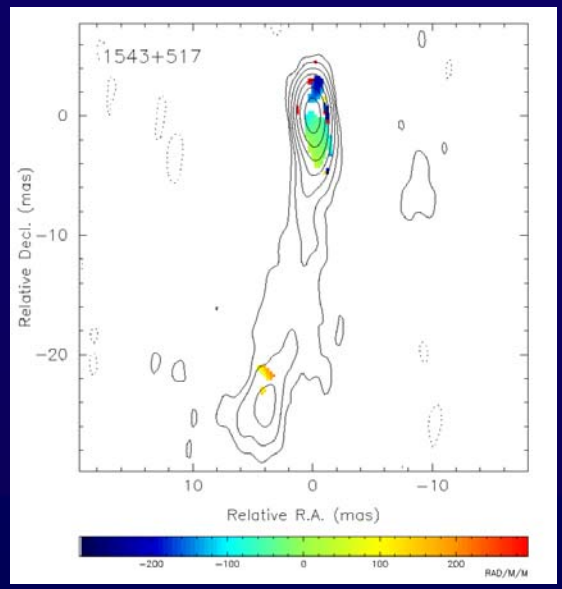

Science Opportunities with GLAST

Greg Taylor

UNM

NRAO Legacy meeting, 2006 May 17

NRAO

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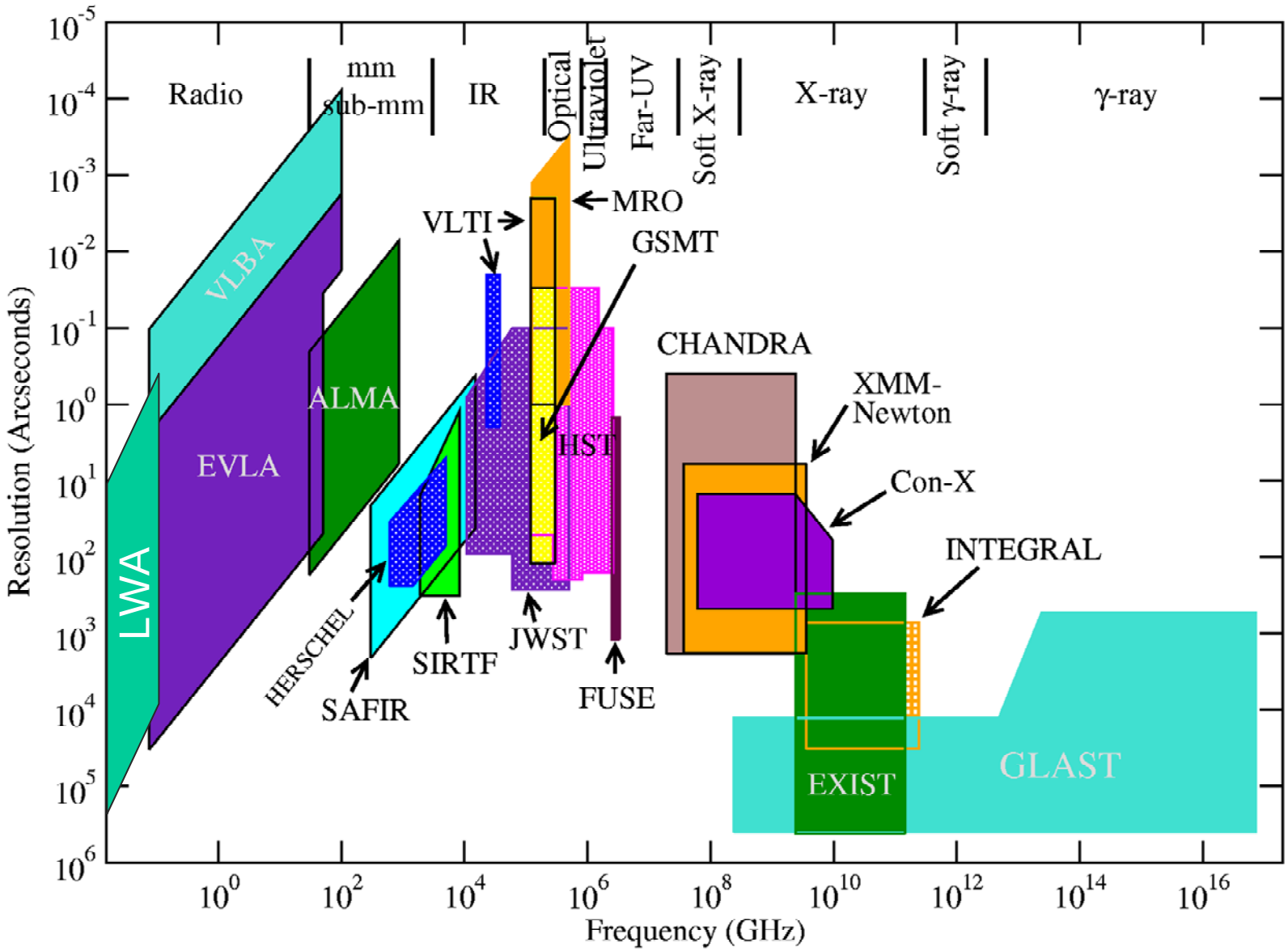


