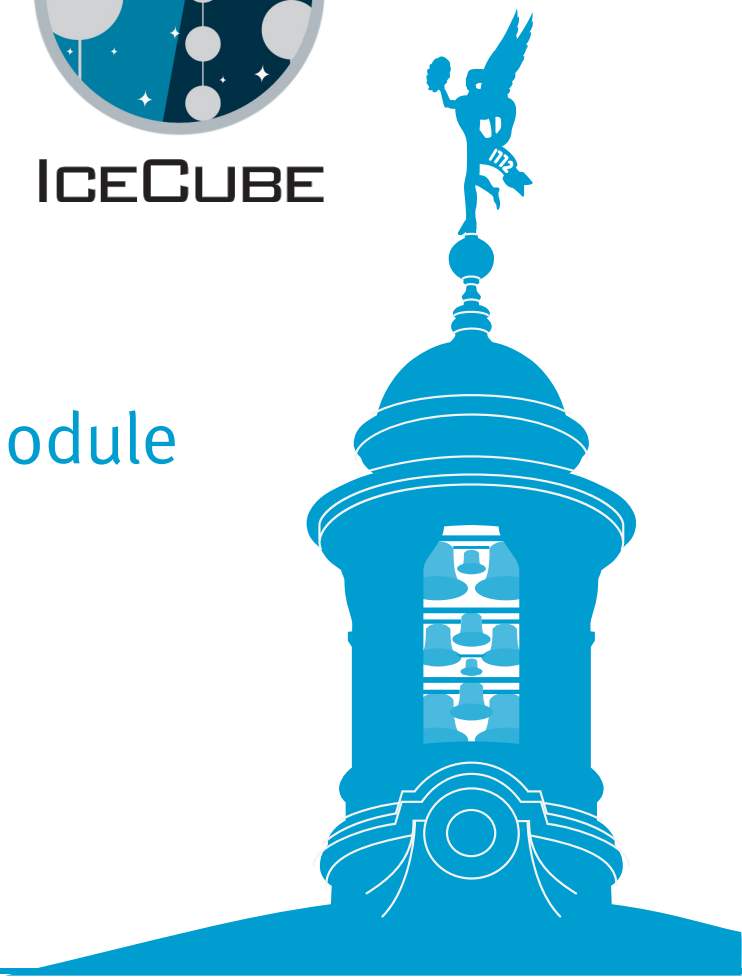
WWU
MÜNSTER

IceCube

Studies on the time-over-threshold readout of the multi-PMT optical module for future IceCube extensions

