Inventory of the ECAL spare Inner modules Scanning with ^{137}Cs

There are 32 spare ECAL Inner modules stored in b. 156. The purpose of the inventory was to determine whether they are operational and good for replacement of the ECAL central modules after the LHCb upgrade.

The chosen method was to scan the modules with the ^{137}Cs source and measure DC anode current of PMTs. When using the same PMTs at same HV for all the modules, we measure the relative light yield of the cells.

The bad cells are expected to have the (relative) light yield significantly lower than good ones. Also, significant deviation of the shape of $I_{PMT}(x)$ from the standard one can be a signature of a bad cell.

The scan was performed in b. 156 18-22 Nov 2013. The spare HCAL ^{137}Cs source was used. The procedure is described in the EDMS document 111858.

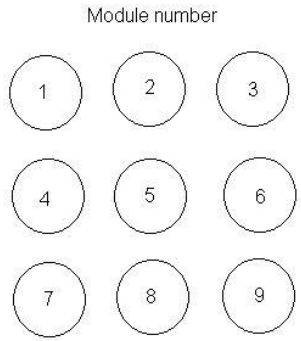
Preliminary checks

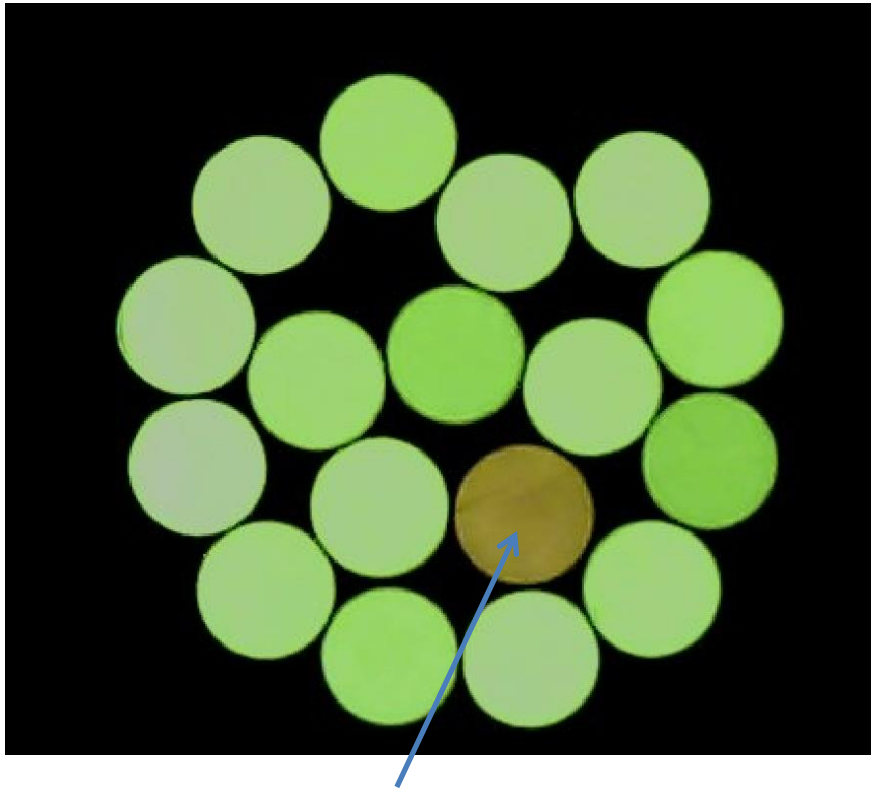
Prior to the scan, all the 32 modules were checked with a pocket light (blue) and a microscope (Sergii Kandybei, KIPT Kharkiv, Ukraine).

2 cells with 1 broken fiber (out of 16) found (-6% in the light yield, not a problem).

Module #31 has many cells with loose LED light input connectors – to be assigned to the non instrumented zone in the centre.

