Observation of the bright Ultra-High-Energy source LHAASO J2018+3651 with the LHAASO-KM2A

Hou Chao, Chen Songzhan, Fang Jun, Qi Yeqing

outline

- Introduction：Observation status of other experiments
- Data analysis
- Morphology and SED
- Discussion: UHE Radiation mechanism study by multi-wavelength observations

Introduction

- LHAASO J2018+3651, which is located in the Cygnus region, is positional coincident with MGRO J2019+37 （2007）
- Argo(2012) and Fermi-LAT give upper limit of flux
- MGRO J2019+37 region including:

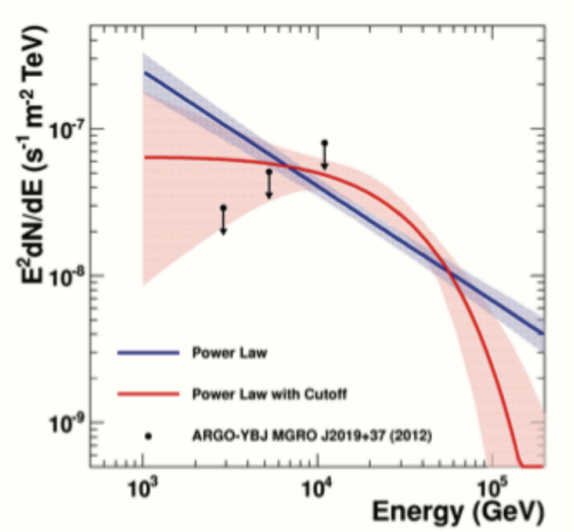
  PSR J2021+3651 and its PWN G75.1+0.2 (X-ray)

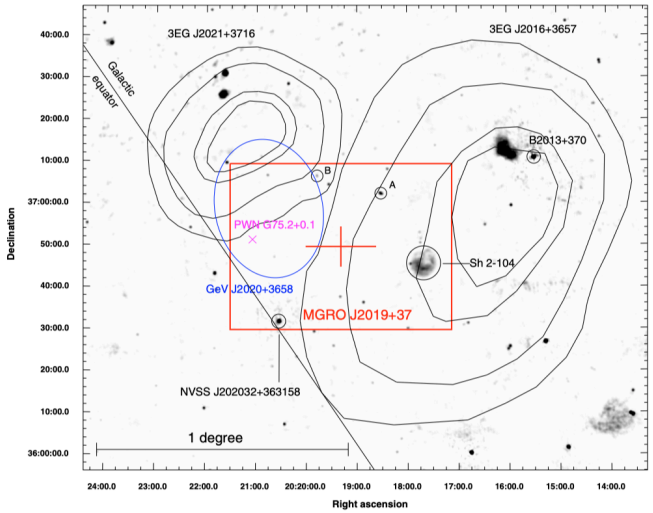
  sh 2-104 HII region, star forming (radio/optical/X-ray)

  SNR CTB 87

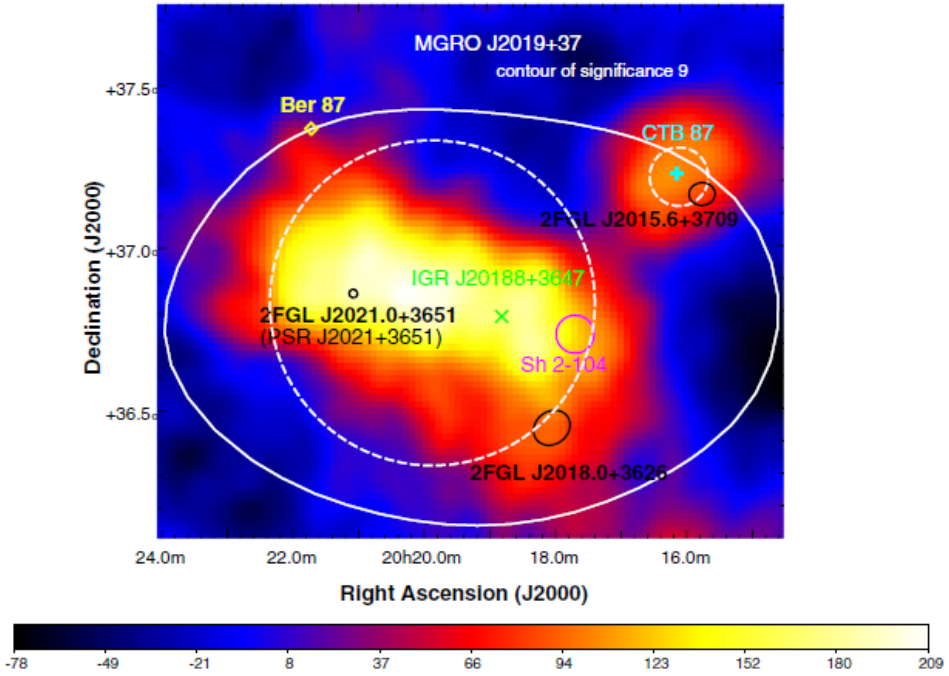
  ...

