

# 2BIGB Sample

**Bruno Arsioli - IFGW Unicamp, Brazil**

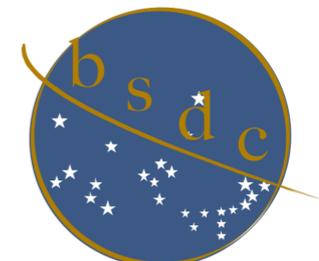
Co-authors: Dr. Yu-Ling Chang, Taiwan &  
Msc. Student Musiimenta Blessing, Mbarara University, Uganda



**UNICAMP**



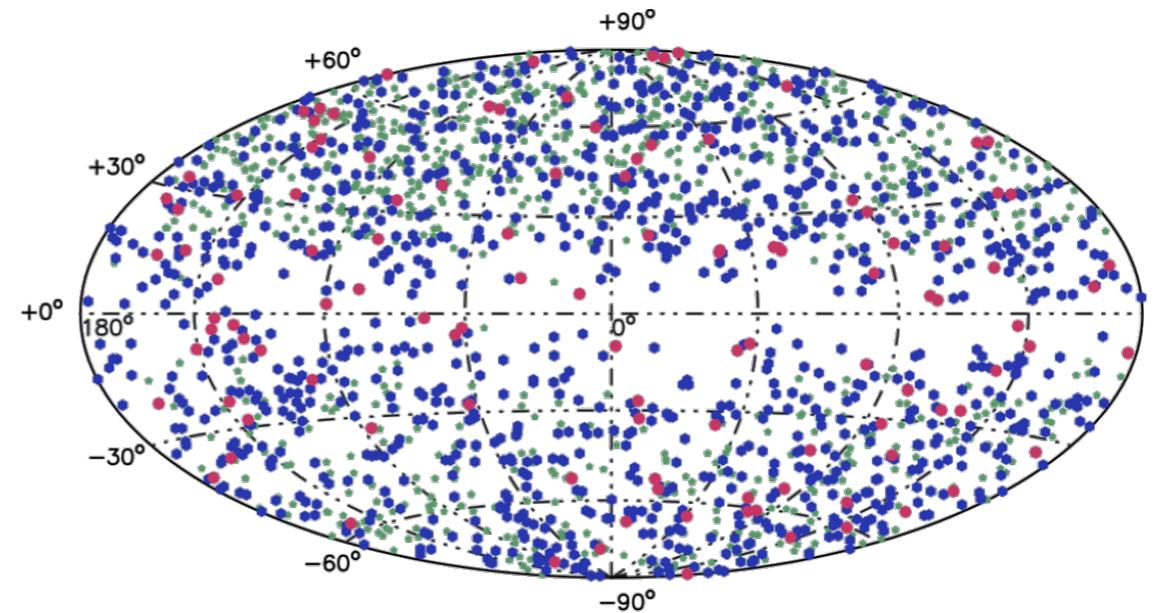
**SAPIENZA**  
UNIVERSITÀ DI ROMA



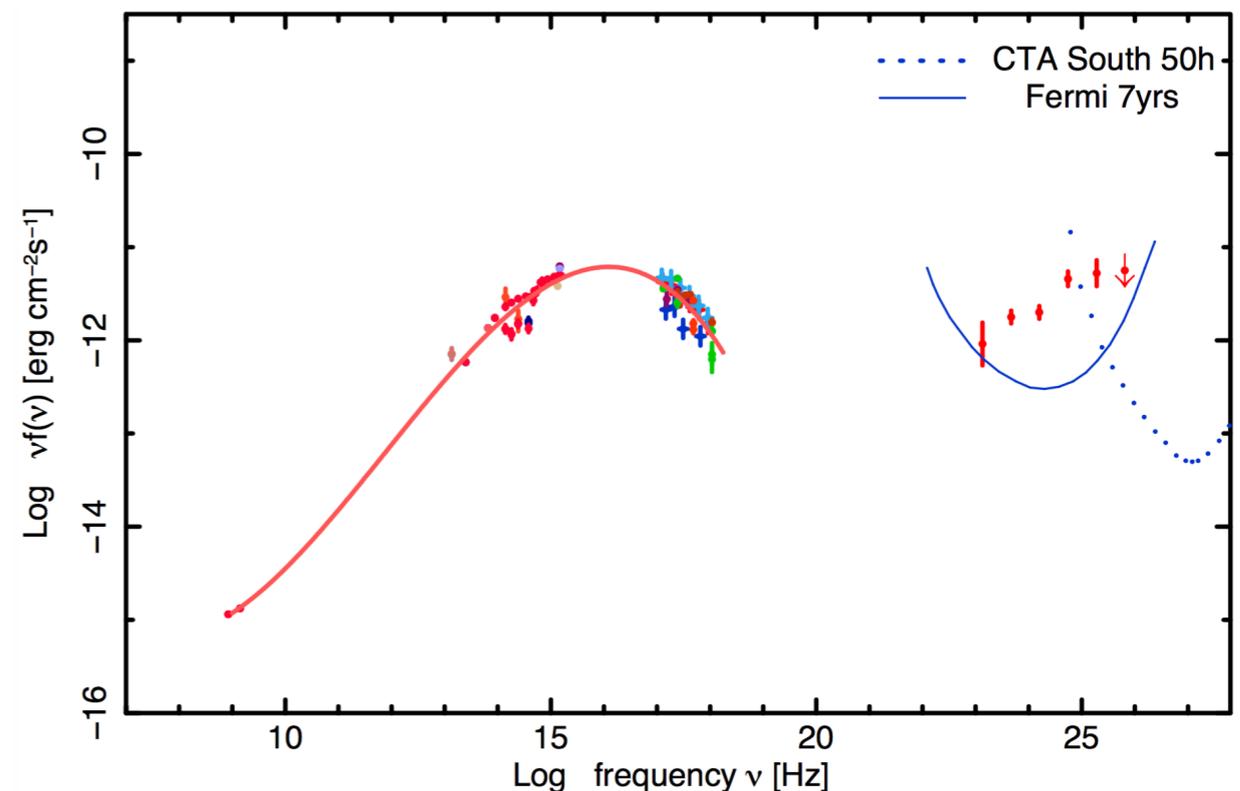
Extreme19 Jan. 22, 2019. Padova - IT

# What is the 2BIGB sample?

- BIGB - Brazil ICRA-Net **Gamma-ray Blazar catalog** (High Synchrotron Peak)
- **3HSP + 10 yrs of Fermi-LAT** (2008-2018)
- Binned Likelihood Analysis
- **500 MeV - 500 GeV**

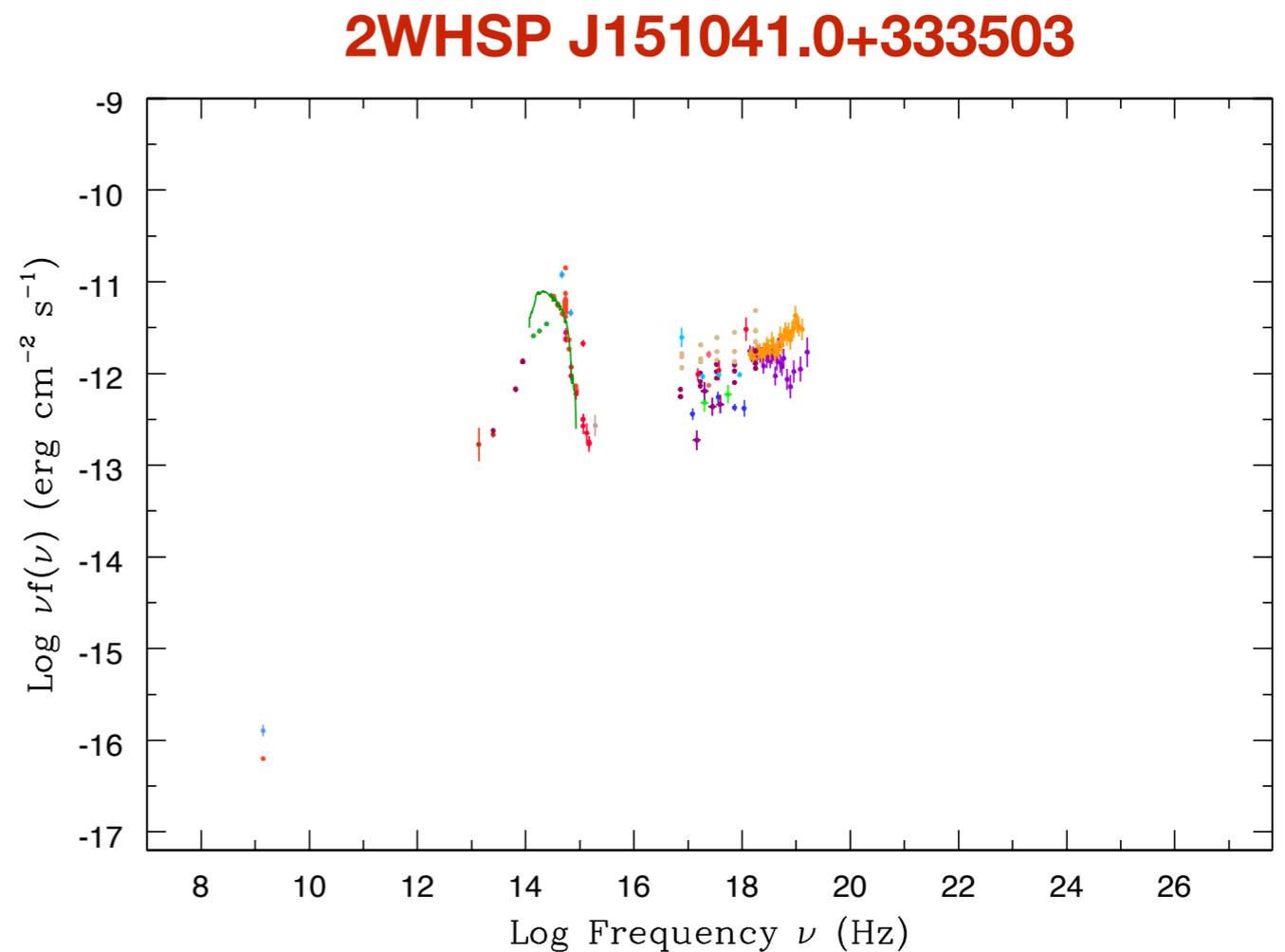


Hammer-Aitoff Equal-Area Projection in Galactic coordinates



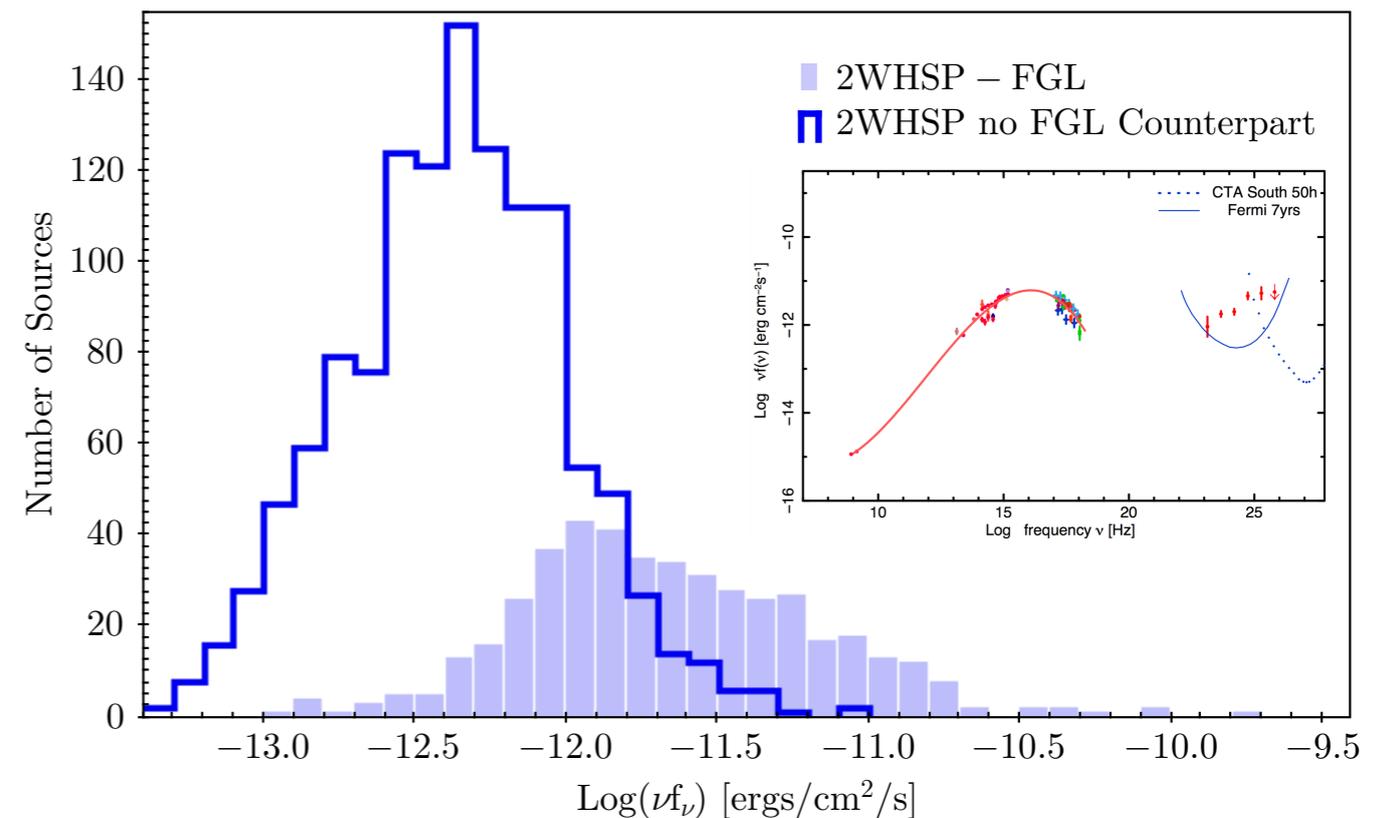
# Motivations

- Samples: Extreme & High Synchrotron Peak Blazars
- 1WHSP < 2WHSP < **3HSP**  
n: 992      1691      **2011**
- Many **bright (Syn)** HSPs with no Gamma-ray counterpart
- Fermi cats: 1-3FGL & 1-3FHL
- Question:  $\gamma$ -Faint, or  $\gamma$ -Quiet?



