



Spectroscopy of the isotopes of transfermium elements at FLNR JINR

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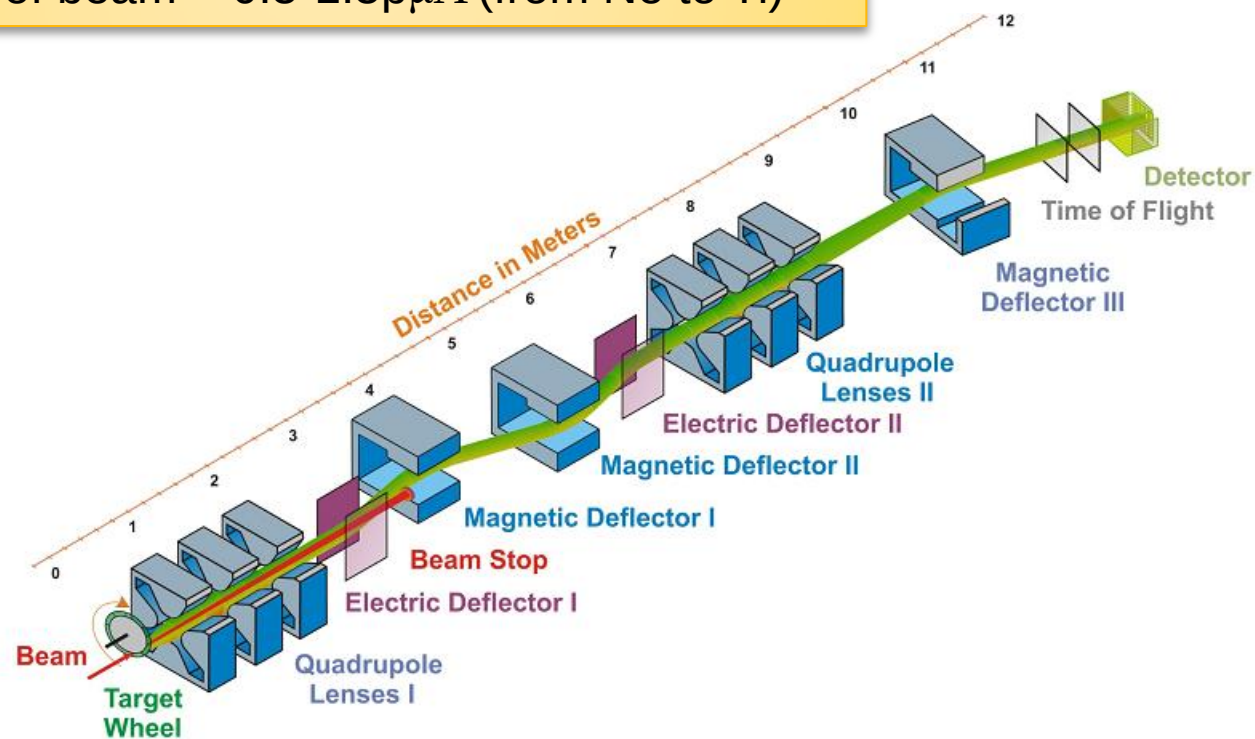


Goals

- ✓ Study of the decay properties of heavy nuclei, isomeric and ground states, by α, β, γ -spectroscopy of mother (implanted) and daughter products of the evaporation residues.
- ✓ Study of the single particle level structure in Fm-Sg region, by moving away from the N=152 towards the N=162 shell.
- ✓ Definition excitation energy, spin and parity of nuclear levels.

SHELS

Efficiency of transition p. through set-up ~ 5-45%
depending on reactions.
Intensity of beam ~ 0.5-1.5 pμA (from Ne to Ti)



SHELS in live



Principal components of the separator



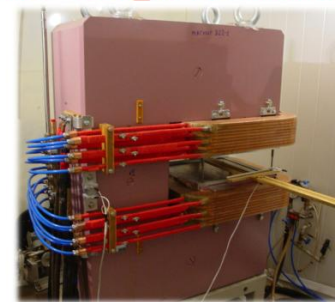
Quadrupole Lenses

Maximum field gradient: 13 T/m;
Effective length: 38 cm;
Aperture radius: 10 cm.



HV Electrostatic Deflectors

Effective length: 65.7 cm;
Distance between plates: 10 - 20 cm;
Maximum field gradient: 40 kV/cm;
Rated deflection angle: 8°.



