Joint Institute for Nuclear Research
Flerov Laboratory of Nuclear Reactions

Detailed study of No and Rf isotopes radioactive decay properties

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Outline

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    - 3.3. ^{252}No
    - 3.4. ^{250}No
4. Conclusion
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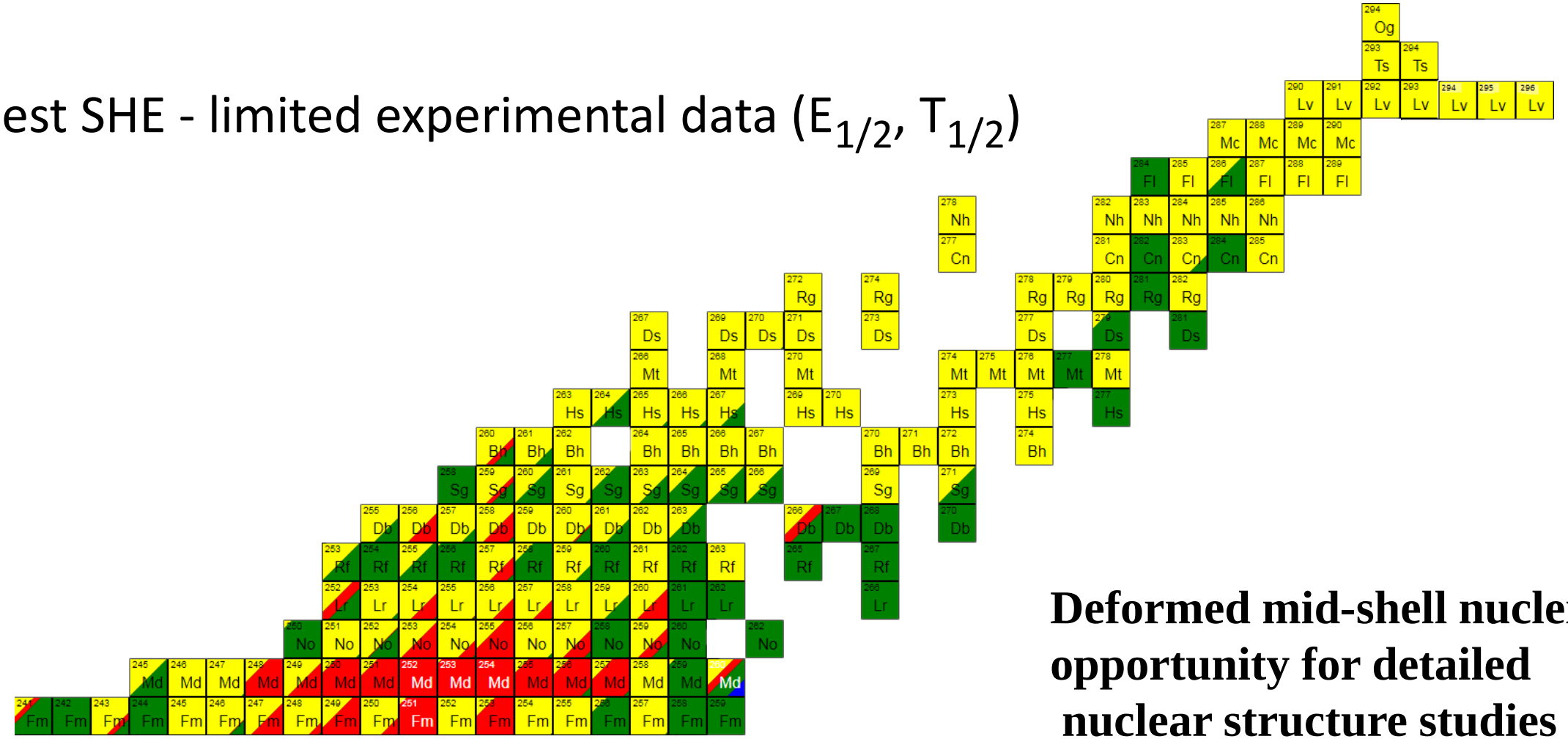
Motivation

