



The Pierre Kaufmann Radio Observatory

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IAG/USP

Summary

- Description of the equipment available along the last 50 years (hardware and software)
- Insertion of the Observatory in the International context
- Relation of equipment available with frontier science at different epochs.
- Future of the Observatory (Radiotelescope).

The PK Radio Observatory

- Located in Atibaia, SP, 800 m above sea level.
- First radio telescope covered by a radome, built by ESSCO, which made radomes for radars, such as Haystack.
- Operates between 10 and 100 GHz (<50 GHz because of the atmosphere)



The Radio Telescope

- **Radiotelescope:**
 - 13.8 m de diameter,
 - Cassegrain focus
 - Alt-azimuth mount
- **Vantages of the radome**
 - Lightweight Frame
 - Pointing accuracy
 - Can observe the Sun
- **Disadvantages**
 - Absorption
 - Standing waves.

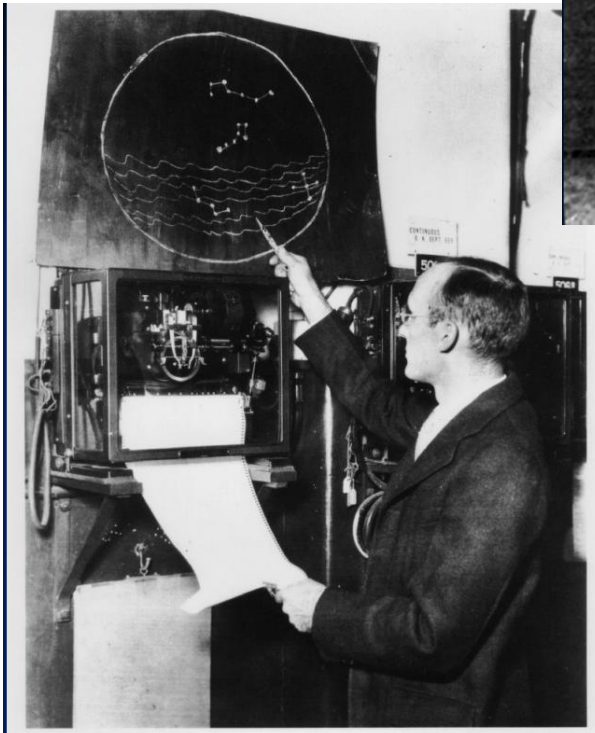


Construction (1971)



History of radioastronomy: 40-20 years before

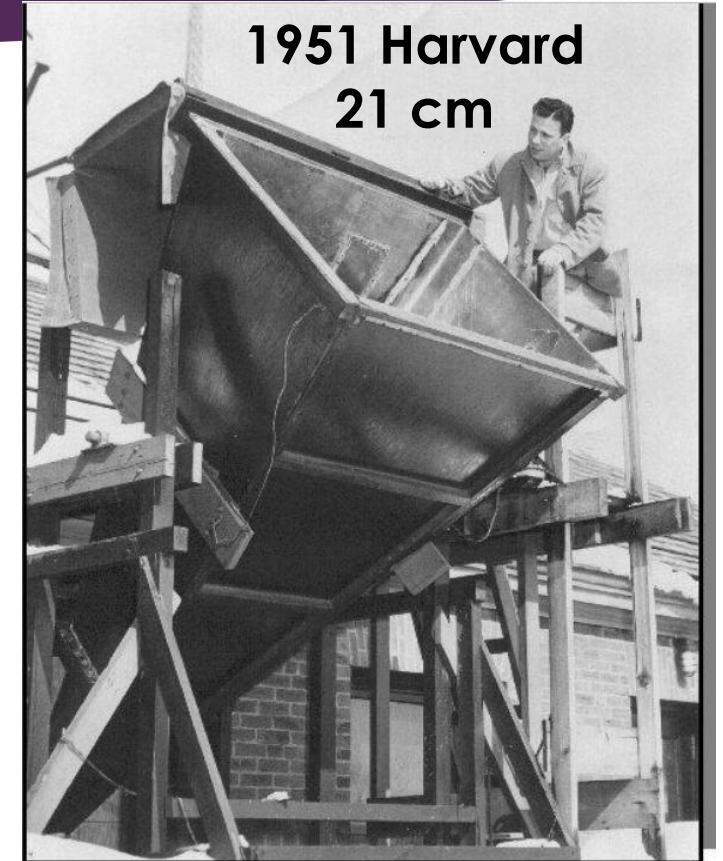
1930 Jansky



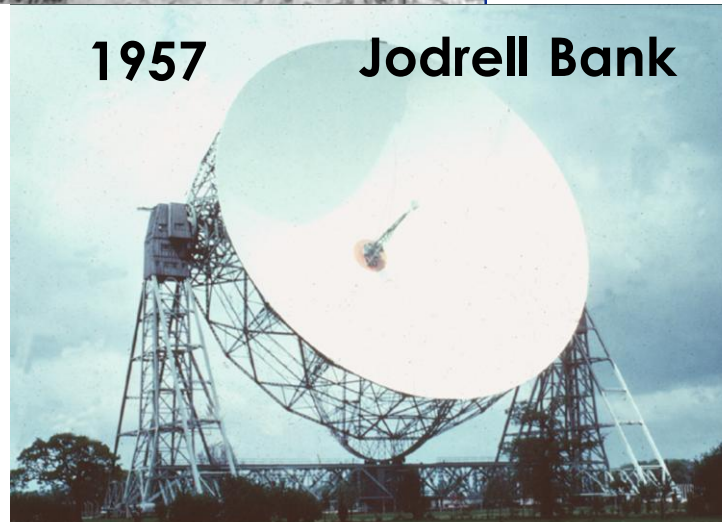
1945 Jodrell Bank

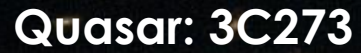


1951 Harvard
21 cm



1957 Jodrell Bank





1963



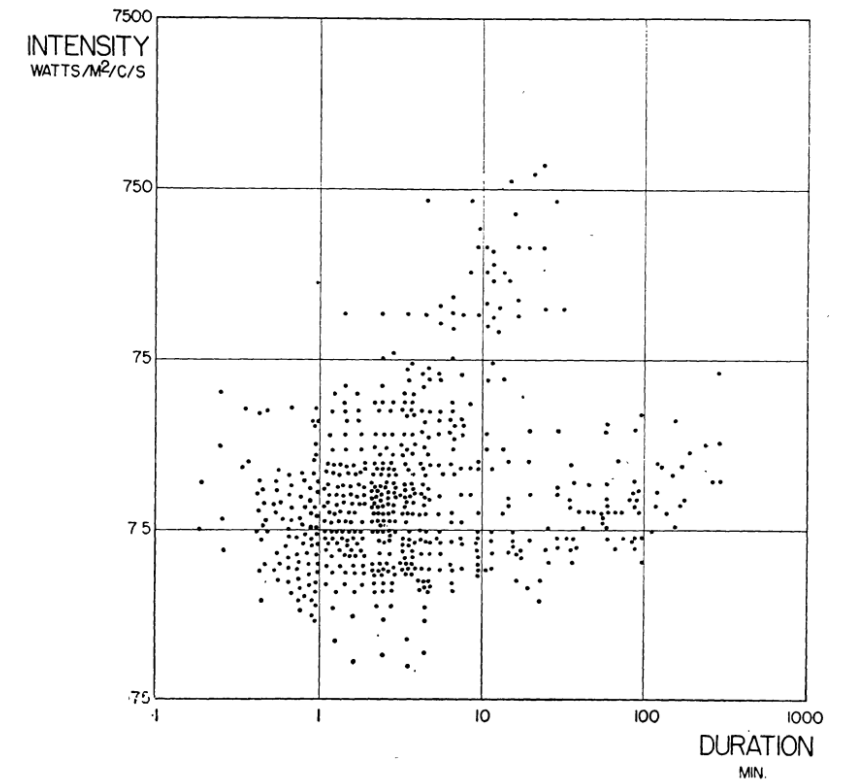
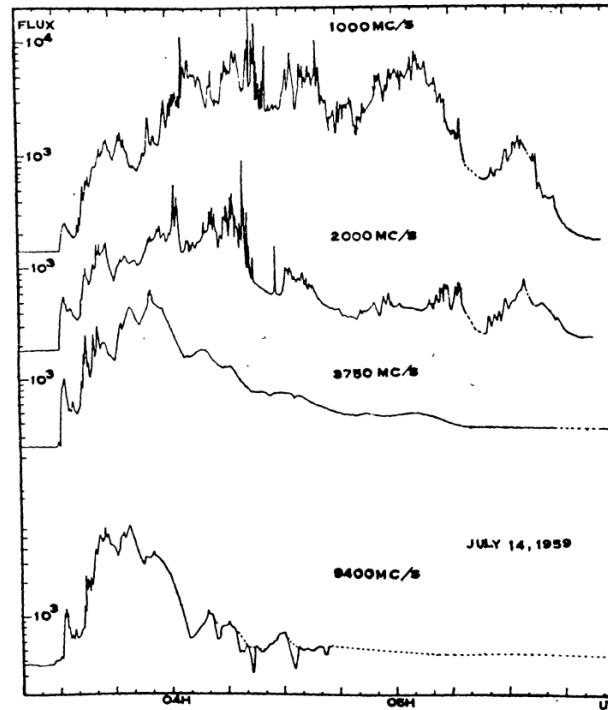
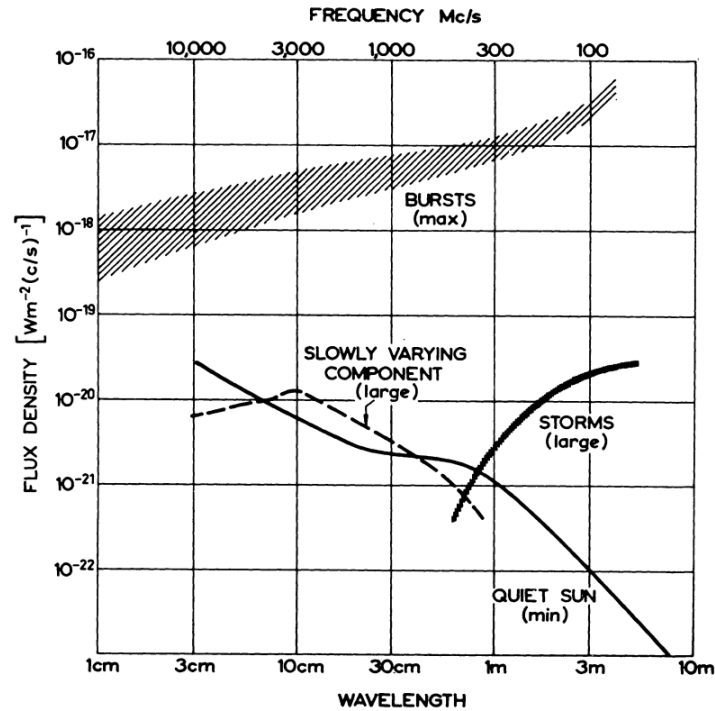
Fig. 1. Observed 1,667 Mc/s OH absorption spectrum in Cassiopeia A. The heavy line shows 8,000 sec of data taken with the antenna beam directed at Cassiopeia A, and the light line shows 6,000 sec of data taken with the beam displaced slightly from Cassiopeia A. The frequency scale is expressed in kc/s with respect to the local standard of rest assuming rest frequency to be 1,667,357 kc/s.



