Observation of TeV gamma ray emissions from PeVatron with the LHAASO-WCDA

Chuandong Gao, Cunfeng Feng, Min Zha, Zhiguo Yao

2021-10-14

Shandong university,IHEP

Outline

◆ **Introduce**

◆ **Data and Mothed**

◆ **Significance**

◆ **J1908+0621**

◆ **J2226+6057**

◆ **Summary and outlook**

Introduce

Twelve gamma ray sources have been detected above 100 TeV by LHAASO-KM2A

Revealing that many PeVatrons exist in the galaxy.

LHAASO-WCDA turns more sensitive than KM2A at TeV energy range

source name	R.A. (°)	dec (°)	Significance (σ) above 100 TeV	E_{Max} (PeV)	Flux ($\pm$ error) (CU) at 100 TeV
LHAASO J0534+2202	83.55	22.05	17.8	0.88 ± 0.11	1.00(0.14)
LHAASO J1825-1326	276.45	-13.45	16.4	0.42 ± 0.16	3.57(0.52)
LHAASO J1839-0545	279.95	-5.75	7.7	0.21 ± 0.05	0.70(0.18)
LHAASO J1843-0338	280.75	-3.65	8.5	$0.26^{+0.16}_{-0.10}$	0.73(0.17)
LHAASO J1849-0003	282.35	-0.05	10.4	0.35 ± 0.07	0.74(0.15)
LHAASO J1908+0621	287.05	6.35	17.2	0.44 ± 0.05	1.36(0.18)
LHAASO J1929+1745	292.25	17.75	7.4	$0.71^{+0.16}_{-0.07}$	0.38(0.09)
LHAASO J1956+2845	299.05	28.75	7.4	0.42 ± 0.03	0.41(0.09)
LHAASO J2018+3651	304.75	36.85	10.4	0.27 ± 0.02	0.50(0.10)
LHAASO J2032+4102	308.05	41.05	10.5	1.42 ± 0.13	0.54(0.10)
LHAASO J2108+5157	317.15	51.95	8.3	0.43 ± 0.05	0.38(0.09)
LHAASO J2226+6057	336.75	60.95	13.6	0.57 ± 0.19	1.05(0.16)

Combined observation provide more information to determine the nature of the source

Data and Mothed

➢ Data

- Data set :   Good file list after data quality check

- date :   from 2021/03/05 to 2021/09/15 exclude 2021/06

- Live time :   133.88 crab's transit

- Select :   zenith<50 degree

- Nhit: [60-100], [100-200], [200-300],[300,500], [500,750],[750,1000],[1000,4000]

- Pincness(<): 1.3,1.24,1.02,1.02,0.9,0.9,0.86

Data and Mothed

➢Analysis method

(1) Background estimation: time swapping

   i. mask region: galactic plane +/-3deg &&TeVCat list

(2) Source analysis: maximum likelihood

ML:

$$P_i = \frac{\lambda_i^{n_i}}{n_i!} e^{\lambda_i}$$

$$n_i = n_s + n_b$$

$$L = \prod P_i$$

Minimize -2lnL ⟶ Get signal, position,extension

Signal Model correction assumption $n_s^{i'} / n_s^{i} = k * n_b^{i'} / n_b^{i}$

Significance@nhit>100

Mean	−0.002681
Std Dev	1.012
χ^2 / ndf	810.5 / 247
Constant	1.54e+05 ± 6.06e+01
Mean	−0.003821 ± 0.000323
Sigma	1.008 ± 0.000
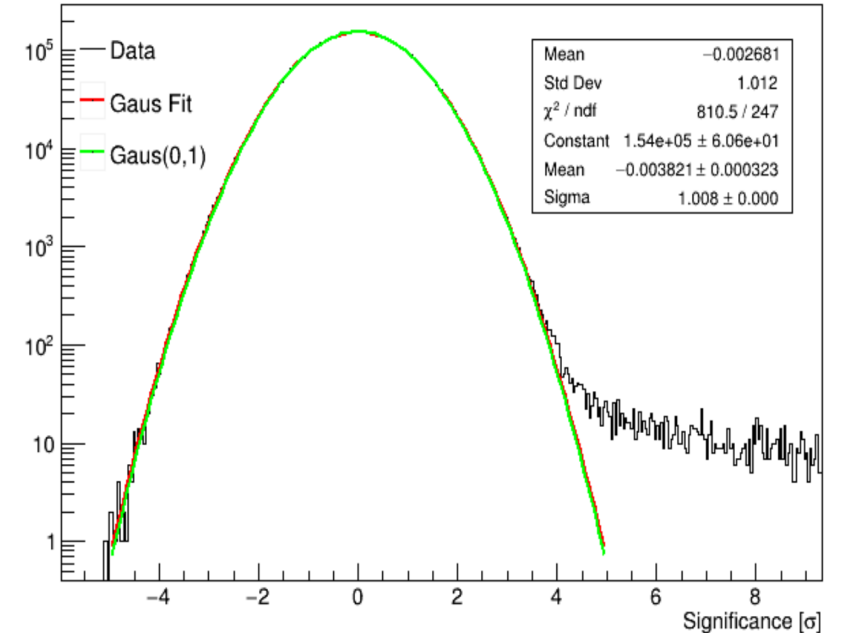
Significance

