Status of Neutrino4+ setups at SM-3 reactor

NRC "Kurchatov institute" - PNPI

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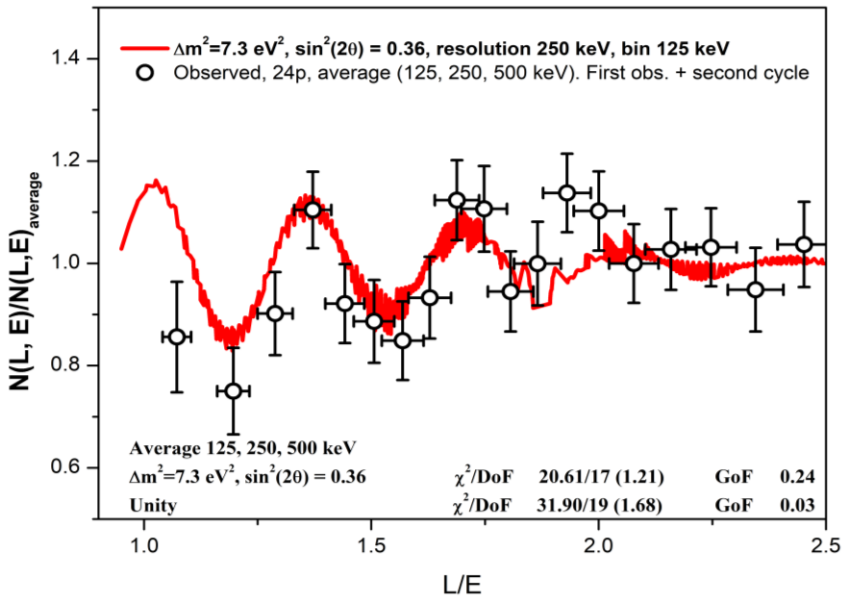
Supported by RSF. Project # 24-12-00091

XXII LOMONOSOV CONFERENCE ON ELEMENTARY PARTICLE PHYSICS

Search for light sterile neutrinos

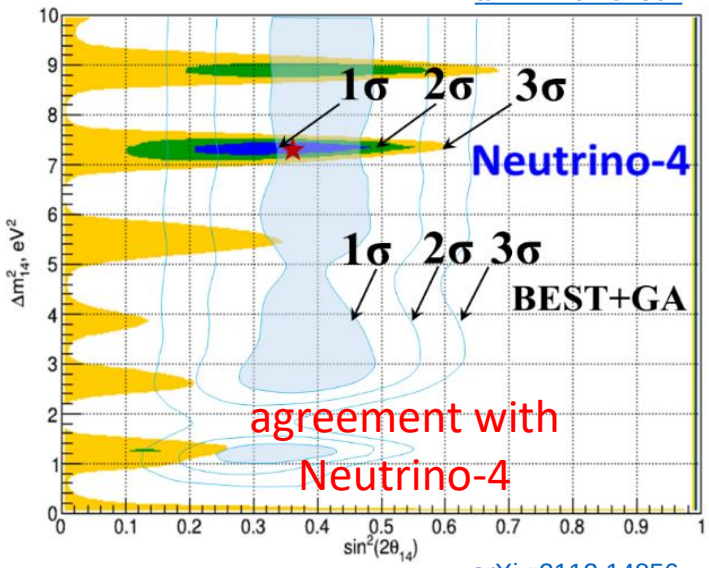
Neutrino-4

arXiv:2005.05301



BEST + Gallium anomaly

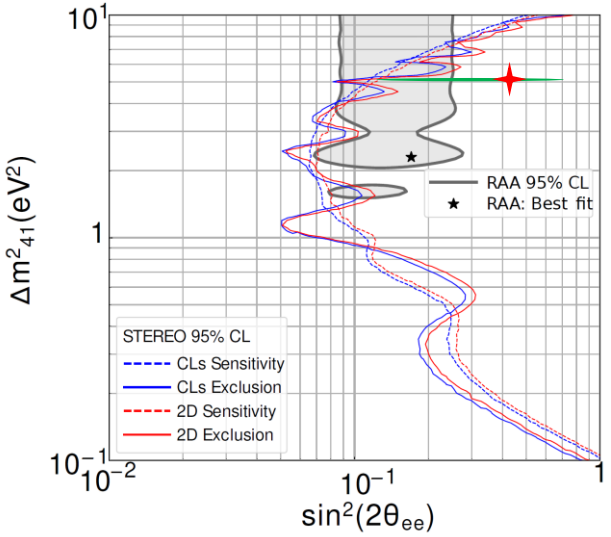
arXiv:2201.07364



arXiv:2112.14856

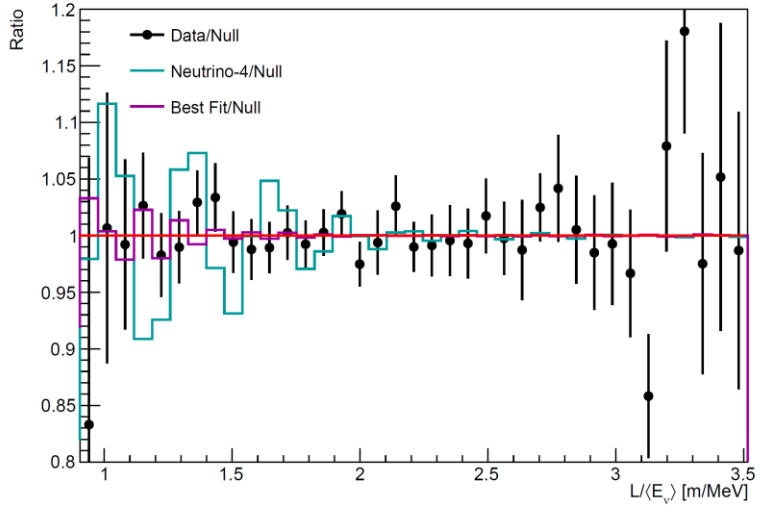
Contradictions with Neutrino-4 and BEST+GA results

