Radio transients and Very Long Baseline Interferometry

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IAUS 339 - Southern Horizons in Time-Domain Astronomy

Workshop 1 - Radio transients in the era of multi-messenger astrophysics, Part 2

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Outline

- VLBI key features
- VLBI - current status
- VLBI - recent results
- VLBI - prospects
- VLBI - issues

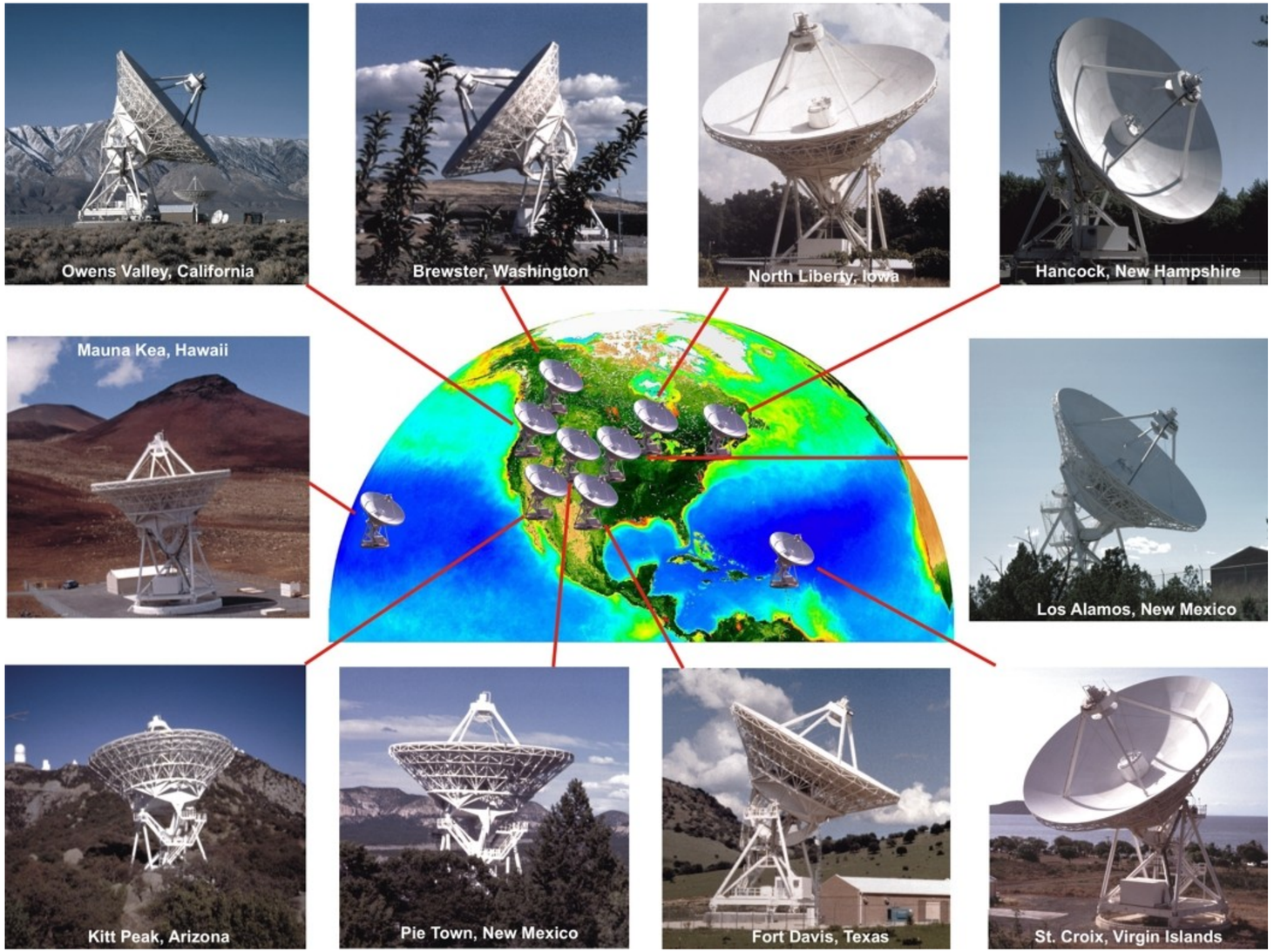
Key features

- very high angular resolution
- 1 mas = 1 AU @ 1 kpc (by definition) or 1 pc at z~0.05
- localisation; eg identify host galaxy, position with respect to core, …
- imaging; possibility to reveal structural changes (proper motions, expansions, etc)
- separate from contaminating diffuse emission

