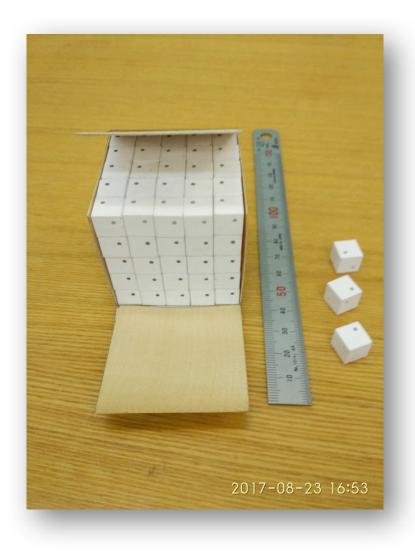
# Preliminary test results of the 3D neutrino detector prototype with CITIROC readout chips

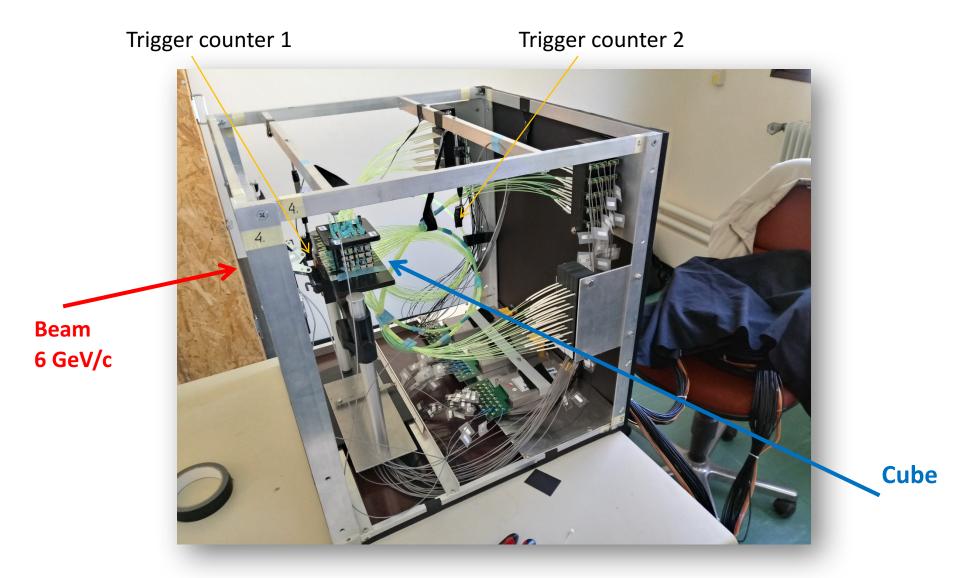
A. Mefodev
INR RAS
December 25, 2017

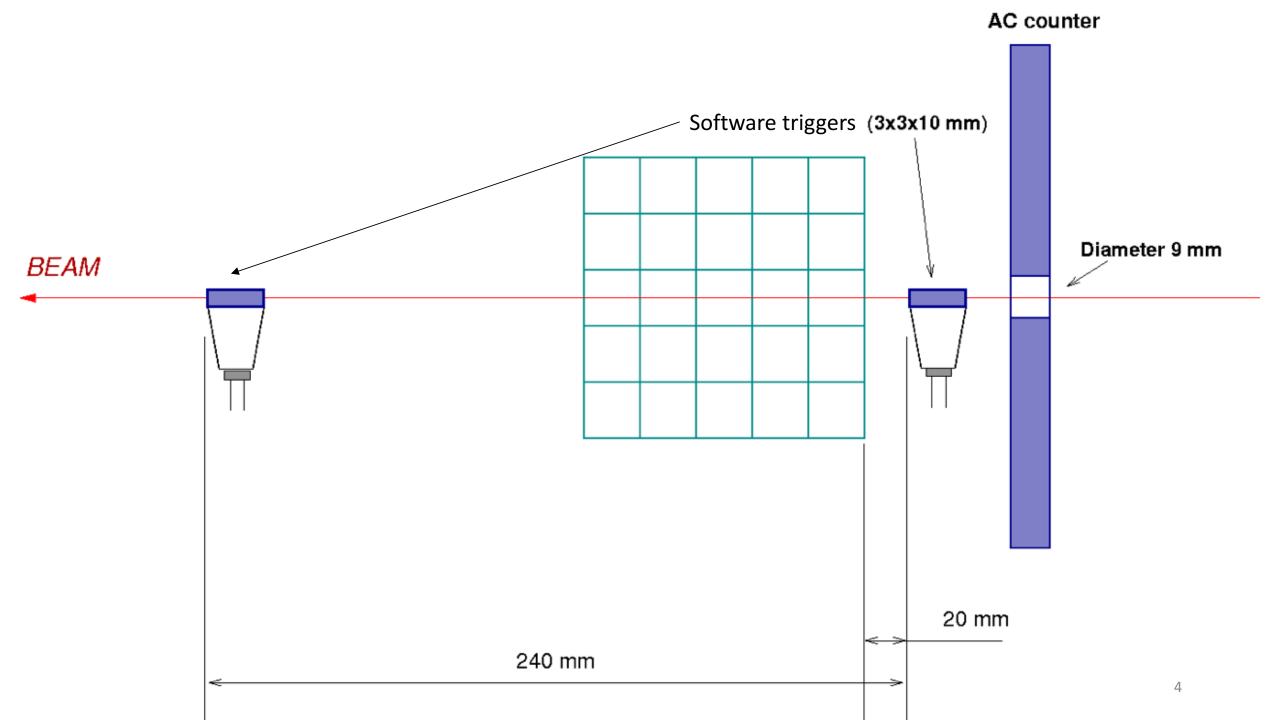
## 5x5 cube from the cubes



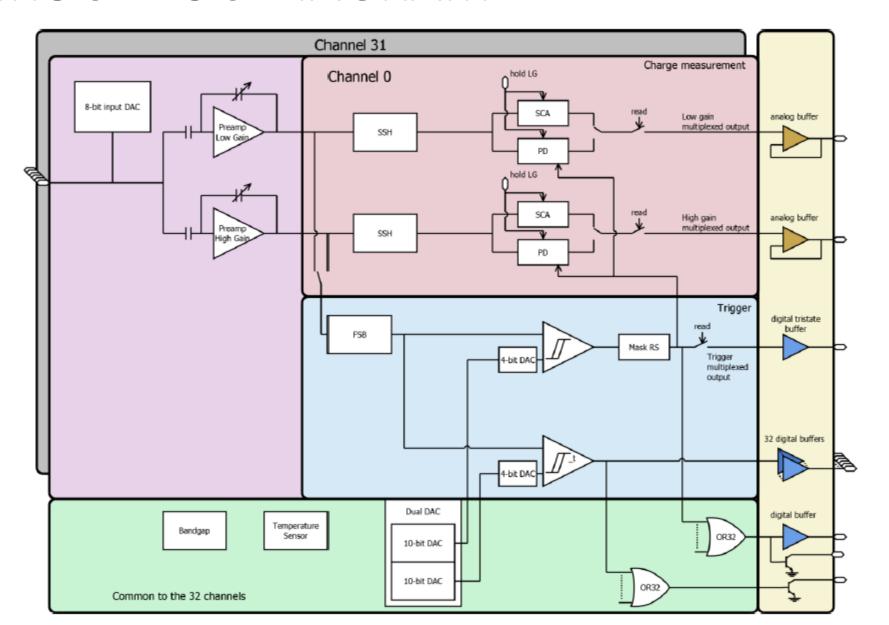
- Manufactured in Vladimir (Uniplast Co.)
- Cube size: 10x10x10 *mm*<sup>3</sup>
- Material: extruded polystyrene doped with 1.5% of paraterphenyl (PTP) and 0.01% of POPOP
- White chemical reflector: thickness is about 50  $\mu m$
- Holes for WLS fibers: three of 1.5 mm diameter

