"Free" meter-wavelength, commensal measurements during VLASS with VLITE

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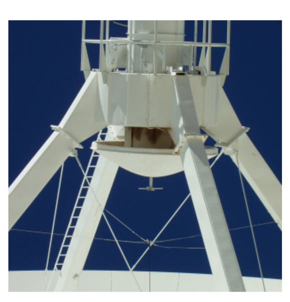
OVERVIEW

The VLA Low Band Ionosphere and Transient Experiment (VLITE) is a funded, radio synoptic, real time transient and ionospheric monitoring capability. It will make use of the primary focus, 330 MHz feeds on 10 VLA antennas to observe in parallel with the higher frequency, Cassegrain feeds. With ~5 deg^2 field-of-view in the 330 MHz band (236 < ν < 492 MHz), VLITE will perform continuous, blind transient searches and generate synoptic, wide-field continuum images annually surveying over 25% of the available sky.

The NRAO VLASS survey will likely be in the cm regime. **We propose that commensal VLITE observations be considered as part of the survey.** The science goals of a VLITE On The Fly (OTF) mosaic survey include: (1) spectral index imaging of cm-wavelength VLASS sources, (2) searches for radio transients, and (3) ionospheric remote sensing. At present, the baseline VLITE specifications exclude its use during VLASS OTF mosaic mode. The compelling requirement is the software for VLITE observing is possible within the OTF mode. ***[VLITE Press Release: https://public.nrao.edu/news/pressreleases/vlite-makes-vla-two-telescopes]***

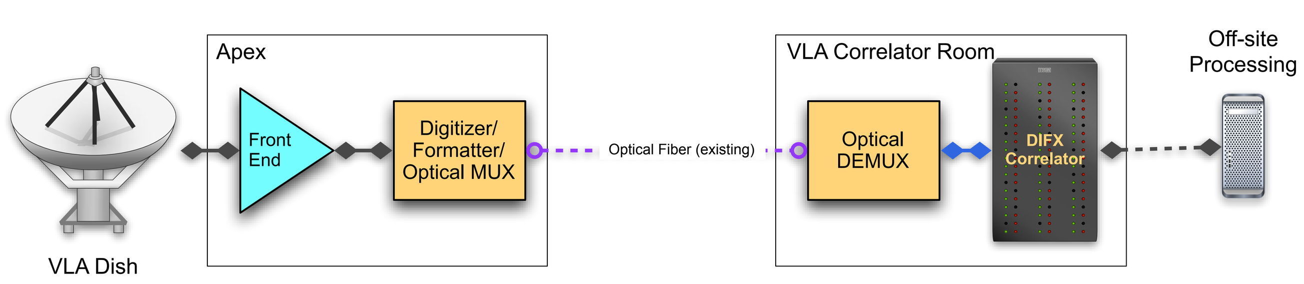
The VLA Below 1 GHz

- 330 MHz (λ=90 cm): ~1990-2009
- 74 MHz (λ=400 cm): ~1998-2009
- Both systems state-of-the art over their lifetimes
  - Two narrow-band legacy receivers: 74 MHz: Δν=1.6 MHz, 330 MHz: Δν= 6 MHz
  - Decommissioned by VLA upgrade
- **Low frequencies back on VLA as "Low Band" & much better than before!**
  - Single receiver accesses to ~50-500 MHz
  - Current feeds utilizing 54-86 MHz, 236-492 MHz – VLITE will initially access the 330 MHz band.



The VLITE System

Below is a block diagram of the VLITE system. The VLA dishes and optical fiber infrastructure are existing assets. The NRL Low Band Front Ends (cyan) were completed in CY13 under earlier NRL funding. The orange components are currently under development.

