

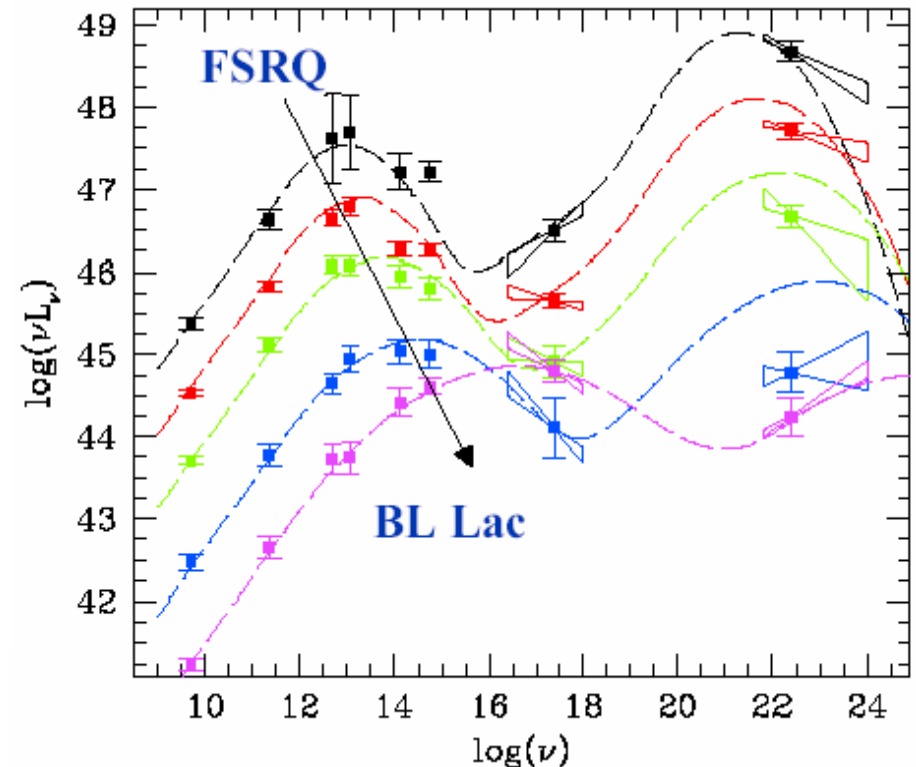
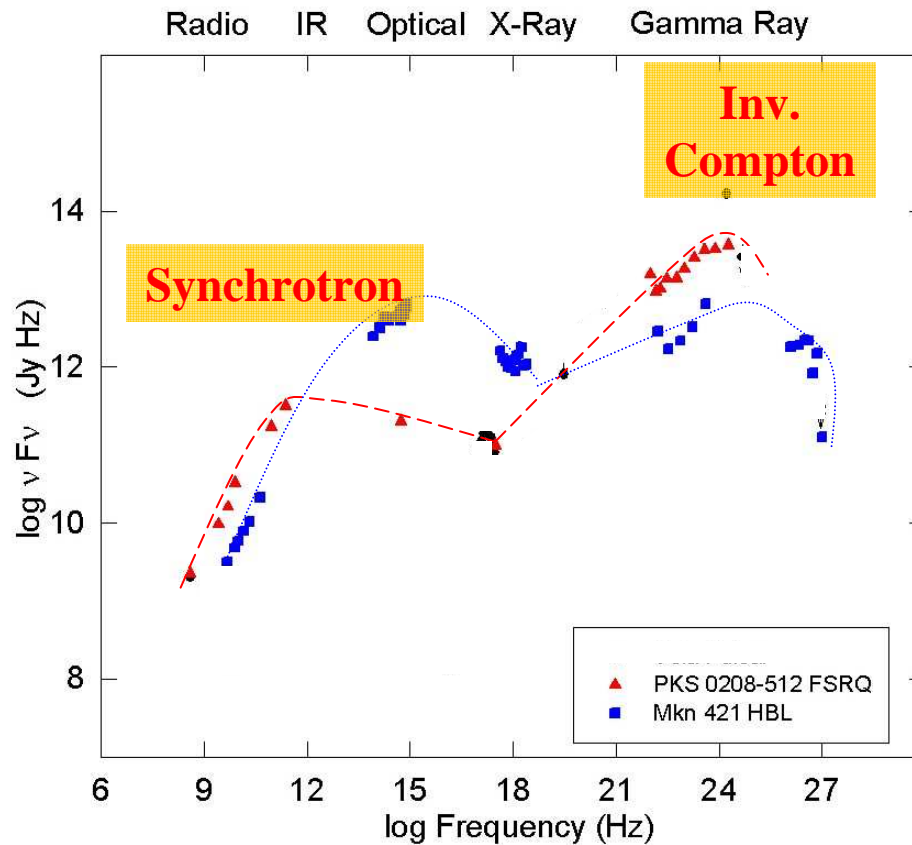


