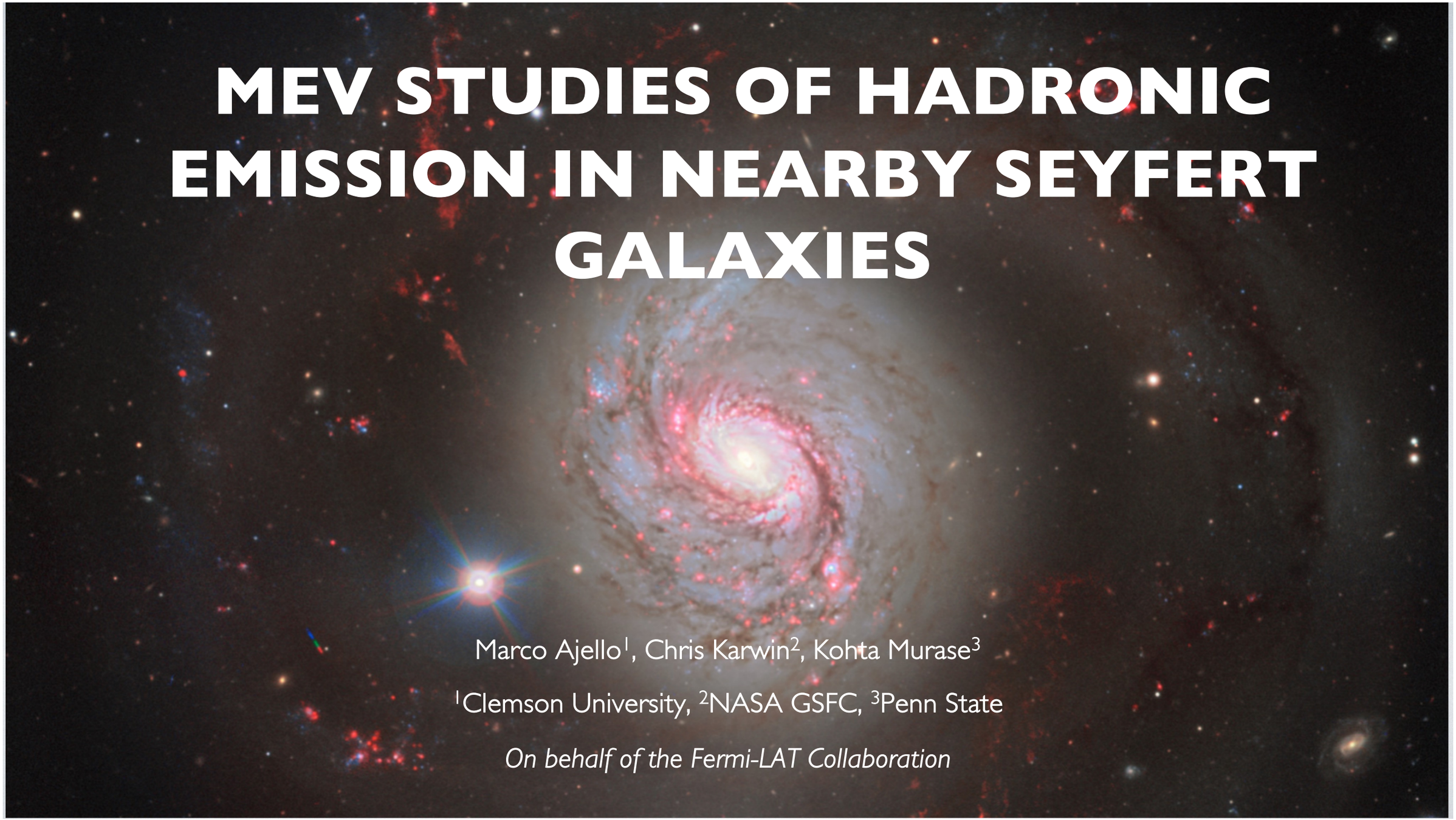
MEV STUDIES OF HADRONIC EMISSION IN NEARBY SEYFERT GALAXIES



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On behalf of the Fermi-LAT Collaboration

SEYFERT GALAXIES

- Seyferts are a type of active galaxy, characterized by their bright, compact nuclei and strong emission lines in their spectra (Carl Seyfert, 1940)

- Seyferts can be of two types: Sy1 and Sy2 depending on the visibility of the BLR

