Radio Transients, Surveys and GLAST

(some slides taken from R. Dubois 11 Aug 05 talk)

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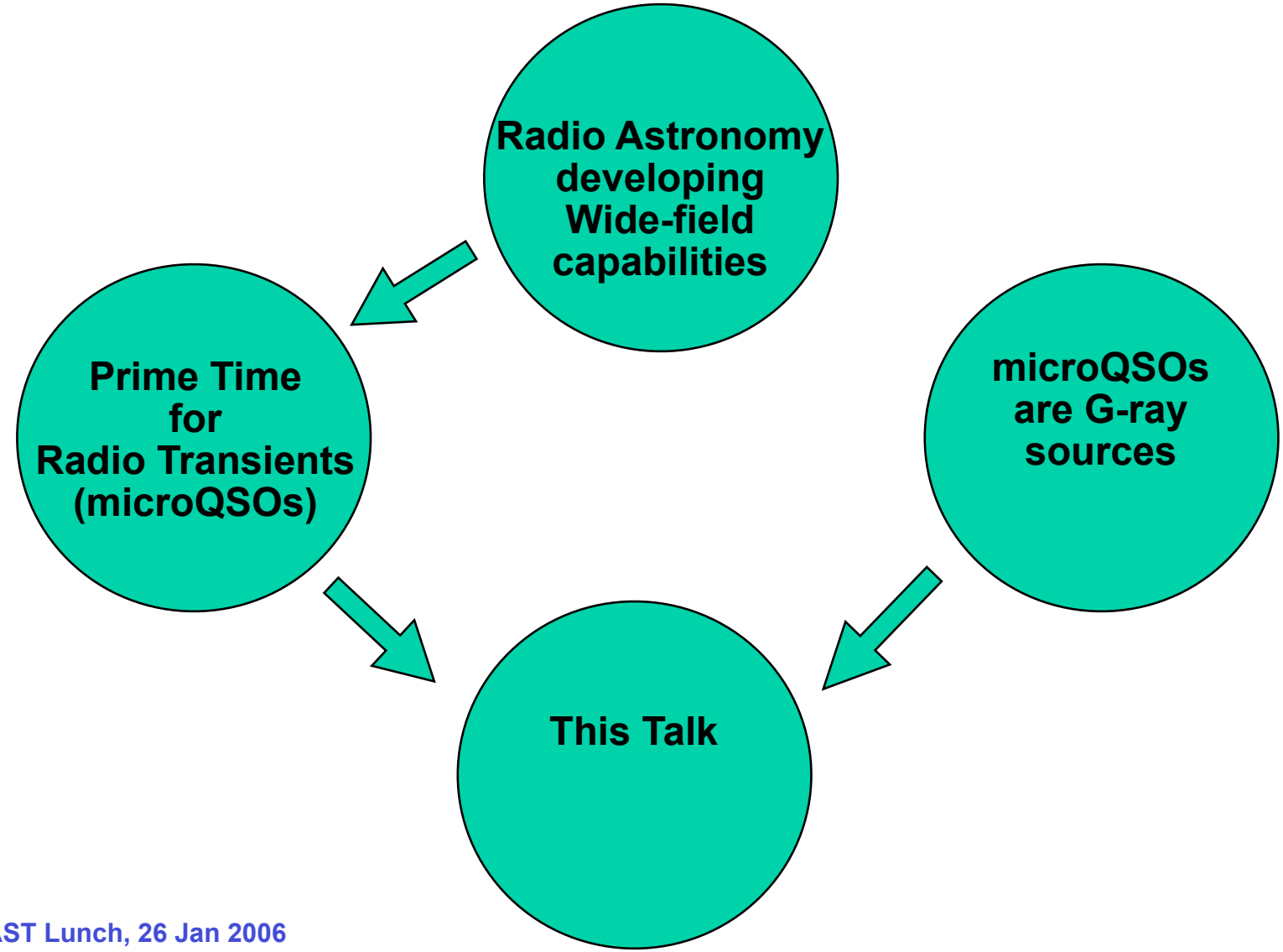
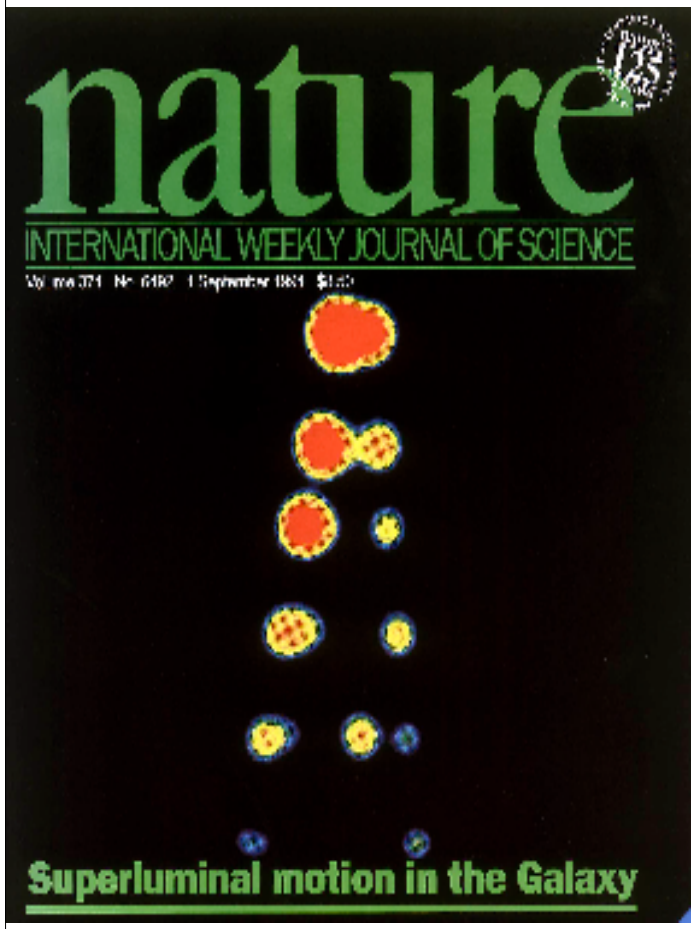
Executive Summary

