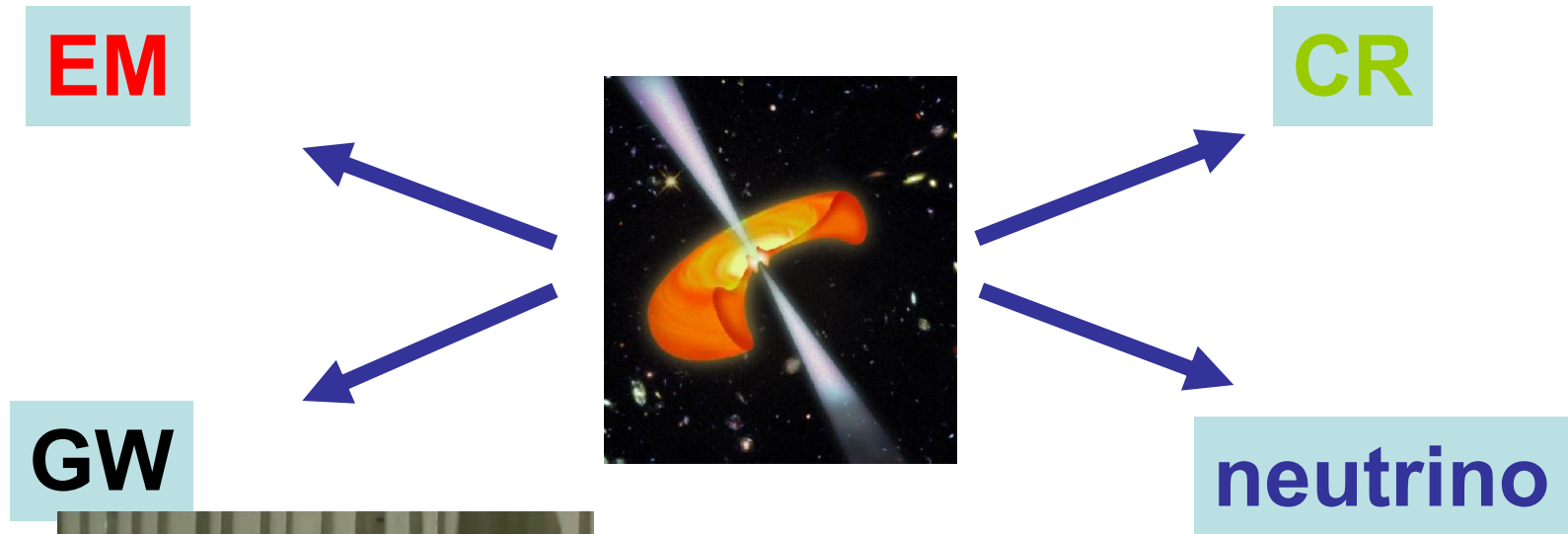


谈谈LHAASO的多信使研究

黎卓 (北京大学)

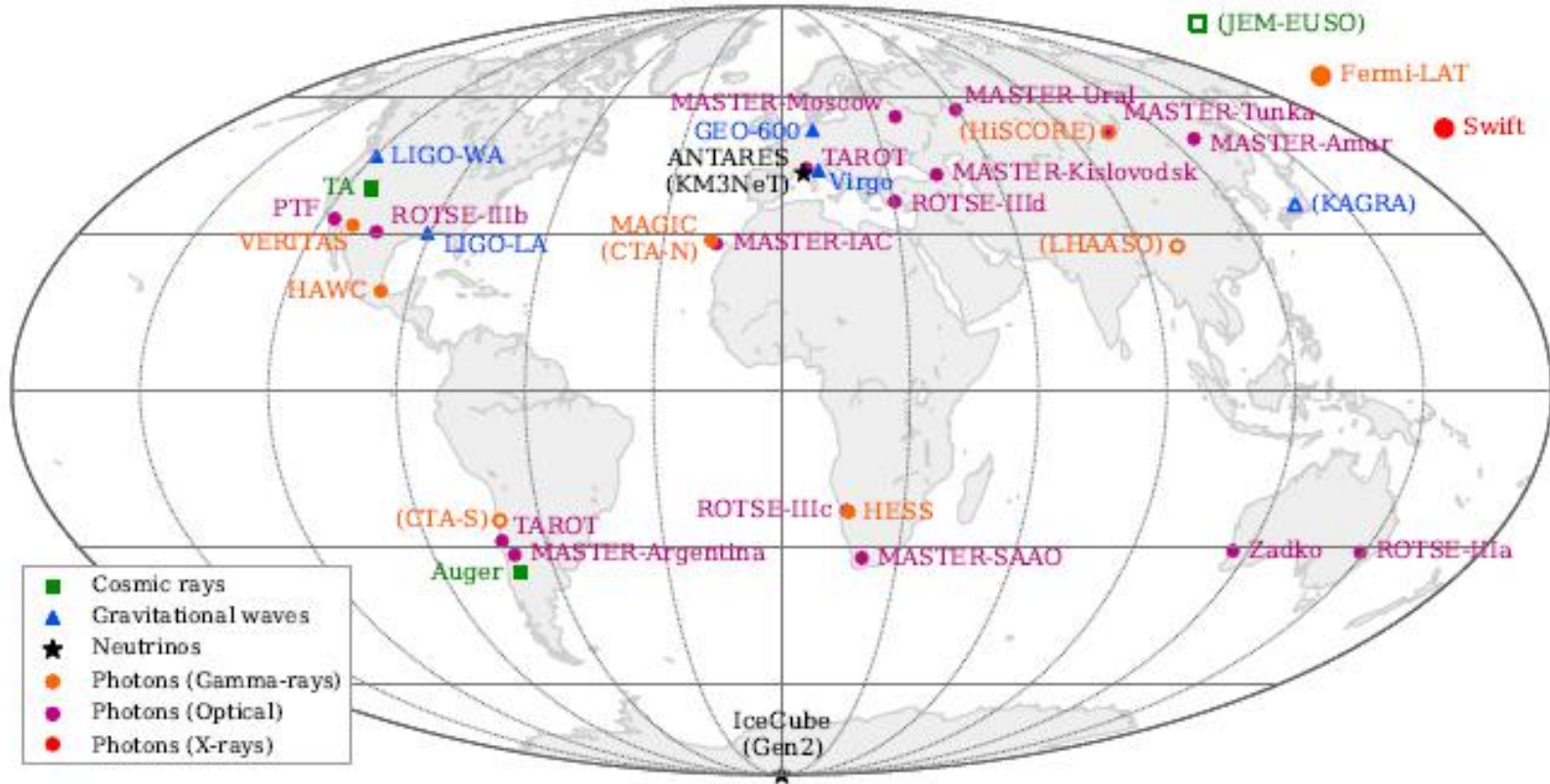
LHAASO合作组会议 · 云大 · 2017.1.18-19

Messengers in astronomy



We did it!!

