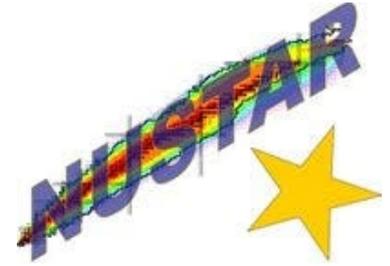




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Fission isomer studies on $^{240\text{f}}, ^{242\text{f}}\text{Am}$ at IGISOL facility

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ISOLDE Workshop and Users Meeting 2025

3-5 December 2025

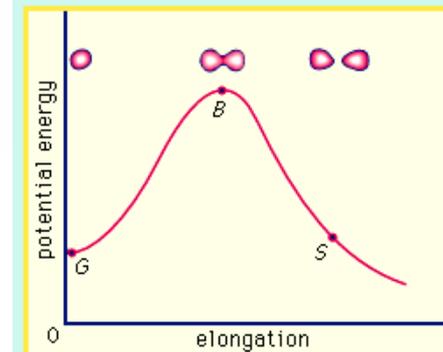
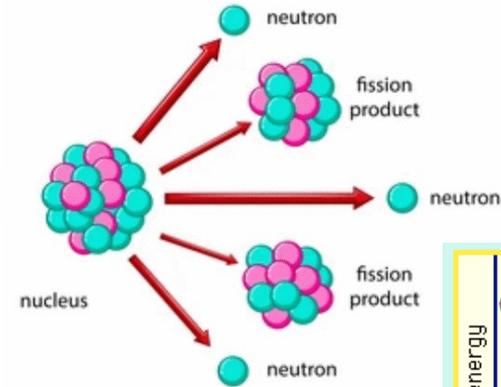


■ **Outline**

- Motivation for fission isomer studies.
- Research methods:
 - » IGISOL facility in the JYFL Accelerator Laboratory.
 - » Experiment on fission isomer $^{240\text{f}, 242\text{f}}\text{Am}$.
- Experimental results and discussion:
 - » Kinetic energy spectra of the single fission fragments of $^{240\text{f}, 242\text{f}}\text{Am}$.
 - » Total kinetic energy spectra of $^{240\text{f}, 242\text{f}}\text{Am}$.
 - » Pre-neutron emission mass distributions of $^{240\text{f}, 242\text{f}}\text{Am}$.
- Conclusions.

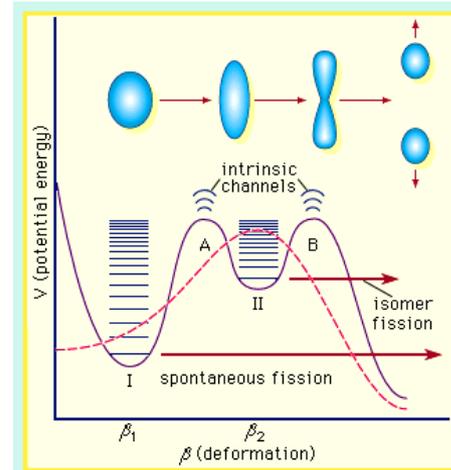
■ Motivation for fission isomer studies

- Nuclear fission is the process of splitting a large, unstable atomic nucleus into two smaller nuclei, which releases a large amount of energy and additional neutrons.
- The height and shape of the fission barrier are dependent on the particular nucleus and play central role in understanding fission probabilities.
- Multi-humped fission barriers occur in the actinide region. Such barrier shapes can be described as the result of superimposing microscopic shell corrections to the macroscopic liquid drop barrier.
- Testing of theoretical predictions done by measuring different observables of nuclei: half-life, the excitation function, the fission isomer's excitation energy, the kinetic energy spectra of fission fragments.
- The goals of present experiment: measured the kinetic energy spectra of single fission fragments for ^{240}f , ^{242}f Am.



G is the ground state of the nucleus; B is the top of the barrier to fission (called the saddle point); and S is the scission point. The nuclear shape at these points is shown at the top.

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Research methods: IGISOL facility in the JYFL Accelerator Laboratory

➤ The IGISOL facility is a versatile facility equipped with light-ion guide, dipole magnet, MR-TOF and Penning trap etc.