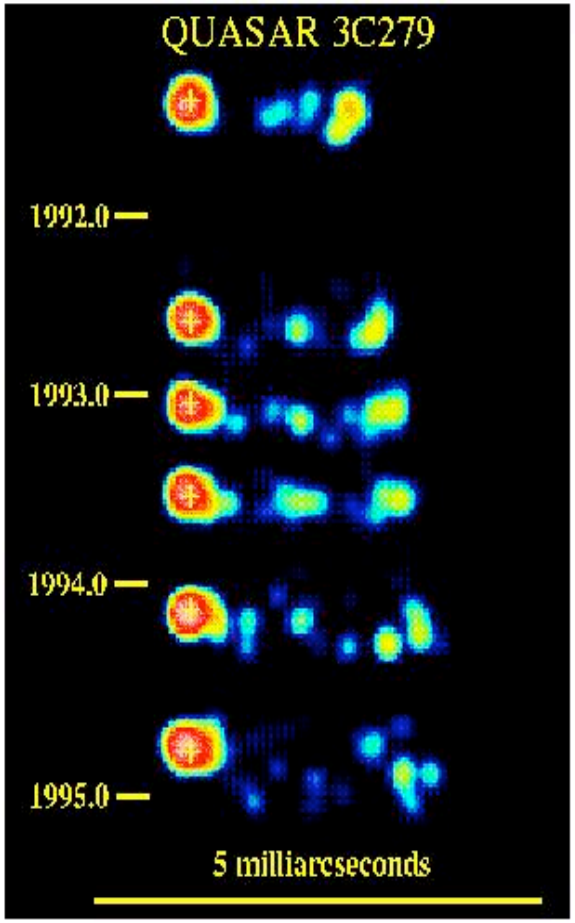


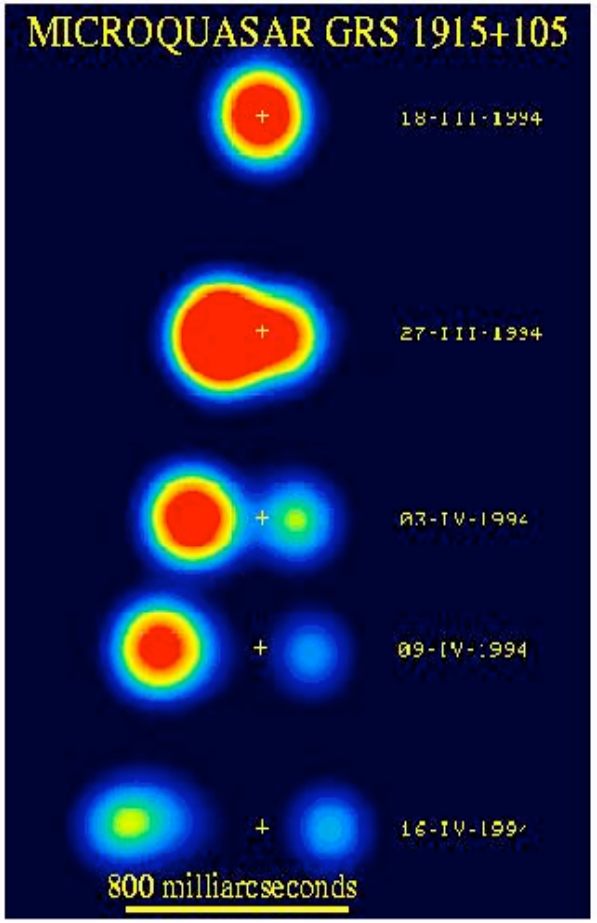
Radio Transients and GLAST

- **Motivation 1:**
  - Various known classes of radio transients (see Cordes et al. 2004, NewAR): Sun, Jupiter, Brown dwarfs, Crab and other pulsars, X-ray binaries (microQSOs), blazars, GRBs
- **Motivation 2:**
  - X-ray binaries are under-explored as potential gamma-ray sources: see e.g. R. Dubois, 11 Aug 05 (LS 5039 with HESS) and P. Nolan, 17 Nov 05 (Cyg X-3)
  - Gamma-rays connected to relativistic (radio) jets
- **Impeding Factors**
  - Few `persistent' radio emitting XRBs (up to ~2 dozen) with already low duty cycles (but we know where to point)
  - Association of XRBS with 3EG sources weak
- **But Why Now?**
  - Radio astronomy moving toward "All-Sky" capability
  - Coordinated "real-time" radio/GLAST scans can reveal a substantial population of XRBs (cf. EGRET on blazars)

