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CONFIRMATION OF A NEW ISOMERIC STATE IN THE 186Re NUCLEUS

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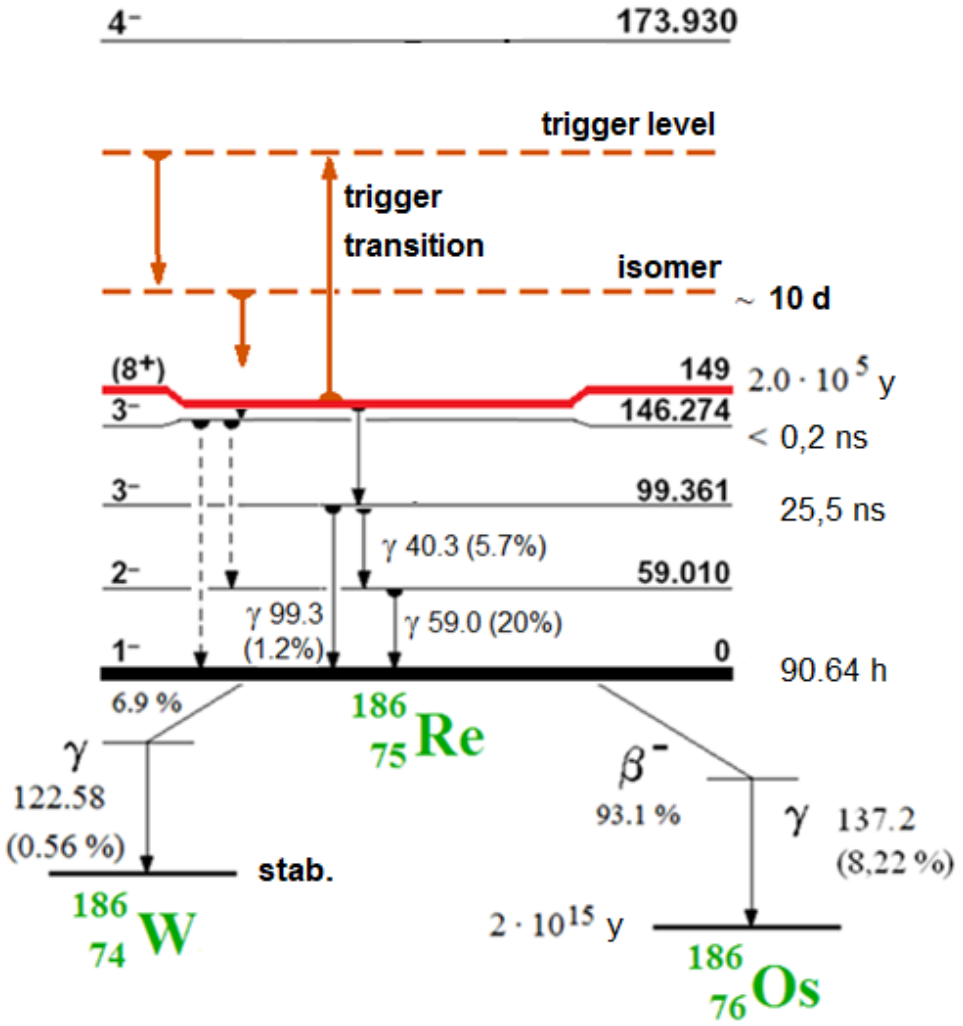
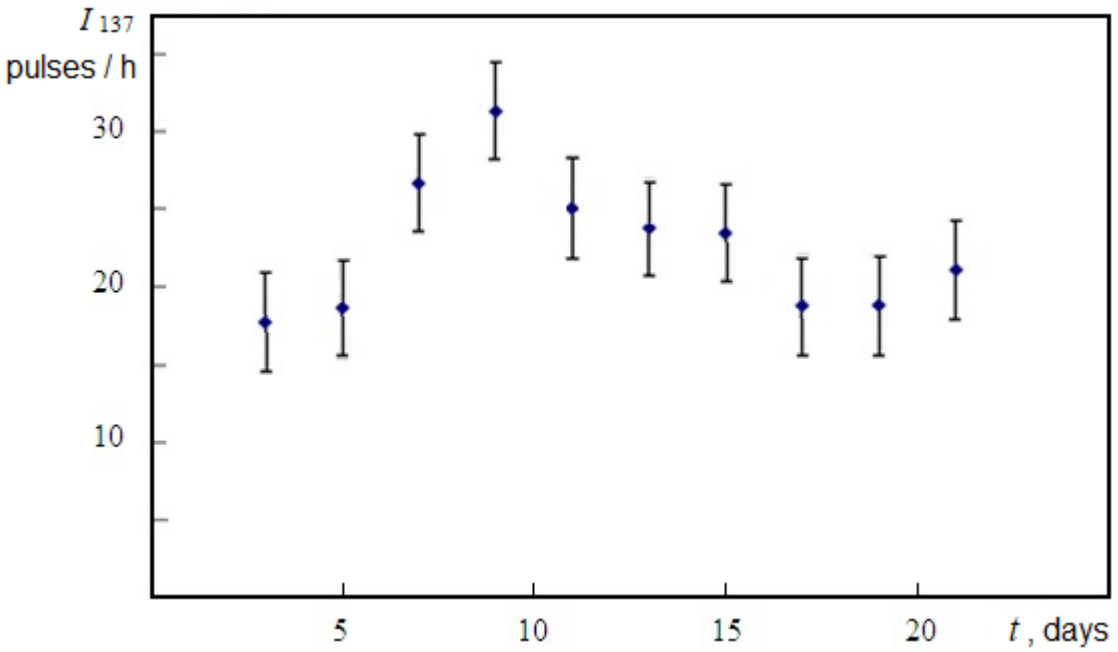
^{186}Re nucleus level diagram



