



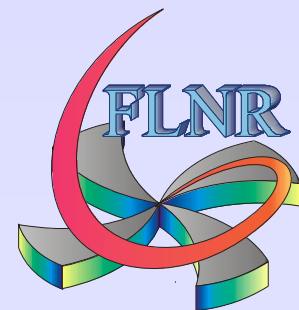
3rd Workshop on Recoil Separator for Superheavy Element Chemistry and Physics

GSI, Darmstadt, August 27, 2004.

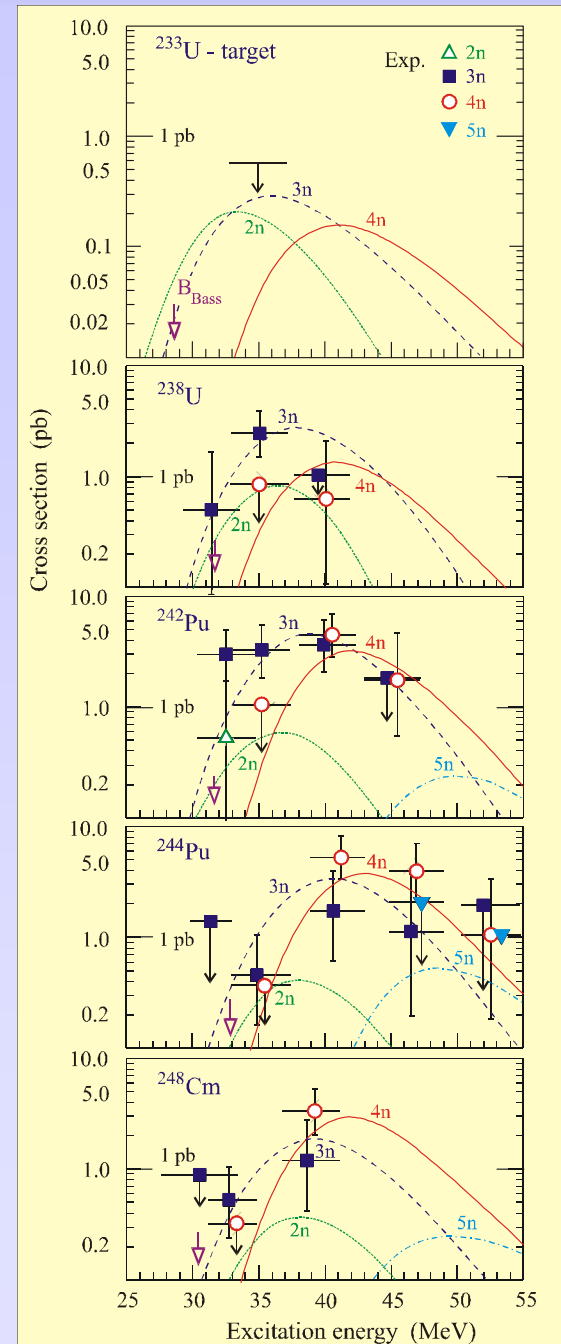
Recent results from FLNR

A.G. Popeko

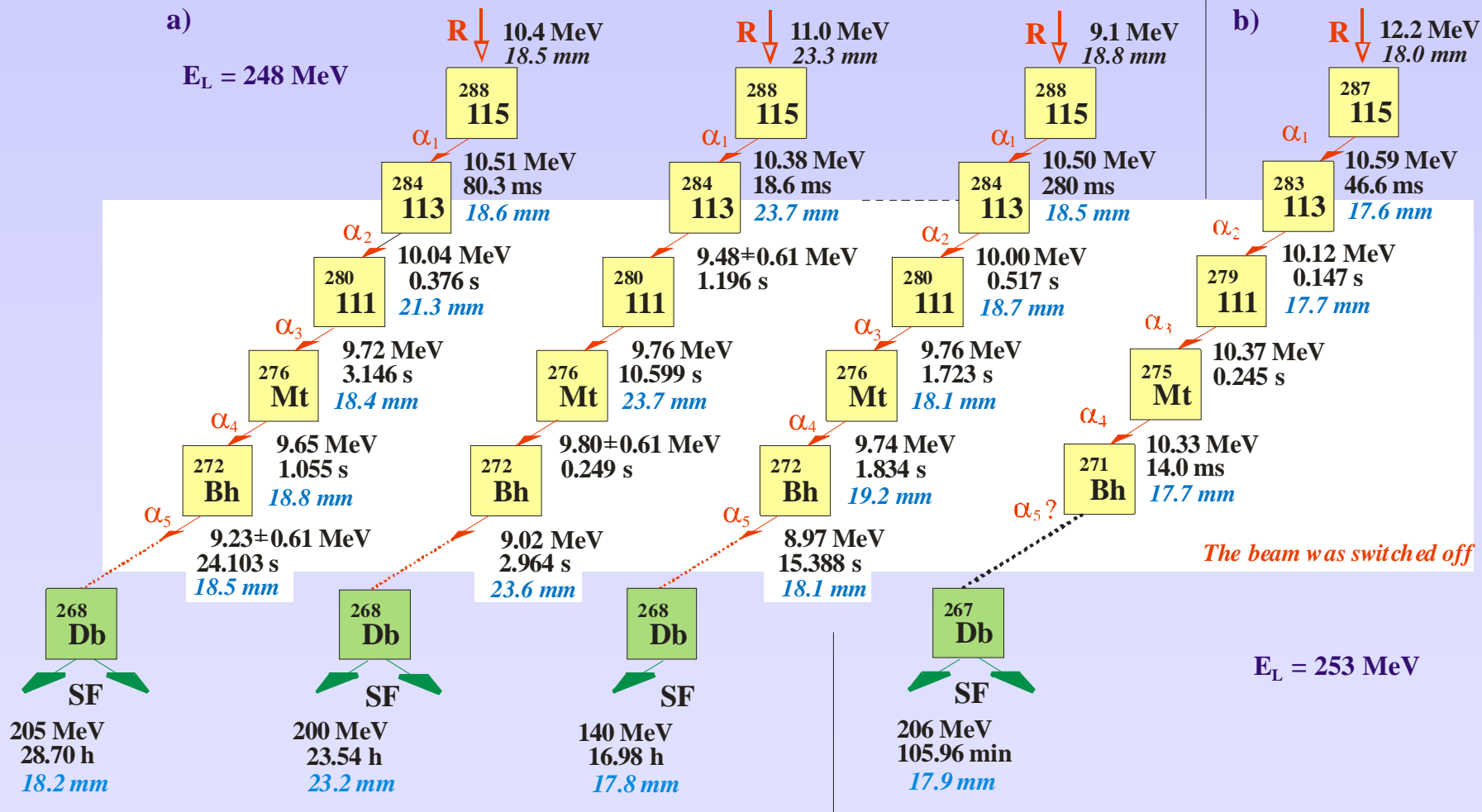
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Joint Institute for Nuclear Research,
Dubna, Russia*



