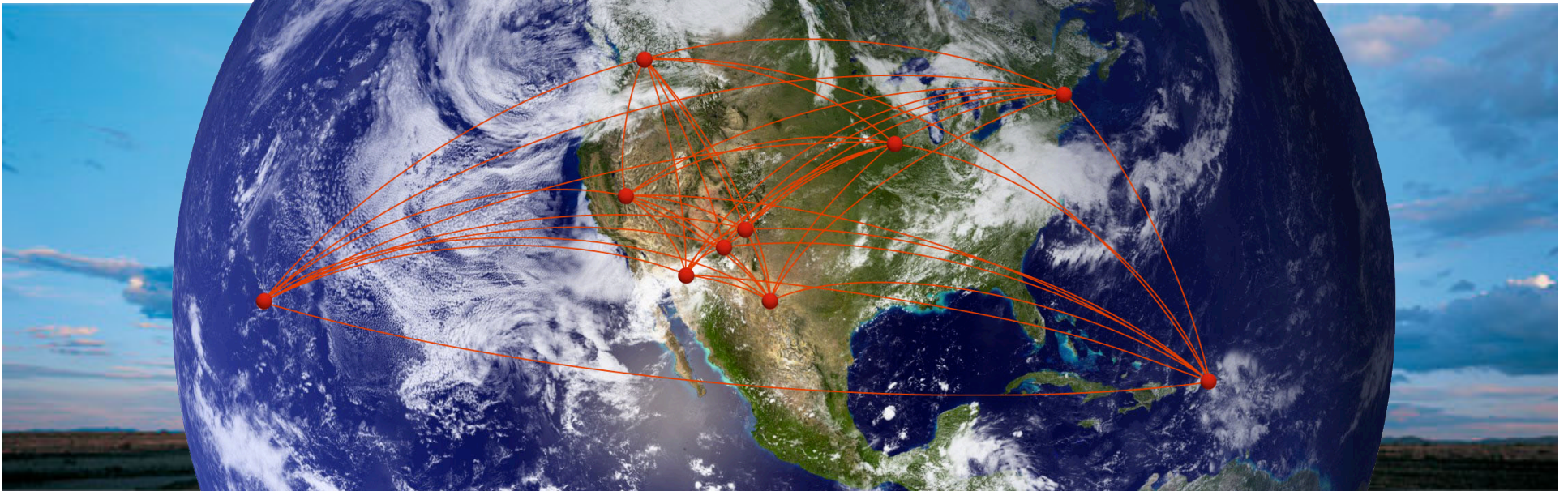


The Very Long Baseline Array



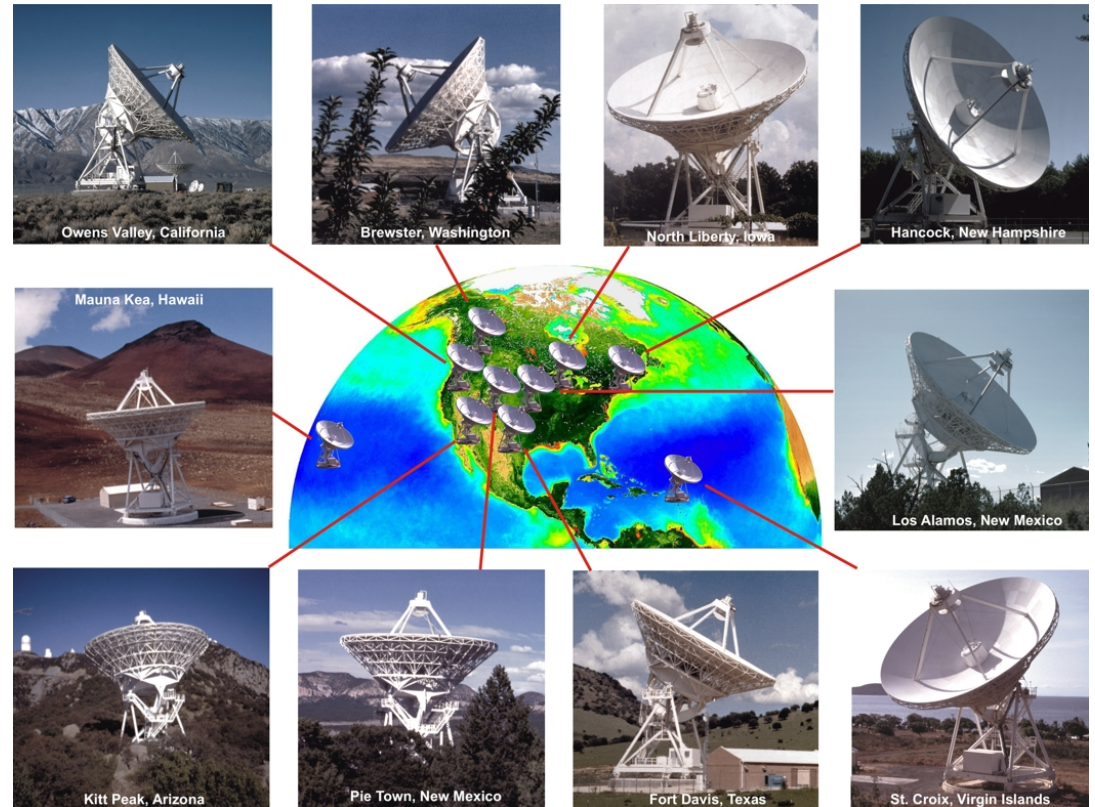
Jim Braatz (NRAO)

