Status of IDREAM detector

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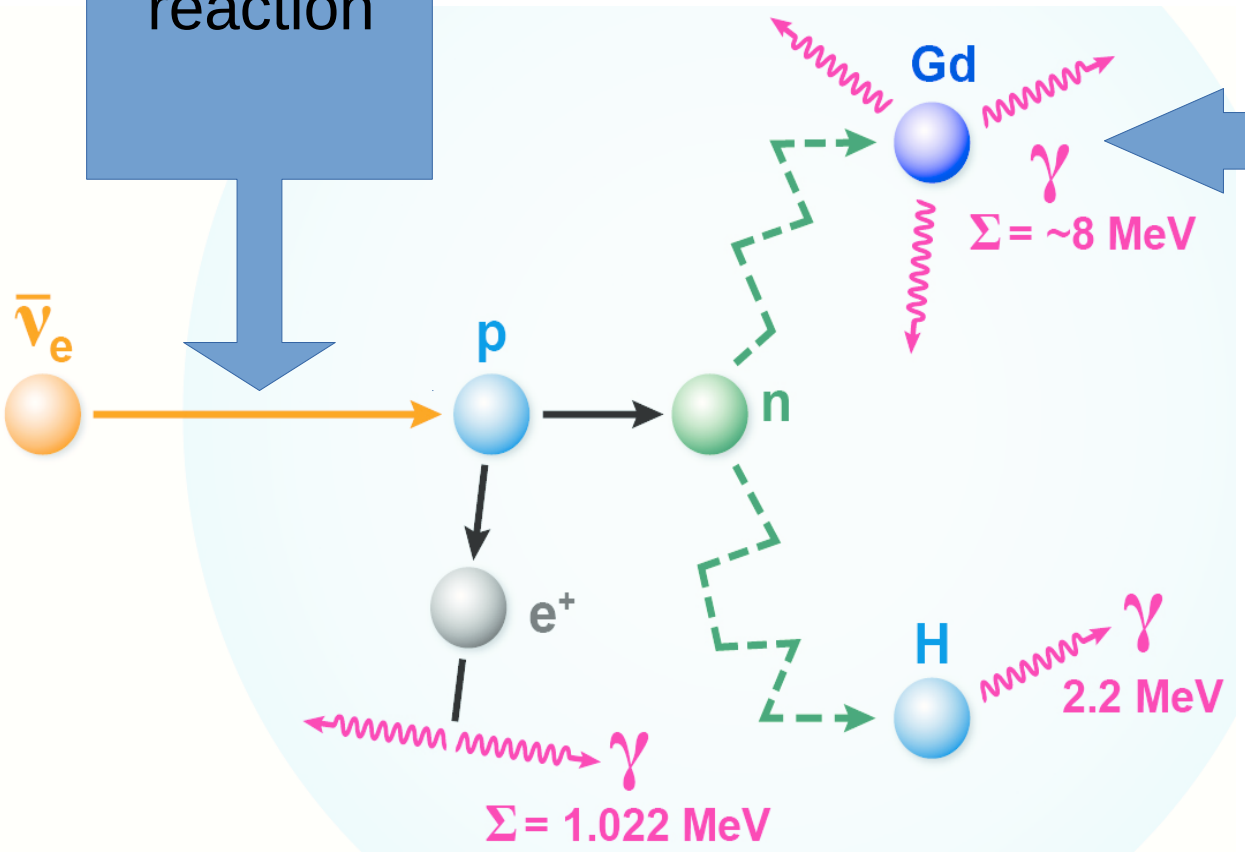
Inverse beta-decay process

Inverse beta-decay reaction

$$\tilde{\nu}_e + p \rightarrow e^+ + n \rightarrow (e^+ + e^- \rightarrow 2\gamma) + n$$