NGC 1068
10 Mpc

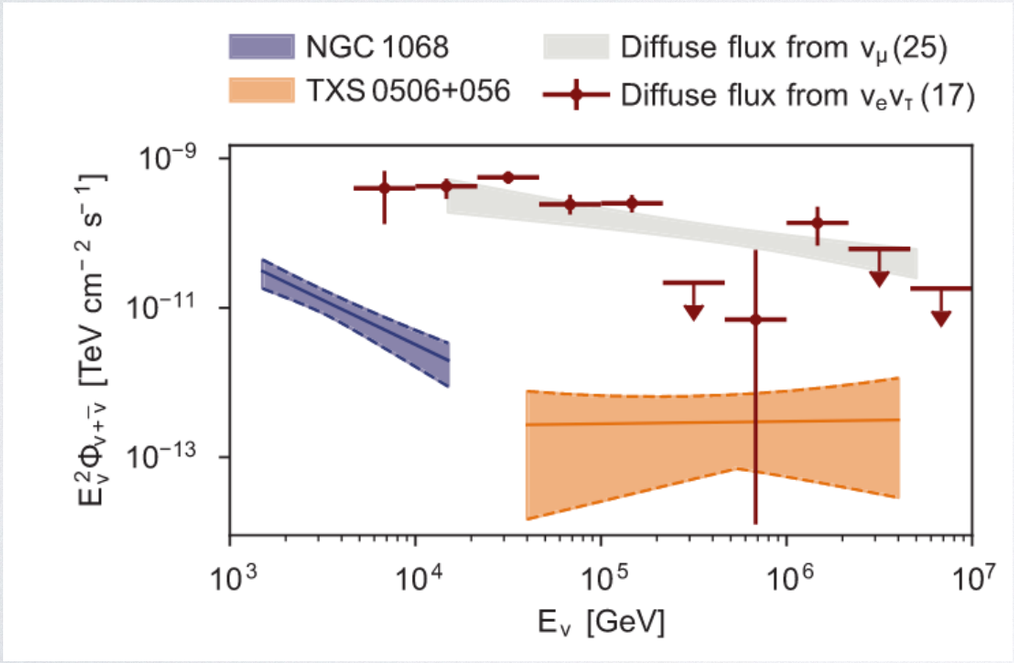
NGC 4945
3.6 Mpc

NGC 4151
15 Mpc

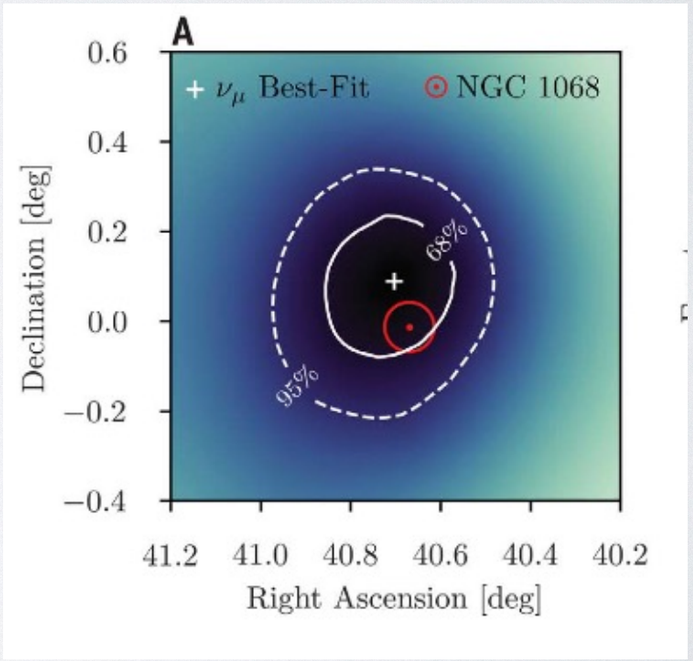
The Circinus Galaxy
4.2 Mpc

TEV NEUTRINOS FROM NGC 1068

- IceCube has reported the detection of NGC 1068 at 4.2 σ (IceCube Collab. 2022) at 2-20 TeV



