First Observation of Excited States in the T=1, Odd-Odd Nucleus ^{48}Mn

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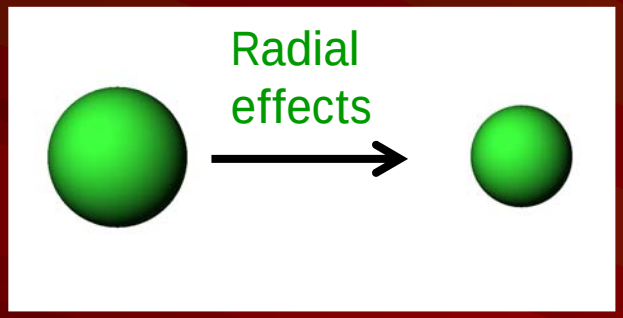
Mirror Symmetry

- Assuming a charge symmetric nuclear force, the energy levels of nuclei with conjugate numbers of protons and neutrons are identical
- Any differences are due to Coulomb effects as these break isospin symmetry
- These effects may be due to a number of reasons…

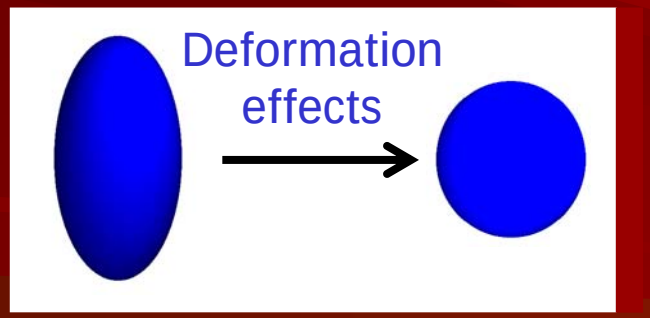
What like just stuff…

Coulomb Effects

One-Body Effects

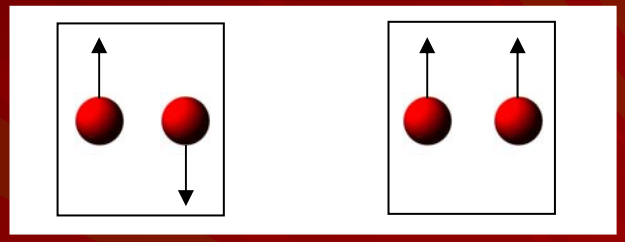


Increasing spin →



Increase in overlapping Ψ's

Two-Body Effects

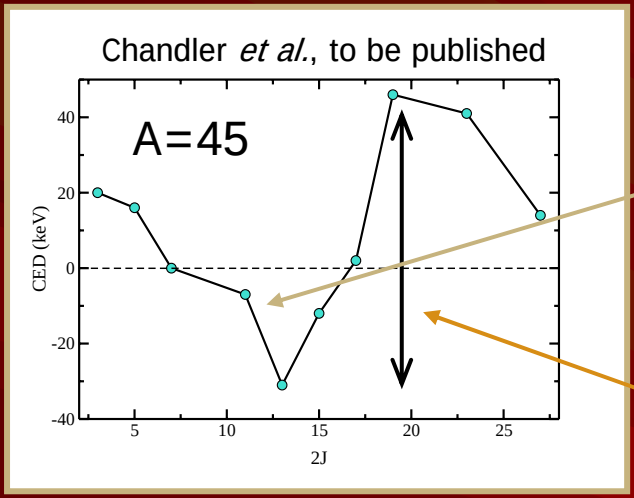


J=0 → J=6

- Coulomb effect associated with aligning a pair of protons in the $f_{7/2}$ shell
- No such effect for neutron alignment

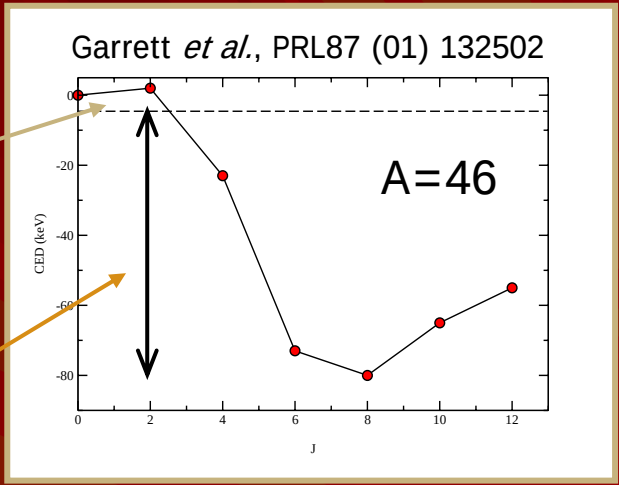
Motivation

$$CED = E_x^J(Z_>) - E_x^J(Z_<)$$



Direction of CED before alignment is unexpected

CED dominated by particle alignment of ~100keV



CED understood in terms of particle alignment, except at low *J*

Any other, more subtle, effects which may be present are swamped

Must eliminate alignments to amplify these effects

This can be achieved by studying an odd-odd pair, where all first alignments are expected to be blocked