Gd improves the efficiency of neutron detection

$E_{threshold}$ = 1.806 MeV

$E_{promt} = E_\nu$ – 0.8 MeV

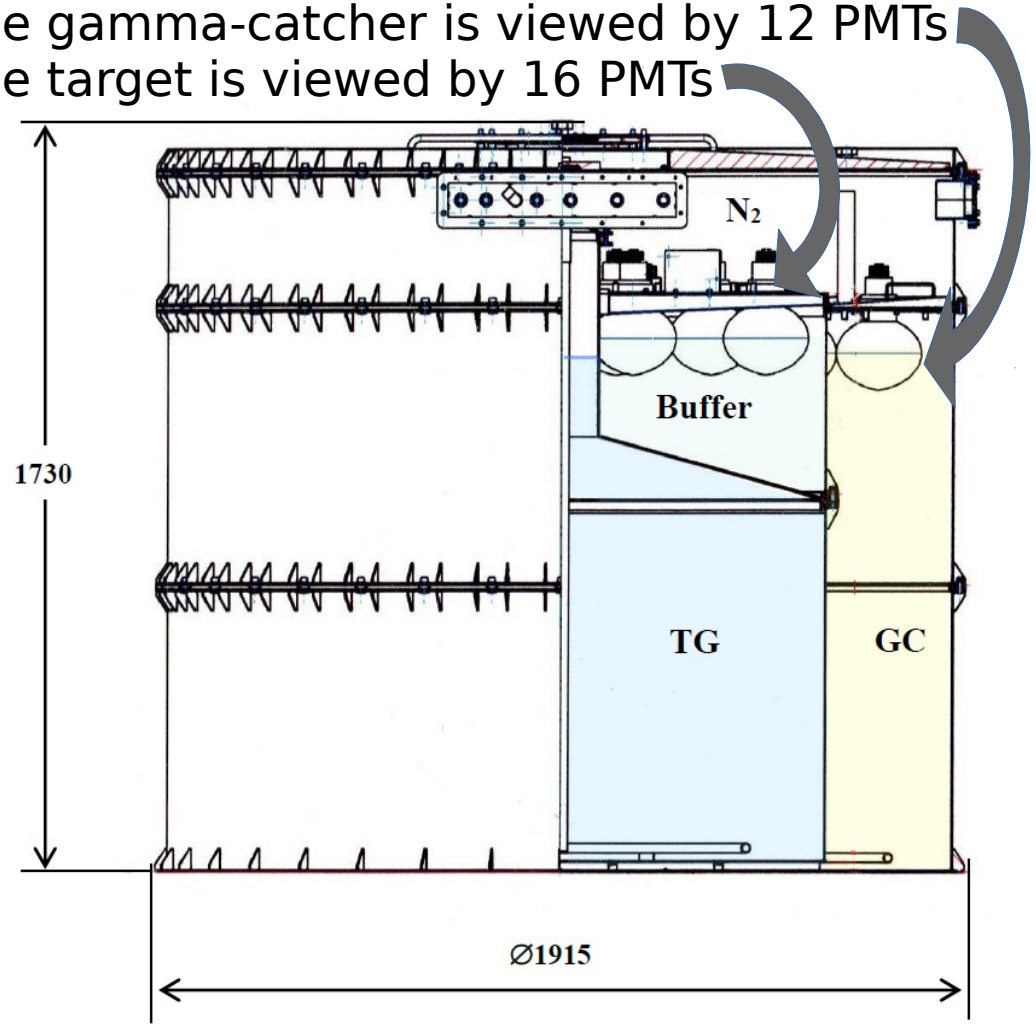
IDREAM design

IDREAM has 3 inner volumes:

- the target(1.1 m^3) contains Gd-loaded LAB-based liquid scintillator: LAB + PPO(3 g/l) + bis-MSB(0.02g/l)+Gd(1g/l);
- the gamma-catcher(1.7 m^3): LAB + PPO bis-MSB;
- the buffer volume(0.4 m^3): LAB(linear alkylbenzene).

Auxiliary IDREAM systems:

- liquids filling and nitrogen purging systems;
- slow control system;
- DAQ system;
- calibration system and other.



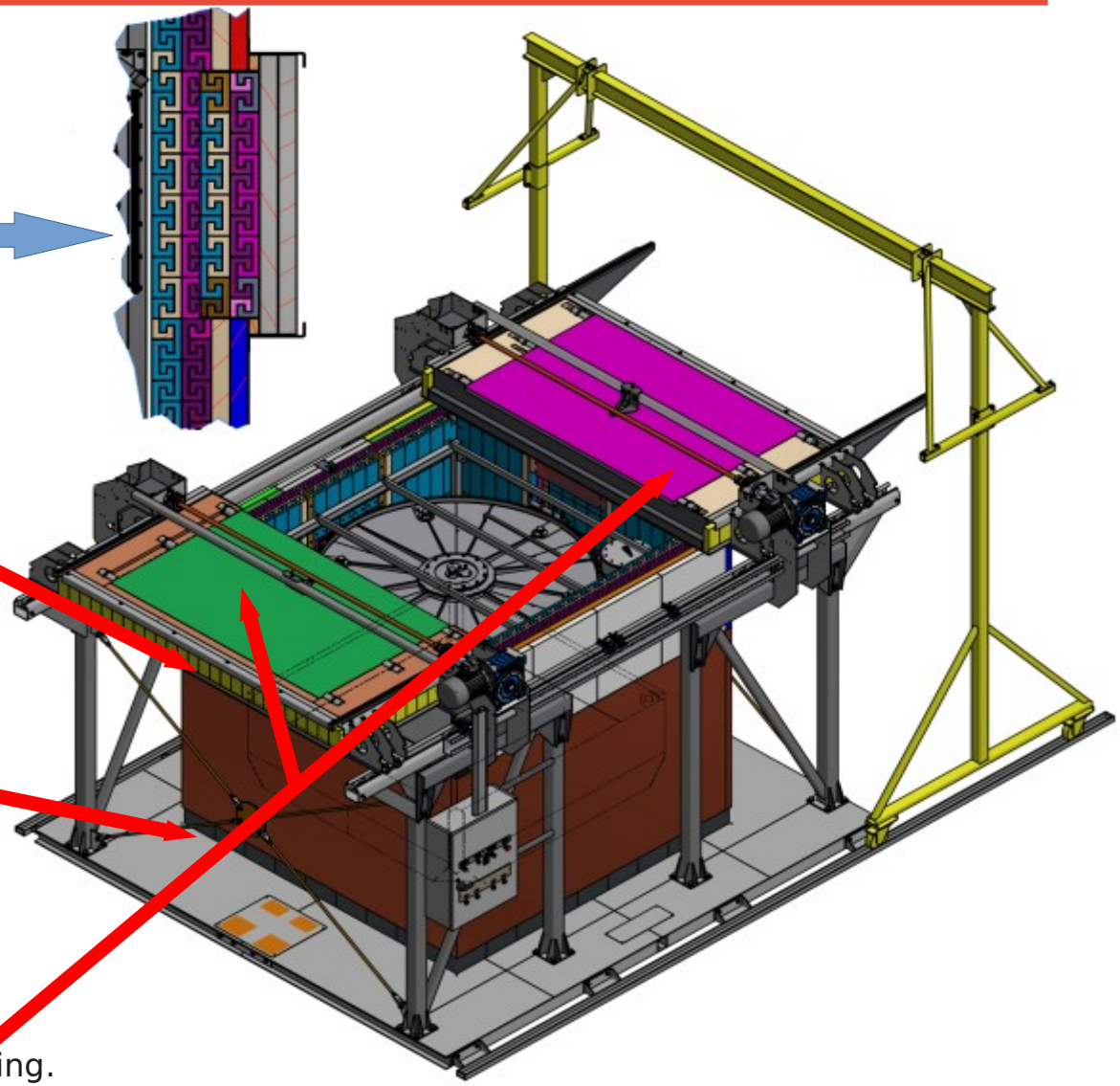
IDREAM shielding

Passive shielding:
- sidewall shield of the detector from left to right: 2 layers of "NEUTRONSTOP" C-type bricks, each 80 mm thick and two layers of pure polyethylene plates, each 50 mm thick, are installed;

- 2 shielding plates on top of the detector: lead (50 mm) + pure p/e (40 mm) + borated p/e (160 mm);

- cast-iron platform under the detector: cast-iron layer (140 mm) + pure p/e (80 mm) + borated p/e (100 mm).