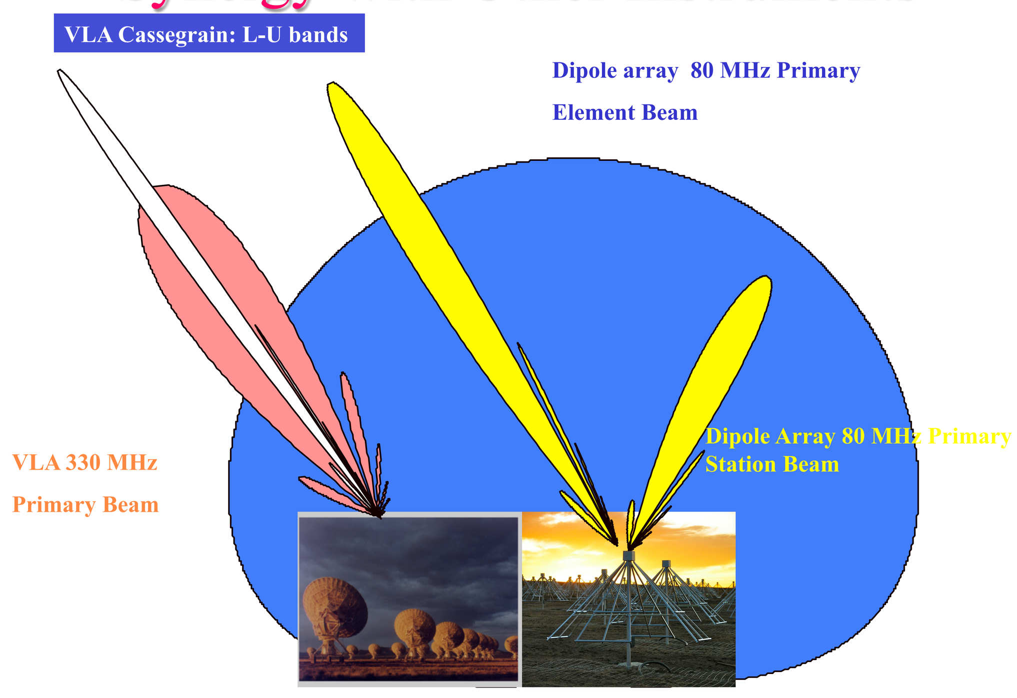


Parameter	VLITE
Feed	Crossed Dipoles at Primary Focus
Center Frequency	350 MHz
Bandwidth	64 MHz
Availability	≥ 50% of VLA on-sky time*
Tsys	150 K
Field of View	5 deg^2
Number of Antennas	10
Polarization	Dual Linear
Receiver Location	Apex
A/D Sample Clock	1024 MHz, 8 bit sampler
Correlator HW	15 Dual 8-core Xeon CPUs
Spectral Resolution	10 KHz
Correlator Input Data Rate	

*A period including at least two complete A and two complete B configuration cycles.

Block diagram (above) and specs (left) of the VLITE system. VLITE will initially operate in the 330 MHz band, and could be expanded to include all VLA antennas and the 74 MHz band in the future.

Synergy with Other Instruments



Telescopes sharing the VLA sky, especially dipole arrays, including LWA1, LoFASM, LWA-OVRO, LOFAR can track the VLITE FoV.