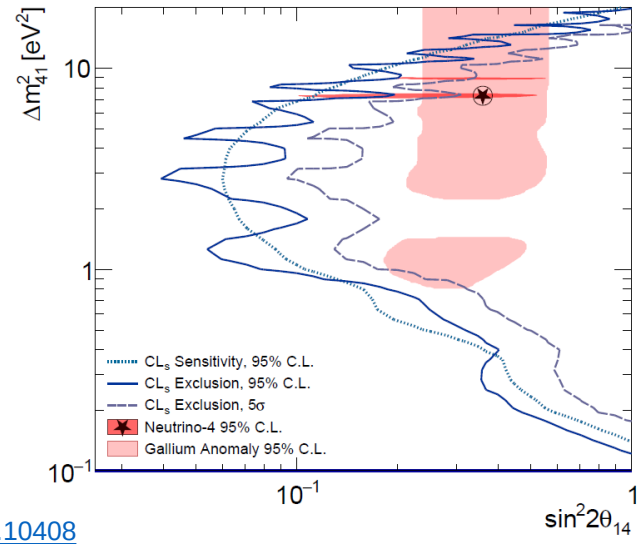
STEREO results



arXiv:2210.07664

PROSPECT results

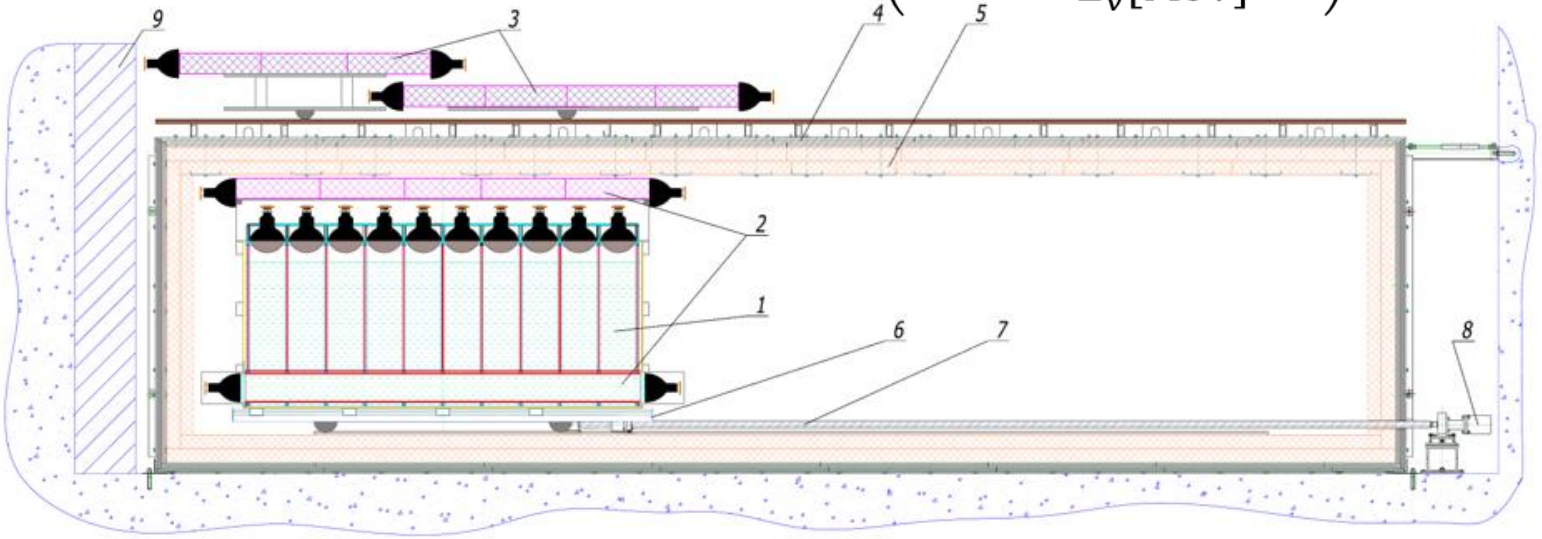




arXiv:2406.10408

Moveable antineutrino detector

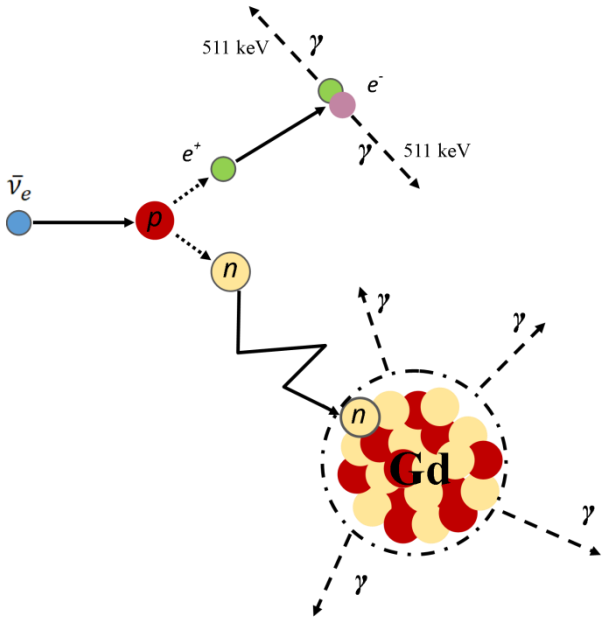
$$P(\bar{\nu}_e \to \bar{\nu}_e) = 1 - \sin^2 2\theta_{14} \sin^2\left(1.27 \frac{\Delta m^2_{14}[eV^2]L[m]}{E_{\bar{\nu}}[MeV]}\right)$$



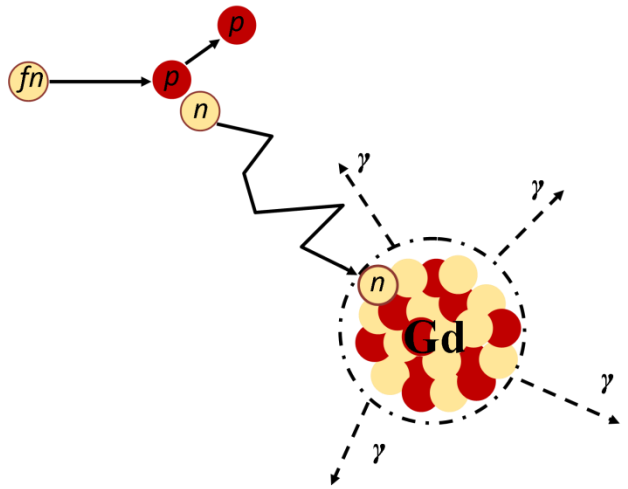
1. detector 2. internal AS 3. external AS 4. steel and lead 5. borated PE 6. platform 7. screw 8. stepper motor 9. cast iron shot

Inverse beta-decay

$$\bar{\nu}_e + p \to n + e^+$$



Fast neutron scattering

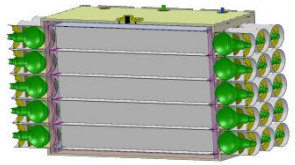
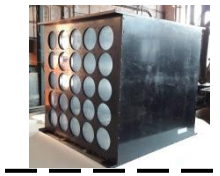
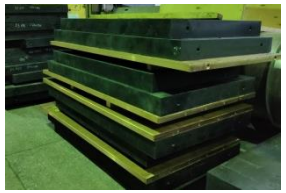
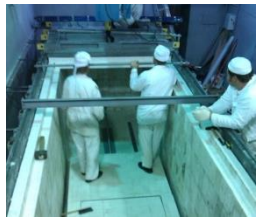
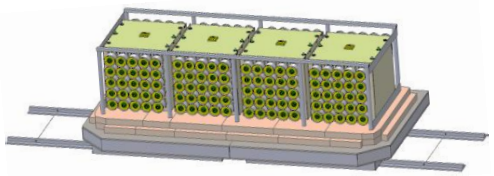
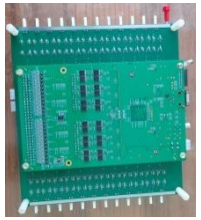
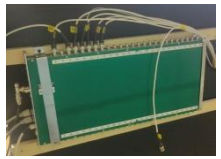
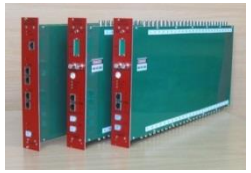


SM-3 active zone size
42x42x35 cm^3

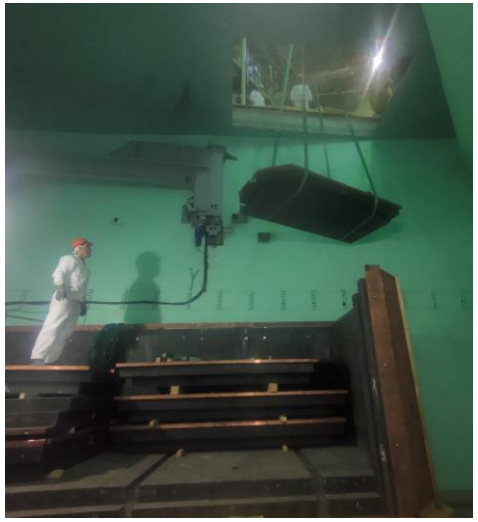
Distance to the SM-3 active zone center : 6 – 12 m

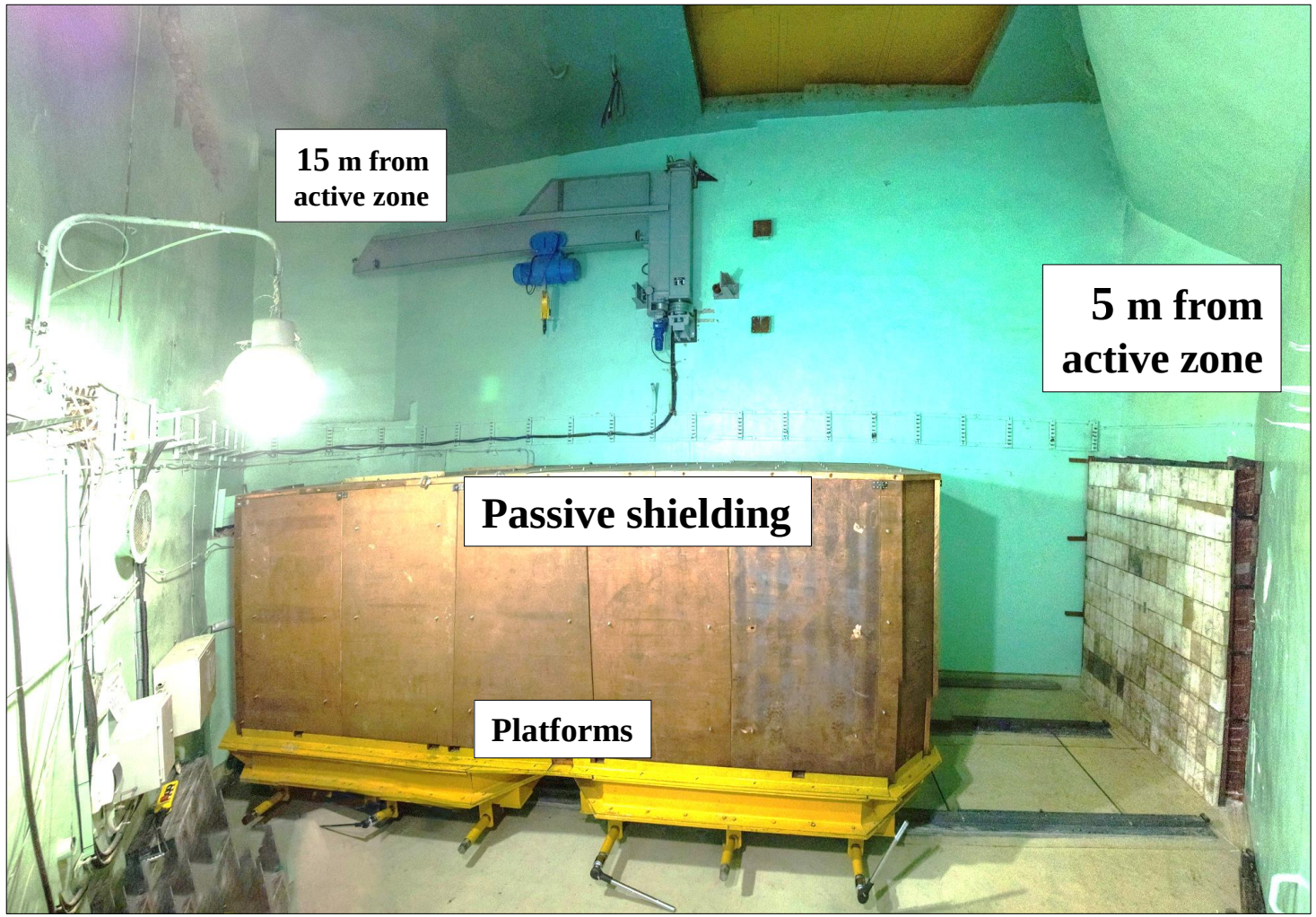
S/B ~ 0.5

Detector design

	Laboratory in room 162	Laboratory in room 170
Detector	 	 
Passive shielding	 	 
Transport system	 	 
Active shielding	  	
DAQ	    	
High voltage distribution	    	

