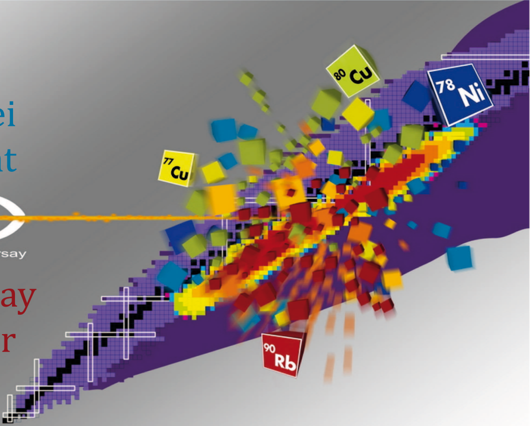
Neutron-rich nuclei produced at ALTO

Accélérateur Linéaire et Tandem à Orsay

investigations of beta-decay properties and the nuclear structure

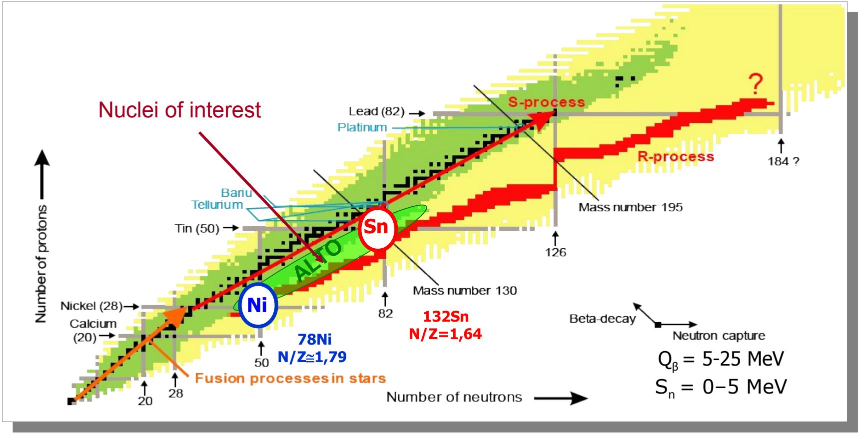


Dmitry Testov

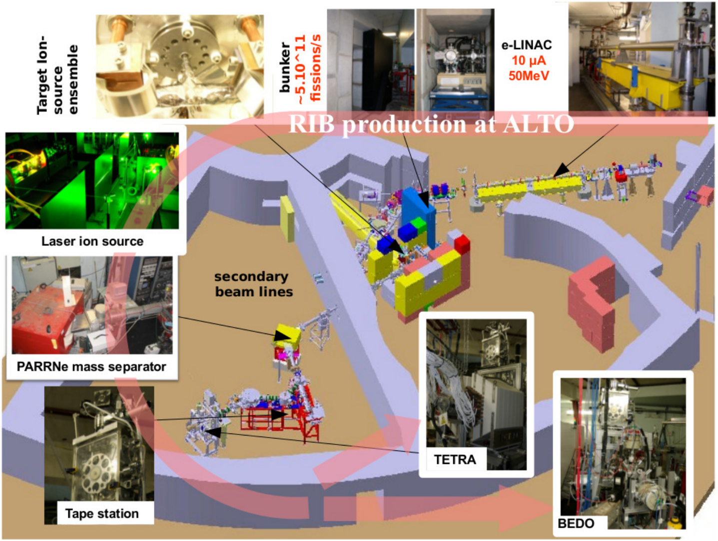
On behalf of the ALTO teams and IN2P3-JINR collaboration

SPES one-day workshops Beta decay Physics and other opportunities with non re-accelerated beams at SPES, Milano, April 2015