The Experiment

Gammasphere + FMA

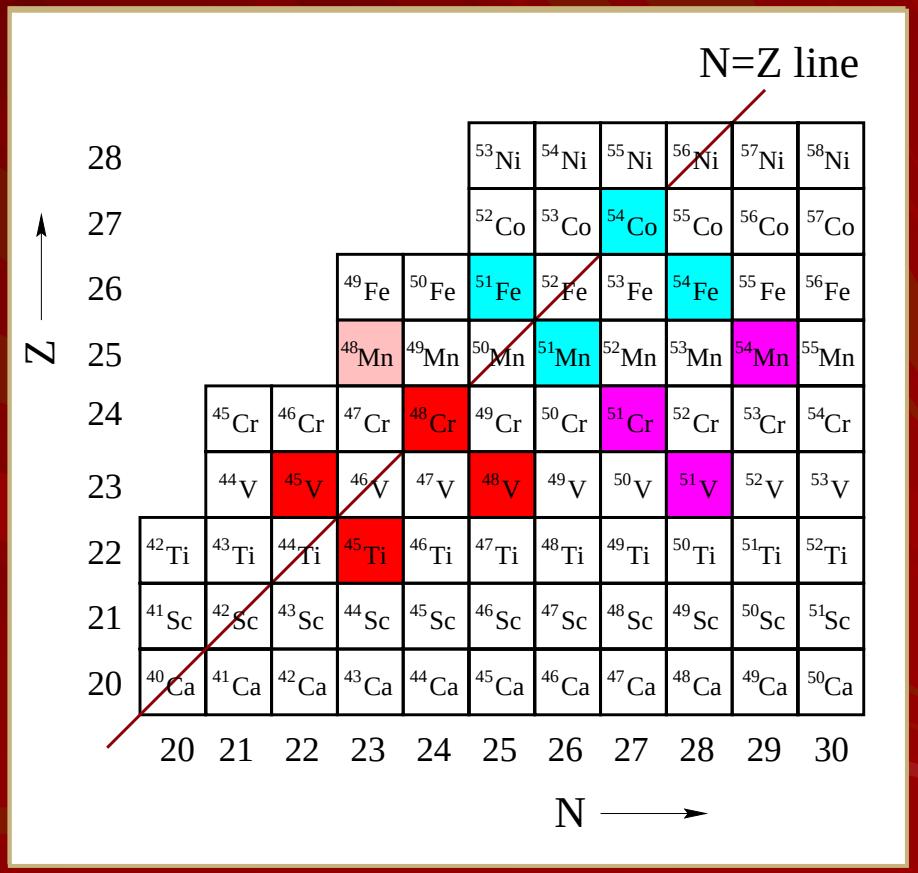
$^{40}Ca + ^{10}B \rightarrow ^{50}Mn$
@ 110MeV

