

# Relative calibration of the TUS photodetector in flight

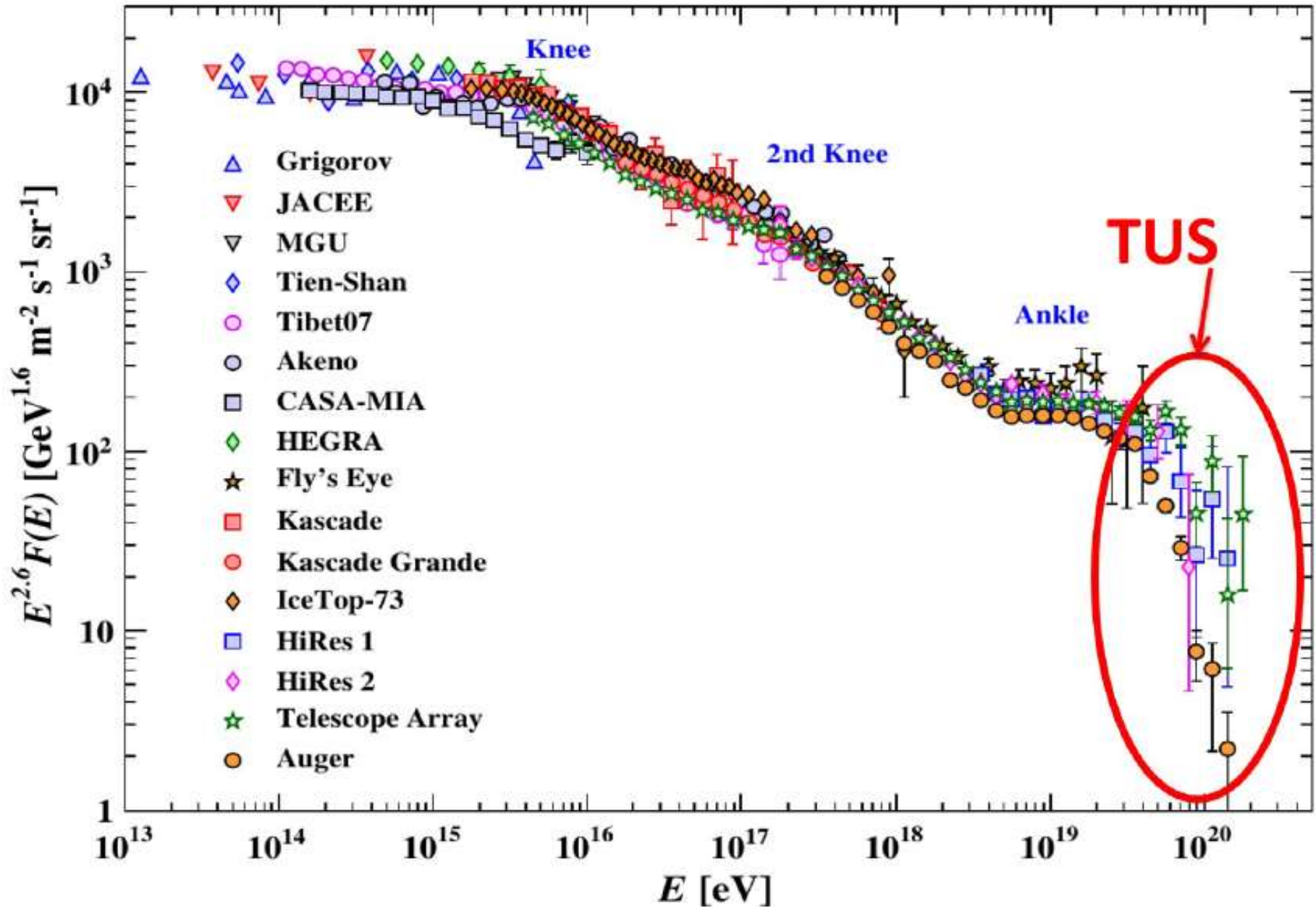
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International conference on particle physics and astrophysics 2024

22-25 october

# Cosmic rays spectrum



# Schematic view of the TUS detector aboard “Lomonosov” satellite



Mass	<60 kg
Power	65 W
Data rate	200 Mbytes/day
Number of pixels	16x16 PMTs
FOV	$\pm 4,5$ degree
Duty cycle	30%
Altitude	500 km
Pixel:	10 mrad
Mirror area	1,8 m <sup>2</sup>
Focal distance	1,5 m
Period	94 min

# EAS candidate event

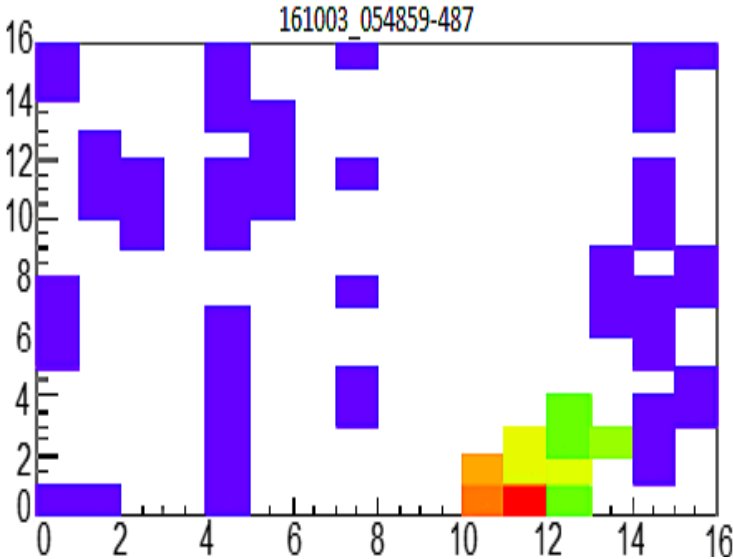
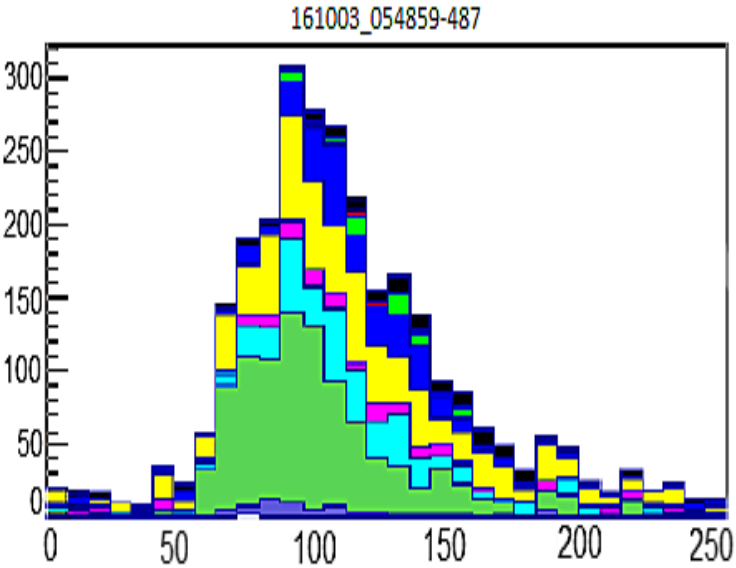
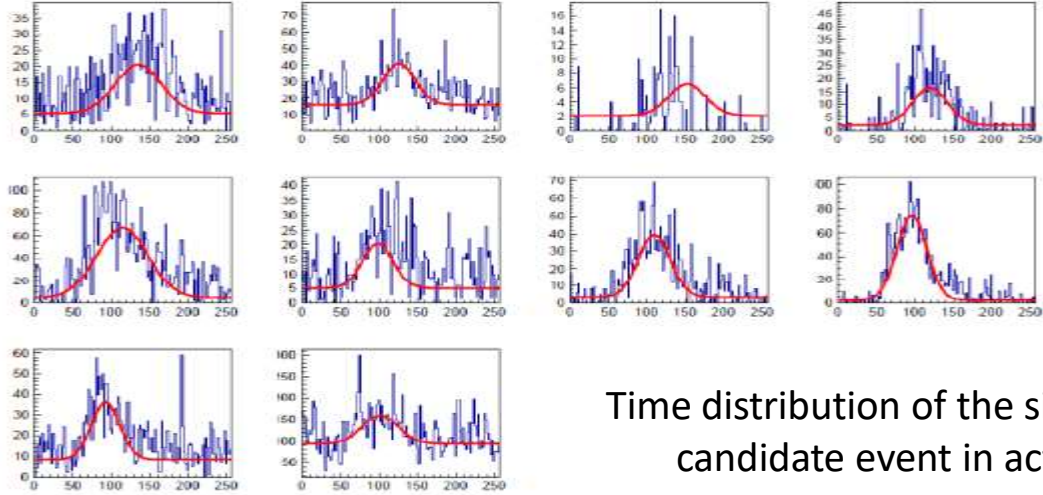


