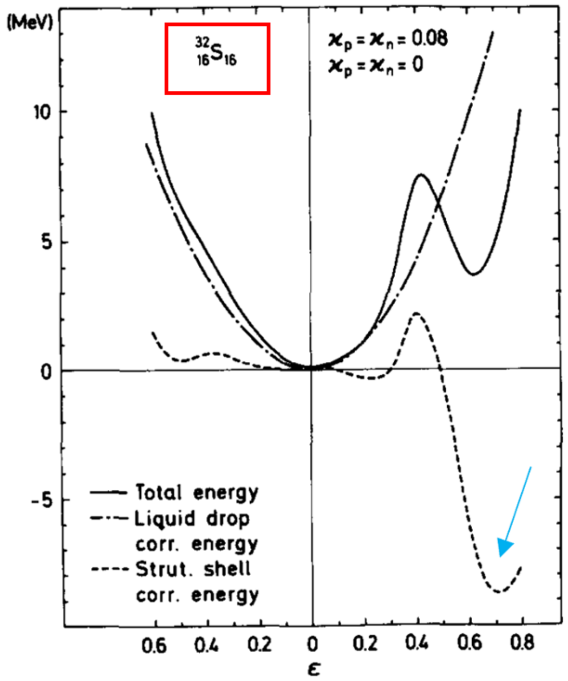
Наблюдение делящихся изомеров формы в осколках спонтанного и вынужденного деления тяжелых ядер.

Д.В. Каманин
ЛЯР ОИЯИ, Дубна

Представляются результаты серии экспериментов, результаты которых указывают на наличие **долгоживущих делящихся изомеров в осколках бинарного деления** слабо возбужденных тяжелых ядер. В качестве специфического детектора таких состояний выступает **неупругое рассеяние подобных осколков в твердотельных фольгах.** В результате рассеяния осколок испытывает бинарный развал (break-up). Обсуждаемые результаты характеризуются абсолютной новизной: индуцированное деление холодного среднетяжелого ядра из состояния изомера формы не наблюдалось ранее экспериментально и отсутствуют теоретические предсказания наблюдаемого эффекта.

Некоторые известные данные
об изомерии в широком диапазоне ядер

Shape isomers - predictions

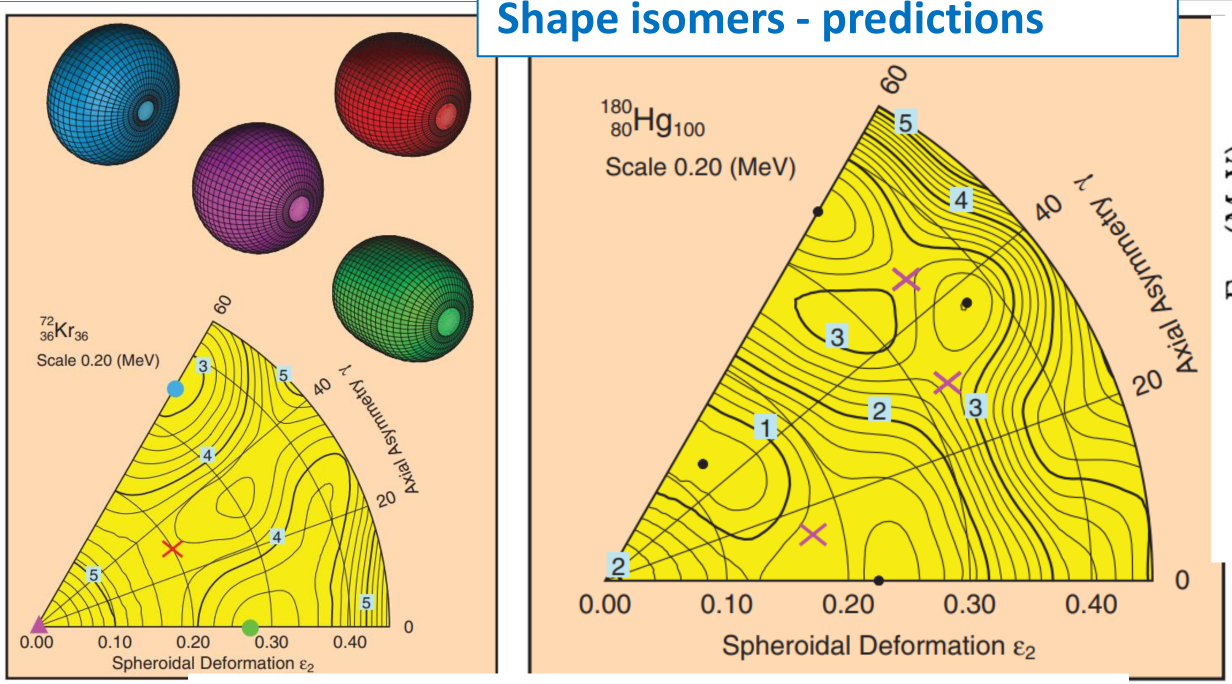


Volume 41B, number 2 PHYSICS LETTERS 18 September 1972

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

When one of these additional minima is sufficiently deep, then the nucleus may exist in a state corresponding to the energy and shape of this minimum; this state is a shape isomer. The lifetime of the shape isomer will depend on the overlap between the nuclear wavefunctions of the shape isomer and the ground state, the excitation energy of the shape isomer, and the height of the saddle separating the shape isomer and the ground state.



PRL 103, 212501 (2009) PHYSICAL REVIEW LETTERS week ending 20 NOVEMBER 2009

Global Calculation of Nuclear Shape Isomers

Peter Möller,[1,*] Arnold J. Sierk,[1] Ragnar Bengtsson,[2] Hiroyuki Sagawa,[3] and Takatoshi Ichikawa[4,†]

Atomic Data and Nuclear Data Tables 98 (2012) 149–300
Contents lists available at SciVerse ScienceDirect
Atomic Data and Nuclear Data Tables
journal homepage: www.elsevier.com/locate/adt
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Nuclear shape isomers

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[b] Department of Mathematical Physics, Lund Institute of Technology, P.O. Box 118, SE-22100 Lund, Sweden
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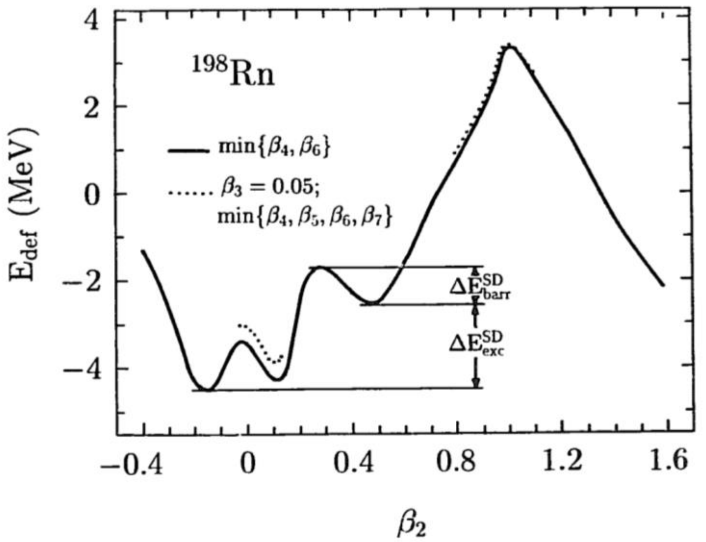
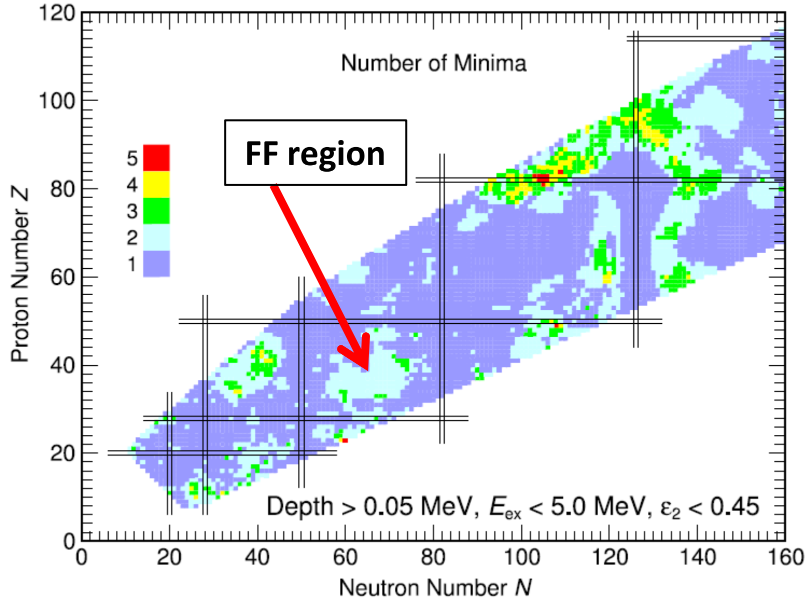
We calculate potential-energy surfaces as functions of spheroidal (ϵ2), hexadecapole (ϵ4), and axial asymmetry (γ) shape coordinates for 7206 nuclei from A = 31 to A = 290. We tabulate the deformations and energies of all minima deeper than 0.2 MeV and of the saddles between all pairs of minima. The tabulation is terminated at N = 160.... We also present potential-energy contour plots versus ϵ2 and γ for 1224 even–even nuclei in the region studied. We can identify nuclei for which a necessary condition for shape isomers occurs, namely multiple minima in the calculated potential-energy surface.



Nuclear Physics A529 (1991) 289–314
North-Holland

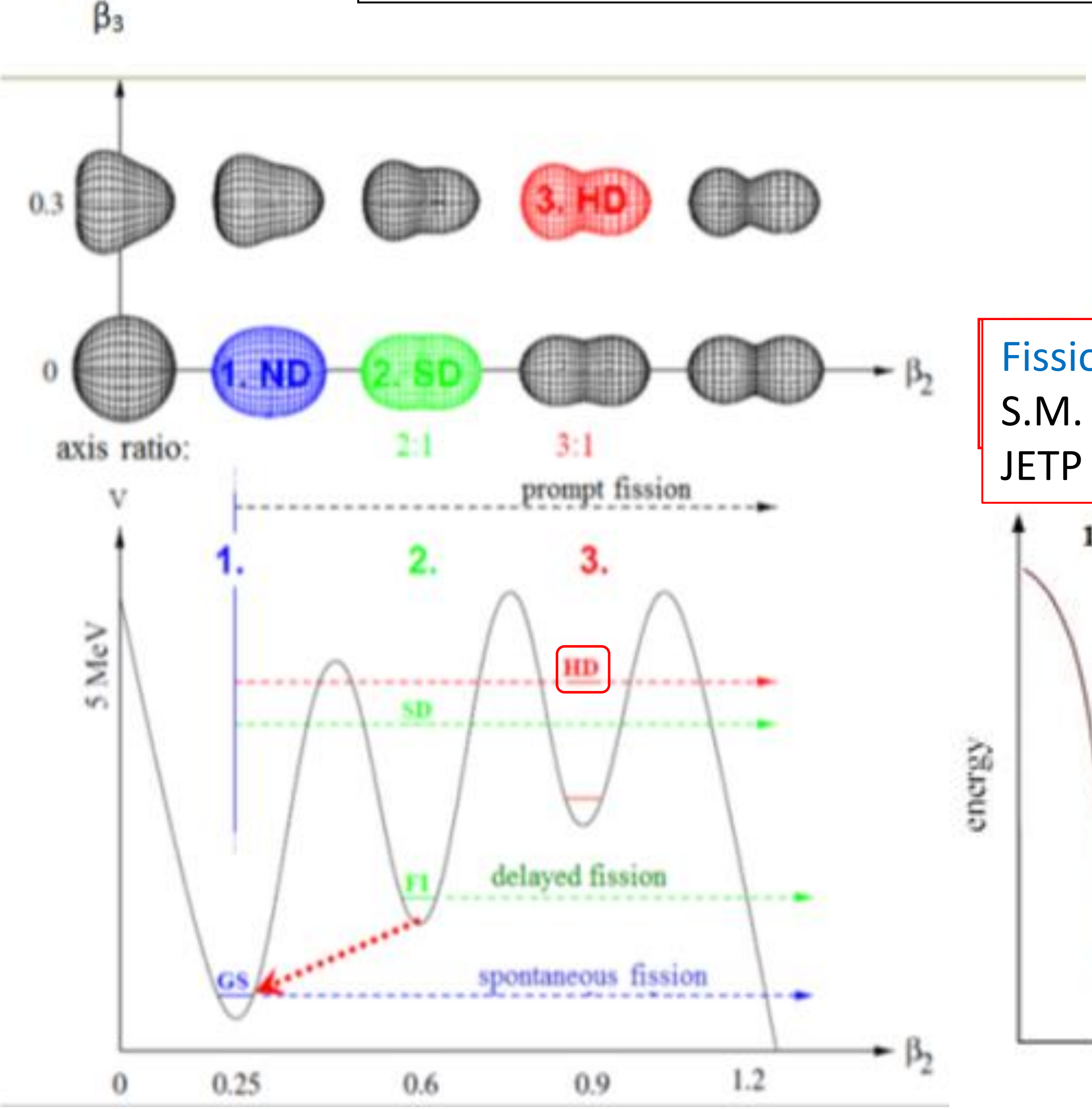
STRUCTURE OF SUPERDEFORMED STATES IN Au–Ra NUCLEI

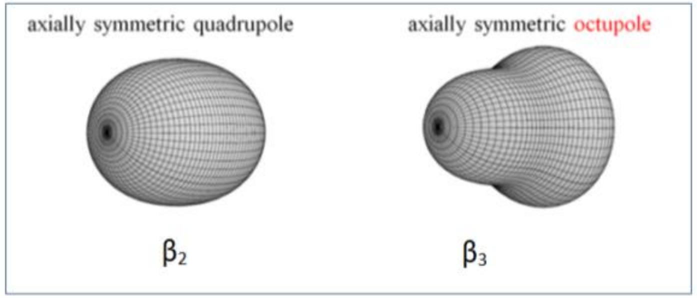
W. SATUŁA[a,b], S. ĆWIOK[c], W. NAZAREWICZ[b,c], R. WYSS[a,d] and A. JOHNSON[a]



Thus, 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.

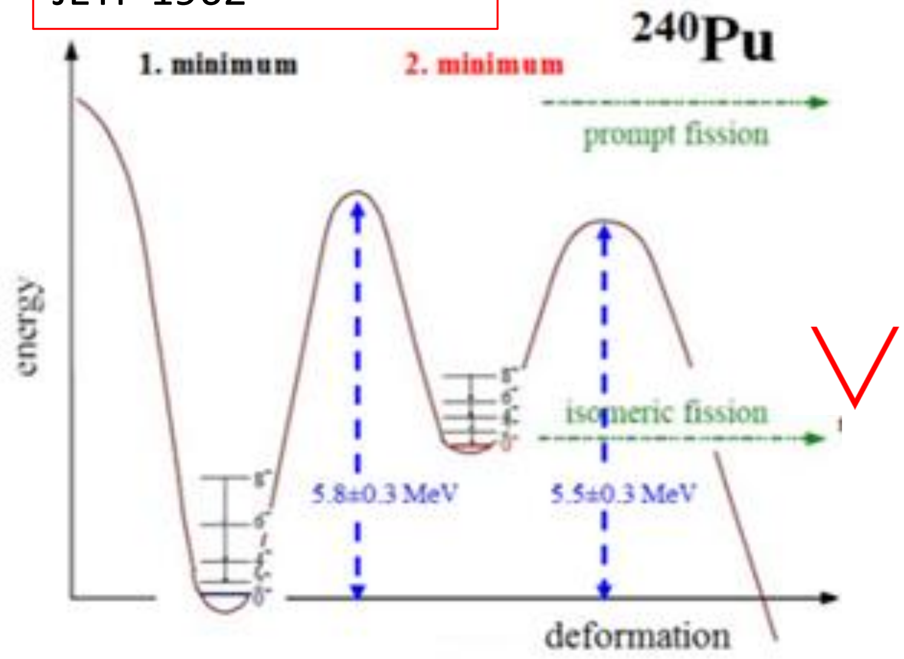
Next stage in studies of shape isomers : fission isomers





Fission isomers
S.M. Polikanov
JETP 1962

Discovered in
FLNR (JINR)

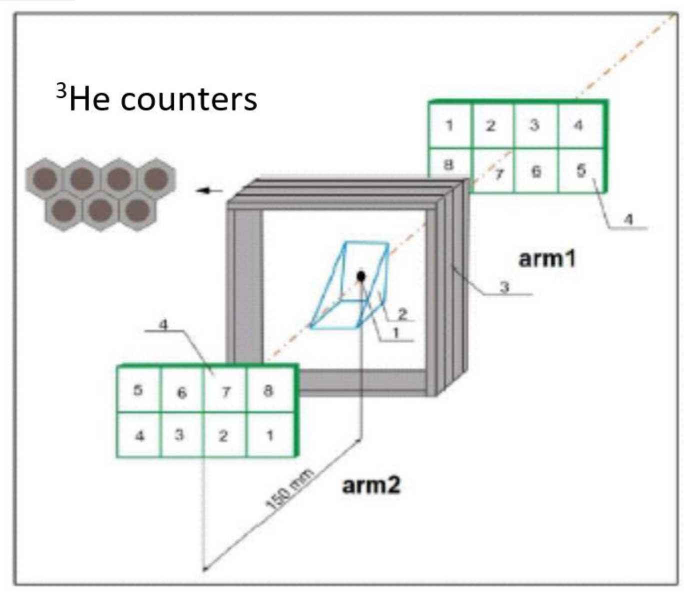


http://ns.ph.liv.ac.uk/posters/ptg/poster2.html

Экспериментальные подходы и полученные результаты в рамках данного исследования

Experimental approach №1:

Мозаичная система для регистрация трехкратных совпадений
Спектрометер COMETA (Correlation Mosaic E–T Array)
CAMAC, ^{252}Cf (sf),



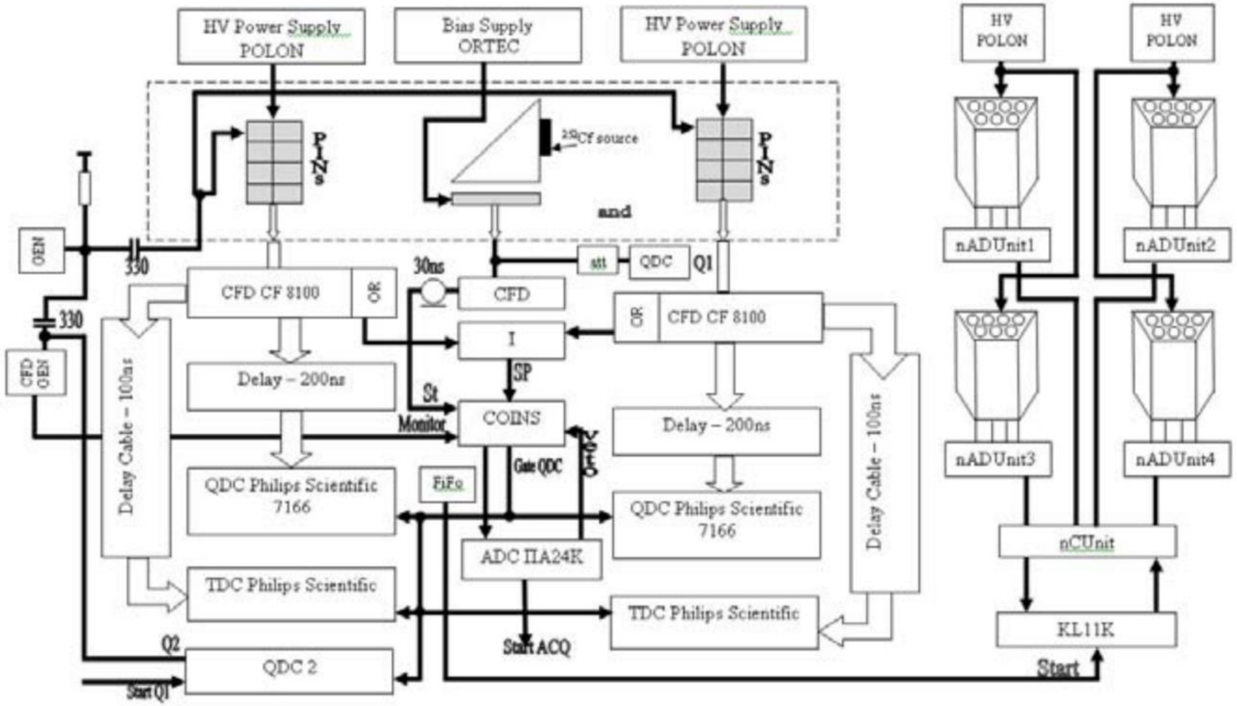


Fig. 1. a) – Scheme of the COMETA setup which consists of two mosaics of eight PIN diodes each (4), MCP based start detector (2) with the 252Cf source inside (1) and a “neutron bel”" (3) consisting of 28 3 He-filled neutron counters in a moderator. The section of the belt is marked by the arrow. b) – overall view of the spectrometer.

