Calibration in an Experiment

KM3NeT Masterclass

Why Do We Need Calibration?

Calibration is meant to ensure that what we measure corresponds to the quantity that we want to measure:

- Detectors are not perfect.
- Each detector has intrinsic offsets.
- Electronics introduce timing uncertainties.
- Environmental conditions can affect the measurements.
- Without calibration → biased physics results.

What is Calibration?

Calibration is the process of correcting systematic deviations in detector measurements.

True signal → Detector → Offset → Measured signal



Calibration → Corrected signal

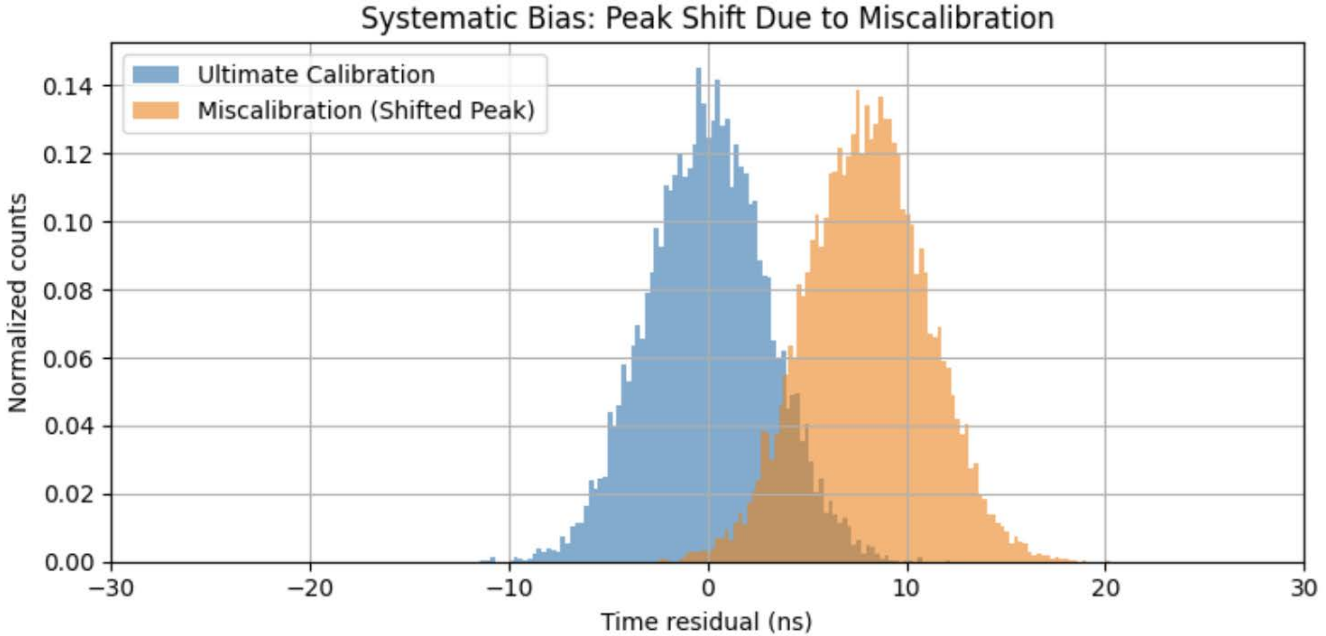
Example: Timing Offsets in Detection Units

- Each Detection Unit (DU) may have a non-negligible time offset.
- Even a few nanoseconds matter!
- Timing affects:
  - Direction reconstruction
  - Event classification
  - Angular resolution

Small timing shifts can translate into large angular errors.

Miscalibration Effects

Miscalibration increases systematic uncertainty.



Time residual = the difference, for each PMT hit detected in a detection unit, between detection time and the estimated time (inferred from the reconstruction of a muon track based on the signals collected from the other detection units)

Our calibration exercise

In this exercise, we reconstruct the direction of particles using timing.
If one detection unit is even slightly miscalibrated, the reconstruction algorithm may think the particle came from a slightly different direction.

You have a set of fifteen, miscalibrated detection units that you need to calibrate based on their time residual plots:

-> look at the plots using a null-calibration set (+ look at the corresponding sky map if you wish)
-> recursively apply a correction offset to each DU (in an attempt to place the peaks as close as to zero time residual), then look at the changes in the sky map (but beware: measurements from different detection units may be correlated, hence it won't help to fix the offset of one detection unit at a time: you always need to consider how to optimize the full set)
-> set up the best calibration you can reach and finalize the sky map analysis

Open the calibration tool here (don't worry if it takes a bit of time to open – just follow the progress on the bar to check that it is working) and follow the instructions you will find there