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Before Fermi met Jansky

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Overview

- Why Roopesh asked me to give this talk
- Why I'm not going to give the talk Roopesh asked me to give
- 50th anniversary celebrations
- A few observations about EGRET observations
  - Gamma-ray high states and mm-radio flares
  - EGRET id's
  - The ATCA-PMN sample
  - VLBI component motions
  - Intra-Day Variable radio sources
- Concluding remarks

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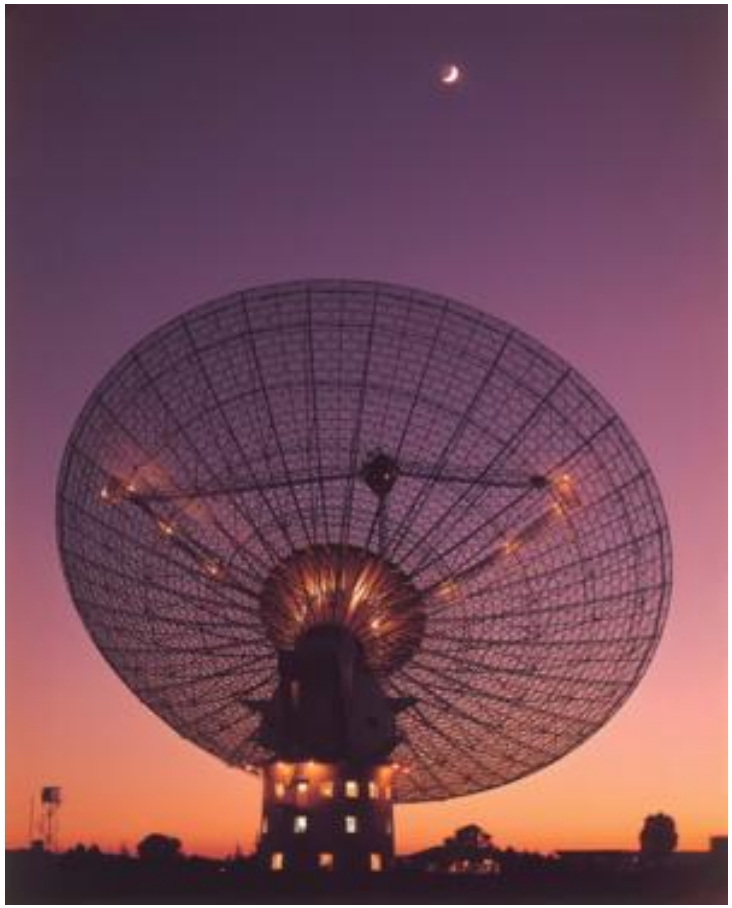
31 October 2011

Early results from Parkes

- Linear polarisation in extragalactic sources
  - Synchrotron radiation
- Faraday Rotation in Cen A
- Faraday Rotation vs (*l*,*b*)
  - Galactic magnetic field
- Location of 3C273 (by lunar occultation)
  - Discovery of quasars
- Southern sky surveys at 408 MHz, 2.7 GHz, 4.8 GHz



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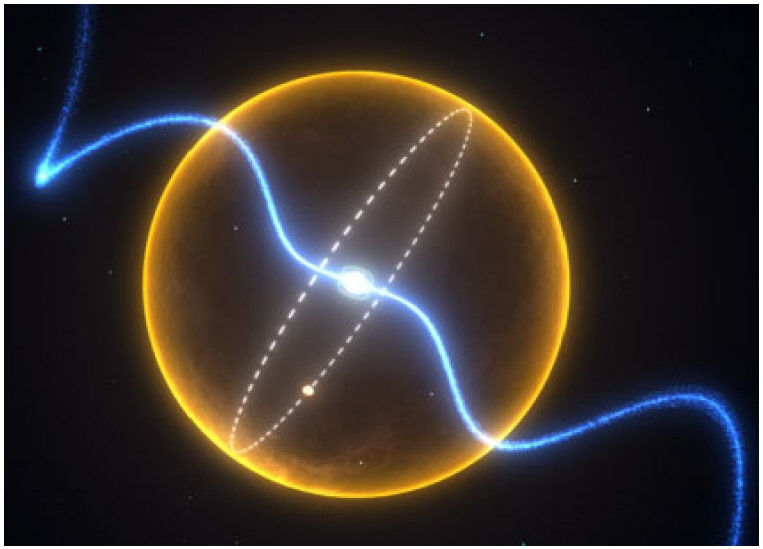
Parkes today

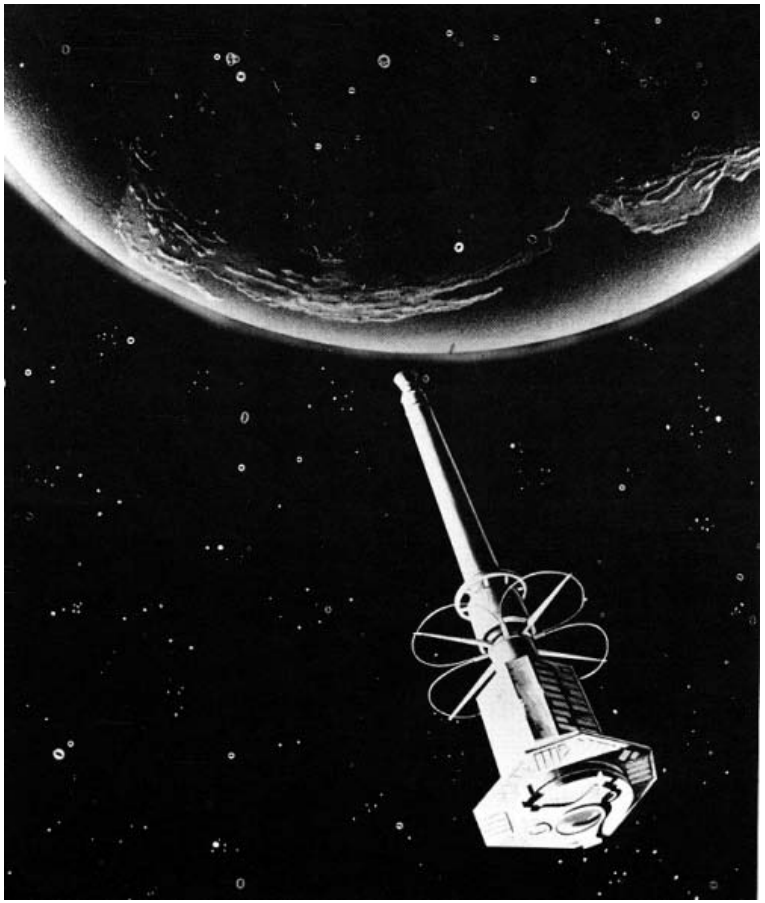
- About 2/3 of the ~2000 known pulsars were discovered at Parkes
- About 2/3 of Parkes observing time is used for pulsar observations:
  - Timing known pulsars
  - Following up Fermi detections
  - Blind survey for new pulsars



