PMTs and Light Sources for Cherenkov Muon Veto Detector of GERDA Experiment

PMTs

- ET9350
- MACRO, AMANDA-I, SNO, TUNKA-WF ...
- High gain (>10**7)
- High sensitivity - high CB index - high blue sensitivity
- Relatively low noise
- Relatively fast

ET9350 Time Response

- Jitter ~ 2.5-3 ns (FWHM)
- Prepulses - ~1%
- Late pulses - 4-5%
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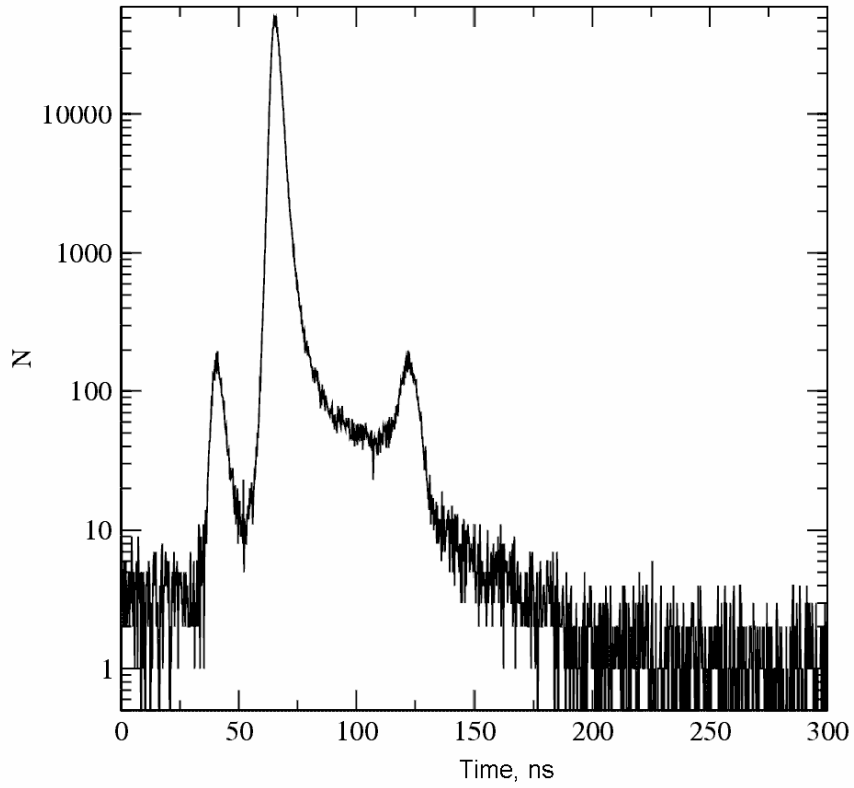
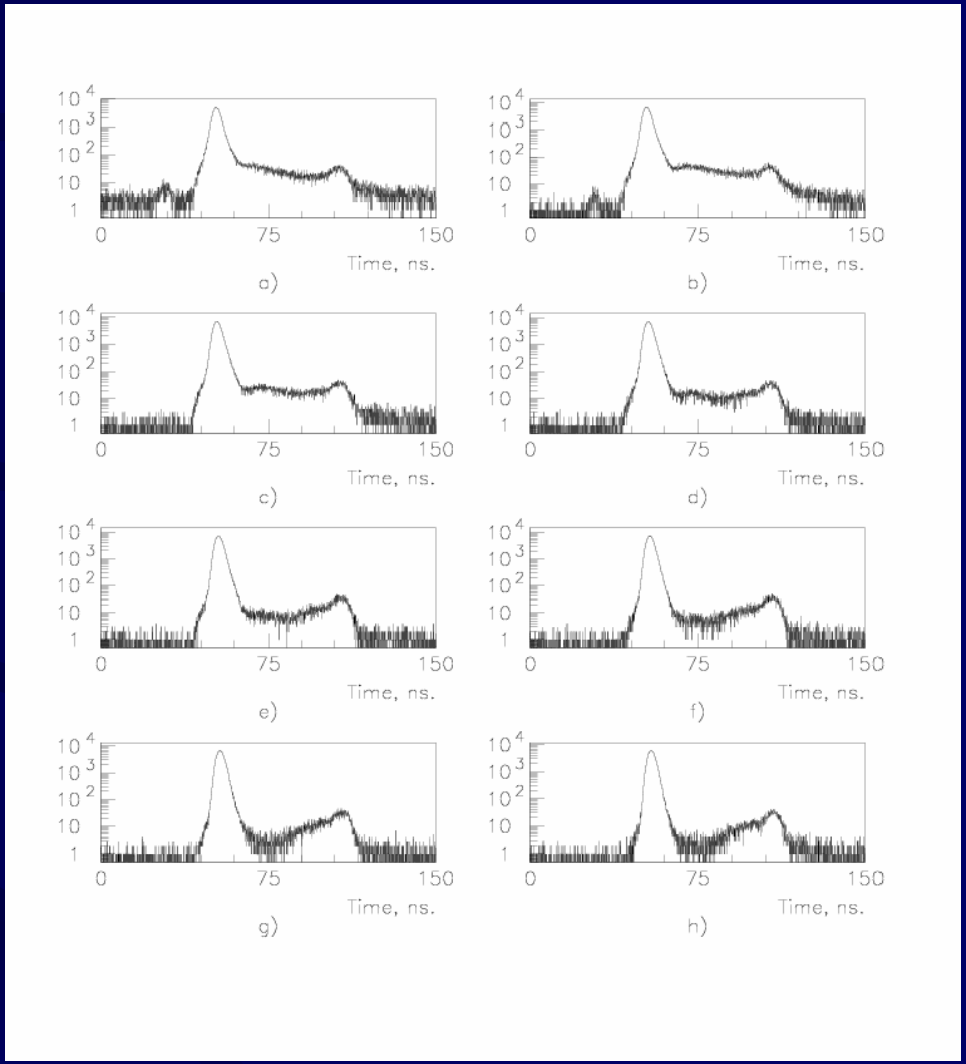
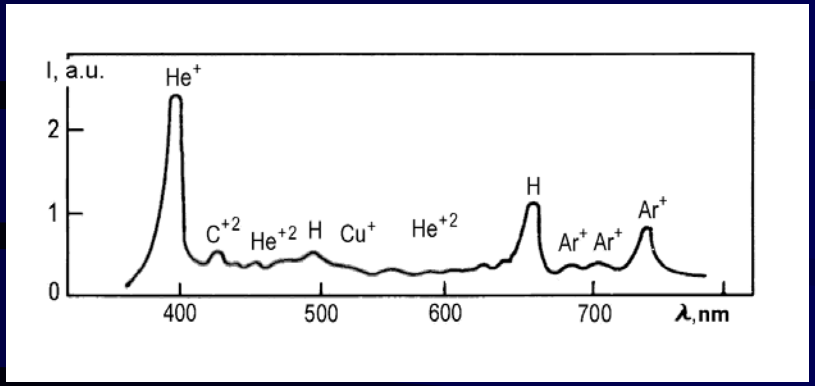


