THE USE OF RESONANCE NEUTRON METHOD FOR SEARCHING OF PALLADIUM OF THE PROTON ROCKET ENGINE

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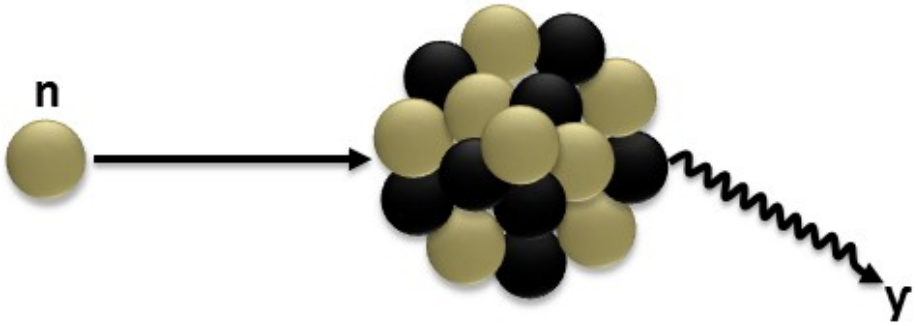
Motivation of Experiment with Pd

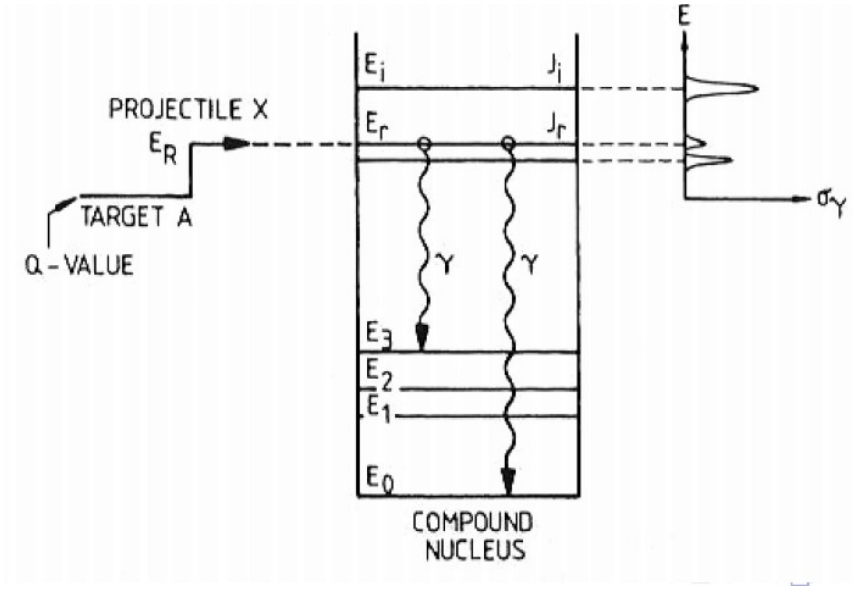
One hypothesis for crash of the Proton Rocket - M is presence of Palladium in some critical components of the engine