VLITE VLASS Commensal Science

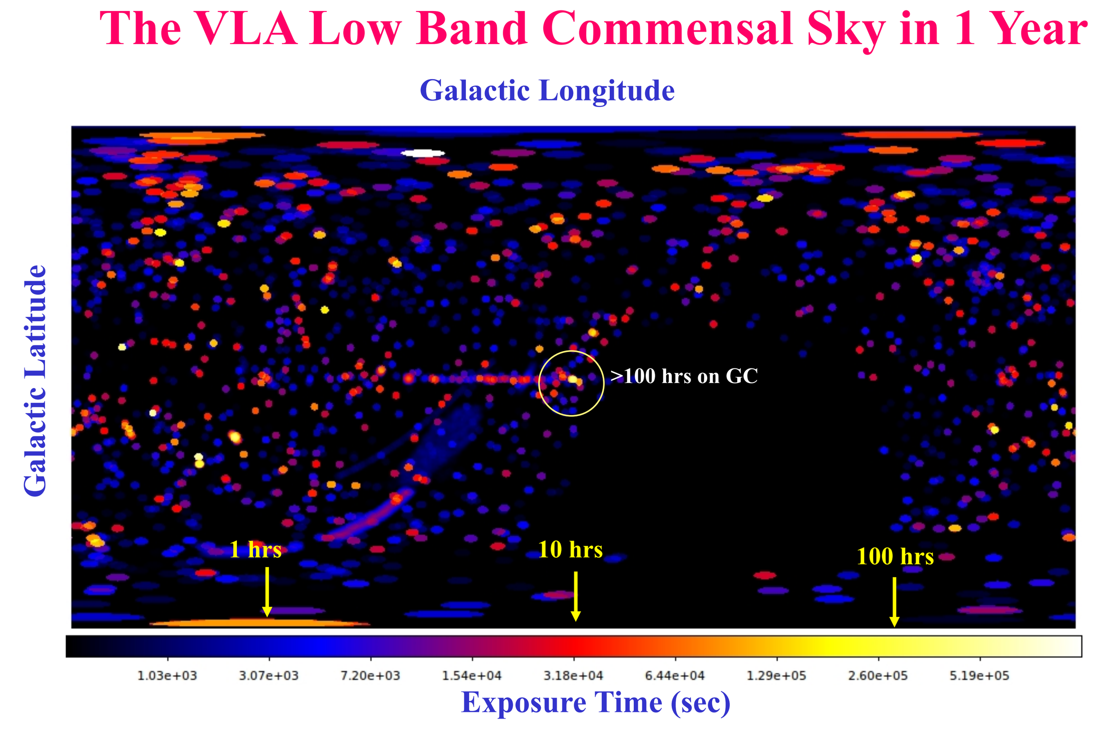
VLITE VLASS commensal science can be divided into three general areas:

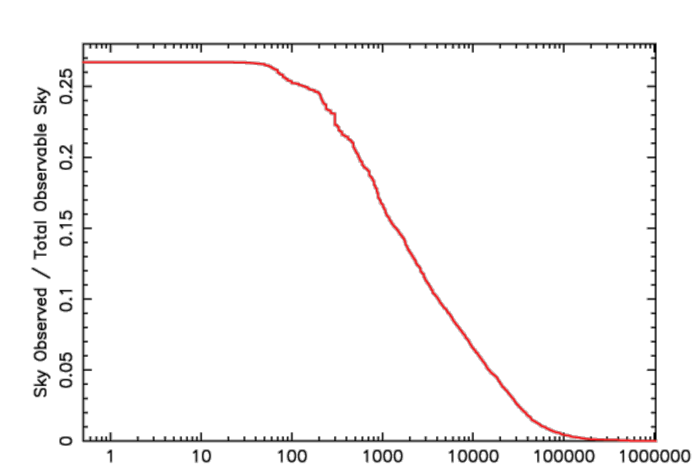
(1) Continuum spectra. Much of VLASS cm-wavelength science would benefit from complimentary, meter-wavelength observations to constrain continuum spectra and delineate thermal and nonthermal components. Especially for steep spectrum, low surface brightness emission e.g. cluster relics and halos (Clarke et al. 2013).

(2) Transient searches benefit from maximizing Ω (field-of-view) * t (observing time), both naturally inflated with VLITE. The statistics of *slow, radio-selected*, low frequency transients suggest VLITE could detect *hundreds* of transients annually. The detection of *fast, radio transients* at cosmological distances (Thornton et al. 2012) would benefit enormously through sourrce localization wanting in single dish searches.

(3) Ionospheric waves: Continuous monitoring of ionospheric disturbances at far greater sensitivity than GPS, bringing an expansion of the breadth, and funding base, of the VLA towards atmospheric science – only one scientific area relevant outside the traditional, and narrow framework of radio astronomy.