## The cube inside support frame at CERN

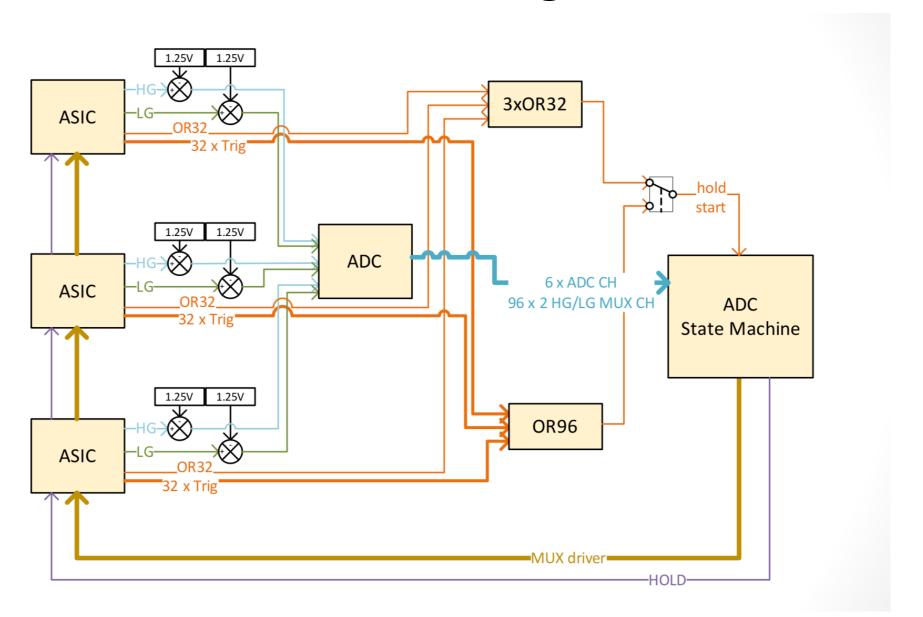




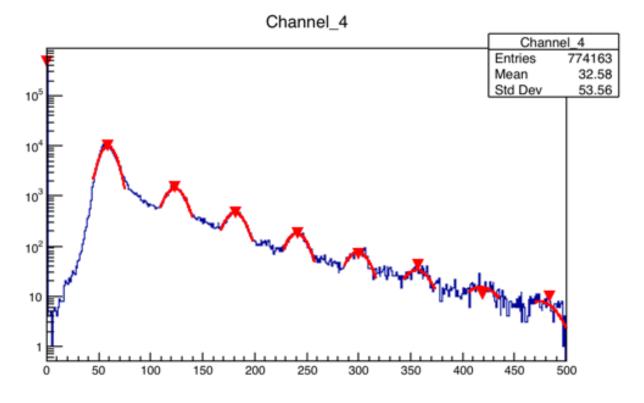
## CITIROC BLOC DIAGRAM



## FEB v2 details: ADC Signal chain



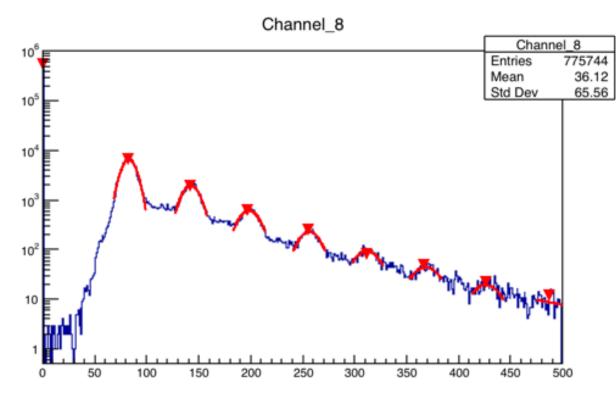
## HG vs p.e. Calibration



ch4: gain — 59.3235; pedestal — -0.4051; Peak position:

1pe - 58.9184; 2pe - 123.151; 3pe - 180.87;

4pe - 240.565; 5pe - 299.056.

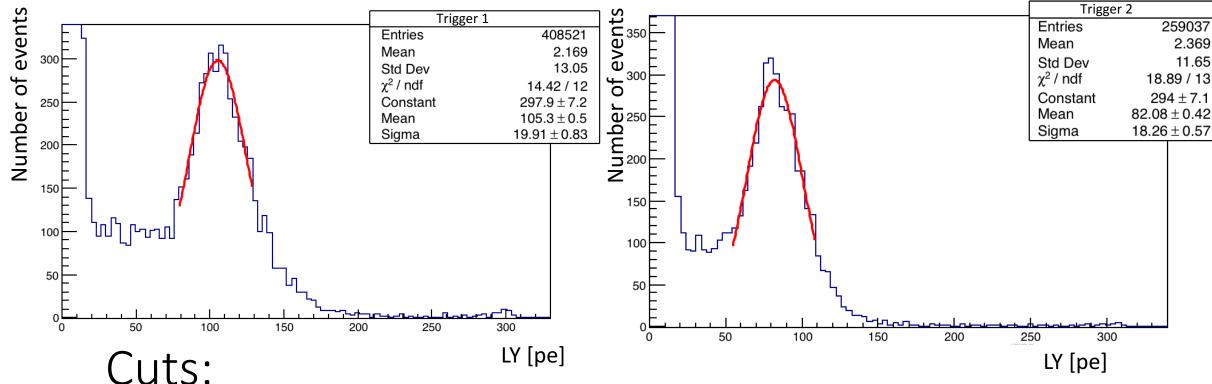


ch8: gain — 57,226; pedestal — 25,6138; Peak position:

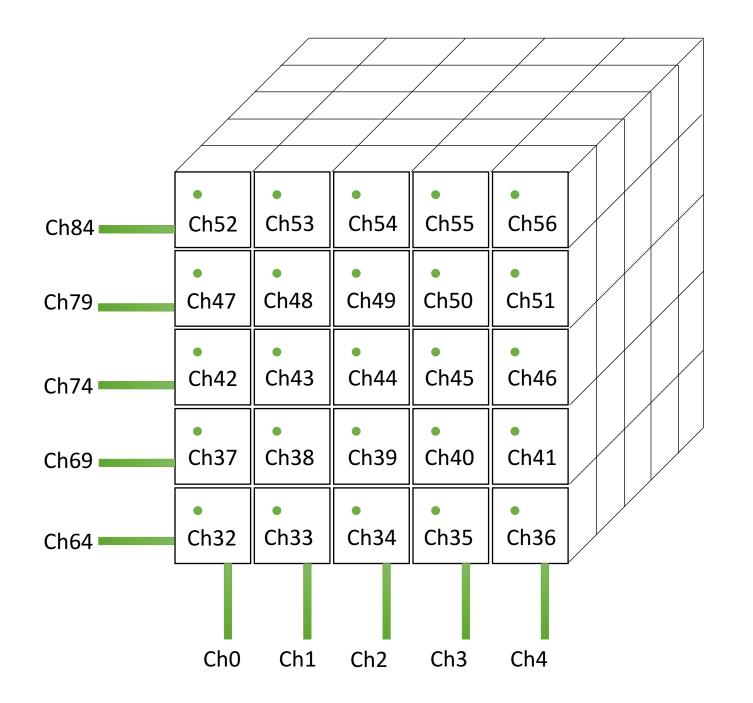
1pe - 82.8398; 2pe - 142.372; 3pe - 198.355;

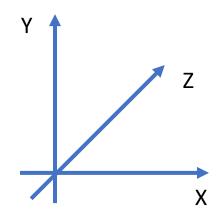
4pe - 256.374; 5pe - 311.696.

