PPM DOM calibration in CPPM

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KM3NeT Collaboration meeting

CPPM
29.01.2013

PPM-DOM calibration runs in CPPM: general info

Plan of the calibration tests were done:

*** Time calibration: several tens of PPM DOM runs made to see the time offsets for all the 31 PMTs from full DOM sphere (separate testing setups for upper and lower hemisphere).**

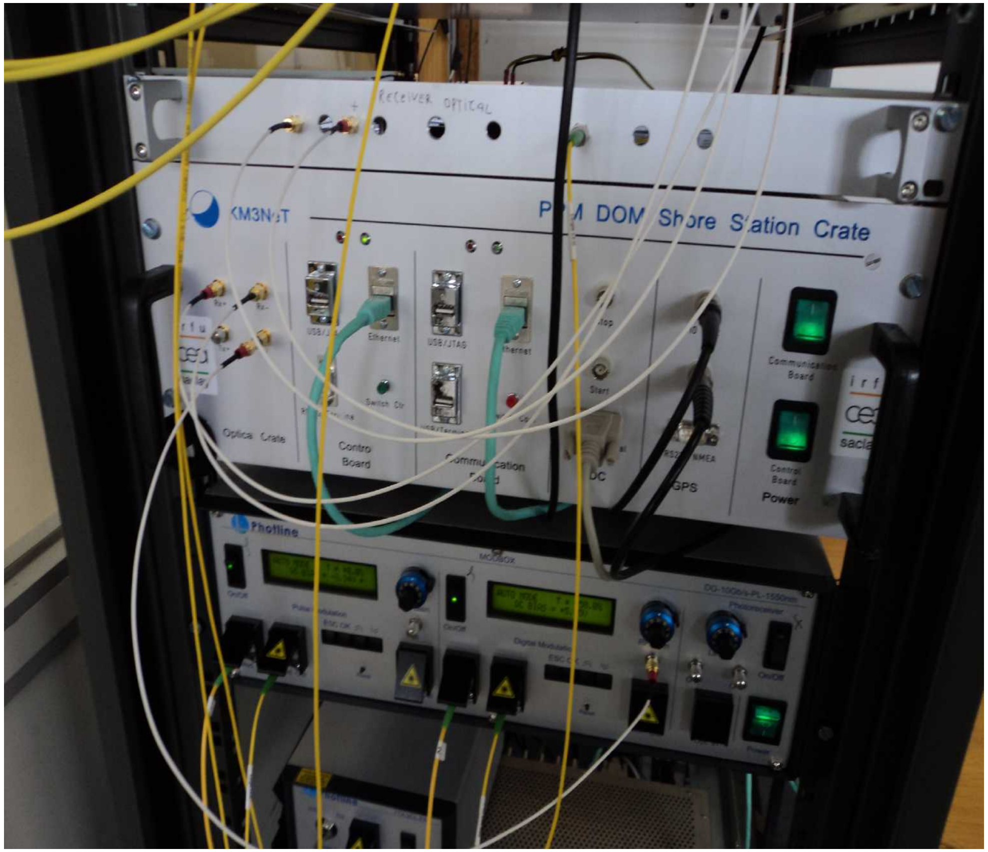
*** Obtained data analysis (studying features of outputs).**

*** Gain calibration check.**

*** Mapping test: PMTs positions.**

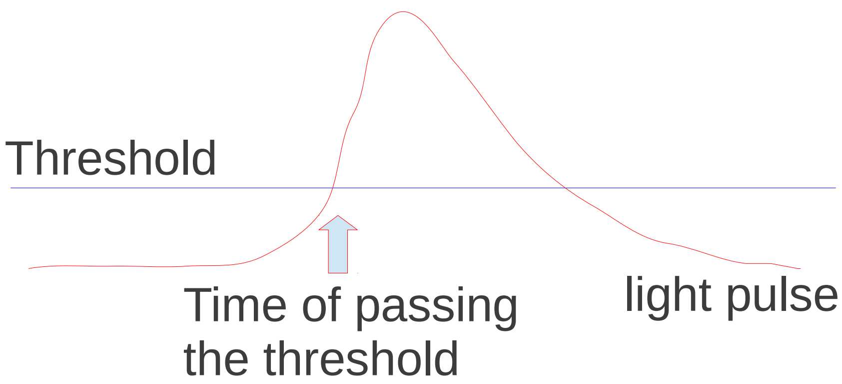
*** Gathering ideas for the future tests (what kind of setup is preferable to have for the future calibration runs).**

Data available with PPM DOM runs:



PPM DOM shore station crate in CPPM during run

Data converted from "items" to "hit" format :

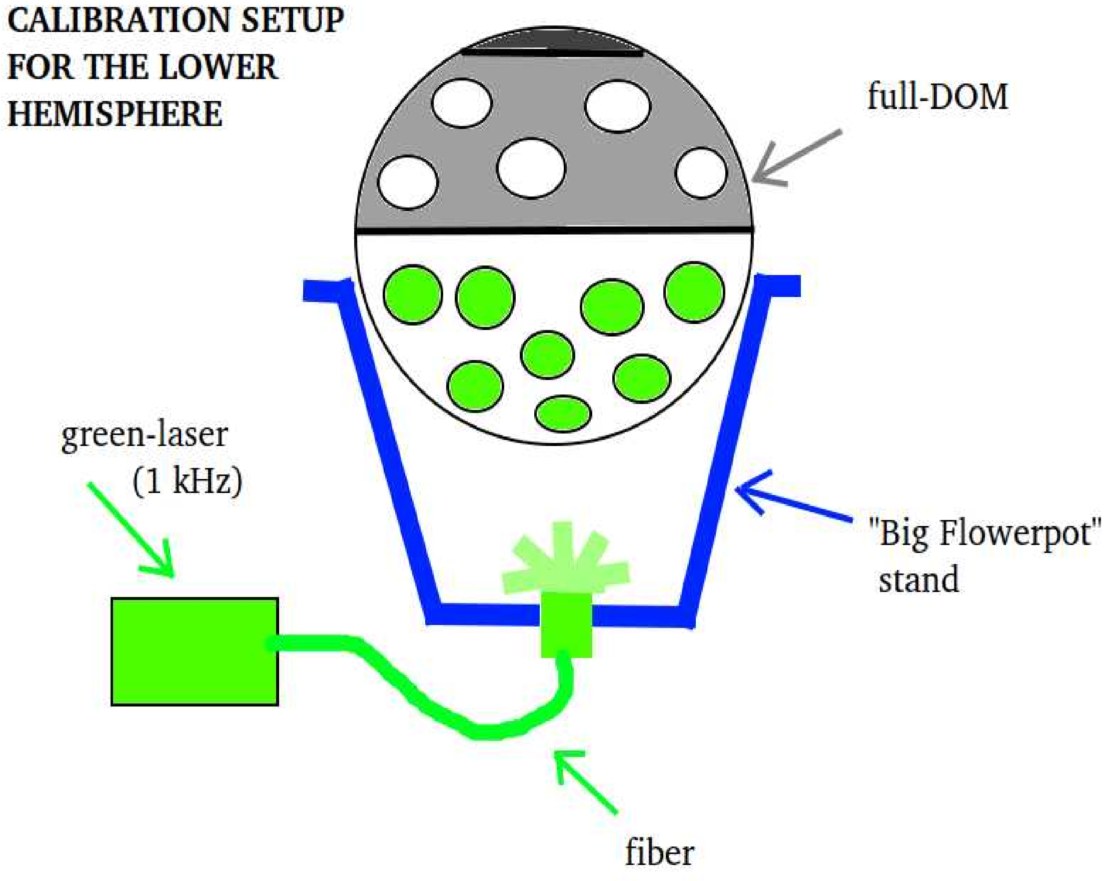


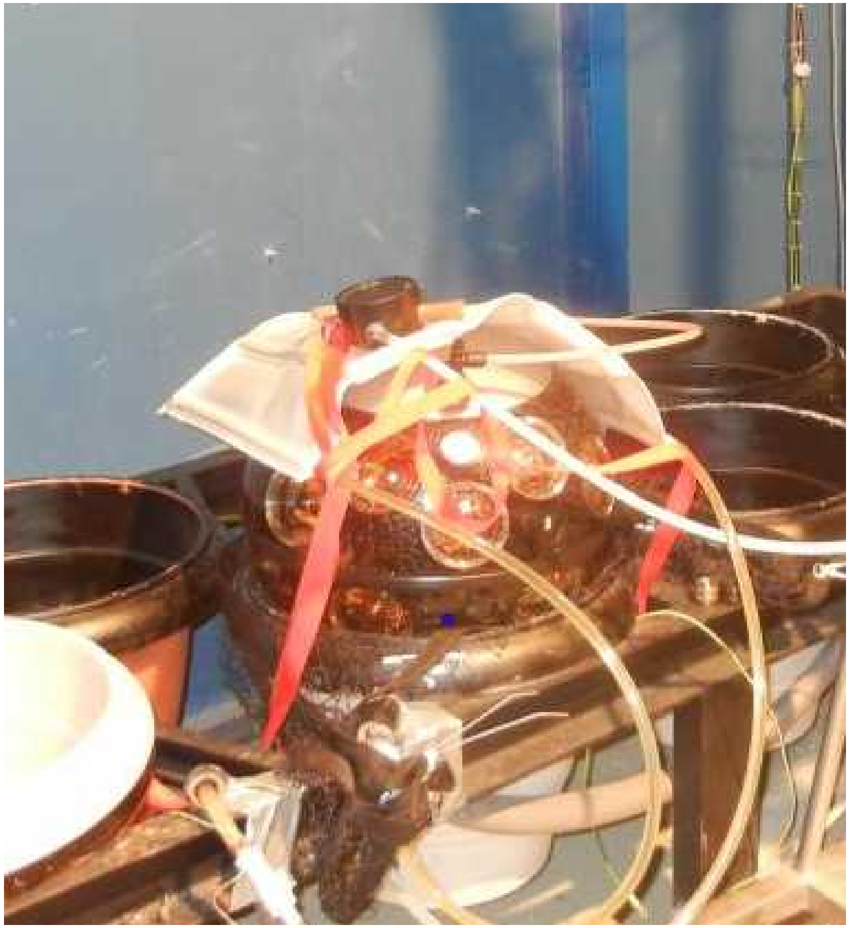
We have in recorded data:

*Time over threshold
*Time of passing the threshold

All runs data is available at Lyon: "/in2p3/data/raw/DOM/"

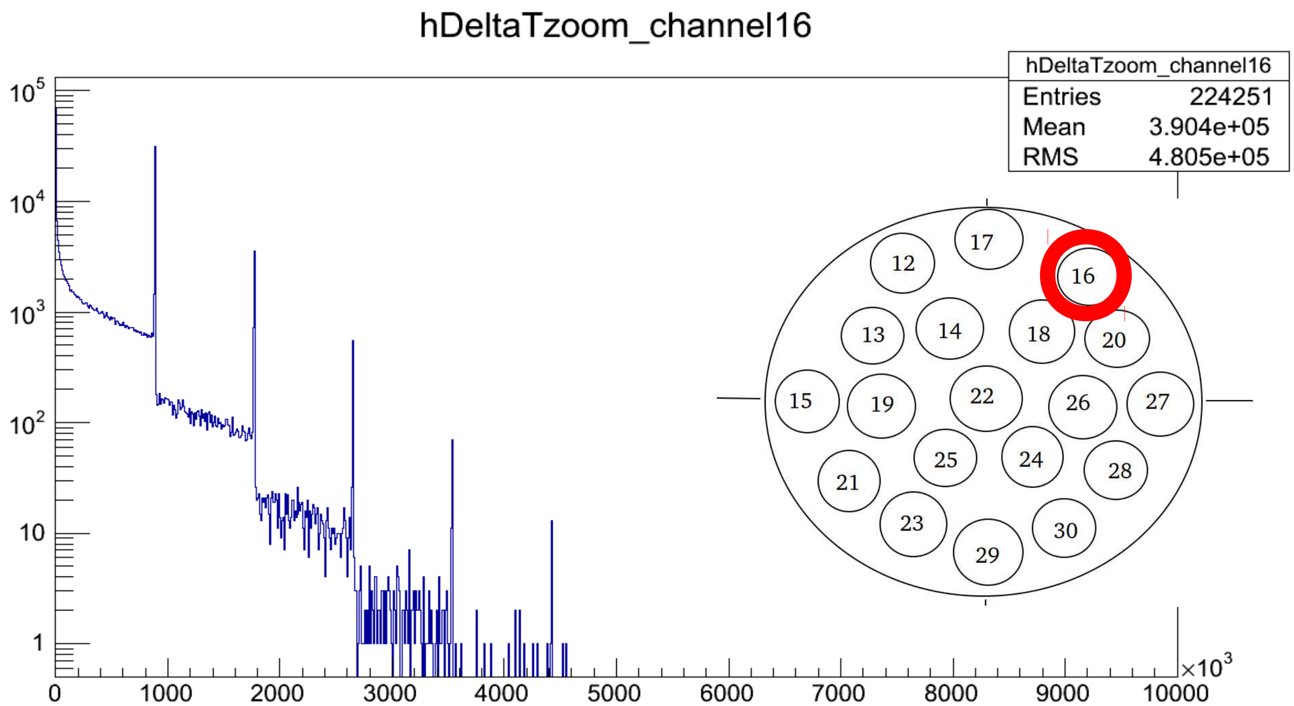
Setup 1 “Big flowerpot”: tests for lower hemisphere