Quasars/microQuasar (XRB) Analogy



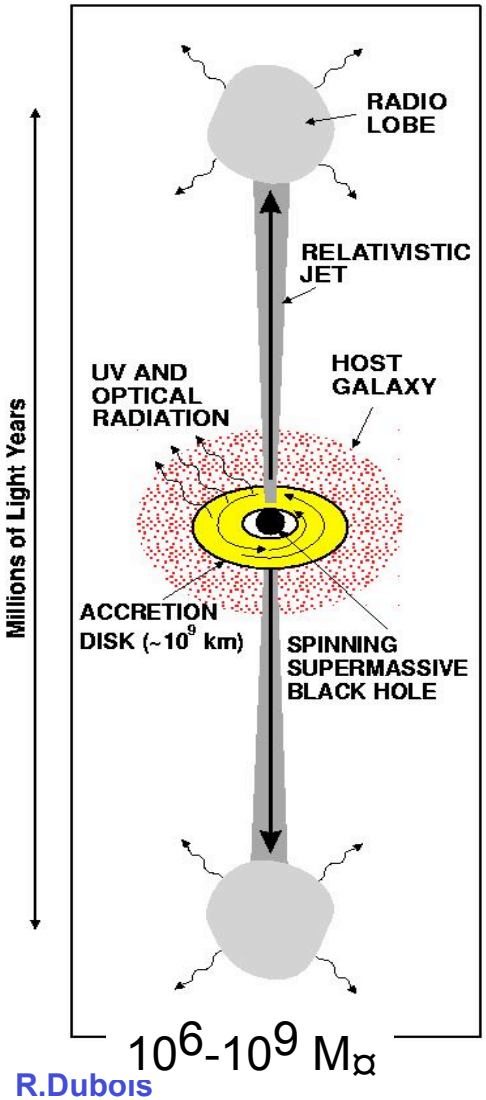




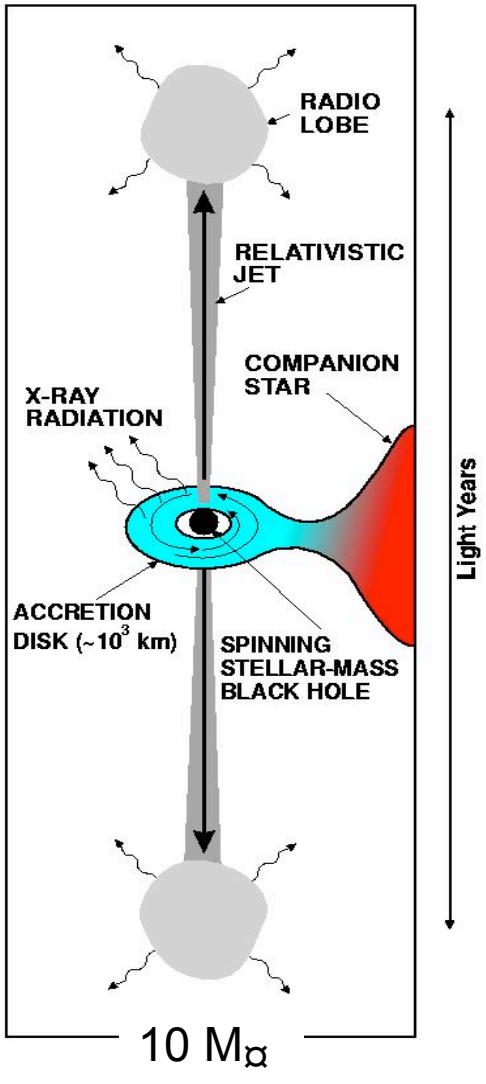
Mirabel & Rodriguez 1994
B.G. Piner et al. for 3C279

QUASAR-MICROQUASAR ANALOGY

QUASAR



MICROQUASAR



M. & L.F. Rodriguez; Nature 1992, 94, 98

The scales of length and time are proportional to M_{BH}

$R_{sh} = 2GM_{BH}/c^2$; $\Delta T \alpha M_{BH}$

The maximum color temperature of the accretion disk is:

$T_{col} \alpha (M/ 10M_{¤})^{-1/4}$

(Shakura & Sunyaev, 1976)

For a given accretion rate:

$L_{Bol} \alpha M_{BH}$; $l_{jet} \alpha M_{BH}$;

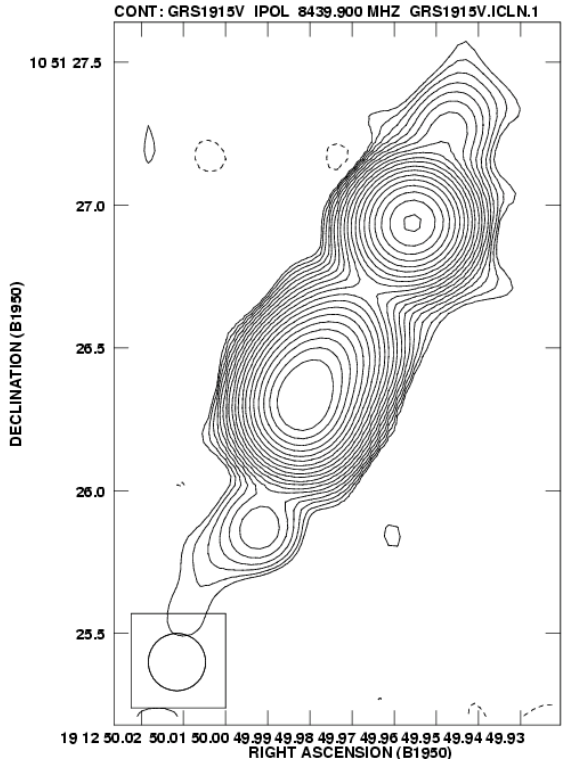
$\varphi \alpha M_{BH}^{-1}$; $B \alpha M_{BH}^{-1/2}$

