

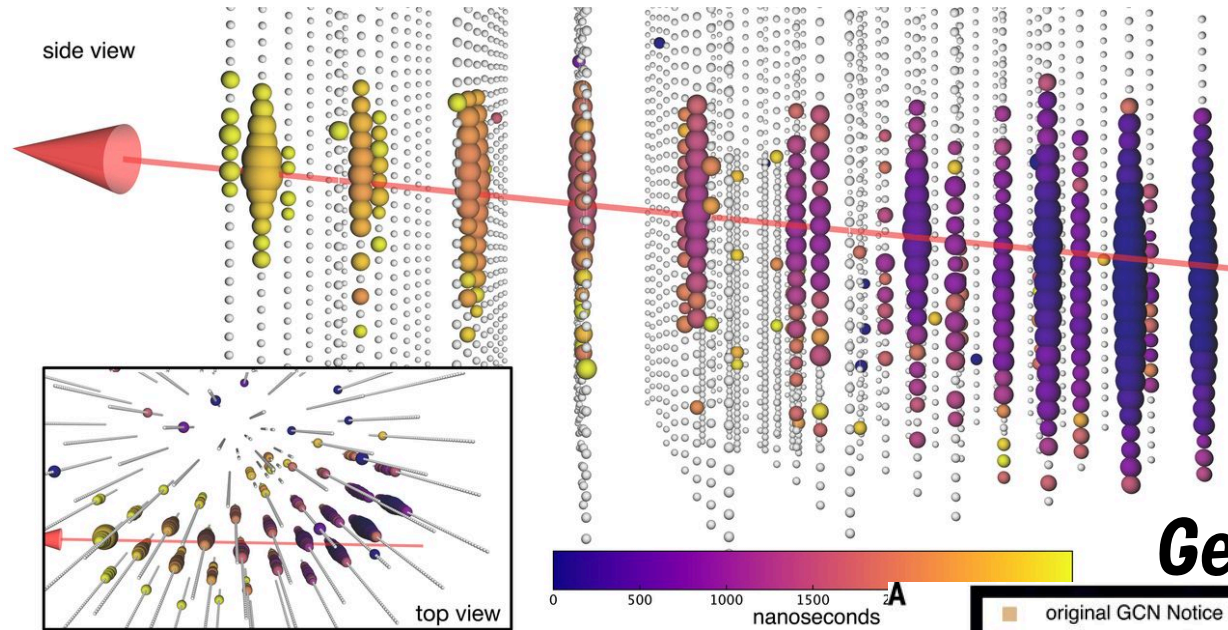


# ***Multimessenger Astronomy with MAGIC***

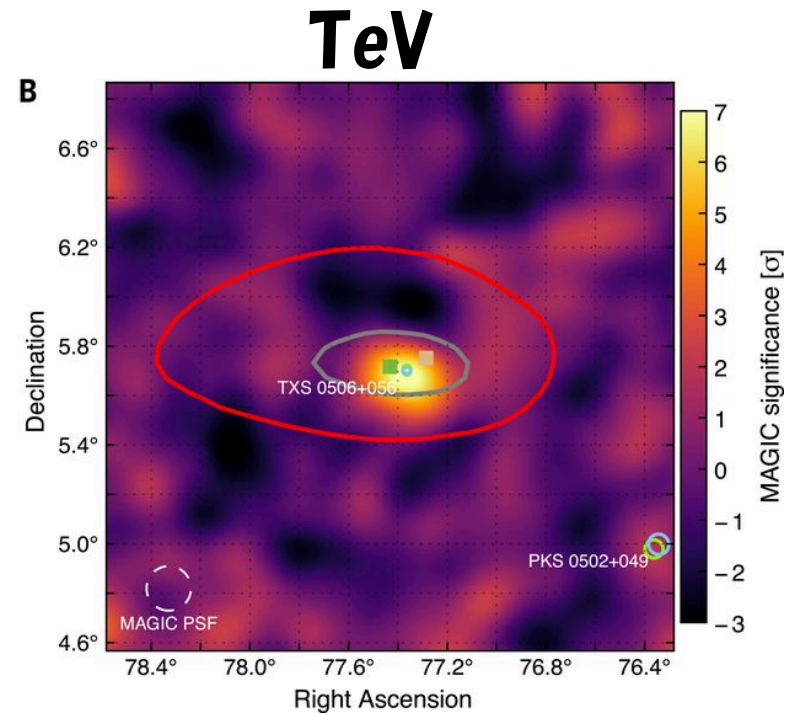
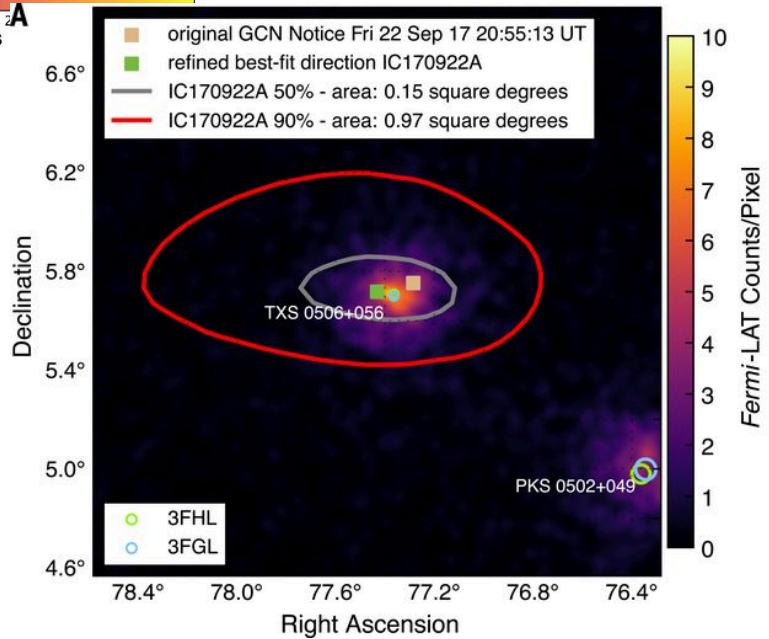
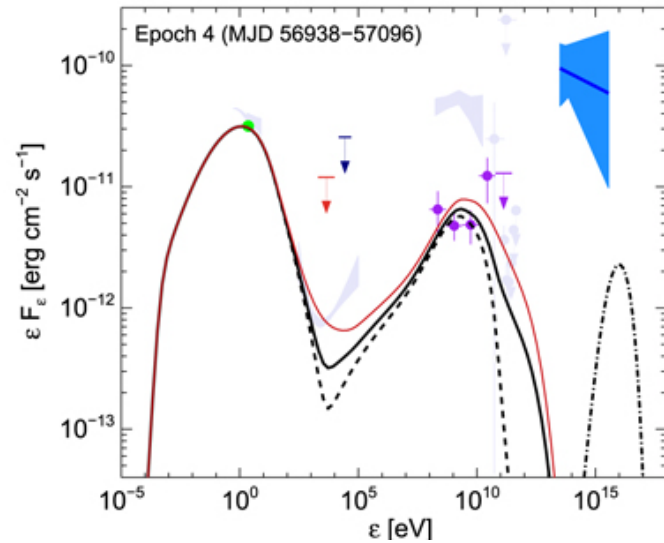
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**Katsuaki Asano**  
**(Institute for Cosmic Ray Research, Univ. Tokyo)**

# “Typical” Multi-messenger Event



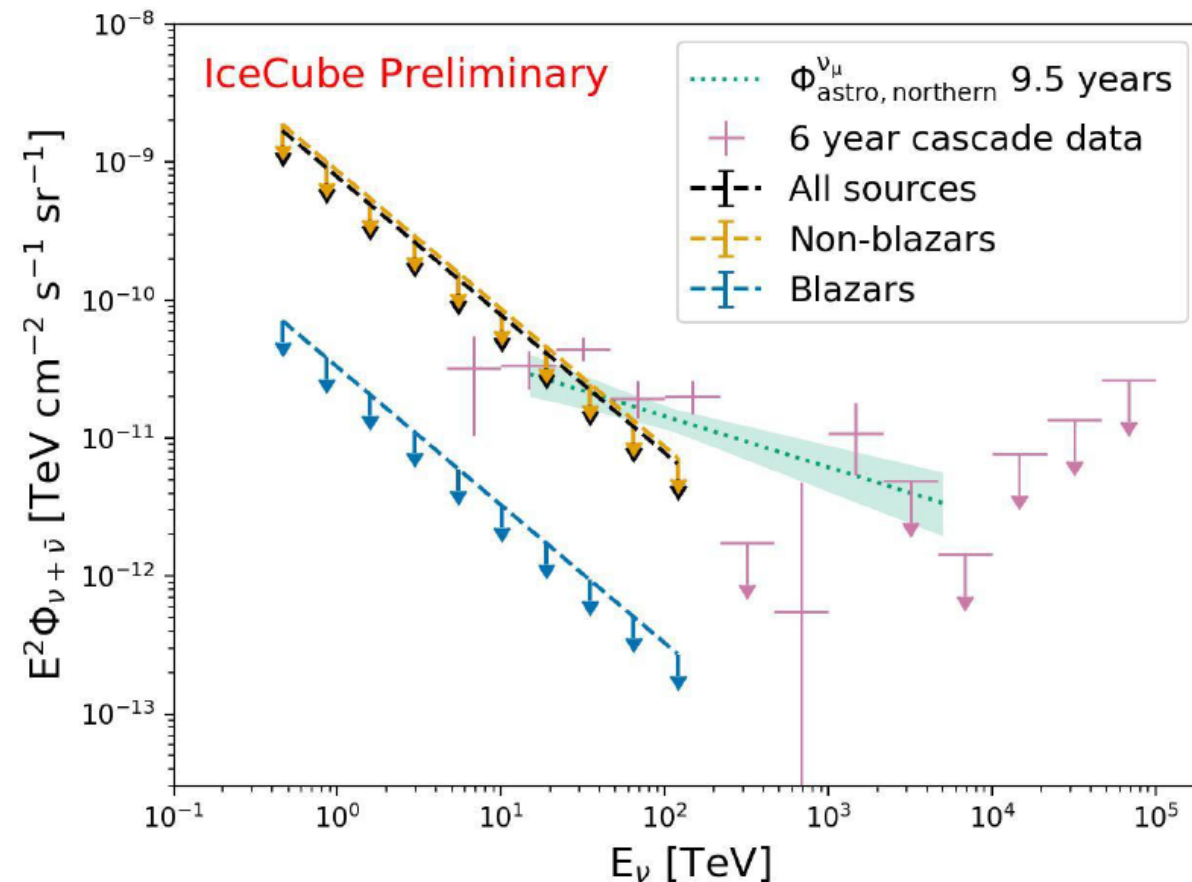
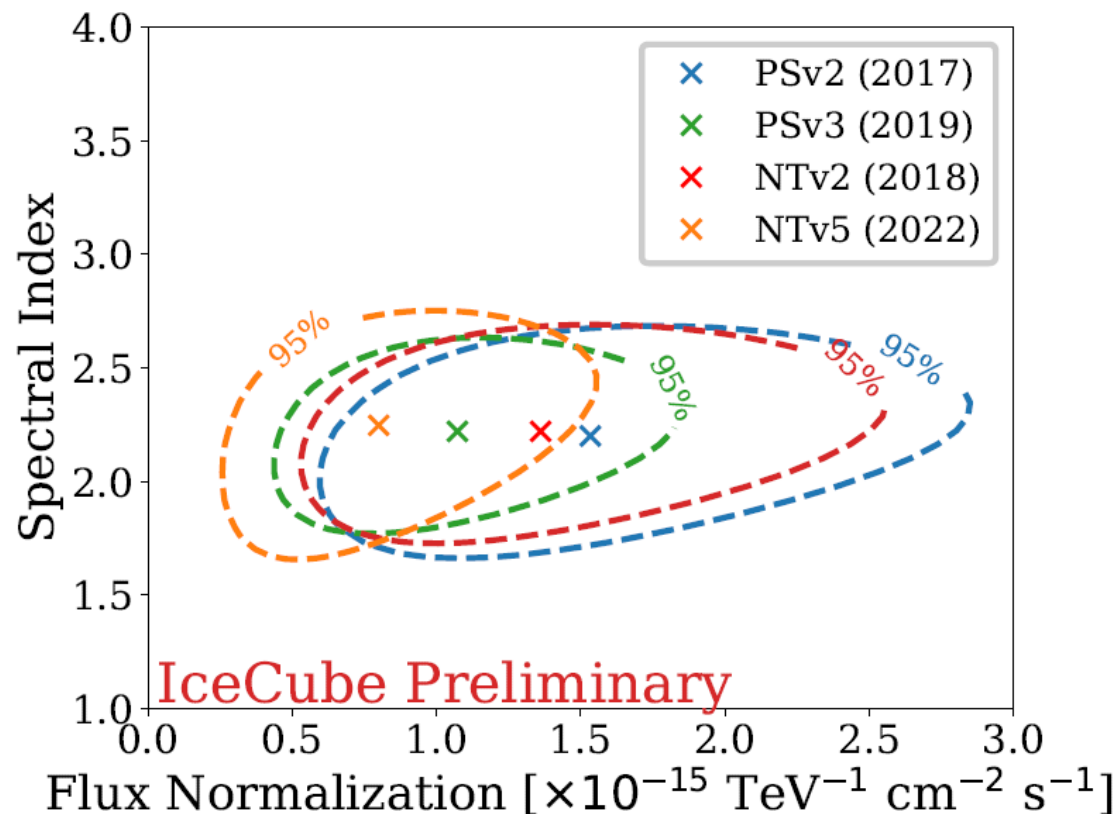
## IceCube-170922A and Blazar TXS 0506+056



