PROSPECTS FOR THE DETECTION OF BL LACS WITH THE CTA EXTRAGALACTIC SURVEY

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LUMINOSITY FUNCTION (LF)

Imaging Atmospheric Cherenkov Telescopes (IACTs) have detected over seventy TeV gamma-ray blazars;

LF gives the comoving space density of blazar sources as a function of their luminosity;

LFs can be used to estimate the contribution of blazars to the diffuse extragalactic gamma-ray background at ~ 100 GeV and above;

LFs are fundamental for understanding the main physics drivers within the sources and their evolution;

LFs of TeV emitting BL Lacs can be used to understand if this type of blazars are plausible sources of astrophysical neutrinos.

LUMINOSITY FUNCTION (LF)

Problem for measuring the LF

Number of objects

Affects the uncertainties

Ability to discriminate between different LF distributions

Bias introduced in targeting

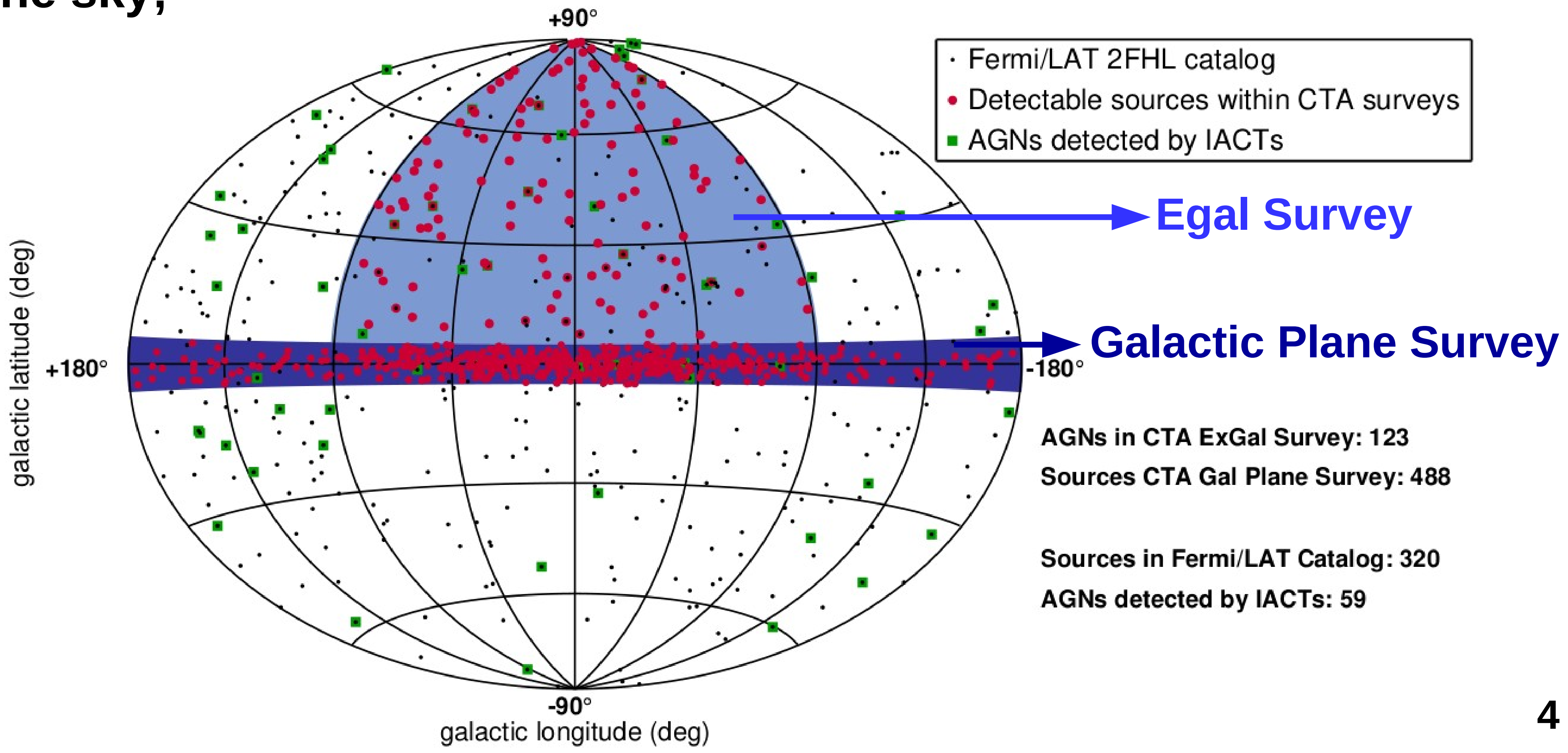
Solved with a wide survey (uniform exposure)

CTA extragalactic survey

CTA EXTRAGALACTIC SURVEY (KSPs)

The Egal survey KSP is the ideal data sample to reconstruct the LF of blazars;

Targets to provide 6 mCrab sensitivity above 125 GeV for 25% of the sky;



GOAL OF THE LUMINOSITY FUNCTION (LF) TASK

Provide an updated revision to the Egal survey. INVESTIGATE: i) the feasibility of the arrays; ii) expected number of sources with updated LAT catalogs and iii) LF reconstruction of BL Lacs.

ANALYSIS PROCEDURES

The analysis consists of 4 parts:

1) Define an observation strategy based on the planned extragalactic survey (KSPs);

2) Define a LF and generate a random population of blazars (with spectra as consistent as possible as those analyzed from the 4LAC);

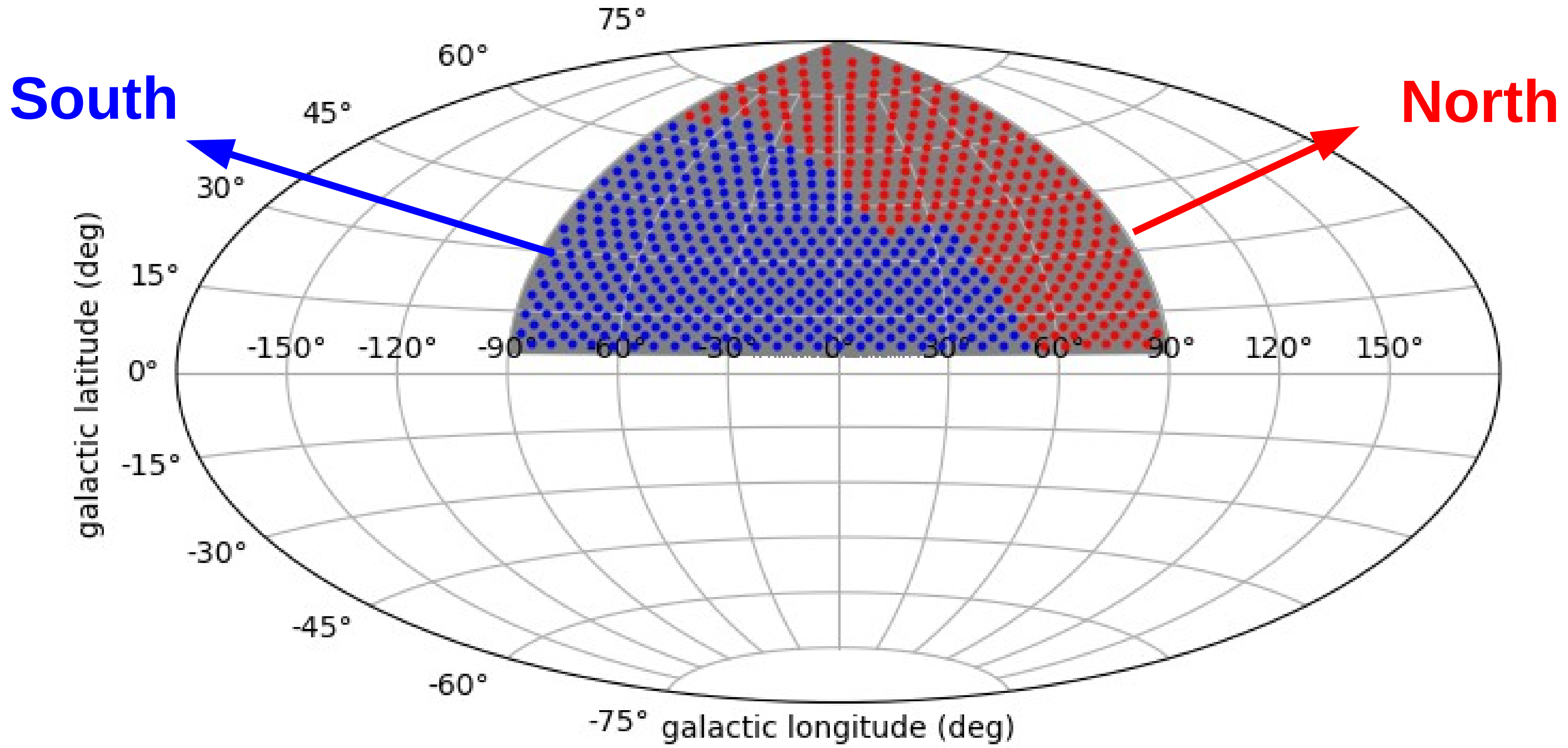
3) Perform a gammapy analysis to study their detectability;

