首届LHAASO合作组会议
2016年8月15-18日，南开大学

关于LHAASO对伽玛暴和星暴星系观测的一点思考

王祥玉
南京大学

Outline

- 伽玛射线暴与LHAASO简要讨论
- 星暴星系与LHAASO简要讨论

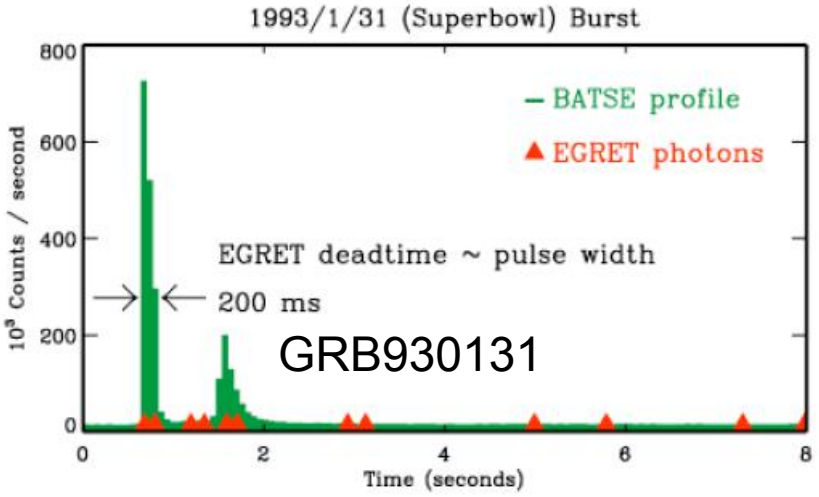
I. GRB 高能光子(>100MeV)辐射—观测现状

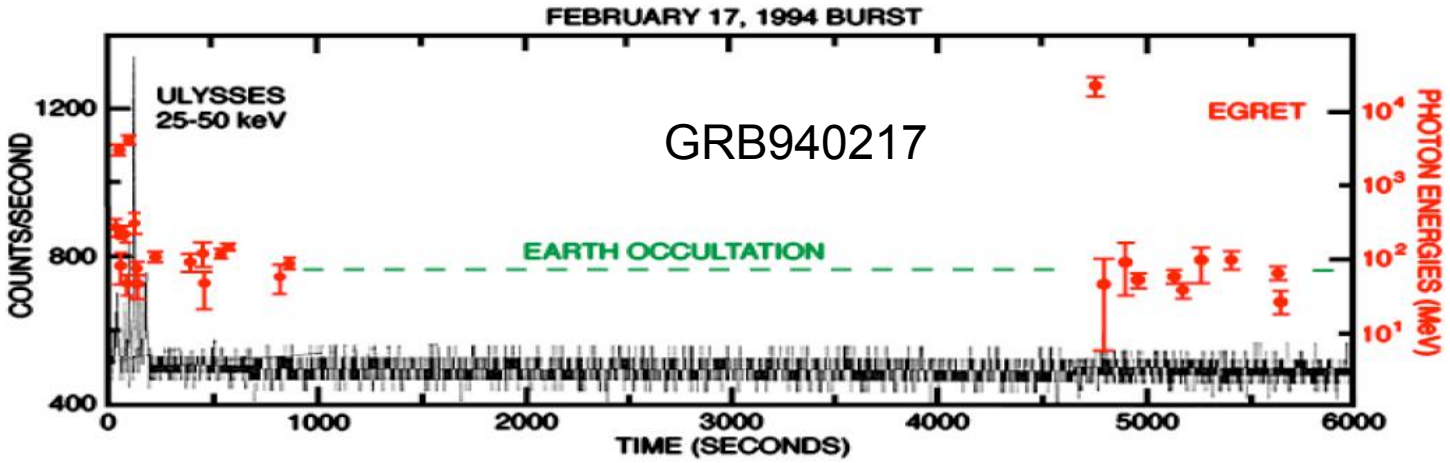
- EGRET/CGRO: 探测到少数几个GRB的GeV光子辐射
- Fermi: LAT已经探测到100个GRB的高能（>100 MeV）辐射
- 甚高能(VHE, >100GeV)：至今都是upper limit

EGRET on CGRO

1) Prompt

2) Delayed, ~18 GeV光子

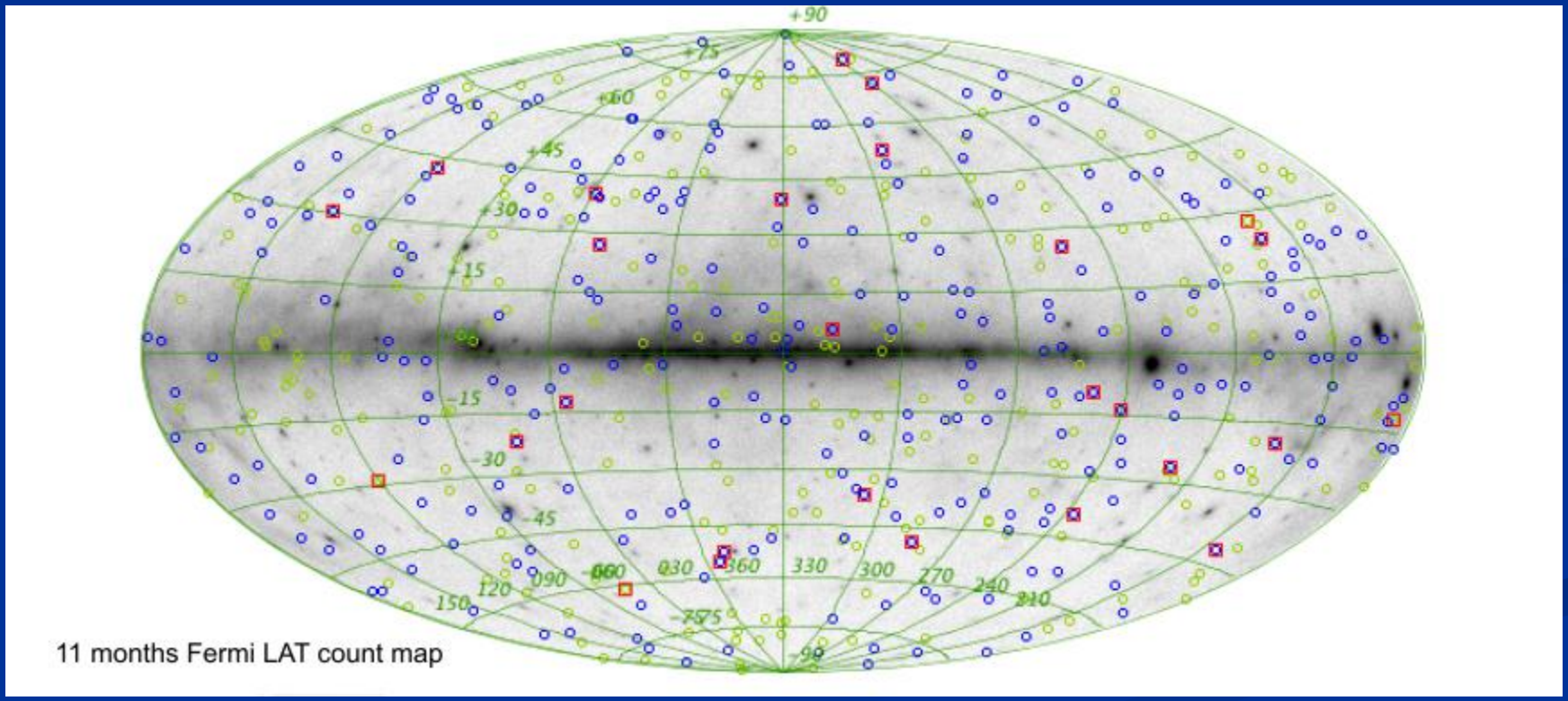




Fermi detections as of 2011-01-20

- GBM: 250 GRB/yr
  LAT: 10 GRB/yr

Circles:
In Field-of-view of LAT (<70˚): 275
Out of the FOV
Squares:
LAT detections

