The Long Baseline Component of the Next Generation VLA

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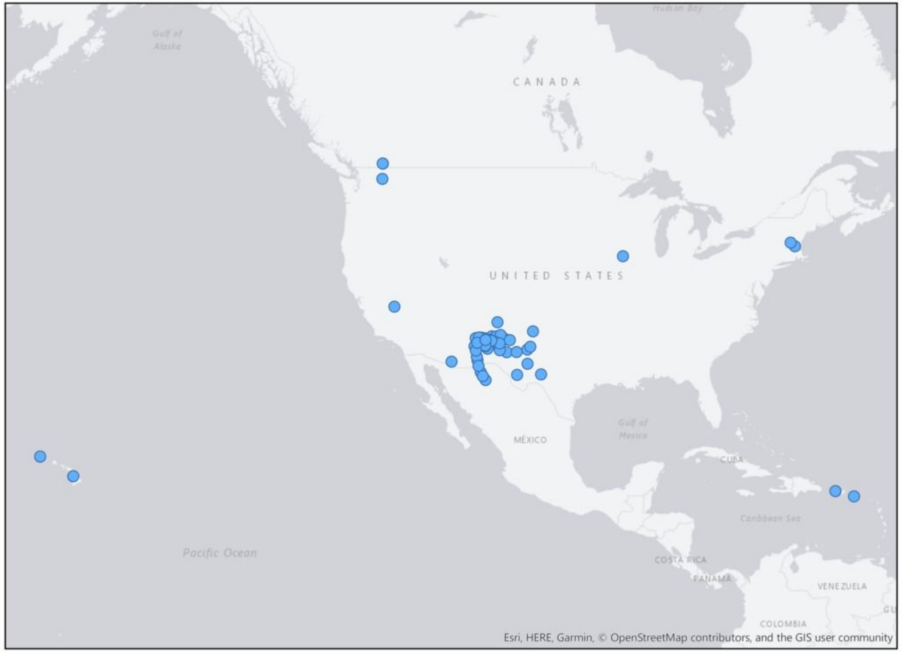
Overview

The Array

Technical Capabilities

Science goals

Array



- Make use of existing infrastructure as much as possible
- Clusters of 2-4 antennas
- Pairs of sites on long baselines for calibration, UV coverage
- Likely Green Bank will be included some other way

Technical capabilities

At 1 masec resolution: 0.2 muJy or 350 K brightness temperature in one hour at 27 GHz

With just the 30 outer antennas, a factor of a few worse

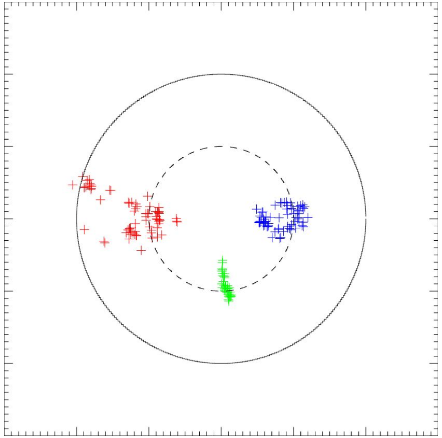
Thermal imaging possible on these scales!

Science Goals

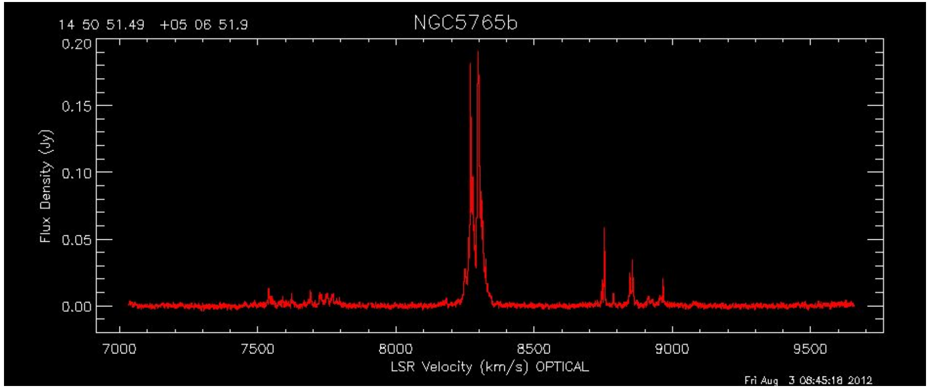
- Some things which are now too time consuming
  - Continuum astrometry (XRB, galaxy proper motions)
  - Measurements of faint jets evolution
  - Large maser samples
- Some things which are now impossible/severely sample-size limited without more metal
  - GWR follow-up
  - Imaging of stars & stellar coronae

