

# Evidence of Neutrinos from the Galactic Plane

**Steve Sclafani, University of Maryland for the IceCube Collaboration**

Mirco Hünnefeld, TU Dortmund University

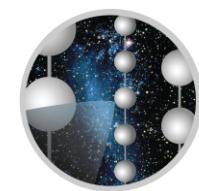
TAUP 2023

Vienna, Austria

August 29, 2023



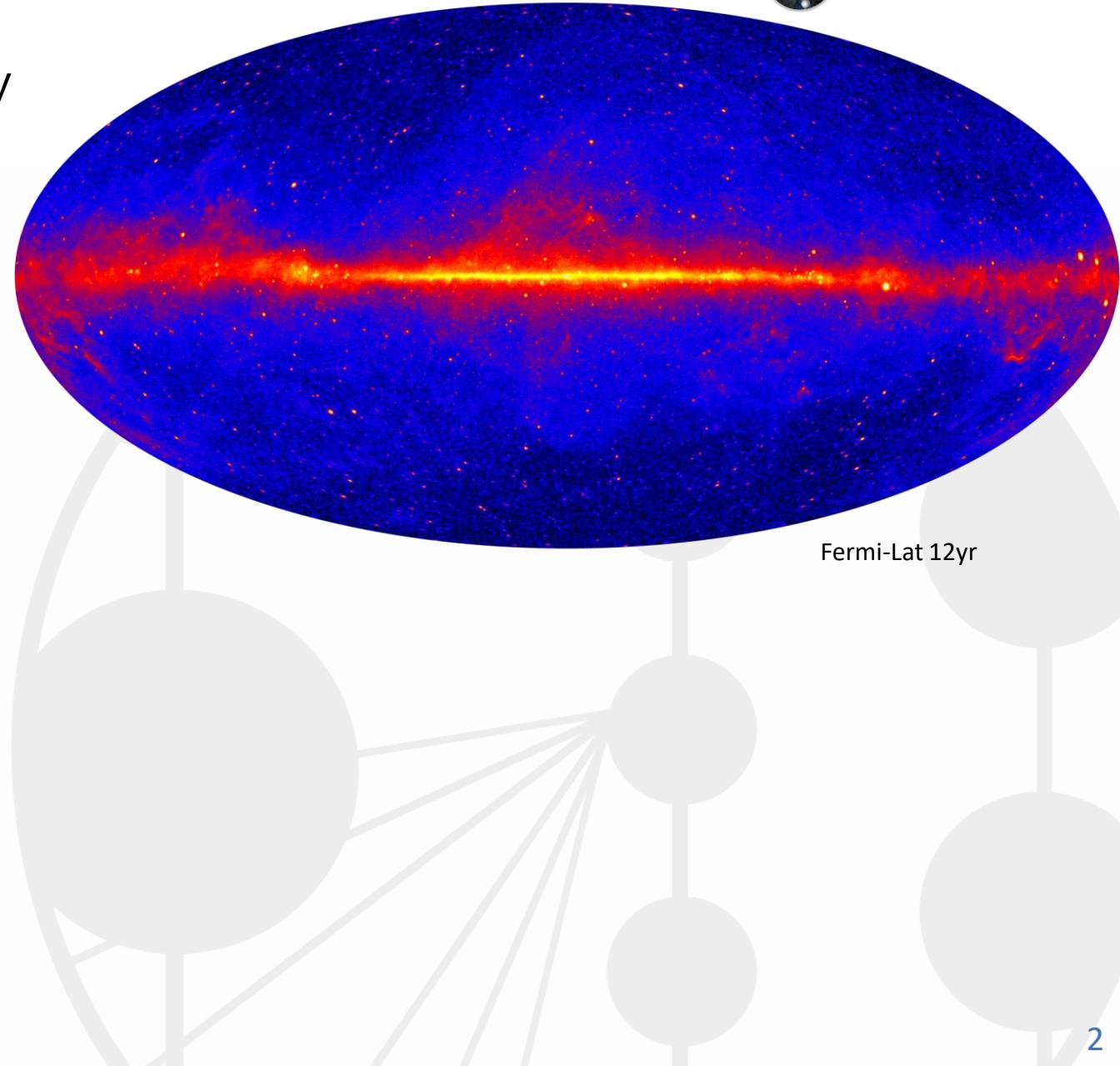
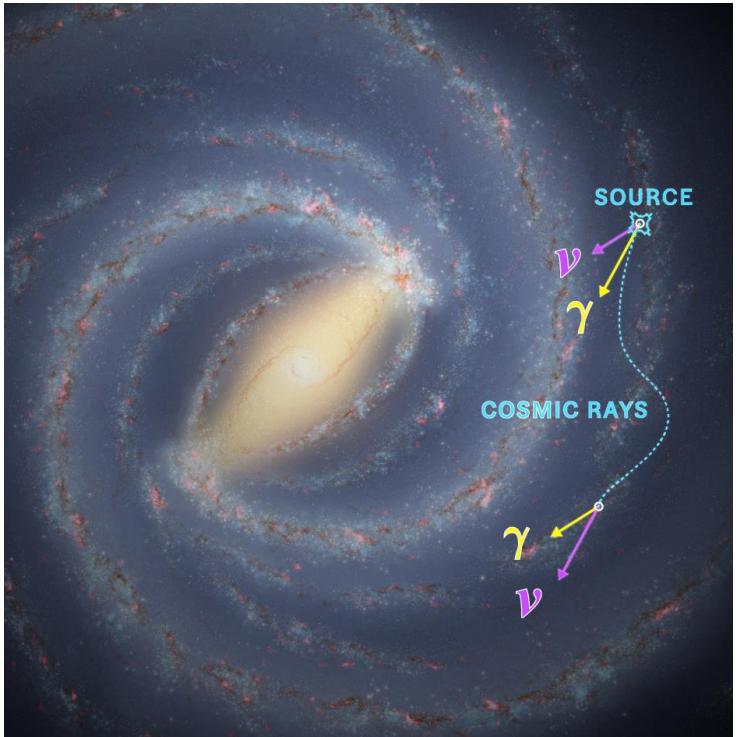
UNIVERSITY OF  
**MARYLAND**