Active shielding from cosmic Muons: detector is equipped with two scintillation polymethyl methacrylate plates. Each plate, 1900x1200x33 mm in size, is placed on the top of each half-door above the shielding.



IDREAM design features

IDREAM is a prototype of industrial detector that
can be placed at NPPs:

- IBD as well-established neutrino detection technology;
- simple design;
- quick-assembly / dismountable construction, high maintainability;
- no need for daily maintenance;
- remote control from other building within NPP site.

IDREAM mounting at Kalinin NPP

Initially, **February 2021** - IDREAM installation started in 3A-121 room(IDREAM place).

IDREAM mounting and commissioning

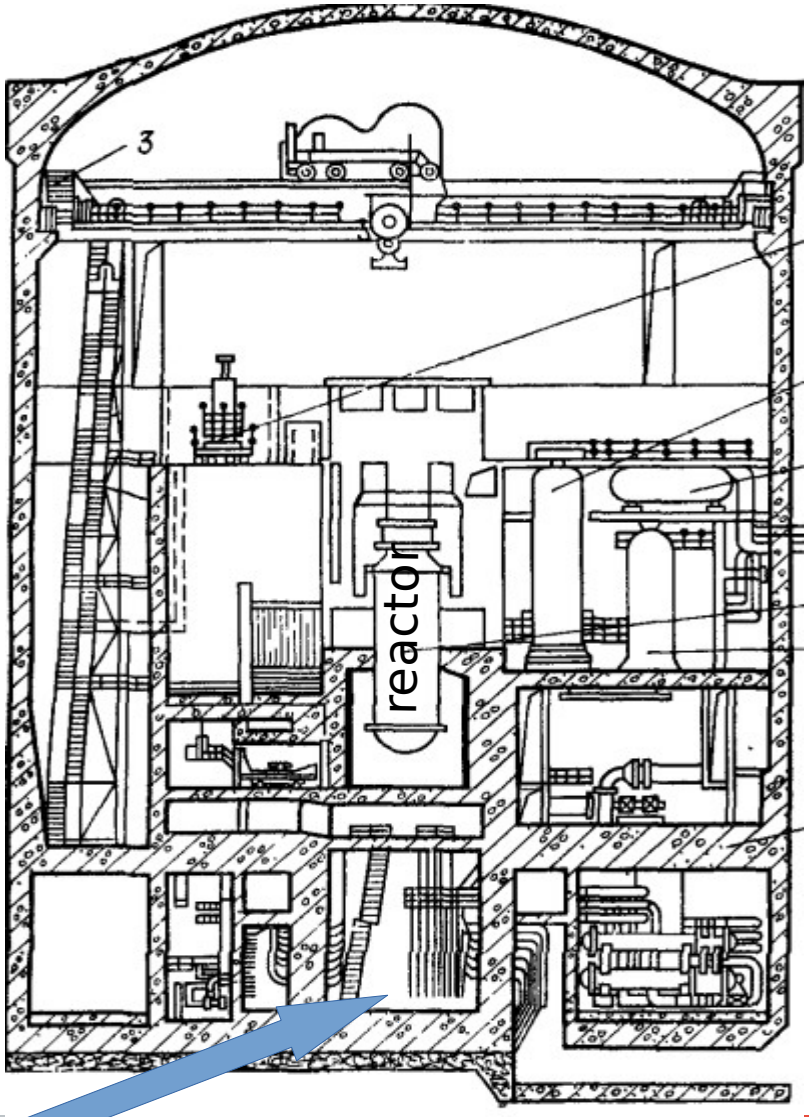
IDREAM mounting at Kalinin NPP

9-12/04/21 - removing part of the scintillator and adding the Gd concentrated solution, nitrogen purging

24/03/21 - Detector filled with the scintillator w/o Gd

IDREAM has been installed at Kalinin NPP (3rd power unit) in the spring 2021

16/04/21 - installation of passive shielding completed.

