In-situ gain monitoring and calibration of KM3NeT PMTs

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On behalf of the KM3NeT collaboration

KM3NeT: km^3 Neutrino Telescope

KM3NeT ARCA/ORCA

ARCA: Astroparticle Research with Cosmics in the Abyss

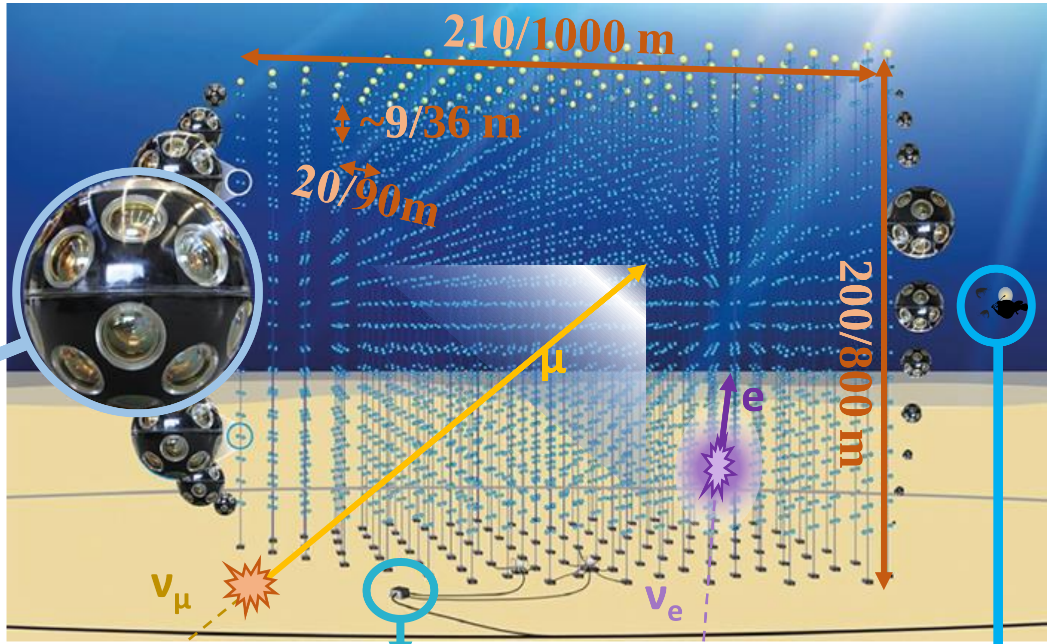
- 100 km off-shore from Capo Passero (Sicily); 3.5 km depth
- Focus: origin of cosmic neutrinos
- **Large, sparse grid → high energy (> TeV)**

ORCA: Oscillations Research with Cosmics in the Abyss

- 40 km off-shore from Toulon (France); 2.5 km depth
- Focus: atmospheric neutrino oscillations
- **Small, dense grid → low energy (GeV)**

115 strings	per building block	**64.170 PMTs per block**
18 optical modules	per string	
31 PMTs	per module	

x1 (x2) for ORCA (ARCA)



Max. 200 Mbps / optical module

Background
~ 7kHz per PMT
^{40}K-decay

Extreme data-reduction essential; From full analogue pulse to 6 Bytes: PMT address (1B), hit arrival time (4B), Time-over-Threshold (1B)