# Getting IDs for the GLAST Catalog: Blazar FoM analysis

w/ Greenhill, Michelson, Readhead, Sadler, Taylor, Ulvestad,  
**D. Sowards-Emmerd, S.E. Healey, etc.**

- **Looking Under the Lamppost**
  - **The bright 3EG blazars share common characteristics**
    - **Radio Bright FSRQ and BL Lacs**
  - **These are a dominant sky population**
    - **With 3EG ~35% of  $|b| > 10^\circ$  sources IDed, now  $> 70\%$  IDed**
  - **These sources will be important for some key multi- $\nu$  GLAST physics**
    - **E.g. want correlated observations for jet physics, EBL studies**
- **We need to quickly ID the EGRET-like blazars all-sky**
  - **Want to be uniform, at least at high  $|b|$** 
    - **Improve prospects for IDing new populations (esp. high  $|b|$  Galactic)**
    - **Improve understanding of background**
  - **Need to be *quantitative* (controlled selection fn)**
  - **Need to be *deep* ( $\sim 100$  blazars  $\rightarrow > 5,000$  blazars)**

# Blazar SEDs -- Blazar sequence



**FSRQ -- 'Red' Blazar**

**Flat optical, Faint IC X-ray, High z**

**{LBL – intermediate**

**Low peak BL Lac}**

**HBL -- 'Blue' Blazar**

**Blue Optical (BL Lac spectrum)**

**Bright Syn X-ray, Low z**

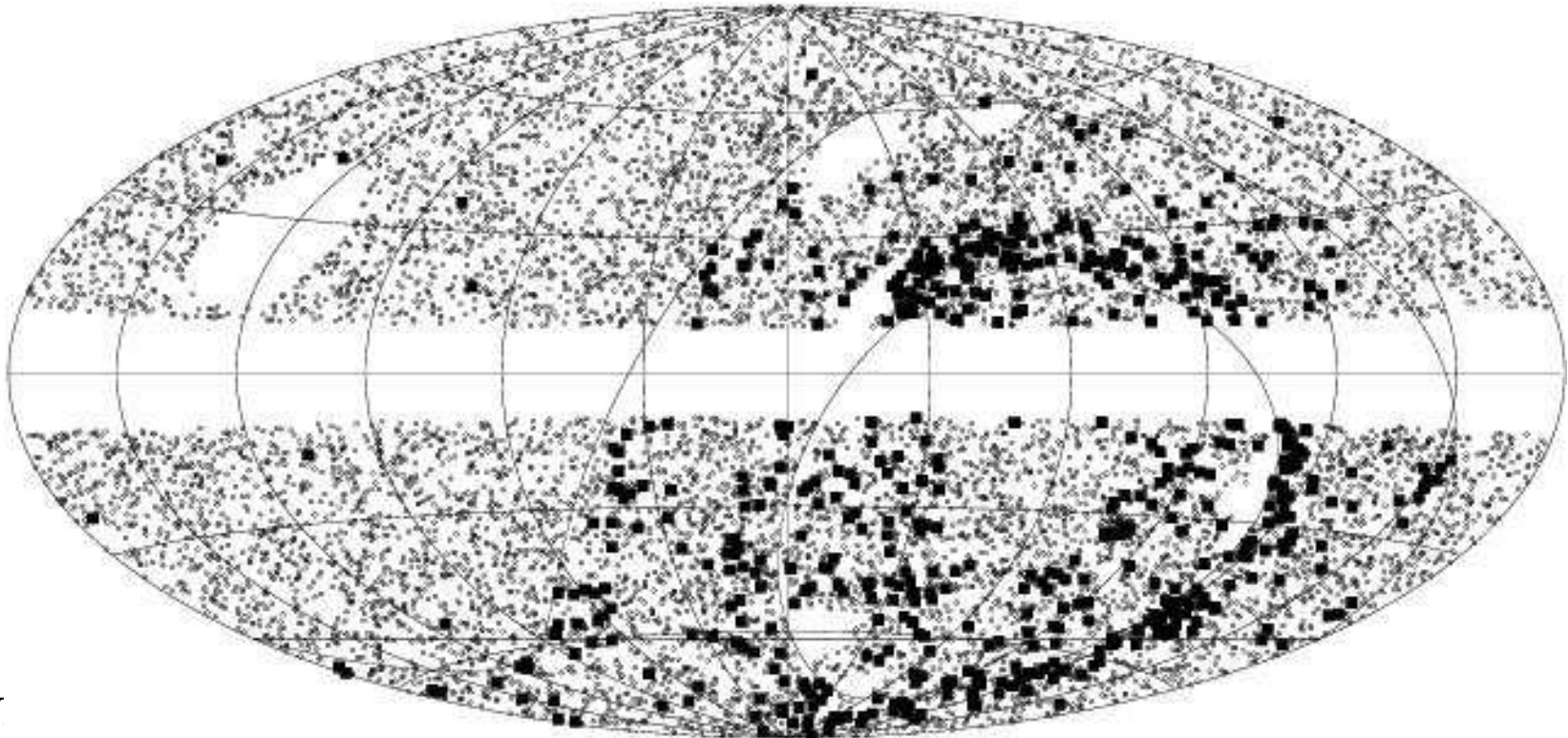
**N.B. – Some of this trend may be selection effects.**

