Измерване на g-фактор на изомер на ^{127}Sn с помощта на спектрометричната система RISING

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Мотивация

g-фактор ($\mu = gI\mu_N$)

→ носи информация за едночастичната структура:

вълнова функция, магнитен диполен оператор, …

→ изучаване на промените в структурата на ядрата далеч от линията на стабилност

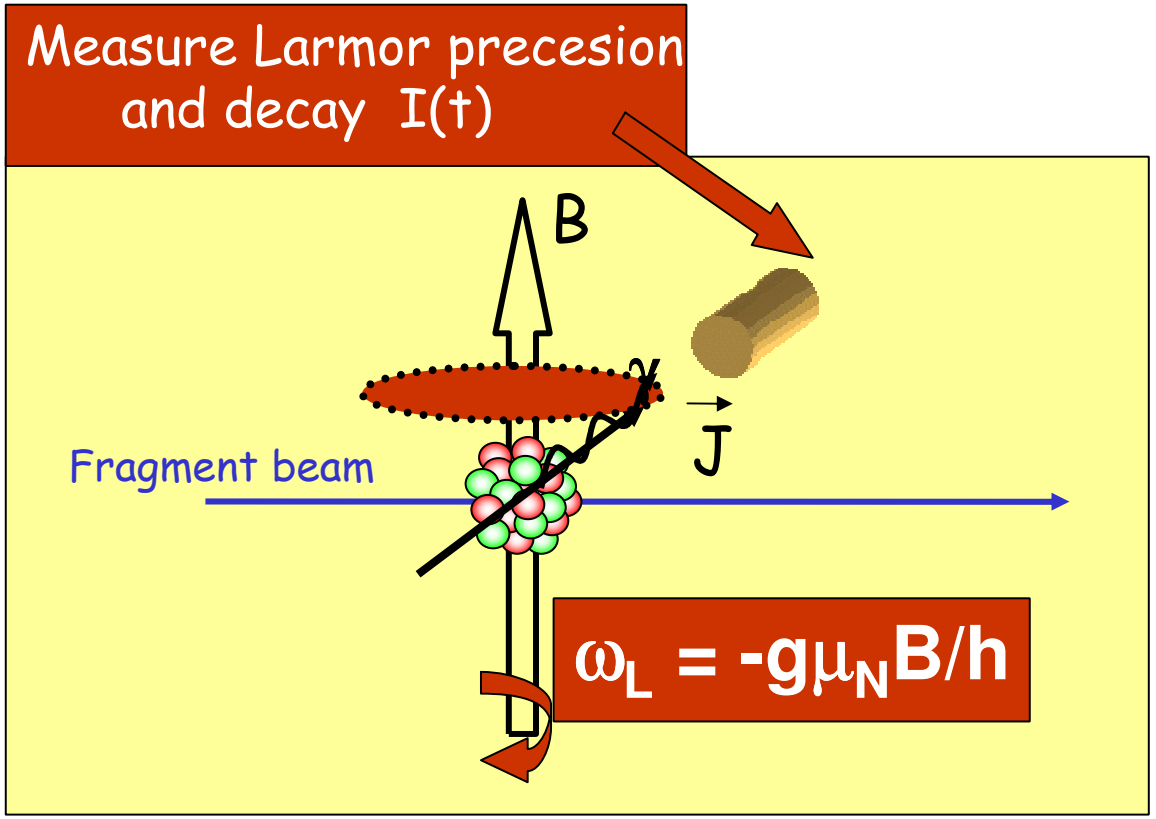
ориентация на спина – получена от фрагментация на сноп с Z>30

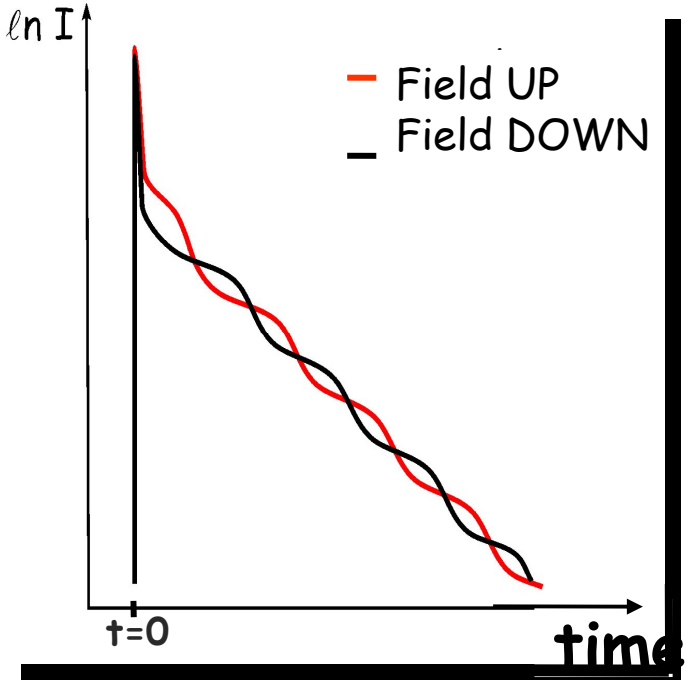
→ става достъпно изучаването на ядрените моменти на неутронно богати ядра

Методология

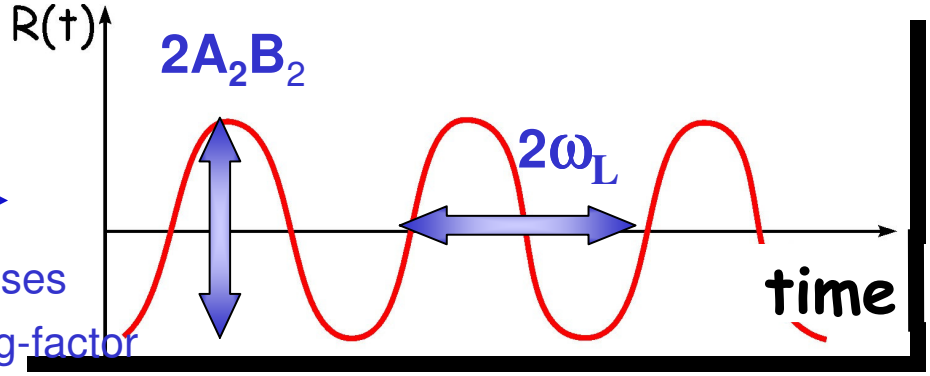
Time Differential Perturbed Angular Distribution

$$R(t) = \frac{I_1 - \varepsilon I_2}{I_1 + \varepsilon I_2}$$





relative phases
depend on g-factor



Spin-alignment and g-factors of isomers in ^{127,128}Sn from fragmentation of a ^{136}Xe beam.