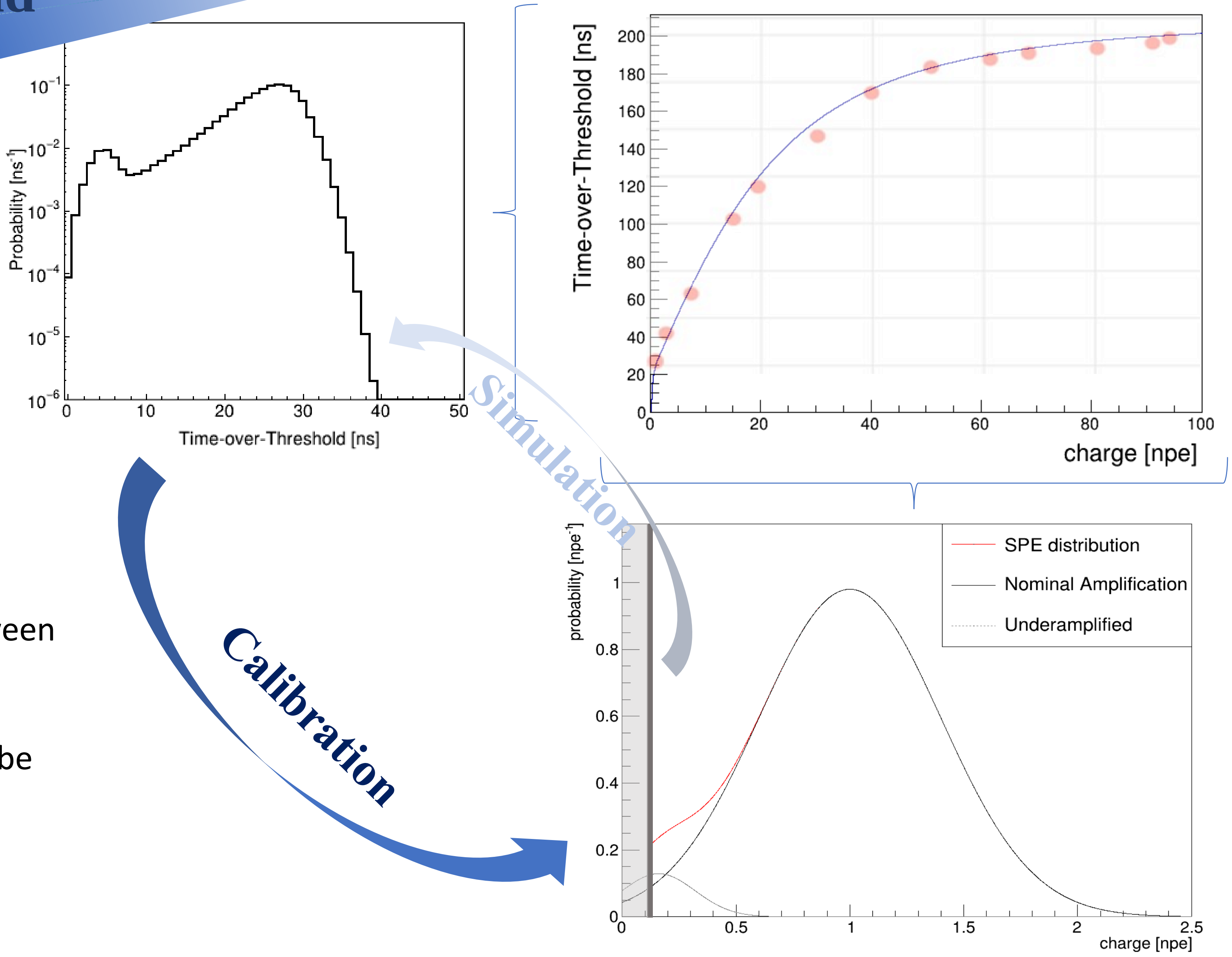
Time-over-Threshold and charge

PMT gain =
average single photo-electron (SPE) current amplification

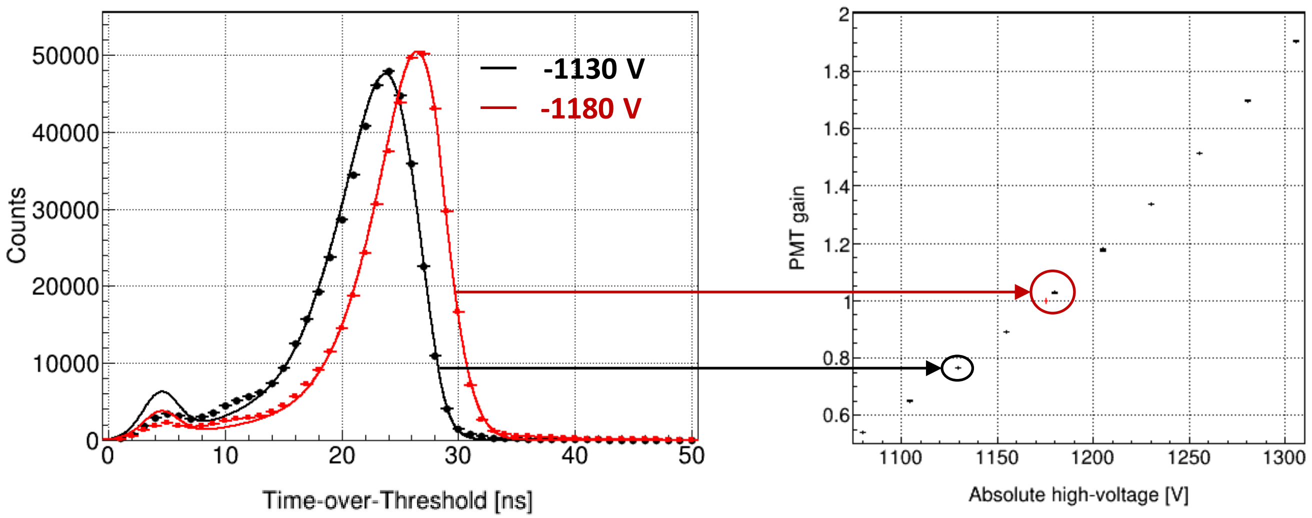
To good approximation,
PMT analogue pulses can be modeled as Gaussians with Exp. Tails

