Possible Fission Case for the GRIT Project

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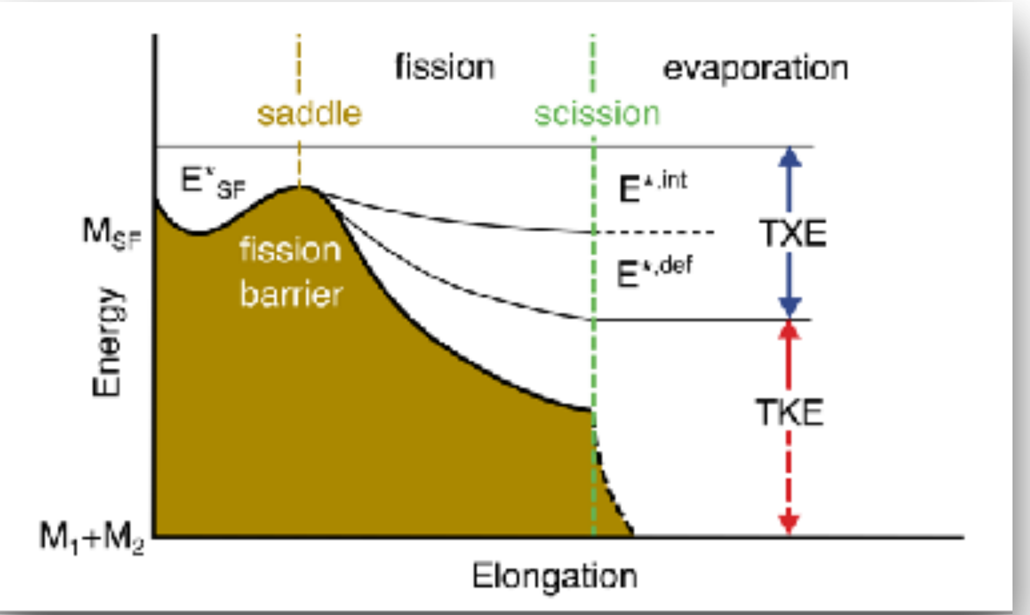
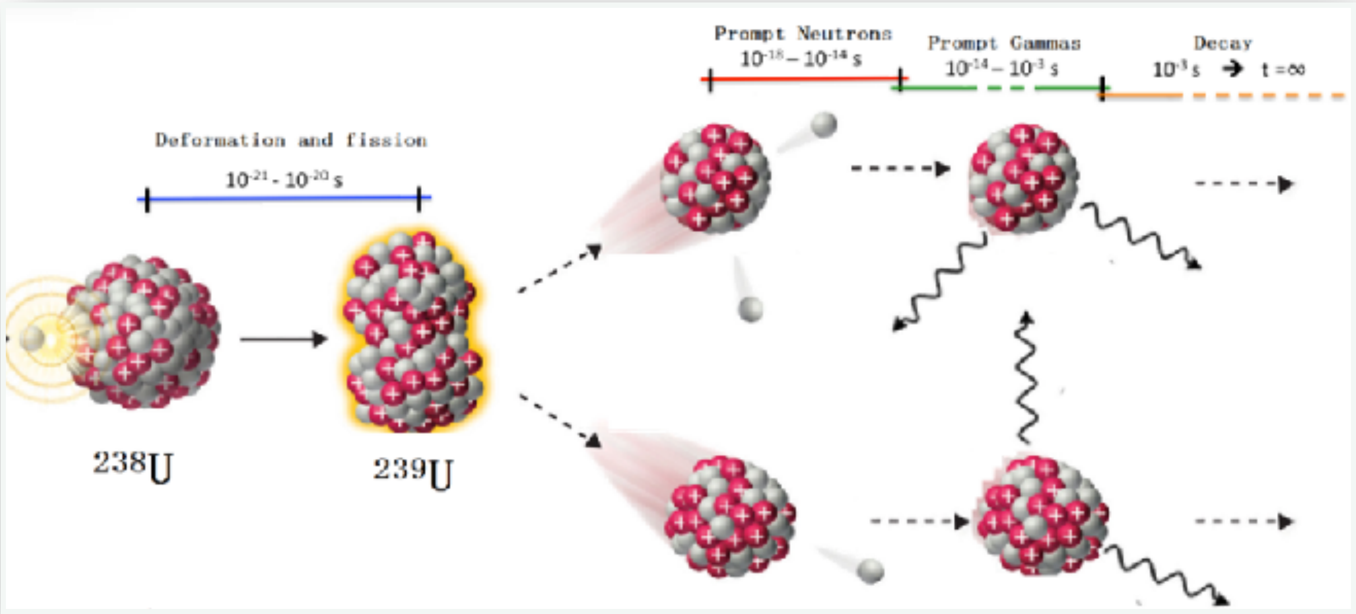
Fission Observables





Incoming channel:

- Fissioning system
- Initial excitation energy
- Angular momentum

Outgoing channel (fission)

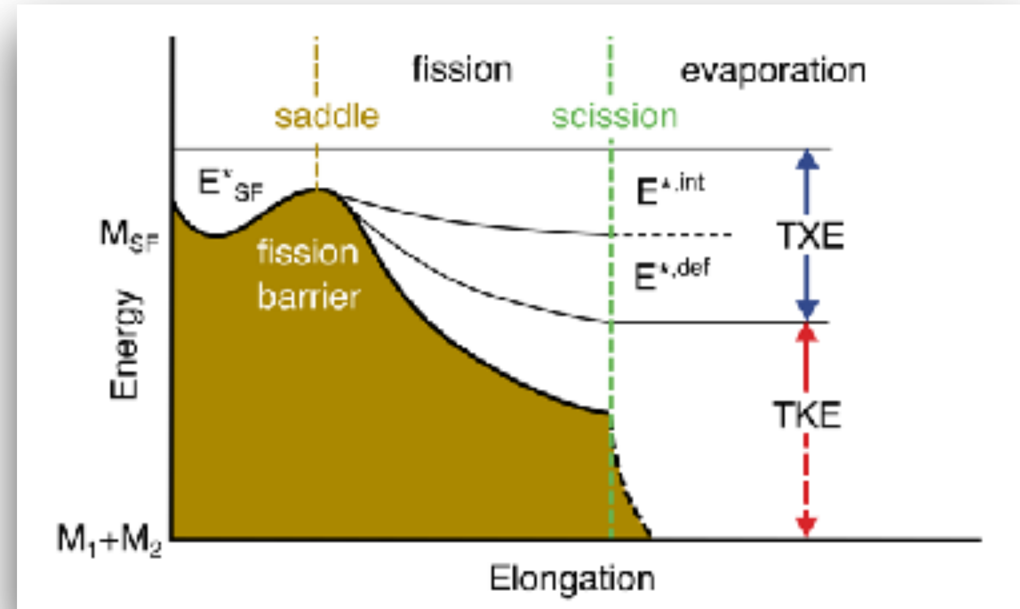
- Fission probability
- Fission Yields (Z,A)
- Total kinetic energy
- Neutron, gamma evaporation

