The Baikal Optical Module for GVD

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OUTLINE

1. GVD optical detector concept

2. Optical sensor and OM design

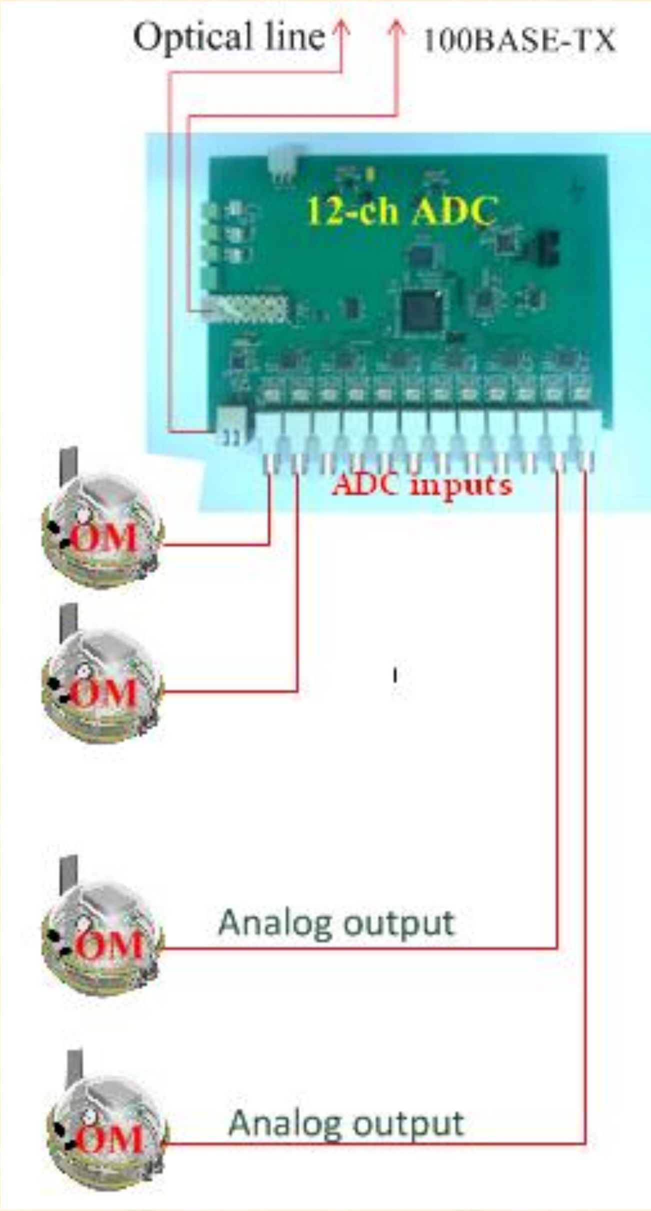
3. Electronics

4. OM reliability

Summary

GVD Optical detector concept

GVD Section



A group of Optical Modules (Section) are connected to one multi-channel ADC board, that provides data processing.

- Optical module design: as simple as possible;
- Possibility to use two modes of operation:

(1) Slow data transmission (triggered mode): OM coincidences produce a trigger that rejects the PMT noise.

(2) Fast data transmission: optical line from ADC module to Shore Center (all data to shore).

Basic mode of GVD operation – slow data transmission (10Mbit per string). Possibility to use optical line for the string under consideration. For the last version of ADC board (2014) two data output 100BASE-TX and –FX are foreseen.

