Nikhef outing
K40 efficiency calibration

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Contents

- What have I been focusing on? -> determination of the PMT efficiencies & the accuracies of these efficiencies

Why is efficiency important?

- We want a full understanding of the detector

- We want to know the energy of the incoming particle(s) & this energy scales with the number of measured photons

What did I do so far

- Single rates/QE relation
- Diff bkg methods & influence on QE
- QE over runs

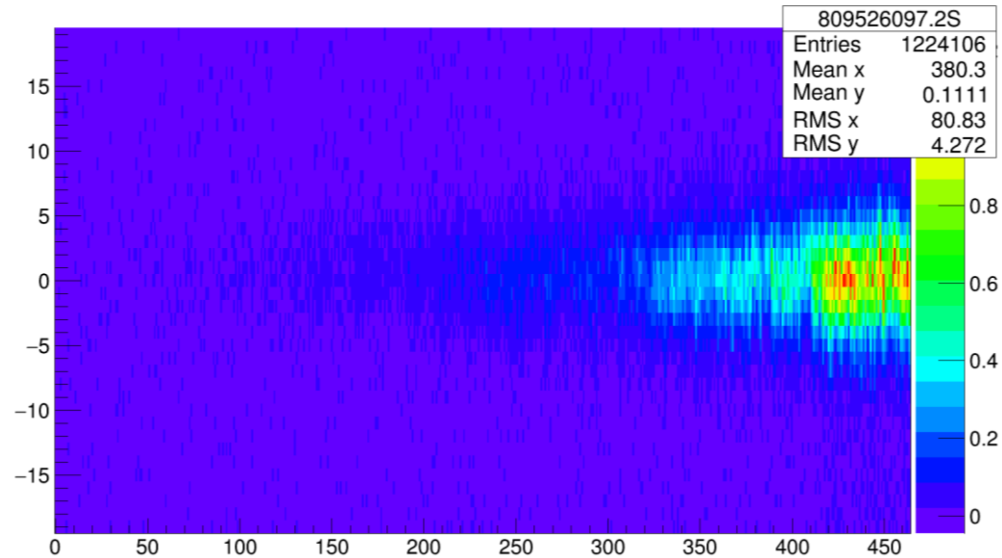
What did I do so far - II

- Single rates/QE relation
- Diff bkg methods & influence on QE
- QE over runs

- Influence of faulty PMTs on QE
- K40 model

First: how does QE calibration work

- Using JMonitorK40/JFitK40
- JMon takes all coincidences from data (multiplicity 2 or higher) & plots time differences for pmt pairs