Current status - global arrays

- **VLBA** - dedicated 10-station array, full time operation, frequency agility, 1-90 GHz frequency range
- **EVN** - network of 10-15 diverse stations (including several 60-100m class telescopes), three session per year, not frequency agile, 1-43 GHz frequency range
- **e-EVN** - subset of the EVN stations capable of real time correlation; ideal for transients! ~one 24-hr session per month, plus ToO
- **GMVA** - Effelsberg + GBT + VLBA + NOEMA + OnMhPvYs 2 sessions per year at 86 GHz
- **EHT** - one session per year at 230 GHz, including ALMA, best angular resolution; limited sensitivity, challenging atmospheric and instrumental conditions

VLBA


Owens Valley, California
Brewster, Washington
North Liberty, Iowa
Hancock, New Hampshire
Mauna Kea, Hawaii
Los Alamos, New Mexico
Kitt Peak, Arizona
Pie Town, New Mexico
Fort Davis, Texas
St. Croix, Virgin Islands

EVN

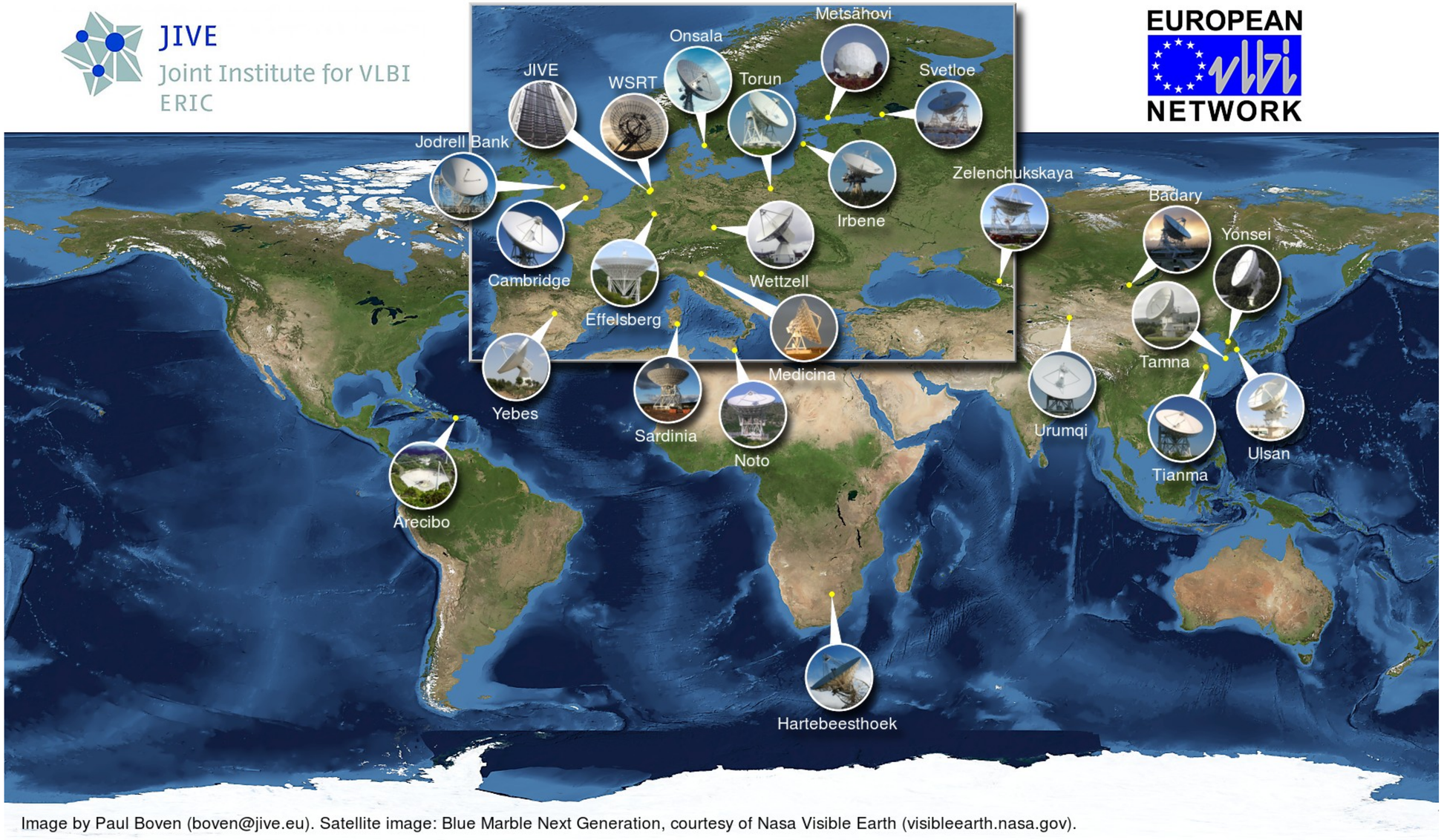


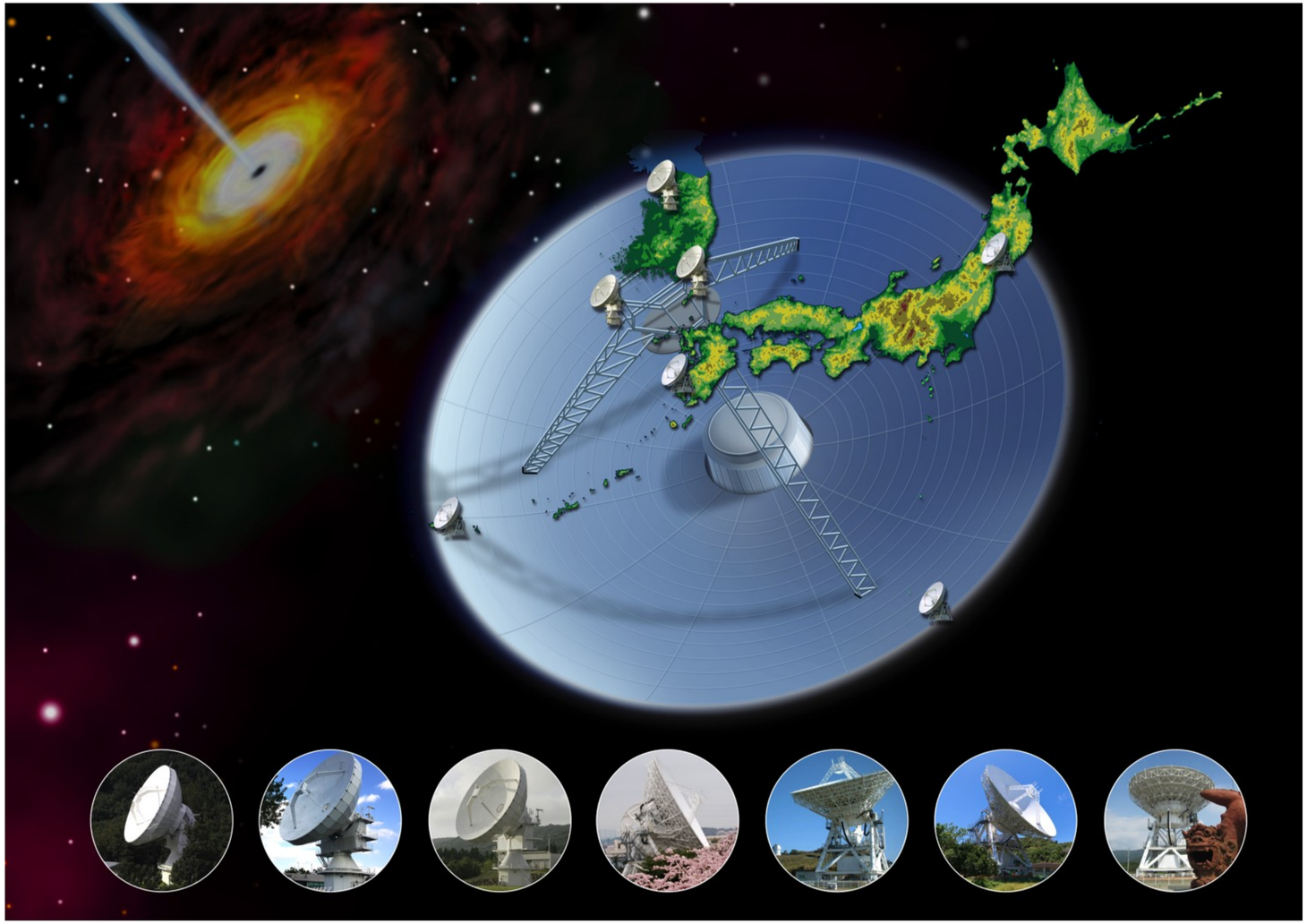
Image by Paul Boven (boven@jive.eu). Satellite image: Blue Marble Next Generation, courtesy of Nasa Visible Earth (visibleearth.nasa.gov).

