

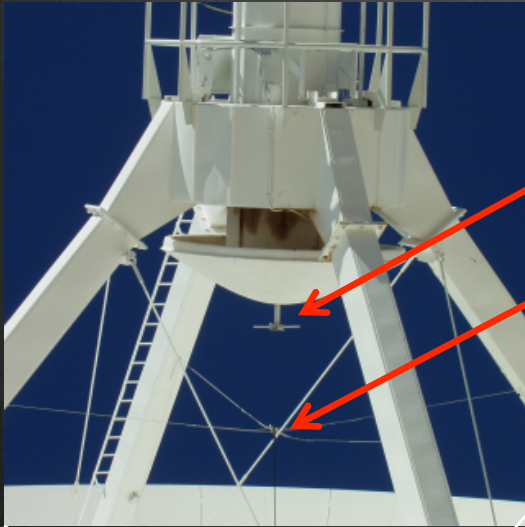
The VLA Low Band Ionospheric and Transient Experiment (VLITE): A Commensal Sky Survey

T. E. Clarke
Naval Research Laboratory

N. E. Kassim, E. Polisensky, W. Peters (NRL),
S. Giacintucci (CPI) and the NRL VLITE team



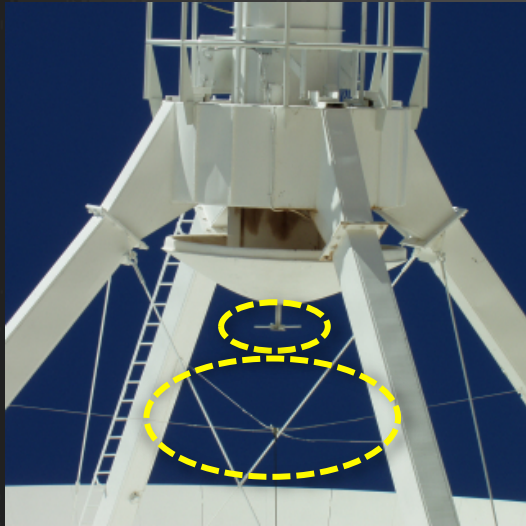
National Radio Astronomy Observatory's Very Large Array



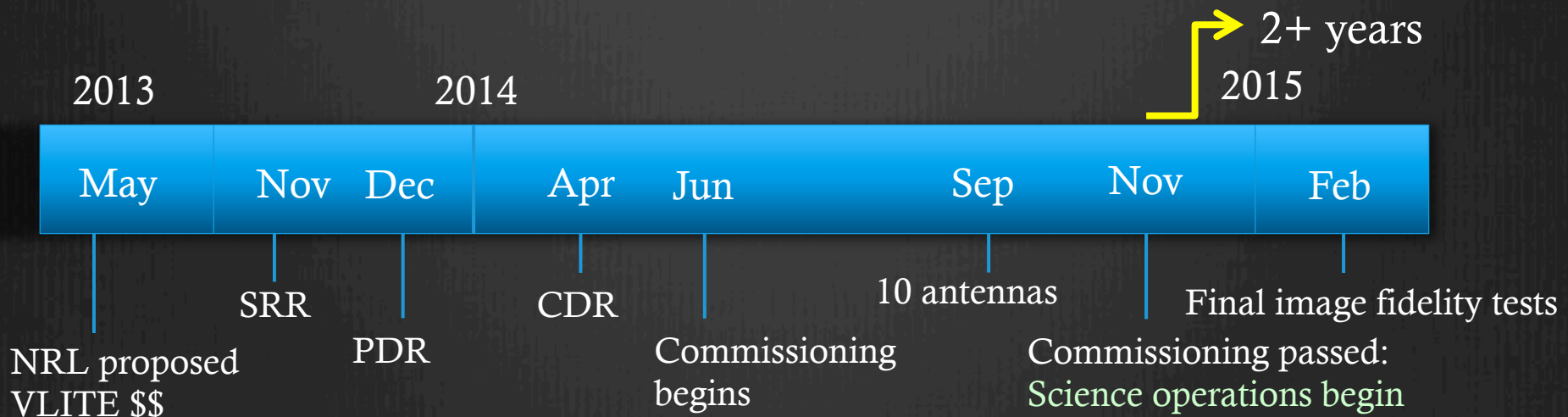
- VLA operates 1-50 GHz Cassegrain feeds
- Narrow-band 330 MHz dipoles and receiver installed on VLA in 1990, and narrow-band 74 MHz system installed in 1998
- NRL and NRAO developed a new broad, low band receiver: 56-86 MHz and 240 – 470 MHz
- In use since 05/2012 mainly at 240 – 470 MHz



The Birth of a Commensal Low Band System



- Feeds $> 1\text{GHz}$ are Cassegrain, $< 1\text{GHz}$ prime focus
- New opportunity: simultaneous prime and Cassegrain operation with a new low band correlator
- 05/13 NRL proposed to build a commensal system on the VLA with Navy funding
- Consists of dedicated samplers, fibers, and a custom DiFX software correlator running real-time:



VLA Low Band Ionospheric and Transient Experiment (VLITE)

- Correlates 330 MHz band for 10 VLA antennas
 - Frequency range: 320 – 384 MHz
 - Channel width: 100 kHz
 - Integration time: 2s
 - Products: 4 polarizations (linears)
 - Field of view: > 5 square degrees
 - Resolution: $5'' - 3'$, large scale structure up to 1°
 - Data rate: 2GB/hour operating 24/7 for 3 years!
 - On-sky wall time: $\sim 70\%$
 - Science operations started 11/25/2014
- Minimal impact on VLA infrastructure
- No impact on primary observer program resources

The Power of a Commensal System: Field of View

VLITE 8°

- Low frequencies have a large field of view

NGC404 field



○ 1.5 GHz FWHP

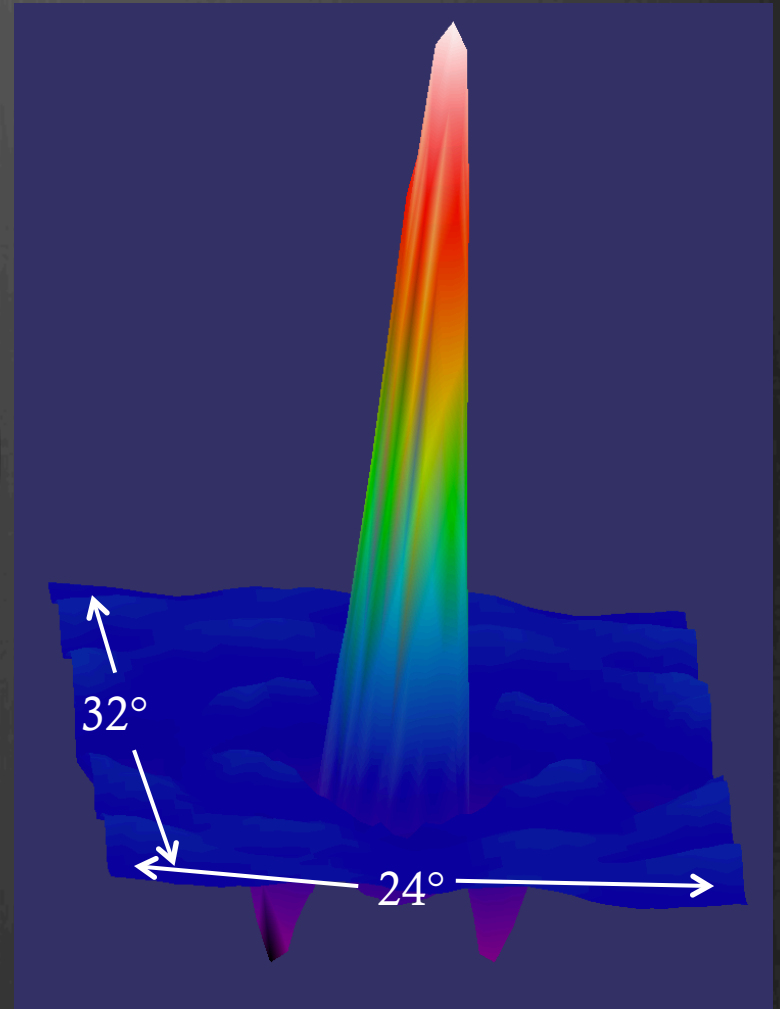
○ 3.0 GHz FWHP

40 GHz FWHP

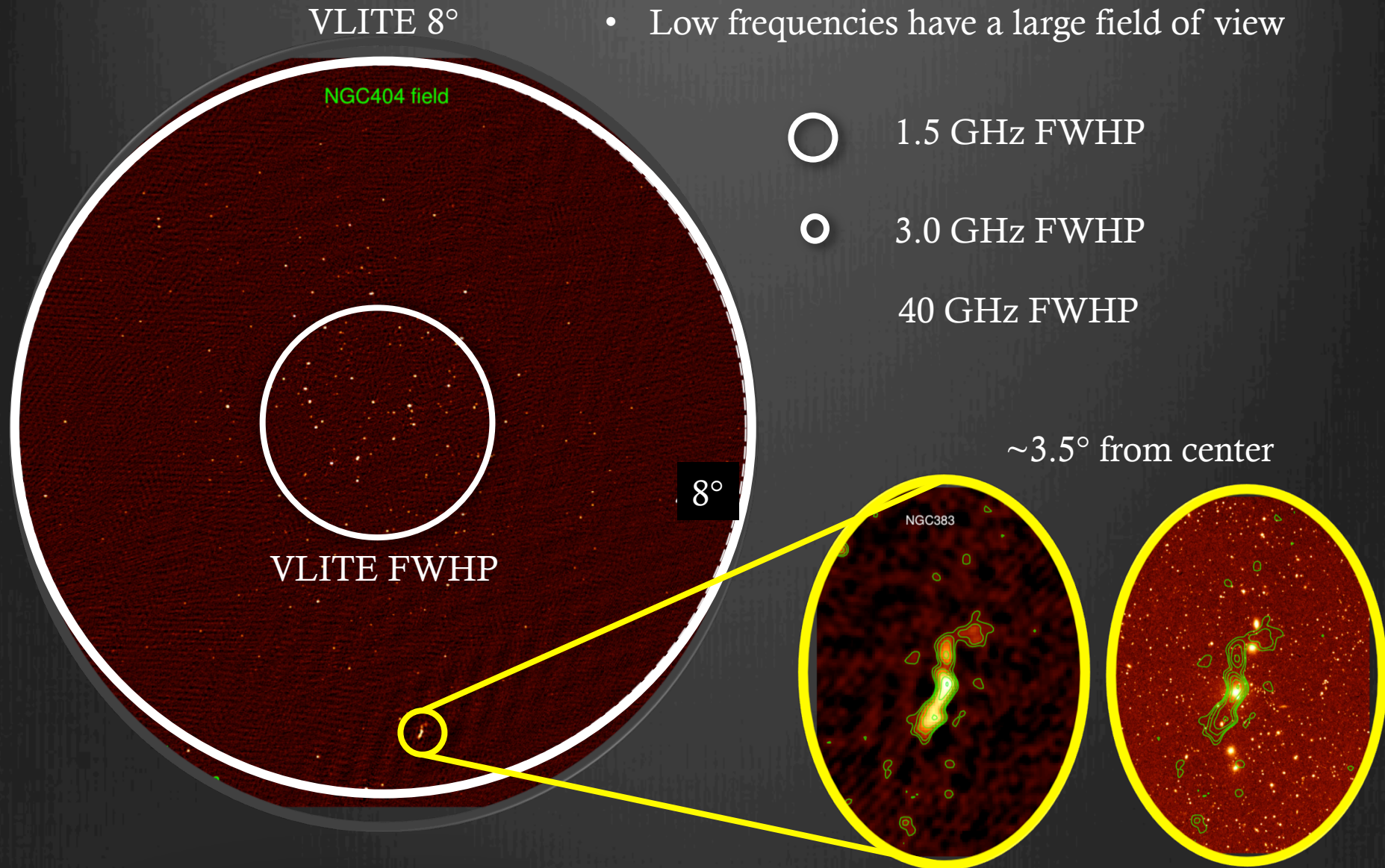
The Power of a Commensal System: Field of View

