Time...
And Time again

Some remarks on ORCA time calibration and JGandalf CPU time

KM3NeT group meeting
Bouke Jung (bjung@nikhef.nl)

2019-09-25

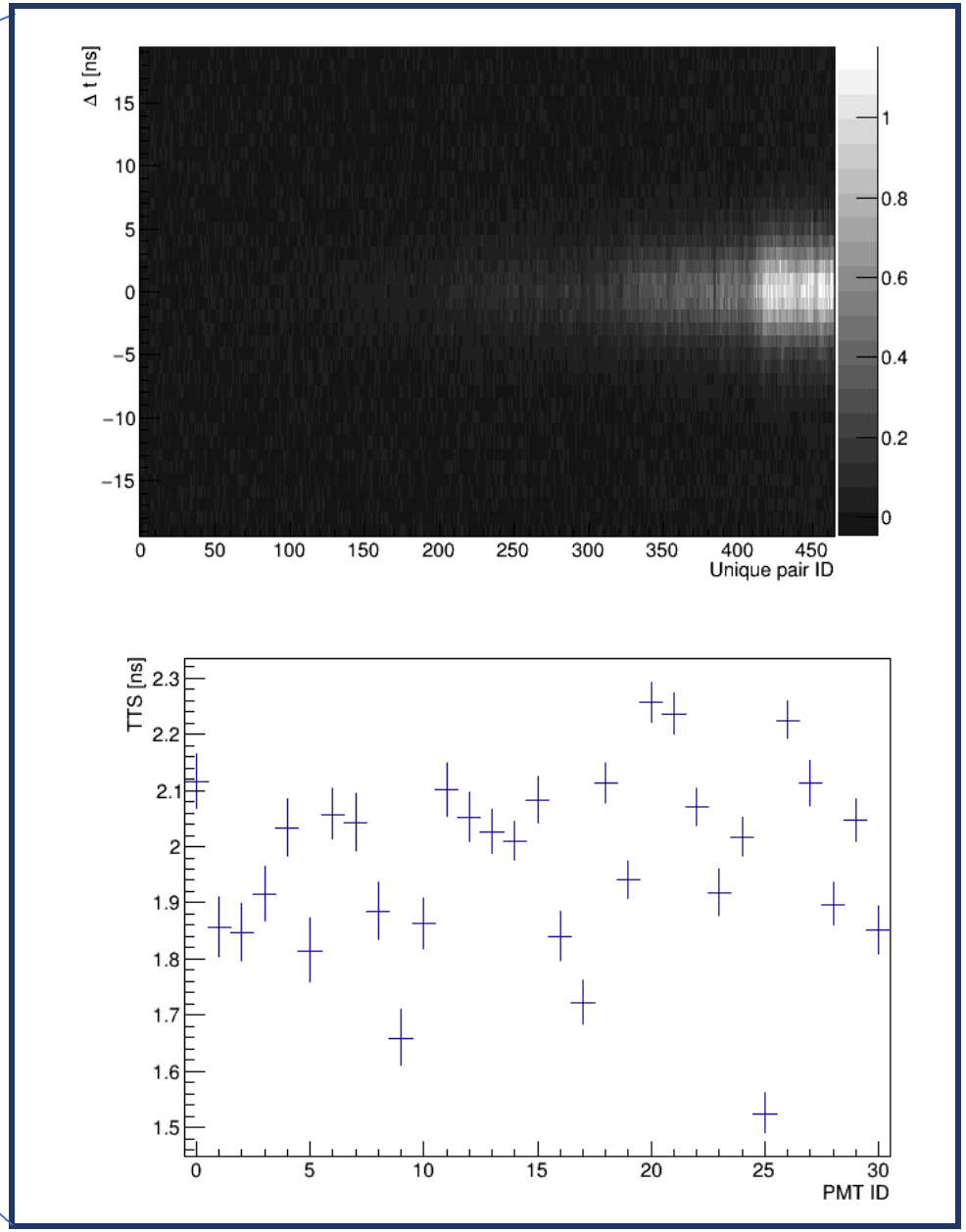
Time calibration stages

- Three stages:
    1. PMT time calibration
        i. Laser calibration (in the lab)
        ii. K-40 calibration

Bouke Jung (bjung@nikhef.nl)

Time calibration stages

- Three stages:
    1. PMT time calibration
        i. Laser calibration (in the lab)
        ii. K-40 calibration
            - Take all unique PMT pairs (= 31nCr2=465)
            - Store time offsets between pair members
            - Fit rate w.r.t. t0, QE and TTS



