



26th International Seminar on Interaction of Neutrons with Nuclei

2018, Xi'an China

十三朝历史文明古都
Thirteen **D**ynasties

西安是我国公布的首批国家历史文化名城。历史上有周、秦、汉、唐等在内的13个朝代在此建都，是中国四大古都之一，曾经作为中国古代政治、经济、文化中心长达1100多年。早在100万年前，蓝田人猿就在这里建造了房屋；7000年前的仰韶文化时期，这里已经出现了城市的雏形；2008年，西安高陵杨官寨出土距今6000余年的新石器时代晚期城市遗址，被选为当年中国考古发现之首。这是中国目前发现的迄今最早的城市遗址。也将西安地区城市历史推进到6000多年前的新石器时代晚期。建国以来，世界上已经有200多位国家首脑和政要访问过西安，包括联合国秘书长、美国总统、俄罗斯总统、德国总理、法国总统、英国女王、日本天皇、教皇约翰等。



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

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and TANGRA collaboration**



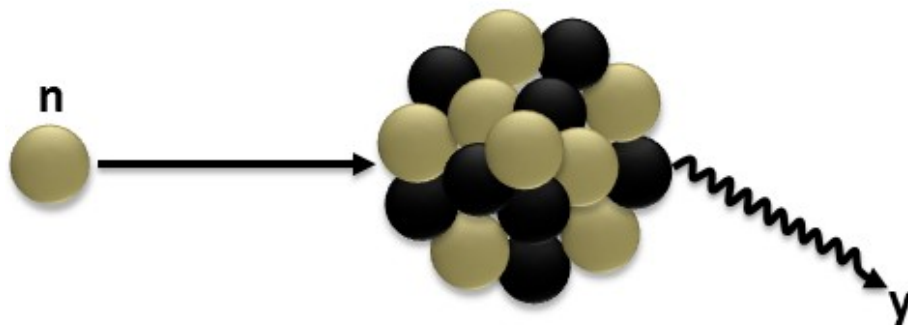
Motivation of Experiment with Pd



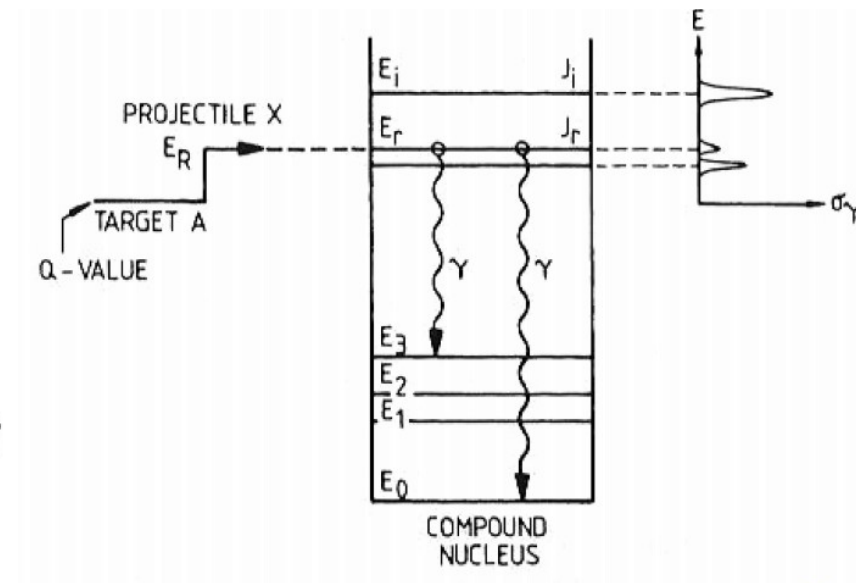
One hypothesis for crash of the Proton Rocket - M is presence of Palladium in some critical components of the engine