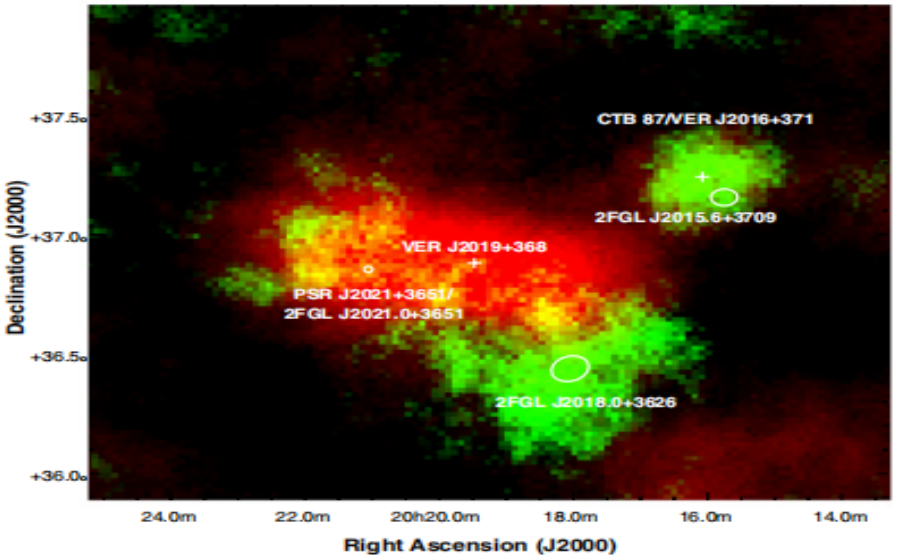
- LHAASO J2018+3651 is a bright extended VHE and UHE source, Its radiation mechanism is worth discussion





Observation status of other experiments





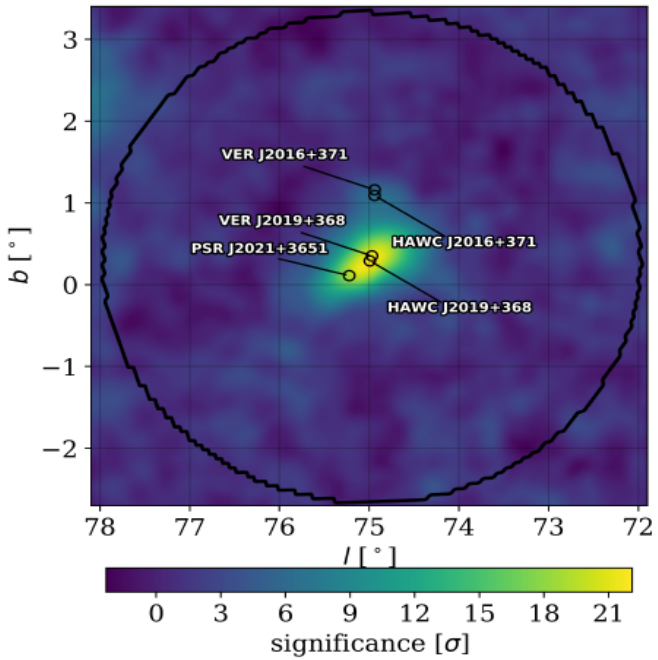
The Astrophysical Journal, 788:78 (10pp), 2014 June 10

