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

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Extremes of the Nuclear Landscape

# Outline

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- Conclusions.

# ▪ *Motivation for fission isomer studies*

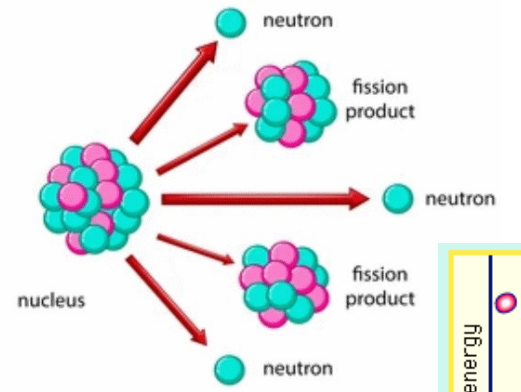
- Nuclear fission is the process of splitting a large, unstable atomic nucleus into two smaller nuclei, which releases a large amount of energy and additional neutrons.

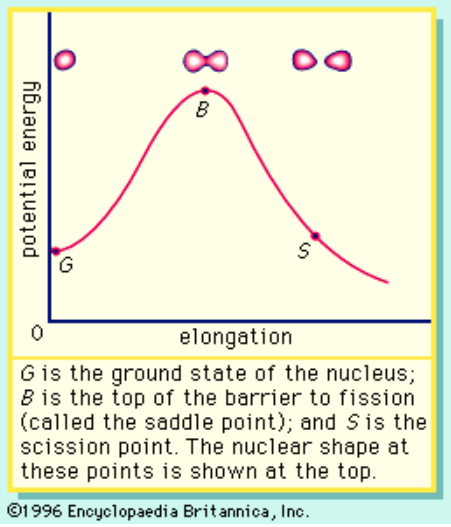
- The height and shape of the fission barrier are dependent on the particular nucleus and play central role in understanding fission probabilities.

- 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.

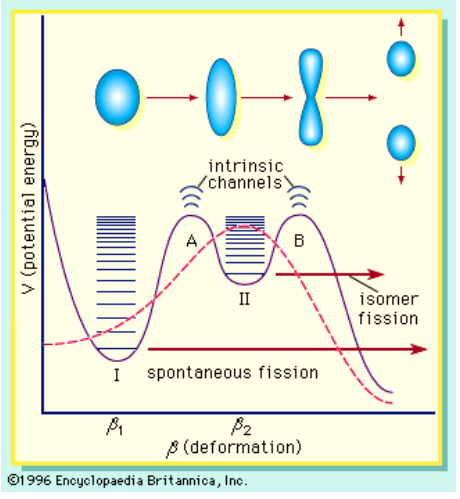
- The goals of present experiment: measured the kinetic energy spectra of single fission fragments for $^{240f,\ 242f}$Am.



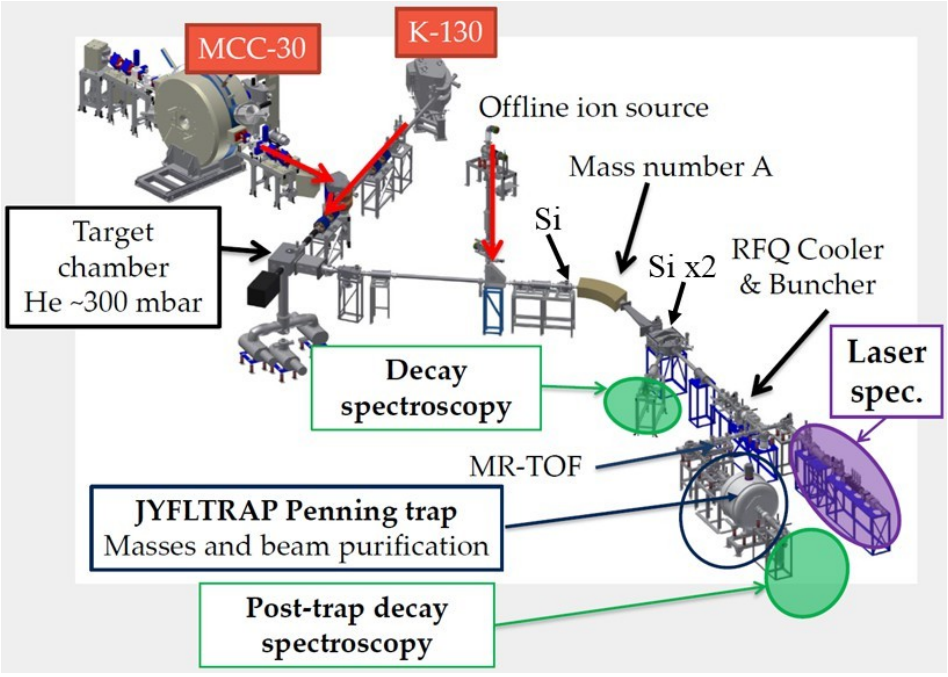




*G* is the ground state of the nucleus; *B* is the top of the barrier to fission (called the saddle point); and *S* is the scission point. The nuclear shape at these points is shown at the top.