Passive shielding and movement system

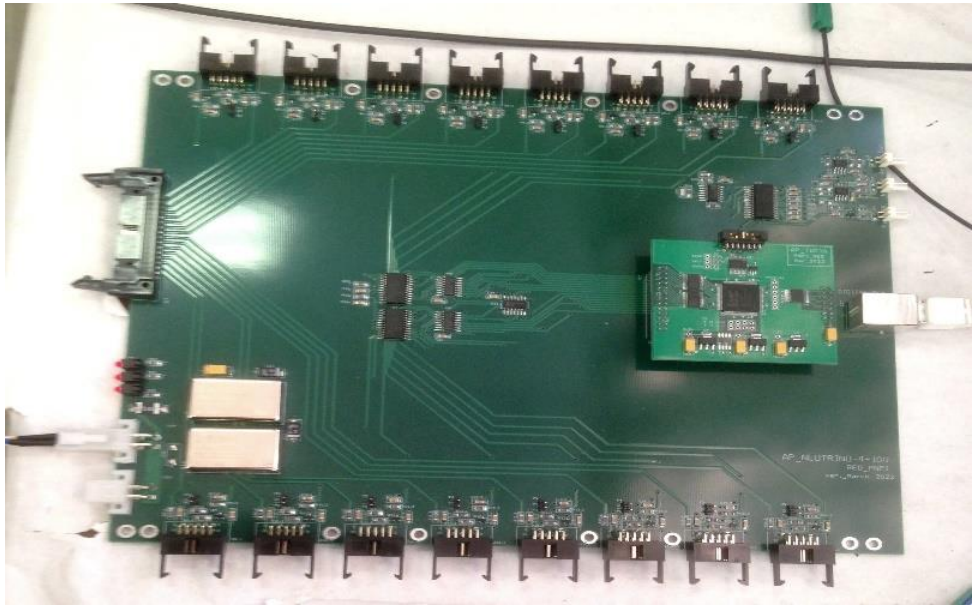




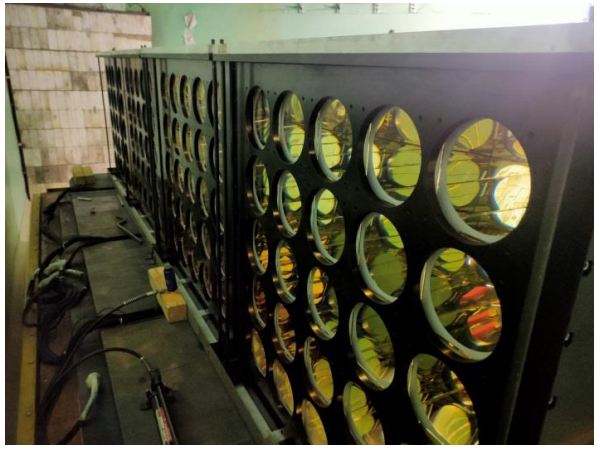
Active shielding

✓	Frame	ready
✓	Plates	ready
✓	Electronics	ready

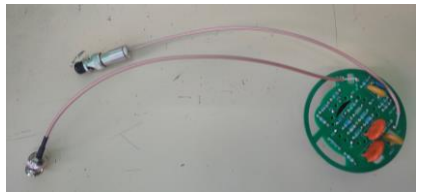
Plates are made from polystyrene based scintillator. Light yield 9000 photons per MeV.

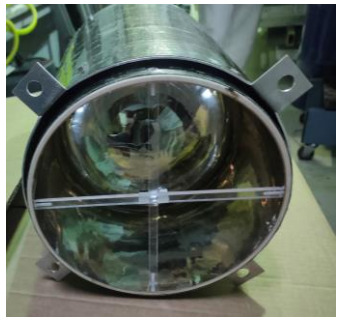


Detection modules. Scintillator



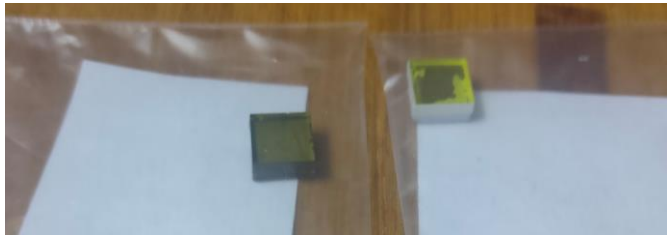
Detection modules. PMT installation

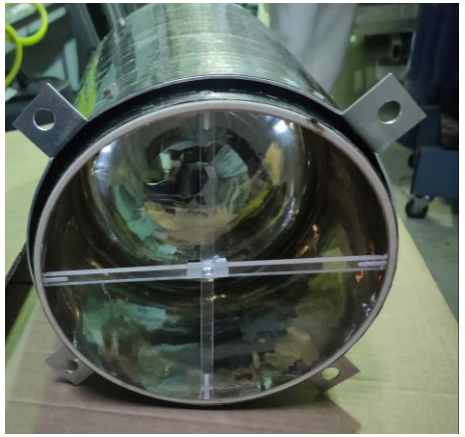




Completion of installation of photomultipliers

Each PMT module has 2 light signal sources based on the GGAG crystal.





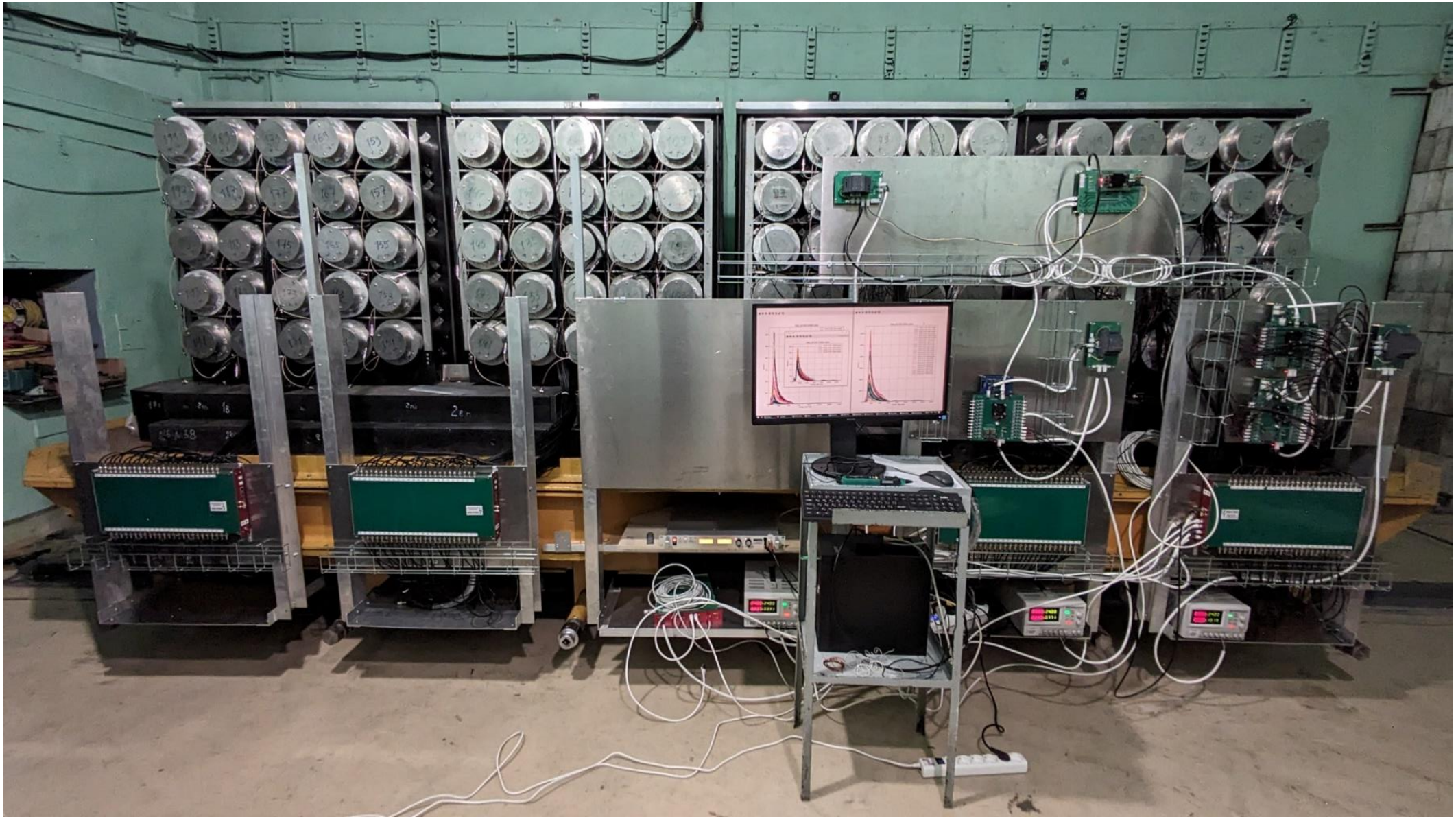
Electronics systems connection

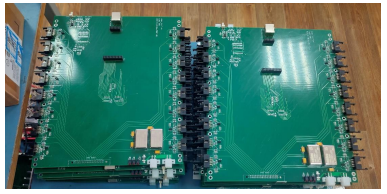
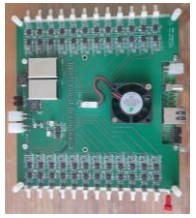
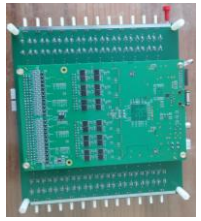
All DAQ system boards are manufactured.
3 digitizers and 1 concentrator in Dimitrovgrad.
The rest were being tested at PNPI and ready to be installed

Electronics systems connection

All detection modules are connected to the high voltage distribution system. Only the first module is connected to the DAQ system.