NGC 1068



IceCube Collab 2022

γ AND ν PRODUCTION

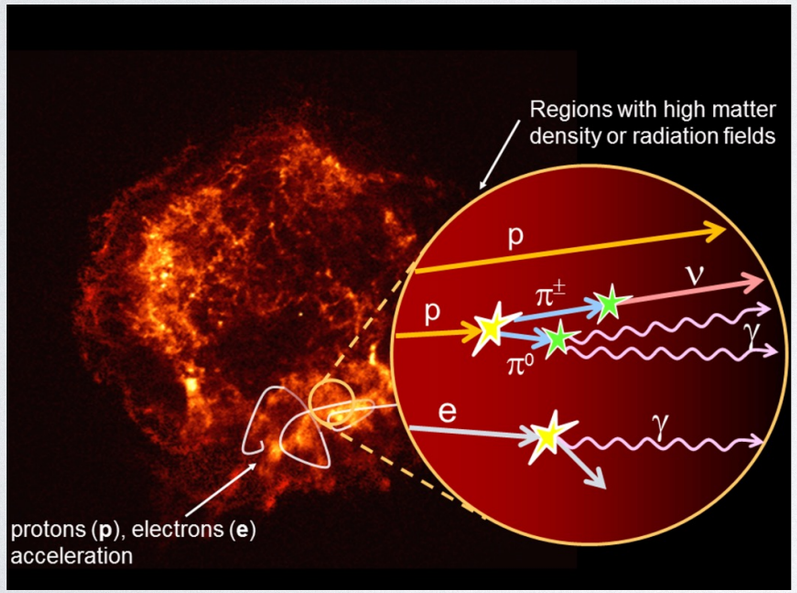
$p + \gamma -> n + \pi^+$

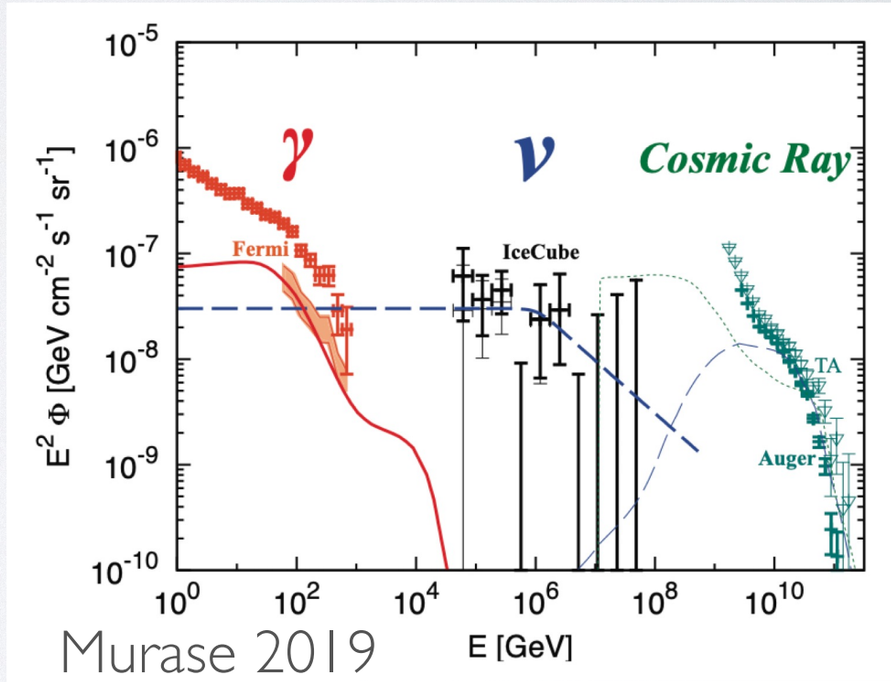
$\pi^+ -> \mu^+ + \nu_\mu$

$\mu^+ -> e^+ + \nu_e + \bar{\nu}_\mu$

$p + \gamma -> p + \pi^0$

$\pi^0 -> \gamma + \gamma$

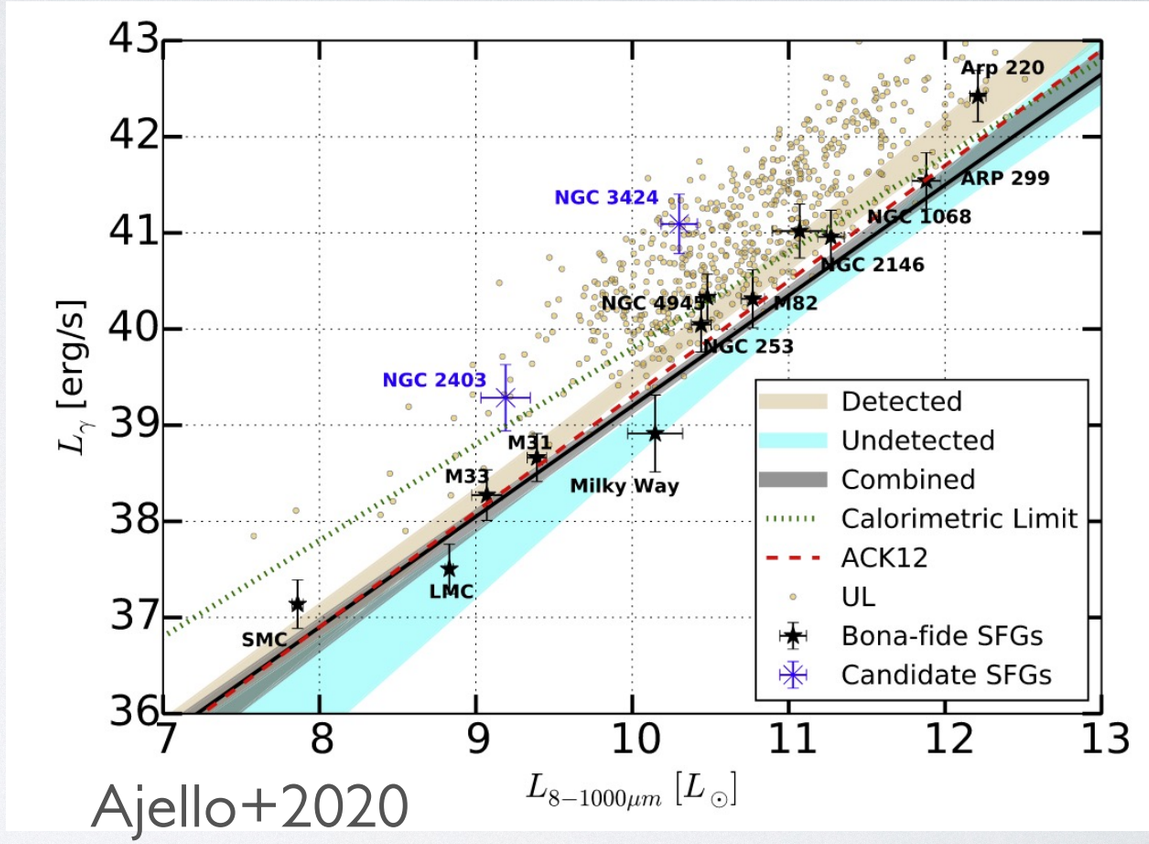




