DESIR parallel session 27 January 2010

High efficiency ^{3}He neutron detector TETRA for DESIR

First trial gamma-beta-neutron experiment at ALTO

Dmitry Testov

Neutron Emission form Exotic Nuclei: Goal to study

Neutron emission from unstable nuclei far from stability can provide us with valuable information about insight nuclear shell structure and it could be interesting to see nuclear deformation changes toward the drip line.

Precise beta-decay half-lives, end point energies, probability of neutron emission are crucial input parameters for calculations of the astrophysical rapid neutron capture process.

Also investigation of 2,3 and 4 neutron emission, as well as correlations between the emitted neutron will allow obtaining information on the possibility of existence of multi-neutron clusters and the size of the zone from which they are emitted (interference experiments).

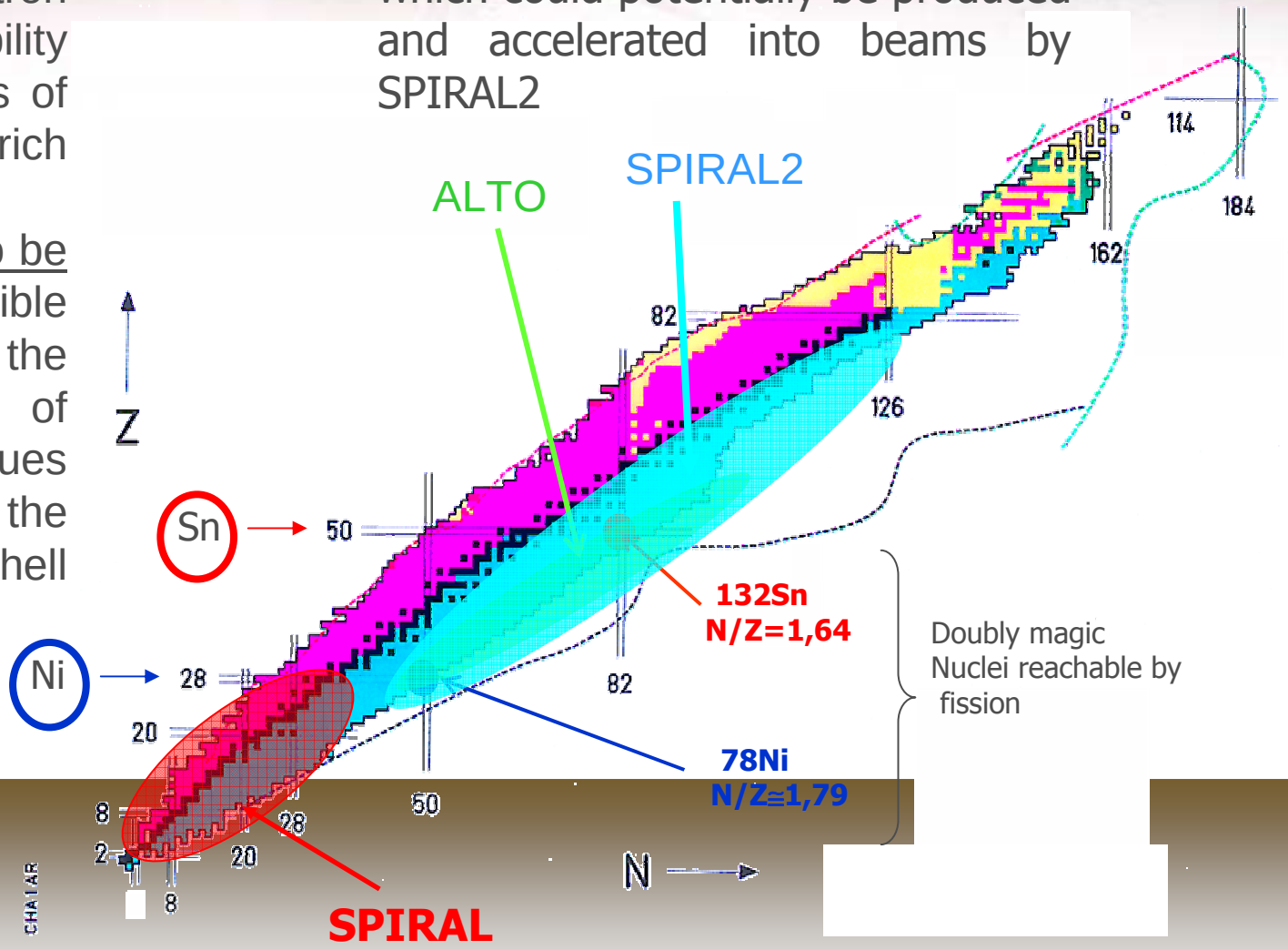
The selective method of beta decay, in combination with spectroscopic measurements of gamma-rays and neutrons, will open new opportunities to study

beta-delayed neutron emission from fission products in the ^{132}Sn region

To measure the β -delayed neutron emission probability along the chains of very neutron-rich isotopes.

The effects to be detected: possible irregularities in the A-dependence of the P_{total-}values after crossing the major neutron shell of N=82.

