Radio Bright Supernovae Observed by Australian SKA Pathfinder

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Bob Aloisi at CSIRO Parkes PAF Prototype

Science Motivation

- Demonstrate successful detections of transient radio sources
- Develop procedures for ongoing detection of radio transients
- Classify transient sources
- Constrain physical models through lightcurves

Australian SKA Pathfinder (ASKAP; Johnston et al., 2008)

- 36 x 12-m dish interferometer
- Located in radio quiet Western Australia
- SKA Prototype, designed for fast surveys
- Phased array feed (PAF) with 36 beams
- Large field of view (FOV), 36 deg.^{2}, allowing frequent cadence.
- 700 MHz to 1.8 GHz frequency range, 300 MHz bandwidth
- Rapid ASKAP Continuum Survey (RACS)
  - All sky -90º to 40º
  - 15 arcsec resolution, 22 m to 6400 m baselines
  - 888 MHz center frequency
  - Sensitivity (0.25 mJy beam^{-1}) 2x NVSS survey (Condon, et. al., 1998)

Innovative ASKAP PAF Feed
https://www.skatelescope.org

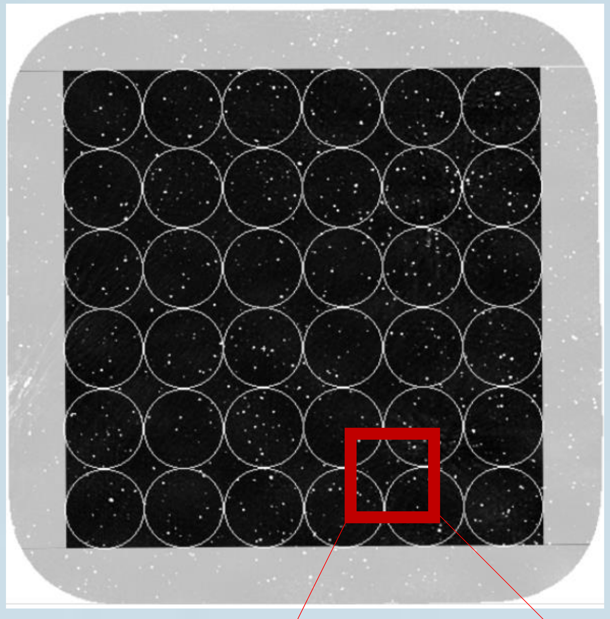
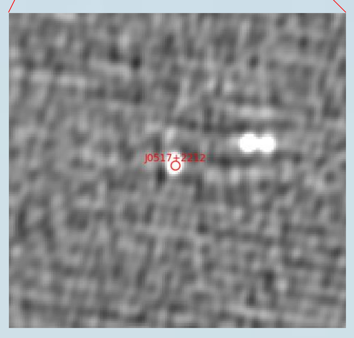


