Study on TeV γ Ray Emission from Cygnus Region Using the Tibet Air Shower Array

1. Brief introduction to Cygnus region
2. The Tibet ASγ Experiment
3. The known extended source MGRO J2019+37 observing and its energy spectrum measurement
4. Preliminary Results
5. Conclusions

Tibet ASγ collaboration

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Brief Introduction about Cygnus region

$65^\circ < l < 85^\circ$, $-3^\circ < b < 3^\circ$, d:1~2kpc

this region contains a great deal of molecular clouds and was one of the richest star formation region
Multi-wave bands observation in Cygnus region

Radio Continuum (408MHz)
Atomic Hydrogen
Radio Continuum (2.5GHz)
Molecular Hydrogen
X-Ray
Gamma-Ray (100 MeV)
Gamma-Ray (10 TeV)
A possible association with a blazar was found in the Cygnus region.

**IACTs**

- **Whipple** (excess close to J2032+4130)

- **HEGRA** (TeV J2032+4130)

**EAS**

- **MAGIC** (compatible with HEGRA reported)
  - arXiv:0801.2391v1

**Milagro** (MGRO J2019+37 and other candidates)


**As γ** (the highest significance ~5.8 σ; Cygnus hot spot)

- 30th ICRC (2007)
- 2006, Science, 314, 439
The previous AS γ observation result about Cygnus

Performed the highest precise measurement on large scale cosmic ray anisotropy and first pointed out the Cygnus hot spots
Tibet Air Shower Array

- Located at an elevation of 4300 m (Yangbajing, China)
- Atmospheric depth 606g/cm²
- Wide field of view
- High duty cycle (>90%)
Tibet HD and III air shower arrays

<table>
<thead>
<tr>
<th>Run time</th>
<th>Live time</th>
<th>Mode energy</th>
<th>Angular resolution (@3TeV)</th>
<th>Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>TibetII (HD) 1997.2~1999.9</td>
<td>555.9day</td>
<td>~3TeV</td>
<td>0.9°</td>
<td>5175m²</td>
</tr>
<tr>
<td>TibetIII (P1_6) 1999.11~2005.11</td>
<td>1318.4day</td>
<td>~3TeV</td>
<td>0.9°</td>
<td>22050m²</td>
</tr>
</tbody>
</table>
Event Selection

- Analysis Data:
  Tibet II-HD data obtained from 1997 February to 1999 September (Live time: 555.9 days) and Tibet III data obtained from 1999 November to 2005 November (Phase 1~6 Version B4, Live time: 1318.9 days)

- Data cut condition:
  1.25 particle any4, $\Sigma \rho FT > 15 \& \& \Sigma \rho FT < 1000$, Zenith angle < 40°, internal event, Residual error < 1.0 m

- About $2.0 \times 10^{10}$ shower events were available for analysis.
2D All Sky Significance map(1)
—All sky point sources surveying

List of sky cells with clustered directions (5) having statistic significance larger than 4.5 \( \sigma \)

<table>
<thead>
<tr>
<th>No.</th>
<th>R.A.</th>
<th>Dec</th>
<th>( N_{ON} )</th>
<th>( N_{OFF} )</th>
<th>( N_S )</th>
<th>( \Delta N_S )</th>
<th>( S_{pretrials} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>57.96</td>
<td>53.25</td>
<td>2405072.8</td>
<td>2397926.7</td>
<td>7146.1</td>
<td>1548.5</td>
<td>4.6</td>
</tr>
<tr>
<td>2</td>
<td>70.55</td>
<td>11.35</td>
<td>2306840.6</td>
<td>2299785.4</td>
<td>7055.2</td>
<td>1516.5</td>
<td>4.7</td>
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<tr>
<td>3</td>
<td>83.75</td>
<td>21.95</td>
<td>3078848.1</td>
<td>3066434.9</td>
<td>12413.3</td>
<td>1751.1</td>
<td>7.1</td>
</tr>
<tr>
<td>4</td>
<td>89.45</td>
<td>30.05</td>
<td>3359526.5</td>
<td>3350799.7</td>
<td>8726.8</td>
<td>1830.5</td>
<td>4.8</td>
</tr>
<tr>
<td>5</td>
<td>166.25</td>
<td>38.25</td>
<td>3301780.3</td>
<td>3292945.8</td>
<td>8834.4</td>
<td>1814.6</td>
<td>4.9</td>
</tr>
</tbody>
</table>
Extended source MGRO J2019+37 observing

