PhD's 2-nd year seminar

Calibration and testing of PPM-DOM as a future optical module for the new KM3NeT detector

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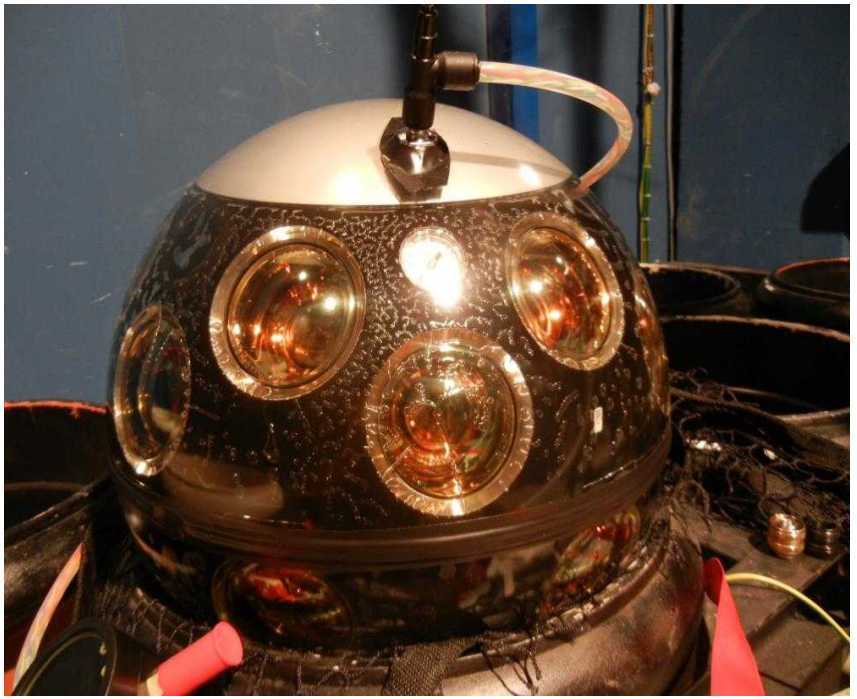
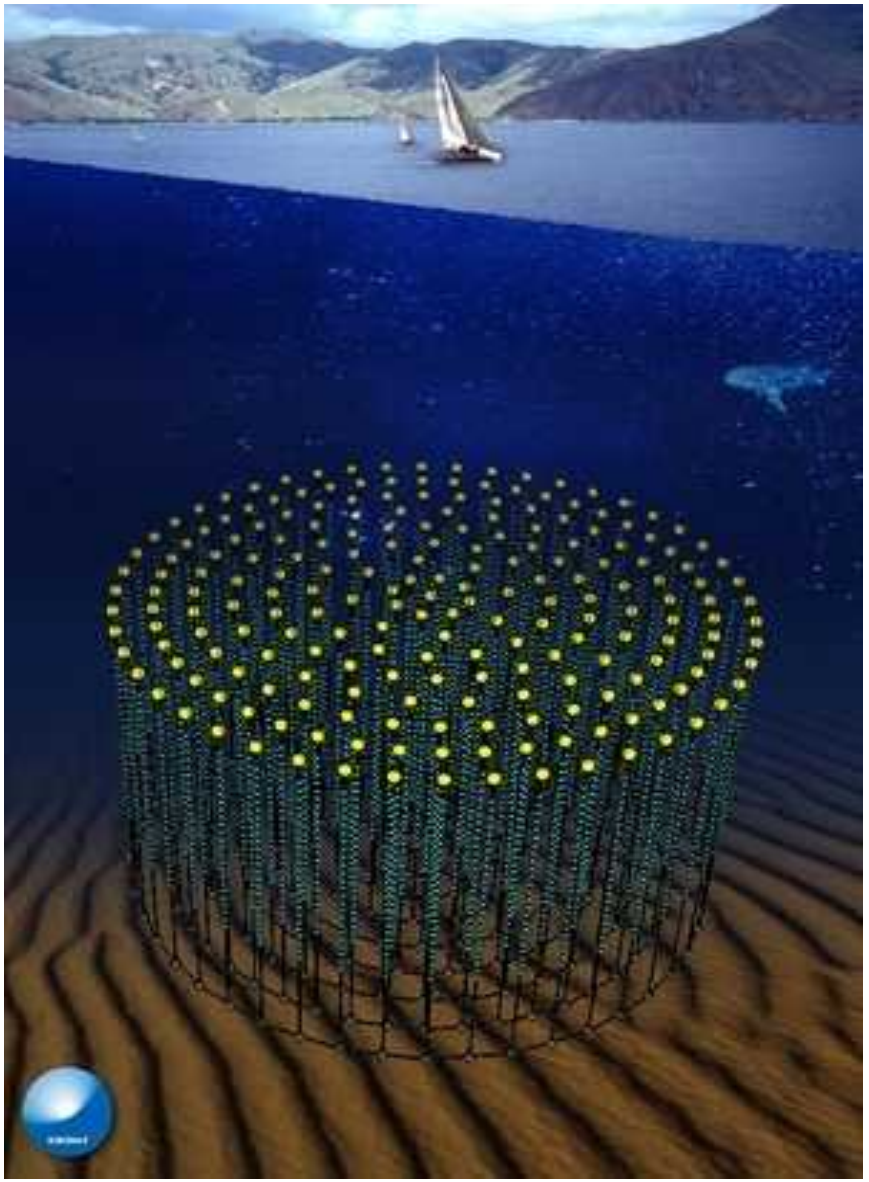


CPPM – 17.12.12

KM3NeT
Opens a new window on our universe

Introduction: future KM3NeT detector



KM3NeT: Cubic Kilometer Neutrino Telescope

Future location: deep water of Mediterranean Sea.
Aim: to search for neutrinos from distant astrophysical sources:

* gamma ray bursts
* supernovae
* colliding stars, etc.
* could also be used in search for dark matter in the Universe.