Murase 2019

STAR-FORMING GALAXIES

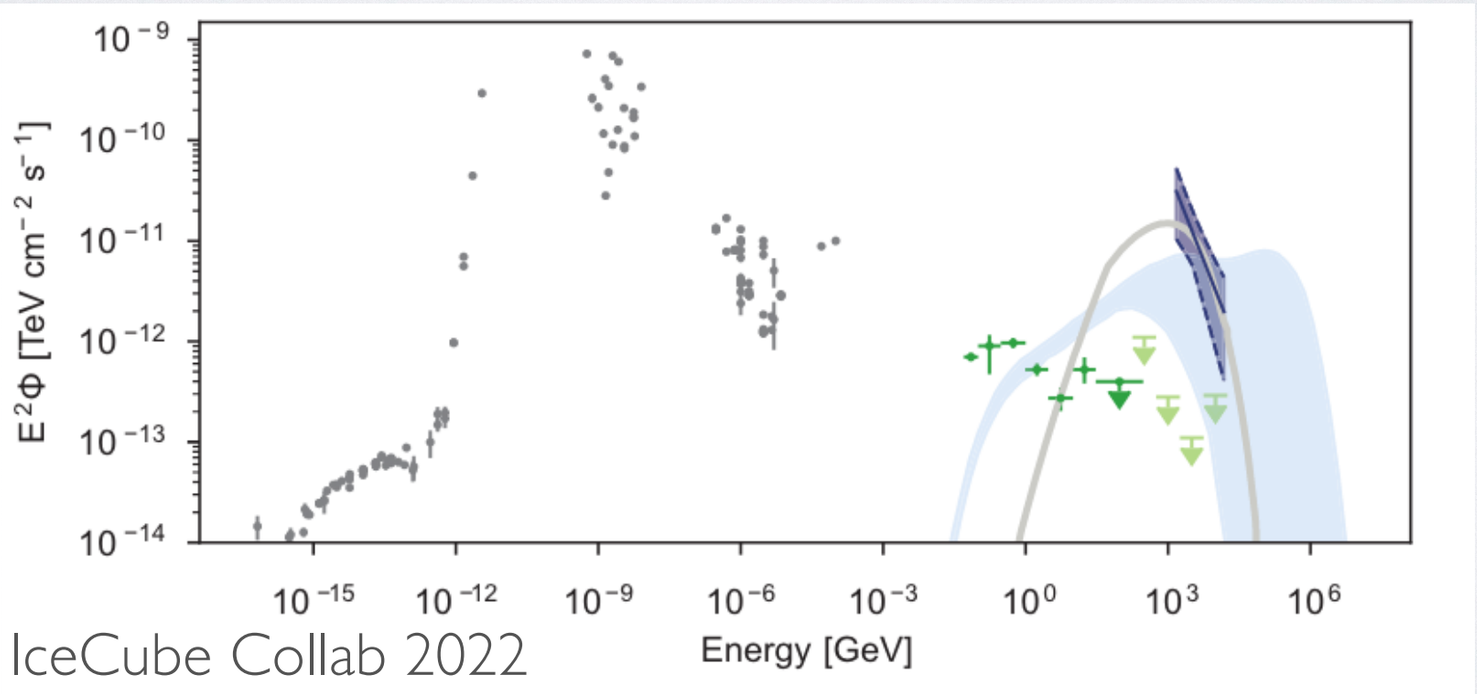
- GeV emission of star-forming galaxies correlates well with tracers of star-formation activity (IR and 1.4 GHz luminosities)
- No variability has so far been observed, consistently with the hypothesis that this emission is powered by star formation



