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Future usage of quasi-infinite depleted uranium target (BURAN) for benchmark studies

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XII International Baldin Seminar on High Energy Physics Problems
Relativistic Nuclear Physics & Quantum Chromodynamics
September 15-20, 2014, Dubna, Russia

Outline

- *BURAN setup description*
- *Neutron flux spectra*
- *Longitudinal maximums of neutron fluxes*
- *Energy neutron spectra*
- *Hardening of energy neutron spectra*

Preliminary simulations and calculations

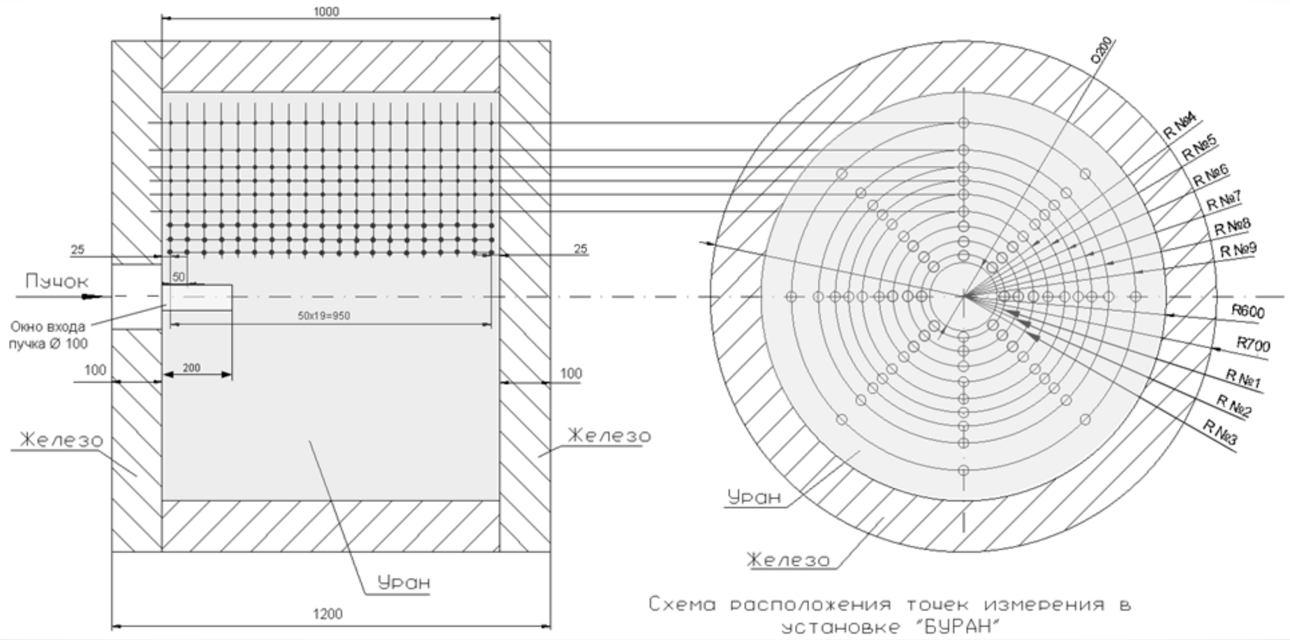
- For designing of ADS (Accelerator Driven Systems) or fast reactors, it is necessary to use simulation programs which are able to simulate the production and transport of neutrons - MCNPX
- For benchmark studies of such simulation programs (which use various models and cross sections libraries), experiments with simple or more complicated setups are being realized (E+T, KVINTA, BURAN)
- These experiments practically test the function of transmutation systems

- **Simulation code:** MCNPX 2.7a
- **Experimental setup:** BURAN
- **Incident beam on the setup:** 1 GeV protons
  1 GeV deuterons