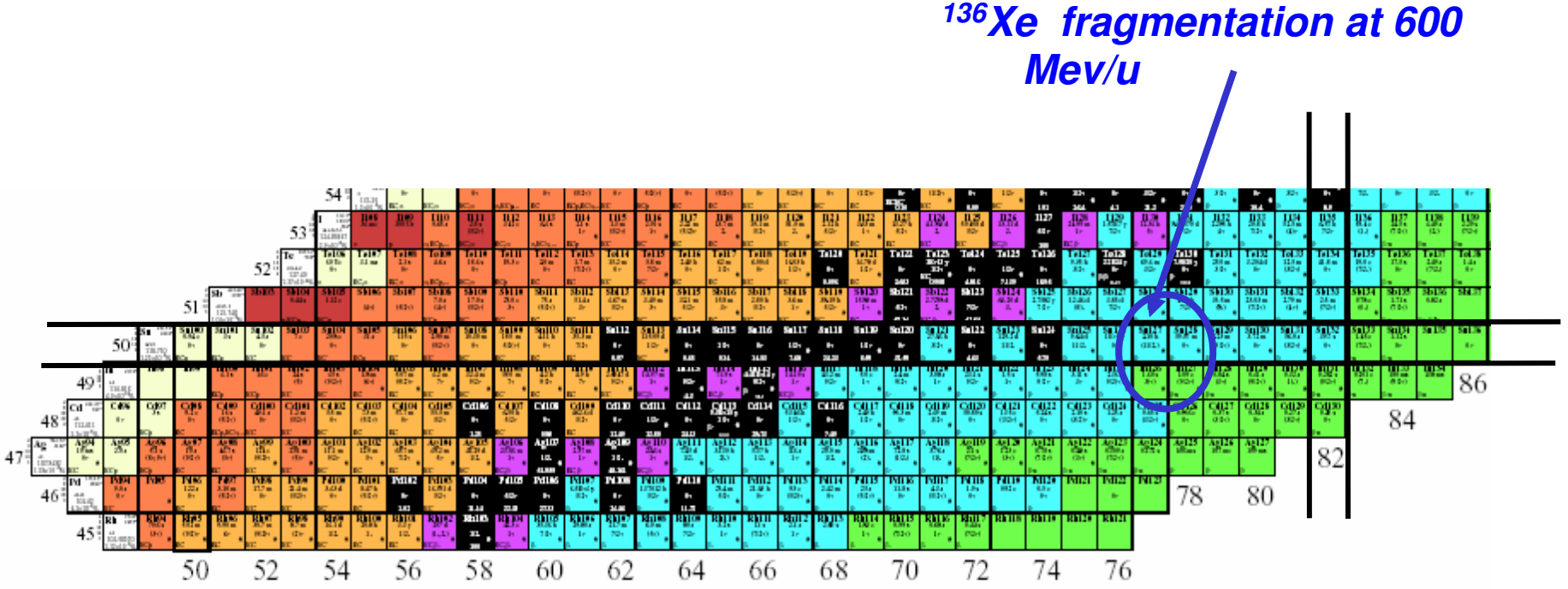
Сноп: ^{136}Xe при 600 MeV/u

Мишена: ^{9}Be с дебелина: 1023 mg/cm^2

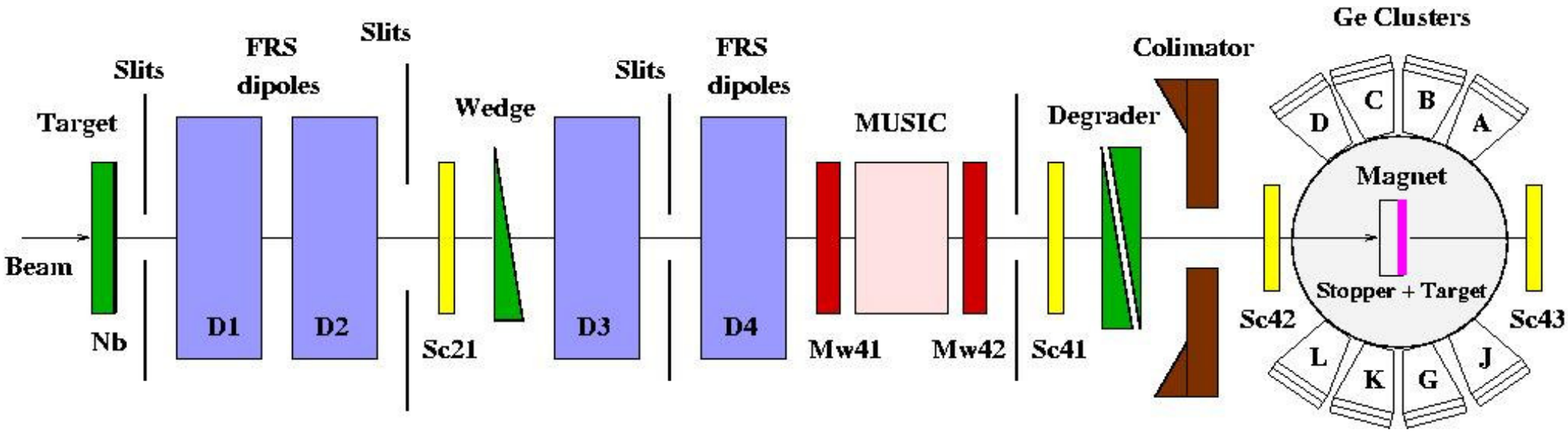
Селекция на изотоп: ^{127}Sn при 300 MeV/u

Имплантиране: 15mm plexiglass + 2 mm Cu (кубична кристална решетка, без градиент на електричното поле)

Цел: 19/2$^+$ 4.5 μs изомер в ^{127}Sn



EXPERIMENTAL SET-UP



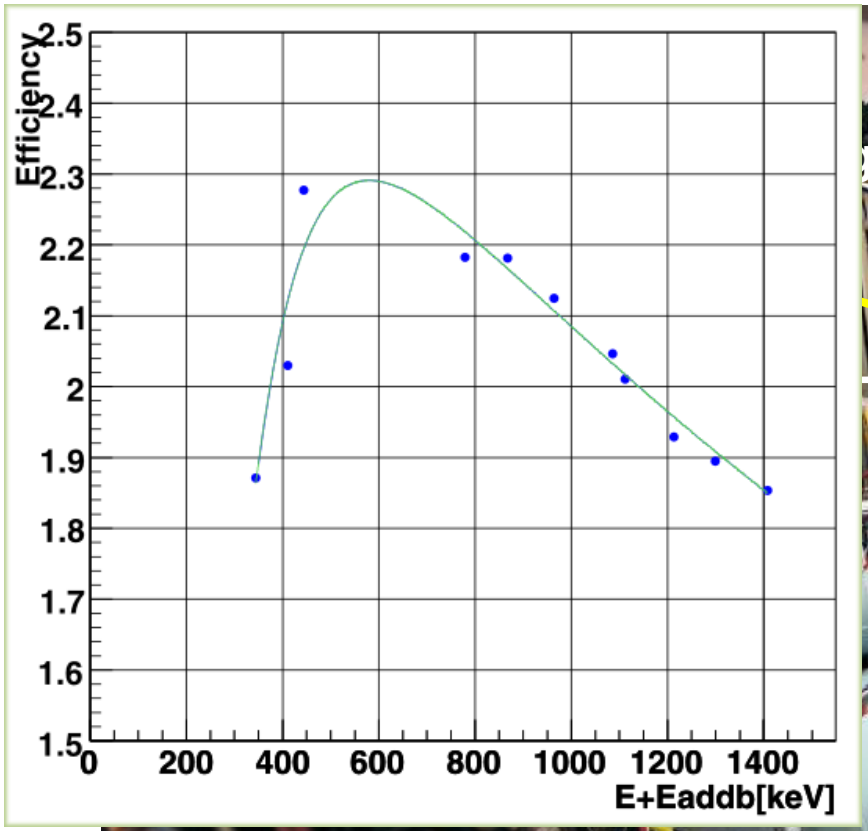
Spin-aligned secondary beam selected
(S2 slits + position selection in **SC21**)