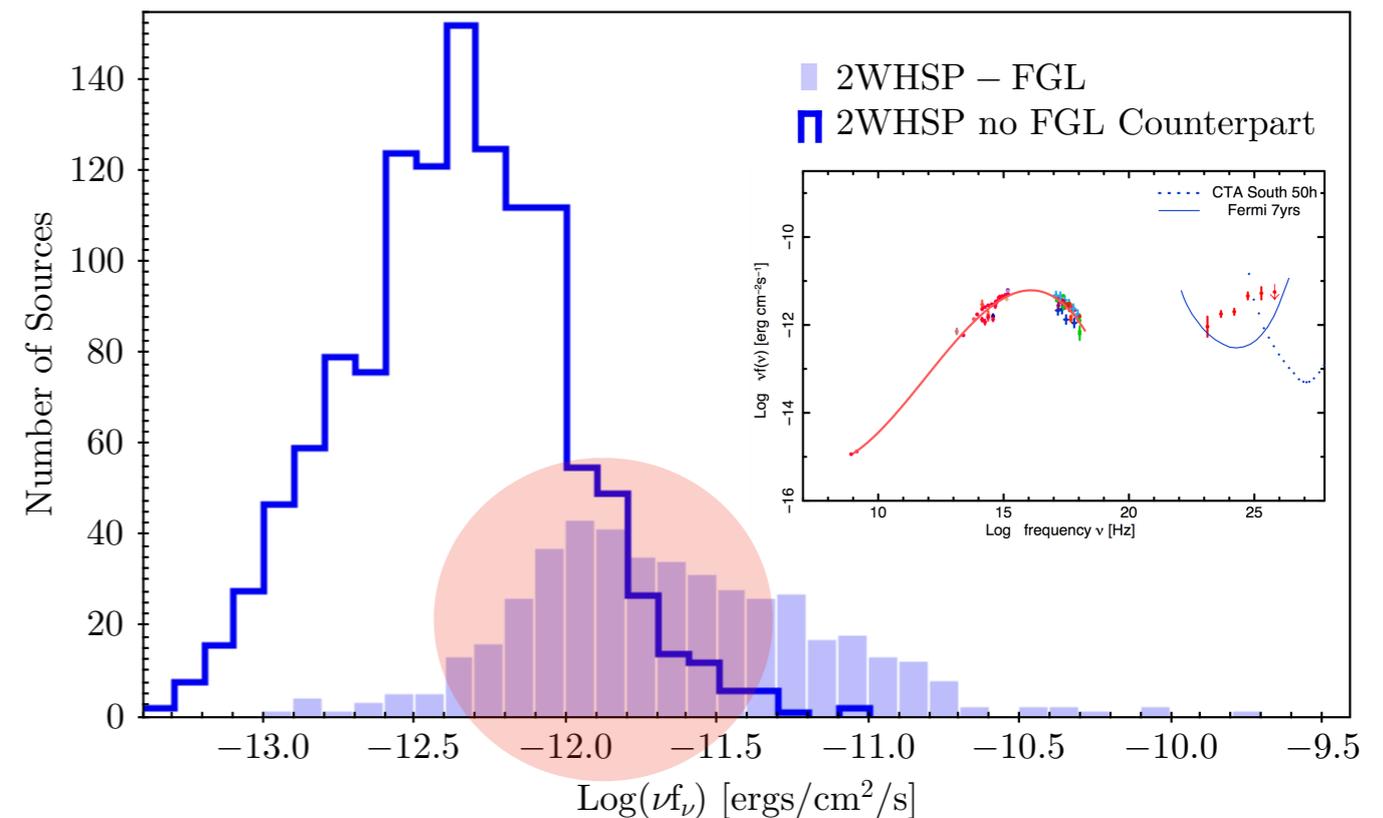
# 2WHSP Synchrotron Peak & Gamma-ray Detection

- **Histograms**  $\text{Log}(n_{\text{fn}})$ -peak
- **Detected vs. Undetected**  $\gamma$
- Bright HSPs: Seen in  $\gamma$ -rays
- **Intermediary region**
- Undetected:  $\text{Log}(n_{\text{fn}}\text{-Syn})$  similar to the detected ones
- **Promising  $\gamma$ -rays candidates?**



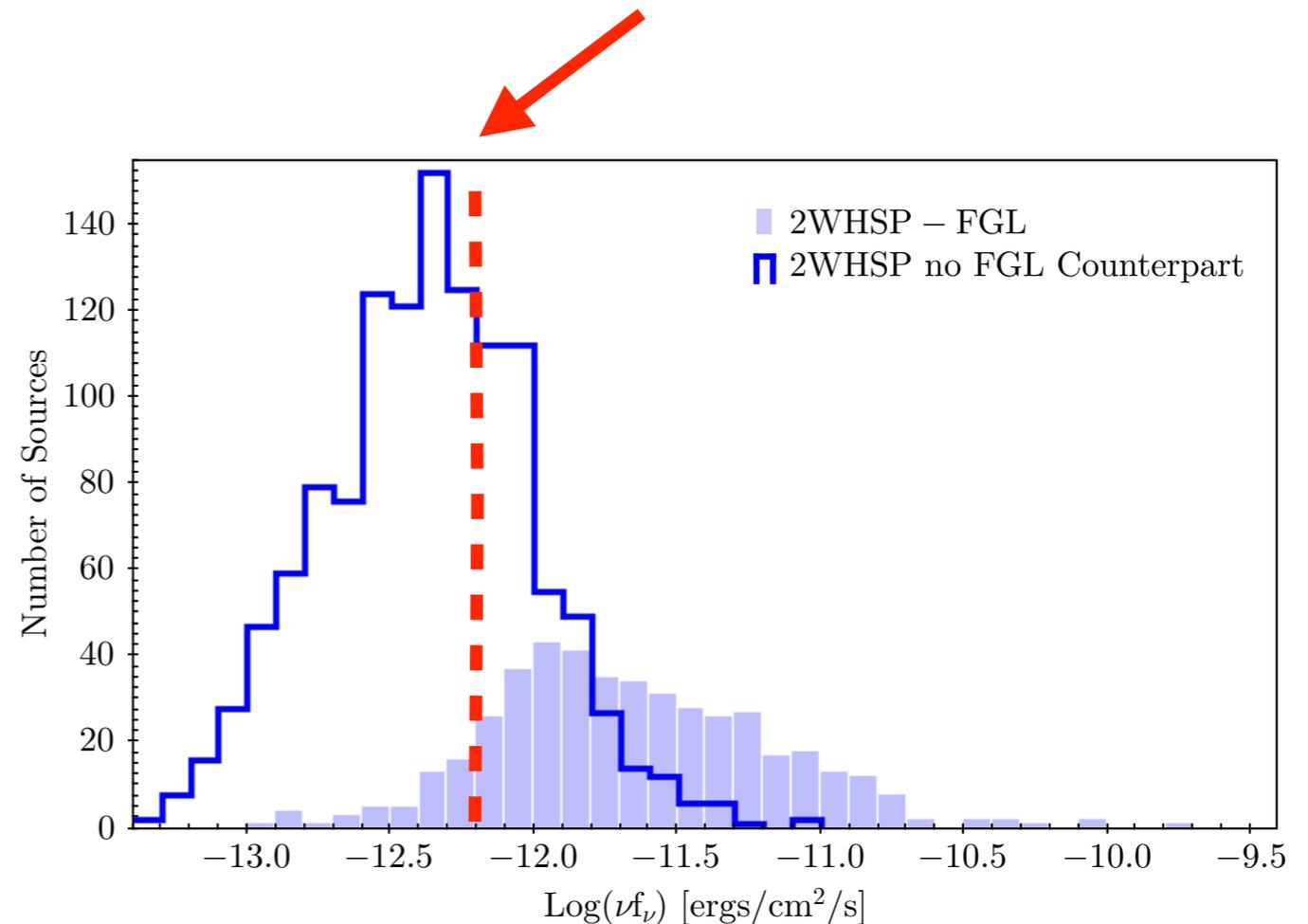
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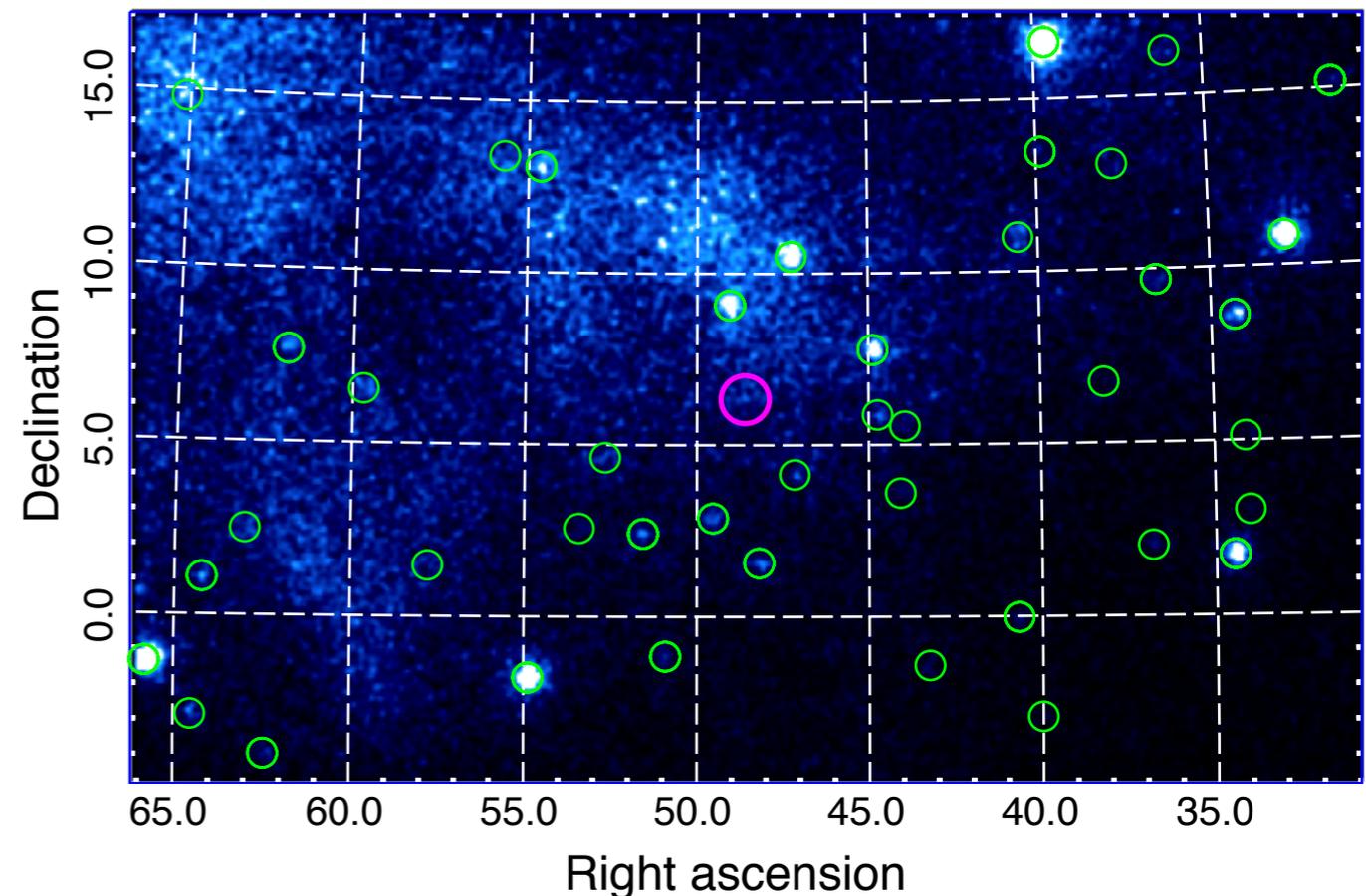
# Multifrequency Data & Seed Selection

- To answer that:
- Evaluation phase: 400  $\gamma$ -rays candidates
- Selection based on  $\text{Log}(n_{\text{fn}}) > -12.2$  ; **flux cut**
- All well localised (Radio)
- Seeds for the  $\gamma$ -ray analysis: from multi-frequency data