Discovery Space

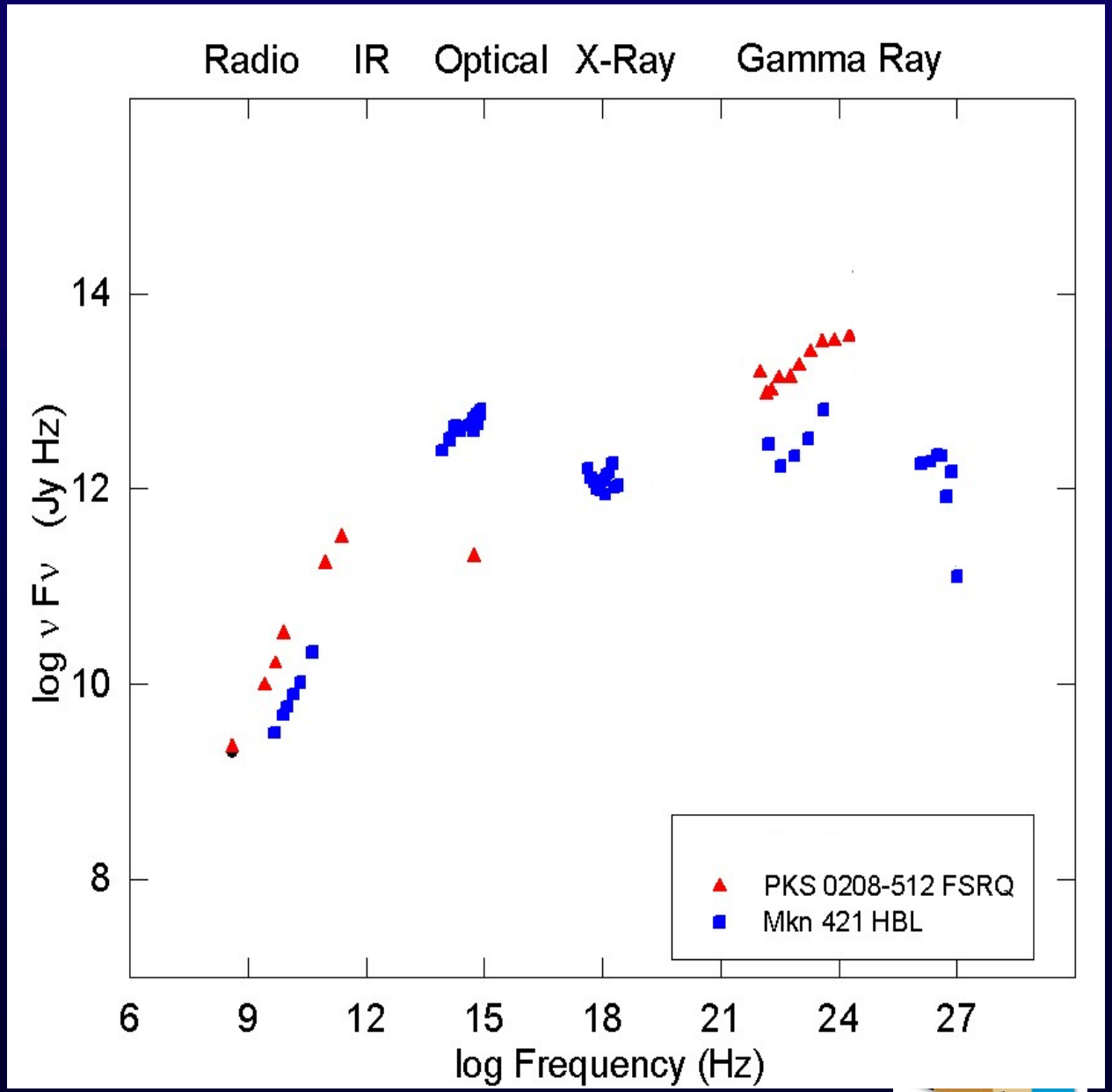
Blazar SEDs

FSRQ -- `Red' Blazar
Flat optical
(FSRQ spectrum)
Faint IC X-ray
High z

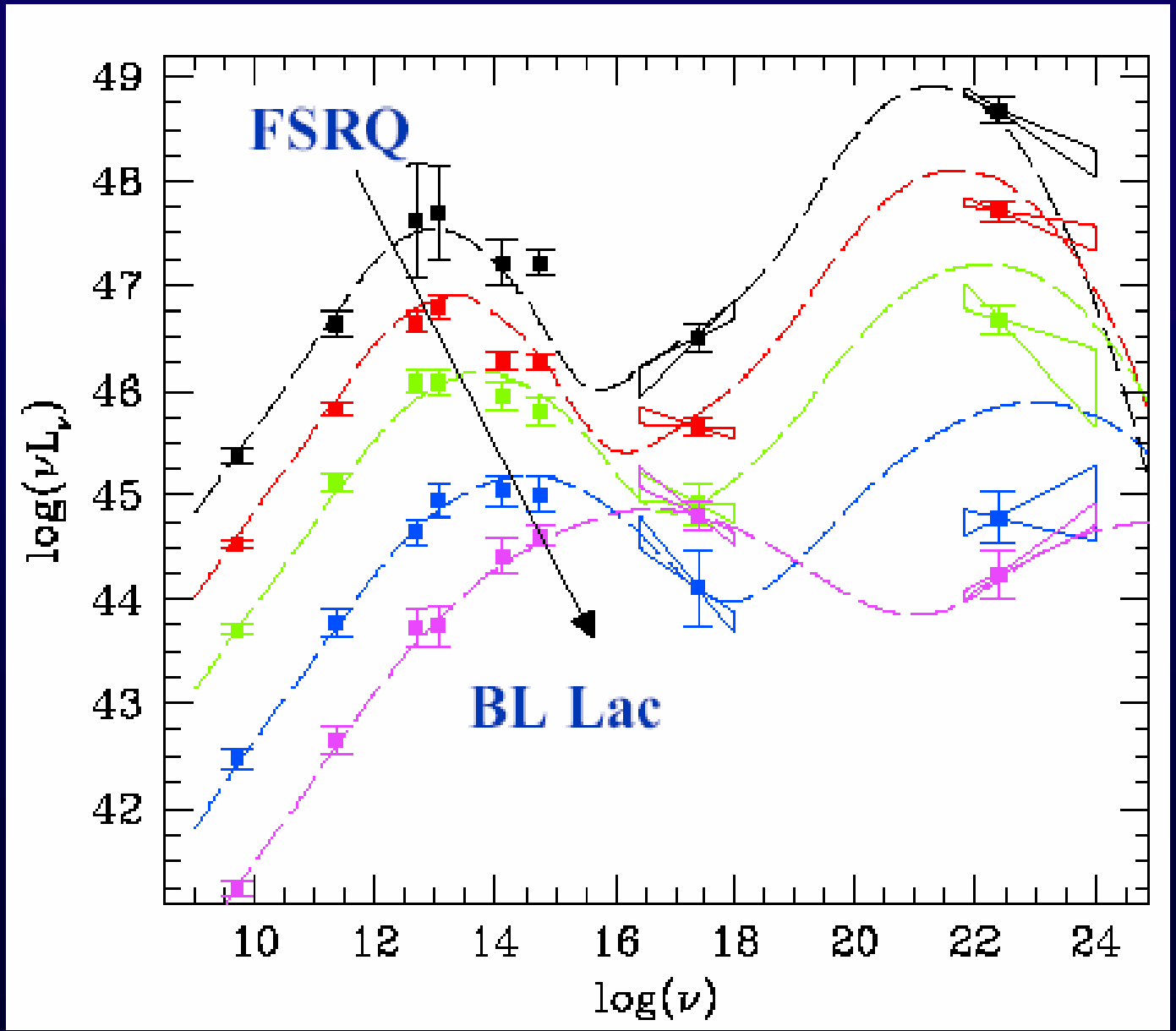
HBL -- `Blue' Blazar
Blue Optical
(BL Lac spectrum)
Bright Syn X-ray
Low z

Radio selection indiscriminate

X-ray selection (eg. ASI sample → HBL)



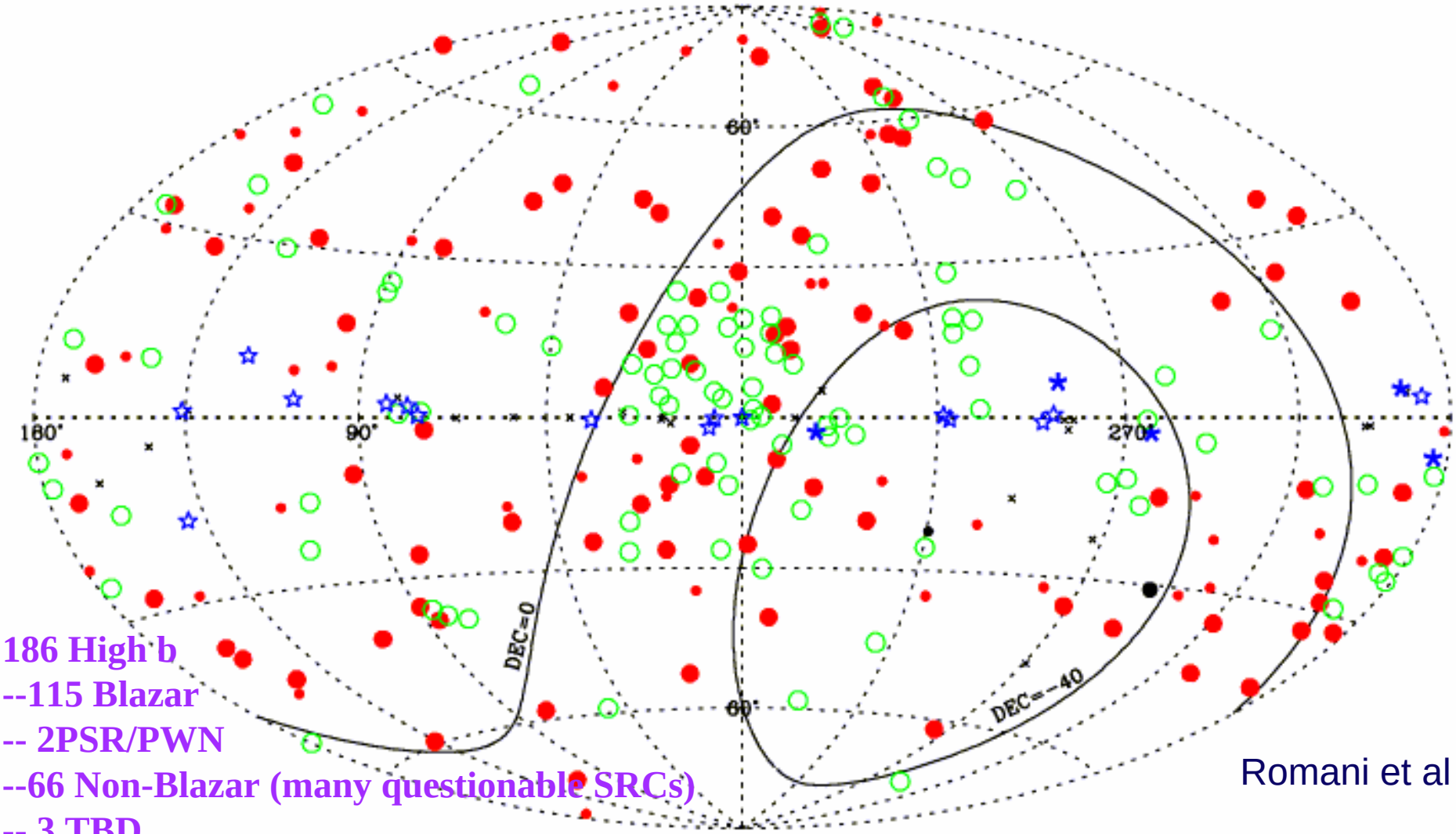
AGN spectra


FSRQ
BL Lac
log(νL_ν)
log(ν)
49
48
47
46
45
44
43
42
10
12
14
16
18
20
22
24

3EG Blazar Follow-up Survey

- EGRET sources -- start from 3EG (some are spurious!!)
  - **Select flat spectrum**
    - **(NVSS/SUMSS+CLASS/new VLA/ATCA 8GHz <1" resol.)**
    - **FoM approach: increasing weight with large S_ν, small α**
  - **Including X-ray, γ-ray position:**
    - **Total FoM has weak X-ray weight**
  - **Optical ID of high FoM, R<22 w/ Hobby*Eberly Telescope**
    - **Optical Arecibo → DEC>-10**

