A SUMMARY OF EXPERIMENTAL RESULTS ON THE REACTIONS IN URANIUM SAMPLES IRRADIATED WITH A DEUTERON BEAM OF ENERGIES UP TO 8 GeV AT THE QUINTA TARGET

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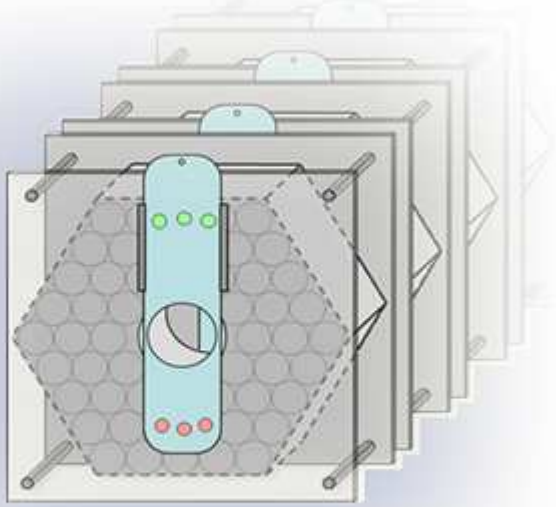


Objectives of this presentation

- Introduce our work
- Present results of experiments in 2011-2012 (E_d = 1, 2, 4, 6, 8 GeV)

The aims of our work

- Find products of the reactions in U samples (natural abundance, ^{235}U)
- Determine the rates of production of these isotopes
- Assess the main type of reaction
- Comparison of experimental results and MCNPX 2.7 calculation (if done)

How can we do that

- Activation measurement technique
- Gamma spectroscopy with the use of HPGe detectors Canberra and ORTEC (20%, resp. 30% relative efficiency) Calibrated with standards made in 2011

Isotope identification

- **Half-life**
  (at least 10 measurements)
- **Energy and intensity of gamma line**

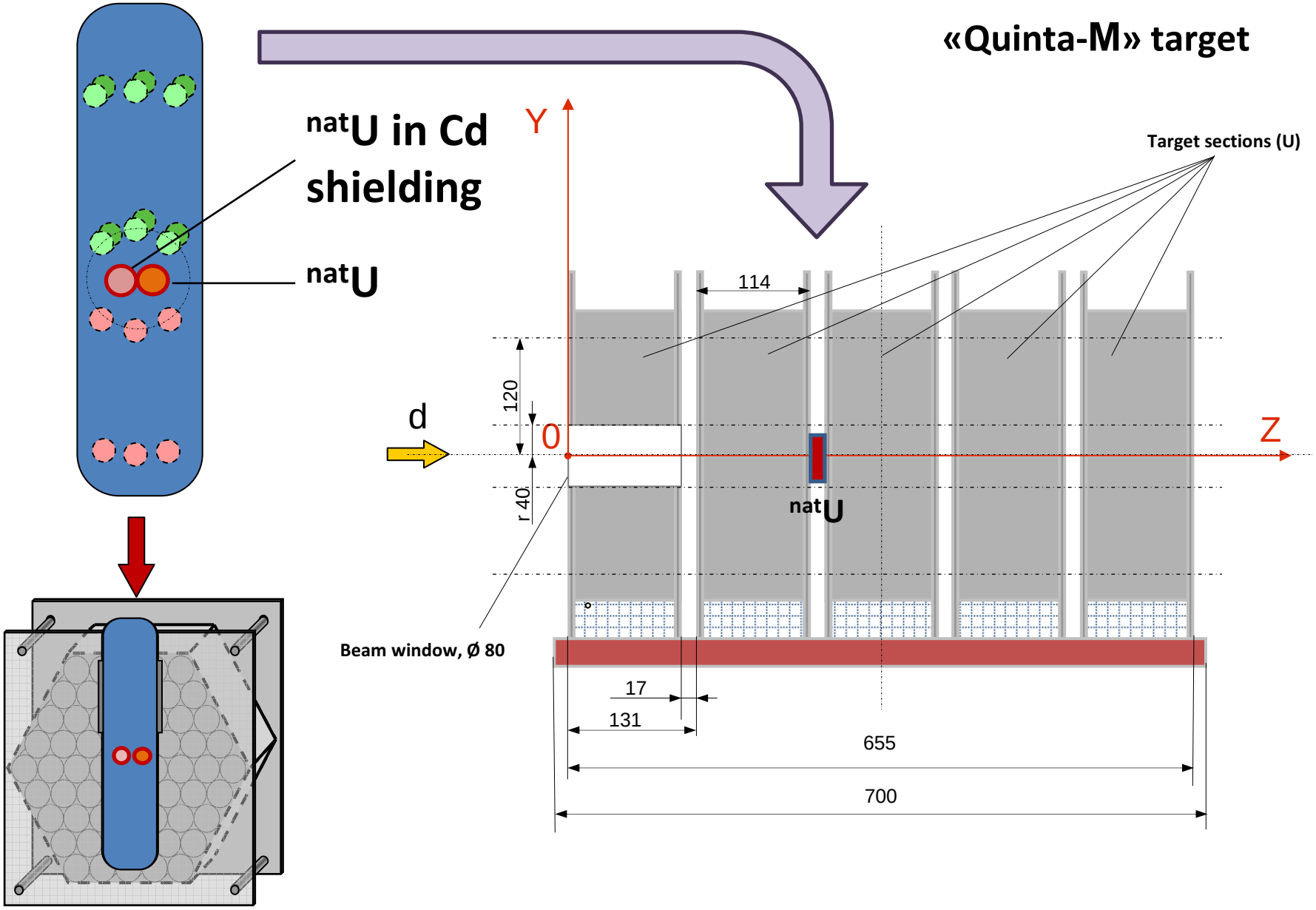
- **Reaction rates calculated**
  from measured activity

Isotope identification

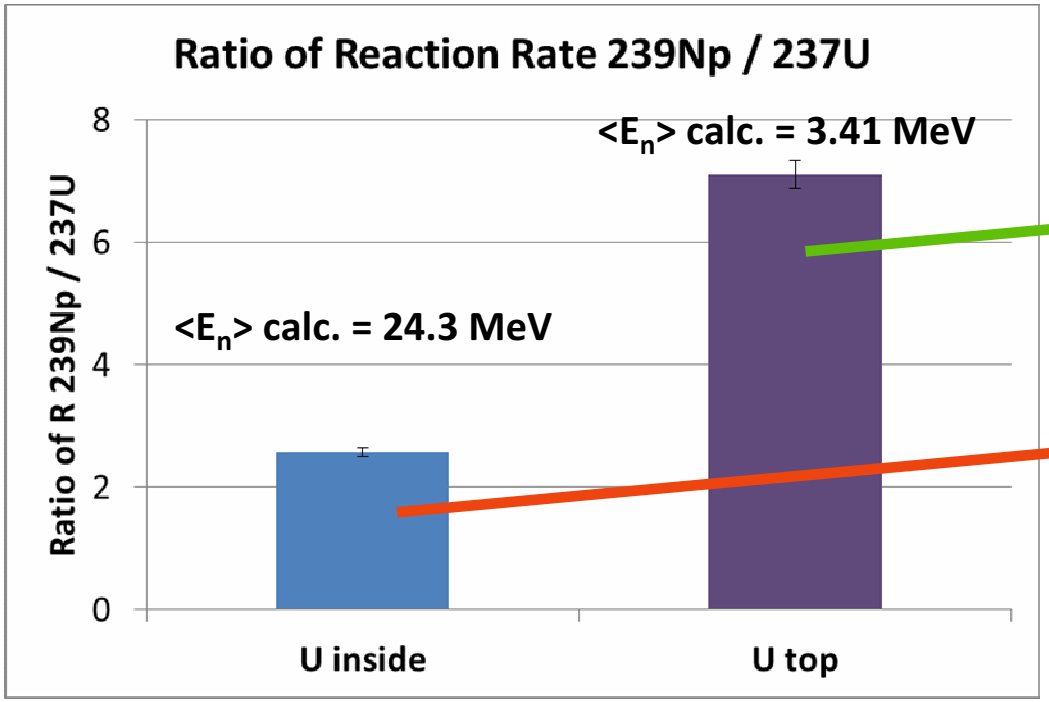
- More than 100 residual nuclei identified in extensive spectra
- Included corrections:

  decay during irradiation, cooling and measurement, dead time, detector efficiency, nonlinearity, beam instability gamma line intensity, self-absorption

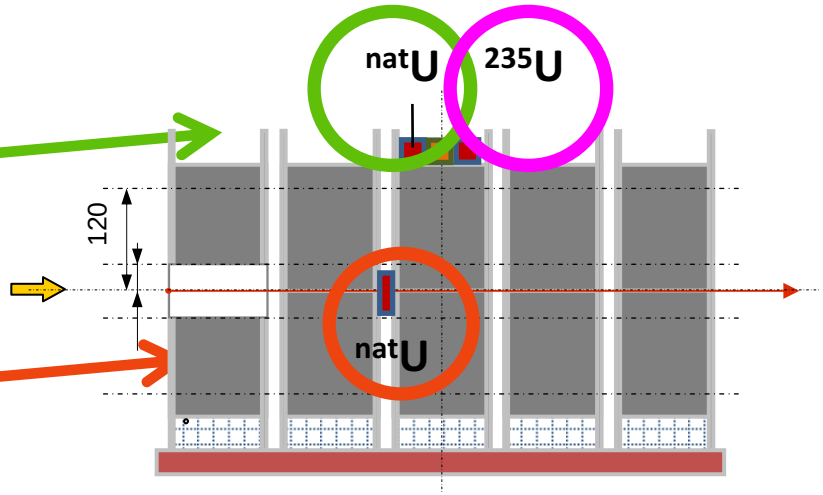
Location of samples



Location of samples 6 GeV experiment



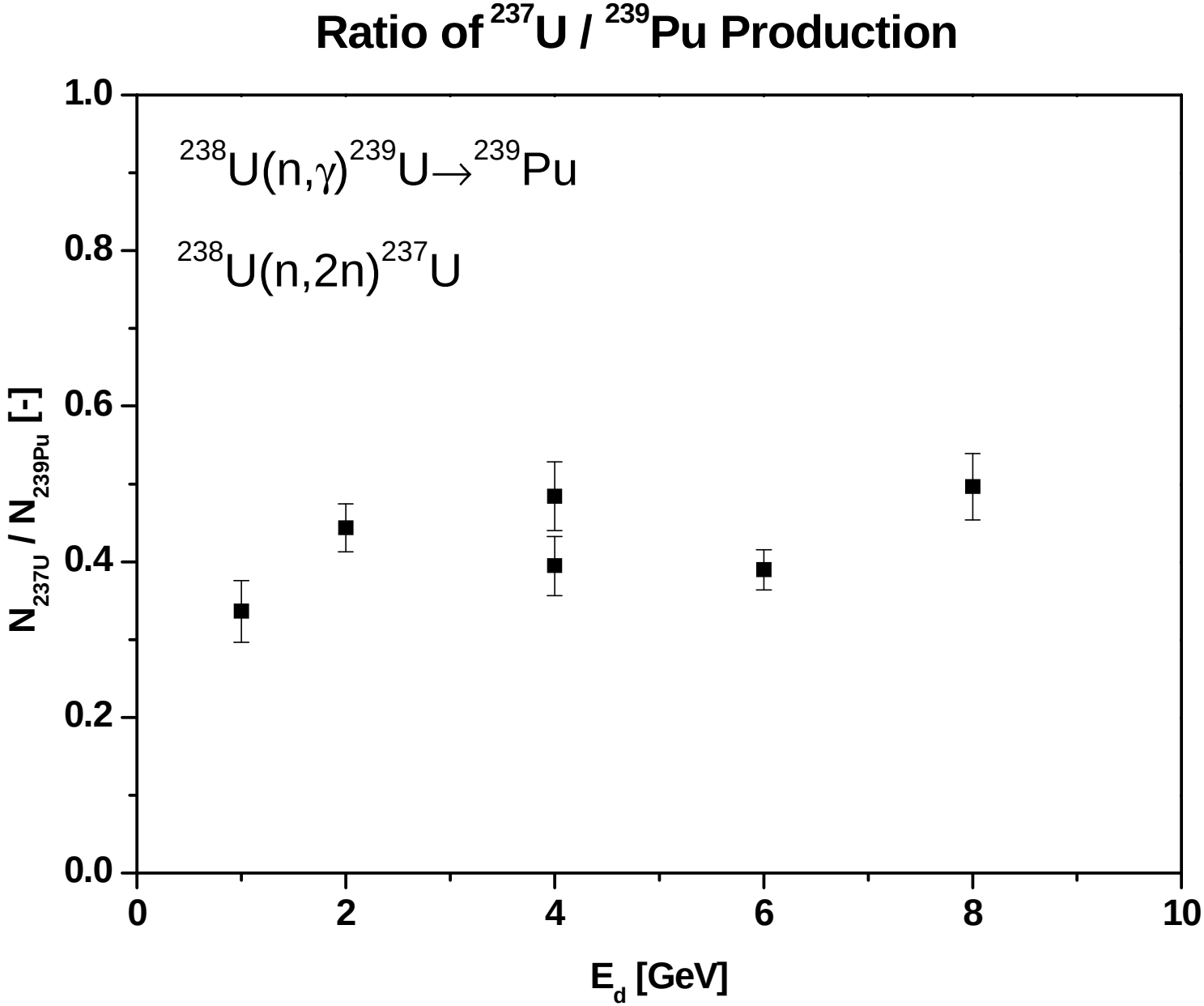
Fission $^{235}U/^{238}U$: 7.1(5)



$^{238}U(n, \gamma)^{239}U \xrightarrow[\beta^-]{T_{1/2} = 23.5\ min} {}^{239}Np \xrightarrow[\beta^-]{T_{1/2} = 2.3\ d} {}^{239}Pu$ non E_{thr}

