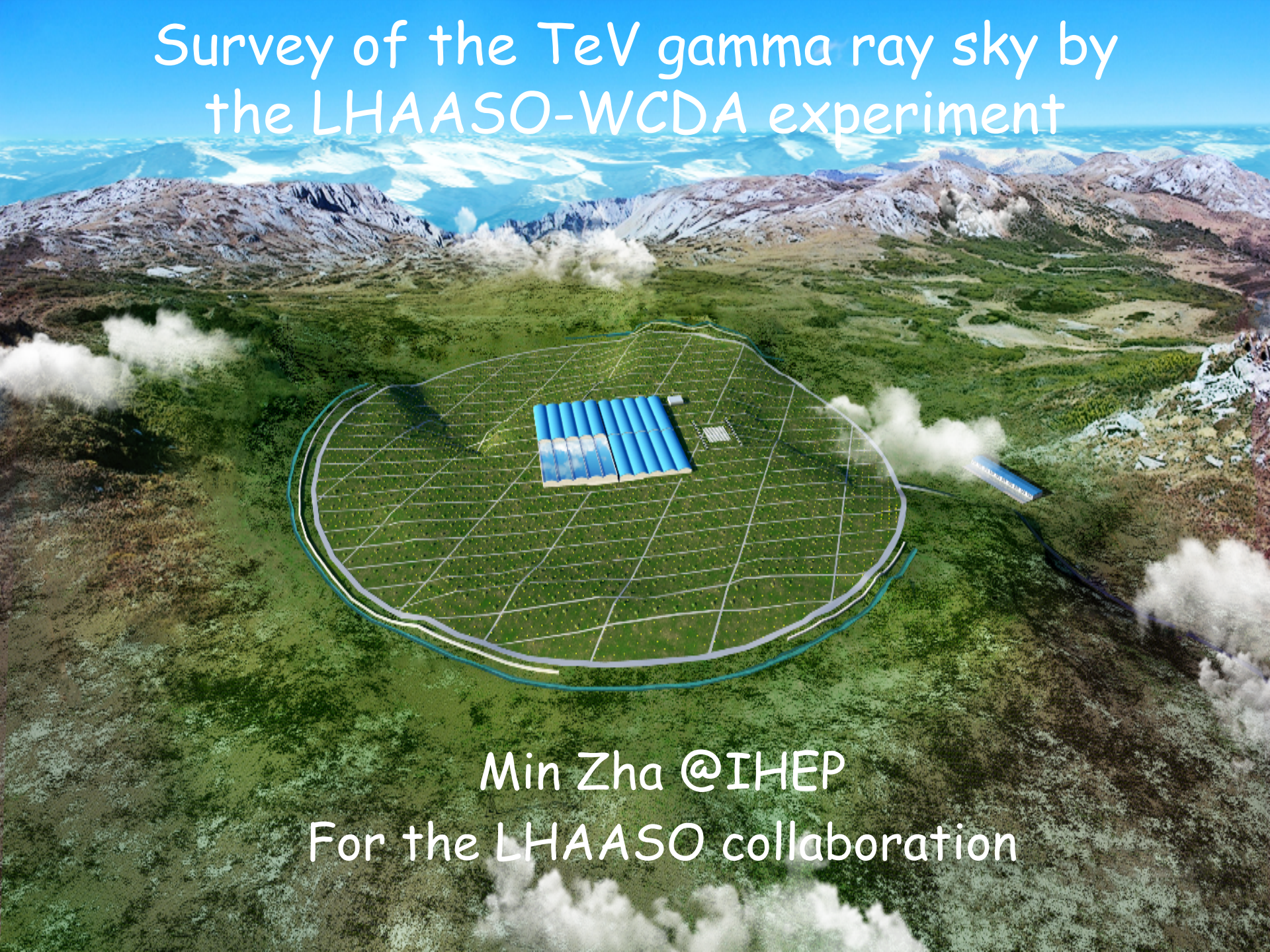
Survey of the TeV gamma ray sky by the LHAASO-WCDA experiment

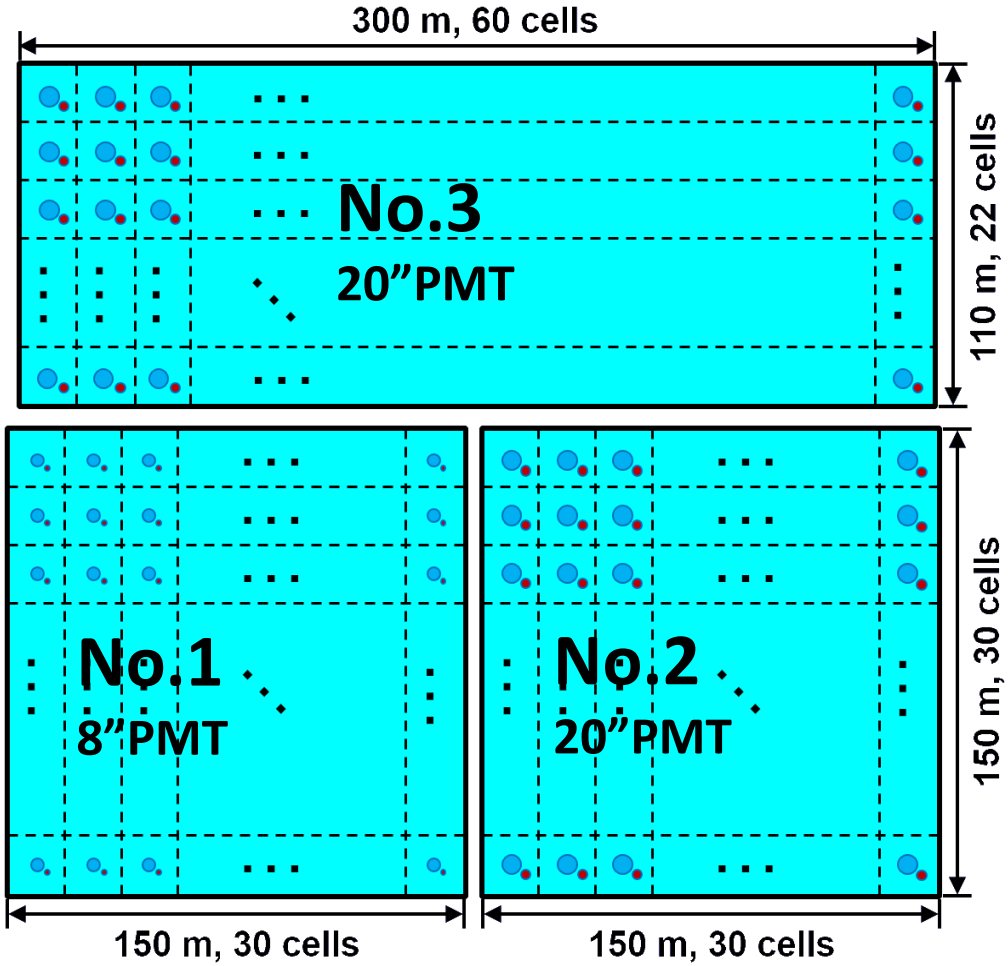


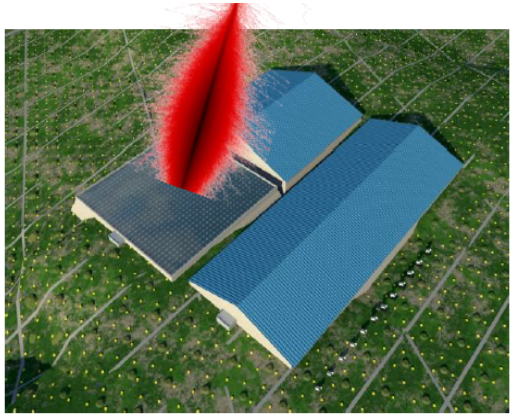
Min Zha @IHEP
For the LHAASO collaboration

outline

- Water Cherenkov Detector Array status
- Preliminary results from WCDA-1
- Summary and outlook

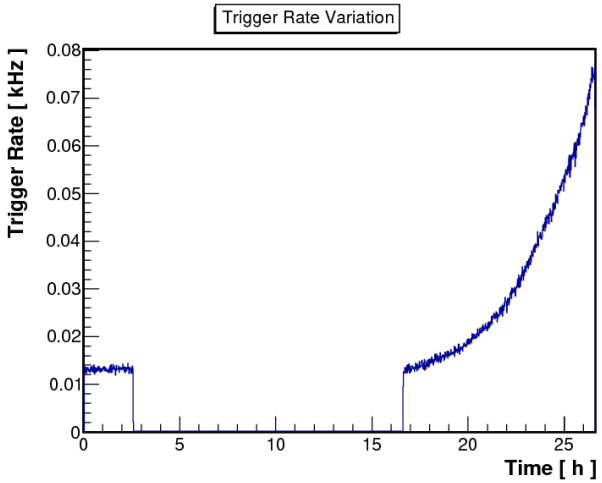
LHAASO-WCDA

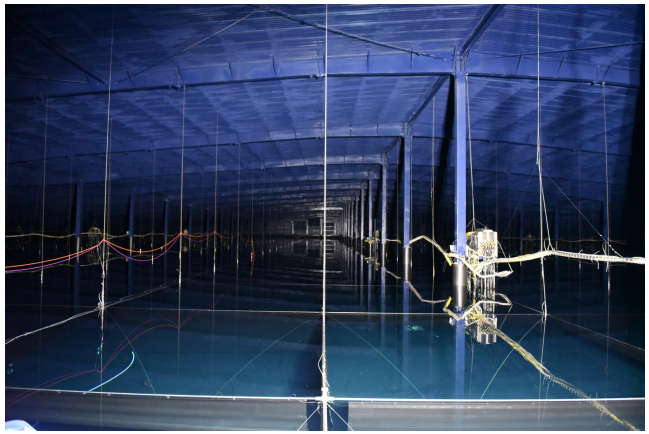

300 m, 60 cells
110 m, 22 cells
No.3
20”PMT
No.1
8”PMT
No.2
20”PMT
150 m, 30 cells
150 m, 30 cells
150 m, 30 cells


μ±
e±
e±
γ
γ
Curtain
4 m
8”/9” PMT
5 m
5 m

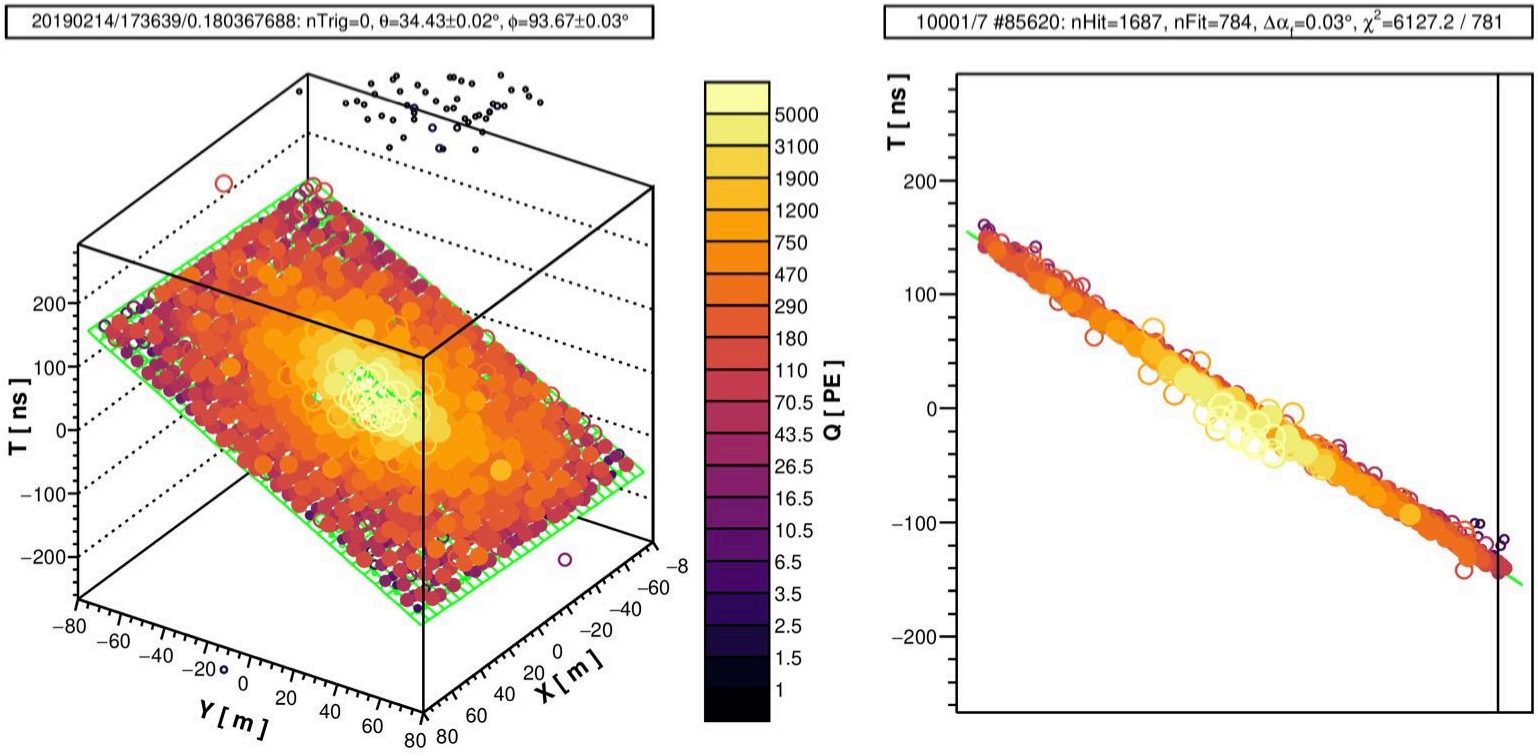
Timeline of WCDA#1

- 2018/10/22: start deployment;
- 2019/01/10: deployment complete;
- 2019/01/11: start dry data-taking mode;
- 2019/02/25: DAQ with water ;
- 2019/04/07: achieve full water depth;
- 2019/04/26: start scientific data-taking 。
- Running mode @ test water running mode
  - 2 hours + multi-mode looping
  - S3:90s E2:30m S3:90s SH4:20m S3:90s E2:30m S3:90s E2:30m
- Normal running mode from 20190511
  - EM17
  - 17 hits within 300 ns;
- GRB + shower mode from 20190604
  - GRBM17
  - To now: 36 GRBs
- B-pmt + S-pmt joint mode from 20191009
  - P1GRBM20M