VLITE 8°

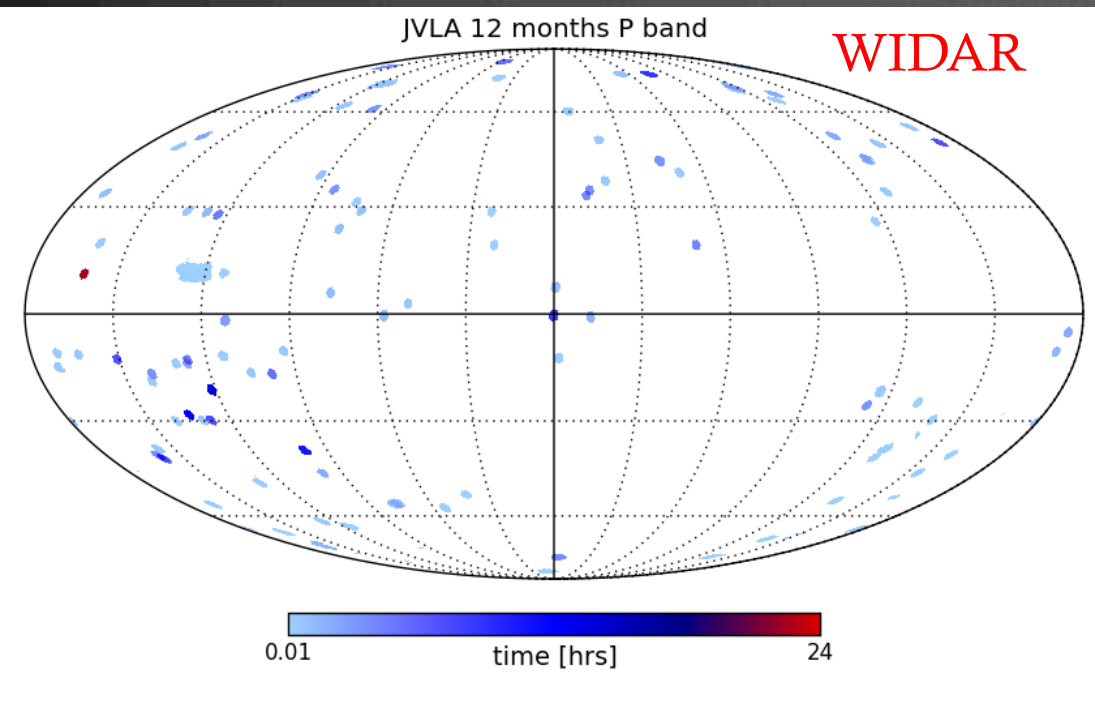
- Low frequencies have a large field of view



The Power of a Commensal System: Field of View



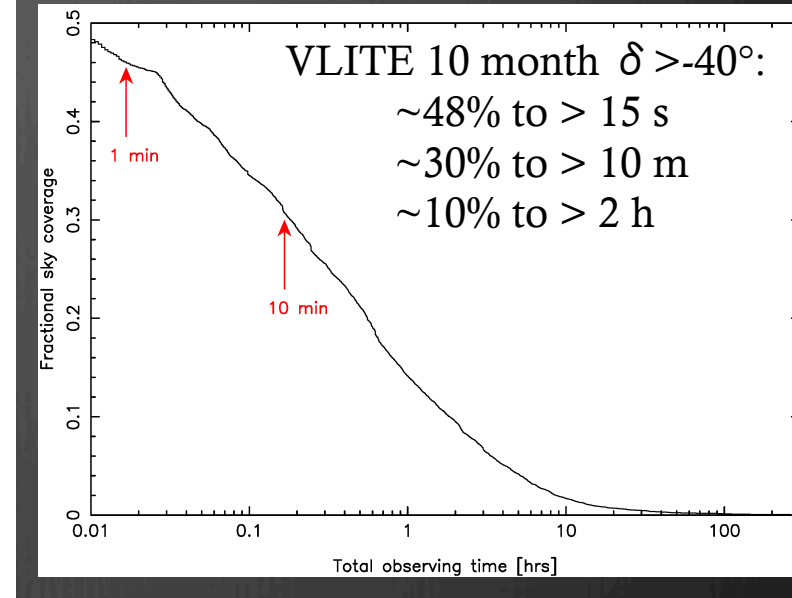
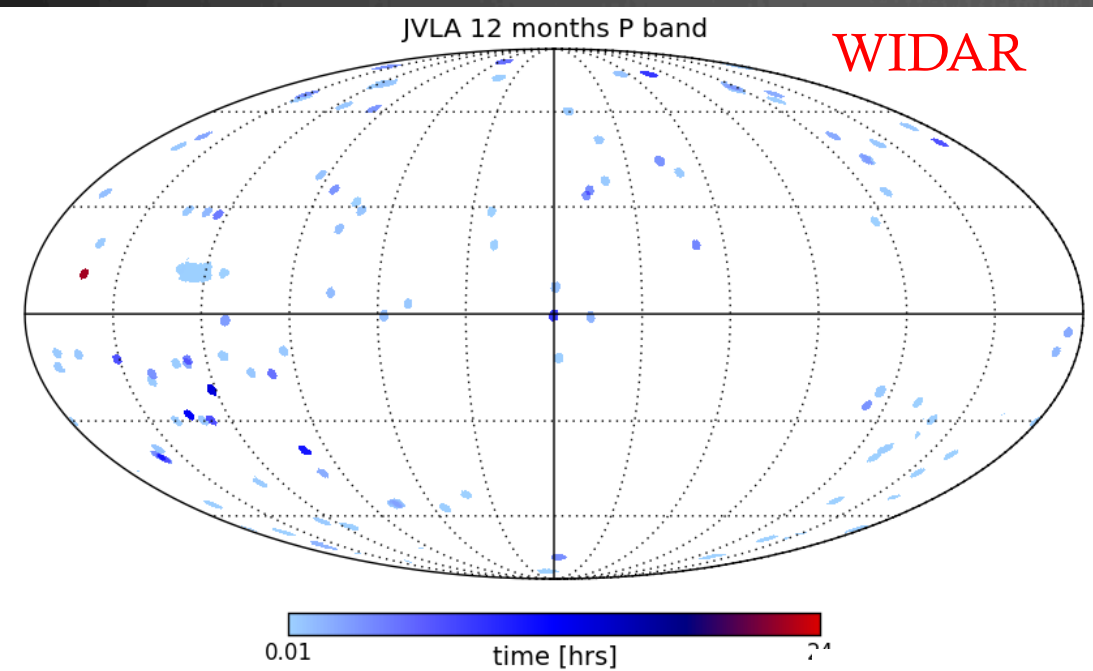
The Power of a Commensal System: Sky Coverage (Tile)



WIDAR 12 months:

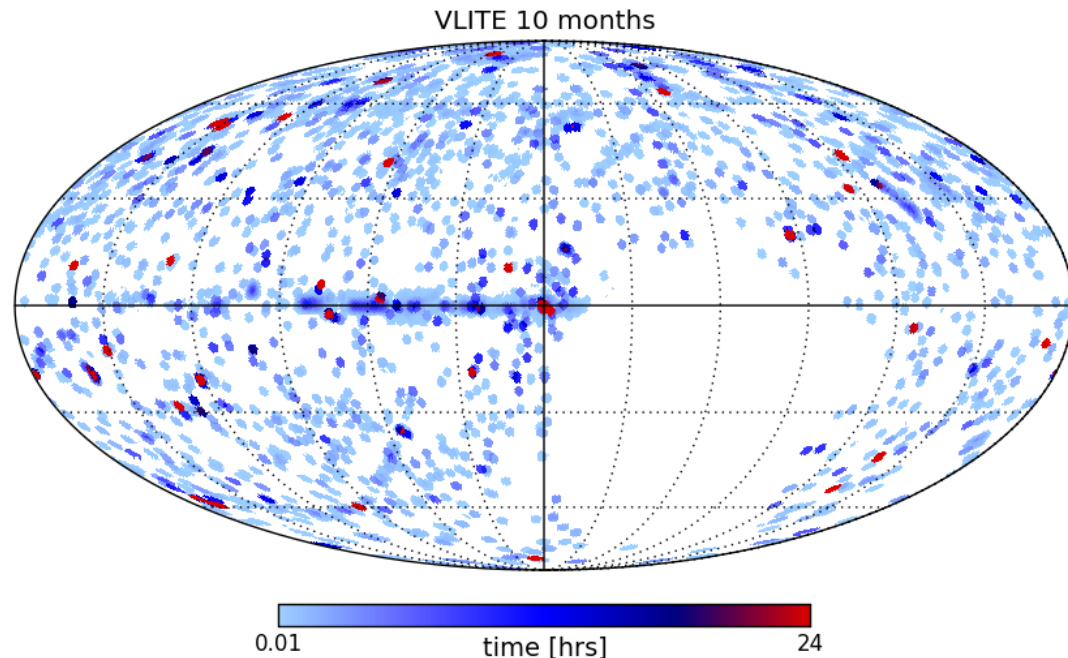
- Deepest P band field is 22h

The Power of a Commensal System: Sky Coverage (Tile)



WIDAR 12 months:
- Deepest P band field is 22h

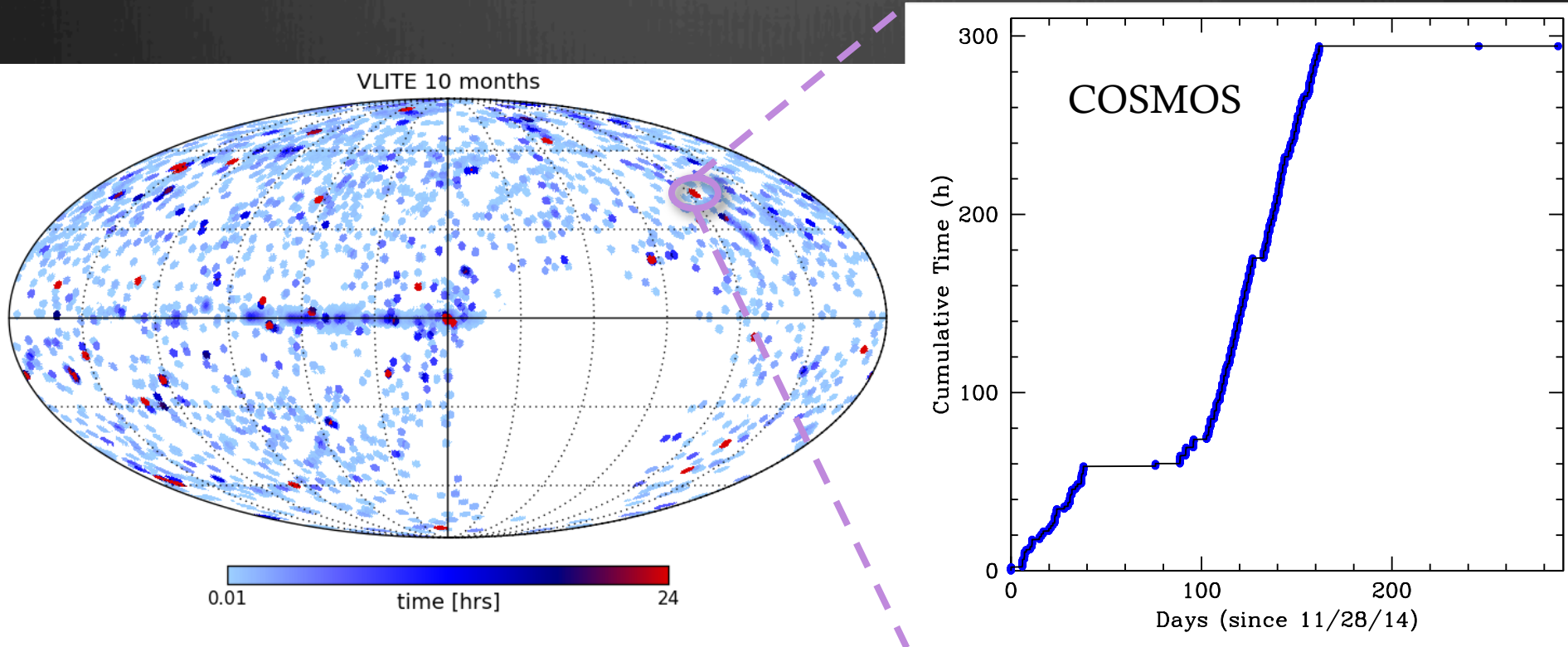
VLITE 10 month:
- VLITE recorded ~5400 h or 68% wall time
- Deepest P band field is > 290 h (COSMOS)