# IDing Blazars

- We will call a  $\gamma$ -ray blazar IDed when
  - We get a high probability association with a counterpart blazar-like SED. Minimum is a compact flat radio spectrum extending to  $\sim 10\text{GHz}$ .
    - Optional optical, X-ray fluxes and spectral indices
  - AND we need an optical spectrum with a redshift (FSRQ, RG, etc.) or clear BL Lac spectrum
- To *quantify* high probability we need flux limited, all sky surveys – GB6/PMN, 2MASS, POSS, RASS
  - 3EG experience: all accepted counterparts are radio loud ( $> 0.5\text{Jy}$  in 3EG, down to  $\sim 100\text{mJy}$  w. DSE et al) & flat spectrum ( $\alpha > 0.5$ )
    - $> 1/3$  do NOT have USNO POSS mag ( $R > 21$ ),  $> 1/2$  have no 2MASS detection
    - $> 1/2$  do NOT have RASS X-ray detections

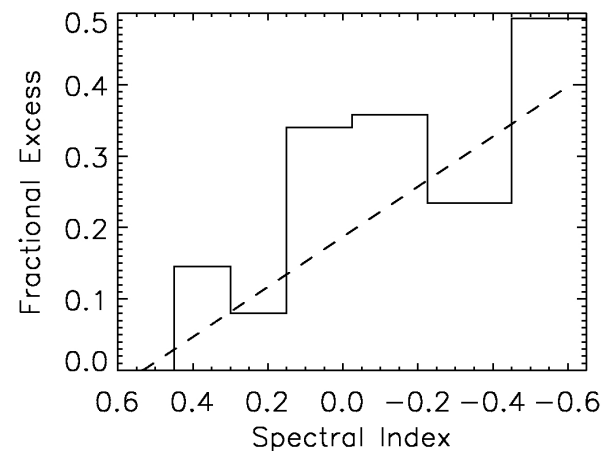
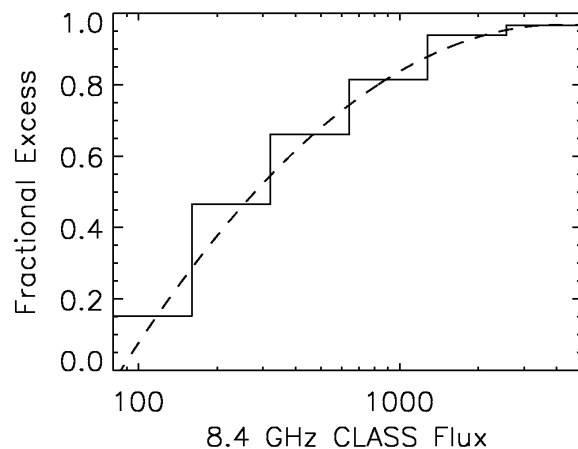
# ID Probabilities: FoM

- Candidates have flat radio (GB6+PMN/ NVSS+SUMSS) spectrum
  - $S_{4.8\text{GHz}} > 65 \text{ mJy}$ ,  $\alpha_R > -0.5$  : 11,000 sources nearly all sky
- We obtain sub-arcsec 8.5GHz images— compact flat spectrum cores are the winners.
  - A few sources still need interferometry, esp. in the south (Black squares)
  - A few holes in the 4.8GHz sky, esp in North