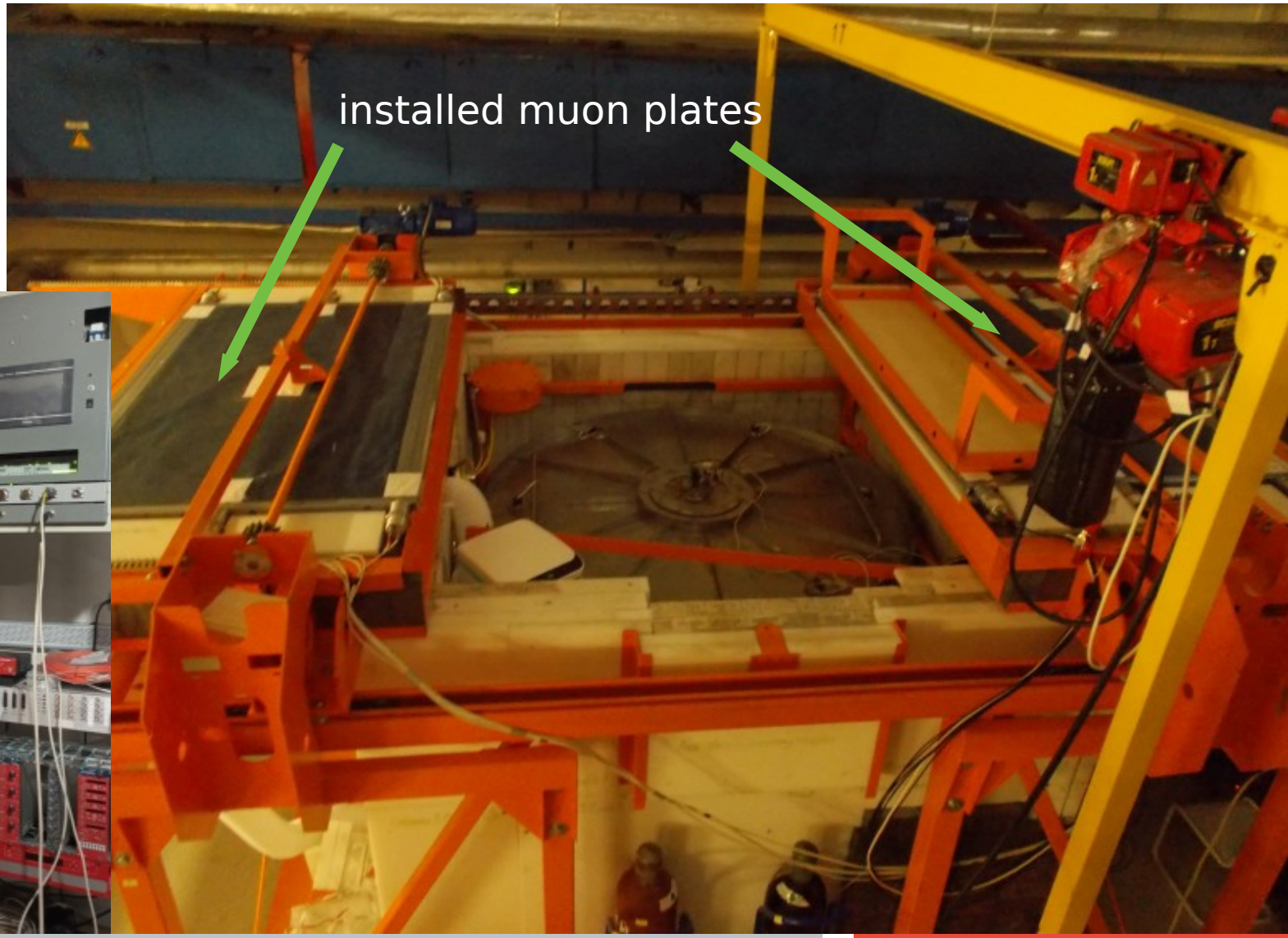


The detector is located in a ground level hall(A-121 room), 19 m from the 3 GW reactor core

VVER-1000 reactor

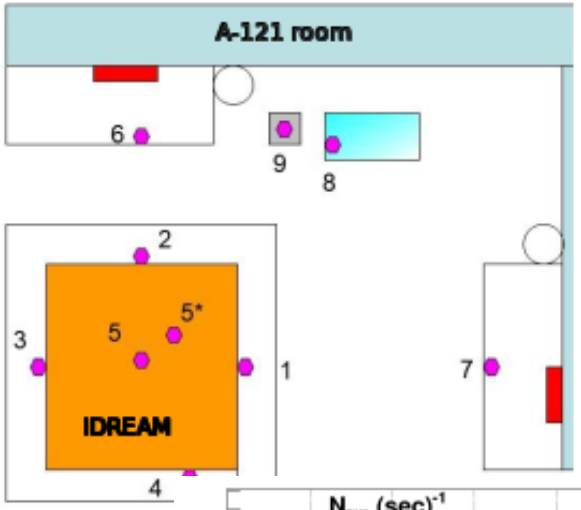
IDREAM setting up at Kalinin NPP

Setting up electronics and DAQ system

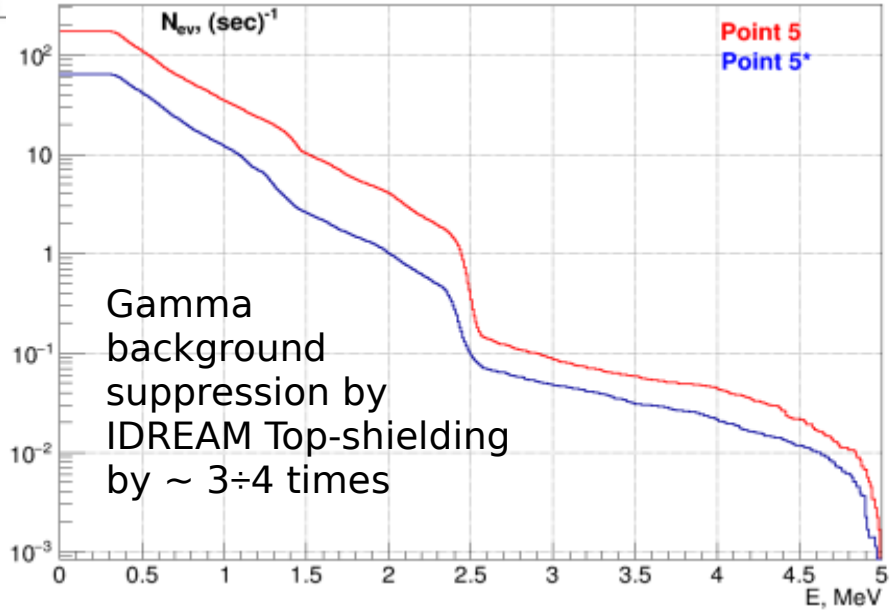


Starting from May - commissioning runs.