Fig. 3. Observed spectral intensity of H_2O transition in the direction of $W49$. The position of peak emission is $\alpha_{1950.0} = 19^h 07^m 55^s \pm 5^s$, $\delta_{1950.0} = +09^\circ 04' \pm 1'$.



Scientific motivation: Solar physics



First Observations: AGNs, H₂O masers , HII regions (1974)

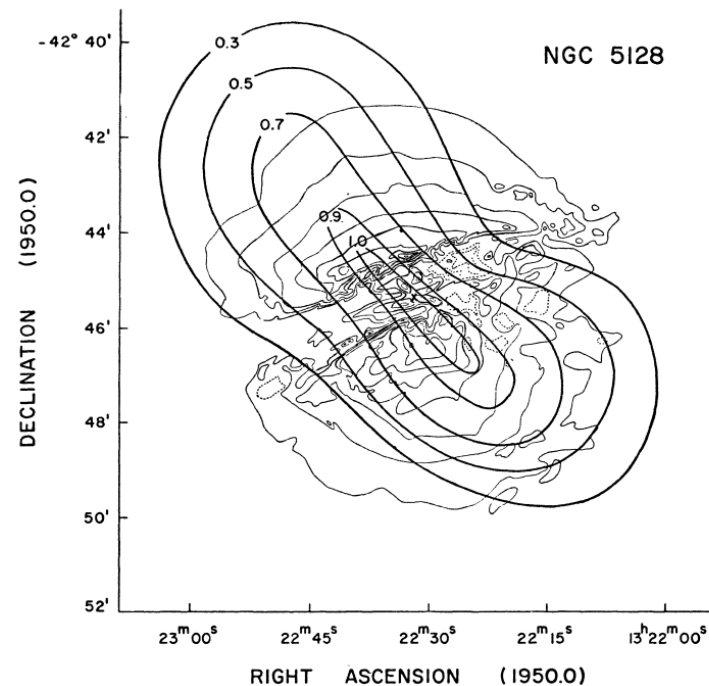
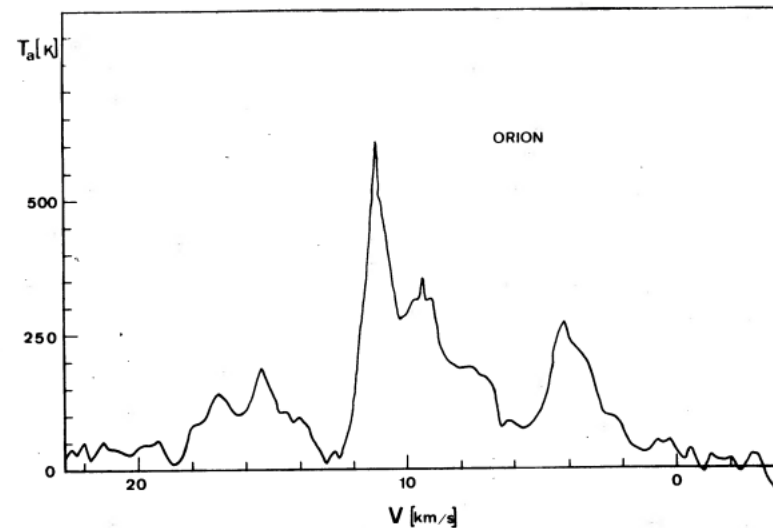


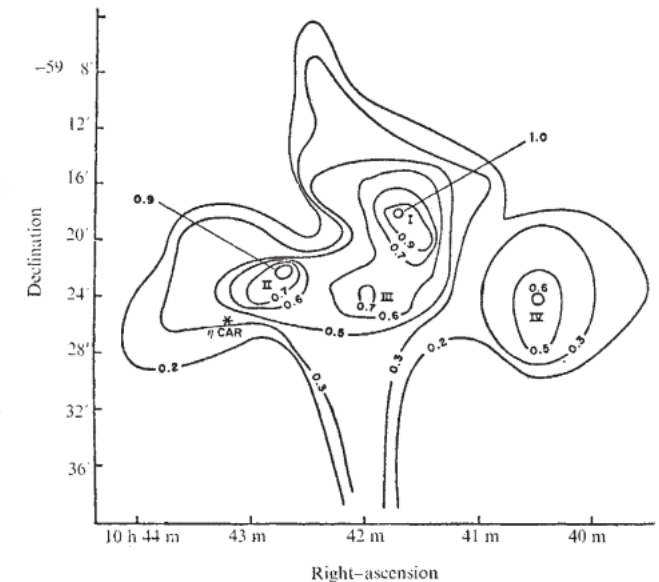
FIG. 1

Centaurus A
Kaufmann et al. AJ 1974

Receptor de banda larga com analisador espectral

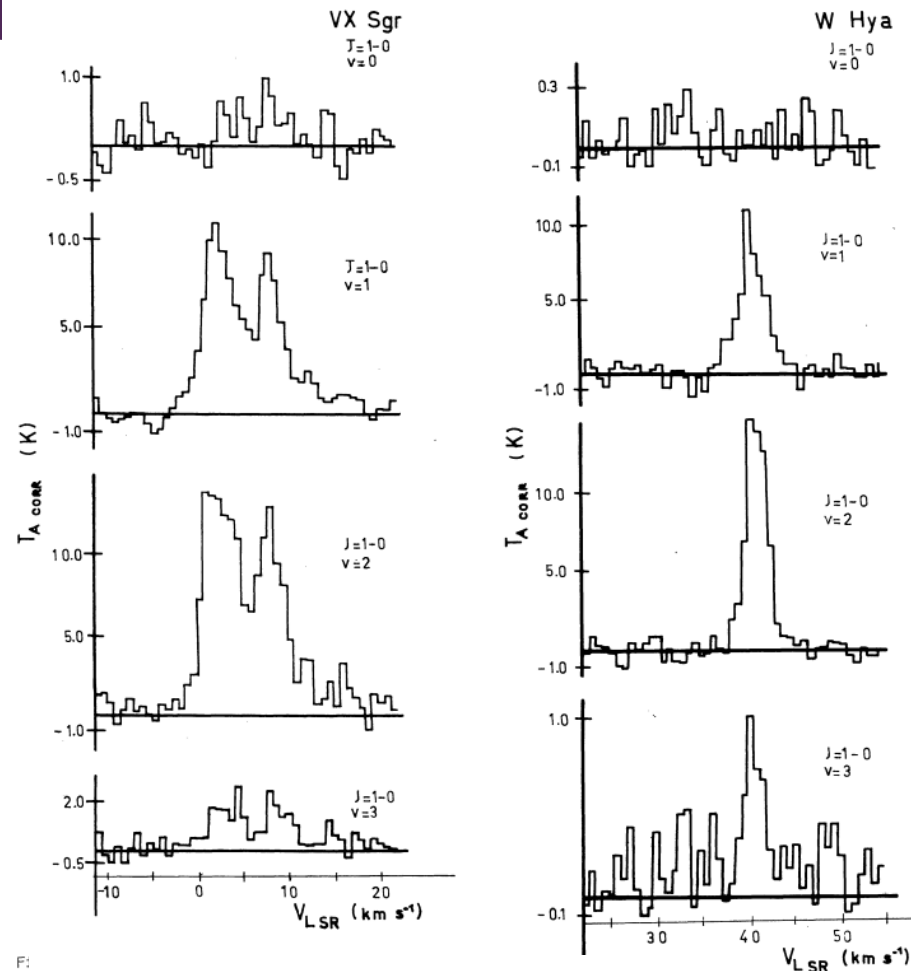


Maser de H₂O em Orion
Kaufmann et al. 1974



Carina HII region 22 GHz
Scalise et al. Nature
1974

The 43 GHz receiver: SiO masers

F:
pi

Scalise & Lépine (1978)