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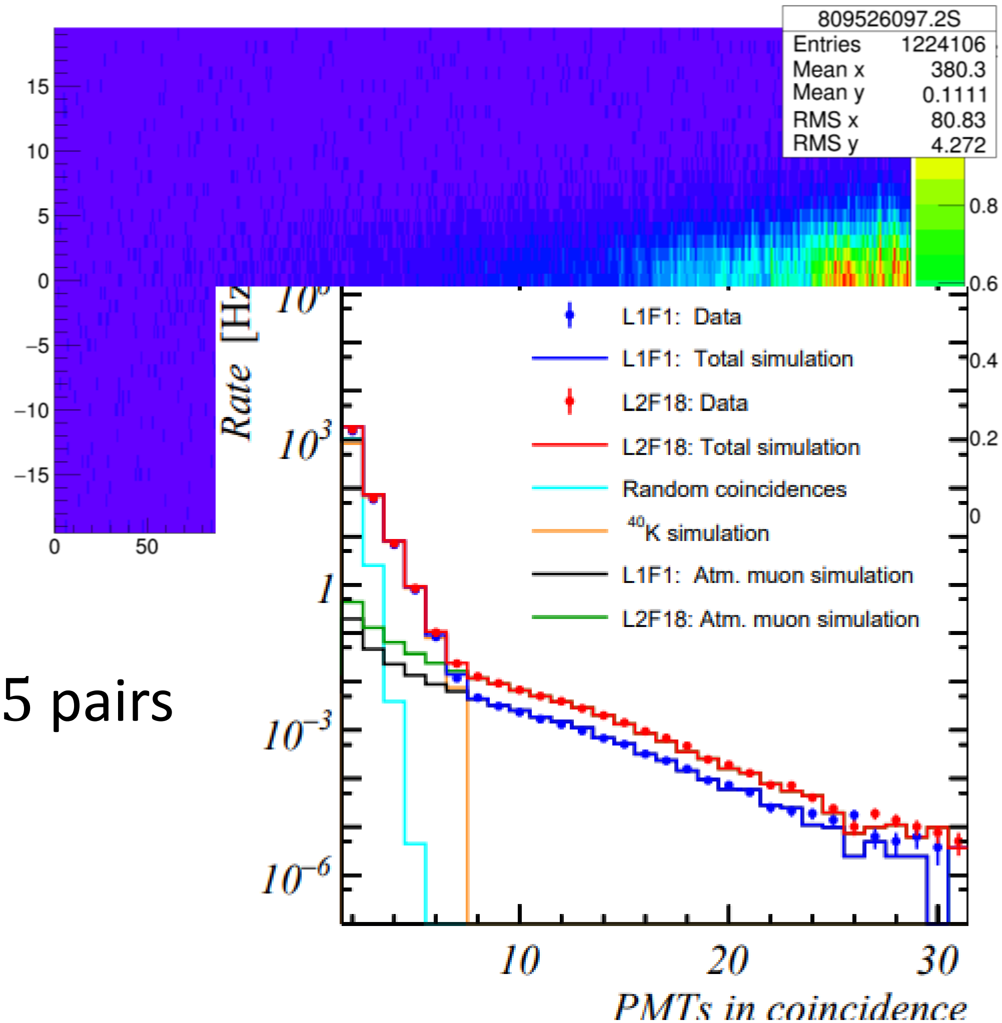
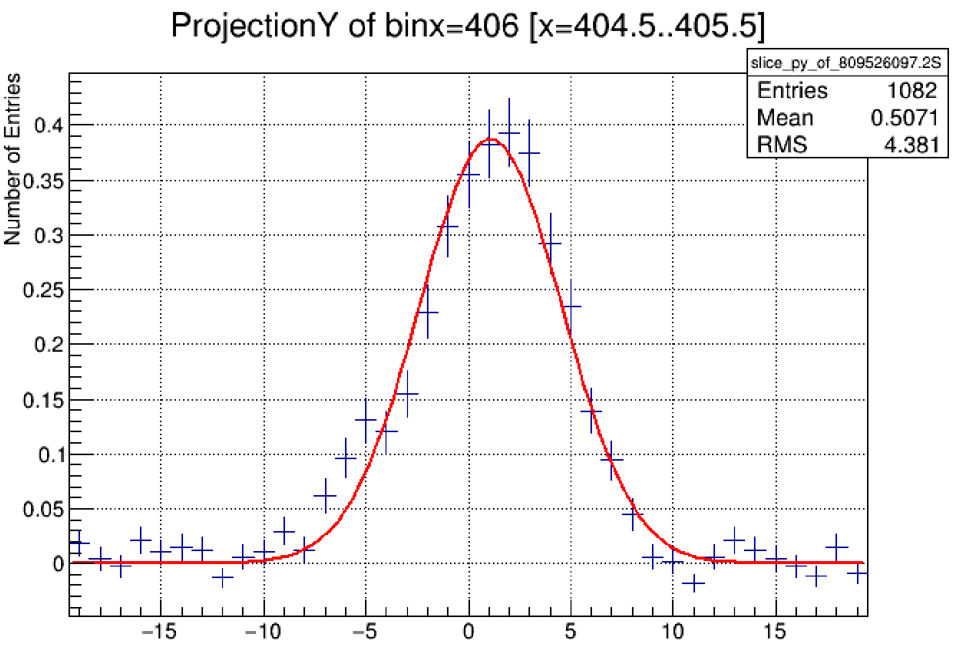