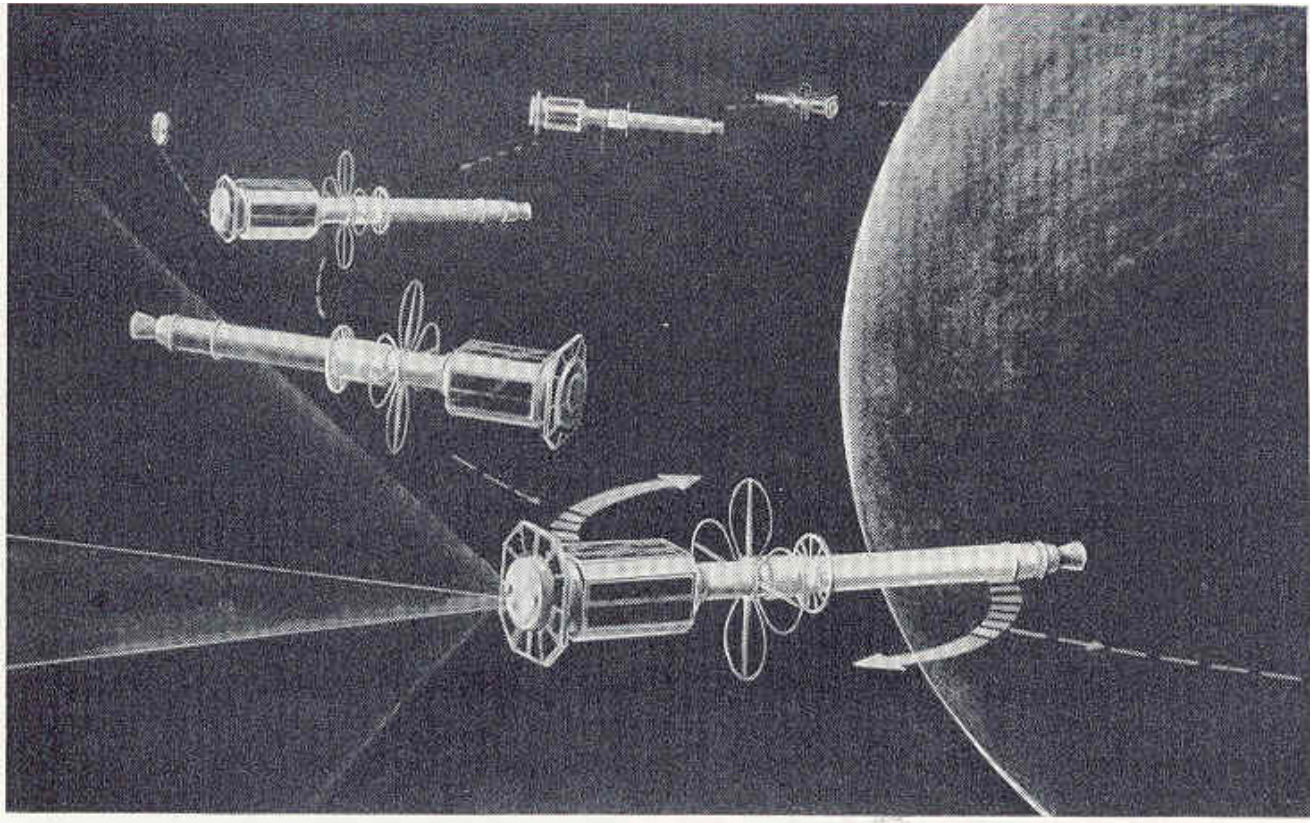
1973

Explorer XI

- Launched 27 Apr 1961
- First gamma-ray astronomical satellite (E>50 MeV)
- Operated for 7 months
- Detected 22 gamma-rays and 22,000 cosmic rays



Explorer XI



Immediately after launching, Explorer XI began to spin around its long axis. The satellite's tumbling motion, sketched here, was needed for its telescope to scan both Earth and sky. To add inertia around a transverse axis, the fourth stage was left attached. A hollow doughnut containing liquid mercury was mounted above the rocket's nozzle to dissipate rotational energy. The small aluminum disk shown leaving the payload is a meteoric bombardment shield, removable by ground command. The 88-inch-long package weighs 95 pounds. National Aeronautics and Space Administration picture.

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- SAS-2
  - November 1972 – June 1973
  - 55% of celestial sphere surveyed
  - Crab, Vela, Geminga, …
  - Bignami, Fichtel, Hartman & Thompson (1979) set upper limits for a number of sources, many of which are 2LAC detections
- COS-B
  - August 1979 – April 1982
  - Most exposure to galactic plane
  - Possible detection of 3C273

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Conclusions from the EGRET era

- AGN are bright, variable gamma-ray sources!
- A gamma-ray high state is accompanied by a flare at mm wavelengths and the ejection of a new, often superluminal, component on the parsec scale.
- The relative timing of these events is unclear, and so the physical processes were uncertain.
- Identifications with Jy-level sources.
- There are many unidentified sources.
- AGN are more variable than other classes.
- Better sky coverage and sensitivity required!

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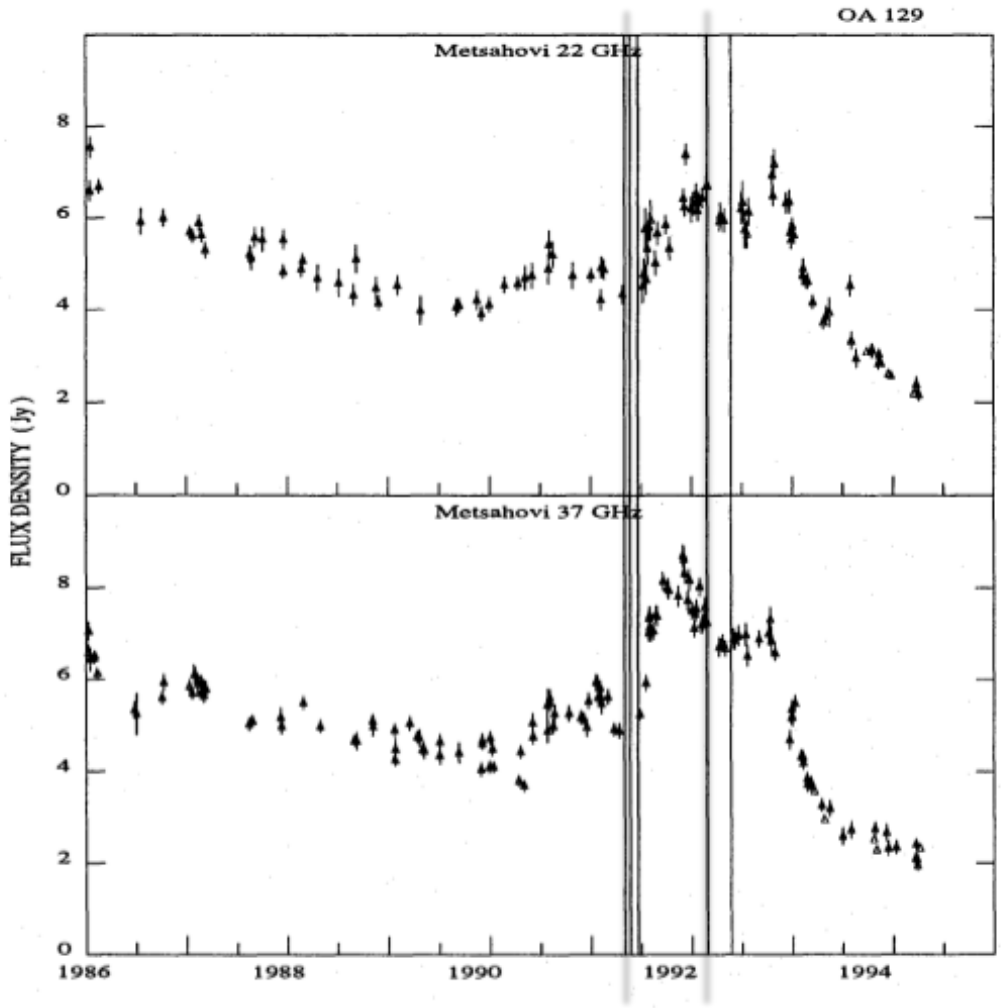
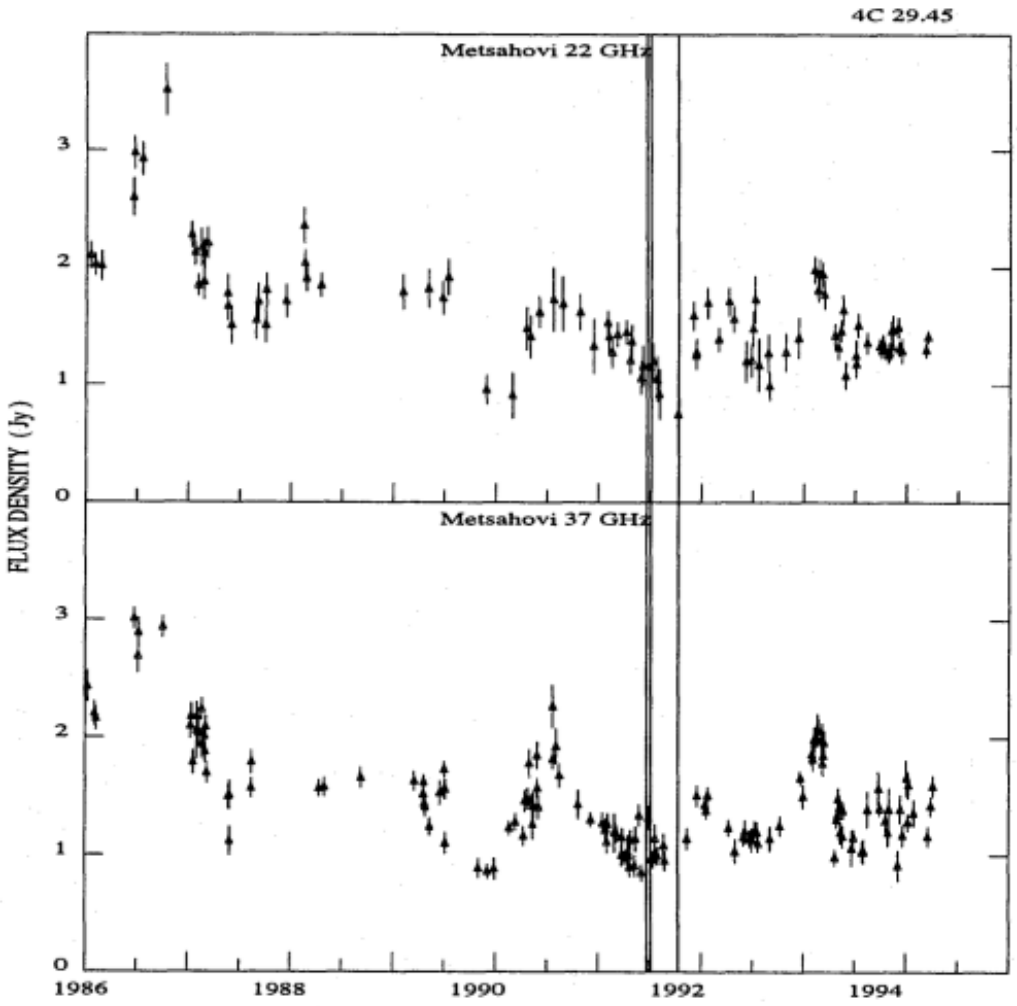
PKS 0420-014 – a 1EG source