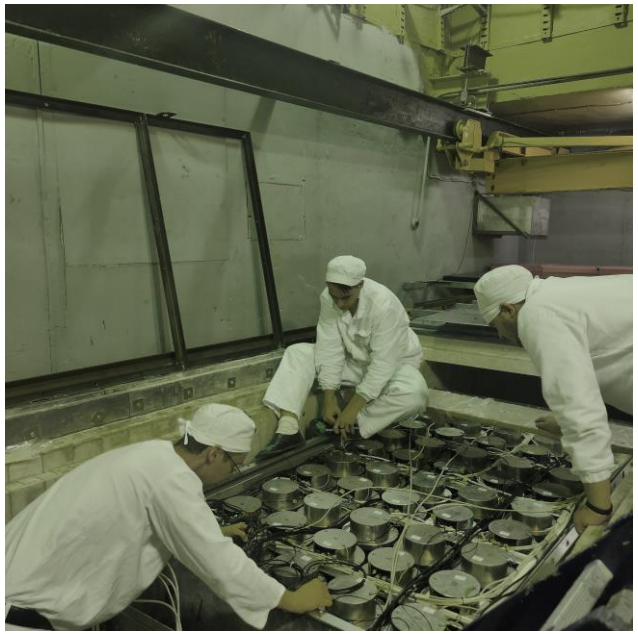
Current status of RC Neutrino

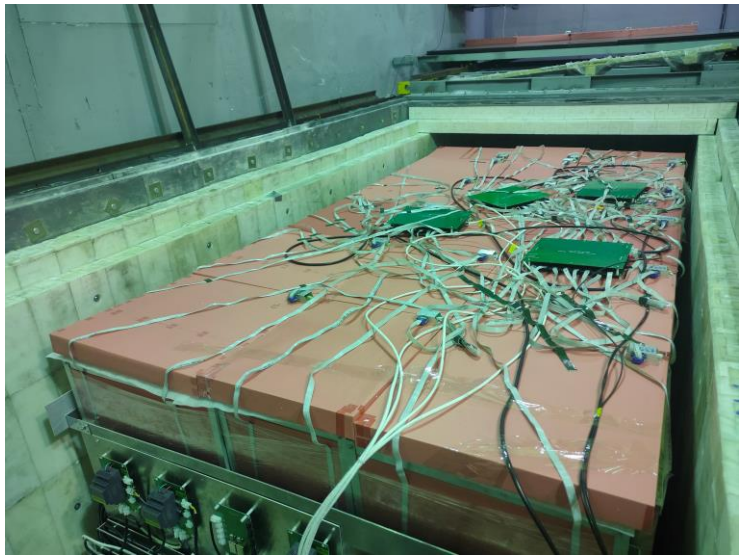


System	Readiness	
Detection modules		✓✓
Passive shielding		✓
Transport system	 	✓✓
Active shielding	 	✓
DAQ	  	✓
High voltage distribution	 	✓✓

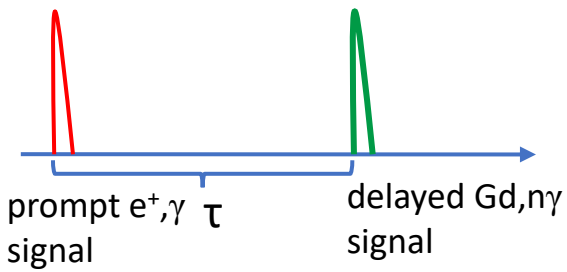
Modernization of the first neutrino laboratory

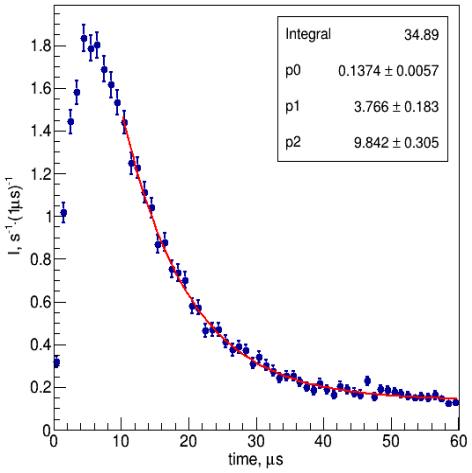
- Active shielding (almost 4π)
- Scintillator with PSD
- Data acquisition system
- Magnetic shields
- Monitoring with Am+GAGG