$^{40}Ar + ^{10}B \rightarrow ^{50}V$

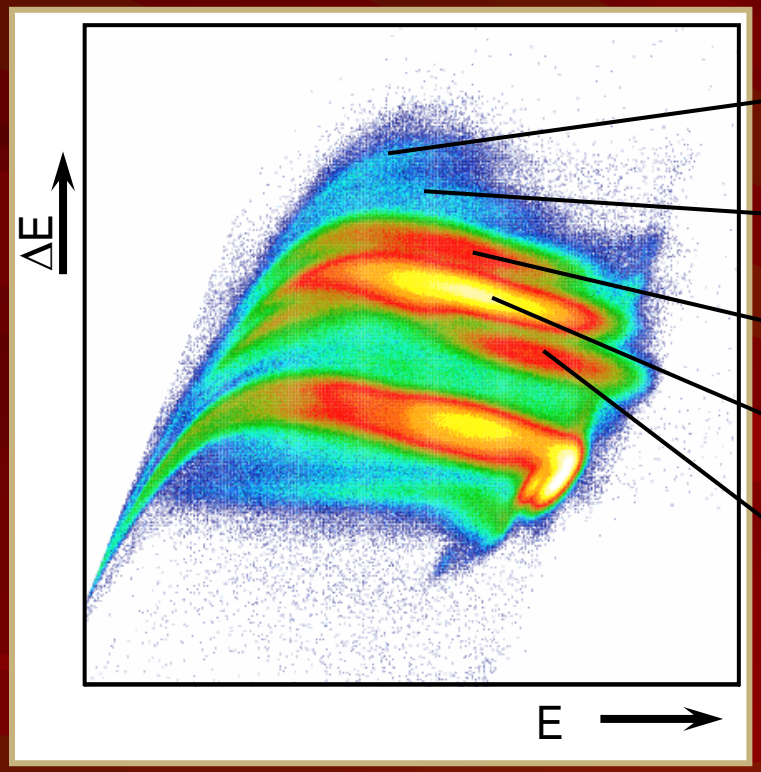
$^{40}Ca + ^{16}O \rightarrow ^{56}Ni$

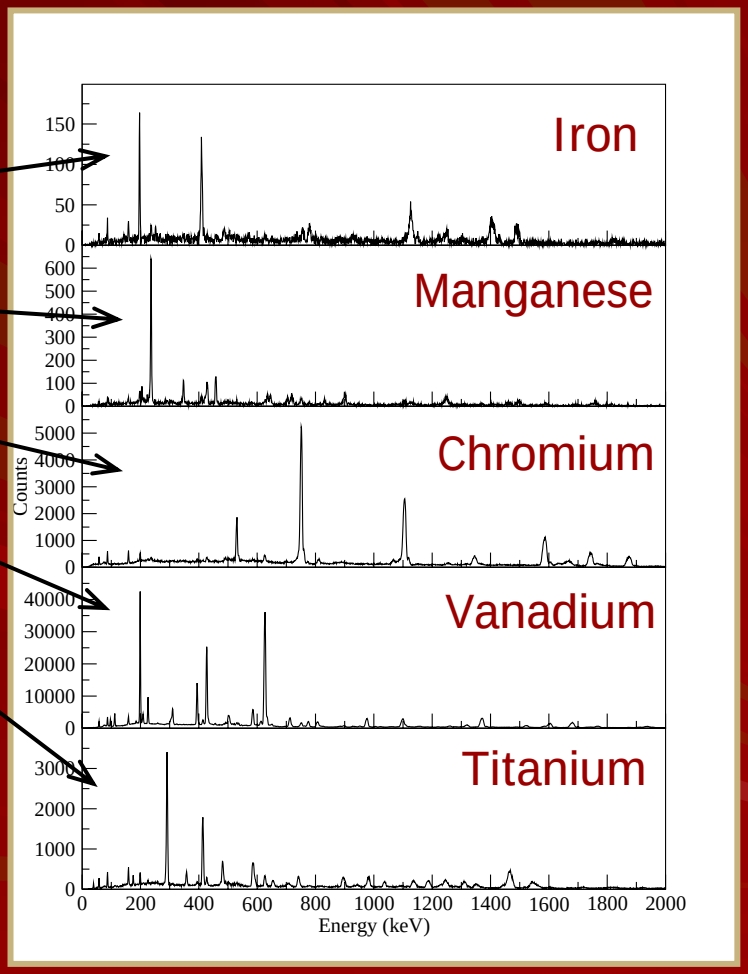
$^{40}Ar + ^{16}O \rightarrow ^{56}Fe$

So now we're detecting everything with A/Q = 3!

