KLOE-2 ID 30
April 2015

Mapping and data structure of the QCALT calorimeter

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Abstract

In this memo we summarize the information about the detector map and the offline data structure for the new quadrupole calorimeter QCALT.

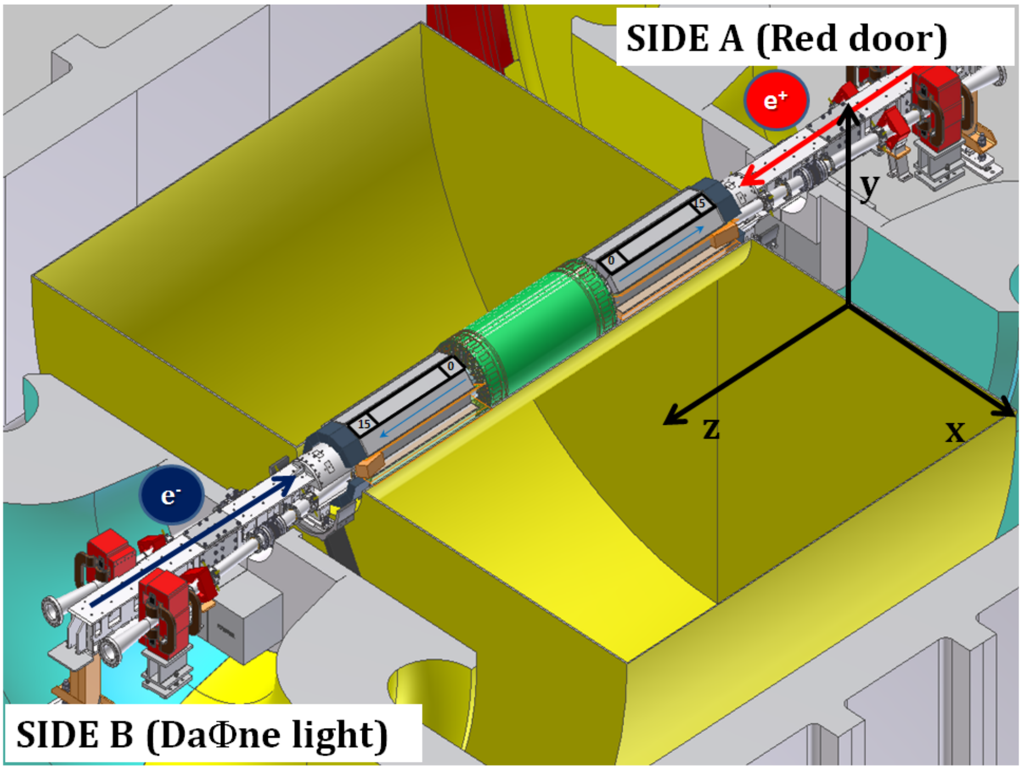

Figure 1: Schematic view of the location of two QCALT detectors. The reference frame shown in the figure corresponds to the KLOE coordinate system.

1 Introduction

The new Quadrupole Calorimeter, QCALT, covers the area of the inner focalizing quadrupoles to increase on photon detection efficiency. There are two detectors, one per side, distant by 54.6 cm with respect to the IP (see Fig 1), each consisting of 11 modules ∼0.9 m long forming a dodecagonal structure. Every module is composed by a sampling of five layers of 5 mm thick EJ-200 scintillator plates alternated with 3.5 mm thick W/Cu (90/10) plates. The active part of each plane is divided into sixteen ∼55 cm^2 tiles with 1 mm diameter WLS fibers embedded in circular grooves. Each fiber is then optically connected to a silicon photomultiplier of 1 mm^2 area, SiPM, for 80 channels/module (1760 in total) [1, 2].