Excitation functions of the $^{48}\text{Ca} + ^{233}\text{U}, ^{238}\text{U}, ^{242}\text{Pu}, ^{244}\text{Pu} +$ xn



Decay Chains Observed in $^{243}\text{Am} + ^{48}\text{Ca}$ Reaction



CHEMICAL IDENTIFICATION of the element Db as decay product of the element 115 in the $^{48}\text{Ca} + ^{243}\text{Am}$ reaction

FLNR (Dubna):

Yu. Oganessian, S. Dmitriev, V. Utyonkov, S. Shishkin, A. Yeremin, G. Vostokin, N. Aksenov, Yu. Lobanov, V. Chepygin, E. Sokol, Yu. Tsyganov, G. Gulbekian, A. Mezentsev, S. Tretiakova, M. Voronuk, A. Voinov, O. Malyshev, V. Gorshkov, M. Hussonnois, J. Kim, M. Itkis

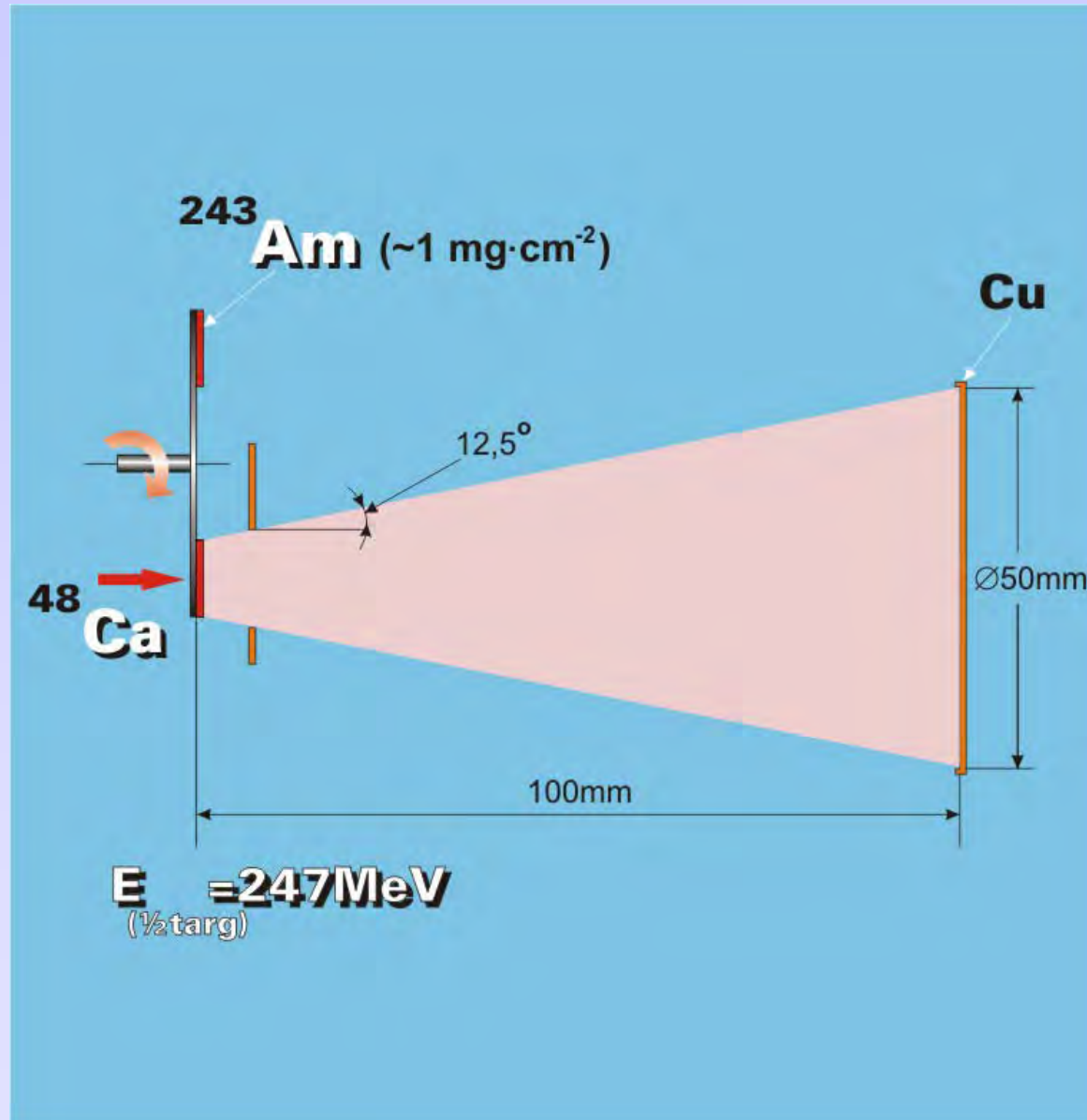
PSI, University of Bern (Switzerland):

