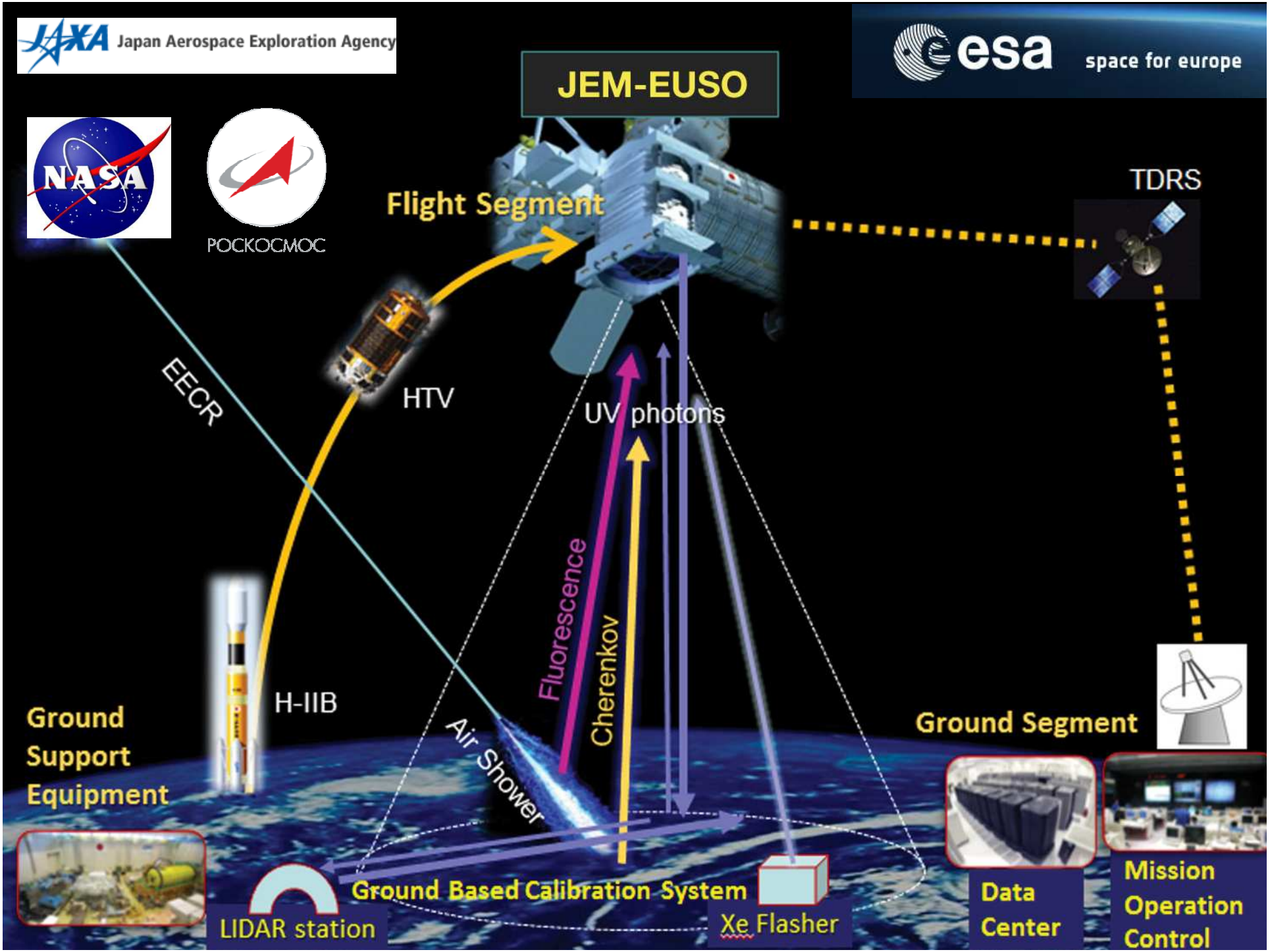
TEST OF THE ALGORITHM EMPLOYED IN THE 1ST TRIGGER LEVEL OF THE JEM-EUSO EXPERIMENT

ANIKE N. BOWAIRE
IMAG2E 2013
UFR
UNIVERSITÉ DE NICE FRANCE

The JEM-EUSO experiment

JEM-EUSO (Extreme Universe Space Observatory on Japanese Experiment Module) is a new type observatory to detect extreme-energy cosmic rays (EECR) and neutrinos as its main objective of exploration.

- To measure the cosmic rays energy spectrum $\left(10^{19.5} eV < E < 10^{21} eV\right)$
- Orbit at the altitude ~400 km
- Super-wide FoV $\left(\pm 30^{\circ}\right)$
- Viewing at night atmosphere in $> 1.4x10^{5} km^{2}$ area
- One orbit is every 90 minutes


Japan Aerospace Exploration Agency
JEM-EUSO
esa
space for europe
NASA
POCKOCMOC
Flight Segment
TDRS
EECR
HTV
UV photons
Fluorescence
Cherenkov
H-IIB
Air Shower
Ground
Support
Equipment
Ground Segment
Ground Based Calibration System
LIDAR station
Xe Flasher
Data
Center
Mission
Operation
Control

JEM-EUSO Telescope

Bus System: JAXA

Optics

Rear Fresnel Lens

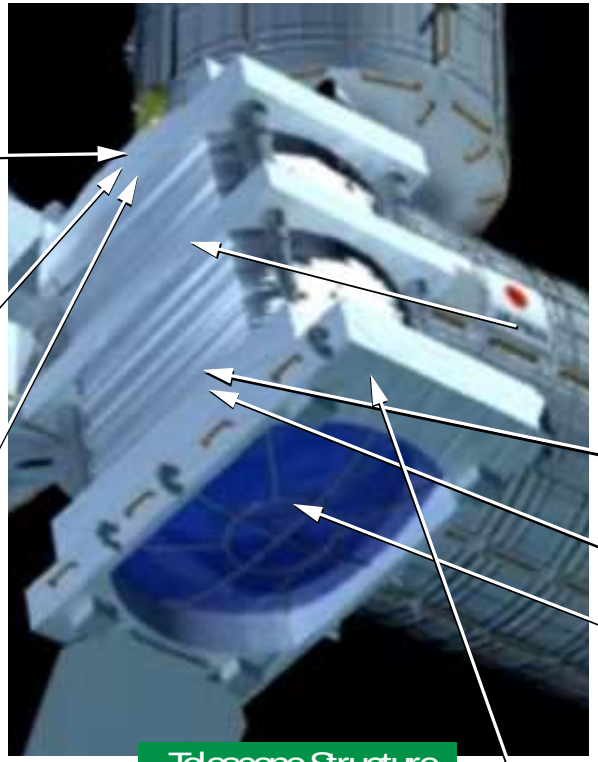
Diffractive and Fresnel Lens

Iris

DAQ Electronics

Support Structure

Focal Surface Detector

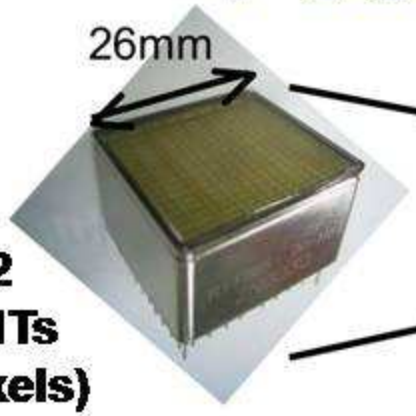


Telescope Structure

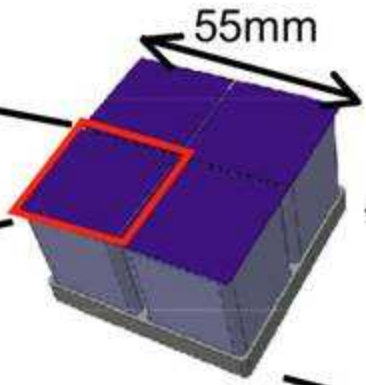
Front Fresnel Lens

Atmospheric Monitoring

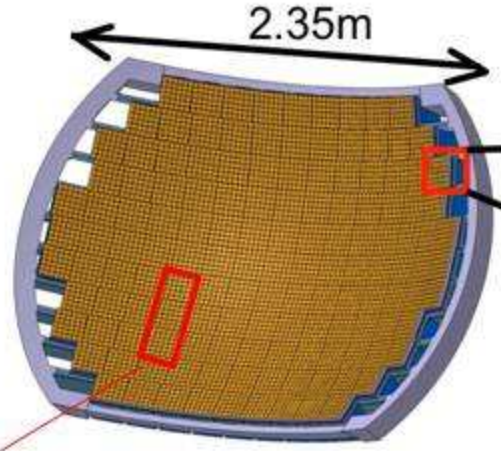
Focal Surface Detector

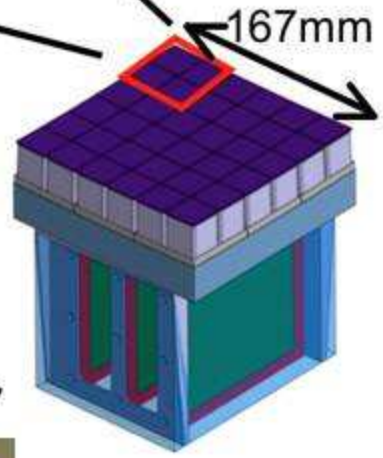


4932 MAPMTs (8x8 pixels)



Elementary Cell (EC) (2x2 PMTs = 256 pixels)





Focal Surface detector 137 PDMs = 0.3M Pixels

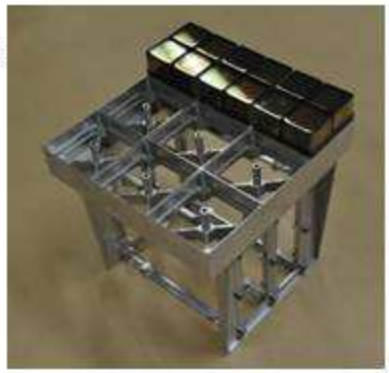
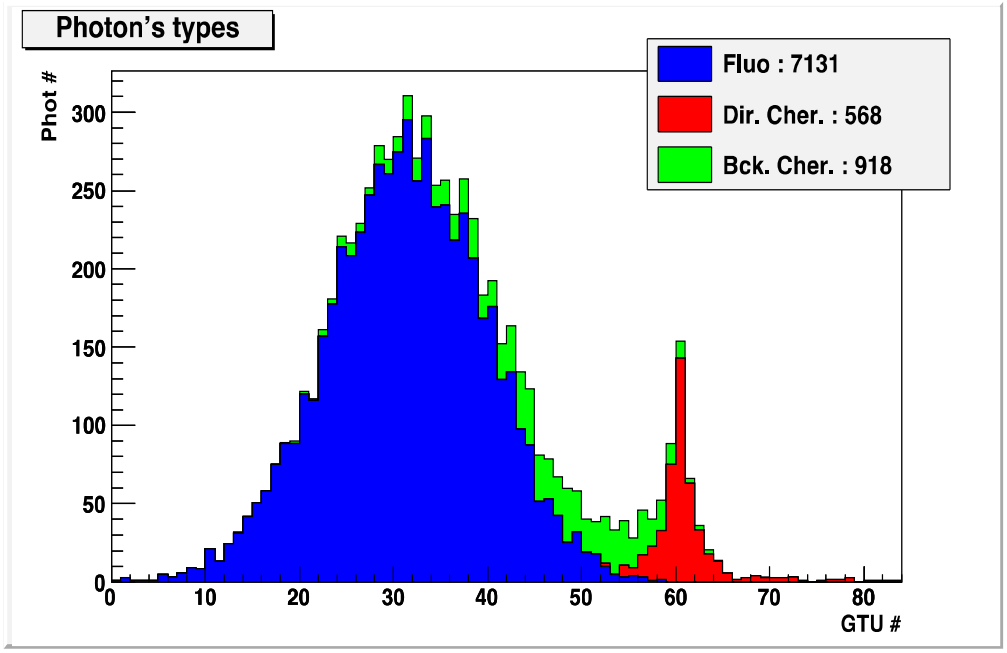