# Blazars are not dominant source

ICRC2023

## Updated analysis for TXS0506

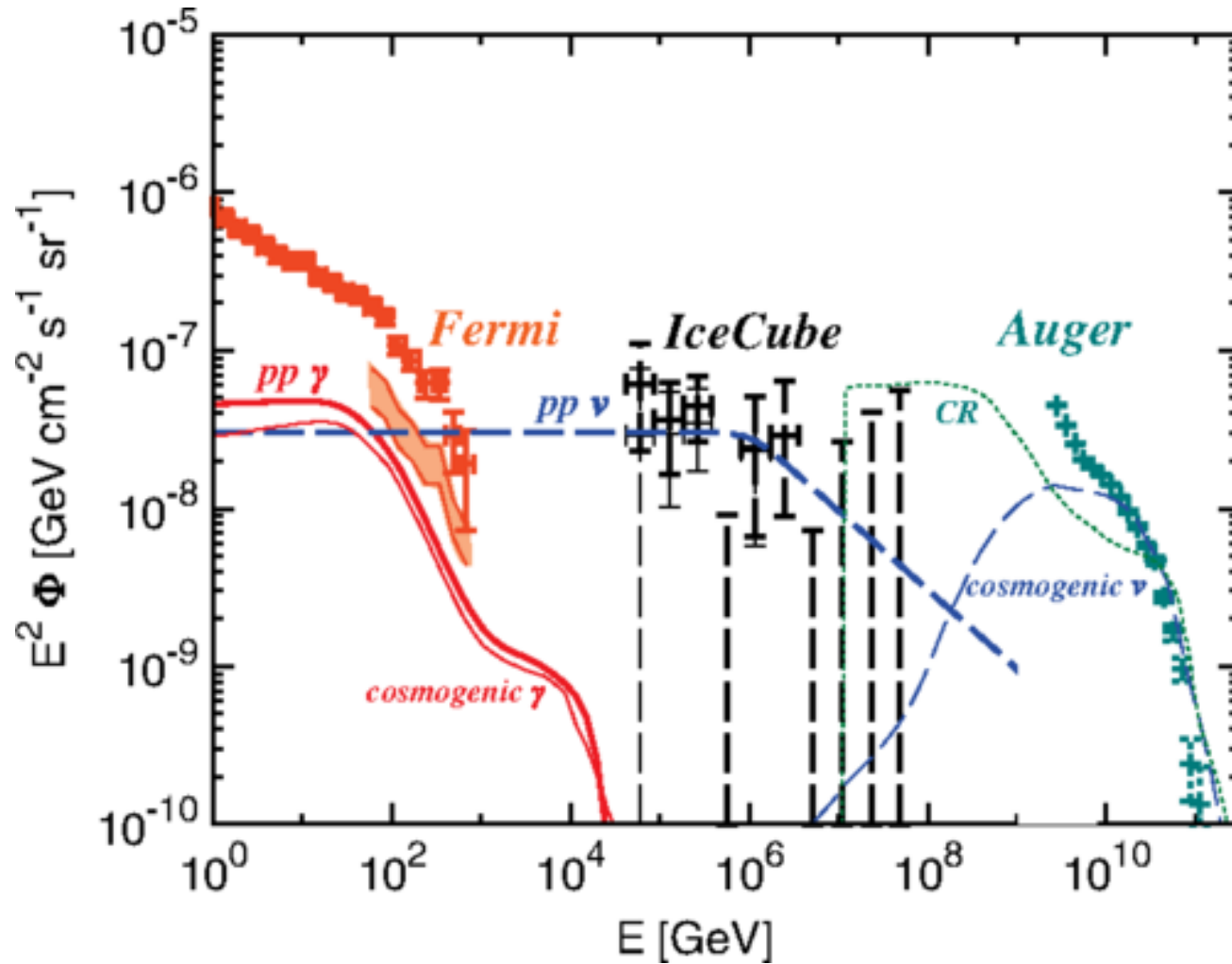


**Blazar < 7%**  
**GRB < 1%**

	$T_{\text{start}}$	$T_{\text{stop}}$	TS	$n_s$	$\gamma$	$p$
PSv2 (2017)	56937.81	57096.22	30.34	14.39	2.20	7e-5
NTv5 (2022)	56927.86	57091.33	18.7	9.21	2.24	1e-3

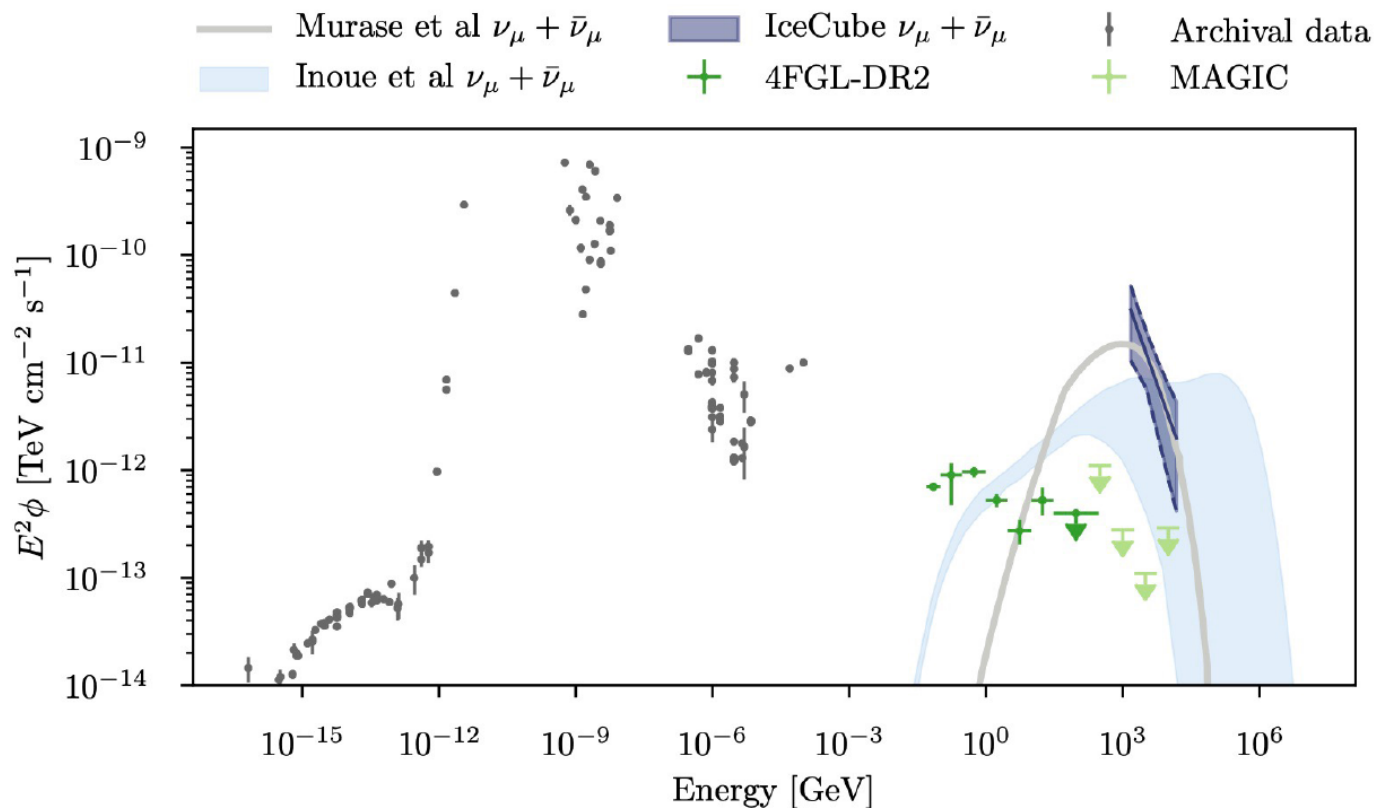
# Neutrino Source: tension in $pp$ model (hidden?)

## Murase & Waxman 16

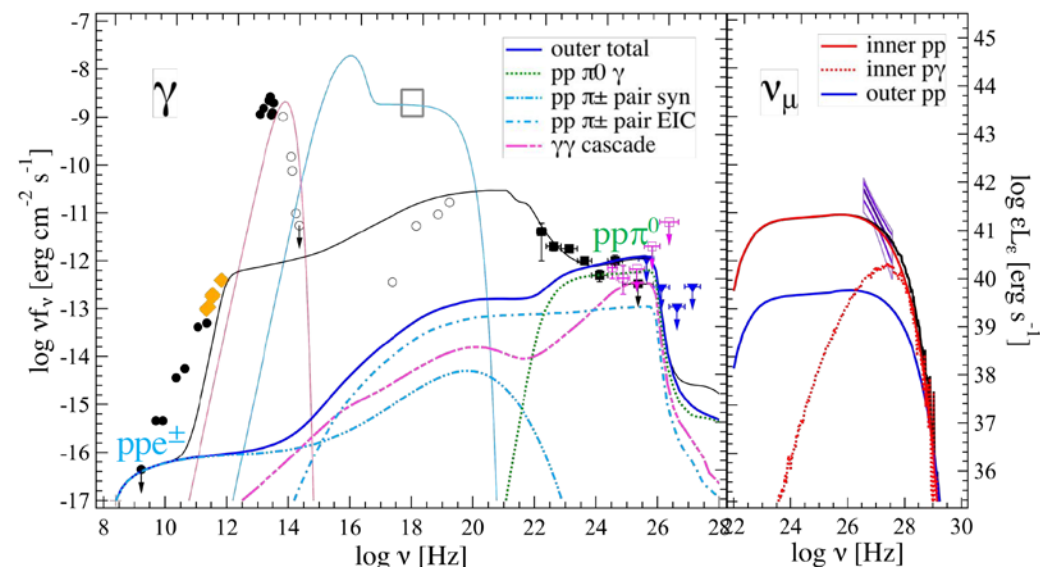


# Neutrinos from Seyfert, beyond one-zone model

## NGC 1068 IceCube Collab. 22



## Inoue+22 Wind model



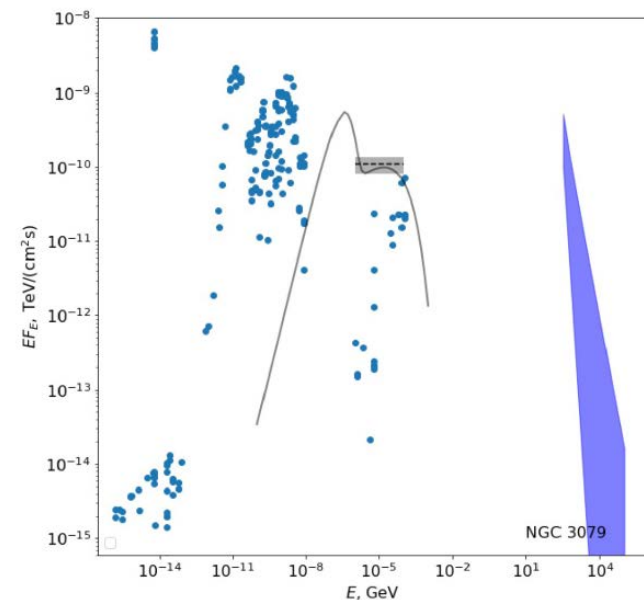
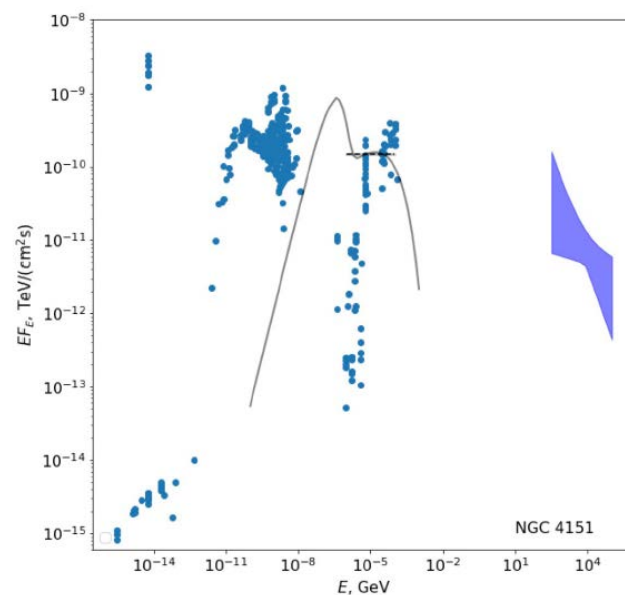
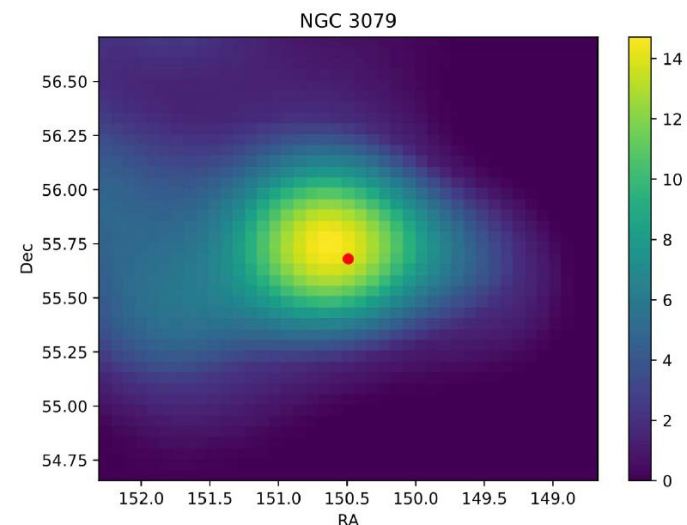
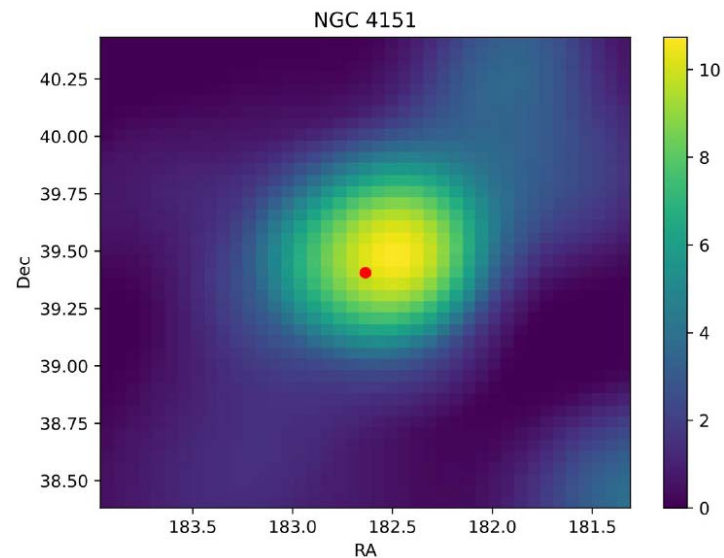
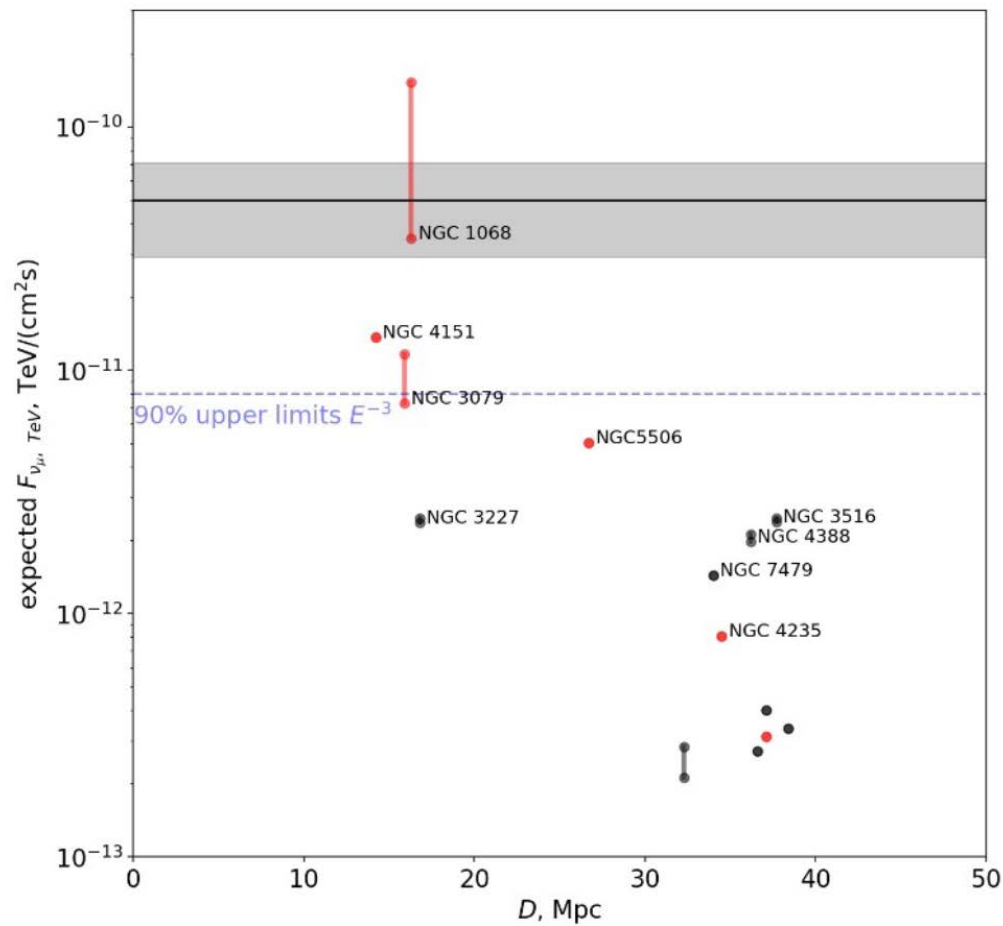
**Gamma-rays are absorbed.**