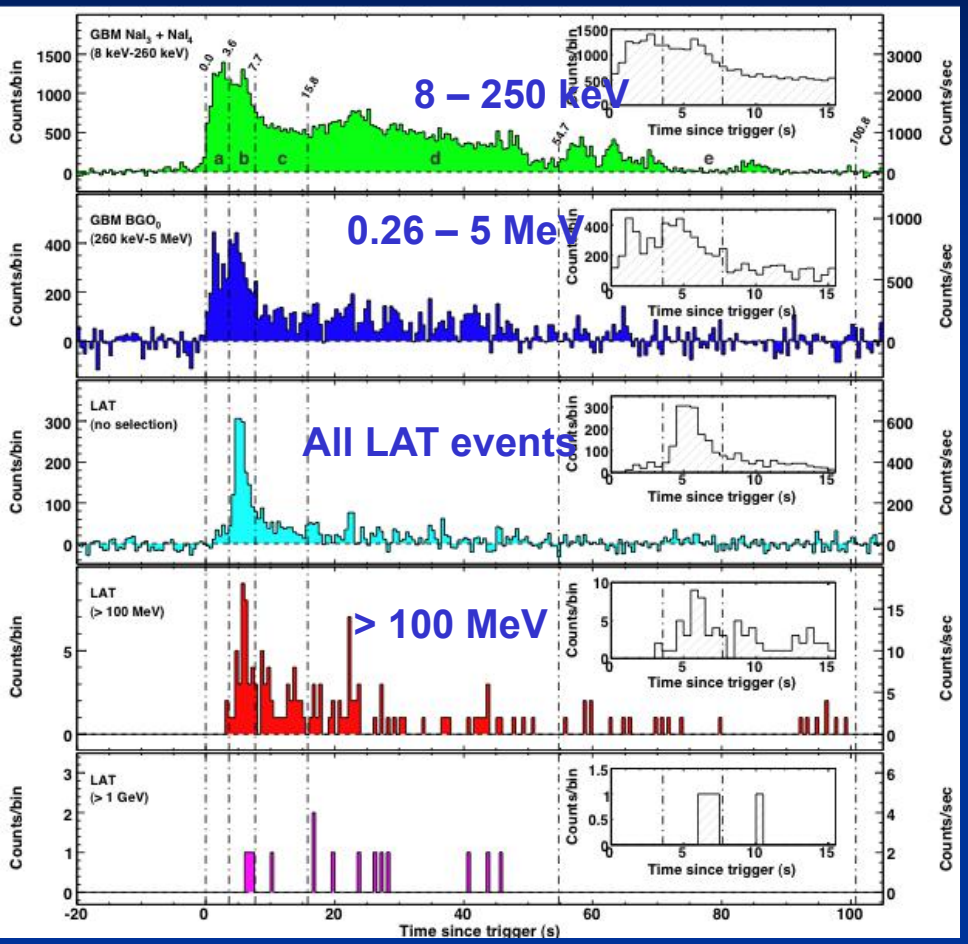


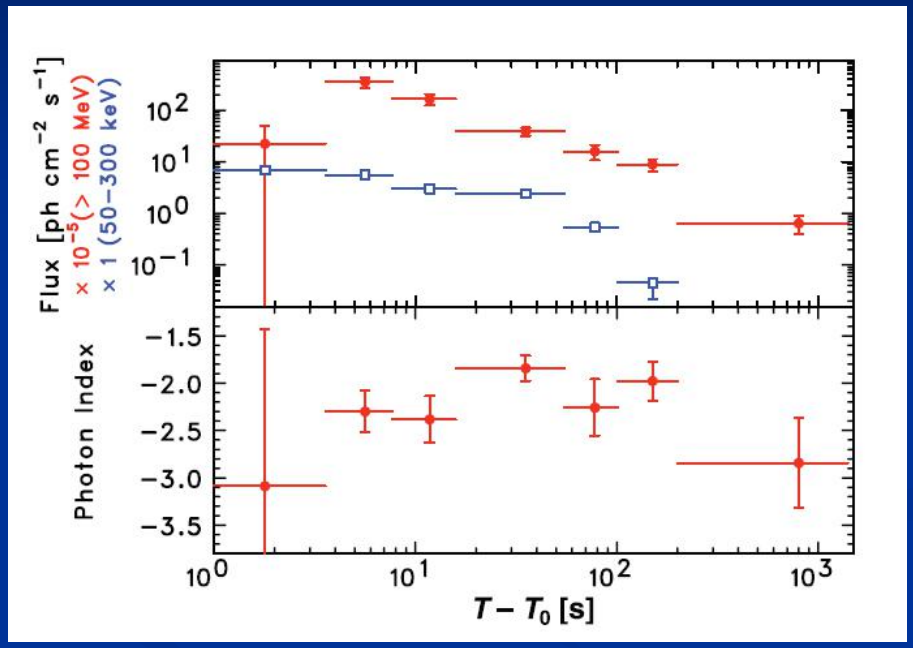
11 months Fermi LAT count map

Credit: N. Omedi

GRB080916C: LAT light curves

Abdo et al. 2009, Science

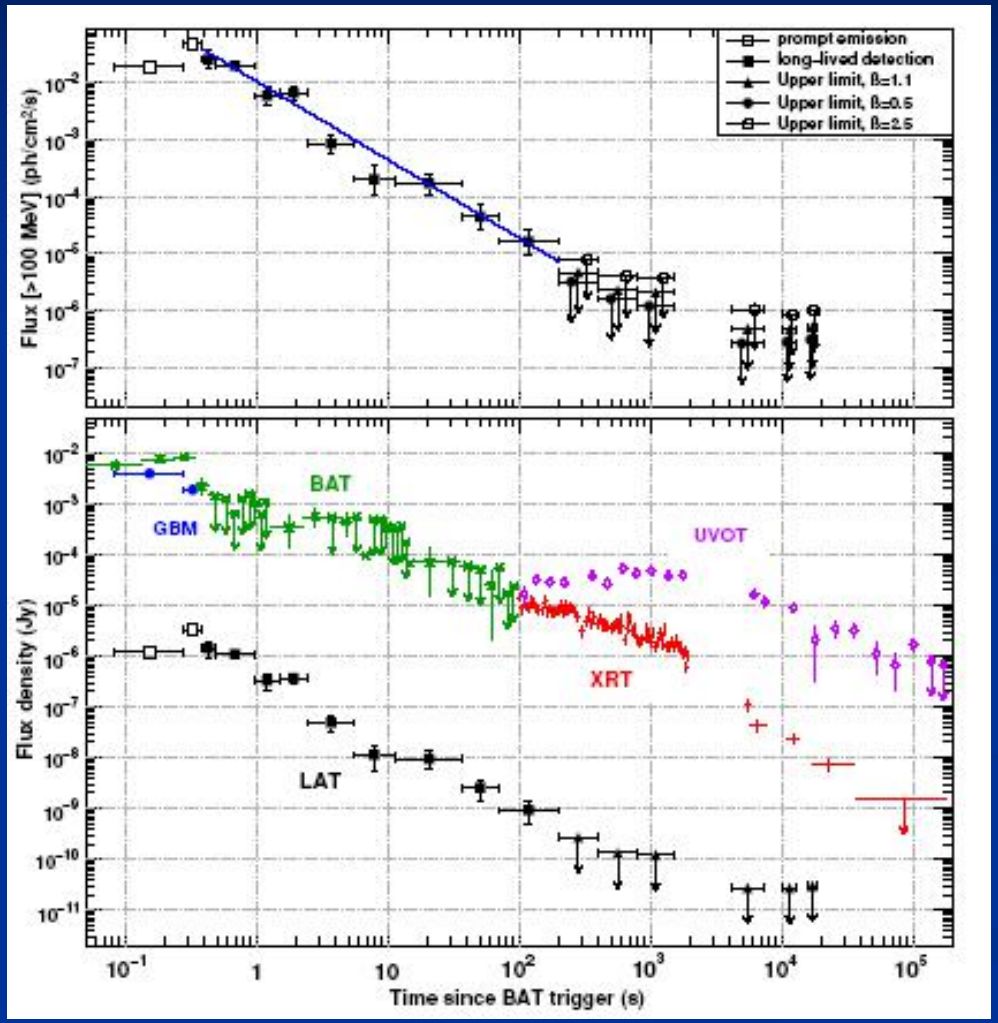




145 photons >100MeV

14 photons >1GeV

GRB090510: A short GRB seen by Fermi



150 photons >100MeV
20 photons >1GeV

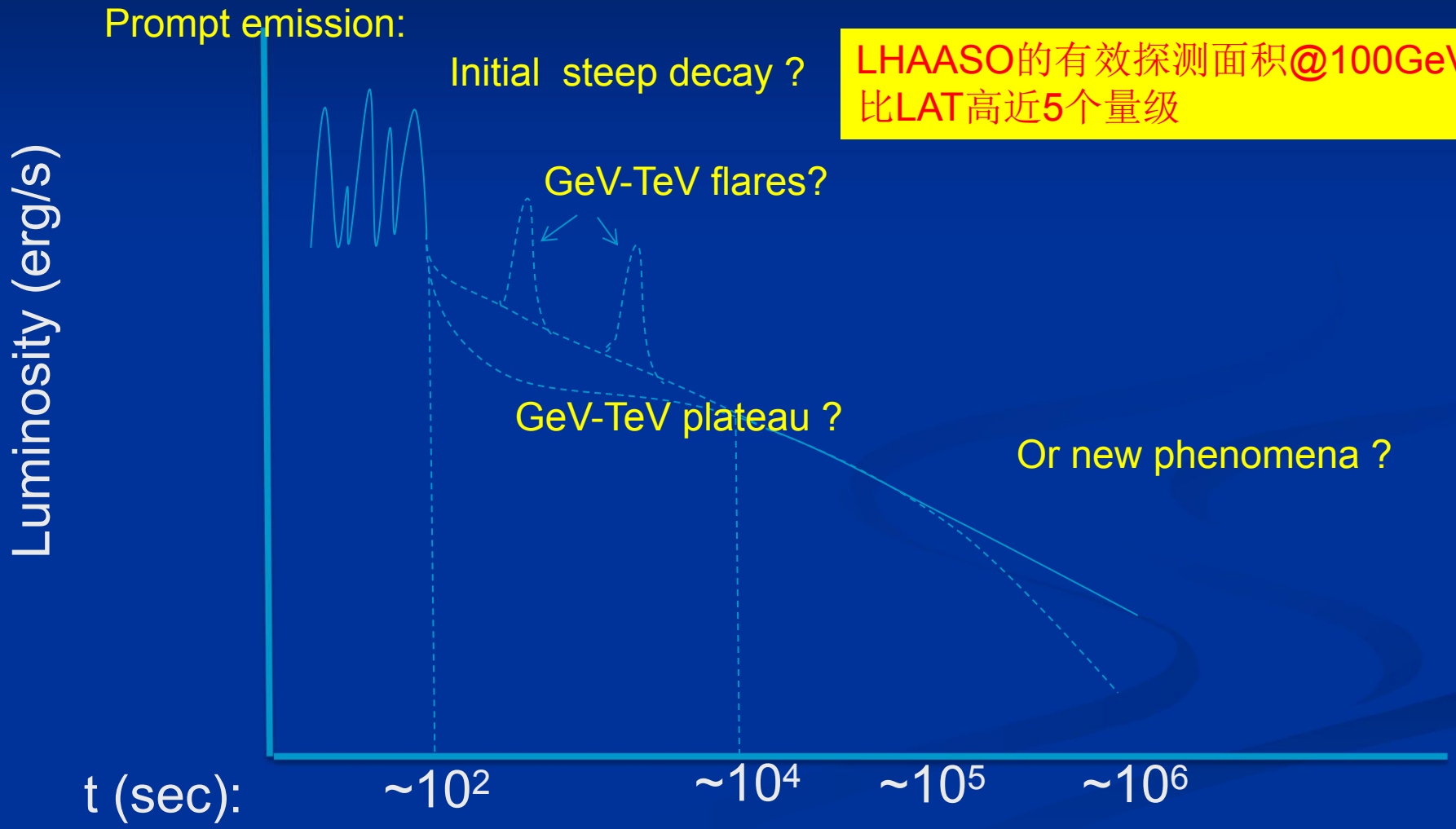
De Pasquale, M., et al. 2010

一些暴的总结

GRB	Angle from LAT	Duration (or class)	# of events >100 MeV	# of events >1 GeV	Delayed HE onset	Long-lived HE emission	Additional spectral component	Highest photon energy	Redshift
080825C	~ 60°	long	~ 10	0	✓	✓	X	~ 560 MeV	
080916C	49°	long	145	14	✓	✓	?	~ 13 GeV	4,35
081024B	21°	short	~ 10	2	✓	✓	?	~ 3 GeV	
081215A	~ 86°	long	-	-	-	-	-	-	
090217	~ 34°	long	~ 10	0	X	X	X	~ 1GeV	
