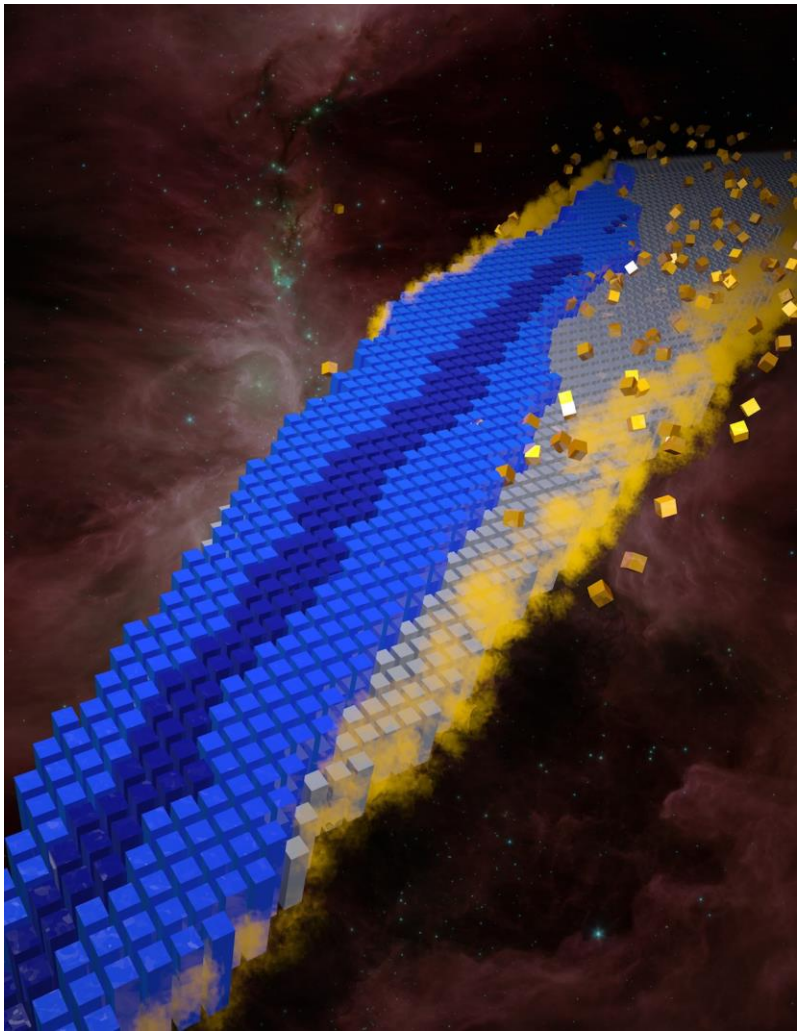
Periodic Table




Proton number
Neutron number

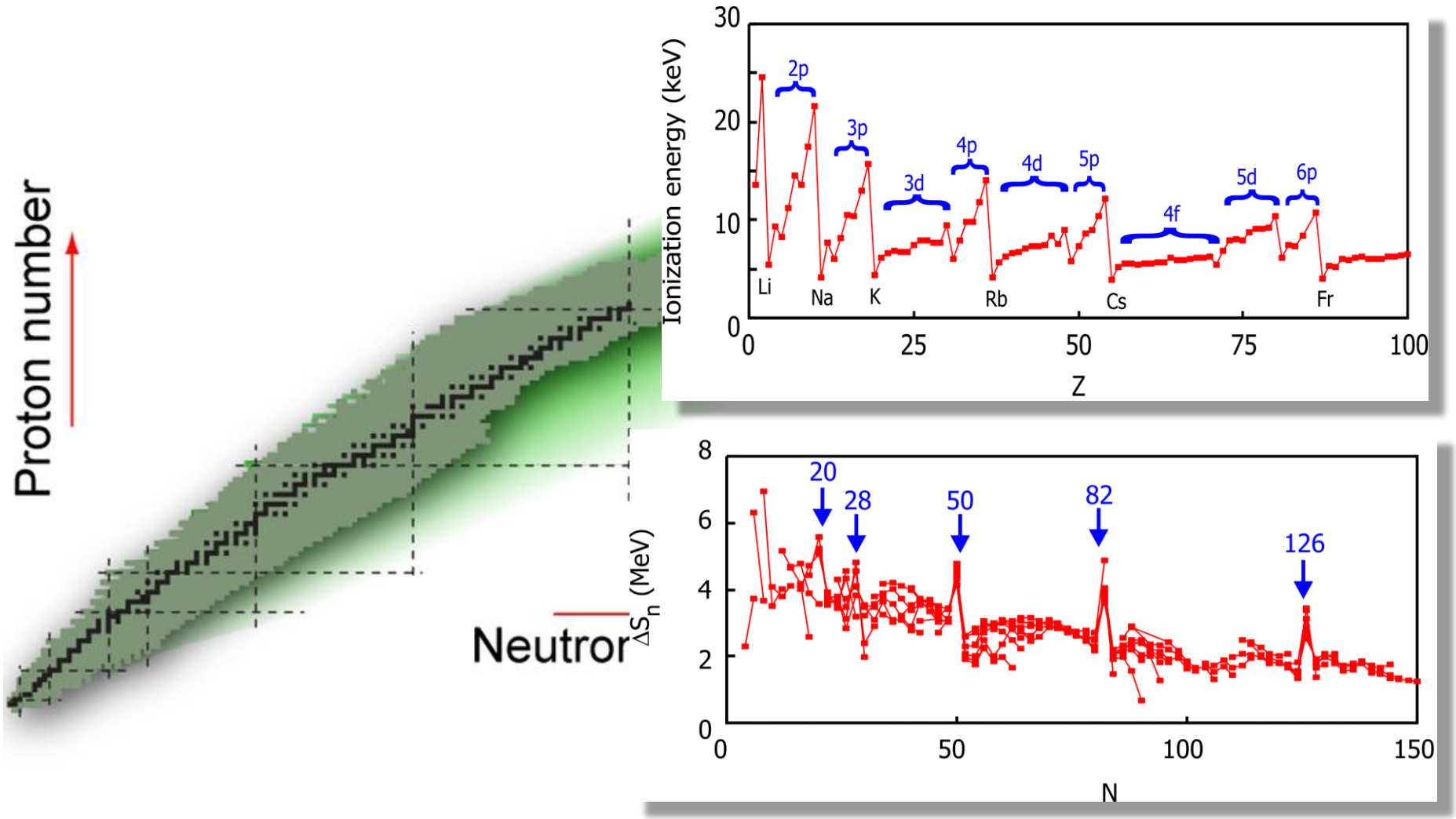
Nuclear Science Challenges

- Comprehensive and predictive model of atomic nuclei.
  - Evolving structure of atomic nuclei as a function of protons and neutrons from first principles.
- Understanding the origin of the elements.
  - Explosive nucleosynthesis
- Use of atomic nuclei to test fundamental symmetries.
- Search for new applications of isotopes and solutions to societal problems.