4) Attempt to reconstruct the initial LF.

1) OBSERVATION STRATEGY

Proposed region of the extragalactic survey in Galactic coordinates: b > 5°; -90° < l < 90°, 25% of the sky;

Observation pointing directions are uniformly distributed on a grid with ~3.16° separation between the points (HEALPIx – nside = 16).



15% of the sky (60% of the survey) is covered from the south in 400 h and 10% of the sky (40% of the survey) from the north in 600 h

2) Define BL Lac Luminosity Function

(Ajello, M., et al. 2014, ApJ, 780, 73)

- Sources observed in the first year of Fermi operation (1FGL);

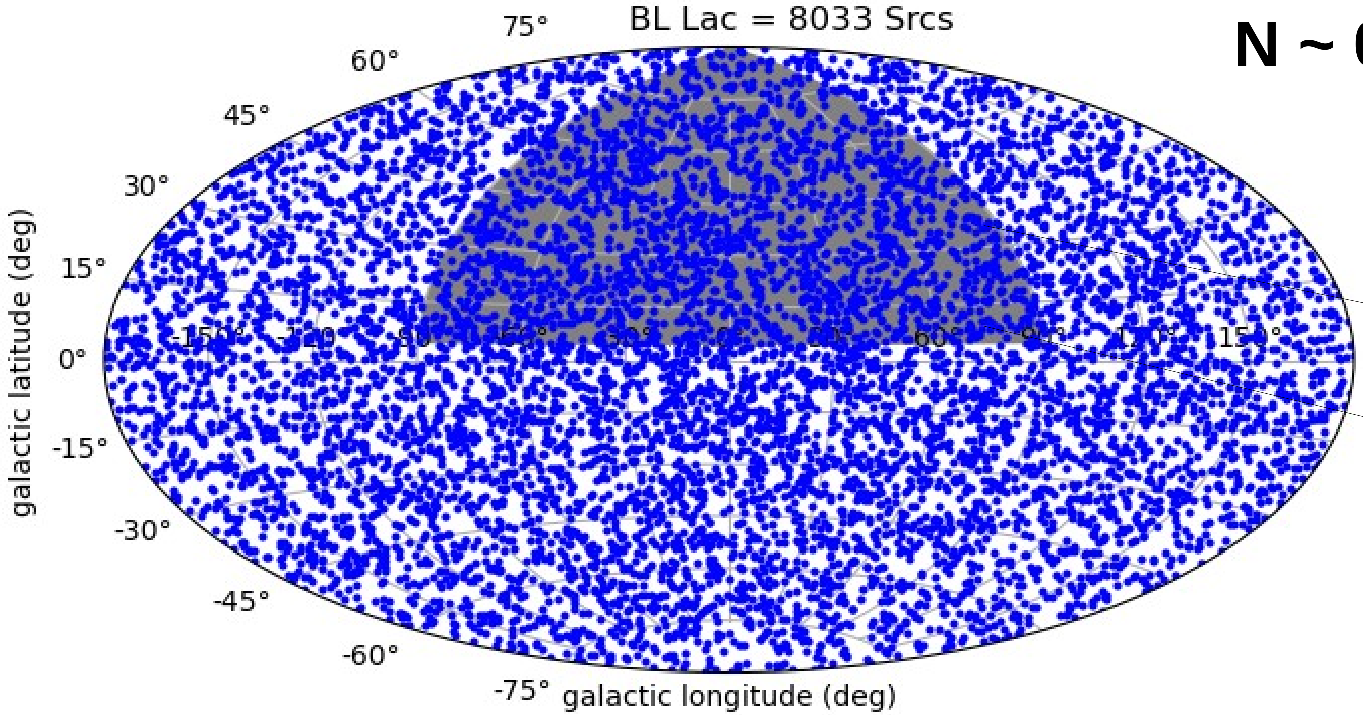
- Luminosity-Dependent Density Evolution (LDDE);

$$\Phi(L_\gamma, z, \Gamma) = \Phi(L_\gamma, z=0, \Gamma) \times e(z, L_\gamma)$$

$$\Phi(L_\gamma, z=0, \Gamma) = \frac{A}{\ln(10) L_\gamma} \left[\left(\frac{L_\gamma}{L_*} \right)^{\gamma_1} + \left(\frac{L_\gamma}{L_*} \right)^{\gamma_2} \right]^{-1} e^{-0.5[\Gamma - \mu(L_\gamma)]^2/\sigma^2}$$

Lγ is the rest-frame gamma-ray luminosity at 0.1-100 GeV in units of erg s^{-1} and Γ is the photon index of the source.