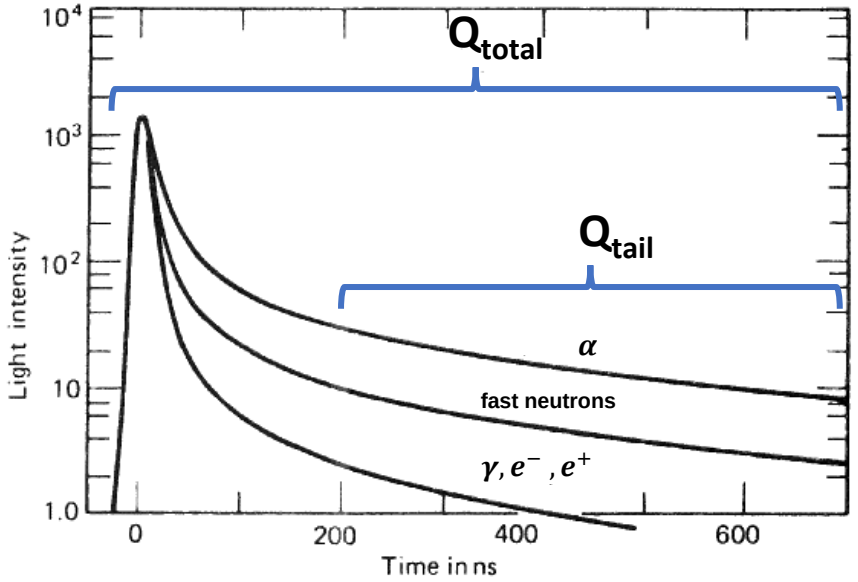




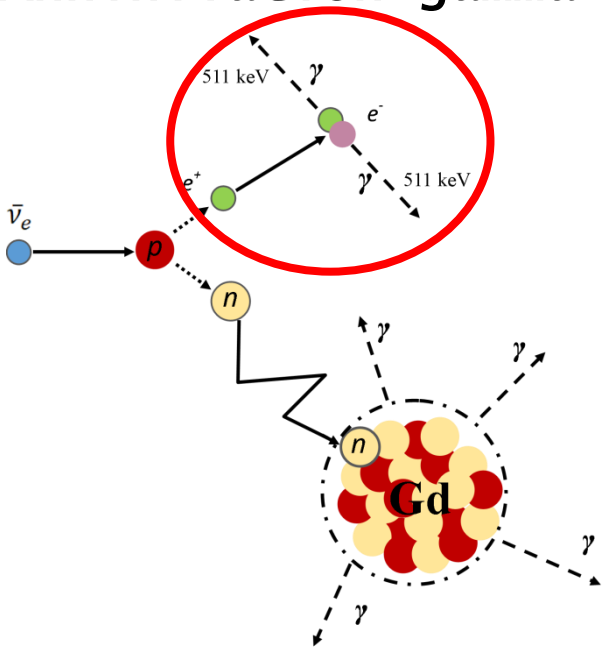
Selection of inverse beta decay events

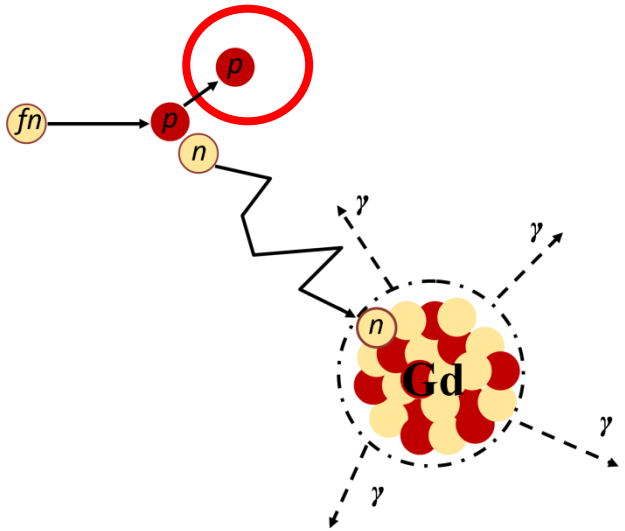




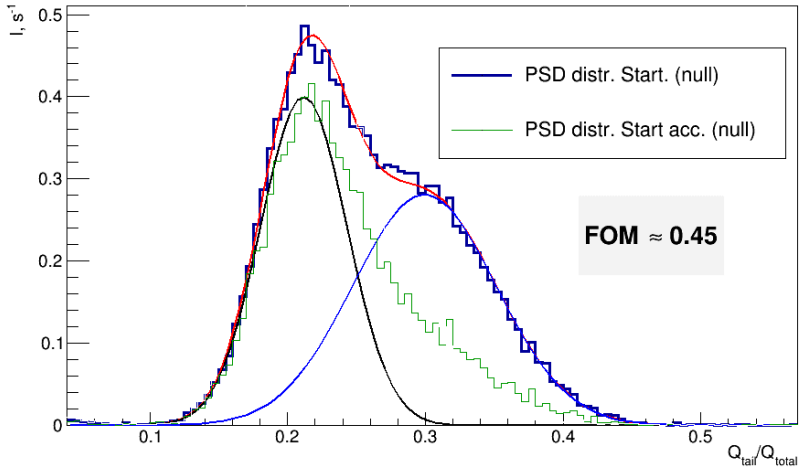


Annihilation gamma detection in adjacent cell



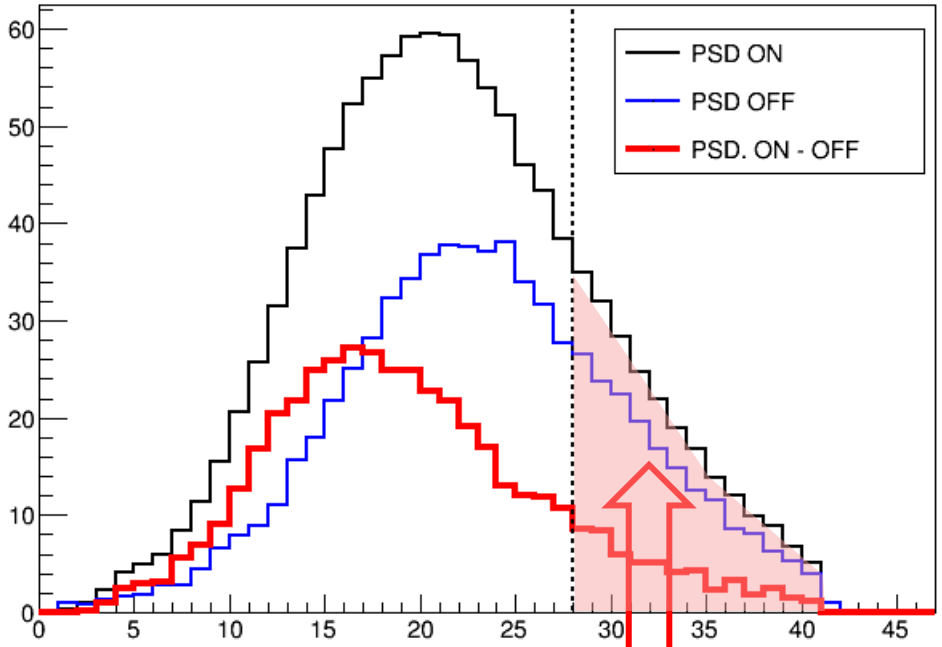


Pulse shape discrimination



Selection of inverse beta decay events

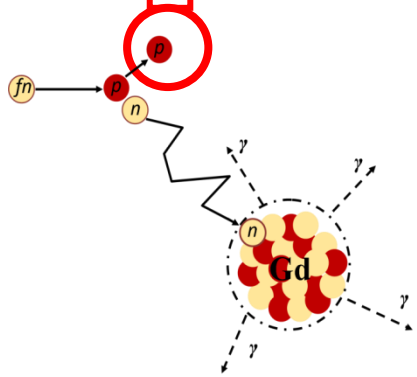
PSD parameter distribution

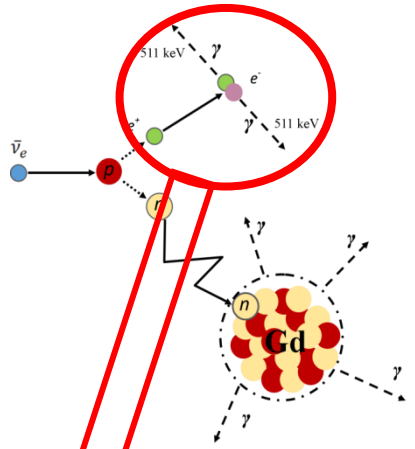


PSD S/B improvement

0.5 ⟹ **0.7**

1.4 times better

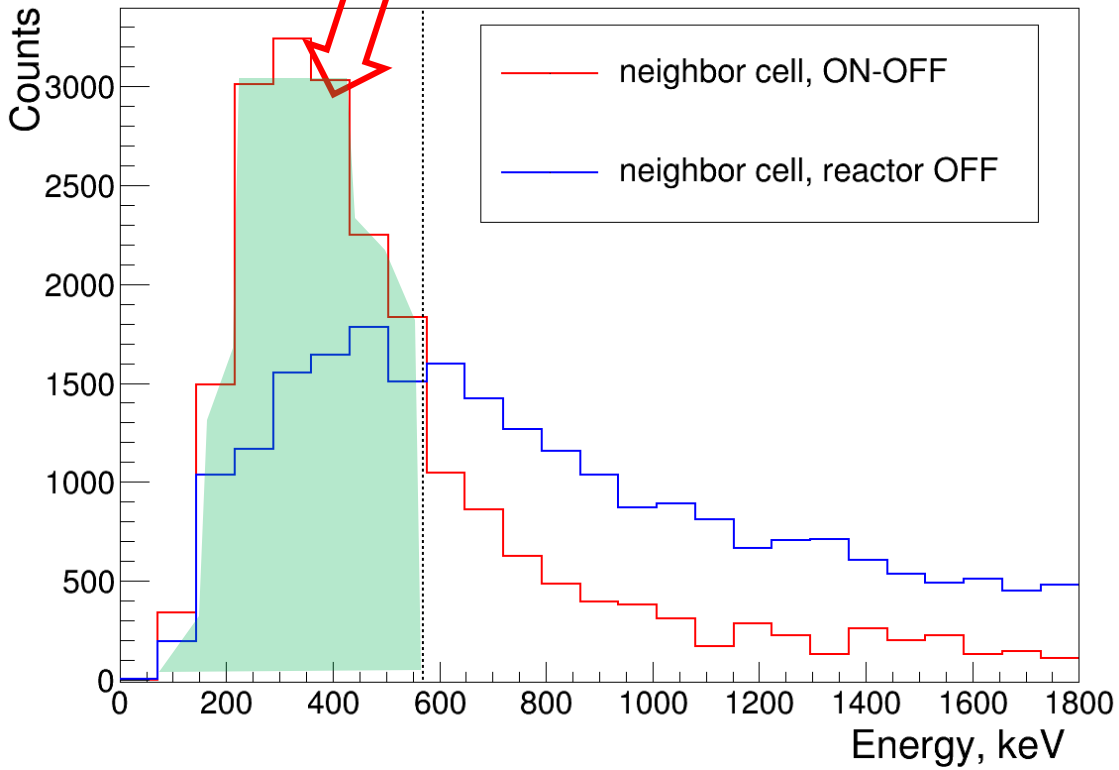




Annihilation gamma detection in neighboring cell S/B improvement

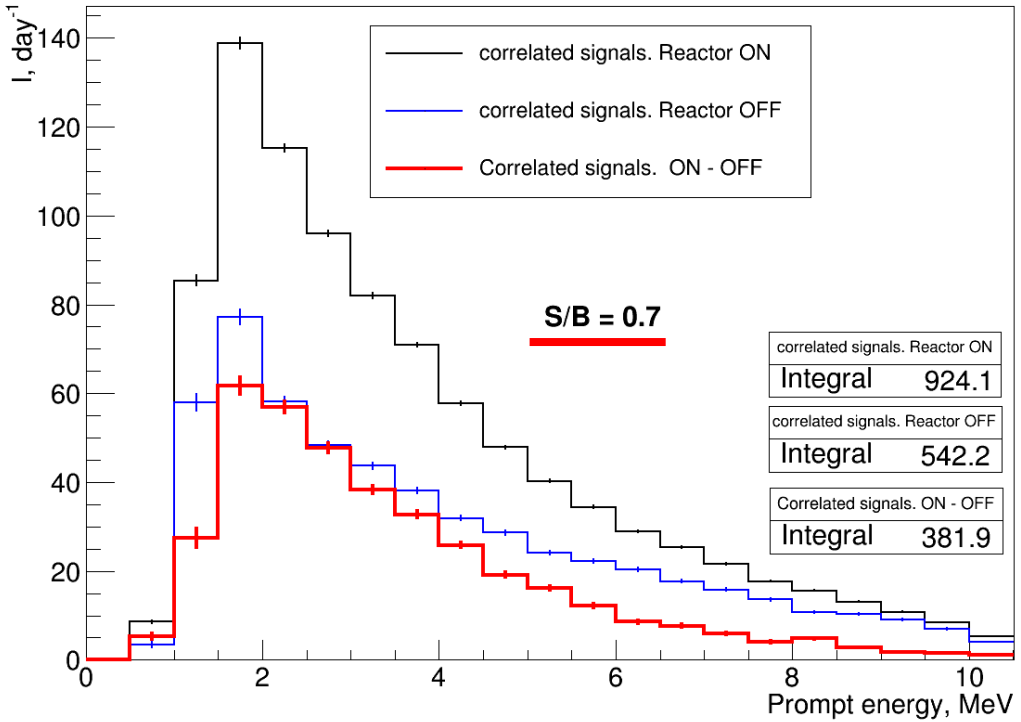
0.7 ⟹ **1.7**

more than 2 times better

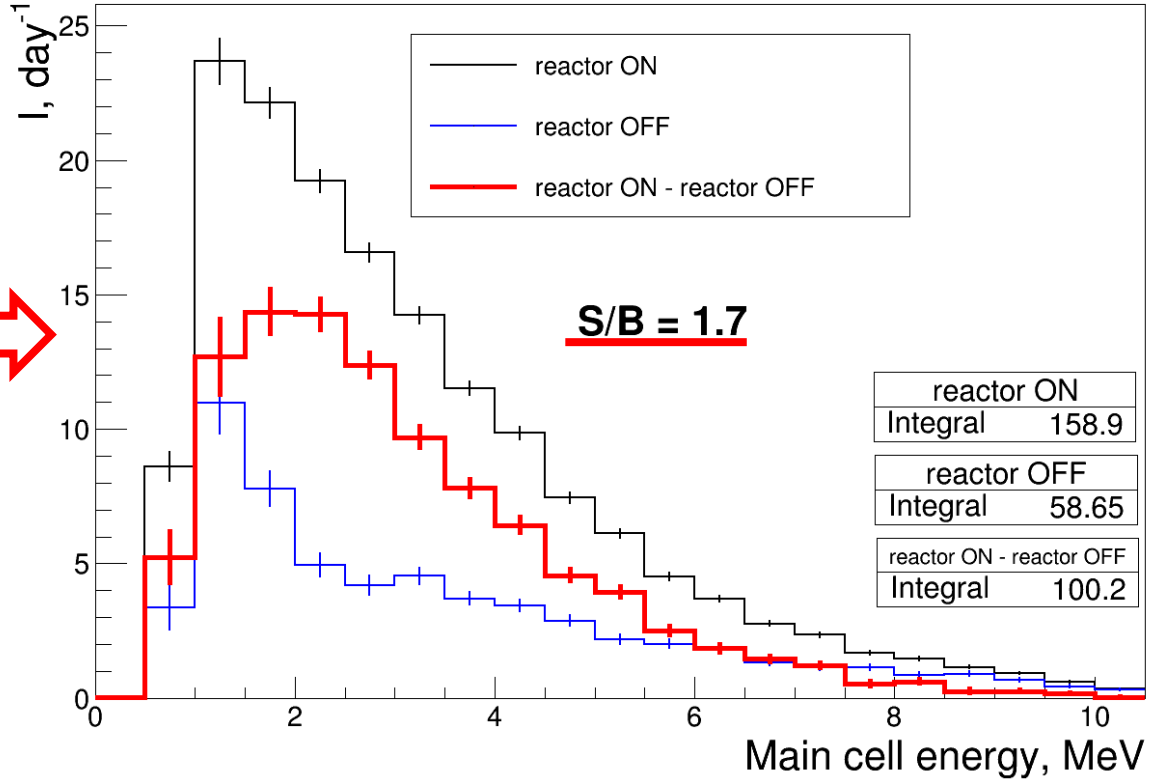


Signal/background ratio improvement

Prompt signals w/o 511 keV condition