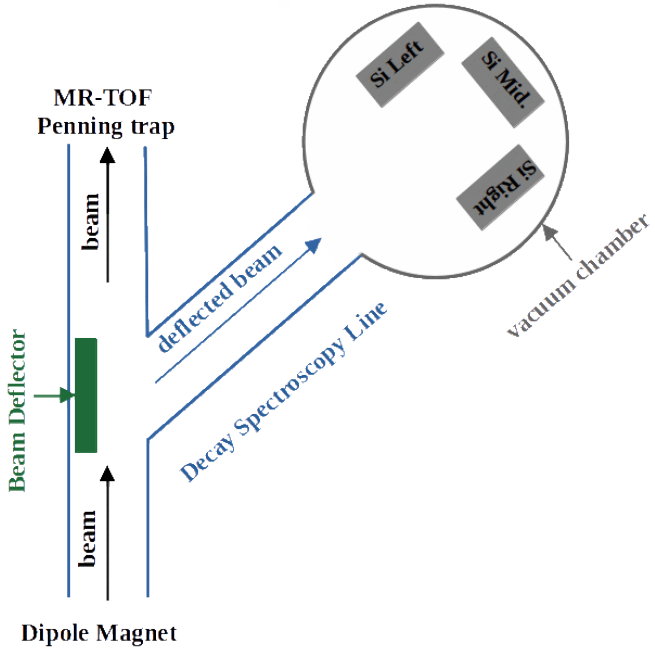


# ▪ *Research methods: IGISOL facility in the JYFL Accelerator Laboratory*




- The IGISOL facility is a versatile facility equipped with light-ion guide, dipole magnet, MR-TOF and Penning trap etc.
- $^{240f,242f}$Am was populated via deuteron induced fusion-evaporation reactions on a $^{242}$Pu target:
  **$^{242}$Pu(d,2n)$^{242}$Am, $^{242}$Pu(d,4n)$^{240}$Am**
- 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 ~3 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, whith resolving power of about 200.

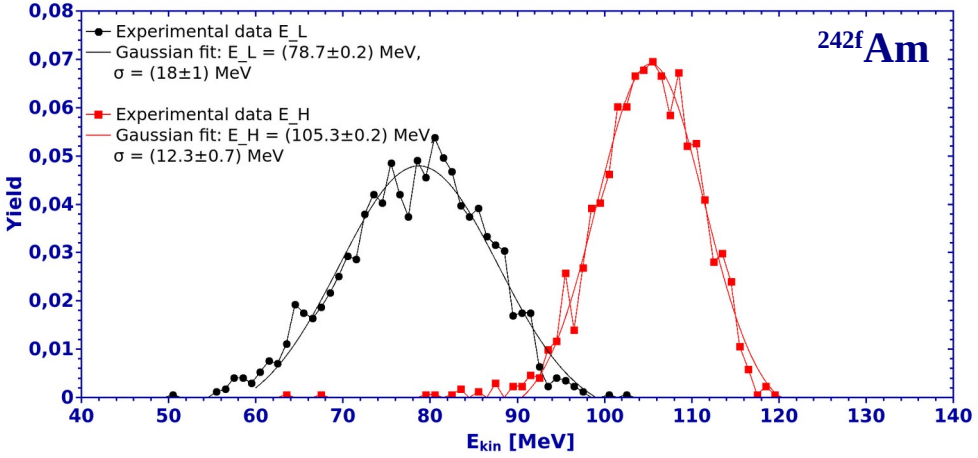
# ▪ Research methods: Experiment on fission isomer $^{240f, 242f}$Am