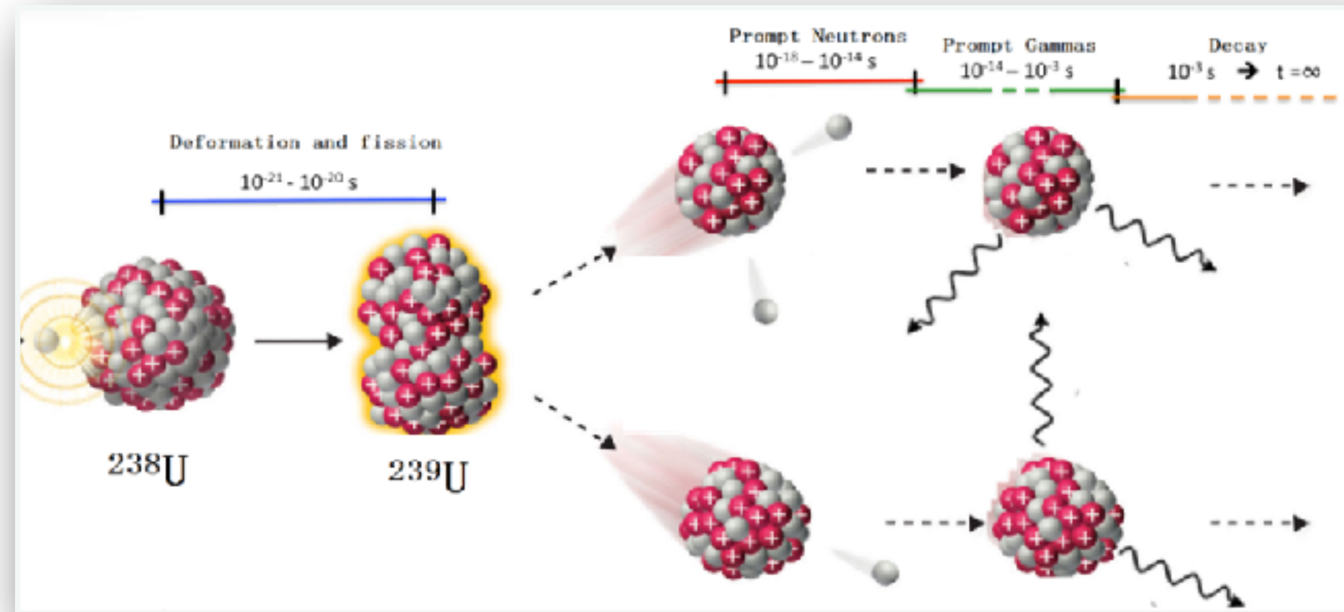
?

?

- **Fission dynamics** (dissipation, fission kinematics, transient time, …)
- **Potential energy surface** (fission barriers, scission configuration, fission modes, …)

Fission Observables





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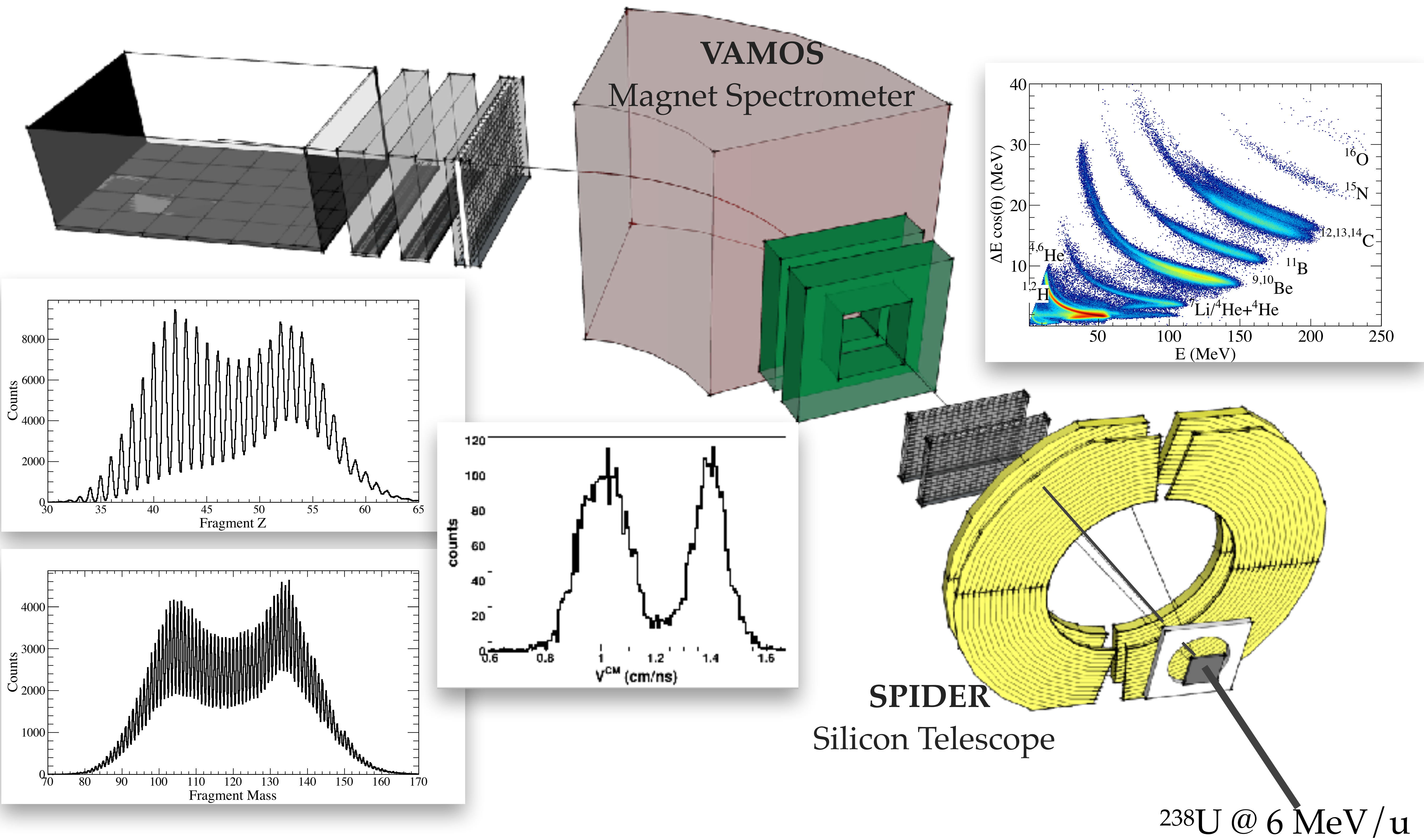
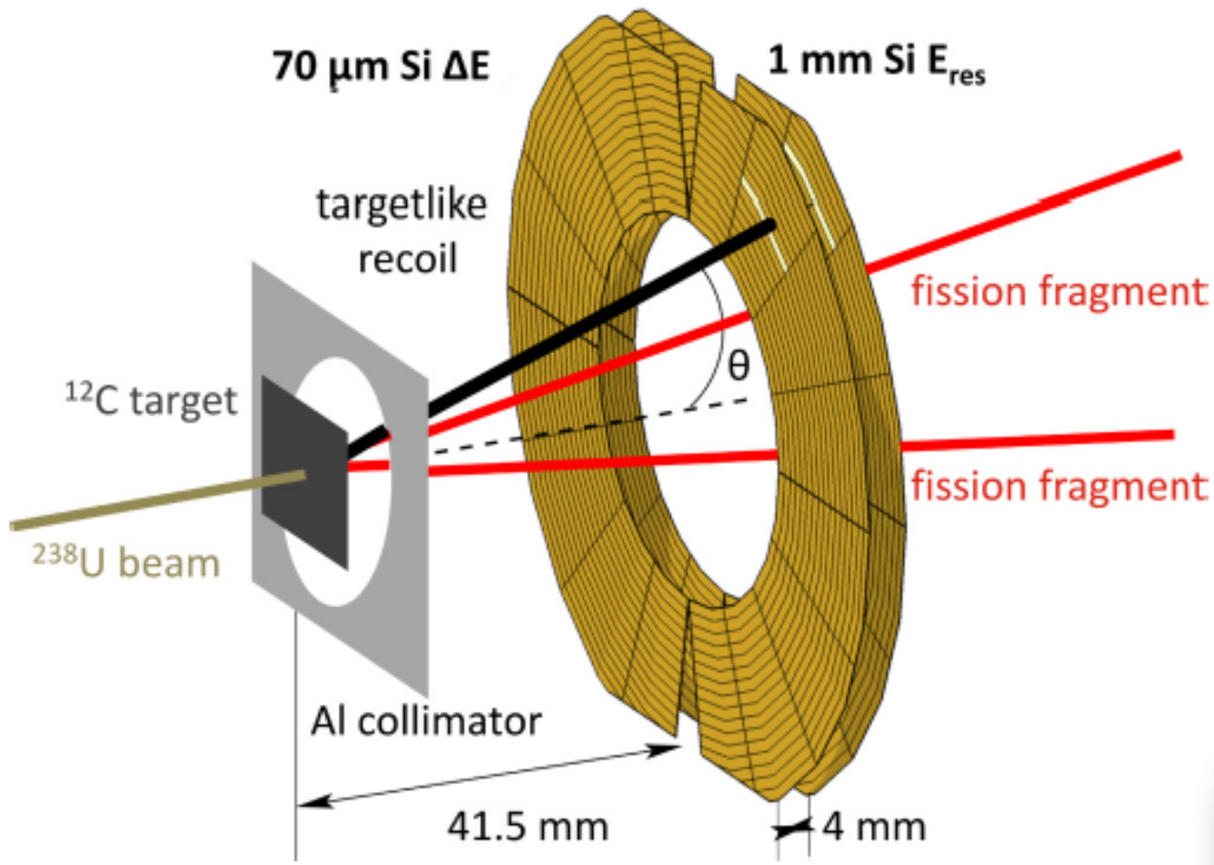
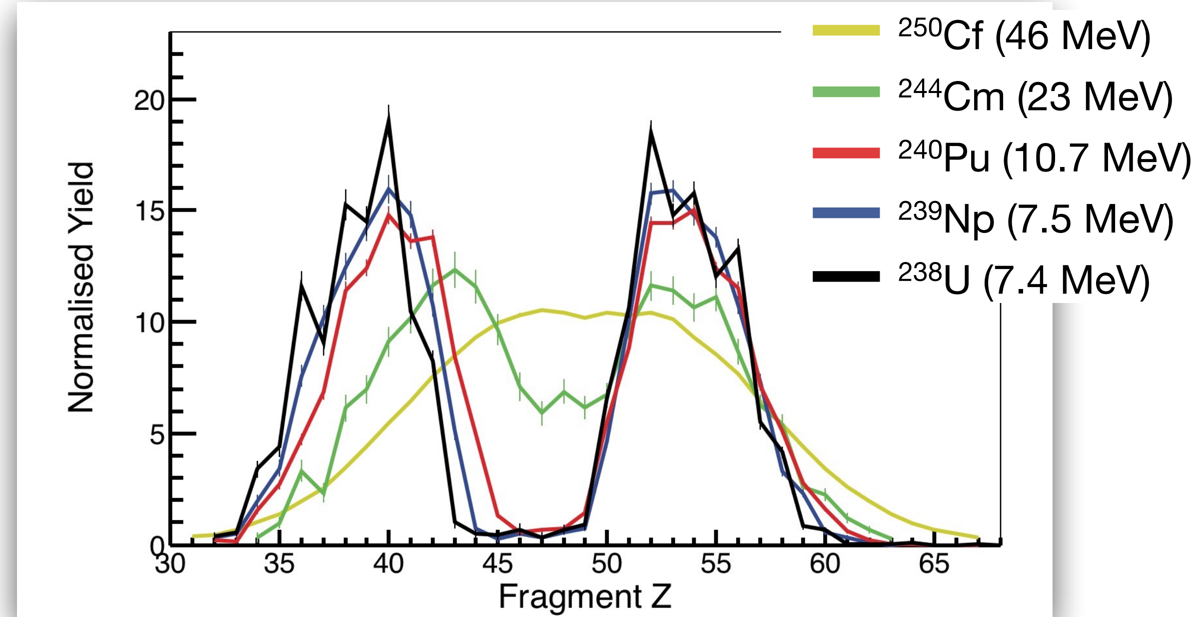
Fission at VAMOS/GANIL