2 Detector Mapping

There are two QCALT detectors labeled in the offline numbering scheme as 1 (side A) and 2 (side B, see Fig. 1). Each detector consists of 11 modules forming a dodecagonal structure surrounding the quadrupole (the space of the missing module is occupied by the LET). As shown in Fig. 2 and Fig. 3, the modules numbering is done according to the ϕ angle definition of the KLOE coordinate system. For

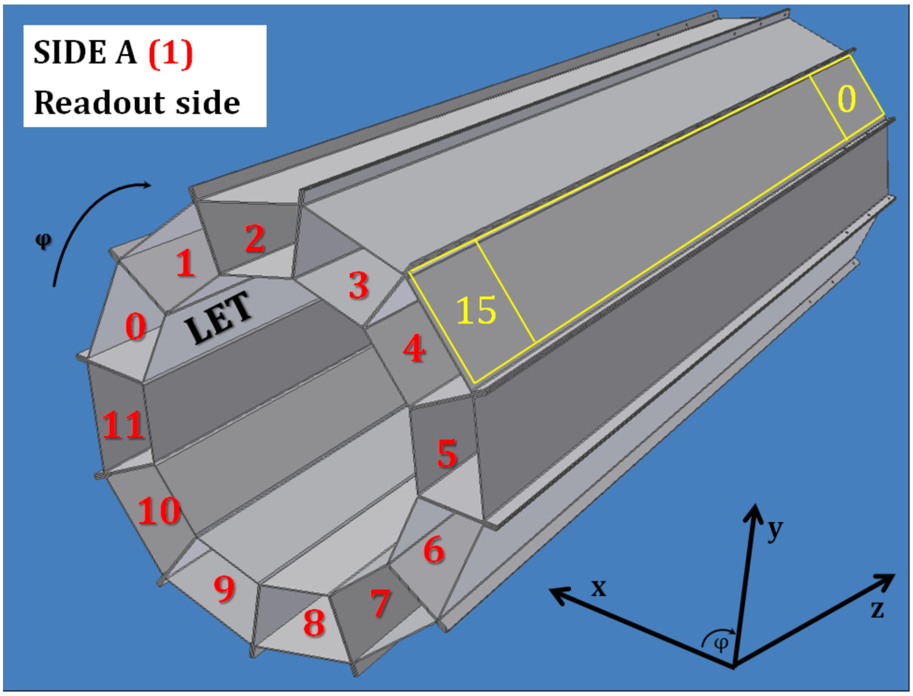

Figure 2: The scheme of QCALT detector located on Side A. The reference frame shown in the figure corresponds to the KLOE coordinate system.

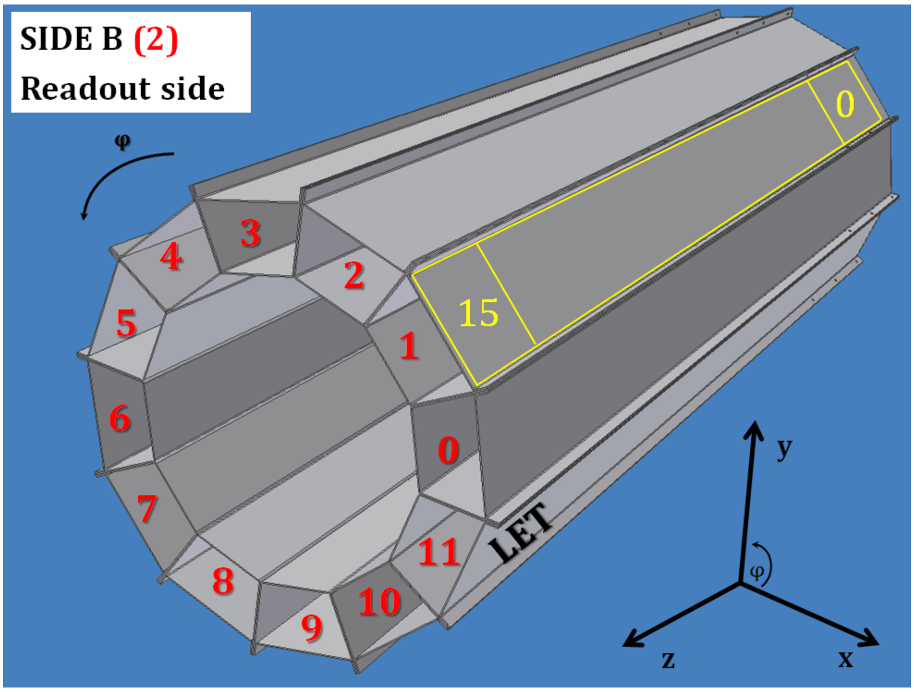

Figure 3: The scheme of QCALT detector located on Side B. The reference frame shown in the figure corresponds to the KLOE coordinate system.