significance@nhit>100
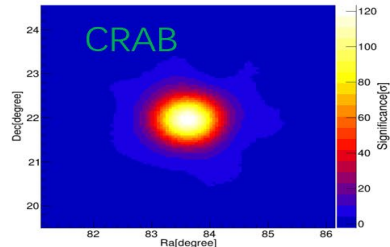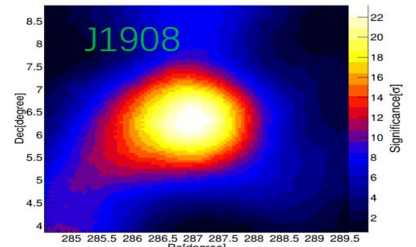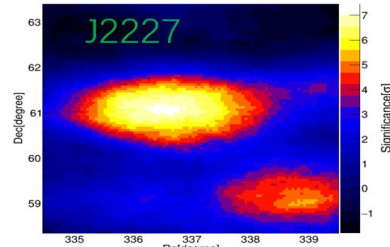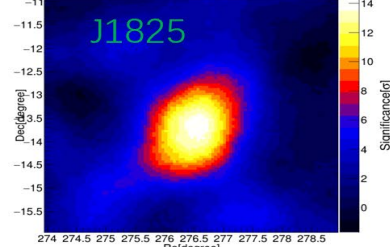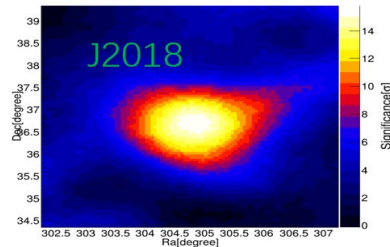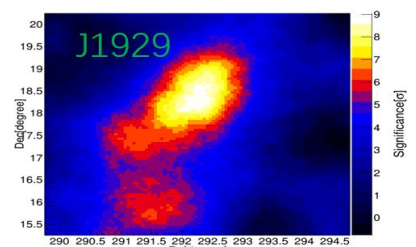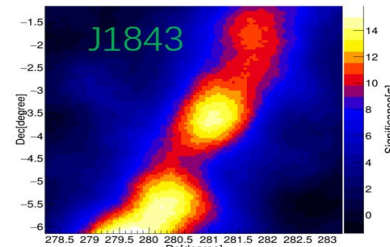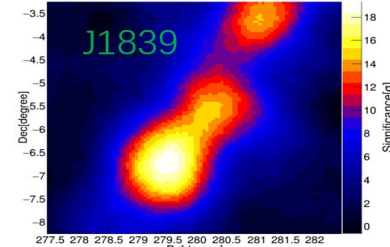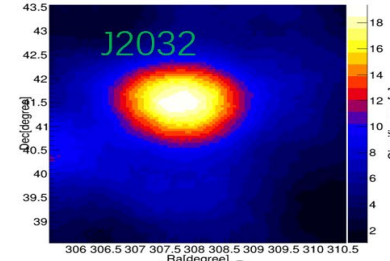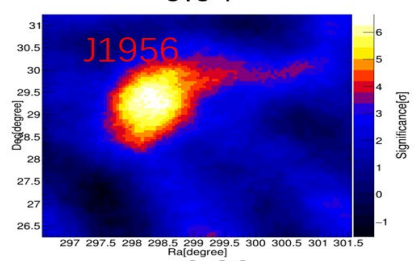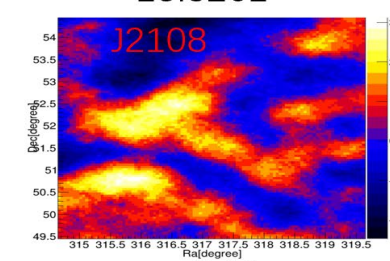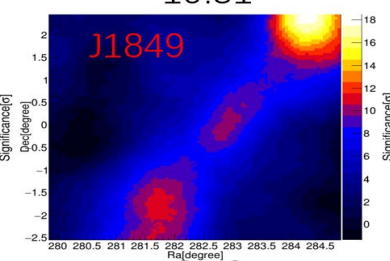
Source	significance
CRAB	123.3
J1908+0621	23.2
J2226+6057	7.5
J1825-1326	14.3
J2018+3651	15.8
J1929+1745	9.0
J1843-0338	15.8
J1839-0545	19.3
J2032+4102	19.38
J1956+2845	6.66
J2108+5157	3.31
J1849-0003	18.46

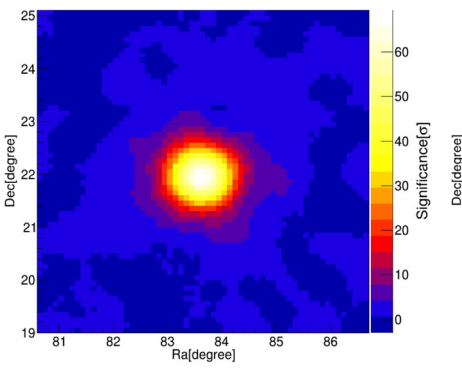•The red words indicate that no significance is seen under the current analysis conditions
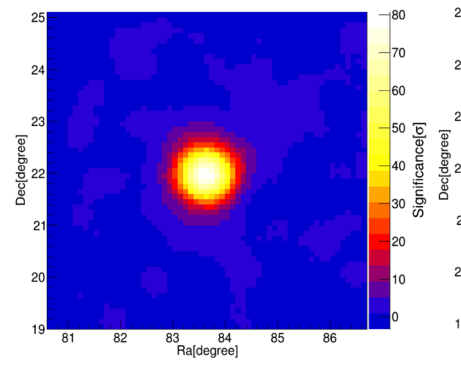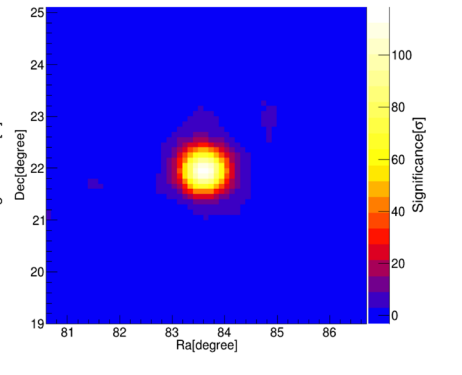
CRAB

➢significance

60<nhit>100
100<nhit<200
200<nhit<300
300<nhit<500
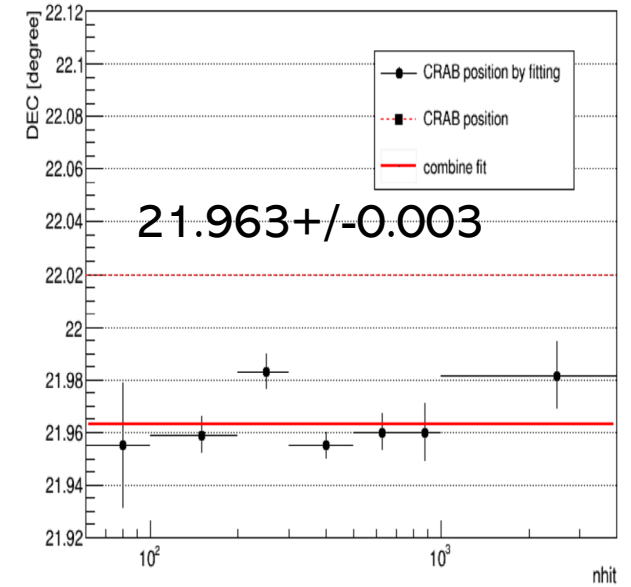### 500<nhit<750

