Observations of the brightest UHE Gamma-Ray Sources With the LHAASO-KM2A

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on behalf of the LHAASO Collaboration

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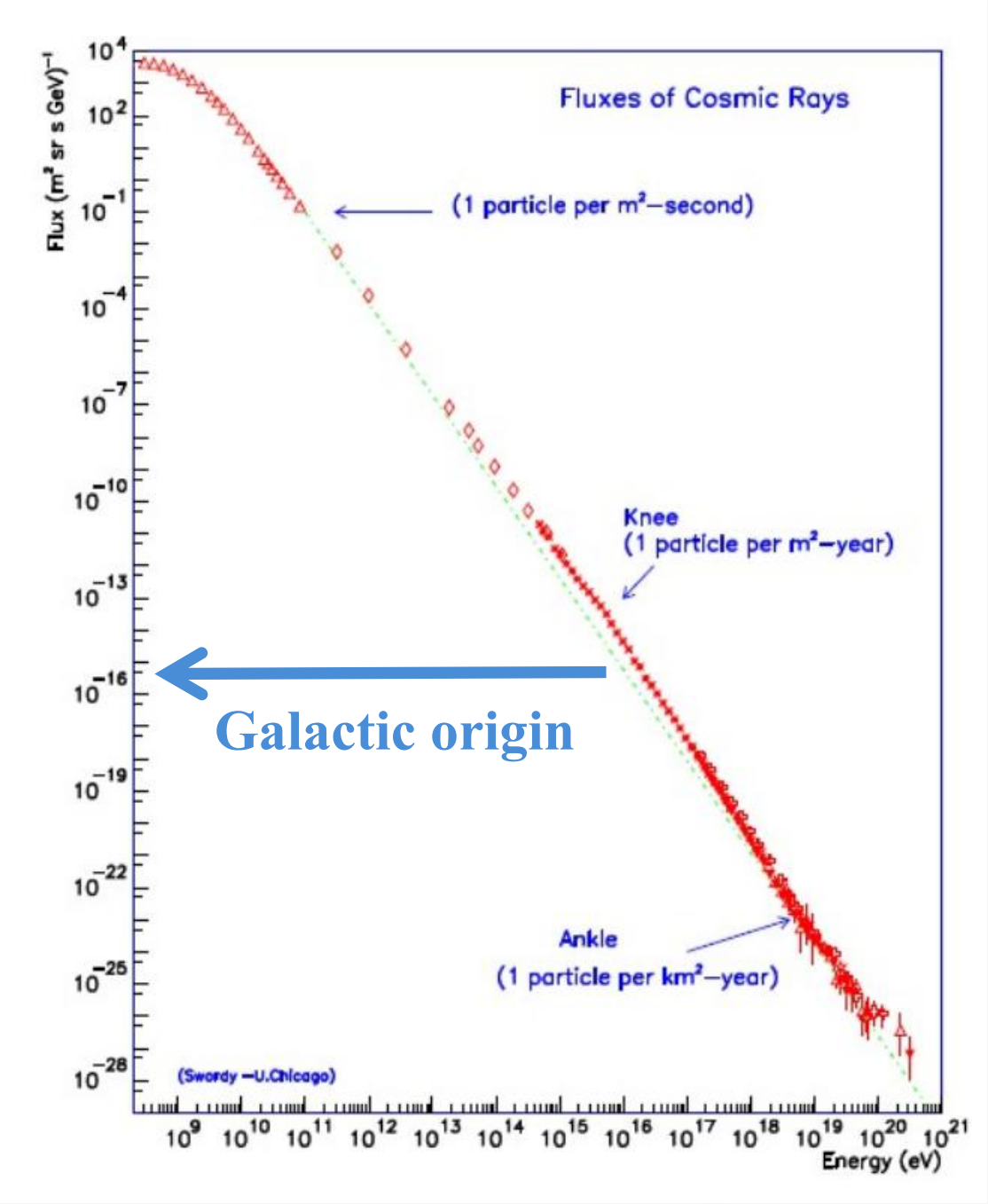
Content

1. Introduction

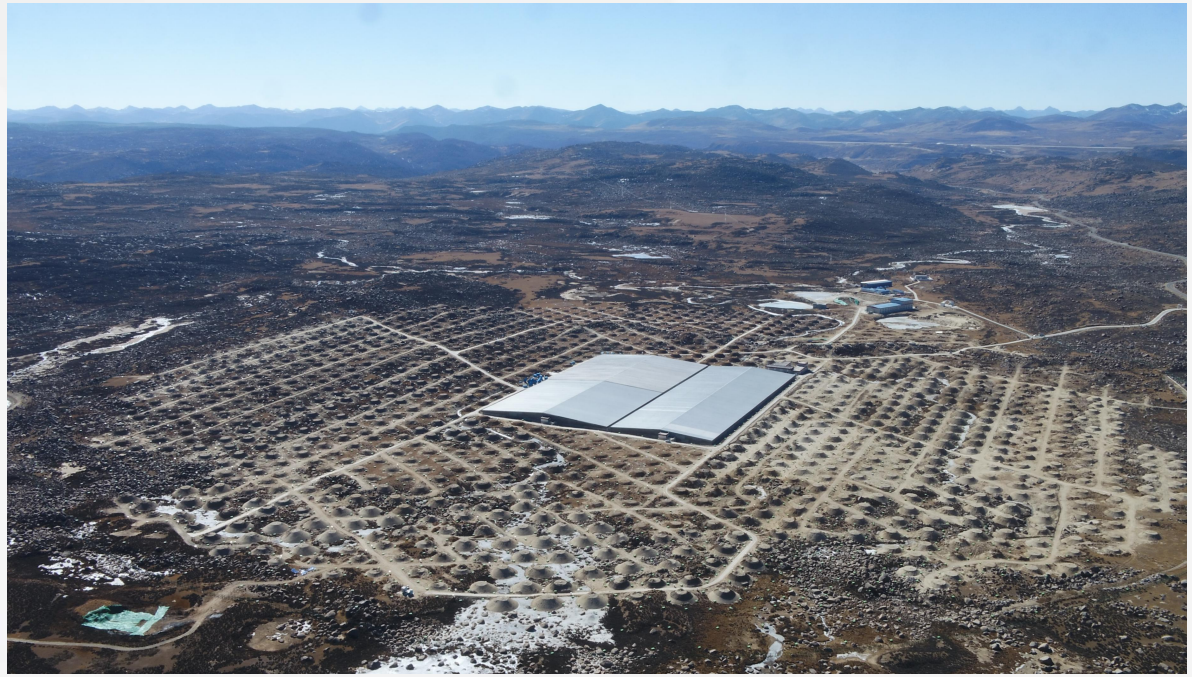
- One or more factories of PeV CRs, or PeVatrons, must be active within our Galaxy.
- The possible candidates include SNR, Galactic Center, Star forming regions and so on.
- The identication of PeVatrons needs more observations of ultra-high energy (**UHE; E≥0.1 PeV**) gamma-rays sources.