**Compact region for neutrino source**

**Different spectrum from the neutrino background.**



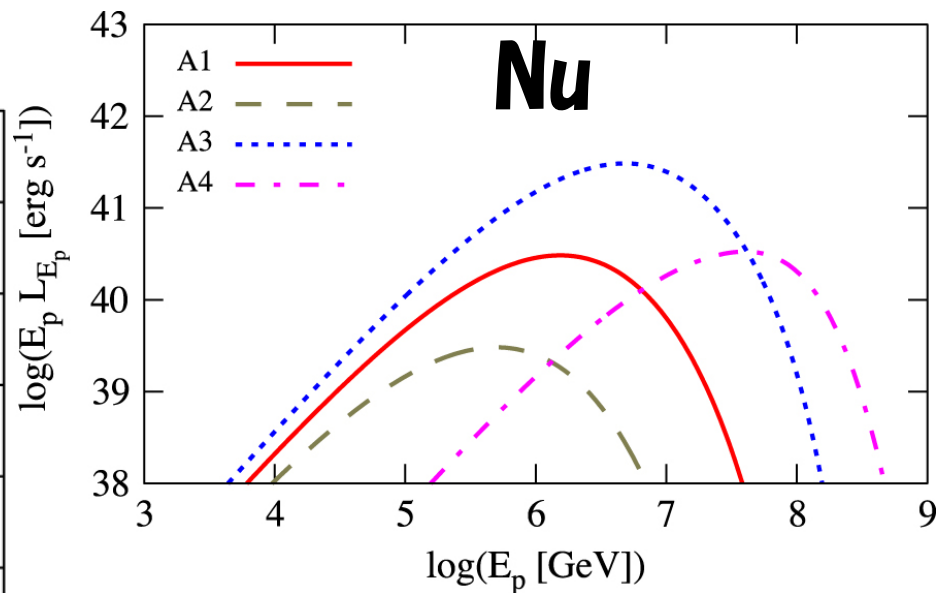
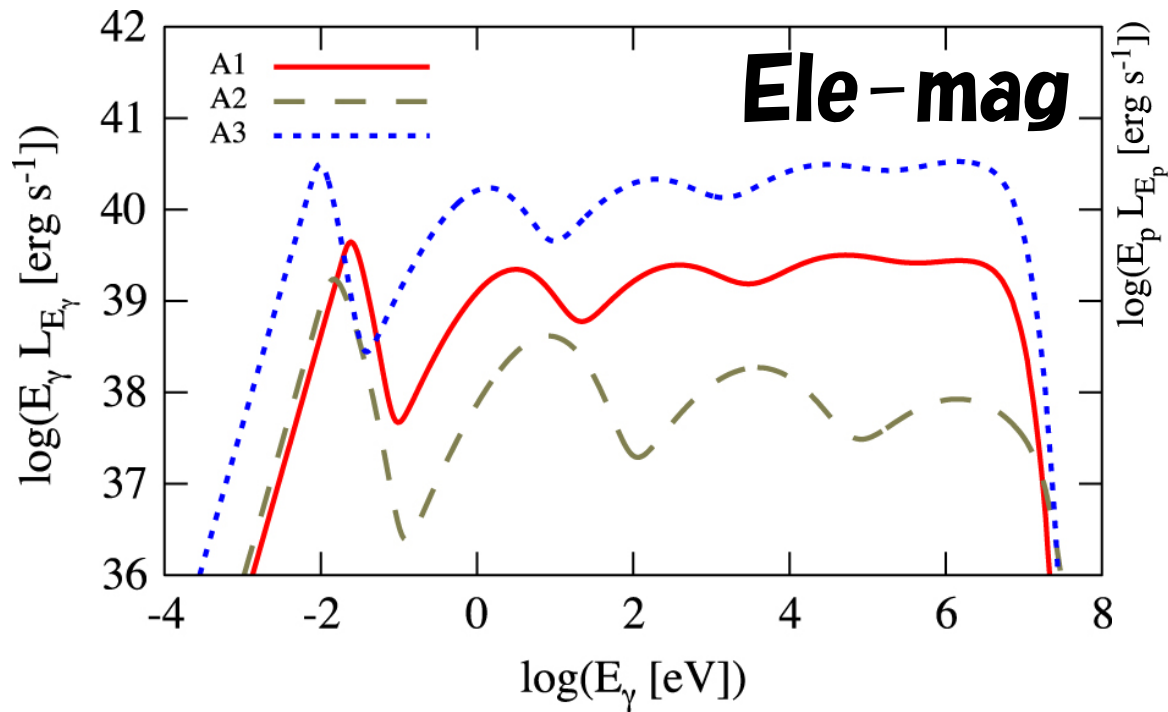
# Other Seyferts



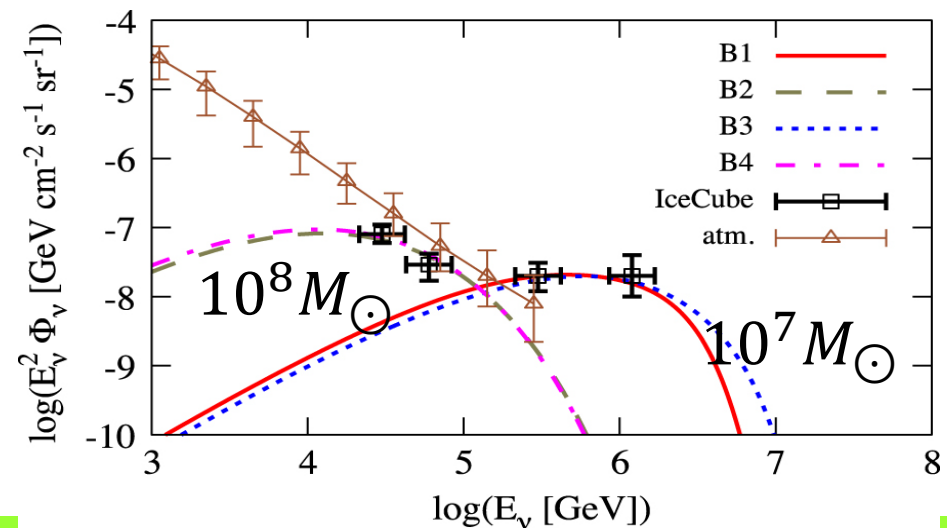
**Semikoz TeVPA Talk**

# CR acceleration in accretion disk

## Neutrinos from Low-luminosity AGNs Kimura+15

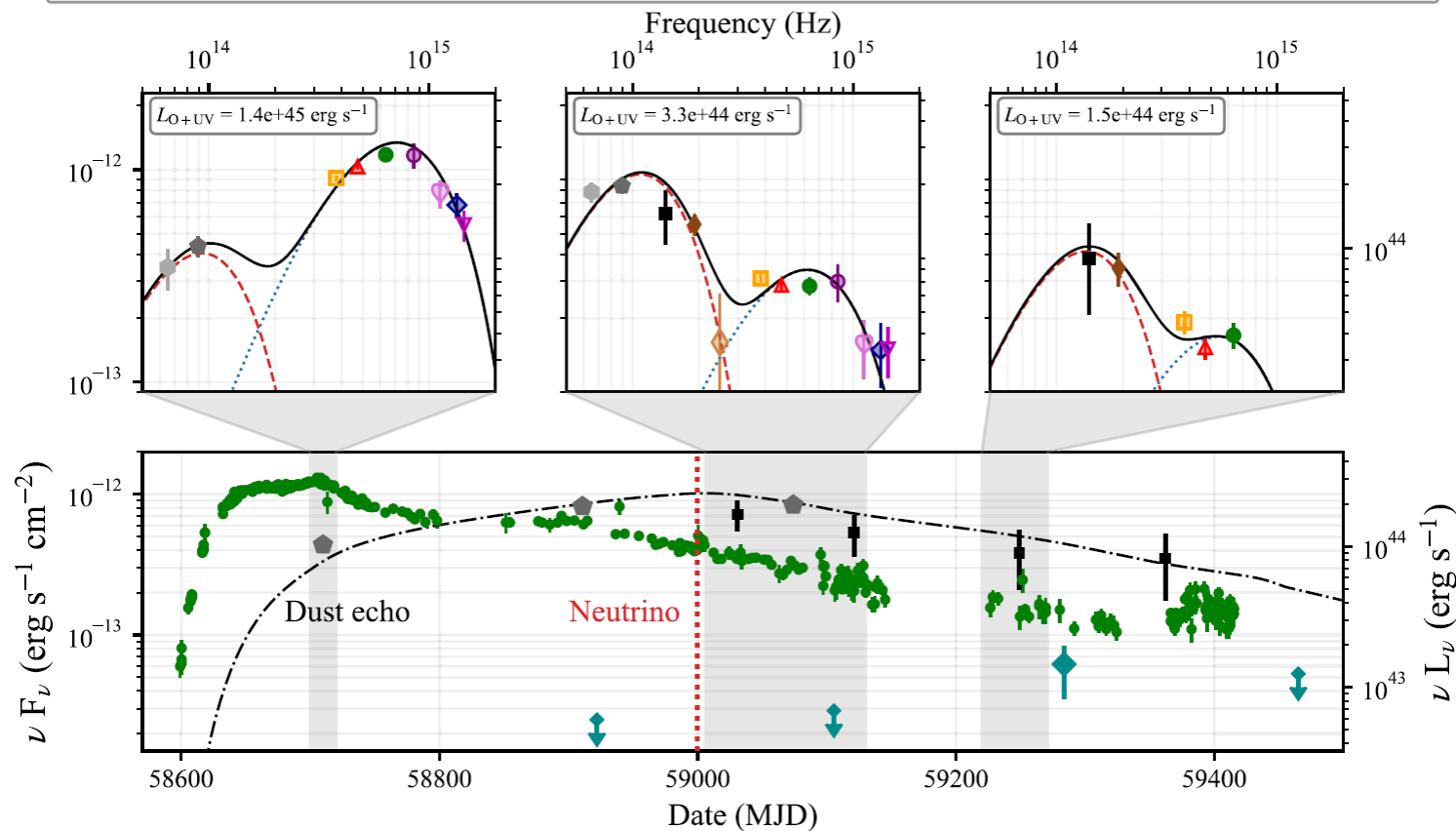
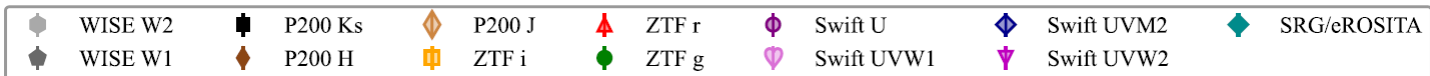


