High Energy γ-ray Observation

Team B

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1.Introduction

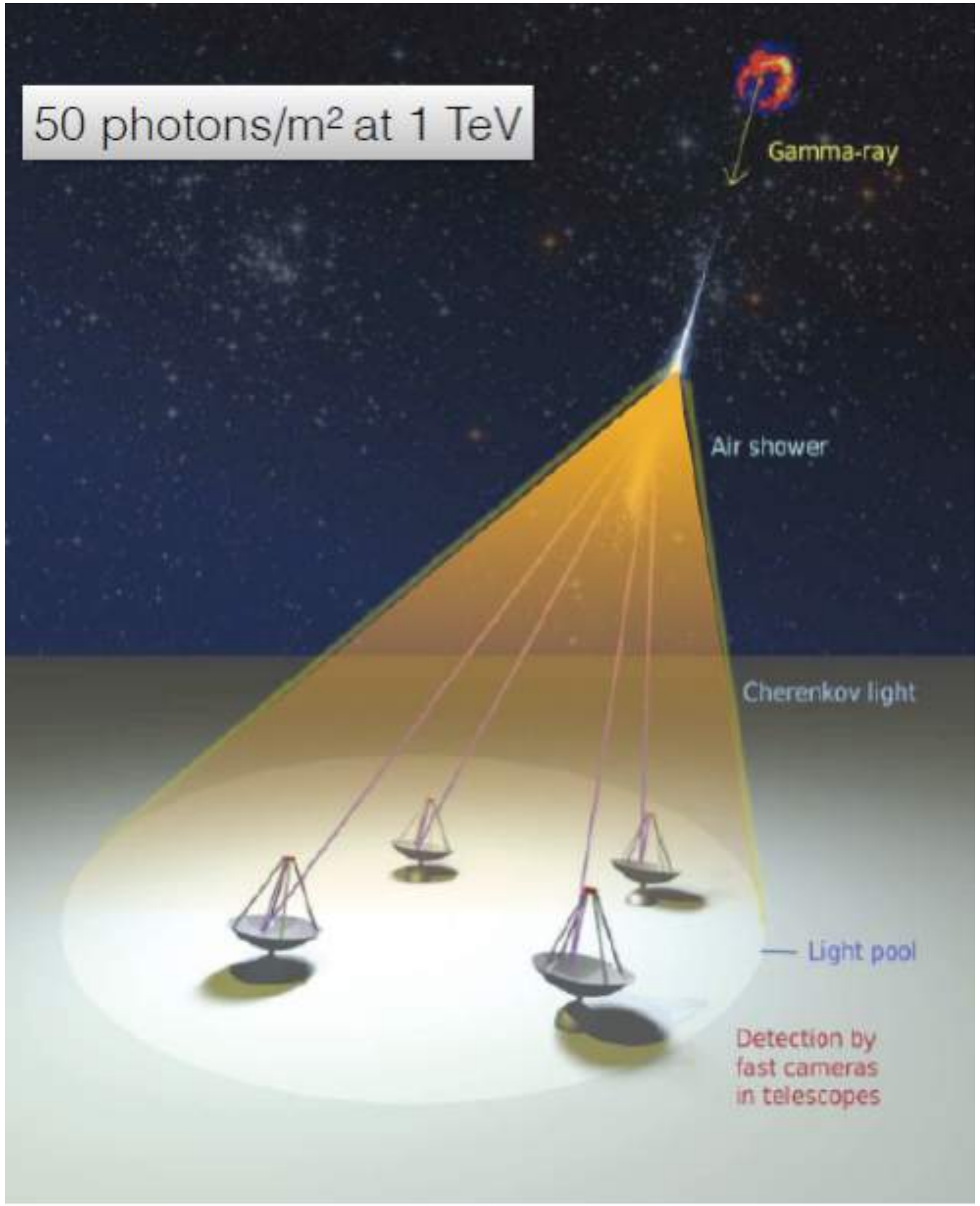
1.1 Abstract

High energy gamma-rays produce electromagnetic showers in the top of the atmosphere.

Electromagnetic showers emit Cherenkov lights.

We have build Atmospheric Cherenkov Telescope,

observed and analyzed the result.

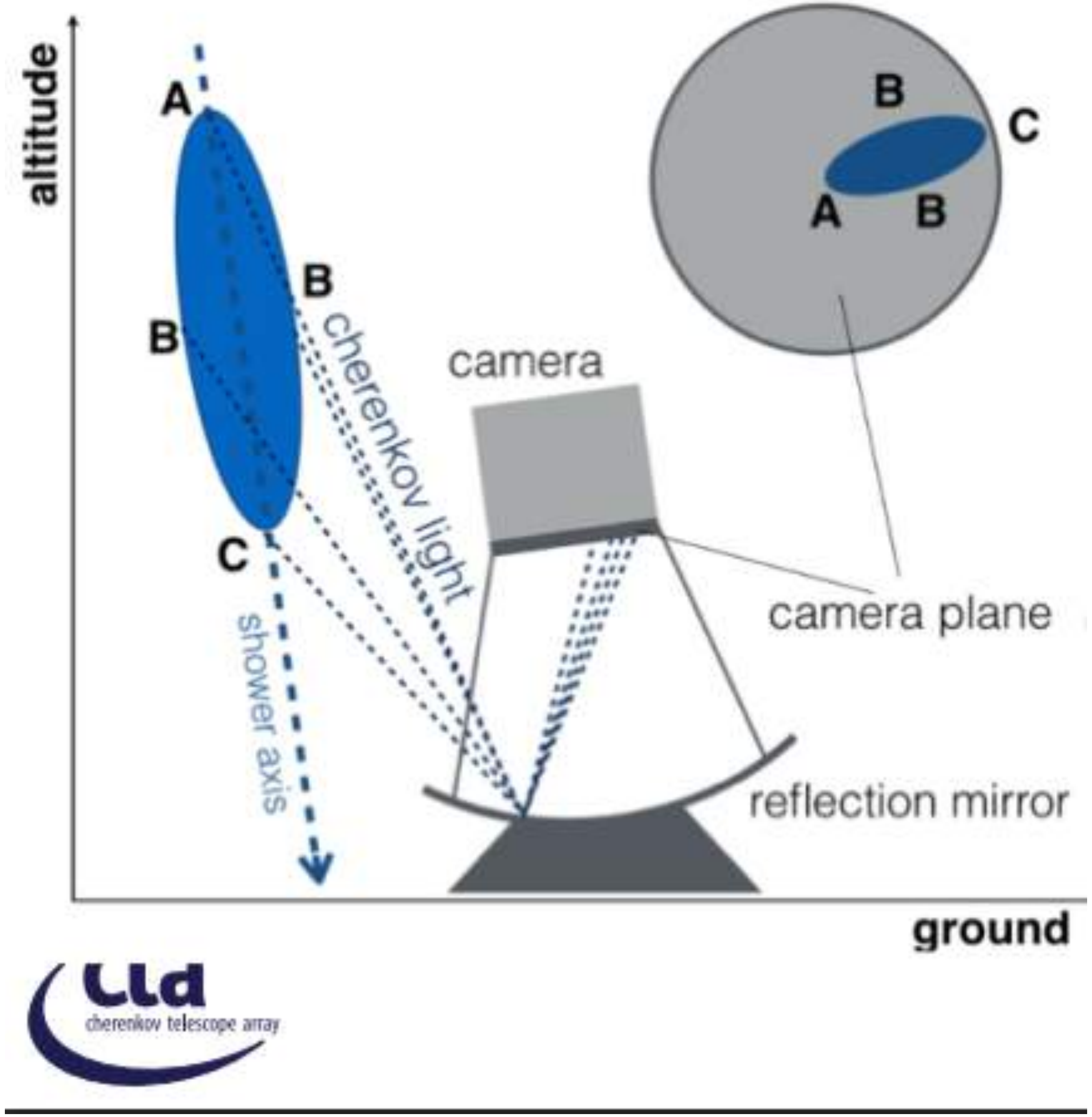


1.2 How to detect?

・Capture the image of cherenkov light using reflection mirror

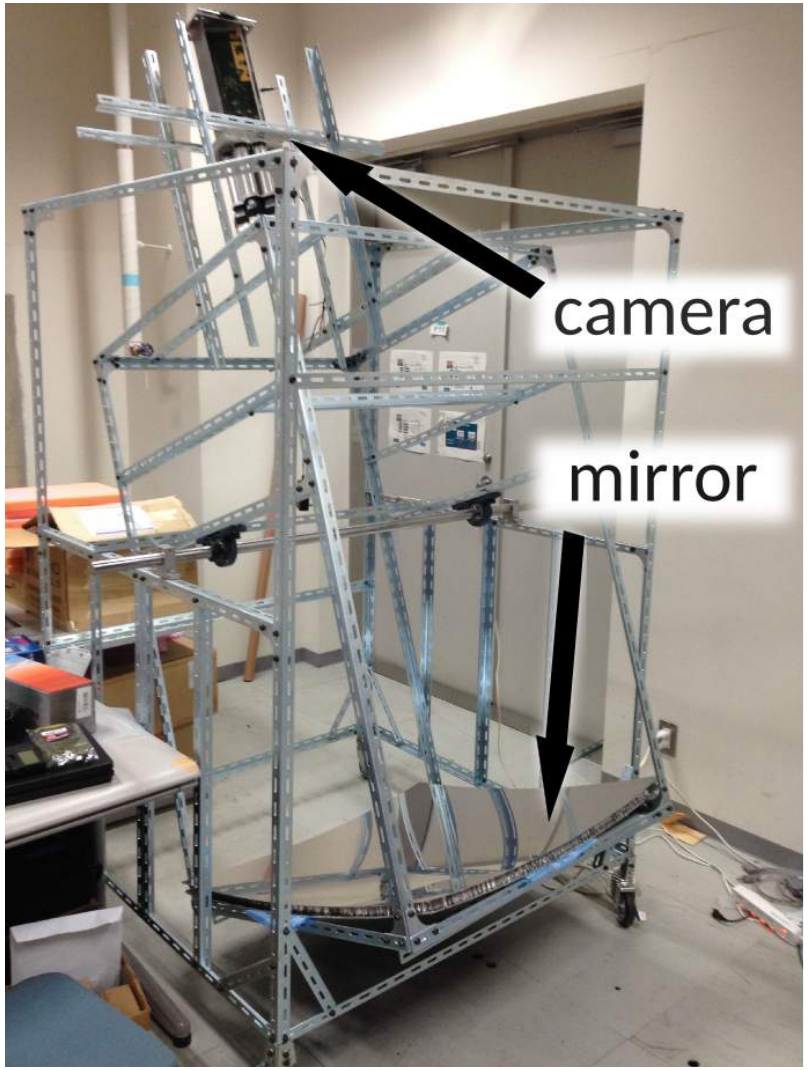
1.3 Task

・Build Atmospheric Cherenkov Telescope
・Detect Cherenkov emission
・Observe Crab Nebula