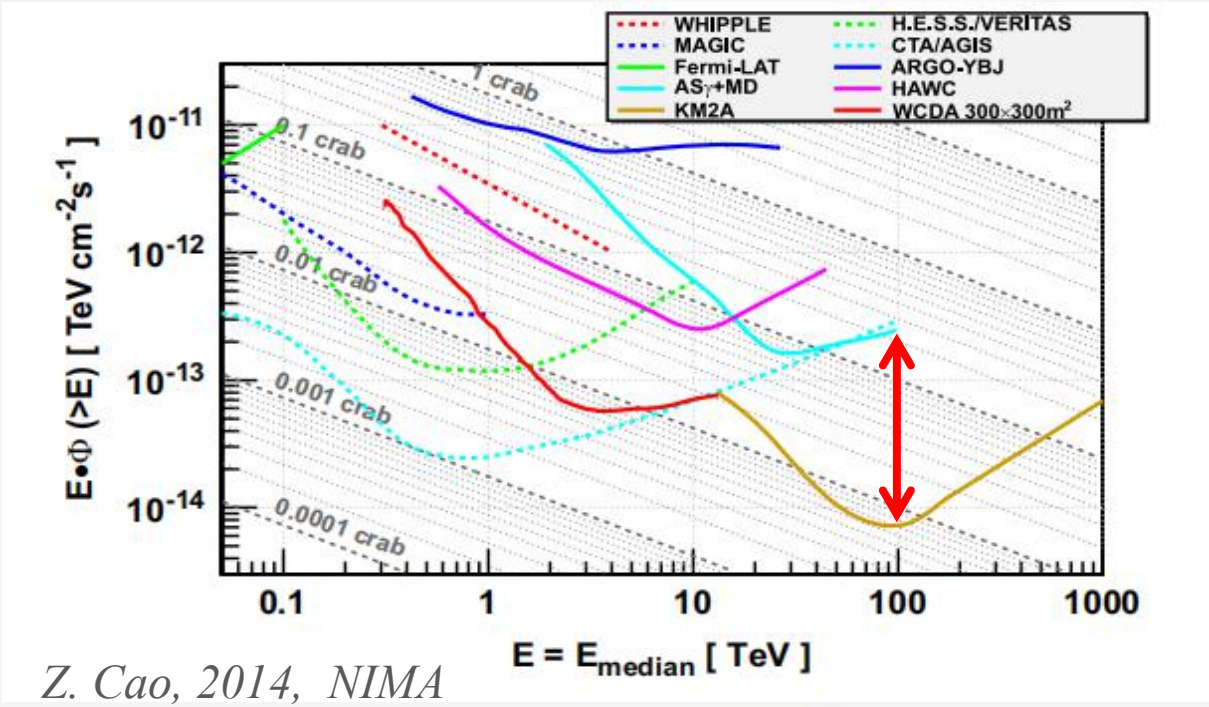


2. The LHAASO Detectors Array

- LHAASO, 4410 m a.s.l. :
  KM2A+WCDA+WFCTA

- The KM2A is most sensitive detector array above 20 TeV.