Side A (1)												
Offline numbering	0 (LET)	1	2	3	4	5	6	7	8	9	10	11
Old numbering	0 (LET)	1	2	3	4	5	6	7	8	9	10	11
Side B (2)												
Offline numbering	0	1	2	3	4	5	6	7	8	9	10	11 (LET)
Old numbering	11	10	9	8	7	6	5	4	3	2	1	0 (LET)

Table 1: Relation between the offline and construction QCALT modules numbering scheme.

both detectors module covering ϕ angle in the range [0°;30°] is labeled with 0 and the module number increases with increasing ϕ. The LET modules occupy slot number 0 (side A) and 11 (side B). This numbering scheme is different from the old convention used during the construction and cabling, where the LET modules were labeled as 0 and module numbers were increasing always clockwise. The relation between old and new numbering schemes is presented in Tab. 1. Each module of a QCALT detector consists of five planes numbered as it is shown in Fig. 4. On every plane there are 16 scintillator tiles numbered accordingly to the increasing z coordinate of the tile. On side A z is negative so the first tile on the readout side is numbered with 15 and the tile closest to the IP is the 0-th tile. On side B we keep the convention of increasing z coordinate of the tile, so that again the tile closest to the IP is labeled with 0.

Each tile of the QCALT module is optically coupled to a silicon photomultiplier (SiMP) which is then read by a Front End Electronics board (FEE). Each FFE has 20 channels connected to the SiMPs belonging to two planes of a module as shown in Fig. 4. Signals from FEE boards are transferred to the Transition boards and General Interface Boards (GIBs) and then sent with an optical link. Each Transition Board is connected to a pair of FEEs. For every module FEE1 and FFE4 form the first pair, and FEE2 and FEE3 are coupled together to the other Transition Board (see Fig. 5). Each Transition board is divided into A (also called TB Up) and B (or TB Down) parts. The TB A has 20 input channels numbered from 20 to 39, while the B part channel numbers are 0 to 19. The connection between the QCALT detector modules to the optical links of the TBs and GIBs is presented in Tab. 2 and Tab. 3 together with other useful information. In Tab. 4 we report also the correspondence between the Gib channel number and numbers of plane and tile connected. Again the tile numbering used during the construction is different from the offline scheme and these differences are also reported in Tab. 4. This table closes the detector map which allows to create the element and hit Ybos banks of QCALT described in the next section.