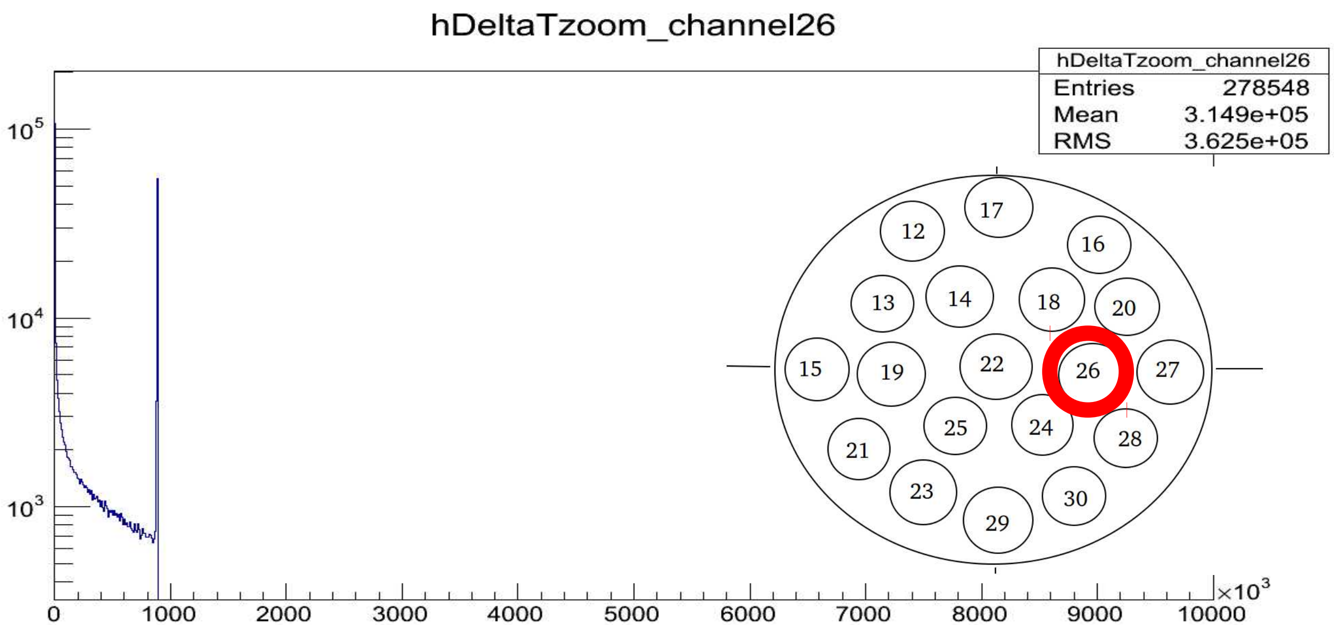


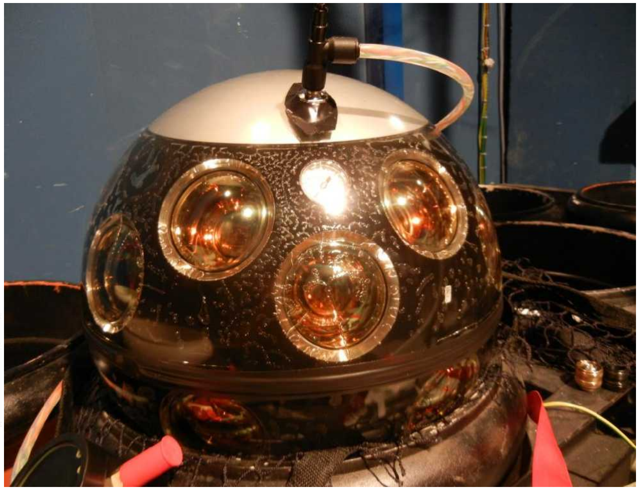


PPM-DOM with “Big flowerpot” setup

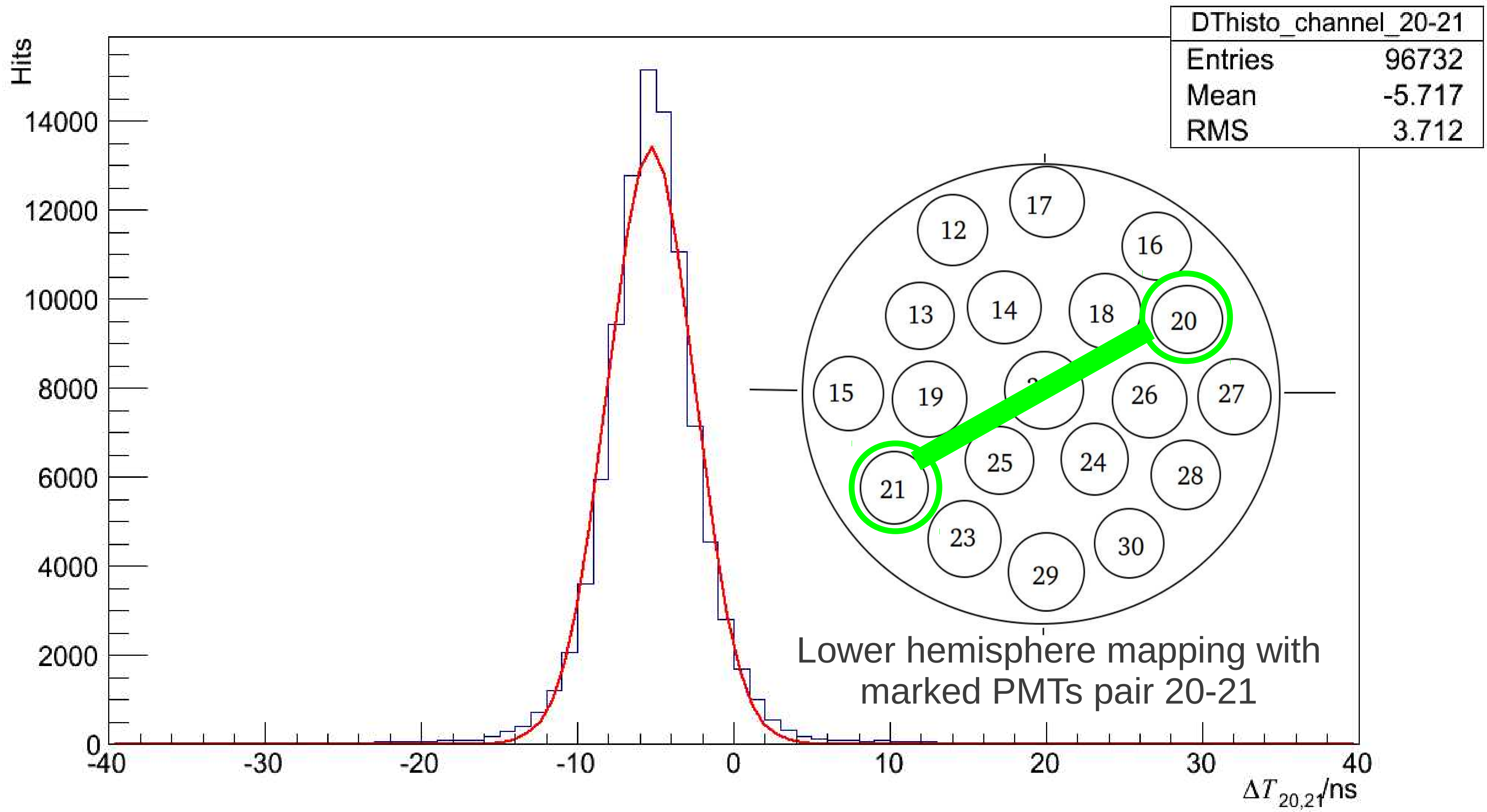
Setup “loosing light” problem...







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 for each PMT:

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:

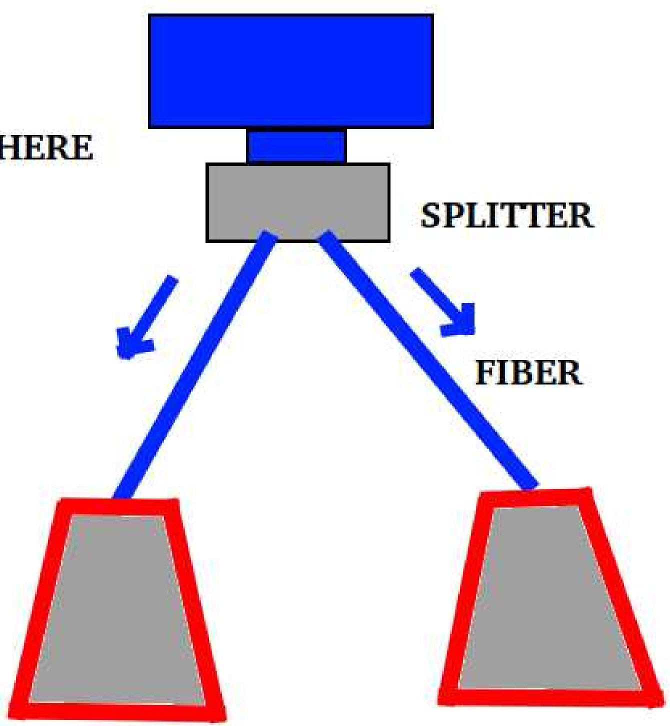
$$\langle \Delta T_{i,j} \rangle = \langle \Delta T_i \rangle - \langle \Delta T_j \rangle$$

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

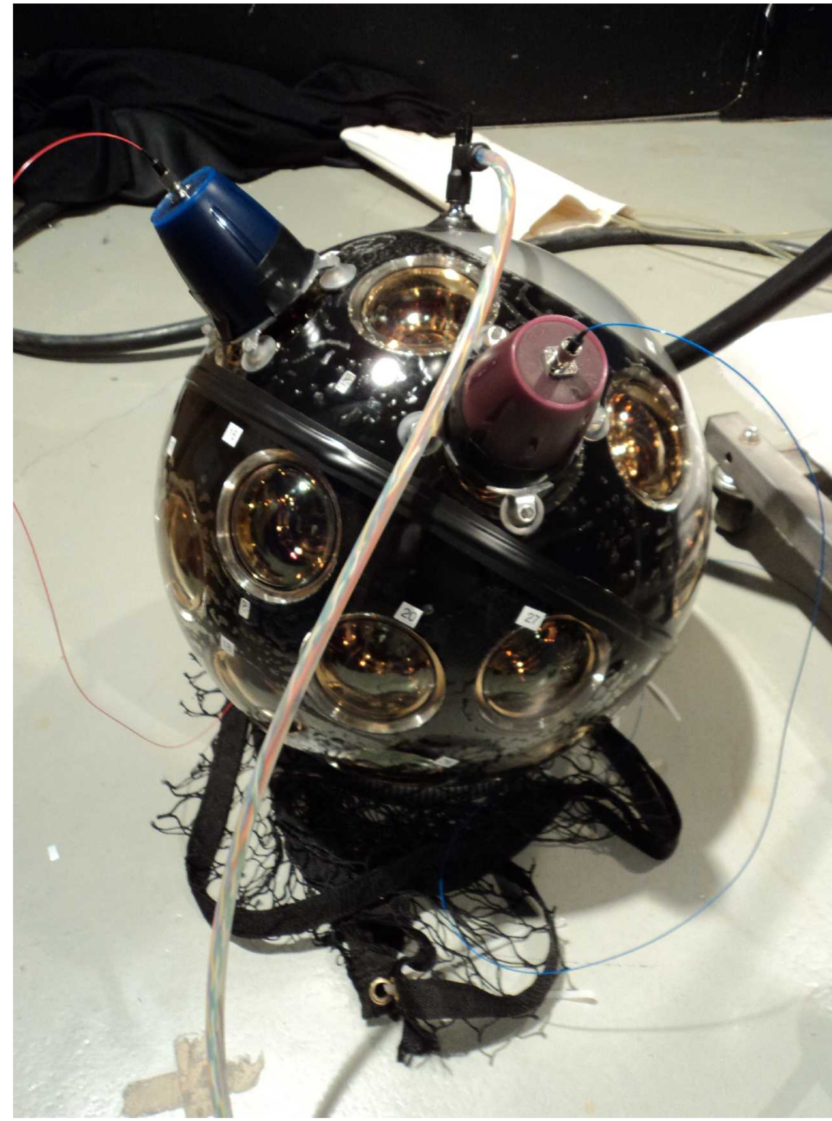
Setup 2 “Double-cup”: tests for upper hemisphere

UPGRATED SETUP FOR UPPER HEMISPHERE CALIBRATION

Light source
(LED)



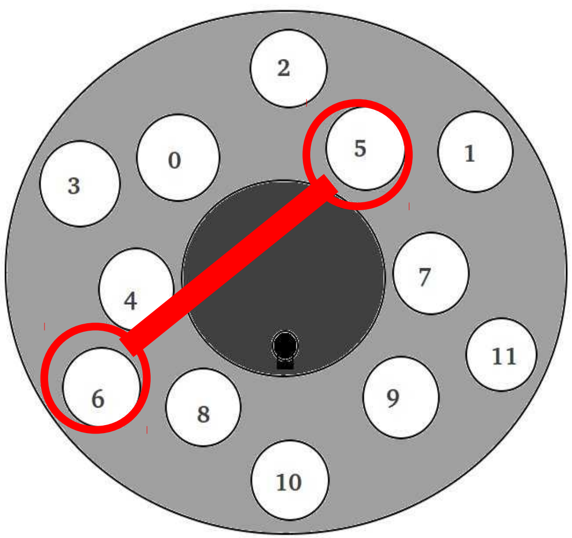
Two cups (to be placed directly
on PMT position)



