

EVN Transient Science

Long-term partnership with China

Zsolt Paragi, Joint Institute for VLBI ERIC

Contribution from Jun Yang (OSO), Zhigang Wen (Urumqi),
Yuping Huang (Carleton College), An Tao (ShAO),
Benito Marcote (JIVE), Aard Keimpema (JIVE) and others

Radio transients zoo

(Beam-formed) sensitivities at 1 kpc
and 1 Gpc for:

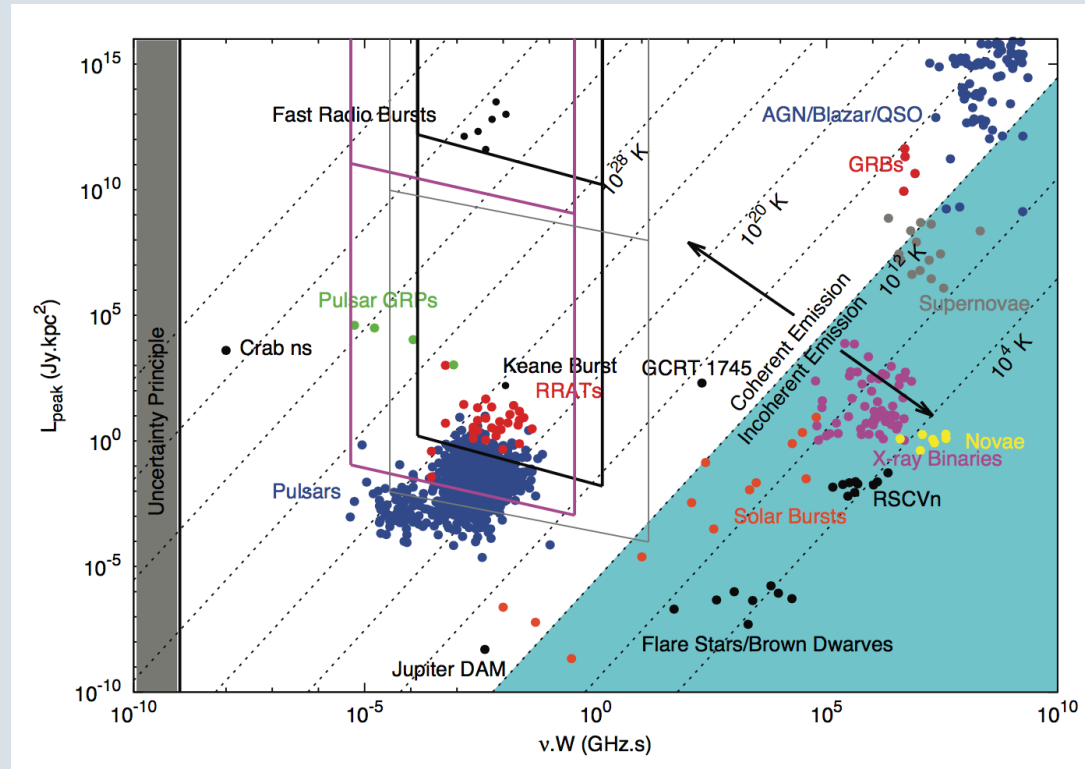
Parkes (black lines)

SKA1-LOW (pink)

SKA1-MID (grey)

(EVN ~ SKA1-MID)

*SKA Transient WG - Macquart et al. (2015);
update of Cordes, Lazio & McLaughlin 2004*



