

CONSTRAINING THE SOURCES OF HIGH-ENERGY NEUTRINOS WITH MULTIPLE MESSENGERS

MATTHIAS VEREECKEN

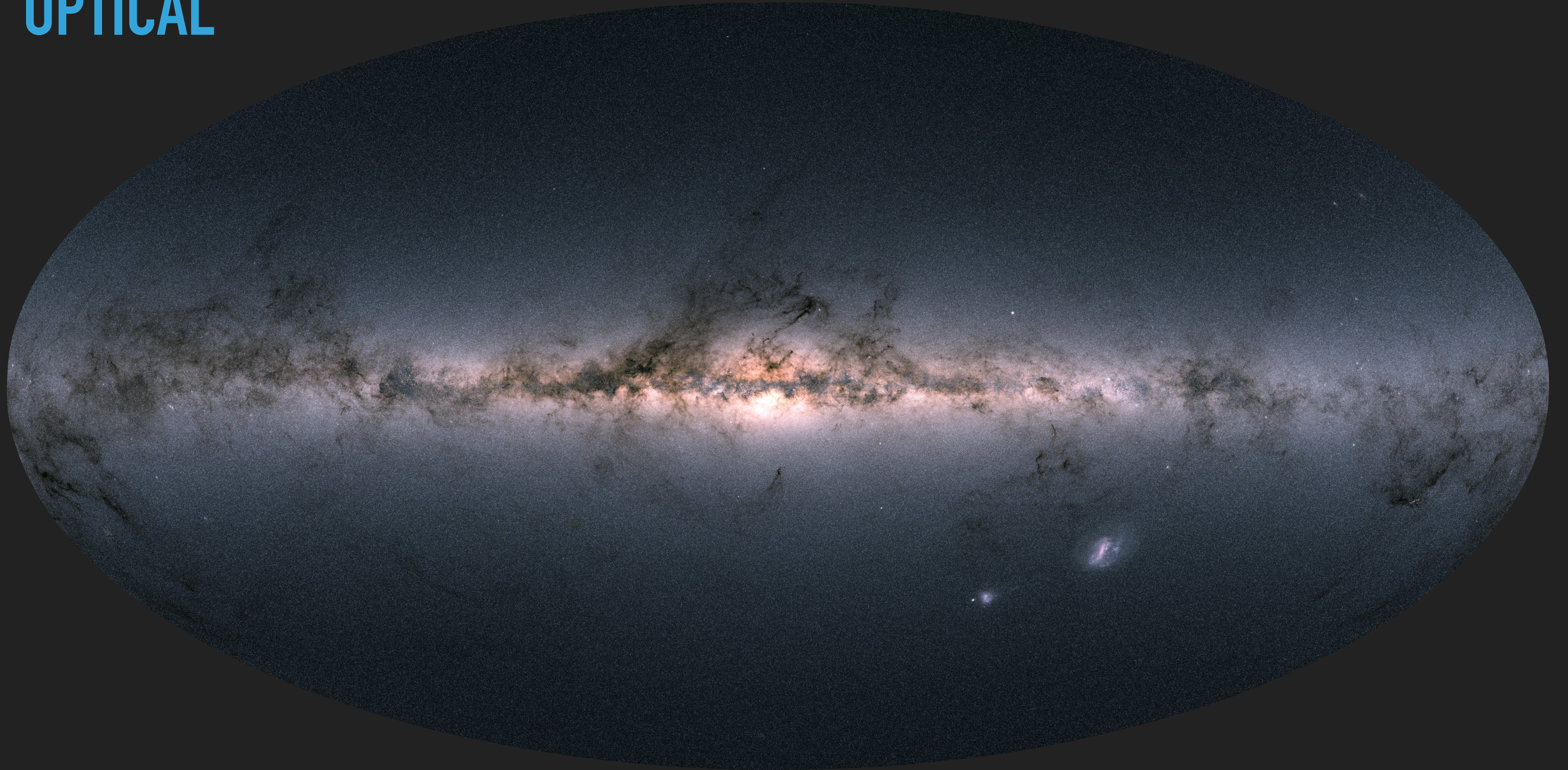
OVERVIEW

- ▶ PhD @ VUB (2014-2019)
 - ▶ Z-peaked excess in gauge mediation with multiple hidden sectors
 - ▶ Obscured ν -sources
 - ▶ Constraining neutrino emission from binary black hole mergers
- ▶ Teaching assistant @ KUL (2020-2021)
- ▶ Risk model developer @ KBC (2021-2023)

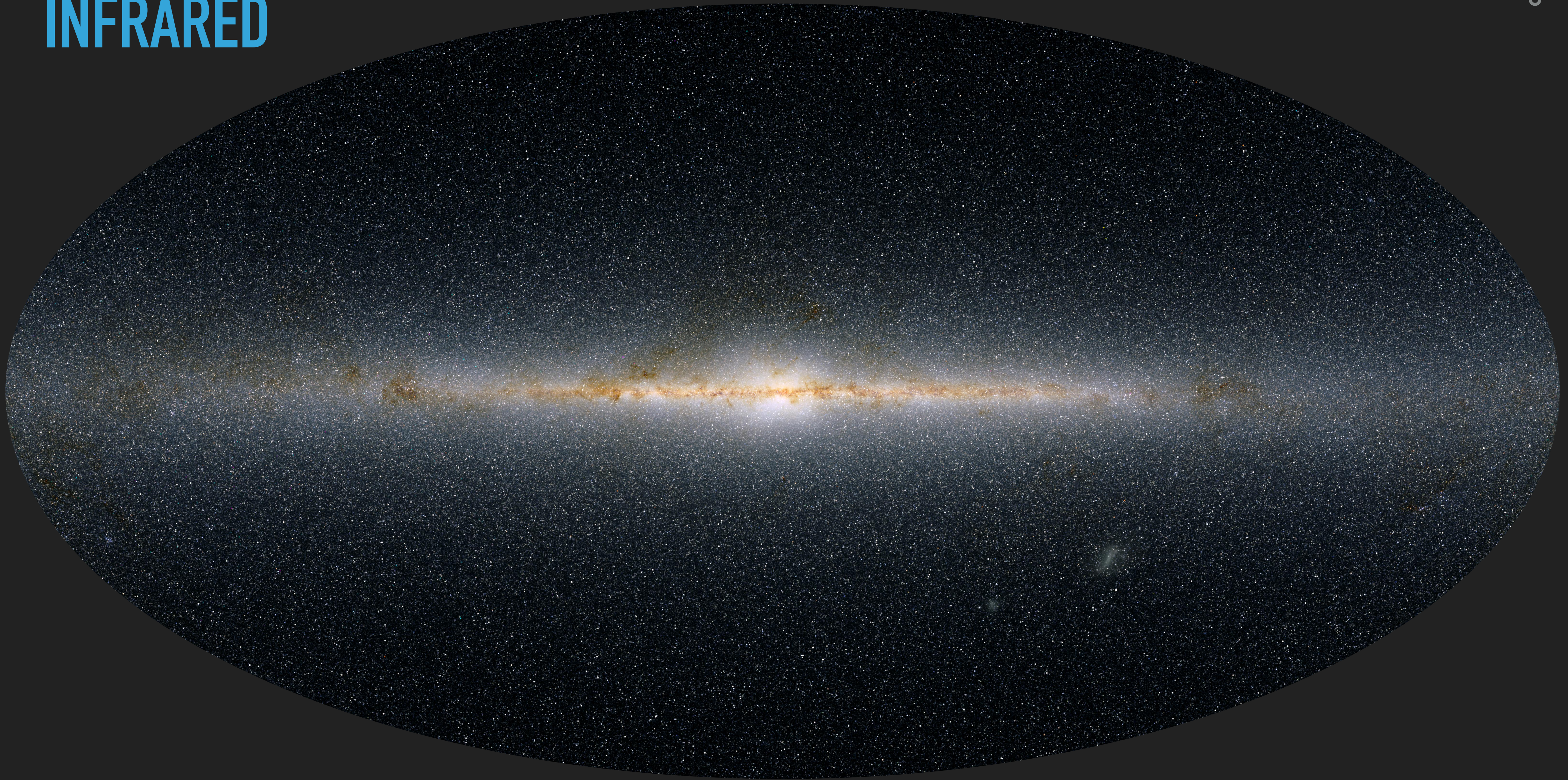


Photo by [eberhard grossgasteiger](#) on [Unsplash](#)

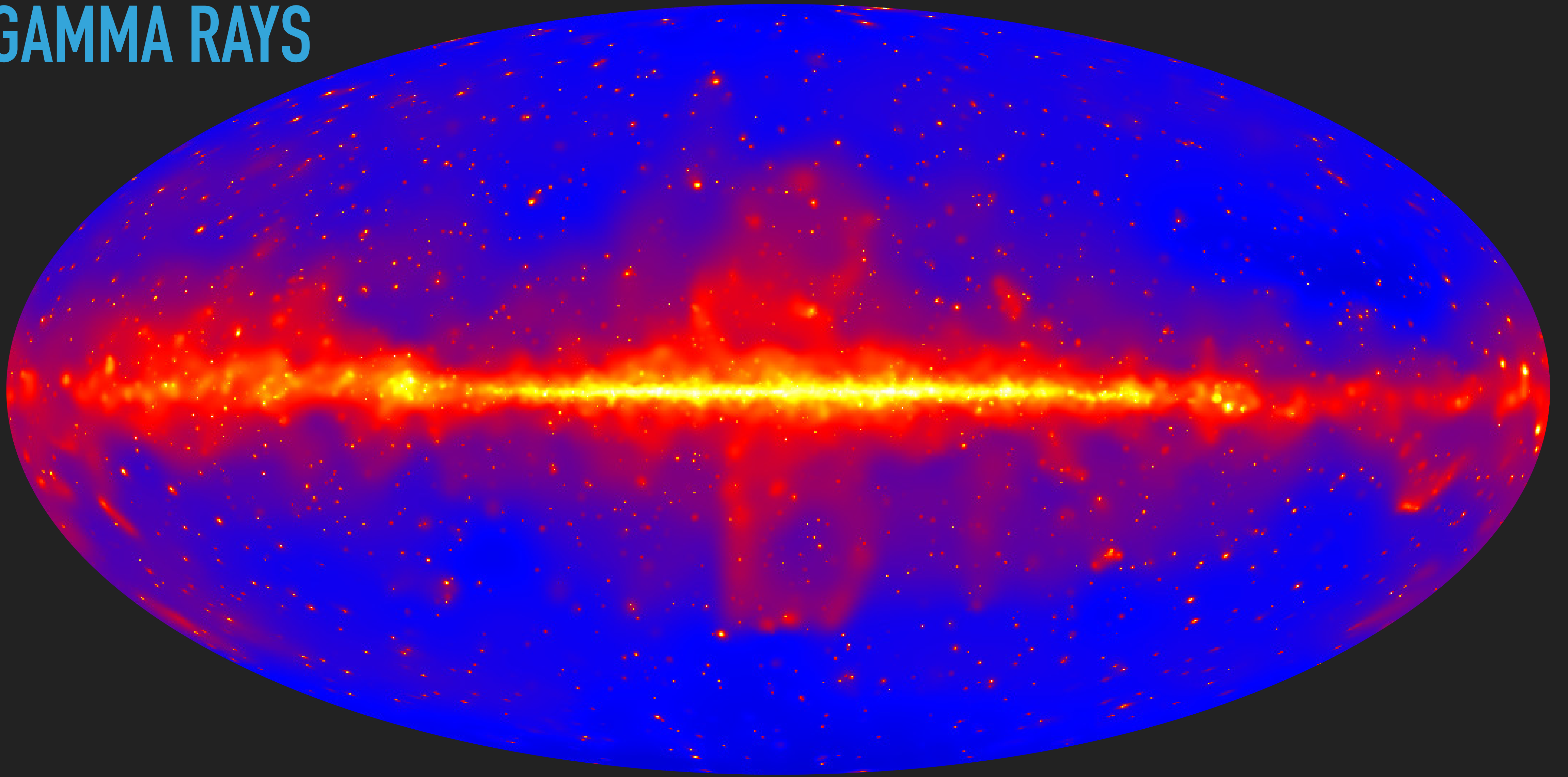
OPTICAL



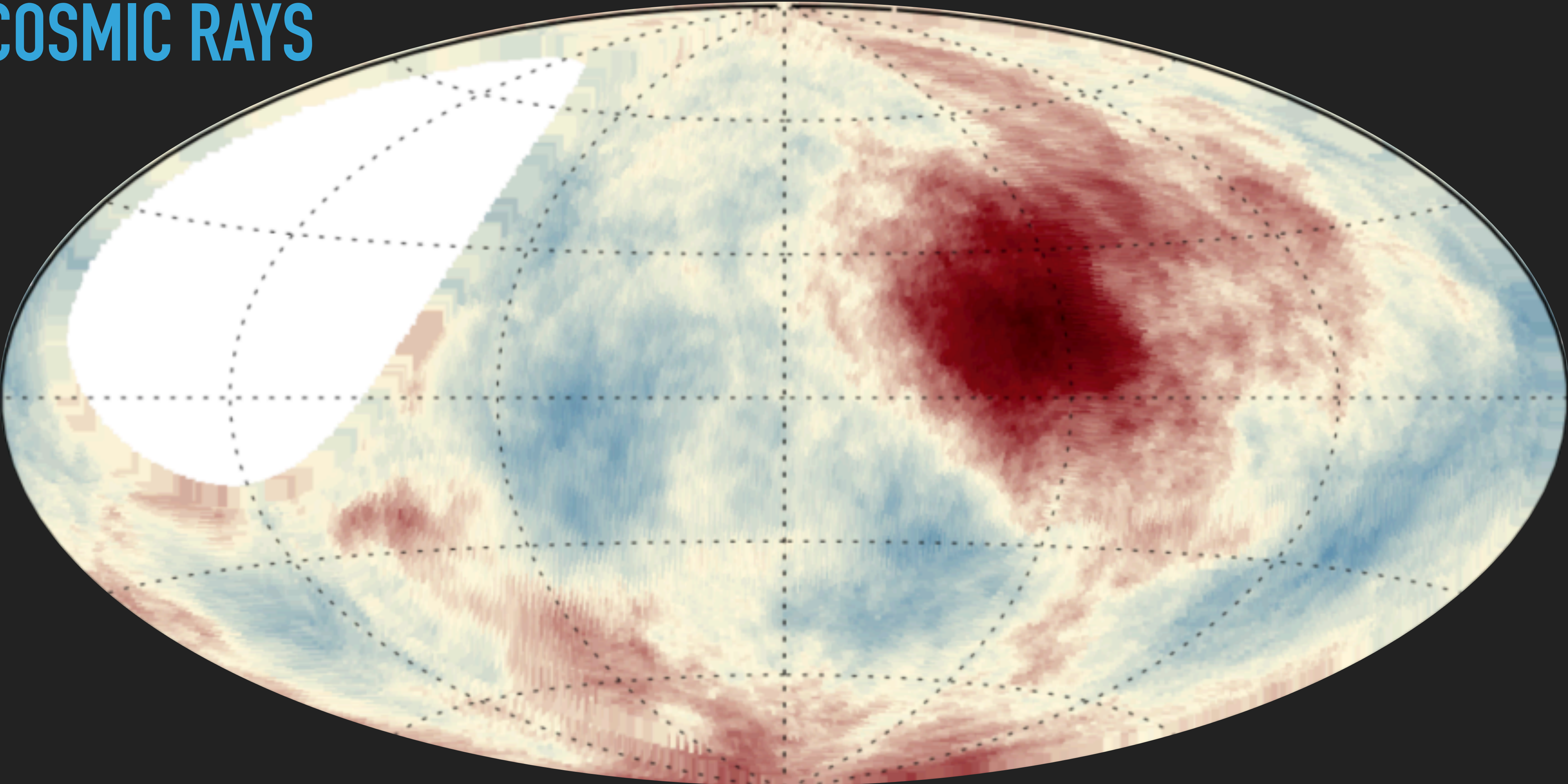
INFRARED



GAMMA RAYS

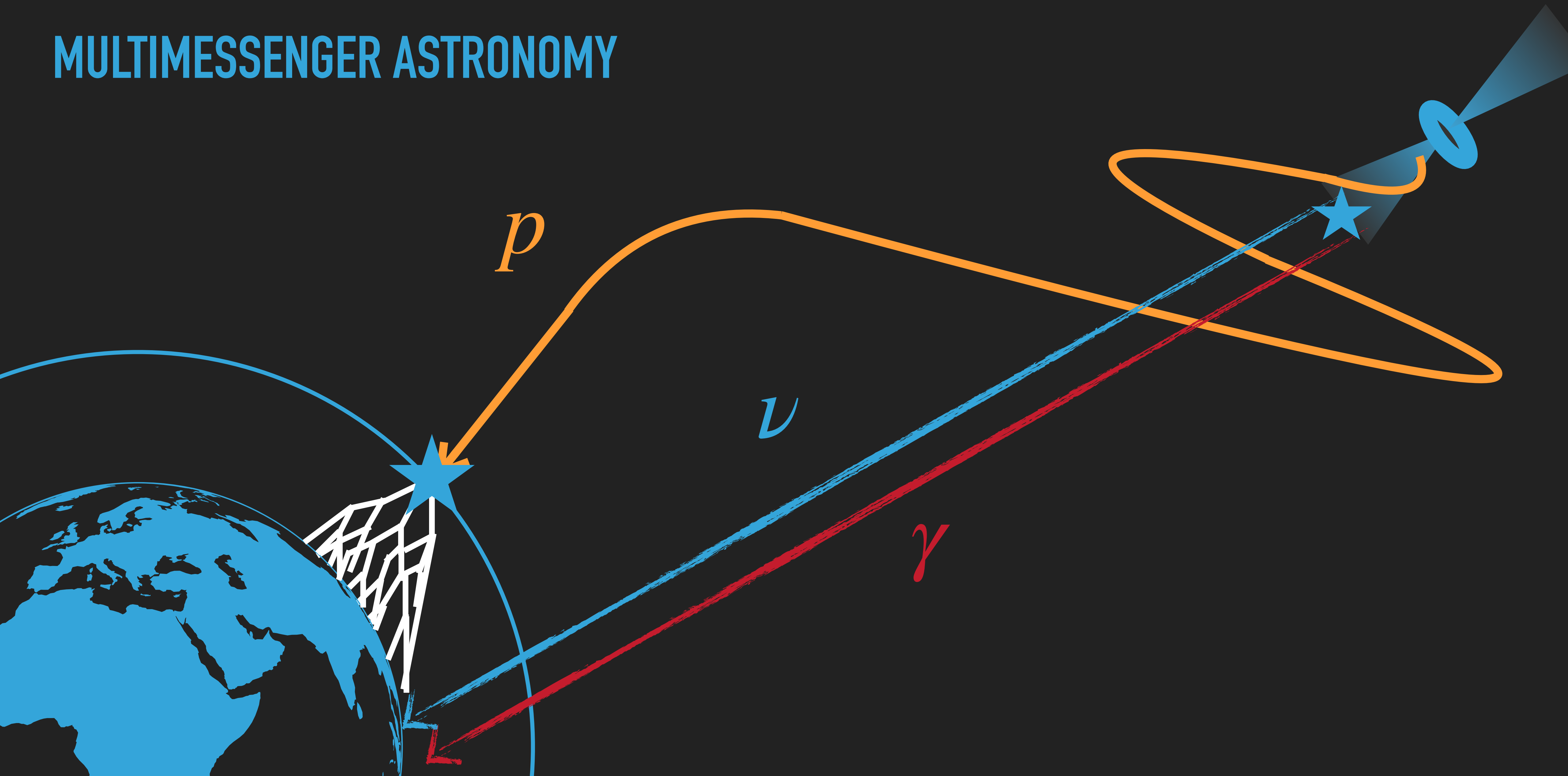


COSMIC RAYS

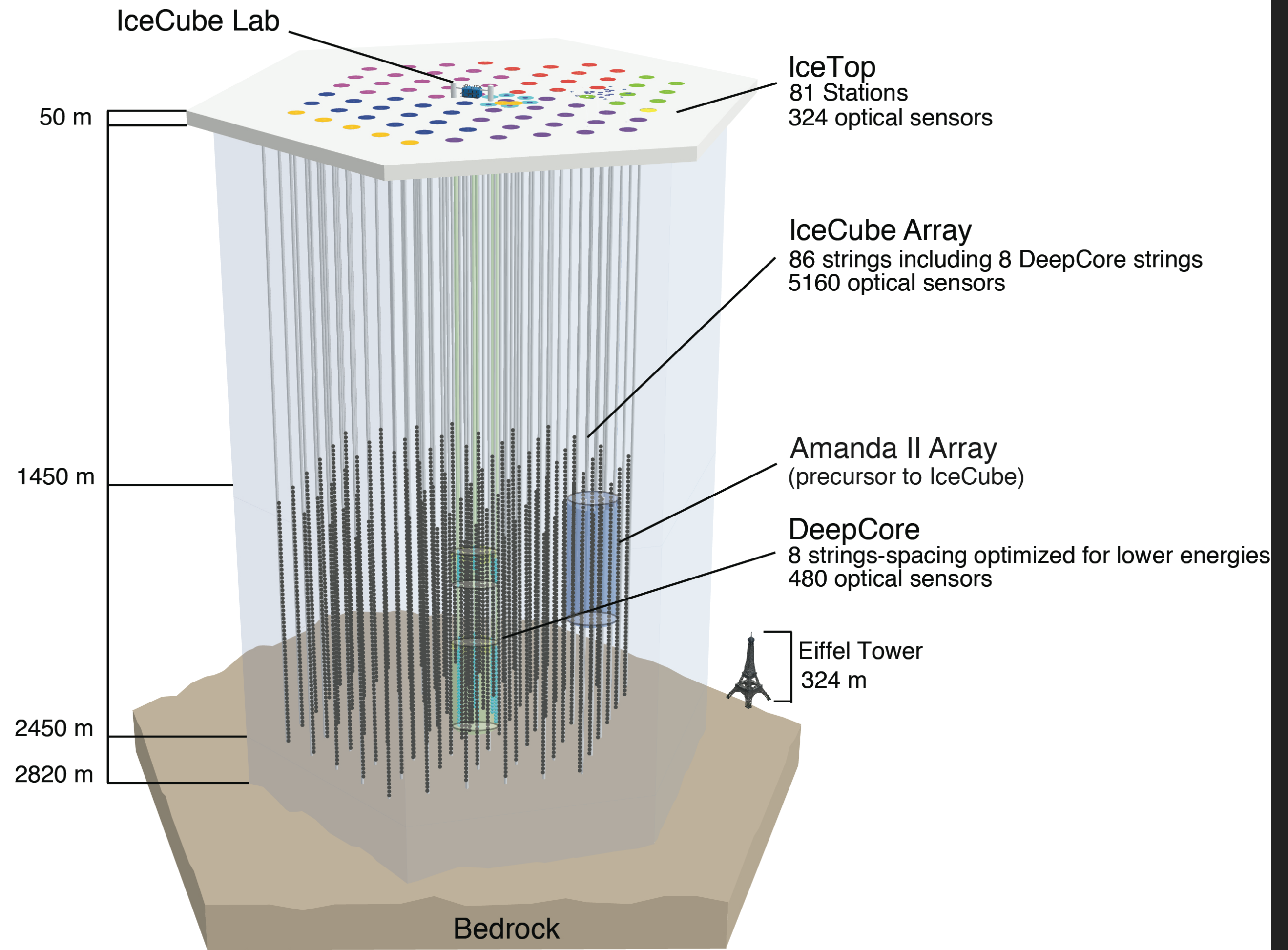


**WHAT ARE THE SOURCES OF
THESE HIGH-ENERGY PARTICLES?**

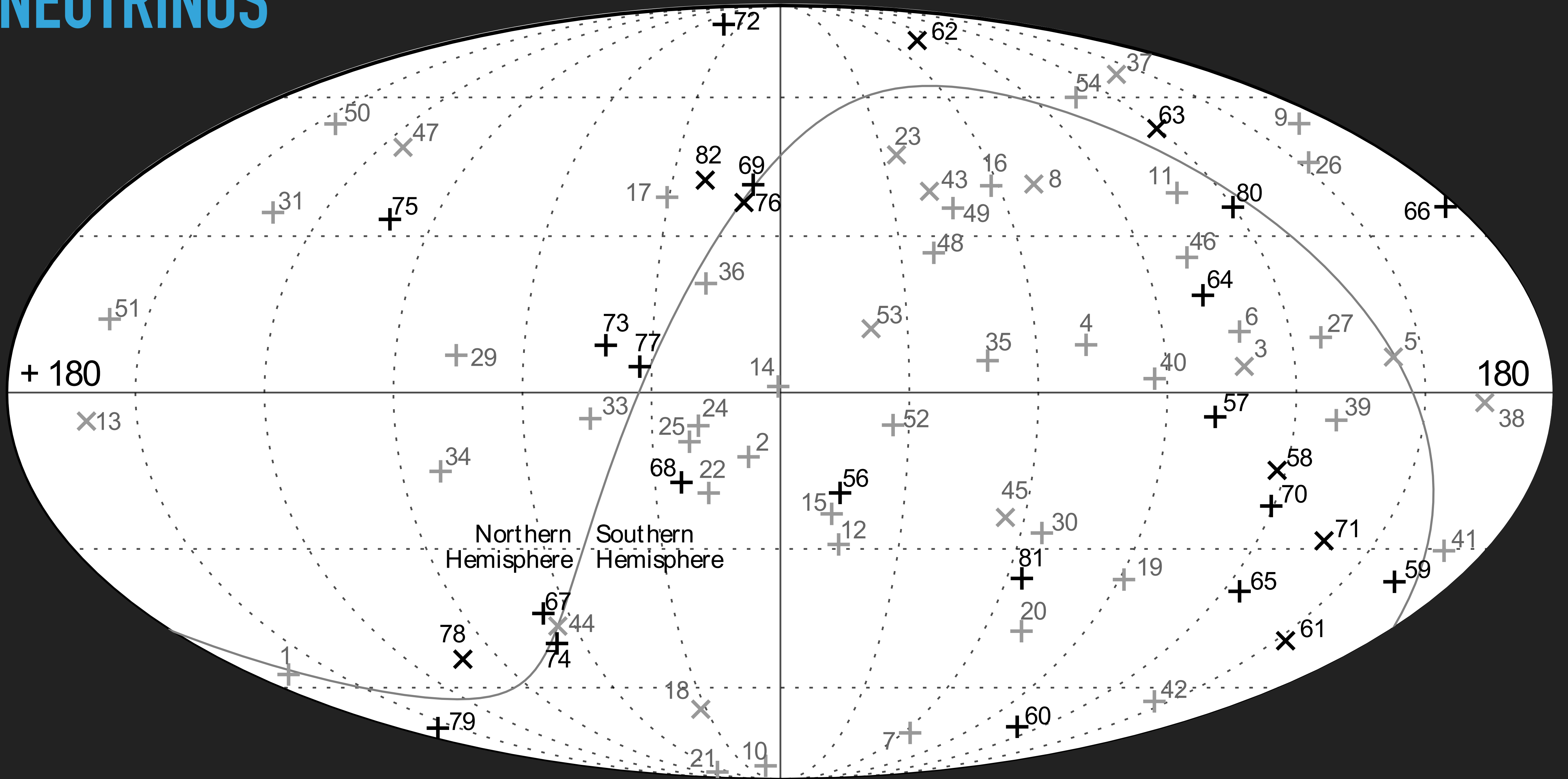
MULTIMESSENGER ASTRONOMY

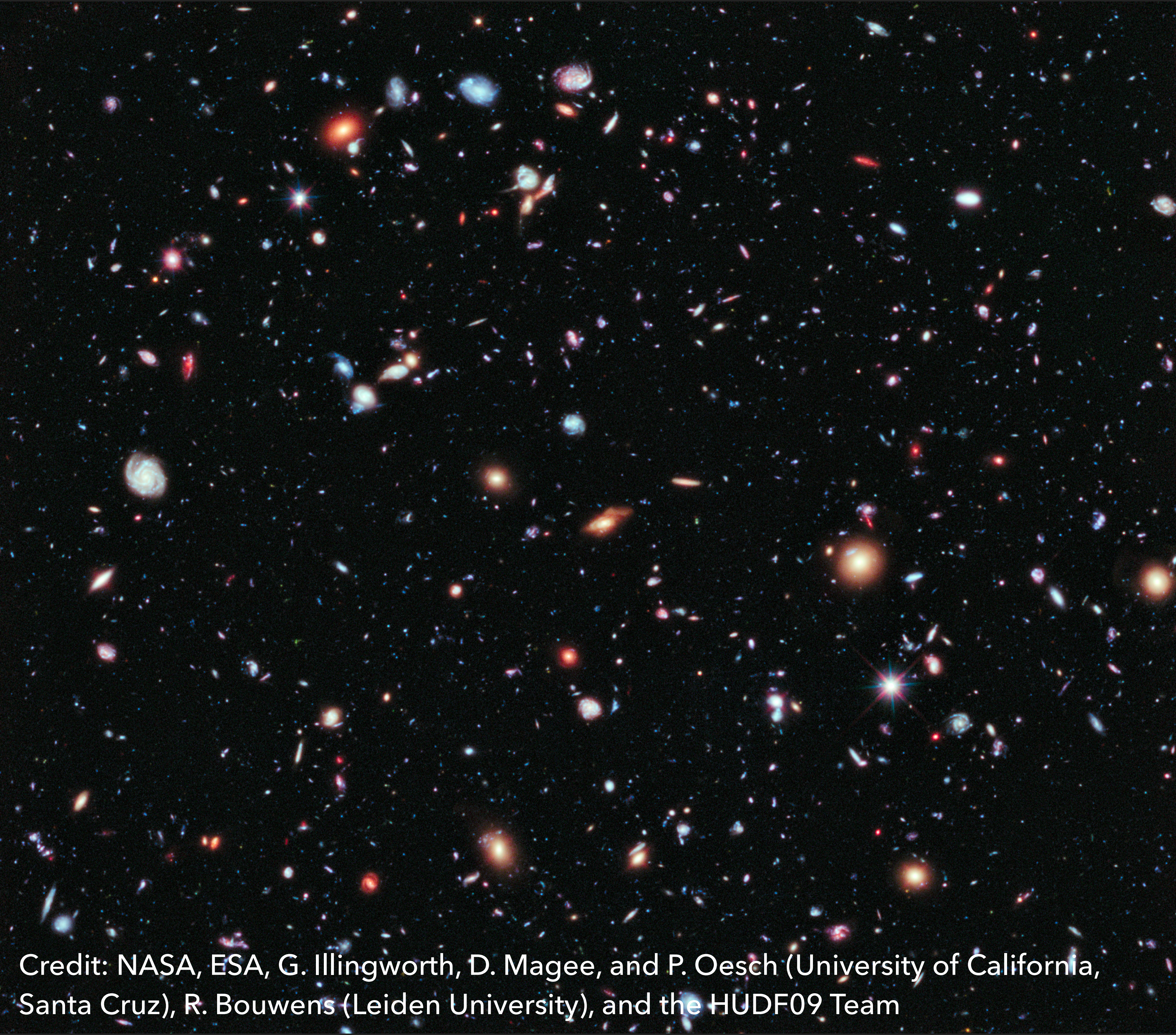


NEUTRINO ASTRONOMY: ICECUBE



NEUTRINOS





HUBBLE XDF

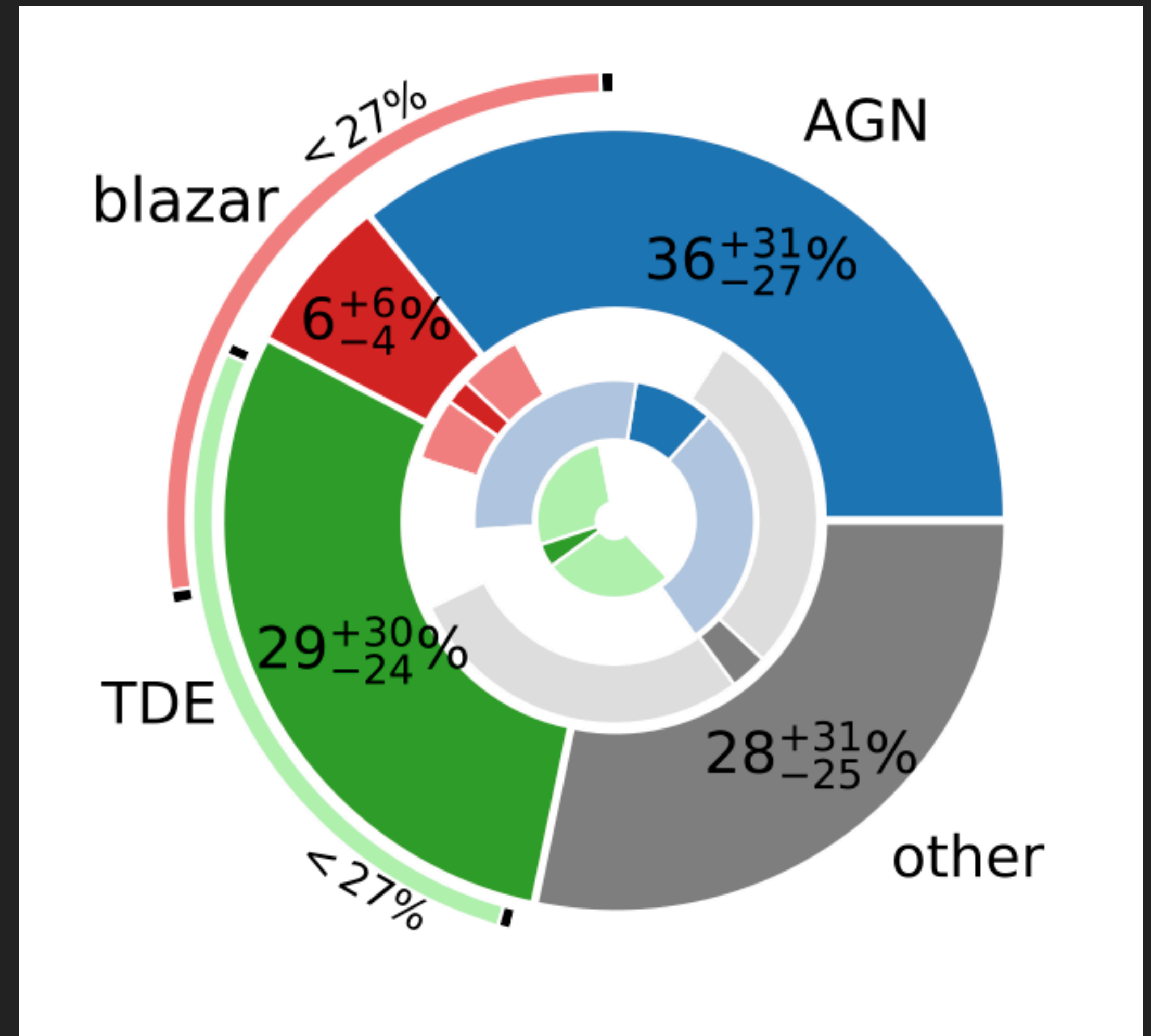
Credit: NASA, ESA, G. Illingworth, D. Magee, and P. Oesch (University of California, Santa Cruz), R. Bouwens (Leiden University), and the HUDF09 Team