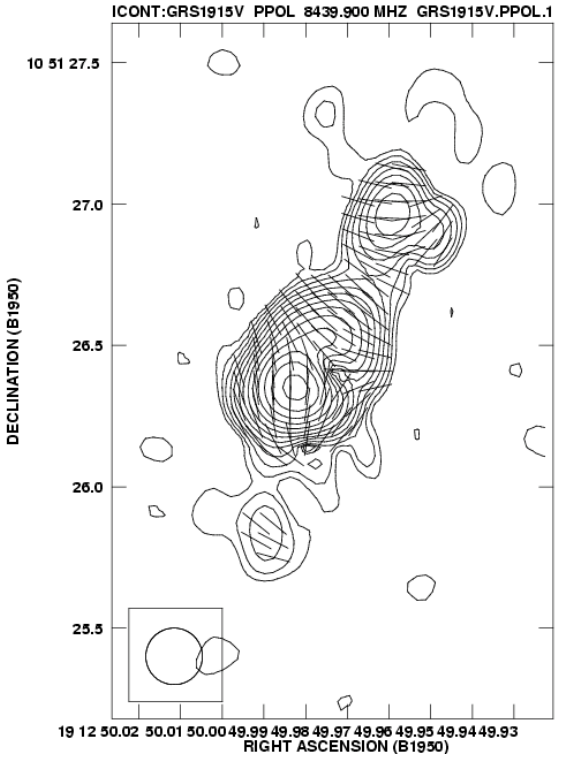
(Sams, Eckart, Sunyaev, 96; Rees 04)

From Mirabel: Hong Kong 2003

Quasar/microQuasar Analogy

- Microquasars are the `radio-loud' X-ray binaries
- Radio emission from relativistic jet (power-law, polarized -> synchrotron radiation)
- X-rays argued as extension of radio synchrotron PL (Markoff et al. 01) and can be resolved by Chandra (Corbel et al. 02, 05)





C.C. Cheung (in prep)

LS 5039: Relativistic Radio Jet

Paredes: Science 288 (2000) 2340

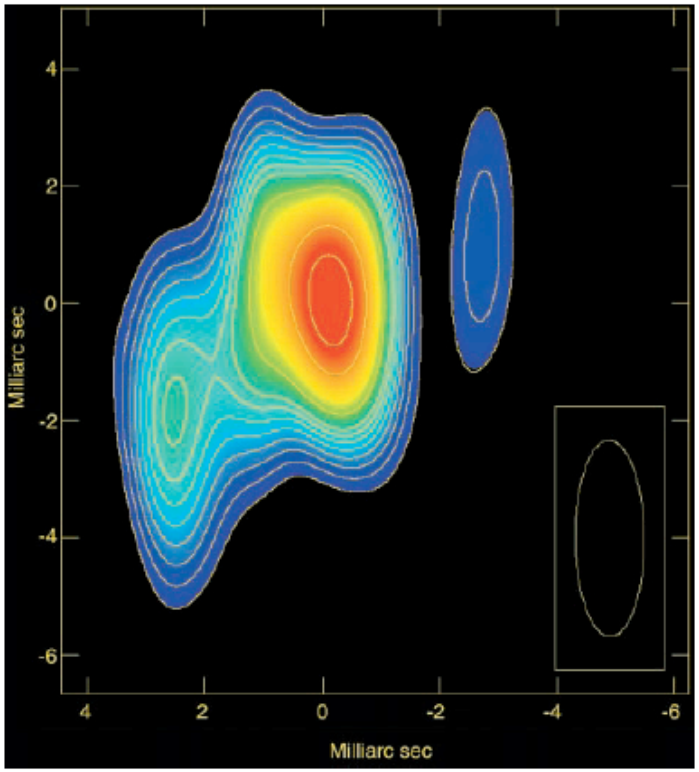


Fig. 1. High-resolution radio map of the nearby star LS 5039 obtained with the VLBA and the VLA in phased array mode at 6-cm wavelength. The presence of radio jets in this high-mass x-ray binary is the main evidence supporting its microquasar nature. The contours shown correspond to 6, 8, 10, 12, 14, 16, 18, 20, 25, 30, 40, and 50 times 0.085 mJy per beam, the rms noise. The ellipse at the bottom right corner represents the half-power beam width of the synthesized beam, 3.4 × 1.2 (milliarc sec^2) with a PA of 0°. The map is centered at the LS 5039 position $\alpha_{J2000} = 18^h26^m15.056^s$ and $\delta_{J2000} = -14°50'54.24''$. North is at the top and east is at the left. One milliarc sec is equivalent to 4.5 × 10^{13} cm (3 AU) for a distance of 3 kpc.