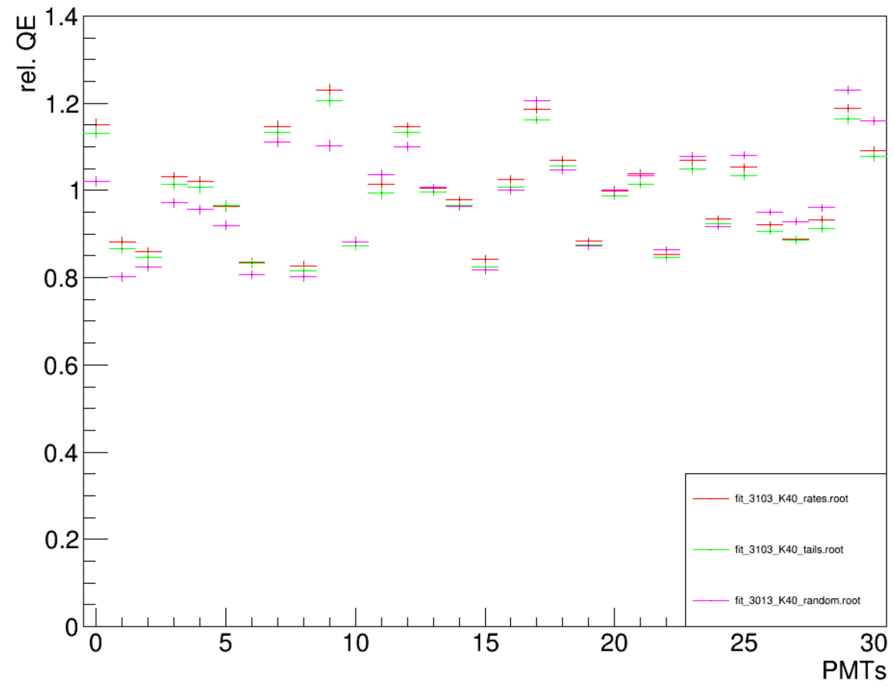
First: how does QE calibration work

- JFit fits coincidence rates to gauss
- Mean tells us something about t_0, sigma about the timespread and the area under the gauss about the QEs of the PMT pair
- Comparison is made between all pmt pairs to determine individual PMT QE's



Influence of background estimation

- JMon has 3 options for background estimation (tails, rates and random)
- Random shows great differences with respect to other two methods
- Tails shows consistent lower QE -> maybe due to throwing out some of the signal



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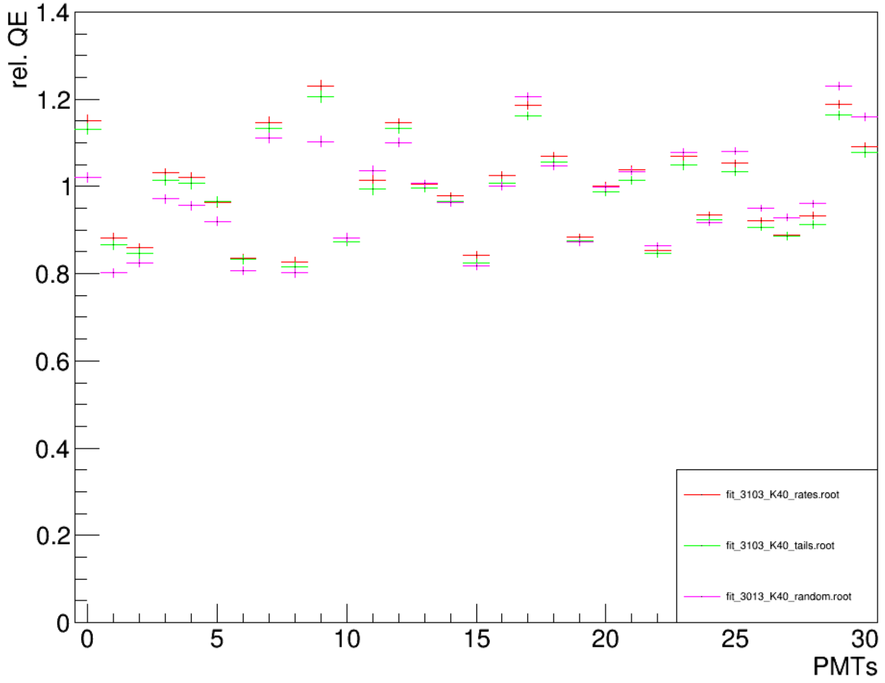

Discussion: I did not rerun this determination for the new JPP version (v10) but I do not expect this result to change a lot

Single rate/QE relation

- Single rates arise from events with multiplicity 1

- One would expect a linear relation between the measured single rate of a PMT and its determined QE

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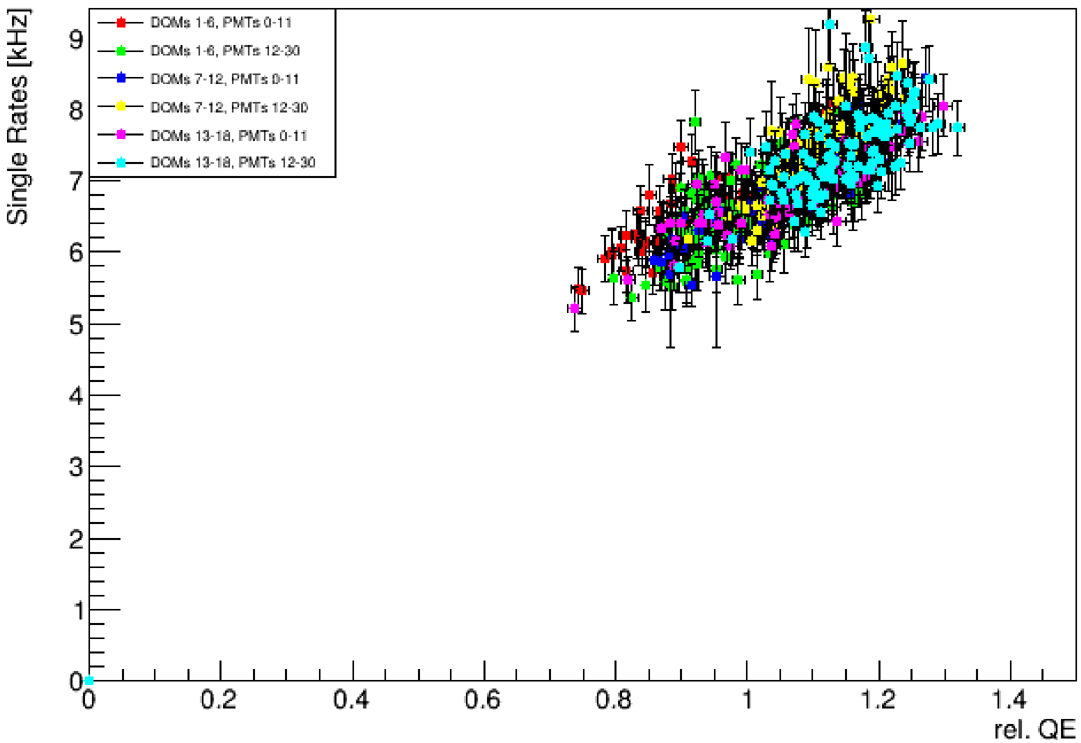