Up arrow – the possibility of exciting the trigger level.

- In reactor isomer of 200000 y half-live is populated in 0.3% of cases of neutron capture by ^{185}Re nuclei.
- Recently de-excitation of the isomer has been stimulated in laser plasma of 1 keV temperature.
- The supposed mechanism of stimulation is the excitation of the isomer to the trigger level, from where it decays to the ground state of the nucleus.
- Detection of stimulation by the decrease in the intensity of 137 keV γ-quanta after a jump-like population of the ground state.
- Now the trigger level parameters are unknown.

Intensity of the 137 keV line in the γ-spectrum of ^{186m}Re irradiated in a laser plasma



Intensity decay corresponds to $T_{1/2}$ = 112 ± 10 hours

If the effect is due to the stimulated discharge of ^{186m}Re nuclei, then the discharge of ~ 10^{-5} % of the ^{186m}Re nuclei is stimulated.

We have to assume that there is an unknown excited state in the ^{186}Re nucleus with $T_{1/2}$ for several days, which is populated upon stimulated discharge of the ^{186m}Re isomers.

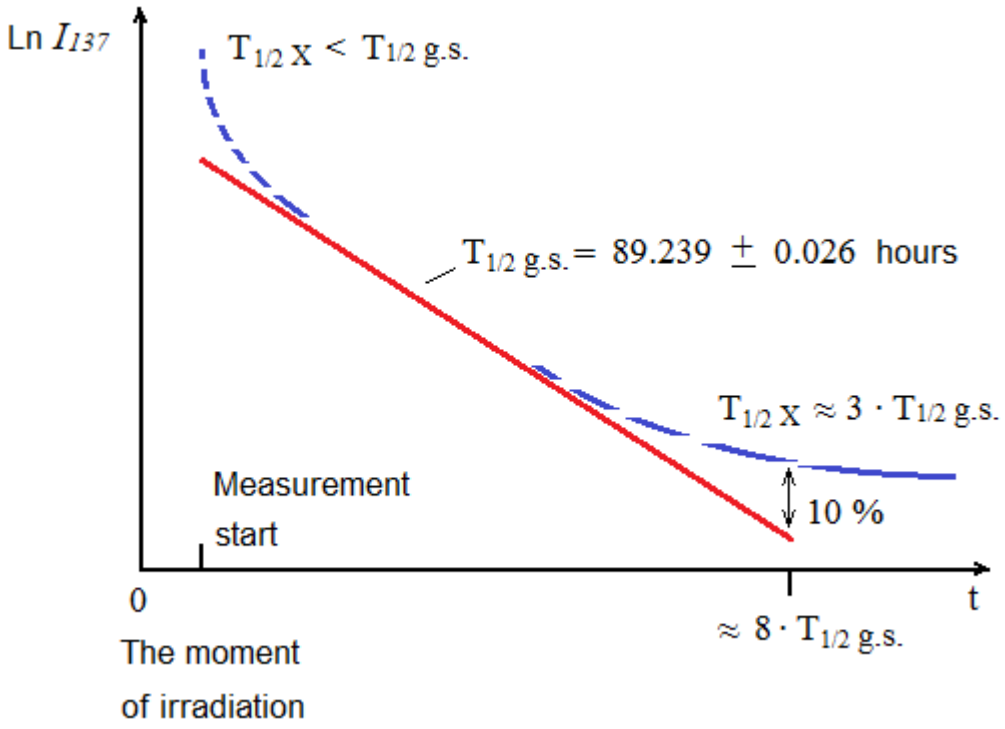
The difference in the known results of measuring the ^{186}Re half-live