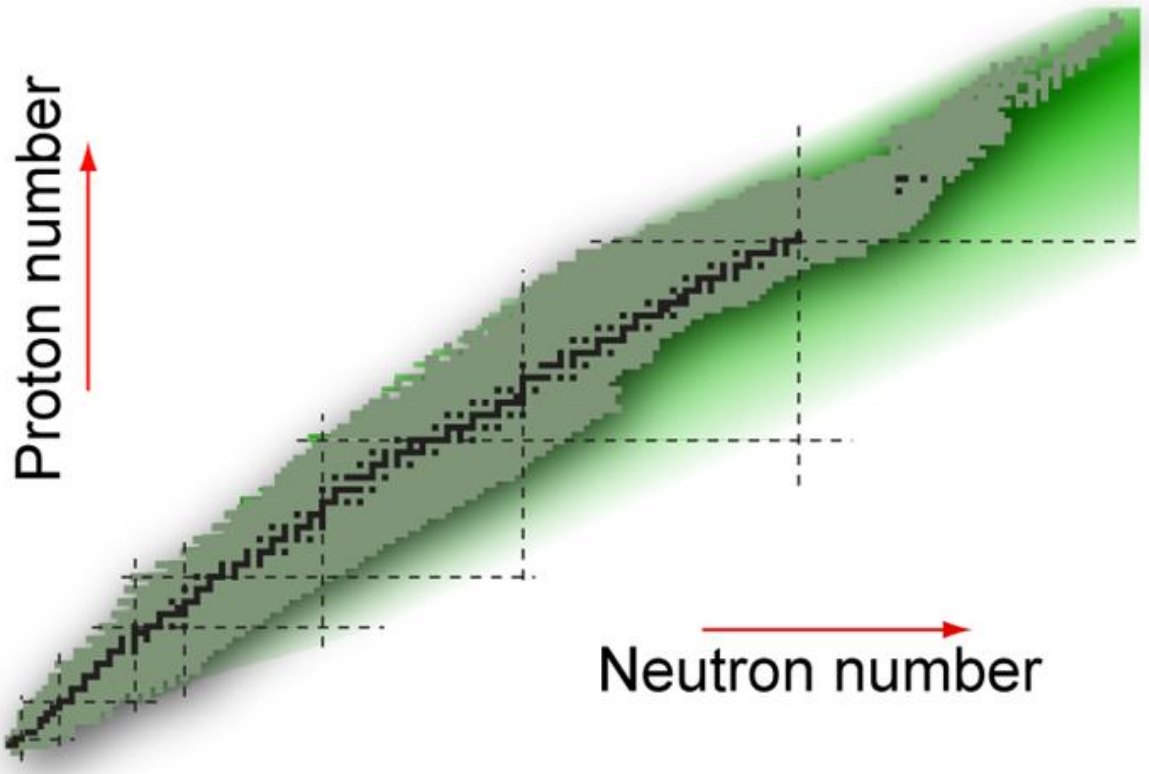


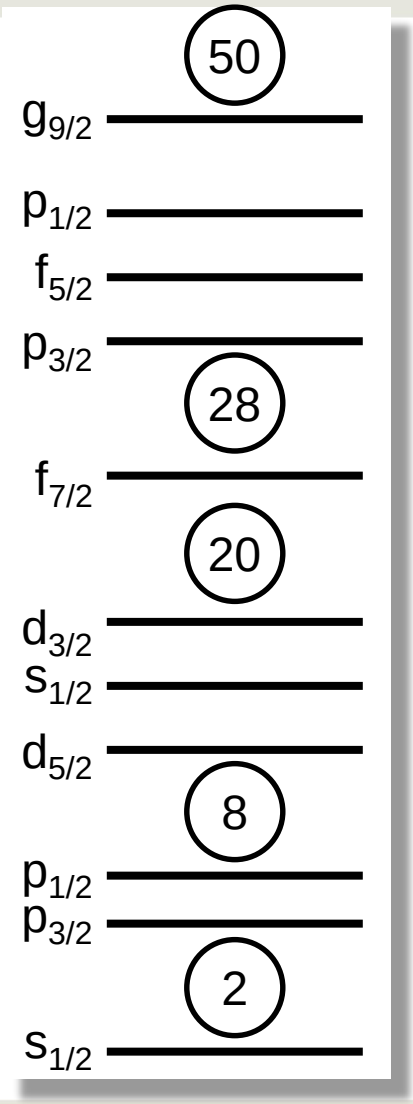
A. Sproles, Oak Ridge National Laboratory