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



The VLBA

- A dedicated VLBI array
- 10 identical 25 meter antennas
- Spanning from Mauna Kea to St. Croix
- Baselines 200 to 8600 km
- Sensitive to compact structures with $T_b > 10^5$ K



VLBA Frequency bands and Sensitivity

λ (cm)	ν (GHz)	σ ($\mu\text{Jy}/\text{beam}$) 4 hrs at 2 Gbps
90 cm	0.312 - 0.342	277*
50 cm	0.596 - 0.626	782*
21 cm	1.35 - 1.75	13
13 cm	2.15 - 2.35	14
6 cm (upgrade)	3.9 - 7.9	8
4 cm	8.0 - 8.8	13
2 cm	12.0 - 15.4	24
1 cm	21.7 - 24.1	20
7 mm	41.0 - 45.0	66
3 mm	80.0 - 90.0	316†

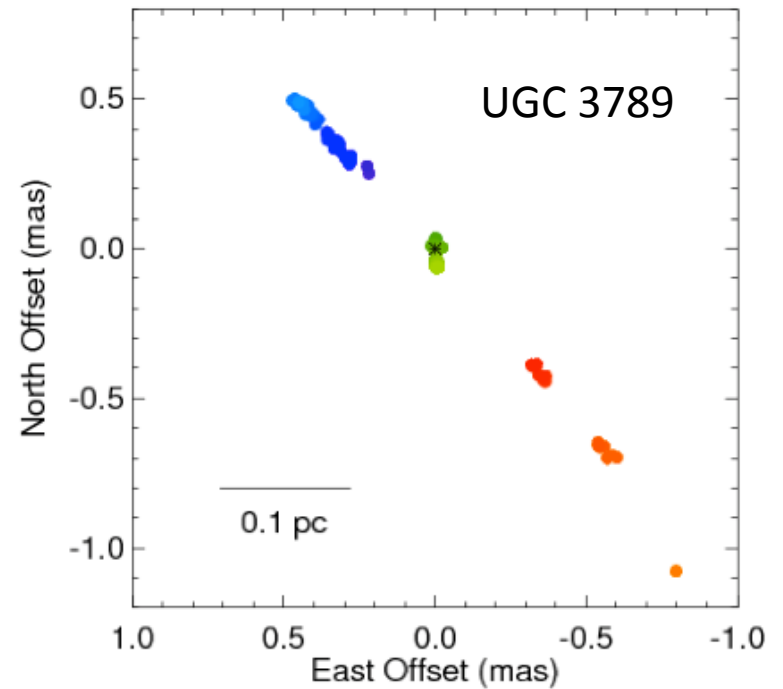
2 Gbps recording delivers a bandwidth of 256 MHz with two polarizations.

* Narrower bandwidths

† 8 stations

Resolution!

