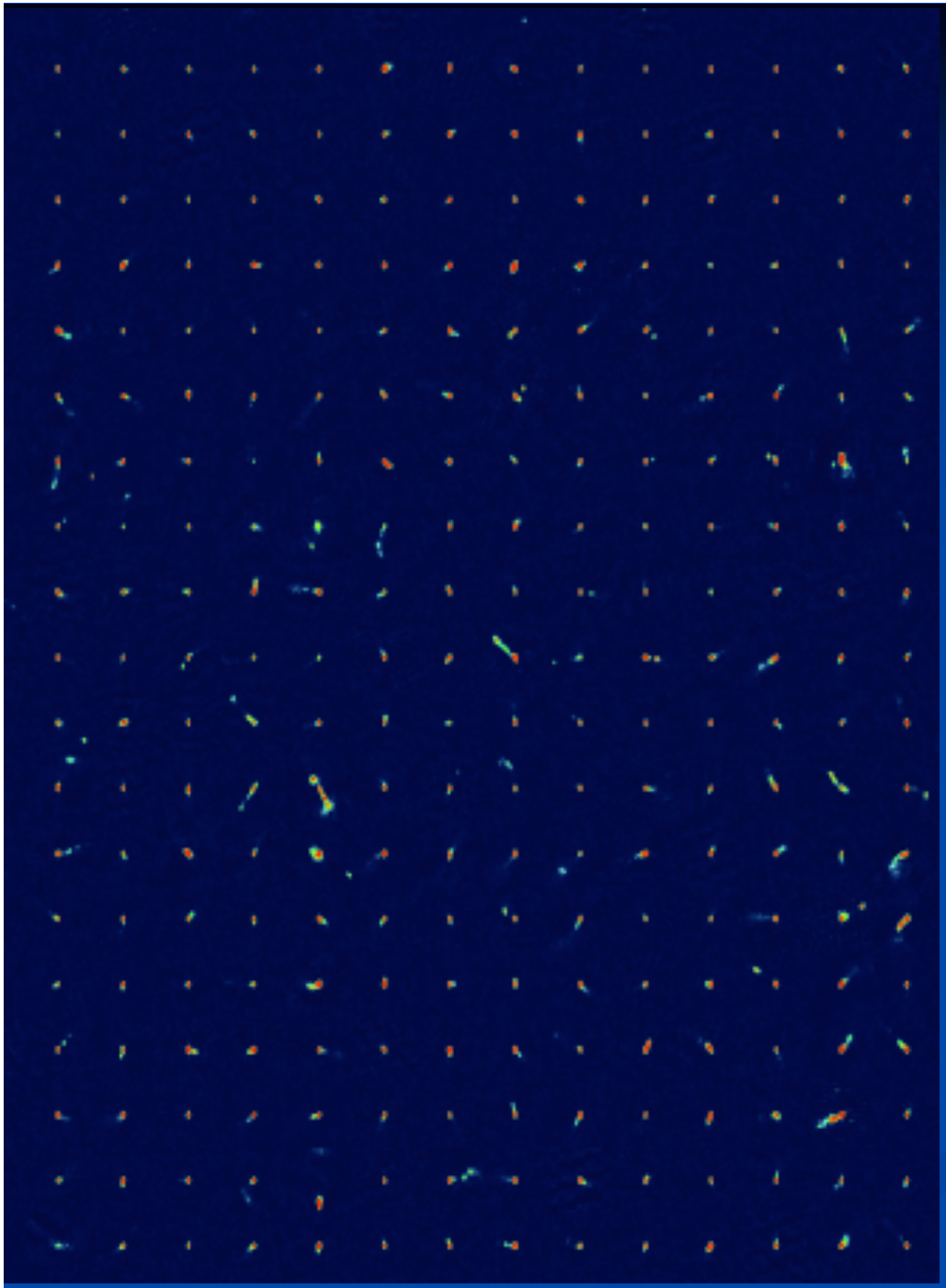
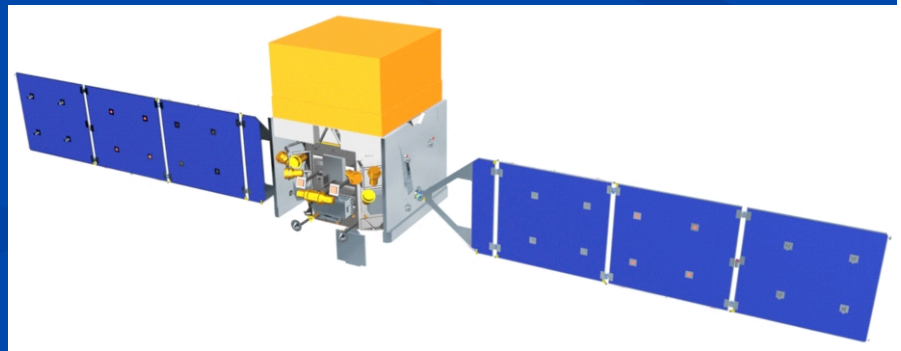


The Radio Perspective
(from the fringe)