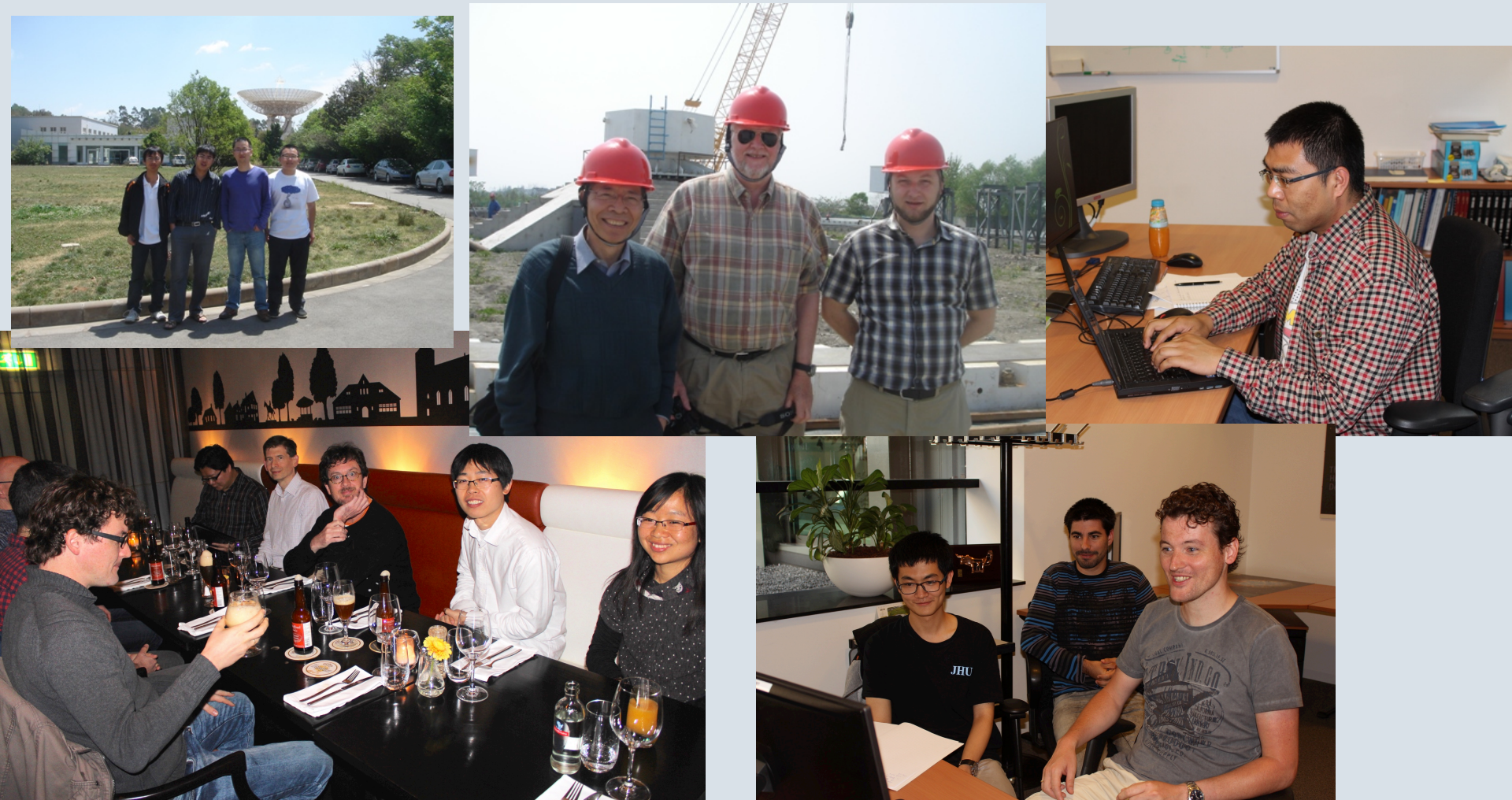
- ❑ **Extreme physical laboratories; the realm of unknowns**
- ❑ **Natural targets for VLBI:**
 - May resolve relativistic ejecta out to great distances
 - Parallax distances for Galactic sources
- ❑ **Primary targets for the SKA**