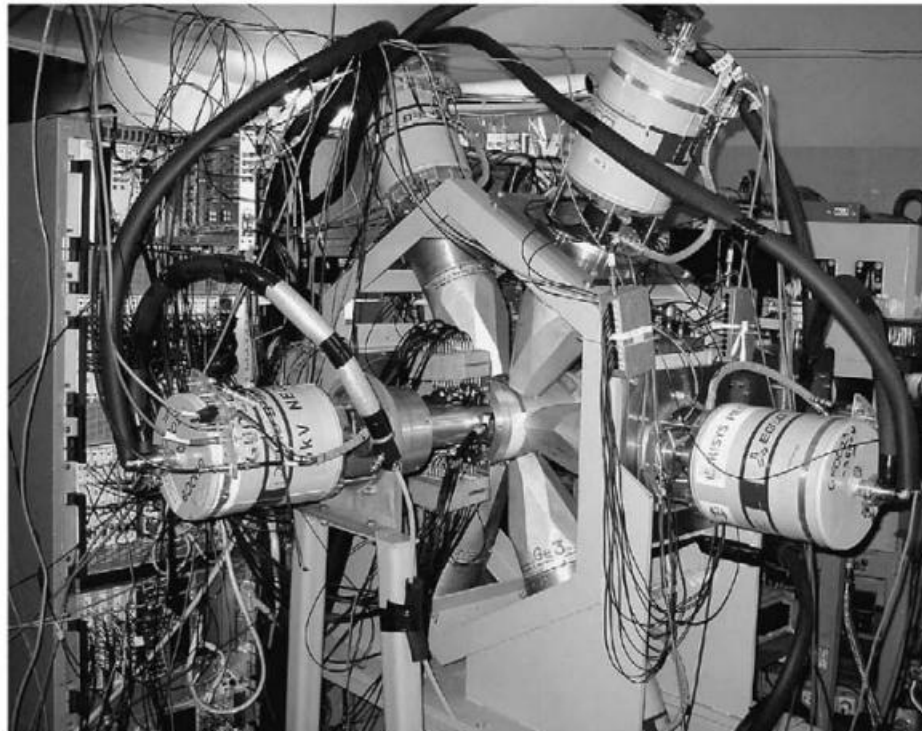
Dipole Magnets

Effective length: 59.7 cm;
Dipole aperture: 13.5 cm;
Maximum field strength: 0.8 T;
Rated deflection angle: 21.8°.

GABRIELA

Gamma Alpha Beta Recoil Investigation with the Electromagnetic Analyser

Old set-up
(2006)



Seven single crystal Ge-detectors and one box of DSSD

GABRIELA^{NEW}

Gamma Alpha Beta Recoil Investigation with the Electromagnetic Analyser

Nowadays
set-up
(2019)

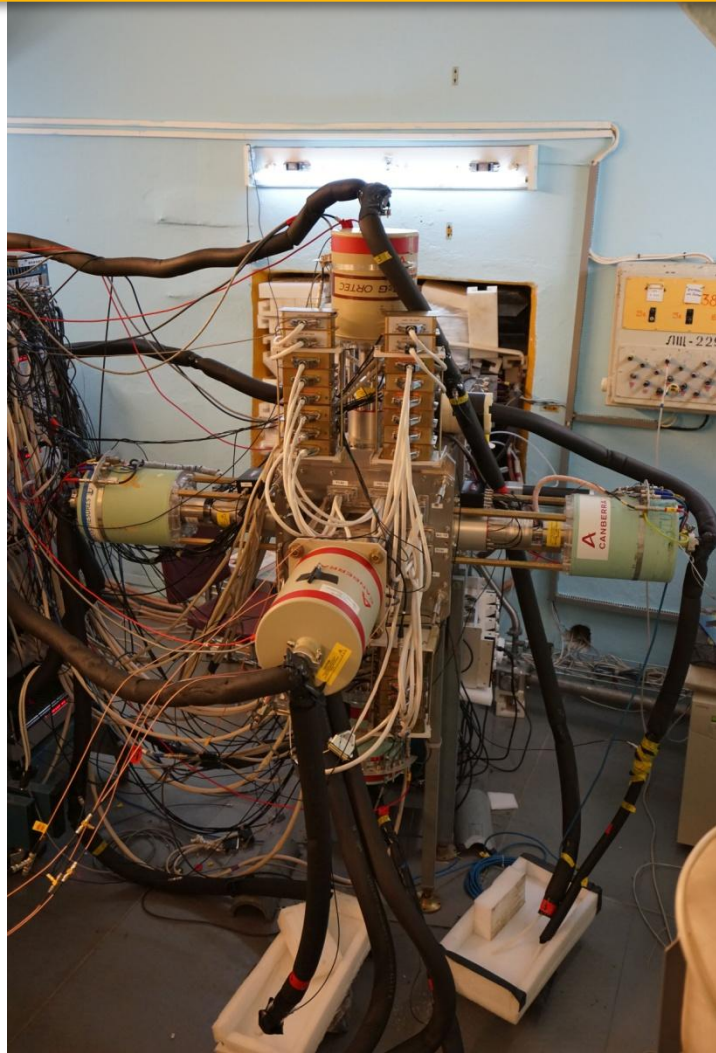
For alpha:

Resolution ~ 15keV

1 box of silicon det.
4 Ge-detectors
1 Clover detector

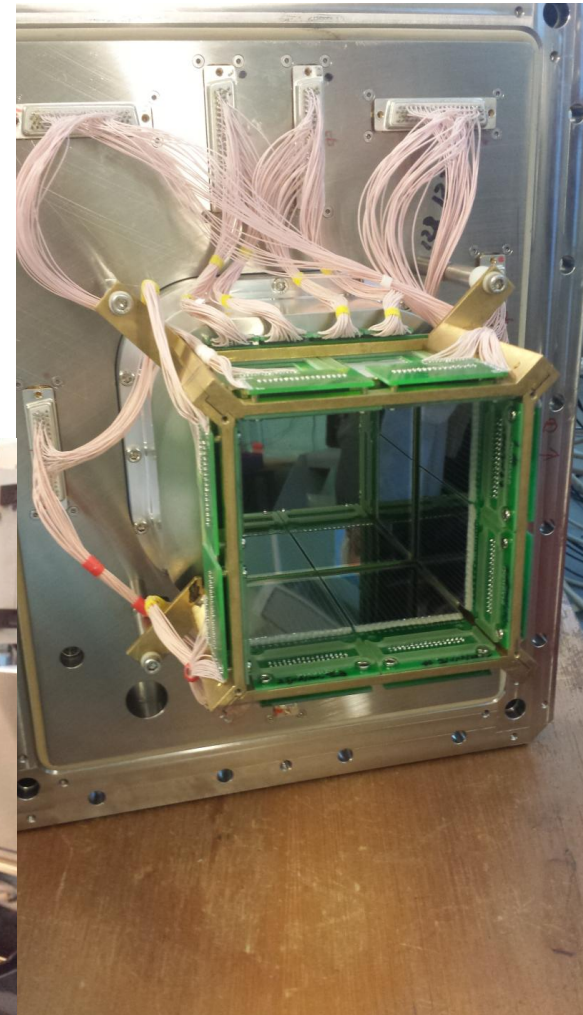
For gamma:

Resolution ~ 2 keV

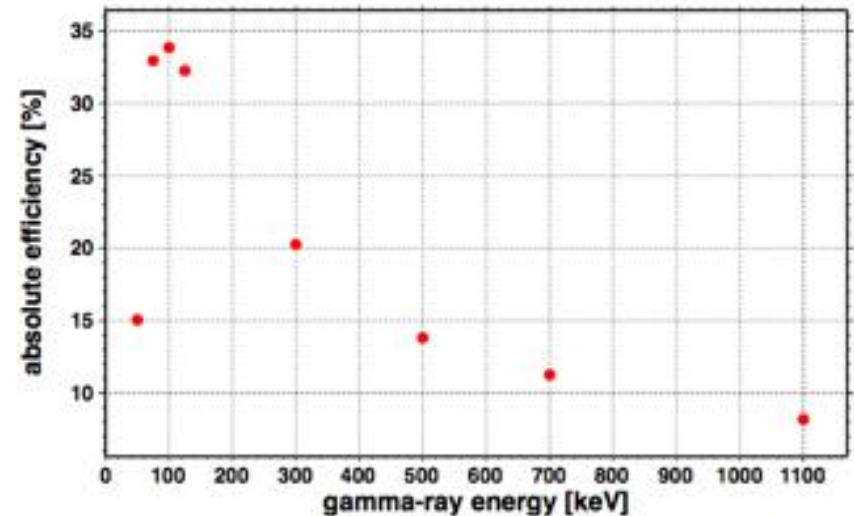
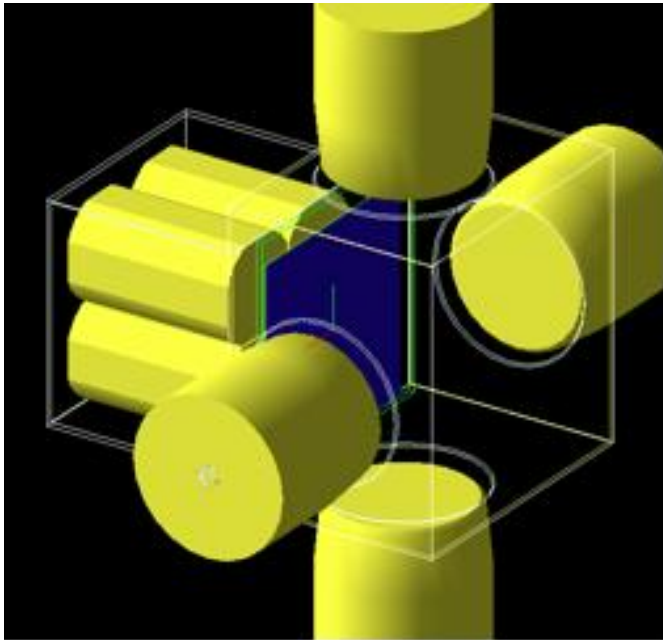


Box of DSSD

Detection system include:
one 128x128 DSSD(10x10mm) and
eight 32x32 DSSD (50x60mm)
Efficiency of reg. 70-80%
Resolution ~ 15 keV



