

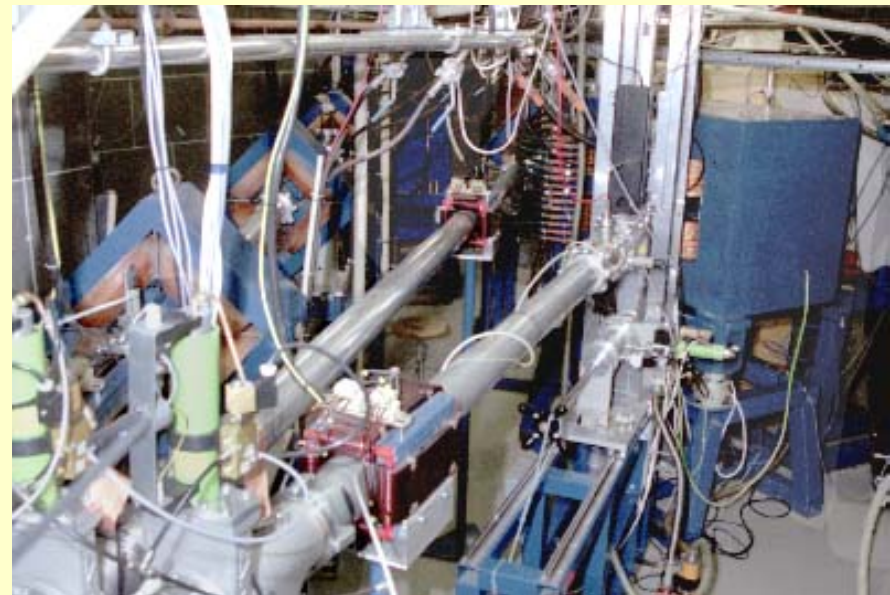
**Workshop on modern methods using fast neutrons for research related to the transmutation of nuclear waste (EFNUDAT workshop).**