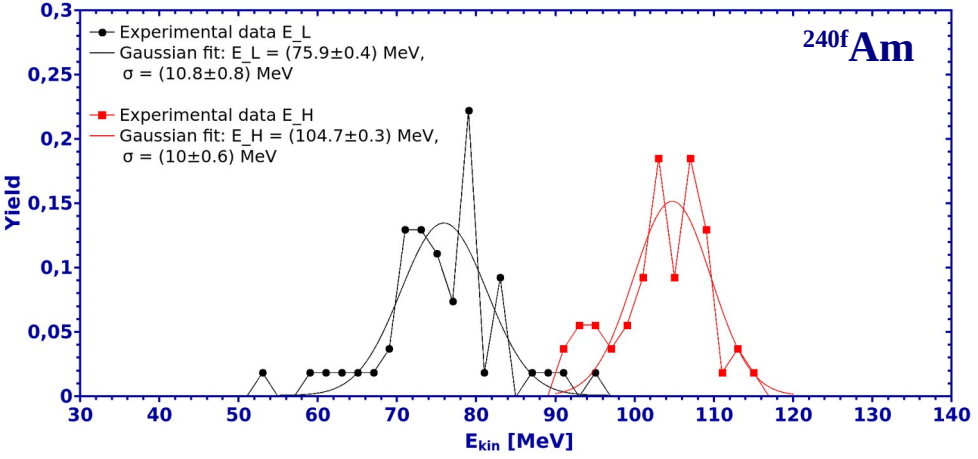



- **$^{242f}$Am: E*=2.2 Mev $T_{1/2}$=13.8 ms**
  **$^{240f}$Am: E*=3.2 Mev $T_{1/2}$=0.93 ms**
- With this time scale isomers can be separated and transported sufficiently.
- In order to use the measuments efficiently beam regularly deflect between two lines.
- Fission isomer decays detected by a tree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




### $^{242f}$Am fission fragments:

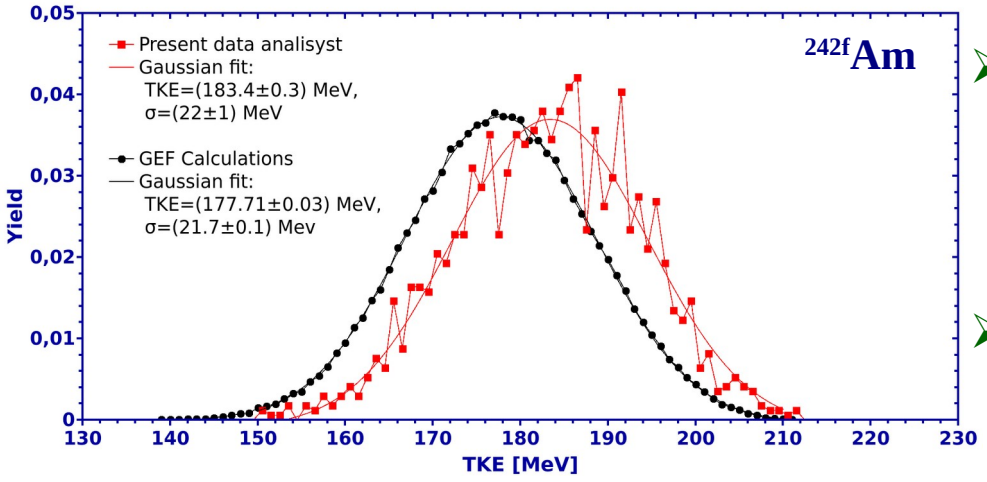
- 12323 - total counts
  1711 - correlated events (coincident fission fragments)
- Data from: Phys.Rev. C13, 189 (1976) J. Weber et al.
  $E_{\_L}$ = (78.10 ± 0.11) MeV
  $E_{\_H}$ = (105.93 ± 0.15) MeV
  Good agreement with previously measurements

### $^{240f}$Am fission fragments:

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

# ▪ *Experimental results and discussion:*

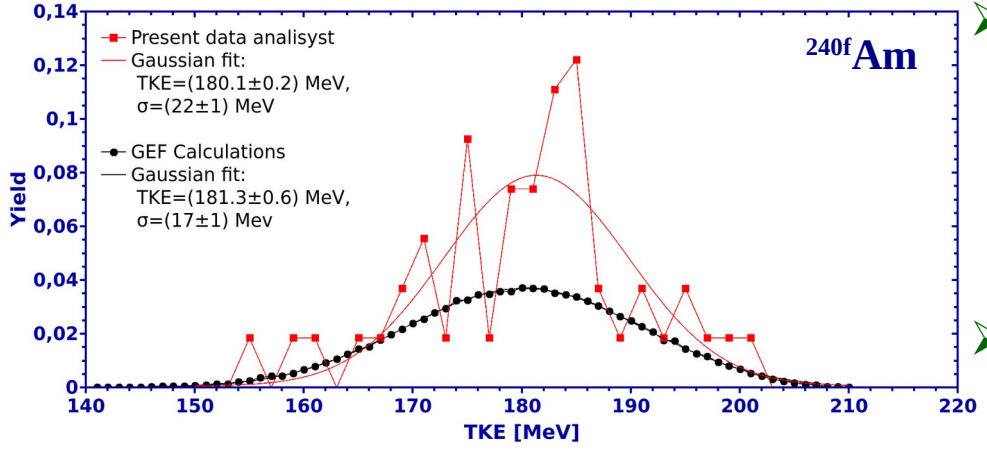
## *Total kinetic energy spectra of $^{240f, 242f}$Am*




