Time Domain Science with the VLASS

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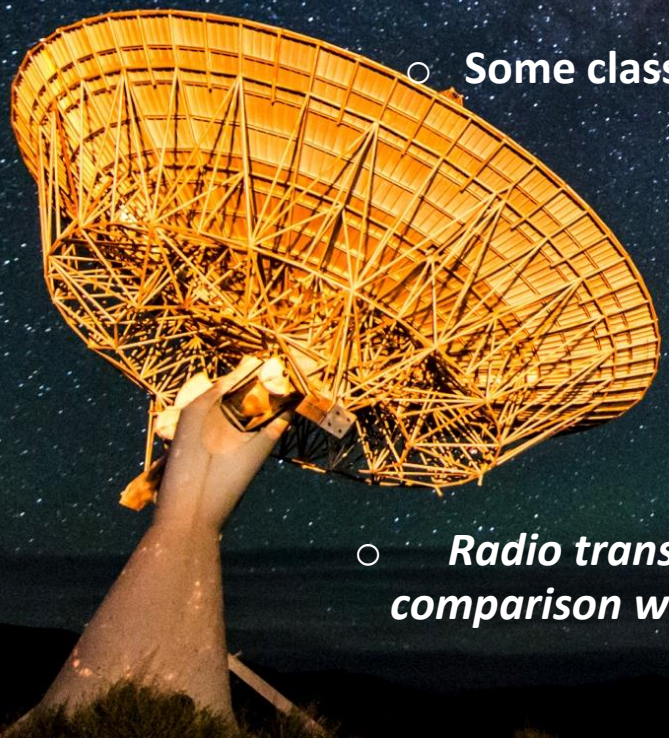
Why search for radio transients?

- Signal dynamic and often explosive events, in some cases probing the highest energy particle populations in the observable universe
- Offer unique diagnostic information on magnetic field, plasma densities and energetics that are unavailable at other wavebands
- Some classes of transients are unique to radio wavelengths

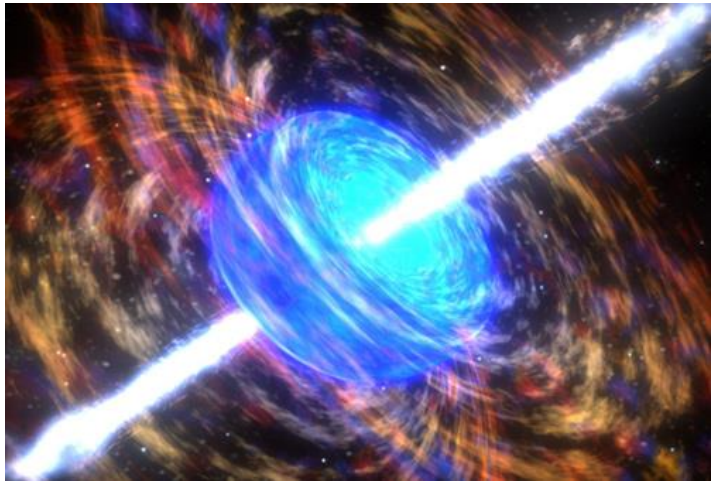


- *Radio transient sky on timescales > 1 sec is largely unexplored by comparison with γ-ray, X-ray and optical (eg. Fermi, PTF, Pan-STARRS)*

Types of Transients

Incoherent

- Typically synchrotron emission
- Variable on timescales of seconds – years
- Brightness temperature limited to $<10^{12}$ K
- Typically discovered in image data

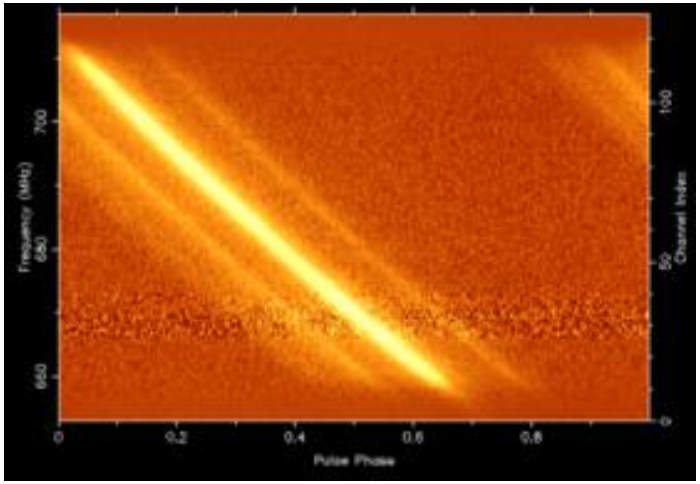


Examples:

- AGN and Microquasar jets
- Supernovae & GRBs afterglows
- Black hole tidal disruption events (TDEs)
- Giant flares from magnetars

Coherent

- Various flavors of coherent emission
- Variable on timescales of ns - minutes
- Brightness temperatures as high as $>10^{38}$ K
- Typically discovered in time-series data



Examples:

- Various classes of neutron stars
- Galactic Center Radio Transients
- Stellar bursts and pulsing brown dwarfs
- Fast Radio Bursts (FRBs)

Ripe for Exploration…

- GRB afterglows (Frail et al. 1997)

- Giant flares from SGRs (Cameron et al. 2005, Gaensler et al. 2005)

- Pulsing brown dwarfs (Berger et al. 2001, Hallinan et al. 2007)

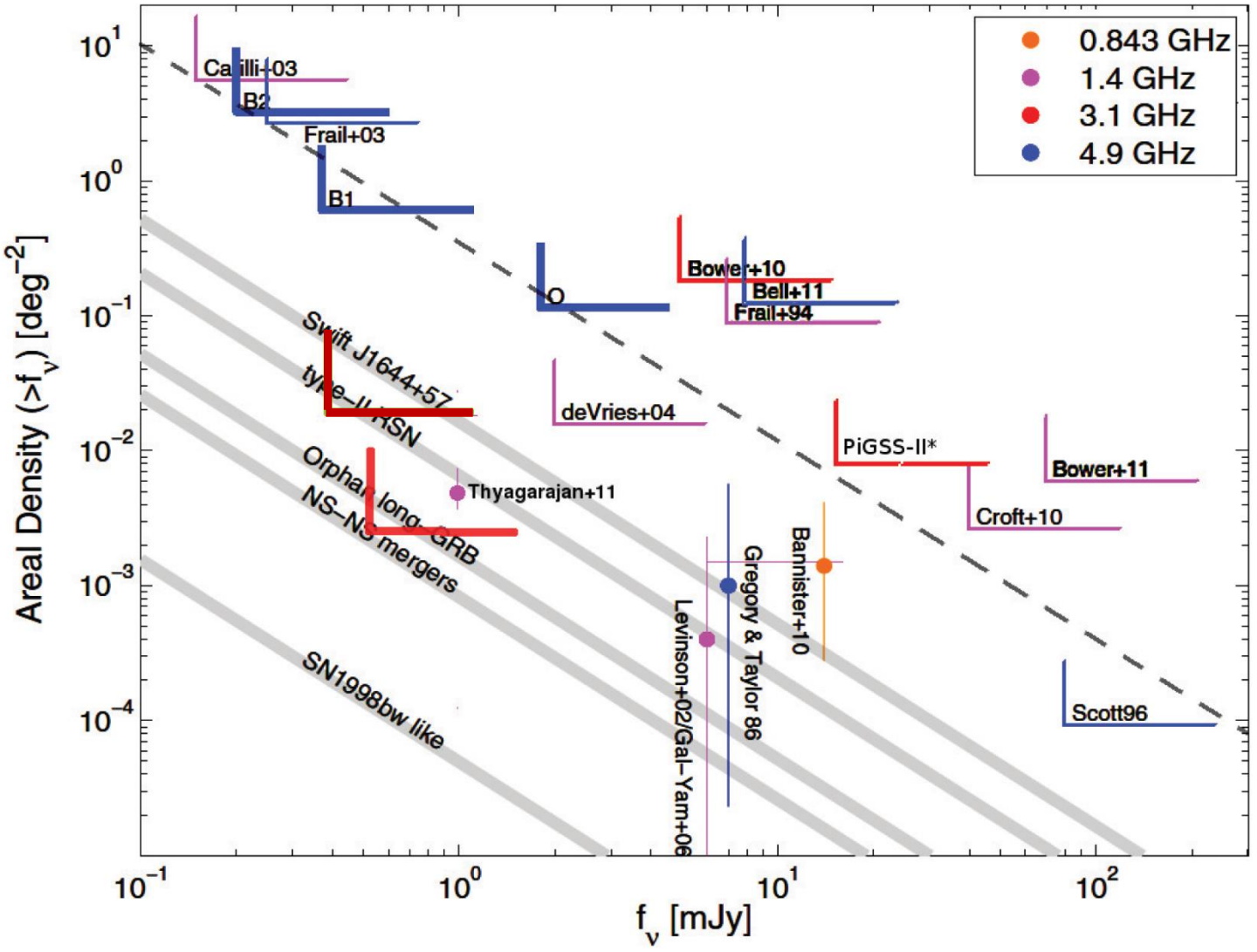
- Black hole tidal disruption events (TDEs) (Zauderer et al. 2011)