- The results are normalized to one incident particle

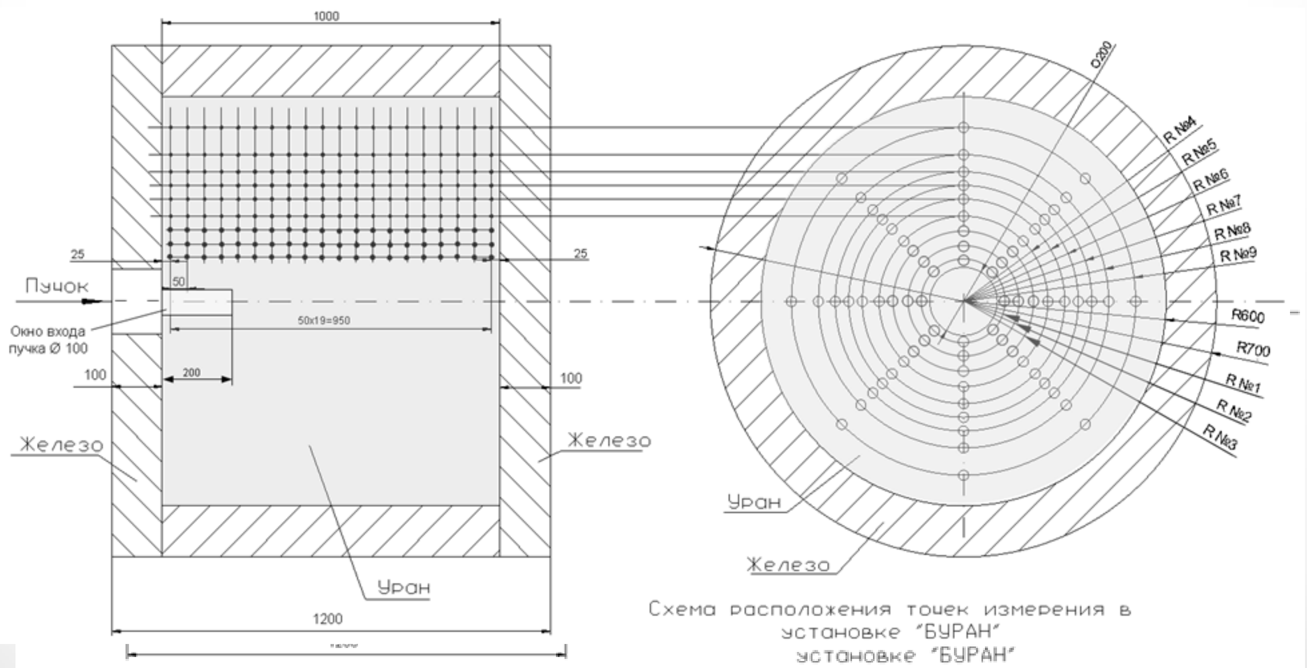
BURAN setup

- Setup for study of transport and multiplication of high energy neutrons
- Cylindrical shape : depleted uranium (0.3% ^{235}U)
  longitudinal distance = 1000 mm
  diameter = 1200 mm
  surrounded with 100 mm steel covering
- The beam enters the setup in the Ø 200 mm hole in the steel cover and Ø 100 mm channel (length of the channel: 0 mm, 100 mm, **200 mm**)



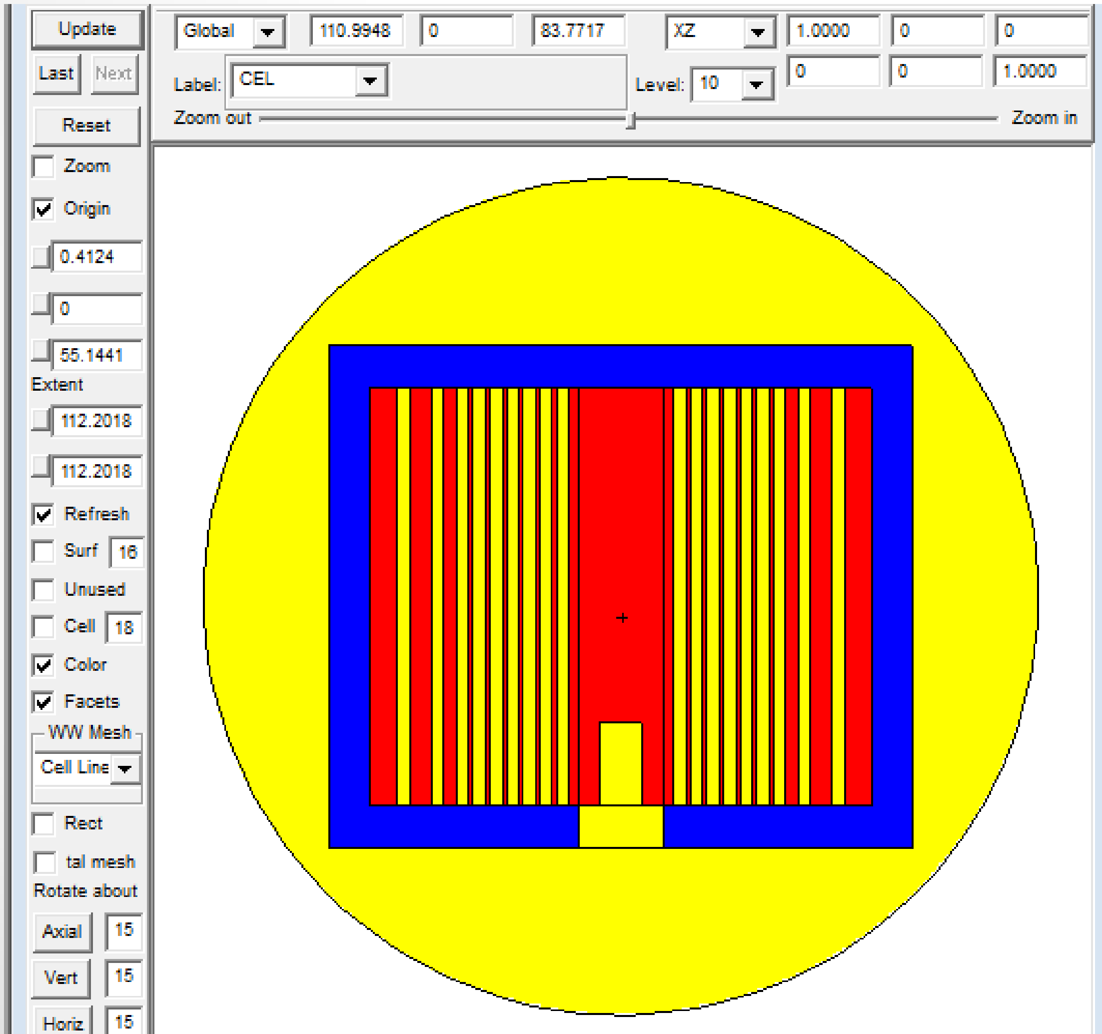
BURAN setup

- **72 channels in the blanket**
  - parallel with the central longitudinal axis
  - Ø 30 mm
  - various distances from the center (140, 180, 220, 260, 300, 340, 380, 440, 520 mm)
- **20 measuring points in every channel**
  - for placing of detectors
  - first point in 25 mm from the edge
  - each next point in 50 mm from the previous one
  - 72 channels × 20 points = 1440



