Using the techniques of beta and gamma-ray spectroscopy to study nuclear shape in exotic, neutron-rich nuclei in the A~100 region.
Outline

• Background
  • Deformation
  • Systematic review
  • Previous work

• Experimental setup
  • Penning traps
  • Post-trap spectroscopy setup
  • Ramsey cleaning technique
  • Frequency scans

• Preliminary results

• Future work
Introduction

Isomeric state \[ 102^\gamma \] 

Ground state

\[ \Delta E < 200 \text{ keV} \]

\[ \Delta t_{1/2} \approx 0.06 \text{ s} \]
Introduction

Shape change at N=59

• Systematic study of yttrium isotopes

• From N=50 the nuclear deformation becomes increasingly oblate and soft. At N=60 a transition to a strongly deformed rigid prolate shape occurs.

---

**Introduction**

Low spin state produced by thermal fission of a $^{235}$U target at TRISTAN facility at Brookhaven National Lab.

High spin state produced by thermal fission of a $^{235}$U target using the JOSEF recoil separator at the research reactor DIDO at Kernforschungsanlage Jülich, without the use of an ion source.

---

**Gamma-ray energy (keV)**

<table>
<thead>
<tr>
<th>Low spin state</th>
<th>High spin state</th>
</tr>
</thead>
<tbody>
<tr>
<td>152</td>
<td>100(4)</td>
</tr>
<tr>
<td>160</td>
<td>&lt;1.1</td>
</tr>
<tr>
<td>327</td>
<td>8.6(9)</td>
</tr>
<tr>
<td>579</td>
<td>&lt;1.1</td>
</tr>
<tr>
<td>1059</td>
<td>29(3)</td>
</tr>
<tr>
<td>1091</td>
<td>&lt;1.3</td>
</tr>
</tbody>
</table>

---


Introduction

Introduction
Introduction

14 µA proton beam
130 MeV

Uranium target

Experimental Setup

Separated by mass

Spectroscopic line

Trap line

Experimental Setup

Experimental Setup

Tape station – moves about every 60 s

Beam direction
Experimental Setup

Magnetron motion: Mass independent
Cyclotron motion: Mass dependent

Experimental Setup

Primary beam: $14 \mu$A $\approx 9 \times 10^{13}$ protons/s

$^{102}$Y after traps: $\sim 1$ ion/s
Primary beam: $14 \, \mu A \approx 9 \times 10^{13}$ protons/s

$^{102}$Y after traps: $\sim 1$ ion/s
Preliminary Results

University of Brighton

Counts vs. $E_\gamma$ (KeV)

- 152 keV
- 327 keV
- 579 keV
- 618 keV
- 1054075 Hz

Counts vs. (Dipole frequency - 1054000) [Hz]

- 1060 keV
- 1090 keV
- 1211 keV

Counts

- 0
- 10
- 20
- 30
- 40
- 50
- 60
- 70

Counts

- 0
- 10
- 20
- 30
- 40
- 50
- 60
- 70
Preliminary Results

327 keV / 152 keV

1060 keV / 152 keV

579 keV / 152 keV

1090 keV / 152 keV
Preliminary Results

618 keV origin?

- Not seen in previous experiments
- Not from background
• $^{102}$Y was produced, and Ramsey cleaning was applied

• The two states were not clearly separated

• Hope to obtain more experimental data

• It would also be interesting to identify the origin of the 618 keV peak

• In the future we would also like to do some model calculations to further understand this region
Questions?

C.R. Nobs\textsuperscript{1}, A.M. Bruce\textsuperscript{1}, T. Eronen\textsuperscript{2}, V.S. Kolhinen\textsuperscript{2}, A. Kankainen\textsuperscript{2}, P. Campbell\textsuperscript{2,3}, J. Hakala\textsuperscript{2}, A. Jokinen\textsuperscript{2}, S. Kelly\textsuperscript{3}, J. Koponen\textsuperscript{2}, I.D. Moore\textsuperscript{2}, H. Penttilä\textsuperscript{2}, I. Pohjalainen\textsuperscript{2}, J. Reinikainen\textsuperscript{2}, S. Rinta-Antila\textsuperscript{2}, V. Simutkin\textsuperscript{2}

\textsuperscript{1}School of Computing, Engineering and Mathematics, University of Brighton, Brighton, BN2 4GJ, UK
\textsuperscript{2}Department of Physics, University of Jyvaskyla, P.O. Box 35, FI-40014 University of Jyvaskyla, Finland
\textsuperscript{3}Schuster Laboratory, University of Manchester, Manchester, M13 9PL, UK
From Spins to Shapes
From Spins to Shapes

More information is needed!
Ramsey Cleaning

Excitation pattern:

10ms ON
80ms OFF
10 ms ON

Provides much better mass resolution.

$^{54}\text{Co}^+$ (0$^+$ g.s.)
$T_{1/2} = 193\ ms$

$^{54m}\text{Co}^+$ (isomer)
$T_{1/2} = 1.48\ min$