- 25 *milli* arcsecond at 330 MHz.
- 80 *micro* arcsec at 90 GHz.
- 1 mas is
 - 0.1 AU at 100 pc (Galactic)
 - 10 AU at 10 kpc
 - 1000 AU at 1 Mpc (Extragal)
 - 5 pc at 1 Gpc

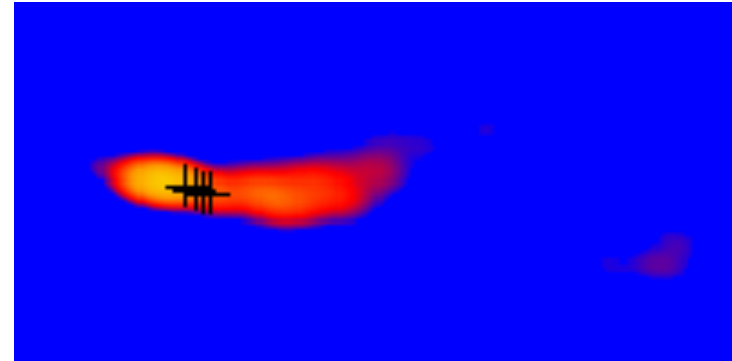


The Megamaser Cosmology Project (Braatz et al.)

Mapping H₂O maser disks to measure H₀ and determine SMBH masses

Fast Response & Monitoring

- Dedicated array with Dynamic Scheduling
 - Targets of Opportunity
 - Monitoring



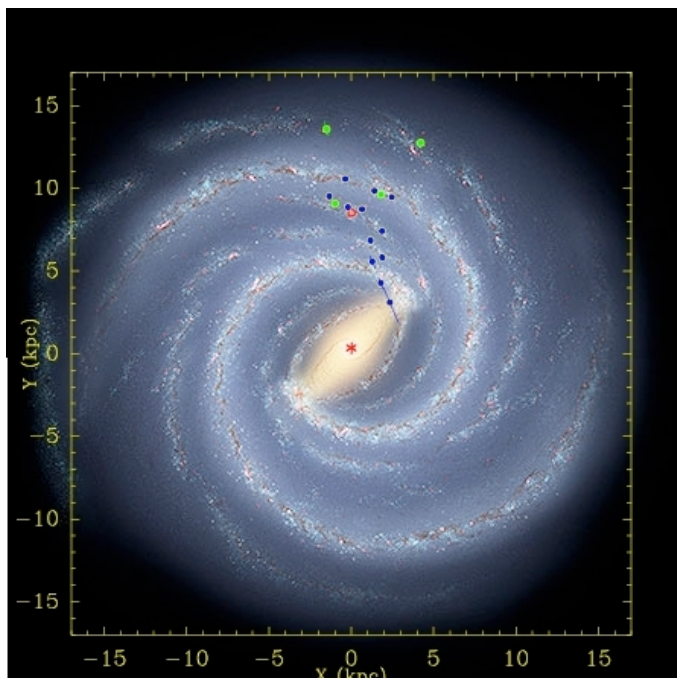
AGN 1222+216

The MOJAVE project (Lister et al.)

Examining the evolution of AGN jets and their magnetic fields, and the medium into which the jets are expanding

Astrometry

- High-precision parallax and proper motions
 - Instrumental stability and long baselines
 - < 0.1 mas position accuracy is routine
 - ~ 0.01 mas demonstrated in some cases
 - c.f. Gaia at 0.024 mas
 - Allows 1% distance measurements at 1 kpc



The BeSSeL project (Reid et al):

Mapping Galactic structure and measuring fundamental parameters by measuring parallaxes and proper motions of SF regions