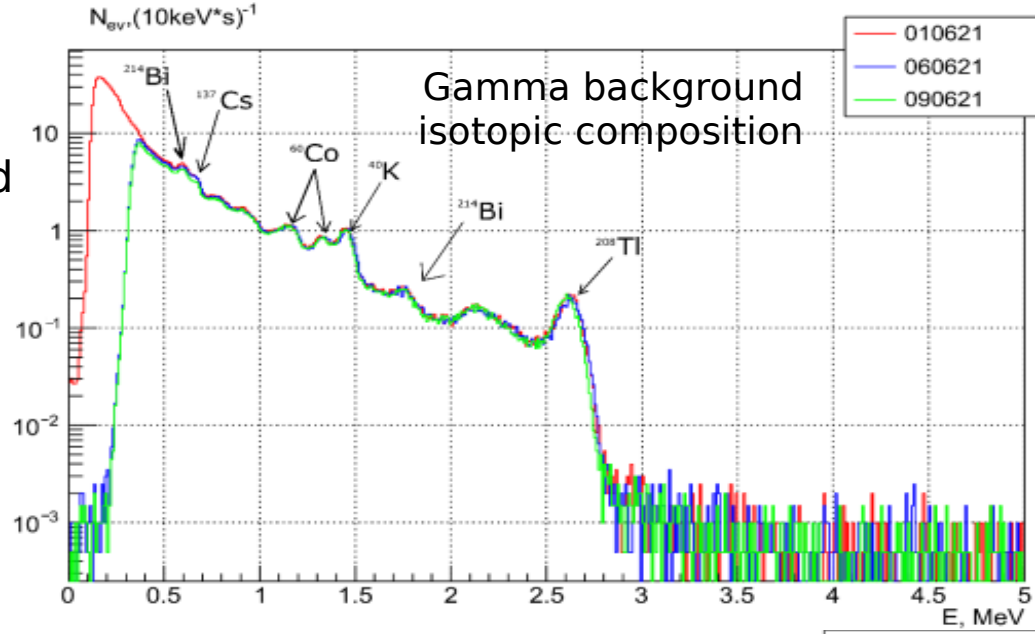
Gamma background



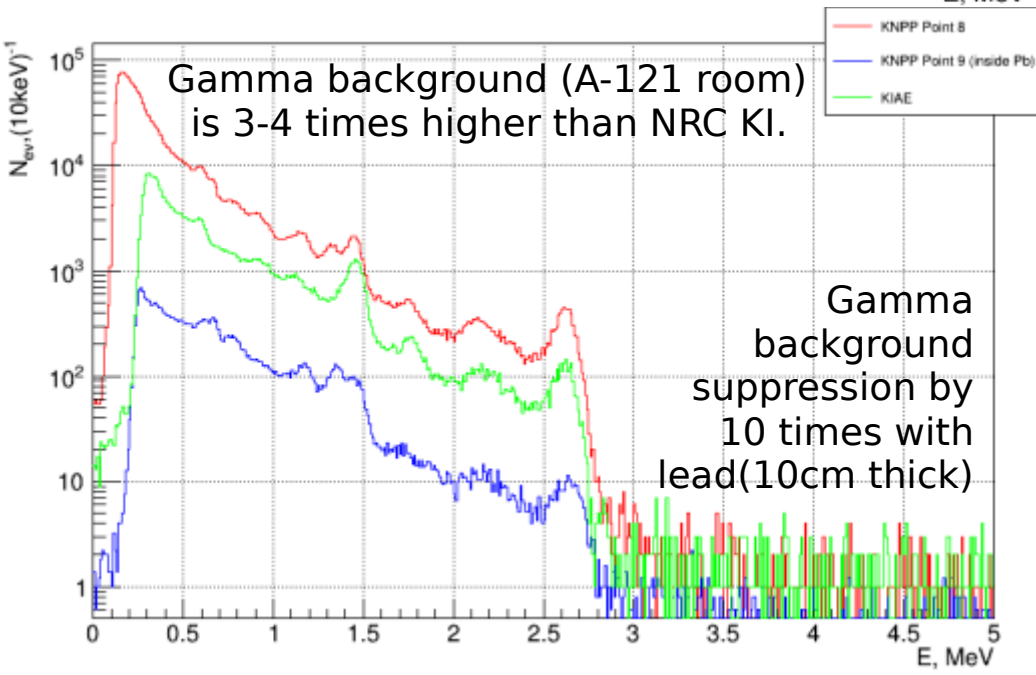
Data collection points of gamma Background using NaI-detector (90x90mm diameter) in A-121 Room (IDREAM place).



Gamma background suppression by IDREAM Top-shielding by ~ 3÷4 times



Gamma background isotopic composition



Gamma background (A-121 room) is 3-4 times higher than NRC KI.

Gamma background suppression by 10 times with lead(10cm thick)

Measurements of the gamma fields in 3A-121(IDREAM place)

Neutron background

Neutron background measurements were carried out using ^{3}He counters:

- the detector made from 12 proportional ^{3}He counters,

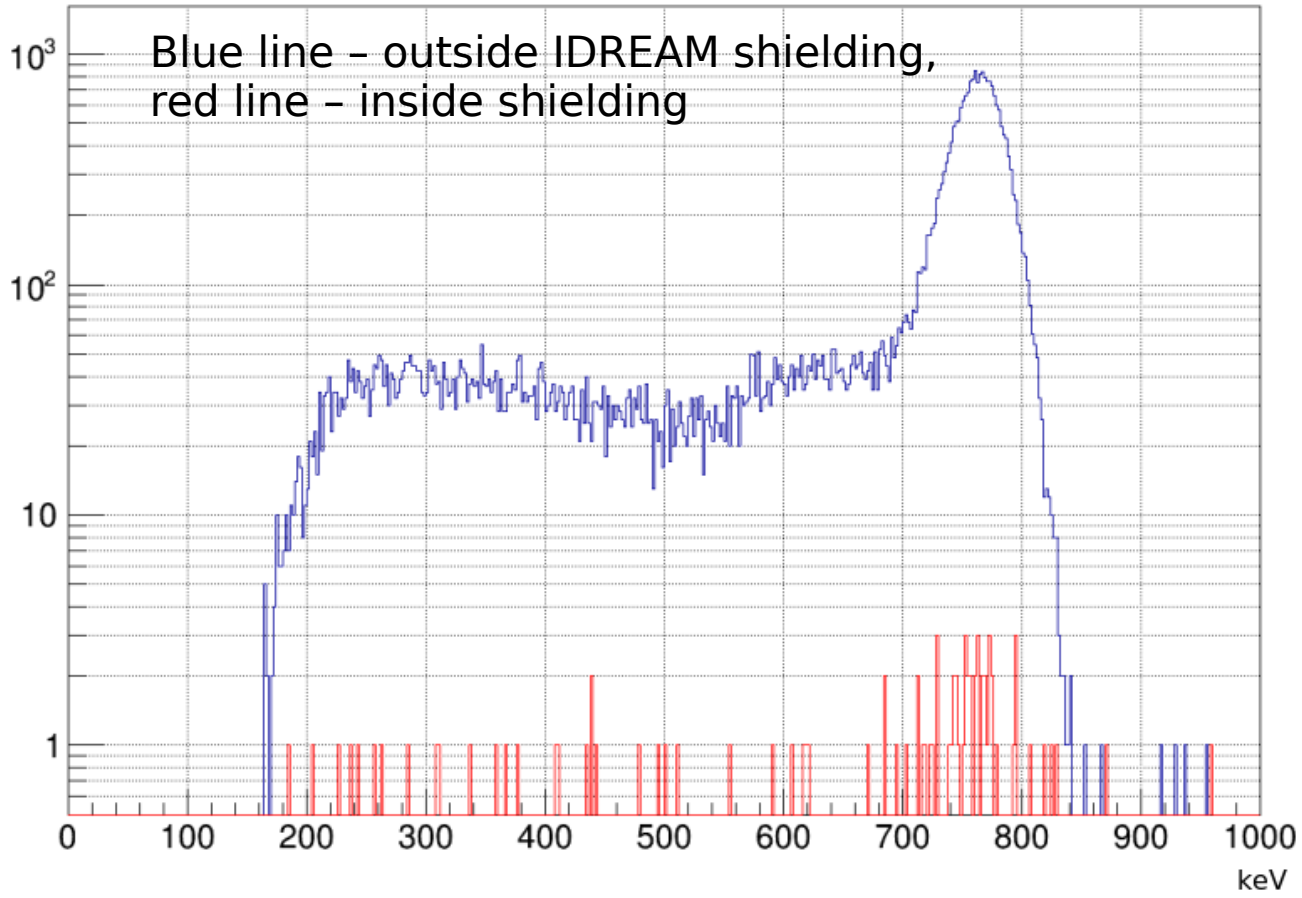
1 m in length;