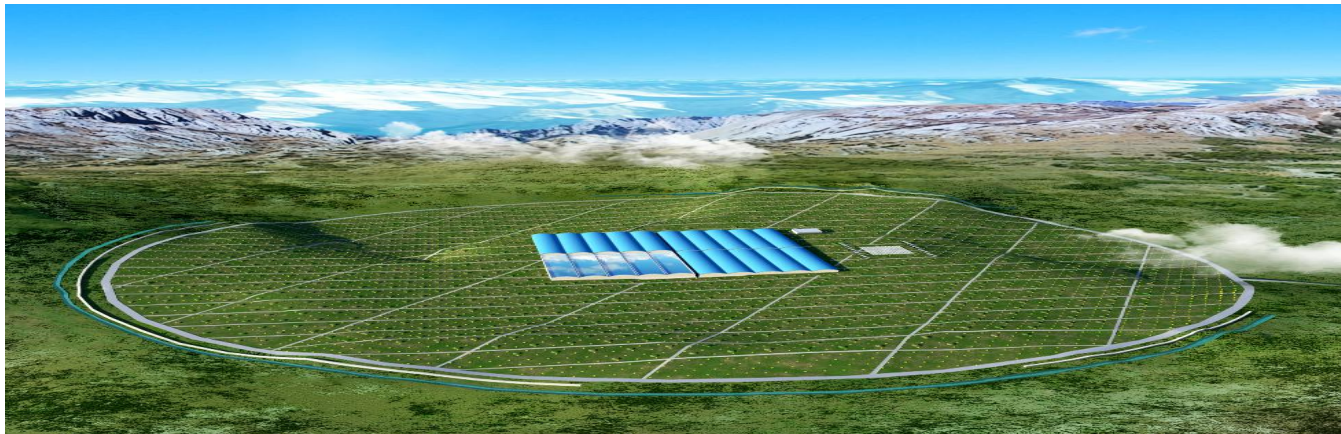
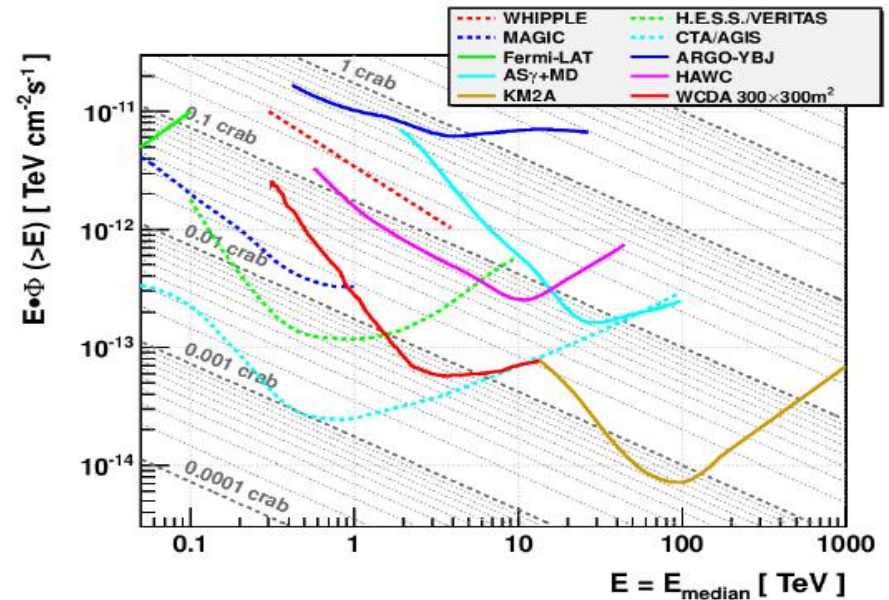
Multi-messenger Astronomy Era



Past, present, future observatories

LHAASO's important role

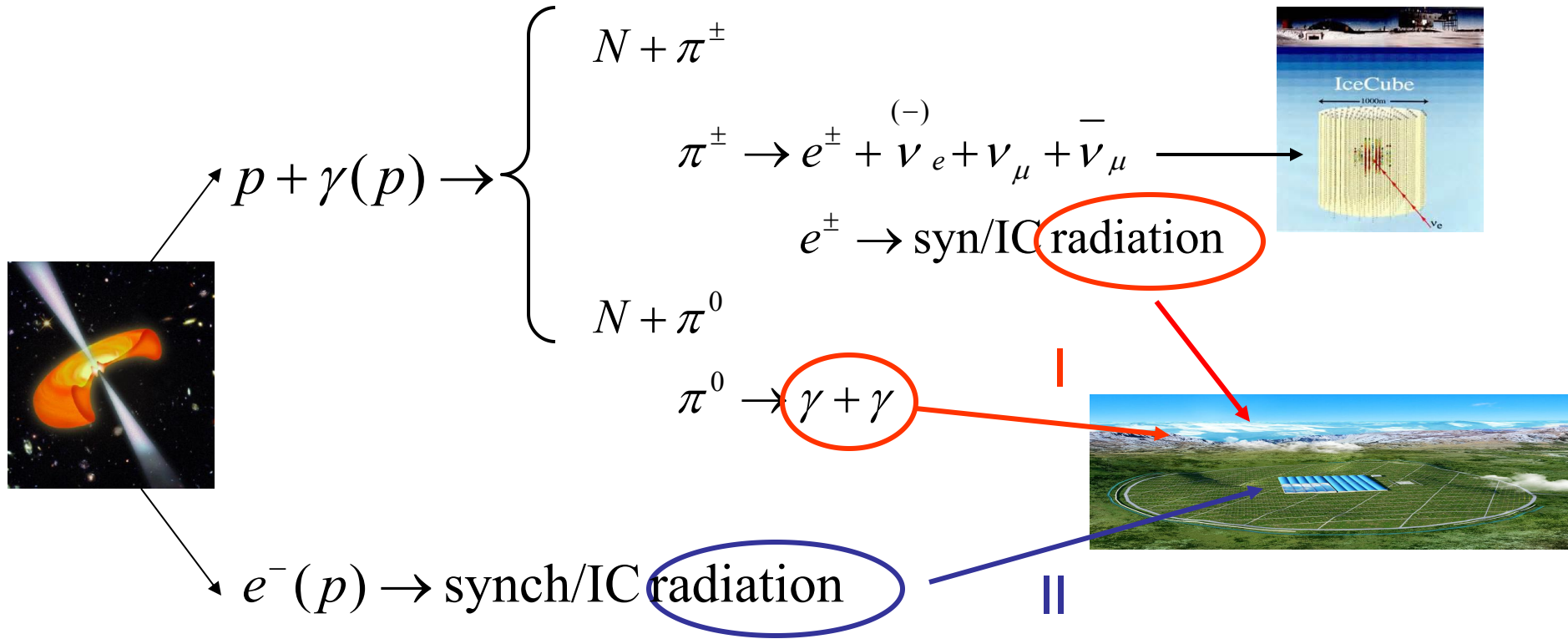
- Large field of view
- High duty cycle
- High sensitivity
 - unprecedented at 100TeV