3EG Survey Status



186 High b
--115 Blazar
-- 2PSR/PWN
--66 Non-Blazar (many questionable SRCs)
-- 3 TBD

Romani et al

>60% High b sources identified as blazars

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Large Area Telescope: Overview

GLAST is composed of two instruments:

- Large Area Telescope (LAT)
- Gamma-ray Burst Monitor (GBM)

Orbit

565 km, circular

Inclination

28.5°

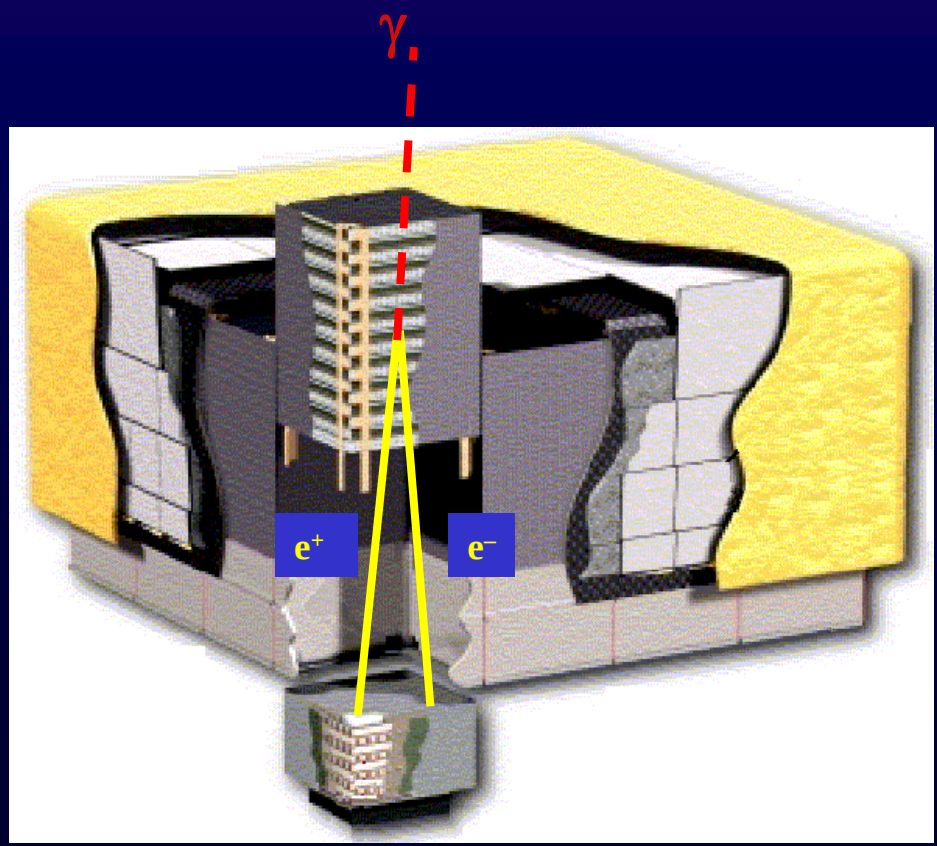
Lifetime

5 years (requirement)

10 years (goal)

Launch Date

Fall 2007



Subsystems work together to identify and measure the flux of cosmic γ-rays:

Silicon Microstrip Tracker

Measures γ direction

γ identification

Calorimeter

Measures γ energy

Shower imaging

Anti-Coincidence Detector

Rejects background of charged cosmic rays

segmentation removes self-veto effects at high energy

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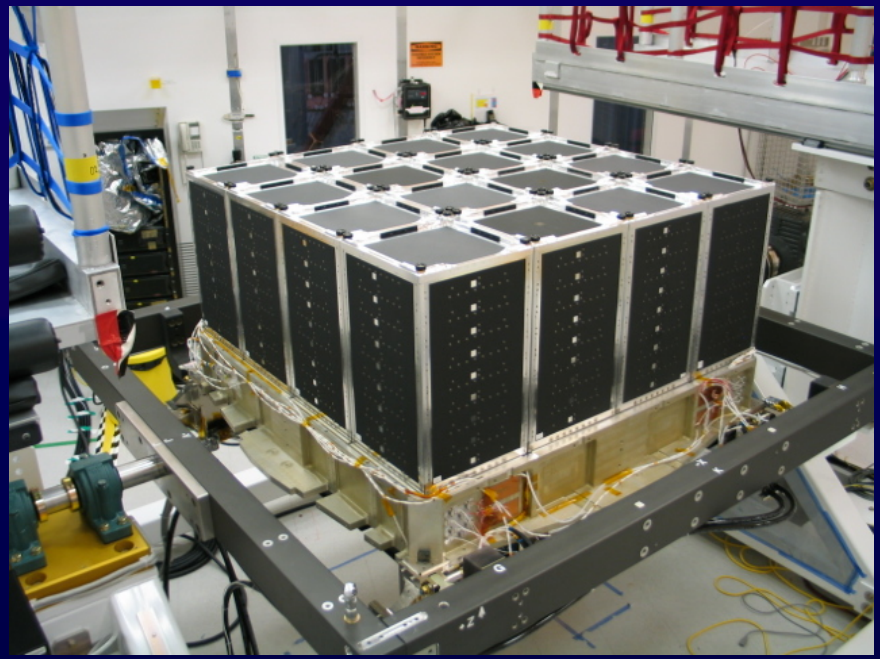
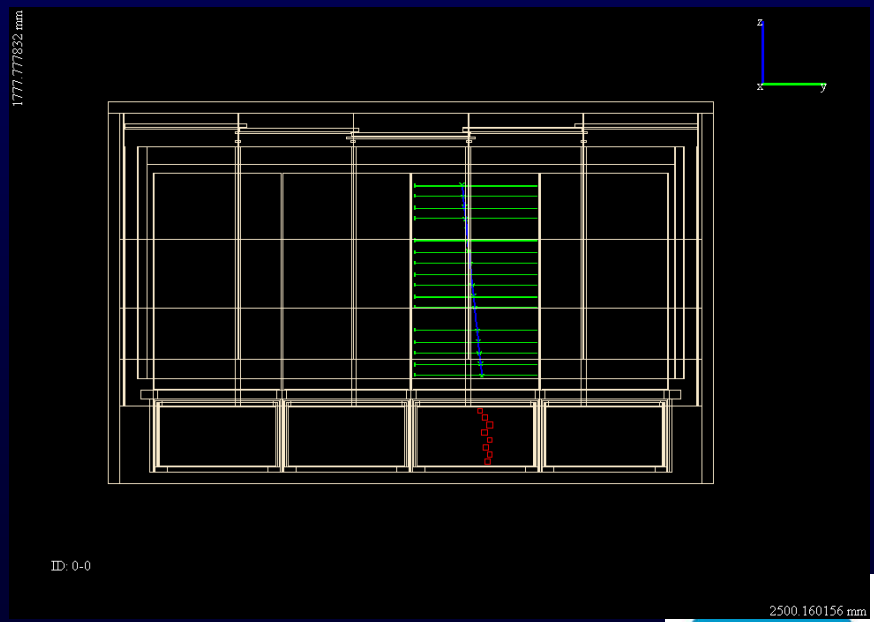
LAT Current Status



- LAT is fully integrated (ACD + Tracker + Calorimeter)

- Test and calibration with data from cosmic ray showers.