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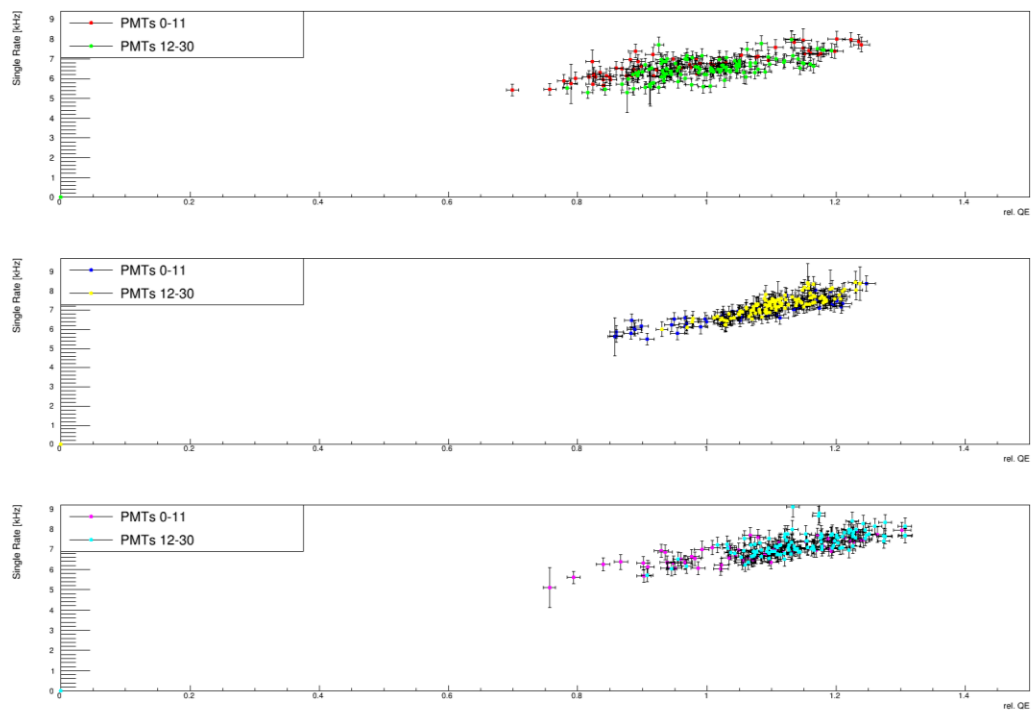
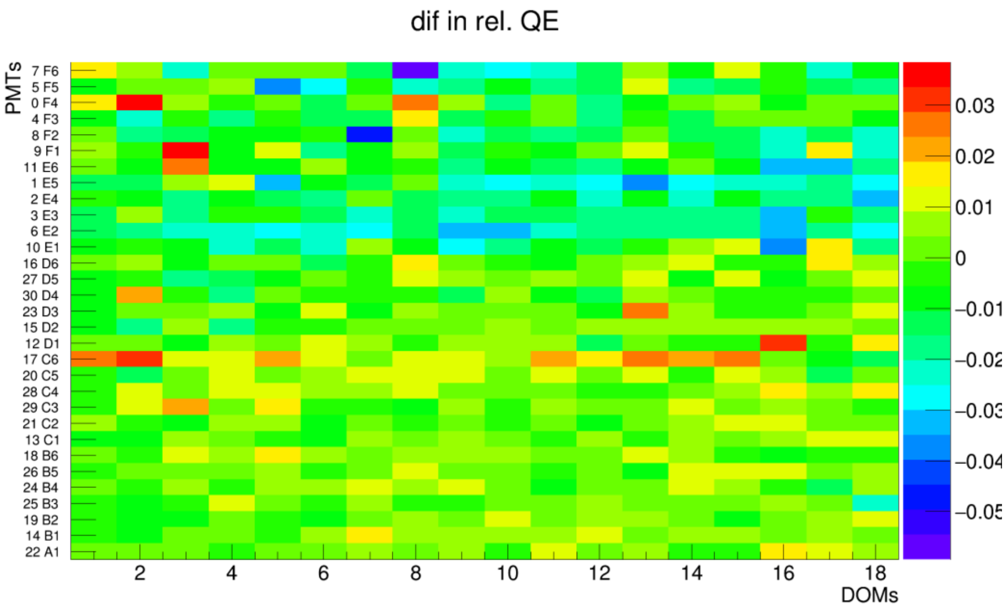