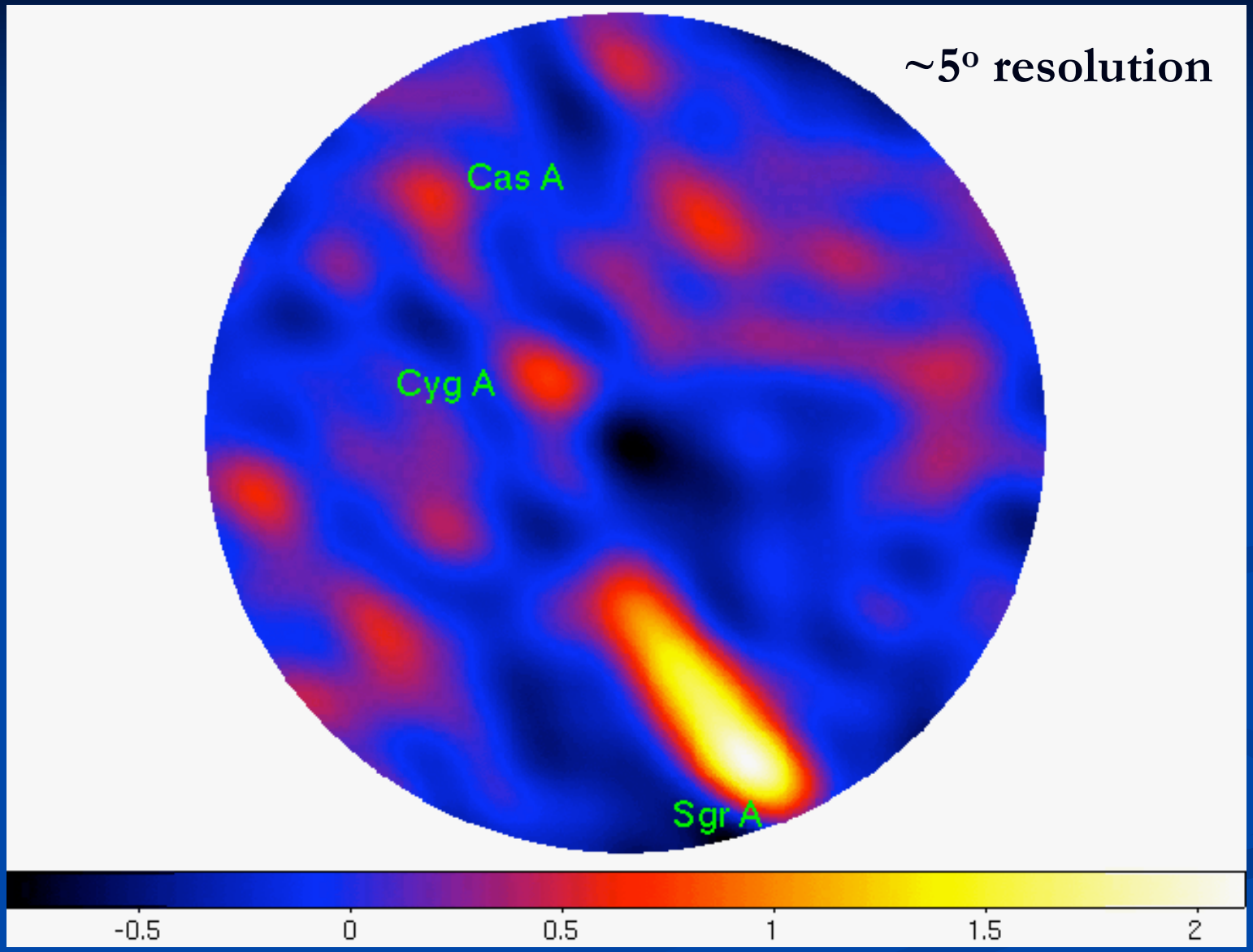
Greg Taylor
University of New Mexico

GSFC
April 24, 2007



The Long Wavelength Demonstrator Array (LWDA) Site on February 18, 2007

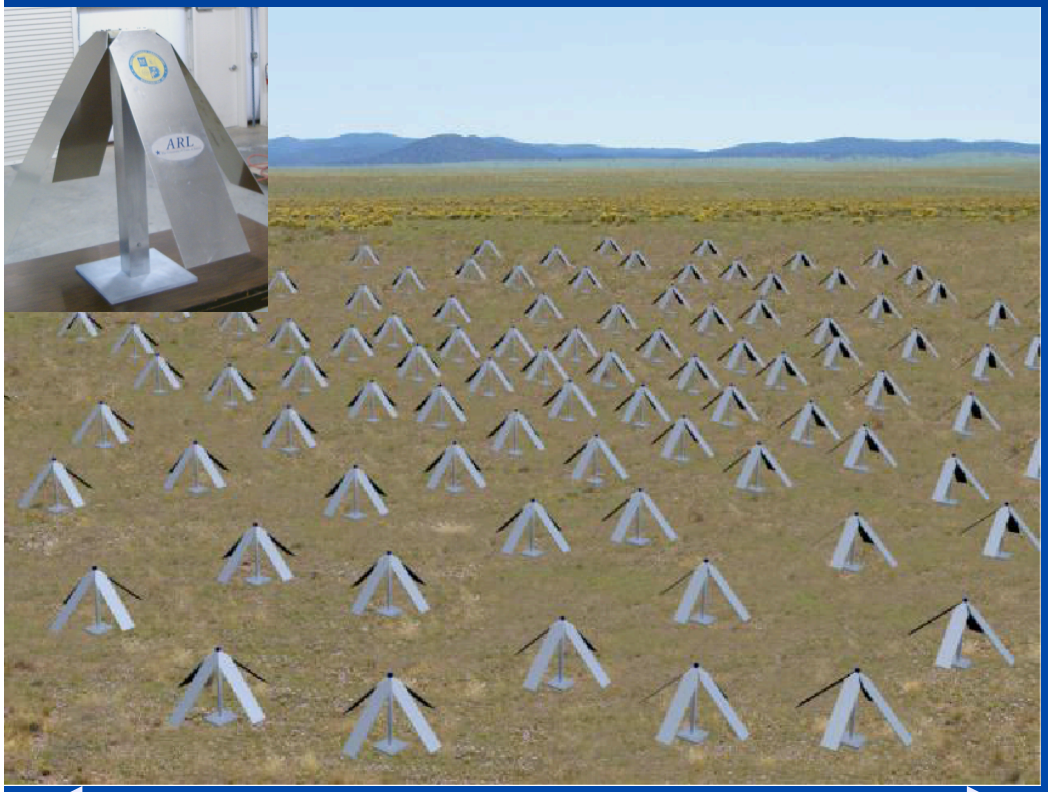
LWDA Movie 24 hours 6 steradians @ 74 MHz



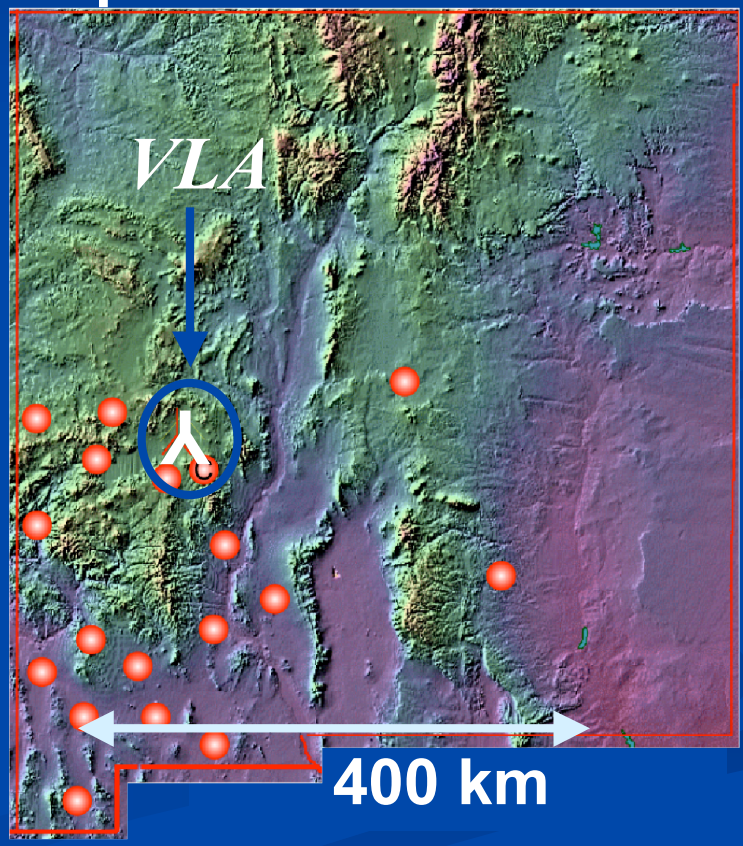
"resolution of 2 degrees is poor" - Bob Hartman