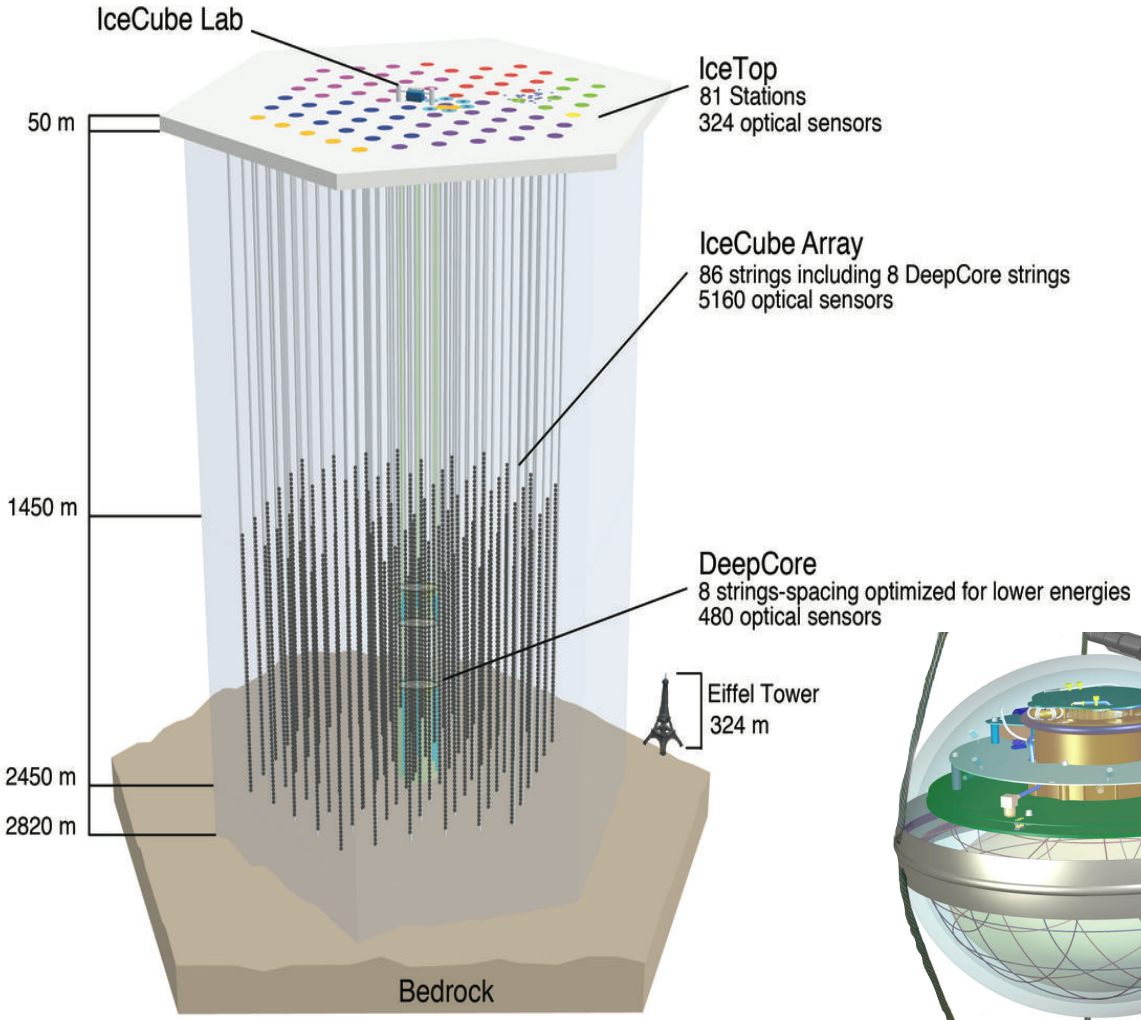
Astroparticle School 2018

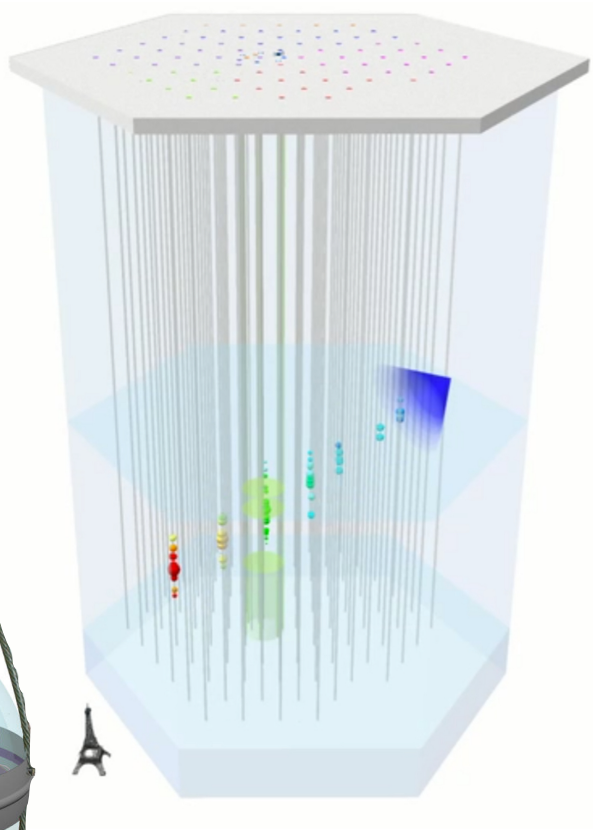


wissen.leben Daniel Guderian - Institut für Kernphysik

10.10.2018

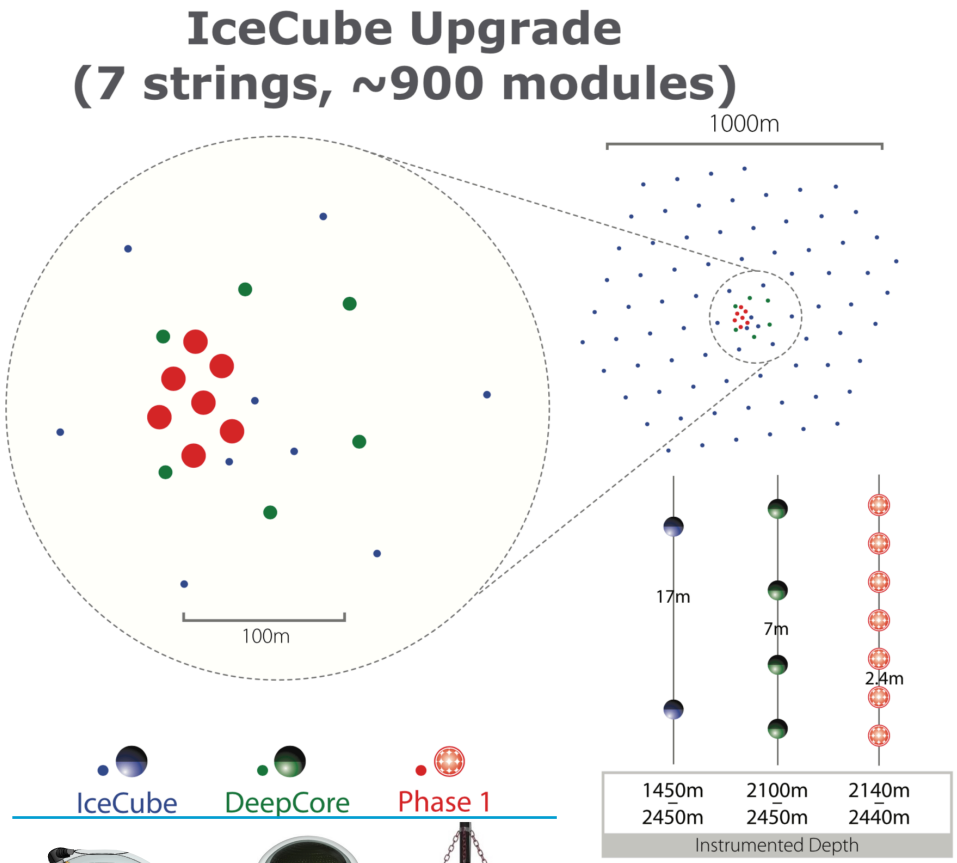
The neutrino telescope IceCube





IceCube collaboration

IceCube extensions and the mDOM



IceCube collaboration

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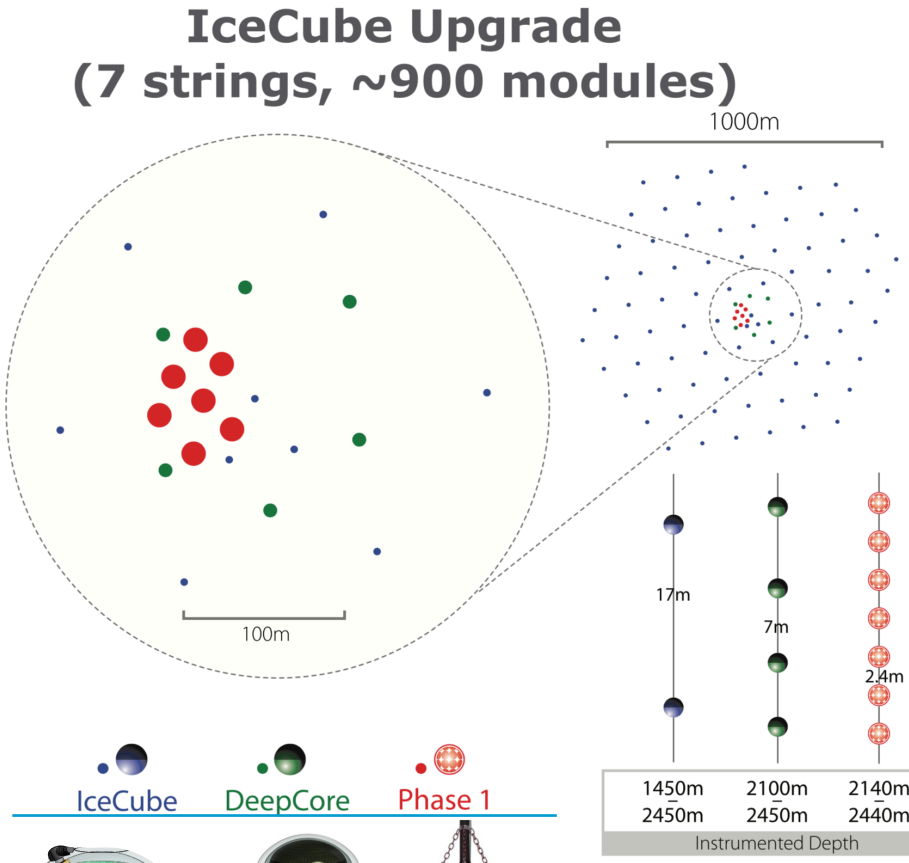
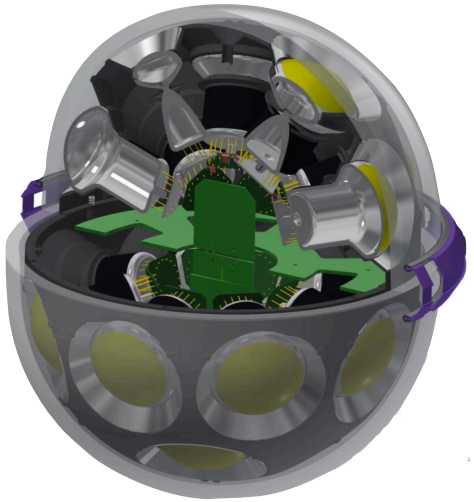


IceCube collaboration

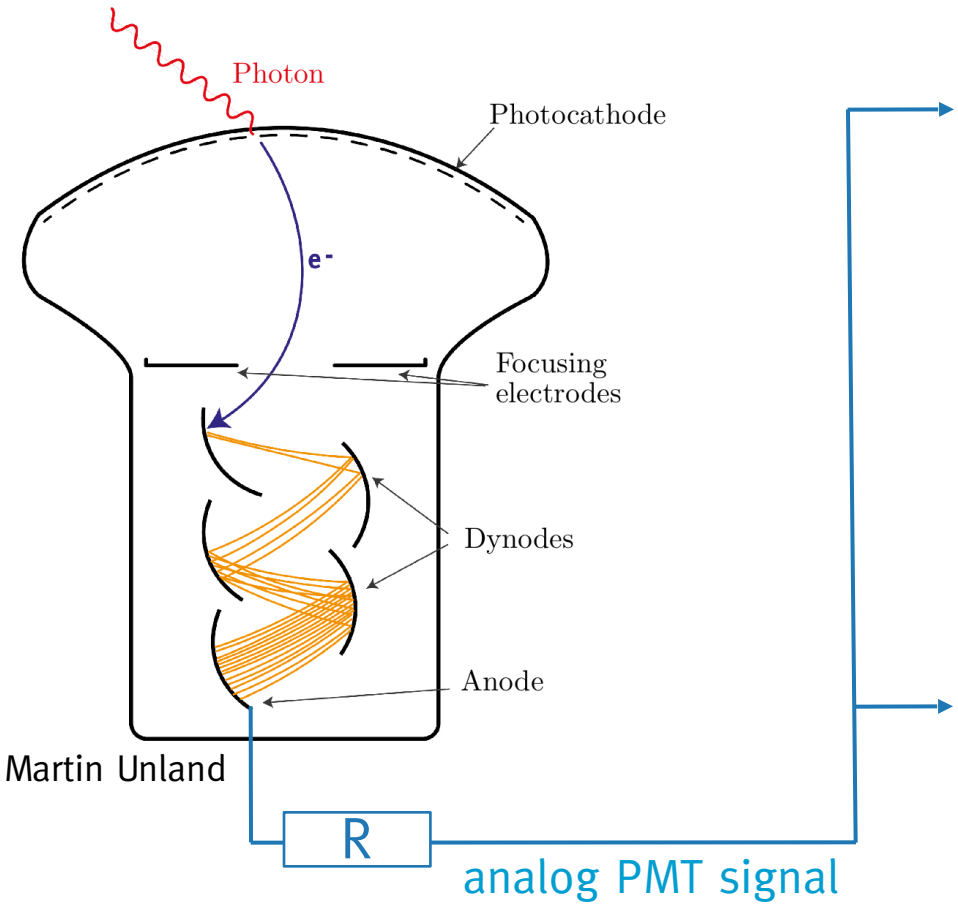


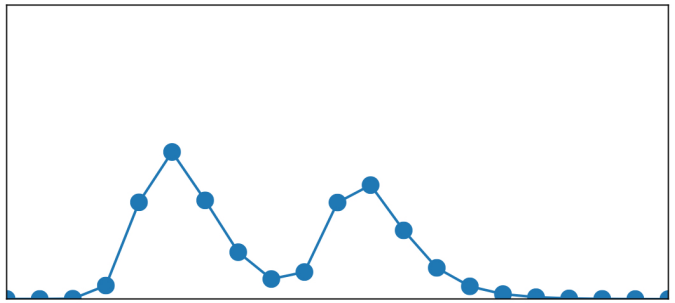
multi-PMT Digital Optical Module:

- homogeneous 4π angular acceptance
- larger photocathode area
- directional sensitivity
- enhanced photon counting

problem to investigate:
tight power budget!

time-over-threshold digitization

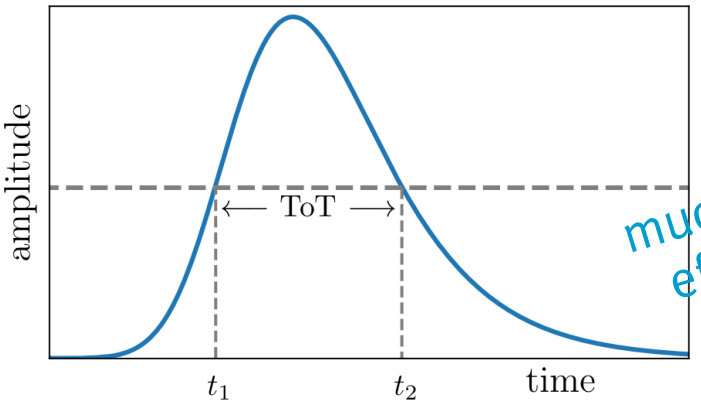




continuous in time

vs

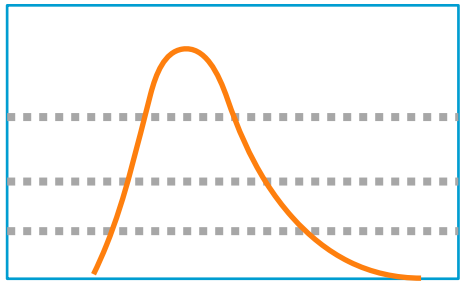
time-over-threshold(ToT)



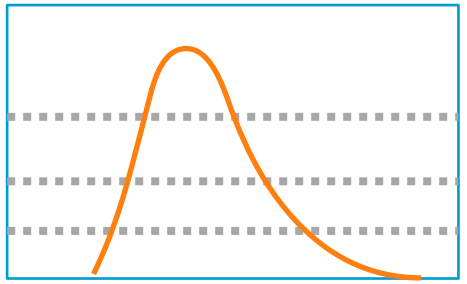
much more efficient!

Studies

- Aim: Optimize such a setup for small pulses (single photoelectron(pe))

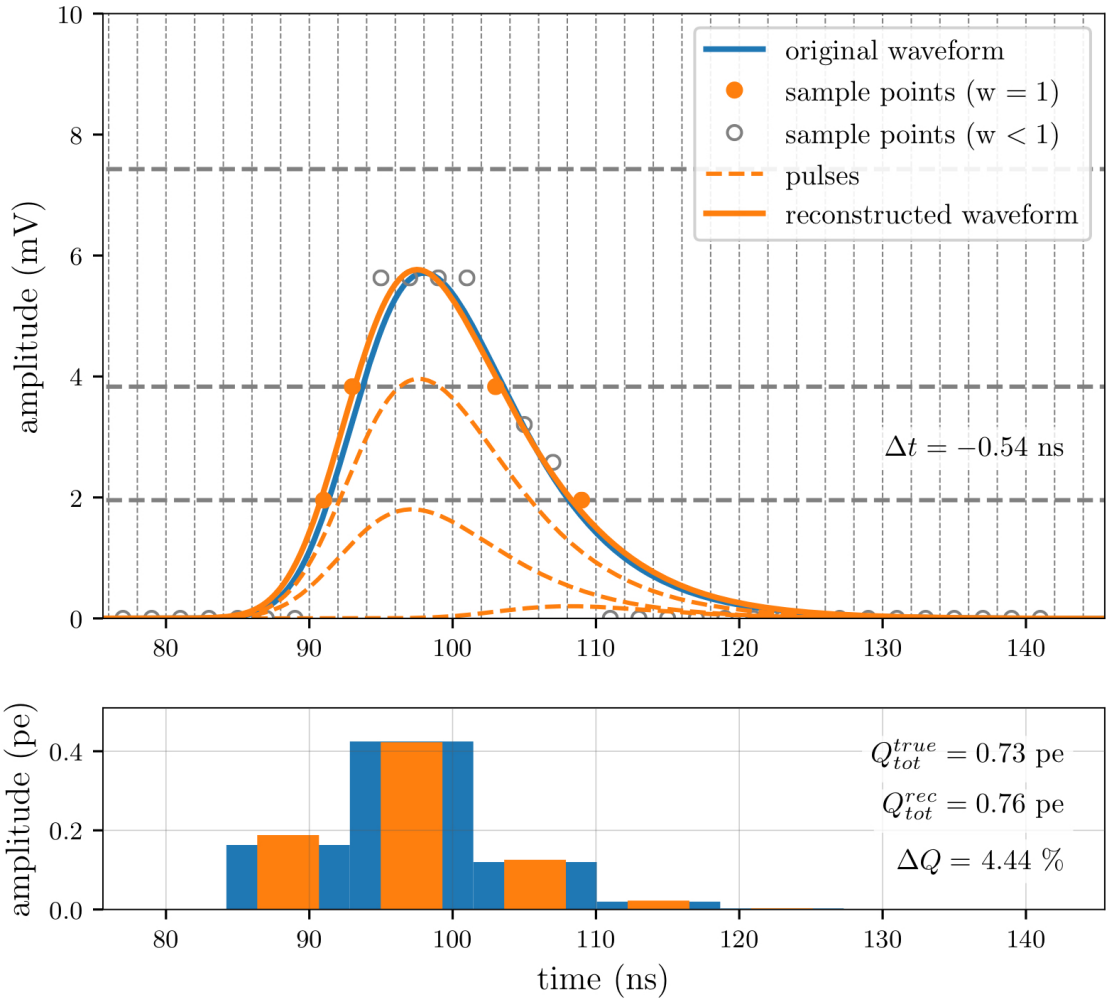


- Simulation: generate waveforms and simulate their digitization



- Analysis: find parameters to single out optimal threshold positions

time-over-threshold algorithm



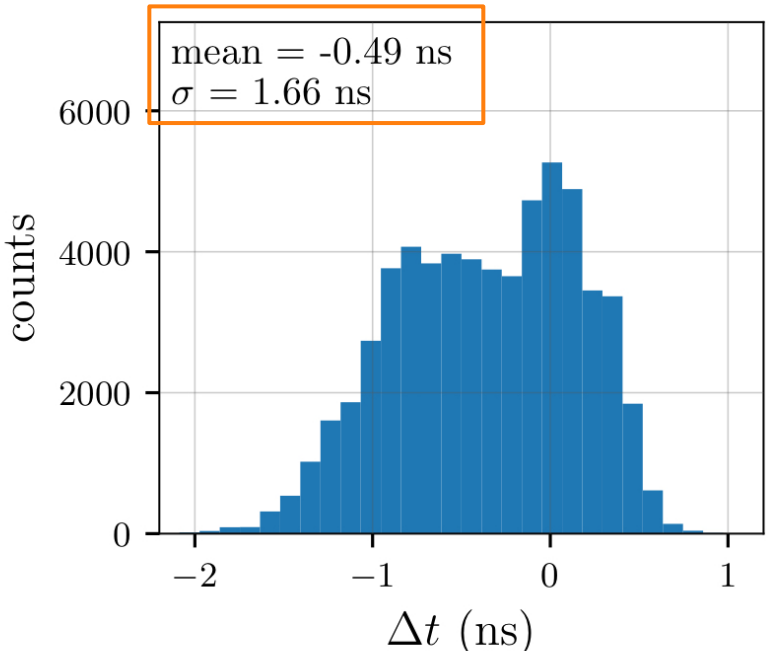
- create sample points
- reconstruct the waveform out of these points using a single pe template
- compare the obtained waveform to the original; calculate Δt and ΔQ