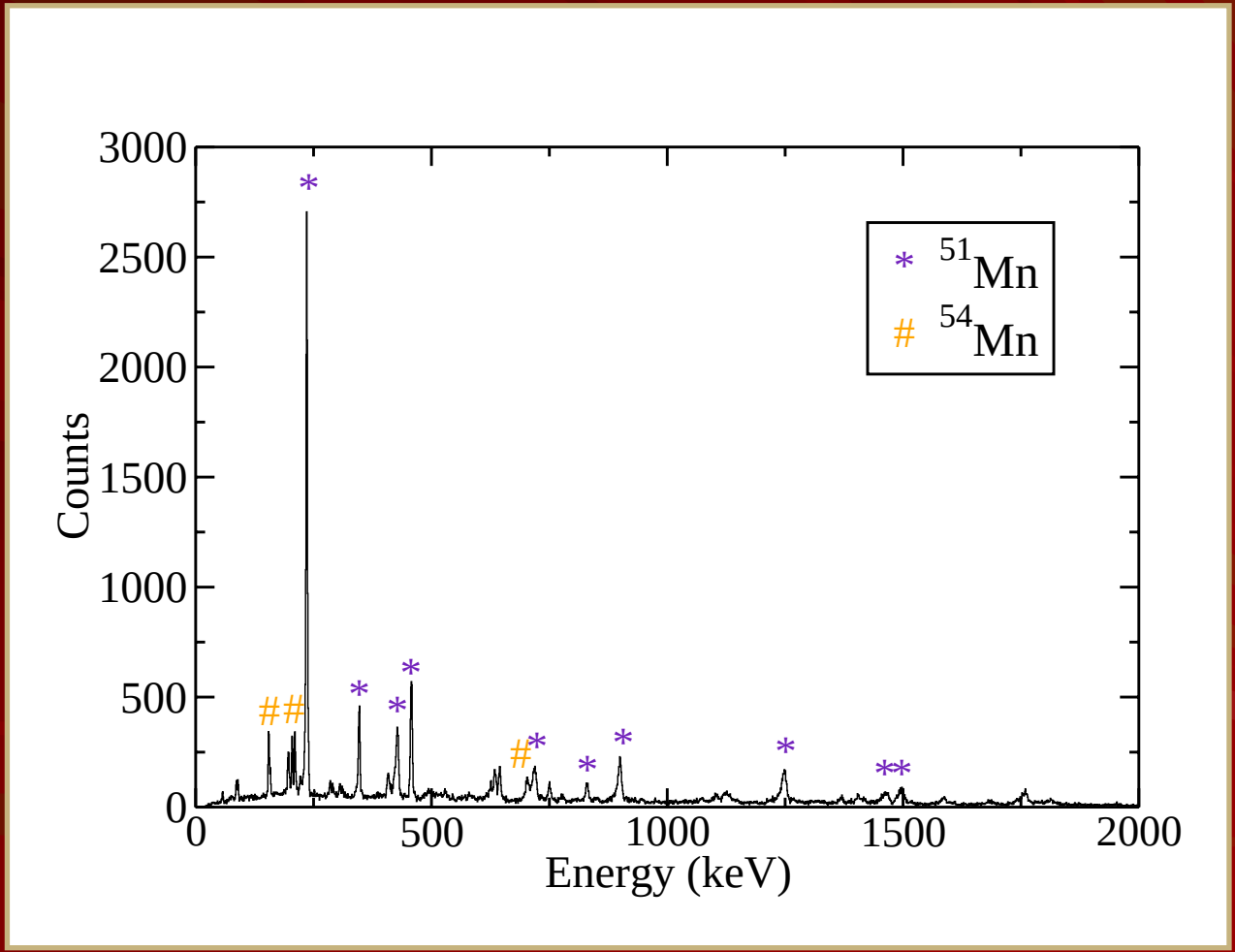


Recoil Identification





Charge State Ambiguities



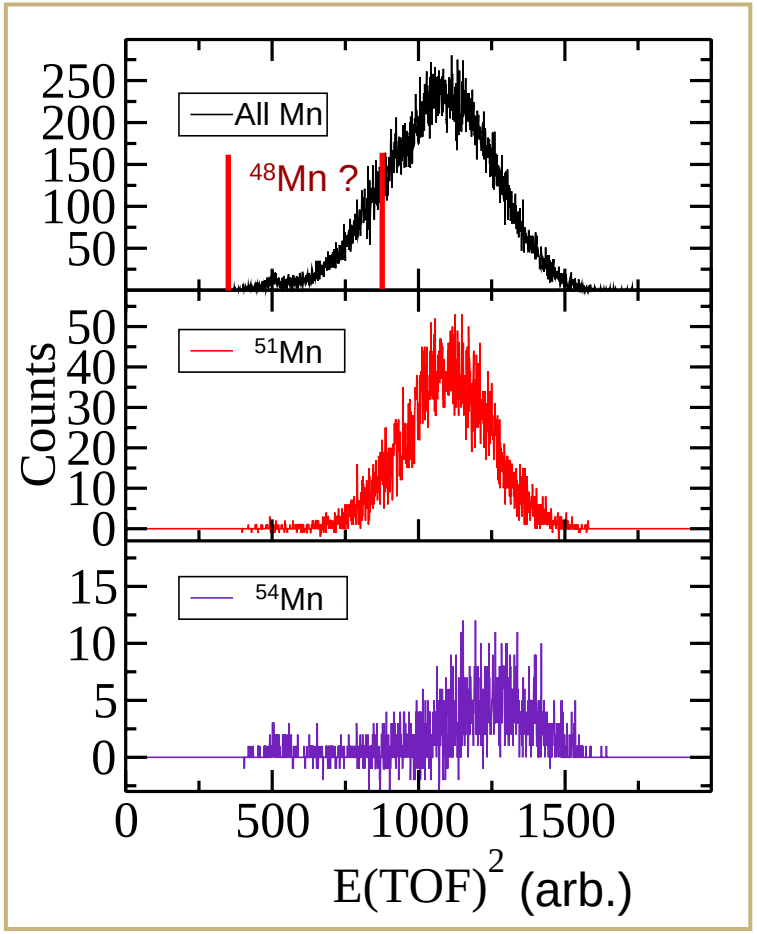
Mass Identification

In order to eliminate contaminant Mn isotopes from '*extra*' reactions, can distinguish masses using the energy and time-of-flight of the recoil (á la SJF), i.e.

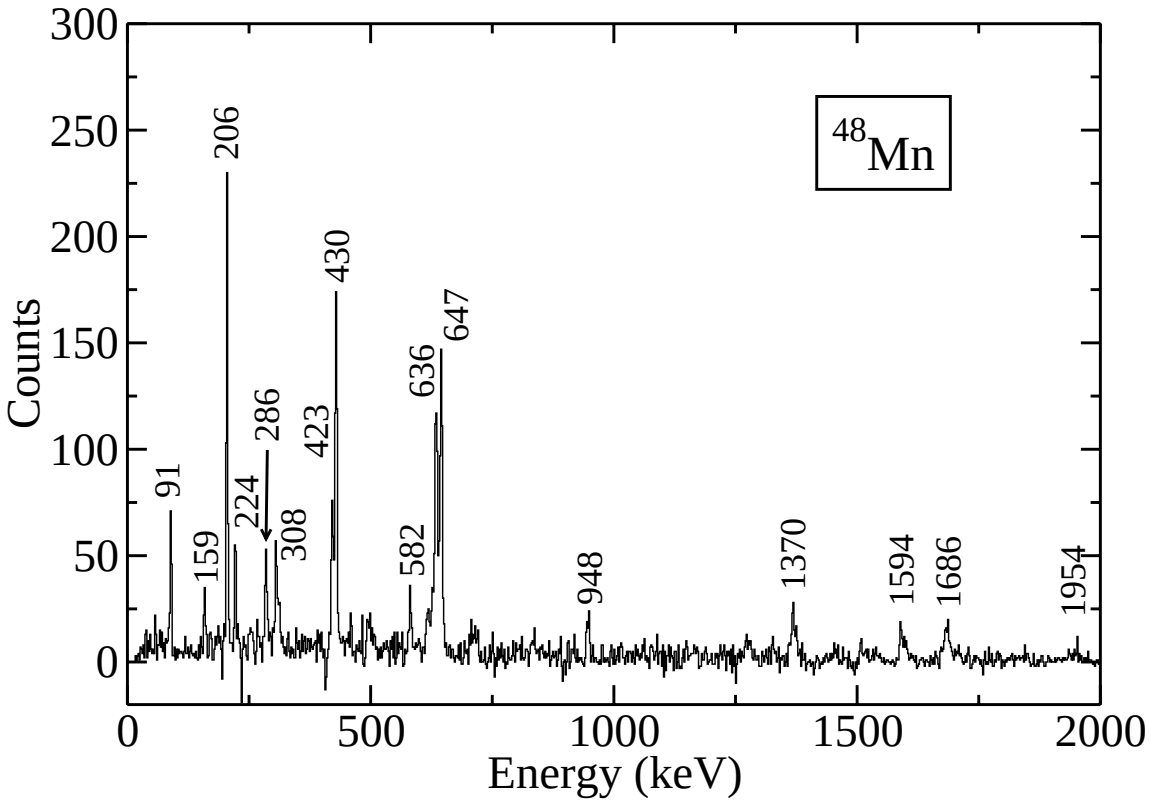
$$E = \frac{mv^2}{2} \qquad v = \frac{d}{TOF}$$

Which combine to give:

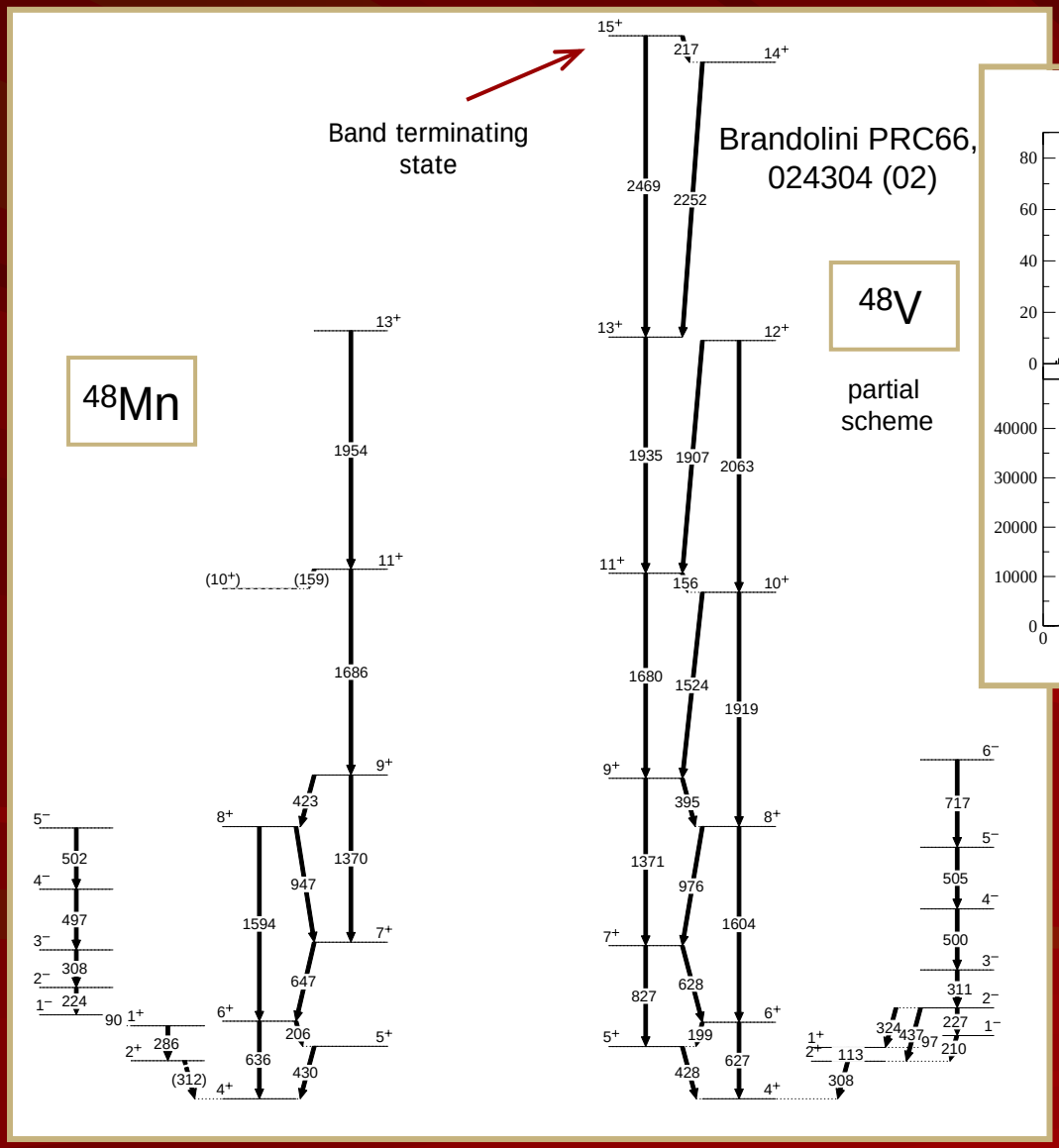
$$\text{Mass} \propto E(TOF)^2$$

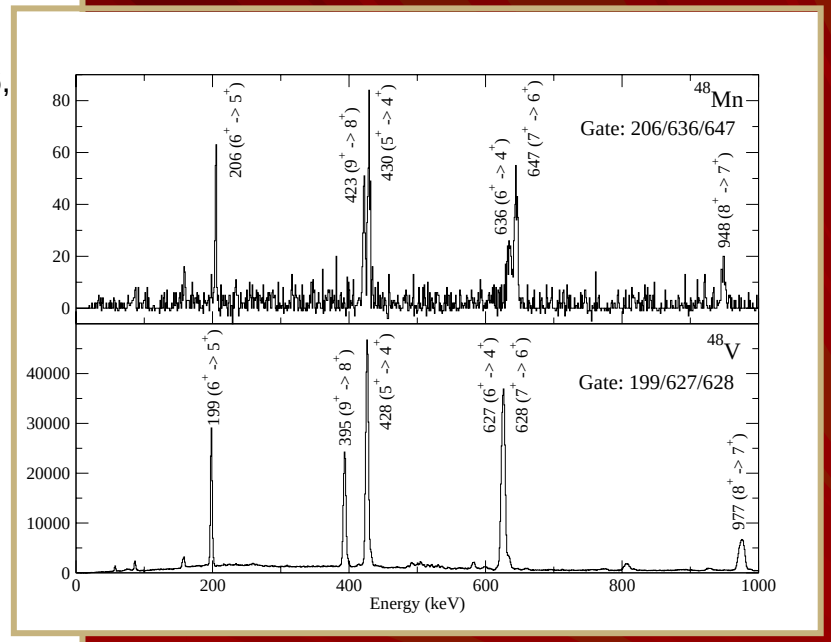


Will the real ^{48}Mn please stand up

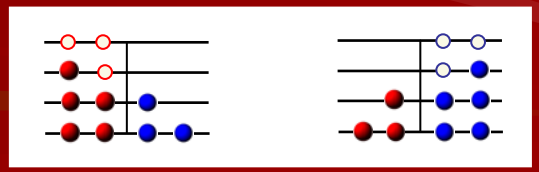


Level Schemes





$\pi(f_{7/2})^{-3}\nu(f_{7/2})^{3}$ $\pi(f_{7/2})^{3}\nu(f_{7/2})^{-3}$