System of Ge-detectors

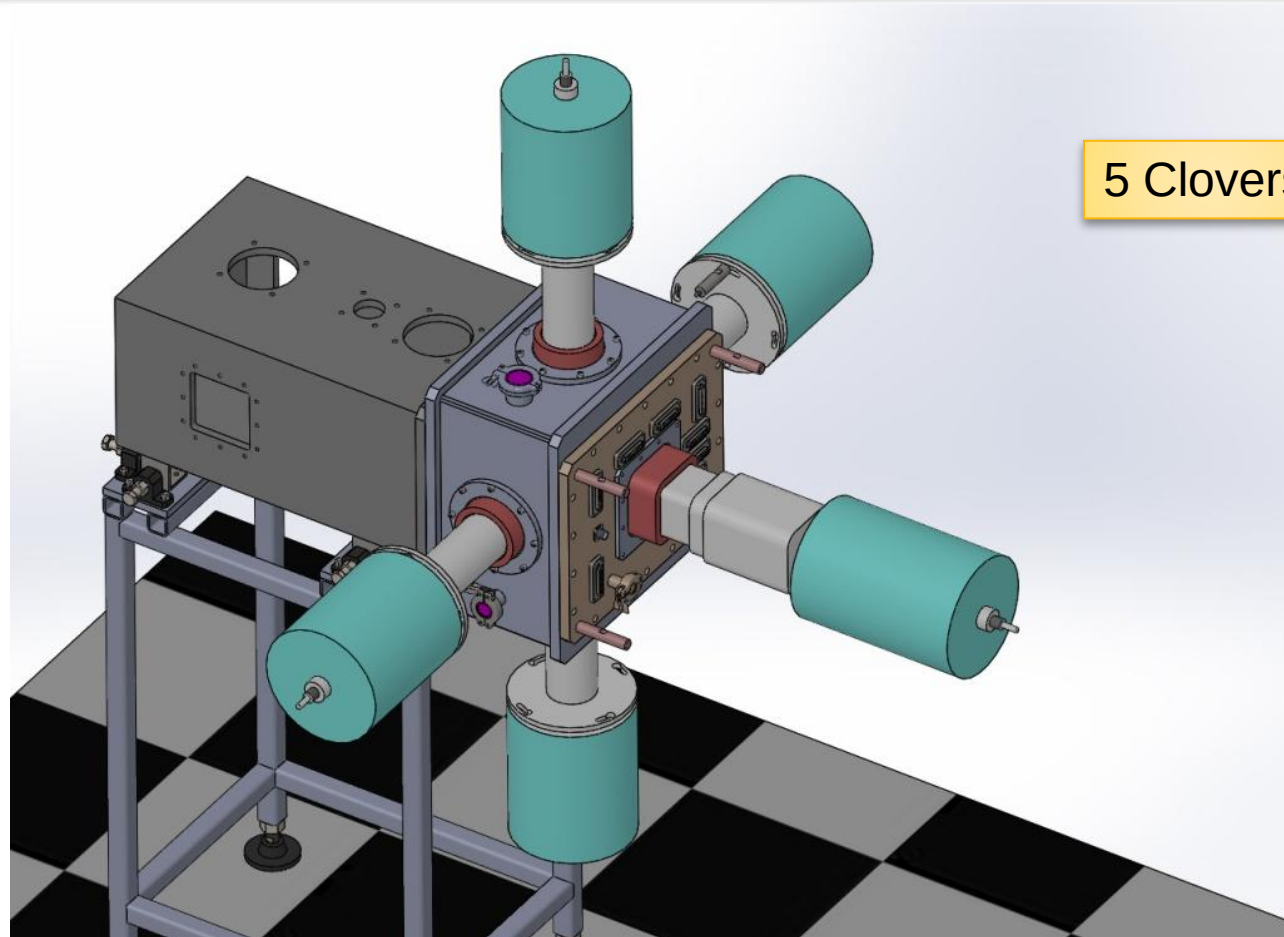


Preliminary GEANT4 detector arrangement including a Clover and 4 EUROGAM phase-I. These surround the 10x10 cm² implantation detector (in blue) and its PCB (green).

Right : A first estimate of the achievable singles efficiency as a function of photon energy for a distributed source.