- According to:
  Milagro adopted $3^\circ \times 3^\circ$ windows to perform the Cygnus region and found MGRO J2019+37’s extension $0.32^\circ$

- Smooth radius is $1.5^\circ$

- Smooth radius is optimal radius($0.99^\circ$) observing $0.32^\circ$ extension source
All Sky Significance map(2)

Extended source MGRO J2019+37 observing

--- Smooth radius is 1.5°

Solid line—all sky;
Dashed line—gaus fit;
Dotted line—without Mrk421 and Crab;
Dot-dashed line—without Mrk421, Crab and MGRO J2019+37;

Preliminary result

Entries 2800000
χ²/ndf 2612/99
Constant 1.143e+05
Mean -0.002656
Sigma 1.005
All Sky Significance map(3)

— Extended source MGRO J2019+37 observing

Smooth radius is optimal angular resolution (0.99°) thinking about the extension 0.32° of MGRO J2019+37.
Four other candidates with significance $> 4 \sigma$ were found.

<table>
<thead>
<tr>
<th>Smooth radius is 1.5°</th>
<th>Smooth radius is optimal radius 0.99°</th>
</tr>
</thead>
<tbody>
<tr>
<td>No.</td>
<td>R.A.</td>
</tr>
<tr>
<td>------</td>
<td>------------</td>
</tr>
<tr>
<td>1\textsuperscript{a}</td>
<td>304.1°</td>
</tr>
<tr>
<td>2</td>
<td>307.1°</td>
</tr>
<tr>
<td>3</td>
<td>311.6°</td>
</tr>
<tr>
<td>4</td>
<td>318.6°</td>
</tr>
<tr>
<td>5\textsuperscript{b}</td>
<td>304.8°</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>No.</th>
<th>R.A.</th>
<th>Dec</th>
<th>$S_{pretrials}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1\textsuperscript{a}</td>
<td>304.6°</td>
<td>37.2°</td>
<td>4.6$\sigma$</td>
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<tr>
<td>2</td>
<td>307.8°</td>
<td>41.6°</td>
<td>4.3$\sigma$</td>
</tr>
<tr>
<td>3</td>
<td>311.4°</td>
<td>37.1°</td>
<td>4.4$\sigma$</td>
</tr>
<tr>
<td>4</td>
<td>317.9°</td>
<td>41.0°</td>
<td>4.7$\sigma$</td>
</tr>
<tr>
<td>5\textsuperscript{b}</td>
<td>304.8°</td>
<td>36.8°</td>
<td>4.2$\sigma$</td>
</tr>
</tbody>
</table>

\begin{itemize}
  \item \textsuperscript{a}---Stands for \textit{As} highest significant position nearest to MGRO J2019+37 in the Cygnus region.
  \item \textsuperscript{b}---Stands for the position of MGRO J2019+37.
\end{itemize}

- As for MGRO J2019+37, the significance is consistent at two different smooth radius Milagro adopted $3° \times 3°$ windows to study MGRO J2019+37 and got its extension is $0.32°$.
- As for the other four candidates, we need to go on studying with the data accumulating.
MGRO J2019+37 Energy Spectrum Measurement (preliminarily)

Using optimal angular resolution as smooth radius in every energy interval

Note: when the significance <2 σ , we set 90% C.L upper limits
MGRO J2019+37 Energy Spectrum Measurement (preliminarily)

\[ F(E) = 1.84 \times 10^{-13} \left( \frac{E}{6 \text{TeV}} \right)^{-2.86} \left( \text{cm}^{-2} \text{s}^{-1} \text{TeV}^{-1} \right) \]

Note: when the significance < 2σ, we set 90% C.L upper limits.

※At two different smooth radius conditions, the observed energy spectrum is consistent with what measured by Milagro at 12TeV within statistical and systematic errors.
We find that both the hadronic and leptonic models can account for the current observational data.