Interaction of slow neutrons with nuclei

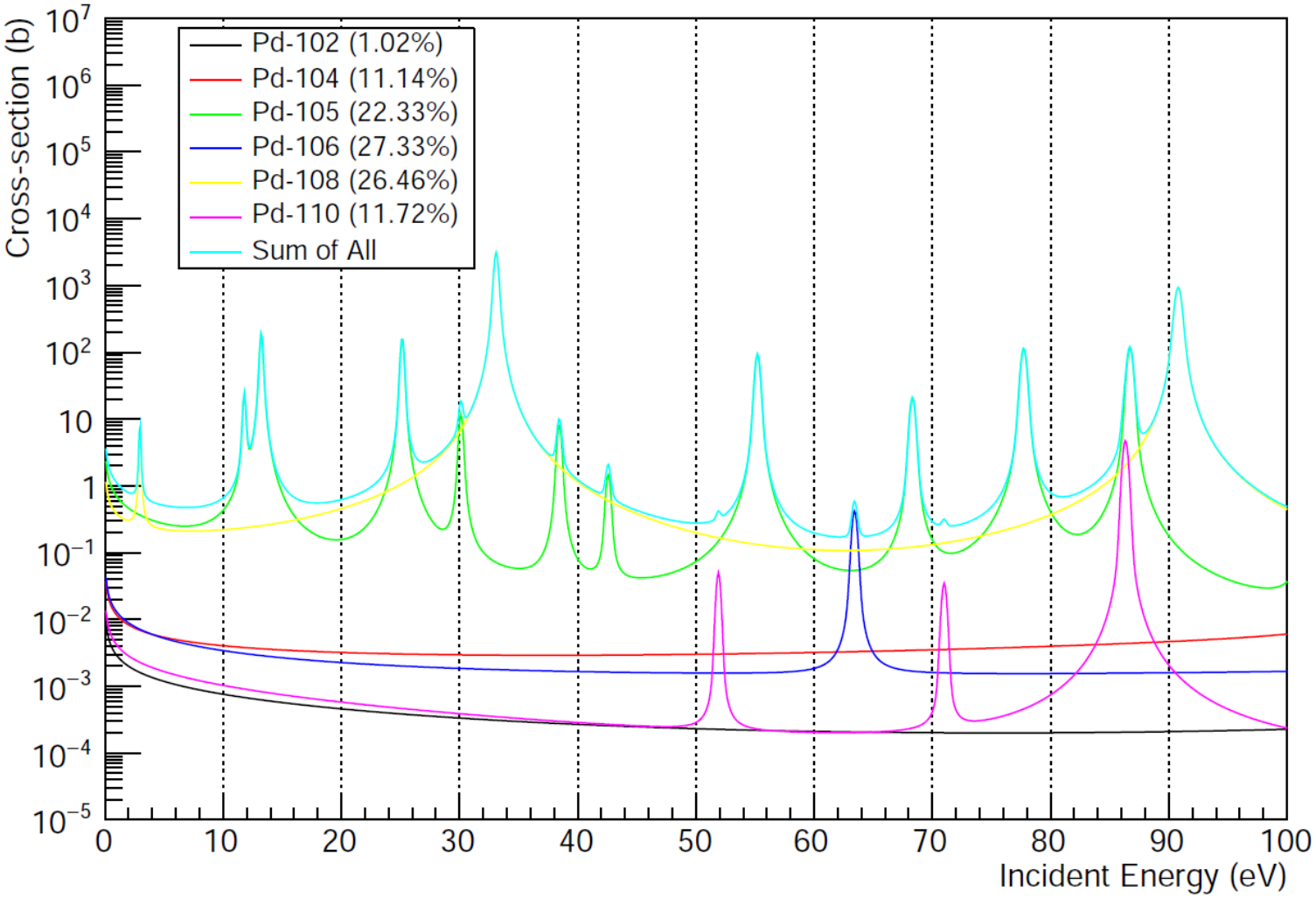
$$n + A \rightarrow (A + 1)^*$$



Resonance capture



Resonances in Pd isotopes (ENDF/B-VII.1)



Neutron source: IREN Facility (layout)

Parameter	Project	I Stage	II Stage
Peak current (A)	1.5	1.5–2.5	1.5–2.5
Repetition rate (Hz)	150	25	50
Electron pulse duration (ns)	250	100	100
Electron energy (MeV)	212	32–42	45–65
Beam power (kW)	12	0.1–0.4	0.3–1.2
Neutron intensity (n/s)	2×10^{13}	3×10^{11}	6×10^{11}