Transit time distributions of ET9350 under different thresholds

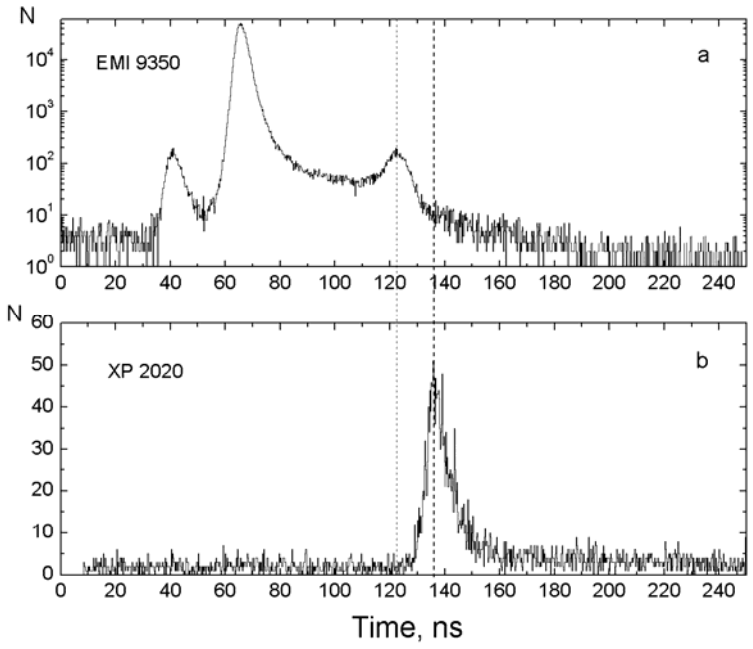
- a) - h)
- 0.05 - 0.5 p.e.



Anode afterglow

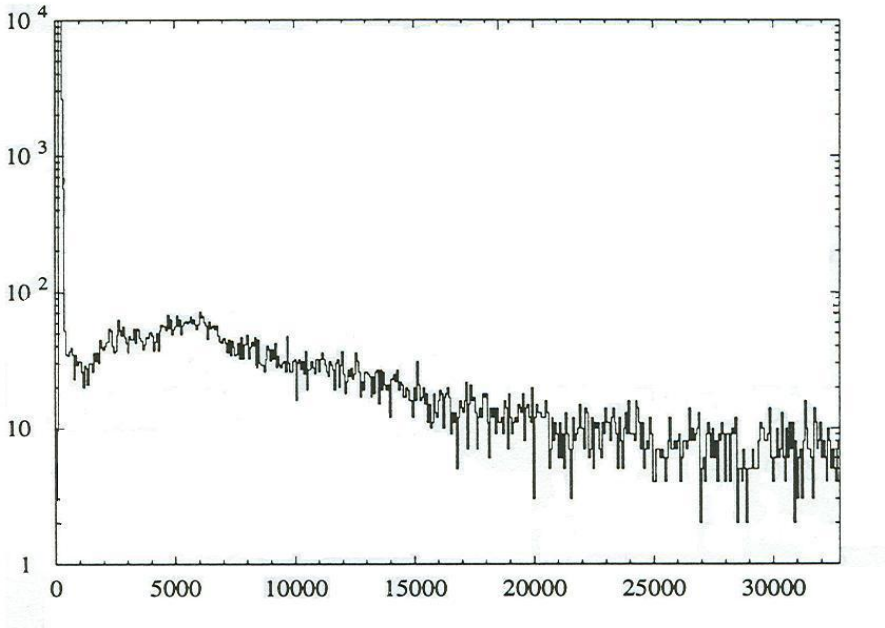


- Spectrum of anode afterglow - predominantly in visible region
- < 0.1%, negligible