Ajello+2020

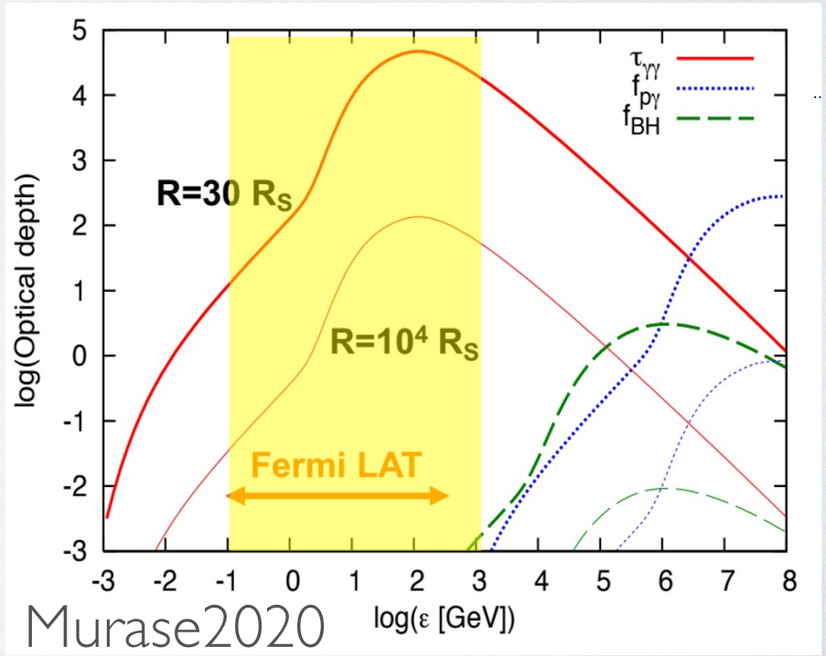
GEV/TEV OBSERVATIONS OF NGC 1068

- At ~1-2 TeVs the neutrino source is >10 times brighter than the γ-ray one
- It implies the neutrinos are generated in a region of the galaxy which is opaque to γ rays



IceCube Collab 2022

WHERE TO HIDE A VERY BRIGHT SOURCE?