The blue areas indicate the nuclei which could potentially be produced and accelerated into beams by SPIRAL2



Neutron detectors with ^{3}He filled counters

- Zero energy threshold
- Zero cross-talk
- Low gamma sensitivity
- Free geometry
- Easy in use
- High efficiency
- Low internal background

^{3}He + n = ^{3}H + p + 780 keV

σth = 5320 barns

Pressure of ^{3}He 7 atm

Eff. 60% (0.4 – 1.5 MeV)

	^{3}He-detector	**"Large" scintillator**
Neutron energy	?	Yes
Threshold	0	High(~30÷300 keV)
Cross talk	0	Yes
Efficiency	30-60%	10-30%
Multiplicity	Yes	?
Angle correlation	Yes ($<20^0$)	?
Time scale	10 μs	ns

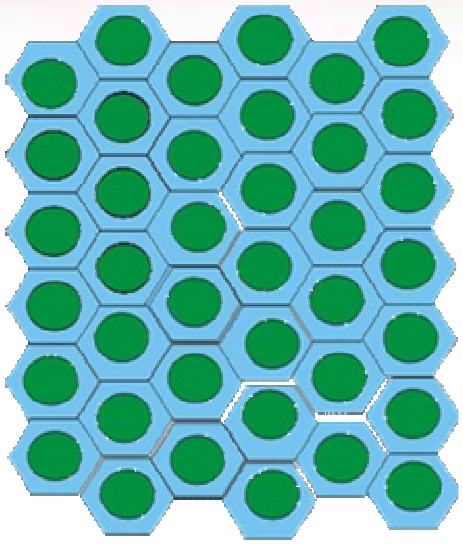
Preprint JINR P13-2007-154

Calibration for average delayed neutron energy measurements E_n=400-1500 keV

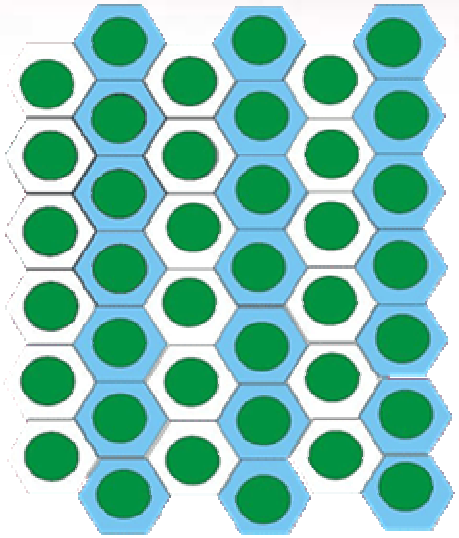
Nucl. Instr. and Meth. A540 (2005) 430-436