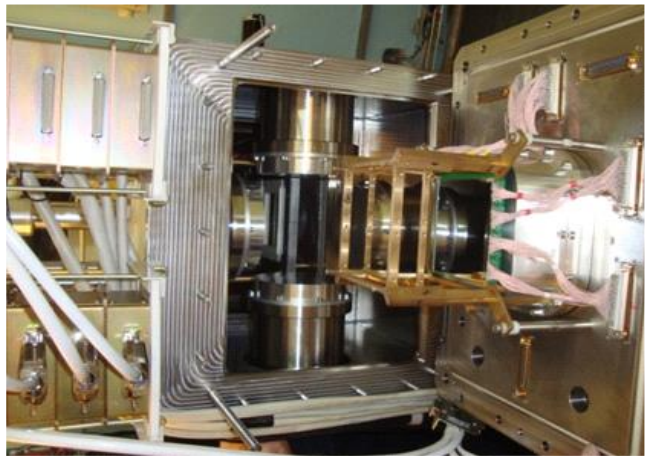
Haviest SHE - limited experimental data ($E_{1/2}$, $T_{1/2}$)



Deformed mid-shell nuclei: opportunity for detailed nuclear structure studies

Spectroscopy of transfermium elements at Dubna

- High intensity heavy ion beams with good energy resolution 0.5 – 1.5 pμA – cyclotron U400.
- Experimental set up – recoil kinematic separator VASSILISSA / SHELS with good background conditions at the focal plane
- Sophisticated detector systems at the focal plane-GABRIELA.



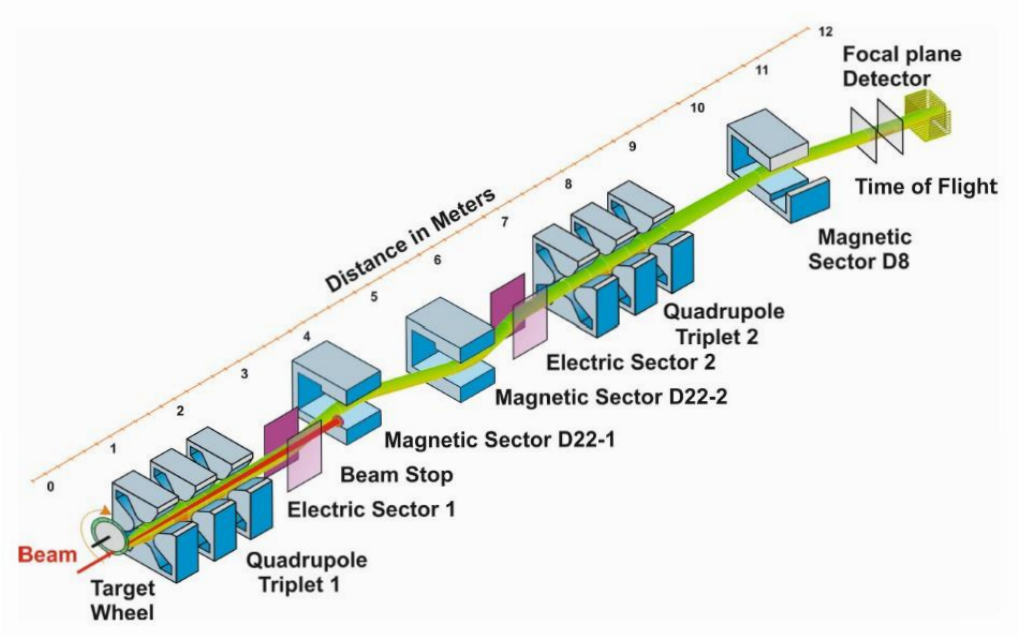
Experimental set-up

GABRIELA

Gamma **A**lpha **B**eta **R**ecoil **I**nvestigation with the **El**ectromagnetic **A**nalyser