LWA Overview: Far Larger than the VLA

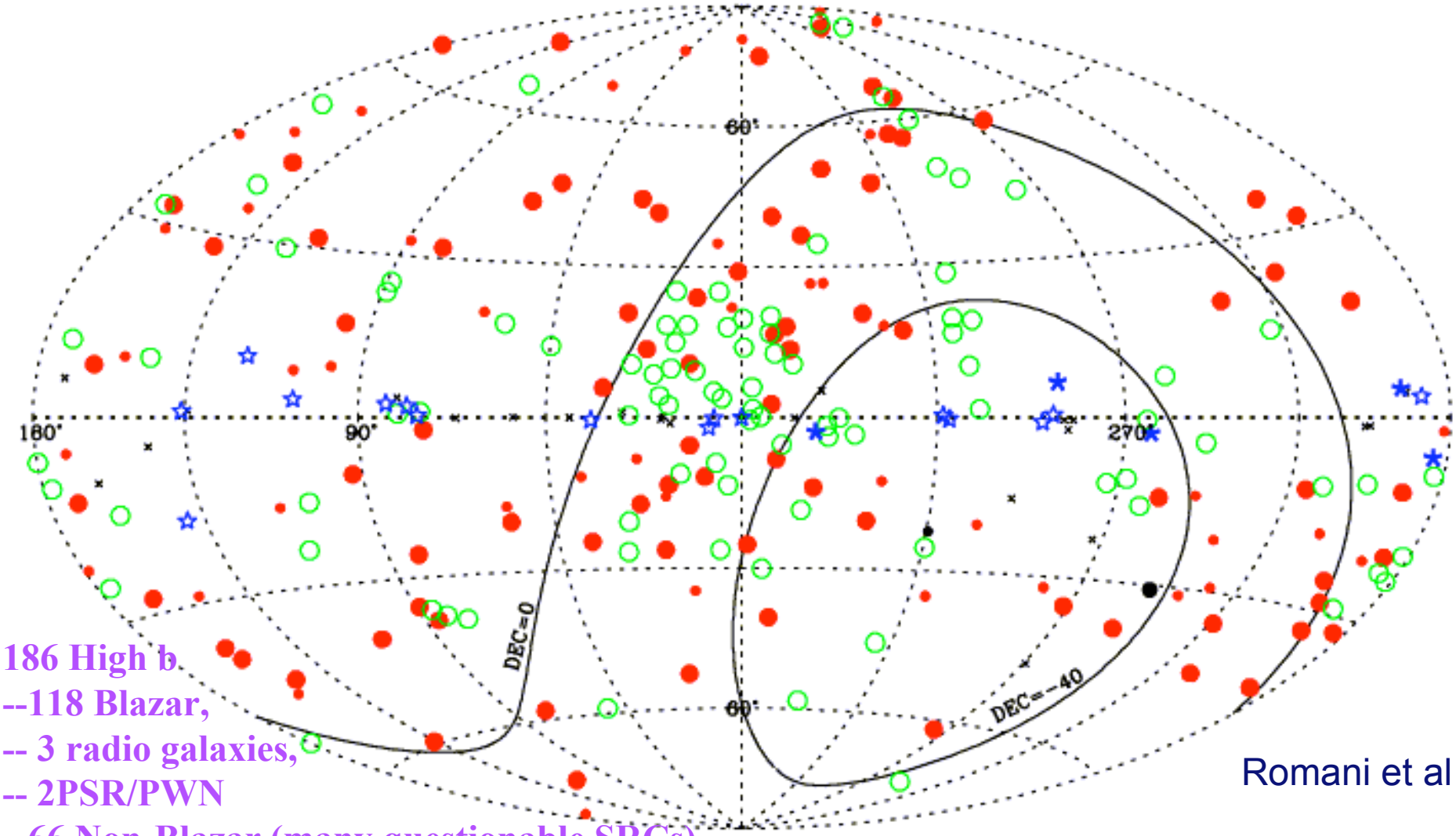
1 "LWA Station" = 256 antennas



Full LWA: 52 stations spread across NM



3EG Survey Status



186 High b
--118 Blazar,
-- 3 radio galaxies,
-- 2PSR/PWN
--66 Non-Blazar (many questionable SRCs)

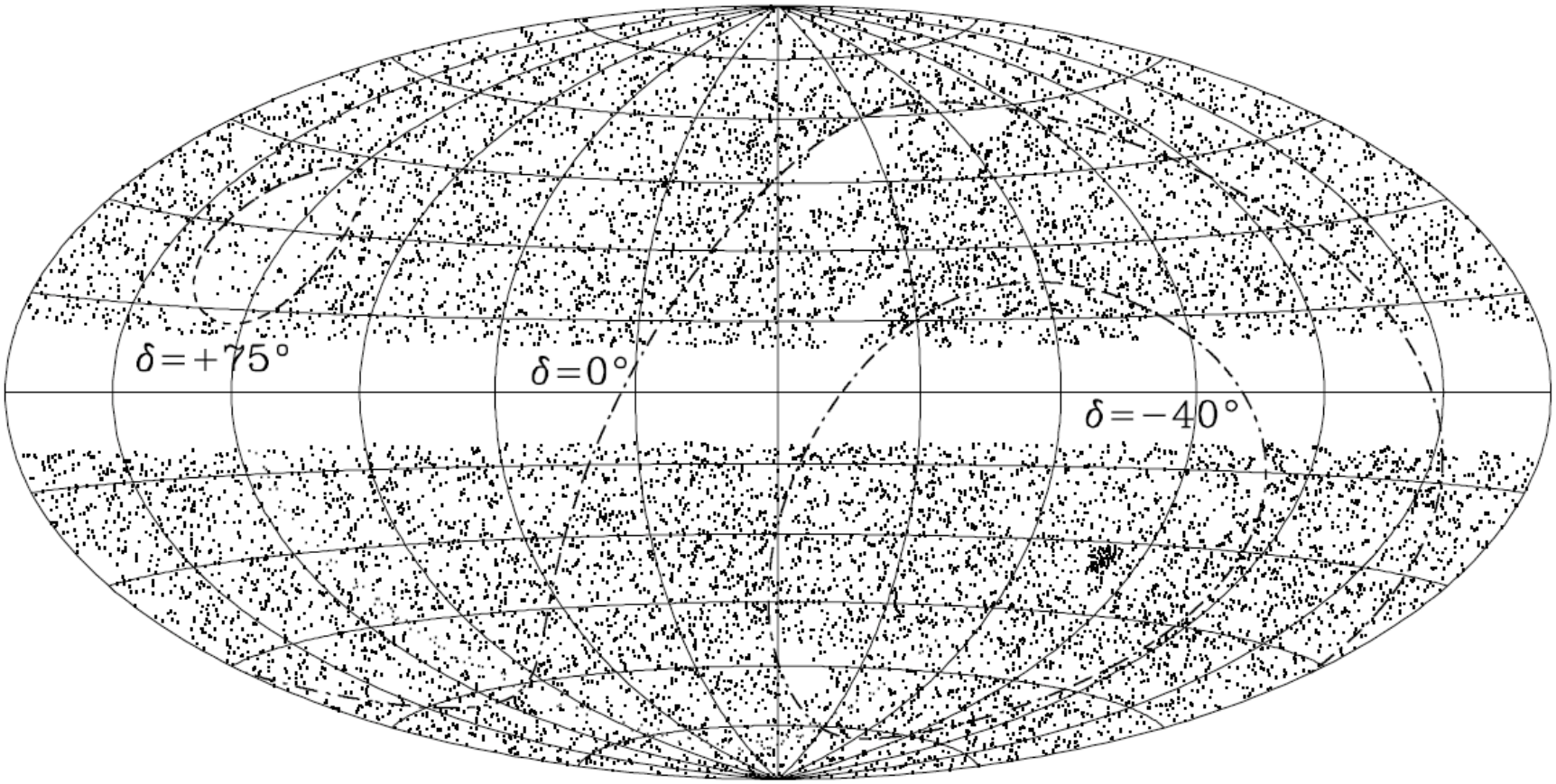
Romani et al

>60% High b sources identified as blazars

Gamma-ray flux variations by factor 100, factors of 2 on timescales of ~4 hours

Radio Target List

- Selection $S_{4.8}$>65mJy, |b|>10^0, α<0.5 -- CLASS+
  - 11,131 sources - Healey et al. 2007
  - Attempts to fill in PMN holes w/ S5, lower ν-selected sources
  - Combined Radio All-sky Targetted Eight-GHz Survey: CRATES



VLBI 101

- Many jets have $\Gamma > 10$
- Max observed Speed ~ Maximum Γ

  (e.g. Lister & Marscher 1997)

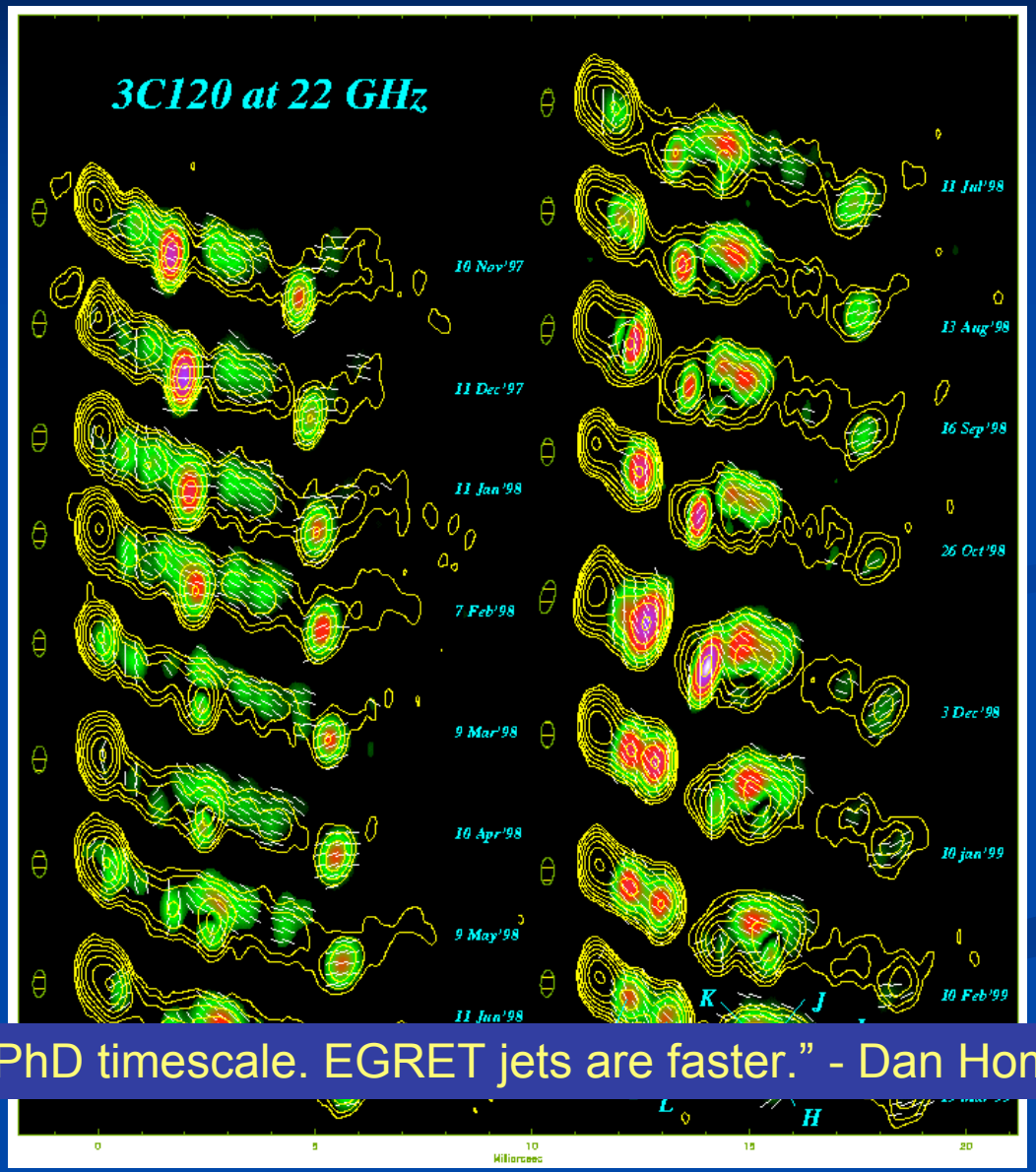
  → $\Gamma_{max} \sim 40$ for Blazar Jet Population
- For jet cores, T_{obs} measurements and limits range from 10^{11}K to 5 x 10^{13} K, a few > 10^{14} K >> T_{eq}
- Jet ejection angle wanders around (don't forget pol'n)
- 3-D field structures of jets?
  - Connection with SMBH/accretion disk system?
  - Do Jets carry a current?

"There may be a great deal more to the jet than we see." - Dan Homan

"40 or 50 in Astronomy is the same number." - Al Marscher

Sample Jet Evolution Imaged with VLBA

- Monthly VLBA imaging of radio galaxy 3C 120 at 22 GHz (Gomez et al. 2000)
- What were the gamma rays doing during this period?
- Desire imaging on time scales of weeks or less for z~0.5



"Jets are fast and change on a PhD timescale. EGRET jets are faster." - Dan Homan

Questions

- Where are the gamma-rays produced?
- Do gamma-ray blazars have intrinsically faster jets?
- Are there multiple classes of gamma-ray emitting blazars?
- What controls the duty cycle of outbursts?