Optical sensor

R7081HQE, R7081-100 Hamamatsu
10 inch. Super Bialkali photocathode
QE ≈ 35% @ 400nm

Spectral Response, nm	**300 to 650**
Effective Surface Area, cm^2	**530**
Number of Stages	**10**
Max Supply Voltage, V	**2000**
Quantum Efficiency at peak	**0.35**
Gain	**10^7**
Peak to Valley	**2.8**
Rise Time, ns	**3.8**
TTS (FWHM), ns	**3.4**
Dark Count, Hz	**8000**

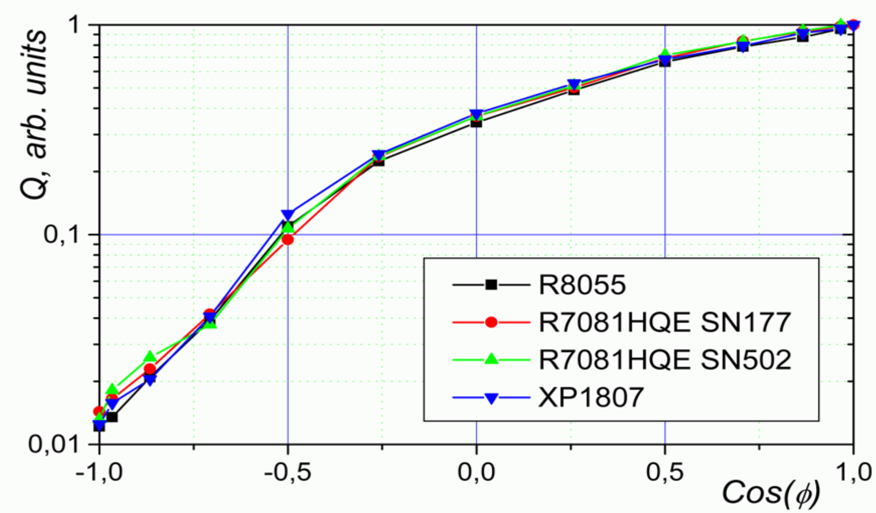
Optical module design

Glass pressure sphere
VETROVEX (17”)

SubConn LP, 5-contacts:
- PMT analog pulse (coax)
- 2-wire RS485
- 12 V power supply

