GLAST Blazars: Preparation and Anticipation

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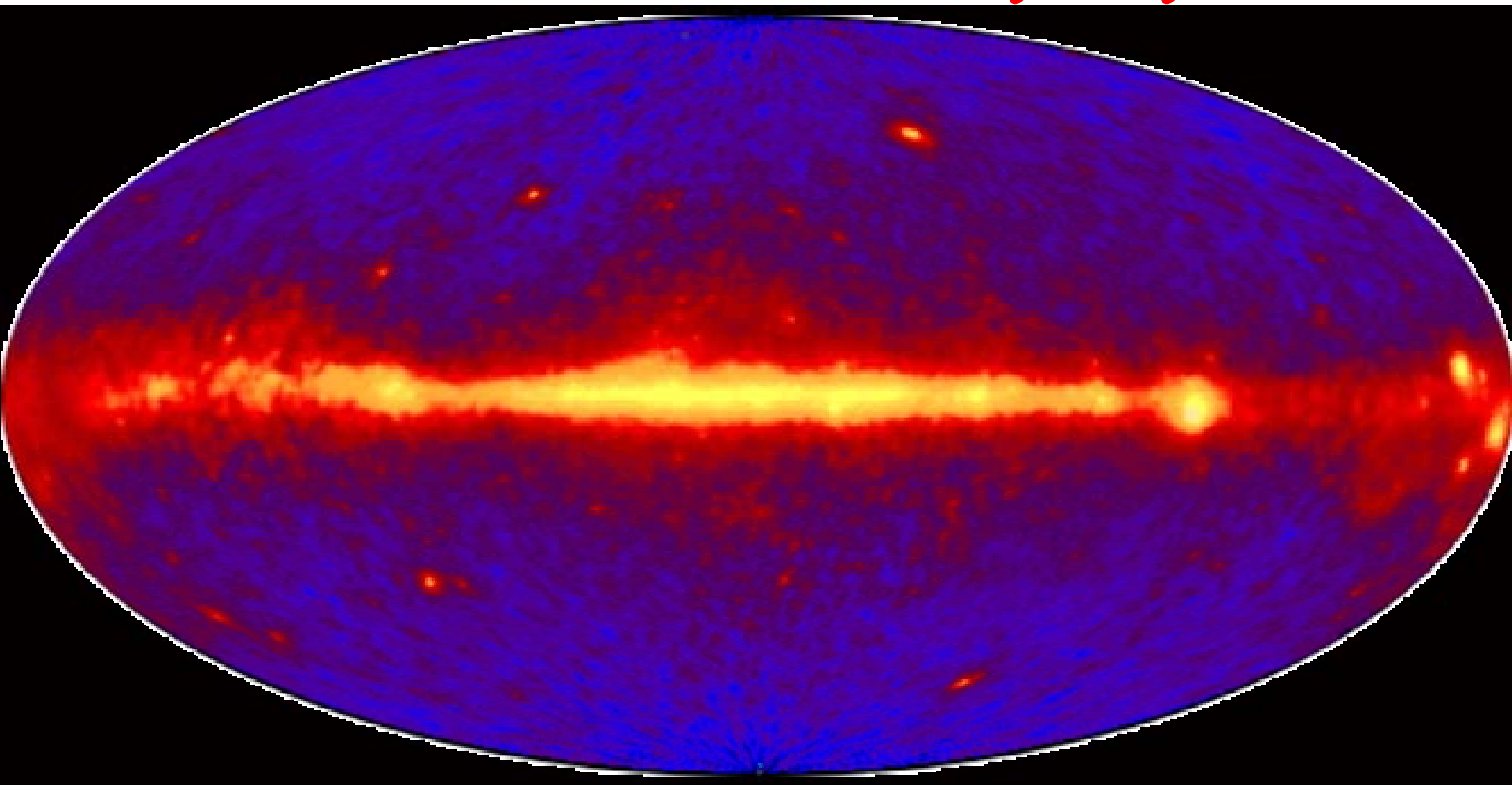
The GeV sky – persistent point sources

- **To date only pulsars, blazars securely identified**
  - **Individual variability to cement ID w/ lower energy**
  - **Statistical association for population as a whole**
  - **other candidates: HMXB, clusters, SNR, …**
- **Common Physics of γ-ray dominated sources:**
  - **Flywheel – bulk storage of mechanical energy**
  - **Strong magnetic field coupling to a low density (γ *and* ρ) environment**
  - **Pair production + weak cascading to lower energy**

GLAST Gamma-Ray Sky



Looking forward to GLAST (2007)

- >30x EGRET sensitivity
- Expect 4000-10,000 Blazars, >200 Pulsars

Lessons from EGRET

- The bright blazar population is decently characterized
  - Nominally, expect population surprises at the few % level
  - Luminosity, high duty cycle bias
  - w/ 2,000-10,000 expected, we can do serious work with rare sub-sets of the blazar population
- Pulsars are much less well characterized
  - Expect surprises at the 30% level
  - Geminga's, MSP, B star binaries…
- Beyond this we revel in lightly constrained speculation...