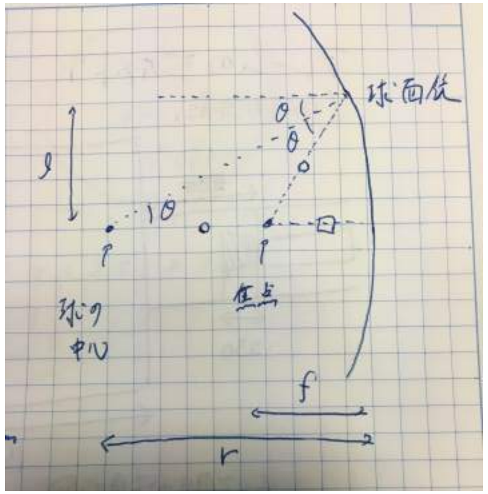


2. Setup

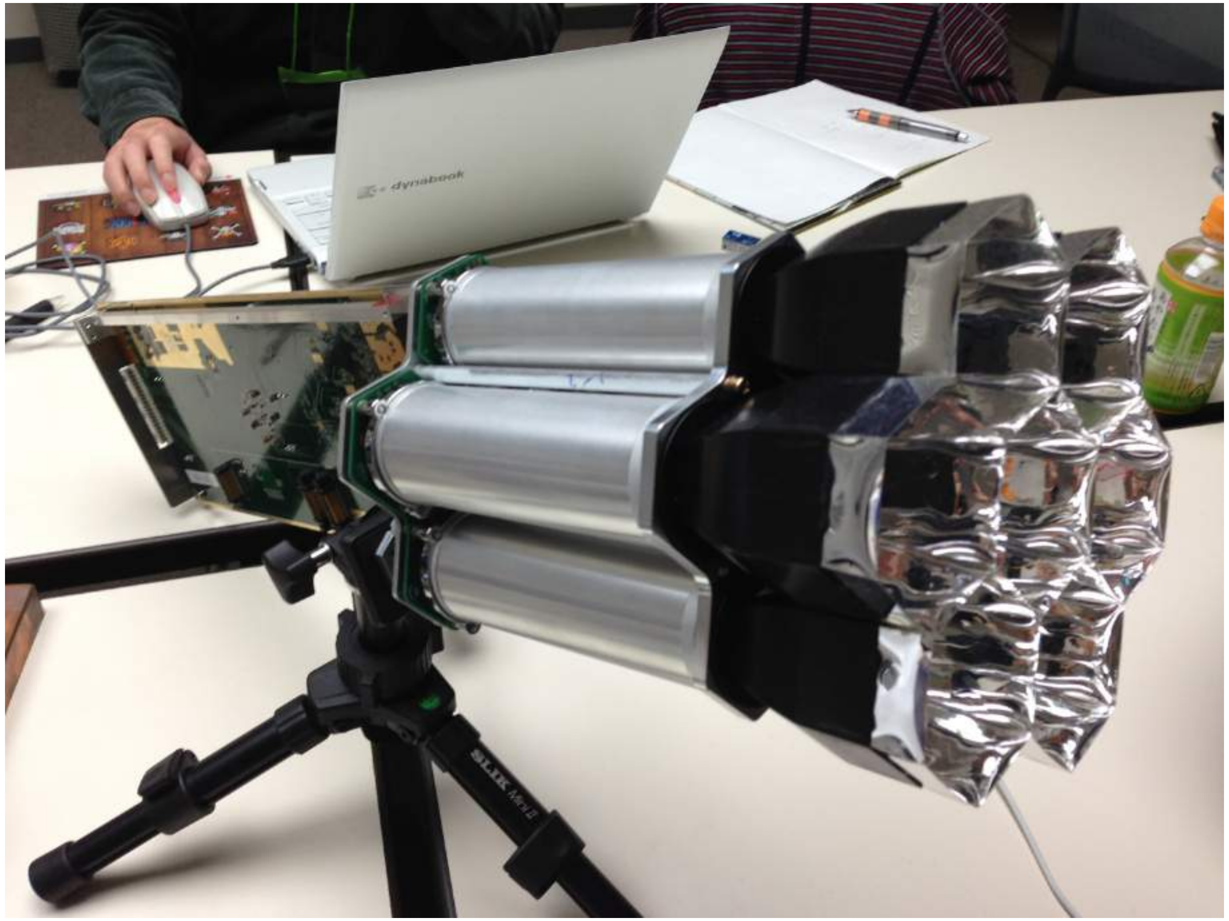
2.1 Specs



- spherical mirror(radius:3.3m)
- Focal length: 1.66 m
- Point Spread Function: < 1cm
- Field of view 5° (we calculated)
- Calculate focal point and set the camera in the position
- Confirm that each module covers the entire mirror



2.2 Camera



Consists of

- 7 PMTs (light sensor) with high quantum efficiency
- 2 level Trigger system
- Readout based on DRS4

2.3 Trigger system

・Data should be acquired when the large signal comes
→Trigger is needed
・The signal from PMT is sent to detector and trigger
・Trigger consists of two stages , L0 and L1
・First stage(L0) is to sum up signals from all PMTs, large signals from PMT are clipped
・Second stage(L1) triggers when the output of L0 exceeds the threshold, and then detector preserves the data

3. Calibration

3.1How to calibrate?