090323	~ 55°	long	~ 20	> 0	?	✓	?	?	3,57
090328	~ 64°	long	~ 20	> 0	?	✓	?	?	0,736
090510	~ 14°	short	> 150	> 20	✓	✓	✓	~ 31 GeV	0,903
090626	~ 15°	long	~ 20	> 0	?	?	?	?	
090902B	51°	long	> 200	> 30	✓	✓	✓	~ 33 GeV	1,822
090926A	~ 52°	long	> 150	> 50	✓	✓	✓	~ 20 GeV	2,106

总的来说，在进行统计研究光变、能谱时**counts**仍较少！

Prospect of Ground-based GeV-TeV detector



LHAASO的有效探测面积@100GeV
比LAT高近5个量级

预计CTA GRB探测率

- 0.5个/年 for afterglow， 0.1个/年 for prompt emission (假定阈能到30 GeV)

Prospects for Detecting Gamma-Ray Bursts at Very High Energies with the Cherenkov Telescope Array

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IACT observations of gamma-ray bursts: prospects for the Cherenkov Telescope Array

Rudy C. Gilmore[1⋆], Aurelien Bouvier[2]†, Valerie Connaughton[3], Adam Goldstein[3], Nepomuk Otte[2], Joel R. Primack[2,4], David A. Williams[2,4]