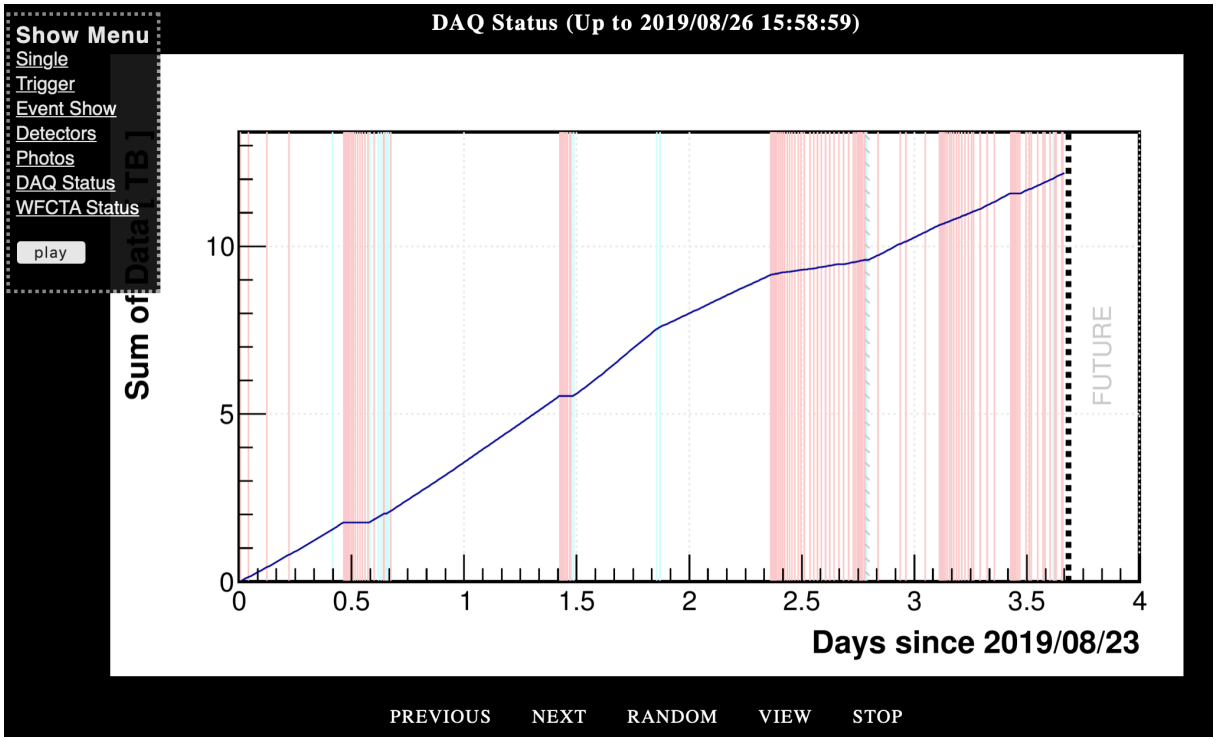


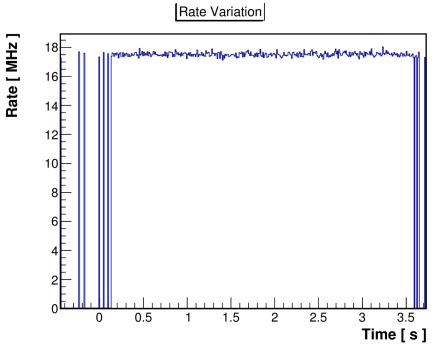
Valentine day event

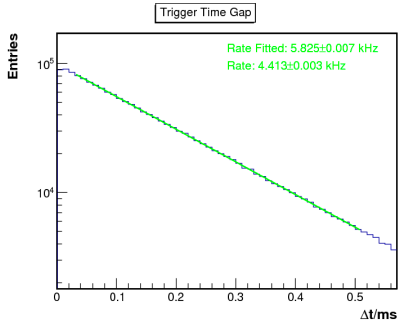


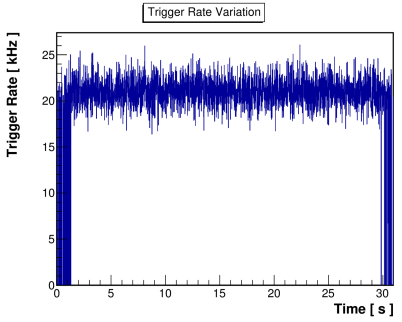
Data on-line monitor

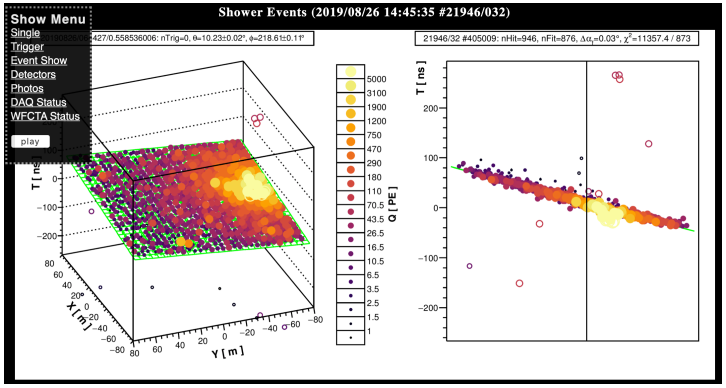
http://202.38.128.103:9019/wcda_detectors/