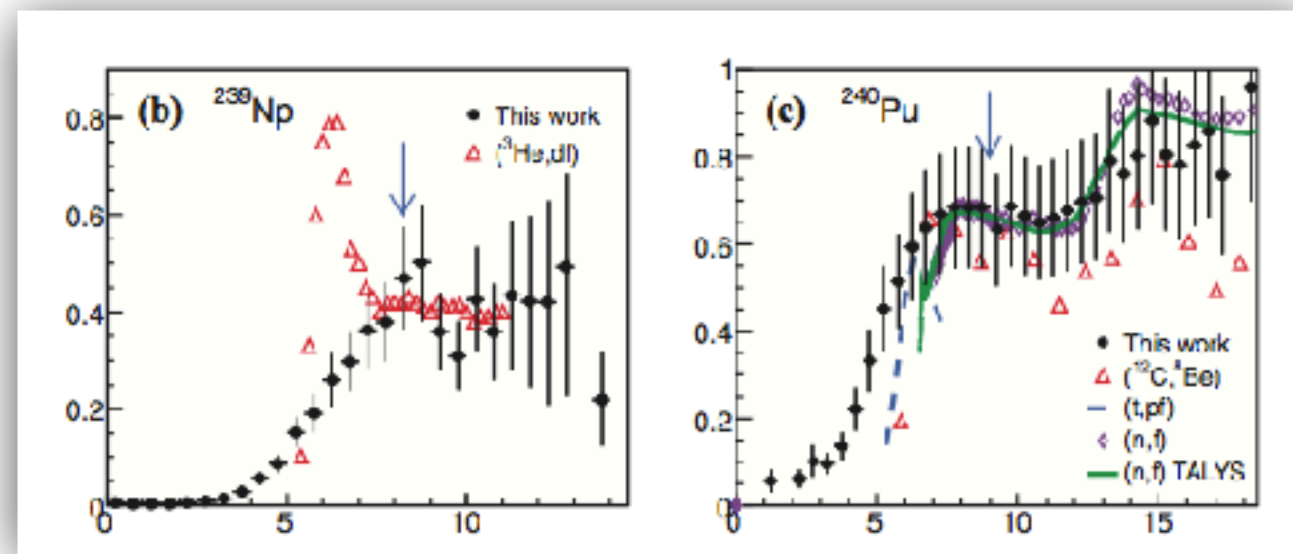
- Fragment mass identification
- Fragment Z identification
- **Velocity in CM (Coulomb Energies)**

