

Inspiring, Binary, and Recoiling Black Holes in Nearby Galaxies



Jim Condon (NRAO), Jeremy Darling (Colorado),
Yuri Kovalev (Astro Space Center), & Leonid Petrov (NASA)

Atacama Large Millimeter/submillimeter Array
Expanded Very Large Array
Robert C. Byrd Green Bank Telescope
Very Long Baseline Array





Method and science goals

Make a high-resolution 8.6 GHz VLBA search for off-nuclear and binary SMBHs in a complete sample of $\sim 10^3$ nearby ($\langle D_A \rangle \sim 200$ Mpc) massive galaxy bulges to:

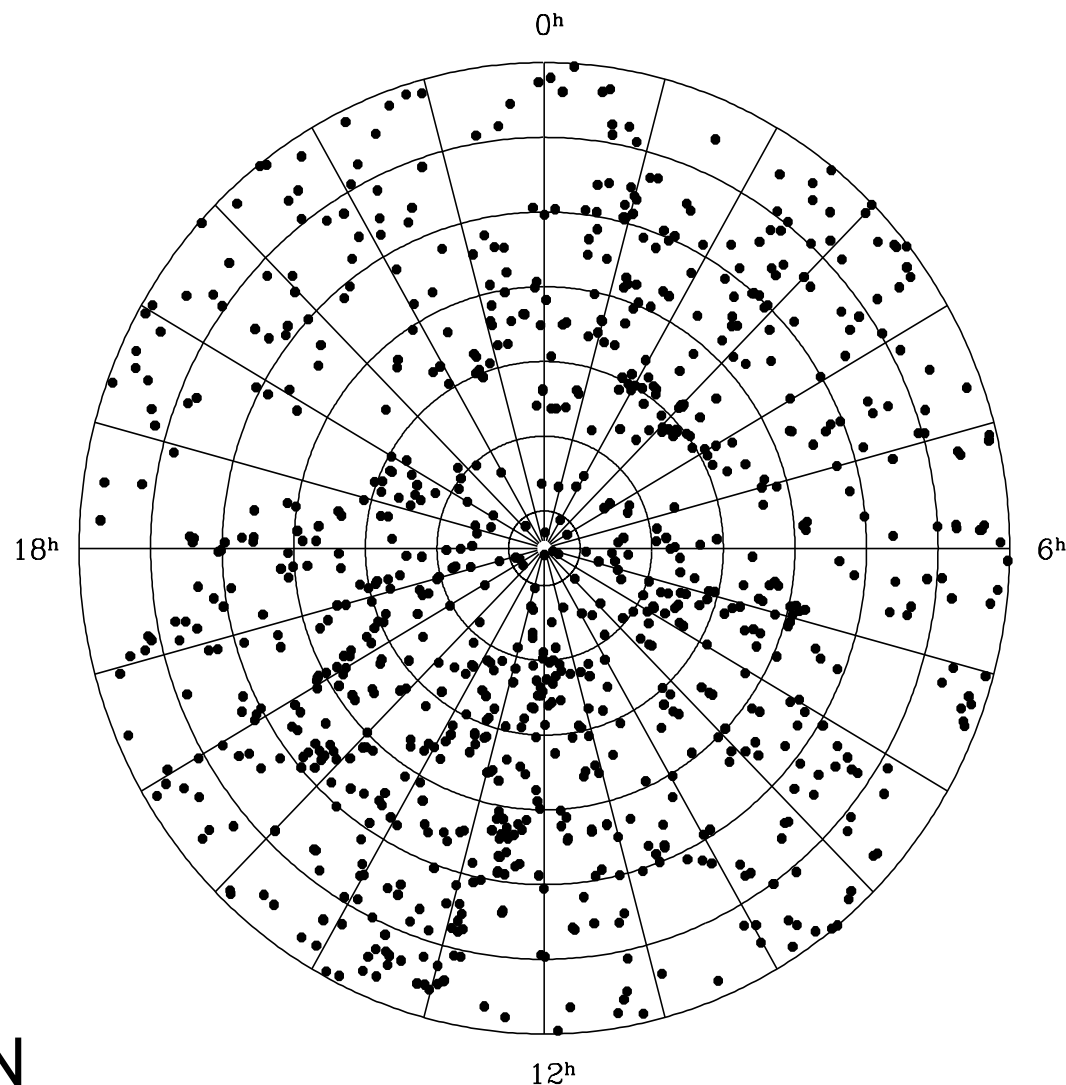
- (1) discover off-nuclear inspiraling SMBHs predicted by the “merger tree” theory for massive galaxy evolution
- (2) resolve “stalled” binary SMBHs in tight ($d \sim 10$ pc) orbits
- (3) discover off-nuclear recoiling SMBHs kicked out by the strong anisotropic gravitational radiation sought by LISA and NANOgrav
- (4) discover currently active nearby SMBHs (no dust bias)