Assuming a simple power-law:

\[ \phi \propto E^{-\alpha} \exp(-E / E_c) \]

- hadronic model: (index=-2.25)
  Protons Ec = 198 TeV
- leptonic model: (index=-2.1)
  Electrons Ec = 25 TeV
Conclusion (very preliminarily)

- We surveyed the known source MGRO J2019+39 and found $\sim 4.0 \sigma$ significance due to our lower sensitivity which mainly because AS $\gamma$ has no $\gamma/p$ separation power.
- Four other candidates with significance $> 4 \sigma$ were found and the nearest candidate to the MGRO J2019+37 is $4.6 \sigma$ when using optimal angular resolution as smooth radius. But they are not significant enough to be claimed as diffuse gamma emissions.
- Very Preliminary energy spectrum of the MILAGRO source J2019+37 measured to be (when smooth radius is optimal angular resolution):
  \[
  \frac{dN}{dE} = (1.84 \pm 0.39_{\text{stat}}) \times 10^{-13} \left(\frac{E}{6\text{TeV}}\right)^{(-2.86 \pm 0.23_{\text{stat}})} \text{TeV}^{-1}\text{cm}^{-2}\text{s}^{-1}
  \]
- At present both the hadronic and leptonic models are consistent with the measured spectrum of the source.
- More studies on systematic uncertainty are undergoing.
Thank you!
Bake up

Sumft interval:

$(10,17.8], (17.8,31.6], (31.6,56.2], (56.2,100],
(100,215.4], (215.4,464.2], (464.2,1000]$

Just as before!!
The $\gamma$ -ray emission mechanism

- The Galactic diffuse $\gamma$ -ray emission provides important information to understand the origin and propagation of Galactic cosmic rays.
- In general the emission mechanisms of the high energy $\gamma$ -rays are thought to be of three types:

  CR protons + ISM nuclei $\rightarrow \pi^0 \rightarrow \gamma$ rays

  \[
p + p \rightarrow \cdots + \pi^0 \rightarrow \gamma \gamma
  \]

  CR electrons + ISM nuclei $\rightarrow \gamma$ rays

  \[
e + p \rightarrow \cdots + \gamma
  \]

  IC: CR electrons + ISRF photons $\rightarrow \gamma$ rays

  \[
eg + \gamma \rightarrow e + \gamma
  \]

暗物质自湮灭？
Some observations of Cygnus region from ground-based experiments

- **Whipple**

- **IACTs**
  - HEGRA (unidentified TeV γ ray source J2032+4130)
  - MAGIC
    - arXiv:0801.2391v1

- **EAS**
  - Milagro (MGRO J2019+37 and some other candidates)
  - As γ (the highest significance ~5.8 σ)  
    - (30th ICRC 2007)

  - The wide of view and high duty cycle
HEGRA serendipitously observation about the unidentified source

Original objects: Cygnus X-3 region (1999-2001) (~113hrs)
serendipitously discovery a signal,

---- The position :
\[ Ra=20^\text{h}32^\text{m}07^\text{s} \]
\[ Dec=41^\circ\text{30'}30''(J2000) \]
(consistent with Crimean reported)

---- significance: 4.6 \( \sigma \)
---- nature: steady
---- extended radius: \( \sim 5.6' \)
---- \( \gamma = -1.9 \pm 0.3_{\text{stat}} \pm 0.3_{\text{sys}} \)
---- Flux (>1 TeV): \( \sim 3\% \) that of the Crab

disfavor an exclusive pulsar or AGN origin
(acceleration : 1) not co-located TeV source, may be from the winds of the young/massive stars of cyOB2—no strong indication;
2) Alternative source involves a jet-driven termination shock (e.g. Cy-X3…..bi-lobal jet)
Whipple observation about the unidentified TeV source

- Focus Cygnus X-3 and found no evidence of a signal
  
  \[1989-1990 \text{ (50.4hrs) }\]

- Later analysis by Lang(2004) for TeV J2032+4130
  
  --- Analysis result: \~3.6' to the northwest of TeV J2032+4130
  --- Significance: 3.3 \(\sigma\)
  --- Position: \~0.6º to the north of Cygnus X-3
  --- Flux: \~12\% of the Crab(> 400GeV )

The flux variability seen with Crimean and HEGRA is easier to explain in terms of a point source such as the proton blazer or the microquasar explanations.