OM electronics: HV converter, amplifier, controller, LEDs

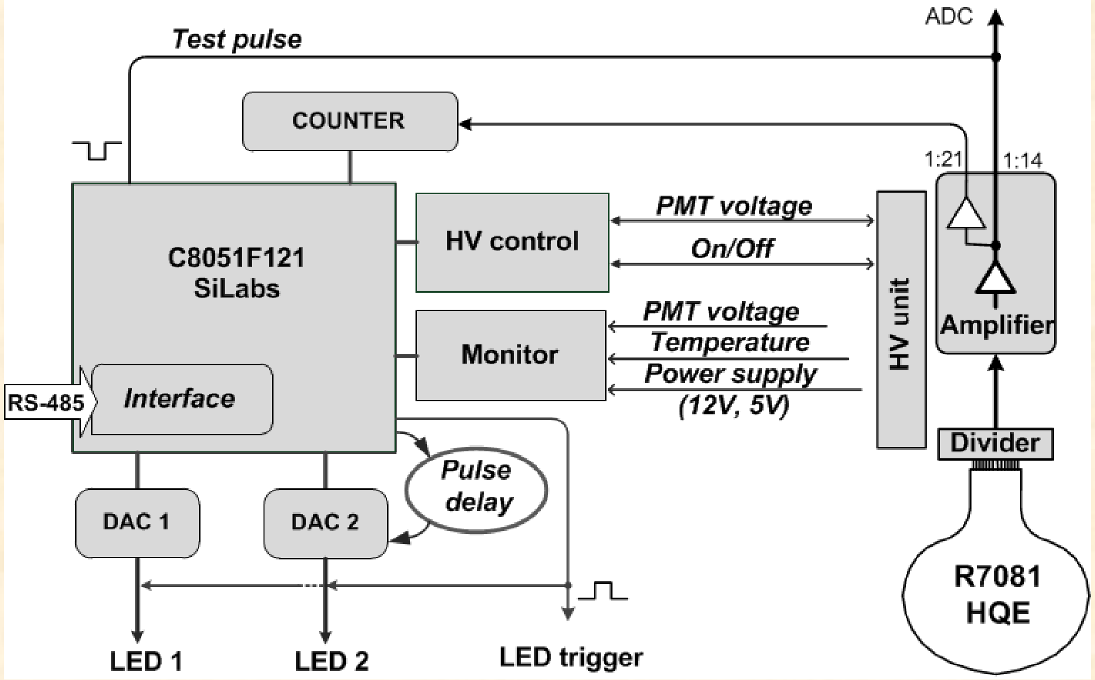
Mu-metal grid



Angular dependences of OM response

Optical module electronics

Functional scheme of the optical module electronics



HV converter: SHV 12-2.0 K 1000 P

0 …+ 2000 VDC, stability 0.05%

ripple and noise 8 mVpk-pk

Passive divider: 18 MΩ

2-channel amplifier: Output channel and PMT noise monitoring channel.

2 LEDs L7113: 470 nm, 5-7 ns

- regulation of intensities in the range 1…~10^8 photons (100m Baikal water)
- LED pulse delay regulation: 0 … 1000 ns

Slow control board: SiLabs C8051F121

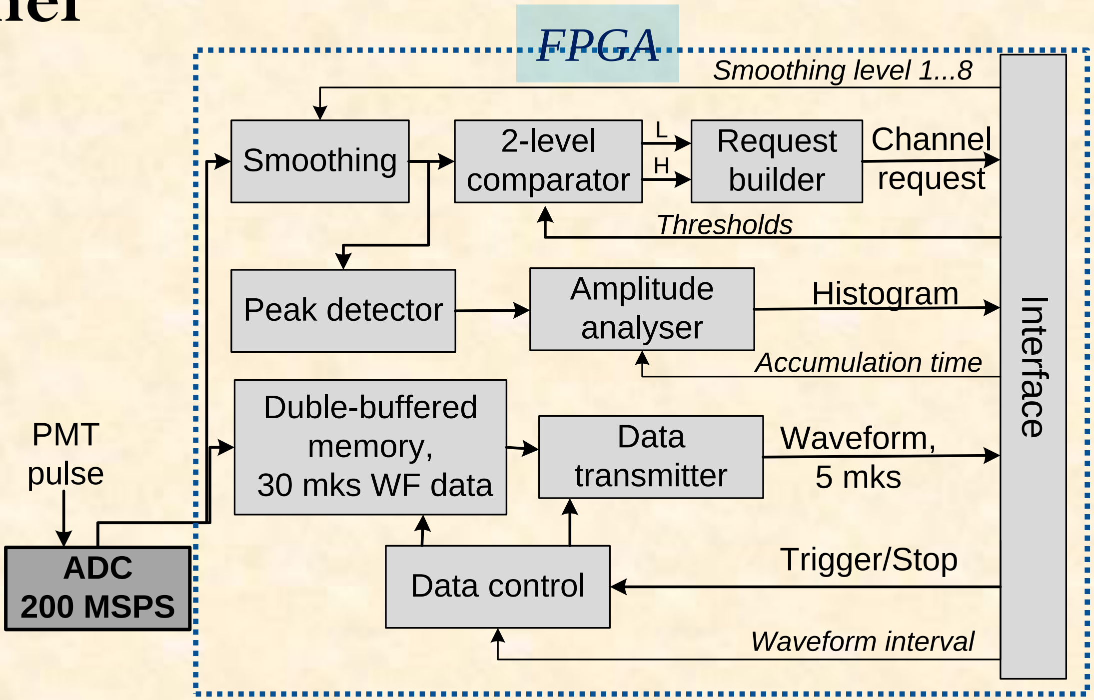
Control of electronics operation and monitoring of PMT parameters via RS485 interface.