- Fissioning system identification
- **Excitation energy reconstruction**

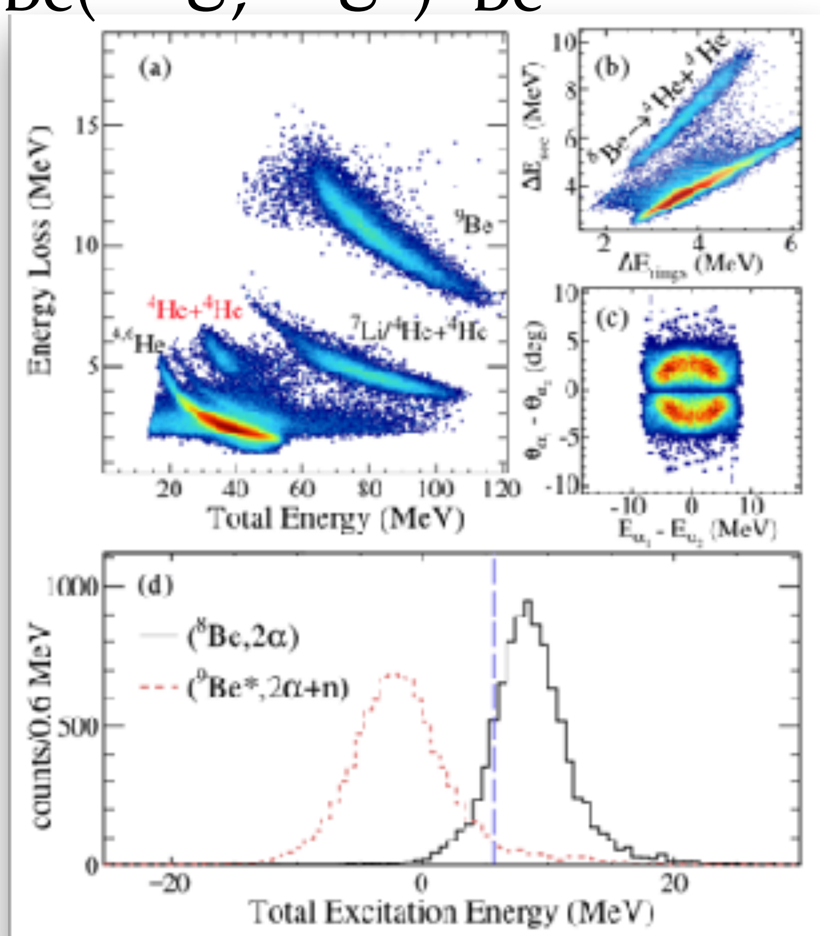




^{12}C(^{238}U, A*) b



^{9}Be(^{238}U, ^{239}U*) ^{8}Be

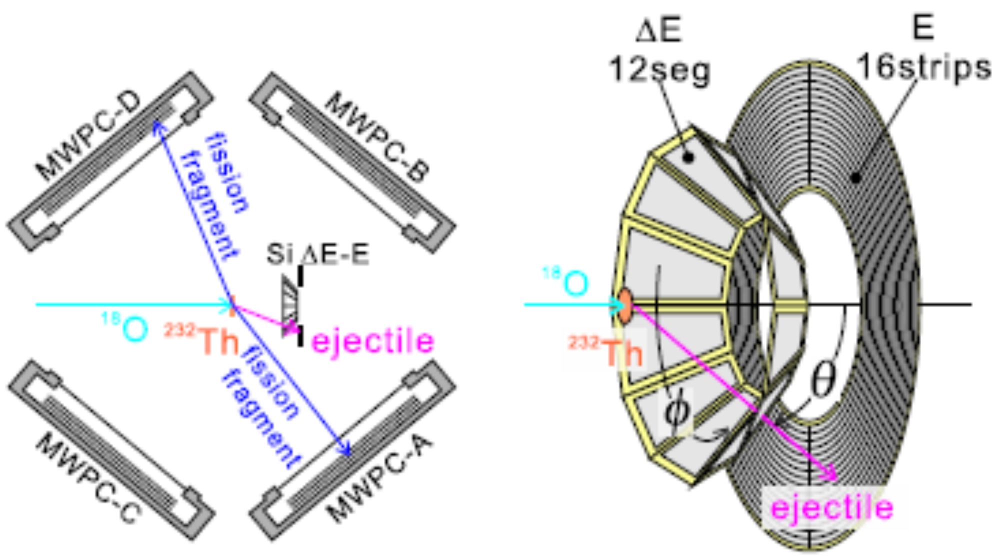


The fission program at VAMOS is already a well stablished program:

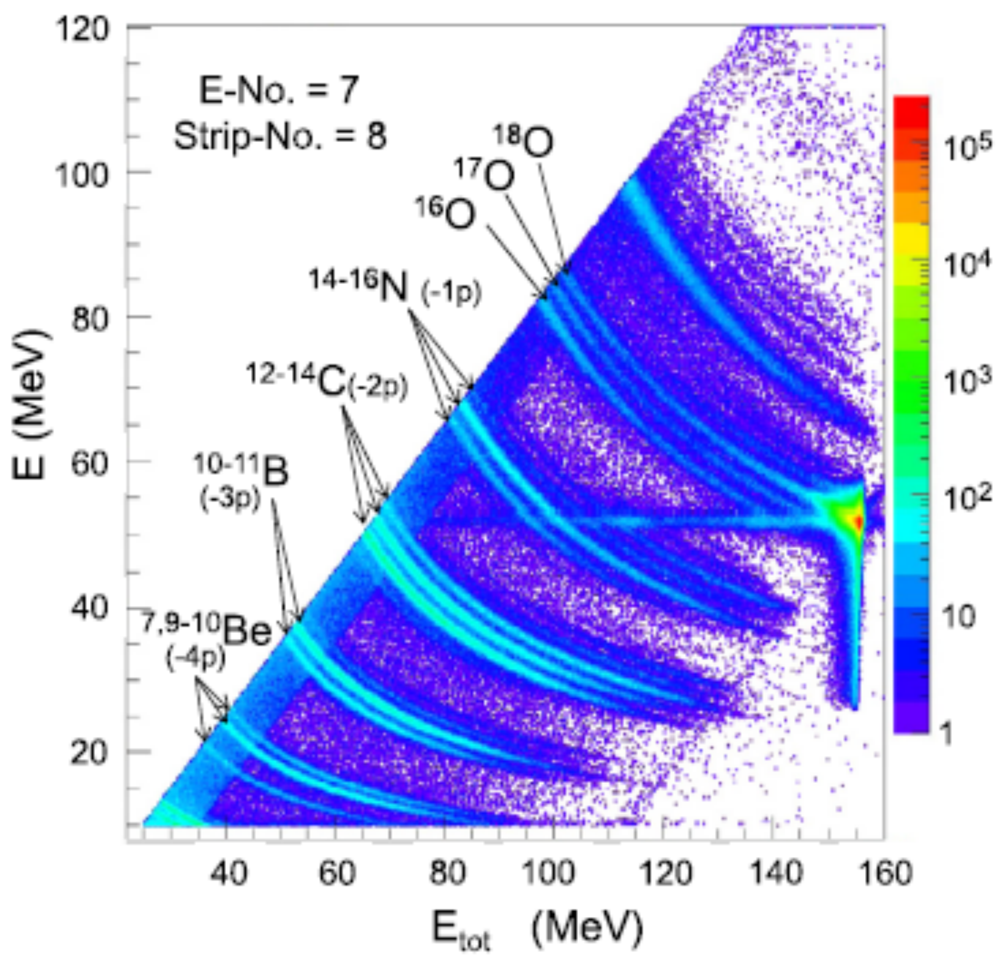
M. Caamaño et al., Phys. Rev. C 88, 024605 (2013).
C. Rodríguez-Tajes et al., Phys. Rev. C 89, 024614 (2014).
M. Caamaño et al., Phys. Rev. C 92, 034606 (2015).
M. Caamaño et al., Phys. Lett. B 770, 72 (2017).
D. Ramos et al., Phys. Rev. C 97, 054612 (2018).
D. Ramos et al., Phys. Rev. C 99, 024615 (2019).
D. Ramos et al., Phys. Rev. Lett. 123, 092503 (2019).