The Power of a Commensal System: Depth (Stare)

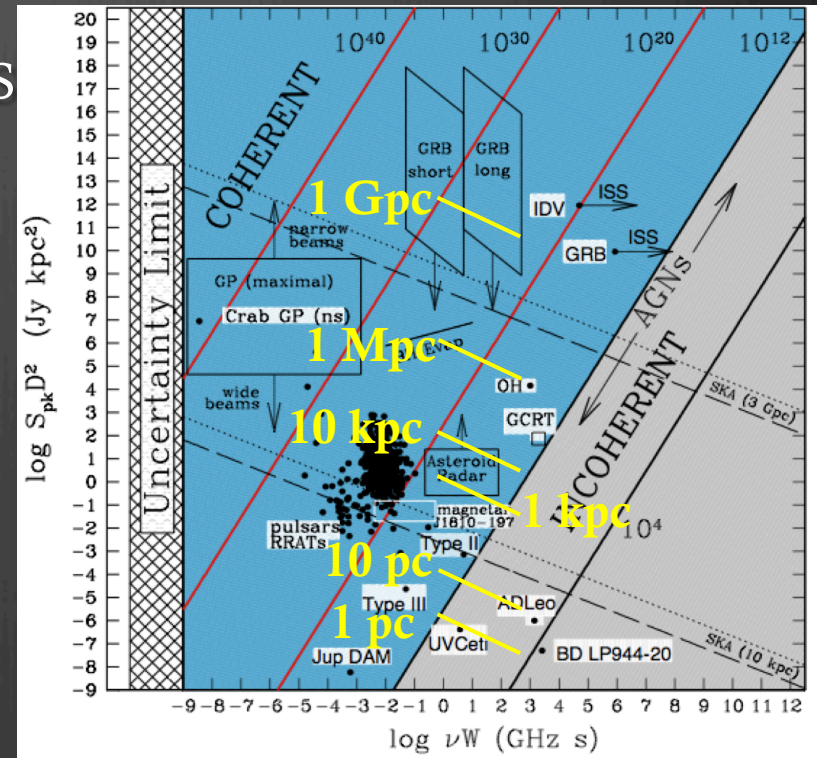
Numerous areas of the sky are intrinsically interesting for many science cases (e.g. deep multi-wavelength survey fields). These fields are observed by the JVLA with a variety of instrumental configurations but appear homogeneous to VLITE!

VLITE has accumulated over 294 h of data on the COSMOS field. These data span a length of 287 days.



VLITE Transient Program

- Slow transient searches of large FoV with thousands of hours on-sky time in both real-time (> 2 s) and off-line searches for longer term (> 1 h) transients
 - Initial searches will cross-compare VLITE catalog for each scan to NVSS and WENSS catalogs to ID targets
 - Refine sky catalog (variability studies, spectral studies, population studies, ...)
 - Low frequencies are ideal for finding coherent emission from transients. Coherent sources include:
 - Plasma emission (e.g. Solar bursts)
 - Electron cyclotron maser emission (e.g. Jupiter/extrasolar planets, flare stars)
 - Pulsar emission, GRB afterglow, X-ray binaries, SNRs
 - Exploration of new mechanisms
-
- VLITE placed on Cordes plot showing slow transient sensitivity for transients 2s – 1 hr.



VLITE placed on Cordes plot showing
slow transient sensitivity for transients
 $2\text{s} - 1\text{ hr}$.

First VLITE Transient: ATel #7728

V404 Cyg – BH and star binary

$S = 186 \pm 6$ mJy (June 22, 2015)
 $\sigma = 1.5$ mJy/bm
 $\Theta = 10'' \times 4''$
 $\Delta t \sim 4.5$ h

Outside

GCN
IAUCs

Other

ATel on Twitter and Facebook
ATELstream
ATel Community Site
MacOS: Dashboard Widget

The Astronomer's Telegram

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6 Jul 2015; 17:57 UT

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VLITE meter-wavelength detection of V404 Cyg at 341 MHz

ATel #7728; *N. E. Kassim (NRL), S. Giacintucci (CPI), W. M. Lane-Peters (NRL), S. D. Hyman (SBC), T. E. Clarke (NRL), E. J. Polisensky (NRL), J. F. Helmboldt (NRL), P. S. Ray (NRL), J. S. Deneva (NRC)*
on 29 Jun 2015; 03:01 UT
Credential Certification: Scott Hyman (shyman@sbc.edu)

Subjects: Radio, Millimeter, Sub-Millimeter, Infra-Red, Optical, X-ray, Binary, Black Hole, Nova, Transient, Variables

Referred to by ATel #: 7740

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We observed V404 Cyg with the Very Large Array Low Band Ionospheric and Transient Experiment (VLITE, <http://vlite.nrao.edu>) at 341 MHz (38 MHz bandwidth) between 2015 June 17 10:52 UTC (MJD 57190.45) and June 25 12:17 UTC (MJD 57198.51). The upper limit on the flux density for the 3 min, June 17 observation is ≤ 20 mJy (3 sigma). The source was detected at 186 ± 6 mJy on June 22 from ~11:30 to 14:30 UTC (centered on MJD 57195.54) and at 90 ± 7 mJy on a 3 min, June 25 observation. For these measurements we have applied the flux scale of Scaife & Heald (2012). Finer resolution time and frequency analysis of our data are underway and will be reported if significant. These VLITE meter-wavelength data are bracketed by higher (ATEL #7716) and lower (ATEL #7720) frequency radio detections, helping constrain the broadband, radio continuum spectrum and radio light curve. We note that the two VLITE detections bracketing the lower flux density LOFAR detection at 150 MHz may suggest a component of thermal absorption.

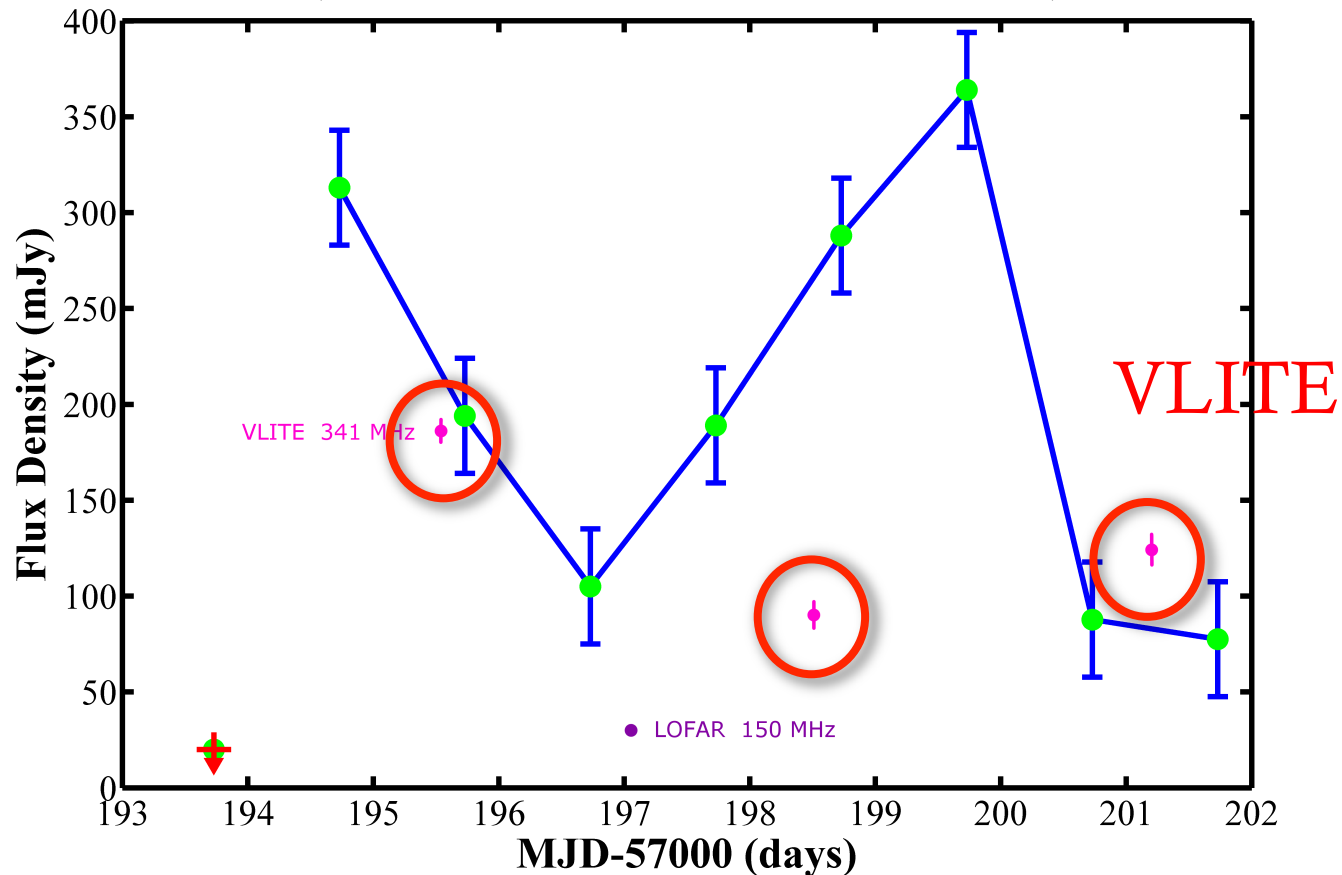
VLA Low Band Ionospheric and Transient Experiment

Cross-correlation of V404 Cyg with VLITE archive shows we have 1755 scans since December 6, 2014 where V404 Cyg is within 0.5 degrees of field center!

Waseda University Nasu 1.4 GHz light curve

V404 Cyg light curve at 1.4GHz (preliminary)

(from: 2015 June 20 17:28 to: June 28 16:57 UT)

