Motivation: Toward new energy dependent FPY data to support fission theory and evaluation

Goal: Predicting independent and cumulative FPYs data simultaneously and consistently in the energy-dependent manner
Motivation: Toward new energy dependent FPY data to support fission theory and evaluation

- Peculiar energy dependency
  - There is a positive slope of the $^{147}$Nd FPY from 0.5 to $\sim$4.0 MeV:
    \[
    \frac{\Delta Y(^{147}\text{Nd})}{\Delta E_n} = (5.8 \pm 1.5)\%/\text{MeV}
    \]
  - At higher energies the FPY for $^{147}$Nd turns over and decreases

FPY = (Gamma_count) / Fission_count) * (m_{\text{thin}} / m_{\text{thick}}) * C_i

Building the Fastest Sample-Irradiated Transfer System in the Entire NNSA Complex

RApid Belt-driven Irradiated Target Transfer System

Features

- Fully automated operation
- Fully synchronized with the DAQ system and beam time structure
- User defined cycles \( (t_{\text{irr}}, t_{\text{dec}}, t_{\text{mes}}) \) can be repeated many times
- List-mode digital DAQ based on digital electronics

Initially supported by NA-113

- Transfer time = 400ms/1m or 1s/10m
- Highly reproducible irradiation and counting positions (+/- 40 \( \mu \)m)
- Properly oriented target with respect to the irradiation beam and \( \gamma \)-ray detectors
- Soft acceleration and deacceleration
- Sample weight is not a speed limitation

December 15, 2018
Building the Fastest Sample-Irradiated Transfer System in the Entire NNSA Complex

**RApid**  
**Belt-driven**  
**Irradiated**  
**Target**  
**Transfer**  
**System**

**R A B I T T S**

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- Soft acceleration and deacceleration
- Sample weight is not a speed limitation
Cycle information:

- $T_{\text{tot}} = 3969$ s
- $T = 81$
- $t_{d1} = 40$ s
- $t_i = 40$ s
- $t_{d2} = 40$ s

$E_p = 3.6$ MeV
$E_n = 2$ MeV

$E_{\gamma} = 279.0$ keV
$T_{1/2} \text{ (Meas)} = 7.75 \pm 0.09$ s
$T_{1/2} \text{ (NNDS)} = 7.73 \pm 0.06$ s

$E_n = 2.0$ MeV
$\sigma(n,n')_{\text{meas}} = 507 \pm 32$ mb
$\sigma(n,n')_{\text{NNDC}} = 510 \pm 42$ mb

$^{197}\text{Au}(n,n')^{197m}\text{Au}$
Short-Lived Fission Product Yields (min – hours)

- Three irradiations on $^{235}\text{U}$, $^{238}\text{U}$, and $^{239}\text{Pu}$ at 14.8 MeV
  - $t_{\text{irr}} = 1\ h$
  - $t_{\text{tra}} \sim 4\ minutes$ using the JACK-RABITT System
  - $t_{\text{mea}} = \text{continuous one week of counting}$
- FPY data for more than 45 fission products with half-life of few minutes to a few days
- Time Dependent FPY information to the FIER$^*$ code

$^*$ E. Matthews et al. FIER code. NIMA A 891 (2018) 111–117
Very Short-Lived Fission Product Yields (~1s)

- Three irradiations on $^{235}\text{U}$, $^{238}\text{U}$, and $^{239}\text{Pu}$ at 2.0 MeV
  - $t_{\text{irradiation}} = 1$ s
  - $t_{\text{transition}} \sim 0.5$ s using the RABITT System
  - $t_{\text{measurement}} = 1$ s, 5 s and 10s
  - $T_{\text{tot}}$ continuous of 4 h
- FPY data for with half-live of 1 second to a few minutes
- Time Dependent FPY information

Cycle information:

- $T_{\text{tot}} = 4$ h
- $T = 3$ s
- $t_{d1} = 1$ s
- $t_{i} = 1$ s
- $t_{d2} = 1$ s
- $t_{m} = 1$ s

✅ Successful commissioning of the RABITT system
✅ The very short-lived FPY data is in our reach
Impact of the New Fission Product Yield Data

- Reactor neutrino study
- Nuclear astrophysics and cosmochemistry
- Nuclear Forensics
- Radio-isotope production for medical applications

New FPY data base

Basic Physics

Application
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