750<nhit<1000
nhit>1000

S=123@nhit>100

CRAB

➢PSF and position

83.622+/-0.003

21.963+/-0.003
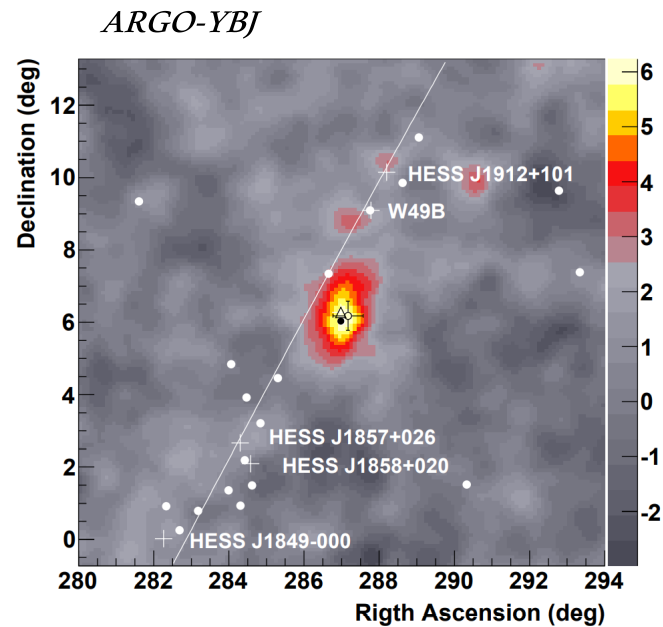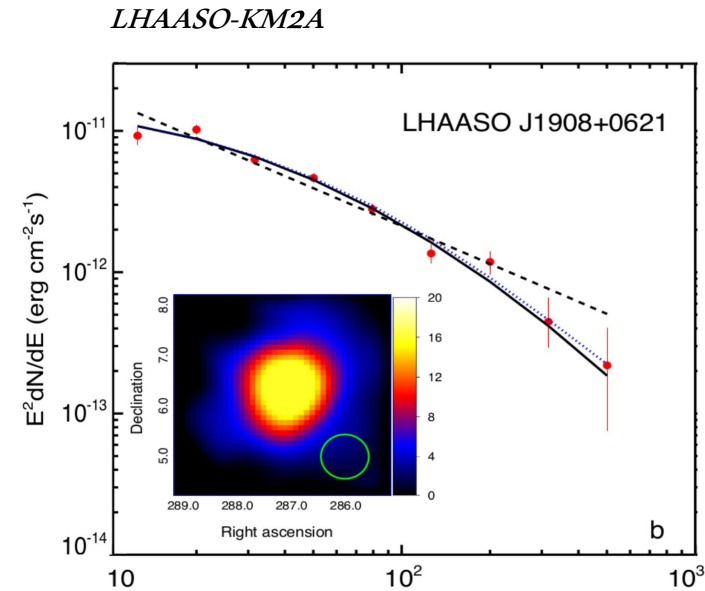
•The point err is less than 0.06(0.01) degree in DEC(RA) direction
•PSF will be used in the later source extensibility analysis

J1908+0621

➤Previous observation

ARGO-YBJ

LHAASO-KM2A

Extension: $\sigma_{ext} = 0.49° \pm 0.22°$

$a = 2.40, b = 0.47 \text{ vs } \Gamma = 2.89$

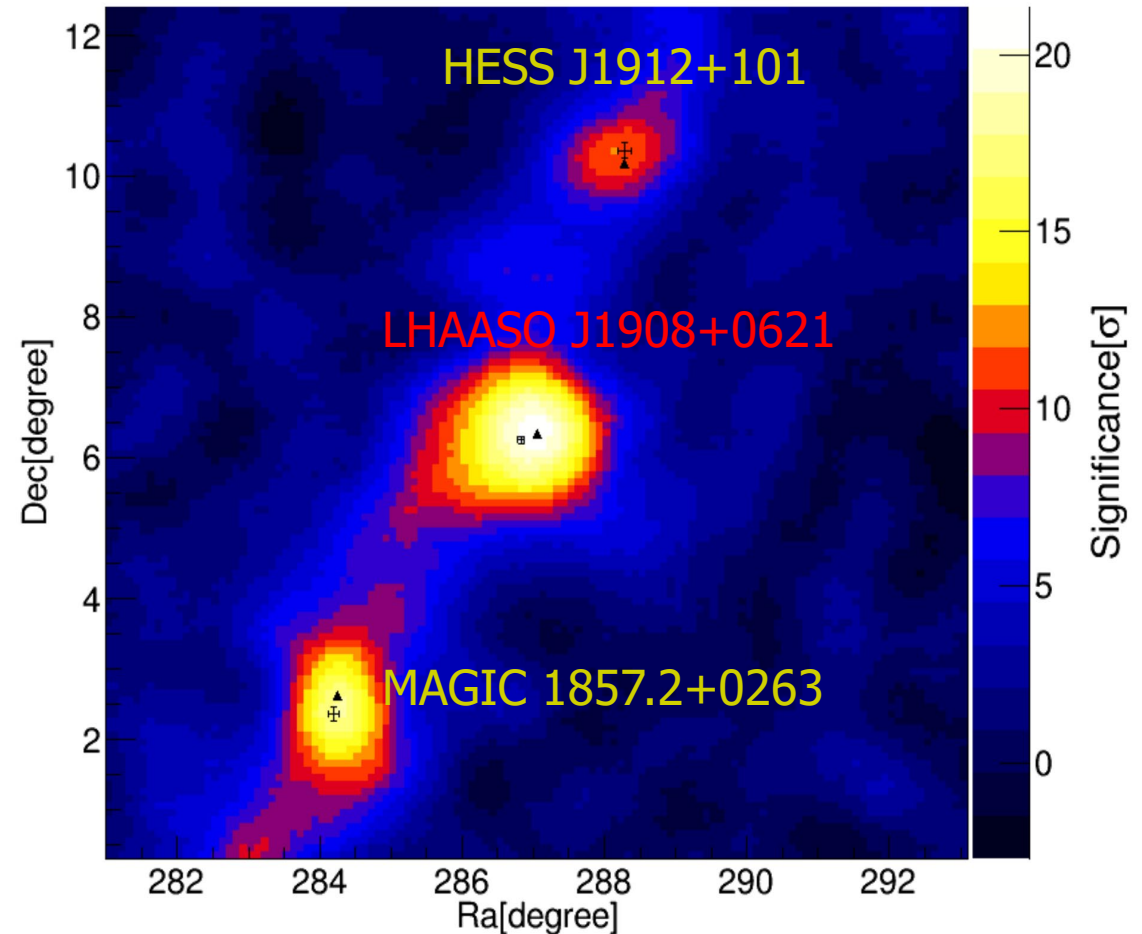This source is extended according observation from ARGO-YBJ

J1908+0621

➤significance

Model	Ra(deg)	Dec(deg)	Extension(deg)
three sources	286.82+/-0.05	6.26+/-0.05	1.04+/-0.05
one source	286.83+/-0.05	6.23+/-0.05	0.98+/-0.04

