Calibration in an Experiment

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 may have an intrinsic offset.
- 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

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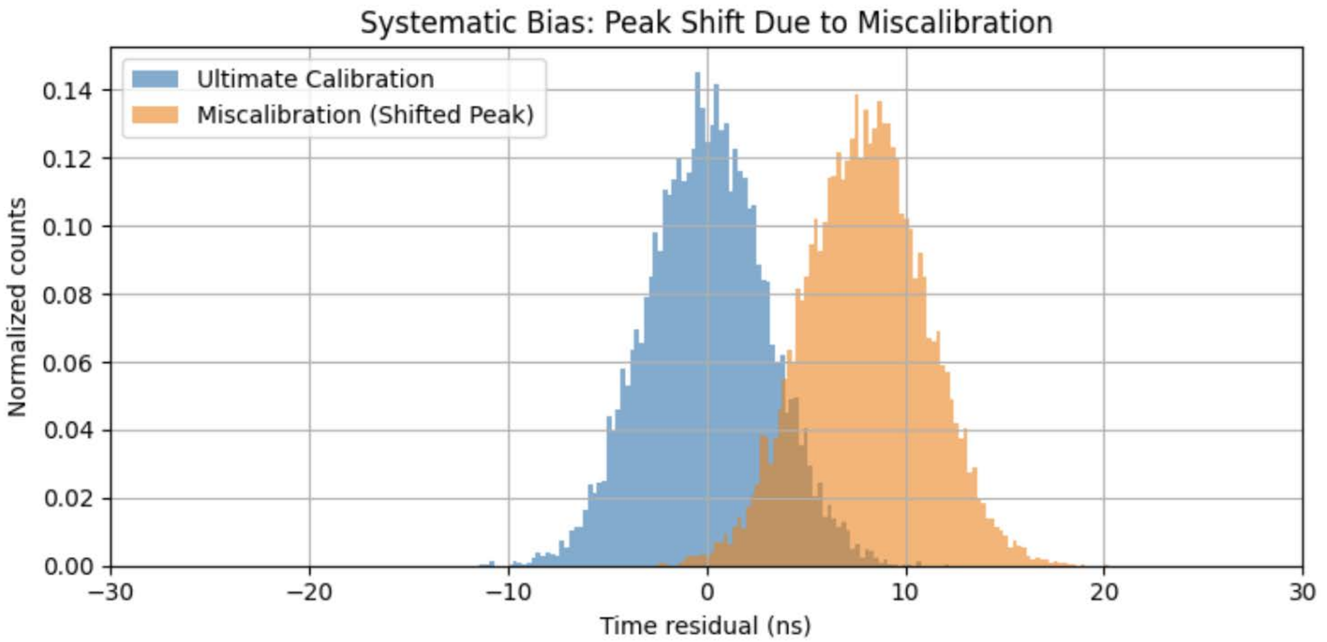
Calibration → Corrected signal

Miscalibration Effects

Miscalibration increases systematic uncertainty.



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

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

<u>Small timing shifts can translate into large angular errors.</u>

Our 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)
→ recursively apply a correction offset to each DU (in an attempt to place the peaks as close as possible to zero time residual), then look at the changes in the sky map
→ set up the best calibration you can reach and finalize the sky map analysis