1) All discovered in optical/X-ray/Gamma-rays surveys and followed up at radio frequencies

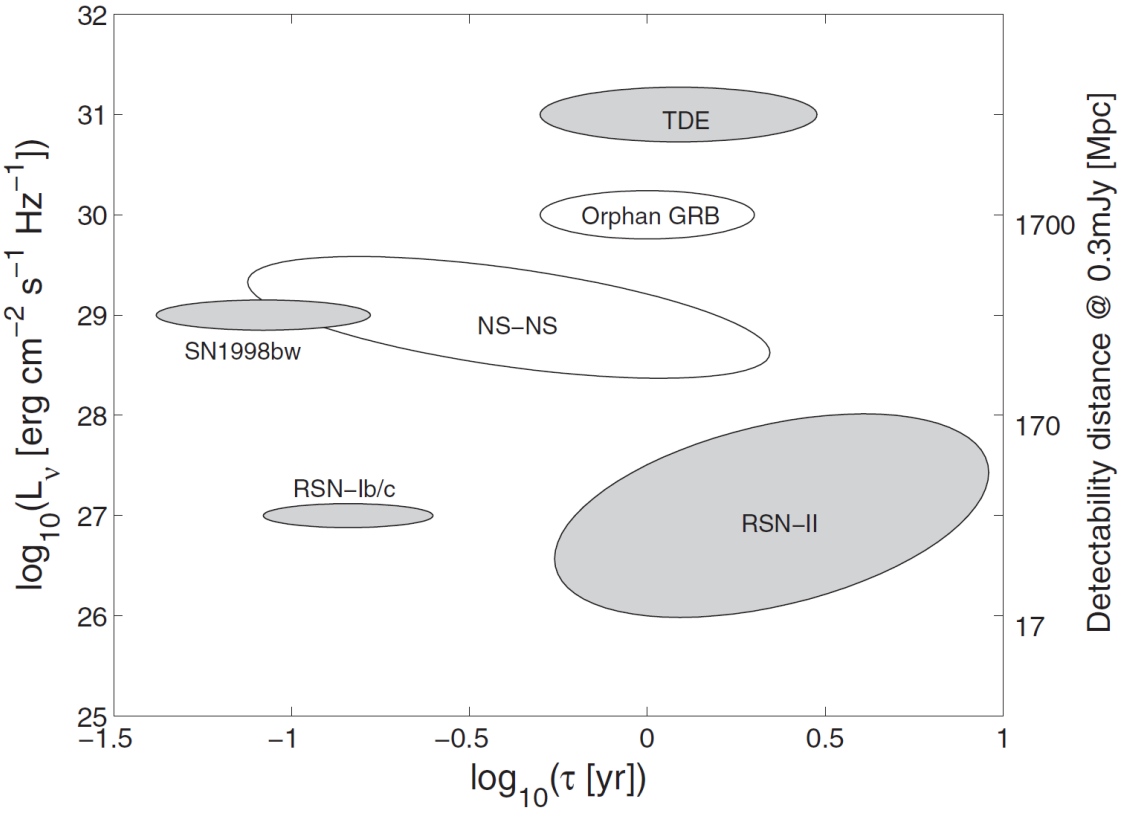
2) Radio observations provided unique and powerful insight in all cases

However, most key questions can only be addressed by blind surveys

Blind Searches Thus Far



Blind Searches Thus Far



- For explosive extragalactic transients, the duration, luminosity and spectral behavior is dependent on the total energy and velocity of the ejecta, as well as the density of the surrounding circumstellar medium

- Well separated radio observations required to maximize science return

- Optical data to confirm host galaxy is essential

- Broadband radio follow up (VLA and VLBA) is also key

Key Questions for the VLASS

1) What is the rate of known and unknown classes of radio transients, both extra-galactic and Galactic?

2) What is the rate, and hence inverse beaming fraction, of GRBs and TDEs.

3) What is the rate of obscured supernovae in the local Universe?