Measurement technique			$T_{1/2,g}$, hours
^{186}Re production method	Method measurements	Measurement duration, days	
$^{185}Re\ (n, \gamma)\ ^{186}Re$	4π γ-ionization chamber	33	89.239 ± 0.026 *(Schonfeld et al, 1994)*
$^{185}Re\ (n, \gamma)\ ^{186}Re$		21	89.25 ± 0.07 [6] *(Coursey et al., 1991)*
$^{185}Re\ (n_{th}, \gamma)\ ^{186}Re$	γ – spectra	18	90.600 ± 0.024 *(Abzouzi et al., 1989.)*
$^{186}W\ (p, n)\ ^{186}Re$		36	88.35 ± 0.16 *(Our previous work, 2018)*

Accuracy is shown at the one standard deviation level.

- The discrepancy in the $T_{1/2,g}$ measurement results is another indication of the possibility of the existence of an unknown isomeric level in the ^{186}Re nucleus.
- The measurement technique did not take into account the possible dependence of the observed $T_{1/2,g}$ on the method of obtaining ^{186}Re nuclei, on the duration of measurements, and on the time of the beginning of measurements after the end of target irradiation.

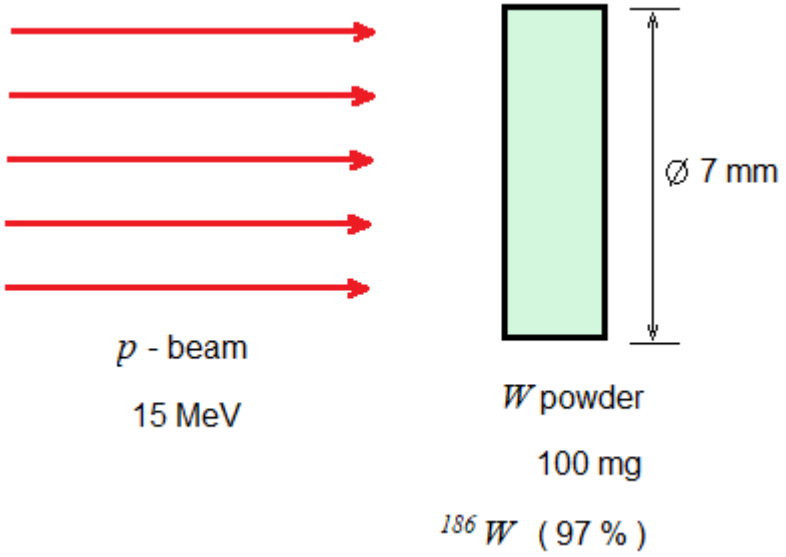
The idea of the experiment



- It is possible that the new isomer can be populated in the (p, n) reaction of formation of the ^{186}Re nucleus from ^{186}W.