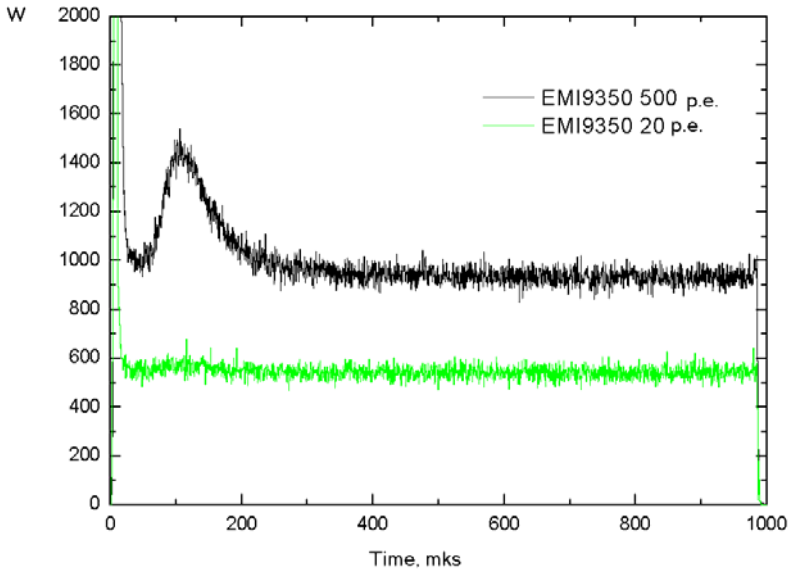
EMI9350 anode afterglow kinetics

Afterpulses

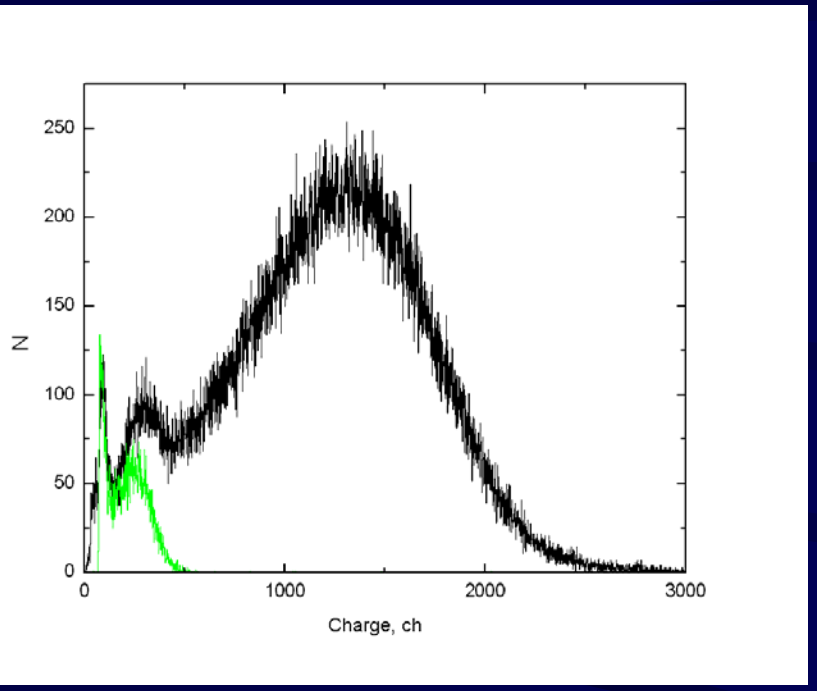


- > 100 ns - 1÷10%

Long delayed afterpulses
~150 μs
< 1 % (*Lubsandorzhiev, Vasiliev 1999*)
so far not observed in GERDA PMTs batch



ET9350 SER under extremely low threshold



- Threshold - ~ 0.005 p.e.! (just for some PMTs)
- ET9350 collection efficiency is low - ~ 60% at 500V cathode - 1 dynode (*Lubsandorzhiev, Pokhil, Spiering 2000)*

Linearity

- 150 p.e. (<5% nonlinearity) at the gain of 10**7 with nonuniform voltage divider

ET9350 dark current

- Dark current counting rate - < 10 kHz at 20 C and 0,25 p.e. threshold
- Nonpoissonian behavior in some tubes
- Discharges?

- Qualification tests of all PMTs
- Absolute calibration of PMTs (with a set of LEDs: 255 nm ÷ 655 nm)
- Precalibrated PMTs in the array

Calibration Light Sources

- 2 types of light sources:
- a) to illuminate every individual PMT
- b) to illuminate all PMTs in the array through water with a few fibers and diffusing balls at the caps of the fibers

a) LED driver based on a complementary pair of fast transistors.

Driver's light output is adjustable - 0÷10**8 γ/pulse, 1÷2 ns width

One LED illuminates a bundle of 80 fibers - one fiber for one PMT.

LED - ultra bright LED from YolDal, G-nor or Lumitronix.