MCNPX Visual Editor

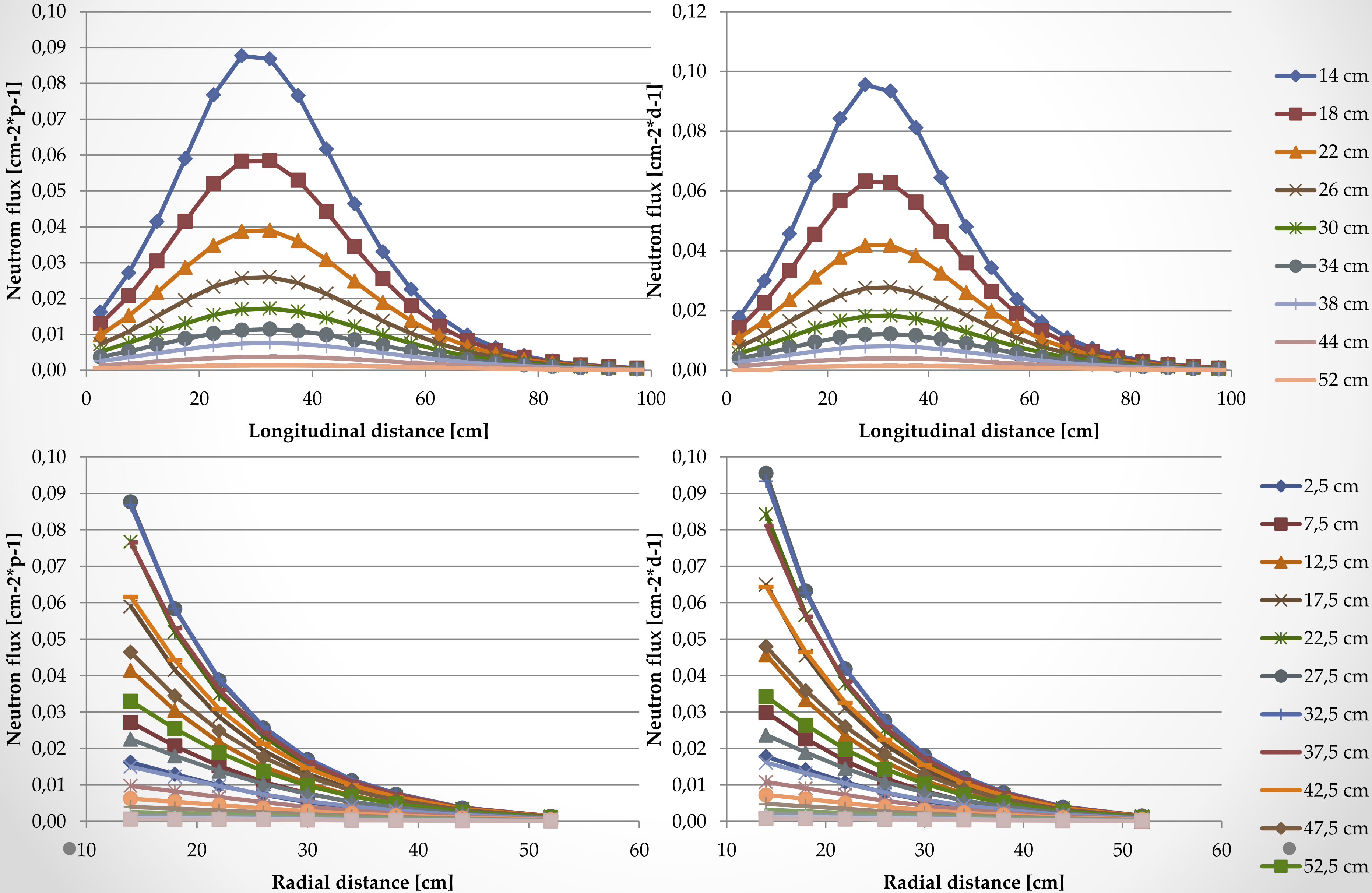
BURAN setup



- Geometry modeled by Martin Suchopár

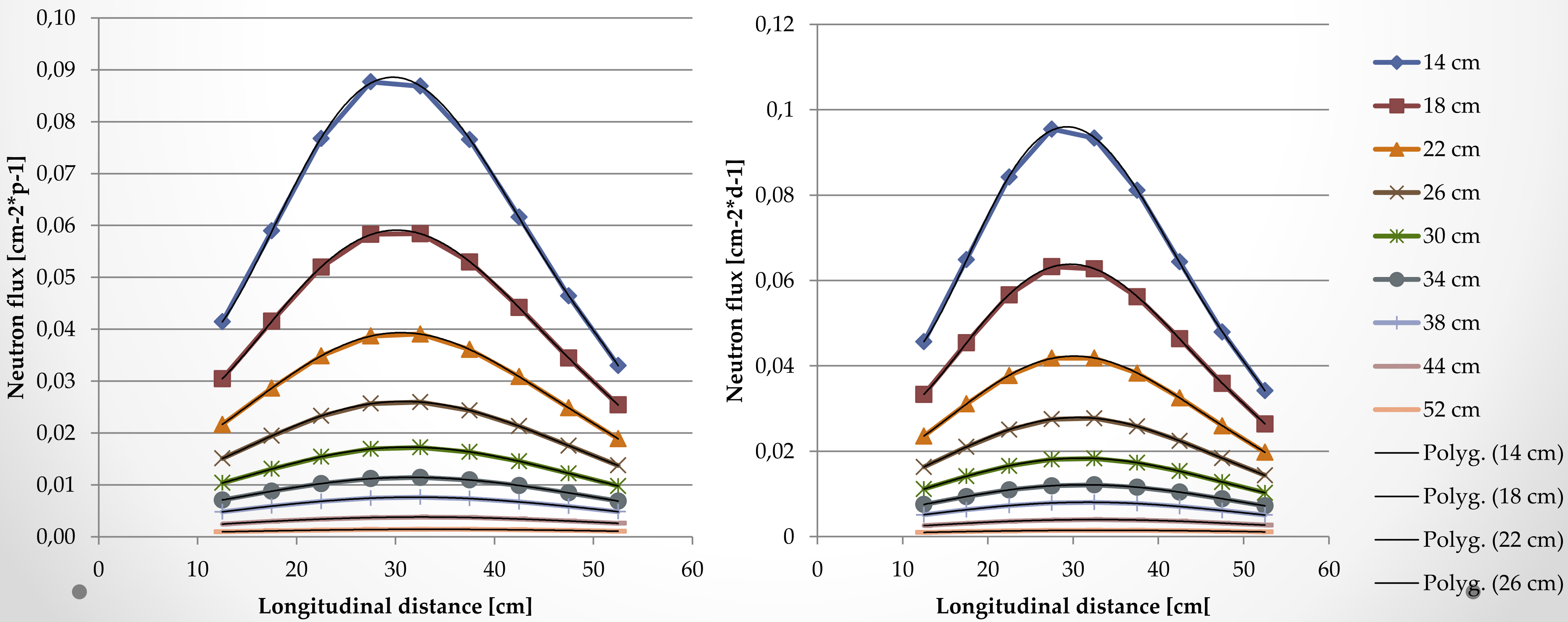
Neutron flux

- Average neutron fluxes in the setup for 1 GeV proton (left) and 1 GeV deuteron (right) beam



Neutron flux - longitudinal maximums

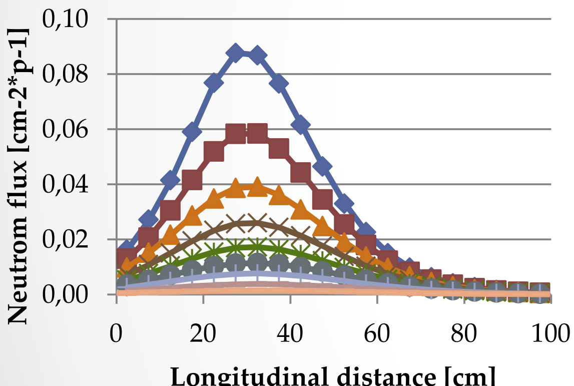
- Positions of the neutron flux maximums were determined by fitting the central part of neutron flux spectra by polynomial functions of degree 6
