Revisiting the VLBA Calibrator Surveys, VCS-II

David Gordon and the VCS-II Team

NVI Inc./NASA GSFC

EVGA Meeting

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The VLBA Calibrator Surveys (VCS):

- 6 VLBA campaigns, VCS1-6, 24 24-hr sessions, 1994-2007.
- Observed ~2500 sources to evaluate their usefulness as phase-referencing calibrators and determine precise positions.
- Greatly enhanced the ability to do precise mapping and astrometry (parallaxes, etc.) on the VLBA and EVN.
- Precision goals were ≤1 milli-arc-second (mas).
- All sources also mapped.
- Added ~2200 sources to the X/S astro/geo catalog which later became ICRF2 in 2009/2010.

ICRF2:

- Had 3414 sources.
- ~1/3 were observed in many geodetic and/or astrometric VLBI sessions by IVS and its predecessors over a nearly 30 year period.
- ~2/3 were observed only in the VCS1-6 sessions and are mostly single-epoch. Their ICRF2 position uncertainties were ~5X larger than the other 1/3. Thus they represented a second class of ICRF2 sources.

So in 2013, the VCS-II team was formed and requested VLBA time to re-observe these sources an eliminate the 2-class distinction for ICRF3.

The VCS-II Team

David Gordon, PI	-	NVI Inc./GSFC
Anthony Beasley		NRAO
Christopher Jacobs		JPL
Alison Peck		NRAO/ALMA
Alan Fey		USNO
Chopo Ma		GSFC
Ralph Guame		NSF
David Boboltz		NSF
Oleg Titov		Geoscience Australia
Patrick Charlot		Observatoire de Bordeaux

Goals of VCS-II:

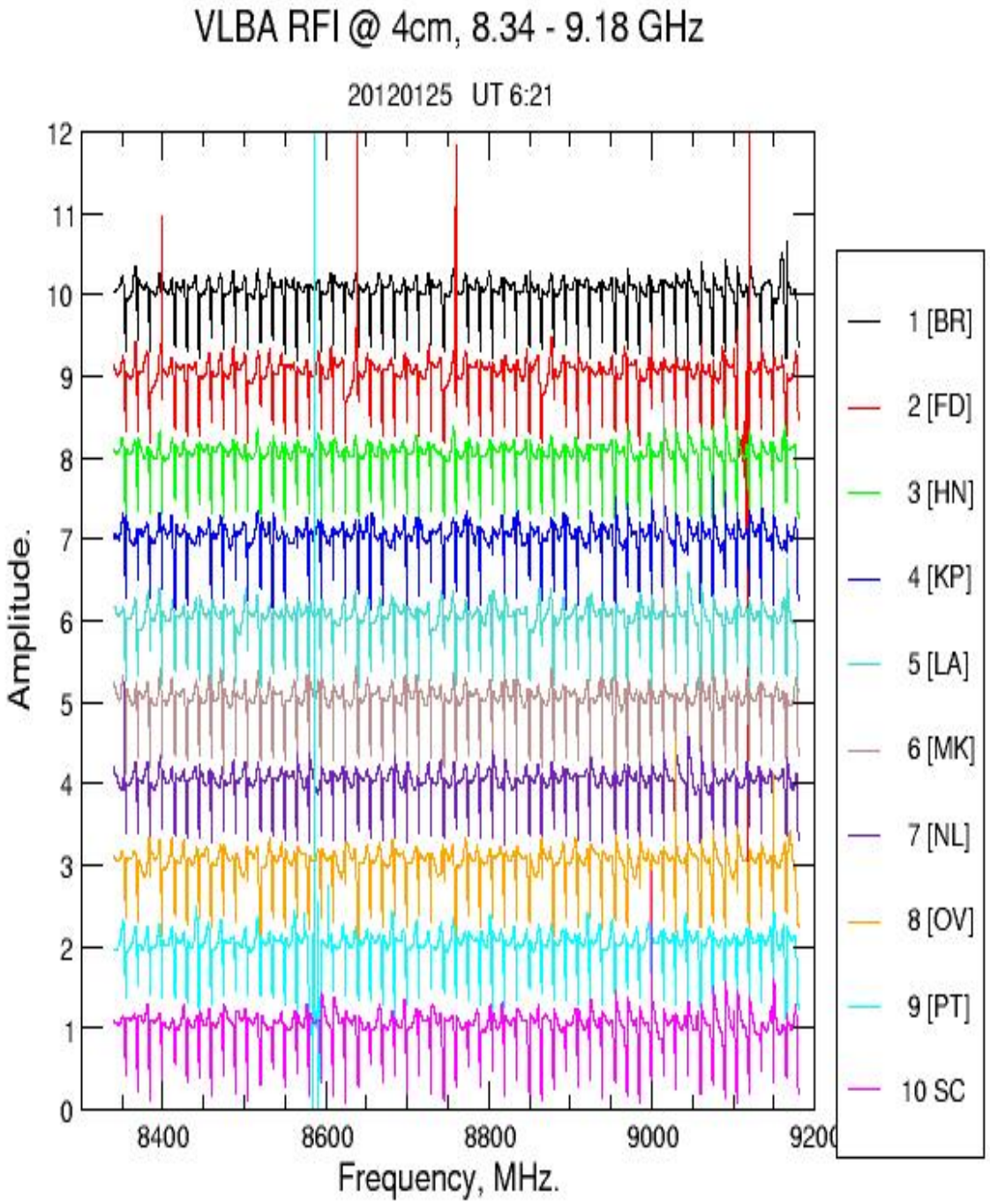
- Re-observe ~2100 VCS/ICRF2 single-epoch sources and significantly reduce their formal position uncertainties.
- Re-observe ~300 VCS sources that were originally undetected.
- Compute fluxes all sources.
- Image all sources.
- Compute structure indexes.
- Add to the pool of proper motion measurements available for galactic aberration studies.