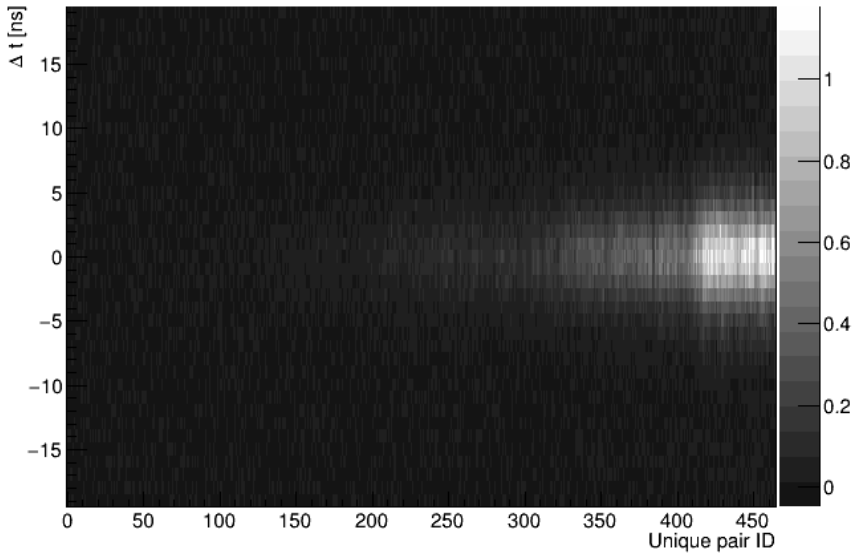
Bouke Jung (bjung@nikhef.nl)

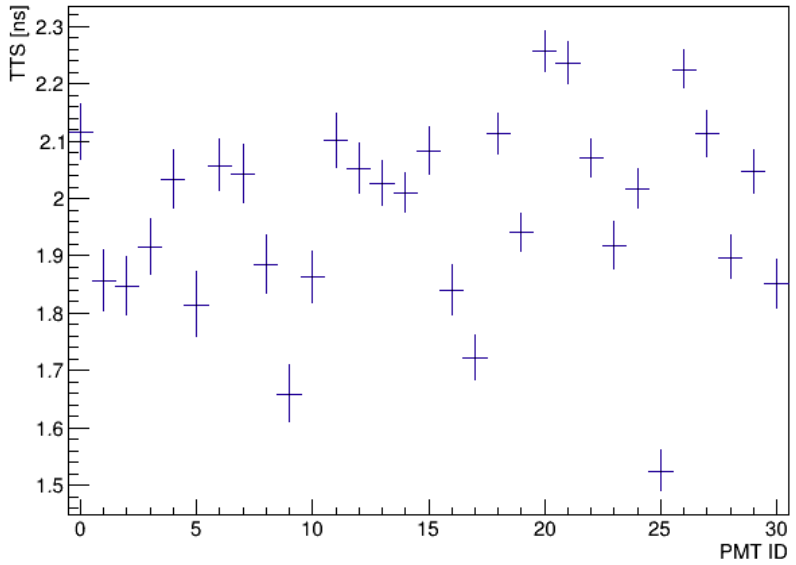
Time calibration stages

- Three stages:
  1. PMT time calibration
     - i. Laser calibration (in the lab)
     - ii. K-40 calibration
       - Take all unique PMT pairs (= 31nCr2=465)
       - Store time offsets between pair members
       - Fit coincidence rate w.r.t. t0, QE and TTS

```
/**
 * Get K40 coincidence rate as a function of cosine angle between PMT axes.
 *
 * \param  ct           cosine angle between PMT axes
 * \return              rate [Hz]
 */
Double_t getValue(const Double_t ct) const
{
  return Rate_Hz * TMath::Exp(-(p1+p2+p3+p4)) * TMath::Exp(ct*(p1+ct*(p2+ct*(p3+ct*p4))));
}
```

?