Interaction of slow neutrons with nuclei

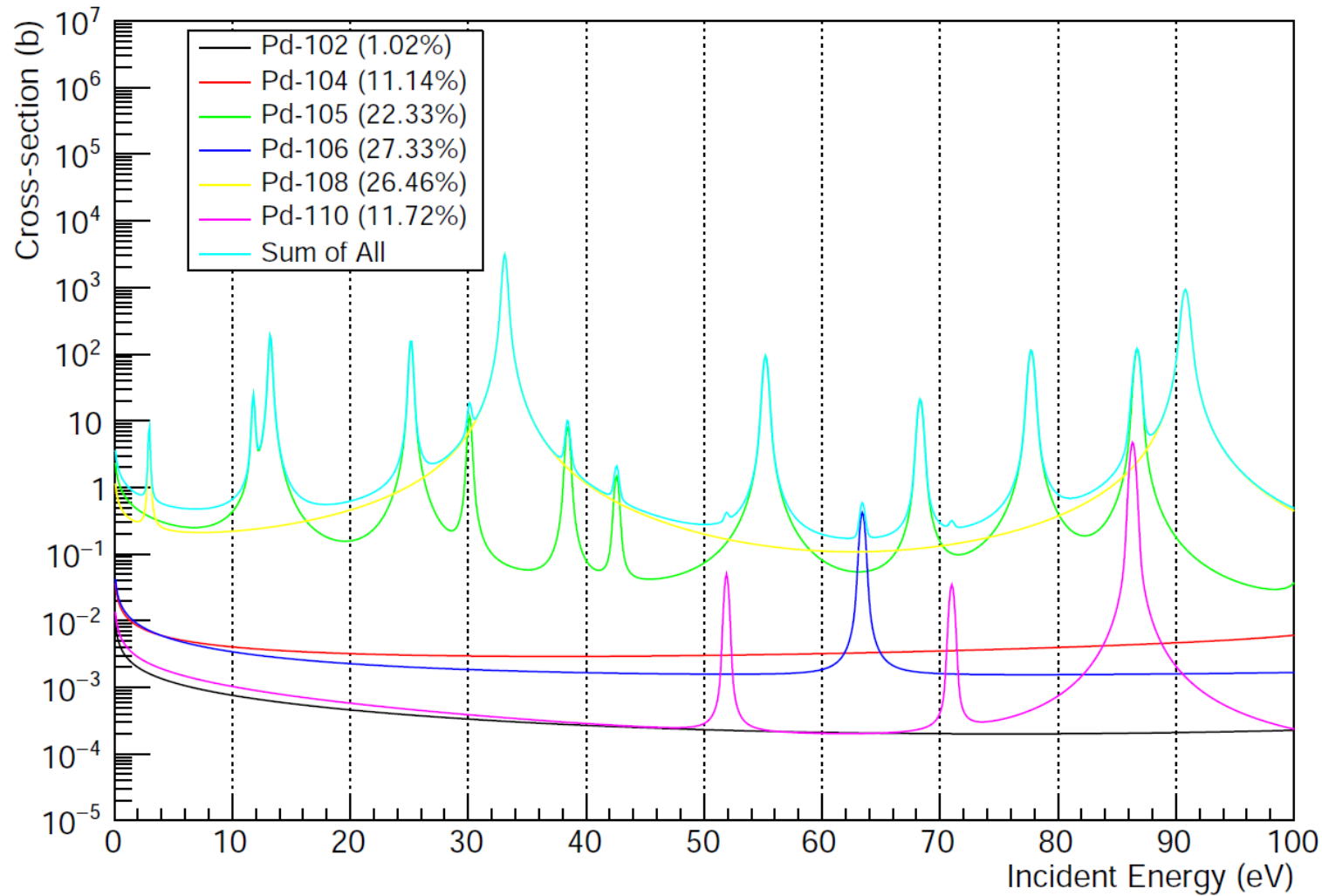


Resonance capture





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





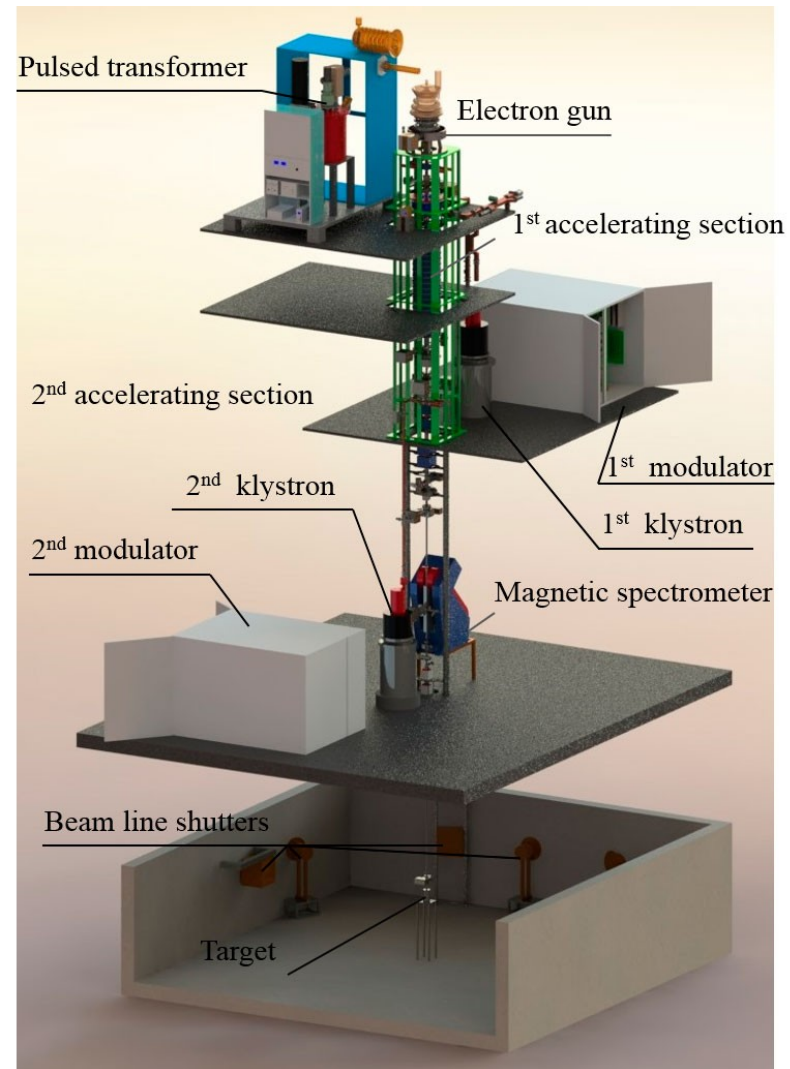
Neutron source: IREN Facility (layout)