System of Ge-detectors

FUTURE PLANS

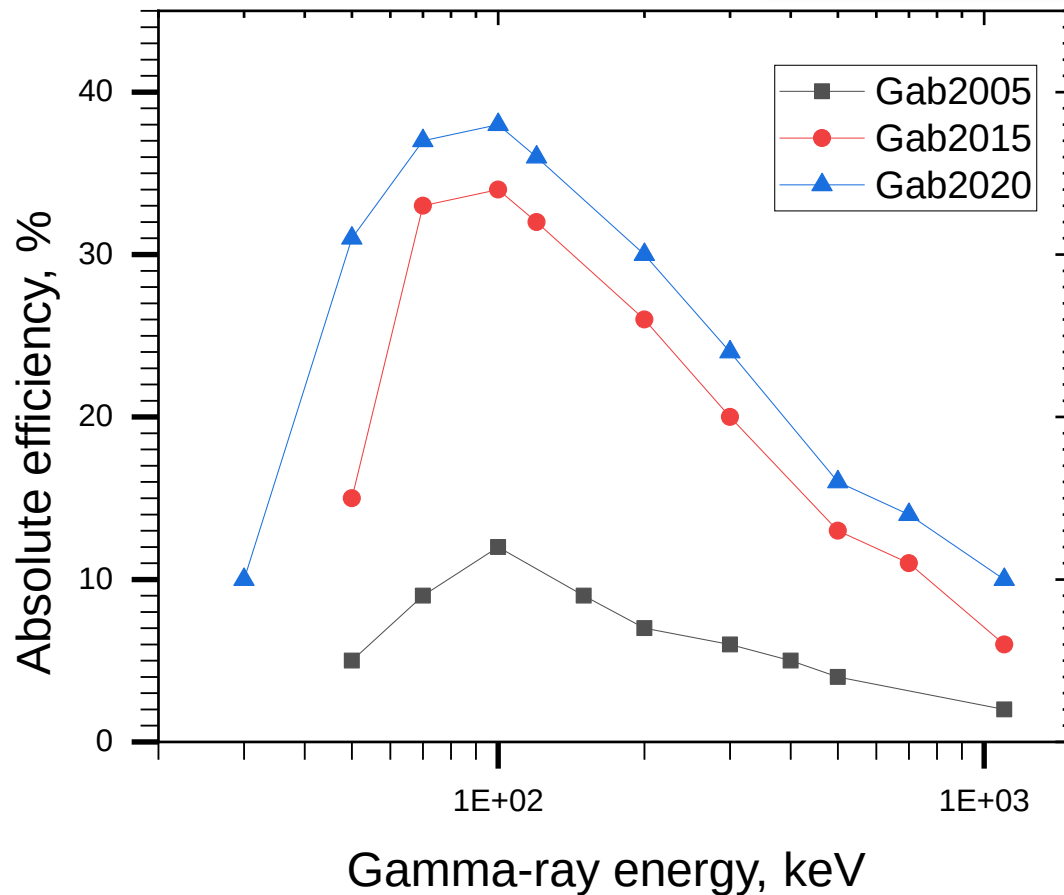


Design of the new detector arrangement at the focal plane of SHELS

Efficiency

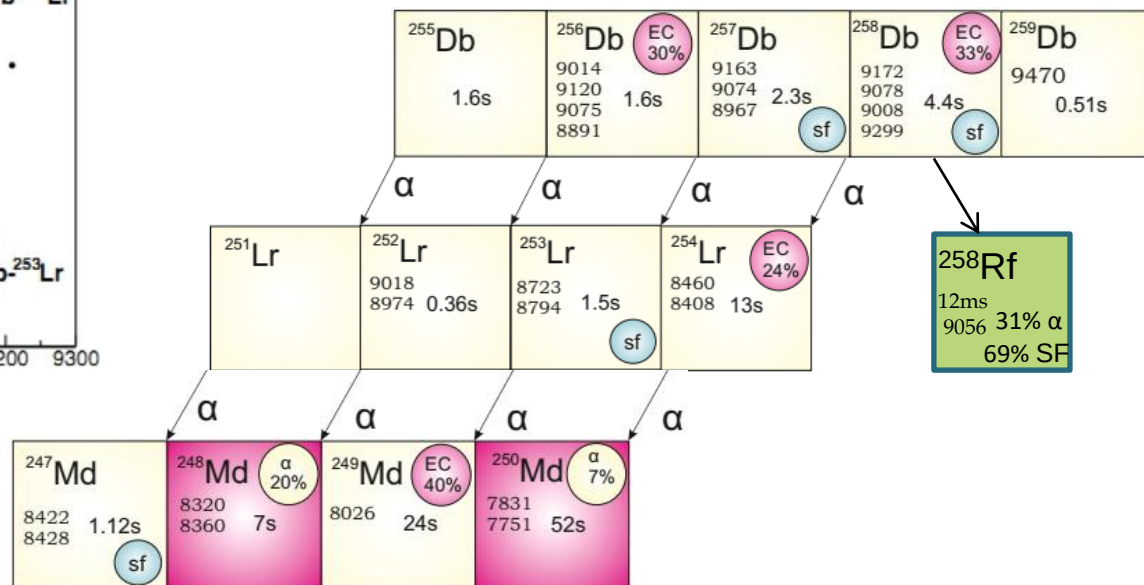
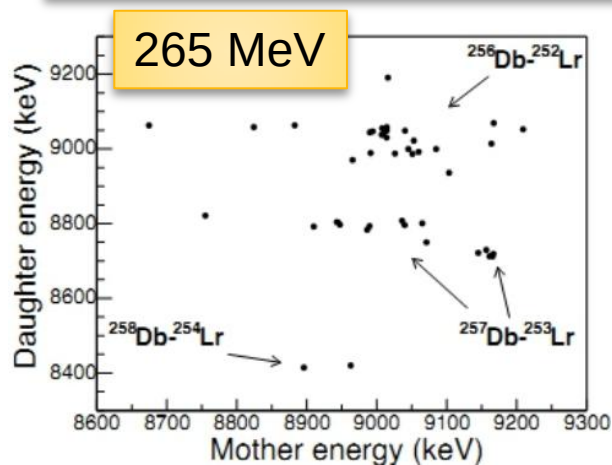
FUTURE PLANS

GABRIELA



Experiments at 2017-2019

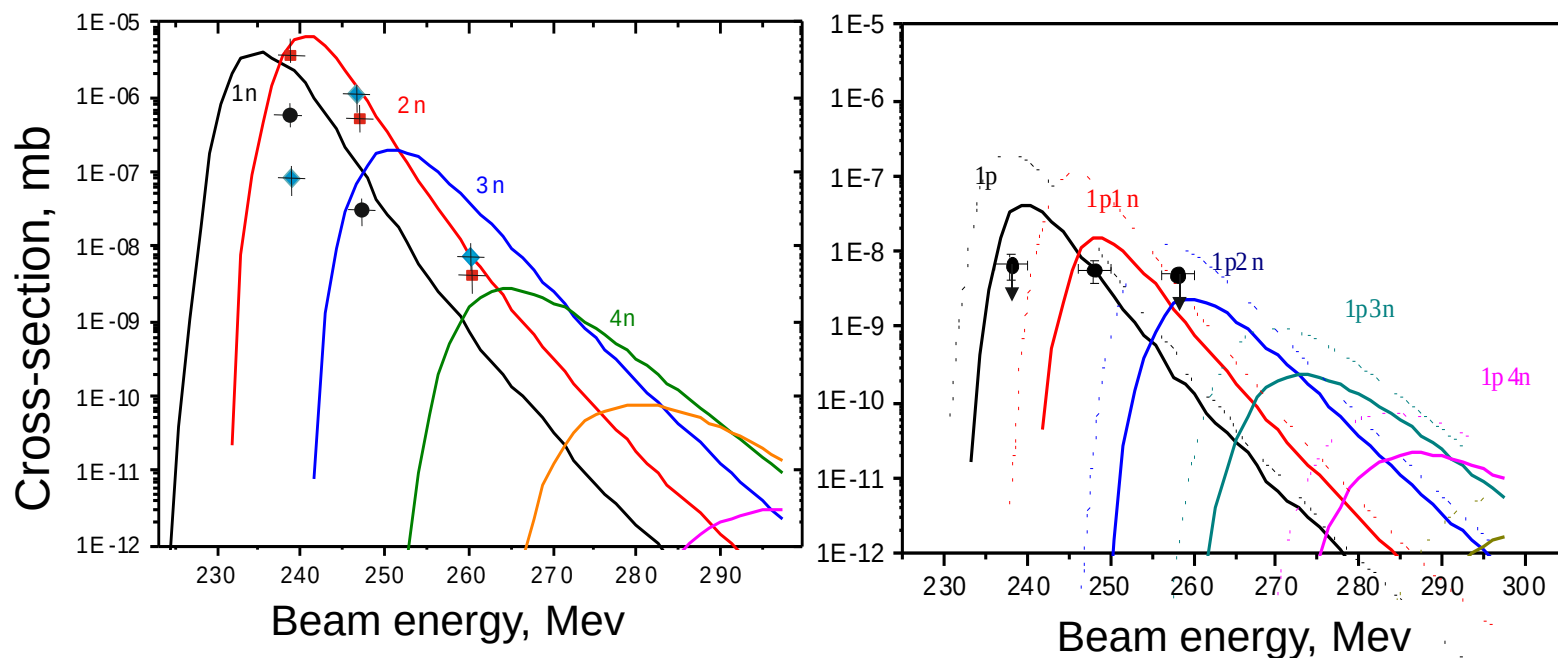
Reaction	Goal	Experimental results
16 November – 19 December 2017		
$^{209}\text{Bi} (^{50}\text{Ti}, \text{xn}) ^{259-x}\text{Db}$	Collecting of statistic for $^{259-x}\text{Db}$. Search pxn and xn channels.	Results for xn, pxn channels.
10 January – 15 March 2018		
$^{208}\text{Pb} (^{50}\text{Ti}, \text{xn}) ^{258-x}\text{Rf}$	Collecting of statistic for $^{258-x}\text{Rf}$.	Good statistic for $^{255,256,257}\text{Rf}$. New results for level structure.
June – the end 2018		
$^{206}\text{Pb} (^{50}\text{Ti}, 2\text{n}) ^{254}\text{Rf}$ $^{208}\text{Pb} (^{54}\text{Cr}, \text{xn}) ^{262-x}\text{Sg}$	Study of isomeric states in ^{254}Rf . First test of ^{54}Cr beam.	Good statistic for in ^{254}Rf . Good prediction for future experiments.
$^{236}\text{U} (^{22}\text{Ne}, \text{xn}) ^{258-x}\text{No}$ $^{208}\text{Pb} (^{22}\text{Ne}, \text{xn}) ^{228-x}\text{U}$	Test. Study of the decay modes.	<5% transmission. Data analysis.
14 January – 11 February 2019		
$^{204}\text{Pb} (^{48}\text{Ca}, 2\text{n}) ^{250}\text{No}$ $^{206}\text{Pb} (^{48}\text{Ca}, 2\text{n}) ^{252}\text{No}$ $^{208}\text{Pb} (^{48}\text{Ca}, 2\text{n}) ^{254}\text{No}$	Collecting of statistics ^{252}No and find metastable levels of $^{250,254}\text{No}$;	Good statistic. Data in analysis, and already see isomeric state for ^{250}No .