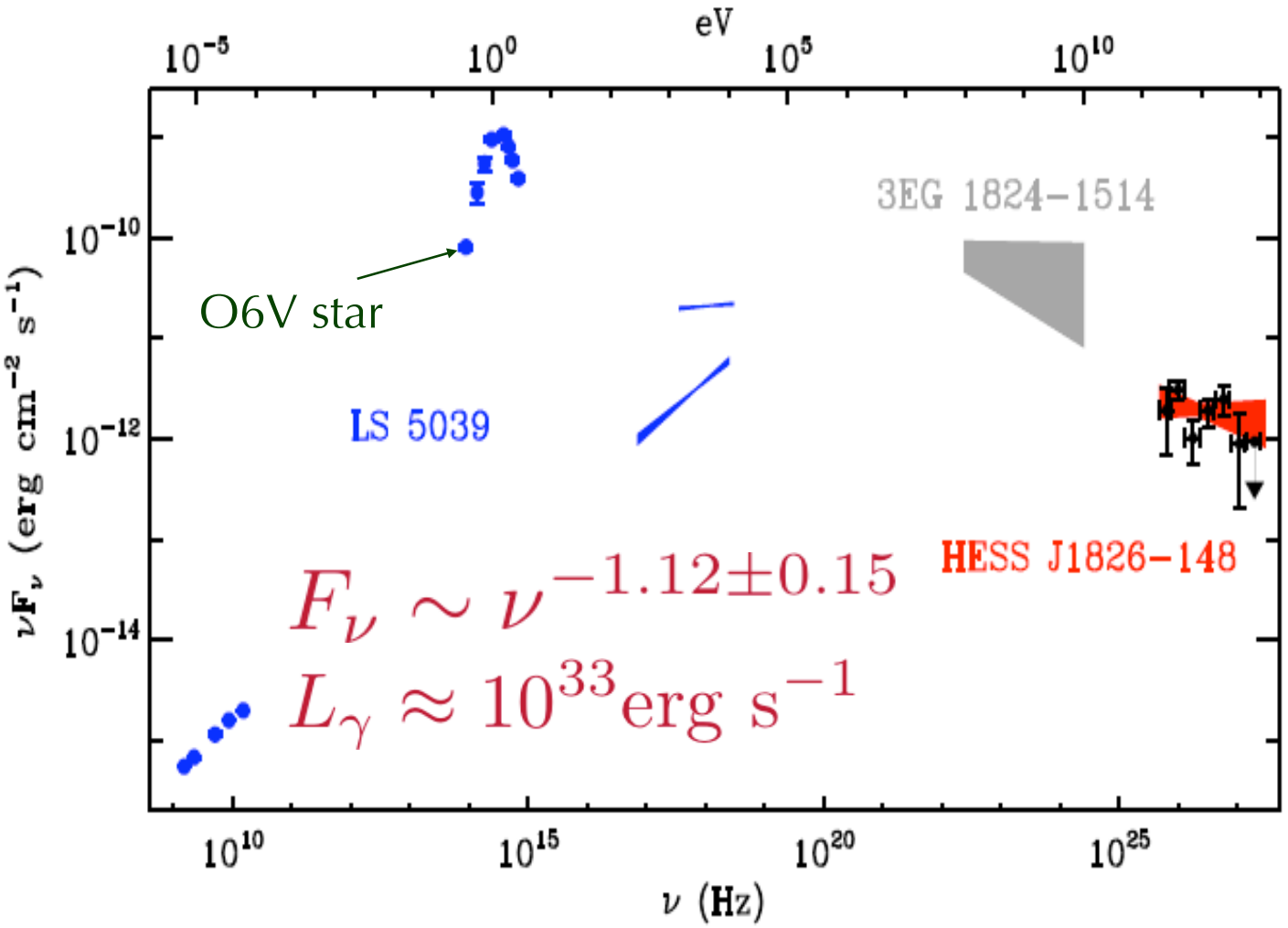
VLBA/VLA radio map

They assume these are 2 jets with Doppler boosting affecting apparent luminosity.

2:1 density difference à
v > 0.15 c

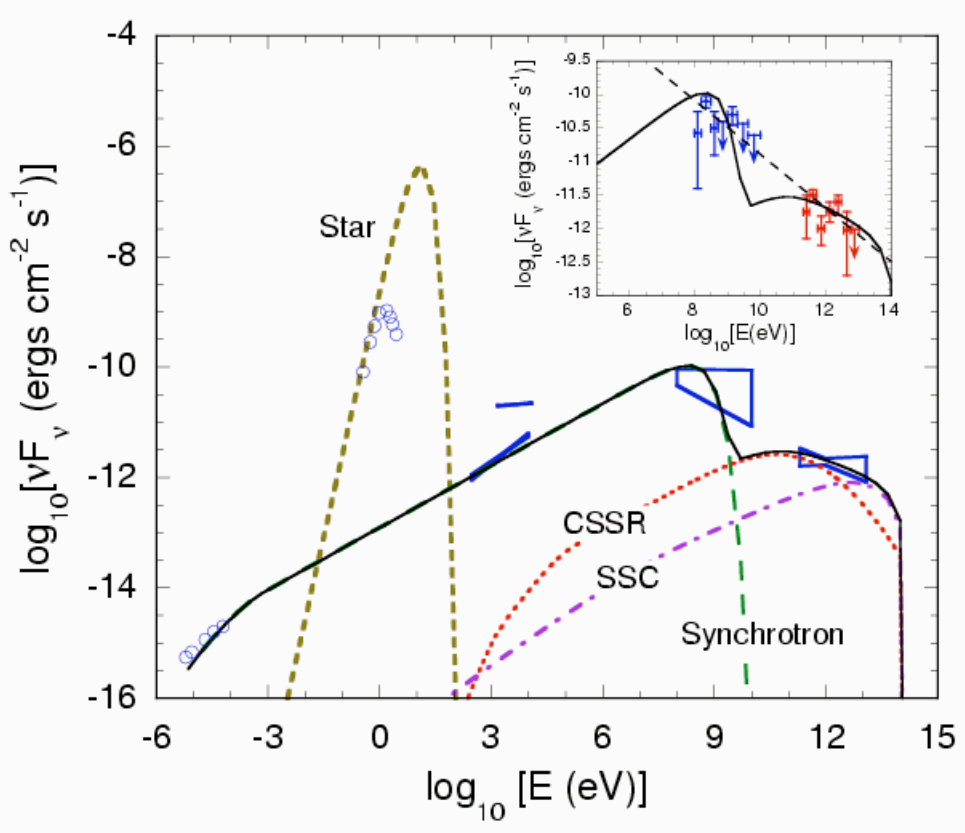
Hence = microQuasar!