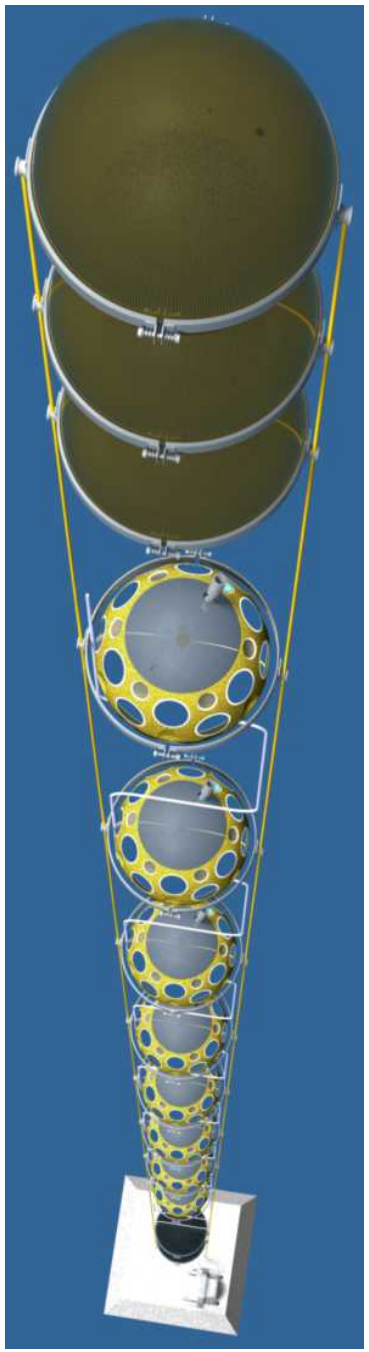
Structure: an array of tens of thousands of optical sensors (to detect the faint light in the deep sea from charged particles originating from collisions of neutrinos with ground/water).

+ instrumentation for marine biology, oceanography and geophysics.

* **Line lenght:** ~ 800 m.
* **Distance between lines:** ~ 100 m.

KM3NeT project builds on the experience of the ANTARES detector.

PPM-DOM: main purposes and structure



PPM-DOM external view

PPM-DOM upper hemisphere

* **31of 3-inch PMTs:** 12 for upper hemisphere and 19 for lower hemisphere.

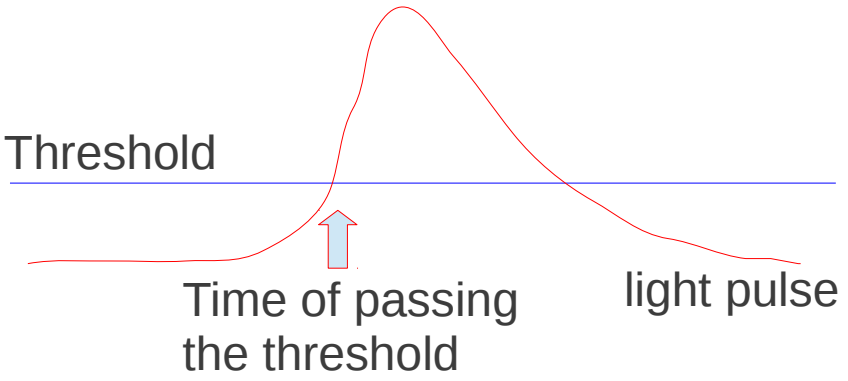
* **PPM (Pre-Production-Model)** is ready to be deployed on instrumental line.

* Better angular acceptancce

* Better directional sensitivity.

* Better energy estimation.

Data record:



*Time over threshold
*Time of passing

← design of the new KM3NeT line with the new DOMs

PPM-DOM calibration runs in CPPM: general info

Why do we need to calibrate?
In order to achieve a high angular resolution of the telescope, the position of the optical module with the photo-sensors **and their timing** must be accurately monitored. For the timing we need to know all the time-offsets and their origins.

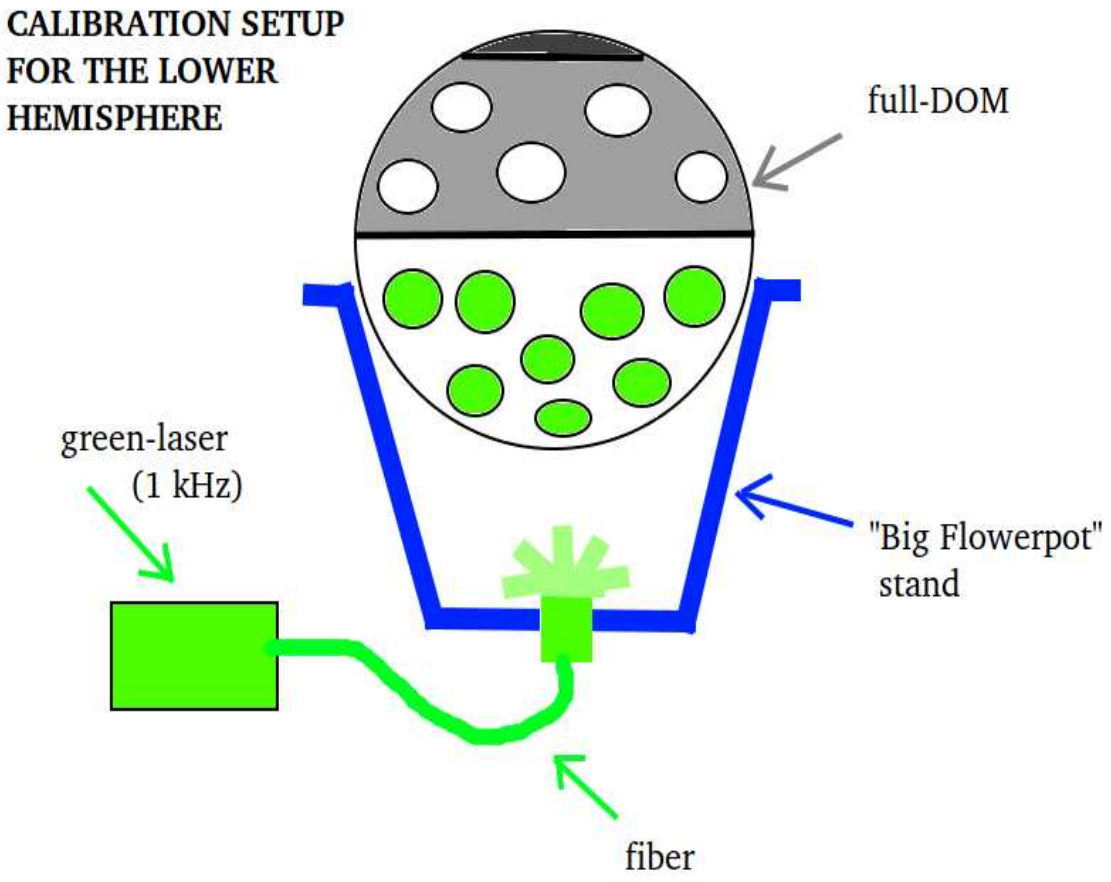
What we've already done:

* **Calibration runs for the lower hemisphere of PPM-DOM:**
  Several runs with different light intensity, using the setup-1 in the CPPM “dark room”.

* **Calibration runs for the upper hemisphere:**
  ~ 20 runs with setup-2 in CPPM “dark room”.

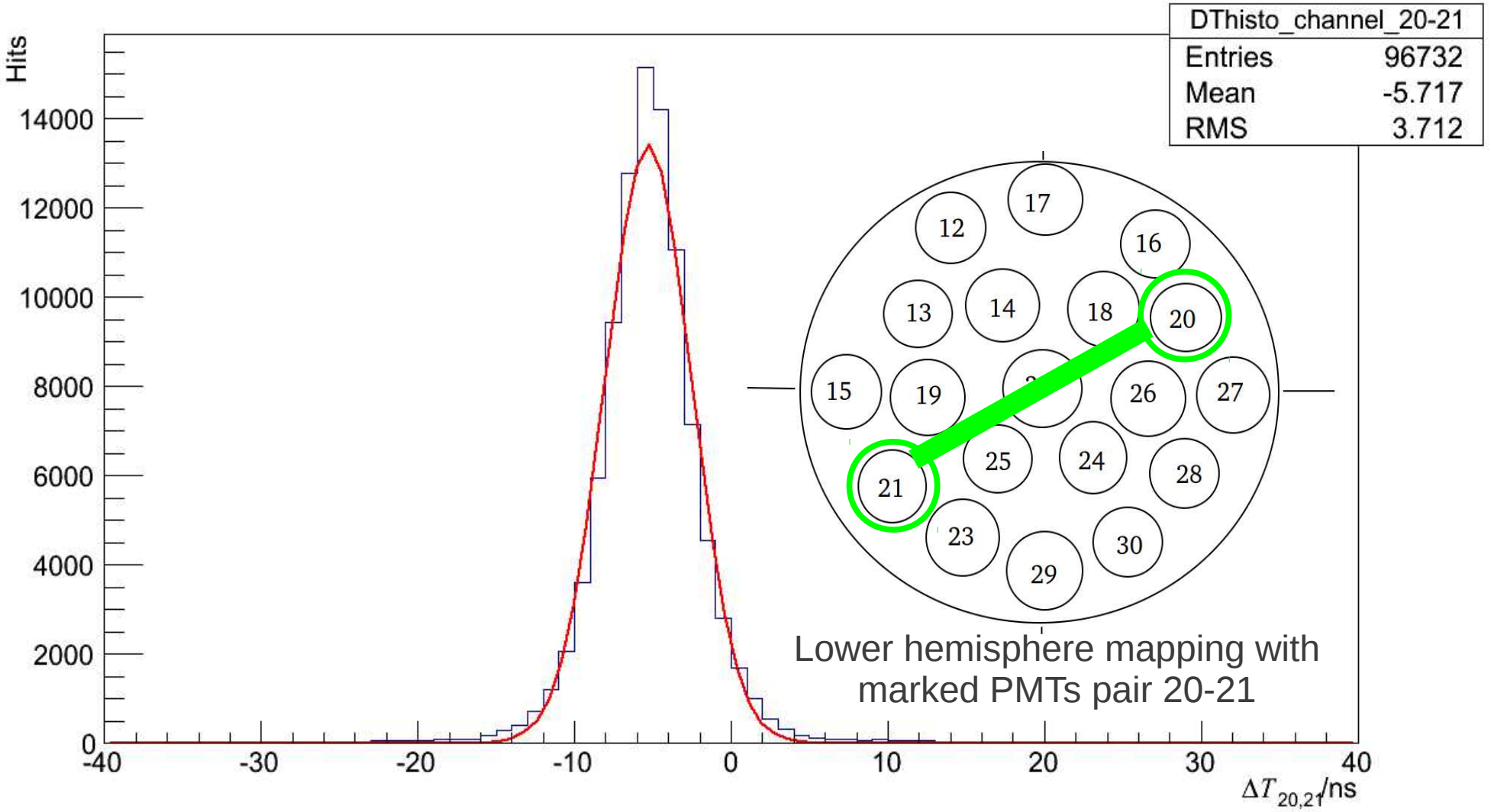
* **Mapping test for PPM-DOM sphere:**
For lower hemisphere: one short run for each of 19 PMTs, using one of the “cups” from the setup-2. Mapping for the upper hemisphere was done during the calibration runs.