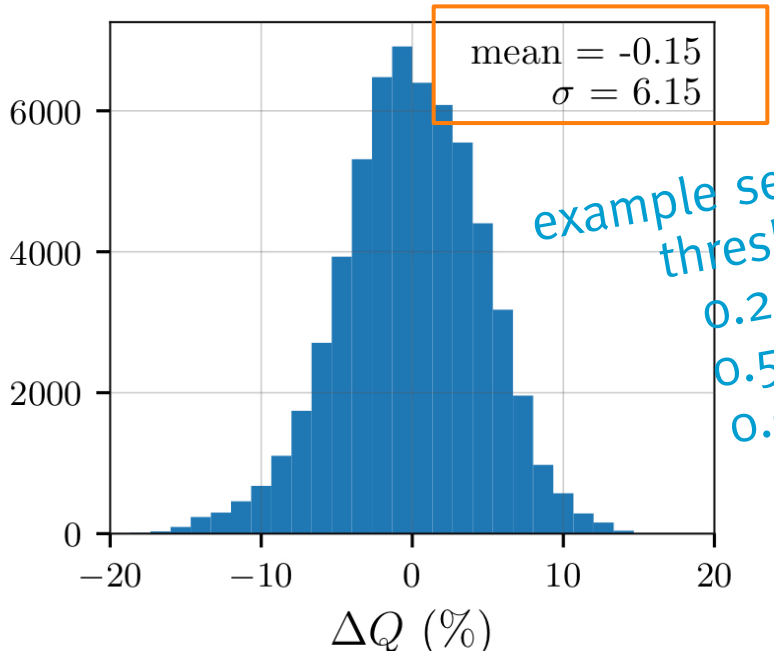
$$\Delta t \equiv t_0^{rec} - t_0^{true}$$

$$\Delta Q \equiv \frac{Q_{rec} - Q_{true}}{Q_{true}}$$

Single pe studies - method

generate and process a large number of single pe pulses (σ=0.3pe)



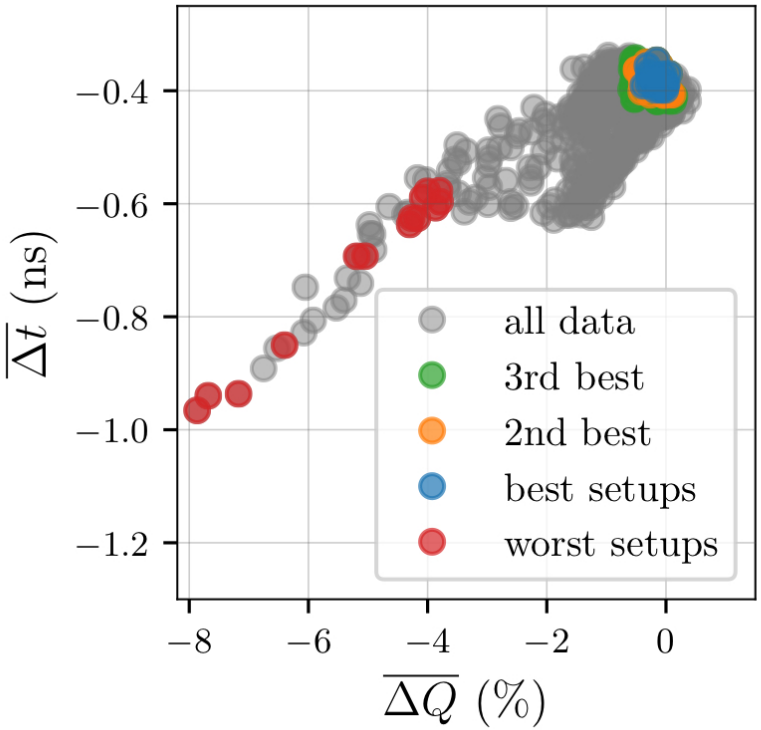


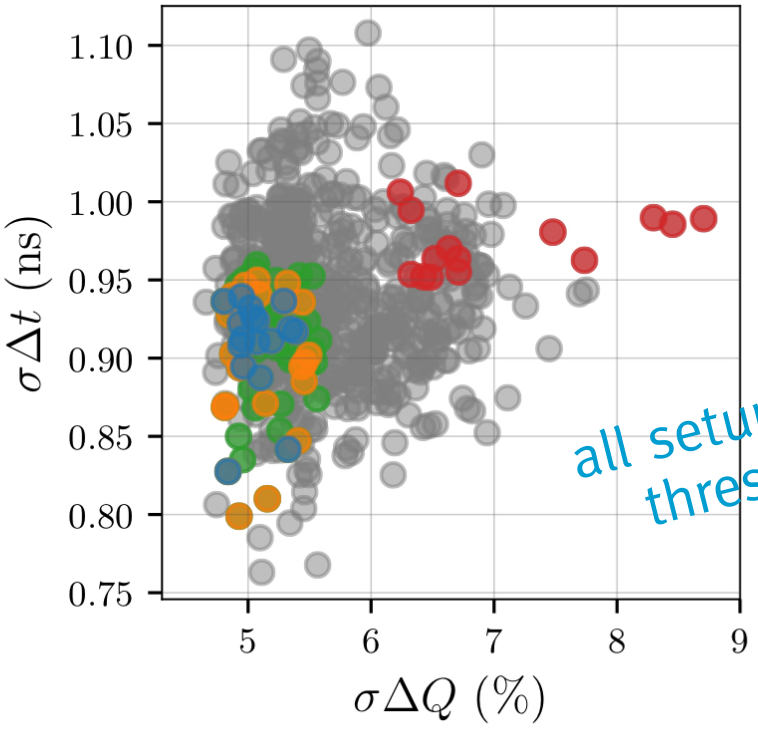
example setup with 3 thresholds:
0.25 pe,
0.59 pe,
0.99 pe

- collect their Δt and ΔQ → get mean and standard deviation
- test different setups

Data for 3 thresholds

- each data point is one setup with 3 thresholds distributed between 0.25pe and 2pe with the lowest one fixed
- apply cuts