The maser receiver and multichannel spectrometer (1976)

22 GHz receiver

Ruby Traveling Wave Maser cooled with liquid He (open cycle), donated by Haystack

Spectrometer

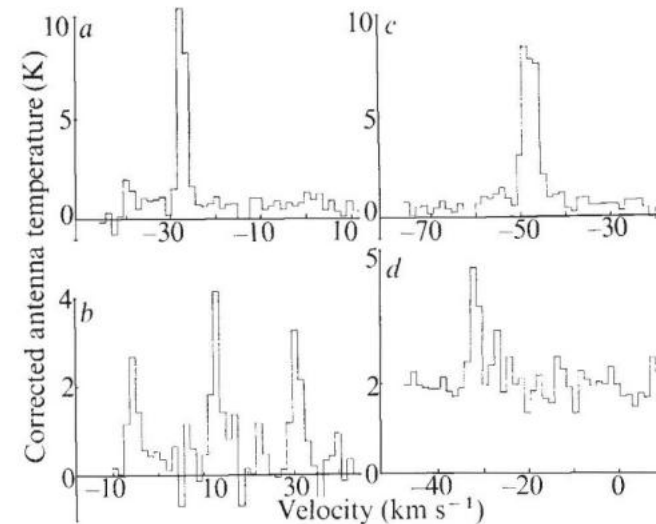
47 channels of 100 kHz (1.3 km/s)

Observing method

Beam-switching (2 horns)

letters to nature

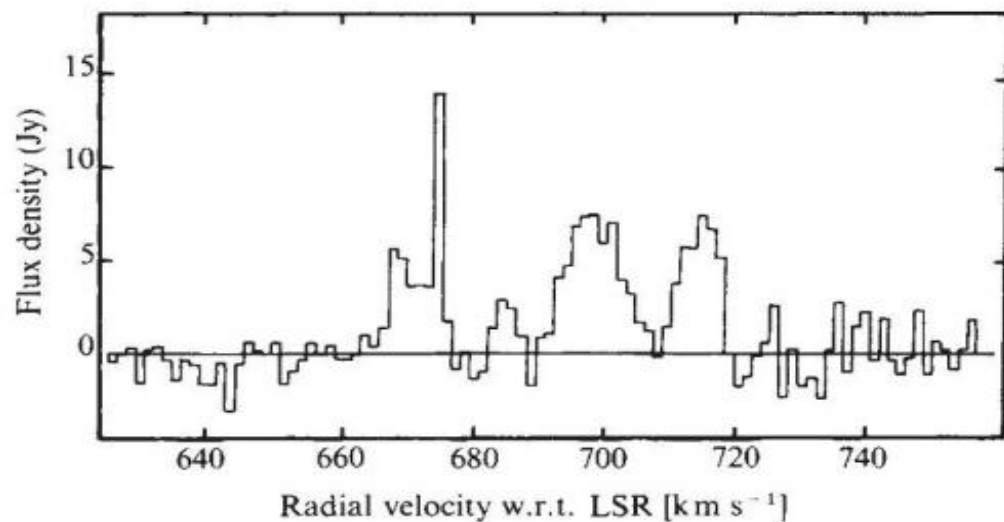
New H₂O celestial sources associated with H II regions in the Southern Hemisphere



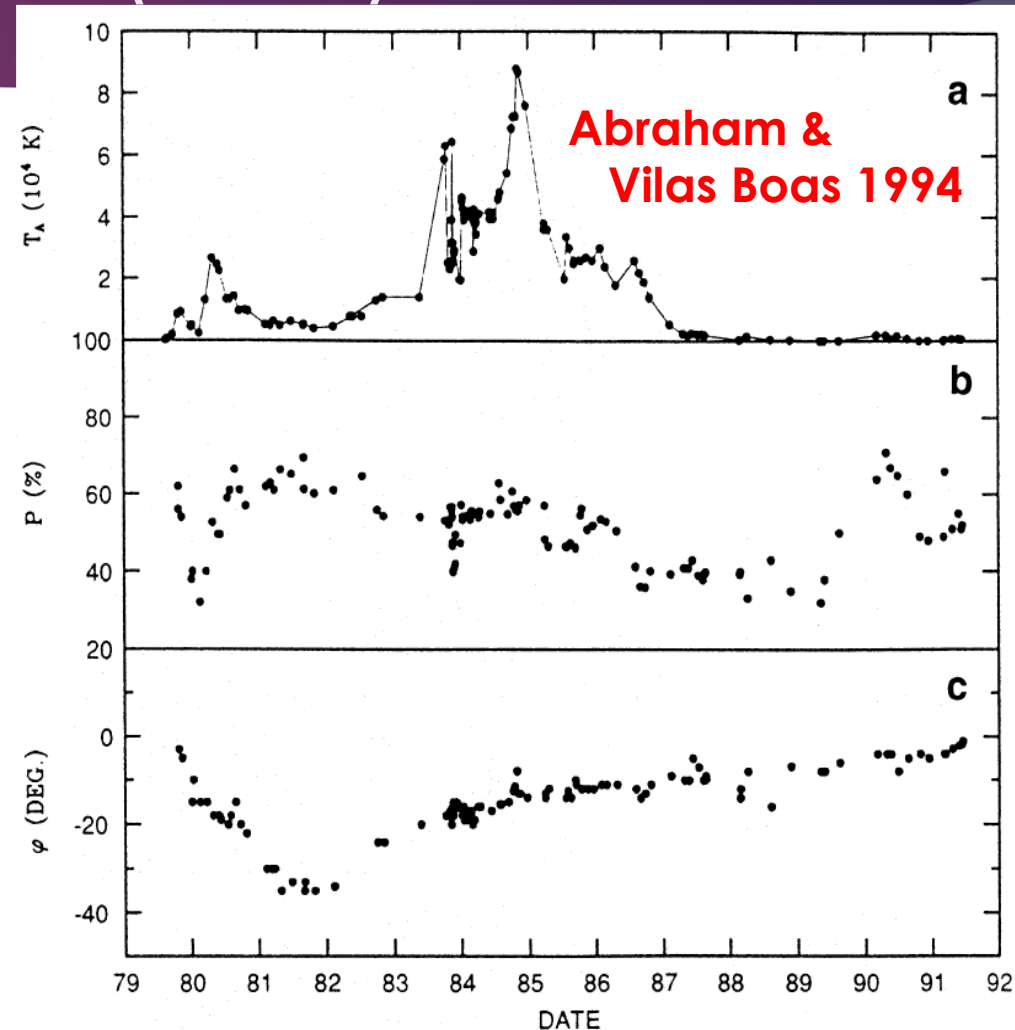
Kaufmann et al. (1976)

The maser receiver and multichannel spectrometer (1979)

Detection of strong H₂O emission from galaxy NGC4945



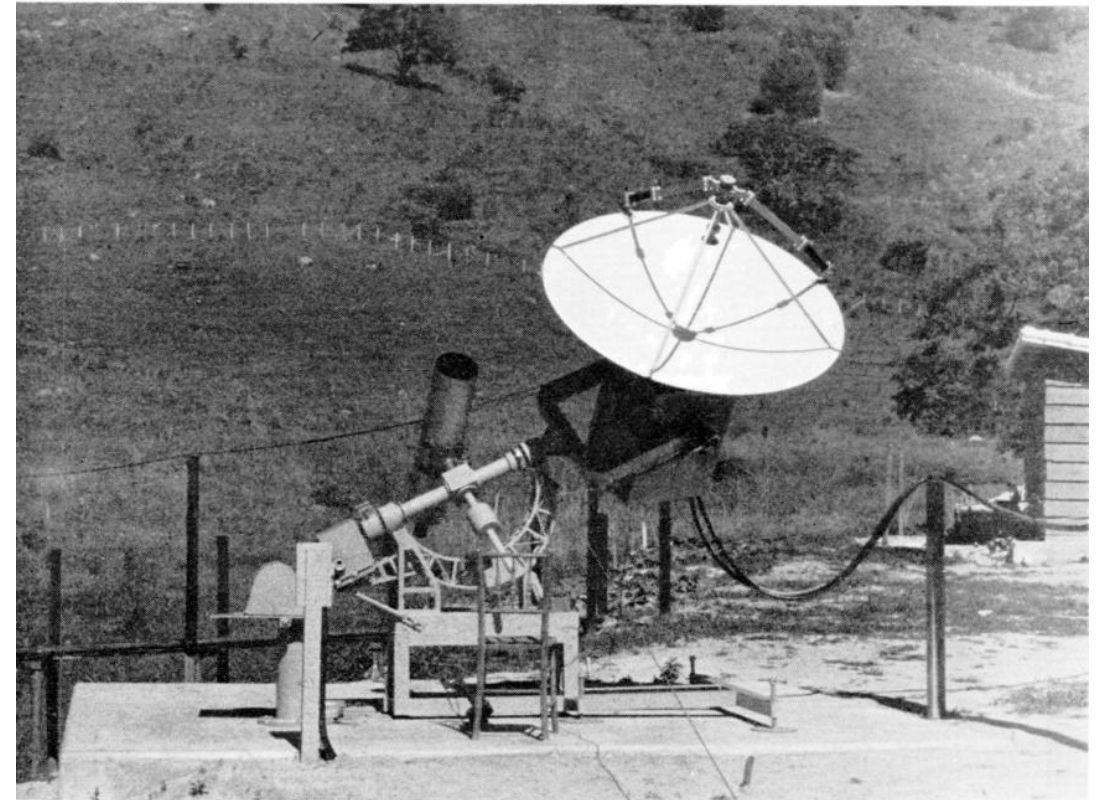
dos Santos e Lépine (1979)



Solar Observations?