More Questions

- What makes some blazars brighter in gamma-rays? δ? L? M_{BH}? Spin? Accretion?
- Do gamma-ray flares coincide with the emission of new components?
- Do gamma-ray flares coincide with jet bending?
- How are jets confined?
- Can we come up with a self-consistent model?

"The combination of GLAST and VLBI presents us with the best chance to answer these questions is the past 30 years (40 for Ken)." - Tony Readhead

Lessons Learned from EGRET/VLBI

(0) gamma-ray loud AGN are radio loud (and blazars)

(1) EGRET blazars are faster (Jorstad et al. 2001)

(2) Gamma-ray flares lag the mm flares (Valtaoja)

(3) Gamma-ray flares lag the ejection of new VLBI components

(4) EGRET detected jets and jet components have higher average fractional polarization (Lister & Homan 2005)

(5) Also have brighter jet components by ~ x 2 (Lister & Homan)

(6) Are more compact overall, more variable (Kovalev)

(7) Have higher core brightness temperatures (Helmboldt)

"What did we not learn from EGRET, and why not?" - Marscher/Kadler

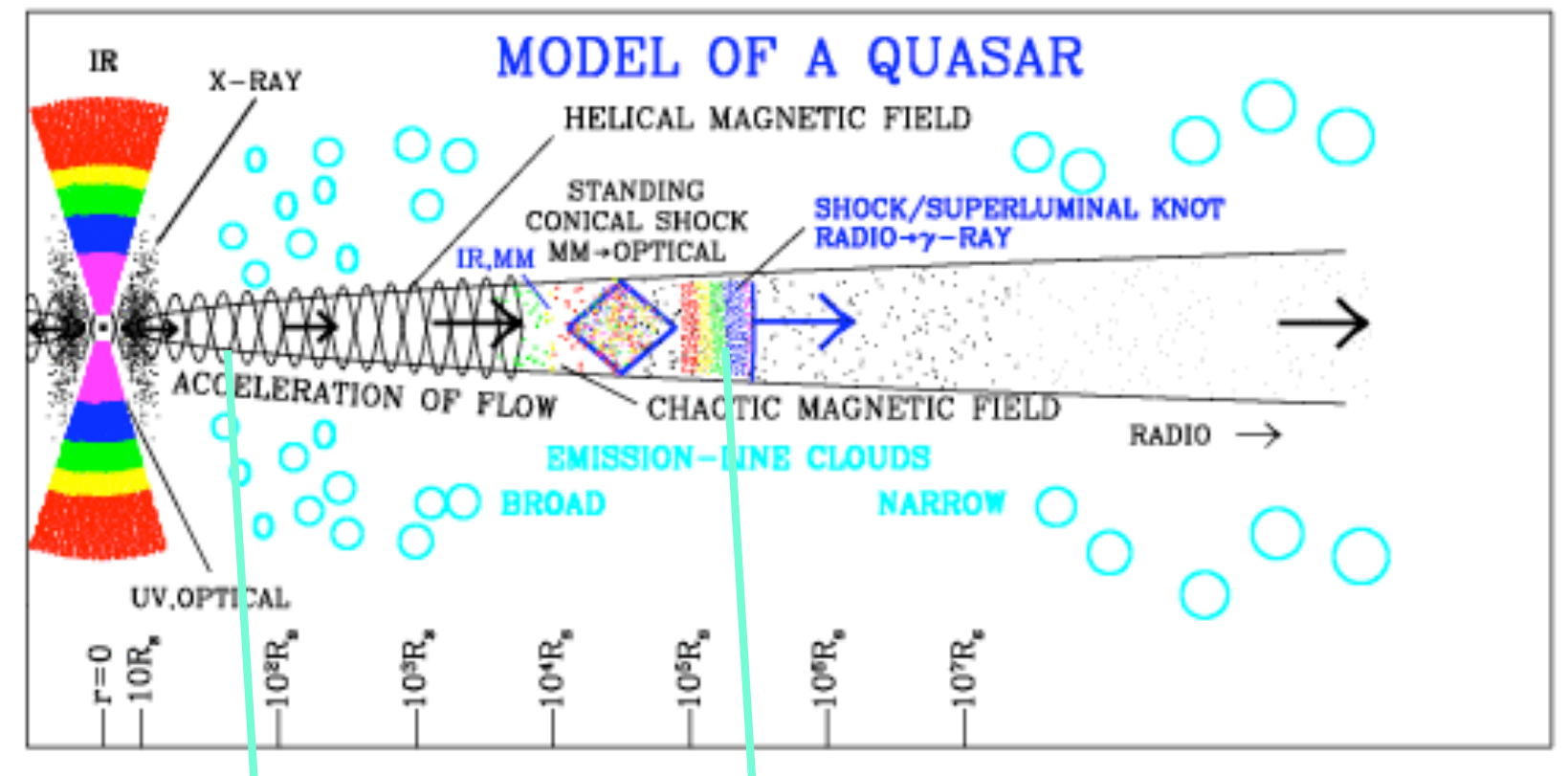
"Energy range of EGRET missed HBLs" - Girolettii

New with GLAST

- Much improved energy range, resolution, & sensitivity
- Much improved sampling of Gamma-ray light curves
- Expect ~ 2/month GLAST flares above 2×10^{-6}
- List of 22 Famous Blazars
- Radio galaxies? Seyferts?

"The low luminosity AGN deserve attention too." - Ulvestad

Gamma-Ray Emission Mechanisms for Blazars



Here?

Here?

Radio Monitoring programs

- UMRAO program - ~200 objects at 5, 8, 15 GHz
- OVRO 40 m program - 1000 objects at 15 GHz with noise ~1 mJy and timescales 1-1000 days

"Lets include some semi-boring sources also" - Esko Valtaoja

- Metsahovi program - ~100 sources 22 and 37 GHz
- ATA, MIRANdA programs?

VLBI Programs

- GMVA - 86 GHz

~10 sources?