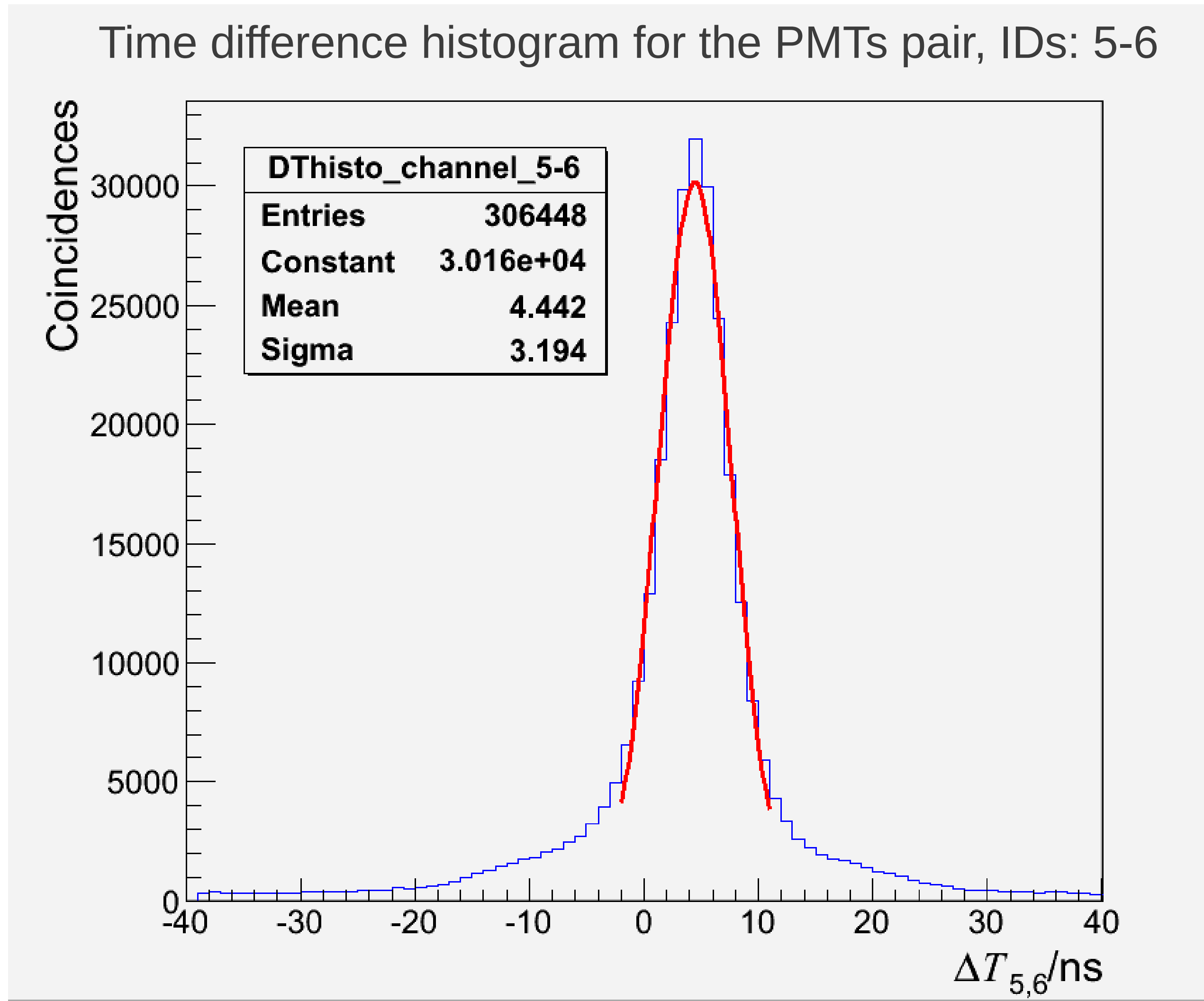
PPM-DOM with “Double cup” setup

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

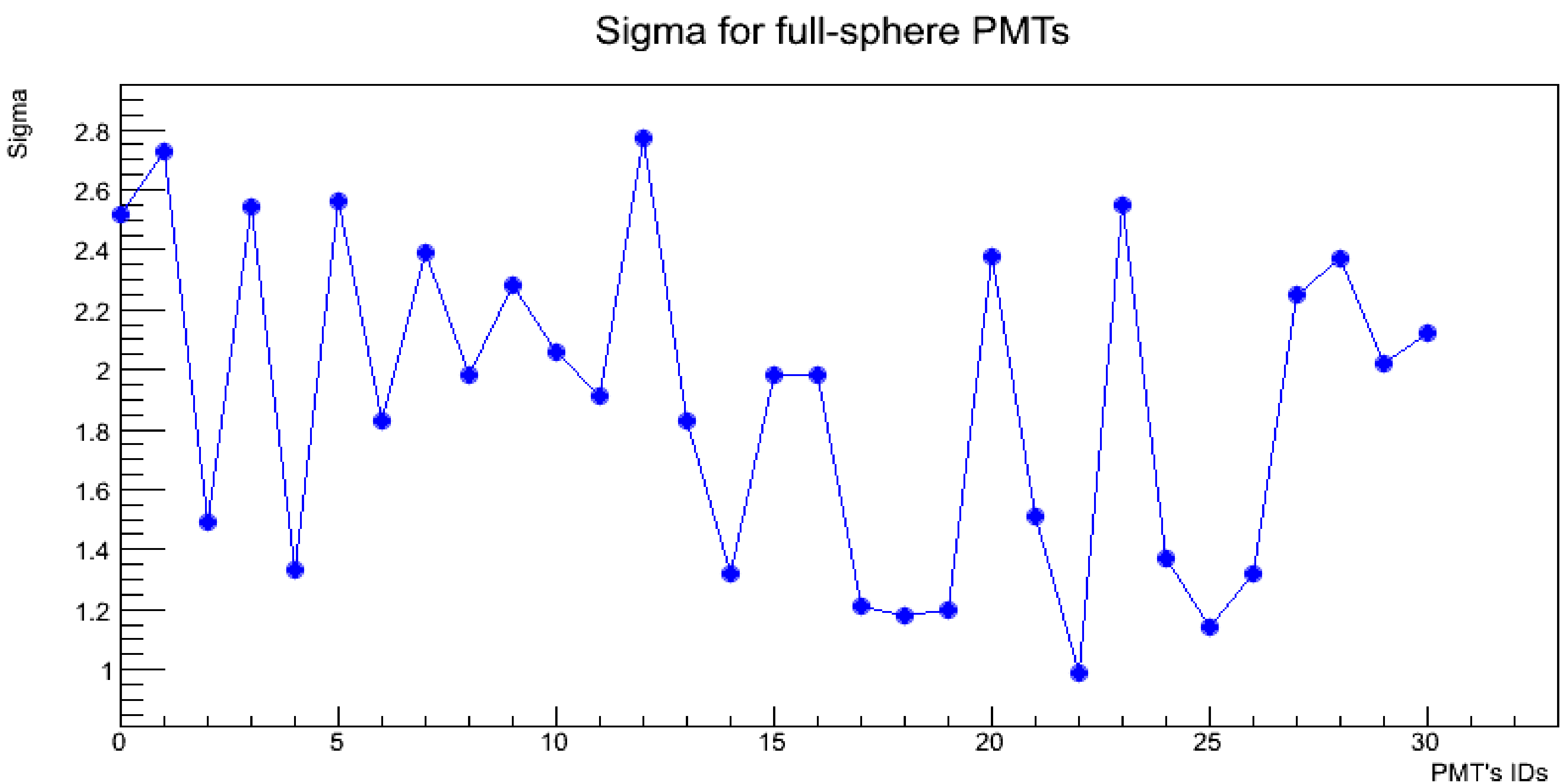


Setup 2 “Double-cup”: time offsets results for upper hemisphere*

PMT ID	Mean DeltaT [ns]	Sigma
0	10.35	2.52
1	8.96	2.73
2	4.15	1.49
3	5.27	2.54
4	9.12	1.33
5	4.41	2.56
6	0	1.83
7	4.54	2.39
8	6.04	1.98
9	6.89	2.28
10	7.16	2.06
11	2.38	1.91

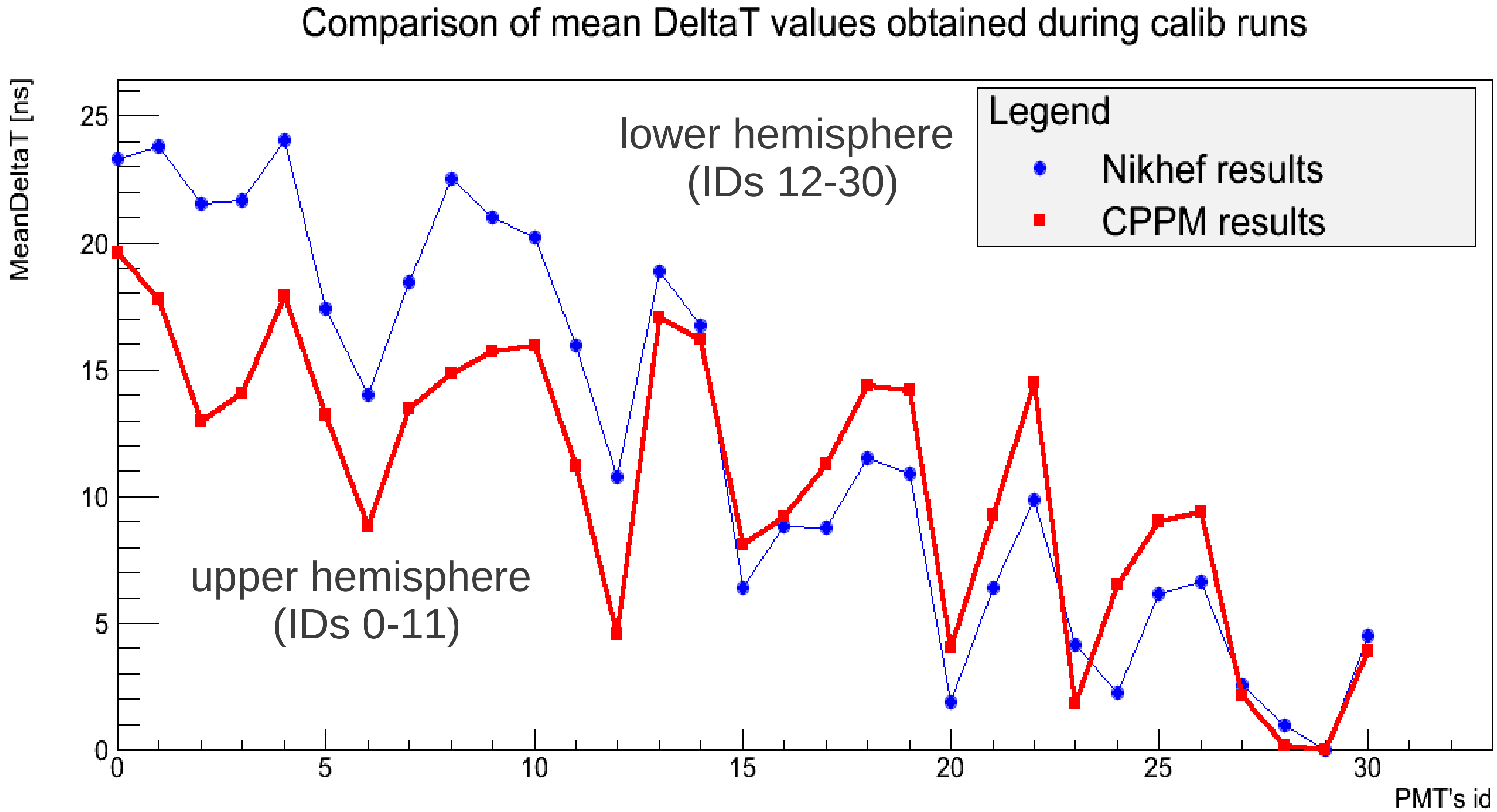
* Same method used like for the “Big flowerpot” setup.

Sigma distribution for DOM full-sphere PMTs:



* This information will be useful to evaluate accuracy when performing the MC simulations.

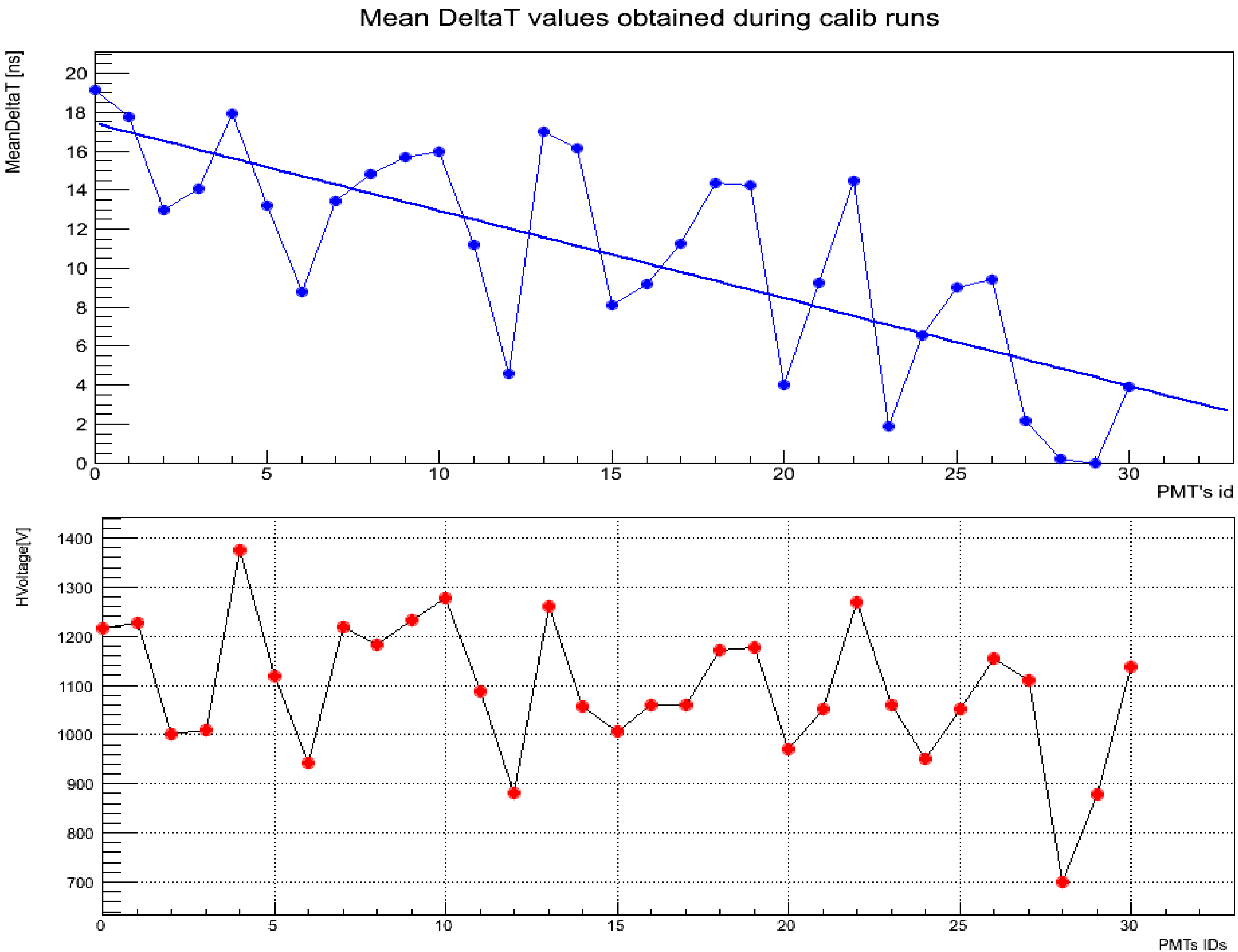
Time offsets for PPM DOM full-sphere PMTs:

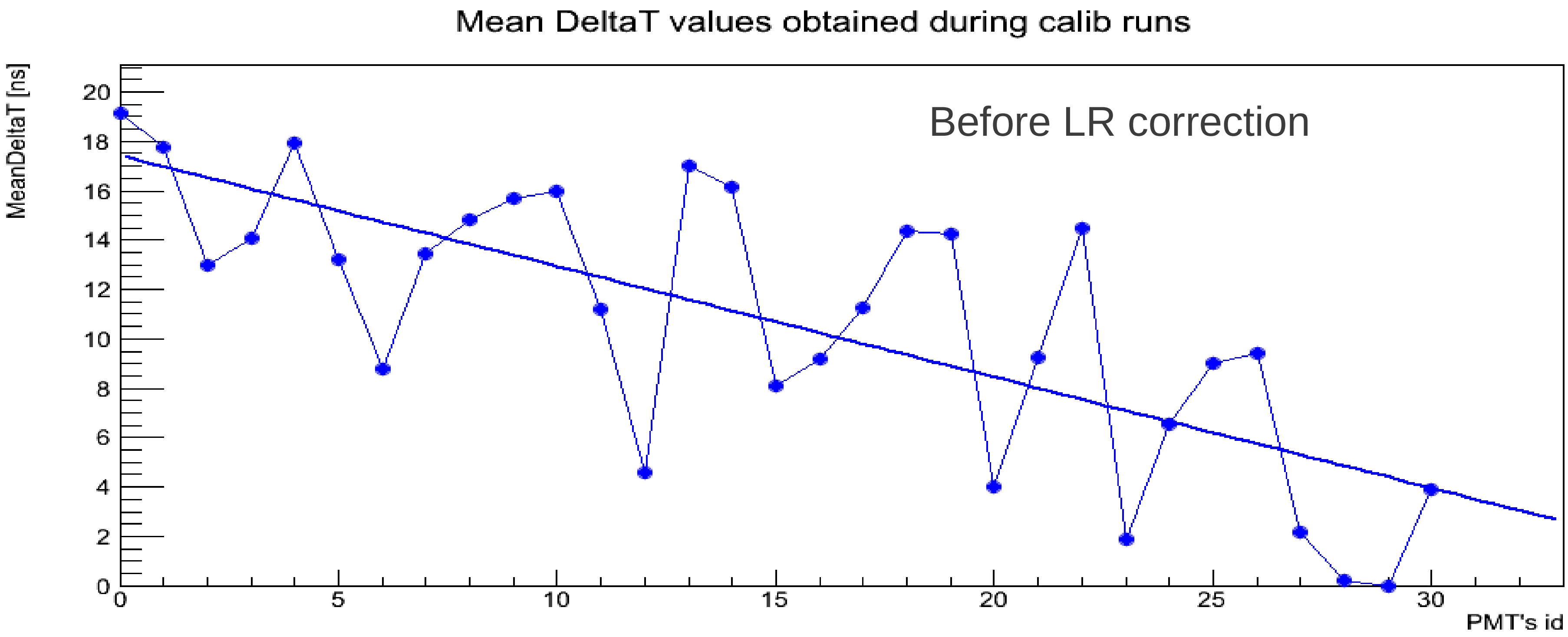


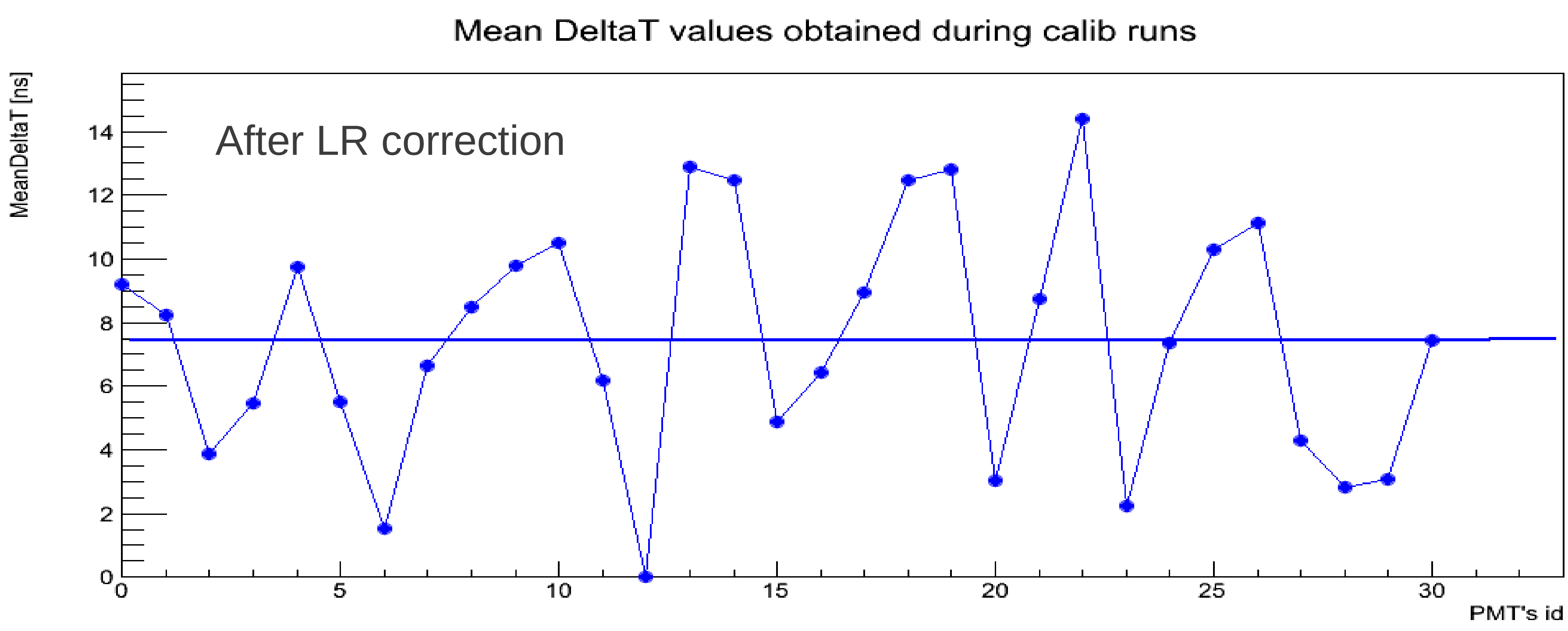
* Special run was made with the “Double-cup” setup to connect two different setups data sets: PMT pair 11-12 (one is on upper hemisphere, another – on lower).

* On the plot we observe two main effects: “oscillation” on a short range (SR) and “slope” on a long range (LR).

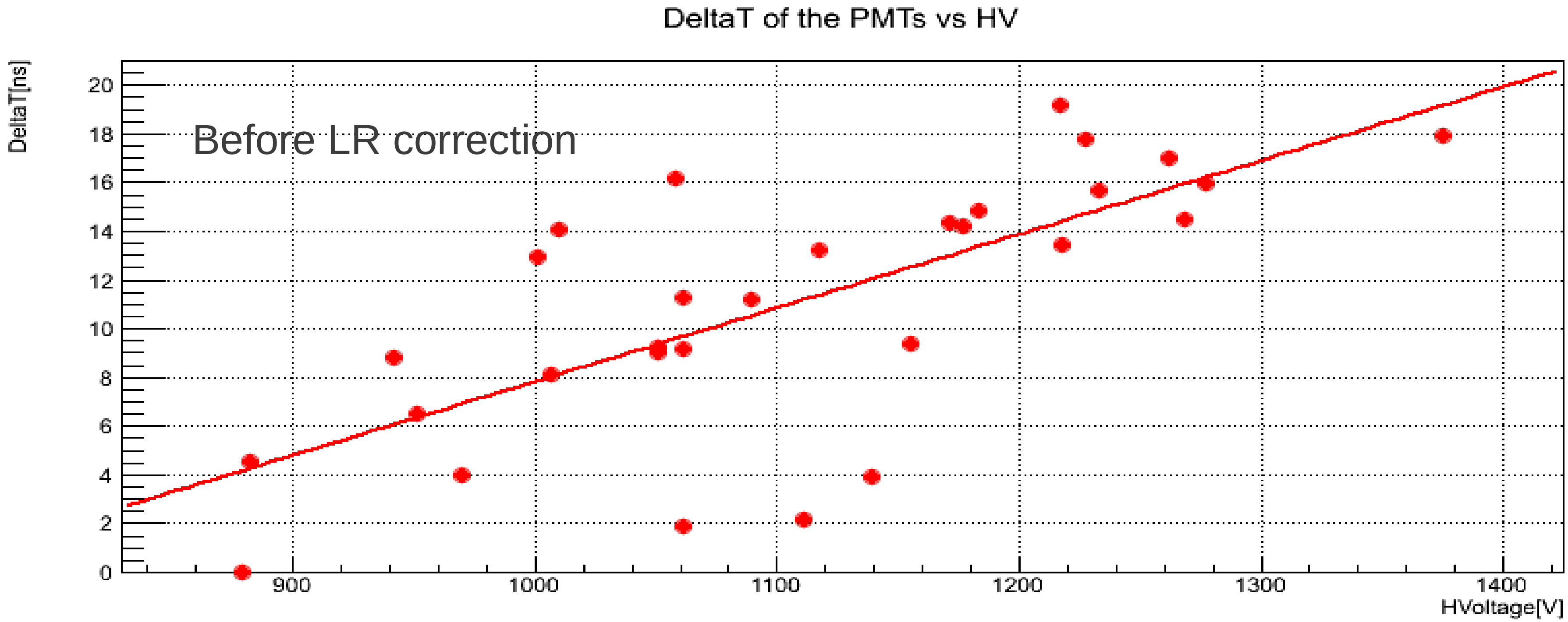
Correlation with the HV:

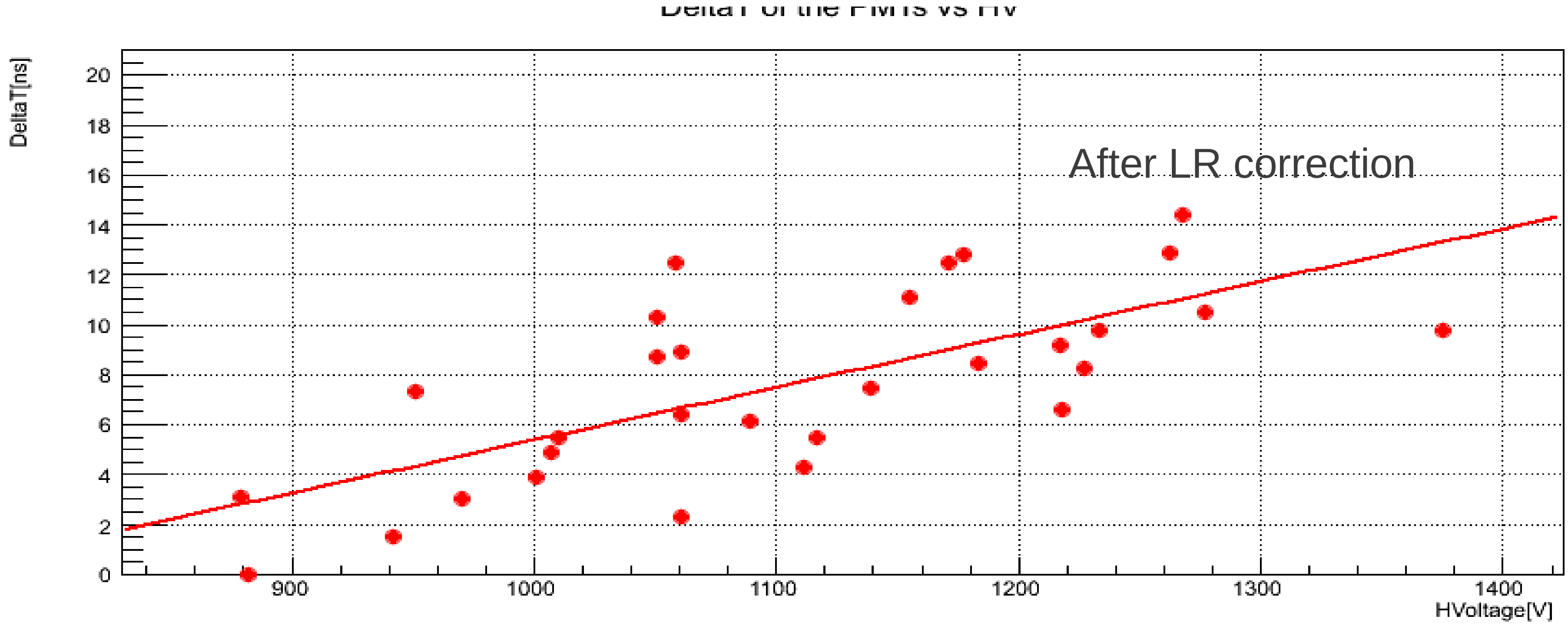


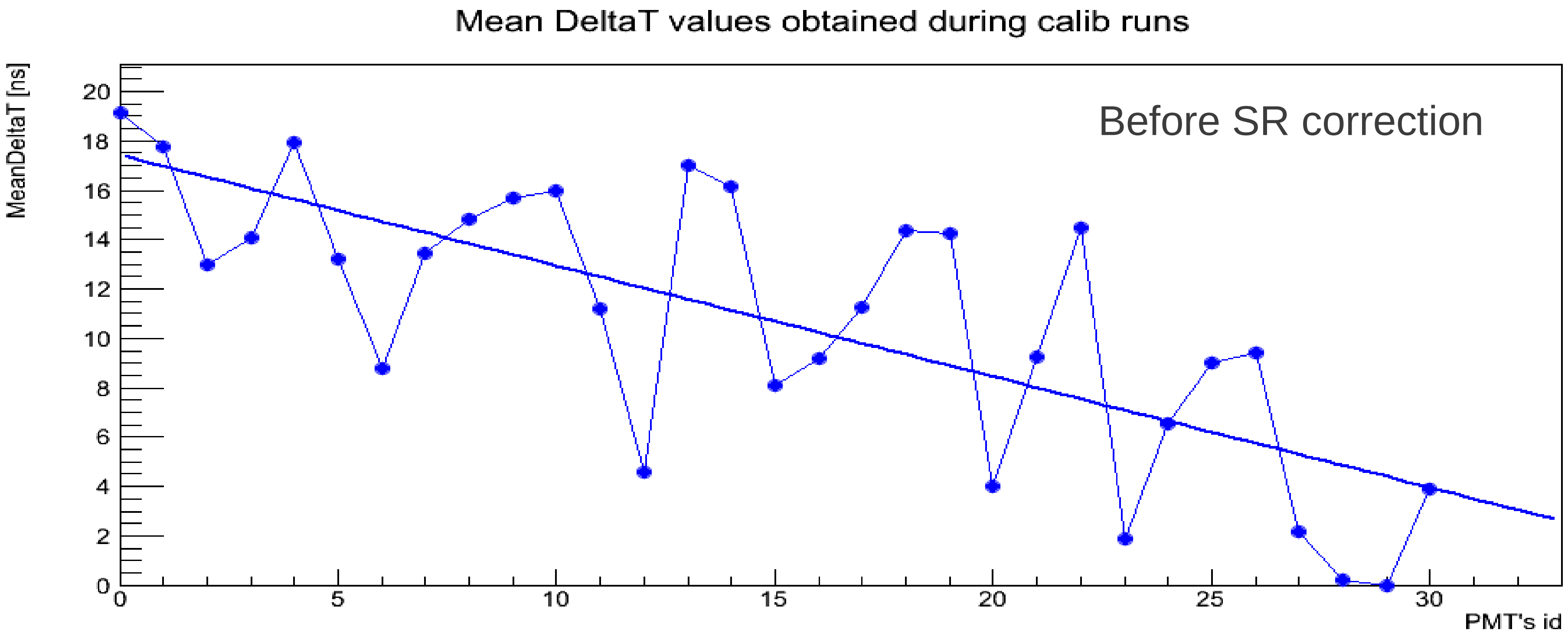

Mean DeltaT values obtained during calib runs
Before LR correction
MeanDeltaT [ns]
PMT's id
0
2
4
6
8
10
12
14
16
18
20
5
10
15
20
25
30

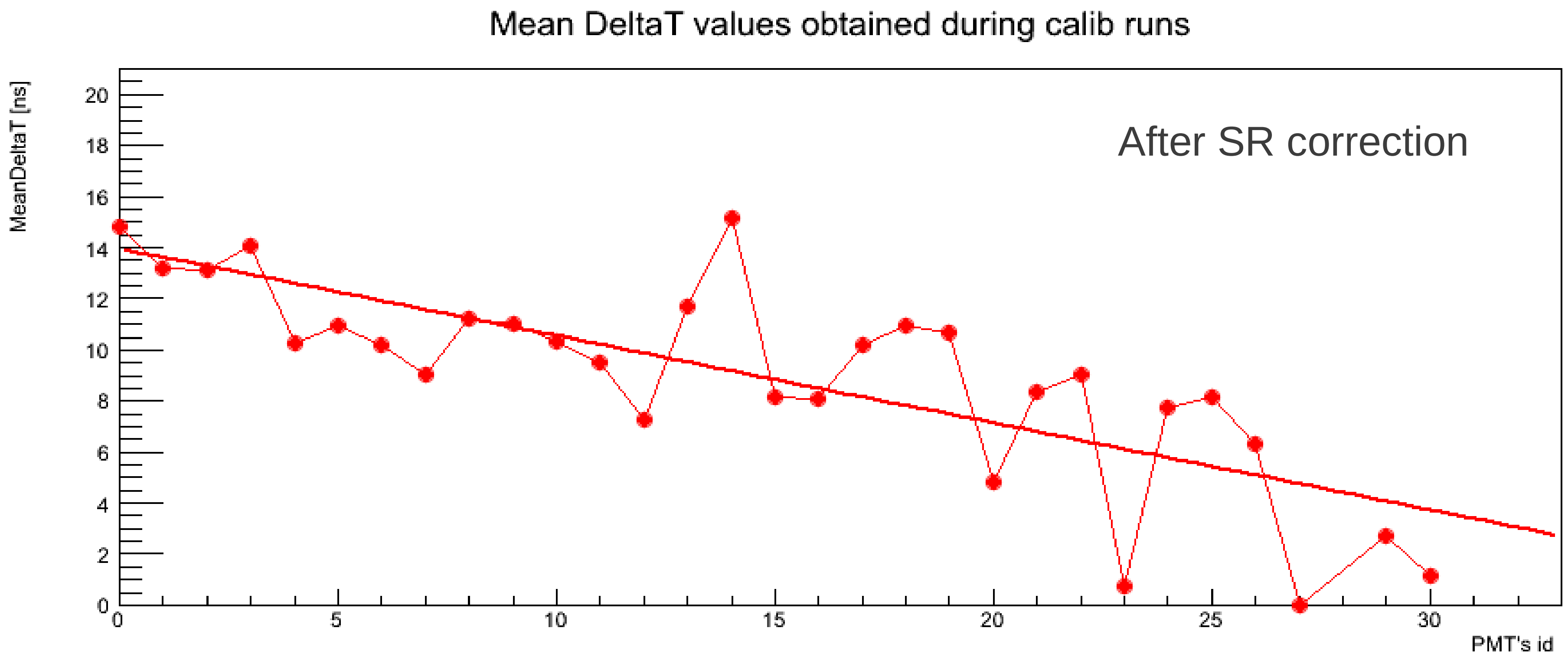

Mean DeltaT values obtained during calib runs
After LR correction
MeanDeltaT [ns]
PMT's id
0
2
4
6
8
10
12
14
5
10
15
20
25
30

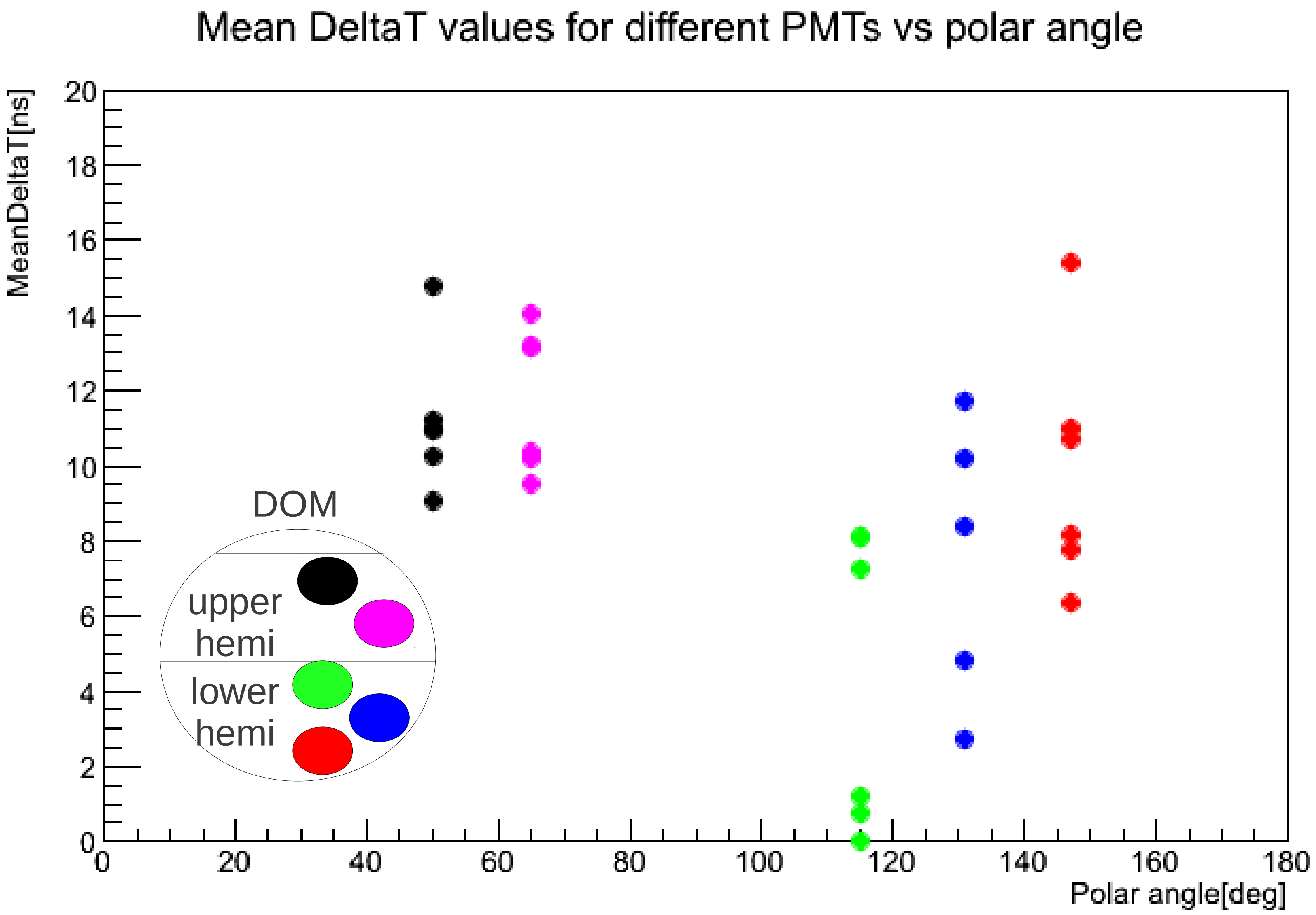
Time offsets and HV correlation plots





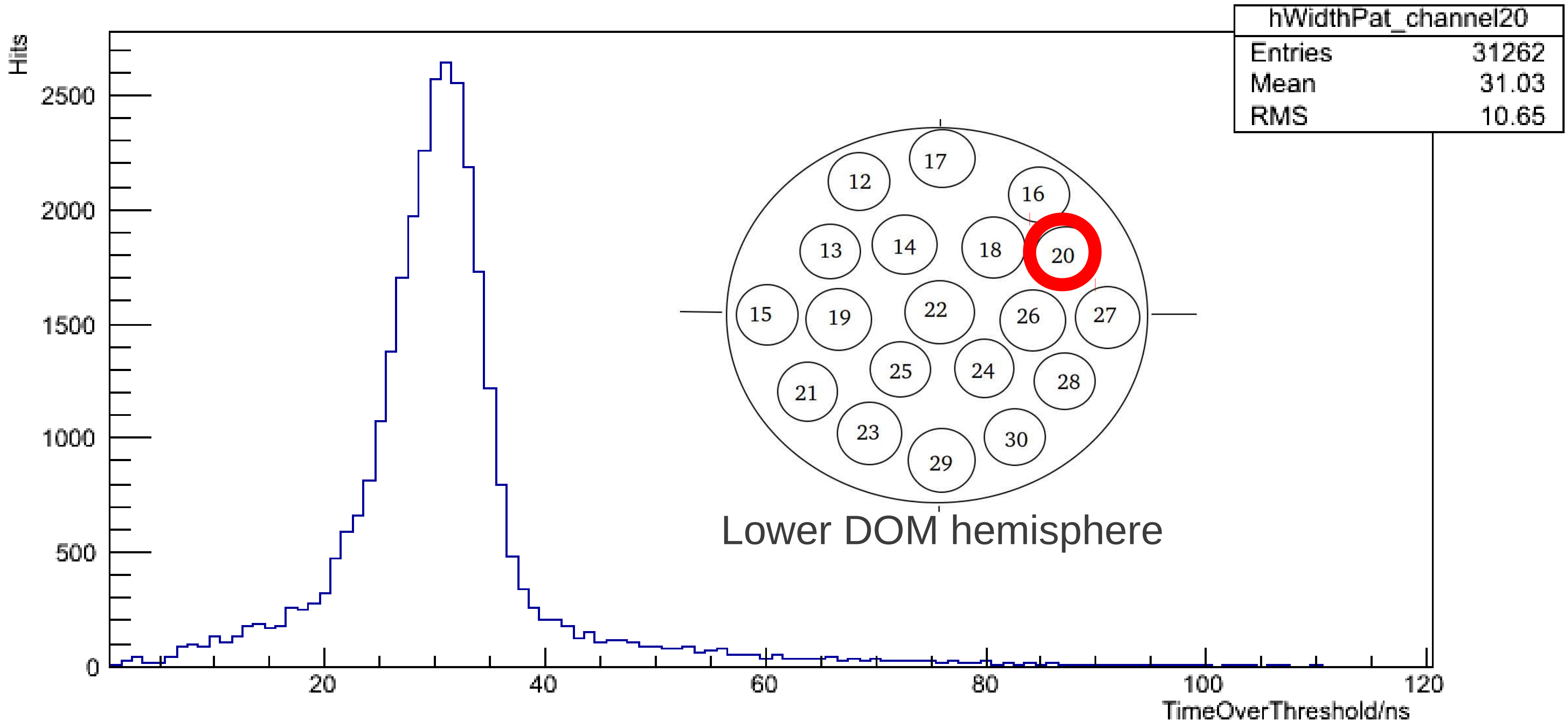

Mean DeltaT values obtained during calib runs
Before SR correction
MeanDeltaT [ns]
PMT's id