D. Schumann, H. Bruchertseifer, R. Eichler, H. Gaggeler

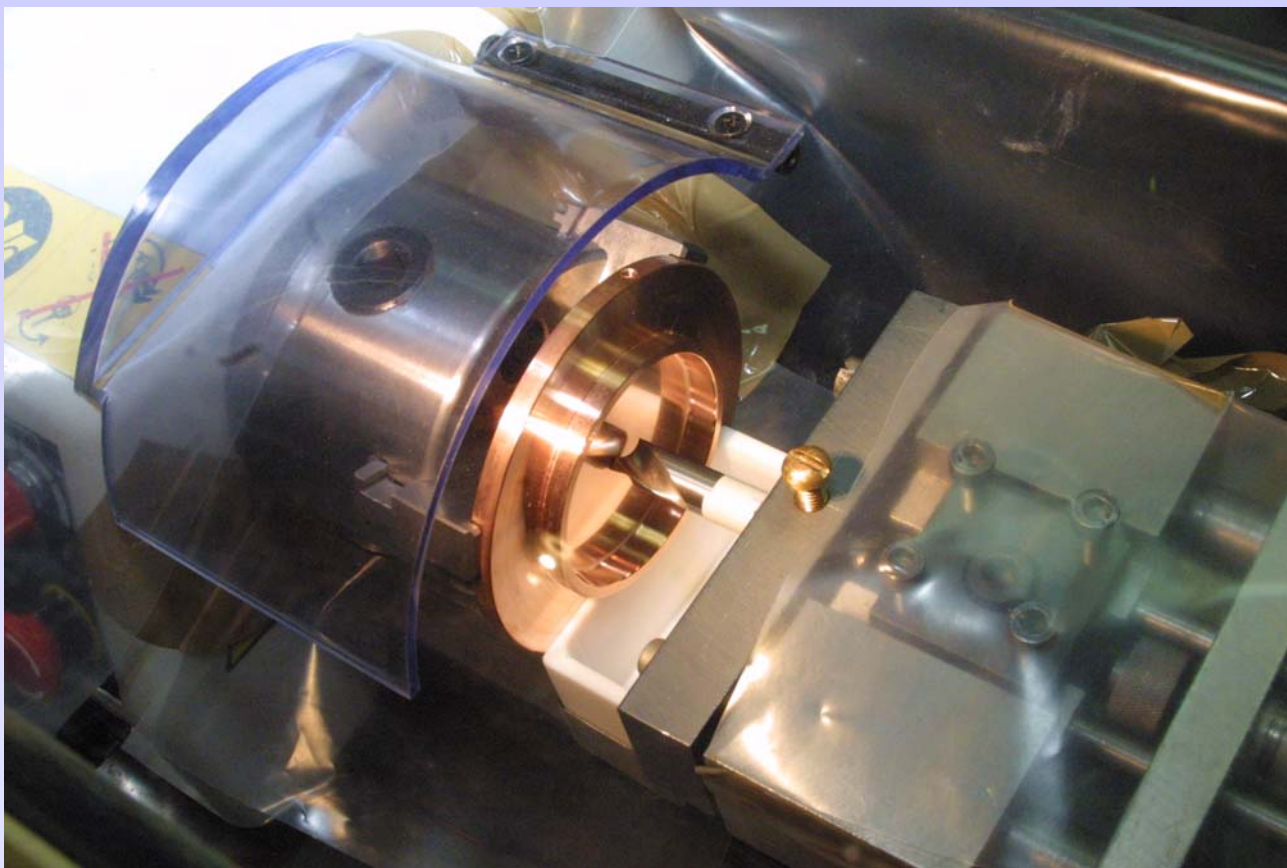
LLNL (Livermore, USA):

J. Wild, M. Stoyer, D. Shaughnessy, J. Kenneally

Irradiation of ^{243}Am -target with ^{48}Ca -ions



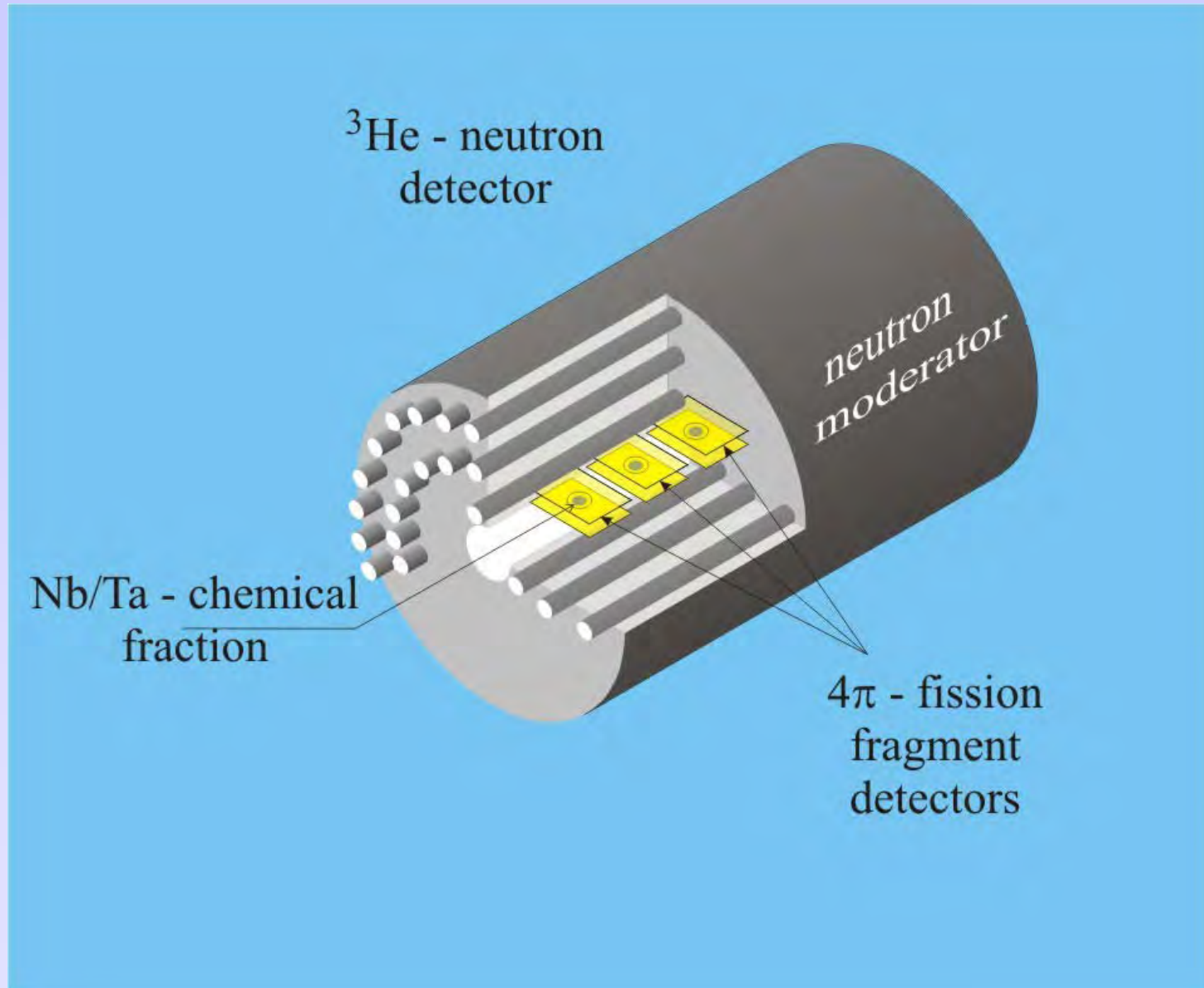
Taking off thin layer of Cu-catcher (100÷150 mg of Cu)



