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DISCOVERY OF A NEW SHAPE ISOMER IN MEDIUM HEAVY NUCLEI AT FLNR (JINR)

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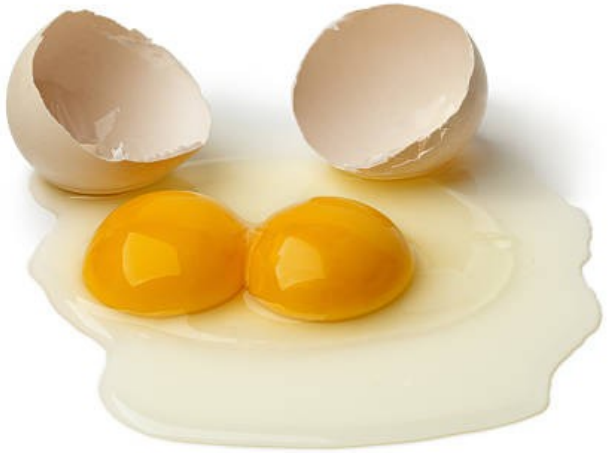
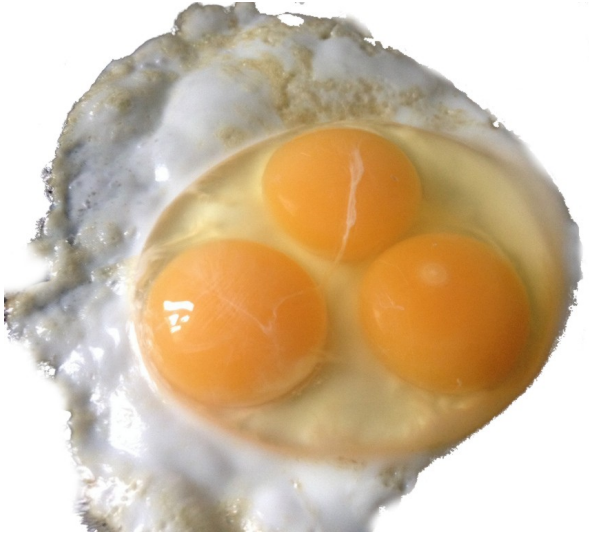
DIAS, Dubna, 2026







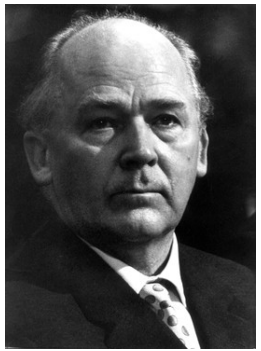
NUCLEAR FISSION

Otto Hahn & Fritz Strassmann (1938): Experimental discovery of fission

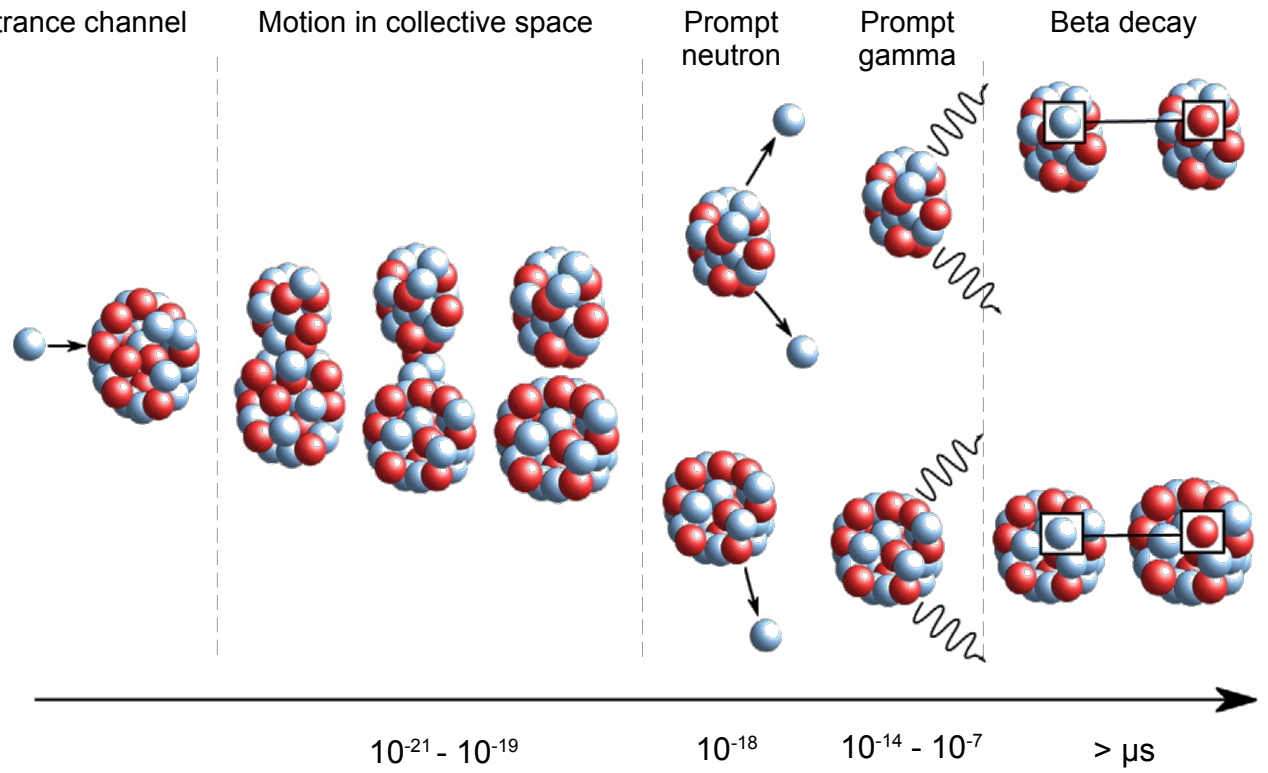
Lise Meitner & Otto Frisch (1939): Theoretical explanation and the name “fission”