Mean DeltaT values obtained during calib runs
After SR correction
MeanDeltaT [ns]
PMT's id

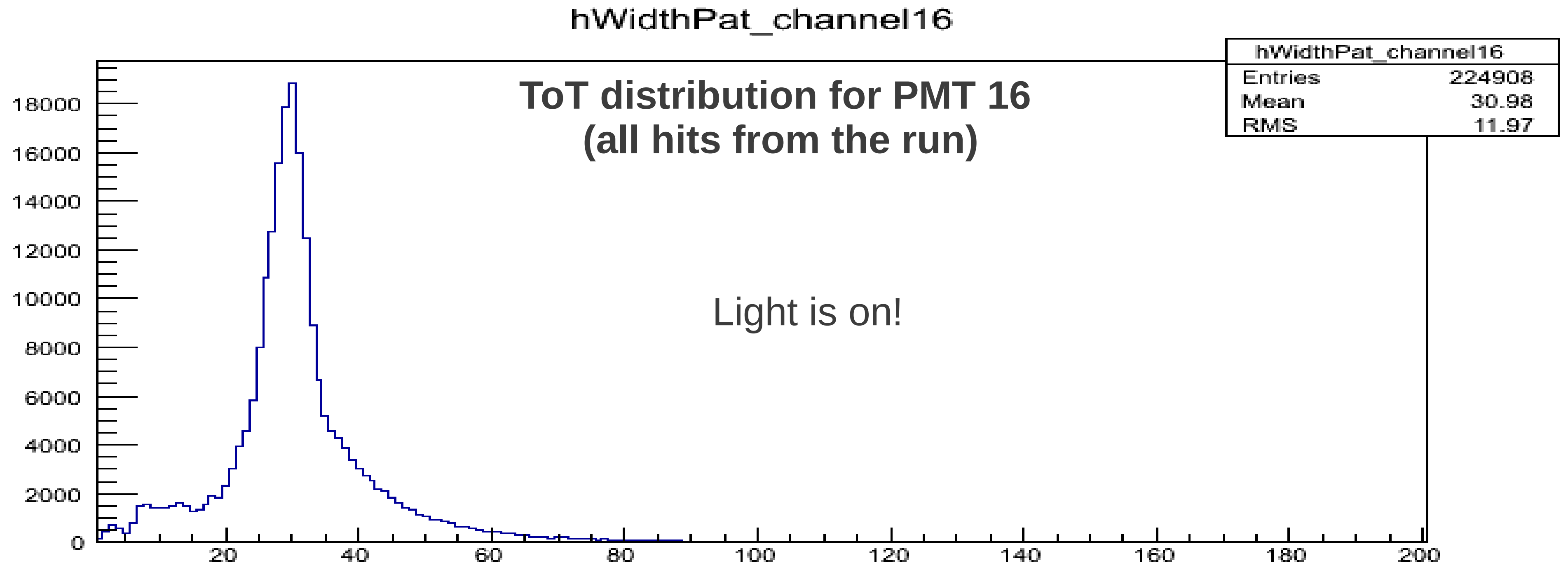

Mean DeltaT values for different PMTs vs polar angle
MeanDeltaT[ns]
20
18
16
14
12
10
8
6
4
2
0
0
20
40
60
80
100
120
140
160
180
Polar angle[deg]
DOM
upper
hemi
lower
hemi

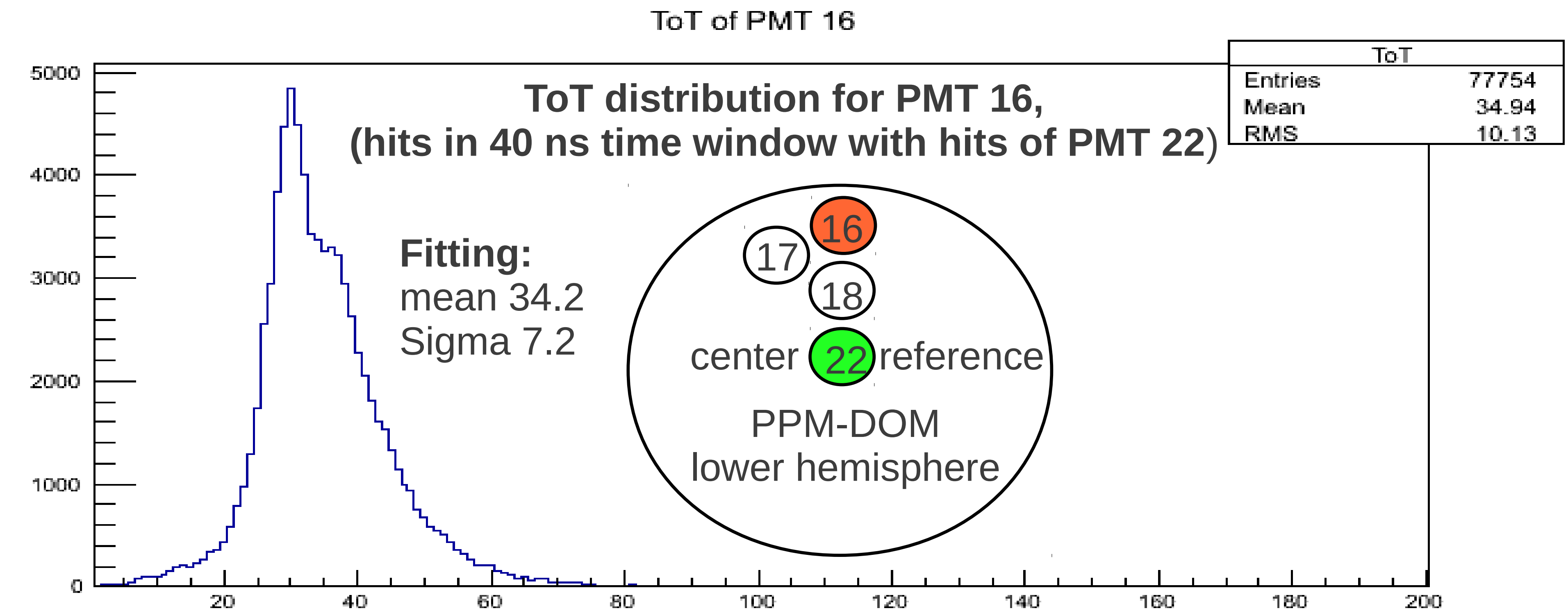
Time Over Threshold (ToT) functionality check

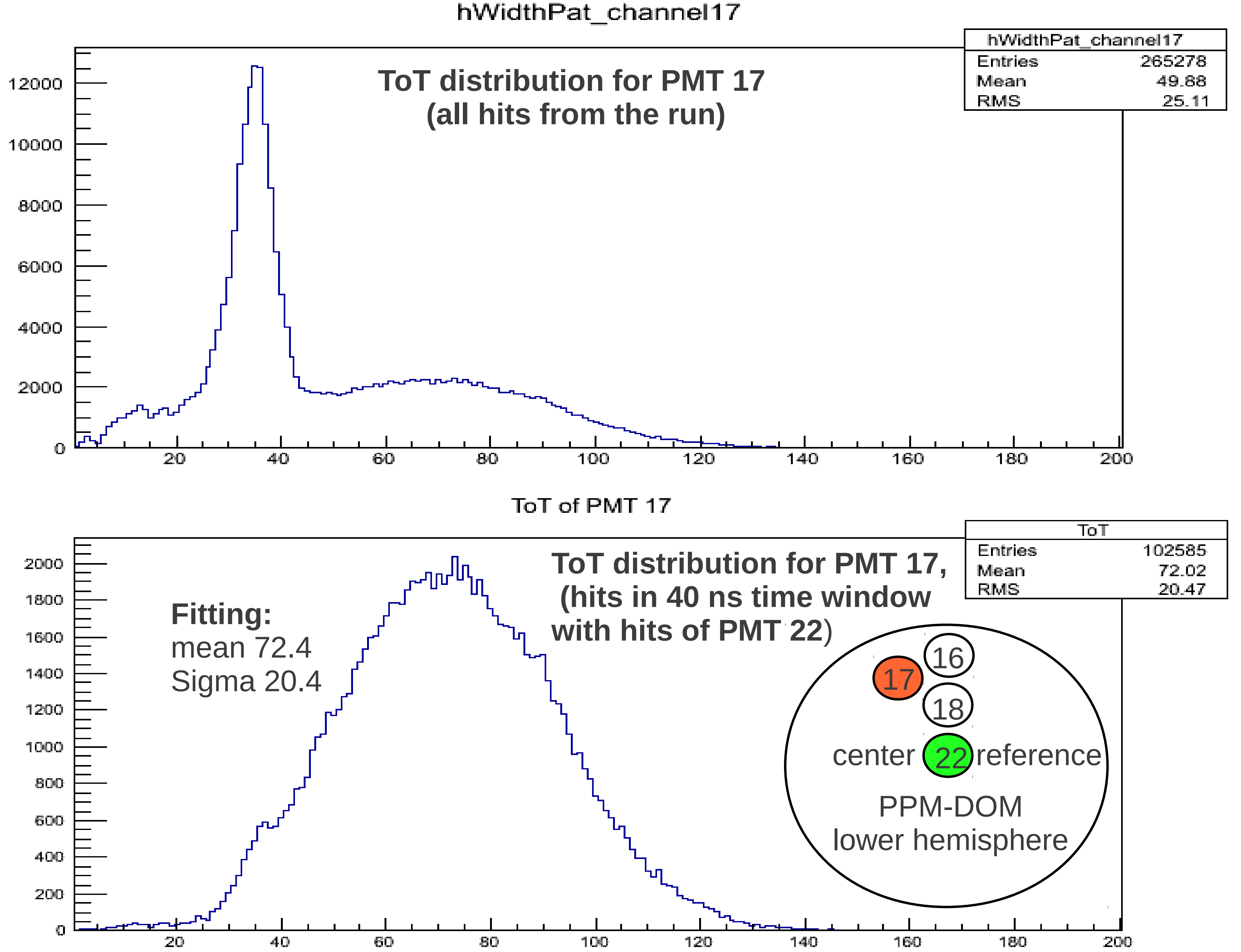
ToT distribution for the full run (30 s long)
for one of the PMTs from lower hemisphere



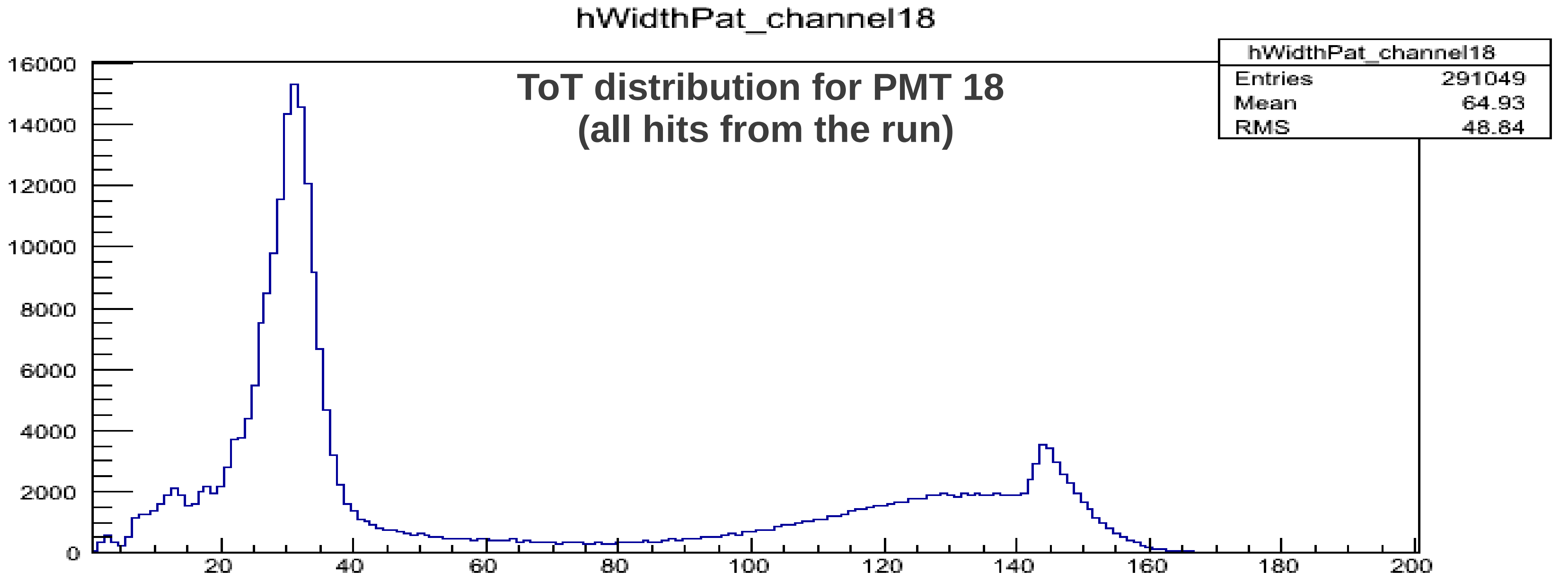
* Reference run [474], no light from LED or laser, just background light noise