Actual Data →



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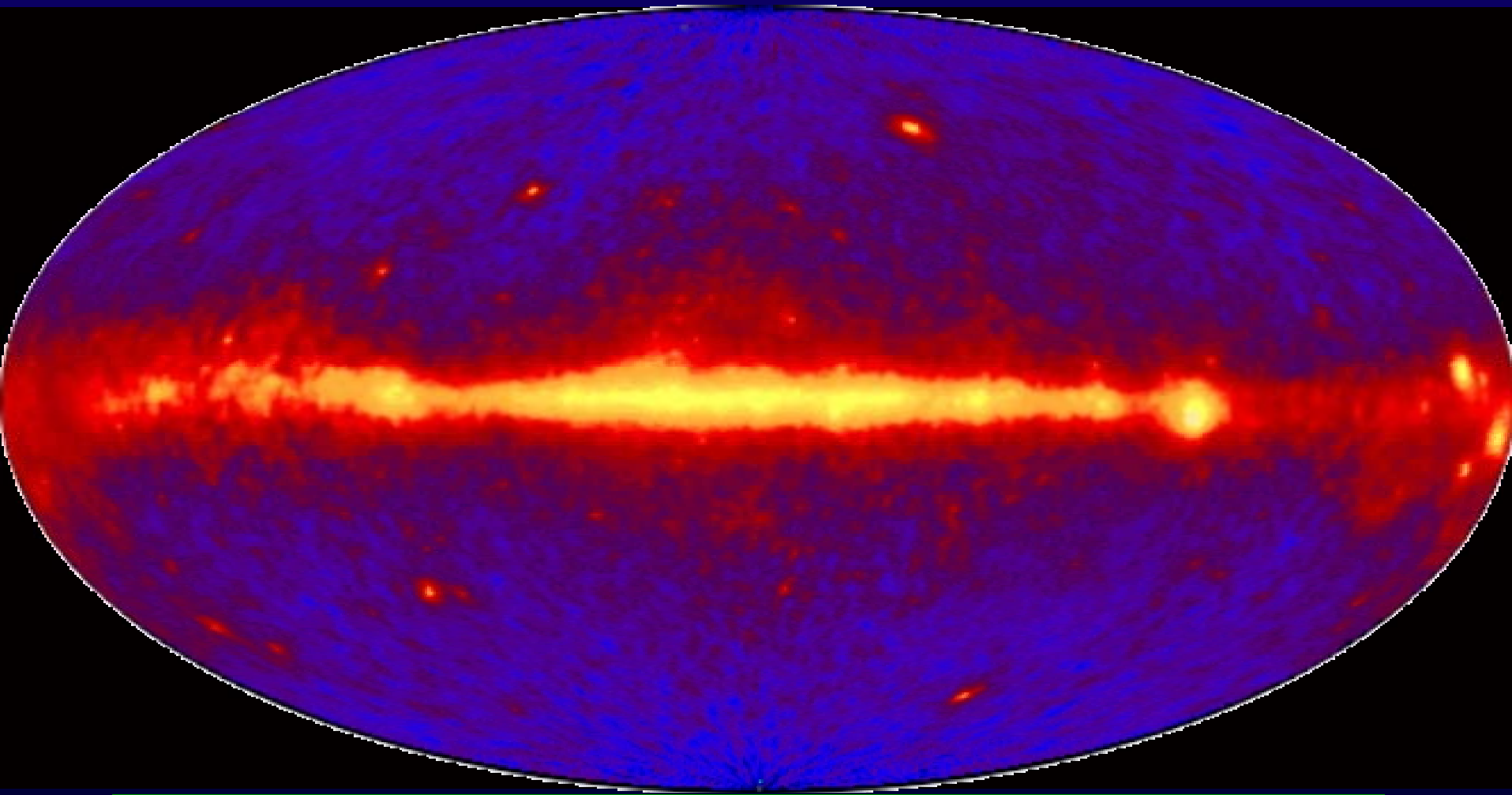
Summary of LAT strengths for AGN Science

- FOV (> 2.4 sr ; 20 % of the sky at any instant!)
- All-sky coverage in survey mode
  (samples the entire sky every 3 hours)
- Effective Area
  (factor >4 better than EGRET: ~ 1 m^2 for E > 1 GeV)
- Energy Range (20 MeV - > 300 GeV)
  (including the unexplored E > ~10 GeV energy range)
- Resolution 2’ at 10 GeV (factor > 3 better than EGRET for E > 1 GeV)

GLAST Gamma-Ray Sky

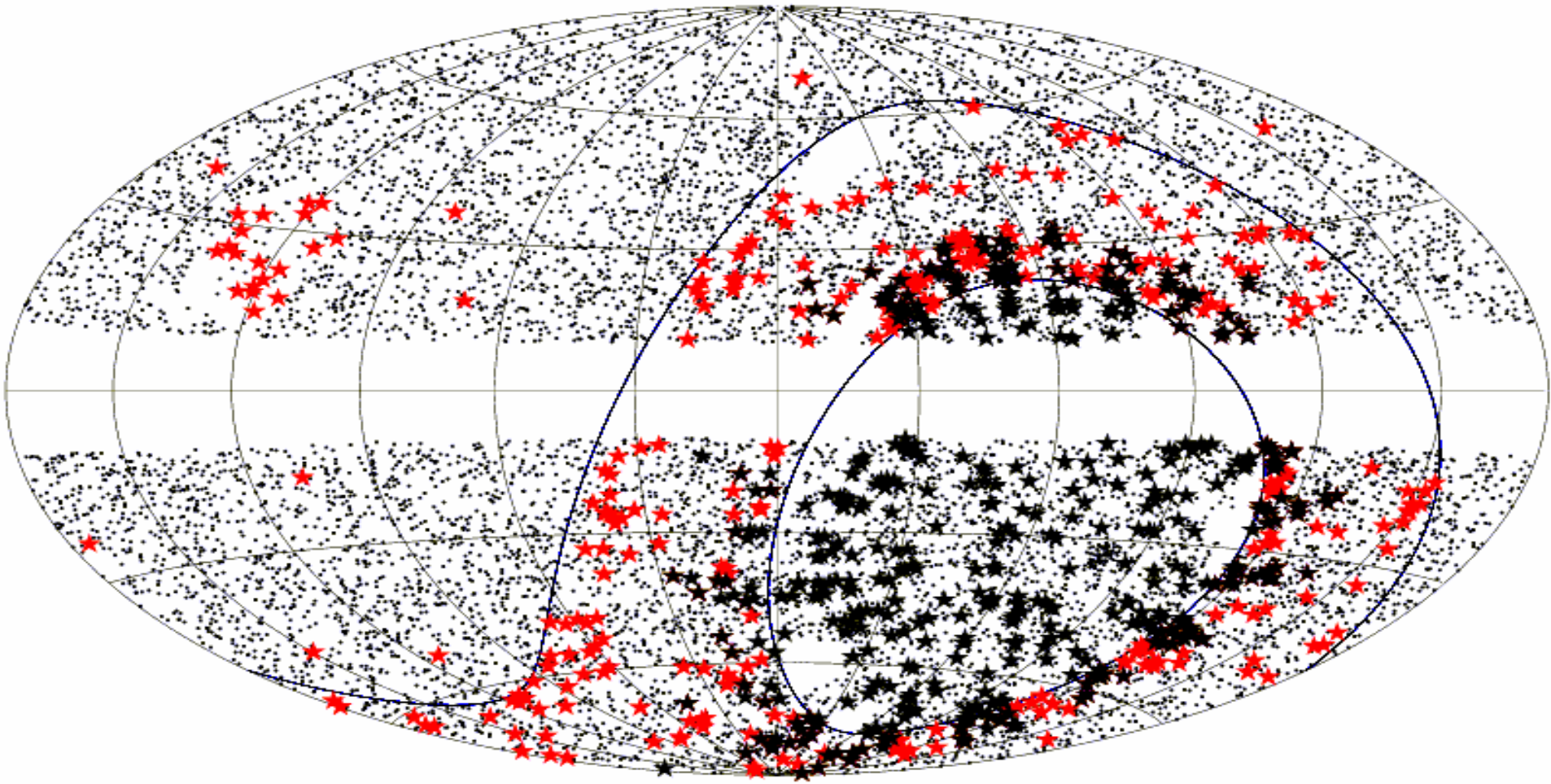


GLAST (2007)

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

Radio Target List

- Selection $S_{4.8}$>65mJy, |b|>10^0, α<0.5 -- CLASS+
  - 10,931 srcs [99.9% obs, finished w/ VLA run last month (orange)]
  - Attempts to fill in PMN holes w/ S5, lower ν-selected sources
  - `CLASSIER'? CLASS Including Extra Regions



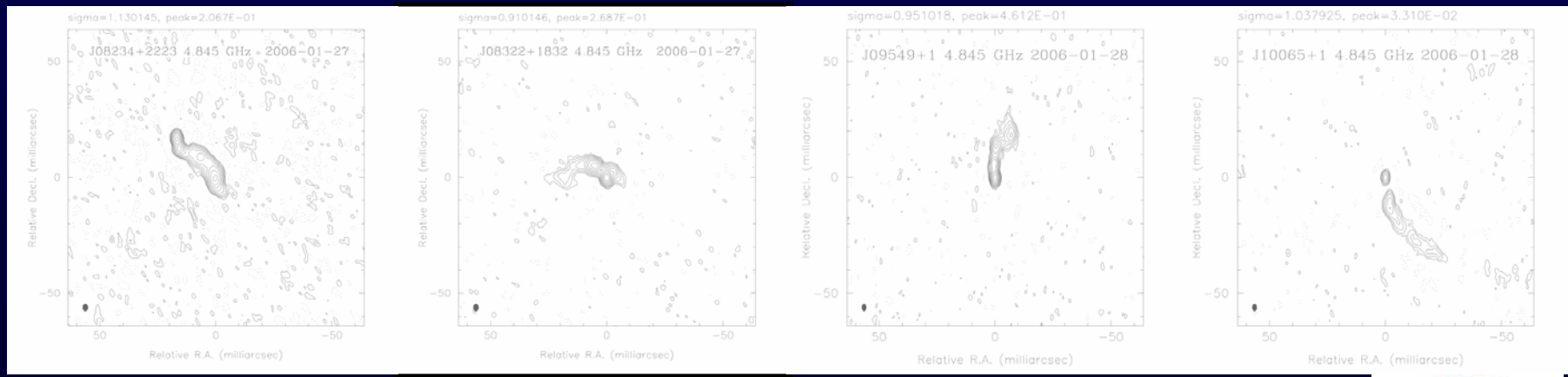
Downselect to CGRaBS

- Use FoM ($S_{8.4}$, α, S_X) trained against 3EG
- Candidate Gamma-Ray Blazar Survey
  - 1520 sources
  - These are the best and brightest of the EGRET-like Blazars
- Optical Follow-up – Hard work!
  - Archival/SDSS
  - Most at McDonald Observatory (HET/2.7m)
  - Handful w/ Palomar 5m, trying for some 10m time
  - Some CTIO in South, few on SALT queue
  - ESO NTT (4nights August) requesting more NTT, VLT time