**Cross-section measurements proposed by NPI for TSL in Uppsala**

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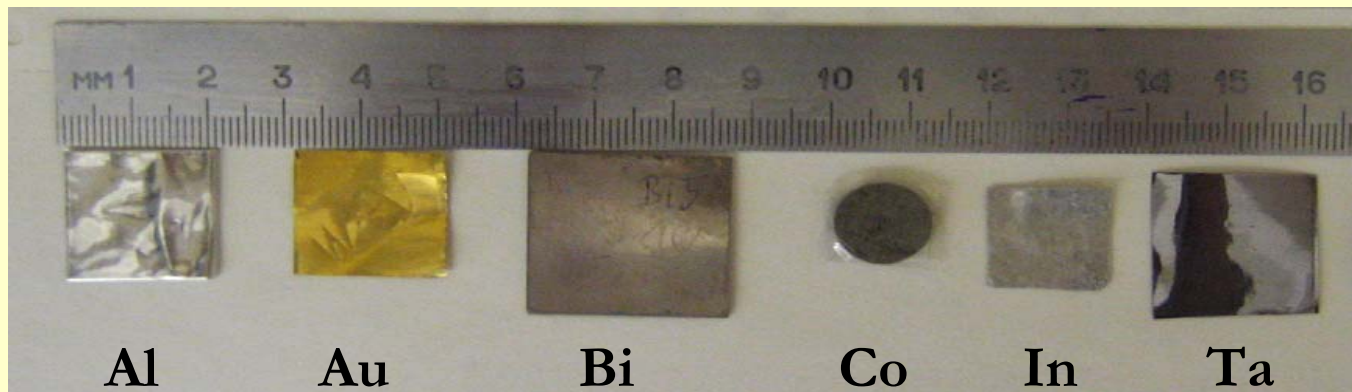
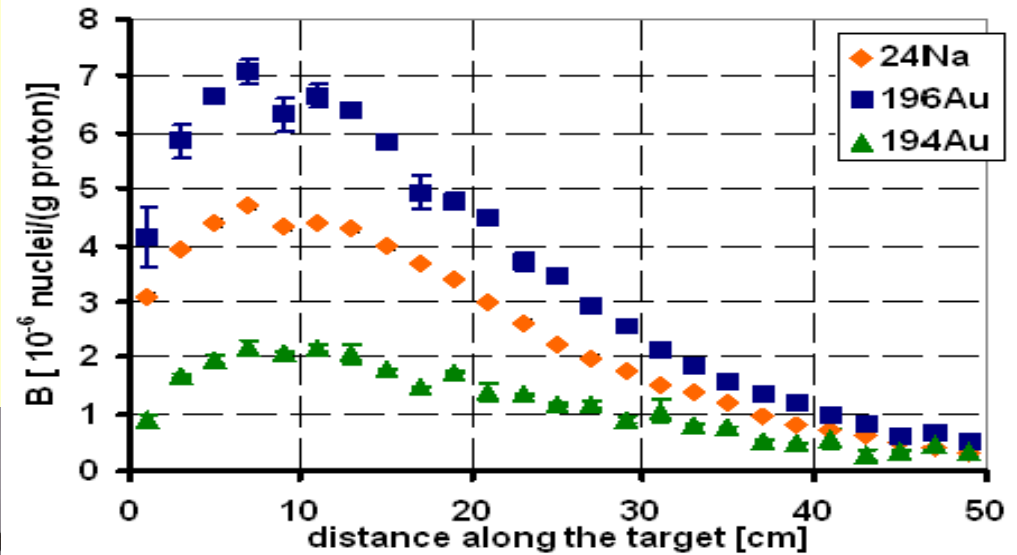
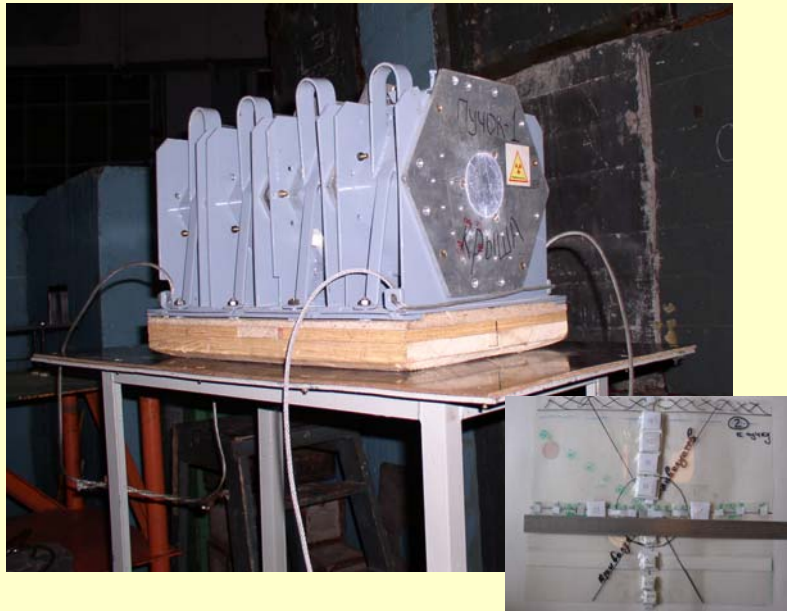
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**for EFNUDAT project**



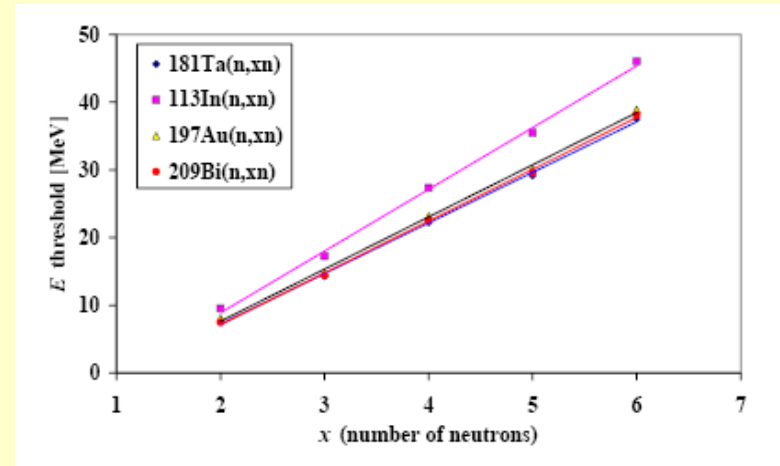
## Why this proposal?