**GeV-TeV gammas are from Star forming region?**

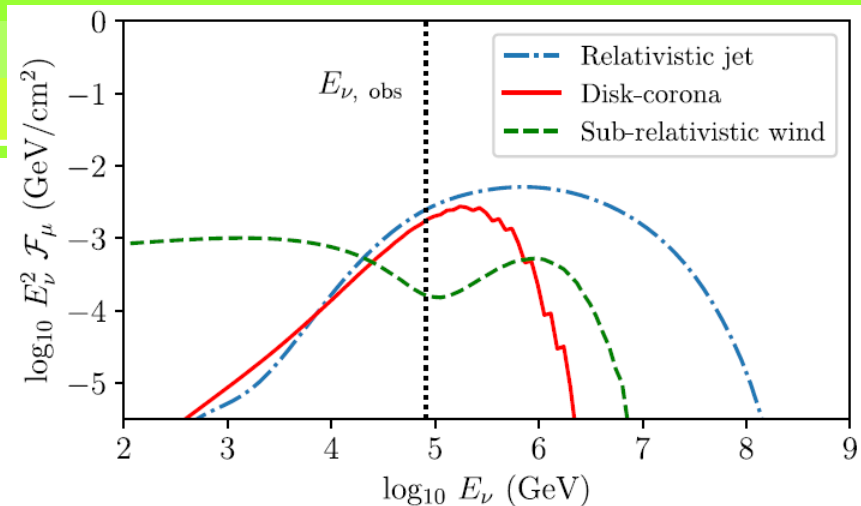


# Tidal disruption event

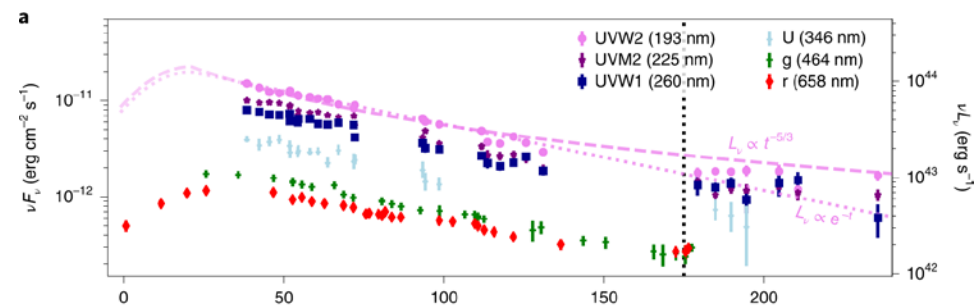
## AT2019fdr



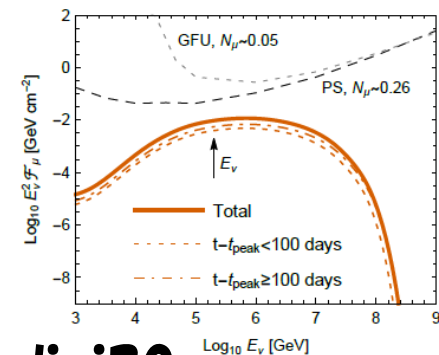
**Reusch+22**



**0.002-0.027 events**



**AT2019dsg  
Stein+21**



**Jet model Winter & Lunardini20**

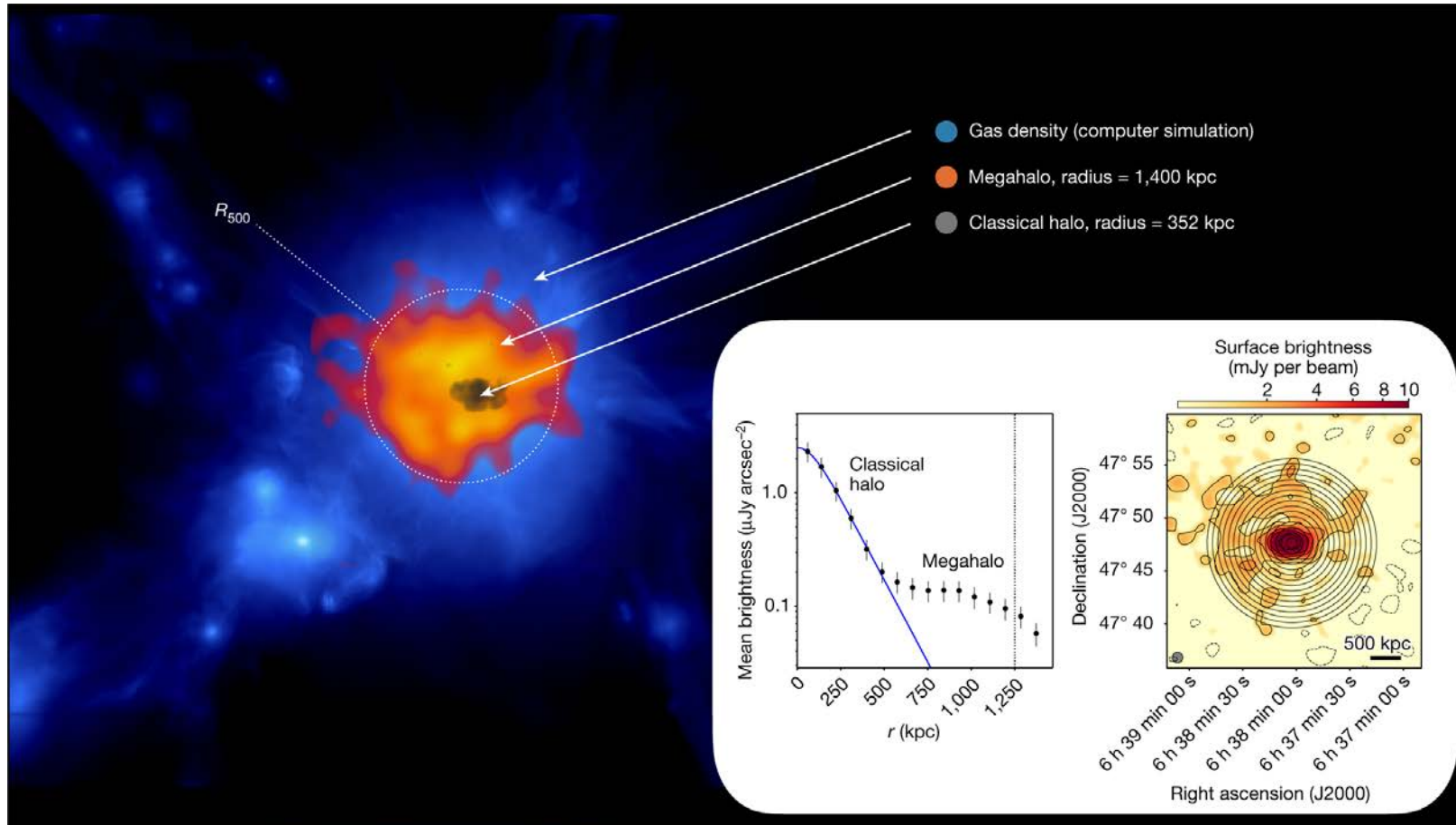


# Clusters of Galaxies

Cosmic rays are deposited in clusters.

Mega Halo: LOFAR detected giant radio structure

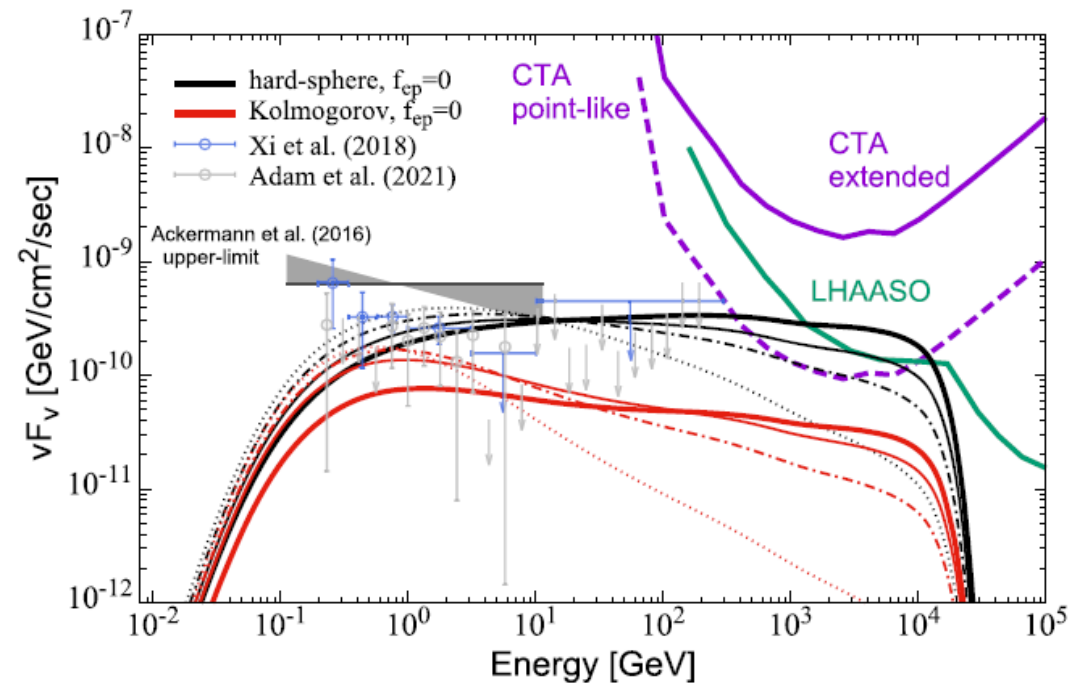
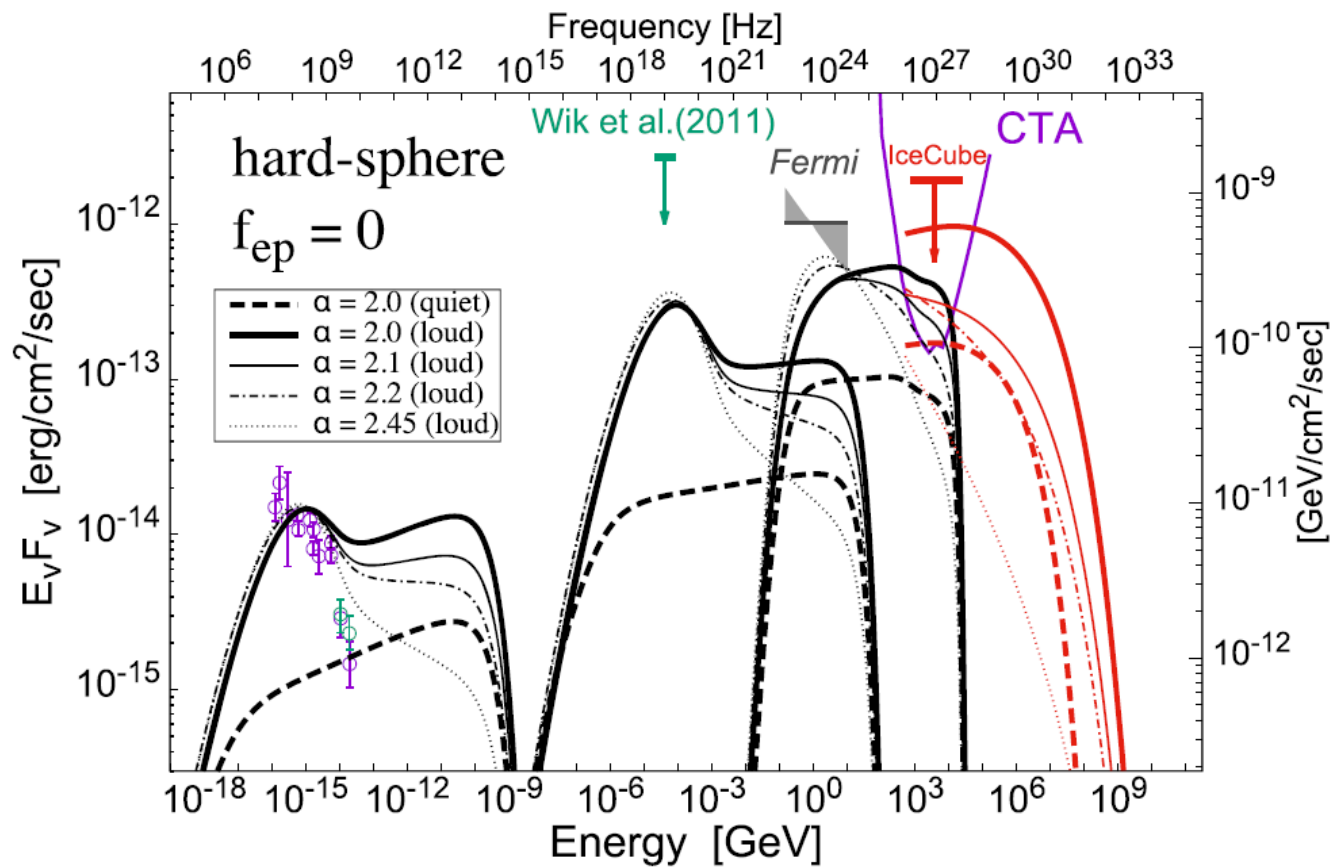
Cuciti+ 22



**Electrons are accelerated by turbulence.**  
**Electrons are probably injected as secondary of pp collision.**

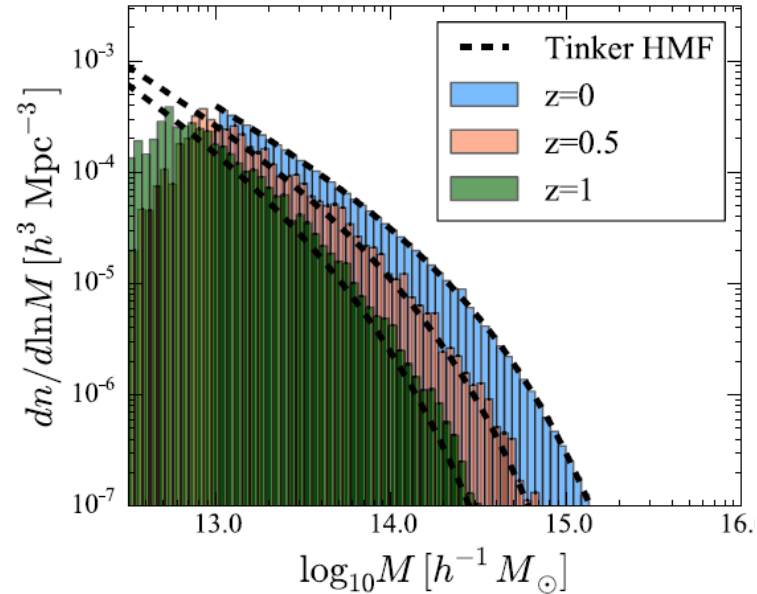
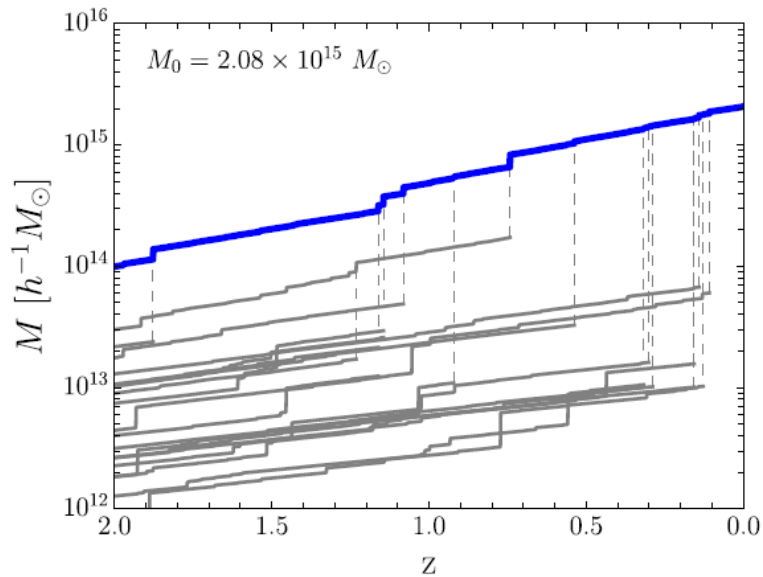
# Coma cluster