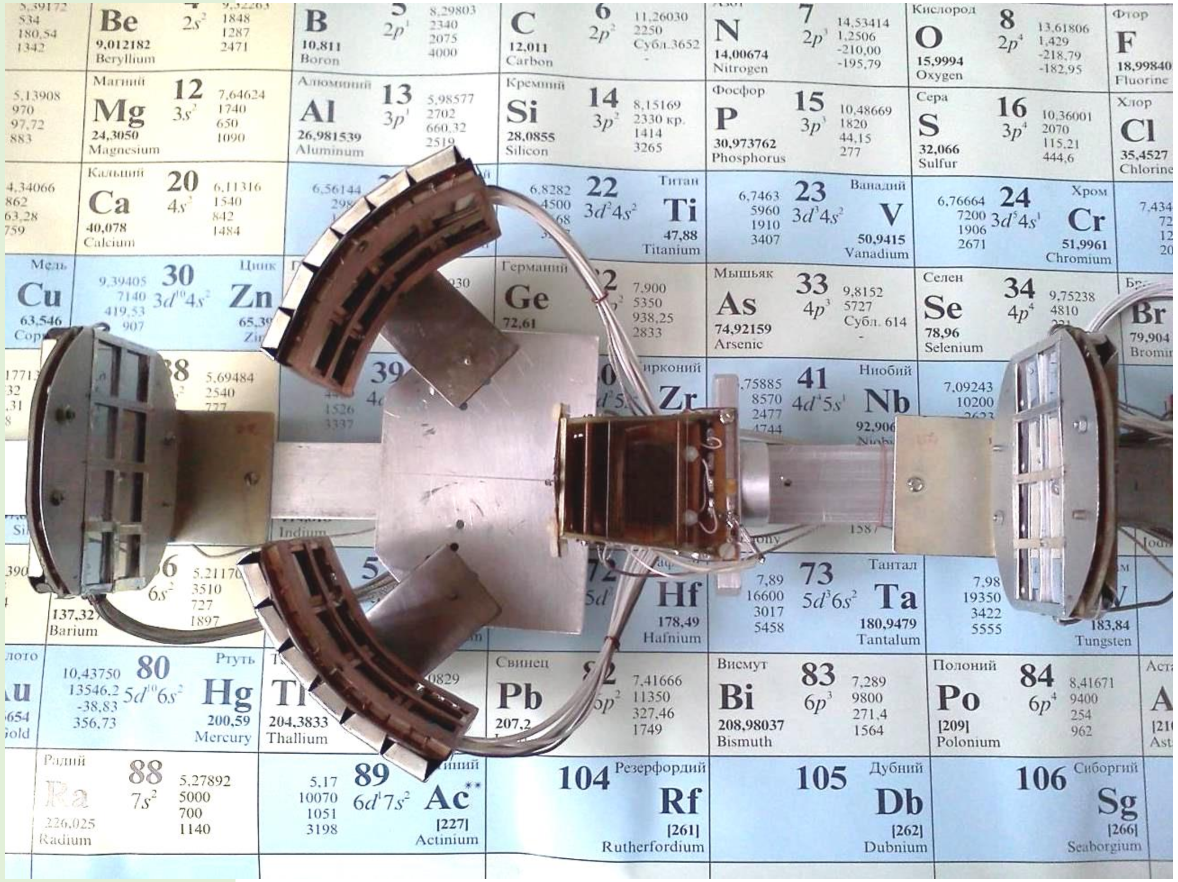
International Symposium on Exotic Nuclei "EXON-2012", Vladivostok, Russia, 01-06 October 2012. Conference proceedings, Editors: Yu.E.Penionzhkevich, and Yu.G.Sobolev. Published by World Scientific Publishing Co. Pte. Ltd., 2013. p. 411-416.

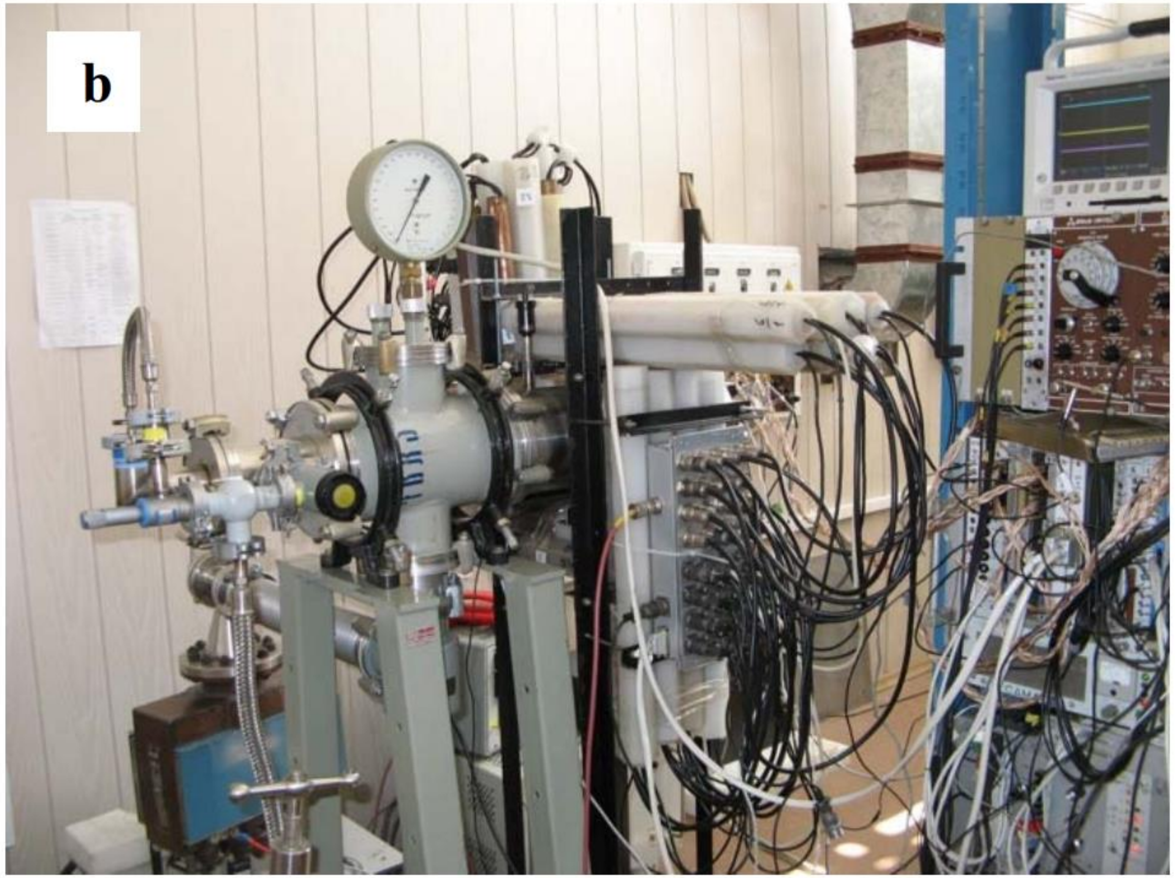
Experimental approach №1:

Расширение углового диапазона COMETA-2 setup

PIN-diodes 120˚& MCP

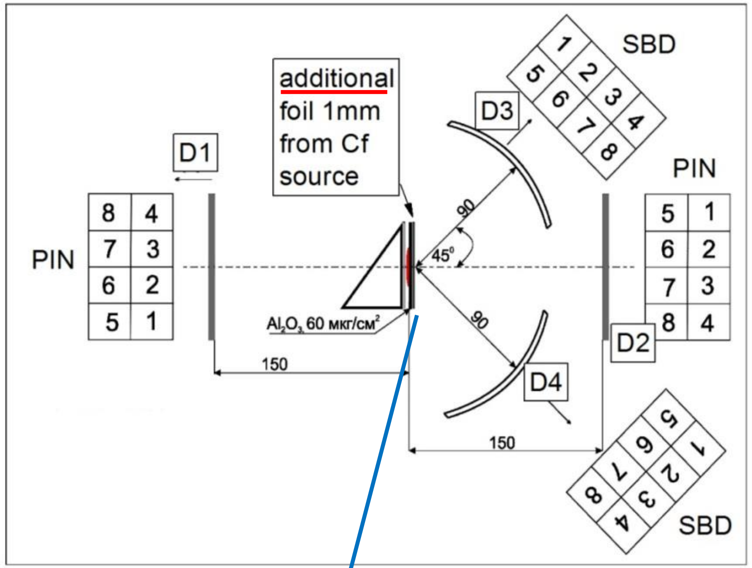
neutron belt 28 ^{3}He counters

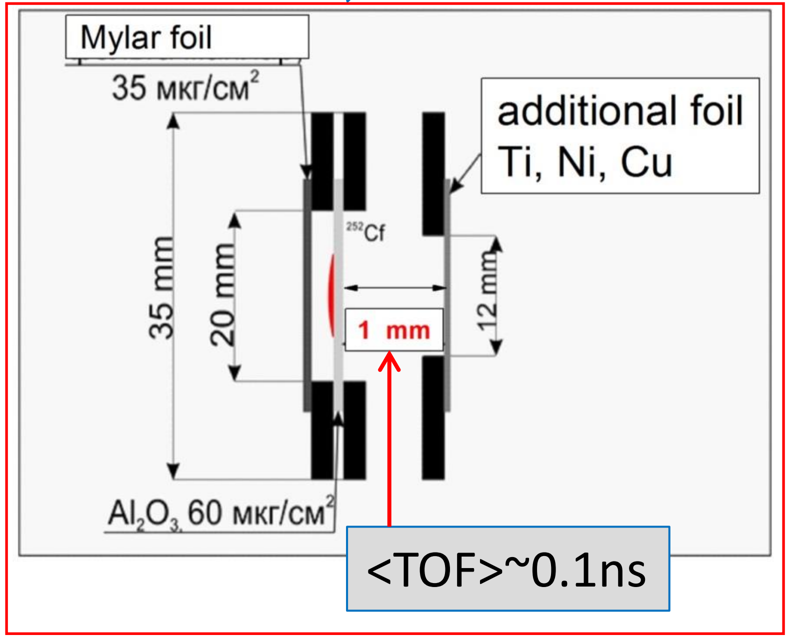


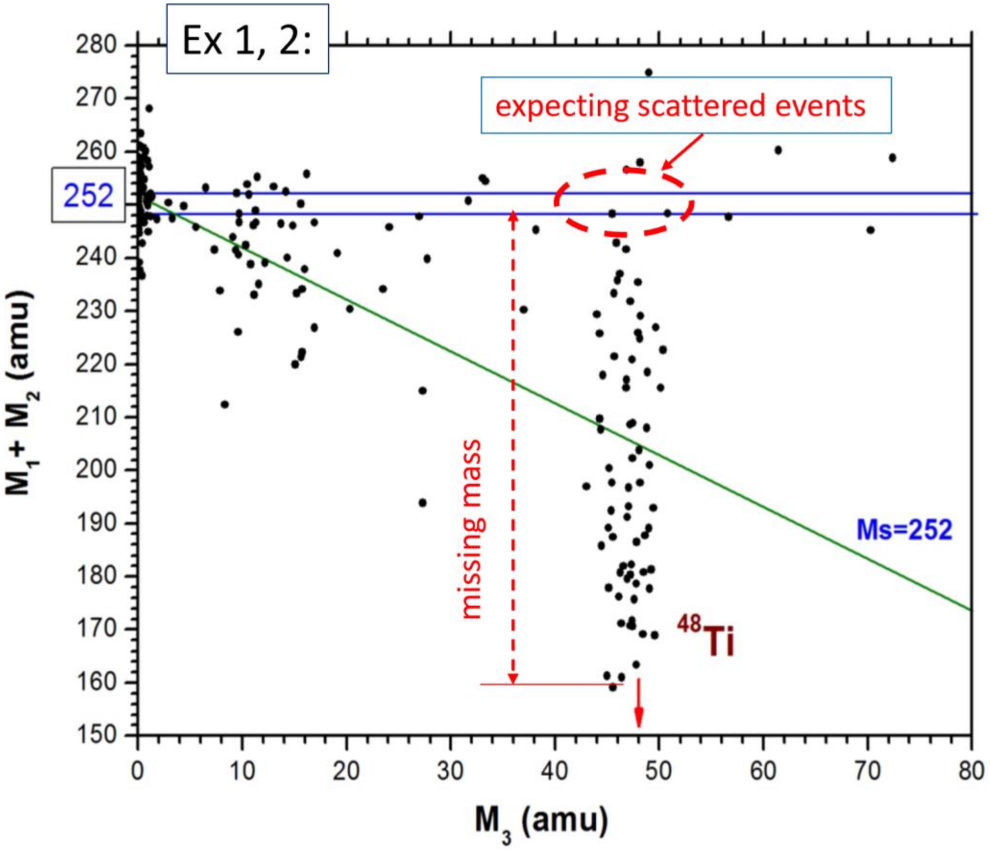


Experimental approach №1:

Экспериментальные результаты с титановой фольгой-дегрейдером







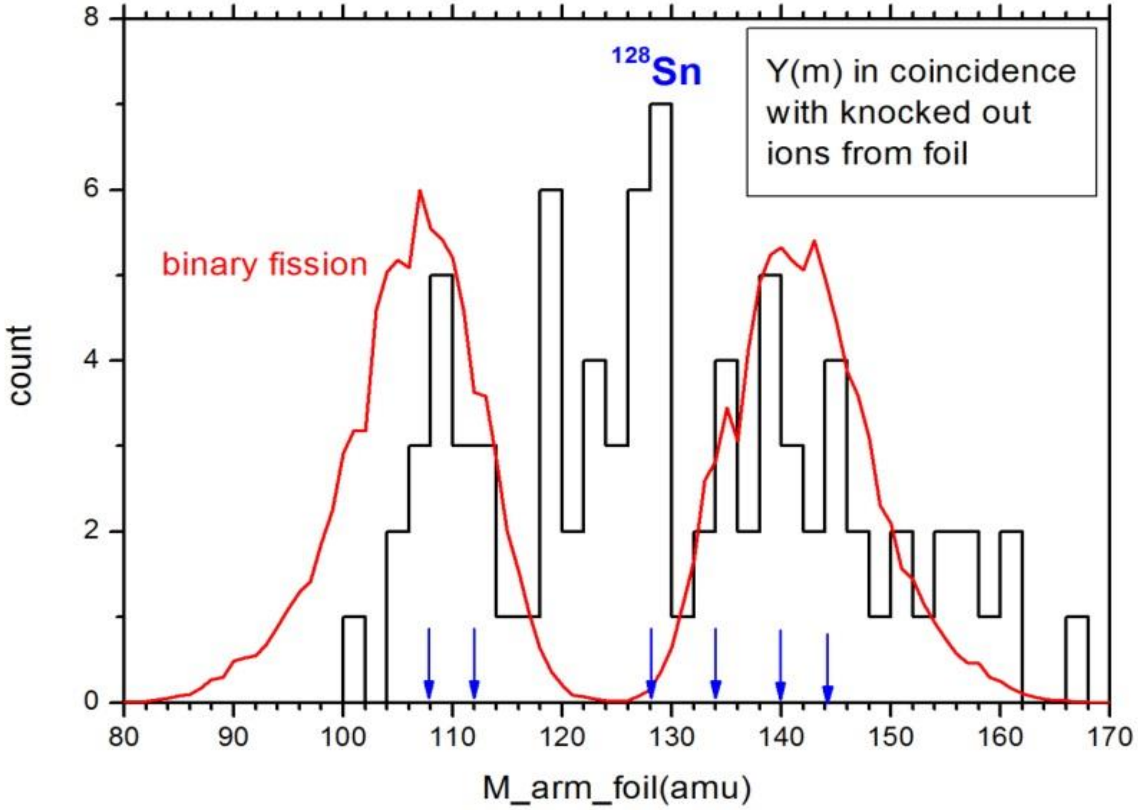
In each ternary event:
$M_1 > M_2 > M_3$

Ti, 1, 1&2.2 mkm

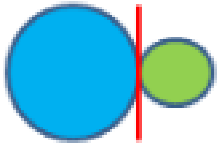
3-point calibr.
E(Ti)=25-70 MeV
S=342events

Experimental approach №1:

Массовый спектр зарегистрированных фрагментов в совпадении с выбитыми ионами Ti, Ni, Cu



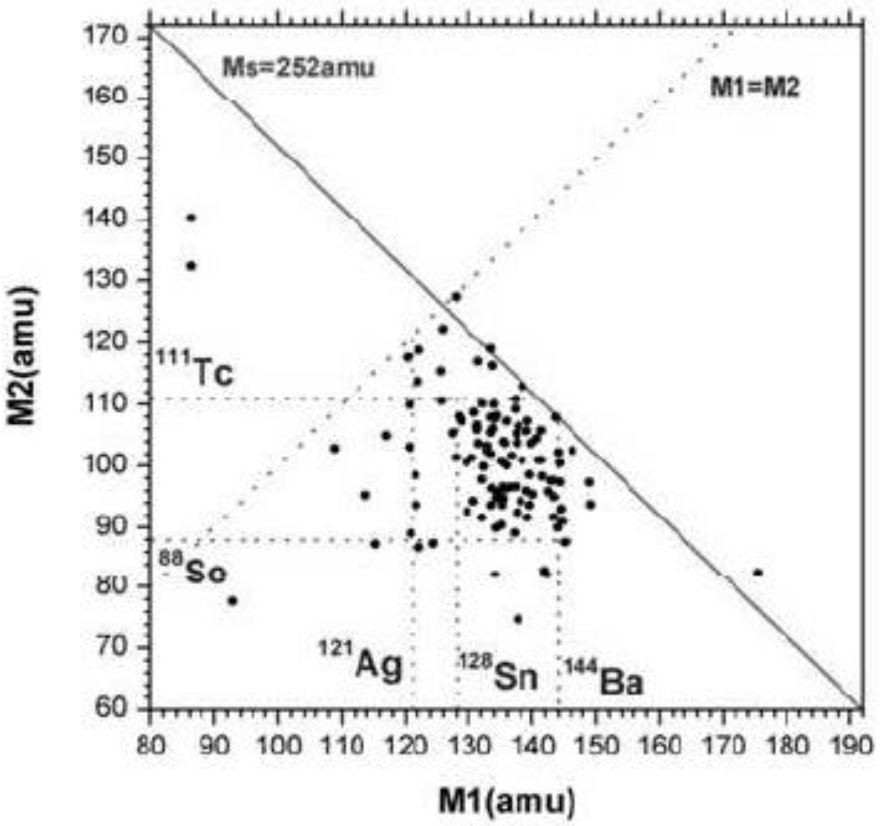
Hypothesis:
we suppose each FF, at least just after scission, looks like a di-nuclear system "magic cluster + light ion "



Due to the brake-up in the foil both constituents become free. Thus one of them should be magic nucleus.