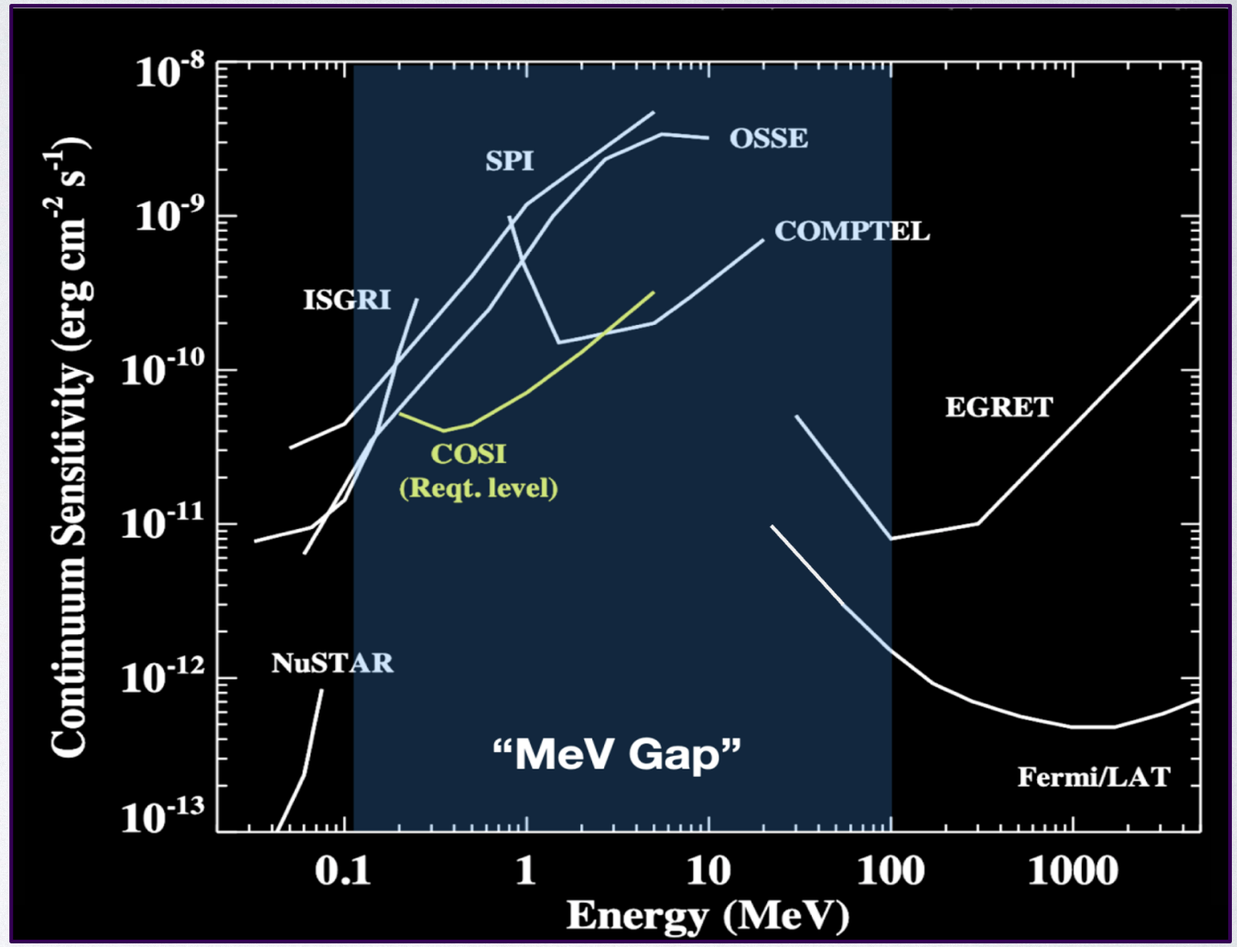


Murase2020

SOLUTIONS

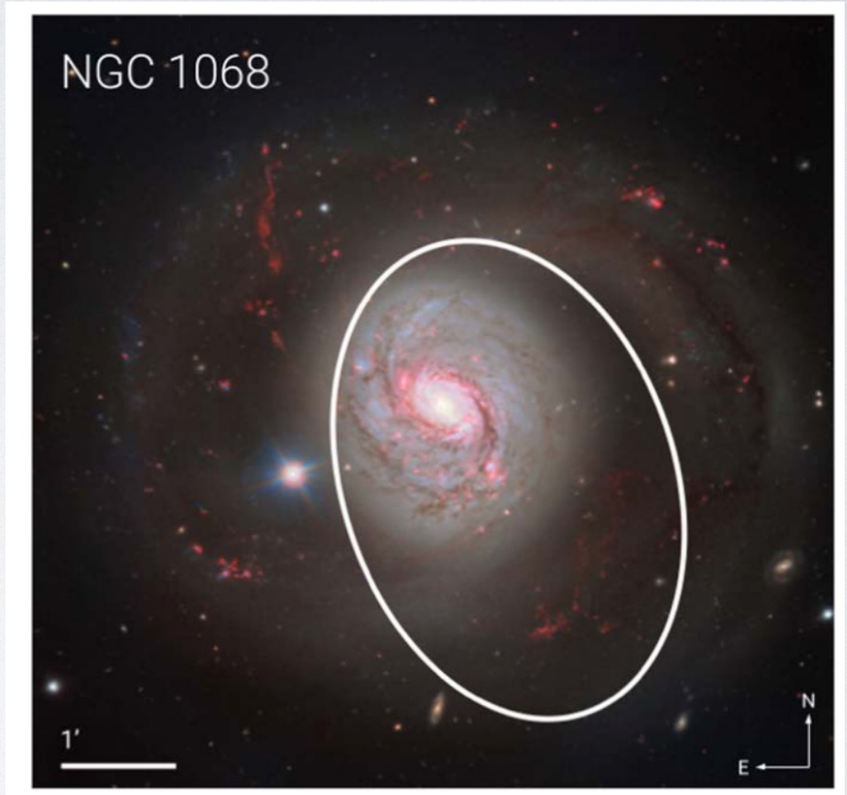
1. Wait for the launch of COSI or future MeV missions