Prompt signals with 511 keV condition



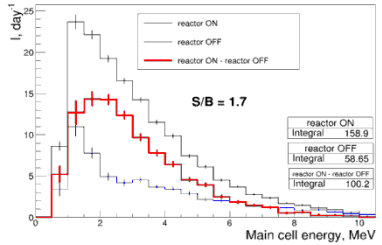
PSD ~511 keV

S/B: 0.5 ⇨ 0.7 ⇨ 1.7

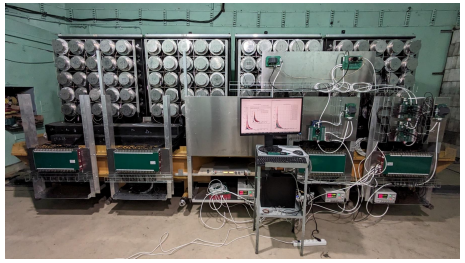
more than 3 times better

100 IBD events per day

59 background events per day

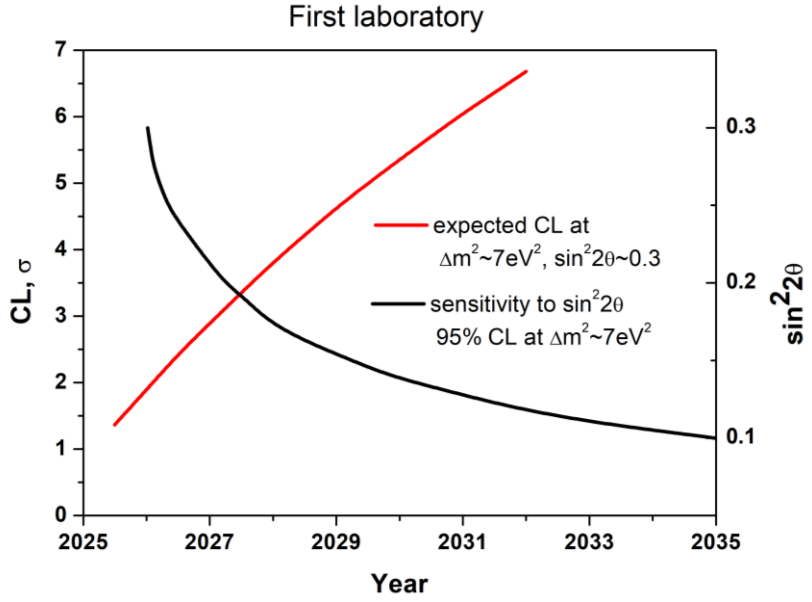


Conclusion



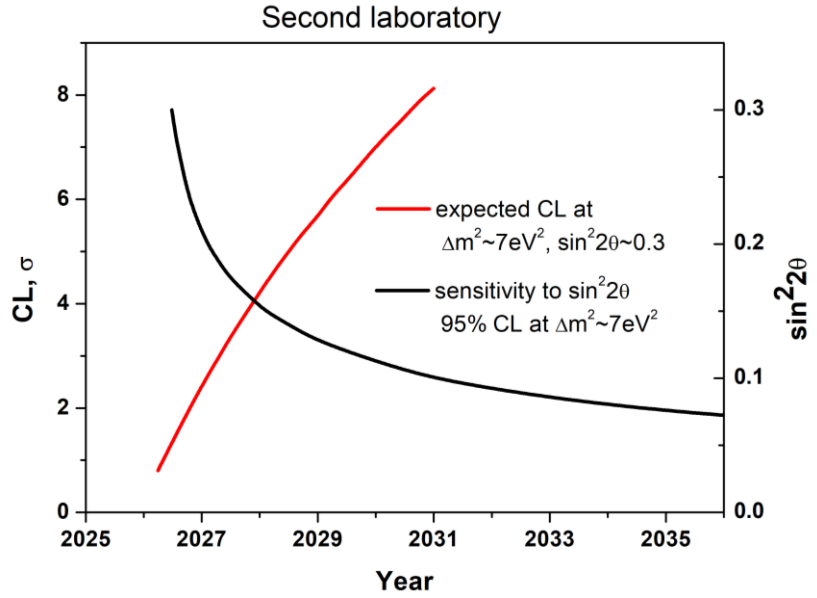
First laboratory

- data taking continues
- S/B ratio was improved more than 3 times
- expected confidence level and sensitivity



Second laboratory

- installation of the detector will be completed at the end of the year data taking will begin
- expected confidence level and sensitivity

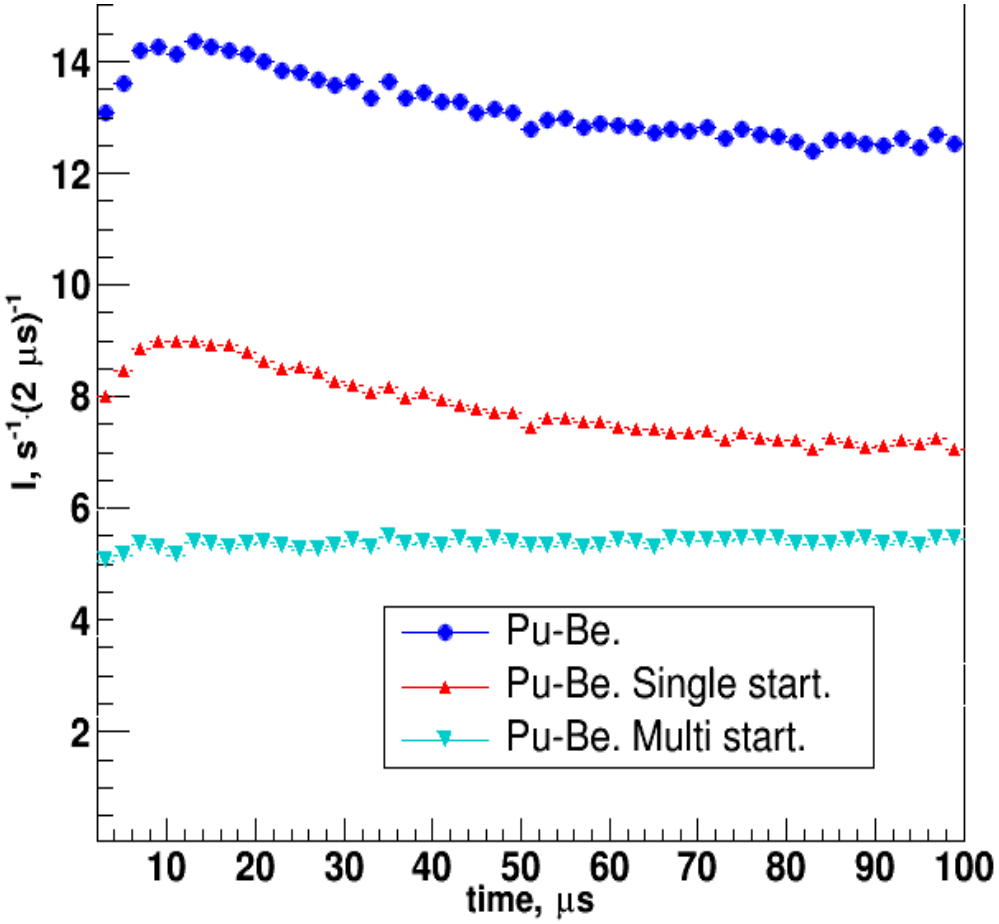


After 2 years of data taking situation around light sterile neutrino and Neutrino-4 result will be clarified

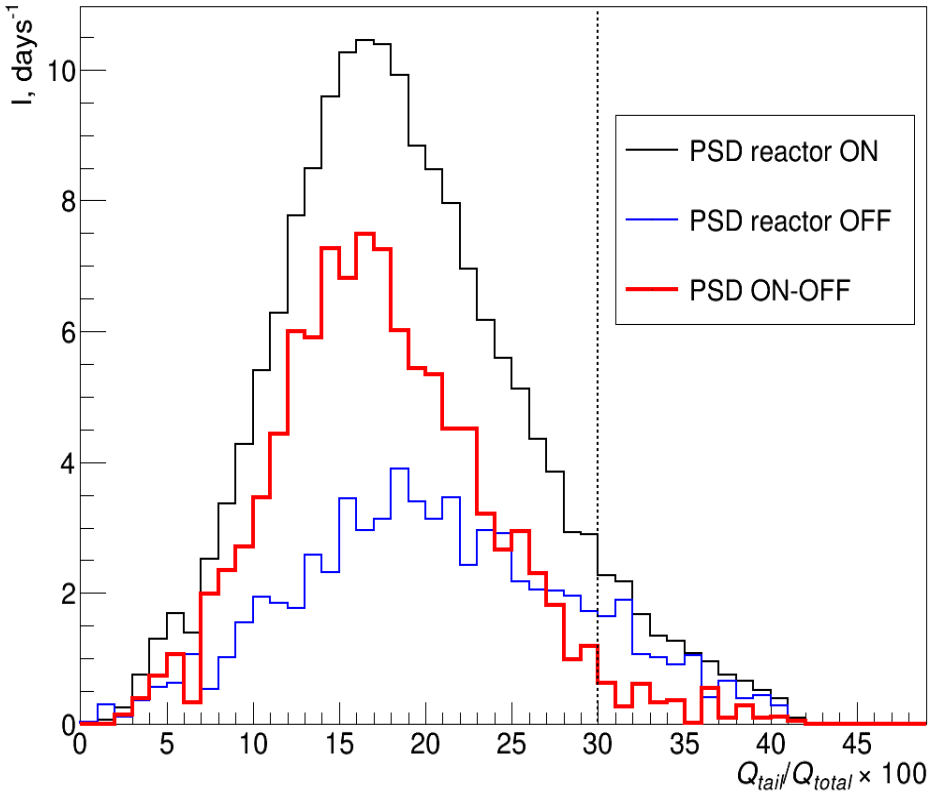
Thank you for your attention!

