First results of the νGeN experiment

A.Lubashevskiy on behalf of the νGeN collaboration

Joint Institute for Nuclear Research, Dubna, Russia

νGeN collaboration

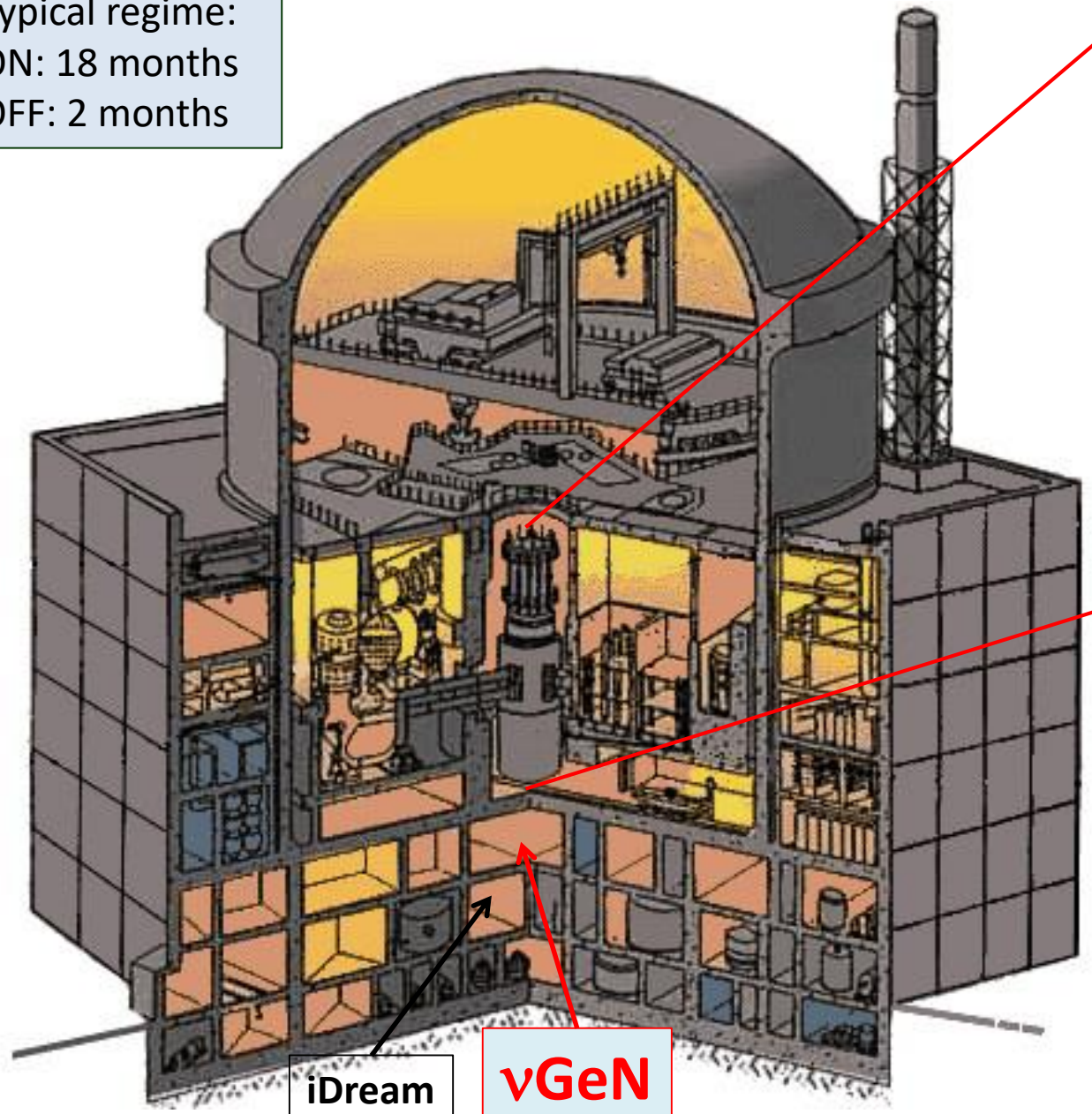
νGeN reactor site at Udomlya, Russia

Kalinin Nuclear Power Plant (KNPP) 4xWWER – 3.1 GW_{th}

JINR, Dubna, 285 km from KNPP

Reactor unit #3 @ KNPP

Typical regime:
ON: 18 months
OFF: 2 months



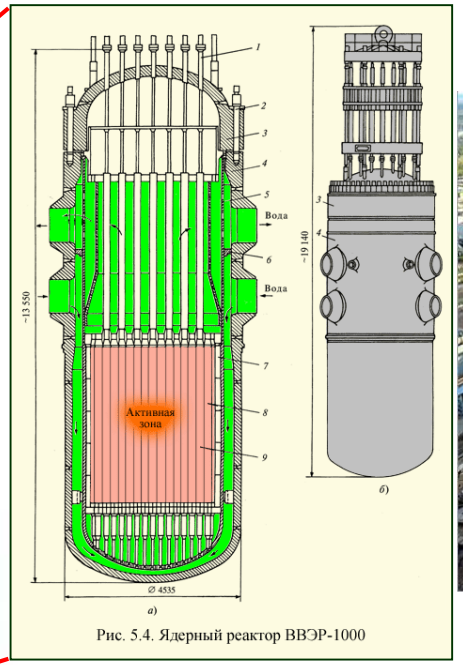


Рис. 5.4. Ядерный реактор ВВЭР-1000

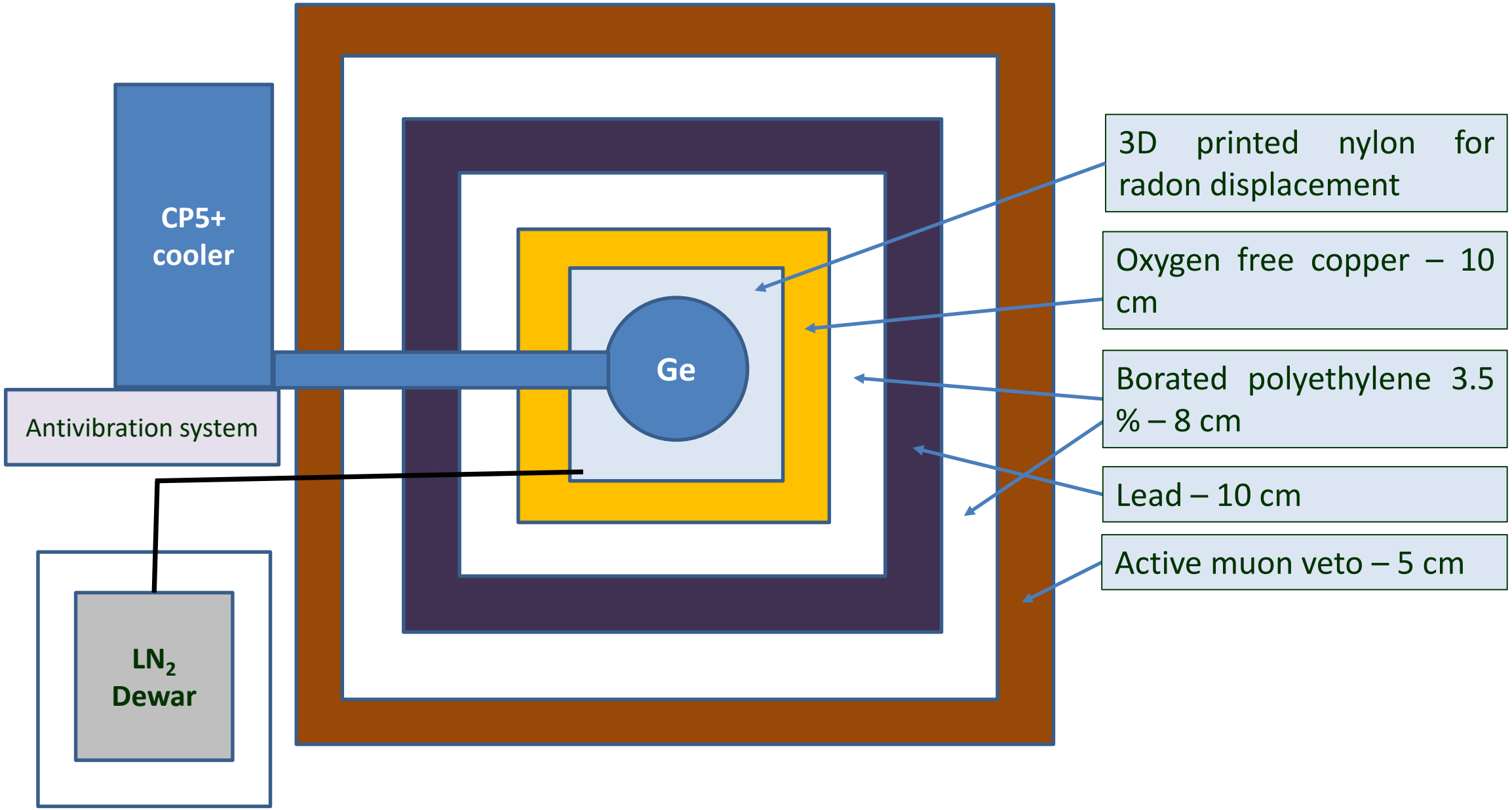
KNPP #3

- Spectrometer **νGeN** is located under the reactor unit #3 (3.1 GW_{th} – thermal power)
- Distance to the center of reactor core is about 10 m, this gives **> $5 \cdot 10^{13}$ ν/(sec·cm²)**
- Overburden **~ 50 m w.e.** – good shielding against cosmic radiation due to reactor's surrounding
- Good support from KNPP administration

HPGe detector for νGeN

To detect signals from neutrino scattering we use a specially produced by CANBERRA (Mirion, Lingosheim) low-threshold, low-background HPGe detectors. The detectors are chilled by electric and nitrogen types of cooling. Four detectors with masses of 1-1.4 kg were fabricated.