Magic Numbers

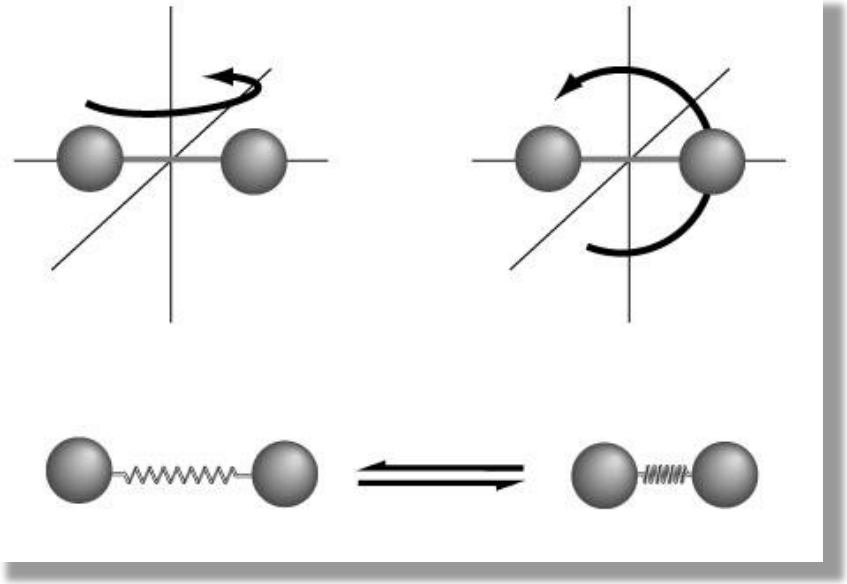


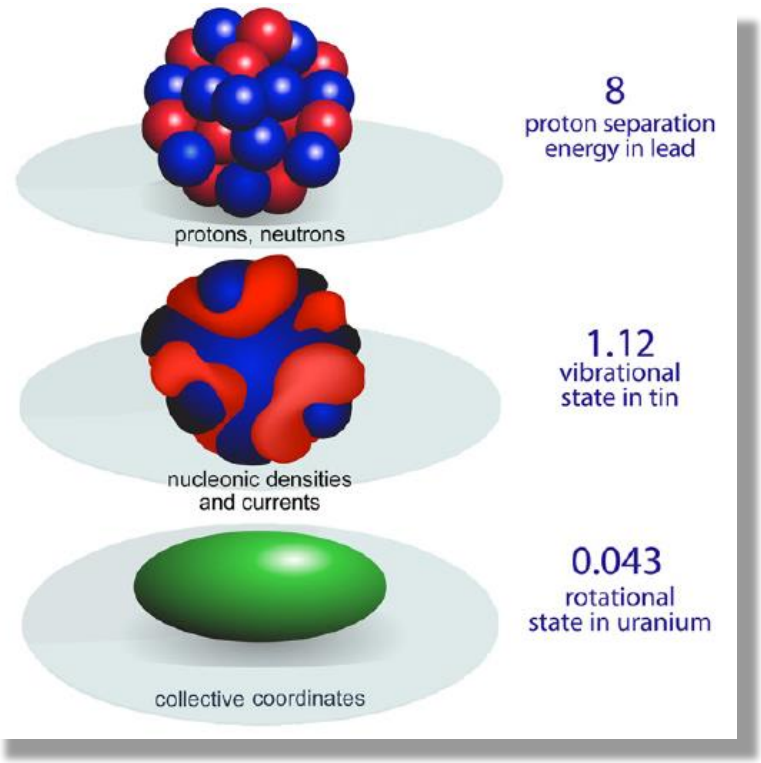
Shell Structure





Energy Scales





- Molecular excitations occur on very different energy scales:

$E_{elec} >> E_{vib} >> E_{rot}$

UV/VIS >> IR >> Microwave