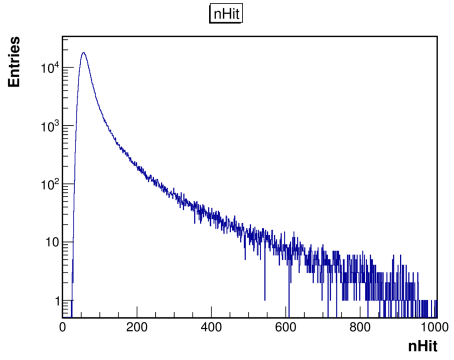


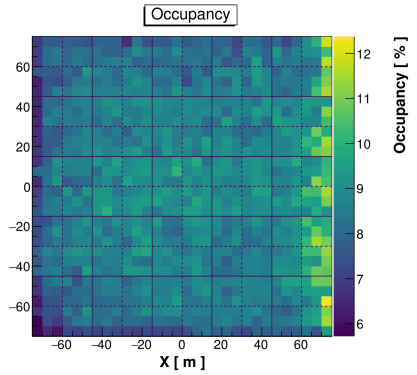




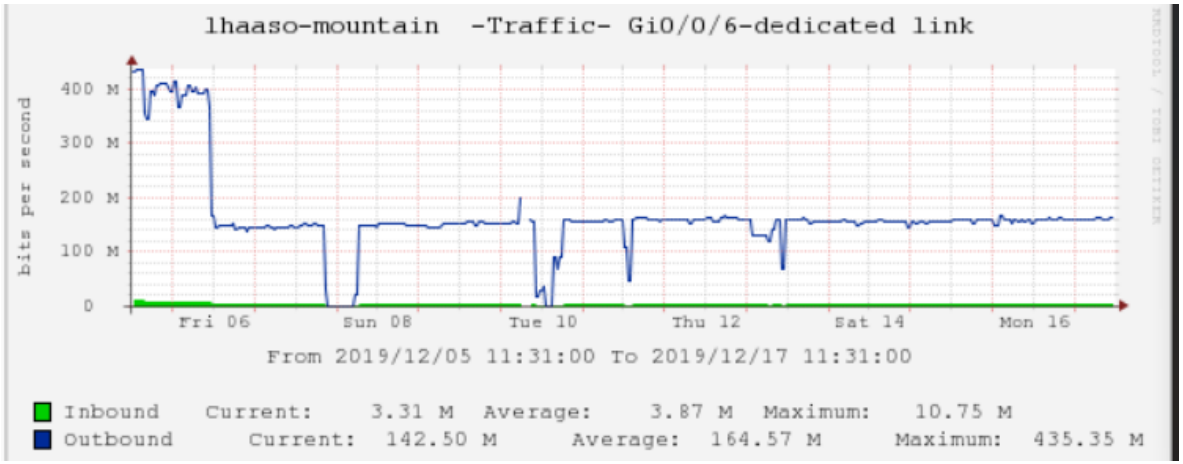




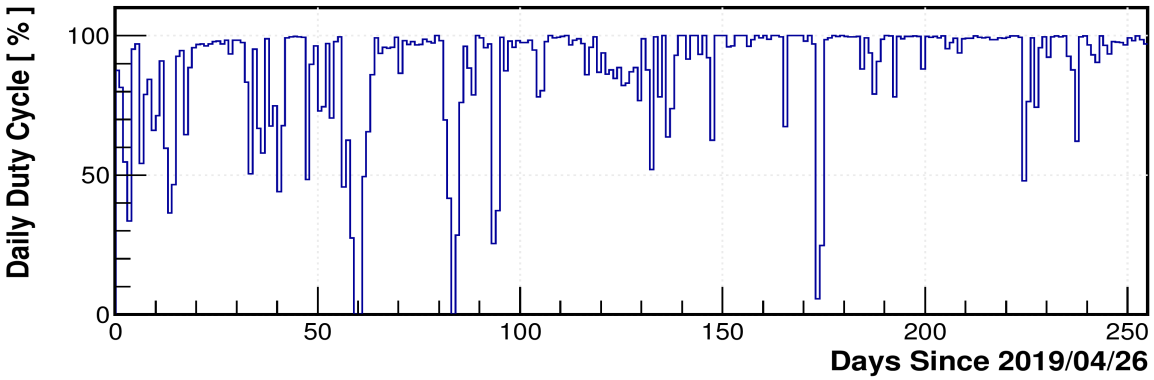


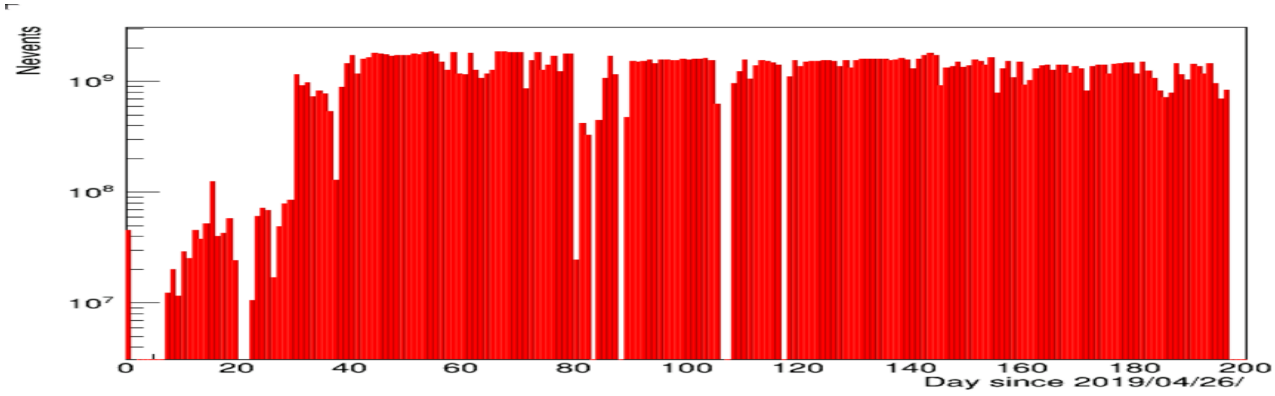


WCDA-1 data taking

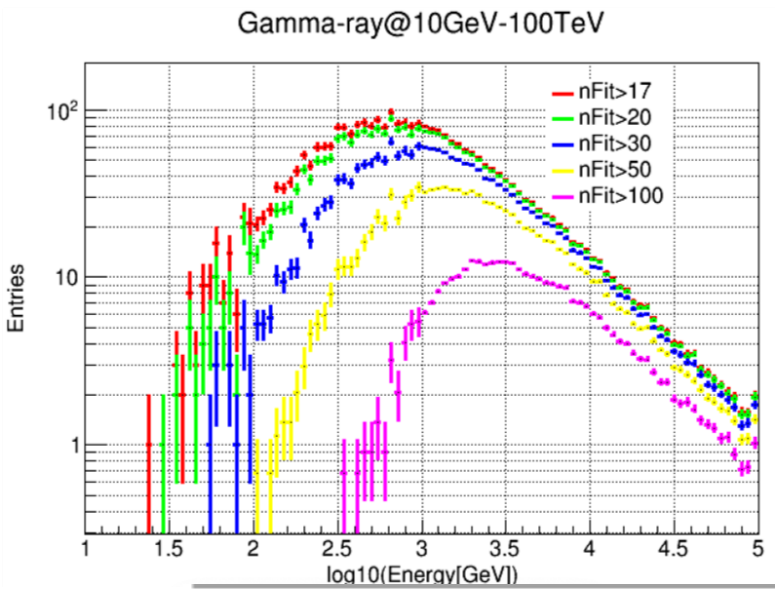


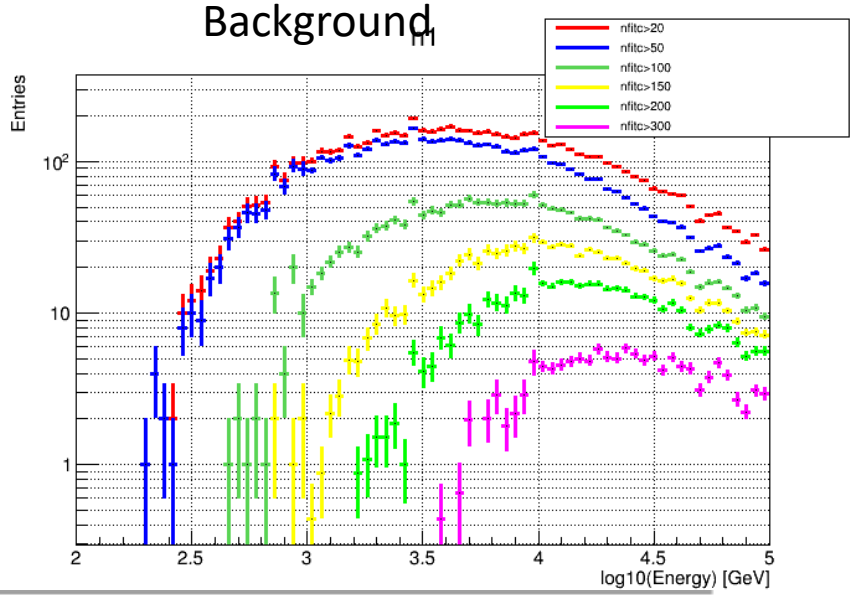
Overall Duty Cycle = 88.12%





Data .vs. MC

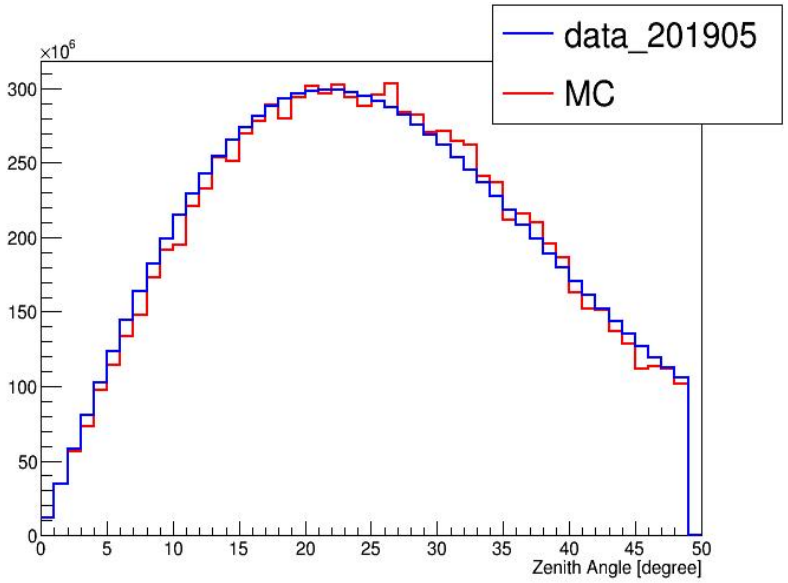


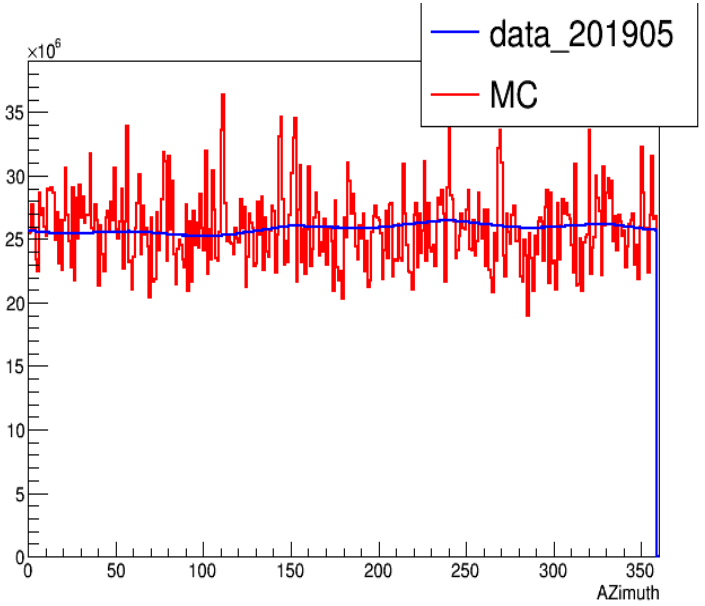


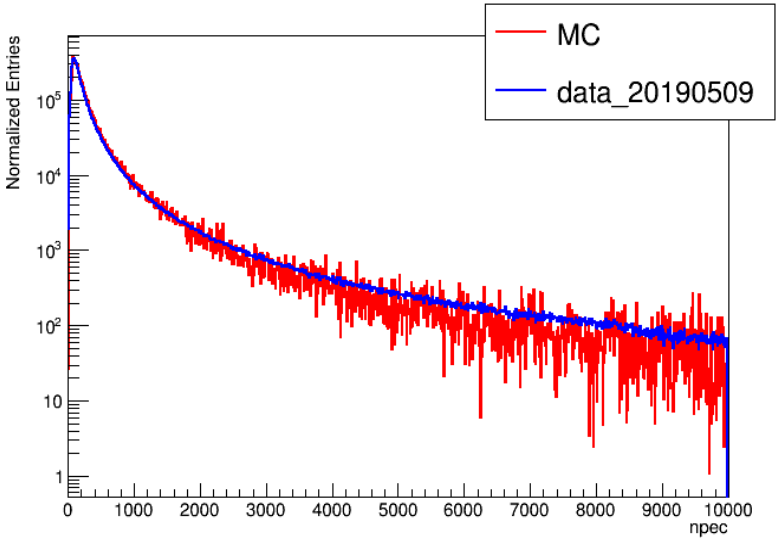
CR	>17 (NHit)	>20 (NHit)	>30 (NHit)	>50 (NHit)	>100 (NHit)
P	13.2 kHz	9.7 kHz	4.7 kHz	1.9 kHz	0.6 kHz
He	4.9 kHz	3.5 kHz	1.7 kHz	0.8 kHz	0.3 kHz
CNO	1.3 kHz	0.9 kHz	0.4kHz	0.2 kHz	0.07 kHz
MgAlSi	0.6 kHz	0.4 kHz	0.2 kHz	0.08 kHz	0.03 kHz
Fe	0.5 kHz	0.3 kHz	0.16 kHz	0.07 kHz	0.02 kHz
All (8m)	20.5 kHz	15.0 kHz	7.2 kHz	2.9 kHz	1.0 kHz

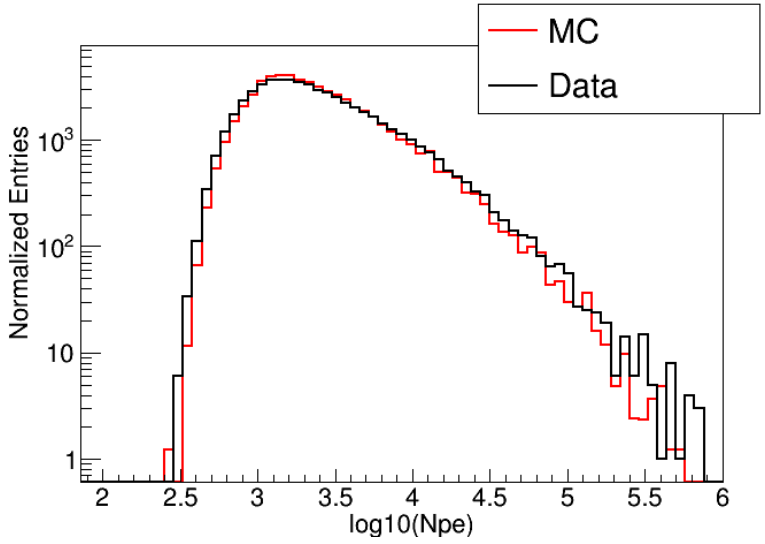
- The data trigger is about 22.1 KHz and the M.C is 20.5 KHz, thus the M.C. trigger rate is consistent with data within 8% level.

--continued


data_201905
MC
×10^6
Zenith Angle [degree]

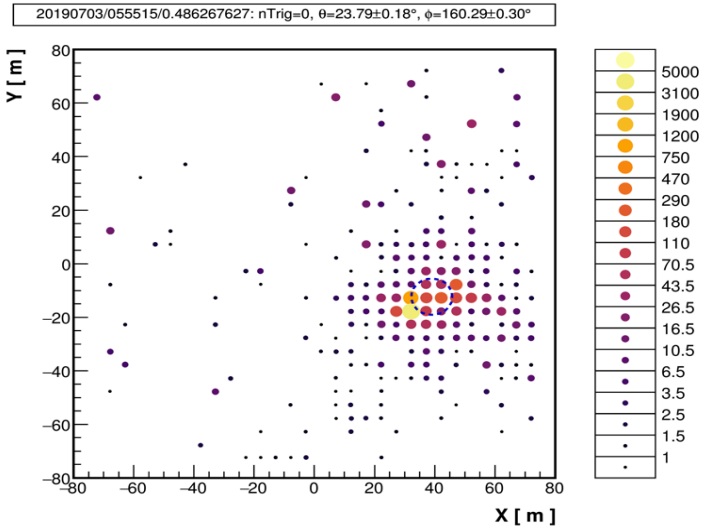

data_201905
MC
×10^6
AZimuth


MC
data_20190509
Normalized Entries
npec

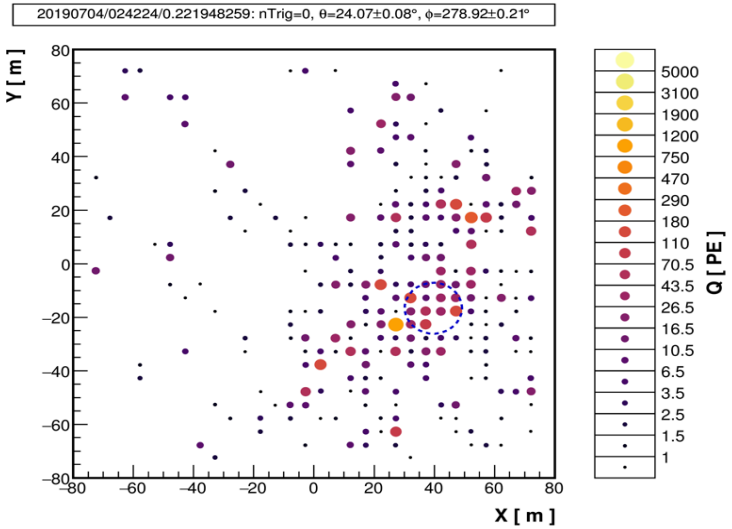

MC
Data
Normalized Entries
log10(Npe)