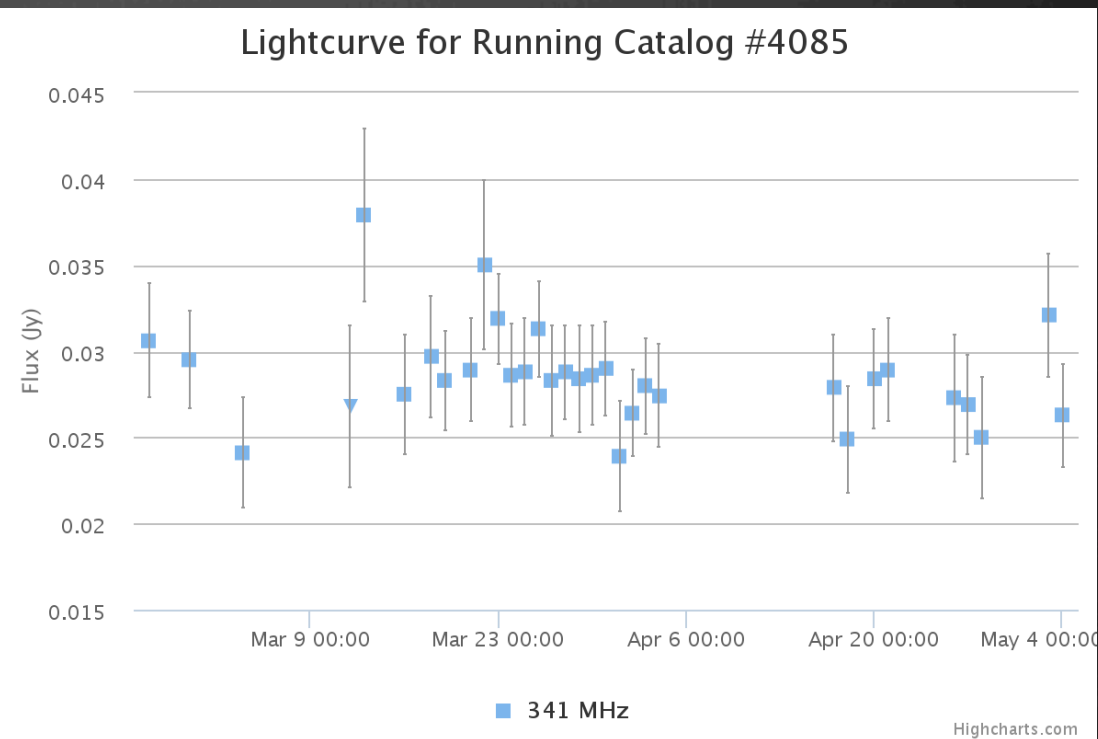
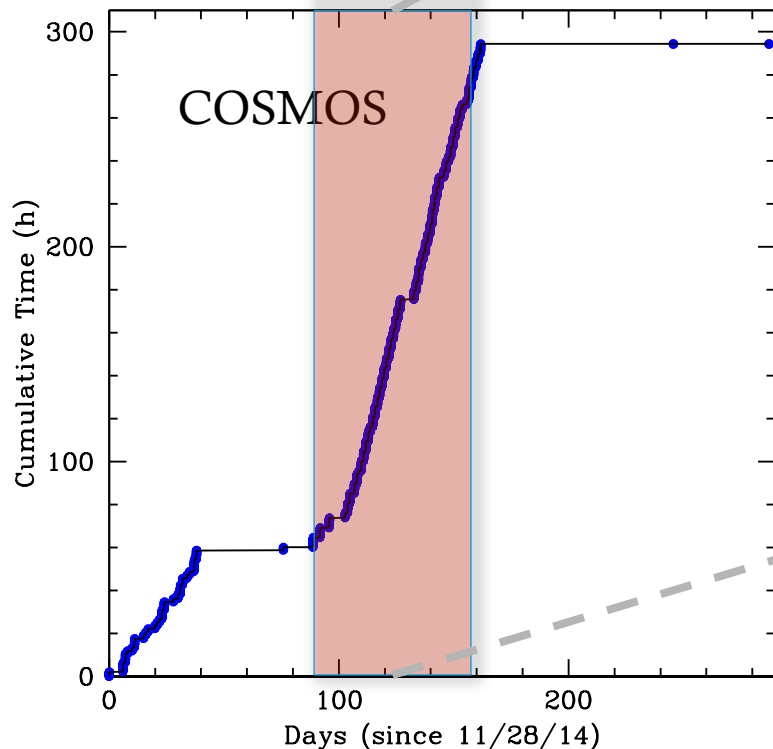


The green dots/blue line are a 1.4 GHz light curve. 3 VLITE detections are shown in red. (The upper limit in the lower left occurred several days earlier than shown and is approximately the same level at both frequencies.)

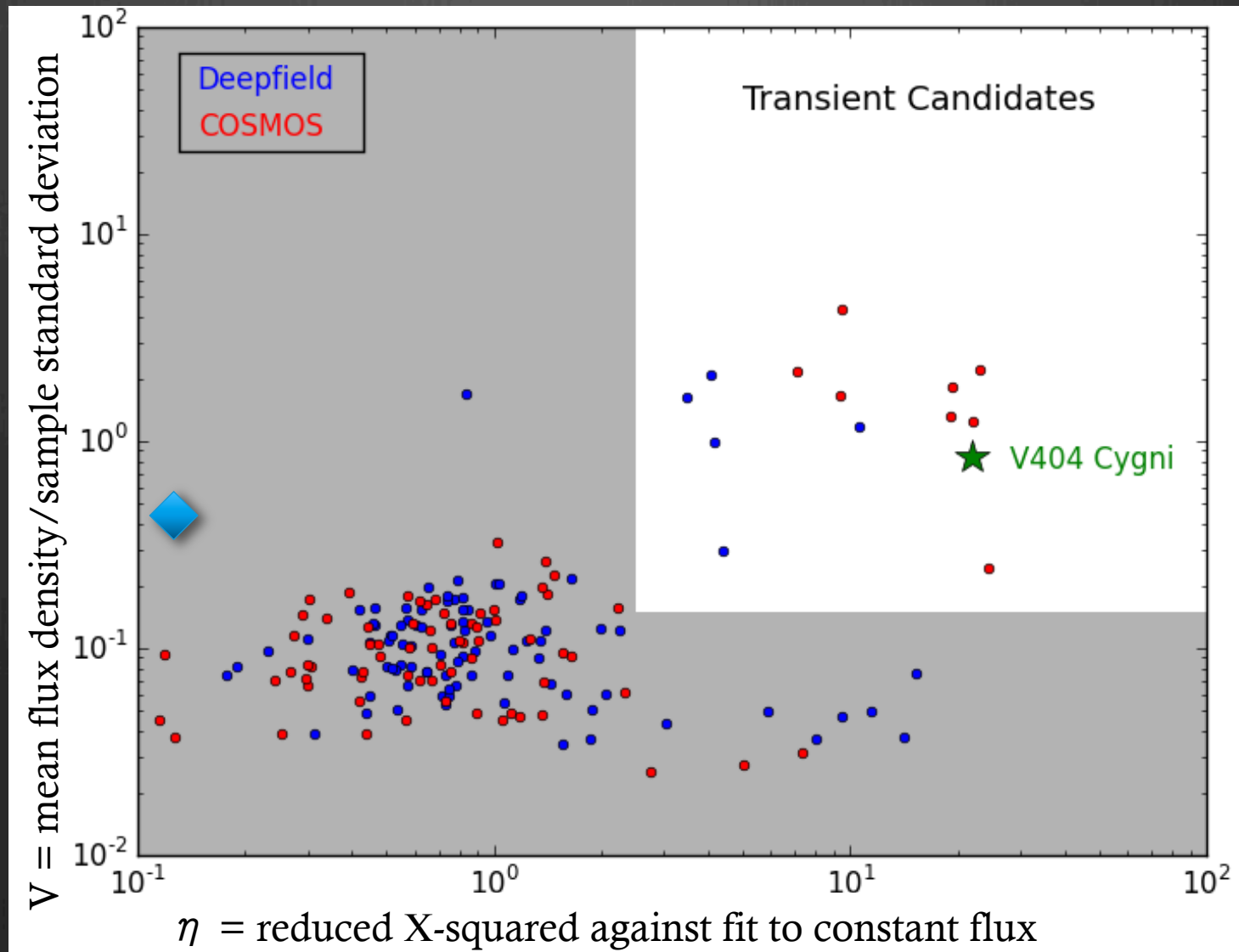
Tuning the TrAP on the COSMOS Field

The LOFAR Transient Analysis Pipeline (TrAP) is open source (GitHub, Swinbank et al. 2015). Takes image stack, does source extraction and de-blending, cross-matches with known source catalog, and identifies new transients.

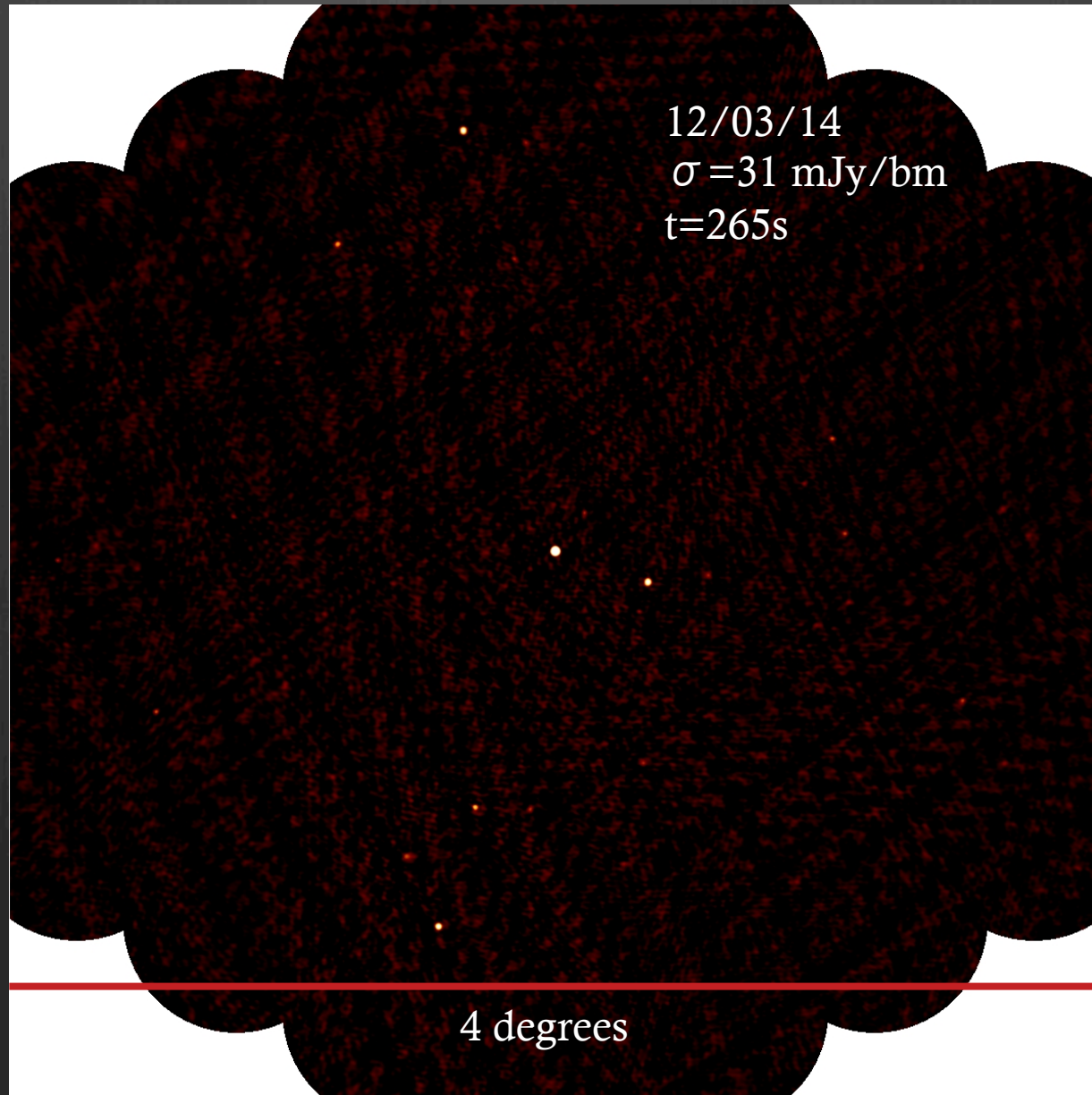
Produces a catalog of light curves with detection limits.