# Multifrequency Data & Seed Selection

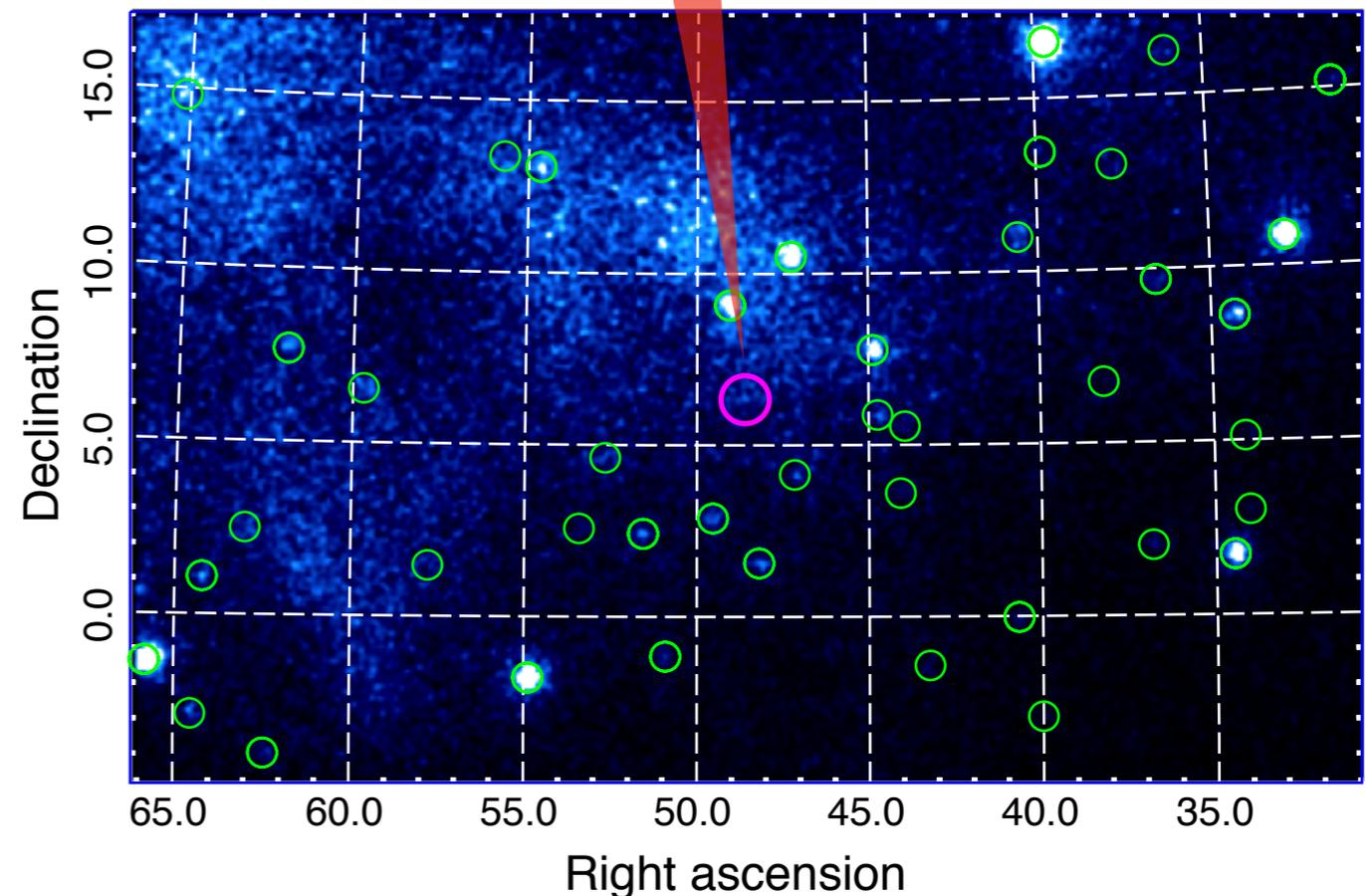
- Seeds: **Multi-frequency** data
- Bring **complementary information** to the analysis
- Main  $\neq$  with respect to the analysis done for FGL & FHL
- FGL & FHL seeds: Clustering Photon Counts
- Only based in  $\gamma$ -ray data



# Multifrequency Data & Seed Selection

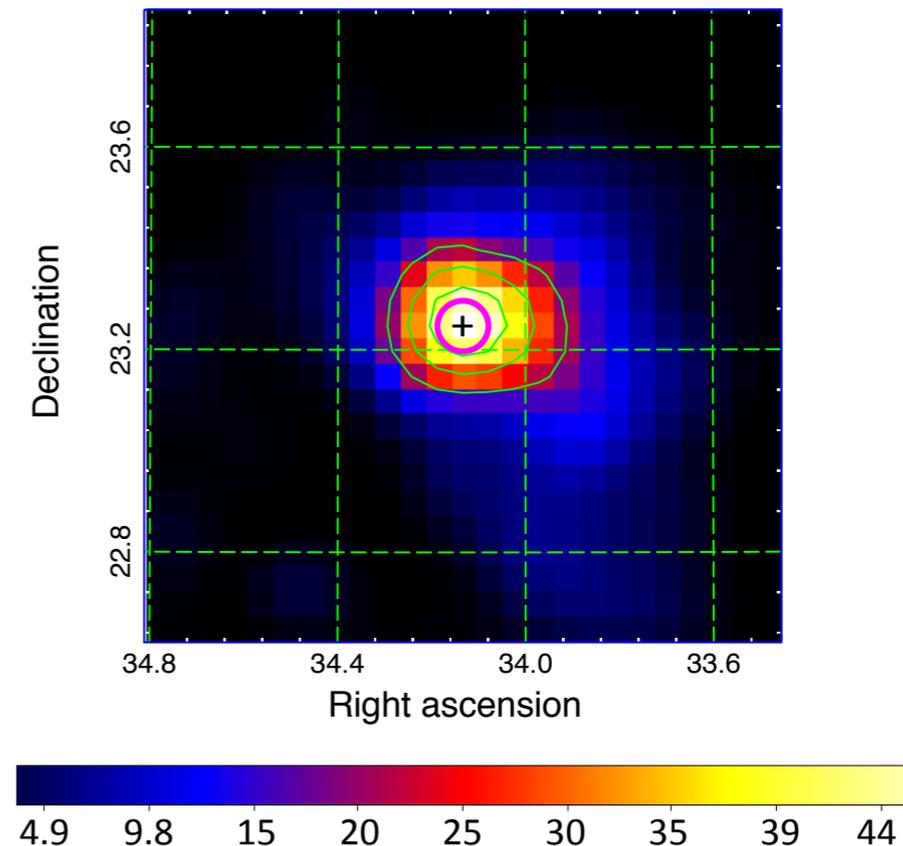
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**HSP Blazar**  
Check for  $\gamma$ -ray signature



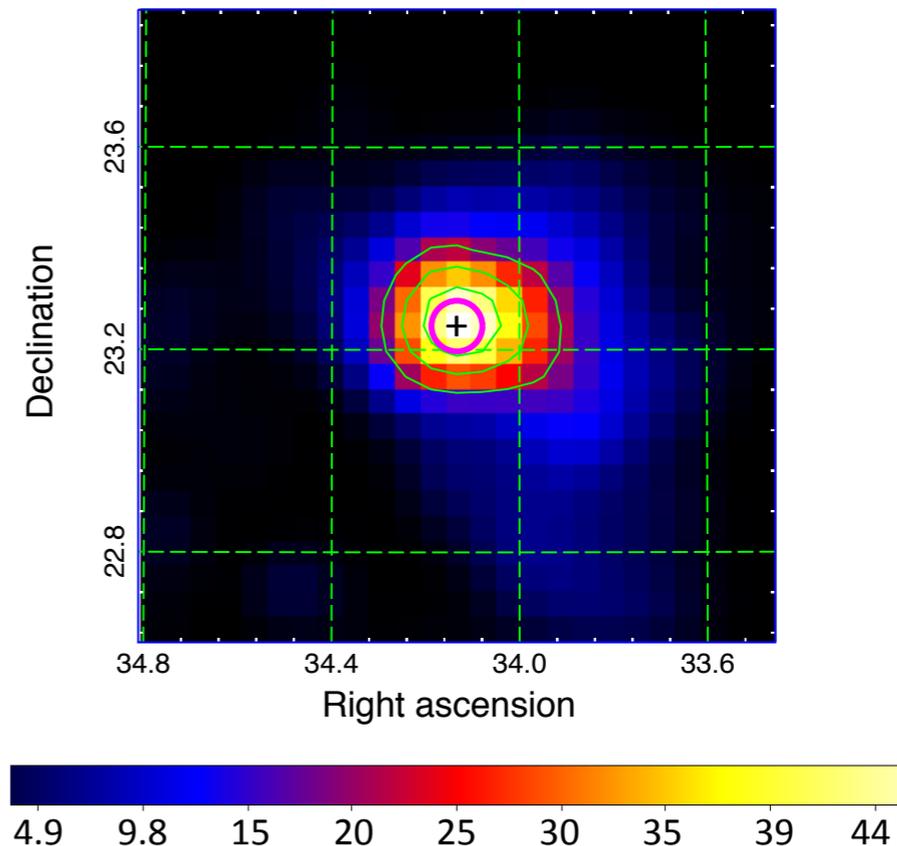
# 1 BIGB Results

- **400 seeds**  $\rightarrow$  400 Likelihood analysis
- **150 new**  $\gamma$ -ray signatures  $> 3$  sigma
- TS map: Source emerge as point-like signature
- 85 high-significance:  $TS > 25$
- 65 low-significance:  $10 < TS < 25$
- Catalog: PowerLaw Model
- Discussion:



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**Astronomy  
&  
Astrophysics**

## Searching for $\gamma$ -ray signature in WHSP blazars

### *Fermi*-LAT detection of 150 excess signal in the 0.3–500 GeV band

B. Arsioli<sup>1,2,3</sup> and Y.-L. Chang<sup>1,2</sup>

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<sup>2</sup> Sapienza Università di Roma, Dipartimento di Fisica, Piazzale Aldo Moro 5, 00185 Roma, Italy

<sup>3</sup> ICRA Net-Rio, CBPF, rua Dr. Xavier Sigaud 150, 22290-180 Rio de Janeiro, Brazil

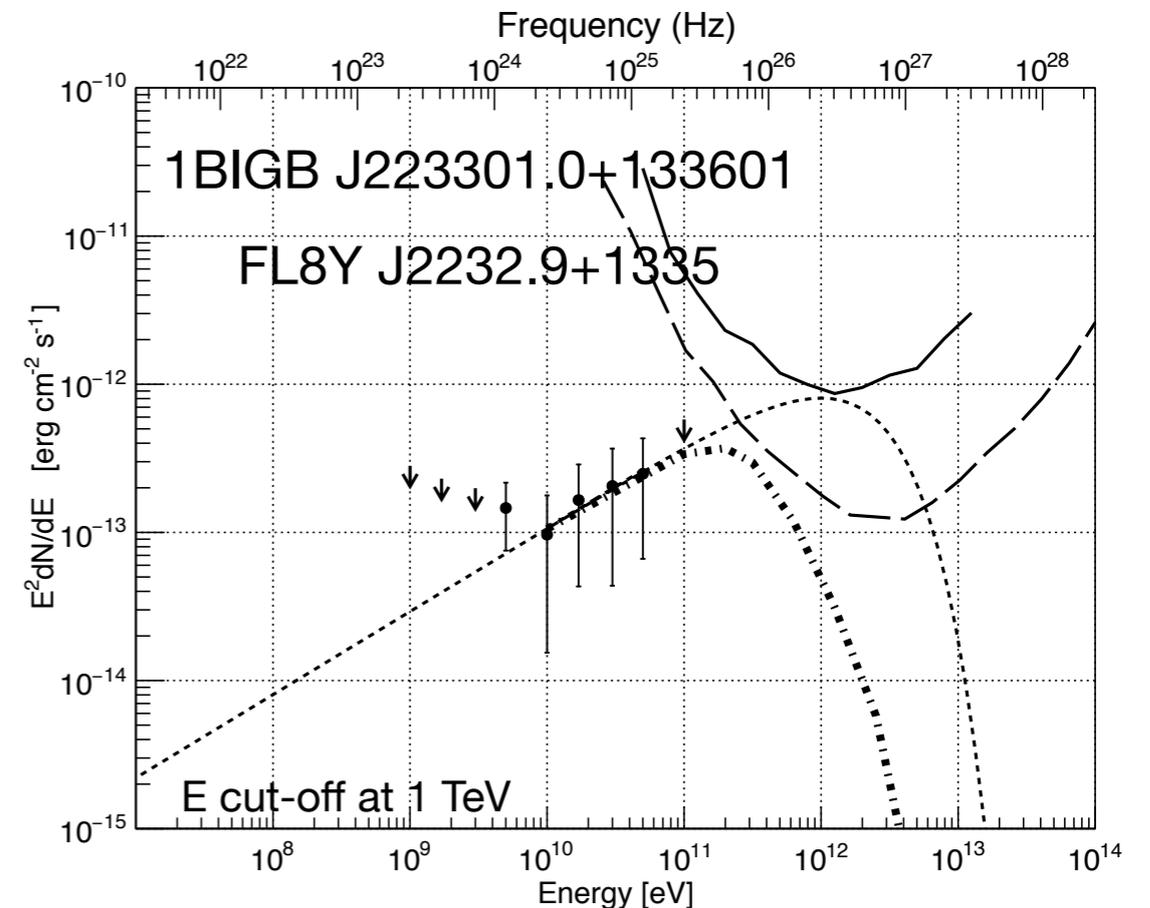
Received 11 April 2016 / Accepted 1 September 2016