- Yields logarithmic dependence between Time-over-Threshold and charge

This allows SPE time-over-threshold to be fitted in terms of the gain



Tuning the gain

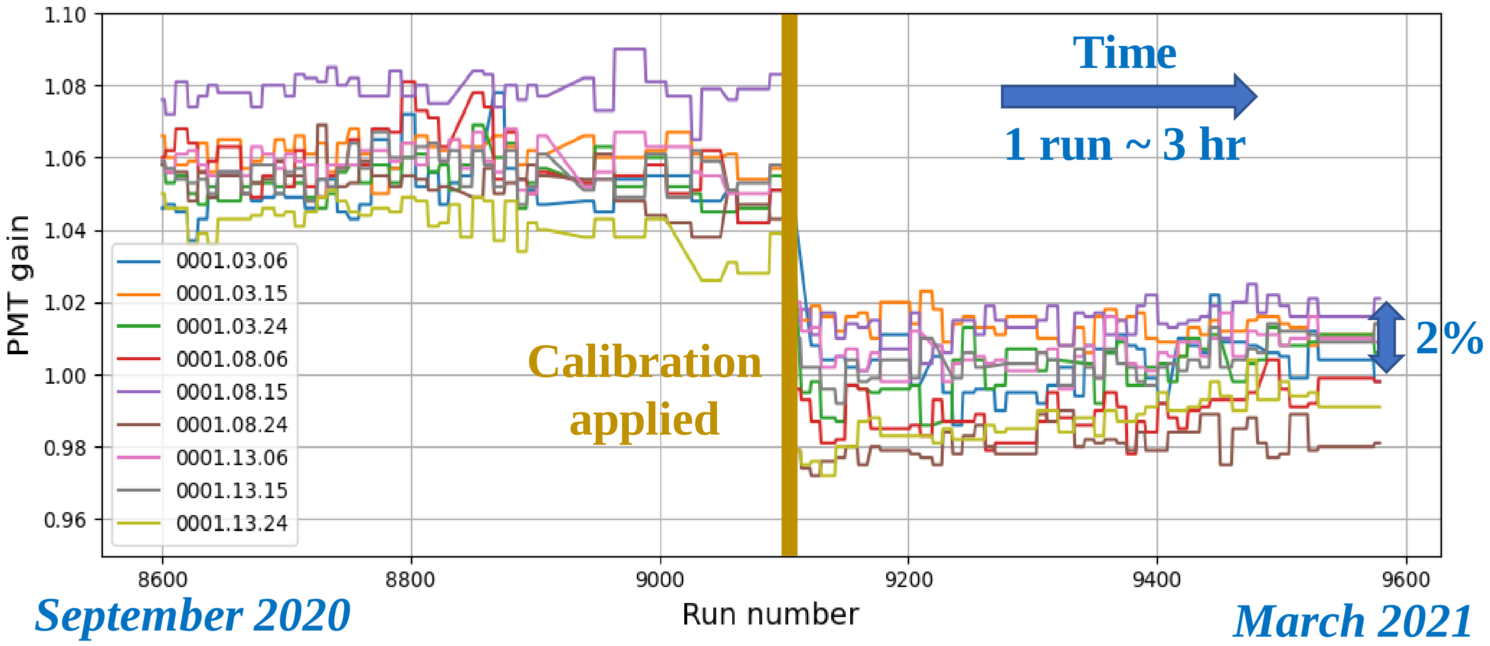


Gain and high-voltage are related by a power-law

$$G = A \cdot V^{kN}$$

#dynodes (N)

Material constants (A, k)



Allows gain-calibration in two steps:

I. Fit PMT gains for SPE time-over-threshold distributions taken at different HV
II. Interpolate the HV which yields a nominal gain

Previous calibrations show that **PMT gains can be equalized to within 2% of nominal value**

In conclusion

- The **data acquisition** challenge in KM3NeT is **tackled in a unique way**:
  - Extreme compression of PMT hit information
    → only identifier, leading edge and time-over-threshold stored
- The **time-over-threshold** can be used effectively **for gain-diagnostics**
  - Logarithmic charge-dependence guarantees great sensitivity in single photo-electron region
  - Great dynamic range
- The time-over-threshold can be used **to monitor and calibrate the PMT gains in-situ**
  - Linear inter-/extrapolation of nominal gain from HV-scans
  - Demonstrated to work during a number HV-tuning campaigns over the past year

Stay tuned!