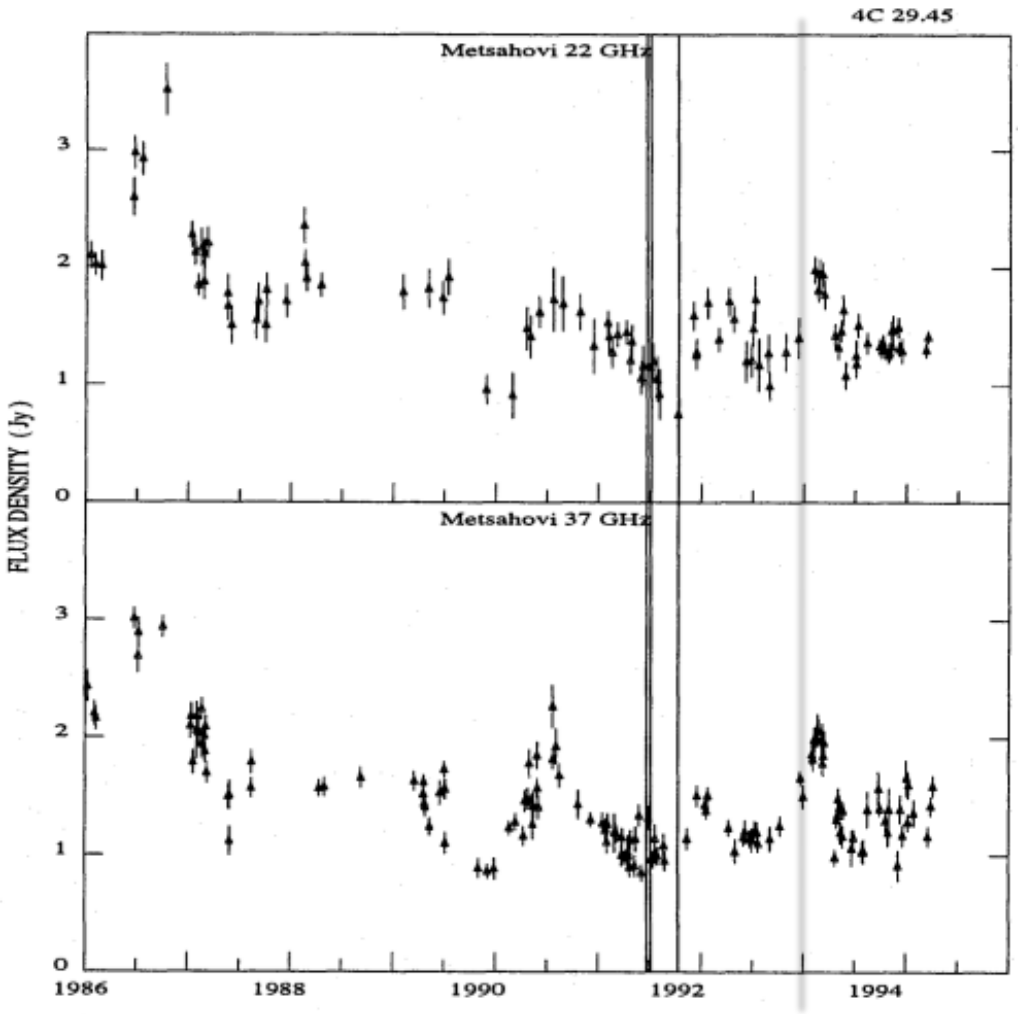
Valtaoja & Terasranta 1995, A&A

1156+295 – not a 1EG source

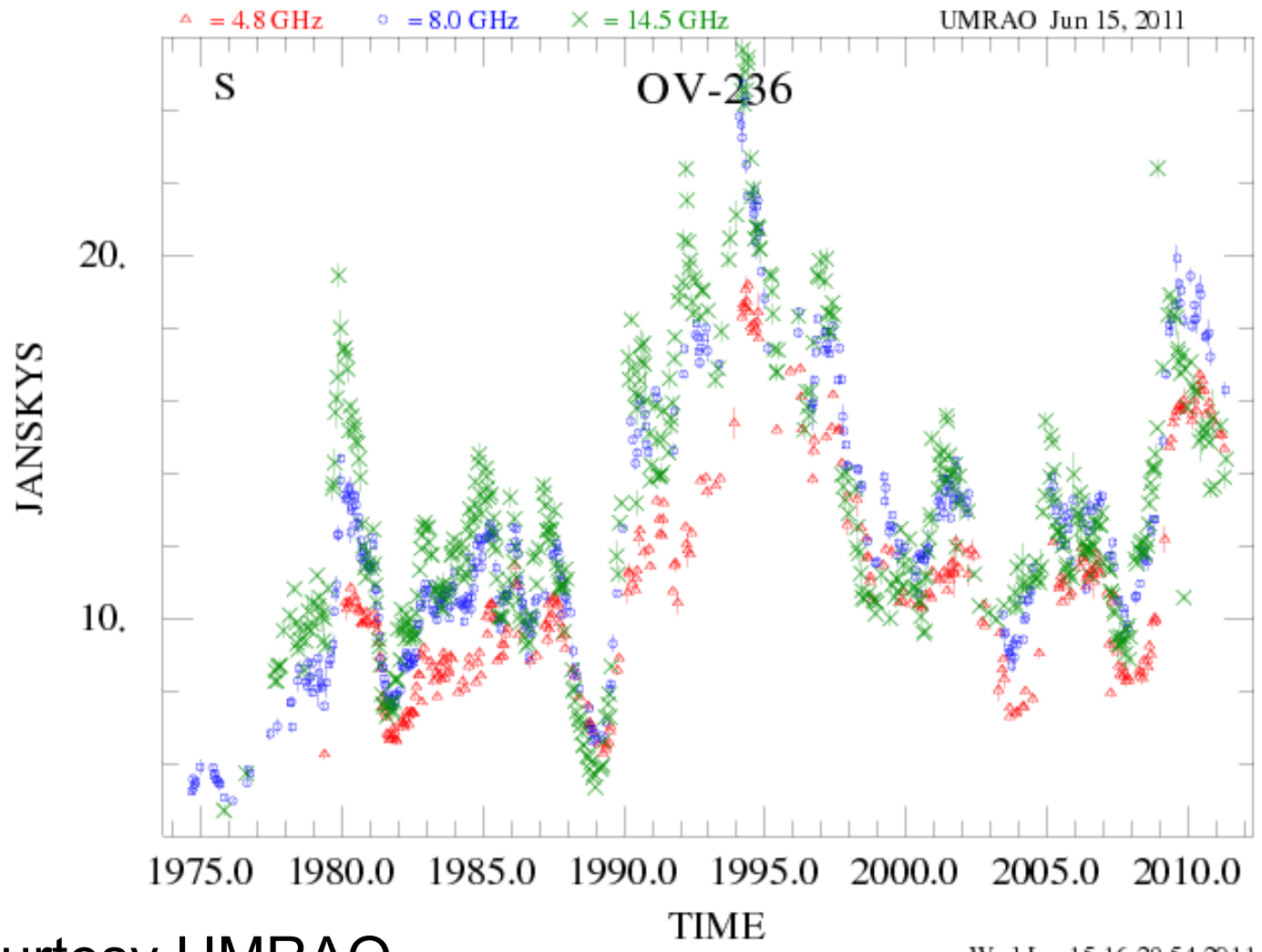


Valtaoja & Terasranta 1995, A&A

1156+295 – a 2EG source!



So why wasn't PKS 1921-293 an EGRET source?



Courtesy UMRAO

EGRET id's

- Identifications with EGRET sources were made on the basis of:
  - Proximity
  - Radio brightness
  - Spectral index
  - …. but rarely with contemporaneous data

Courtesy Dave McConnell

Single-dish surveys at 5GHz

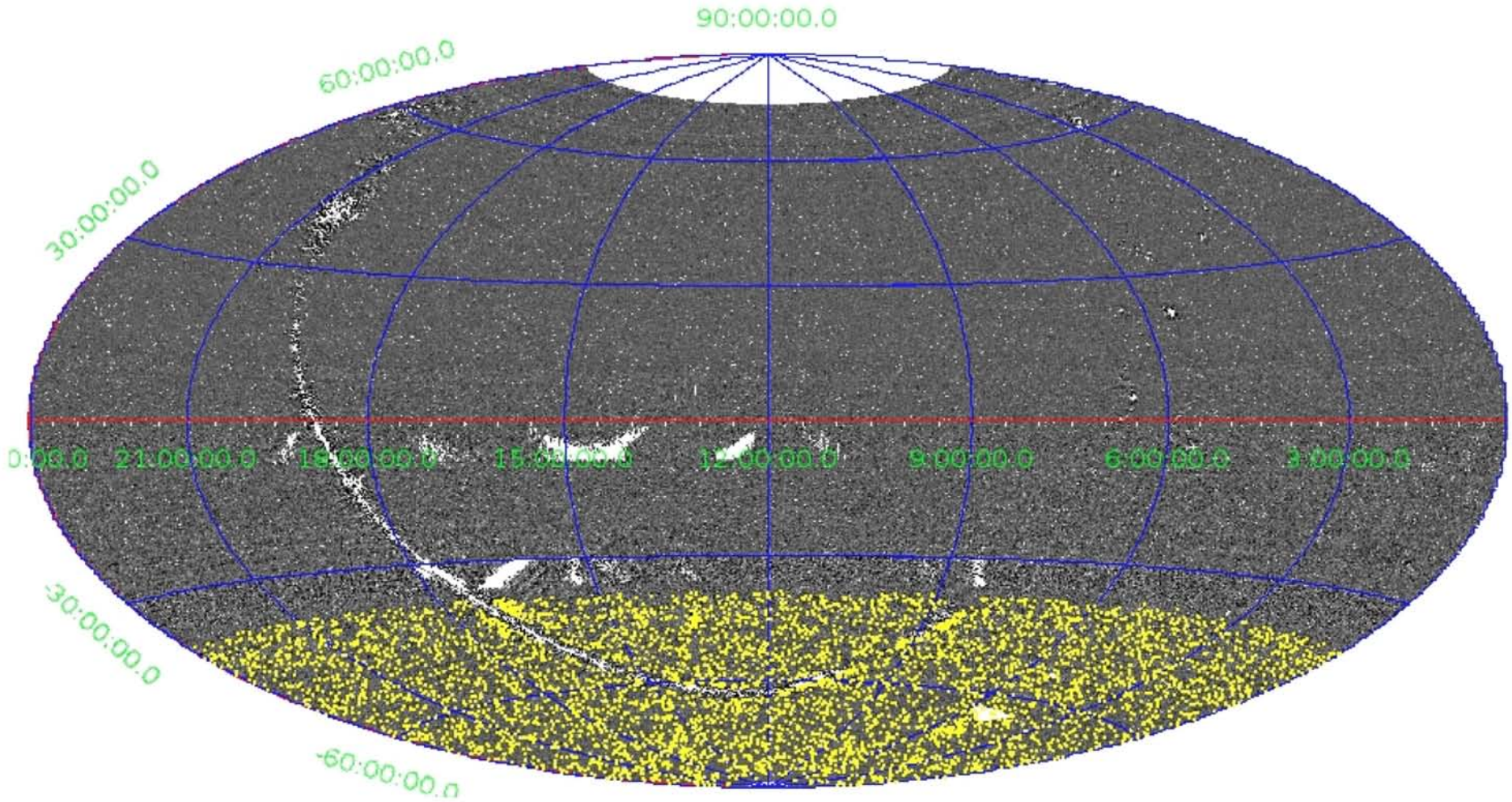
NRAO 300ft (91m) at Green Bank
1987 October
Declination $0^\circ < \delta < 75^\circ$
Beam 3.7′ × 3.3′
Noise 5mJy rms

CSIRO 64m at Parkes
1990 June & November
Declination $-87.5^\circ < \delta < +10^\circ$
Beam 4.2′ × 4.2′
Noise 5-10 mJy *rms*

NRAO 7-beam dual polarization receiver at 4.86GHz
600MHz bandwidth T_{sys} 50 - 60 K