7 GHz with a 1.5 m antenna

- ▶ Motivation:
- ▶ Antenna did not track the Sun
- ▶ Antenna beam (4') $\ll$ Size of the Sun (30').
- ▶ It was not possible to storage the data while waiting for a flare
- ▶ The receiver saturated.



First tracking and data acquisition computers



HP 2114, 4 kB memory
No operational system

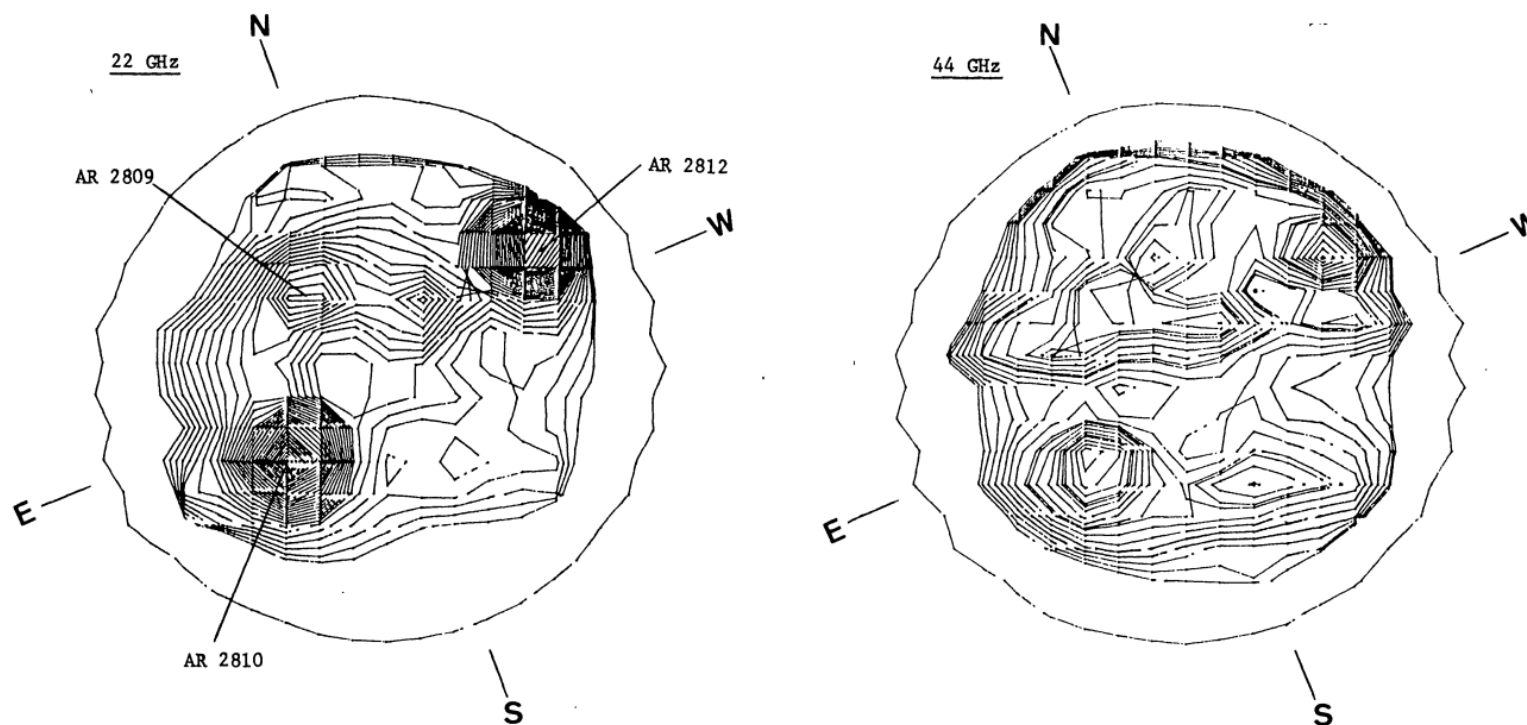


The International Telegraph Alphabet

● INDICATES A MARK ELEMENT (A HOLE PUNCHED IN THE TAPE)
○ INDICATES POSITION OF A SPROCKET HOLE IN THE TAPE

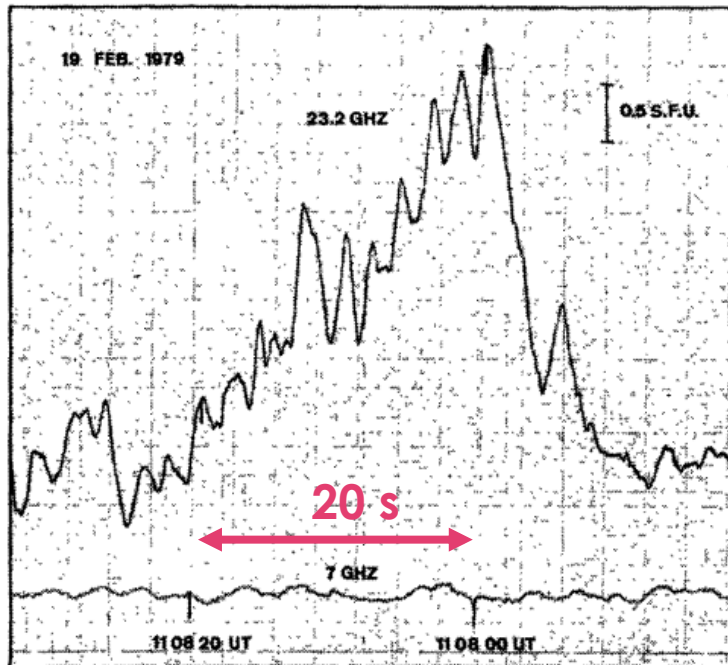
LETTERS	FIGURES	CODE ELEMENTS
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1980s New software: Tracking and solar maps (6 min)

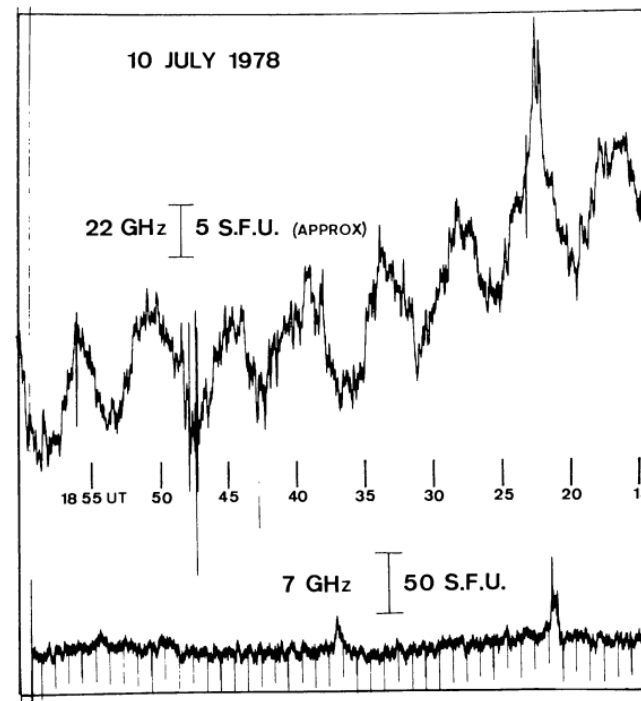


Kaufmann et al. (1981)

Solar observations: high spatial and temporal resolution

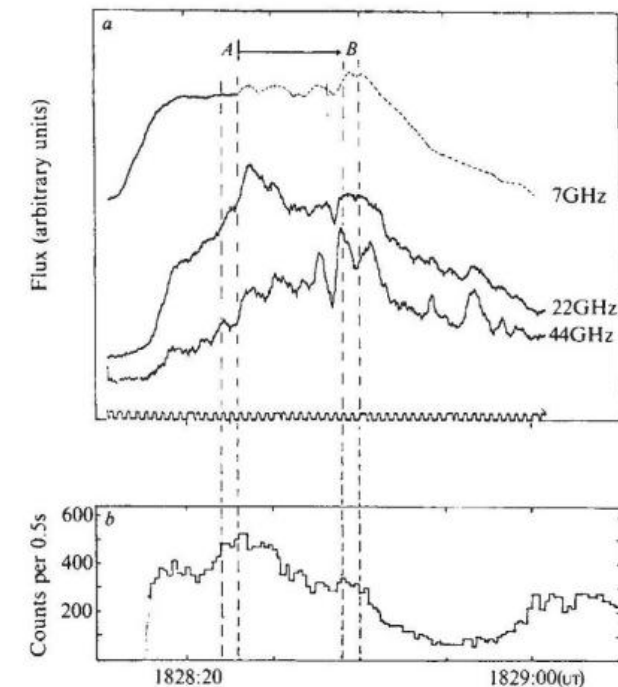


Kaufmann et al. (1980)