Photo-Detector Module (PDM) (3x3 ECs = 36 PMTS 2,304 pixels)

1 High Voltage / PDM

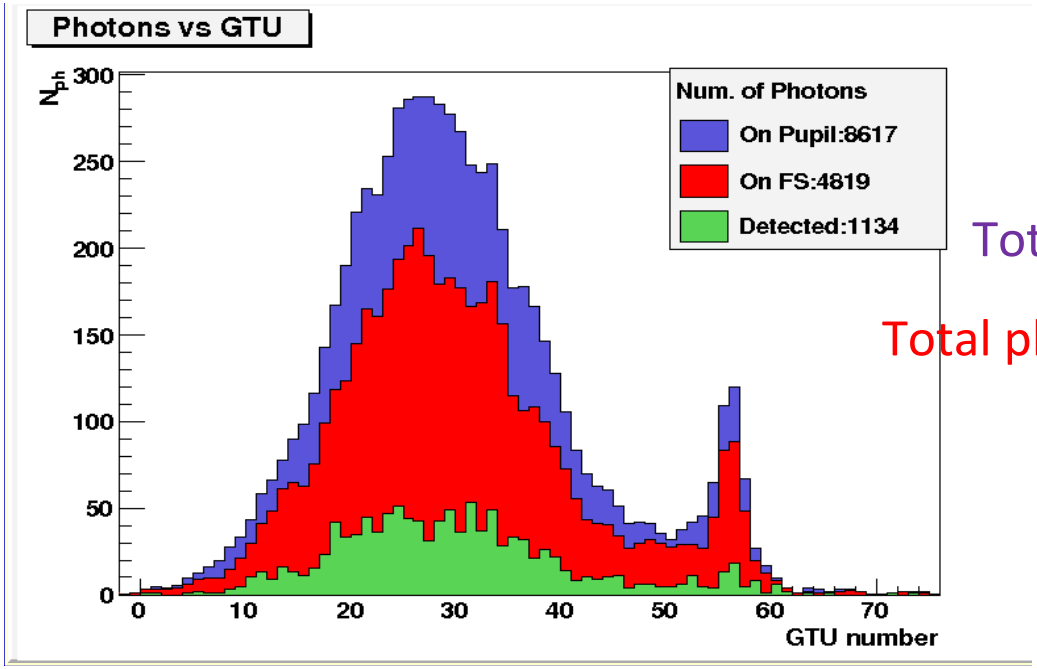


Fluorescence

Scattered Cherenkov

Diffusively reflected Cherenkov

$$1 \text{ Gate Time Unit } (GTU) = 2.5\ \mu\text{sec}$$



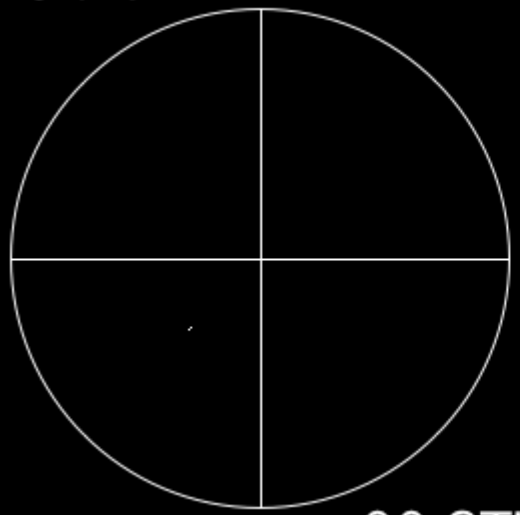
Total photon enter on telescope

Total photon enter the Focal Surface

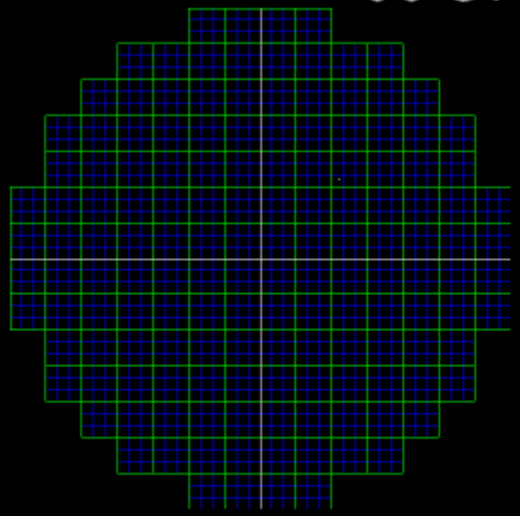
Total photon detected

The JEM-EUSO observe cosmic rays

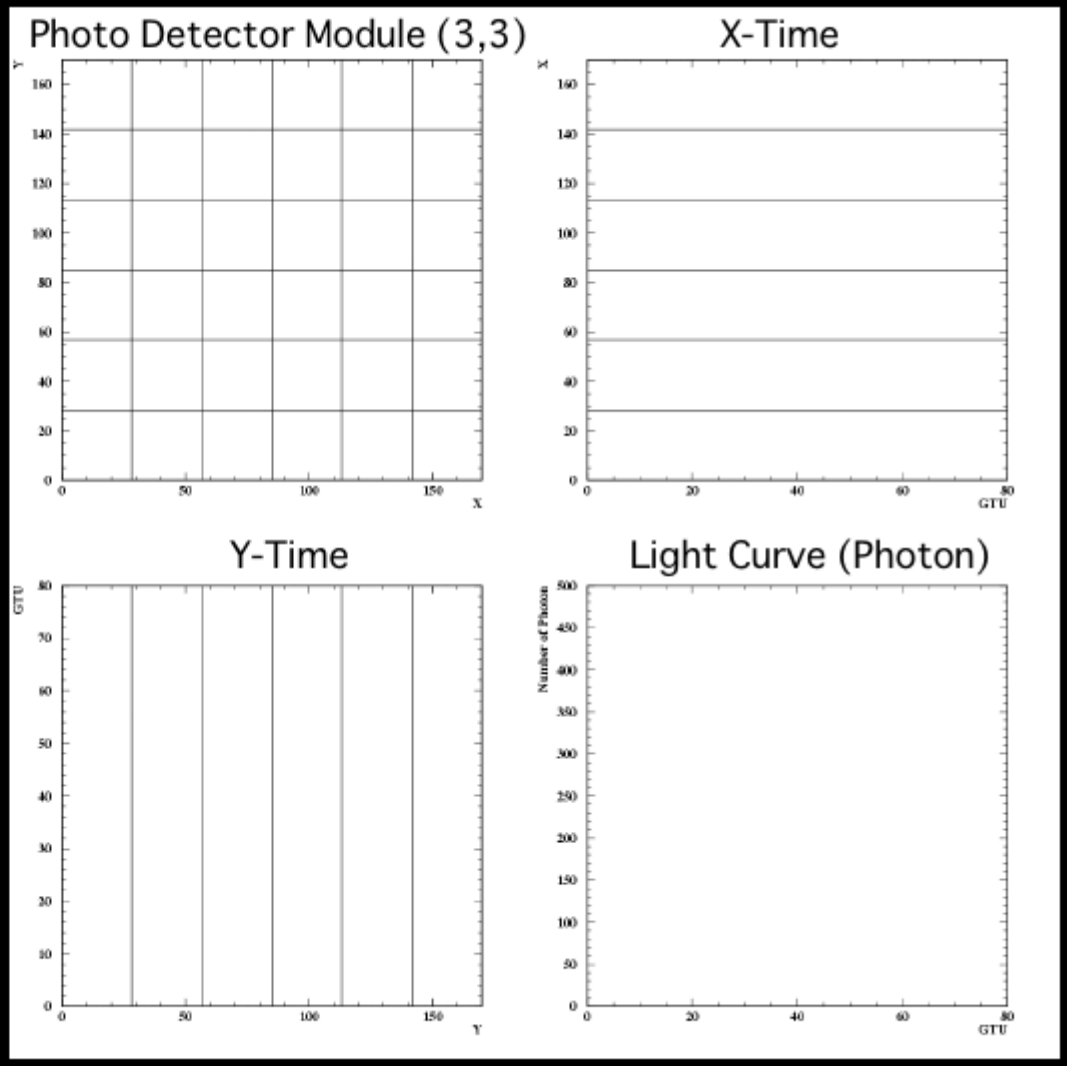
Air Shower



00 GTU

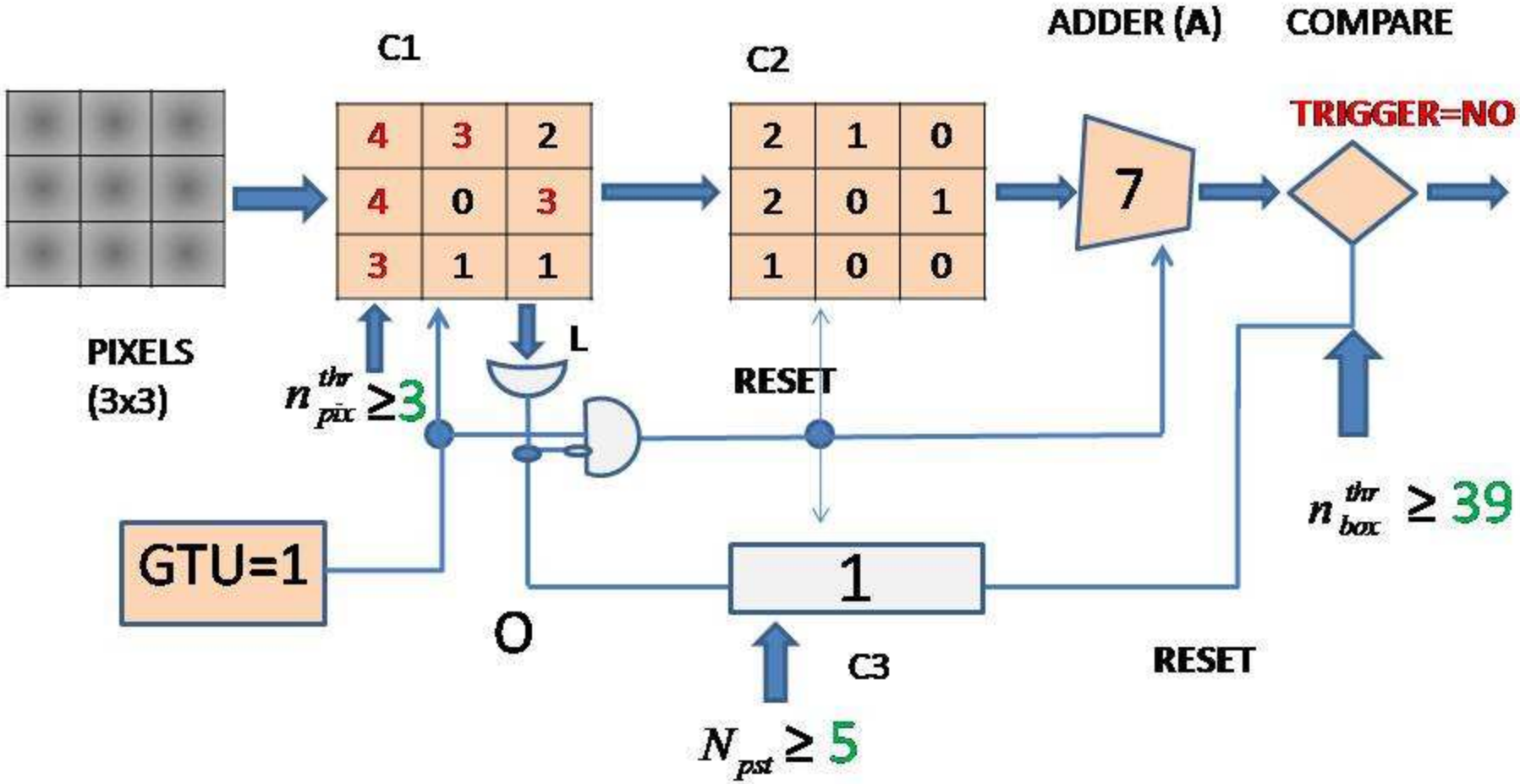


EUSO Focal Surface



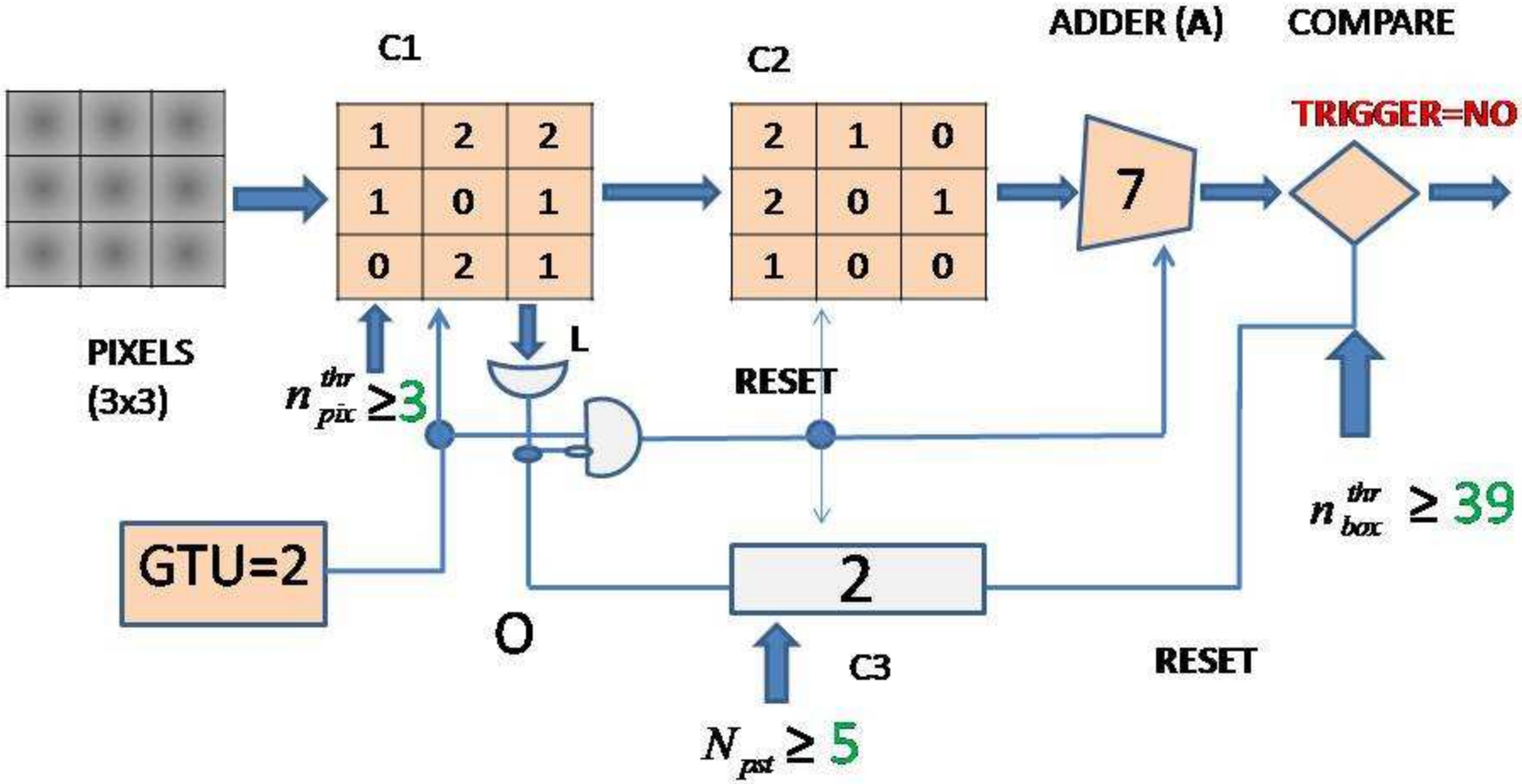
THE GTU COLLECTED FOR AN EVENT OF $1 \cdot 10^{20}$ eV