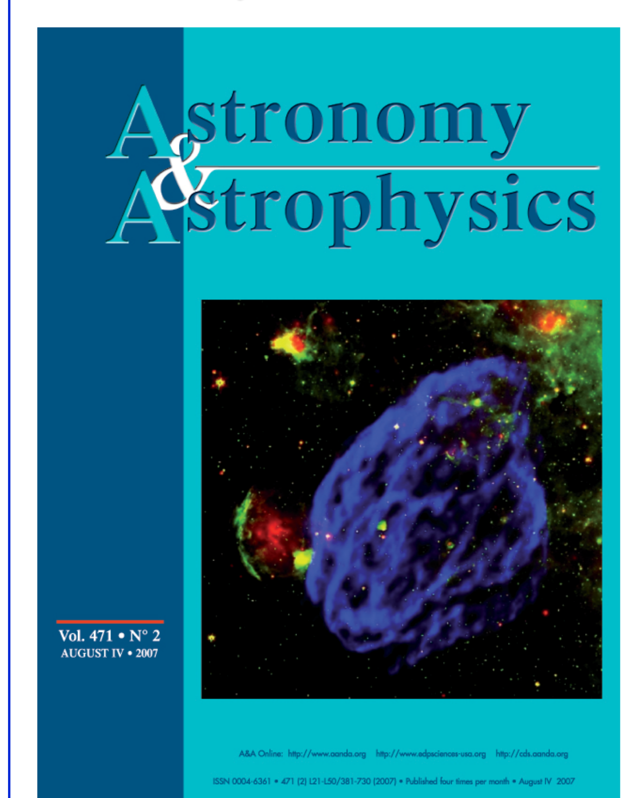
The VLA Low Band Commensal Sky in 1 Year

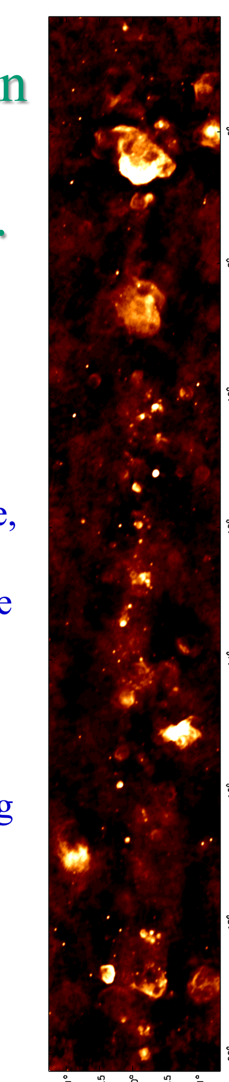




The top figure is a hypothetical VLITE exposure map based on VLA archival statistics. The bottom figure indicates the fraction of the sky observable by the VLA as a function of dwell time. About 25% of the accessible sky was observed for at least 100 seconds per year, and about 10% was observed for at least 1 hour per year. (The VLA accessible sky covers ~ 33,000 deg^2.) The exposure map for VLITE run commensally with the VLASS is TBD, but would naturally encompass a large region of the sky, with significant synoptic cadence since the VLITE FoV is so much larger than for the nominal cm-wavelength VLASS.