SC41 gives t=0 signal for γ-decay time measurement

Implantation: plexiglass degrader + 2 mm Cu (annealed)

SC42 and SC43 validates the event

g-RISING setup (Rare Isotope Spectroscopic INvestigations at GSI)

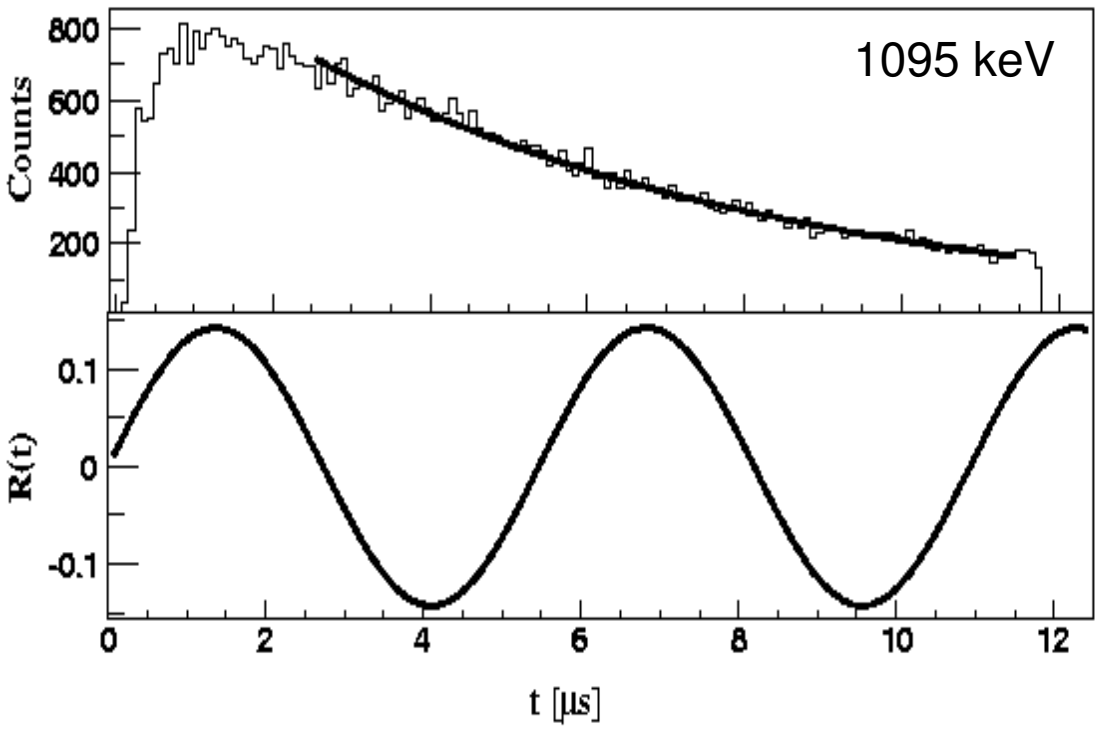


4 clusters with BGO anticompton shields and short collimators
4 clusters with the former RISING shields Electronics: VXI and DGF

Stopper: 15mm plexiglas + 2 mm Cu

Total efficiency (^{152}Eu source) = 1.9 – 2.3 %

Избор на магнитното поле



Крива на разпад на $19/2^+$ изомер на ^{127}Sn

$T_{1/2} = 4.5(3)$ μs

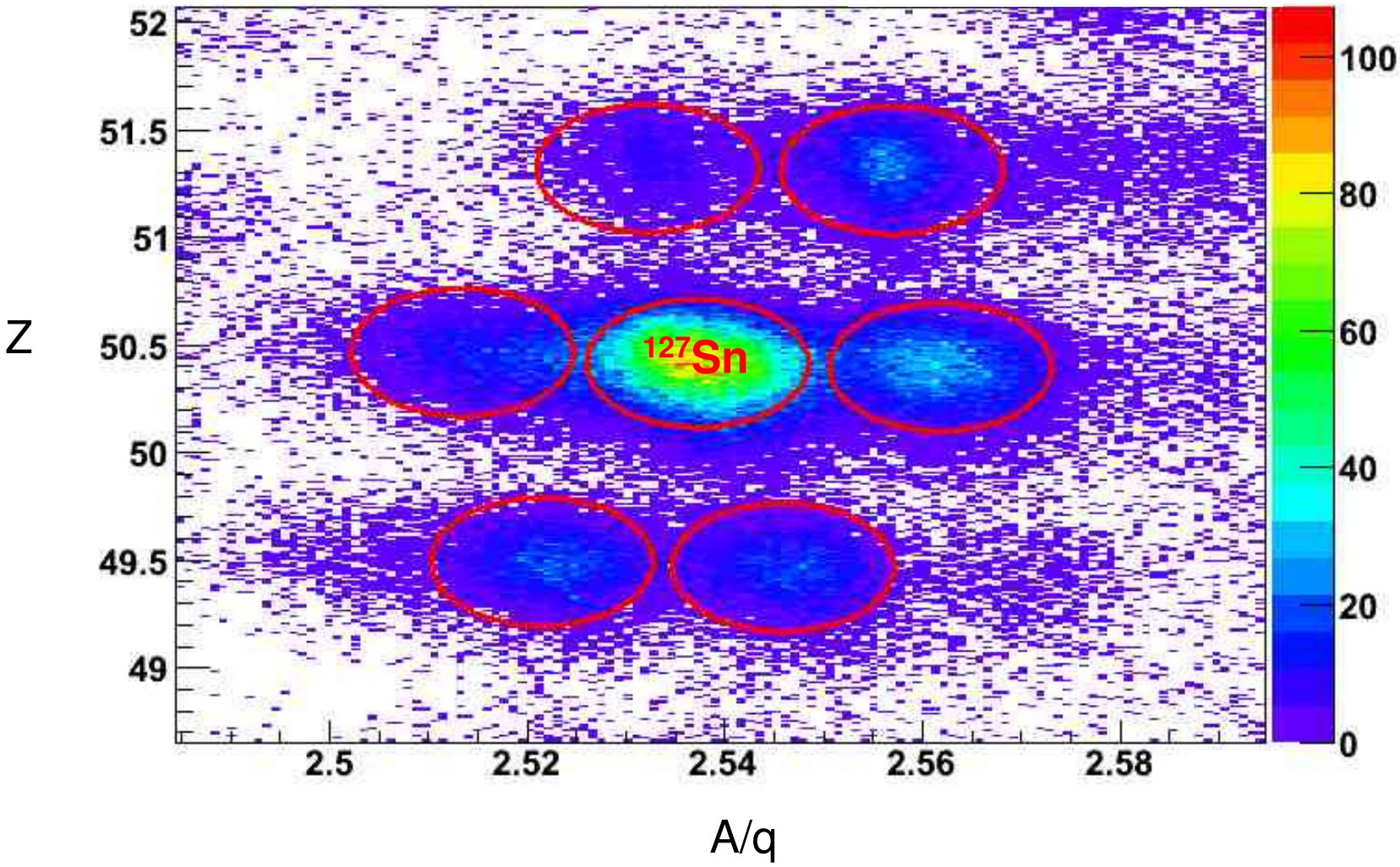
J. Pinston et al., PRC 61, 024312 (2000)