The European VLBI Network



❑ Chinese telescopes form some of the longest baselines in the EVN

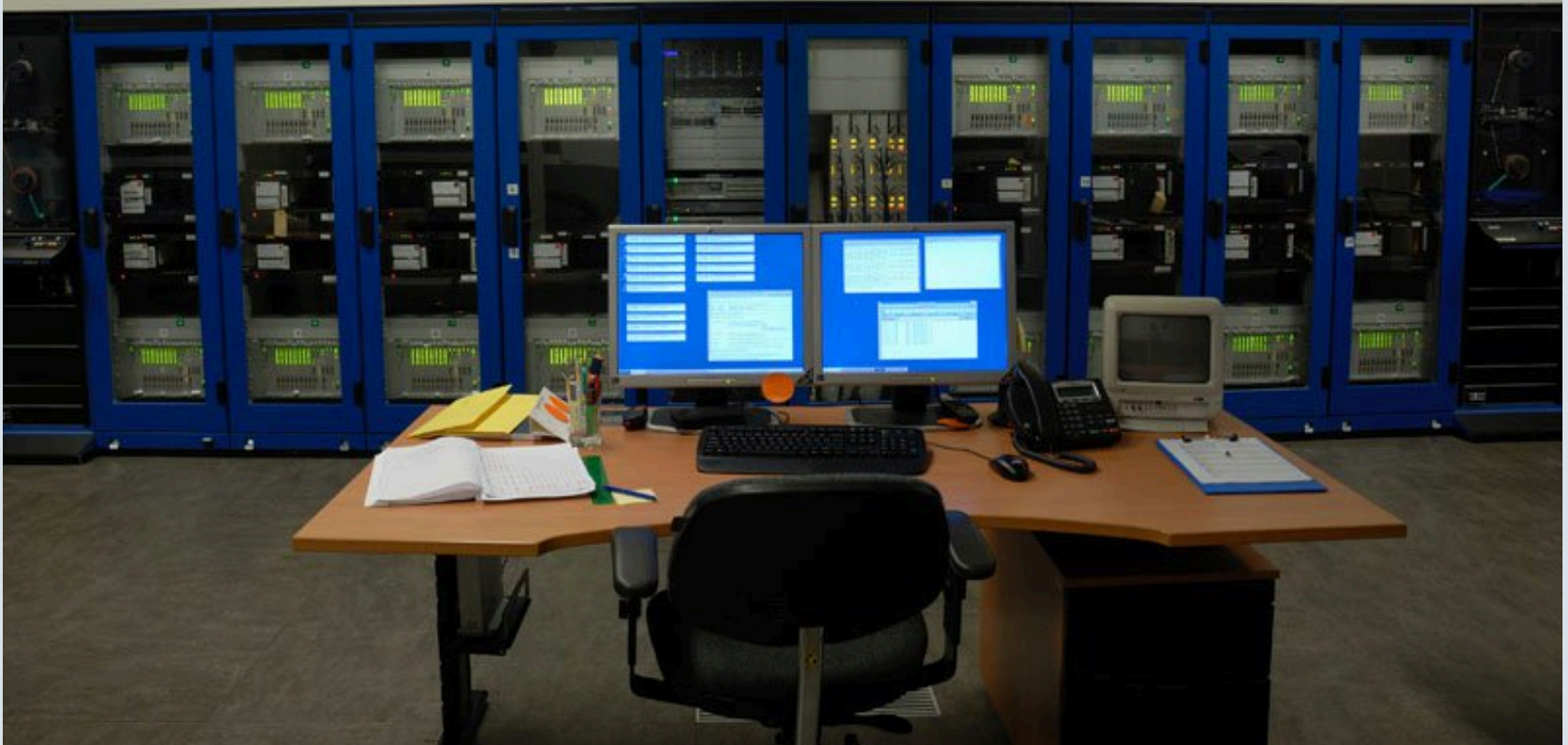
Decades of Partnership



❑ Exchange visits, training, joint projects...

Joint Institute for VLBI ERIC (JIVE)

- ❑ JIVE's mandate is to support EVN operations, maintain the EVN data archive, and support users
- ❑ JIVE has developed the EVN Software Correlator, allowing for cutting-edge EVN science
- ❑ JIVE has led the real-time e-VLBI developments in the EVN



The role of e-VLBI in transient science

e-EVN observations of V404 Cyg in outburst

ATel #7742; **V. Tudose (ISS), Z. Paragi (JIVE), J. C.A. Miller-Jones (ICRAR-Curtin), A. Rushton (Oxford), J. Yang (Chalmers), R. Fender (Oxford), S. Corbel (CEA), M. Garrett (ASTRON/Leiden), R. Spencer (Manchester)**
on 1 Jul 2015; 16:43 UT

Credential Certification: Valeriu Tudose (tudose@spacescience.ro)

Subjects: Radio, Binary, Black Hole, Transient

Referred to by ATel #: 7959

[Tweet](#) [Recommend](#) 20

Following the outburst of the transient X-ray binary V404 Cyg, we observed the system at 1.6 GHz on 2015 June 23/24 between 22:08-07:58 UT with the European VLBI Network (EVN), using the e-VLBI technique. The participating radio telescopes were Effelsberg, Hartebeesthoek, Jodrell Bank MkII, Medicina, Onsala85, Shanghai, Torun, Westerbork (5 telescopes of the phased-array).

Due to the heavy scattering towards the target, the longer baselines with Shanghai were significantly affected and had to be deleted. Significant variations in the flux density of the source (by a factor 1.5) also influenced the quality of the radio image. However, we clearly detected V404 Cyg as a point-like source (beam FWHM: 30×13 mas; PA: 83 deg) with a peak brightness of 166 ± 5 mJy/beam at the position (J2000):

RA: 20h24m03.8183983
Dec: +33d52m01.840768"

We estimate the systematic error in astrometry to be of a few mas due to poorly modeled ionosphere and large line-of-sight scattering.