EXAMPLE: TRIGGER IS NOT ISSUED



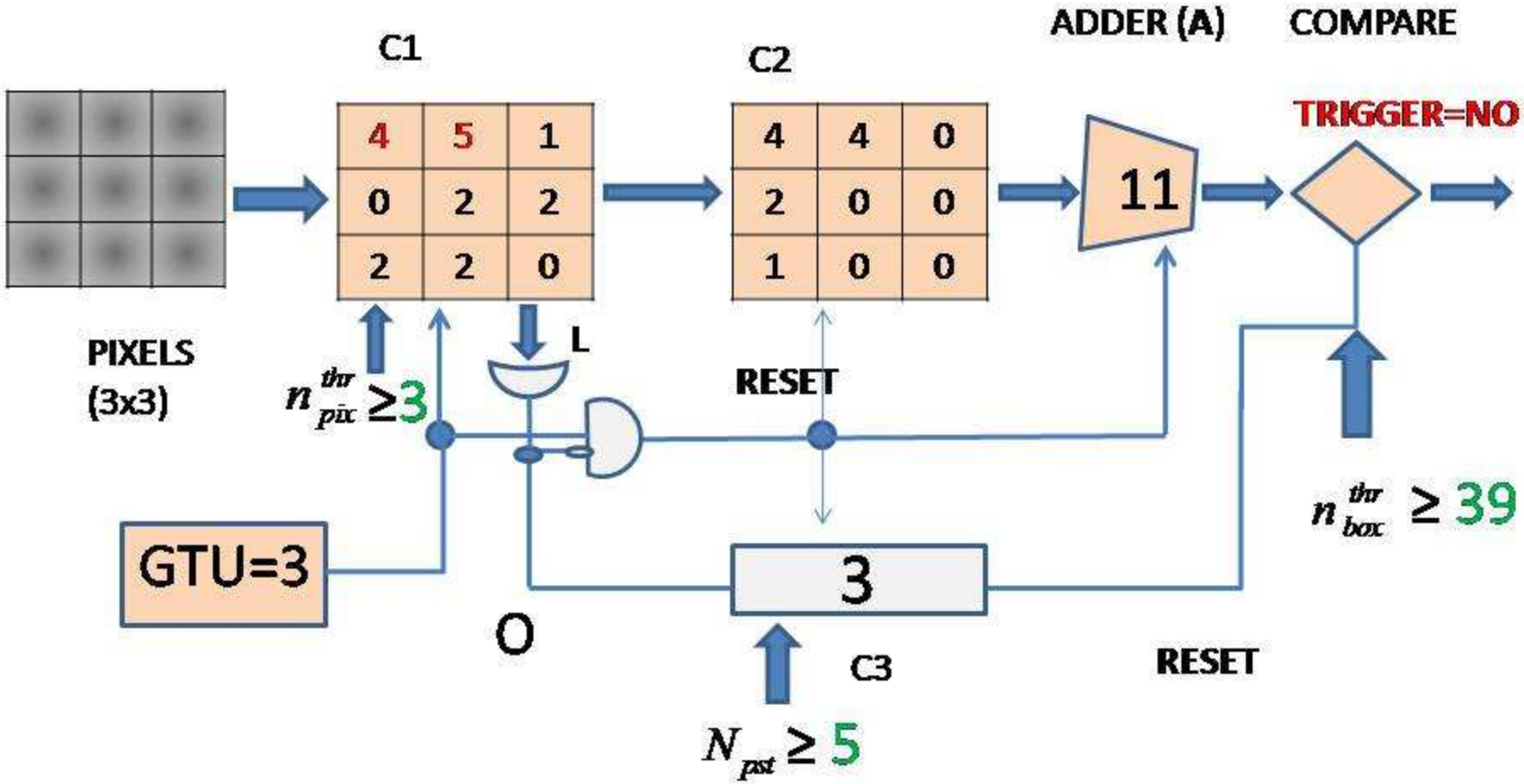
$$N_{C2} = N_{C1} - n_{pix}^{thr} + 1$$

EXAMPLE: TRIGGER IS NOT ISSUED



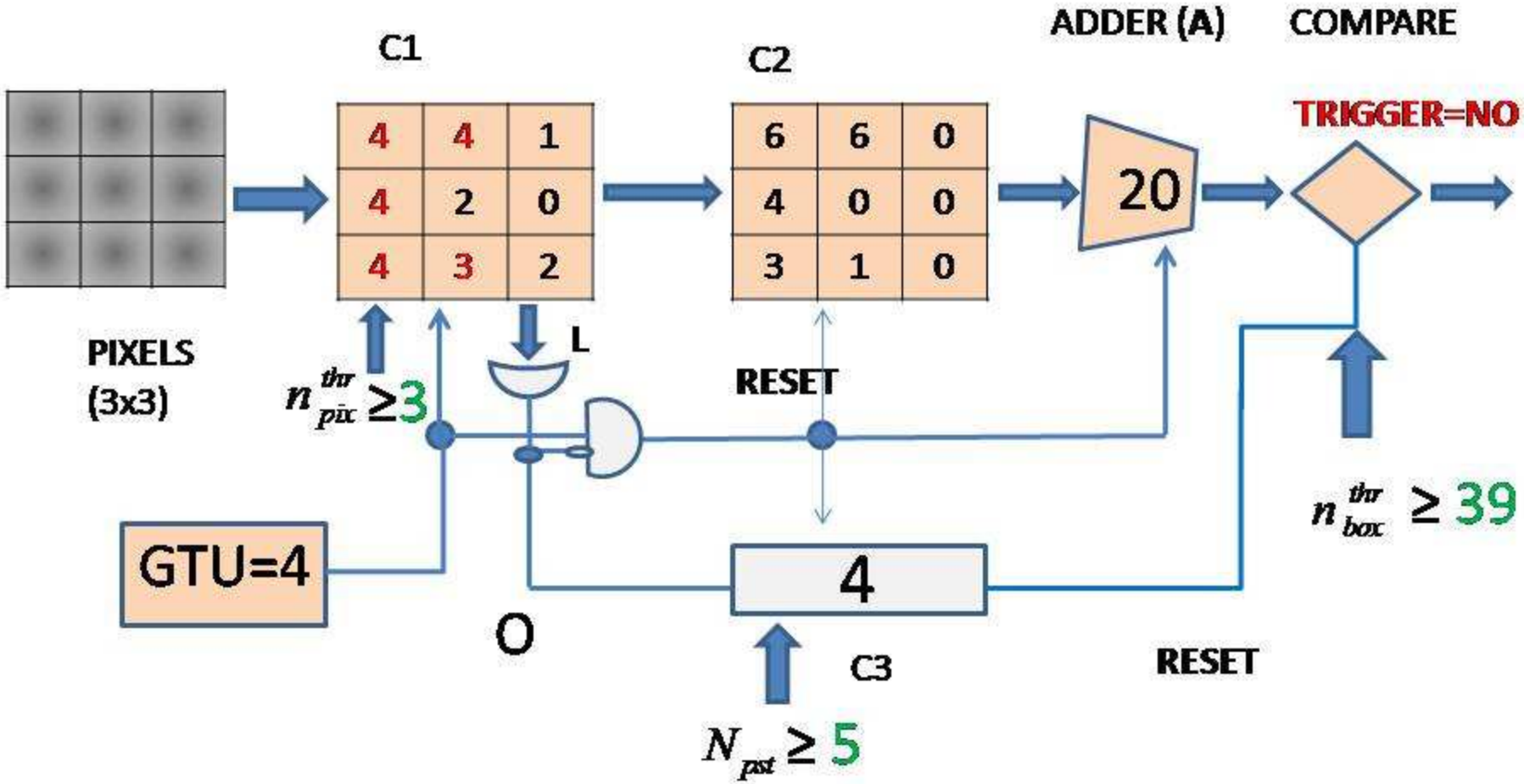
$$N_{C2} = N_{C1} - n_{pix}^{thr} + 1$$

EXAMPLE: TRIGGER IS NOT ISSUED



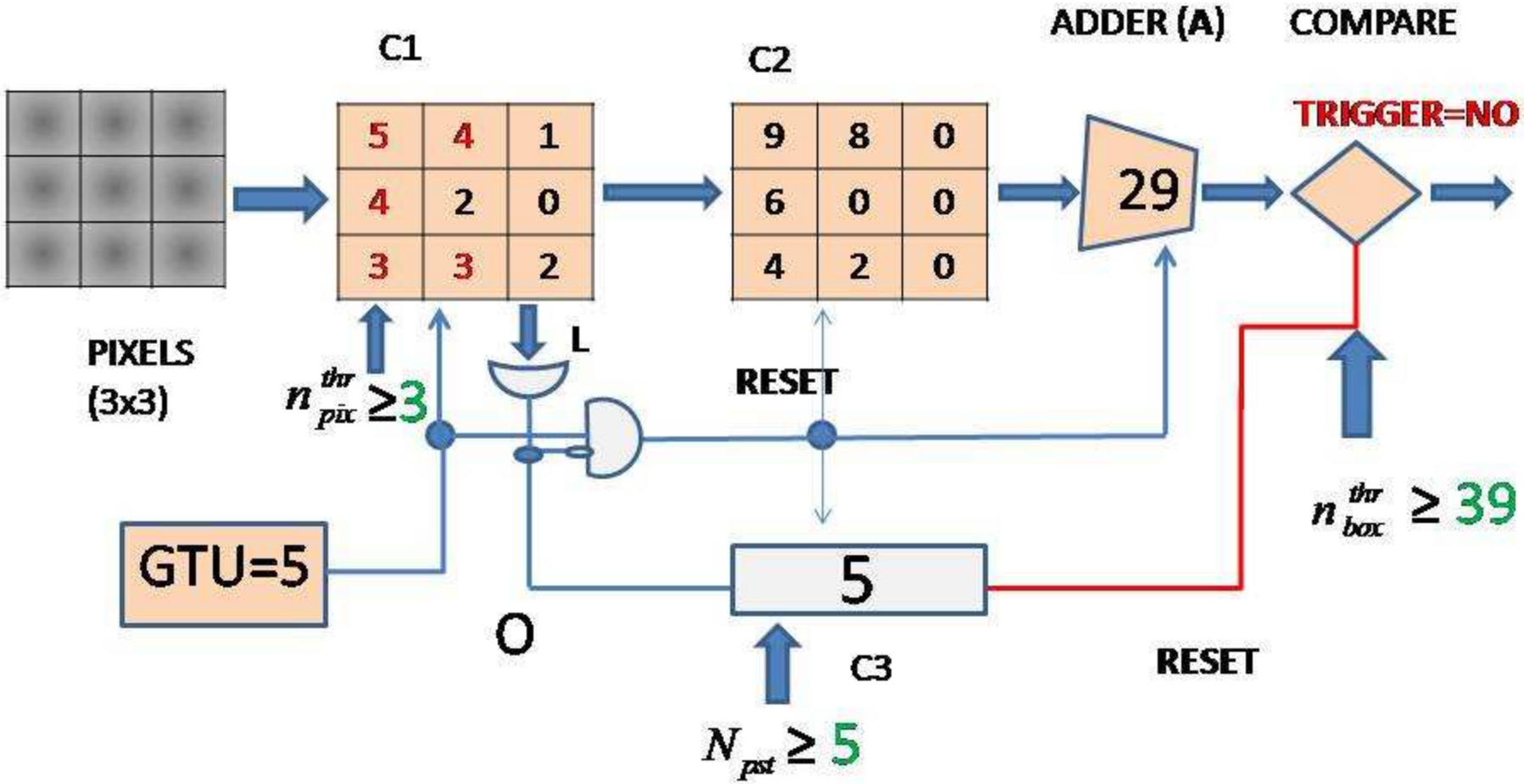
$$N_{C2} = N_{C1} - n_{pix}^{thr} + 1$$

EXAMPLE: TRIGGER IS NOT ISSUED