$$R_0 = 8.4 \pm 0.6 \text{ kpc}$$

$$\Theta_0 = 254 \pm 16 \text{ km/s}$$

VLBA Correlator (DiFX) Capabilities

Spectral Resolution

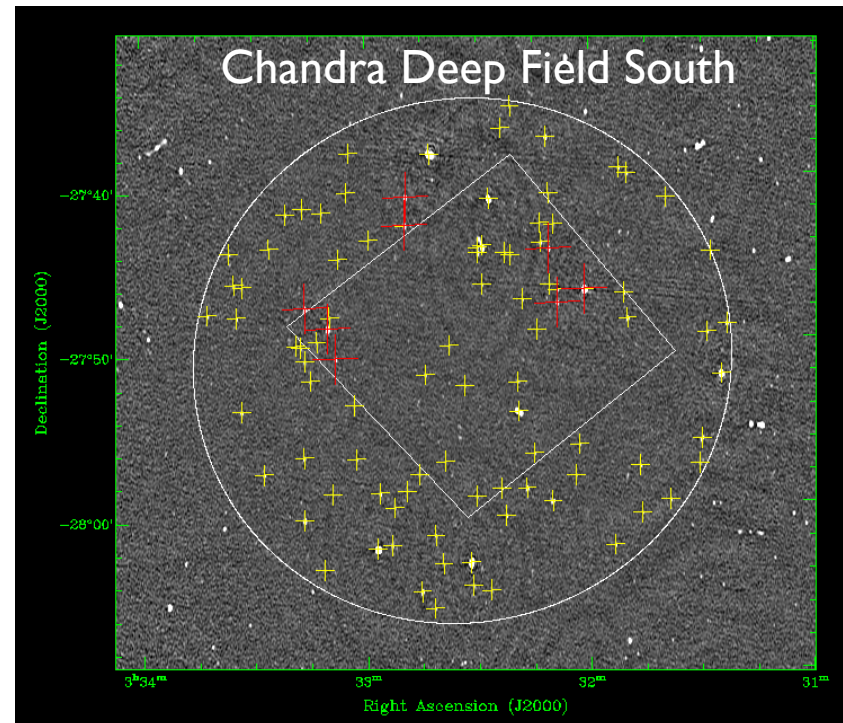
- DiFX is a flexible software correlator in Socorro, NM
 - 1-8 sub-bands up to 128 MHz wide
 - 4K channels per sub-band is routine; 32K with justification
- Spectral zooming – higher resolution in narrower windows.
Useful for:
 - Masers with in-beam continuum calibrators: wide bands for maximum sensitivity on calibrator + high spectral resolution for the masers.
 - Masers with multiple transitions: wide bands to cover a large number of widely separated maser transitions + high spectral resolution for each transition.

VLBA Correlator (DiFX) Capabilities

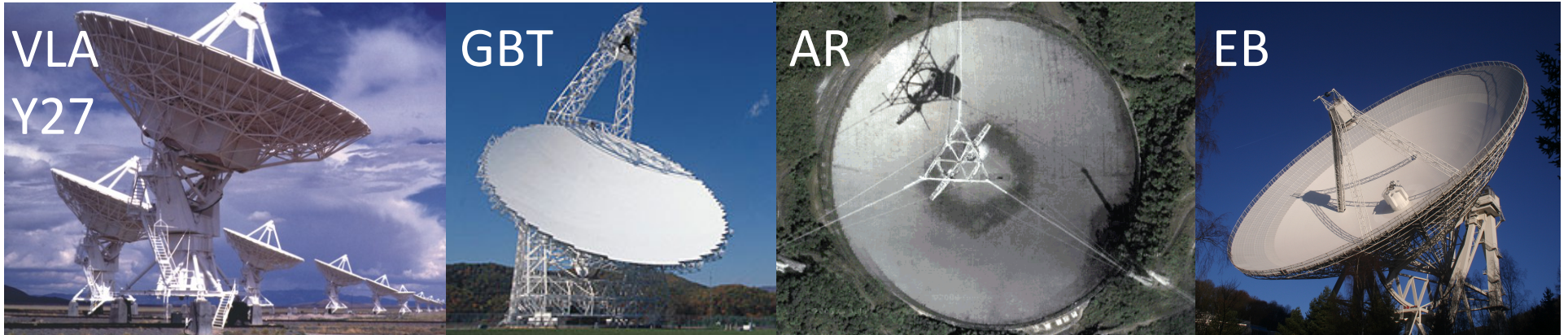
Multi- Field Imaging

- The sky is almost entirely empty at VLBI resolution
 - “full beam” imaging not needed; rather, many small “fields” (phase centers)
 - DiFX allows many phase centers in one correlator pass
 - Low overhead ($\sim 2.5X$) is only weakly dependent on number of phase centers
- 200 phase centers require only 20% more correlator time than 2 phase centers.