- The particular values of longitudinal maximums were calculated by using Wolfram Mathematica and Polynomial & Scientific Calculator from http://xrjunque.nom.es

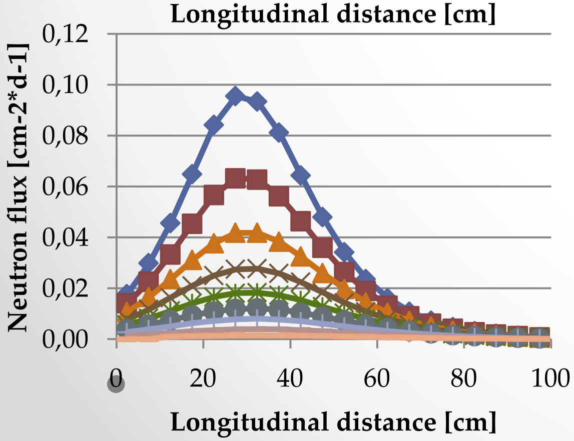


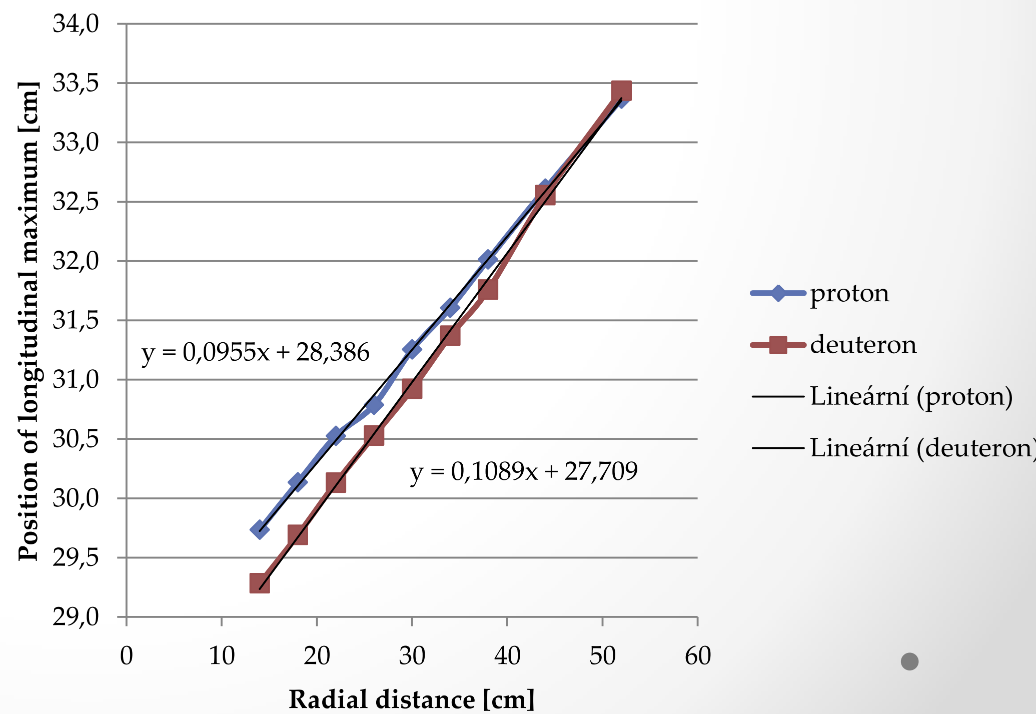
Neutron flux – longitudinal maximums

- Longitudinal positions of the neutron flux maximums

Radial distance [cm]	Maximums for 1GeV proton beam [cm]	Maximums for 1GeV deuteron beam [cm]
14 cm	29,734	29,281
18 cm	30,134	29,691
22 cm	30,525	30,131
26 cm	30,786	30,527
30 cm	31,252	30,922
34 cm	31,603	31,369
38 cm	32,012	31,758
44 cm	32,609	32,553
52 cm	33,366	33,435