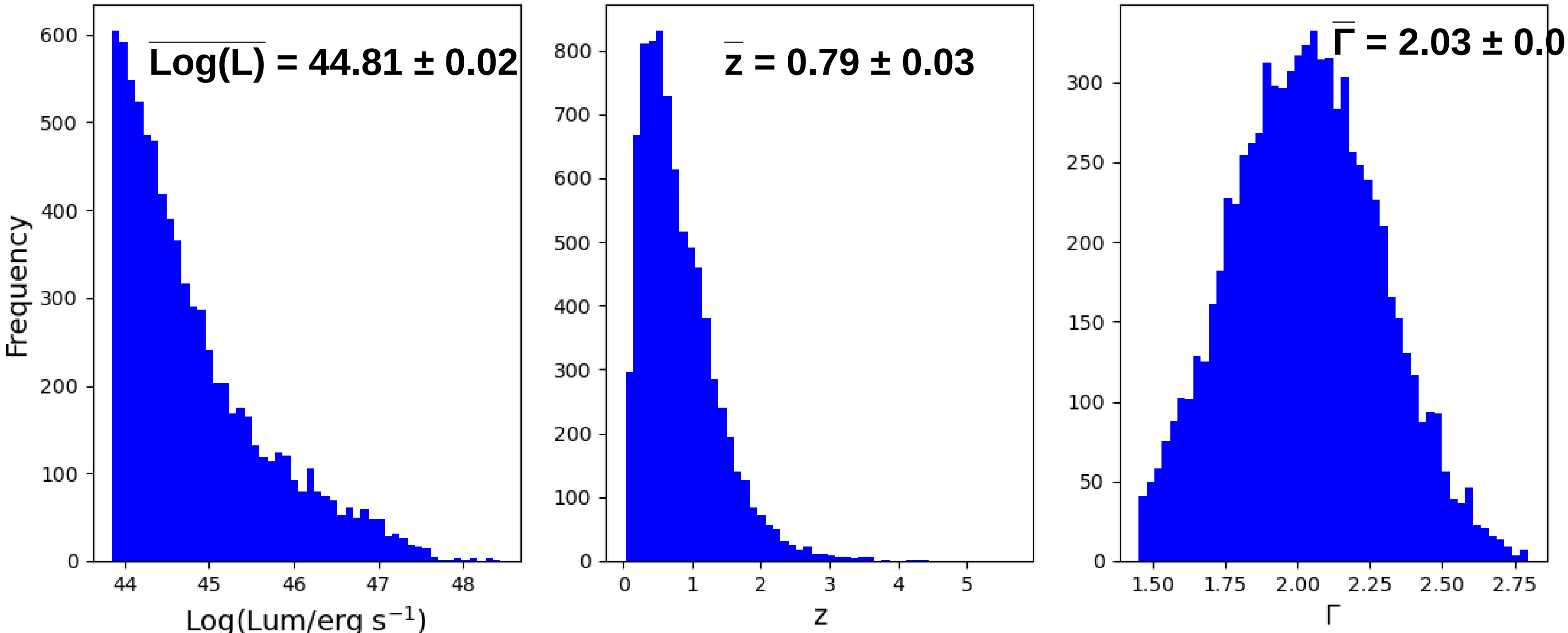
$$e(z, L_\gamma) = \left[\left(\frac{1+z}{1+z_c(L_\gamma)} \right)^{-p_1(L_\gamma)} + \left(\frac{1+z}{1+z_c(L_\gamma)} \right)^{-p_2(L_\gamma)} \right]^{-1}$$