Blazars Dominate the known EGRET sky

- Blazars:
  - **Bright EGRET Sources clearly assoc. w/ flat spectrum radio QSO – 3EG, Mattox, etc. → ~40 IDs, +20 Candidates**
  - **Blazar definition heuristic, blazar studies are hetrogeneous**
  - **Striving to be more physics based: (from at least some direction) a jet-dominated AGN with a bimodal, synchrotron+Compton SED (Giommi)**

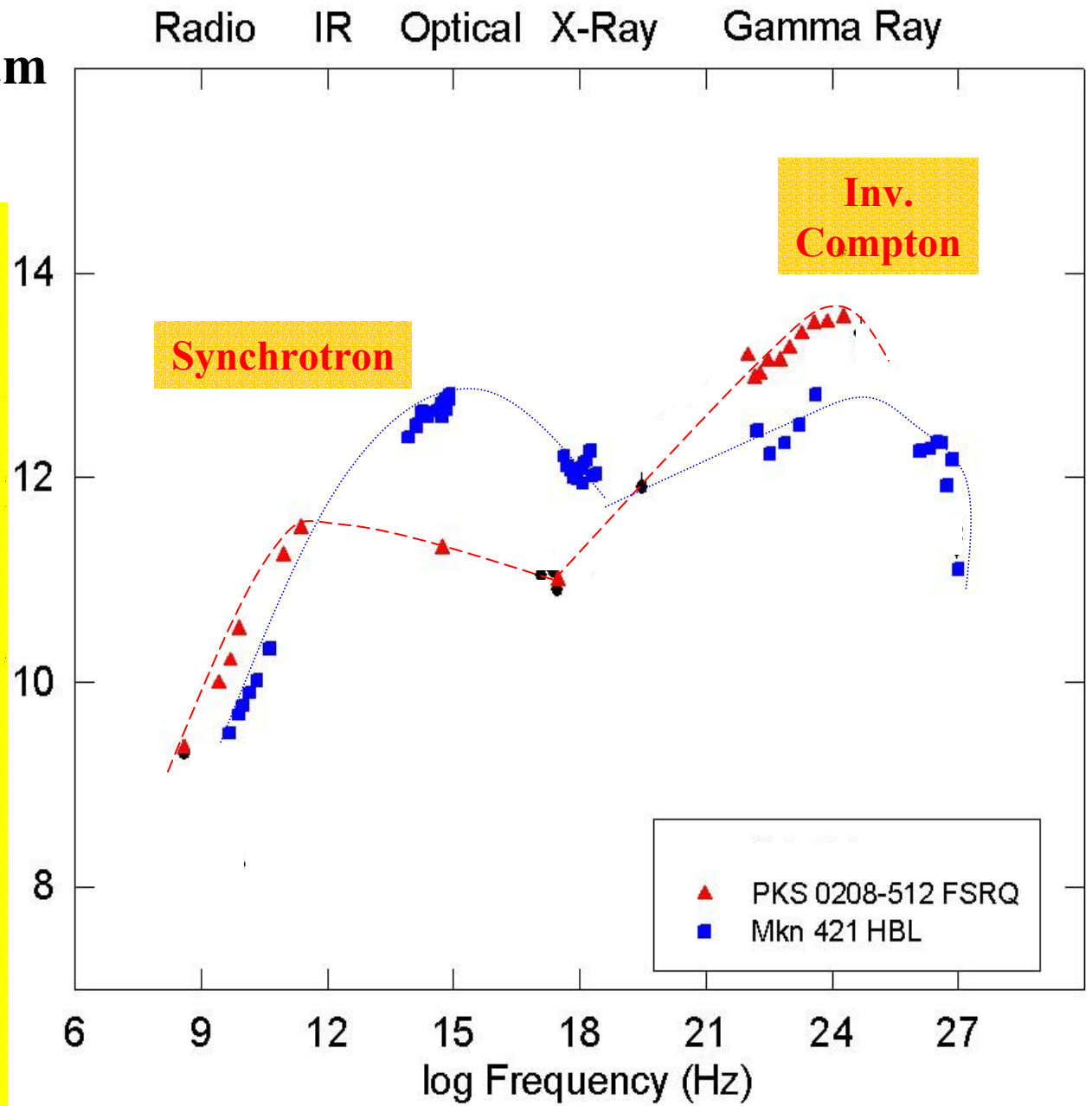
Blazar SEDs

GLAST MW Team
(D Thompson)

FSRQ -- `Red' Blazar
Flat optical
(FSRQ spectrum)
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

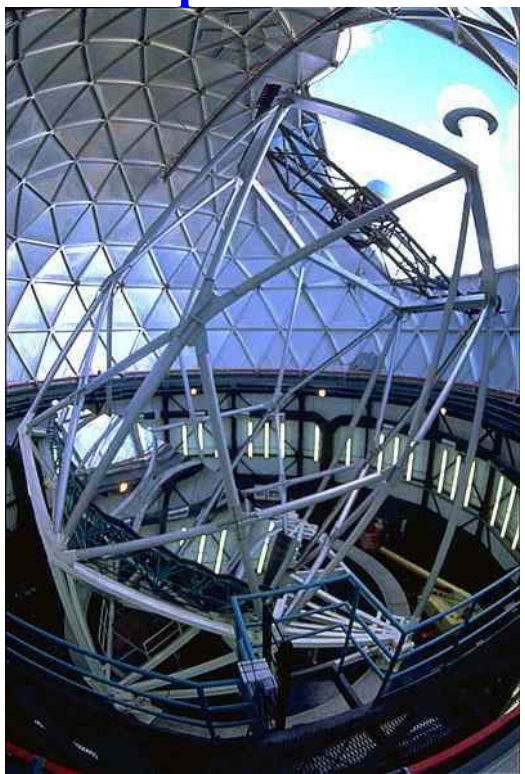


Evaluating Blazar counterparts

- **Need deep all-sky samples.**
- **Train SED FoM against clear EGRET counterparts**
- **Radio: flux, spectrum, compactness**
- **X-ray: (RASS) weak selection for detection**
- **Position w/in 3EG uncertainty contour**
- **Issues:**
  - **False Positives**
  - **Confusion**
  - **Variability**
  - **Looking under the lamppost**