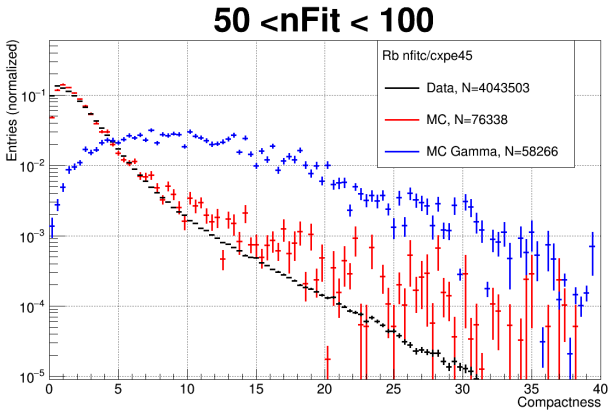
Background rejection @ compactness

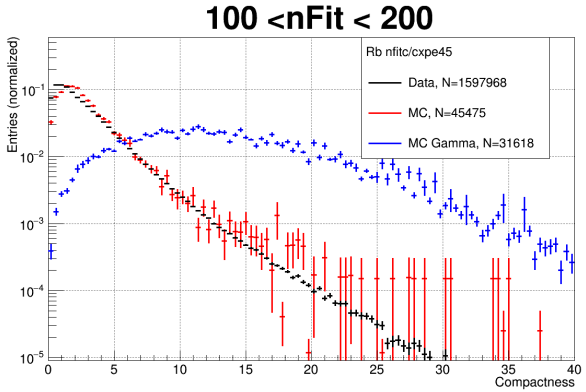
Top3: Nhit=236 C=39



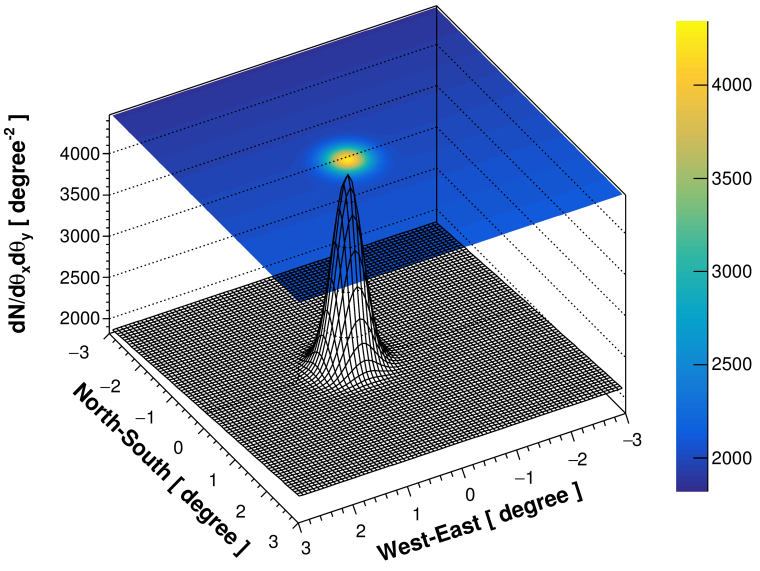
Ptop3: Nhit=261

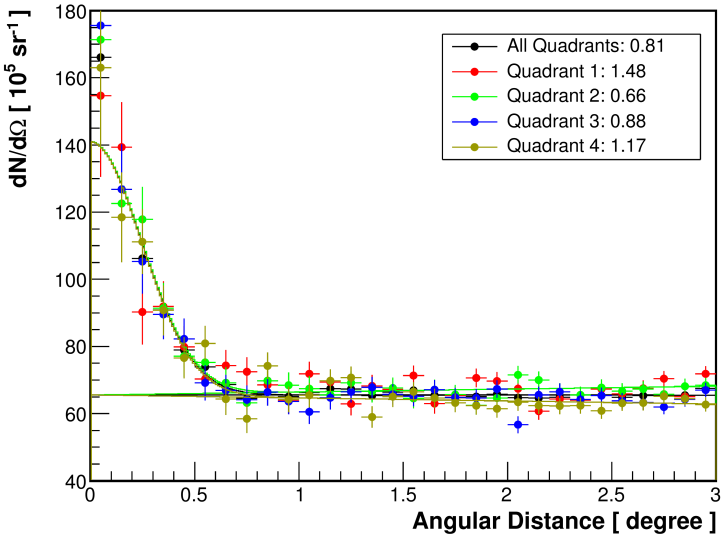


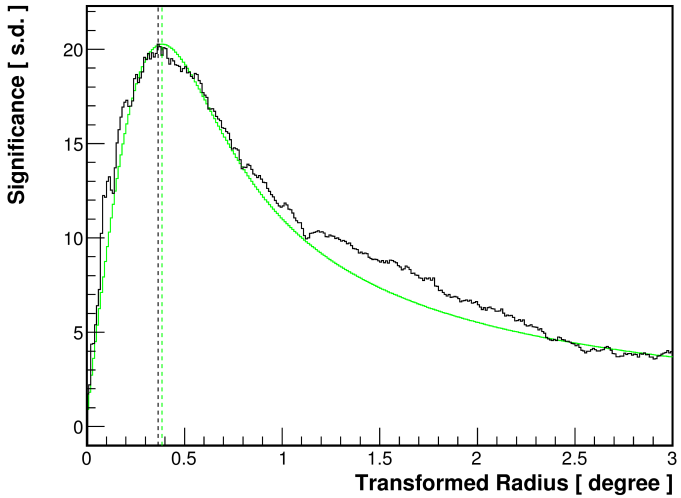




Crab Nebular observation per month



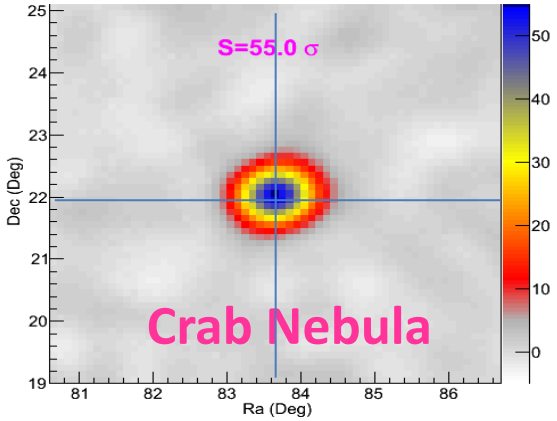


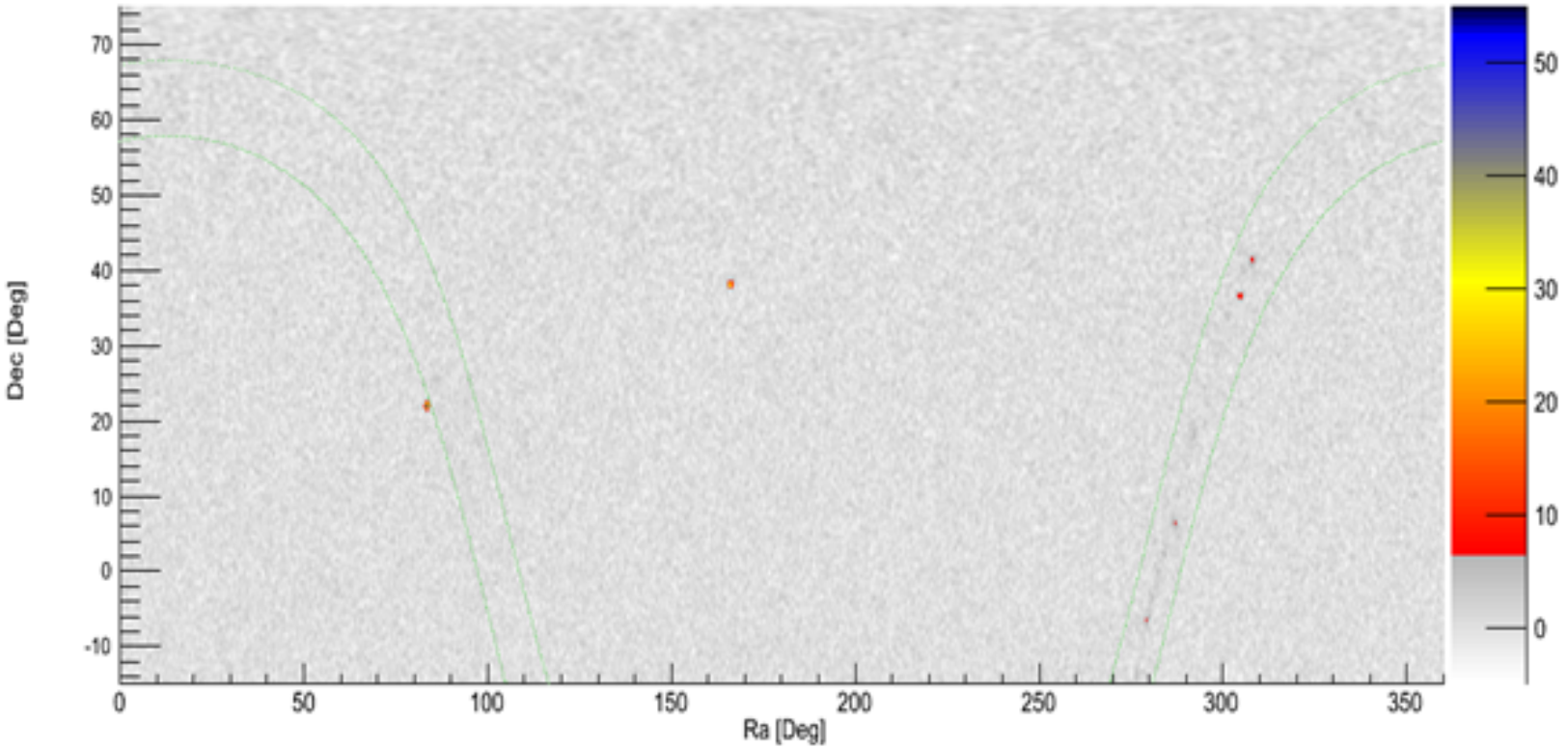


- 20 sigma/month;
- Sigma is 0.25 deg;
- Pointing is less than 0.1

200 days Sky map

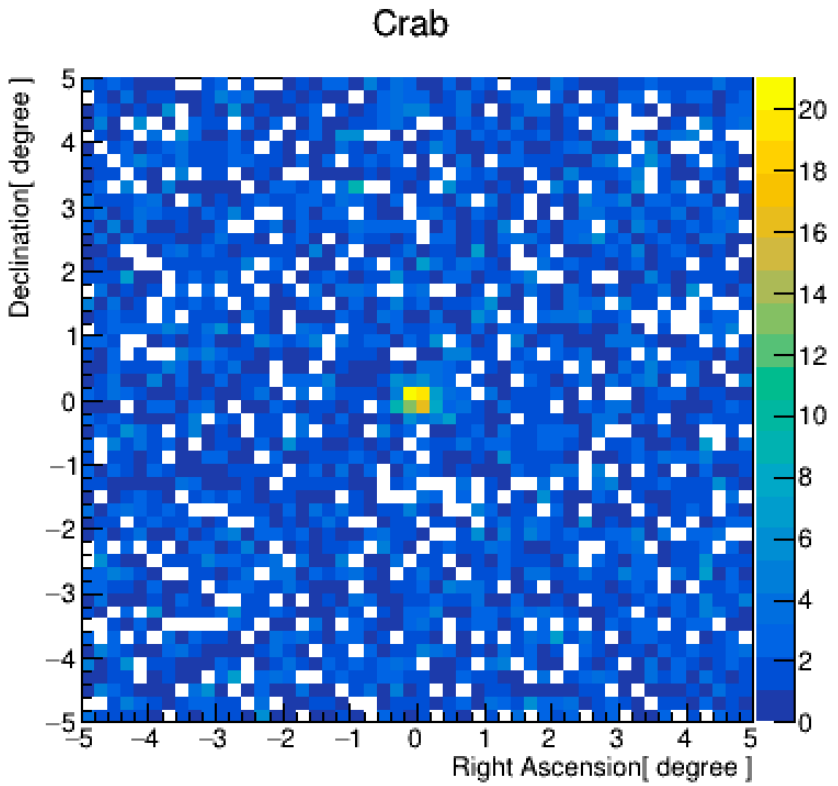
- Data samples
  - Nfit>100;
  - 60 mCU
  - PSF: 0.26
  - 6 hot points with significance >7 σ