#### ABSTRACT

*Aims.* A direct search of  $\gamma$ -ray emission centered on multifrequency selected candidates is a valuable complementary approach to the

# 1 BIGB SEDs

- Algo. to perform SED calculation in large scale
- Cluster resources: Icranet + IFGW Unicamp
- Collaboration with CTA team: **Extrapolation to VHE**
- **SED Data available at BSDC**  
Brazilian Science Data Center



## Extreme & High Synchrotron Peaked Blazars at the limit of Fermi-LAT detectability: the $\gamma$ -ray spectrum of 1BIGB sources

B. Arsioli<sup>1,2,5</sup>★, U. Barres de Almeida<sup>3,5</sup>†, E. Prandini<sup>4</sup>‡, B. Fraga<sup>3,5</sup>, L. Foffano<sup>4</sup>,

<sup>1</sup>Instituto de Física Gleb Wataghin, Universidade Estadual de Campinas (UNICAMP), Rua Sérgio Buarque de Holanda 777, 13083-859 Campinas, Brazil

<sup>2</sup>Science Data Center della Agenzia Spaziale Italiana, SSDC - ASI, Rome, Italy

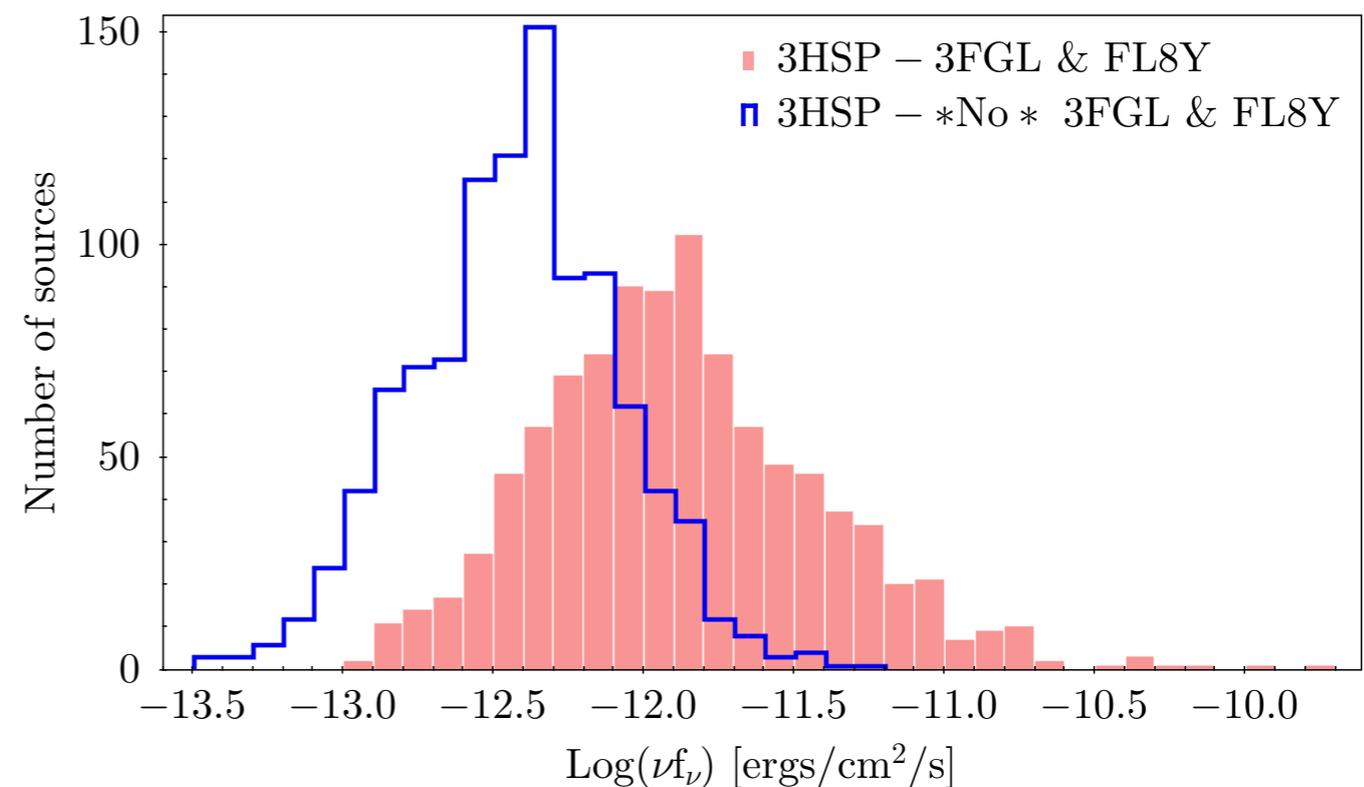
<sup>3</sup>Centro Brasileiro de Pesquisas Físicas (CBPF), Rua Dr. Xavier Sigaud 150, 22290-180 URCA, Rio de Janeiro, Brazil

<sup>4</sup>University of Padova, Department of Physics and Astronomy, and INFN sez. Padova, Italy

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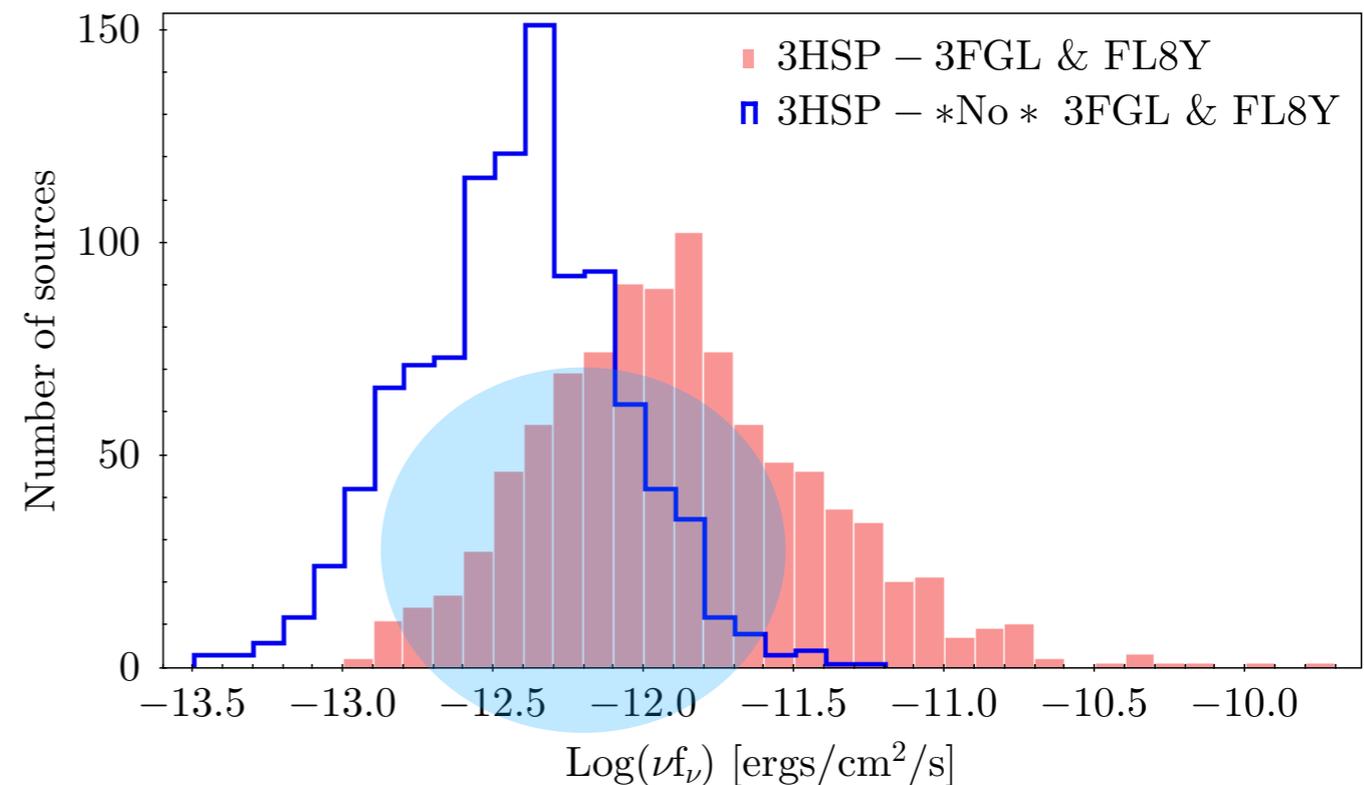
# 3HSP Synchrotron Peak & Gamma-ray Detection

- Preliminary 4FGL = FL8Y
- FL8Y reports TS down to 10 ~5000 sources
- Cross-match 3HSP to 1-3FGL & FL8Y sources
- ~970 3HSP have a  $\gamma$ -ray counterpart
- ~1040 Undetected
- Histograms  $\text{Log}(n_{\text{fn}})$ -peak
- Intermediary region:  
Promising  $\gamma$ -rays candidates!



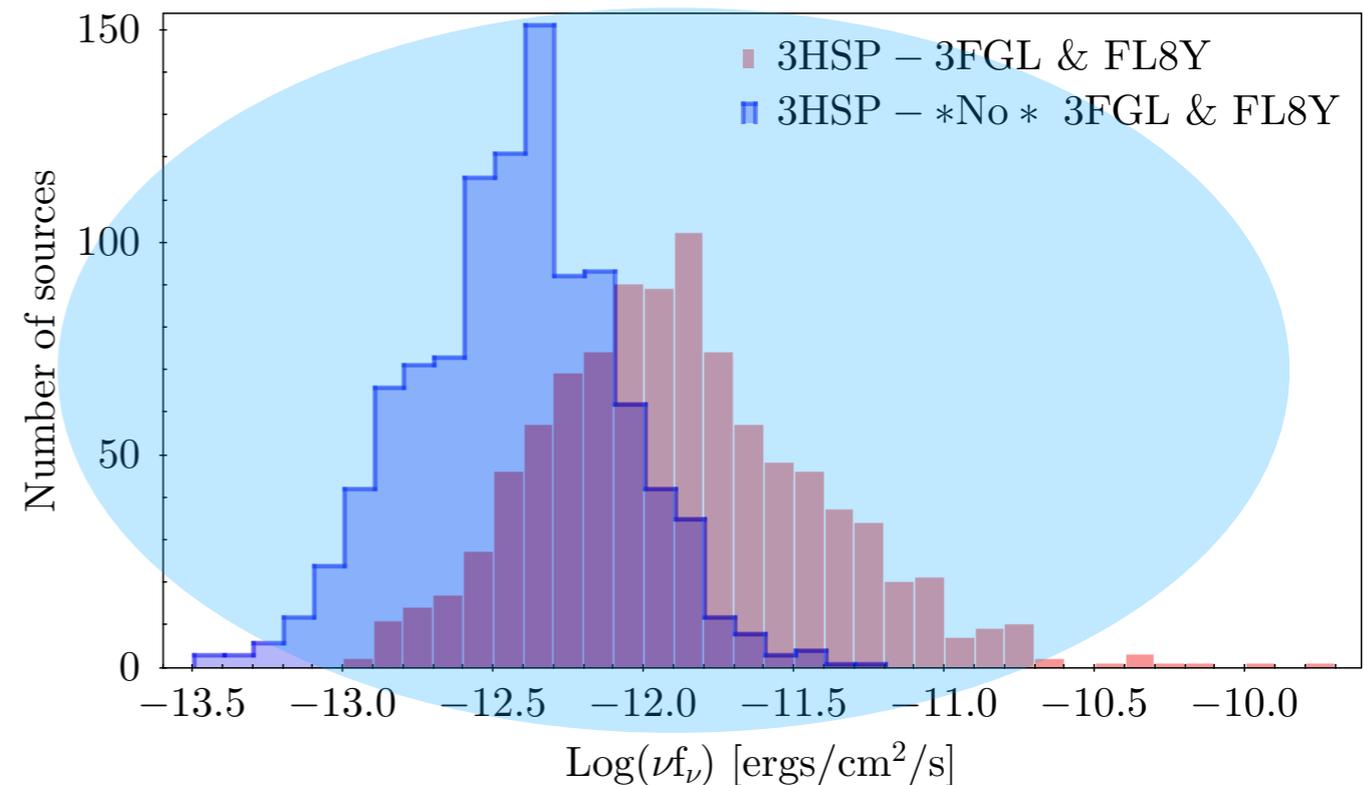
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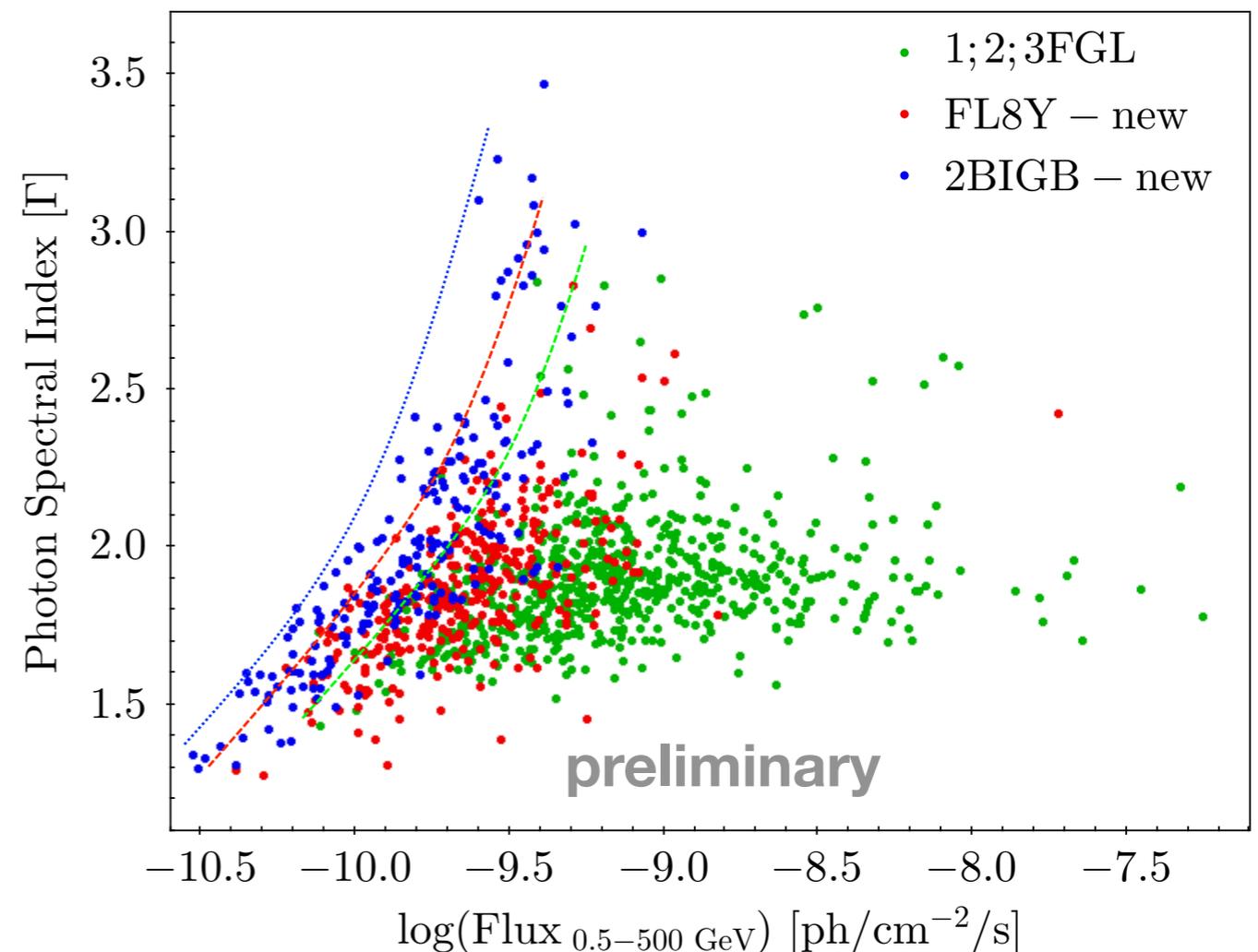
# Multifrequency Data & Seed Selection