Bouke Jung (bjung@nikhef.nl)

Time calibration stages

- Three stages:
    1. PMT time calibration
        i. Laser calibration (in the lab)
        ii. K-40 calibration

    2. DOM time calibration
        i. T**ime residuals** between recorded hits and expectation from muon trajectory
        ii. Nano-beacon

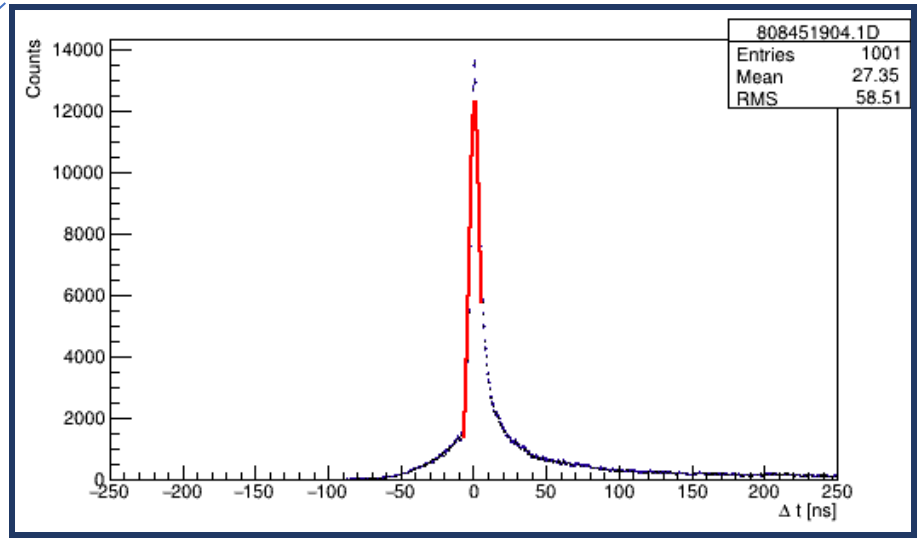
        Potential cross-check for different directions of illumination (muon cherenkov ↓; nano-beacon ↑)

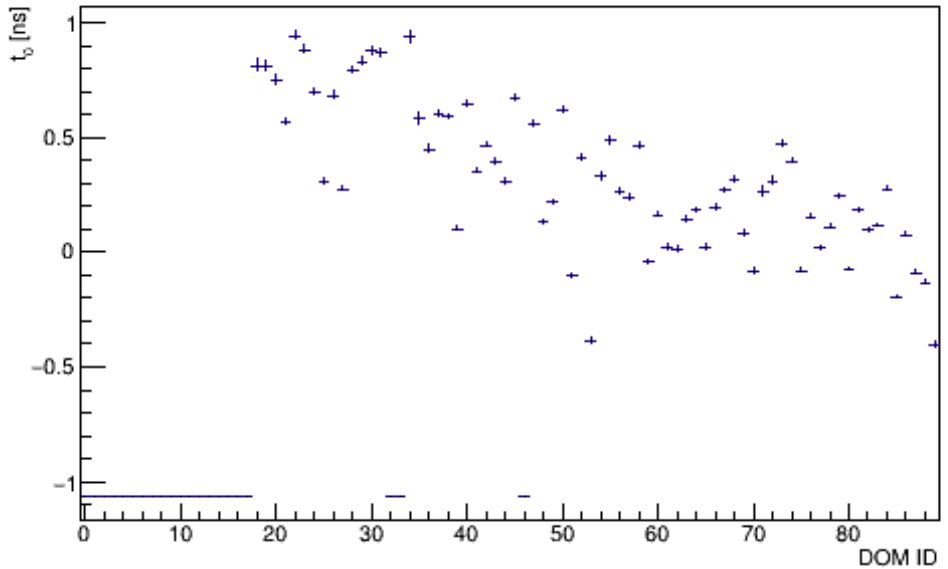
KM3NeT group meeting
Bouke Jung (bjung@nikhef.nl)

Time calibration stages

- Three stages:
  1. PMT time calibration
     i. Laser calibration (in the lab)
     ii. K-40 calibration
  2. DOM time calibration
     i. **Time residuals** between recorded hits and expectation from muon trajectory
     ii. Nano-beacon

Potential cross-check for different directions of illumination (muon cherenkov ↓; nano-beacon ↑)





KM3NeT group meeting
Bouke Jung (bjung@nikhef.nl)

Time calibration stages

- Three stages:
    1. PMT time calibration
        i. Laser calibration (in the lab)
        ii. K-40 calibration

    2. DOM time calibration
        i. T**ime residuals** between recorded hits and expectation from muon trajectory
        ii. Nano-beacon

        Potential cross-check for different directions of illumination (muon cherenkov ↓; nano-beacon ↑)

    1. String time calibration
        i. White Rabbit system (directly after deployment)
        ii. Grid search over multiple detector calibration settings to maximize muon track fit quality

KM3NeT group meeting
Bouke Jung (bjung@nikhef.nl)