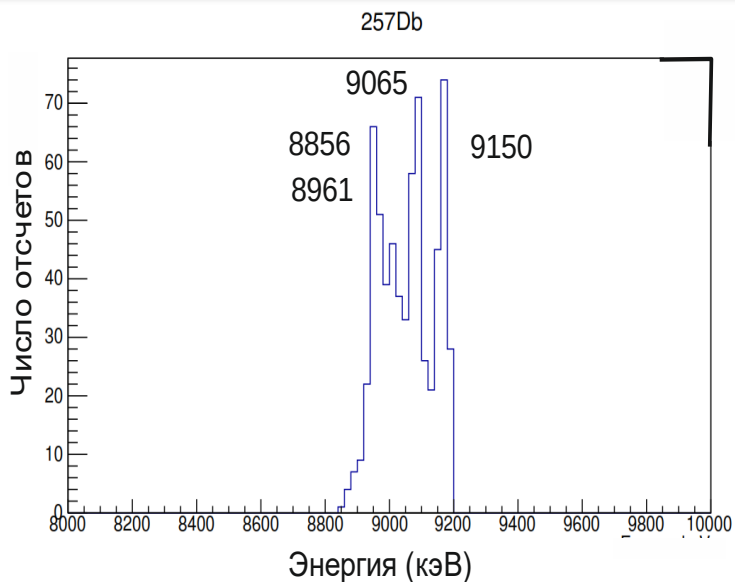
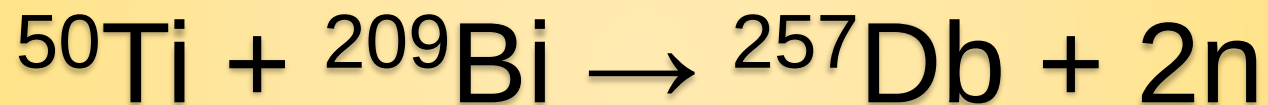
Energy beam, MeV	Flux	$^{256}\text{Db} - ^{252}\text{Lr}$ (3n)	$^{257}\text{Db} - ^{253}\text{Lr}$ (2n)	$^{258}\text{Db} - ^{254}\text{Lr}$ (1n)	Fast fission(Ge/well det.)	$T_{1/2}$ (ms)	σ (pb)
255	6.8×10^{17}	0	142	5	0		$<6.6^{+15}_{-6}$
265	2.1×10^{18}	28	18	2	3 (2/1)	12^{+16}_{-4}	5.7^{+17}_{-3}
275	7.1×10^{17}	1	2	0	0		$<4.9^{+11}_{-4}$

Cross-section for xn and pxn channels

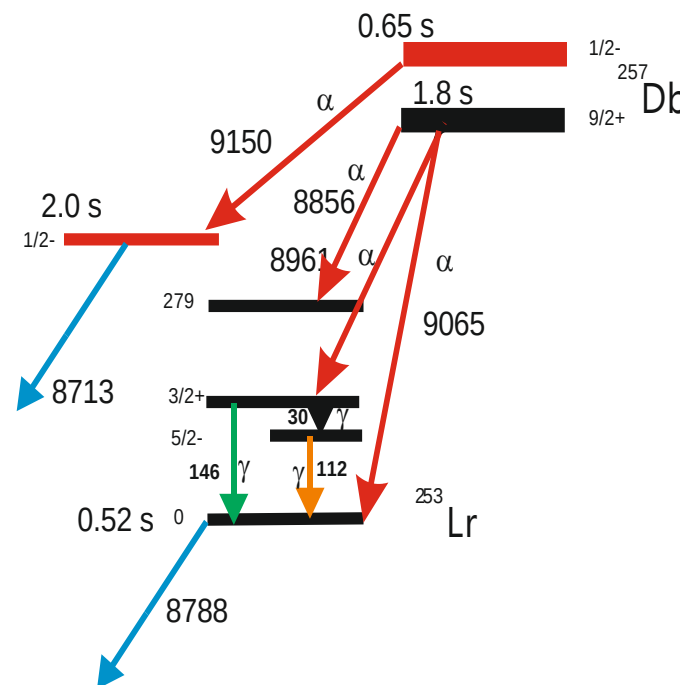
Cross-sections of xn and pxn channels were measured in experiment.