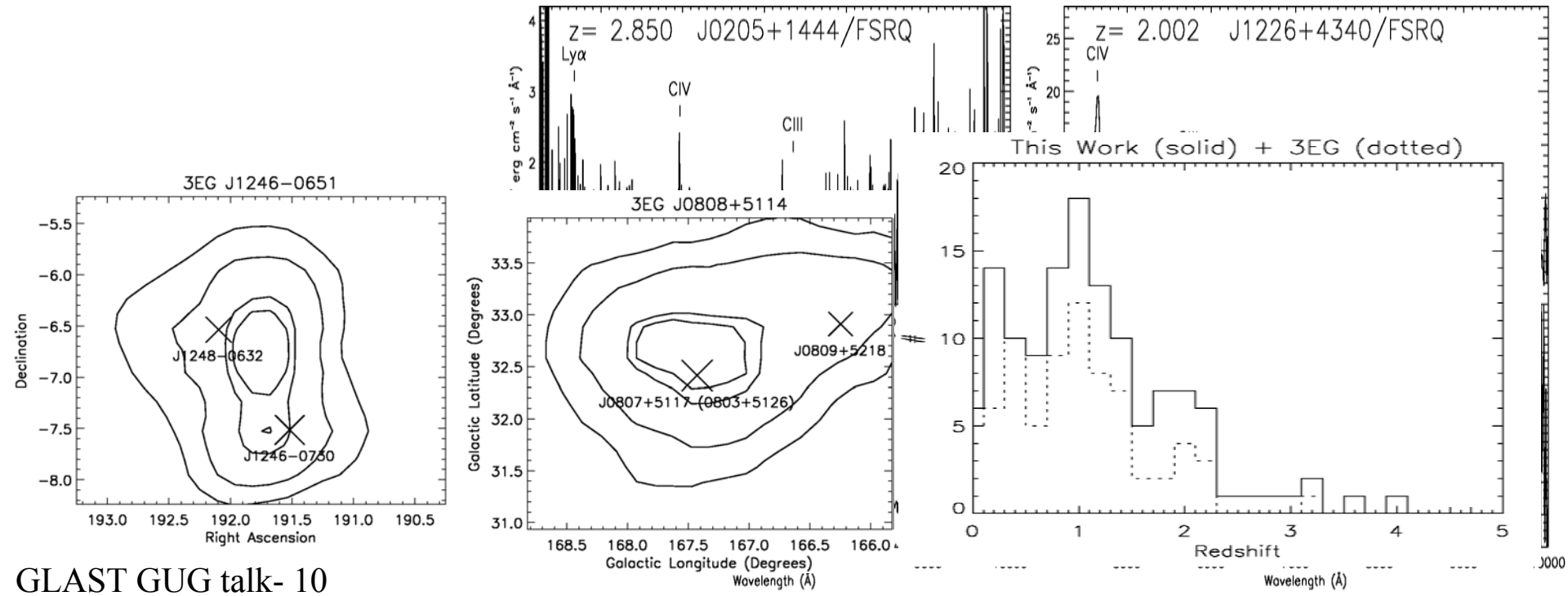
HET 3EG Blazar Survey

- EGRET sources -- start from 3EG (some are spurious!!)
  - **Select flat spectrum radio counterparts (NVSS+CLASS or new VLA 8.4GHz A-array)**
    - **FoM approach: increasing weight with large S_ν, small α**
  - **Including X-ray, γ-ray position:**
    - **Total FoM has weak X-ray weight, uses 3EG TS maps**
  - **Optical ID of high FoM, R<23 w/ Hobby*Eberly Telescope**
    - **Optical Arecibo → DEC>-10**