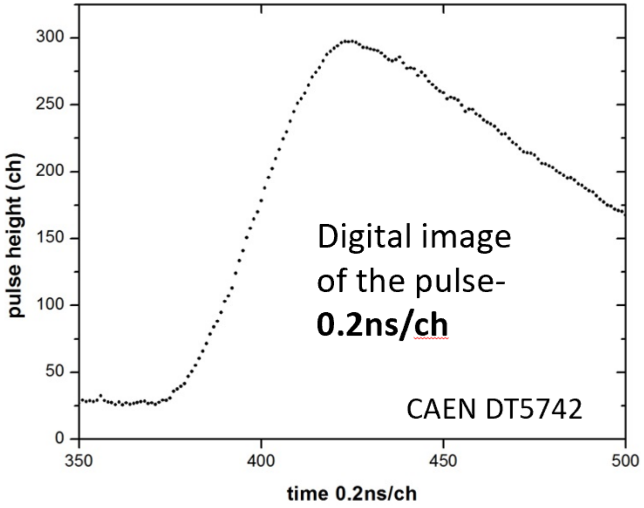
Experimental approach №1:

Данные установки COMETA.
Только подложка Al_2O_3 в роли фольги-дегрейдера



Structure of the M_1-M_2 plot for ternary events.
Zero distance between the Cf source and a foil

Двукратное «взвешивание» осколков деления
LIS (Line Ions Spectrometer), fast flash-ADC, ^{252}Cf (sf),



DT5742 12 bit 5 GS/s Switched Capacitor Digitizer

$$E = E_{det} + R(M,E), \quad (1)$$

PHD:

$$R(M,E) = \frac{\lambda \cdot E}{1 + \varphi \cdot \frac{E}{M^2}} + \alpha \cdot ME + \beta \cdot E, \quad (2)$$

$$E = \frac{M \cdot V^2}{1.9297} \quad (3)$$

$$\longrightarrow \quad G(\{\lambda, \varphi, \alpha, \beta\}, M, V) = 0$$

Combining equation (1), (2) and (3), we obtain:

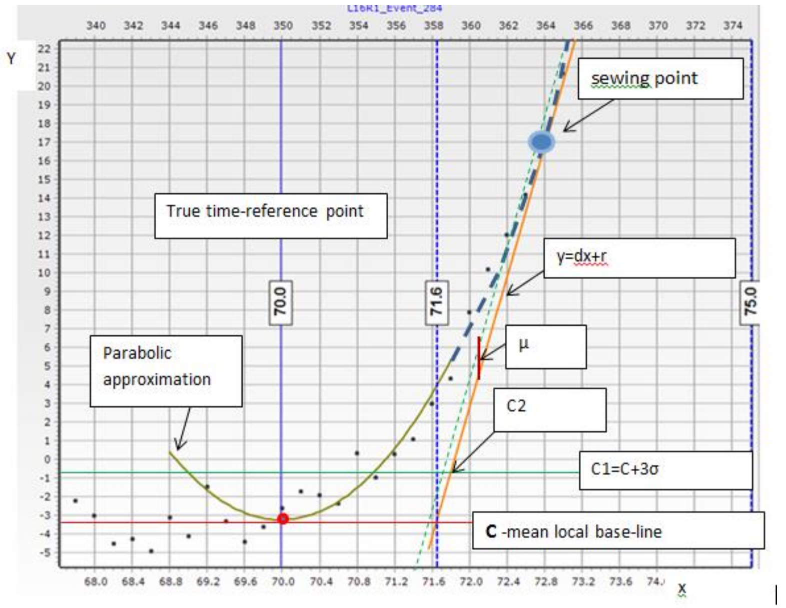
$$G = \frac{MV^2}{k} - [E_{det} + \frac{\lambda \cdot \frac{MV^2}{k}}{1 + \varphi \cdot \frac{V^2}{Mk}} + \alpha \cdot \frac{M^2V^2}{k} + \beta \cdot \frac{MV^2}{k}] = 0,$$

where $k = 1.9297$.

min $F = [(<ML_T> - <ML>)^2 + (<MH_T> - <MH>)^2] + \mu \sum_{M_{TE}} \frac{(Y(M_{TE}) - Y_T(M_{TE}))^2}{Y(M_{TE})}$

PD:

$$\Delta t_p = \gamma \frac{M^{1/6} E^{1/2}}{} \quad (4)$$



Special iterative procedure to take into account PHD & PD effects

True time reference point ← New off-line methods of “true” time-pickoff

Двухкратное «взвешивание» осколков деления в спектрометре LIS

Experimental approach №2

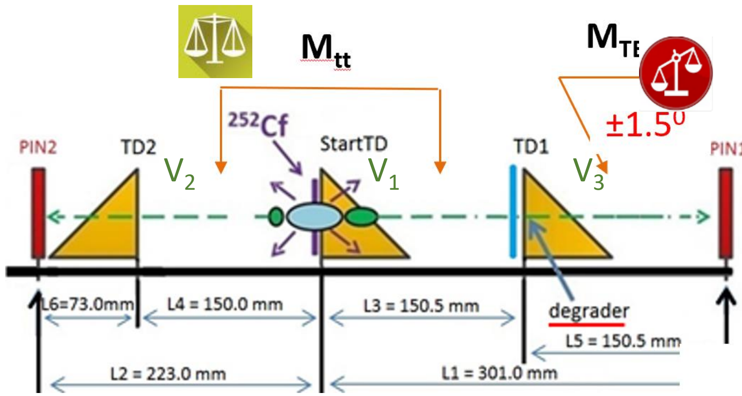


Fig.1

$M_{tt} = Mc/(1+V_1/V_2)$ - "initial" FF mass

$M_{TE}=2E/(V_3^2)$ - "resultant" FF mass

$\tau_{life} > 15ns$

Fig.2

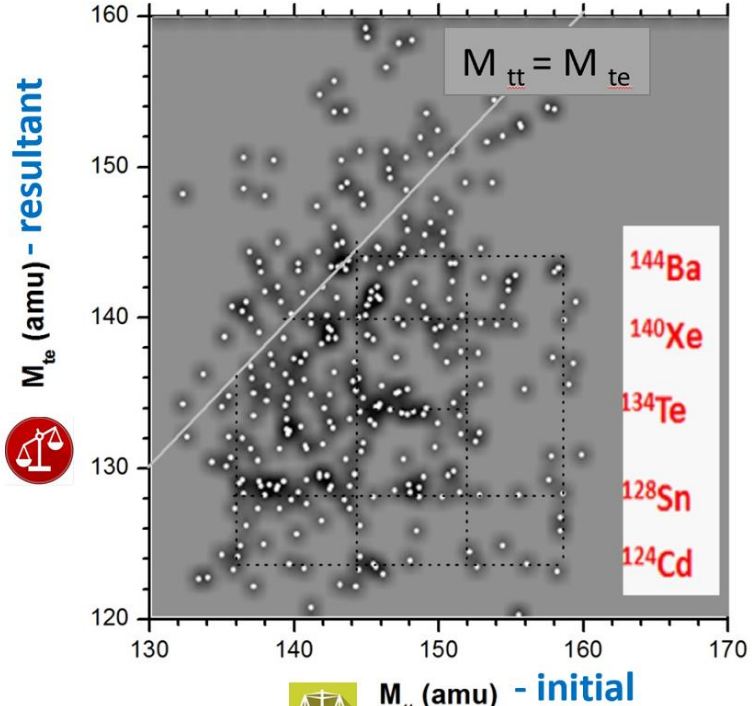


Fig.3

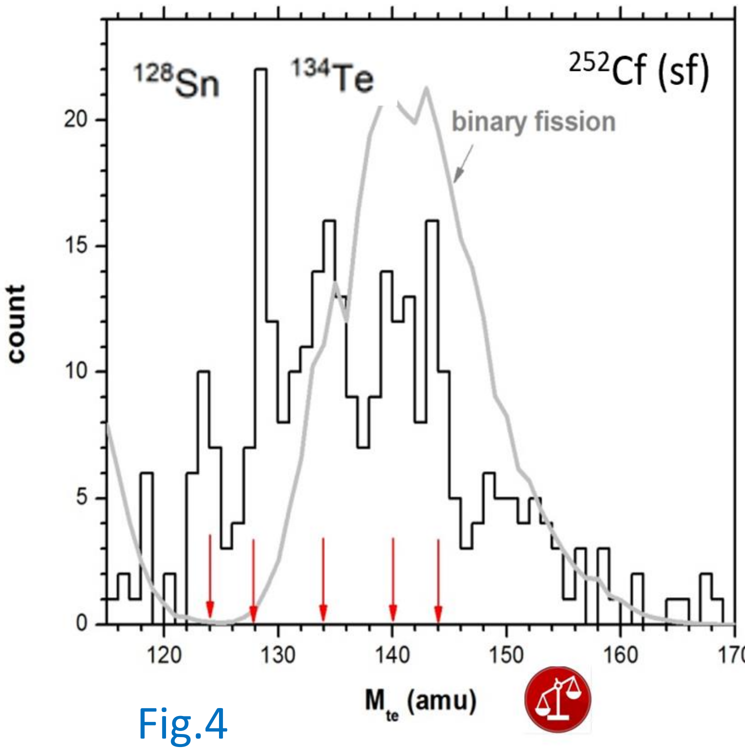


Fig.4

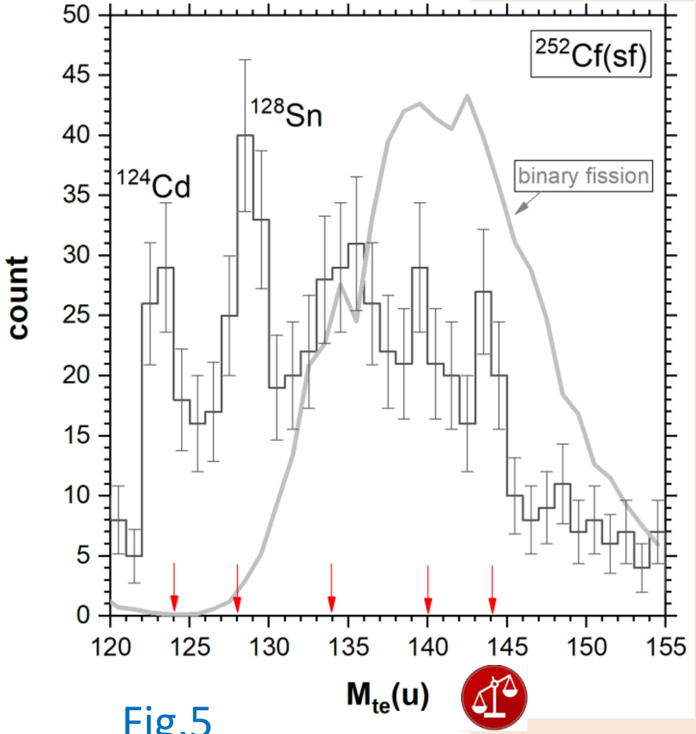
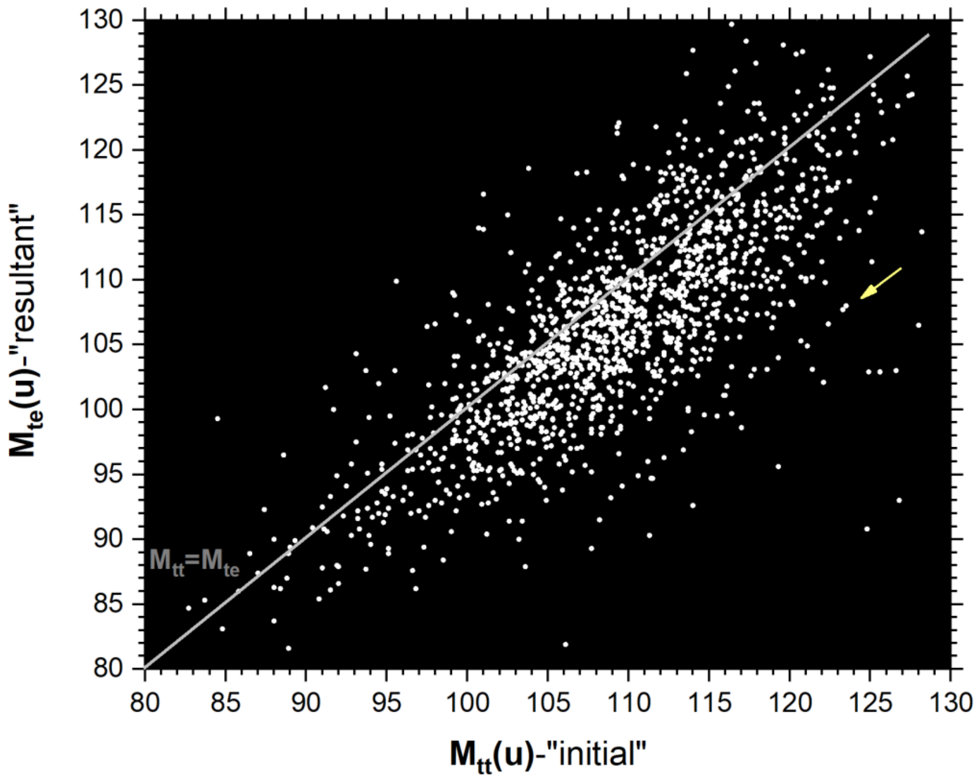
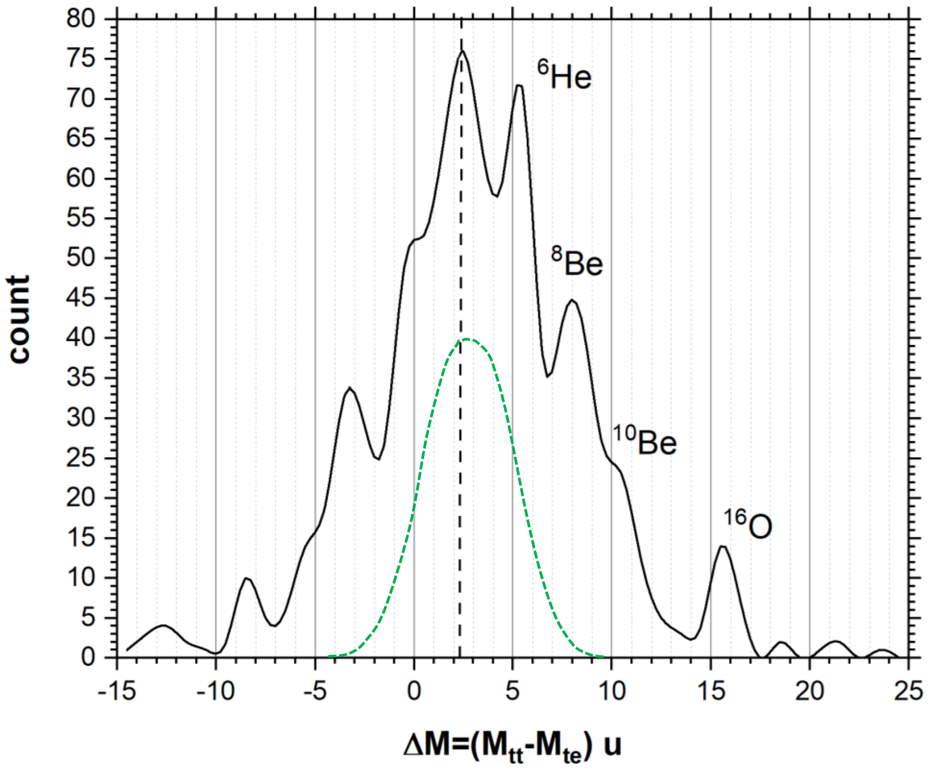


Fig.5

Experimental approach №2

Двукратное «взвешивание» осколков деления на установки LIS, легкий пик

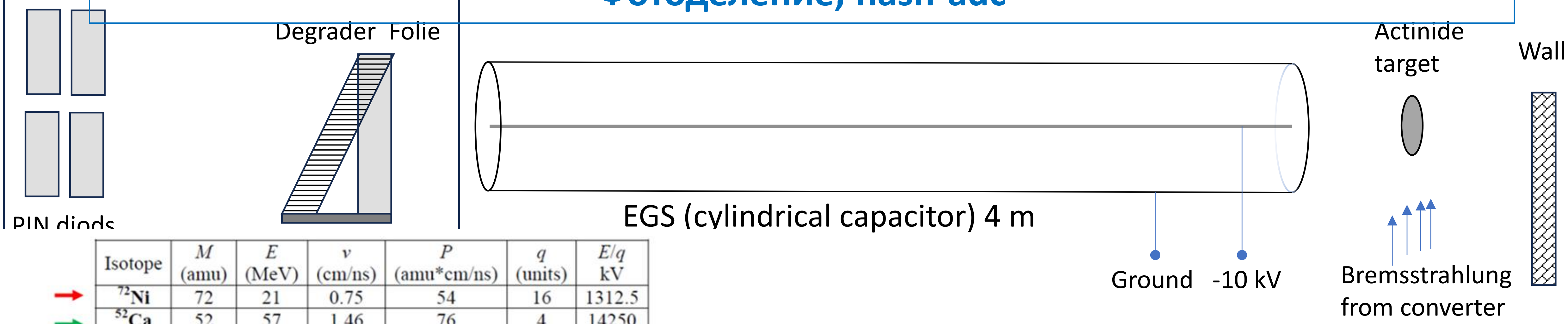




Kinematical selection of the cold events-Yiso~10^{-3}/bin fiss

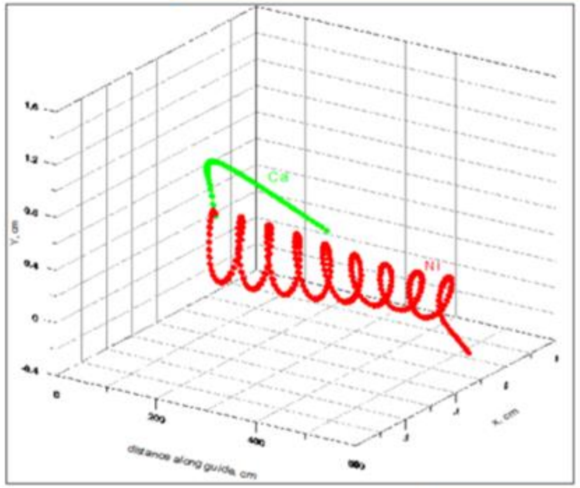
Experimental approach №3

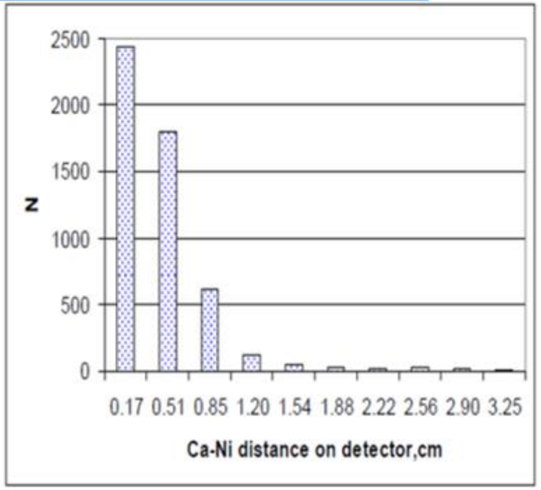
VEGA (V-E Guide based Array) на электронном пучке МТ-25 в ЛЯР
Фотоделение, flash-adc

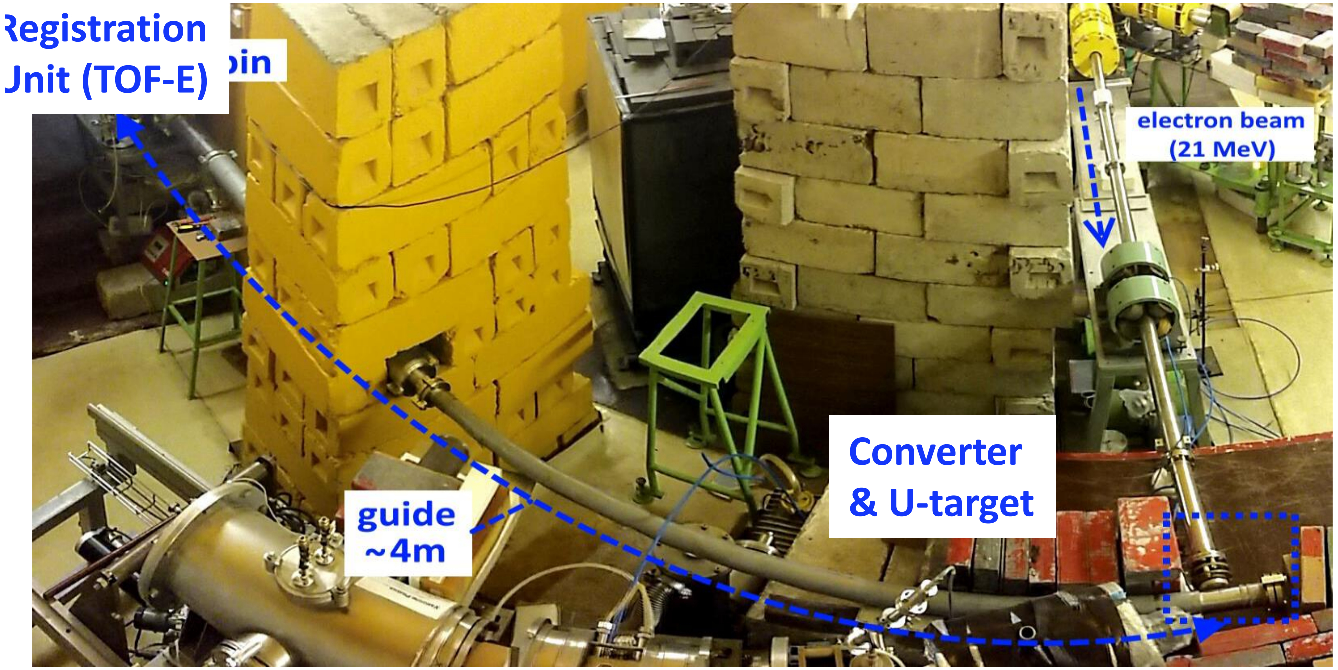


Isotope	*M* (amu)	*E* (MeV)	*v* (cm/ns)	*P* (amu*cm/ns)	*q* (units)	*E/q* kV
^{72}Ni	72	21	0.75	54	16	1312.5
^{52}Ca	52	57	1.46	76	4	14250
^{128}Sn	128	68	1.01	130	22	3090.9

parameters used for the calculations :*V0* = 10 kV, *s* = 0.1 mm, channel diameter (outer cylinder) is 56 mm, the length of one guide arm is 5 m, the target diameter is 5 mm.