- the thermal neutrons are detected in the reaction:

$n + {}^3He \rightarrow {}^3H + p + 764$ keV;

- measurements outside

and inside IDREAM shielding.



Count rate outside IDREAM shielding in A-121 room: 5,2±2,3 neutron/s.

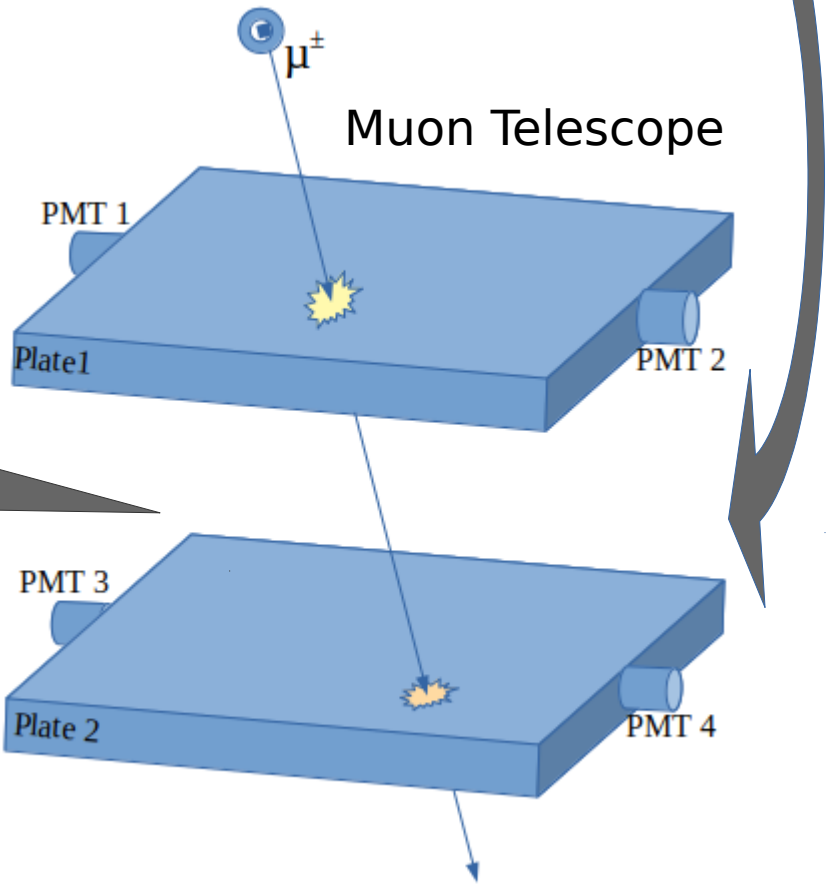
Count rate inside IDREAM shielding ~ 0,03 neutron/s.

So, IDREAM passive shielding suppressed the neutron background by more than 100 times

Muon background

A detector made from 2 parallel plates was used for muon data collection in room A-121 (IDREAM place), each plate is 50x50x5 cm and has two 3” PMTs.

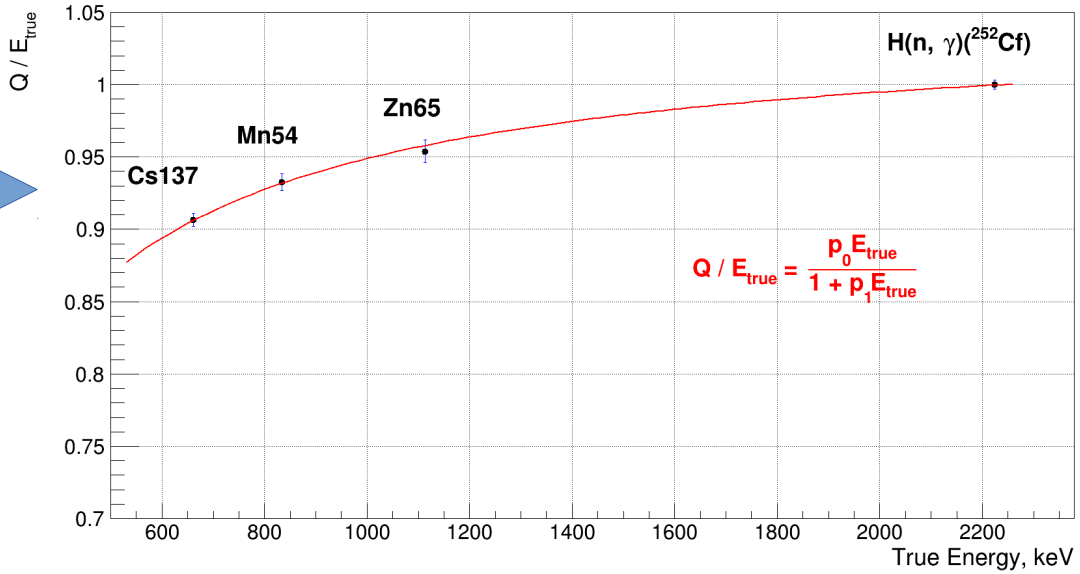
Muon spectra measurements were done for two cases:
0 and 30 cm between the plates.