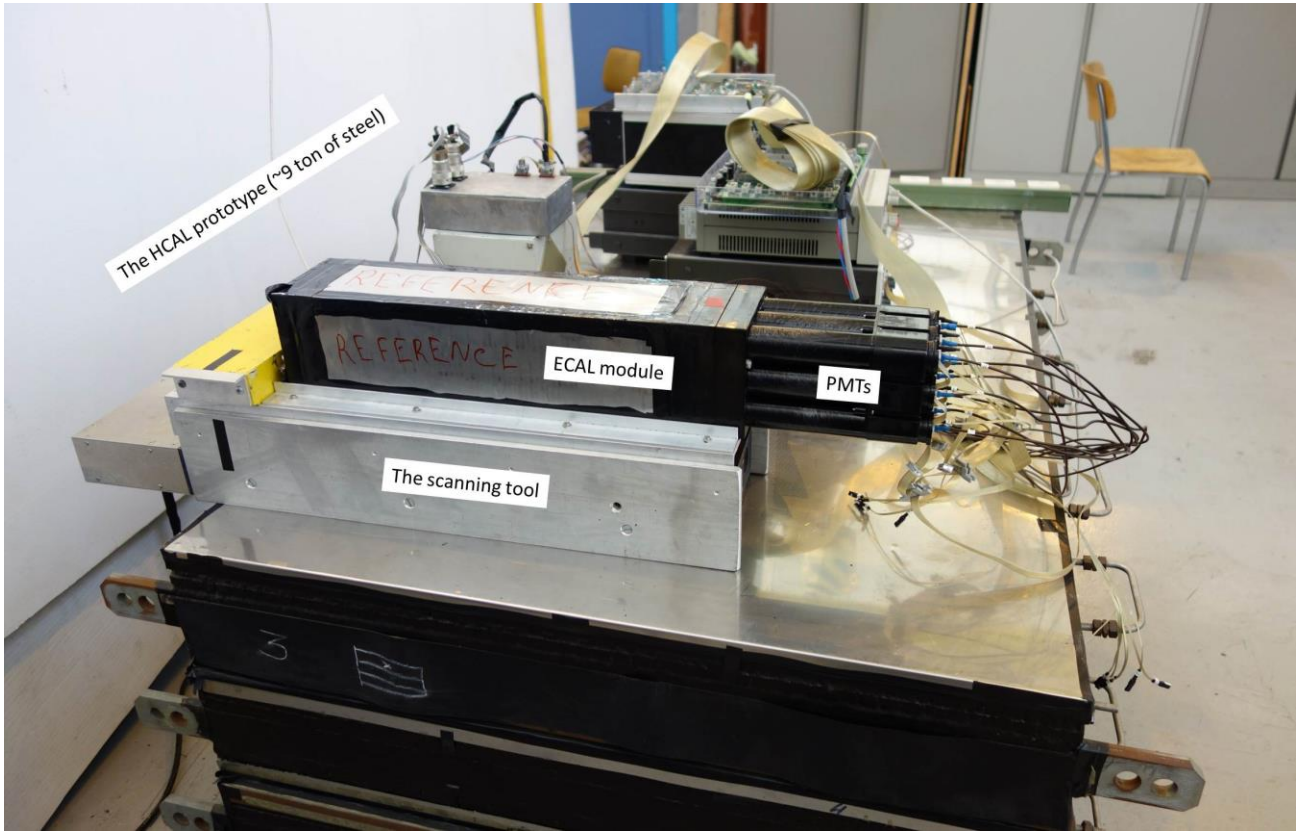
Module	Status	
1	OK	
2	OK	
3	OK	
4	ch 9: 1 broken fiber	
5	OK	
6	OK	
7	OK	
8	OK	
9	OK	
10	ch 5: 1 broken fiber	
11	OK	
12	OK	
13	OK	
14	OK	
15	OK	
16	OK	
17	OK	
18	OK	
19	OK	
20	OK	
21	OK	
22	OK	
23	OK	
24	OK	
25	OK	
26	OK	
27	OK	
28	OK	
29	OK	
30	OK	
31	OK	Loose calibration light inputs in ch 2,3,5,6,8,9