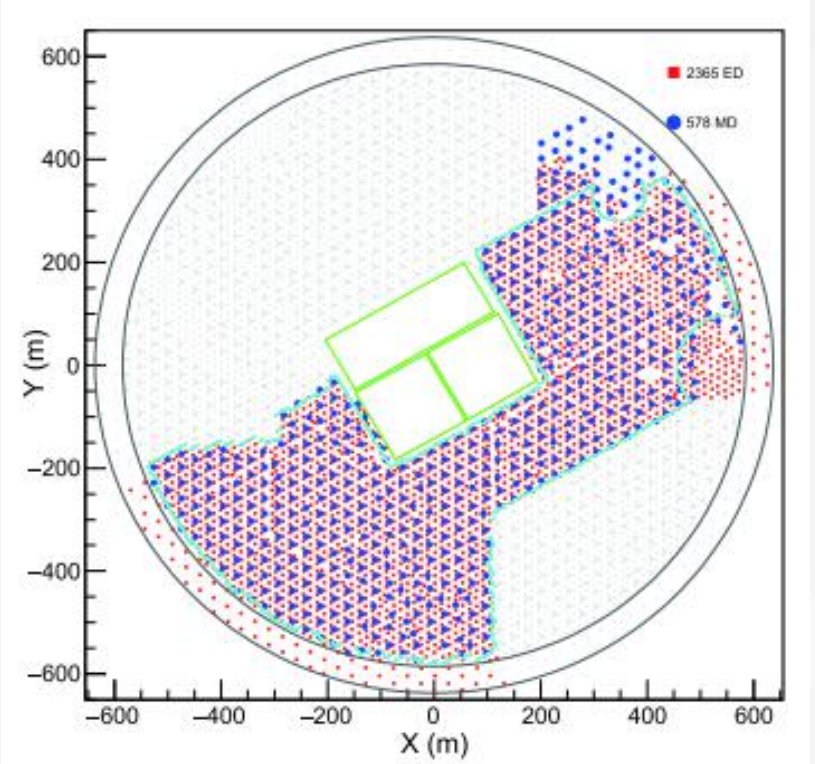


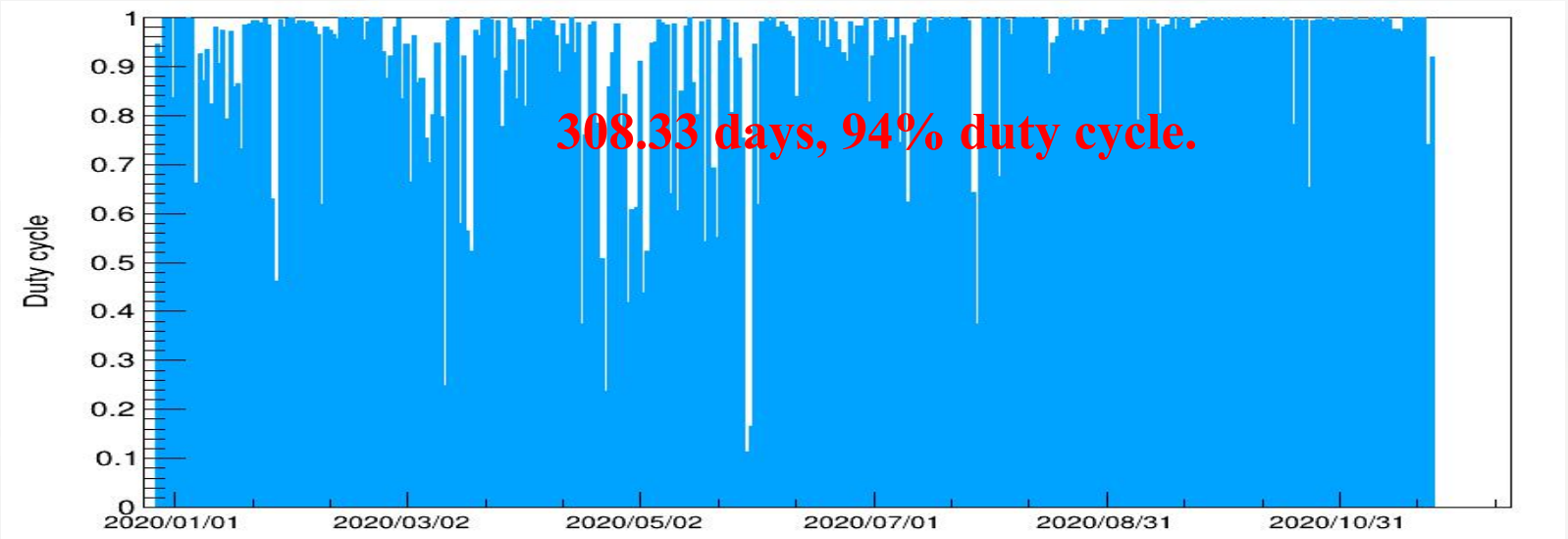


Z. Cao, 2014, NIMA

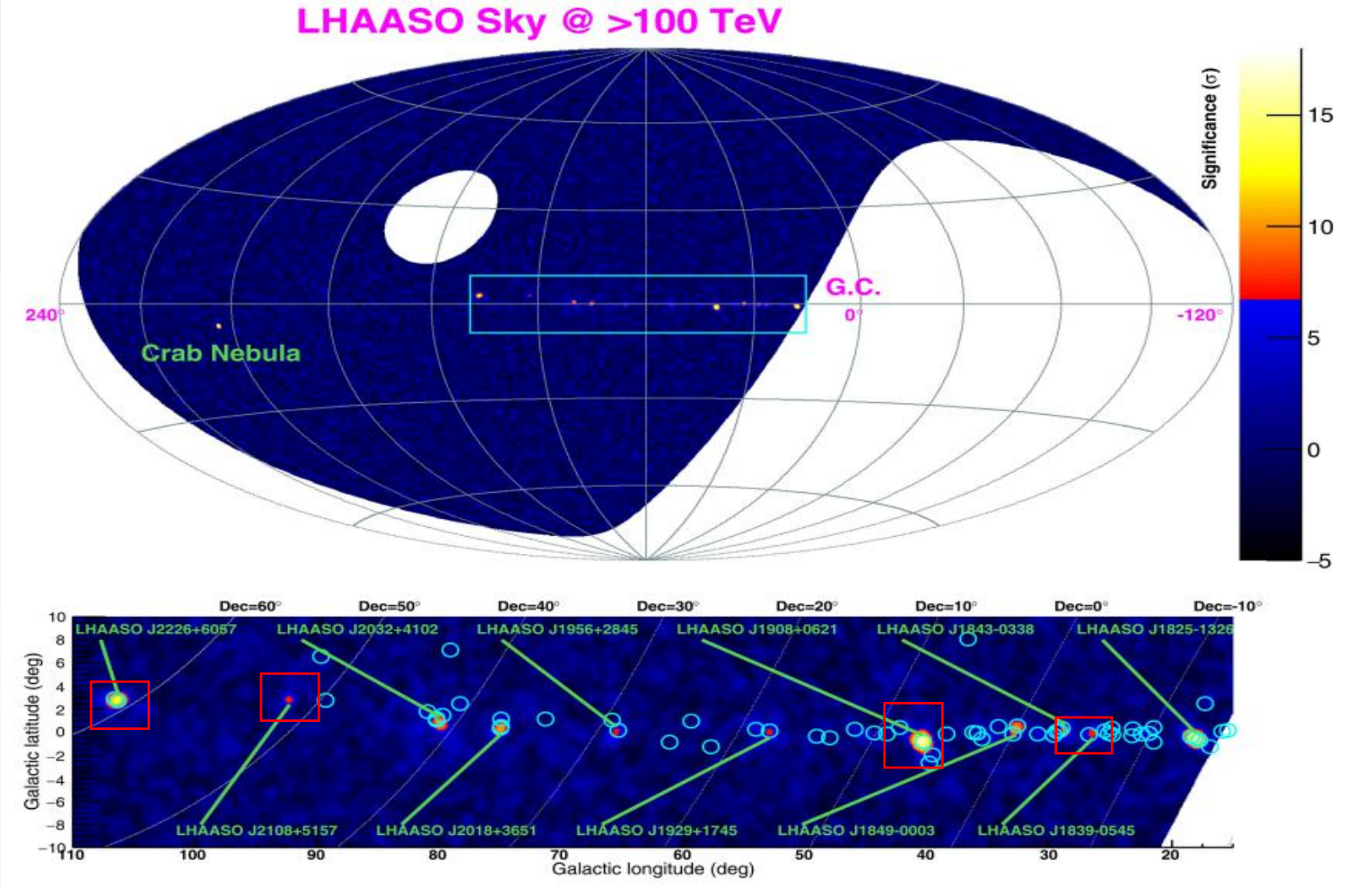
The KM2A half-aray

- **Data :**
  27th December 2019 to 24th November 2020
- **Analysis Methods:**
  direct integration method->background
  likelihood analysis->significances
  forward-unfolding method-> SED





