Upgrade of the DANSS detector of reactor antineutrino

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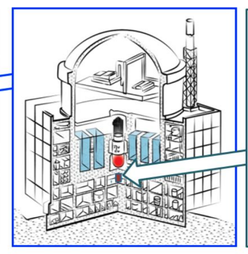
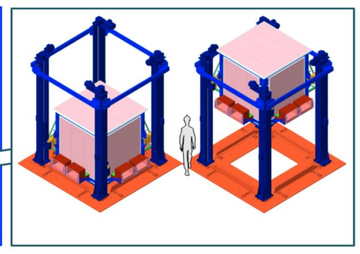
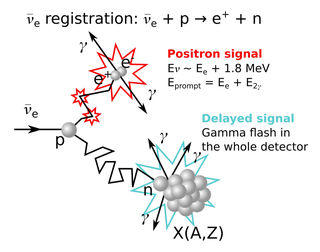
Nataliya Skrobova for the DANSS collaboration

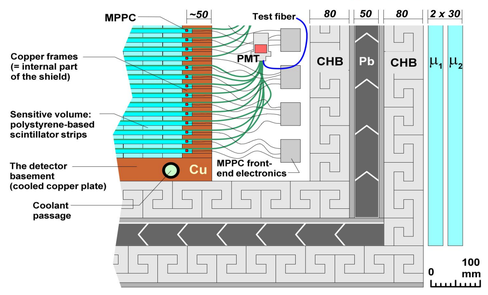
Current design (JINST 11 (2016) no.11, P11011)

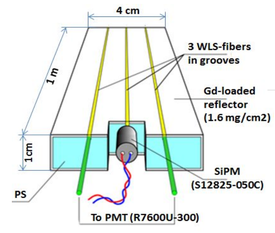
- DANSS – Detector of reactor AntiNeutrino based on Solid-state Scintillator
- Location: Kalinin Nuclear Power Plant, 3 GW commercial reactor, 5 10^{13} ν cm^{-2} s^{-1}, 50 m w.e. overburden
- 10.9 -12.9 m from the reactor core center, movement online
- Multilayer Cu (5 cm) + CHB (8 cm) + Pb (5 cm) + CHB (8 cm) passive shielding
- Two-layer muon μ-veto on 5 sides
- 2500 scintillator strips with Gd containing coating for neutron capture
- Light collection with 3 WLS bers
- Central ber read out with individual SiPM
- Side bers from 50 strips make a bunch of 100 on a PMT cathode = Module
- Dedicated WFD-based DAQ system

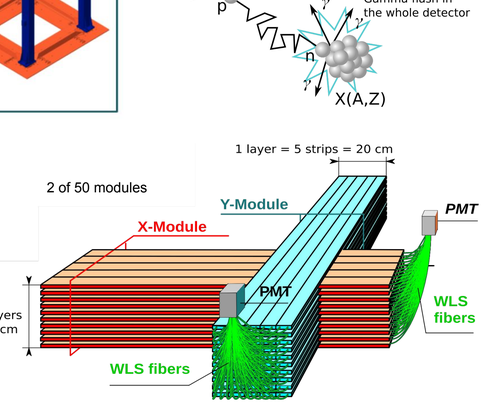


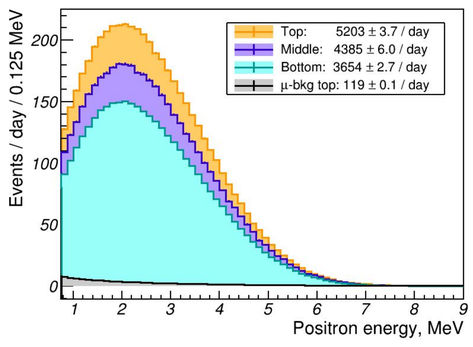






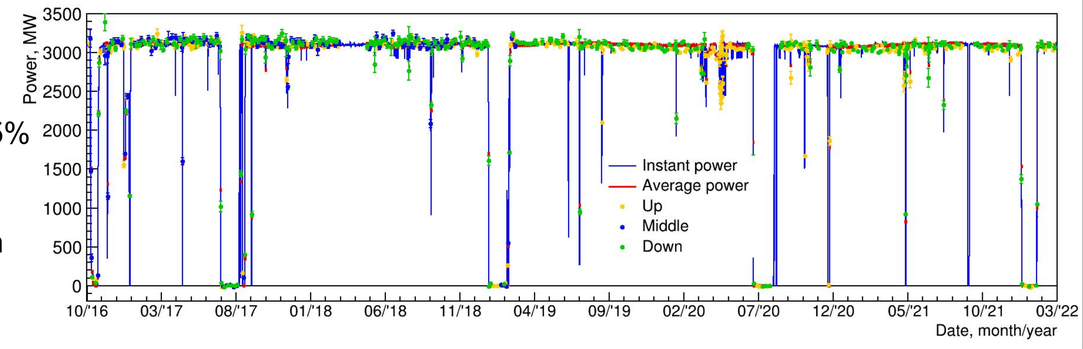






6 years of running

- > 6 mln IBD events, > 5000 events per day in the closest position
- Signal/Background > 50
- Reactor power is measured by the DANSS with neutrino ux with 1.5% accuracy in 2 days during more than 5 years, consistent with statistical fluctuations.
- IBD rate and spectrum dependence on fuel evolution is clearly seen
- Our data excludes a large portion of the sterile neutrino parameter space. See the talk by M.V. Danilov