5÷10 cd SQW/MQW InGaN LEDs with λ_{max} ~ 470 nm, 1÷2 Euros

Measured range of light yield on PMT's cathode after 35 m long

fiber - 0 ÷ >1500 p.e.

Fiber - ∅ 1 mm PMMA.

b) LED driver based on avalanche transistors

LED - ultra bright LEDs from YolDal, G-nor or Lumitronix

Light yield - 10**9 ÷ 10**10 γ/pulse with 1÷2 ns width (FWHM)

or powerful LEDs from LUMILED, G-nor or Cree (star, V, III series).

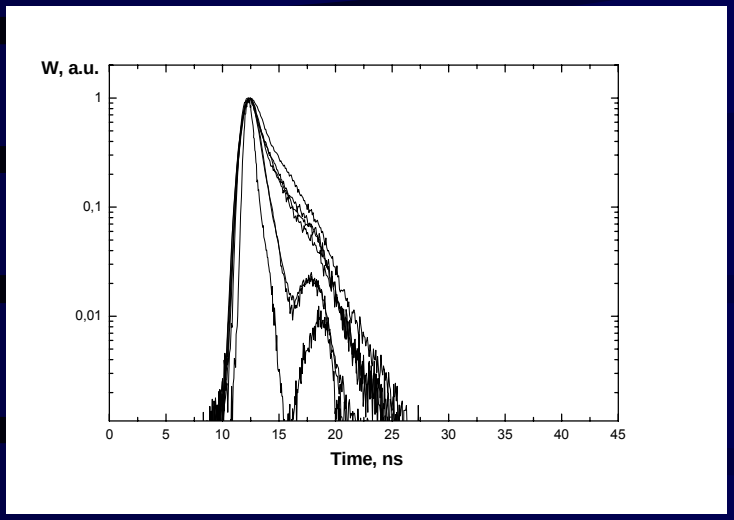
Light yield 10**11 ÷ 10**12 γ/pulse with 5÷10 ns width (FWHM)

470 nm peak (D-A) is predominant under low current pulses

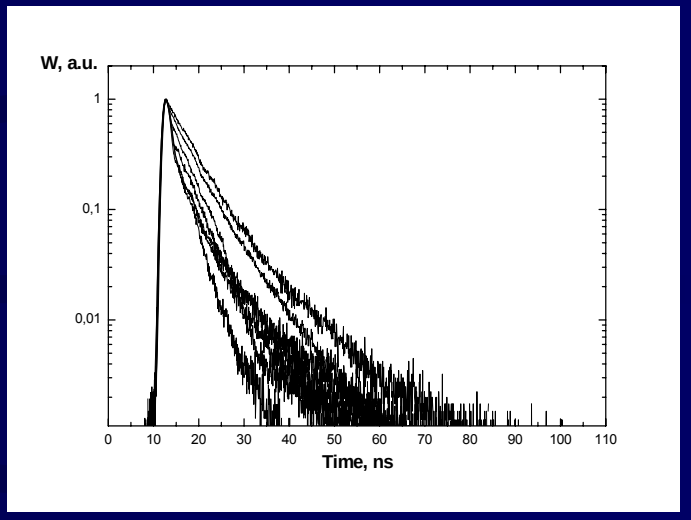
Second peak 380÷400 nm (CB-VB) appears at high current pulses

Cree XLamp UVV - 400 nm, 0.5W 1A DC current, lambertian.