Otto Hahn



Fritz Strassmann



NUCLEAR MODEL

George Gamow (1930): Originator of the liquid drop concept

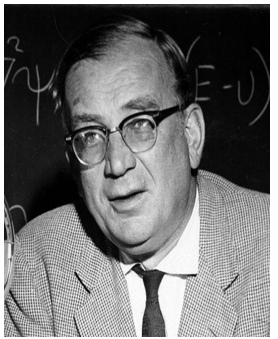
Niels Bohr & John A. Wheeler (1939): Extended the model to describe fission



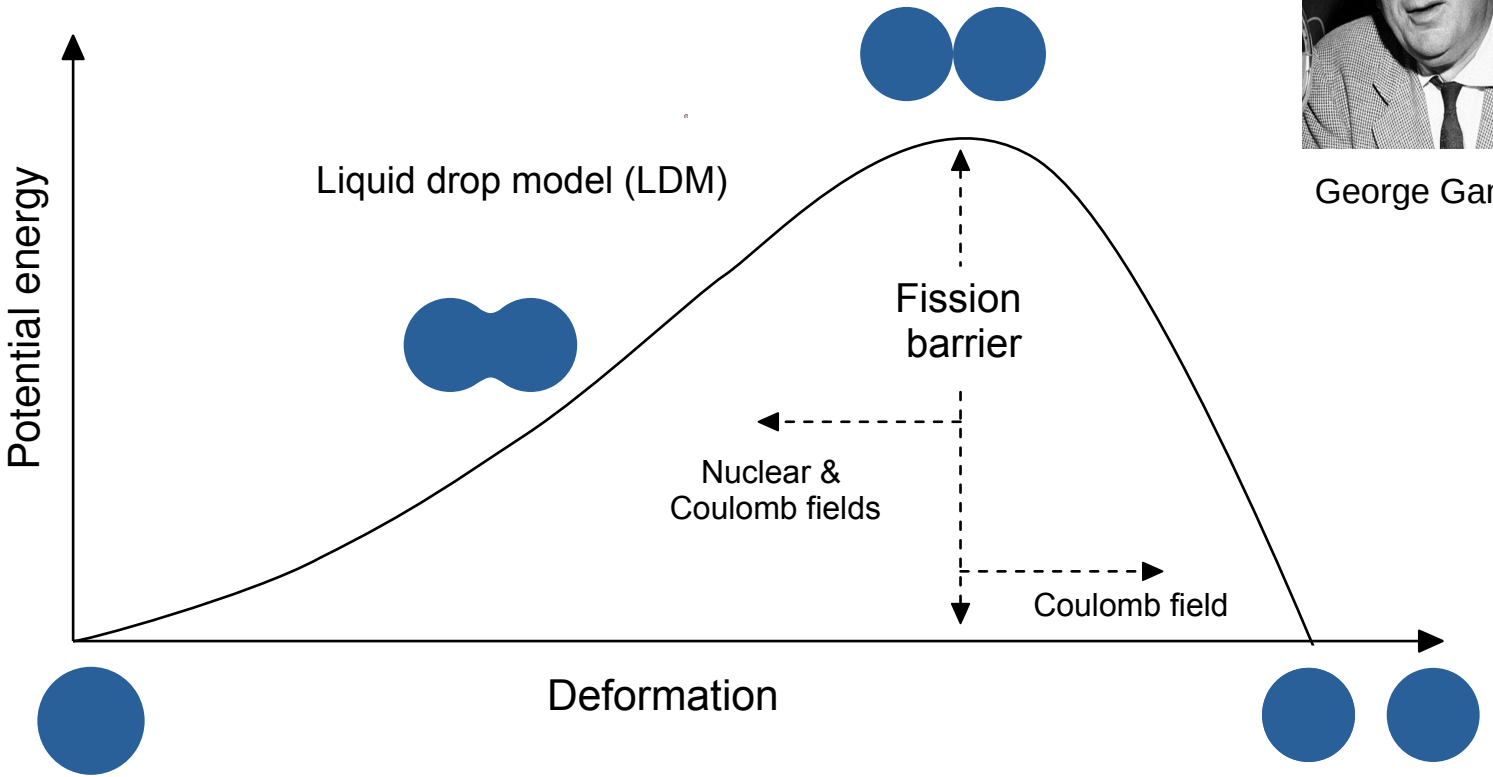
Niels Bohr



John A. Wheeler



George Gamow



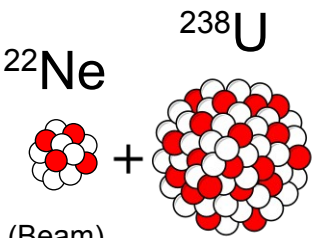
DISCOVERY OF FISSION ISOMER

In1962, fission isomer was firstly discovered at **FLNR (JINR)**



S. M. Polikanov

S. Polikanov et al., Zh. Eksp. Teor Fiz. 42, 1464 (1962)



^{242}Am was formed at an excited state and undergone fission

Some fission fragments were observed with the half-life of 14 ms

Fission occurred from an isomeric excited state

This state resists gamma decay for such a time and has a small fission half-life compared with its ground state

New model to descript new physics

SOVIET PHYSICS JETP VOLUME 18, NUMBER 3 MARCH, 1964

HALF-LIFE OF A SPONTANEOUSLY FISSIONING ISOMER

V. P. PERELYGIN and S. P. TRET'YAKOVA

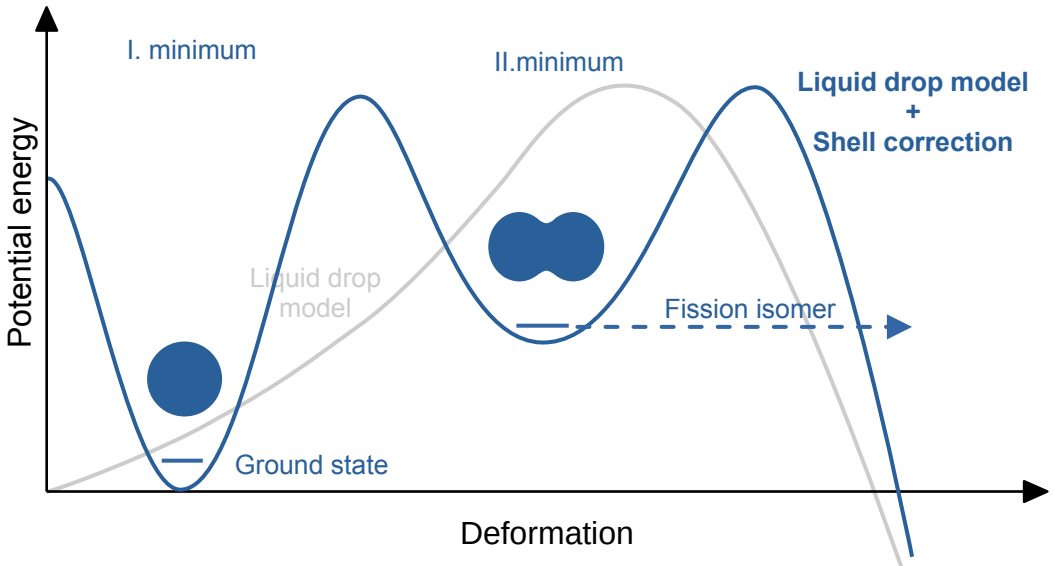
Joint Institute for Nuclear Research

A subsequent experiment confirmed the same fission isomer was produced in the corresponding reaction.

FISSION ISOMER VS SHAPE ISOMER

V. M. Strutinsky (1967): incorporate the shell effect into LDM

Distinctive features of actinide nuclei is that their fission barrier is not a simple single hump, but rather a double-humped barrier.