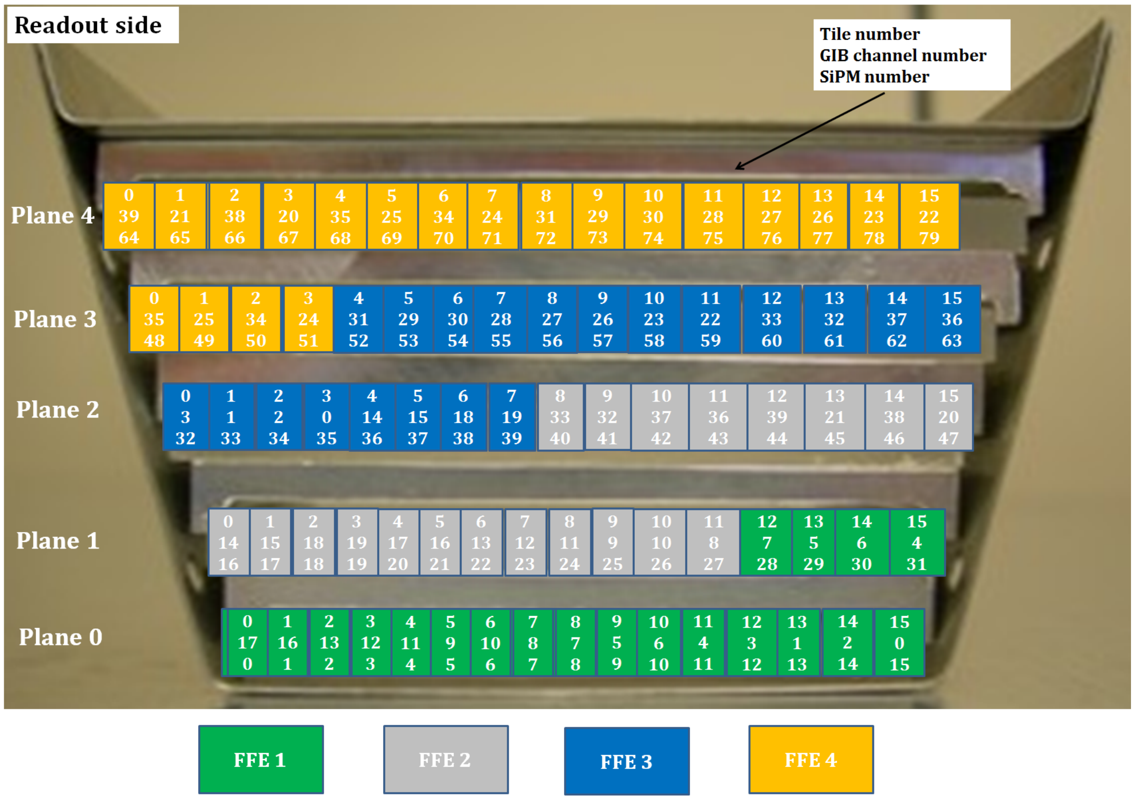

Figure 4: The scheme of FEE boards connection to a QCALT module. Channel numbers correspond to the tile number in a plane, channels belonging to the same FEE are indicated with the same color.

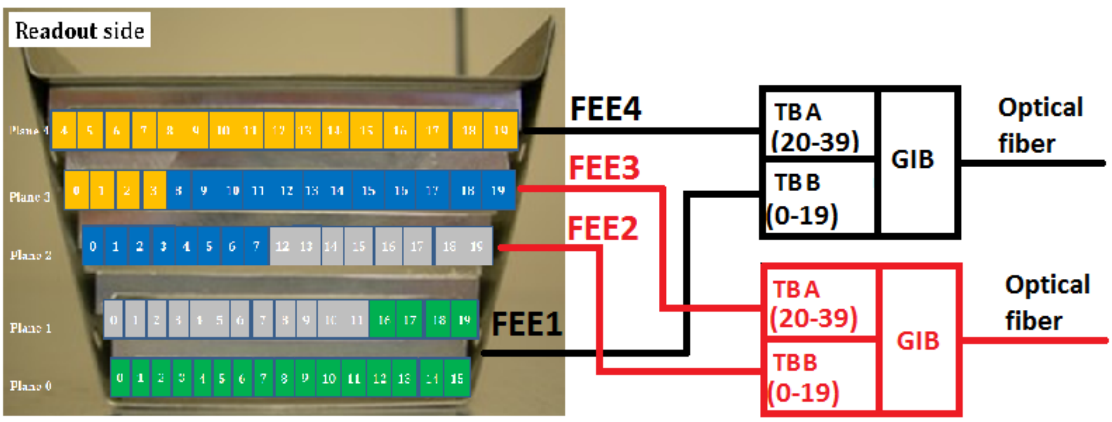

Figure 5: The schematic view of FFE connection to the Transition Boards. For every module FEE1 and FEE4 are connected to one TB, while FEE2 and FEE3 are coupled to the next TB.