## Event selection

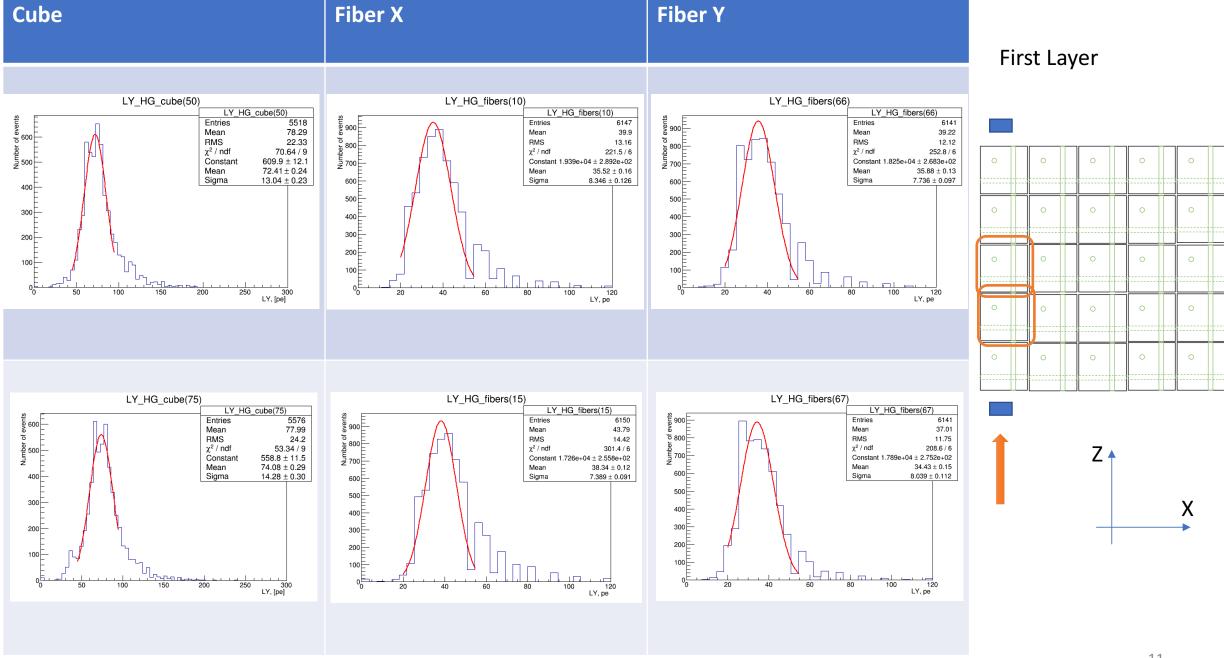


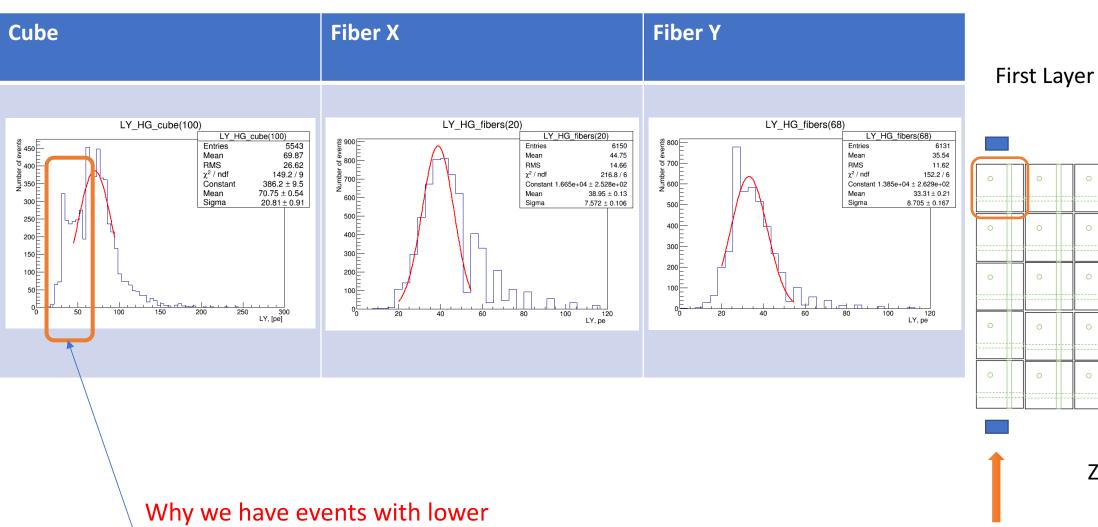
- $L.Y._{tr2} > 45 p.e.$
- Window  $|LY_{tr1} LY_{tr2}| < 100 \, ns$
- Window  $|LY_{tr1} LY_{channel}| < 100 ns$
- Anti-coincidence counter:
  - !L.Y.<sub>AC1</sub> || !L.Y.<sub>AC2</sub>
  - $|LY_{tr1} LY_{AC2}| > 100 \text{ ns}$