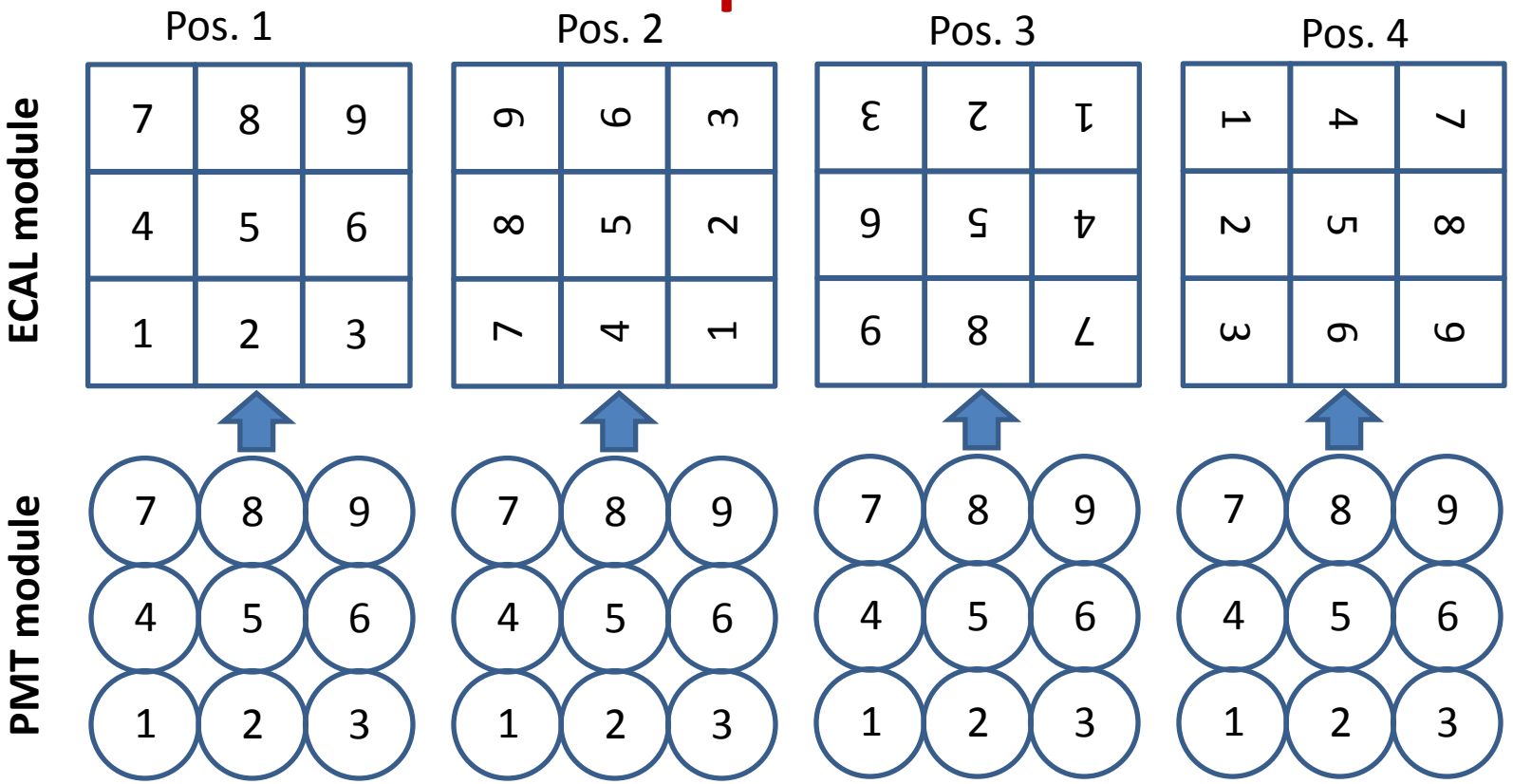
The clear fiber (LED light guide)