*The subsequent extensibility analysis will use a single source model
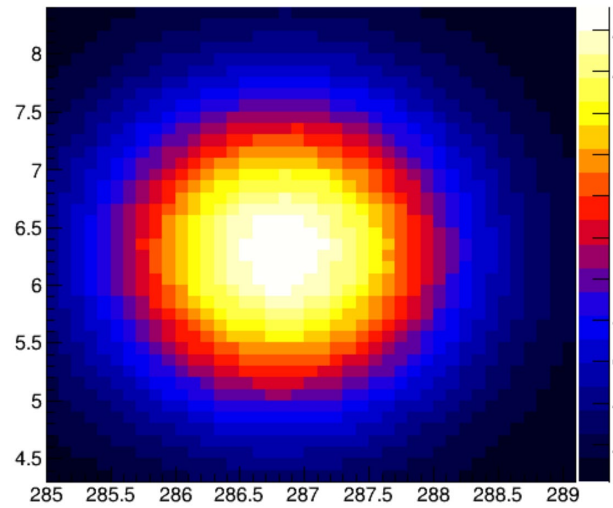
Significance=23.17@nhit>100

HESS J1912+101

LHAASO J1908+0621

MAGIC 1857.2+0263

J1908+0621

➢ Model validation
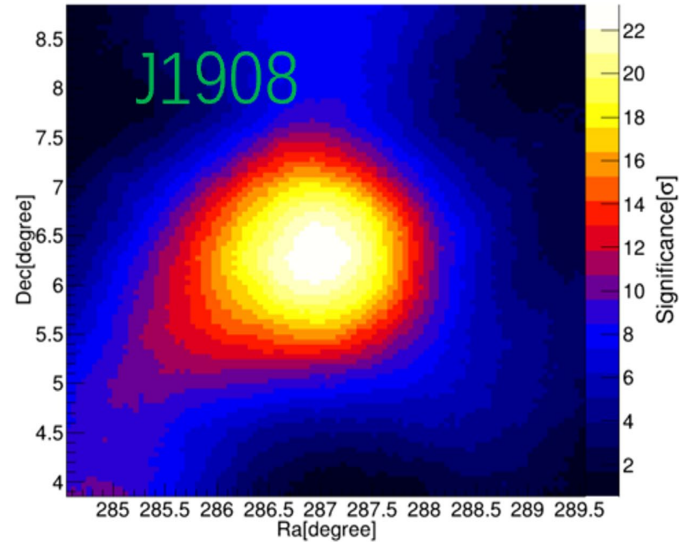
Data   Model   Res map
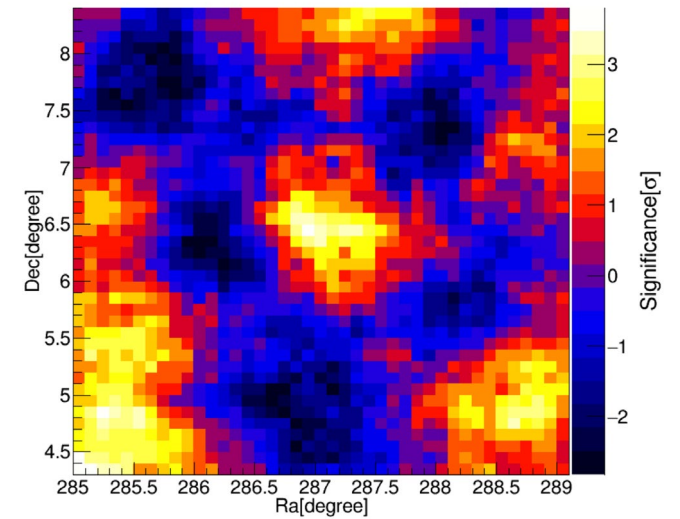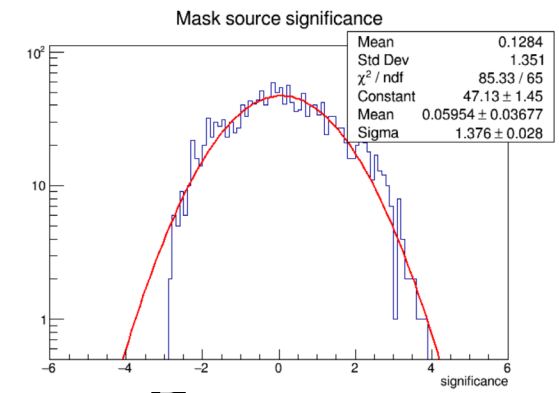
J1908+0621

➤morphology

60<nhit>100
100<nhit<200
200<nhit<300
300<nhit<500
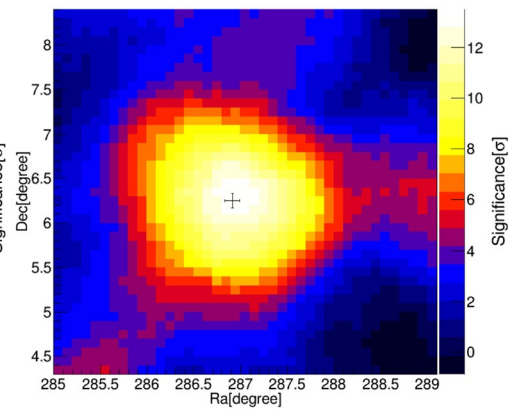
500<nhit<750
750<nhit<1000
nhit>1000