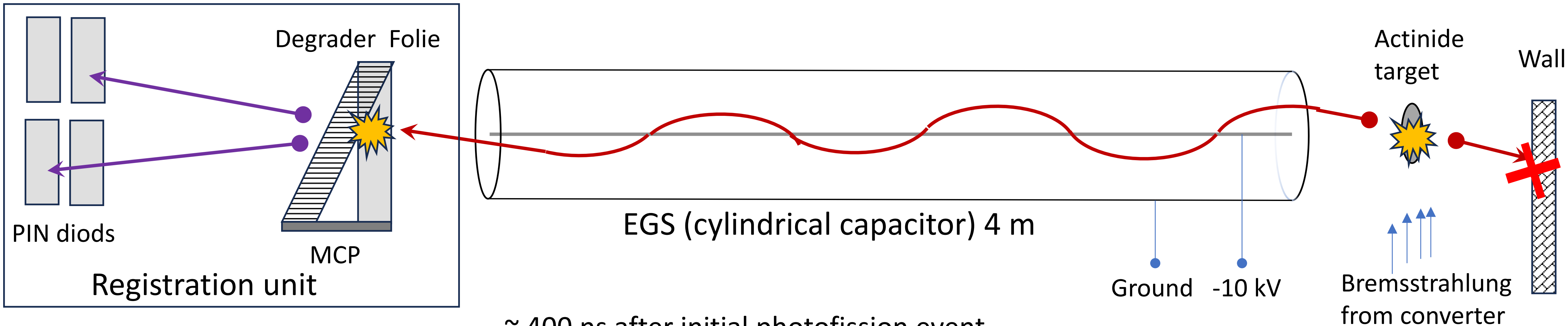






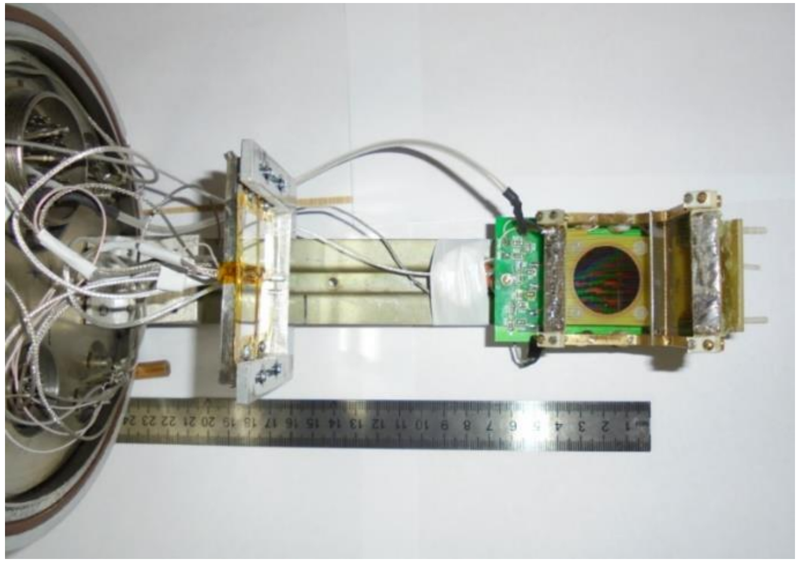
Experimental approach №3

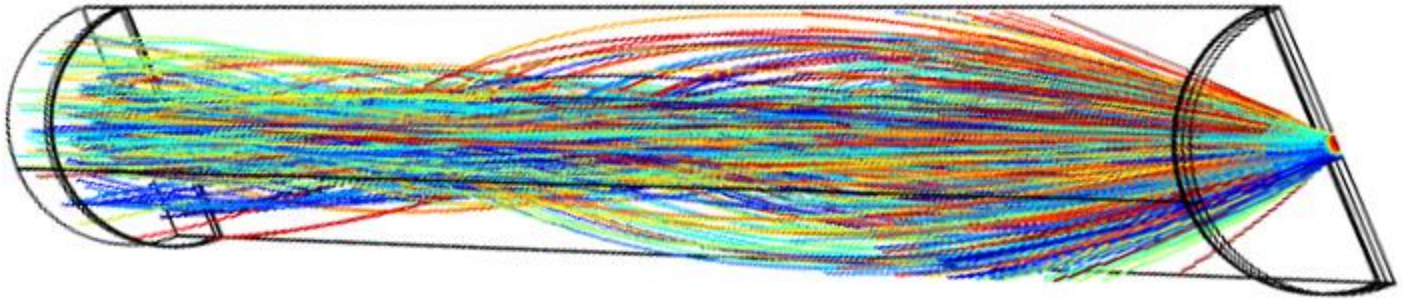
VEGA (V-E Guide based Array) на электронном пучке МТ-25 в ЛЯР



~ 400 ns after initial photofission event

2PIN

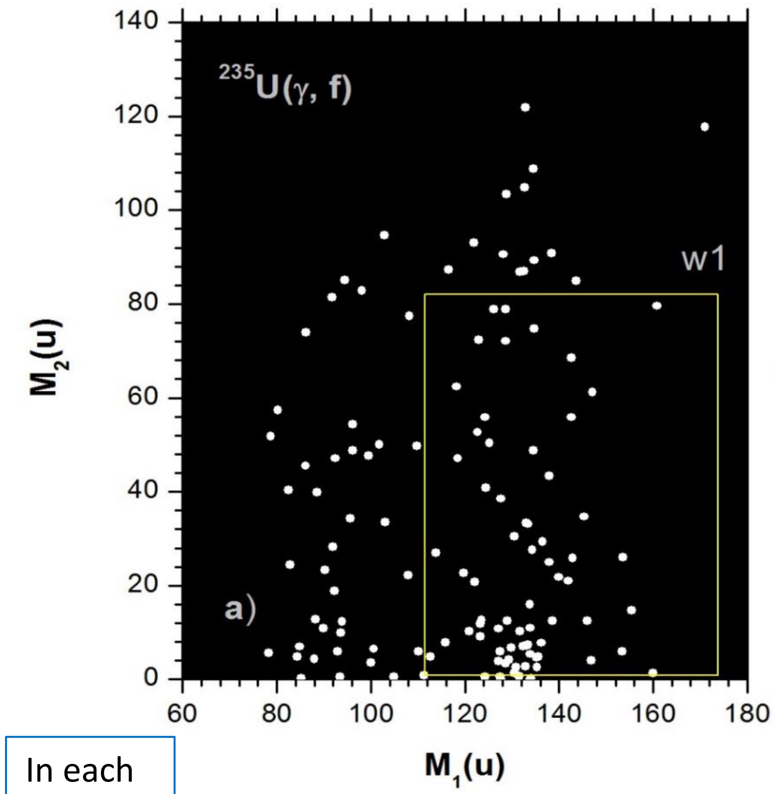


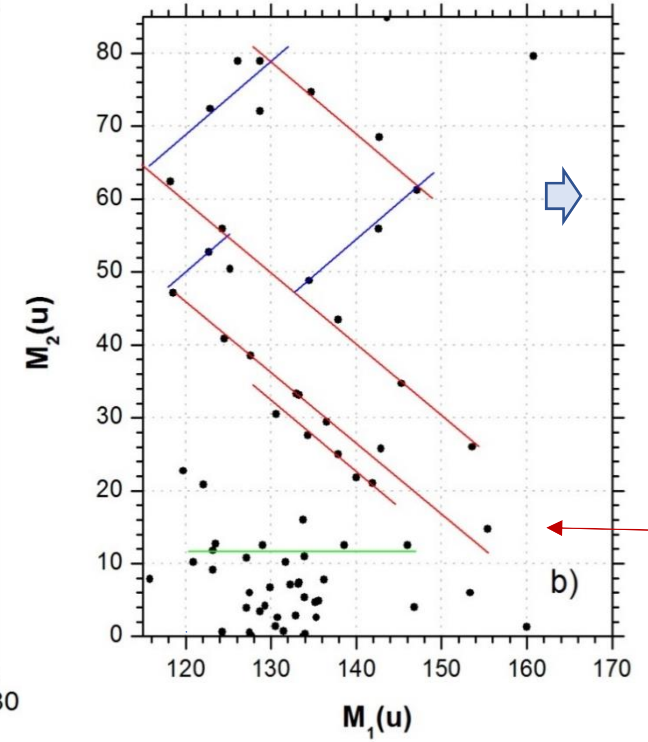


Modelling of the trajectories for fission fragments
Capturing angle is ~1^{o}

Experimental approach №3

Регистрация двух коррелированных фрагментов в одном плече & недостающий Ni в реакции $^{235}U(\gamma, f)$





Missed $^{68, 72}$Ni

In each event $M_1 > M_2$

Y(Ni _miss)~ 10^{-3}

τ_{life} > 400ns

for ^{68,72}Ni missed

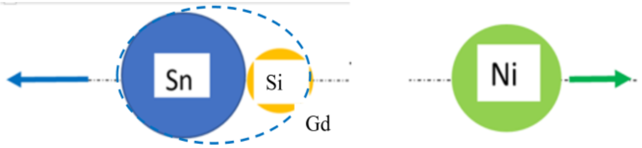
<E1>=63.7 ~64MeV;

<E2>=2.97~ 3MeV;

<V1>=0.96 cm/ns;

<V2> =0.43 cm/ns

delayed brake-up in the start-foil



Break-up of the **heavy** FF, both detected fragments are in **the same spectrometer arm**

Experimental approach №3

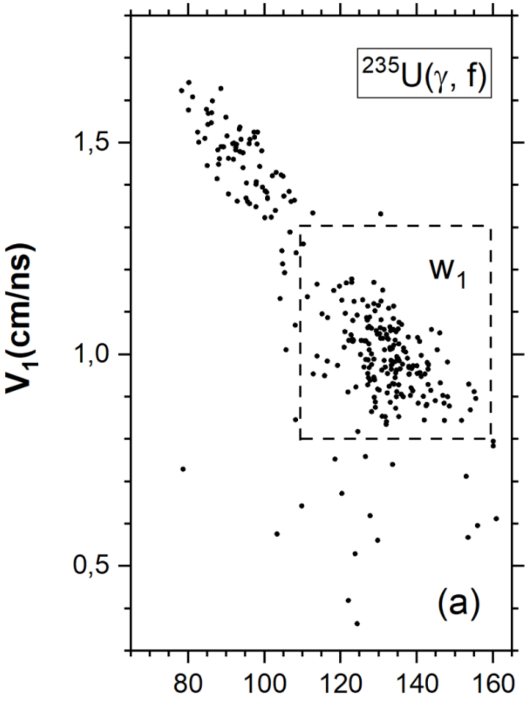


Fig.1

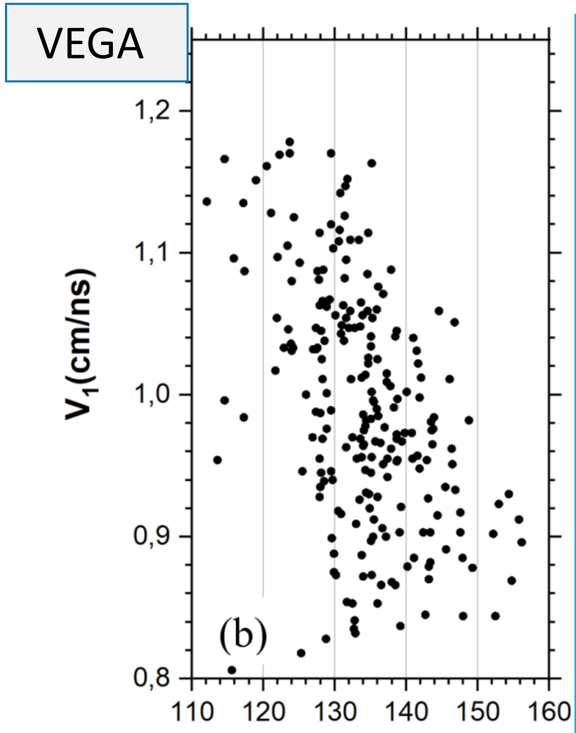


Fig.2

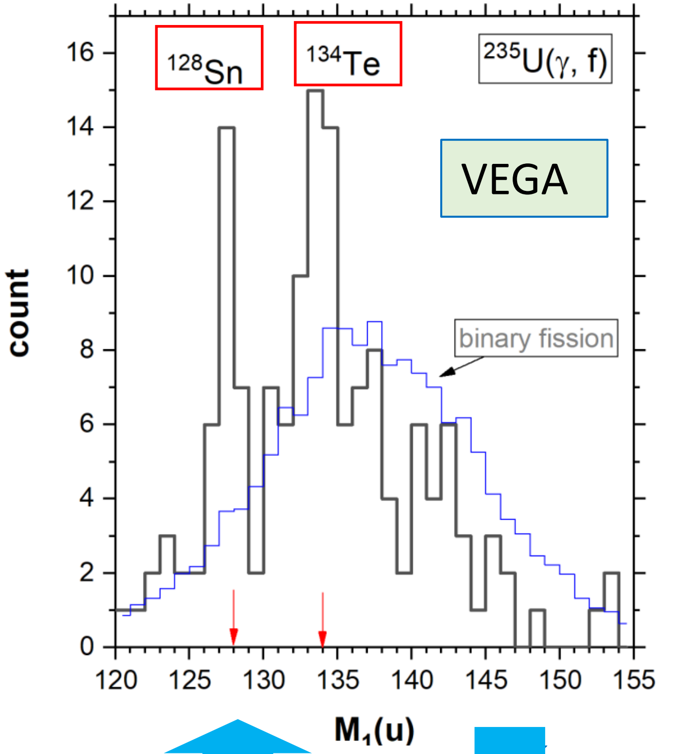


Fig.3

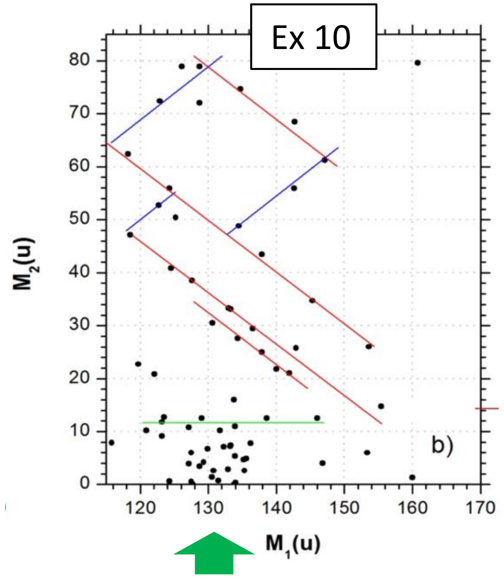


Fig.4

Similar result of the 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.

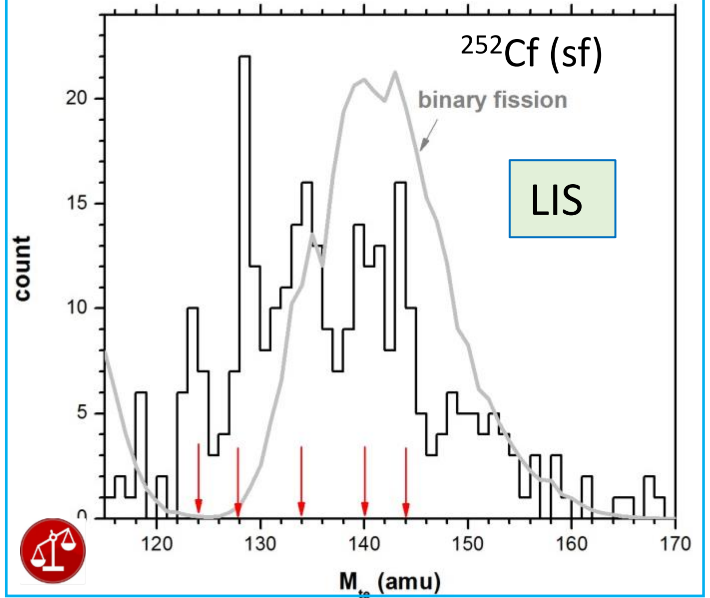
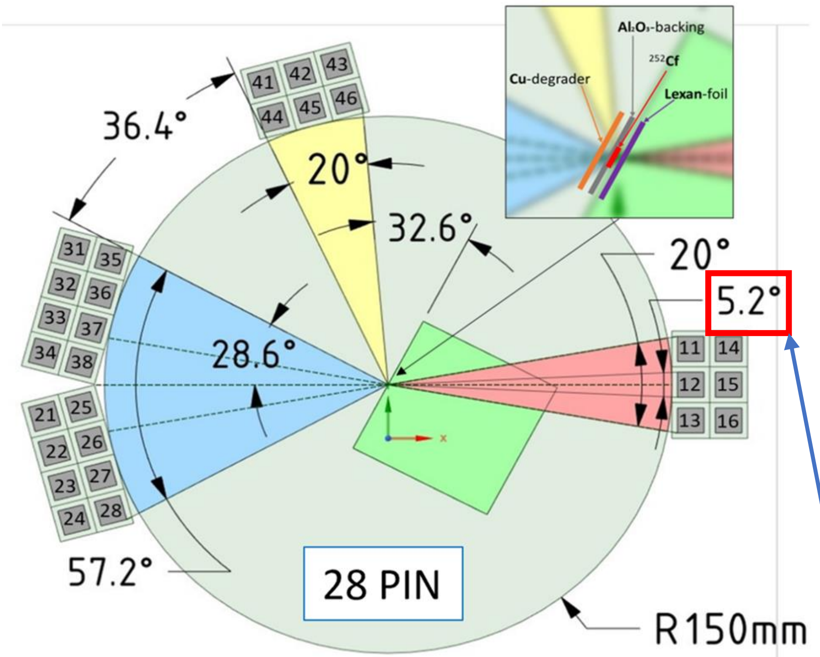
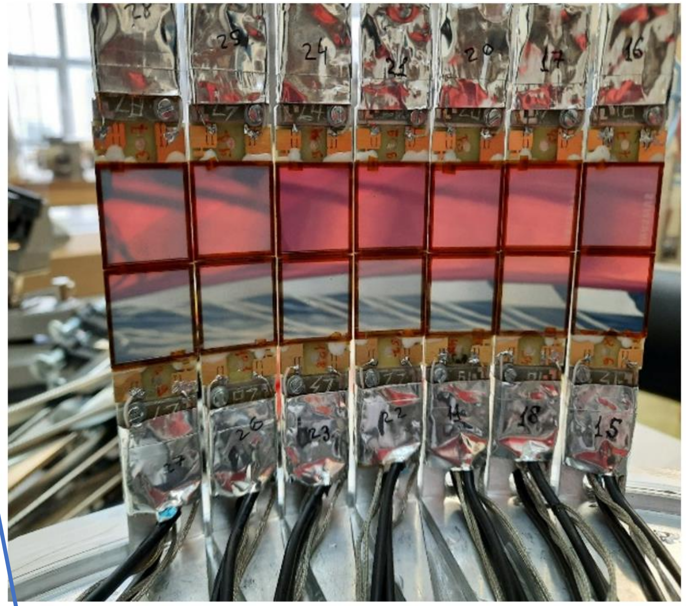