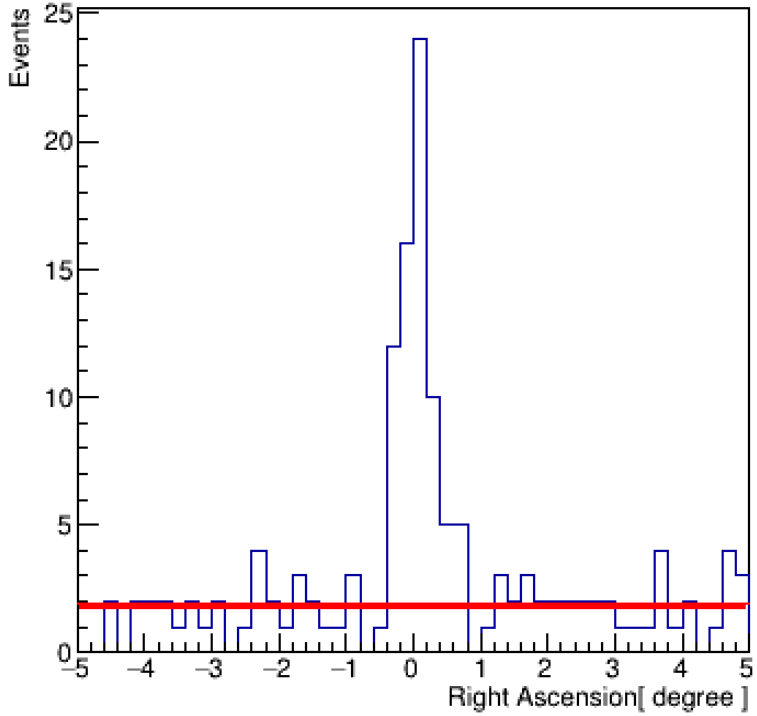


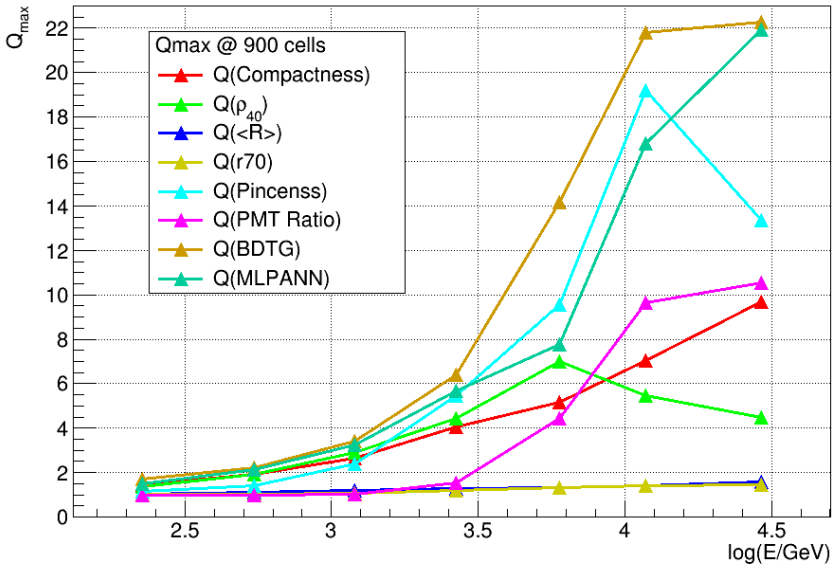


Gamma-rich sample from the Crab

- Hard cuts on high energy sample: S/N ~ 12





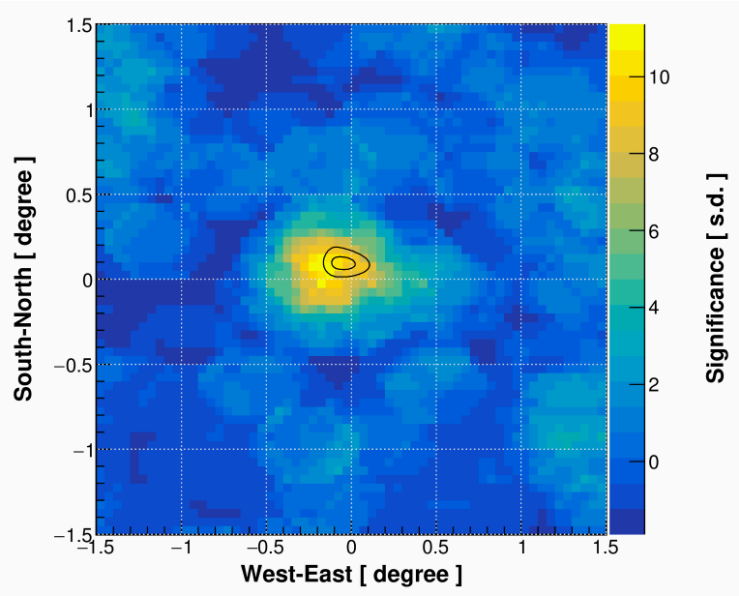


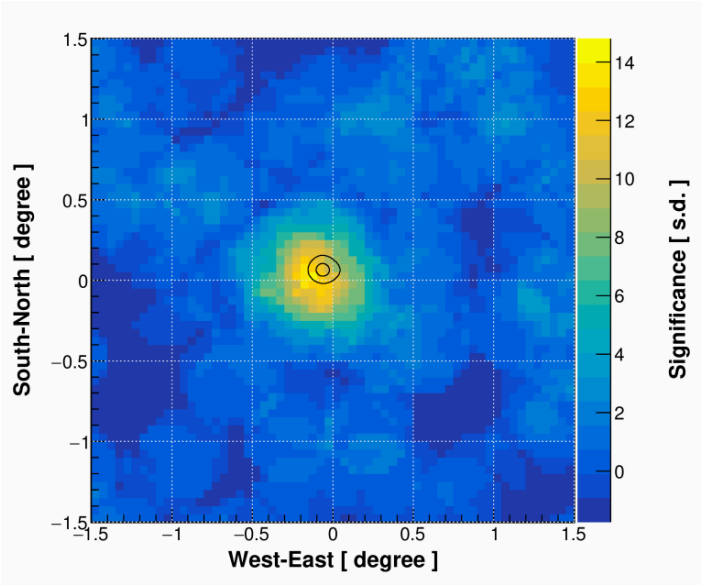
Compactness cut

nfitc:300-500

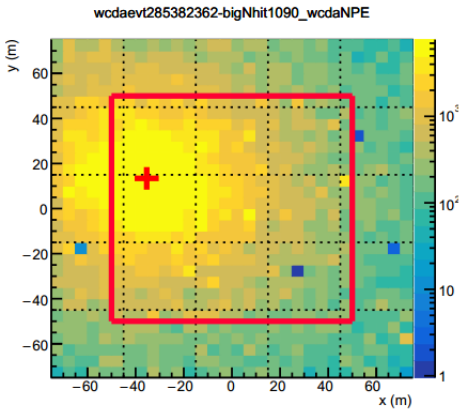
BDTG

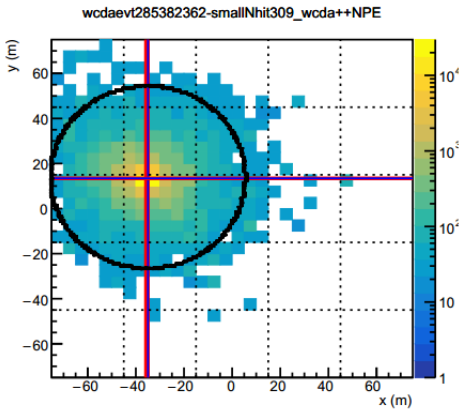
Improvement: 32%

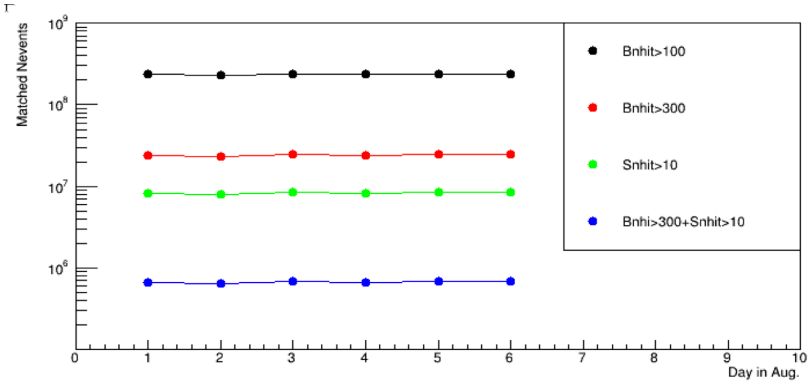


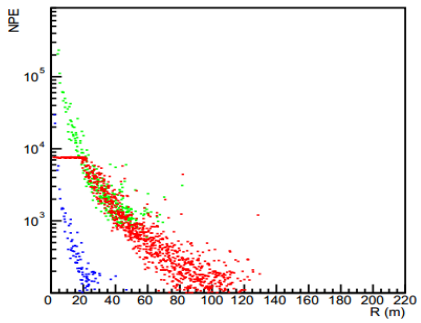


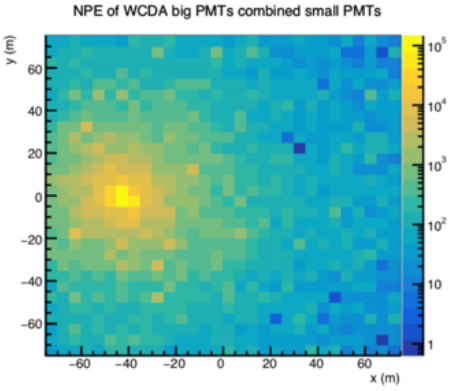
Joint B-PMT + S-PMT event analysis

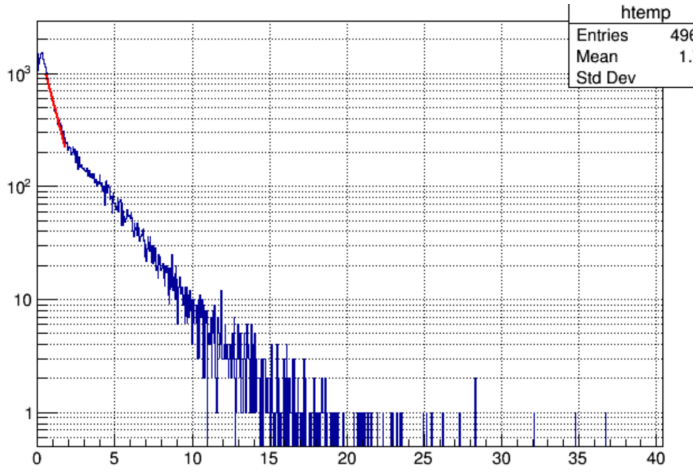






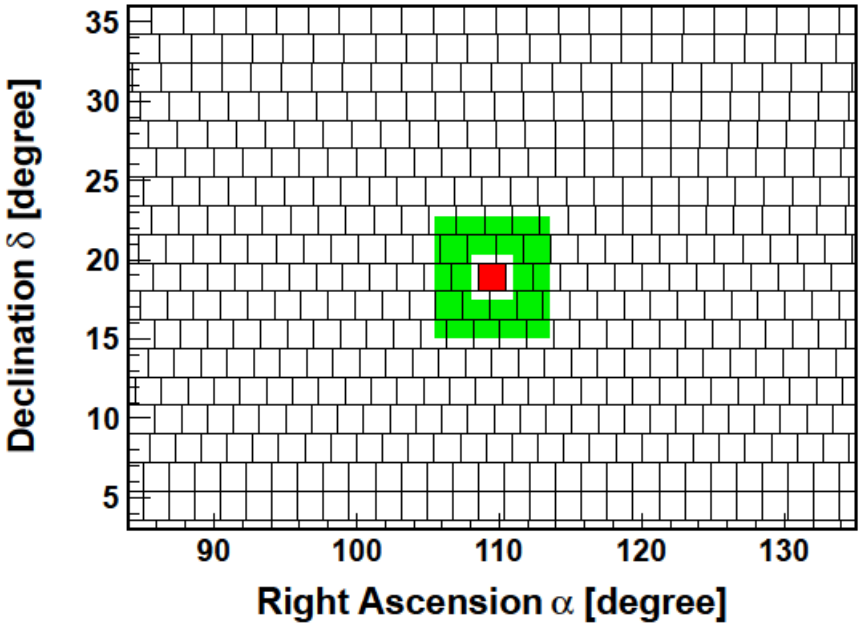


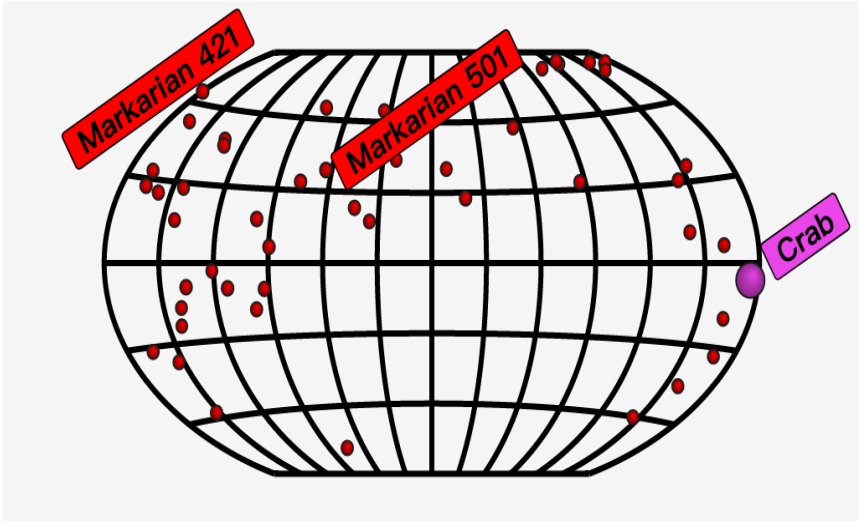




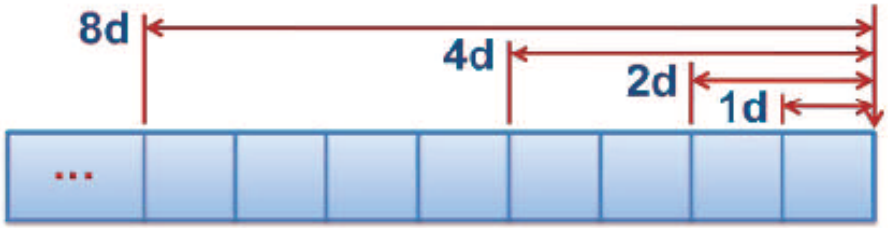
- New G/P separation parameter ?