# ID Probabilities: FoM

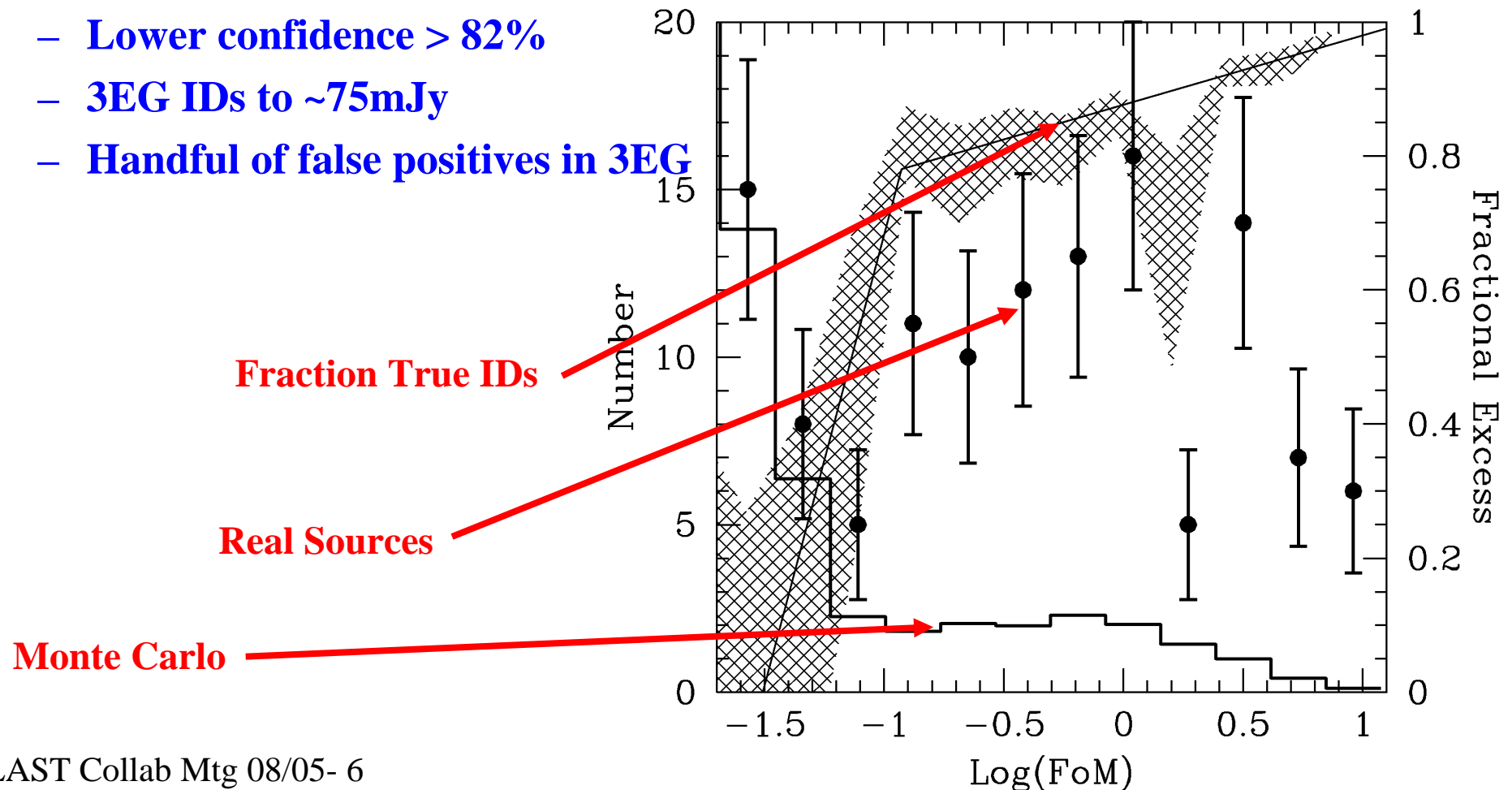
- From this uniform radio sample, quantify the association with the 3EG training set for any desired property
  - we use compact 8.5GHz flux, radio spectral index, X-ray flux
    - other possibilities: Gamma variability, spectrum
    - Must use uniform samples w/ known flux limits, areal densities
  - Find fractional excess of sources w/in 3EG 95% contours associated with each property