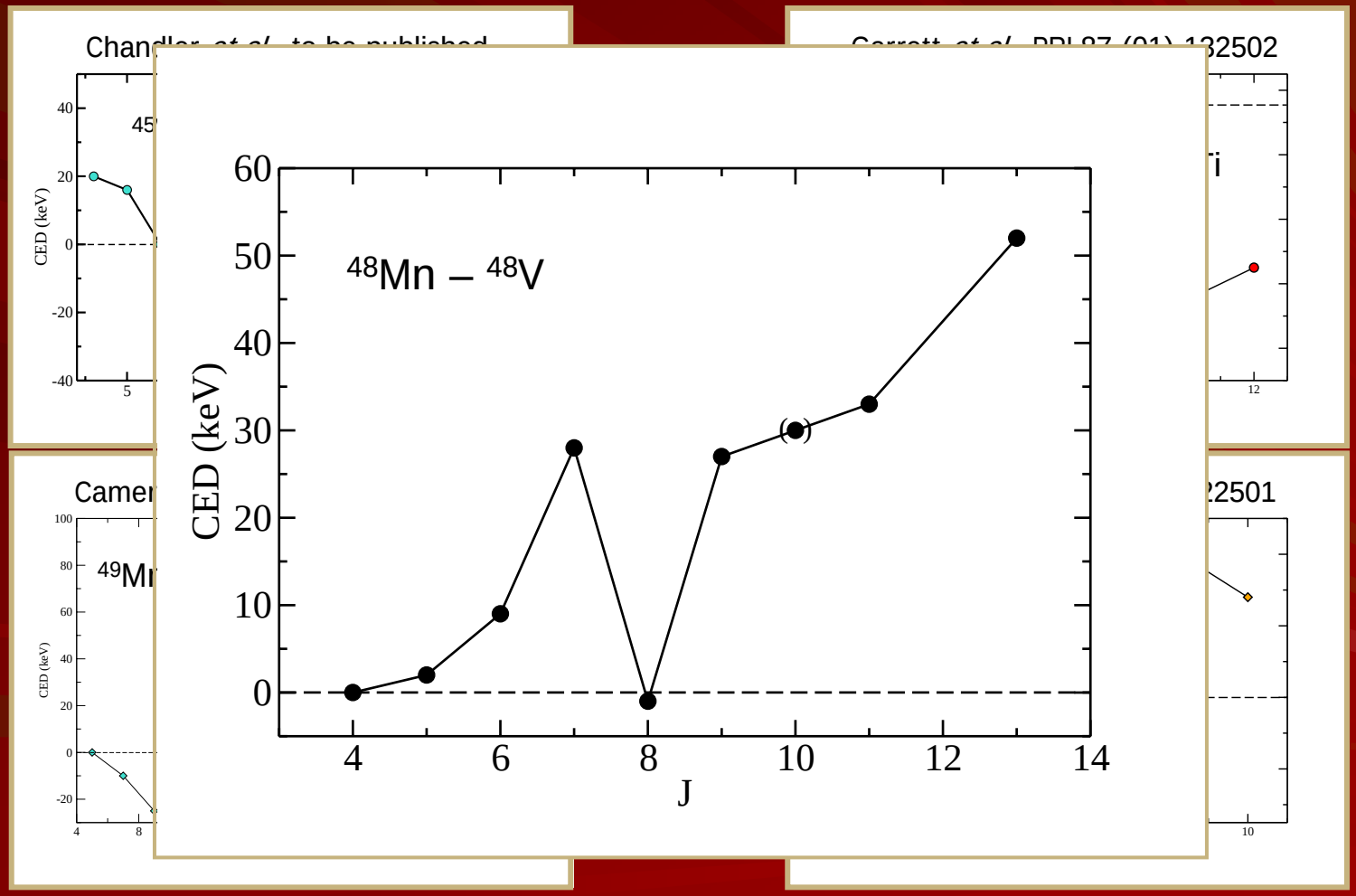


^{48}Mn ^{48}V

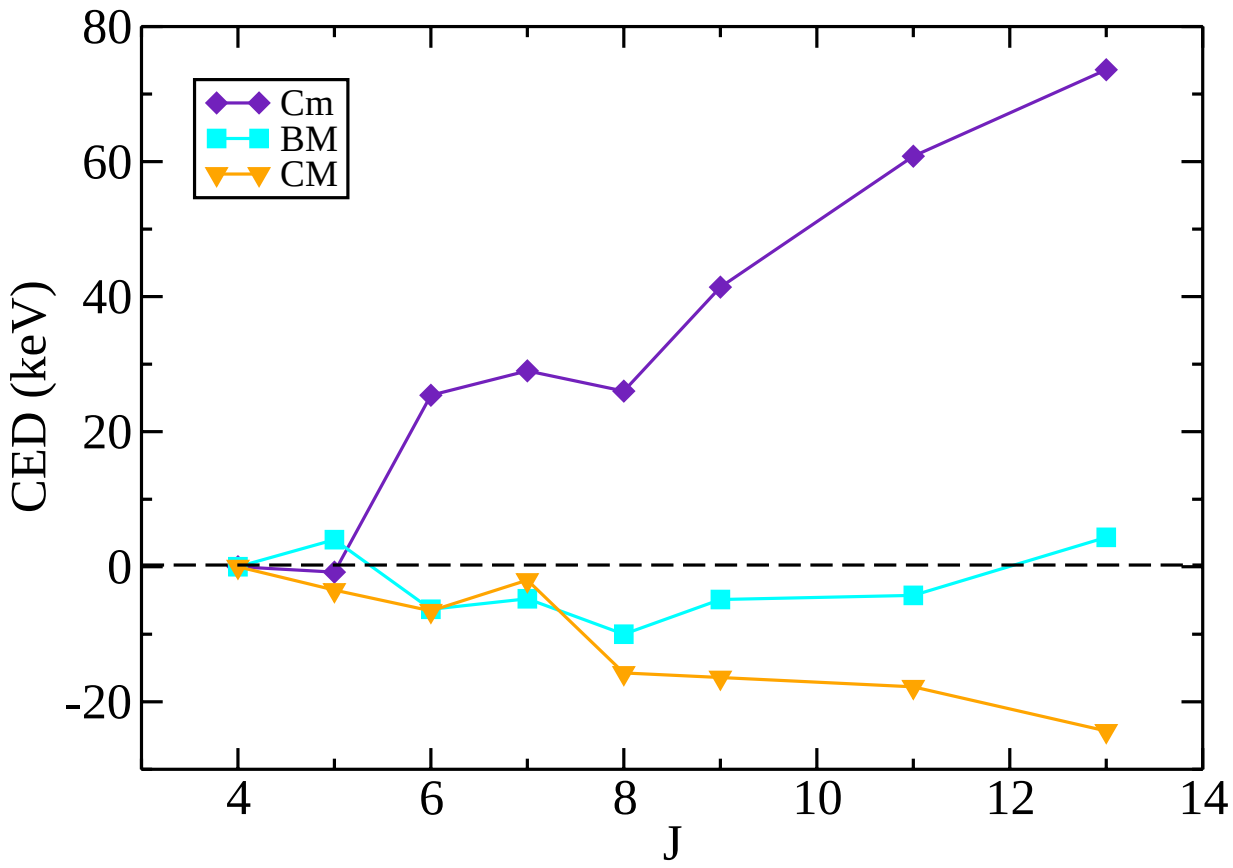
CED Studies To Date

T=1/2 Nuclei

T=1 Nuclei



The Intriguing CED



Summary

- First observation of gamma decays in ^{48}Mn
- First CED analysis of an odd-odd, T=1 mirror pair in $f_{7/2}$ region
- Magnitude of CED is small
- Radial/deformation effects obviously important
- Calculations would fail without considering contribution from *pf* orbits
- Future projects include ^{44}V (odd-odd, T=1), accepted for study here at ANL

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