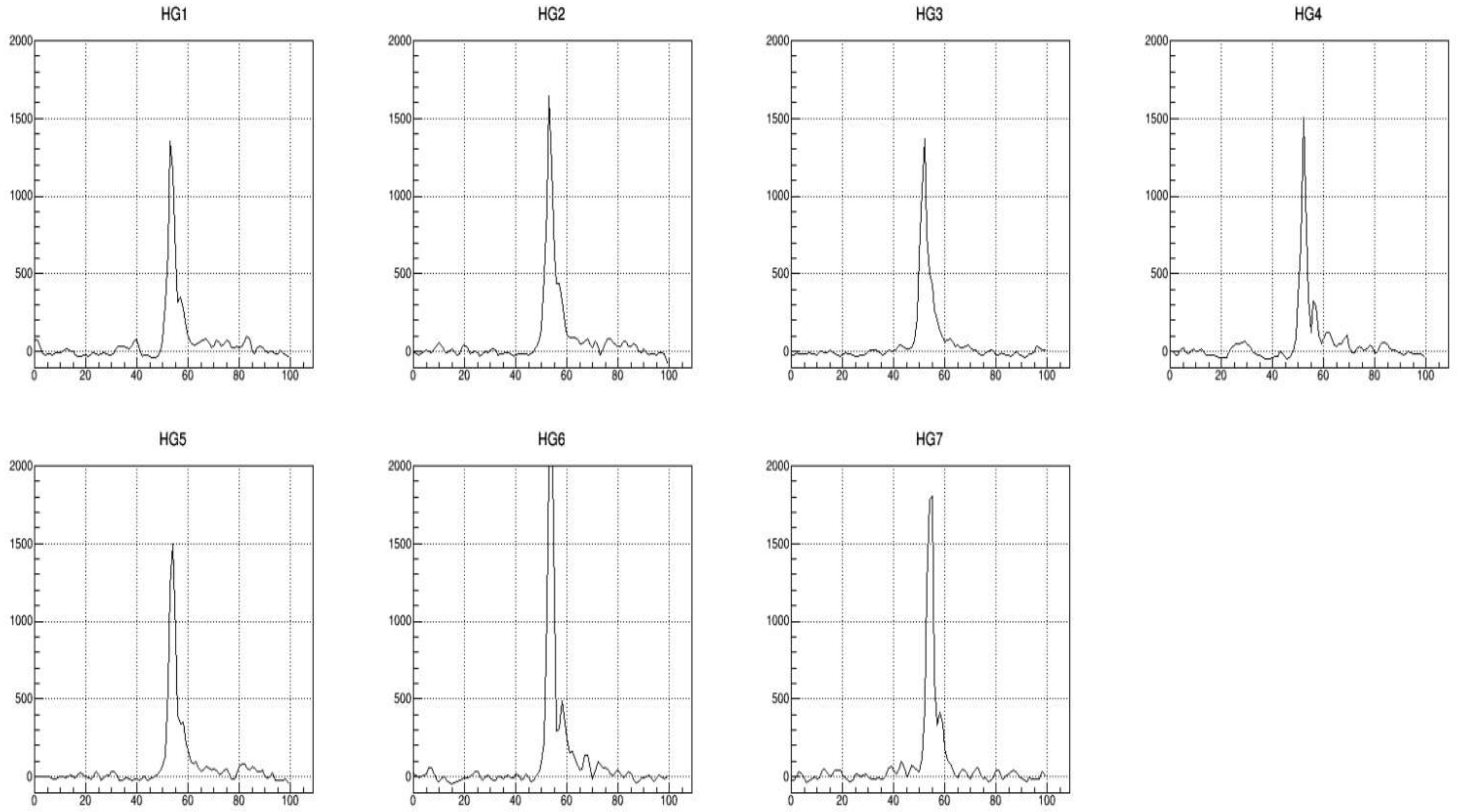
・Adjust HV to make flat field
・Method

1.in the Dark room

2.Spot isotropic light using Semiconductor laser

3.Collect and analyze data to determine the appropriate HV for each PMT

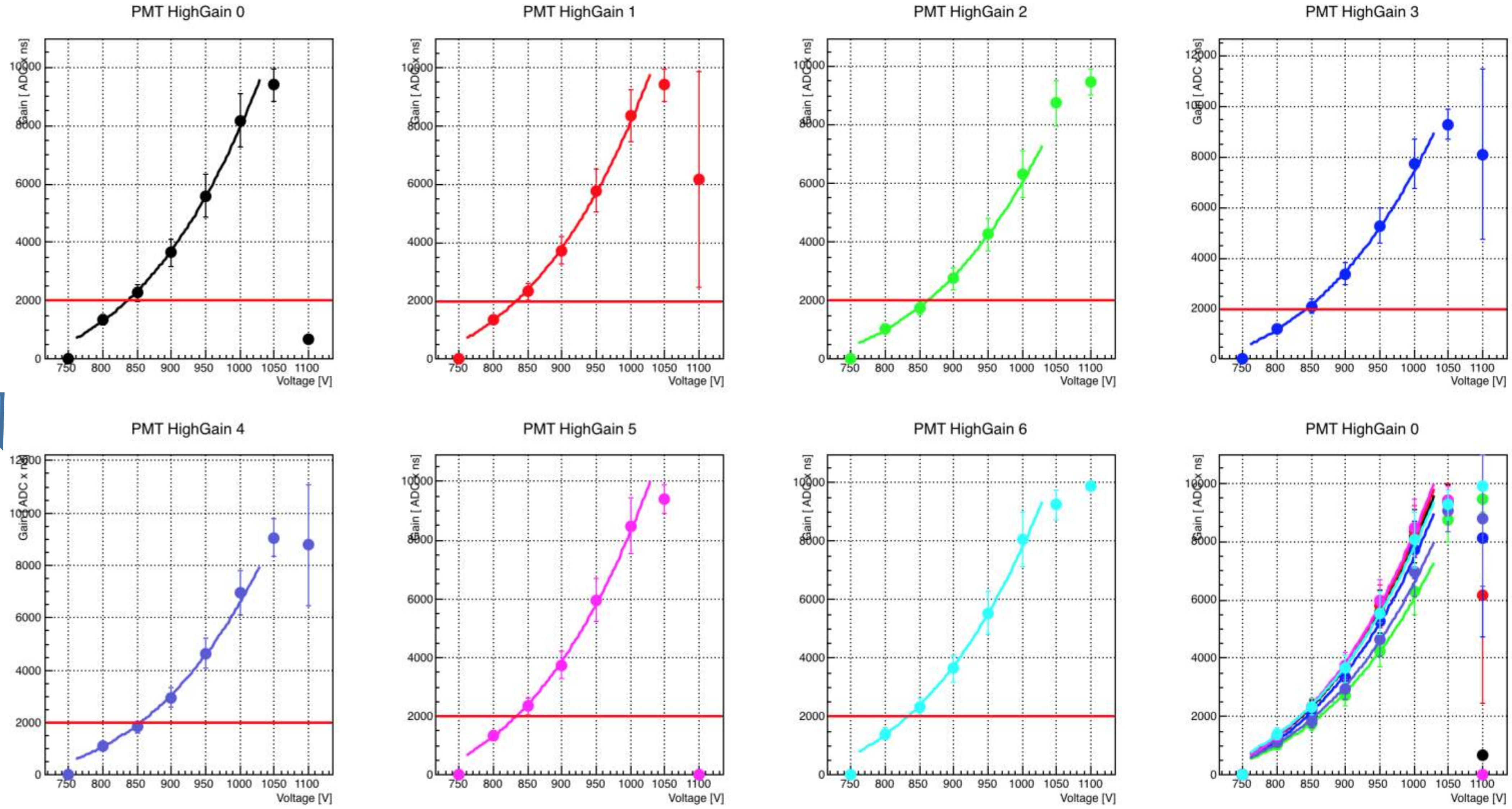
3.2 Pulse Shape with 1 Gsample /s



3.3 Calculating gain from the data

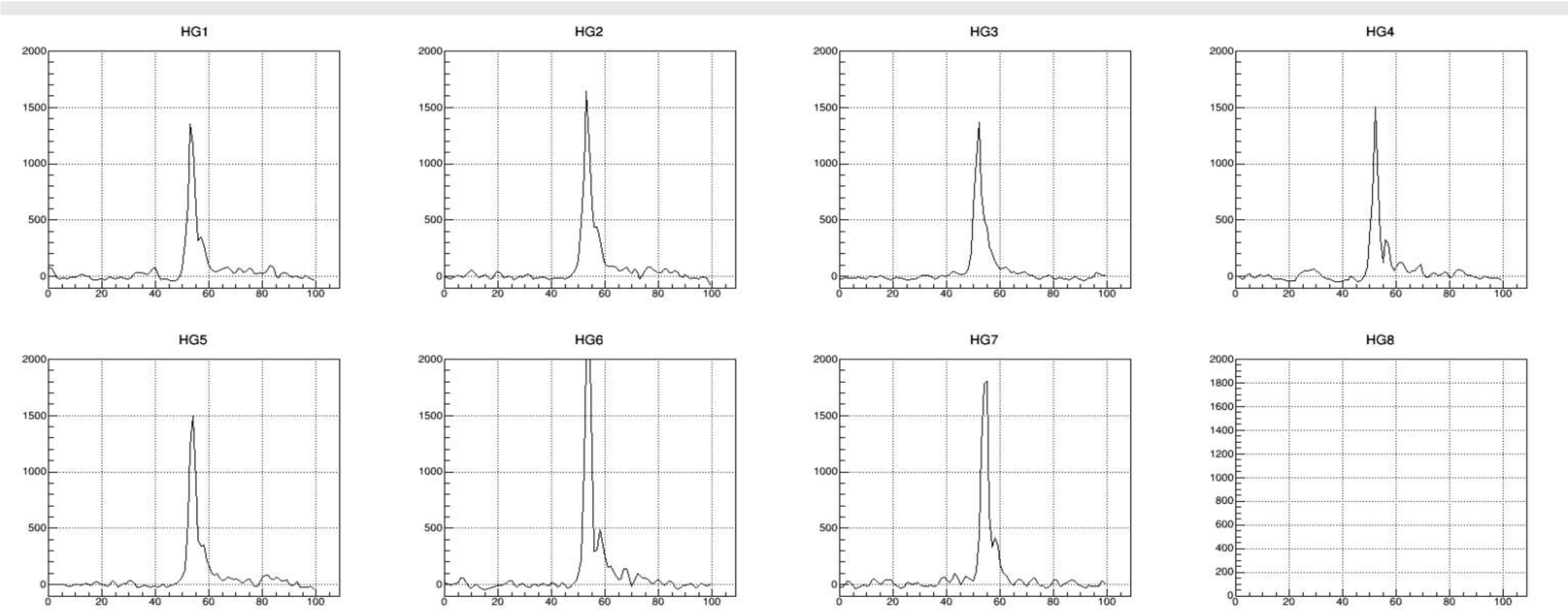
Method1
Compare
the peak
height

Method2
Compare
the peak
integration



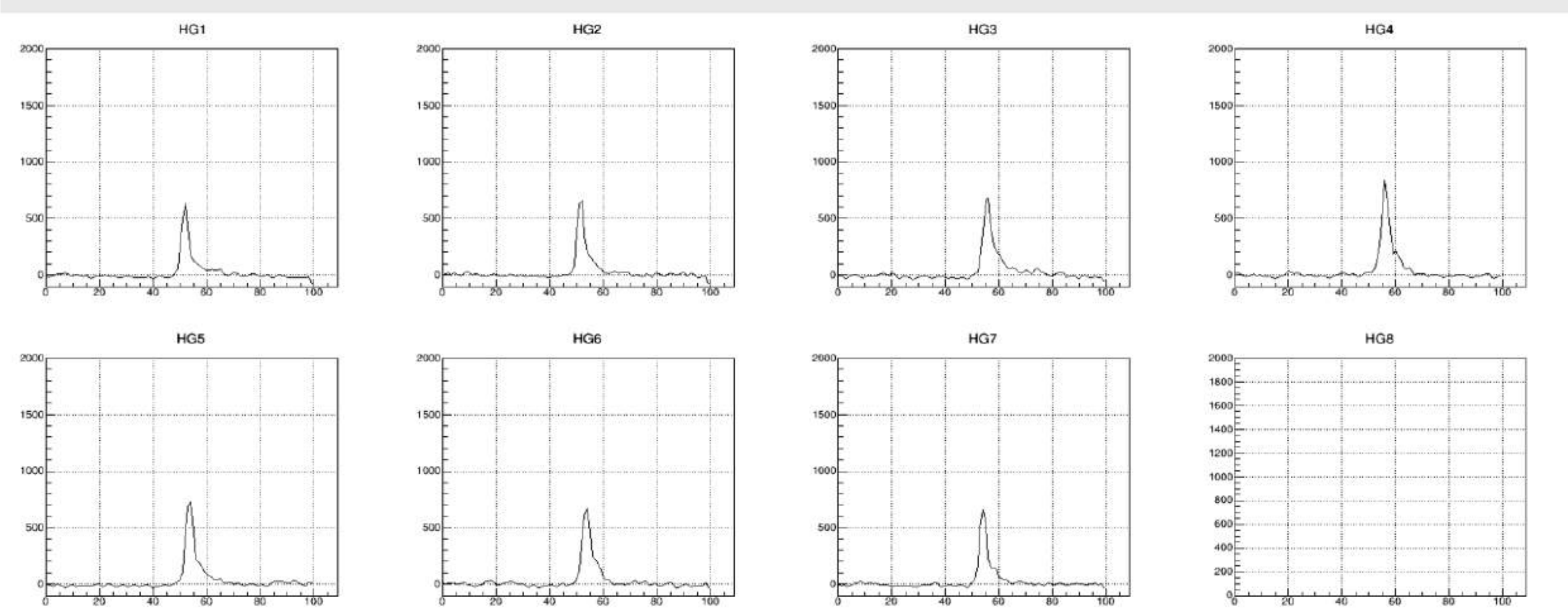
3.4 Flat fielding

Before



・Gain is aligned by adjusting HV

After



4. Observation

4.1 Observation

- Set HV and threshold to suited values
- Point the telescope to the zenith angle
(Watching Leo Minor)

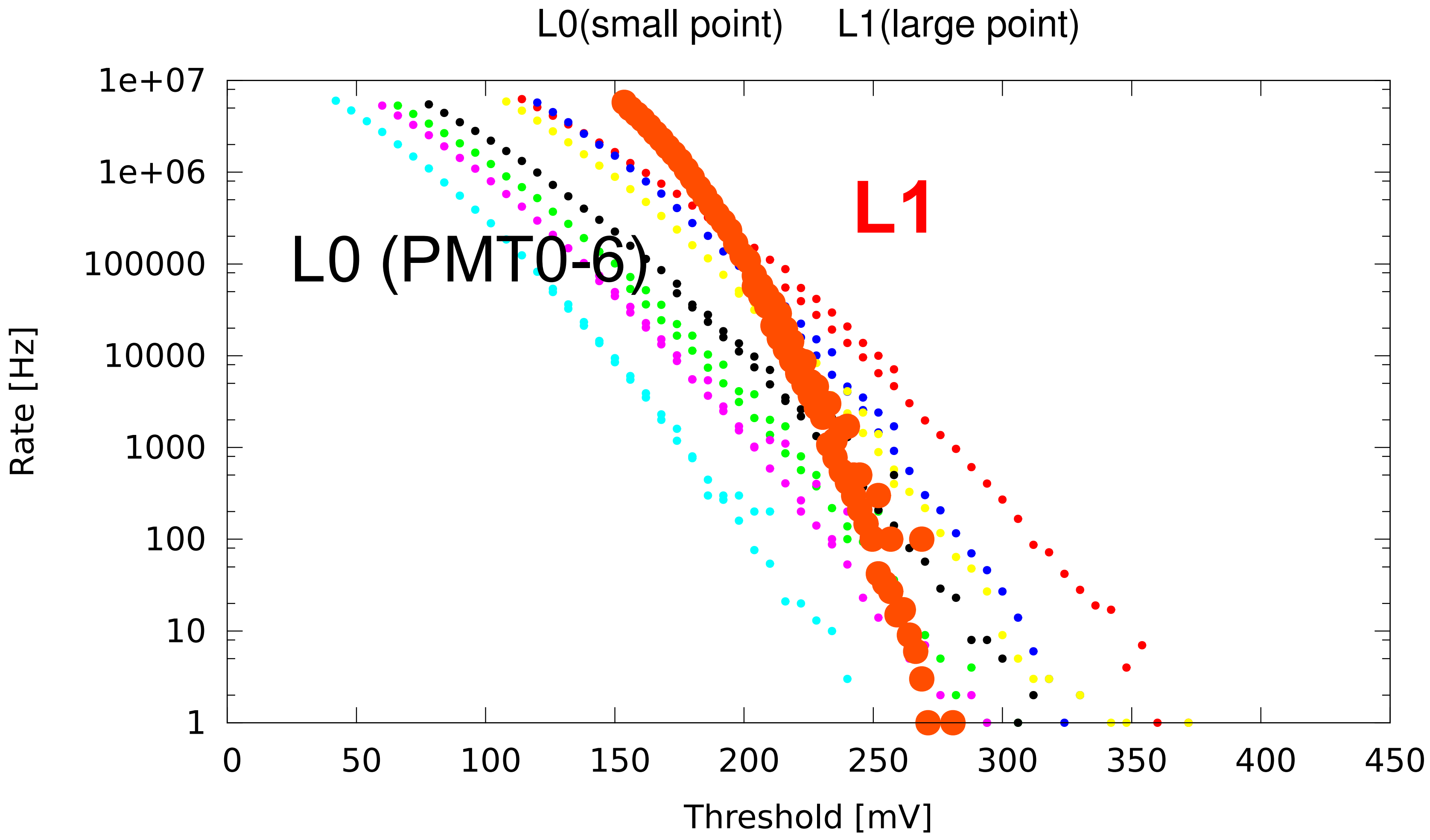
2016 March 10th Cloudy PM9:15~PM10:40

Moon phase: 1.0

5.Analysis and Discussion

5. 1 L0 and L1 Scan (to adjust threshold)

・Event rate vs Threshold data of each PMT before L0 system and after L1
・Event rates were Poisson because of artificial light
・The inclination of L1 is about twice as large as that of L0