- Population of a new isomer in this reaction would lead for γ-quanta from an irradiated source to the dependence of the γ-intensity $I_{137}\ (t)$ on time t after the formation of ^{186}Re nuclei, which differs from the simple exponent associated with the decay of the ground state of ^{186}Re with a half-life of $T_{1/2,g}$ = 89.239 hours

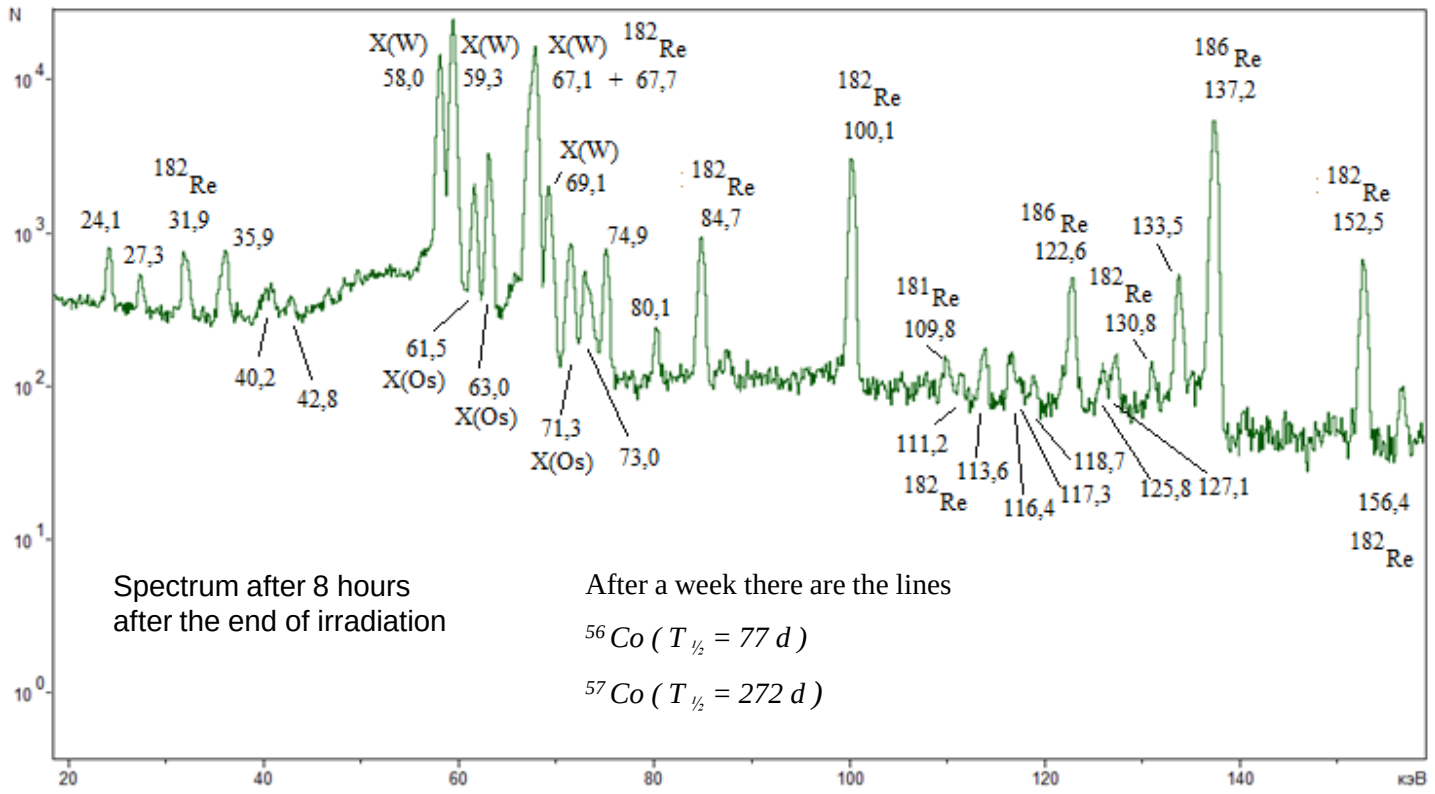
Experimental method



Irradiation parameters	Our work (2018)	Present work
p - current , μA	4	4
Exposition, min	15	100