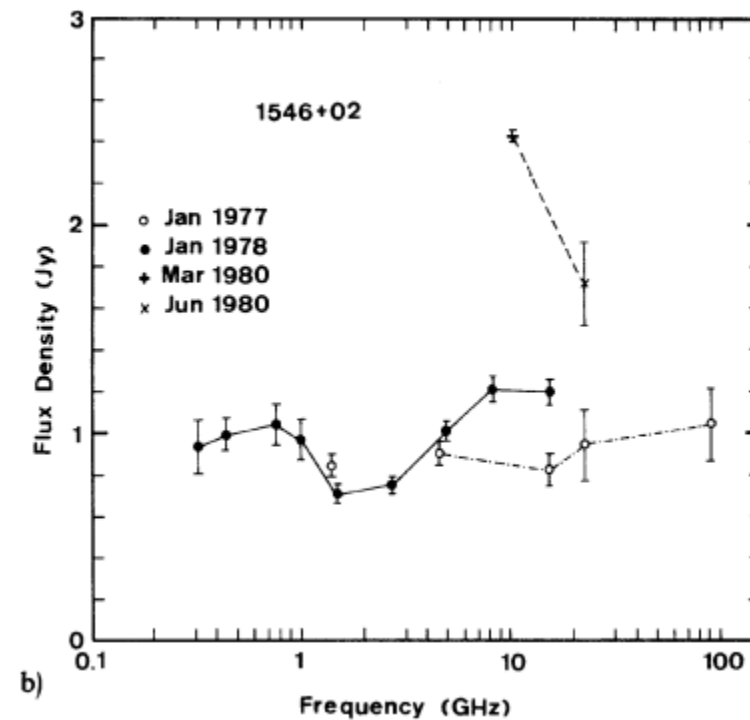
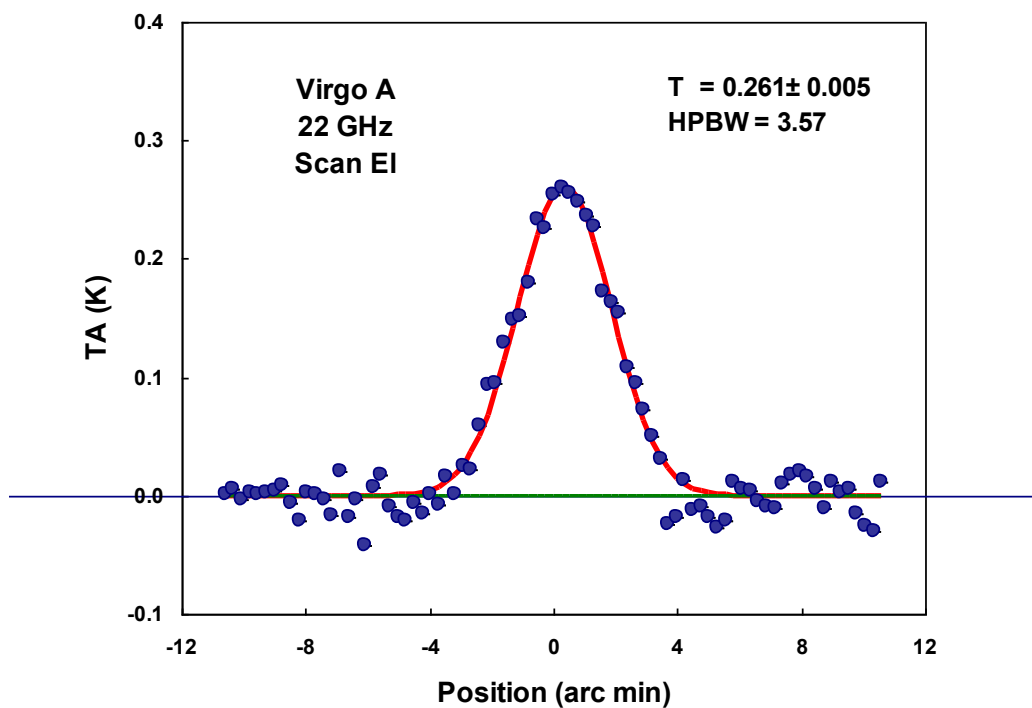
Strauss et al. (1980)

Sub-second pulsations simultaneously observed at microwaves and hard X rays in a solar burst



Takakura et al. (1982)

New software: Scans (on-the-fly) for the continuum



Abraham, et al. 1984

VLBI: MarkII (1985)

Biretta et al. 1985

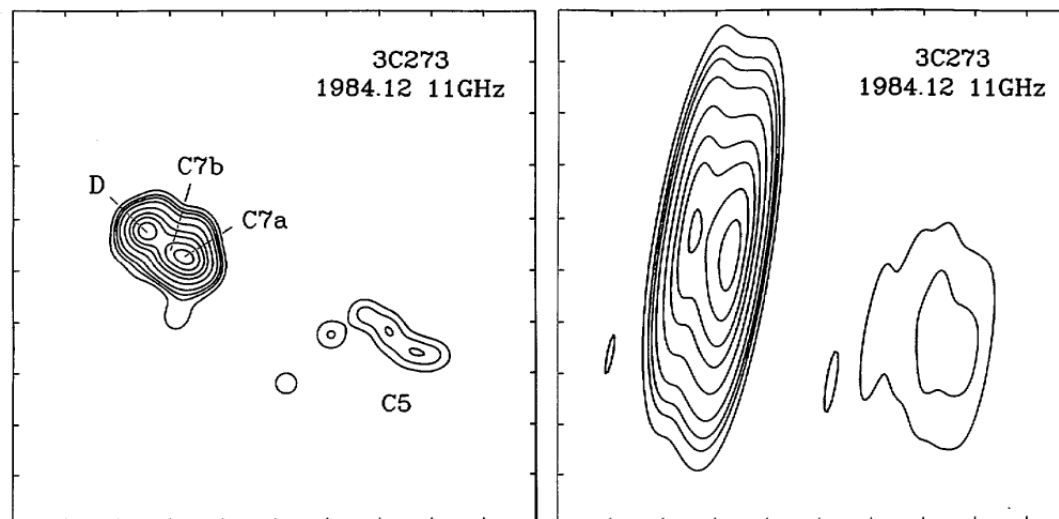


FIG. 1a

FIG. 1b

**Max Plank 100 m; Owens Valey 40 m,
Haystack 37 m, Green Bank 43,
Fort Davies 26 m, Itapetinga 14 m**

1990s New tracking computer: PC

- ▶ Program in C++
- ▶ Interface with Instruments: GPIB, serial, parallel
- ▶ Back-end: Digital programmable voltmeter for the continuum, with memory to storage the data of each scan

1990's: data acquisition computer (Work Station)

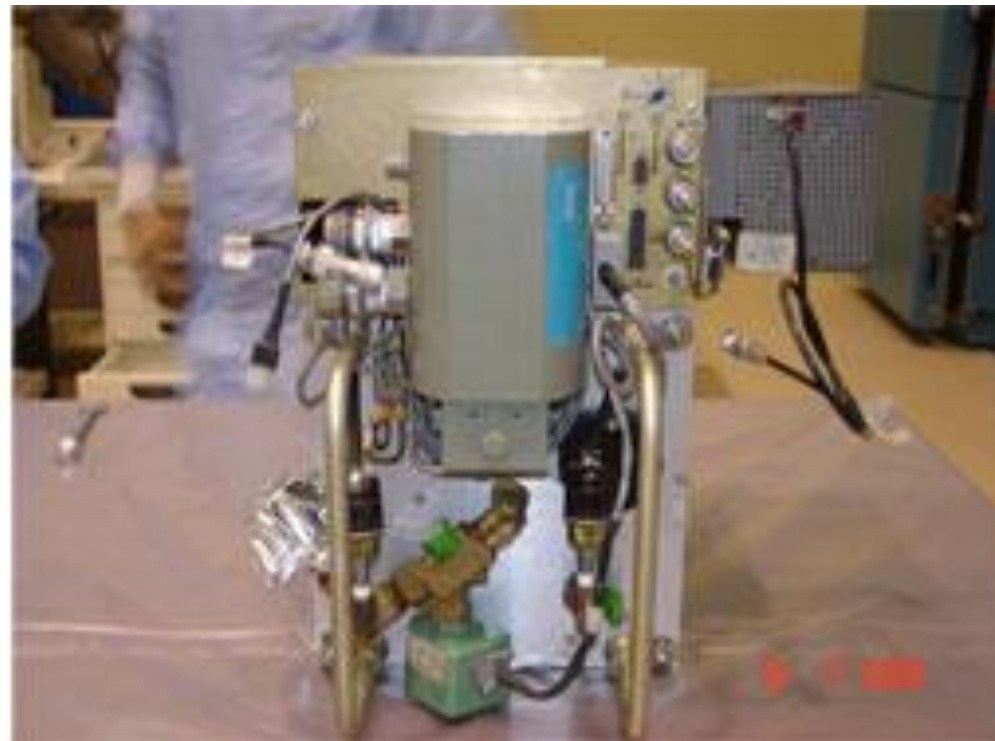
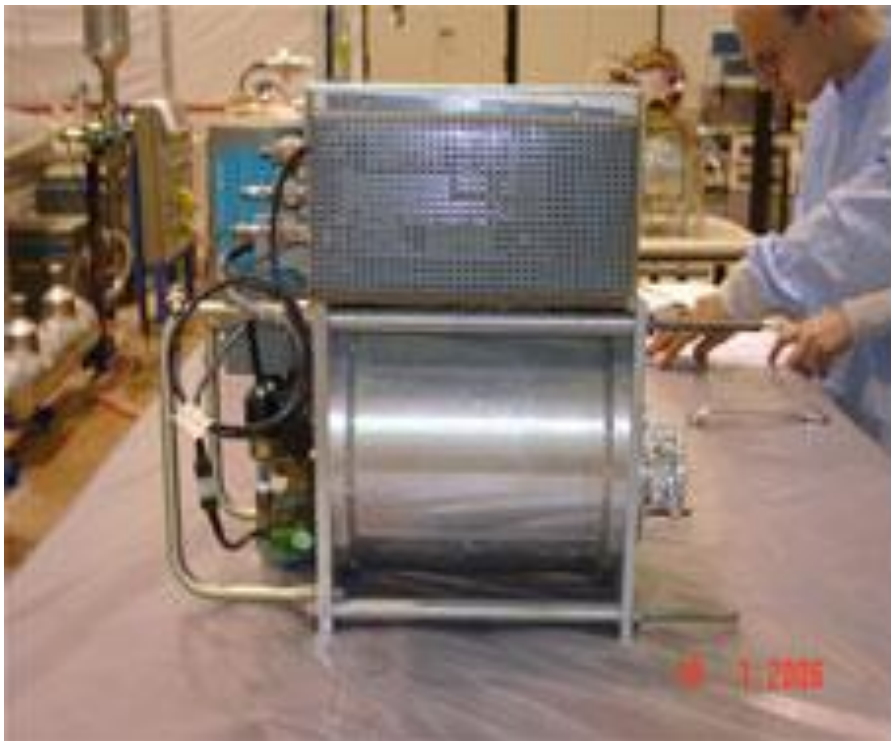