Setup 1 “Big flowerpot”: tests for lower hemisphere



PPM-DOM with “Big flowerpot” setup

Setup 1 “Big flowerpot”: tests for lower hemisphere



Lower hemisphere mapping with marked PMTs pair 20-21

Time difference histogram for the PMTs pair, IDs: 20-21

Setup 1 “Big flowerpot”: time offsets results for lower hemisphere

PMT ID	Mean DeltaT [ns]	Sigma
12	4.58	2.77
13	17.03	1.83
14	16.17	1.32
15	8.09	1.98
16	9.19	1.98
17	11.27	1.21
18	14.37	1.18
19	14.22	1.20
20	4.00	2.38
21	9.26	1.51
22	14.48	0.99
23	1.86	2.55
24	6.53	1.37
25	9.04	1.14
26	9.40	1.32
27	2.14	2.25
28	0.21	2.37
29	0	2.02
30	3.91	2.12

Example of some obtained sigmas for pairs of PMTs:

sigma_ij = 3.24	sigma_ik = 3.22	sigma_jk = 2.33
sigma_ij = 2.33	sigma_ik = 2.68	sigma_jk = 2.43
sigma_ij = 2.43	sigma_ik = 2.42	sigma_jk = 2.87
sigma_ij = 2.87	sigma_ik = 2.29	sigma_jk = 2.38
sigma_ij = 2.38	sigma_ik = 2.23	sigma_jk = 1.67
sigma_ij = 1.67	sigma_ik = 1.69	sigma_jk = 1.65
sigma_ij = 1.65	sigma_ik = 2.66	sigma_jk = 2.64

Method used to obtain individual values:

assume:

$$\sigma_{i,j}^2 = \sigma_i^2 + \sigma_j^2$$

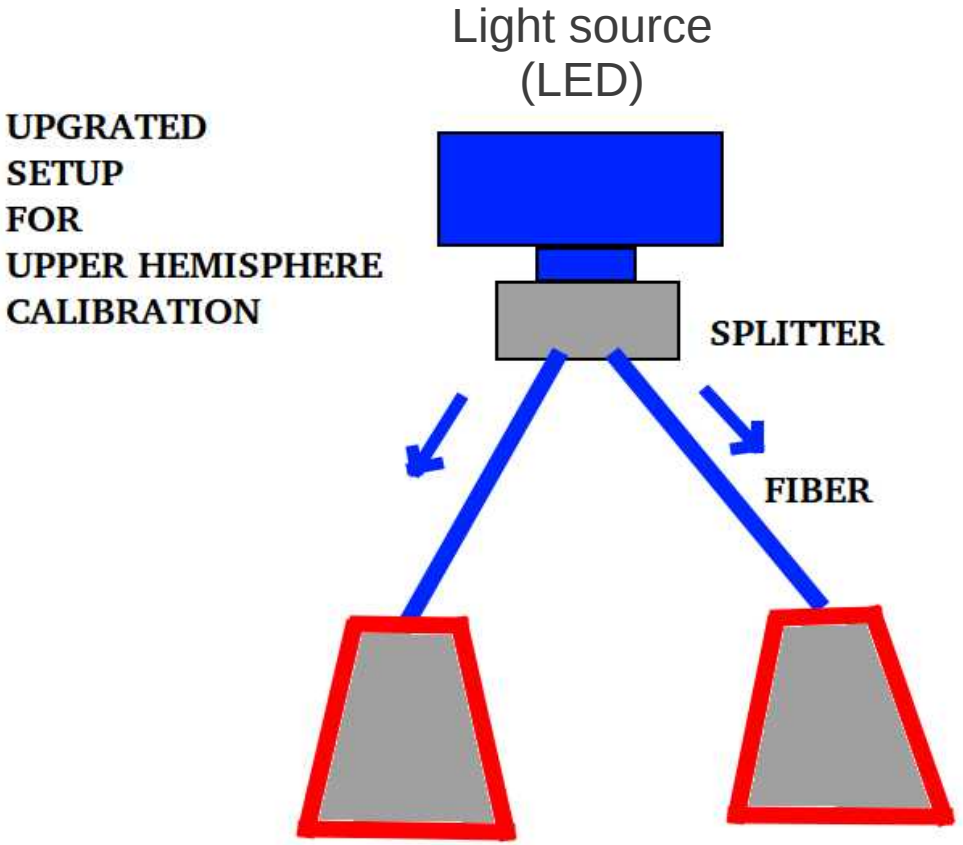
$$\Rightarrow \sigma_i^2 = \frac{1}{2}(\sigma_{i,j}^2 + \sigma_{i,k}^2 - \sigma_{j,k}^2)$$

