In-beam spectroscopy of the extremely proton-rich N=85 isotone $^{159}$W

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The Nuclear Landscape around $^{159}$W

Segré Chart$^1$ of the nuclides

p drip line $S_p = 0$

n drip line $S_n = 0$

Physics Motivation

- Low lying yrast states in heavy N = 85 isotones are based on valence $h_{11/2}$ protons and the $f_{7/2}, h_{9/2}$ neutrons.

Attractive tensor force between $h_{11/2}$ protons and $h_{7/2}$ neutrons.
The Experiment

- $^{58}\text{Ni}^{12+} + 1.1\text{mgcm}^{-2} \ 10^6\text{Cd} \ @ \ 290\text{ MeV} / 310\text{ MeV}$.

- Optimised for $^{160}\text{Re} \ (p4n) / ^{159}\text{W} \ (2p3n)$ channels; $\sigma \sim 1\mu\text{b}$.

Drawing courtesy of D.Seddon, Department of Physics, University of Liverpool.
Jurogam (TDR DAQ) spectrum correlated with $^{159}\text{W}$ alpha line:
• Which is the ground state configuration in $^{159}\text{W}$, $\nu f_{7/2}$ or $\nu h_{9/2}$?

• Alpha-decay spectroscopy measurements allow the configuration to be firmly assigned.
• Two alpha-decaying states in $^{155}$Lu are populated, via $\beta^+$ decay of $^{155}$Hf.

\[
\begin{align*}
^{155}\text{Hf} & \rightarrow 9/2^- & \Delta L = 1; \text{favoured Gammow-Teller transition} & \rightarrow 11/2^- \\
^{155}\text{Lu} & \rightarrow 1/2^+ \\
^{155}\text{Hf} & \rightarrow 7/2^- & \rightarrow 11/2^- \\
^{155}\text{Lu} & \rightarrow 1/2^+
\end{align*}
\]

• Observation of two alpha-decays from $^{155}$Lu confirms a 7/2- spin-parity for the ground-state in $^{159}$W.
Jurogam (TNT2 cards) spectrum correlated with $^{159}\text{W}$ alpha line:
$E(9/2^-) - E(7/2^-)$ for $N = 85$, even $Z$ / keV
Summary / Outlook

• Gamma rays tagged by $^{159}$W alpha decay have been observed for the first time.

• Three low-lying yrast levels in $^{159}$W have been tentatively assigned.

• The 80 keV transition is a candidate for the $9/2^- - 7/2^-$ energy gap in $^{159}$W.

⇒ Look at coincidence correlations in $^{159}$W to establish as complete a level scheme as possible.
Thank you to my collaborators...

- **Nidge**: S. Ertüürk.
- **STFC Daresbury**: J. Simpson.
Discussion / Questions
Attractive tensor force between $h_{11/2}$ protons and $h_{7/2}$ neutrons

SkM* interaction with tensor term

Graph showing $E(9/2^-) - E(7/2^-)$ vs $Z$ for $N = 83$ and $N = 85$.
Focal Plane Correlations:

\[ \text{6512} \pm 19 \text{ keV} \sim 12 \text{ms}^* \]

\[ \epsilon_{\text{6512}} - \epsilon \]

• Use single alpha line from $^{159}$W as a tag for prompt $\gamma$ emission.

$^{155}$Lu $\beta^+ \sim 1\ s^{**}$ $^{155}$Hf $\alpha$ $^{159}$W

$^{153}$Lu $\alpha$ $^{157}$Ta $\alpha$ $^{161}$Re

6213 $\pm$ 4 keV
4.3 $\pm$ 0.1 ms*

6292 $\pm$ 5 keV
8.2 $\pm$ 0.7 ms*

6265 $\pm$ 5 keV
14 $\pm$ 2 ms*