Other Measurements

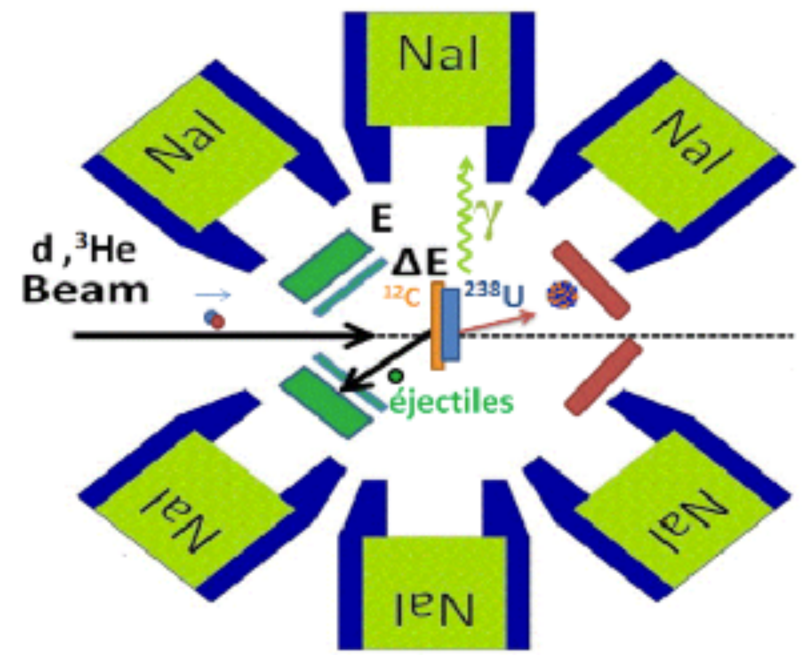
Leguillon et al. PLB (2016) JAEA

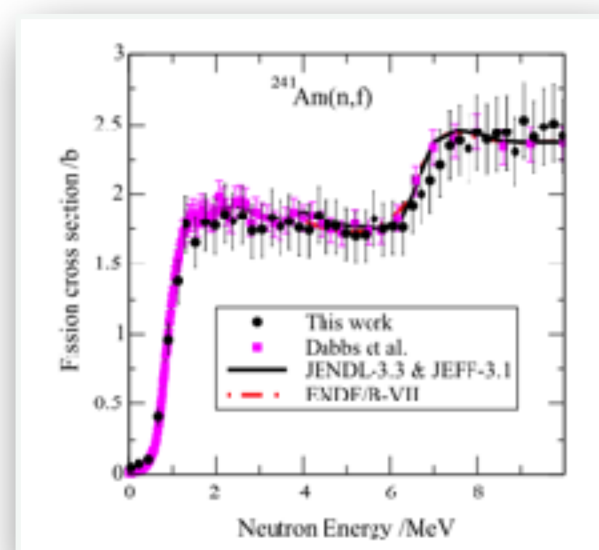


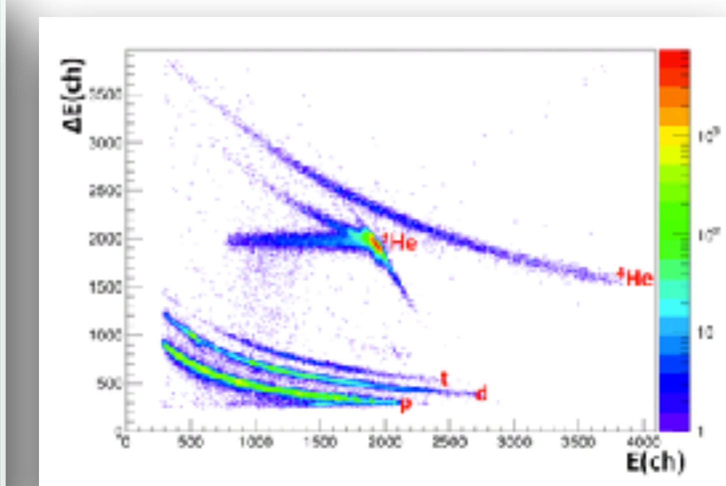
(a) Schematic detection set-up (left) and expanded view of the silicon ΔE–E detector telescope (right). See text for details.



G. Kessedjian et al. PLB 692 (2010) 297
BORDEAUX





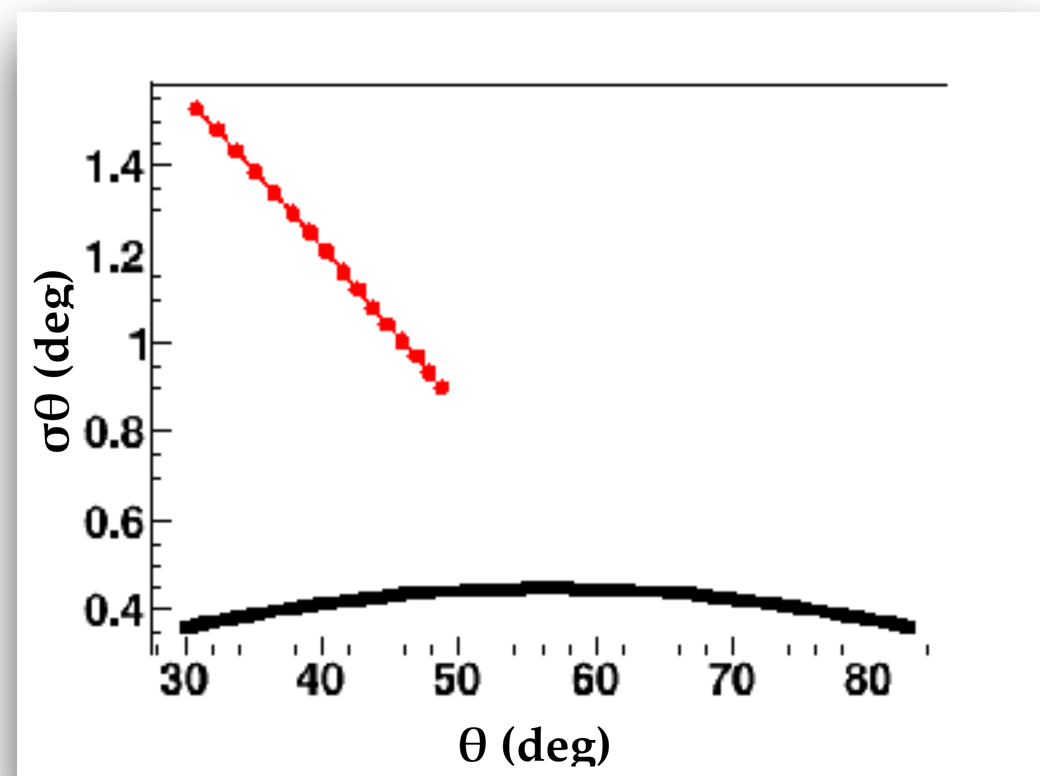


- **Direct kinematics:**
  - Less challenging Ex measurement
  - No Isotopic fission fragments