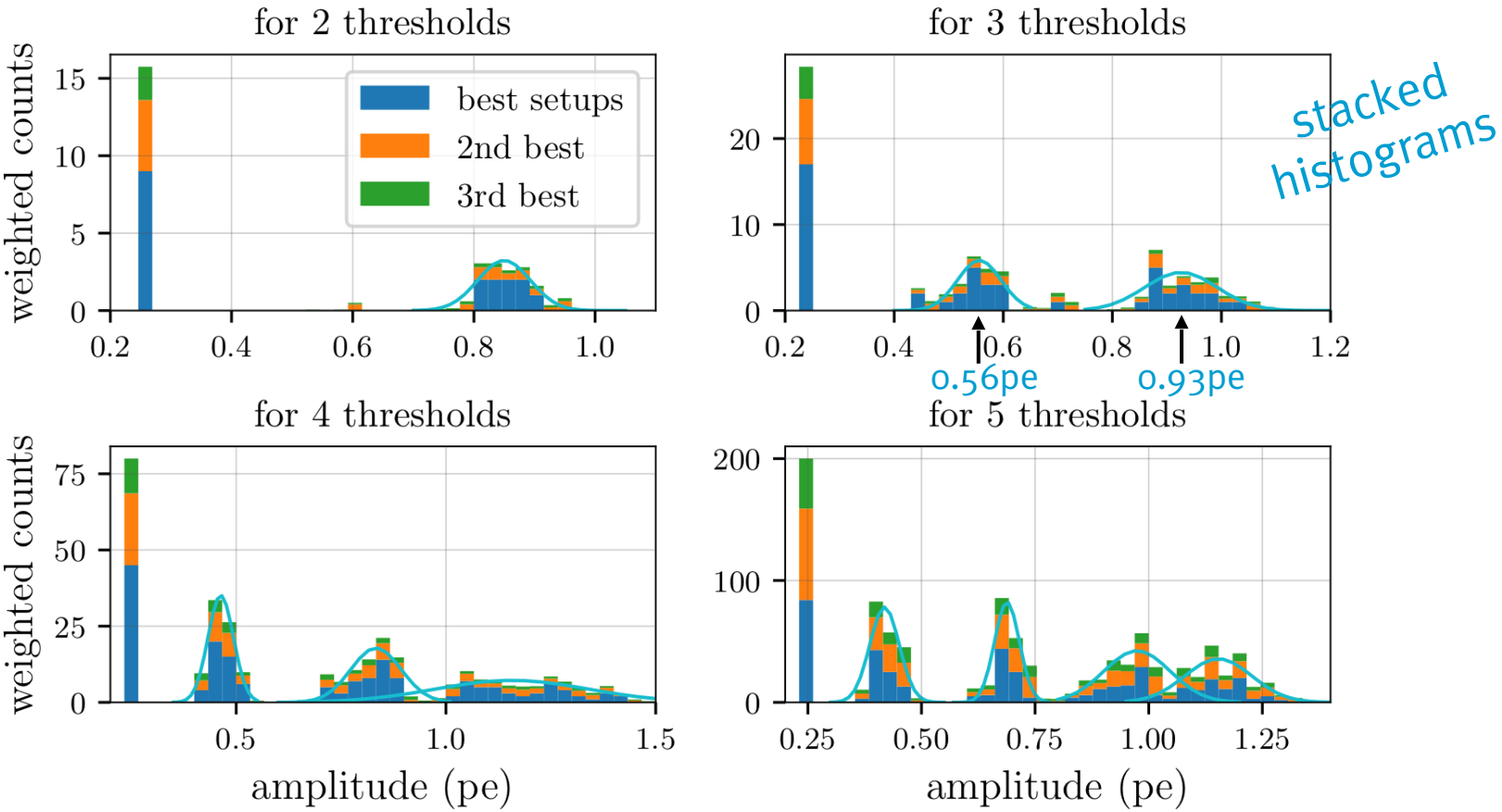




all setups for 3 thresholds

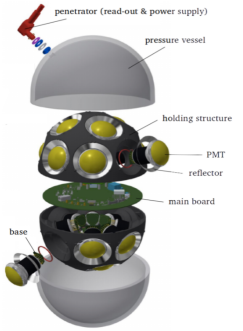
Optimal positions

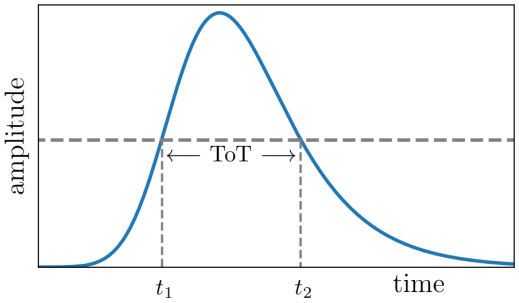
fill the amplitudes of the selected setups into histograms



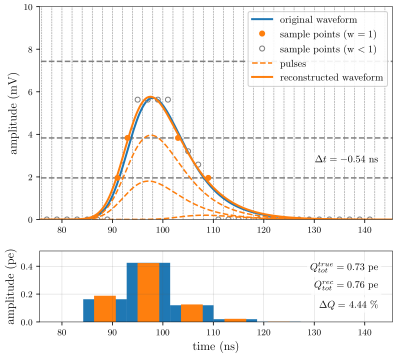
Summary

- ToT readout needed for the mDOM!

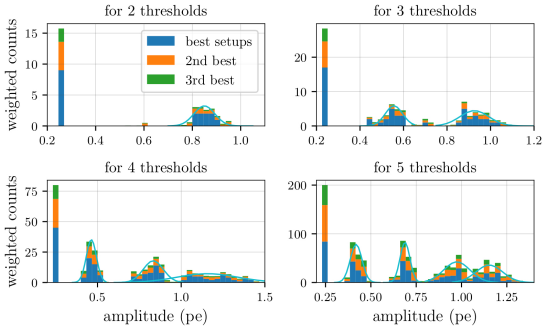




- single pe studies: method of using time and charge reconstruction to find optimal threshold positions



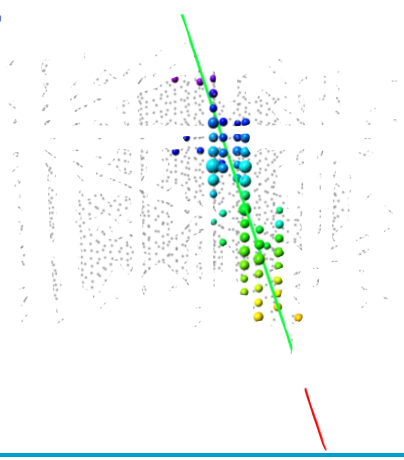
- results show amplitudes of max 1.2pe and evenly spaced thresholds in between



Outlook

- studies on the ToT are continued in the IceCube collaboration
- electronical design about to be finalized for prototype

- my topic for my doctoral dissertation: analysis of KM3NeT ARCA data



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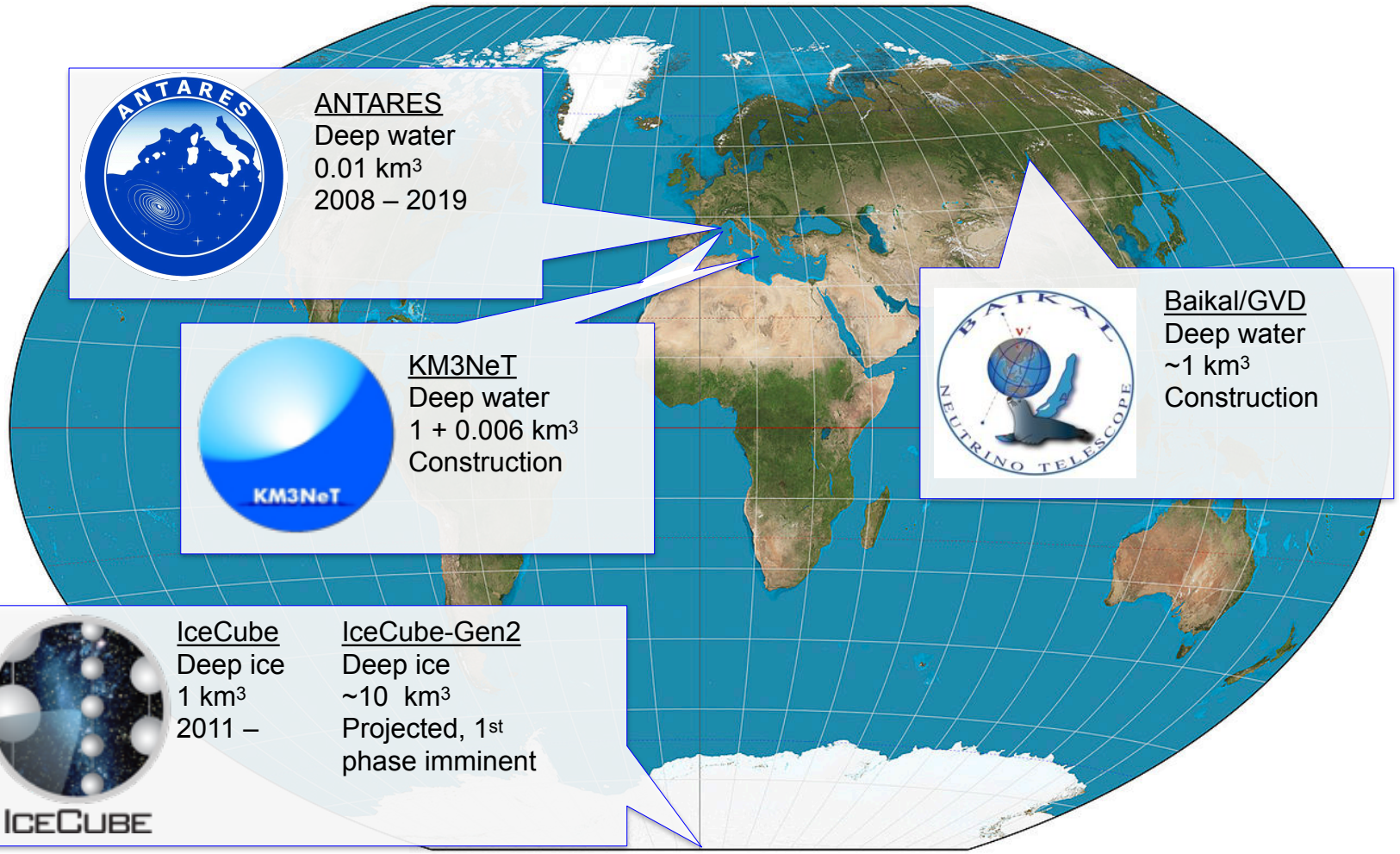
End of talk...