Nearby galaxy sample

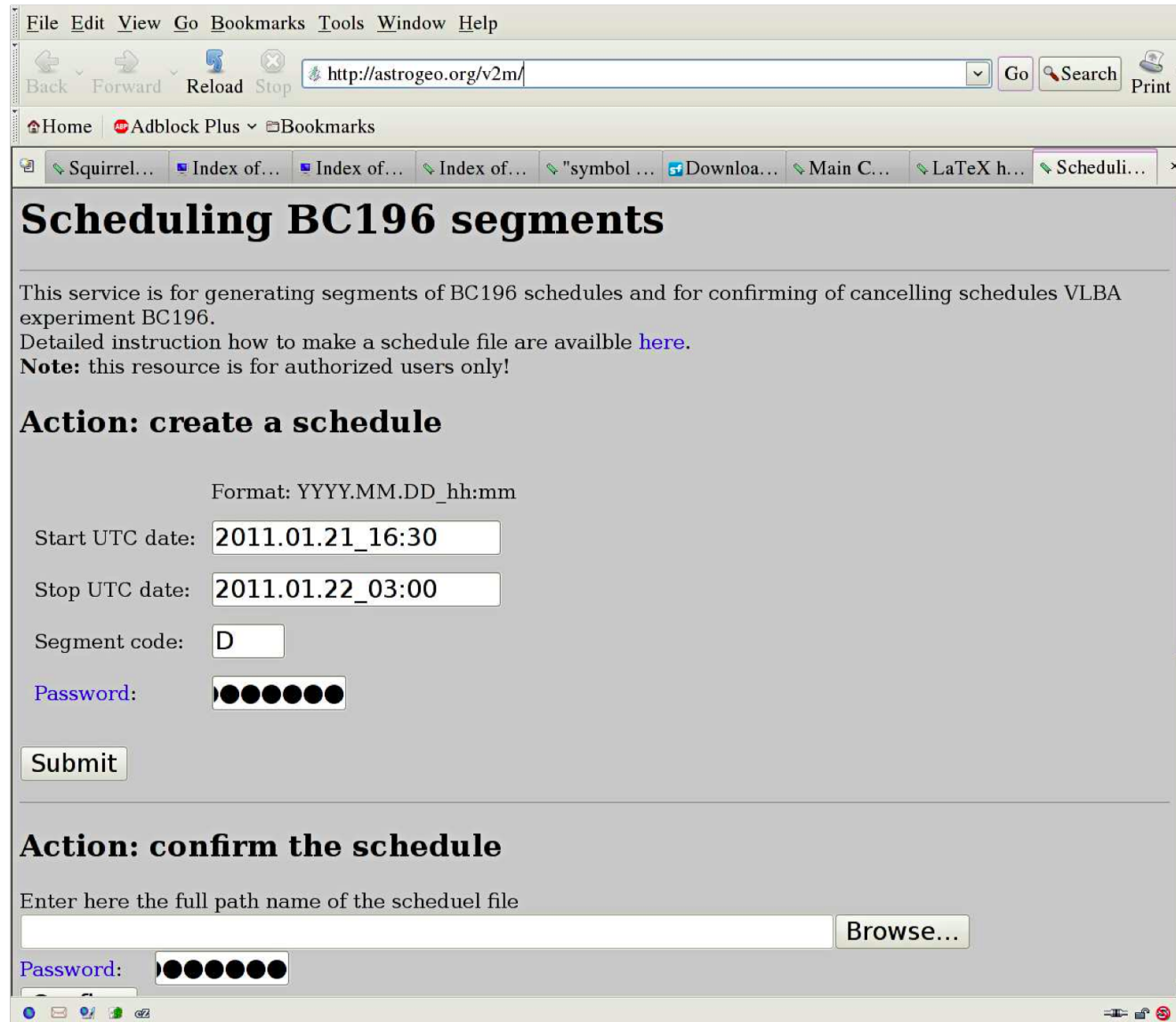
2MASS $K_{20fe} < 12.25$
NVSS $S_{1.4} > 100$ mJy
 $\delta \geq -40^\circ$, $|b| \geq 5^\circ$
 $N = 923$ galaxies