J1908+0621

➢position

Ra VS nhit

Dec VS nhit

The position changes obviously with the energy especially in the DEC directions
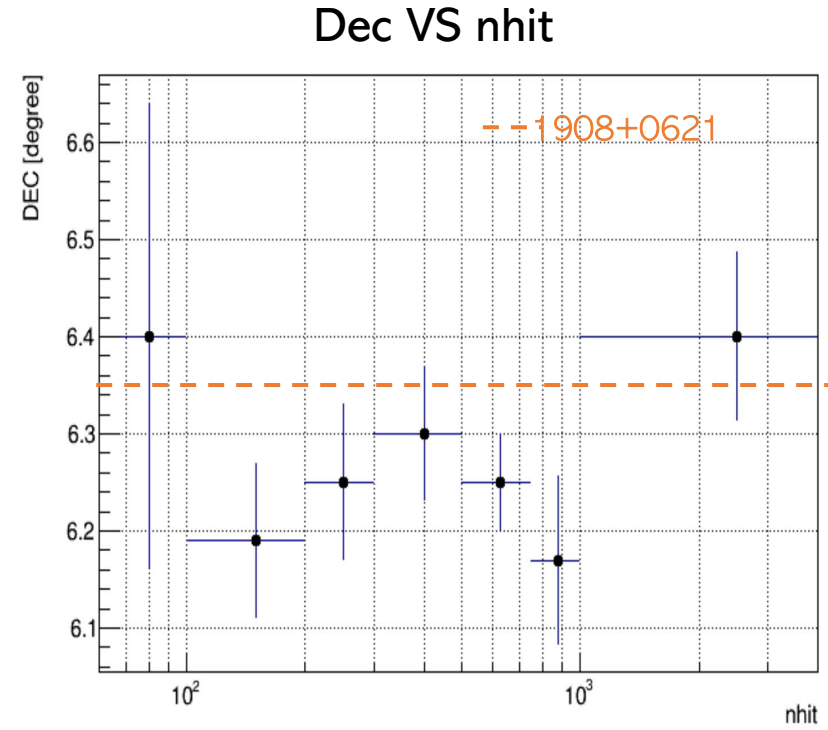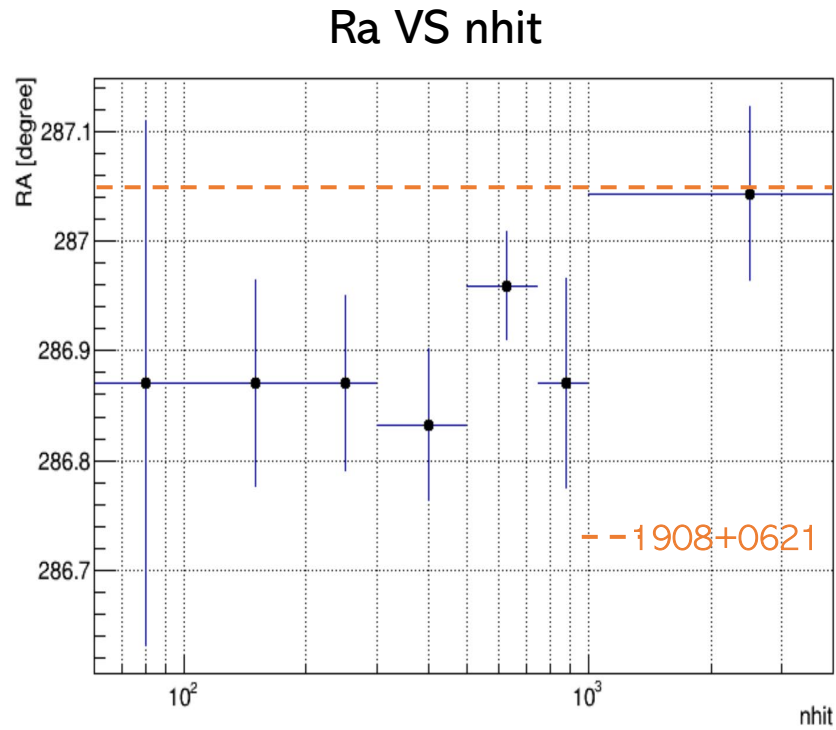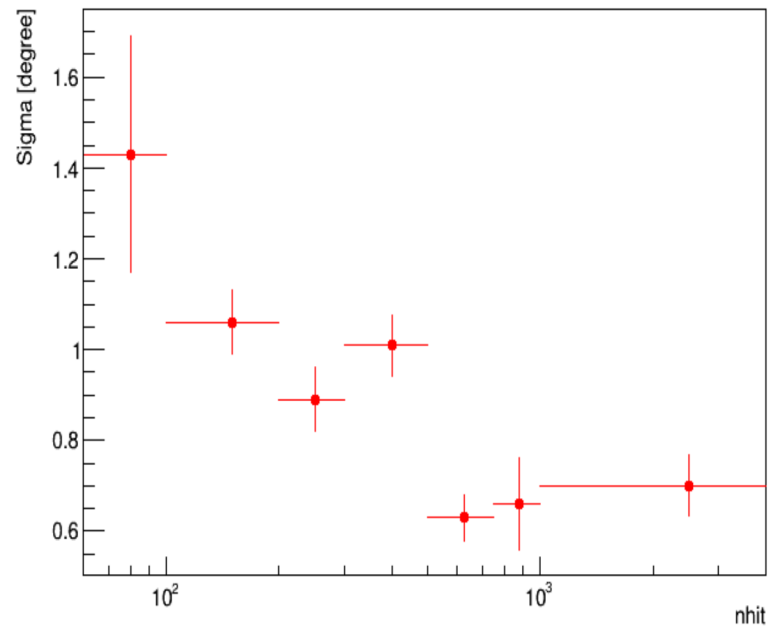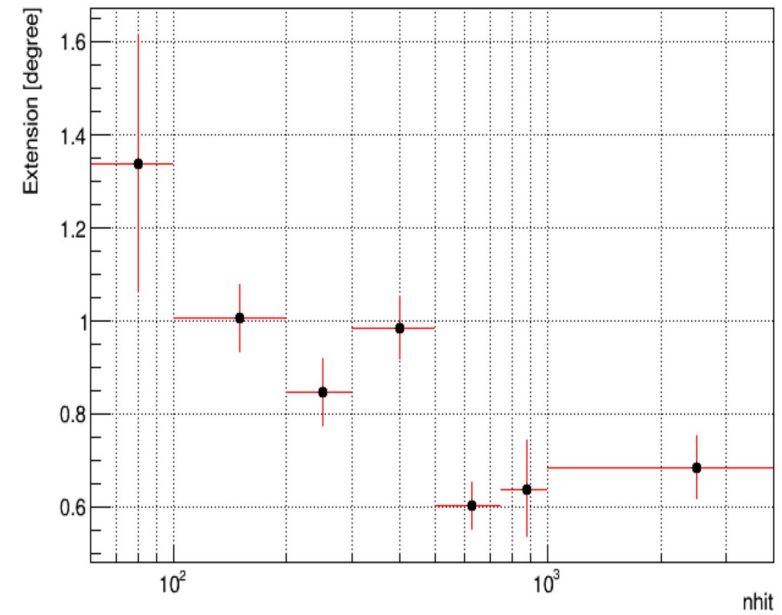
J1908+0621