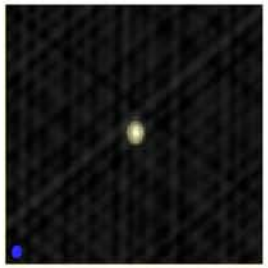
Courtesy Dave McConnell

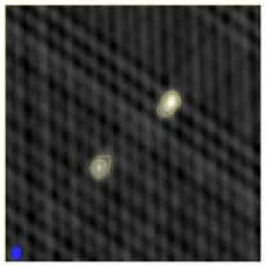
ATCA follow-up selection — 8385 fields

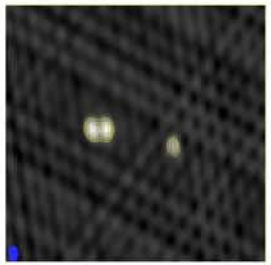


Courtesy Dave McConnell

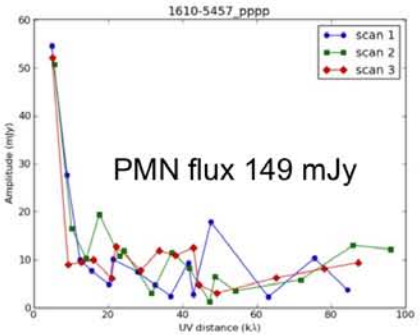
What the ATCA sees

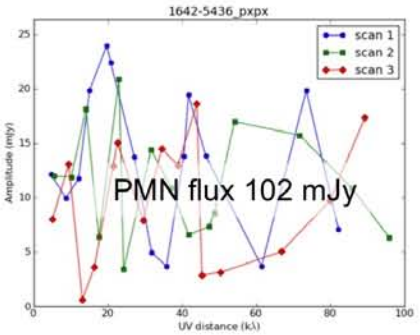






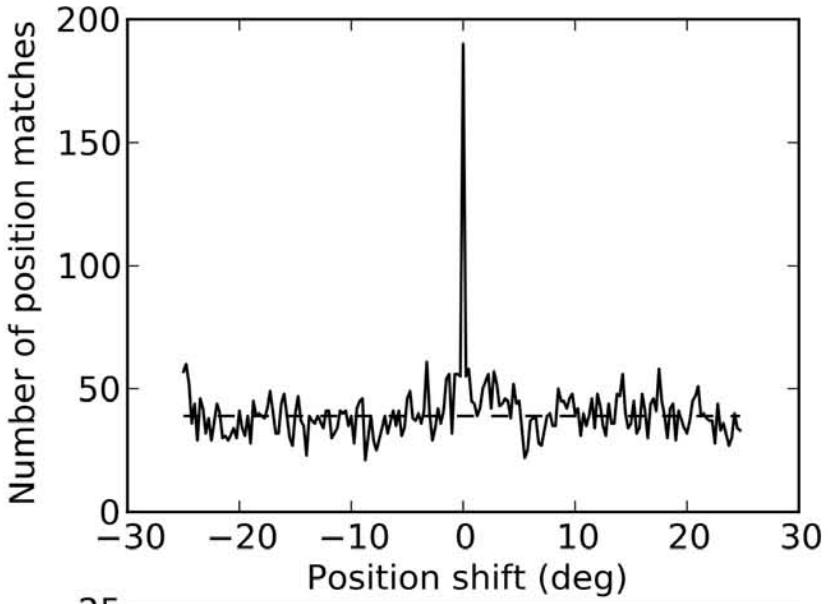
Single source	4909
Two sources	1704
Three or more	280
Not much	890
Nothing at all	592
Total	8385