Van de Graaff Accelerator, Charles University, Prague

Neutron flux

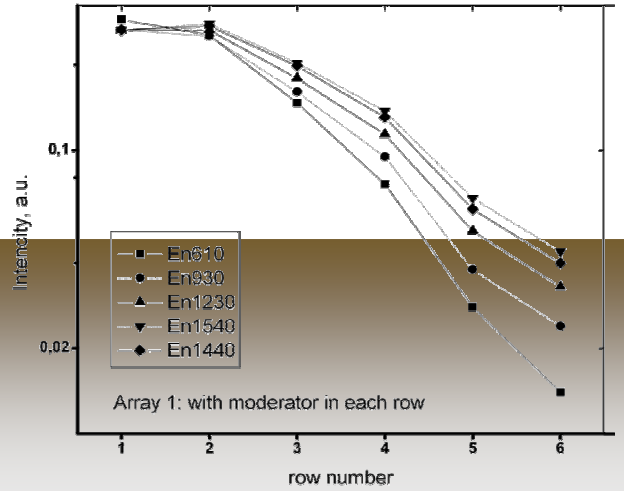


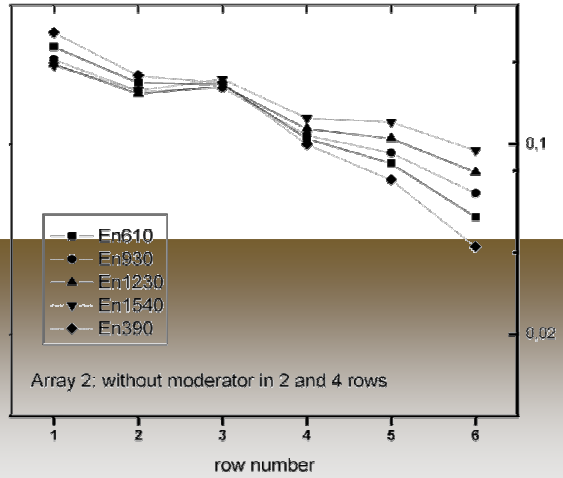
Neutron flux



moderator

counters



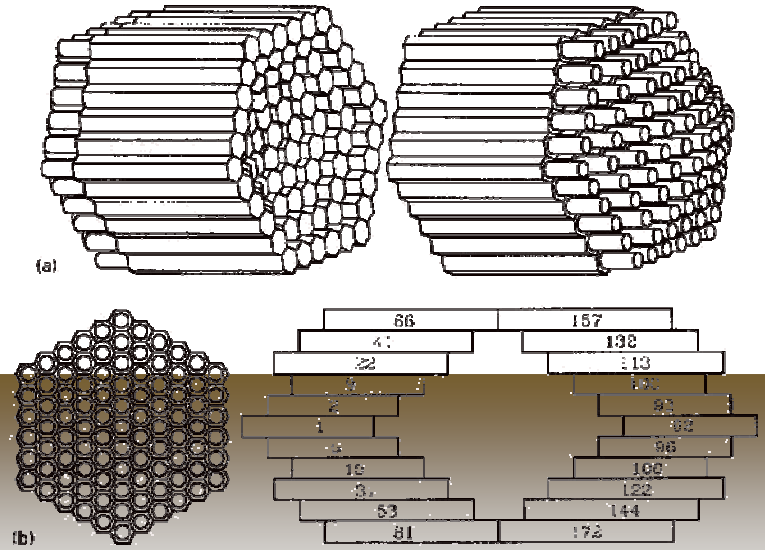


JINR-GANIL JINR-RIKEN βn-experiments

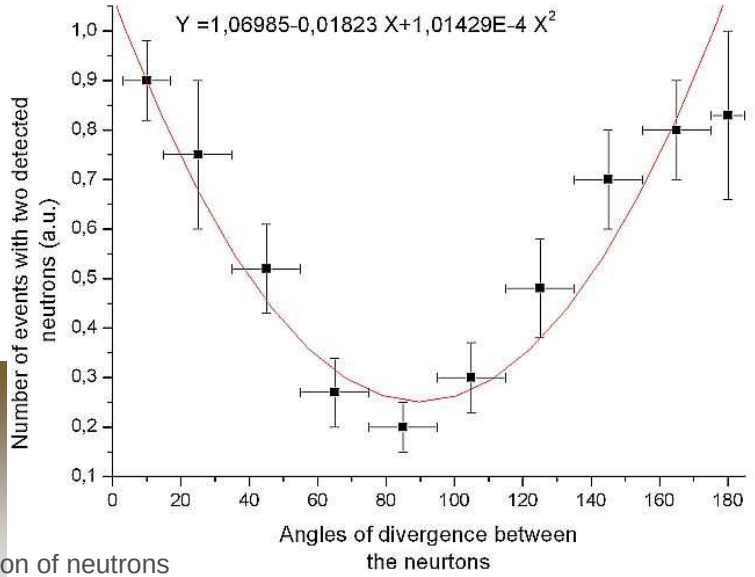
	Our work [6]		Literature [8]
	^{15}B as a calibration source	^{11}Be as a calibration source	
^{31}Na	82± 42	43± 22	37 ±5
^{32}Na	59 ±17	31± 9	24± 7
^{33}Na	136± 34	72± 18	47± 6
^{32}Mg	6± 4	3± 2	2.4± 0.5
^{33}Mg	50± 18	26± 10	17± 5
…	…	…	…