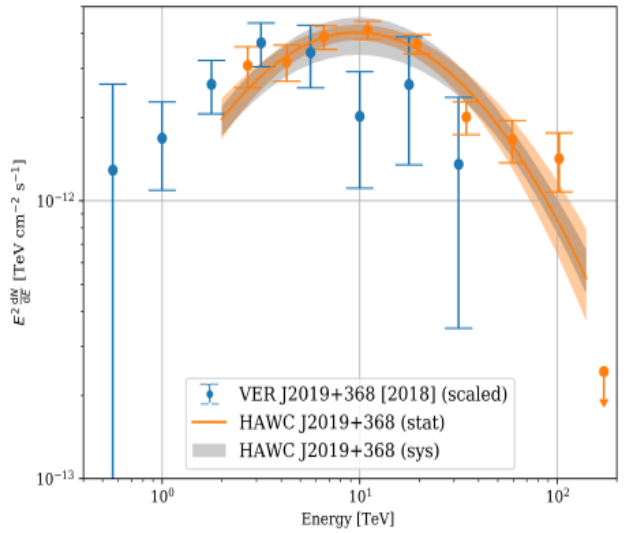
Red: >1 TeV Green: 0.6-1TeV

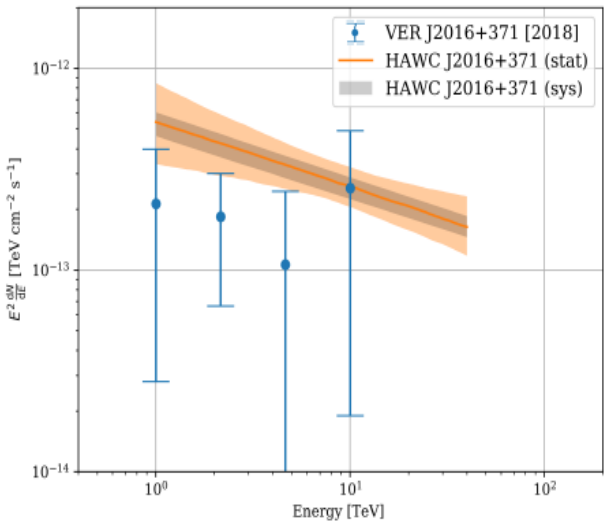
- **VERITAS**: 600GeV<E<1TeV
- Divided into two sources:

  VER J2019+368(0.34degree)

  VER J2016+371 position SNR CTB 87 (0.13degree)







arXiv:2101.01649v1

- **HAWC**: 100TeV>E>300GeV
- resolves the region into two sources:

  HAWC J2019+368

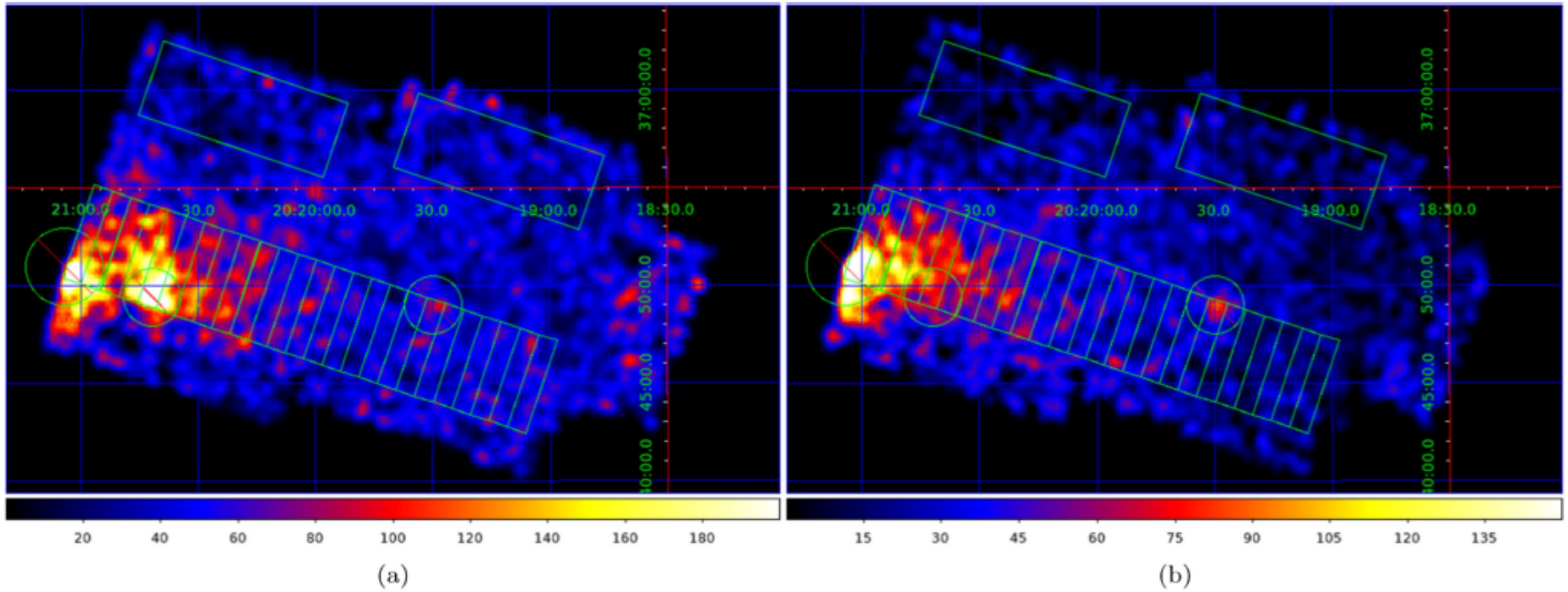
  HAWC J2016+371

Source Name	Spectral Parameters	Morphology
HAWC J2019+368	$\phi_{10\,\mathrm{TeV}} = 4.05 \pm 0.26 \times 10^{-14}$ $\alpha = -2.02 \pm 0.06$ $\beta = -0.29 \pm 0.05$	$\mathrm{a} = 0.368^\circ \pm 0.021^\circ$ $\mathrm{e} = 0.943 \pm 0.017$ $\theta_{\mathrm{rot}} = 21.7^\circ \pm 2.5^\circ$
HAWC J2016+371	$\phi_{10\,\mathrm{TeV}} = 2.6^{+0.7}_{-0.5} \times 10^{-15}$ $\alpha = -2.32 \pm 0.18$	Point Source
Background	$\phi_{10\,\mathrm{TeV}} = 8.2^{+1.5}_{-1.3} \times 10^{-14}$ $\alpha = -2.75 \pm 0.08$	Uniform over ROI

Table 1. Description of model parameters assuming HAWC J2019+368 has a log parabolic spectrum. $\phi_{10\,\mathrm{TeV}}$ is the flux normalization at 10 TeV in units of $\mathrm{TeV}^{-1}\,\mathrm{cm}^{-2}\,\mathrm{s}^{-1}$. Reported uncertainties are statistical.

Source Name	Spectral Parameters	Morphology
HAWC J2019+368	$\phi_{10\,\mathrm{TeV}} = 4.8^{+0.5}_{-0.4} \times 10^{-14}$ $\alpha = -1.67 \pm 0.10$ $E_{\mathrm{cut}} = 37^{+8}_{-7}$ TeV	$\mathrm{a} = 0.358^\circ \pm 0.022^\circ$ $\mathrm{e} = 0.953 \pm 0.017$ $\theta_{\mathrm{rot}} = 21.9^\circ \pm 2.6^\circ$
HAWC J2016+371	$\phi_{10\,\mathrm{TeV}} = 2.9^{+0.7}_{-0.6} \times 10^{-15}$ $\alpha = -2.28 \pm 0.17$	Point Source
Background	$\phi_{10\,\mathrm{TeV}} = 8.1^{+1.5}_{-1.3} \times 10^{-14}$ $\alpha = -2.74 \pm 0.09$	Uniform over ROI

Table 2. Description of model parameters assuming HAWC J2019+368 has an exponentially cutoff power law spectrum. $\phi_{10\,\mathrm{TeV}}$ is the flux normalization at 10 TeV in units of $\mathrm{TeV}^{-1}\,\mathrm{cm}^{-2}\,\mathrm{s}^{-1}$. Reported uncertainties are statistical.