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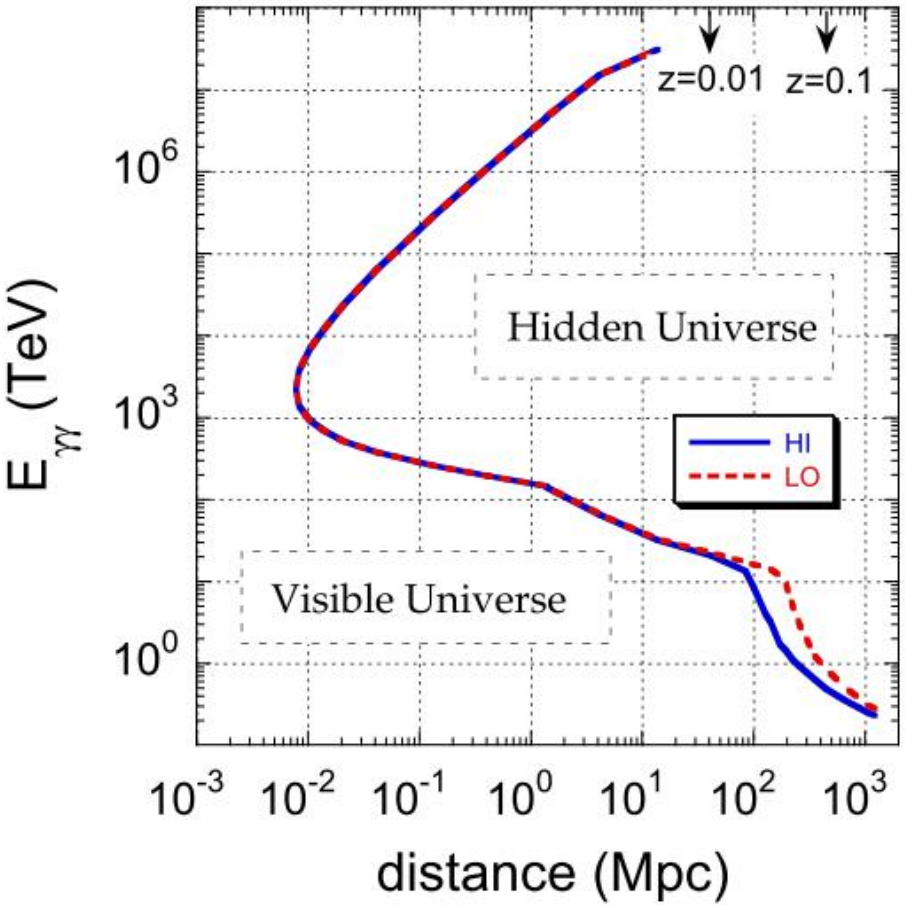
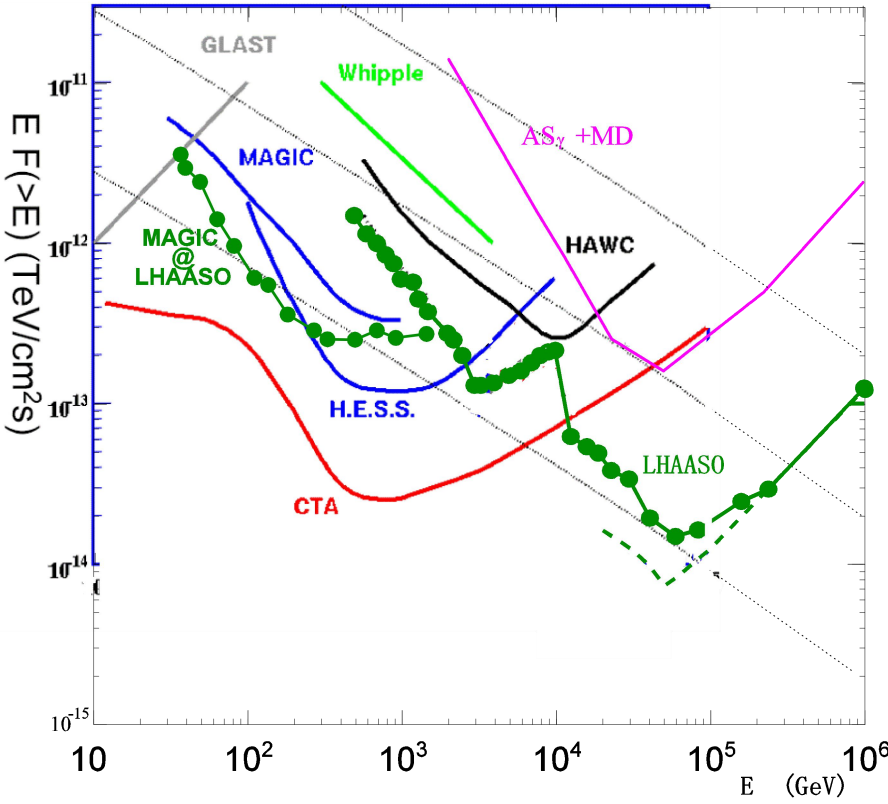
宽视场望远镜将很必要！

Cutoff energy by EBL





Distance < 100 Mpc

邻近低光度GRB

Name	Distance	comments
SN1998bw	**38 Mpc**	GRB980425
SN2006aj	**120 Mpc**	GRB060218
SN 2010bh	**260 Mpc**	GRB100316D
SN2009bb	**40 Mpc**	No GRB associated

(Soderberg et al. 2006; Liang et al.06)

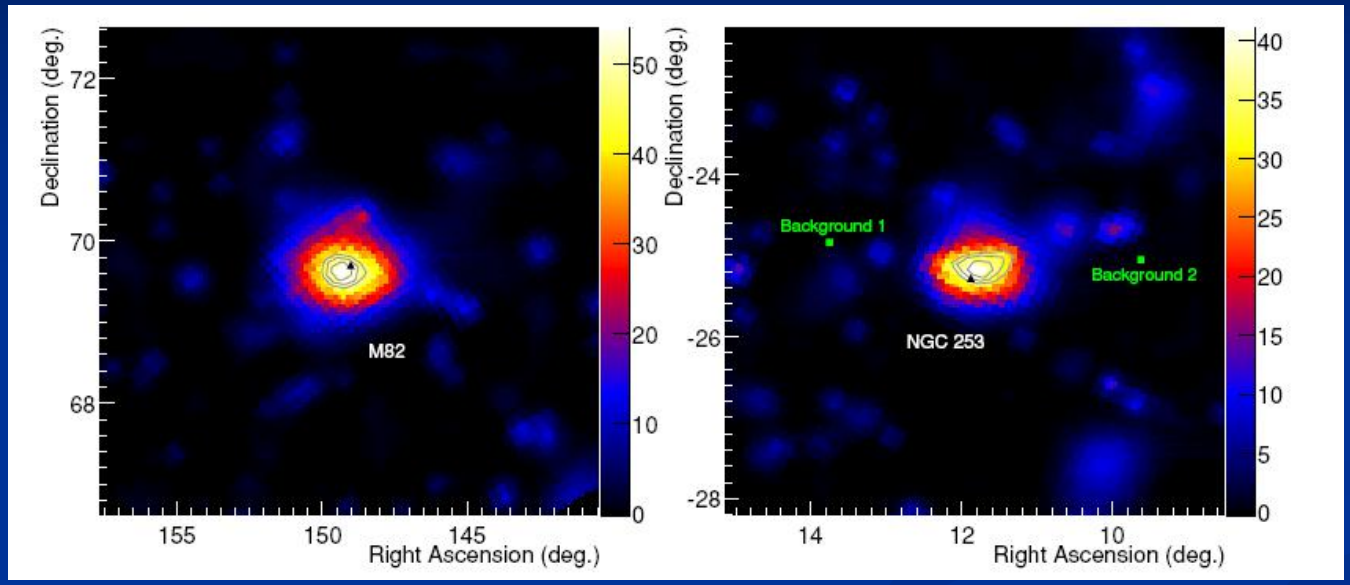
Within 200 Mpc, rate~=3-10/yr (全天立体角)