Middelberg et al., 2011



The High Sensitivity Array



To boost the sensitivity of the VLBA by an order of magnitude

Recent Upgrades and Special Notices

- Recent Development Efforts:
 - New wide-band “6 GHz” receivers (4.9-8.9 GHz) cover the 6.7 GHz methanol line
 - New recorder systems provide 2 Gbps capability to improve continuum sensitivity (256 MHz in dual pol)
 - Phased VLA now part of HSA
- Notices:
 - Resident Shared Risk Observing (RSRO) program available
 - NRAO is soliciting large “Filler” programs
 - Global Millimeter VLBI Array (GMVA) proposals accepted through NRAO PST

Proposing for VLBA/HSA

My Proposals Available Authors Available Organizations Monday 06 January 2014


Create Help

VLA

GMT

VLBA/HSA

GMVA



The image displays a grid of four radio telescope facility images. The top-left image shows the Very Large Array (VLA) with multiple large white parabolic dishes in a field of purple flowers. The top-right image shows the Green Bank Telescope (GMT), a single large white dish on a tall tower. The bottom-left image shows a close-up of a large white dish, likely part of the VLBA or HSA. The bottom-right image is a collage of various radio telescope dishes and structures, representing the GMVA.

VLBA/HSA Resources in the PST

My Proposals Available Authors Available Organizations Friday 31 May 2013

Validate Print Submit Copy Resources Help

VLBA/HSA RESOURCES

Order	Name	Wavelength	Processor	Observing Mode	Session
		3.6 cm	Socorro-DIFX	Standard	

Stations	Observing Parameters	Correlation Parameters	Special Features
VLBA <input type="checkbox"/> BR <input type="checkbox"/> FD <input type="checkbox"/> HN <input type="checkbox"/> KP <input type="checkbox"/> LA <input type="checkbox"/> MK <input type="checkbox"/> NL <input type="checkbox"/> OV <input type="checkbox"/> PT <input type="checkbox"/> SC <input type="checkbox"/>	Observing System: DDC System Bandwidth: 128 MHz	Number of Correlator Passes: 1 Integration Period(sec): 2.0	Full Polarization <input type="checkbox"/> Pulsar Gate <input type="checkbox"/>
HSA <input type="checkbox"/> GBT <input type="checkbox"/> AR <input type="checkbox"/> EB <input type="checkbox"/> VLA-Y27 <input type="checkbox"/>	Baseband Channels: 4	Spectral Points/BBC: 256	Output Format Conversion to Mark4 <input type="checkbox"/>
VLA <input type="checkbox"/> Y1 <input type="checkbox"/>	Polarization: Dual	No. of Phase Centers per Pointing: 1	
Geodetic <input type="checkbox"/>	Agg. Bit Rate (Mbits/sec): 2048		

- Wavelength**
- Select
 - 90 cm
 - 50 cm
 - ✓ 21 cm
 - 18 cm
 - 13 cm
 - 6 cm
 - 3.6 cm
 - 3.6/13 cm
 - 2 cm
 - 1.3 cm
 - 7 mm
 - 3 mm

VLBA/HSA Resources in the PST

My Proposals Available Authors Available Organizations Friday 31 May 2013

Validate Print Submit Copy Resources Help

VLBA/HSA RESOURCES

Order	Name	Wavelength	Processor	Observing Mode	Session
		3.6 cm	Socorro-DiFX	Standard	

	Stations	Observing Parameters	Correlation Parameters	Special Features
VLBA	BR <input type="checkbox"/> FD <input type="checkbox"/> HN <input type="checkbox"/> KP <input type="checkbox"/> LA <input type="checkbox"/> MK <input type="checkbox"/> NL <input type="checkbox"/> OV <input type="checkbox"/> PT <input type="checkbox"/> SC <input type="checkbox"/>	Observing System: DDC System Bandwidth: 128 MHz	Number of Correlator Passes: 1 Integration Period(sec): 2.0	Full Polarization <input type="checkbox"/> Pulsar Gate <input type="checkbox"/>
HSA	GBT <input type="checkbox"/> AR <input type="checkbox"/> EB <input type="checkbox"/> VLA-Y27 <input type="checkbox"/>	Baseband Channels: 4	Spectral Points/BBC: 256	Output Format Conversion to Mark4 <input type="checkbox"/>
VLA	Y1 <input type="checkbox"/>	Polarization: Dual	No. of Phase Centers per Pointing: 1	
Geodetic		Agg. Bit Rate (Mbits/sec): 2048		