Demanding case 1: Maser cosmology & BH masses

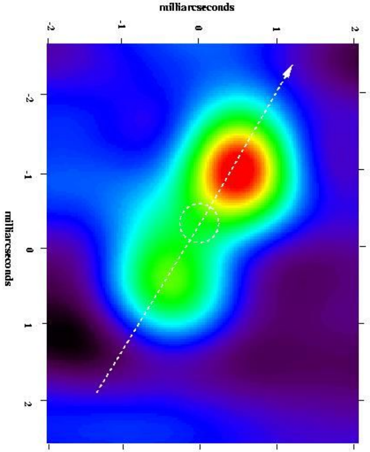
- Get *local* Hubble constant to ~1%
- Better calibration of standard candles
- Black hole masses to <10%
- Spectral lines: cannot improve with better backends; need more metal
- Current ngVLA receiver set-up suboptimal



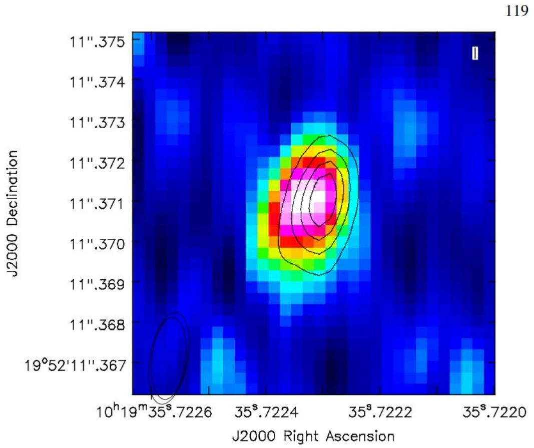
Gao et al. 2015



Demanding case 2: evolution of stellar coronae



Benz et al. 1989

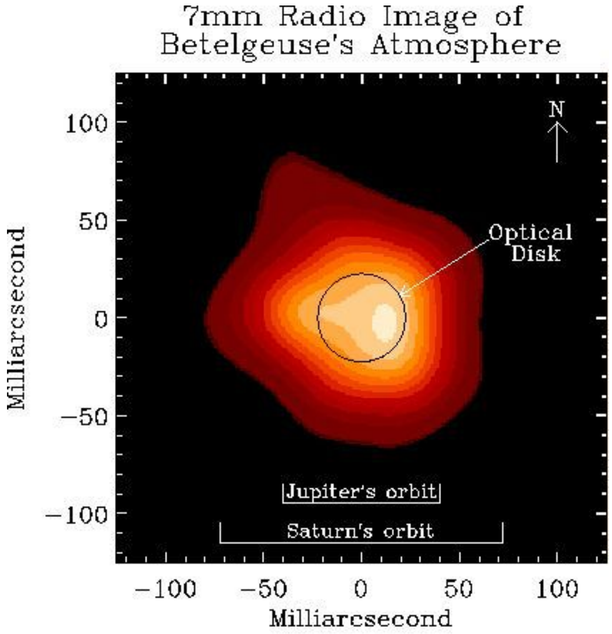


Villadsen 2017, PhD Thesis

Must make the images faster than the source structure changes!