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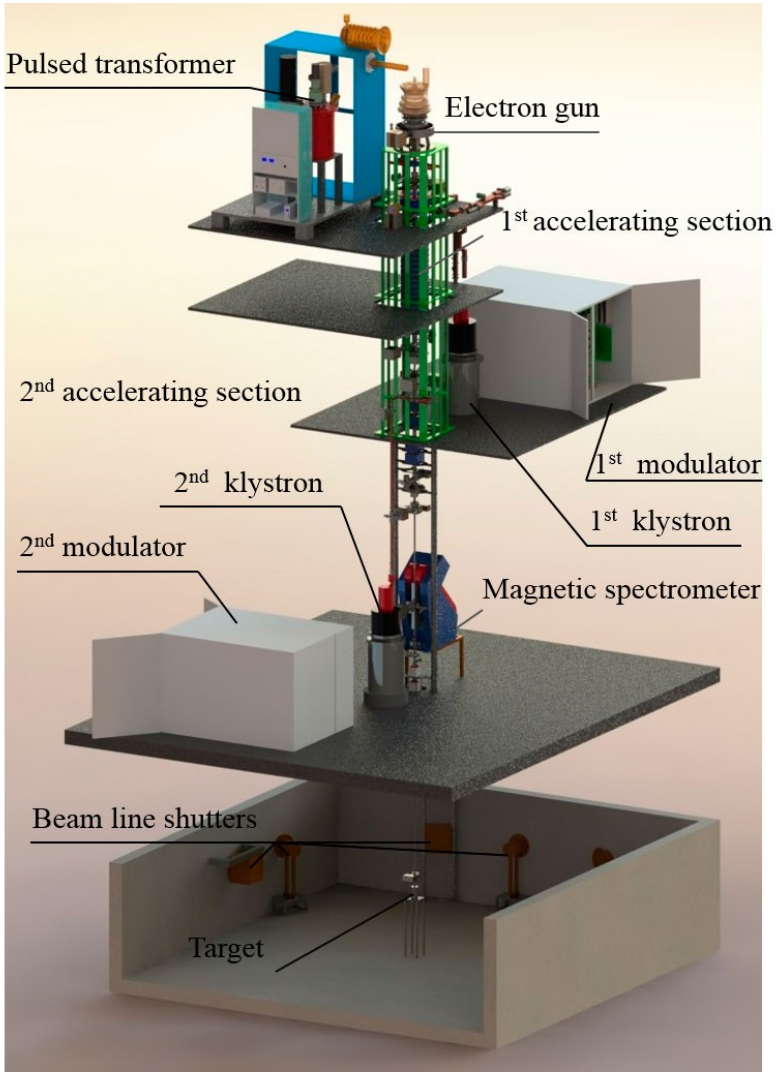
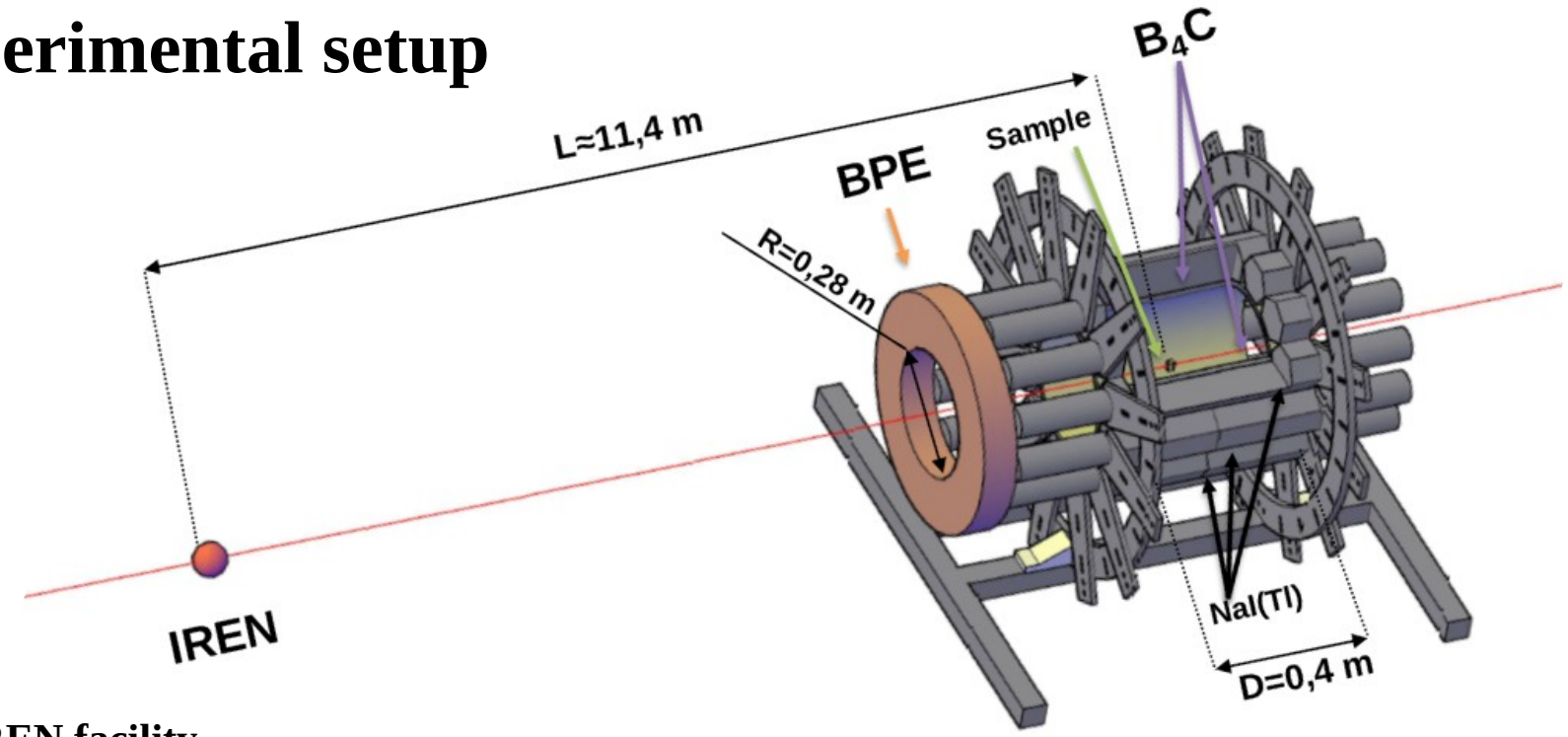


Current IREN characteristics:

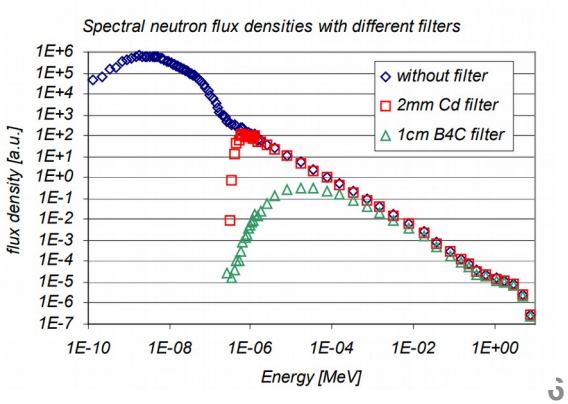
- **pulsed electron beam current – 2.0 A**
- **electron energy – 40 MeV**
- **pulse width – 100 ns**
- **repetition rate – 25 Hz**
- **integral neutron yield (3÷5)×10¹⁰ n/s.**