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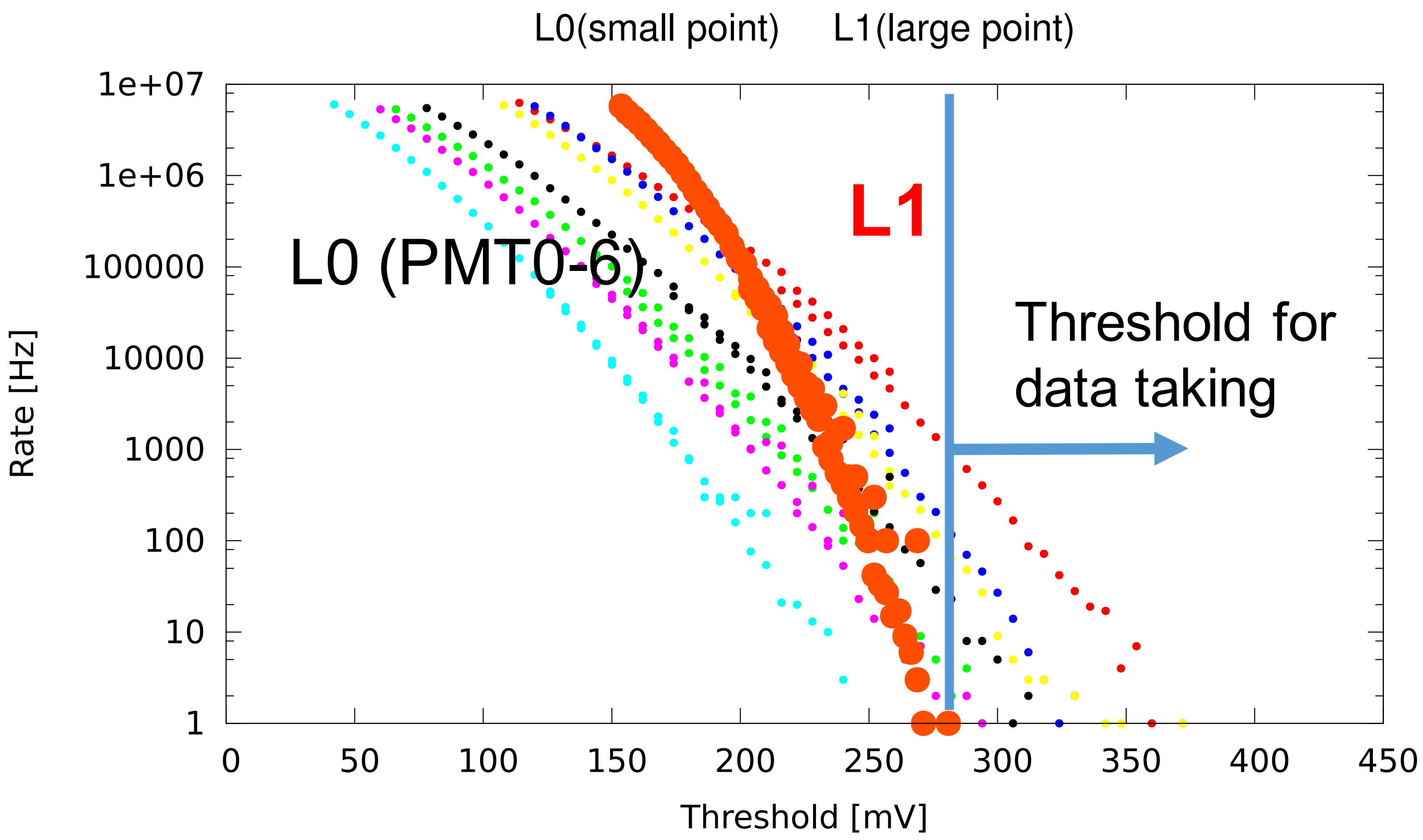
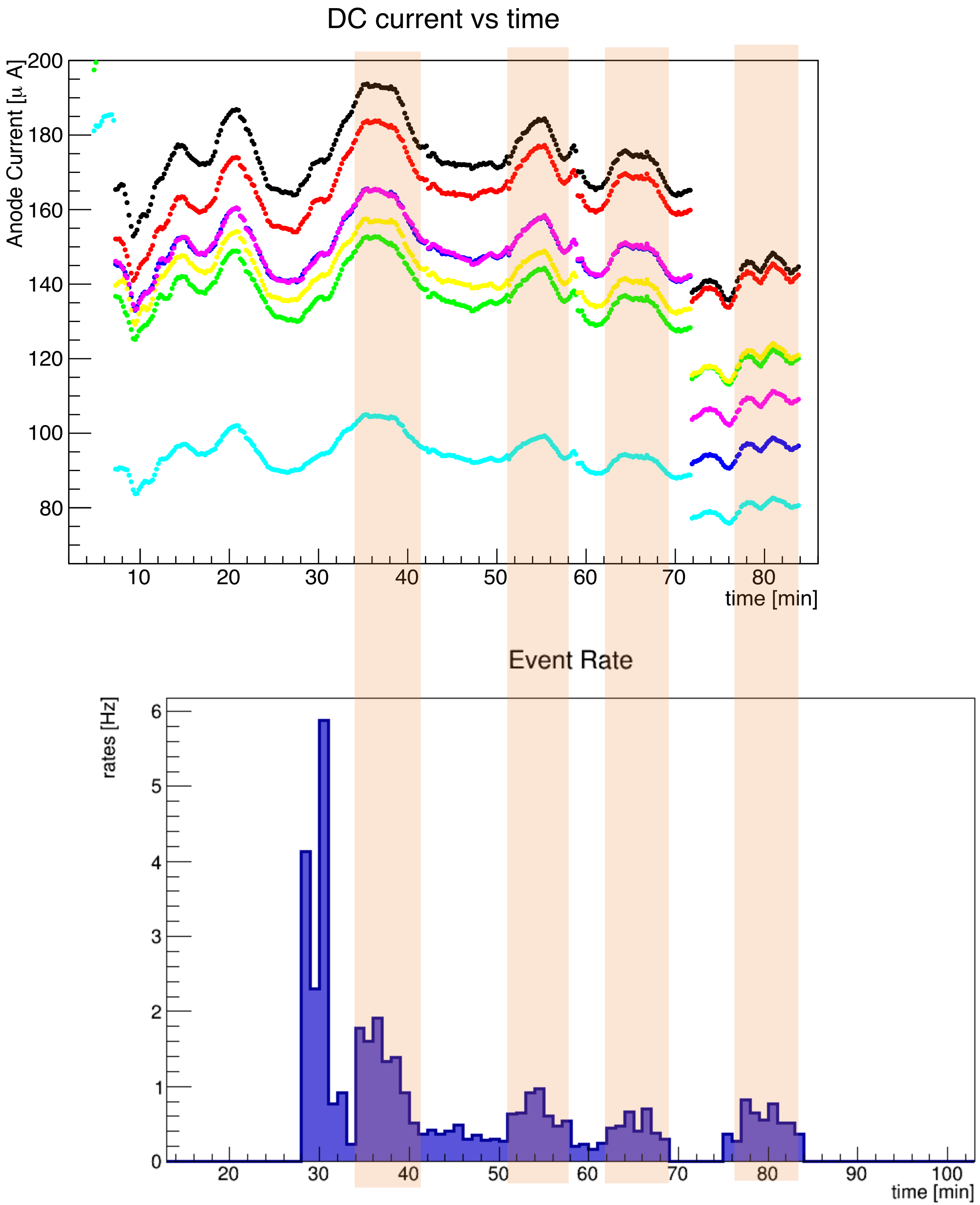


5.2 Data rate, DC vs Time

Correlation of data rate vs time and DC vs time

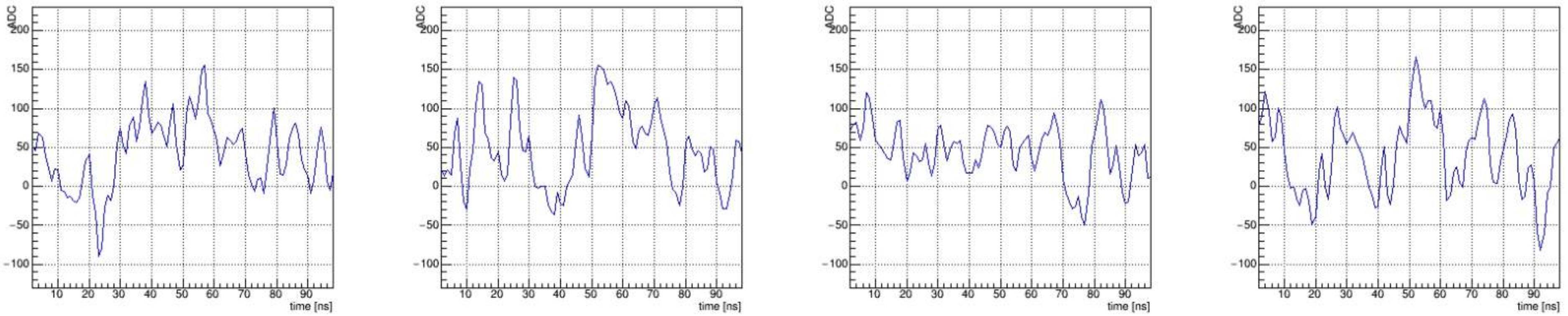
They are totally coincident.

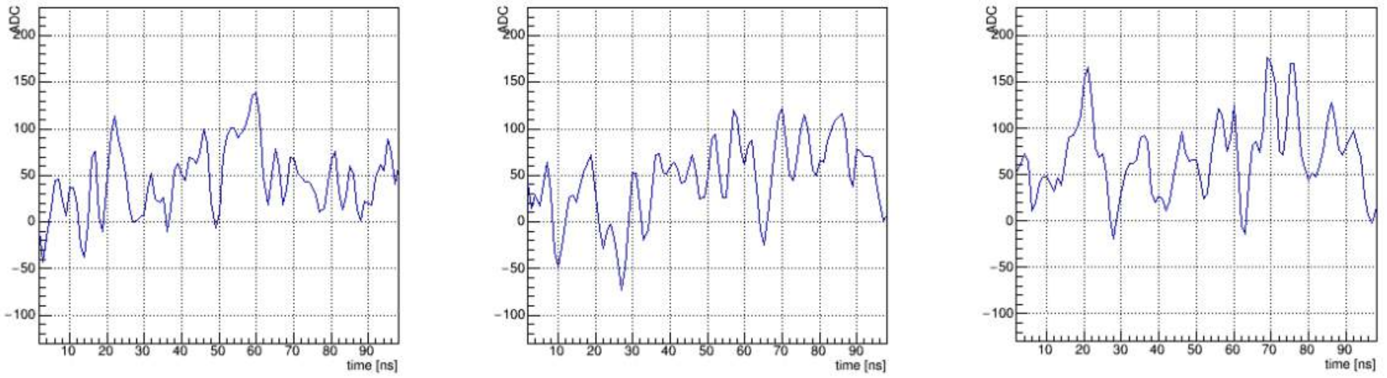


5.3 Beautifulness

We triggered 1500 events in one hour !