Beta decay of neutron rich nuclei



ALTO ISOL facility

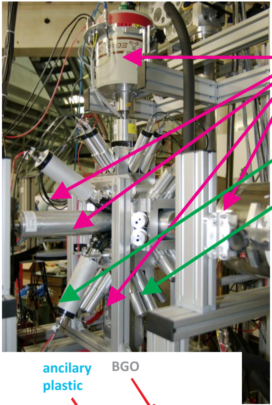


The Alto photofission facility at IPN Orsay, S. Franchoo

Beta-decay experimental setup at ALTO

BEDO setup in gamma mode

4 small EXOGAM clovers

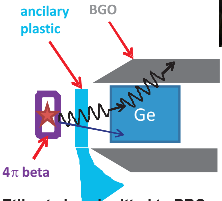


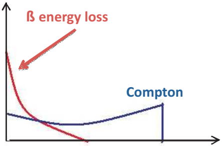
up to 5 Ge detectors

6plastic detectors

Anti-Compton belt

4 EXOGAM small prototypes
Source-cap distance = 5 cm
measured efficiency (1MeV) = 5-6 %





A. Etile et al., submitted to PRC

BEDO setup in neutron mode

Neutron array TETRA

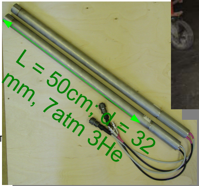
80 counters 3He
(efficiency 52% measured using 252Cf source)

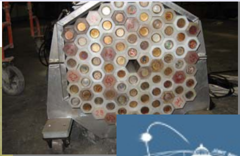
D. Testov et al., submitted to NIMA

TETRA neutron detector

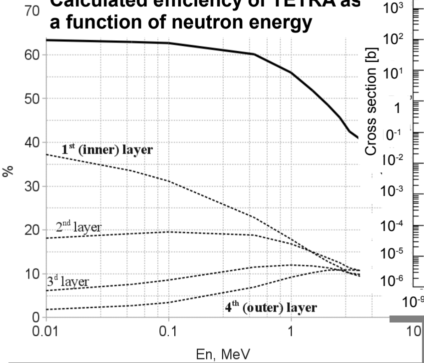
- Zero energy threshold
- Zero cross-talk(multiplicity)
- Perfect gamma separation
- Easy in use/ geometry
- High efficiency
- Low internal background

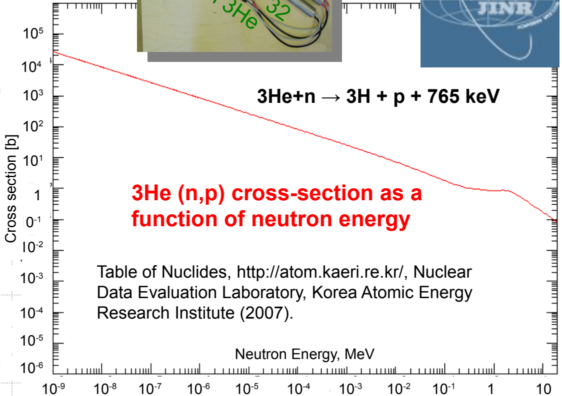
^{3}He 7 atm x 80 counters





Calculated efficiency of TETRA as a function of neutron energy



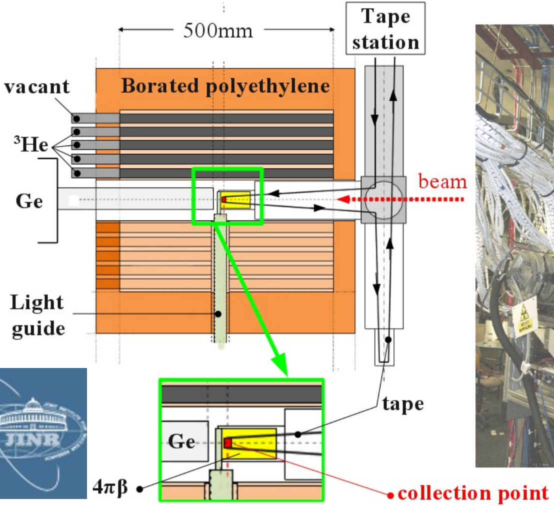


3He (n,p) cross-section as a function of neutron energy

Table of Nuclides, http://atom.kaeri.re.kr/, Nuclear Data Evaluation Laboratory, Korea Atomic Energy Research Institute (2007).