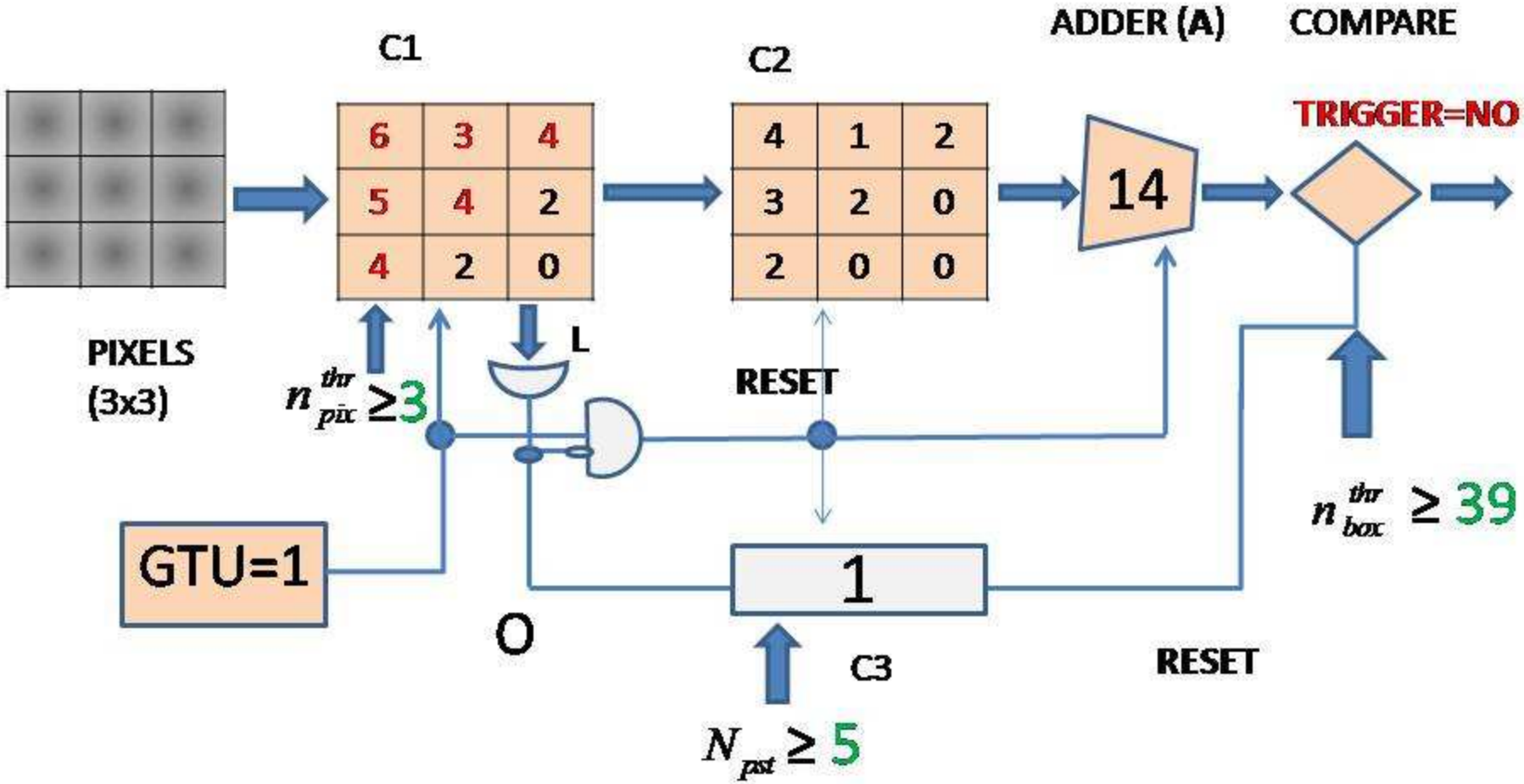
$$N_{C2} = N_{C1} - n_{pix}^{thr} + 1$$

EXAMPLE: TRIGGER IS NOT ISSUED



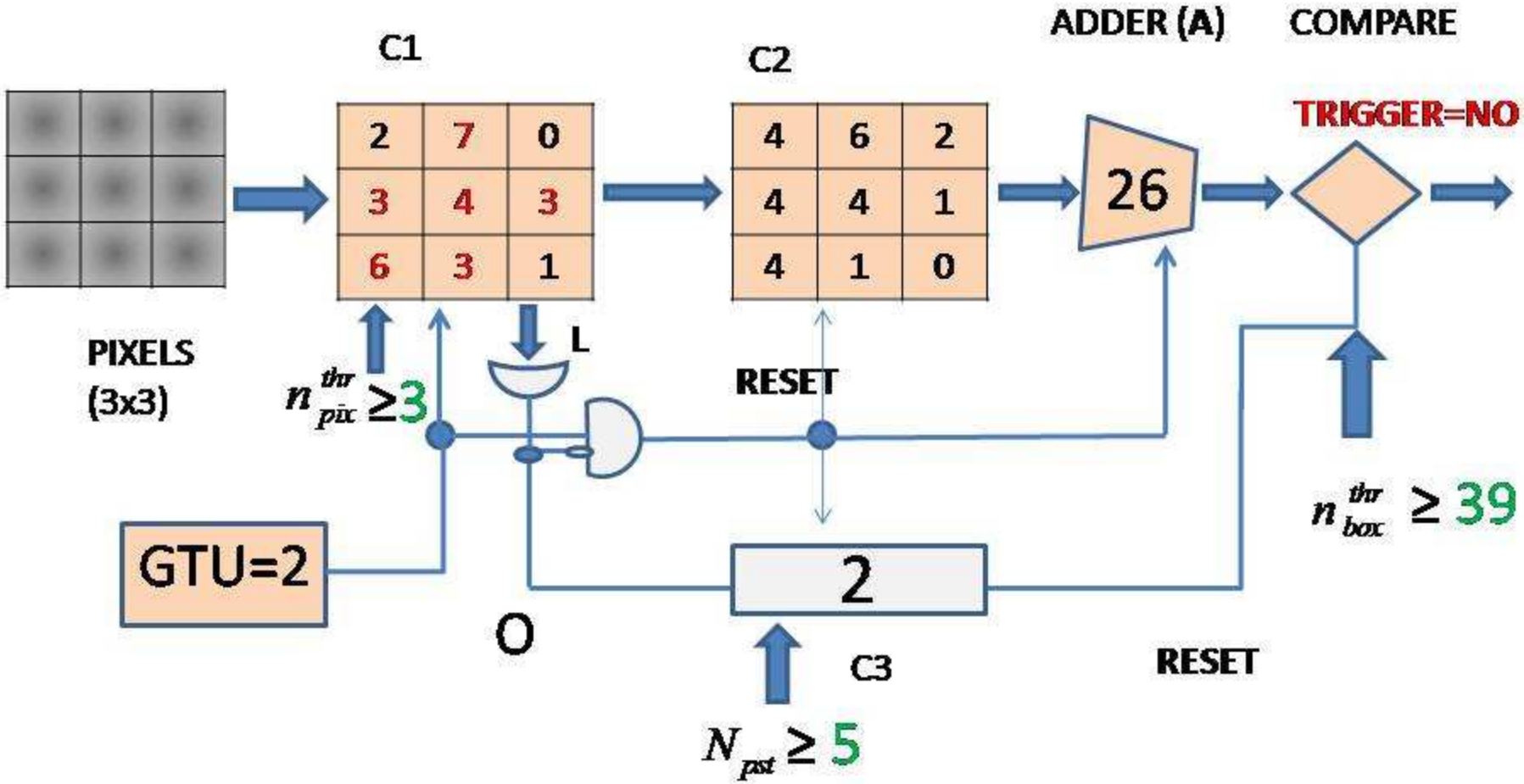
$$N_{C2} = N_{C1} - n_{pix}^{thr} + 1$$

EXAMPLE: TRIGGER IS ISSUED



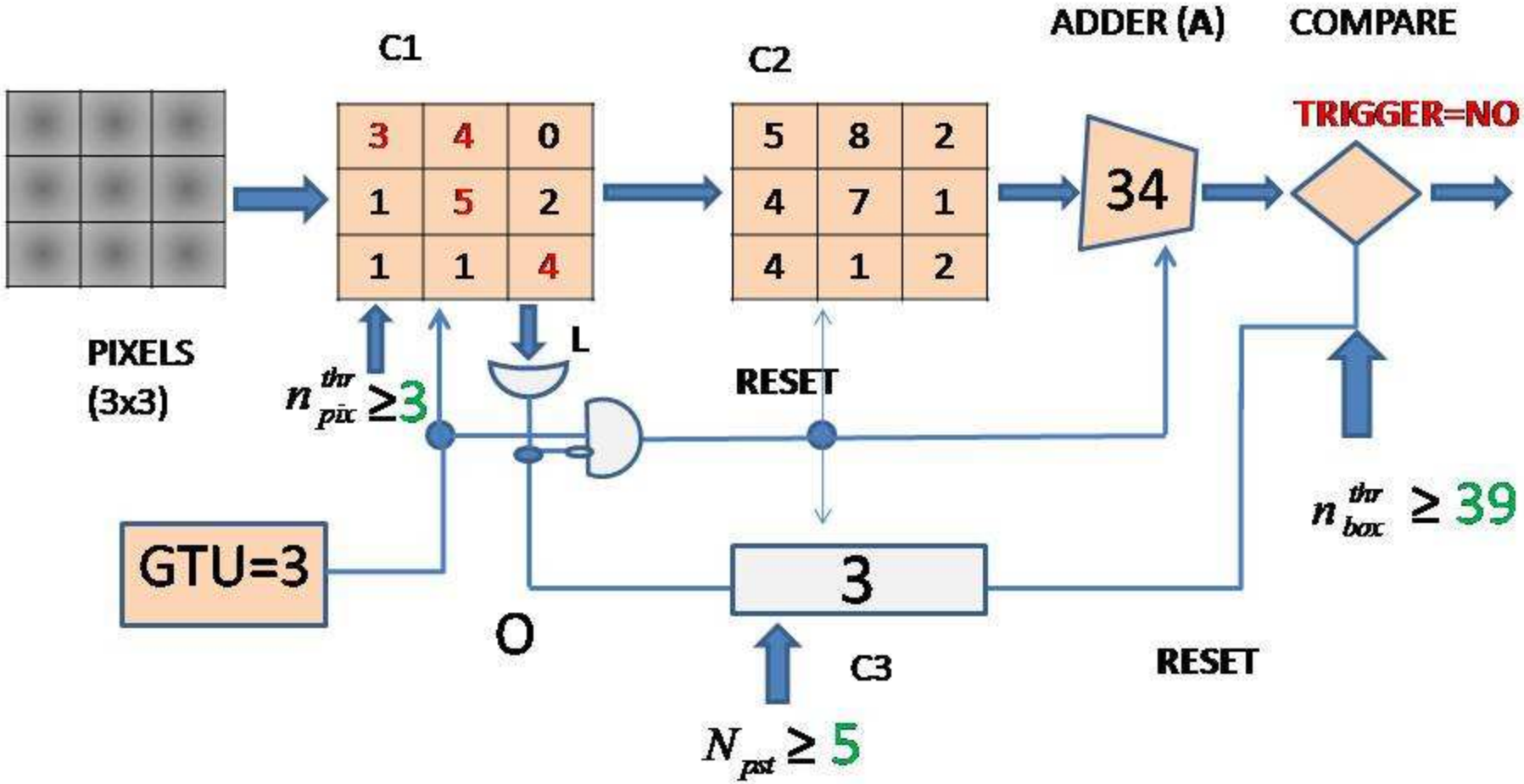
$$N_{C2} = N_{C1} - n_{pix}^{thr} + 1$$

EXAMPLE: TRIGGER IS ISSUED



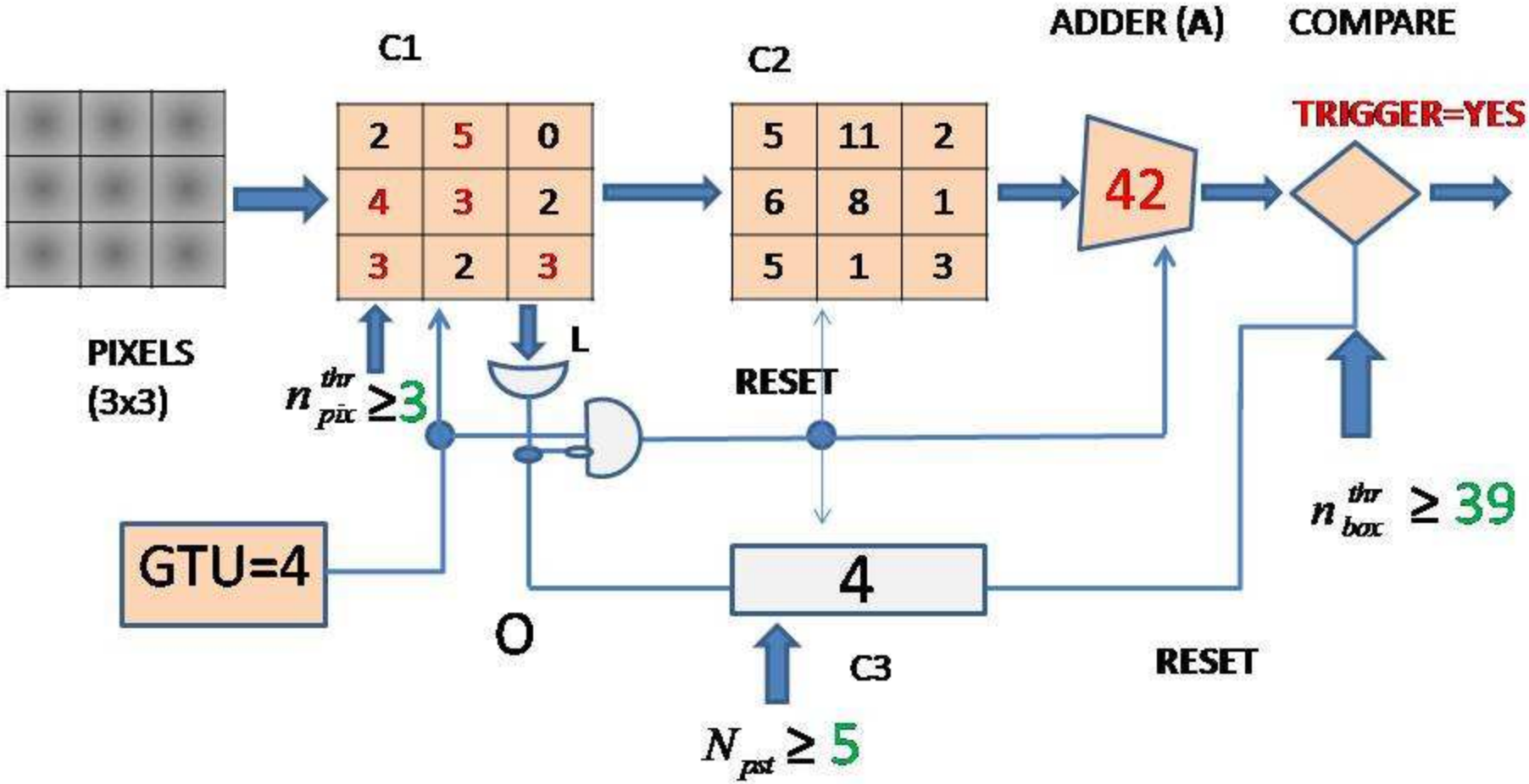
$$N_{C2} = N_{C1} - n_{pix}^{thr} + 1$$