$\langle D_A \rangle \sim 200$ Mpc so
1 mas ~ 1 pc
 $\langle L_{1.4} \rangle \sim 10^{24}$ W Hz $^{-1}$
> 90% are radio-loud AGN



$\delta \geq -40^\circ$, $|b| \geq 5^\circ$

Automated Dynamic Scheduling



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Squirrel... Index of... Index of... Index of... "symbol ... Downloa... Main C... LaTeX h... Scheduling...

Scheduling BC196 segments

This service is for generating segments of BC196 schedules and for confirming of cancelling schedules VLBA experiment BC196.
Detailed instruction how to make a schedule file are available [here](#).
Note: this resource is for authorized users only!

Action: create a schedule

Format: YYYY.MM.DD_hh:mm

Start UTC date:

Stop UTC date:

Segment code:

Password:

Action: confirm the schedule

Enter here the full path name of the scheduel file

Password:



Automated Analysis

- Fringe-fitting: dedicated AIPS-independent software *PIMA* . Results are exported to
 1. Astrometry software VTD/post-Solve for source position estimation;
 2. Program flux_est for coarse flux density estimation;
 3. DIFMAP for imaging.
- Quality control and interactive astrometric analysis. Second run of re-fringing outliers.
- Coarse flux density estimation.
- Global astrometric analysis using all astro/geo VLBI data since 1980 through present.
- Update of the project web page.

Typical cost for a 6^h segment: 20^h CPU time and 0.5^h human time.