- This time: Instead of selecting a 3HSP subsample...
- Work with the entire 3HSP sample - Compare FL8Y
- Integrate over 10yrs Fermi-LAT
- E range: 500 MeV - 500 GeV  
Improved PSF
- Improve Computation Time
- Prevent Spurious detection driven by diffuse background



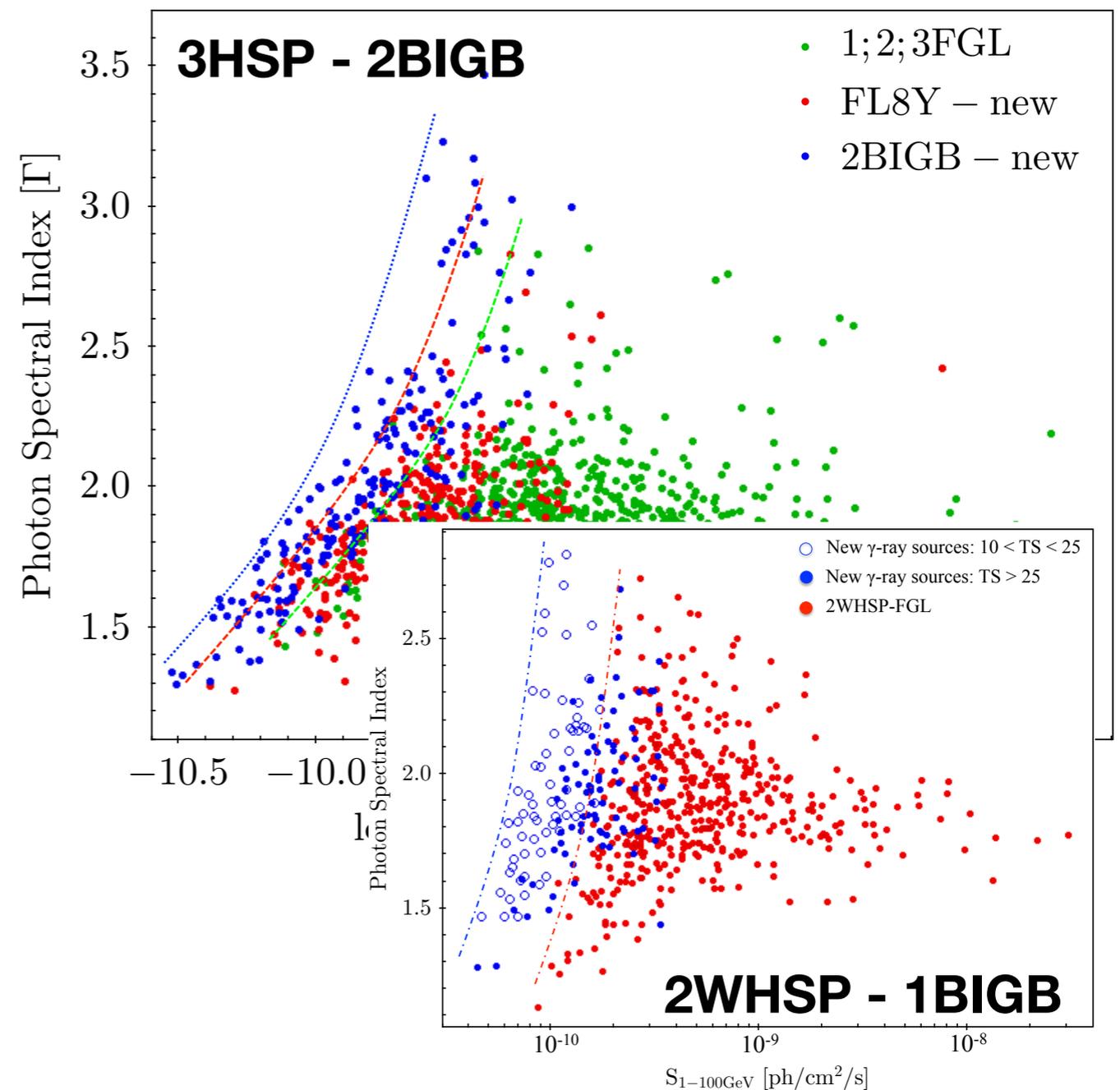
# 2BIGB: Preliminary Results

- Capture cases with 1-3FGL & FL8Y counterparts, ~970
- **Extra ~200 new signature with respect to FL8Y (+20%)**
- Extra detection due to improved sensitivity but... not only that
- Intersection Region:
- Multi-frequency as complementary method
- Improve the efficiency of detection close to Fermi-LAT sensitivity limit



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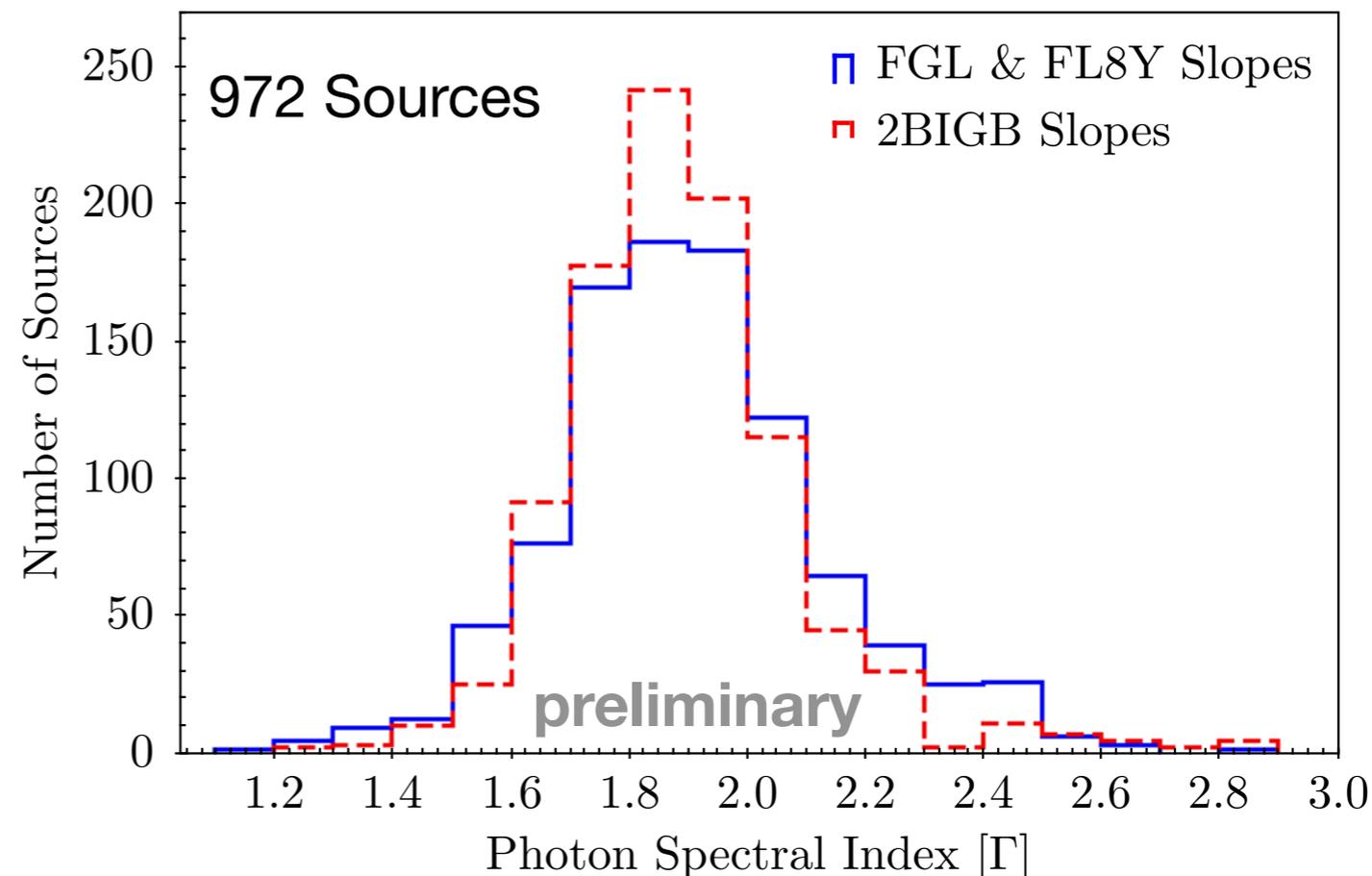
# Power law model & fitting strategy

- Fit to  $N_0$  and  $\Gamma$
- **Scan over pivot Energy:  
1 - 3 - 5 - 10 GeV**
- $N_0$  (pre-factor) is the diff-flux calculated at  $E_0$
- Minimise the error associated to fitting  $N_0$  and  $\Gamma$
- Improvement (1BIGB->2BIGB)