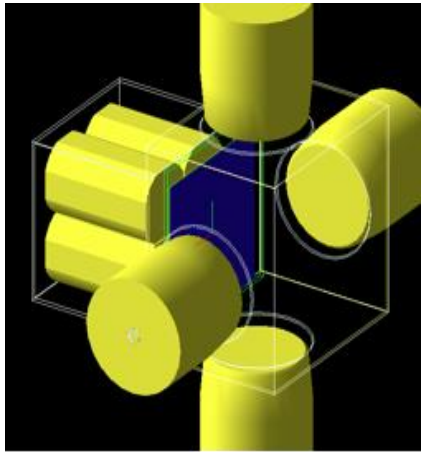
Velocity filter **SHELS**

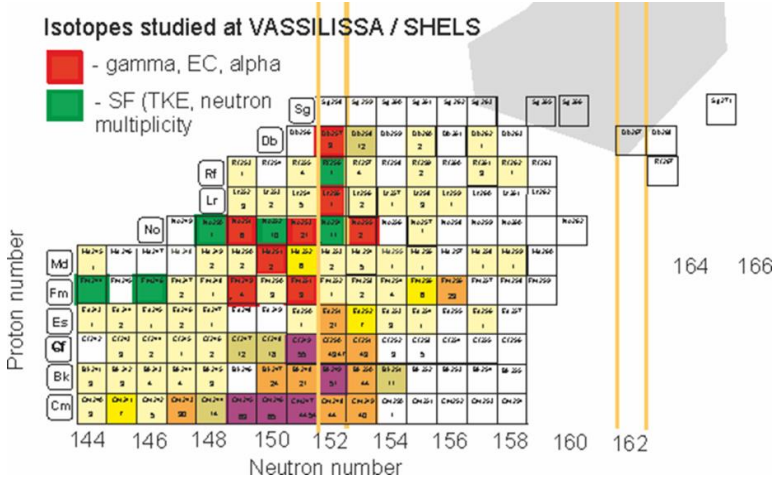
Separator for **H**eavy **El**ement **S**pectroscopy



- Study of the SF isomers.

- 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.



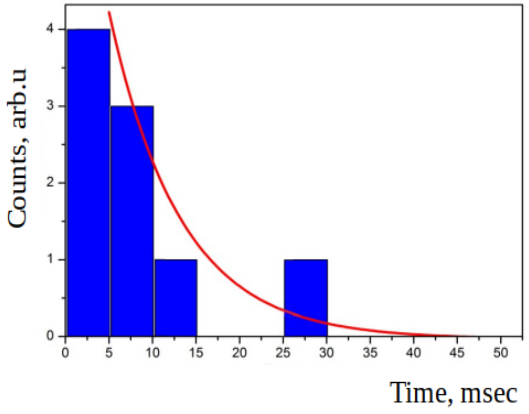


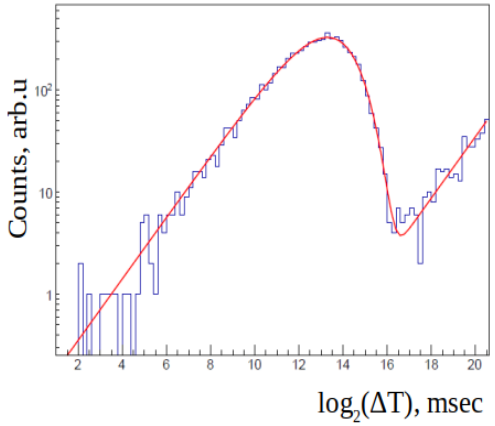
SHELS Result: ^{256}Rf

Experiment

$^{50}Ti + ^{208}Pb \rightarrow ^{258}Rf^{*} \rightarrow ^{256}Rf + 2n$

Experiment	α-decay events	$T_{1/2}$(SF), msec	$T_{1/2}$(α), msec	b_{sf}	b_{α}
1997 year F.P.Heßberger et. all.,// Z. Phys. A 359, pp. 415–425	1	6,2 ±0,2		0.9968	0.0032
2016 year A. I. Svirikhin et.all., //Phys. of Part. and Nucl. Lett, Vol. 13, No. 4, pp. 480–482.	0	5.75 ± 0.17		~ 100%	
2018 year A.V. Yeremin, M.S. Tezekbayeva et. all.,// Phys. of Part. and Nucl. Lett, Vol 16, №3, pp. 224-228	9 (8726-8798) keV	6.9 ±0.23	5.7 ±1.2	0.9971	0.0029





SHELS Result: Isotopes of No.