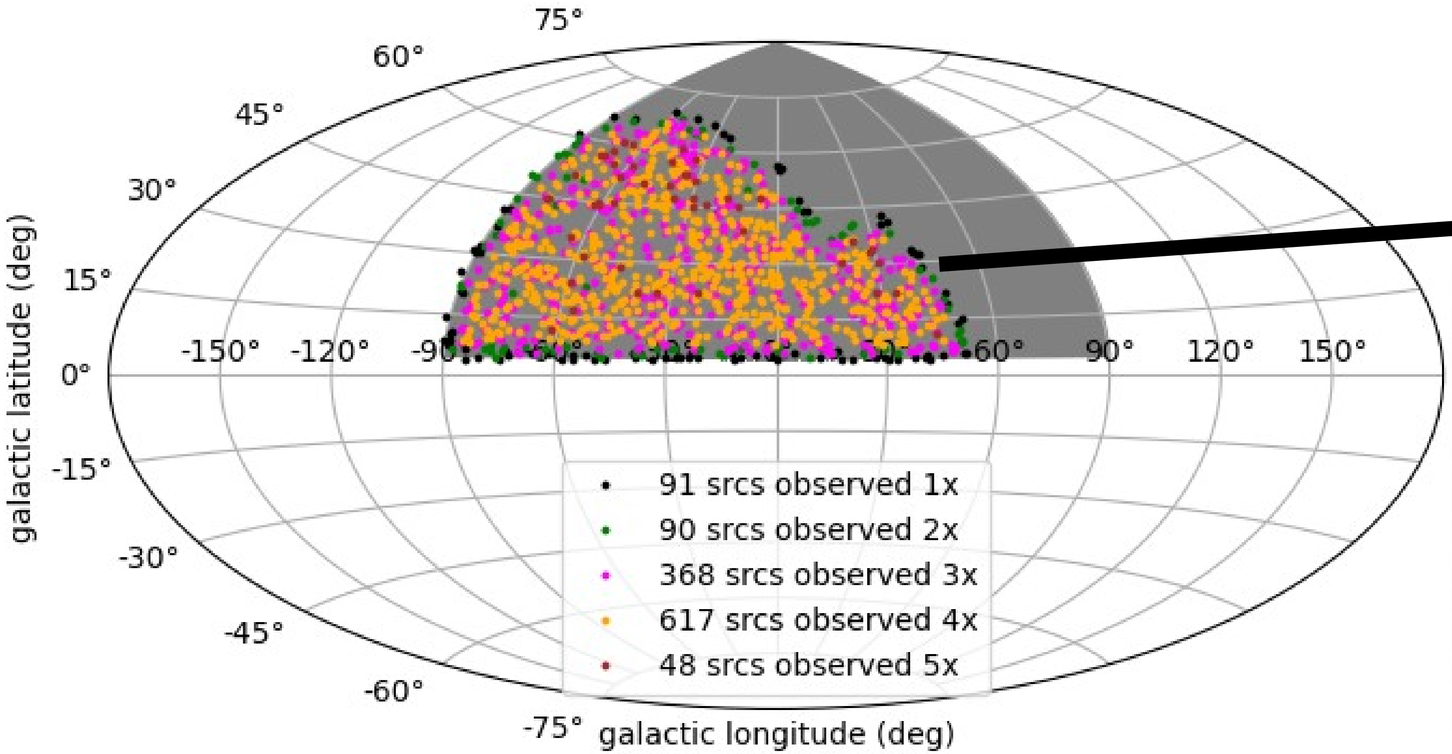
N ~ 0.2 source/deg^2

25% sky coverage
A = 10000 deg^2

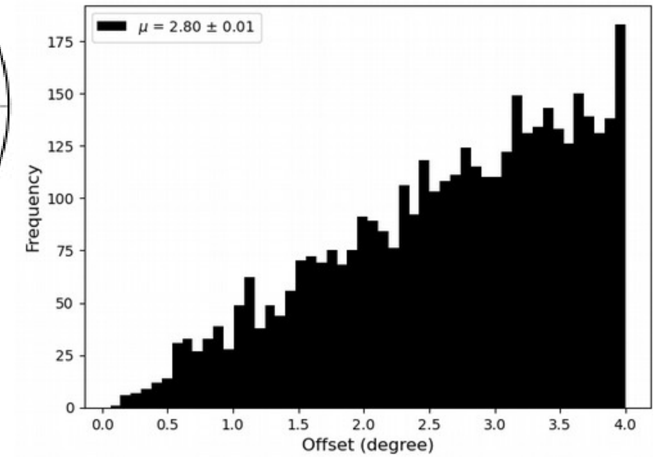
1901 sources

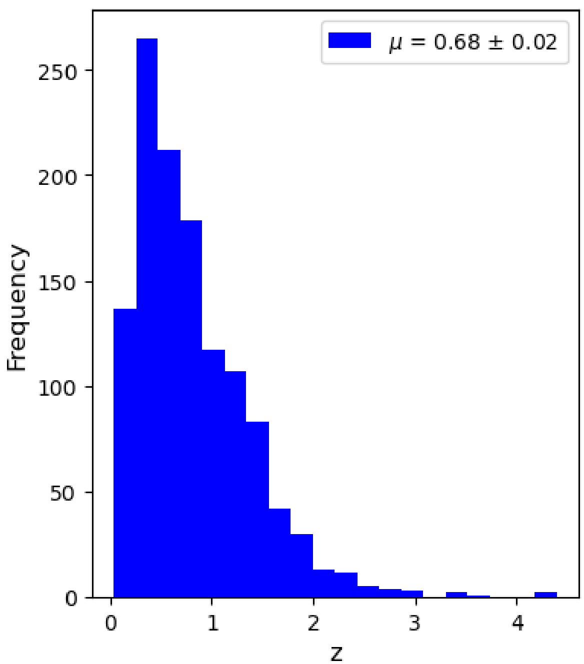


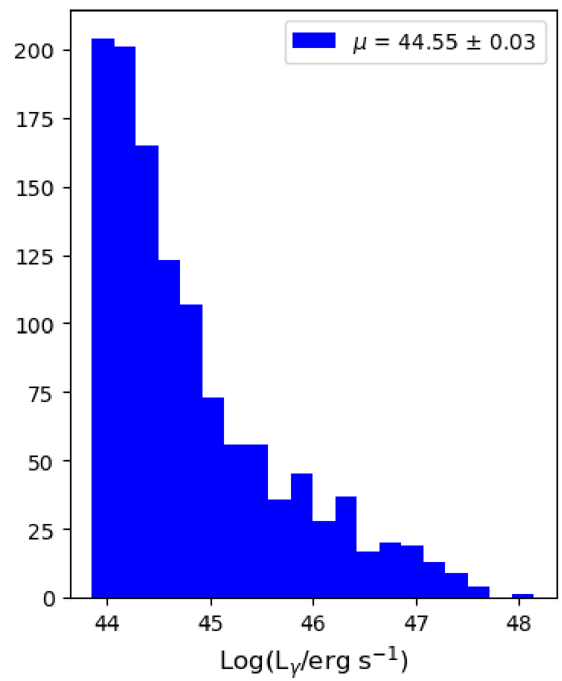
BL LACS (SOUTH) – LDDE (LUMINOSITY DEPENDENT DENSITY EVOLUTION)