Current scheme of νGeN shielding



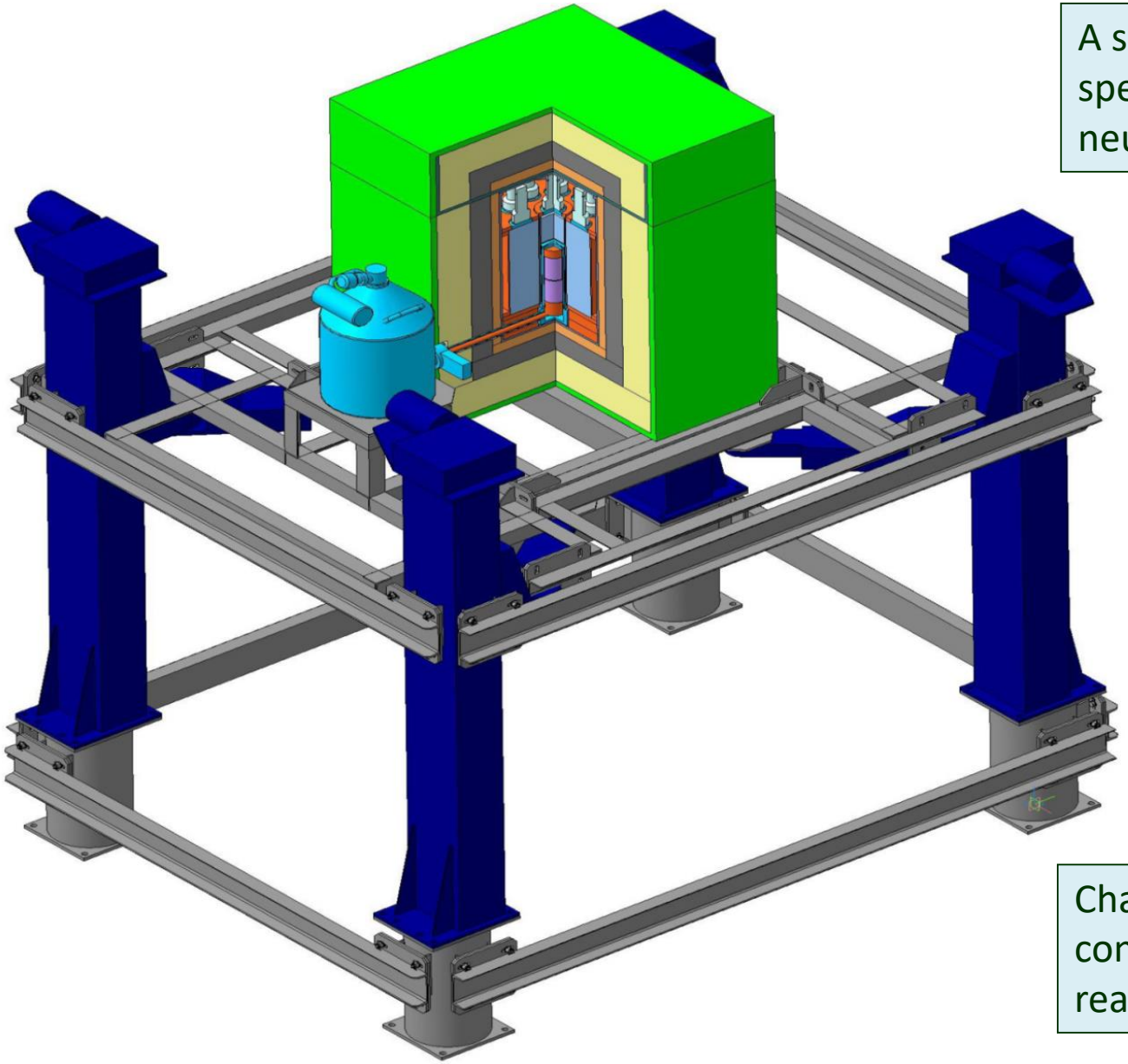
Installation at KNPP

- One detector with the stable performance was installed at KNPP in the end of 2019
- Detector equipped with electric cooling is used
- Passive and active shielding was installed
- Start data taking

Installation at KNPP

- Background coming from radon is decreased with the help of nitrogen flushing inside the shielding
- Active antivibration platform is used to suppress microphonic noises from various vibrations from reactor's equipment.
- Air conditioners provides stable temperature conditions in the experimental hall (< two degrees variation).

νGeN @ KNPP – lifting mechanism



A special lifting mechanism has been installed to move the spectrometer towards the reactor core to change the neutrino flux through the detector.

10.869 m – top position

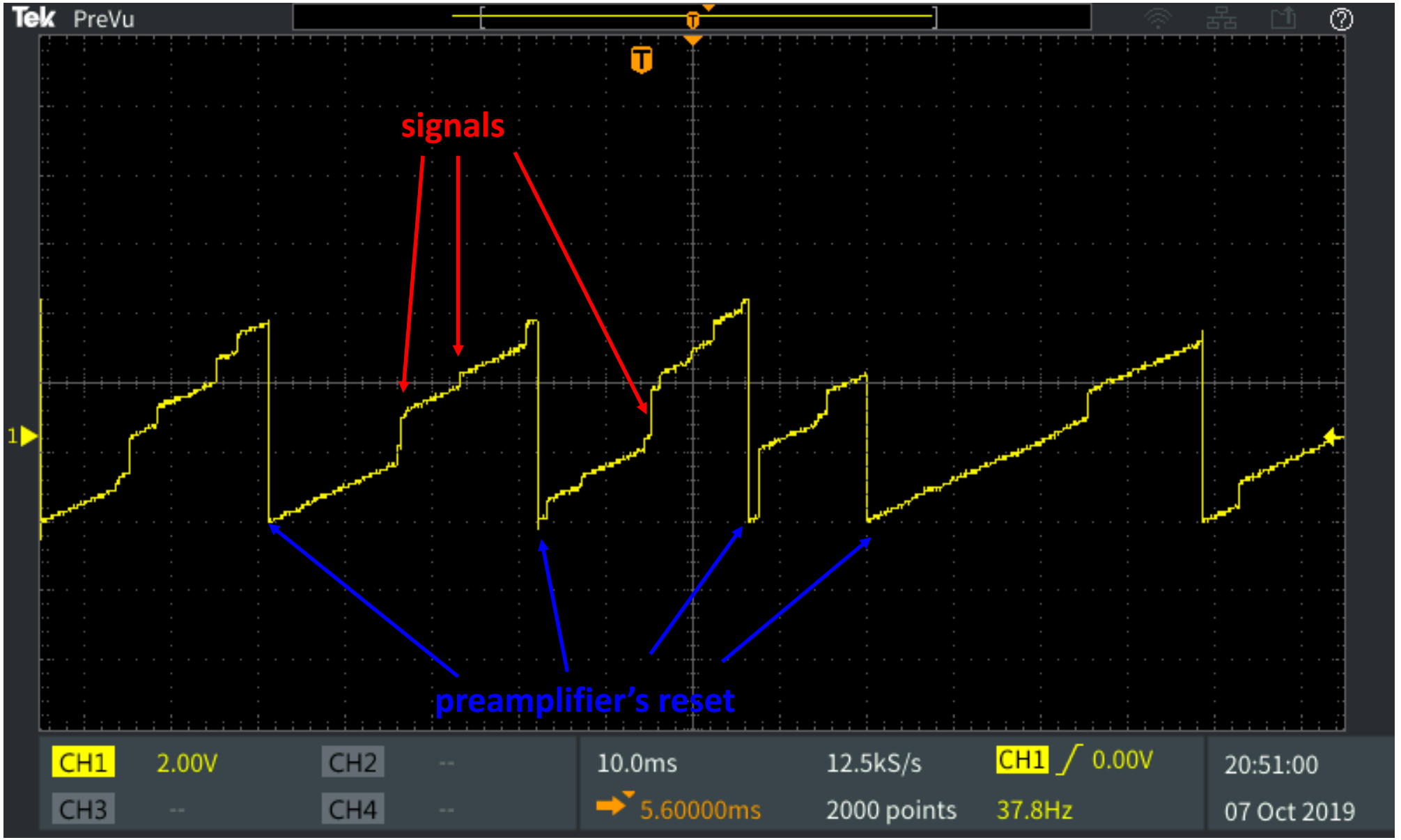
Distances to the center of reactor core:

11.835 m – current position

11.935 м – lower position

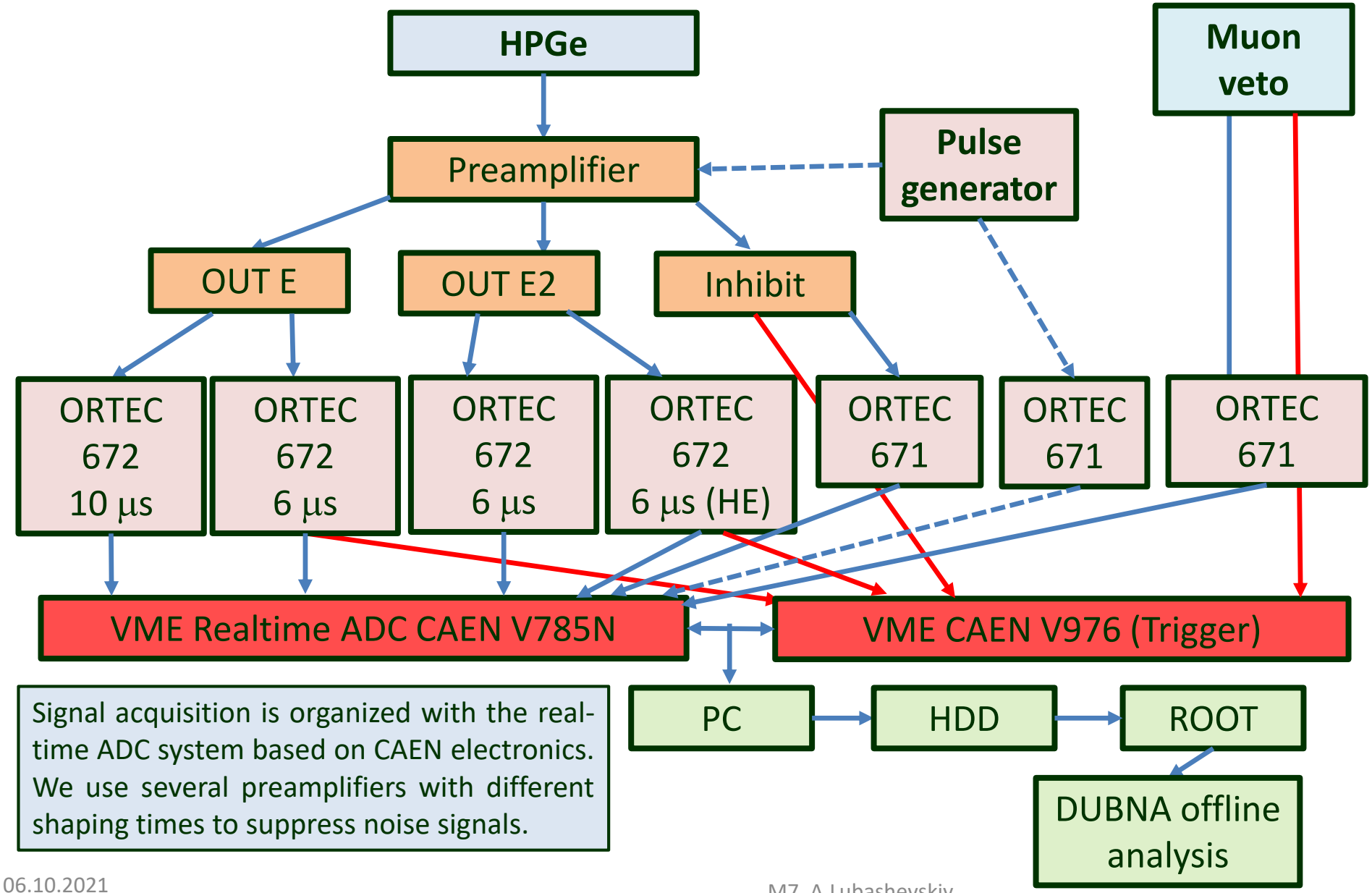
Changes of the ν flux help to suppress systematic errors connected with changes of the background while the reactor ON/OFF

Signals from detector

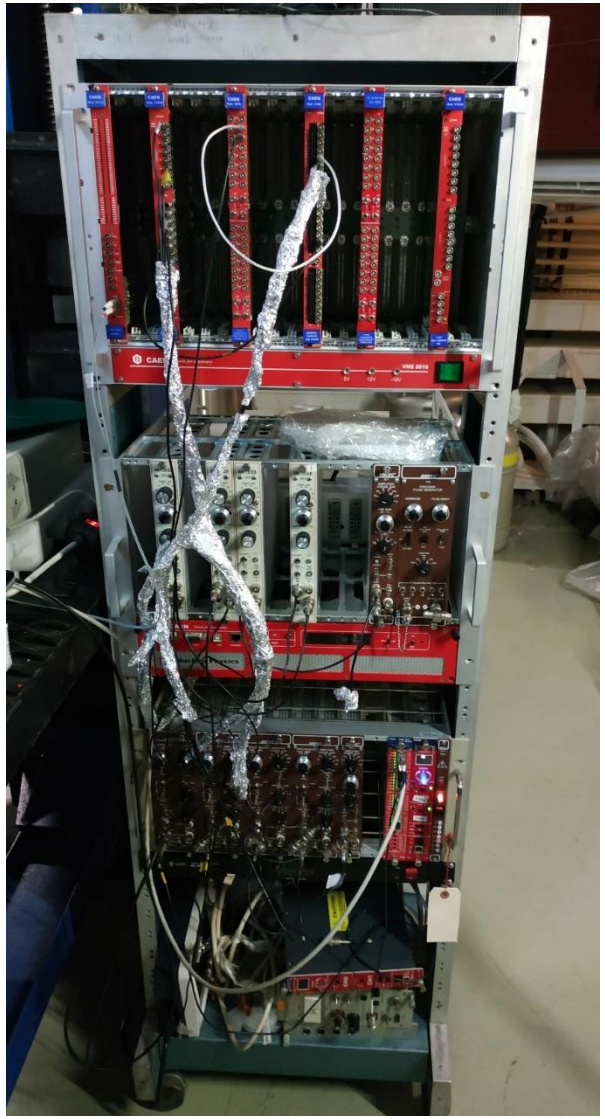


- Detectors are equipped with reset preamplifier.
- A typical rate of reset is ~ 5 Hz
- There is a special inhibit signal that indicates the time when the reset happens.
- The signals are shaped with amplifiers and processed with a real-time ADC.