VLBI Imaging in Preparation for GLAST

VLBA Imaging Polarimetry Survey (VIPS)

- 1127 sources: S > 90 mJy, 65 > dec > 20, |b|>10 at 5 GHz
  in SDSS northern cap
- First epoch observations on the VLBA in 2006
- Identifications and redshifts from SLOAN, HET, Palomar, …
- Goals:
  - Characterize GLAST sources
  - Understand polarization properties of AGN classes
  - Study AGN environments
  - Find close binary black hole systems



http://www.phys.unm.edu/~gbtaylor/VIPS/

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VIPS - VLBI Imaging and Polarimetry Survey

The VIPS team is:

Greg Taylor (UNM/NRAO),
Joe Helmboldt (UNM),
Steve Healey (Stanford),
Steve Myers (NRAO),
Tim Pearson (Caltech),
Neil Gehrels (NASA GSFC),
Peter Michelson (Stanford),
Chris Fassnacht (UCD),
Larry Weintraub (Caltech)
Craig Walker (NRAO),
Lorant Sjouwerman (NRAO),
Tony Readhead (Caltech),
Roger Romani (Stanford),
Roger Blandford (KIPAC)

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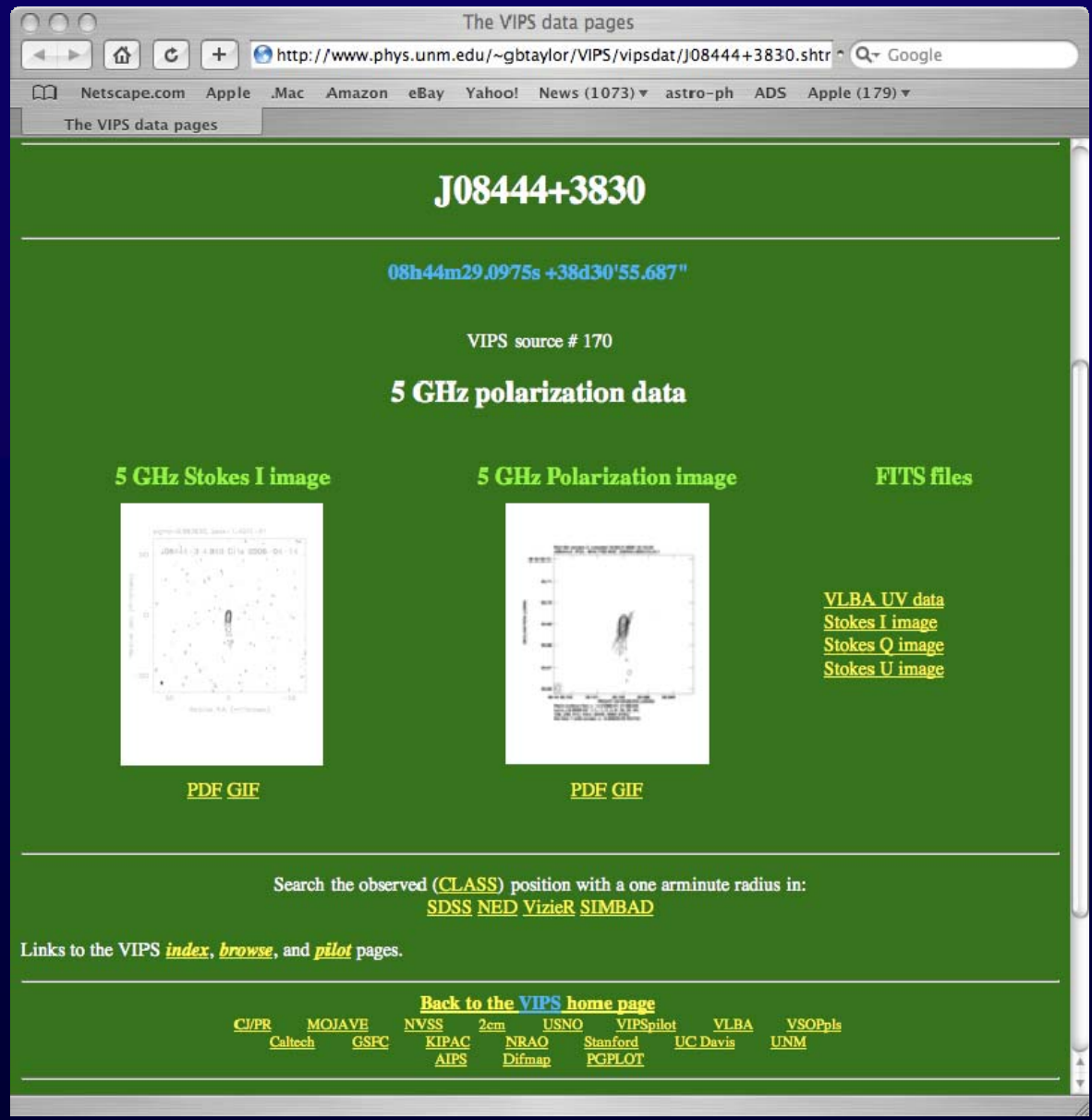
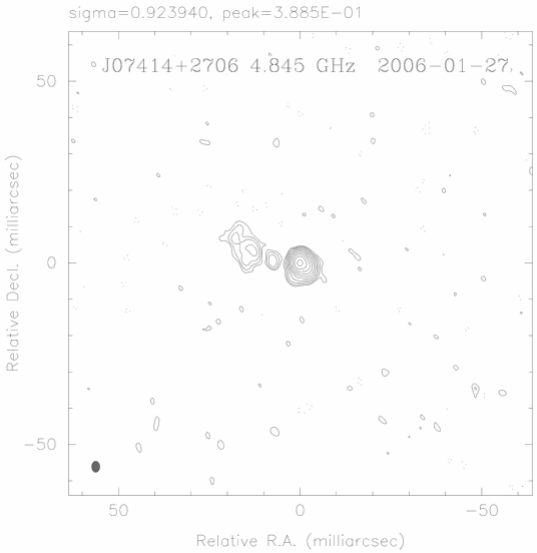
VIPS on the web