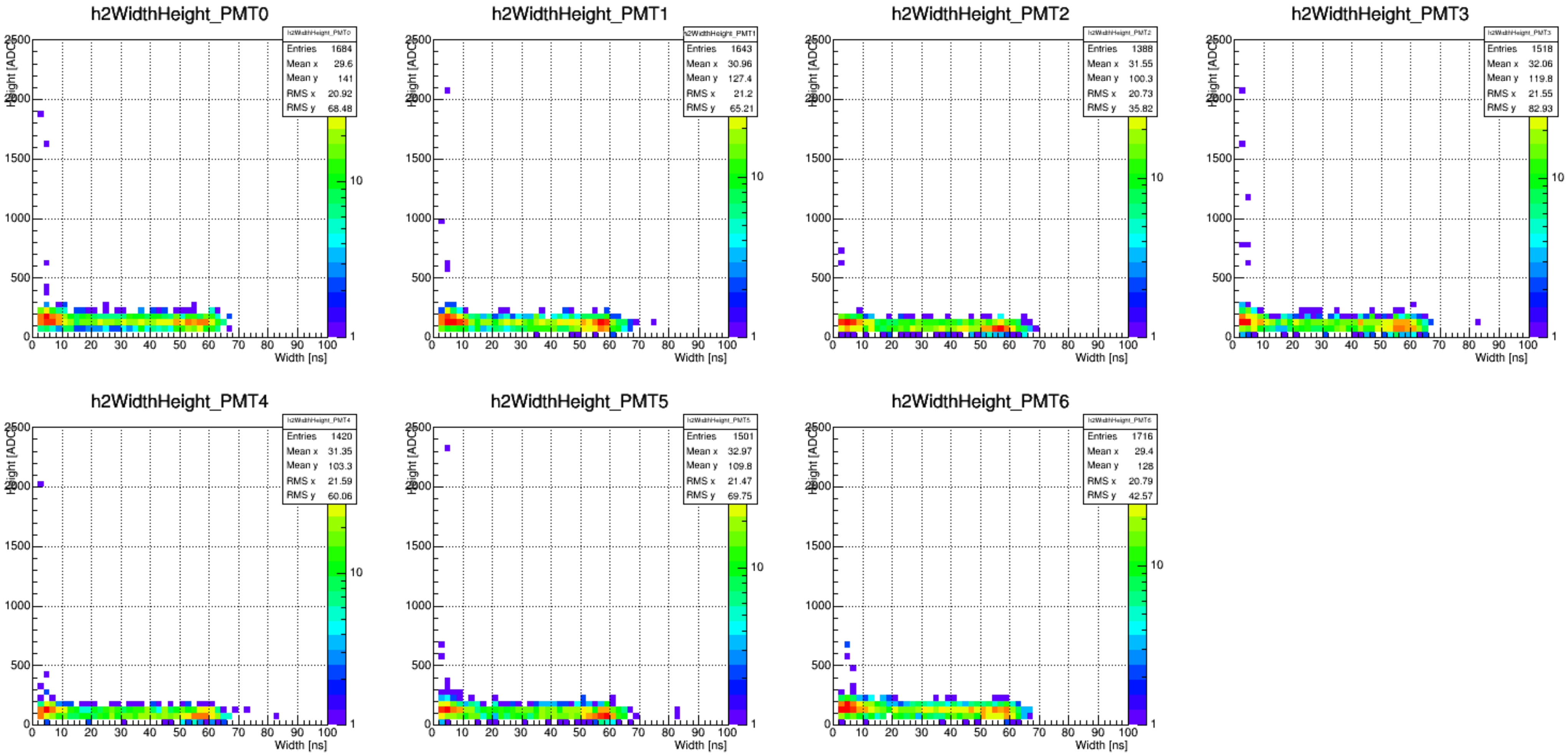
5.4 Beautifulness



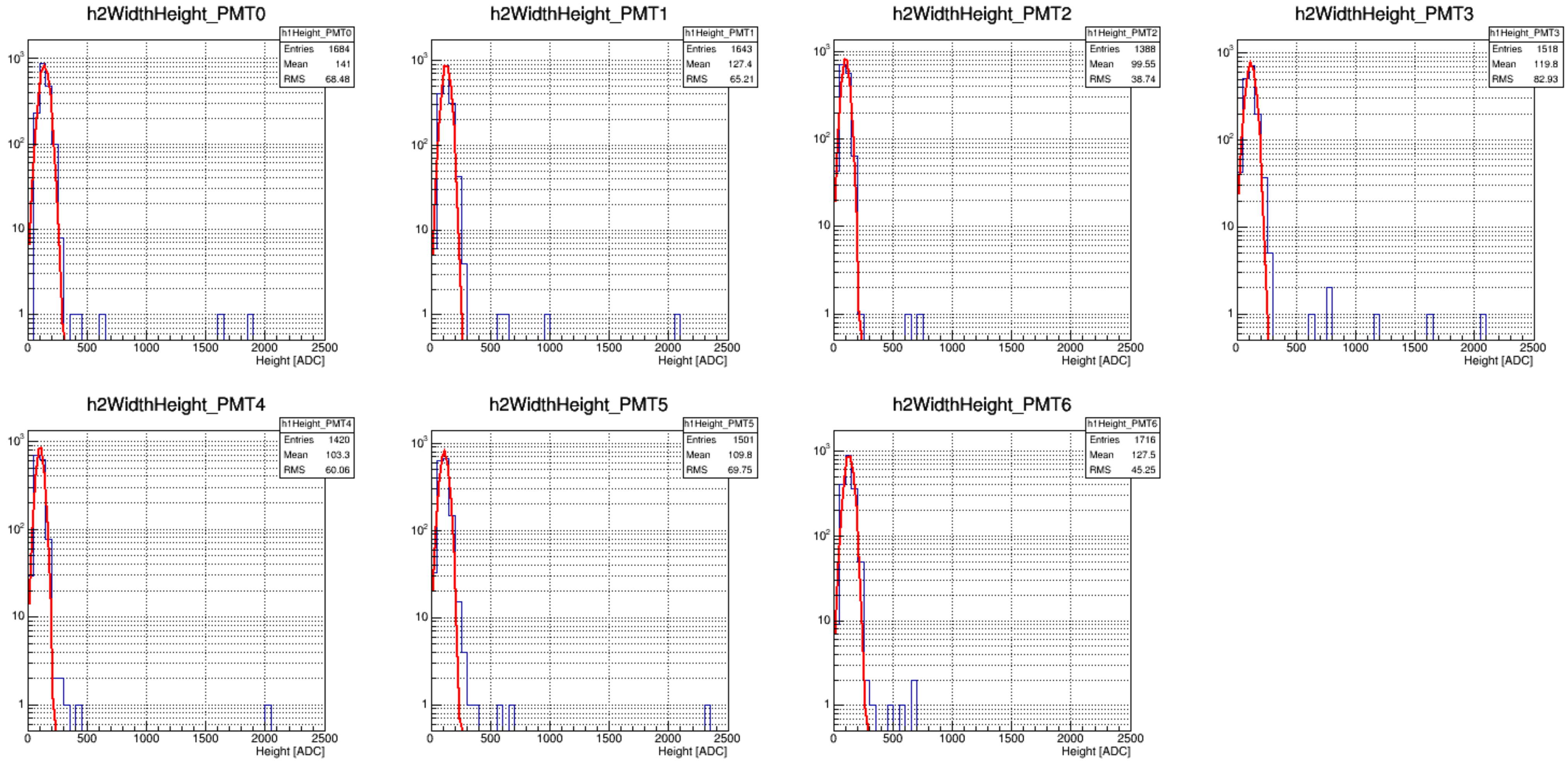


Bad events, not including cherenkov light

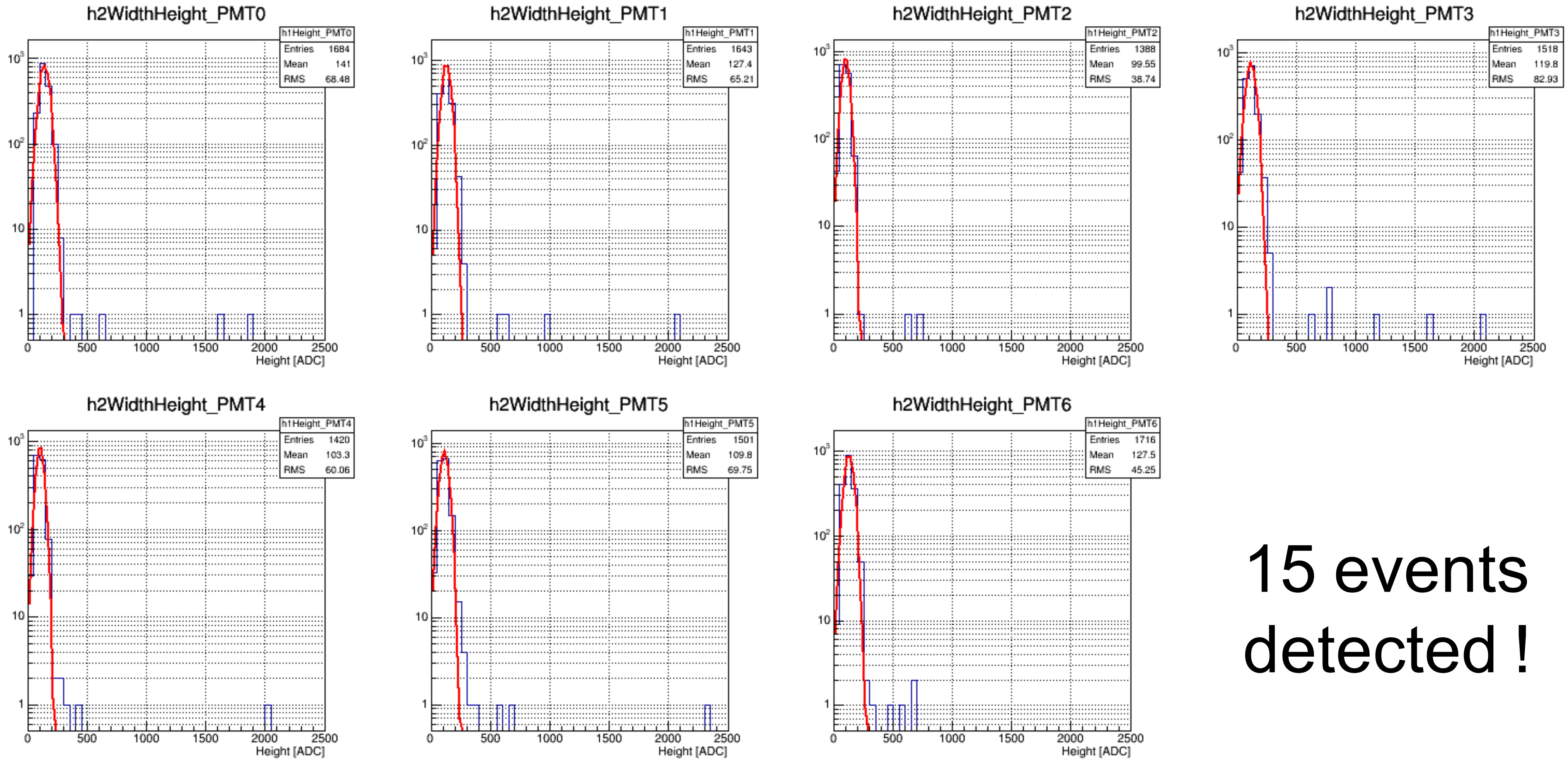
5.4 Beautifulness



5. 4 Beautifulness

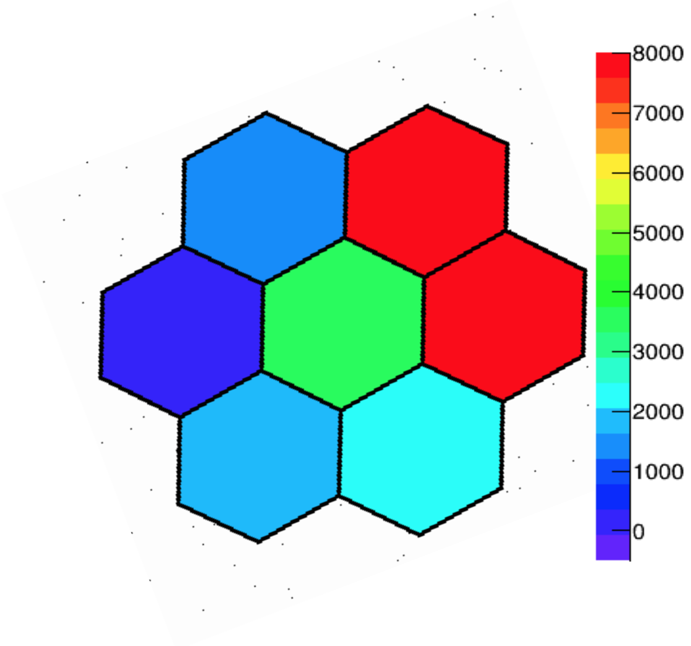


5. 4 Beautifulness

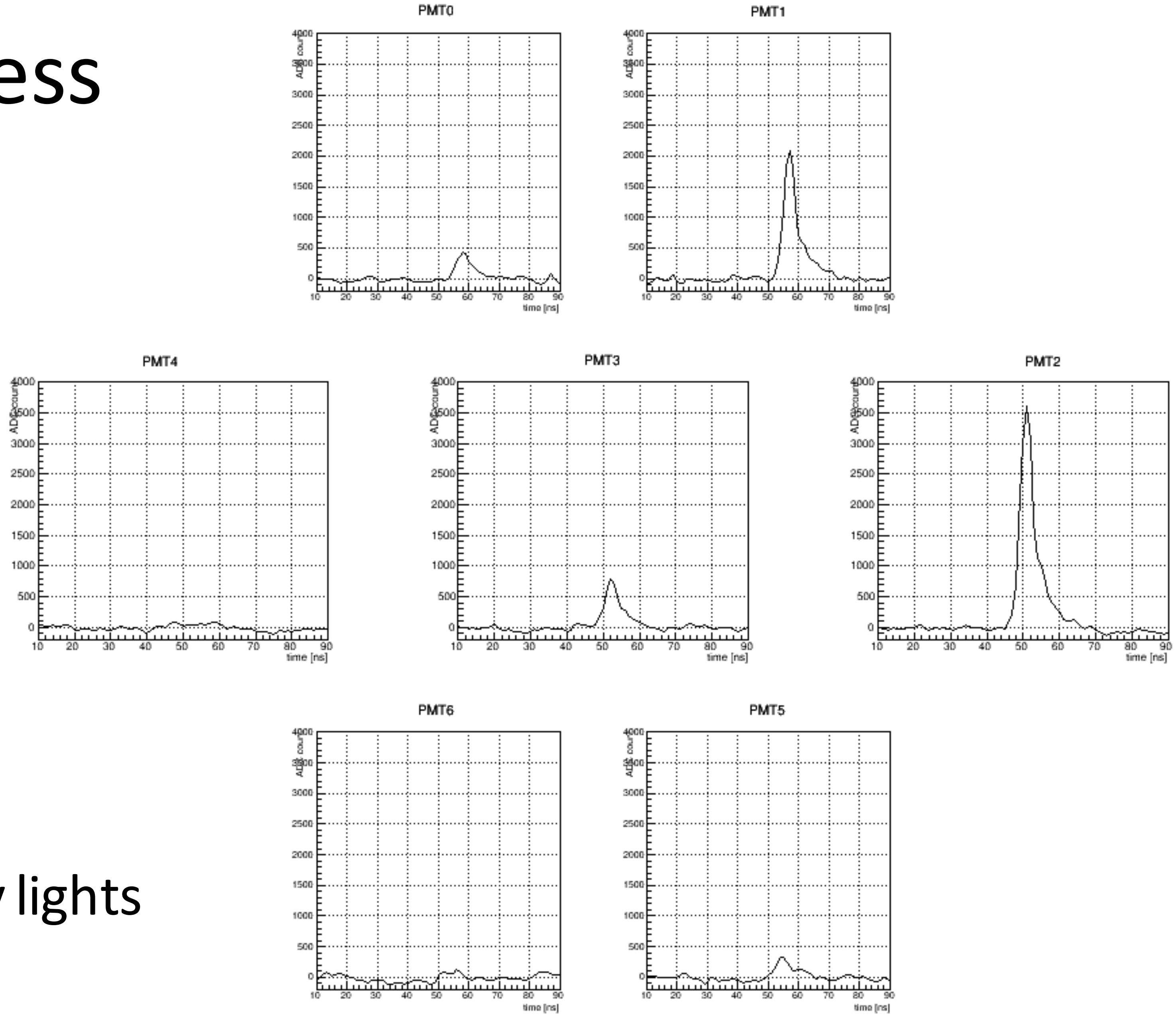


15 events detected !