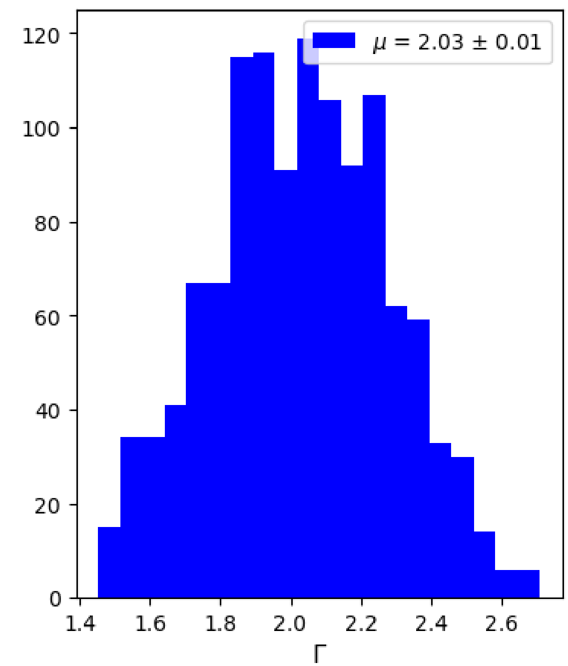


1214 sources

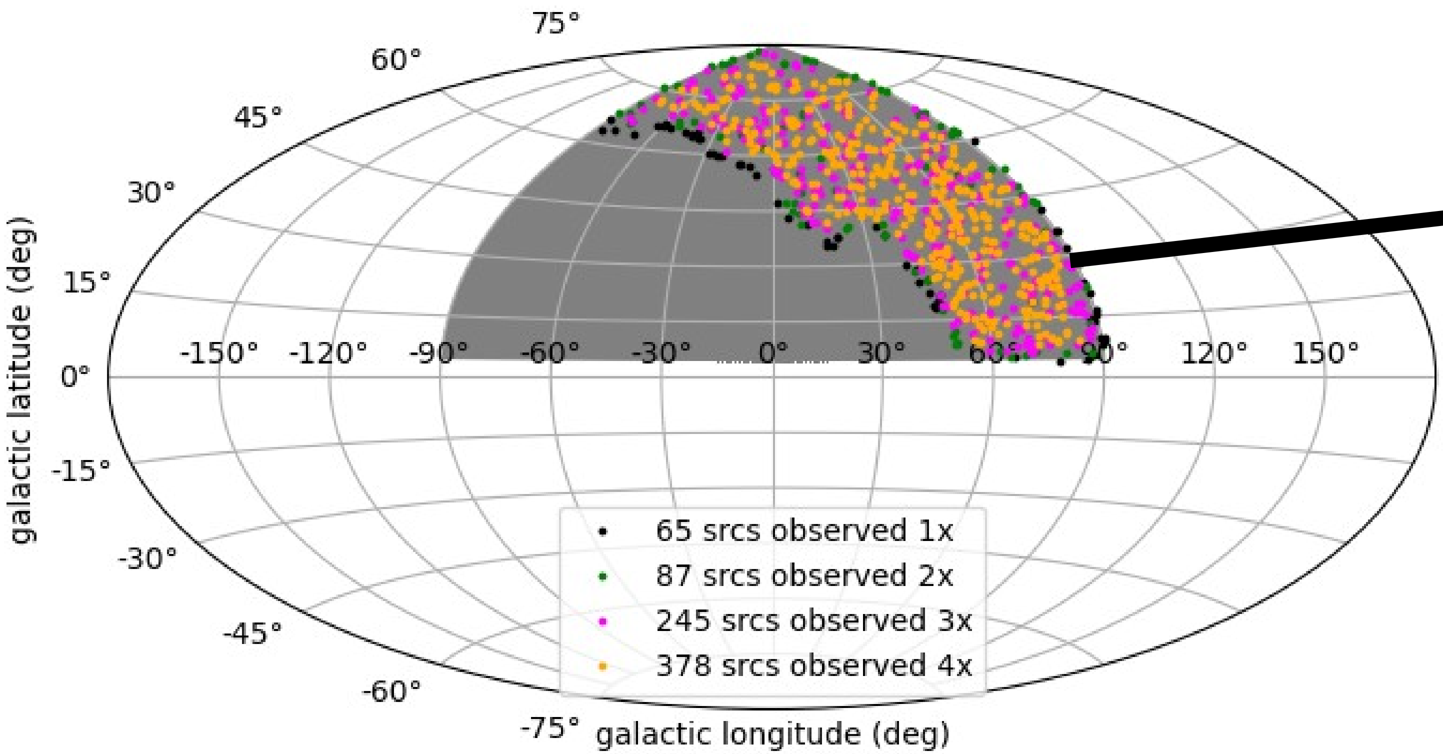




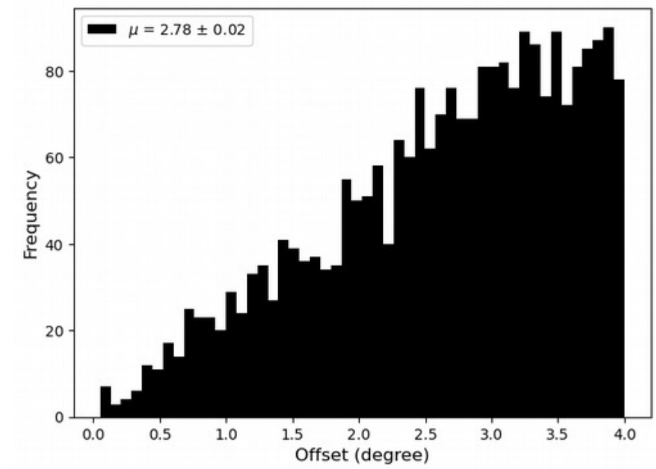


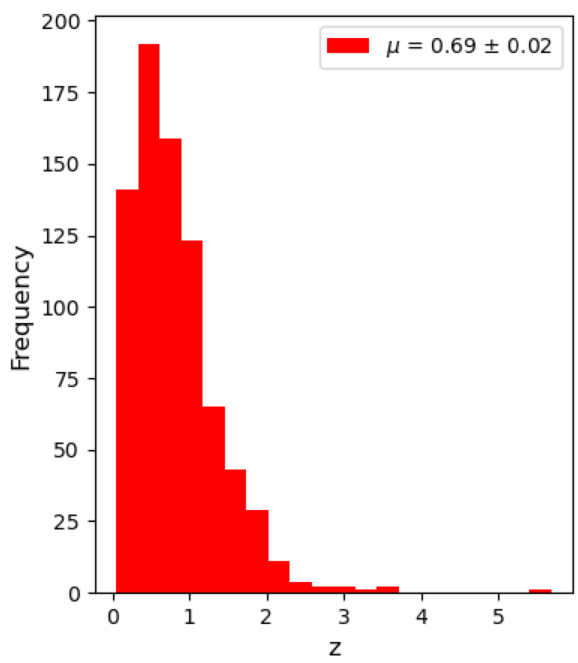


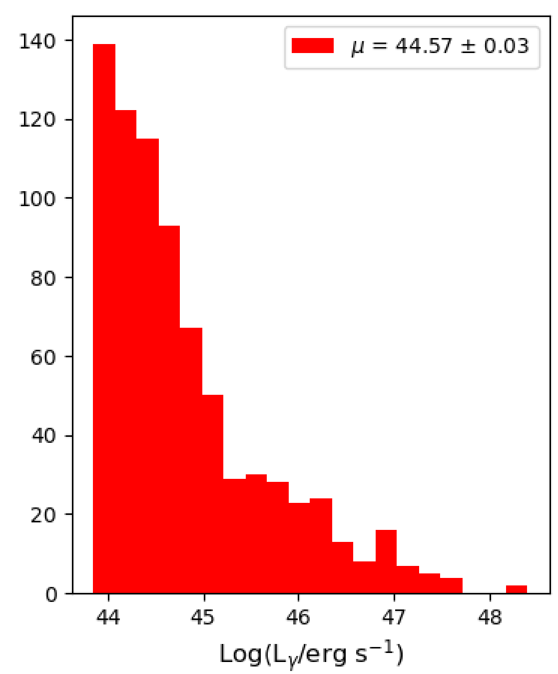
BL LACS (NORTH) – LDDE (LUMINOSITY DEPENDENT DENSITY EVOLUTION)