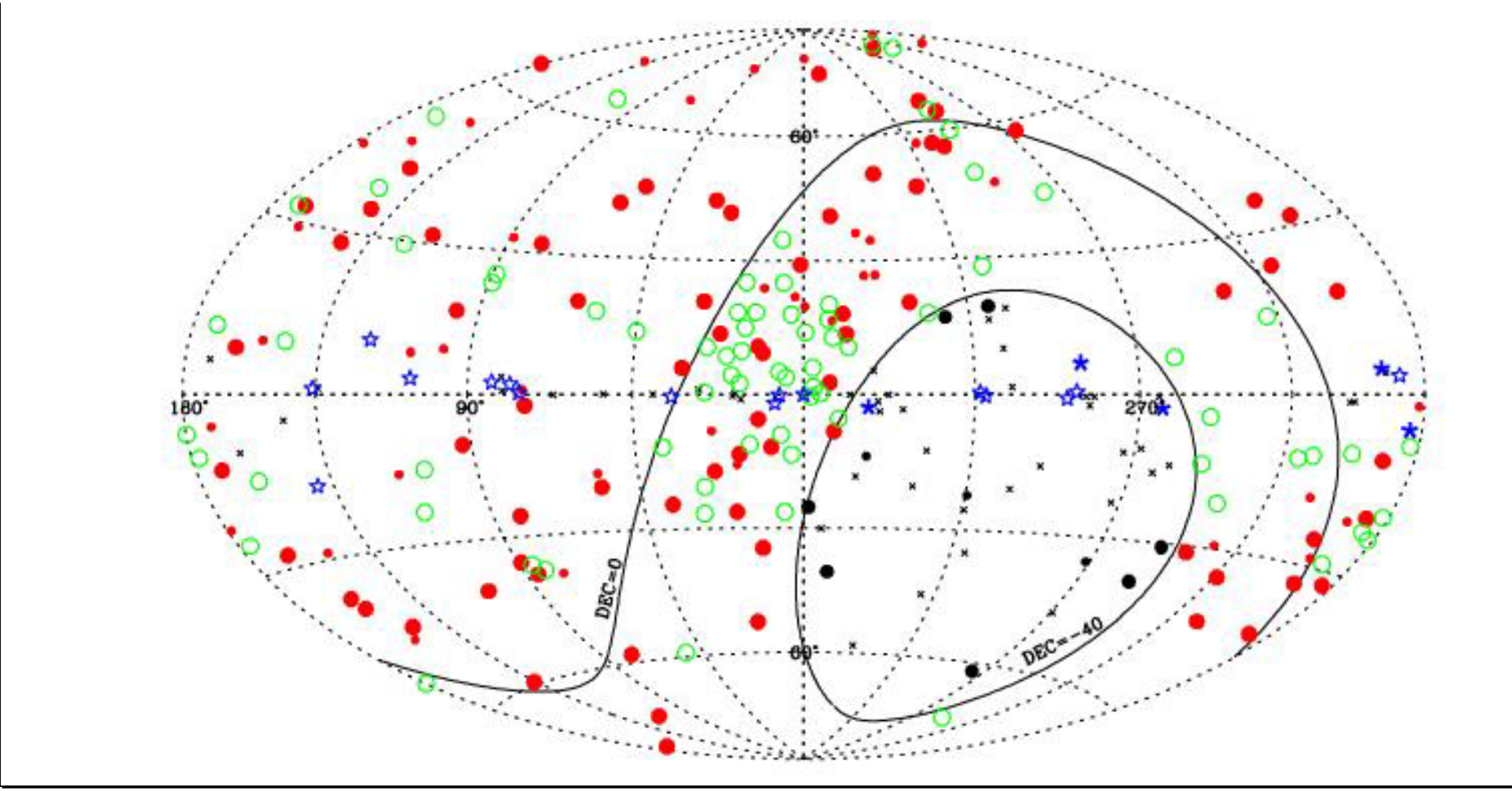


HET 3EG Blazar Survey

- Results
  - **>70% IDs at high b**
  - **18% are BL Lac, almost all of rest are FSRQ**
  - **Multiple IDs (composite γ-ray sources)**
  - **~Doubled maximum z**
  - **Found 2 radio faint (non-blazar) populations**
    - **Isotropic, bulge**



3EG Survey Status



GLAST-sized samples

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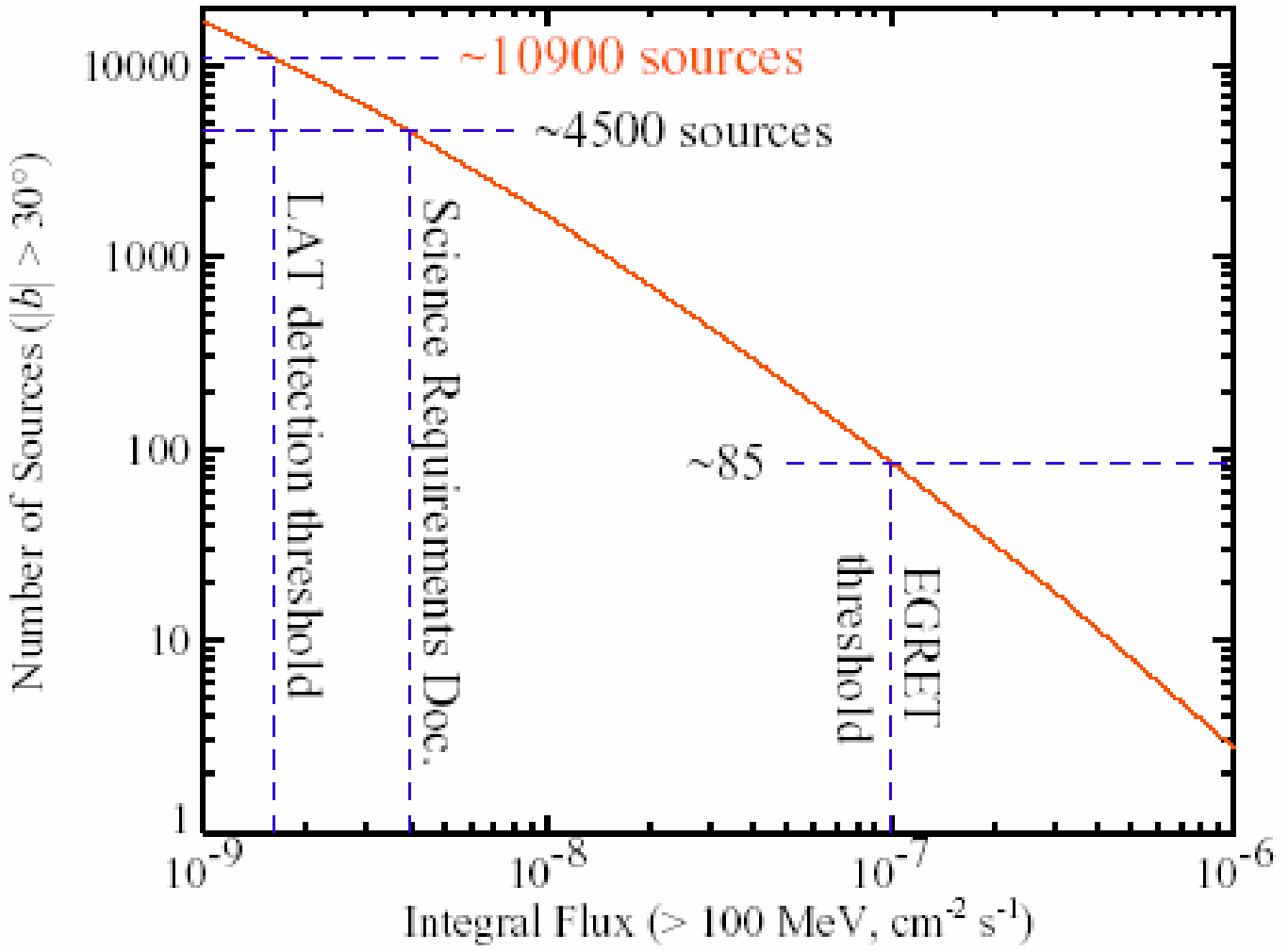