Simplified scheme of measurements

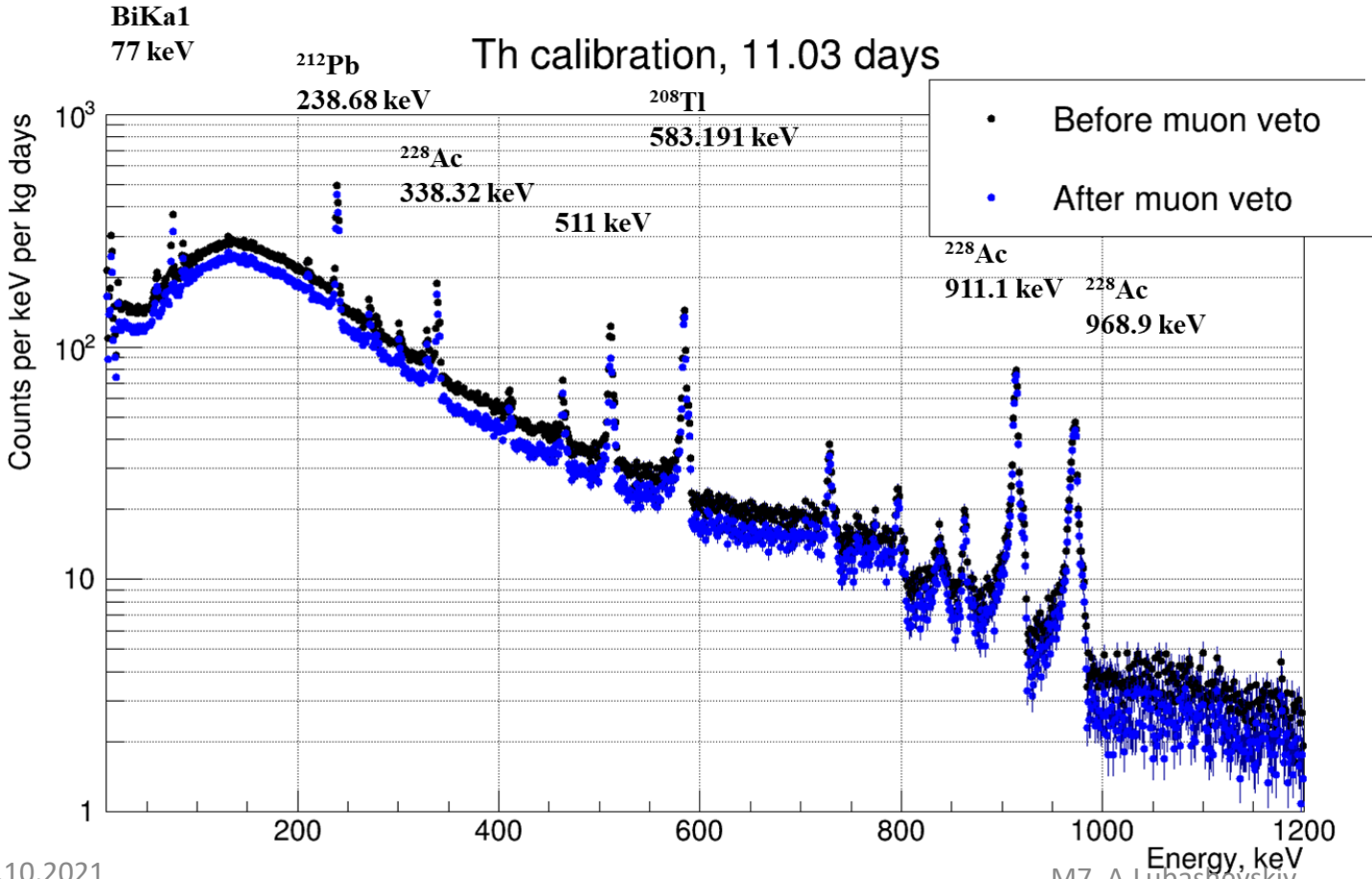


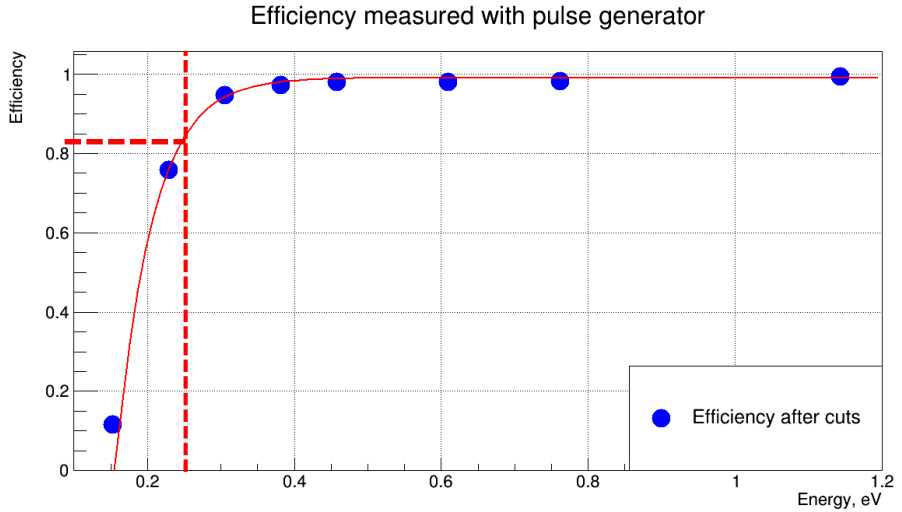
Signal acquisition is organized with the real-time ADC system based on CAEN electronics. We use several preamplifiers with different shaping times to suppress noise signals.

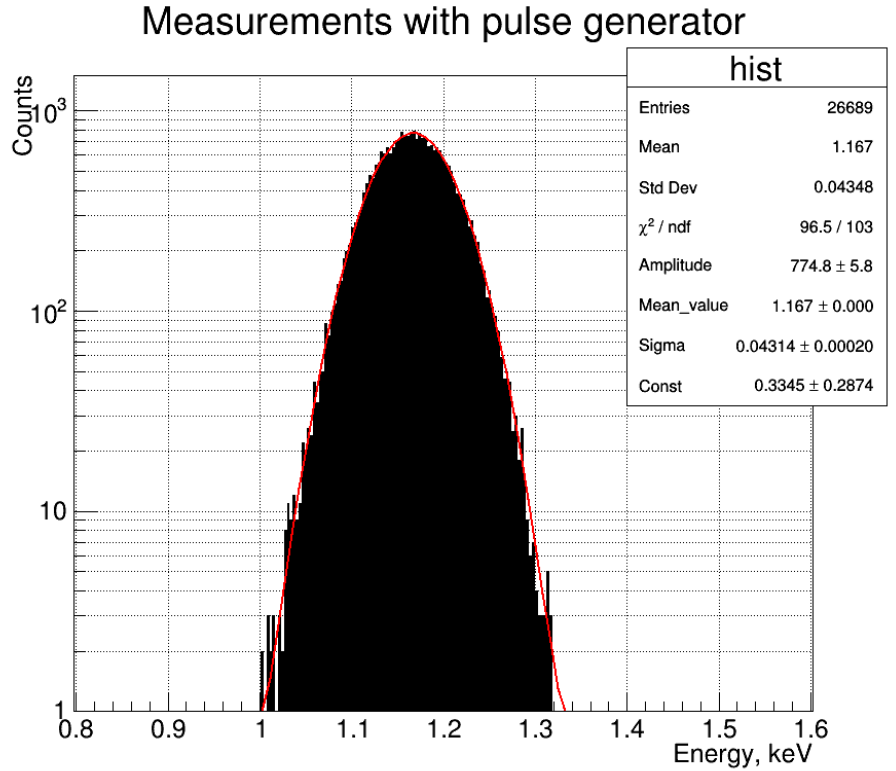


Measurements at KNPP

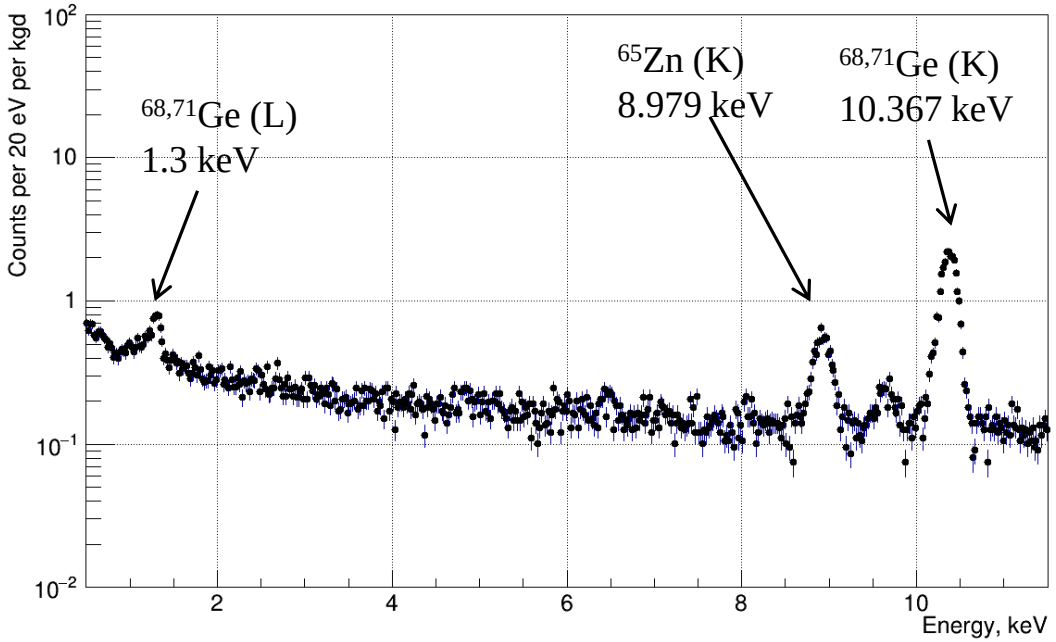
- High energy part of the spectra is calibrated with the help of welding rods (with 2% of Th)
- Energy resolution of 1.4 kg detector at KNPP is **101.6(5) eV** (FWHM).
- Trigger efficiency of signals above 250 eV is > 80%.