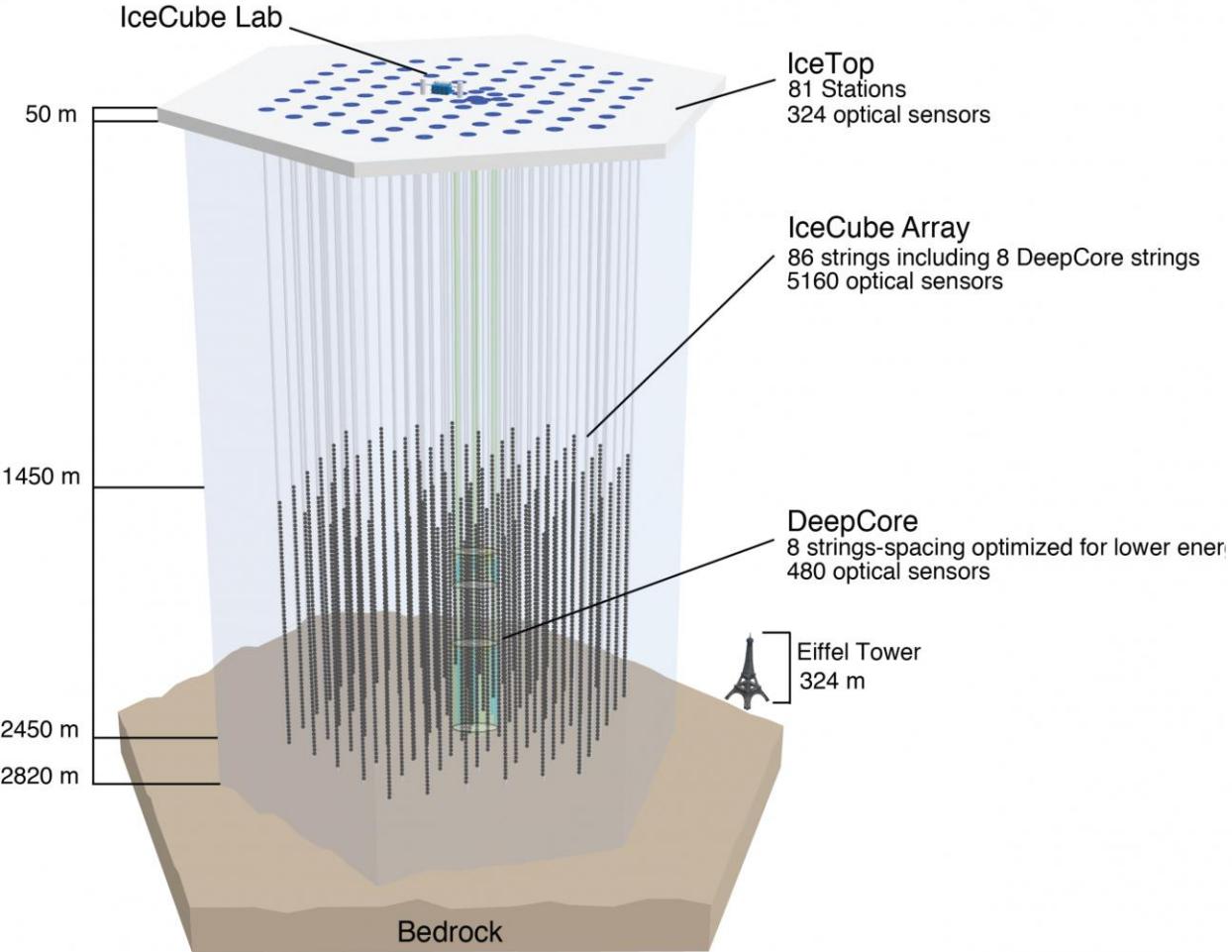
**ICECUBE**  
SOUTH POLE NEUTRINO OBSERVATORY

# Motivation

- Galactic plane dominates the gamma-ray sky
- Neutrinos could be created at sources or after cosmic-ray diffusion
- First neutrino sources from other galaxies

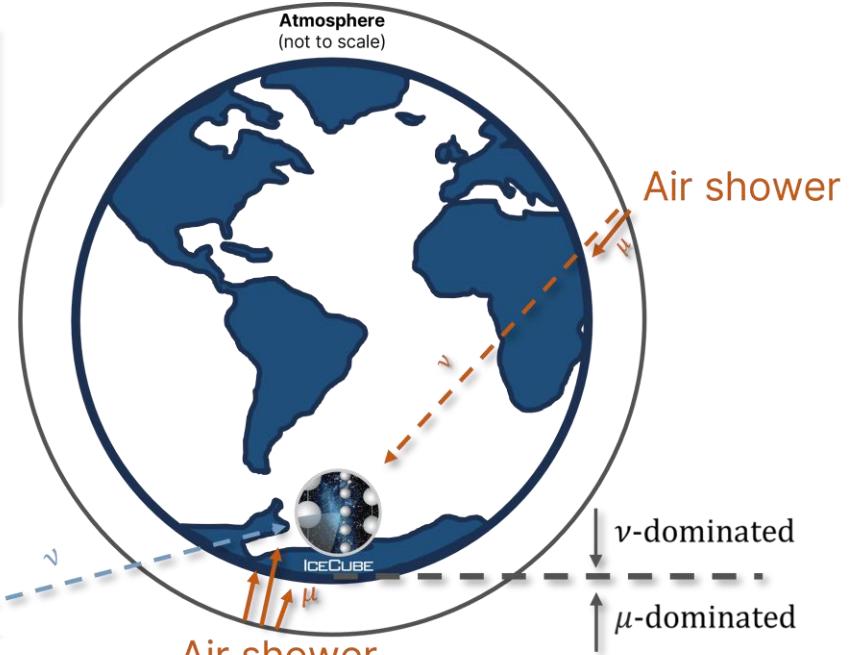
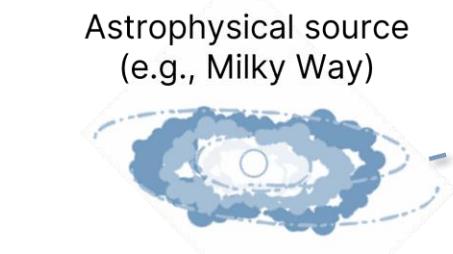


# IceCube



Rates:

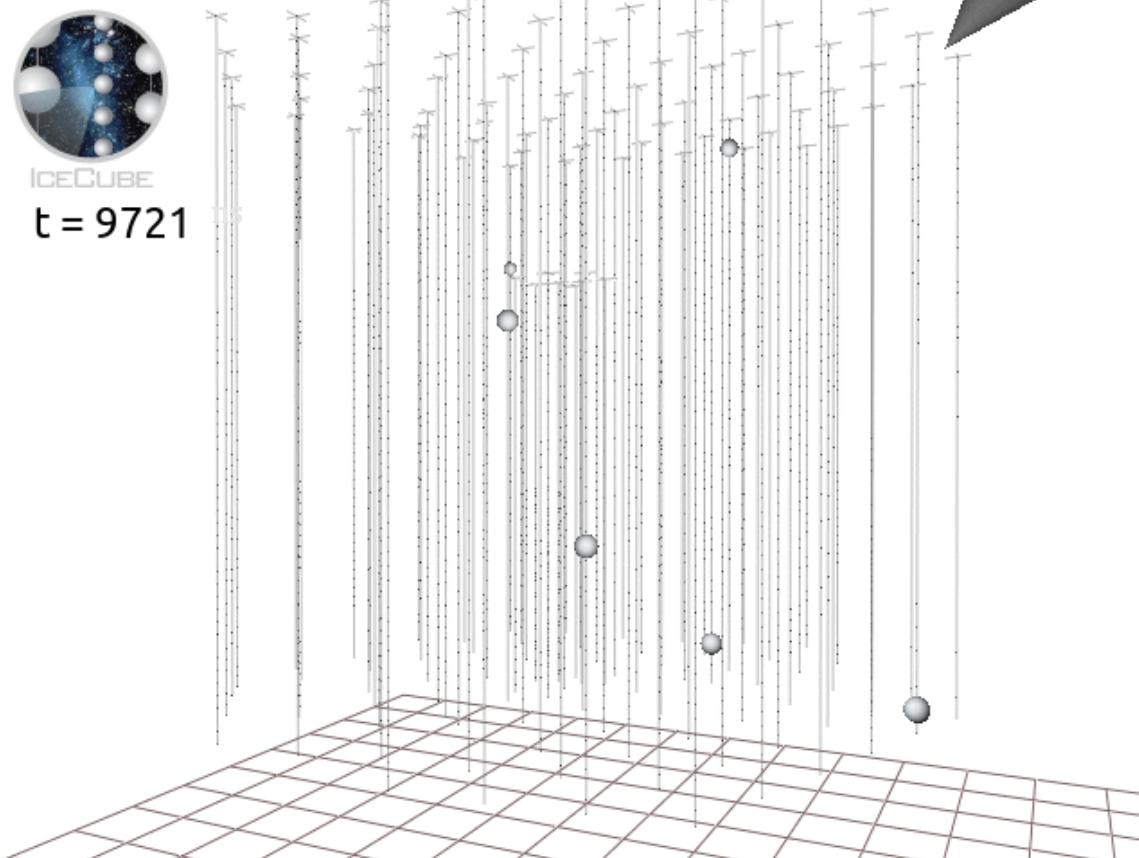
- Atmospheric Muons: ~2700 / s
- Atmospheric Neutrinos: ~1 / hour
- Astrophysical Neutrinos: ~1 / day



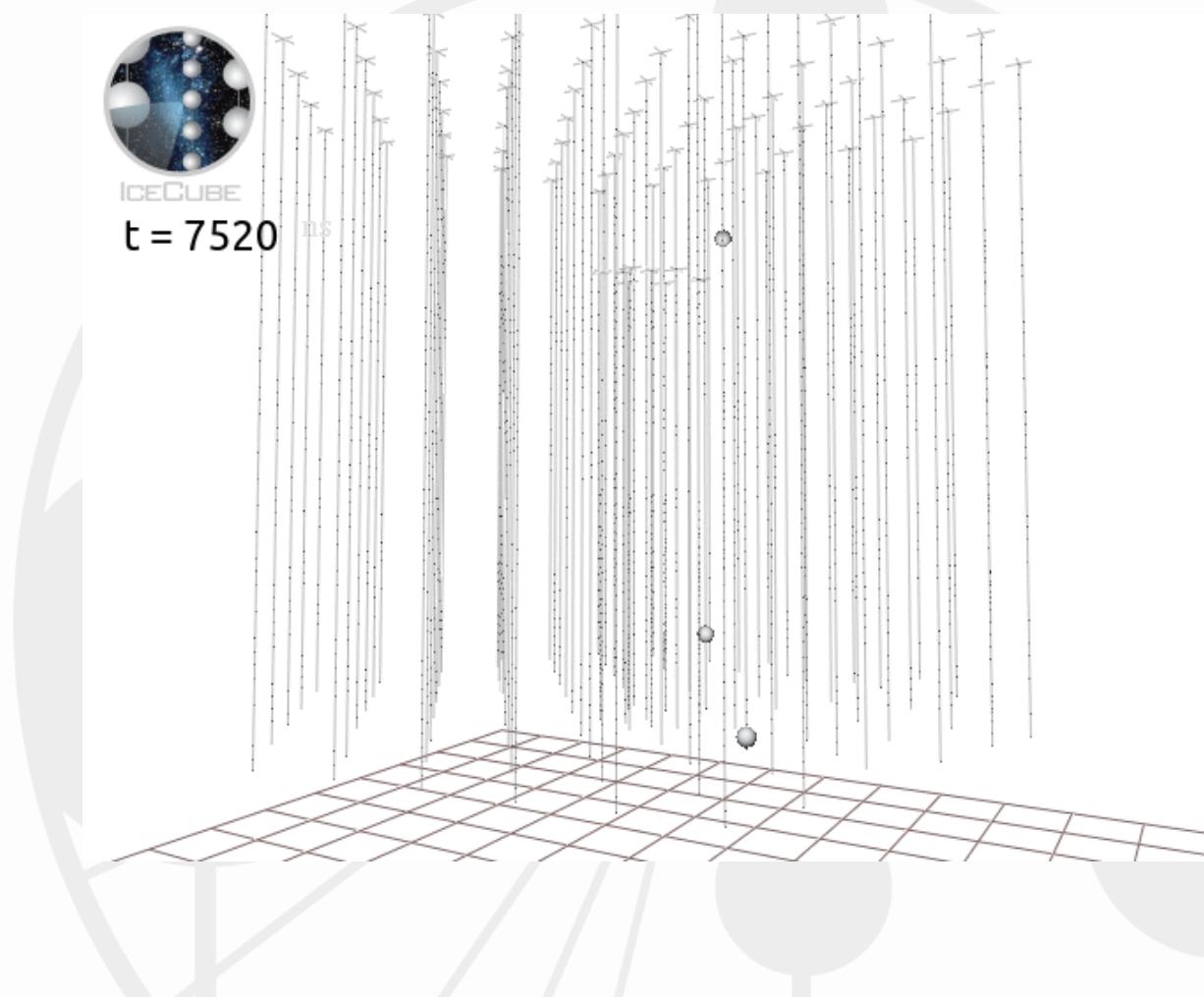
# Starting Cascades



Entering  $\mu$   
(Likely produced in atmosphere)