H.E.S.S. spectrum: hard



Aharonian et al., Science (in press)

Synchrotron + Compton Models



Dermer & Bottcher (astro-ph/0512162)
see also
Bosch-Ramon & Paredes 04a,b
Georganopoulos et al. 02

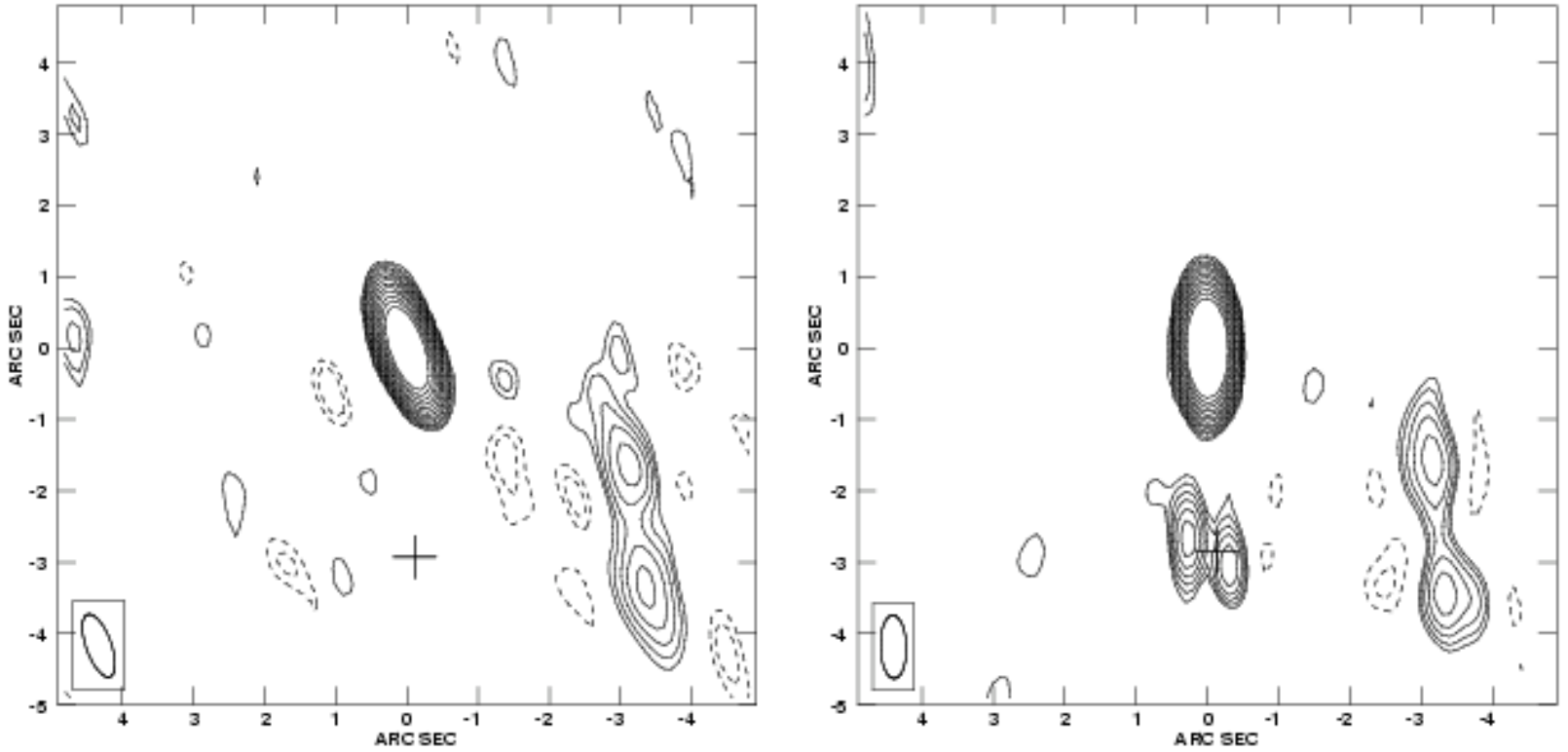
- **Radio-to-GeV (synch) + Compton Scattered Stellar Radiation (from the companion) for TeV**
- **Requisite radio emission**

What is the uQSO Contribution to GLAST?

- Few uQSOs known (~16; Paredes astro-ph/0409226)
- Current `sensitivity' to radio transients poor
  - Figure of merit for transients (Cordes et al. 04):
  - Field of View * Collecting area * Int. Time / Time resolution
  - Radio FOV is main bottleneck (but not for long)
  - Radio observations triggered on X-rays or else serendipitous discoveries of well-visited sky regions (galactic center)
- New radio arrays WILL find new uQSOs
- Coordination of scans/campaigns (e.g. galactic plane) with X-ray missions and GLAST (variable and short lived)
- Gamma-rays with GLAST could have same impact on XRB/ uQSO understanding as Compton/blazars

Galactic Center Radio Transients

- Transient searches concentrated over small fields
- Most recent RT 0.1pc from Sgr A* (Bower et al. 05)
- 2 others known: Zhao et al. 92 and Hyman et al. 02
- Rapid rise followed by slow decay (month scale)