eV >> meV >> ueV

- Nuclear excitations occur on similar energy scales:

$E_{sp} \sim E_{vib} \sim E_{rot}$

MeV scales

1 eV = $1.6*10^{-19}$ J

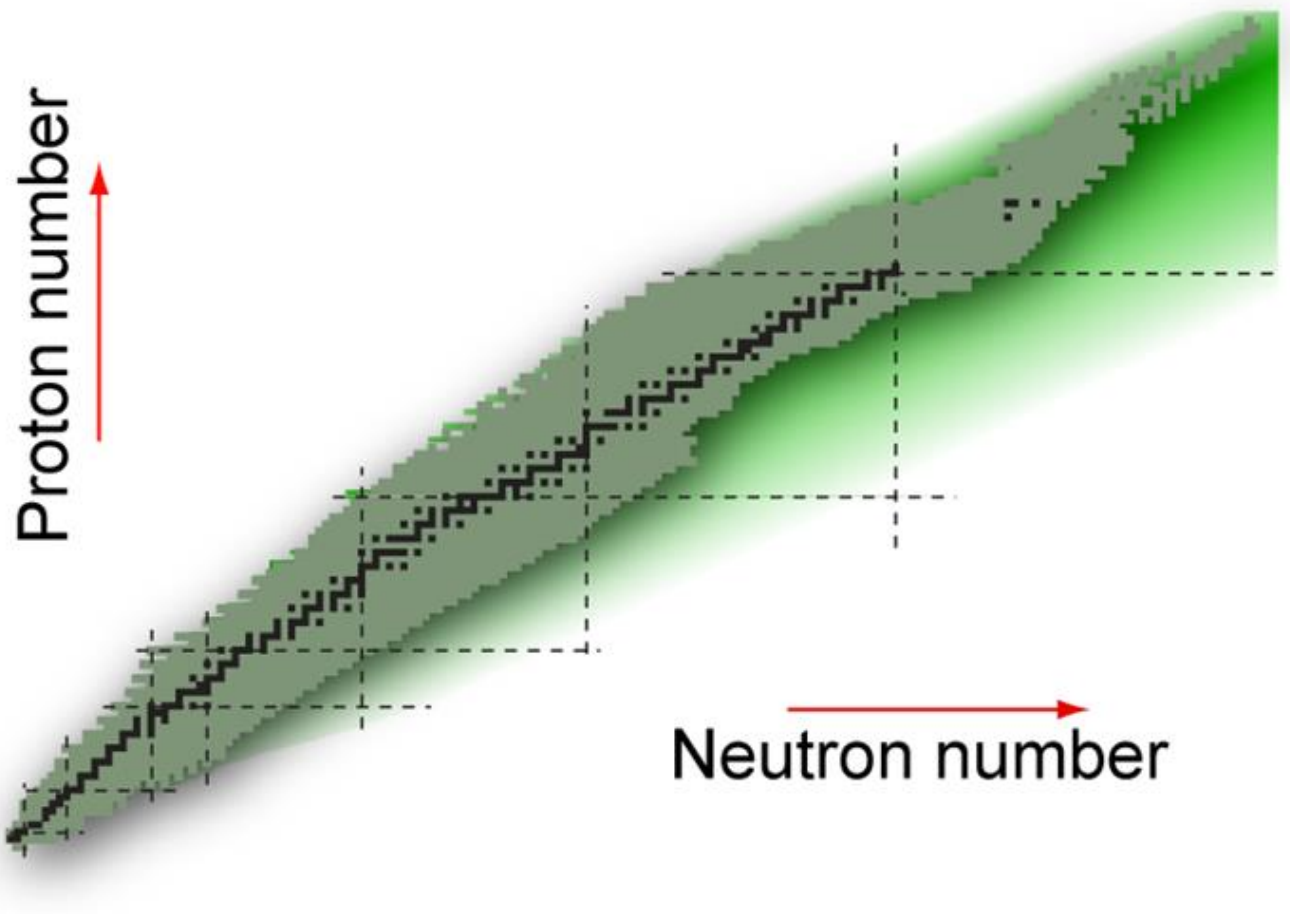
Observables and Problems

- Determine the properties of exotic nuclei.