$^{238}U(n,2n)^{237}U$ $E_{thr} = 6.2$ MeV

All energies: U samples inside



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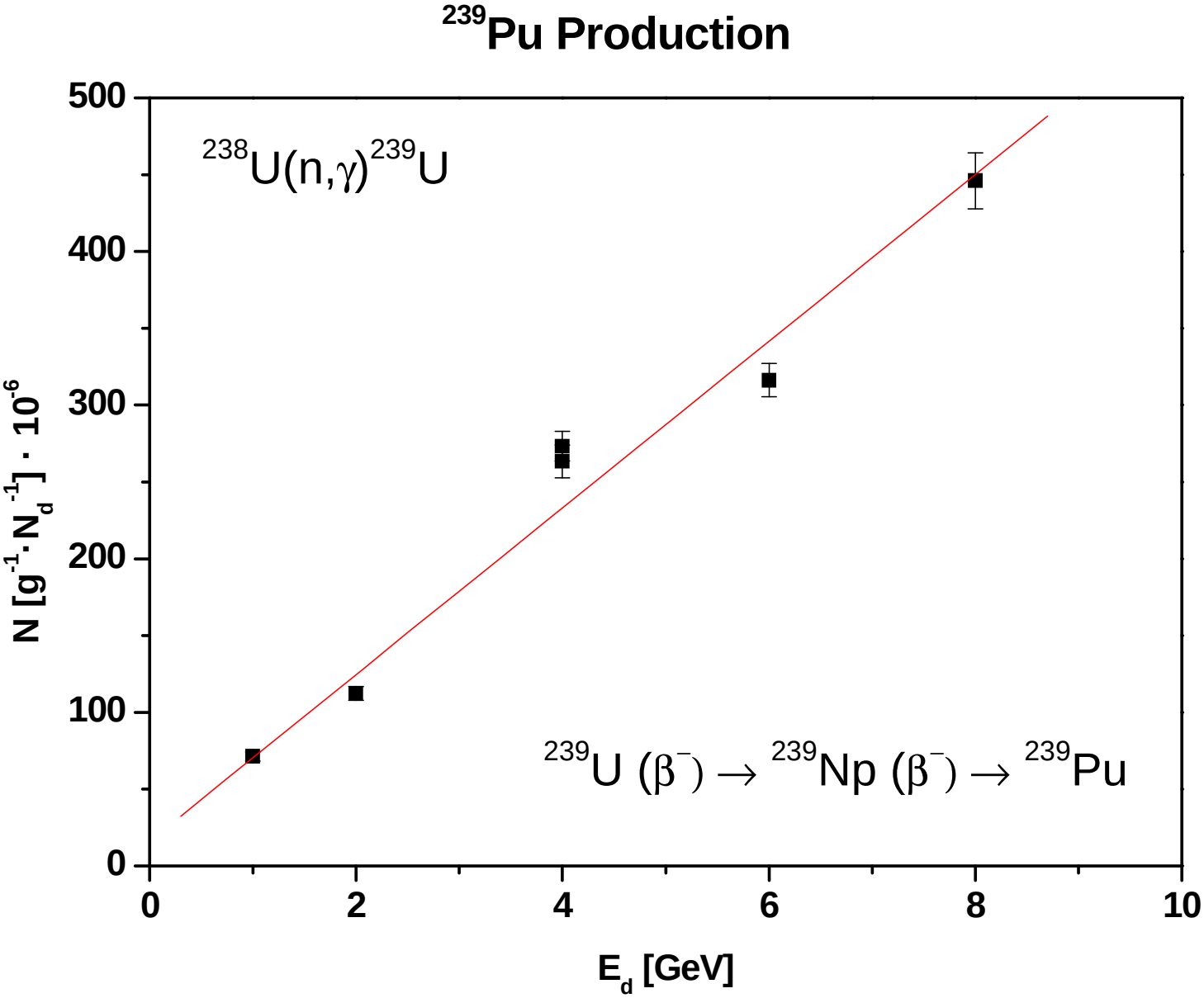
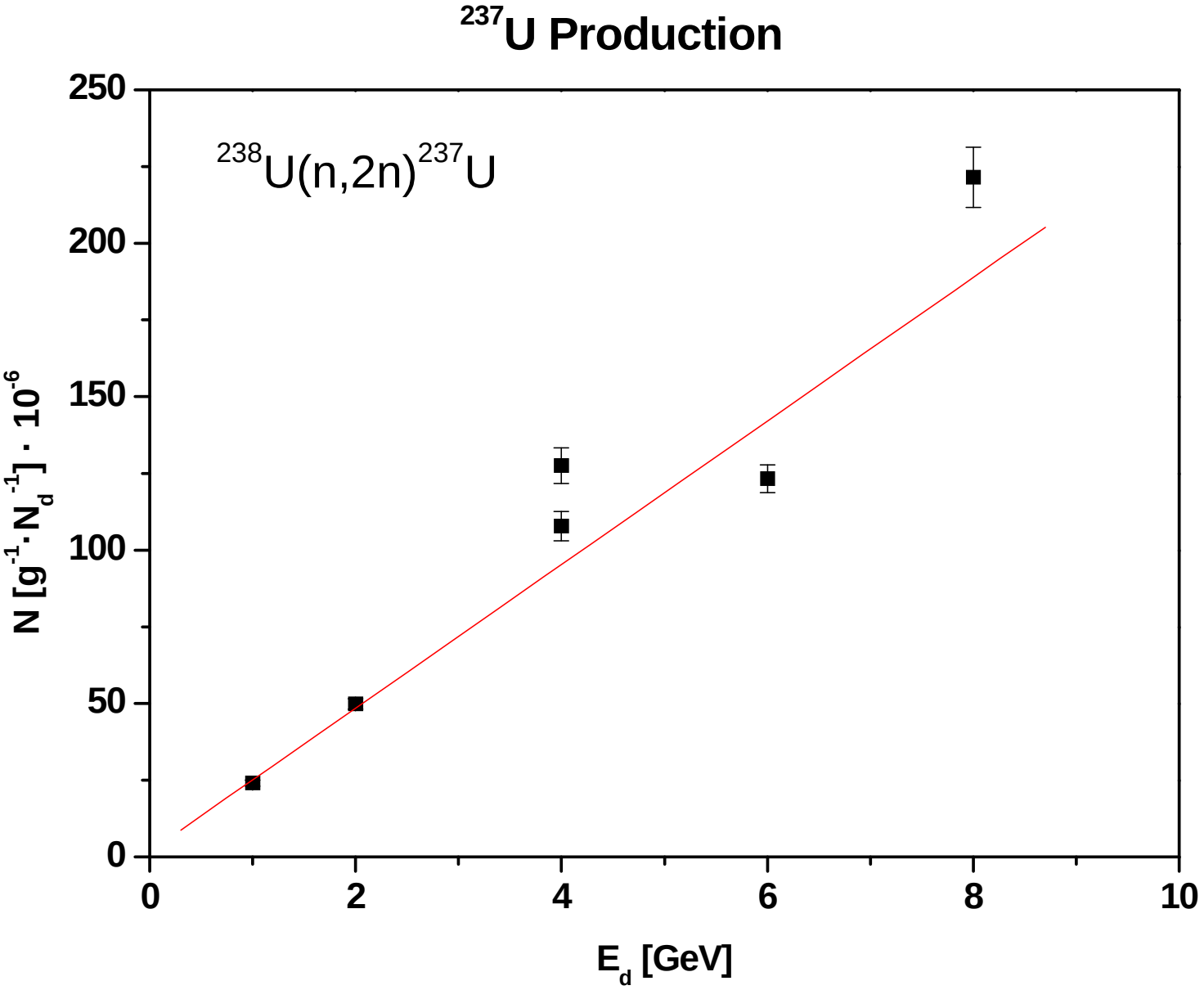
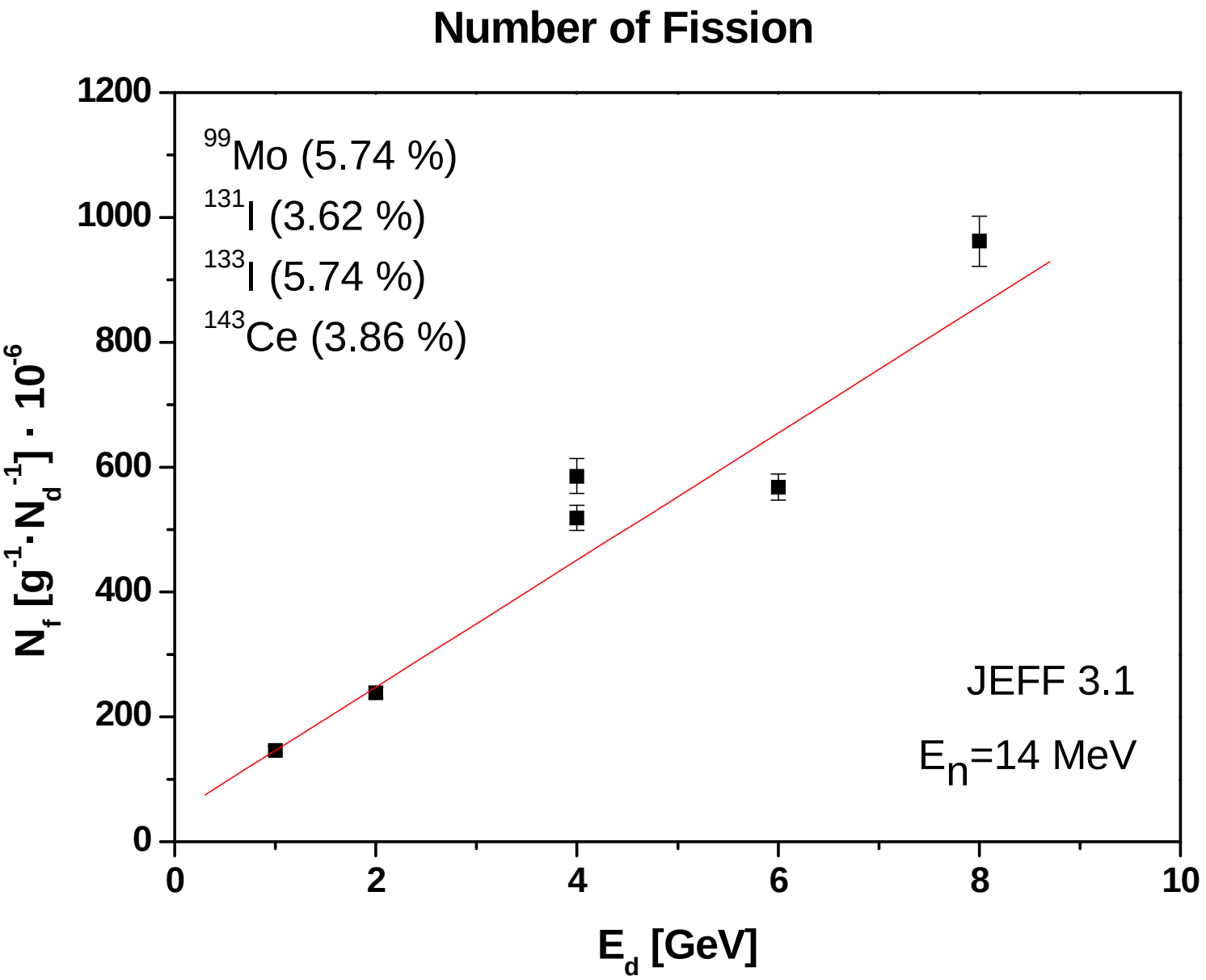