The setup



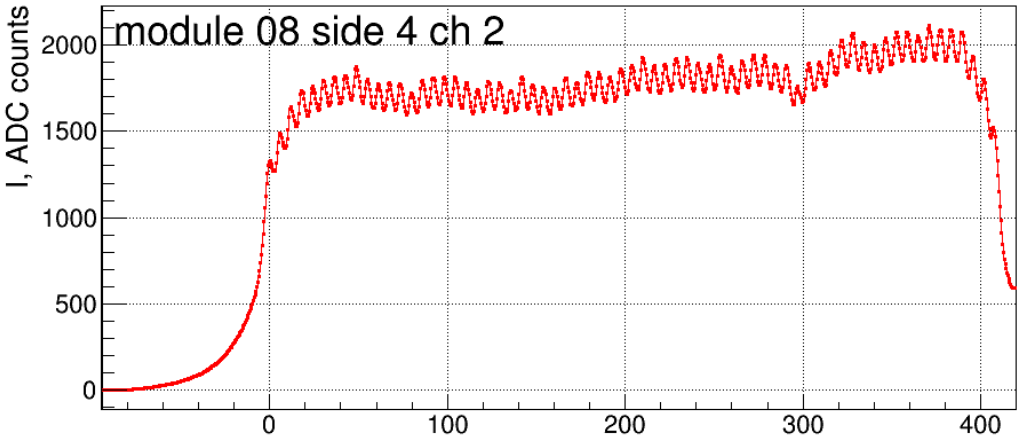
The standard xCAL control boards (communicated via SPECS) were used to set PMT HVs and measure DC anode currents.

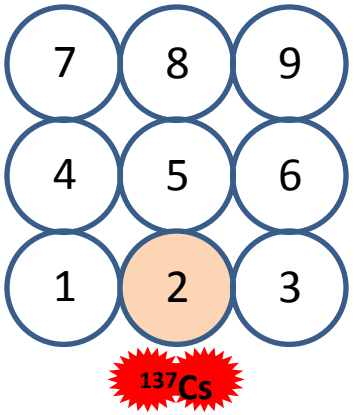
Test procedure

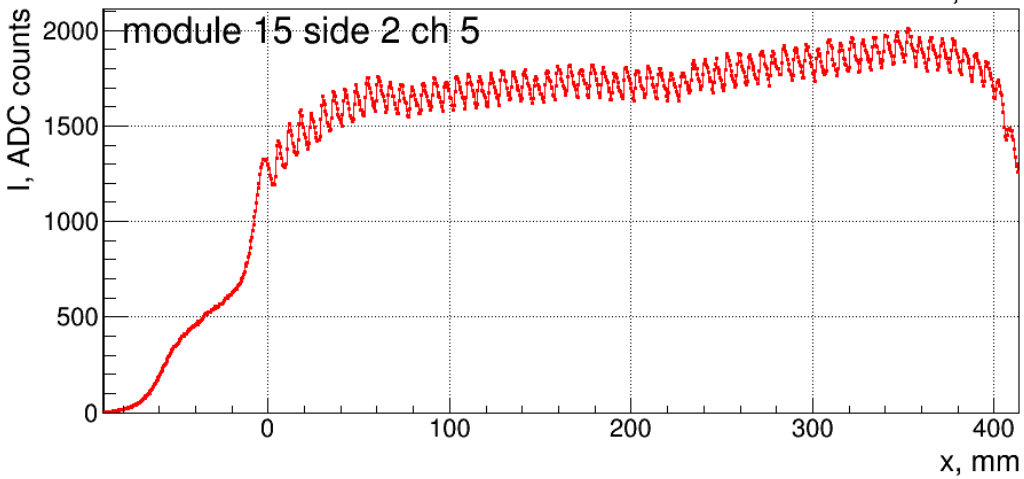


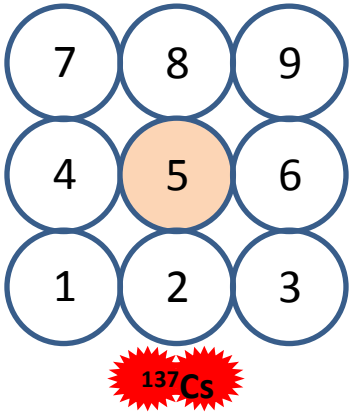
Each ECAL module was scanned in 4 positions; the PMT block was always in the same position.
Only PMTs ##1,2,3,5 were used.
The PMTs ##1 and 3 looked through all the corner cells; the PMT #2 – all the side cells, the PMT #5 – all the central cells, 4 times each.
The module #32 (“reference”) was scanned twice, at the beginning and at the end (<5% difference).
Total of 132 runs were performed during 5 days, 18-22 Nov.