Measurement method	Our work (2018)	Present work
Measurement time after the end of irradiation, days	0,2 - 36	30 - 105
HPGe detector	∅25 x 15 mm	150 cm^3 with the well
Measurement geometry	10 mm above the detector	In the well
Initial loading of the spectrometer, s^{-1}	~ 10^3	~ 10^3

γ-spectrum of the sample



Spectrum after 8 hours
after the end of irradiation

After a week there are the lines

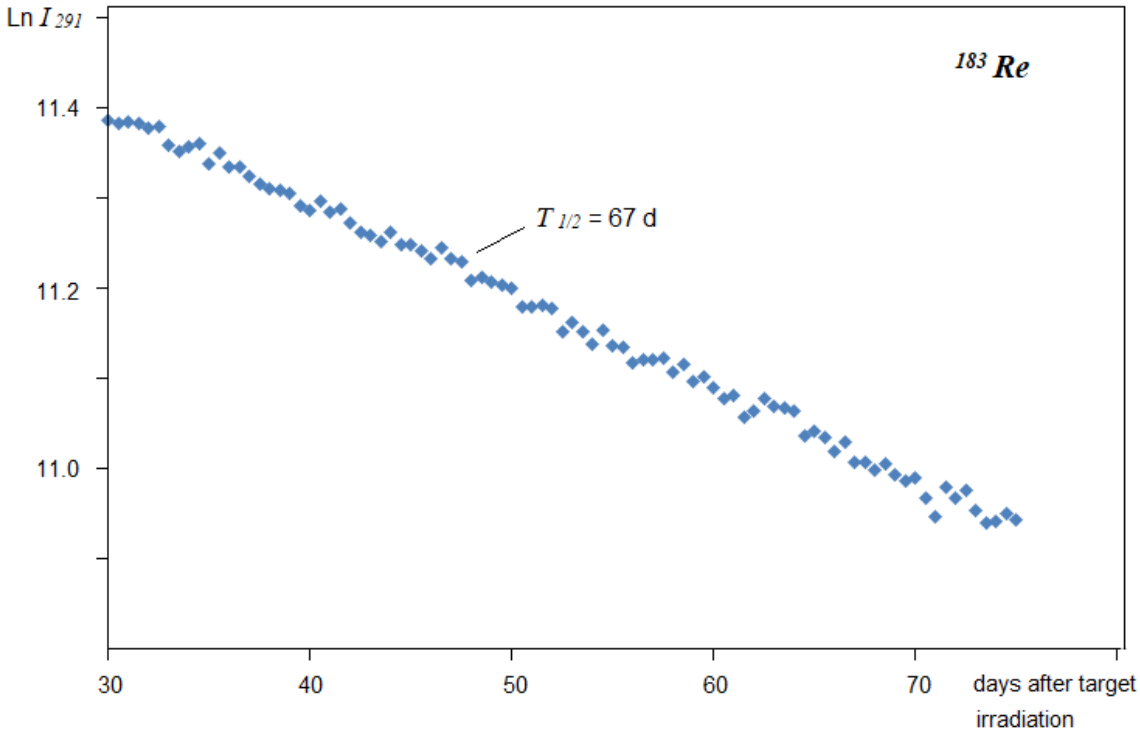
$^{56}Co\ (T_{1/2} = 77\ d)$

$^{57}Co\ (T_{1/2} = 272\ d)$

Stable isotope	^{180}W	^{182}W		^{183}W	^{184}W		^{186}W
Nature content, %	0,13	26,3		14,3	30,67		28,6
Reaction products (p, n) , $(p, 2n)$	^{180}Re	^{181}Re	^{182}Re	^{183}Re	^{184}Re	^{184m}Re	^{186}Re
$T_{1/2}$	2,4 min	20 h	64 h	70 d	38 d	165 d	90, 64 h
Decay mode	e^- capture						β