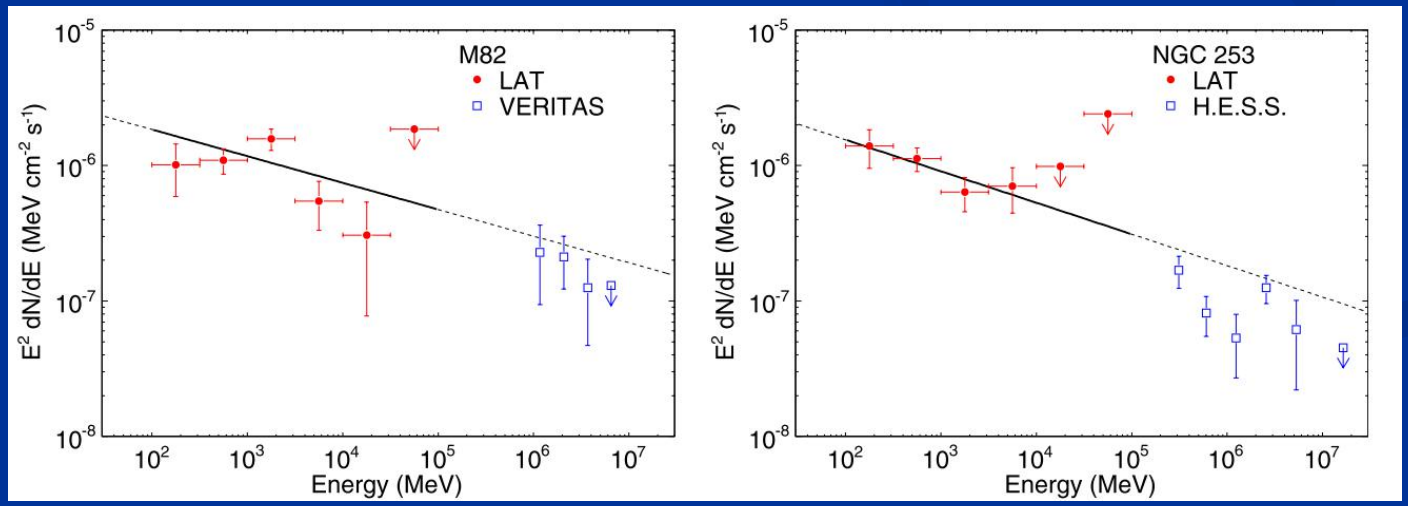
Event rate: 300-1000/Gpc^3/yr

对这些低光度暴进行深度的follow-up观测

II. 星暴星系与LHAASO

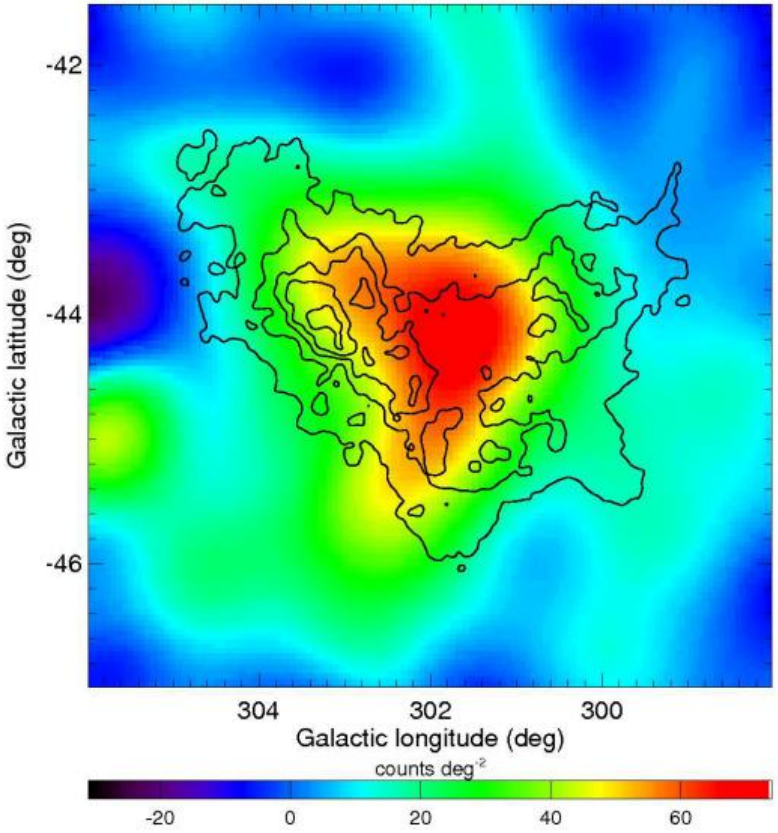
Abdo et al. 2010

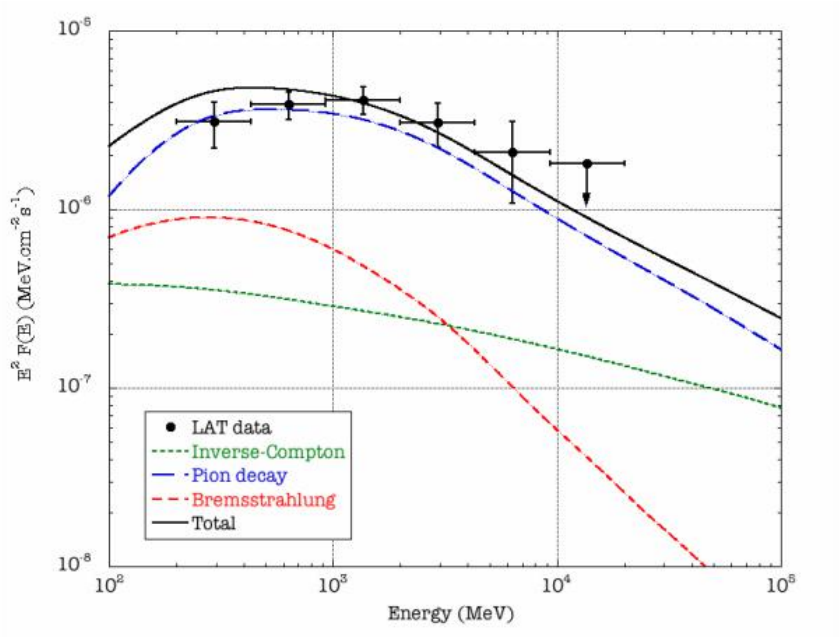




SMC-LAT observations

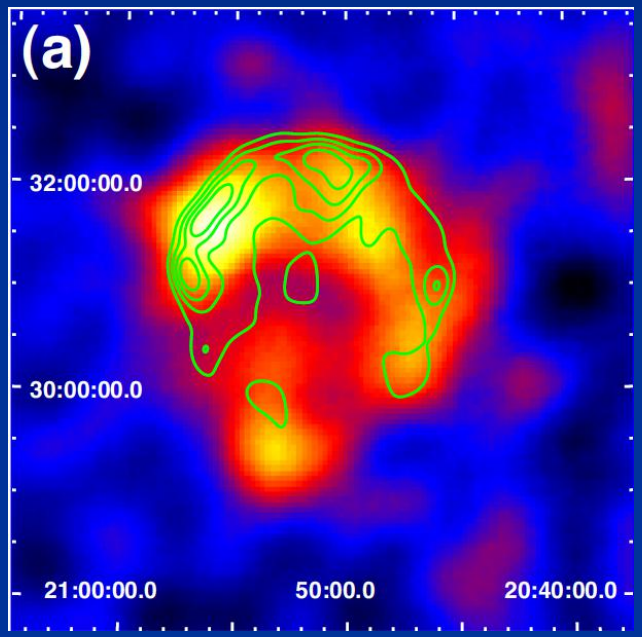
Abdo et al. 2010





Cosmic rays accelerated by SNRs

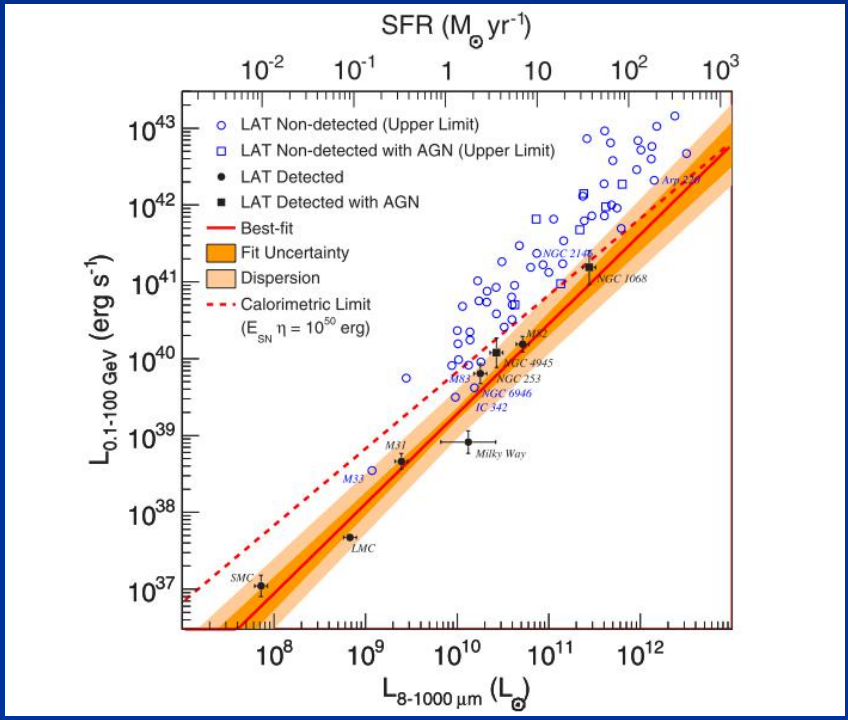
Cygnus Loop (0.5-10 GeV)



- Supernova explosions induce shocks (SNRs)
- Cosmic rays are accelerated across these shock fronts
- GeV Gamma-rays are produced by Cosmic rays

$$p^{+}_{CR} + p^{+}_{ISM} \rightarrow p^{+} + p^{+} + \pi^{0},\ \pi^{0} \rightarrow \gamma + \gamma$$

Correlation between gamma-ray and infrared luminosities



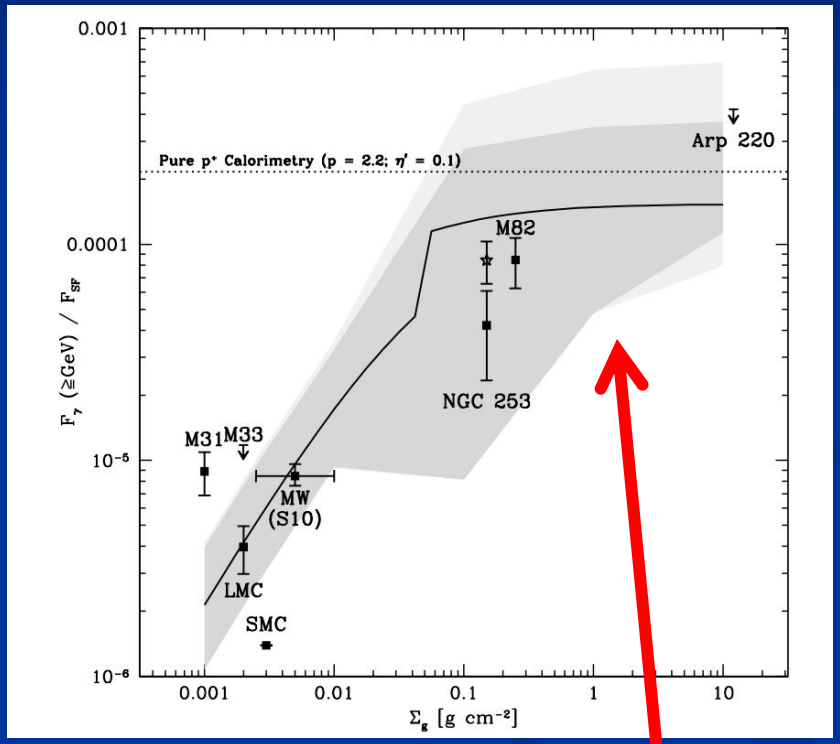