GEFÖRDERT VOM

Bundesministerium
für Bildung
und Forschung

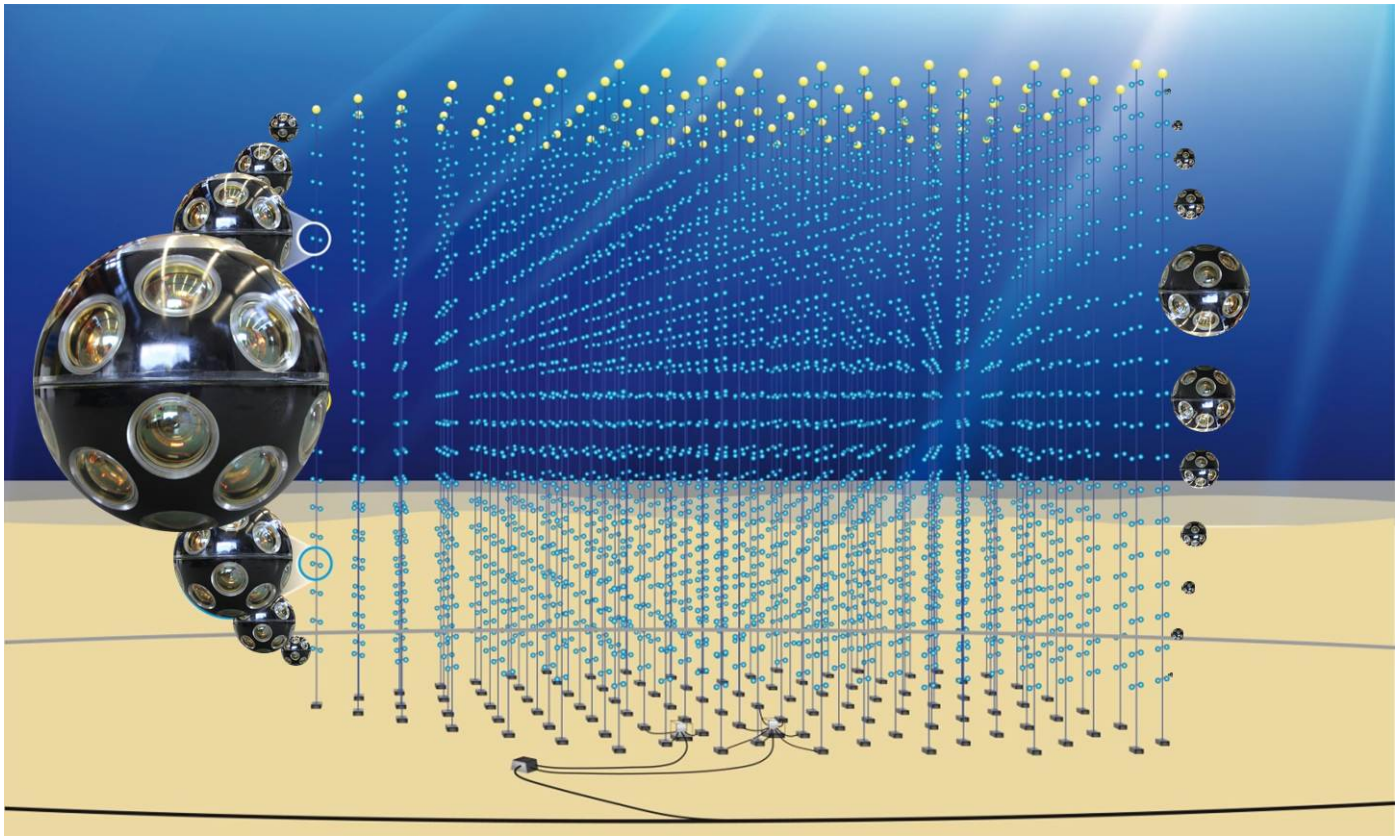
Thank you for your attention!

Neutrino telescopes



from Uli Katz: Future neutrino telescopes, Neutrinos 2018 Heidelberg

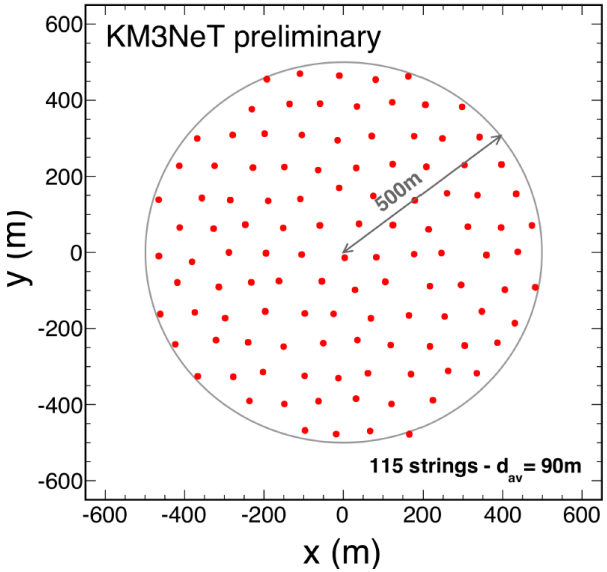
The KM3NeT experiment

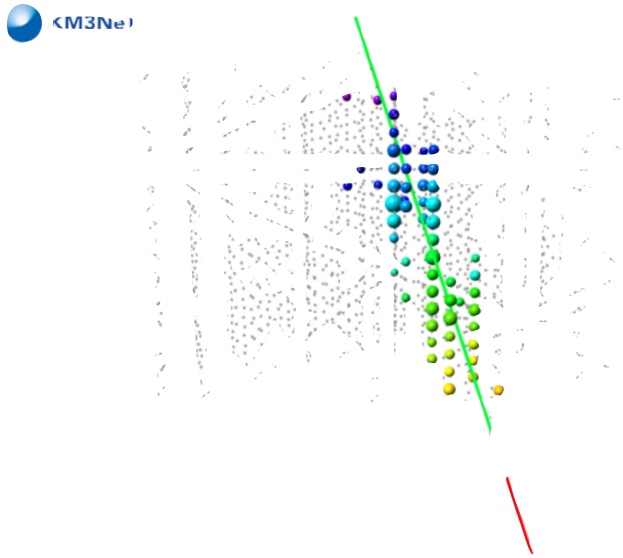


- multi PMT design
- 18 DOMs per string (Detection Unit, DU)
- 115 DUs per building block
- time-over-threshold digitization (single threshold), glass fiber