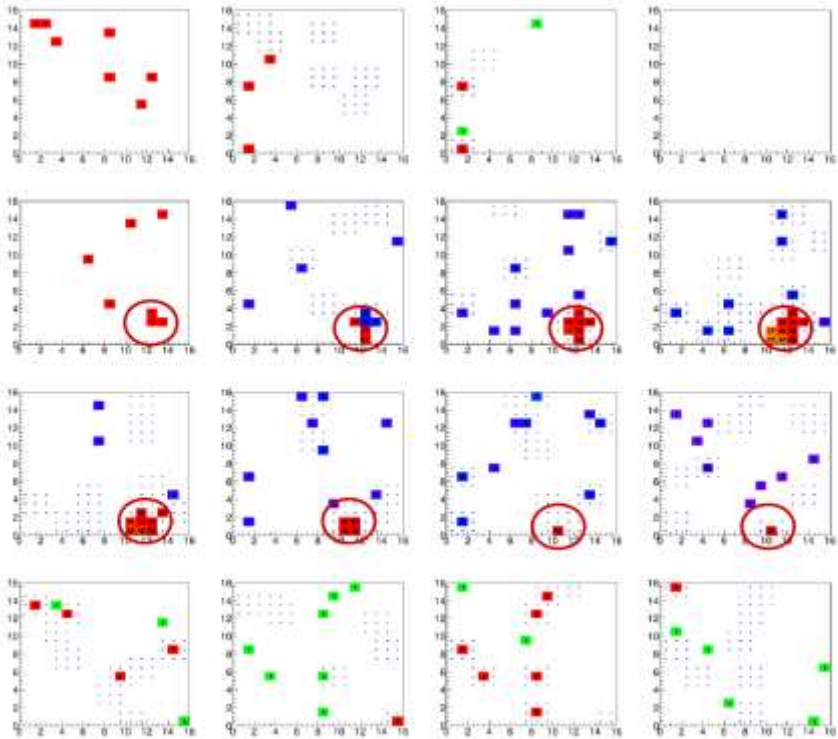
Image of the photodetector matrix with active pixels



Stack-histogram of this event



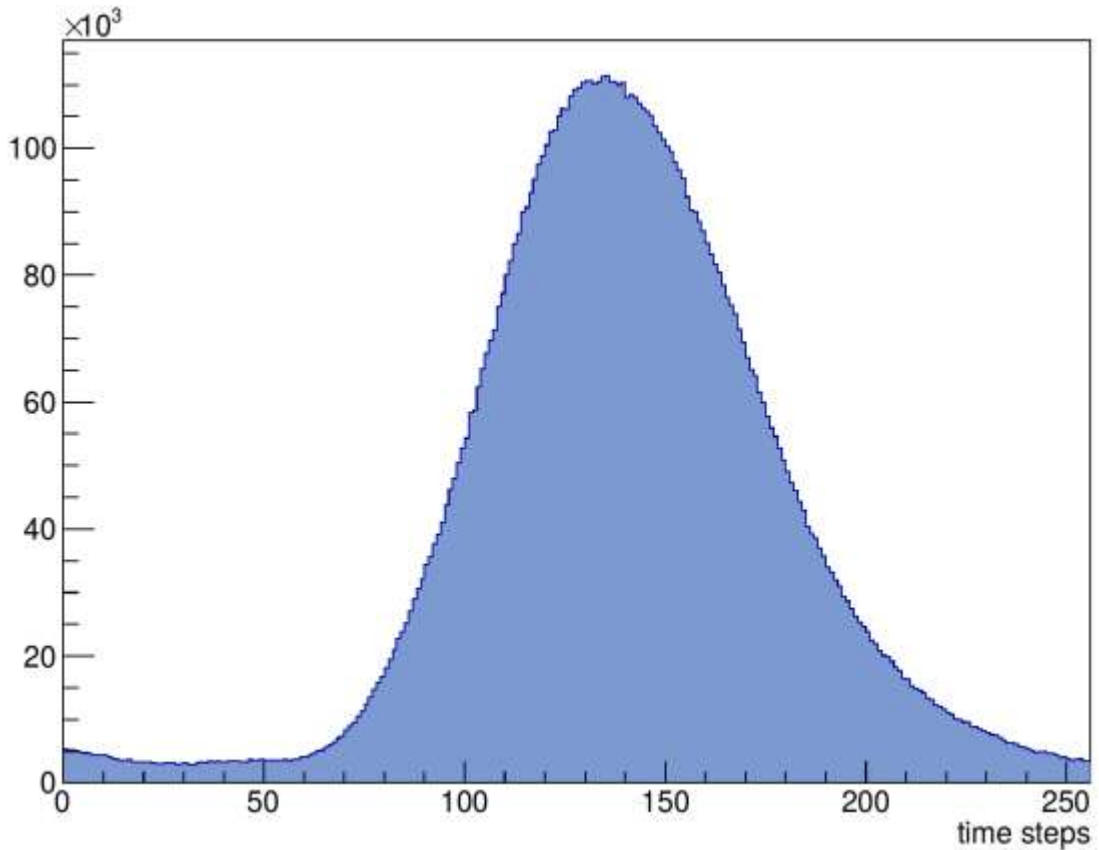
Time distribution of the signal from the candidate event in active pixels



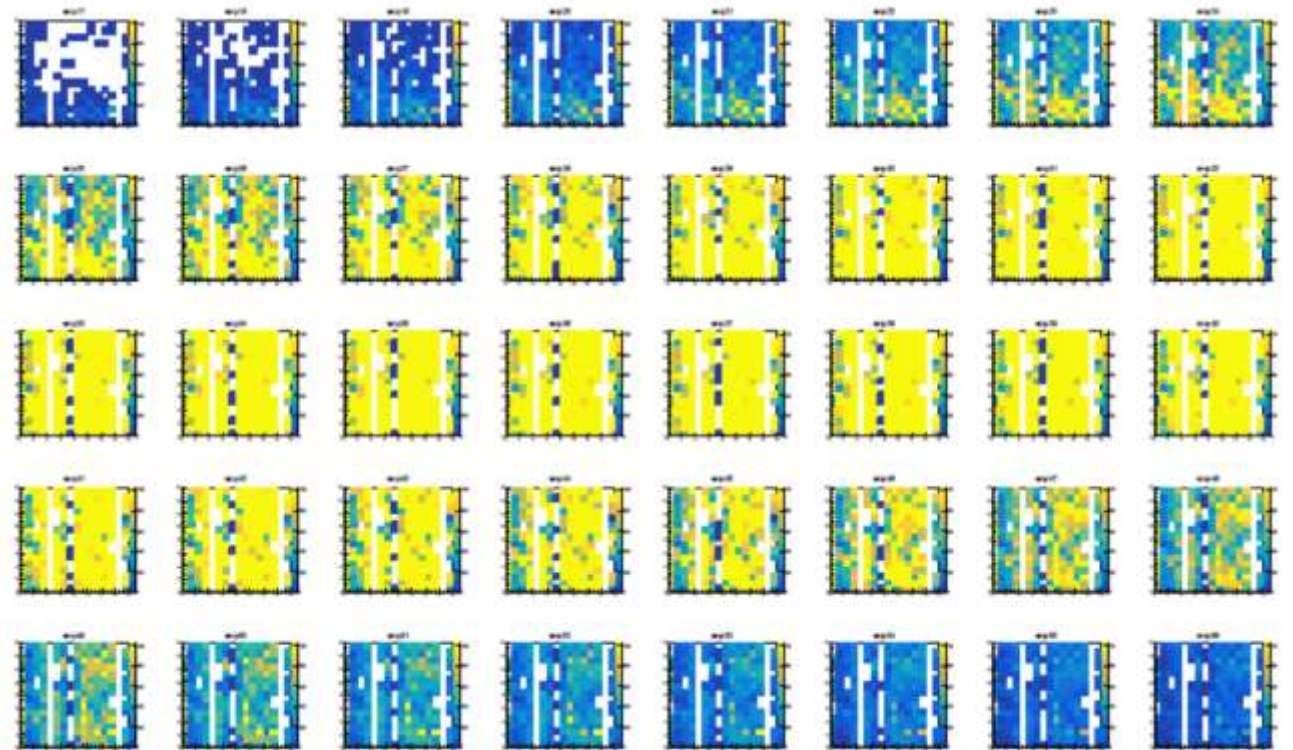
The image of the triggered pixels on a event map-plot with step  $16 \times 0.8 \mu s$