Neutron flux – longitudinal maximums

- Positions of longitudinal maximums increase towards higher radial distances
- Linear dependence of the maximum shifts
- Positions of maximums are of lower values for deuteron beam – shorter range of deuterons in material

Radial distance [cm]	Maximums for 1GeV proton beam [cm]	Maximums for 1GeV deuteron beam [cm]
14 cm	29,734	29,281
18 cm	30,134	29,691
22 cm	30,525	30,131
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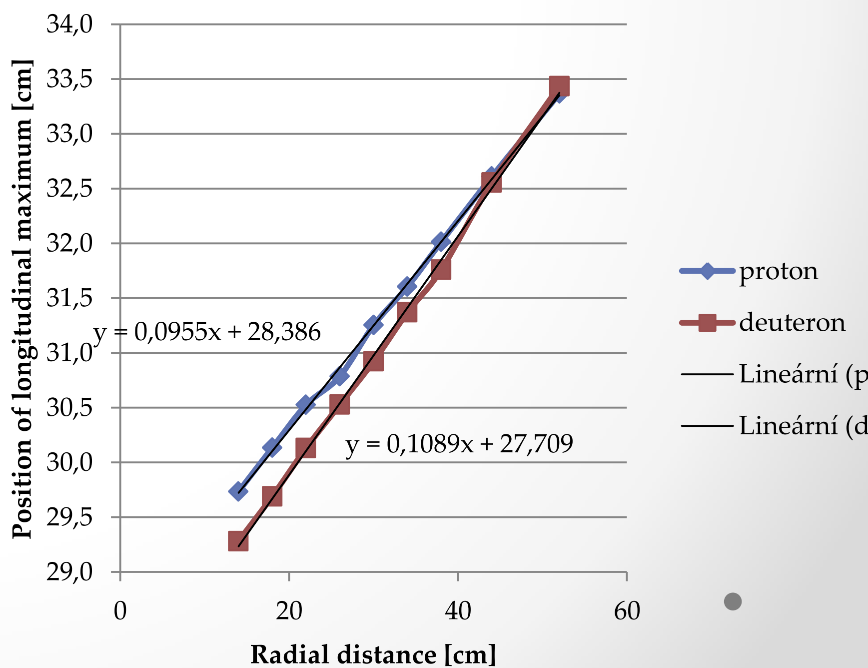
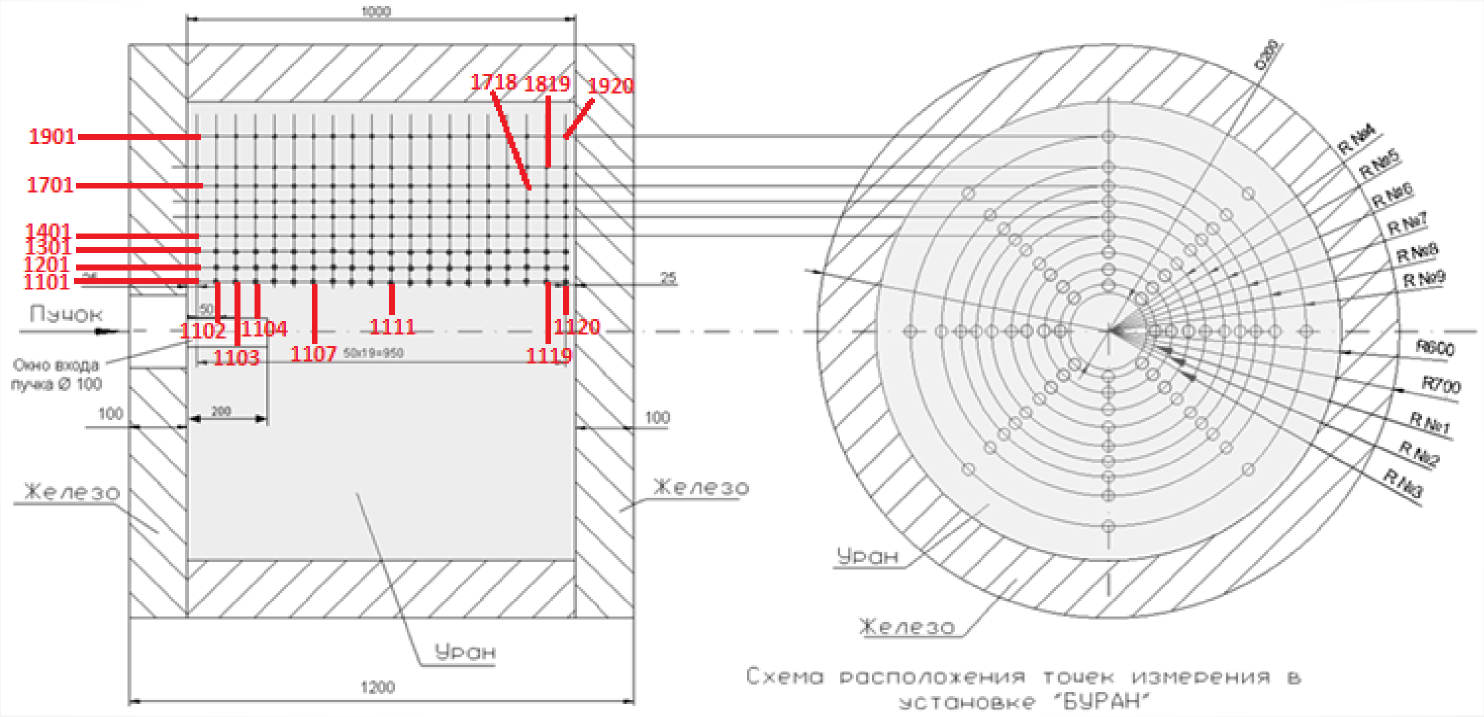