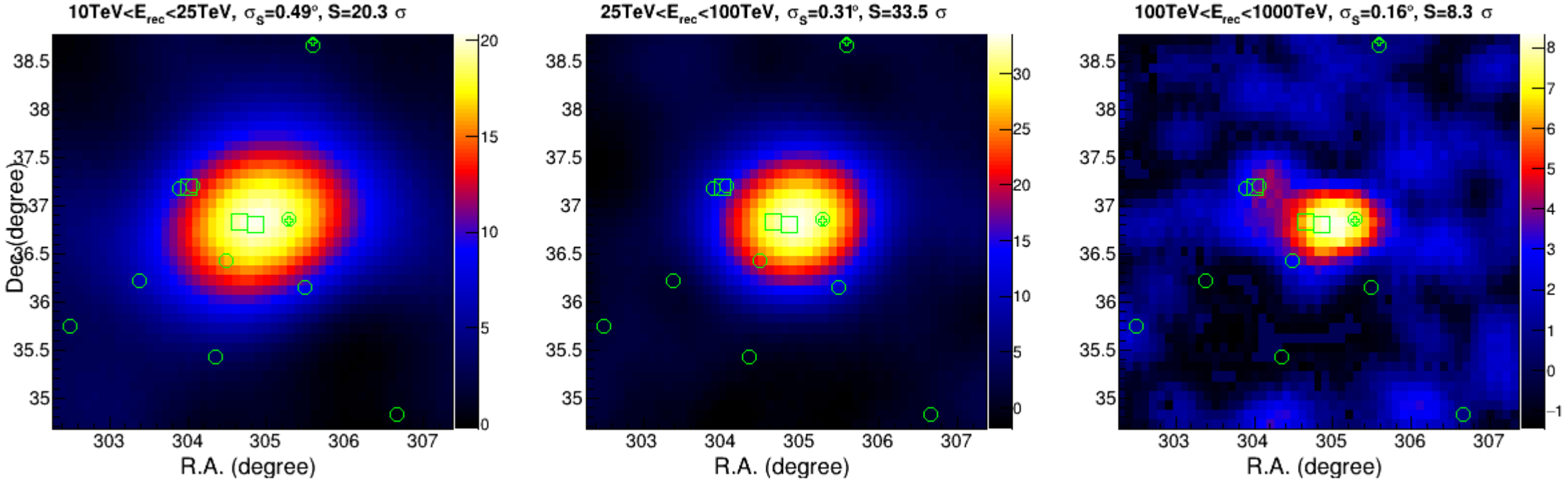
- **Suzaku**: (a)0.7~2keV, (b)2~10keV
- Confirm that the extended X-ray radiation is only from PWN of PSR J2021+3651. The spectrum is fitted by an absorbed power law with $\Gamma = 2.05 \pm 0.12$, no significant change inside the region
- distance is much less than 10kpc

Data analysis

- Observation time: 2019.12~2020.12　　LHAASO-KM2A ½
- Data analysis: based on the all sky map obtained by standard LHAASO-KM2A data analysis method of crab to analyse the morphology and energy spectrum of this source