- The correlation of time variations with observations at longer wavelengths will be particularly important.
HEGRA updated observation confirmed the unidentified source J2032+4130

Confirmed the TeV source:
(1999 to 2002 (~158hrs)
— significance: ~7σ
— position: Ra=20h31m57s
  Dec=41º29'56.8" (J2000)
— extended radius:
  6.2' ± 1.2'stat ± 0.9'sys
— γ = -1.9 ± 0.1stat ± 0.3sys
— Flux(>1 TeV): (6.89 ± 1.83) × 10^{-13}
  cm^{-2}s^{-1} (~5% that of the Crab)
— nature: steady

Skymap of correlated event excess significance from all HEGRA data (3º × 3º FOV) centered on TeV J2032+4130
Spectrum of TeV J2032+4130

- hadronic model: (index=-2.0)
  Protons $E < 100$ TeV

- leptonic model: (index=-2.0)
  Electrons $E < 40$ TeV

—likely the galactic TeV source

Expected in the Galactic disk
Whipple observation of J2032+4130

- **2003-2005 (65.5hrs of good on-source data)** -- observations of the sky region around the unidentified TeV \( \gamma \)-ray source (TeV J2032+4130)

- Significance: 6.1 \( \sigma \)
- Location:
  - RA = 20\(^{h}\) 32\(^{m}\) 27\(^{s}\), Dec = 41° 39' 17"
  - (9' from J2032+4130)
- Flux: \(~8\%\) Crab
  - (assuming a Crab like spectrum).
- Extended radius: no more than 6'.
- Accumulated mechanical power in the Cygnus OB2 accelerate TeV source.
- X-ray counterpart need to be detected and now may be favor hadronic origin

It is note that a second excess located to the southwest of the HEGRA source less 3 \( \sigma \) need to be confirmed
MAGIC observation about J2032+4130

Observation result:

— Significance: 5.6 $\sigma$

— Flux($>1\text{TeV}$):
  $(4.5 \pm 0.3_{\text{stat}} \pm 0.35_{\text{sys}}) \times 10^{-13} \text{ ph cm}^{-2}\text{s}^{-1}$

— $\gamma = -2.0 \pm 0.3_{\text{stat}} \pm 0.2_{\text{sys}}$

(The flux, position, and angular extension are compatible with HEGRA reported five years ago)

(arXiv:0801.2391v1)
Part results from different observations

<table>
<thead>
<tr>
<th>实验名称</th>
<th>谱指数</th>
<th>与Crab流强比(倍数)</th>
<th>积分流强值 (E&gt;1TeV) (ph cm⁻²s⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crimean</td>
<td>Assuming -1.5</td>
<td>~1.7</td>
<td>$3 \times 10^{11}$</td>
</tr>
<tr>
<td>Observatory</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HEGRA</td>
<td>$\gamma = -1.9 \pm 0.1_{stat} \pm 0.3_{sys}$</td>
<td>~5%</td>
<td>$(6.89 \pm 1.83_{stat}) \times 10^{-13}$</td>
</tr>
<tr>
<td>Whipple (1989-90)</td>
<td></td>
<td>~12%</td>
<td></td>
</tr>
<tr>
<td>Whipple (2003-05)</td>
<td>Assuming Crab-like</td>
<td>~8%</td>
<td></td>
</tr>
<tr>
<td>MAGIC</td>
<td>$\gamma = -2.0 \pm 0.3_{stat} \pm 0.2_{sys}$</td>
<td></td>
<td>$(4.5 \pm 0.3_{stat} \pm 0.35_{sys}) \times 10^{-13}$</td>
</tr>
</tbody>
</table>
Conclusion about TeV J2032+4130

- No evidence for variability within any individual databases (steady?)
- Extended radius no more than 6°
- No established counterparts at other wavelengths.
- Cygnus OB2 association may be a tremendous mechanical power density accumulated to accelerate the TeV sources.
- The *Chandra* satellite revealed no obvious X-ray counterpart, evidently favoring a hadronic origin for the γ-rays from the Cygnus region.
Conclusion about MGRO J2019+37