- **New project:**
- **200-MeV linear accelerator LUE-200 with a beam power of ~10 kW**
- **Subcritical neutron multiplying target**
- **Integral neutron yield of ~10¹⁵n/s and pulse width of ~0.6 μs.**

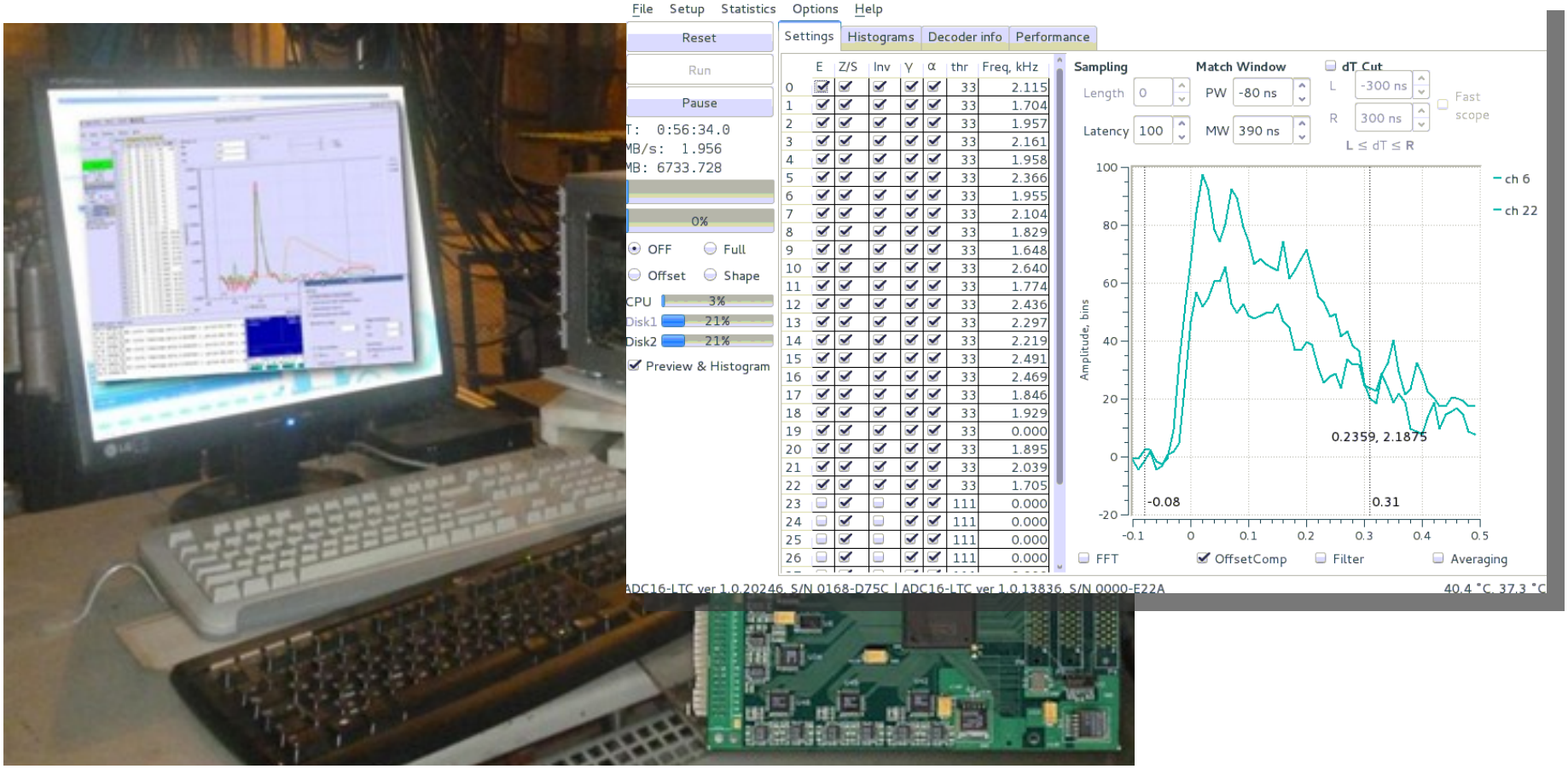
Experimental setup



- **IREN facility**
- **“Romashka” gamma-spectrometer: 24 hexagonal NaI(Tl) crystals (78x90x200 mm)**
- **10cm-thick Boron polyethylene (BPE) collimator**
- **B_4C powder of 1cm thickness (ρ=1.8 g/cm3), encapsulated in-between 2 Al cylinders of 0.5 mm wall thickness, was used to capture the neutrons scattered by the sample**
- **Samples (in the center of “Romashka” system)**