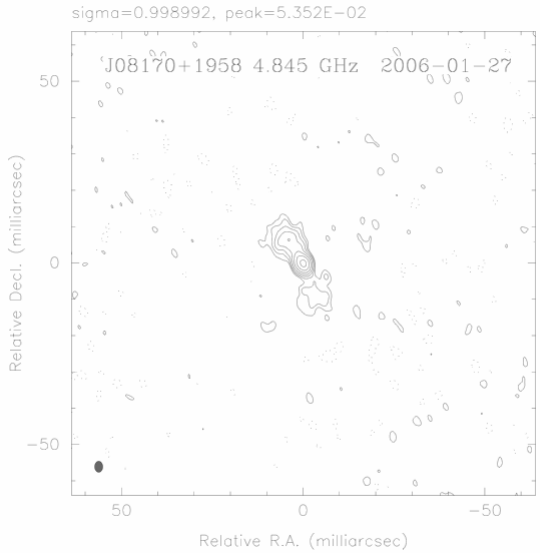
432 new sources correlated to date

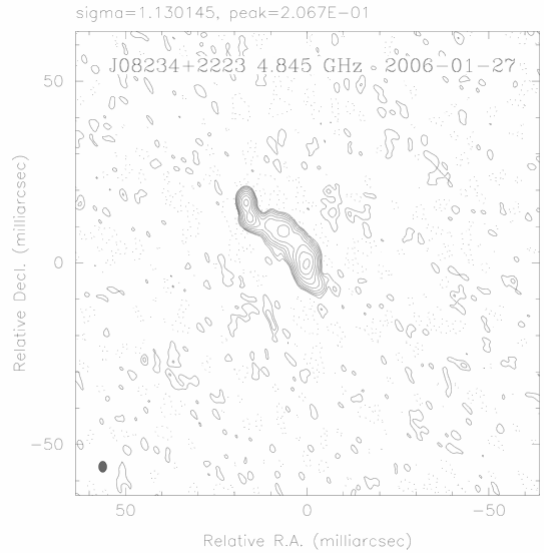


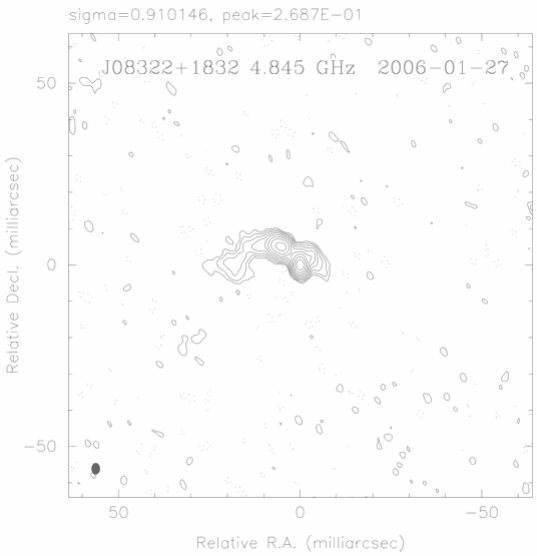
http://www.phys.unm.edu/~gbtaylor/VIPS/

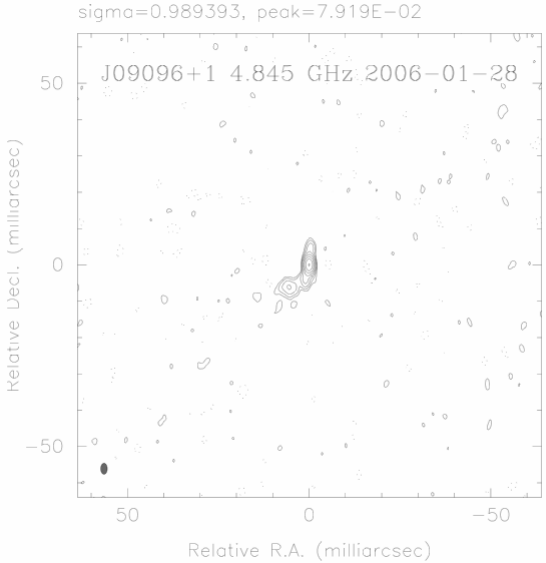
Oddballs in VIPS

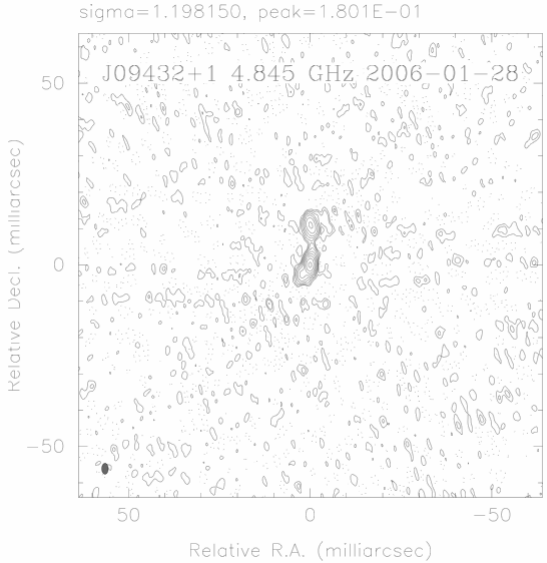




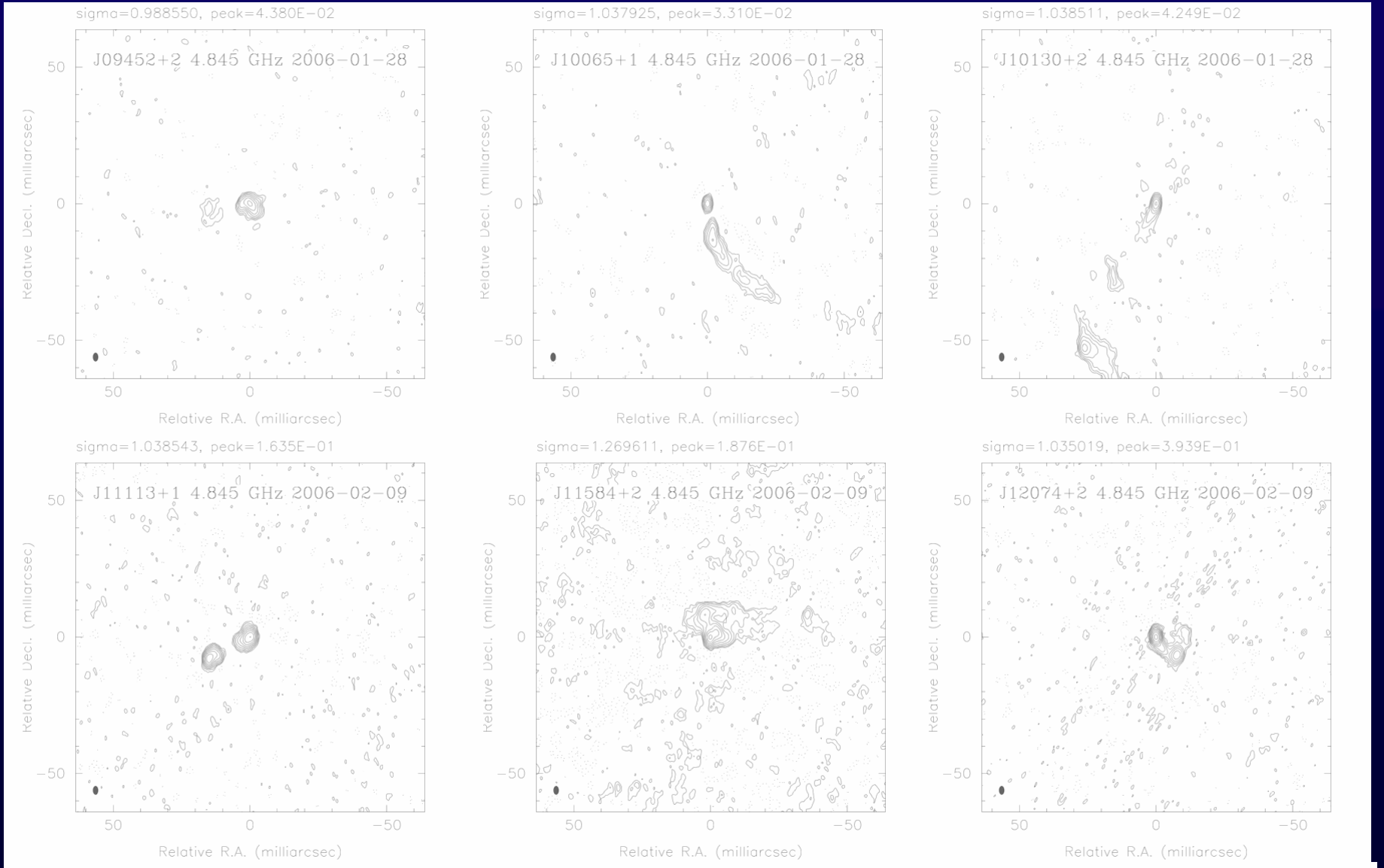








Oddballs in VIPS page 2



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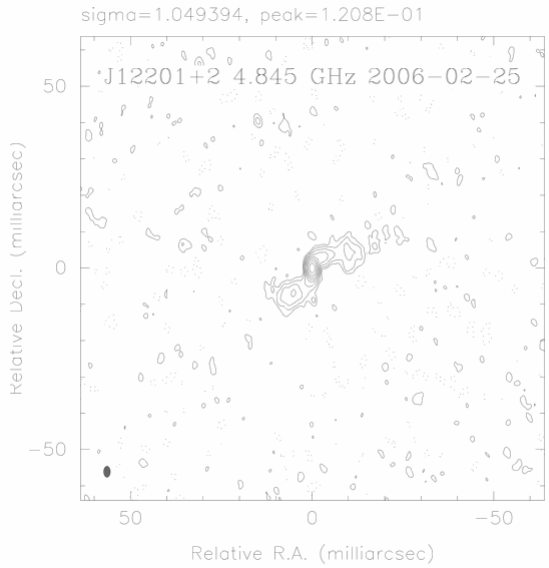
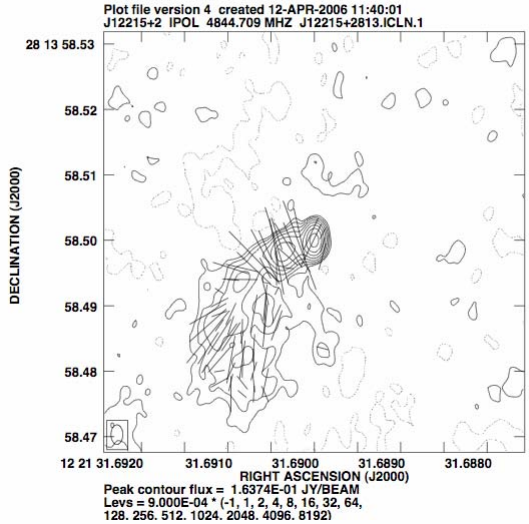
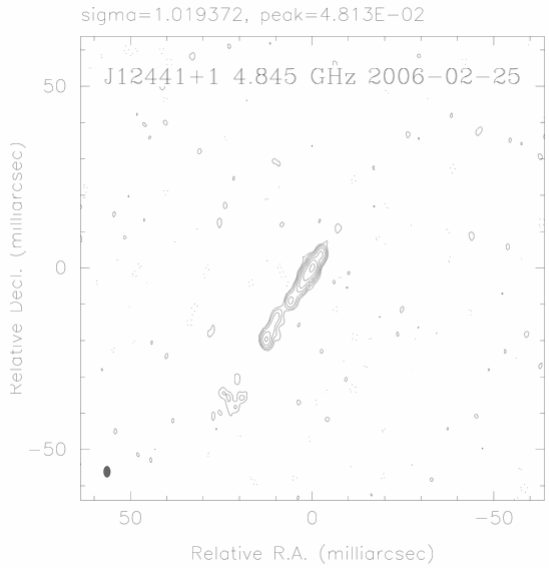
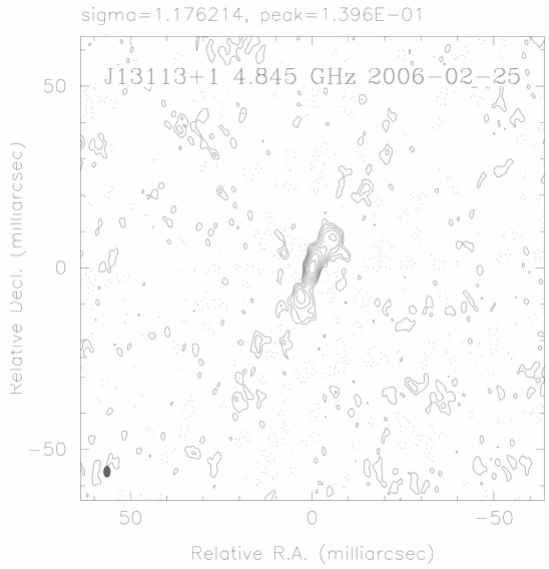