Ackermann et al. 2012

- Several nearby star-forming galaxies detected
- Gamma-ray and infrared luminosity well correlated
- Naturally expected if more CR energy is converted into gamma-rays in more luminous galaxies

CR calorimeter?

- "calorimetry fraction limit"

$$F_{\rm cal} \equiv \frac{L_\pi}{L_{\rm CR}(K \geqslant K_{\rm th})}$$

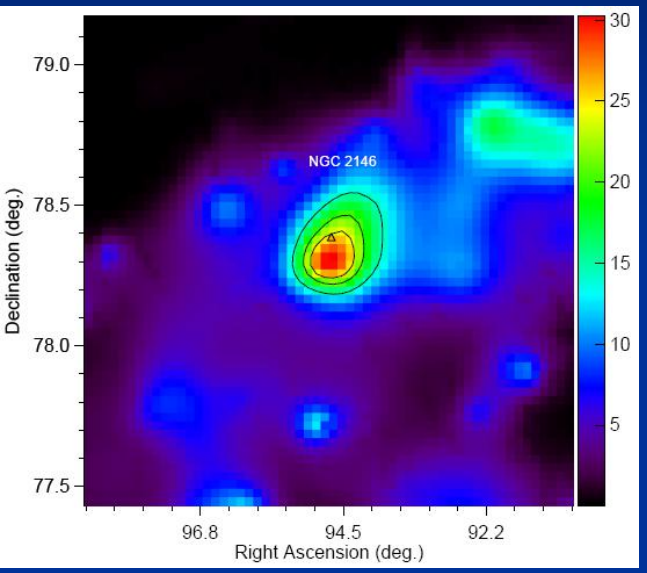


Best target: (ultra) luminous infrared galaxies

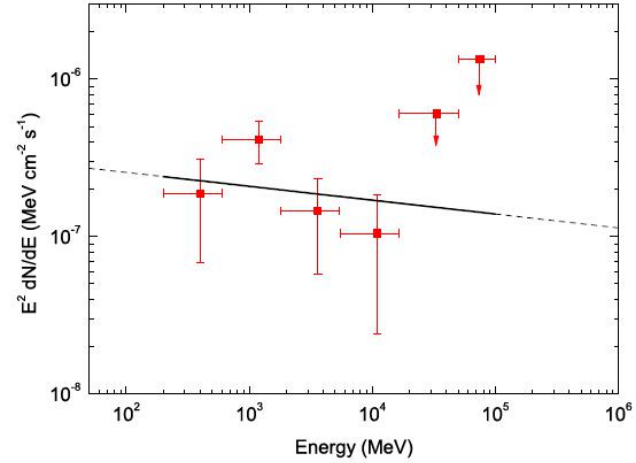
Lacki et al. 2011

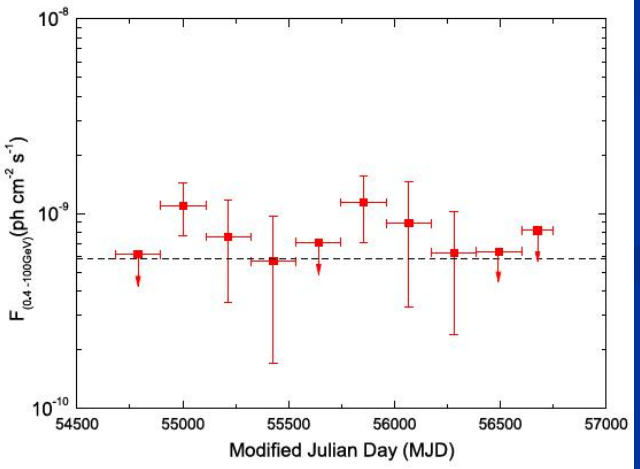
GeV emission from LIRG NGC 2146

Tang, Wang & Tam 2014



- A luminous infrared galaxy
  – CR calorimeter ?
- using the 68 month Fermi data
- 5.5 σ detection of gamma-ray emission above 200 MeV