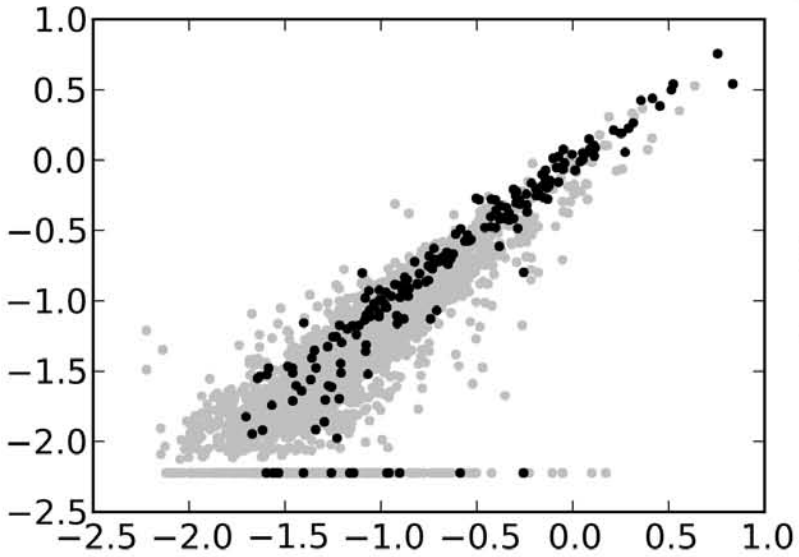


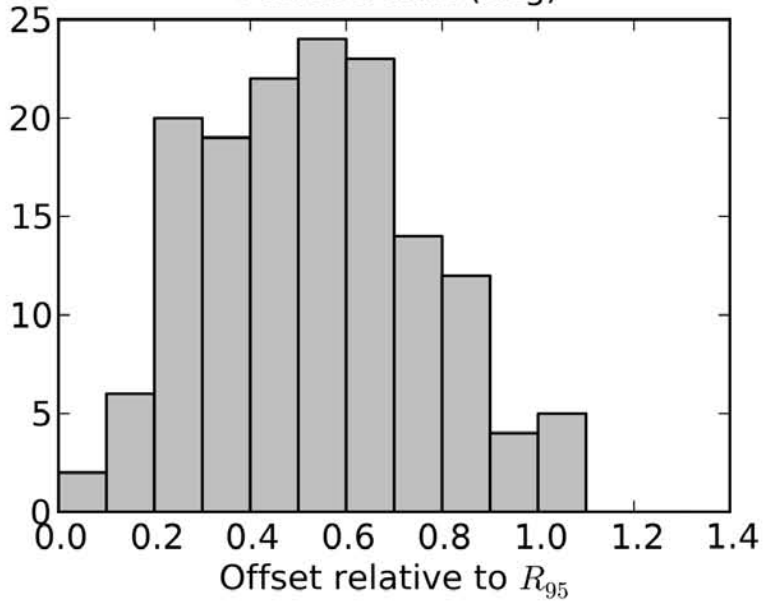


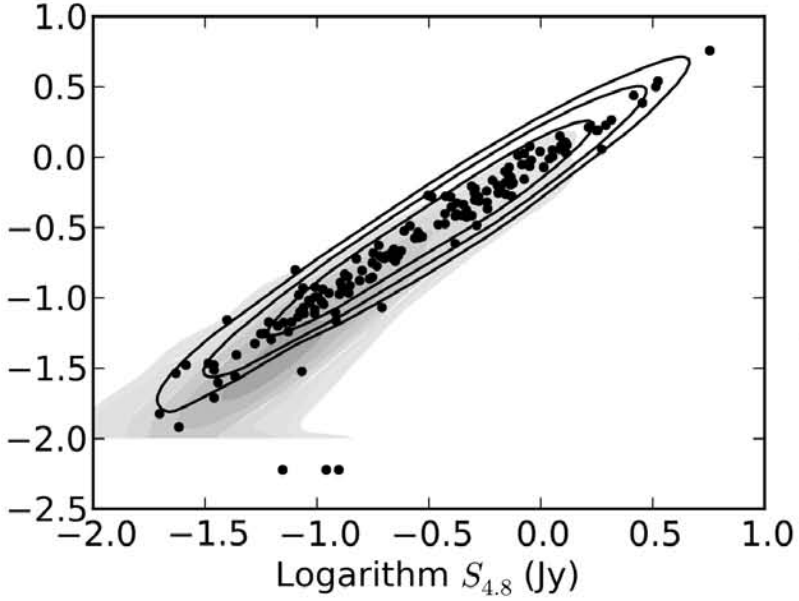
Courtesy Dave McConnell

Fermi-LAT2 — ATPMN







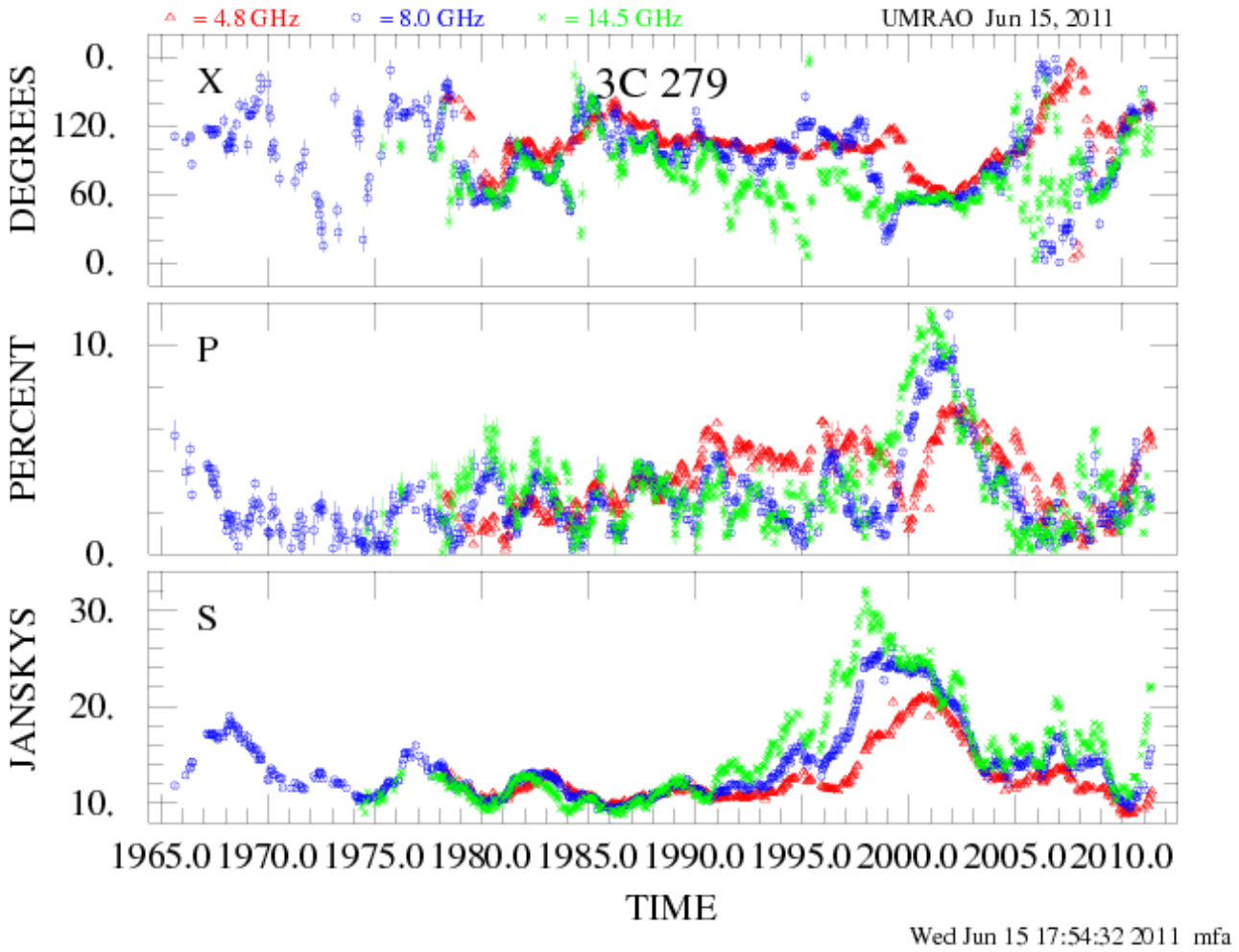


EGRET id's

- Iler, Schachter & Birkinshaw (1997) used NVSS fractional radio polarization data to identify EGRET id's for
  - 8 unidentified 2EG sources
  - 4 high confidence 2EG associations
  - 1 low confidence 2EG association

  with some success…

3C279 -- UMRAO monitoring