## Nishiwaki+ 21 Coma

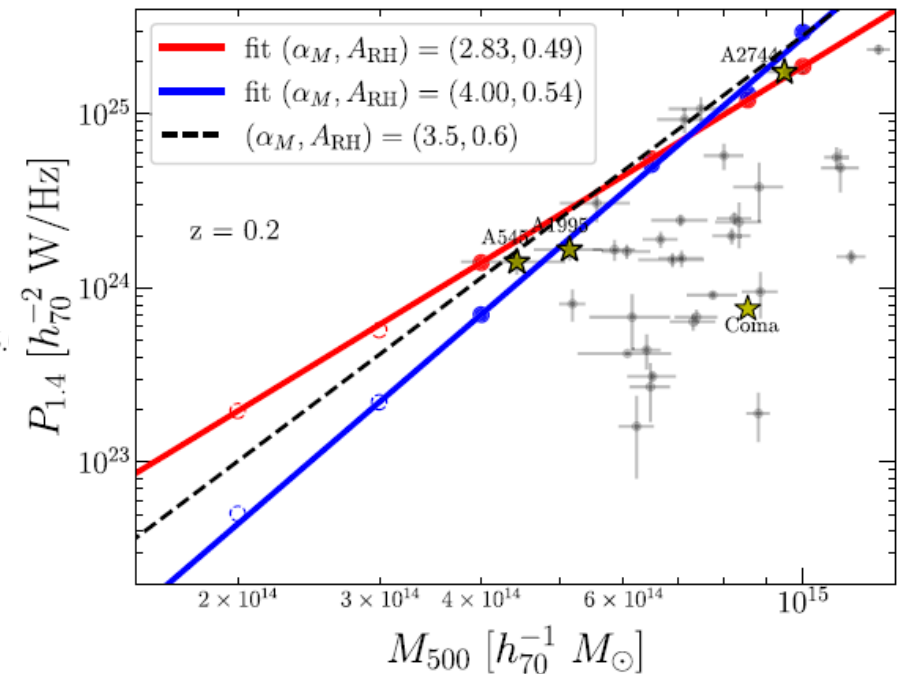


# Simulations of Cluster Merger

## Nishiwaki & Asano 22



## Mass-radio relation

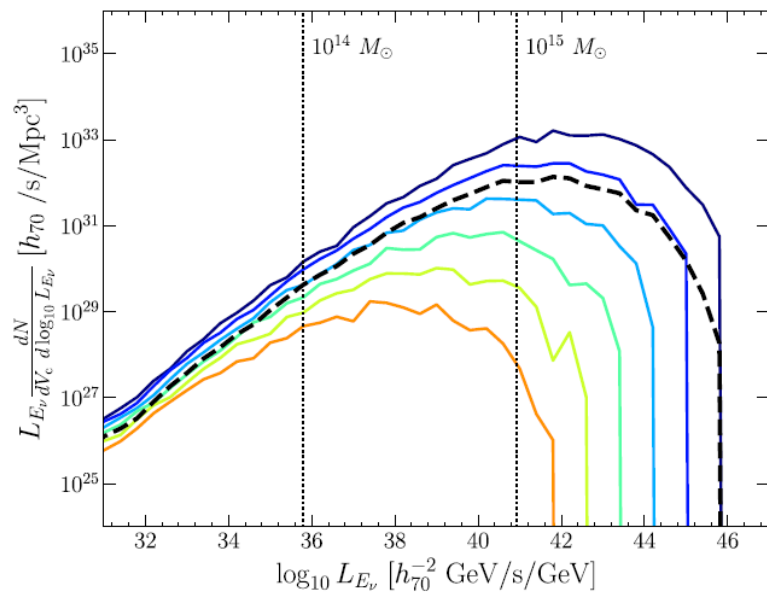
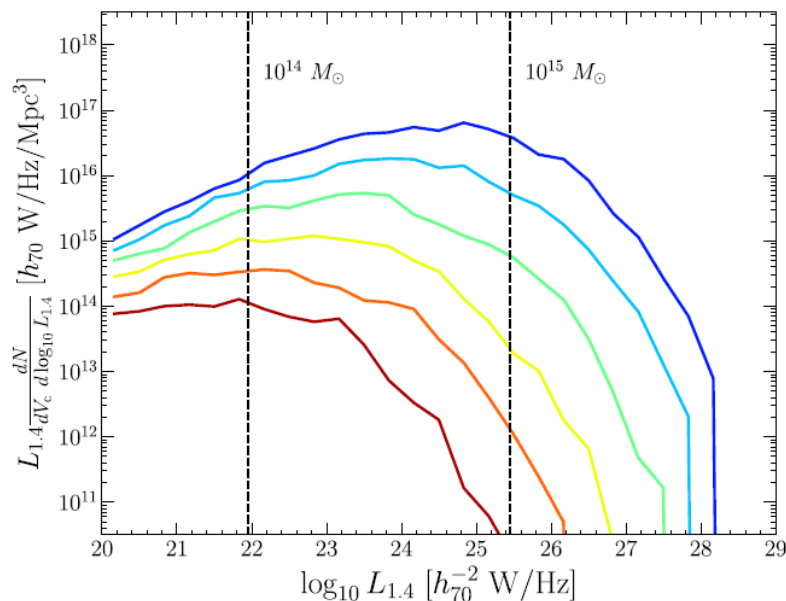


**Evolution of cluster & Mass function**

**Merger induces turbulence acceleration**

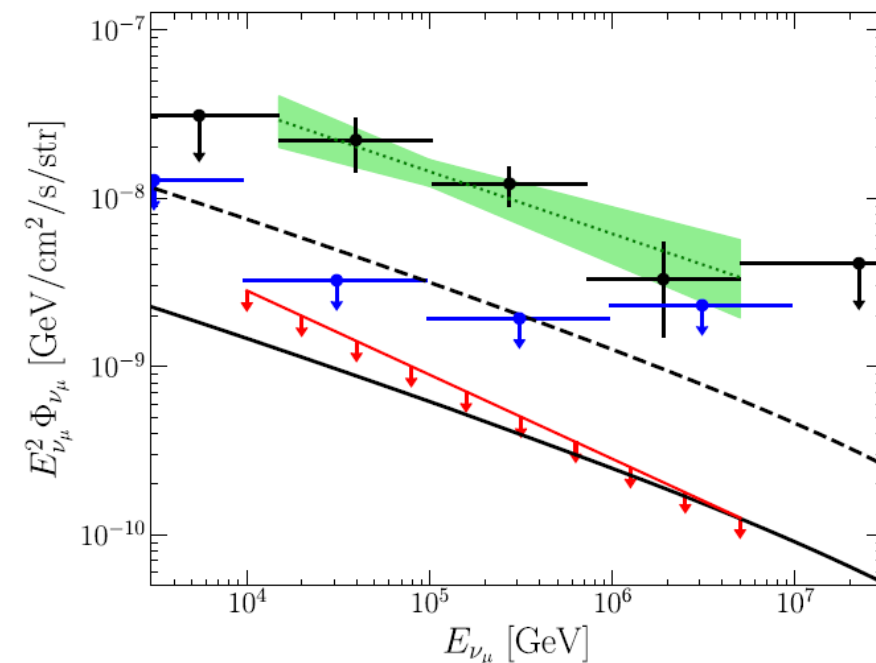
# Contribution to IceCube neutrino from clusters

Nishiwaki+23



Evolution of radio and neutrino luminosity function

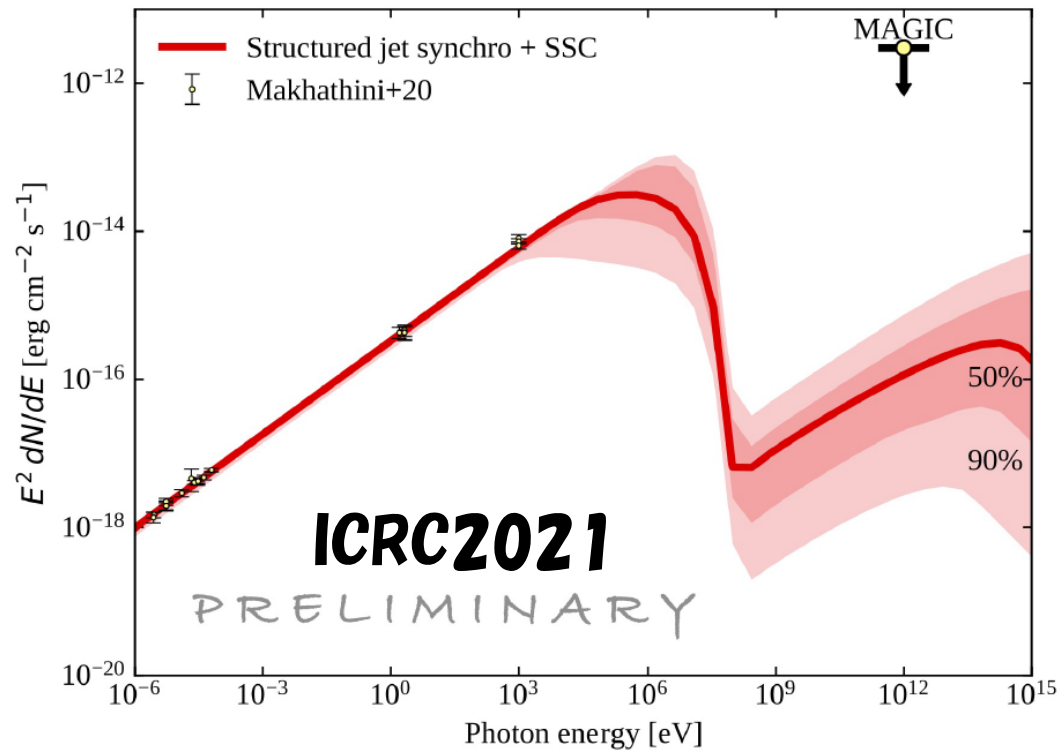
Close to the IceCube limit  
→ testable!



GeV-TeV stacking?