D. Testov et al., Physics of Atomic Nuclei 72, 1 (2009)

Beta-decay experimental setup at ALTO: neutron mode



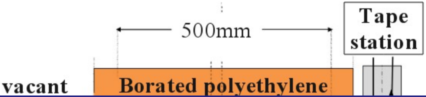
ε (gamma) ≈0.8% (1 MeV)
ε (beta) ≈60%

D. Testov et al., World Sci., Conf. Proc. 47, 365 (2013)

JINR

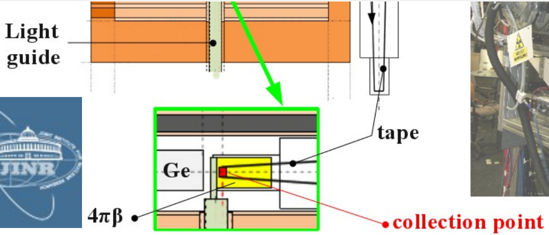
IPN
INSTITUT DE PHYSIQUE NUCLÉAIRE
ORSAY

Beta-decay experimental setup at ALTO: neutron mode



Experimental observables:

- Parameters of β-decay $T_{1/2}$, P_n, P_{xn}, I_β
- Spectroscopy-tagging: β-neutron gated γ-spectra
- Advantage: High efficiency of neutron detection
  Performance using A-, Z- separated beams / only A-separated

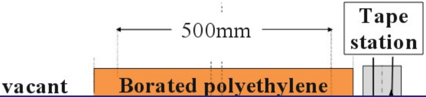


ε (gamma) ≈0.8% (1 MeV)
ε (beta) ≈60%

INSTITUT DE PHYSIQUE NUCLÉAIRE
ORSAY

D. Testov et al., World Sci., Conf. Proc. 47, 365 (2013)

Beta-decay experimental setup at ALTO: neutron mode

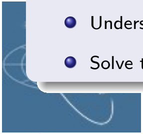


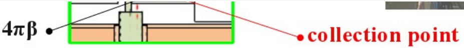
Experimental observables:

- Parameters of β-decay $T_{1/2}$, P_n, P_{xn}, I_β
- Spectroscopy-tagging: β-neutron gated γ-spectra
- Advantage: High efficiency of neutron detection
  Performance using A-, Z- separated beams / only A-separated

Main theoretical challenges:

- Construct the universal spin-dependent nuclear density functional
- Understand the forbidden decays in nuclei above the neutron shell closures
- Solve the problem of the short r-process time-scale



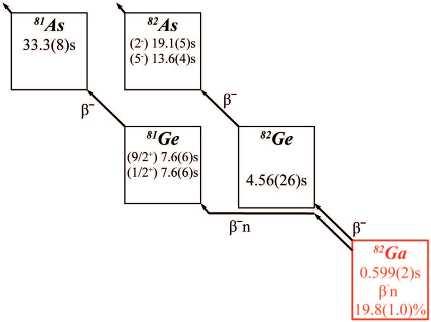


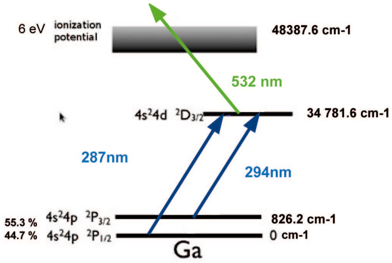
ε (gamma) ≈0.8% (1 MeV)
ε (beta) ≈60%

INSTITUT DE PHYSIQUE NUCLÉAIRE ORSAY

D. Testov et al., World Sci., Conf. Proc. 47, 365 (2013)

Experiments on the laser-ionized beams

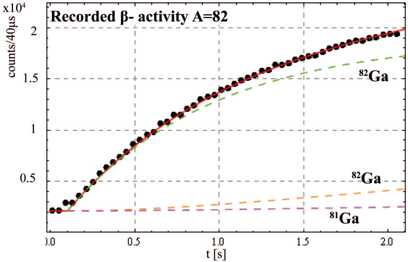


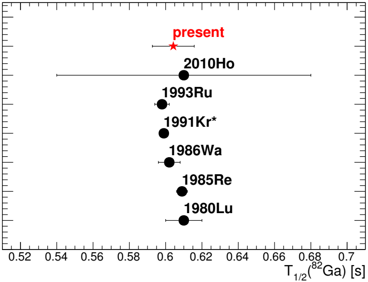


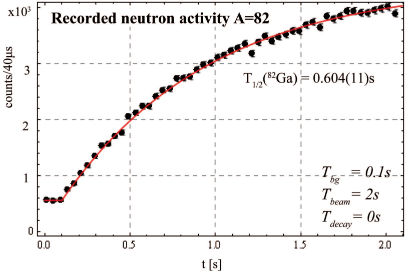
287nm (250mW)	294nm (130mW)	532nm (~10W)	Impact factor
off	off	off	1
√	off	√	2
off	√	√	4.4
√	√	√	6.1