Preliminary experimental results: January 2019, GABRIELA setup

Reactions: $^{48}Ca + ^{204,206,208}Pb = 2n + ^{250,252,254}No$
SHELS separator transmission: **32%**
Beam: ^{48}Ca (18+), 0.4 pμA, $E_{1/2}$ = 225 MeV
Detectors: focal plane DSSSD-detector (128×128 strips), 4 side DSSSD-detectors (32×16 strips), 1 clover Ge-detector and 4 Ge-detectors (with BGO shields).
Registration: α, β, γ and fission fragments.

^{254}No

Target: 360μg/sm^2 PbS (99.57% of ^{208}Pb); **Beam dose:** 2.3^{18} ^{48}Ca ions
Correlations: **600** Recoil – Fission Fragment (focal detector)
Measured: ff-TKE, **cross-section**, isomeric states, γ-multiplicity

^{252}No

Target: 400μg/sm^2 PbS (99.51% of ^{206}Pb)
Correlations: **15000** Recoil – Fission Fragment (focal detector)
Measured: ff-TKE (using for calibration), cross-section, γ-multiplicity

^{250}No

Target: 470μg/sm^2 PbS (99.94% of ^{204}Pb); **Beam dose:** 6^{18} ^{48}Ca ions
Correlations: **19000** Recoil – Fission Fragment (focal detector, 0-500 μs), **no** Re – α correlations
Measured: ff-TKE, **b_{SF}**, cross-section (35 nb), **isomeric states**, γ-multiplicity