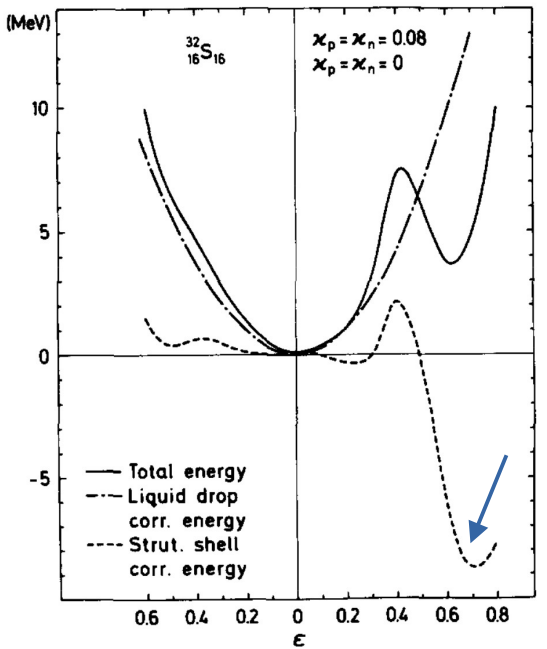


When these additional minima are sufficiently deep, then the nucleus may exist in a shape isomer

Volume 41B, number 2 PHYSICS LETTERS 18 September 1972

SHELL STRUCTURE FOR DEFORMED NUCLEAR SHAPES

R. K. SHELINE *, I. RAGNARSSON and S.G. NILSSON
Department of Mathematical Physics, Lund Institute of Technology, Lund, Sweden

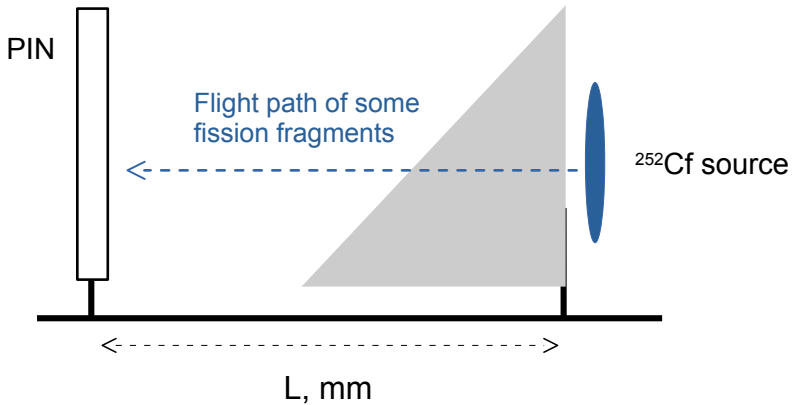


The existence of numerous shape isomer states even in the same isotope are predicted in the wide range of nuclei from very light one as ^{32}S up to super-heavy.

TIME OF FLIGHT MEASUREMENT

PIN diode is used as both energy and stop time detector

Time detector for recording start time



The method is to determine the speed of a ion by measuring the ion flight time t across a know distance L

Knowing the ion velocity V, energy E one obtain the mass and thus the identity of the ion by using the formula

$$E = \frac{M \cdot V^2}{1.9297}$$

The interaction of ions in the PIN diode lead to some phenomena that restrict the energy and time measurement

Thus only parts of the energy and time are recorded

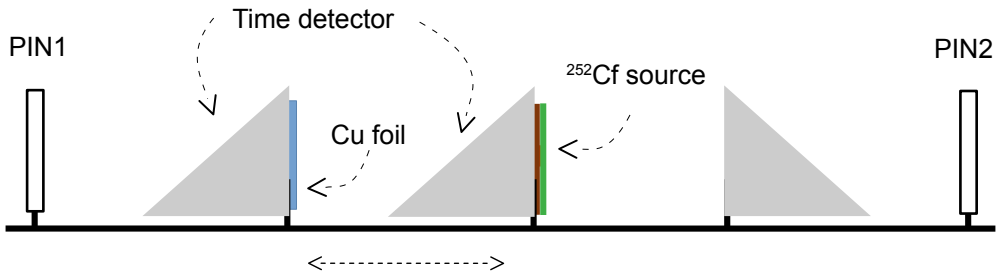
Quantify the phenomena into parameters and include these variables in a complicated calculation procedure

Plasma delay: $t_P = \gamma \cdot M^{1/6} \cdot E^{1/2}$

Pulse height defect: $R(M,E) = \frac{\lambda \cdot E}{1 + \varphi \cdot \frac{E}{M^2} + \alpha \cdot M \cdot E + \beta \cdot E}$