Current status - regional arrays

Smaller networks, *less powerful* but potentially *more flexible*

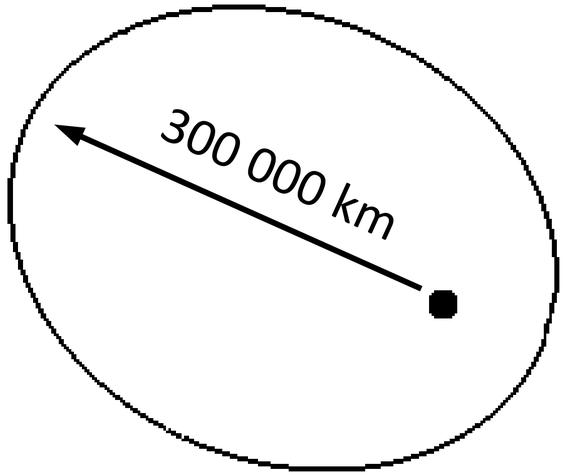
- **KVN** (Korea VLBI Network) - dedicated 3x21m-station array, full time operations, simultaneous 22-43-86-130 GHz bands
- **VERA** in Japan, (**KaVa** = KVN + VERA), **LBA** in Australia
- **Italian VLBI**: one 64m + two 32m stations, currently 1-22 GHz range
- future: **East Asia VLBI Network**, **African VLBI Network**