5. 4 Beautifulness

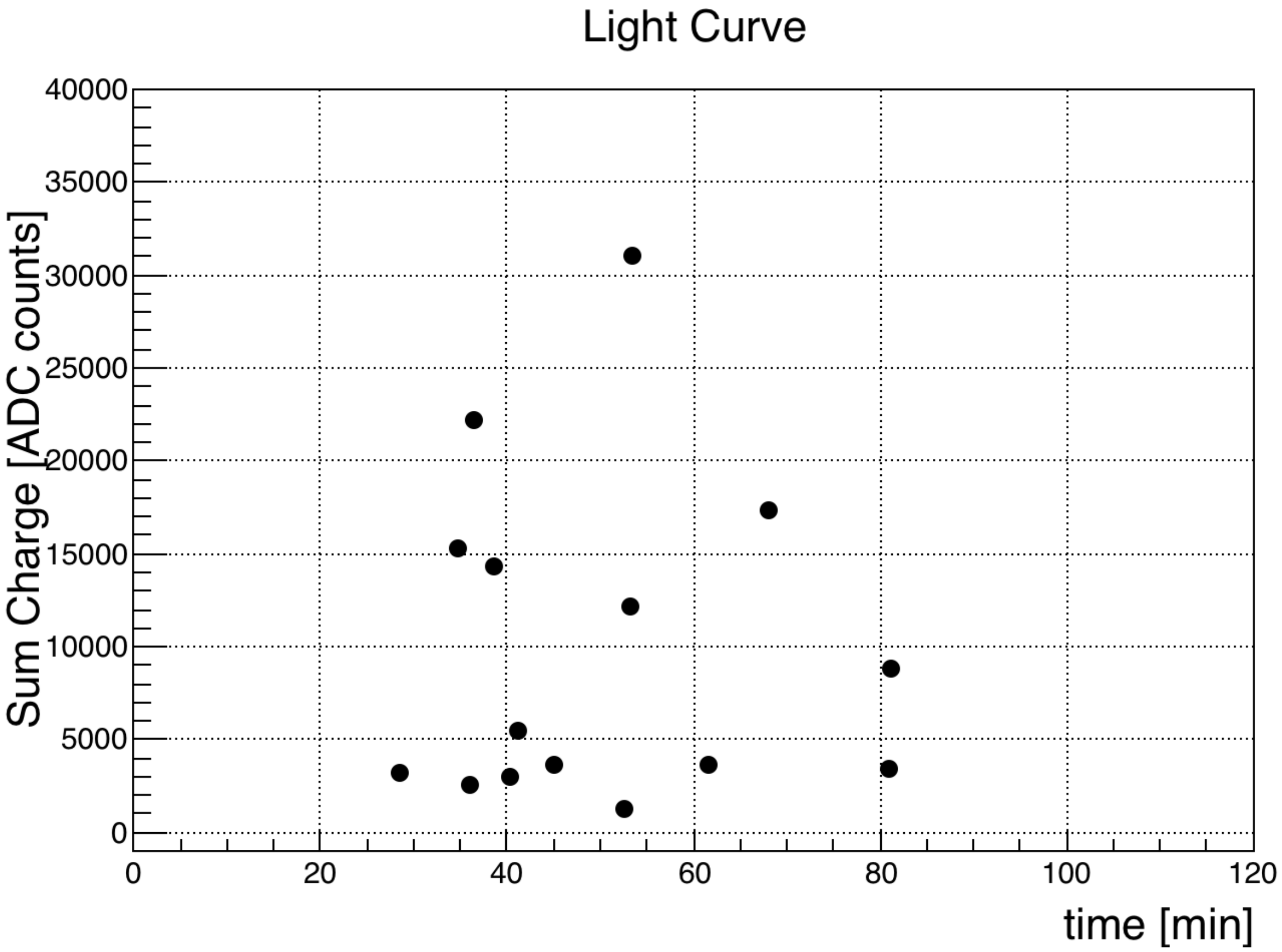


Events catching cherenkov lights



5. 5 Light Curve

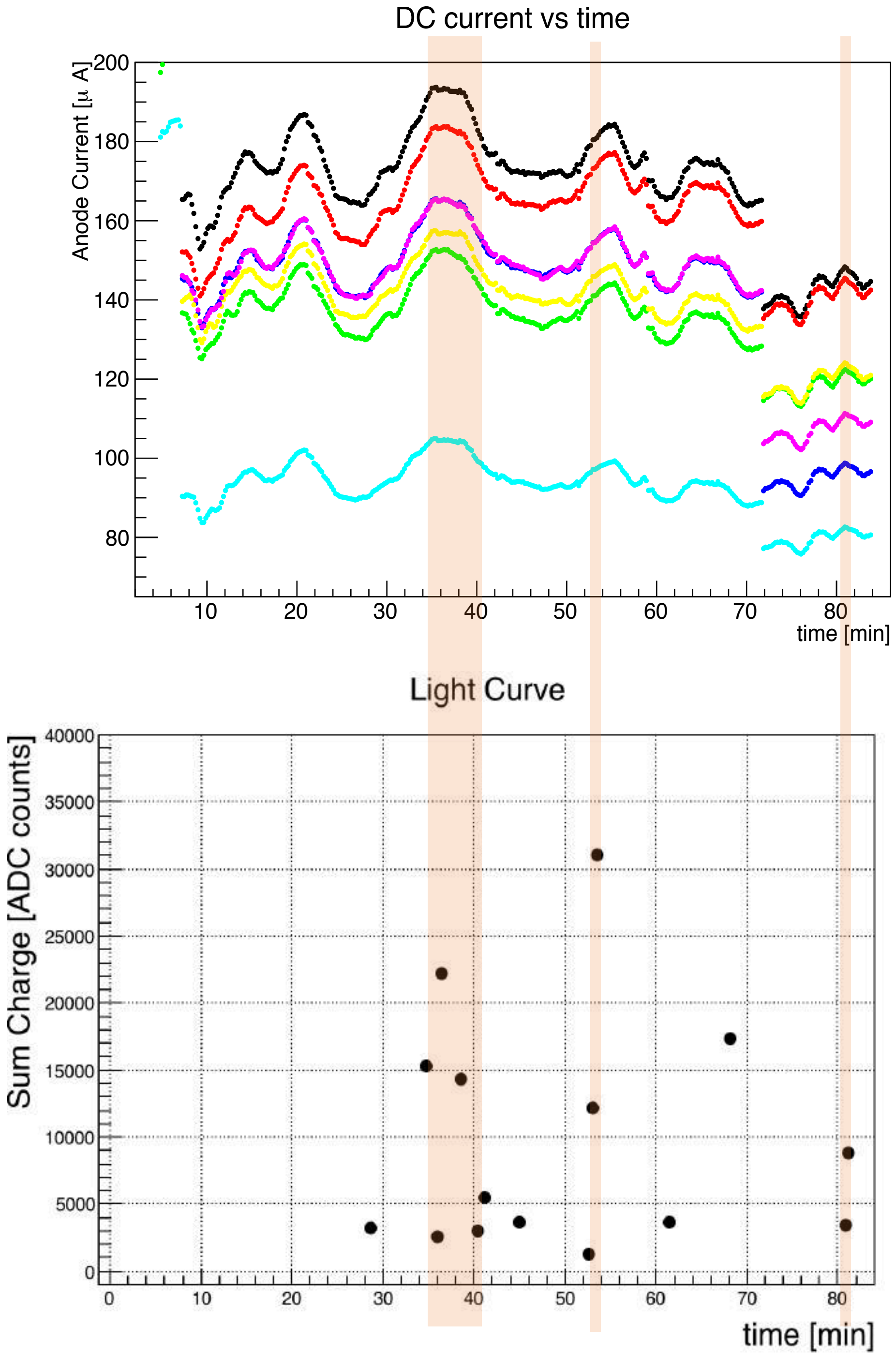
We caught 15 events from our observation!!



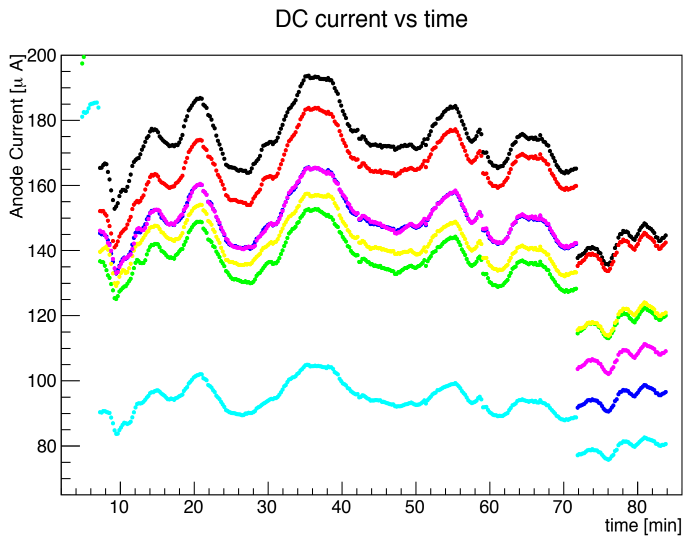
5.6 Light Curve

The events occurred when DC current was high

It may because the height of the clouds changed
(Clouds in the higher sky may reflect the city light while clouds near the ground shut it out)



5.7 NSB rate from DC vs L0 Scan

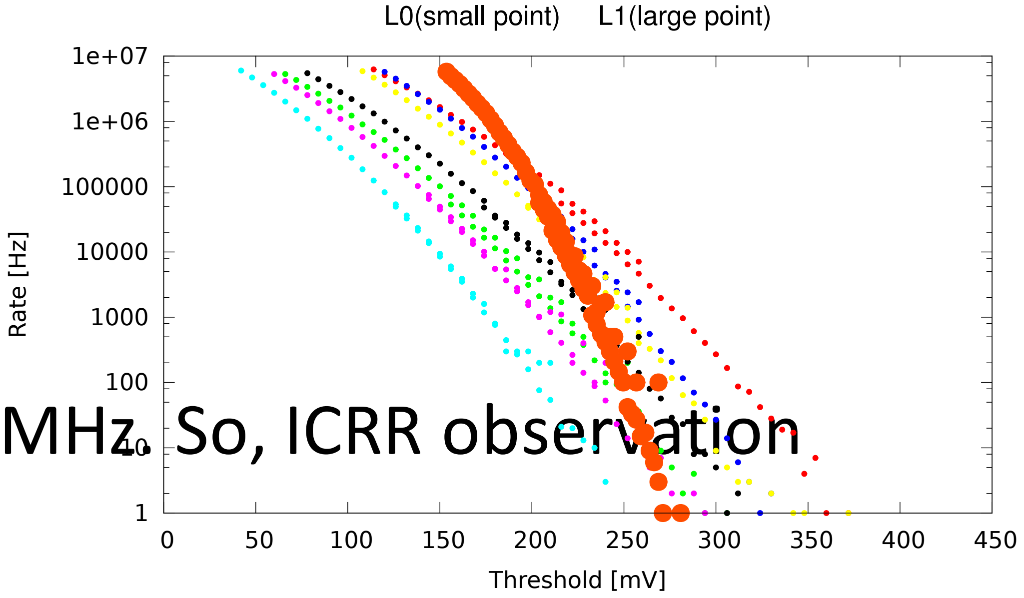


- Night sky background (event rate) is assumed by DC and L0 scan

→They should match

- Event rate from DC is 8×10^{10} Hz
- Event rate from L0 scan is 7×10^{10} Hz

→They are almost the same

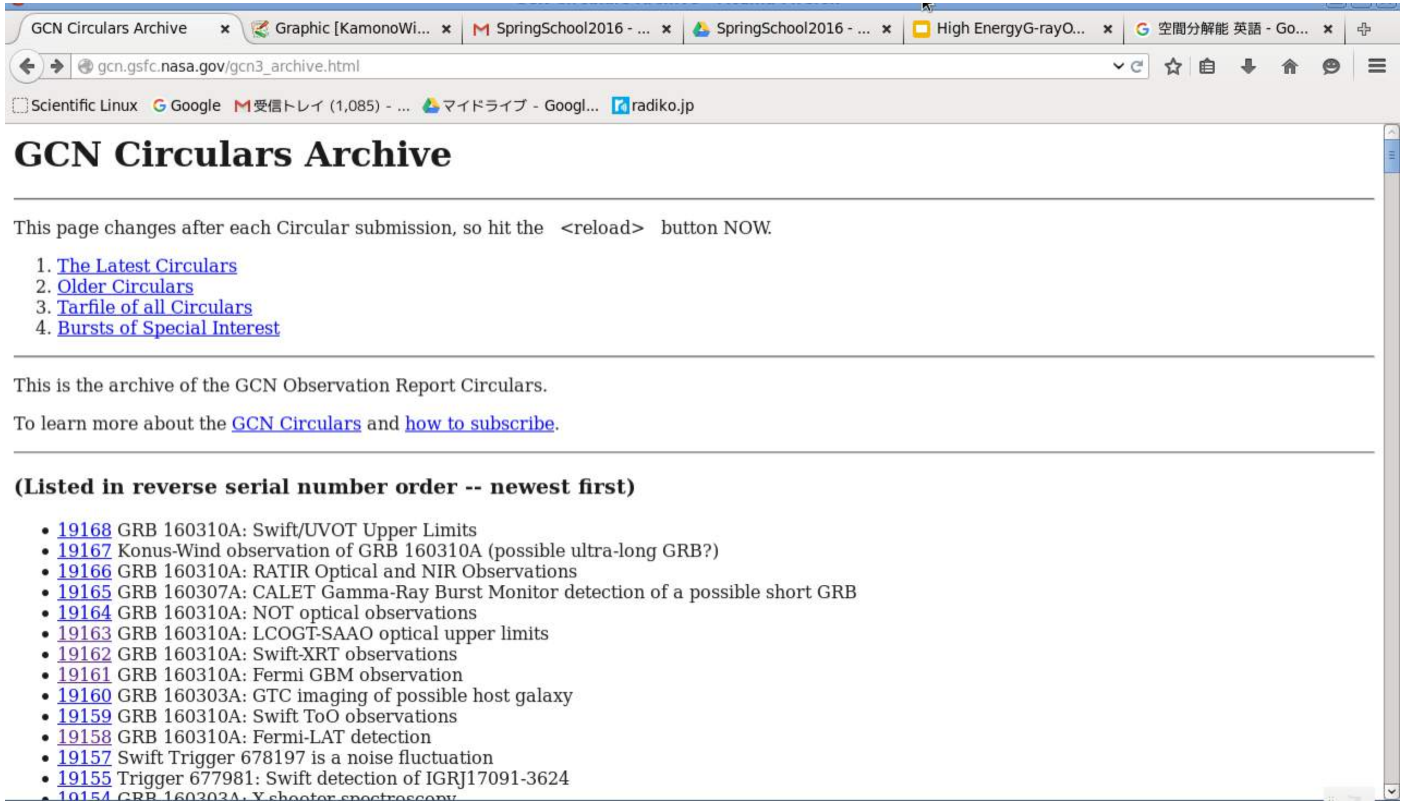


We are told in La Palma the NSB rate is 300 MHz. So, ICRR observation site is not so good…

5.8 GCN

At **AM** 9:30 on March 10, the Fermi satellite observed GRB event!