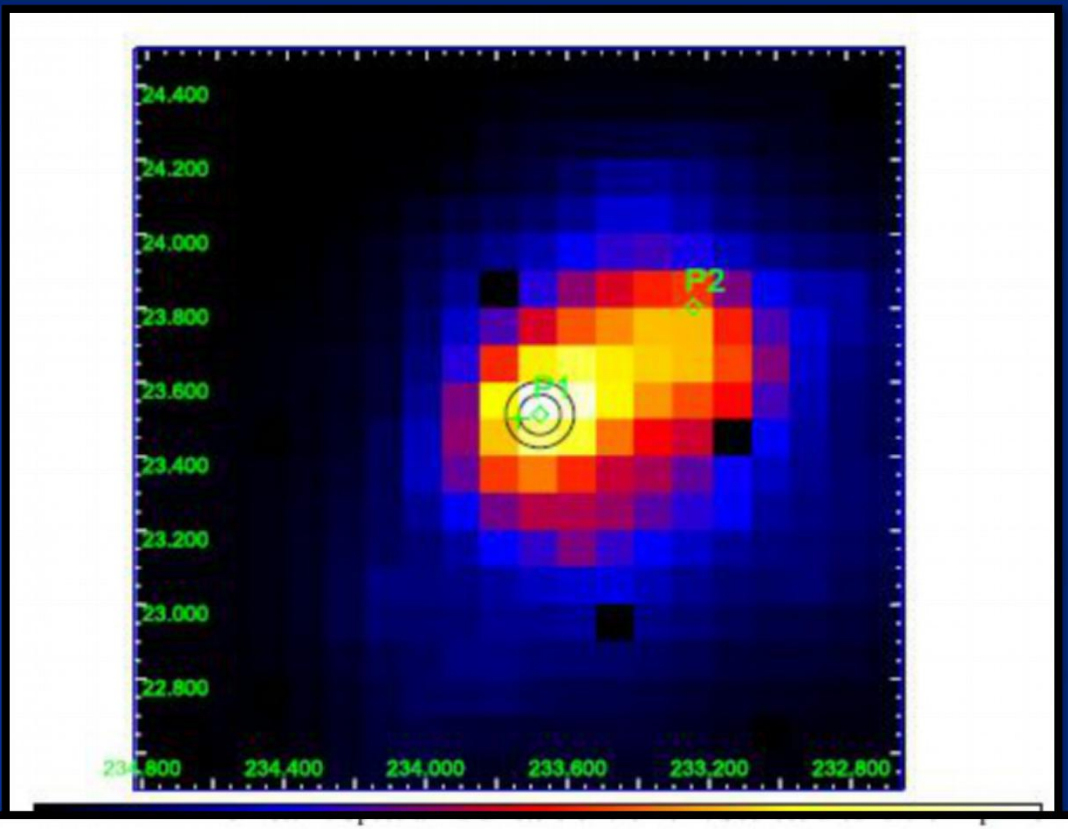
Arp 220- the nearest ULIRG: must be calorimeter!

- A prototype of ULIRG: $L_{IR}=1.4*10^{12}L_{sun}$
- D=78Mpc
- $n\sim10^{4}cm^{-3}$

  $t_{pp}<t_{escape}$
- Possible AGN
- SN rate: 4+-2/yr
- Long predicted to be GeV sources

(e.g.,Torres 2004; Lacki+ 2011; Yoast-Hull+2015)