MM approach advantages

- Provide a boost of sensitivity for searching sources
- Provide different angles towards the astrophysical objects

Gamma – neutrino connection



Connections:

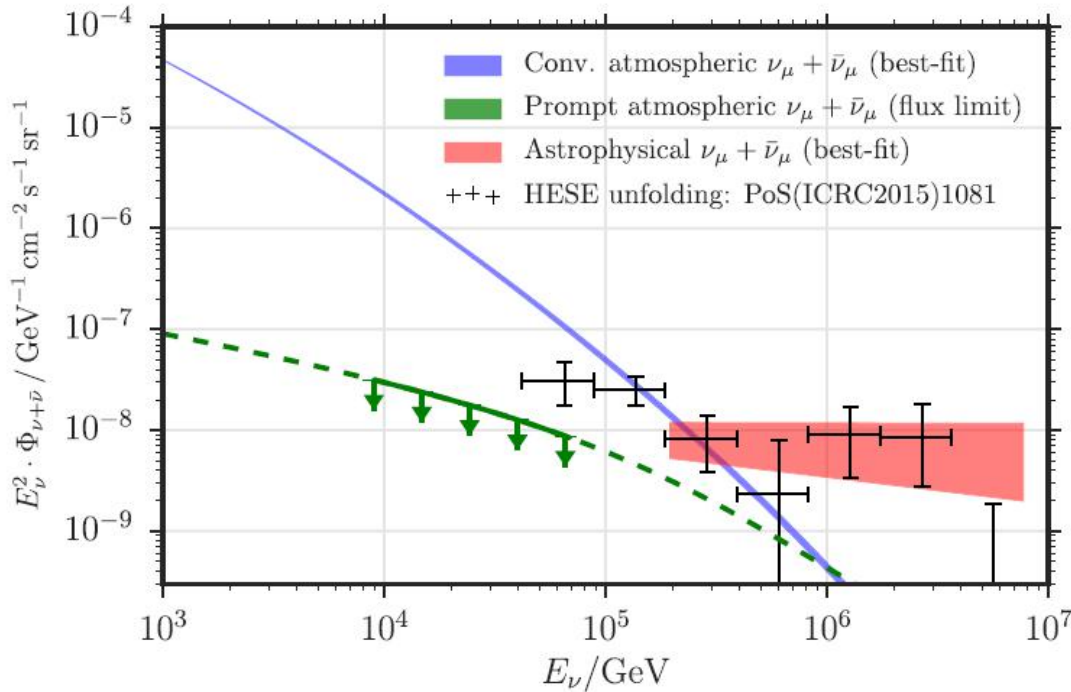
- I. neutrino – secondary electron/gamma-ray
- II. neutrino – primary electron/proton

Two approaches

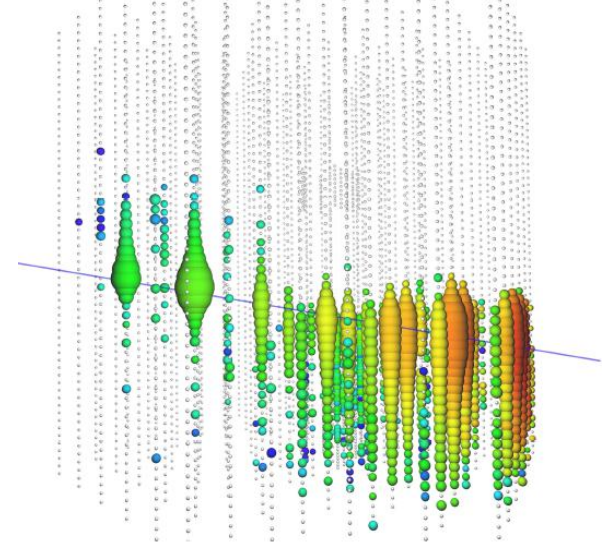
- gamma-ray → neutrino
 - search neutrino signal for known gamma sources
 - limits to GRBs/AGNs/SNRs/GCs/...
- neutrino → gamma-ray
 - search gamma ray signal at neutrino positions

TeV-PeV neutrinos at IceCube

$E^2\Phi \sim 1e-8 \text{ GeV/cm}^2\text{s sr @100TeV}$
 starting evts (southern) consistent w/
 upgoing track evts (northern)