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

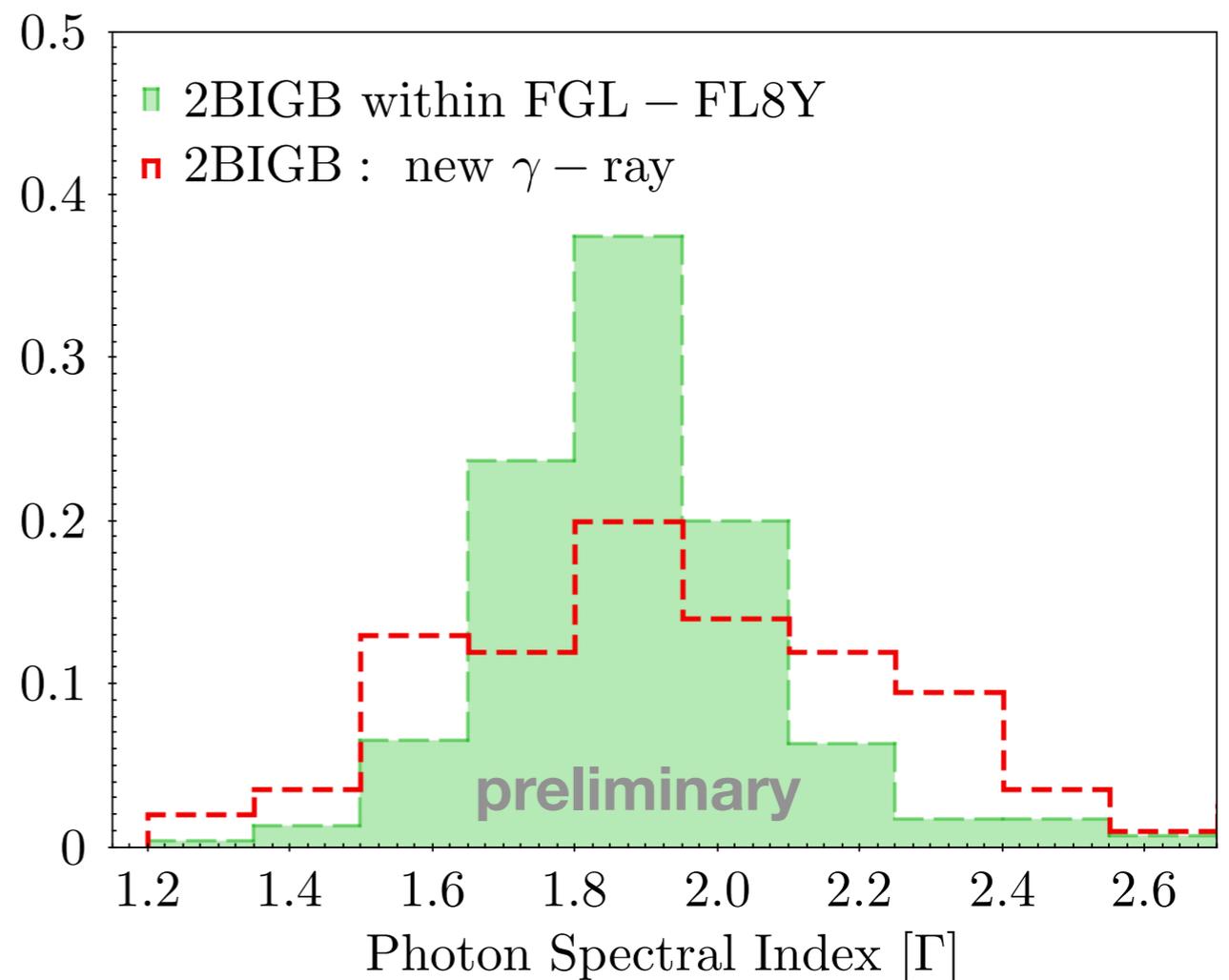
# Comparing 2BIGB & FL8Y Photon Spectral Index

- 972 **2BIGB** with counterpart in 1-3FGL & FL8Y
- Mean Values  $\langle \Gamma \rangle$   
FL8Y :  $1.90 \pm 0.01$   
2BIGB :  $1.89 \pm 0.01$
- Similar as for 2WHSP-FGL sample:  $\langle \Gamma \rangle = 1.93$
- Preliminary: FGL + FL8Y



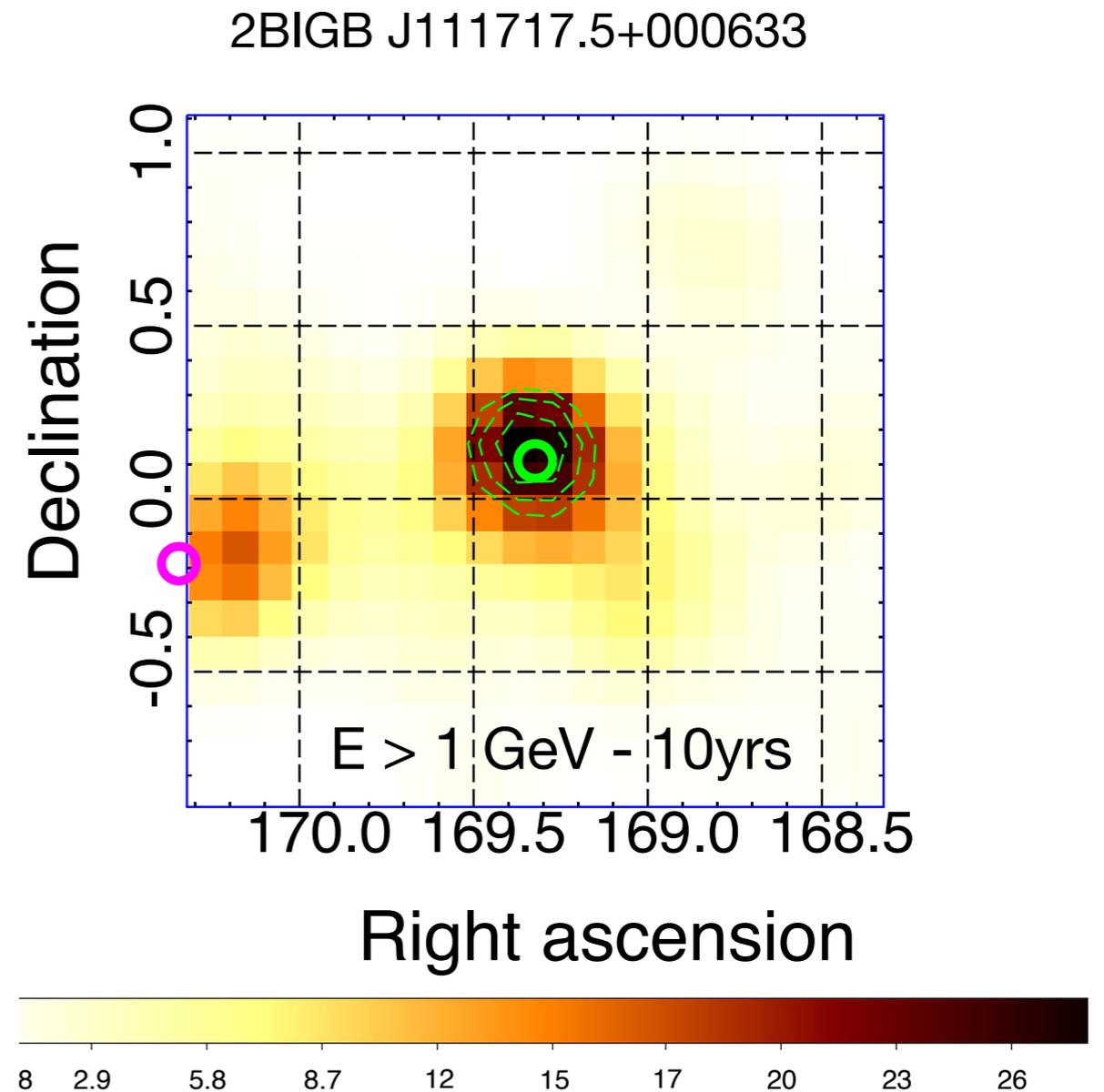
# Distribution of Photon Spectral Index

- Mean  $\sim 1.9 - 2.0$
- Similar as for 2WHSP-FGL sample:  $\langle \Gamma \rangle = 1.93$
- Preliminary: Still Cleaning
- Check all new-detection via TS maps



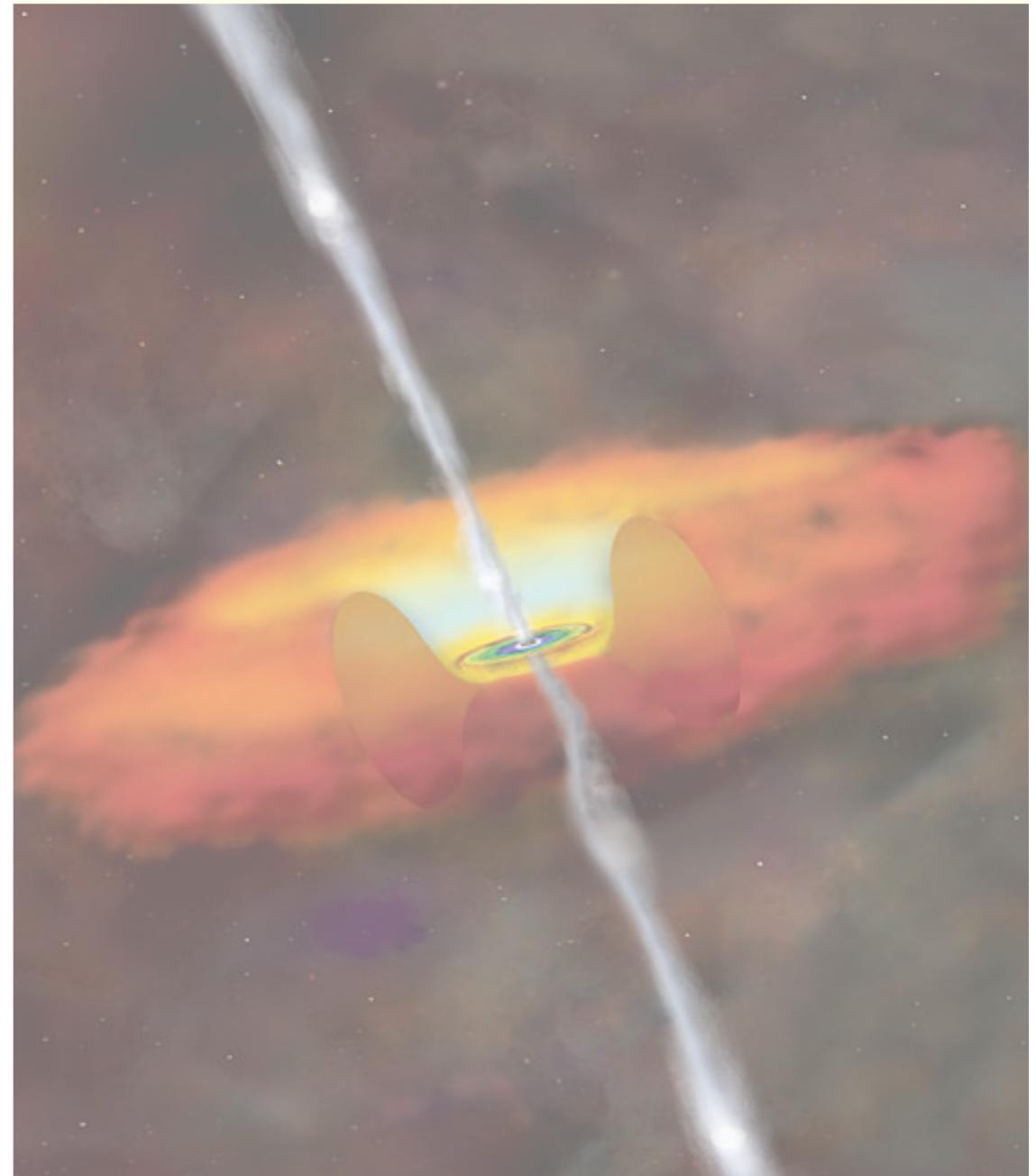
# Ongoing...

- Validation of all new 2BIGB gamma-ray sources
- Inspect via TS maps
- Very Time Consuming: but...  
1/2 already done!
- Build their  $\gamma$ -rays SED



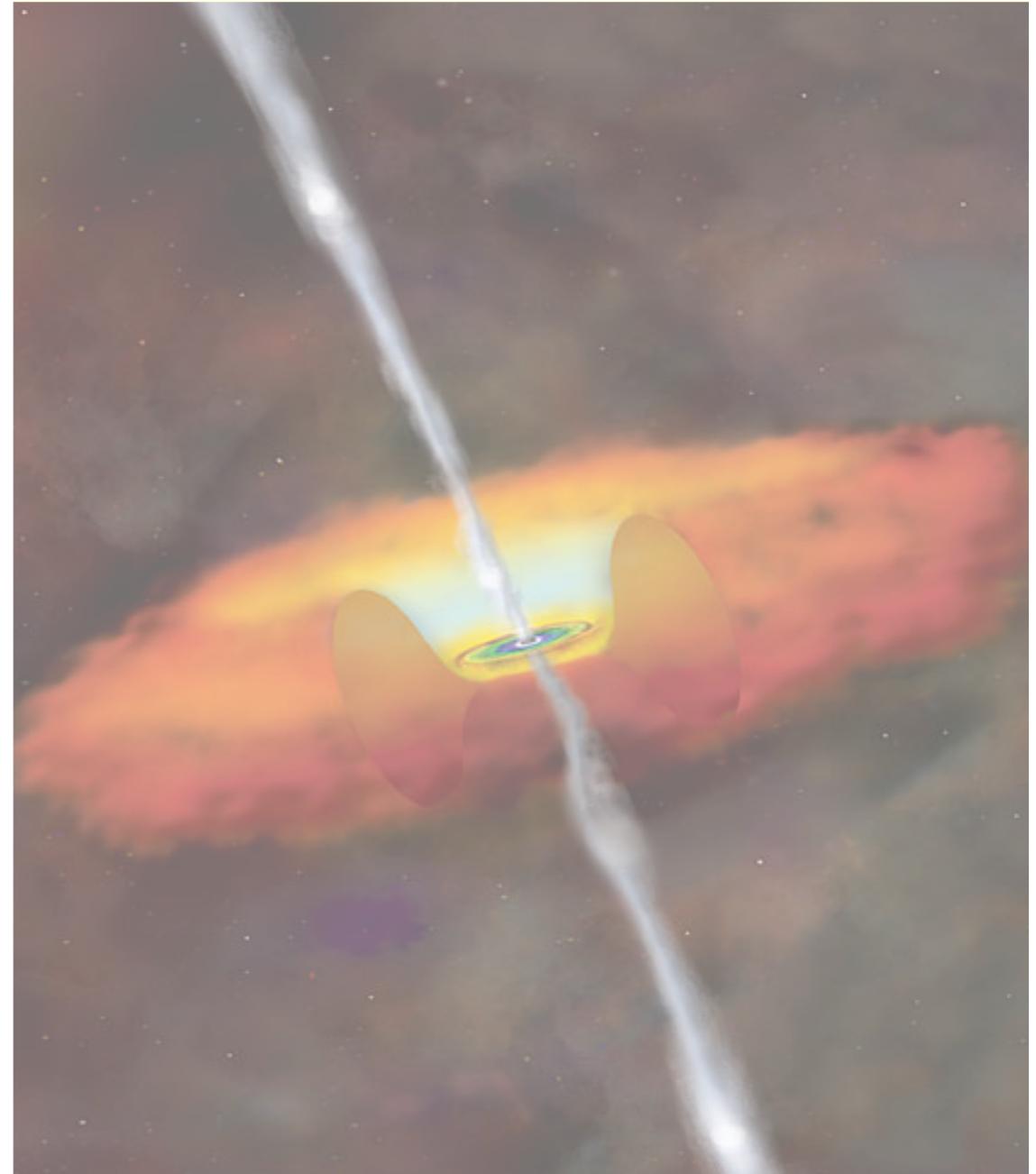
# Message

- **Multi-frequency data do unveil new gamma-ray source - Complementary**
- Fermi-LAT database is a great scientific achievement
- Initial phase: Seeds from Gamma-ray data only
- Important to prevent spurious association
- Currently: Good Understanding on the main pop. of  $\gamma$ -rays emitters
- Out of disk: Use AGN multi-frequency info to select seeds for Likelihood Analysis with Fermi-LAT