Chemical isolation of Db

- Dissolution of the Cu-cuttings in HNO₃ conc.
- Addition of the La³⁺ (0.7 mg), tracers (^{92m}Nb, ¹⁷⁷Ta, ¹⁶⁷Tm, ¹⁶⁹Yb) and carriers Nb, Ta (1 μg)
- Precipitation of La(OH)₃ by NH₄OH (La, Nb, Ta, Db, Ac – precipitate; Cu-solution) – 3 times (Nb, Ta ≈99%)
- Dissolution of the La(OH)₃ in 2M HNO₃
- Sorbtion of La, Ac, Nb, Ta, Db on Dowex 50 (cation-exchange resin)
- Elution of group 5 elements (Nb, Ta, Db) with 2 ml 1M HF
- Evaporation of the solution to 0.1 ml
- Pipetting of the 0.1 ml solution on a PE-foil (40 μg/cm²) - Σ≈3 hr
(^{92m}Nb ≈ 85±5%)
(¹⁷⁷Ta ≈ 75 ± 5%)

Detection system



$^{48}\text{Ca} + ^{243}\text{Am}$

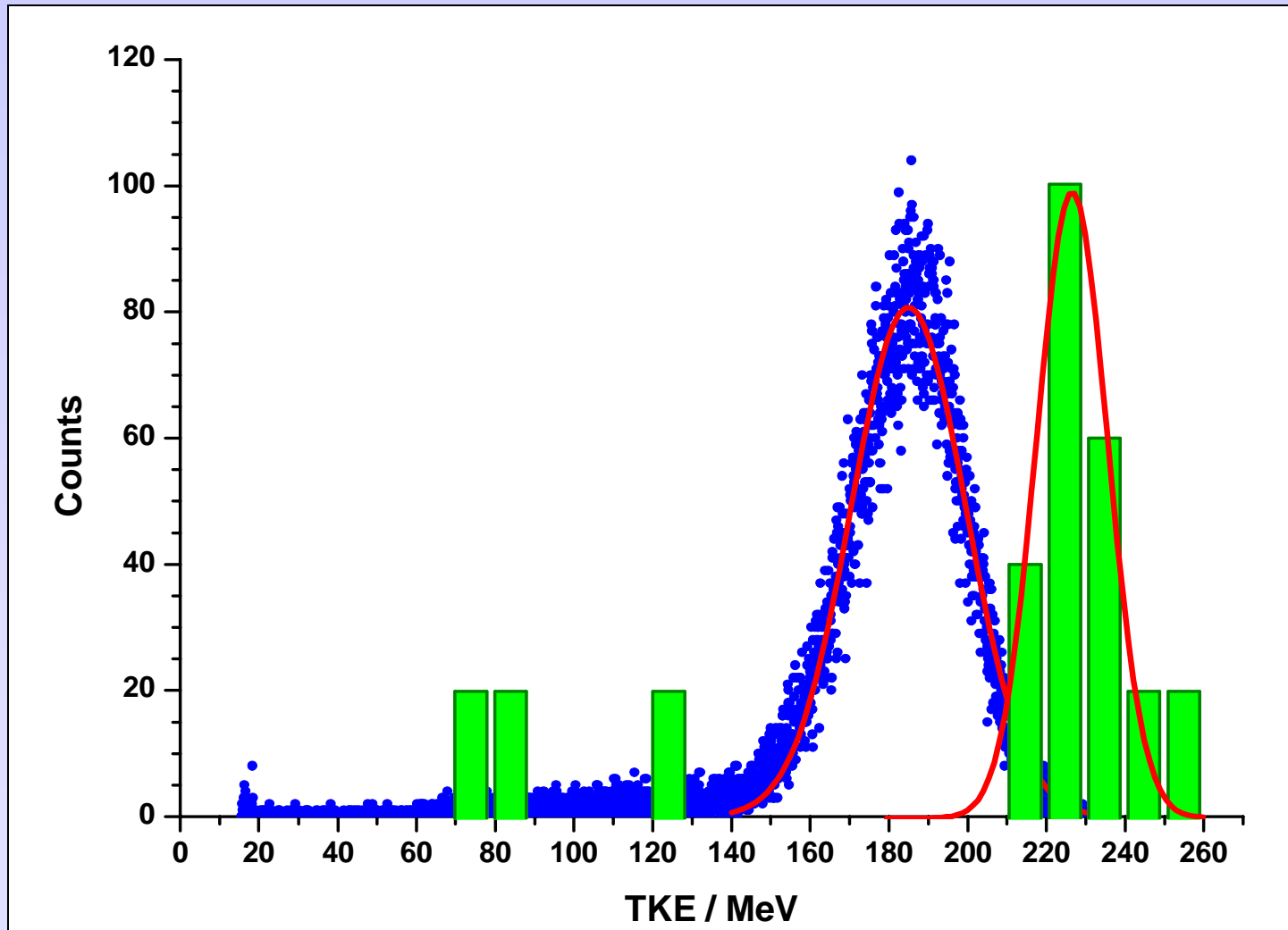
31.07.04

N Sample (data)	t_{irr} hr	Beam Dose	$E_{\text{bot}}+E_{\text{top}}+ Nn$ (t, μs)	t_{detect} hr	$t_{\text{measurement}}$ hr
1 (12.06)	20	$2,5 \cdot 10^{17}$	120+126+2n (5;64)	20	429
2 (13.06)	22	$3,7 \cdot 10^{17}$	- +86+1n (57)	74	186
3 (14.06)	22	$3,4 \cdot 10^{17}$	131+124+1n (3) 116+122+2n (8;16)	15 72	385
4 (15.06)	22	$2,9 \cdot 10^{17}$	104+120+1n (2) 97+125+1n (151) 100+128+1n (89)	22 29 51	358
5 (17.06)	38	$6,7 \cdot 10^{17}$	117+118+2n (6,98) 108+107+3n (4,31,43) 110+104+0n (89) 0+76+2n (6,41)	6 9 15 68	476
6 (18.06)	23	$3,9 \cdot 10^{17}$	120+114+2n (2,2)	39	453
7 (19.06)	22	$3,6 \cdot 10^{17}$	-	-	429
8 (21.06)	45	$7,4 \cdot 10^{17}$	119+110+2n (5;33) 118+105+2n (72,165) 65+58+3n (12,19,29)	5 93 174	382