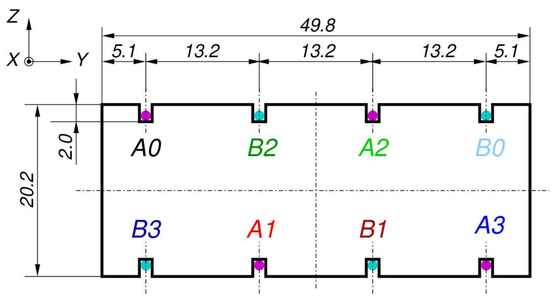
Upgrade aims:

- Achieve better energy resolution. Now ~34 % @ 1 MeV. After upgrade ~12 % @ 1 MeV
- Get larger sensitive volume and increase counting rate

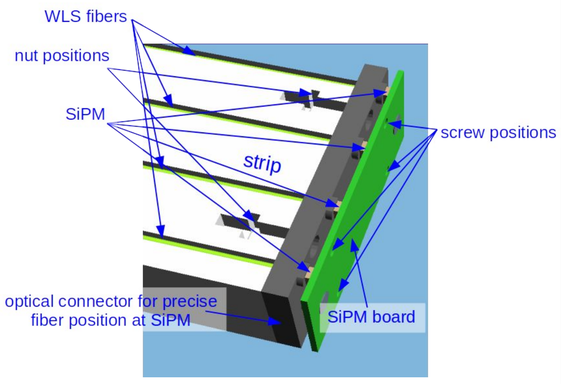
Upgrade approach:

- New scintillation strips: 20x50x1200 mm^3;
- 60 layers x 24 strips — cube (120 cm)^3 ⇒ 1.7 times larger sensitive volume;
- No PMT – SiPM readout from both sides;
- 8 grooves with WLS, 8 (16?) SiPM per strip;
- Triggerless DAQ ⇒ all hits seen from both strip sides are taken for further analysis;
- Strips are machined from a block of a bulk polystyrene by IPTP (Dubna, Russia);
- TOF to get longitudinal coordinate in each strip;
- Chemical whitening of strips – no large dead layer with titanium and gadolinium;
- Gadolinium in polyethylene film between layers;
- New front end electronics – low power inside passive shielding. Cool SiPMs to 10ºC for lower noise.

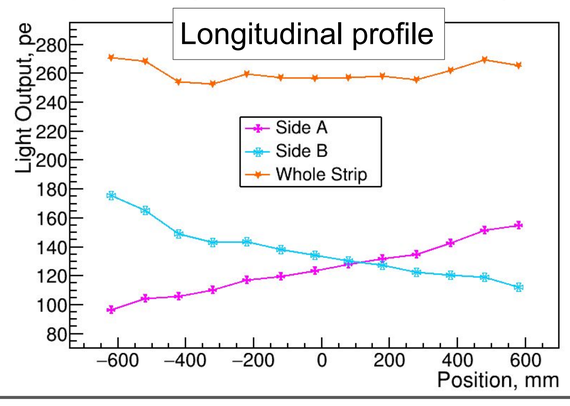
Strip cross section

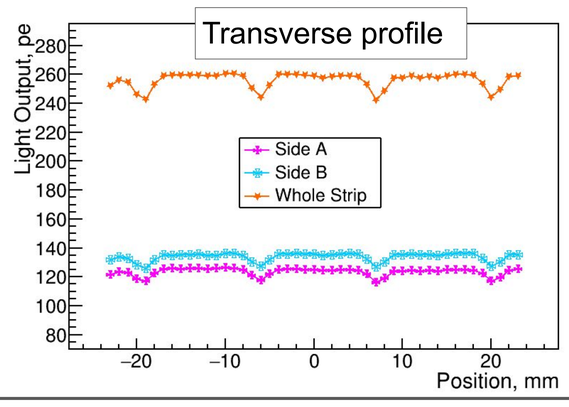


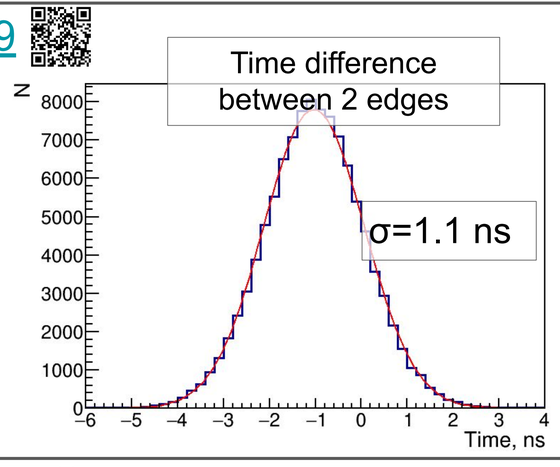
Video with WLS fibers cutting: https://youtu.be/R6fSq_PWAkQ