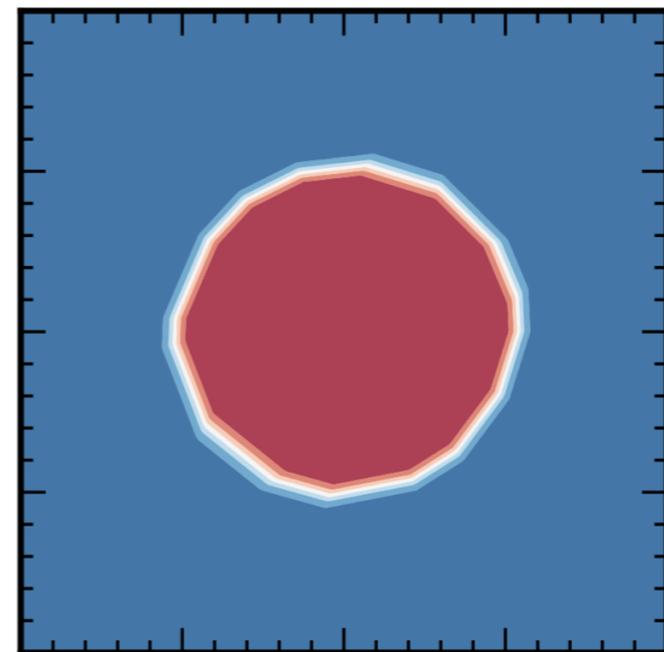
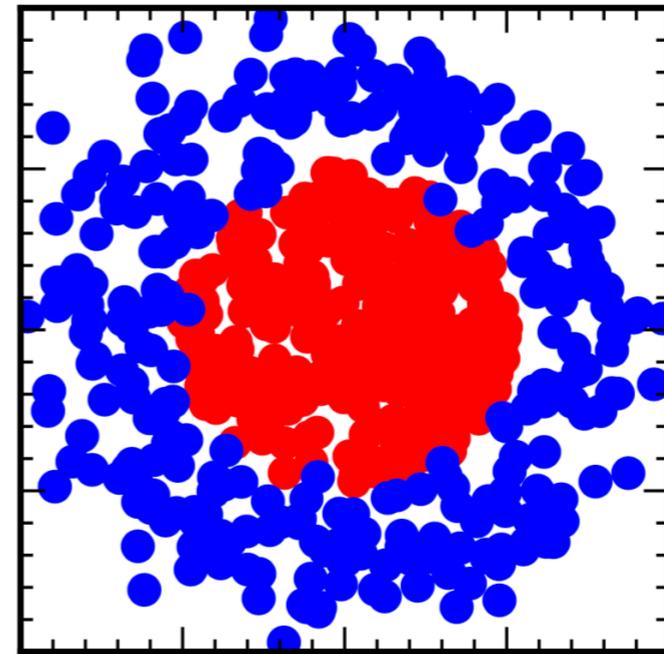
# Perspectives

- Validation of all new sources (out of FL8Y)
- SED extrapolation to highest energies:
- **Focus on 2BIGB-new**
- \*Collaboration with CTA Team\*



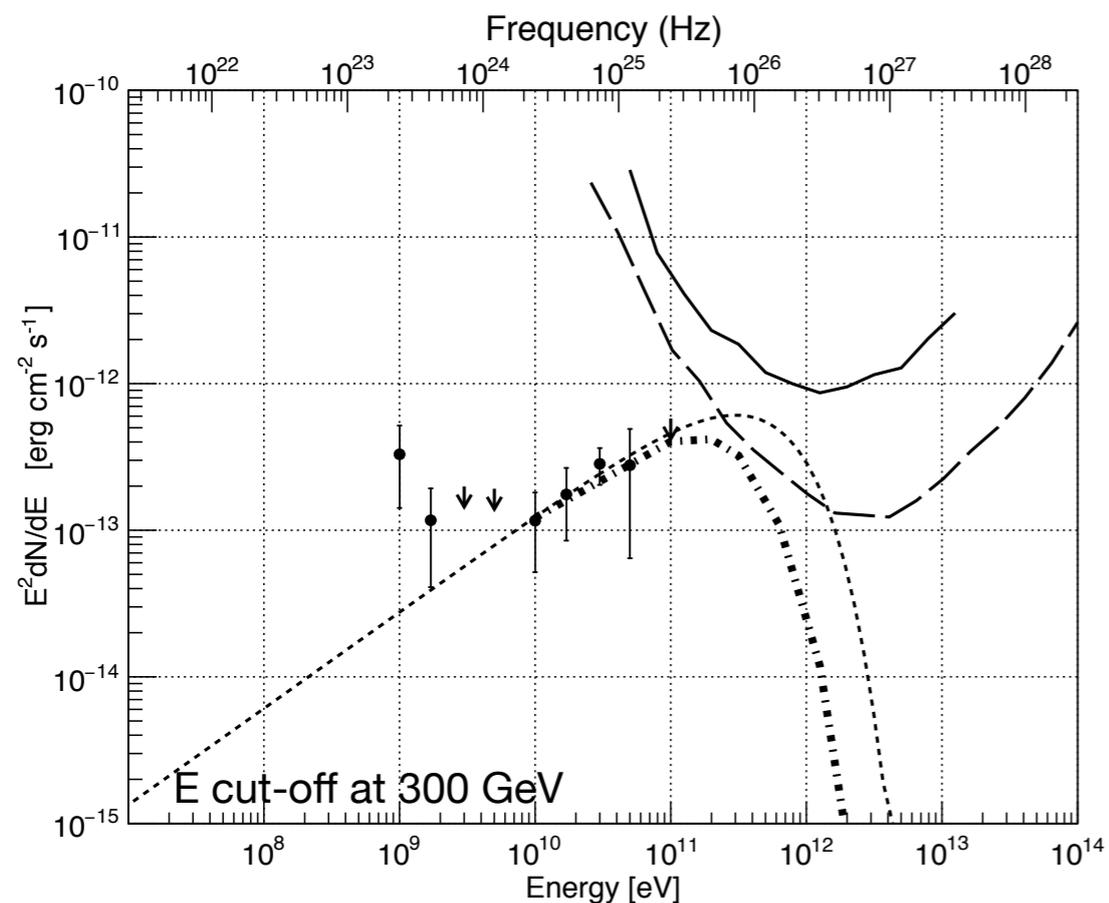
# Perspectives

- Apply Machine Learning Techniques
- Train CNN to detect faint point-like sources
- Train sample: Scramble Source Data + Counts from gtsrcmap
- Distinguish Signal/Background based on counts-density
- Plugin Multi-Frequency Info within Clustering-Structure



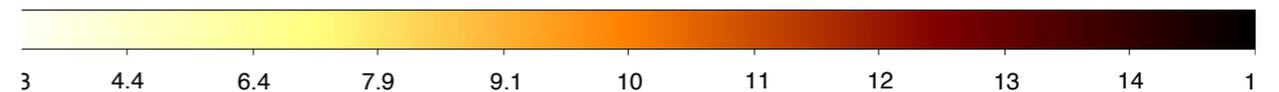
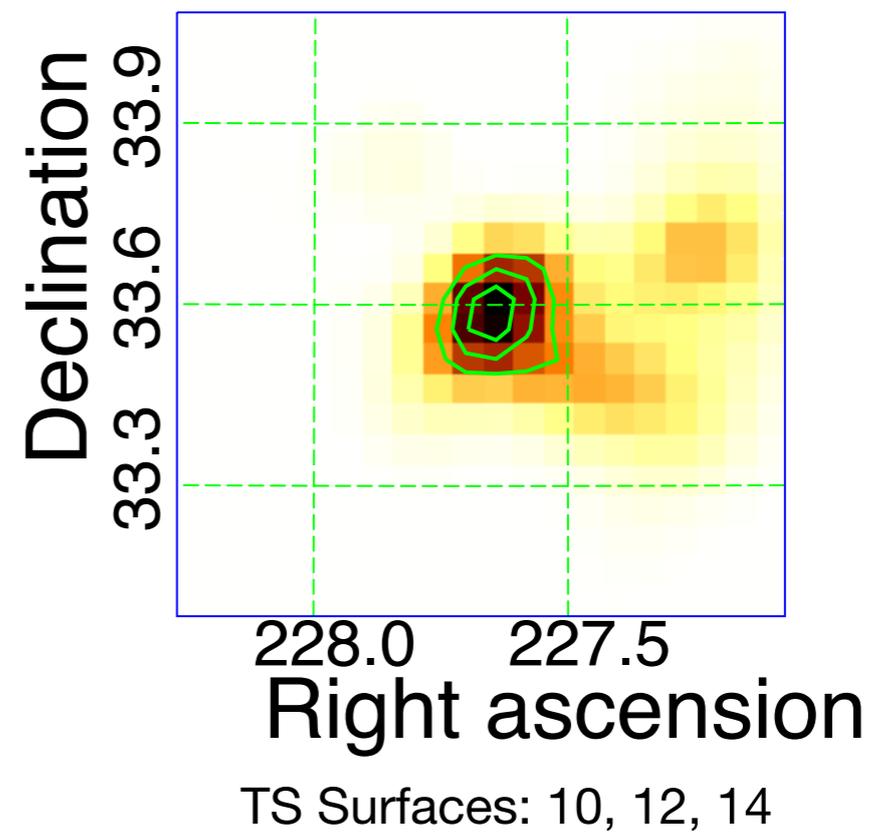
# Example: 1-2BIGB source