Method for processing the results of γ-spectra measurements

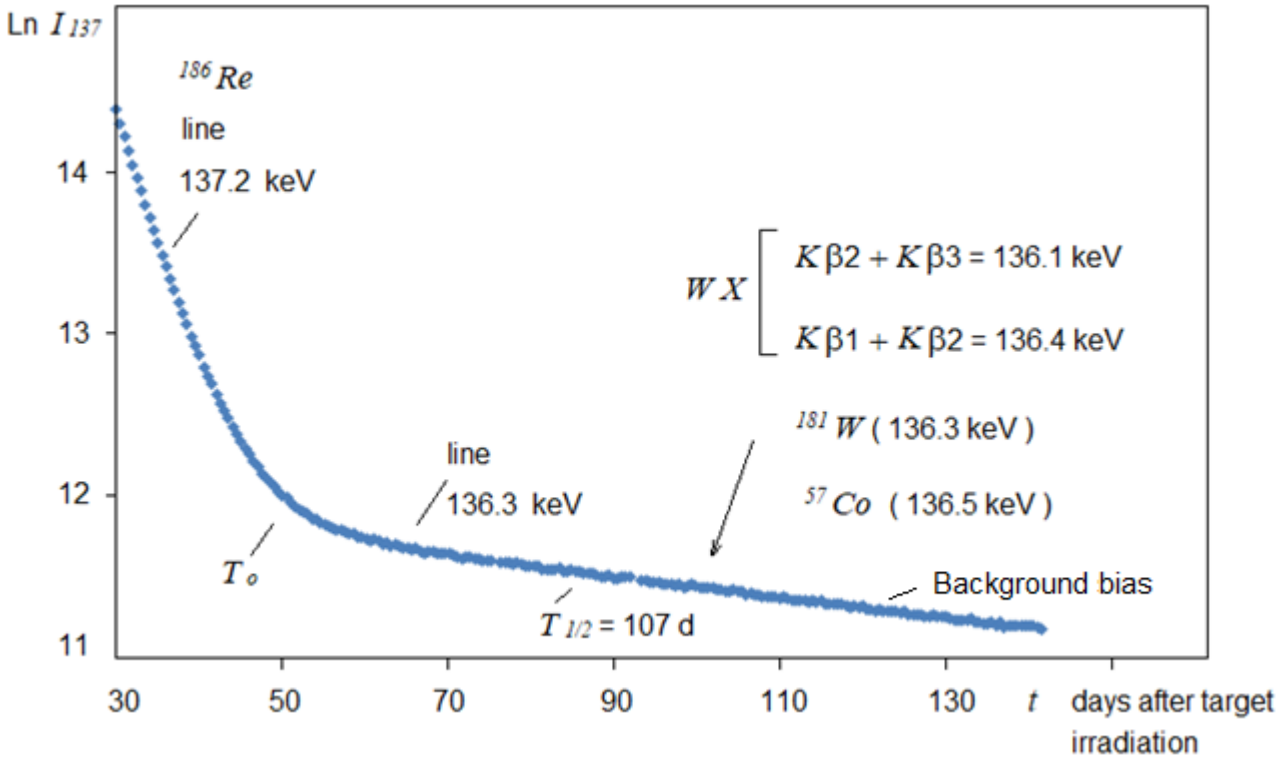
- γ-spectra were measured sequentially in time with an exposure of 12 hours.
- The areas of γ-lines in the spectra were determined by fitting Gaussian peaks by the least squares method; in this case, the center of the line, its half-width, and area were determined.
- Half-lives were determined by fitting the decay curve with one or two exponents. The exponents were inscribed using the least squares method.
- The γ-lines of radionuclides in the spectrum remained in place with an accuracy of 0.2 keV.



Determination of $T_{1/2}$ for ^{183}Re is a measurement correctness test.

The decay curve is plotted by measuring the intensity of γ-quanta 291 keV from ^{183}Re.

Time variation of the intensity of the 137 keV γ-line



Background bias model when the measurement time is $t < T_o$.