Data Acquisition & Analysis System

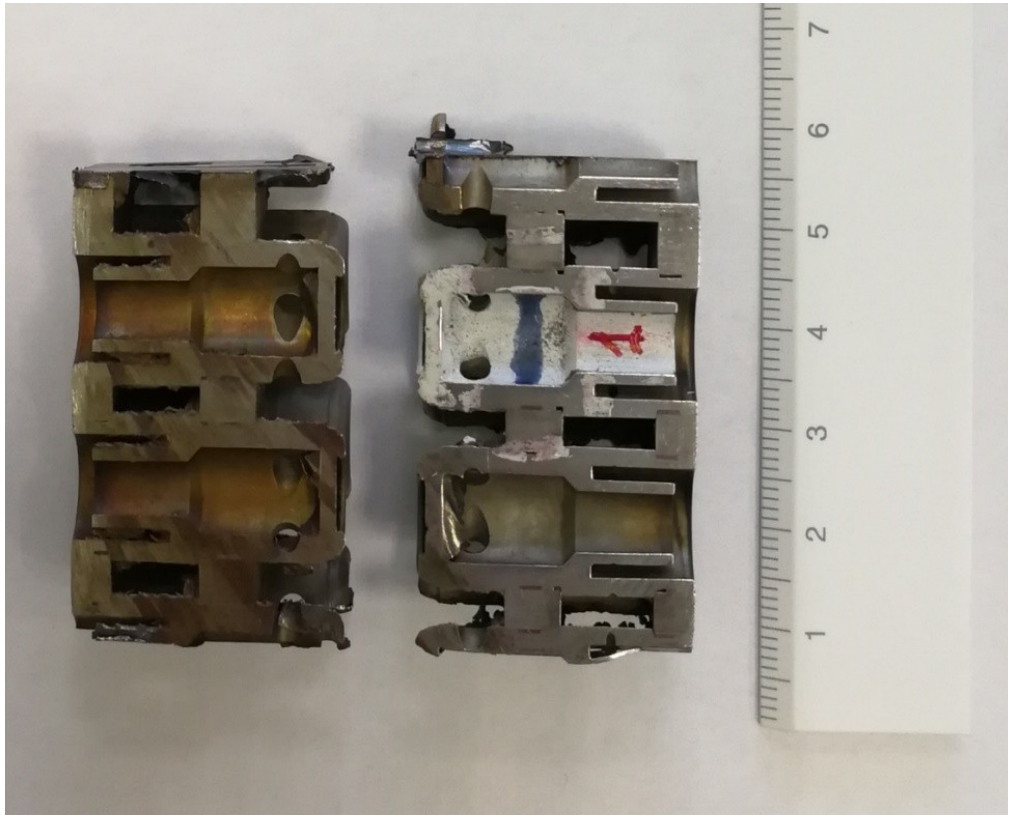


ADCM16-LTC, 32-channel/14-bit/100MHz ADC-boards from JINR AFI Electronics.