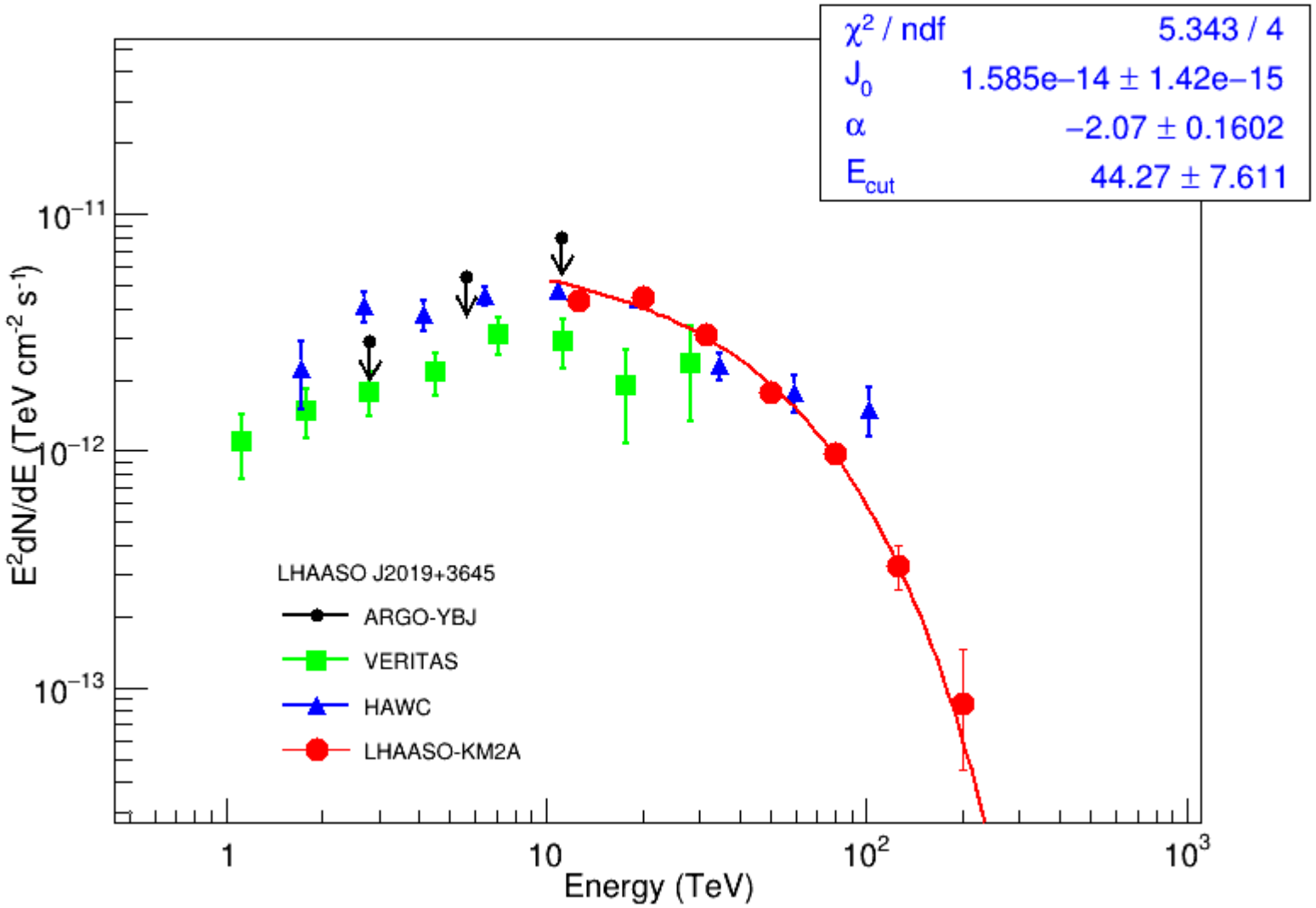
Morphology and SED

- Three energy band extended degree: 0.258±0.042, 0.308±0.021, 0.303±0.070(No obvious change)
- Three energy band location: (No obvious move)
  - Ra=304.875±0.046, Dec=36.761±0.034,
  - Ra=304.857±0.024, Dec=36.762±0.019,
  - Ra=304.838±0.100, Dec=36.759±0.071,