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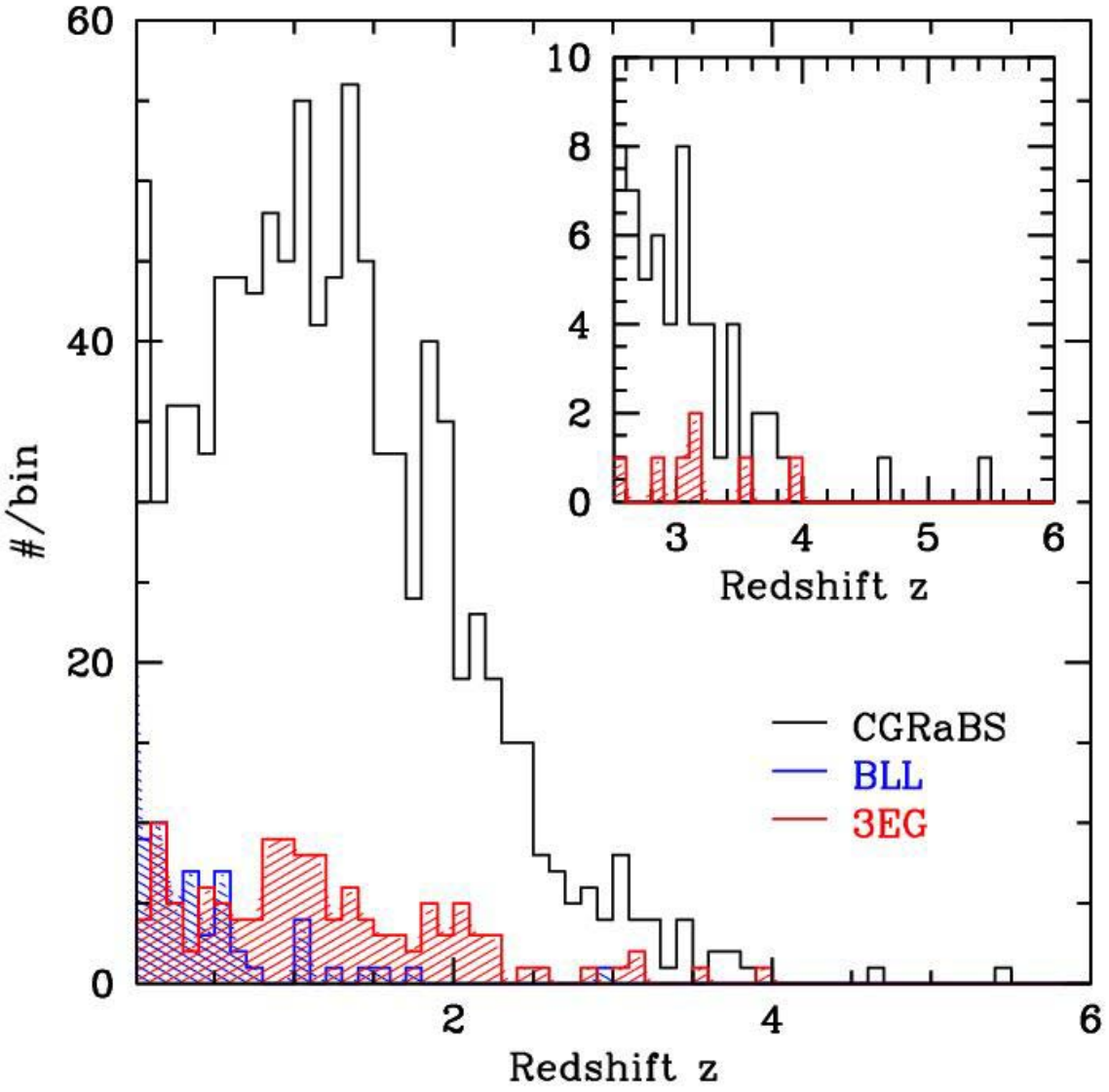
`CGRaBS': ID fractions

- **All-sky $|b|>10^0$**
  - **1030/1742 optically classified (59%)**
  - **964 (94%) of these w/ z – *we've contributed 60% of all z***
  - **115 (11%) are IDed as BL Lac (about ½ w/ redshifts)**