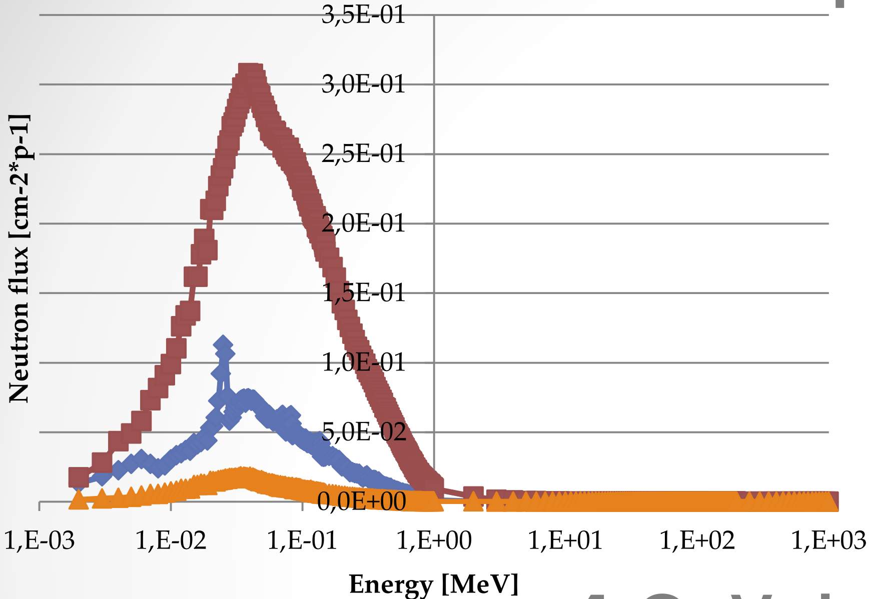
Energy neutron spectra

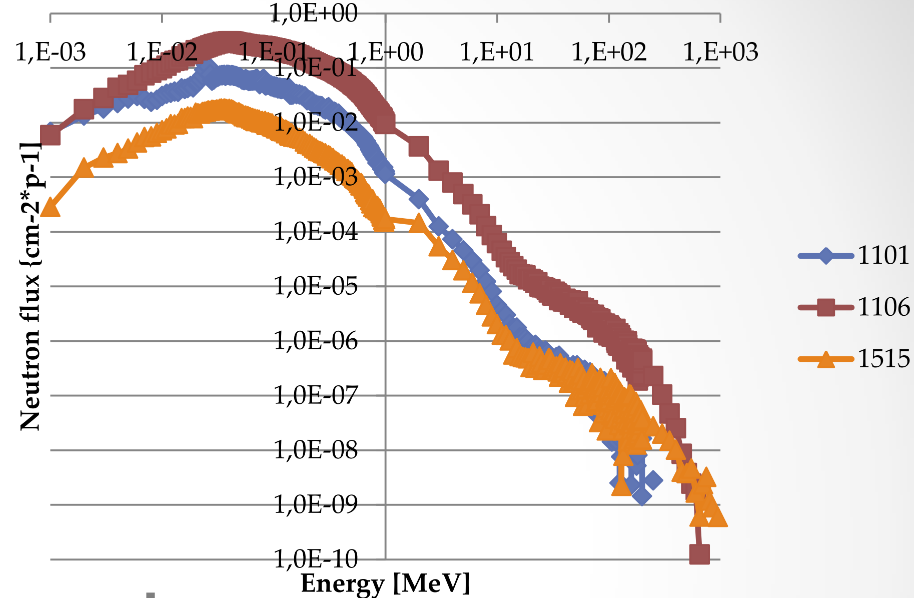
System of marking of measuring points in BURAN setup