Time calibration stages

- Three stages:
    1. PMT time calibration
        i. Laser calibration (in the lab)
        ii. K-40 calibration

    2. DOM time calibration
        i. T**ime residuals** between recorded hits and expectation from muon trajectory
        ii. Nano-beacon

        Potential cross-check for different directions of illumination (muon cherenkov ↓; nano-beacon ↑)

    1. String time calibration
        i. White Rabbit system (directly after deployment)
        ii. Grid search over multiple detector calibration settings to maximize muon track fit quality

Takes **a lot of CPU time**
(days, depending upon number of evaluated detector settings)

KM3NeT group meeting
Bouke Jung (bjung@nikhef.nl)

JGandalf CPU time

- Ran JGandalf for multiple input parameter settings
  - Significant speed increase when maximum nr. Iterations is set to 1, but…
  - No corresponding increase for considered time window (only x2 speed increase for x10000 time window increase)
  - Speed increase only observed for real data file

CPU time [s]	maxIt = 1	maxIt = 1000
Real data file (1000 evts)	38	262
MC file (2785 evts)	14	14

Bouke Jung (bjung@nikhef.nl)

JGandalf CPU time

- Ran JGandalf for multiple input parameter settings
  - Significant speed increase when maximum nr. Iterations is set to 1, but…
  - No corresponding increase for considered time window (only x2 speed increase for x10000 time window increase)
  - Speed increase only observed for real data file

CPU time [s]	maxIt = 1	maxIt = 1000
Real data file (1000 evts)	38	262
MC file (2785 evts)	14	14

- Gprof also suggests fit to be the bottle-neck

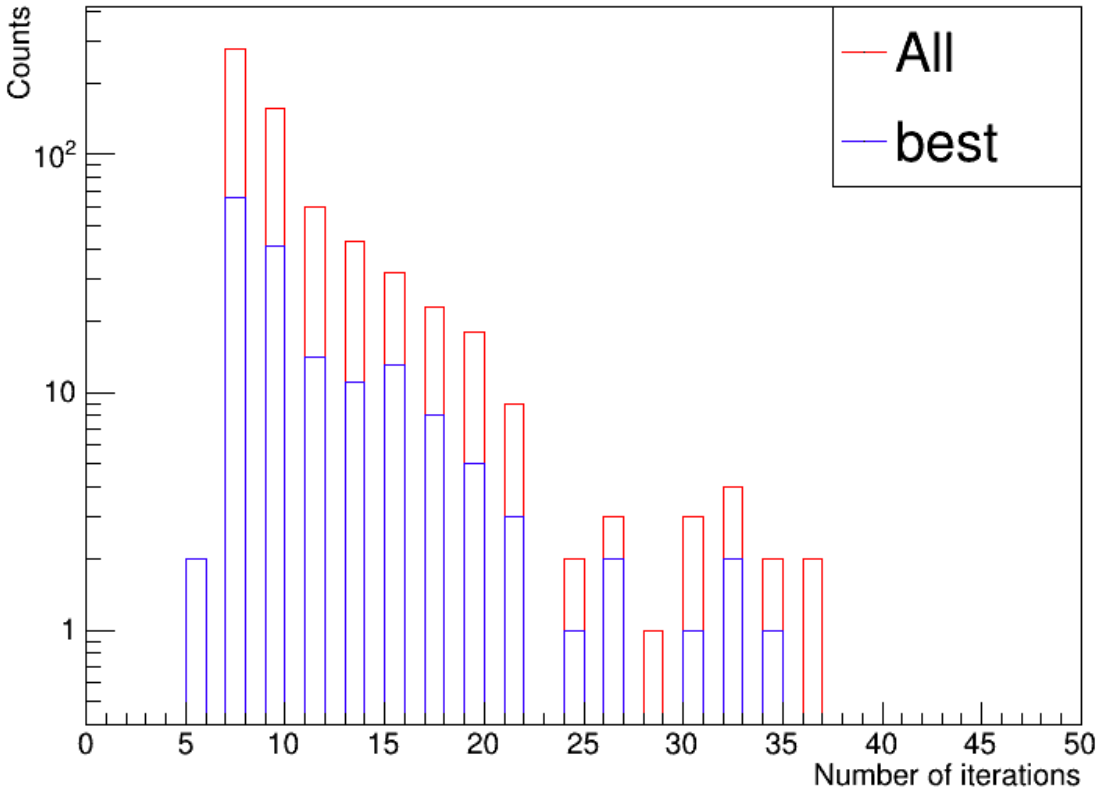
```
Each sample counts as 0.01 seconds.
  %   cumulative   self              self     total
 time   seconds   seconds    calls   s/call   s/call  name
 56.72      5.91     5.91 136012943     0.00     0.00  JTOOLS::JSplineFunction<JTOOL
 11.04      7.06     1.15 13880352     0.00     0.00  JTOOLS::JPolintFunction<0u, JT
  3.93      7.47     0.41 13880352     0.00     0.00  JTOOLS::JPolintFunction<0u, JT
  2.78      7.76     0.29   323745     0.00     0.00  JTOOLS::JSplineCollection<JTOO
  2.21      7.99     0.23        4     0.06     1.63  JPHYSICS::JPDFTable<JTOOLS::JS
  1.92      8.19     0.20  6940176     0.00     0.00  JTOOLS::JPolintFunction<1u, JT
```