True energy and time measured values

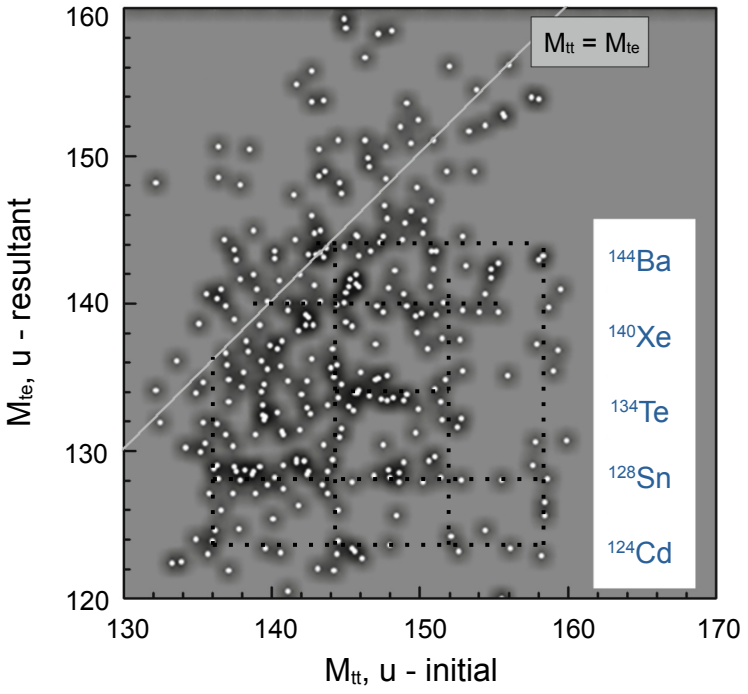
LIGHT IONS SPECTROMETER (LIS)