"real time" VHE gamma-ray flares





- 62 VHE blazars from TeVCat
- Crab: a direct check for the monitoring scheme



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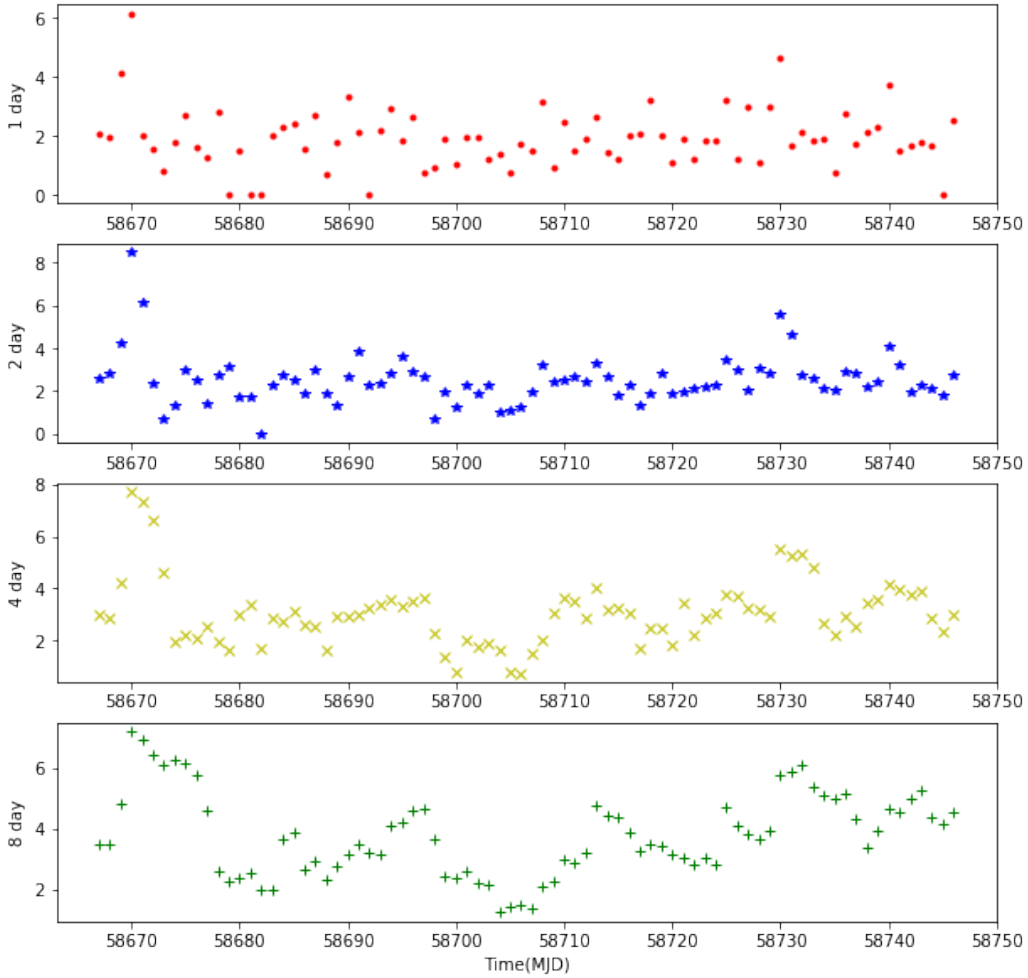
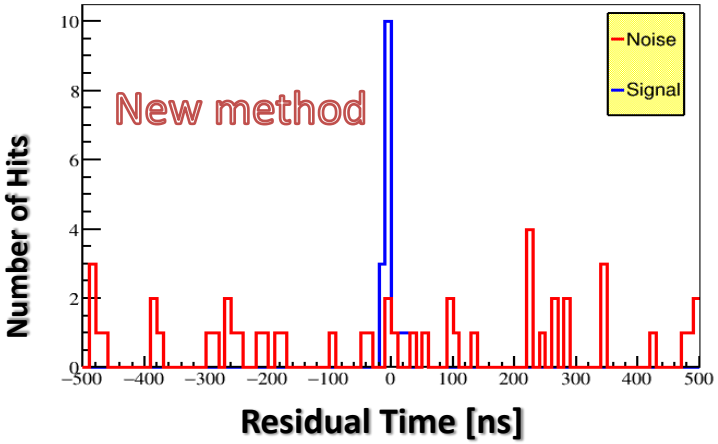
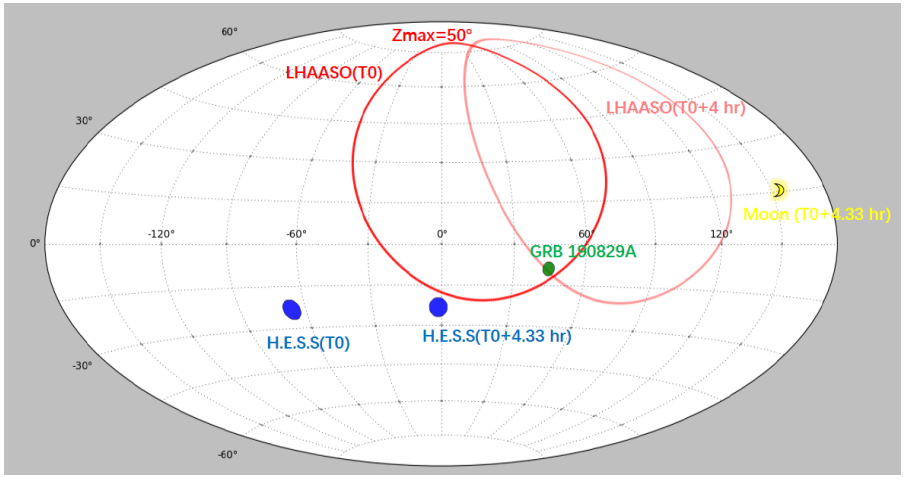


- Preliminary result
- Mrk421 flaring behavior
- Event selection:
  - Without LED signal;
  - $N_{fitc} > 100$
  - $Zenith < 60°$
  - $Compactness > 15$

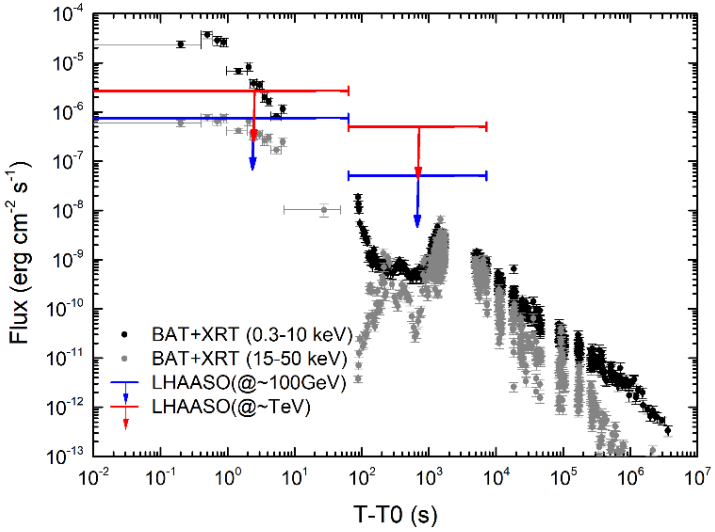
GRB follow-up

- Develop a new method to search for GRBs
- Set up GRBs Monitor software
- Carry out analysis of GRB190829A
- 36 GRB follow-ups (Since June 2019) the statistical analysis is on the way.