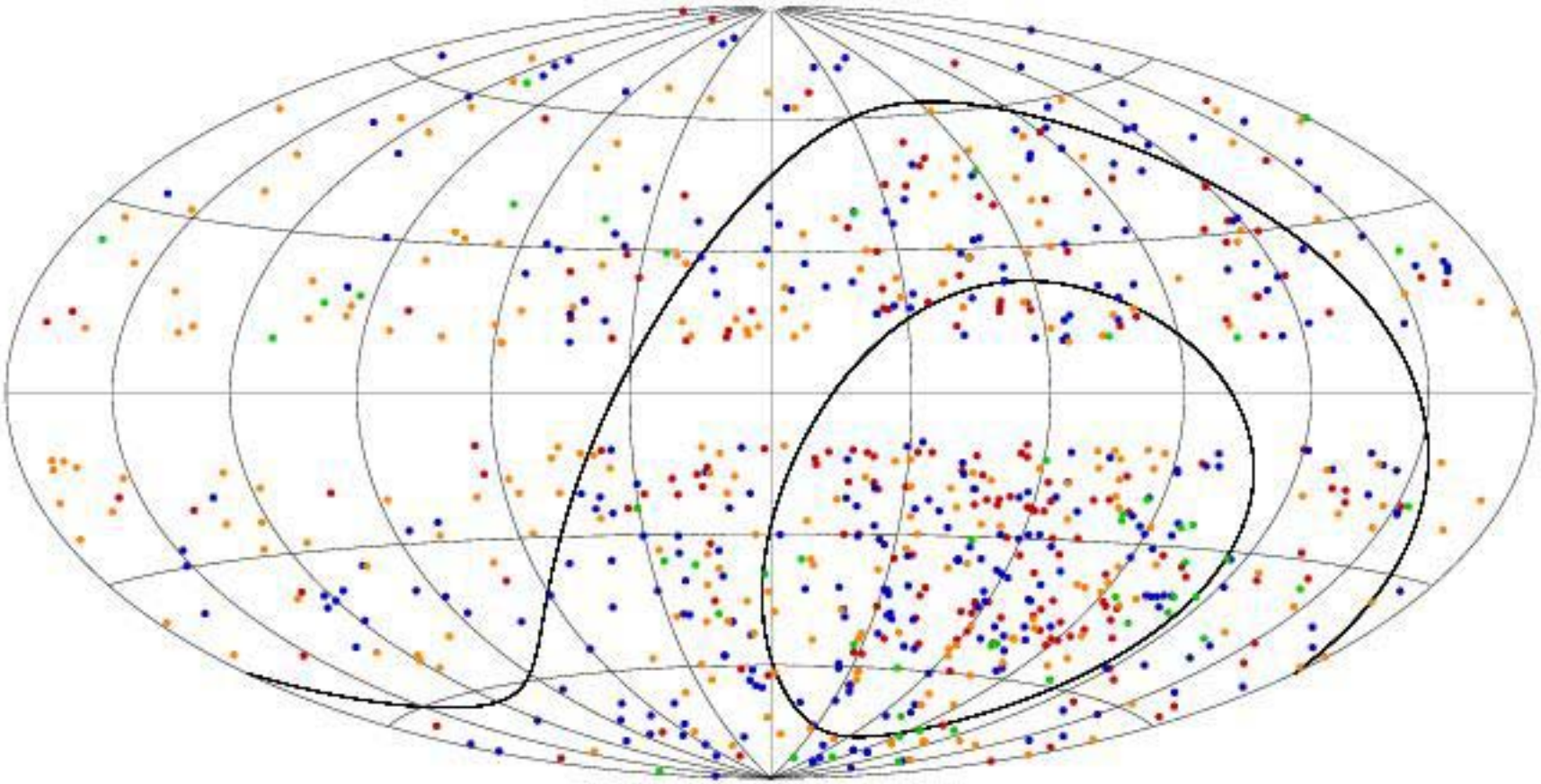
- **Above DEC= 0^0**
  - **672/837 optically classified (80%)**
  - **624 (94%) with z**
  - **81/672 (12%) are BL Lacs**

Redshift Dist'n

- 60 z >2.5 (8 in 3EG)
- 30 z >3.0 (5 in 3EG)



CGRaBS optical



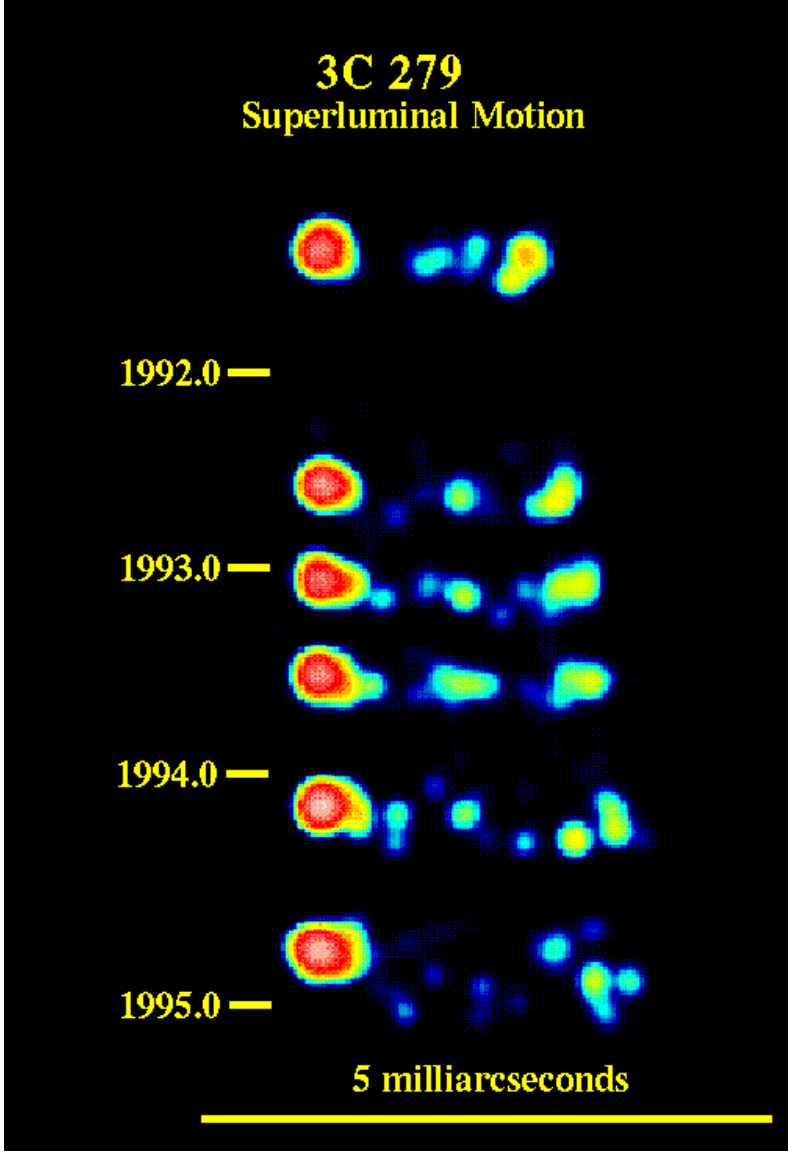
Done **Yet to Observe**

Why Now?

- GLAST sky will be **variable**
- A externally selected sample complements `triggered', i.e. γ-selected, objects.
- Important (e.g. high z) sources need to be pre-selected for correlated study
- Secure IDs may still require **simultaneous** monitoring

Blazar Jet Monitoring

- VLBI monitoring to get δ
  - Comparison of δ at γ-ray (0.1pc) and VLBI (~1pc) scales
  - HBL: VLBI δ < 4c (Giroletti et 03)
    - But δ~50–100 needed to model TeV!
  - FSRQ (EGRET Blazars): VLBI δ peaks at 10-12 (Marscher & co)
    - Compare w/ 2-3 for RQSO in general
- Key Question:
  VLBI ejection vs. γ flare
  - GLAST cont. coverage essential
  - Secondary issue: δ vs. GeV power
    (Macomb, Ulvestad, et….)