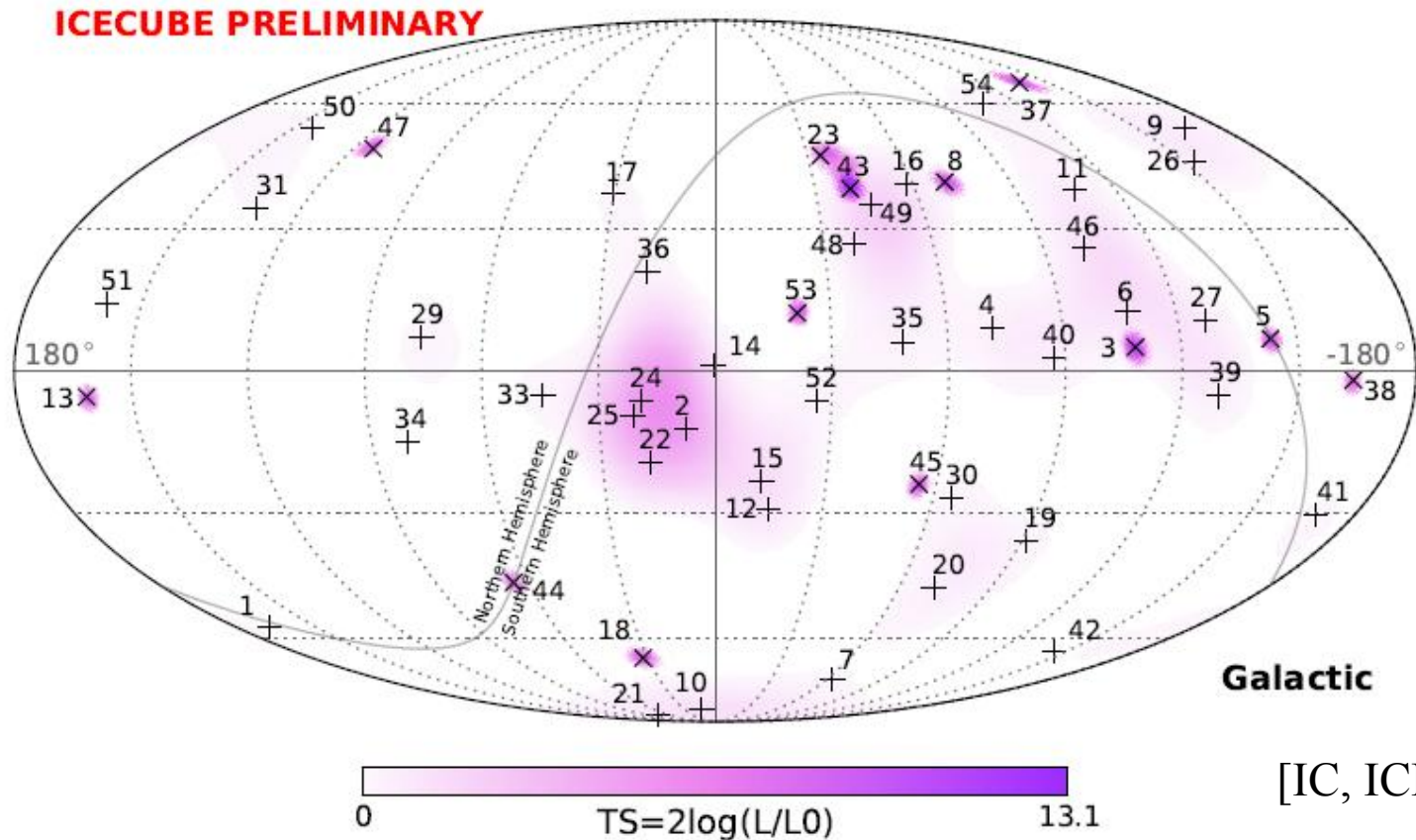
2.6PeV track event



[IC 16, ApJ]

Hard spectrum at $>200 \text{ TeV}$: $s \sim -2$
 Cutoff at few PeV

Neutrino arrival directions



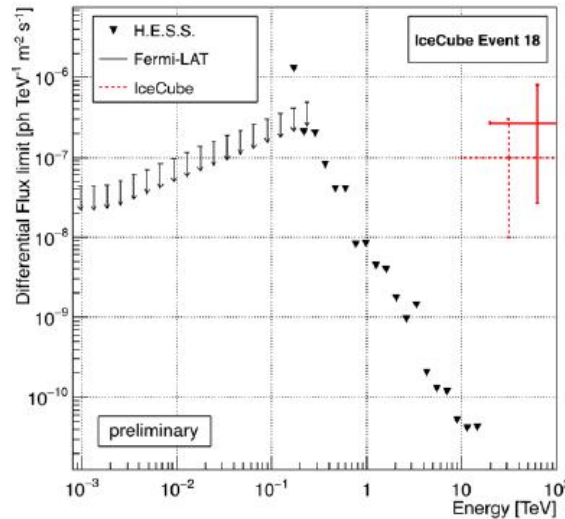
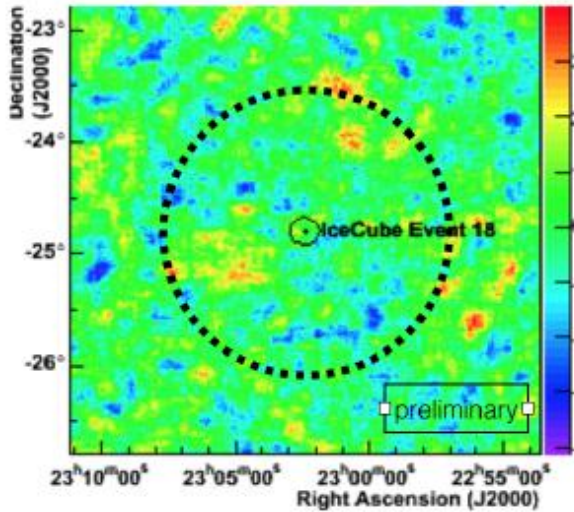
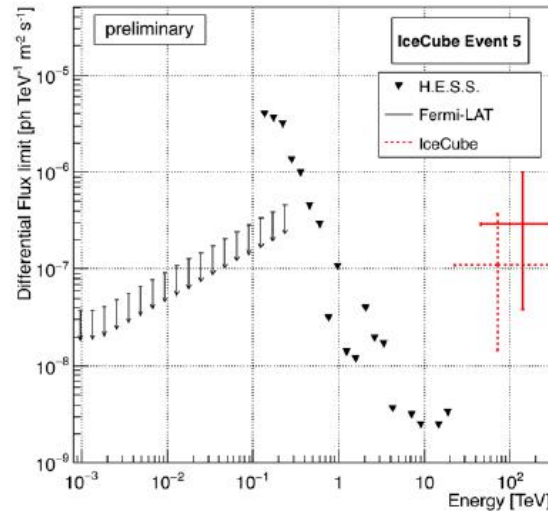
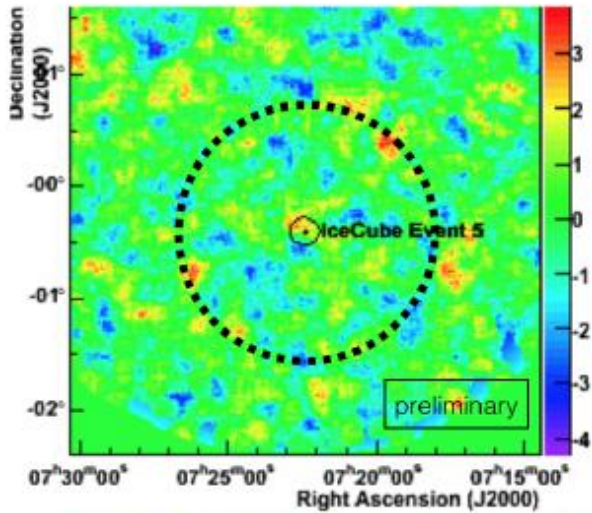
Starting events, 4yr