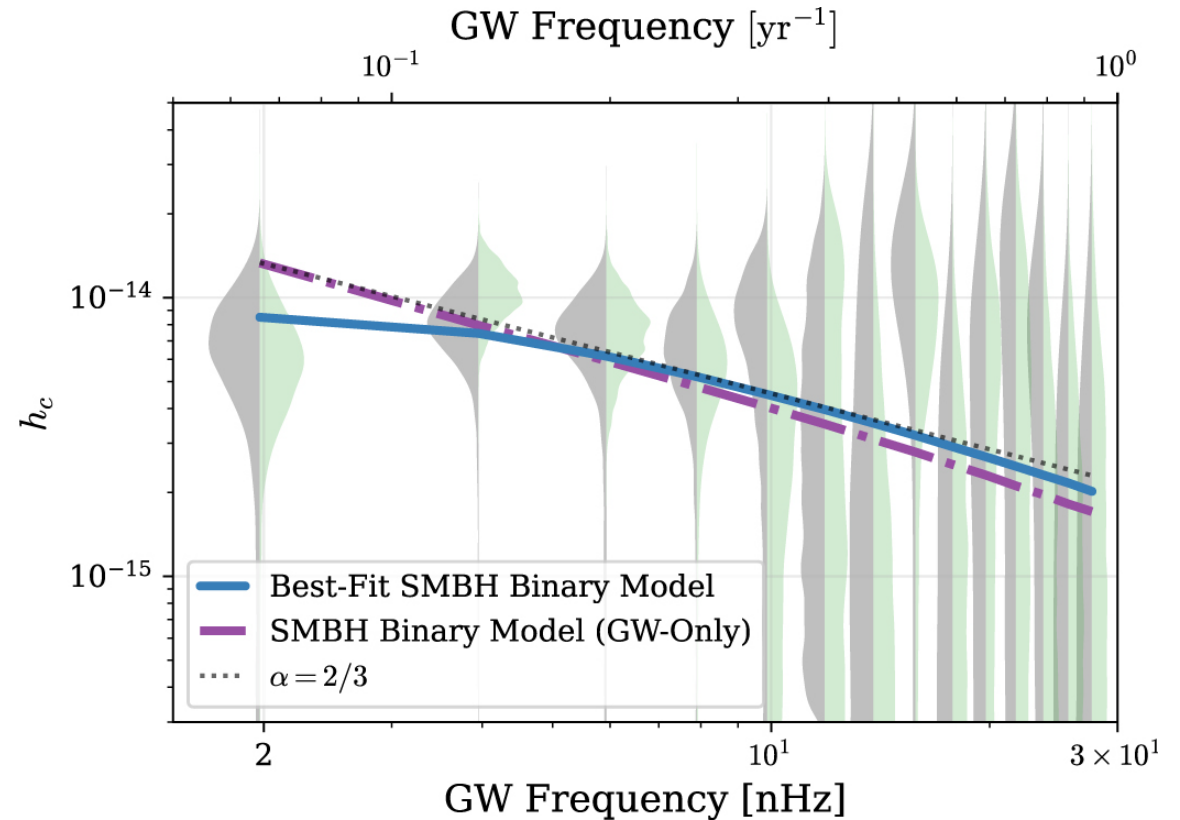
# Another messenger: Gravitational wave

## GW170817 (kHz GW)



**Difficult to detect TeV photons  
from NSNS mergers**

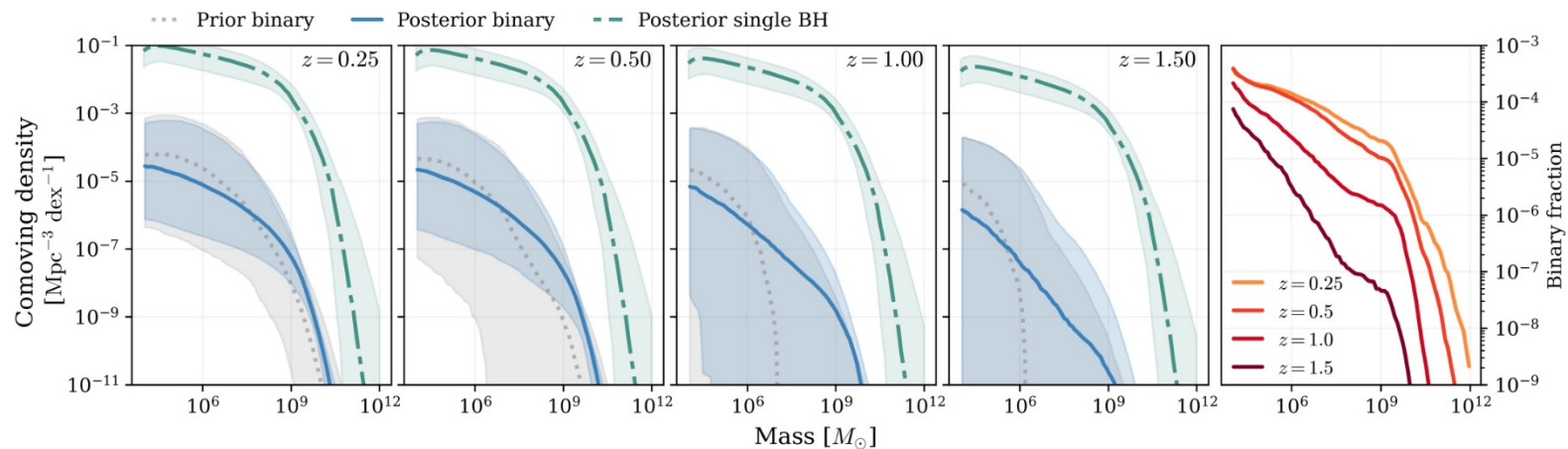
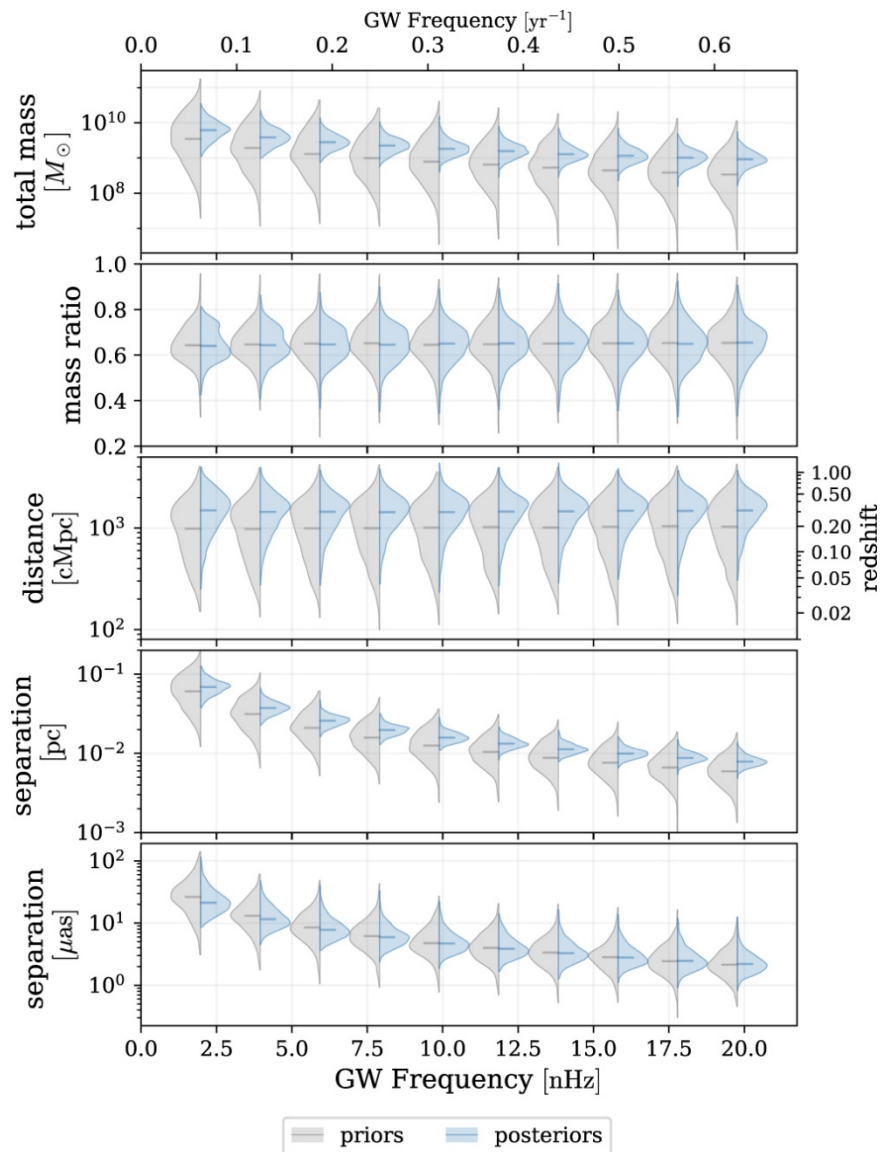
## Different frequency



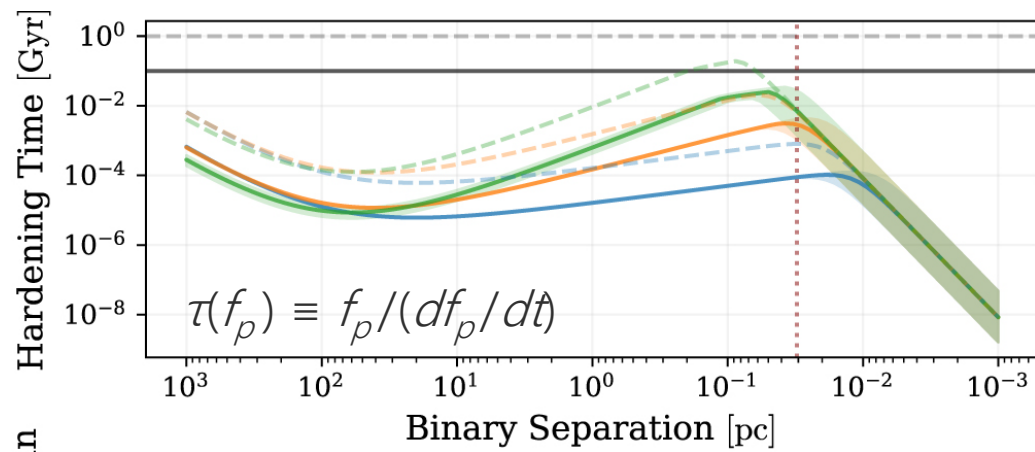
**nHz GW detection  
by NANOGrav 15 yr observation**



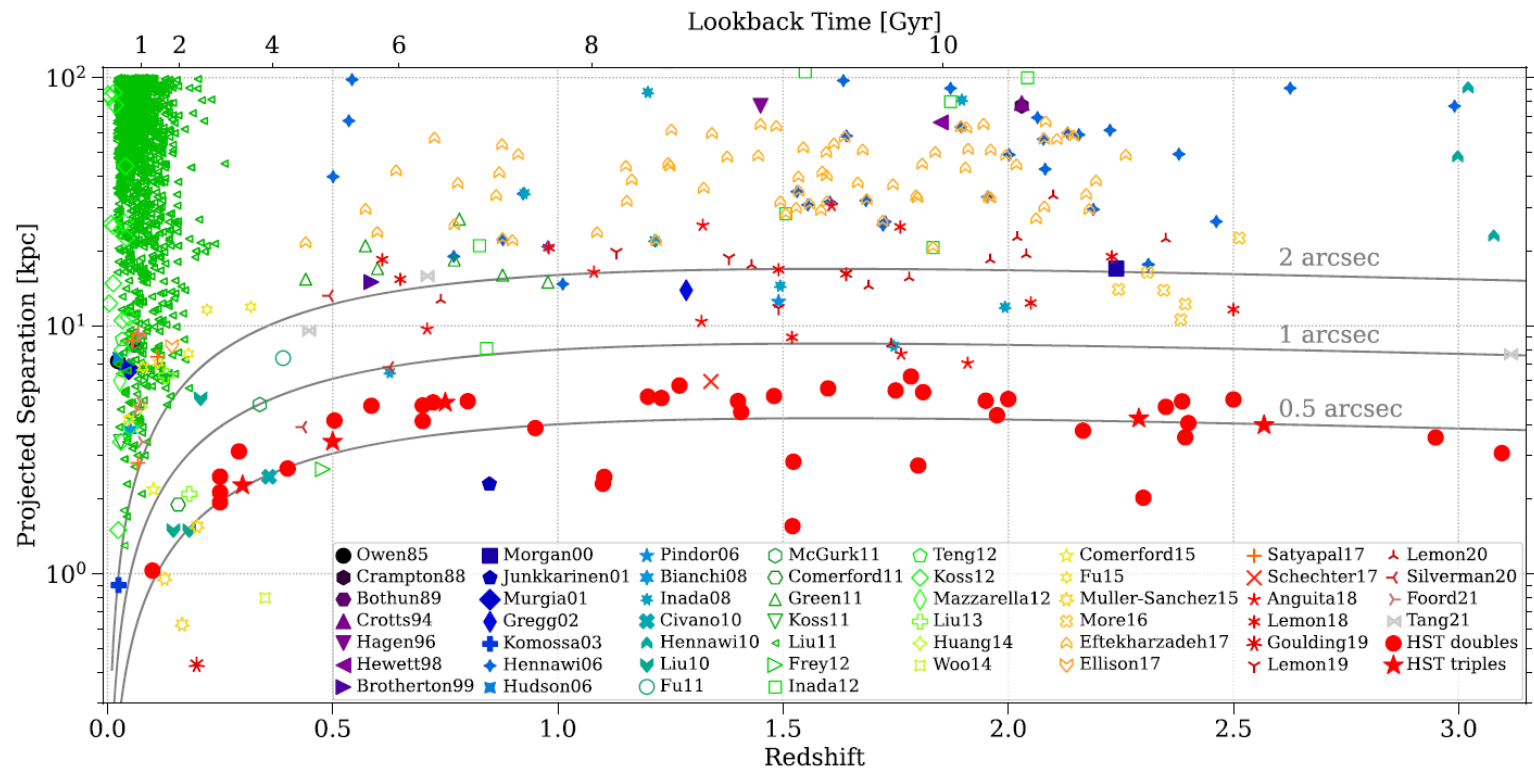
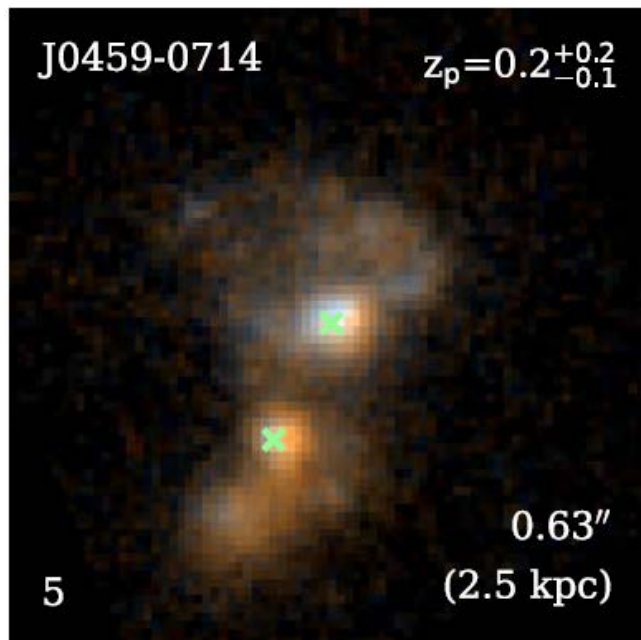
# SMBH binary with sub-pc separation



**Population study by Agazie+ 23**  
**Contribution of  $10^9 M_{\text{sun}}$  BH binary**  
**with sub-pc separation.**  
**Binary fraction is small (?)**



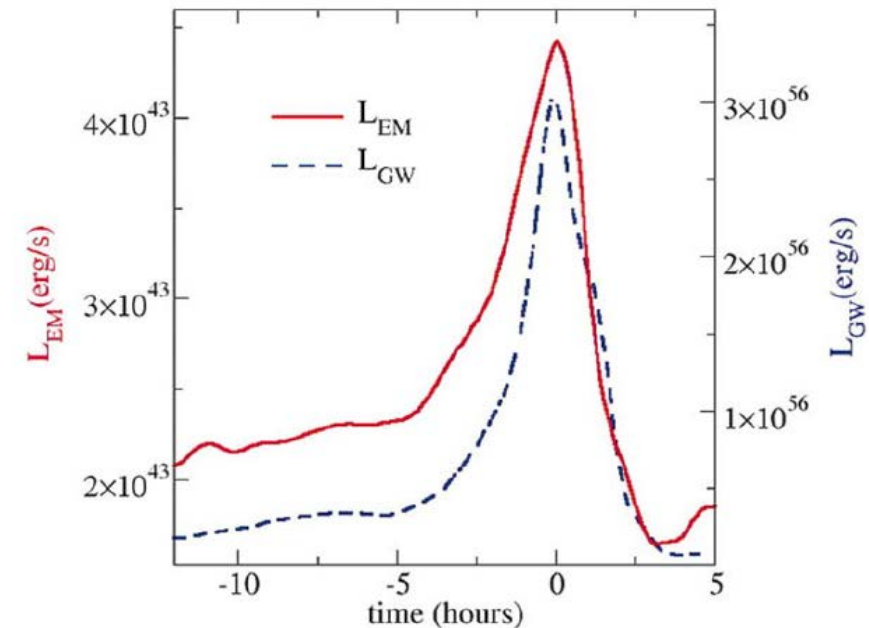
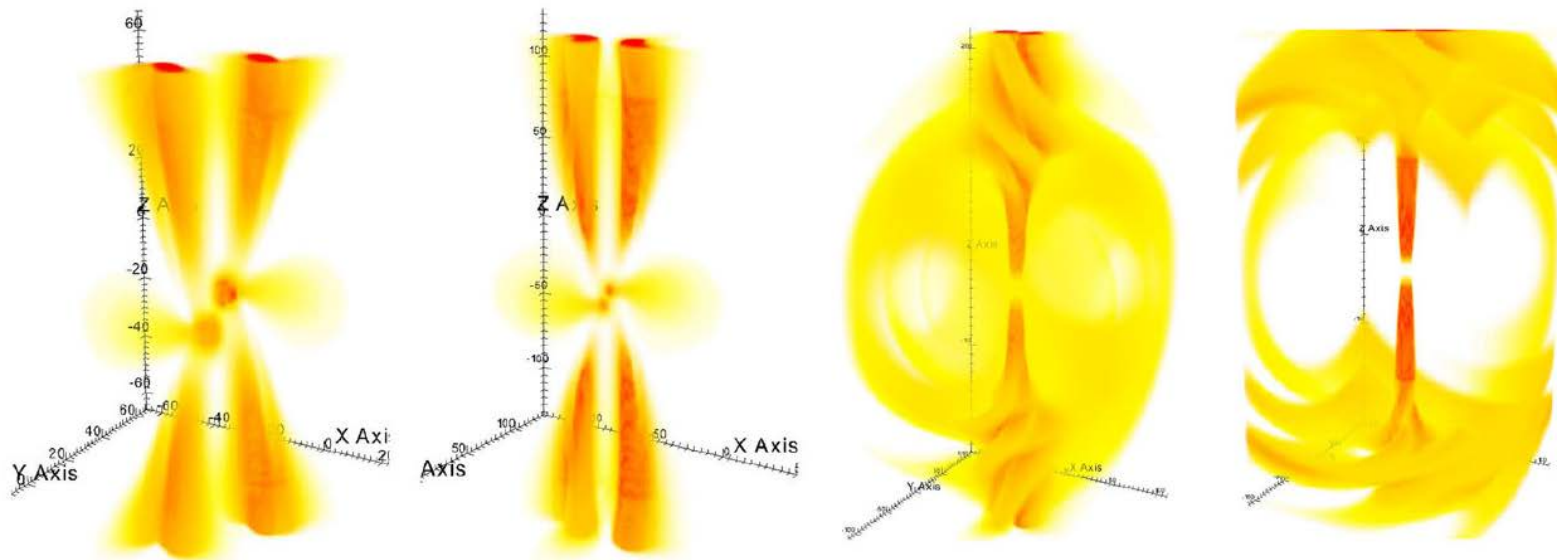
# SMBH with kpc separation