QE over runs

- I looked at the change in QE over multiple runs
- It showed that between changes between consecutive runs were fairly small (<1%) and mostly due to fluctuations in QE determination
- Compared mean QE's of runs 2771-2274 to mean QE's of runs 3103-3107
- Changes showed significant, but my feeling is that these results aren't right (especially increase in QE seems odd to me -> no apparent reason why QE should increase over time



K40 model

- K40 model: $^{40}K_{rate}(\cos\theta) = \mathrm{Exp}[p1 + \cos\theta\,(p2 + \cos\theta\,(p3 + \cos\theta\, p4))]$

where θ is the separation angle between the PMTs that make up the pmt pair

- Fitted this model to mean rates of PMT pairs and found different values than the ones used to determine the QEs

Parameter	JFitK40	My fit	Error
p0	-1.07061	-0.586	0.006
p1	3.17173	2.568	0.018
p2	-1.35769	-0.637	0.062
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Discussion: The mean rates per angular separation were not nice gaussians so I want to rerun this analysis with more data

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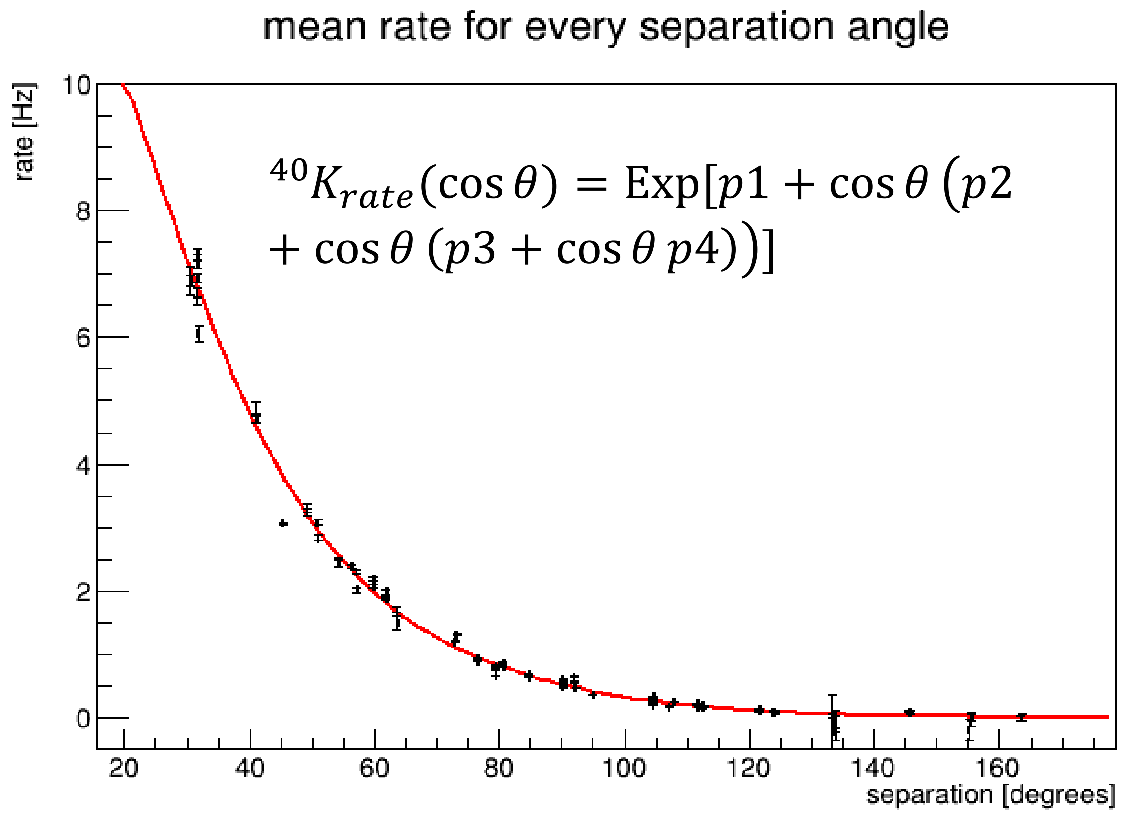
K40 model

- Fitted K40 rate to mean of rates of same angular separation



$$ {}^{40}K_{rate}(\cos\theta) = \mathrm{Exp}[p1 + \cos\theta\,\big(p2 + \cos\theta\,(p3 + \cos\theta\, p4)\big)] $$

Faulty PMTs: What if a PMT were to fail?