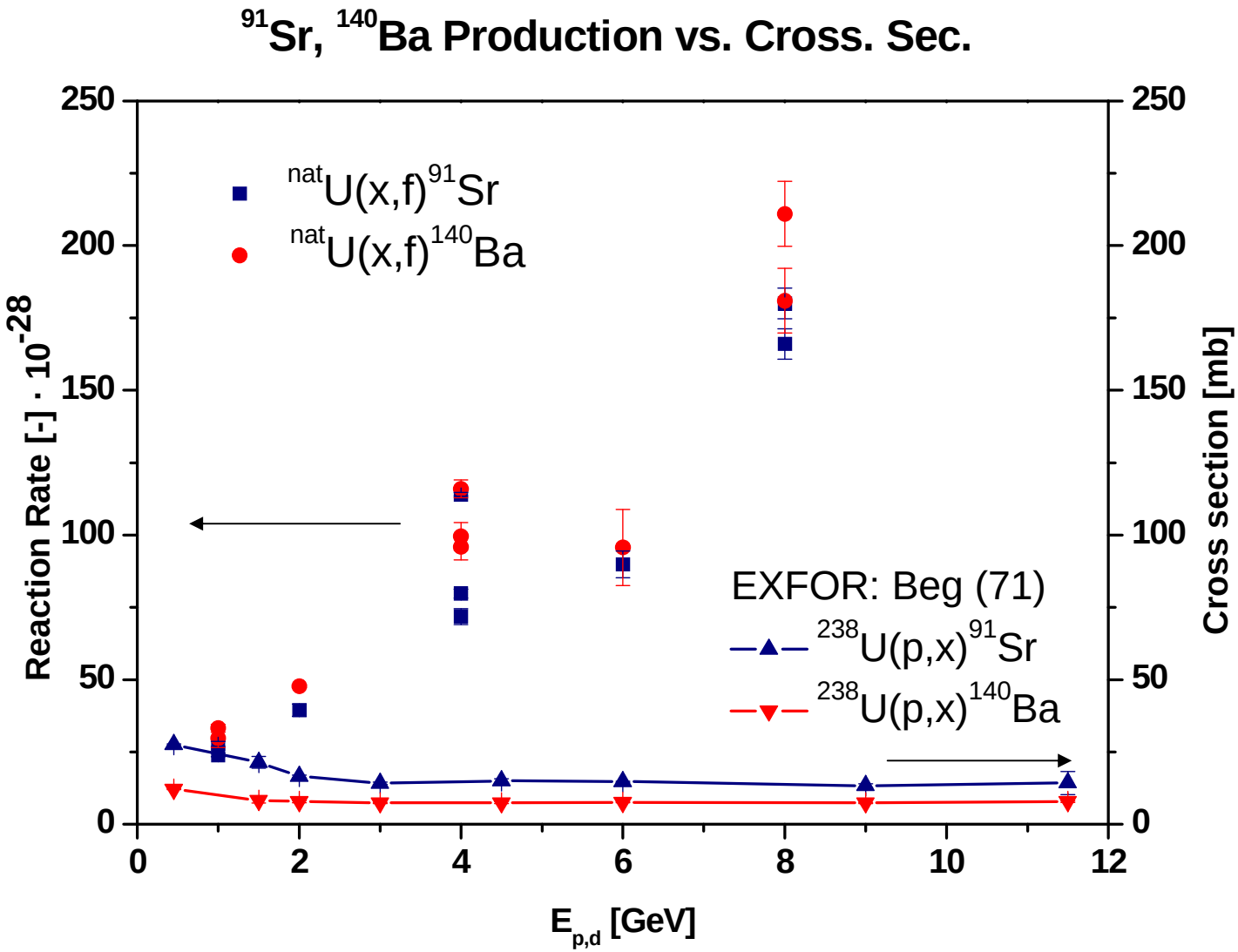
All energies: U samples inside

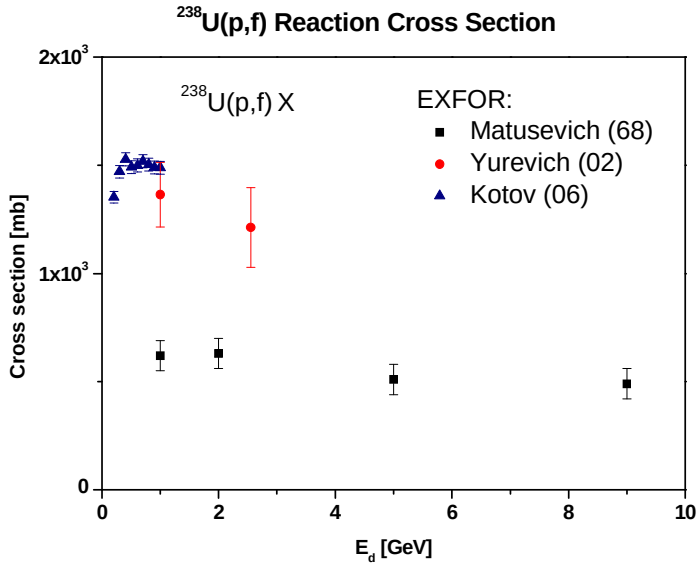


U samples inside: fission



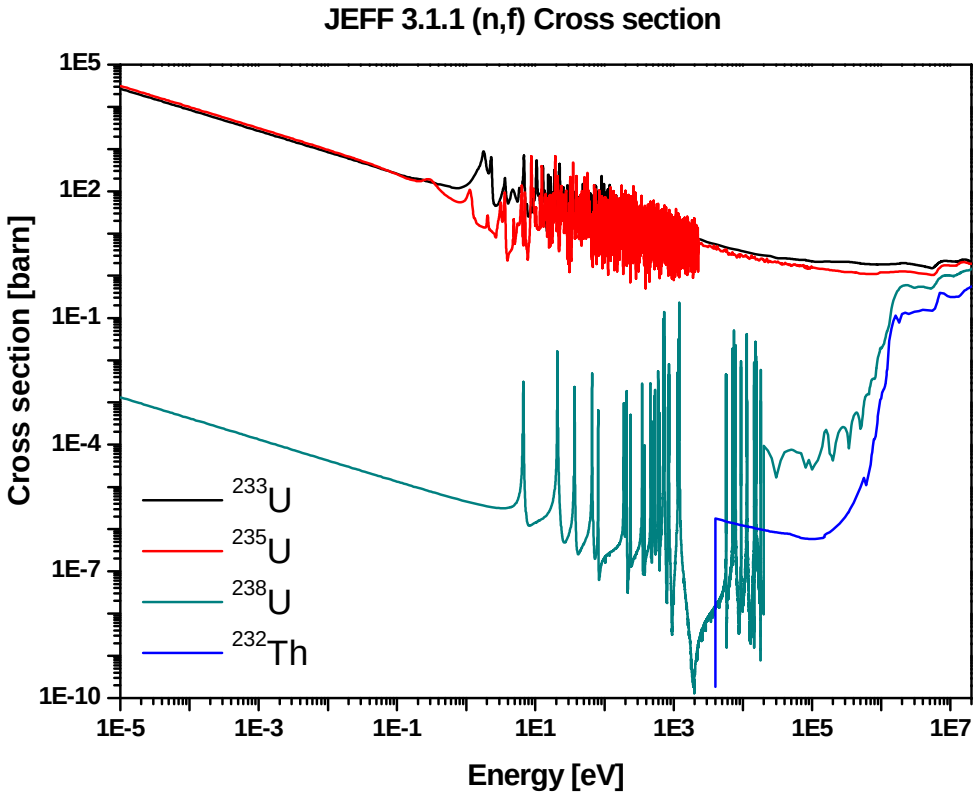
U samples inside: fission



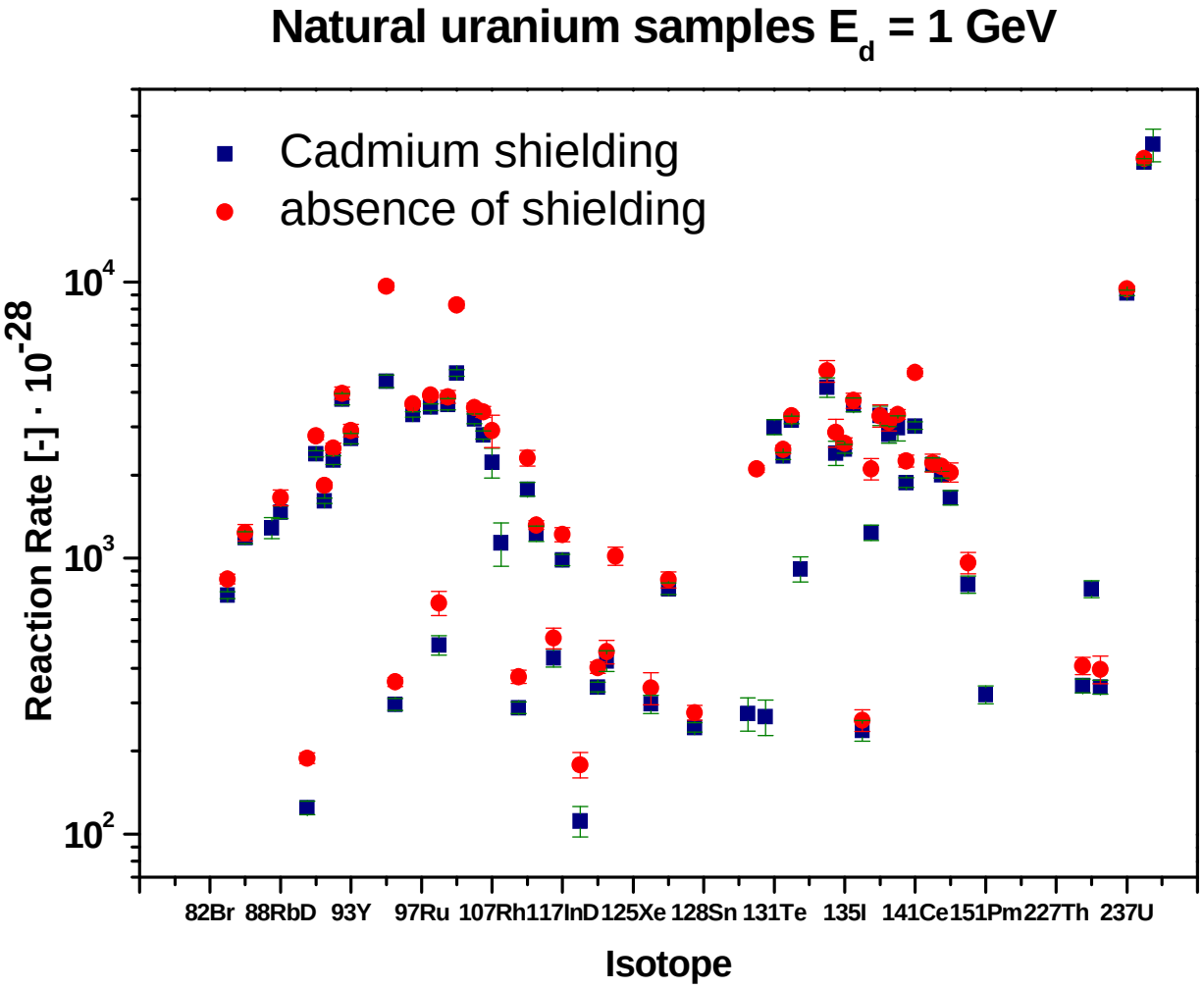