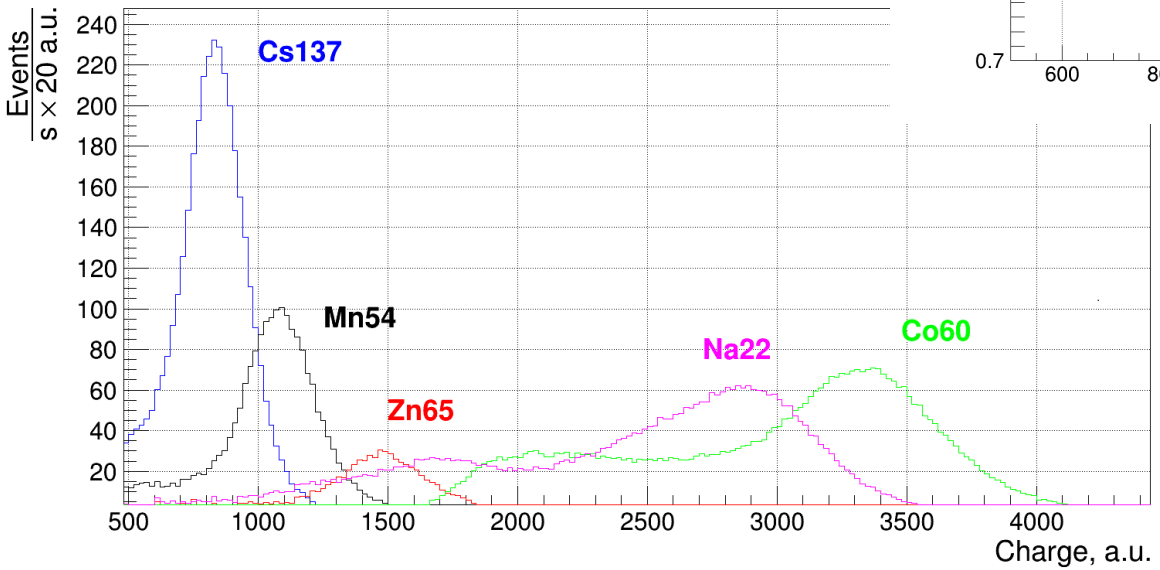


Based on the measurements, the muon flux into A-121 room of Kalinin NPP was suppressed by ~ 8 times compared to the flux in the laboratary hall of Kurchatov institute.

IDREAM calibrations

Study of quenching effect in our scintillator using calibration sources: ^{252}Cf,^{54}Mn,^{65}Zn,^{137}Cs.

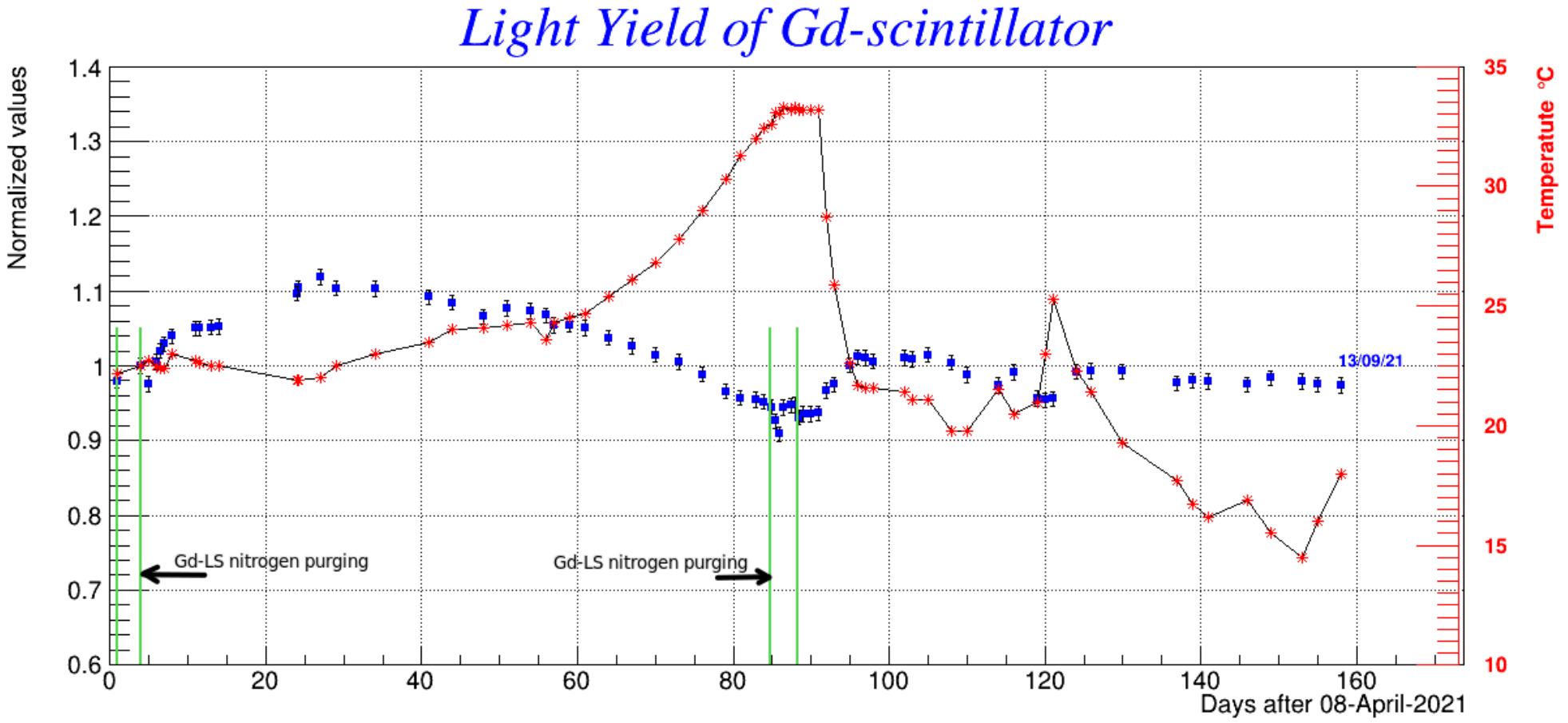




Carrying out calibrations using several sources: ^{22}Na,^{54}Mn,^{60}Co,^{65}Zn,^{137}Cs.