- May be a diffuse source
- No established counterparts at other wavelengths.
- The origin is still mystery
- The later observations from GLAST, VERITAS et al. will be helpful
Large scale anisotropy subtraction
MGRO J2019+37 Expected significance calculation (using HD+TibetIII data)

According to the MGRO J2019+37’s flux value at 12TeV from MILAGRO, We can know the differential flux is:

\[ \frac{dN}{dE} = (1.55 \pm 0.21_{\text{stat}} \pm 0.47_{\text{sys}}) \times 10^{-11} \text{ TeV}^{-1} \text{cm}^{-2} \text{s}^{-1} \]

The effective area: \( A_{\text{eff}} = \varepsilon S_0 \)

\[ \varepsilon_{\text{smr}1.5^\circ} = \frac{N_{\text{cut1.5}}}{N_{\text{all}}} = \frac{18970}{20000 \times 97 \times 10} = 9.78 \times 10^{-4} \]

\[ \varepsilon_{\text{smr}0.99^\circ} = \frac{N_{\text{cut0.99}}}{N_{\text{all}}} = \frac{13489.3}{20000 \times 97 \times 10} = 6.95 \times 10^{-4} \]

\[ N_{\text{smr1.5}^\circ} = 9182654.8 \quad , \quad N_{\text{smr0.99}^\circ} = 4000614.6 \]

Then we can know the significance is:

\[ S_{\text{smr1.5}^\circ} = \frac{N_{\text{smr1.5}^\circ}}{\sqrt{N_{\text{smr1.5}^\circ}}} = 3.0\sigma \]

\[ S_{\text{smr0.99}^\circ} = \frac{N_{\text{smr0.99}^\circ}}{\sqrt{N_{\text{smr0.99}^\circ}}} = 3.2\sigma \]
Crab energy spectrum measurement

$F(E) = \alpha (E/3\text{TeV})^\beta (\text{cm}^{-2}\text{s}^{-1}\text{TeV}^{-1})$

$\chi^2 / \text{ndf} = 4.425 / 5$

$p_0 = 2.233 \pm 3.123 \times 10^{-13}$

$p_1 = -2.961 \pm 0.1253$

$\alpha = (2.23 \pm 0.31_{\text{stat}}) \times 10^{-12}$

$\beta = -2.96 \pm 0.13_{\text{stat}}$

Consistent with other results, measurement method is reliable
Energy spectrum measurement method

\[
\begin{pmatrix}
    s_1 \pm \sigma_1 \\
    s_2 \pm \sigma_2 \\
    \vdots \\
    s_n \pm \sigma_n
\end{pmatrix} =
\begin{pmatrix}
    M_{1,1} & M_{1,2} & \cdots & M_{1,m} \\
    M_{2,1} & M_{2,2} & \cdots & M_{2,m} \\
    \vdots & \vdots & \ddots & \vdots \\
    M_{n,1} & M_{n,2} & \cdots & M_{n,m}
\end{pmatrix}
\begin{pmatrix}
    T_1 \\
    T_2 \\
    \vdots \\
    T_m
\end{pmatrix}
\]

\[
\chi^2 = \left( s_1 - \sum_{j=1}^{m} M_{1,j} \cdot T_j \right)^2 / \sigma_1^2 + \left( s_2 - \sum_{j=1}^{m} M_{2,j} \cdot T_j \right)^2 / \sigma_2^2 + \ldots + \left( s_n - \sum_{j=1}^{m} M_{n,j} \cdot T_j \right)^2 / \sigma_n^2
\]

where: 
- \( s_i \) (i=1,2,...n) : the real excess in \( \sum_i \rho \) FT bin \( i \) 
- \( M_{i,j} \) (i=1,2...n; j=1,2...m) : efficiency of detector at energy band \( j \) and \( \sum_i \rho \) FT bin \( i \) (obtained by MC) 
- \( T_j \) (j=1,2,...n) : the integral value at the energy band \( (E_{ij}, E_{uj}) \)