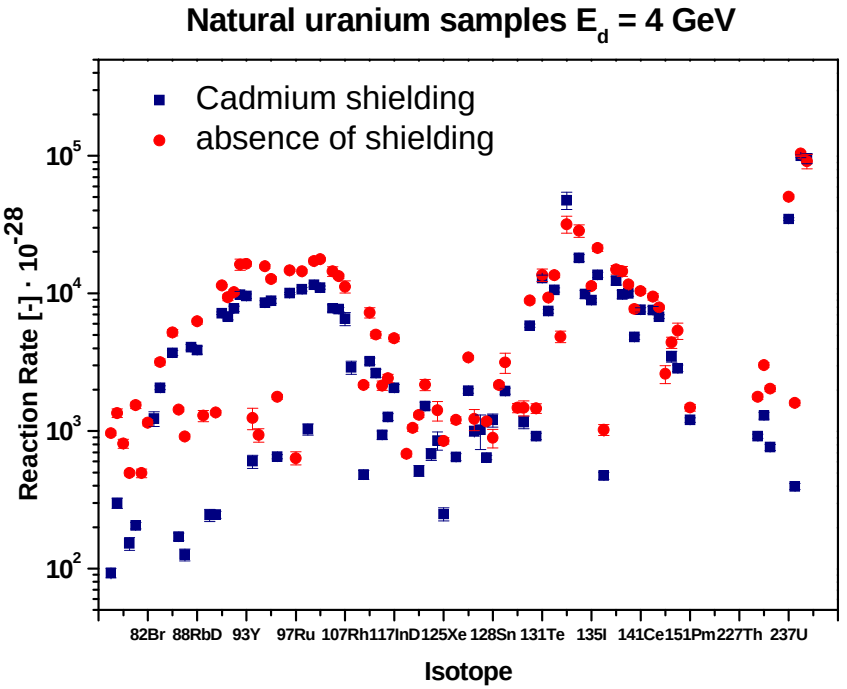
U samples inside: thermal fission

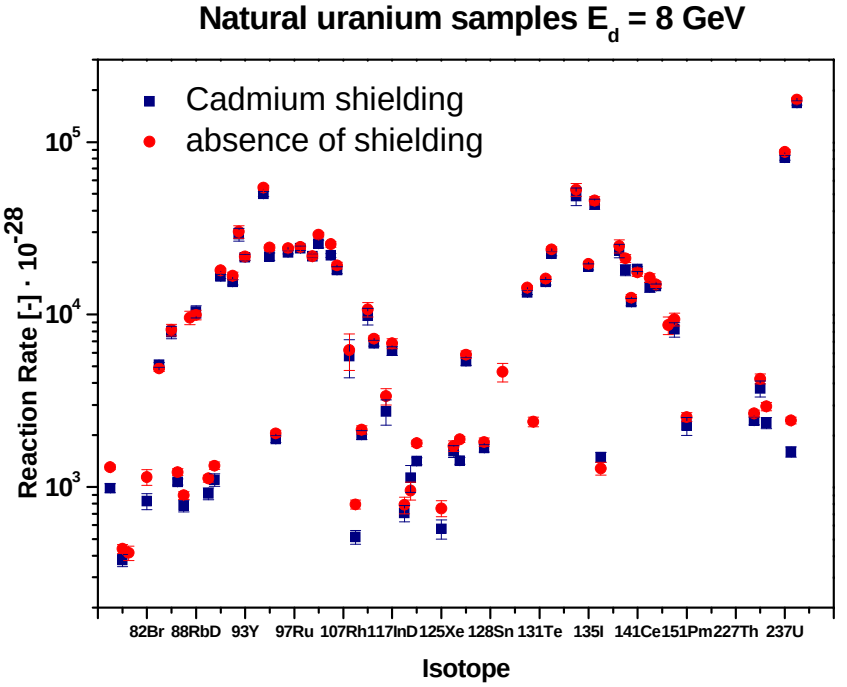
- Estimation of the contribution of thermal neutrons to the total number of fission
- During 2012 run U samples in Cd shielding