Fig.5

Установка COMETA-F, ^{252}Cf (sf), разделение наложенных сигналов (double-hit), FADC

Experimental approach №4



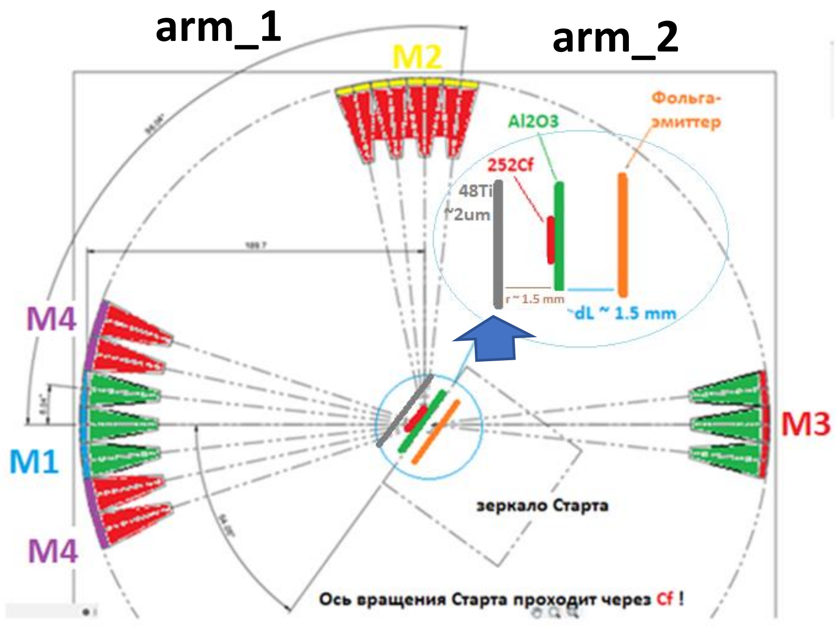


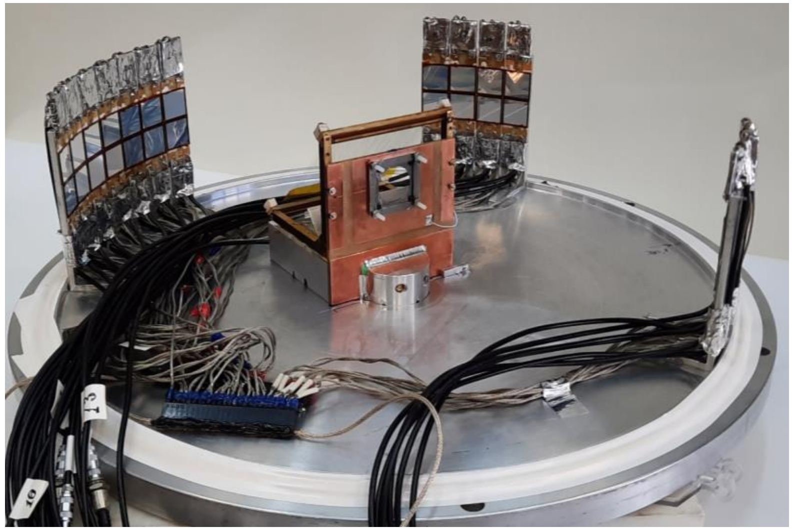
ToF-E method for triple coincidences:

ToF_i & E_i -> M_i

i = 1,2,3

angular uncertainty





COMETA-f

^{252}Cf (45 kBq)
Spot d= 3 mm
on Al_2O_3 65 ug/cm^2

VX1742
32+2 Channel
12bit 5 GS/s
Digitizer
200ps/ch

"Double-hit" approach for searching for the multi-body decays

Experimental approach №4

Fig 1

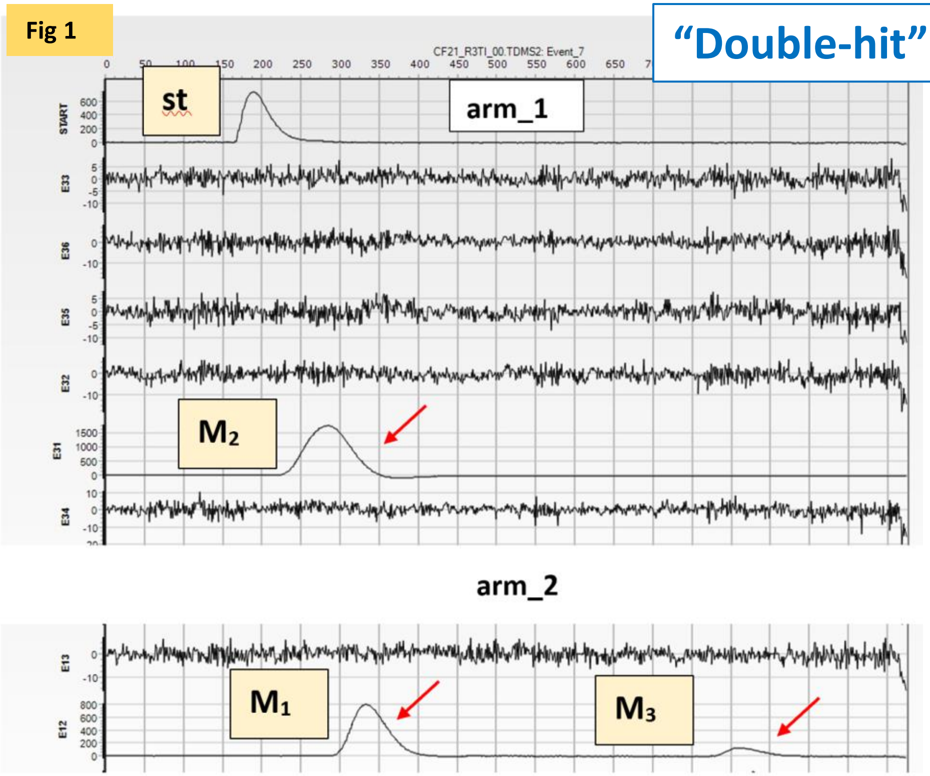
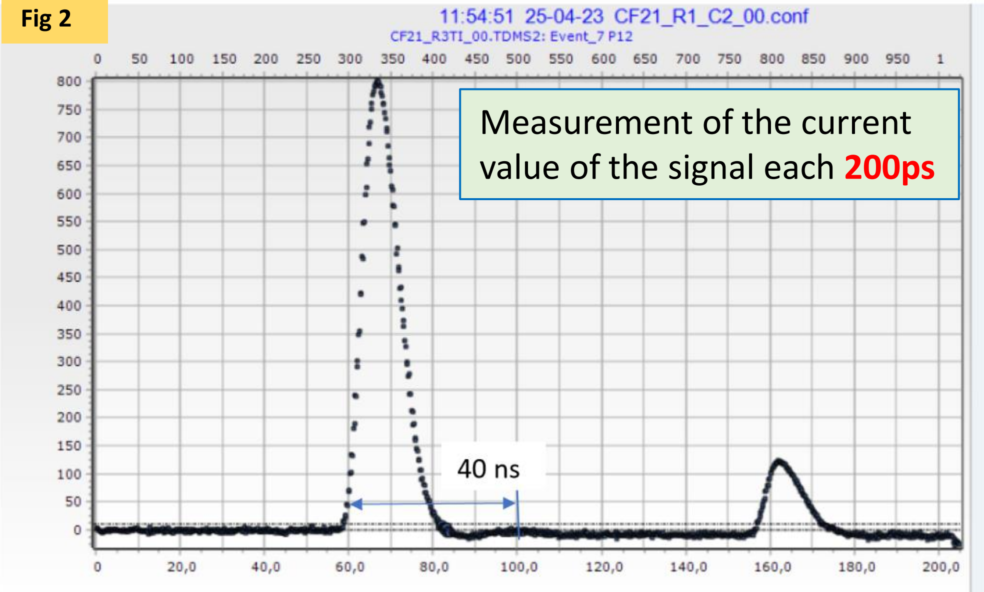
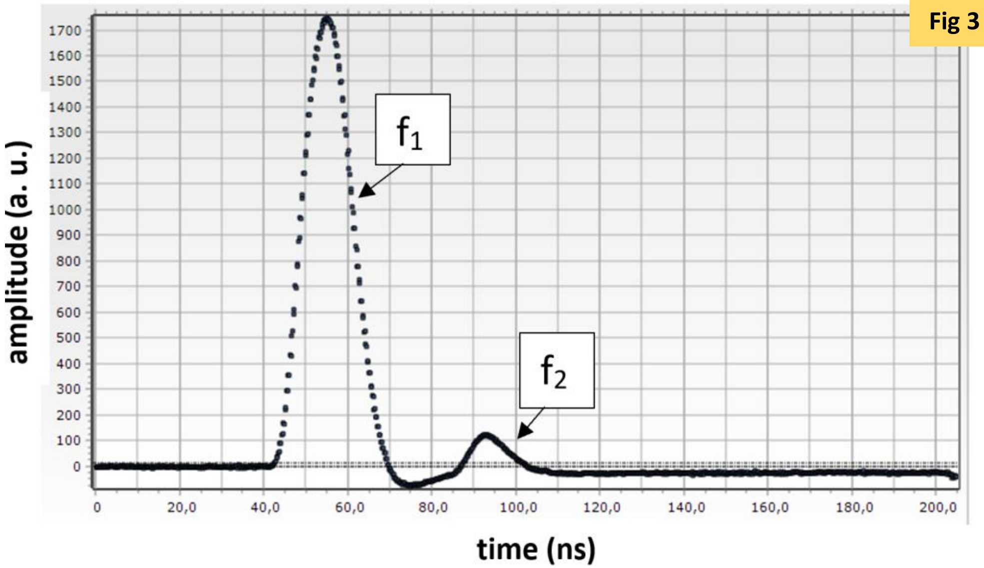


Fig 2



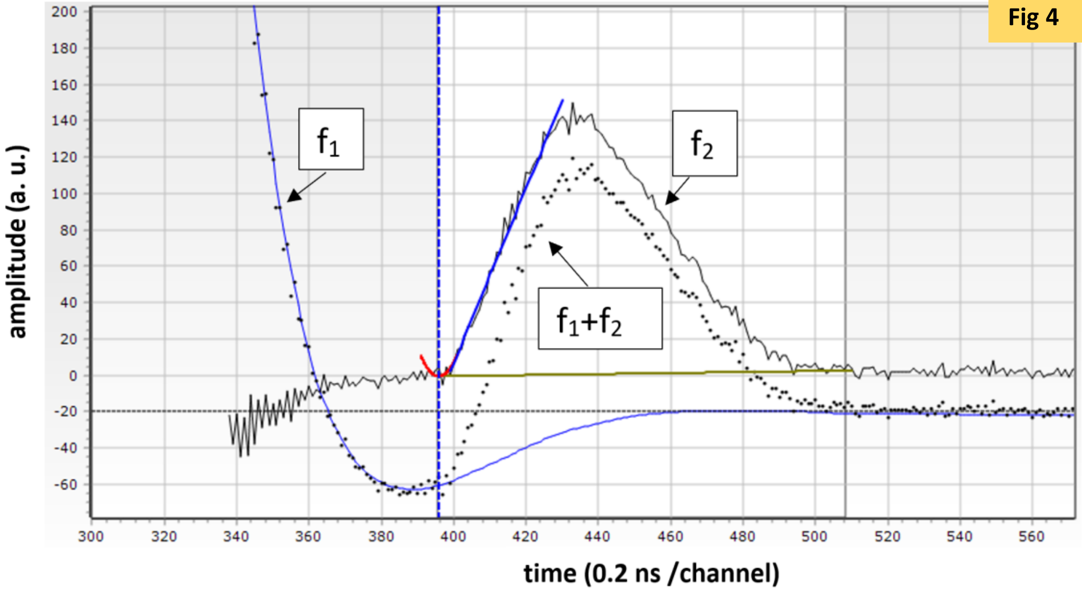
Measurement of the current value of the signal each **200ps**

Fig 3



Double-hit event, pile-up of the signals f_1 and f_2 detected in the same PIN diode

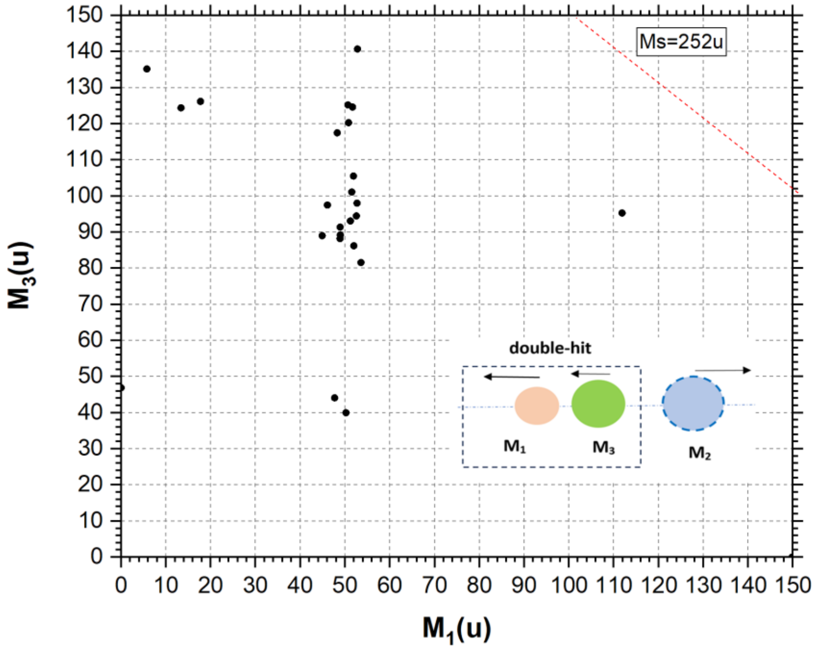
Fig 4



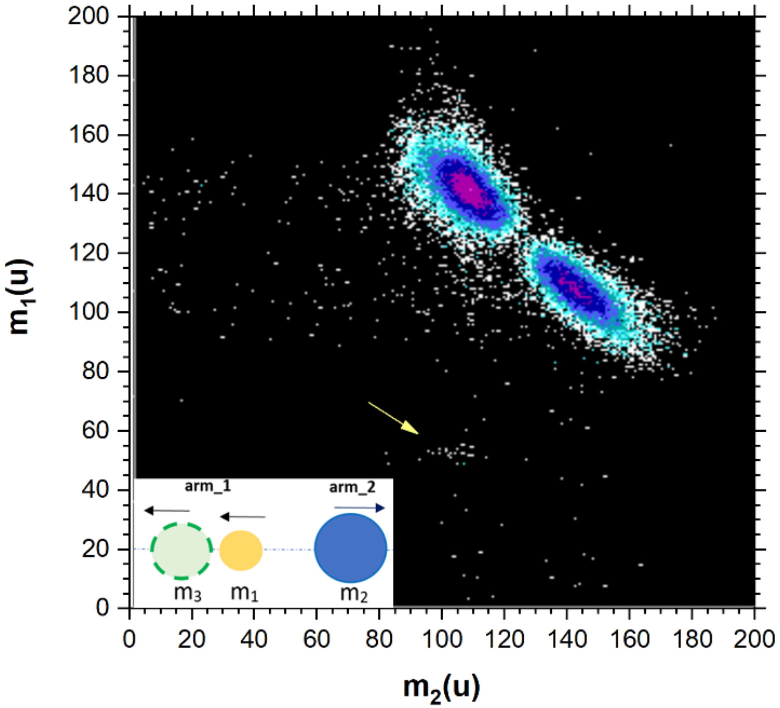
Restoring original signals f_1 and f_2 from pile-up.
The error in the time-stamps does not exceed 112 ps, while the relative difference in energies $\delta E=0.35\%$.
The two signals in the pile-up event were separated by approximately 30 ns.

Experimental approach №4

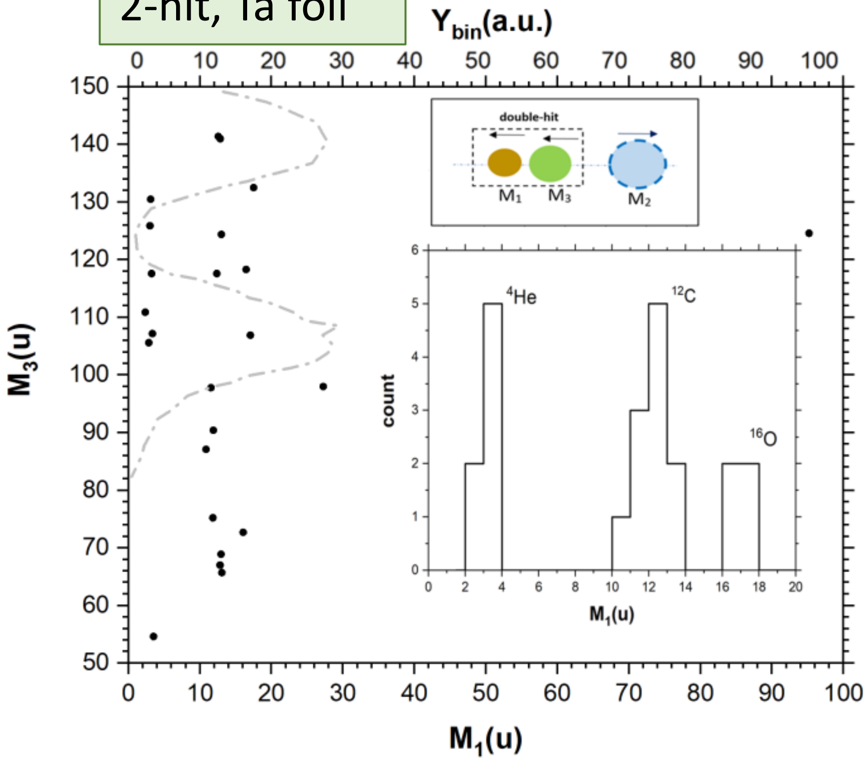
2-hit, Ti foil

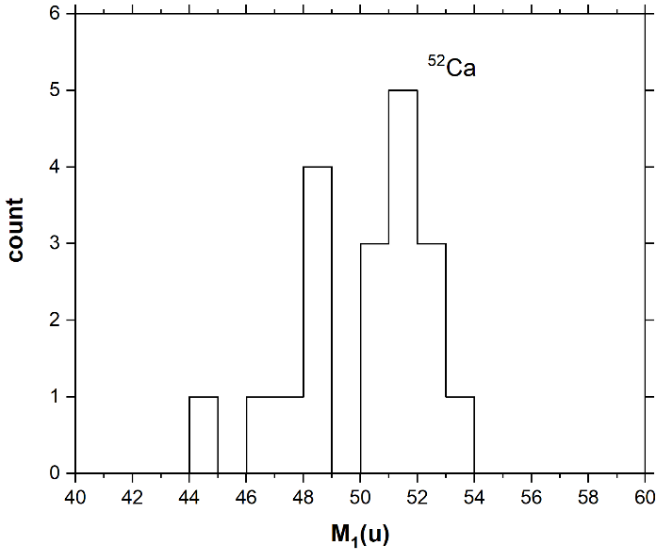


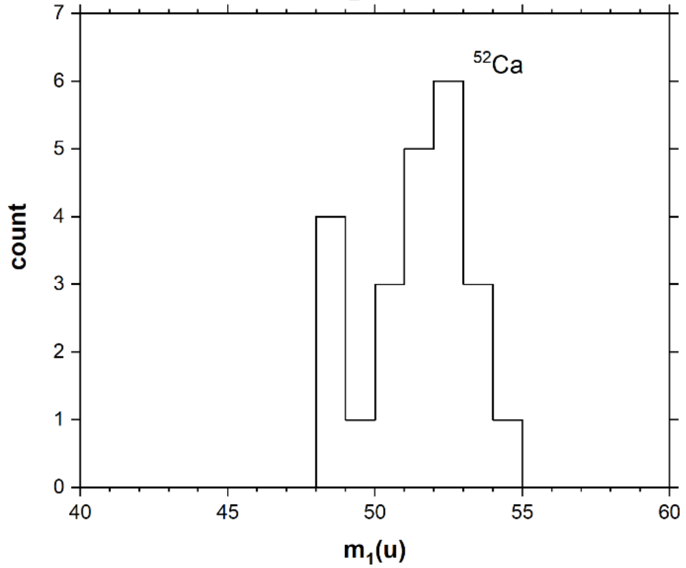
mul_2, Ti foil

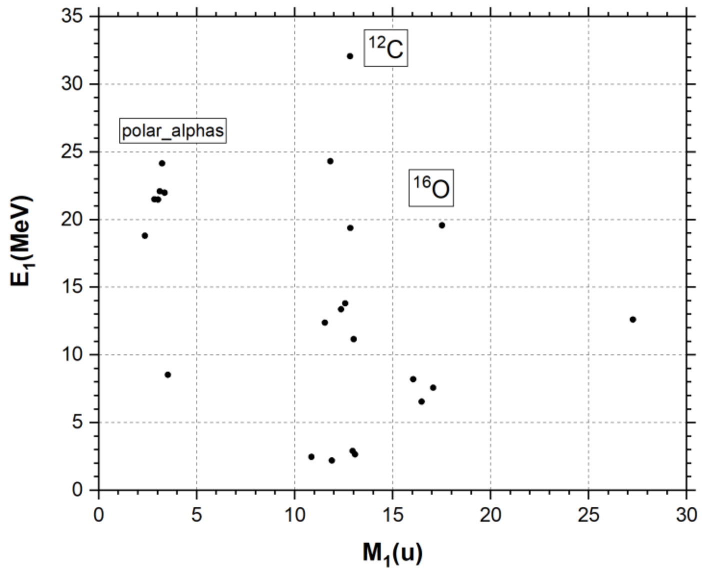


2-hit, Ta foil









Ti foil, ПЭЧАЯ in press

Ta foil, IJMP E, submitted

Experimental approach №4

Ti foil, mul_3: all 3 FFs were detected

Here : M1>M2>M3

CF21_r3(Ti)_mul_3				
	FF1	FF2	FF3	ΔM=252-Ms
№ 52				0.01
E (MeV)	16.5	80.8	11.02	
M (u)	126.3	112.07	13.62	
PIN	43	33	45	
	← $^{140}_{54}$Xe	/	→ $^{112}_{44}$Ru	
	← $^{13}_{5}$B ← $^{127}_{49}$In			
	arm_1		arm_2	