- Improve predictive power of theory.

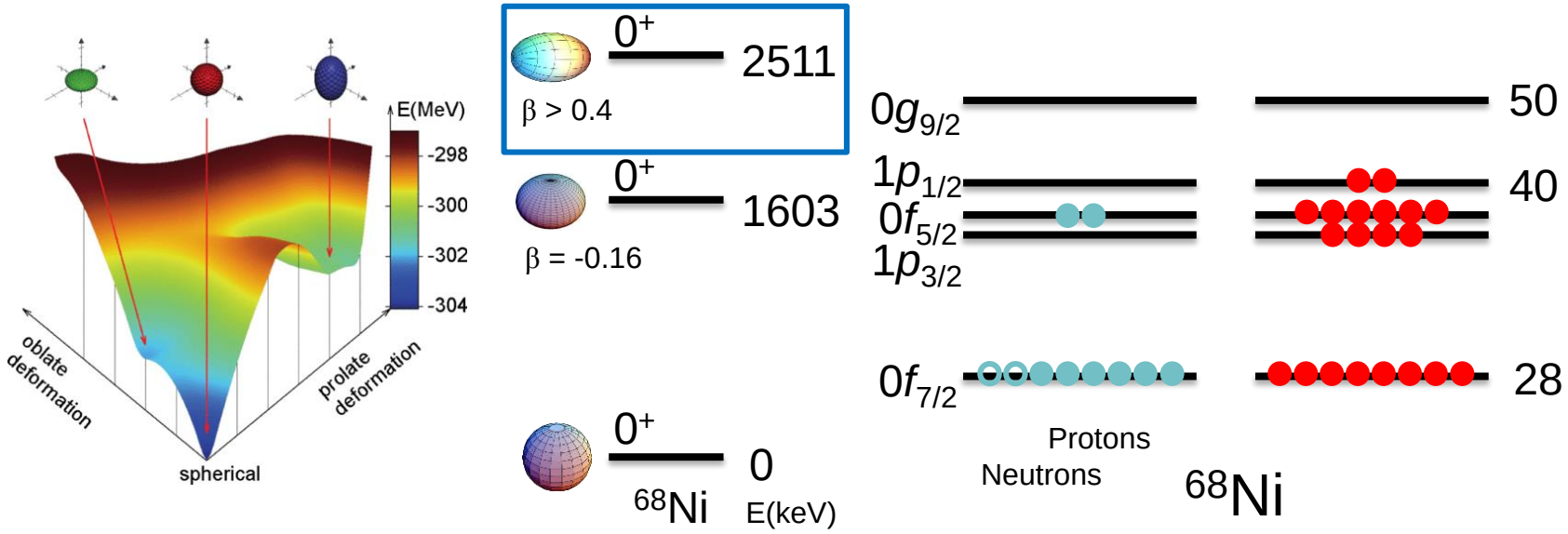
- Available information includes
  - Excitation energies,
  - half-lives,
  - decay modes,
  - moments,
  - production cross sections, …

- However, many desirable nuclei for study
  - Only live fractions of a second.
  - Are produced in limited quantities.