We do not see any evidence for extended radio emission above a 3-sigma rms noise level of 0.5 mJy/beam, at scales from 5 mas up to 200 mas.

We take the opportunity to note that these observations represent the last occasion on which the MFFE receivers and TADU system were used to form the Westerbork tied array. We thank the "old" Westerbork for the excellent VLBI science it has generated over the last few decades and look forward to the "new" Westerbork system employing the APERTIF Phased Array Feeds.

The European VLBI Network (EVN) is a joint facility of European, Chinese, South African, and other radio astronomy institutes funded by their national research councils. The observations presented here were obtained under the project code ET031A.

e-EVN radio detection of Aql X-1 in outburst

ATel #5158; **V. Tudose (ISS), Z. Paragi (JIVE), J. Yang (JIVE), J. C.A. Miller-Jones (ICRAR), R. Fender (SOTON), M. Garrett (ASTRON), A. Rushton (SOTON), R. Spencer (JBO)**
on 24 Jun 2013; 12:49 UT

e-EVN detections of GRB130427A and GRB130702A

ATel #5242; **Z. Paragi (JIVE), A. J. van der Horst (UvA), J. Yang (JIVE), C. Kouveliotou (NASA/MFSC), R. A.M. J. Wijers (UvA), J. Granot (Open U. Israel)**
on 1 Aug 2013; 16:01 UT

EVN measurements show no evidence for radio emission from the Type Ia SN 2014J

ATel #6153; **M. Perez-Torres (IAA-CSIC, Granada; CEFCA, Teruel), P. Lundqvist (Dept. of Astronomy, Stockholm University), Z. Paragi (JIVE, Dwingeloo), C. I. Björnsson (Dept. of Astronomy, Stockholm University), C. Fransson (Dept. of Astronomy, Stockholm University), A. Alberdi (IAA-CSIC, Granada), M. K. Argo (JBCA, Manchester), R. Beswick (JBCA, Manchester), J. C. Guirado (Universidad de Valencia), J. M. Marcaide (Univ. de Valencia), I. Martí & iacute; Vidal (Onsala Space Observatory), T. W.M. Muxlow (JBCA, Manchester), E. Ros (Max-Planck Institute fuer Radioastronomie, Bonn) S. Ryder (AAO, Sydney), B. Schmidt (Mount Stromlo Observatory)**
on 21 May 2014; 06:43 UT

EVN measurement of the FRB 150418 host galaxy candidate and its stability on VLBI scales

ATel #8959; **B. Marcote (JIVE), M. Giroletti (INAF), M. Garrett (ASTRON), J. Yang (OSO), Z. Paragi (JIVE), K. Hada (NAOJ), C. C. Cheung (NRL)**
on 16 Apr 2016; 08:13 UT