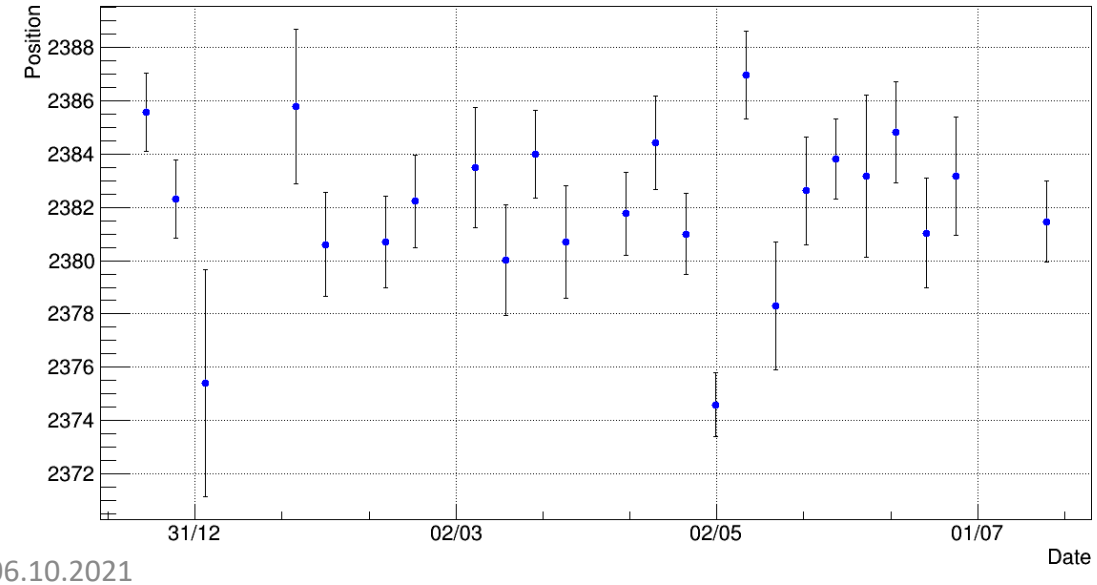


Calibration at low energies

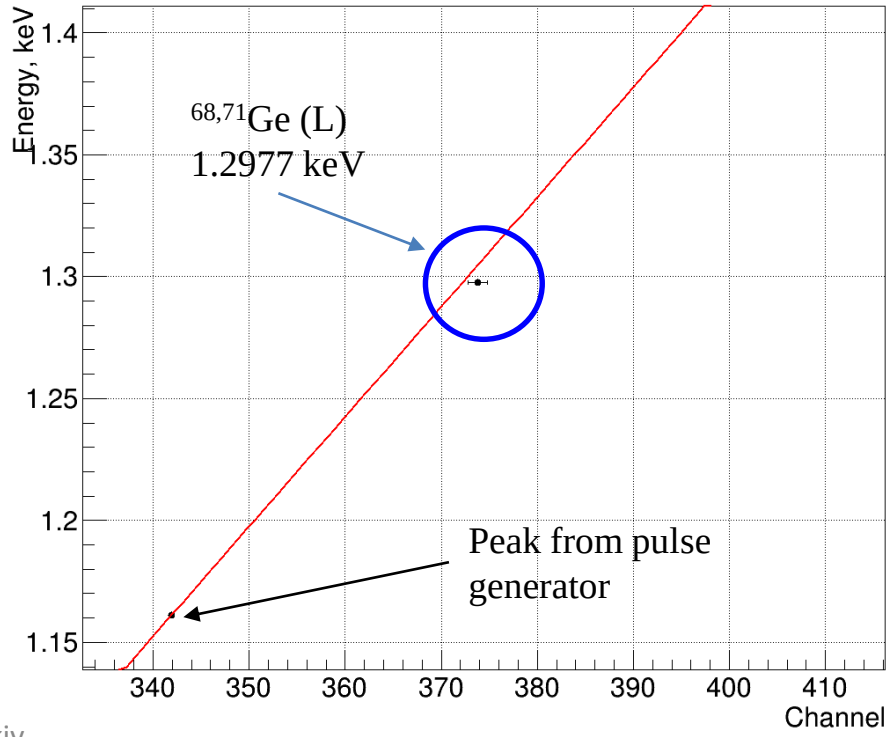


- Energy calibration at low energy is performed with the help of 10.37 keV cosmogenic line and pulse generator.
- Calibration check with 1.3 keV line
- Data taking shows very good stability of peak position during all measurement time.