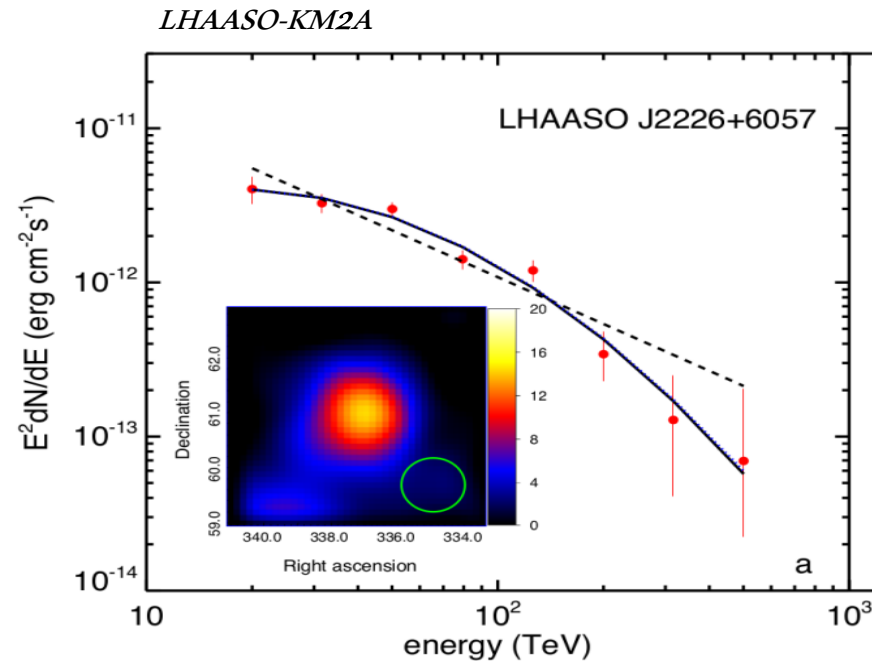➢Extension

Model Extension VS nhit

Minus PSF

Extension VS nhit

J1908 Intrinsic extension is about 0.63 degree at hight energy.

J2226+6057

➤ Previous observation

$$a = 1.84, b = 0.87 \text{ vs } \Gamma = 3.01$$

This source energy spectrum is hard according KM2A's observation and is extended.
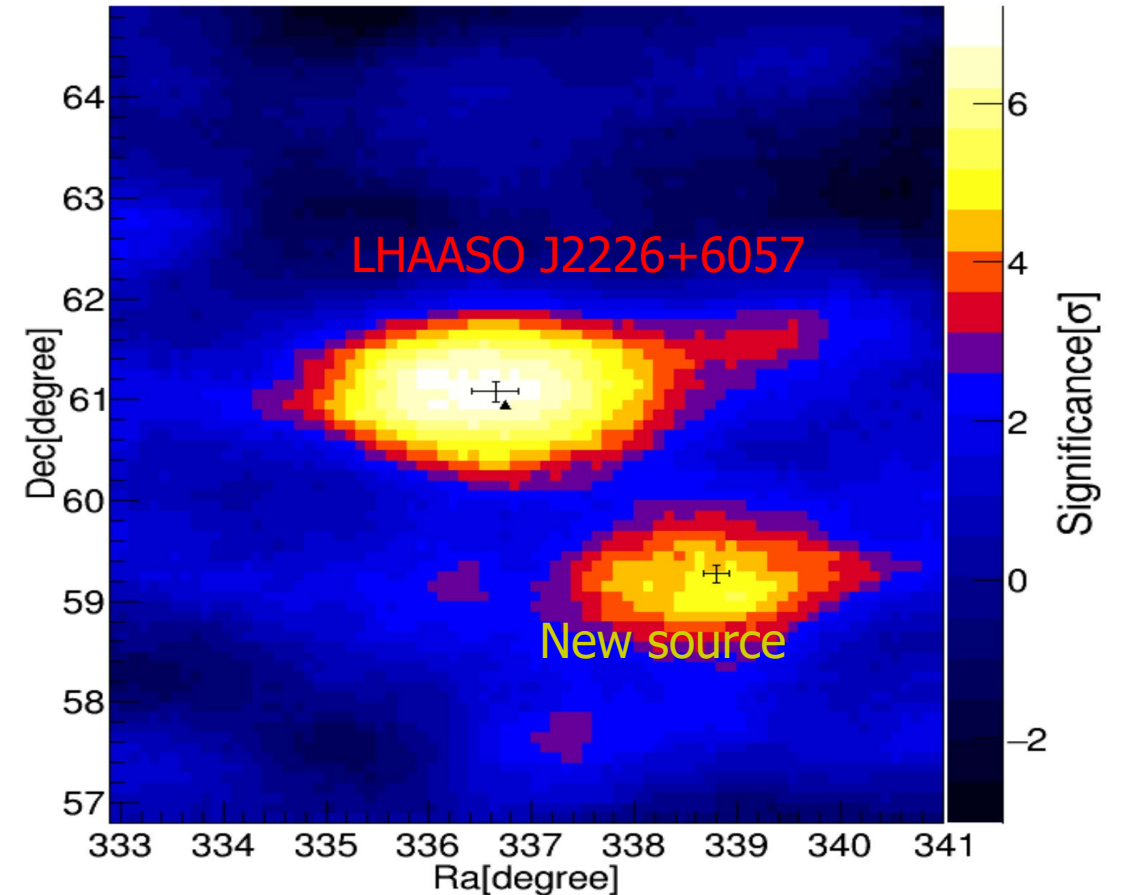
J2226+6057

➤significance

Model: two sources

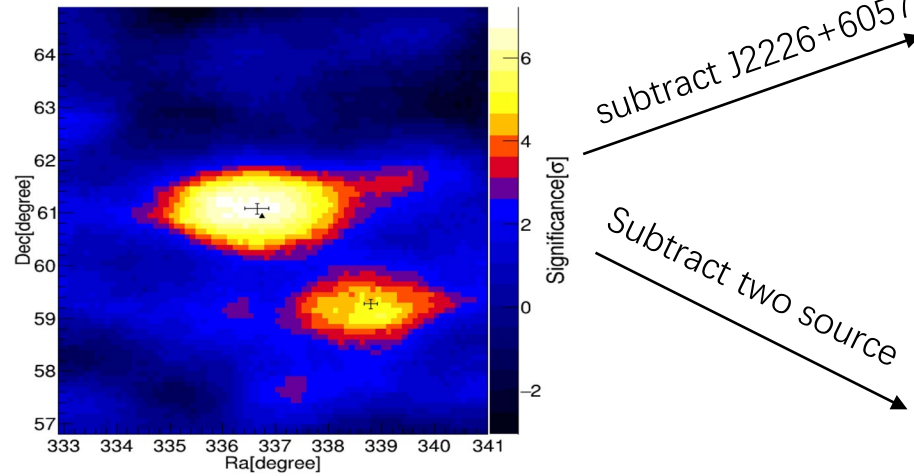| source	Ra(deg)	Dec(deg)	Extension(deg)
J2226 +6057	336.65+/-0.23	61.08+/-0.10	0.56+/-0.07
New source	338.79+/-0.13	59.27+/-0.08	0.27+/-0.07