Bower et al. 05

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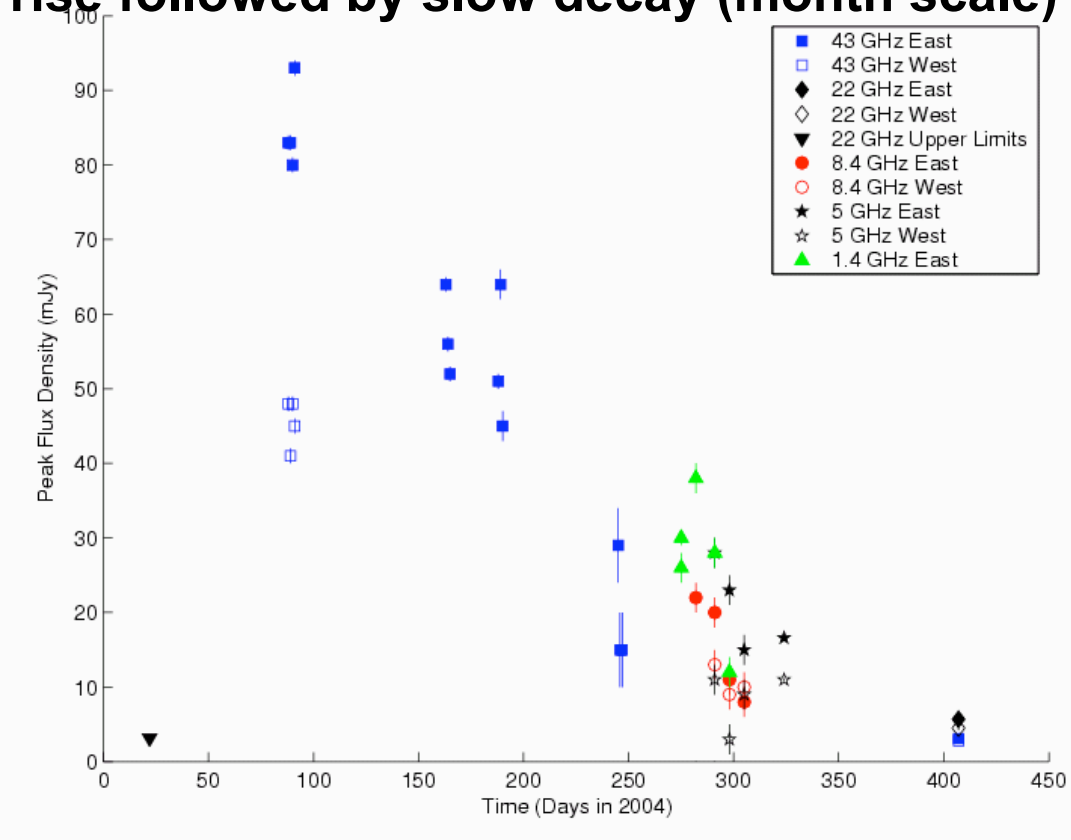
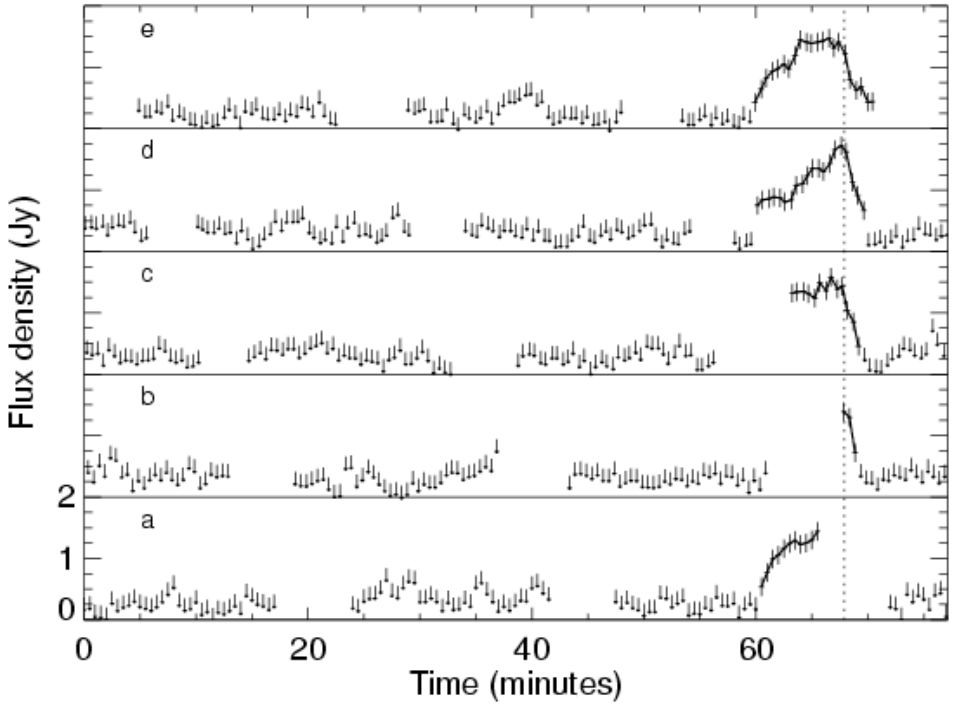


Bower et al. 05

Radio-based Classification of Gamma-Sources

- Timing in gamma-rays not likely; radio/X-ray can more easily
- Radio bursts from uQSOs show rapid rise, slow decay over longer timescales (weeks/months)
- RAdio Transients are also Pulsed (Rotating RATs) - GCRT J1745-3309, Hyman et al. 05; also McLaughlin et al. astroph/ 0511587



Hyman et al. 05

-GCRT J1745 is ~1.25d from GC

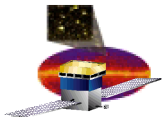
-Five ~10 min. burst, P~1.27 hr

-3EG J1744-301 (Mayer-Hasselwander et al. 98) in error circle (~20') but dense region (cf. Nolan on Cyg X-3)

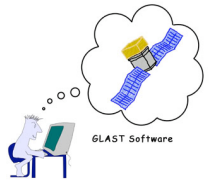
Existing Radio Surveys

- **NVSS (NRAO VLA Sky Survey)**: 1400 MHz (dec > -40d), 50”
- **VLSS (VLA Low-freq Sky Survey)**: 74 MHz (dec > -30d), 80”
- **WENNS (Westerbork Northern SS)**: 326 MHz (dec > +30d), ~60”
- **SUMMS (Sydney Uni Molonglo SS)**: 843 MHz (dec < -30d), ~40”
-
- **FIRST (NRAO)**: 1400 MHz (patchy coverage), 5” resolution
-
- **MAGPIS (Multi-Array Galactic Plane Imaging Survey)**: 5000,1400, 325 MHz (Gal. Plane), various resolution