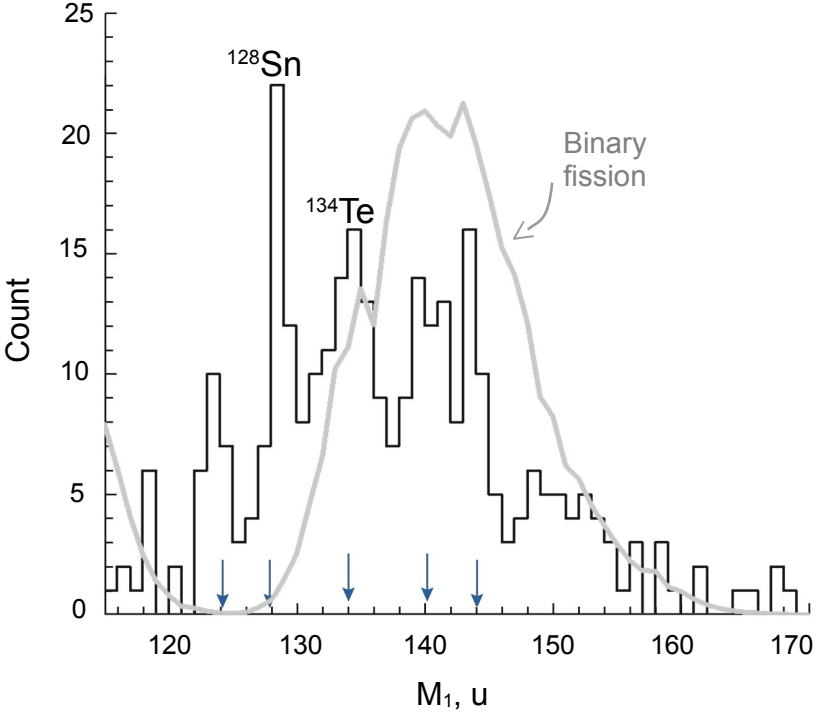
Fast multichannel digitizer VX1742



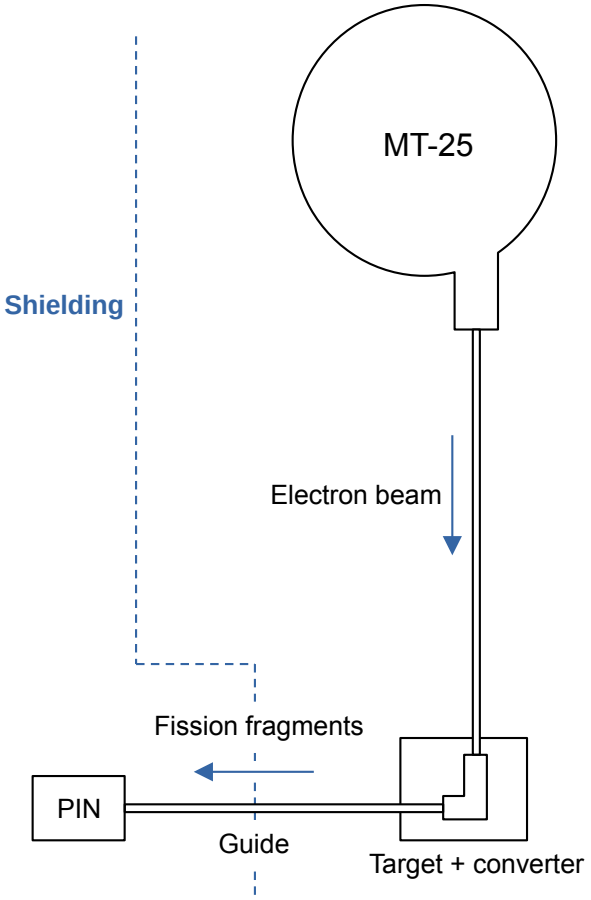
Digitization interval 0.2 ns

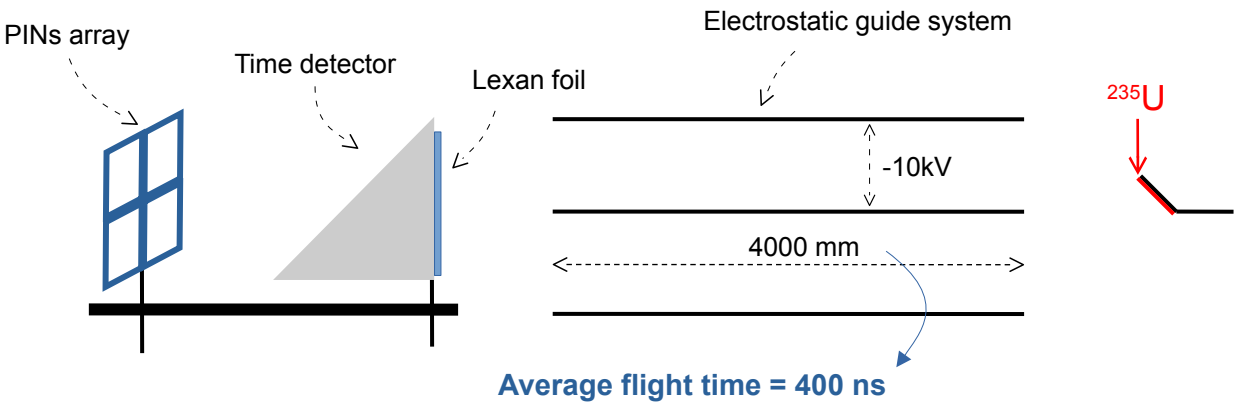


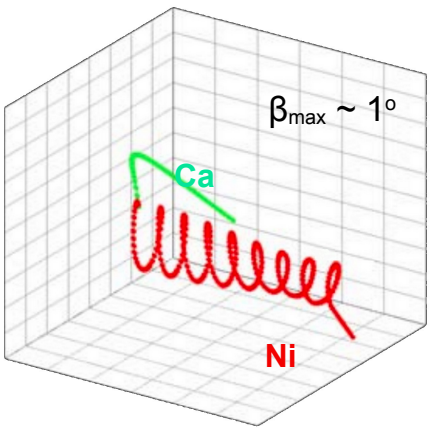