Save Delete Cancel

- Processor
- ✓ Socorro-DiFX
 - JIVE
 - Bonn
 - Washington

VLBA/HSA Resources in the PST

My Proposals Available Authors Available Organizations Friday 31 May 2013

Validate Print Submit Copy Resources Help

VLBA/HSA RESOURCES

Resources << >>

Order	Name	Wavelength	Processor	Observing Mode	Session																				
		3.6 cm	Socorro-DIFX	Standard																					
<table border="1"> <thead> <tr> <th>Stations</th> <th>Observing Parameters</th> <th>Correlation Parameters</th> <th>Special Features</th> </tr> </thead> <tbody> <tr> <td> VLBA <input type="checkbox"/> BR <input type="checkbox"/> FD <input type="checkbox"/> HN <input type="checkbox"/> KP <input type="checkbox"/> LA <input type="checkbox"/> MK <input type="checkbox"/> NL <input type="checkbox"/> OV <input type="checkbox"/> PT <input type="checkbox"/> SC <input type="checkbox"/> </td> <td> Observing System: DDC System Bandwidth: 128 MHz Baseband Channels: 4 Polarization: Dual Agg. Bit Rate (Mbits/sec): 2048 </td> <td> Number of Correlator Passes: 1 Integration Period(sec): 2.0 Spectral Points/BBC: 256 No. of Phase Centers per Pointing: 1 </td> <td> Full Polarization <input type="checkbox"/> Pulsar Gate <input type="checkbox"/> Output Format Conversion to Mark4 <input type="checkbox"/> </td> </tr> <tr> <td> HSA <input type="checkbox"/> GBT <input type="checkbox"/> AR <input type="checkbox"/> EB <input type="checkbox"/> VLA-Y27 <input type="checkbox"/> </td> <td></td> <td></td> <td></td> </tr> <tr> <td> VLA <input type="checkbox"/> Y1 <input type="checkbox"/> </td> <td></td> <td></td> <td></td> </tr> <tr> <td> Geodetic <input type="checkbox"/> <input type="text"/> </td> <td></td> <td></td> <td></td> </tr> </tbody> </table>						Stations	Observing Parameters	Correlation Parameters	Special Features	VLBA <input type="checkbox"/> BR <input type="checkbox"/> FD <input type="checkbox"/> HN <input type="checkbox"/> KP <input type="checkbox"/> LA <input type="checkbox"/> MK <input type="checkbox"/> NL <input type="checkbox"/> OV <input type="checkbox"/> PT <input type="checkbox"/> SC <input type="checkbox"/>	Observing System: DDC System Bandwidth: 128 MHz Baseband Channels: 4 Polarization: Dual Agg. Bit Rate (Mbits/sec): 2048	Number of Correlator Passes: 1 Integration Period(sec): 2.0 Spectral Points/BBC: 256 No. of Phase Centers per Pointing: 1	Full Polarization <input type="checkbox"/> Pulsar Gate <input type="checkbox"/> Output Format Conversion to Mark4 <input type="checkbox"/>	HSA <input type="checkbox"/> GBT <input type="checkbox"/> AR <input type="checkbox"/> EB <input type="checkbox"/> VLA-Y27 <input type="checkbox"/>				VLA <input type="checkbox"/> Y1 <input type="checkbox"/>				Geodetic <input type="checkbox"/> <input type="text"/>			
Stations	Observing Parameters	Correlation Parameters	Special Features																						
VLBA <input type="checkbox"/> BR <input type="checkbox"/> FD <input type="checkbox"/> HN <input type="checkbox"/> KP <input type="checkbox"/> LA <input type="checkbox"/> MK <input type="checkbox"/> NL <input type="checkbox"/> OV <input type="checkbox"/> PT <input type="checkbox"/> SC <input type="checkbox"/>	Observing System: DDC System Bandwidth: 128 MHz Baseband Channels: 4 Polarization: Dual Agg. Bit Rate (Mbits/sec): 2048	Number of Correlator Passes: 1 Integration Period(sec): 2.0 Spectral Points/BBC: 256 No. of Phase Centers per Pointing: 1	Full Polarization <input type="checkbox"/> Pulsar Gate <input type="checkbox"/> Output Format Conversion to Mark4 <input type="checkbox"/>																						
HSA <input type="checkbox"/> GBT <input type="checkbox"/> AR <input type="checkbox"/> EB <input type="checkbox"/> VLA-Y27 <input type="checkbox"/>																									
VLA <input type="checkbox"/> Y1 <input type="checkbox"/>																									
Geodetic <input type="checkbox"/> <input type="text"/>																									