**Integral Flux**

\[
\text{Integral Flux}(> E_{\text{min}}) = \frac{a}{\Omega S_{\text{sim}} T_{\text{obs}}} \int_{E_{\text{min}}}^{\infty} E^b dE
\]

\[
S_{\text{sim}} = \pi r^2, \quad r = 300 m
\]

\[
d\Omega = \sin \theta d\theta d\phi, \quad (\theta, \varphi) = (\frac{\pi}{2} - \text{dec}, \text{ra})
\]

\[
T_{\text{obs}} = T(1 - P_{dr})
\]

\[
P_{dr} \text{ -- is the mean dead time rate}
\]

--- 用地面宇宙线阵列推算原初 γ 射线能谱时，需要将观测到的总粒子数转换成原初 γ 光子的初能 \( E_0 \)，而由于探测器的能量分辨率差，实际上观测的每组信号数是各能段原初 γ 光子贡献的总和。
Flux Estimation (Kawata) method so as to check each other

\[ N_{obs} = T_{obs} \int_0^{2\pi} \int_0^R \int_{E_{min}}^{\infty} \alpha_{obs} E^\beta \varepsilon_{obs}(E, r, \omega, O) dE dr dO \]

\[ N_{sim} = T_{sim} \int_0^{2\pi} \int_0^{R_{sim}} \int_{E_{min}}^{\infty} \alpha_{sim} E^\beta \varepsilon_{sim}(E, r, \omega, O) dE dr dO \]

\[ N_{obs} = \frac{\alpha_{obs} T_{obs}}{N_{sim}} = \frac{\alpha_{sim} T_{sim}}{N_{obs}} \]

\[ N_{all}^{sim} = S_{sim} T_{sim} \int_{E_{min}}^{\infty} \alpha_{sim} E^{-\beta} dE \]

\[ \alpha_{obs} = \frac{N_{obs}}{N_{sim}} \int_{E_{min}}^{\infty} \frac{N_{all}^{sim}}{E^{-\beta} dE S_{sim} T_{obs}} \]

\[ f(E_{log_{m-i}}) = \frac{N_{obs,i}}{N_{sim,i}} \int_{E_{min}}^{\infty} E^\beta dE S_{sim} T_{obs} \]

\[ f_i(E_{log-m-i}): \text{Differential flux at } E_{log_{m-i}} \]

\[ E_{log_{m-i}}: \text{Representative energy in each } \Sigma \rho \text{ FT bin } i \]

(logarithm mean[10 $<\log_{10}(E)>$ ] in each $\Sigma \rho$ FT bin i)

\[ N_{obs,i}: \text{Experimental excess in each } \Sigma \rho \text{ FT bin } i \]

\[ N_{sim,i}: \text{Simulated excess in each } \Sigma \rho \text{ FT bin } I \]

\[ N_{sim}^{all}: \text{All simulated event number at the top of atmosphere for a diurnal motion} \]

\[ S_{sim}: \text{Simulated core location area}(300m*300m* \pi) \]

\[ T_{obs}: \text{Live time}(1319*86400s) \]

\[ \beta: \text{Simulated spectrum index} \]

Energy spectrum index convert: Weighted event $\omega$ at different spectral index $\beta$ is used for counting $N_{sim,i}$, To change spectral index -2.6 to $\beta$, $\omega$ is expressed by:

\[ N_{sim}^{all} = a_1 \int_{E_{min}}^{\infty} E^{-2.6} dE = a_2 \int_{E_{min}}^{\infty} E^\beta dE \Rightarrow \omega = \frac{a_2 E^\beta}{a_1 E^{-2.6}} = \frac{-(\beta + 1.0)}{1.6} E_{sim}^{min - 2.6 - \beta} E^{\beta + 2.6} \]
The information at different energy interval

Smooth radius is optimal angular resolution ($0.99^\circ$)