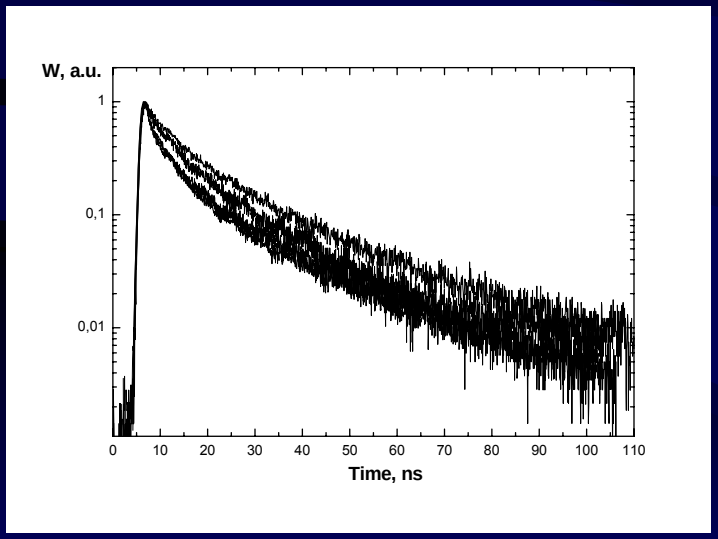
Ultra bright LEDs emission kinetics



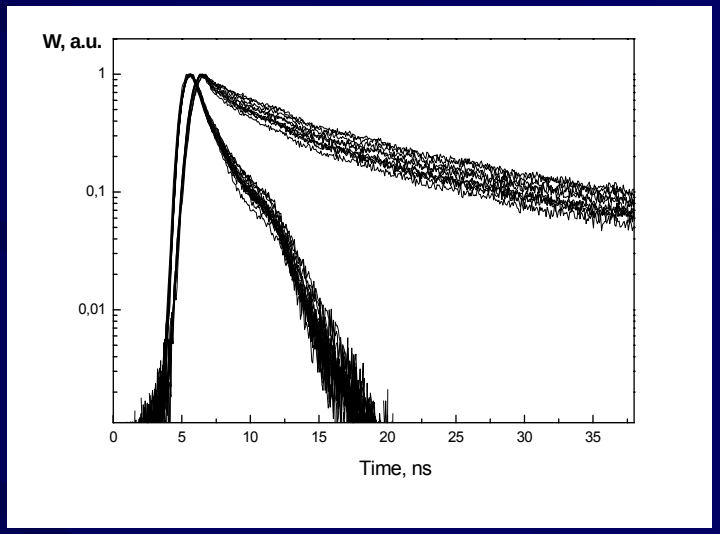
Fast LEDs(Nichia «old», G-nor, YolDal)