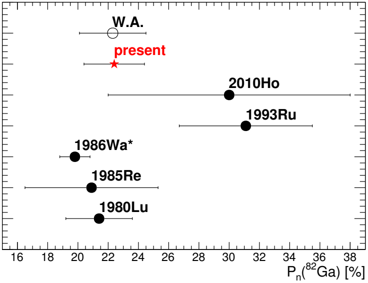
The Alto photofission facility at IPN Orsay, S. Franchoo

Direct β-delayed neutron emission measurements of ^{82}Ga



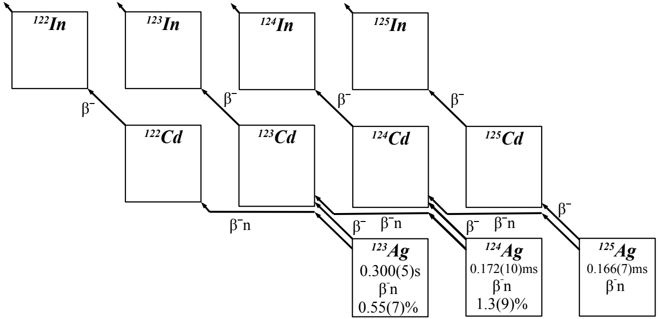




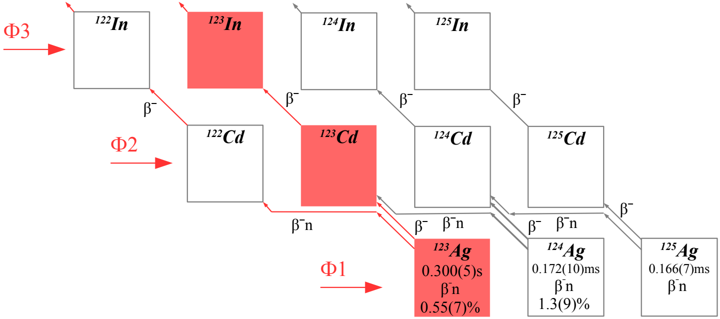


Spectroscopic studies via delayed-neutrons tagging

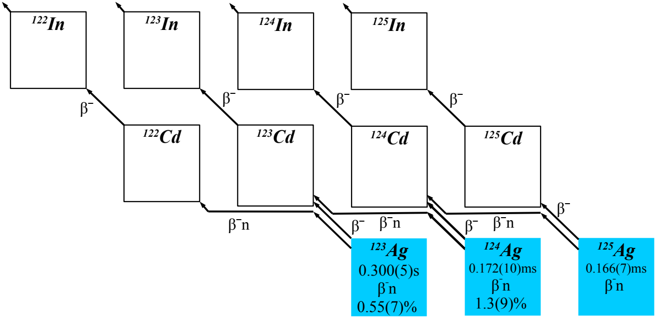
Experiments on the mass-separated beams



Experiments on the mass-separated beams

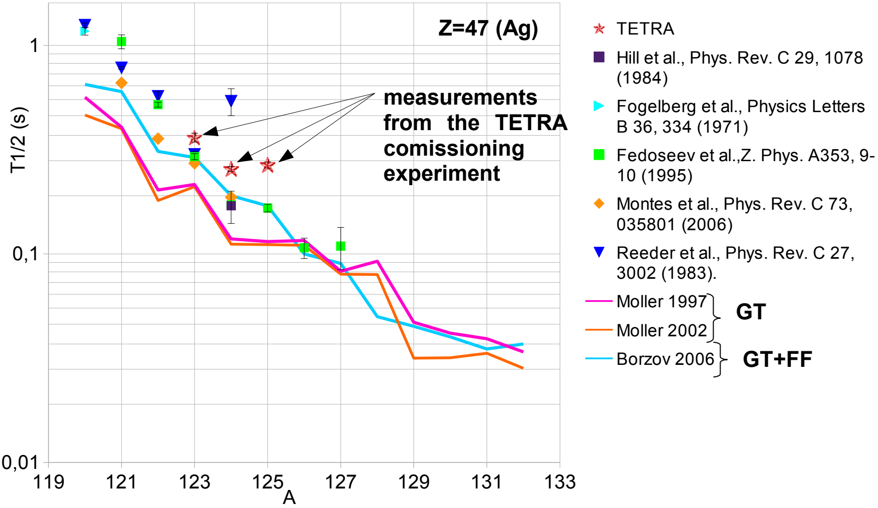


Experiments on the mass-separated beams



$T_{1/2}$ of neutron rich $^{123-125}$Ag

Half-lives of for Ag isotopes



Measured γ-spectrum ^{123}Ag