Monitoring the stability of the detector response

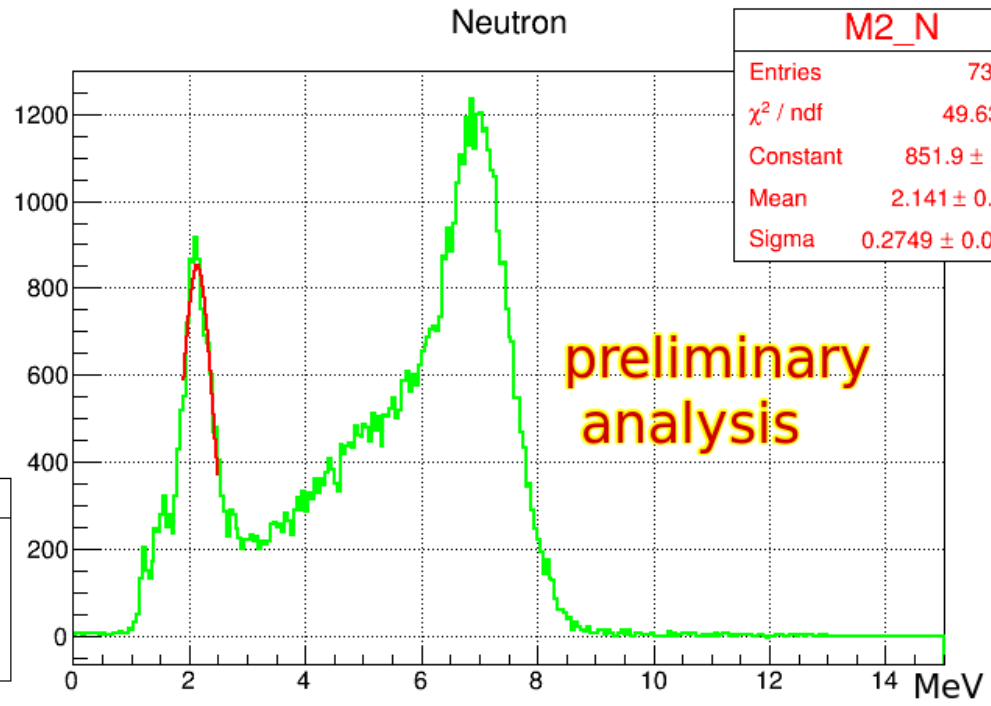
Regular monitoring of the stability of detector response by means of ^{60}Co source.

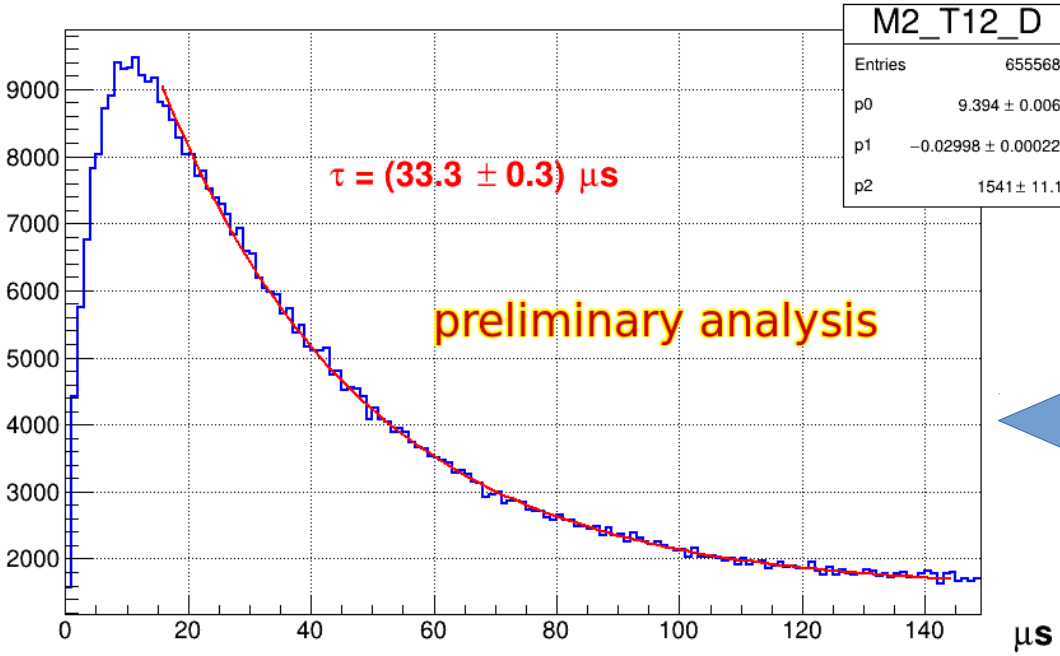


Higher temperature - lower detector response?

Preliminary evaluation of neutron lifetime(^{252}Cf)

Neutron energy spectrum in Gd-LS





Neutrons life-time in Gd-Ls.

Calibration using ^{252}Cf-source

^{252}Cf source

Conclusion

- IDREAM is a compact prototype of industrial detector for reactor monitoring;

- IDREAM detector is mounted on Kalinin NPP and first dataset is coming now;

- cosmic muons, neutron and gamma background measurements were performed at detector's location;

- detector response is regularly monitored since the commissioning;

- studies of the scintillator quenching and neutron's lifetime measurements performed.

Stay tuned and wait for our new results!

The End

www.rosenergoatom.ru/stations_projects/sayt-kalininskoy-aes/fotogalereya/

Kalinin NPP
Udomlya, Russia