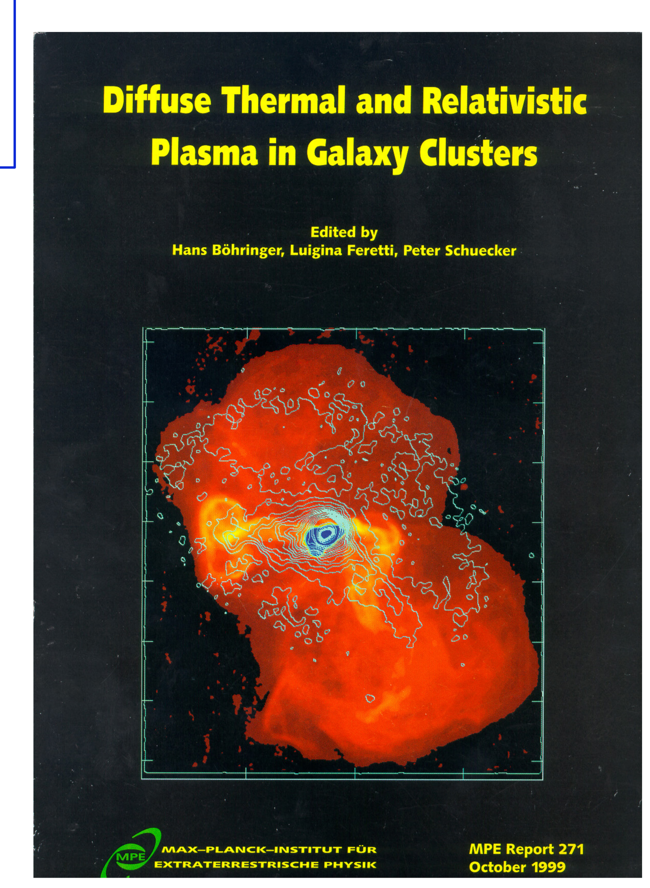
Below are a few, classic images from the legacy VLA P band system. They illustrate the type of complimentary images that VLITE could provide for a cm-wavelength VLASS, with an emphasis on enhanced surface brightness sensitivity to extended, nonthermal emission.





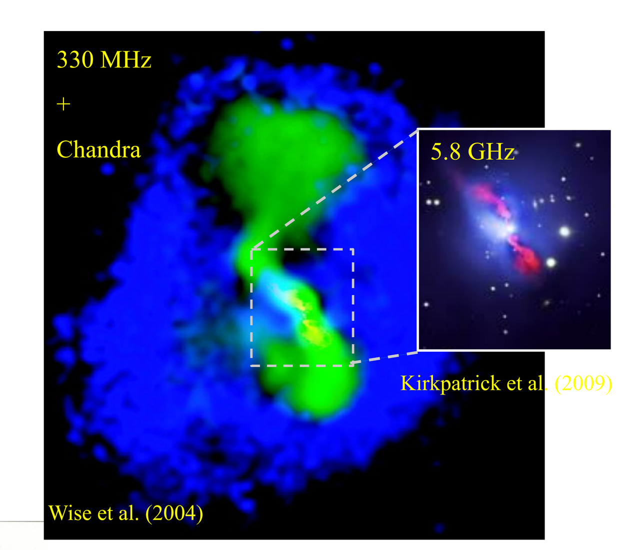
Left: A comparison of radio continuum and infrared emission from the classic shellt-ype SNR W44. Radio is blue, while the green and red images correspond to the Spitzer 8 and 24 micron emission (Castelletti et al. 2007).

Right: A ~10° strip along the Galactic plane tripling the SNR census in the region (Brogan et al. 2006).



Left: Virgo A radio emission (red) superimposed on ROSAT X-ray contours (Owen et al. 2000). This image helped catalyze debate about the role of AGN feedback in galaxy clusters.

Below: A wide-field radio (green) and Chandra X-ray mosaic of Hydra A, again highlighting the role of AGN feedback in cooling flow clusters. The inset illustrates how cm-wavelength maps may significantly underestimate the extent of radio emission.



Left: A VLA image of the Galactic center (GC) region obtained in a single pointing. P band VLA GC imaging has contributed to several areas of research including: 1) providing the lowest frequency detection of Sgr A*(Nord et al. 2004; 2) uncovering new nonthermal filaments and sparking a viable debate about the existence and origin of a strong, pervasive, GC magnetic field; 3) detected several radio-selected slow transients (Hyman et al. 2005) and contributing to the growing excitement for the search for radio transients.

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