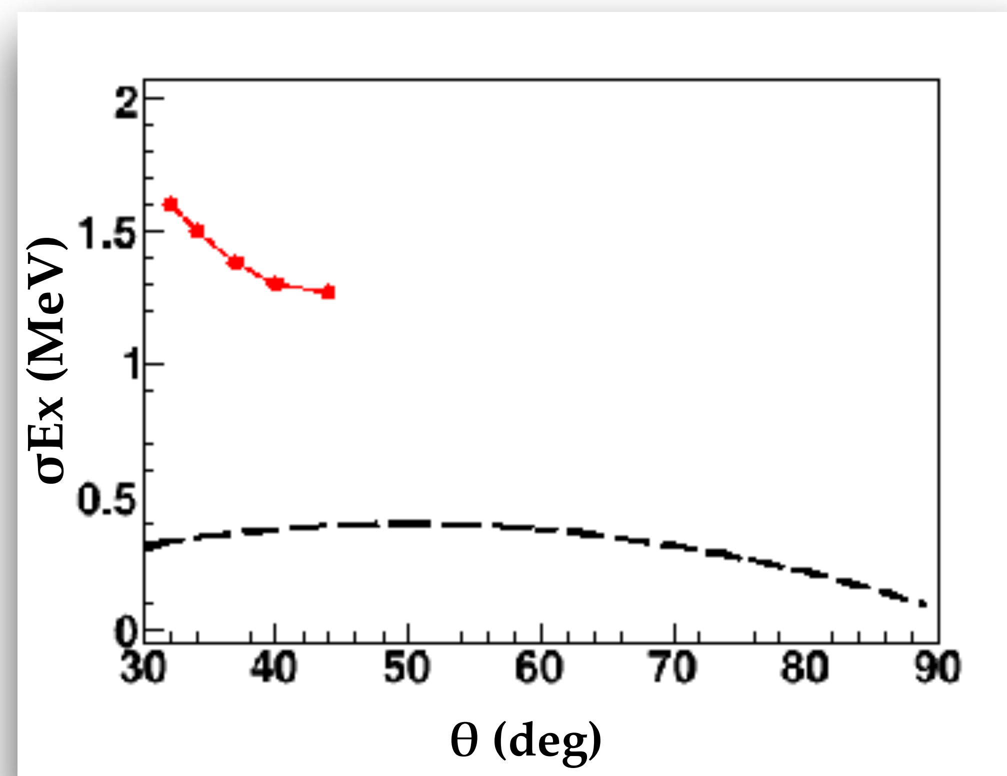
Step Forward

- ~500 keV Ex resolution -> High granularity
- Isotopic identification up to O -> Uniformity in ΔE (~70 μm)
- Ion energies up to 300 MeV -> PSA? ΔE-E method?
- Geometrical efficiency -> At least same angular coverage
- Allocate different kinematics -> Mechanical adaptation

SPIDER:
1.5 mm strips @ 4 cm from target
30 deg <θ<47 deg
No isotopic identification above C
No mechanical adaptation