- In an ideal world: set QE of that PMT to zero
- The rest of the QE’s stay the same

- However this is not what happens!

Faulty PMTs

- How to simulate a faulty PMT? -> set corresponding rate to 0
- (this is also done if high rate veto is triggered)

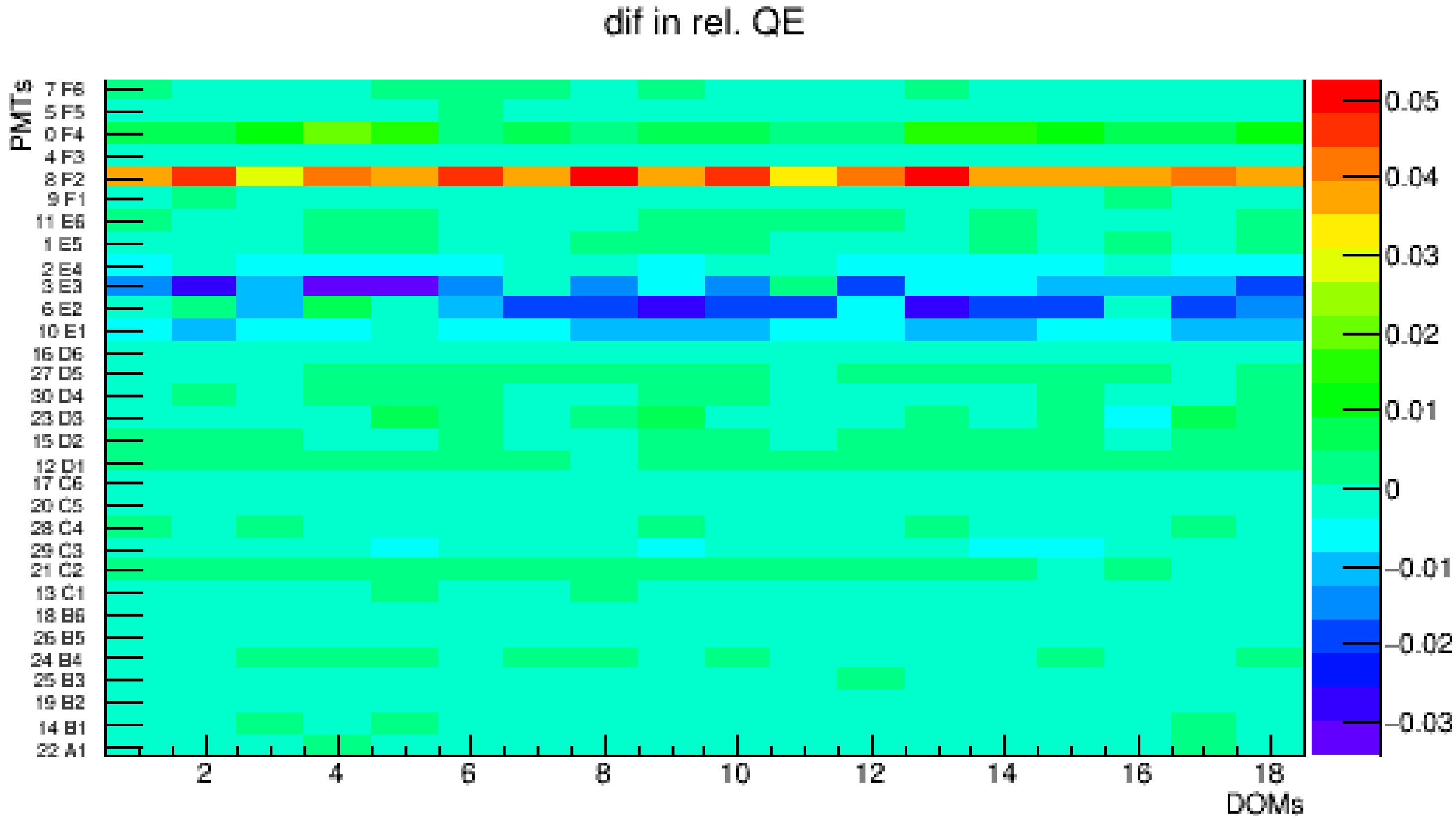
- JFit has feature that recognizes 0 rates & sets corresponding QE to 0

- What happens to the other QE's?