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}

Quantum Beam Sci. 2017, 1, 6

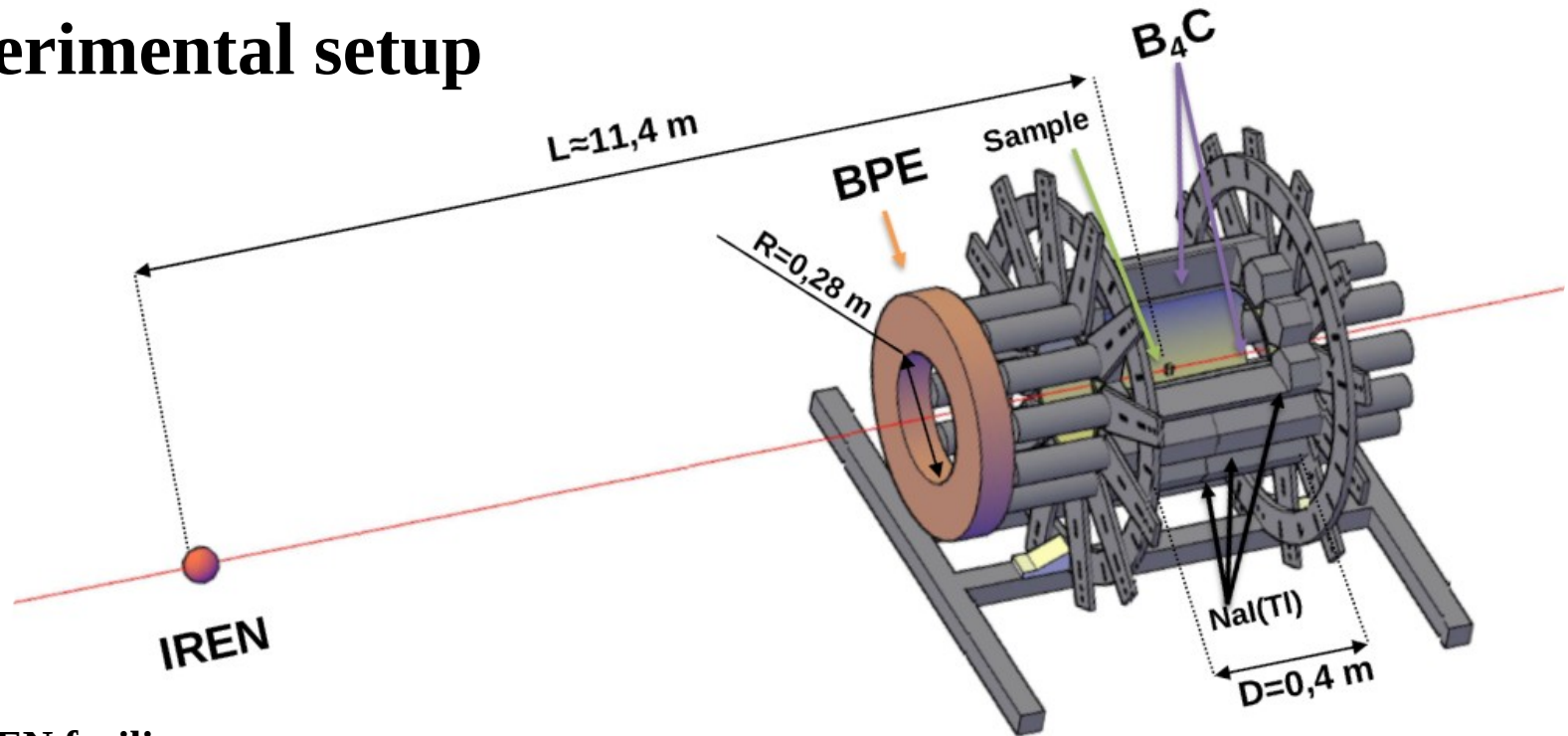
Current IREN characteristics:

- **pulsed electron beam current – 2.0 A**
 - **electron energy – 40 MeV**
 - **pulse width – 100 ns**
 - **repetition rate – 25 Hz**
 - **integral neutron yield $(3 \div 5) \times 10^{10}$ n/s.**
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- **New project:**
 - **200-MeV linear accelerator LUE-200 with a beam power of ~10 kW**
 - **Subcritical neutron multiplying target**
 - **Integral neutron yield of $\sim 10^{15}$ n/s and pulse width of $\sim 0.6 \mu\text{s}$.**