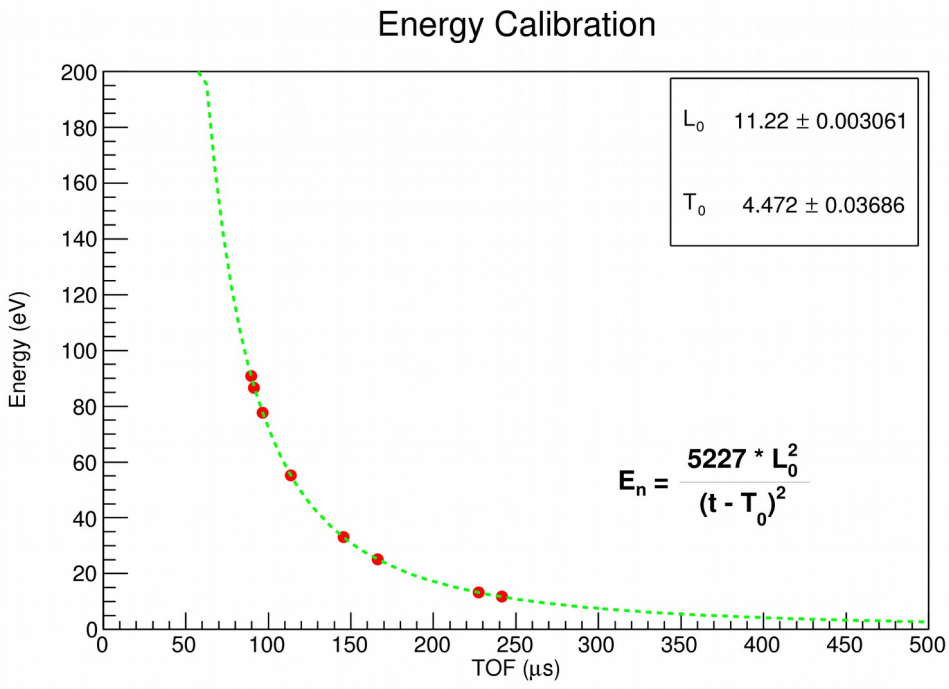
The samples

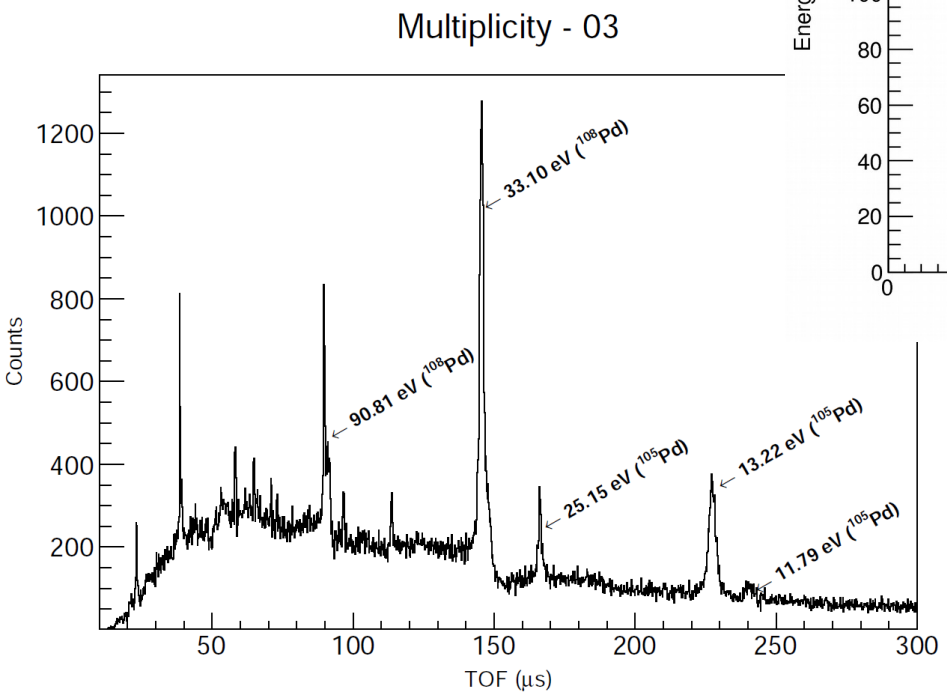
The initial sample was divided into two pieces each of about 60 grams.

The existence of Pd in right-hand sample, marked by "1", was proven by X-ray fluorescence analysis in the Institute of Physical-Technical Problems. There was no Pd found in left-hand sample.