X-band Images

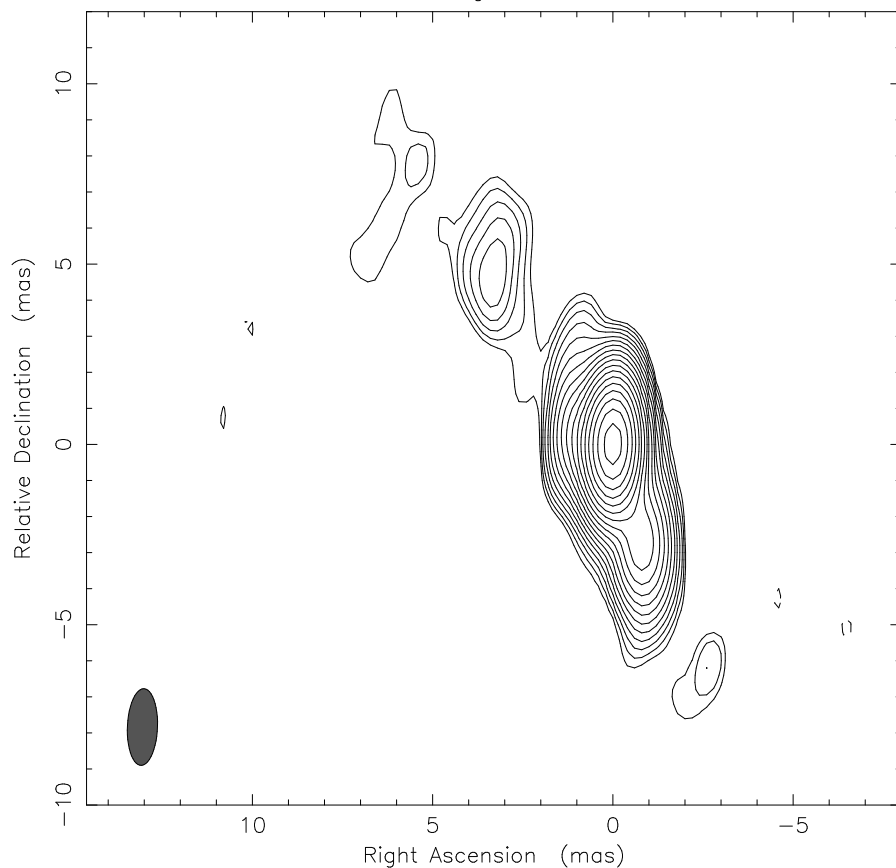
$5\sigma \sim 6$ mJy in 8 min

$\Delta\alpha, \Delta\delta \sim 1$ -3 mas

$\Theta \sim$ mas

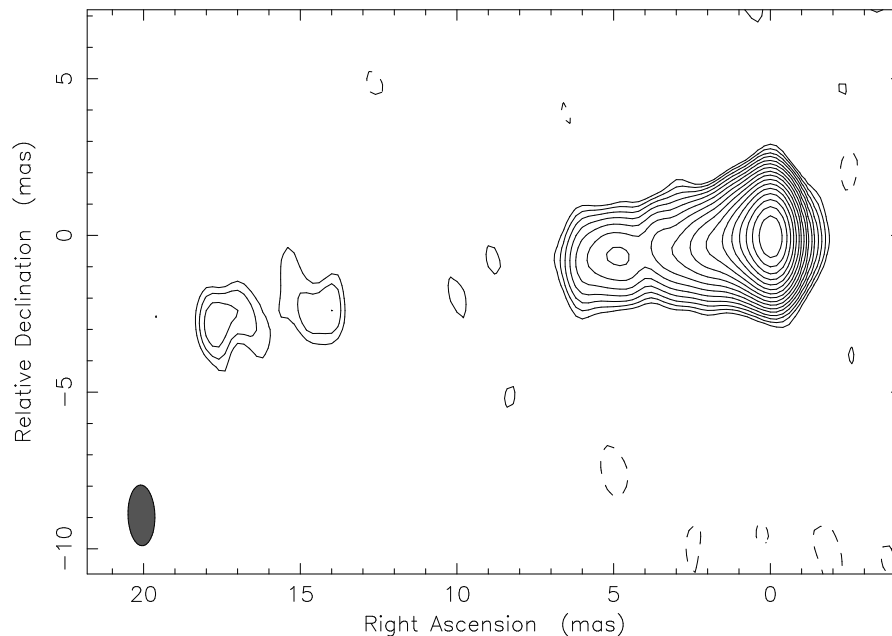
DR \sim 100:1

Clean RR map. Array: BFHKLMNOPS
1801+007 at 8.648 GHz 2010 Aug 03



Map center: RA: 18 04 08.850, Dec: +00 42 22.300 (2000.0)

Clean RR map. Array: BFHKLMNOPS
1834+196 at 8.648 GHz 2010 Aug 03



Map center: RA: 18 36 39.660, Dec: +19 43 45.400 (2000.0)



First results