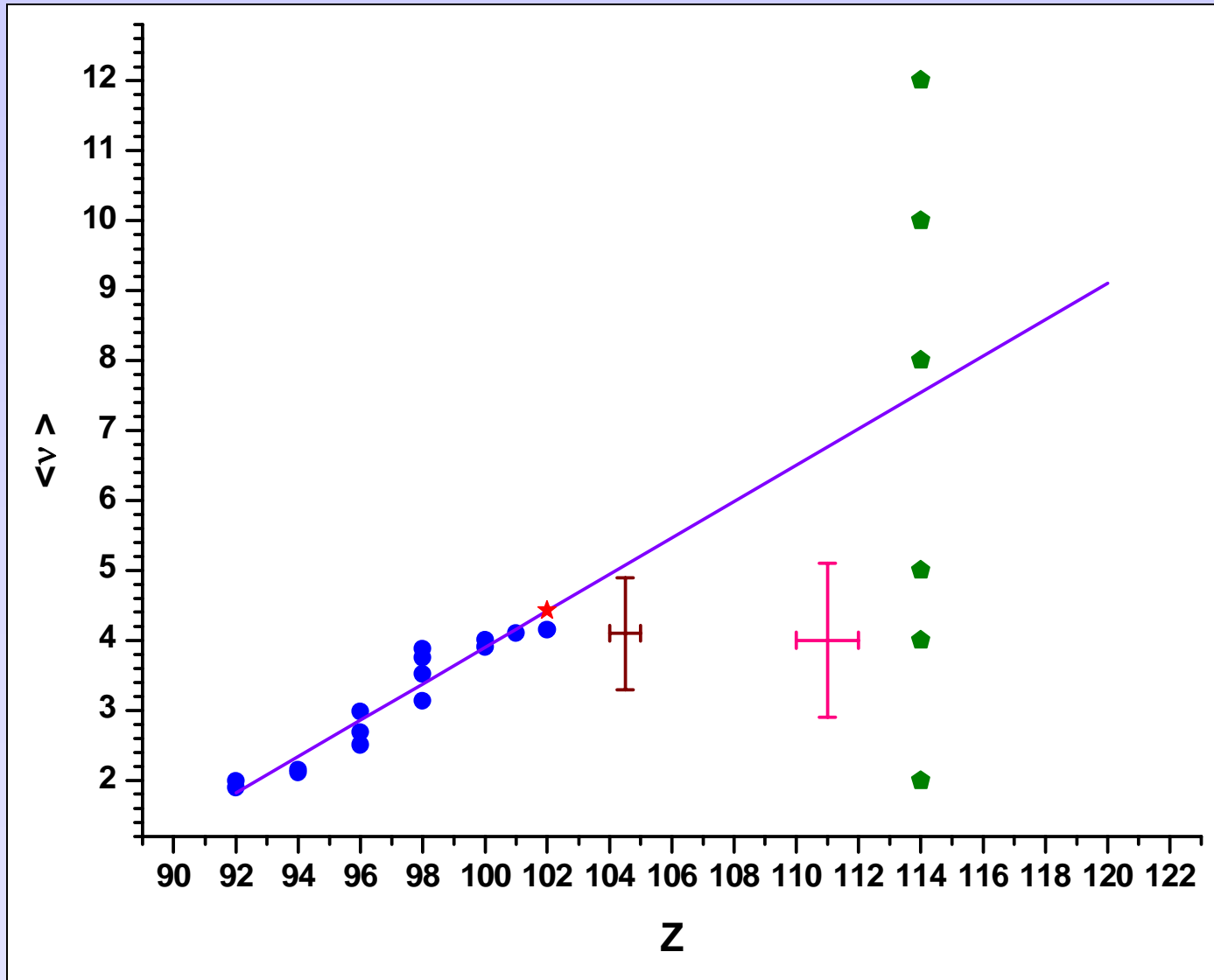
$\Sigma 3,4 \cdot 10^{18}$

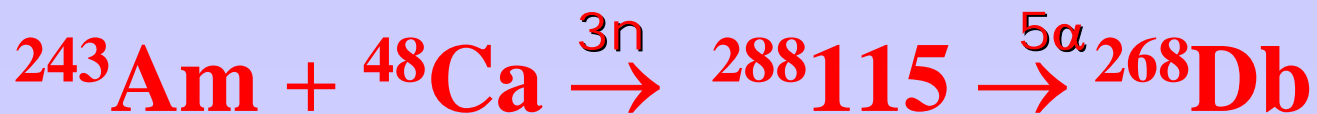
15 events

Total Kinetic Energy distributions of ^{252}Cf and ^{268}Db



Average numbers of prompt neutrons emitted in spontaneous fission





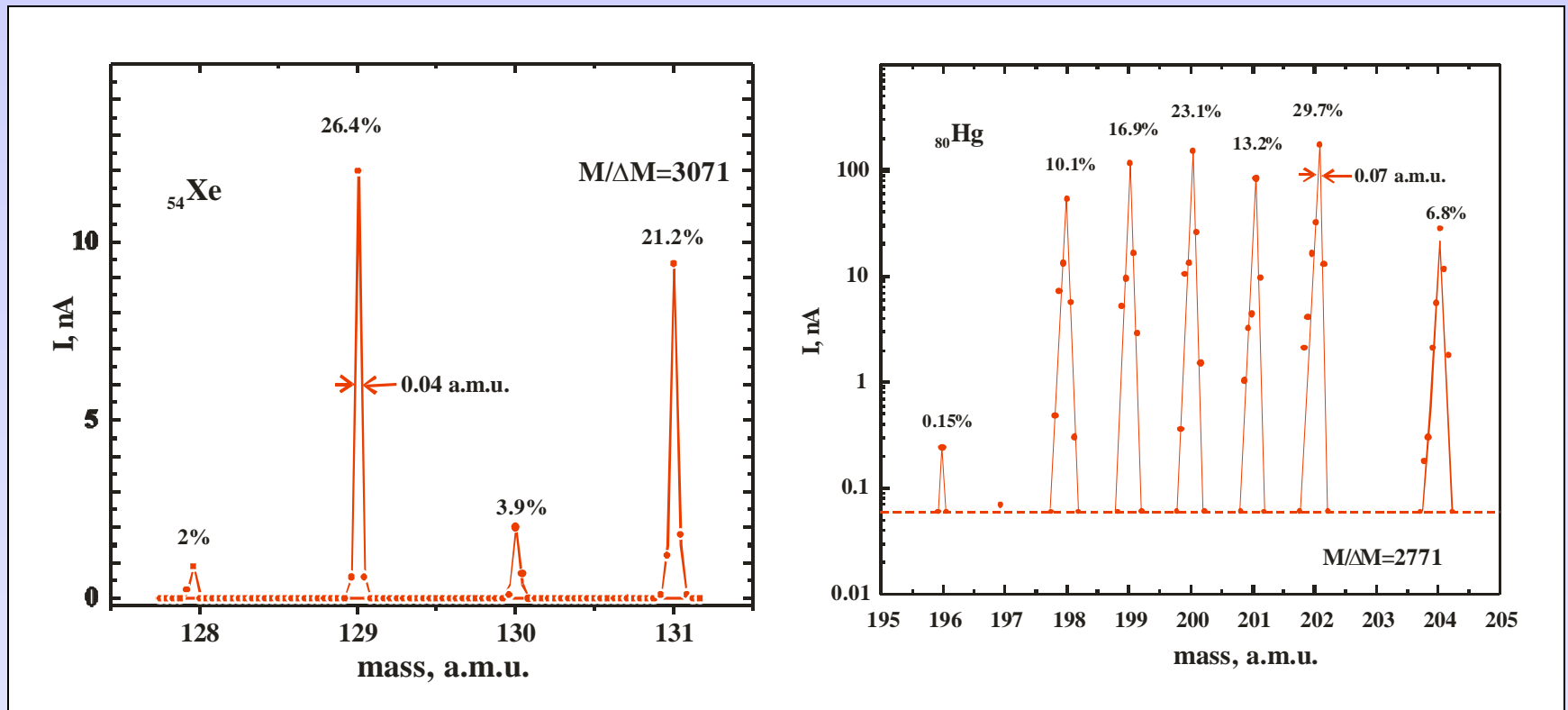
	DGFRS	CHEMISTRY
Target Thickness	0.36 mg·cm ⁻²	1.15 mg·cm ⁻²
Energy Range	3.3 MeV	10,5 MeV
Transmission	~ 35%	80±5%
Beam Dose	4.3·10 ¹⁸	3.4·10 ¹⁸
Events Number	3	15
Decay Mode	SF	SF
Half Life	16 ⁺¹⁹ ₋₆ hr	27 ⁺¹¹ ₋₆ hr
Cross section	2.7 ^{+4.8} _{-1.6} pb	4.7 ^{+1.8} _{-1.3} pb

- TKE = 227 MeV
- $\langle v \rangle = 4.1 \pm 0.8$
- Off-line experiment at MASHA