Efficiency strongly depends

on energy of neutron



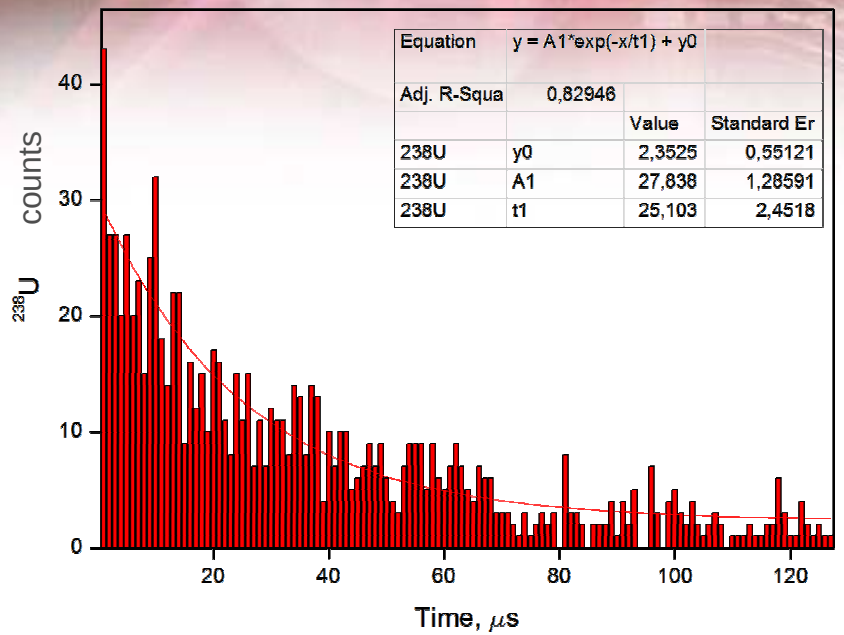
Angular distribution

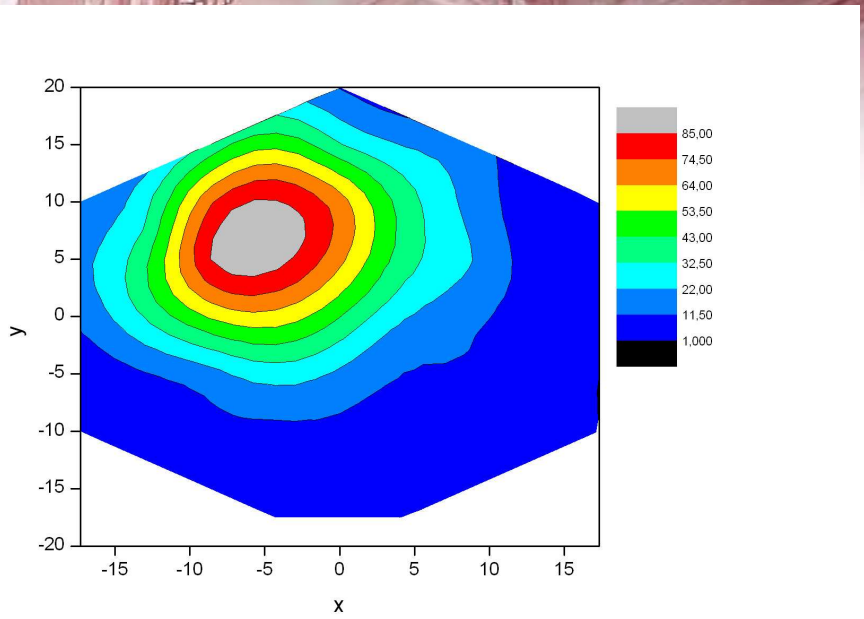


A detector for measuring the multiplicities and the angular correlation of neutrons

Nucl. Instr.& Meth. in Phys. Research A, v.400, 1997, p.96-100

Neutron Capture Time, calibration for SF neutrons of ^{238}U, November 2009





Efficiency in the center of the detector (consists of 60 counters placed in moderator) for single neutrons measured (62±4)%

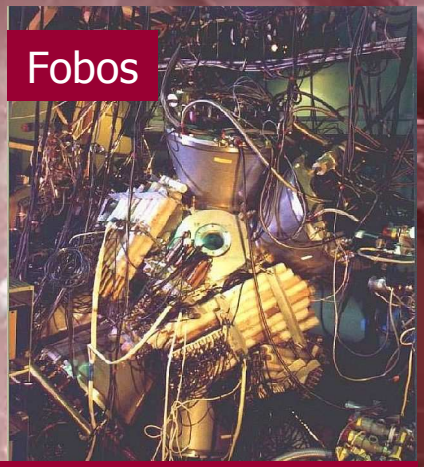
Life time of a neutron in the detector measured 25 μs

The detector is used at low background laboratory (LSM, Modane) to detect neutron flashes of high multiplicity. Experiment is running for more than 43 000 hours