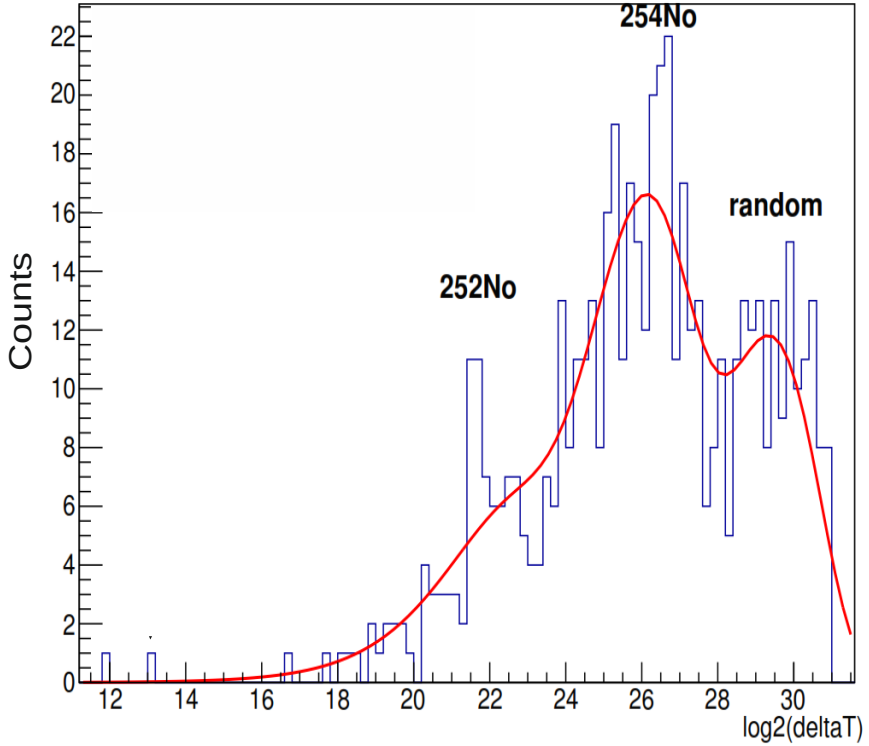
SHELS Result: ^{254}No

Experiment

$^{48}Ca + ^{208}Pb \rightarrow ^{256}No^{*} \rightarrow ^{254}No + 2n$

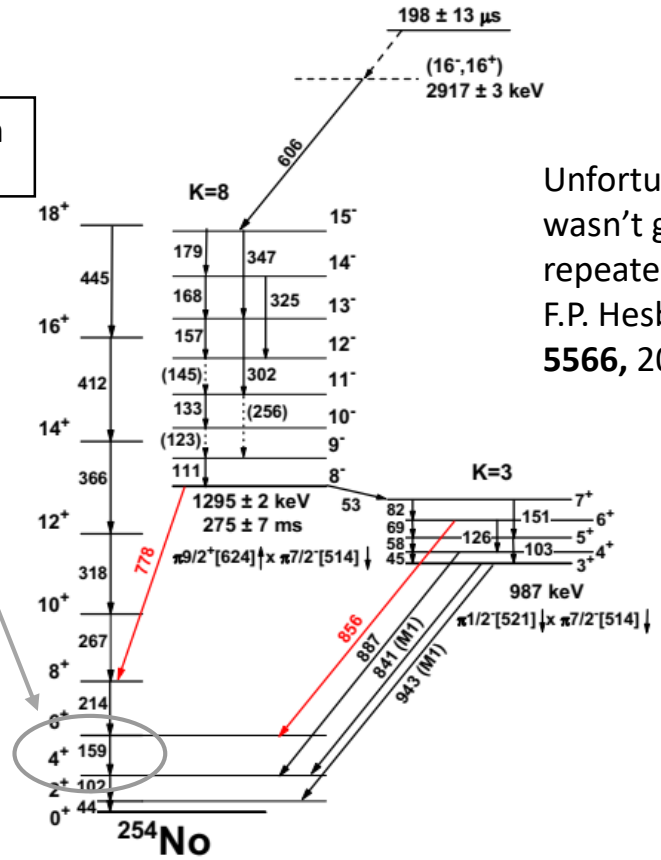
^{254}No (b_{SF} = 0.17%) & ^{252}No (b_{SF} =30%, reaction on addition ^{206}Pb in ^{208}Pb target) good separated by half-live time!

Flux ~ $8 \bullet 10^{17}$
SF = 310 events
6 days



Observed 6+ in 4+ transition.

Eγ ~ 159keV



Unfortunately, beam intensity wasn't good. Thus, we only repeated GSI experiment.
F.P. Hesberger, Eur. Phys. J. A **43, 5566,** 2010

SHELS Result: ^{252}No

Experiment

$^{48}Ca + ^{206}Pb \rightarrow ^{254}No^{*} \rightarrow ^{252}No + 2n$

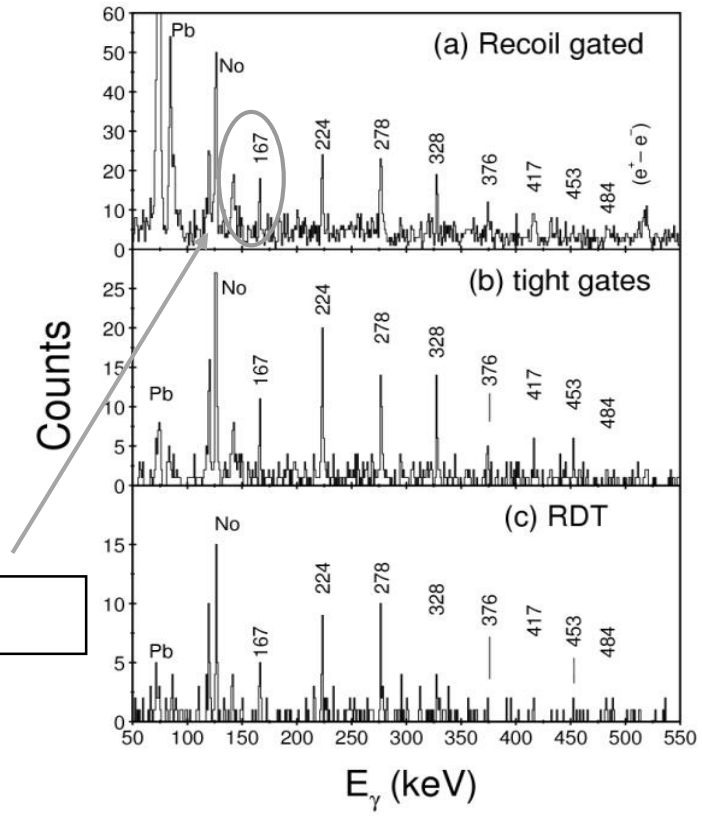
4 days

Flux ~ $4.6 \bullet 10^{17}$

SF = 22 000

Enough statistics for
TKE calibration of detectors.