Времеви интервал $T_{exp} \approx 12$ μs

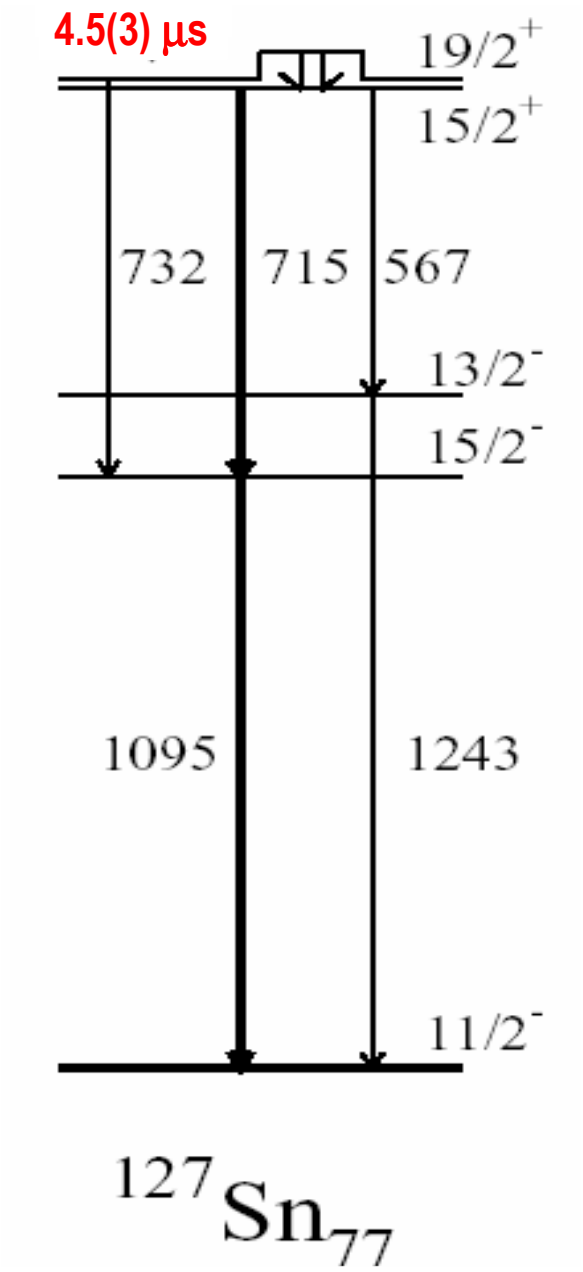
$g_{min} = -0.1 \quad \longrightarrow \quad T_{exp} \approx 2T_{osc}$