*The subsequent extensibility analysis will use a two source model
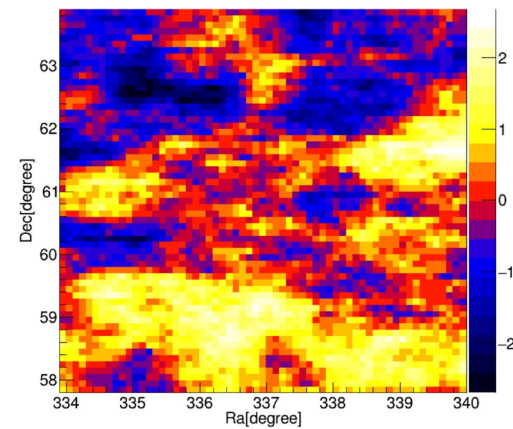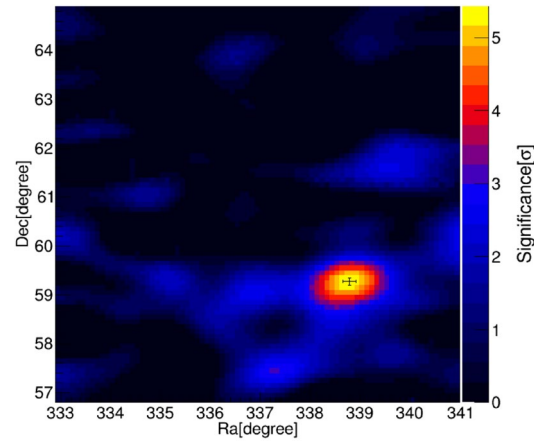

Significance=7.5@nhit>100

LHAASO J2226+6057

New source

J2226+6057

➢New source

TS Map

subtract J2226+6057

Subtract two source

Mask source significance

Mean	0.08295
Std Dev	0.9313
χ² / ndf	68.89 / 51
Constant	157.2 ± 3.2
Mean	0.07908 ± 0.01567
Sigma	0.9305 ± 0.0114
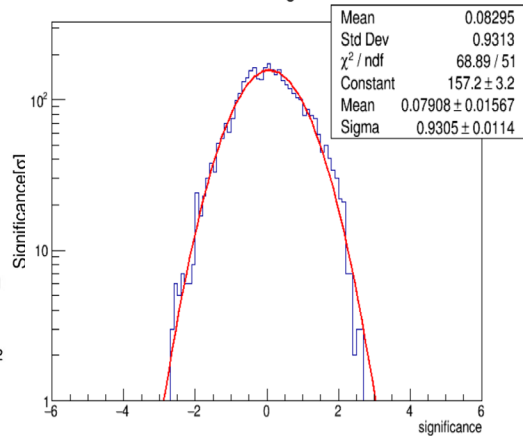
*new sources significance is great than 5σ.

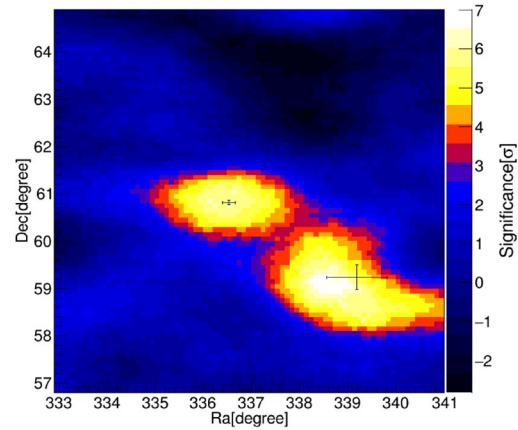# J2226+6057

➢morphology
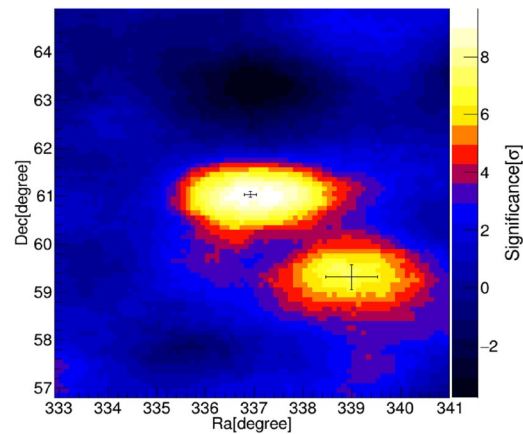
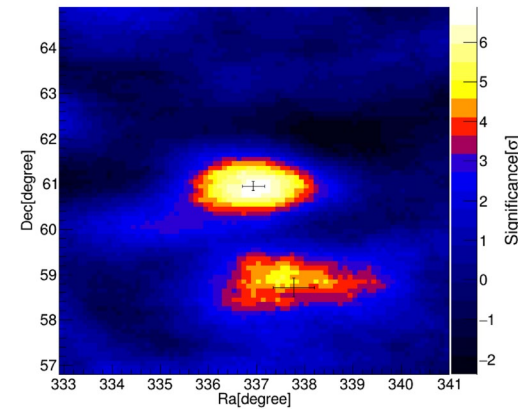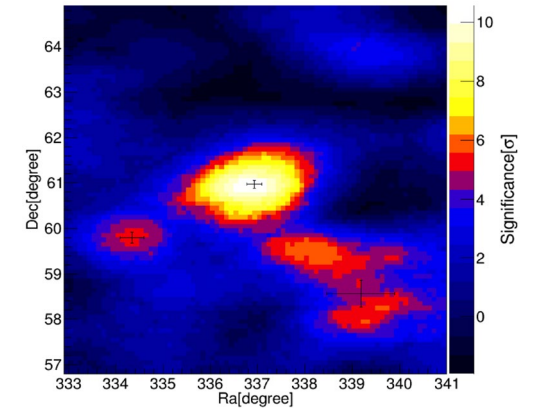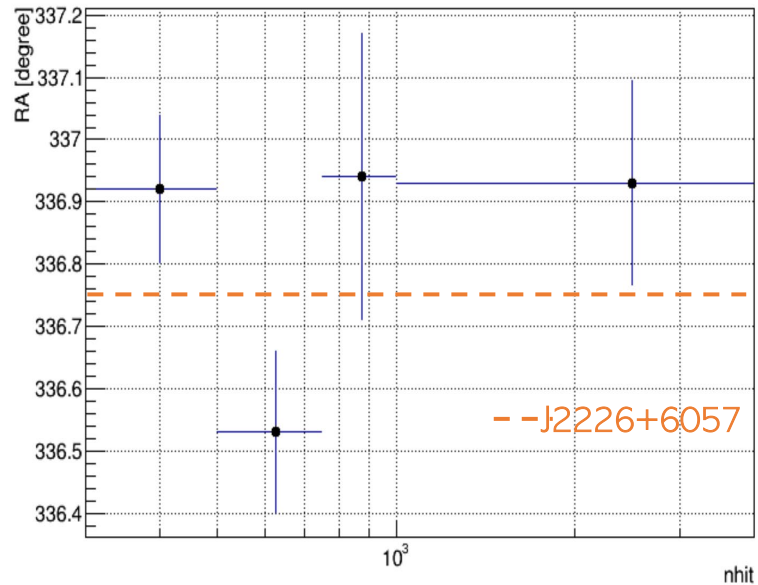300<nhit<500 500<nhit<750 750<nhit<1000 nhit>1000