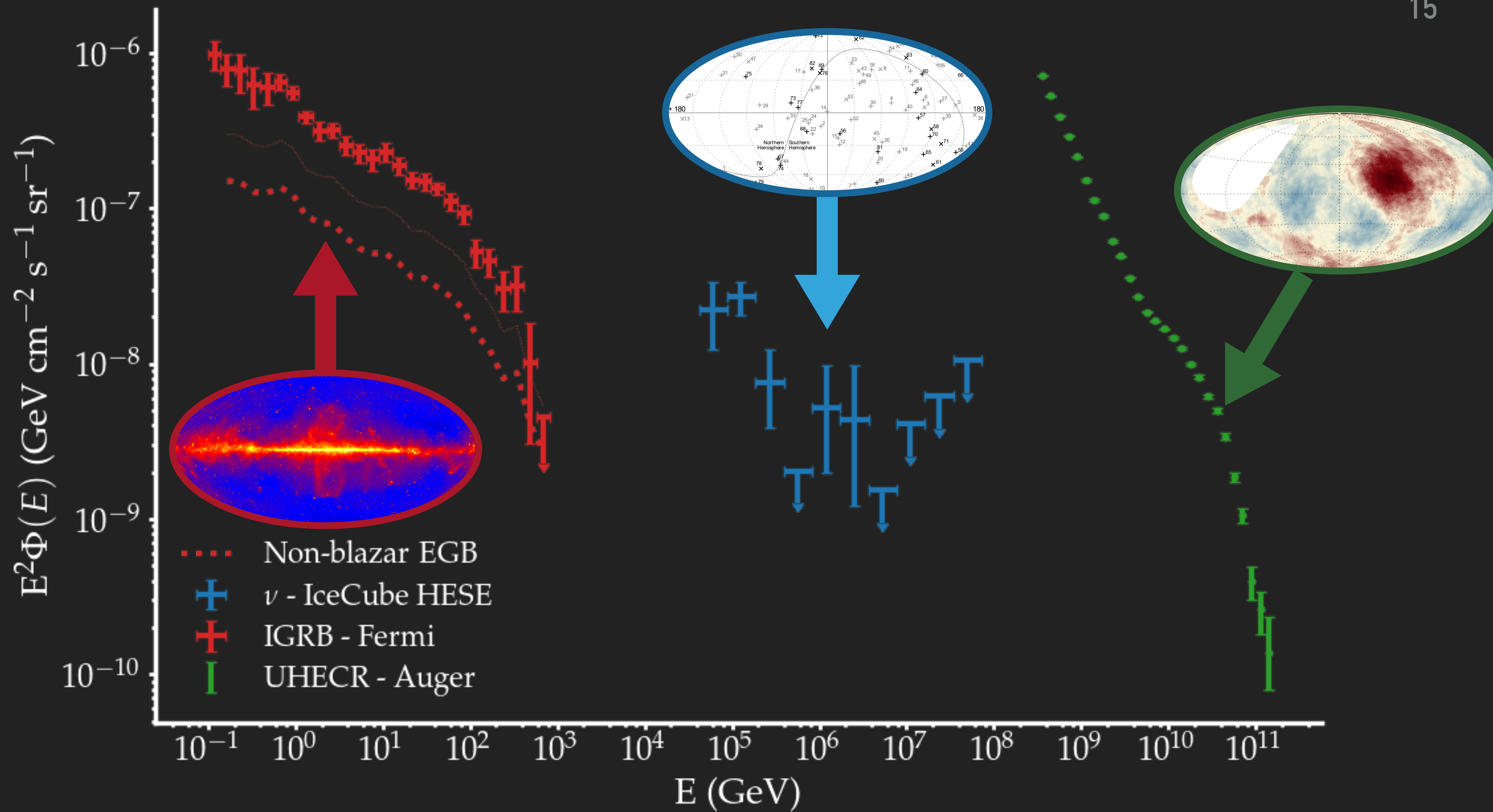
Size of Hubble eXtreme Deep Field on the Sky



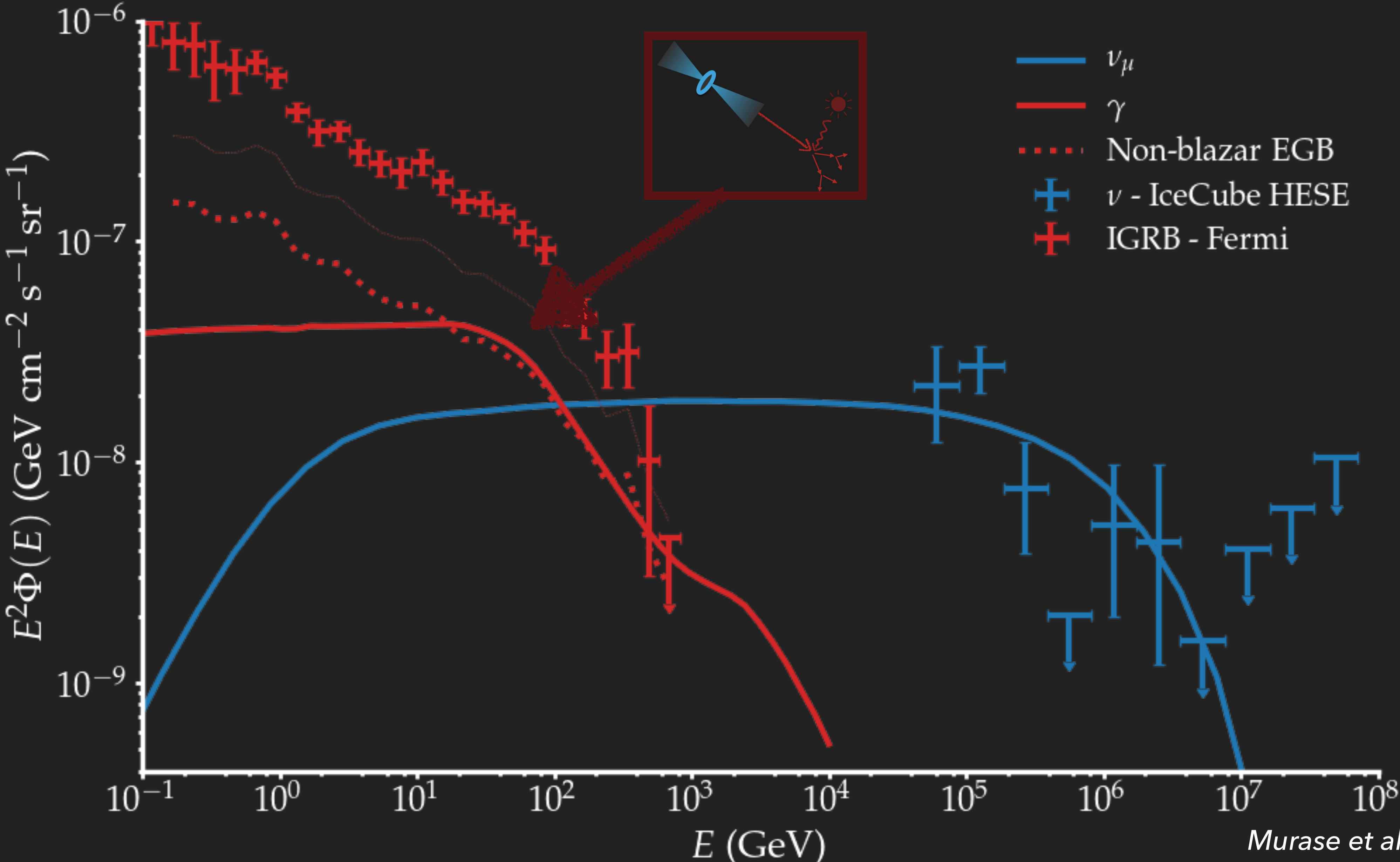
WHAT ARE THE SOURCES?

- ▶ Identified several sources already
 - ▶ Flaring blazar TXS 0506+056
 - ▶ Active galaxy NGC 1068
 - ▶ Tidal disruption event?
- ▶ What is total contribution of these classes?



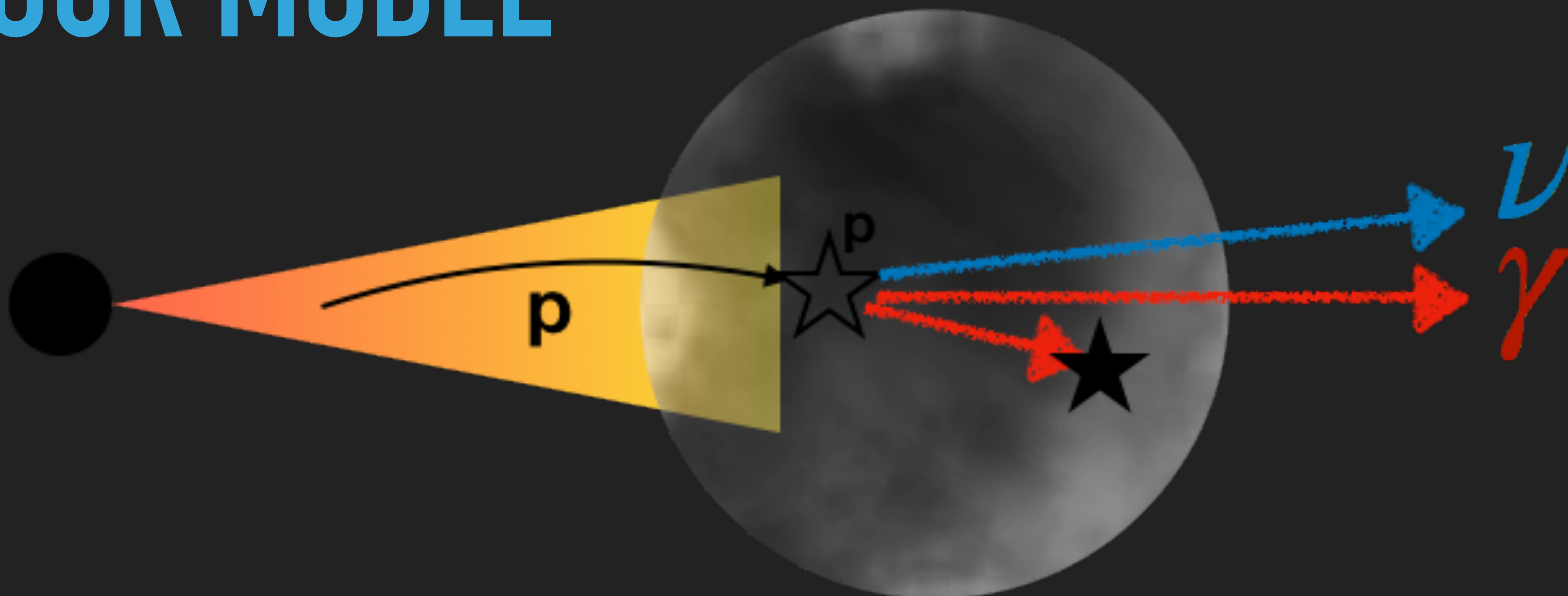


EXAMPLE: STARBURST GALAXIES



NEUTRINO SOURCES OBSCURED BY MATTER

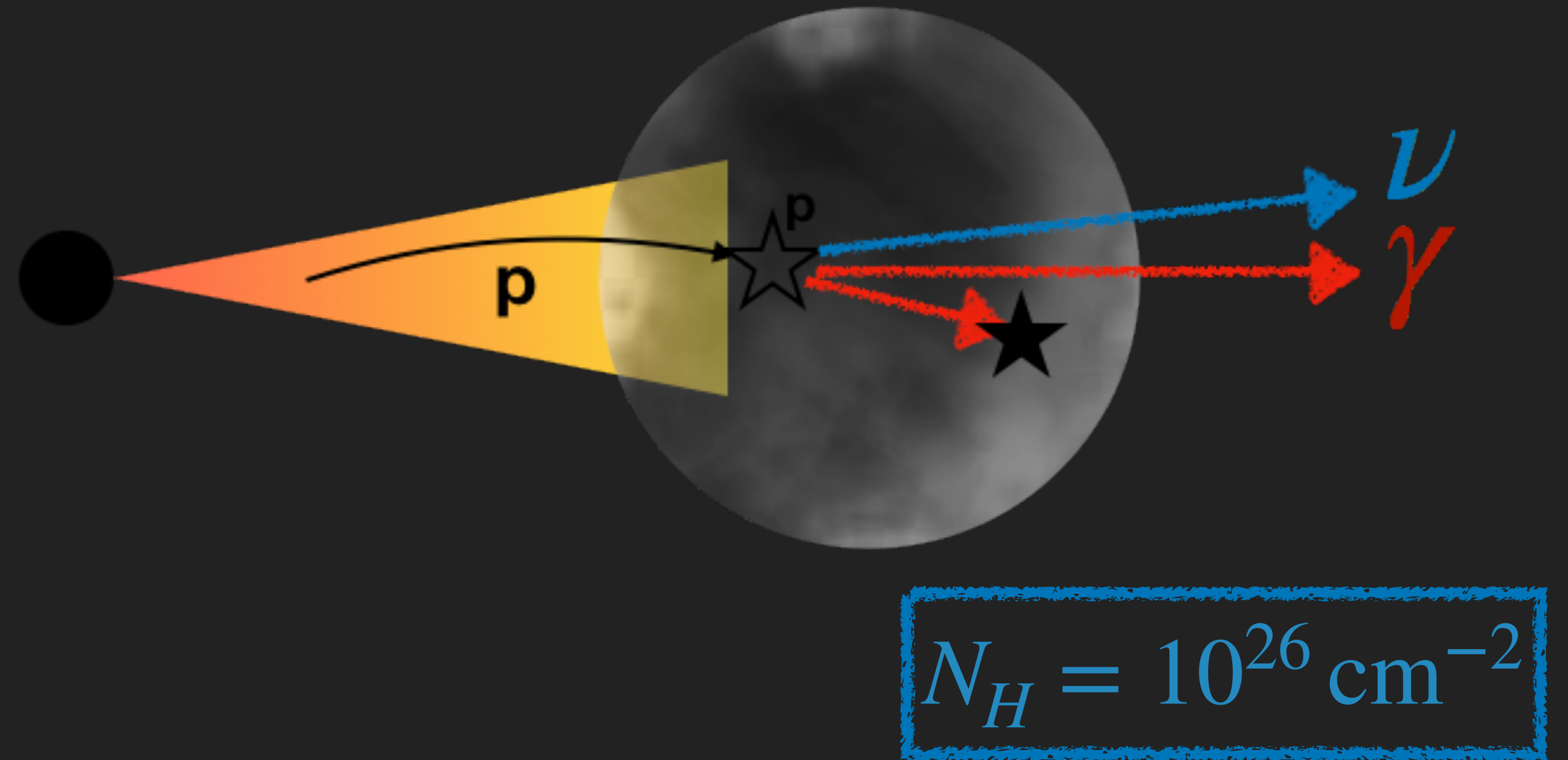
OUR MODEL



$$N_H = 10^{26} \text{ cm}^{-2}$$

WHICH SOURCES?

- ▶ Compton-thick AGN
- ▶ Tilted torus (*Lawrence and Elvis 1002.1759*)
- ▶ Ultra-luminous infrared galaxies
E.g. ARP 220



OBSCURED NEUTRINO SOURCES

OBSCURED AGN

INDIVIDUAL SOURCES

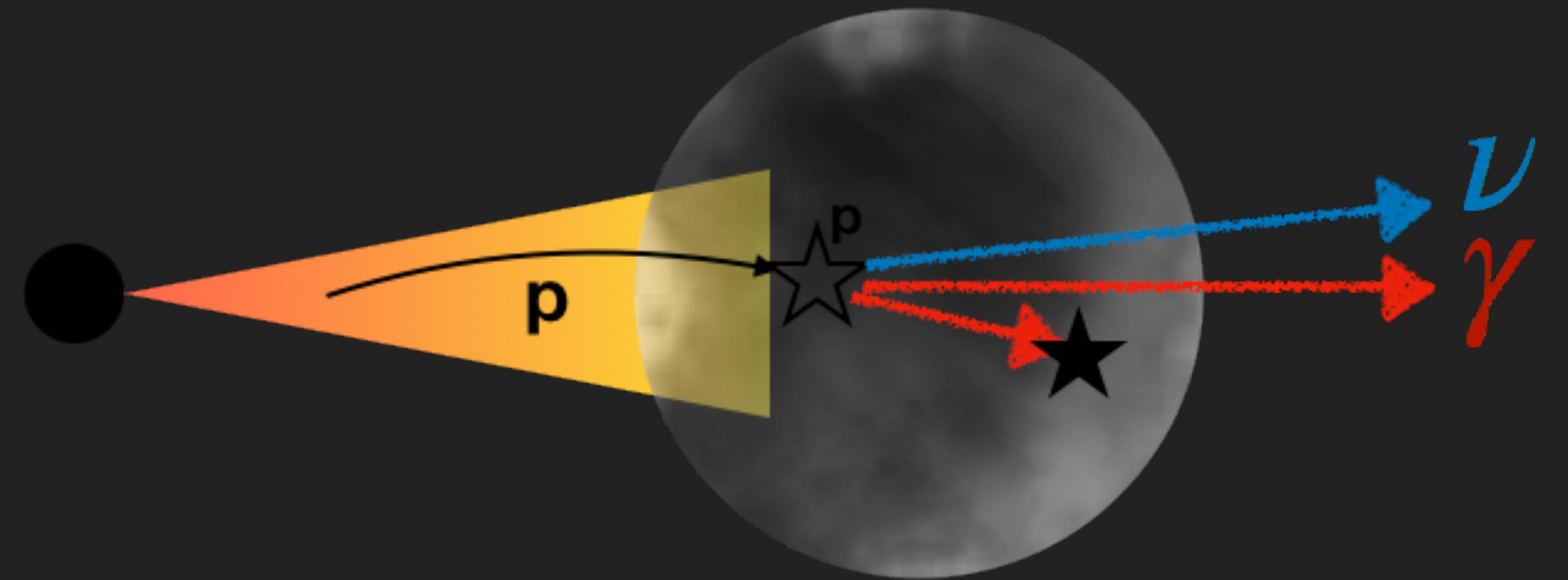
- ▶ AGN with lower-than-expected X-ray flux

- ▶ Estimating neutrino flux:

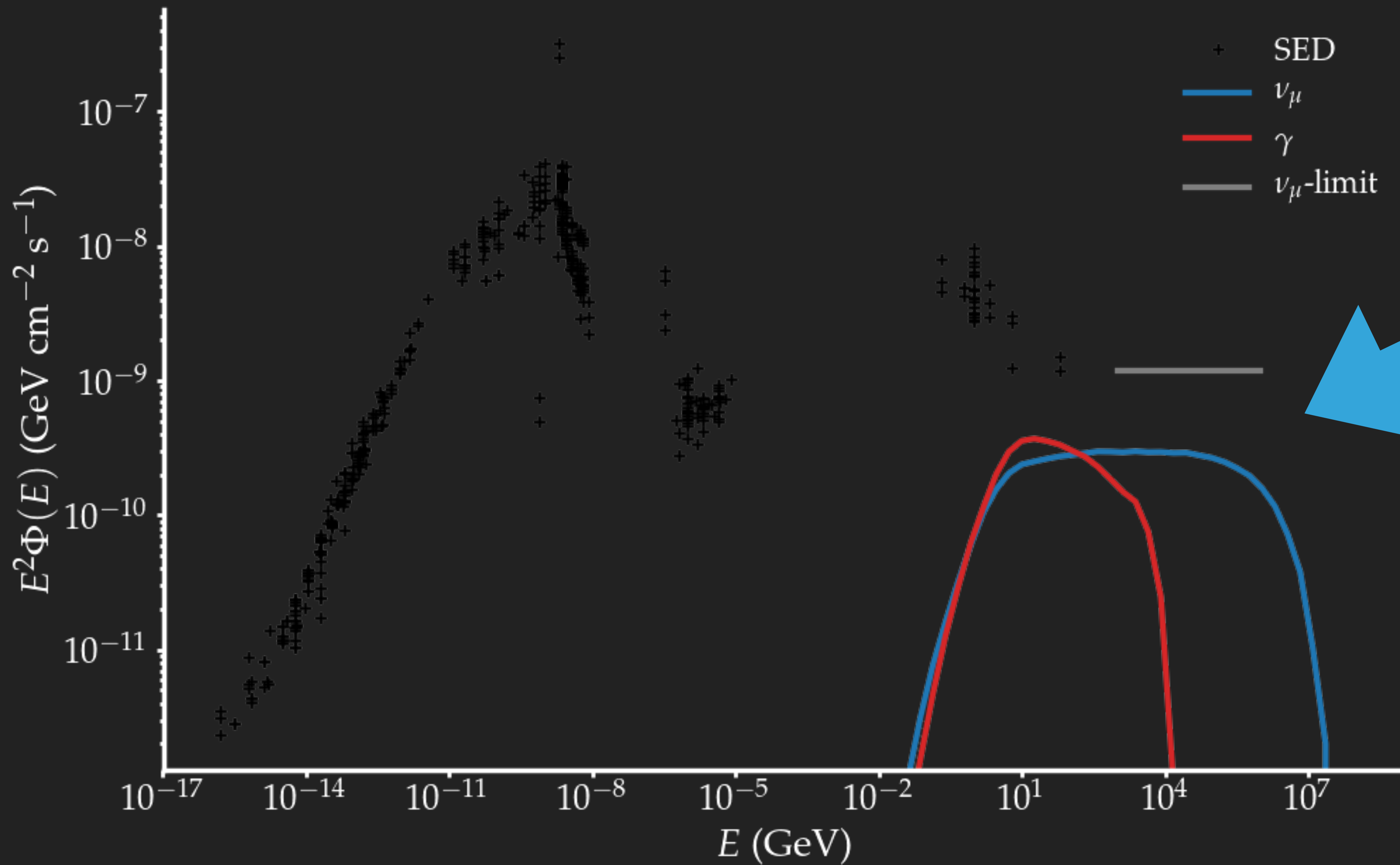
- ▶ $\chi = \frac{L_e}{L_R} \approx 100$

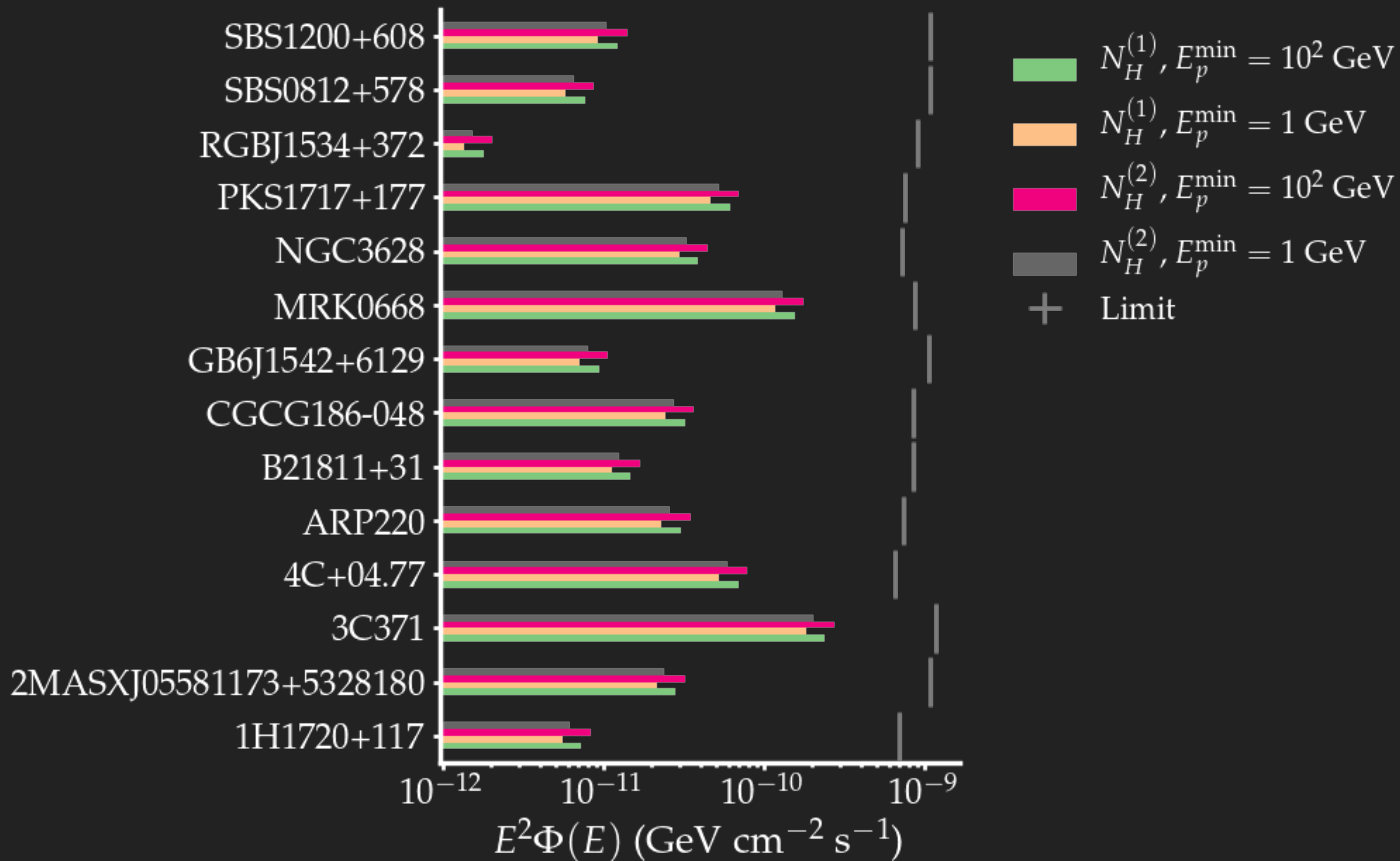
- ▶ $f_e = \frac{L_e}{L_p} \approx \frac{1}{10}$

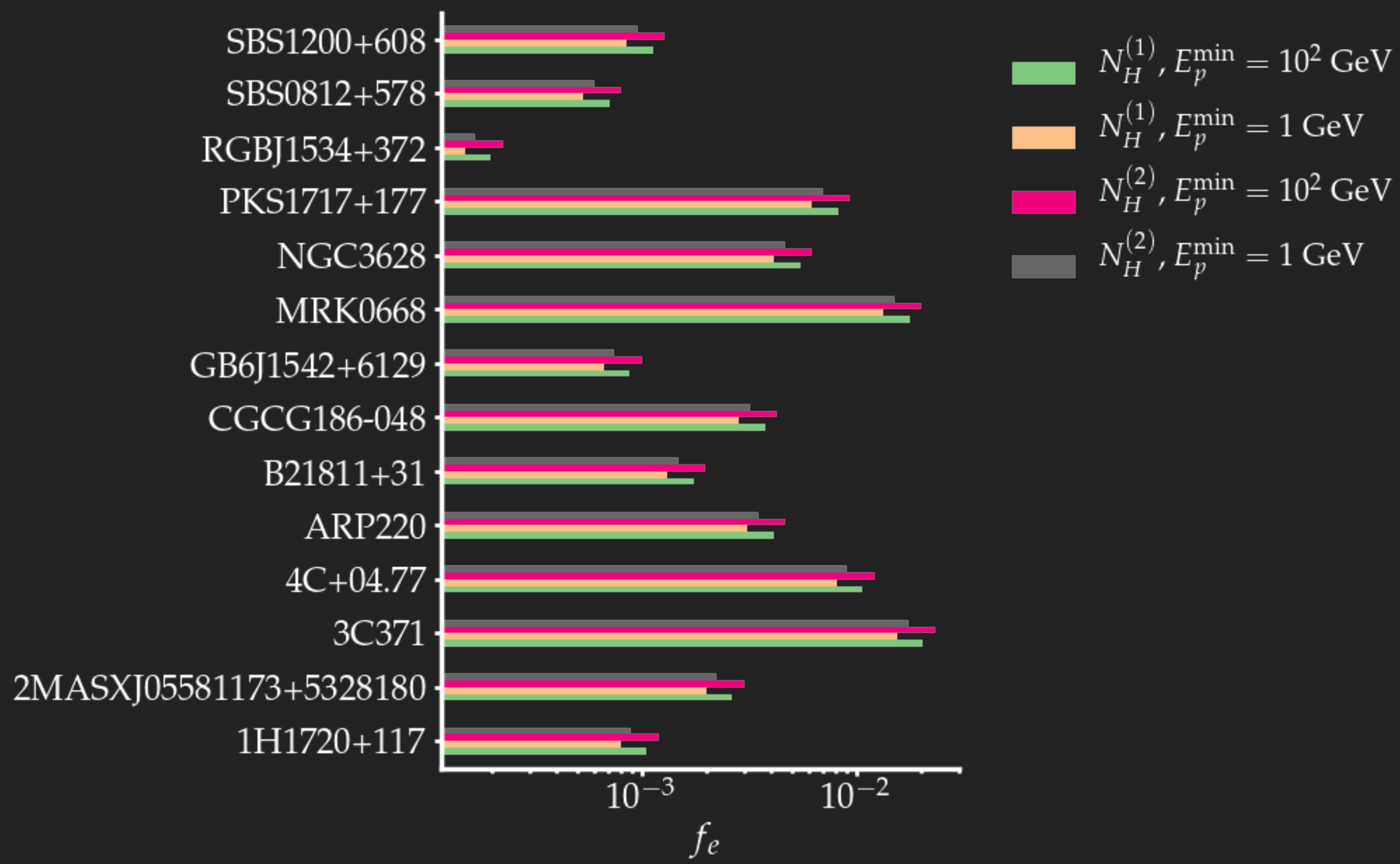
- ▶ Direct measurement of proton content