Side A (1)									
Module	TB B	TB A	GIB	GIB IP	Fibre	Chain	Mot.	Conc.	pcb
6 (6)	1	4	11	192.135.26.112	13	19	20	12	6
6 (6)	2	3	10	192.135.26.111	14	19	20	11	6
8 (8)	1	4	9	192.135.26.110	15	19	20	10	8
8 (8)	2	3	8	192.135.26.109	16	19	20	9	8
4 (4)	2	3	7	192.135.26.107	17	19	20	8	4
4 (4)	1	4	6	192.135.26.106	18	19	20	7	4
2 (2)	2	3	5	192.135.26.105	19	19	20	6	2
2 (2)	1	4	4	192.135.26.104	20	19	20	5	2
1 (1)	2	3	3	192.135.26.103	21	19	20	4	1
1 (1)	1	4	2	192.135.26.102	22	19	20	3	1
9 (9)	2	3	1	192.135.26.101	23	19	20	2	9
9 (9)	1	4	0	192.135.26.100	24	19	20	1	9
5(5)	1	4	21	192.135.26.126	37	18	19	10	5
5 (5)	2	3	20	192.135.26.125	36	18	19	9	5
7 (7)	1	4	19	192.135.26.124	35	18	19	8	7
7 (7)	2	3	18	192.135.26.123	34	18	19	7	7
3 (3)	2	3	17	192.135.26.120	33	18	19	6	3
3 (3)	1	4	16	192.135.26.119	32	18	19	5	3
10 (10)	2	3	15	192.135.26.118	31	18	19	4	10
10 (10)	1	4	14	192.135.26.117	30	18	19	3	10
11 (11)	2	3	13	192.135.26.116	29	18	19	2	11
11 (11)	1	4	12	192.135.26.115	28	18	19	1	11

Table 2: The connection between QCALT modules and Transition Boards for detector A. Module numbers in brackets correspond to the old numbering scheme. The TB or GIB is here identified by the number of the corresponding optical fibre output.

Side B (2)									
Module	TB A	TB B	GIB	GIB IP	Fibre	Chain	Mot.	Conc.	pcb
2 (9)	1	4	9	192.135.26.156	29	17	14	10	20
2 (9)	2	3	8	192.135.26.155	28	17	14	9	20
0 (11)	1	4	7	192.135.26.154	27	17	14	8	22
0 (11)	2	3	6	192.135.26.153	26	17	14	7	22
8 (3)	2	3	5	192.135.26.150	25	17	14	6	14
8 (3)	1	4	4	192.135.26.149	24	17	14	5	14
4 (7)	2	3	3	192.135.26.148	23	17	14	4	18
4 (7)	1	4	2	192.135.26.147	22	17	14	3	18
6 (5)	2	3	1	192.135.26.146	21	17	14	2	16
6 (5)	1	4	0	192.135.26.145	20	17	14	1	26
1 (10)	1	4	21	192.135.26.172	11	18	19	16	21
1 (10)	2	3	20	192.135.26.171	10	18	19	15	21
3 (8)	1	4	19	192.135.26.170	9	18	19	14	19
3 (8)	2	3	18	192.135.26.169	8	18	19	13	19
9 (2)	2	3	17	192.135.26.167	7	18	19	12	23
9 (2)	1	4	16	192.135.26.166	6	18	19	11	23
10 (1)	2	3	15	192.135.26.165	5	17	14	16	12
10 (1)	1	4	14	192.135.26.164	4	17	14	15	12
5 (6)	2	3	13	192.135.26.163	3	17	14	14	17
5 (6)	1	4	12	192.135.26.162	2	17	14	13	17
7 (4)	2	3	11	192.135.26.161	1	17	14	12	15
7 (4)	1	4	10	192.135.26.160	0	17	14	11	12

Table 3: The connection between QCALT modules and Transition Boards for detector B. Module numbers in brackets correspond to the old numbering scheme. The TB or GIB is here identified by the number of the corresponding optical fibre output.