Fermi observation- PASS 8

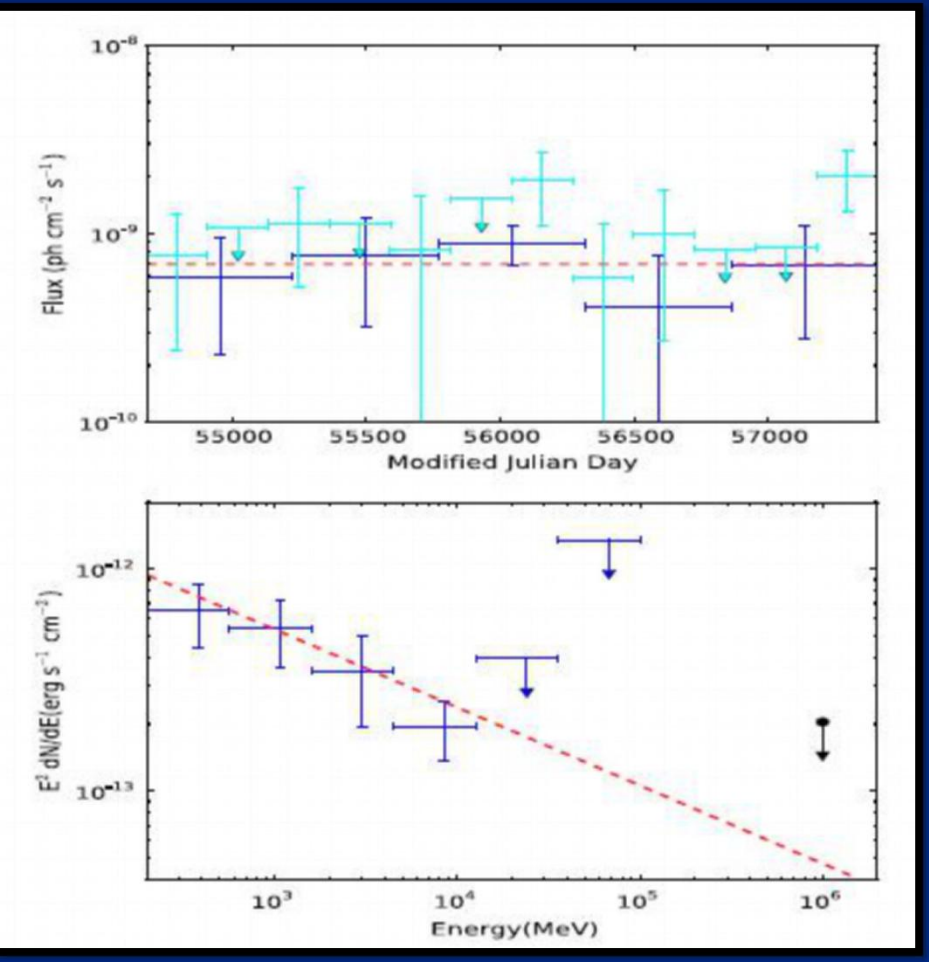


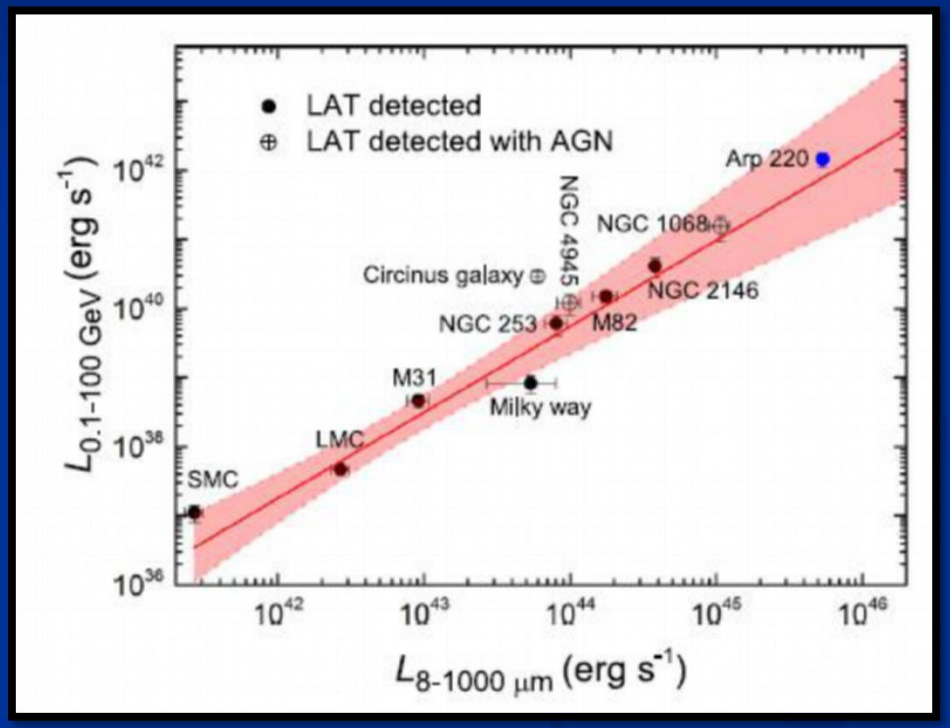
Peng, Wang et al. 2016, ApJL

Point	Position (degree)	r_{95} (degree)	Separation (degree)	Photon Flux (10^{-9} ph cm^{-2} s^{-1})	Energy Flux (10^{-12} erg cm^{-2} s^{-1})	Γ	TS	Association
P1	(233.677, 23.5163)	0.090	0.058	1.76 ± 0.52	1.92 ± 0.43	2.35 ± 0.16	40	Arp 220
P2	(233.239, 23.8049)	0.279	0.547	1.45 ± 0.52	1.39 ± 0.40	2.45 ± 0.19	22	···

LC and SED of Arp 220

Peng, Wang et al. 2016, ApJL





Favor cosmic Rays origin

LHAASO proposal: VHE observations of star-forming/starburst galaxies

LHAASO Science: VHE observations of star-forming/starburst galaxies

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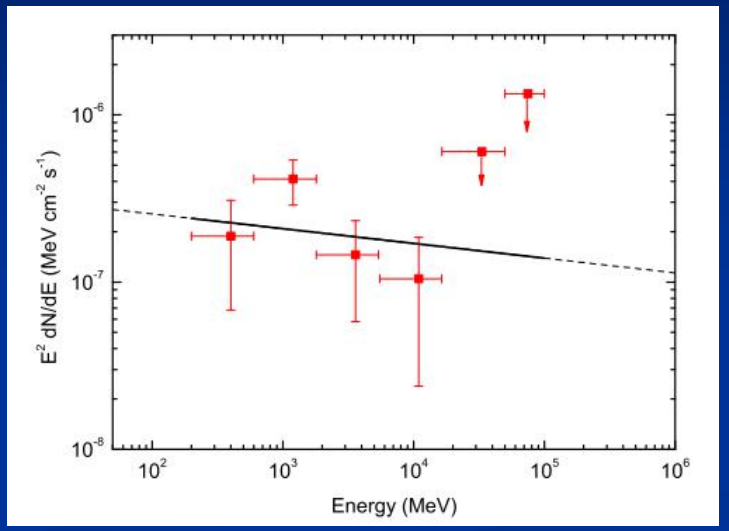
Abstract



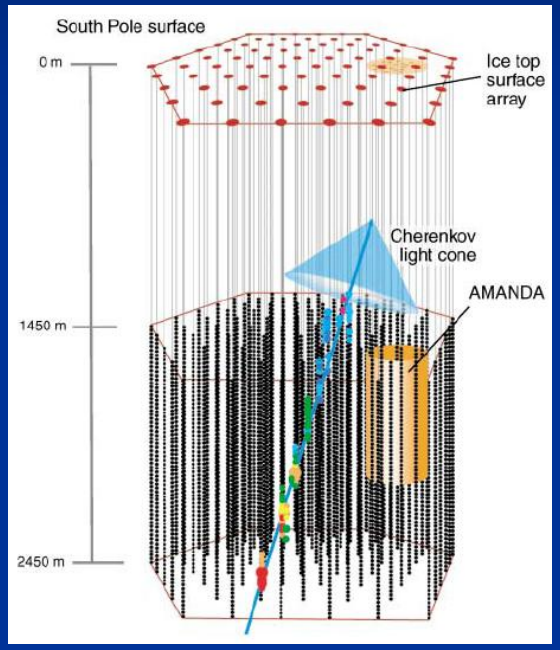
- Using NGC 2146 as a template (d=15Mpc), we estimate the VHE flux assuming a simple power-law extrapolation:

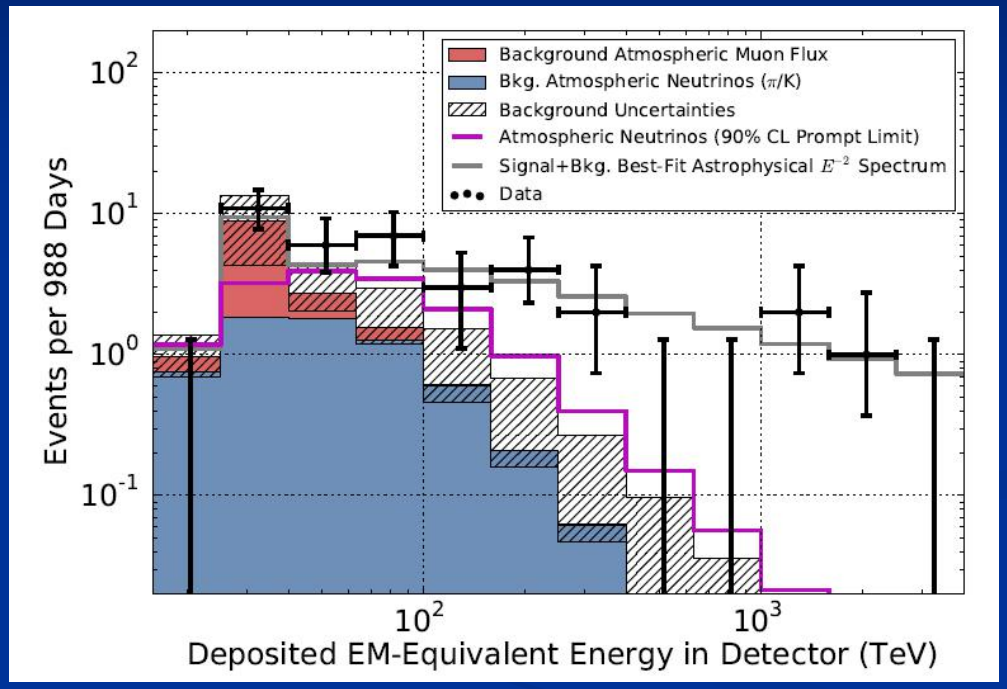
  E^2 dN/dE =10^-13 TeV cm^-2 s^-1 (E/1TeV)^-0.1

- **Observe nearby star-forming and starburst galaxies within 20 Mpc (up to 100 TeV energies).**

IceCube: diffuse PeV neutrinos detected

IceCube collaboration , 2014, 2015





- **LHAASO 如能探测到星暴星系100TeV光子，对中微子起源有重要意义。**

Conclusions

- LHAASO对伽玛暴、低光度暴的研究有重要价值
- LHAASO对邻近星系、星暴星系的研究有重要价值(>10 TeV)