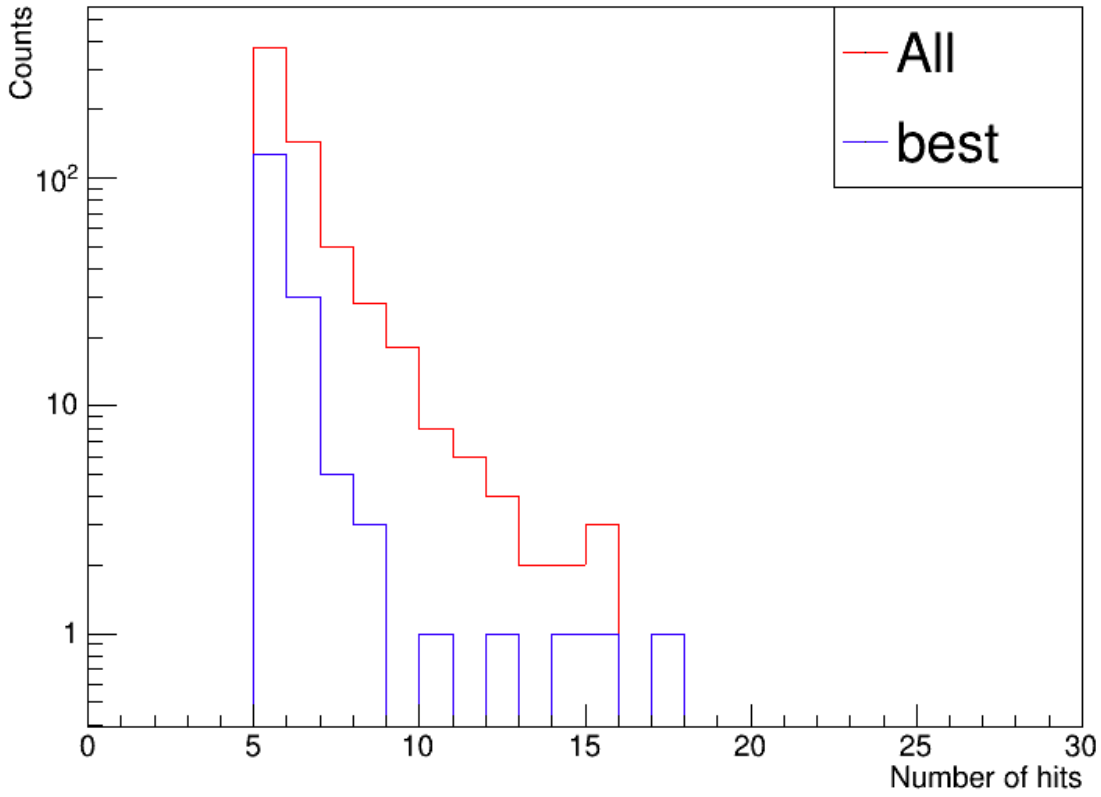
Huge number of calls to spline?