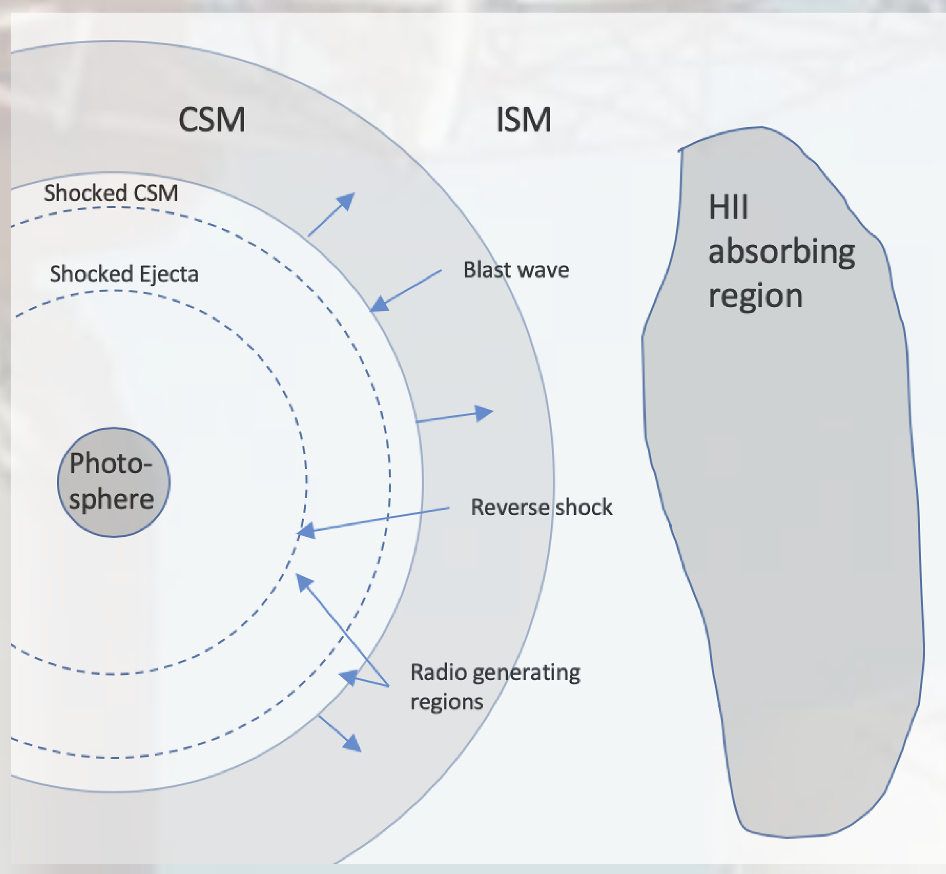
Image (*right*) showing RACS field of view with 36 beams



Postage stamp showing source matched to supernova location (red circle).

Variable and Slow Transient Survey (VAST)

- One of 10 ASKAP Survey Science Projects https://www.atnf.csiro.au/projects/askap/ssps.html
- Focusing on transient timescales longer than 5 s
- VAST Pilot – 4,000 deg.^{2,} ~6 epochs, 0.25 mJy beam^{-1}
- VAST Wide – 10,000 deg.^{2} observed frequently, 0.5 mJy beam^{-1}
- VAST Deep – 10,000 deg.^{2} observed in multiple epochs, 50 uJy beam^{-1}
- VAST Galactic – 750 deg.^{2}, multiple epochs, 0.1 mJy beam^{-1}



SN Physical Model Cartoon

(adapted from figure in Weiler, 2001)