Position of 10.37 keV peak, channel 1

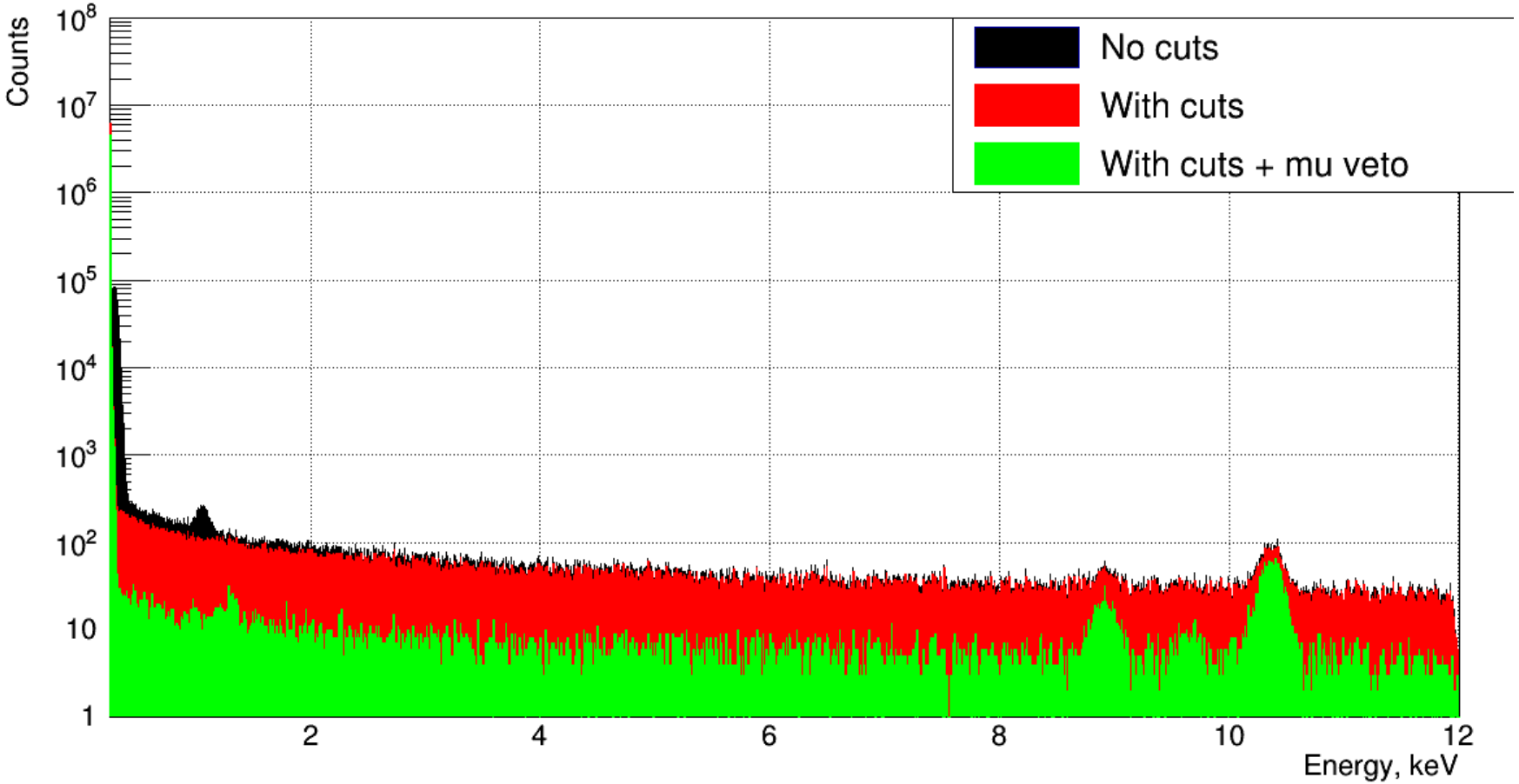


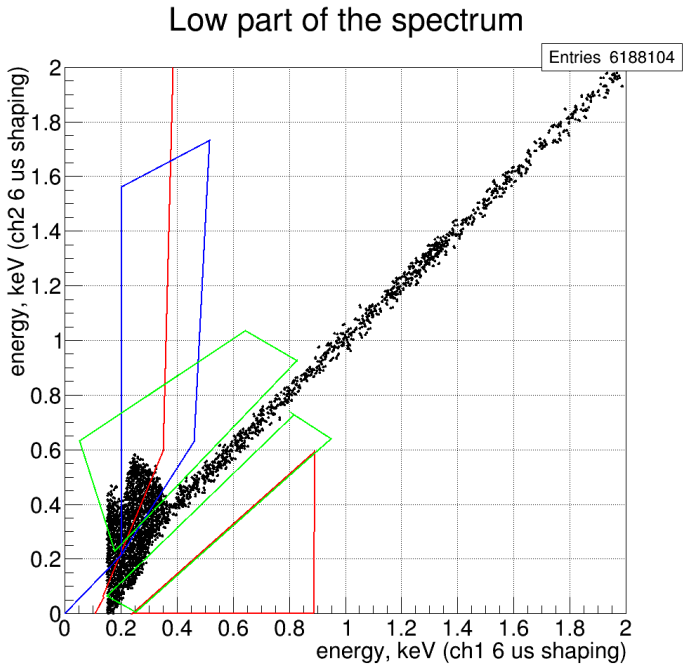
Low energy calibration

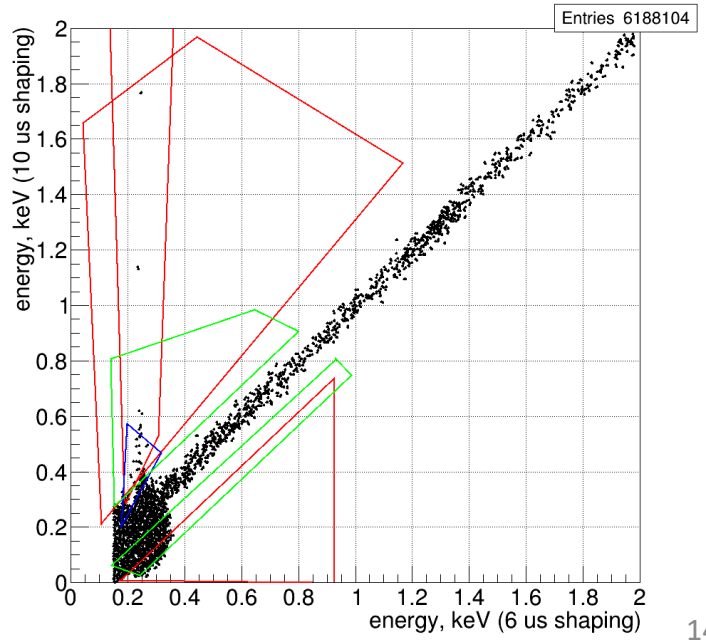


Cuts

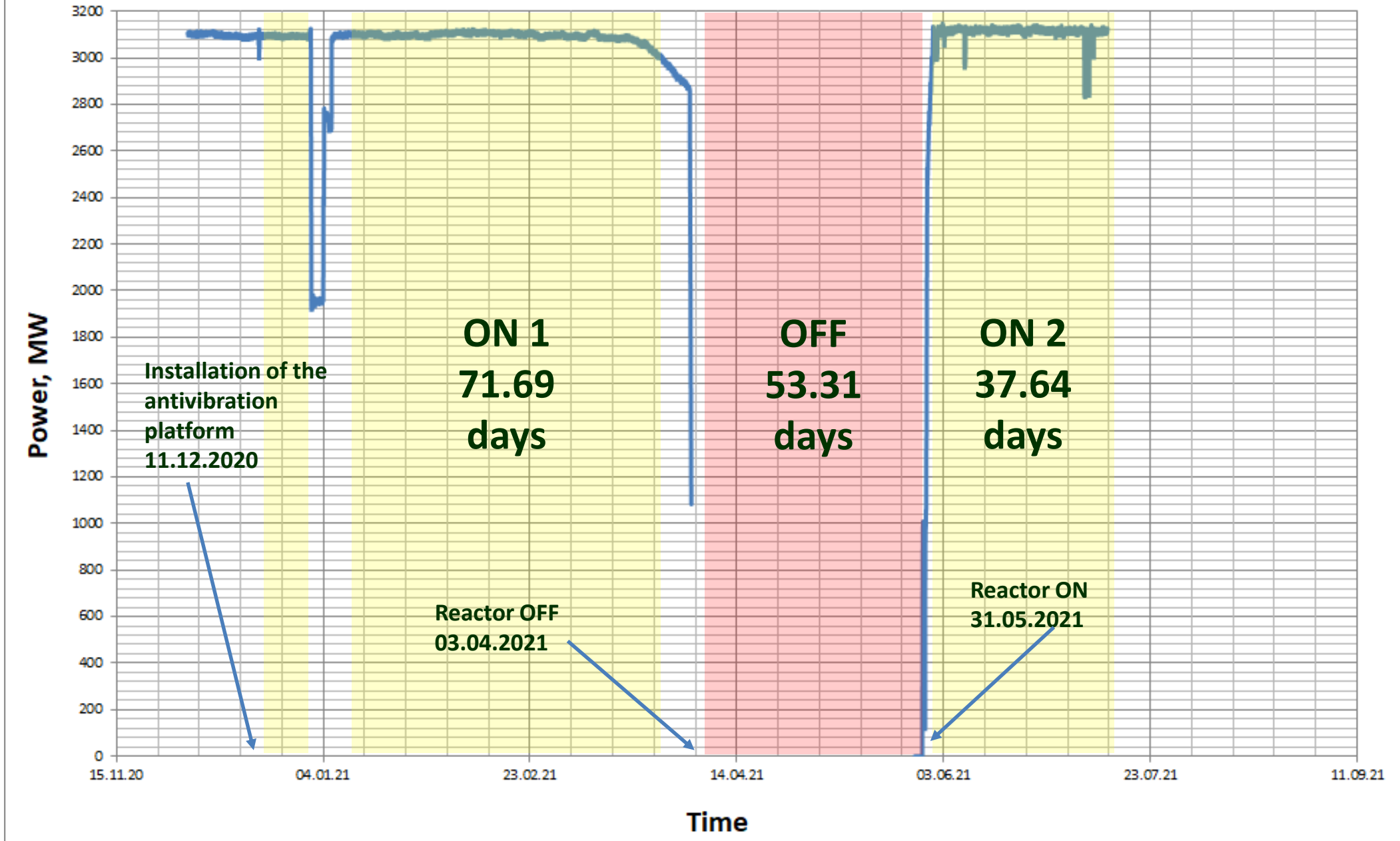
- Time cuts allow to suppress signals generated by reset of the preamplifier and other artificial signals.
- Different shaping times of preamplifiers are used to suppress the noise with the help of graphical cuts.
- **Efficiency of all cuts and muon veto determined by 10.37 keV line is 83.4(25)%**