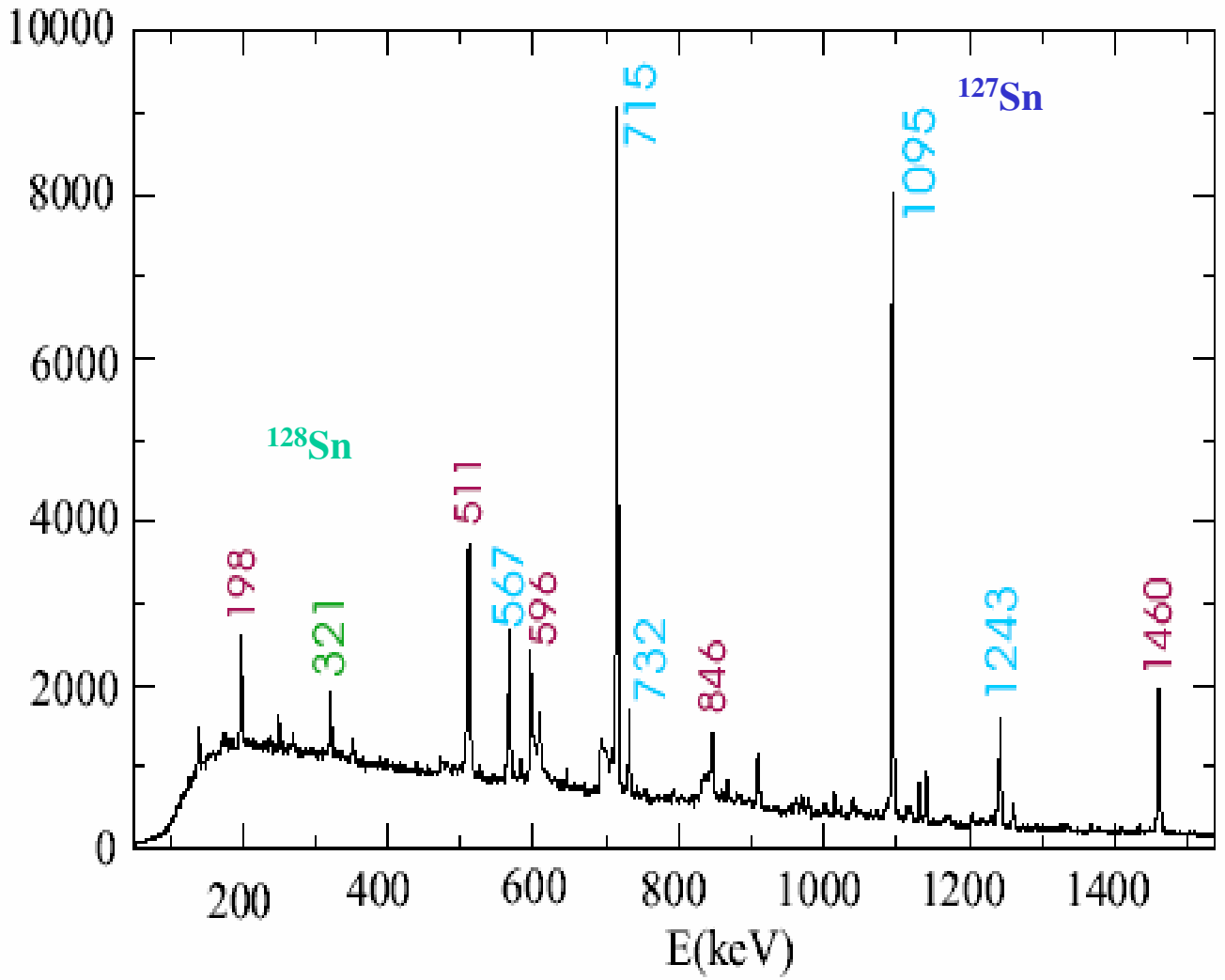
Магнитно поле B = 0.12 T

Изотопи получени в експеримента



Енергитичен спектър на ^{127}Sn





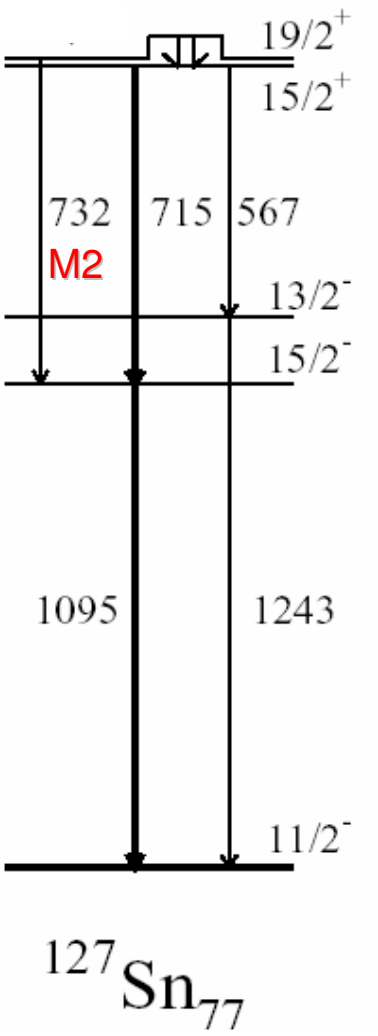
J. Pinston et al., PRC 61, 024312 (2000)

Structure of $19/2^+$ isomer

Isomeric states below N = 82 in Sn isotopes – neutron holes in: $\boldsymbol{h_{11/2}\ s_{1/2}\ d_{3/2}}$

Experimental g-factors:

$g_{exp}(h_{11/2}) \sim -0.24$ $g_{exp}(s_{1/2}) \sim -2.1$ $g_{exp}(d_{3/2}) \sim 0.50$



The spin-parity assignment of the $19/2^+$ isomer is based on energy systematics.

$19/2^+$ isomer configuration: $(\nu h_{11/2}^{-1} \otimes 5^-)_{19/2+}$

J. Pinston et al., PRC 61, 024312 (2000)

5^- → 2 neutron state admixture of $(\nu h_{11/2}^{-1} d_{3/2}^{-1})_{5-}$ with $g_{emp} = -0.26$

$(\nu h_{11/2}^{-1} s_{1/2}^{-1})_{5-}$ with $g_{emp} = -0.09$

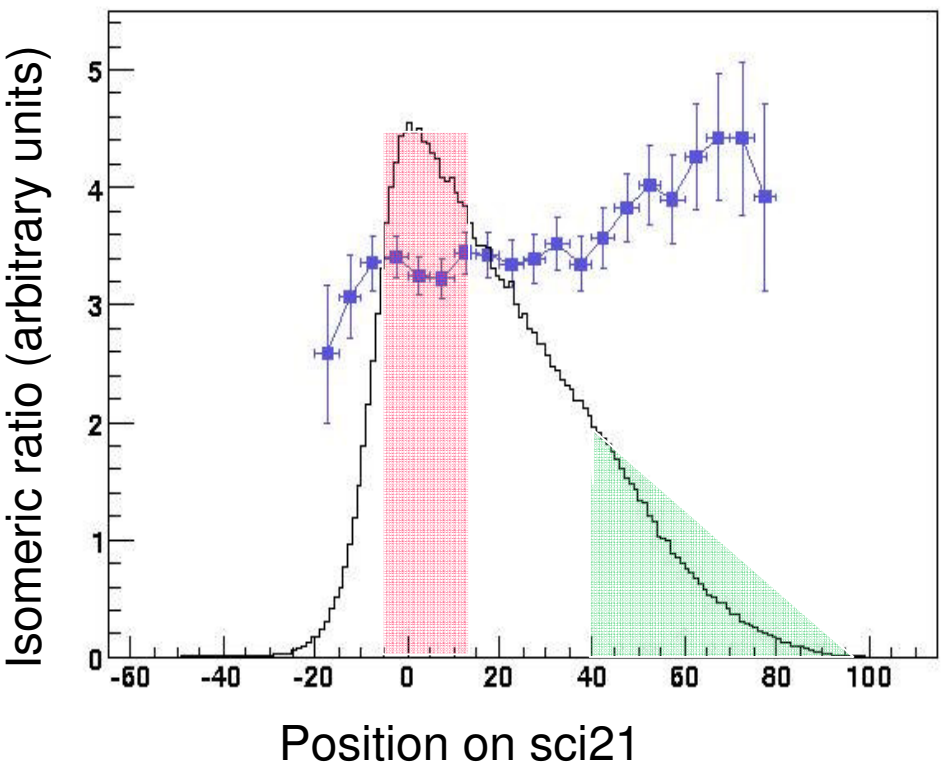
Experimental value $\boldsymbol{g_{exp}(5-) \approx -0.06}$

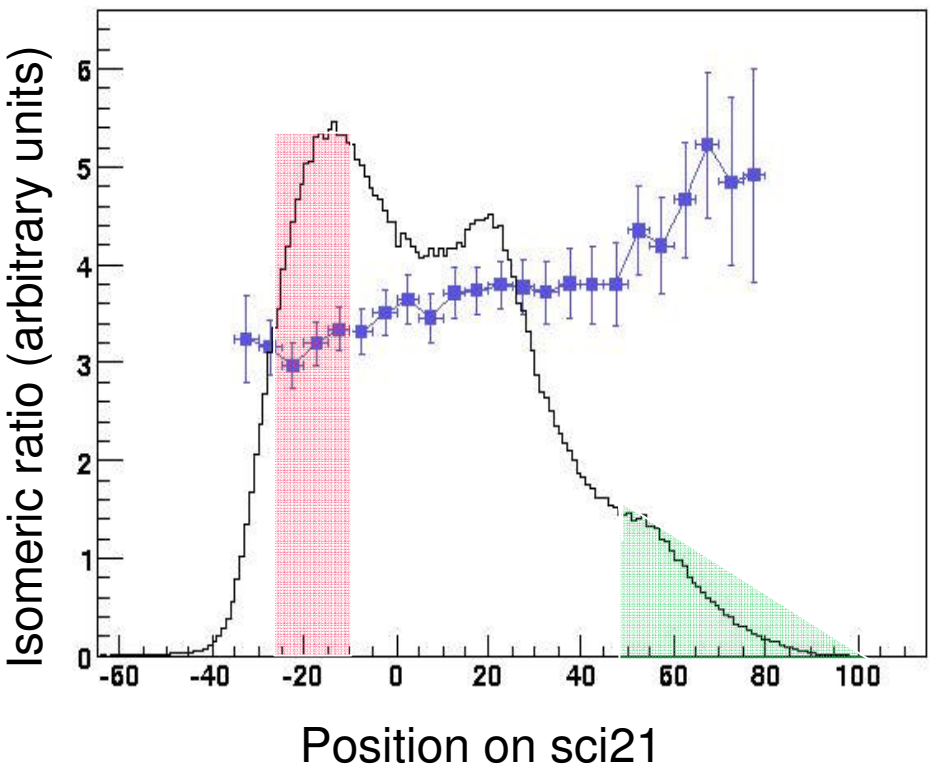
$19/2^+ \longrightarrow 15/2^-$ M2 transition => admixture with $\nu g_{7/2}^{-1}$