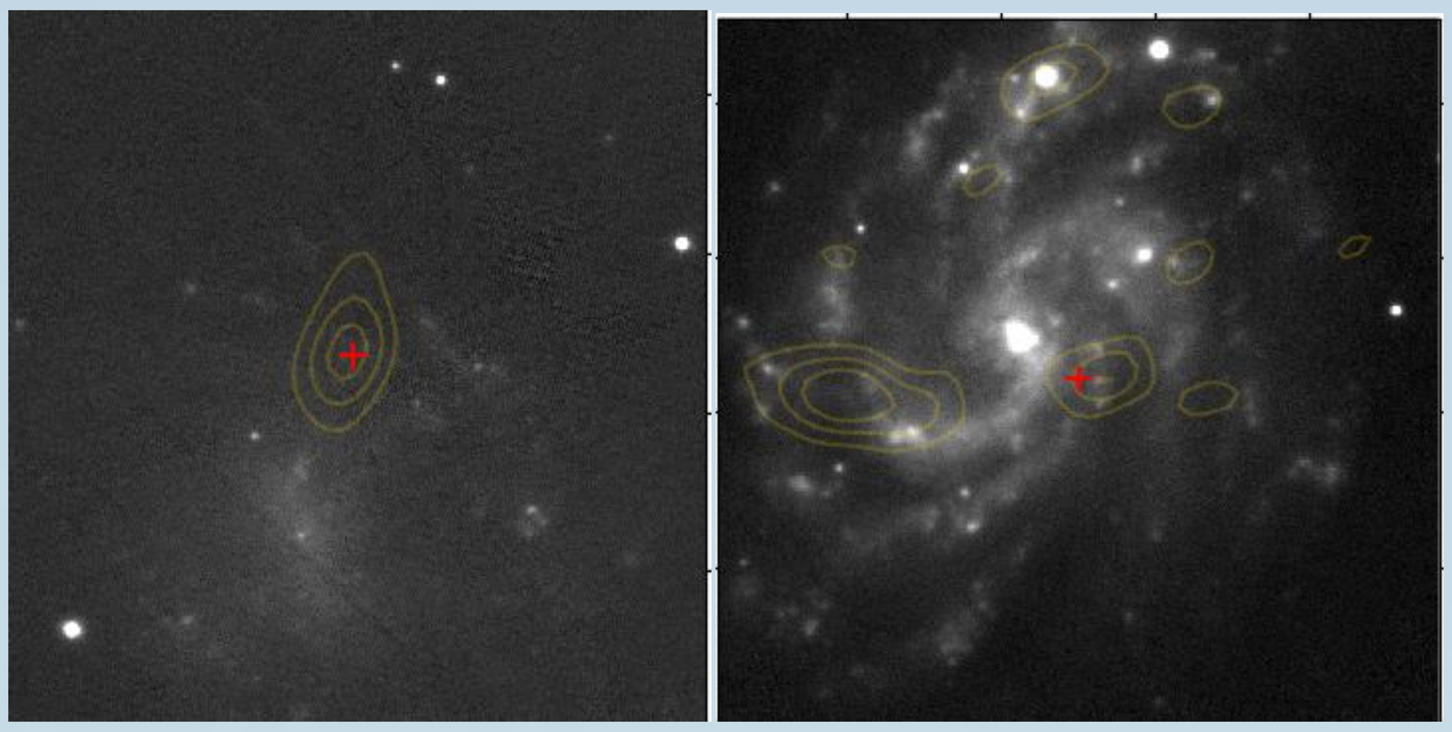
Synchrotron radio emission caused by shock wave interacting with circumstellar (CSM) material. Emission may be self absorbed near shock wave or partially absorbed by distant HII ionized region.