Activation detectors are commonly used for neutron measurements.  
Cross-section data are missing for higher threshold reactions used for measurement of higher energy neutrons (20 – 100 MeV)



Integral neutron production – very good description by simulations (models)

Hard part of neutron spectra and spatial distributions – very sensitive and different for different models



Threshold reactions – test of hard part of neutron spectra

## Neutron beam facility at The Swedberg Laboratory Uppsala

Quasi-monoenergetic neutron source based on  ${}^7\text{Li}(p,n){}^7\text{Be}$  reaction

Neutron energies:  $E_n = 11 - 174$  MeV,  
Standard energies  $E_n = 11, 22, 47, 95, 143, 174$  MeV

Used method: again activation measurements

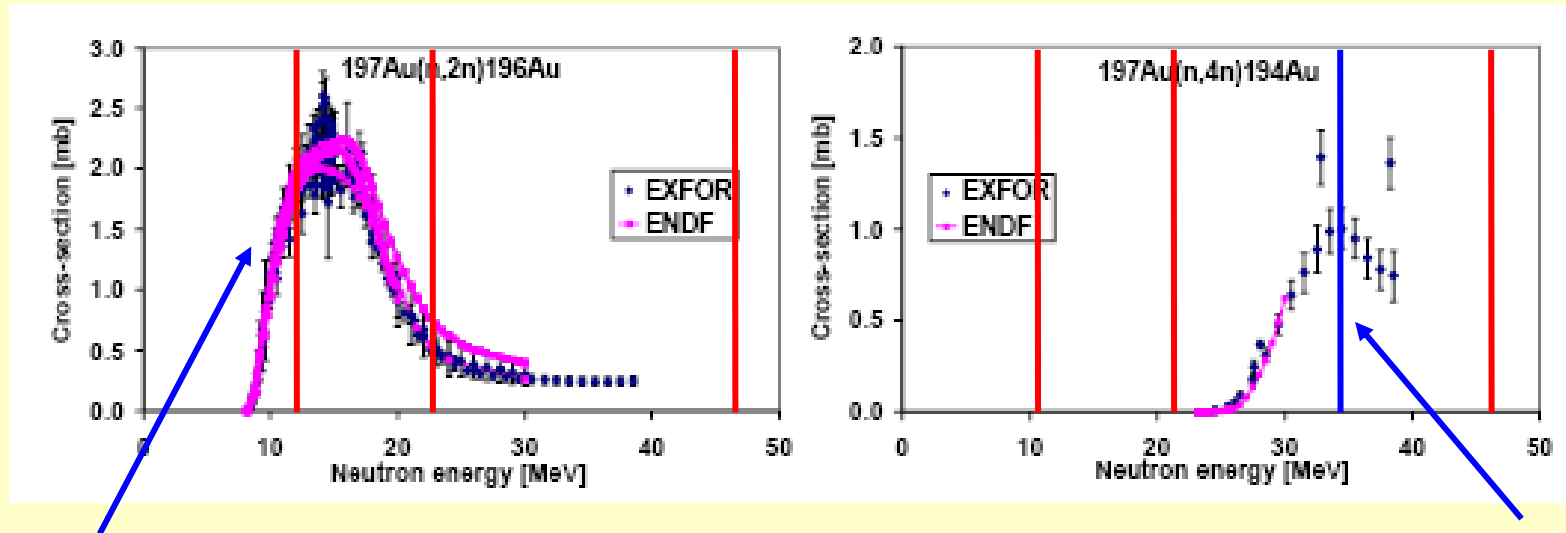
We use activation foils: Al (standard), Au, Bi, In, and Ta  
2x2 cm, 1 mm thickness

Neutron flux densities:  $5 \cdot 10^5 \text{ cm}^{-2}\text{s}^{-1}$   
for activation measurement near to necessary limit