VCS-II Observations:

- 8 24-hr sessions.
- Dual X/S for consistency with current X/S catalog.
- RDBE/Mark5C system.
- 16 32-MHz channels, 2-bit sampling, 2 Gbits/sec bit rate. (VCS was 128 Mbits/sec.)
- X-band was 12 channels, 1.536 Gbits/sec, 448 MHz spanned bandwidth.
- S-band was 4 channels, .512 Gbits/sec., 128 MHz spanned bandwidth.

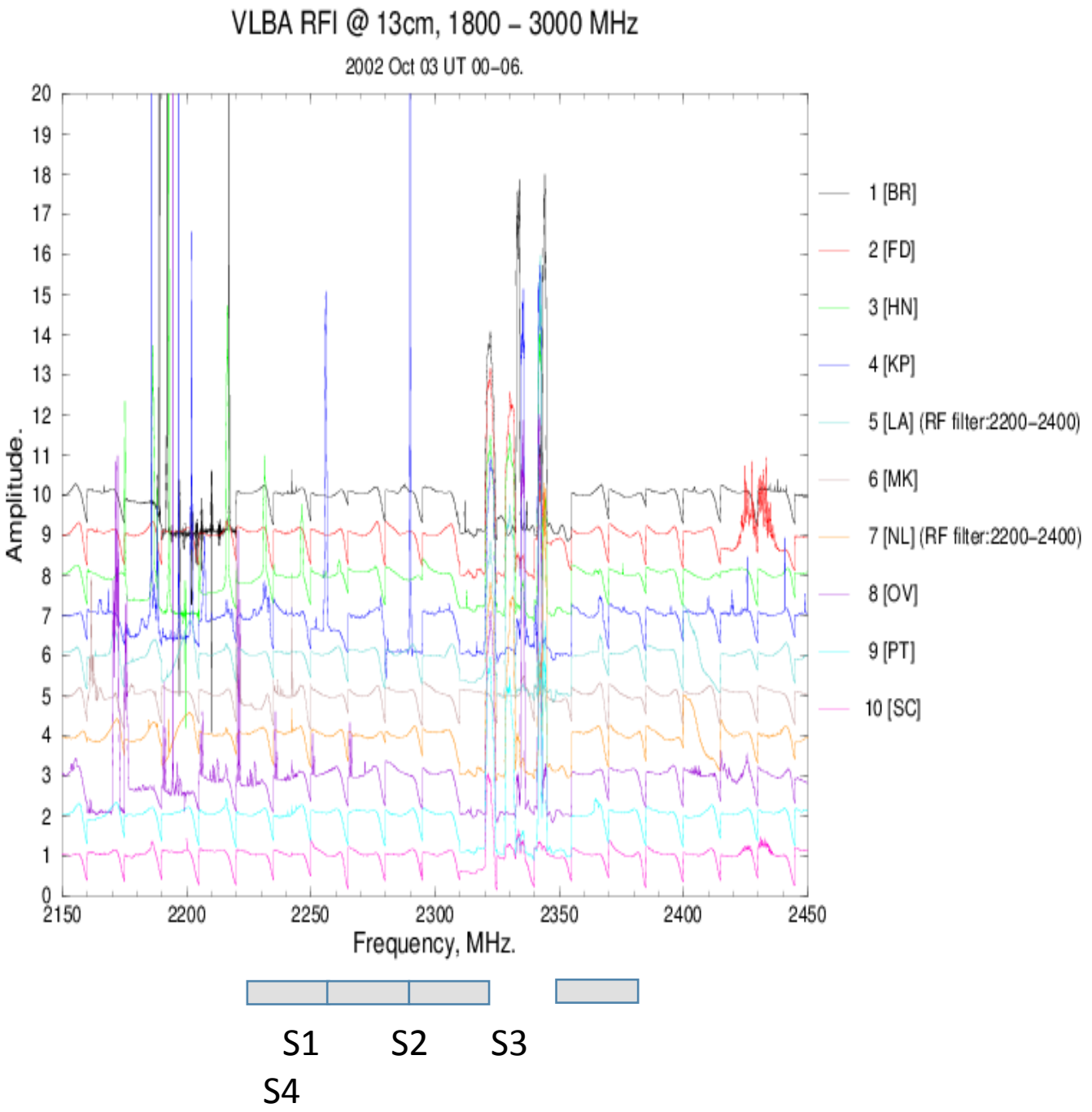
X-band:

8468.0 MHz
8492.0 MHz
8524.0 MHz
8556.0 MHz
8620.0 MHz
8652.0 MHz
8716.0 MHz
8748.0 MHz
8812.0 MHz
8844.0 MHz
8876.0 MHz
8908.0 MHz