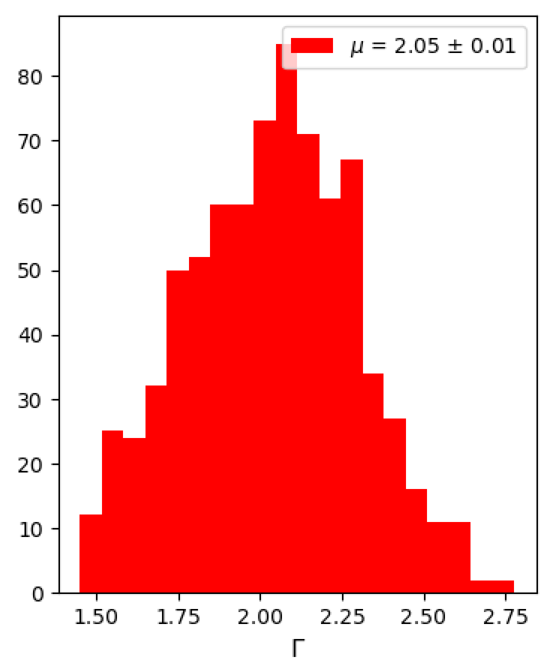


775 sources

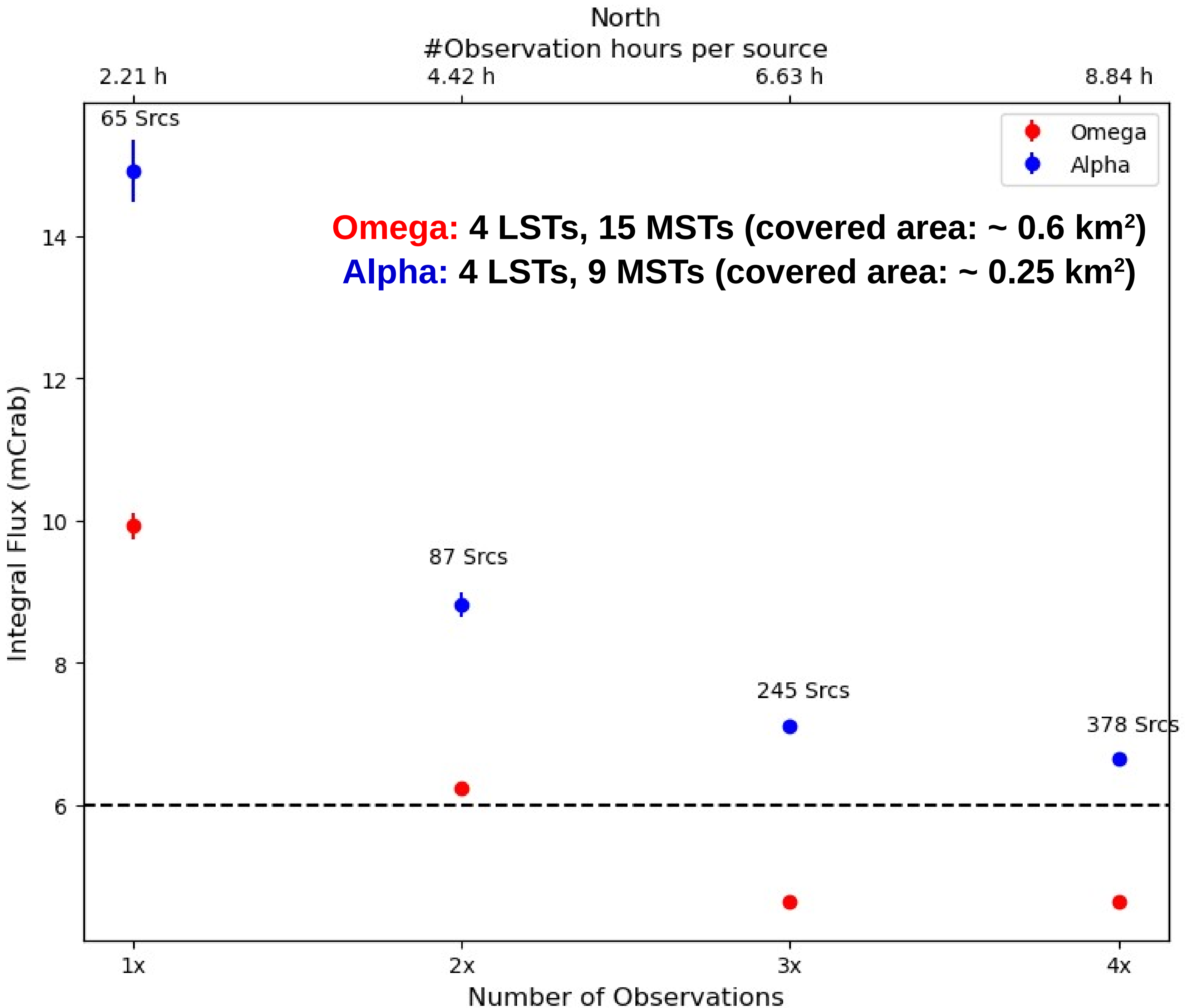








INTEGRAL SENSITIVITY VS #OBSERVATIONS



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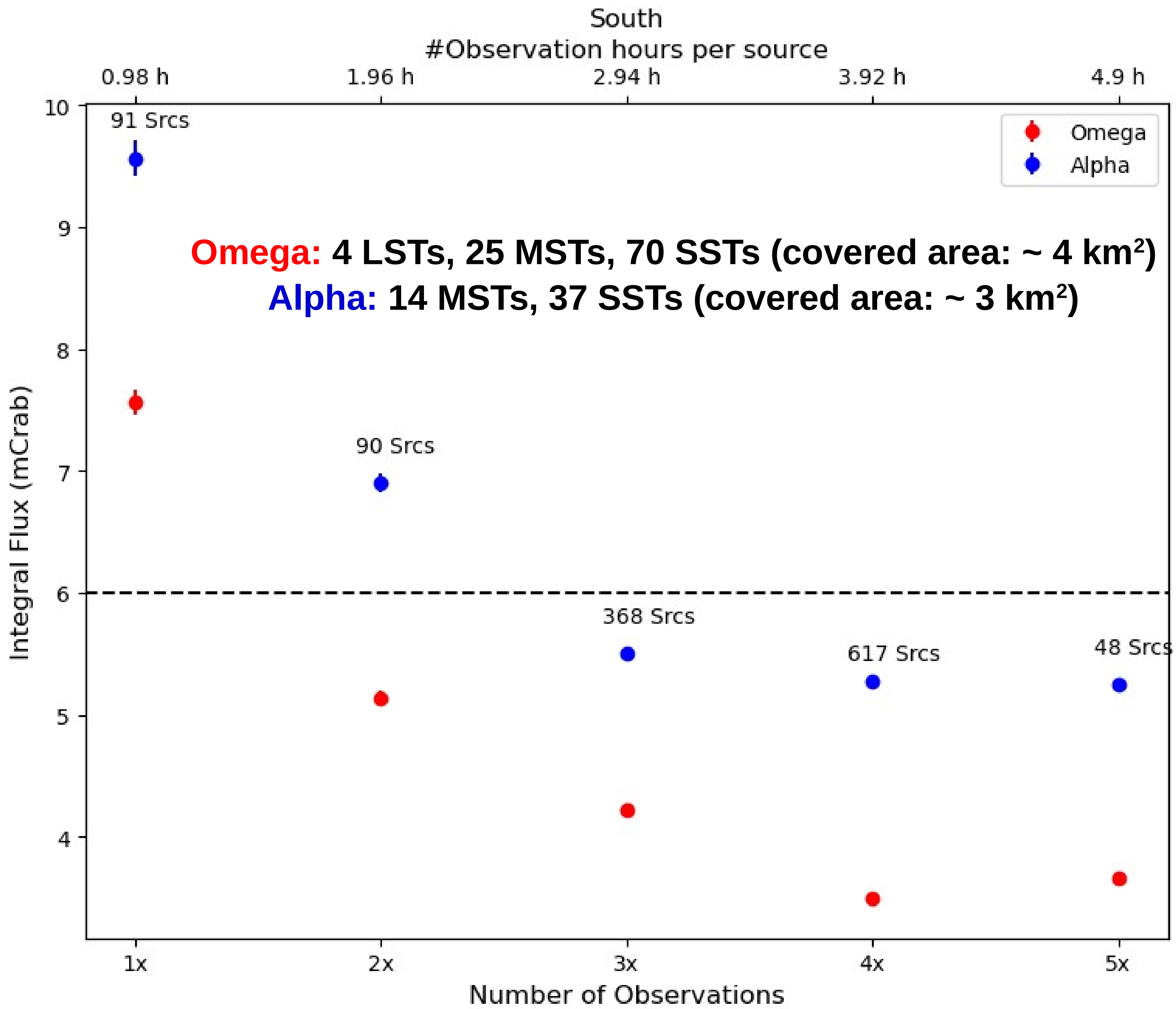
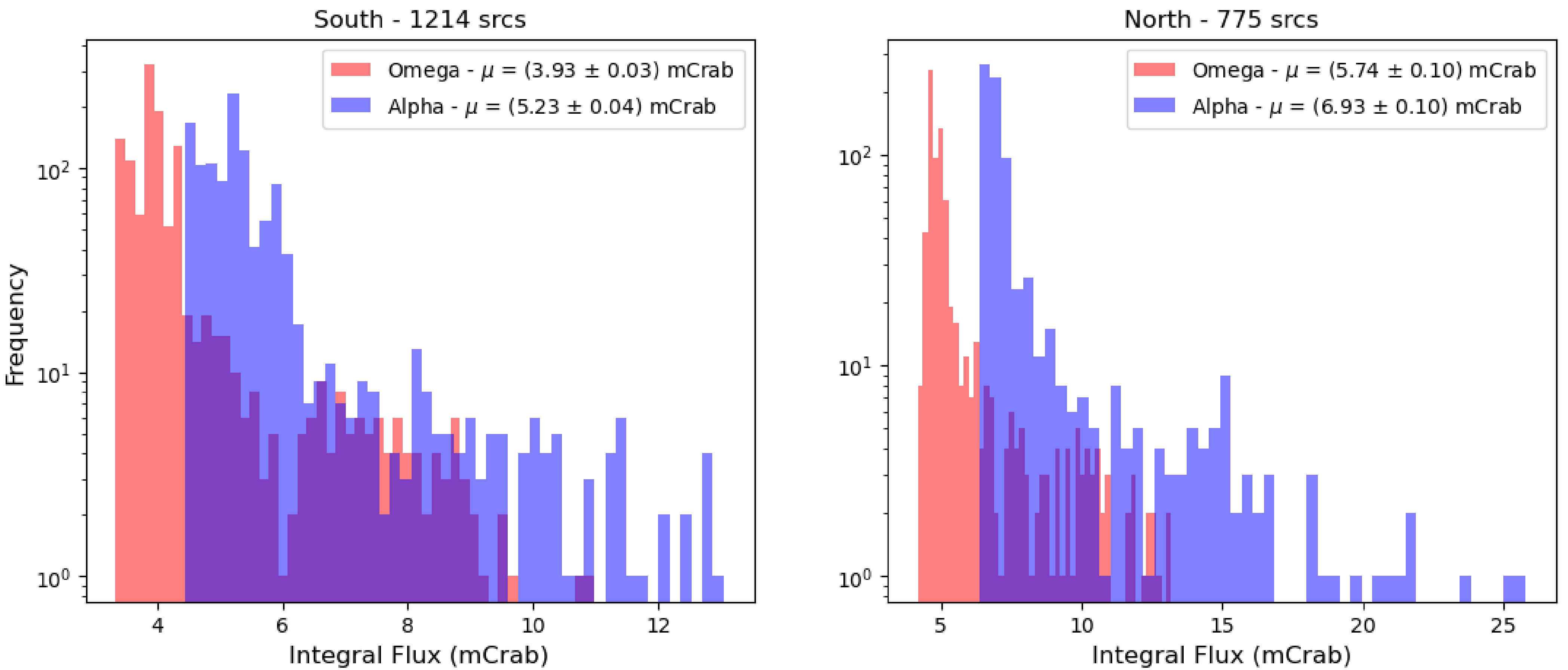