3C371



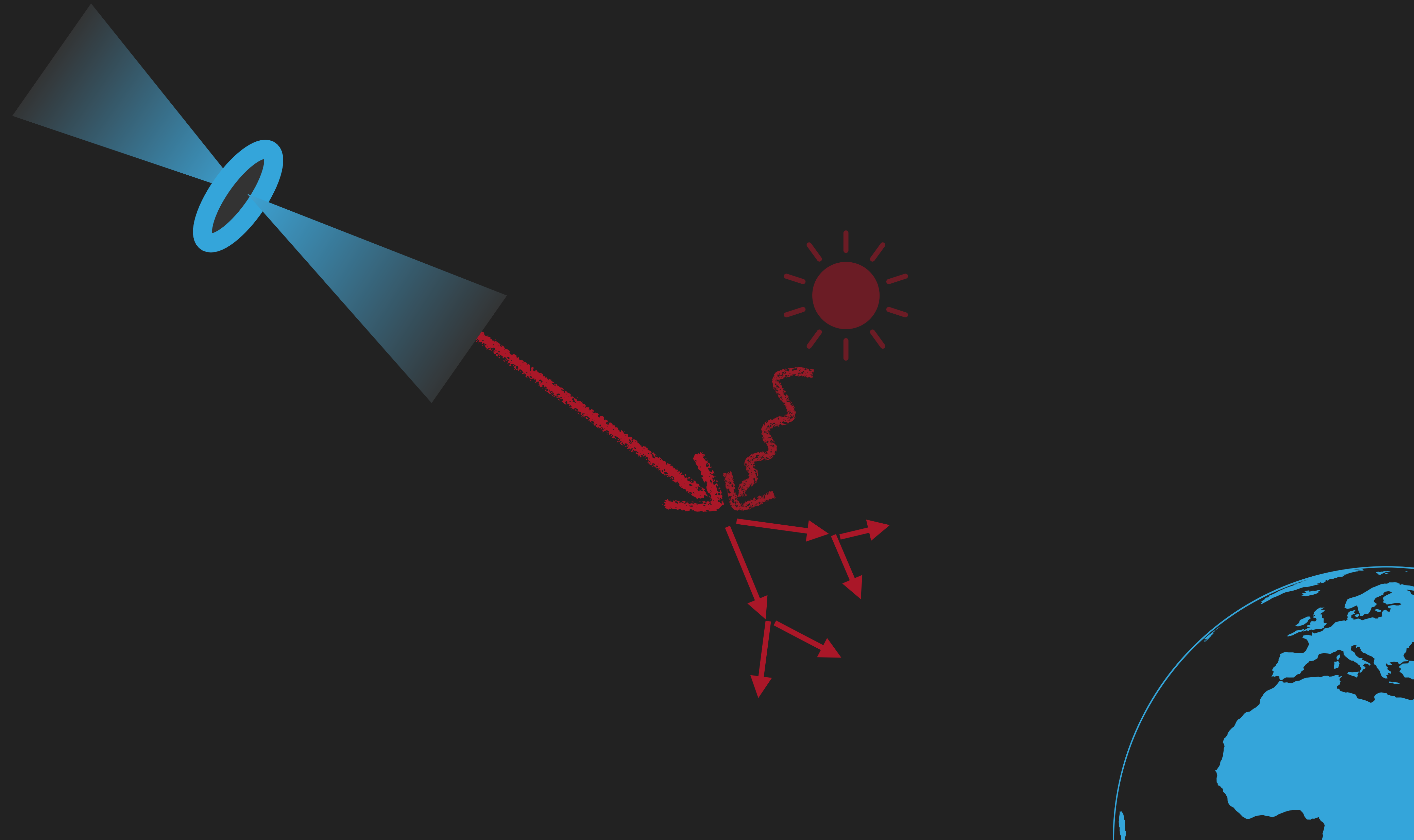




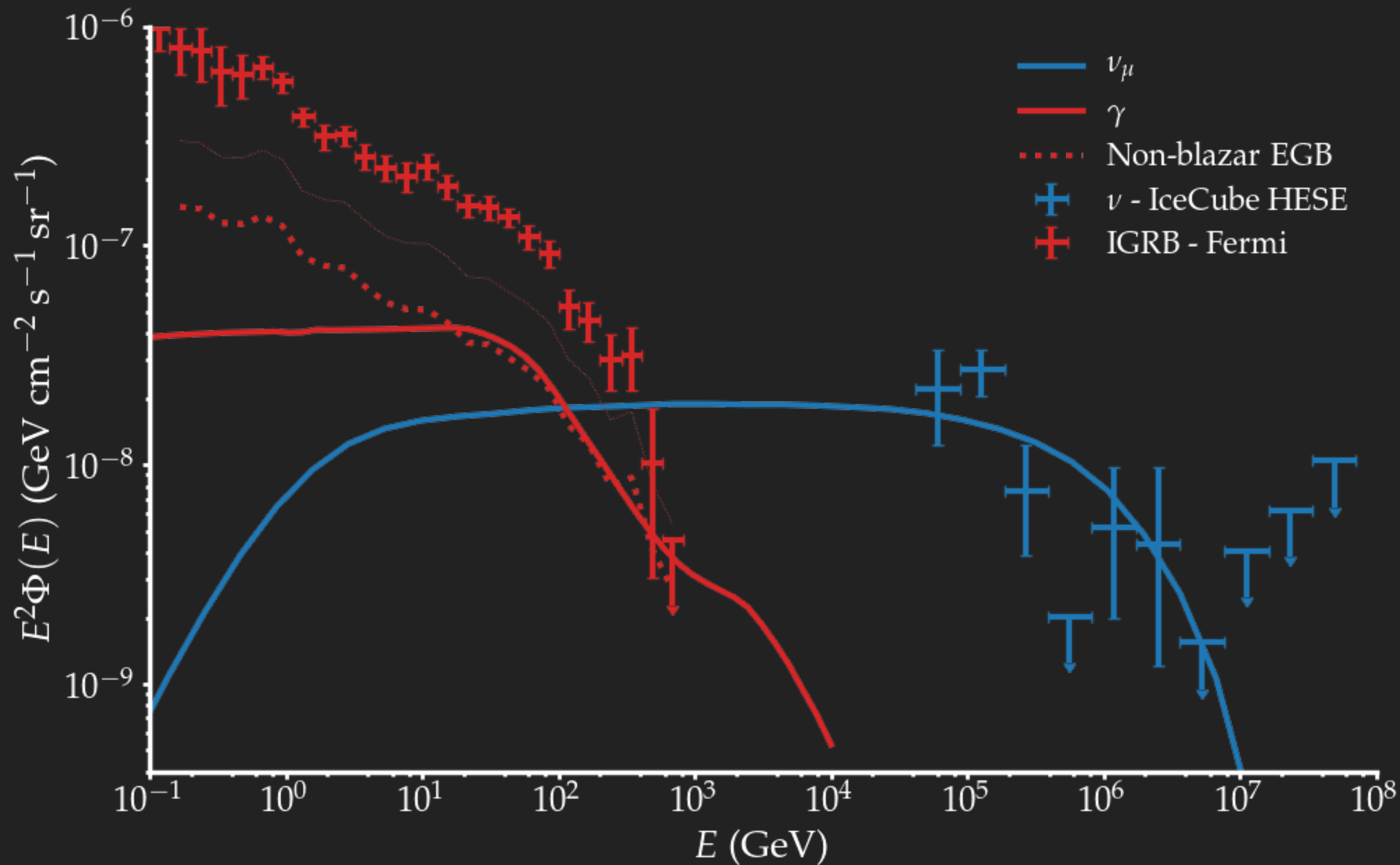
OBSCURED NEUTRINO SOURCES

DIFFUSE FLUX

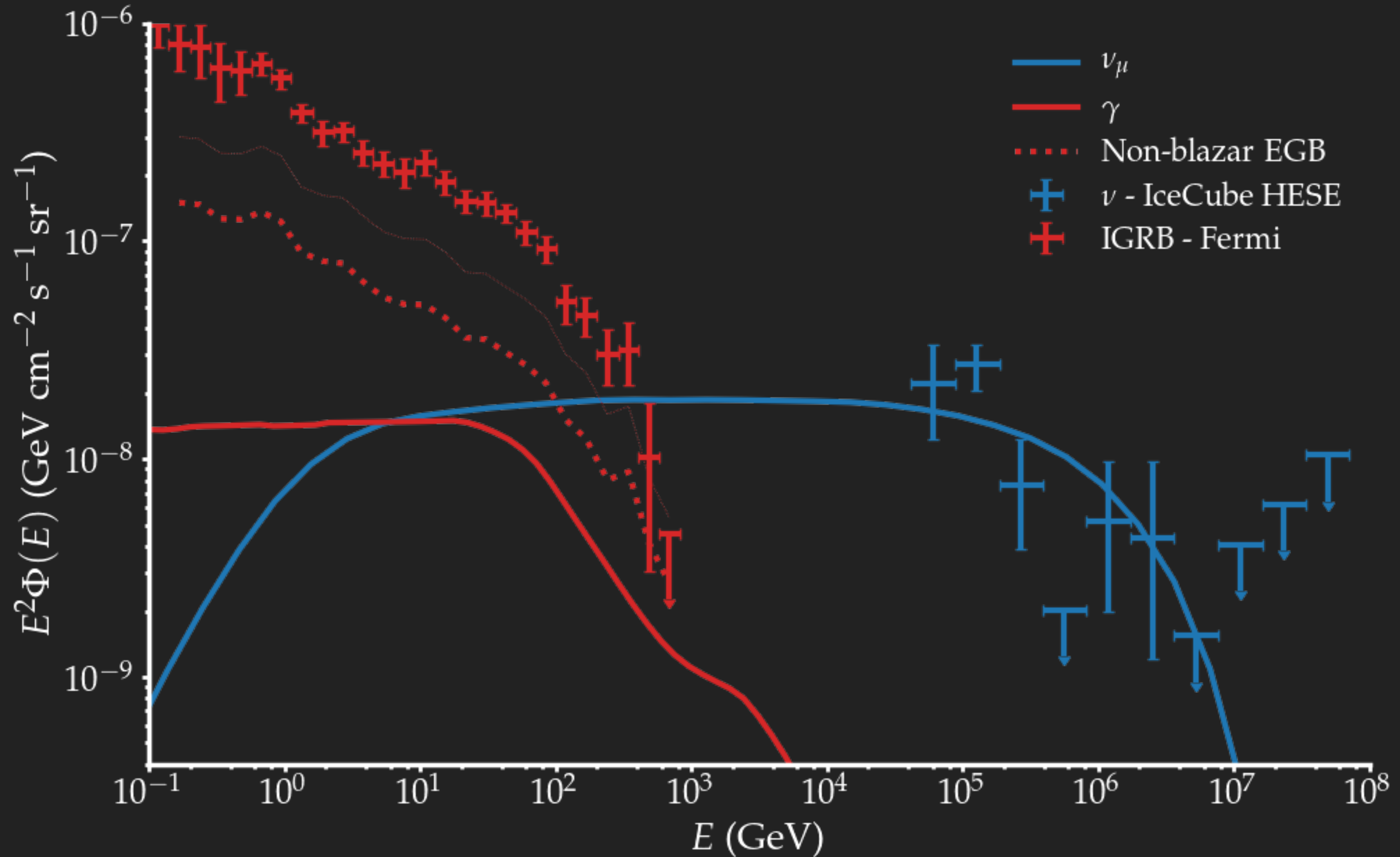
ATTENUATION: EXTRAGALACTIC BACKGROUND LIGHT



RESULTS



RESULTS



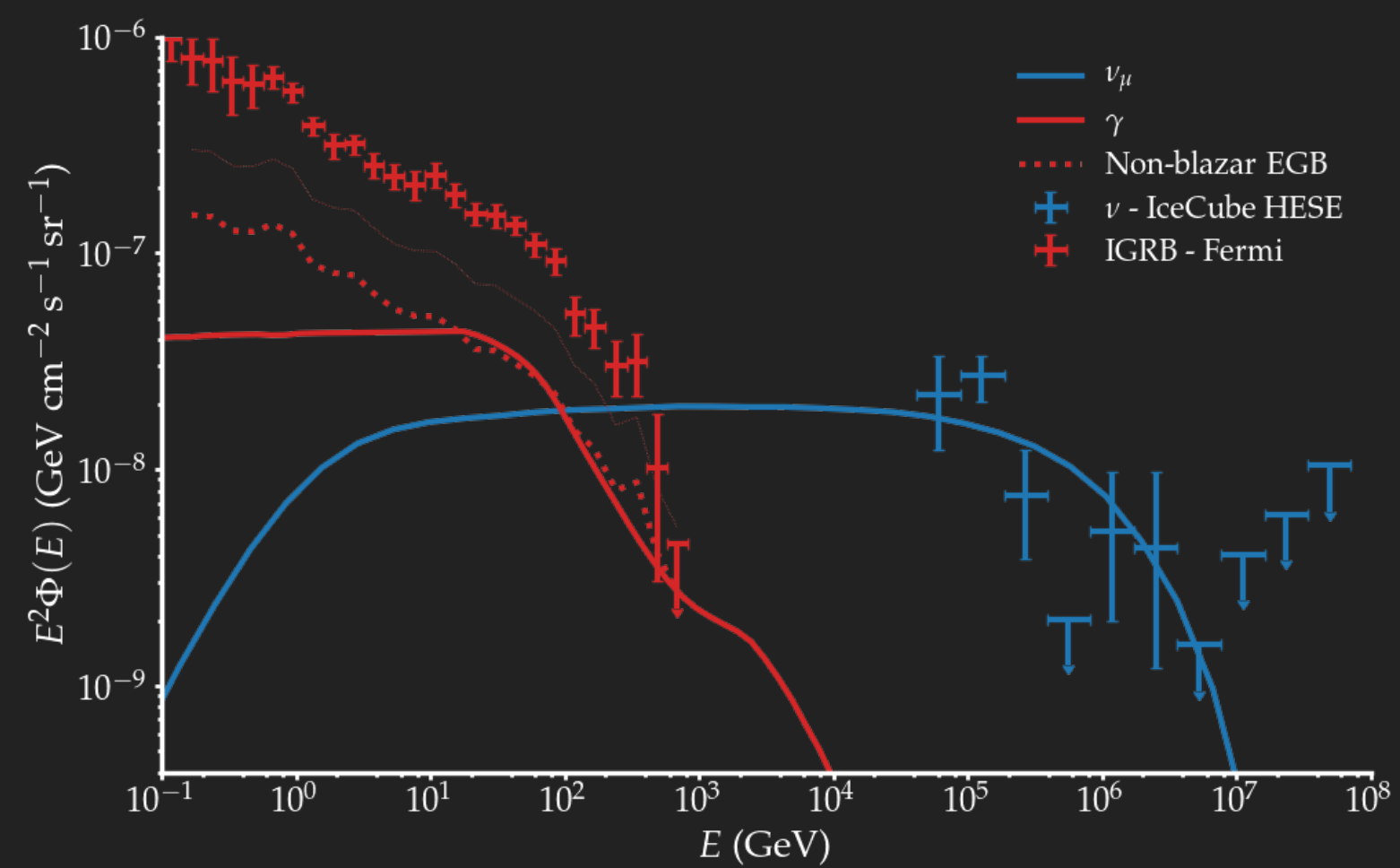
ULTRA-LUMINOUS INFRARED GALAXIES

- ▶ Typically merging galaxies
- ▶ Lots of dust
- ▶ Starburst activity
- ▶ Possibly obscured AGN

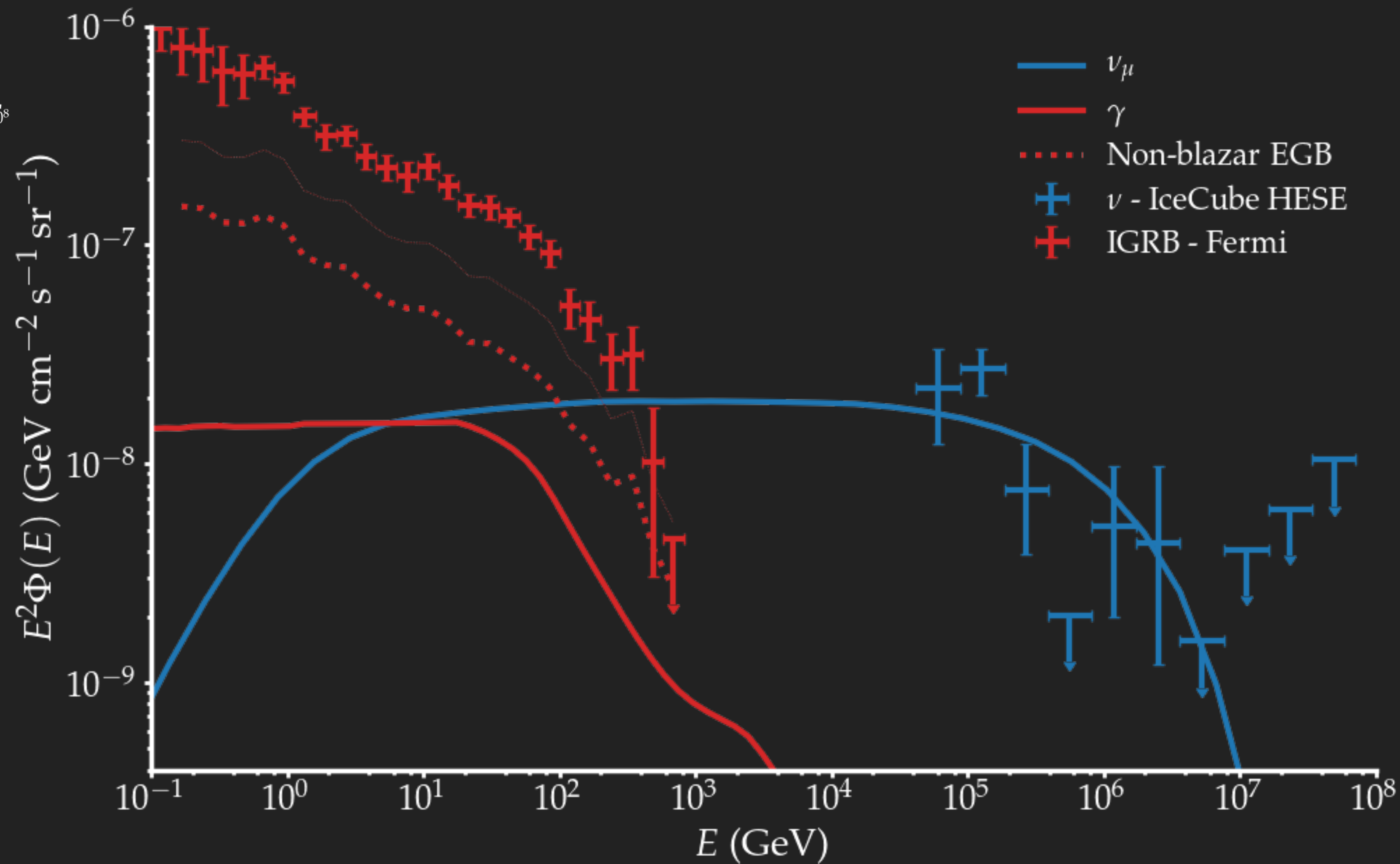
Different redshift evolution!



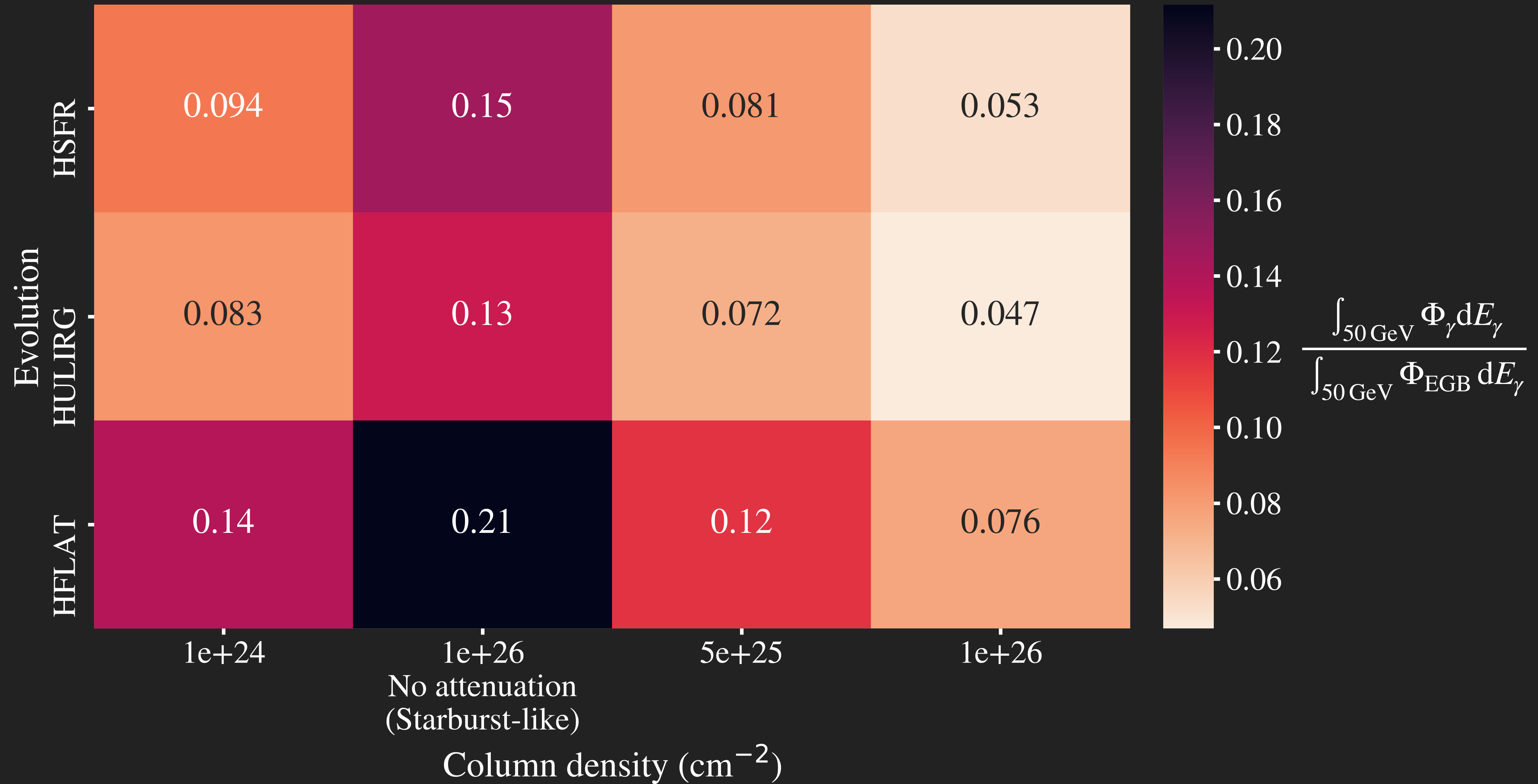
ARP 220 - James Webb



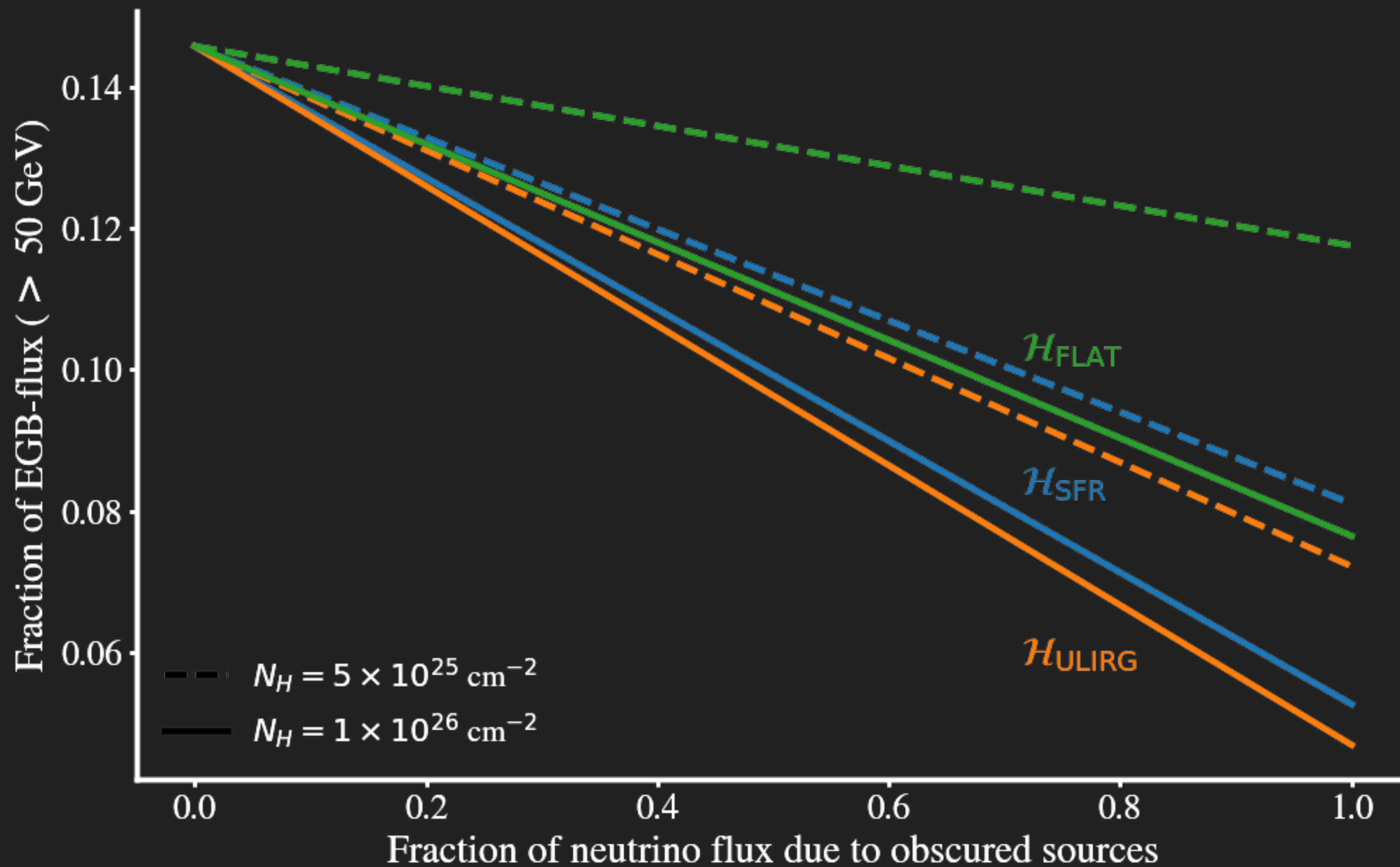
ULIRG



DIFFERENT SCENARIOS



COMBINATION WITH STARBURSTS



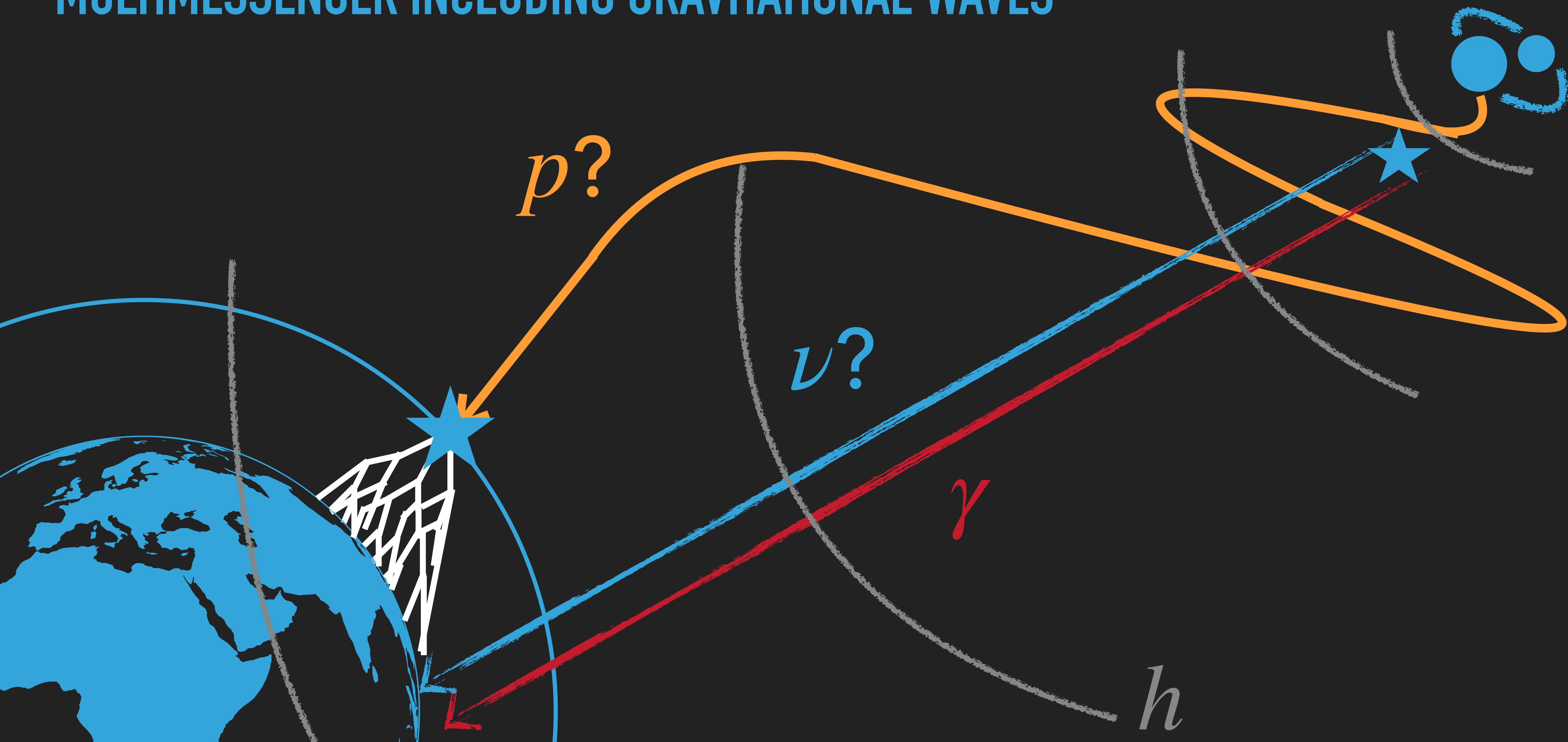
CONCLUSION

- ▶ Individual sources not yet ruled out
- ▶ Obscuration by matter can resolve tension
- ▶ Follow-up works:
 - ▶ Search for High-energy Neutrinos from Ultraluminous Infrared Galaxies with IceCube (Astrophys.J. 926 (2022) 1, 59)
 - ▶ Investigating starburst-driven neutrino emission from galaxies in the Great Observatories All-Sky LIRG Survey (2304.01020)



NEUTRINOS FROM BBH MERGERS

MULTIMESSENGER INCLUDING GRAVITATIONAL WAVES



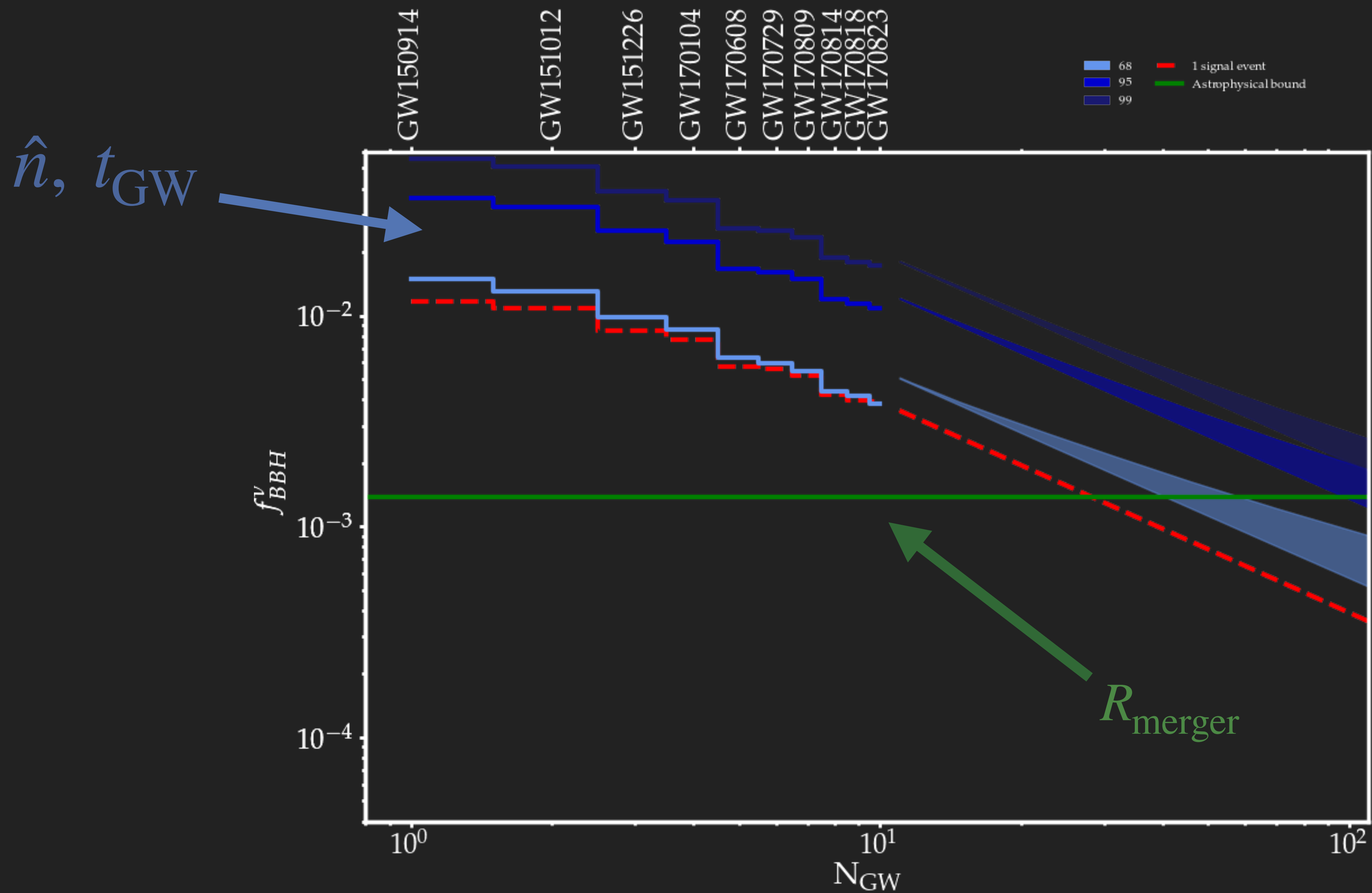
NEUTRINOS FROM BBH MERGERS

$$f_{\nu}^{\text{BBH}} = \frac{E_{\nu}}{E_{\text{GW}}}$$

Constrain:

- ▶ Direct observation
- ▶ Astrophysical ν -flux

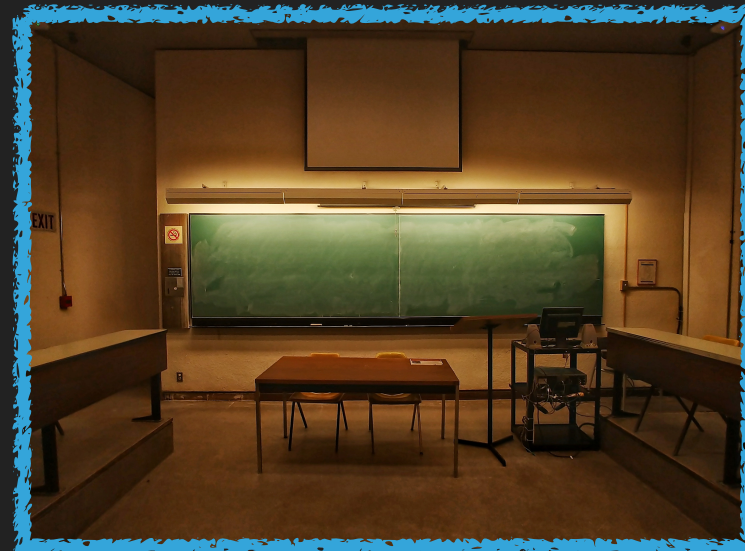
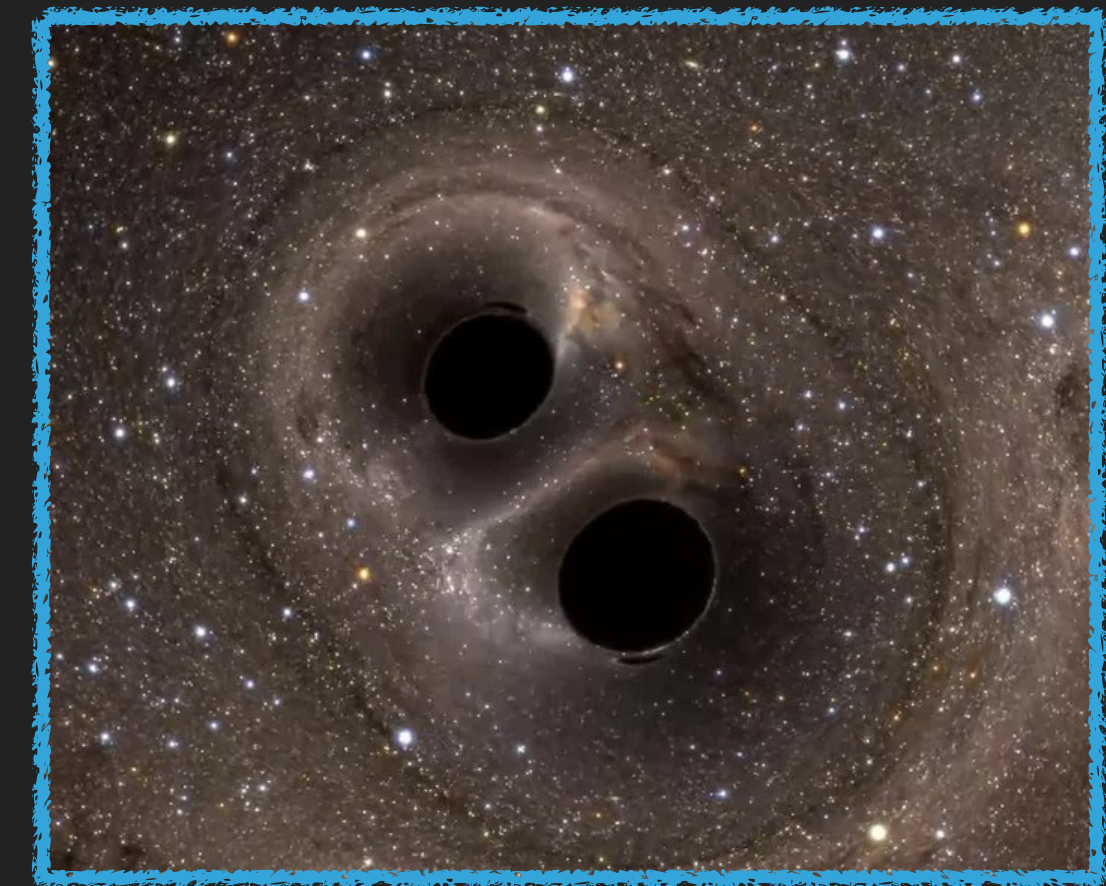
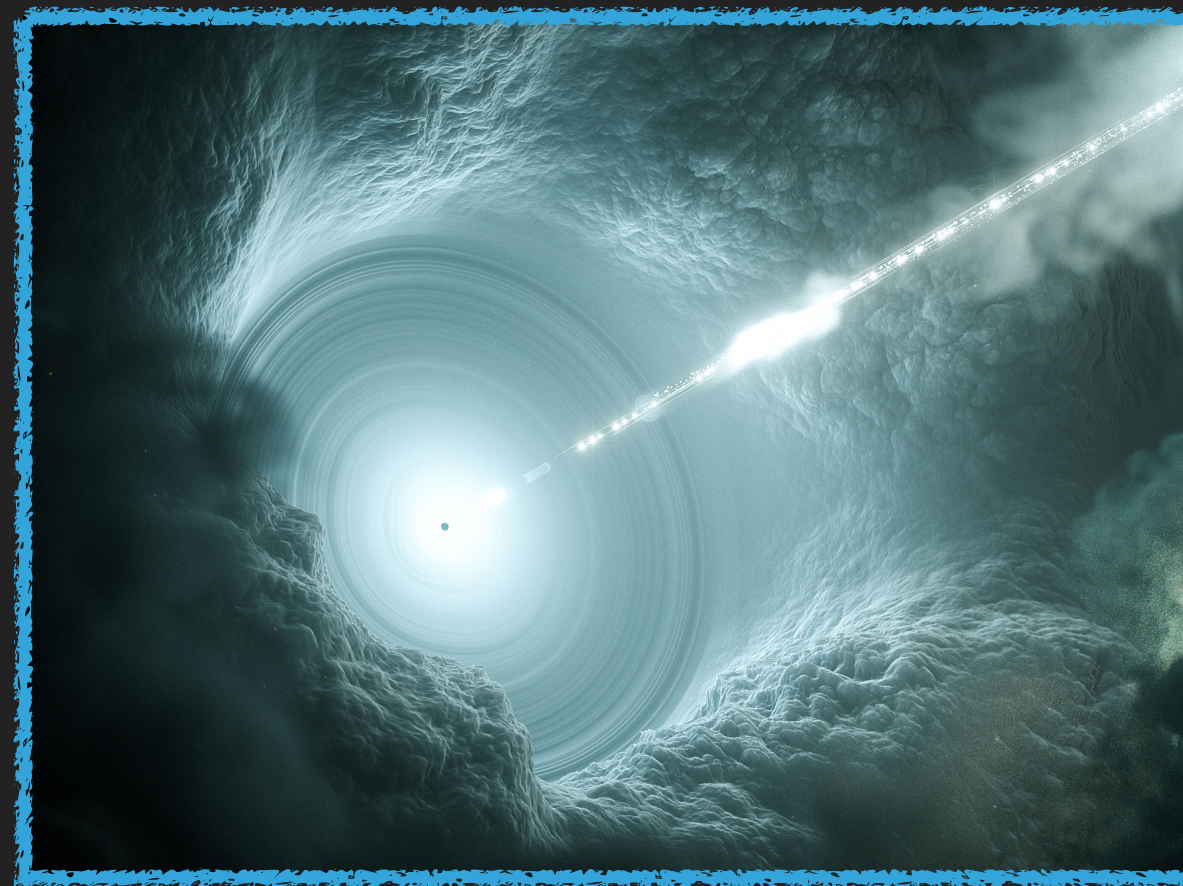
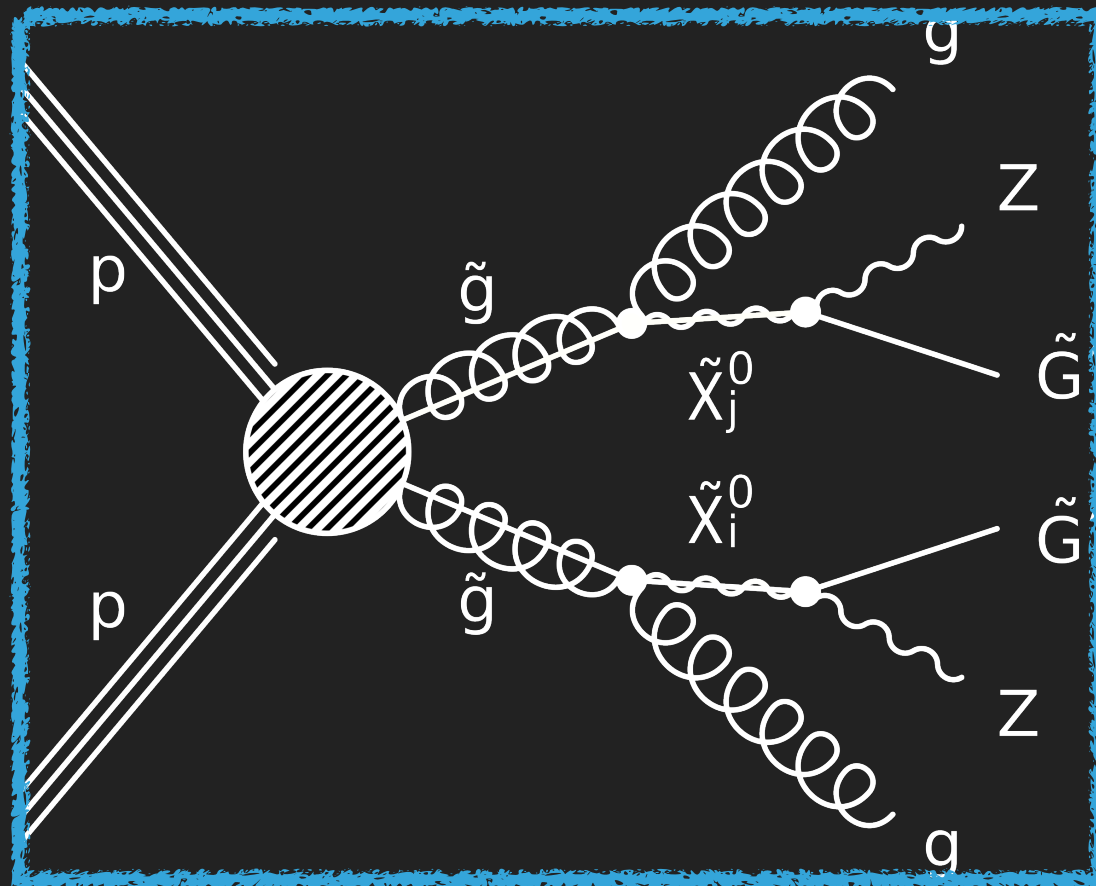
PROSPECTS AFTER RUN 02



CONCLUSION

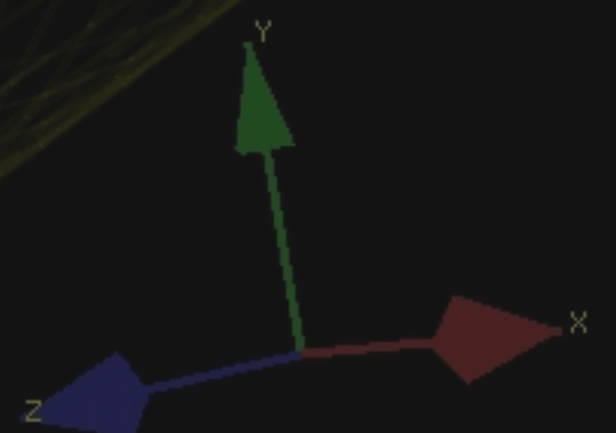
- ▶ BBH mergers not yet ruled out as significant source neutrino flux
- ▶ Relevant constraints in near future
- ▶ Different scalings or sub-populations can change this picture!