The I(t) shapes







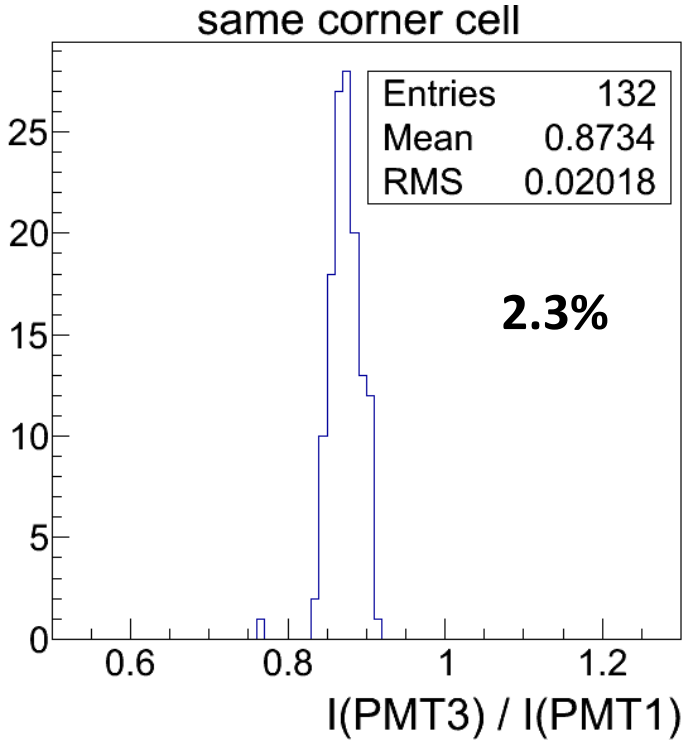


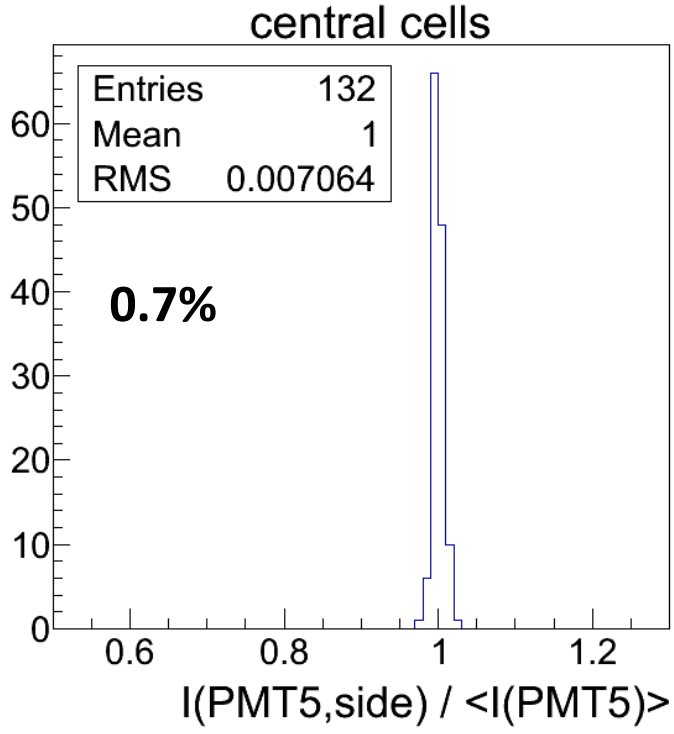
The shape is similar in all the cells. Difference at start and end because of different distance from the source (different shape of I(x) for an individual tile).

No significant peculiarities in the I(x) were found in any cell.

In what follows, the average current for the interval of 50<x<350 mm was taken as a measure of light yield.