Mass Analyzer of Super Heavy Atoms

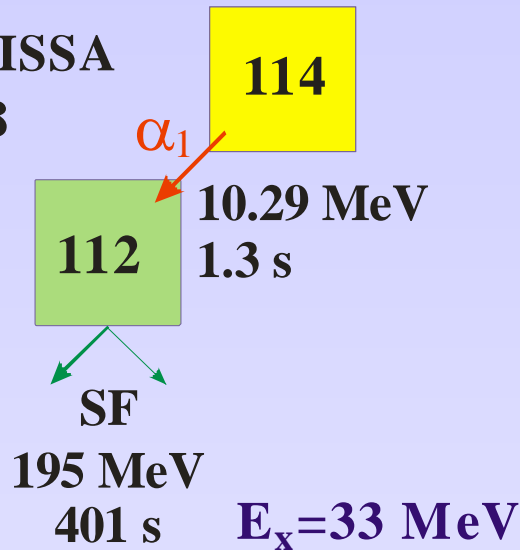


MASHA test with Xe and Hg isotopes

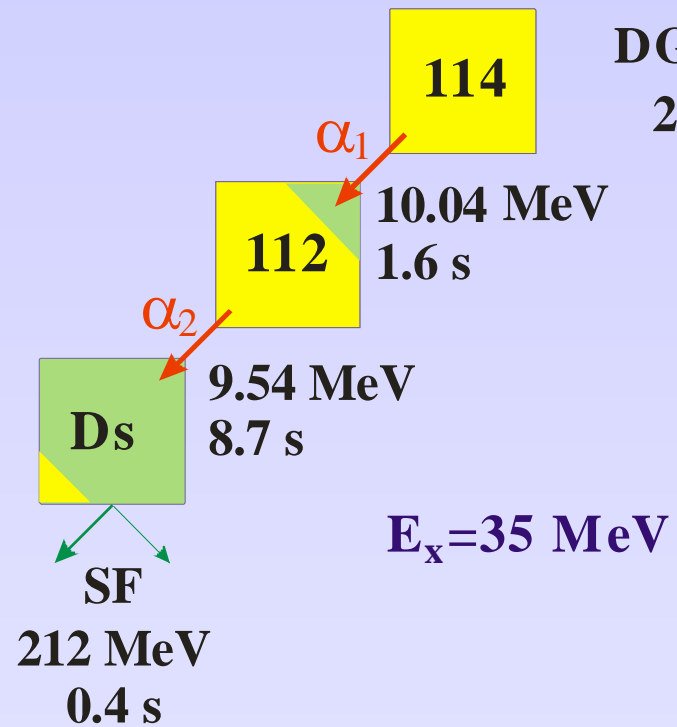


$^{242}\text{Pu}(^{48}\text{Ca}, 3\text{n})^{287}\text{114}$

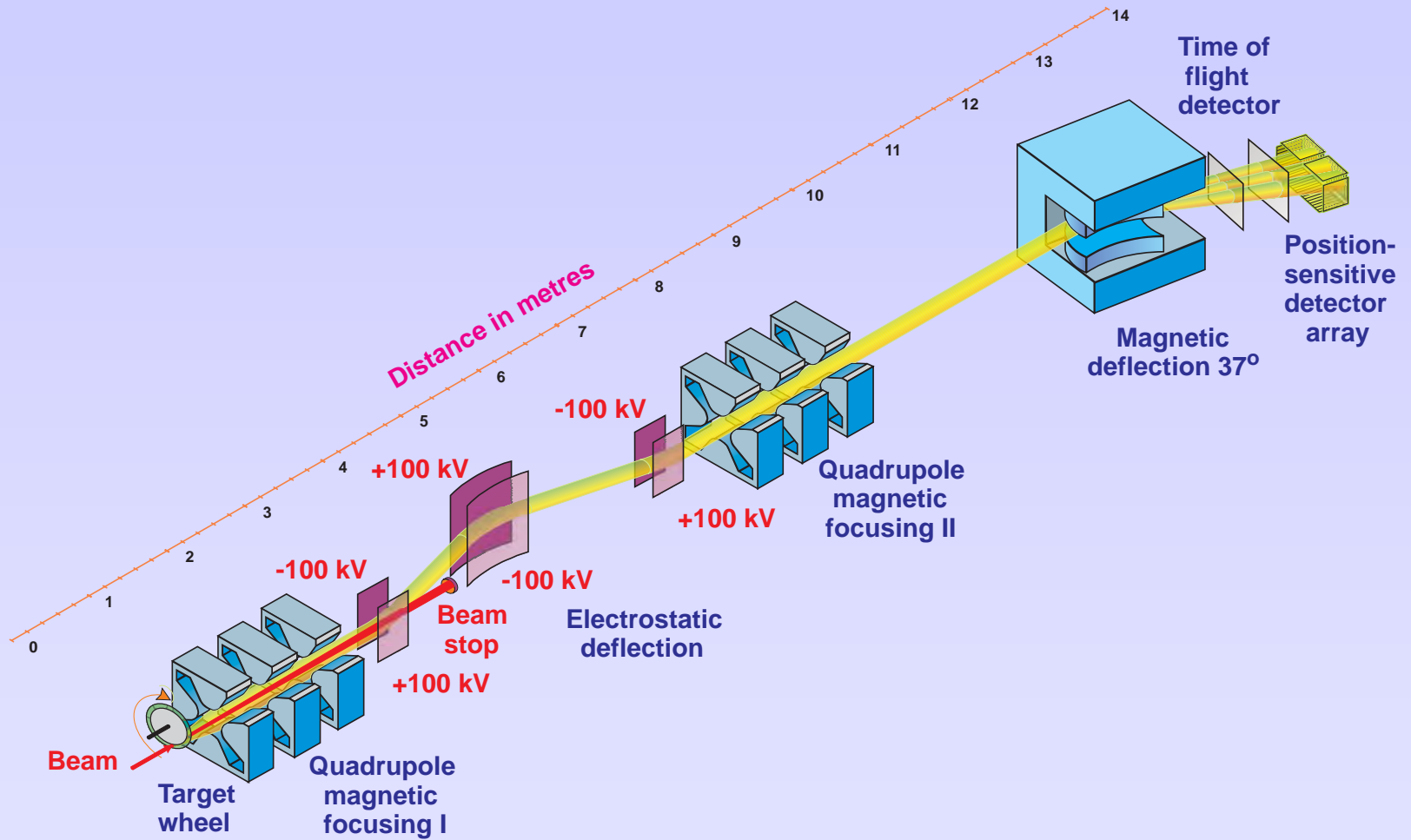
VASSILISSA
1998



DGFS
2003



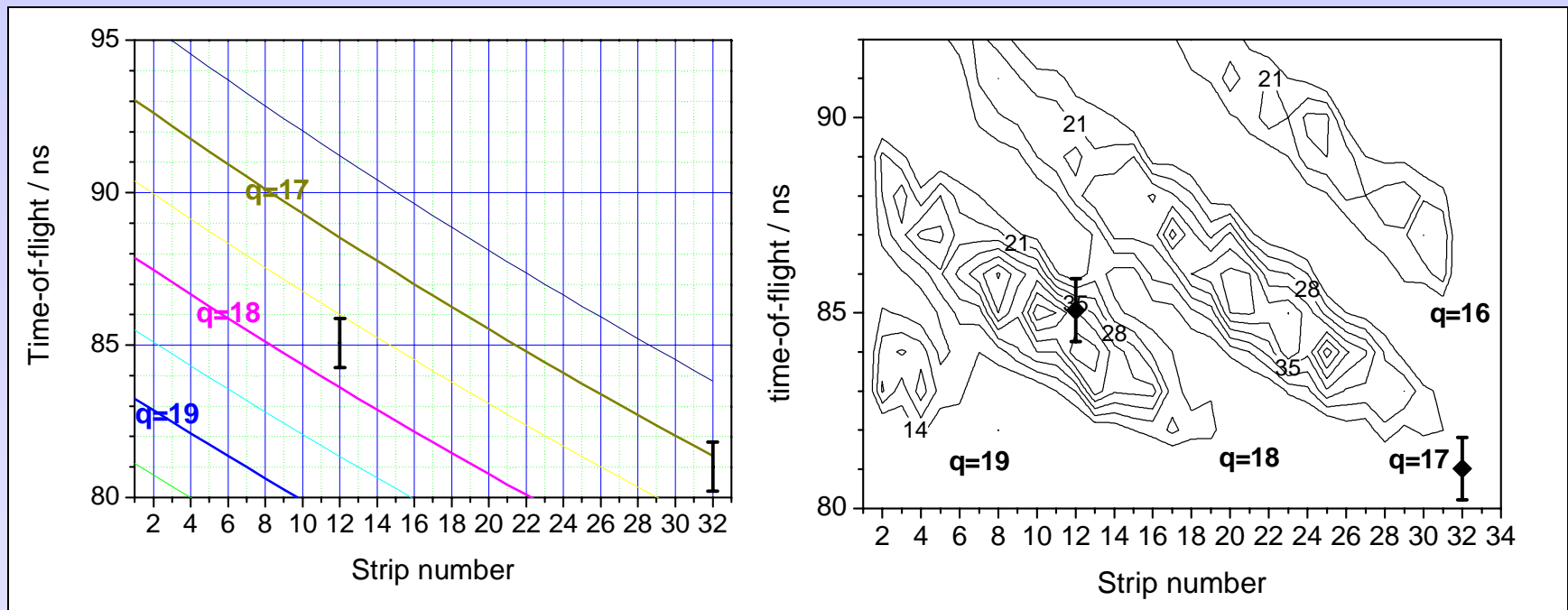
VASSILISSA



Irradiation of ^{238}U target with ^{48}Ca ions

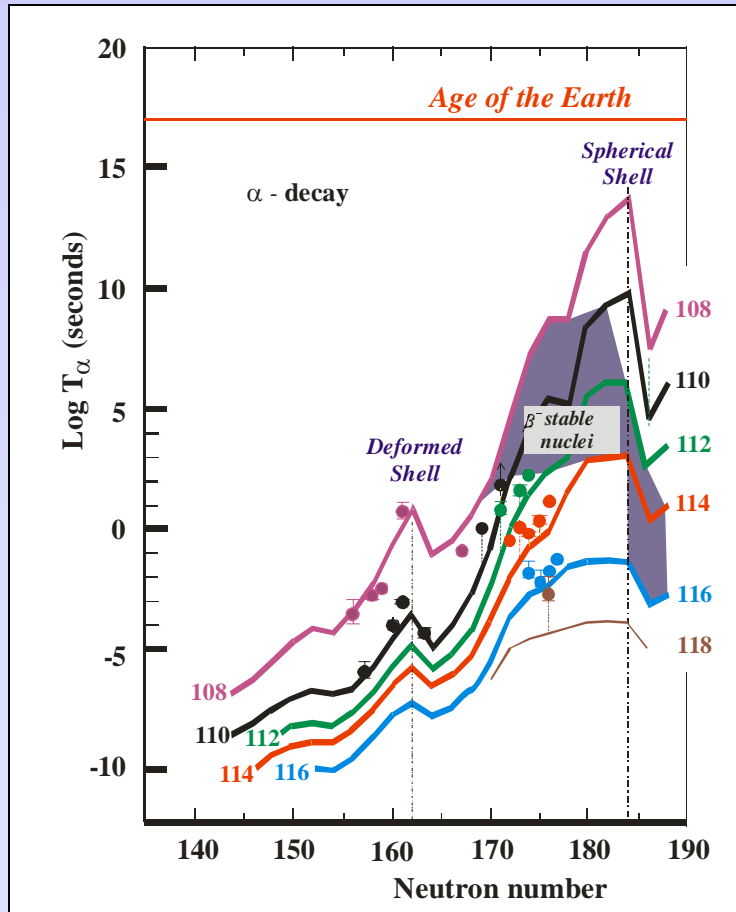
Experimental conditions and results

Time-of-flight - strip number distribution for 283112



$$280 \leq A \leq 286$$

Search for SHE in nature theory and experiment



Decay properties of nuclei produced in the ^{48}Ca -induced reactions

Z	A	No. observed ^{a)}	Decay mode, branch ^{b)}	Half-life ^{c)}	Expected half-life	E_α (MeV)	Q_α (MeV)
118	294	1/1	α	$1.8^{+75}_{-1.3}$ ms	0.4 ms	11.65 ± 0.06	11.81 ± 0.06
116	293	3/3	α	53^{+62}_{-19} ms	80 ms	10.53 ± 0.06	10.67 ± 0.06
	292	4/5	α	18^{+16}_{-6} ms	40 ms	10.66 ± 0.07	10.80 ± 0.07
	291	2/2	α	$6.3^{+11.6}_{-2.5}$ ms	20 ms	10.74 ± 0.07	10.89 ± 0.07
	290	2/2	α	15^{+26}_{-6} ms	10 ms	10.85 ± 0.08	11.00 ± 0.08