Parsec-scale structure of AGN

- High gamma-ray fluxes are correlated with the ejection of new jet components detected with VLBI monitoring (Jorstad et al. 2001)
- The limited time coverage of EGRET observations did not enable conclusions to be drawn on whether all new component ejections were accompanied by gamma-ray high states, and vice versa

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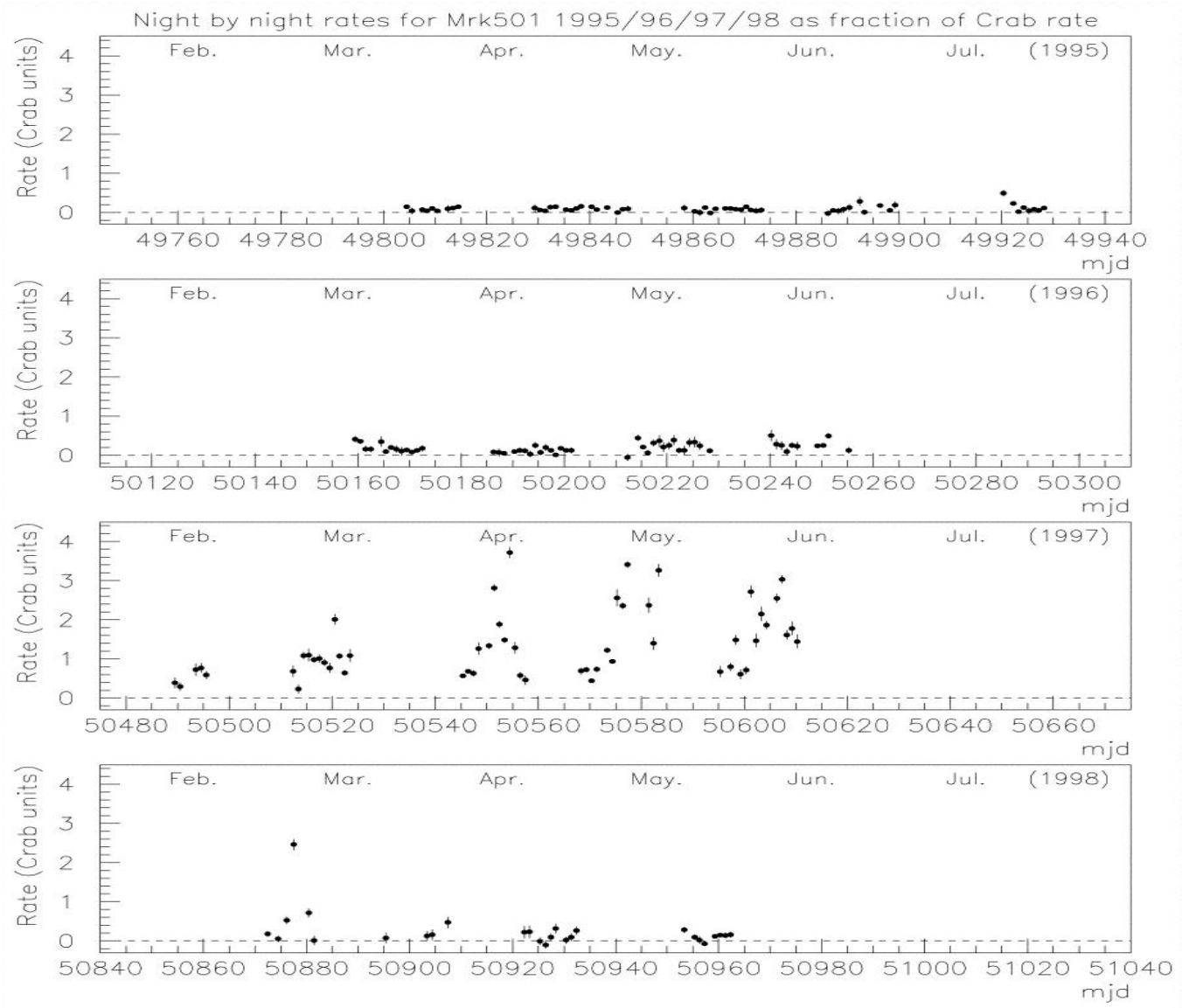
Mkn 501 TeV variability from 1995 to 1998