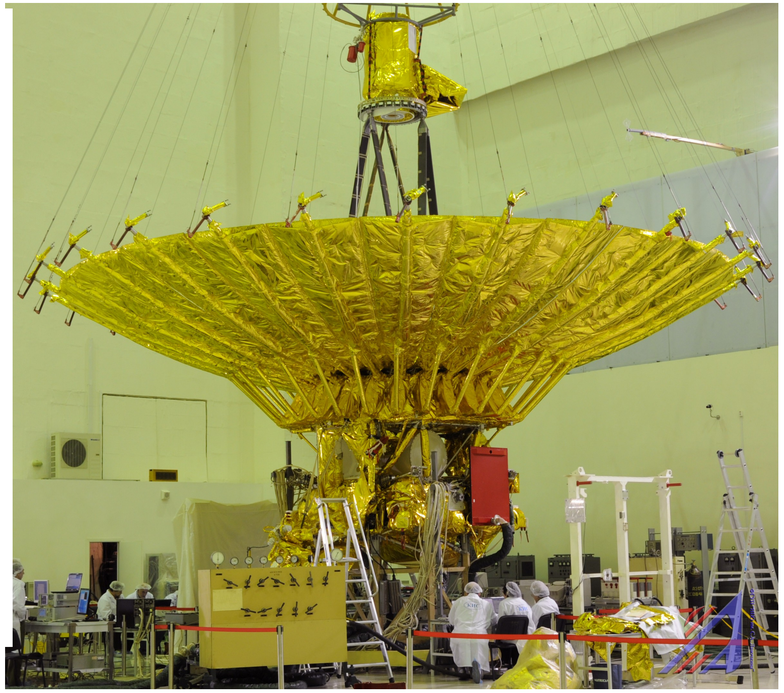
KaVA



Current status - SpaceVLBI

RadioAstron is a 10m telescope
in high elliptical orbit



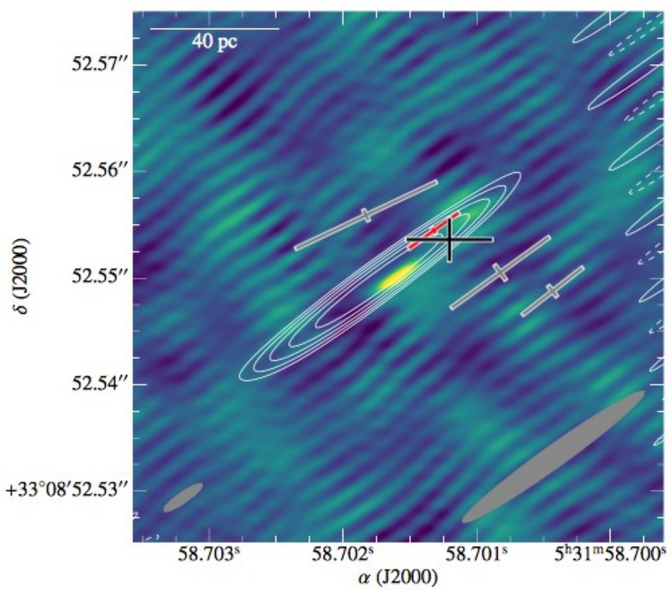


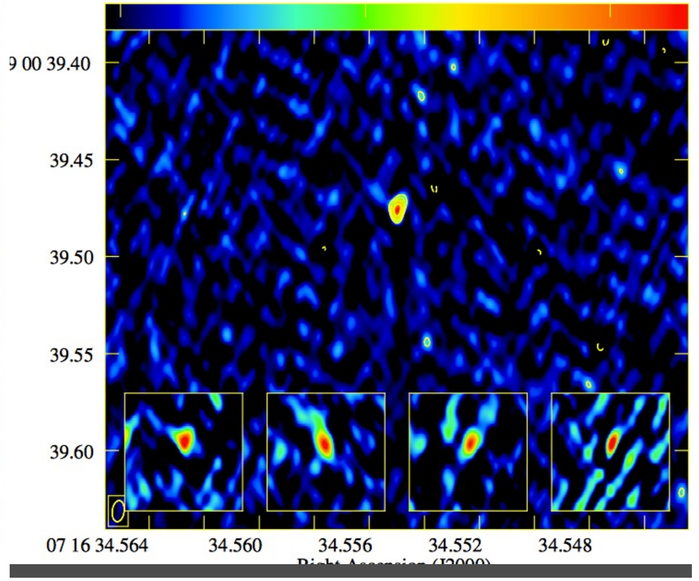
- Operates at 22/5/1.7/0.3 GHz
- Imaging (shorter baselines)
- Visibility tracking (any baseline)
- Better angular resolution at 22 GHz than EHT at 230 GHz *if you find something sufficiently bright* like BL Lac or megamaser in NGC4258
- Triggered observations possible: typical reaction time ~1.5 months, ideally can be as short as 2 days.