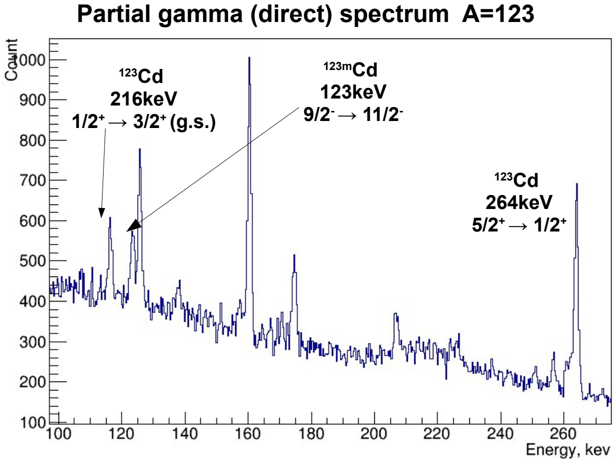
$$P_n = \frac{N_{neutron}}{N^{tot}\varepsilon_n}$$

P$_n$ - probability of β-delayed neutron emission;

N$_{neutron}$ - number of detected neutrons;

ε_n - neutron efficiency;

N^{tot} - total number of decays of the precursors;



Measured γ-spectrum ^{123}Ag

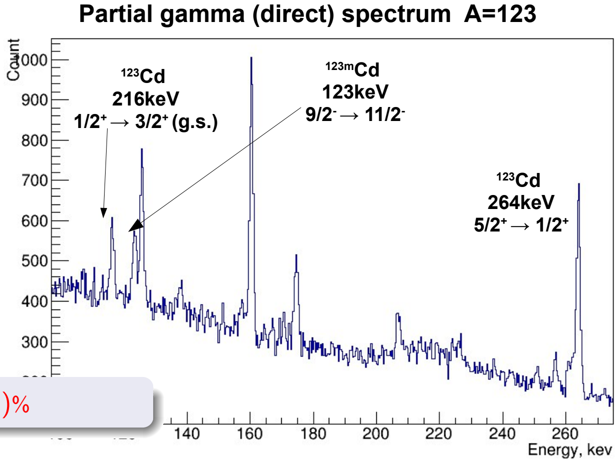
$$P_n = \frac{N_{neutron}}{N^{tot}\varepsilon_n}$$

P$_n$ - probability of β-delayed neutron emission;

N$_{neutron}$ - number of detected neutrons;

ε_n - neutron efficiency;

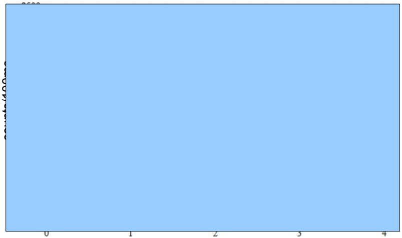
N^{tot} - total number of decays of the precursors;