**1BIGB J151041.0+333503**  
**\*Out of 1-3FGL & FL8Y\***



**2BIGB - Detected & Confirmed via TS maps**

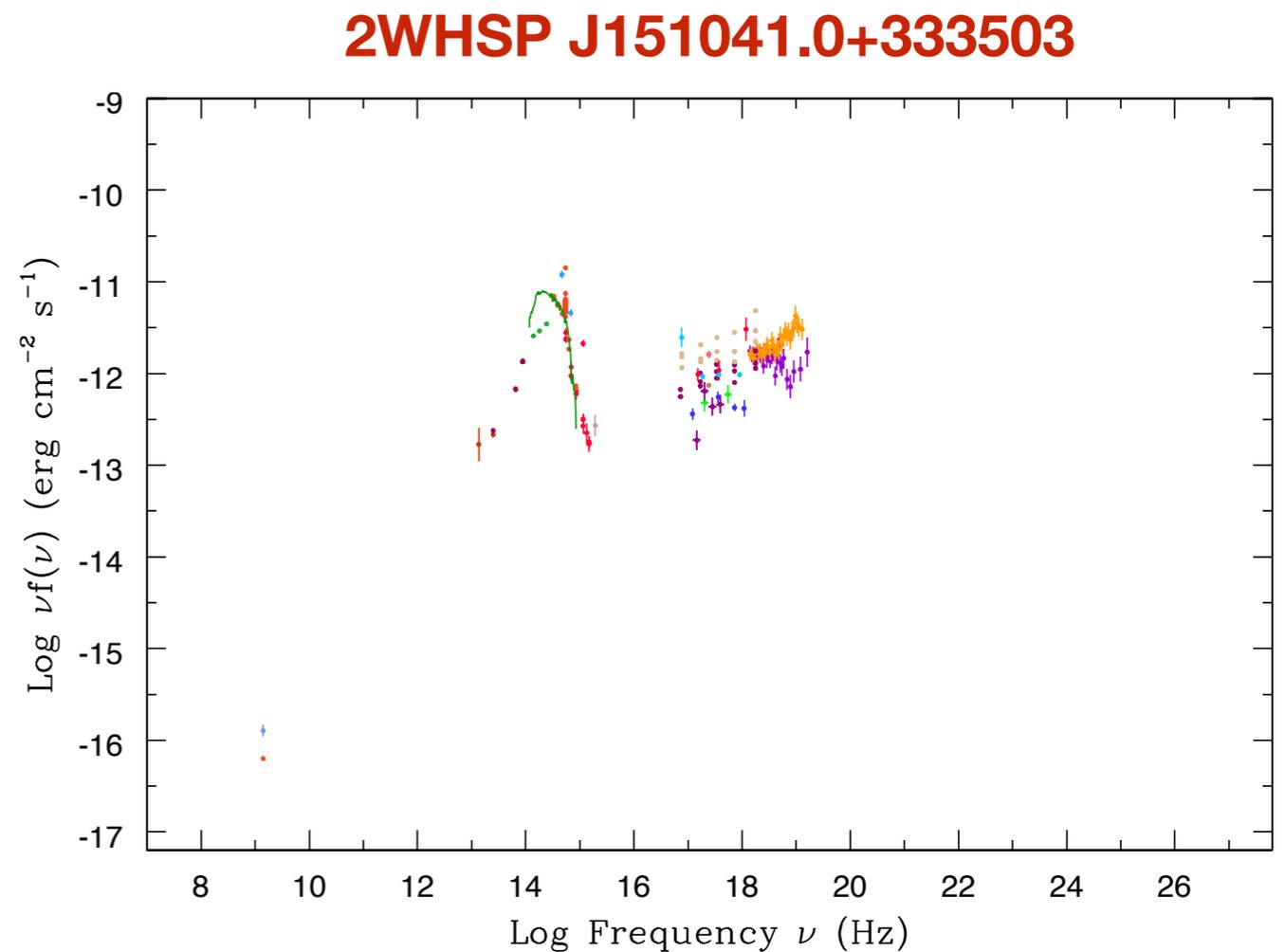
E > 2.5 GeV - 10yrs



# Motivations

## Recap. From 1<sup>st</sup> Slides

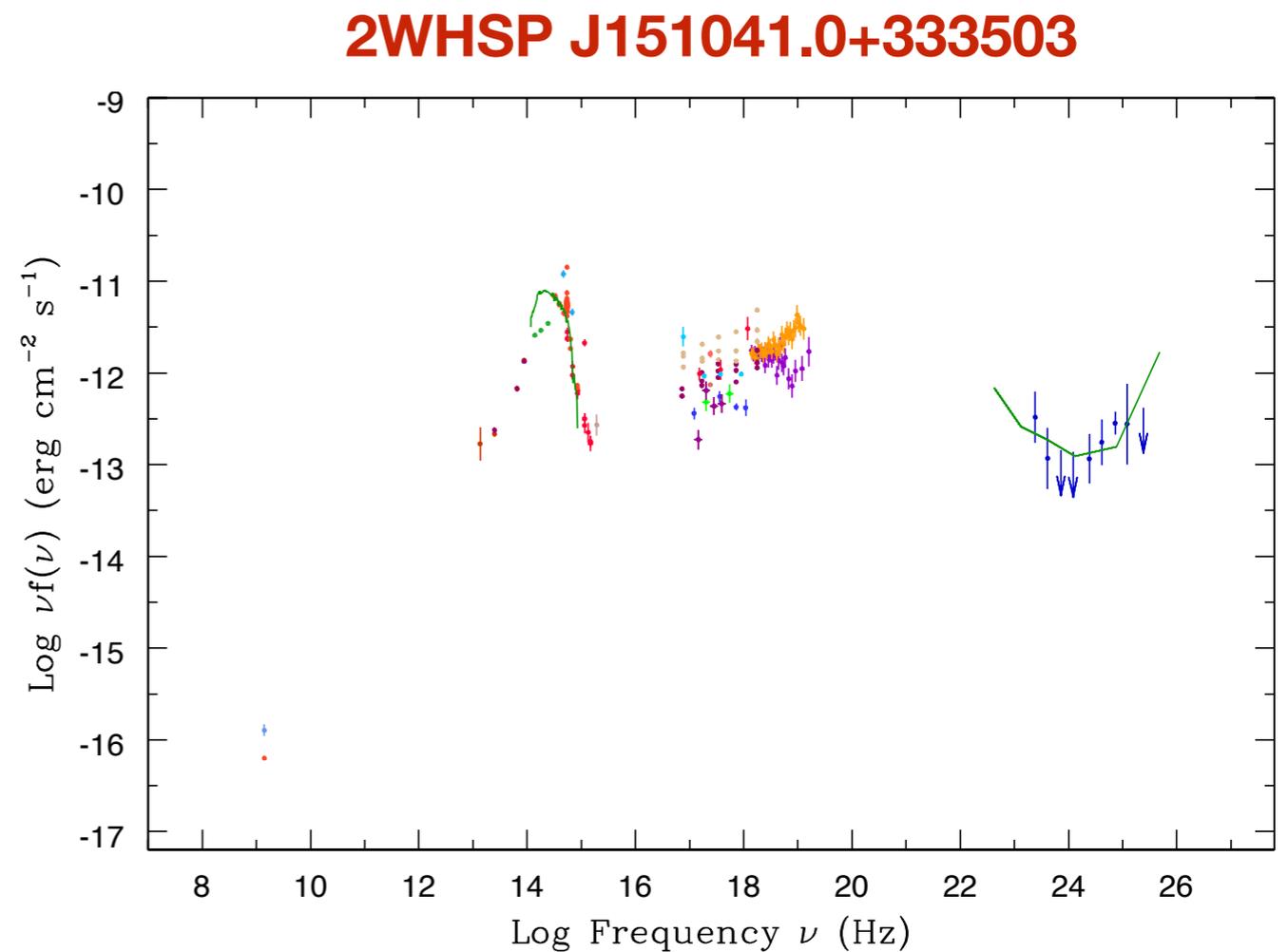
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# Thank you!

[bruno.arsioli@ifi.unicamp.br](mailto:bruno.arsioli@ifi.unicamp.br)



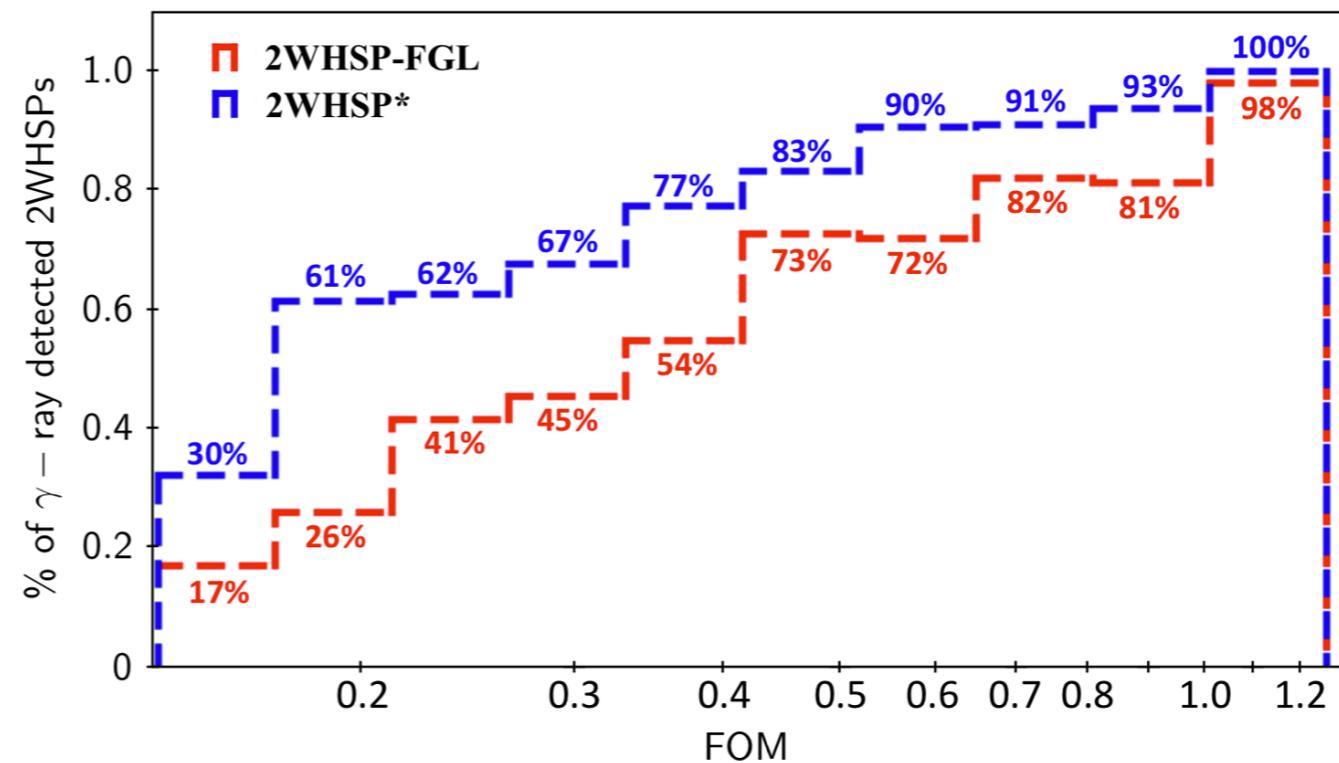
**IFGW**  
Instituto de Física Gleb Wataghin



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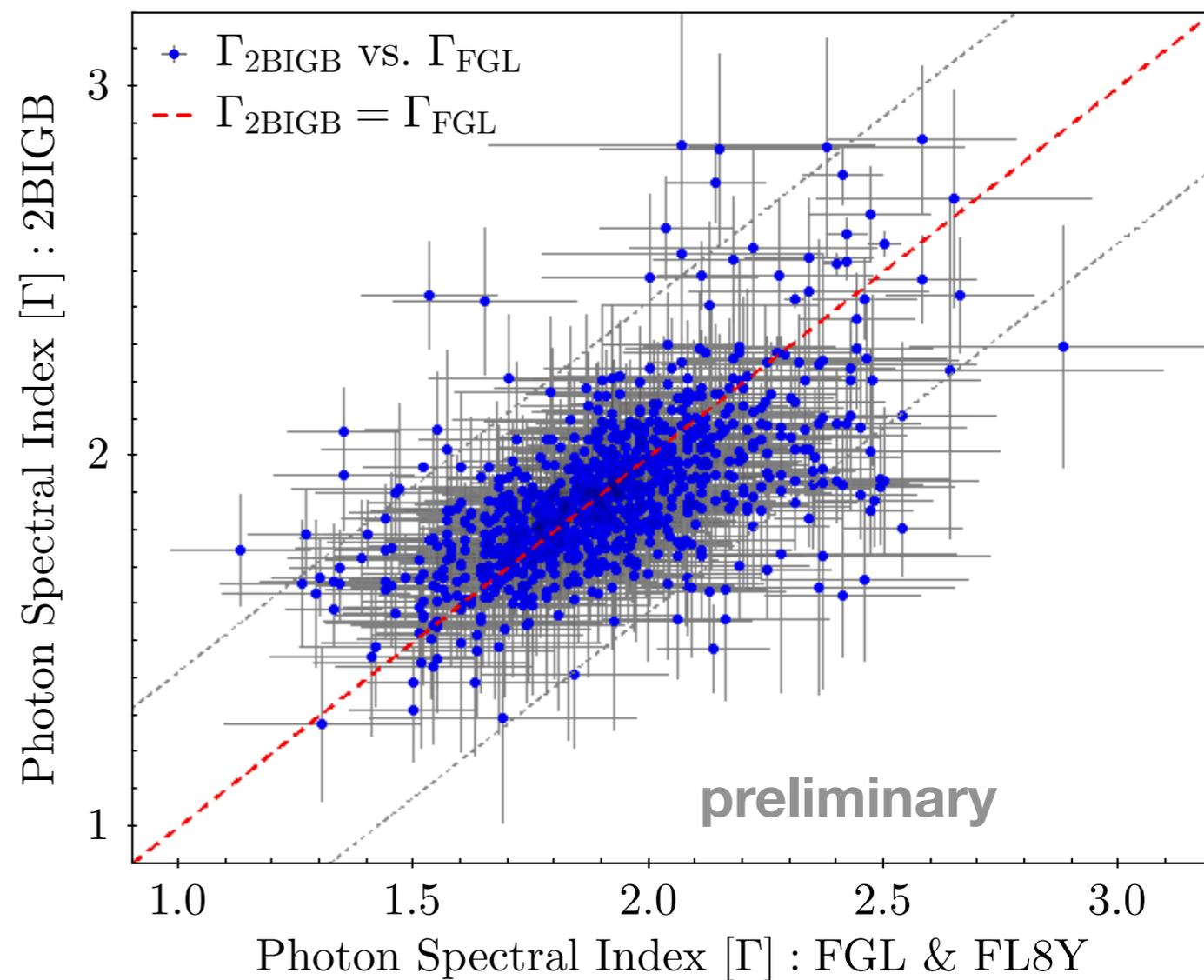
# Why to work on the entire 3HSP sample

- Efficiency of Gamma-Gamma-Ray detection decrease with  $\text{Log}(n_{\text{fn}})$
- Still, a complete analysis can review interesting sources
- Computation Time suffers 2x to 3x effect
- Doable in reasonable time



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- Similar as for 2WHSP-FGL sample:  $\langle \Gamma \rangle = 1.93$
- Preliminary:  
Mix 1-3FGL & FL8Y  
Use only FL8Y, or 4FGL.



# Value of a Multifrequency Approach

- Detection of TXS 0506+056
- High Energy astrophysical Neutrino Source
- How long would it take for an "IceCube-solo" detection?
- Clear example: multi-frequency approach as a powerful tool
- Optimize the discovery potential of current databases