12 UHE gamma-ray sources > 7σ

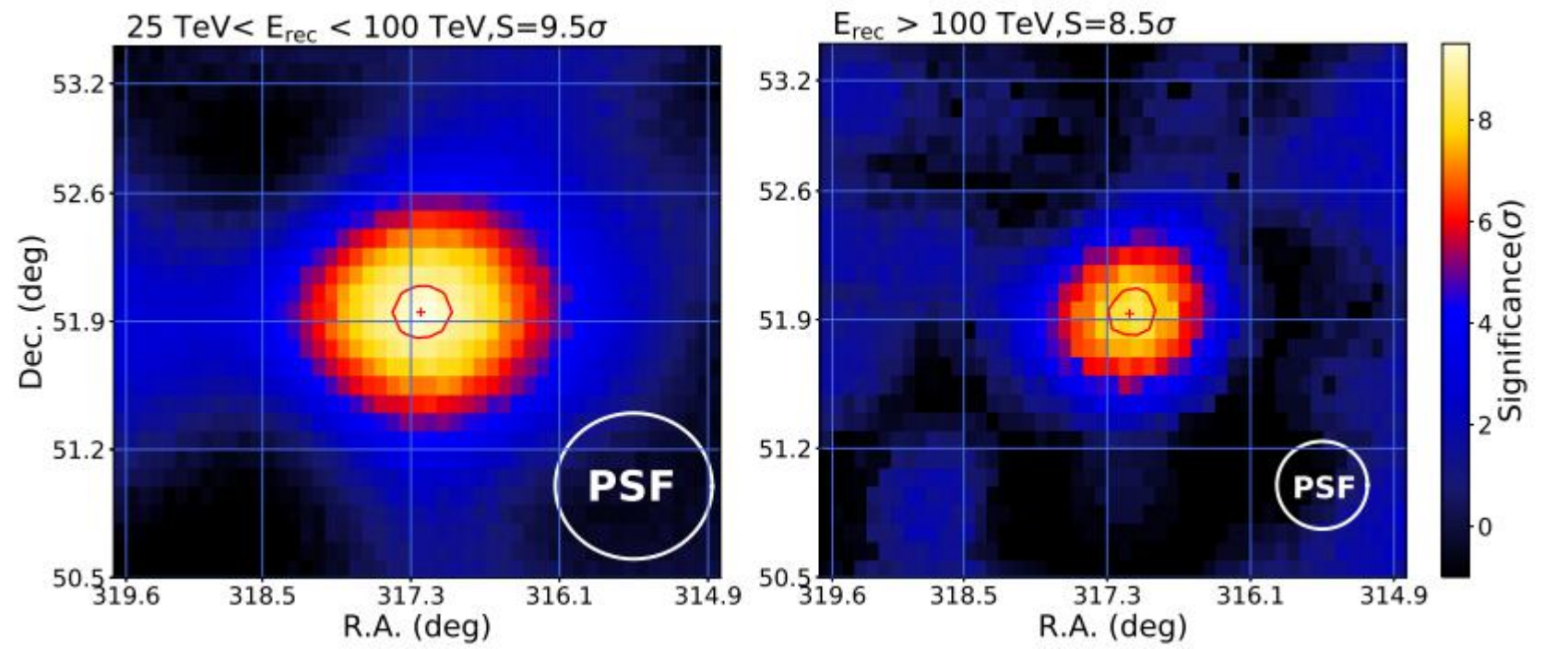


LHAASO, Nature，2021

3. Results

3.1 LHAASO J2108+5157

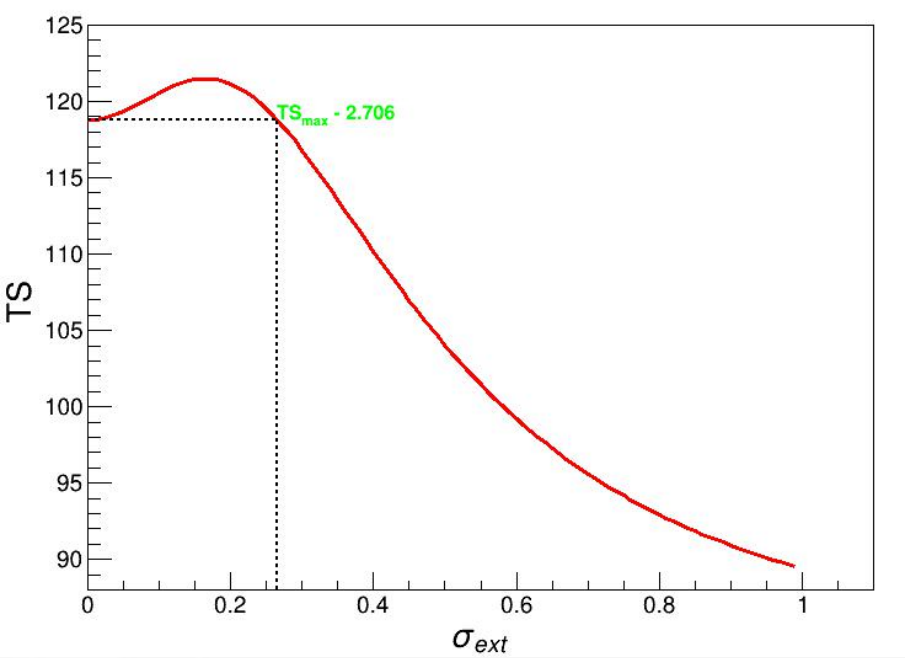
- First discovered by LHAASO at 9.5σ significance level.
- The post-trial significance at >100TeV is about 6.4σ.