Bouke Jung (bjung@nikhef.nl)

JGandalf CPU time

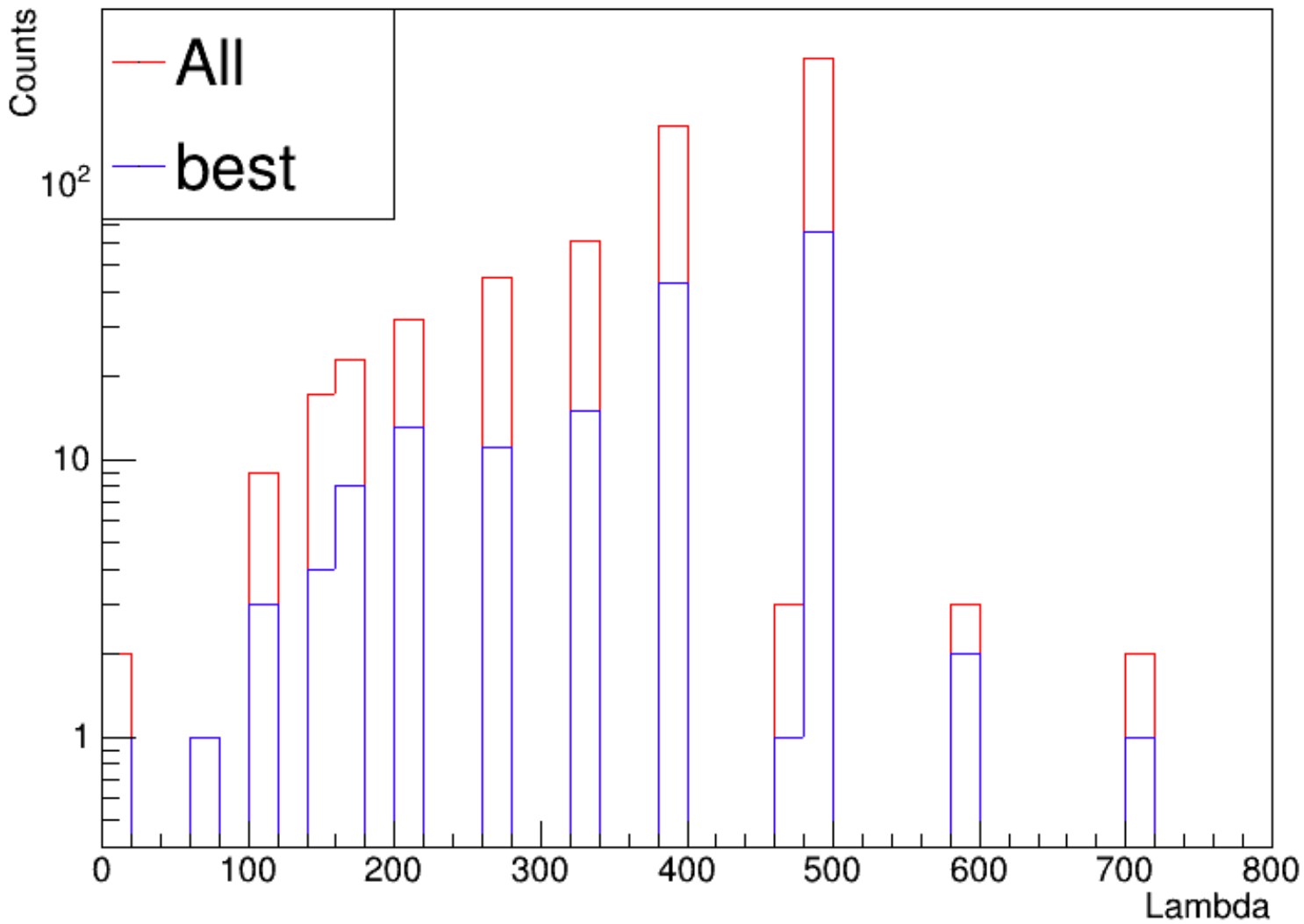
- Produced several postfit histograms as a check
  - Number of iterations, Nhit, lambda
  - For all stored fits and for only the best ones





Bouke Jung (bjung@nikhef.nl)

JGandalf CPU time



KM3NeT group meeting
Bouke Jung (bjung@nikhef.nl)

Outlook

- Could not create postfits for JGandalf output with real data
  - Missing header?

```
7J 10:02:41 bjung@crati:...work > JMuonPostfit -f D44_r6063_gandalf_Nevt1000.root
 -o D44_r6063_postfit_Nevt1000.root -N 1 -A 3 -O N -d 2
FATAL: JMultipleFileScanner<Head>::getHeader(): Missing Header.
[1] 7J 10:02:59 bjung@crati:...work >
```

- Why the difference in fit CPU time between MC and real data?
- Why the many calls to spline?
- Suggestion by Karel:
  - -ln(1.0 - exp(-x)) expression in chi2-evaluation of fitting routine
  - Replace by **std::expm1** and **std::log1p**

Bouke Jung (bjung@nikhef.nl)