OVERVIEW



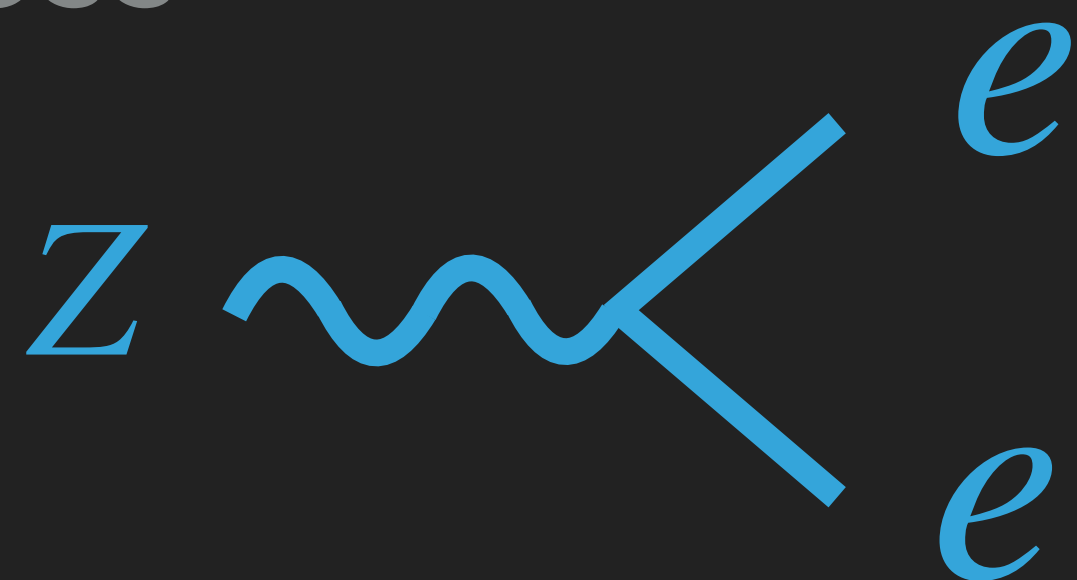
BACK-UP

PHYSICS BEYOND THE STANDARD MODEL: Z-PEAKED EXCESS

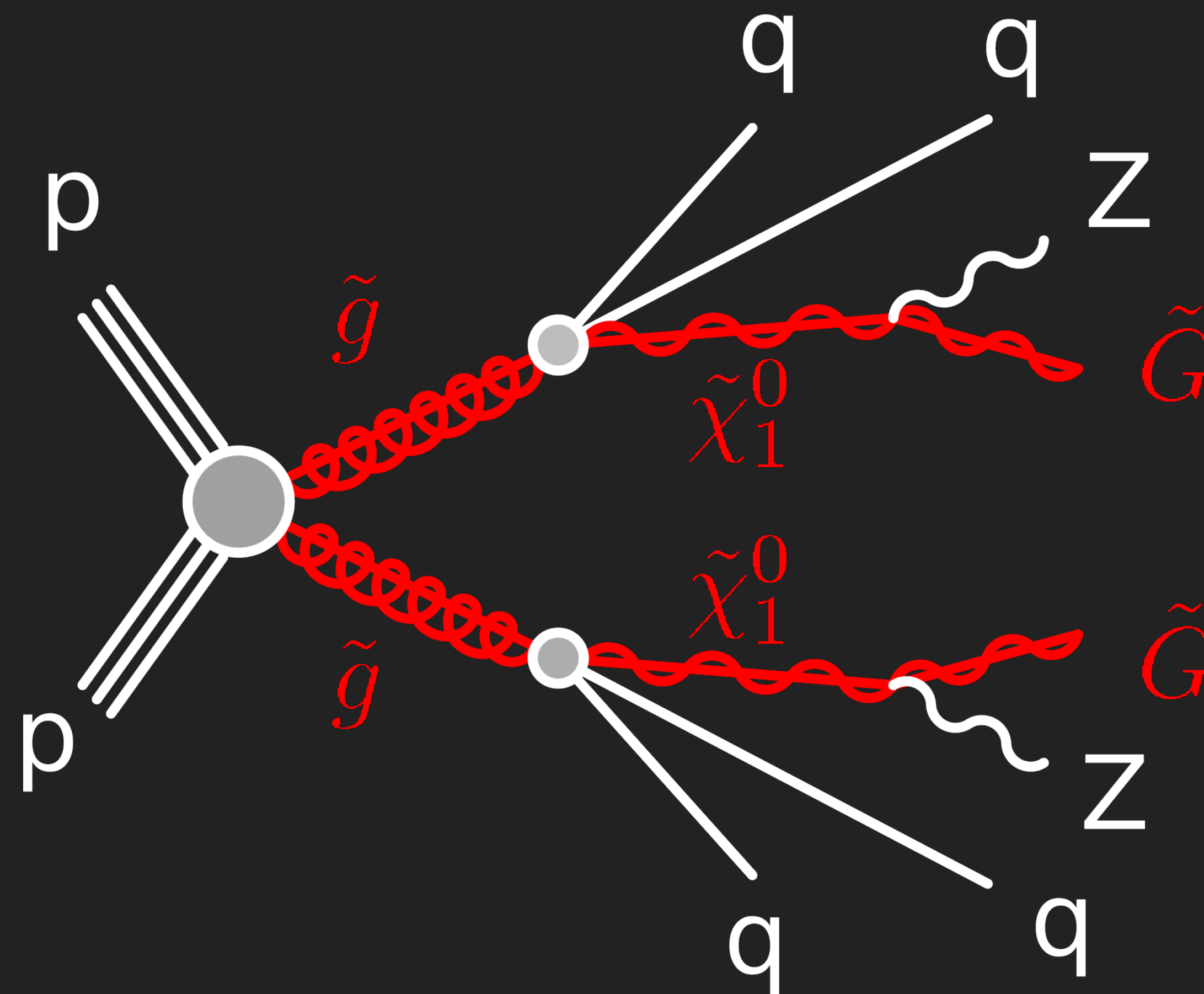


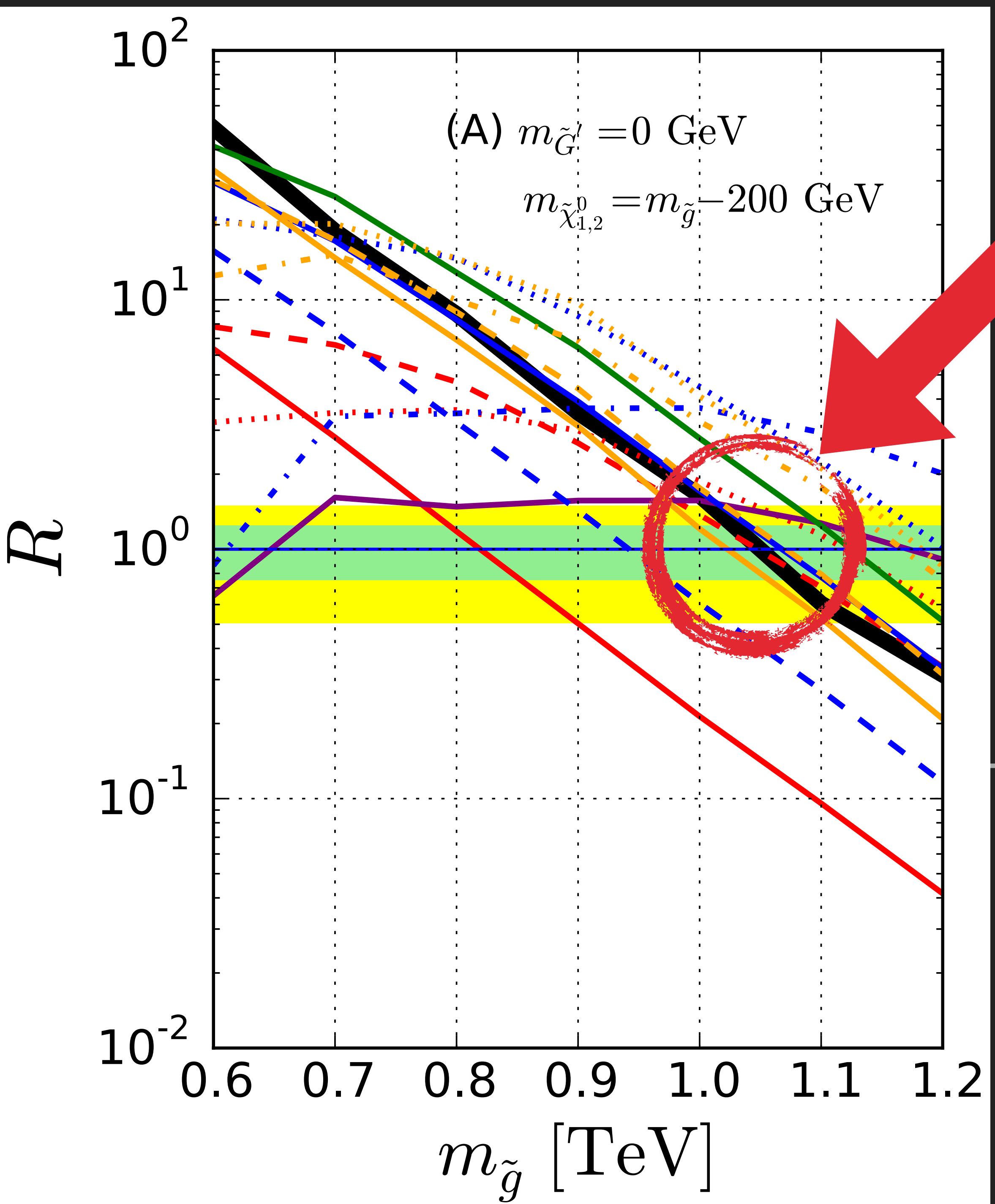
ATLAS SEARCH 2015

- ▶ Jets, missing energy, 2 leptons
- ▶ 3σ excess



- ▶ Interpretation: problematic

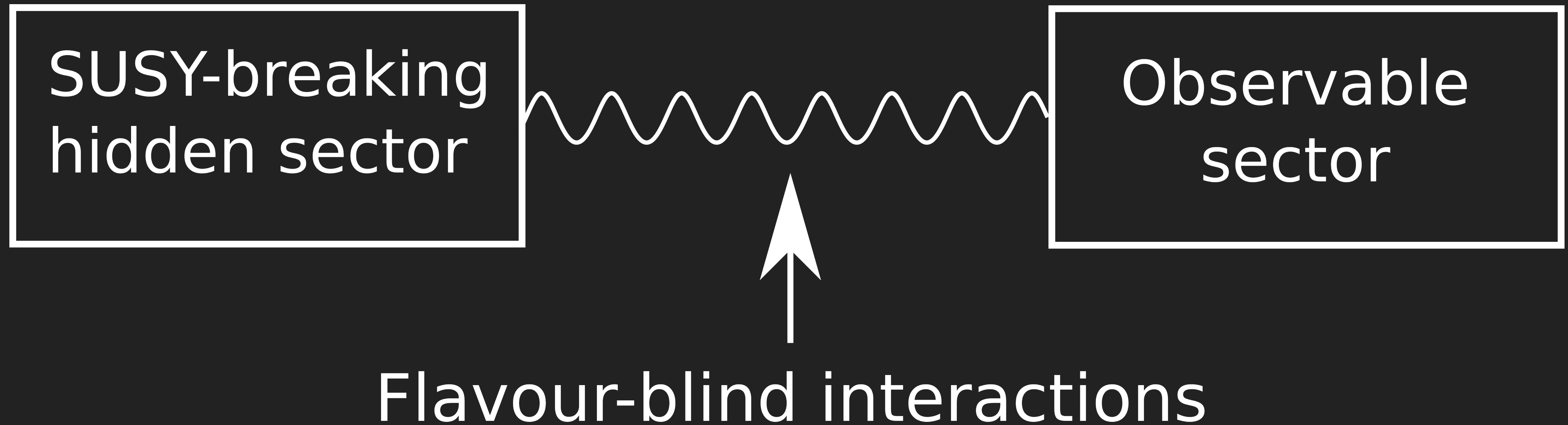




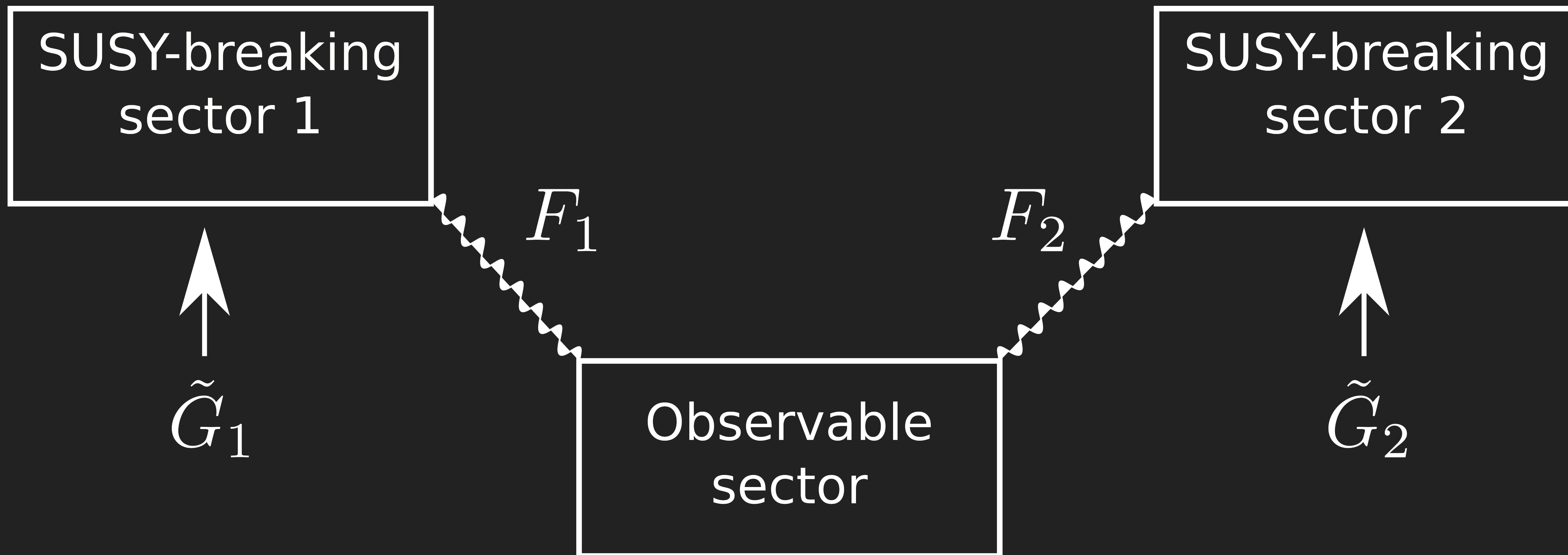
ORIGINAL SEARCH

ATLAS

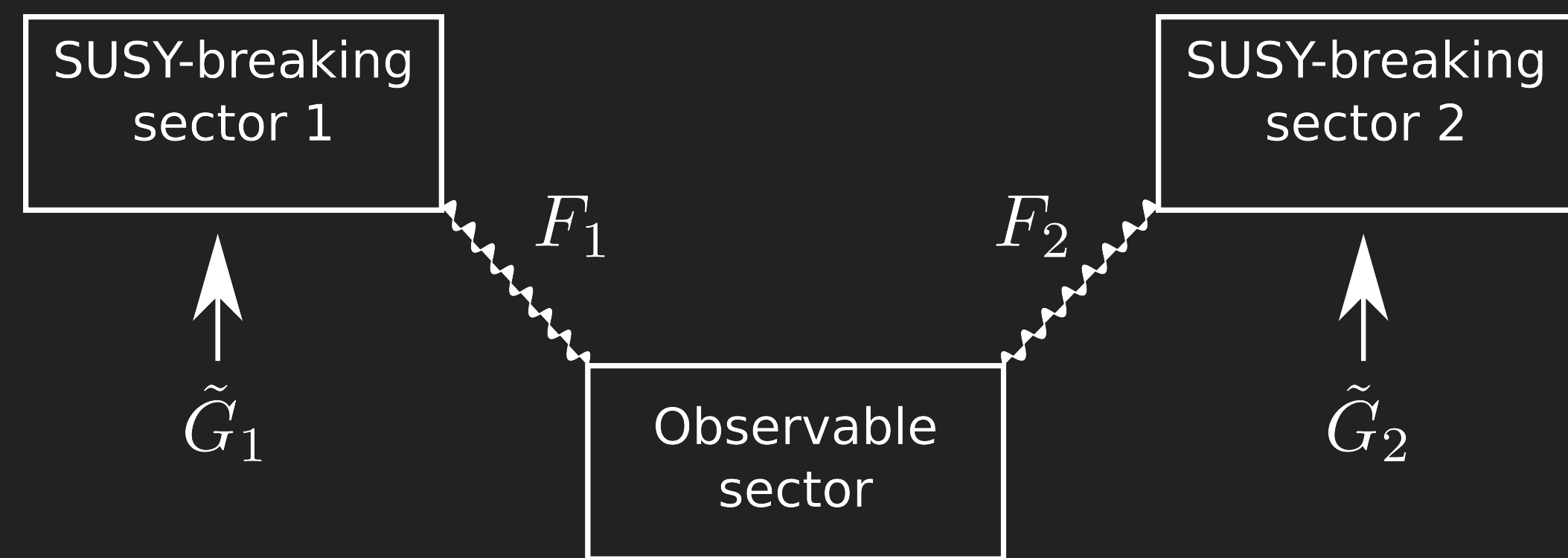
SUSY BREAKING IN A HIDDEN SECTOR – GAUGE MEDIATION



OUR MODEL

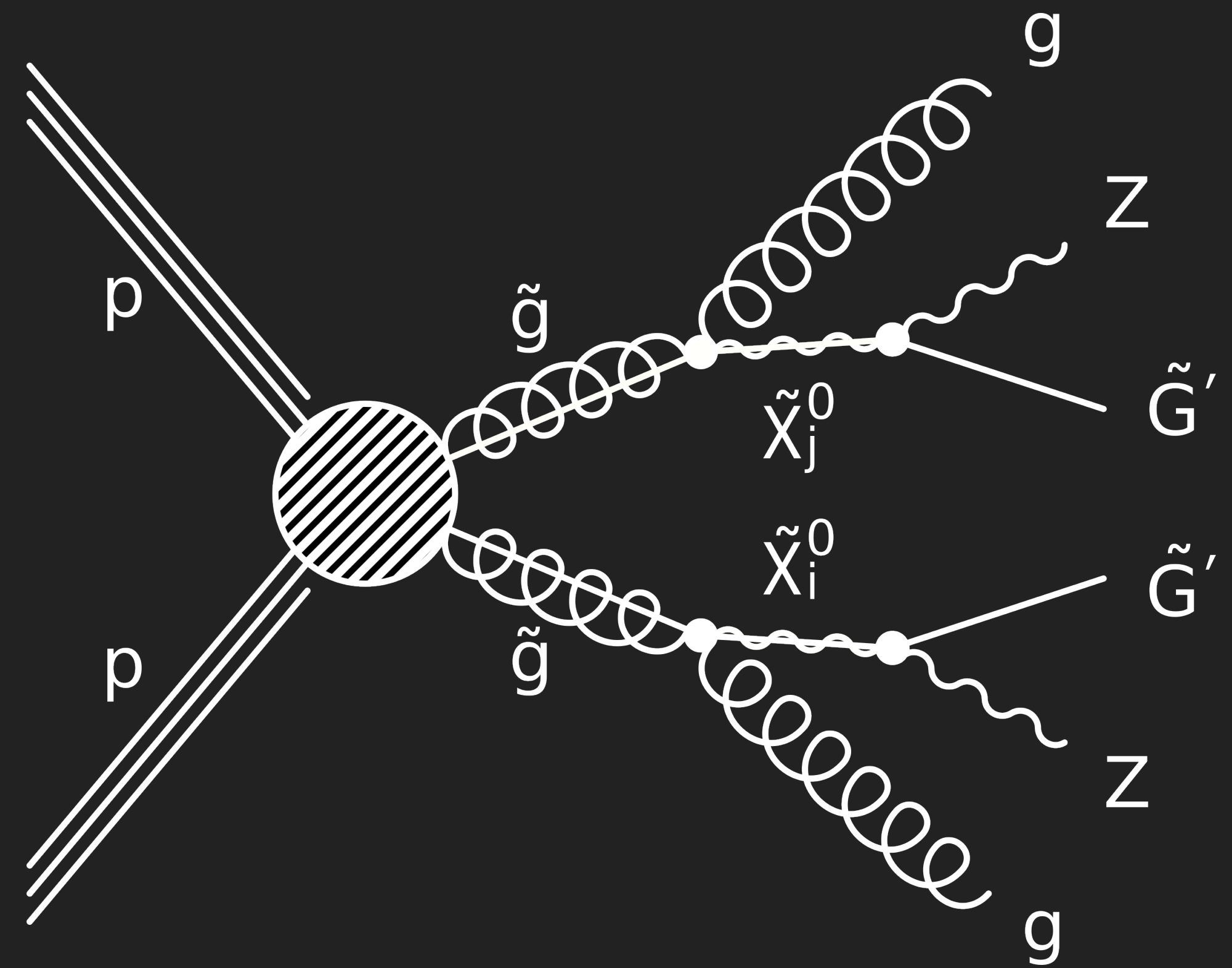
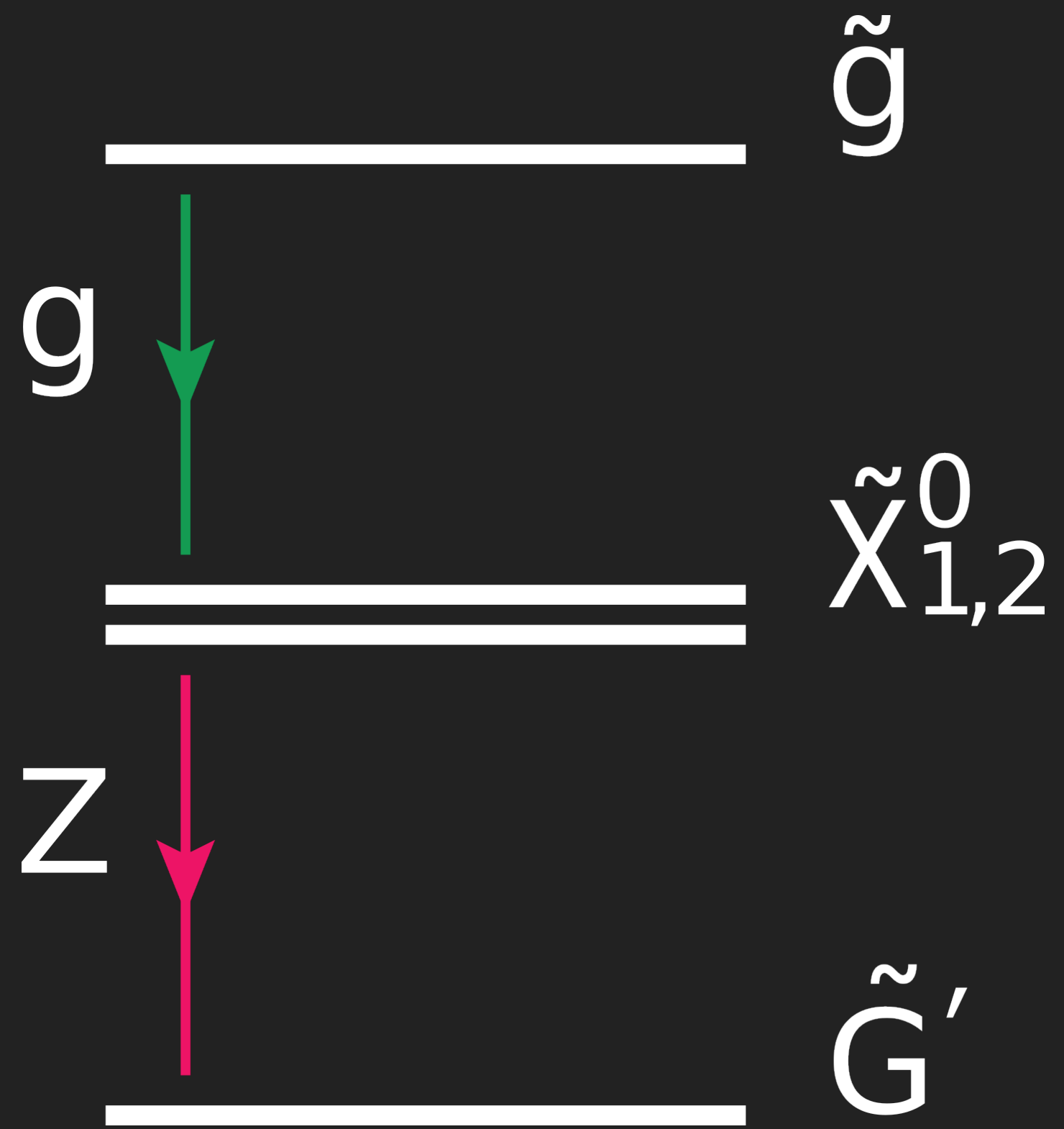


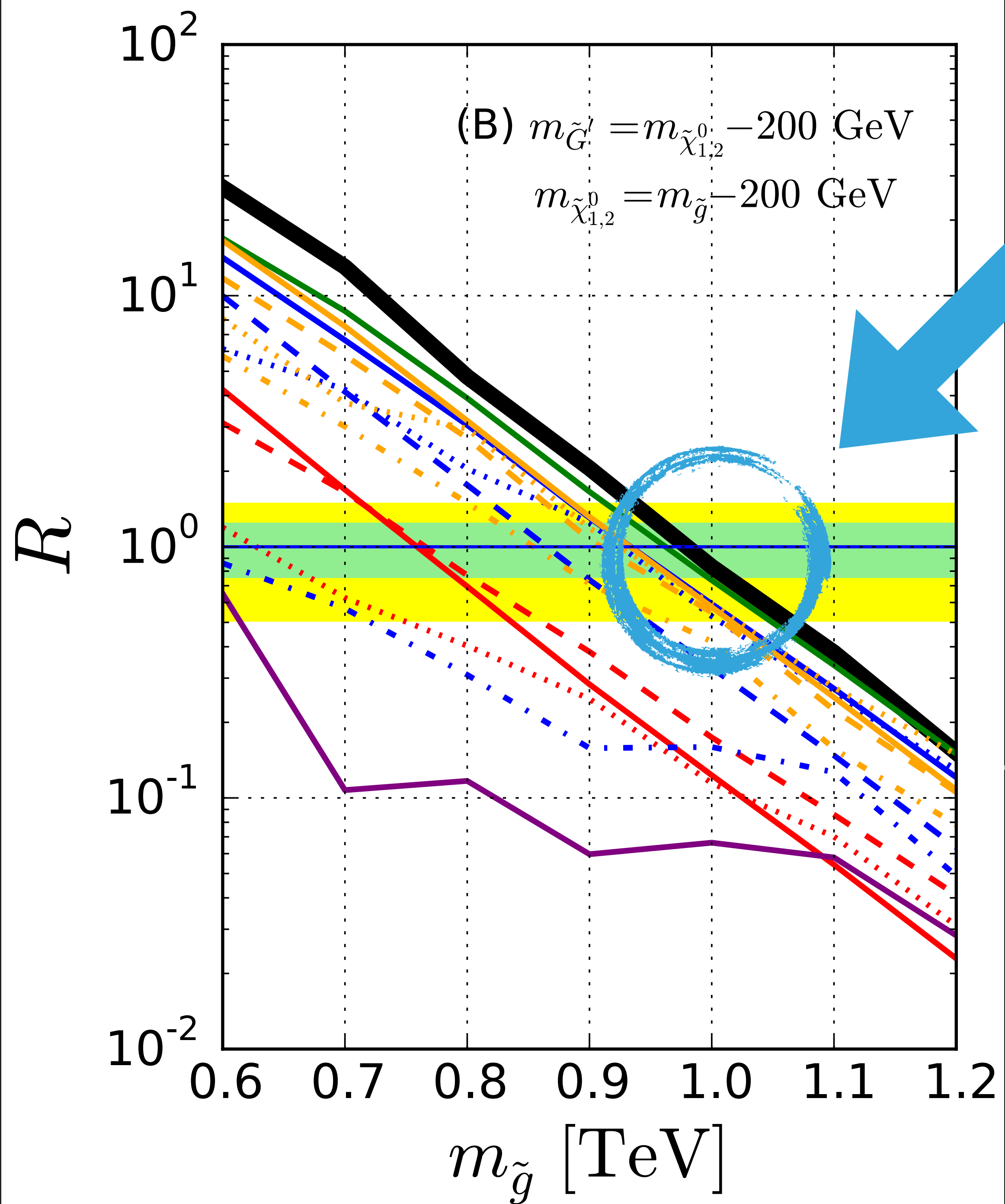
OUR MODEL



- ▶ One massless true goldstone
- ▶ One massive pseudo-goldstino

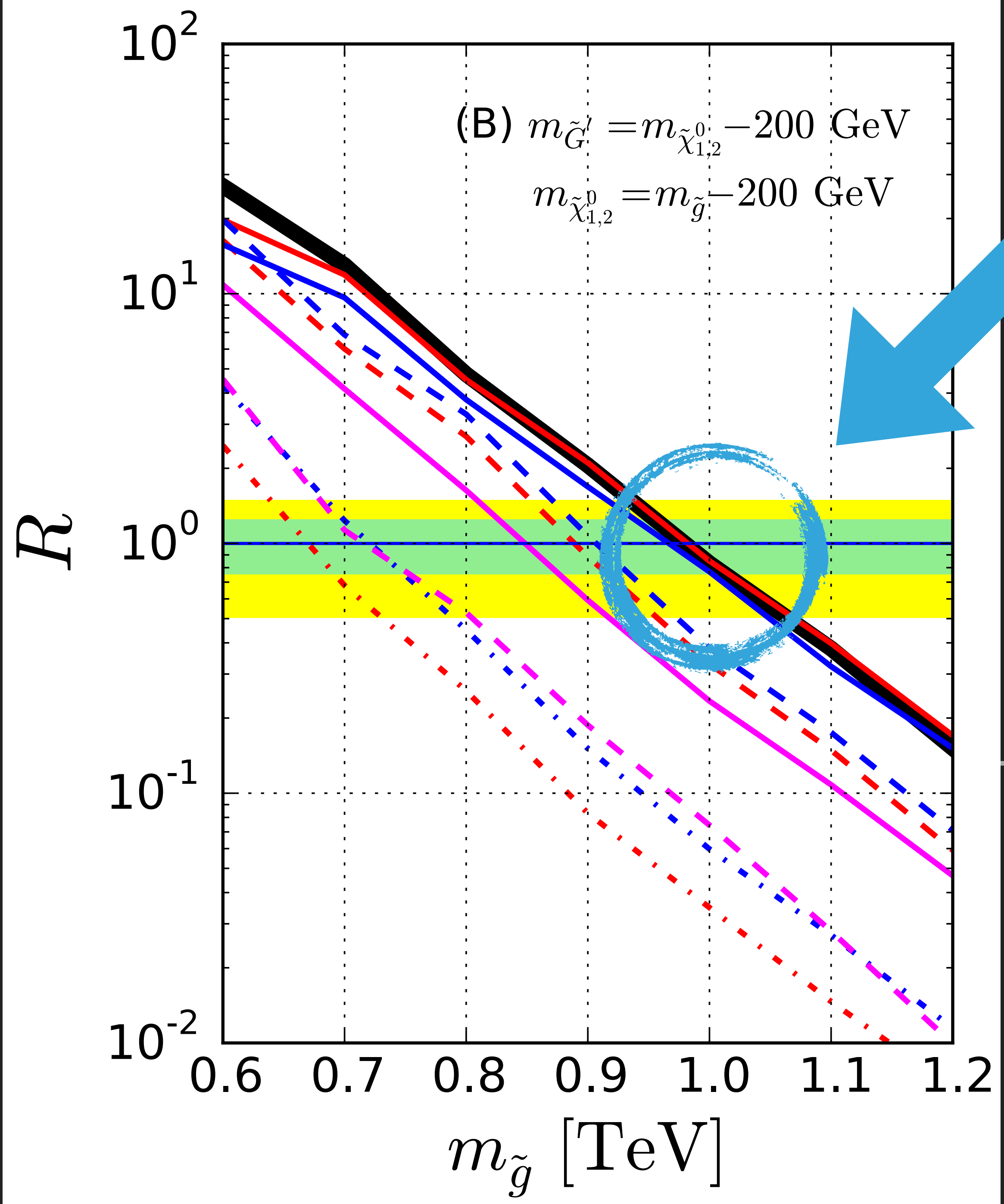
OUR MODEL





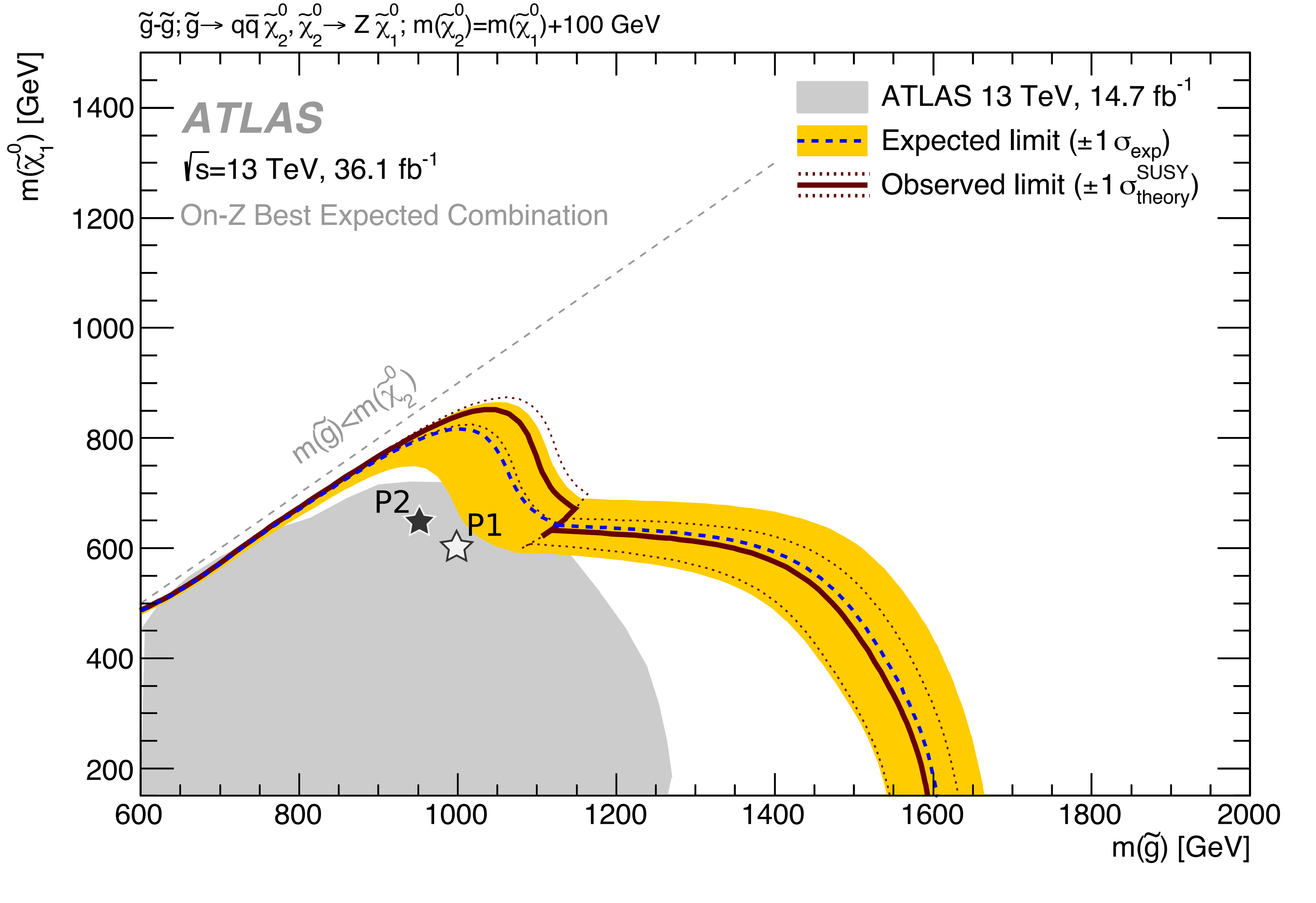
RESULTS

ATLAS



RESULTS

CMS



CONCLUSION

- ▶ Multiple-sector SUSY breaking gives new phenomenology
- ▶ Newer data rules out this specific implementation