CF21_r3(Ti)_mul_3				
	FF1	FF2	FF3	ΔM=252-Ms
№ 118				-1.36
E (MeV)	103.2	5.34	29.06	
M (u)	103.25	100.97	49.14	
PIN	33	16	43	
	← $^{149}_{58}$Ce	/	→ $^{103}_{40}$Zr	
	← $^{49}_{19}$K ← $^{100}_{39}$Y			
	arm_1		arm_2	

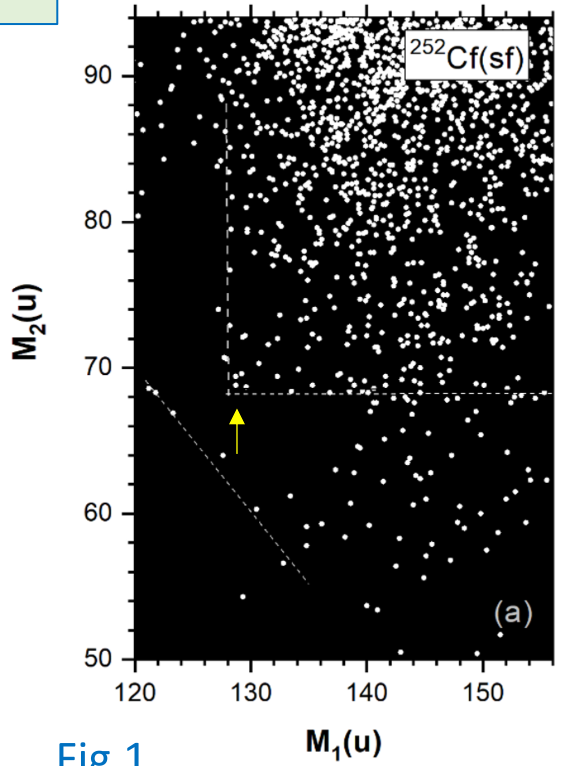
CF21_r3(Ti)_mul_3				
	FF1	FF2	FF3	ΔM=252-Ms
№ 72				2.13
E (MeV)	103.2	5.34	29.06	
M (u)	104.6	92.9	52.3	
PIN	31	16	15	
	← $^{149}_{58}$Ce	/	→ $^{103}_{40}$Zr	
	← $^{52}_{20}$Ca ← $^{98}_{38}$Sr			
	arm_1		arm_2	

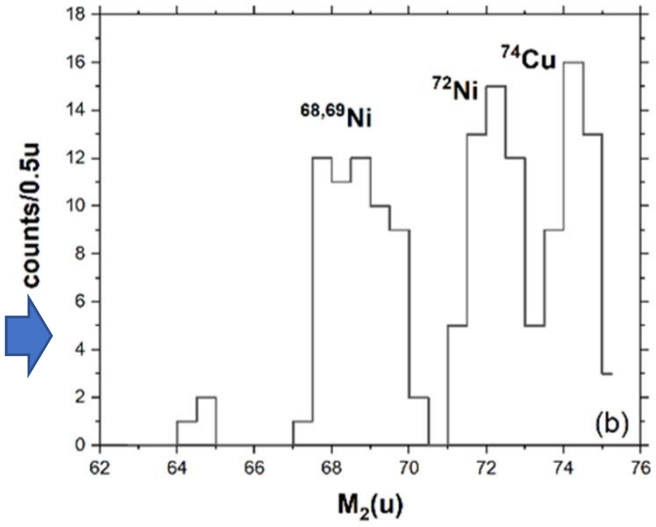
Связь между делящимися изомерами и «ССТ».

Experimental approach №5:
“CCT”

Один из отлично воспроизводимых результатов –Ni «бамп»
подложка Al_2O_3 в роли фольги-дегрейдера, ^{252}Cf (sf), структуры

COMETA

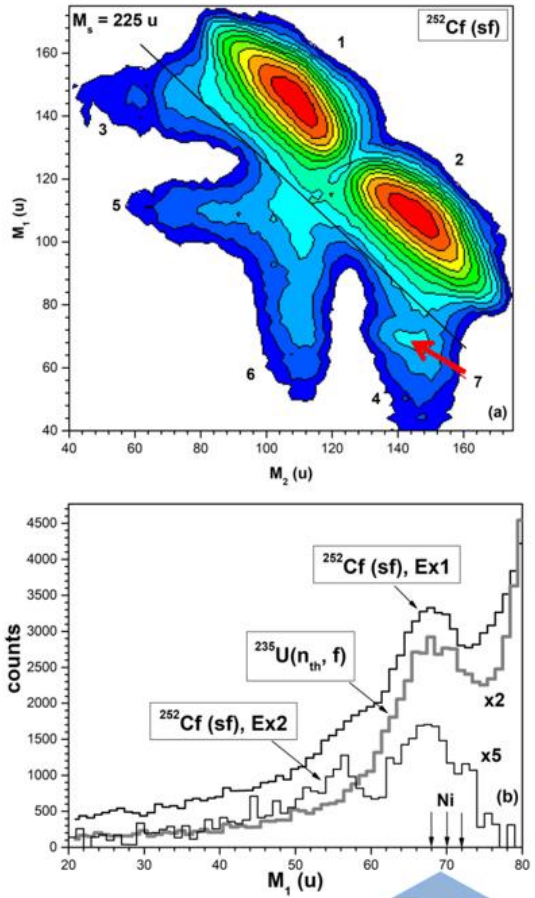




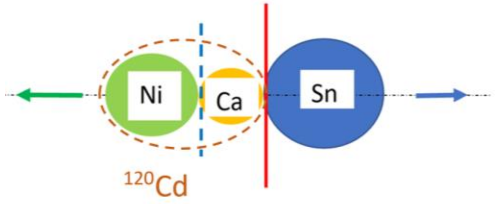
“rhombic meander”
M_1+M_2=const
M_1-M_2=const

Fig.1

FOBOS



“Ni-bump”



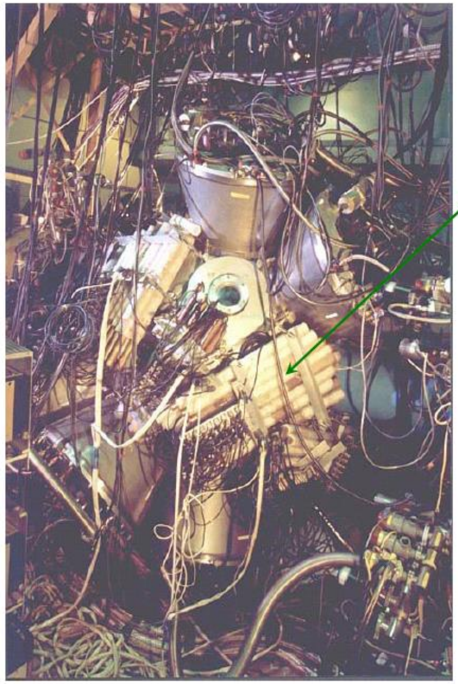
(one specific partition)
Ni always

Fig.3

Ni & **Sn** FFs were really detected in the **opposite arms** due to the break-up of the **light** FF in the backing

Fig.2

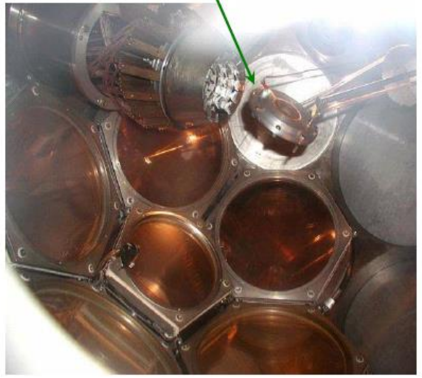
Мозаичный детектор нейтронов «Нейтронный пояс»

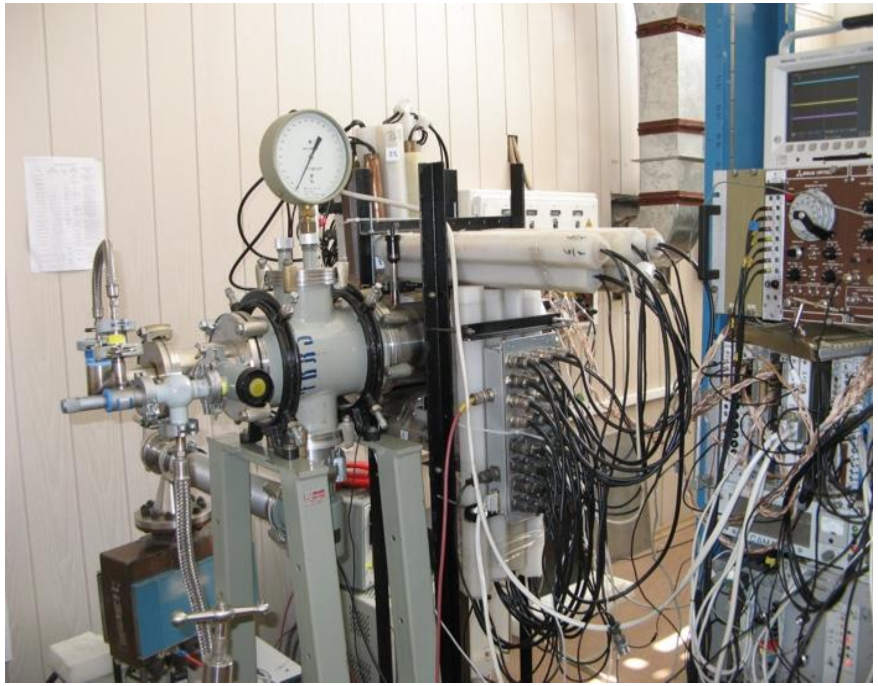


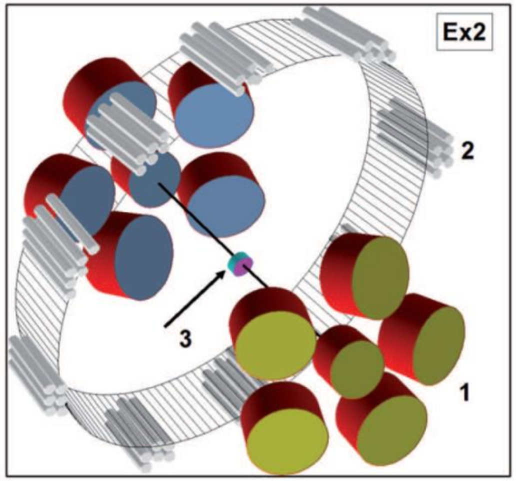
Double arm spectrometer
6+6 modules

Neutron belt of FOBOS
140 ^{3}He (7 bar) conuters
In PE-moderator

Start PAC
with internal^{252}Cf source

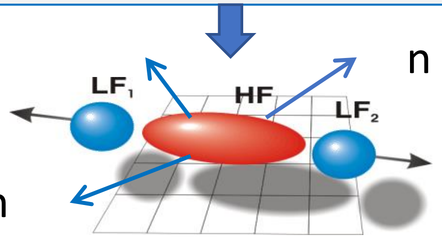


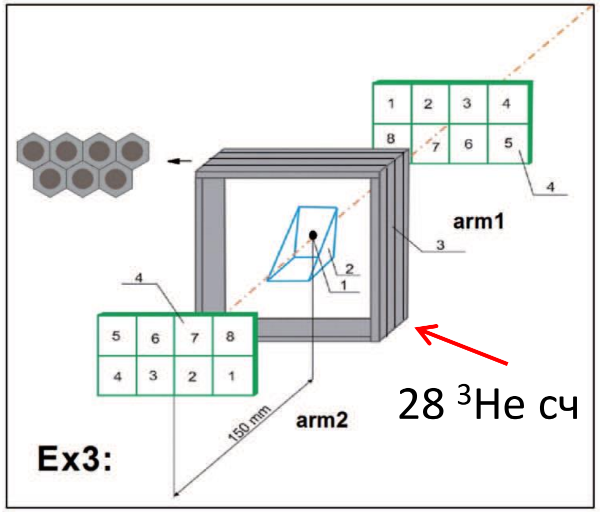




Modified FOBOS setup

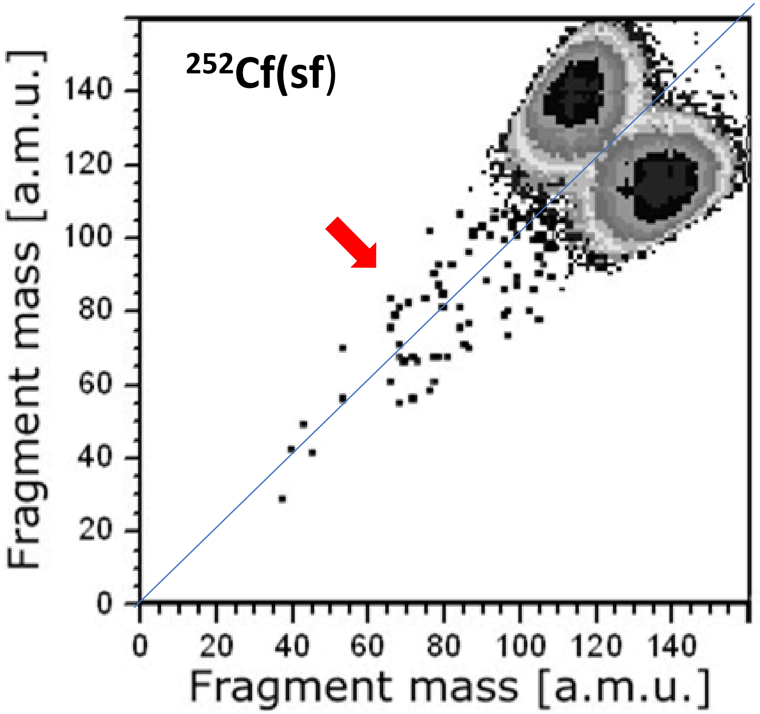
Эффективность n-пояса:
~ 16% геометрическая
~ **4%** из осколков
~**12%** изотропного источника
отбор подобных событий

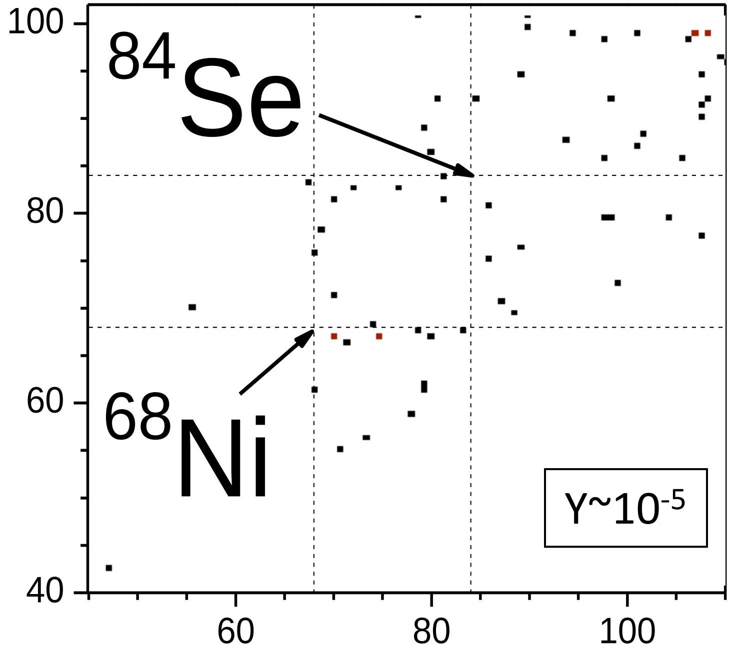


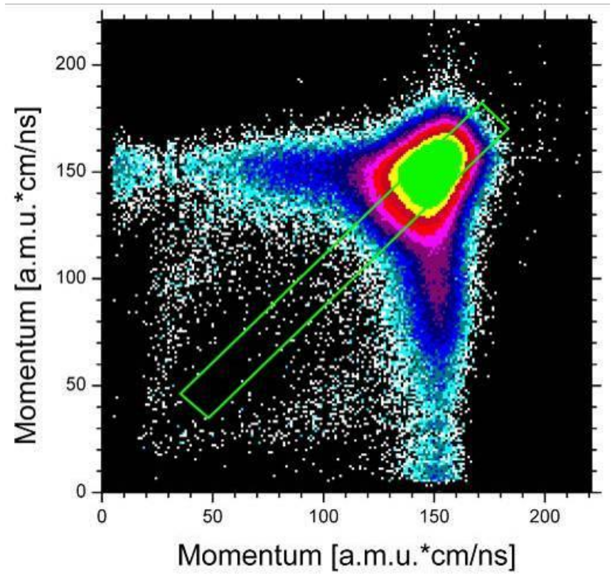


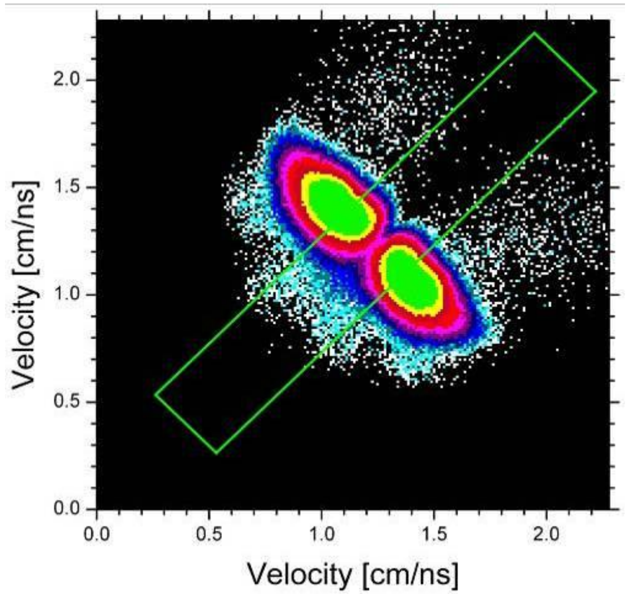
COMETA setup

«Никелевый квадрат» в симметричных событиях ^{252}Cf (sf)