S-band:
2220.0 MHz
2252.0 MHz
2284.0 MHz
2348.0 MHz

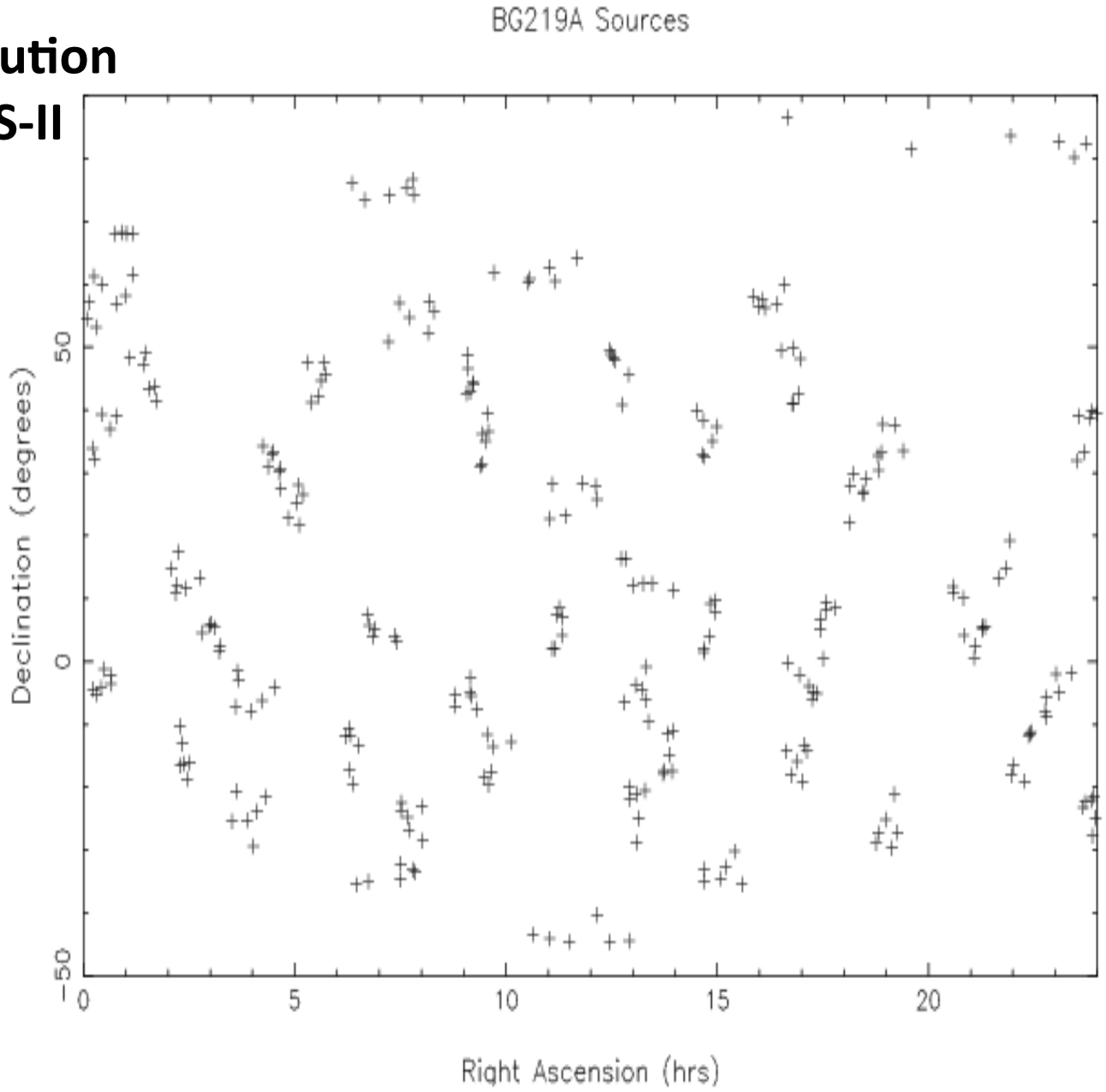
Most VLBA antennas have filters that block <2200 MHz and >2400 MHz.



VCS-II Schedules:

- 2400 single epoch and undetected VCS1-6 sources.
- Divided into 400 groups of 6 nearby sources each.
- Each 24-hr session observed 50 such groups (300 sources) with an ICRF2 defining source in between groups for troposphere calibration.
- Scheduled with the NRAO SCHED program to create dynamic schedules.
- 2 scans each source, separated by a few hours.
- Short slewing time within the groups of 6 sources; longer slews to troposphere calibrator and the next group. Enabled making ~750 scans per session.
- Target source scans were ~60-120 seconds; calibrator scans ~20-30 seconds.

Source distribution in the first VCS-II session.



VCS-II Data Processing:

- Correlated on the VLBA difx software correlator.
- Fits IDI files made for imaging (difx2fits).
- Mark4 files made for astrometric analysis (difx2mark4).
- Mark4 files fringed with HOPS/fourfit.
- Databases made and analyzed with GSFC Calc/Solve system.
- Global astrometric analysis made with Solve/Global system.

Source Fluxes:

Fluxes calculated using:

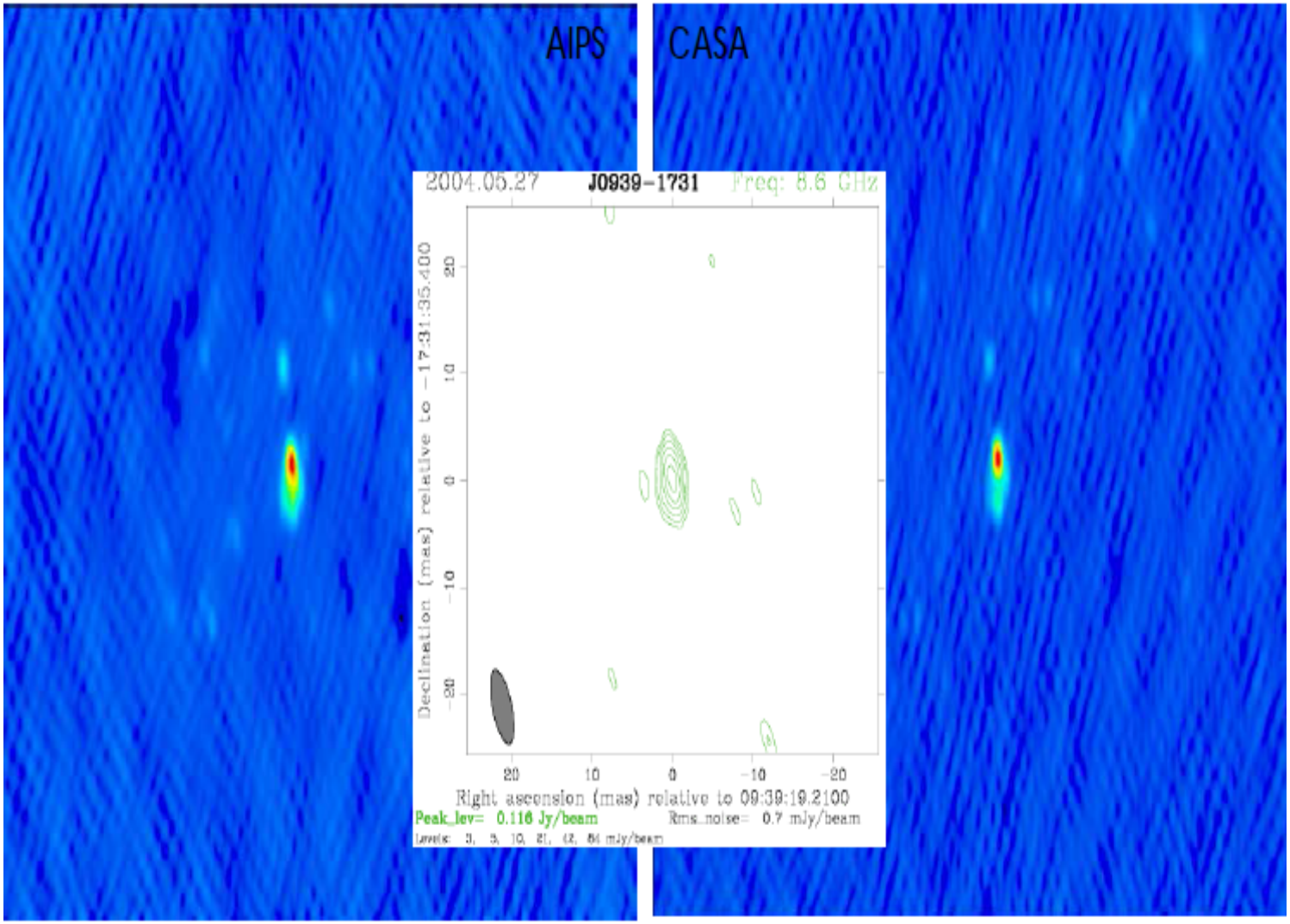
$$\text{Flux (Jy)} = \frac{1.75 * \text{SNR}}{1.38} * \text{SQRT}\left[\frac{(\text{SEFD1}*\text{SEFD2})}{(\#\ \text{Samples})}\right]$$

where: SEFD1 = Tsys1/Gain1

Gain is in degrees per flux unit (DPFU)

Flux limit appears to be **~15 mJy** in X-band, **~30 mJy** in S-band.

Imaging: Work towards imaging is ongoing using both CASA and AIPS (Tony Beasley, Alison Peck and students).



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Astrometric Results:

- All 8 sessions run (Jan. 2014 – March 2015) and processed.
- **2063** sources were re-observed, average formal errors reduced by factors of 3.8 in RA and 3.7 in Declination. [RA: .84 => .22 mas; Dec: 1.44 => .38 mas]
- **325** new sources were detected and added to X/S catalog. [Weaker sources, average sigmas 1.2/2.0 mas]
- **12** sources were undetected (only 0.5%).

We now have **4023** sources in the X/S catalog for ICRF3.

Improvement in source position formal errors from the VCS-II sessions.