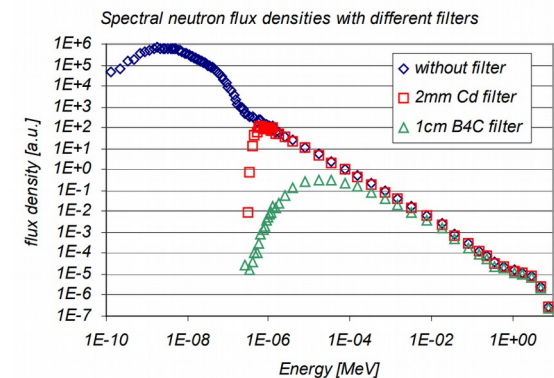




Experimental setup

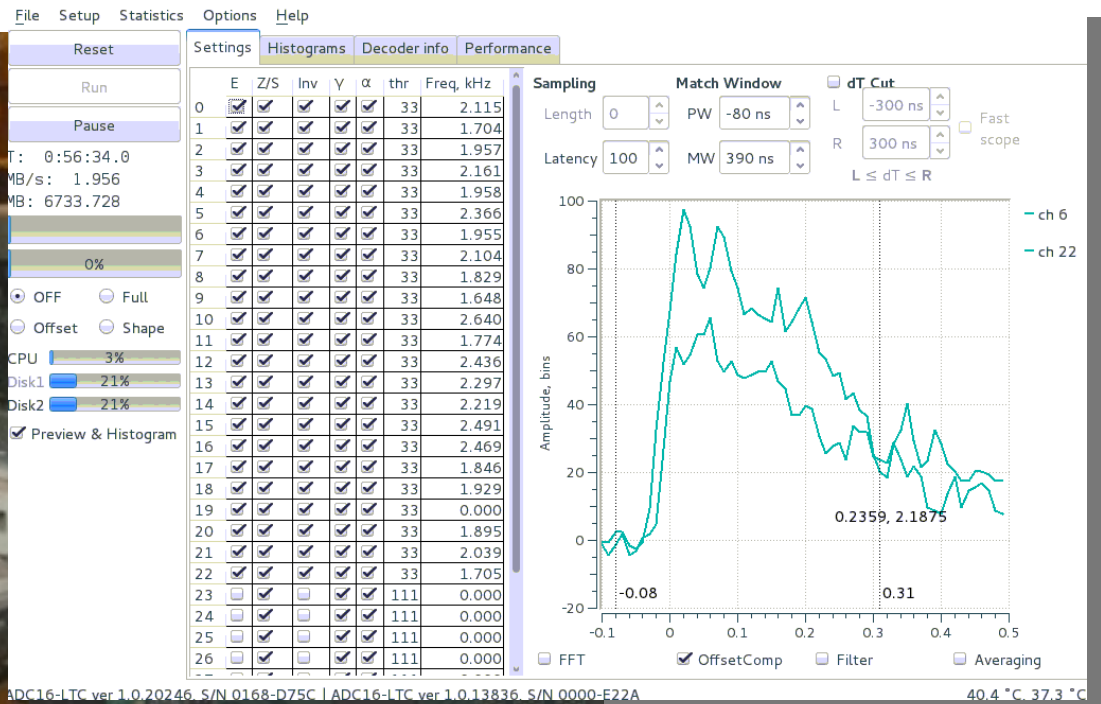
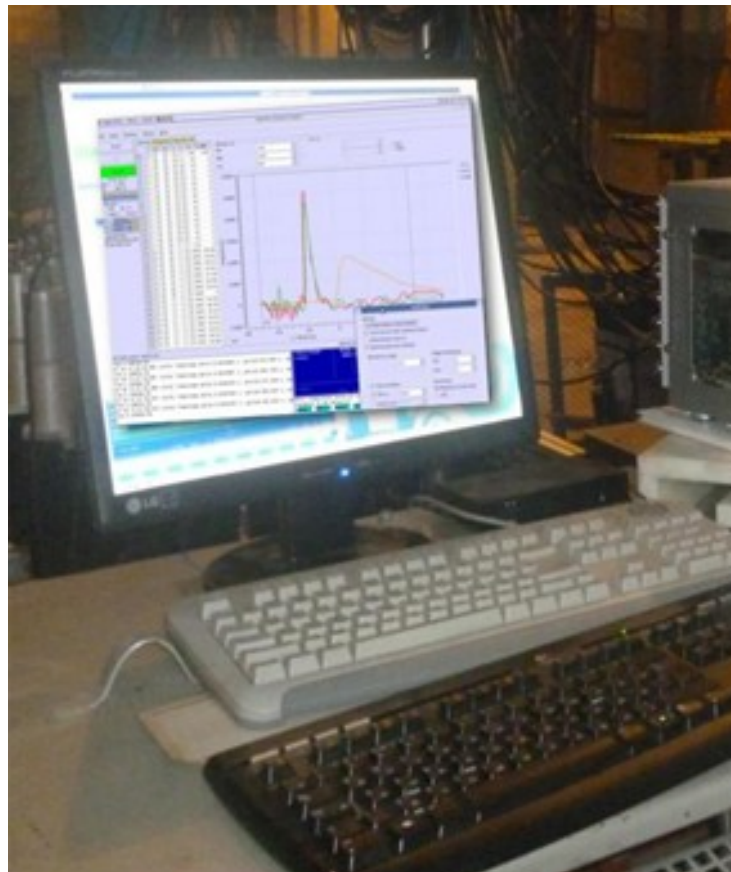


- IREN facility
- “Romashka” gamma-spectrometer: 24 hexagonal NaI(Tl) crystals (78x90x200 mm)
- 10cm-thick Boron polyethylene (BPE) collimator
- B₄C powder of 1cm thickness ($\rho=1.8 \text{ g/cm}^3$), encapsulated in-between 2 Al cylinders of 0.5 mm wall thickness, was used to capture the neutrons scattered 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.