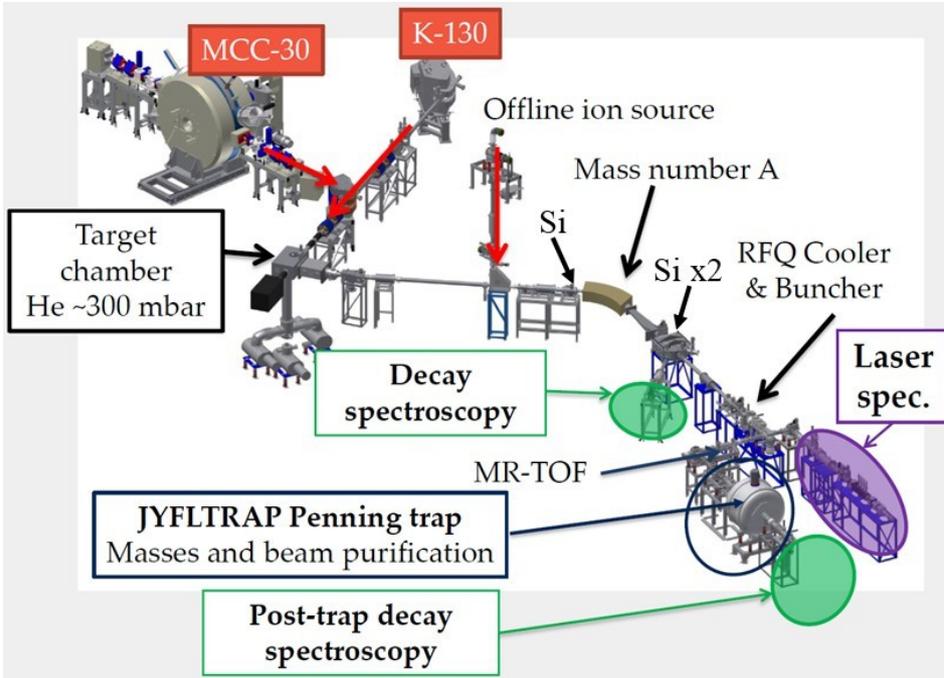
➤ $^{240f,242f}\text{Am}$ was populated via deuteron induced fusion-evaporation reactions on a ^{242}Pu target:



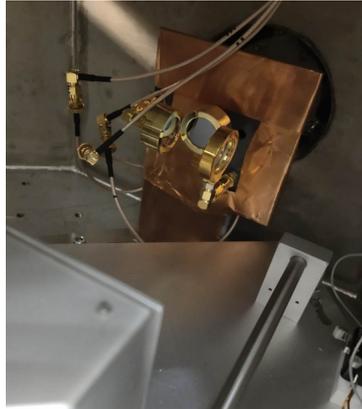
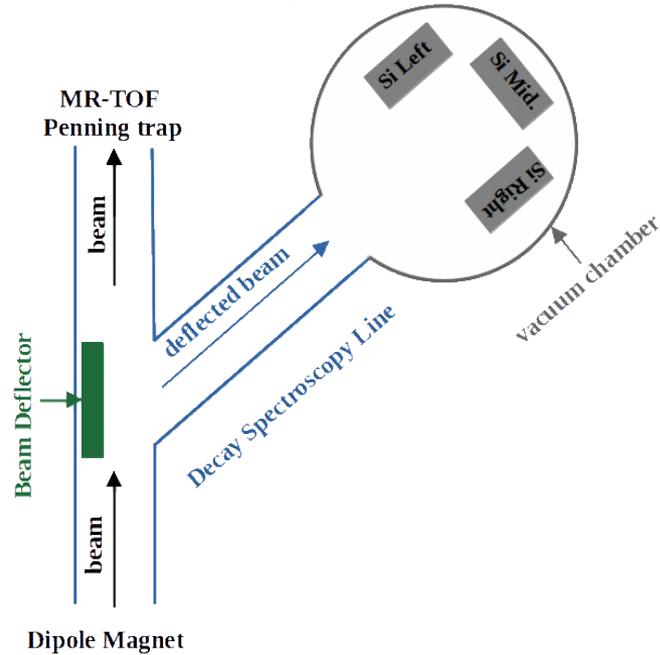
➤ Deuteron beam from the K130 cyclotron with energies from 10 to 28 MeV.

➤ ^{242}Pu target installed in the light-ion guide inside the target chamber. The light-ion guide is a small gas cell (with a stopping volume of $\sim 3 \text{ cm}^3$) filled with He buffer gas.

➤ The separation and selection of ^{242}Am and ^{240}Am was done by the dipole magnet at IGISOL, which resolving power of about 200.