# Anomalous events

## Event №170818-072

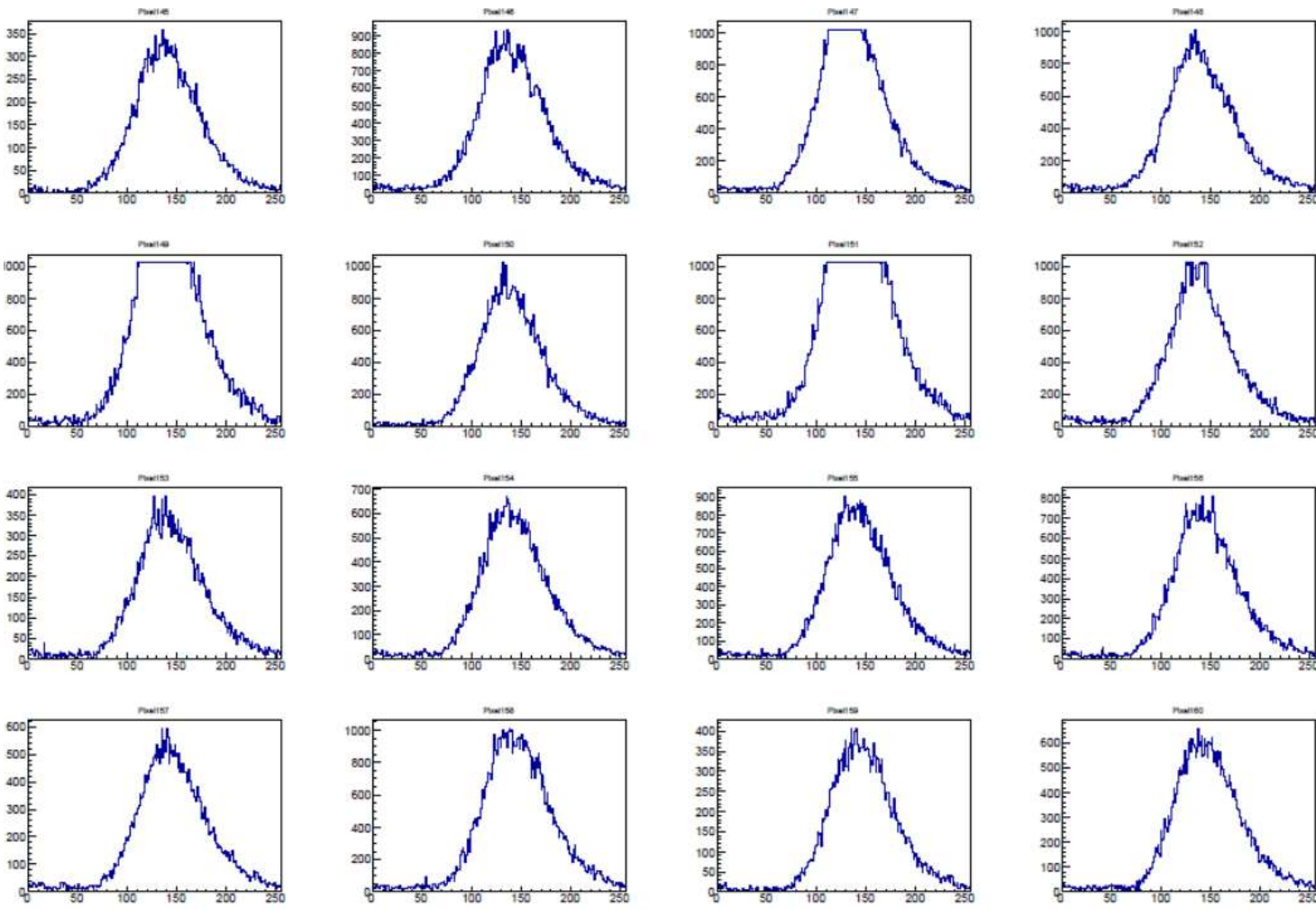


Time dependence of integral amplitude of the signal

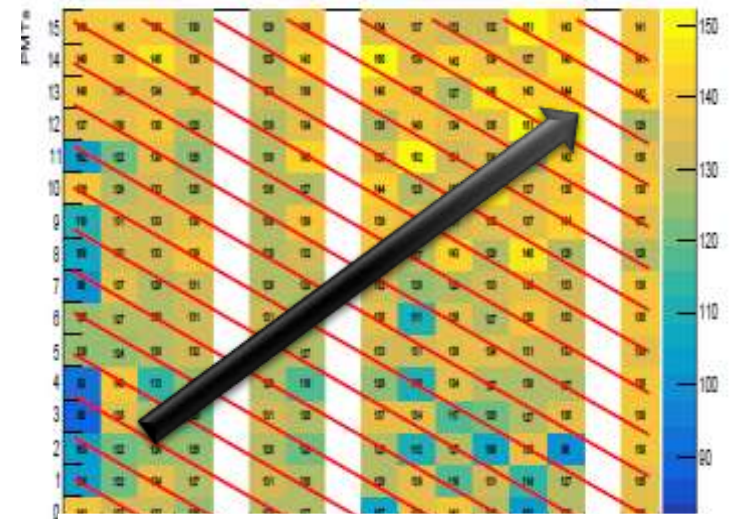


The image of the triggered pixels on a event map-plot with step  $4 \times 0.8 \mu\text{s}$