□ **e-VLBI: Delivering the most sensitive VLBI array in a flexible way...**

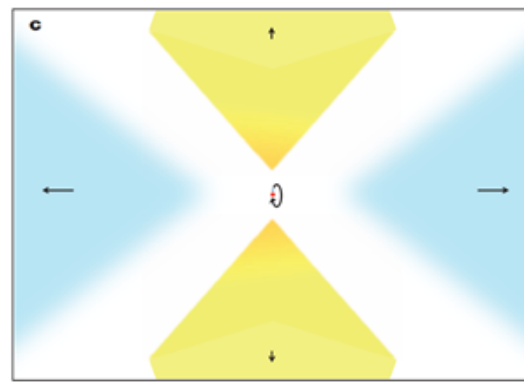
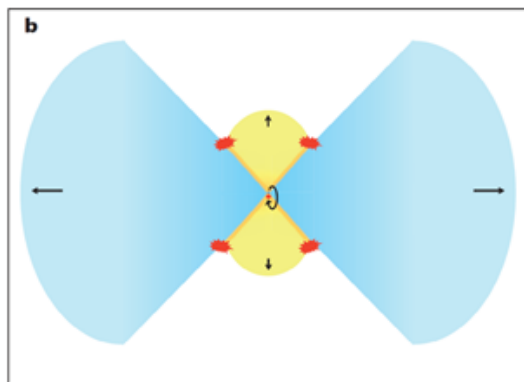
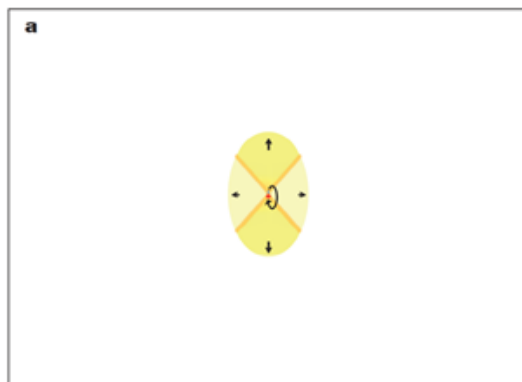
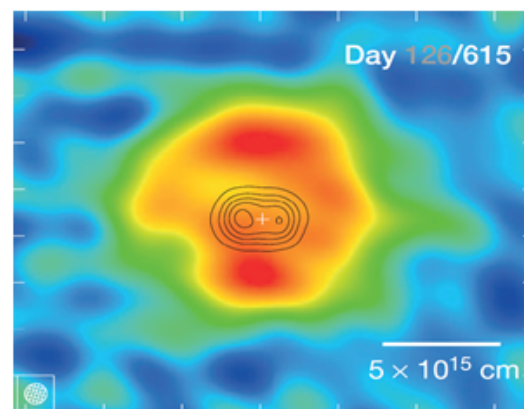
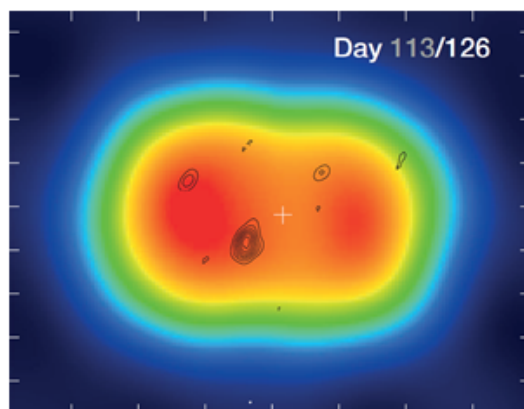
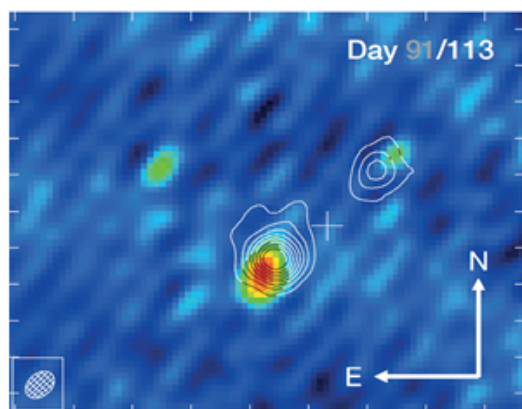
Transient VLBI Science I.

□ Classical Nova V959 Mon

- Mapping the ejecta on a broad range of angular scales
- VLBI localization of possible sites of particle acceleration (sources of gamma rays)