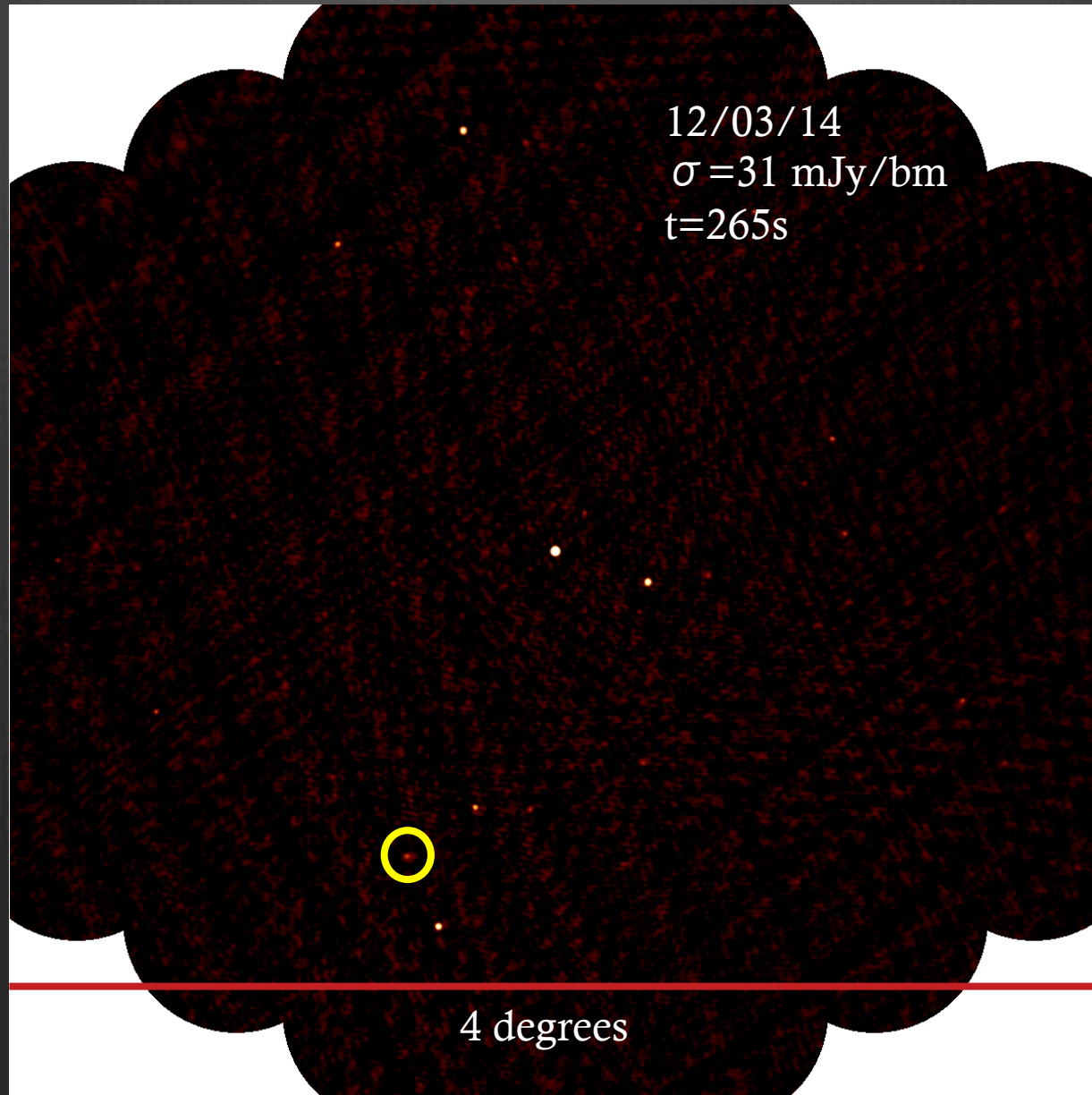
What does a VLITE-tuned TrAP show us?



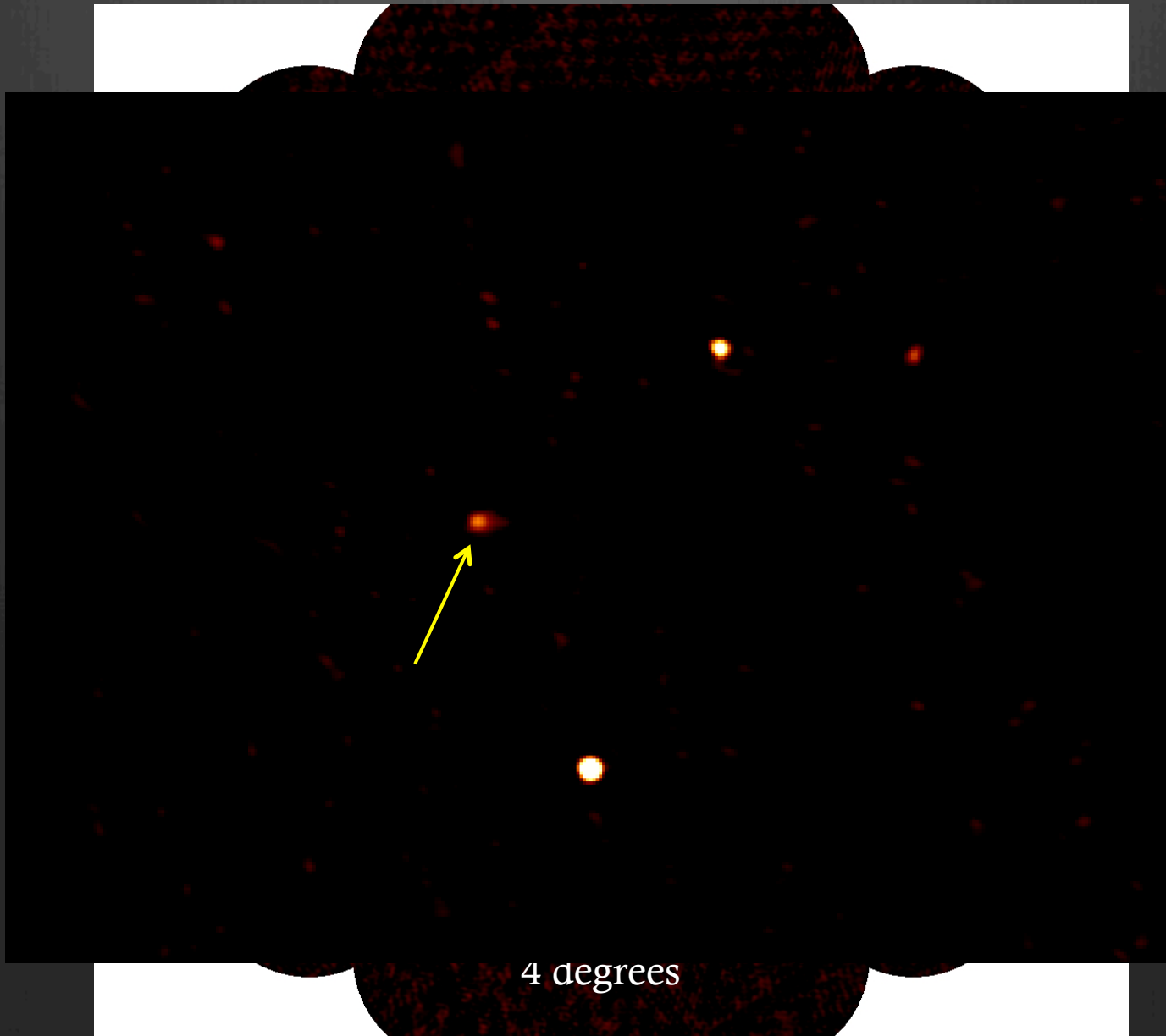
VLITE Discovers a Transient!



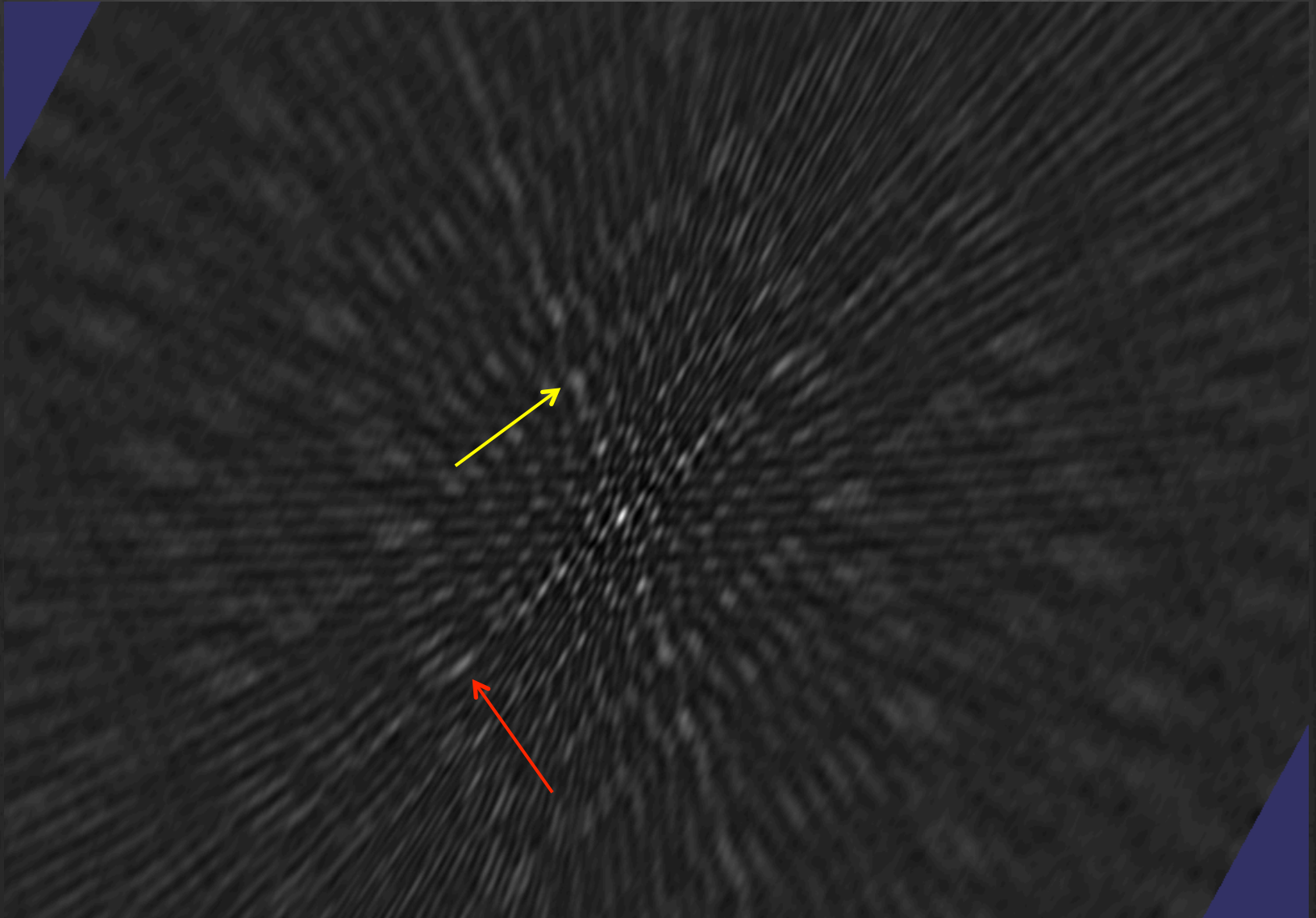
VLITE Discovers a Transient!



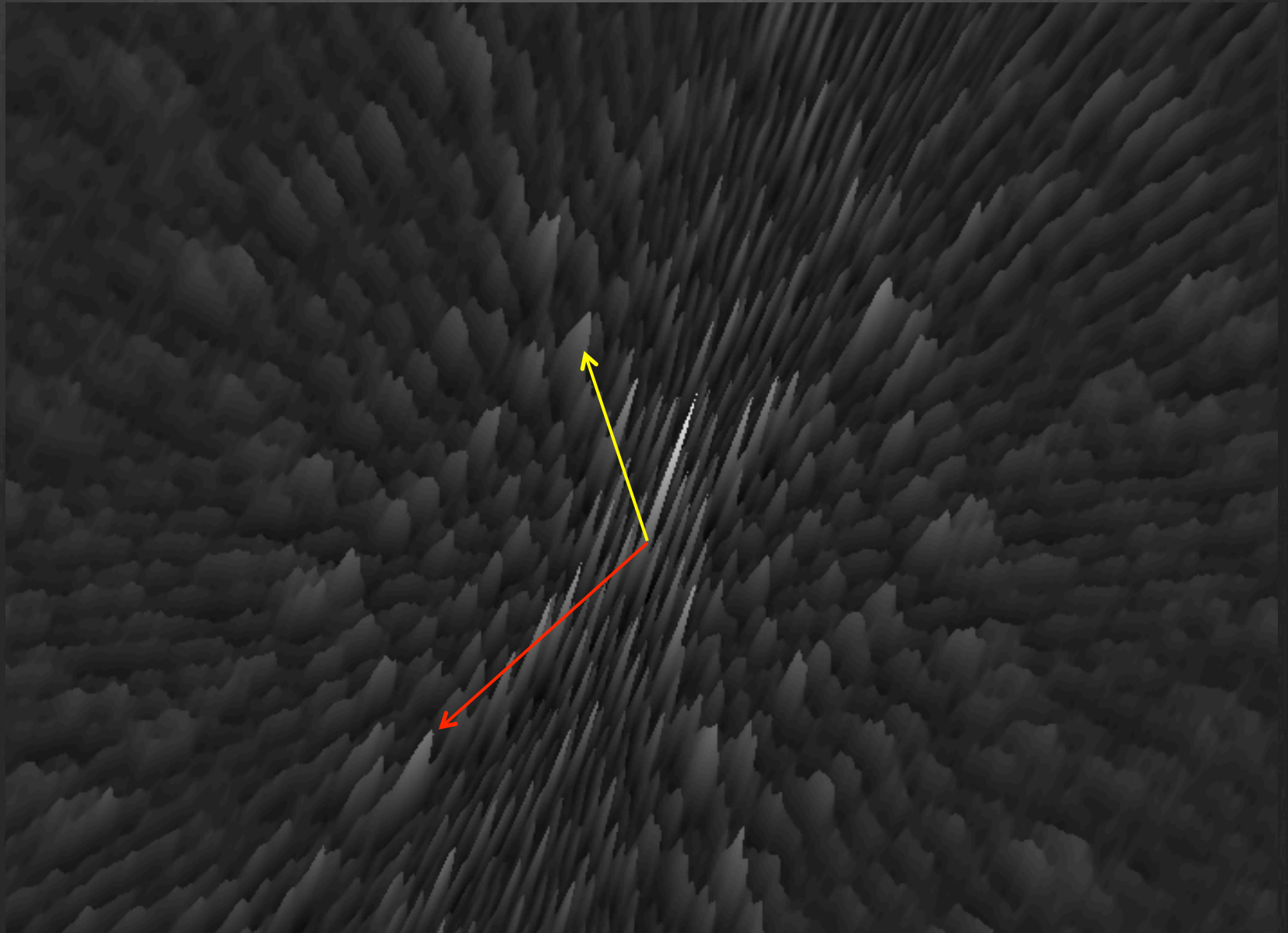
VLITE Discovers a Transient!