U samples inside: Cd





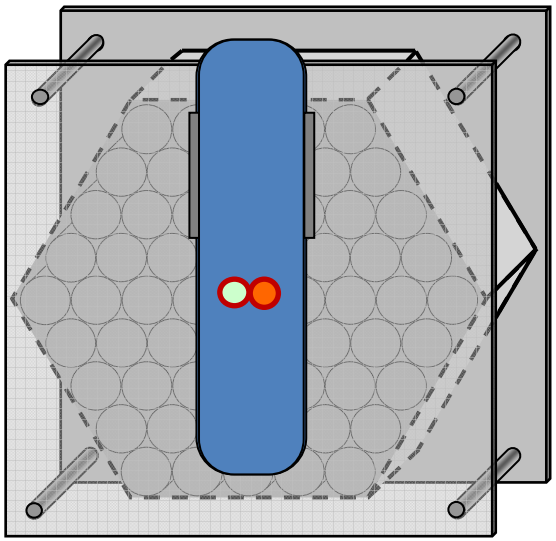


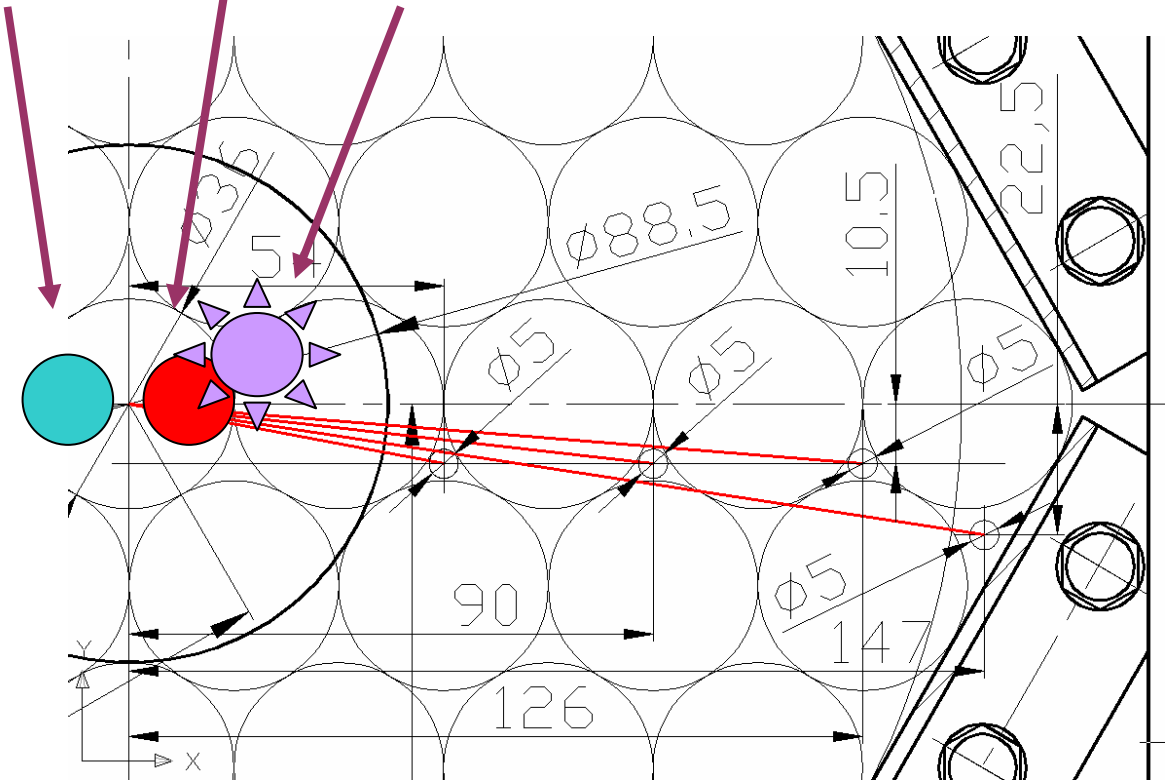
Ratio	1 GeV	4 GeV	8 GeV
NonCd/Cd	1.05(5)	1.33(6)	1.03(4)

U samples inside:
Beam shift during 4 GeV run

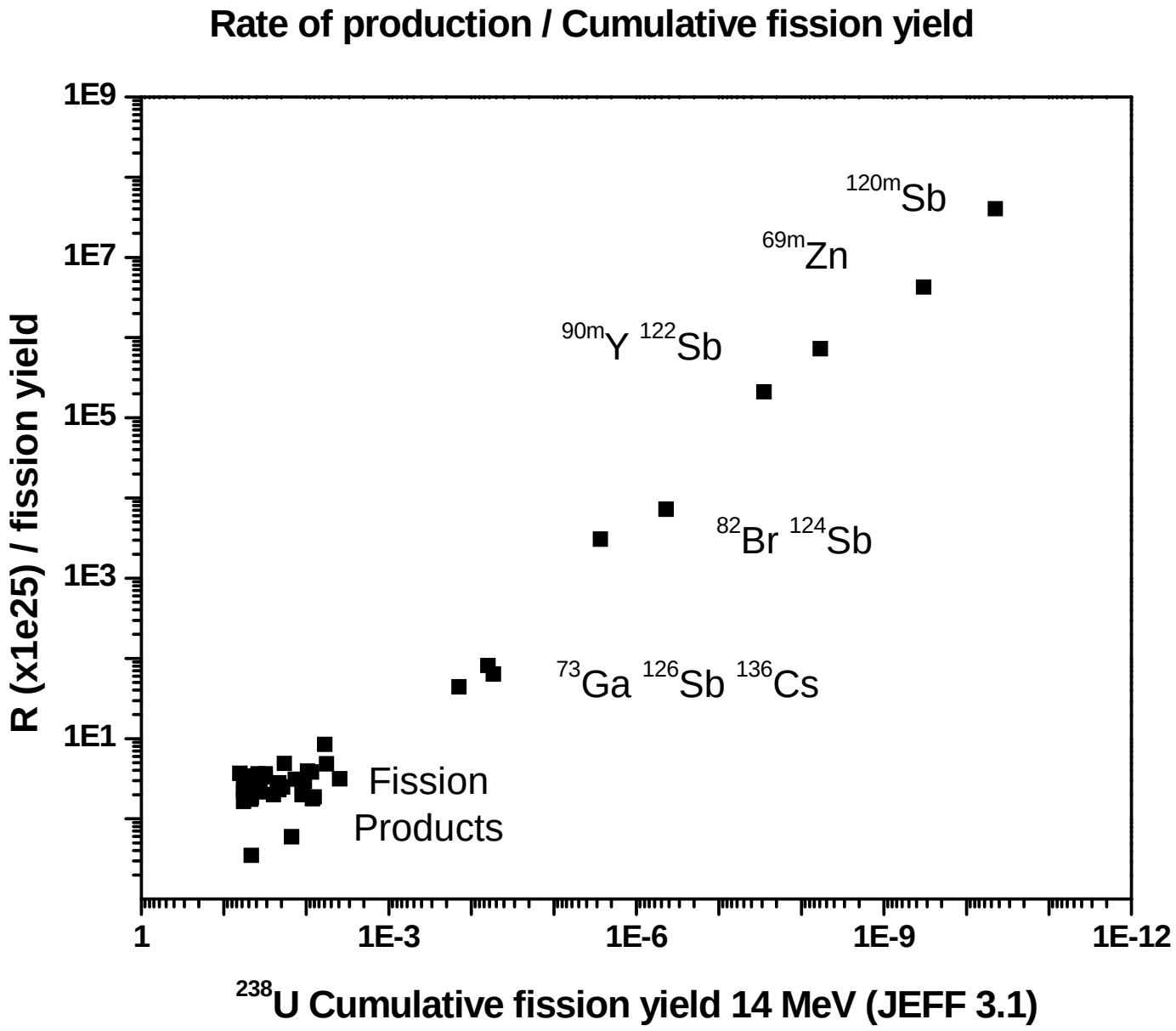
Reported by I.Zhuk, June 5th,
E&T Workshop, Rez