Uses of 3He detectors in different setups

Chemistry of 112

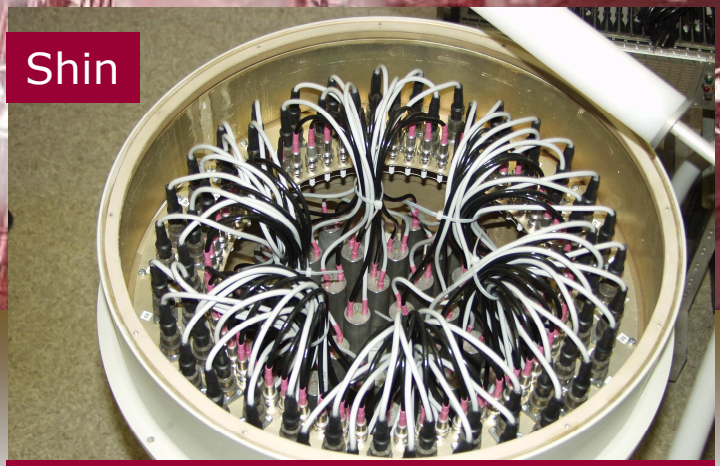
Fobos



Neutron-Fragments coincidence

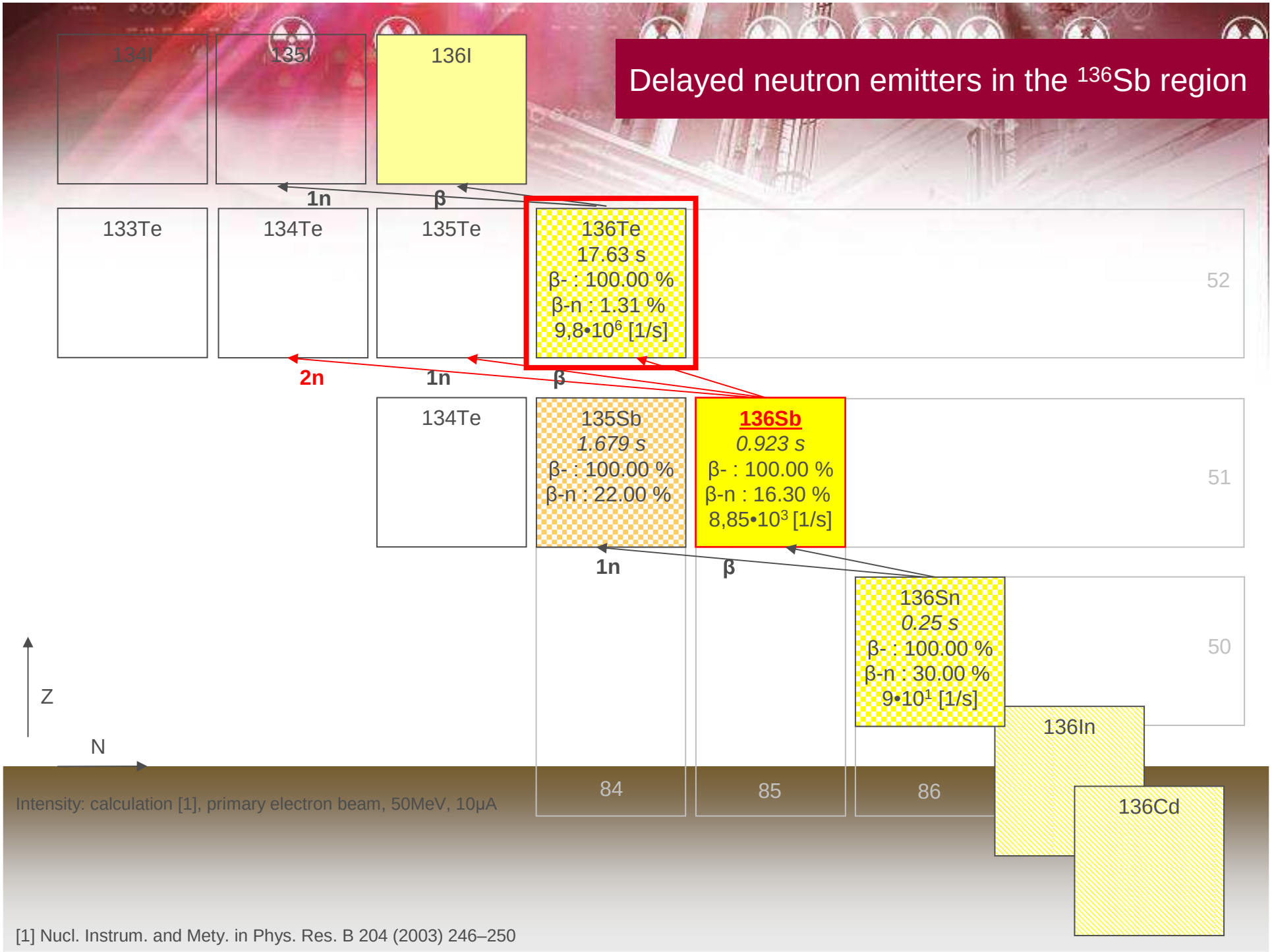
Vassilissa

Shin



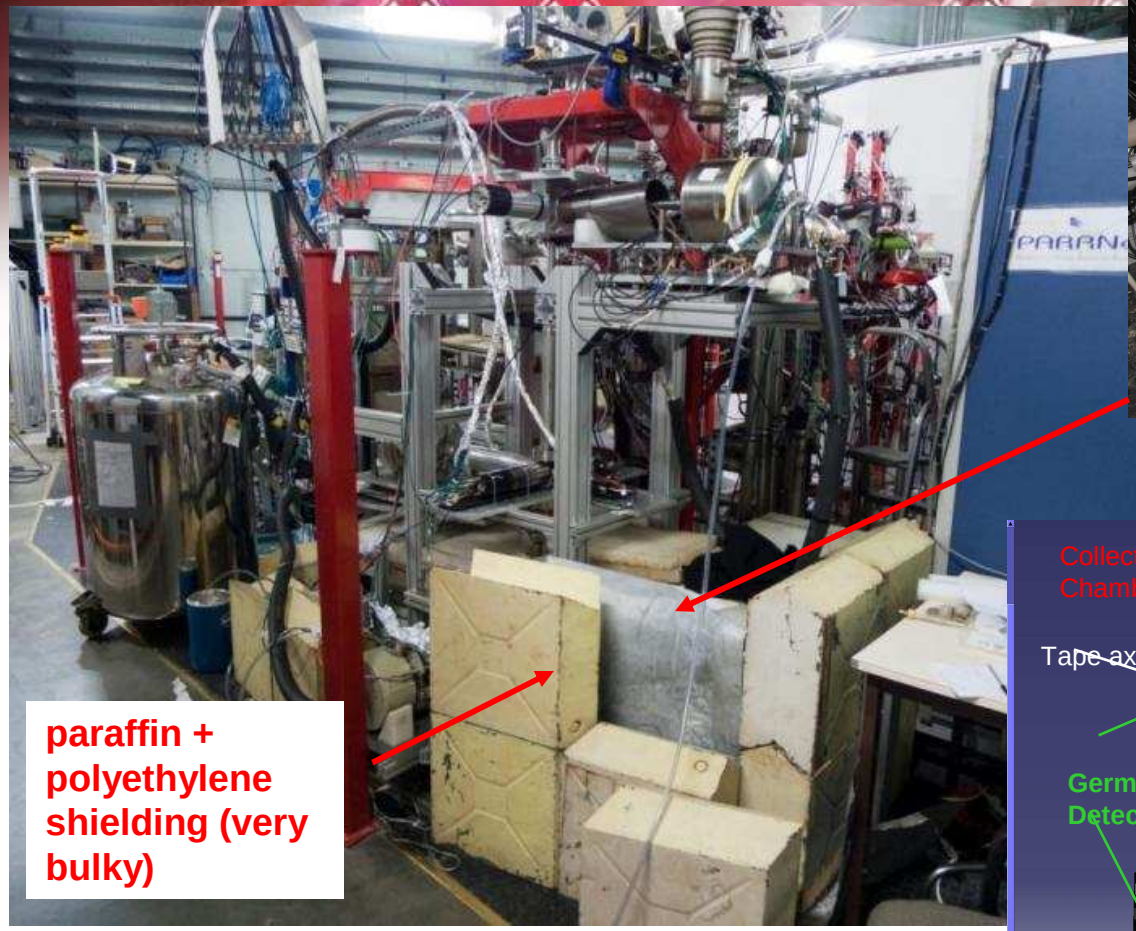
Neutron-Neutron coincidence

Delayed neutron emitters in the ^{136}Sb region