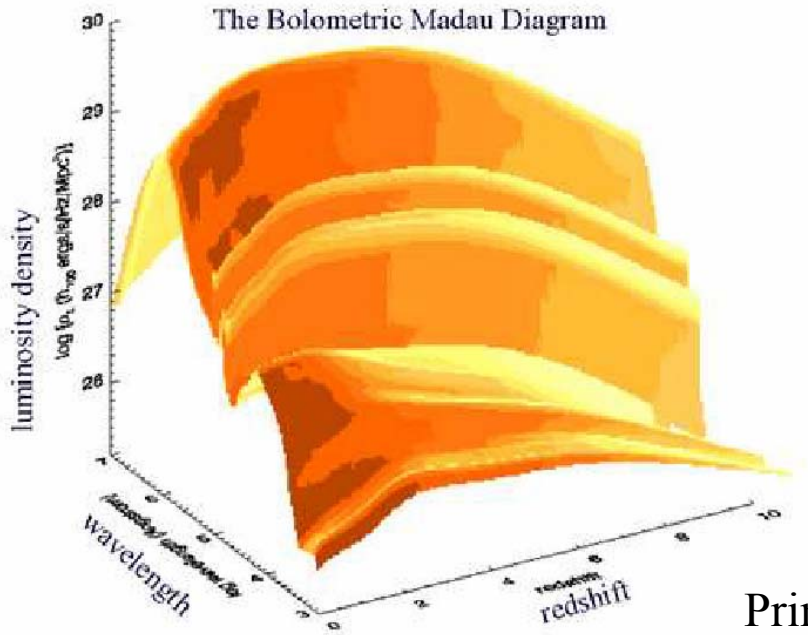
We do all this zoology to enable some Physics

- **Probing the acceleration of the AGN jets**
  - **Step 1 – get β**
    - **(expect high speeds Kellerman, et 04….)**
  - **Step 2 – β→θ, Γ**
    - **Multi-n component studies (Blandford & Koenigl `79 → Marscher `83 →e.g. Piner et '03,….**
  - **Step 3 – field structure of jet, relate activity to γ outbursts**

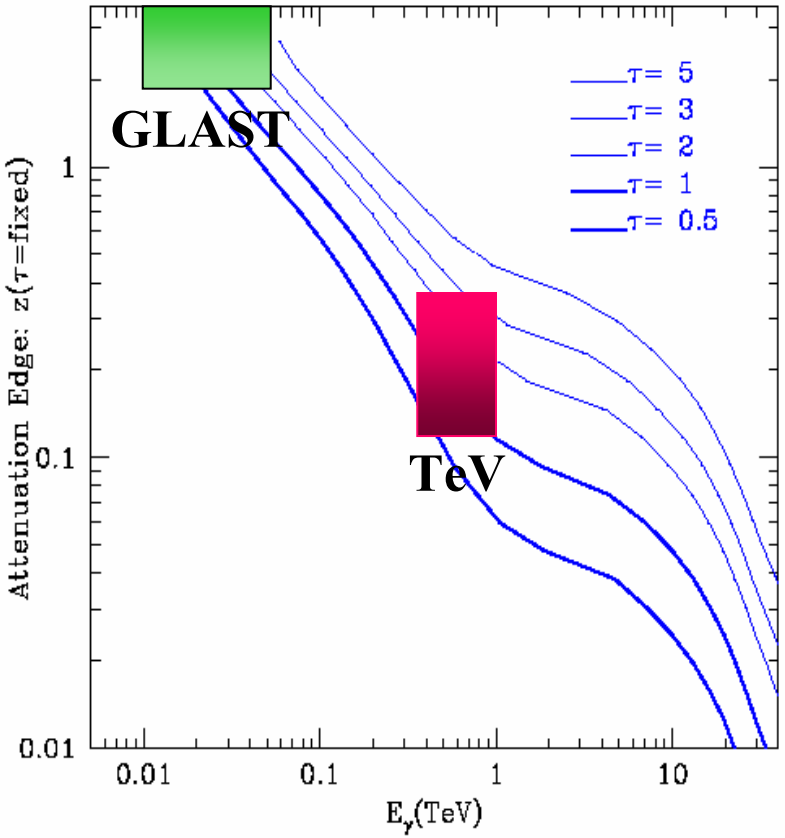
- **Probing the EBL and the onset of star formation**
  - **Step 1 – find high z >10GeV sources (CGRaBS is a start)**
  - **Step 2 –monitor >10GeV flux**
    - **With attendant low energy study**
  - **Step 3 – look for systematic τ(z) cutoff independent of f source, flaring,…**

EBL Absorption (Madau & Phinney)

- Encouraging successes with optical/IR absorption of TeV Blazars at z< ~0.15 (e.g. Dwek & Krennrich)
  - Snapshot of the integral stellar content today
  - Expect such studies will make robust measurements in next few years…
- With >10GeV photons from z>3 can probe optical/UV absorption through the peak of star formation z~
  - Time-resolved monitoring of the onset and growth of star formation