Recent VLBI results on transients

Fast Radio Bursts:

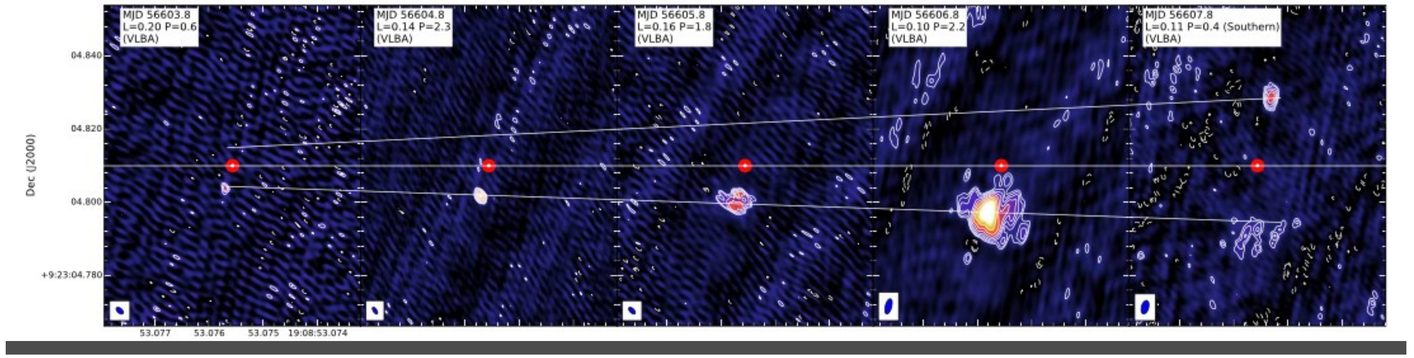
- localization of the repeating radio burst (Chatterjee+17 Nature, Marcote+17)
- variable steady source associated to FRB 1501418 (Giroletti+16)

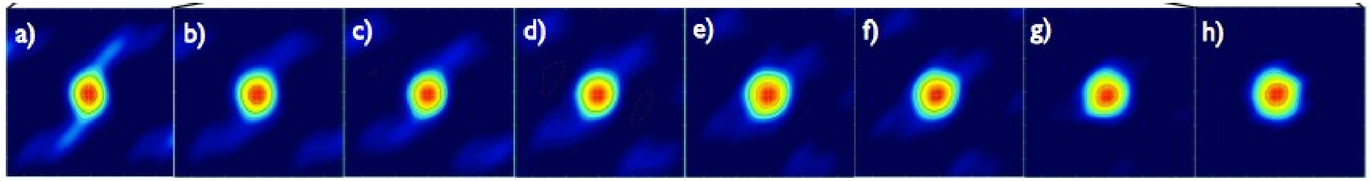




binaries:

- XTE J1908+094 expanding jet (Rushton+17)
- Cyg X-3 giant flare (Egron+17)