Our observation was done from **PM** 9:15 to 10:40



5.9 The source of Cherenkov light

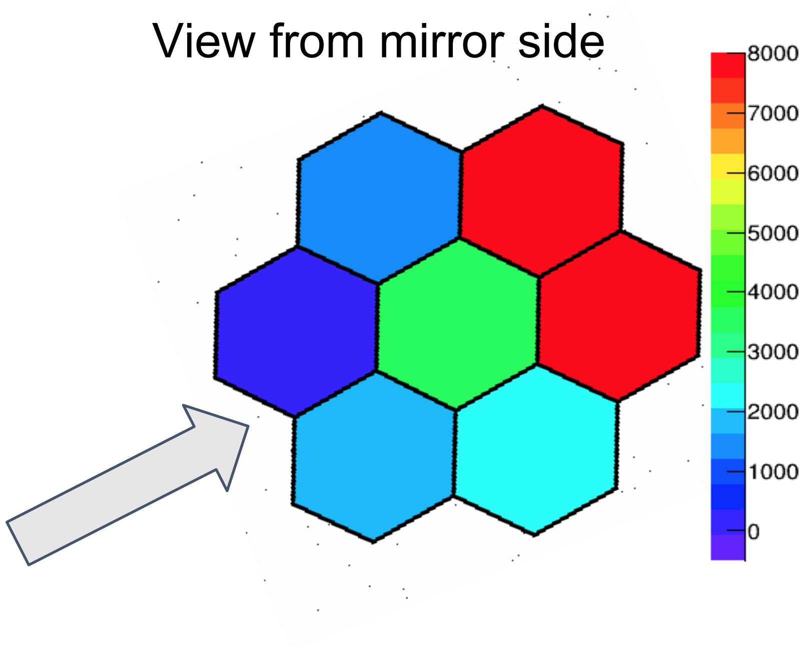
・The shape of the signal denies the possibility that the light is from airplane or lightening.

・The source is the most probably high energy cosmic ray because it was cloudy and only high energy ray could produce a shower large enough to go through clouds

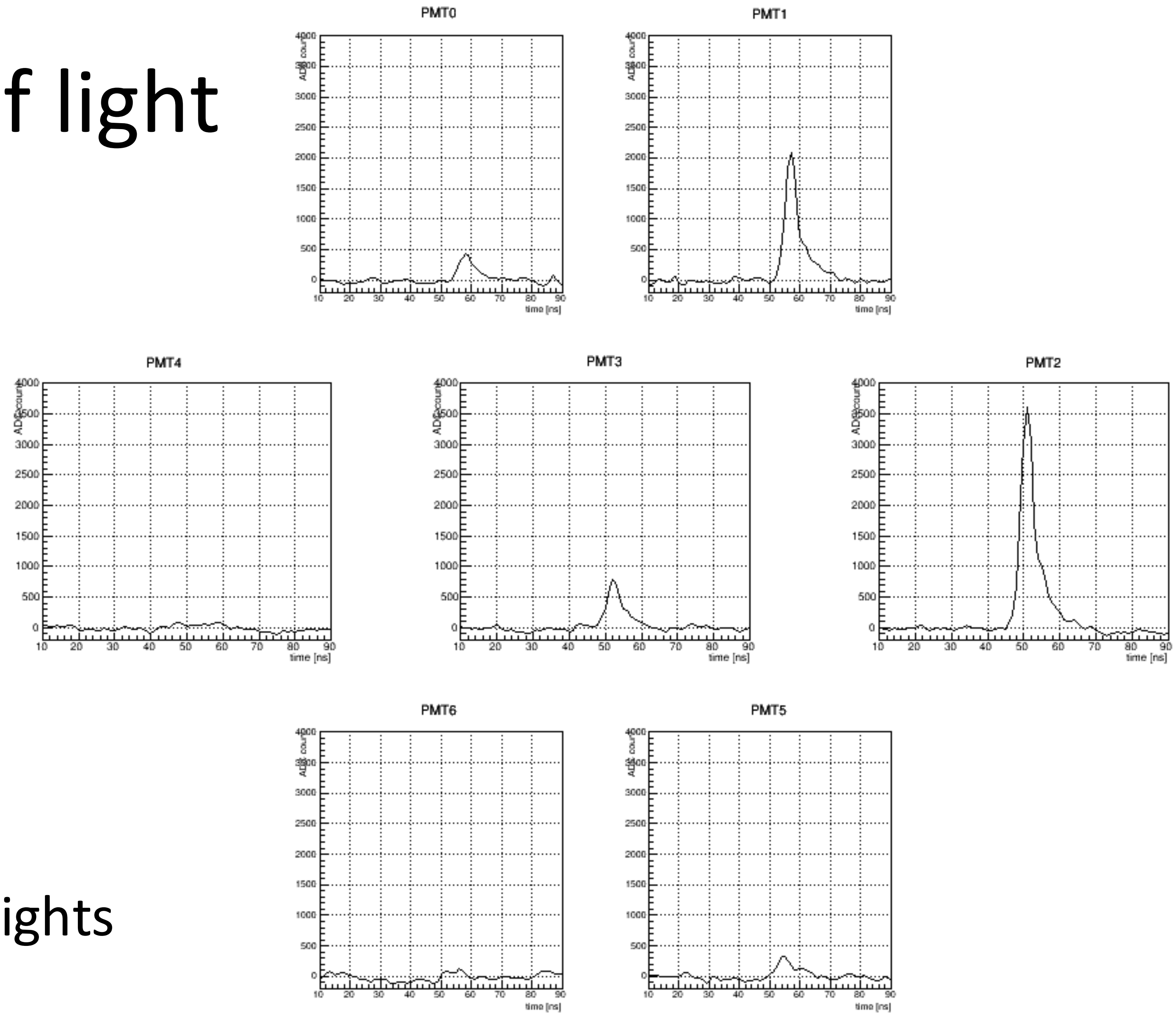
→The source is not gamma-ray but proton

5.10 Direction of light

View from mirror side



Events catching Cherenkov lights



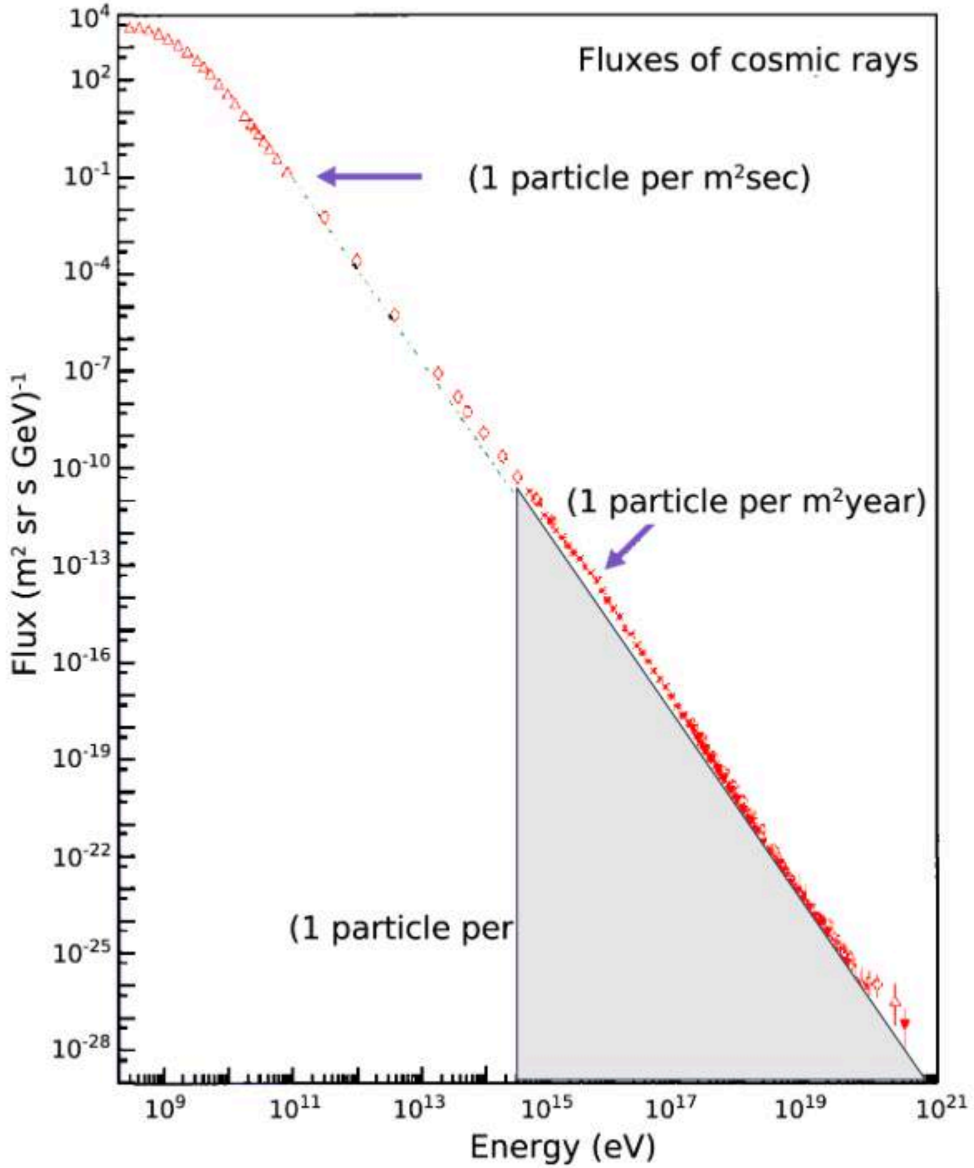
Estimate of energy threshold of our observation

Our Ingredients:

1) differential cosmic ray spectrum from literature
2) Detector effective area is 0.6 km^2
3) field of view for proton is 10 deg
4) observation time is 1 hour
5) we obtained 15 beautiful events