Chomiuk et al., Nature, 514, 339, 2014

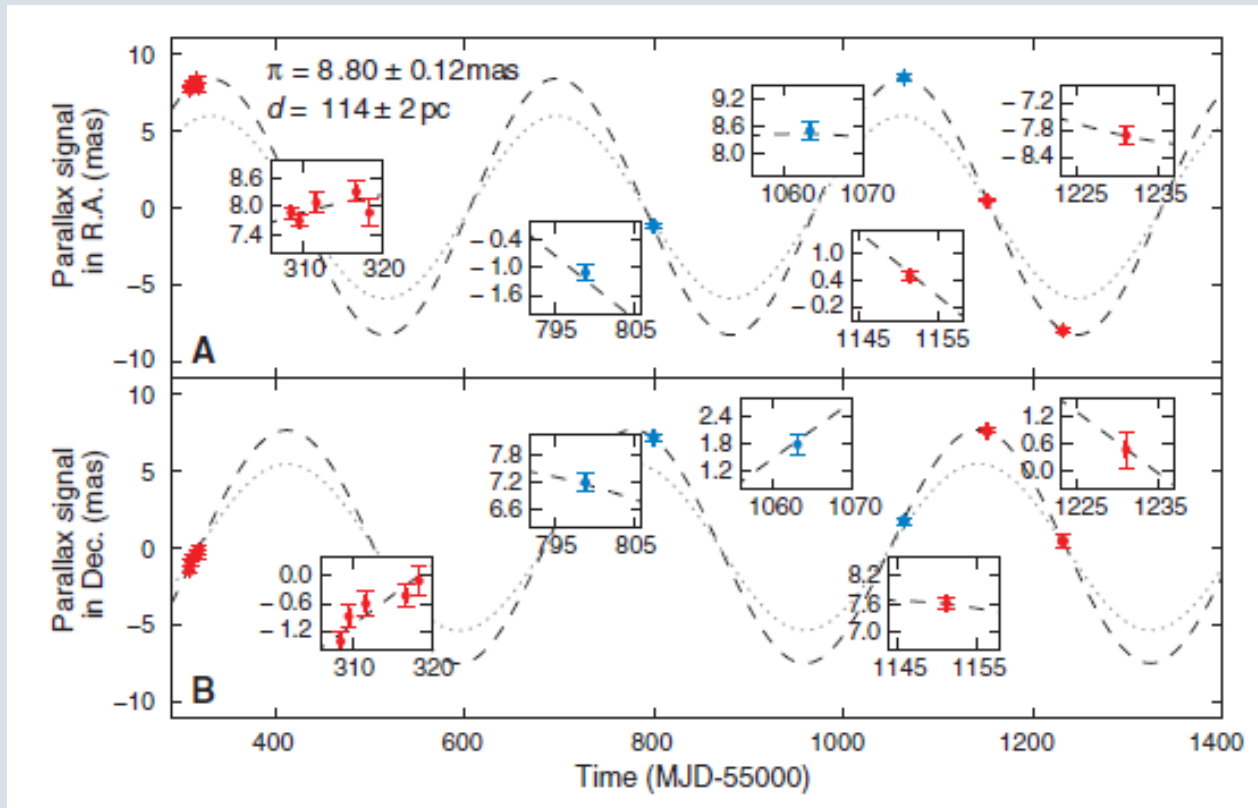
e-EVN, JVLA, VLBA, e-Merlin



Transient VLBI Science II.

□ SS Cyg dwarf nova

- Triggered observations for parallax measurements (VLBA/e-EVN)
- New distance confirms accretion disc theory

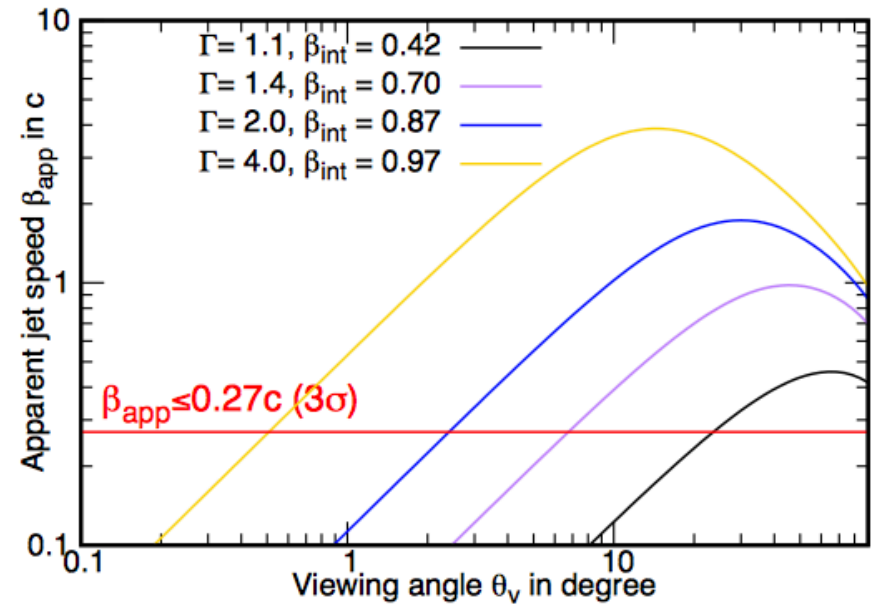
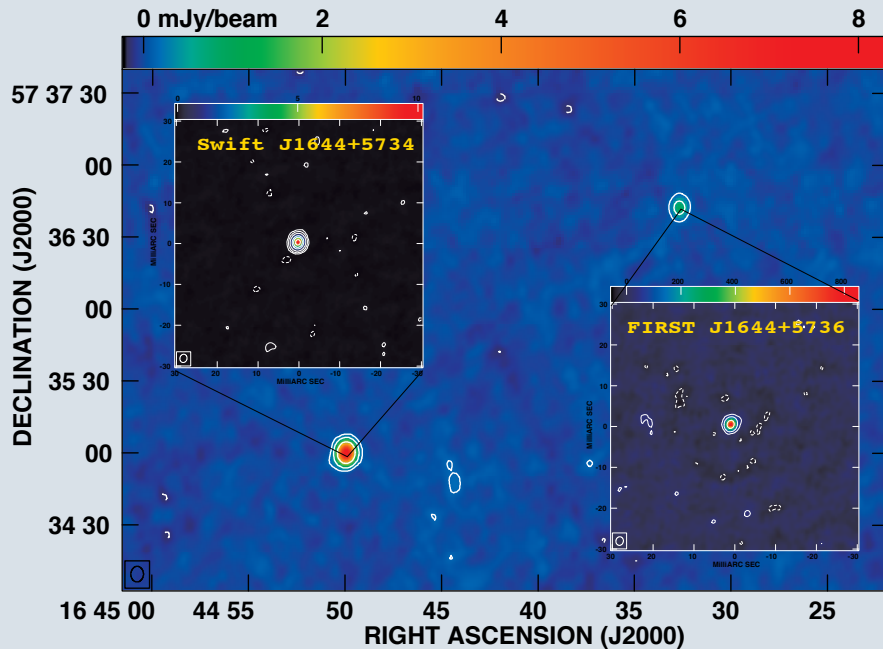