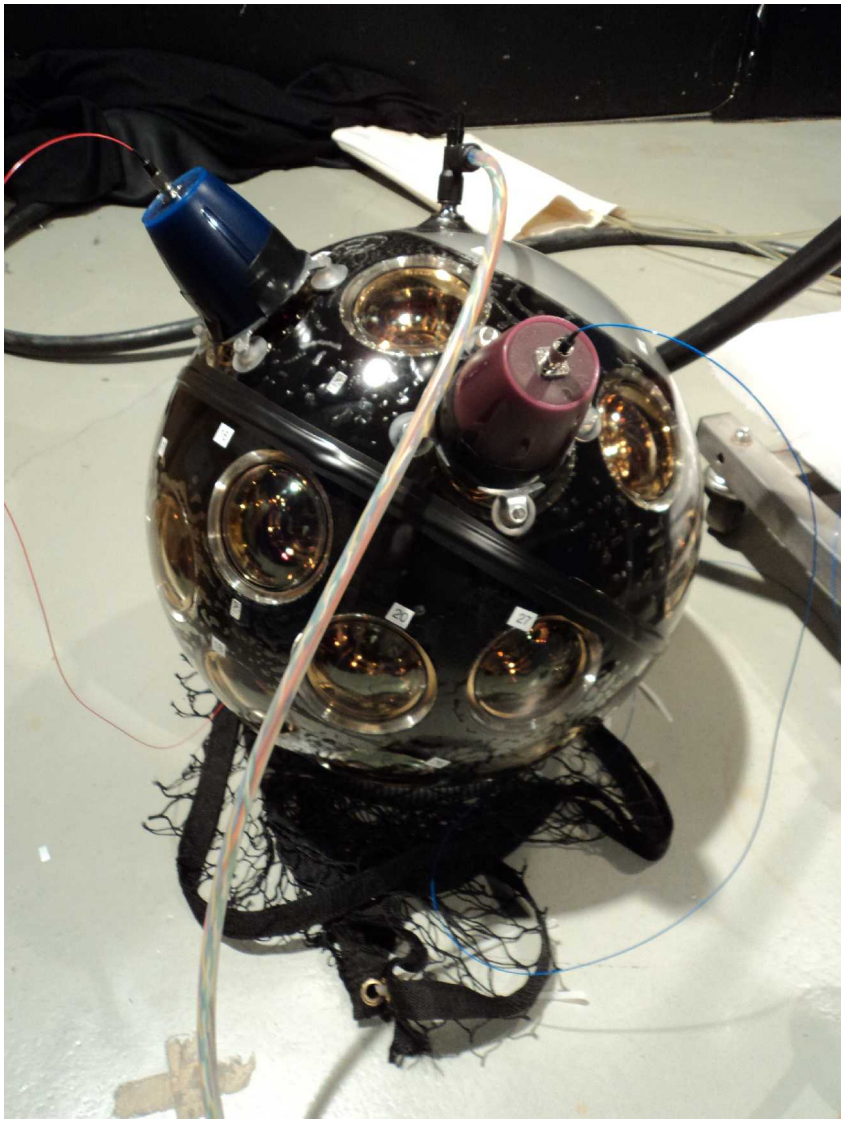
also:

$$\langle \Delta T_{i,j} \rangle = \langle \Delta T_i \rangle - \langle \Delta T_j \rangle$$

$\Rightarrow$ set $\langle \Delta T_1 \rangle = 0$ and iterate through the combinations