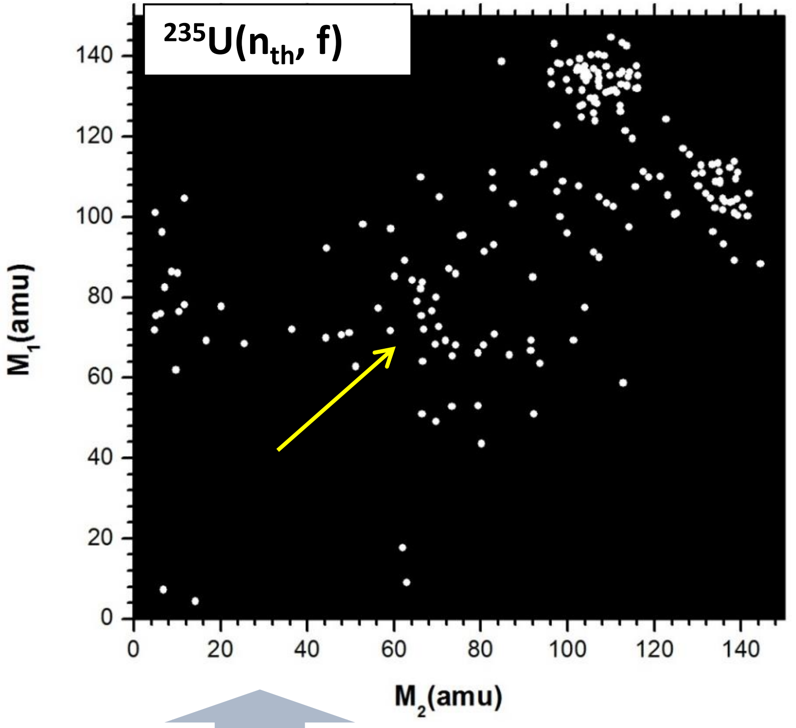


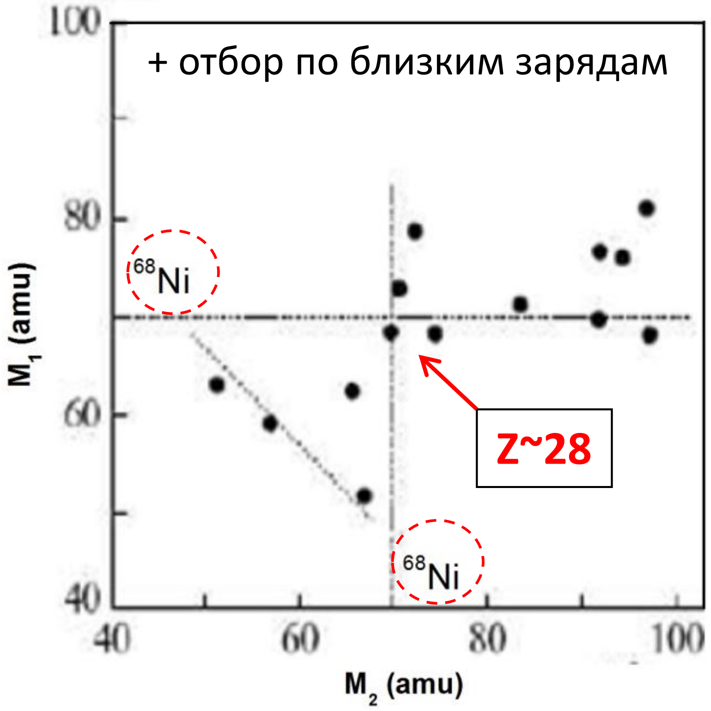




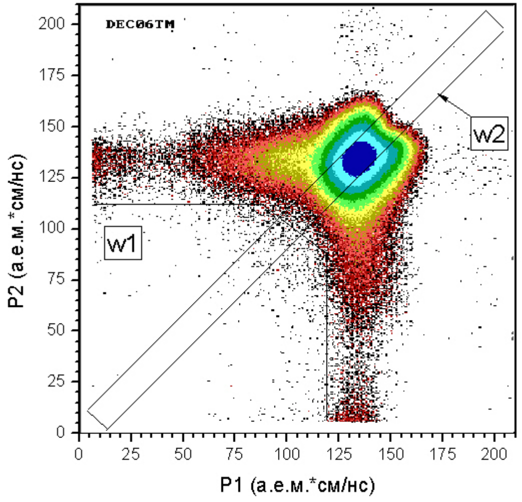
selection windows
P1~P2 & V1~V2

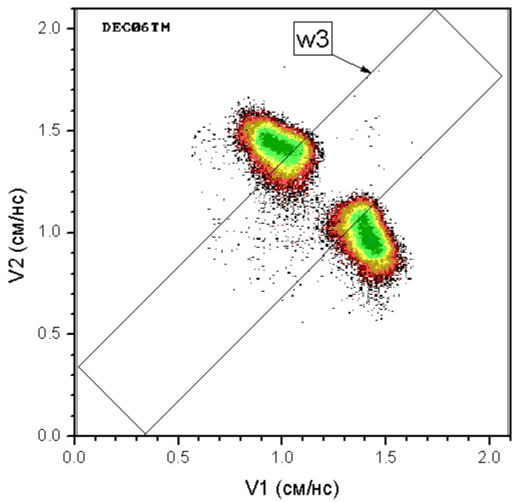
«Никелевый квадрат» в симметричных событиях $^{235}U(n_{th}, f)$





P1~ P2
V1~ V2
Z1~Z2



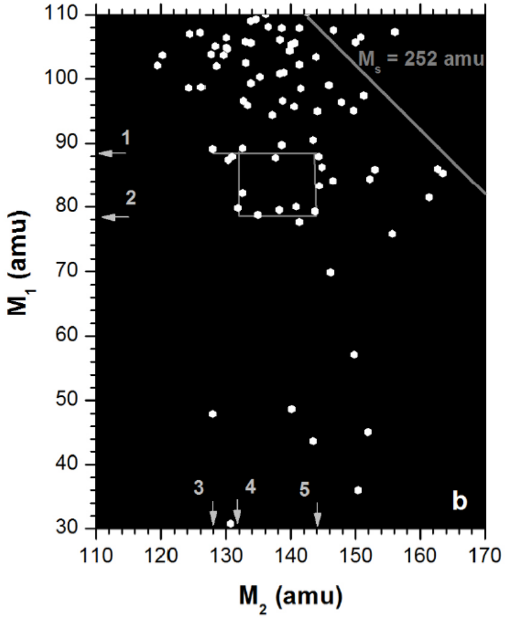


selection windows P1~P2 & V1~V2

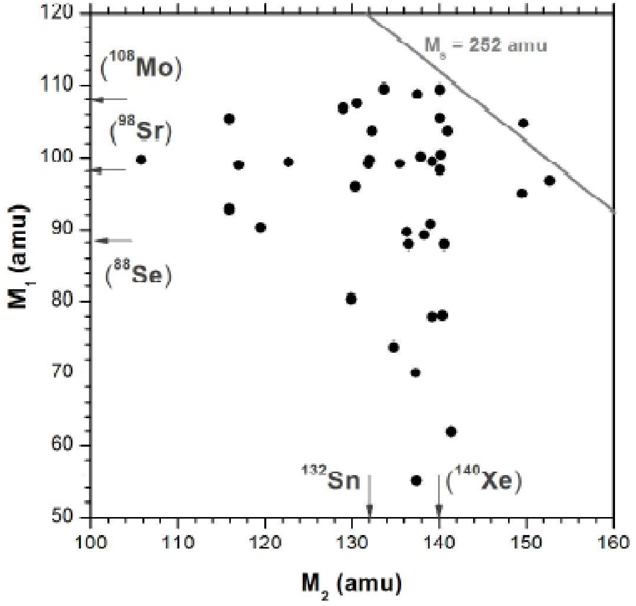
Примеры структур другого типа при разных условиях отбора

FOBOS

COMETA

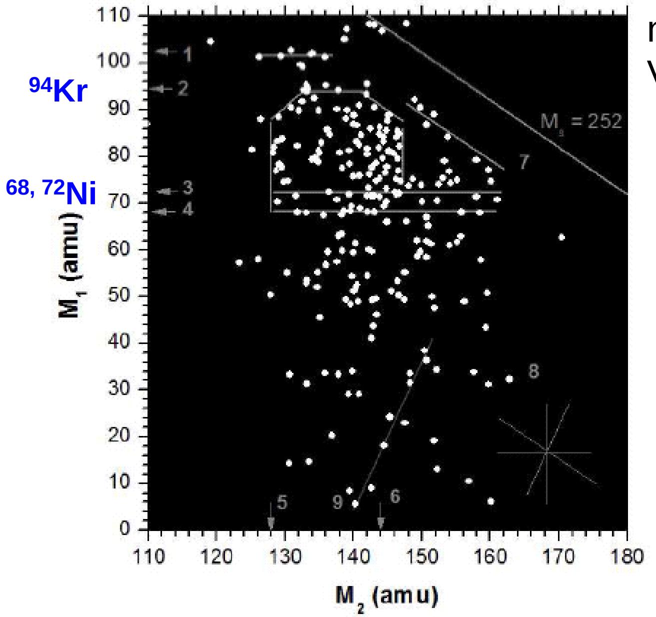


n=3
V-E

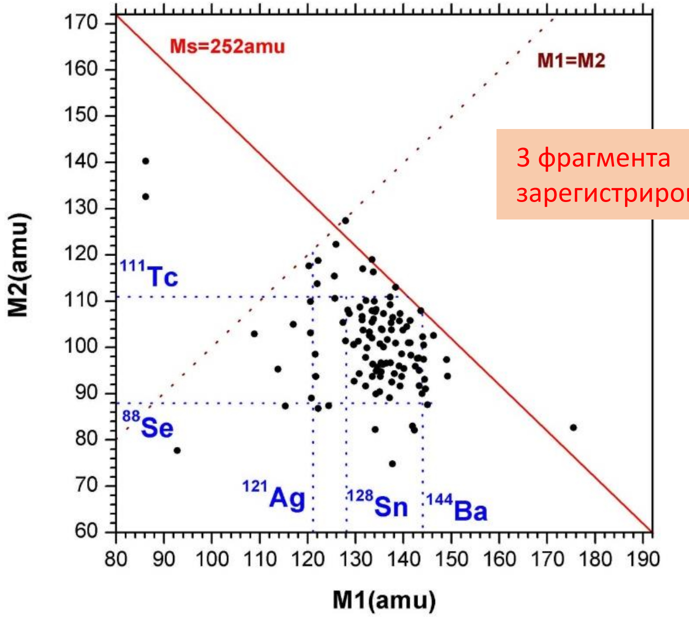


n=3
V-E

Pyatkov, Kamanin et al., EPJ A 48, 94-109 (2012):
- Отбор по нейтронной множественности
- Детали структур
- Вопрос их достоверности

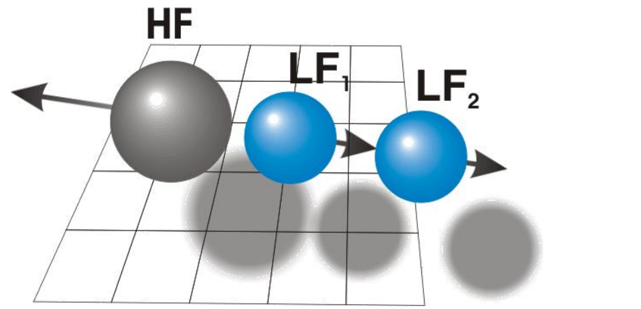


n=2
V-E



3 фрагмента зарегистрировано!

Наши публикации по теме «CCT»



Prescission ternary configurations supposed to be in game

The main benefit drown from the “CCT” studies:
confirmation of the effect
using the selection gates
which differ from that applied in a pure mass-spectrometry.
We mean the neutron multiplicity and nuclear charge gates used.

PHYSICAL REVIEW C 96, 064606 (2017)
Examination of evidence for collinear cluster tri-partition
Yu. V. Pyatkov,[1,2] D. V. Kamanin,[2] A. A. Alexandrov,[2] I. A. Alexandrova,[2] Z.
V. Malaza,[3] N. Mkaza,[3] E. A. Kuznetsova,[2] A. O. Strekalovsky,[2] O. V. Strekal
1National Nuclear Research University MEPhI (Moscow Engineering Physics Institu
2Joint Institute for Nuclear Research, Dubna, Russia
3University of Stellenbosch, Faculty of Military Science, Military Academy, Saldanha
(Received 10 August 2017; published 11 December 2017)
Background: In a series of experiments at different time-of-flight spectrometers of h
manifestations of a new at least ternary decay channel of low excited heavy nuclei. D

http://fobos.jinr.ru/

Источник вдохновения по изучению «ССТ»

44 *W. J. Świątecki*

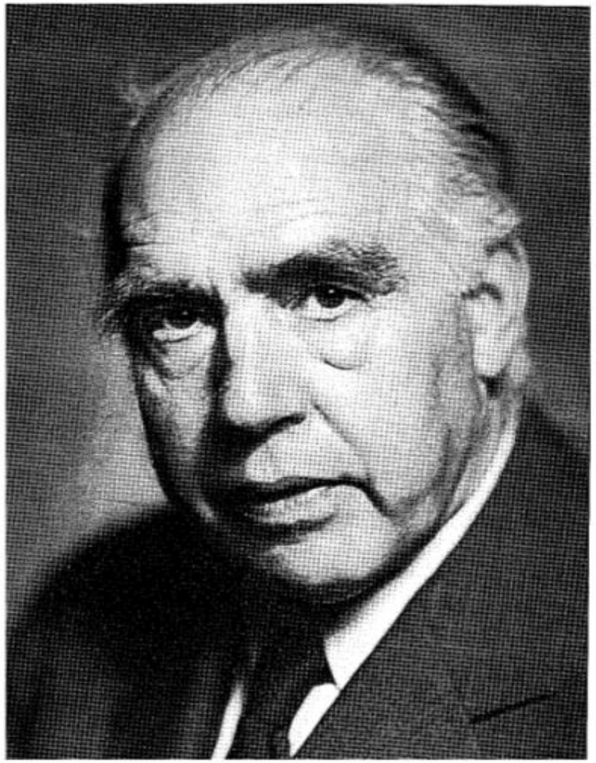


Fig. 3. Niels Bohr

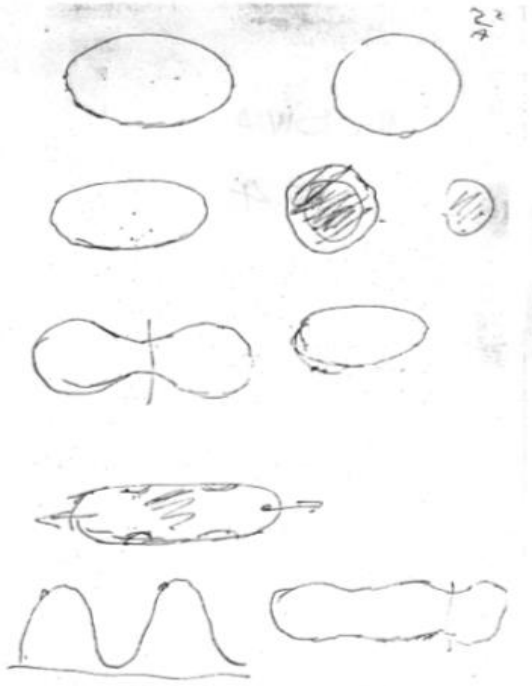
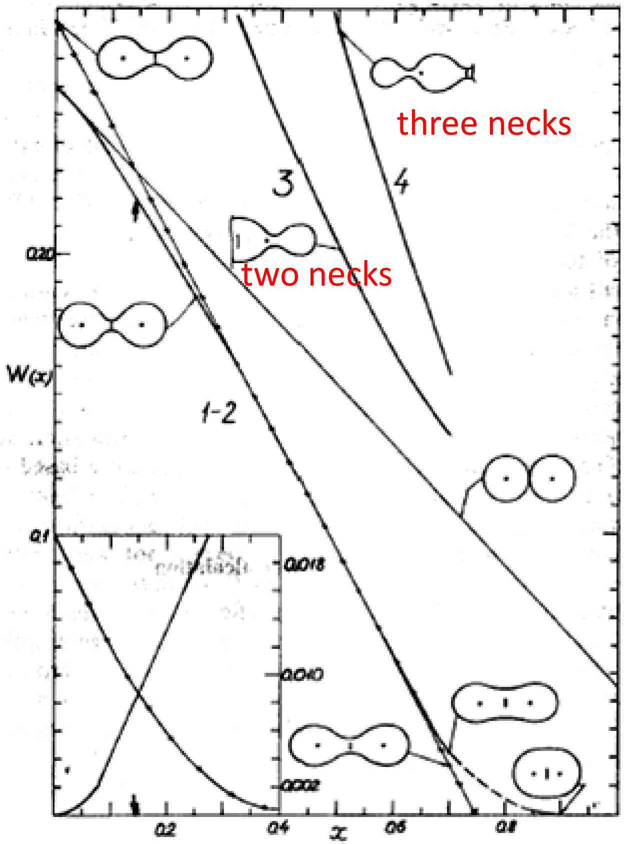


Fig. 4. Bohr's notes, 7th October 1950, his 65th birthday.

…what if the strong electric repulsion would stretch out the post-saddle shape into a sufficiently long cylinder that would actually prefer to divide into three rather than two pieces? This would not be unexpected, because for Uranium the energy released in a division into three equal fragments is actually greater than into two.

SYMMETRICAL SHAPES OF EQUILIBRIUM FOR A LIQUID DROP MODEL

V.M. STRUTINSKY, N.Ya. LYASHCHENKO and N.A. POPOV



Nucl. Phys. **46** (1963) 639

Наиболее близкие к обсуждаемой тематике теоретические работы

EPJ manuscript No.
(will be inserted by the editor)

A New Radioactive Decay Mode, True Ternary Fission, the Decay of Heavy Nuclei Into Three Comparable Fragments.