- BU - 43 GHz

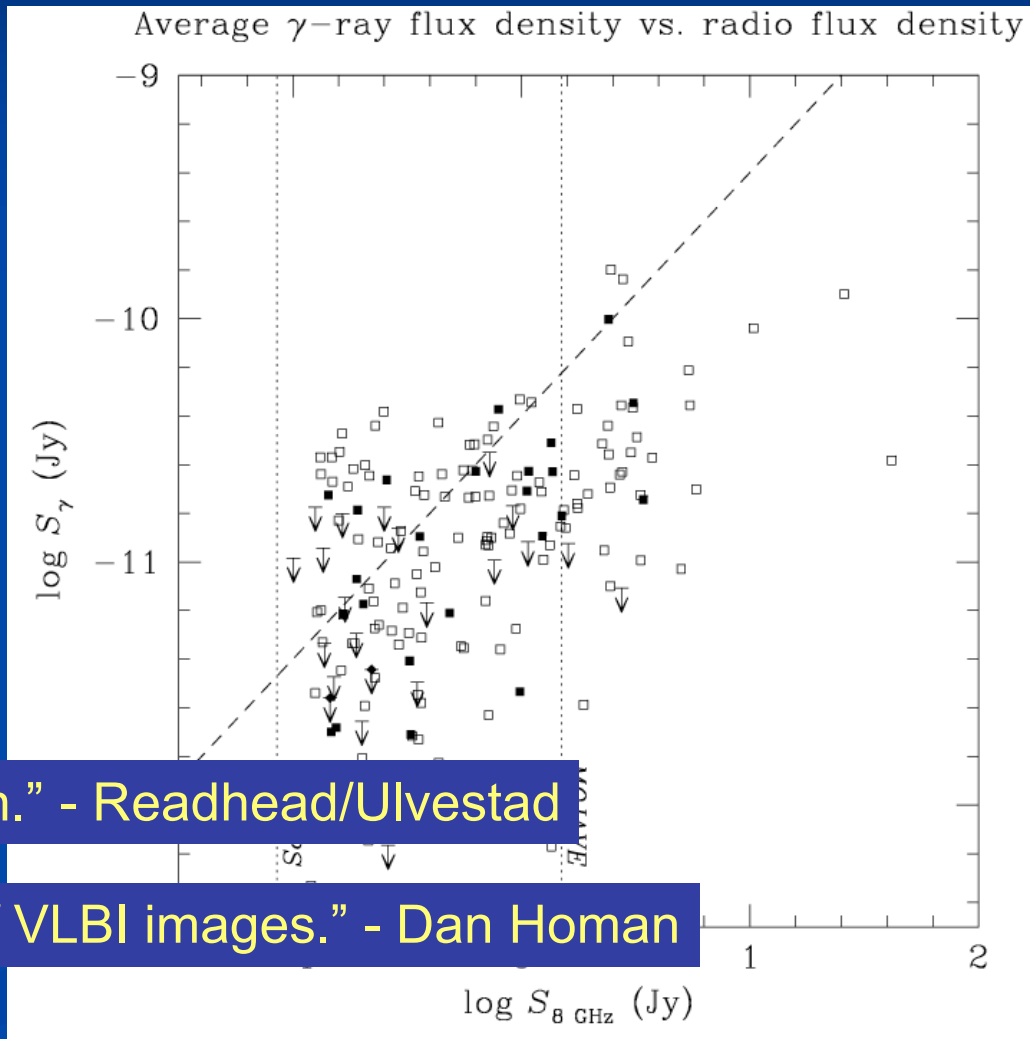
monitoring of ~35 blazars

- MOJAVE - 192 bright

@ 15 GHz + blazars + AGN

- VIPS - 1127 sources

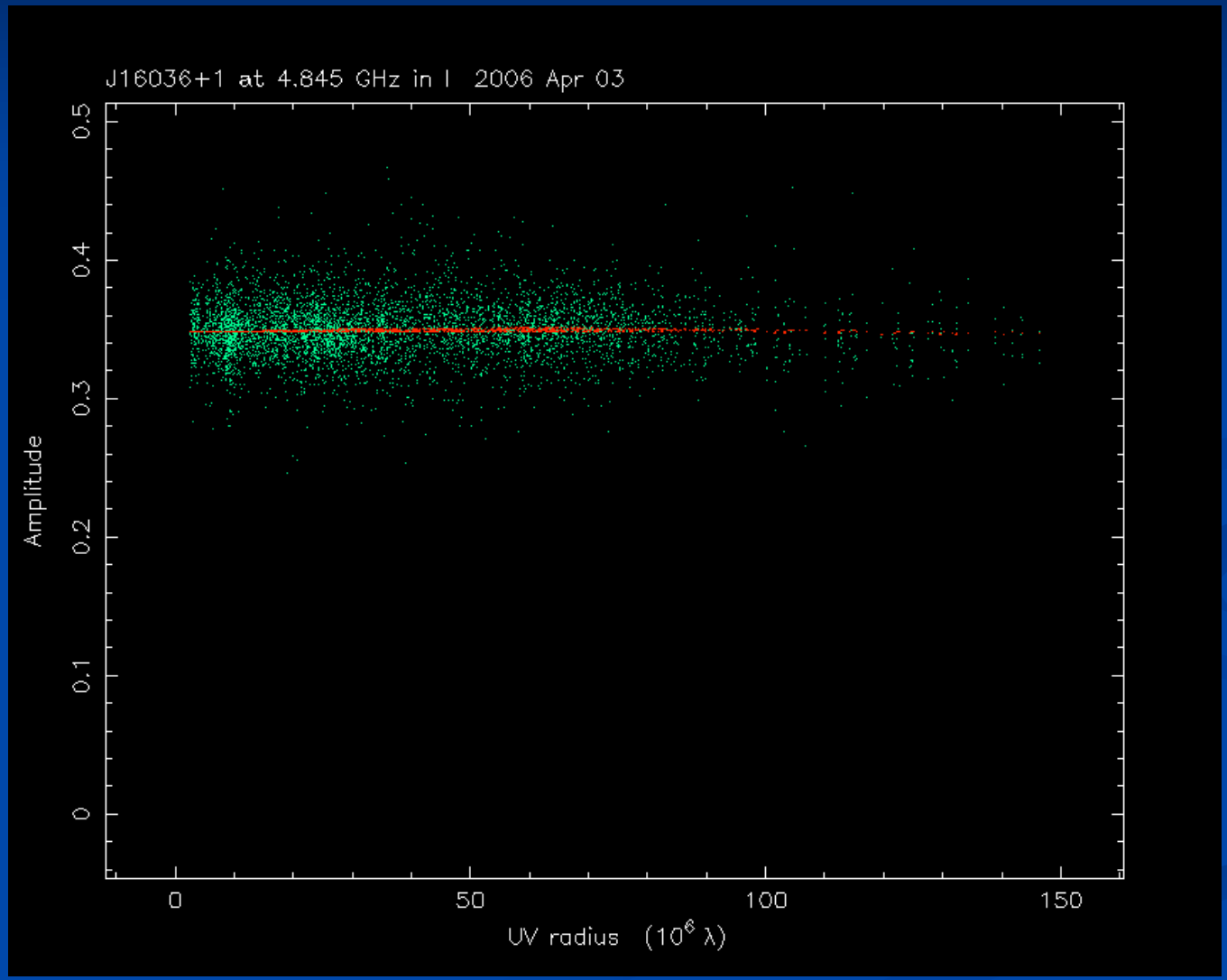
@ 5 GHz



"We need a balanced approach." - Readhead/Ulvestad

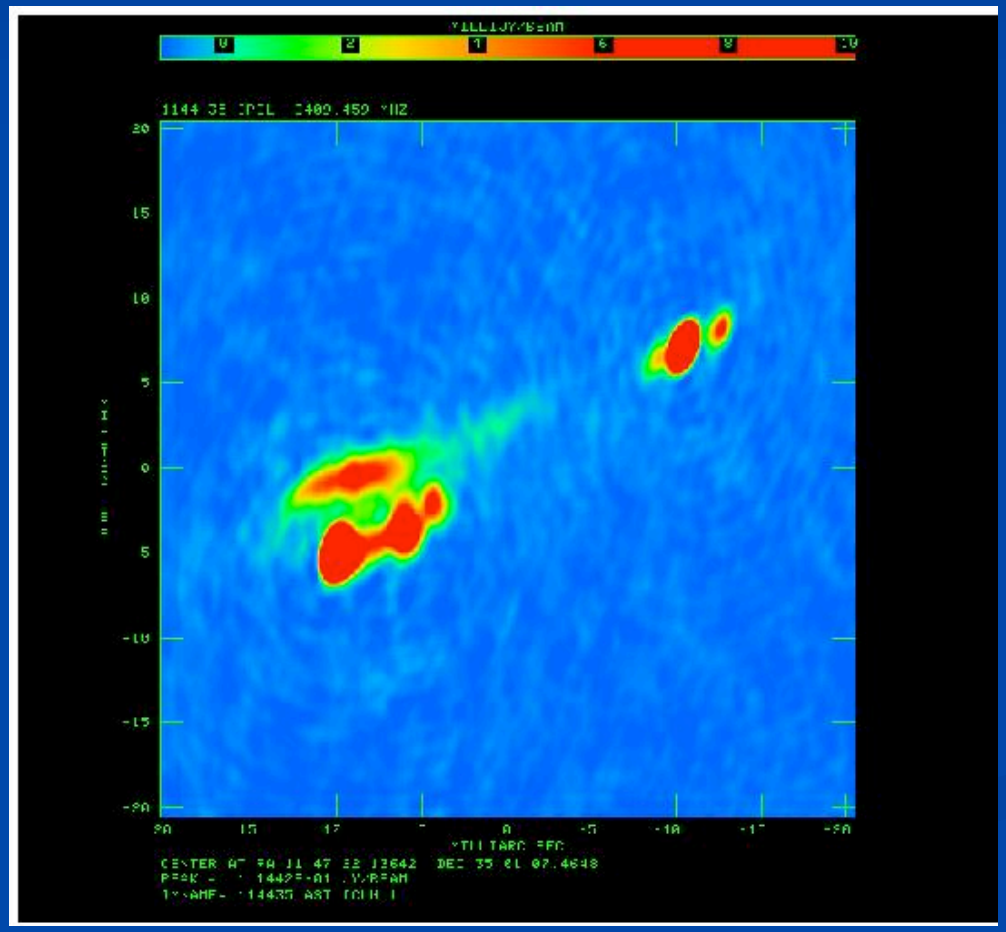