# Anomalous event №170818-072

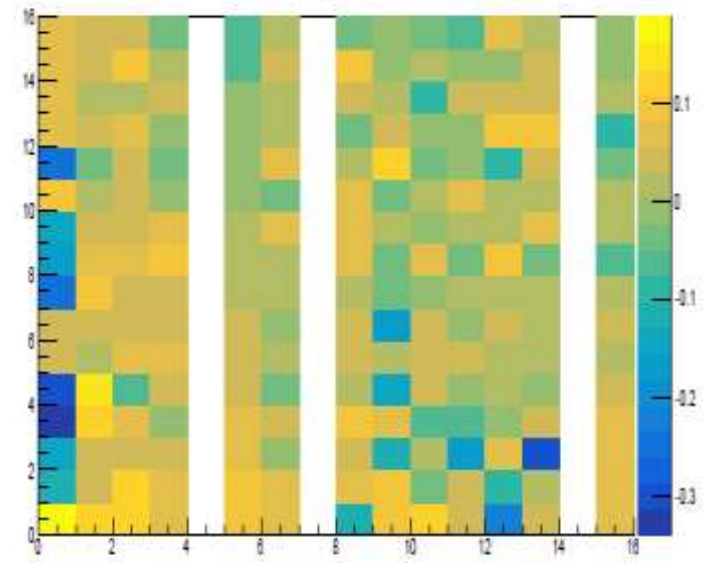


Time dependence of amplitude in 10<sup>th</sup> module



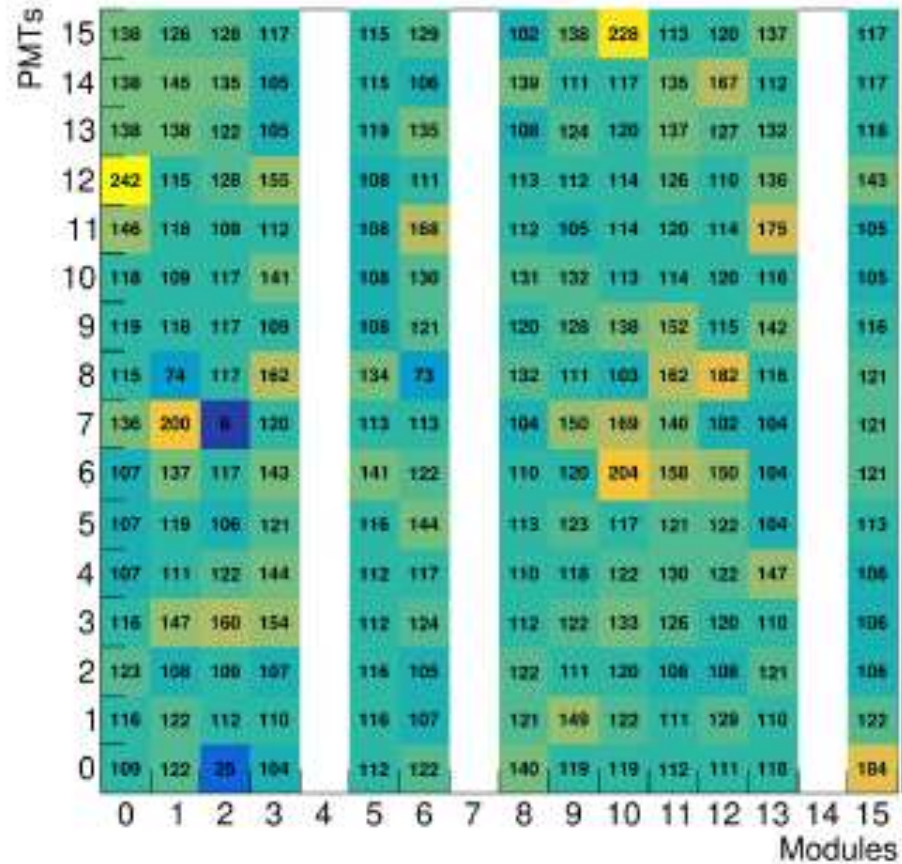
$$z = p_0 + p_1 \cdot x + p_2 \cdot y$$

fit\_CvdiIII

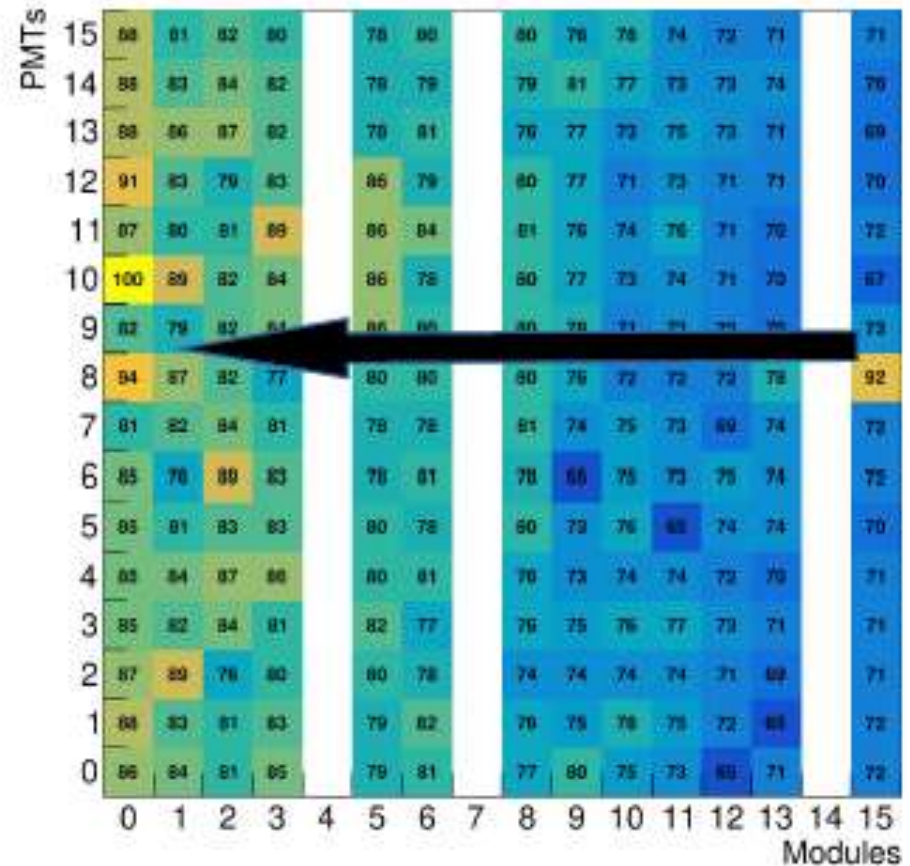


# Movement in anomalous events

Event without movement in plane of the photodetector

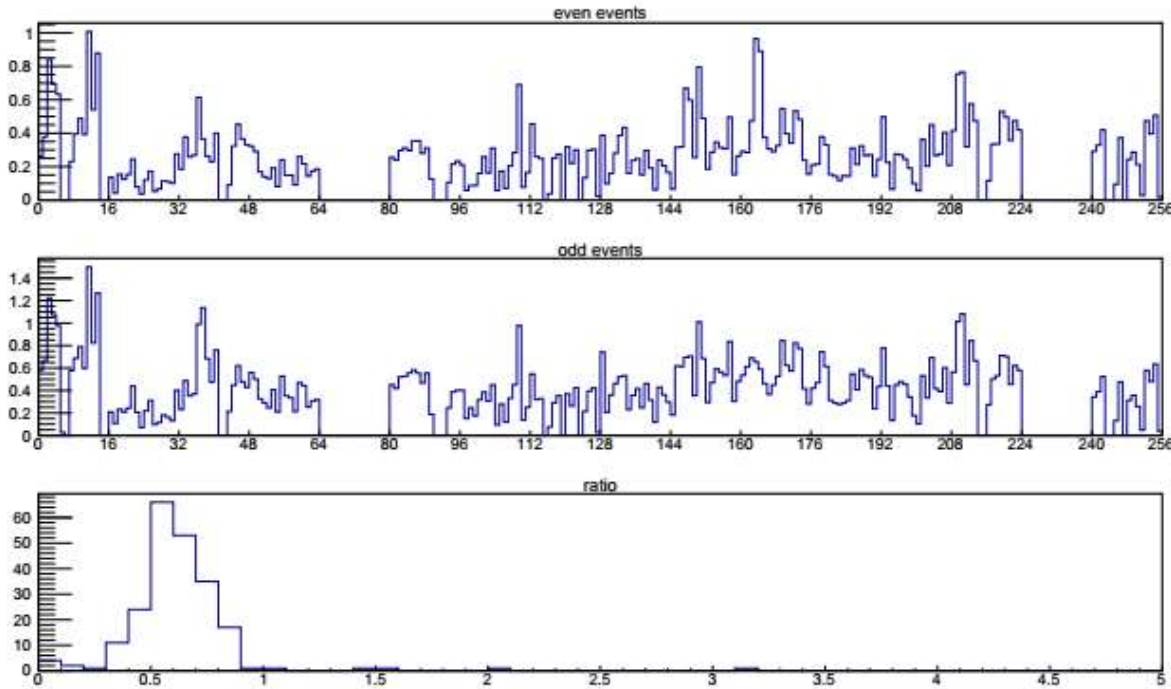


Event with movement in plane of the photodetector

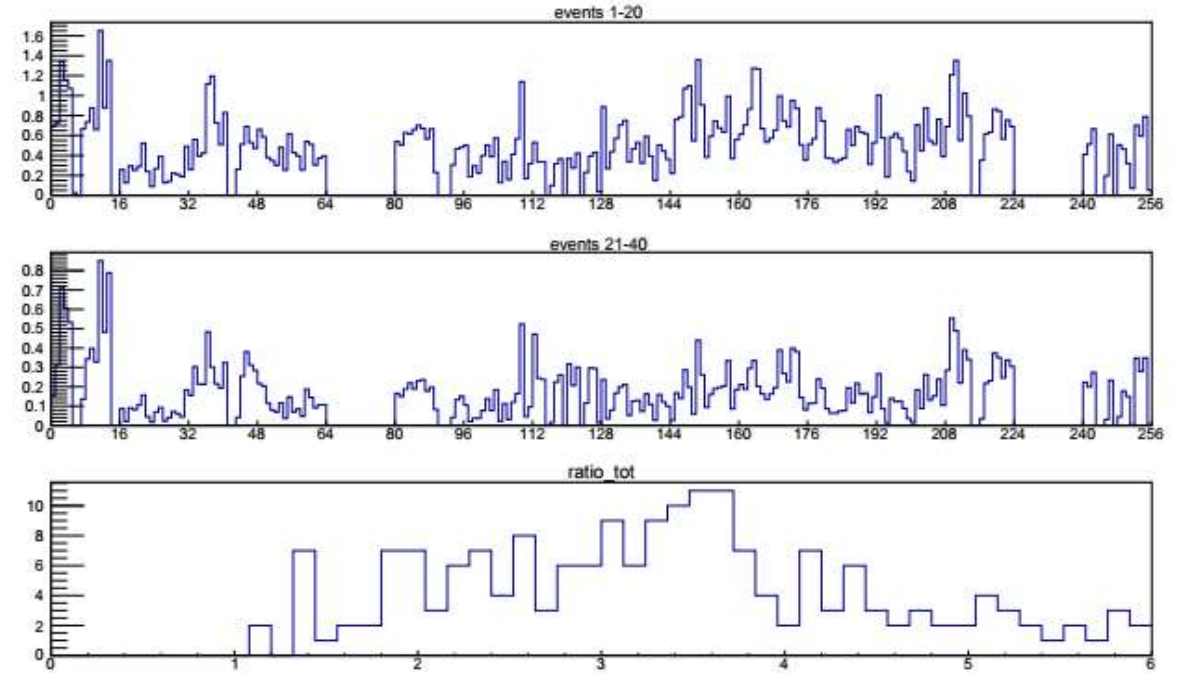


2D Distribution of the transit times of the signal amplitude maxima on the photodetector matrix.  
The arrow indicates the direction of movement of the signal

# Relative calibration of the photodetector matrix



Comparison of calibrations obtained by analyzing only odd and even events

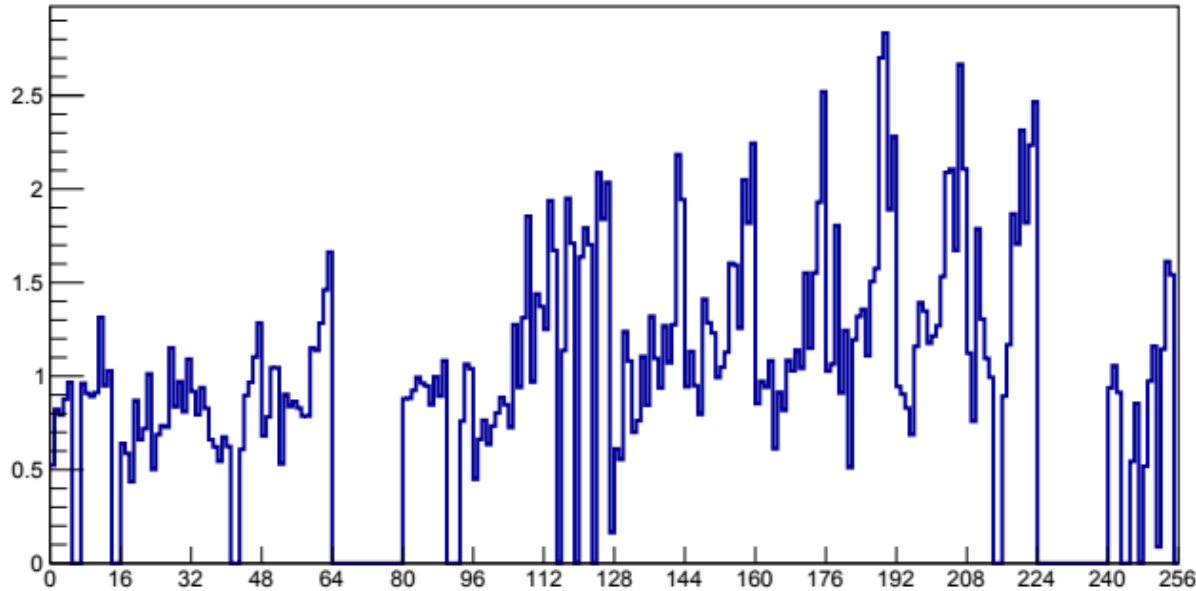


Comparison of calibrations obtained for different periods of the data set  $N \leq 20$  and  $N > 20$ .