Energy beam in mid-target, MeV	Channels	Isotopes	Cross-section, pb
248	p0n	^{258}Rf	5.7
	2n	^{257}Db	600

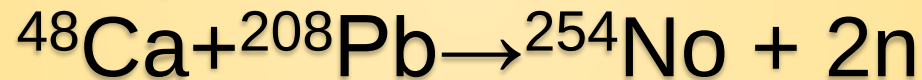


Alpha lines of ²⁵⁷Db.



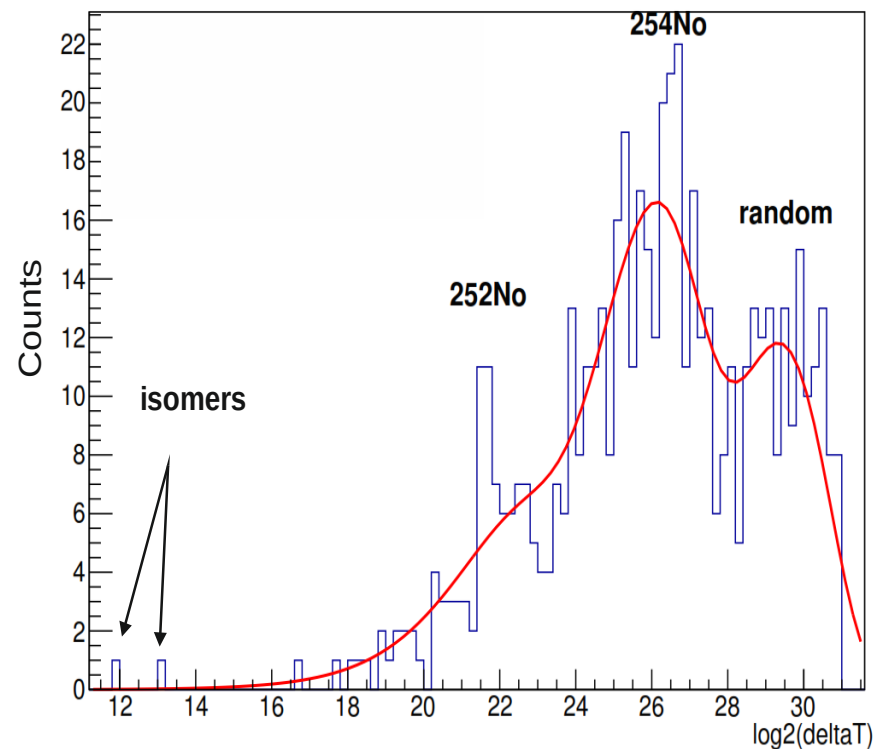
Level scheme from the α-γ correlations analysis.

Experiment **nowadays**

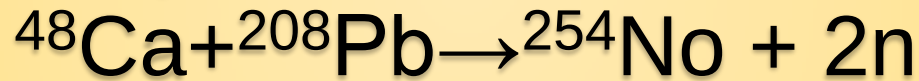


^{254}No ($B_{\text{SF}} = 0.17\%$) & ^{252}No ($B_{\text{SF}} = 30\%$,
reaction on addition ^{206}Pb in ^{208}Pb target) good
separated by half-live time.

Flux $\sim 8 \cdot 10^{17}$
SF = 310 events
6 days
2 isomers



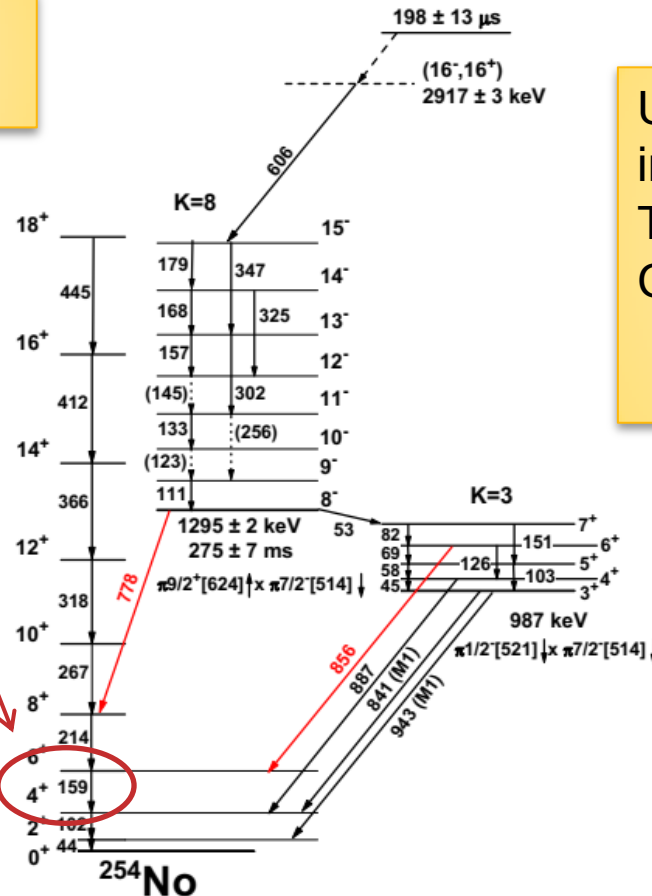
Experiment nowadays



- According to preliminary analysis:

Observed 6^+ in 4^+ transition.

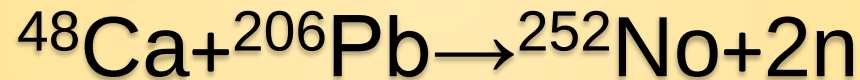
$E_\gamma \sim 159 \text{ keV}$



Unfortunately, beam intensity wasn't good. Thus, we only repeated GSI experiment.