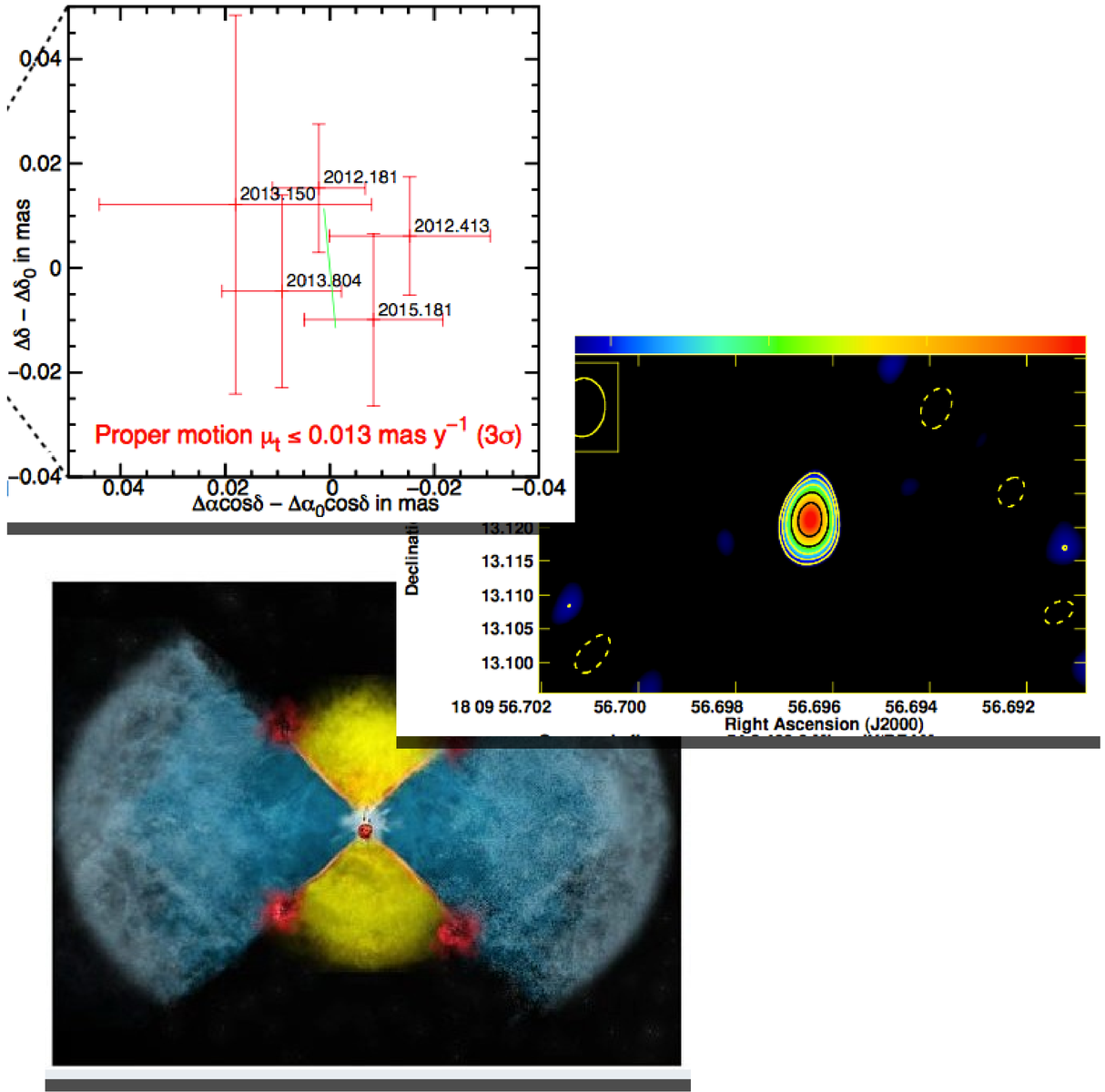
Recent VLBI results on transients

Tidal Disruption Events: no apparent superluminal motion in Swift J1644+5734 (Yang+16)

Gamma-Ray Bursts: wind density profile around GRB 151027A (Nappo+17)

Novae: shocks in gamma-ray nova V959 Mon (Chomiuk+14 Nature)

“classical” AGN flares, SNe, etc…



Prospects

- “Prompt” emission - short time scales
  - work towards high frequency to probe self-absorbed events in early phases of GRBs (short-GW related and long), TDEs, AGN flares
  - get early measurements as references, both for structure (motions, expansions of novae, SNe, jets) and light curve (initial flux density, or upper limit)
- “Late” emission - long time scales
  - follow evolution, on different spatial scales and with full spectral information
  - iteratively refine models and design observations to pick sources at most suitable times
- Exploit sensitivity through large apertures and wide bandwidths

Issues

- Alert/triggering procedures - not straightforward to trigger fast repointing on different sites, particularly if not dedicated/full time arrays
  - different transients require different triggers (from space or ground, photometry or spectrum) and different reaction times
- Disk availability and shipping, correlation time can cause delays - real time VLBI is still a relatively scarce resource
- **Small, flexible arrays for prompt observations, full/global arrays for follow up of truly interesting events?**
- SKA1 (and precursors) need to be fully VLBI-ready (receivers/backends compatible with existing telescopes, phased array capabilities, data formats and transfer, …)

Points for discussion

- **VLBI follow-up of transients** discovered by other facilitates classical imaging and fringe-detection experiments?
- **VLBI search for long-lived** (compared to the experiment duration) **transients** - how to implement?
- **VLBI search for fast transients** - FRBs?