**Chen+ 22**

# SMBH merger

Palenzuela+ 10

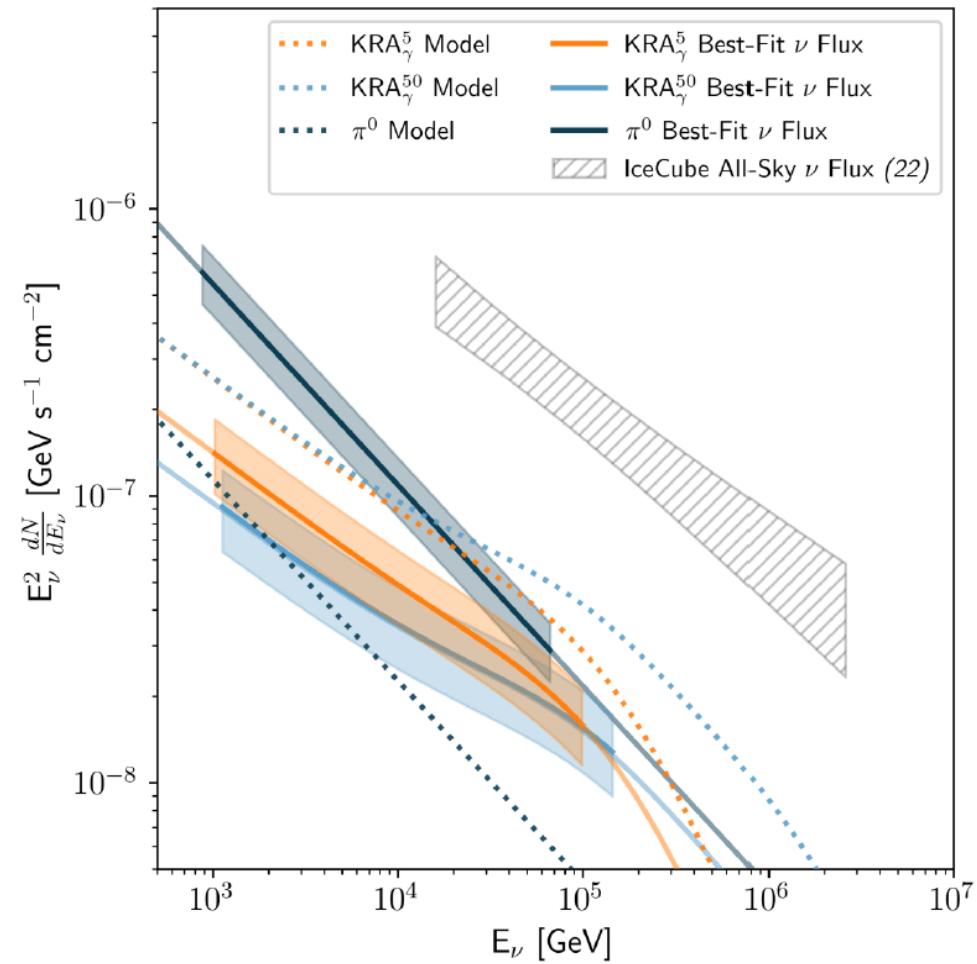
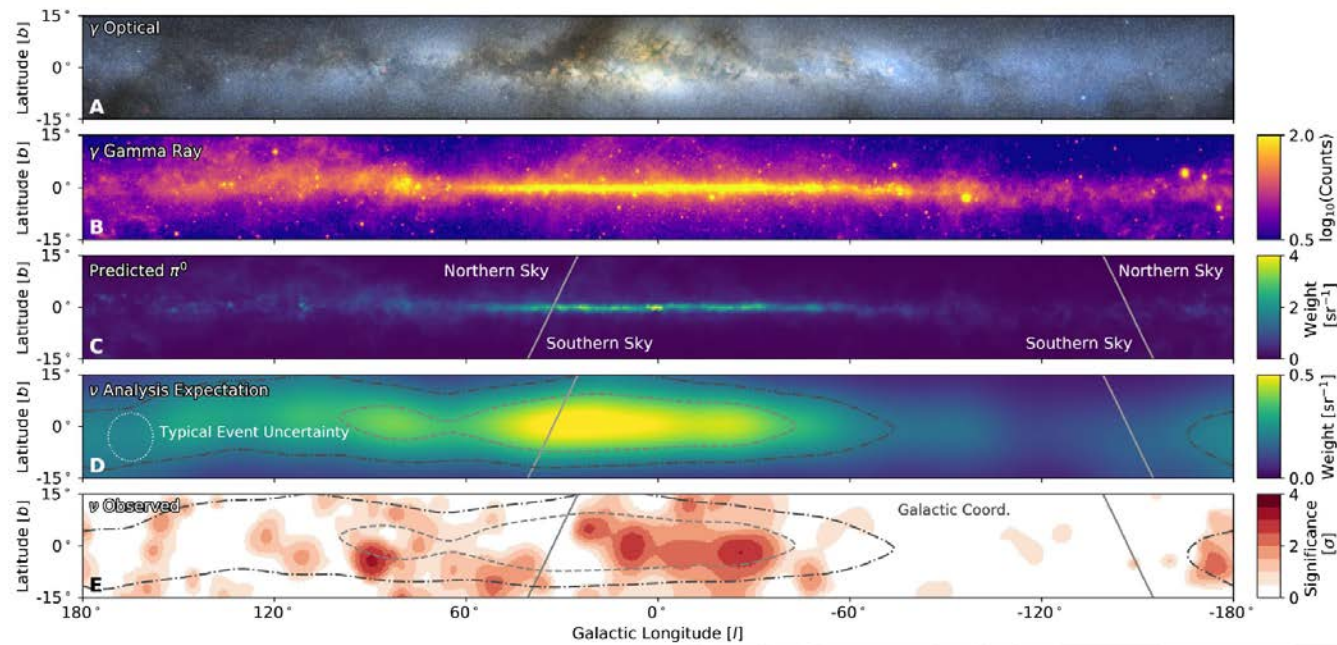


## Magnetized binary

$$L_{\text{Poynt,peak}} \approx 3 \times 10^{43} \text{ erg s}^{-1} \left( \frac{B_0}{10^4 \text{ G}} \right)^2 \left( \frac{M}{10^8 M_\odot} \right)^2$$

**How much fraction for TeV?**

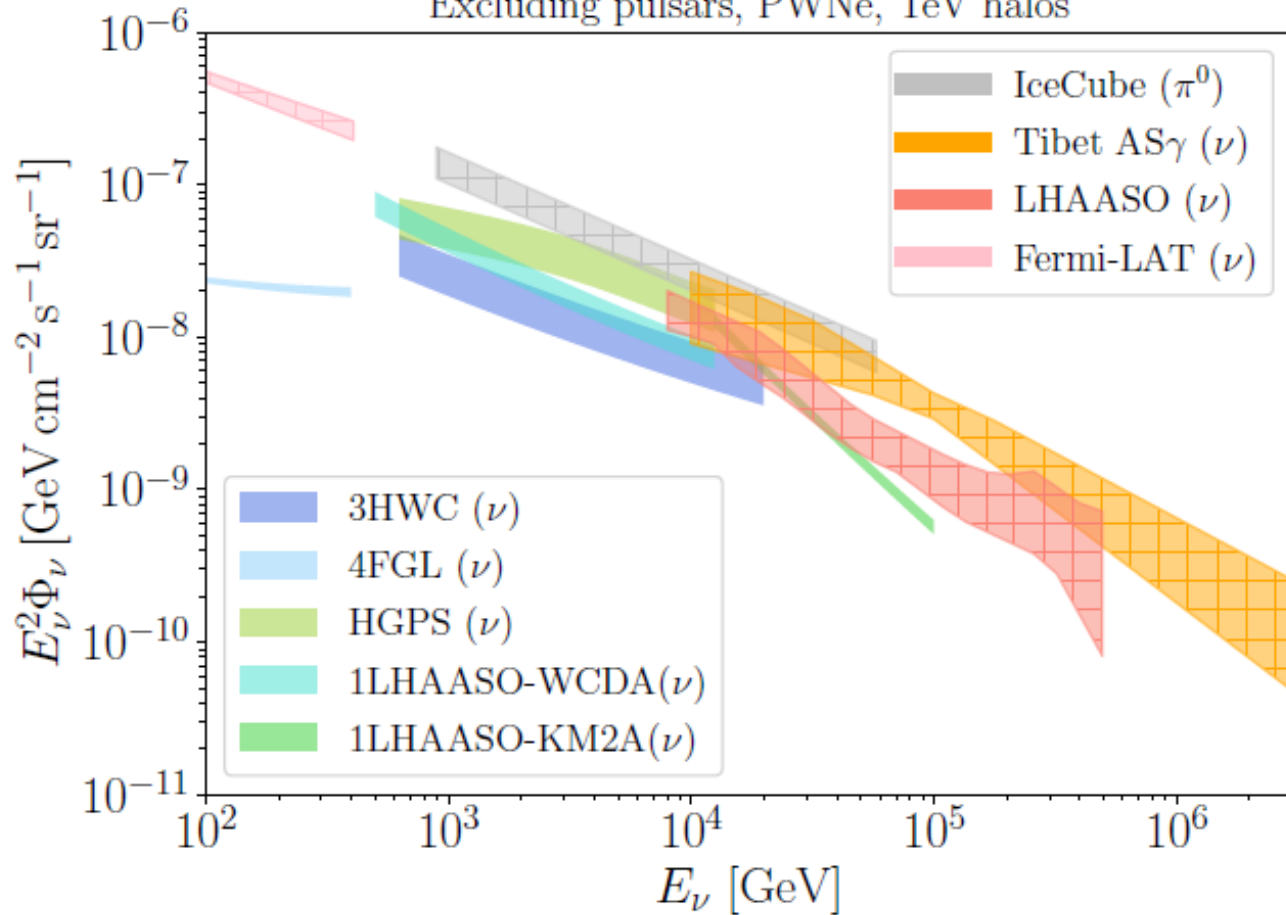
# Galactic Neutrinos



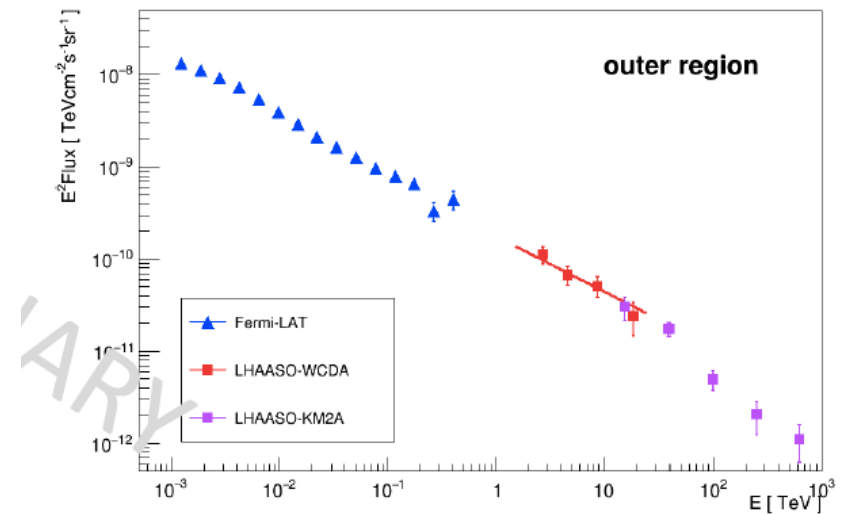
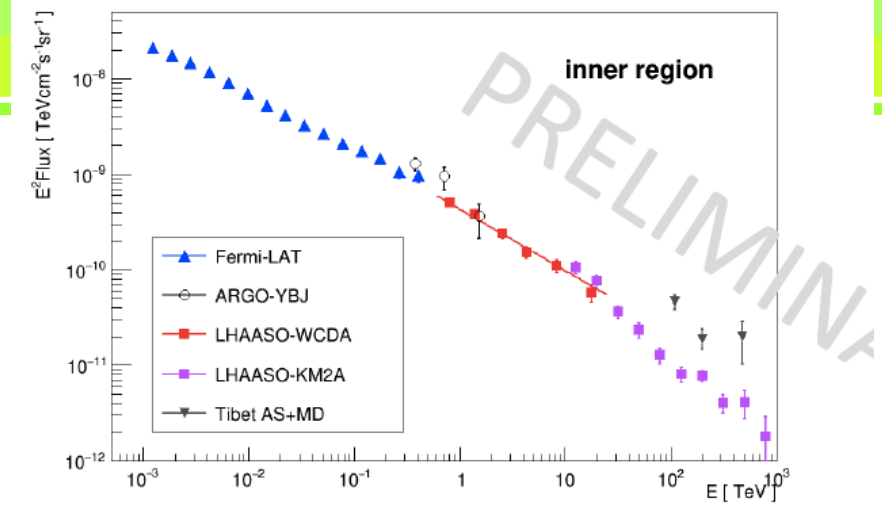