Cosmic Conspiracy: TrAP'd by Sidelobes

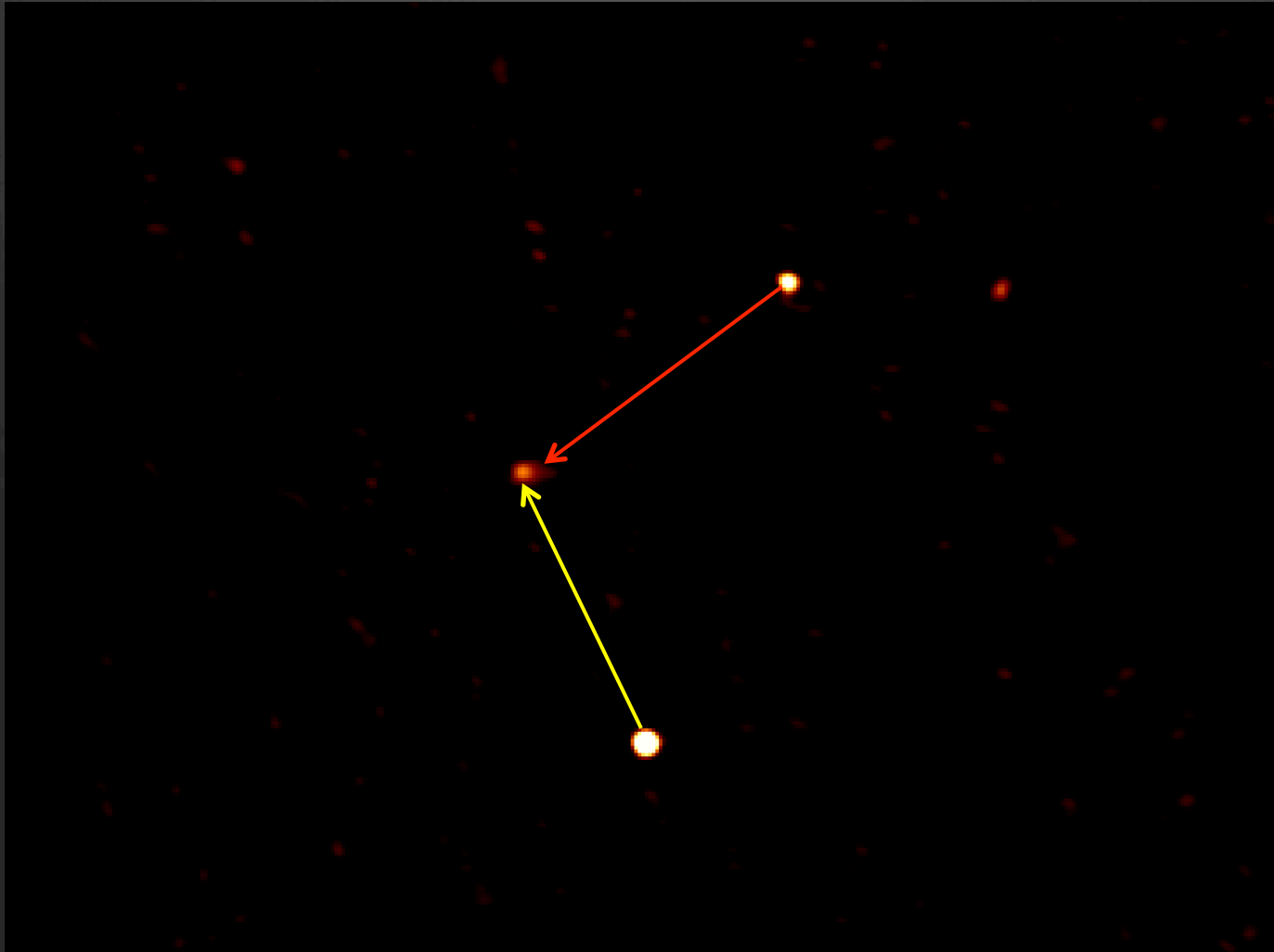


Cosmic Conspiracy: TrAP'd by Sidelobes



Cosmic Conspiracy: TrAP'd by Sidelobes

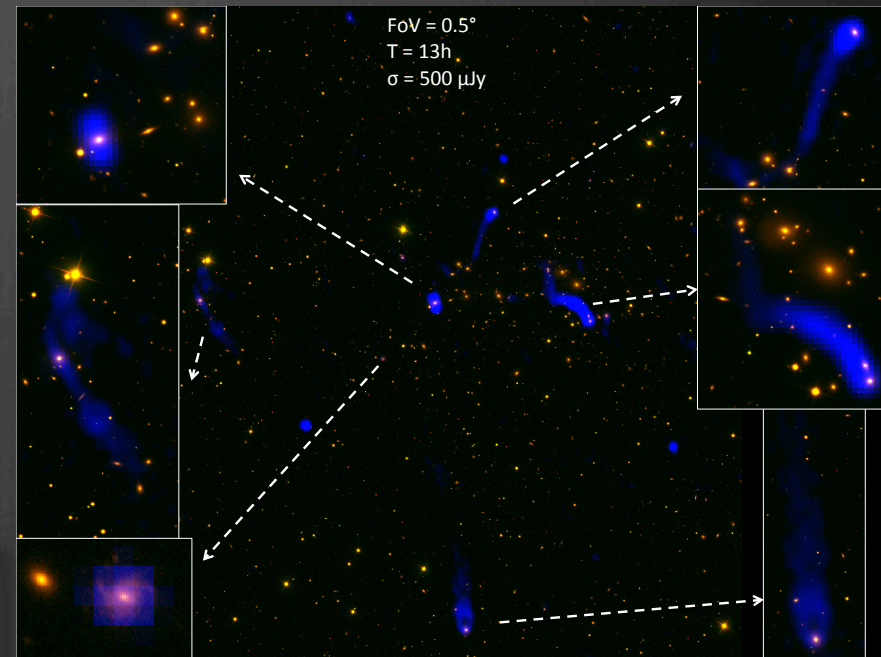
With only 10 antennas for VLITE we must be very careful with transient searches. Several other days had slightly different beams and two sidelobes did not overlap!



VLITE Archive Products

- Pipeline: real-time + 1 day lag post processing
 - Add depth by combining images on bimonthly basis
 - *Future addition of polarization products is possible*
- Pipeline products are wide-band full-field images (~2.5 degrees on a side), spectral index maps, spectral window images (narrow band), calibration tables, calibrated uv data, sky catalog, and light curves
- Can process one day of data in 3-15 hrs, depending on VLA configuration
- Significant improvement can be obtained by minimal user flagging and re-imaging of pipeline products