114	289	8/8	α	$2.7^{+1.4}_{-0.7}$ s	2 s	9.82 ± 0.06	9.96 ± 0.06
	288	12/11	α	$0.80^{+0.32}_{-0.18}$ s	0.8 s	9.95 ± 0.07	10.09 ± 0.07
	287	15/15	α	$0.51^{+0.18}_{-0.10}$ s	0.5 s	10.02 ± 0.06	10.16 ± 0.06
	286	11/5	α : 0.4 SF: 0.6	$0.16^{+0.07}_{-0.03}$ s	0.2 s	10.20 ± 0.06	10.35 ± 0.06
112	285	8/8	α	34^{+17}_{-9} s	50 s	9.16 ± 0.06	9.29 ± 0.06
	284	12	SF	101^{+41}_{-22} ms			≤ 9.85
	283	18/18	α : 1 SF: ≤ 0.1	$4.0^{+1.3}_{-0.7}$ s	3 s	9.54 ± 0.06	9.67 ± 0.06
	282	6	SF	$0.50^{+0.33}_{-0.14}$ ms			≤ 10.82
110	281	8	SF	$9.6^{+5.0}_{-2.5}$ s			≤ 9.05
	279	21/2	α : 0.1 SF: 0.9	$0.18^{+0.05}_{-0.03}$ s	0.2 s	9.70 ± 0.06	9.84 ± 0.06
108	275	2/2	α	$0.15^{+0.27}_{-0.06}$ s	0.8 s	9.30 ± 0.07	9.44 ± 0.07
106	271	2/1	α : 0.5 SF: 0.5	$2.4^{+4.3}_{-1.0}$ min	0.8 min	8.53 ± 0.08	8.65 ± 0.08
104	267	1	SF	$2.3^{+98}_{-1.7}$ h			≤ 8.22

^a Number of events used for calculations of half-lives / α -particle energies, respectively.

^b Branching ratio is not shown if only one decay mode was observed.

^c Error bars correspond to 68%-confidence level if more than one event was observed, for only one registered event the error bars correspond to 95%.