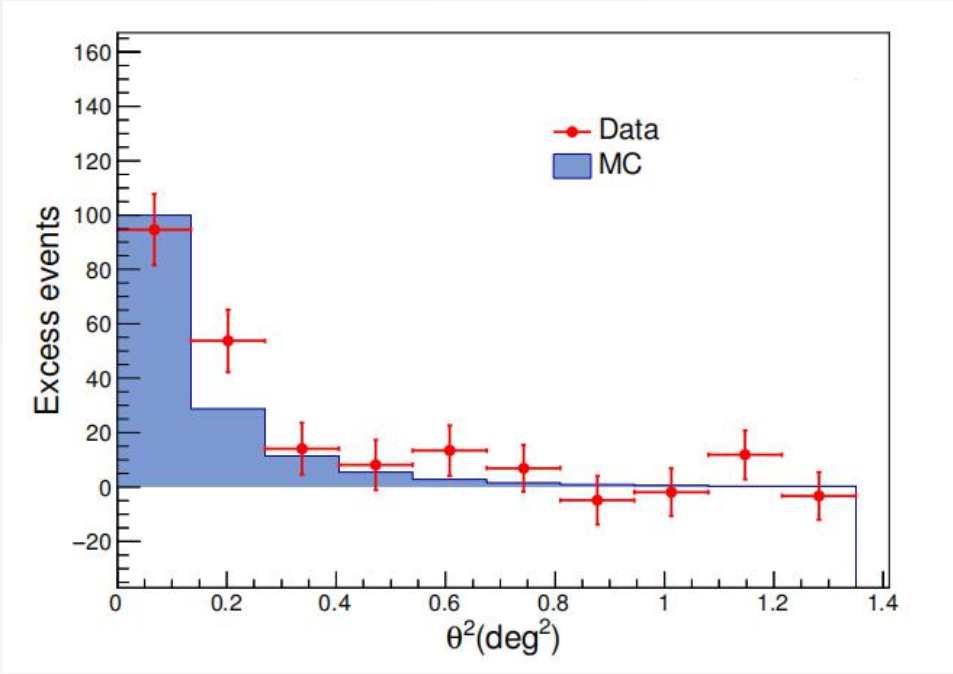
http://arxiv.org/abs/2106.09865

3.1 LHAASO J2108+5157

- An upper limit on the extension is 0.26° at 95% confidence level.



- The distribution is generally consistent with the PSF obtained using MC simulations(χ^2/ndf,9.1/10).



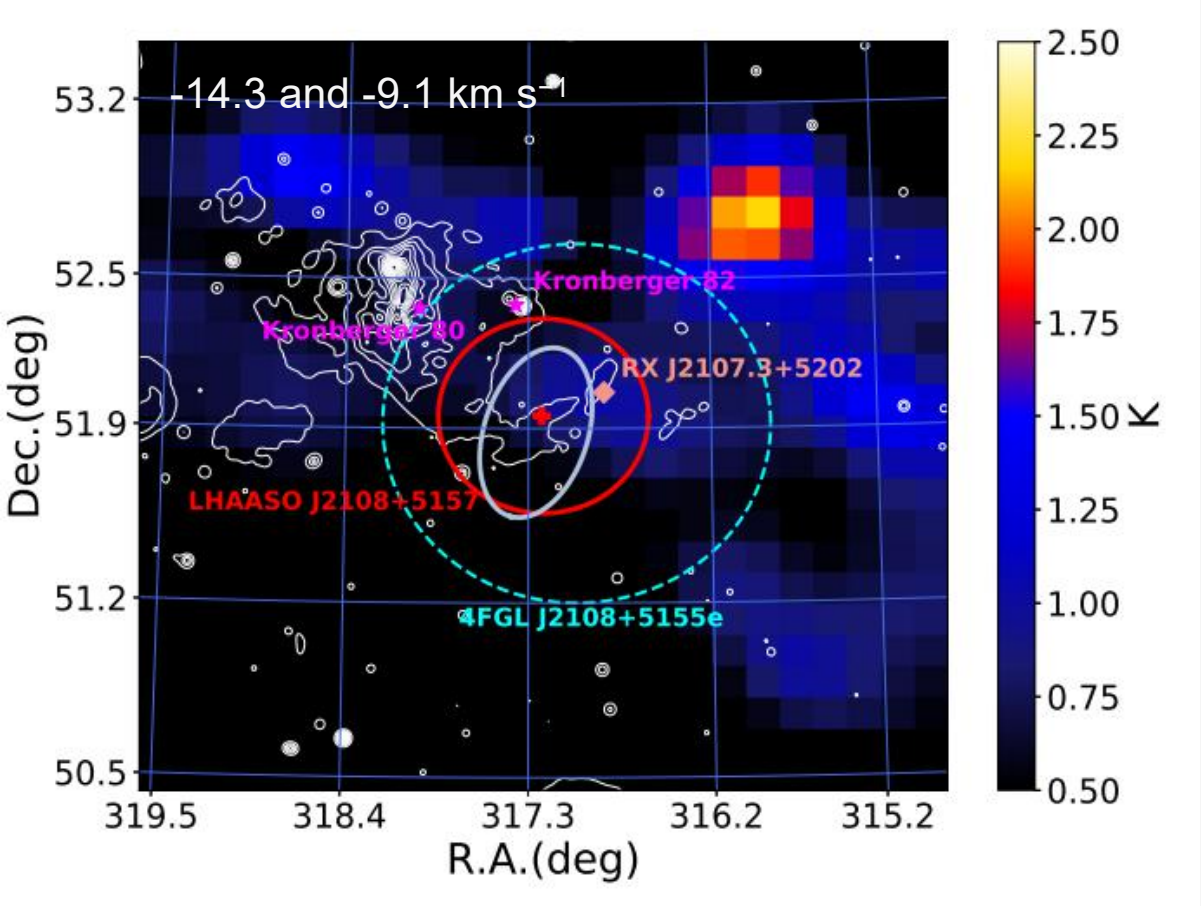
3.1 LHAASO J2108+5157

Searching for counterparts at other wavelengths

- TeV，X-Ray，Radio: No counterpart.
- GeV:

4FGL J2108.0+5155(Fermi catalog),
4FGL J2108.0+5155e(reanalysis,**0.48°** ,7.8σ).

- CO :[MML2017]4607,3.28 kpc, 30cm^{-2}.