Configuration: $(\nu s_{1/2}^{-1} h_{11/2}^{-2})_{19/2+}$ and $(\nu g_{7/2}^{-1} h_{11/2}^{-2})_{19/2+}$

Corresponding g-factors: $\boldsymbol{g_{emp} \sim -0.15}$ $\boldsymbol{g_{emp} \sim -0.23}$

Селекция на разпределението по импулс





Разпределение на фрагментите по импулс и Изомерното отношение в началото и в края на експеримента

Изомерно отношение: $$R = \frac{N_\gamma (1+\alpha_{tot})}{\varepsilon_{eff} b_\gamma N_{imp} FG}$$

Статистика

Брой импулси в изомерните γ-линии за ^{127}Sn

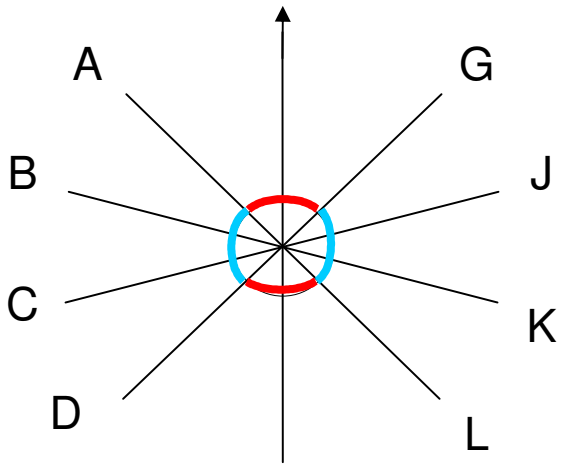
	1095 keV	Compton edge of 1095 keV	732 keV	715 keV
Center	23980	99710	8360	33590
Wing	13700	57300	4870	19030
Total	68100	282200	23700	94900
Total - bg	66435		6318	58998

Брой импулси в изомерните γ-линии за ^{128}Sn

	Field up	Field down	Total
321 keV	7721	7965	15686

From S. Lakshmi

R(t) функции



- 45º

- 30º

Интензитет на излъчването в хоризонтална равнина:

$$I(\theta, B, t) = I_0 e^{-t/\tau}\left(1 - A_2 B_2 P_2[\cos(\theta - \omega_L t)]\right)$$

R(t) функции $$R(t) = \frac{I_1 - \varepsilon I_2}{I_1 + \varepsilon I_2}$$

Детектори на 90º (±45º и ±135º спрямо снопа)

$I_1 = (A+L)\uparrow + (D+G)\downarrow$
$I_2 = (A+L)\downarrow + (D+G)\uparrow$

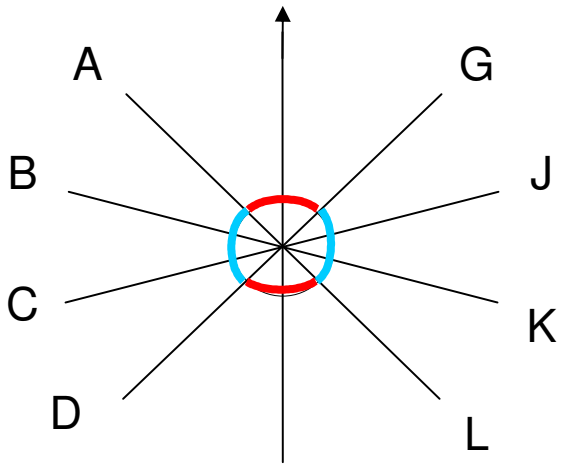
$$R(t) = \frac{3A_2B_2}{4 + A_2B_2}\sin(2\omega_L t)$$

Детектори на 30º (±75º и ±105º спрямо снопа)

$I_1 = (B+K)\uparrow + (C+J)\downarrow$
$I_2 = (B+K)\downarrow + (C+J)\uparrow$

$$R(t) = \frac{3A_2B_2\sin(2\omega_L t)}{8 + 2A_2B_2 - 3\sqrt{3}A_2B_2\cos(2\omega_L t)}$$

R(t) функции



Интензитет на излъчването в хоризонтална равнина:

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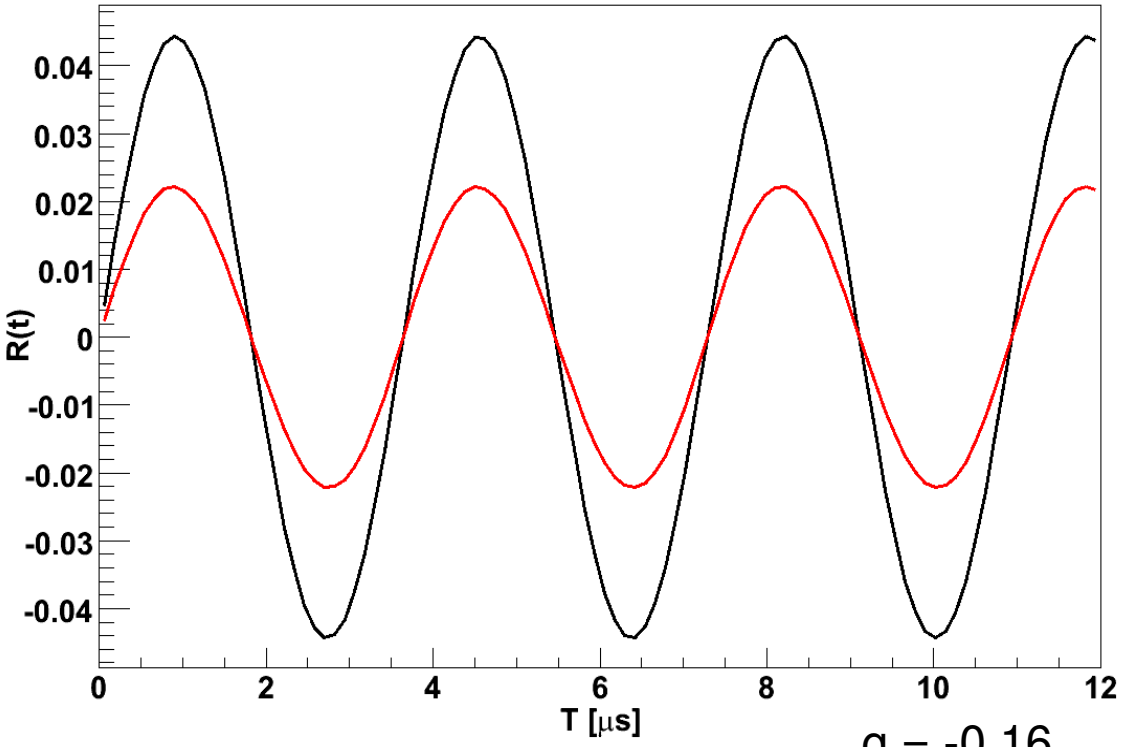
R(t) функции $$R(t) = \frac{I_1 - \varepsilon I_2}{I_1 + \varepsilon I_2}$$