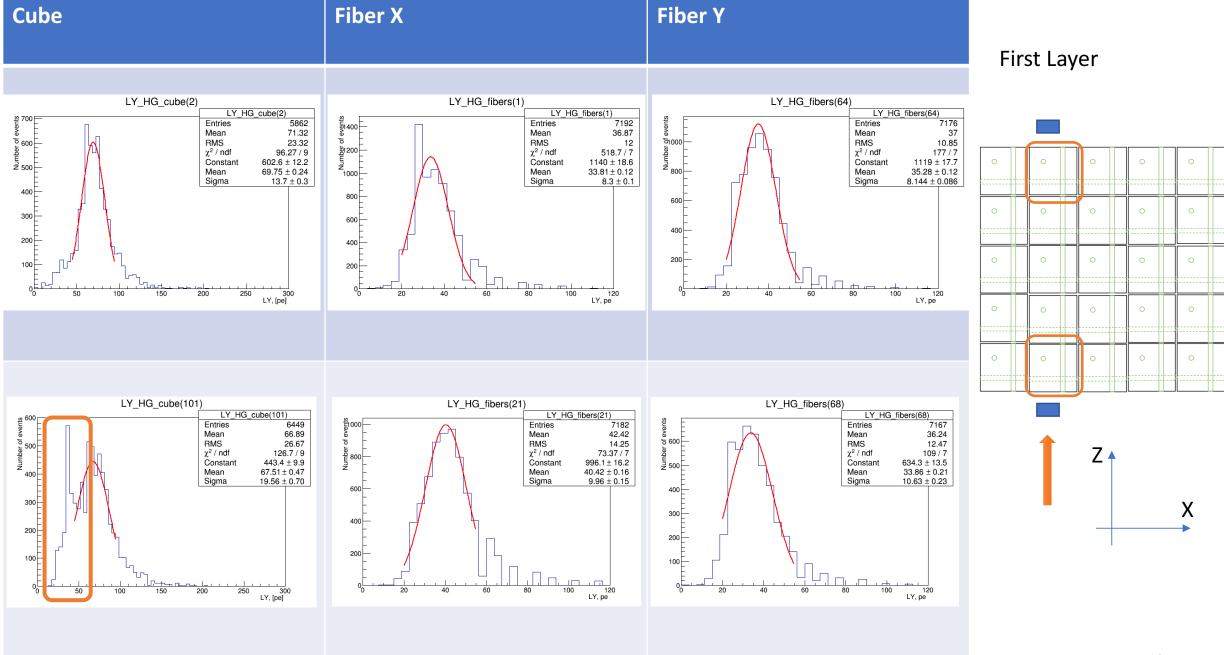


### Cube Fiber X Fiber Y First Layer LY\_HG\_fibers(0) LY\_HG\_cube(0) LY\_HG\_fibers(64) LY\_HG\_fibers(0) LY\_HG\_fibers(64) LY\_HG\_cube(0) 6146 30.53 6135 Entries 5566 1400 100 Mean 63.85 35 RMS 19.07 RMS 10.27 10.28 Number 600 Number 2000 $\chi^2$ / ndf 76.27 / 9 $\chi^2$ / ndf 467.8 / 6 $\chi^2$ / ndf 649.3 / 6 Constant 1.774e+04 ± 3.147e+02 Constant 1.709e+04 ± 2.746e+02 Constant $617.1 \pm 12.1$ **₹** 800 Mean $63.05 \pm 0.26$ $29.99 \pm 0.16$ Mean $32.11 \pm 0.13$ 1000 6.923 ± 0.120 500 Sigma $13.95 \pm 0.27$ Sigma $6.658 \pm 0.135$ 800 600 400 600 300 400 400 200 200 200 100 200 LY\_HG\_fibers(65) LY\_HG\_fibers(5) LY\_HG\_cube(25) LY HG fibers(65) LY\_HG\_fibers(5) LY HG cube(25) Entries 6156 5376 79 6151 Mean Mean 41.17 39.5 RMS RMS RMS 13.15 11.99 22.95 111.2 / 9 $\chi^2$ / ndf 14.12 / 6 χ² / ndf Constant χ2 / ndf 581.8 / 6 Constant 2.053e+04 ± 3.371e+02 564.6 ± 11.7 ₹ 800 Constant 1.71e+04 ± 2.53e+02 Mean $36.23 \pm 0.11$ Mean $38.03 \pm 0.18$ $74.57 \pm 0.29$ Sigma $6.794 \pm 0.090$ $10.05 \pm 0.22$ Sigma $13.57 \pm 0.28$ X 400 300 200 200 100 200 300 LY, [pe] 250 10