<table>
<thead>
<tr>
<th>$\sum \rho_{FT}$</th>
<th>$R_{optimal}/(^\circ)$</th>
<th>$N_{on}$</th>
<th>$N_{off}$</th>
<th>$N_s$</th>
<th>$\triangle N_s$</th>
<th>$S_{pretrials}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>[10,17.8)</td>
<td>1.76</td>
<td>391014.0</td>
<td>390887.0</td>
<td>127.0</td>
<td>625.3</td>
<td>0.20</td>
</tr>
<tr>
<td>[17.8,31.6)</td>
<td>1.52</td>
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<td>2699763.1</td>
<td>1920.9</td>
<td>1643.7</td>
<td>1.17</td>
</tr>
<tr>
<td>[31.6,56.2)</td>
<td>1.22</td>
<td>2099870.0</td>
<td>2094503.1</td>
<td>5366.9</td>
<td>1449.1</td>
<td>3.70</td>
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<tr>
<td>[56.2,100)</td>
<td>0.94</td>
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<td>694662.4</td>
<td>1711.6</td>
<td>834.5</td>
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<tr>
<th>$\sum \rho_{FT}$</th>
<th>$N_{sim_i}$</th>
<th>$E_{log_i}/$(TeV)</th>
<th>$flux_i$</th>
<th>$\triangle flux_i$</th>
<th>uplimit$_{90% C.L.}$</th>
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<tbody>
<tr>
<td>[10,17.8)</td>
<td>391.79</td>
<td>1.33</td>
<td>4.00e-12</td>
<td>1.97e-11</td>
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<td>[17.8,31.6)</td>
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<td>1.98</td>
<td>2.38e-12</td>
<td>2.04e-12</td>
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<td>[31.6,56.2)</td>
<td>3229.65</td>
<td>3.12</td>
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The information at different energy interval

—Smooth radius is 1.5°

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<th>$\sum \rho_{FT}$</th>
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<th>$N_{off}$</th>
<th>$N_s$</th>
<th>$\Delta N_s$</th>
<th>$S_{pretrials}$</th>
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<tbody>
<tr>
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<td>283061.0</td>
<td>282884.0</td>
<td>177.0</td>
<td>532.0</td>
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<tr>
<td>[17.8,31.6)</td>
<td>2617672.0</td>
<td>2616030.5</td>
<td>1641.5</td>
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<td>[31.6,56.2)</td>
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<td>3135010.5</td>
<td>6249.5</td>
<td>1772.4</td>
<td>3.53</td>
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<td>-79.9</td>
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<tr>
<th>$\sum \rho_{FT}$</th>
<th>$N_{sim_i}$</th>
<th>$E_{log_{10}}/(\text{TeV})$</th>
<th>$flux_i$</th>
<th>$\Delta flux_i$</th>
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<tr>
<td>[10,17.8)</td>
<td>326.55</td>
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<td>6.54e-12</td>
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<td>[17.8,31.6)</td>
<td>3111.27</td>
<td>1.93</td>
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<td>1.93e-15</td>
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Cygnus region—MILAGRO research status

Contour - matter density
Crosses - EGRET source location


MGRO J2019+37

2007, PRD75, 083001

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<thead>
<tr>
<th>Object</th>
<th>Location (deg)</th>
<th>Error (deg)</th>
<th>Significance ($\sigma$)</th>
<th>Flux at 20 TeV (10^{-11} TeV^{-1} cm^{-2} s^{-1})</th>
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</thead>
<tbody>
<tr>
<td>Crab</td>
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<td>15.0</td>
<td>10.9 ± 1.2</td>
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<td>8.7 ± 1.4</td>
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<td>MGRO J2038+41</td>
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<td>C2</td>
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<td>C4</td>
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<td>4.0 ± 1.3</td>
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</table>
All Sky Significance map(2)

—Extended source MGRO J2019+37 observing

~—Smooth radius is 1.5°~

Solid line—all sky; Dashed line-gaus fit; Dotted line-without Mrk421 and Crab; Dot-dashed line-without Mrk421, Crab and MGRO J2019+37.

MGRO J2019+37

Entries 2880000

χ² / ndf 26312 / 99

Constant 1.143e+05

Mean -0.002656

Sigma 1.005

Prelliminary result
All Sky Significance map(3)

—Extended source MGRO J2019+37 observing

—Smooth radius is optimal angular resolution (0.99 °)
thinking about the extension 0.32 ° of MGRO J2019+37

Solid line—all sky;
Dashed line—gaus fit;
Dotted line—without Mrk421 and Crab;
Dot-dashed line—without Mrk421, Crab and MGRO J2019+37;