Miller-Jones et al., *Science*,
340, 950, 2013

Transient VLBI Science III

❑ First jetted Tidal Disruption Event

- Top-level VLBI astrometry result (10 μ as), monitoring for three years
- Strong EVN constraint on proper motion (limits on viewing angle & Lorentz factor)



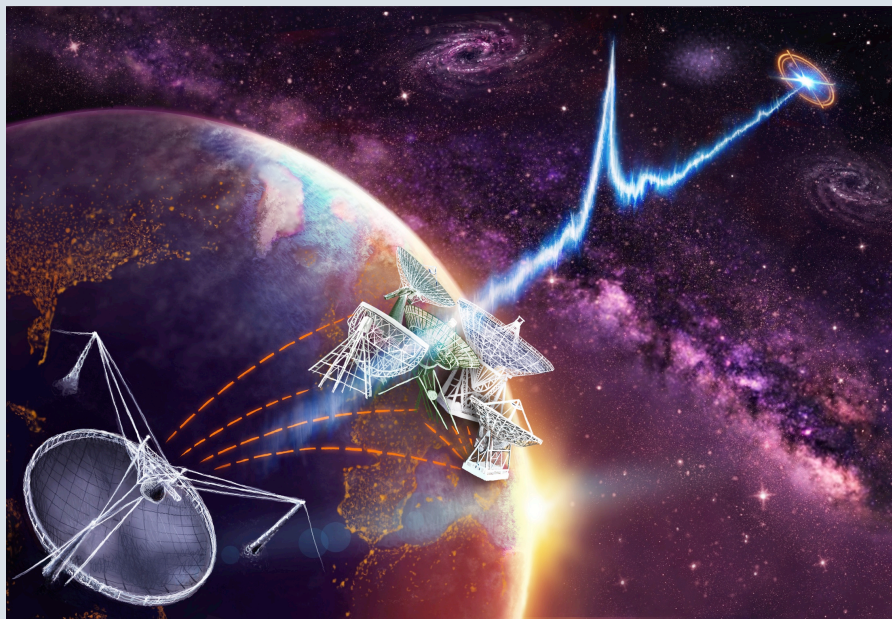
"No apparent superluminal motion in the first-known jetted tidal disruption event Swift J1644+5734"

Yang et al. 2016, MNRAS 462, L66

Transient VLBI Science IV

□ JVLA and EVN+Arecibo localization of FRB121102 (the “repeater”)