Power consumption – max 0.3A×12V

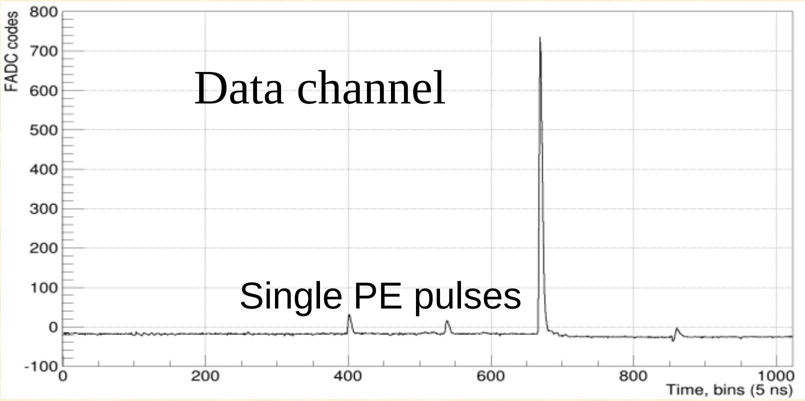
ADC channel

FADC (AD9430) 12bit, 200 MSPS
FPGA (Xilinx Spartan 6)

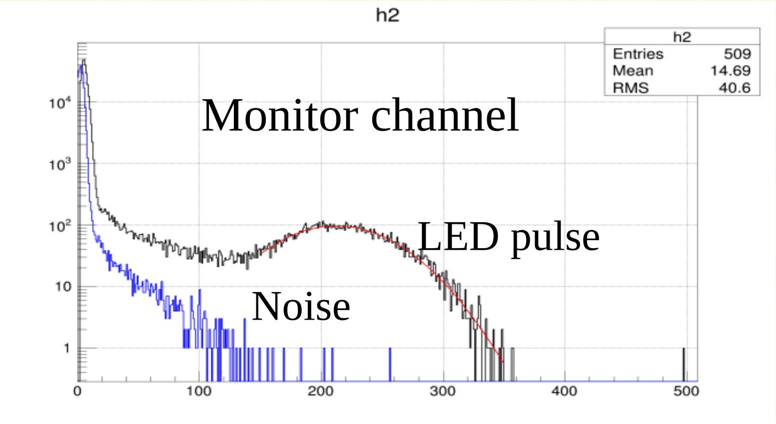
- Trigger logic: 2-level adjustable digital comparator forms low threshold ***L*** and high threshold ***H*** channel requests (section trigger is ***L&H*** coincidence of neighboring channels).
- Data channel (triggered) consists of double-buffered memory and data transmitter.
- Monitor channel (non-triggered) includes peak detector and amplitude analyzer.



Functional scheme of one FADC channel

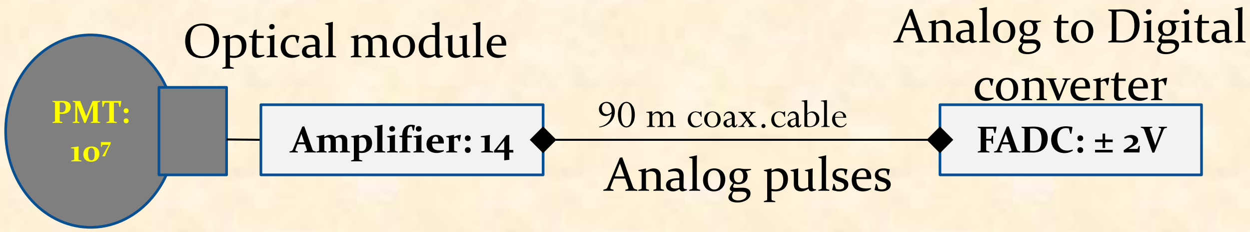


Waveform stamp example (5 mks)