Strip test (8 SiPM per strip) with π beam JINST 17 (2022) P04009

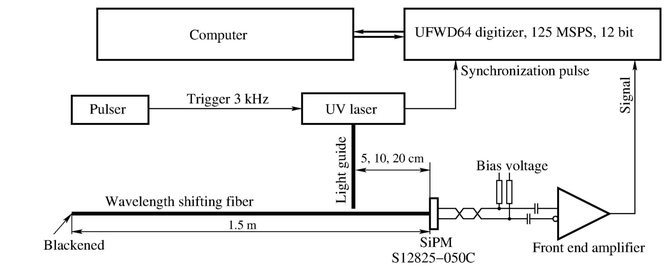




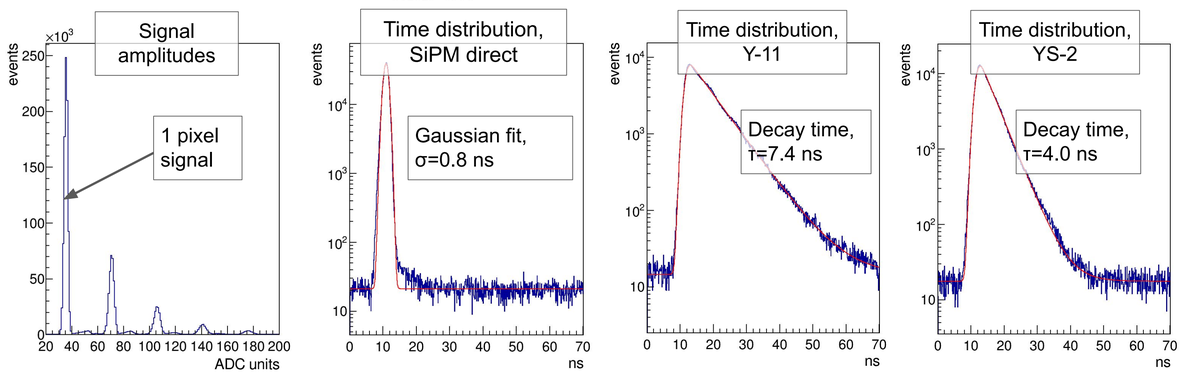


The test results are very promising. Working on double side WLS readout (16 SiPM per strip) and optimization of strip assembly.

New KURARAY WLS fiber YS-2 decay time measurement



JINST 17 (2022) P01031

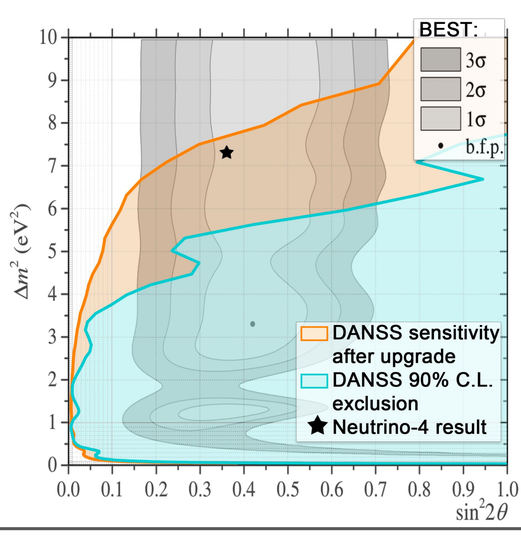


Single pixel events only are used ⇒ no time walk, etc.
In case of Gaussian hardware resolution with width σ and exponential emission decay with time τ event distribution is given by:

$$N(t) = C\left(1 + \mathrm{erf}\left(\frac{t - t_0 - \sigma^2/\tau}{\sqrt{2}}\right)\right) e^{-(t-t_0)/\tau}$$

A comparison of the light output and attenuation length between Y-11 and YS-2 was also performed using cosmic rays and ^{90}Sr β-source and demonstrated that YS-2 is at least as good as Y-11.

Sterile neutrino searches



DANSS 90% C.L. expected sensitivity after upgrade and current exclusion. Upgrade will allow to broaden the sensitivity area to the parameter space values which are preferred by BEST experiment.
DANSS will be able to check Neutrino-4 claim.
For more recent results see the talk by M.V. Danilov

- Upgrade has already started. Most of scintillator strips have been produced. We are going to start assembly of scintillator counters this year.
- Current detector is expected to be decommissioned early next year. The aim is to finish the upgrade next year.
- We expect 8500 events/day or 5 mln. in 2 years.