Intermediate LEDs

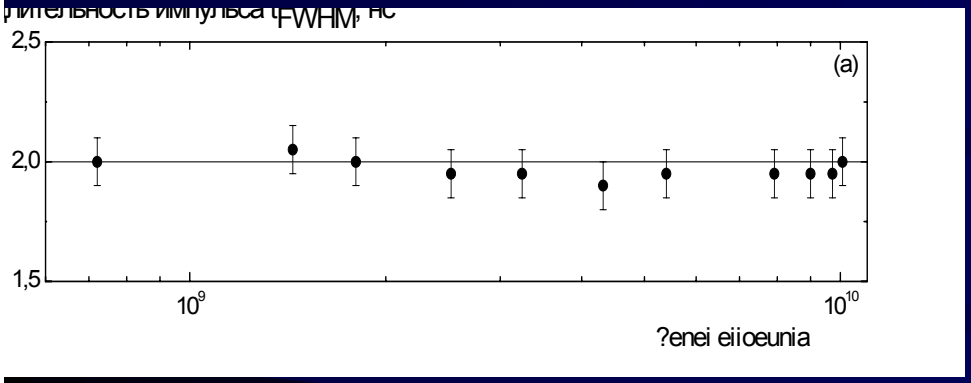


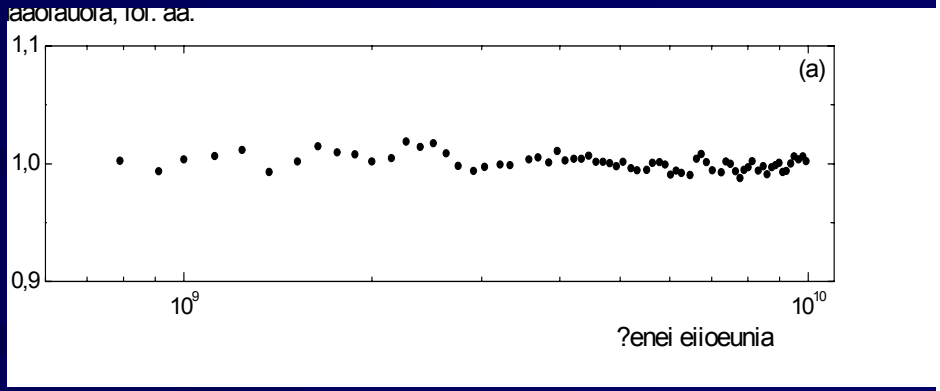
Slow LEDs



Nichia «old» and «new» LEDs

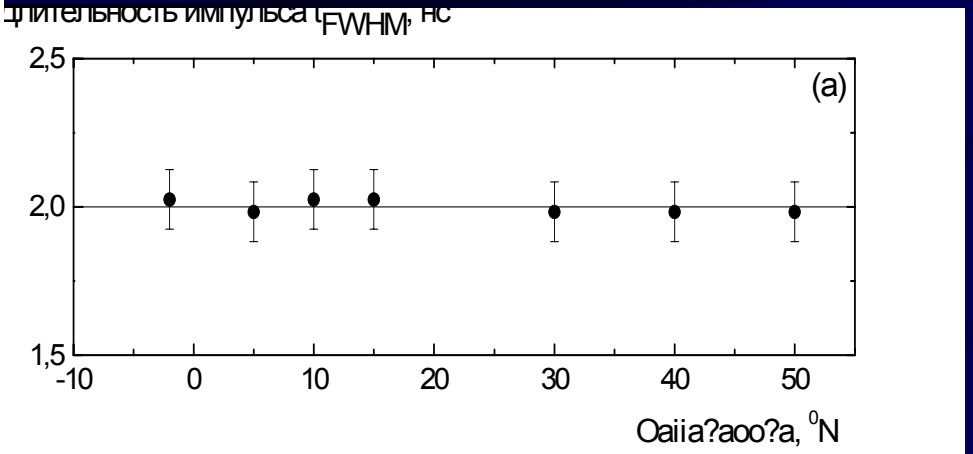
LED stability and life time

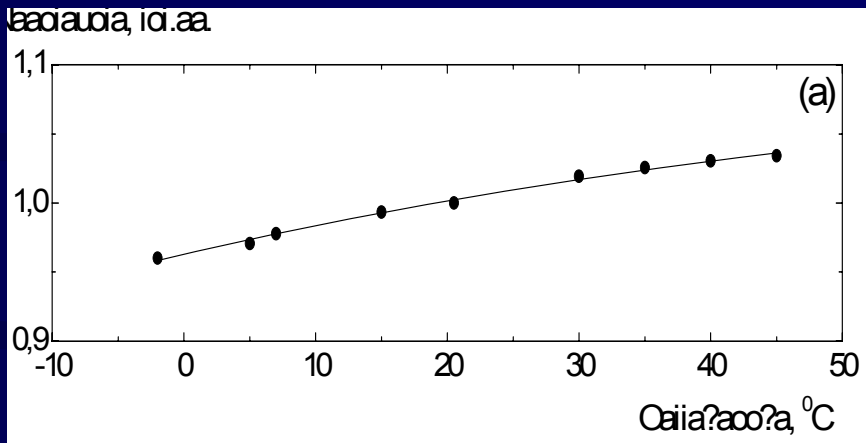




Pulse width (left, ns) and light yield (right, a.u)
vs
the total number of pulses

Driver's parameters temperature dependences





Pulse width (left, ns) and light yield (right, a.u)

vs

temperature

Temperature coeff. - 0.14%/C in the range of -3 ÷ 45 C

- Light sources have been developed for calibration system of Cherenkov Muon Veto Detector of GERDA Experiment
- Ultra Bright LEDs suit very well for this purpose
- They are powerful, fast, stable, reliable, cheap and very simple in operation.