EXAMPLE: TRIGGER IS ISSUED



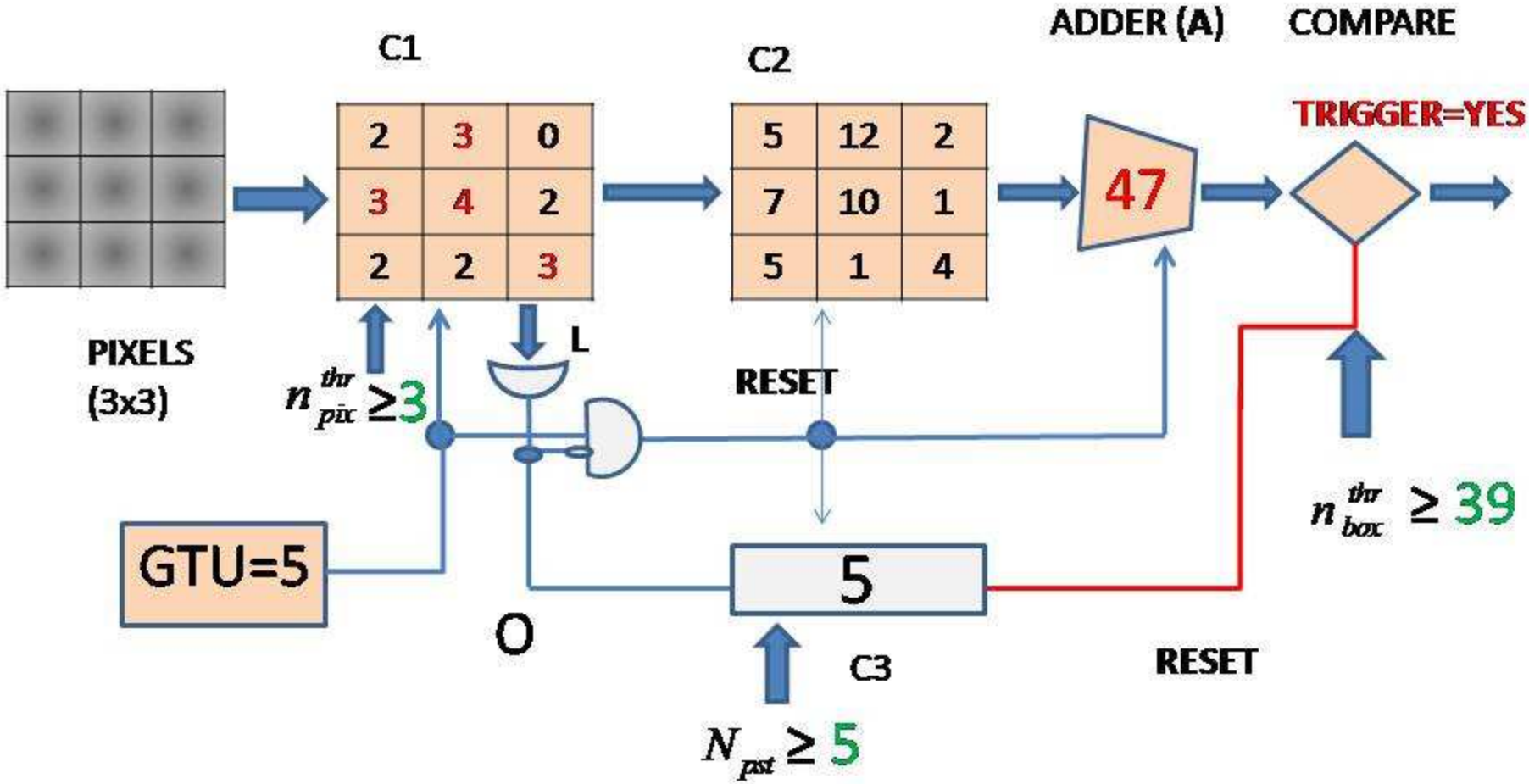
$$N_{C2} = N_{C1} - n_{pix}^{thr} + 1$$

EXAMPLE: TRIGGER IS ISSUED



$$N_{C2} = N_{C1} - n_{pix}^{thr} + 1$$

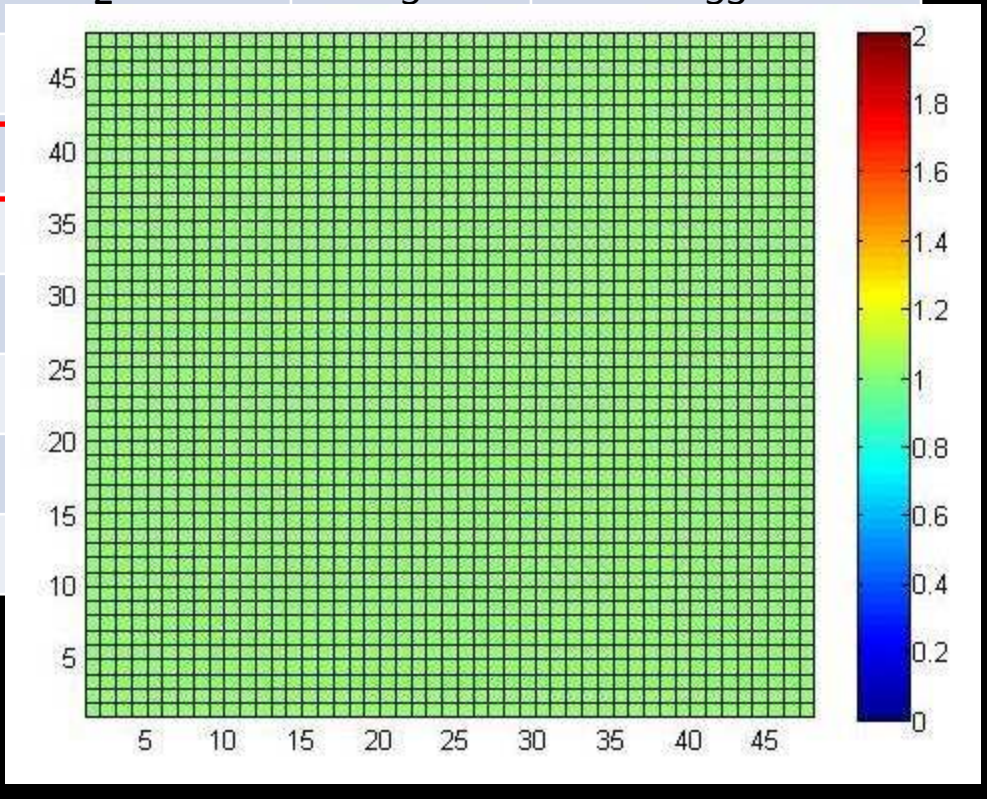
EXAMPLE: TRIGGER IS ISSUED



$$N_{C2} = N_{C1} - n_{pix}^{thr} + 1$$

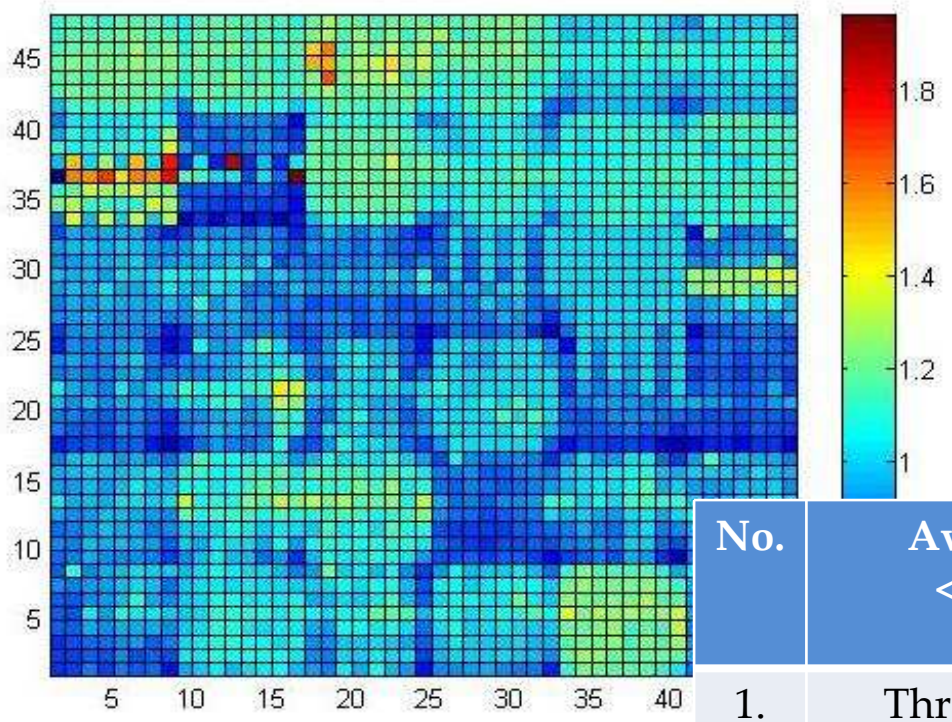
List of threshold