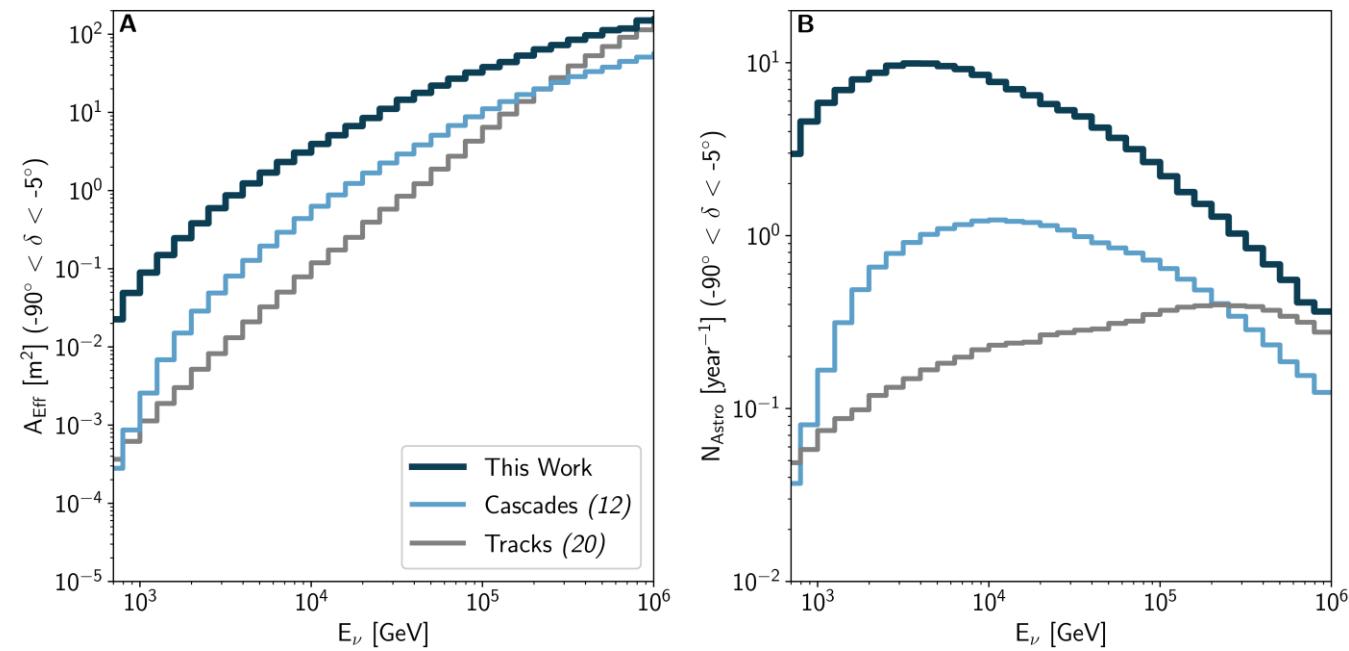
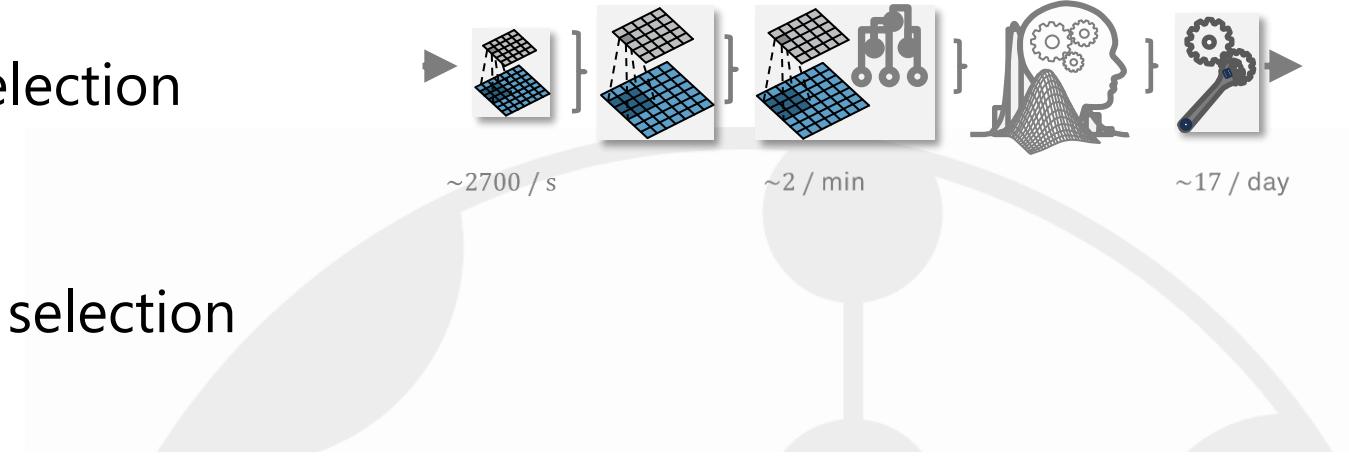
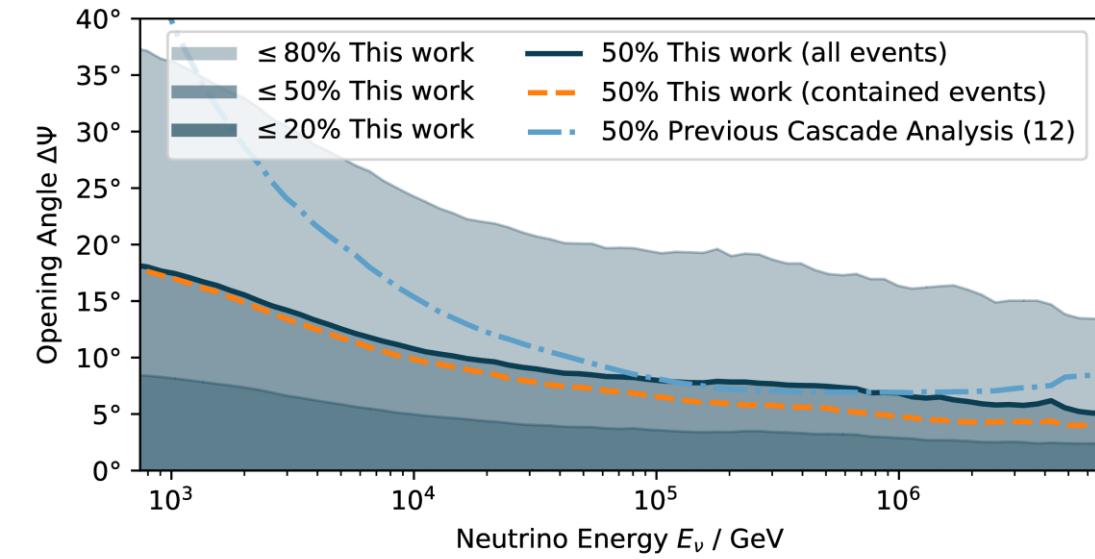
Starting Cascade  
(All flavor NC or CC  $\nu_e, \nu_\tau$ )