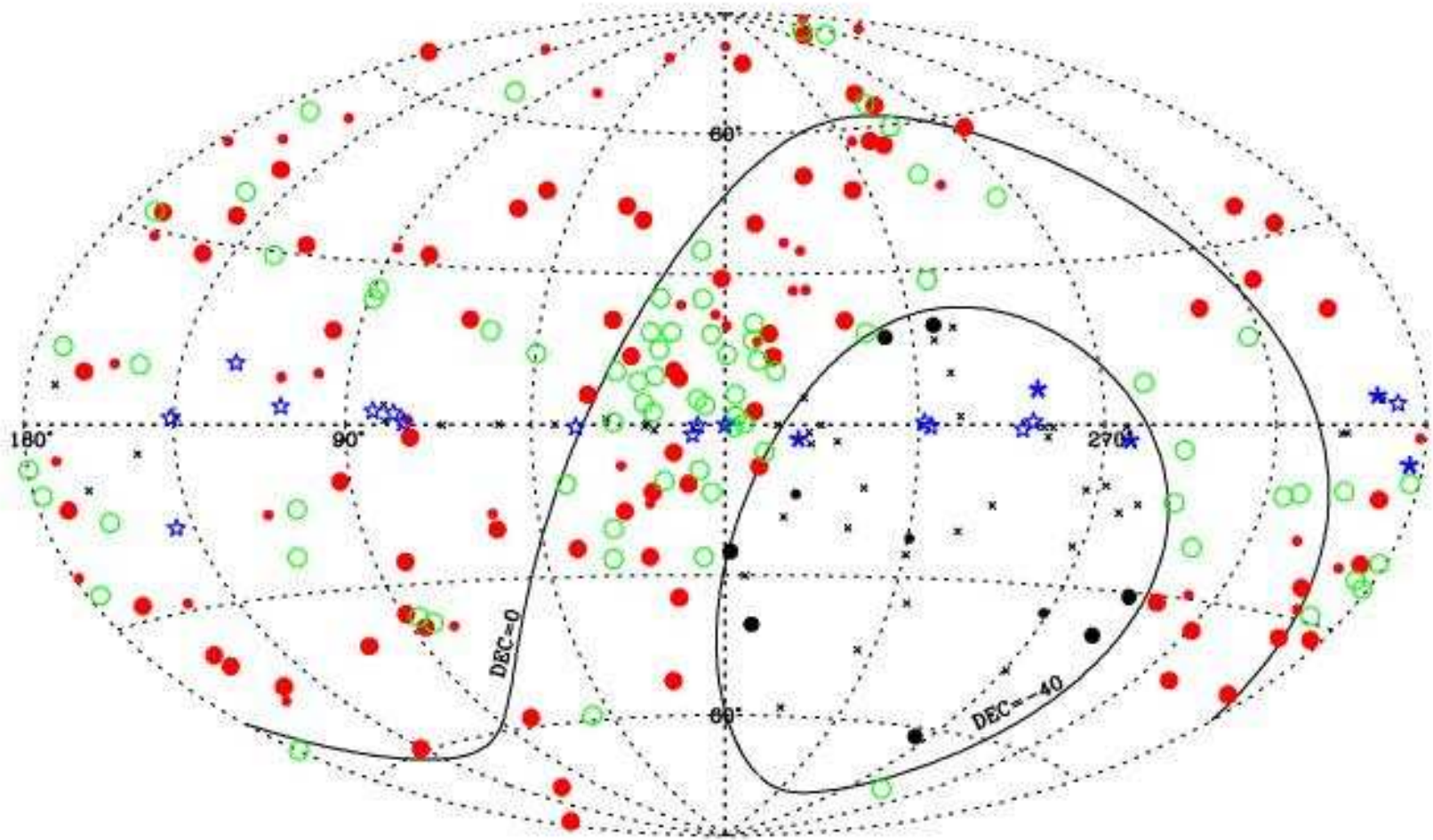
- Combine all probabilities with probability of Gamma-ray source at this position (from TS map):  $\text{FoM} = \Pi P_R P_\alpha P_X P_{\delta\text{TS}}$

# ID Probabilities: FoM

- Finally -- *Normalize* this FoM to an absolute probability, using Monte Carlo experiments scrambling positions within uniformly sampled sky
  - We call high confidence > 92%
  - Lower confidence > 82%
  - 3EG IDs to ~75mJy
  - Handful of false positives in 3EG