Backup

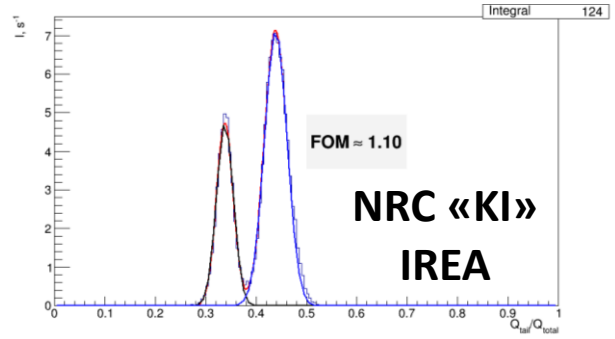
Selection of inverse beta decay events. 511 kev in adjacent sell

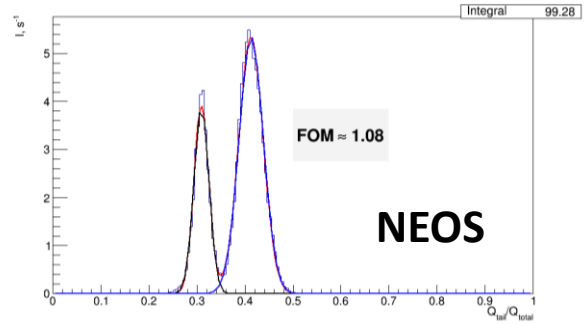


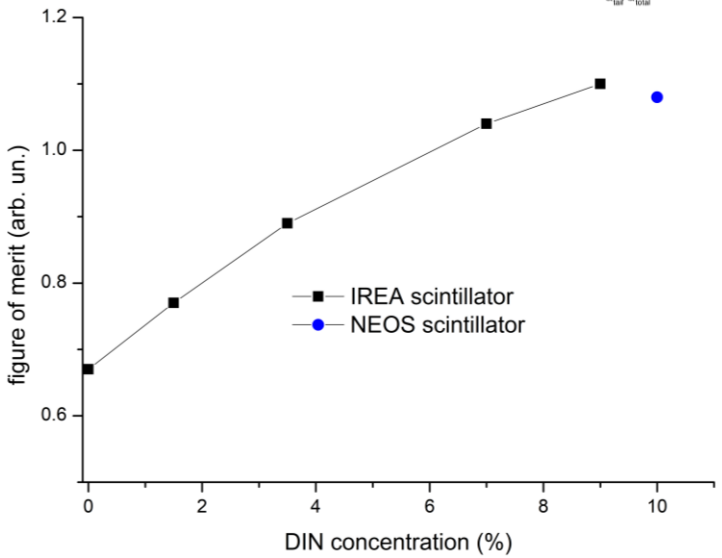
PSD parameter distribution



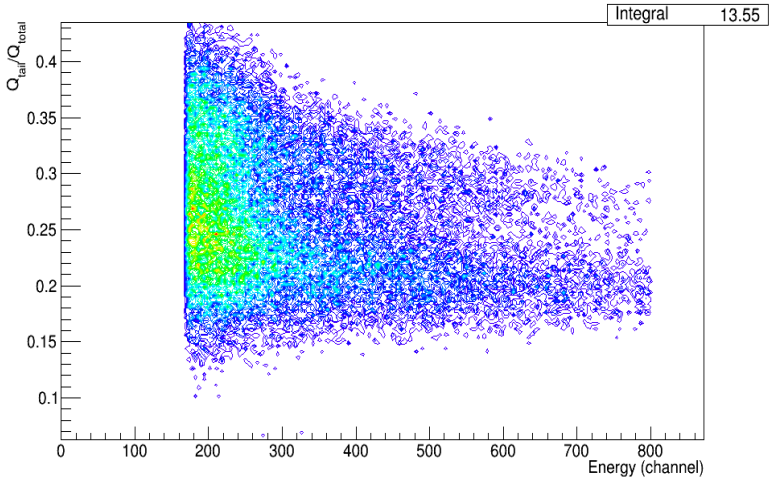
Scintillator

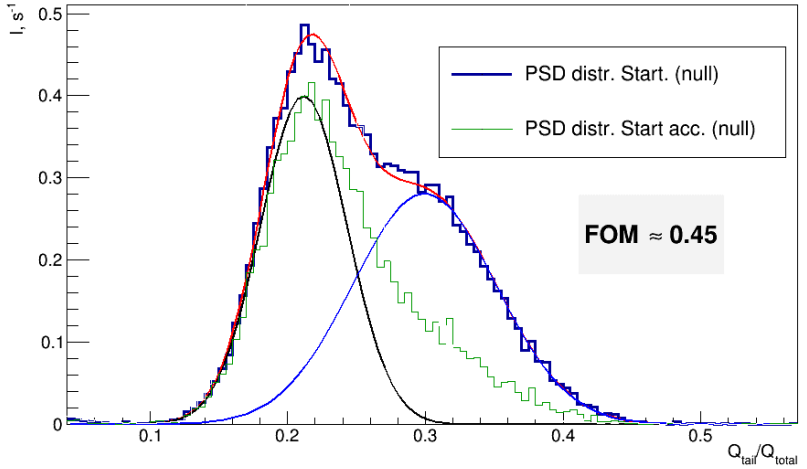






Q_{tail}/Q_{total} resolution on single section



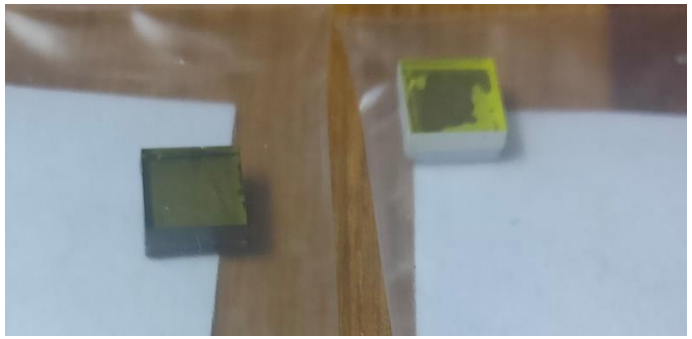


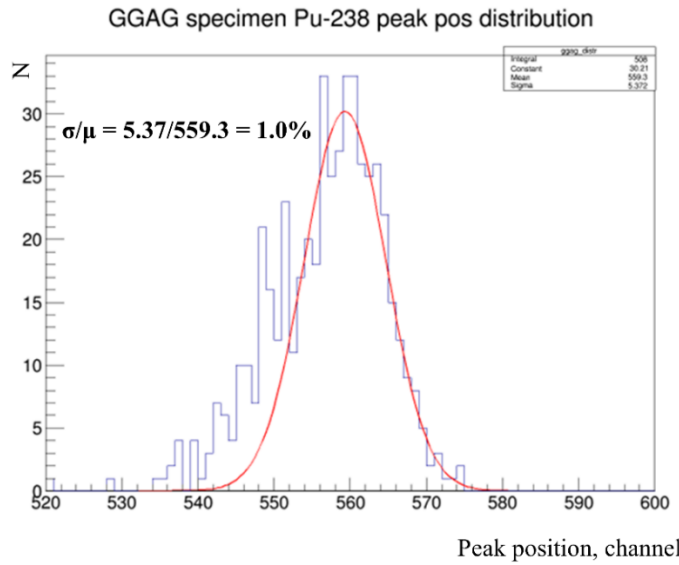
LAB-based LS

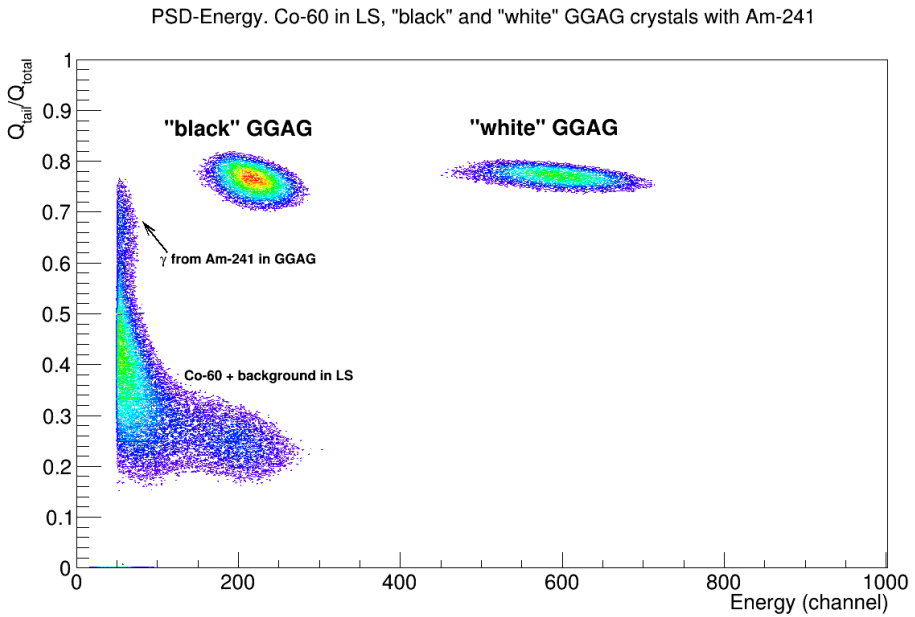
PPO	3 g/l