NRAO/VLA and WENNS: http://lwa.nrl.navy.mil/VLSS/
http://www.astrop.physics.usyd.edu.au/SUMSS/
MAGPIS: http://third.ucllnl.org/gps/

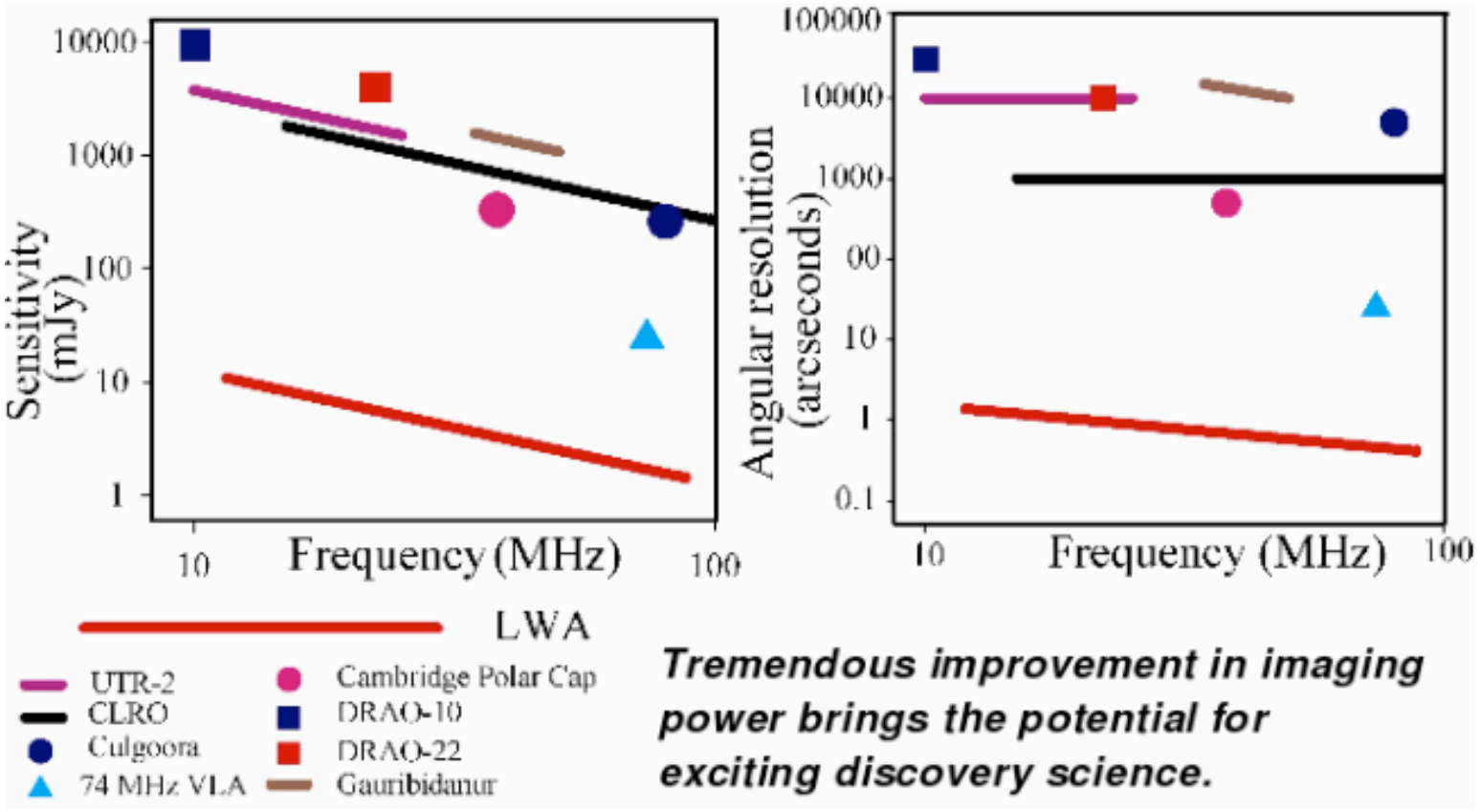


We Need Large Field of Views



- Large N (# antennas) - small D (diameter) now practical ``Digital Radio Telescopes''
- Previous All-Sky Maps took 1000's hours (NVSS=3000 hrs, VLSS~750 hrs) now reduced by order of magnitude
-
- Long Wavelength Array (LWA) - 10's-100 MHz
  - www.phys.unm.edu/~lwa/
- Mileura Widefield Array (MWA) - 80-1600 MHz
  - web.haystack.edu/arrays/MWA/
- Allen Telescope Array (ATA, 350 x 6.1m) ~1-10 GHz
  - astron.berkeley.edu/ral/ata/
- LOFAR and SKA
  - www.lofar.org/
  - www.skatelescope.org/

Long Wavelength Array



www.phys.unm.edu/~lwa/

Summary

- Transient sources REQUIRE contemporaneous observations
- "Non-dedicated" radio observatories becoming available to coordinate scans/campaigns on transient radio/X-ray/g-ray sources (galactic plane, gal. center)
  - develop strategies/agreements with LWA, MWA, ATA
  - GLAST unlikely to trigger : radio/X-ray can (TOO proposals with VLA, MERLIN, VLBA?)
- Well poised for high impact studies of microQSOs and other transient radio/X-ray sources (as CGRO had on blazars)
  - Predictions for g-rays from current few examples?
  - Radio luminosity proxy for g-rays?
  - uQSO extension of Fossati blazar diagram?
  - understand the ``fundamental plane" BH mass/X-ray/radio for BH systems?