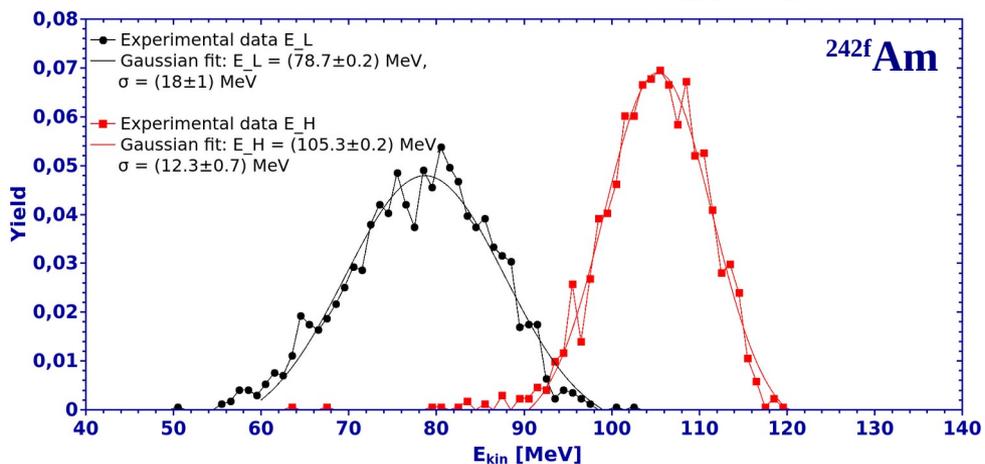
Research methods: Experiment on fission isomer $^{240\text{f}}, ^{242\text{f}}\text{Am}$



- $^{242\text{f}}\text{Am}$: $E^*=2.2$ MeV $T_{1/2}=13.8$ ms
- $^{240\text{f}}\text{Am}$: $E^*=3.2$ MeV $T_{1/2}=0.93$ ms
- With this time scale isomers can be separated and transported sufficiently.
- In order to use the measurements efficiently beam regularly deflects between two lines.
- Fission isomer decays detected by a tree of Si detectors installed after the dipole magnet in the decay spectroscopy line.
- Si Middle detector was used as an implanter for $^{240\text{f}}, ^{242\text{f}}\text{Am}$ isomers.
- Si detectors were calibrated with a ^{252}Cf fission source in order to obtain the kinetic energy spectra of the single fission fragments from fission isomers.

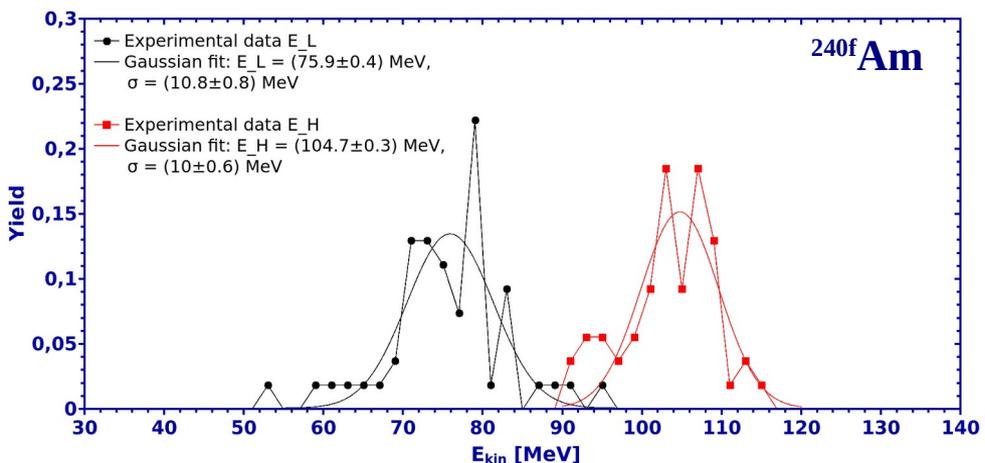
Experimental results and discussion:

Kinetic energy spectra of the single fission fragments of ^{240}f , ^{242}f Am



^{242}fAm fission fragments:

- 12323 - total counts
- 1711 - correlated events (coincident fission fragments)
- Data from: Phys.Rev. C13, 189 (1976) J. Weber et al.
 $E_L = (78.10 \pm 0.11)$ MeV
 $E_H = (105.93 \pm 0.15)$ MeV
Good agreement with previously measurements



^{240}fAm fission fragments:

- 423 - total counts
- 54 - correlated events (coincident fission fragment)

Experimental results and discussion:

Total kinetic energy spectra of ^{240}f , $^{242}\text{f}\text{Am}$

➤ $\text{TKE} = E_{\text{L}} + E_{\text{H}}$ - two fission fragments from the same decay