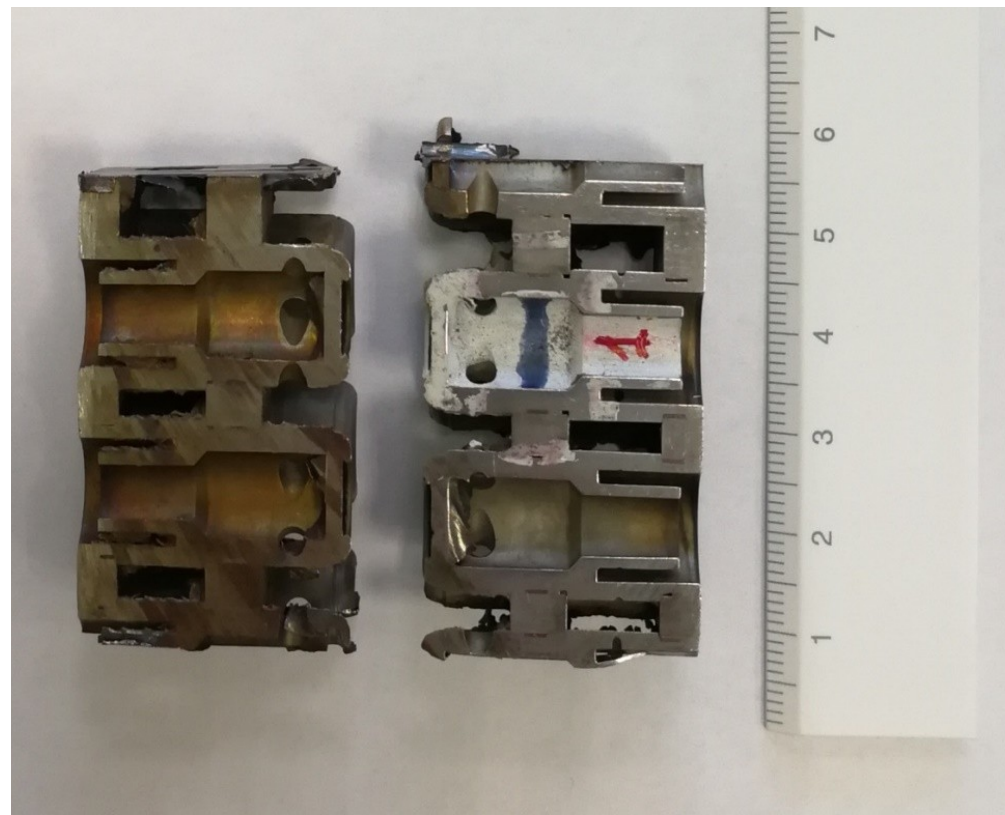


The samples

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.

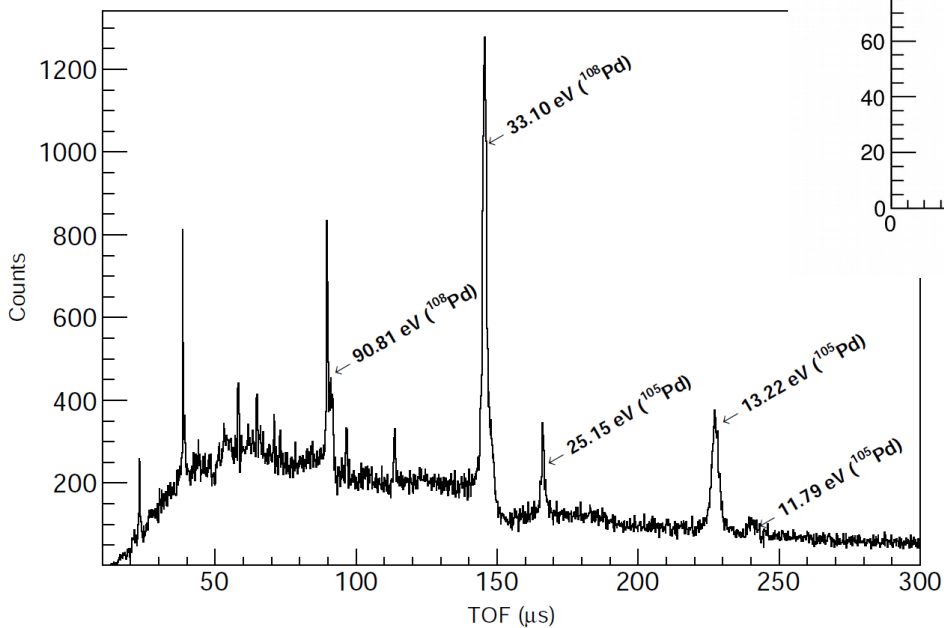
There was no Pd found in left-hand sample.