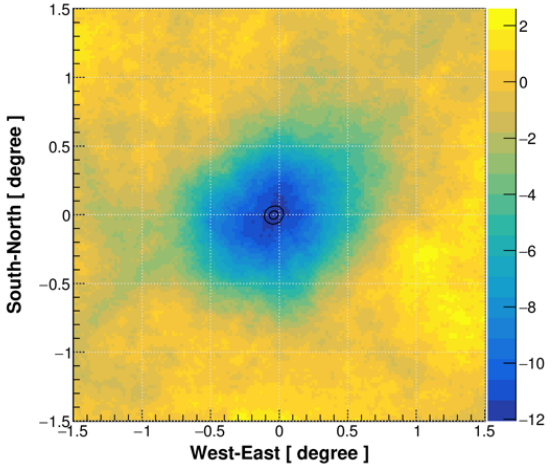


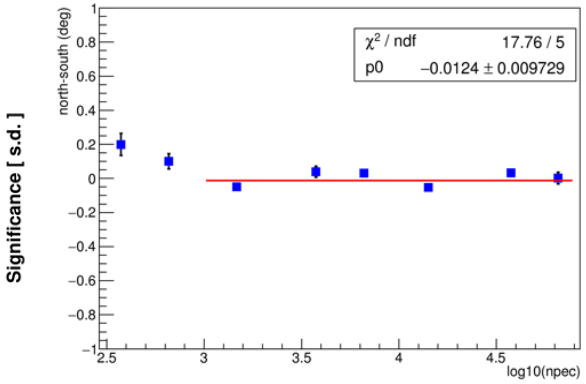
GRB190829A @ LHAASO-WCDA1

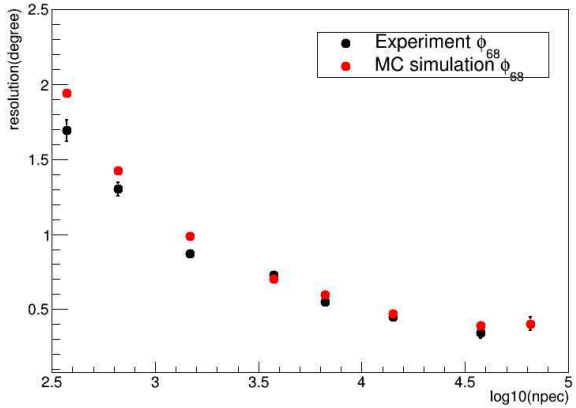


Moon shadow: Geomagnetic spectrometer

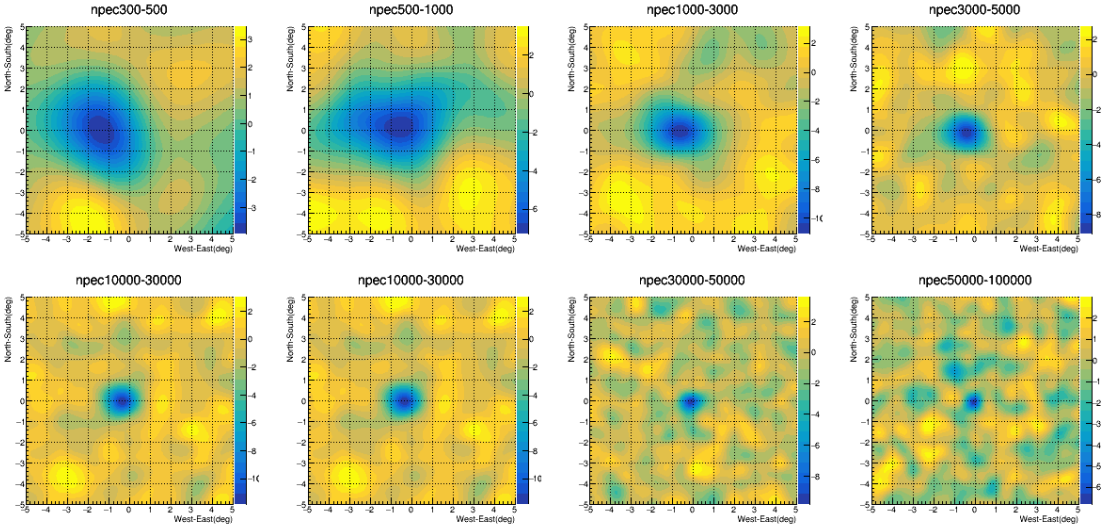
N_{fit} > 300

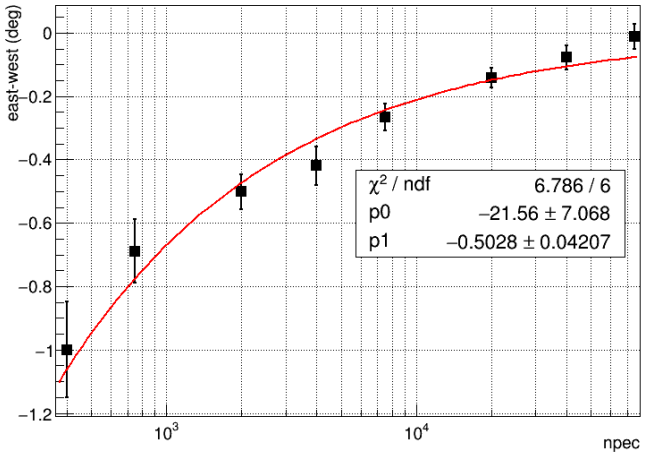




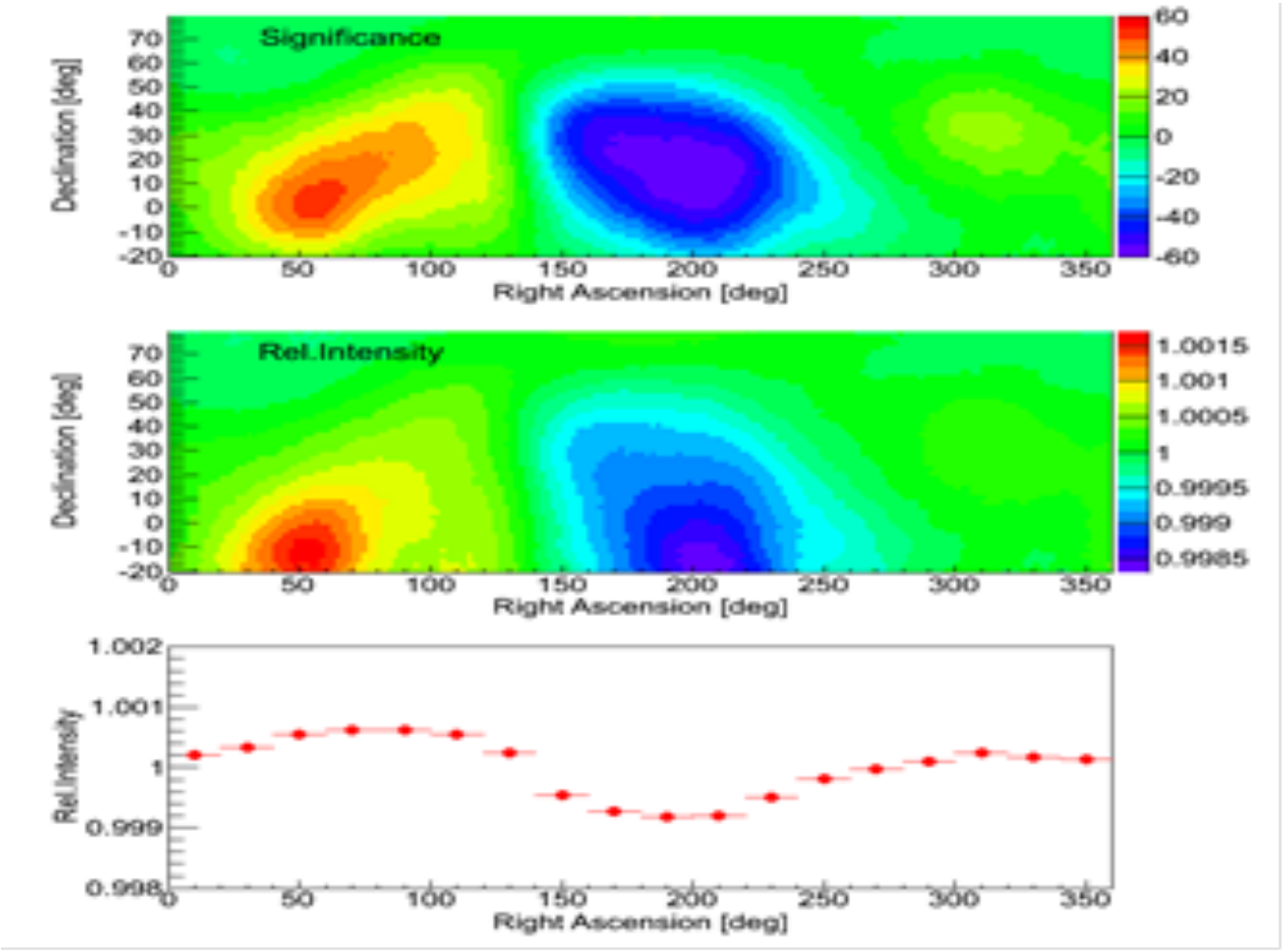


Pointing error <0.05°

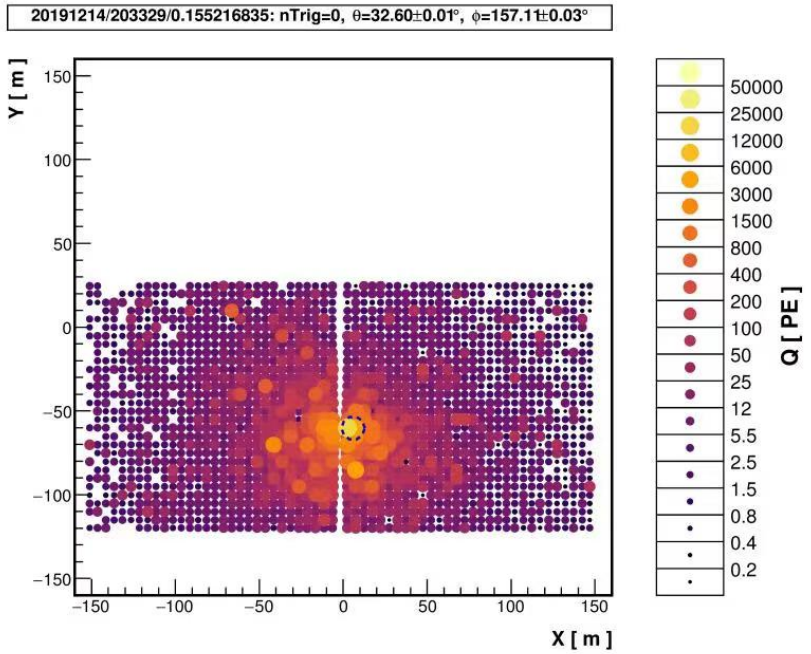


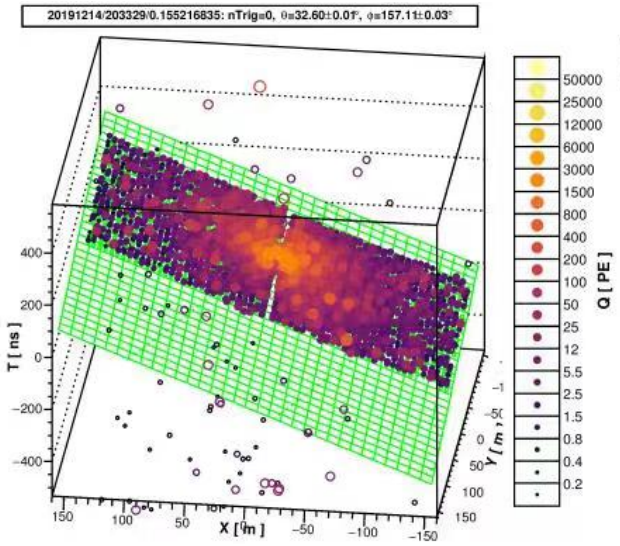


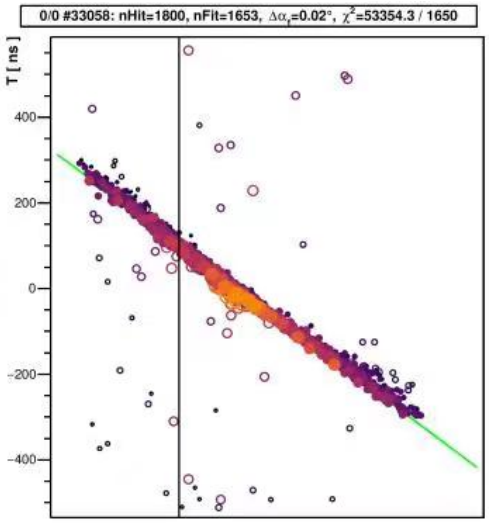
CR-anisotropy @ 120 days data



WCDA-1 + WCDA-2 = a full beautiful event







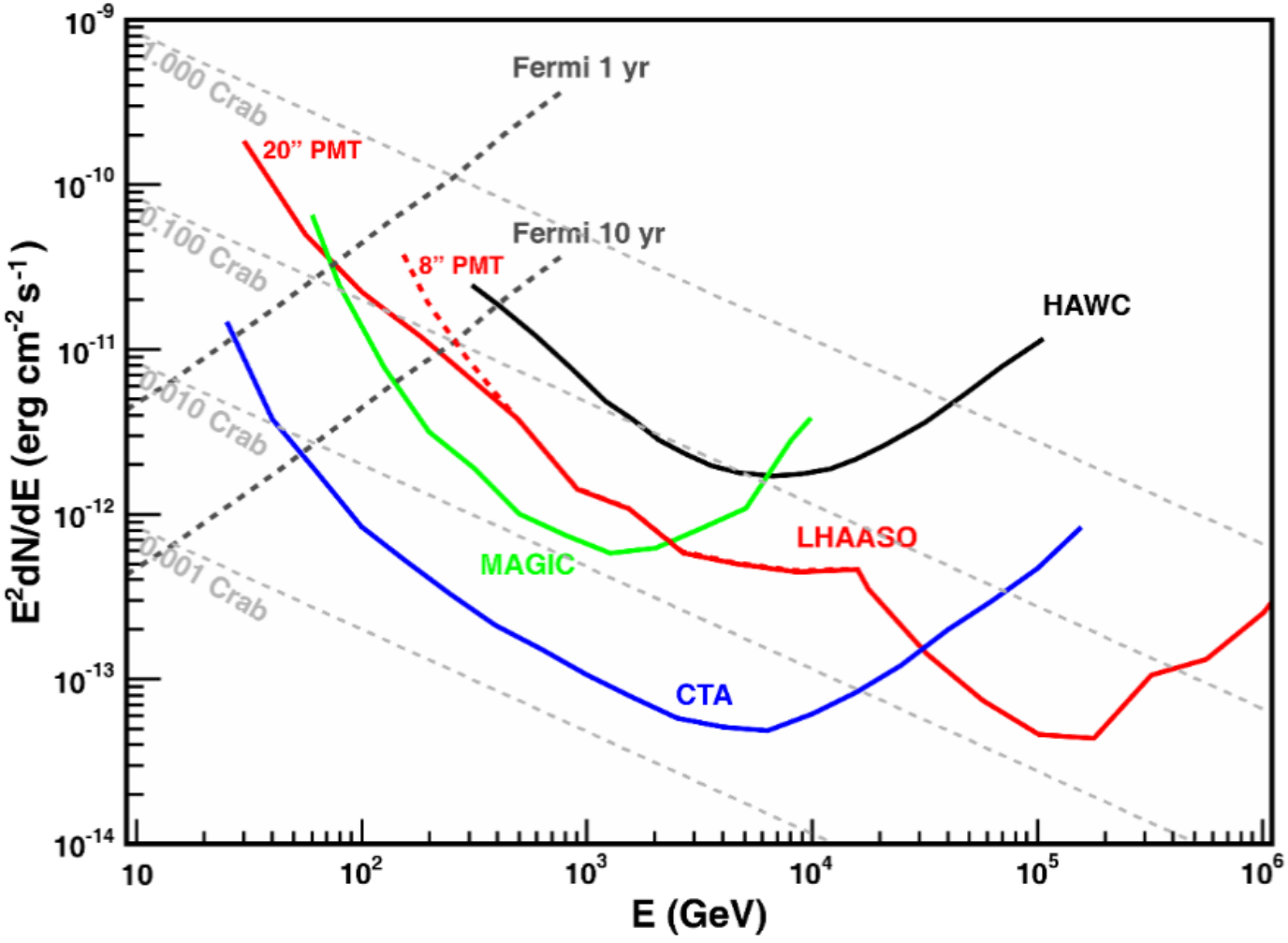
Summary and outlook

- WCDA-1 works smoothly in scientific operation mode;
  - Crab significance is around 20 sigma per month;
  - Moon shadow significance is around 20 sigma per month;
  - Pointing error is less than 0.1 deg;
  - Sky map, Moon/Sun shadow and CR anisotropy have been observed;
  - To understand the systematic error of the analysis;