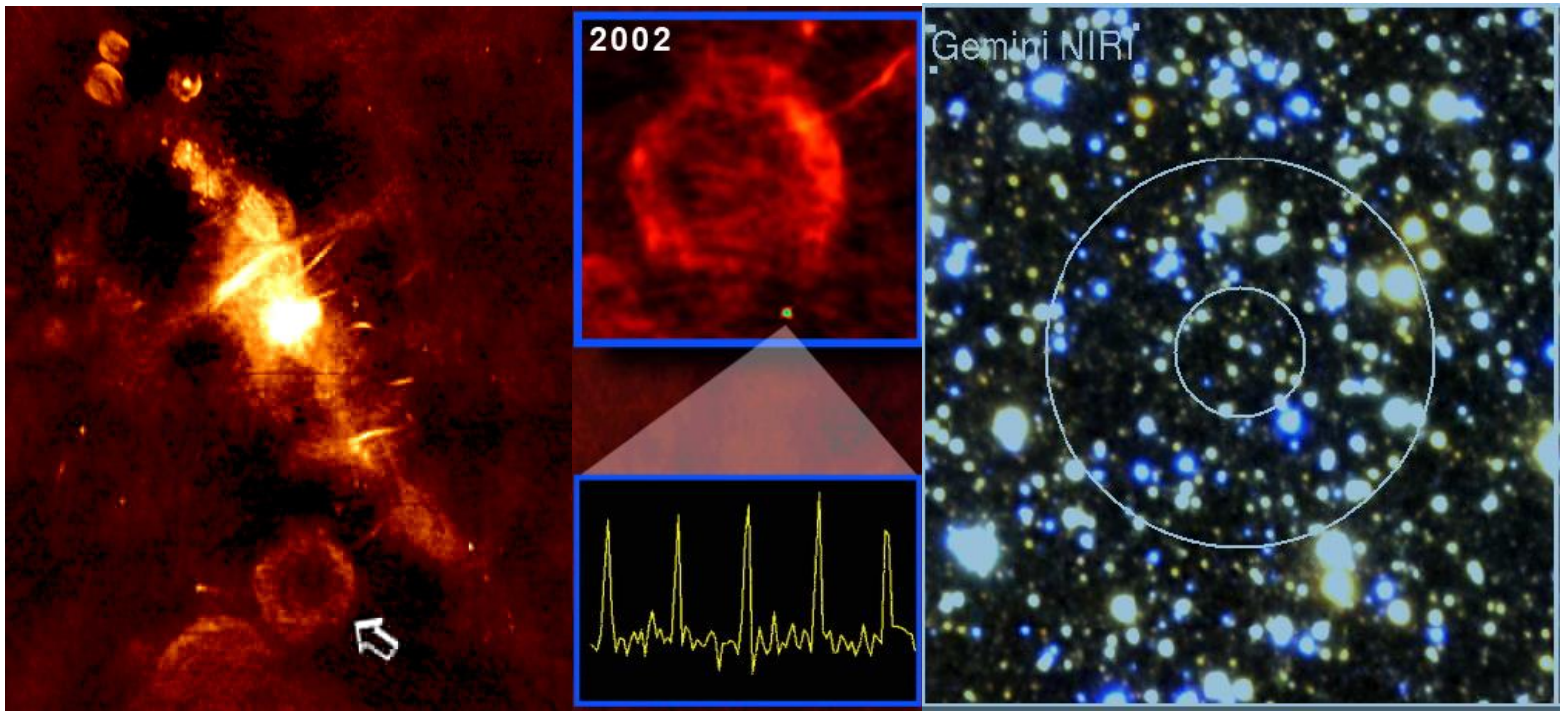
4) What is the rate of binary neutron star mergers?

5) What is the nature of the mysterious Galactic Center Radio Transients (GCRTs)?

Electromagnetic Counterpart to Gravitational Wave Events

- Advanced LIGO (aLIGO) and Advanced Virgo (AdV) are scheduled to commence collecting data in 2015
- Binary neutron star coalescence the most likely source detected
- True rate poorly constrained
- Finding the electromagnetic counterpart will be a huge challenge
- Radio observations may be key (Nakar & Piran 2011)

Galactic -The Mysterious GCRT J1745-3009



- Pulsing source (period 77 mins) discovered in archival 330 MHz VLA data Hyman et al 2007)
- Localization to poor to establish an optical counterpart
- Nulling pulsar? White dwarf pulsar? Brown dwarf?

Key Points for the VLASS

1) Transient science with the VLASS can be included in almost manifestation of the VLASS. On-the-fly mapping enables this science with almost no impact

2) However, shallow and wide is better than narrow and deep, likely contrary to other science cases.

3) Epochs should be well separated (>1 year) to maximize scientific return; 2 is good but 3 would be better

4) Dedicated follow-up resources are key (both NRAO and external). Deep optical catalogs also essential.

5) Real-time data reduction capabilities exist and should be employed. Requirements are (relatively) modest [see talk by Mooley]. Possible synergy with FRB searches.

6) Inclusion of VLITE/LOBO would be a tremendous advantage, particularly for low frequency coherent transients sources (eg. GCRT-type transients)

7) Largest survey volume preferred -> L, S or C band