New frontier 1: Imaging stars & mapping stellar orbits

- Astrometrically robust
  - (coronae, and spots are both weak)
- Lever arm on limb darkening
  - ngVLA similar scale and brightness temp limits as OIR systems
- Imaging in very crowded or extincted fields

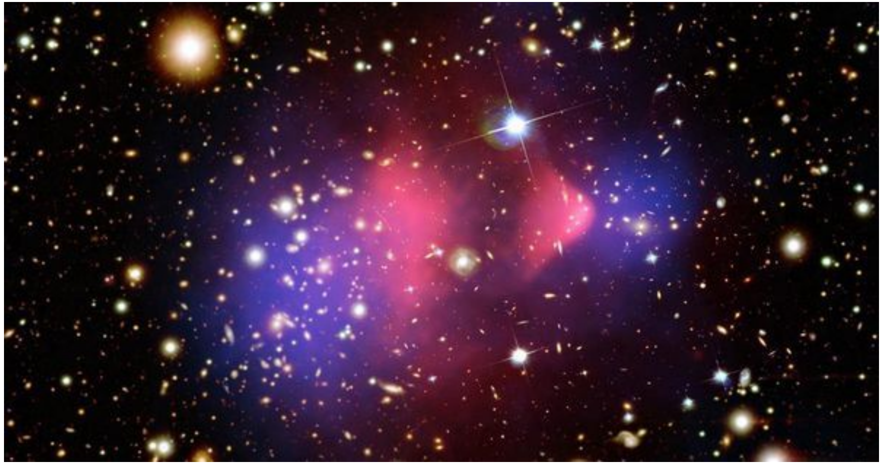


Courtesy of J. Lim, C Carilli, S. M. White, A. J. Beasley, & R. G. Marson

New frontier 2: Proper motions of galaxies complement standard sirens

- Get 6D decomposition of galaxy clusters with PMs plus LISA distances
- Direct tests of dark matter from dynamical friction from proper motions in M81 group
- Get velocities for merging clusters
- Test morphology density relations in a variety of clusters

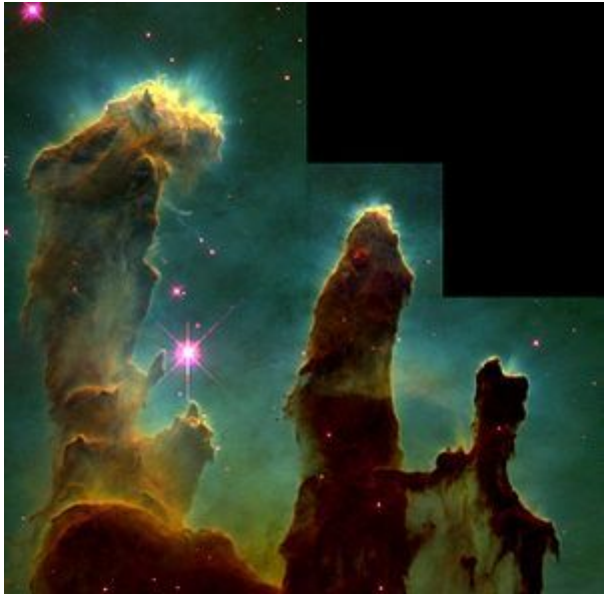
Maccarone & Gonzalez science book chapter