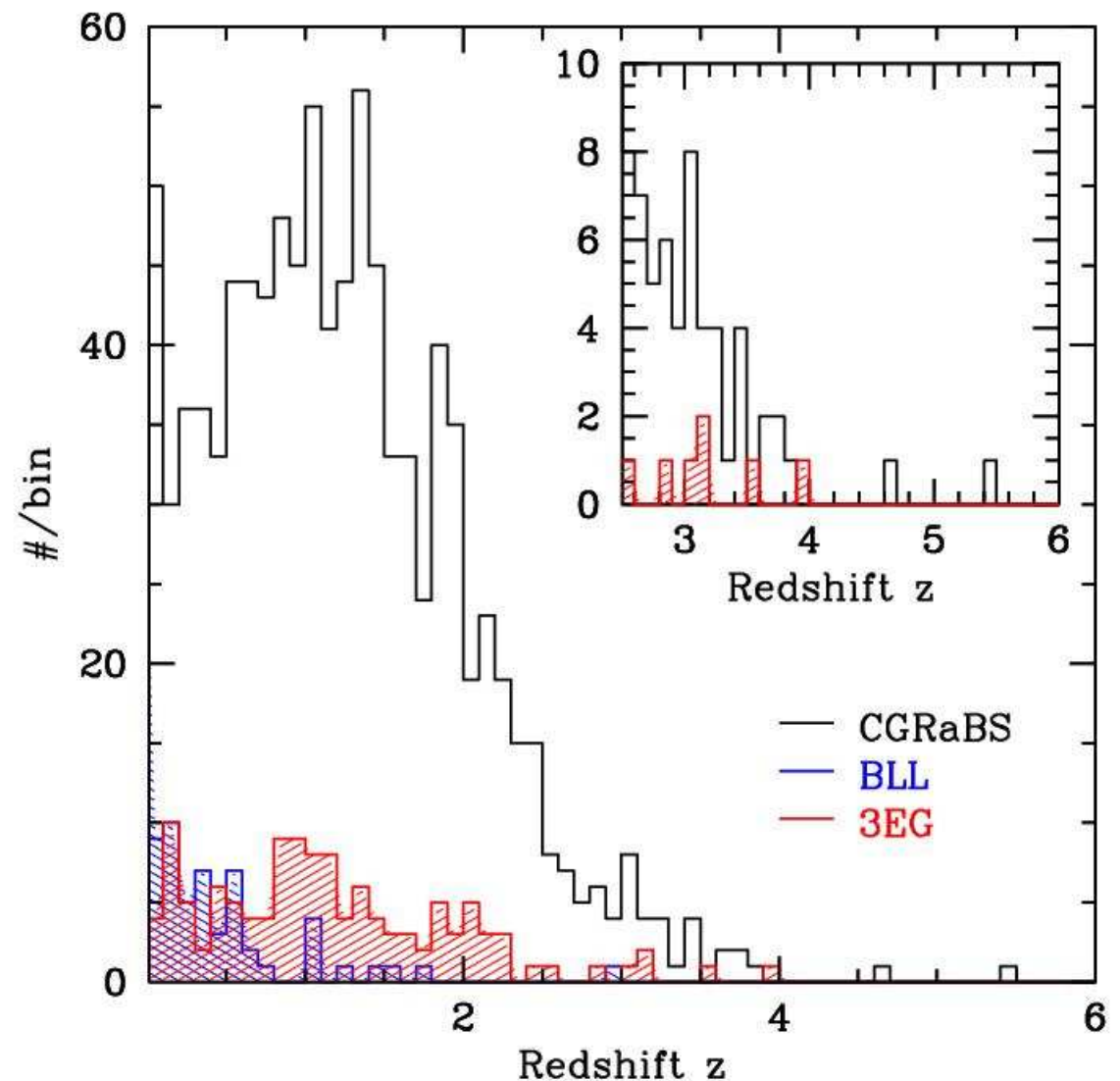


# 3EG Survey Status



# Preparation for GLAST

- Drop the TS part! (but significant association with excess 3EG photons)
- Down-select 'golden' set of ~1800 blazars from flat spectrum radio population
- Confirm w/ optical IDs
- 60  $z > 2.5$  (8 in 3EG)
- 30  $z > 3.0$  (5 in 3EG)
- Obviously will run FoM-type analysis one we have new  $\gamma$ -ray maps



# Bottom Line

- Position-only associations must have a concrete, quantitative prescription that can be applied by catalog group.
  - IDs should flow from well understood, flux limited catalogs
  - Should give association probabilities for individual sources
- Can train up FoM weights using a variety of properties
  - This only works for established source classes
- We should adopt well defined (and conservative) criteria for IDs
- Correlated variability associations should be pursued as a powerful alternative