2. Take advantage of Fermi-LAT's low-energy response



NGC 1068: ANALYSIS

- 14.3 yr of P8R3_Source_V3 data
- Zmax >90 for 50 MeV – 1 TeV
- Zmax > 80 for 20-50 MeV
- 4FGL DR3 background sources



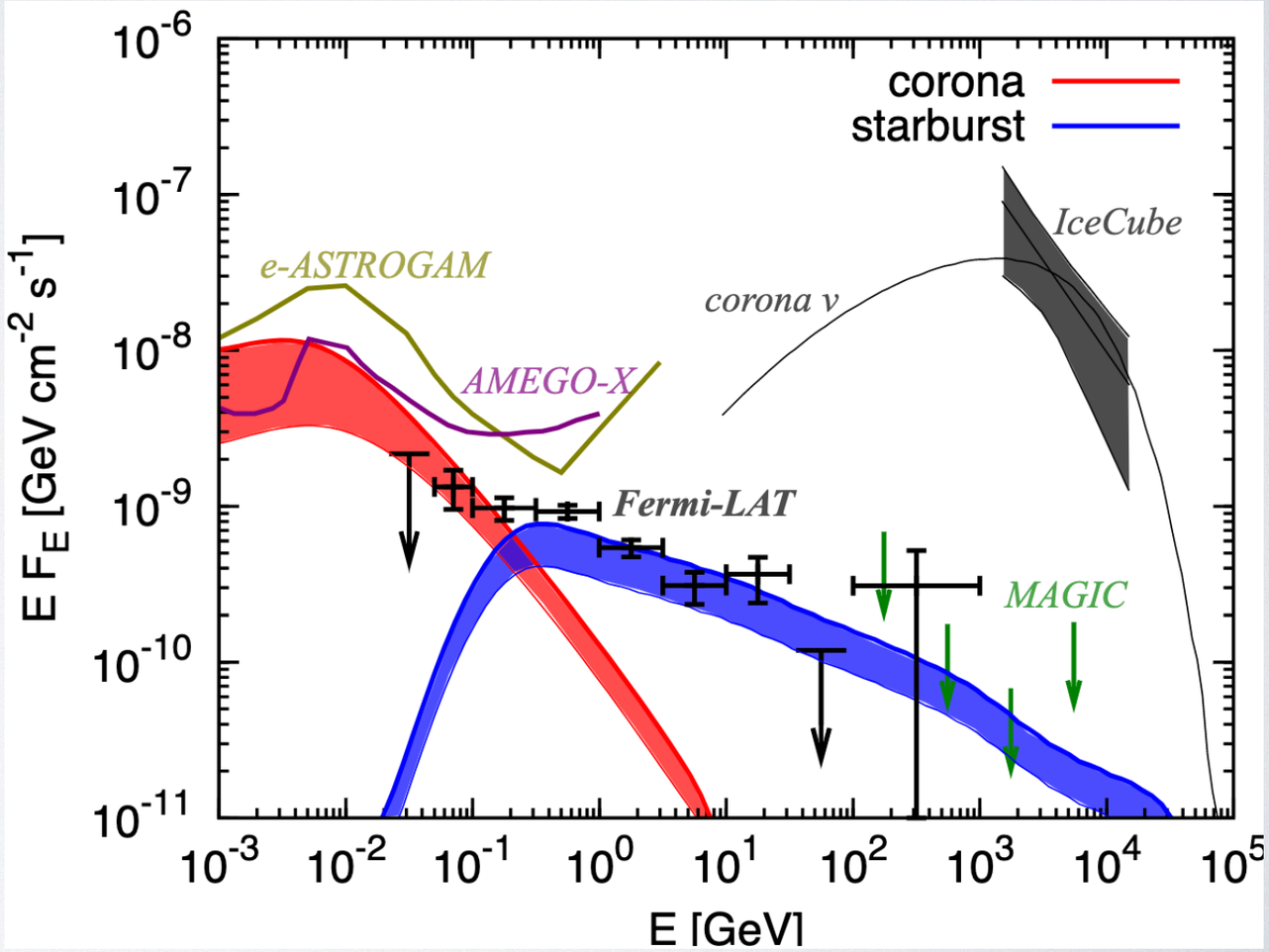
Ajello+2023

The experience around the 2FLE (Joffre's talk) made this analysis possible

NGC 1068: HIDDEN AGN CORE

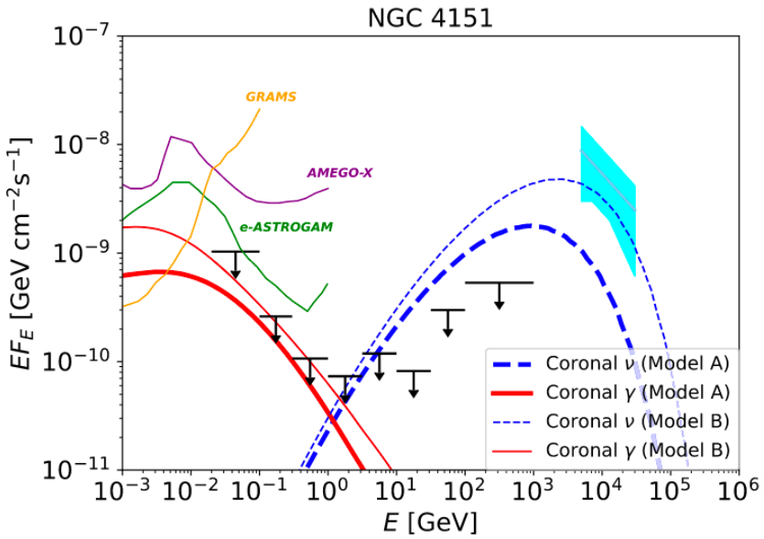
- The starburst component explains well the >300 MeV spectrum, but cannot reproduce the Fermi-LAT low-energy data
- Hadronic emission in the AGN core reproduce the <300 MeV data