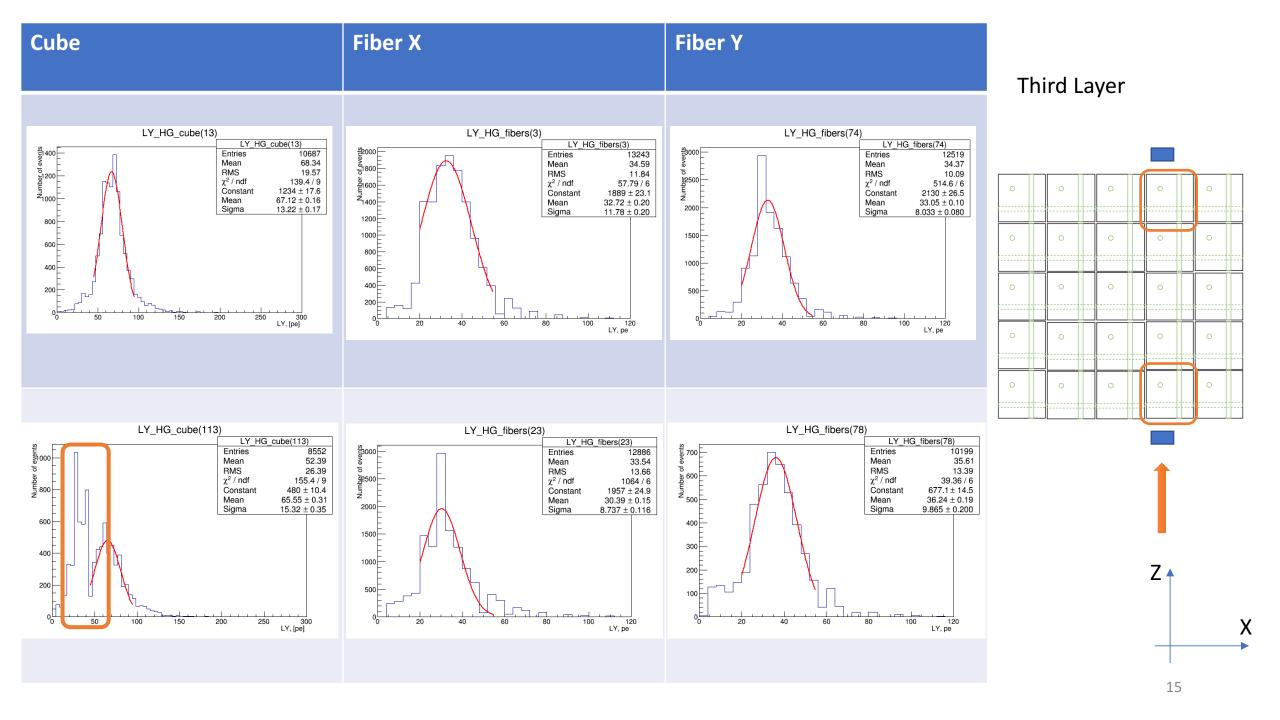


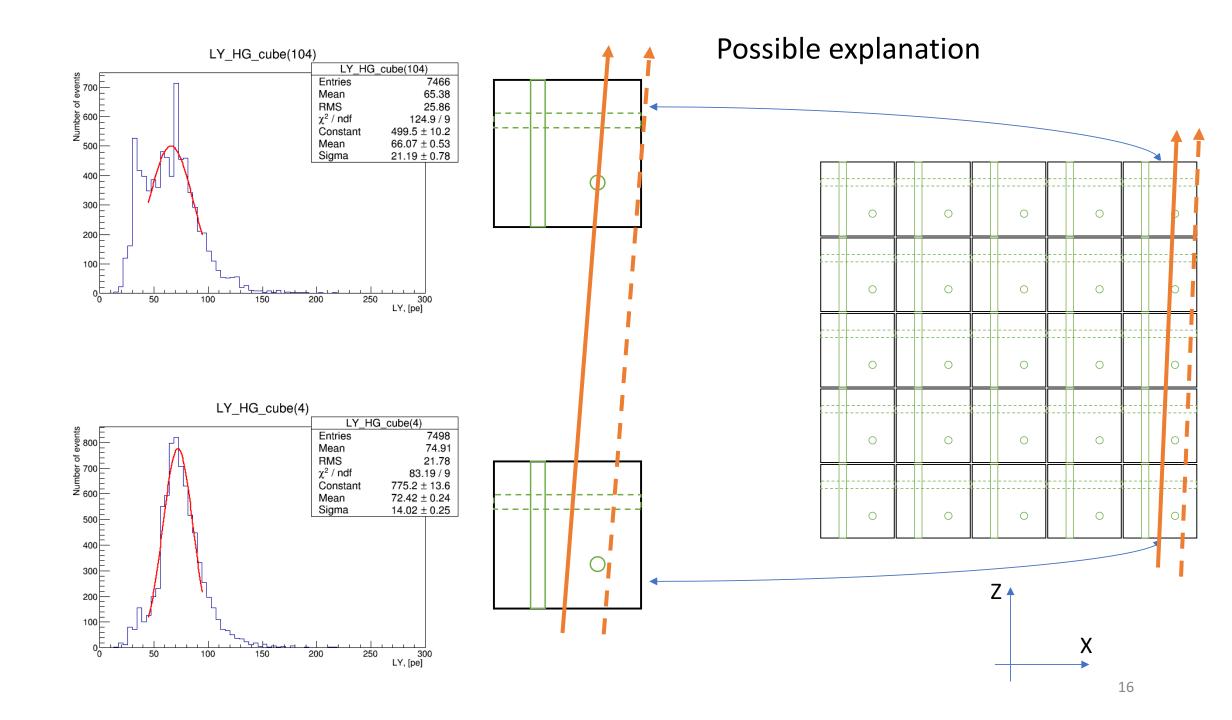


LY on the last cube in row?

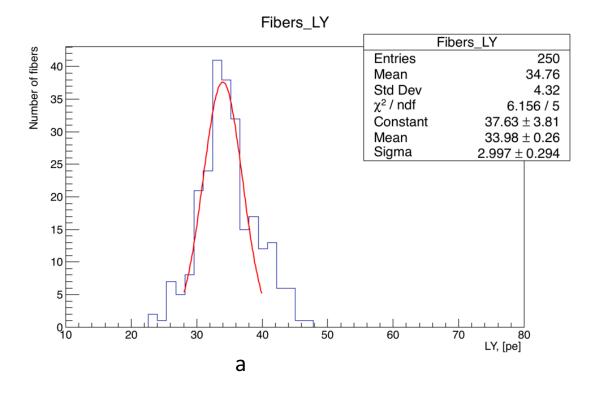


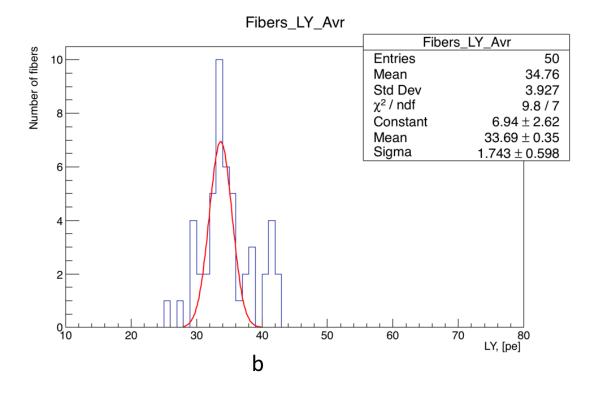
### Fiber X Cube Fiber Y Second Layer LY\_HG\_cube(6) LY\_HG\_fibers(1) LY\_HG\_fibers(69) LY\_HG\_cube(6) LY\_HG\_fibers(1) LY\_HG\_fibers(69) 00081gf events 7775 35.45 Number of events 6877 Entries Mean 73.1 36.91 RMS χ² / ndf RMS χ² / ndf 19.46 11.42 RMS 10.93 136.8 / 9 1062/6 $\chi^2$ / ndf 273.7 / 6 Constant 800.5 ± 13.8 Constant $1302\pm27.6$ Constant $1159 \pm 18.6$ $69.06 \pm 0.20$ $34.86 \pm 0.16$ $10.27 \pm 0.16$ $33.28 \pm 0.13$ Mean Sigma $13.22 \pm 0.20$ $7.727 \pm 0.164$ 1200 600 400 600 400 200 100 0 LY\_HG\_cube(106) LY\_HG\_fibers(21) LY\_HG\_fibers(73) LY\_HG\_cube(106) LY\_HG\_fibers(21) LY\_HG\_fibers(73) 6936 84.25 7771 43.22 14.65 257.4 / 6 7773 Entries Entries Entries Mean RMS χ² / ndf Mean RMS 40.1 Mean RMS χ² / ndf 322.5 / 6 1156 ± 19.4 37.61 ± 0.14 9.799 ± 0.157 25.62 210.8 / 9 Number 800 – $\chi^2$ / ndf $749.2 \pm 13.2$ 1166 ± 18.7 Constant Constant Constant $75.87 \pm 0.25$ Mean Sigma $40.15 \pm 0.15$ $12.78 \pm 0.21$ $9.305 \pm 0.130$ 600 X 400 400 200 200 150 200





## Light Yield of fibers

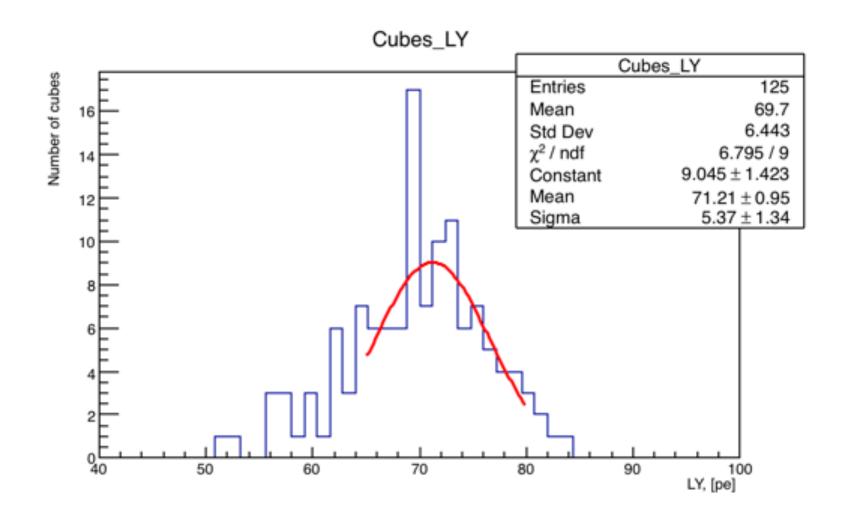




Each fiber was tested 5 times

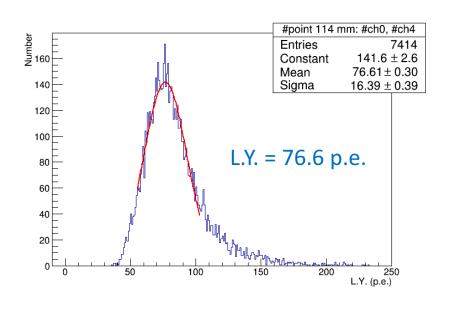
- a) All measurement in one plot;
- b) Calculating LY in average for all channels.