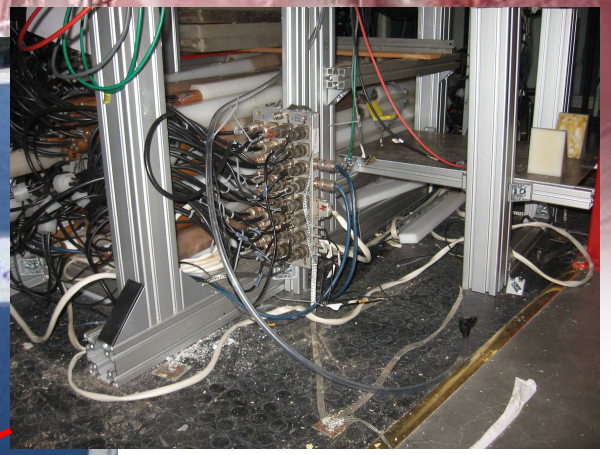


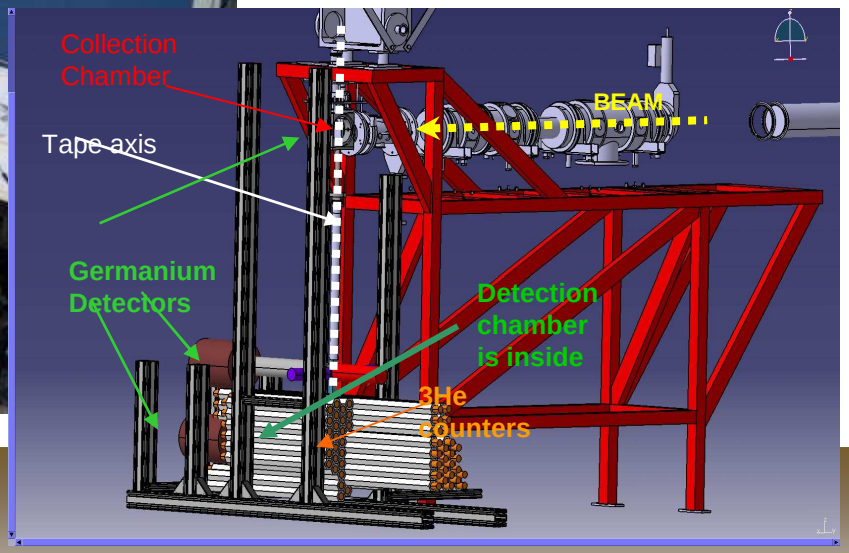
[1] Nucl. Instrum. and Mety. in Phys. Res. B 204 (2003) 246–250

Neutron detector setup at ALTO



paraffin + polyethylene shielding (very bulky)





The efficiency measured is up to 35%

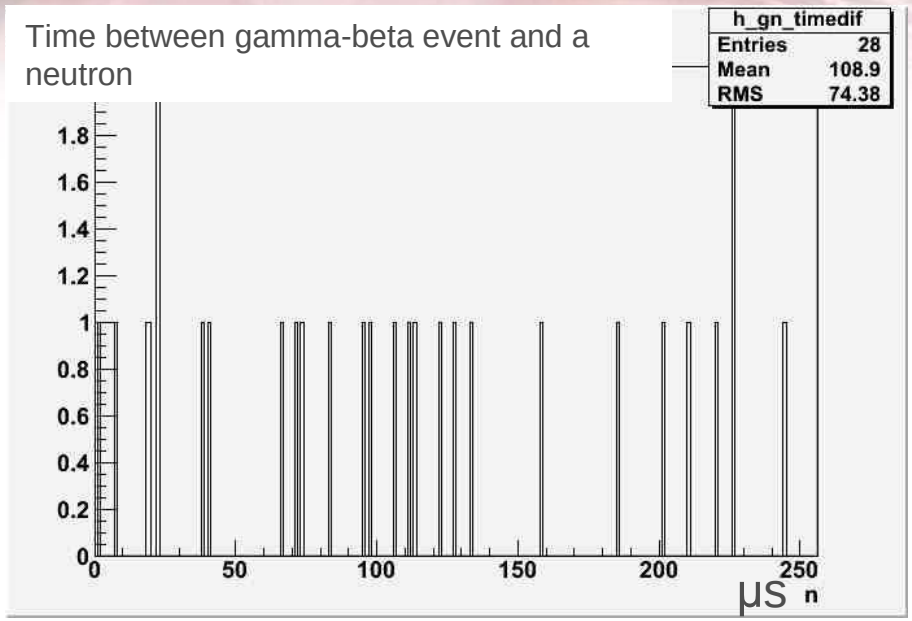
Neutron lifetime in the detector is 35 μs