F.P. Heßberger¹, Eur. Phys. J. A **43**, 55–66, 2010

Experiment nowadays



4 days

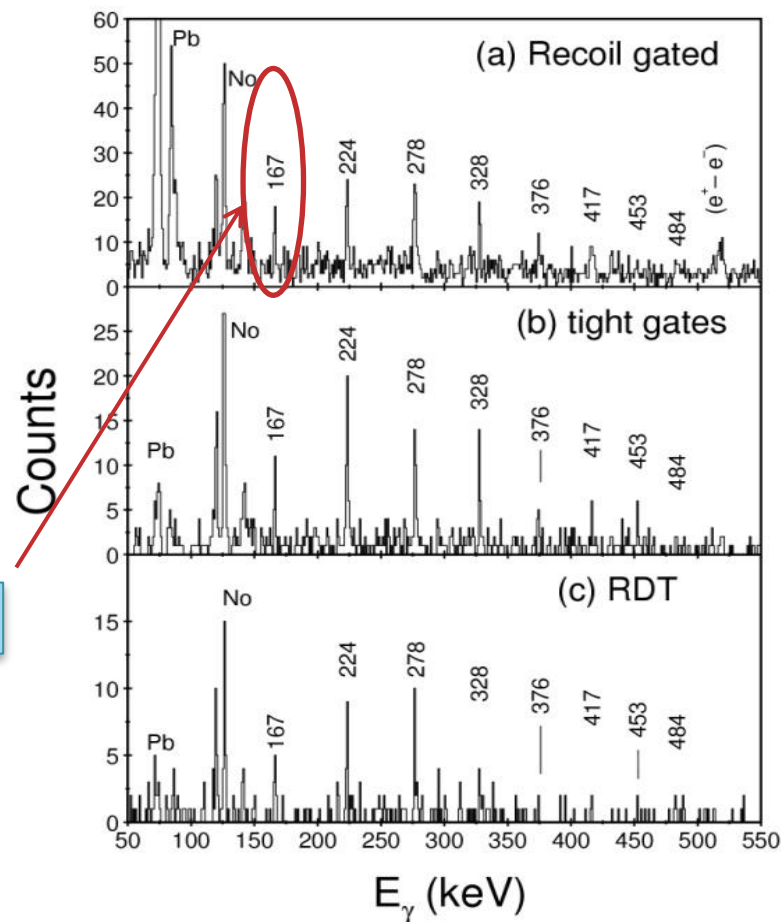
Flux $\sim 4.6 \cdot 10^{17}$

SF = 22 000

Enough statistics for
TKE calibration of detectors.

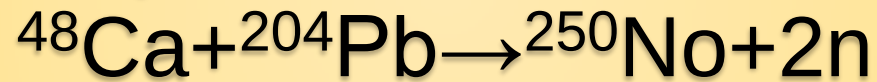
According to preliminary analysis:

$E_\gamma \sim 167\text{keV}$



R. Herzberg, „ PRC

Experiment nowadays



According to preliminary analysis:

From gamma correlation spectrum
was observed new transition in ^{250}No !

13 days
Flux $2.6 \cdot 10^{18}$
SF = 18 000

(6+) 1050 46 μs

(4+)

(0+) 4.2 μs

Future experiments 2019-2020

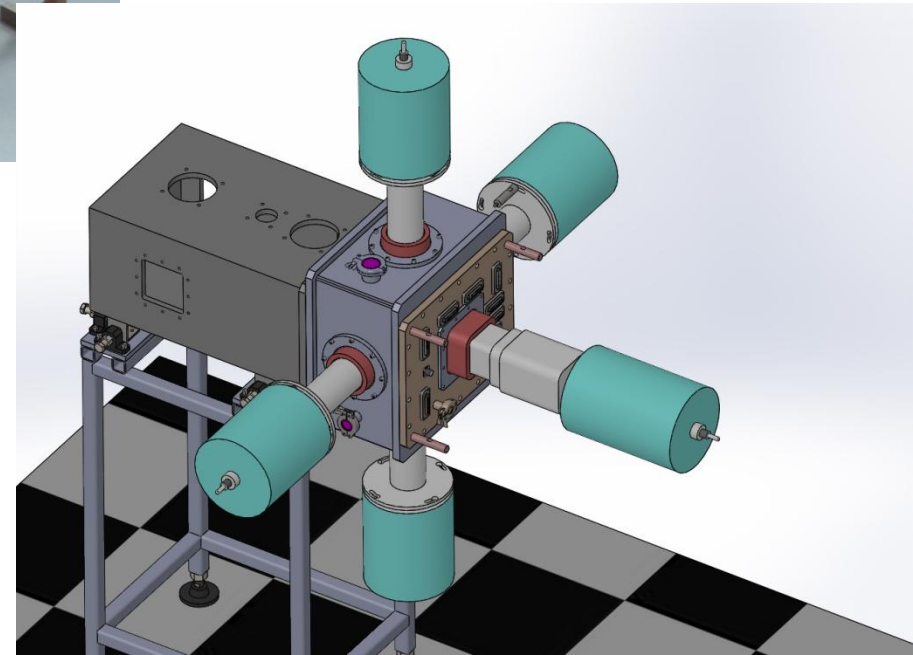
Reactions	Goals
$^{238}\text{U}(^{22}\text{Ne}, xn)^{260-x}\text{No}$	Study of the decay modes.
$^{208}\text{Pb}(^{54}\text{Cr}, xn)^{262-x}\text{Sb}$	Study of the SF.
$^{208}\text{Pb}(^{48}\text{Ca}, 2n)^{254}\text{No}$	Study of the decay modes.
$^{242}\text{Pu}(^{22}\text{Ne}, xn)^{264-x}\text{Rf}$	Study of the decay modes.

Future modernizations 2019-2020



New triplets of lenses:
aperture length of 300mm.

New detectors for
GABRIELA.



The people

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THANK YOU!