Project data points on the M_{te} axis



VELOCITY- ENERGY GUIDE BASED ARRAY (VEGA)

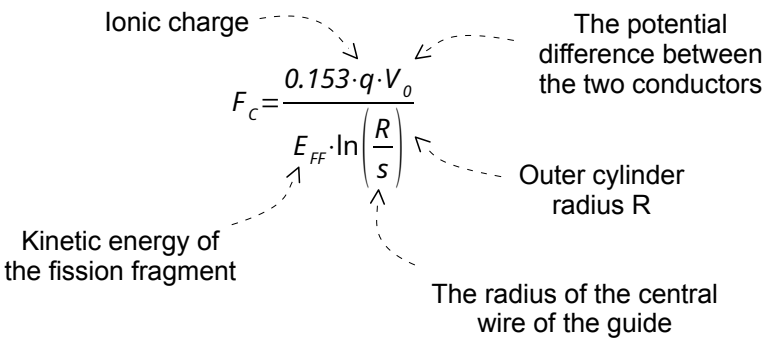




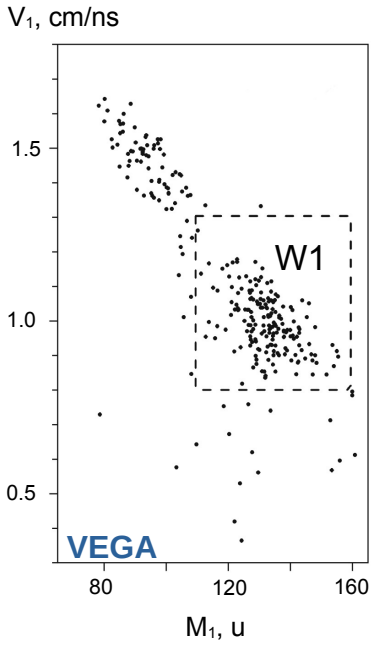


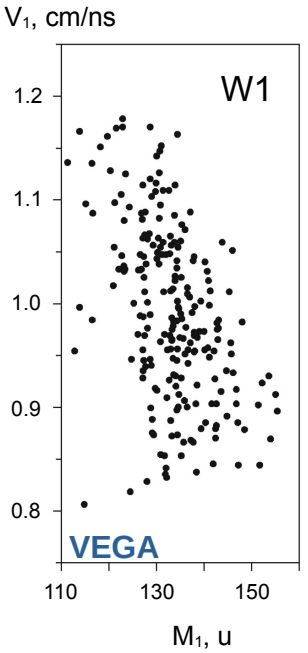
3D trajectories of the initially collinear ions of Ca and Ni