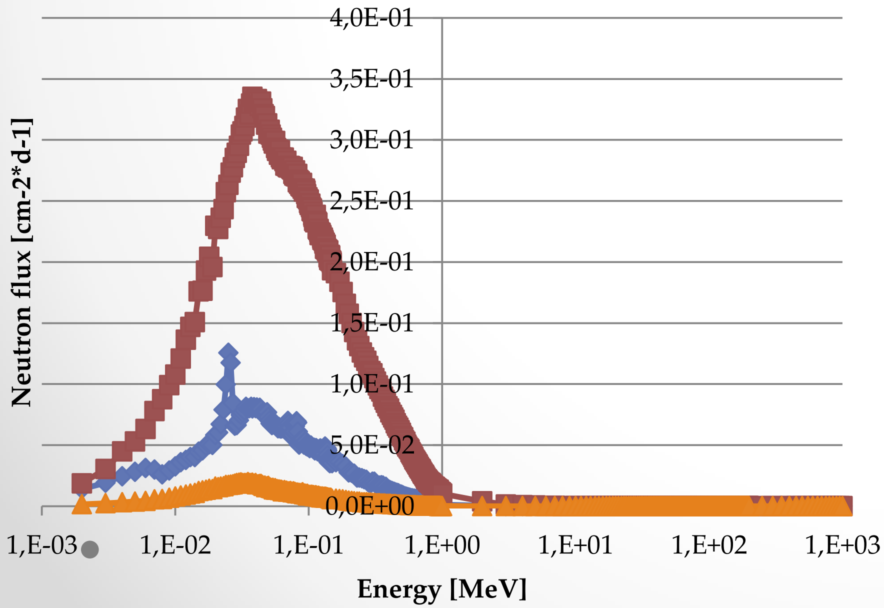
Energy neutron spectra

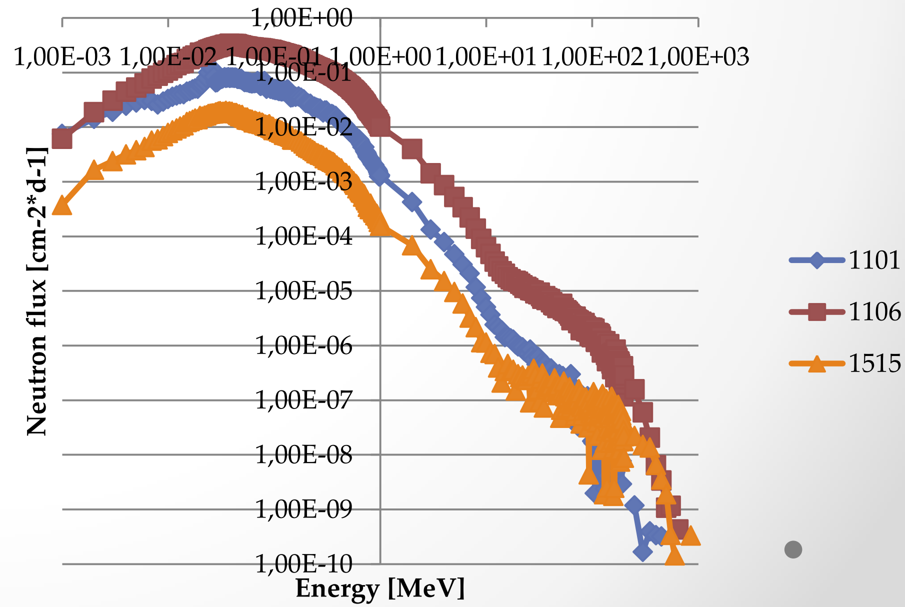
1 GeV proton beam





1 GeV deuteron beam





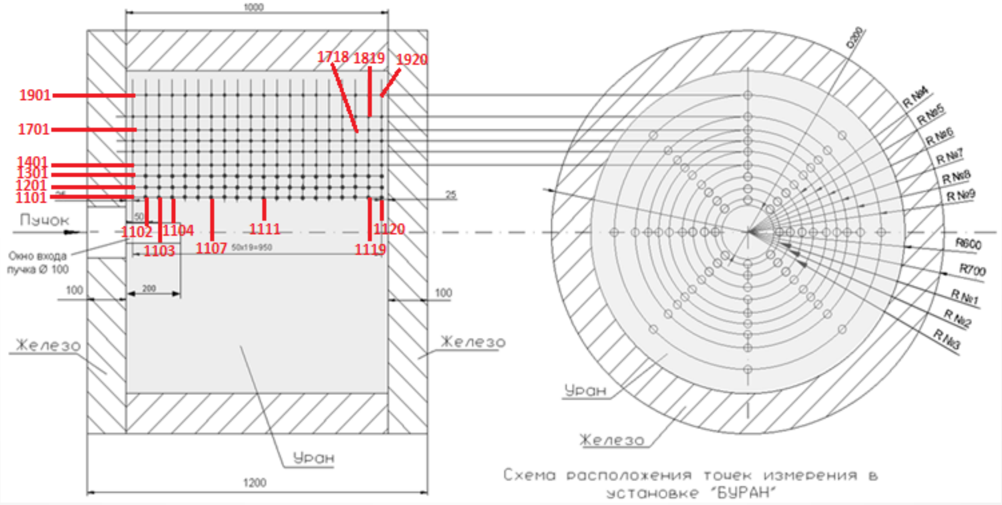
Neutron spectra hardening

- **Hardening** in each measuring point is defined as the ratio of the total flux of neutrons with energies > 10MeV and the total flux of neutrons with energies <= 10MeV
- Hardening in 3 longitudinal lines of measuring points was investigated:

1) Line 11: points 1101 – 1120

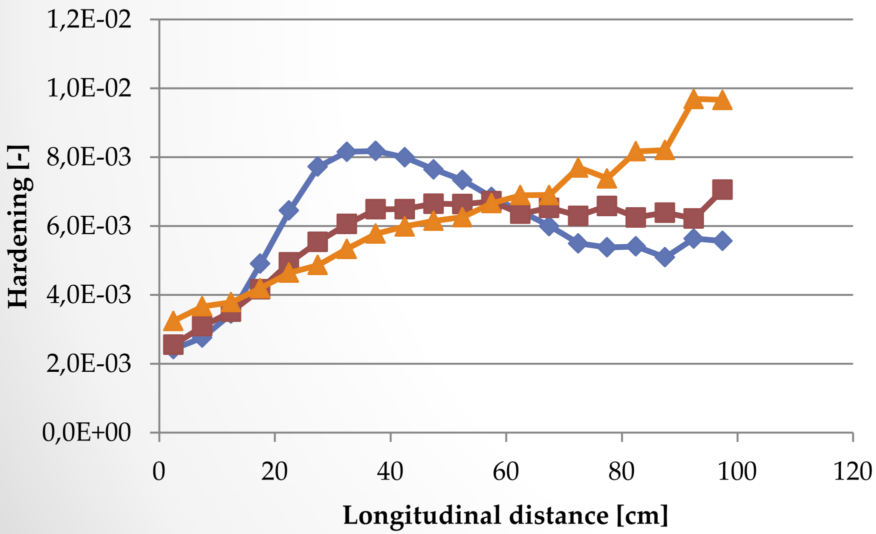
2) Line 13: points 1301 – 1320

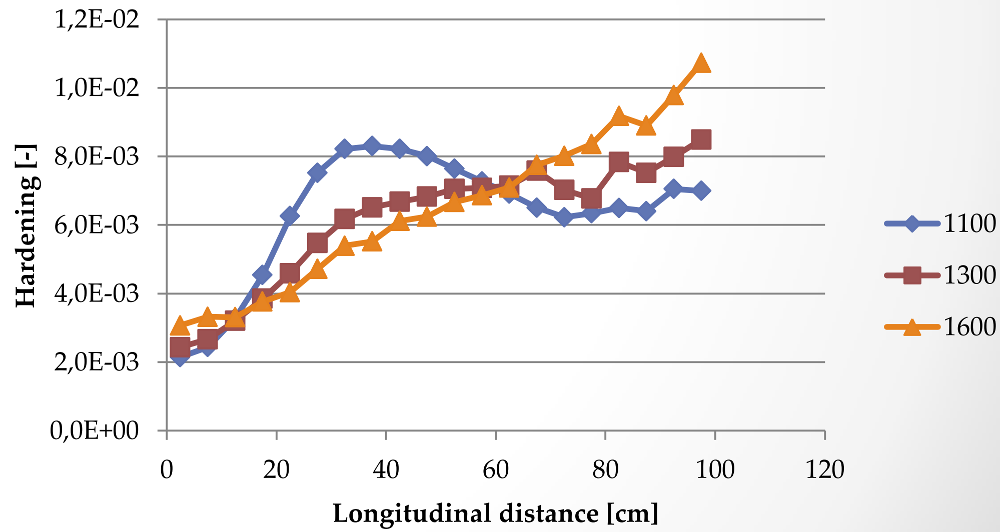
3) Line 16: points 1601 – 1620



Neutron spectra hardening

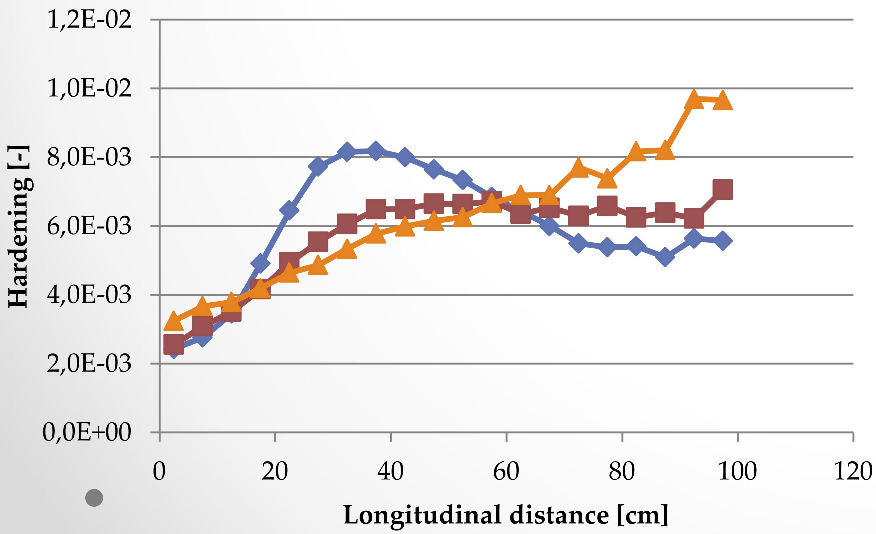
- Dependence of neutron spectrum hardening for 1 GeV proton (left) and 1 GeV deuteron (right) beam

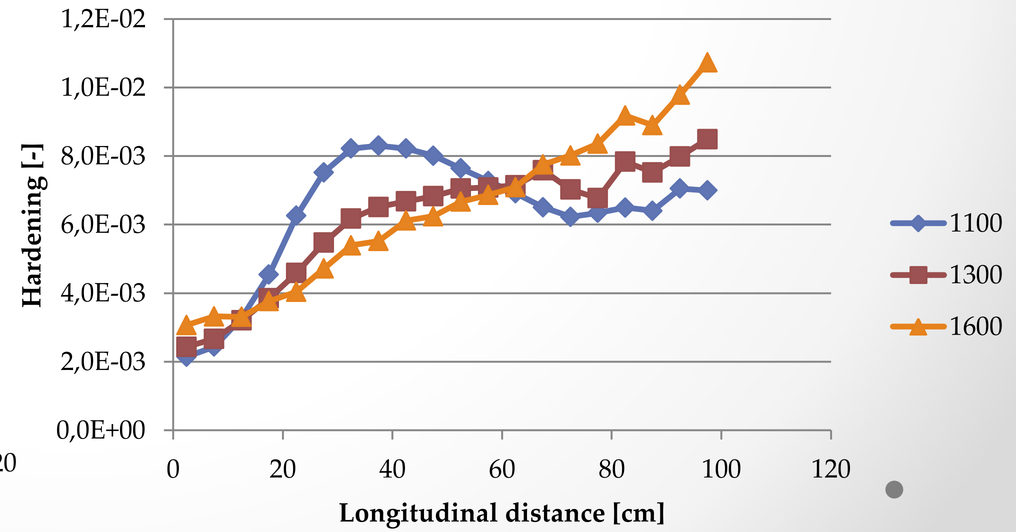




Neutron spectra hardening

- Similar hardness of neutron spectra for lower longitudinal distances both for proton and deuteron beam
- For higher distances – higher values of hardness for spectrums where deuteron beam was used
- The curves cross each other around longitudinal distance of 60 cm – around this value, the hardness is approximately the same for all radial distances
- The shape of dependences becomes more linear with rising radial distance – the most remote distances are reached by the most energetic neutrons





Thank you for attention