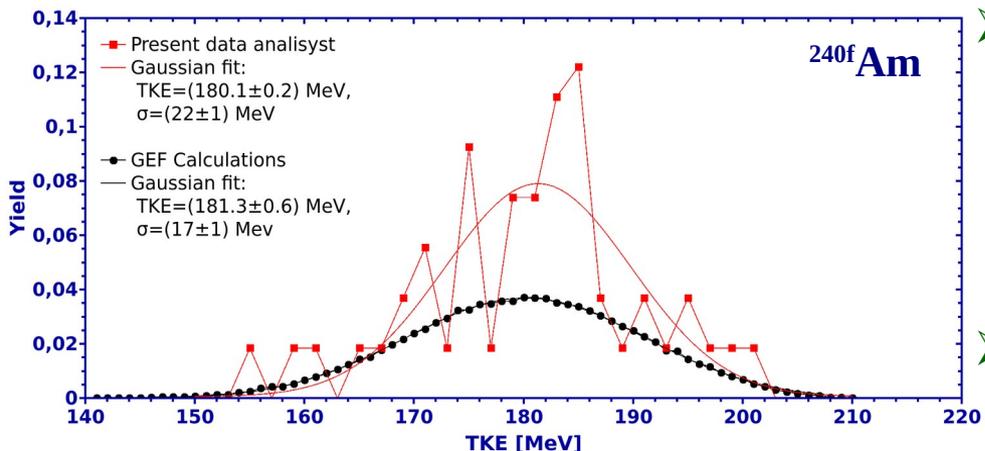
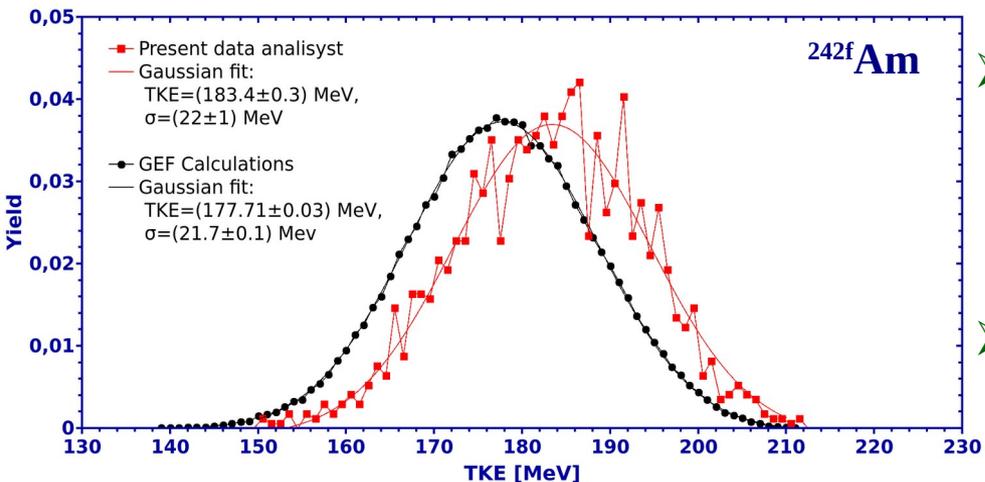
$^{242}\text{f}\text{Am}$ fission fragments:

➤ GEF - A General Description of Fission Observables empirical-theoretical mode by Karl-Heinz Schmidt
The difference in maximal value $\Delta\text{TKE} \approx 6 \text{ MeV}$

➤ Data from: Phys.Rev. C13, 189 (1976) J. Weber et al.
 $\text{TKE} = (184.03 \pm 0.07) \text{ MeV}$
Good agreement with previously measurements