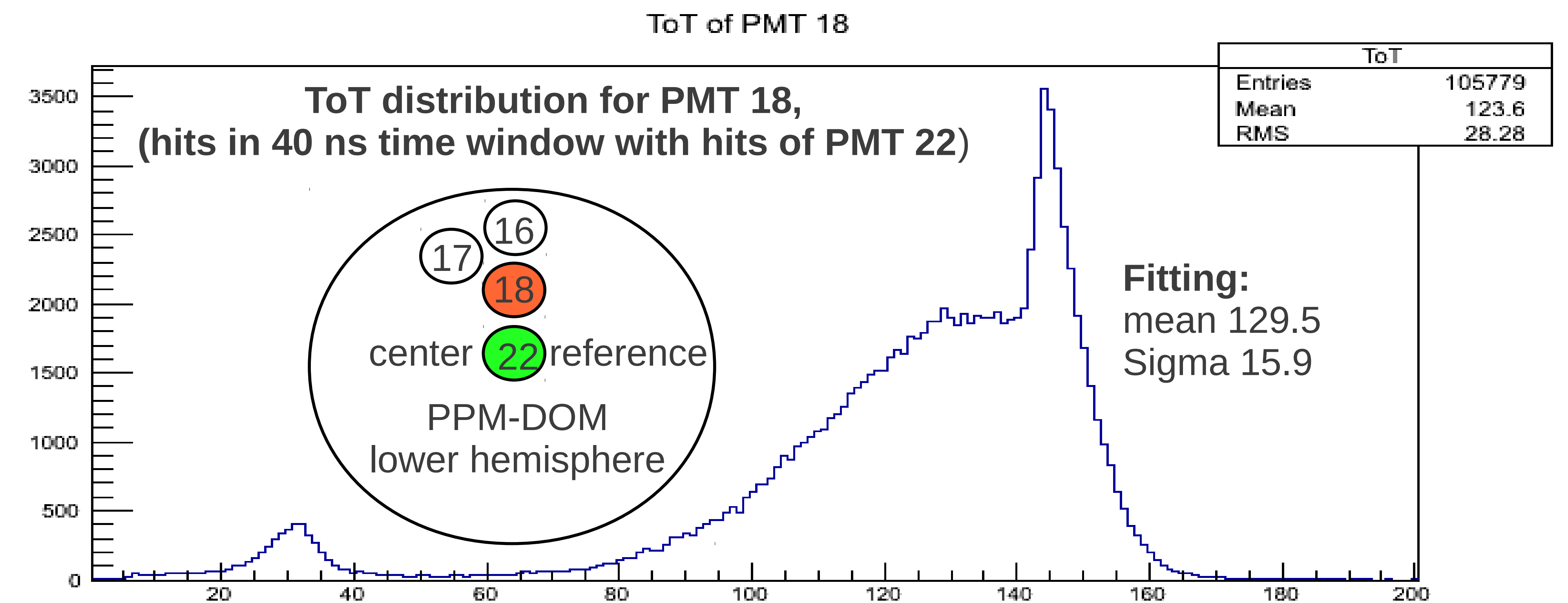

hWidthPat_channel16
hWidthPat_channel16
Entries 224908
Mean 30.98
RMS 11.97
ToT distribution for PMT 16
(all hits from the run)
Light is on!
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
20
40
60
80
100
120
140
160
180
200

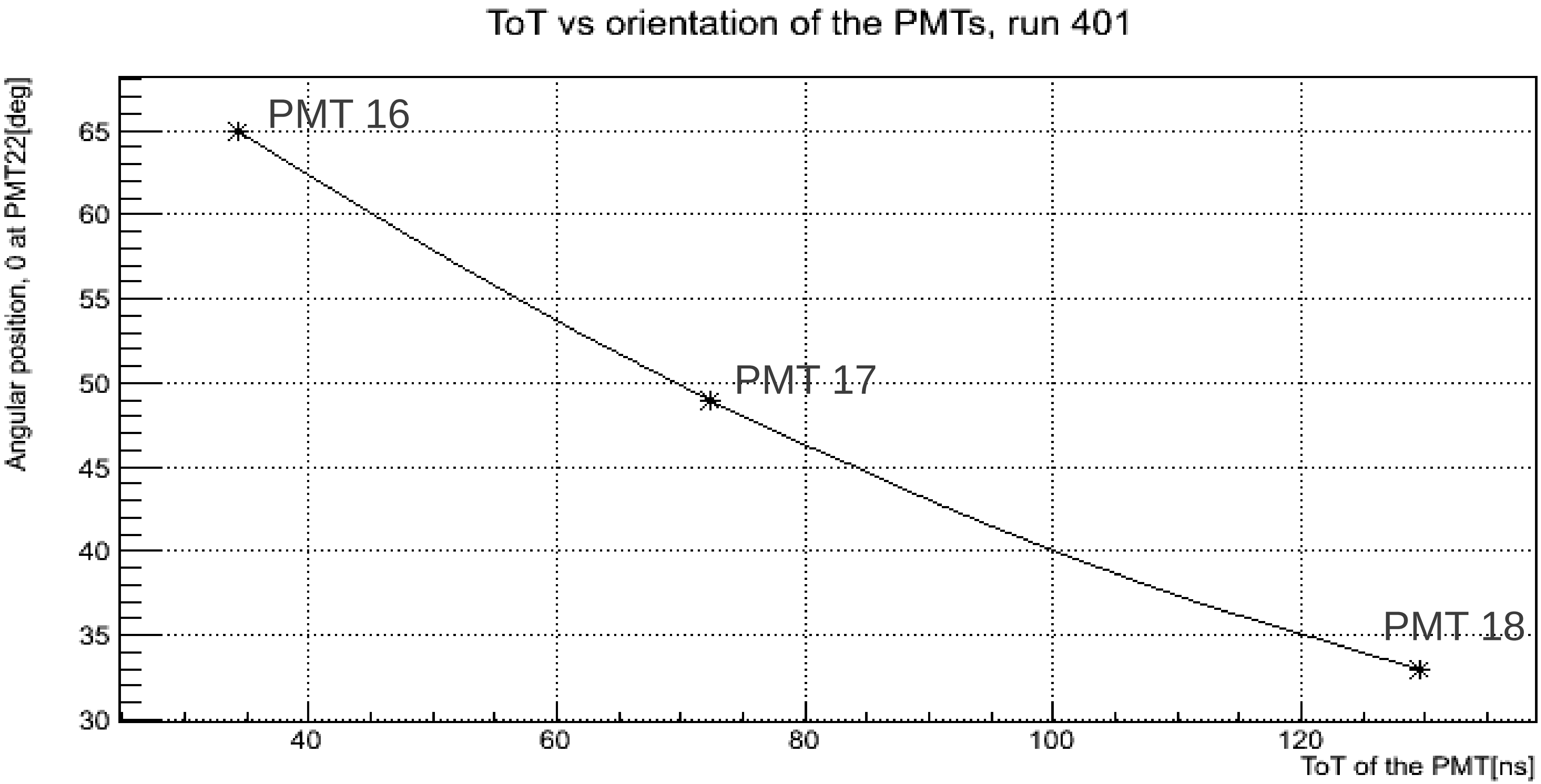

ToT of PMT 16
ToT
Entries 77754
Mean 34.94
RMS 10.13
ToT distribution for PMT 16,
(hits in 40 ns time window with hits of PMT 22)
Fitting:
mean 34.2
Sigma 7.2
16
17
18
center
22
reference
PPM-DOM
lower hemisphere
0
1000
2000
3000
4000
5000
20
40
60
80
100
120
140
160
180
200

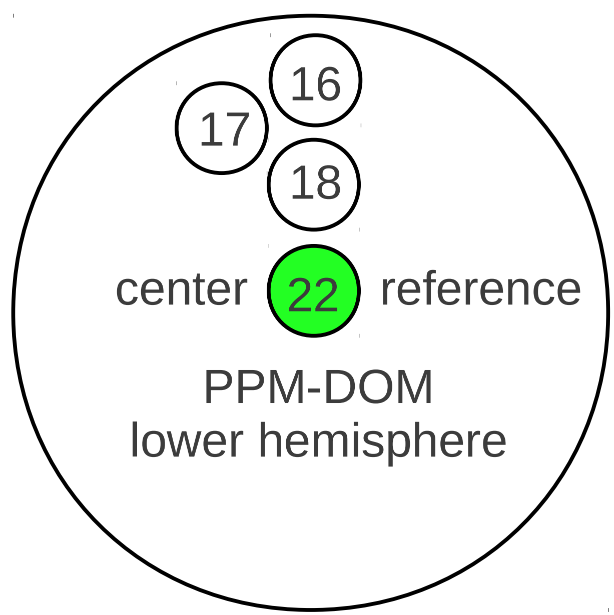


hWidthPat_channel17
hWidthPat_channel17
Entries 265278
Mean 49.88
RMS 25.11
ToT distribution for PMT 17
(all hits from the run)
ToT of PMT 17
ToT
Entries 102585
Mean 72.02
RMS 20.47
ToT distribution for PMT 17,
(hits in 40 ns time window
with hits of PMT 22)
Fitting:
mean 72.4
Sigma 20.4
16
17
18
center
22
reference
PPM-DOM
lower hemisphere

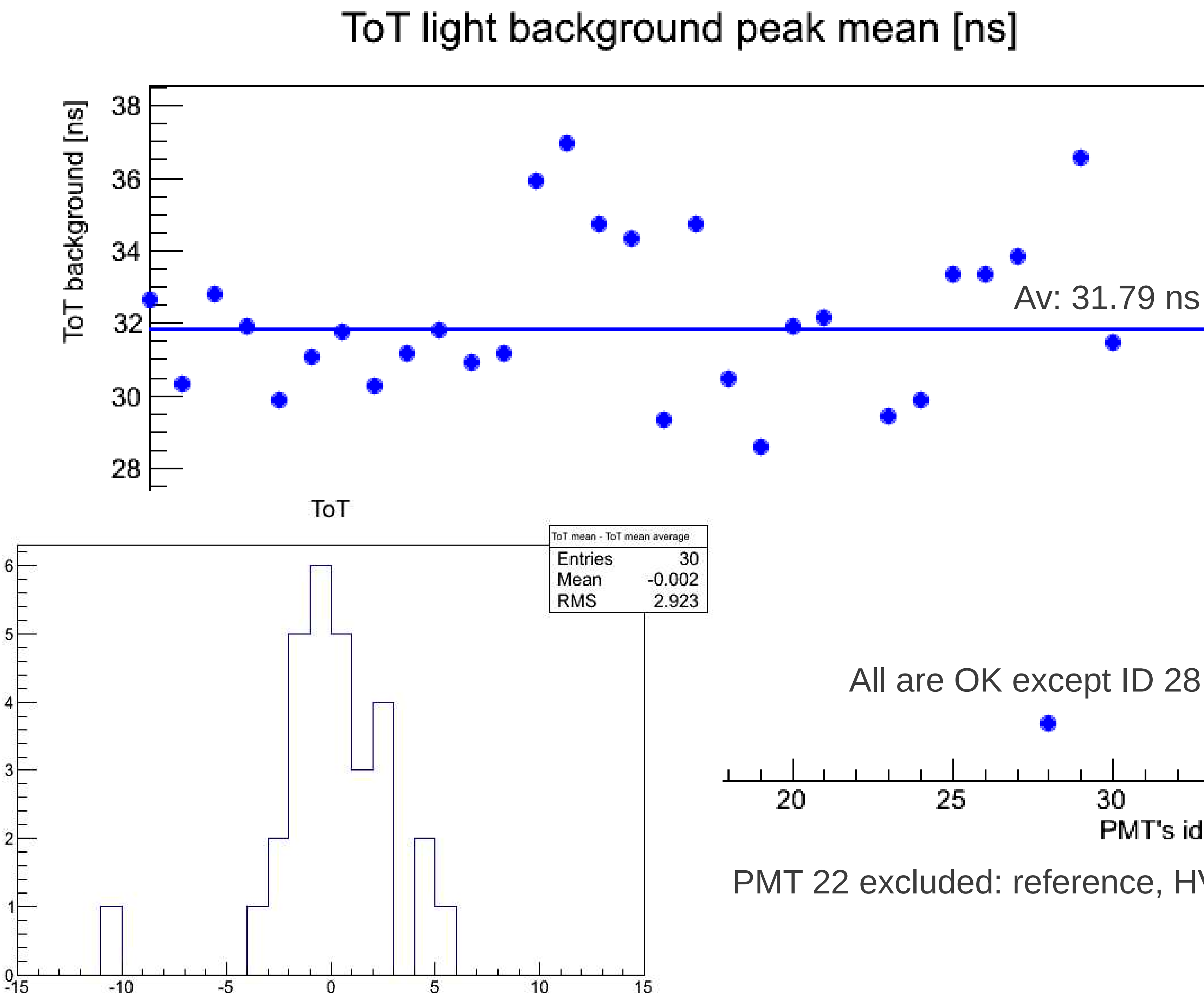

hWidthPat_channel18
ToT distribution for PMT 18
(all hits from the run)
hWidthPat_channel18
Entries 291049
Mean 64.93
RMS 48.84


ToT of PMT 18
ToT distribution for PMT 18,
(hits in 40 ns time window with hits of PMT 22)
ToT
Entries 105779
Mean 123.6
RMS 28.28
16
17
18
center
22
reference
PPM-DOM
lower hemisphere
Fitting:
mean 129.5
Sigma 15.9


ToT vs orientation of the PMTs, run 401
Angular position, 0 at PMT22[deg]
65
60
55
50
45
40
35
30
40
60
80
100
120
ToT of the PMT[ns]
PMT 16
PMT 17
PMT 18


16
17
18
center
22
reference
PPM-DOM
lower hemisphere

Gain calibration check:



PMT 22 excluded: reference, HV reduced

Summary

* We obtained time offsets and sigmas for all PMTs.
* Local time offsets “oscillations” are correlated with the HV.
* Long range time-offsets “slope” still need to be explained.
* ToT functionality tested.
* Gain calibration test, problematic PMT ID28.
* Mapping of PMTs check done.