16 kB memory, no hard disk for storage

Used “floppy disks”



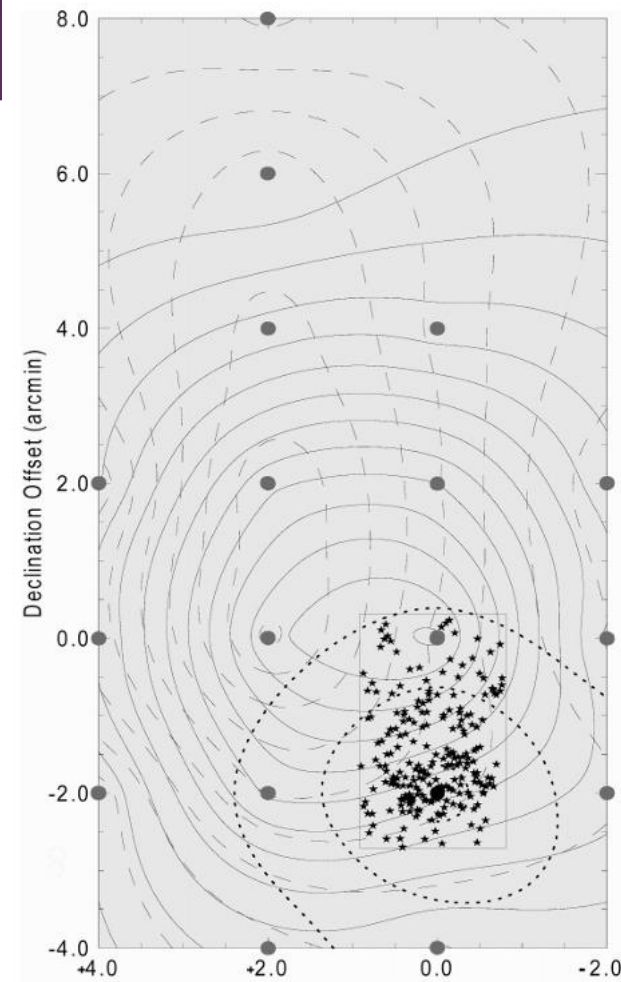
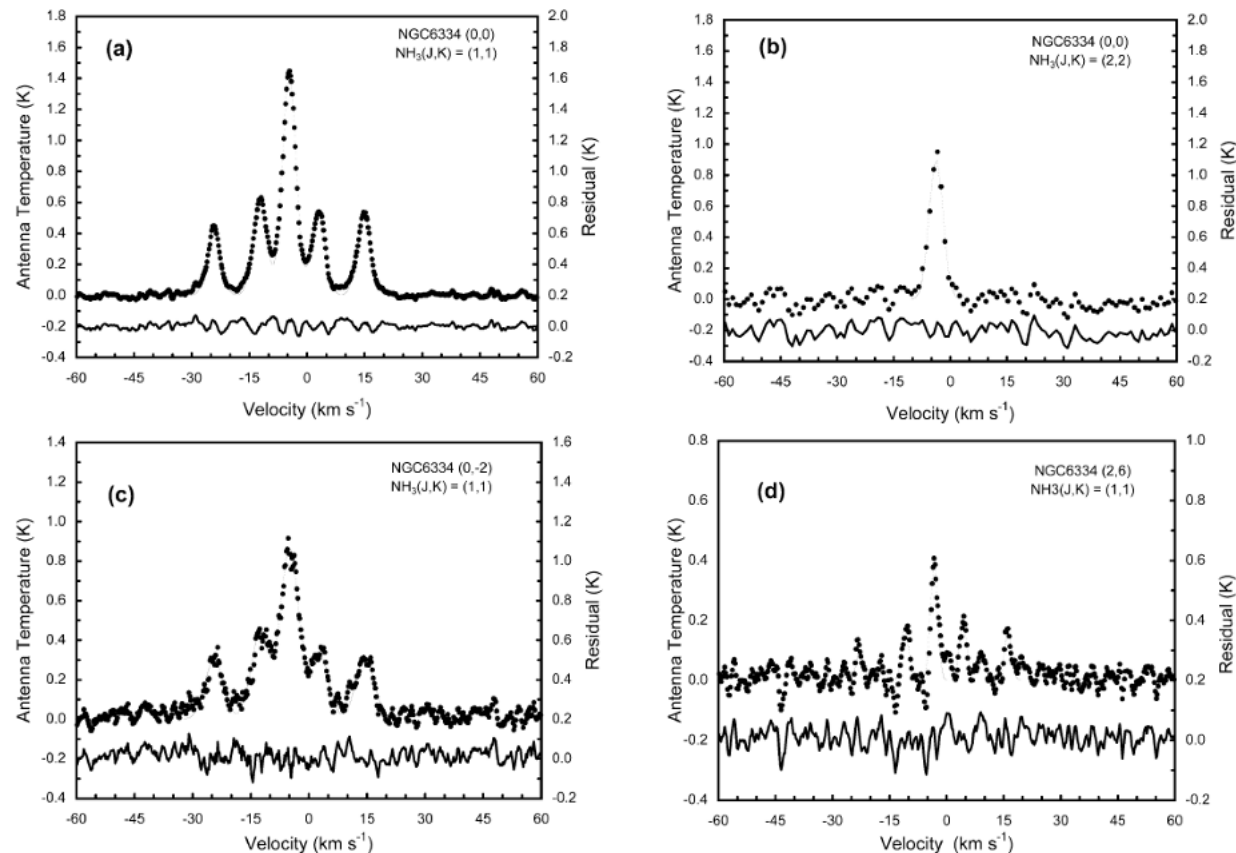
1990's: cryogenic 18-24 GHz line receiver



1990's: Observations of NH_3

Study of the ammonia emission in the NGC 6334 region

A. Caproni¹, Z. Abraham¹, and J.W.S. Vilas-Boas² **A&A (2000)**



2000's: tracking (new PC)

22

Menu Track (Ctrl T) Observe (Ctrl O) Sources (Ctrl S) Utilities (Ctrl U) View (Ctrl V) Exit (Ctrl X)

Antena

Time

Universal h: 17 m: 55 sec: 26.660

Sidereal h: 0 m: 16 sec: 38.691

☐ GPS ☒ Computer ☐ Sidereal

Tracking Form

Continuum

Amplitude: 0.000

Time Interval: 20.000

Tracking Mode

☒ Atibaia ☐ Poli

Position

Encoders Elevation: 166.665 Azimuth: 1666.660 ☐ ON

Source 11.490 90.755 ☐ OFF

Errors -155.175 -1215.910 New Source

Status

Standby Stop Manual Tracking

Source Coordinates

Source: Orion -NH3

Right Asc. h: 5 m: 35 sec: 30.109 DelRaDt: 0.0000

Declination deg: -5 m: 10 s: 31.709 DelDeDt: 0.0000

Time

Date

Today day: 11 month: 2 year: 2001

Day of the year: 42 Julian Day: 2451951.5 Equinox: -0.93670

ST at 0h UT h: 9 m: 24 sec: 30.3054

SelectTracking

Tracking Type

☒ Continuum ☐ Calibrate ☐ Scan Az ☐ Scan El ☐ Scan Ra ☐ Scan De ☐ Scan 3p ☐ Map ☐ OnOff