Search Methodology

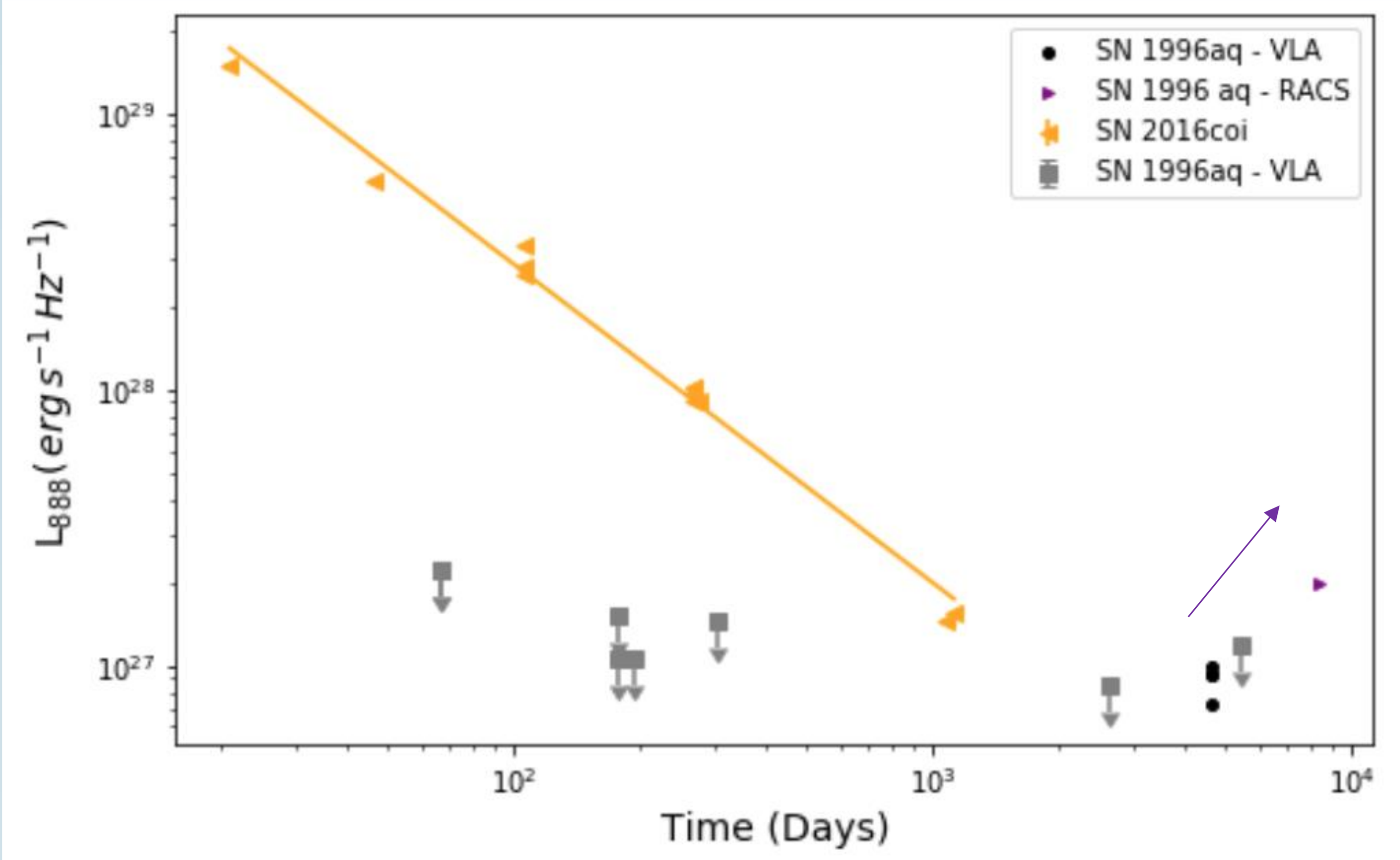
- Search known supernovae (SNe) locations from catalogs: Transient Name Server, Asiago, Wiserep, SDSS-II Supernova Survey, Simbad
- Find matching sources within 15” based on observed size of known sources.
- Screen matches to eliminate other radio sources.
  - Transient flux compared to prior surveys (NVSS; Condon, et. al., 1998, SUMMS; Mauch 2003)
  - Luminosity less than twice that of brightest SN (< 6.8e29 ergs s^{-1} Hz^{-1})
  - Radio flux centered at SNe location
  - Overlay radio contours are centered on SN location in optical images.