º и ±135º спрямо снопа)

$$R(t) = \frac{3A_2B_2}{4 + A_2B_2}\sin(2\omega_L t)$$

º и ±105º спрямо снопа)

$$R(t) = \frac{3A_2B_2\sin(2\omega_L t)}{8 + 2A_2B_2 - 3\sqrt{3}A_2B_2\cos(2\omega_L t)}$$



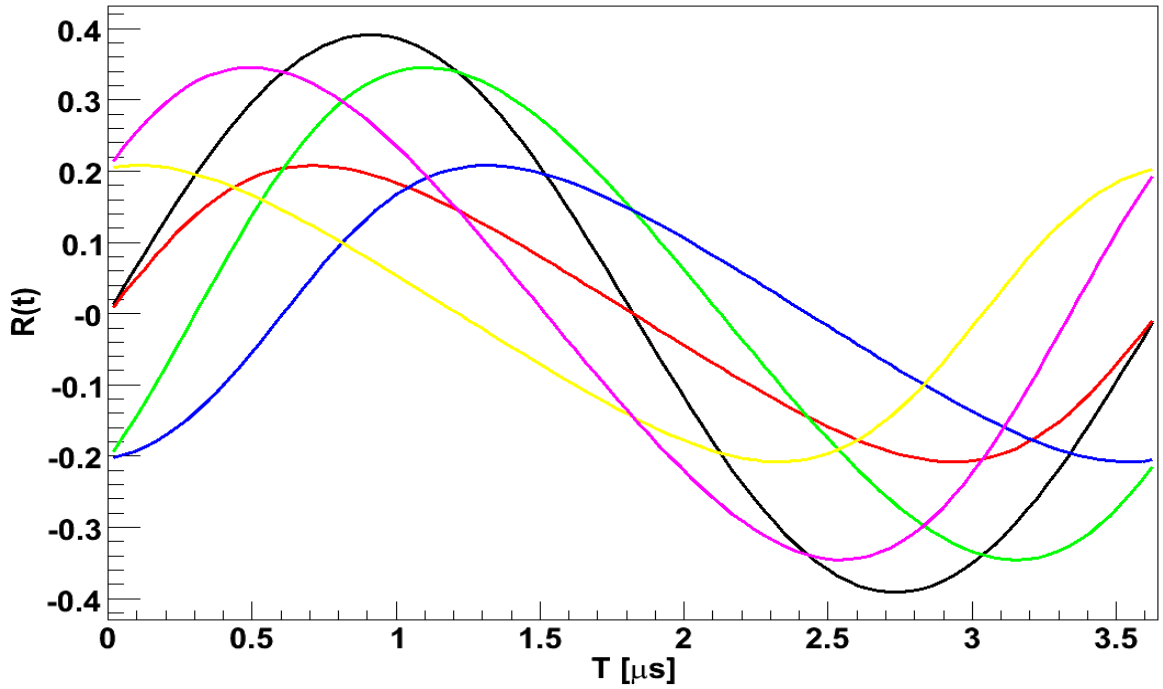
g = -0.16

$$R(t) = \frac{3\sqrt{3}A_2B_2 \sin(2\omega_L t - \pi/6)}{8 + 2A_2B_2 - 3A_2B_2 \cos(2\omega_L t - \pi/6)}$$

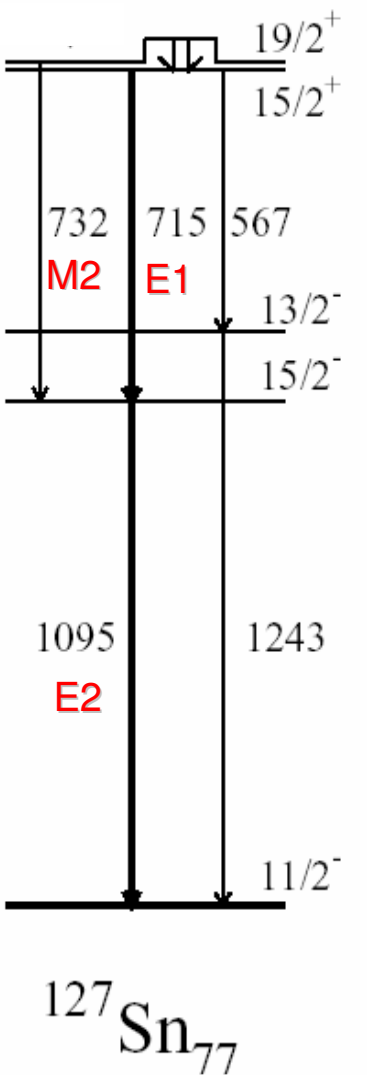
$$R(t) = \frac{-3A_2B_2 \cos(2\omega_L t + \pi/6)}{8 + 2A_2B_2 - 3\sqrt{3}A_2B_2 \sin(2\omega_L t + \pi/6)}$$

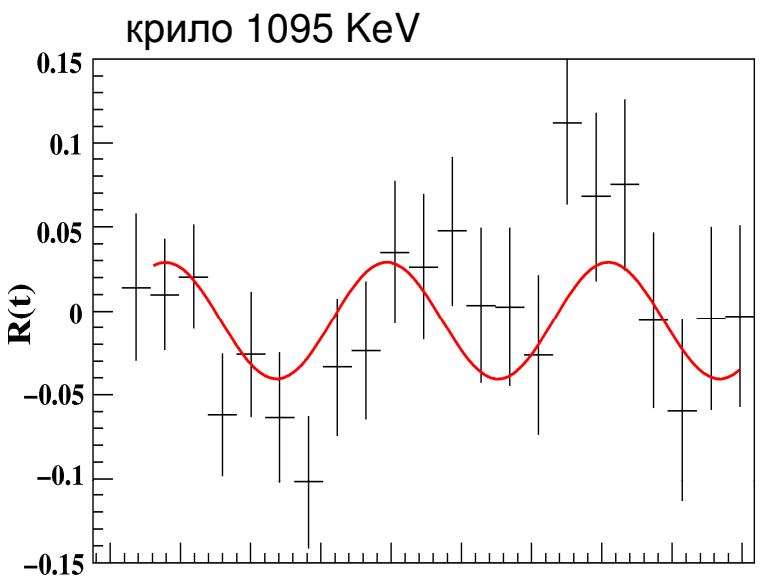
$$R(t) = \frac{3\sqrt{3}A_2B_2 \sin(2\omega_L t + \pi/6)}{8 + 2A_2B_2 - 3A_2B_2 \cos(2\omega_L t + \pi/6)}$$