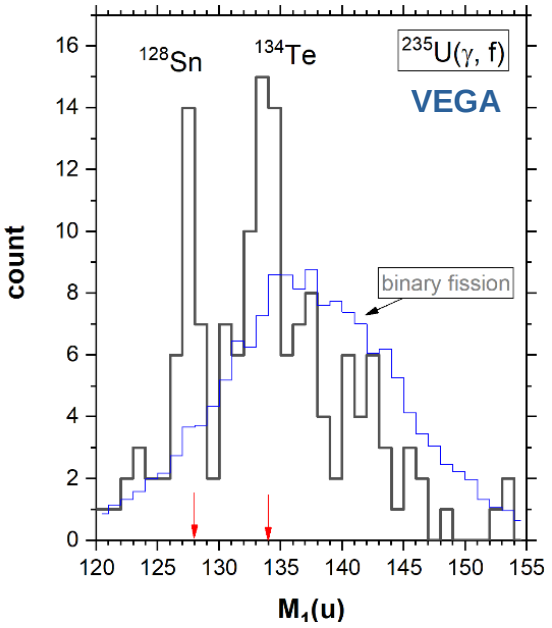
The collection efficiency F_C of the guide:

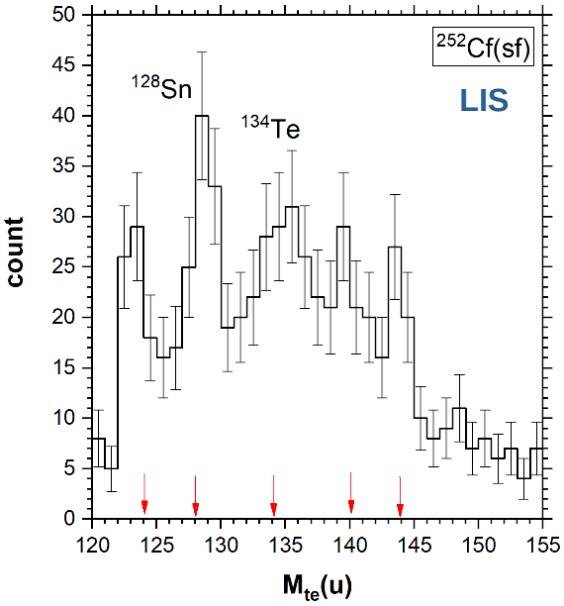


VEGA EXPERIMENTAL RESULTS







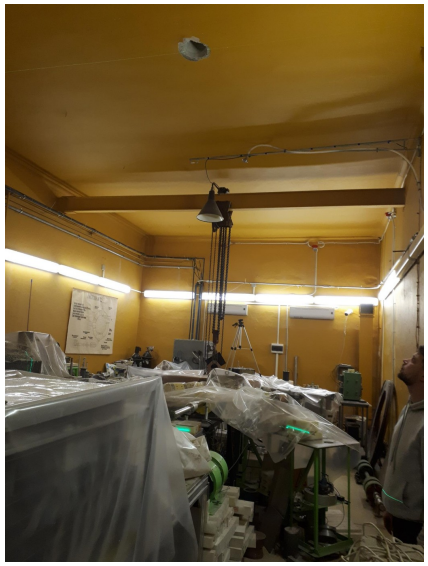


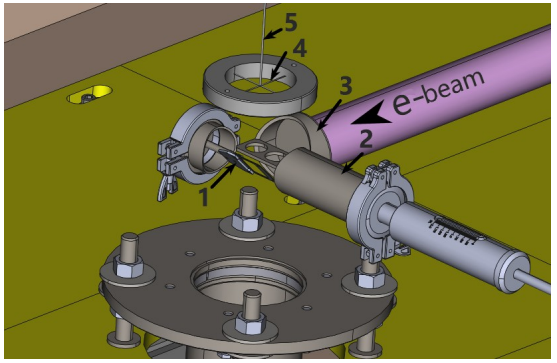
Similar break-up of heavy FFs of two different mother systems in two different foils were observed.