no significant spot, no clustering in time
no correlation with GRBs

LHAASO searches at neutrino positions

LHAASO
unprecedented
@100TeV:
 $10^{-14}/\text{TeV m}^2\text{s}$

Significance Map



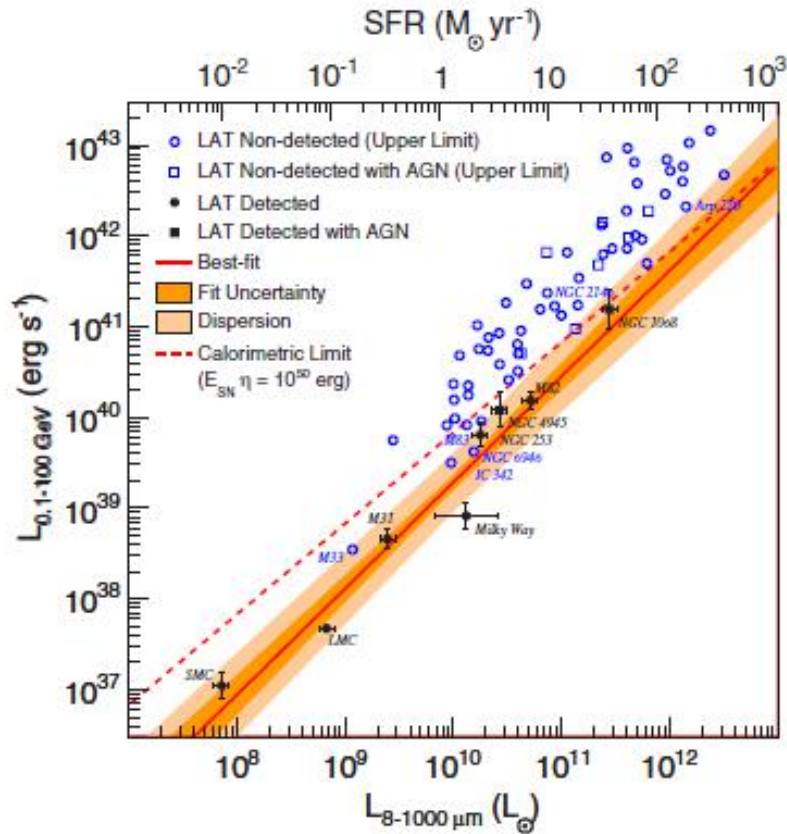
H.E.S.S. searches

HE neutrino sources?

- Fermi-LAT tells
 - ☹️ diffuse Galactic emission, $\sim < 10\%$
 - ☹️ Galactic point sources
 - ☹️ GRBs, $\sim < 10\%$
 - ☹️ AGN jets, $\sim < 10\%$
 - 😊 Starburst galaxies
 - AGN cores?
 - ...

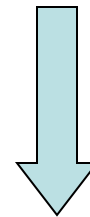
[Wang & Li 14,15]

GeV gamma from starburst galaxies



[Fermi-LAT, Ackermann+12]

$$\nu L_\nu(\text{GeV})/\text{SFR} \approx 10^{46} \text{ erg}/M_\odot$$



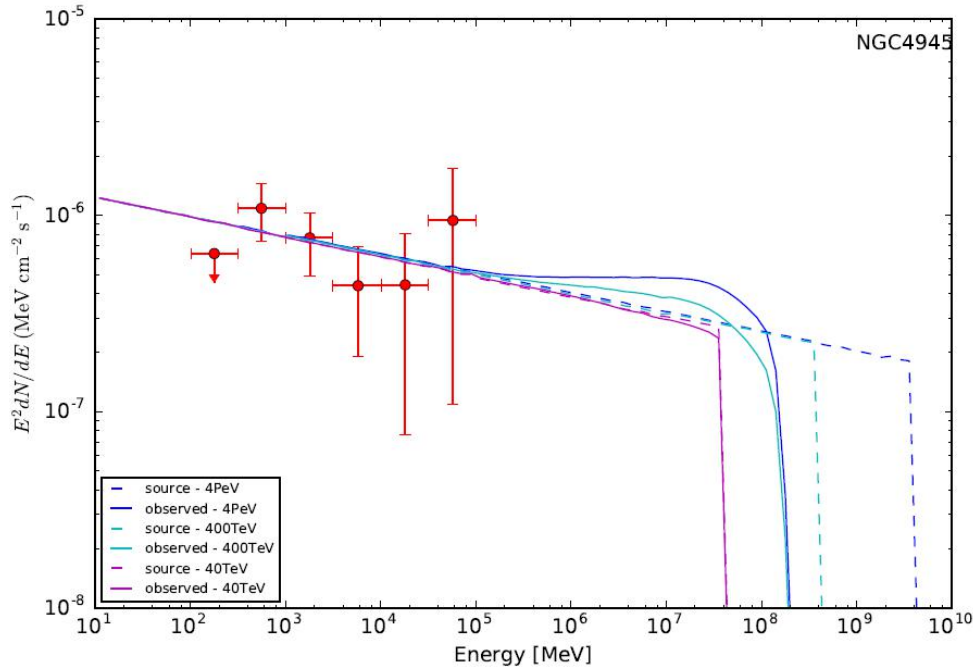
SFR(z)

$$E_\nu^2 \Phi_\nu \approx 10^{-8} \frac{\xi_z}{3} \left(\frac{E_\nu}{1 \text{ PeV}} \right)^{-0.2} \text{ GeV cm}^{-2} \text{ s}^{-1} \text{ sr}^{-1}$$

Consistent with observed flux and spectrum at >60TeV

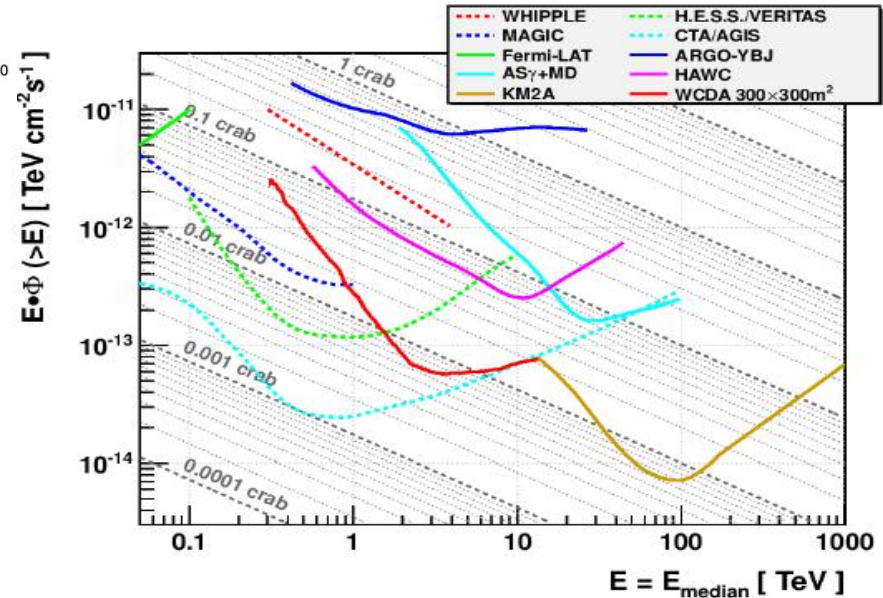
[Wang & LZ 14]