Circle: GeV， cross: Pulsar， square: TeV

SED

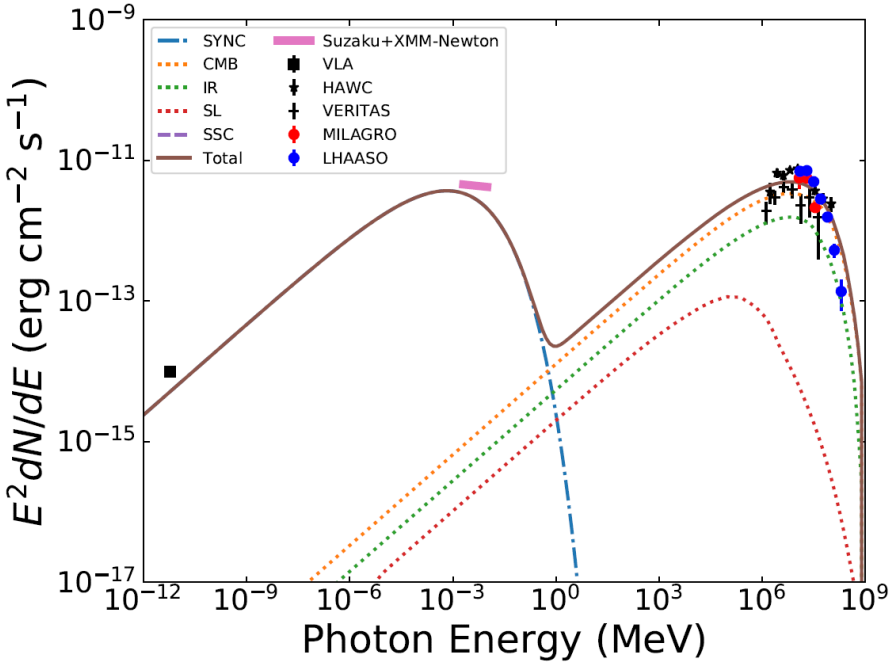


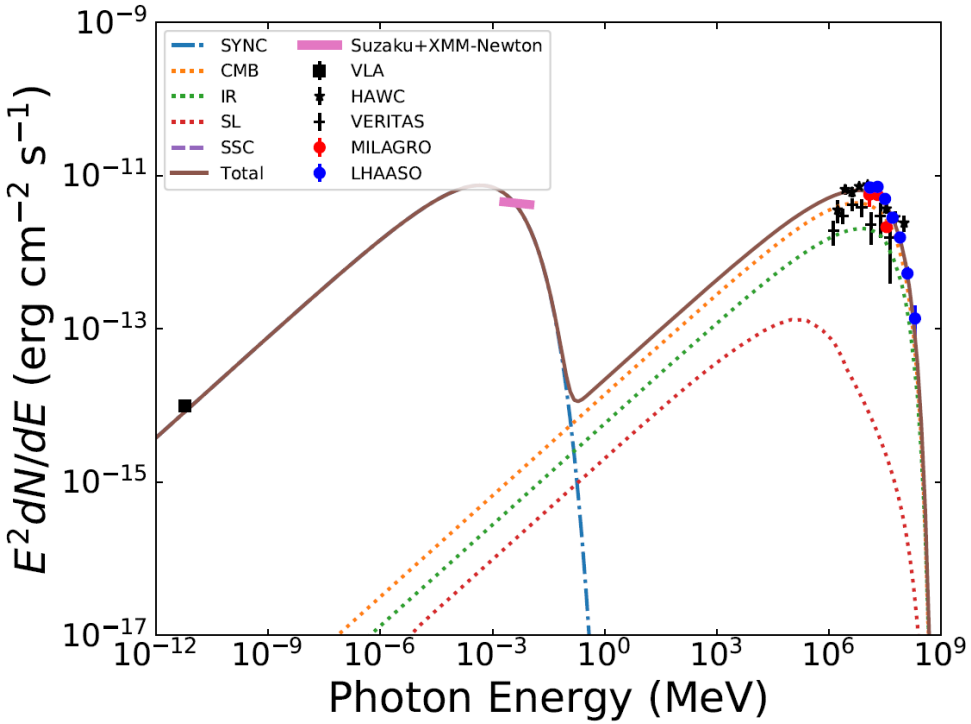
$$dN/dE \propto E^{-\alpha} \exp(-E/E_c)$$

- Obviously cut off

Discussion

- Associate with the PWN G75.1+0.2
- Electron injection energy spectrum ：$E^{-\alpha} \cdot e^{-\left(\frac{E}{E_{cut}}\right)^{\beta}}$ β=1 （left） and β=2 （right）





Thank you !