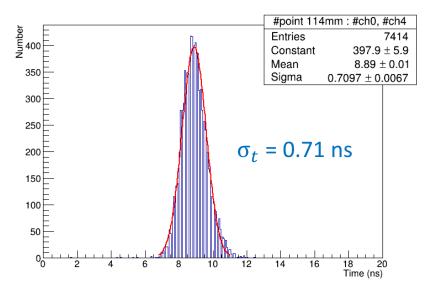
## Light Yield of cubes



# L.Y. and time resolution for cube#121, point 114 mm, ch0 and ch4 combined

### **CAEN** results

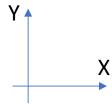


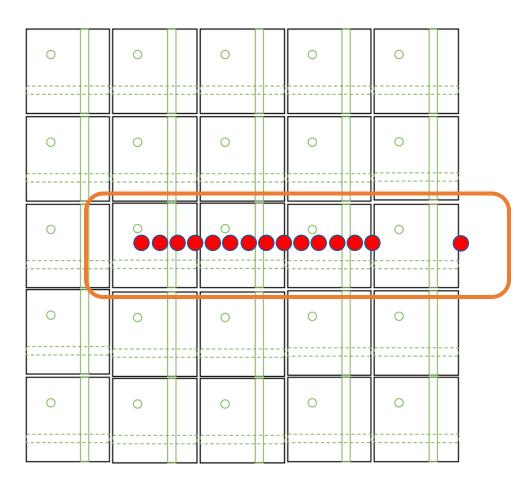


$$L.Y._{cube} = L.Y._{ch0} + L.Y._{ch4}$$

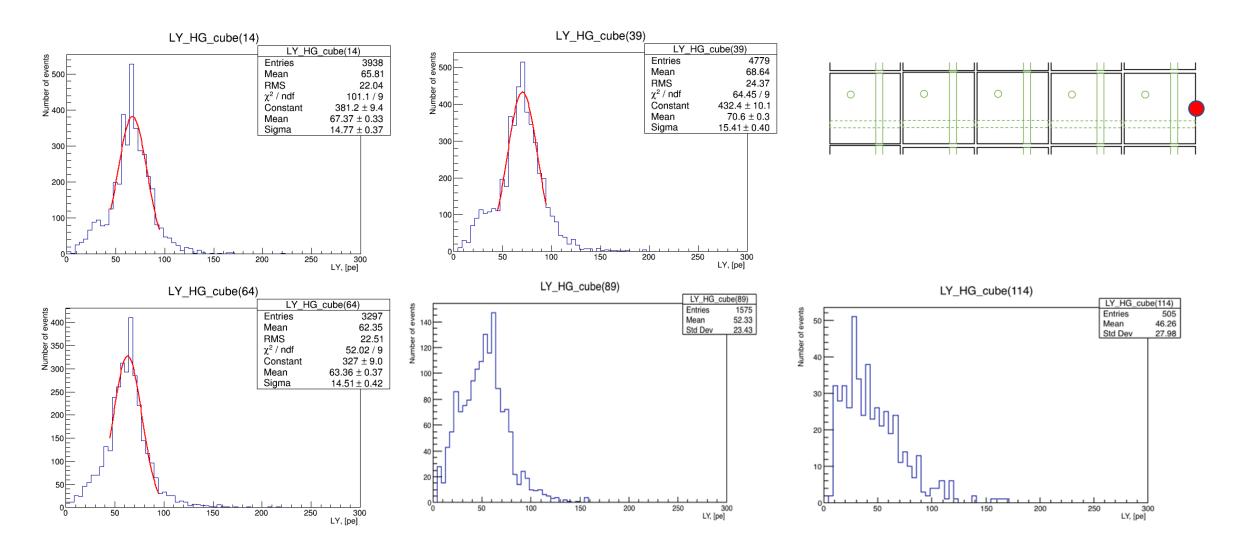
$$T_{cube} = ((T_{ch0} - T_{tr2}) + (T_{ch4} - T_{tr2}))/2$$

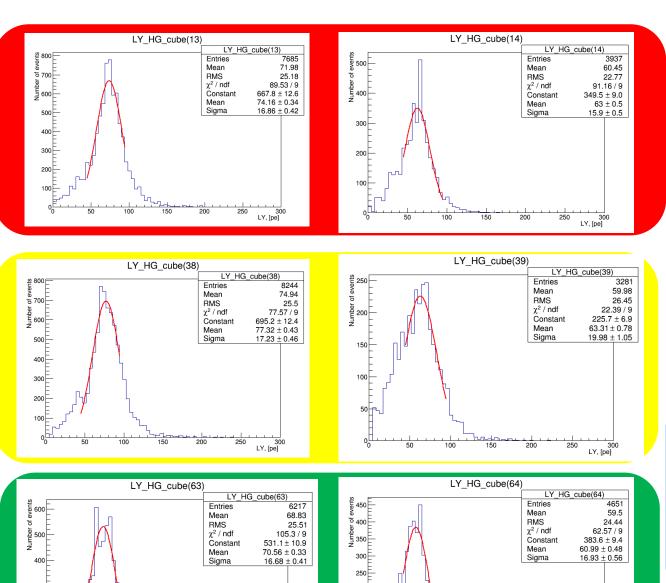
## 2mm scan



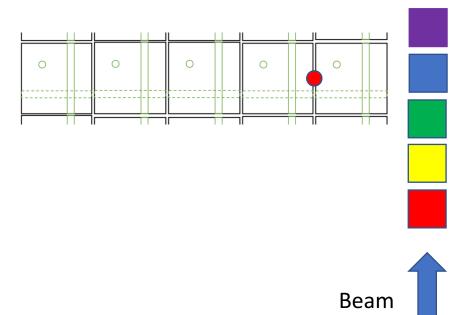


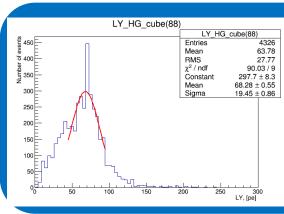
## Side point

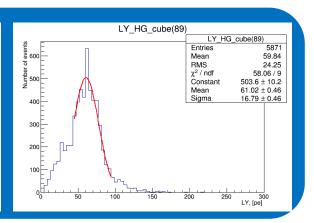




LY, [pe]

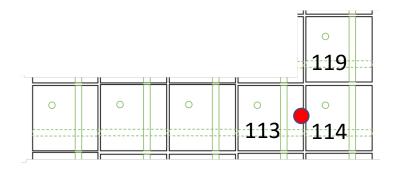


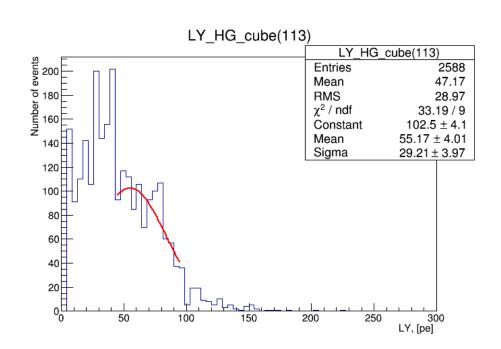


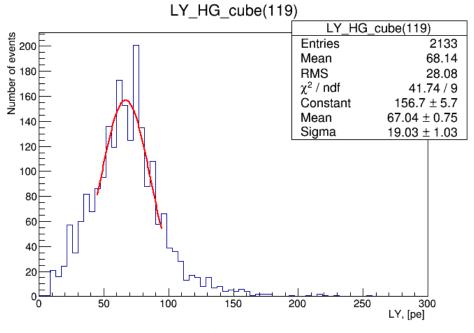


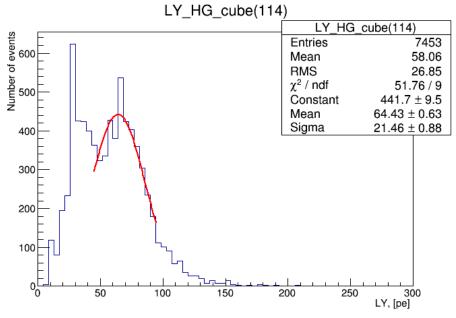
## SURPRISE!!!

