Spin Distribution of Excited Nuclear States in $^{nat}Fe(p,αn)$

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$^{51,52}\text{Mn}$ - Motivation

- Emerging medical radionuclides
  - $^{51}\text{Mn}$ ($t_{1/2} = 46$ min, 97% $\beta^+$) – short-lived PET tracer for metabolic studies
  - $^{52}\text{Mn}$ ($t_{1/2} = 5.6$ d, 29% $\beta^+$) – long-lived PET tracer for neuron tracking, immune studies

  Preparation and in vivo characterization of $^{51}\text{MnCl}_2$ as PET tracer of $\text{Ca}^{2+}$ channel-mediated transport

  Stephen A. Graves, Reinier Hernandez, Hector F. Valdivinos, Paul A. Ellison, Jonathan W. Engle
  Todd E. Barnhart, Weibo Cai, Robert J. Nickles

  - Manganese has well-established biochemistry and uptake via DOTA-based chelation

  Almost no Fe(p,x) XS measurements exist – can use these to probe spin physics in the $A\approx50$ region
Methodology
Two overlapping stacks:
\[ E_p = 55 \rightarrow 21 \text{ MeV}, \ 25 \rightarrow 11 \text{ MeV} \]
- 25 μm-thin $^{nat}Fe$, $^{nat}Cu$, $^{nat}Ti$ foils in 0.1” Al frames

- Dosimetry: IAEA charged particle beam monitor reactions:
  - $^{nat}Ti(p,x)^{48}V$
  - $^{nat}Cu(p,x)^{62,63,65}Zn$

nds.iaea.org/medical/monitor_reactions.html
Fe\(_{(p,x)}\)

Cu\(_{(p,x)}\)

Ti\(_{(p,x)}\)
$^{52m}$Mn (2+)/$^{52g}$Mn (6+) vs. Energy for $^{56}$Fe(p,αn)
TALYS Level Density Models 1-6 (default spin cut-off)

Preliminary

CT + FG
BSFG
GSFM
Microscopic (Goriely)
Microscopic (Hilaire)
T-dep HFB
This Work

Berkeley
UNIVERSITY OF CALIFORNIA
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Results consistent with $R \approx 1$ at high energy.

At low energy, results are ambiguous due to energy straggling.
Measurements @ LANL – Nb(p,x)

- $^{\text{nat}}\text{Nb(p,4n)}^{90}\text{Mo}$ is a high-priority objective as a new proton beam dosimetry standard for $E_p \approx 50 – 100$ MeV
Measurements @ LANL – Nb(p,x)
Measurements @ LANL – Nb(p,x)

• LBNL: 5 – 55 MeV / A, LANL: 45 – 100 MeV p+
• Complementary measurements explore reaction dynamics in different energy regimes, overlap region of 45-55 MeV builds confidence and consistency in results.
Measurements @ LANL – Nb(p,x)

$^{87m}Y$ (9/2+) / $^{87g}Y$ (1/2-) vs. Energy for $^{93}$Nb(p,αp2n)
TALYS Level Density Model CT+FG (default spin cut-off)

This Work
Talys

Preliminary
Summary

- Already completed: Fe(p,x), Zr(d,x), Nb(p,x)
- Upcoming targets: $^{86}\text{Sr}(p,x)^{86}\text{Y}$, $\text{La}(p,x)^{134,135}\text{Ce}$, $^{177}\text{Hf}(n,p)^{177}\text{Lu}$
  - $^{7}\text{Li}(p,n)$ quasi-monoenergetic neutron source development
- Possible future candidates: Access targets previously fielded by $\beta^+$-Oslo in the $A\approx50,90$, rare earth regions via (p,xn), ($\alpha$,xn)
Tusen takk!