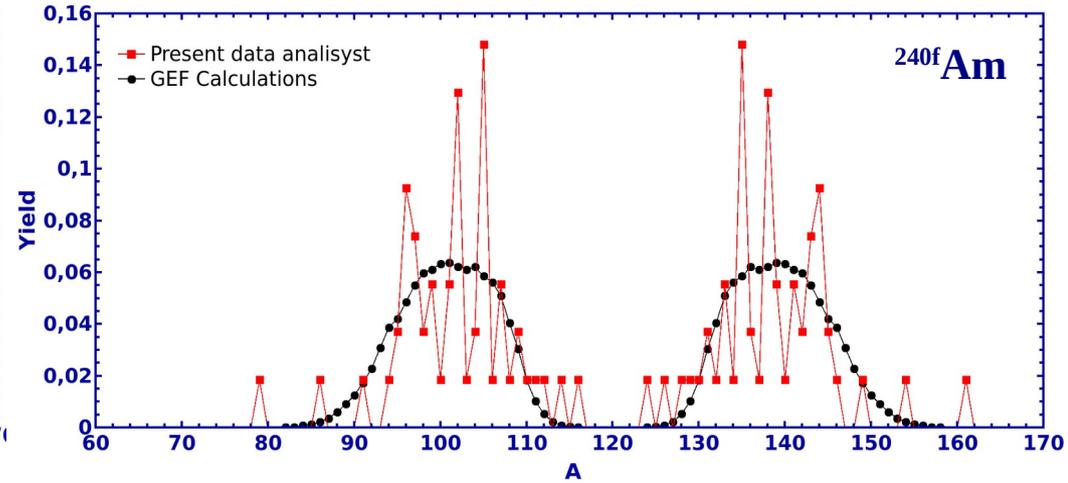
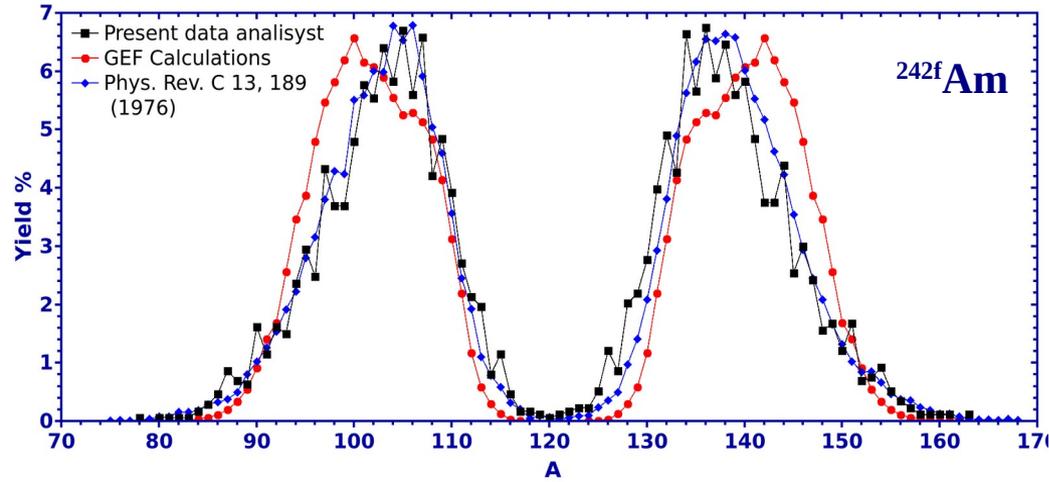
$^{240}\text{f}\text{Am}$ fission fragments:

➤ Statistics must be improve for making conclusions



Experimental results and discussion:

Pre-neutron emission mass distributions of $^{240f}, ^{242f}\text{Am}$



- The pre-neutron emission mass distribution were calculated using 2E method:

$$R = \frac{E_L}{E_H} \quad A_H = \frac{A_m}{(1+R)} \quad A_L = \frac{A_m * R}{(1+R)} \quad \text{were } A_m = 242 \text{ or } 240 \text{ masa number of Americium}$$

- ^{242}Am pre-neutron emission mass distribution to be strongly asymmetric with:

$$A_L = 104.1 \pm 0.2 \text{ and } A_H = 137.7 \pm 0.2$$

- Pre-neutron mass distribution for ^{240}Am exhibit to peak structure with:

$$A_L = 101.9 \pm 0.9 \text{ and } A_H = 138.2 \pm 0.9$$

■ **Conclusions**

- Study fission isomers properties of $^{240\text{f}}, ^{242\text{f}}\text{Am}$ were performed at the IGISOL facility.
- It was possible to measured the kinetic energy spectra of the single fission fragments from fission isomers. Typical for fission two peak distribution of kinetic energy yield were received.
- Total kinetic energy yields two fission fragments from the same decay were obtained.
- The pre-neutron emission mass distributions were calculated from the kinetic energy spectra of the single fission fragments using 2E method. Distributions to be strongly asymmetric.
- Obtained results were compered with GEF calculations and previously measurements, which are in good agreement.
- The proof-of-principle investigations done successfully for the deuteron induced reactions on the ^{242}Pu target proposed in the present experiment, there will be a series of potential experiments can be done at IGISOL for studies on fission isomers in the near future.

Thank you for your attention!