3.1 LHAASO J2108+5157

Scenarios for the origin of UHE emission

Lepton model:

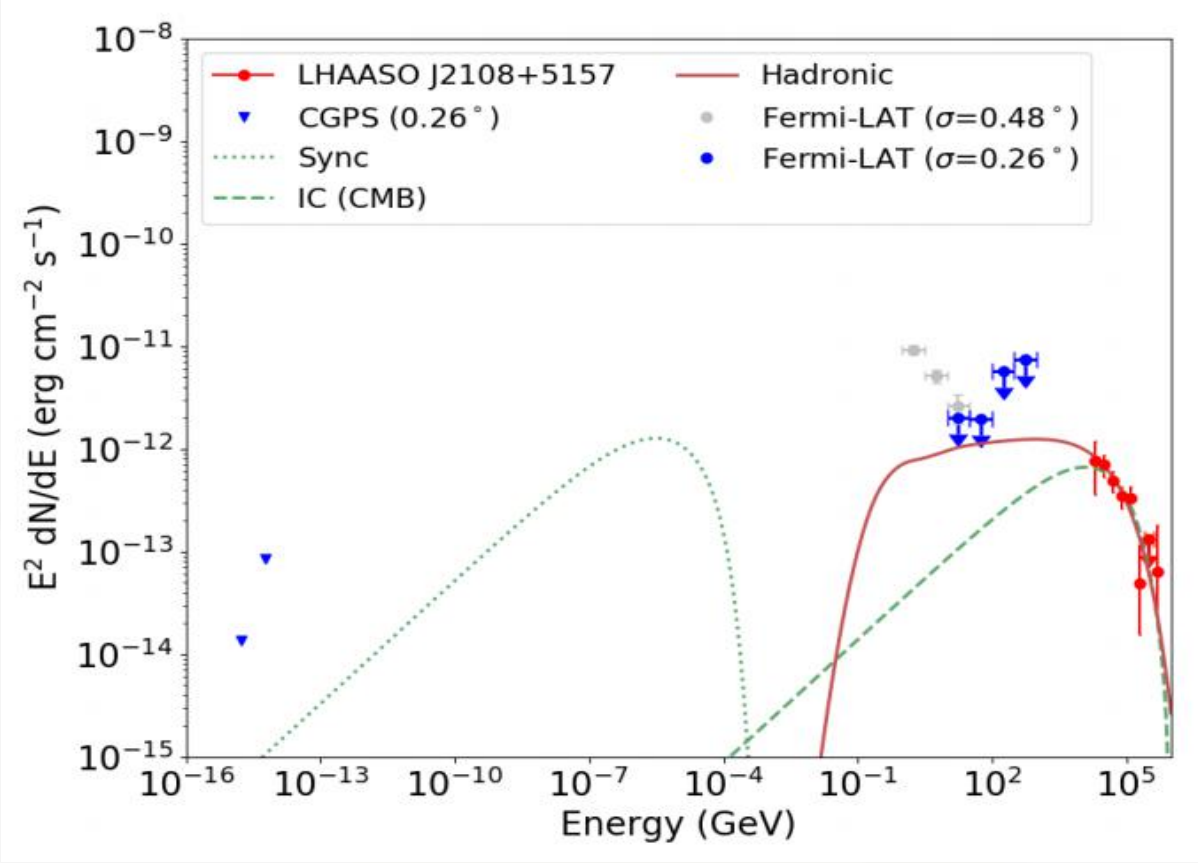
- Ec~200TeV; a=-2.2;B~3uG;
- Total electron energy >10TeV:

$$1 \times 10^{46} \left(\frac{D}{1\ \mathrm{kpc}}\right)^2\ \mathrm{erg}.$$

Hadronic model:

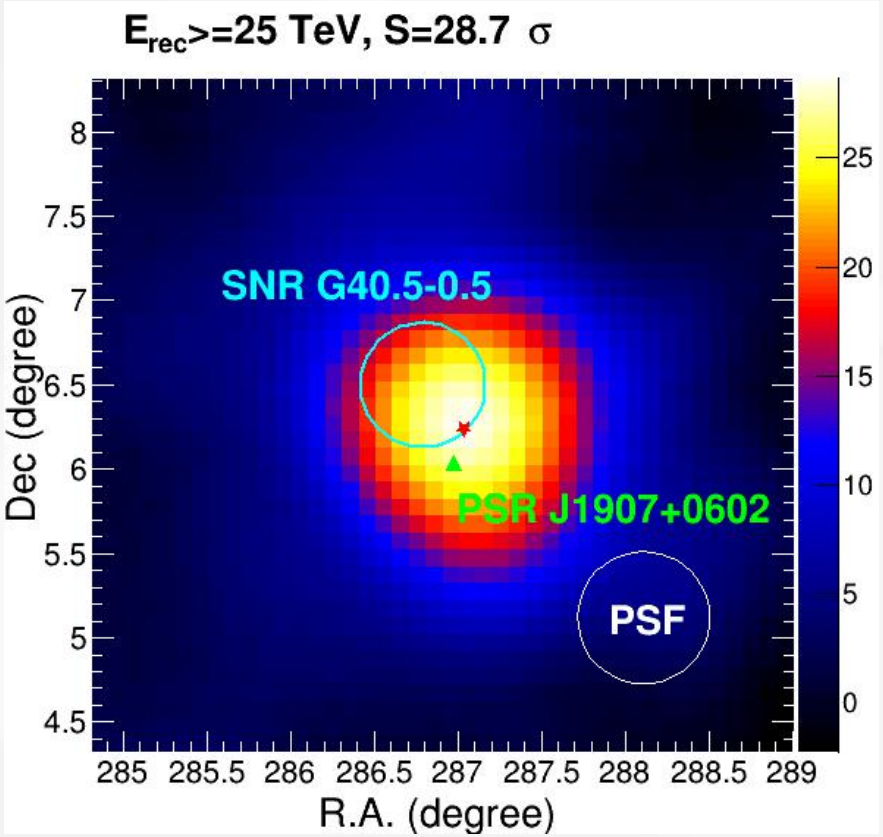
- Ec~600TeV; a=-2;
- Total energy in protons :