Clowe et al. 2006

6D decomposition of young star clusters

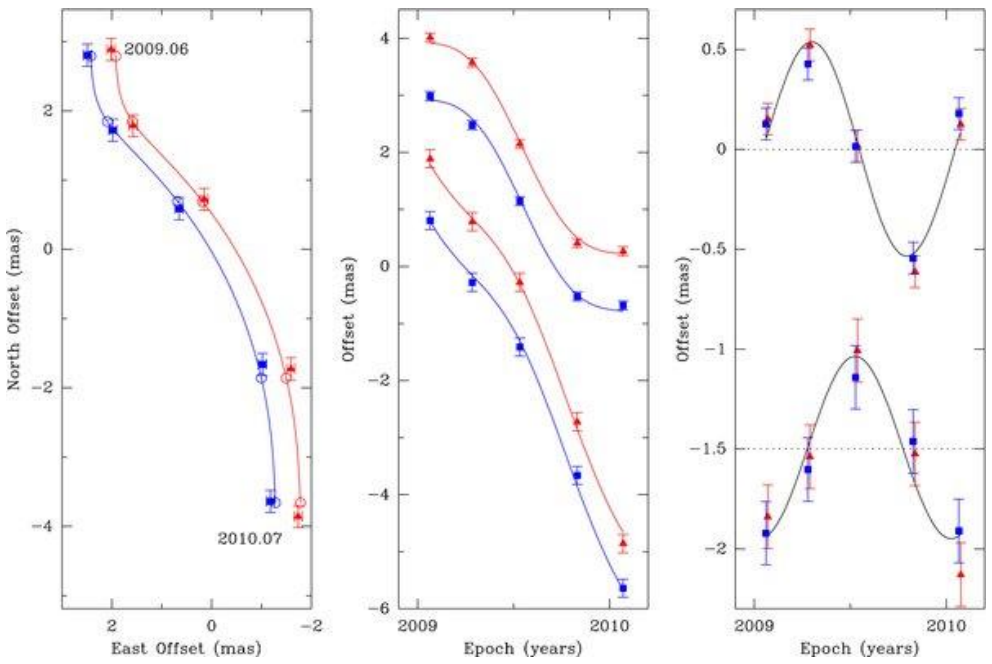
- Distances to sub-percent allow measurements of locations within the star-forming regions!
- Proper motions to extremely good precision as well
- May also be able to get N_H and B from linearly polarized sources



Hester & Scowen

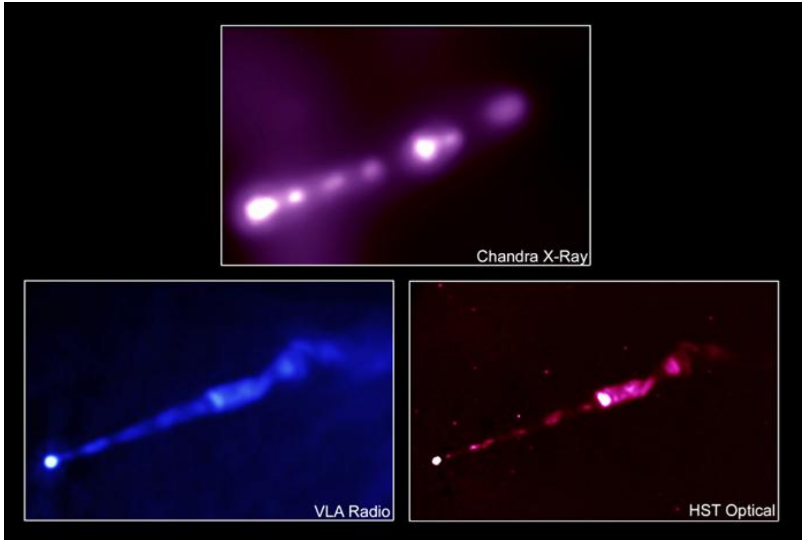
Hard distance problems: X-ray binaries and pulsars

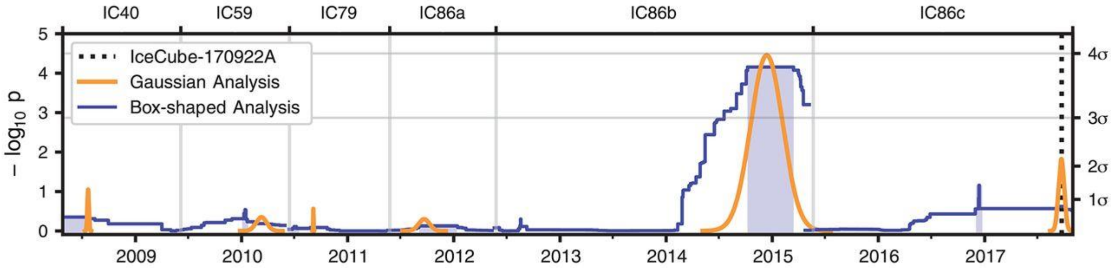
- X-ray binaries in disk plane, far
- Neutron stars-- little or no optical emission
- Need masec astrometry and cannot use Gaia!