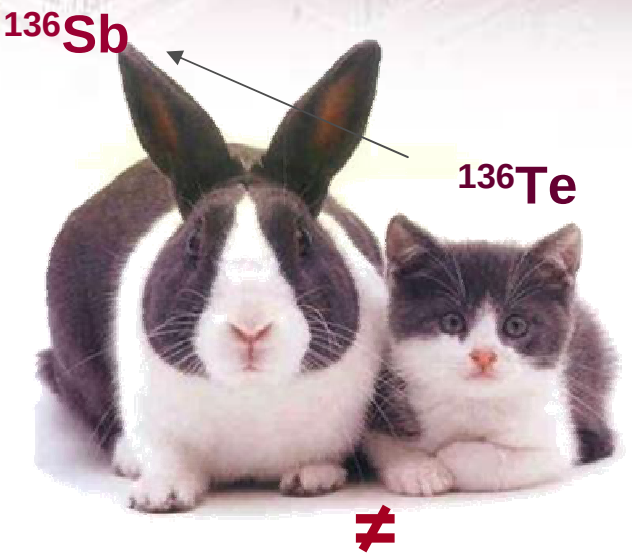
Detector consisted of 6 groups
15 counters each

ALTO

Gamma-beta-neutron coincidence:: preliminary results ^{136}Te

Time between gamma-beta event and a neutron





≠

$P_n(^{136}Te)$ (0.47÷4.89)%

$P_n(^{136}Te)$ 1.31 %

1 Step:

Increase intensity

Reduce transport time

2 Step:

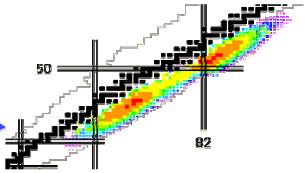
Laser ion source

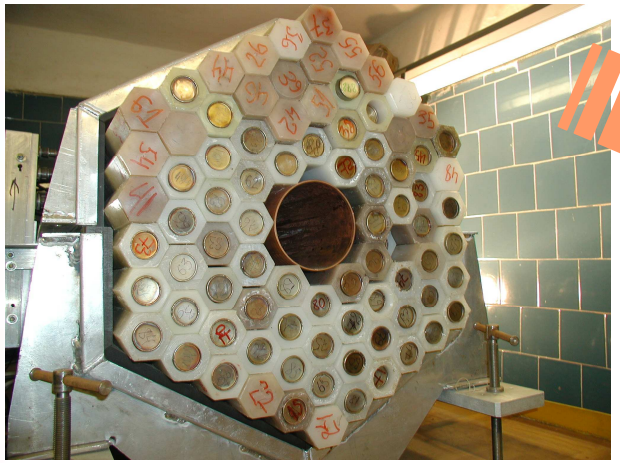
Results are interesting and promising

ALTO Neutron Detector Setup: prototype for DESIR

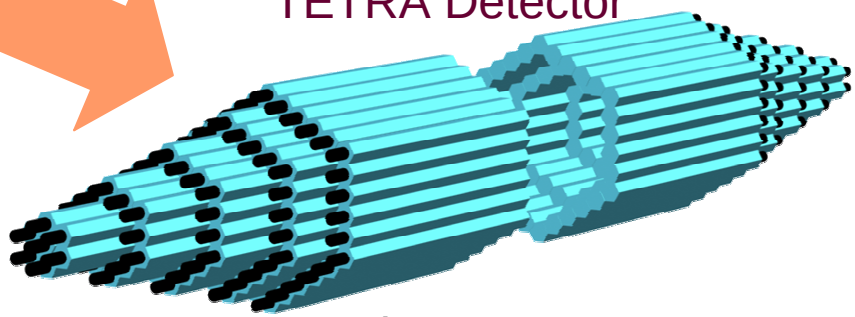
ALTO

Spiral2





TETRA Detector



close to 4-π geometry

Total number of counters: **90**

Geometry: Ø 3 cm, ^{3}He at 7 atm
length 50 cm

Moderator: polyethylene, distance between parallel faces - 5 cm.

Efficiency: 30-60% (depends on geometry)

Life time: 15-30 μs (depends on geometry)

Neutron Detector Setup for DESIR: schedule & cost estimates

2009	2010	2011	2012	2013

ETAPE 1 Tests of a detector prototype at ALTO, 2009.

ETAPE 2 Construction and manufacturing of the neutron detector for DESIR: 1 man year, 2010.

ETAPE 3 Tests of the DESIR neutron detectors at ALTO: 0.5 man year, 2011- 2012

ETAPE 4 Installation of DESIR detectors in the DESIR hall: 0.2 man year, 2012- 2013.

Investment:	
Array of neutron counters	150 k€
Control system:	50 k€
Manpower cost:	
Stuff 2 per/year	60 k€
Travel and indirect coast:	50 k€
TOTAL	310 k€

Flerov Lab

Neutron Detector Setup for DESIR

Risks of the project

Neutron detectors of this type have been used at GANIL and will be tested at ALTO. We have prepared the last detector of this type for the low background measurements of spontaneous fission in LSM (Modane, France) in 2004. The detector for DESIR will be constructed and manufactured with this experience.