# Analysis Level Sample



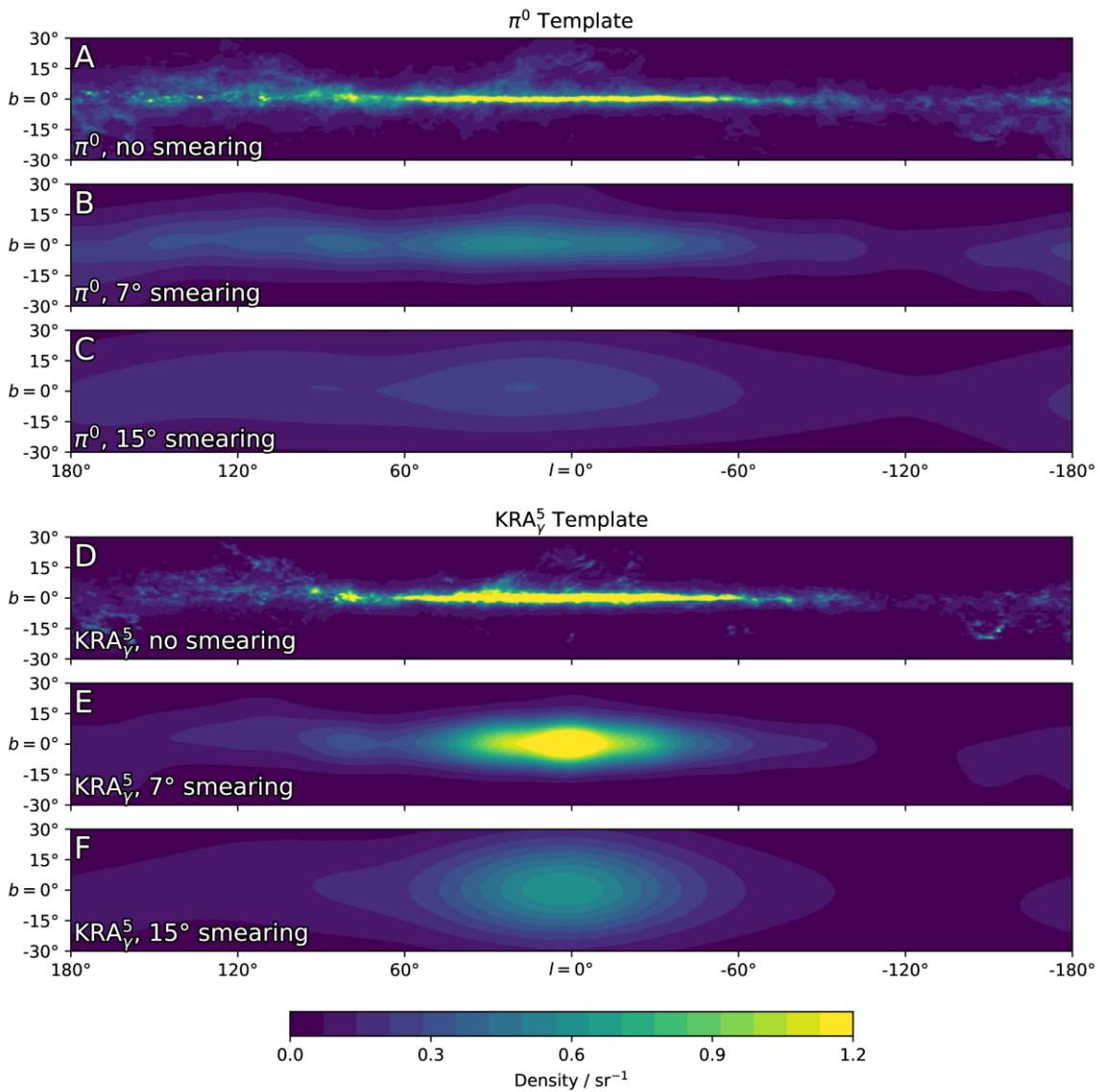
- Machine learning tools for more efficient selection
- 10 years of cascade-like events
  - 60,000 events
  - 30x more events than previous cascade selection
- Improved angular resolution



# Galactic Searches



- (3) diffuse models
  - *Fermi*  $\pi^0$
  - (2) KRA $\gamma$ 
    - Radially dependent CR diffusion
  - Fixed spectrum
  - Fit for flux normalization
- (3) stacking source searches
  - Supernova remnants
  - Pulsar wind nebulae
  - Unidentified TeV sources