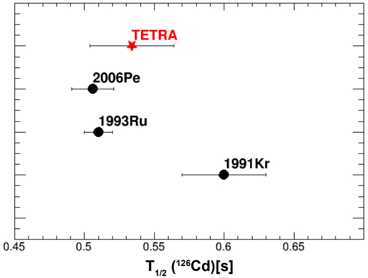


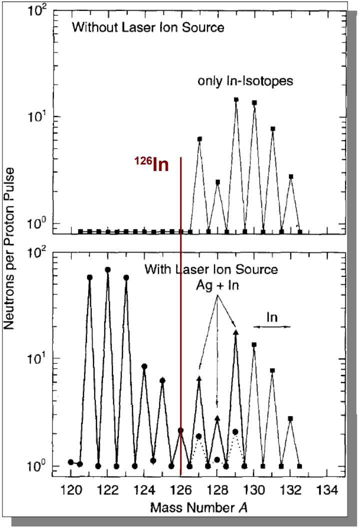
$P_n(^{123}Ag) = 0.60(25)\%$

First neutron precursor on Cd isotopic chain

Neutron activity curve A = 126

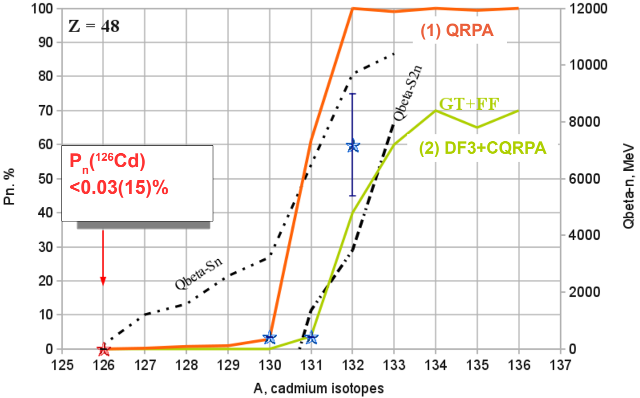






V. Fedoseyev et al., Z. Phys. A 353, 9 (1995)

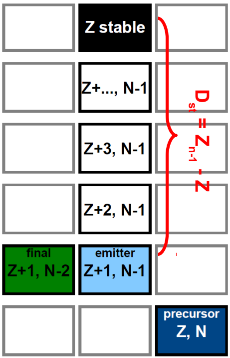
First neutron precursor on Cd isotopic chain

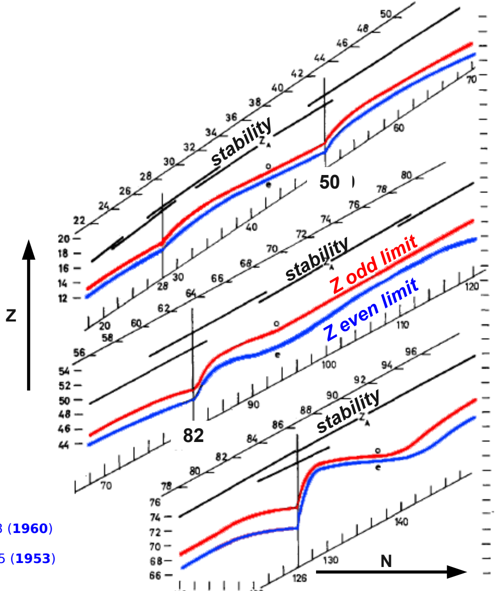


(1) QRPA P. MOLLER, J. NIX, and K.-L. KRATZ, ADNDT 66, 131 (1997)
(2) DF3+cQRPA I. N. Borzov, Phys. Rev. C 71, 065801 (2005)

Upper limit for nuclei showing of characteristics delayed neutron precursors

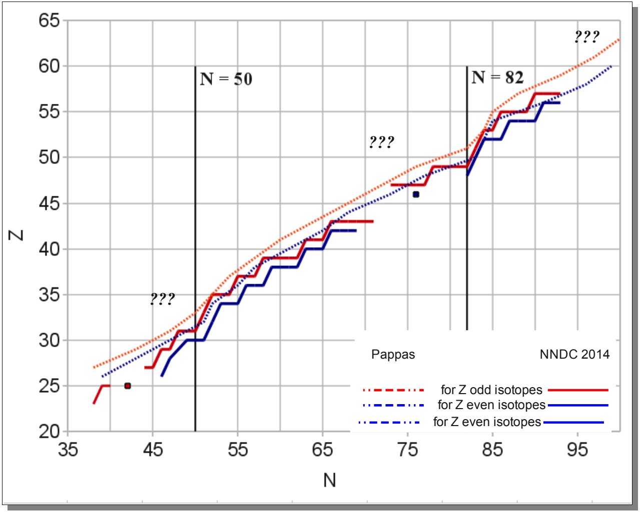
Upper Z limit for nuclei showing caratreristics of delayed neutron precursors