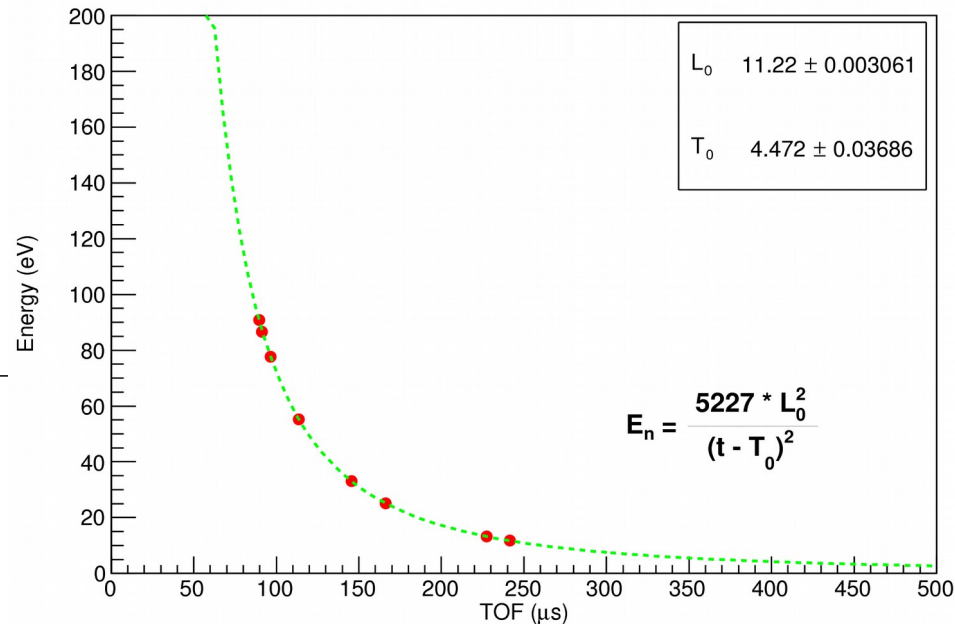


TOF-to-Energy calibration

Multiplicity - 03



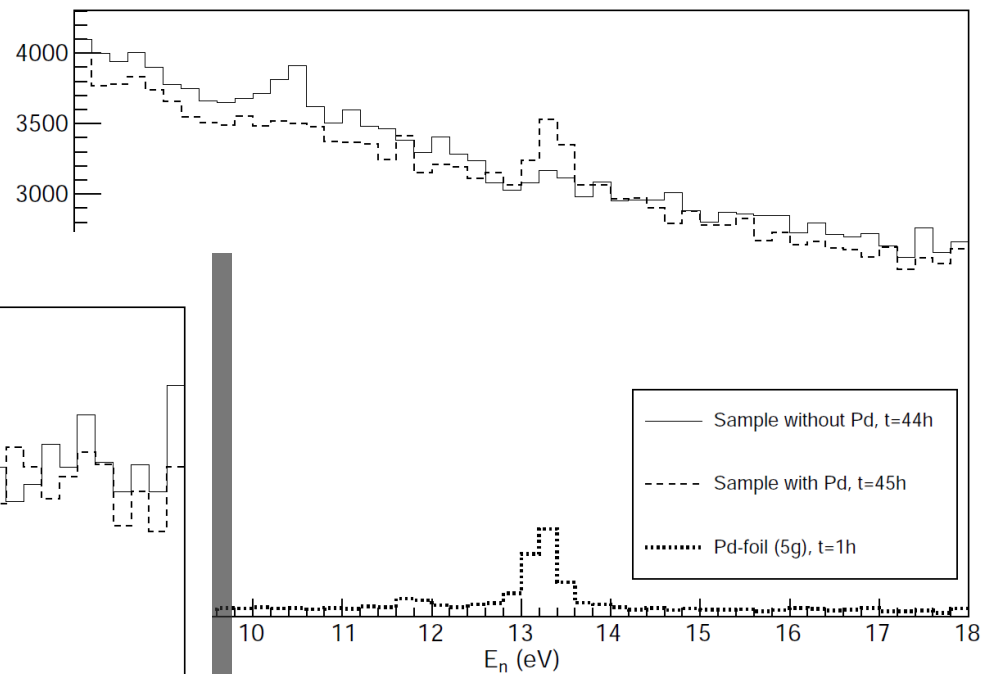
Energy Calibration



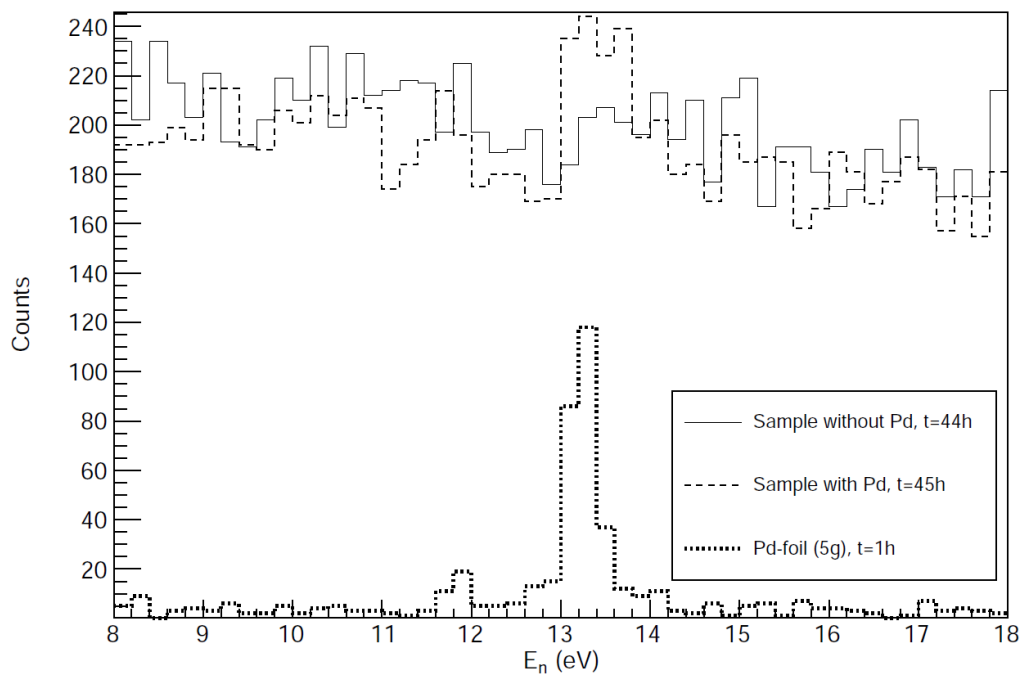


Detecting Pd in the sample