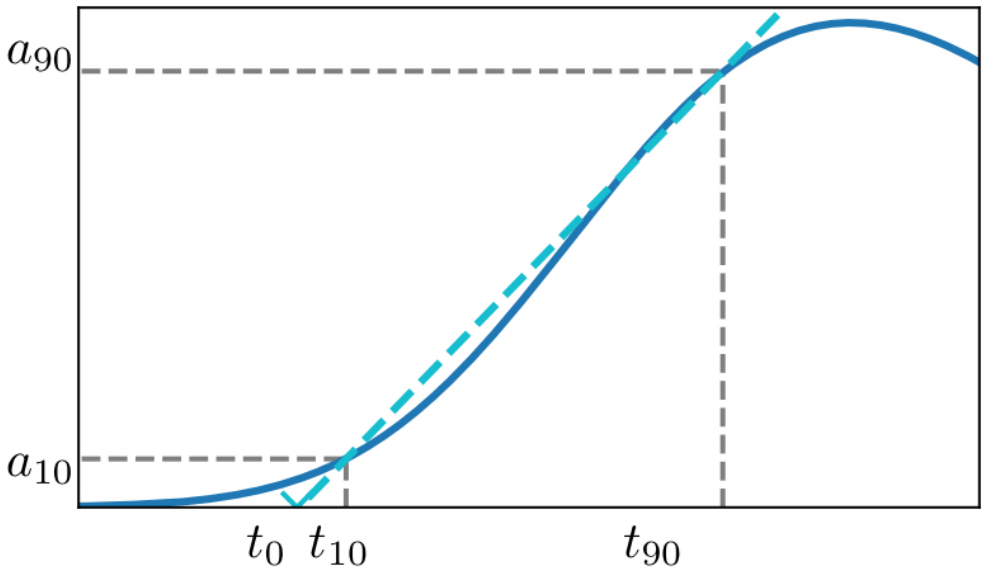
ARCA analysis

- high energy version of the KM3NeT detector; 1.5km^3 water
- under construction; study systematics in a partially build detector
- reconstruction, calibration…