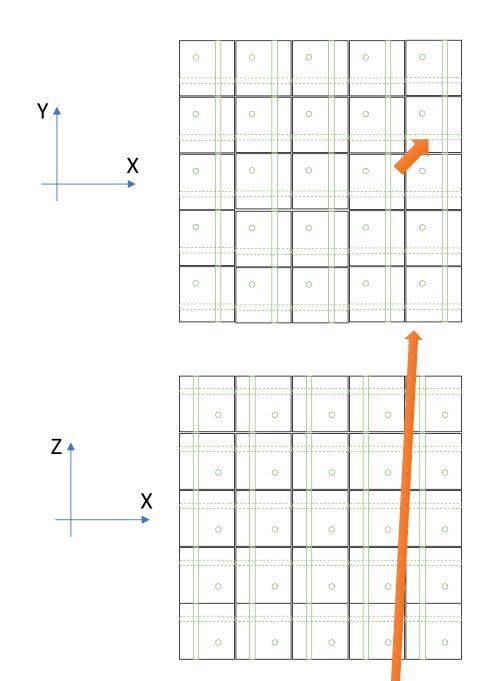
## Surprise

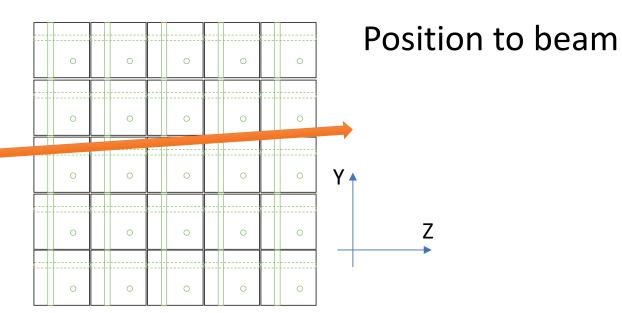




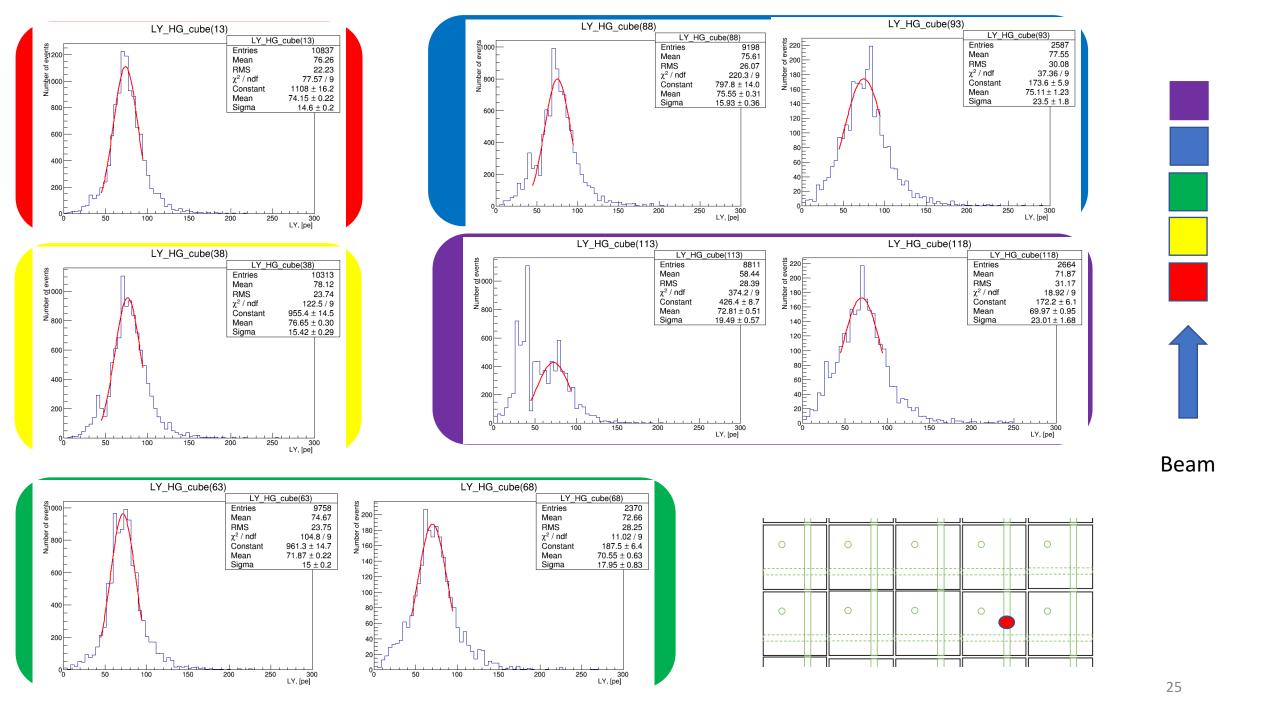


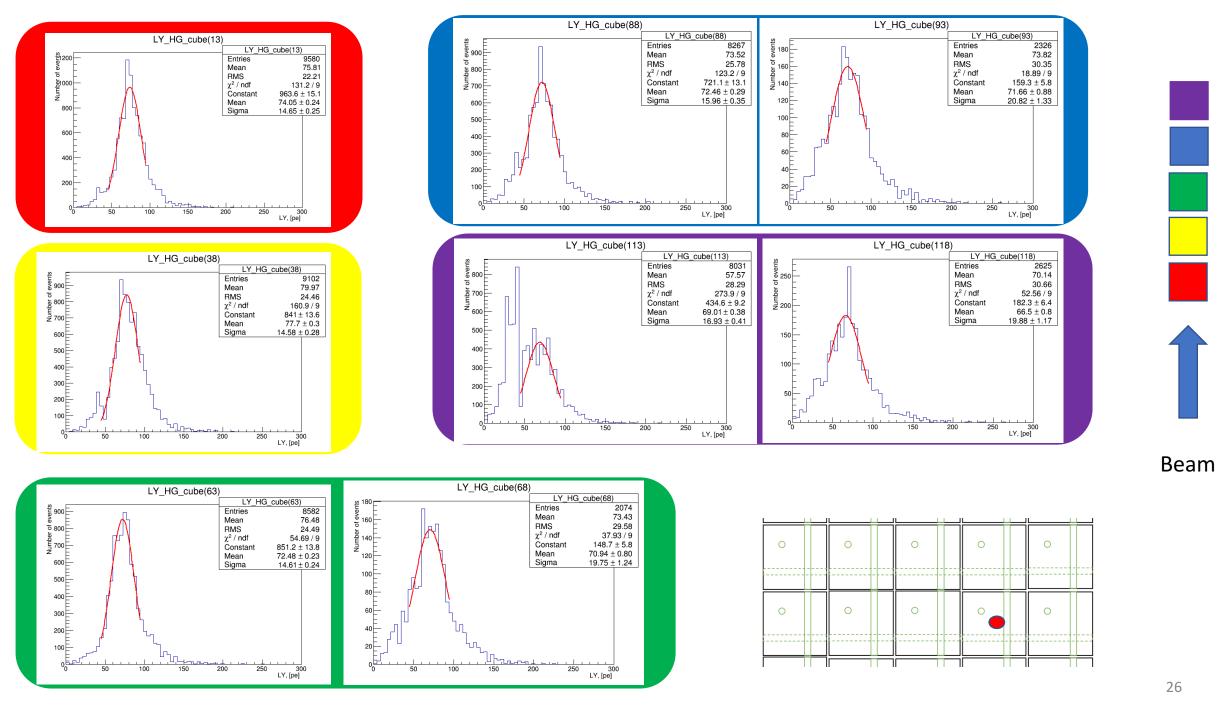


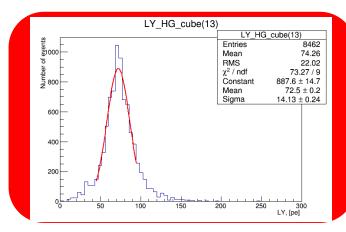


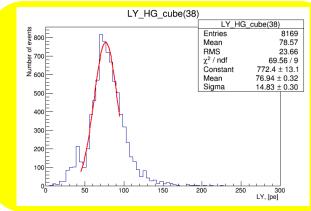


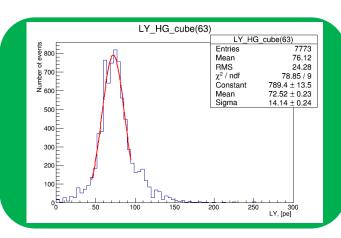
Beam

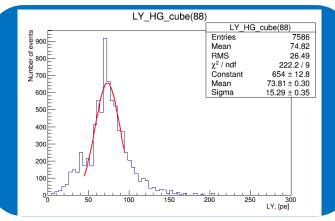


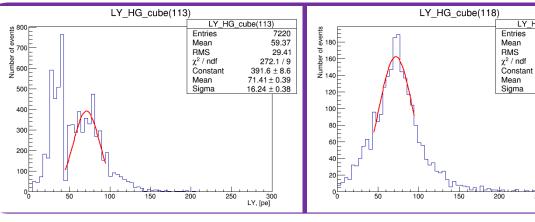


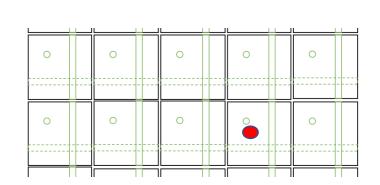












LY\_HG\_cube(118)

2354

74.14

31.28

19.17 / 9

 $162 \pm 6.0$ 

 $72.2 \pm 0.9$ 

 $21.12 \pm 1.45$ 

Entries

Mean

RMS

 $\chi^2$  / ndf

Mean

Sigma

200

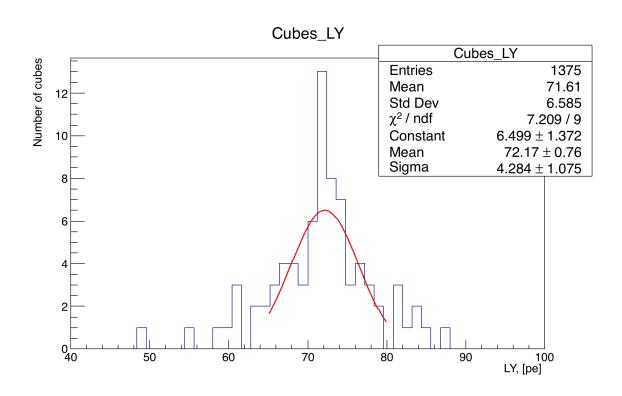
250

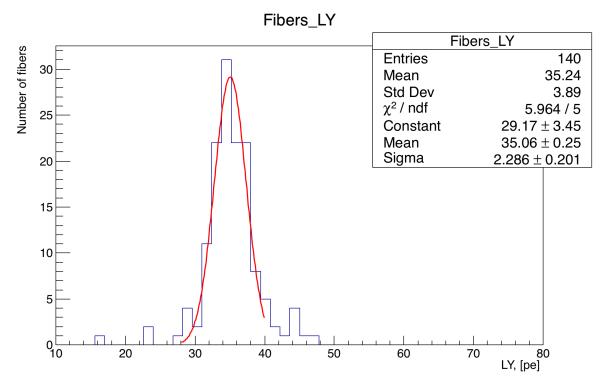
LY, [pe]

Constant



## Scan results in average

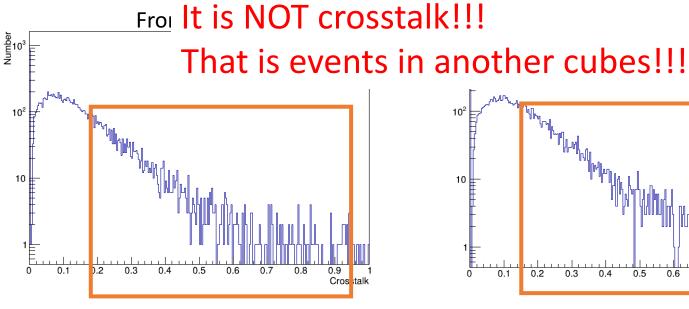


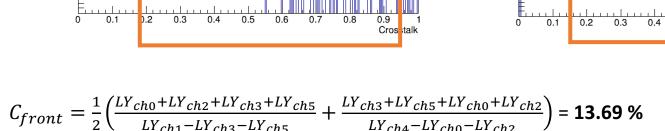


## Crosstalk leaked to four sides

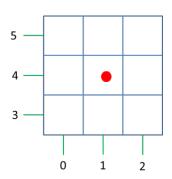