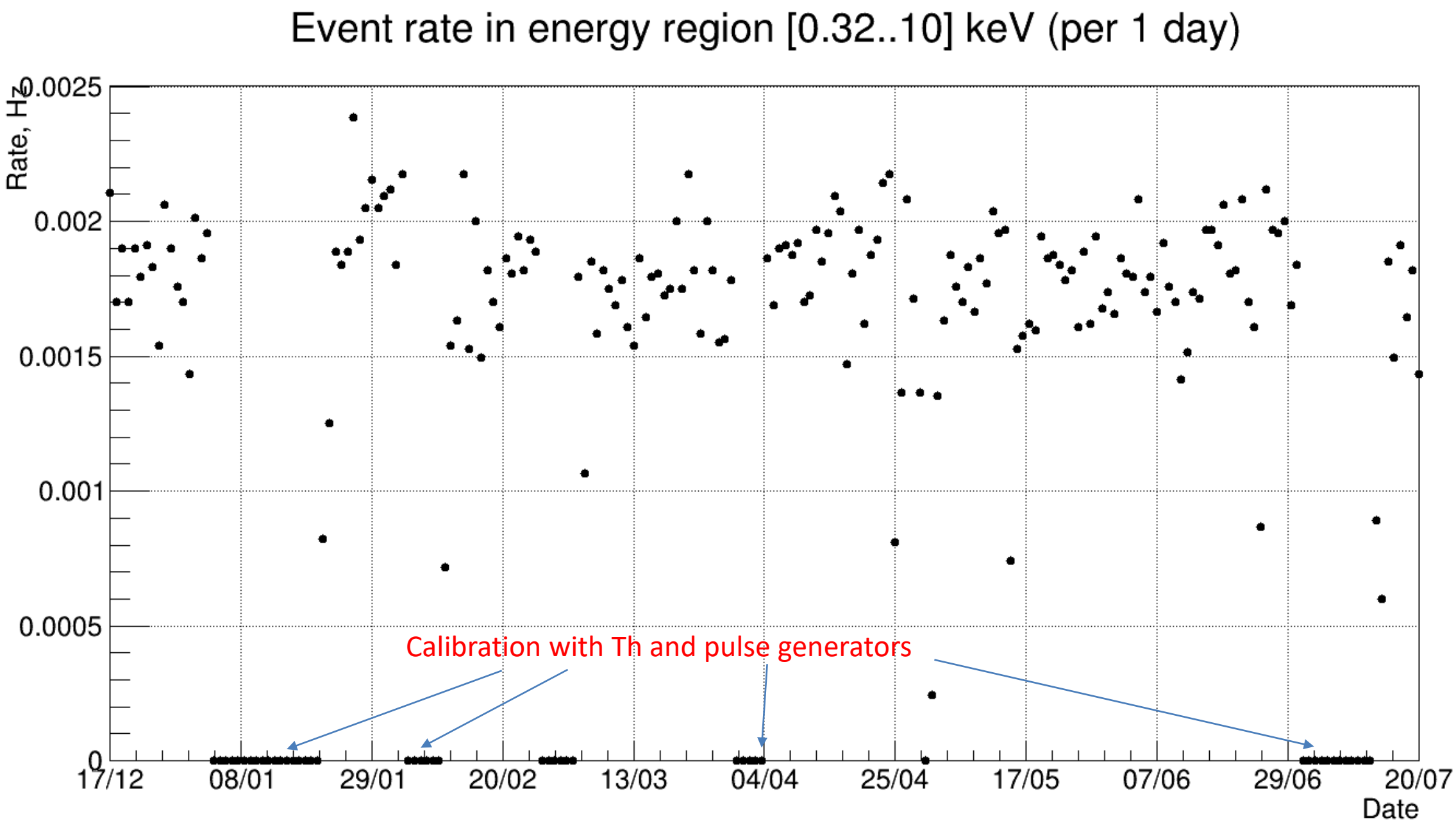




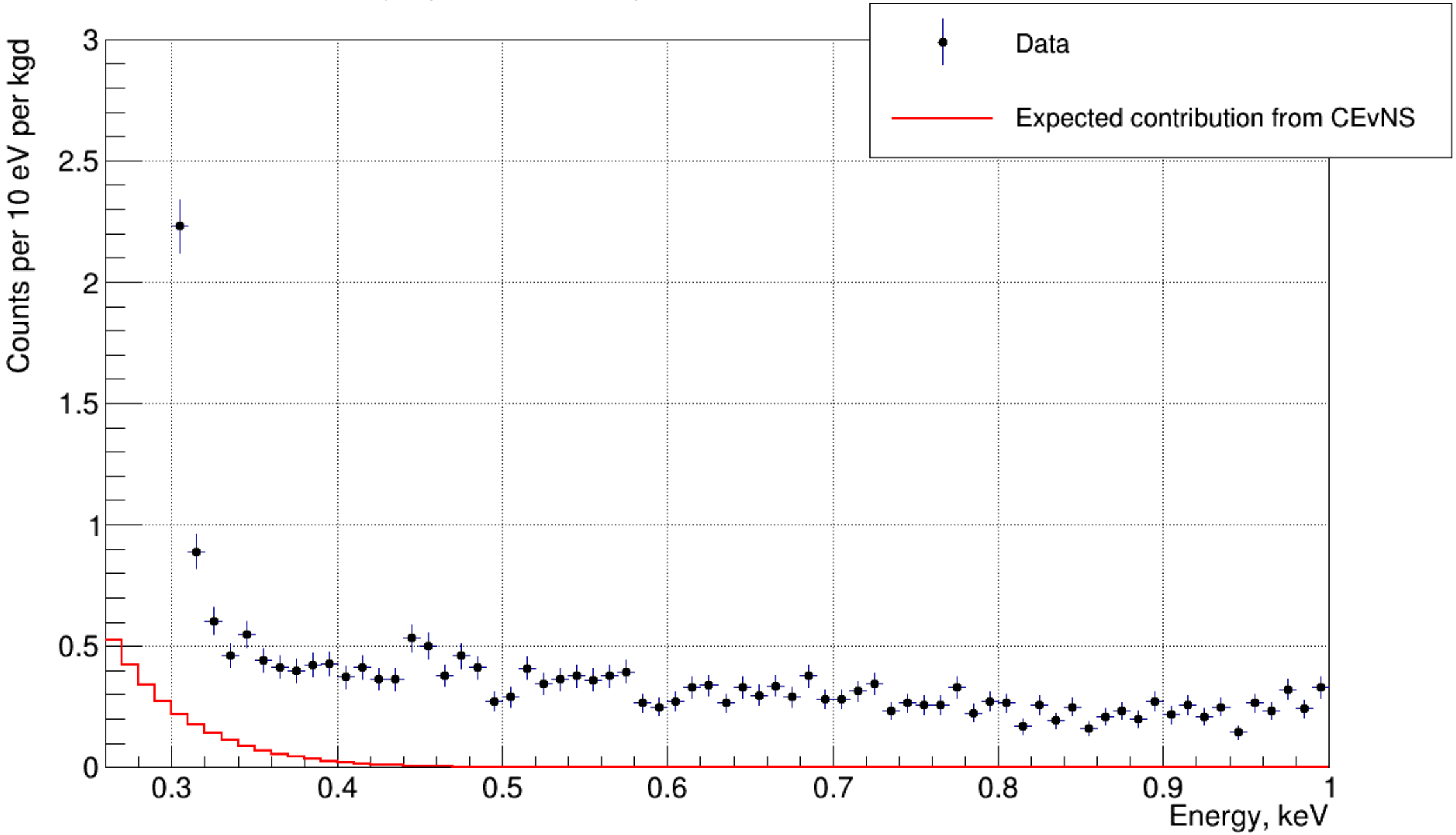


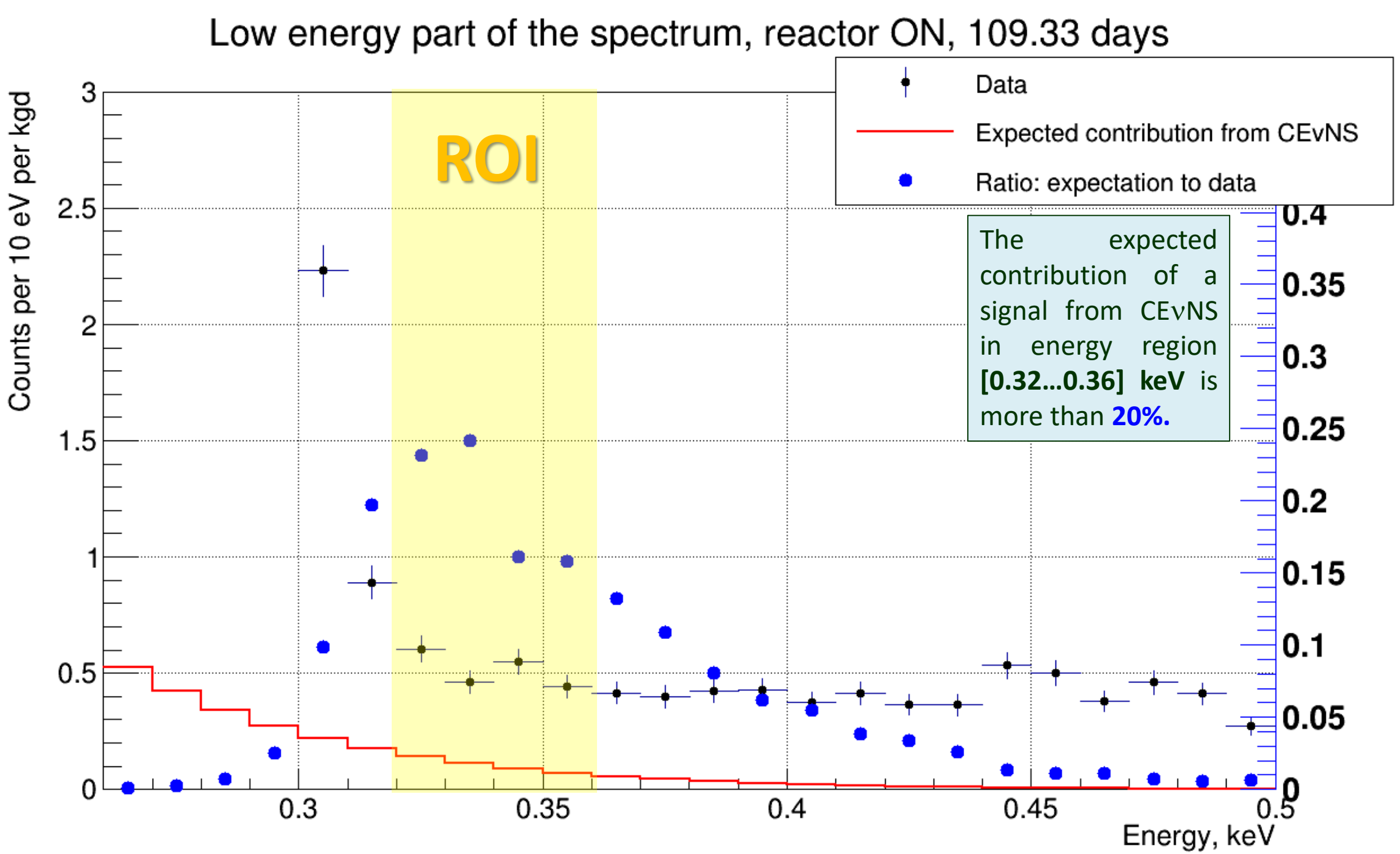
Time changes of the thermal power of reactor unit #3