After integration

we obtain the threshold is: 200 TeV



6.Future Prospects

6.1 Future Prospects

Position reconstruction

more than two telescopes

Imaging analysis

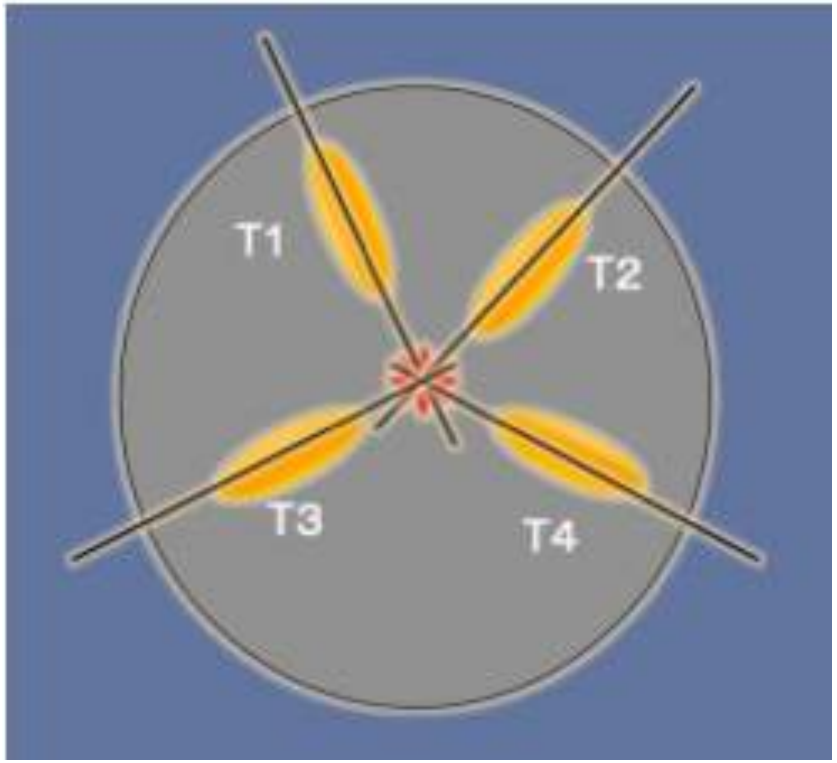
more pixels

Weather condition

less noise & higher S/N

Longer data acquisition time

clear trend & high probability of events



7.Conclusion

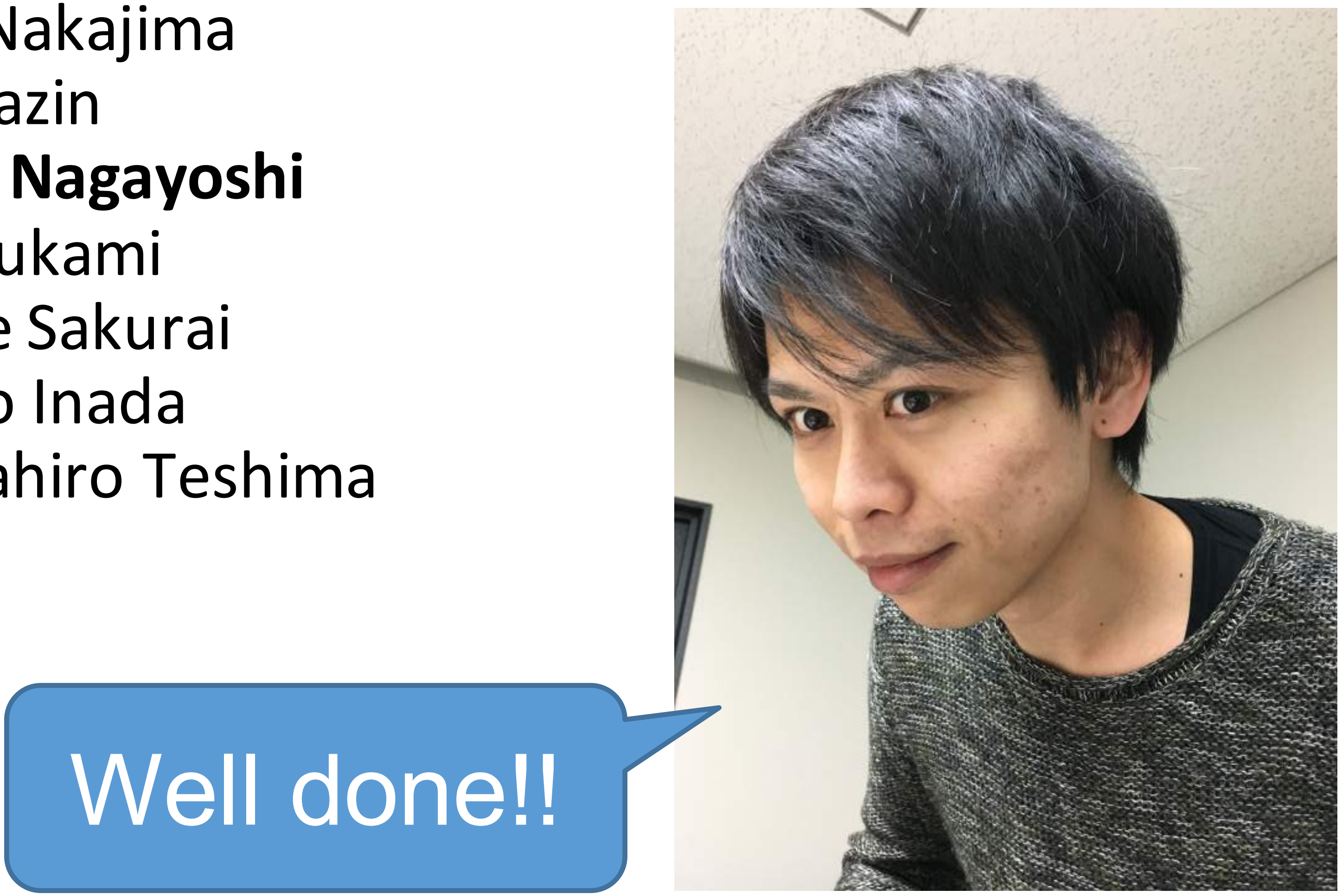
7.1 Conclusion

WE

Arranged a setup of the telescope
Made observations
Analyzed signals
Could not see crab nebula
Saw probable Cherenkov lights not from gamma ray burst
Detected 15 air showers !!

Special Thanks to

Daisuke Nakajima
Daniel Mazin
Tsutomu Nagayoshi
Satoshi Fukami
Shunsuke Sakurai
Tomohiro Inada
and Masahiro Teshima



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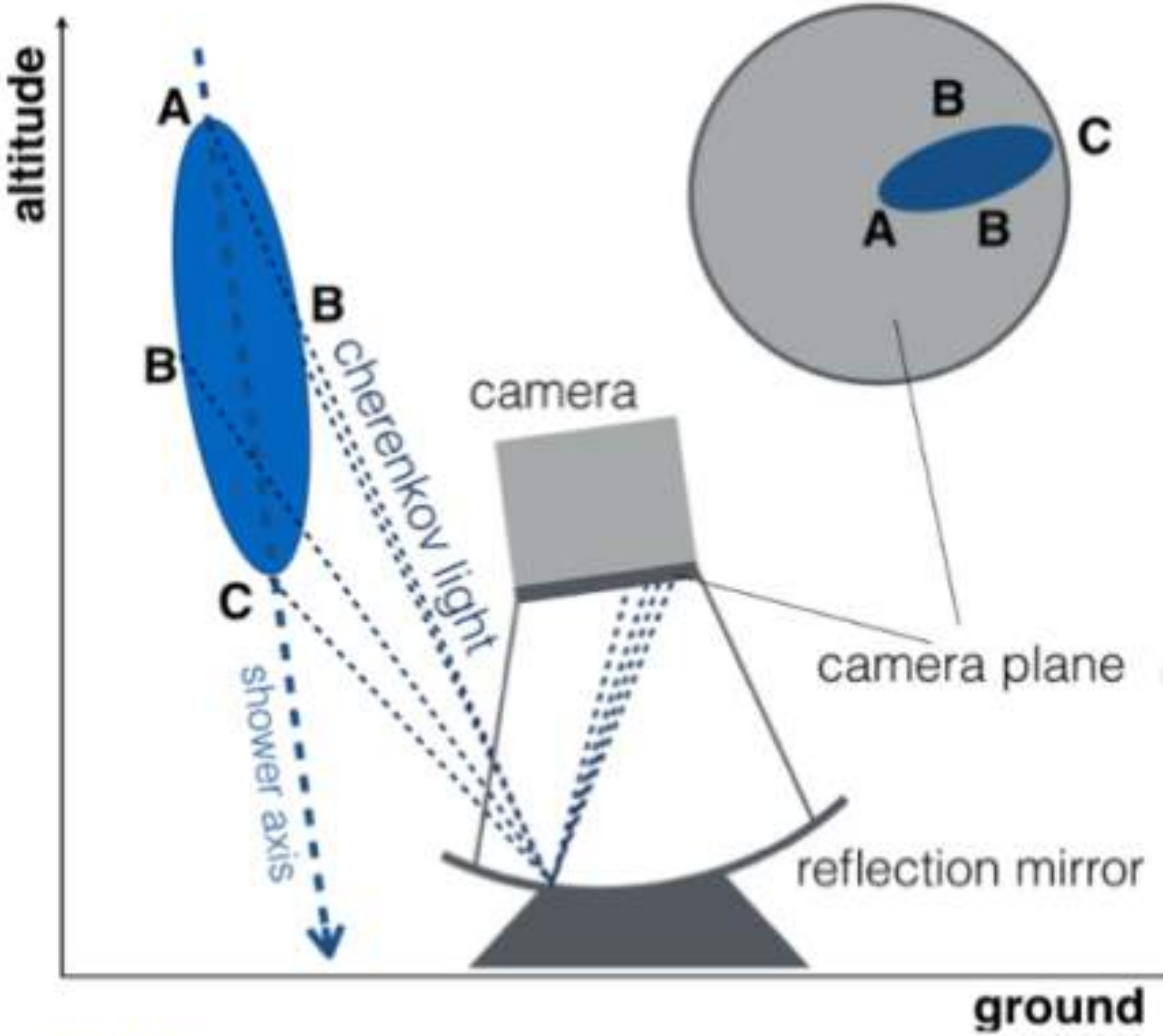
高エネルギーガンマ線天文学

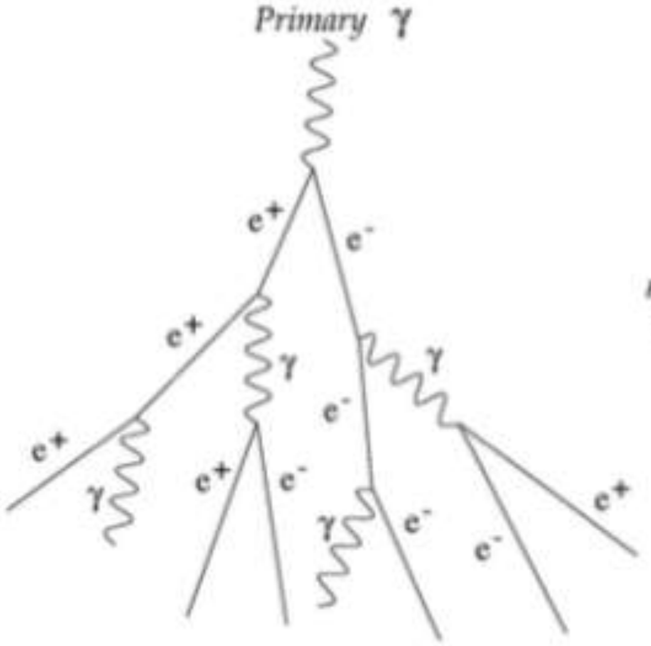
cta
cherenkov telescope array

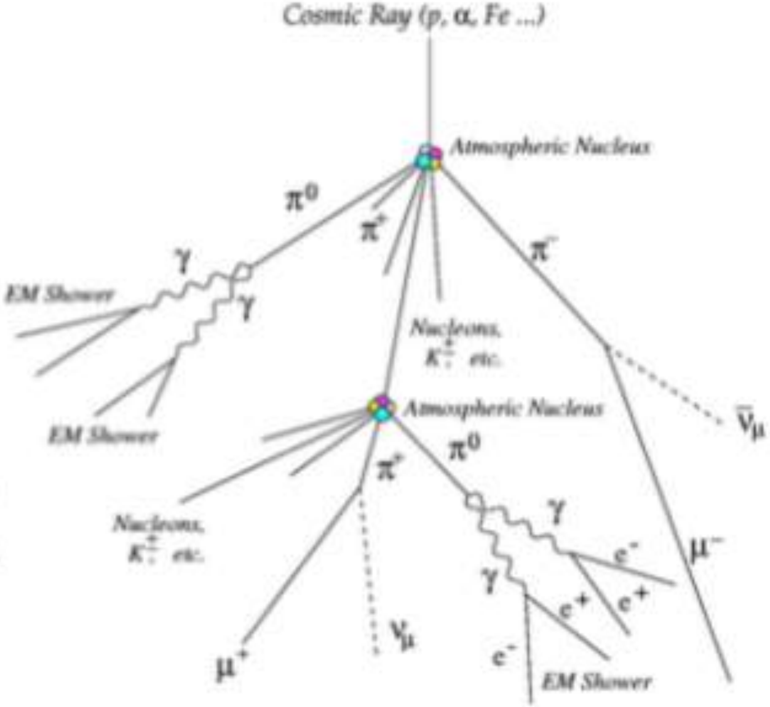
ICRR
Institute for Cosmic Ray Research
University of Tokyo



cherenkov telescope array

電磁シャワーとハドロンシャワー





Parameters	Requirements	R11920-100 (average)
Wavelength sensitivity range	290 - 600 nm	O.K.
Peak Q.E.	> 32%	**41%**
Average Q.E.	> 21%	**30%**
Collection efficiency	> 92%	94%
P/V ratio	> 1.5	3
After pulsing (> 4 p.e.)	0.02%	**0.0038%**
Pulse width (FWHM)	< 3.0 ns	3.7 ns
Dynamic range	1 p.e. - 1000 p.e.	O.K.
Life (50% drop in Gain)	> 200 C	O.K.