W. von Oertzen[1] A. K. Nasirov[2]

Pro and contra collinear cluster tri-partition phenomenon interpretation

T. V. Chuvilskaya[1] and Yu. M. Tchuvil'sky[1]
[1]*Skobeltsyn Institute of Nuclear Physics, Lomonosov Moscow State University, 119991 Moscow, Russia*
(Dated: November 13, 2018)

Formation mechanism of decay fragments in spontaneous ternary fission of heavy nuclei

Sh.A. Kalandarov,[1] R.B. Tashkhodjaev,[2,3,4,*] and O.K. Ganiev[5,6]

ЯДЕРНАЯ ФИЗИКА, 2015, том 78, № 6, с. 1–4

ЯДРА

ДЕЛЕНИЕ ЯДЕР НА ТРИ СРАВНИМЫХ ОСКОЛКА

© 2015 г. Ф. Ф. Карпешин*

PHYSICAL REVIEW C **94**, 064615 (2016)

Ternary fission of a heavy nuclear system within a three-center shell model

A. V. Karpov*

Collinear cluster tri-partition: Kinematics constraints and stability of collinearity

P. Holmvall,[1,2,*] U. Köster,[2] A. Heinz,[1] and T. Nilsson[1]
[1]*Department of Physics, Chalmers University of Technology, SE-41296 Gothenburg, Sweden*
[2]*Institut Laue Langevin, 71 avenue des Martyrs, F-38042 Grenoble Cedex 9, France*
(Dated: December 21, 2016)

Shape isomer states and clustering

S. Ċwiok et al.,
Phys. Lett. B 322 (1994) 304

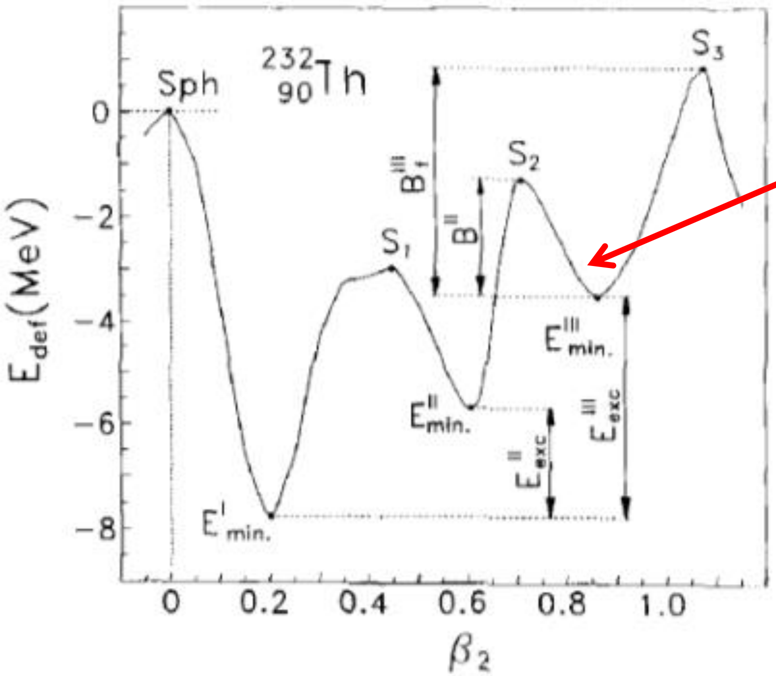
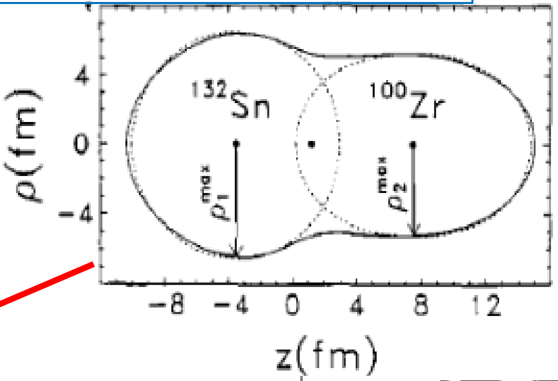


Fig. 1. Potential energy curve for ^{232}Th as a function of quadrupole deformation β_2 along the shorter static fission path of fig. 2.

density distribution at the third minimum looks like a di-nucleus consisting of a nearly-spherical heavier fragment (around doubly-magic ^{132}Sn) and a well-deformed lighter fragment (from the neutron-rich $A \sim 100$ region).



SIS in heavy nuclei

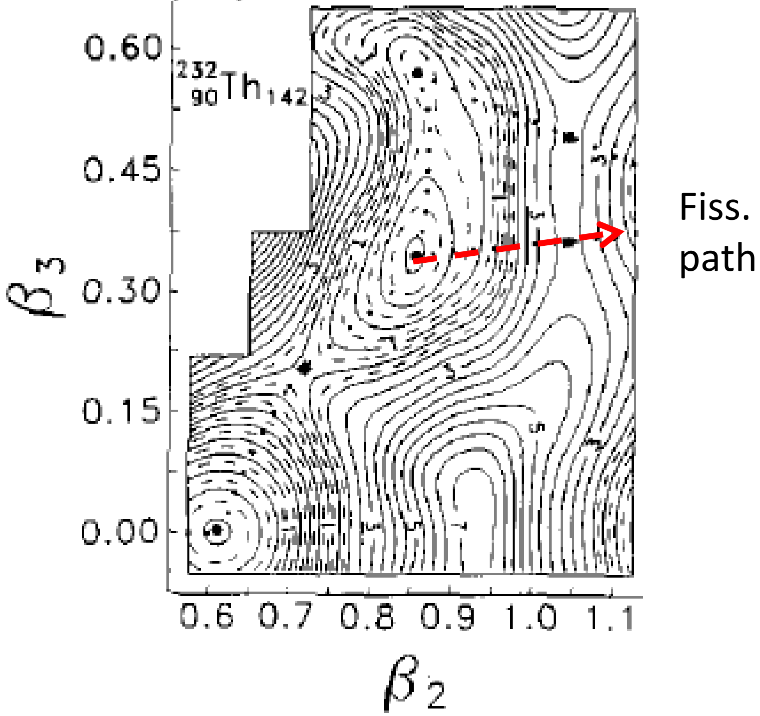
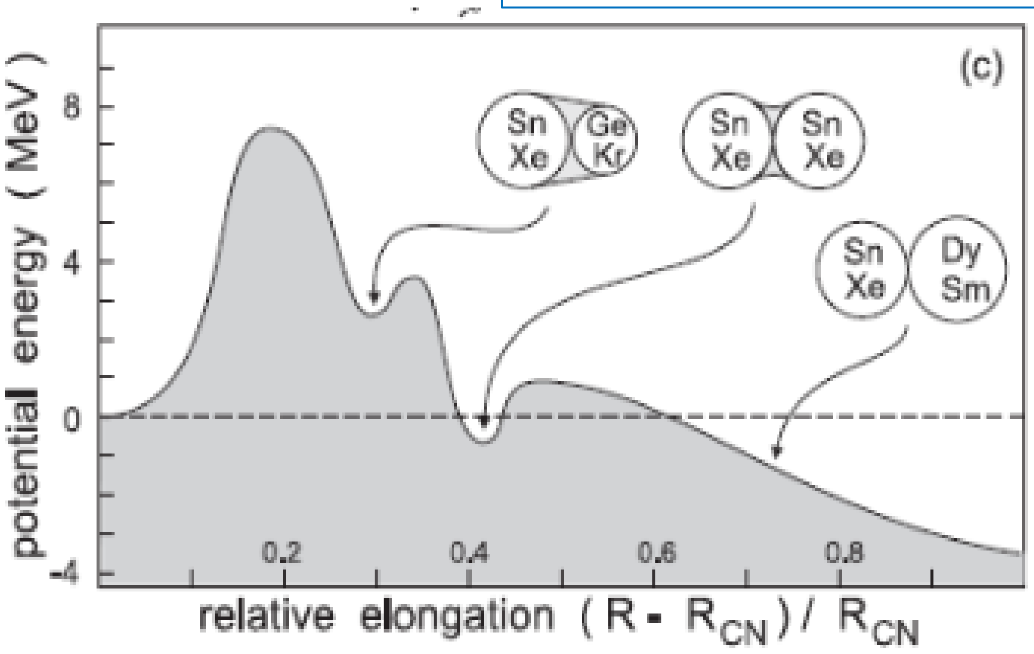


Fig. 2. The Woods–Saxon–Strutinsky total potential energy (relative to the spherical macroscopic energy) for ^{220}Rn, ^{222}Ra, ^{232}Th, and ^{234}U, as a function of β_2 and β_3. At each (β_2, β_3) point the energy was minimized with respect to β_4–β_7. The distance between the solid contour lines is 0.5

SIS in super-heavy nuclei

Shape isomer states and clustering



Three-humped barrier calculated along the fission path of $^{296}_{116}Lv$ (Livermorium).

V. ZAGREBAEV, W. GREINER

Proc. Int. Symp. on Atomic Cluster Collisions (ISACC07), GSI
Darmstadt, 2007, (Imperial College Press, London, 2008), Eds. J.-P.
Connerade and A. V. Solov'yov, p. 23

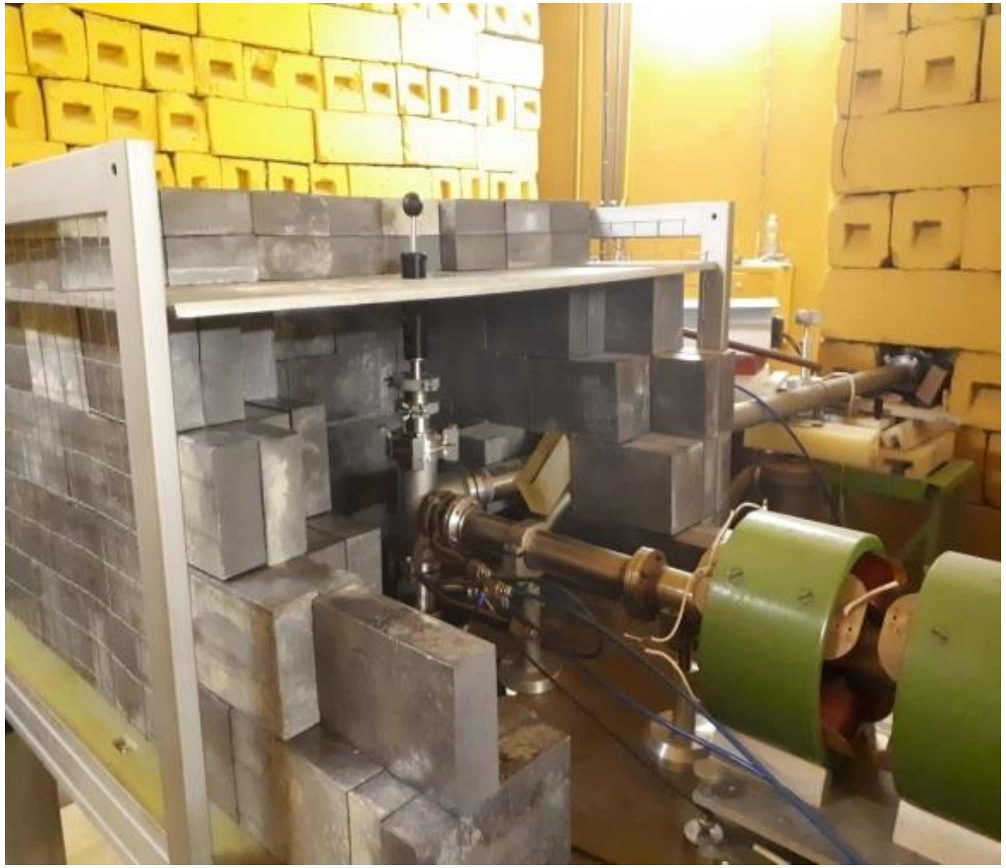
Are there fission isomers in the mass range of fission fragments?

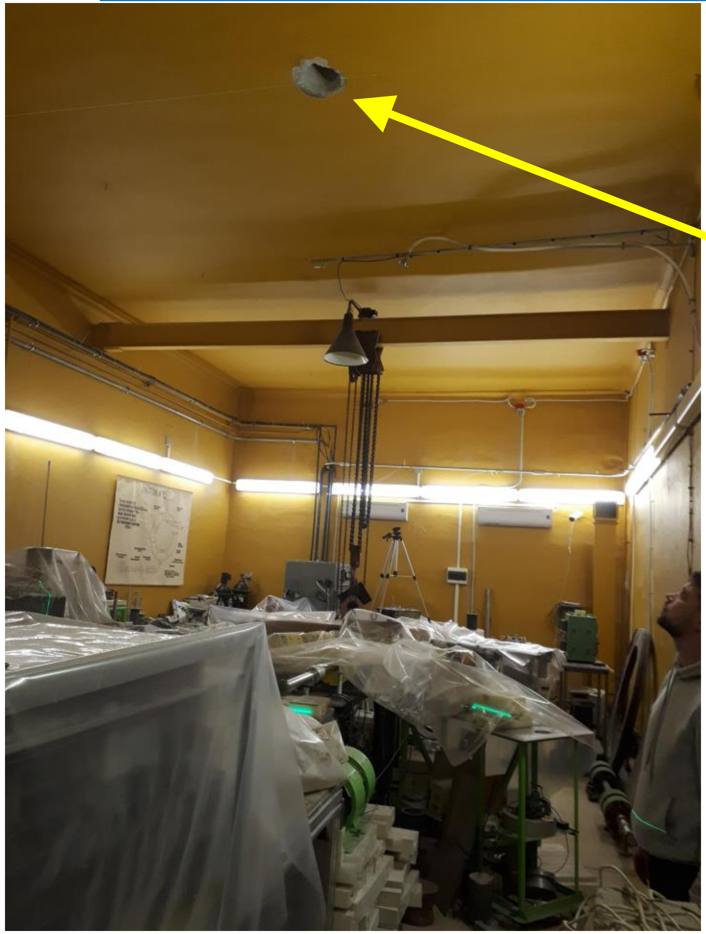
"These intermediate minima correspond to the <u>shape isomer states.</u>
From analysis of the driving potential we may definitely conclude that these <u>isomeric states</u> are nothing else but <u>the two-cluster configurations with magic or semi-magic cores</u> surrounded with a certain amount of shared nucleons."

Наши ближайшие планы

Converter and target in local shielding

A way to the “low-background” lab





International support

Выводы

1. Взаимосогласованные результаты, полученные в рамках 4-х различных экспериментальных подходов, свидетельствуют о том, что некоторая часть осколков бинарного деления слабо возбужденных ядер-актинидов образуются в состояниях долгоживущих изомеров формы.

2. Бинарный распад (break-up) таких ОД при их прохождении через твердотельную фольгу играет роль специфического детектора таких состояний.

3. Результаты наших многочисленных экспериментов также продемонстрировали распад ОД в фольге, *совпадающей по своему положению с источником ОД* (исследования «тройного коллинеарного кластерного распада» «ССТ»), что можно расценивать как косвенное подтверждение обсуждаемого эффекта.

4. Предположительно, ОД в состоянии изомера формы представляет собой деформированное ядро с накопленной энергией деформации, сопоставимой с высотой барьера деления, лежащей в диапазоне 15-40 МэВ.

5. Таким образом, наблюдаемый эффект следует трактовать как индуцированный распад ОД в состоянии изомера формы. **Соответствующий ОД может быть номинирован как «делящийся изомер» по аналогии с известными делящимися изомерами в некоторых актинидах.**

6. По крайней мере один из двух партнеров распада (break-up) демонстрирует магический или полу-магический нуклонный состав. Это позволяет предположить, что состояние изомера формы является ди- ядерной системой с магическим кором или двумя магическими корами, окруженными определенным числом общих нуклонов. Подобная форма была предсказана для гипер- деформированного минимума на барьера деления («второй» ямы) для актинидов и сверхтяжелых ядер.

7. **Как само существование делящихся изомеров в среднетяжелых ядрах (ОД), так и способ их детектирования по распаду в твердотельных фольгах ранее не известны**.

PHYSICAL REVIEW C **86**, 054319 (2012)

Observation of new microsecond isomers among fission products from in-flight fission of 345 MeV/nucleon ^{238}U

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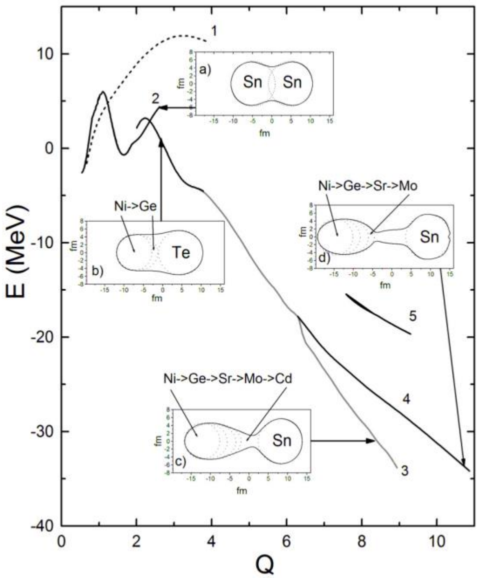
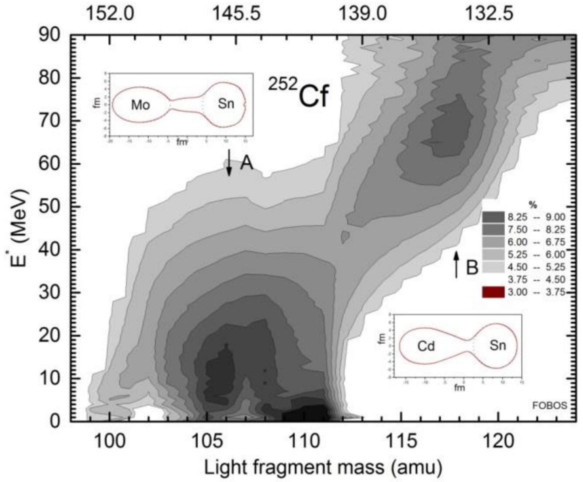
Abstract

A search for isomeric γ decays among fission fragments from 345 MeV/nucleon ^{238}U has been performed at the RIKEN Nishina Center RI Beam Factory. Fission fragments were selected and identified using the superconducting in-flight separator BigRIPS and were implanted in an aluminum stopper. Delayed γ rays were detected using three clover-type high-purity germanium detectors located at the focal plane within a time window of 20 μs following the implantation. We identified a total of 54 microsecond isomers with half-lives of ~0.1–10 μs, including the discovery of 18 new isomers in very neutron-rich nuclei: $^{59}Ti^m$, $^{90}As^m$, $^{92}Se^m$, $^{93}Se^m$, $^{94}Br^m$, $^{95}Br^m$, $^{96}Br^m$, $^{97}Rb^m$, $^{108}Nb^m$, $^{109}Mo^m$, $^{117}Ru^m$, $^{119}Ru^m$, $^{120}Rh^m$, $^{122}Rh^m$, $^{121}Pd^m$, $^{124}Pd^m$, $^{124}Ag^m$, and $^{126}Ag^m$, and

The fast isotopic separation and identification of reaction products, which take place in several hundred nanoseconds, allow event-by-event detection of isomeric γ rays at the focal plane of the separator with small decay losses in flight. The γ decays are observed under low-background conditions after ion implantation. …
In-flight fission of a uranium beam have been used as production reactions to populate isomers. In-flight fission is known to be an excellent mechanism for producing neutron-rich exotic nuclei…

Strongly deformed prescission shapes of the ^{252}Cf nucleus





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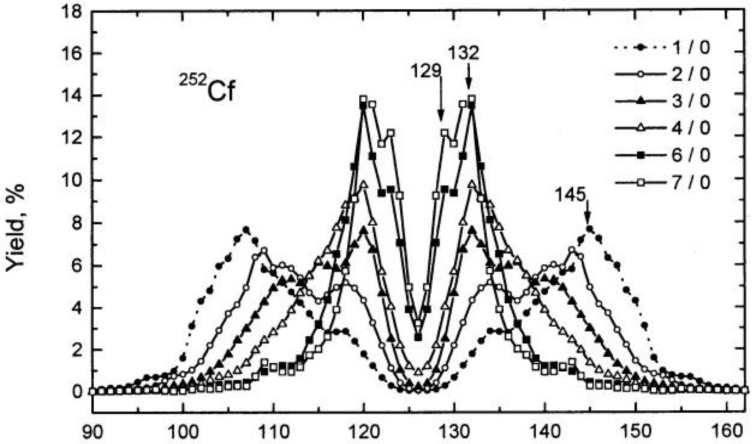

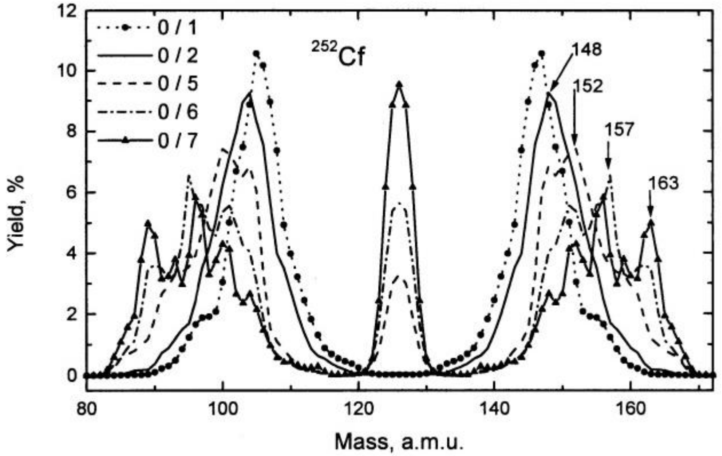

Y of ν_{tot} = 6 and ν_L / ν_H = **6/0**: **2.19 %** and **0.72 %** for ^{248}Cm and ^{252}Cf resp.

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