No.	Average Background (photoelectron/pixel/GTU)	n_{pix}^{thr} (photoelectron)	N_{pst} (GTU)	n_{box}^{thr} (photoelectron)
1.	0.1	0	5	18
…	…	…	…	…
18.	1.8	2	5	53
19.	1.9			
20.	2.0			
21.	2.1			
22.	2.2			
23.	2.3			
…	…			
63.	6.3			



Map of uniform PDM

My stage work



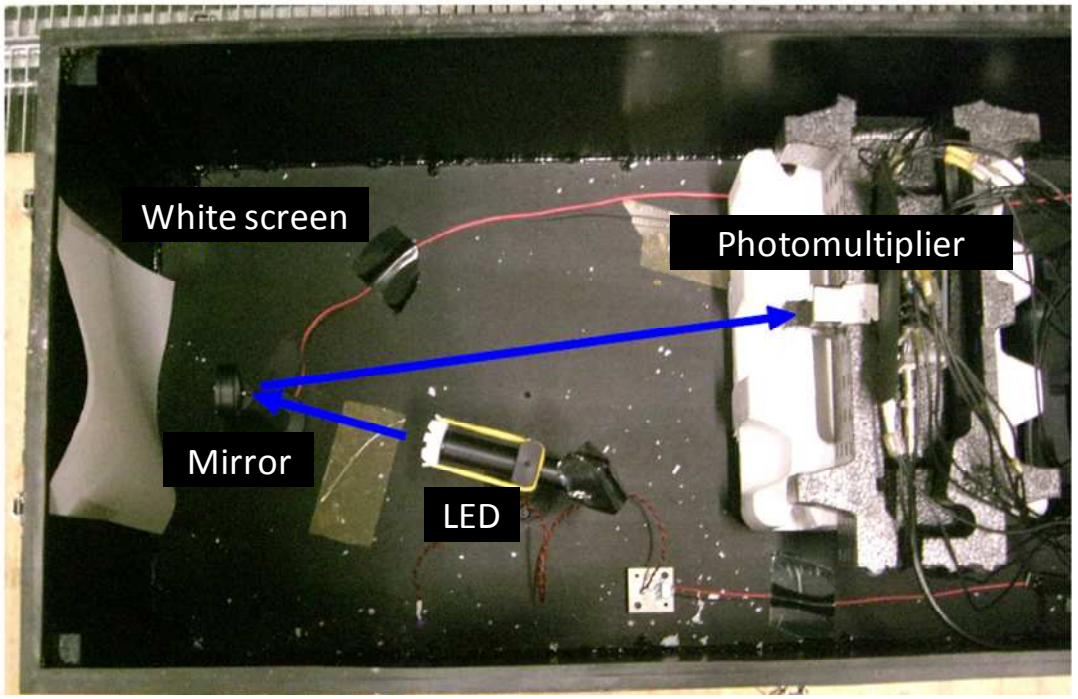
Map Efficiency of PDM

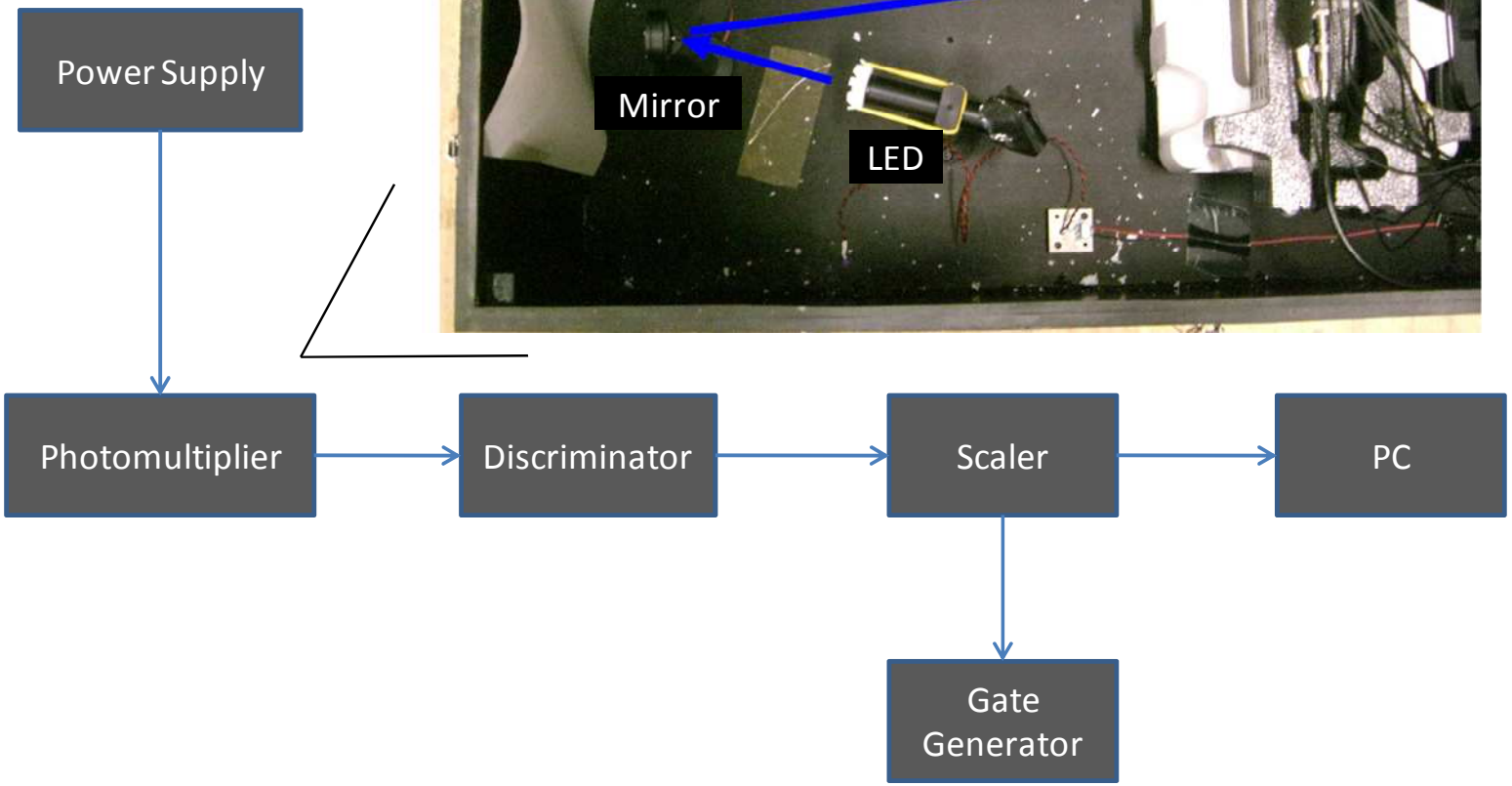
$$P_i(x,\lambda_i) = \frac{-e^{\lambda_i}\lambda_i^{\,x}}{x!}$$