bis-MSB	20 mg/l
DIN:LAB	1:9

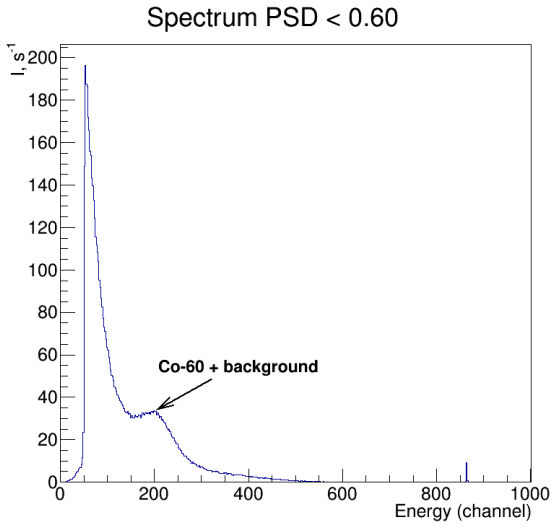
Optical control and calibration system

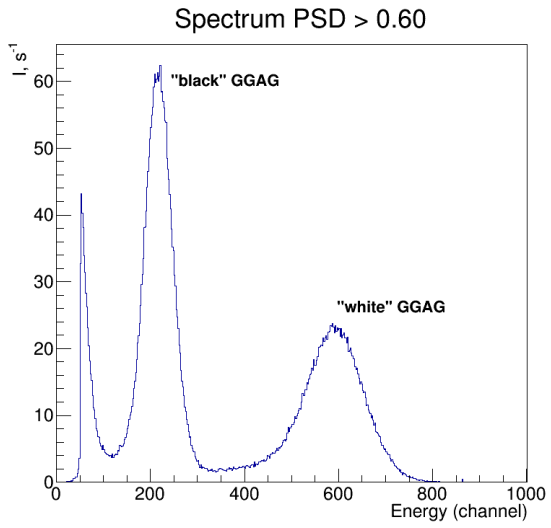
GGAG crystals (gadolinium gallium aluminum garnet) and ^{241}Am



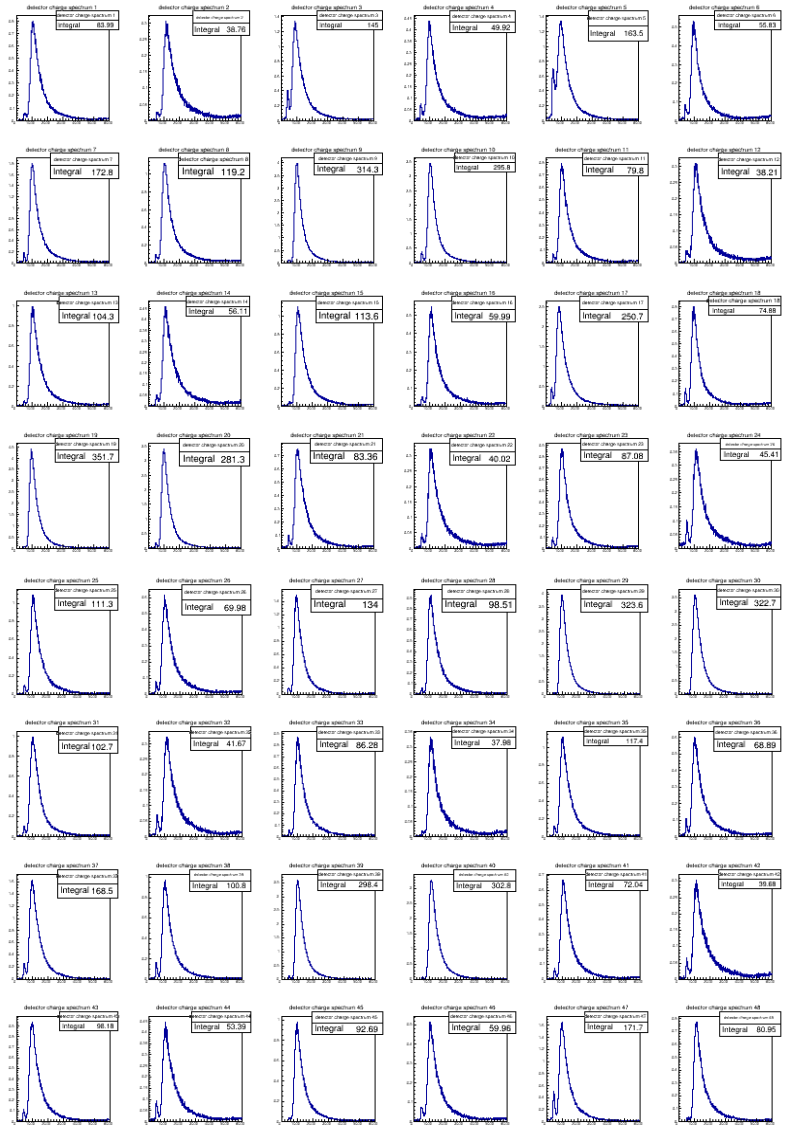






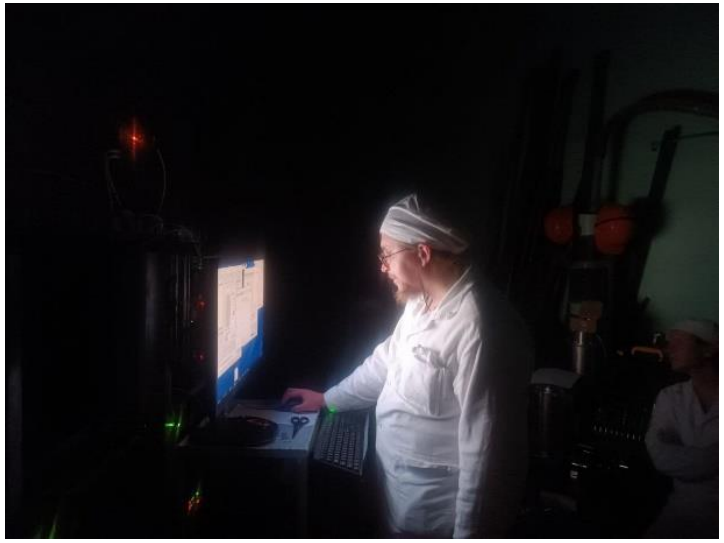


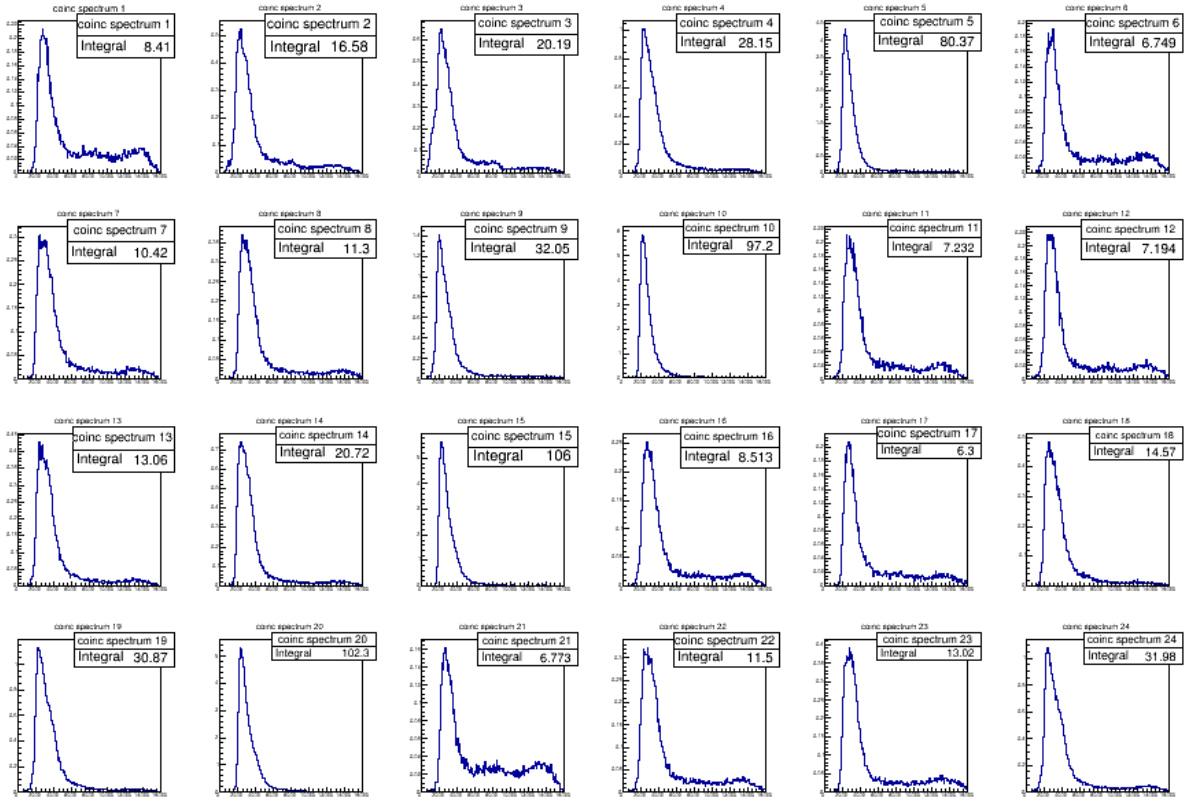
Test background measurements



Spectra of each PMT of the first module

Spectra of each section of the first module with a simultaneous signal in both PMTs





Testing DAQ system boards