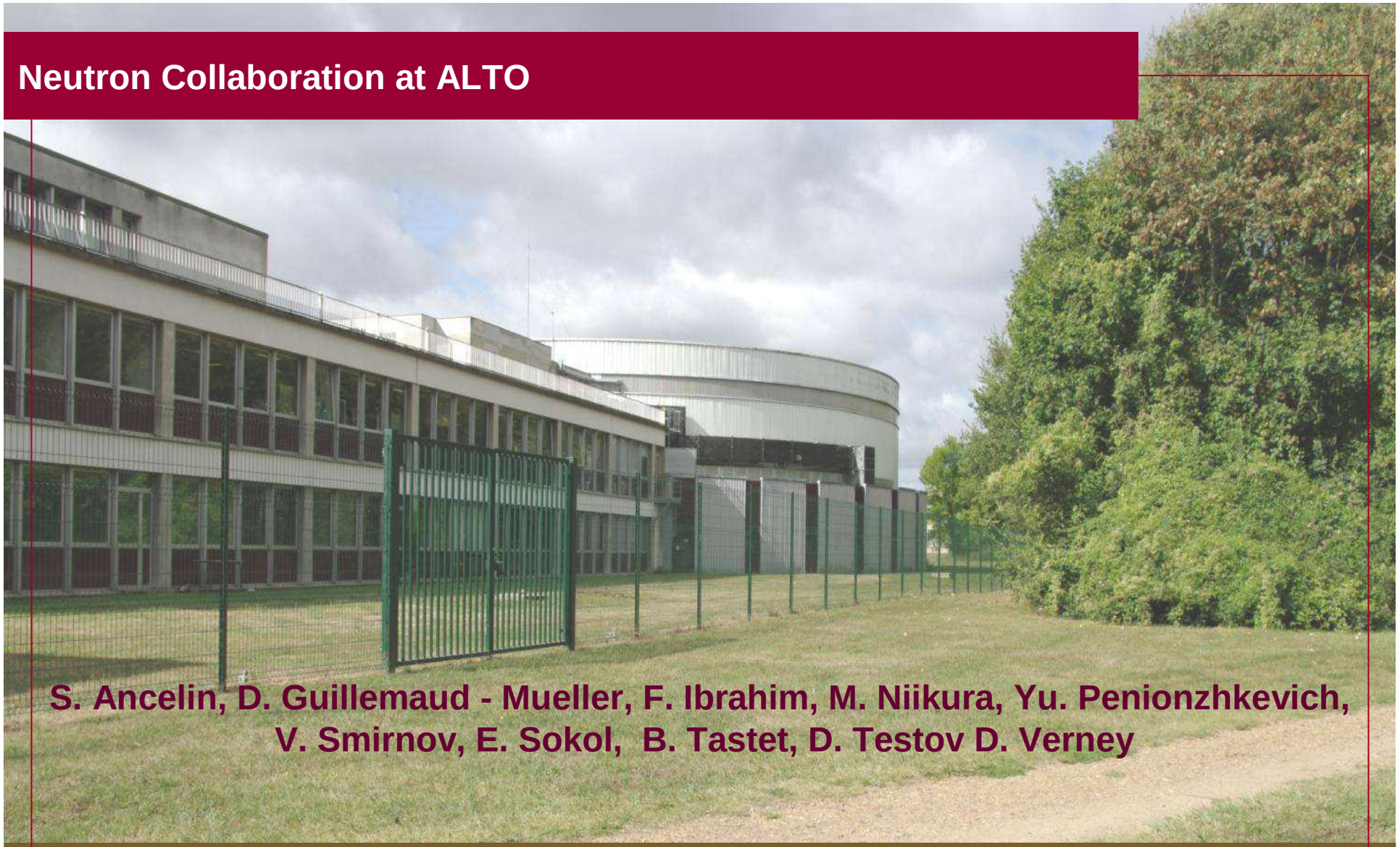
Beam requirements

Beam intensities: To perform the experiments described above, beam intensities of the ions of interest of about 100 pps will be optimum.

Specific requirements

- Required **floor space**: 2x3 m^2
- **Weight**: total with shielding – 2000 kg
- We will need a **spontaneous fission source** for calibrations (^{248}Cm or ^{252}Cf) with an intensity of about 20-100 spontaneous fissions per second)

Neutron Collaboration at ALTO



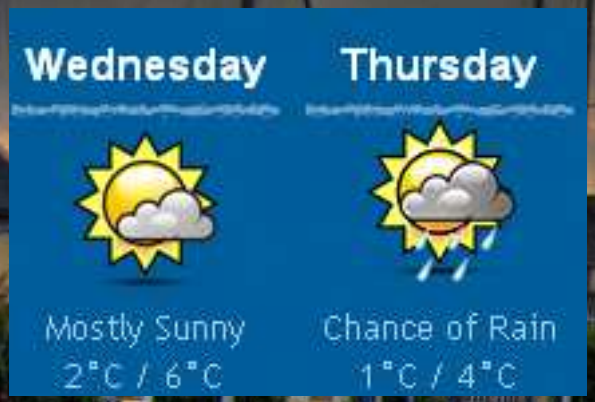
S. Ancelin, D. Guillemaud - Mueller, F. Ibrahim, M. Niikura, Yu. Penionzhkevich,
V. Smirnov, E. Sokol, B. Tastet, D. Testov D. Verney

IPN Orsay

ALTO

FLNR

Getting you way back to home… don’t forget…



Thank you ***organizers for the sp2w in January***

For mo details please see my poster somewhere at coffee place

d'Umon