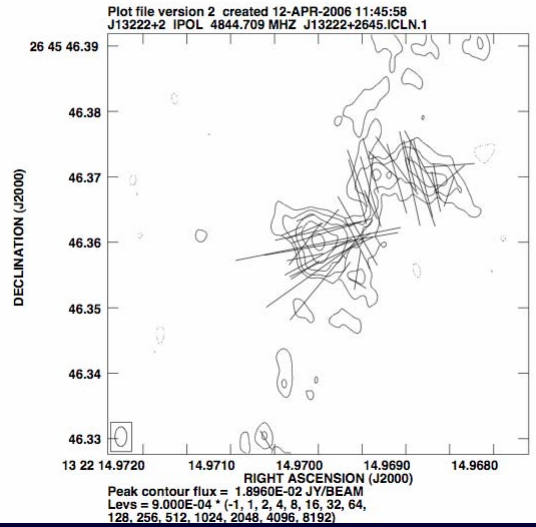
Oddballs in VIPS page 3

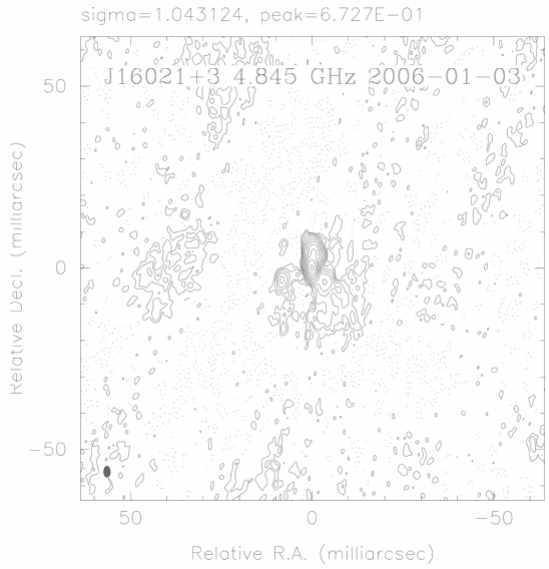












Previous AGN surveys at mas resolution

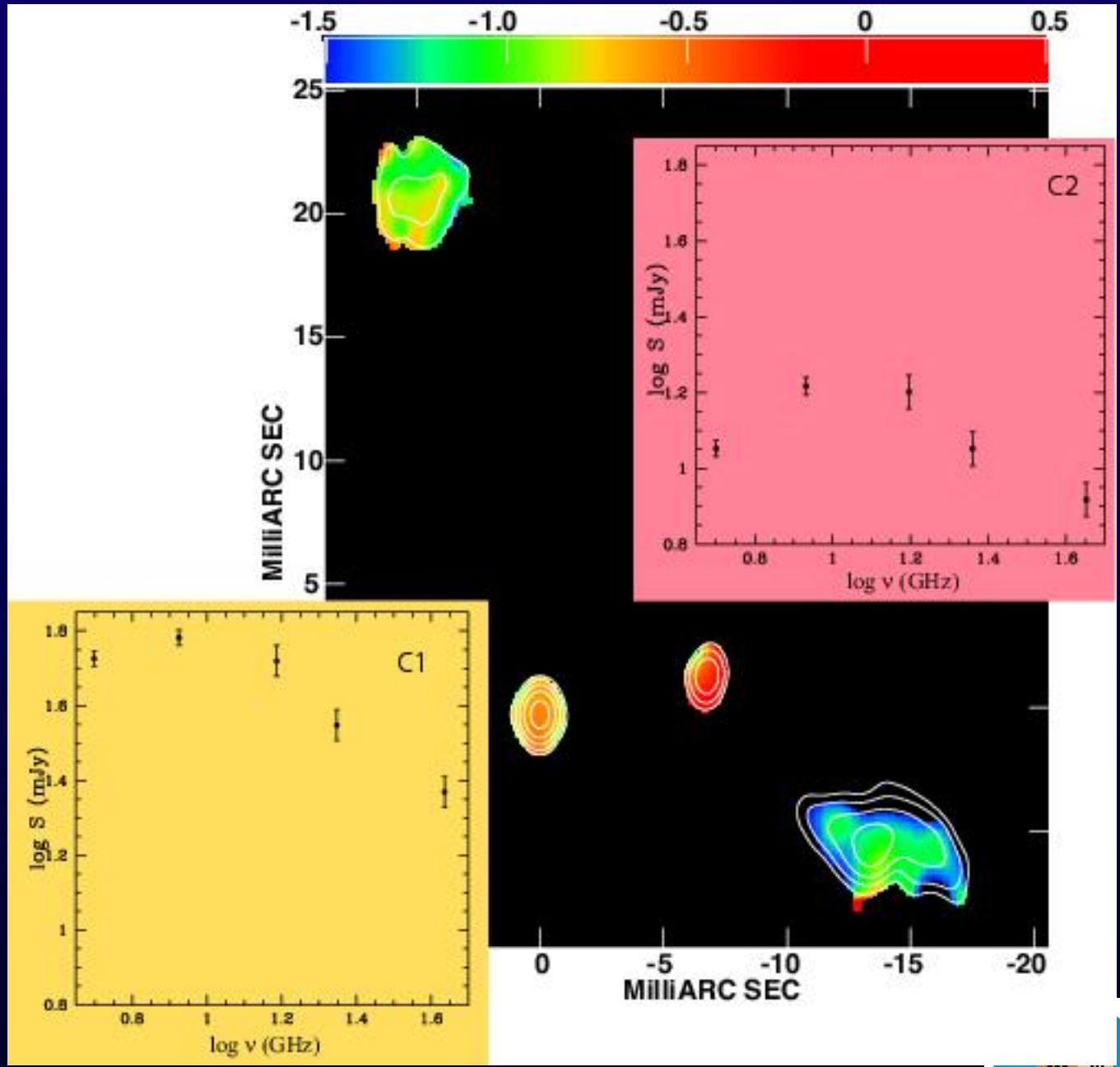
Pearson-Readhead (PR - 1988): 5 GHz, 35 sources
Caltech-Jodrell Bank (CJ1 - 1995): 1.7 and 5 GHz, 65 sources
Second Caltech-Jodrell Bank (CJ2 - 1994): 5 GHz, 192 sources
CJ Flat spectrum (CJF – 1996): 5 GHz, 293 sources
VLBA 2cm survey (2000): 15 GHz, 132 sources
VSOP pre-launch survey (1998): 5 GHz, 374 sources
USNO geodetic survey (2004): 2.2 and 8GHz, 452 sources