WORK AFTER PHD

Teaching assistant @ KUL

Risk model developer @ KBC

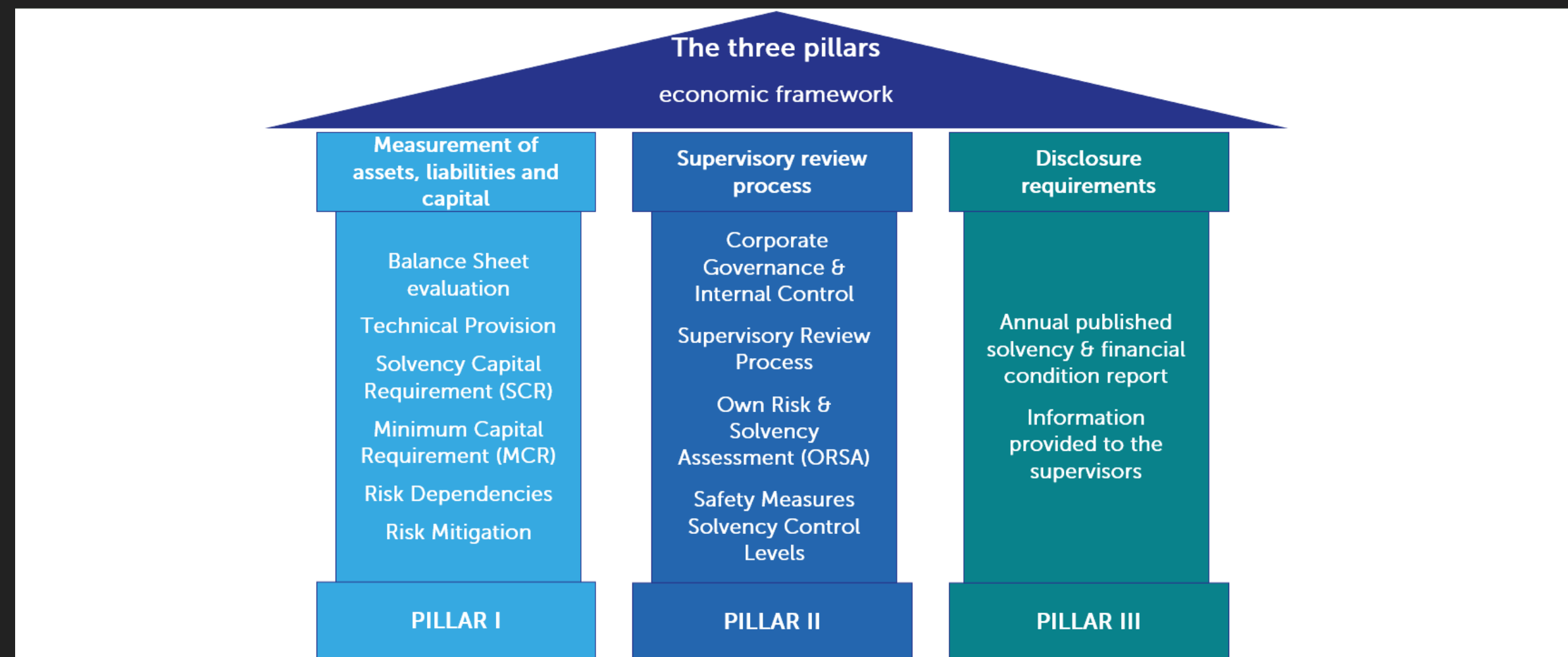


Photo by Niamat Ullah on Unsplash



INSURANCE RISK

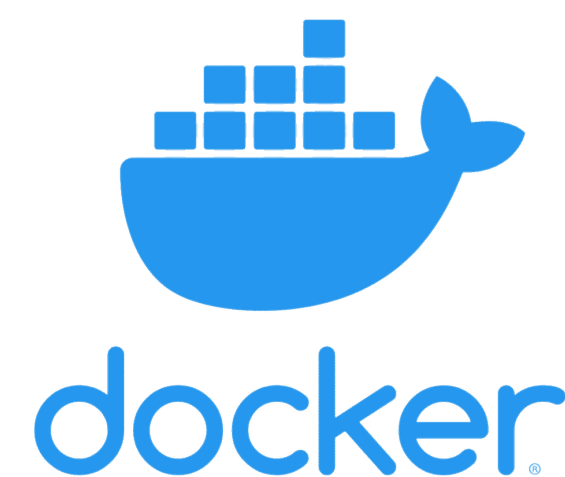
- ▶ Group model aggregating risks across
 - ▶ entities
 - ▶ business lines



MOVE TO CLOUD COMPUTING

- ▶ Coordinate requirements with risk and finance groups
- ▶ Set up governance
- ▶ Translate workflow
- ▶ Identify solutions to serve our programs to internal users
- ▶ Develop training program for our team

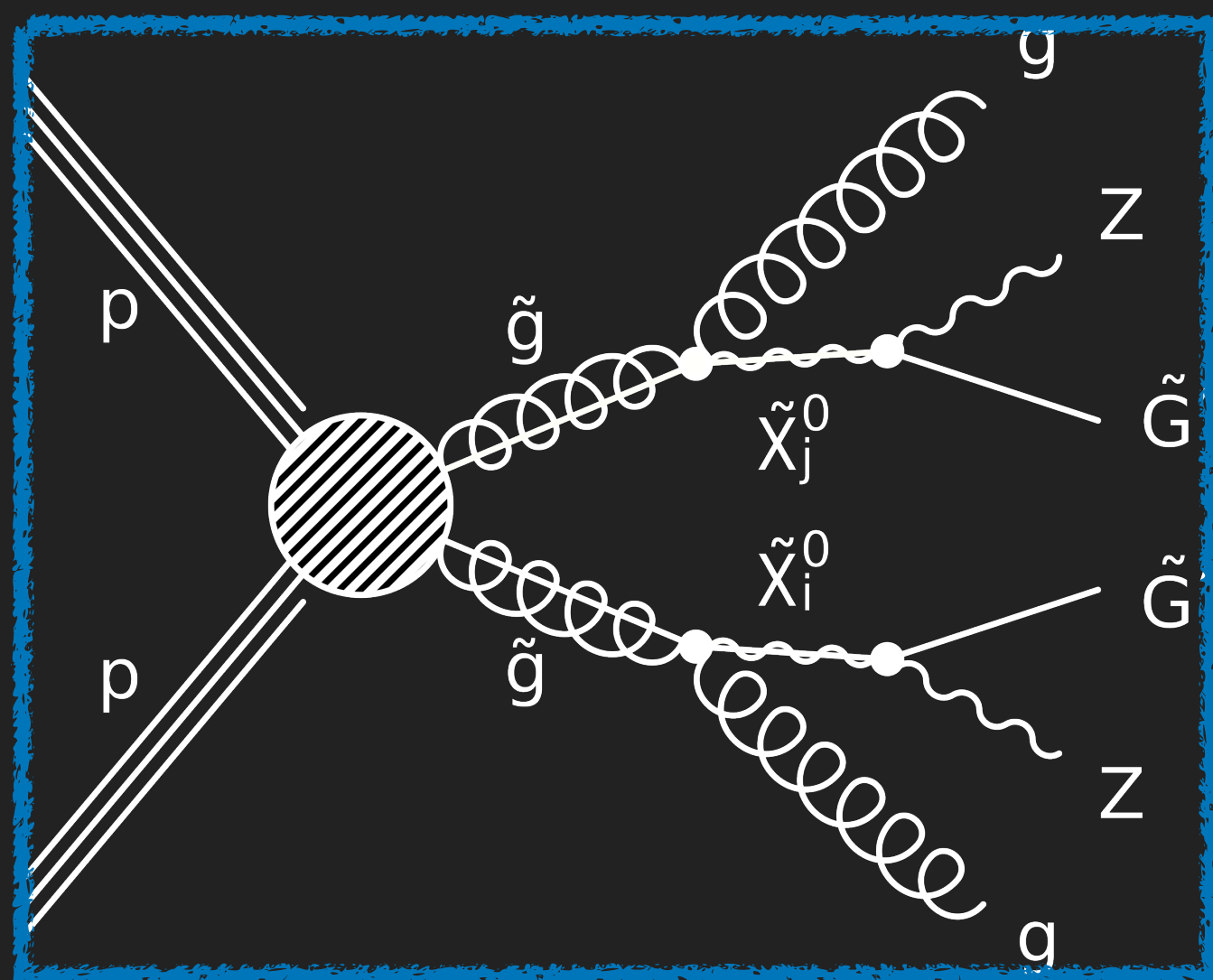
aws



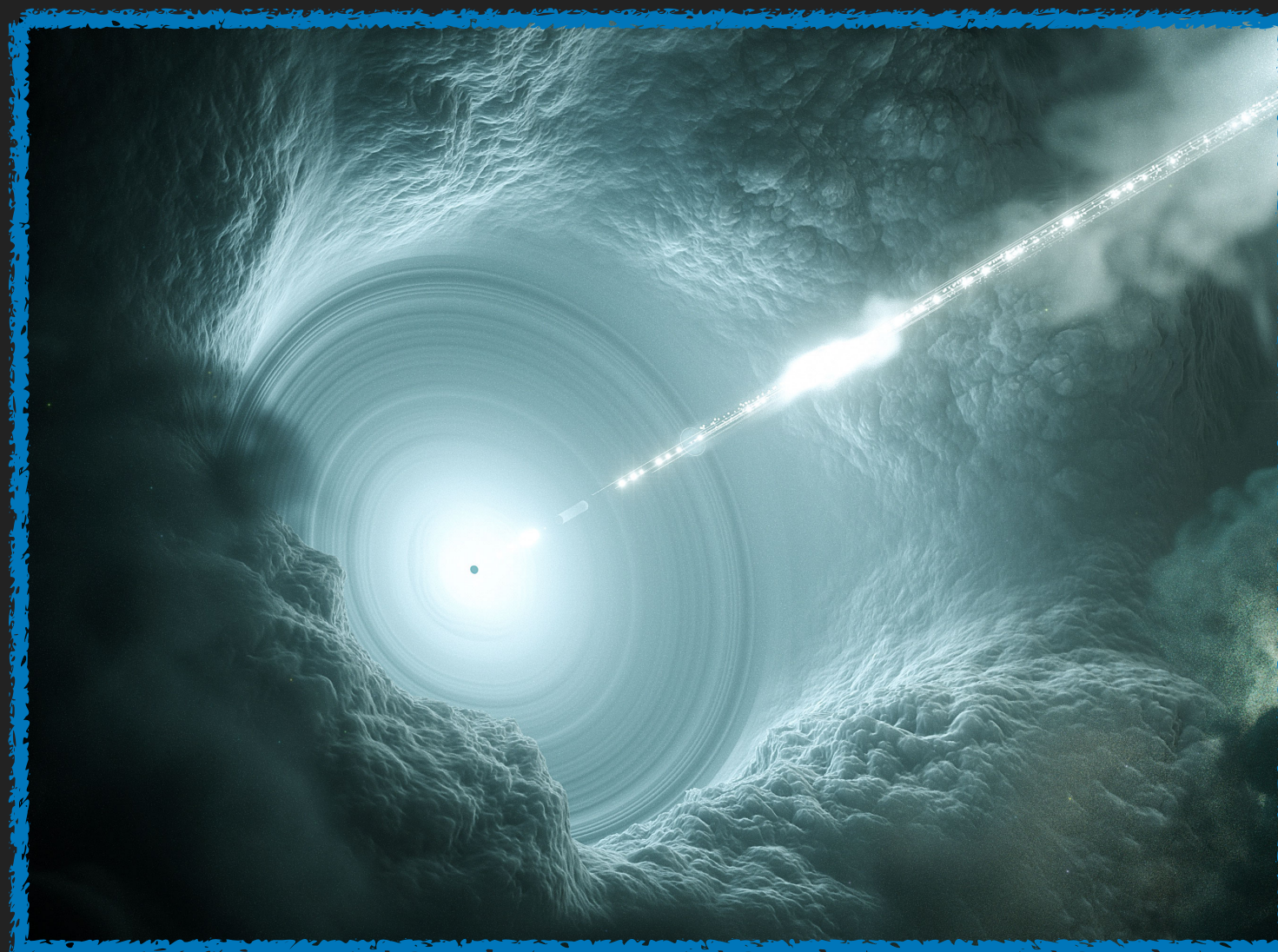
kubernetes

PARTICLE PHYSICS PHENOMENOLOGY

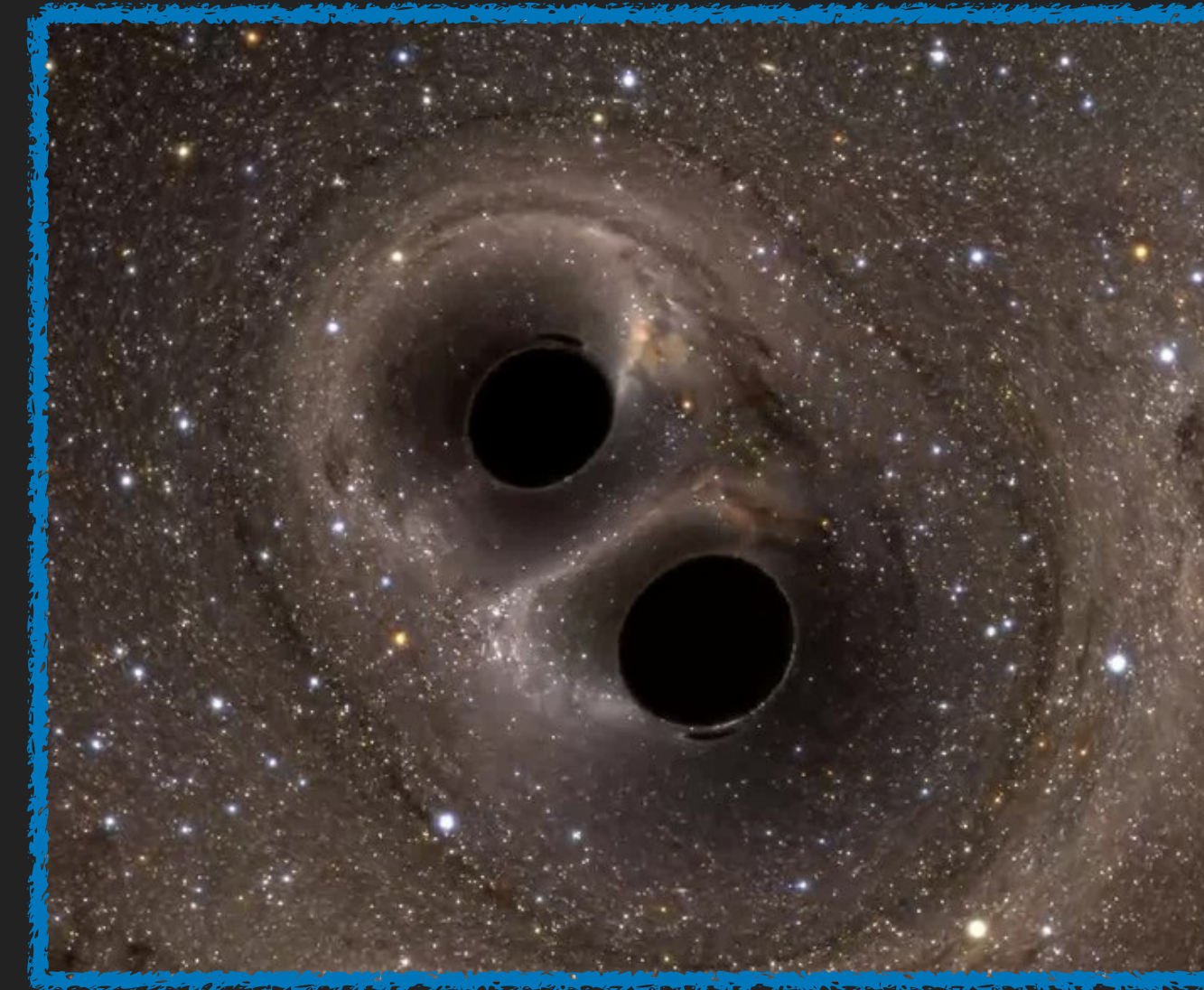
Z-peaked excess

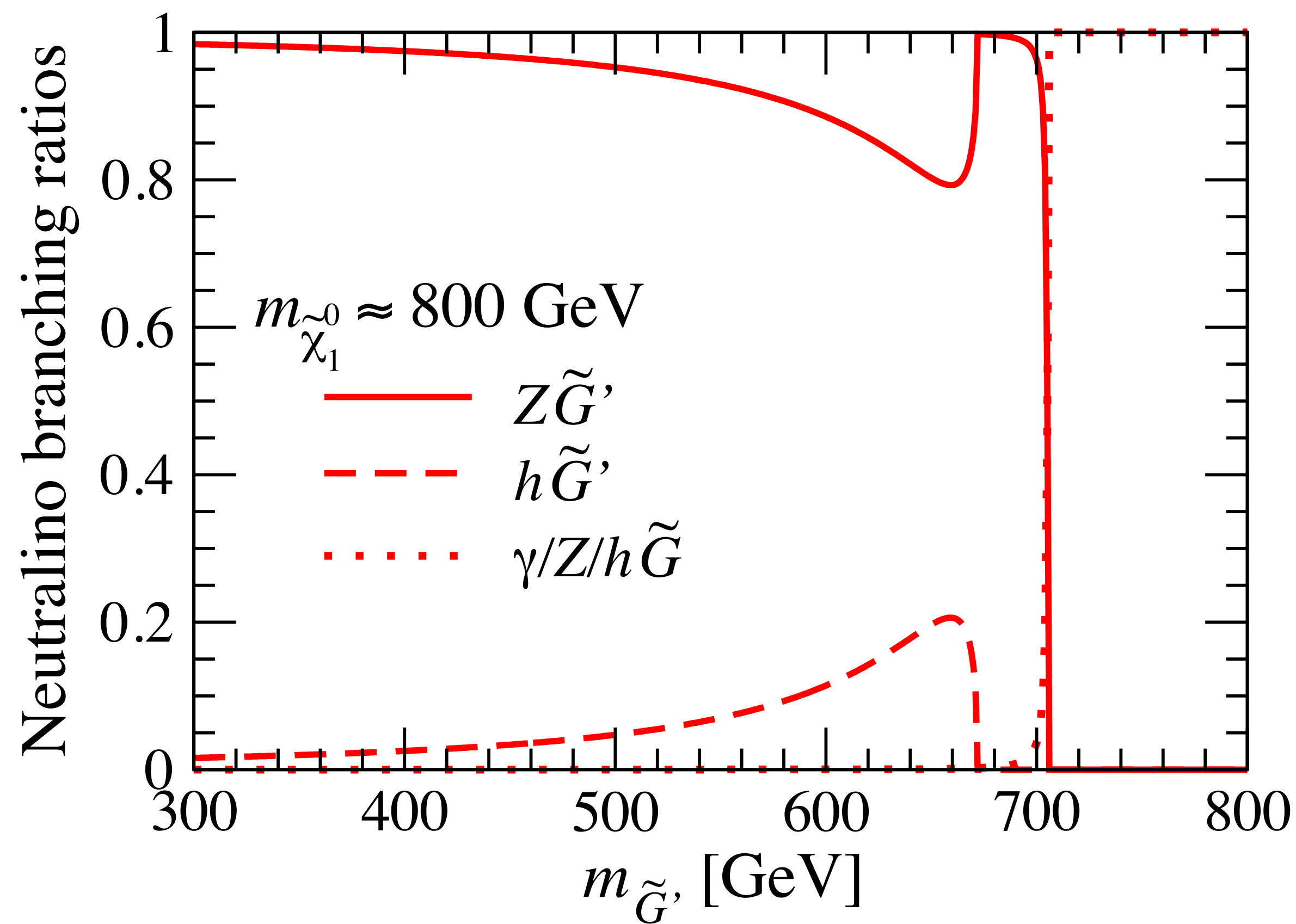
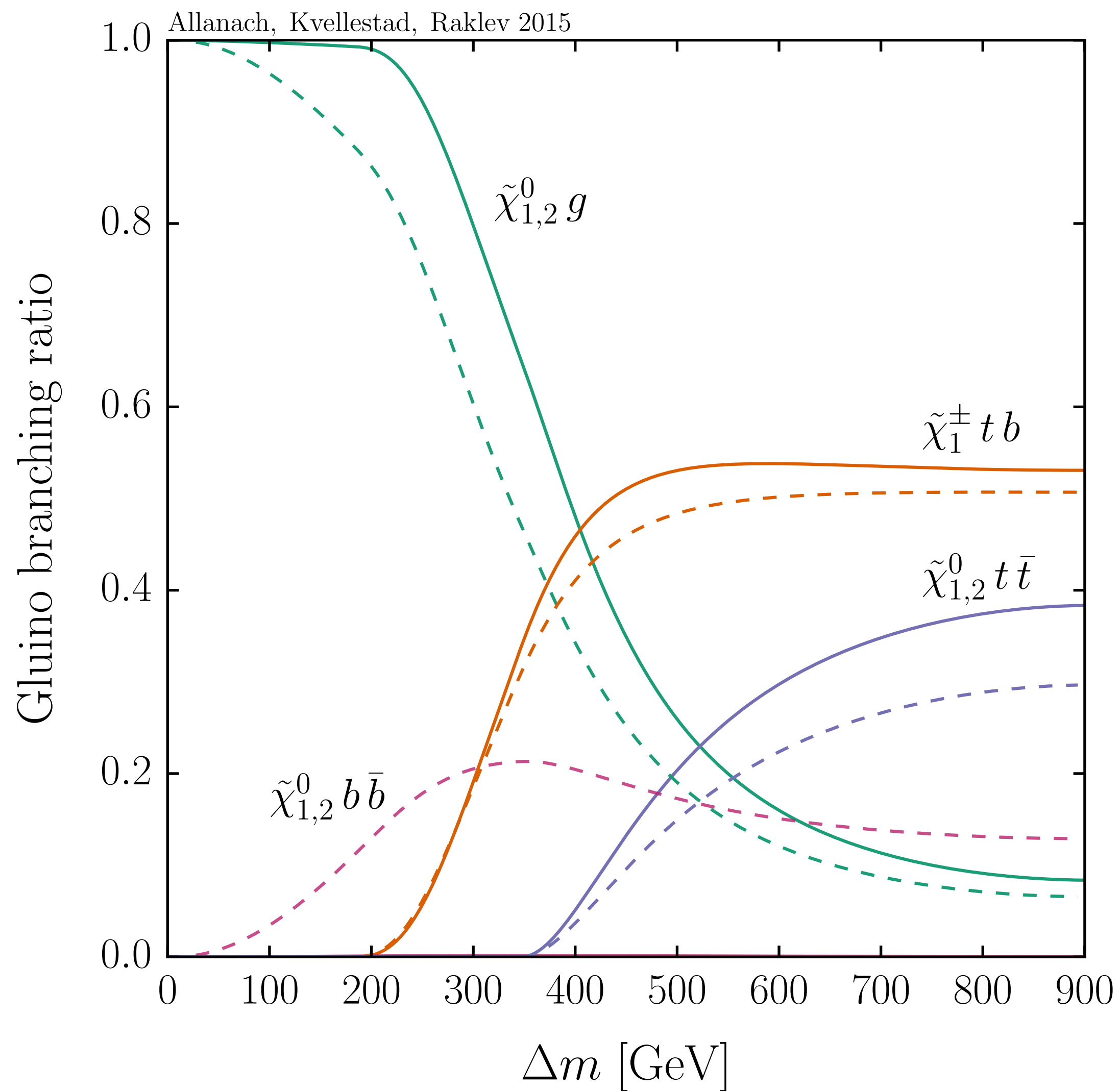