### **CAEN** results

0.1579

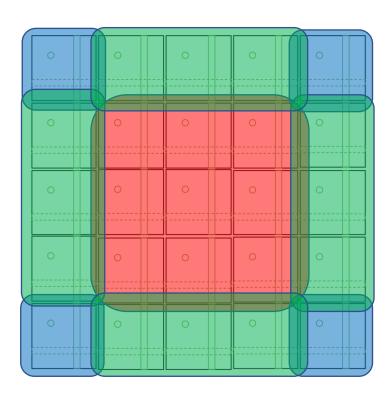




$$C_{back} = \frac{1}{2} \left( \frac{LY_{ch6} + LY_{ch8} + LY_{ch9} + LY_{ch11}}{LY_{ch7} - LY_{ch9} - LY_{ch11}} + \frac{LY_{ch6} + LY_{ch8} + LY_{ch9} + LY_{ch11}}{LY_{ch10} - LY_{ch6} - LY_{ch8}} \right) = 15.79 \%$$



## Reflector effect



**Cubes Inside** 



Cubes near side



$$Re_{blue} = \left(1 - \frac{\sum LY_{Cout}/NC_{out}}{\sum LY_{Cin}/NC_{in}}\right) *100\% = 9,34\%$$

$$Re_{green} = \left(1 - \frac{\sum LY_{Cout}/NCo_{ut}}{\sum LY_{Cin}/NCi_n}\right) *100\% = 2,92 \%$$

## Summary

Preliminary results with the CITIROC:

- Average L.Y.  $\approx$  **33.8 p.e.** per a fiber
- Average L.Y.  $\approx$  **71.21 p.e.** per two fibers (a cube)
- Average Reflector effect (crosstalk???) per cube side:
  ≈ 3 %; three sides ≈ 9.3%

Event display & proper crosstalk is ongiong.