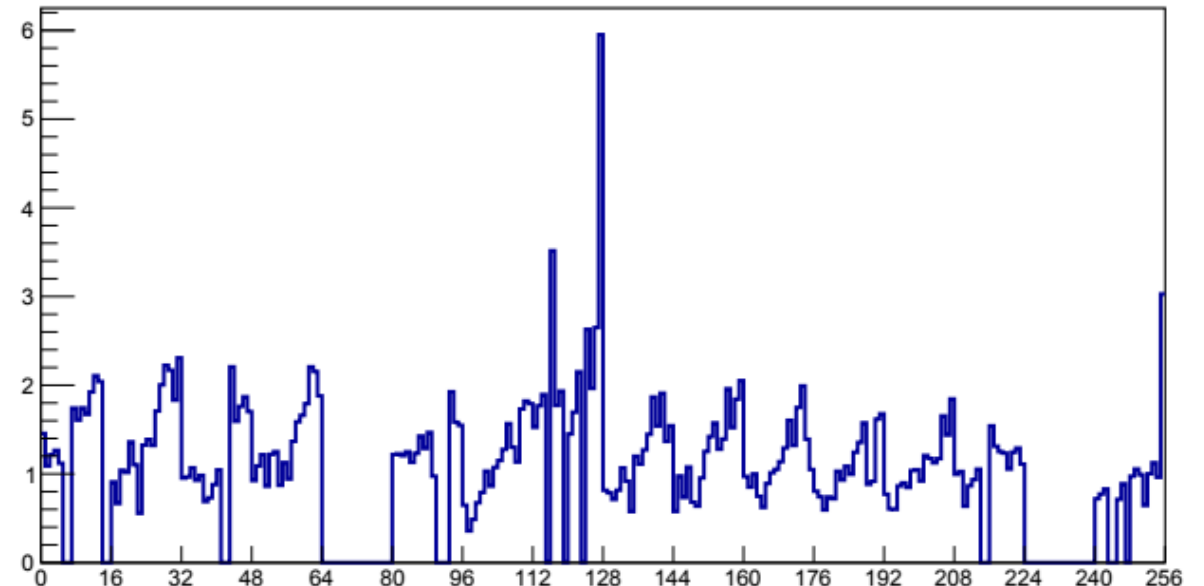


# The ratio of the calibration distributions to the calibration distribution averaged over all events

170826\_153105-270



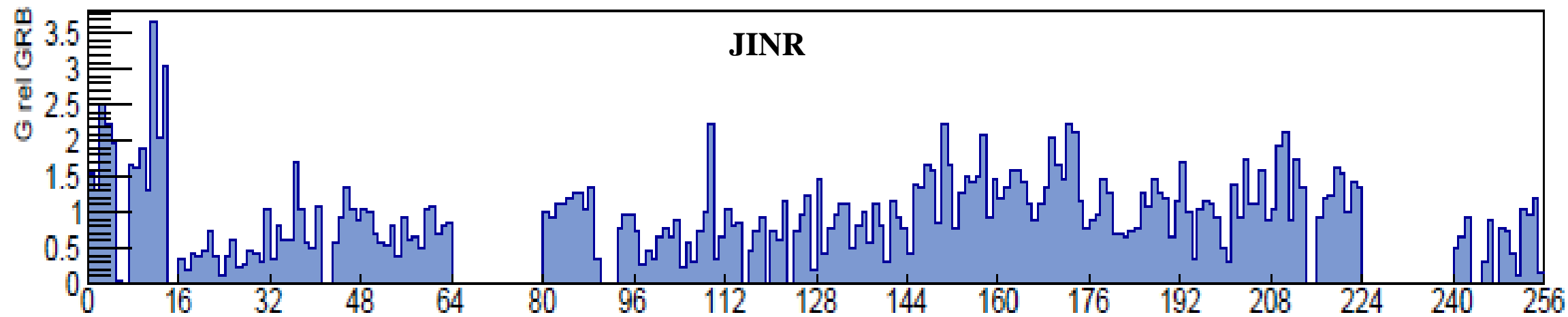
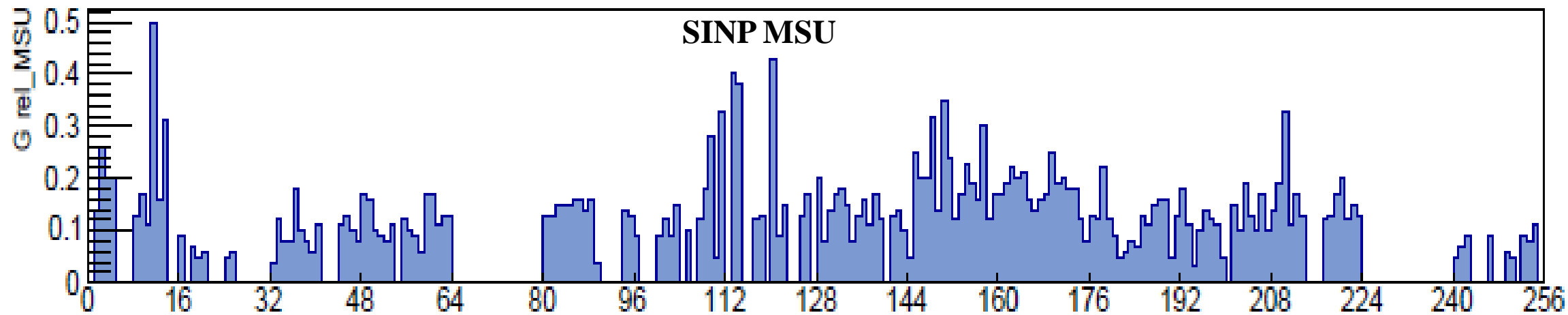
170919\_123032-130



The ratio of the calibration distributions of event 170826\_153105-270 and 170919\_123032-130 to the calibration distribution averaged over all events.

Thank you for your attention!

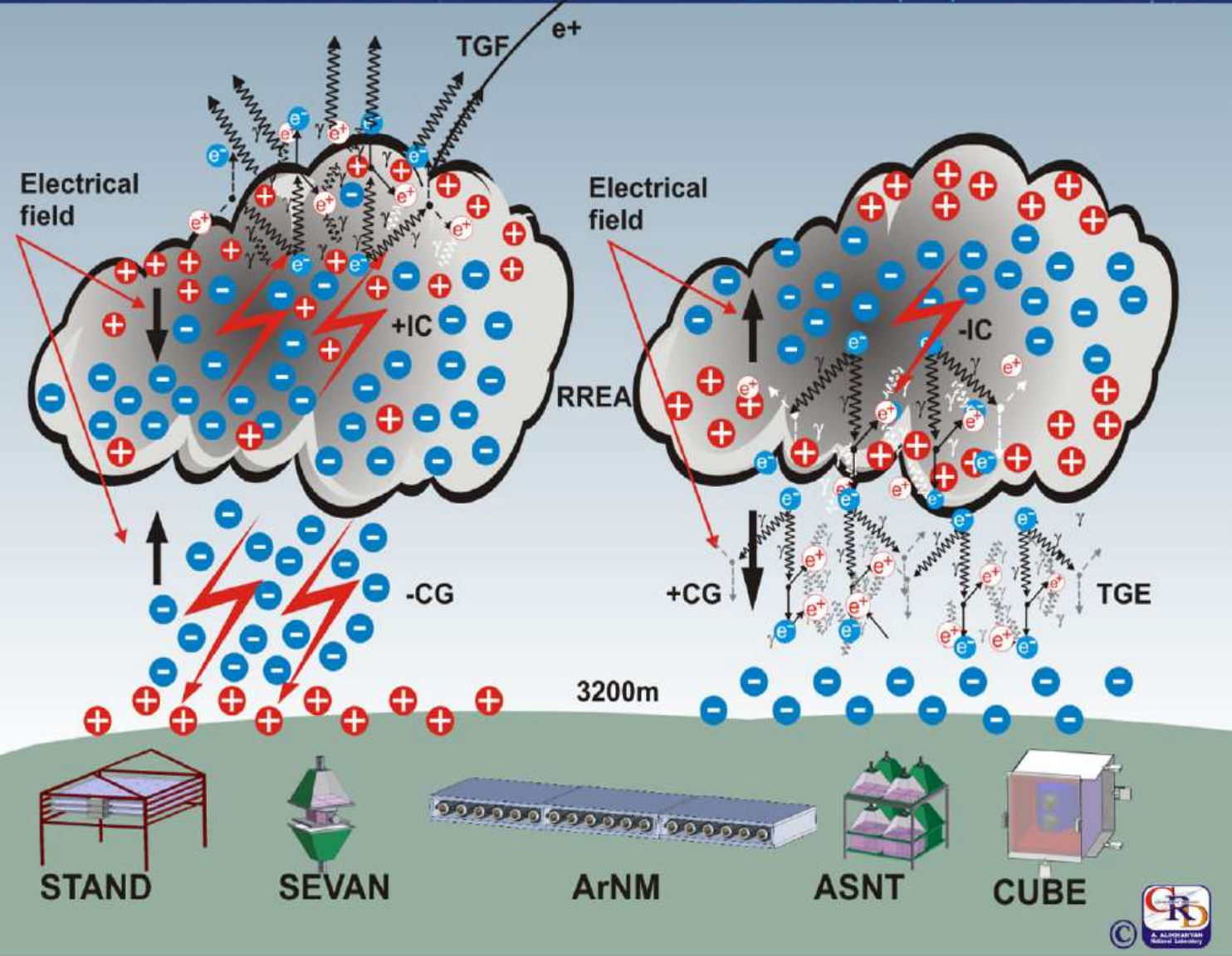
[blinov@jinr.ru](mailto:blinov@jinr.ru)