Eγ ~ 167keV



R. Herzberg, ., PRC

SHELS Result: ^{250}No

Experiment

$^{48}Ca + ^{204}Pb \rightarrow ^{252}No^{*} \rightarrow ^{250}No + 2n$

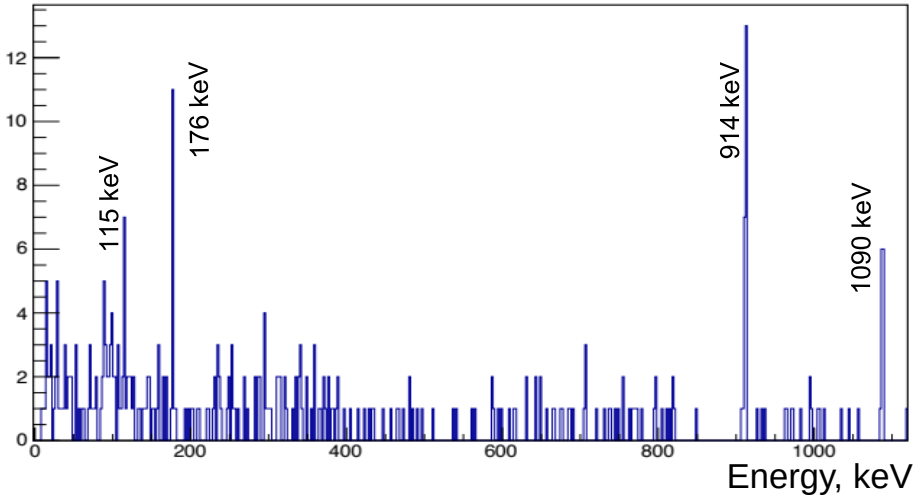
According to preliminary analysis:

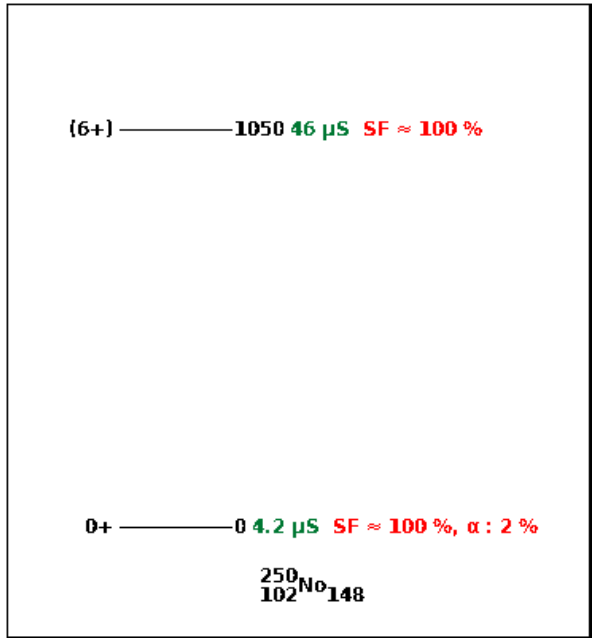
From gamma correlation spectrum was observed new transition in ^{250}No!