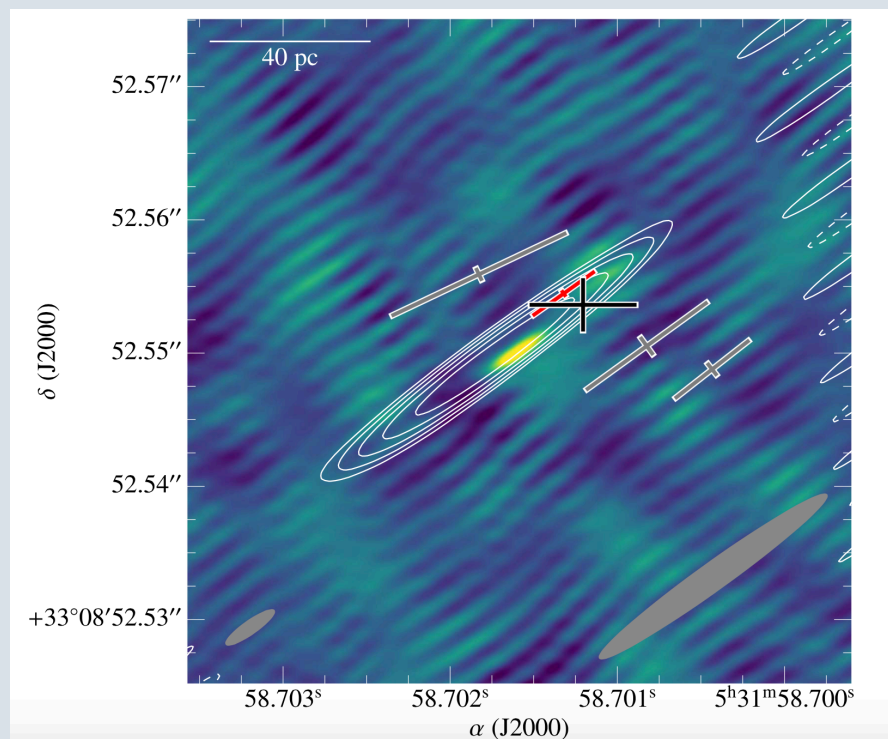
- The FRB host is a dwarf galaxy at a redshift of $z = 0.1927$ (~ 972 Mpc)
- A “game-changer” result, opening up a new way of studying *short transients*



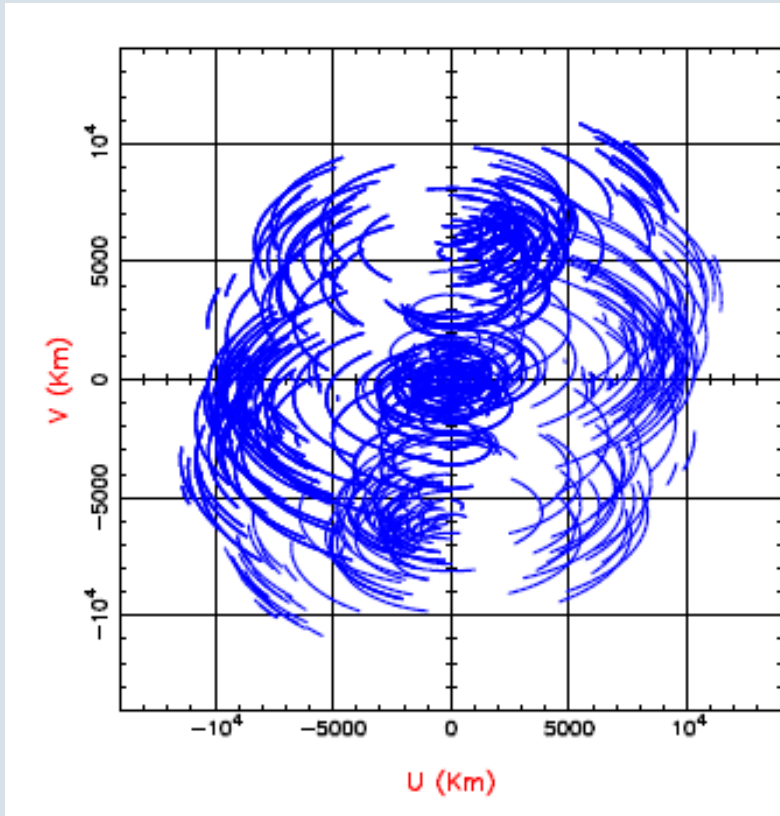
Chatterjee et al. 2017, *Nature*, 541, 58

Marcote et al. 2017, *ApJL*, 834, 8

Tendulkar et al. 2017, *ApJL*, 834, 7



VLBI with the Square Kilometre Array



□ **JIVE has a strong interest in making SKA-VLBI a reality**

"Very Long Baseline Interferometry with the SKA", Paragi et al. 2015, SKA Science book

Future collaboration with Chinese partners

❑ Joint interest in making full use of Chinese telescopes in the EVN

- Sh25, Tm65, Urumqi, Kunming and FAST
- Note FAST will be as sensitive as SKA1-MID (or better)

❑ Synchrotron Transient follow-up science projects

- TDE; gravitational wave EM candidate counterparts; “anything”

❑ Fast transient detection techniques