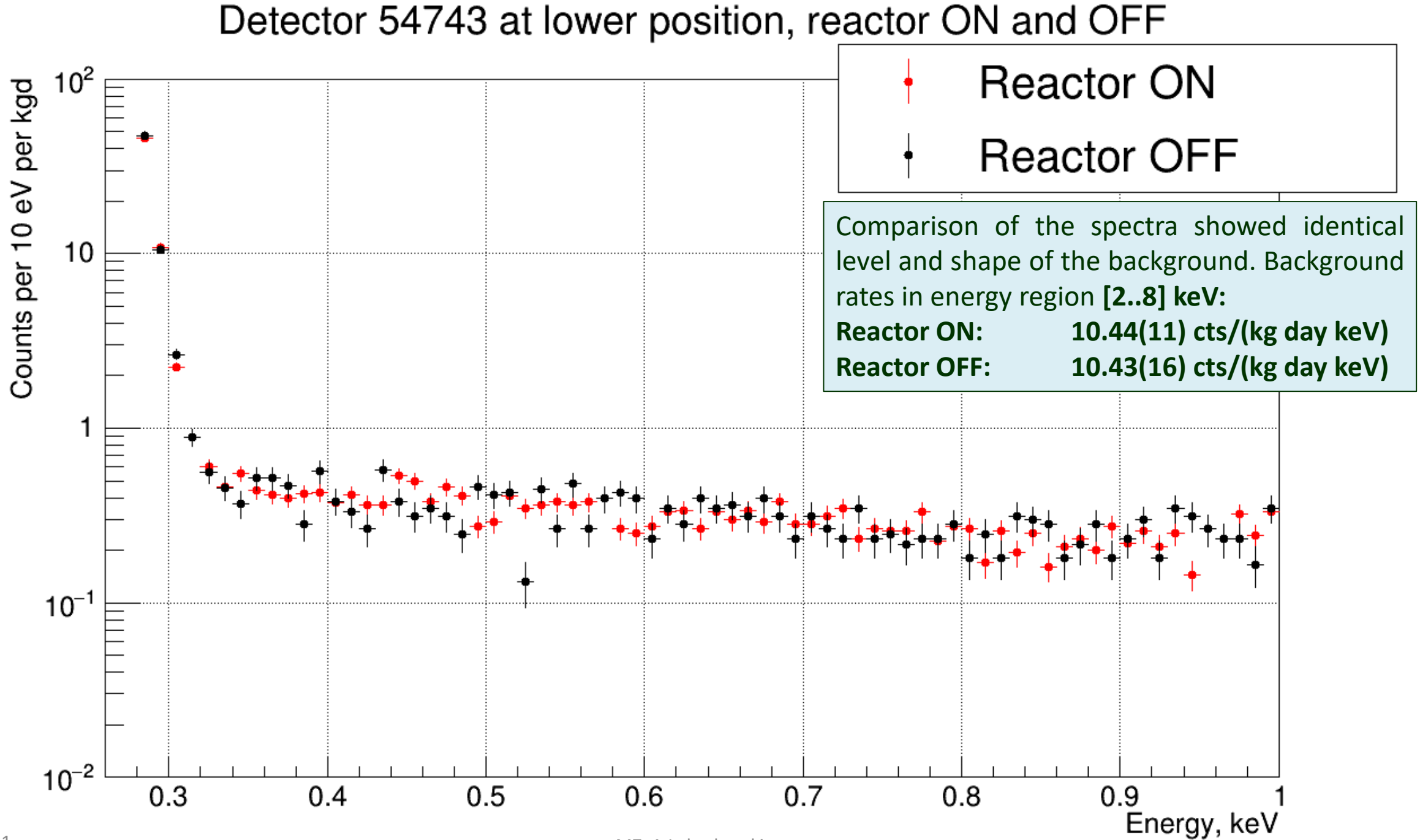




Stable rate is observed during all time of the measurement


Low energy part of the spectrum, reactor ON, 109.33 days
Data
Expected contribution from CEvNS
Counts per 10 eV per kgd
Energy, keV
0
0.5
1
1.5
2
2.5
3
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1


Low energy part of the spectrum, reactor ON, 109.33 days
ROI
Data
Expected contribution from CEvNS
Ratio: expectation to data
The expected contribution of a signal from CEνNS in energy region [0.32…0.36] keV is more than 20%.
Counts per 10 eV per kgd
Energy, keV
0
0.5
1
1.5
2
2.5
3
0.3
0.35
0.4
0.45
0.5
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4

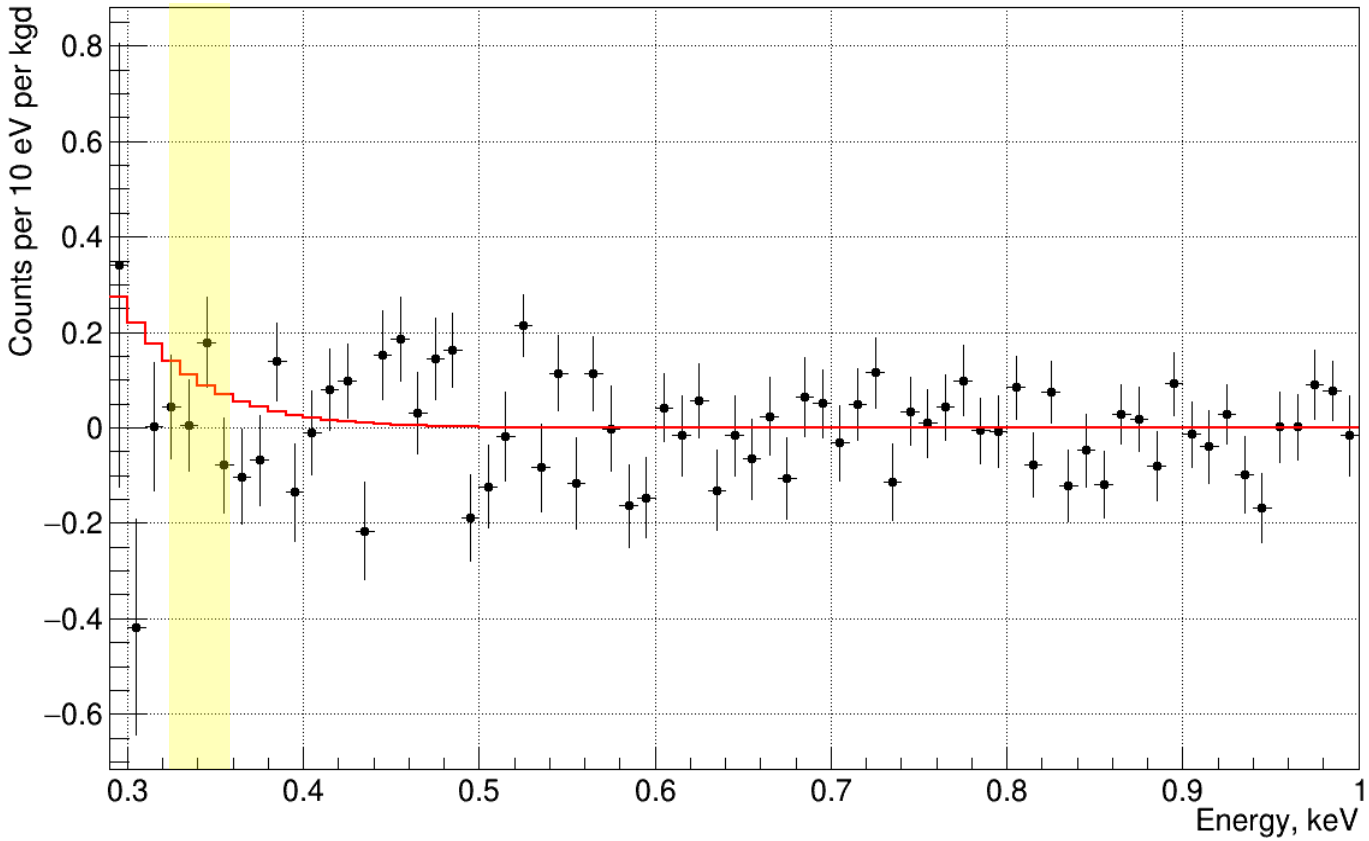


Comparison of the spectra showed identical level and shape of the background. Background rates in energy region **[2..8] keV:**

Reactor ON: **10.44(11) cts/(kg day keV)**

Reactor OFF: **10.43(16) cts/(kg day keV)**

ON - OFF



- Analysis of the data gives **< 0.47 cts/kgd** for CEνNS @ 90% C.L. in energy region of [320..360] eV.
- The expected rate of the events from CEνNS is **0.46 cts/kgd** (With Lindhard model parameter **k = 0.179**). This value has not fully known due to uncertainties of quenching and high energy neutrino spectra from the reactor. So no tension is visible so far?

	Counts in region [320..360] eV	Measurement time, days	Counts per kgd (stat. error only)
Reactor ON	**301**	**109.33**	**2.47 ± 0.14**
Reactor OFF	**144**	**53.31**	**2.42 ± 0.20**
Subtracted			**0.047 ± 0.26**
Expected from CEνNS			**0.46**

Conclusion

- Measurements with νGeN spectrometer with the first detector at Kalinin Nuclear Power Plant has been started.
- First results show that achieved background level allows to search for CEνNS at KNPP. No significant difference between regimes with reactor ON and OFF has been observed so far.
- More optimization of the analysis and new detectors are ongoing.
- Lifting mechanism was tested and it will be used soon for reducing distance to the reactor core.
- New results with more statistics and optimized measurements modes are expected soon.

Thank you!