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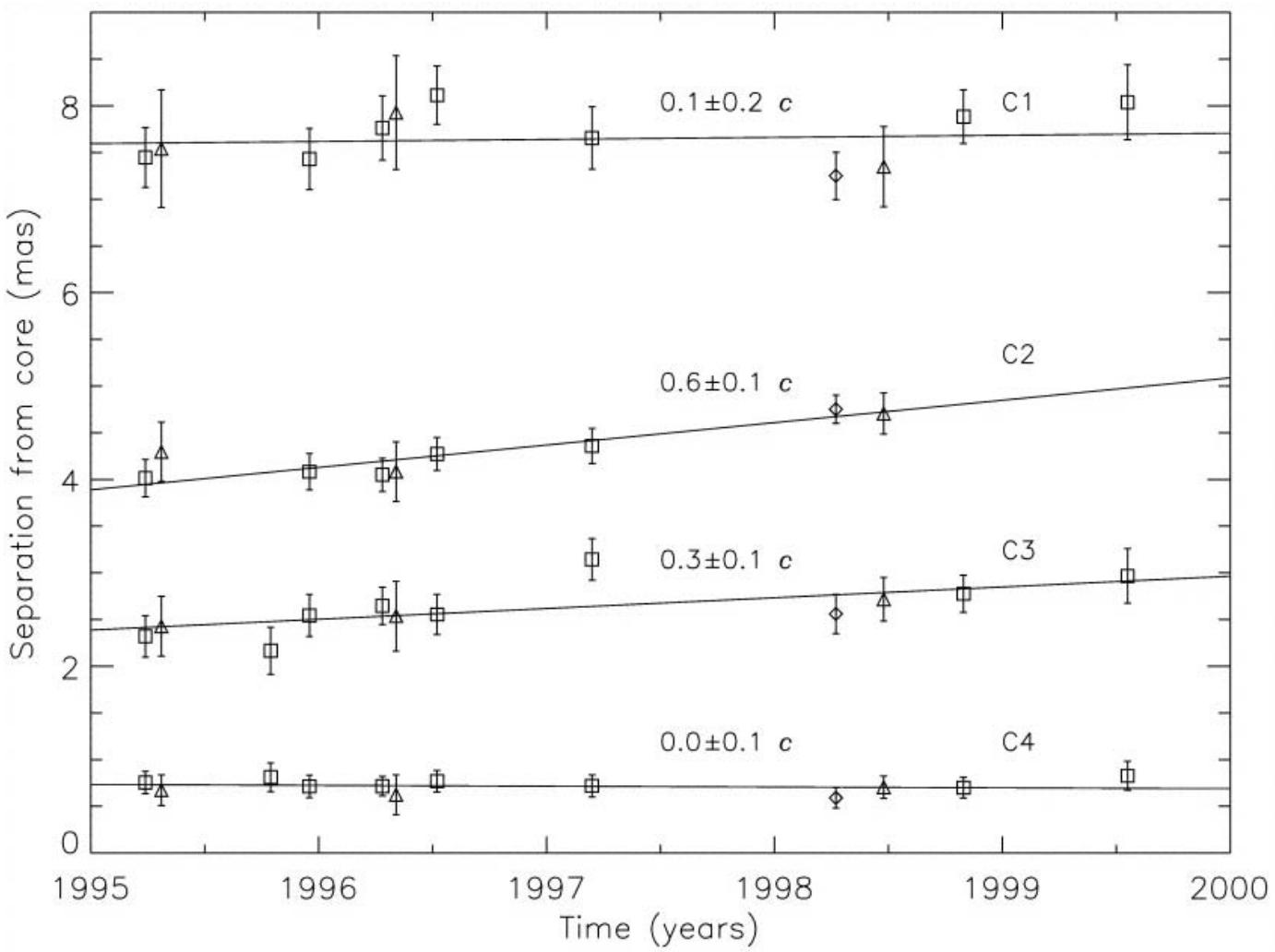
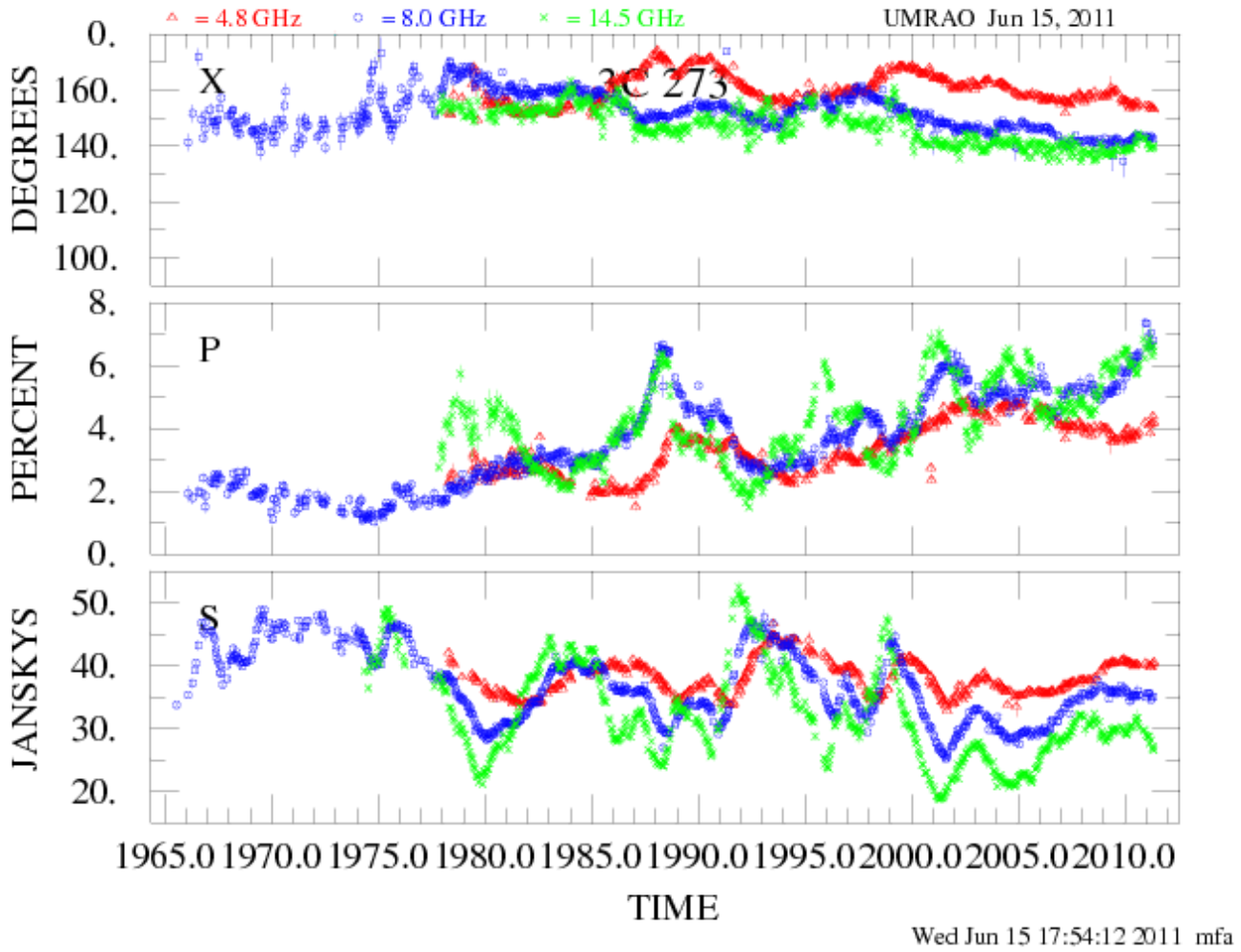
Mkn 501 component motions



3C273 -- UMRAO monitoring



Wagner & Witzel 1995, ARA&A

GAMMA-EMISSION The gamma-ray regime has become accessible with the advent of the *Compton Gamma Ray Observatory* (*CGRO*). One of the early results was the discovery that most of the sources detected at energies of 100 MeV to 1 GeV are radio-loud objects. The all-sky survey led to the discovery of 25 blazars (Fichtel et al 1994), most of which are known to be intraday variable sources in the optical and radio regimes. Conversely, a large fraction of the prominent radio-IDV sources (e.g. 0716 + 714, 0804 + 499) are strong emitters of high-energy gamma rays. For many of them the gamma-ray

PKS 1622-297 (Wajima et al. 2006, PASJ)