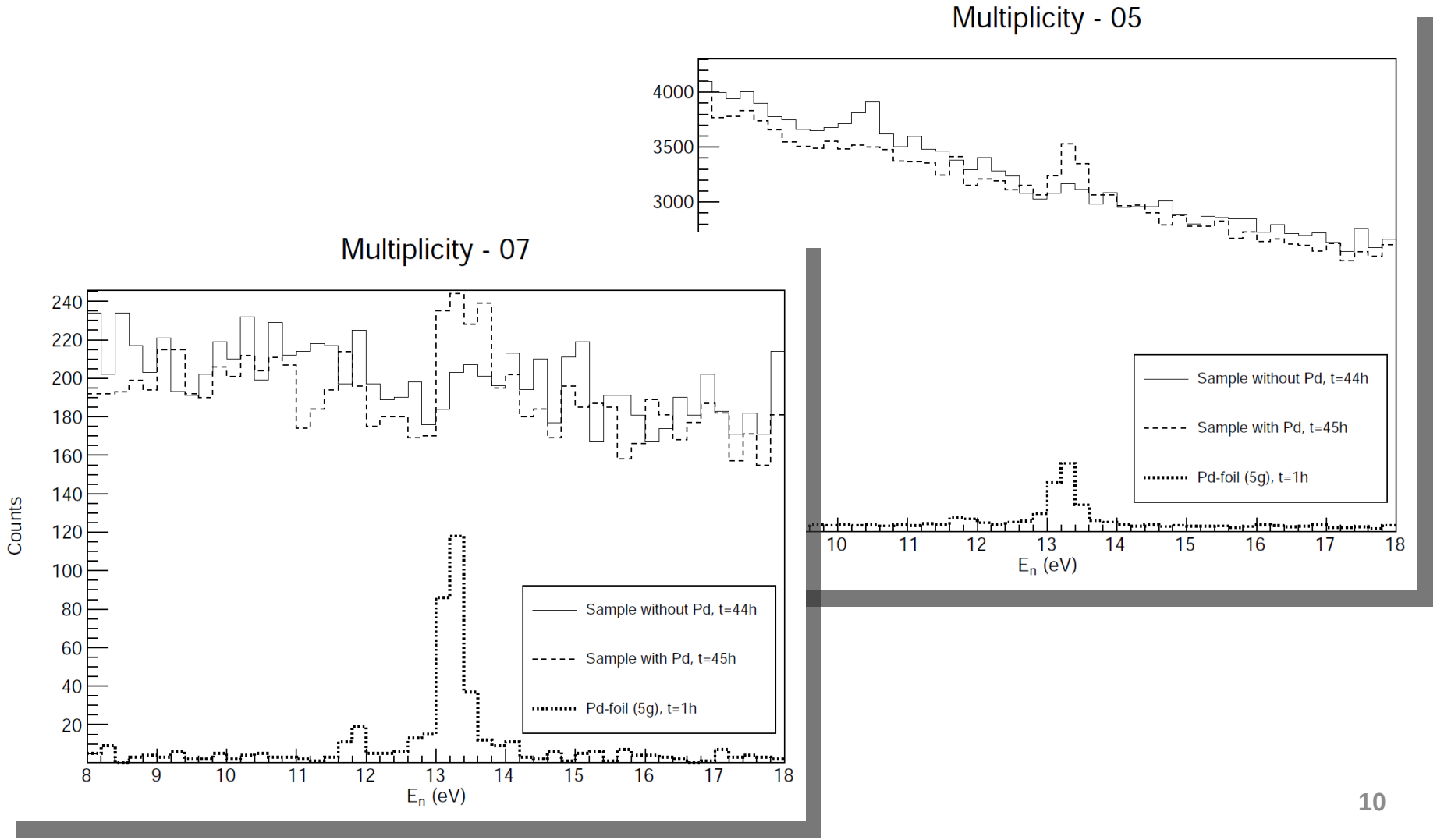


TOF-to-Energy calibration

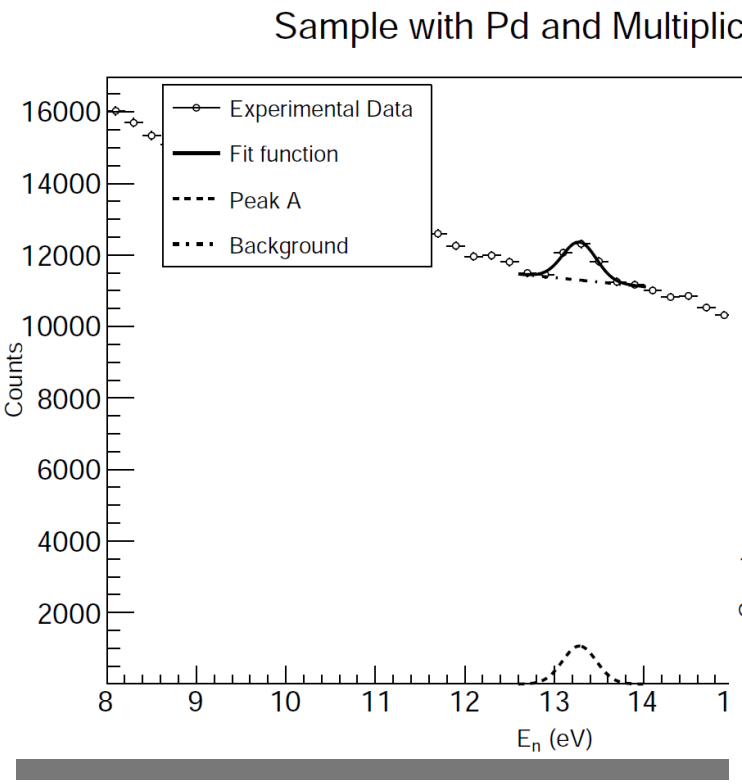


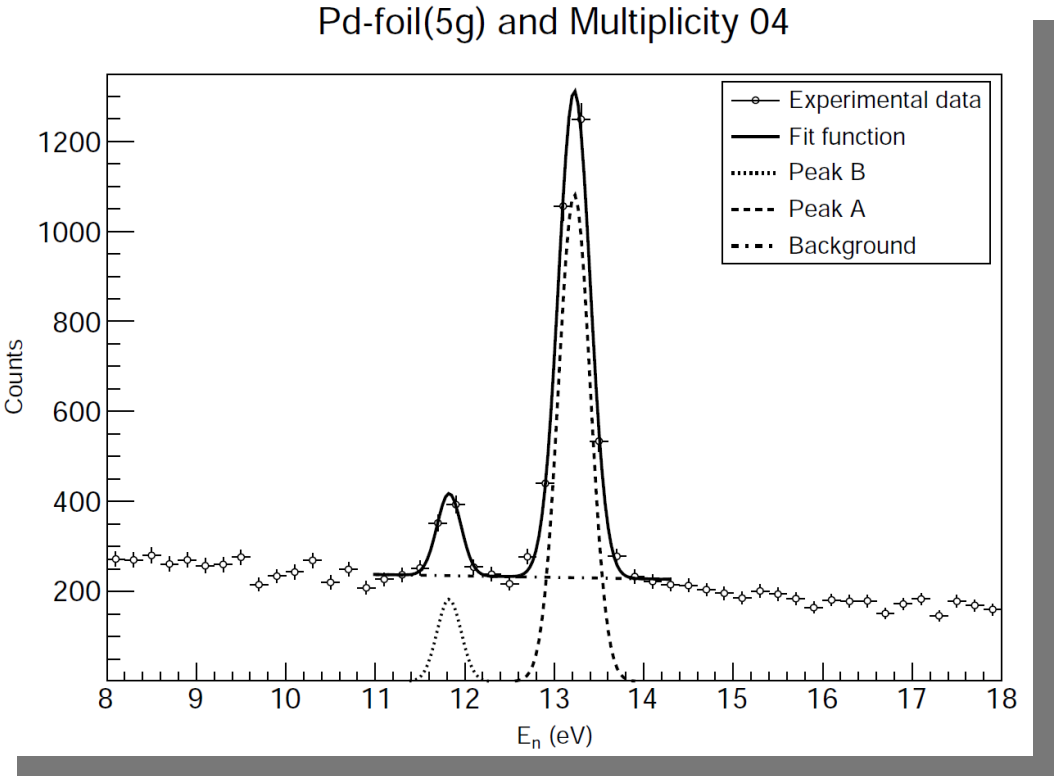


Detecting Pd in the sample



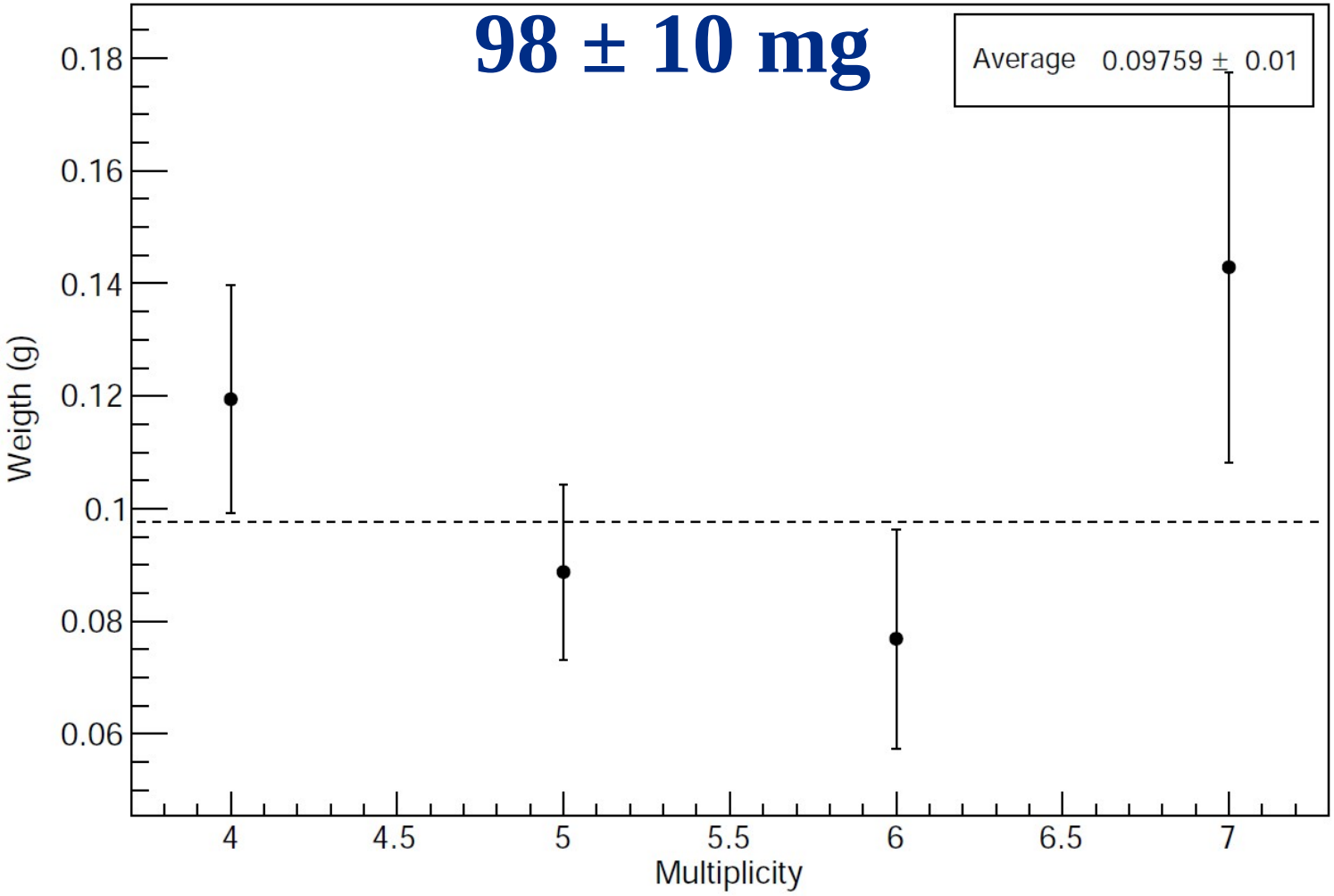
Calculating the amount of Pd in the sample





Average amount of Pd in the sample:

98 ± 10 mg



Conclusions

- **The neutron resonance capture spectroscopy (NRCS) method was used for detecting the Pd in bulk samples and determining its amount.**
- **The amount of Pd in the ~60 g sample was found to be 98 ± 10 mg.**

Thank you for your attention

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