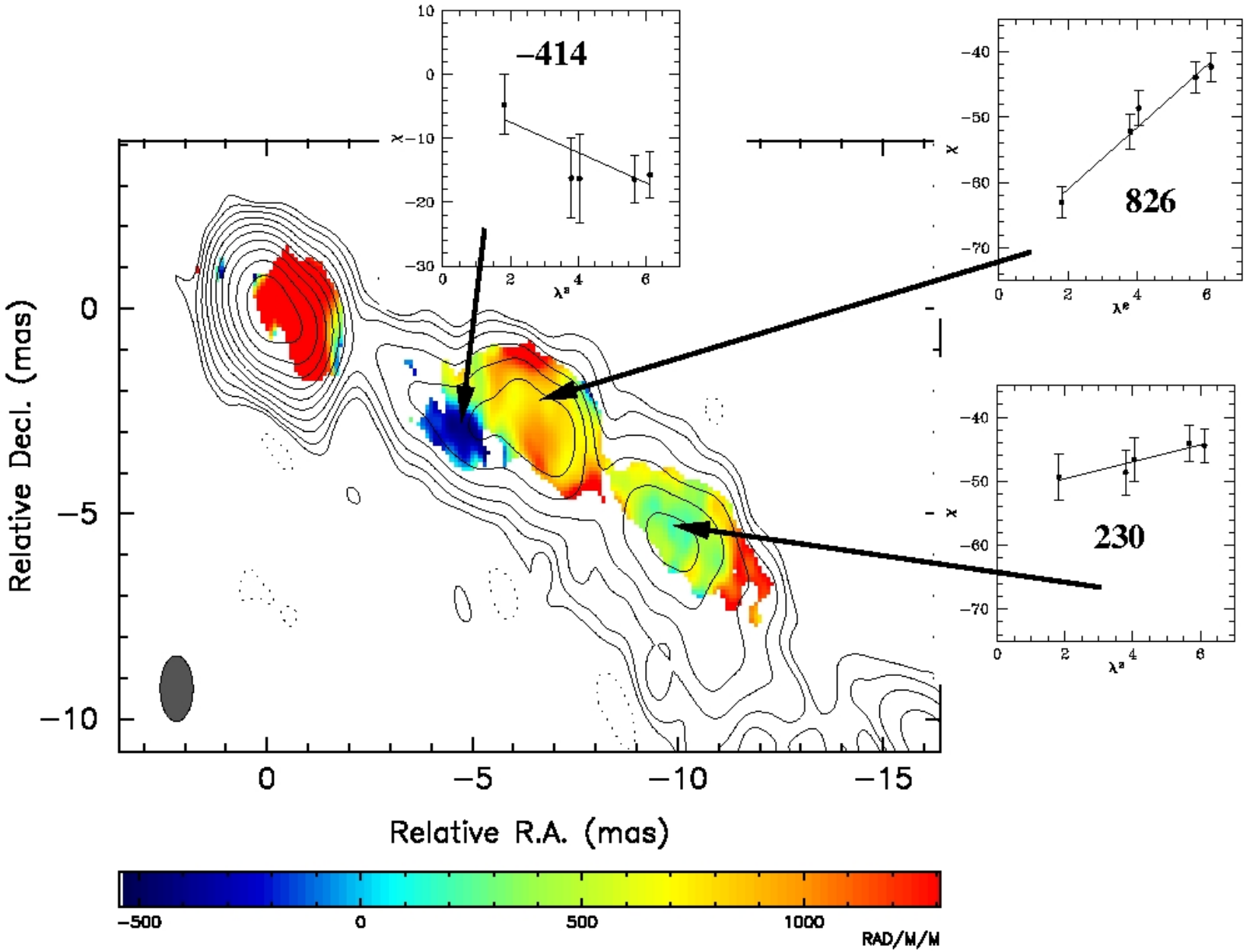
Polarization: partial observations at a single frequency for PR and CJF
Multi-epoch: PR, CJ, VLBA 2cm, USNO, MOJAVE

0402+379

Rodriguez et al. 2006

A Close Binary Black Hole

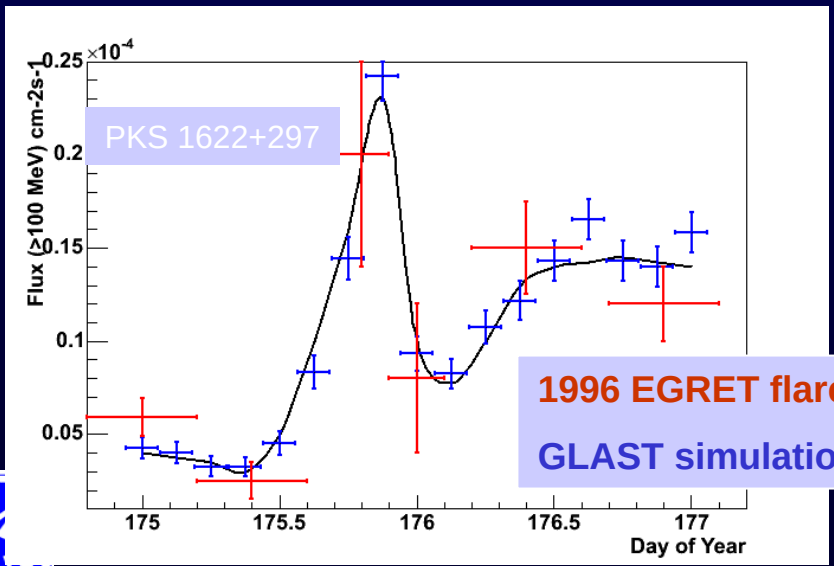


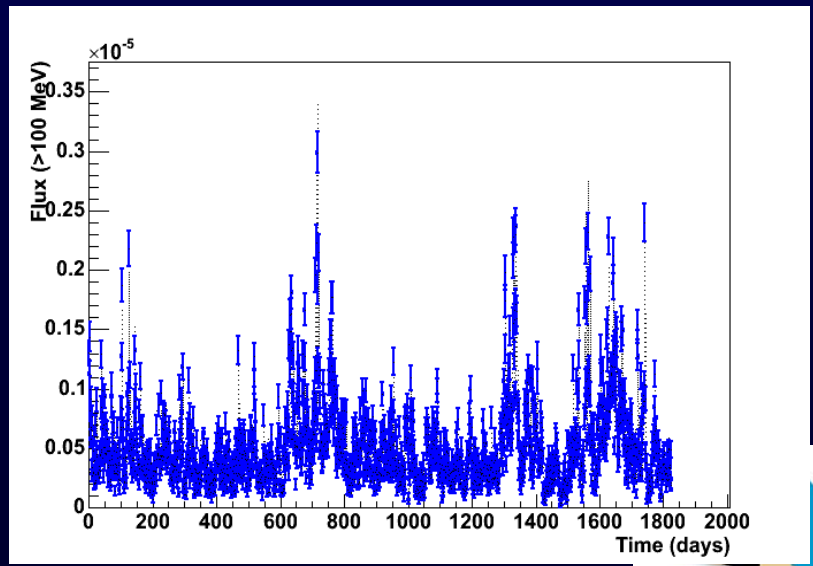

−414
826
230
χ
λ²
Relative Decl. (mas)
Relative R.A. (mas)
0
−5
−10
−15
−500
0
500
1000
RAD/M/M

Multi-wavelength observations of AGNs

- The large FOV will allow GLAST to catch AGN flares consistently:

  - Many EGRET sources were only observable during flares, GLAST will provide detailed lightcurves on a wide range of timescales during flares and quiescent states
  - GLAST can serve as a trigger for observations at other wavelengths, including a VLBA monitoring campaign
  - VIPS provides a reference epoch for ~1000 gamma-ray bright AGN





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GLAST and Community

- Data release plan:
  - All transients sources are immediately public
  - During the first 12 months of science operations, data from specific sources of interest will be made available: (Preliminary) 0208-512, PKS 0528-134, Mrk 421, 3C273, 3C279, etc…
  - After the first 12 months of science operations, GLAST data is public

- Multi-wavelength observations are required for maximum scientific return:
  - VLBI studies of jet motions, broadband SED modeling
  - For transients and unidentified sources, having simultaneous observations may be the only way of positive identification
  - Redshift determination is fundamental to many studies.

Conclusions

- GLAST will increase the γ-ray source catalog by > 30
- Efficient observing mode, improved sensitivity and increased effective area combine to provide superb monitoring of the GeV sky on timescales from hours to years
- GLAST observations will result in a deeper understanding of:
  - Acceleration and emission mechanisms of AGNs
  - Test of the unification model and blazar sequence
  - Luminosity function of γ-ray sources and its cosmic evolution
- GLAST is coming soon, we should be prepared to maximize the science return