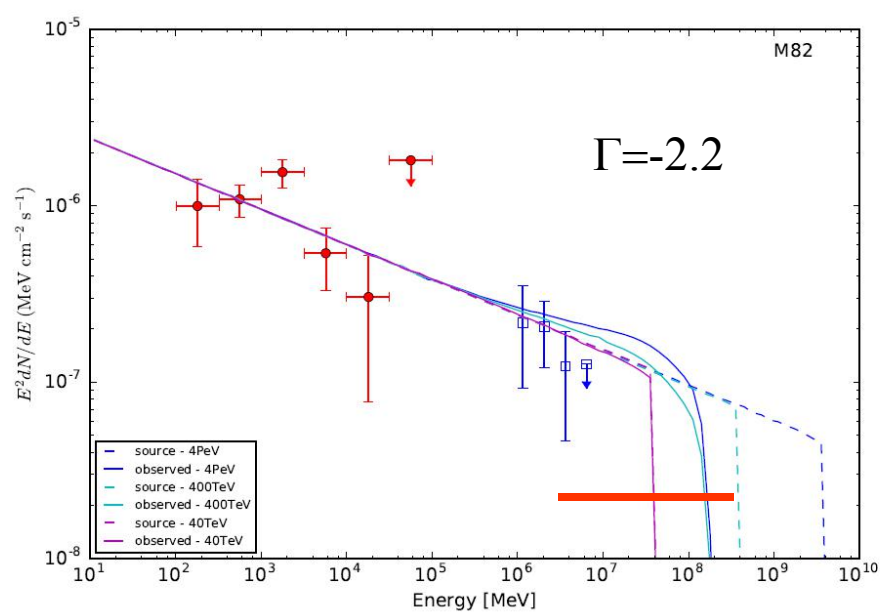
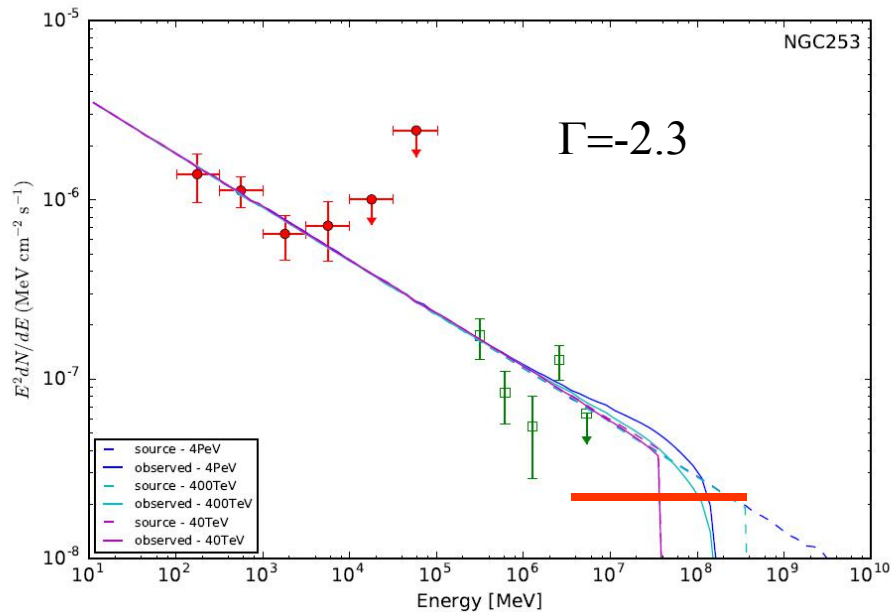
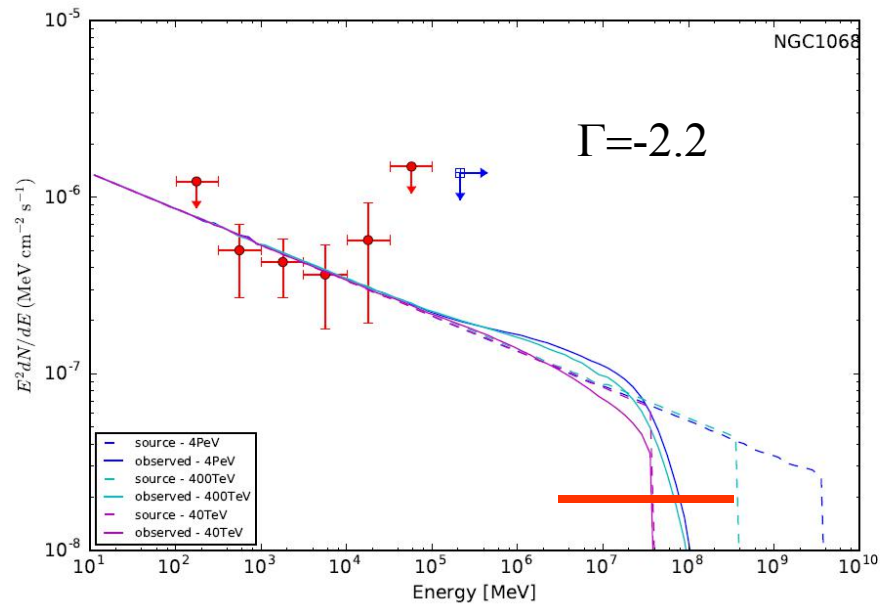
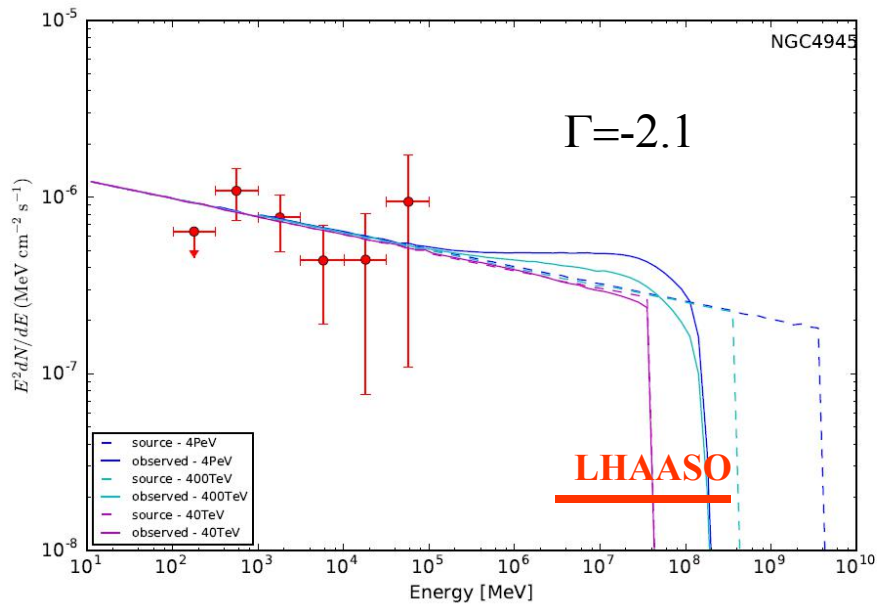
LHAASO to pin down SBG origin