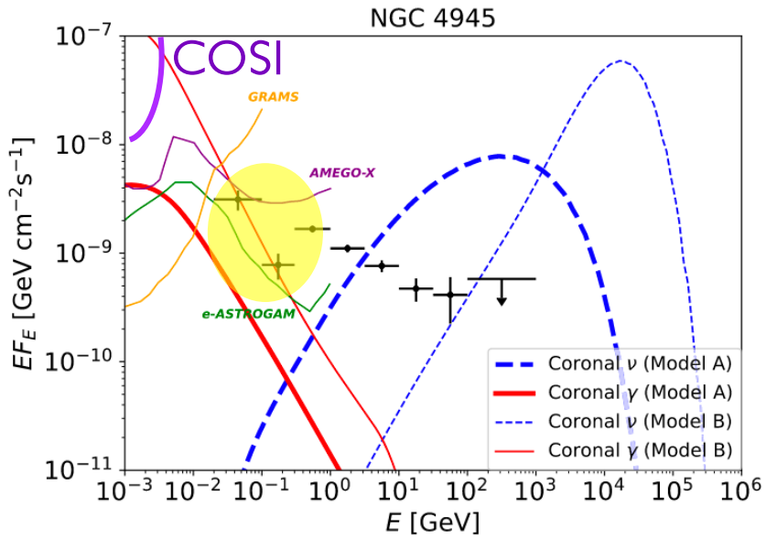
Ajello, Murase & McDaniel 2023

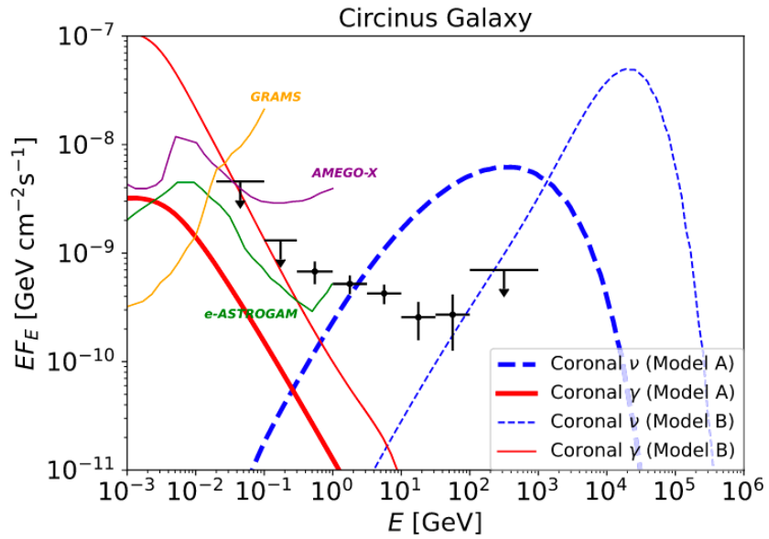


SIMILAR GALAXIES

Murase, Karwin et al. 2024







- NGC 4151, NGC 4945 and Circinus may also have low-energy data compatible with the Corona model (Murase, Karwin+24)
- NGC 4945 may be detectable by COSI

COSI LAUNCHES IN 2027

- COSI (PI J. Tomsick) has been selected by NASA as a SMEX to launch in 2027
- 0.2-5 MeV
- Cryogenically-cooled germanium detectors to provide excellent energy resolution (0.2-1%)
- Instantaneous field of view >25%-sky and covers the whole sky every day


THANK YOU !