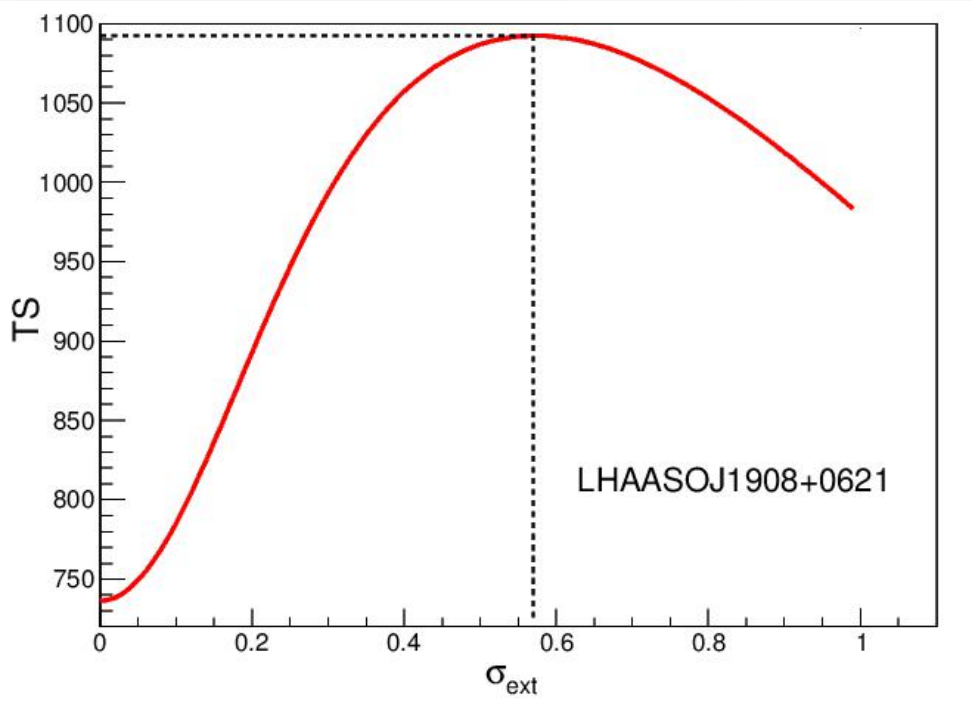
$$2 \times 10^{48} \left(\frac{n}{30\ \mathrm{cm}^{-3}}\right)^{-1} \left(\frac{D}{3.28\ \mathrm{kpc}}\right)^2\ \mathrm{erg}$$



3.2 LHAASO J1908+0621

- LHAASO J1908+0621 is consistent with the MGRO J1908+06
- It spatially associated SNR G40.5-0.5 and an pulsar PSR J1907+0602(3.2kpc)
- Above 25TeV，the fit position is （RA, DEC)=(287.04°±0.03°，6.24°±0.04°), the extension is 0.57°±0.03°.





3.2 LHAASO J1908+0621

Scenarios for the origin of UHE emission

Lepton model: 6% spin-down power of PSR J1907+0602

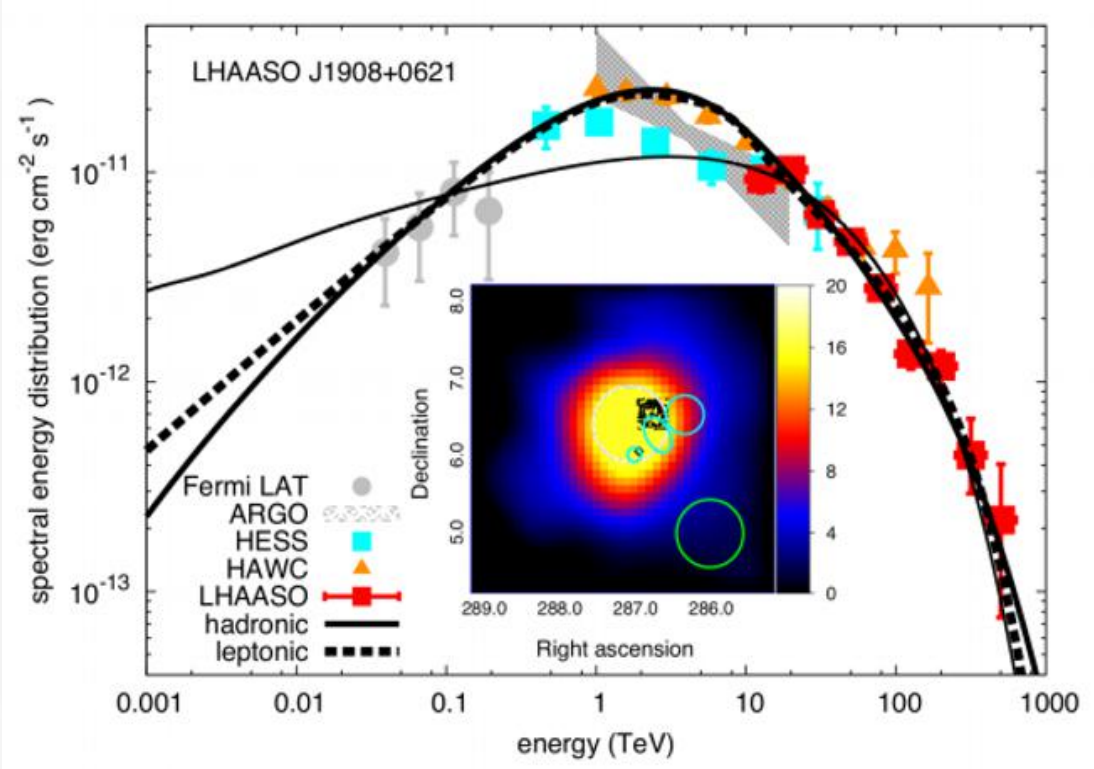
$$N(E) \propto E_e^{-1.75} \exp\{-[E_e/(800\ \mathrm{TeV})]^2\}$$

Hadronic model:

$$N(E) \approx E^{-1.85} \exp[-E/(380\,\mathrm{TeV})]$$

- a broken power-law spectrum with an exponential cutoff:
  a1=1.2,a2= 2.7(25TeV); Ec~600TeV;1.3PeV