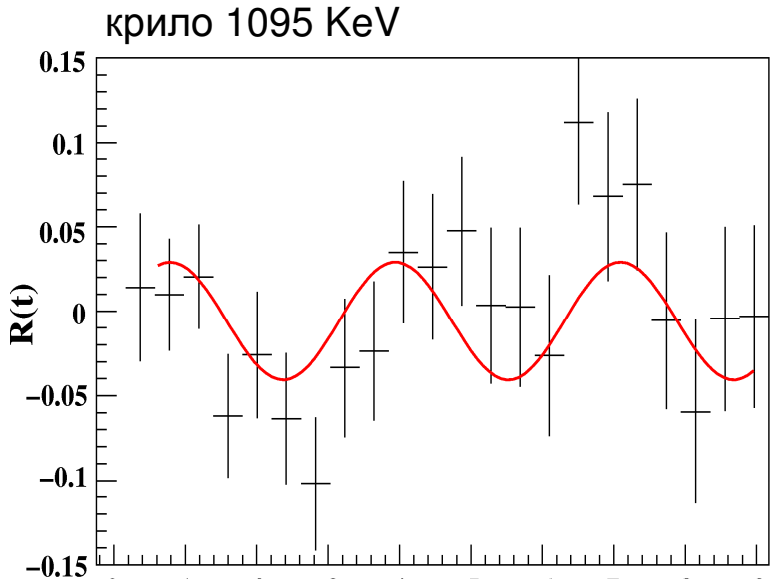
$$R(t) = \frac{3A_2B_2 \cos(2\omega_L t - \pi/6)}{8 + 2A_2B_2 - 3\sqrt{3}A_2B_2 \sin(2\omega_L t - \pi/6)}$$

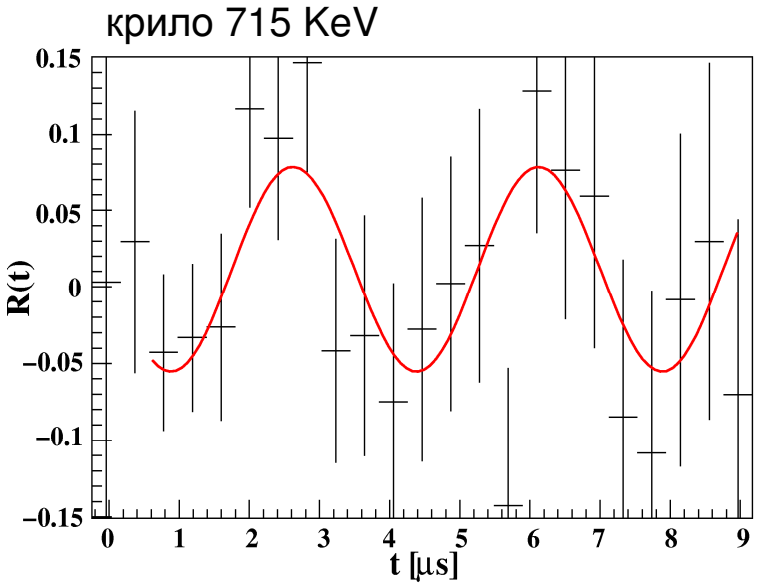


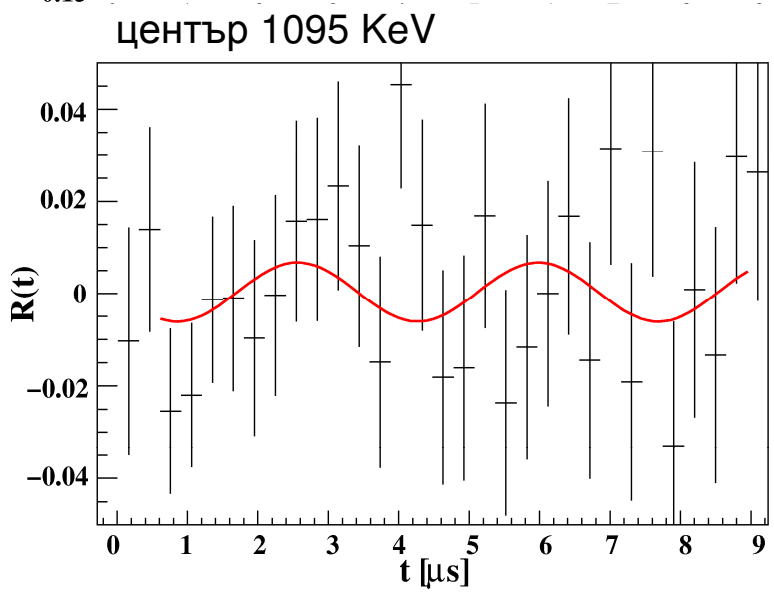
Експериментални R(t) функции











A_2(732-M2)= -0.37 A_2(1090-E2)= -0.39 A_2(715-E1)= -0.4

Experimental g-factor

$g(19/2^+) \approx |0.16|$ $\longrightarrow (\nu s_{1/2}^{-1} h_{11/2}^{-2})_{19/2+}$

Comparison with large-scale shell model calculations

*M. Hjorth-Jensen et al. Phys Rep **261** (1995) 125*

- Model space: $2s_{1/2}$, $1d_{3/2}$, $1d_{5/2}$, $0g_{7/2}$ from N = 4 shell and $h_{11/2}$ from N = 5 shell
- ^{132}Sn core
- NN potential – derived from meson exchange models
- Free-nucleon operator for the magnetic moment

10^+ level	^{124}Sn	^{126}Sn	^{128}Sn
g-factor	0.609	0.616	0.628
$19/2^+$ level	^{125}Sn	^{127}Sn	^{129}Sn
g-factor	0.213	0.209	0.157

Conclusions

1. We have managed to read all the detectors from FRS which allows us to make the proper isotope selection.

2. We report first results for the g-factor of $19/2^+$ isomer of ^{127}Sn. This is the first measurement of this isomer in the Sn region.

3. Our analysis causes questions of the spins and parities of the levels and multipolarities of transitions.

4. We have made comparison with realistic shell-model calculations, which is in agreement with our result.

THE g-RISING COLLABORATION

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Theory

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