Obscured ν -sources

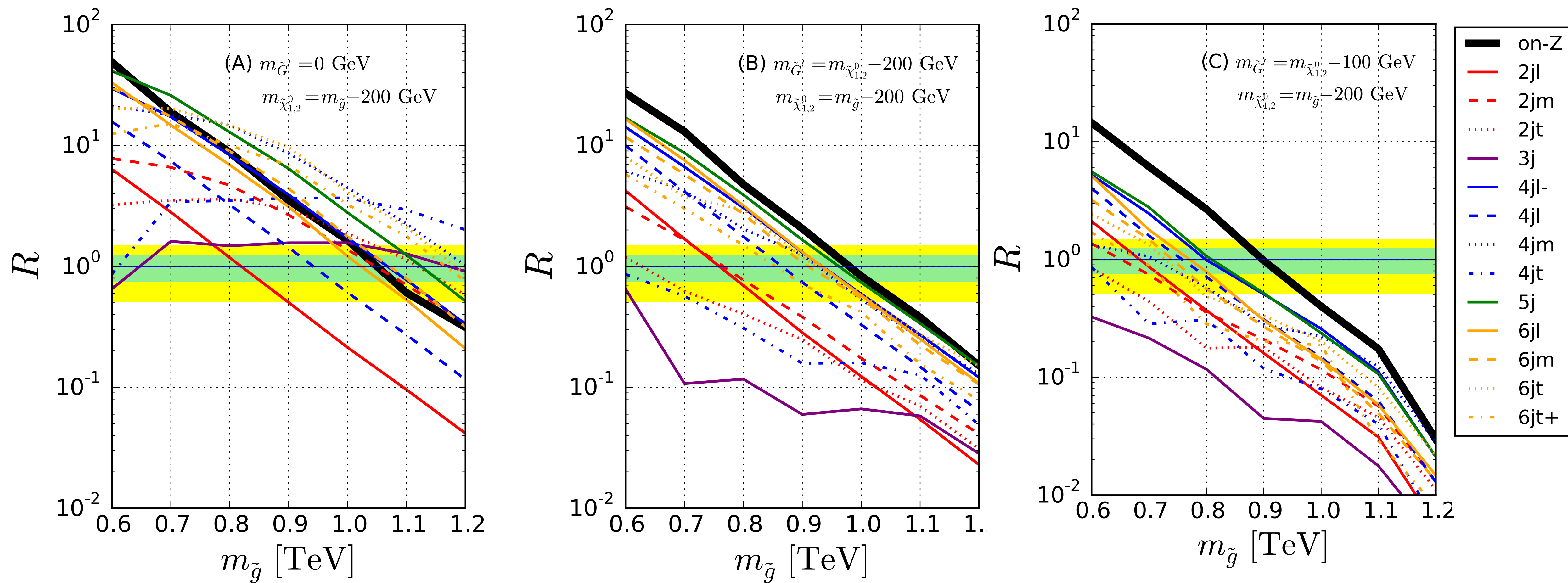


BBH mergers

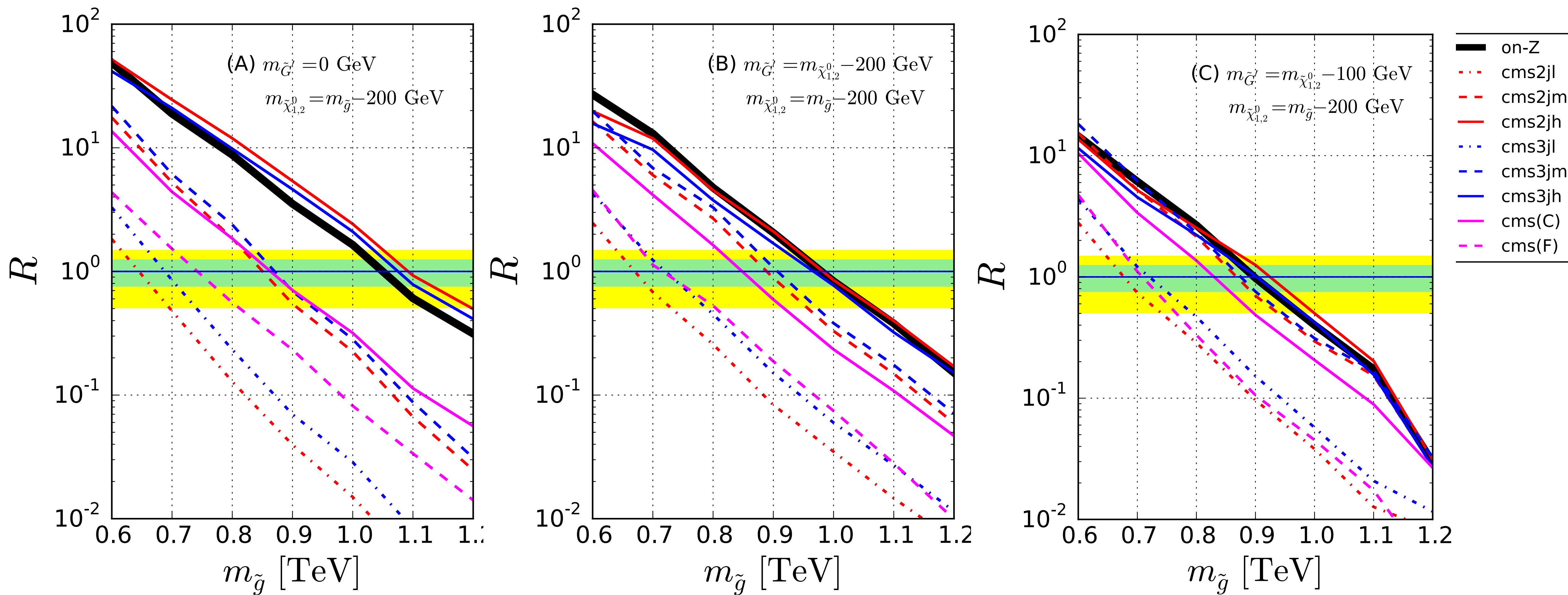


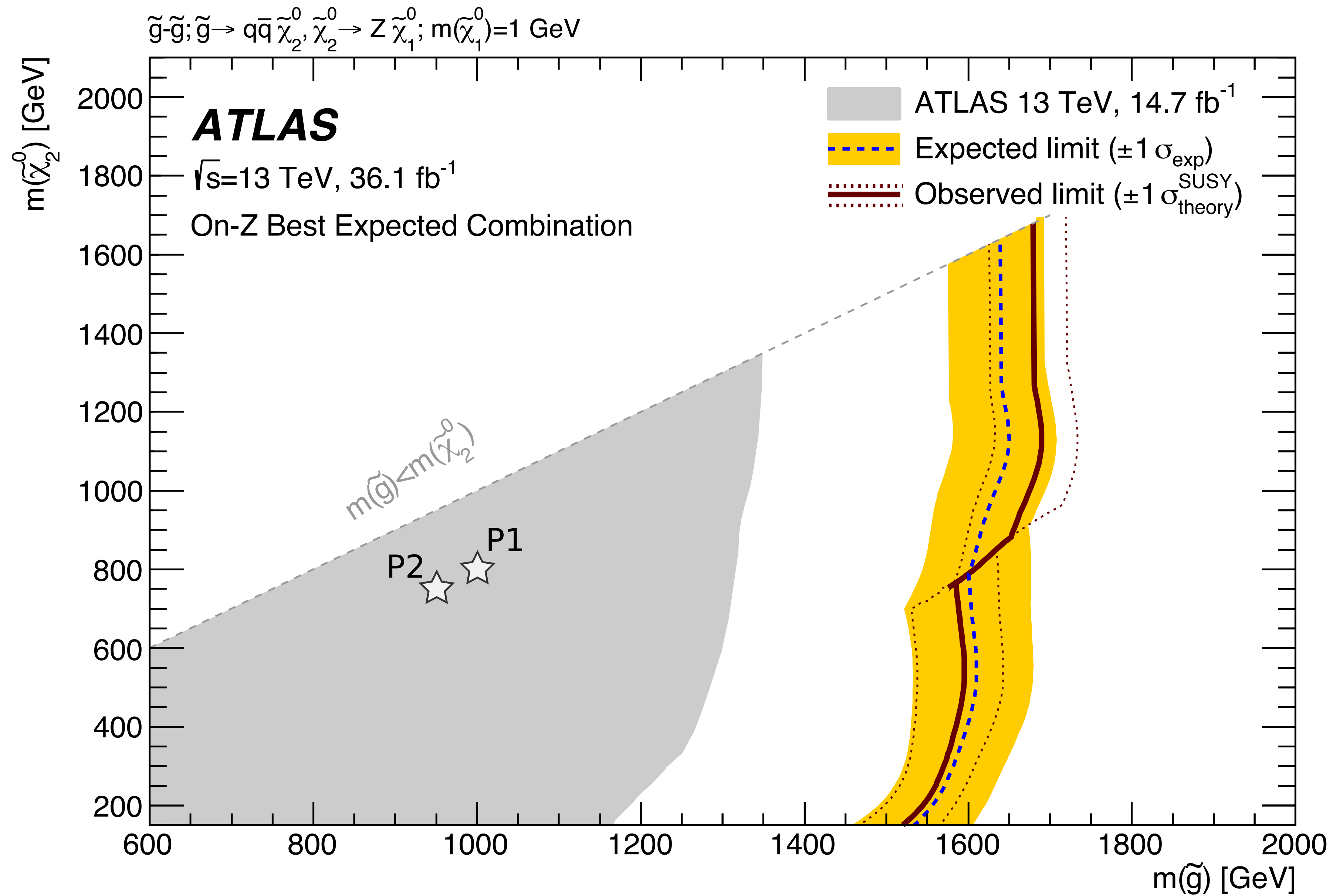


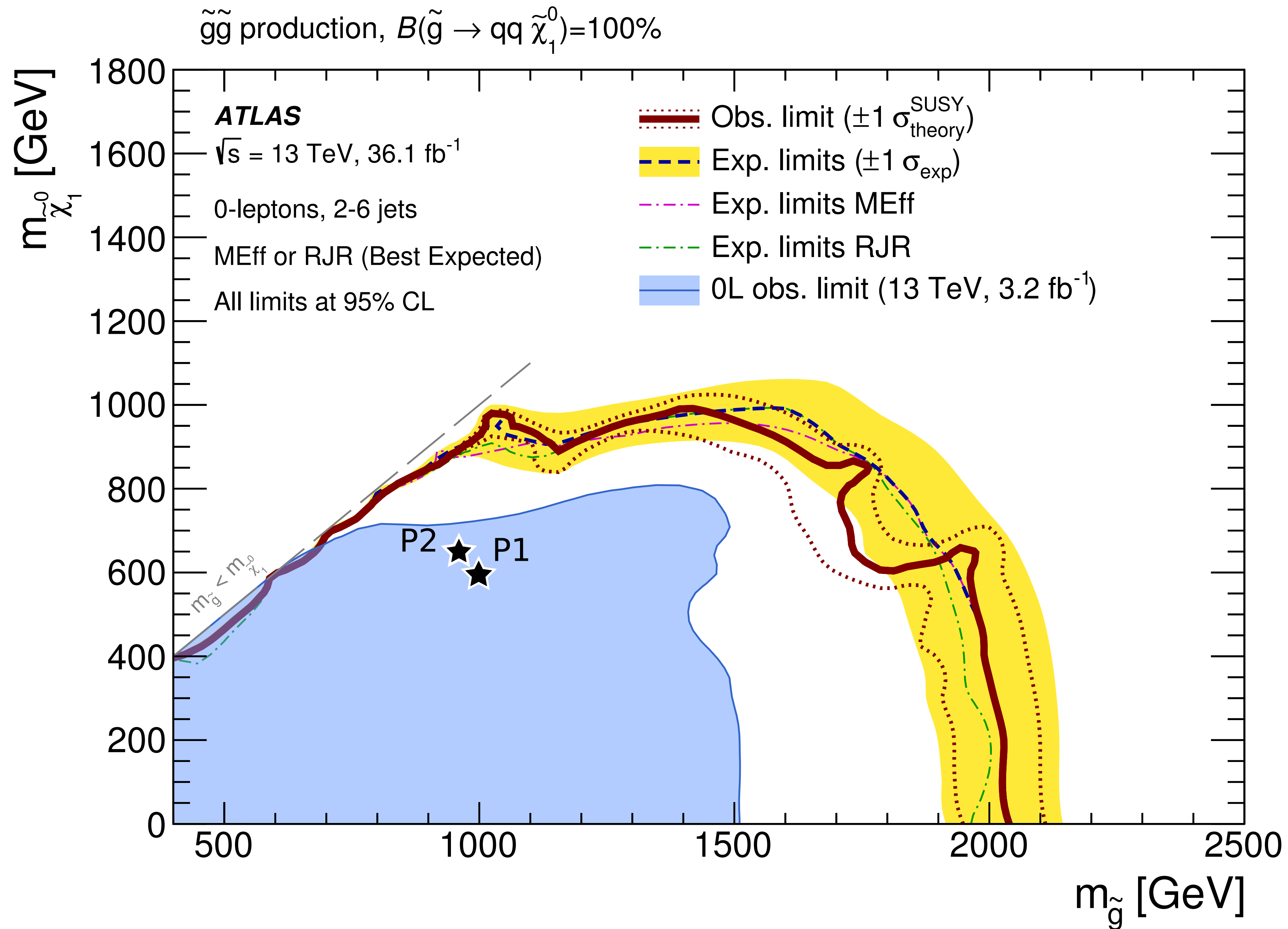
ATLAS

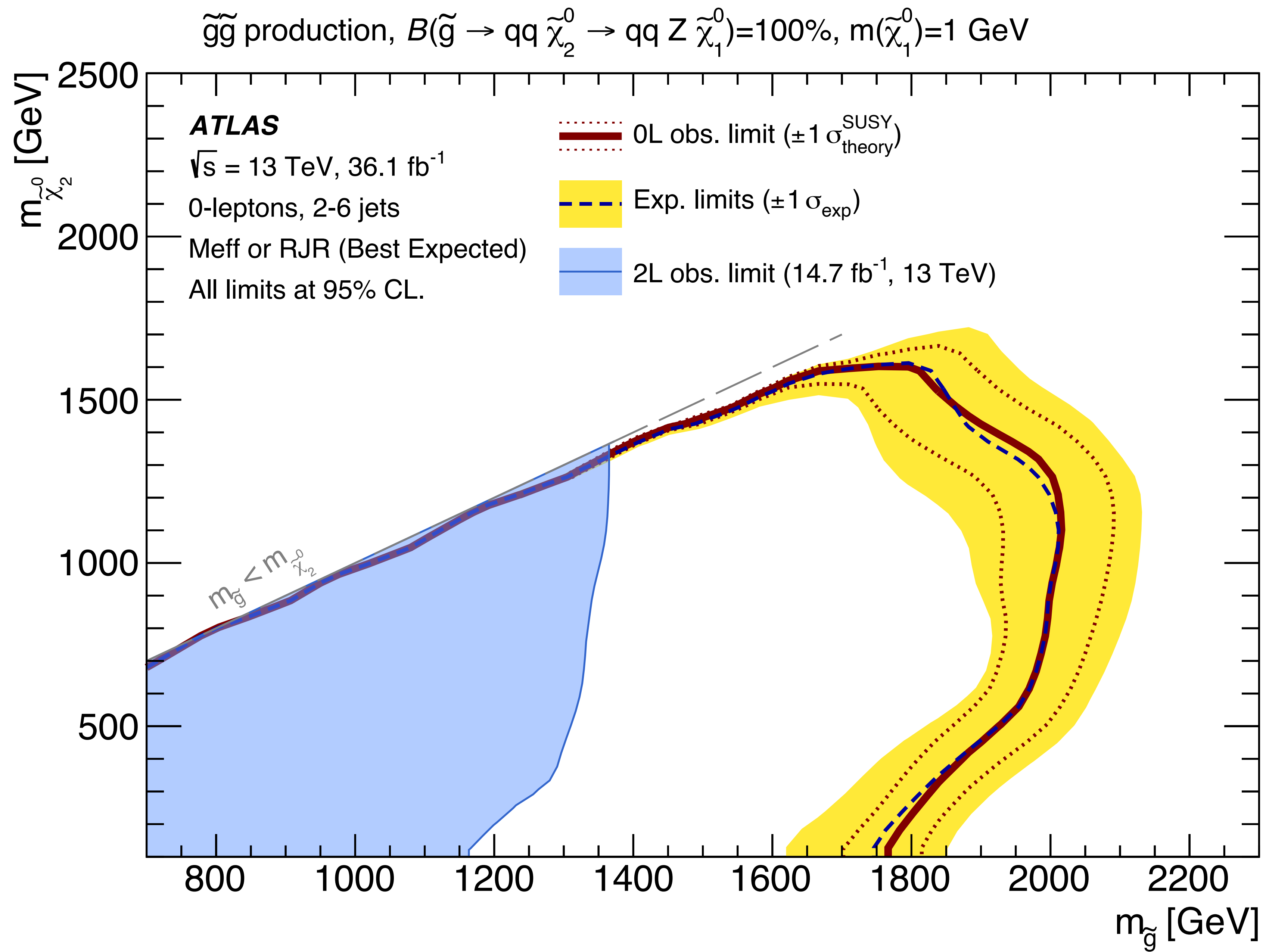


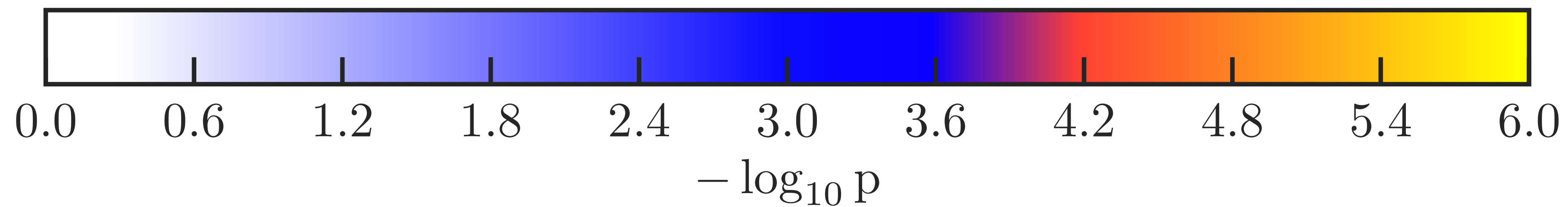
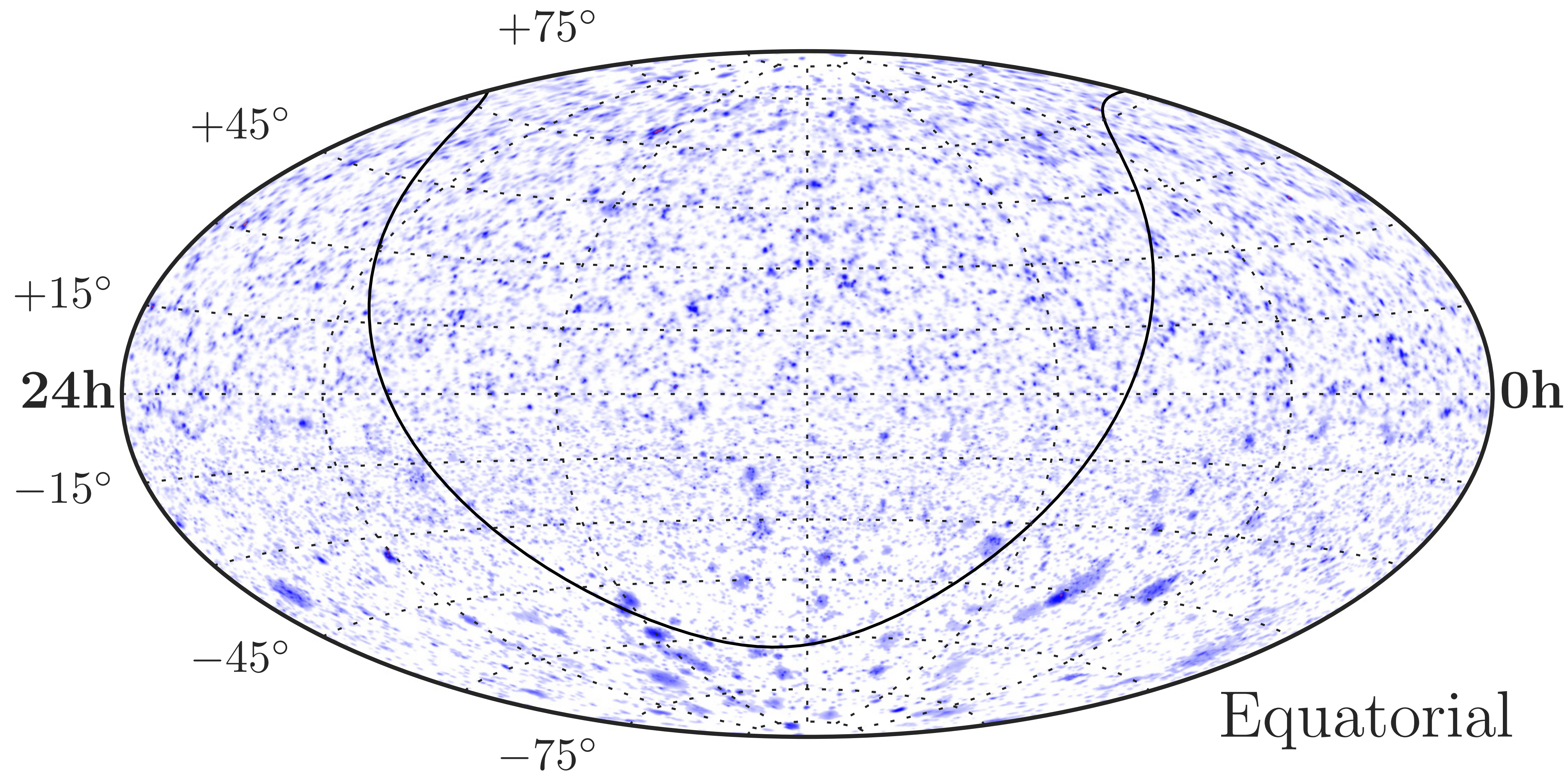
CMS