Faulty PMTs

- What happens to the other QE's?

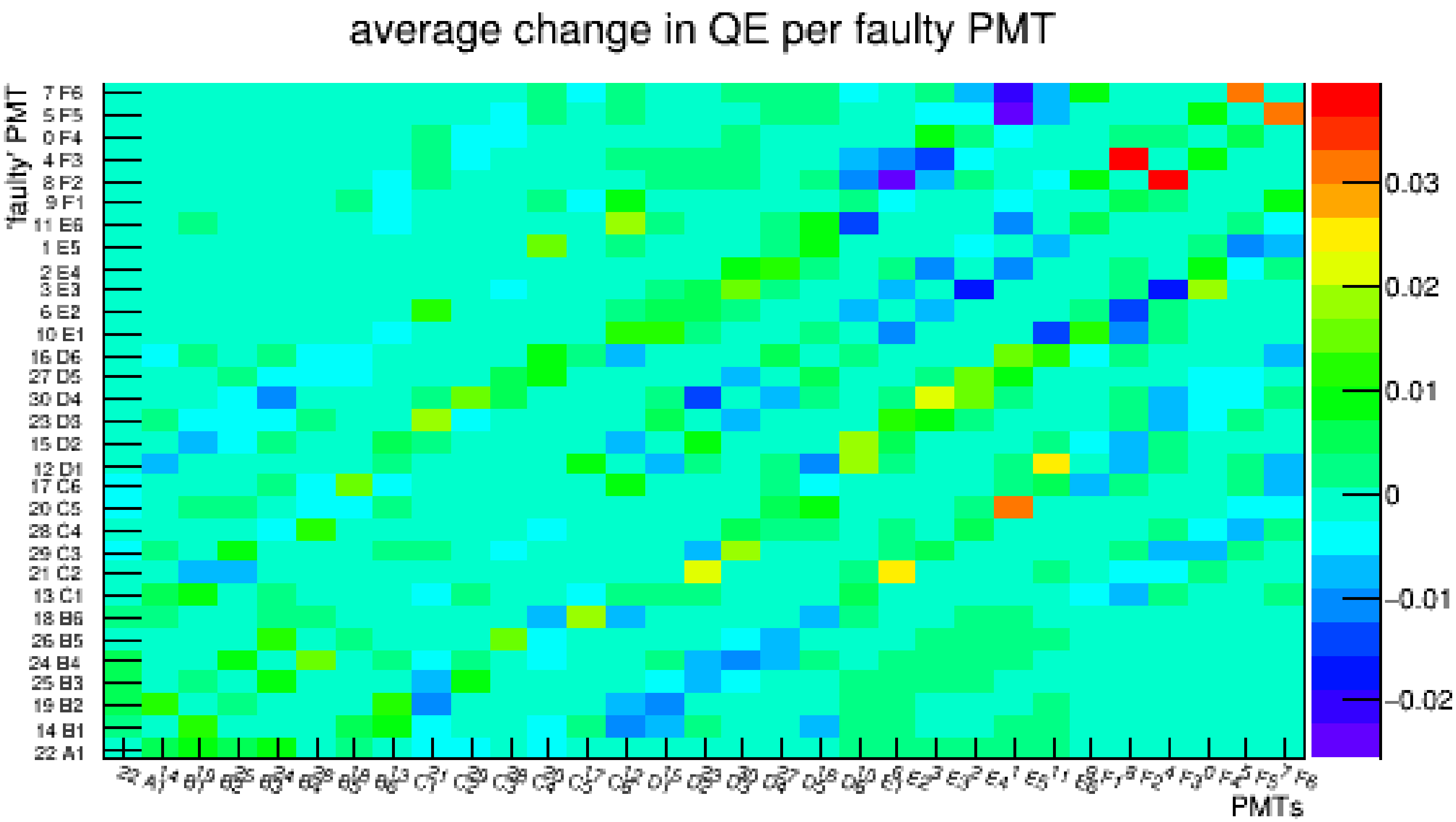
e.g. PMT 4 is switched off



Faulty PMTs

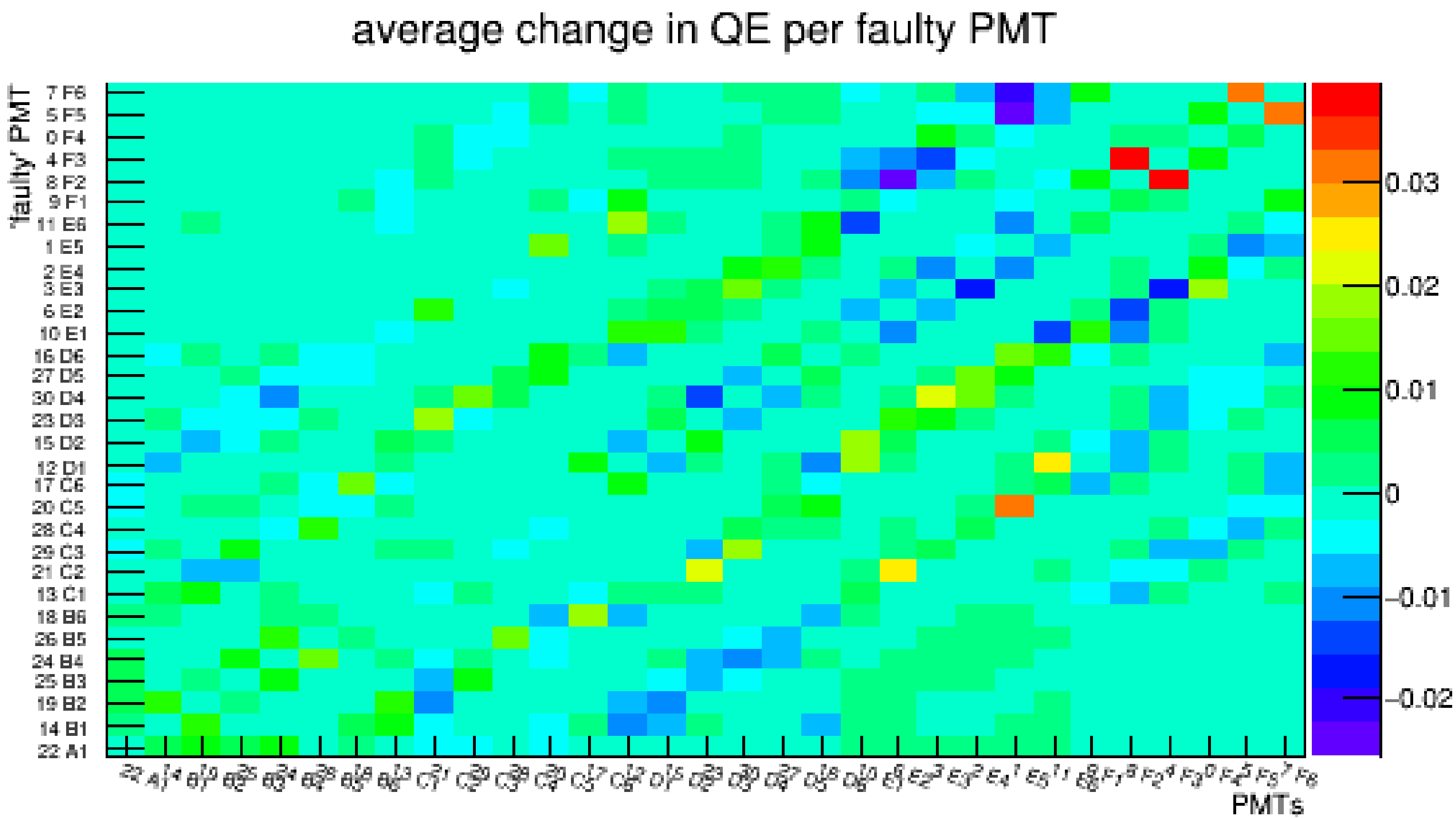
- PMT 4 (F3) shows faulty behaviour, nearest neighbours (E2/E3) show slight decrease in efficiency
- Next-to-nearest neighbours (F2/F4) show then a slightly larger increase in their efficiency, but asymmetrically
- Was hoping to see this structure for every PMT, however…

Faulty PMTs



average change in QE per faulty PMT
'faulty' PMT
7 F6
5 F5
0 F4
4 F3
8 F2
9 F1
11 E6
1 E5
2 E4
3 E3
6 E2
10 E1
16 D6
27 D5
30 D4
23 D3
15 D2
12 D1
17 C6
20 C5
28 C4
29 C3
21 C2
13 C1
18 B6
26 B5
24 B4
25 B3
19 B2
14 B1
22 A1
PMTs
0.03
0.02
0.01
0
−0.01
−0.02

Faulty PMTs



-> Currently running program that shows same change in QE but now as a function of the separation angle between the faulty PMT and the corresponding PMT

-> hopefully this reveals some more hints of the bias that arises from faulty PMTs

What’s next

- So we found a few points of criticism on the K40 model
- My idea would be to do some extensive theoretical research on the K40 rates in the sea and work from there (if this has not already been done)
- Writing my thesis….