"We need a central repository of VLBI images." - Dan Homan

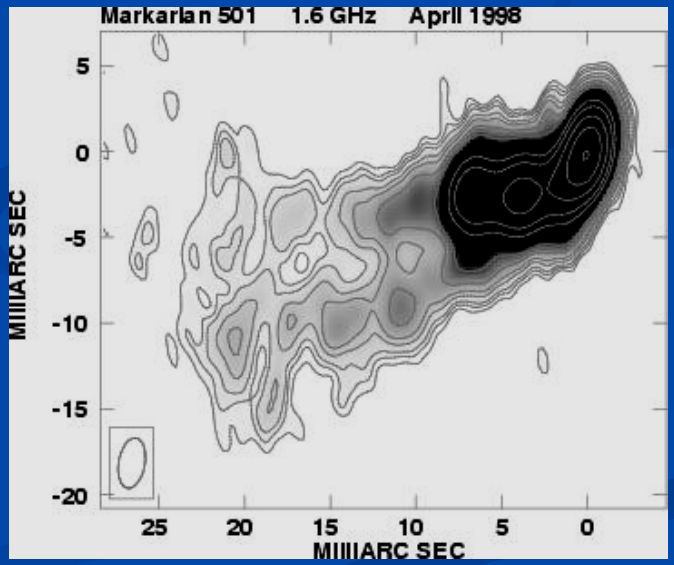
J16036+1554: An EGRET blazar that is extremely compact



Velocity Structures

Evidence for limb brightened jet morphology on the parsec scale is present in some FR I radio galaxies:
1144+35, Mkn 501, 3C 264, M87, 0331+39.....