Proton number
Neutron number

Shape Coexistence in ^{68}Ni

- Predictions and experimental indications for triple shape coexistence

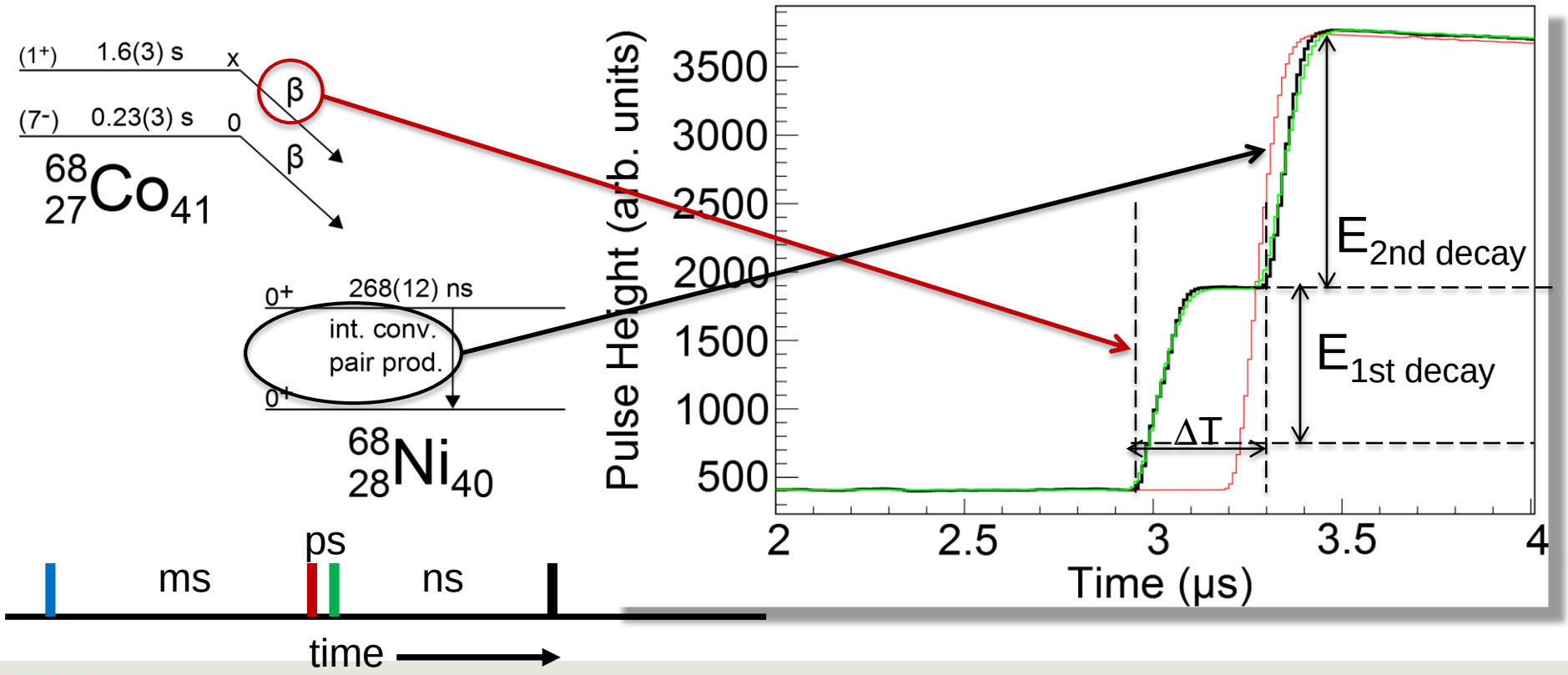


S. Suchyta *et al*., Phys. Rev. C **89**, 021301(R) (2014).

Y. Tsunoda *et al*., Phys. Rev. C **89**, 031301 (2014).

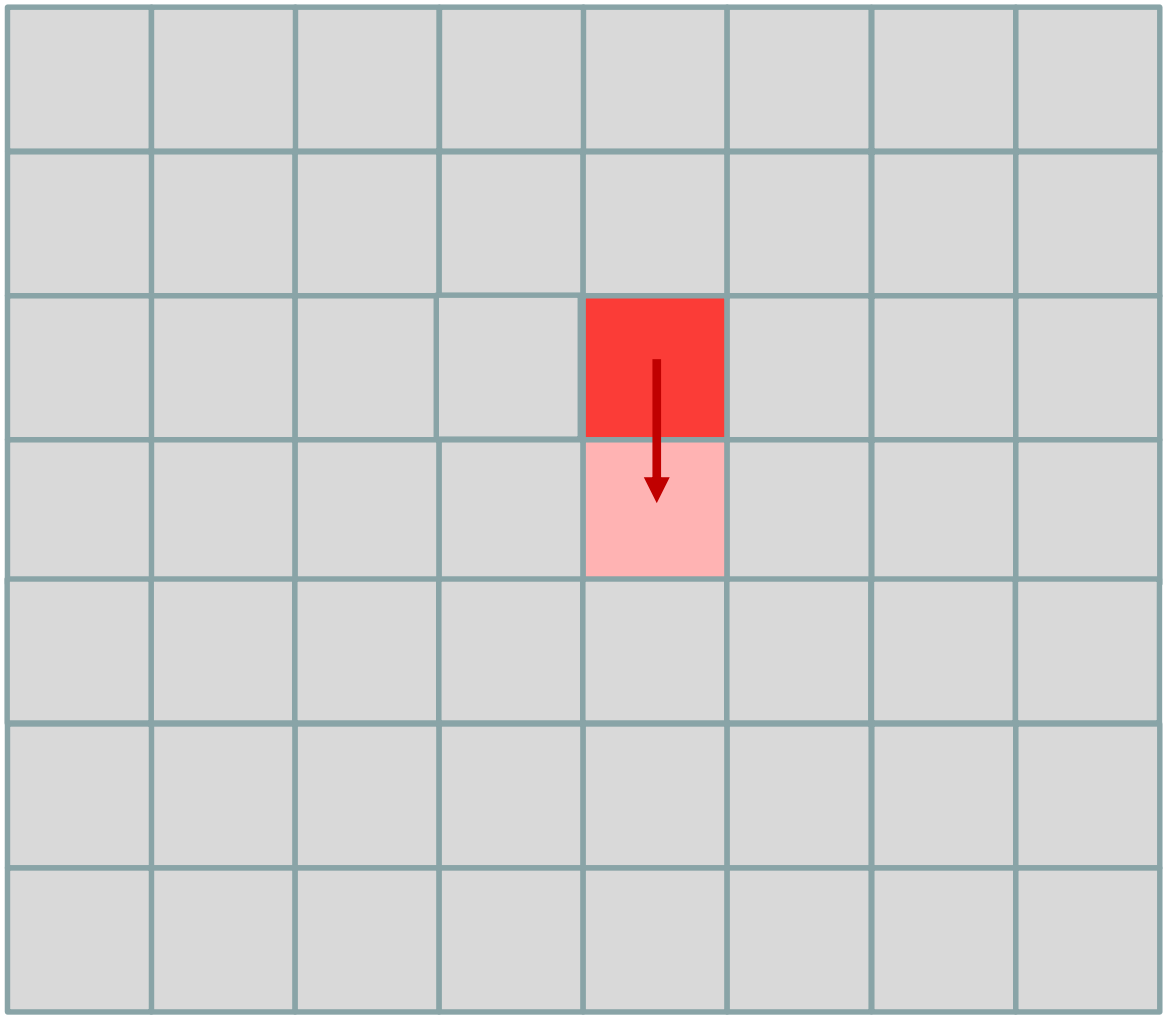
Multiple Interaction Event

- Small fraction of signals show “stair-step” time profile.
- First rise from beta decay.
- Second decay from E0 transition.