Reid et al. 2011

AGN physics: neutrinos and jet physics

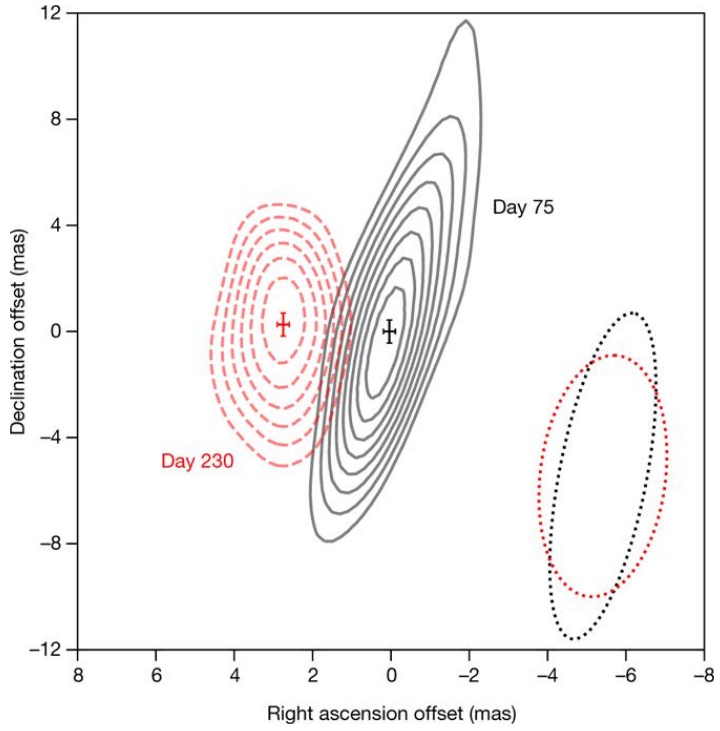




Gravitational wave sources 1: neutron star mergers

Measure jet proper motions

Maybe even get jet-counterjet ratio with much more sensitivity!

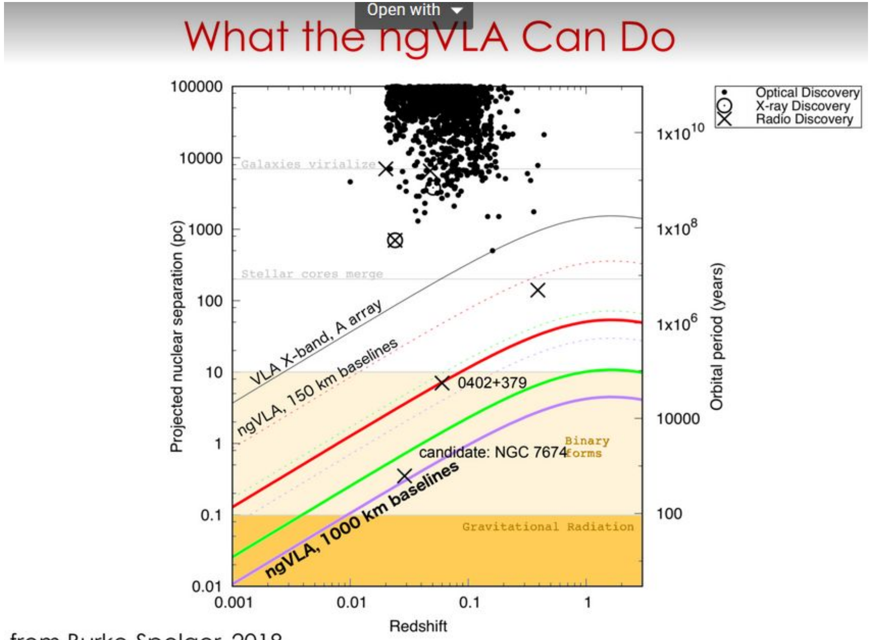


Mooley et al. 2018

Gravitational wave sources 2: Supermassive black hole mergers

1. Catch double AGN
2. Get LISA EM counterparts by seeing AGN turn off
3. Catch high proper motion ejected AGN

Before, during, after!



from Burke-Spolaor, 2018

Summary

Putting about 10% of ngVLA on long baselines opens up a broad range of new science

Substantial contributions from cosmology to black holes of all mass scales to the largest and smallest stars

Also a variety of practical applications - reference frame, satellite tracking