4Mpc
poinic gamma-rays initiate EM cascade

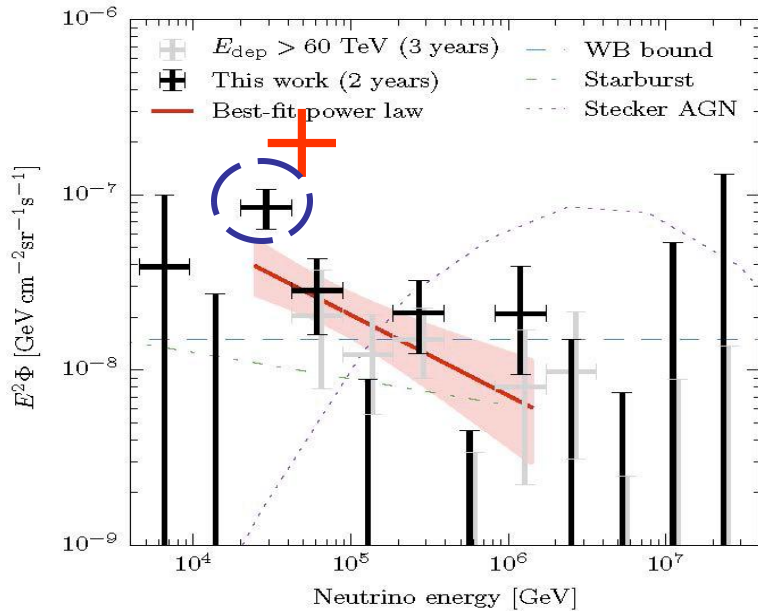
Precise measurement of individual SBG spectrum
→ prove neutrino cutoff at PeV





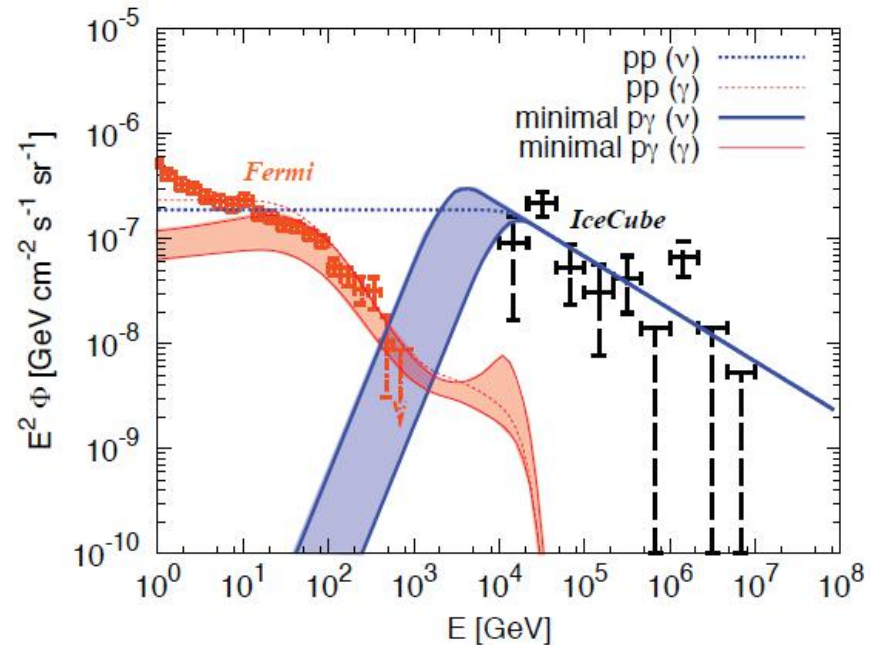
LHAASO to pin down Galactic origin of 30-TeV neutrinos

Low E threshold, 2yrs
Neutrino excess at **30TeV**



[IC 15, PRD]

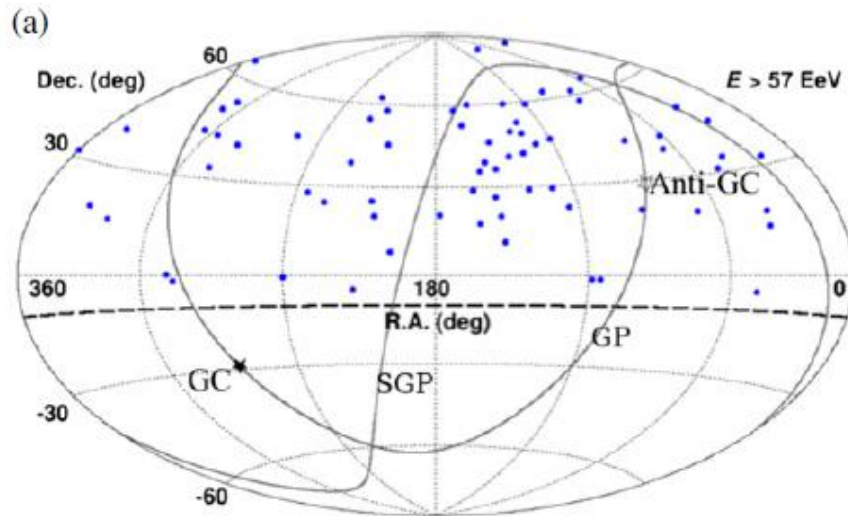
Fermi/IceCube tension



[Murase+15]