INTEGRAL SENSITIVITY DISTRIBUTION

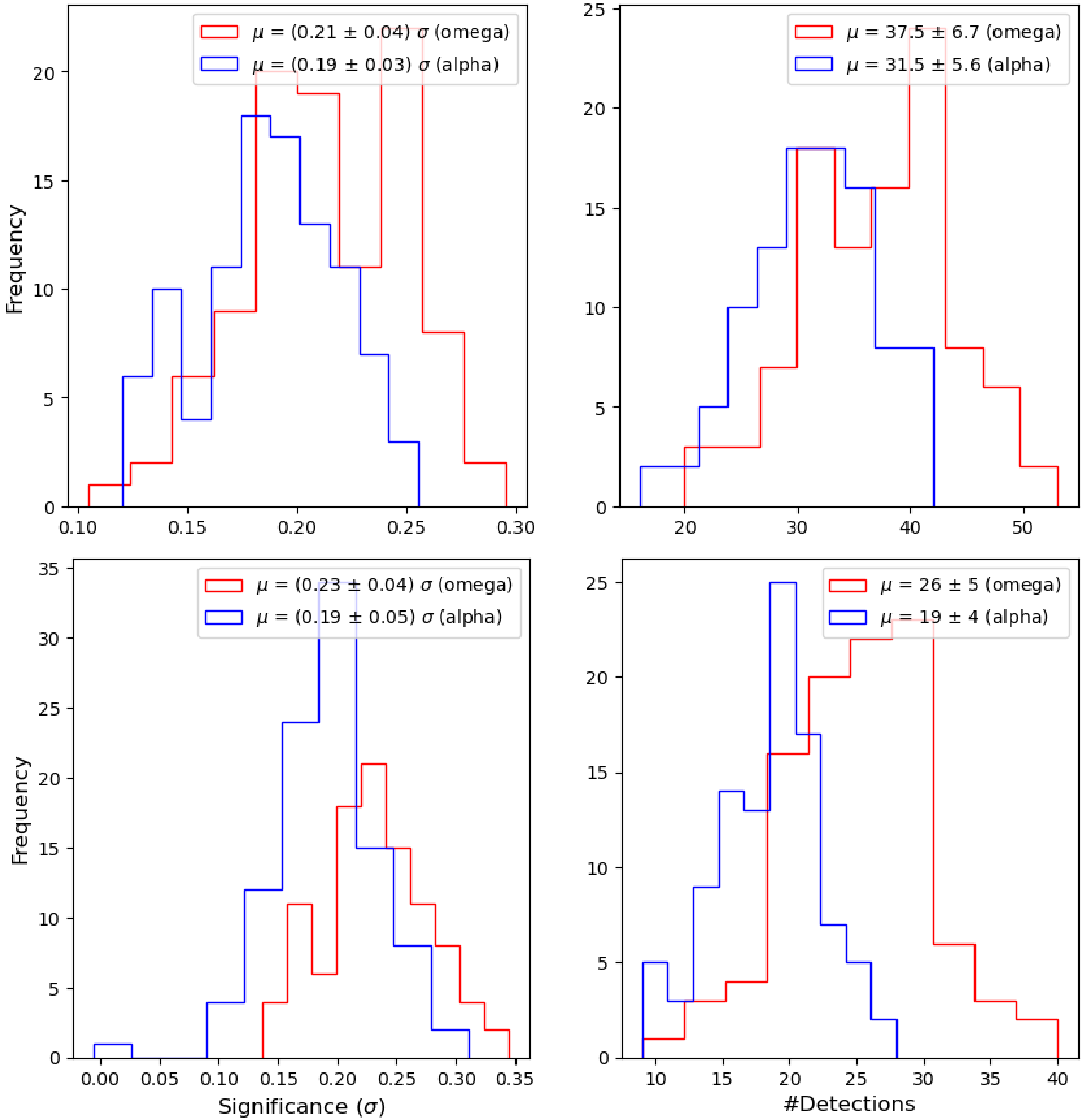
1mCrab = 5.08×10^{-13} cm^{-2} s^{-1} (E > 125 GeV)