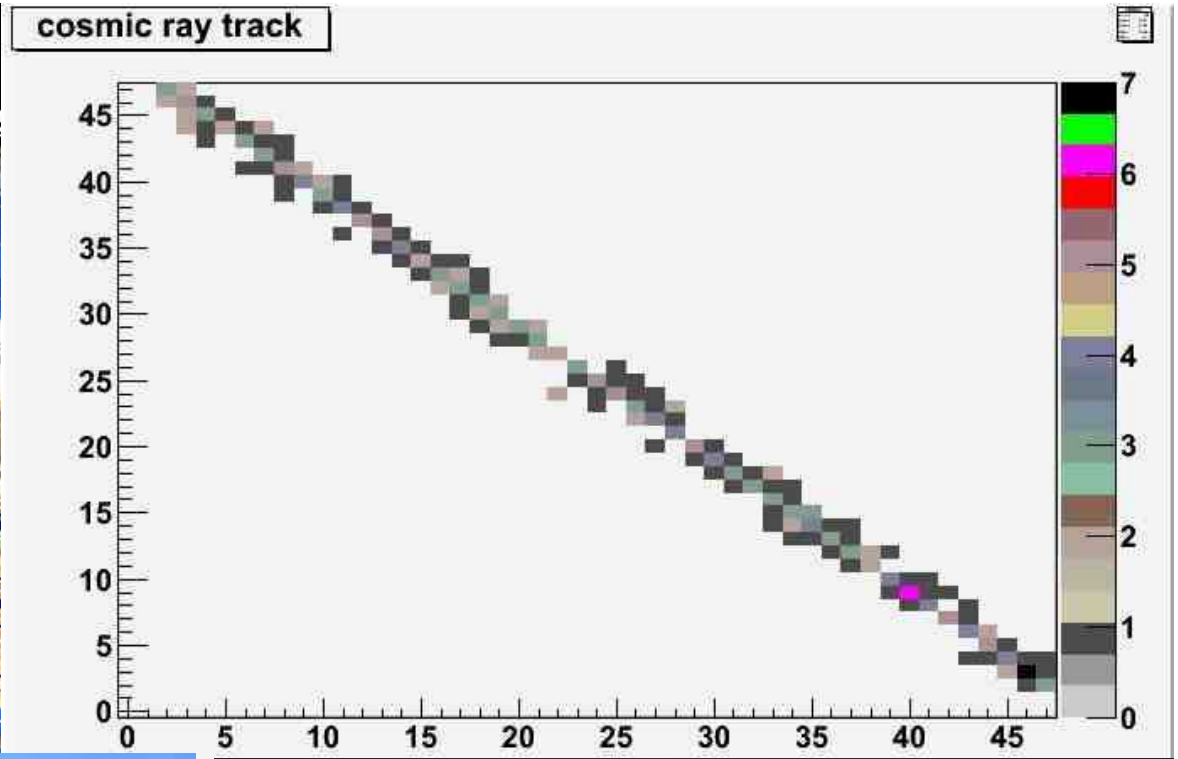
Trigger rate for different threshold and background level

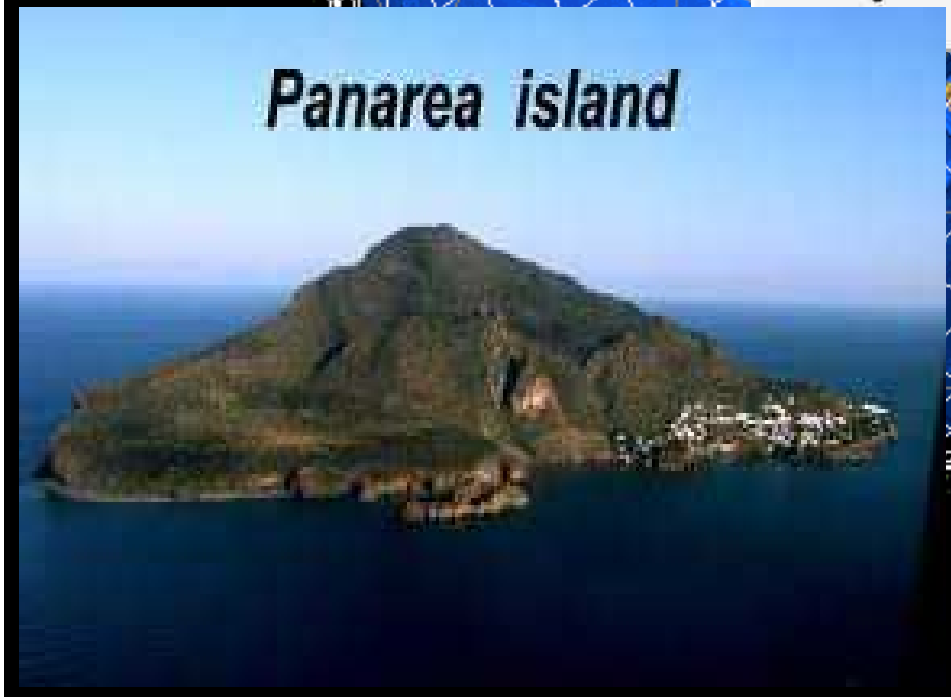
No.	Avg bck <phe>	Trigger rate (Hz/PDM)			
		0.5phe	1phe	1.5phe	2phe
1.	Thr(<phe>)	1656	1605	2985	8121
2.	Thr(<phe>+0.1)	128	644	1326	2449
3.	Thr(<phe>+0.2)	4	39	273	641
4.	Thr(<phe>+0.25)	0	2	130	323
5.	Thr(<phe>+0.3)	0	1	45	74
6.	Thr(<phe>+0.4)	0	0	4	19
7.	Thr(<phe>+0.45)	0	0	0	0

Experimental Setup

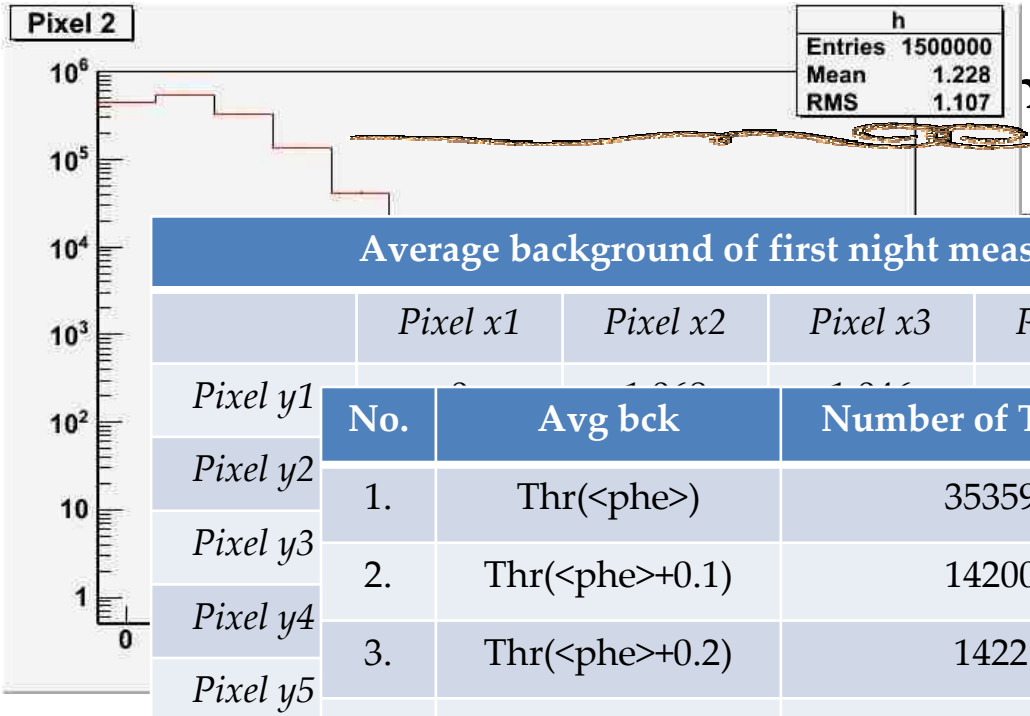





cosmic ray track
45
40
35
30
25
20
15
10
5
0
0
5
10
15
20
25
30
35
40
45
7
6
5
4
3
2
1
0