Conclusions / Future Work

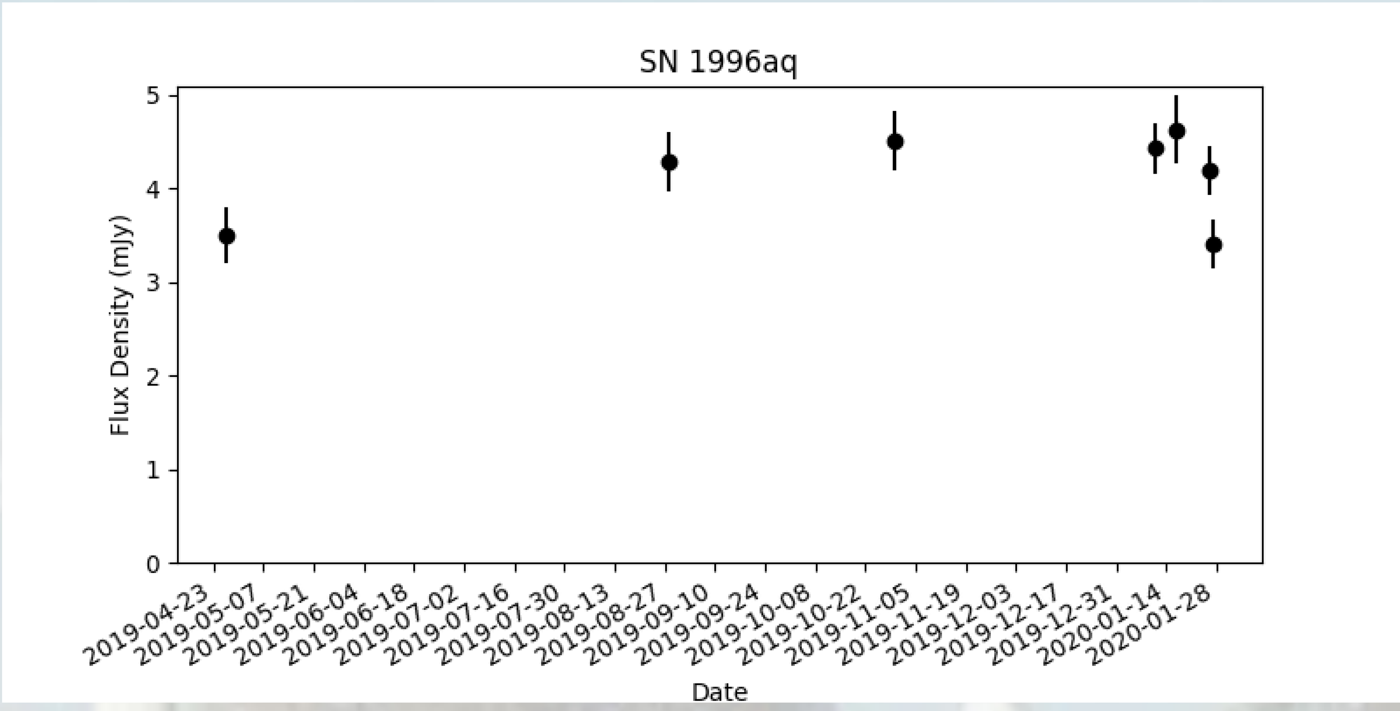
- Found 30+ radio loud supernova candidates in RACS survey.
- Tracking radio flux density for 7 candidates within pilot VAST fields
- All candidates can be monitored in future ASKAP surveys
- Follow-up multi-wavelength observations will be proposed for interesting candidates.



ASKAP radio contours from RACS survey overlaid on Pan-STARRS 1 g filter images. Red cross shows location of SN 2016coi (left) and SN 1996aq (right). Contours are increments of 3 times rms noise.



SN 2016coi flux decreases with time as expected for a uniform supernova blast wave encountering spherical shell of circumstellar material (CSM). SN 1996aq radio flux density was first detected in 2009 by VLA and recently detected in RACS survey with increasing luminosity 23 years later, which may indicate that its blast wave is encountering higher density CSM. Upper limits are shown for non-detections.



Recent ASKAP observations of SN 1996aq from RACS and pilot VAST survey show transient flux density over a period of months.

Acknowledgements & Citations

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Background Image: https://confluence.csiro.au/display/IMG_20161119_074047845.jpg

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Asiago https://heasarc.gsfc.nasa.gov/W3Browse/all/asiagosn.html
Wiserep https://wiserep.weizmann.ac.il/
SDSS-II Supernova Survey http://classic.sdss.org/supernova/snlist_confirmed.html
Simbad http://simbad.u-strasbg.fr/simbad/
Pan-STARRS 1 https://ps1images.stsci.edu/cgi-bin/ps1cutouts

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GROWTH Global Relay of Observatories Watching Transients Happen

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