**Backup slides**

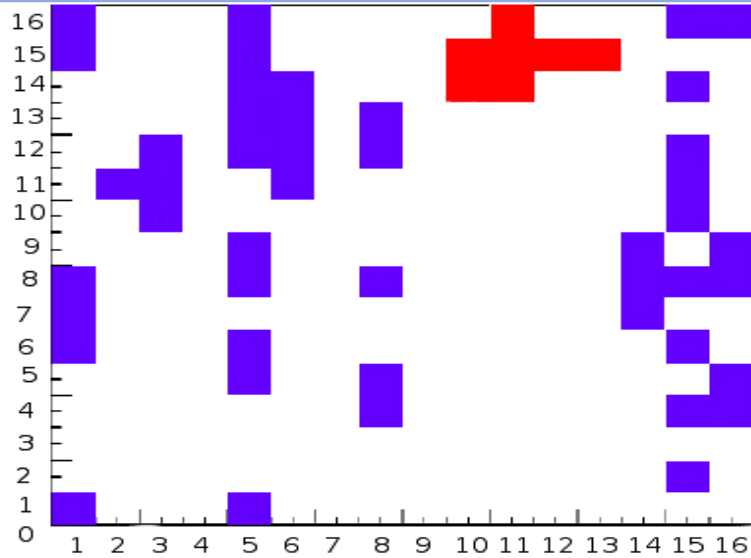


**Terrestrial gamma-ray flashes (TGFs)**—короткая гамма вспышка, рожденная в атмосфере.

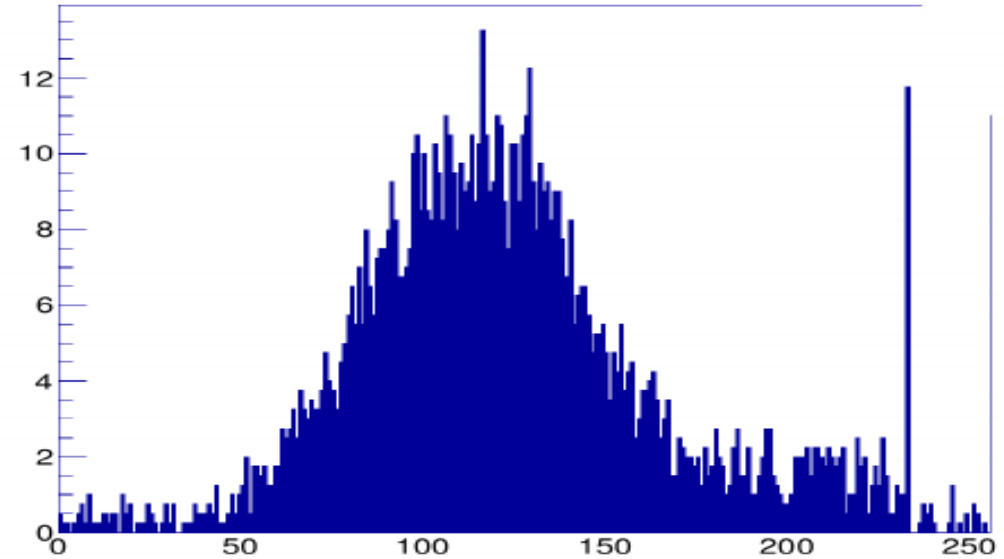


PHYSICAL REVIEW D 83, 062001 (2011)  
**Particle bursts from thunderclouds: Natural particle accelerators above our heads**  
 Ashot Chilingarian, Gagik Hovsepyan, and Armen Hovhannisyann

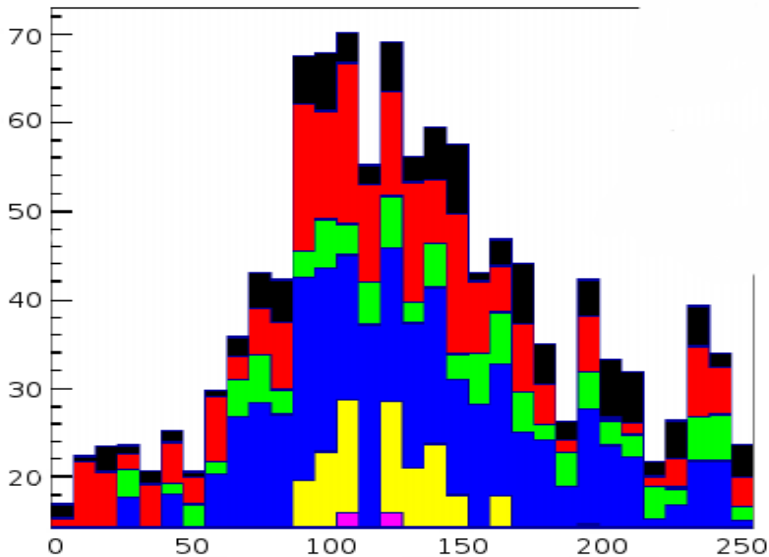
# Шалоподобные события



Изображение события со сработавшими пикселями и не работающими(синие)



ESAF MC event.  $E = 10^{20}$  эВ,  $\theta = 60^\circ$



Пример шалопоподобного события

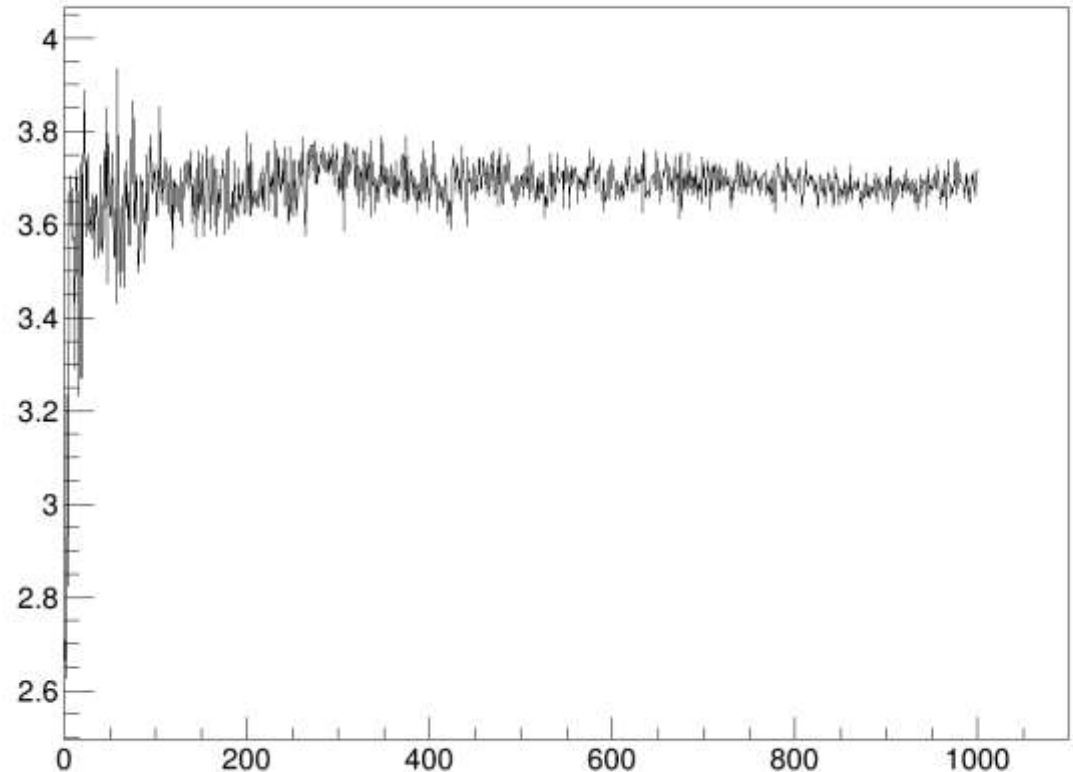


Географическое распределение шалопоподобных событий.