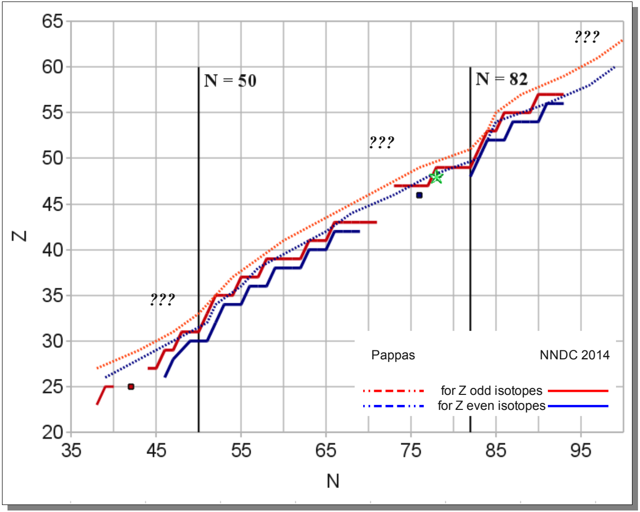
A. C. Pappas and G. Rudstam, Nuclear Physics 21, 353 (**1960**)
Mass estimations:
C. D. Coryell, Annual Review of Nuclear Science 2, 305 (**1953**)

Upper limit for nuclei showing of characteristics delayed neutron precursors



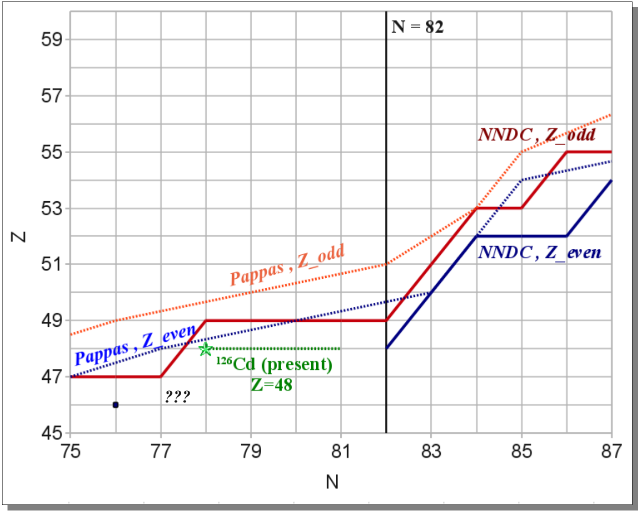
A. C. Pappas and G. Rudstam, Nucl. Phys. 21, 353 (1960)

Upper limit for nuclei showing of characteristics delayed neutron precursors



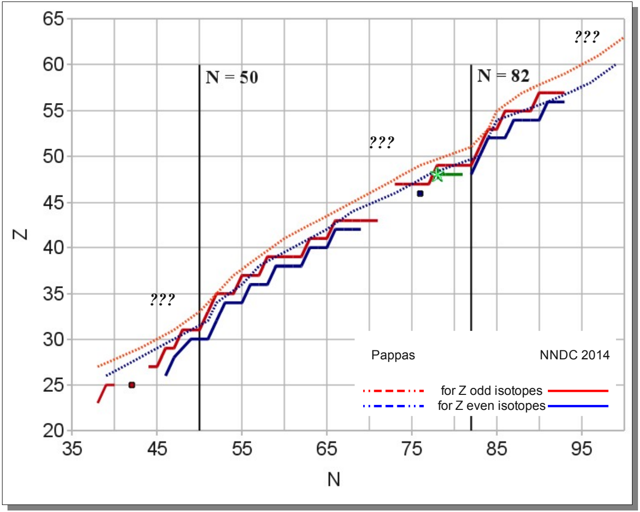
A. C. Pappas and G. Rudstam, Nucl. Phys. 21, 353 (1960)

Upper limit for nuclei showing of characteristics delayed neutron precursors



A. C. Pappas and G. Rudstam, Nucl. Phys. 21, 353 (1960)

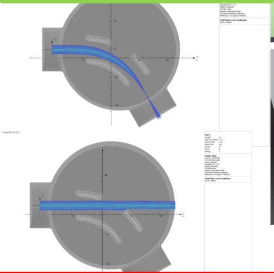
Upper limit for nuclei showing of characteristics delayed neutron precursors