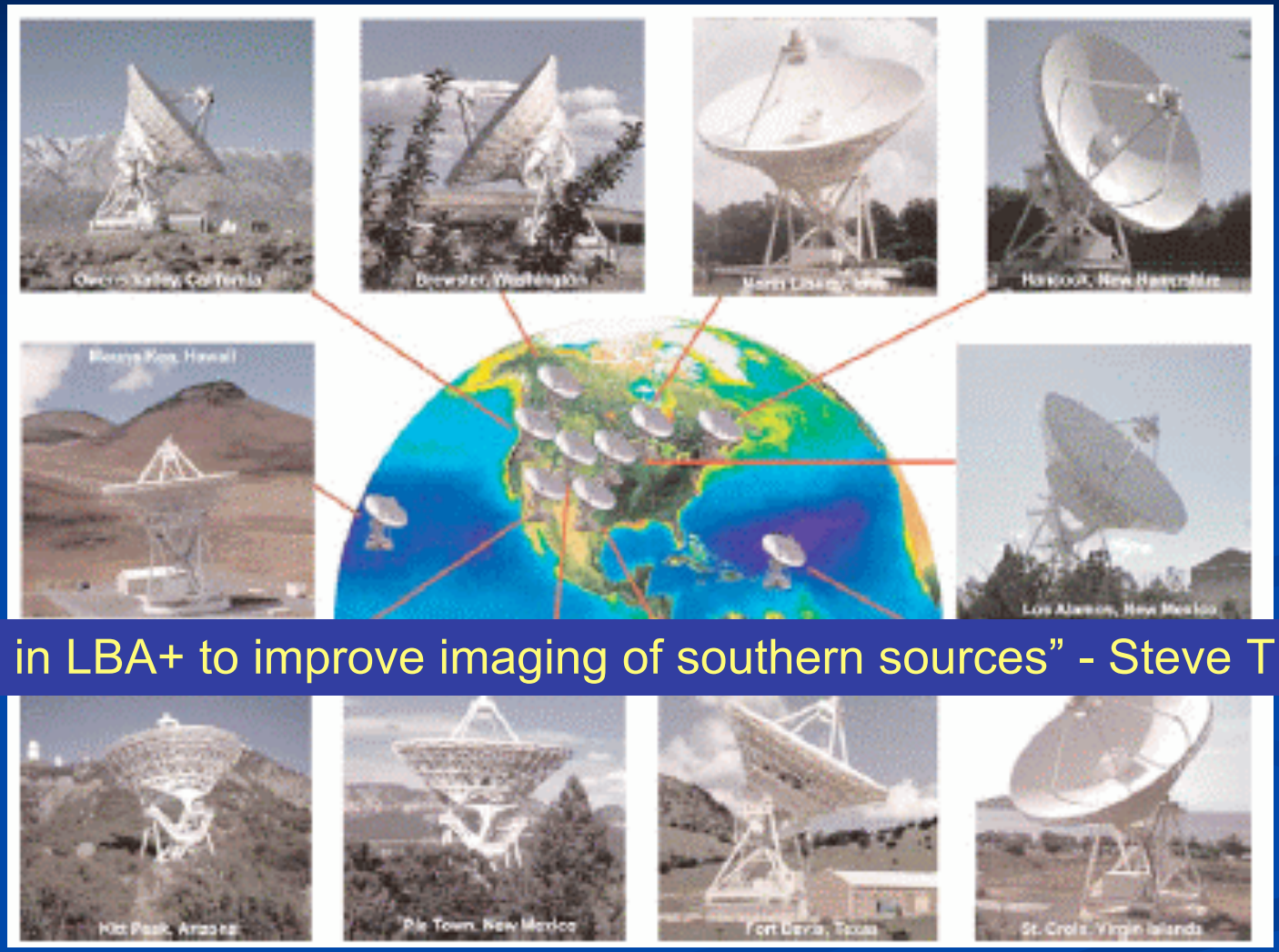


Giroletti

Requirements for Imaging Blazar Jets

- High-frequency capability (> 20 GHz) to image jets where they are optically thin
- Full-polarization imaging
- Frequency agility from 330 MHz -> 86 GHz
- Dynamic scheduling for response to gamma-ray flares at any time of year, and for repeated reliable observations
- Sub-milliarcsecond resolution to detect changes on time scales of days to months, sub-pc scales

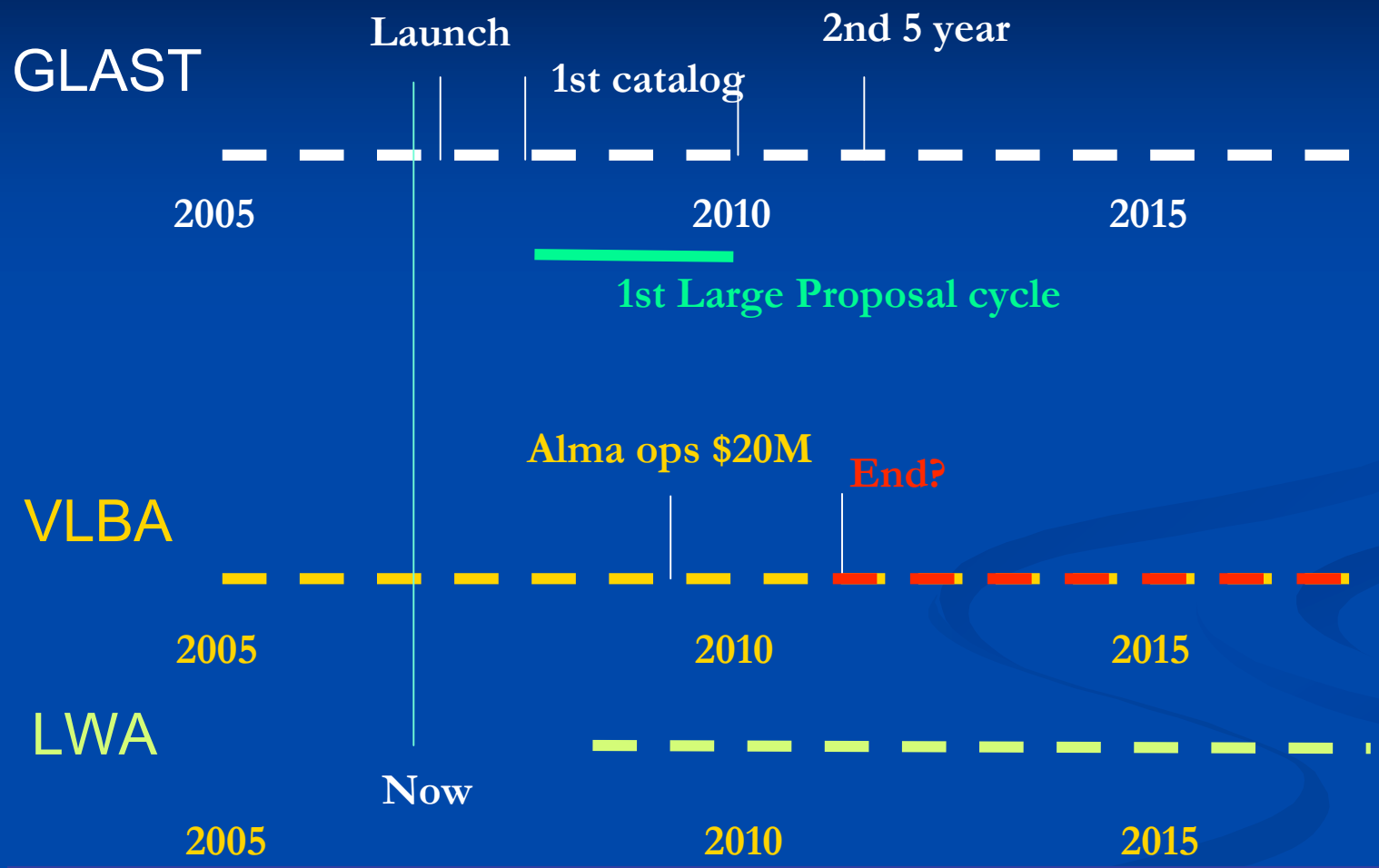
VLBA++



"Add in LBA+ to improve imaging of southern sources" - Steve Tingay

- High Sensitivity Array (add VLA, GBT, Effelsberg, Arecibo) may be desirable for LLAGNs, TeV blazars

GLAST/VLBA Timelines



"VLBI and GLAST is a marriage made in the heavens." - Al Marscher

"Save the VLBA! Tell NRAO, tell NSF" - Al Marscher

SEDs

- Campaigns on individual objects
- Use calibrators from CARMA, SMA, VLA…
- Spitzer, Kepler opportunities early on
- SMARTS, SARA, ROTSE? GTN
- Chandra, XMM
- AGILE, Swift, GLAST
- Veritas, HESS, MAGIC, CANGAROO

"Need your friends and friends' friends." - Ann Wehrle