## Количество фотонов от восходящего ШАЛ

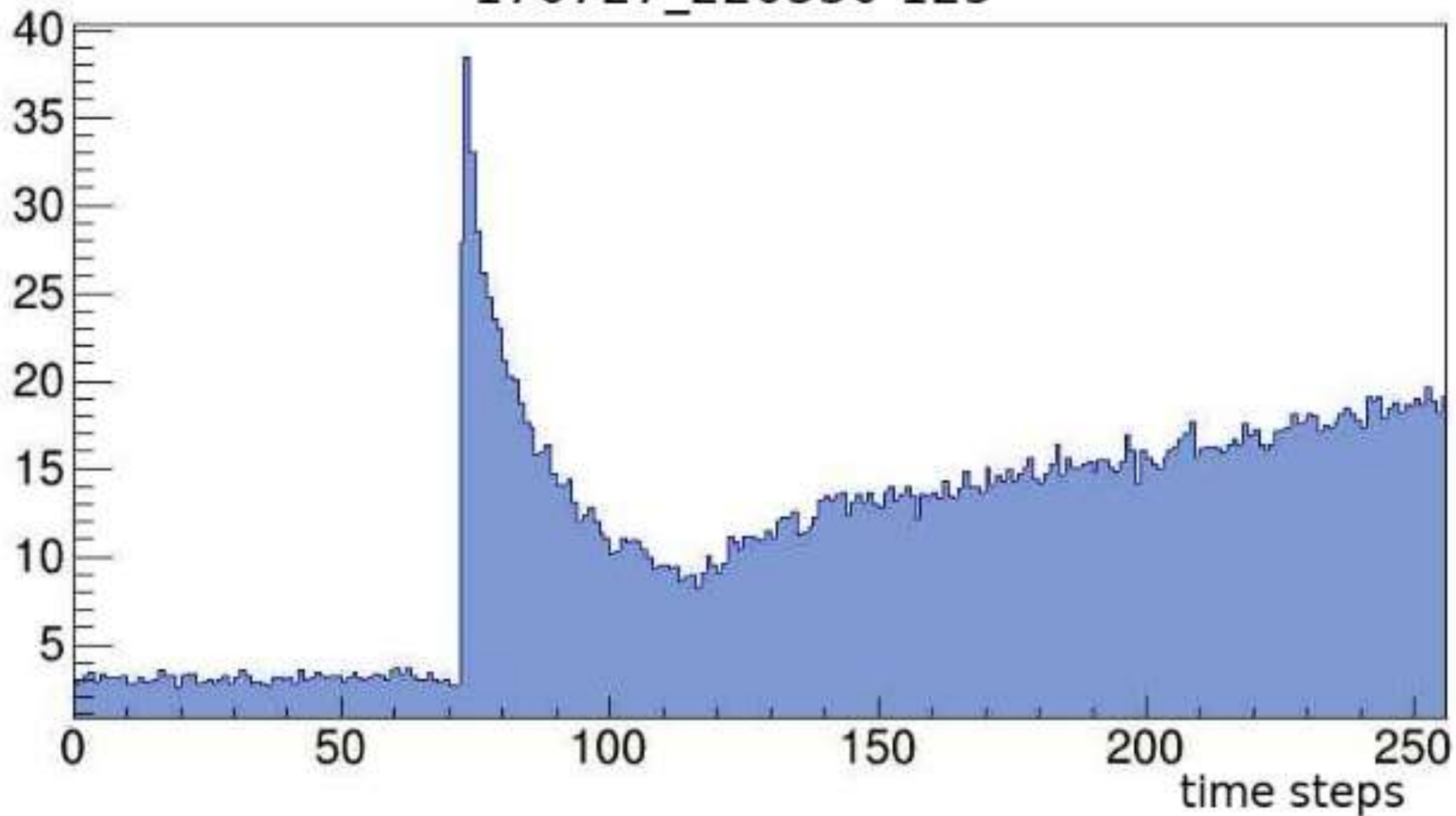
Была взята плоскость, радиусом 1 км. При прохождении через нее черенковских фотонов происходила запись. На данном слайде представлены графики распределения по радиусу нормированное на квадратный метр для двух случаев : Энергия первоначального протона 1 ТэВ и 100 ТэВ.