Multiplicity - 05



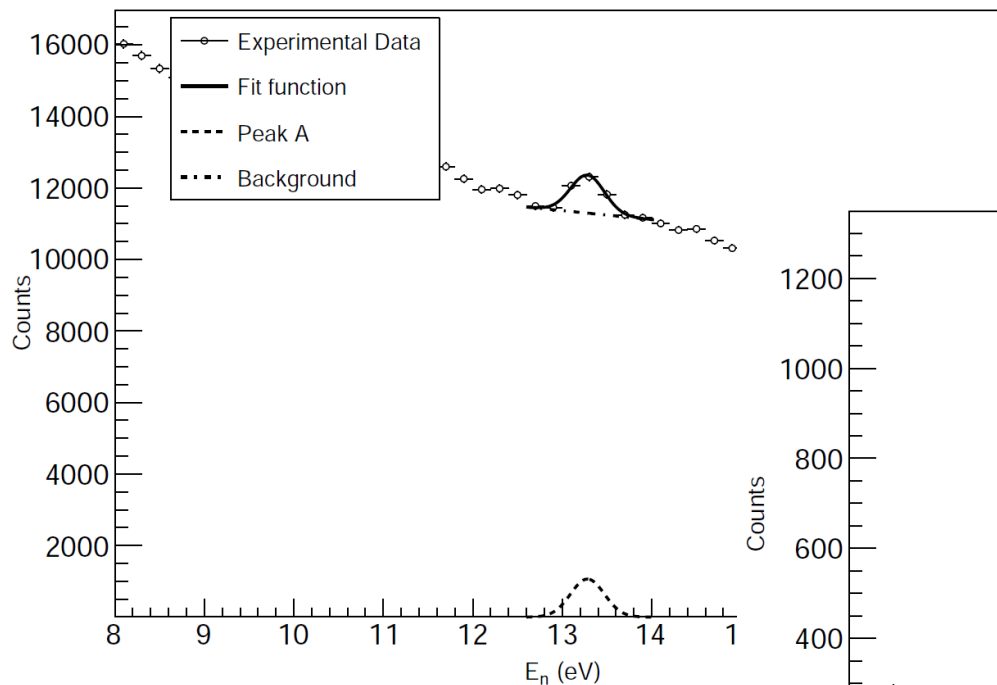
Multiplicity - 07



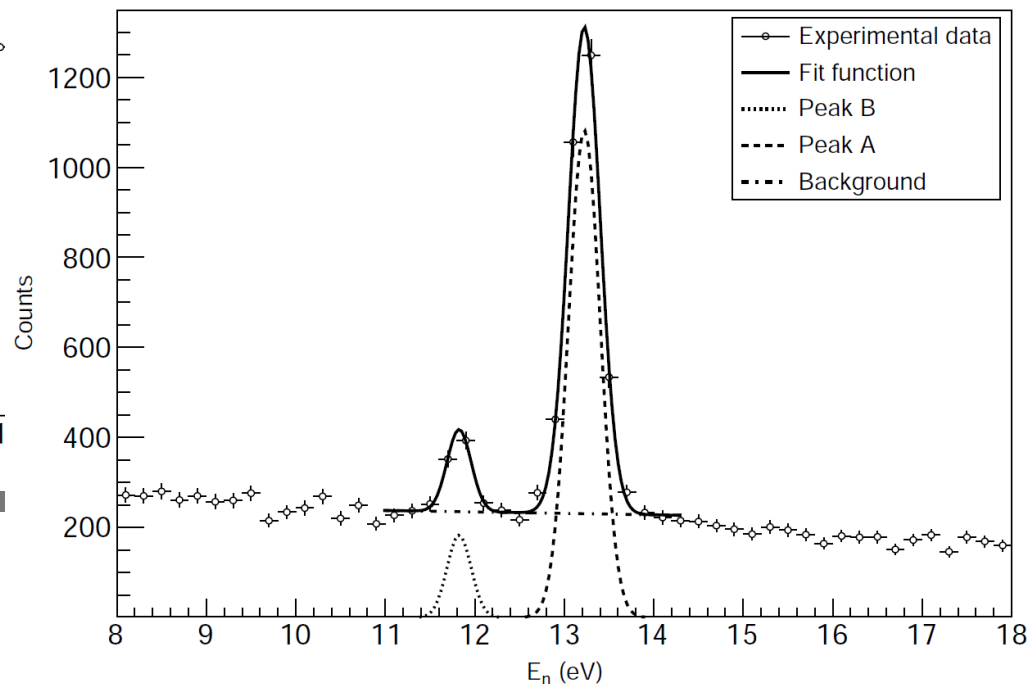


Calculating the amount of **Pd** in the sample

Sample with Pd and Multiplicity 04