Scan and Three Points

Time Interval (sec): 20.0

Dtwait (min): 2.85

Amplitude (min): 60.0

Three Points

Delta Dec (min): 60.0

Input

Input Coordinates

Select Epoch

☐ 1950 ☒ 2000 ☐ Today

Select Position

☐ P2 ☒ Center ☐ P3

Source Coordinates

Source: Orion -NH3 Planet: ☐

Right Asc. h: 5 m: 35 sec: 27.716

Declination deg: -5 m: 10 s: 31.530

DelRaDt: 10 DelDeDt: 10

GetDB Input Clear

Antenna Parameters

Antenna Parameters

IE: 0 IA: 0 OFFL: 0 OFFR: 0

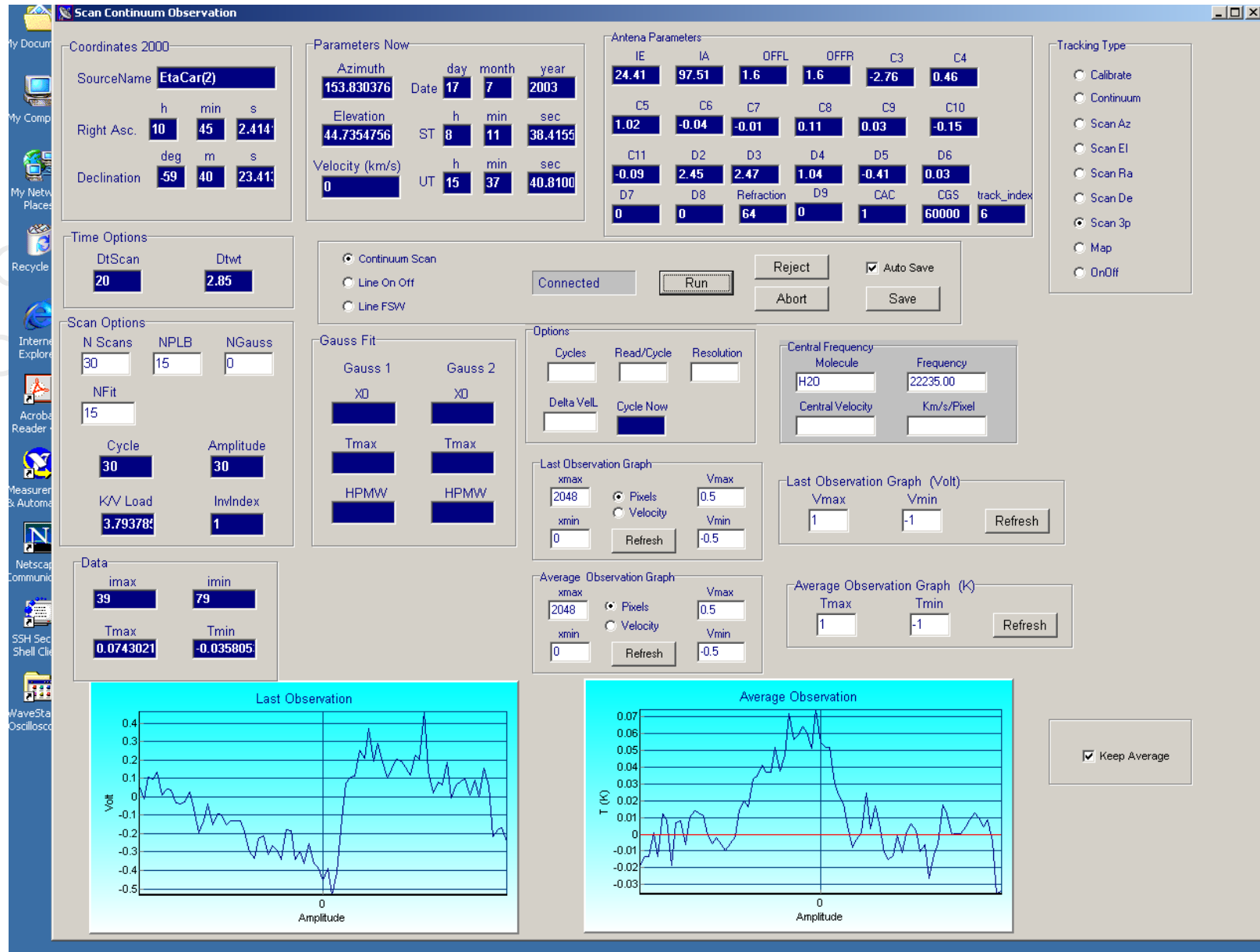
C1: 0.00251 C2: 0.89 C3: -15 C4: 0

CAC: 1 CGS: 10000 Refraction: 60

GetDB Input

2000's: data acquisition (another PC)

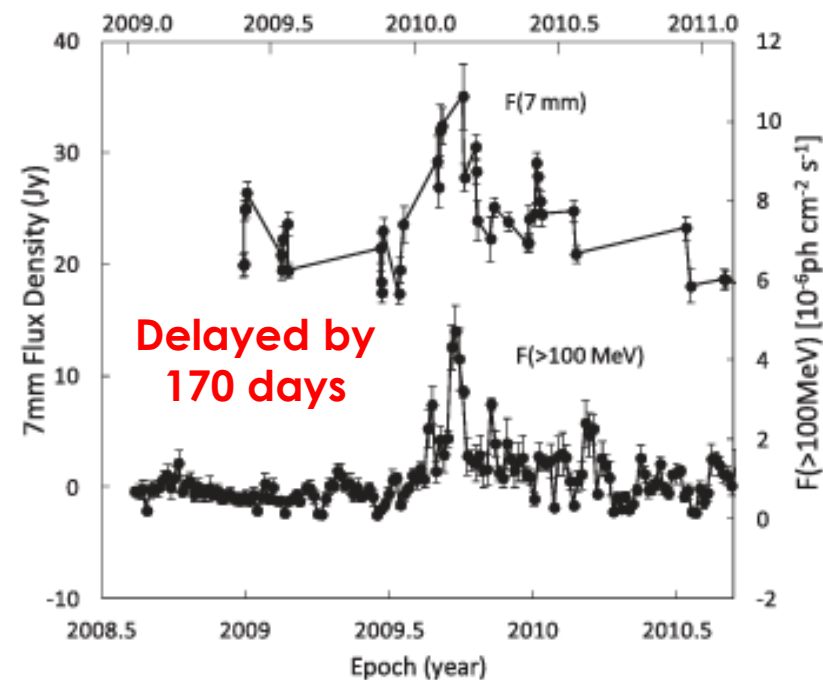
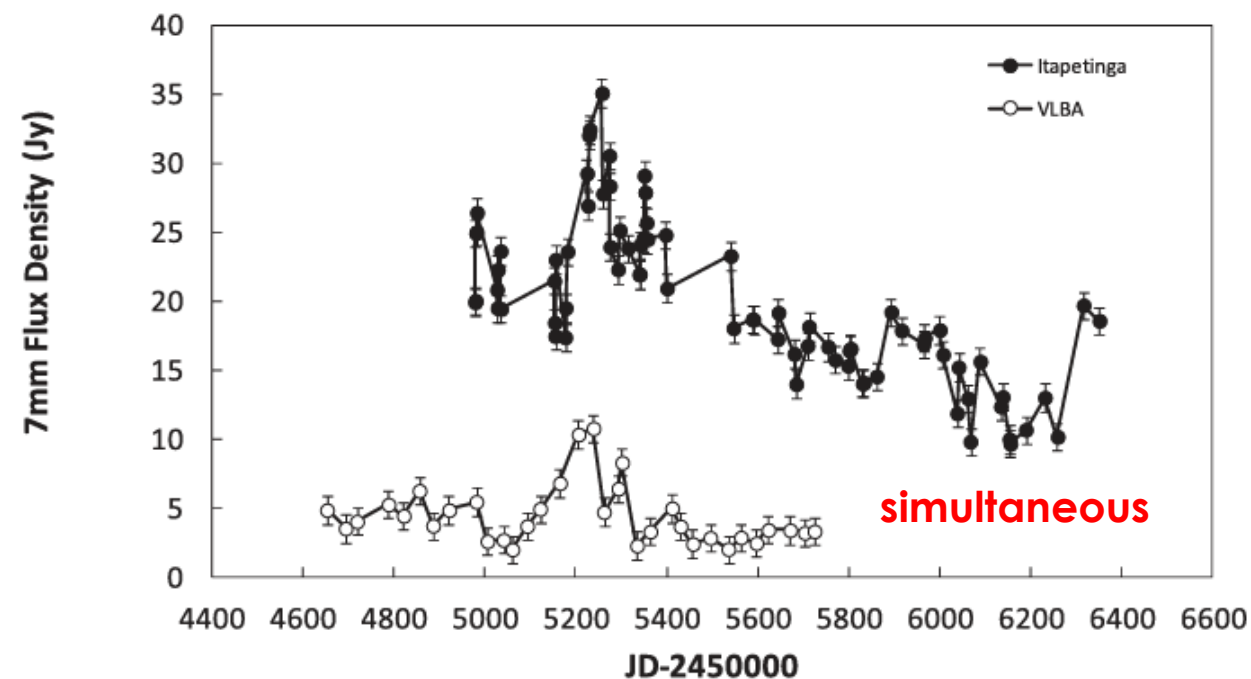
23