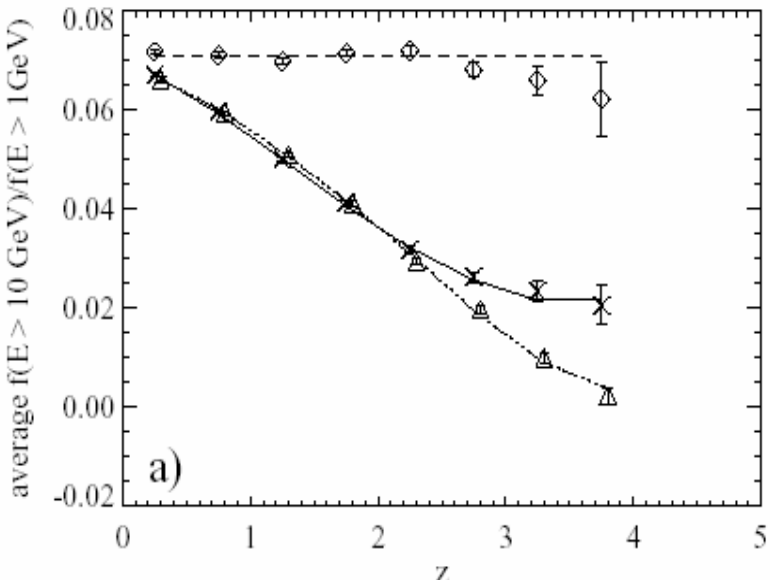


Primak et al 04

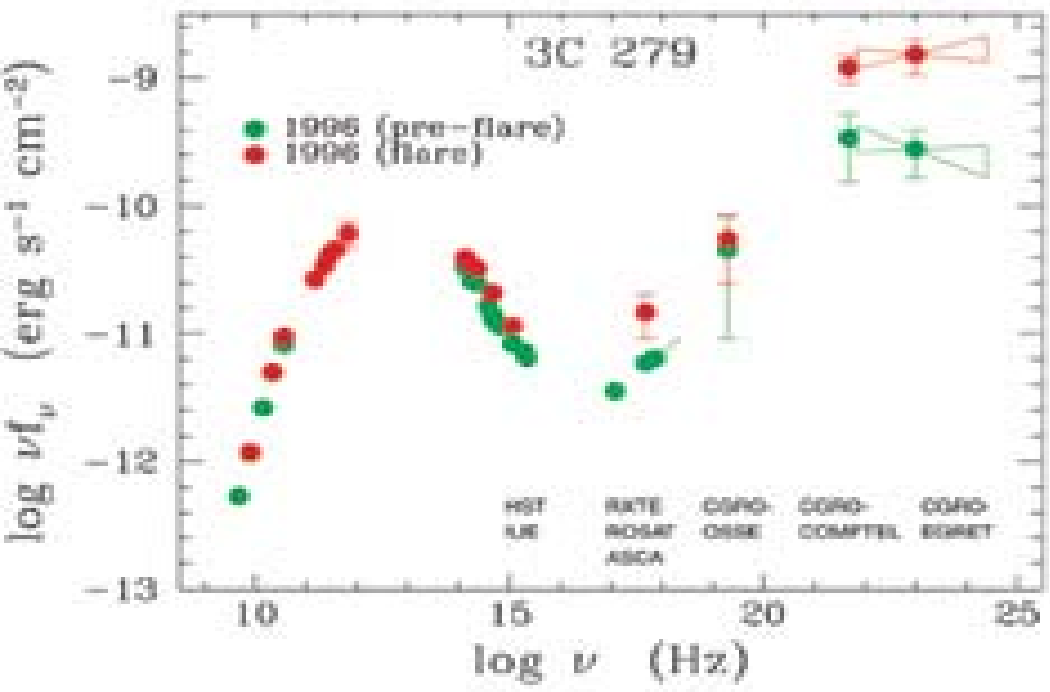


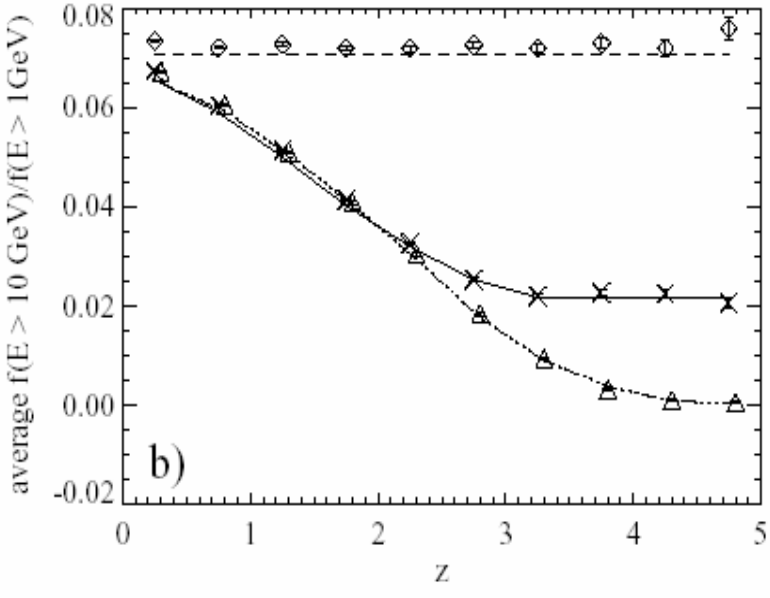
EBL Absorption – Can GLAST measure it?

- Present blazar LF, evolution very uncertain: e.g. Salomen&Stecker (a) and Chiang&Mukherjee (b) differ by >10x in # at z>3
- To get time evolution, need follow systematic with z, flare state.
- Improved SSC models, coupled w. optical/X-ray monitoring will greatly improve the prospects



Chen, Reyes & Ritz





Summary

- **Radio-selected Blazars will likely dominate GLAST sky**
  - **But presently we know of far too few…**
- **Pre-launch efforts to ID powerful blazars can reasonably match the well-measured GLAST sample.**
  - **Helps with IDs in early GLAST catalogs**
  - **Down-selects interesting (i.e. high z, powerful jet) sources for intensive multi-ν study during the GLAST prime mission.**
  - **GeV physics will be substantially aided by low energy modeling, improved SSC, EC models.**
- **Sorting the wheat from the chaff…**
  - **Identify new radio-faint ex-gal populations**
  - **Search for high latitude Galactic (eg. MSP) sources.**