Gib #	FEE	Plane	Tile C	Tile O	Gib #	FEE	Plane	Tile C	Tile O
0	1	0	0	15	0	2	2	12	3
1	1	0	2	13	1	2	2	14	1
2	1	0	1	14	2	2	2	13	2
3	1	0	3	12	3	2	2	15	0
4	1	0	4	11	4	2	1	0	15
5	1	0	6	9	5	2	1	2	13
6	1	0	5	10	6	2	1	1	14
7	1	0	7	8	7	2	1	3	12
8	1	0	8	7	8	2	1	4	11
9	1	0	10	5	9	2	1	6	9
10	1	0	9	6	10	2	1	5	10
11	1	0	11	4	11	2	1	7	8
12	1	0	12	3	12	2	1	8	7
13	1	0	13	2	13	2	1	9	6
14	1	1	15	0	14	2	2	11	4
15	1	1	14	1	15	2	2	10	5
16	1	0	14	1	16	2	1	10	5
17	1	0	15	0	17	2	1	11	4
18	1	1	13	2	18	2	2	9	6
19	1	1	12	3	19	2	2	8	7
20	4	4	12	3	20	3	2	0	15
21	4	4	14	1	21	3	2	2	13
22	4	4	0	15	22	3	3	4	11
23	4	4	1	14	23	3	3	5	10
24	4	4	8	7	24	3	3	12	3
25	4	4	10	5	25	3	3	14	1
26	4	4	2	13	26	3	3	6	9
27	4	4	3	12	27	3	3	7	8
28	4	4	4	11	28	3	3	8	7
29	4	4	6	9	29	3	3	10	5
30	4	4	5	10	30	3	3	9	6
31	4	4	7	8	31	3	3	11	4
32	4	3	2	13	32	3	2	6	9
33	4	3	3	12	33	3	2	7	8
34	4	4	9	6	34	3	3	13	2
35	4	4	11	4	35	3	3	15	0
36	4	3	0	15	36	3	2	4	11
37	4	3	1	14	37	3	2	5	10
38	4	4	13	2	38	3	2	1	14
39	4	4	15	0	39	3	2	3	12

Table 4: Gib channel to QCALT module plane and tile map. We report also the correspondence between the construction tile numbering (Tile C) and offline scheme (Tile O). The first part of the table refers to Gib reading FEE 1 and 4 while the second one to Gib reading FEE 2 and 3.

QCALT Element Bank

- Bank Name QCTE
- Bank Number 1
- Bank Data Length QCTE_HDSZ + NTILE*7 (adress + nhits/tile + 5 leading edge times)
- Bank Type Mixed: 5I*4 ,(2I*4,5R*4)

Offset	Type	Description
QCTEHS	I*4	Header size QCTE_DTSZ
QCTEVN	I*4	Bank version number
QCTECL	I*4	Calibration information
QCTENT	I*4	Total number of fired tile NTILE
QCTENH	I*4	Data block size
QCTADR + (I-1)*QCTE_HDSZ	I*4	Packed adress of fired tile
QCTNHT + (I-1)*QCTE_HDSZ	I*4	# of hits NHITS per tile
QCTR1 + (I-1)*QCTE_HDSZ	R*4	TDC leading edge time of 1st hit
QCTR2 + (I-1)*QCTE_HDSZ	R*4	TDC leading edge time of 2nd hit
QCTR3 + (I-1)*QCTE_HDSZ	R*4	TDC leading edge time of 3rd hit
QCTR4 + (I-1)*QCTE_HDSZ	R*4	TDC leading edge time of 4th hit
QCTR5 + (I-1)*QCTE_HDSZ	R*4	TDC leading edge time of 5th hit

Figure 6: Structure of the element bank of QCALT.

3 QCALT element and hit bank structures

There are three QCALT raw banks, each corresponding to one chain: `QCAR` (chain 17), `QCBR` (chain 18) and `QCCR` (chain 19). Each bank has the same structure having the header with the version and total number of hits in a single event. For each hit the bank contains header with element address and the measured time (in counts). The complete detector map was used to create an Analysis Control module `raw2eleqcalt.kloe` to read all the raw banks and save the element ybos bank `QCTE`. The structure of the bank is presented in Fig. 6. The header contains its size, bank version number, calibration information, the number of fired tiles and data block size which is fixed. The calibration flag so far contains only information if the time stored in the data block is expressed in ns (calibflag = 1) or counts (calibflag = 0). Since we use multi-hit TDCs in the data block of the `QCTE` bank we store for each tile fired packed address, number of hits per tile and times of each hit measured with respect to the trigger. The maximum number of hits per tile is set to five and thus we store five time values in the bank. The `raw2eleqcalt` module can be found in the `TLS` library and provides apart from the QCALT element bank creation