- **TKE= $E_L$+$E_H$** - two fission fragments from the same decay

**$^{242f}$Am fission fragments:**

- GEF - A General Description of Fission Observables empirical-theoretical mode by Karl-Heinz Schmidt
  The difference in maximal value ΔTKE ≈ 6 MeV



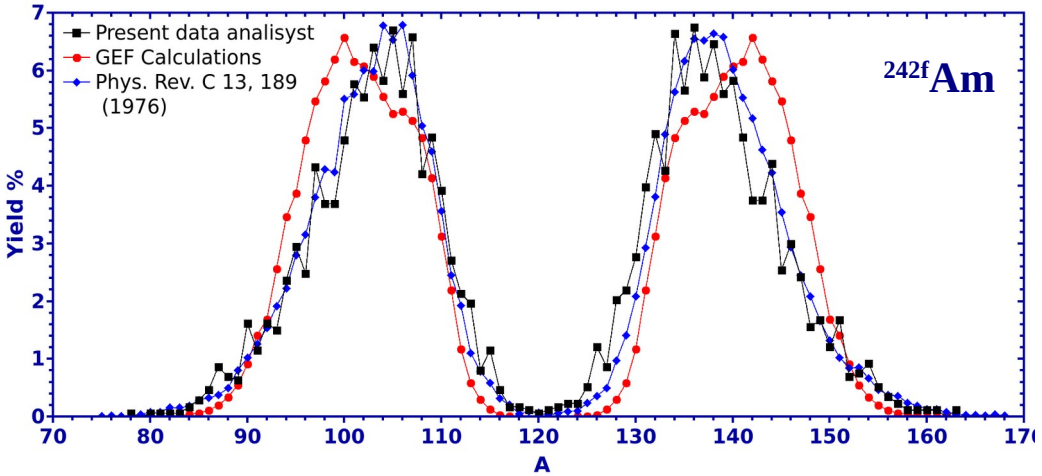

- Data from: Phys.Rev. C13, 189 (1976) J. Weber et al.
  TKE = (184.03±0.07) MeV
  Good agreement with previously measurements

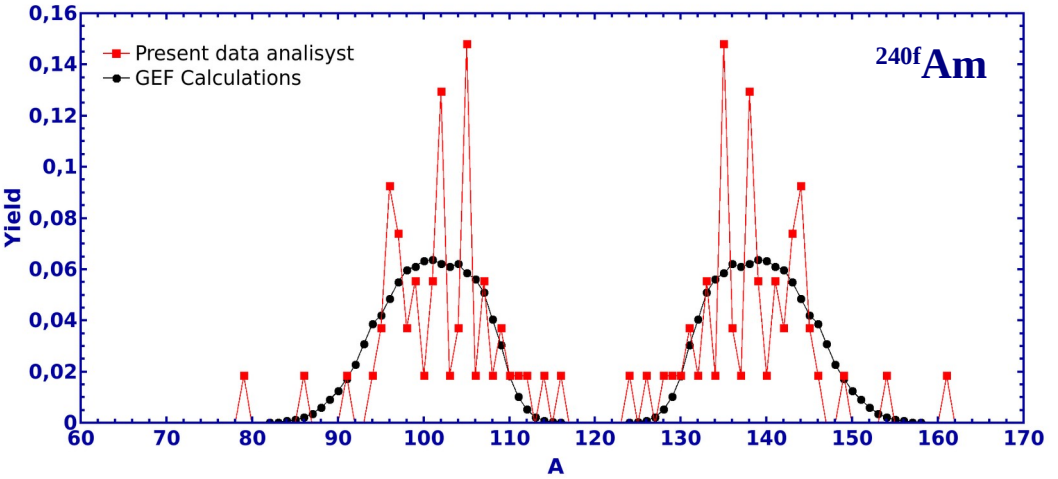
**$^{240f}$Am fission fragments:**

- Statistics must be improve for making conclusions

# ▪ Experimental results and discussion:

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




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

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

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

$A_L$=104.1±0.2 and $A_H$ =137.7±0.2

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

$A_L$=101.9±0.9 and $A_H$ =138.2±0.9

# Conclusions

- Study fission isomers properties of $^{240f, 242f}$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!**