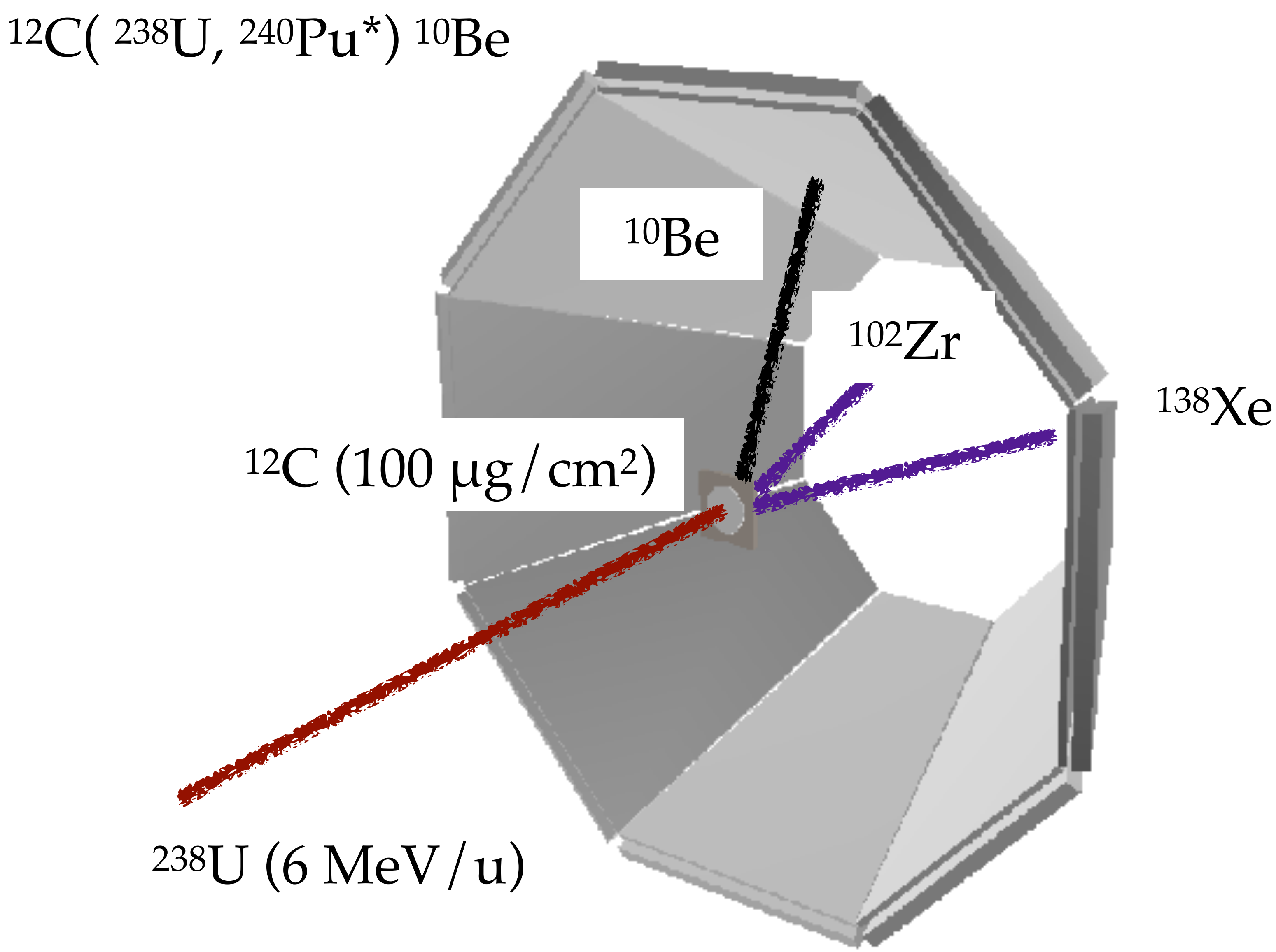


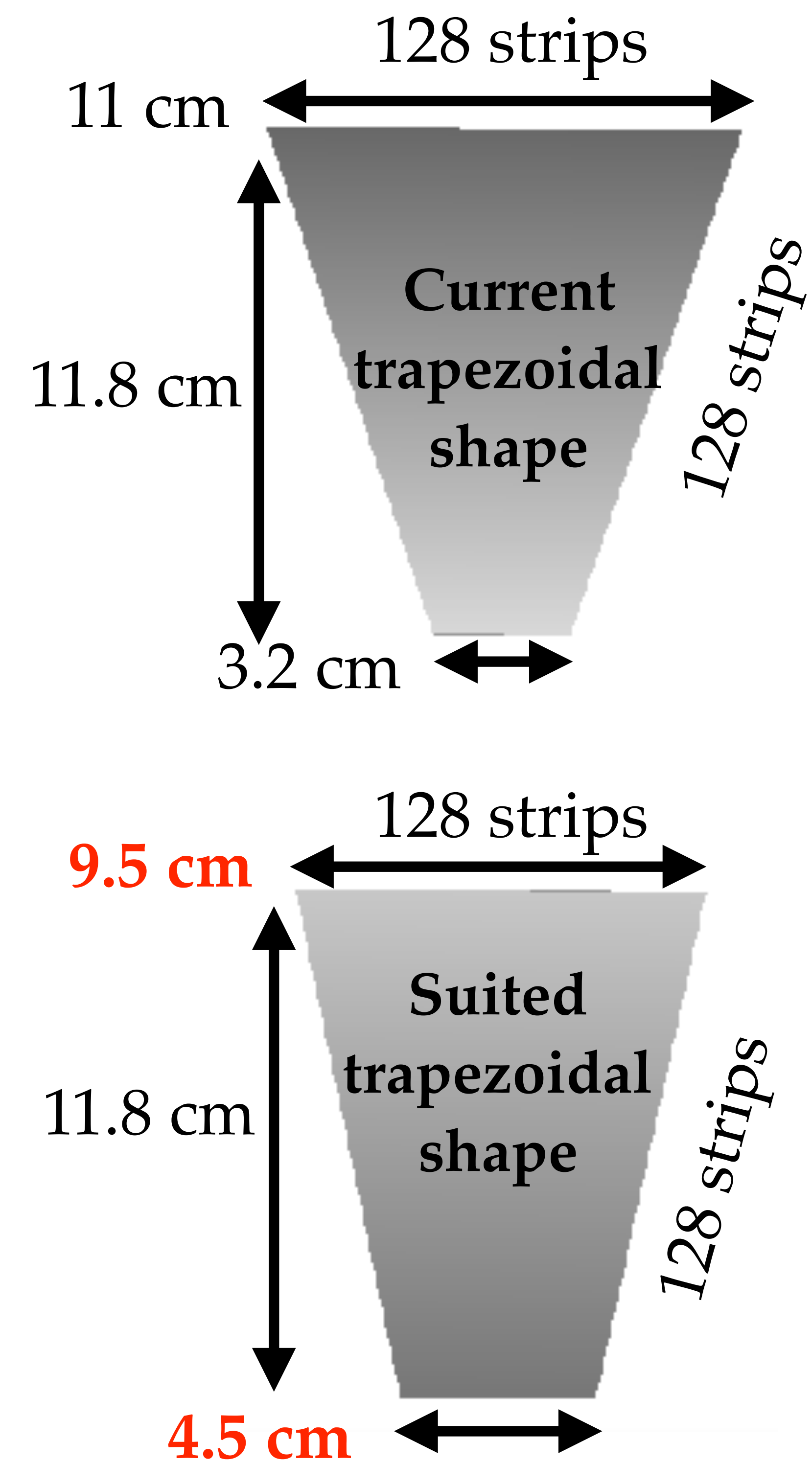
NEW DETECTOR
700 μm strips @ 10 cm from target
30 deg <θ<80 deg



- **This requirements ensure a factor 3 better resolution in excitation energy**

Possible configuration

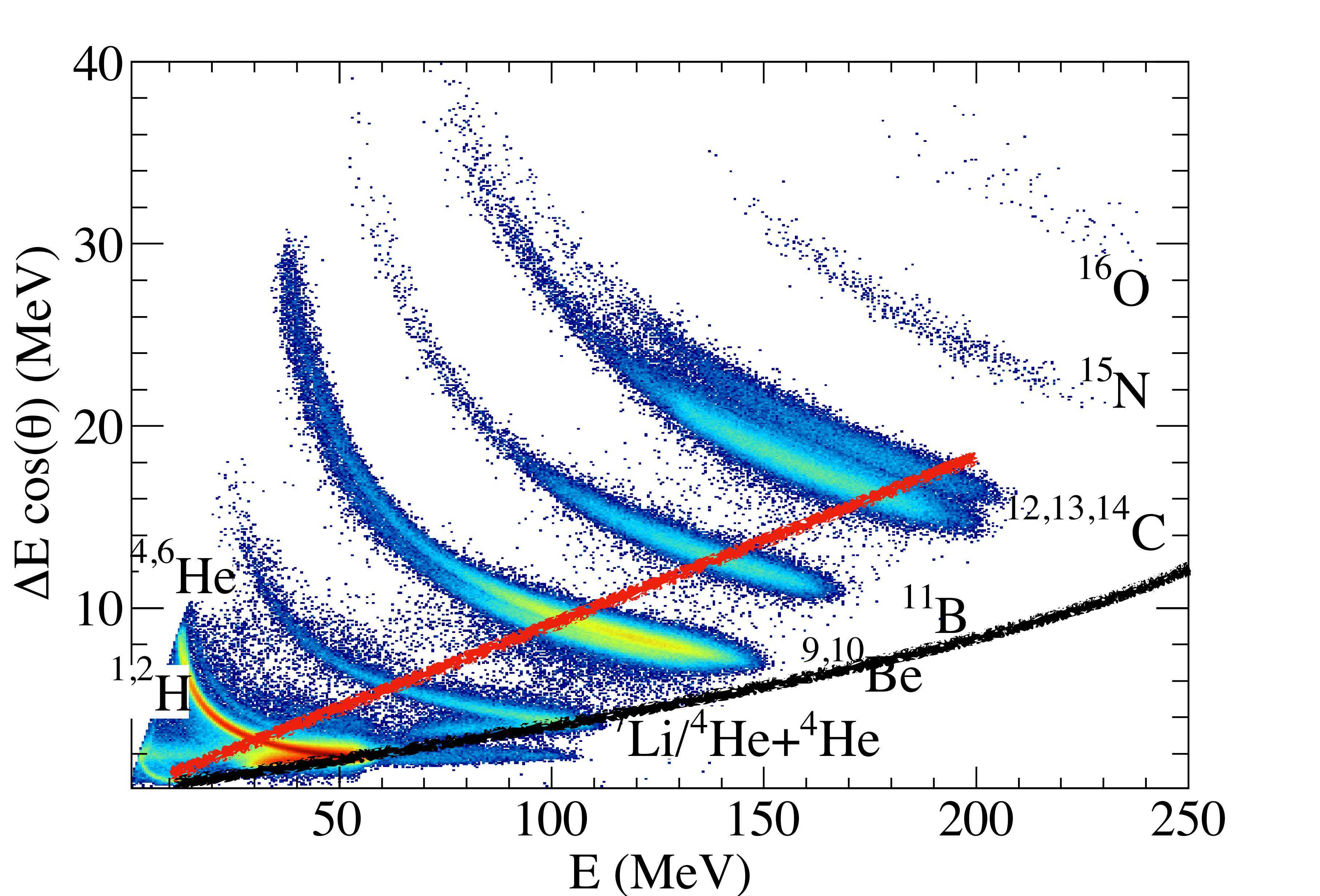




- **Ensure 30 deg hole**
- **10 cm from target**
- **128 x 128 channels (dE)**
- **Adapted mechanics**
- **New shape**
- **PSA or DE vs. E ?**

- Possible coupling with gamma calorimeter at backward angles

Possible configuration



Thickness:

500 µm is not enough to stop the most energetic ions inside detector

~1 mm thickness needed

- Ensure 30 deg hole
- 10 cm from target
- 128 x 128 channels (dE)
- Adapted mechanics
- New shape
- PSA or DE vs. E ?

- Possible coupling with gamma calorimeter at backward angles

Contribution of the detector to the completeness of this setup

GRIT contribution

	VAMOS (GANIL)	SOFIA (GSI)	J-PARC	n-induced
Complete Fission Yields	Yes	Yes	Yes	No
Isotopic Fission Yields	Yes	Yes	No	No
Exotic Systems	Yes	Yes	Yes	No
Heavier than ^{238}U	Yes	No	Yes	Yes (long lived)
Excitation Energy Control	Yes	No	Yes	Yes
Both Fragments Detection	Yes (ongoing)	Yes	Yes	Yes
Isotopic scission Kinetic	Yes (ongoing)	No	No	No

The fission program at VAMOS/GANIL has the chance to provide, in the near future, the most complete measurements in the field so far

Conclusions

- The fission program at VAMOS/GANIL is an ongoing successful program with large perspectives

- Further steps in the setup improvement are required in order to continue this experimental program:
  - Second arm to measure simultaneously both fission fragments
  - Gamma-calorimetry measurement
  - **Improving the detection of the target-like recoil and the E_x measurement**

- This fission project could profit from the knowledge and experience achieved by the GRIT collaboration.