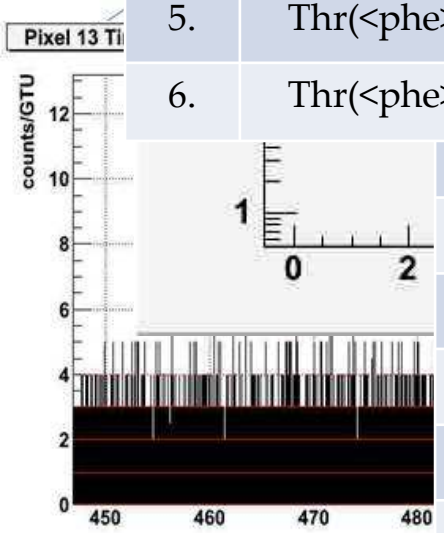

Panarea island

nd measurement



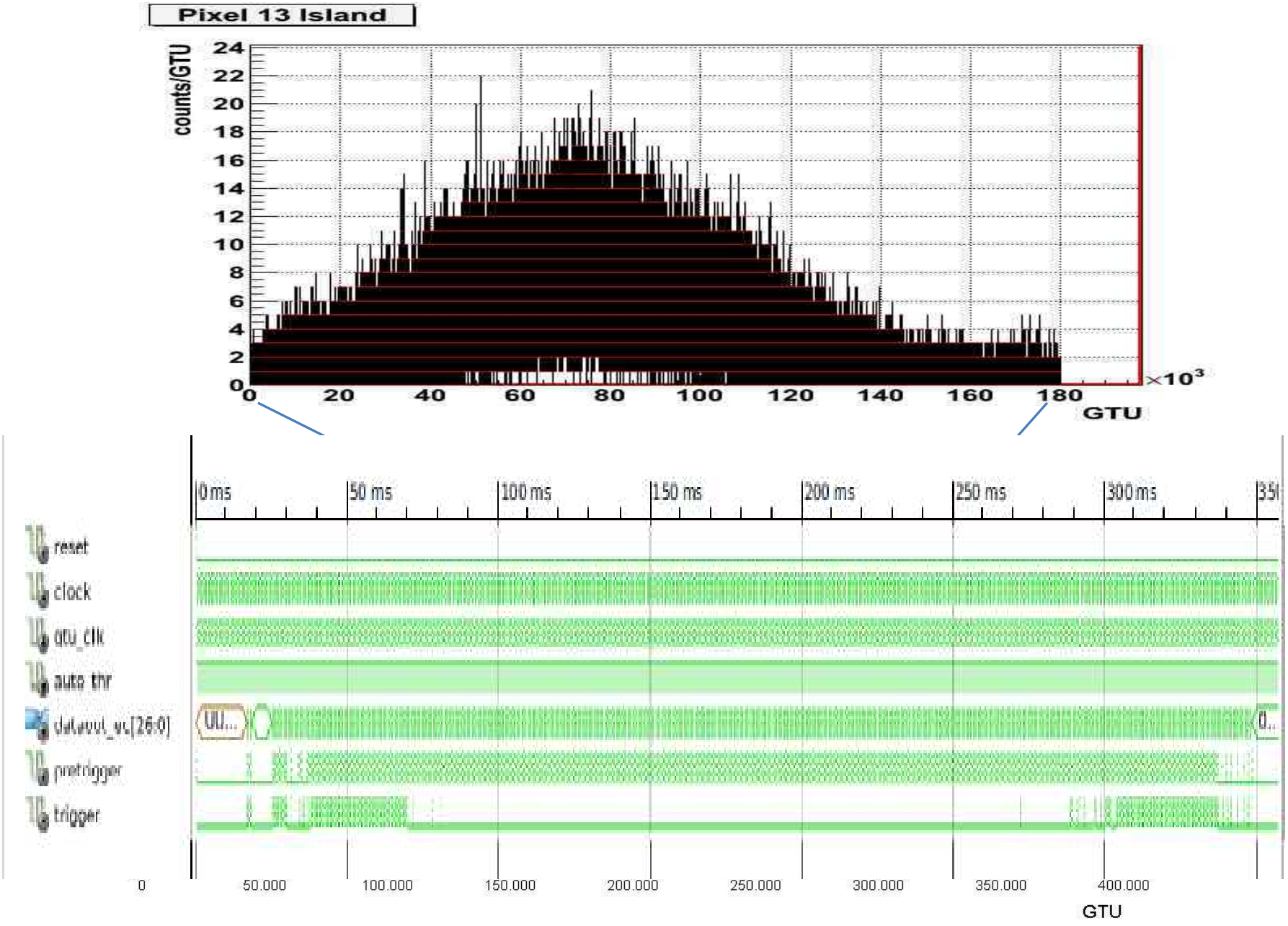
Average background of first night measurement					
	Pixel x1	*Pixel x2*	*Pixel x3*	*Pixel x4*	*Pixel x5*
Pixel y1					
Pixel y2					
Pixel y3					
Pixel y4					
Pixel y5					

No.	Avg bck	Number of Triggers	Trigger rate (Hz/PDM)
1.	Thr(<phe>)	35359	9426
2.	Thr(<phe>+0.1)	14200	3787
3.	Thr(<phe>+0.2)	1422	379
4.	Thr(<phe>+0.3)	84	22.4
5.	Thr(<phe>+0.4)	2	0.533
6.	Thr(<phe>+0.5)	0	0

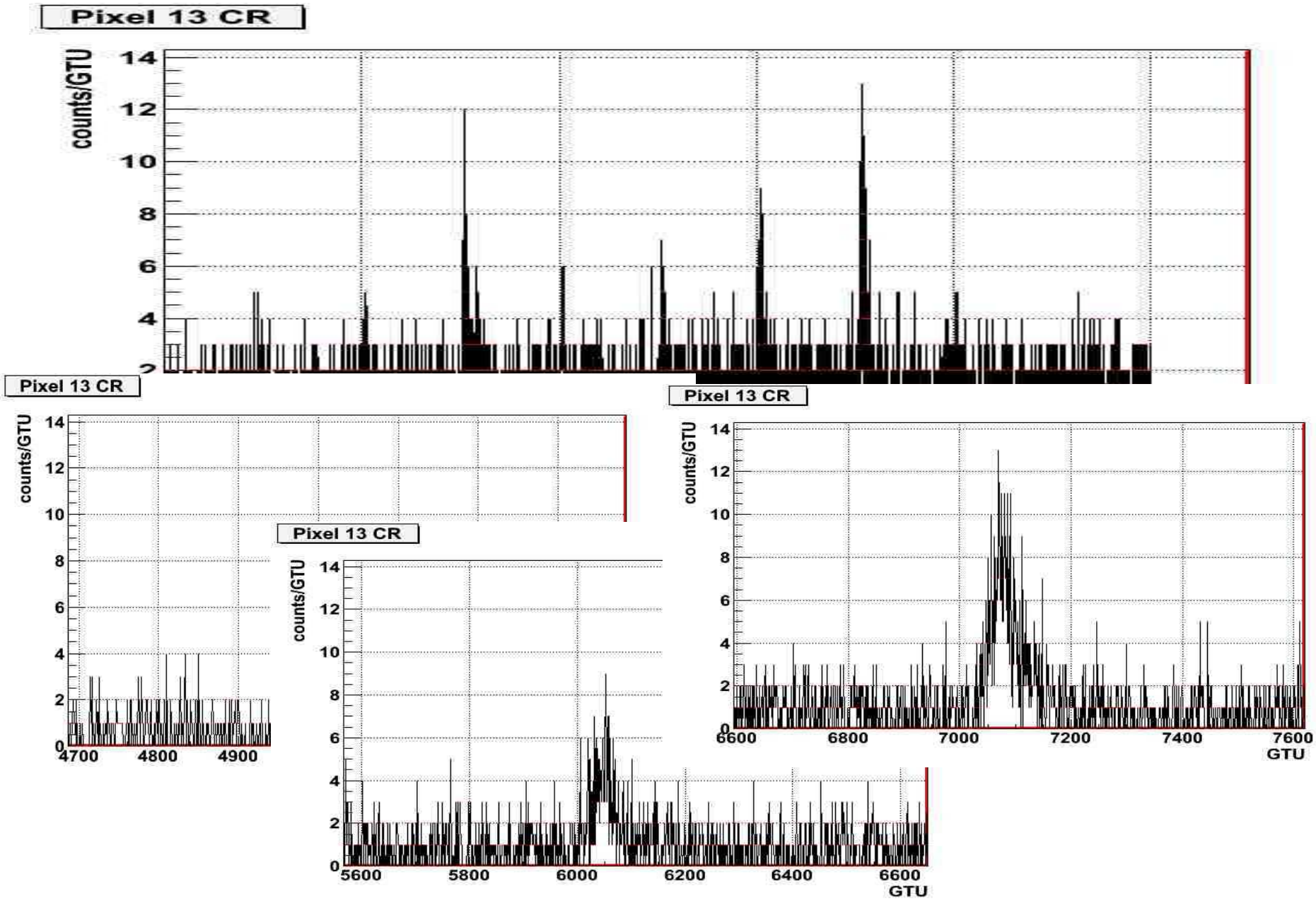


	Pixel x1	*Pixel x2*	*Pixel x3*	*Pixel x4*	*Pixel x5*
Pixel y1	0	1.228	1.208	1.203	0.784
Pixel y2	0.991	1.392	1.691	1.123	1.034
Pixel y3	1.102	0.630	0.868	1.218	0.875
Pixel y4	0.679	1.412	0.742	0.692	0.844
Pixel y5	0.688	0.967	0.898	1.019	0

Time profile of the amount of light by telescope when pass an island

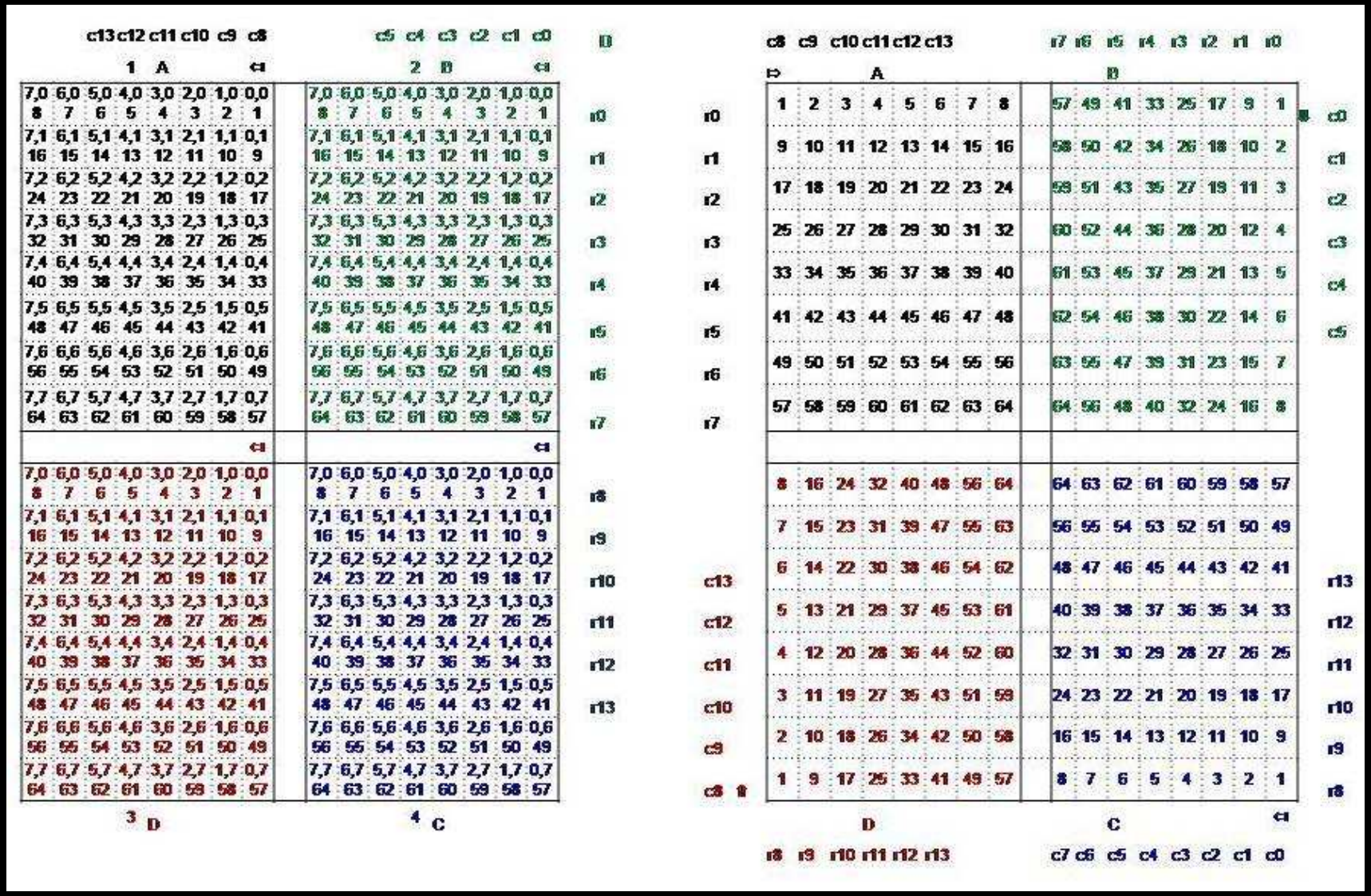


Time profile of the amount of light by telescope when EAS happen



CONCLUSION

- The threshold should be increase (~30%) compared to pure Poissonian fluctuation on a homogeneous layer of PMT
- Cosmic rays events were succesfully triggered
- It is important in future controle some transient in which the number of trigger becomes very high such as island type measurement

Backup slide

Preparation of the data format for VHDL code implemented in the FPGA