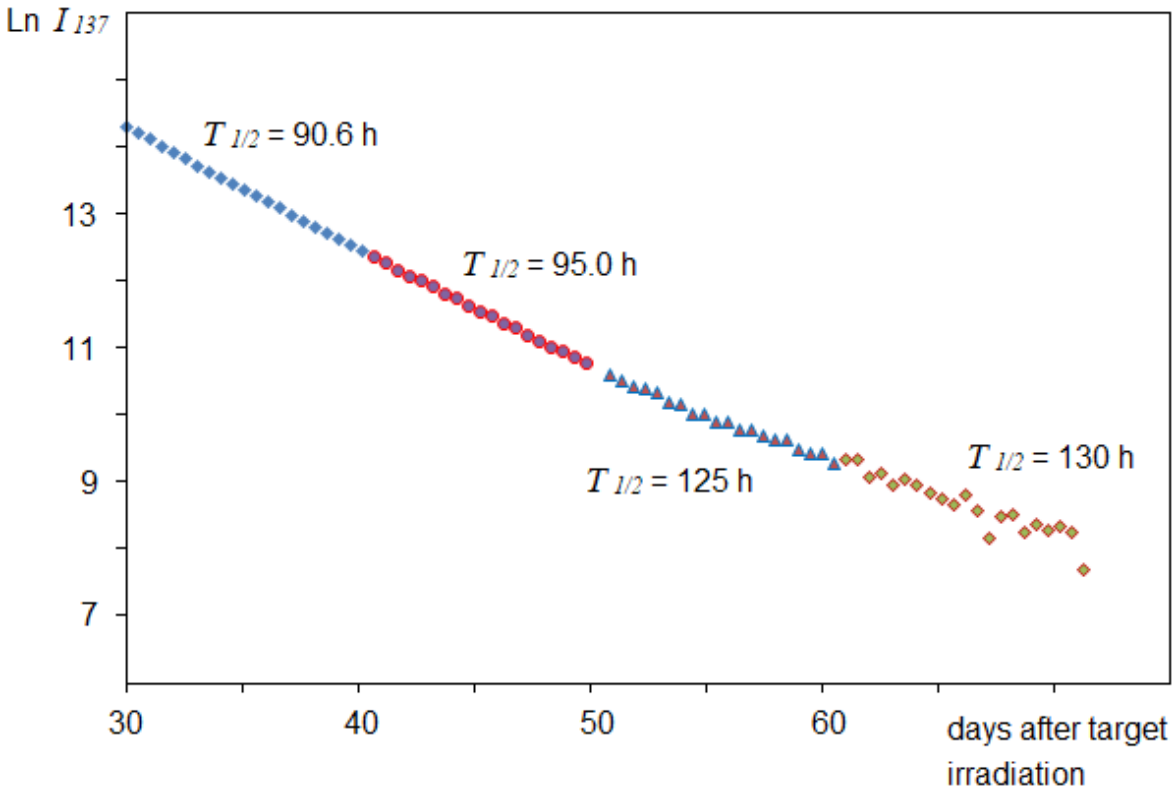
Constant $\lambda = 0.0064\ \mathrm{d}^{-1}$.

$$I_{bac.}(t) = (107900 \times 0.7) \times e^{\lambda\,(T_o - t)} + (107900 \times 0.3)$$

The model takes into account:

- The value of the intensity I_{137} at the time T_o.
- Exponential decay of I_{137} at $t > T_o$.
- Requirement for the decay curve to match the half-life of ^{186}Re at the start of measurements.

Intensity of 137 keV γ-quanta emitted by ^{186}Re



Half-life, calculated from different parts of the decay curve, increases over time after the formation of ^{186}Re.

The time dependence of the I_{137} intensity corresponds to the existence of the new isomer in the ^{186}Re nucleus. However, for complete unambiguity of such a conclusion, it is necessary to carry out similar measurements again using an improved technique:

- The target's 186W isotope enrichment should be much better than 97%.
- The target must be free of impurities, in particular iron.
- Measurements should be carried out in geometry without summation of X-ray lines in the spectrum.

Thanks !