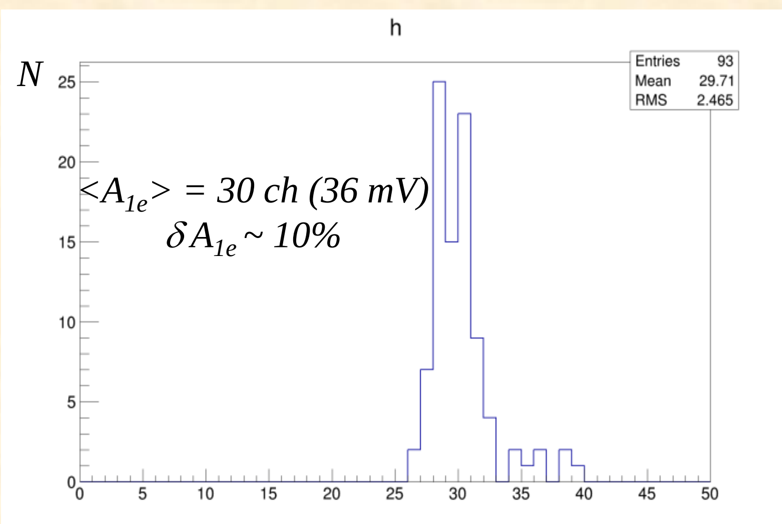


Monitor histogram examples

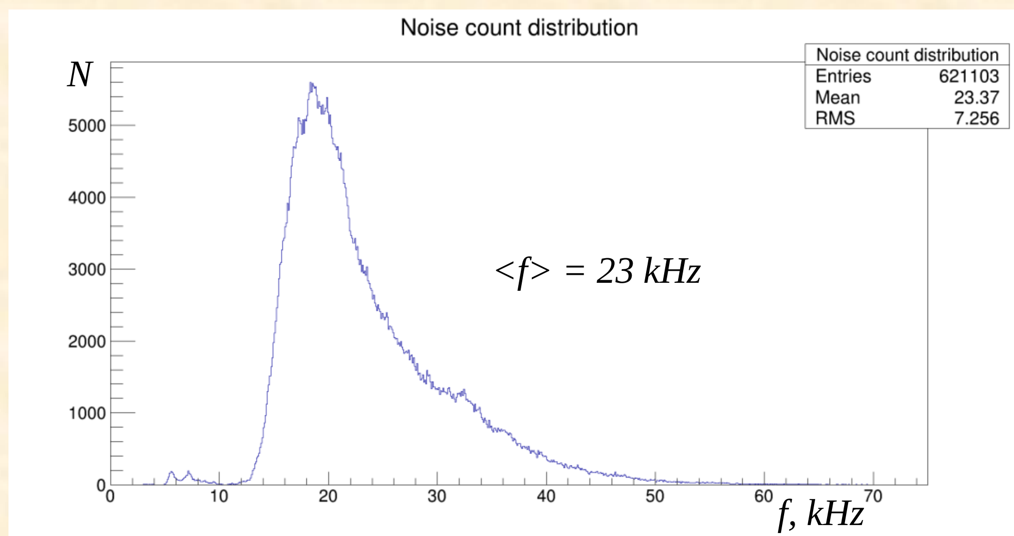
Measuring channel



- PMT nominal gain 1×10^7; Amplifier k_{amp}=14; Cable: =0.7: 10^8 in total
- PMT pulse width after cable: ~20 ns FWHM: → A1e ≈ 40 mV
- FADC: 12 bit 200 MHz; range ± 2V, waveform stamp up to 5 mks;
- Channel counting rates (0.3 PE) 15 … 50 kHz



Distribution of the measuring channels on A_{1e} value (2014), ADC chan.