2000's Science: variability

3C 273 variability at 7 mm: evidence of shocks and precession in the jet

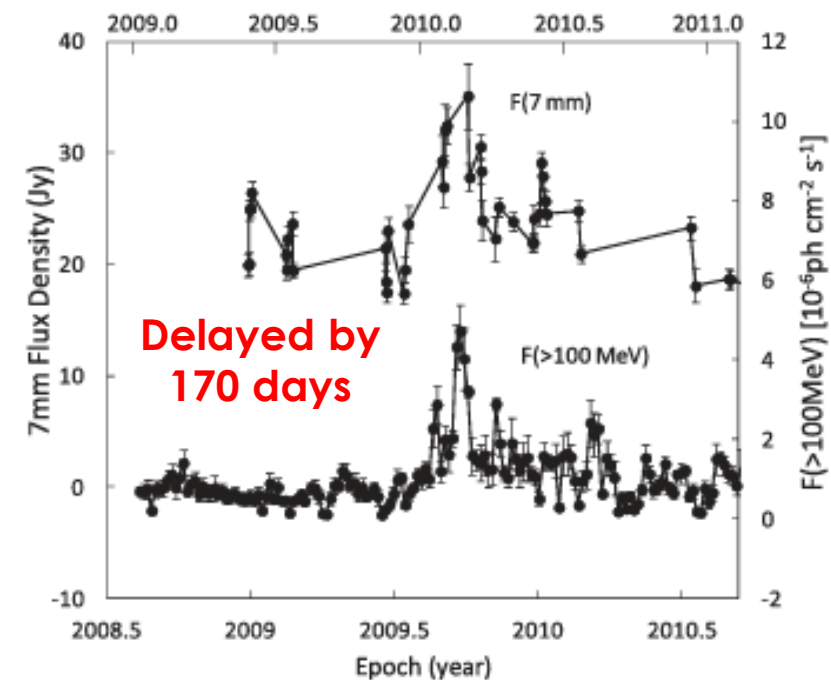
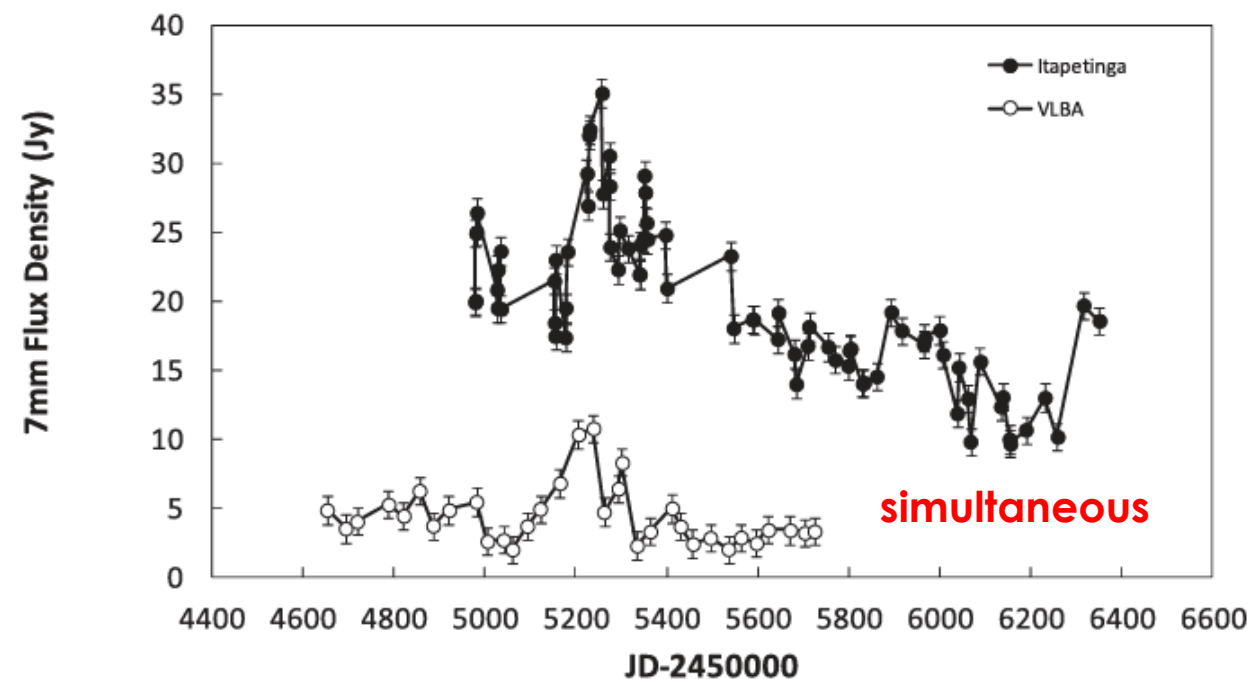
Pedro Paulo B. Beaklini[★] and Zulema Abraham **MNRAS (2014)**



2000's Science: variability

3C 273 variability at 7 mm: evidence of shocks and precession in the jet

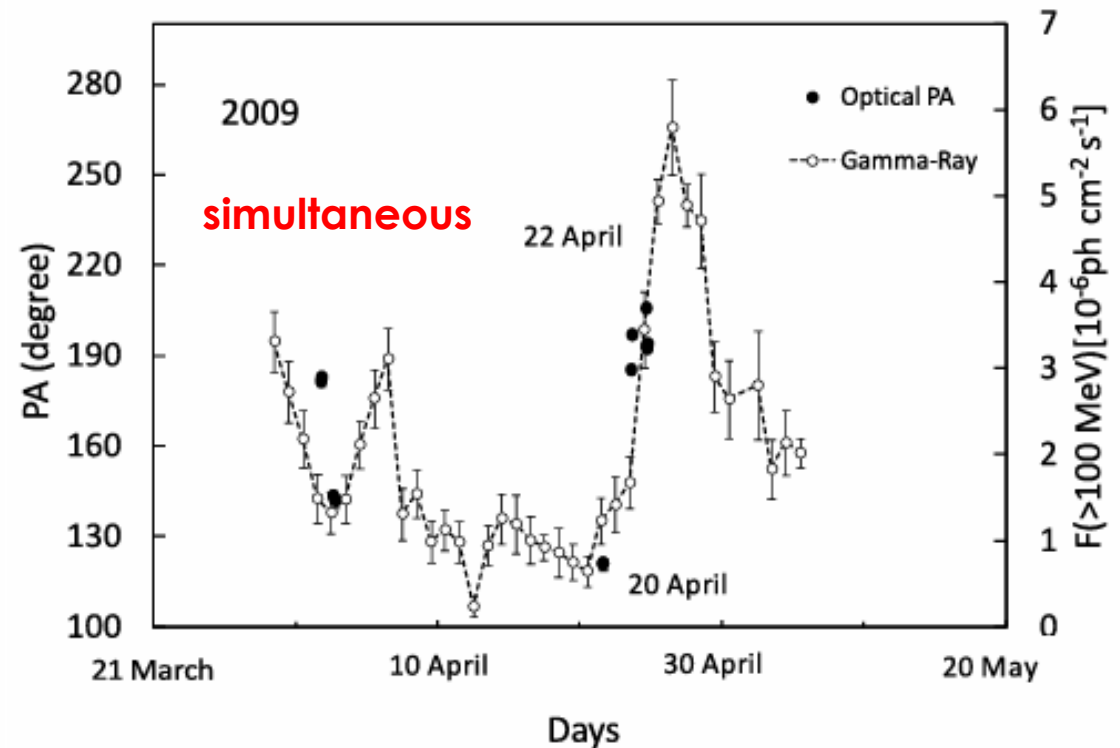
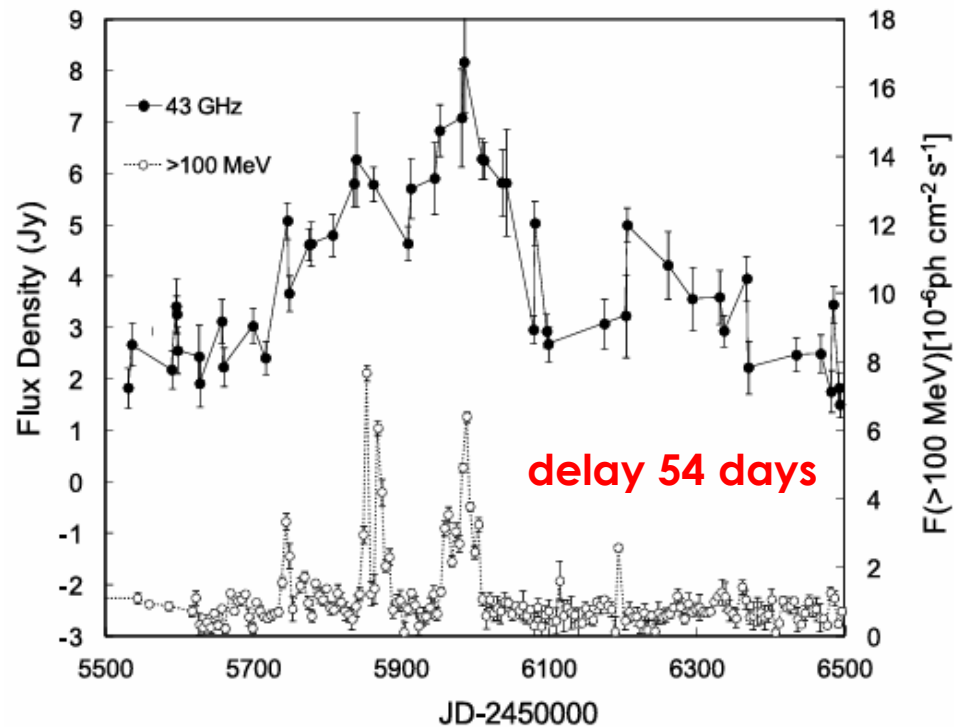
Pedro Paulo B. Beaklini[★] and Zulema Abraham **MNRAS (2014)**



2000's Science: variability

Multiwavelength flaring activity of PKS 1510-089

Pedro P. B. Beaklini¹, Tânia P. Dominici², and Zulema Abraham¹ **A&A (1017)**



Future

- ▶ Finish the upgrade of the radiotelescope (in progress, next talk)
- ▶ Continue with variability studies, entering into the multi-messenger era for AGNs
- ▶ Include variability of H₂O and SiO masers.
- ▶ Open the radiotelescope to the community, calling for proposals

Thank you