## Converted to neutrino flux

Excluding pulsars, PWNe, TeV halos



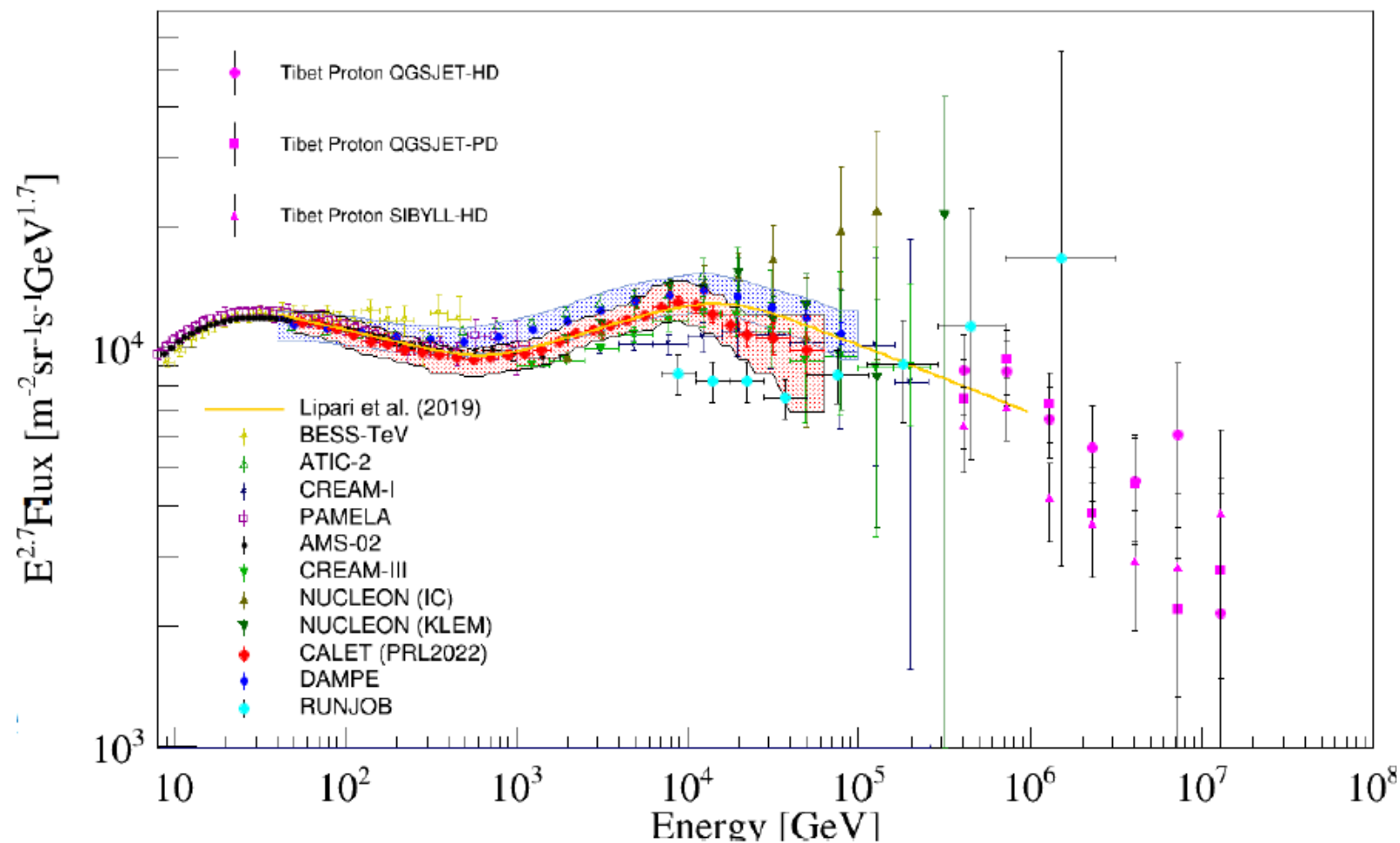
Fang & Murase 23



## LHAASO TeVPA23 Spectral Break

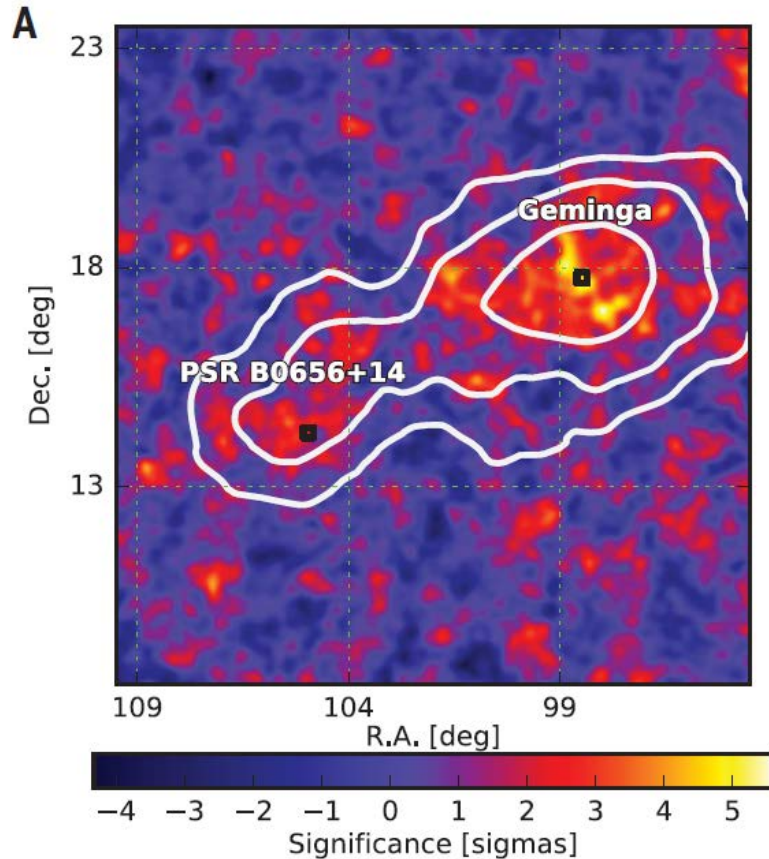


## Proton spectrum Close to the Knee?

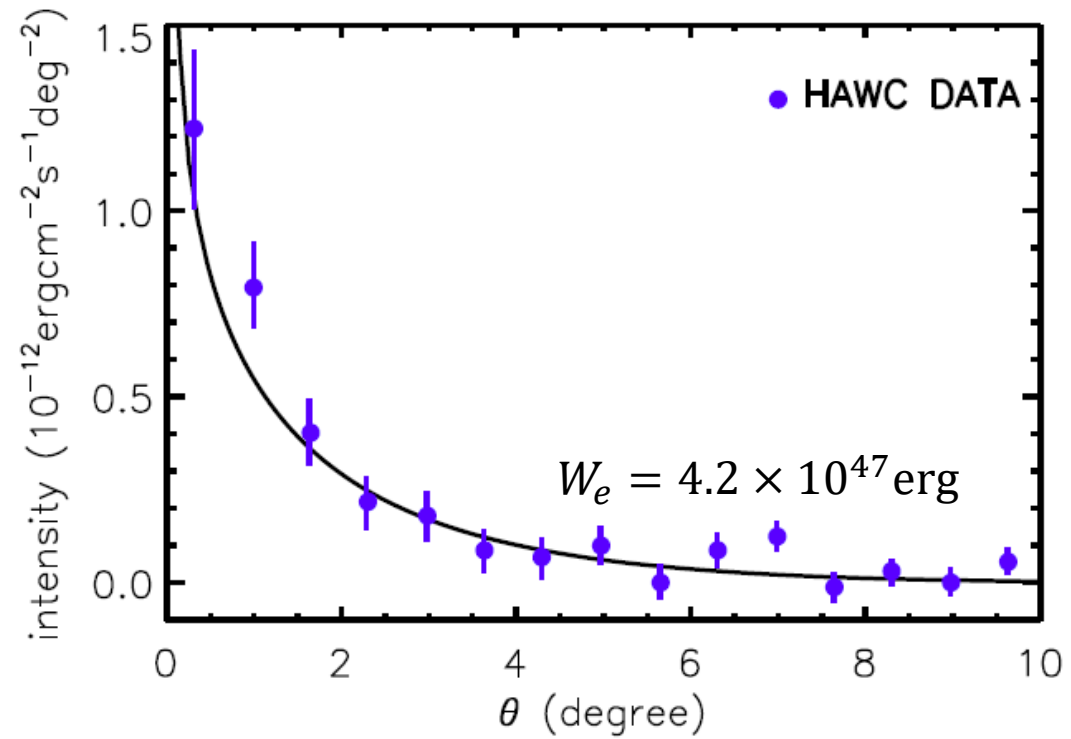


# Note: how to distinguish diffuse and sources?

**Abeysekara+ 17**

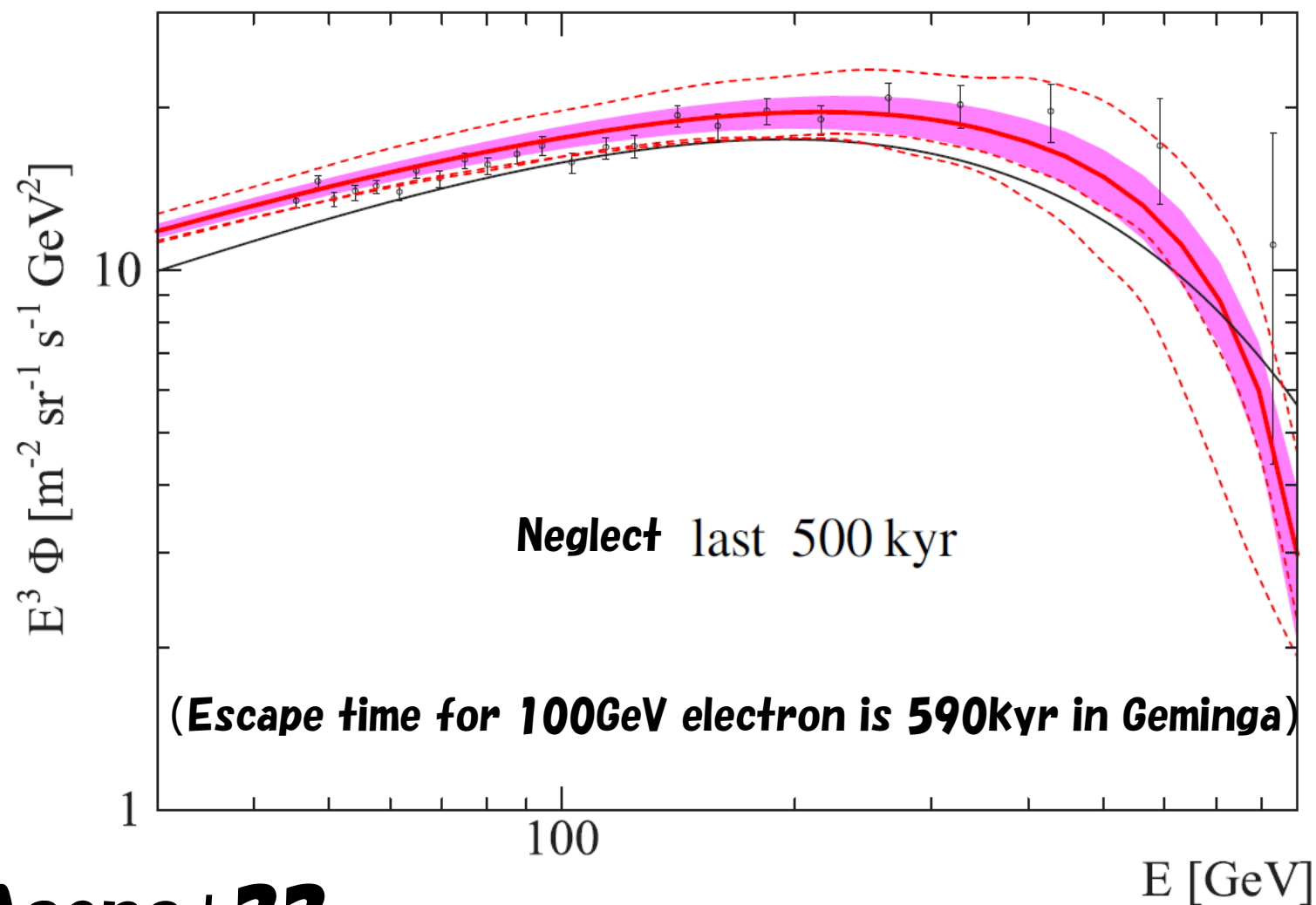


**Liu+ 2019**



**Slow electron escape from pulsar wind nebula  
typically a few hundreds kyr  
Important for study of escape with TeV Obs.**

# Pulsar component consistent with positron CRs



rate of  $1.0 \times 10^{-2} \text{ kpc}^{-2} \text{ kyr}^{-1}$

$E_{\text{tot}} = 6.5 \times 10^{47} \text{ erg}$

$\alpha = 1.9$

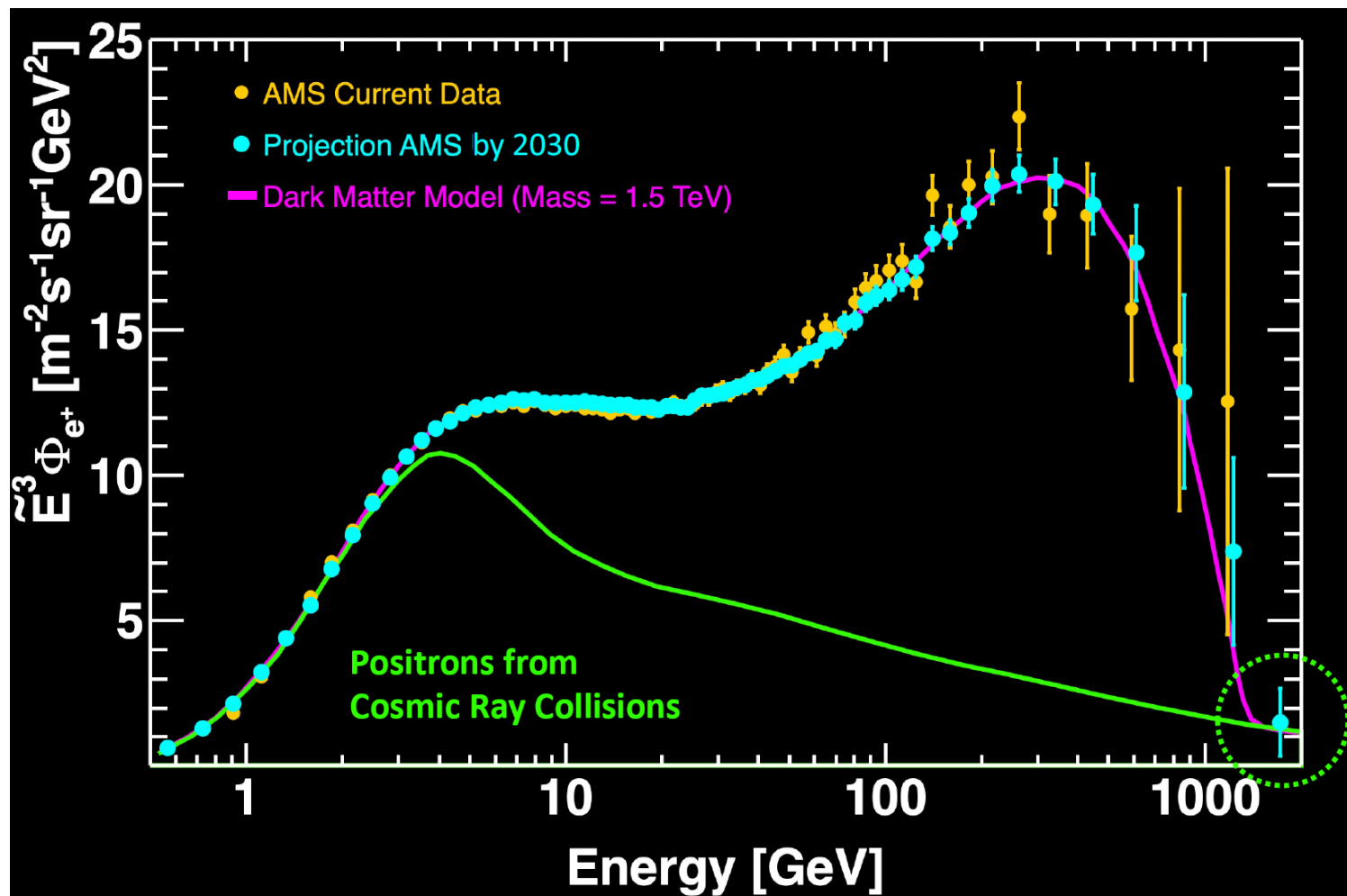
$\gamma_{\text{max}} m_e c^2 = 10 \text{ TeV}$

**Energetics**

$$\mathcal{R}E_{\text{tot}} = 6.5 \times 10^{45} \text{ erg kpc}^{-2} \text{ kyr}^{-1}$$

# Future AMS data for positrons

## AMS-02 ICRC2023



**Check with PWN obs. with TeV**

# Summary

- **Neutrinos from Seyfert, TDE, Galaxy Cluster**
- **Gravitational wave from SMBH binary**
- **CR protons and PeV gamma-rays**
- **CR positrons and Escape process from PWN**