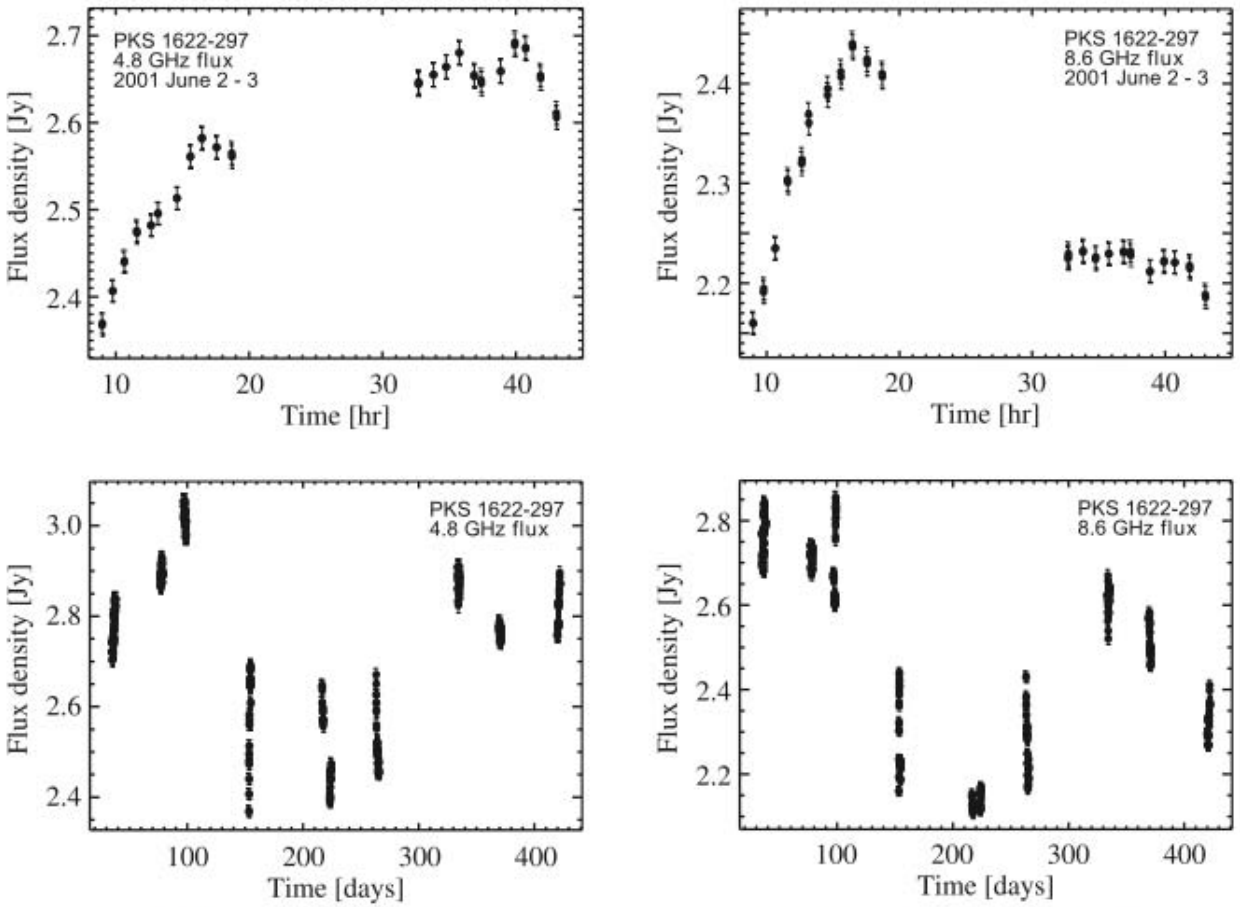


Fig. 5. Results of the flux density monitoring in the ATCA IDV survey program at 4.8 and 8.6 GHz. (Top): Total flux density at 4.8 GHz (left) and 8.6 GHz (right) on 2001 June 2–3, when the largest amplitude IDV was observed. Horizontal axis shows hours (UT) since 2001 June 2 (day 153), 00:00. (Bottom): Long-term flux variation at 4.8 GHz (left) and 8.6 GHz (right). Horizontal axis shows days since 2001 January 1.0.

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Intra-Day Variability

- Extrinsic or instrinsic?
  - An annual cycle in the IDV of some sources is clear evidence of interstellar scintillation as the cause
  - Correlated radio and optical IDV in other sources favors an intrinsic origin
- In either case, the source must contain a very compact component!
- The MASIV survey (Lovell et al. 2003, 2008) studied 443 sources with the VLA
- A trade-off is necessary between # sources, # frequencies, and #snapshots in a finite time!

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Concluding remarks

- Fermi provides great improvements in (among other things) angular resolution, sensitivity, and sky coverage over EGRET
- Can we do better than Fermi?
- We're much better placed with complementary radio monitoring campaigns
  - Single dish, & interferometer multi-epoch, multi-frequency campaigns
  - All-sky VLBI monitoring of parsec-scale structure
- So where does that leave us?

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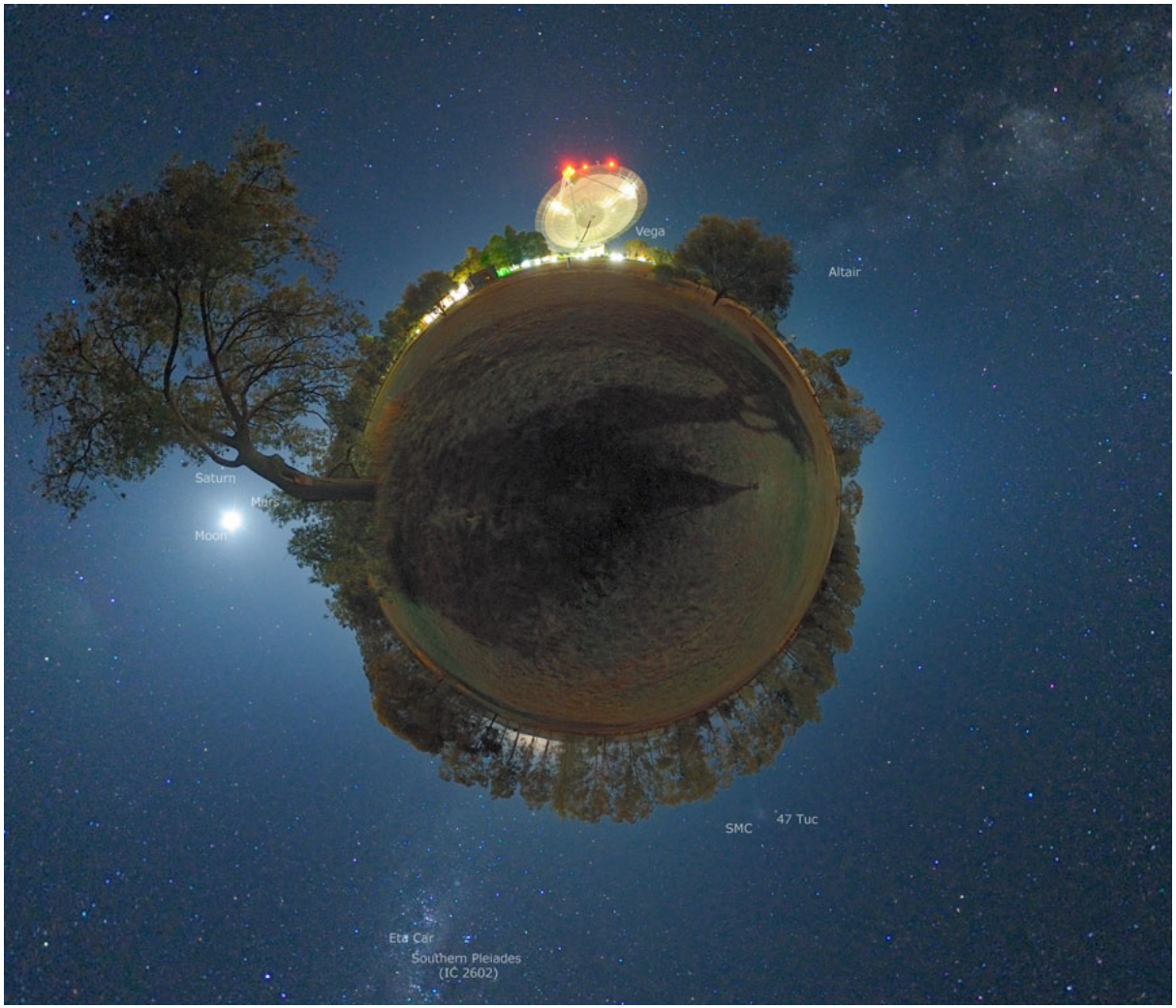
On top of the world!



APOD 100803

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Thank you

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