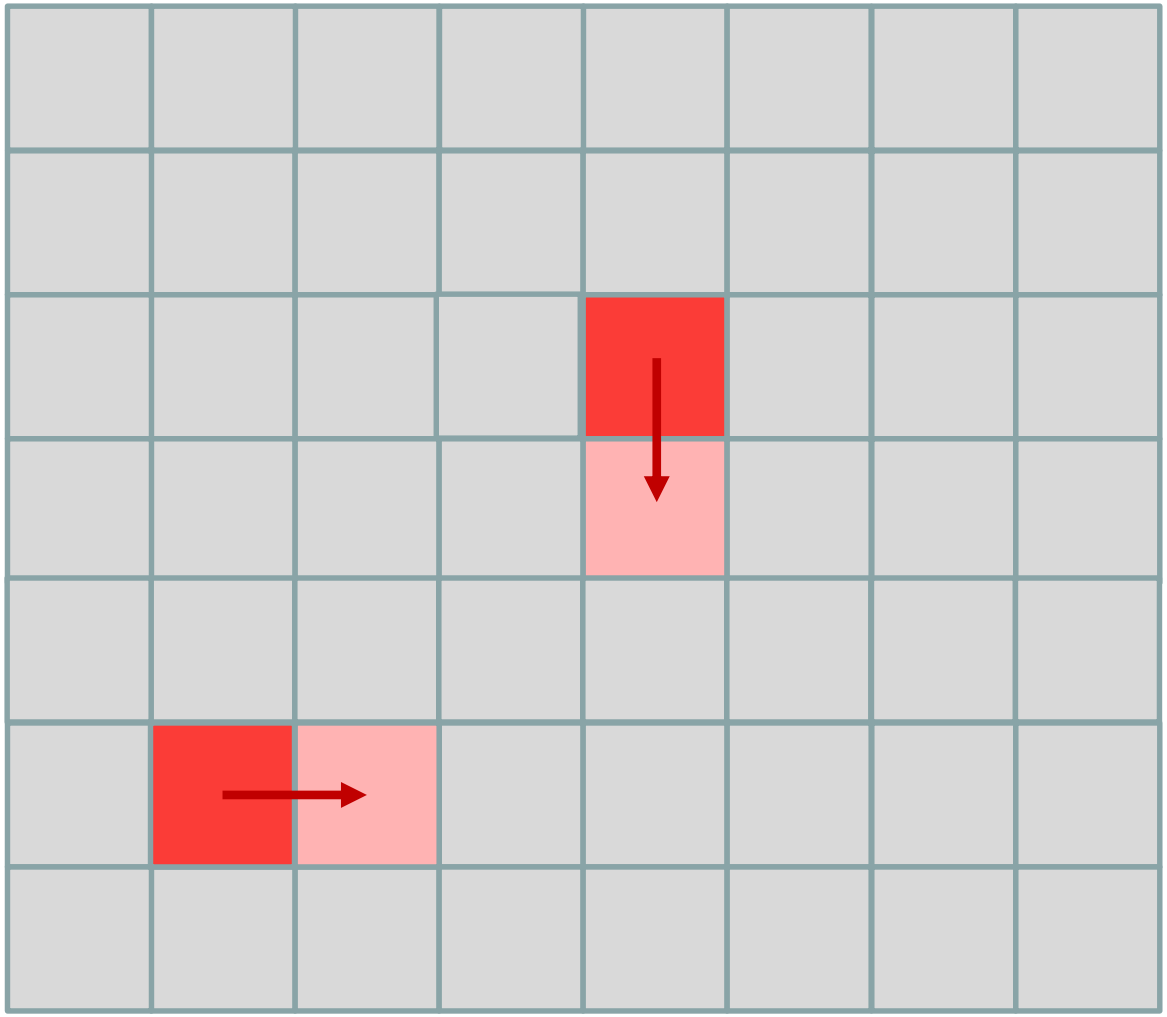


Liddick, S.N. *et al.*, Nucl. Instrum. Methods Phys. Res., Sect. A **669** 70 (2012).

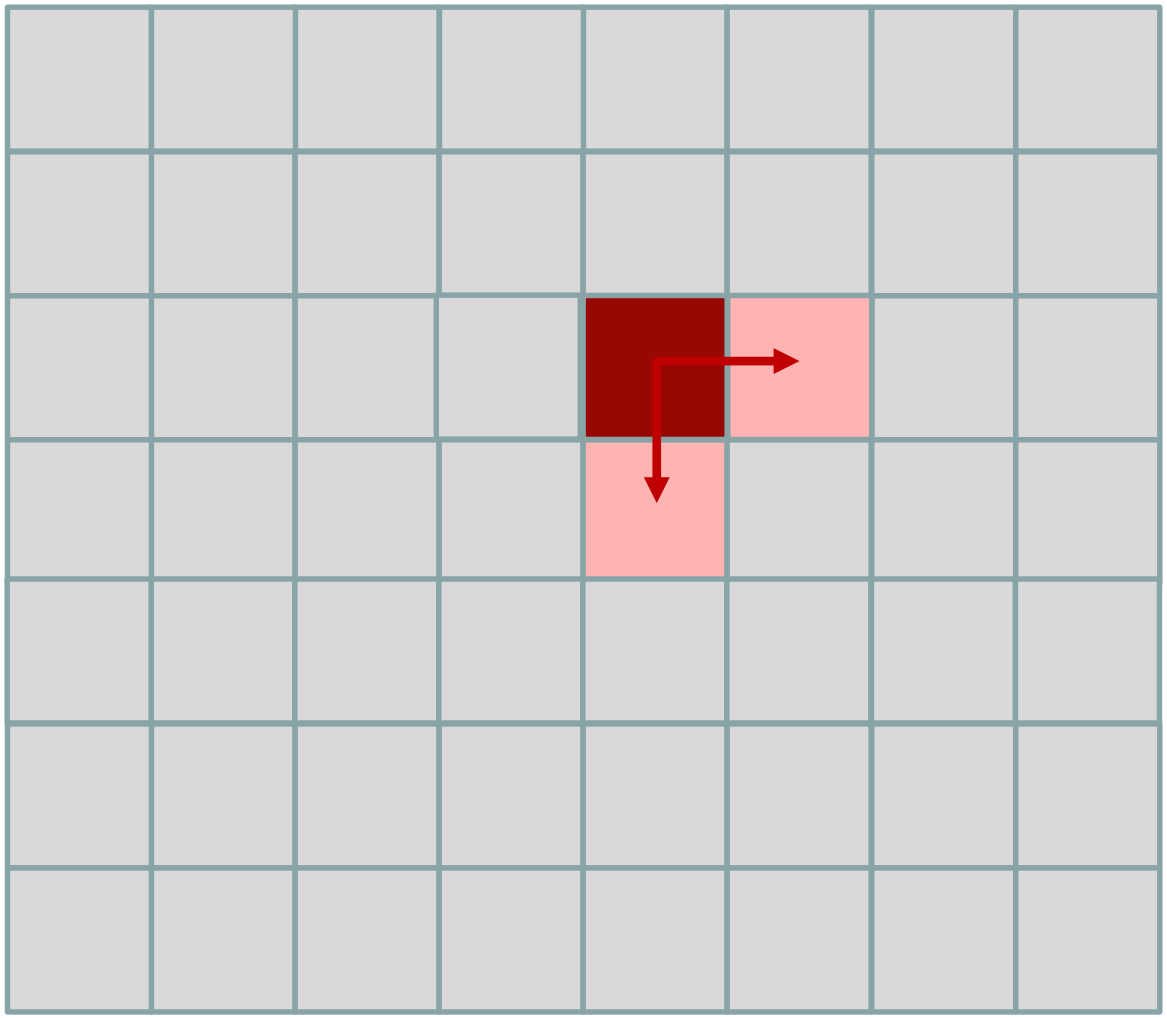
The problem: 1 electron



The problem: 2 electrons widely separated



The problem: 2 electrons close together



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Neutron capture validation