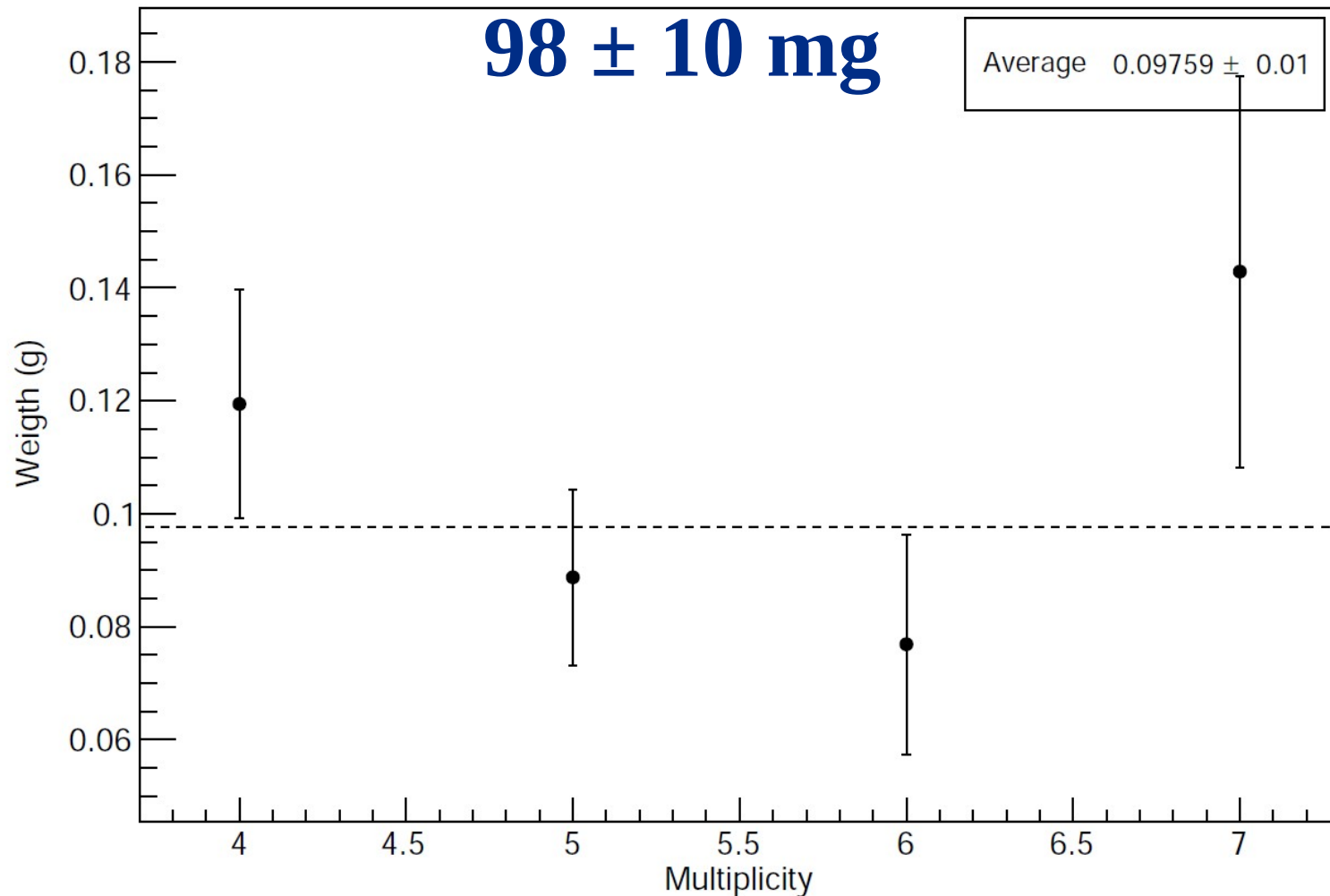


Pd-foil(5g) and Multiplicity 04





Average amount of **Pd** in the sample:





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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