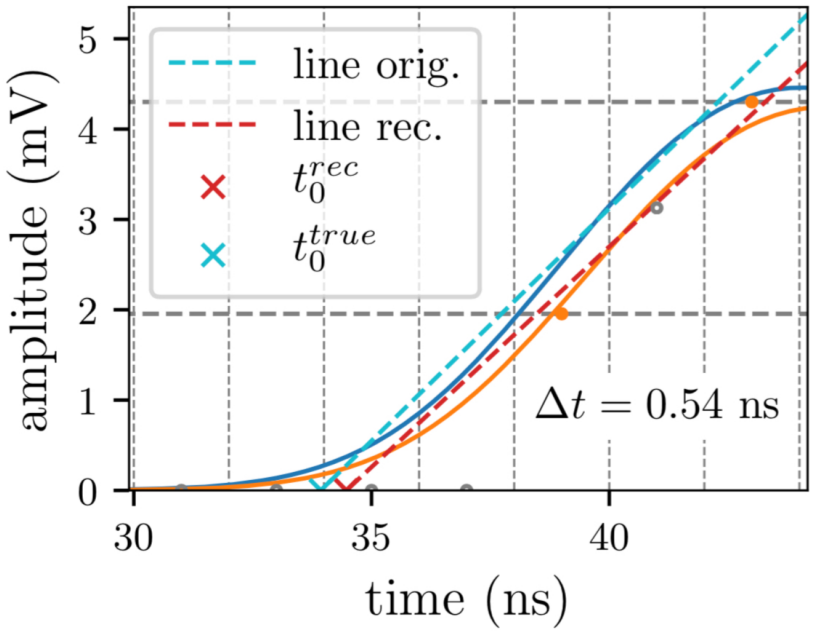


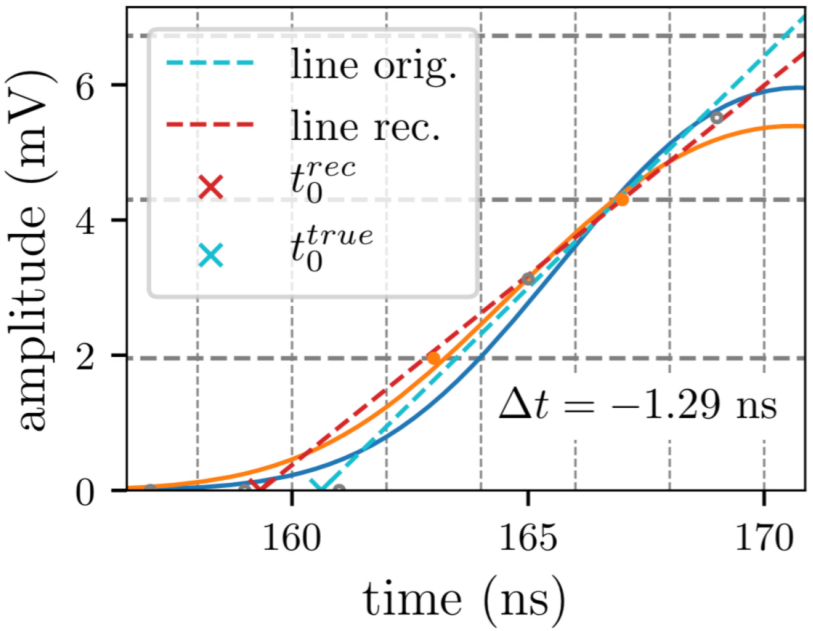


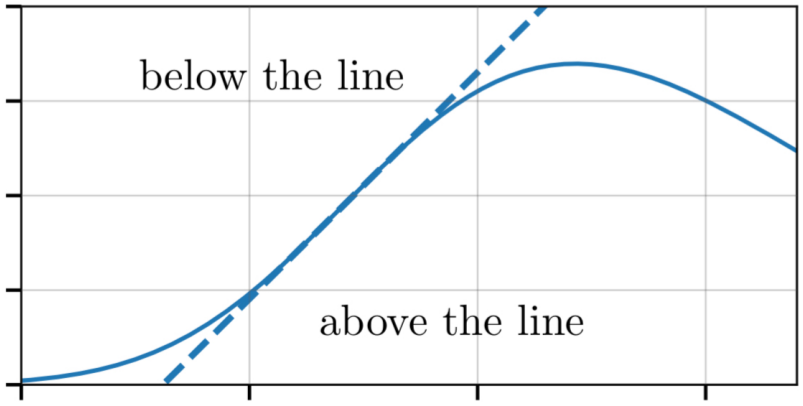
Calculation of t_0



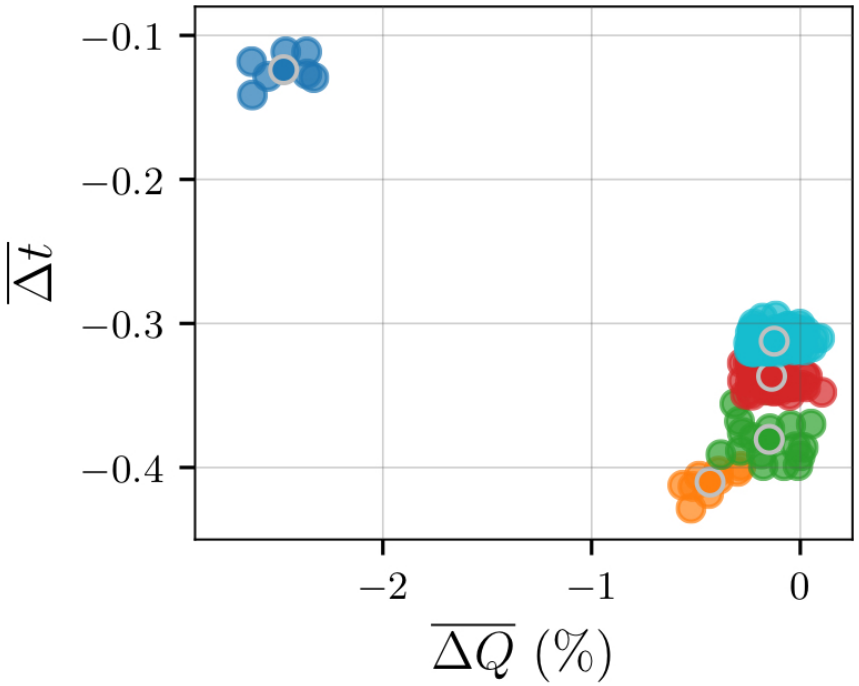
Explanation for Delta t

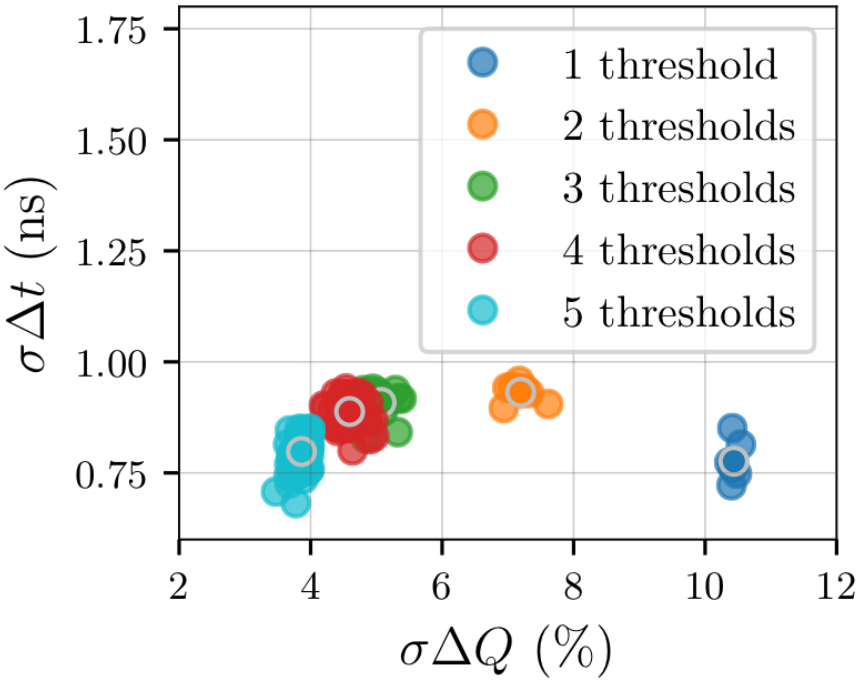






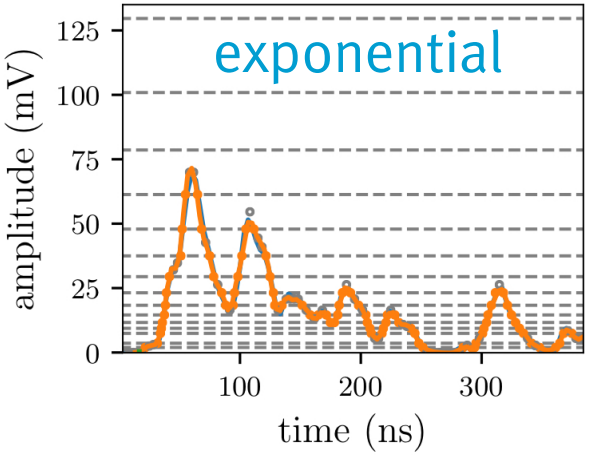
Single pe studies - results

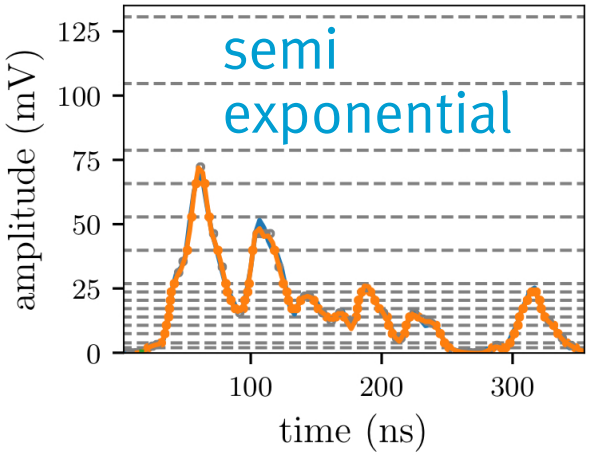


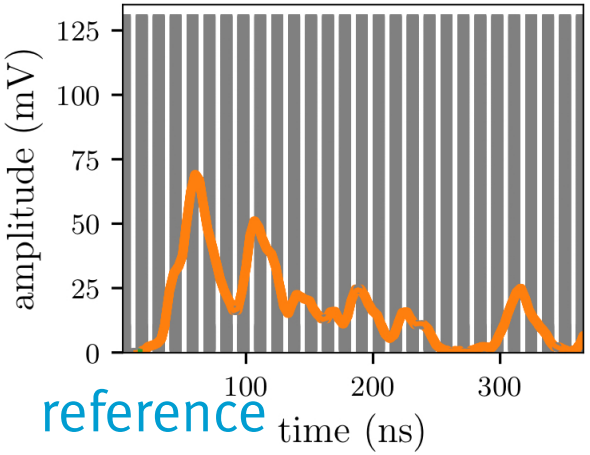


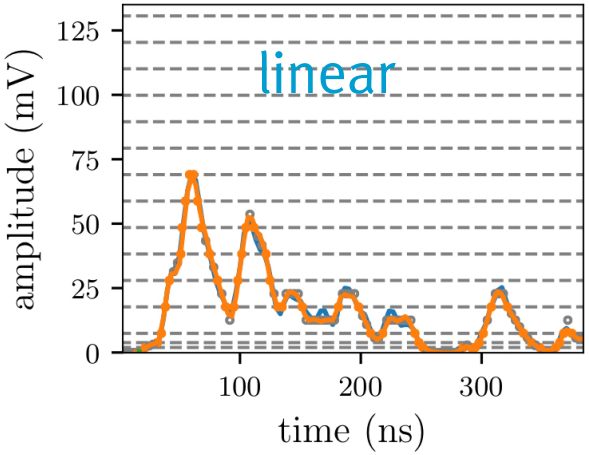
Larger waveform studies

- distribute thresholds over a larger dynamic range
- use waveforms from real IceCube data and the existing framework as input









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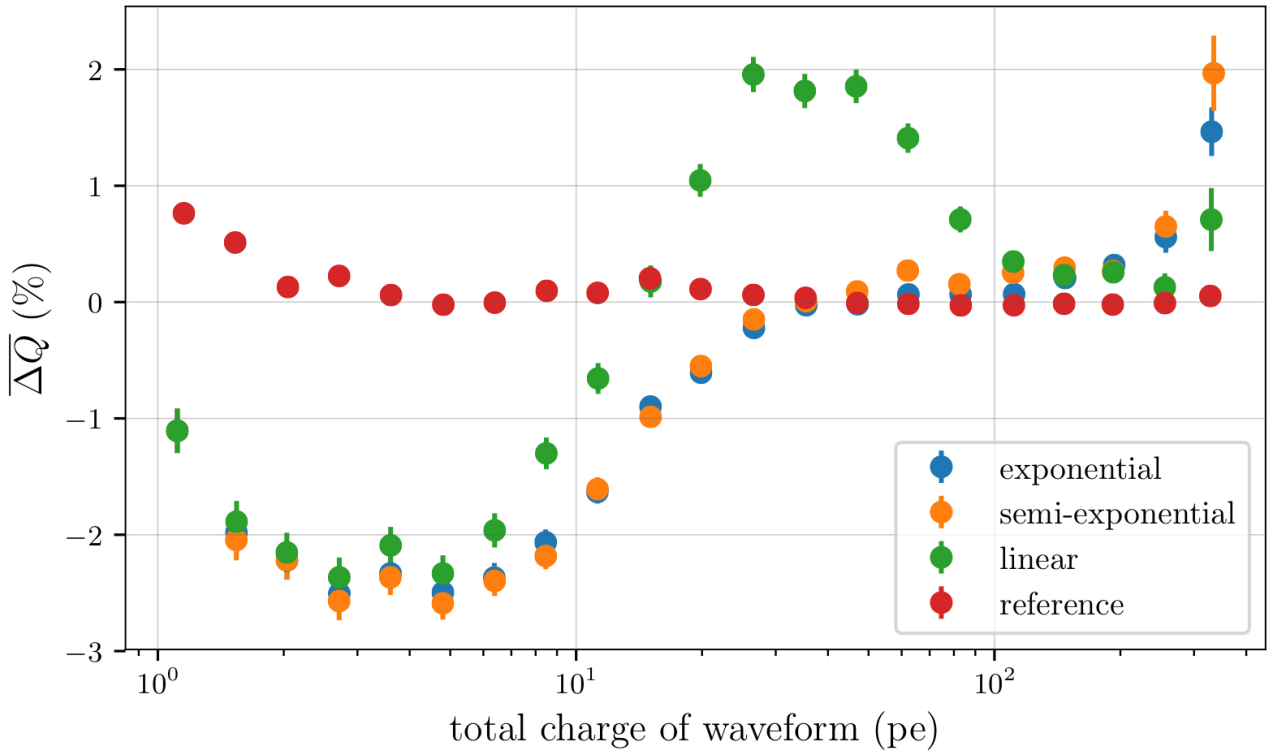

Backup