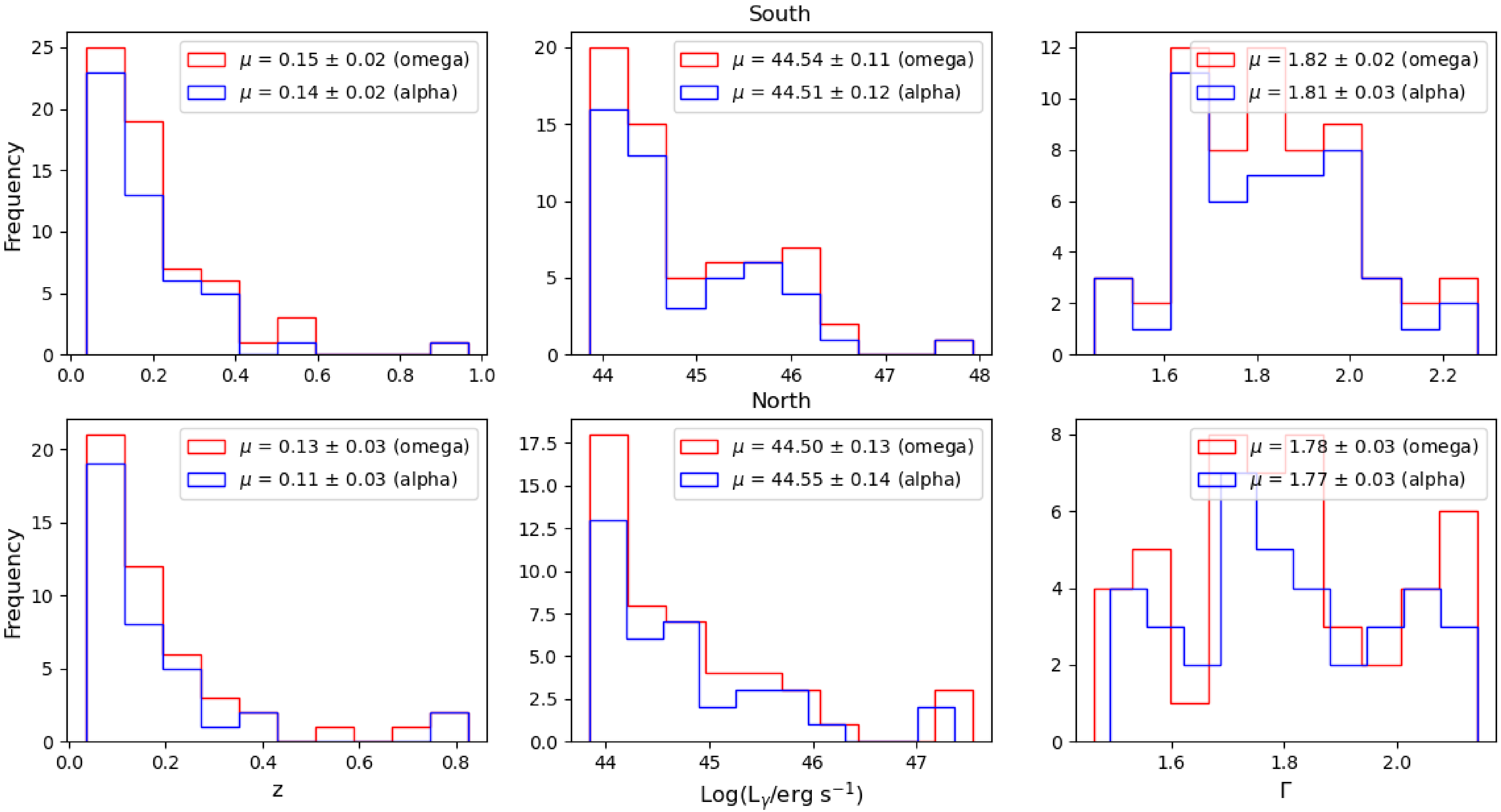
ANALYSIS RESULTS

South

North



INTRINSIC PARAMETERS OF THE DETECTED SOURCES



SUMMARY

- CTA extragalactic survey KSP is the ideal project for constraining the LF of extragalactic sources in the VHE regime;

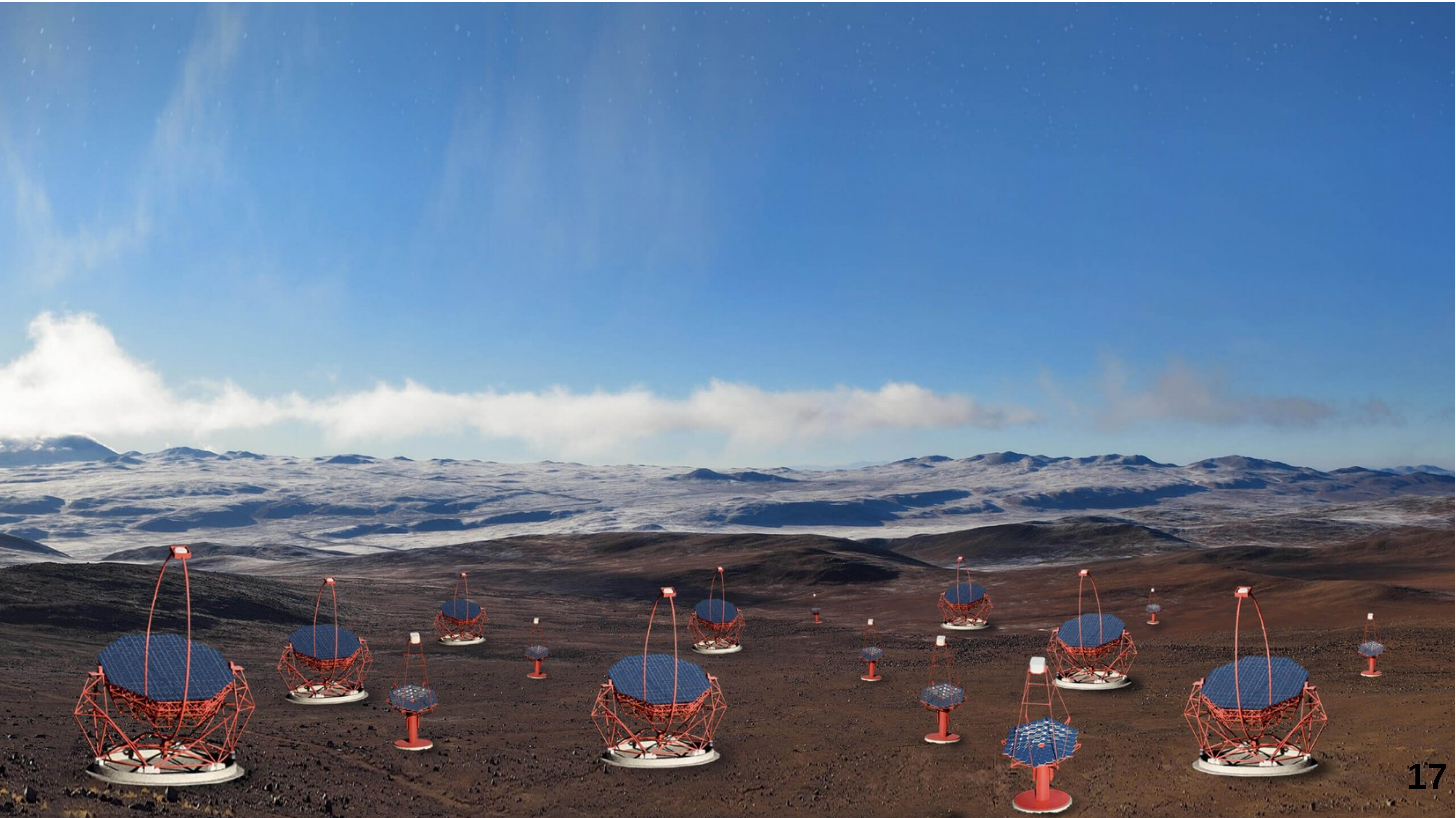
- A task force was defined to explore the capabilities of CTA to reconstruct the LF of BL Lacs. Results will be included in the AGN Populations Consortium Publication;

- The increase in the offset distribution provides a better detection sensitivity for both array configurations;

- For Omega the average detection sensitivity is below the target one (6 mCrab for E > 125 GeV), while for Alpha it is ~ 5.23 mCrab for south and ~ 6.93 mCrab for north;

- The number of detected sources depends on the used array configuration – for alpha we have a total of 48 +/- 7 detected sources, while for omega it is 59 +/- 8.

THANK YOU VERY MUCH FOR YOUR ATTENTION!



BACKUP

GAMMAPY-0.18.2 (1D ON/OFF Analysis)

Acknowledgements to Jean-Phillipe

Source

PL

Intrinsic models →

$$\frac{dN}{dE} = N_0 \left(\frac{E}{E_0} \right)^{\gamma}$$

EBL models → **D11**

Dominguez, A. et al., 2011, MNRAS, 410

Background

IRF – prod3b-v2 | prod5

5 h; θ = 20°, 40°

Energy Threshold =[“0.03”, “0.05”, “0.1”, “0.3”, 0.5”, “1”] * u.TeV;

Emax = 100 TeV.

BL Lac Luminosity Function

Number of expected sources:

$$N = \int_{z_{min}}^{z_{max}} \int_{L_{min}}^{L_{max}} \int_{\Gamma_{min}}^{\Gamma_{max}} \Phi(L_\gamma, z, \Gamma) \frac{dV_c}{dz} d\Gamma dL_\gamma dz,$$

where the comoving volume per unit of redshift is given by

$$\frac{dV_c}{dz} = D_H \frac{(1+z)^2 D_A^2}{E(z)} d\Omega$$

Integration Limits

7×10^{43} erg s^{-1} $\leq L_\gamma \leq 10^{52}$ erg s^{-1}

$0.03 \leq z \leq 6$

$1.45 \leq \Gamma \leq 2.80$