Abell 2255

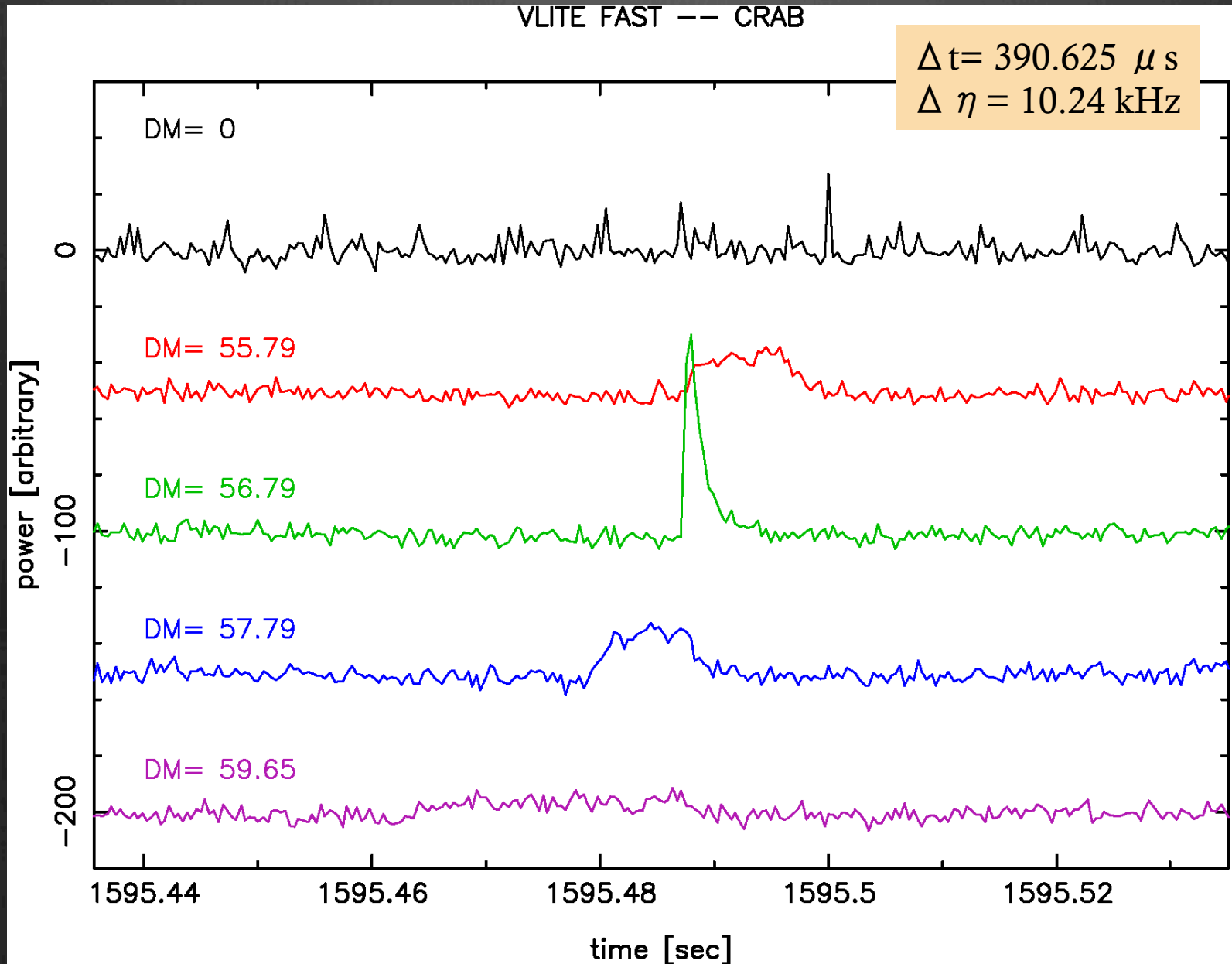


VLITE Summary

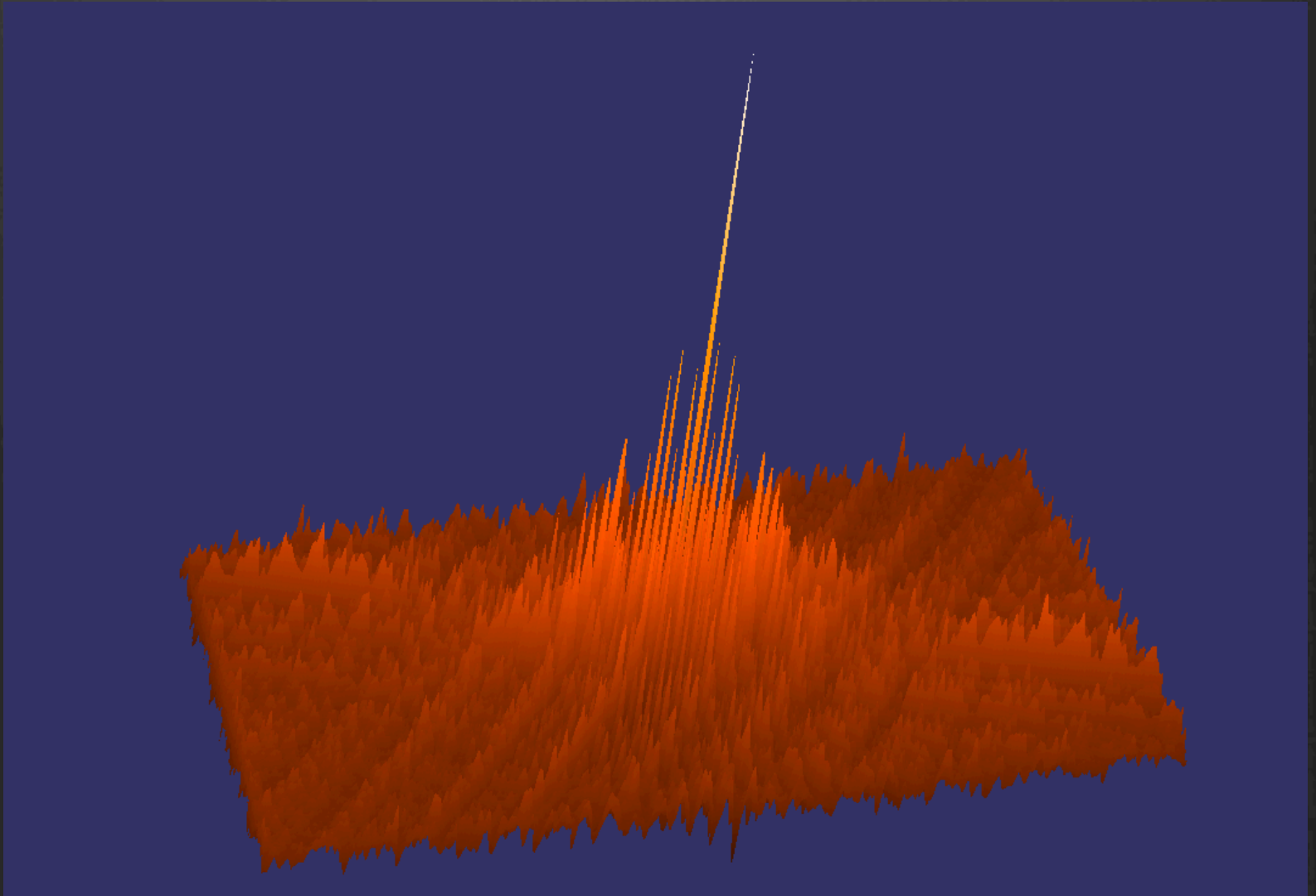
- Science observations commenced 11/25/2014, 3 year lifetime
- As of 9/25/15 VLITE observed 295,851 scans for a total of 5332 hours with ~9100 unique pointing centers (separation $> 0.5^\circ$)
- Enhances PI-driven science (encourage PI to contact NRL)
- Imaging across all VLA configurations but A config is a challenge!
- Contact me (tracy.clarke@nrl.navy.mil) if interested in data/collaborations
- NRC postdoctoral positions at NRL open. Contact me!
- *VLITE transition to a full wideband 27 antennas Low Band Observatory (LOBO) will require evidence of scientific productivity and community interest.*

NRAO VLITE: <http://vlite.nrao.edu>

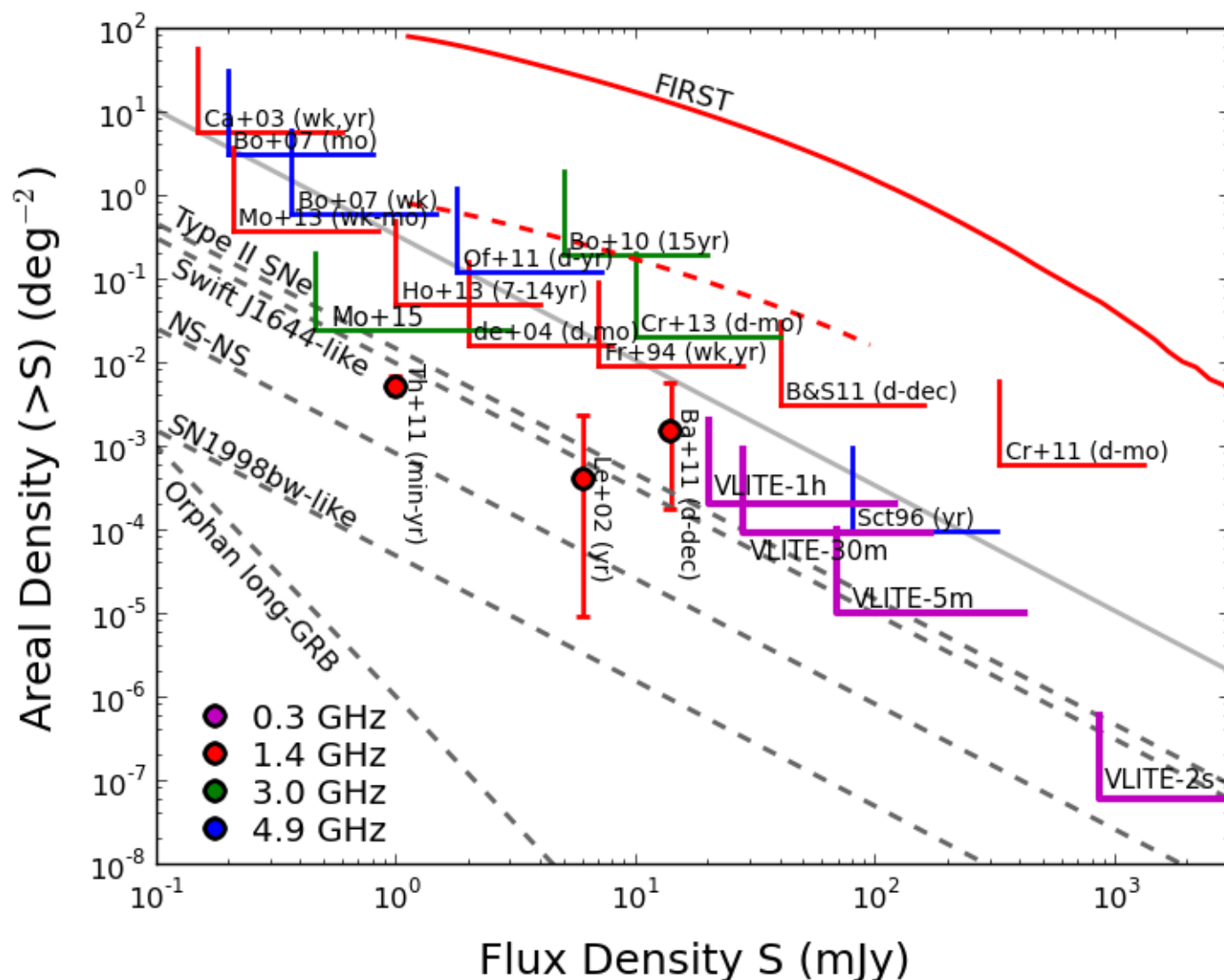
VLITE FAST Transients: Crab Giant Pulses



VLITE 10 Antenna Beam Structure

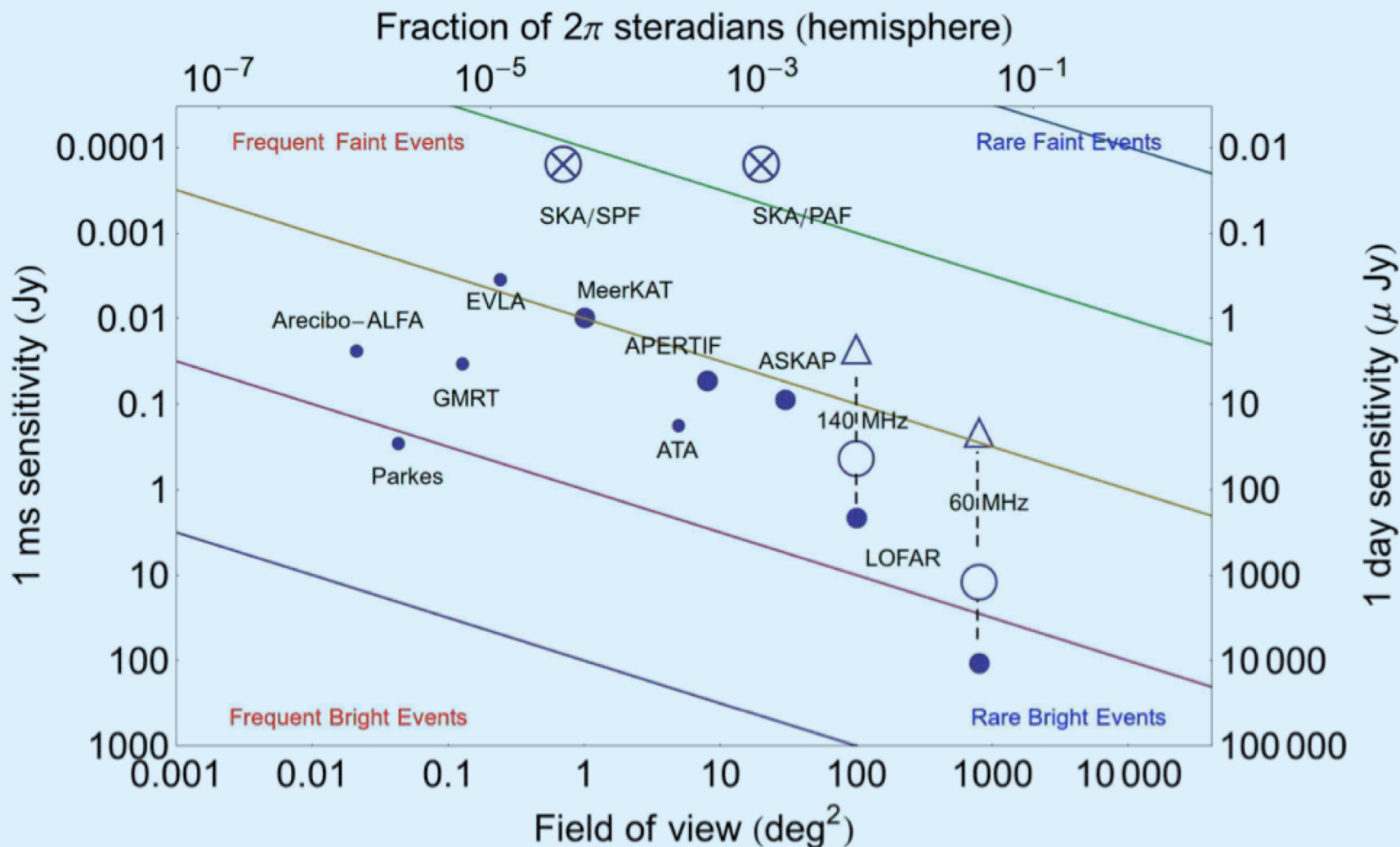


Transient Hunting: Where Does VLITE Fit In?



Where Does VLITE Fit In?