50 % of neutrons at peak, 50 % at continuum



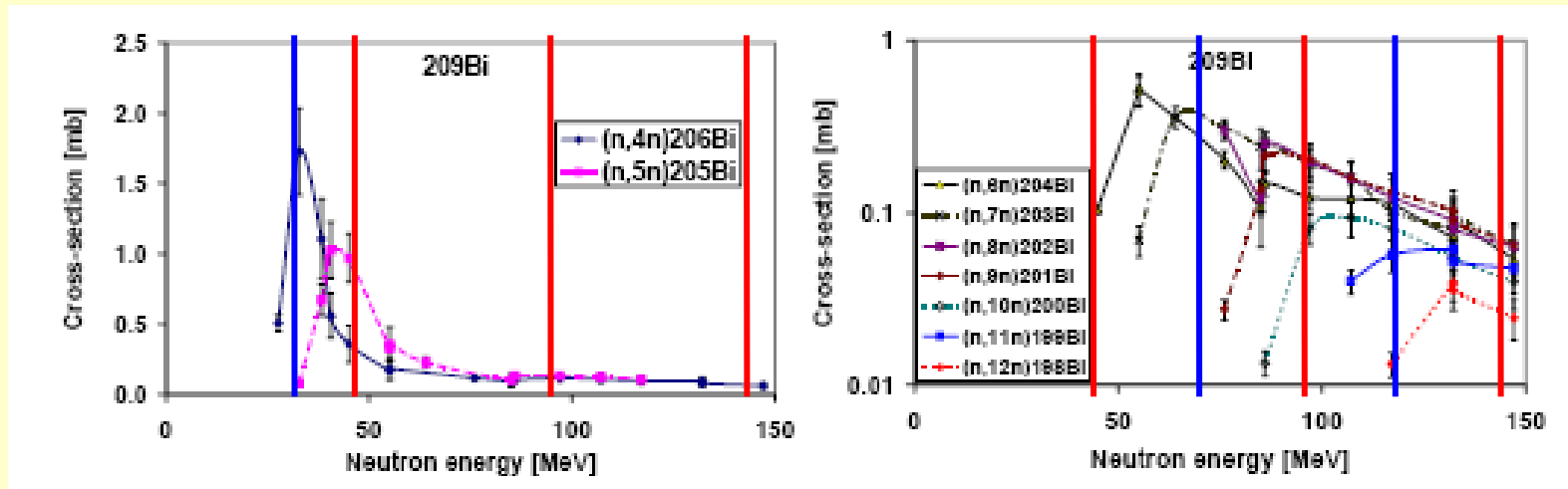
## Gold foils and $^{197}\text{Au}(n,xn)$



Standard point ? small intensity?

Standard point ??

## Bismut foils and $^{209}\text{Bi}(n,xn)$



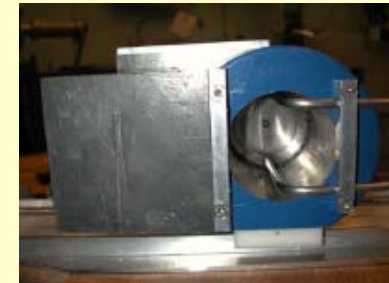
We will use gamma detectors of TSL (dr. Torbjörn Hartman). Maybe will be necessary to determine efficiency curve for nearer position of measured samples. Used 44 cm, we need 5 – 10 cm.

Question of other energies than usual?

Finite number of irradiations: 3      8 hours irradiation per energy

Number of irradiations: three energies, which are the best 22, 47, 95 MeV (maybe 143)

Fight with beam intensity, - 11 MeV so small

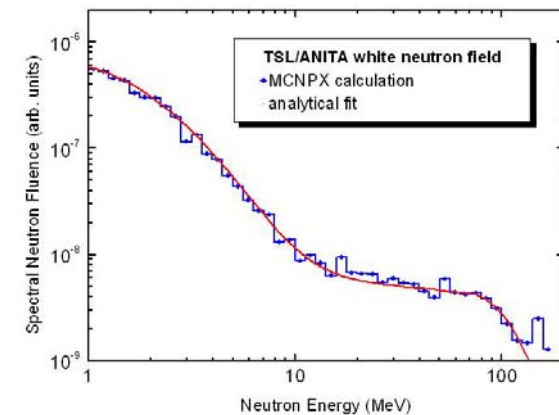


**Possible using of ANITA (Atmospheric-like Neutrons from thick Target)**

White spallation source based on thick Pb target

Neutron flux densities:  $\sim 10^6 \text{ cm}^{-2}\text{s}^{-1}$

Nice test of decomposition of neutron spectra using threshold reactions and help to determine spectrum



## Conclusions and outlooks

- Activation detectors are commonly used, they are small and flexible. We use Al, Au, Bi, In and Ta during our experiments with lead target and uranium blanket at JINR Dubna. High sensitivity of threshold reactions to hard part of neutron spectra and to model differences
- Cross-section data for (n, xn) reactions with higher x are very scarce.
- The quasi-monoenergetic neutron beam at TSL Uppsala is useful device for cross-section measurements.
- We want to measure Al (as standard), Au, Bi, In and Ta.
- The possibility to use also white source ANITA for test of source and decomposition methods
- The April term of proposal for Uppsala beam committee.
- We will use Uppsala HPGe detectors, efficiency of detector for nearer source position will be necessary to measure
- It is necessary compromise between possible and the ideal used beam energy.  $E_n = 22, 47 \text{ and } 95 \text{ MeV}$