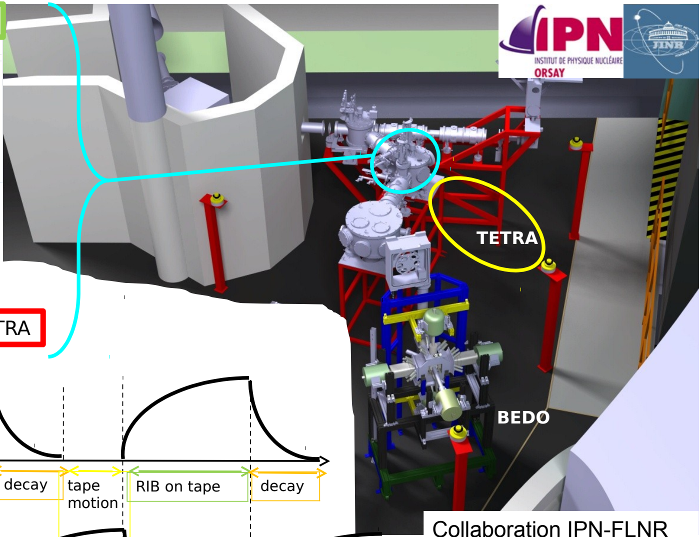
A. C. Pappas and G. Rudstam, Nucl. Phys. 21, 353 (1960)

TETRA and BEDO in sequential mode

dipole ON -> towards BEDO

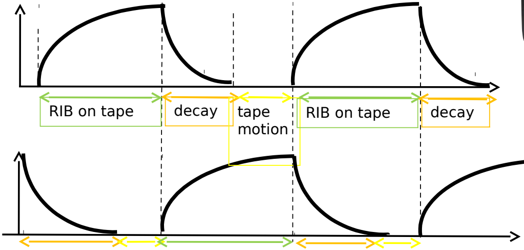


dipole OFF -> towards TETRA



BEDO

TETRA



Collaboration IPN-FLNR Orsay-Dubna

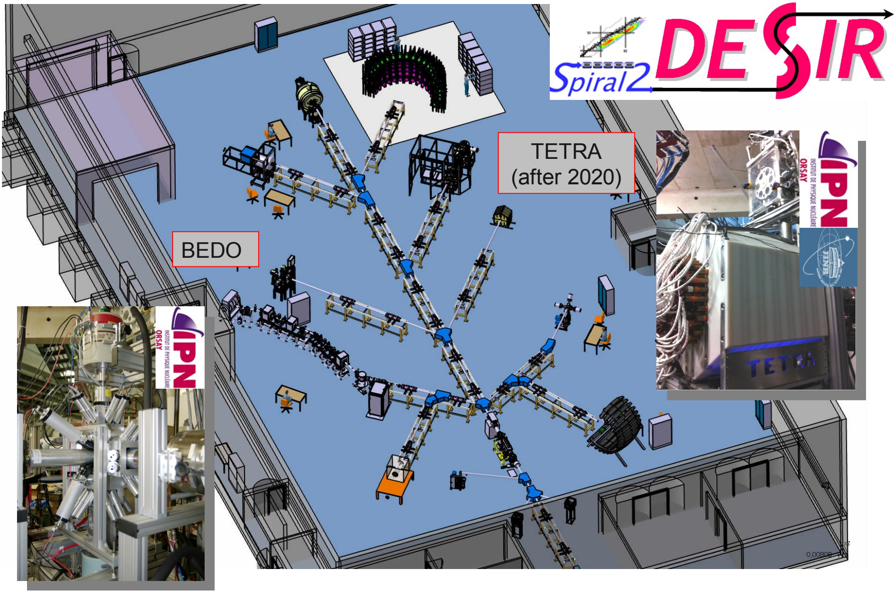
Expected on line October'15

The main objectives

BEDO: neutron mode

- Direct measurements of P_n, P_{nx}; measurements of $T_{1/2}$ be neutron activity
- Possibility to work on high-purity beams as well as on mass-separated beams
- Neutron tagging as a purification method for spectroscopy; I_β-values, logft

BEDO&TETRA is a part of DESIR (SPIRAL-2) project



Grazie per l'attenzione