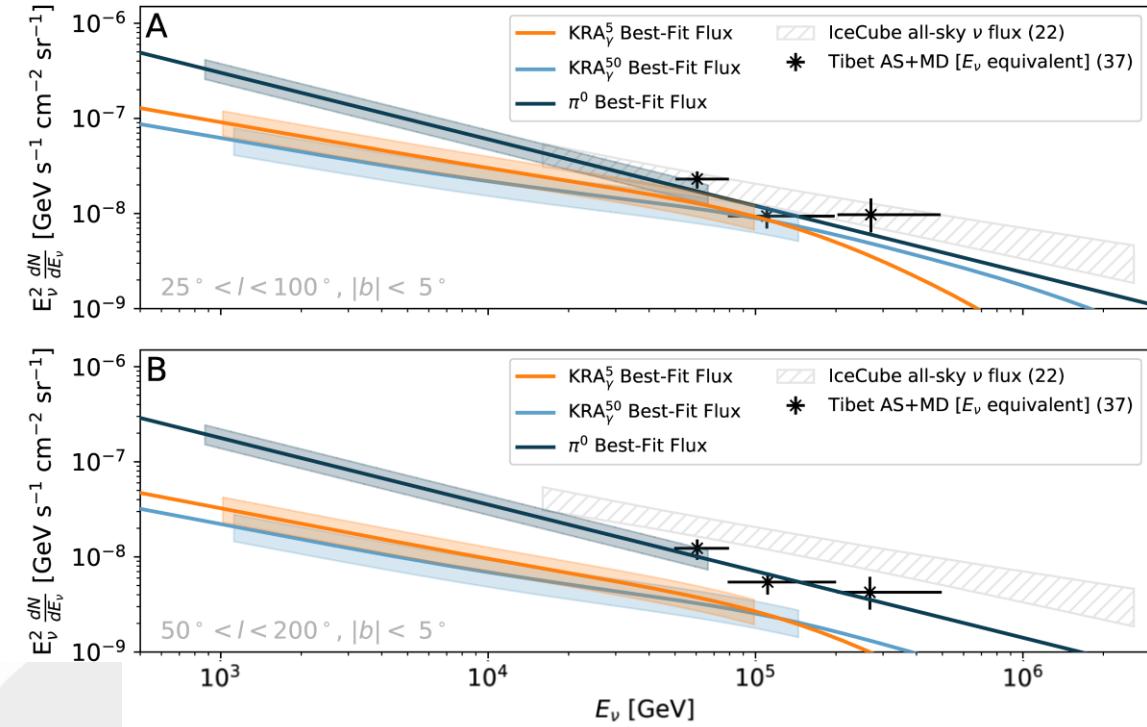
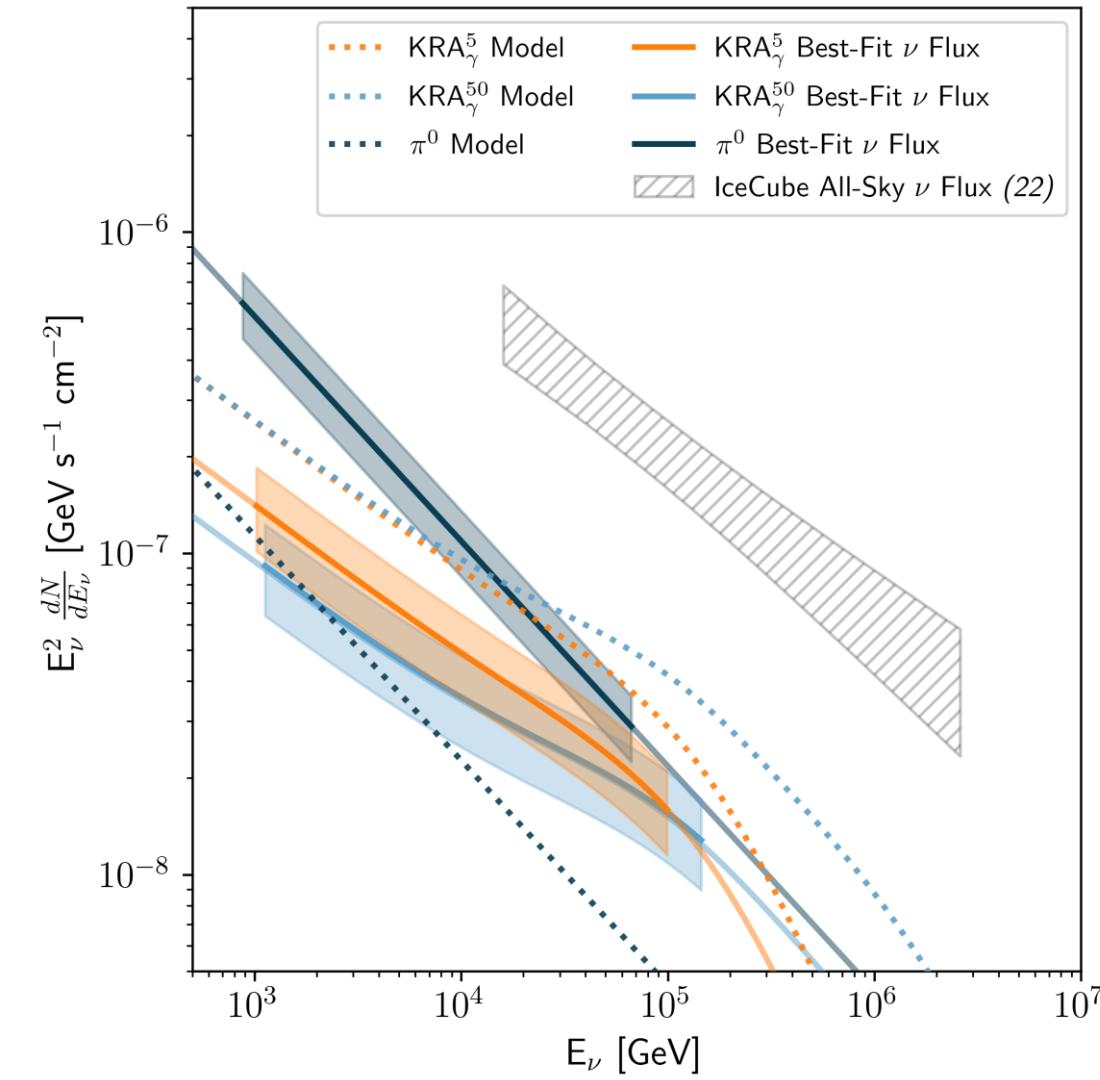


# Results

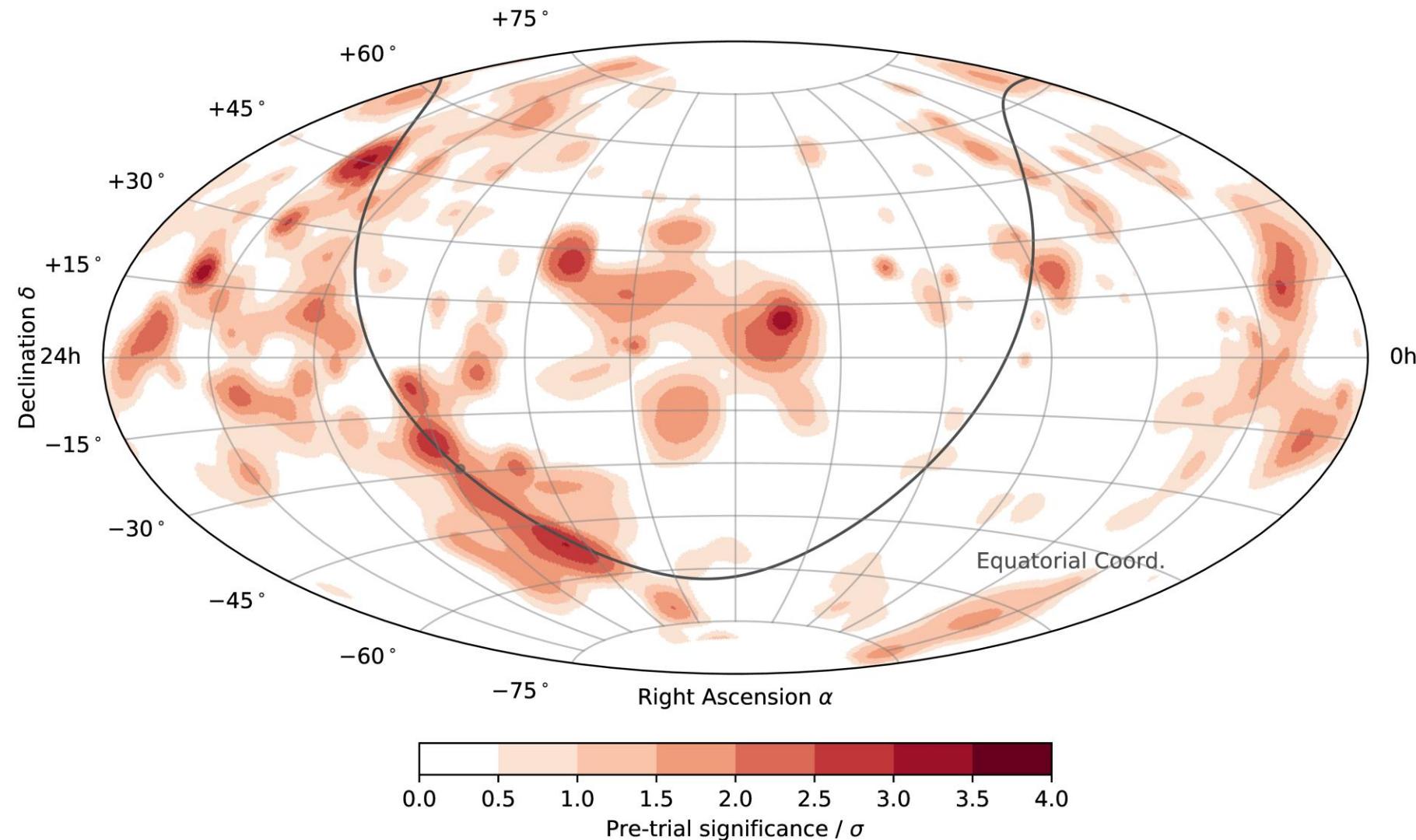
- **Evidence for neutrino emission from the Galactic plane**
  - **Global significance:  $4.5\sigma$**
- $3\sigma$  significance from stacking catalogs
- Data-driven background estimation