Graph



# Integral histogram of the time dependence amplitude on time of combined event

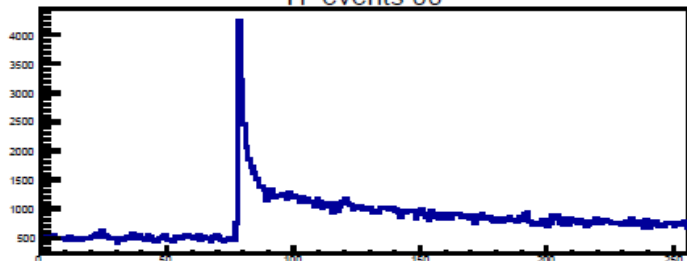
170727\_220330-125



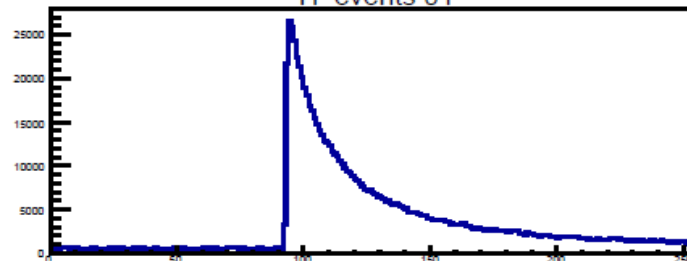


# The time dependence of the total signal amplitude for several anomalous events

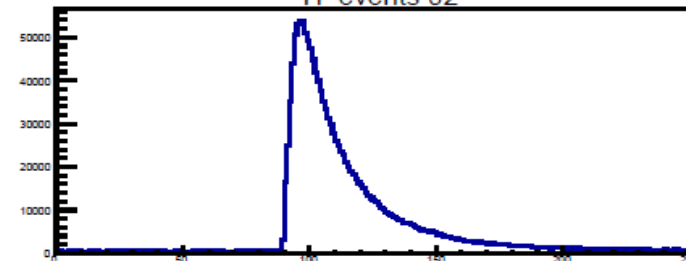
H events 00



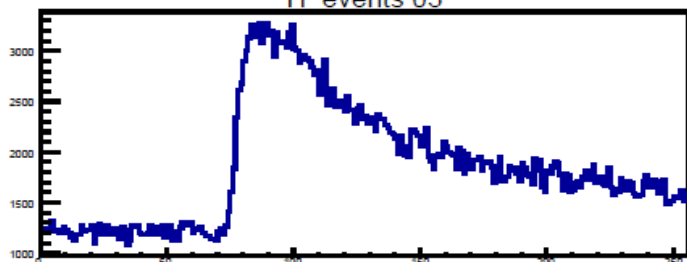
H events 01



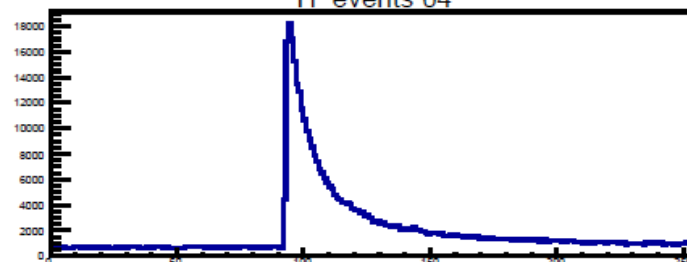
H events 02



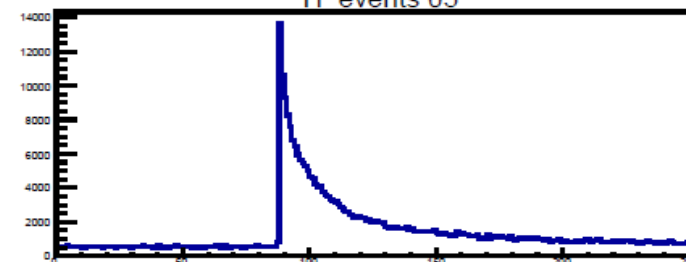
H events 03



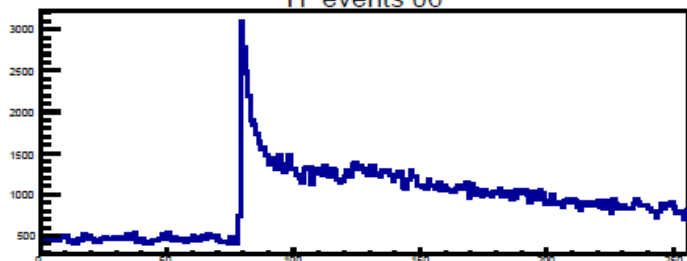
H events 04



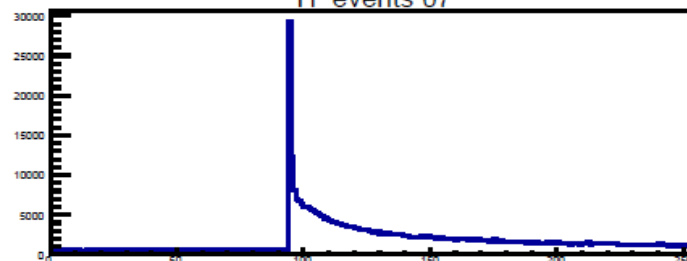
H events 05



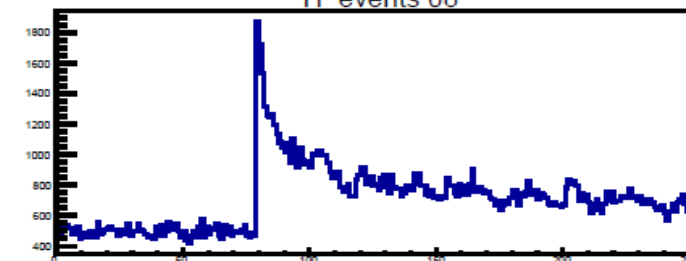
H events 06



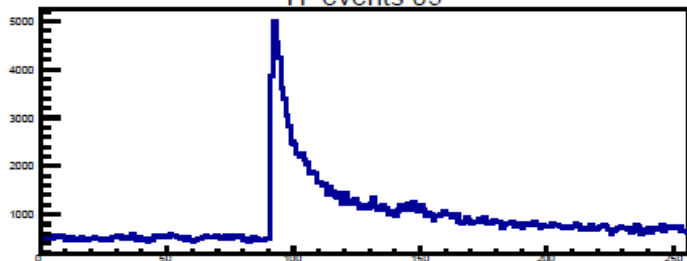
H events 07



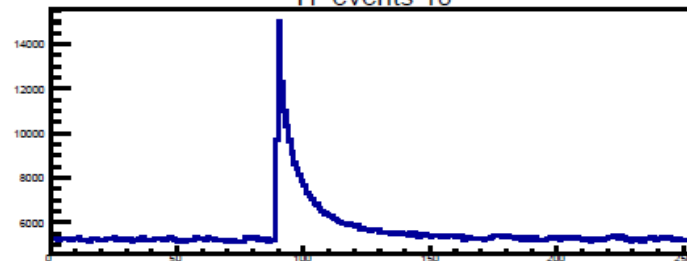
H events 08



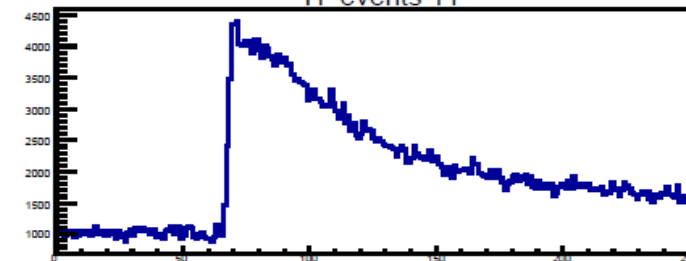
H events 09



H events 10

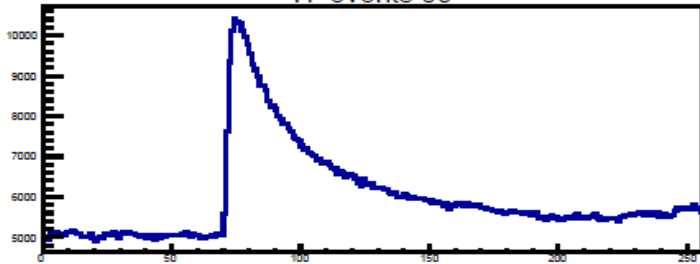


H events 11

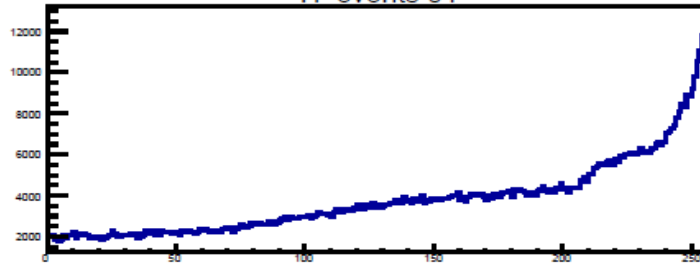


# The time dependence of the total signal amplitude for several anomalous events

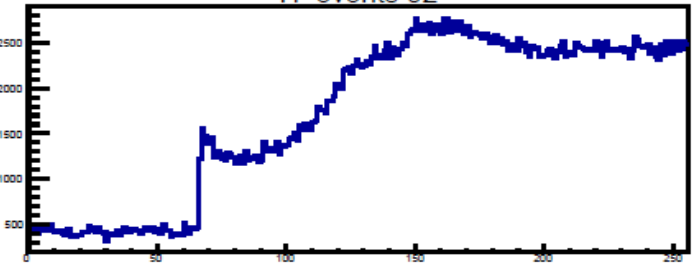
H events 00



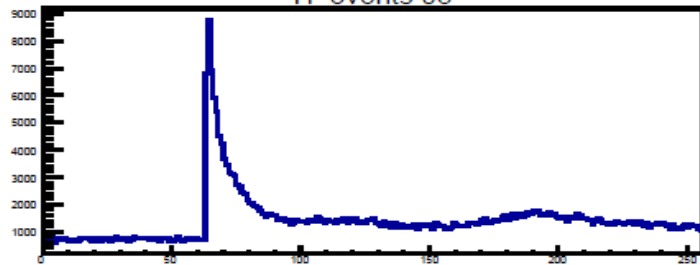
H events 01



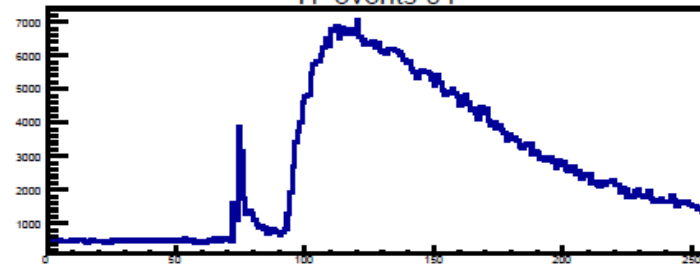
H events 02



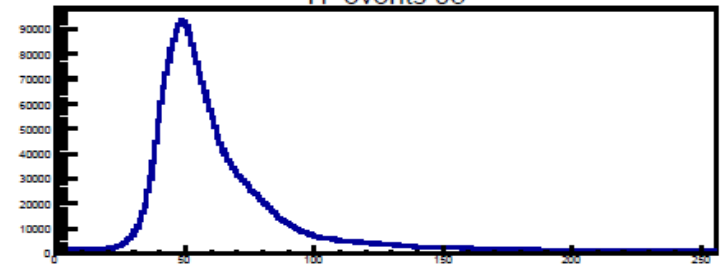
H events 03



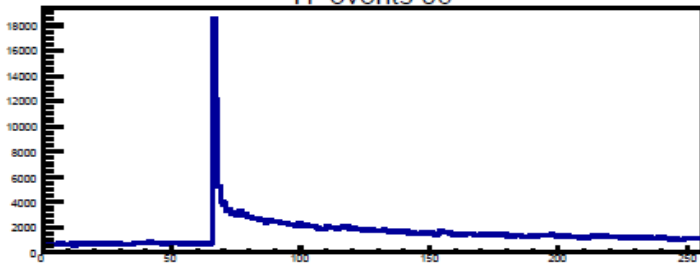
H events 04



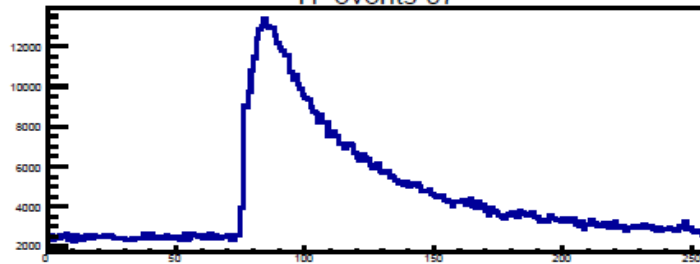
H events 05



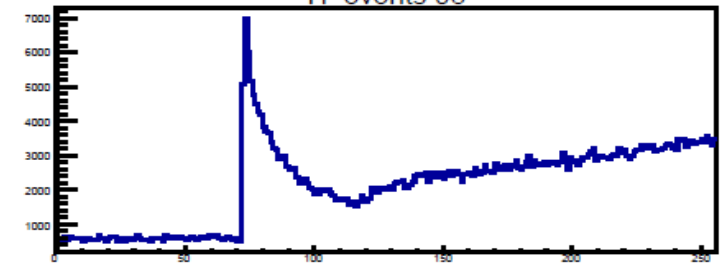
H events 06



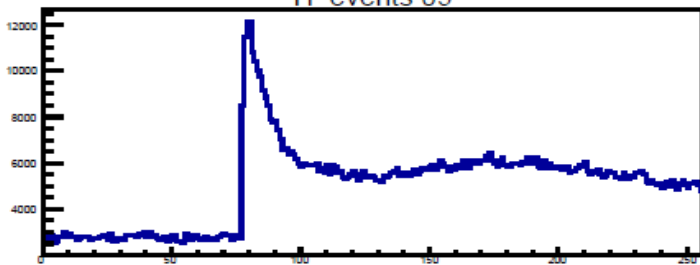
H events 07



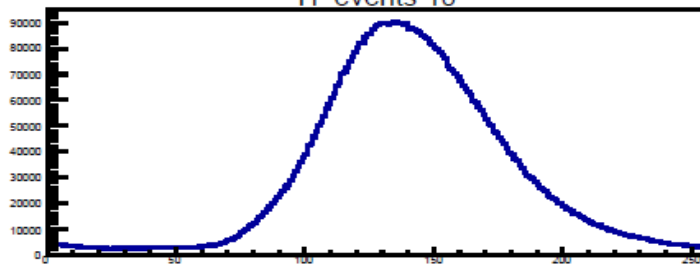
H events 08



H events 09



H events 10



H events 11