13 days

Flux $2.6 \bullet 10^{18}$

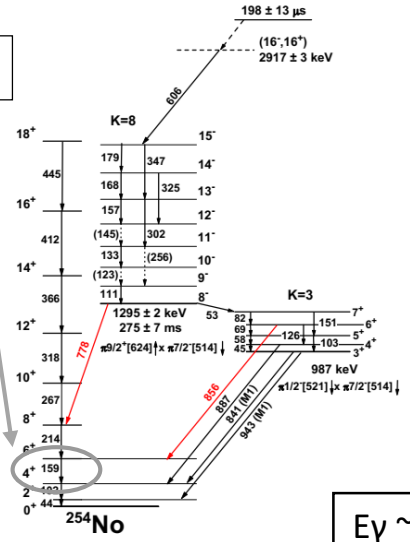
SF = 18 000



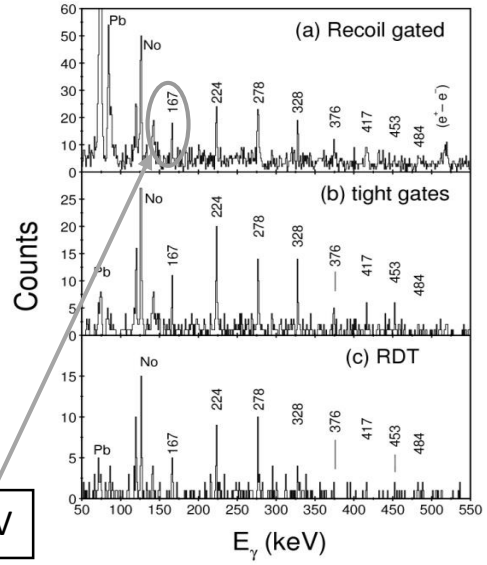


SHELS Result: ^{250}No

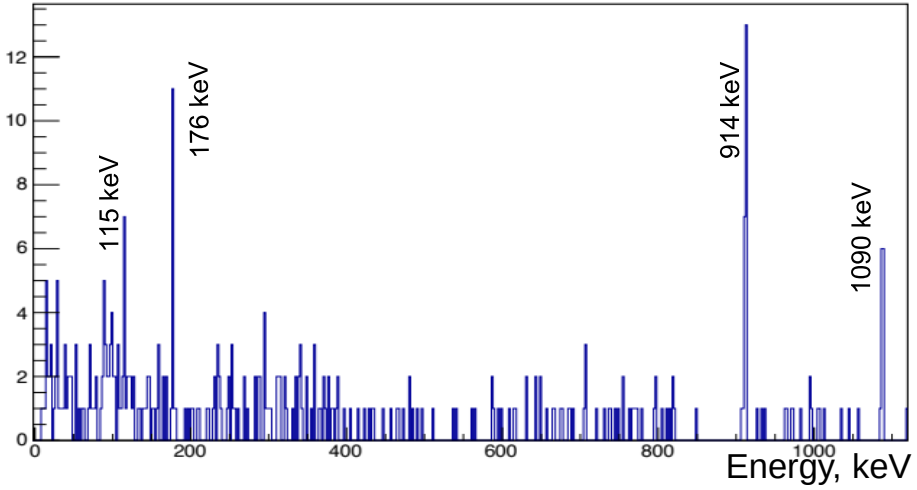
Eγ ~ 159 keV

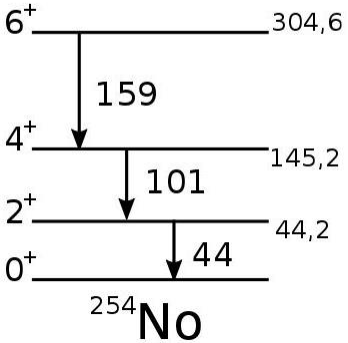


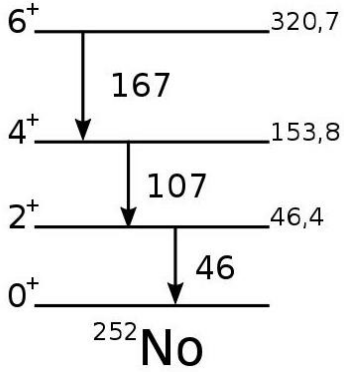
Eγ ~ 167keV

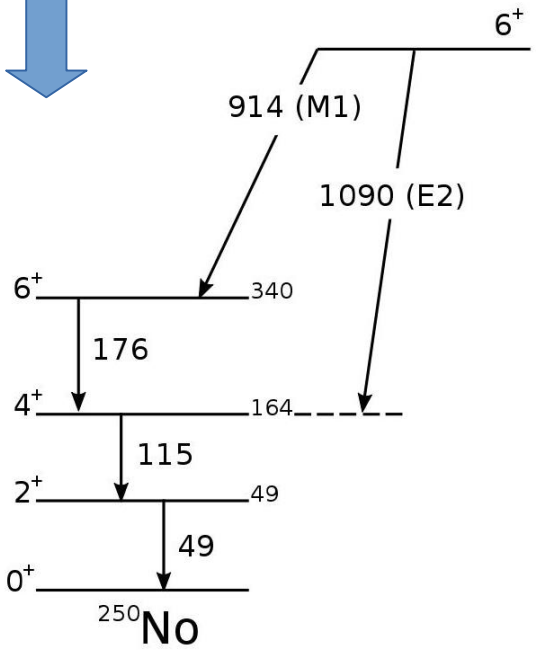


R. Herzberg, ., PRC



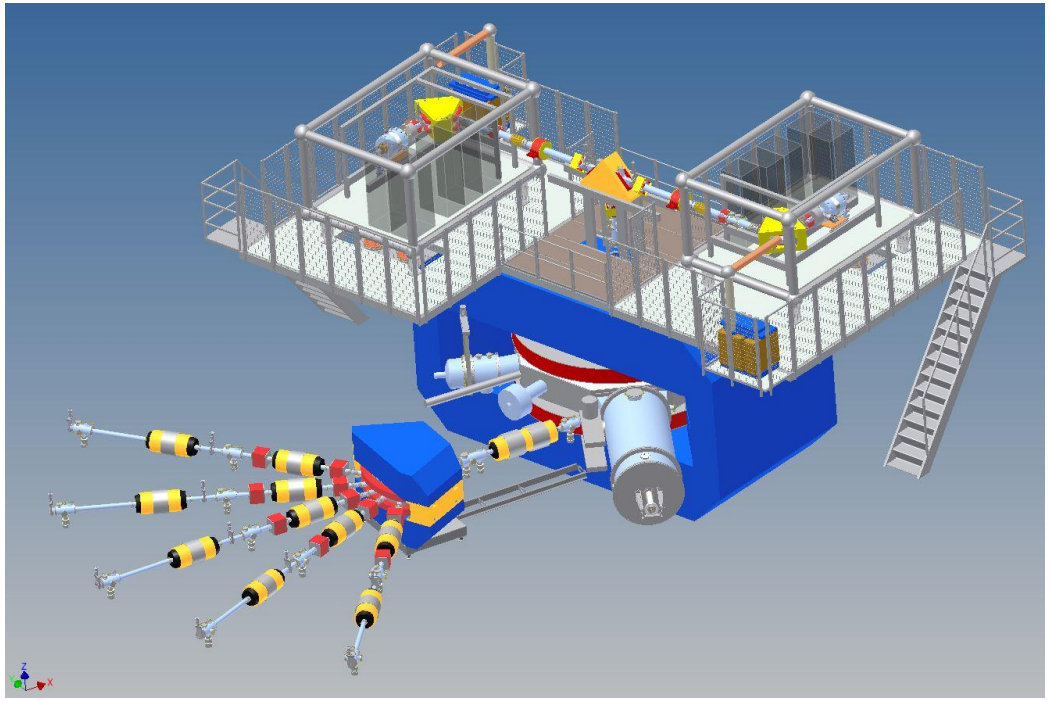






Conclusion

DC280-cyclotron – stand-alone SHE-factory



- **Synthesis and study of properties SHE,**
- **Search for new reactions for synthesis SHE,**
- **Chemistry of new elements.**

DC280 (expected) E=4÷8 MeV/A		
Ion	**Ion energy [MeV/A]**	**Output Intensity**
^{7}Li	4	1×10^{14}
^{18}O	8	1×10^{14}
^{40}Ar	5	6×10^{13}
^{48}Ca	5	$0{,}6\text{-}1{,}2\times10^{14}$
^{54}Cr	5	2×10^{13}
^{58}Fe	5	1×10^{13}
^{124}Sn	5	2×10^{12}
^{136}Xe	5	1×10^{14}
^{238}U	7	5×10^{10}

Future plans

Reactions	Goals
$^{238}U(^{22}Ne, xn)^{260-x}No$	Focal plane spectroscopy, xn-cross sections
$^{208}Pb(^{54}Cr, xn)\ ^{262-x}Sg$	SF with neutron detector
$^{208}Pb(^{48}Ca,2n)^{254}No$	Study of the decay modes, k-isomers.
$^{242}Pu(^{22}Ne,xn)^{264-x}Rf$	Study of the decay modes.

SHE-factory building, January 2019

Thank you for your attention!

Collaboration

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