Diffuse Galactic plane analyses	Flux sensitivity $\Phi$	p-value	Best-fitting flux $\Phi$
$\pi^0$	$5.98$	$1.26 \times 10^{-6}$ ( $4.71\sigma$ )	$21.8^{+5.3}_{-4.9}$
KRA $_{\gamma}^5$	$0.16 \times \text{MF}$	$6.13 \times 10^{-6}$ ( $4.37\sigma$ )	$0.55^{+0.18}_{-0.15} \times \text{MF}$
KRA $_{\gamma}^{50}$	$0.11 \times \text{MF}$	$3.72 \times 10^{-5}$ ( $3.96\sigma$ )	$0.37^{+0.13}_{-0.11} \times \text{MF}$
Catalog stacking analyses	p-value		
SNR	$5.90 \times 10^{-4}$ ( $3.24\sigma$ )*		
PWN	$5.93 \times 10^{-4}$ ( $3.24\sigma$ )*		
UNID	$3.39 \times 10^{-4}$ ( $3.40\sigma$ )*		

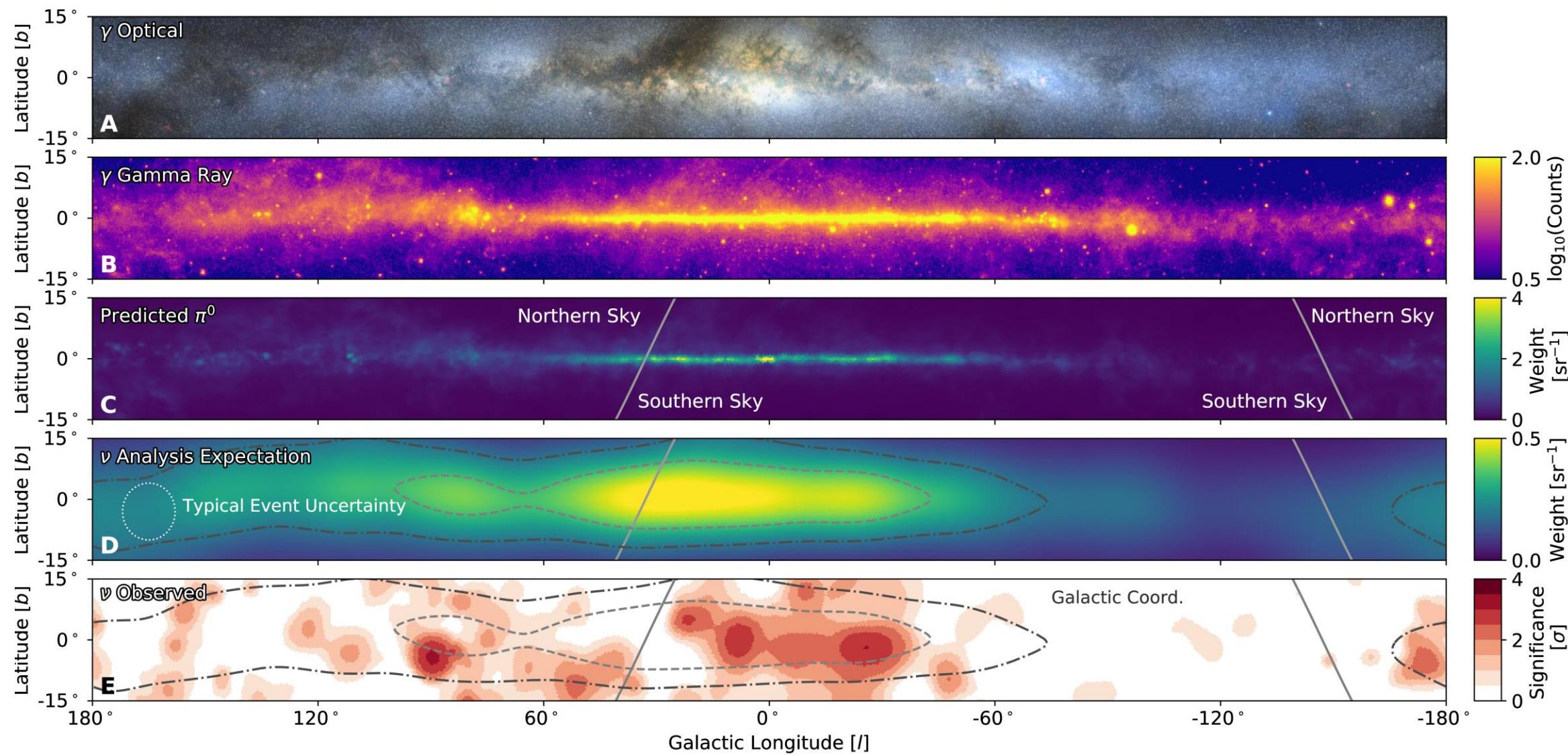
# Best Fit Flux Normalization



# All Sky Results



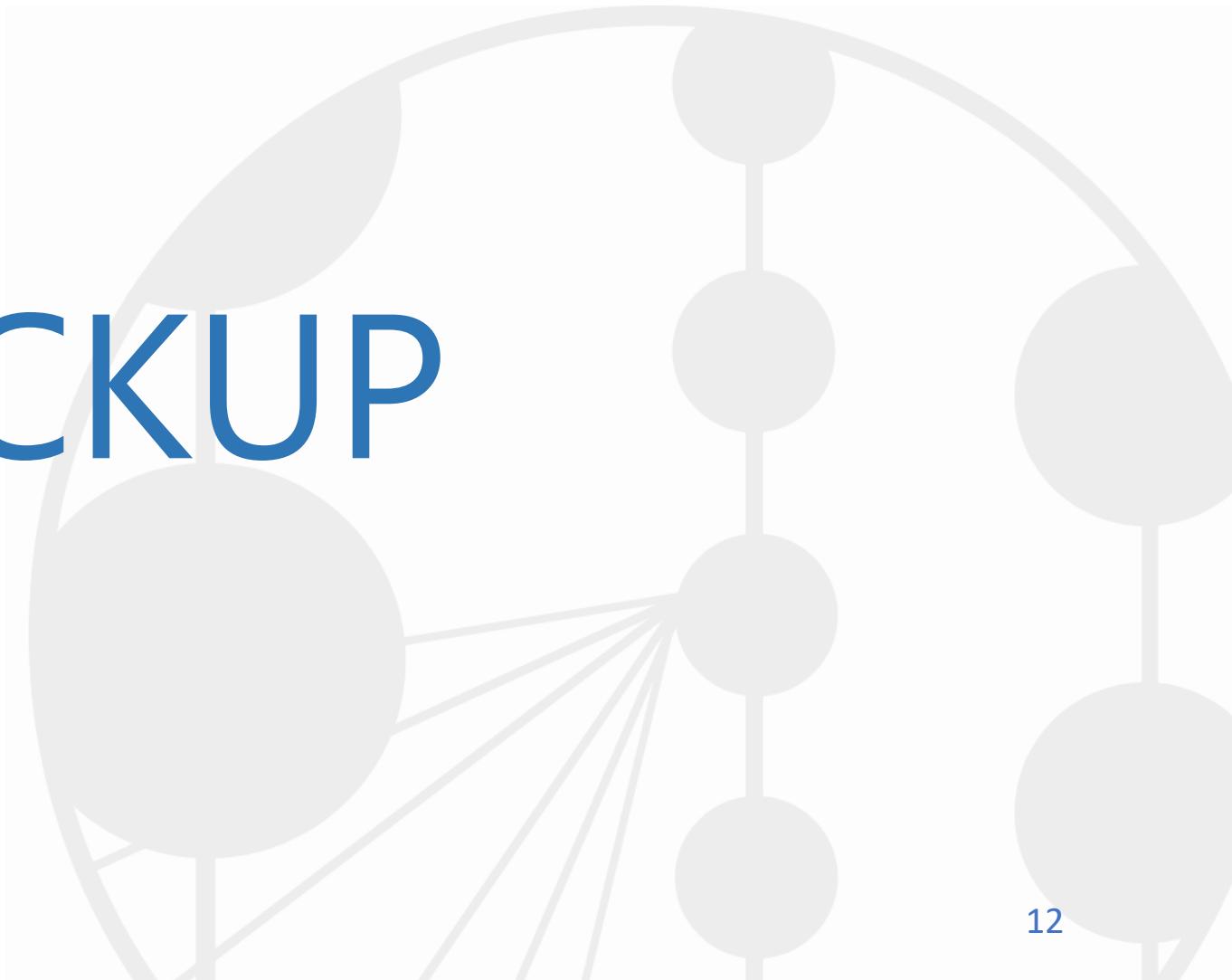
# New View of the Milky Way



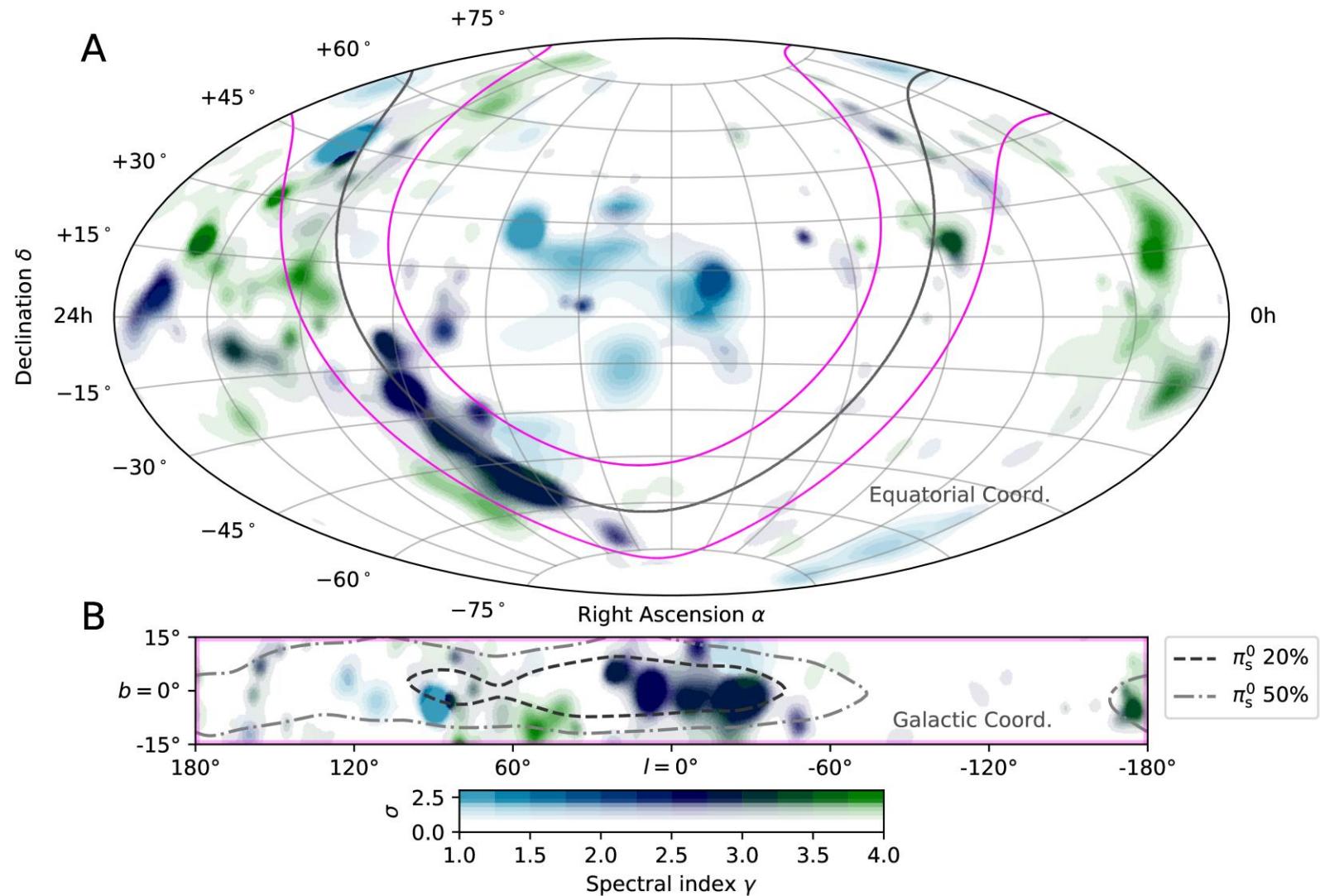
# Conclusions

- Evidence for neutrino emission from the galactic plane
- Result enabled by machine learning selection
- New questions
- Follow-up analyses with IceCube tracks consistent

# BACKUP



# All Sky Results With Spectrum



# TS Contribution