Setup 2 “Double-cup”: tests for upper hemisphere

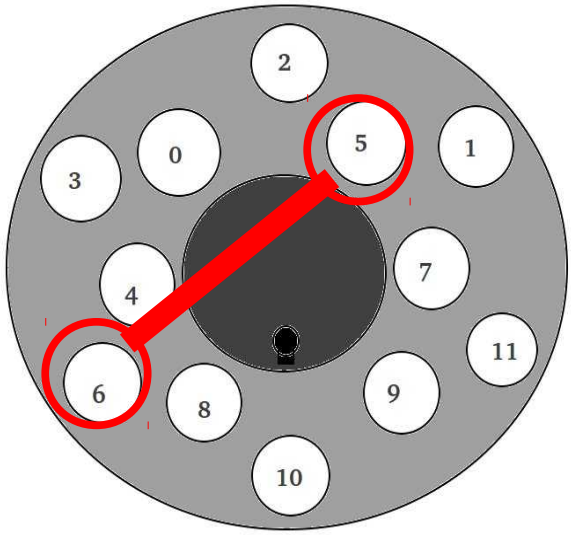




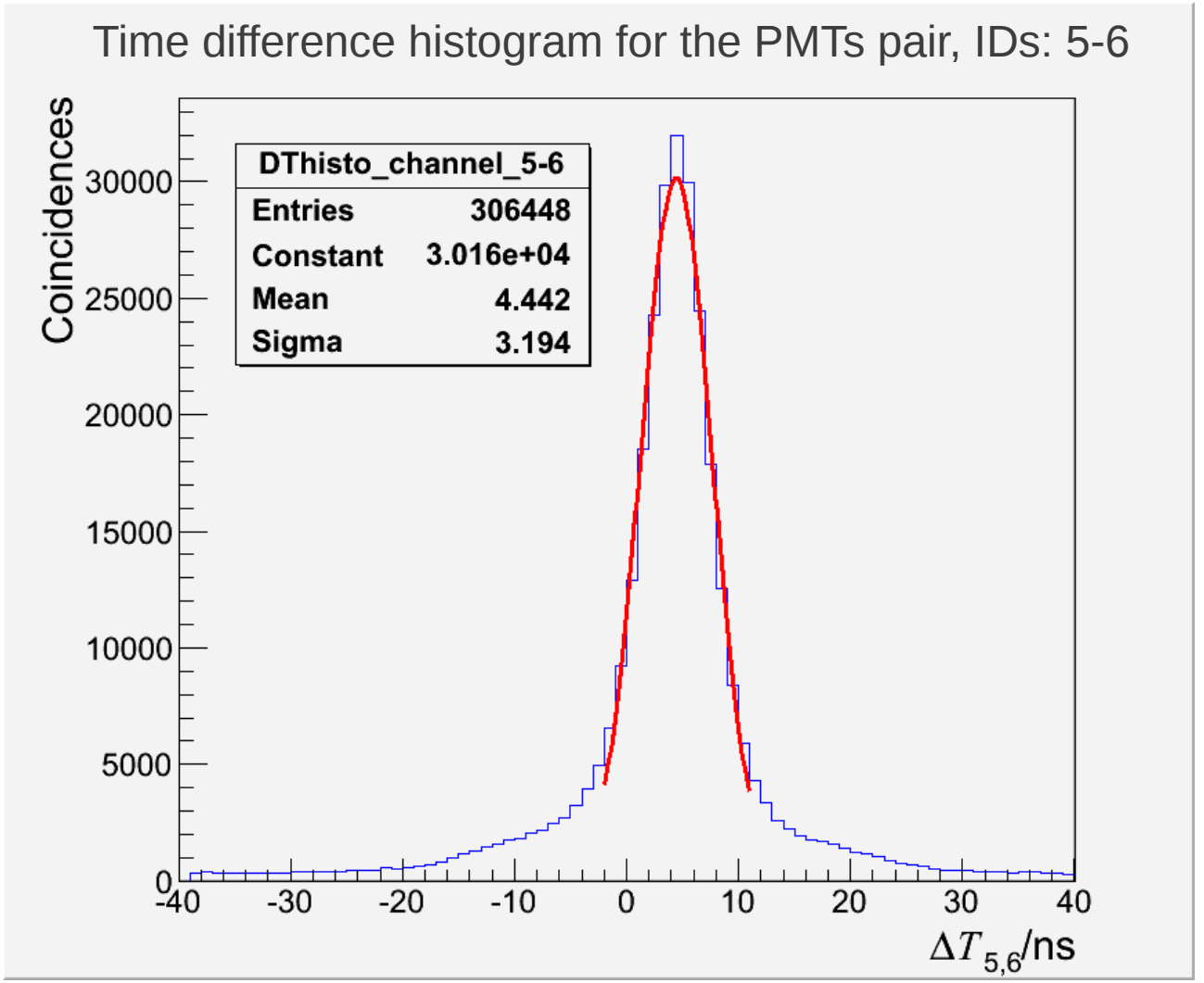
PPM-DOM with “Double cup” setup

Setup 2 “Double-cup”: tests for upper hemisphere

We cover all upper PPM-DOM hemisphere pair-by-pair of PMTs, each time overlapping one PMT from the previous run. As a result we have a set of data which allows to disentangle individual time-offset values for each PMT and corresponding sigmas.



Upper hemisphere mapping with marked PMTs pair 5-6

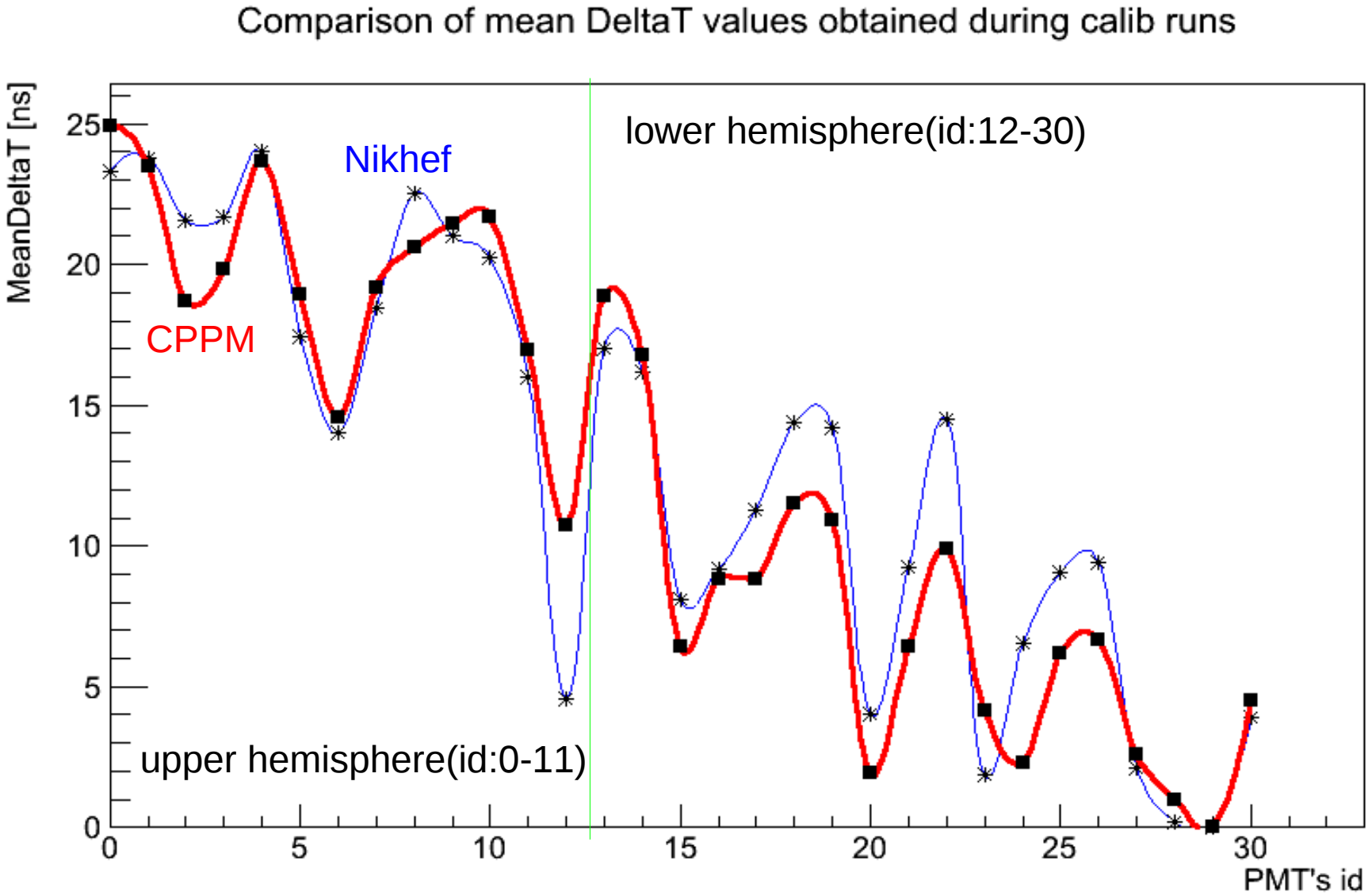


Setup 2 “Double-cup”: time offsets results for upper hemisphere*

PMT ID	Mean DeltaT [ns]	Sigma
0	4.58	2.51
1	17.03	2.73
2	16.17	1.49
3	8.09	2.54
4	9.19	1.33
5	11.27	2.56
6	14.37	1.83
7	14.22	2.39
8	4.00	1.98
9	9.26	2.28
10	14.48	2.06
11	1.86	1.91

* Same method used like for the “Big flowerpot” setup.