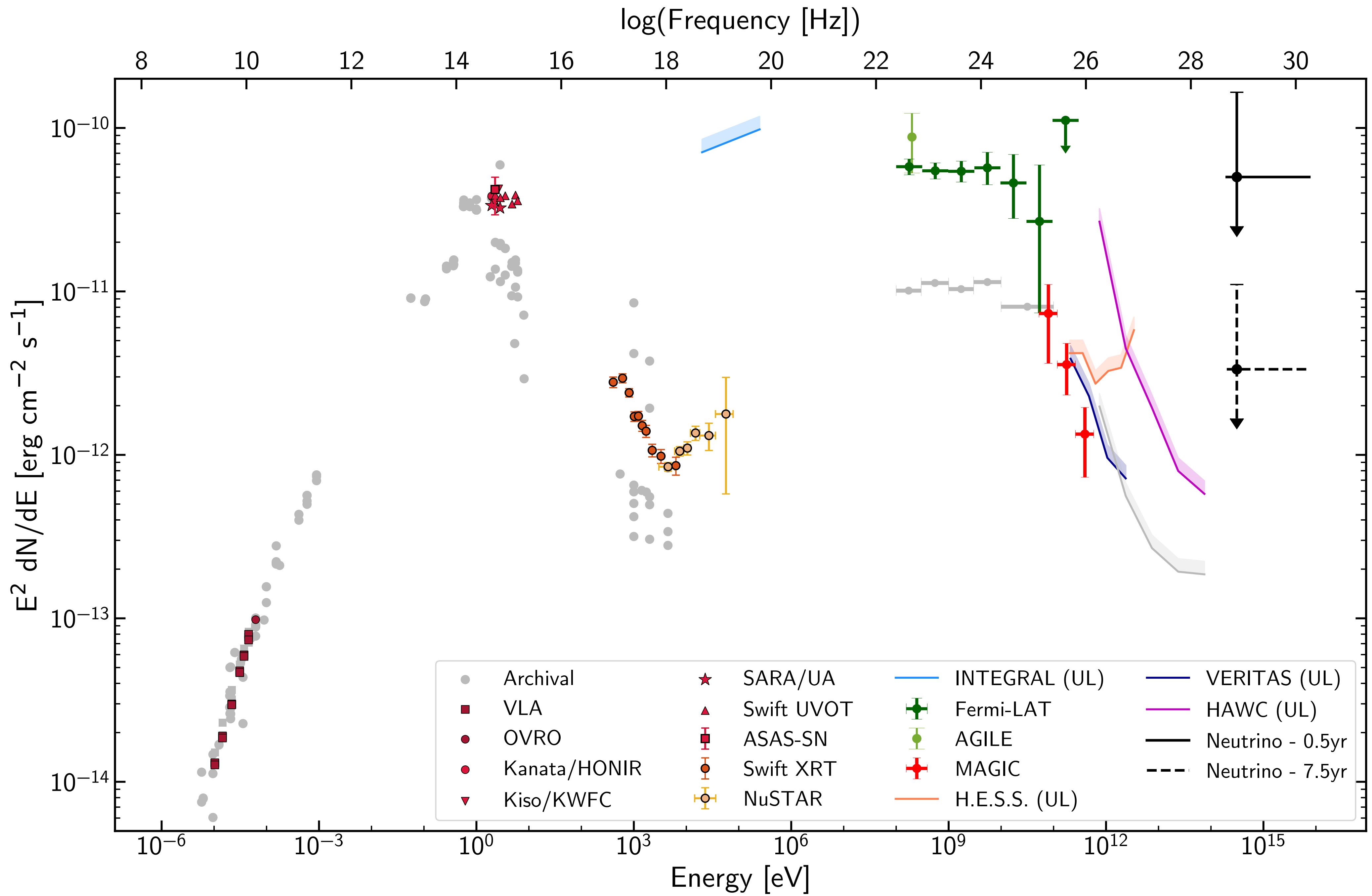




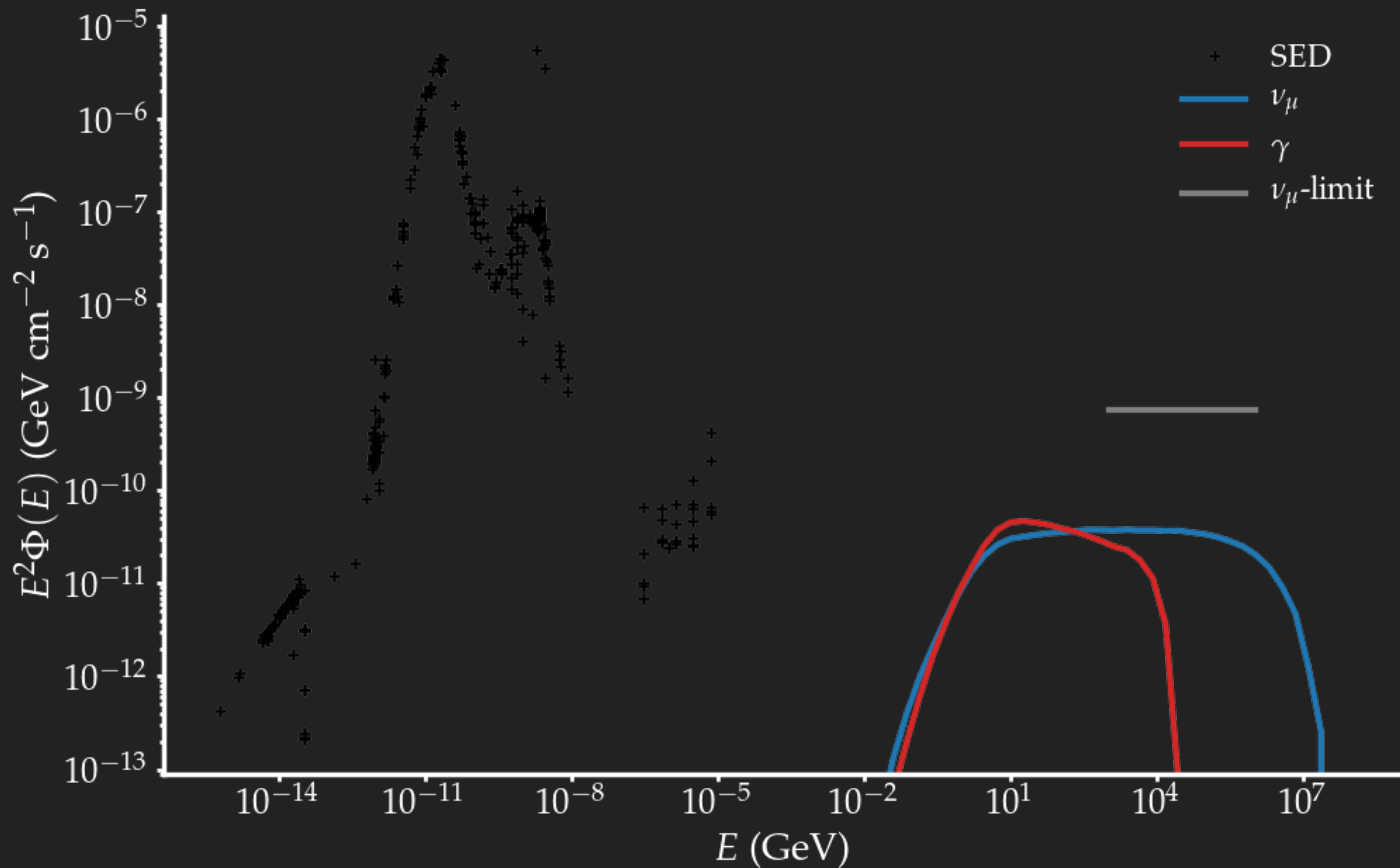


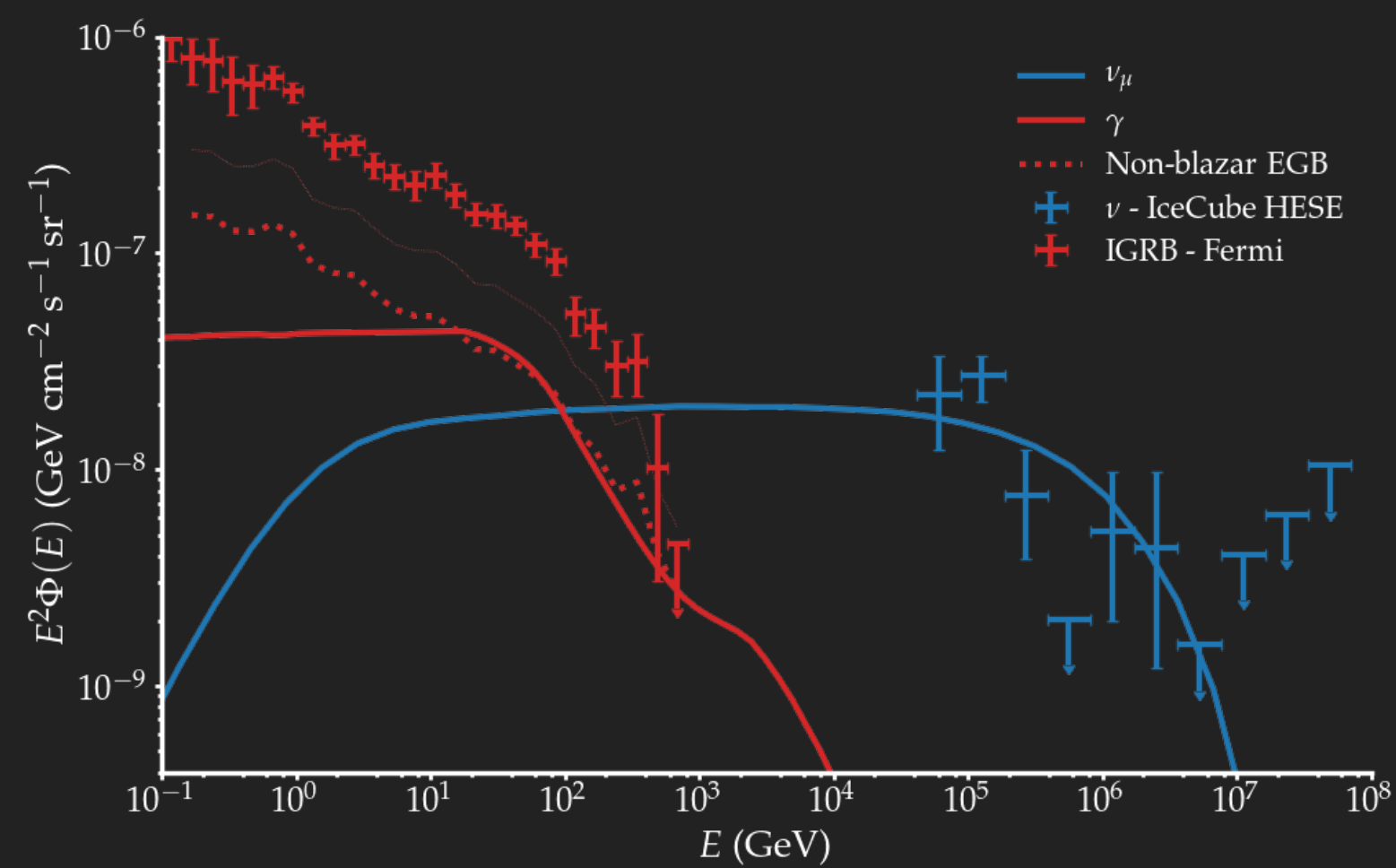




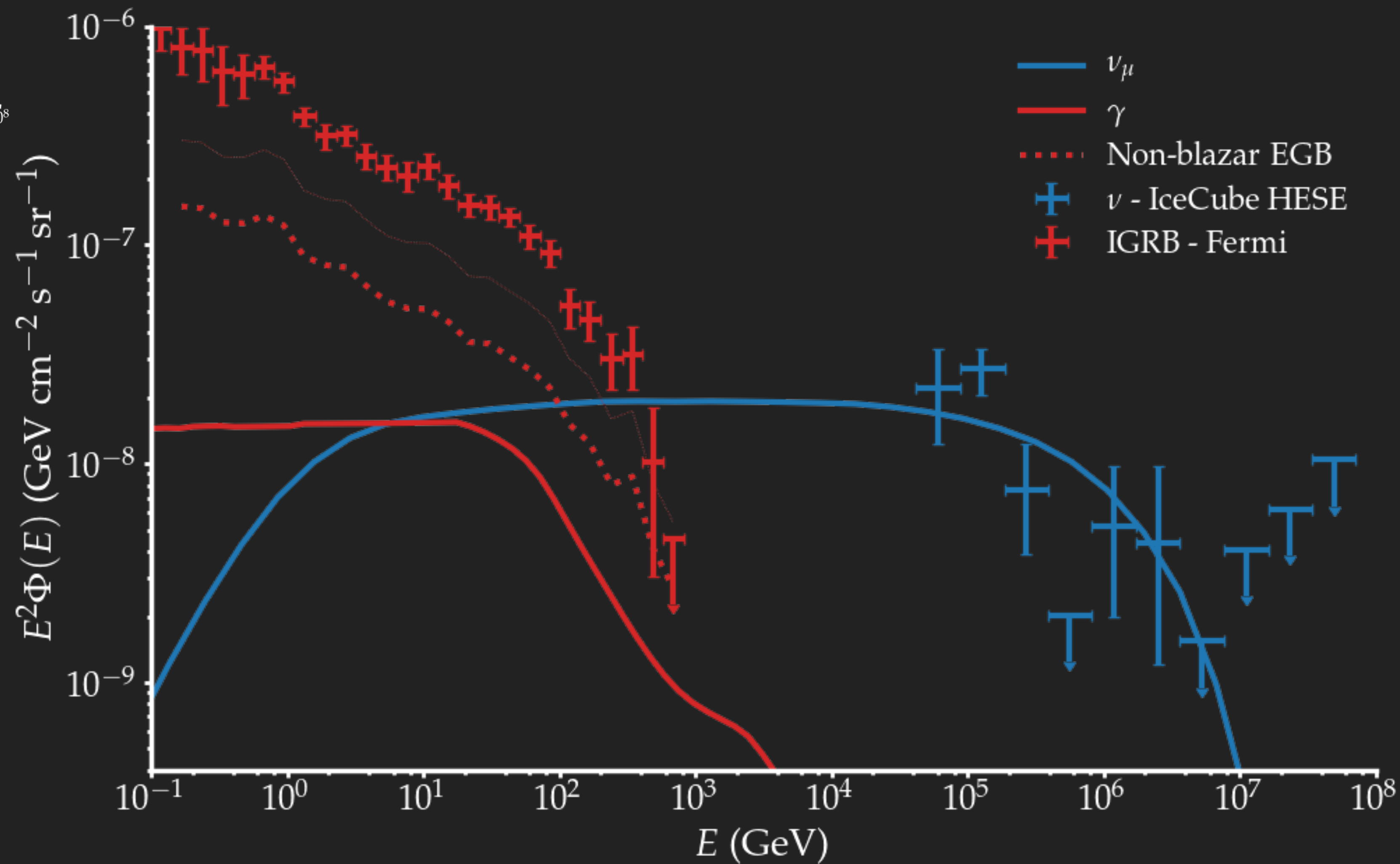


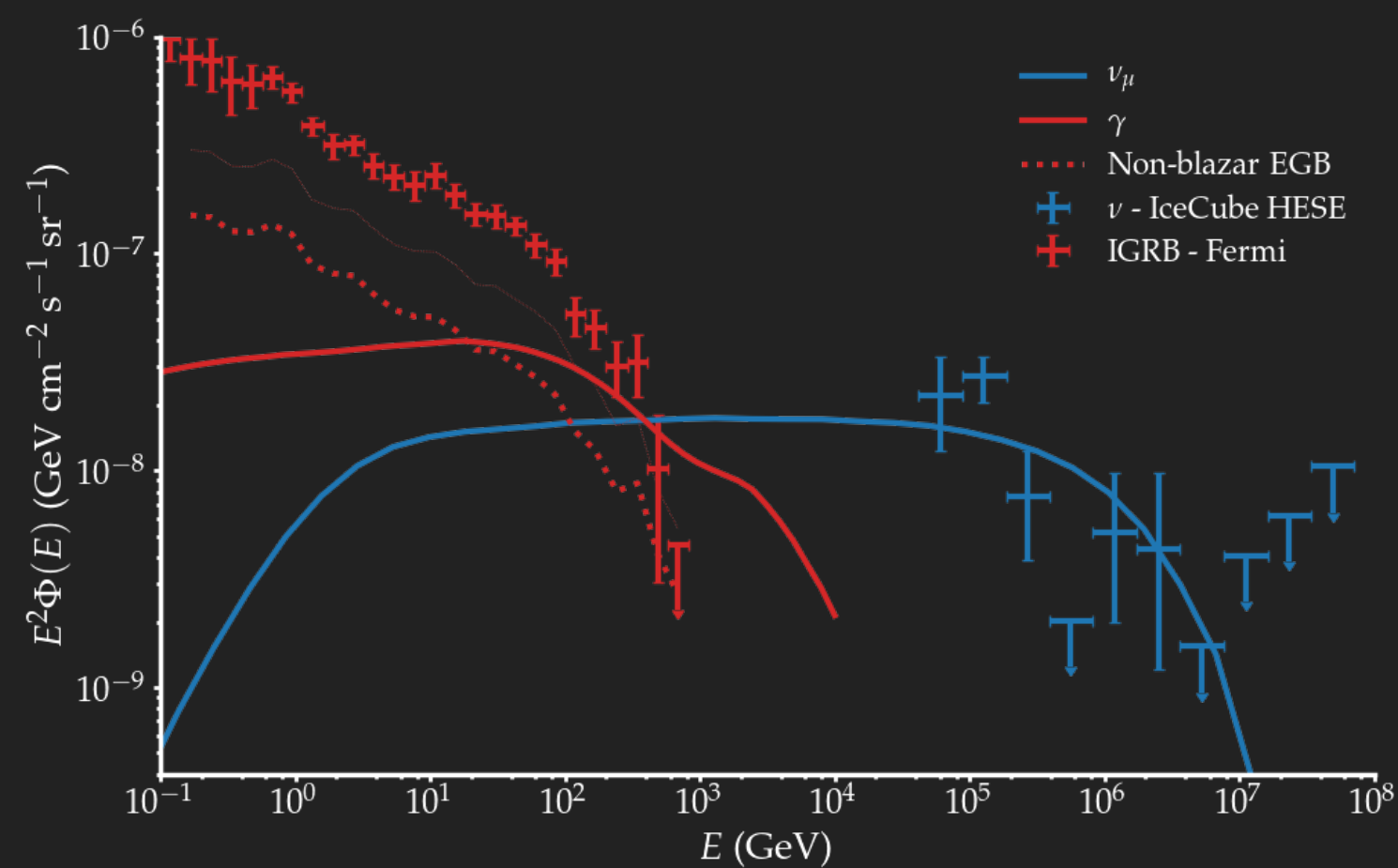
ARP220



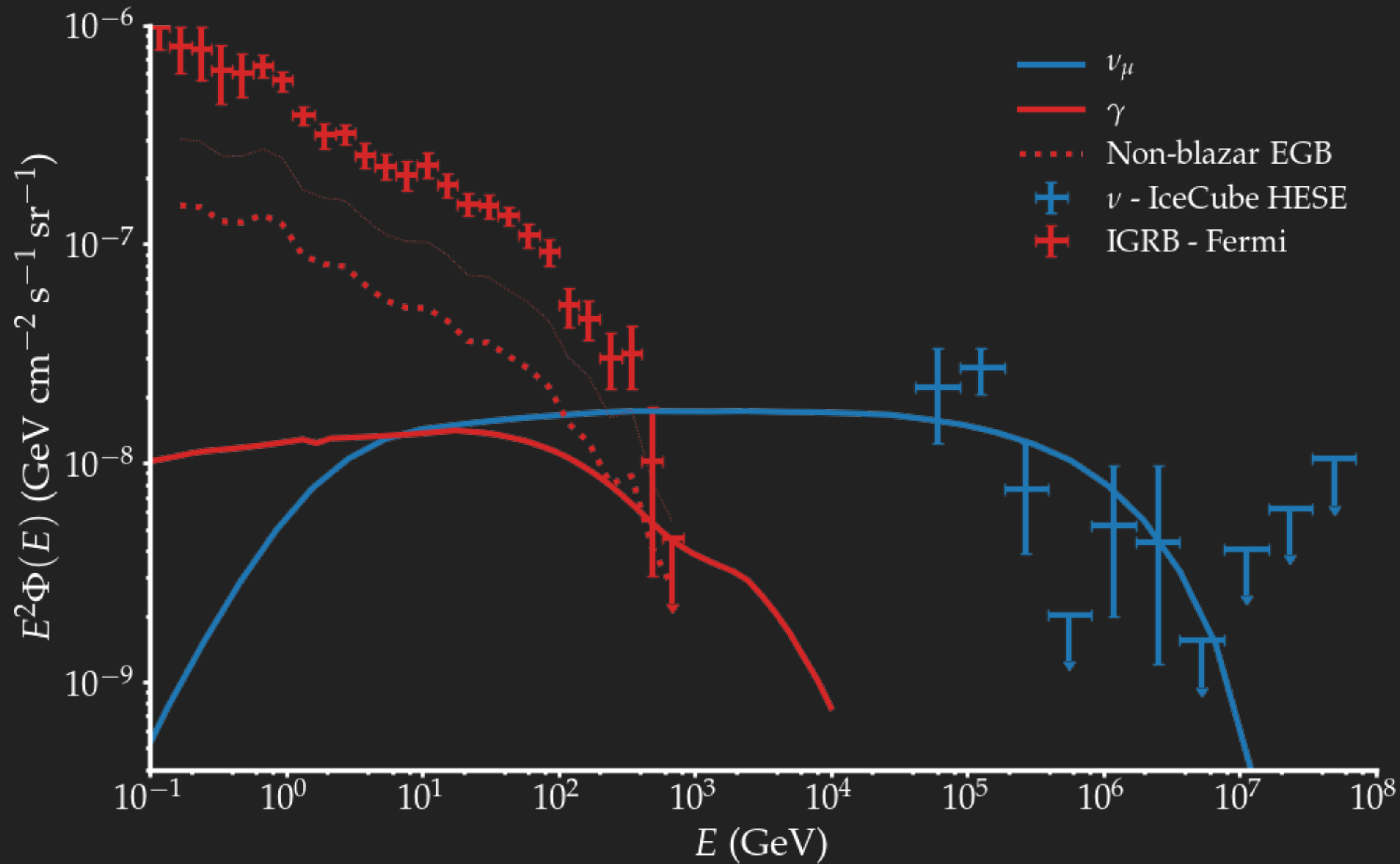


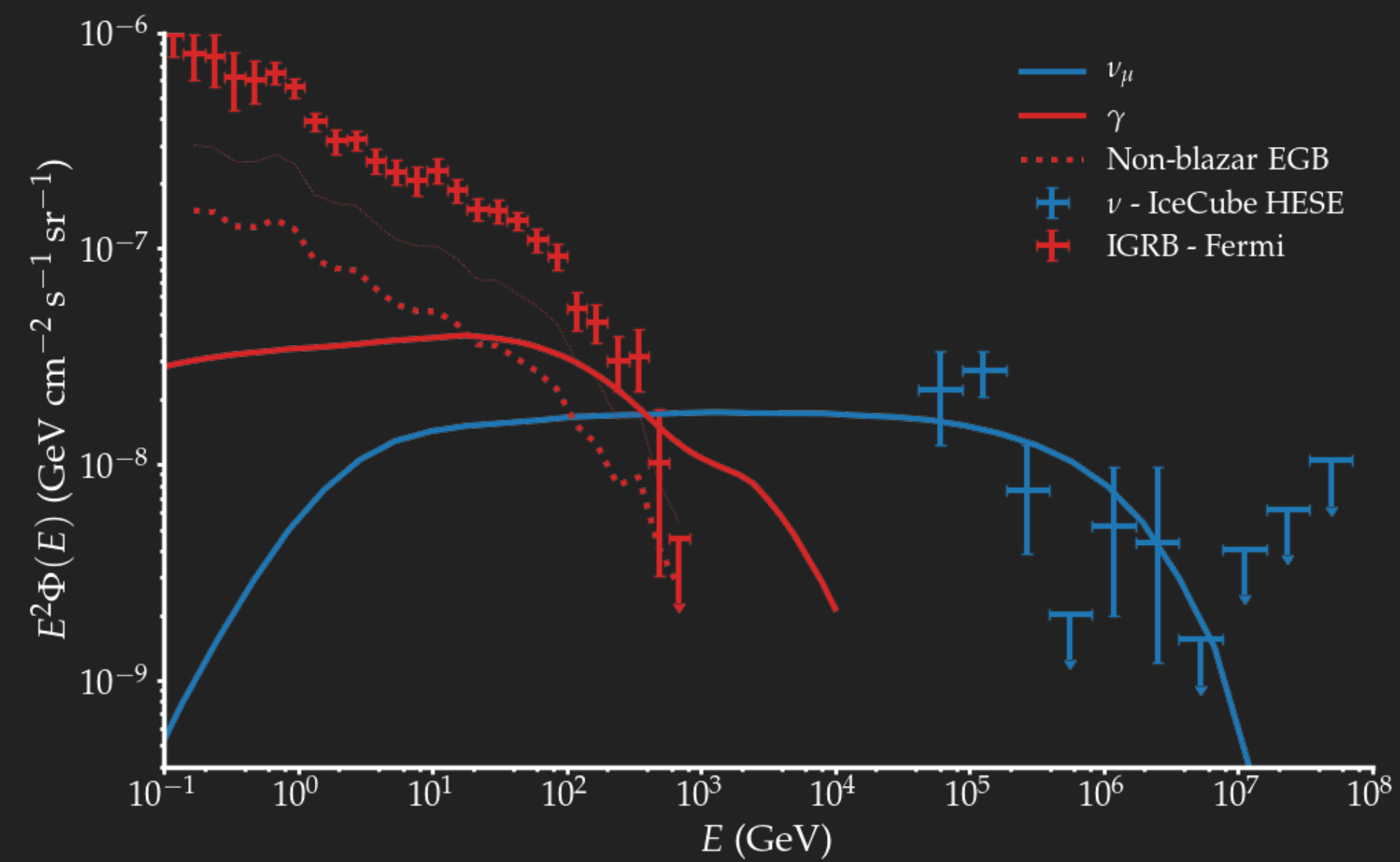
ULIRG



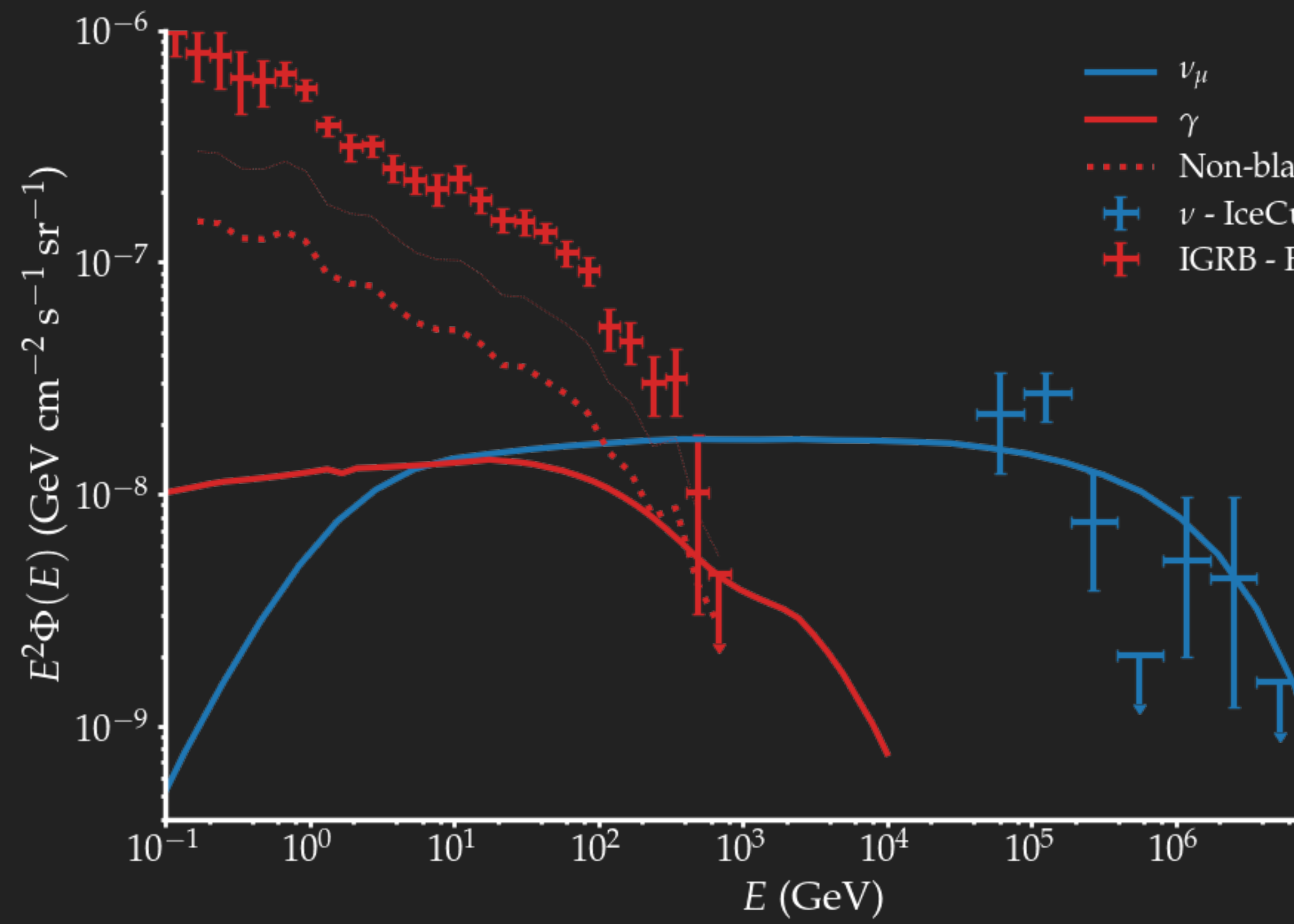


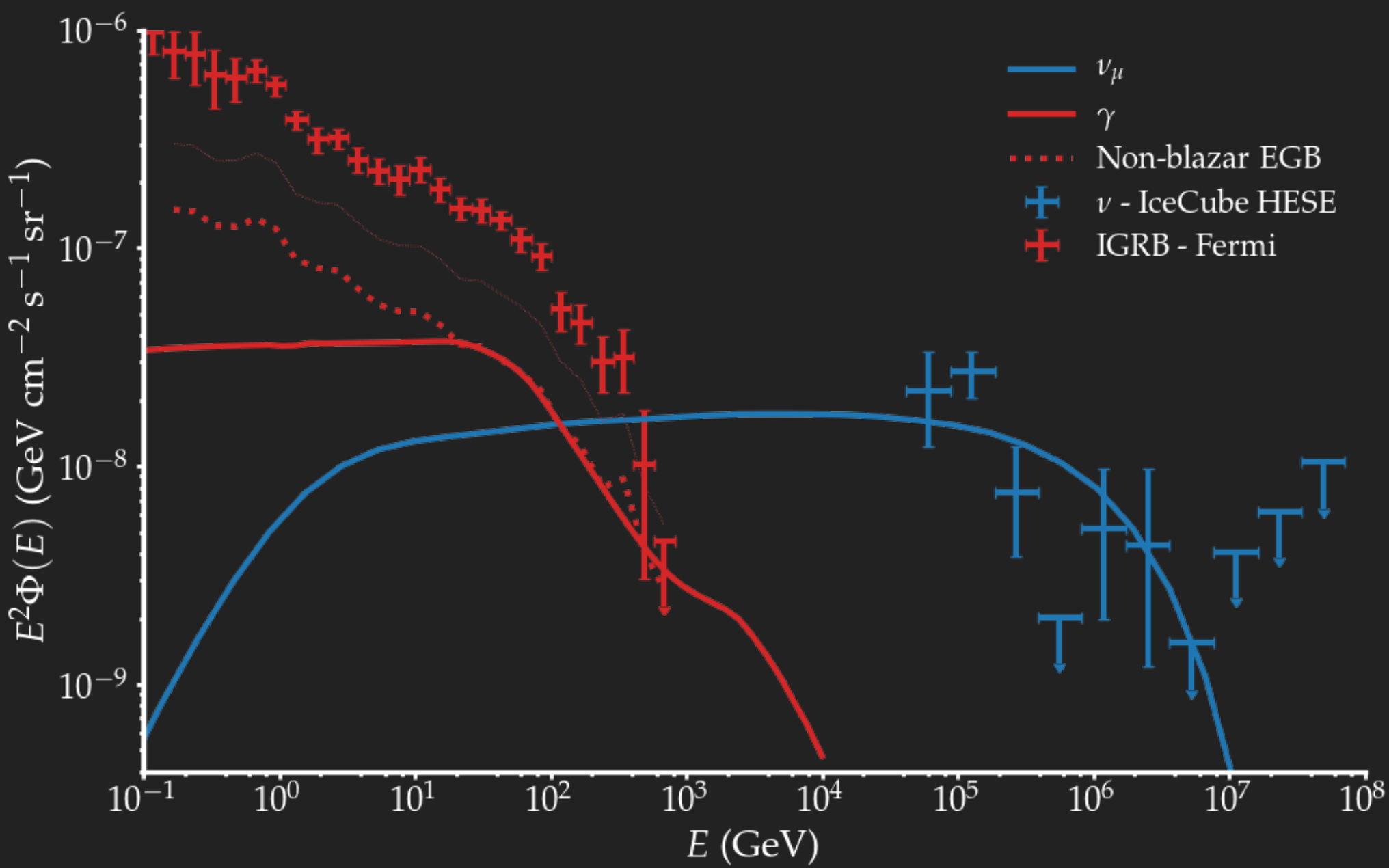
FLAT



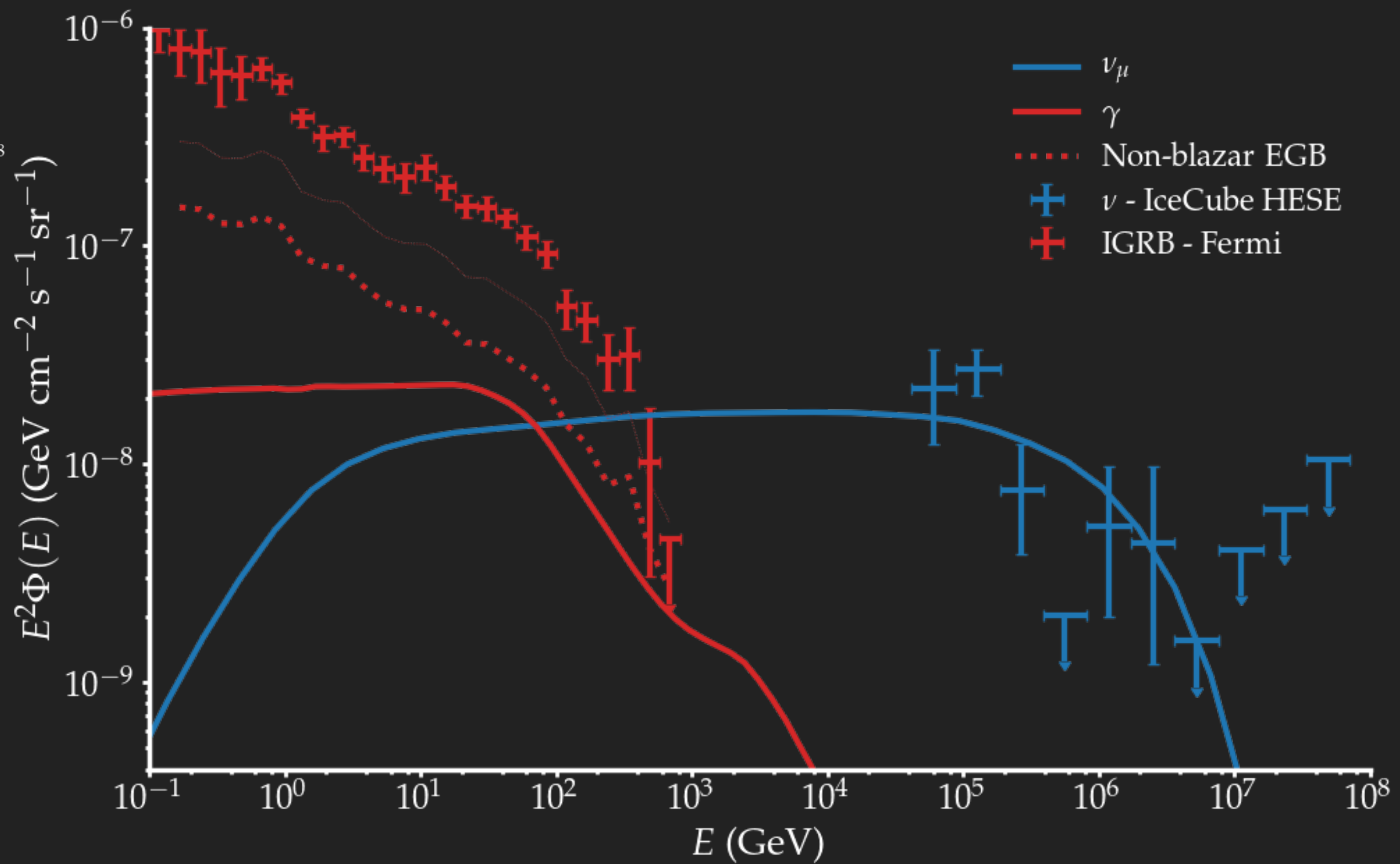


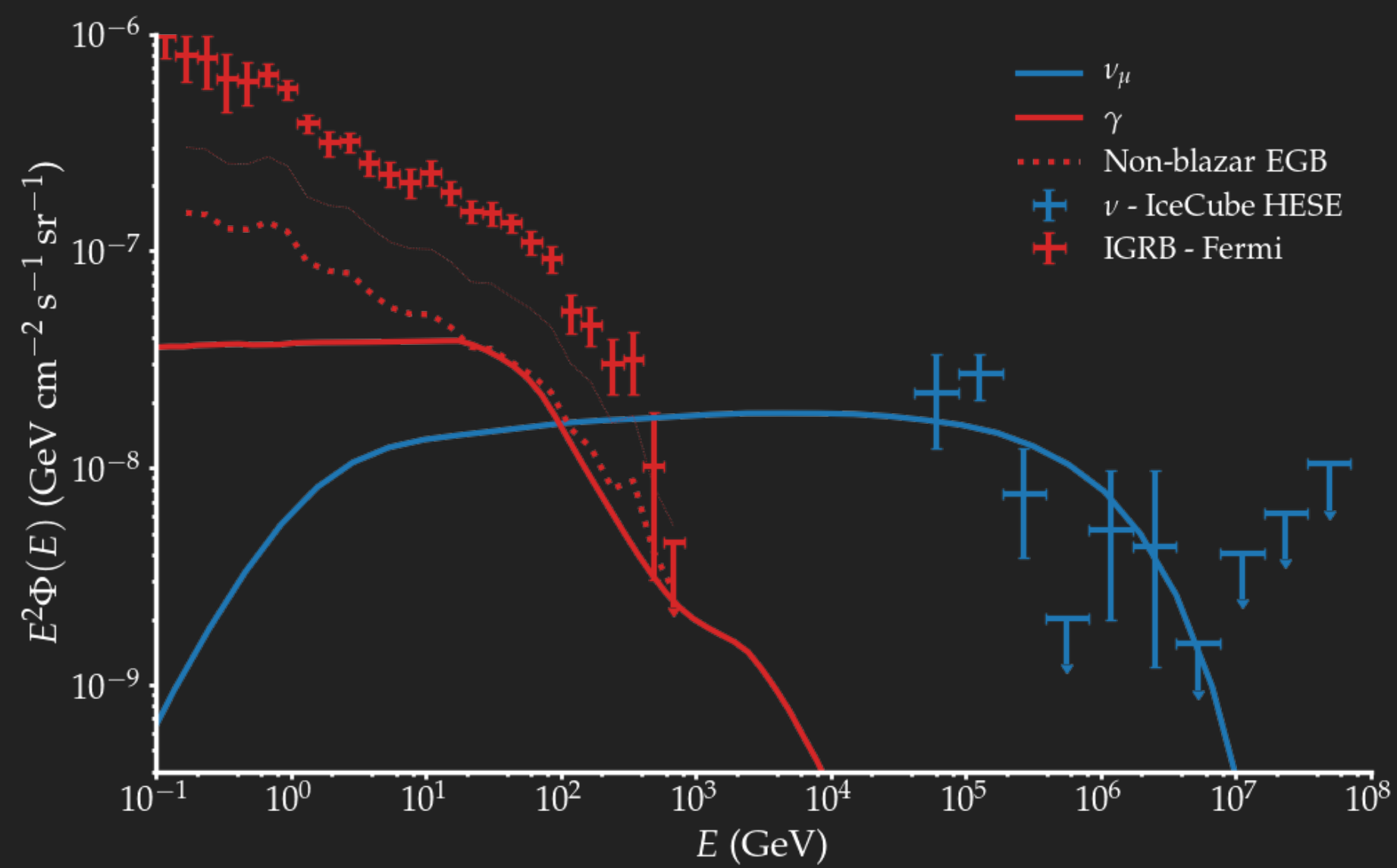
FLAT



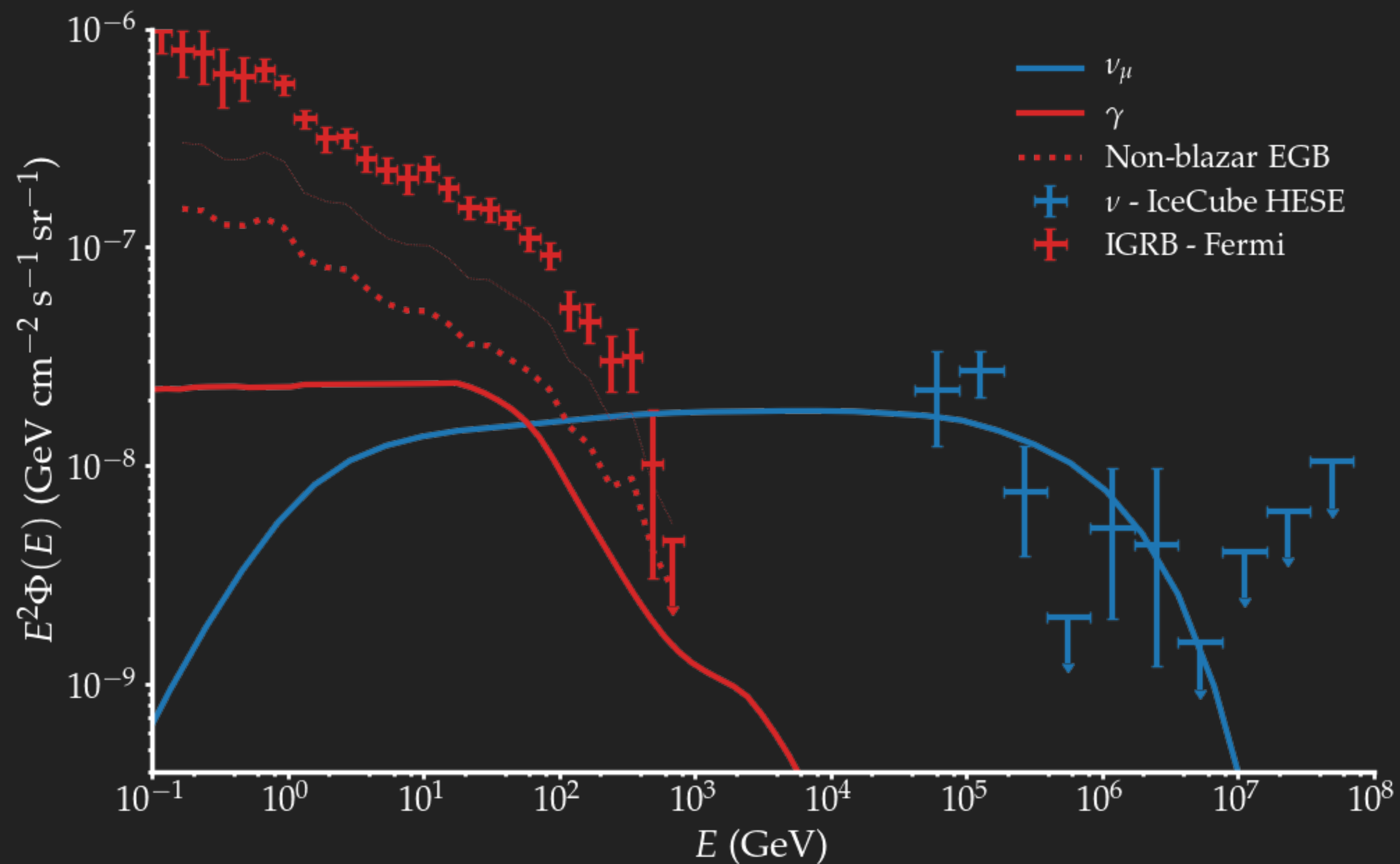


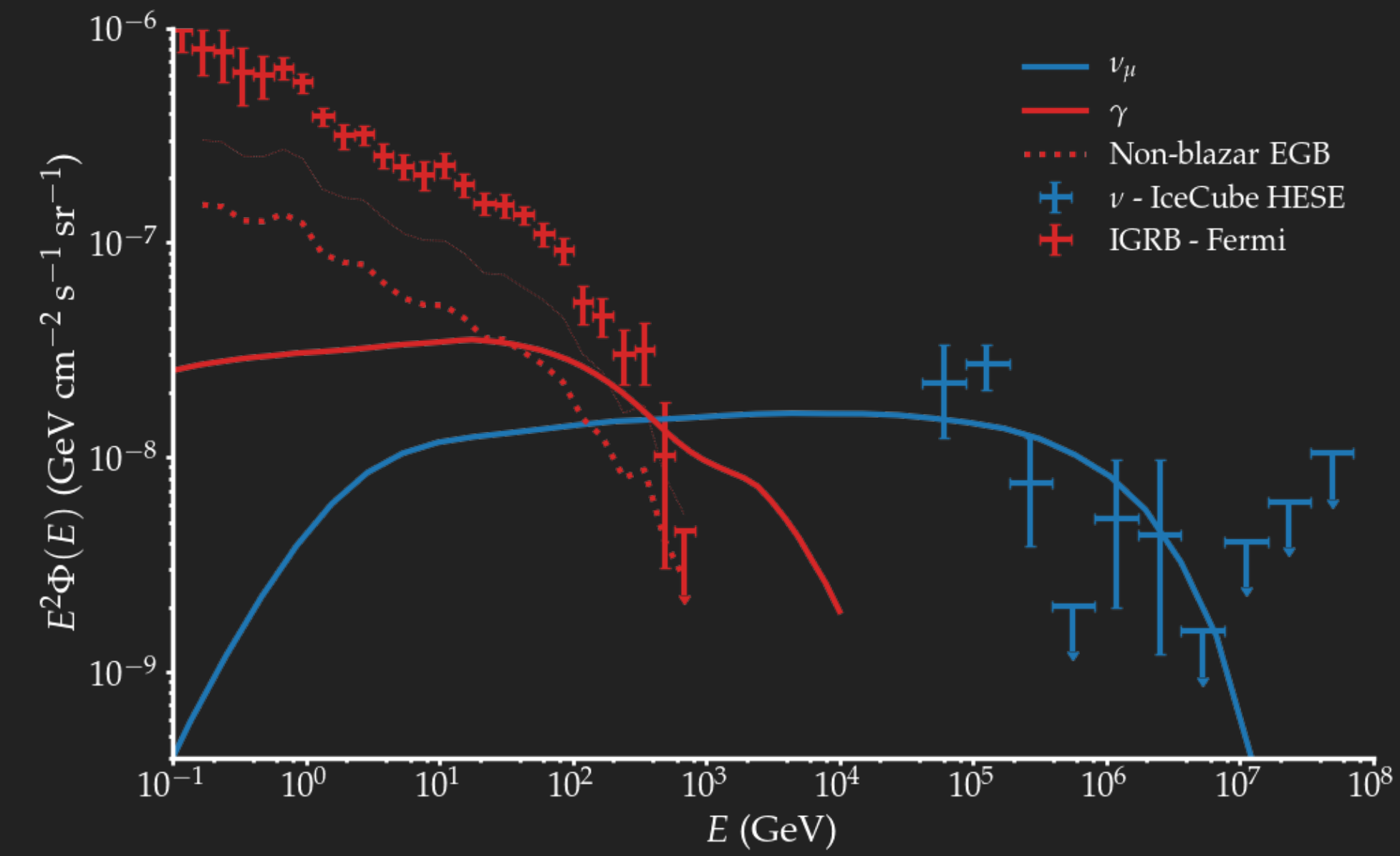
$$\text{SFR } N_H = 5 \times 10^{25} \text{ cm}^{-2}$$



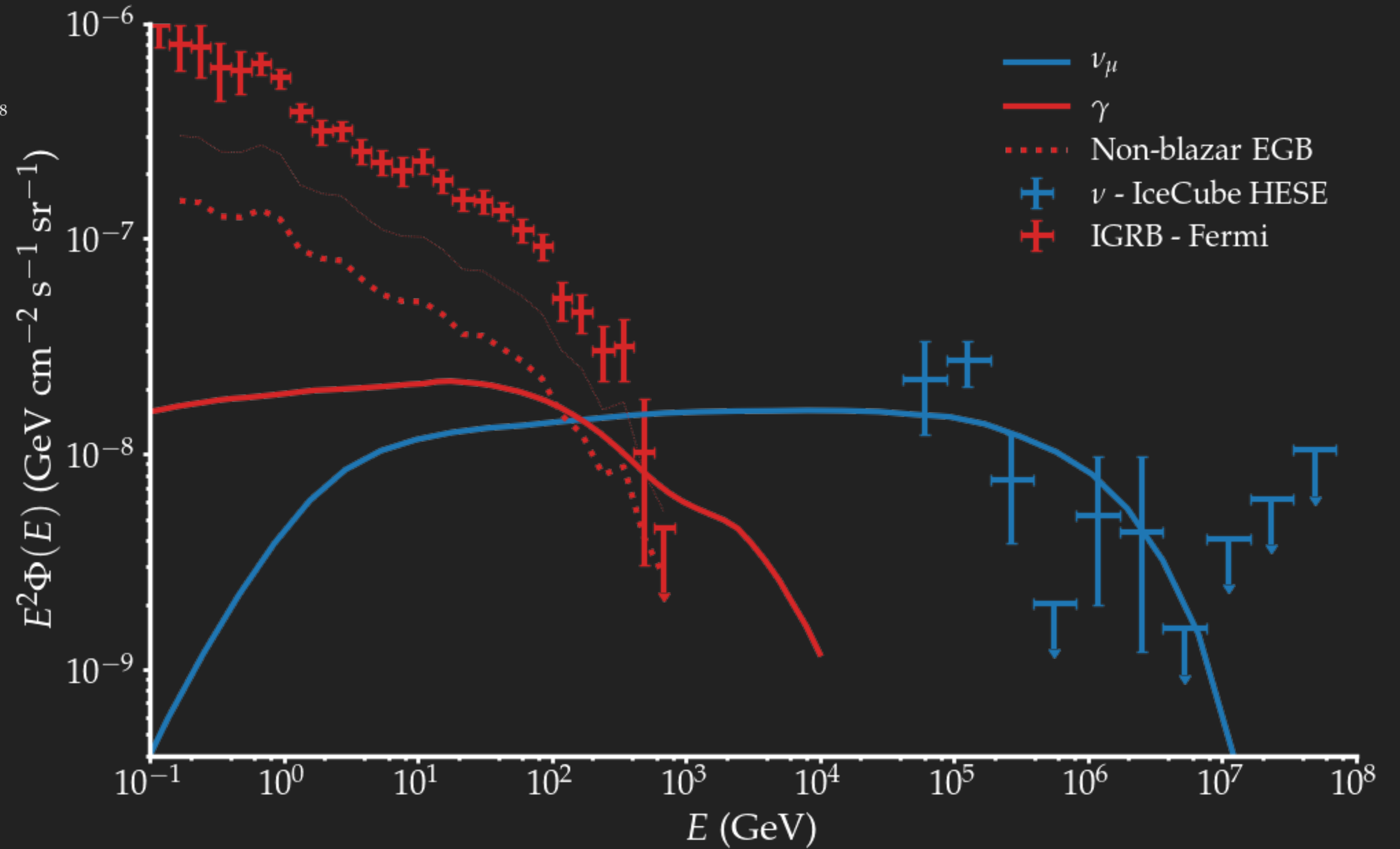


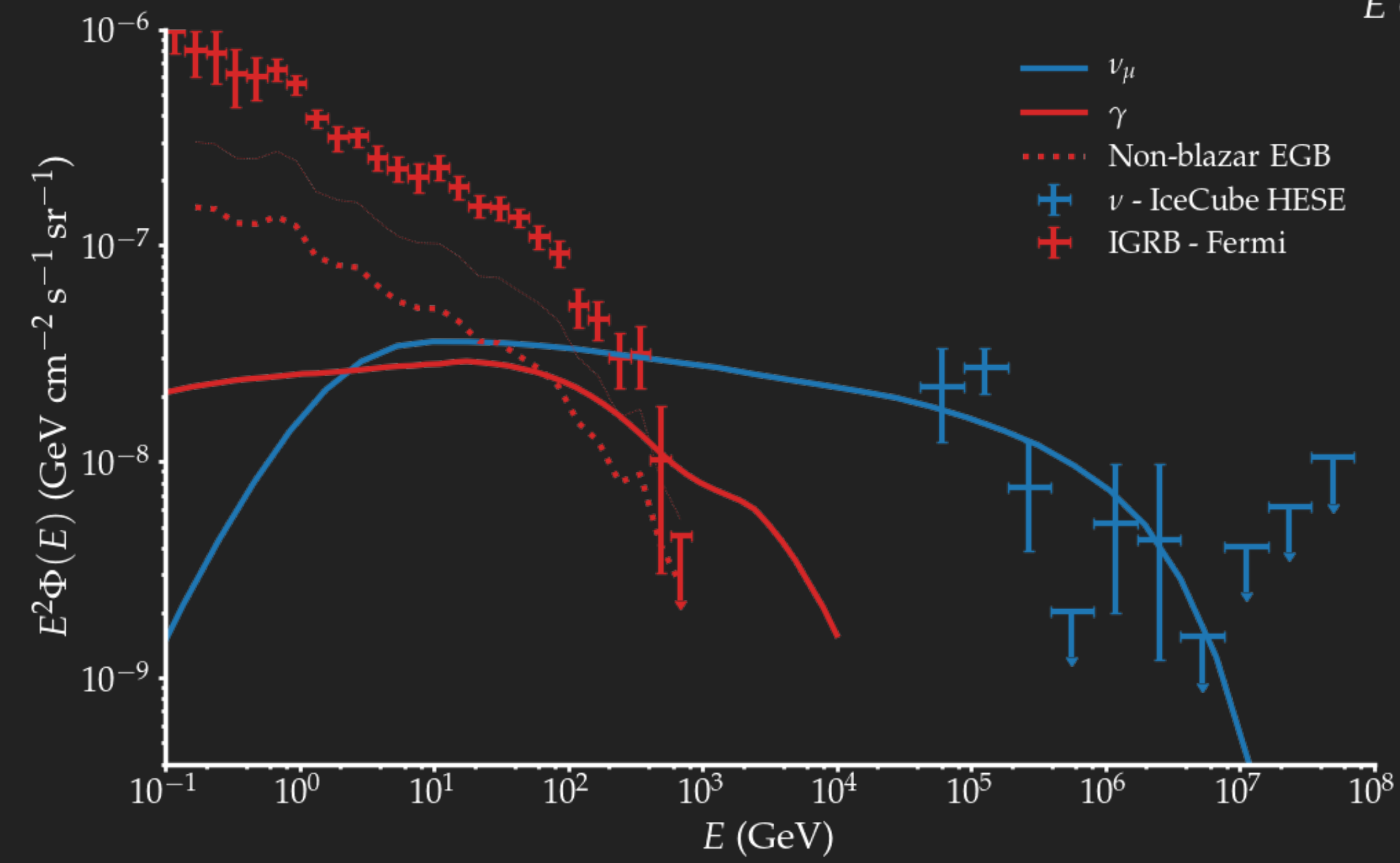
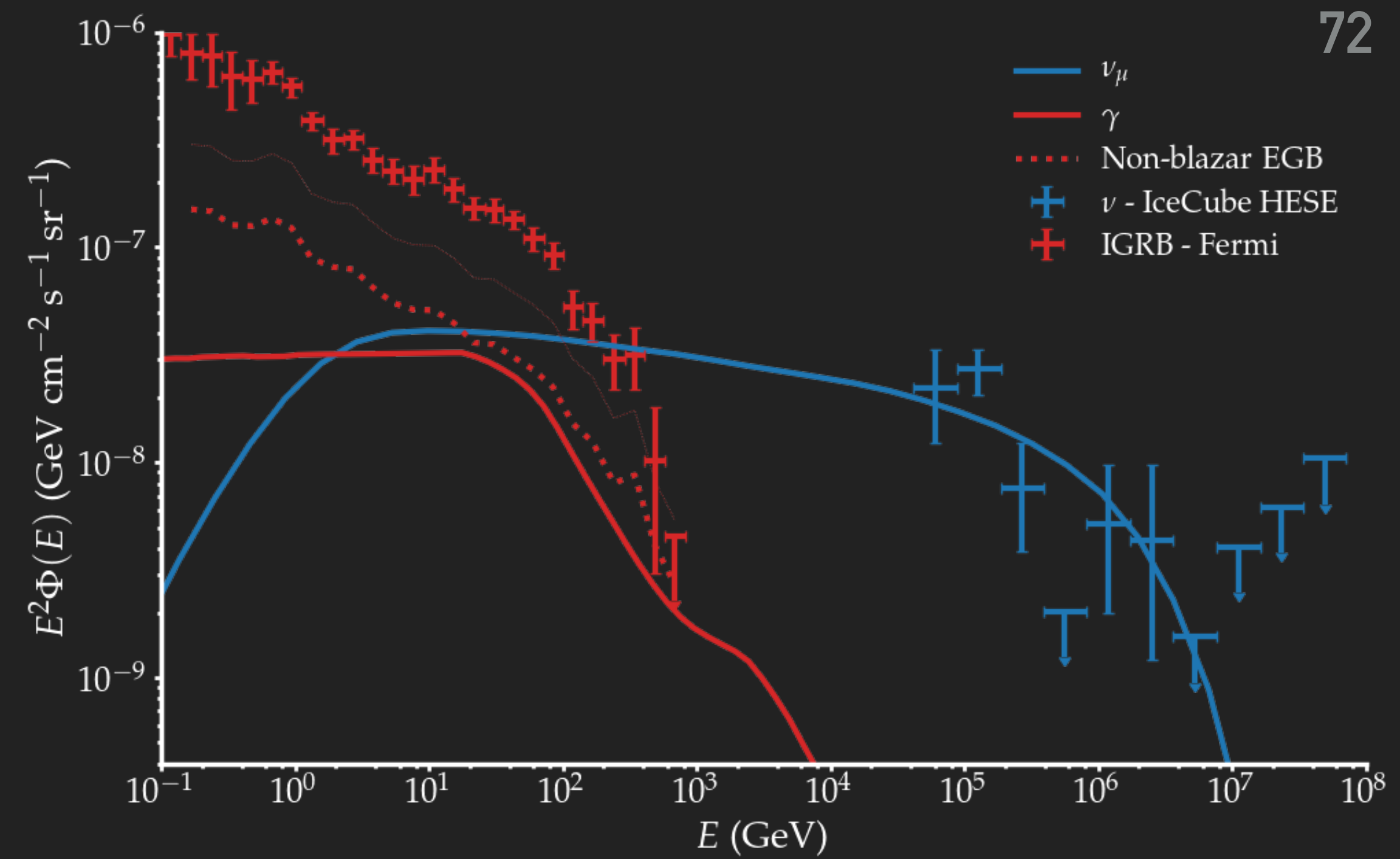
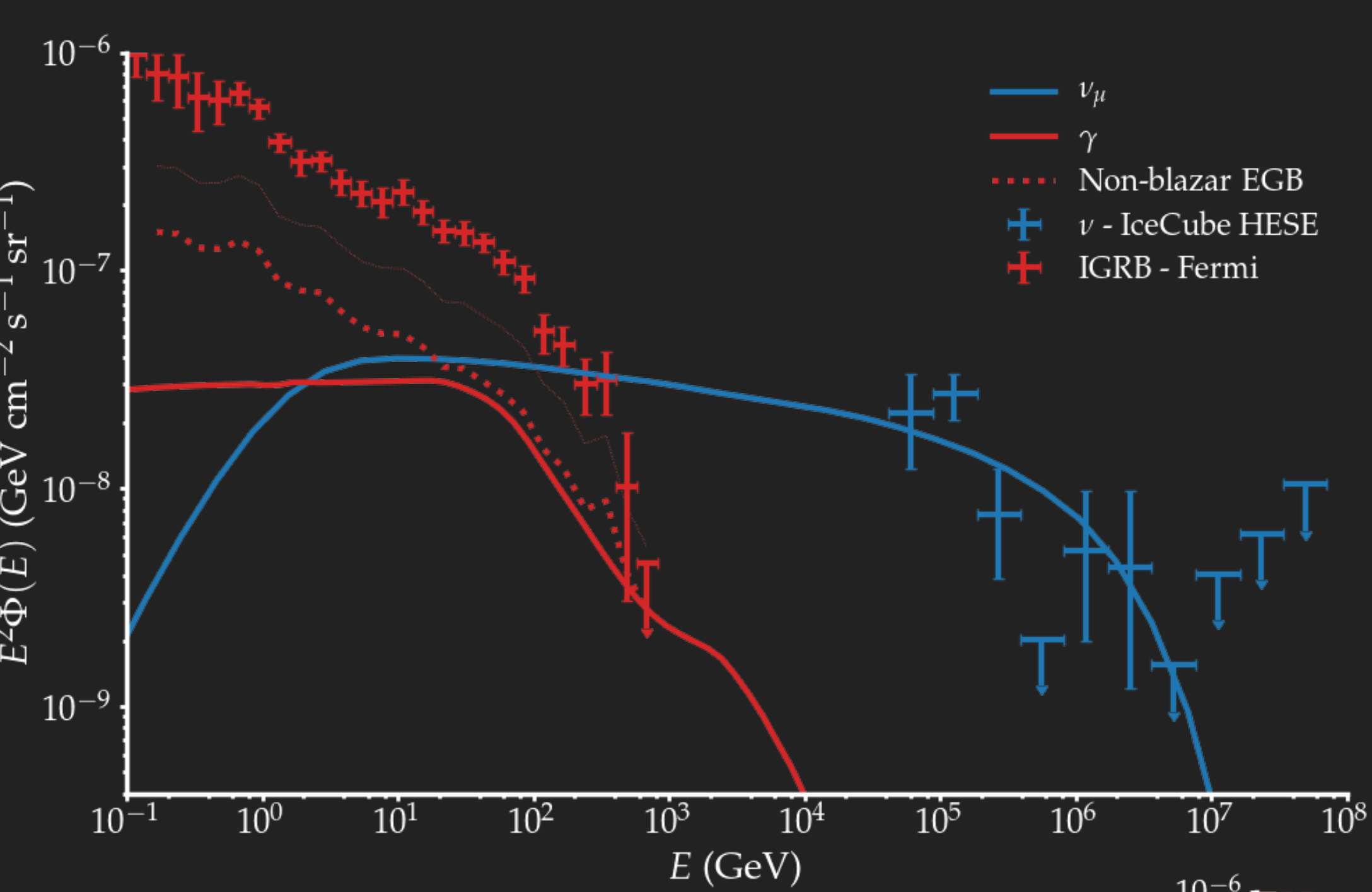
ULIRG $N_H = 5 \times 10^{25} \text{cm}^{-2}$