•The black crosses represent the location of the source by fitting with two sources and three model
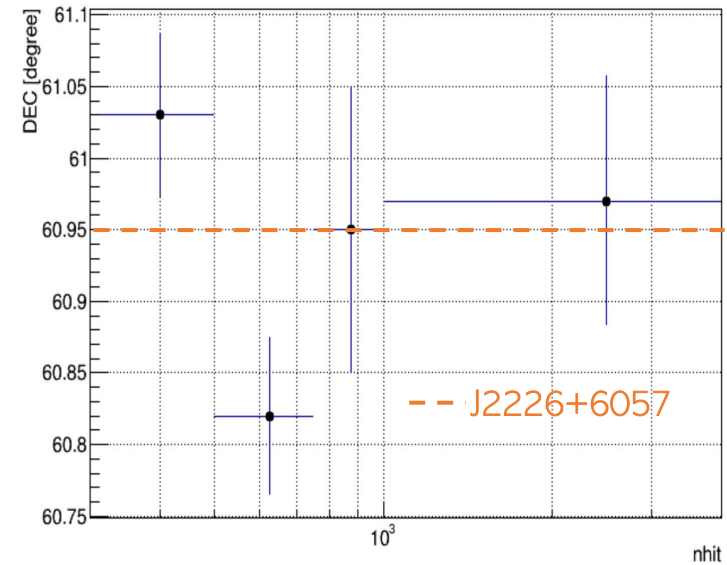
J2226+6057

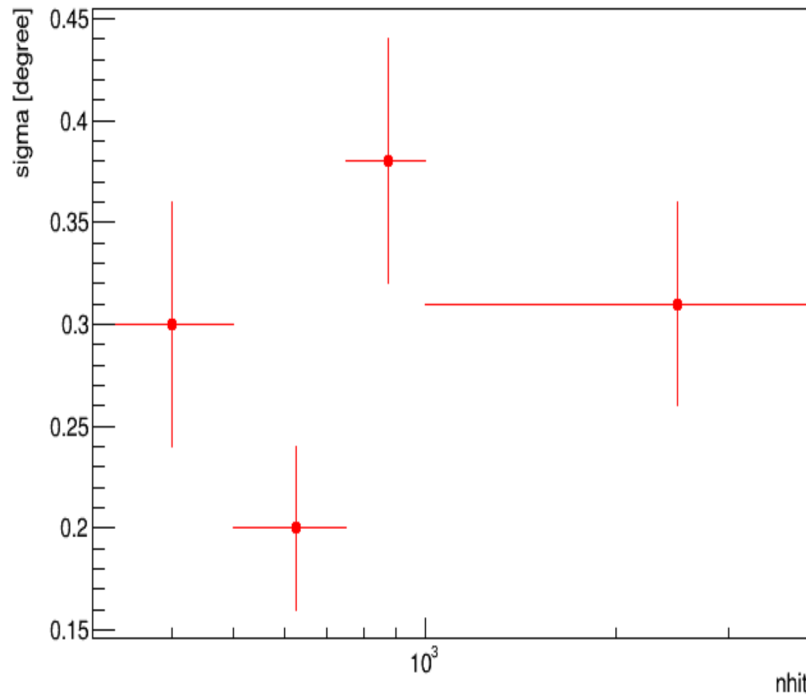➤position

Ra VS nhit

Dec VS nhit

The position of the source does not change significantly except the second energy bin.
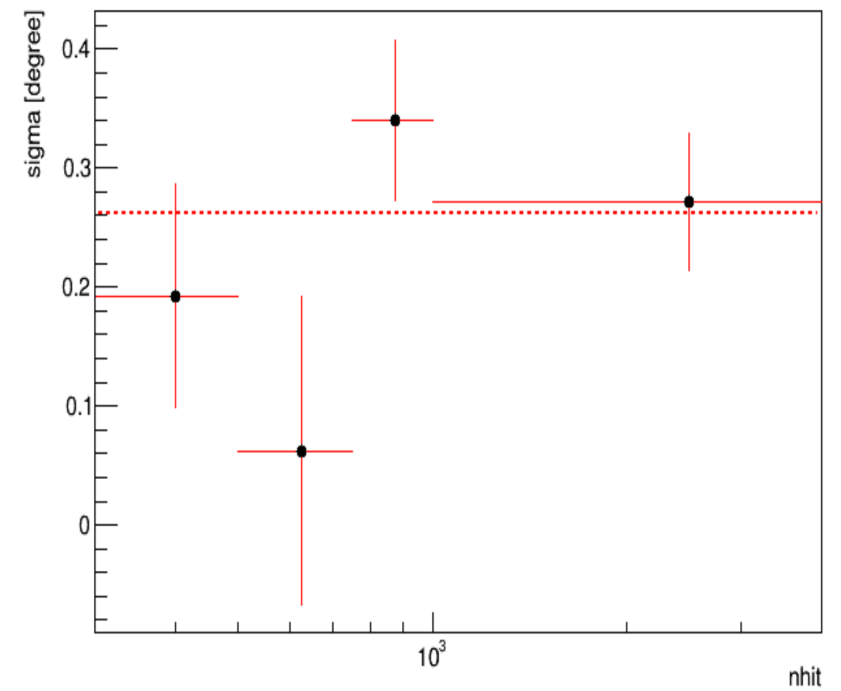
J2226+6057

➢extension

Model Extension VS nhit

Minus PSF

Extension VS nhit

J2226+6057 Intrinsic extension is about 0.26+/-0.04 degree .

Summary and outlook

1. **Most TeV gamma emission from PeVatron region have been observed using WCDA Full array's data with 134 live time.**

2 **We analysis the extension and position J1908+0621 and J2226+6057 by maximum likelihood method**.
   i. J1908+0621
      a. The extension is about 0.6 degree at high energy which depend on energy.
      b. The position changes obviously with the energy especially in the DEC directions

   ii. J2226+6057
      a. The extension is about 0.26 degree.
      b. The position of the source does not change significantly except the second energy bin.
3. **Next work will be done :**
   i. MC and data comparison and SED measurement on CRAB .
   ii. Get better Y/P separation by using F5 parameter
   iii. More detail analysis on those sources morphology and SED.

谢谢！