- The detector requirements would fit, fully or partially (detectors design, electronics, etc), inside the GRIT project.

Collaboration

GANIL, France

- D. Ramos, A. Lemasson, M. Rejmund, J.D. Frankland, J. Piot, D. Ackermann, E. Clement, B. Jacquot, T. Roger

IGFAE, University of Santiago de Compostela, Spain

- M. Caamaño, H. Álvarez-Pol, B. Fernández-Domínguez

IPHC Strasbourg, France

- C. Schmitt

LPC Caen, France

- F. Farget, D. Durand

IPN Orsay, France

- L. Audouin

CENBG Bordeaux, France

- A. Henriques, B. Jurado, I. Tsekhanovich

LIP Lisboa, Portugal

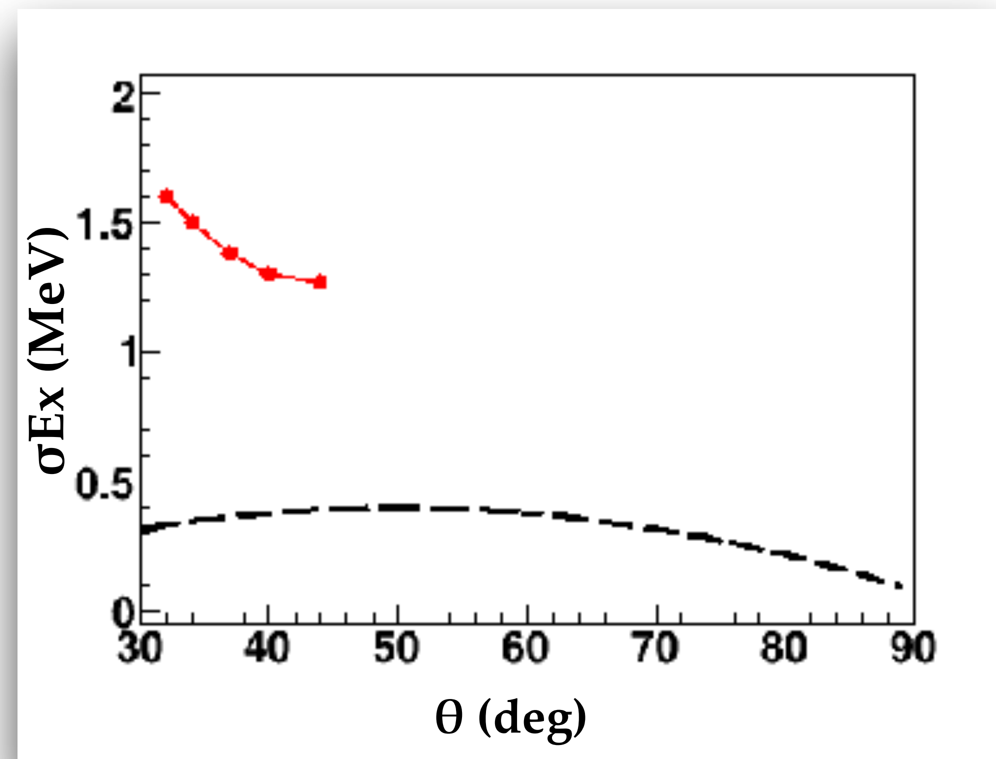
- D. Galaviz, P. Teubig

Chalmers University of Technology, Sweden

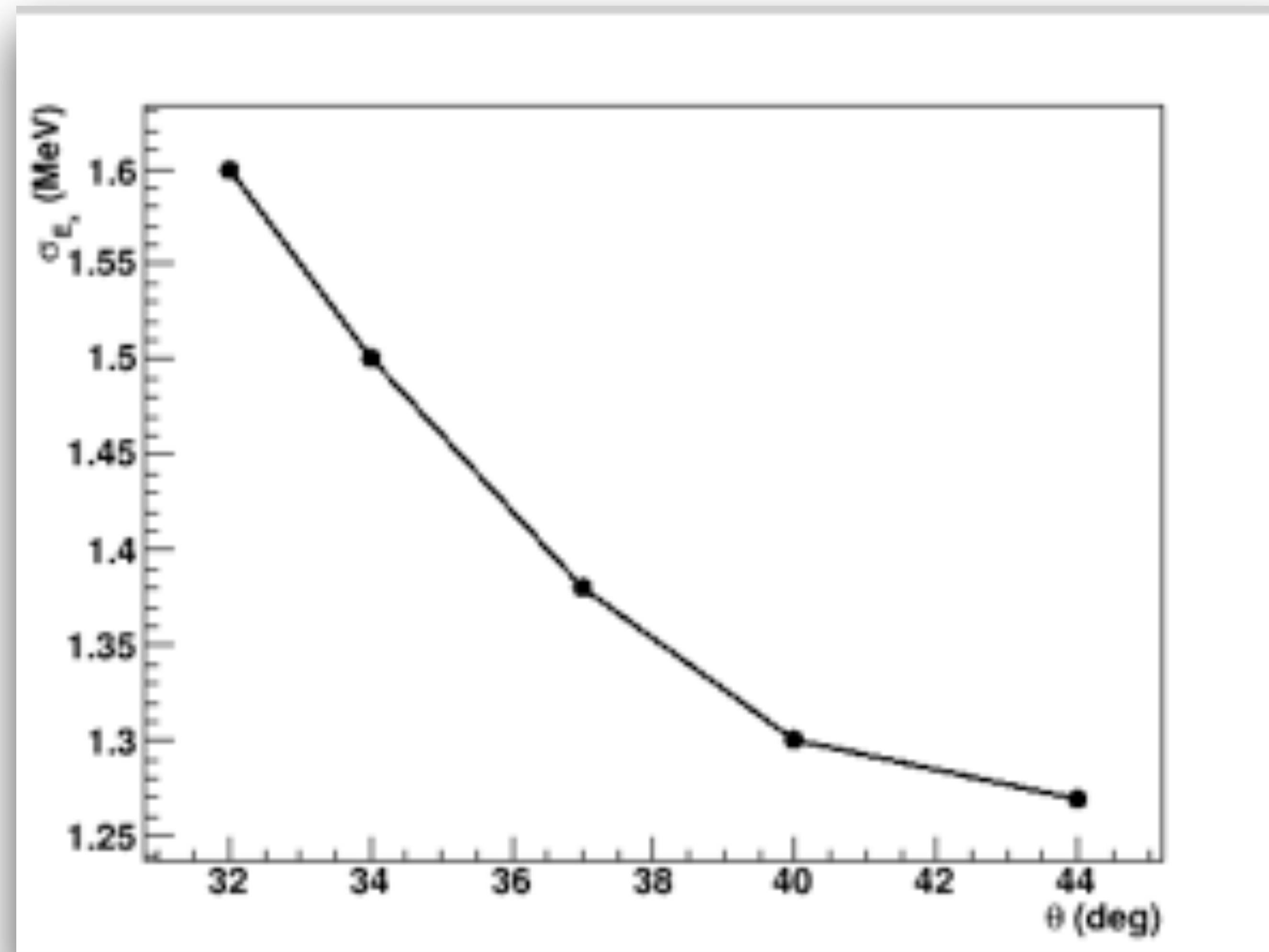
- A. Heinz

Excitation Energy Resolution

Excitation energy resolution
due to the angular granularity



Total excitation energy
measured from the elastic peak



The main contribution to the excitation energy resolution comes from the angular granularity