Count rates ***f*** for all channels, from April up to August 2014

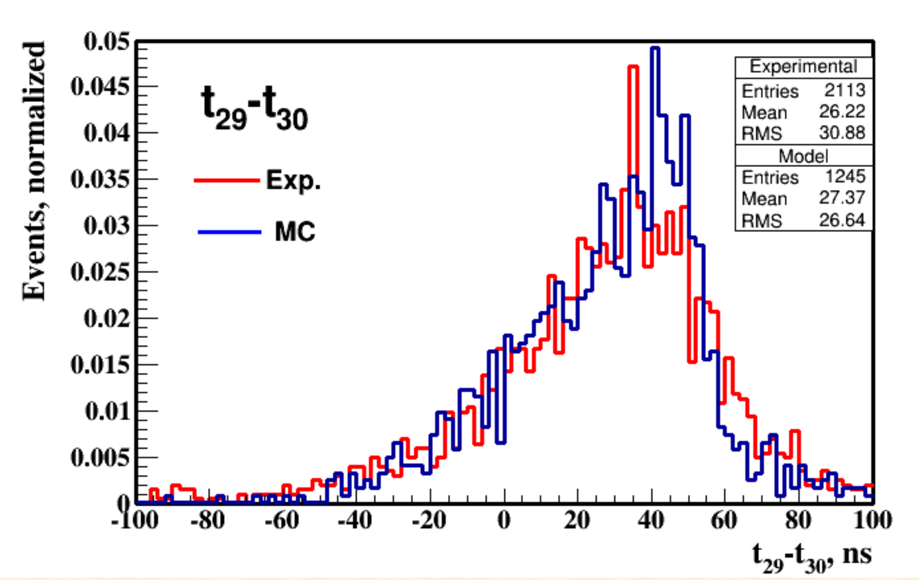
GVD OM - atmospheric muon detection

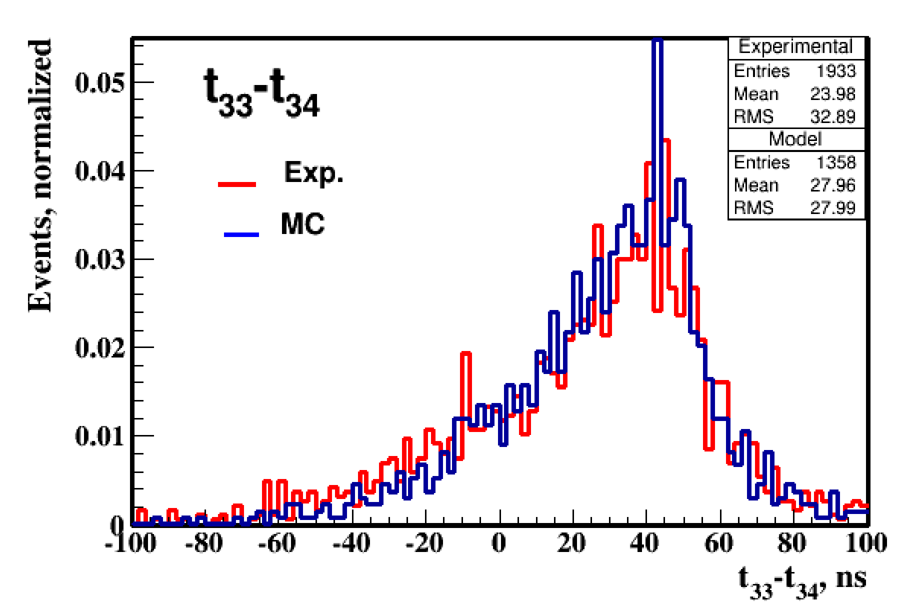
Statistics - 1707896 events

Selection – Q > 2 ph.el.

LED – calibration

Data consistent with expectation





dt distribution between neighboring channels

OM reliability

Results from April 2012 up to September 2014
(without stress tests of electronics during prototyping phase)

Prototype arrays: 2012: 36 OM, 2013: 72 OM, 2014: 120 OM

A summarized time of the OMs operation is ~170 years

3 OM failures during this period:

- 1 OM: HV control system out of operation (2013).
- 2 OM: not reliable connection via RS485 bus (2014).

The OM electronics failure rate ~2% / year

Repairing possibility: 8% / year for 100 strings installation (GVD Phase 1).

Conclusion

1. GVD optical module has conventional design: one PMT (R7081-100, 10”, 0.35 QE), analog output.

2. Integration a group of optical modules with one multi-channel ADC module allows to build basic GVD detection unit - Section. ADC module design gives possibility to use different modes of operation: triggered mode ore transmitting all data to shore (in the case of the optical communications).

3. The Optical Modules failure rate (~2% per year) is significantly less then repairing possibility: (~8% per year).

4. GVD Optical Module design is basically finalized.


THANK YOU