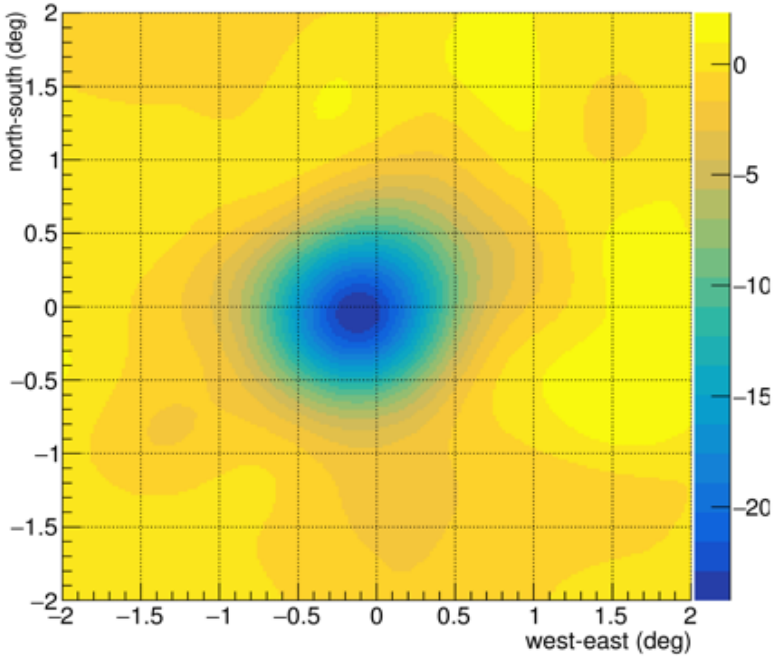
- WCDA-2 begin to take physics data in Dec. 24th 2019;
  - Looking forward to news from 20-inch PMT

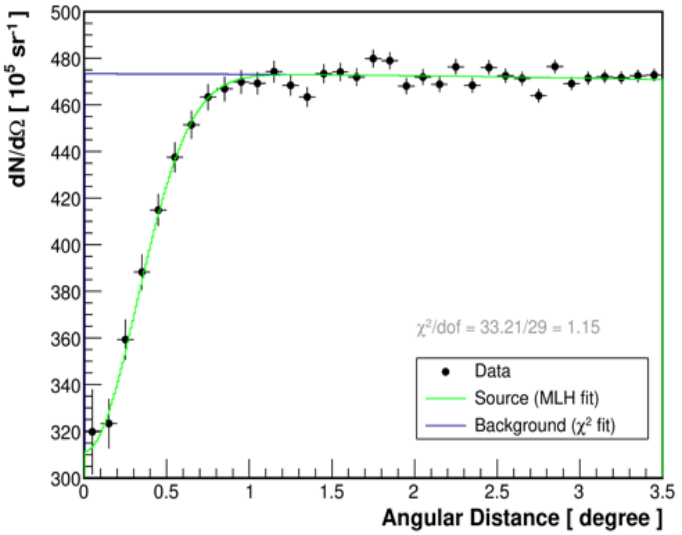
- At the end of 2020, WCDA-3 will be ready.

backup


Fermi 1 yr
Fermi 10 yr
1.000 Crab
0.100 Crab
0.010 Crab
0.001 Crab
20" PMT
8" PMT
HAWC
LHAASO
MAGIC
CTA
E^2dN/dE (erg cm^{-2} s^{-1})
E (GeV)
10^{-9}
10^{-10}
10^{-11}
10^{-12}
10^{-13}
10^{-14}
10
10^2
10^3
10^4
10^5
10^6

Pointing error + angular resolution





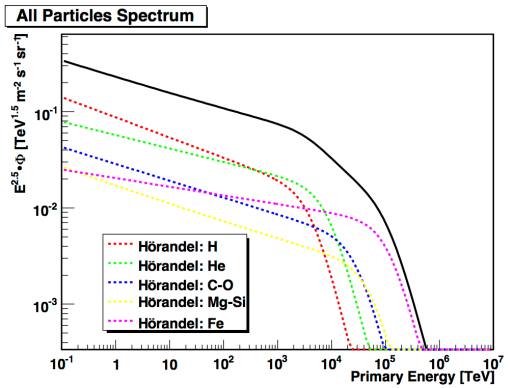
1->2、3号水池的PMTs

- 主要变化：

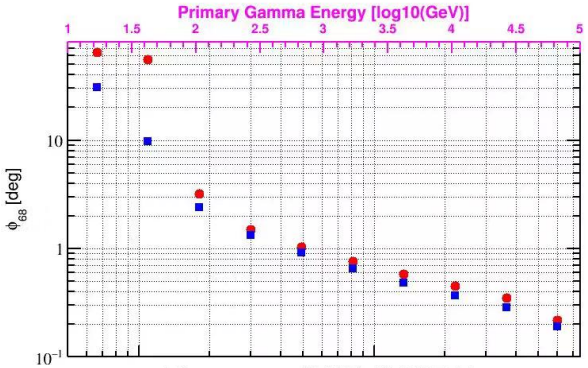
100GeV的γ： 8inch eff=1.7%； 20inch eff=10.5%

MC simulation details

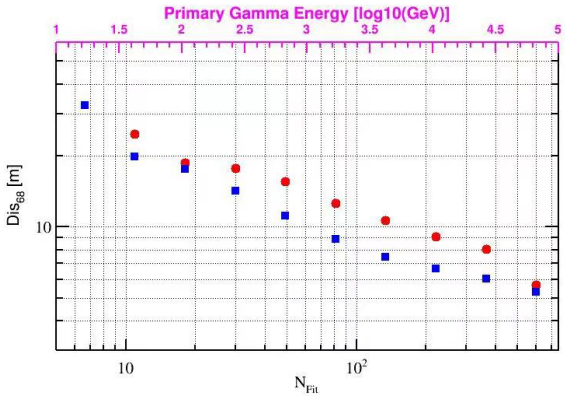
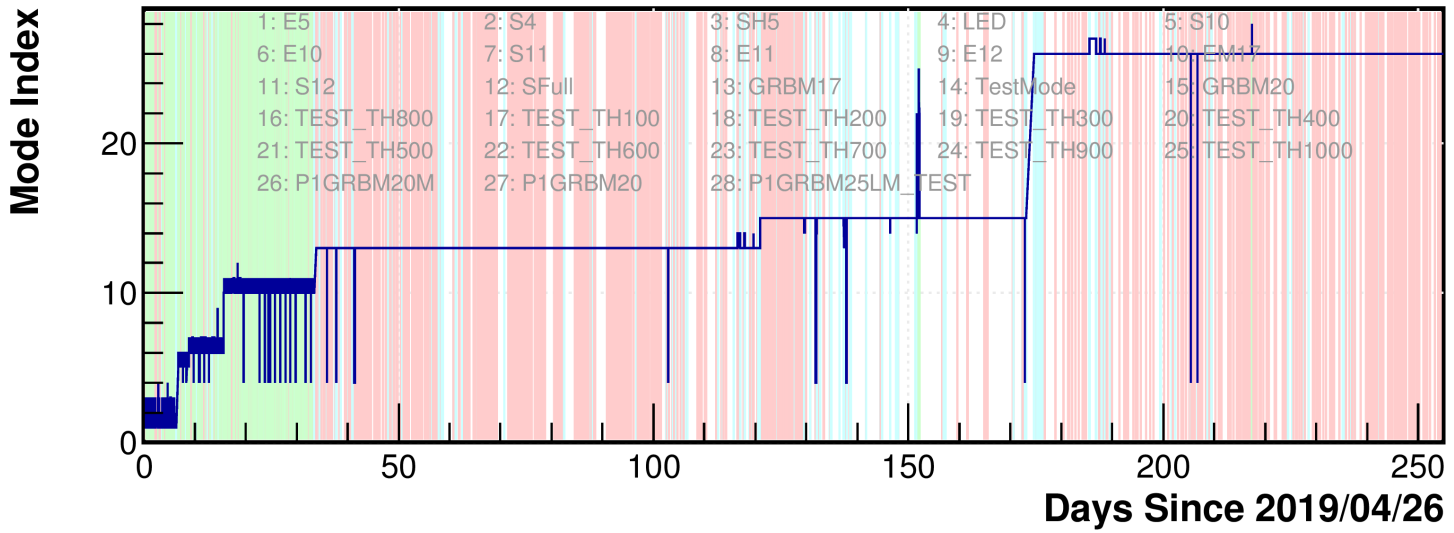
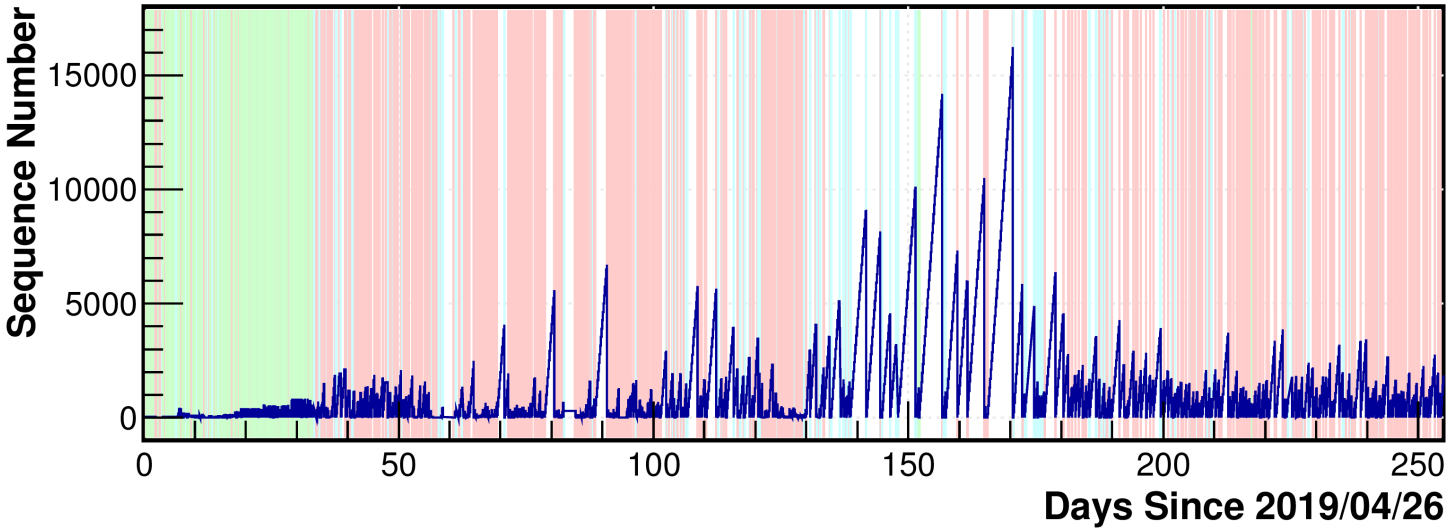
- CORSIKA v74000; total size 2 T
- Hadronic models:
  - FLUKA + EPOS-LHC
- PrimaryID:
  - Gamma ;
  - 5 groups（H/He/CNO/MgAlSi/Fe)
  - Flux from Horandel model;
- primary energy 10 GeV to 100 TeV / 1 PeV;
  - 5 decades: 1.e10-1.e11 / 1.e11-1.e12
  - 1.e12-1.e13 / 1.e13-1.e14 / 1.e14_1.e15
- Zenith angles: 0° - 60° ;
- Azimuth angle 0° - 360° ;
- Shower core projection area: 2000 X 2000 m2
- G4WCDA 4.1 + 4.2;
  - 11.e12-1.e13 eV: 3e7
  - Total size: 230 T
- Core resolution around 10m @100N_{fit} and angular resolution 0.5° @100 N_{fit}



Δangle gamma@10GeV-100TeV



ΔCore gamma@10GeV-100TeV



WCDA-1 data taking