QCALT Hit Bank

- Bank Name QCTH
- Bank Number 1
- Bank Data Length QCTH_HDSZ + NTILE*9 (nhits/tile + 3 coordinates + 5 leading edge times)
- Bank Type Mixed: 5I*4 ,(2I*4,5R*4)

Offset	Type	Description
QCTHHS	I*4	Header size QCTE_DTSZ
QCTHVN	I*4	Bank version number
QCTHCL	I*4	Calibration information
QCTHNT	I*4	Total number of fired tile NTILE
QCTHNH	I*4	Data block size
QCTHN + (I-1)*QCTH_HDSZ	I*4	# of hits NHITS per tile
QCTHX + (I-1)*QCTH_HDSZ	R*4	x coordinate of the hit (KLOE reff. frame)
QCTHY + (I-1)*QCTH_HDSZ	R*4	y coordinate of the hit (KLOE reff. frame)
QCTHNZ + (I-1)*QCTH_HDSZ	R*4	z coordinate of the hit (KLOE reff. frame)
QCTHR1 + (I-1)*QCTH_HDSZ	R*4	TDC leading edge time of 1st hit
QCTHR2 + (I-1)*QCTH_HDSZ	R*4	TDC leading edge time of 2nd hit
QCTHR3 + (I-1)*QCTH_HDSZ	R*4	TDC leading edge time of 3rd hit
QCTHR4 + (I-1)*QCTH_HDSZ	R*4	TDC leading edge time of 4th hit
QCTHR5 + (I-1)*QCTH_HDSZ	R*4	TDC leading edge time of 5th hit

Figure 7: Structure of the hit bank of QCALT.

also ntuple booking used e.g. for debugging. By default the ntuple creation is disabled and the time is booked in ns. These setting can be changed by the Talk To routine. The `QCTE` bank can be read by subroutine `getqcaltstru.kloe` which can be found also in the `TLS` library. This function fills the following Fortran structure (`MaxQCALTChan` = 1920 and `MaxQCALTHits` = 5):

```
TYPE QCTEStructure
SEQUENCE
INTEGER Nele (Number of elements fired for an event)
INTEGER Nhit(MaxQCALTChan) (Number of hits per element)
INTEGER Addr(MaxQCALTChan) (Packed address of fired element)
INTEGER Qdet(MaxQCALTChan) (Number of detector of fired element)
INTEGER Qmod(MaxQCALTChan) (Number of module of fired element)
INTEGER Qpla(MaxQCALTChan) (Number of plane of fired element)
INTEGER Qtil(MaxQCALTChan) (Number of tile of fired element)
REAL Time(MaxQCALTChan,MaxQCALTHits) (Times measured for each hit)
END TYPE
```

The `getqcaltstru` subroutine is used to retrieve the element bank information in the `ele2hitqcalt` module which creates the QCALT hit bank `QCTH` whose structure is presented in Fig. 7. This bank contains the coordinates of fired tiles instead of the tile, plane module and detector numbers. The transformation is done using the `qcaltele2geo.kloe` subroutine. The information about the position and dimensions of both QCALT detectors were taken from the latest drawings of the interaction point. Coordinates of a hit are assumed to be equal to coordinates of a geometric center of fired tail in the KLOE reference frame. In the bank header we store also flag giving information about QCALT calibration. This module provides also ntuple creation (by default it is disabled). The `QCTH` bank can be accessed using `getqhitstru.kloe` subroutine which fills the following structure (`MaxNChan` = 1920 and `MaxNHits` = 5):

```
TYPE QHITStructure
SEQUENCE
INTEGER Nele (Number of elements fired for an event)
INTEGER Nhit(MaxNChan) (Number of hits per element)
REAL X(MaxNChan) (x coordinate of fired tile)
REAL Y(MaxNChan) (y coordinate of fired tile)
REAL Z(MaxNChan) (z coordinate of fired tile)
REAL Time(MaxNChan,MaxNHits) (Times measured for each hit)
END TYPE
```

References

[1] S. Miscetti, J. Phys. Conf. Ser. 335 (2011) 012070.

[2] A. Balla et al., Nucl. Instrum. Meth. A 718 (2013) 95.