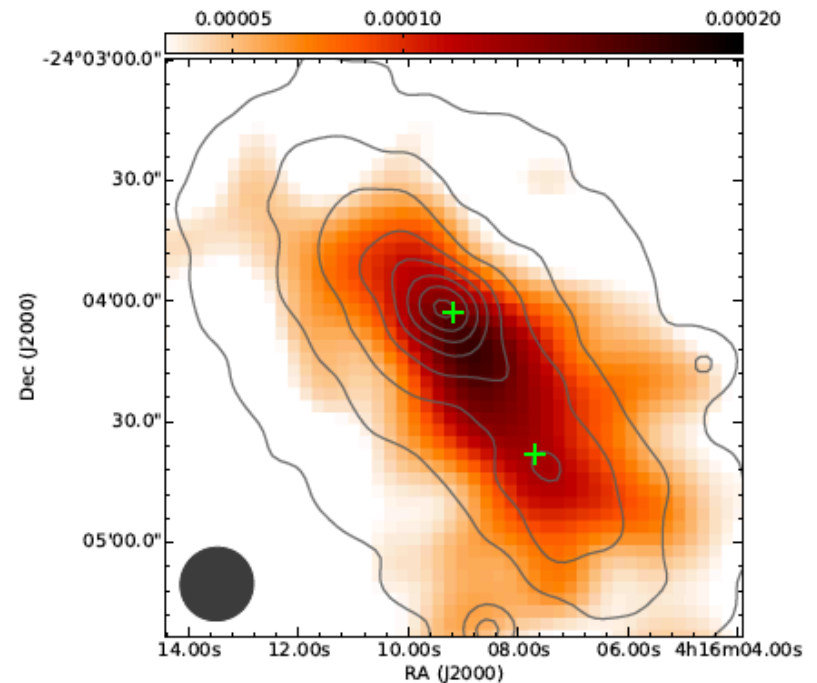
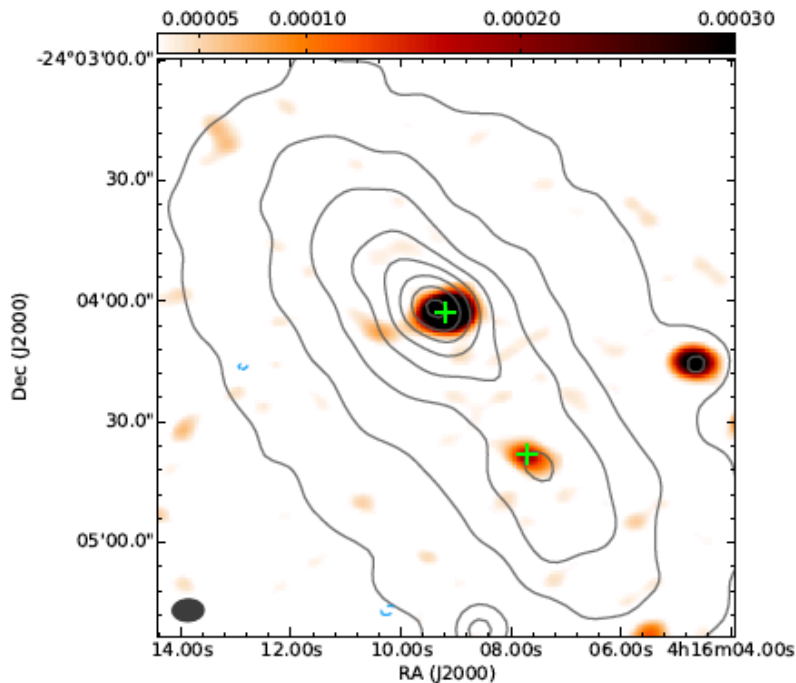
Put VLITE on this plot!



Fender, 2011

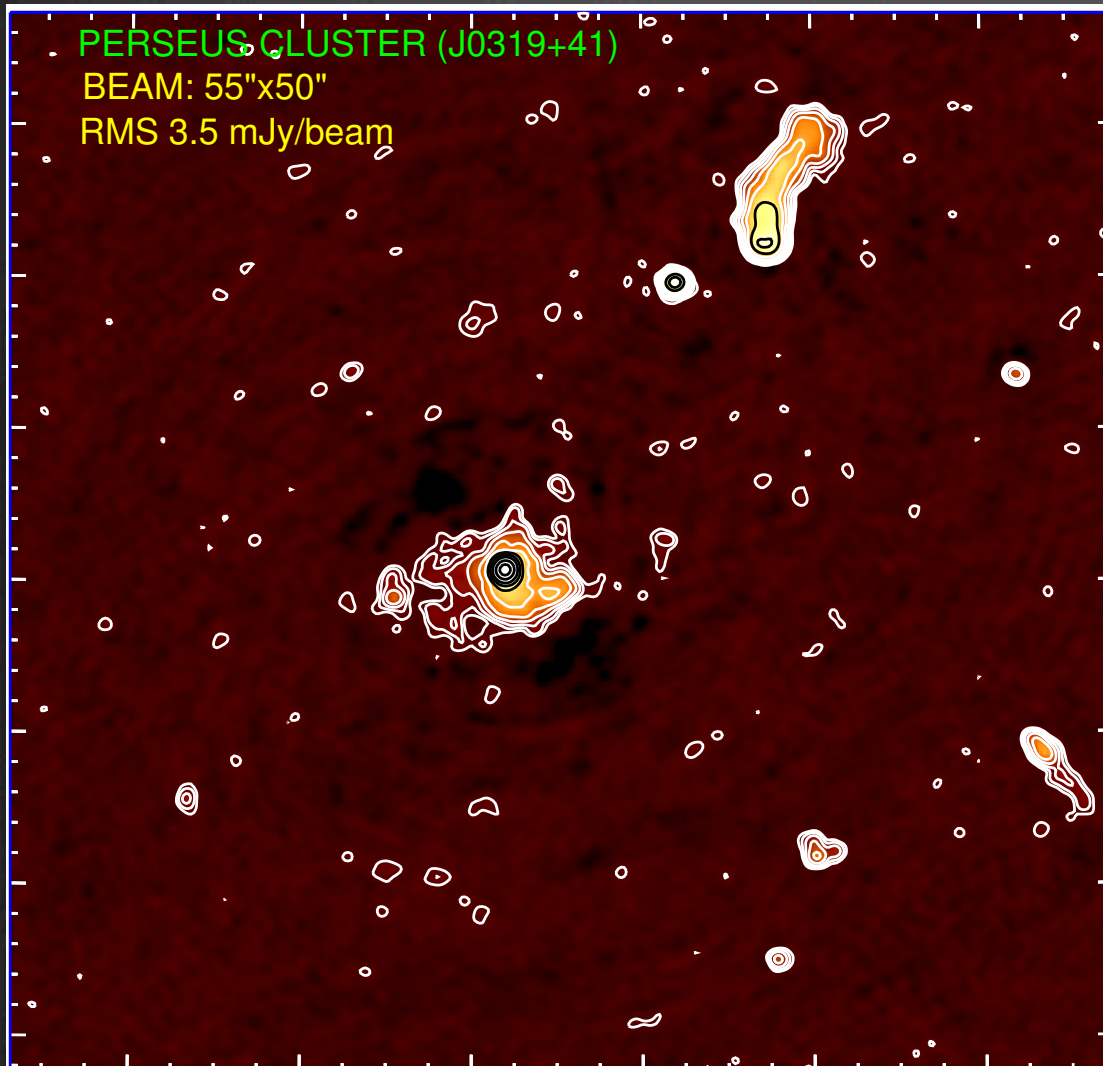
Astrophysics: First VLITE Paper

- Ogorean et al. (2015) – submitted (arXiv:1505.05560v1)
 - PI study of HST Frontier Field Cluster use JVLA 1-2 GHz to detect diffuse emission co-incident with dynamically complex cluster.
 - Commensal VLITE data detects source at $\sim 3\sigma$ and yields a spectral index of $\alpha \sim -1.4$.
 - Additional GMRT follow-up at 610 MHz confirms VLITE-JVLA spectral index



Power of VLITE

Depth: Data from 3 days (total < 1hr) on this 'calibrator'

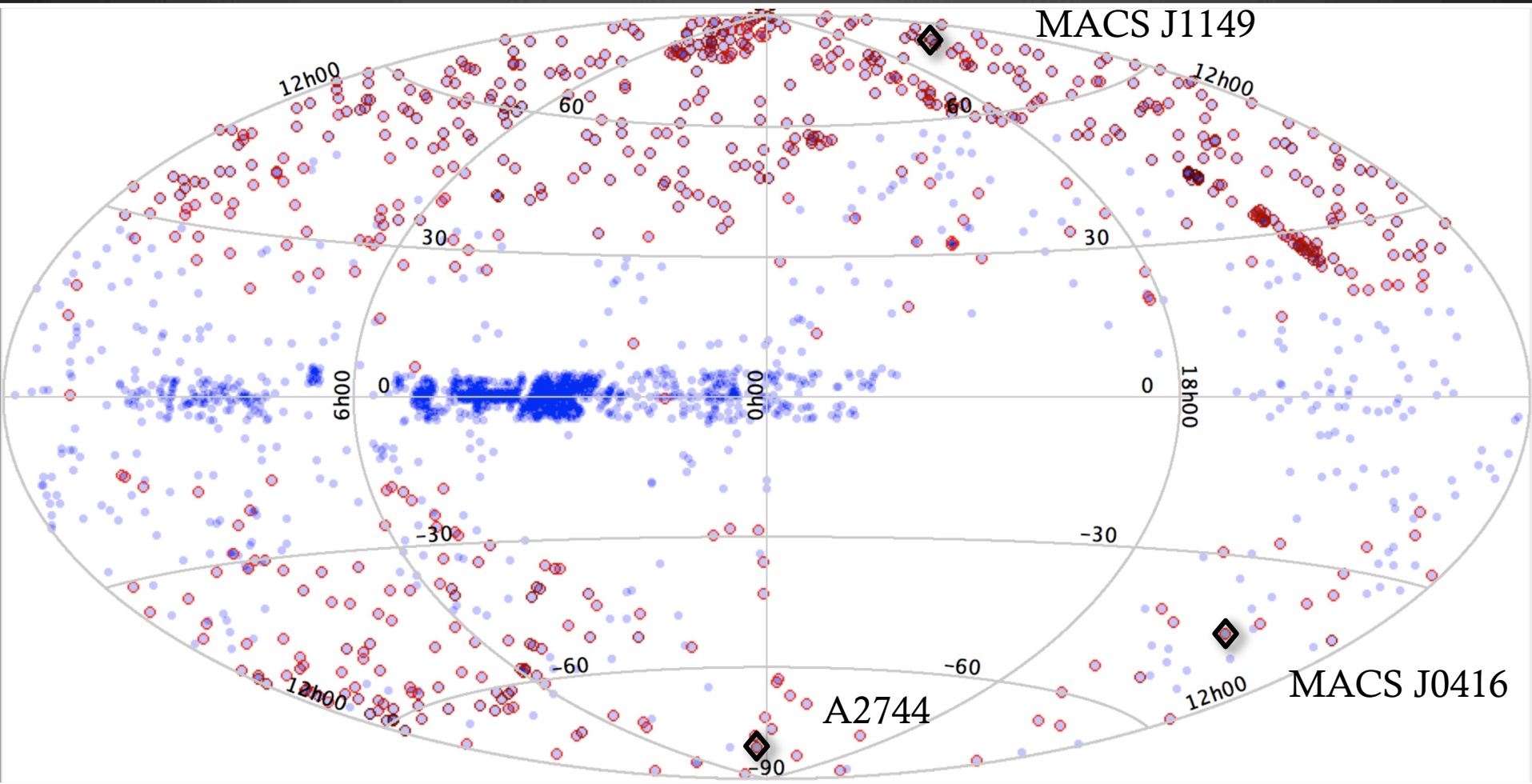


- Noise level is within a factor of a few of the noise in the 48 hr dedicated WSRT observations (Sijbring 1998).

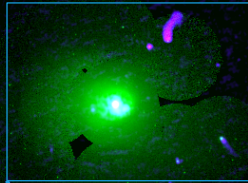
Early VLITE Work on Clusters

Surveys: clusters within 0.5° of VLITE pointing to 3/11/15

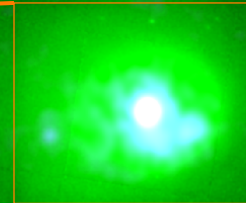
655 clusters matched to VLITE FoV, 3 Frontier Field



VLITE has 64 independent observations available with Perseus in FoV up to 3/11/15



2.5 degrees



0.5 degrees



0.1 degrees