Beam center position	
x	2.0
y	0.8

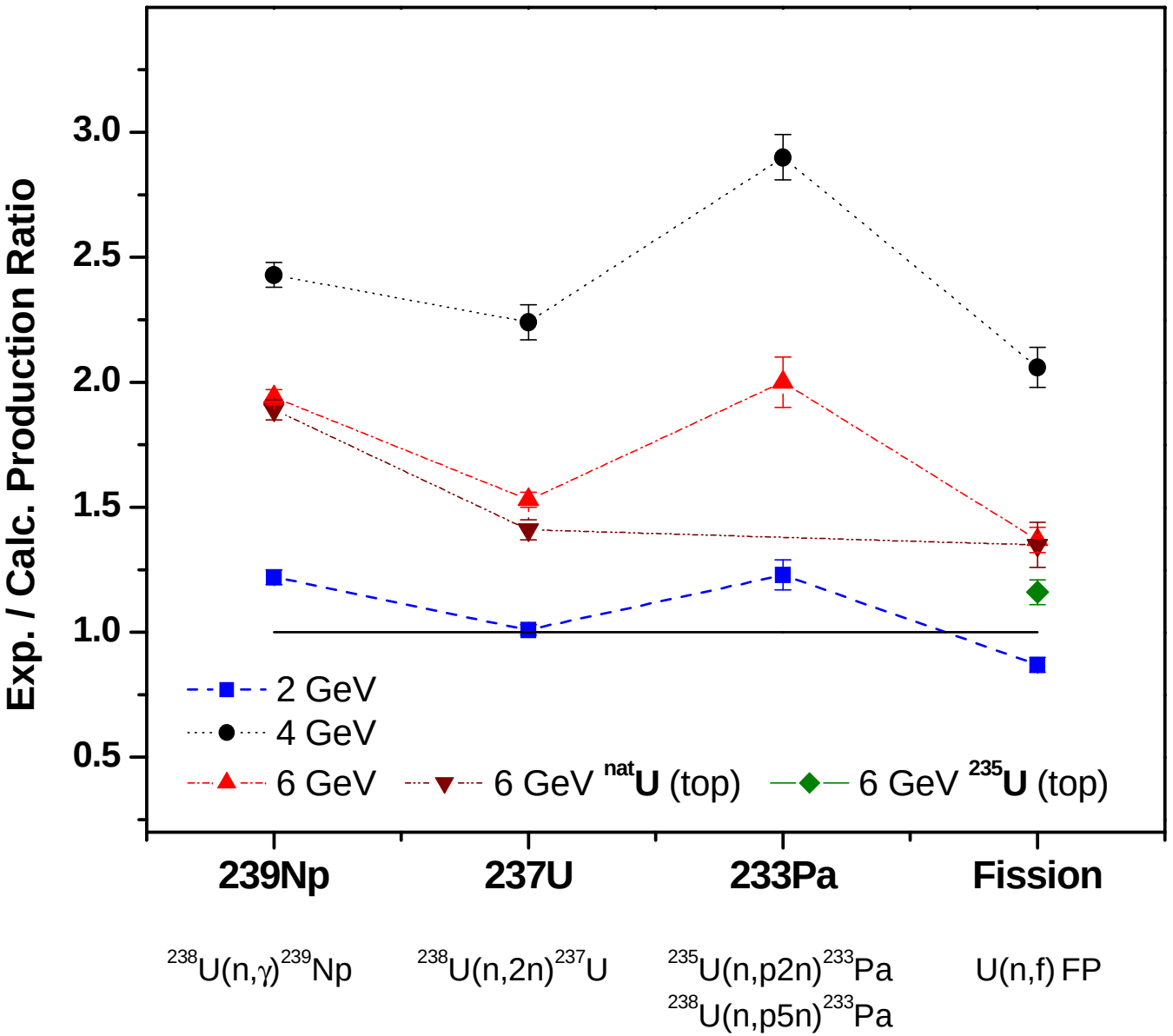




U samples inside: just fission?



Experiment vs. calculation



$$R = \int_{E_0}^{E_{max}} \sigma \cdot \phi \, dE$$

Neutron spectra:

MCNPX 2.7

Cross section:

NJOY 99.112

(up to 20 MeV)

TALYS 1.4

(up to 200 MeV)

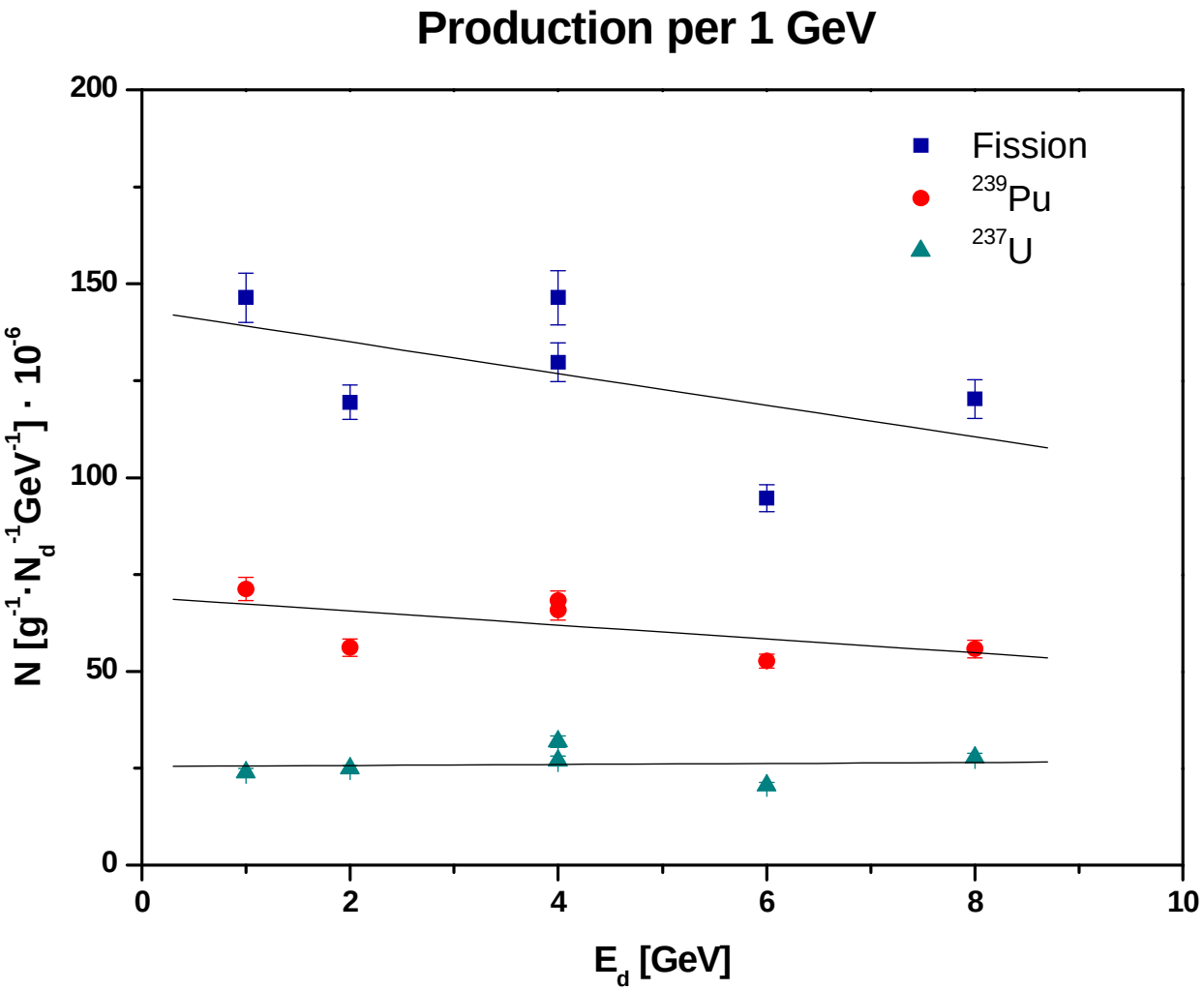
Over 200 MeV max. 3% of total number of neutrons

Conclusion

- **Fast neutron fission:**
  main, but not the only one type of reaction
- **Sensitivity to the beam shape and position**
- **Precise determination of the integral beam intensity is needed**
- **Reaction rate (i.e. number of fission) increases with energy, but:**

Conclusion

...does not increase per 1 GeV with energy



Thank you for
your attention.