Method's accuracy



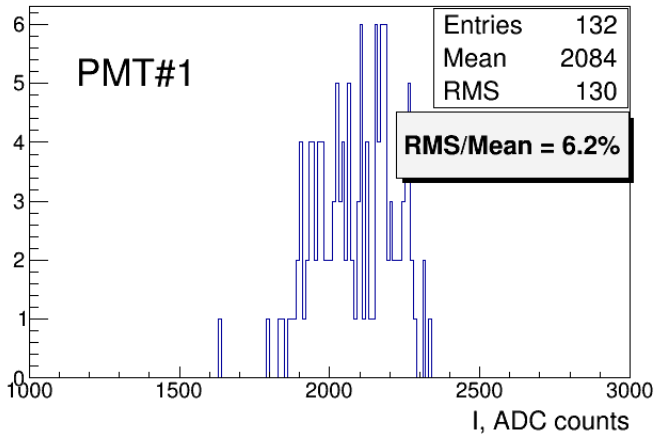


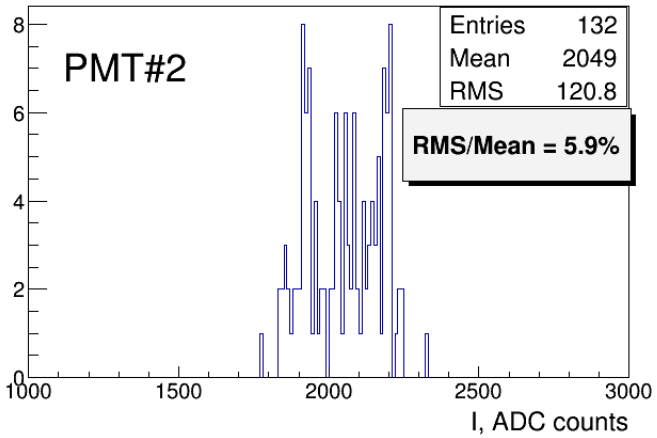
Each corner cell was scanned twice, once with PMT #1 and once with #3. **In figure**: distribution of ratios of the two results for each corner cell (RMS/mean **≈ 2.3%)**. The accuracy (assuming that PMT#1 and #3 are equivalent) is **2.3% / √2 ≈ 1.6%**

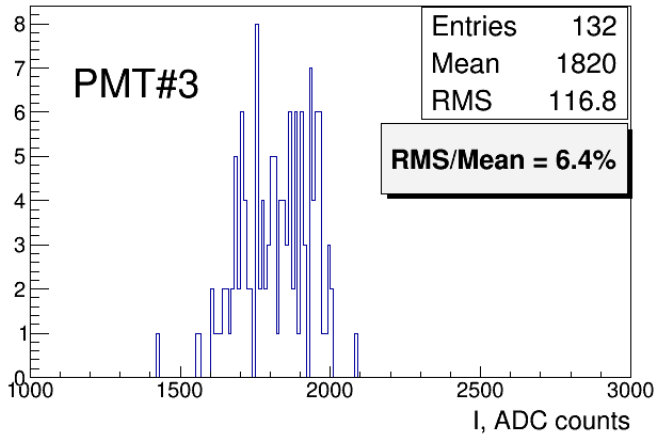
Each central cell was scanned four times with the same PMT #5. **In figure**: distribution of ratios of each result to the average of the four ones. The accuracy is **0.7% * √(4/3) ≈ 0.8%**

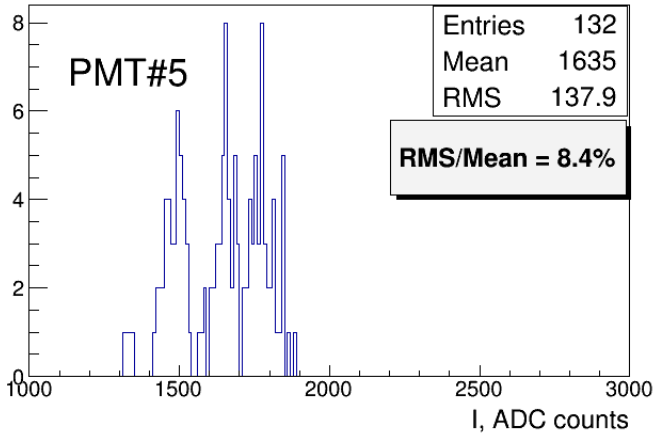
The results are different: possible reasons can be difference in individual PMTs' stability, mechanical positioning etc. In any case, this kind of accuracy is far enough for the purpose of inventory.

Results









All the cells showed rather similar light yield, max/min < 1.5.

We can conclude that the light yield of all the cells is satisfactory. The difference in the light yield is most probably because of the optical contact with PMT (fiber polishing quality).

Optionally, the least bright cells can be assigned to the non instrumented zone in the ECAL centre.