Comparison between CPPM and Nikhef results for the full PPM-DOM sphere (31 PMTs)

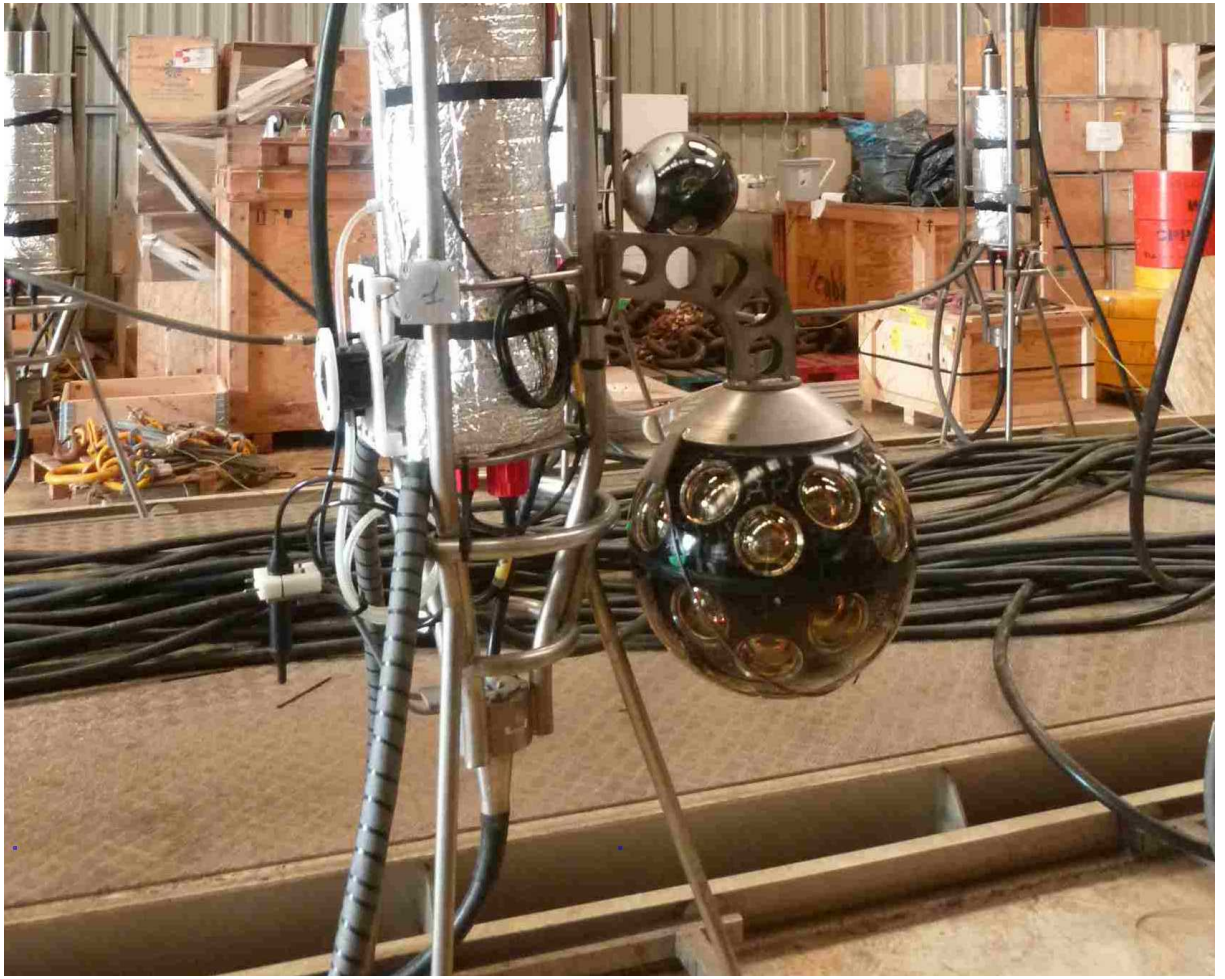


At Nikhef: multiple LEDs (1 per PMT), triggered at 50 kHz (no glass sphere glued on).
At CPPM: * one LED with a light splitter, 10 kHz → upper hemisphere
* green laser, ~ 1kHz → lower hemisphere

Plans for the nearest future:

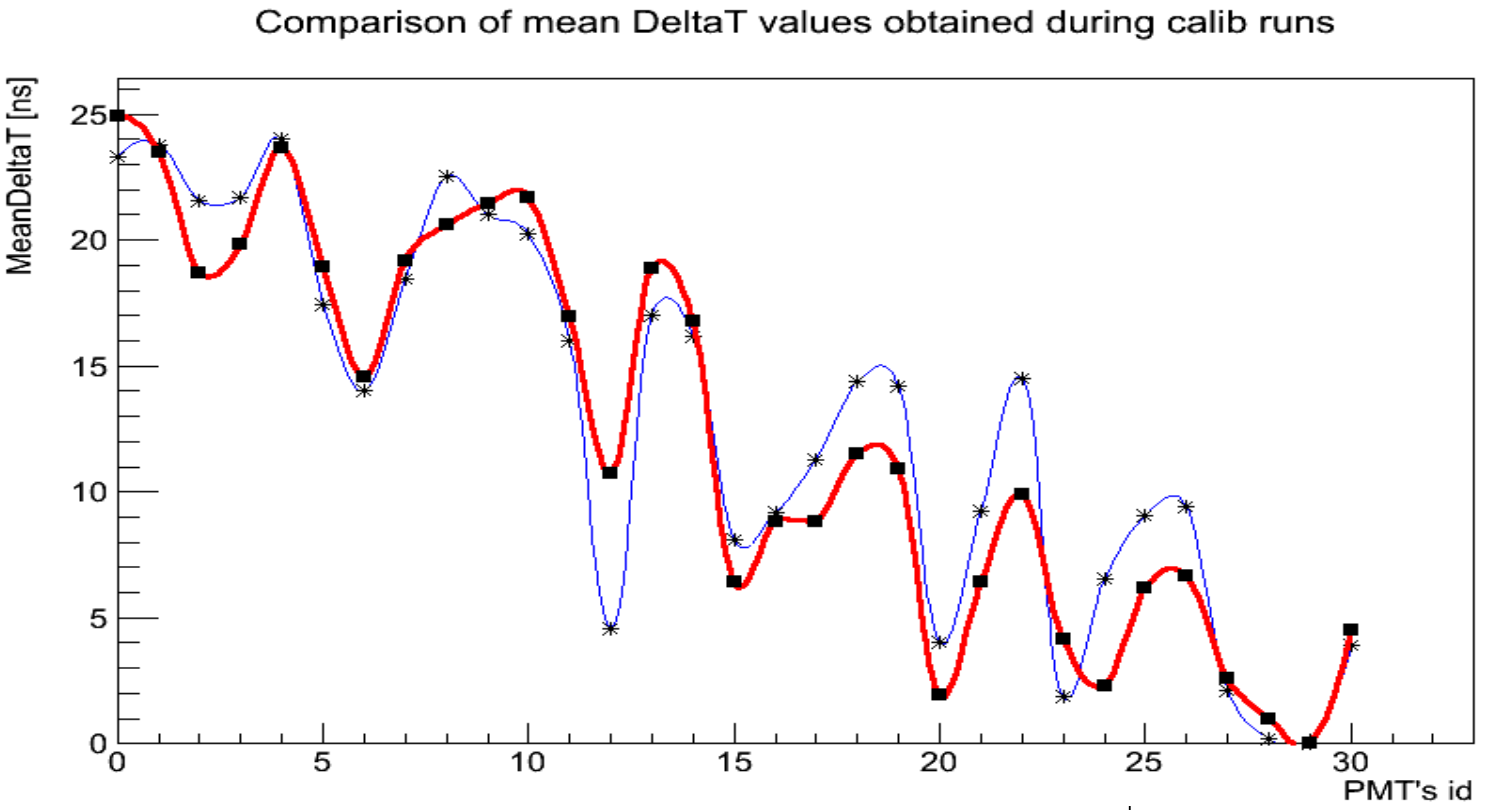
* Investigate reasons of the different time offsets for the PPM-DOM PMTs.

* To wait until the deployment of the instrumental ANTARES line and to work with data taken in sea water conditions.

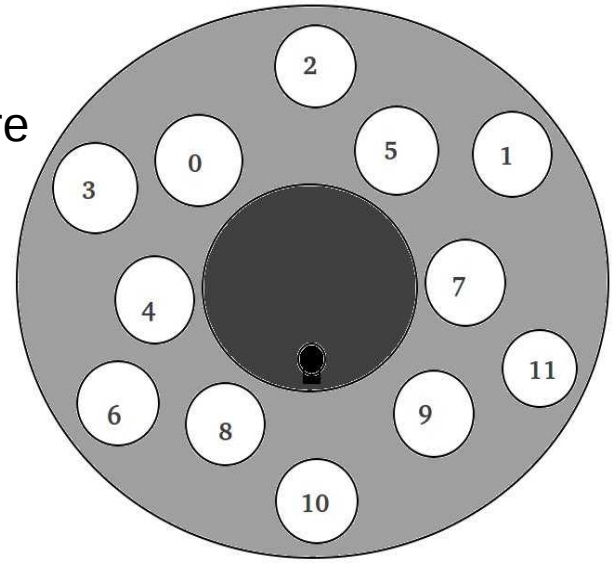


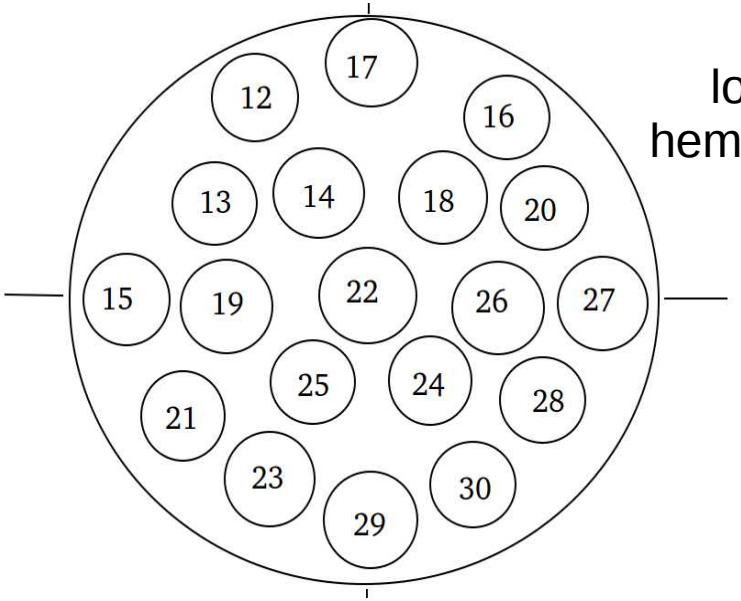
Merci pour votre attention!

Backup slide: mapping factor?



upper hemisphere





lower hemisphere