* Testing setup should be optimized for the future...

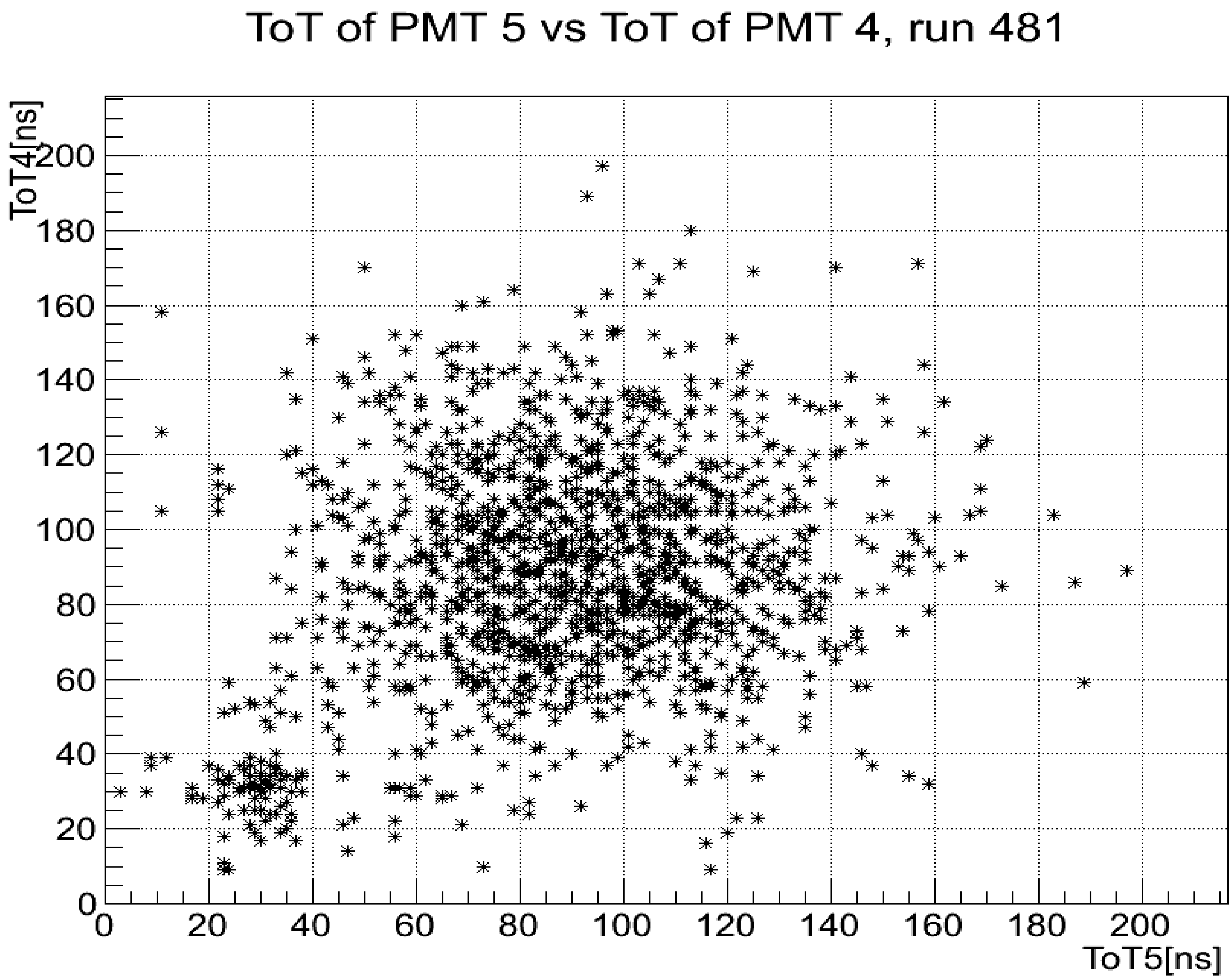
Thanks for your attention!

BACKUP SLIDES

Different reference PMT check

DeltaT for pairs		If T0 = 0		If T8 = 0	
T 0-1 = 1.36	T0	0	10.35	4.31	10.35
T 1-2 = 4.8	T1	-1.4	8.96	2.91	8.95
T 2-3 = -1.11	T2	-6.2	4.15	-1.89	4.15
T 3-4 = -3.85	T3	-5.09	5.27	-0.78	5.26
T 4-5 = 4.71	T4	-1.24	9.12	3.07	9.11
T 5-6 = 4.41	T5	-5.94	4.41	-1.63	4.41
T 6-7 = -4.65	T6	-10.35	0	-6.04	0
T 7-8 = -1.39	T7	-5.7	4.65	-1.39	4.65
T 8-9 = -0.85	T8	-4.31	6.04	0	6.04
T 9-10 = -0.27	T9	-3.46	6.89	0.85	6.89
T 10-11 = 4.78	T10	-3.19	7.16	1.12	7.16
	T11	-7.97	2.38	-3.66	2.38

ToT cleaned for upper hemisphere PMTs pair



(Hits of PMT 5 inside time window (40 ns) around hits of PMT4, data on the plot is from one time slice)

HV hex commands list used for time offsets and HV correlation check

Settings **Upper** hemisphere half.

Octopus ch nr	Saclay PMT nr	DOM position*	PMT_base ID (hex) I2C read	PMT nr ETEL	Thresh(hex)	HV (hex)
0	0	28	C0077	275	B0	A5
1	1	21	C0088	219	B0	A8
2	2	22	3ACA0C	249	B0	60
3	3	23	C0093	254	B0	63
4	4	26	FFFF0F	274	B0	D7
5	5	27	FFFF0F	240	B0	85
6	6	24	C0078	227	B0	4D
7	7	29	C0072	247	B0	A5
8	8	30	C008D	243	B0	9A
9	9	25	C008C	282	B0	AA
10	10	19	C0073	268	B0	B8
11	11	20?	C008F	212	B0	7C

Measurement logs **Upper** hemisphere half — Data based on run 156

PMT_base label visable read	signal on flatcable	Comment	LED source nr	estimated rate	DeltaT
c0077		not in log file: found by Henk P.		1266.6	789516
c0088		not in log file: found by Henk P.		1154.85	865921
c0090		ID failed		1065.43	938586
c0093		not in log file: found by Henk P.		2086.16	479349
c0072		not in log file, duplicate label!, ID failed		3829.6	261124
c0087		not in log file: found by Henk P.		946.224	1.06E+06
c0078				2637.51	379146
c0072		not in log file, duplicate label!, ID failed		1244.25	803699
c008D		not in log file: found by Henk P.		1460.31	684784
c008C		not in log file: found by Henk P.		1467.76	681308
c0073		not in log file: found by Henk P.		1132.49	883011
c008F		not in log file: found by Henk P.		1974.4	506482

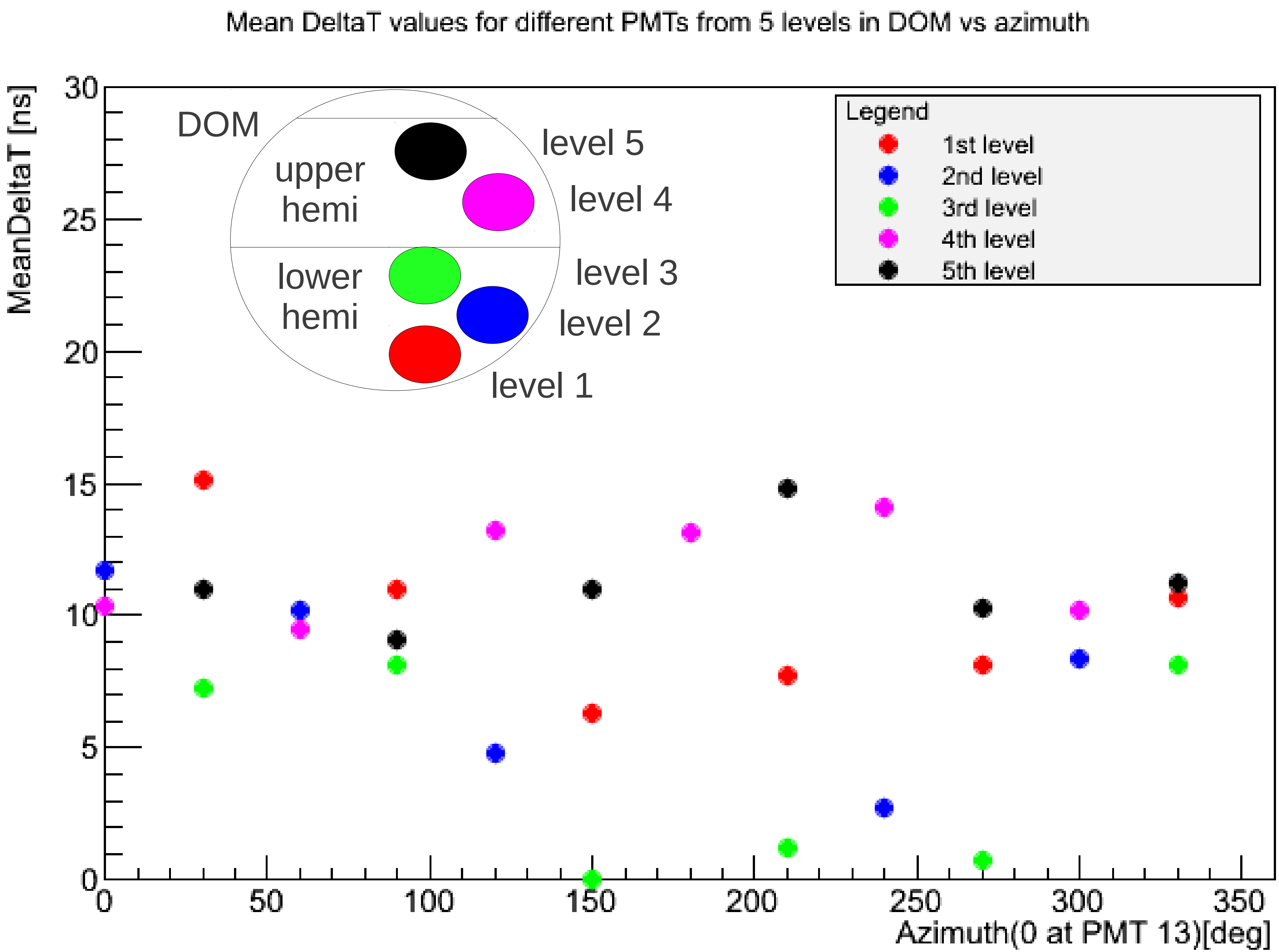
Settings **Lower** hemisphere half

Octopus ch nr	Saclay PMT nr	DOM position*	PMT_base ID (hex), I2C read	PMT nr ETEL	Thresh(hex)	HV (hex)
0	12	18	C0000	257	B0	3A
1	13	12	C0076	261	A0	B3
2	14	6	C006D	257	B0	72
3	15	17	C0065	228	A0	62
4	16	13	C0080	225	B0	73
5	17	7	C0074	221	B0	73
6	18	1	C0075	242	B0	96
7	19	5	C0066	260	B0	98
8	20	8	C007A	182	B0	56
9	21	11	C006C	251	B0	70
10	22	0	C007F	191	B0	DA
11	23	16	C007C	218	B0	73
12	24	3	C0084	233	B0	50
13	25	4	C0078	264	A0	7A
14	26	2	C007E	184	A0	91
15	27	14	C0083	213	A0	83
16	28	9	C0082			
17	29	10	C0085	231	A0	39
18	30	15	C0071	201	B0	8C
19	31		piezo			

Measurement logs **Lower** hemisphere half — Data based on run 156

PMT_base label visable read	signal on flatcable	Comment	LED source nr	estimated rate	DeltaT
C0079 (scanner)	label read via scanner	ID not burned, data in database	17	1624.23	615678
	yes		11	1266.6	789516
	th=0xA0, th=0x10 as test	not in log file	5	447.035	2.24E+06
	yes		16	1735.99	576042
	yes		12	1937.15	516222
	yes		6 ?	1654.03	604584
	yes		0	1460.31	684784
	yes		6 ?	1311.3	762601
	yes		7	1236.8	808541
	yes		10	1460.31	684784
	yes		30	1735.99	576042
	yes		15	2704.56	369746
	yes		2	1400.71	713924
	yes		3	1236.8	808541
	yes		1	1505.02	664444
	yes		13	1348.56	741534
	th=0xA0, th=0x10 as test	not in log file	8	37.2529	2.68E+07
	yes		9	1229.35	813441
	yes		14	1609.33	621378
	yes				

**HV hex commands, taken from Bertrand's PPM DOM ReX meeting slides*



PMT 22 exluded: reference.
Level count starts from bottom.