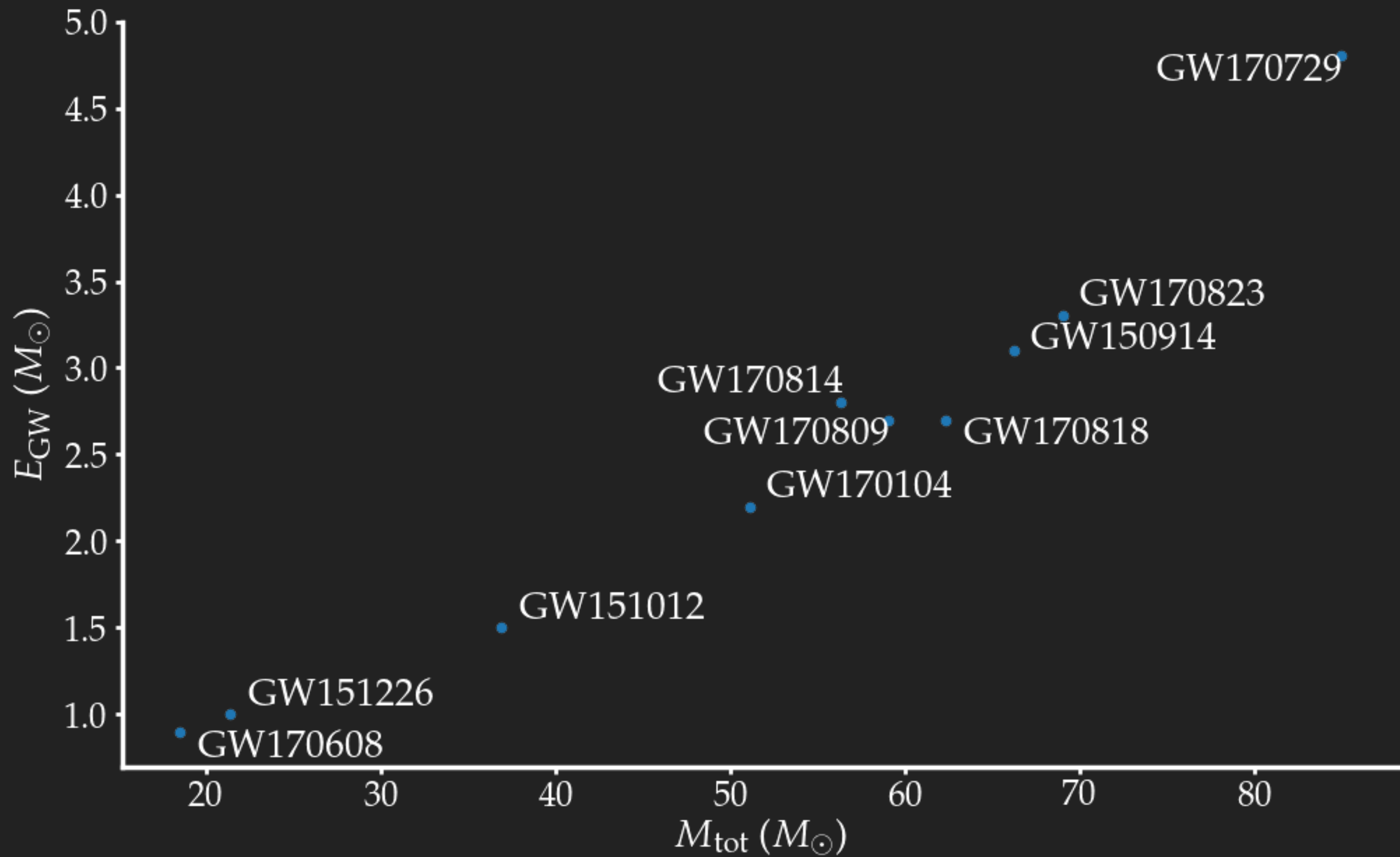


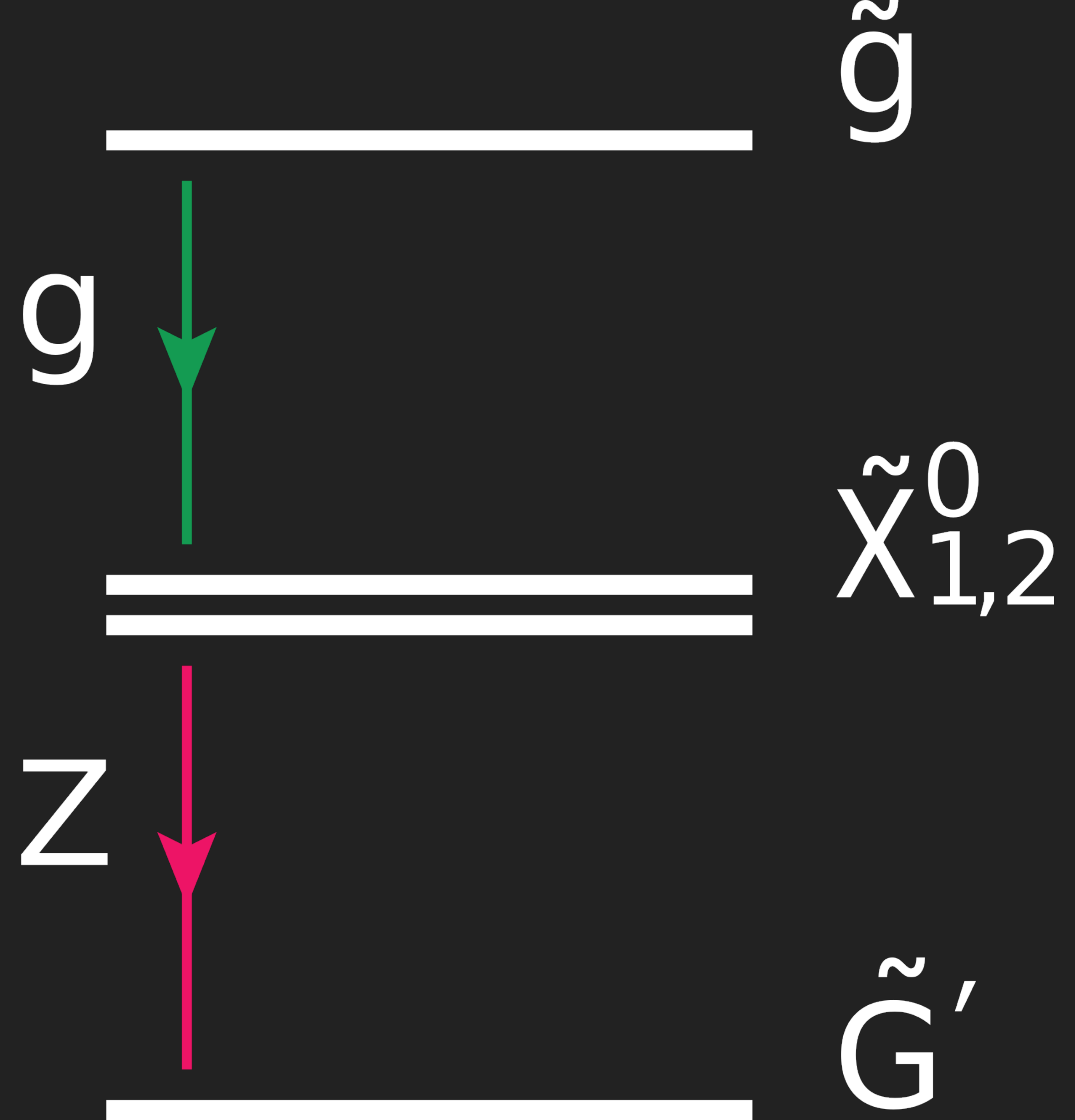
FLAT $N_H = 5 \times 10^{25} \text{cm}^{-2}$

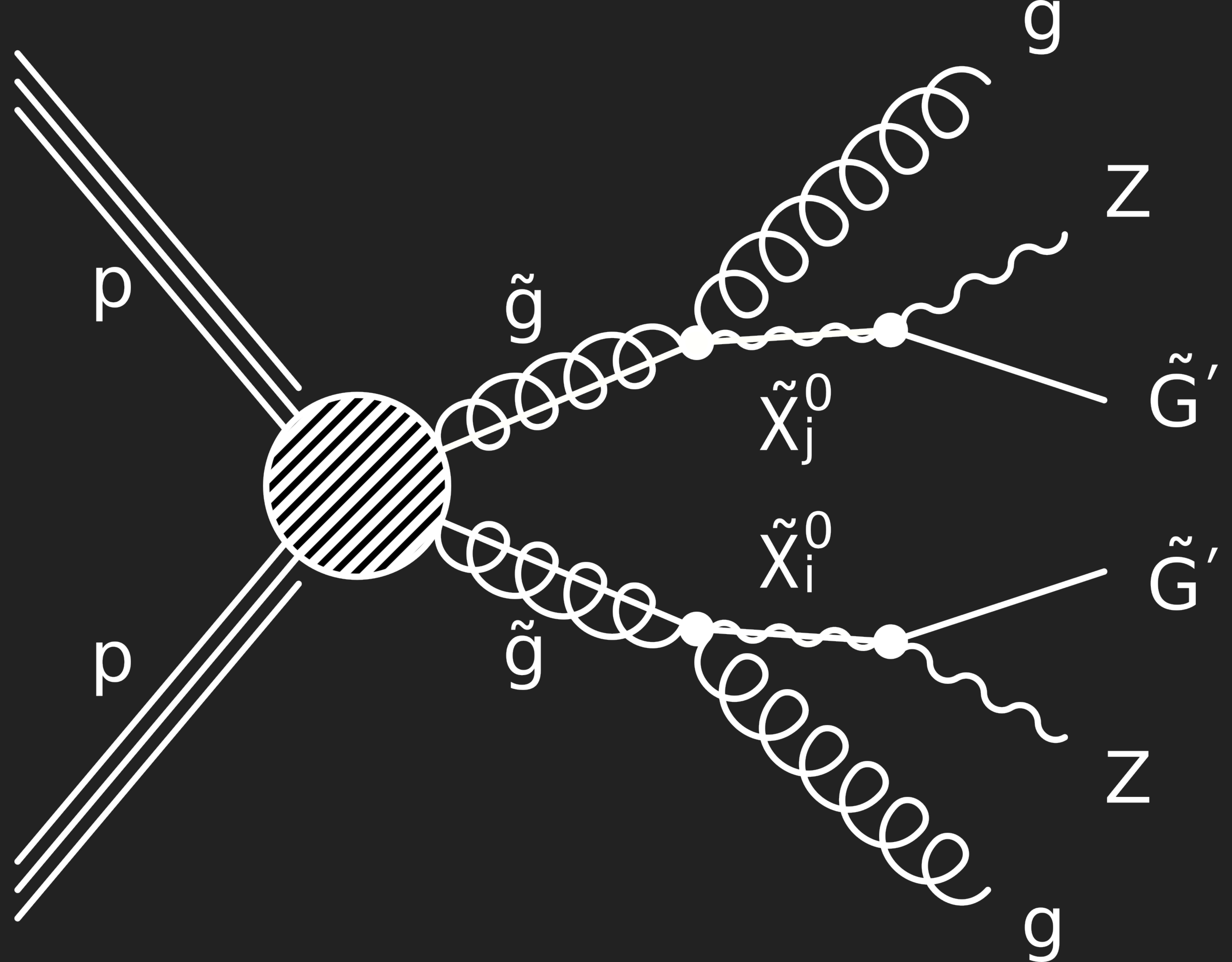




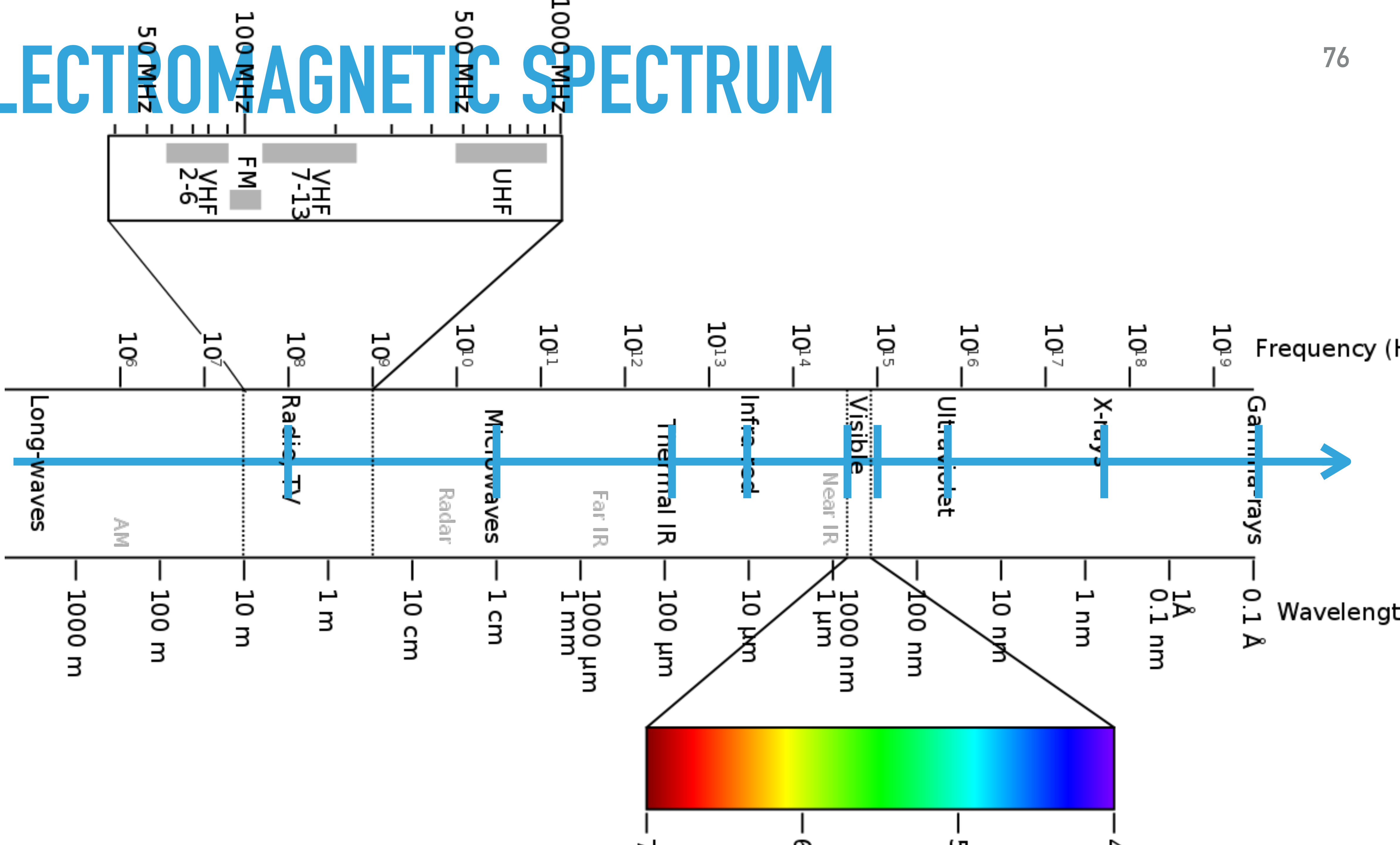
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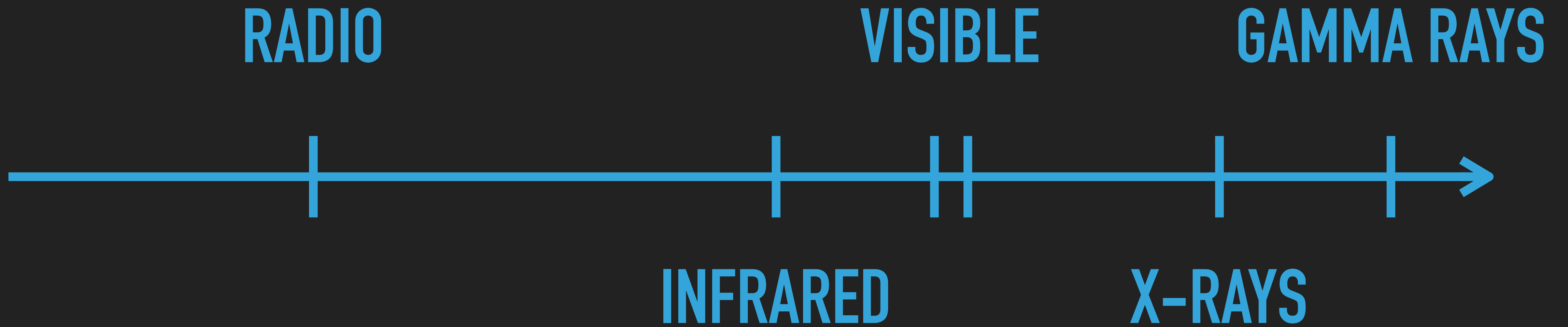


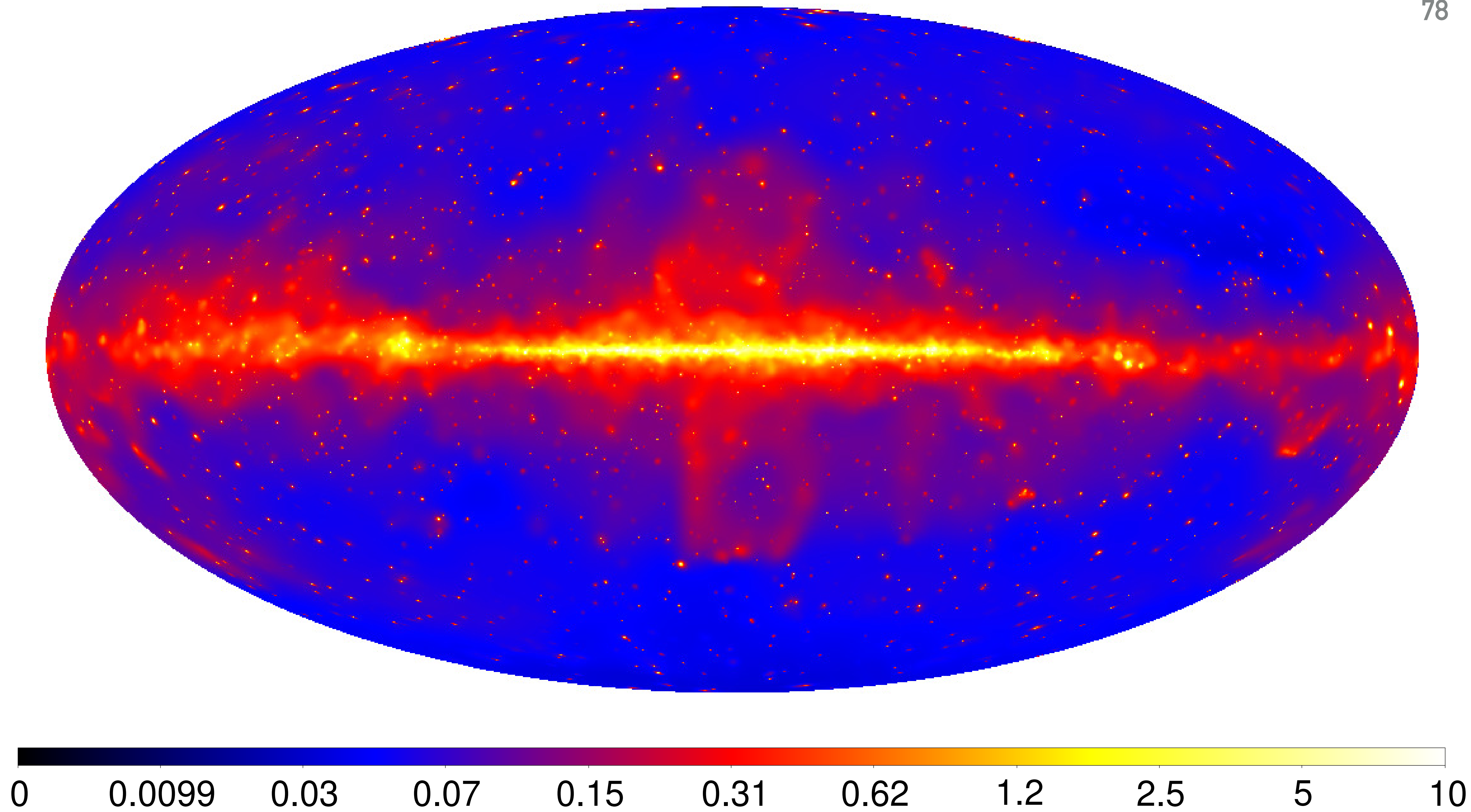


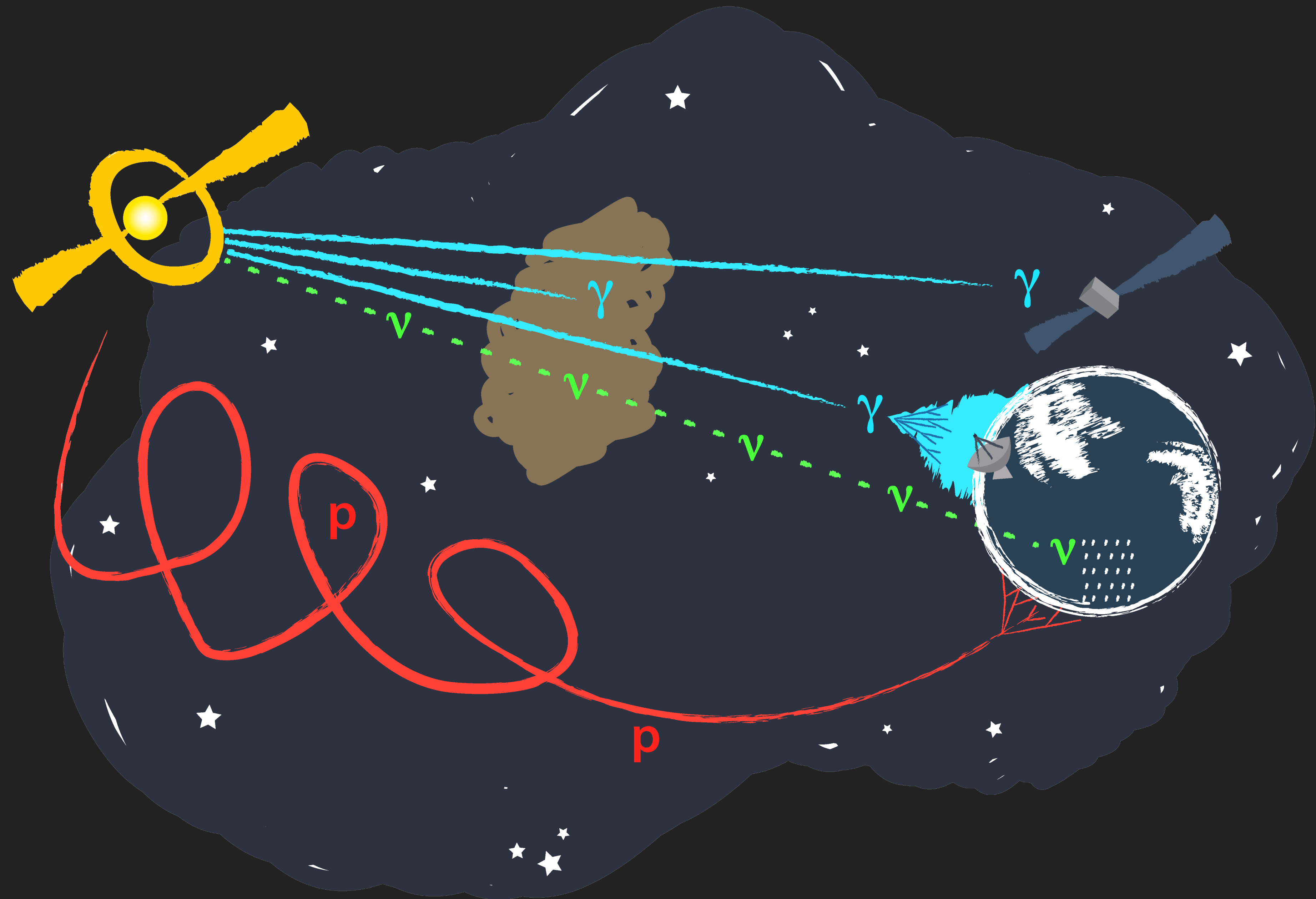
ELECTROMAGNETIC SPECTRUM

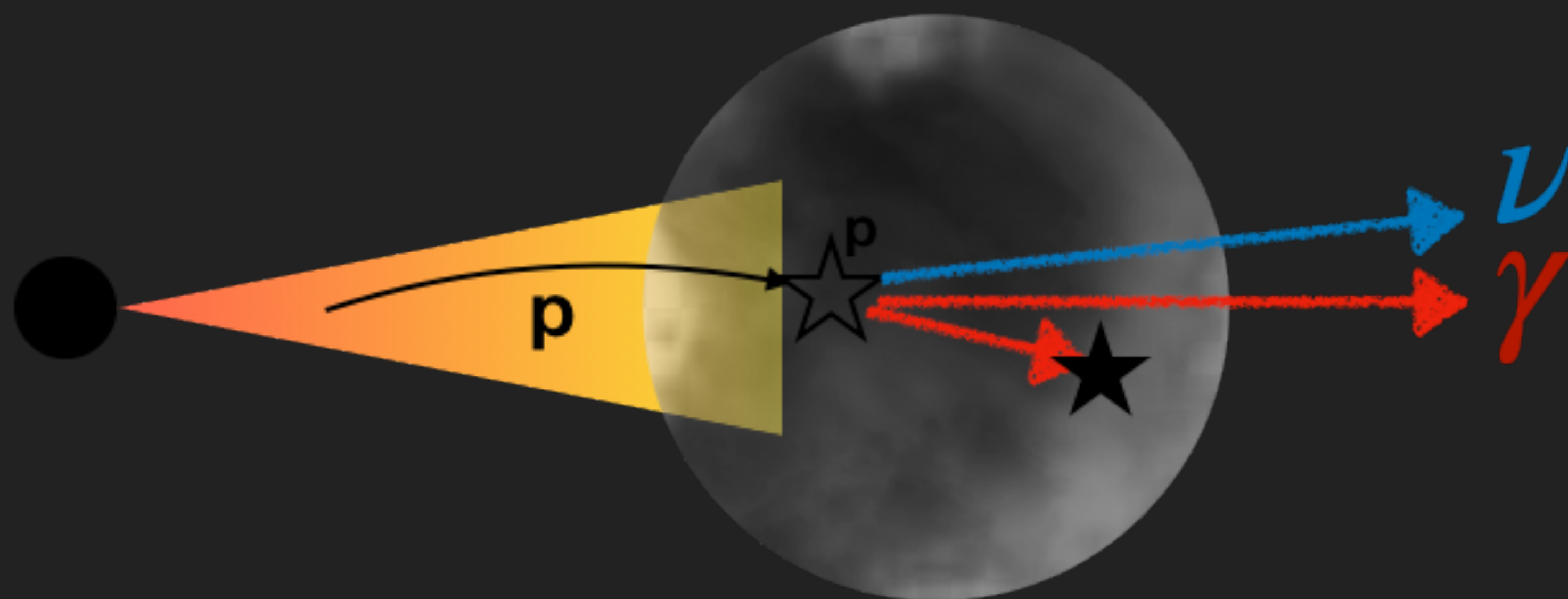


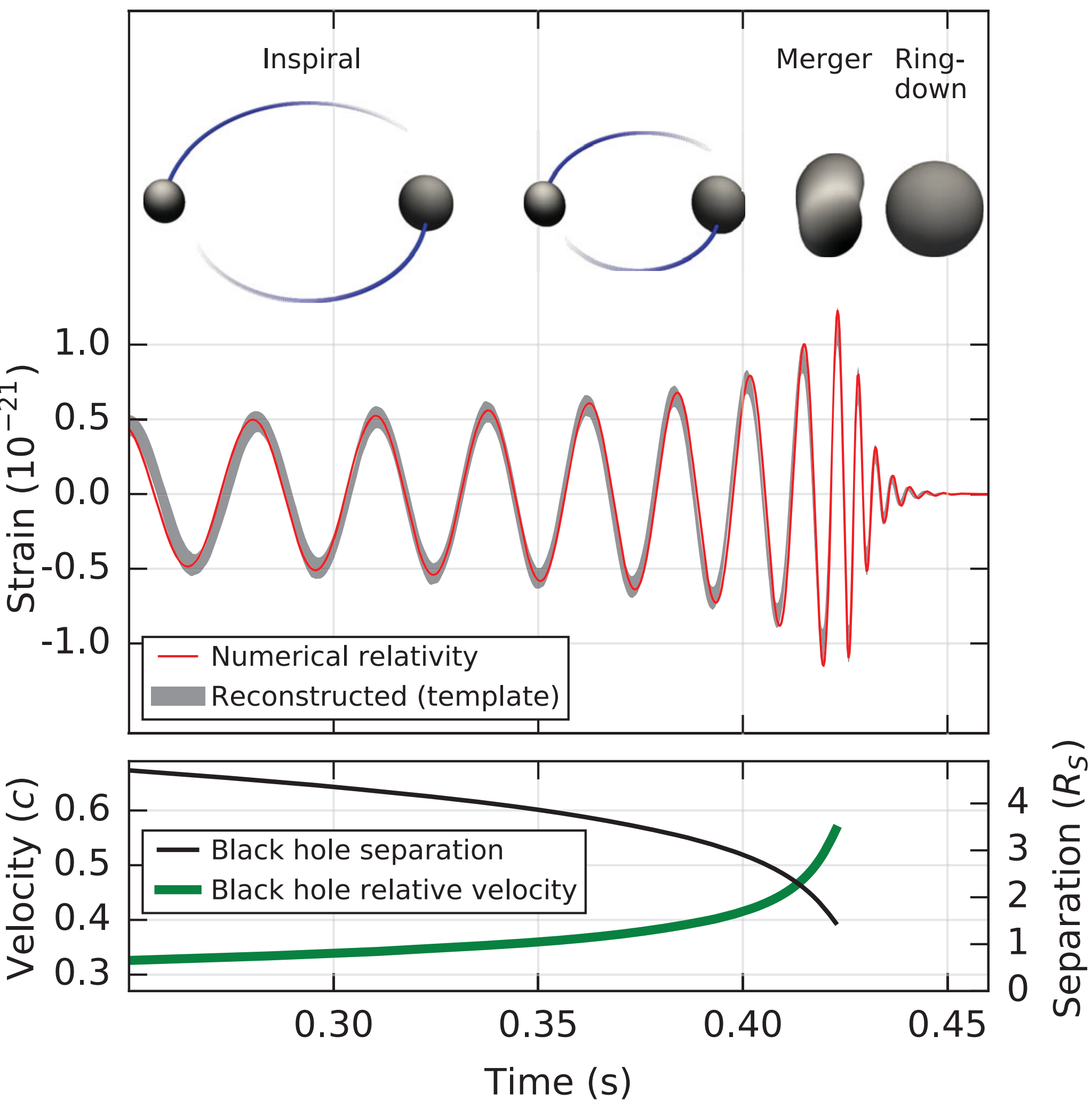
ELECTROMAGNETIC SPECTRUM











GW150914

**BINARY BLACK HOLE
MERGER**

THE STANDARD MODEL OF PARTICLE PHYSICS

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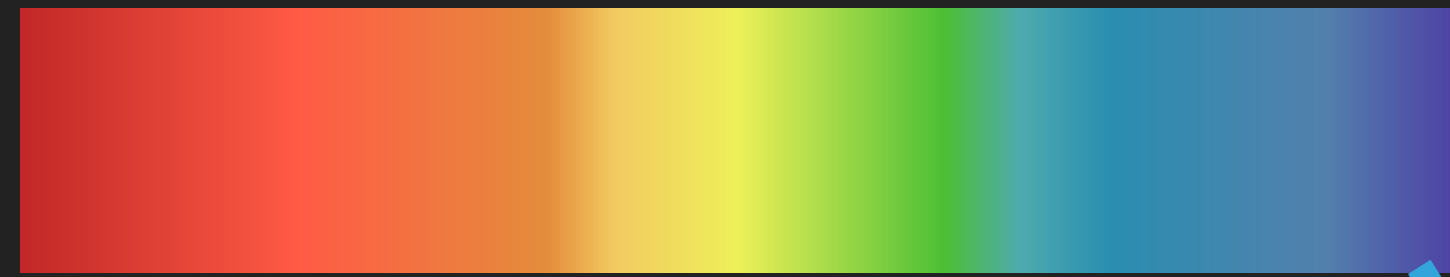
Z

ELECTROMAGNETIC SPECTRUM



RADIO

VISIBLE



GAMMA RAYS



INFRARED



X-RAYS

