ICRC 2021

Novel gain-calibration and –monitoring based on highly compressed PMT hit information

12-23 July 2021
Berlin | Online

The KM3NeT DAQ-challenge

Neutrino research facility in the Mediterranean sea

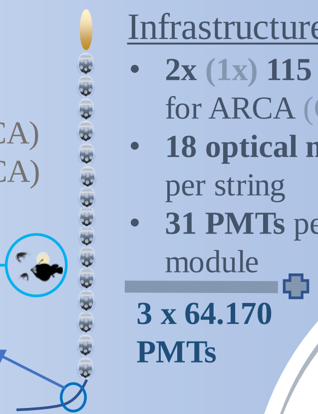
Two water Cherenkov detectors for two research goals:

1. Pinpointing the origin of cosmic neutrinos (ARCA)
2. Determining the neutrino mass ordering (ORCA)

Rigorous data-reduction essential; store only:
PMT address (1B)
Hit arrival time (4B)
Time-over-threshold (1B)

Background ~7kHz / PMT

Max. 200 Mbps / module



Infrastructure:

- 2x (1x) 115 strings for ARCA (ORCA)
- 18 optical modules per string
- 31 PMTs per module

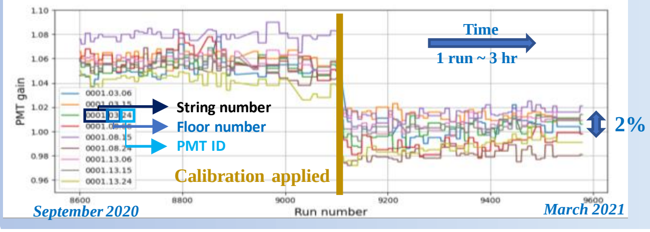
3 x 64.170 PMTs

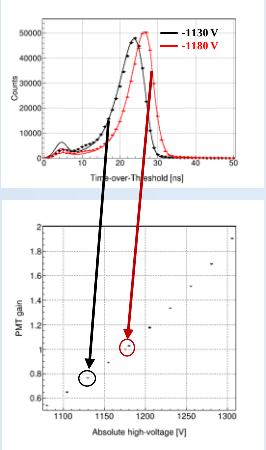
Gain calibration and monitoring

4-step gain tuning procedure:

I. Take ToT-distributions for range of HV settings
II. Fit the gain for each distribution
III. Plot linearized (gain, HV)-data
IV. Interpolate the desired gain

successful gain-equalization with ~ 2% accuracy



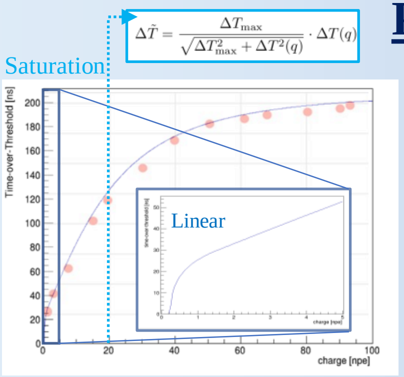


Conclusions

KM3NeT-DAQ addressed uniquely
Extreme compression of PMT hit info from full waveform to 6 Bytes

Time-over-threshold is an effective measure for PMT gain-diagnostics
Gain equalization possible to within ~ 2% of target value

PMT pulse shape modeling



Data-points from Jonas Reubelt's PhD thesis (2018)

Analogue pulses modelled by a Gaussian with an exponential tail

⟶ **Analytical expression** for **time-over-threshold in terms of charge** (ToT)

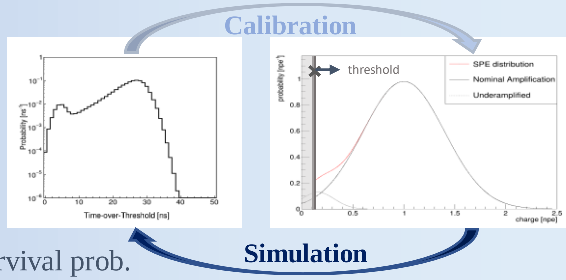
Three main features:

1. Logarithmic dependency between charge and ToT
2. Linear regime below 20 p.e.
3. ToT-saturation above 20 p.e.

The charge distribution

PMT gain = average charge of analogue pulses generated by single primary photo electrons

Charge distribution modeled as a 2-component **Gaussian mixture** (underamplified + normal)



ToT and gain are related
⟶ **ToT-based gain fitting**

Goal: 5% gain accuracy ⟶ < 1% error on signal survival prob.

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