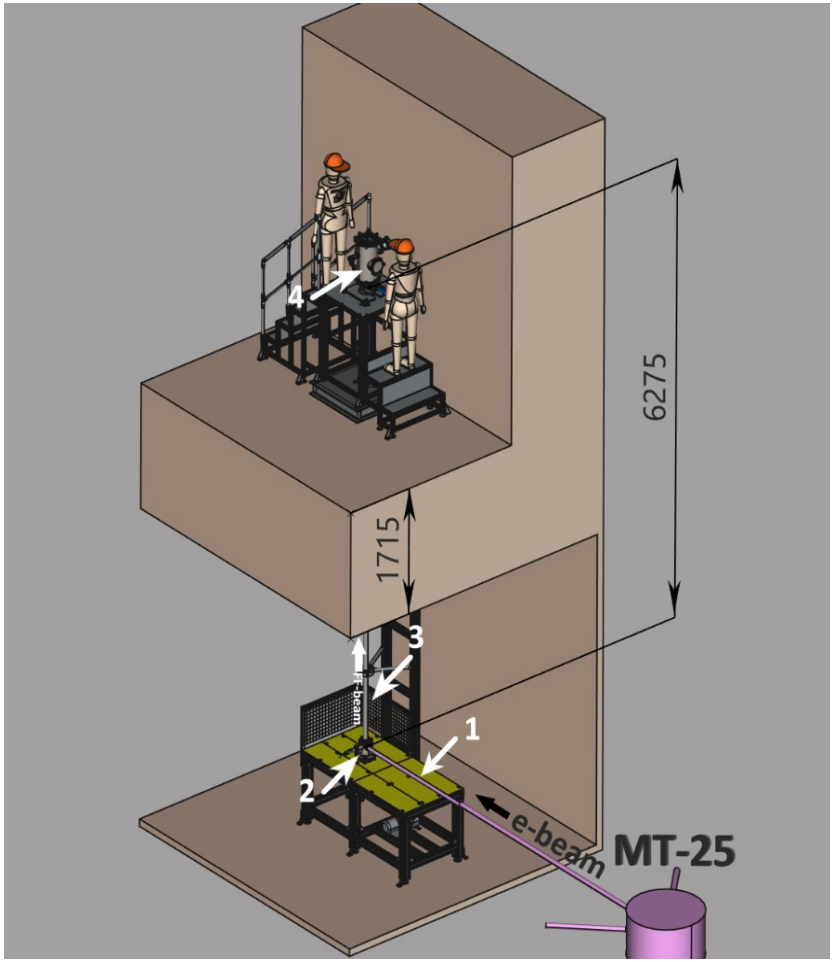
Magic nuclei of ^{128}Sn and ^{134}Te demonstrate themselves as the cores of the deformed heavy fission fragments being in the shape isomer states.

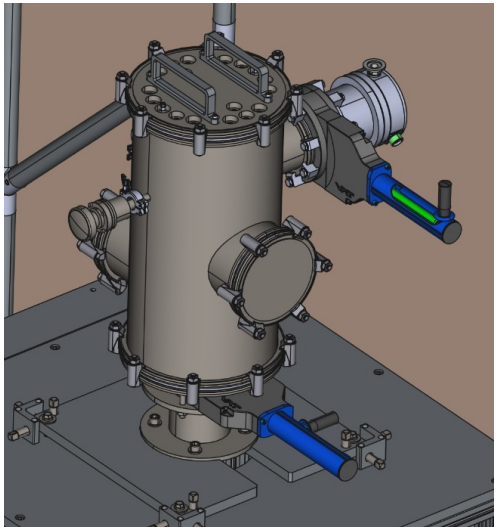
NEAREST PLANS

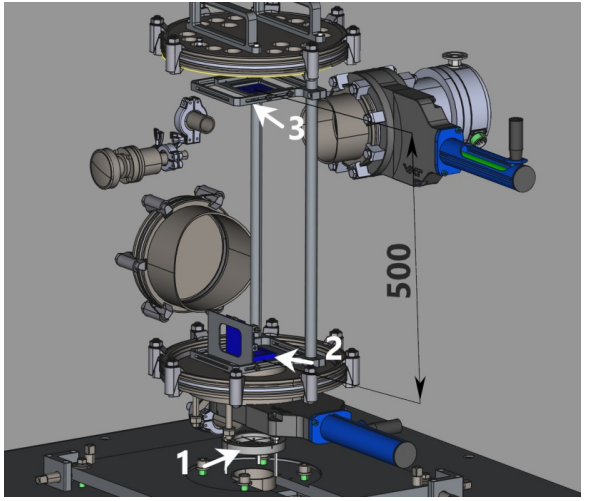
VEGA-m: in progress …











CONCLUSION

1. The induced fission (break up) of a certain part of fission fragments in the shape isomer states was discovered through different experiment methods.

2. The life time of at least some of such states exceeds 400 ns.

3. The shape isomer state in fission fragments manifests itself through delayed break up of the fragments in a solid state foil.

4. This discovery was firstly observed by FOBOS group.

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Thank You

For Your Attention