LHAASO J1908+0621 can accelerate particles to PeV energie



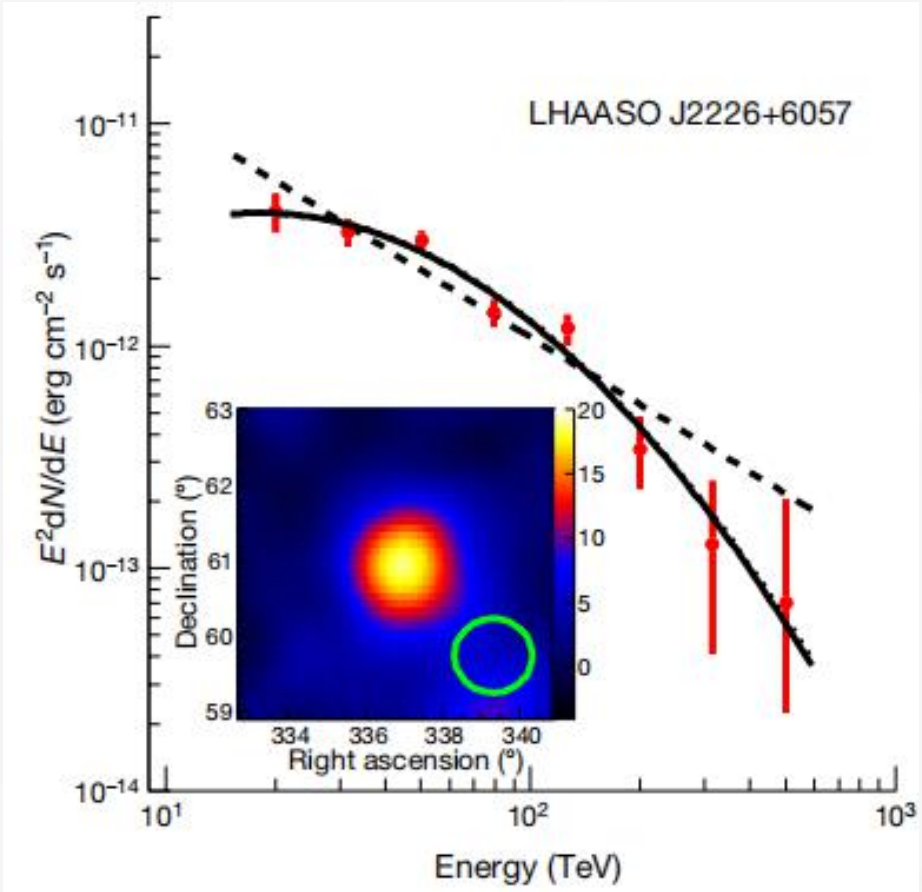
LHAASO, Nature，2021

3.3 LHAASO J2226+6057

- LHAASO J2226+0657 is spatially associated with SNR G106.3+2.7 and an pulsar PSR J2229+6114 (0.8kpc).
- Above 25TeV，the extension is 0.36° ± 0.06° .
- The detected highest photon energies: 0.57±0.19PeV.
- The Spectrum:

$$\frac{dN}{dE} \propto \left(\frac{\mathrm{E}}{10\ TeV}\right)^{-1.56-0.88\log[E/(10\ TeV)]},\ AIC = 12.3$$

$$\frac{dN}{dE} \propto E^{-3.01},\ AIC = 24.4$$



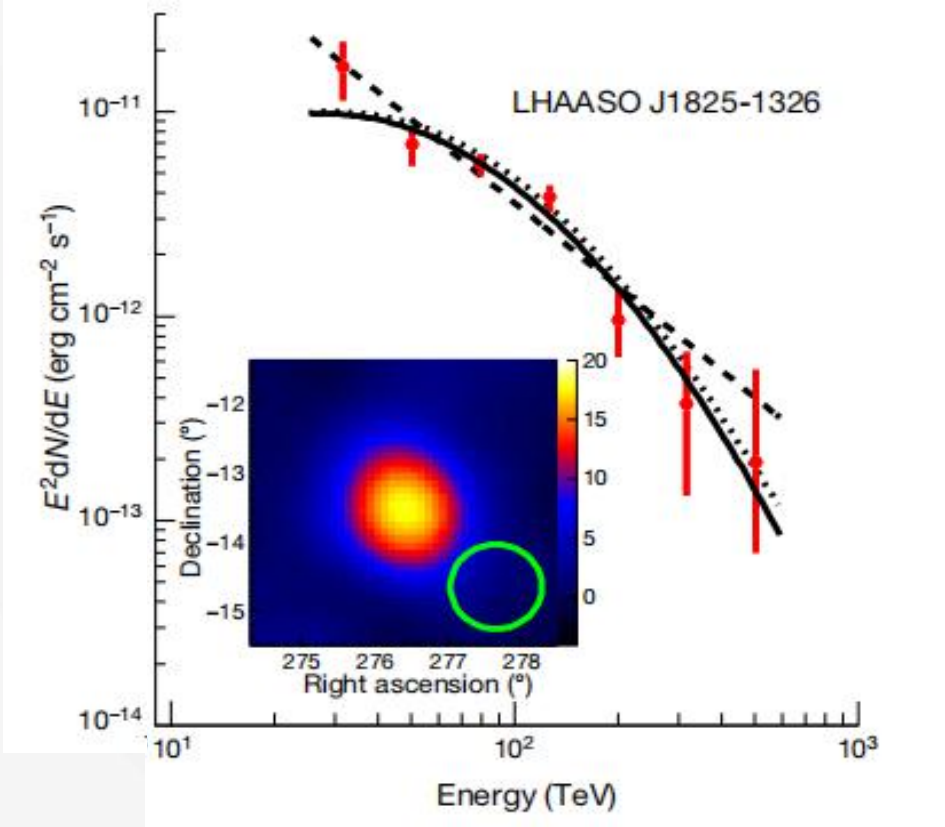
LHAASO, Nature，2021

3.4 LHAASO J1825-1326

- LHAASO J1825-1326 is spatially associated with PSR J1826-1334 and PSR J1826-1256.
- Above 25TeV，the extension is 0.30° ± 0.06° .
- The detected highest photon energies: 0.42±0.16PeV.
- The Spectrum:

$$\frac{dN}{dE} \propto \left(\frac{\mathrm{E}}{10\,TeV}\right)^{-0.92-1.19\log[E/(10\,TeV)]}, AIC = 11.6$$

$$\frac{dN}{dE} \propto E^{-3.36}, AIC = 14.8$$



LHAASO, Nature，2021

4. SUMMARY

- LHAASO has a high ability to observe UHE gamma-ray sources. 12 UHE sources has been observed. It will play an important role in the identification of the PeVatrons.

- The LHAASO J2108+5157 is coincident with molecular clouds. It is a new PeVatron Candidate.

- LHAASO has observed the LHAASO J1908+0621,LHAASO J2226+6057 and LHAASO J1825-1326 at a high significance above 100 TeV. We will make a deep analysis of these three sources in the future.

Thank You!