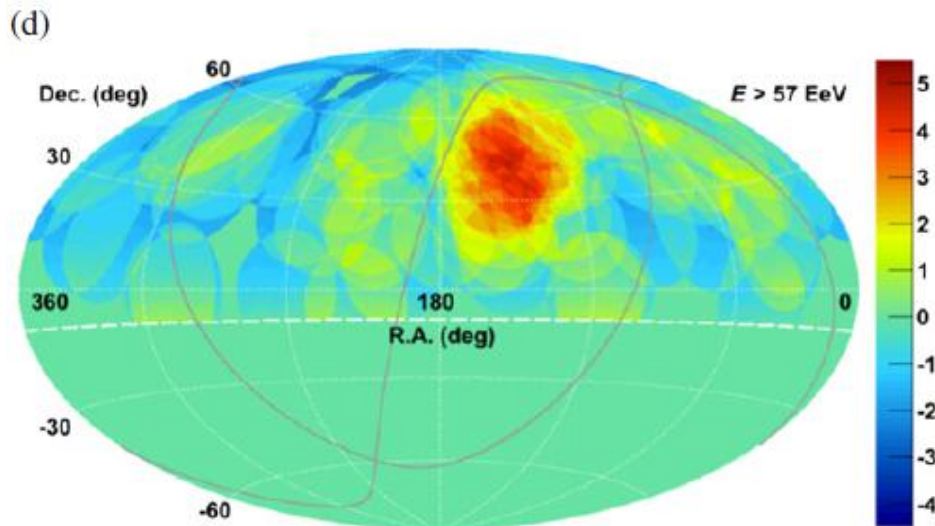
diffuse gamma-rays associated, if Galactic origin:
within reach by LHAASO

LHAASO searches UHECR sources



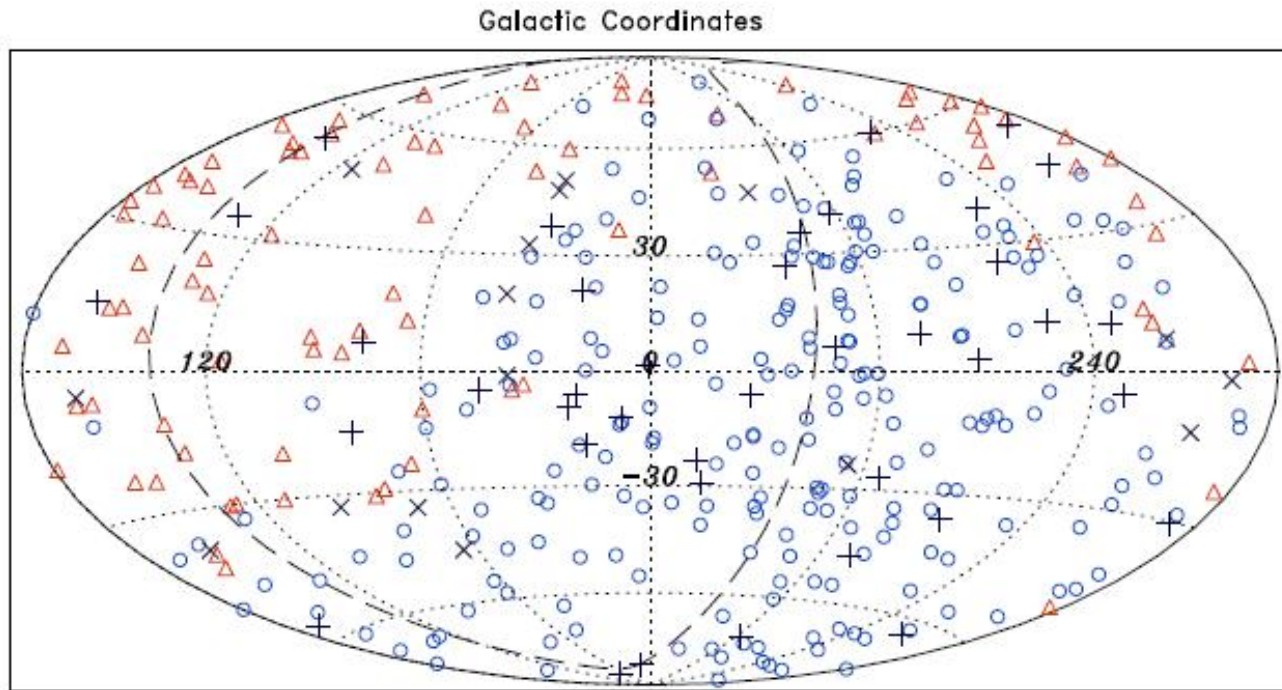
TA $> 57 \text{ EeV}$, 5yr
Hot spot, 5.1sigma

[TA 14, ApJL]



- Within 100Mpc
- Weak EBL absorption

LHAASO searches UHECR sources



x: IceCube tracks, +: IceCube cascades, o: Auger, Δ: TA

[IC 16, JCAP]

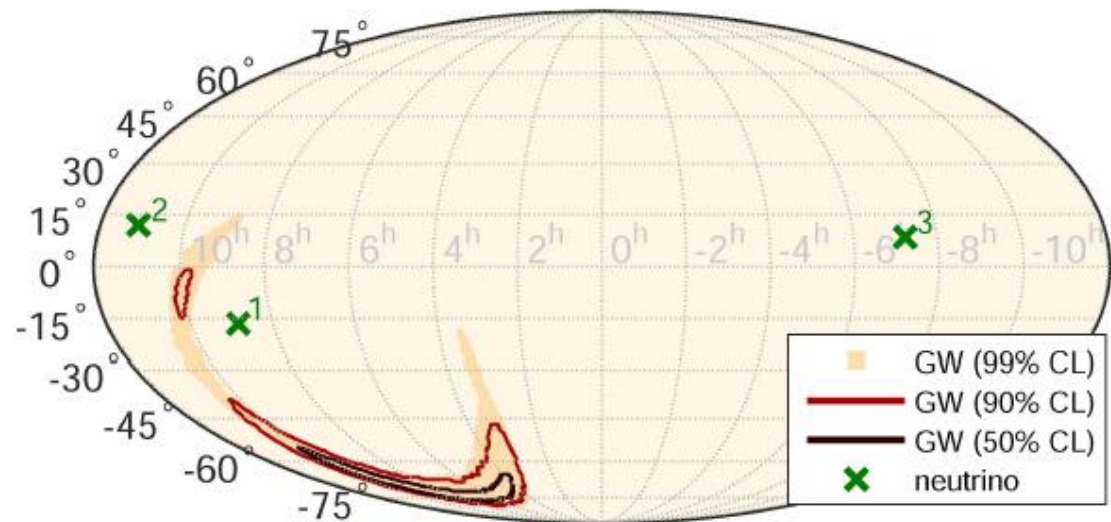
- Gamma ray signals at UHECR position
- Gamma rays and UHECRs correlation

UHECRs & VHE gamma
both within 100Mpc

Searches for GW counterparts

- GW150914
- GW error regions
tens-hundreds
squared degrees

large FOV is important!
IceCube/LHAASO



+/-500s IceCube events

MM astronomy with LHAASO

- neutrino
 - neutrino positions
 - nearby SBGs
 - Galactic diffuse 60TeV gamma
- CR
 - TA hot spot...
 - UHECR positions
- GW
 - Search GW counterparts
- transients
 - GW, GRB, SN, FRB, TDE...
 - LHAASO real-time alerts
 - Very bright/nearby