Save Delete Cancel

Stations	
VLBA <input type="checkbox"/>	BR <input type="checkbox"/> FD <input type="checkbox"/> HN <input type="checkbox"/> KP <input type="checkbox"/> LA <input type="checkbox"/> MK <input type="checkbox"/> NL <input type="checkbox"/> OV <input type="checkbox"/> PT <input type="checkbox"/> SC <input type="checkbox"/>
HSA <input type="checkbox"/>	GBT <input type="checkbox"/> AR <input type="checkbox"/> EB <input type="checkbox"/> VLA-Y27 <input type="checkbox"/>
VLA <input type="checkbox"/>	Y1 <input type="checkbox"/>
Geodetic <input type="checkbox"/>	<input type="text"/>

VLBA/HSA Resources in the PST

My Proposals Available Authors Available Organizations Friday 31 May 2013

Validate Print Submit Copy Resources Help

VLBA/HSA RESOURCES

Order Name Wavelength Processor Observing Mode Session

3.6 cm Socorro-DIFX Standard

	Stations	Observing Parameters	Correlation Parameters	Special Features
VLBA	BR <input type="checkbox"/> FD <input type="checkbox"/> HN <input type="checkbox"/> KP <input type="checkbox"/> LA <input type="checkbox"/> MK <input type="checkbox"/> NL <input type="checkbox"/> OV <input type="checkbox"/> PT <input type="checkbox"/> SC <input type="checkbox"/>	Observing System: DDC System Bandwidth: 128 MHz Baseband Channels: 4 Polarization: Dual Agg. Bit Rate (Mbits/sec): 2048	Number of Correlator Passes: 1 Integration Period(sec): 2.0 Spectral Points/BBC: 256 No. of Phase Centers per Pointing: 1	Full Polarization <input type="checkbox"/> Pulsar Gate <input type="checkbox"/> Output Format Conversion to Mark4 <input type="checkbox"/>
HSA	GBT <input type="checkbox"/> AR <input type="checkbox"/> EB <input type="checkbox"/> VLA-Y27 <input type="checkbox"/>			
VLA	Y1 <input type="checkbox"/>			
Geodetic				

Save Delete Cancel

Observing Parameters	
Observing System	PFB System
Bandwidth	32 MHz
Baseband Channels	16
Polarization	Dual
Agg. Bit Rate (Mbits/sec)	2048

Polyphase Filter-Bank (PFB)
16 channels, each 32 MHz wide
Coarse tuning
For continuum science

Observing Parameters	
Observing System	DDC System
Bandwidth	128 MHz
Baseband Channels	4
Polarization	Dual
Agg. Bit Rate (Mbits/sec)	2048

Digital Down-Converter (DDC)
1, 2, 4, (or 8) channels, each 1- 128 (or 64) MHz wide
Finer tuning capability
For continuum and spectral line science

VLBA/HSA Resources in the PST

My Proposals Available Authors Available Organizations Friday 31 May 2013

Validate Print Submit Copy Resources Help

VLBA/HSA RESOURCES

Resources

Order	Name	Wavelength	Processor	Observing Mode	Session
		3.6 cm	Socorro-DIFX	Standard	

Stations	Observing Parameters	Correlation Parameters	Special Features
VLBA <input type="checkbox"/> BR <input type="checkbox"/> FD <input type="checkbox"/> HN <input type="checkbox"/> KP <input type="checkbox"/> LA <input type="checkbox"/> MK <input type="checkbox"/> NL <input type="checkbox"/> OV <input type="checkbox"/> PT <input type="checkbox"/> SC <input type="checkbox"/>	Observing System: DDC System Bandwidth: 128 MHz	Number of Correlator Passes: 1 Integration Period(sec): 2.0 Spectral Points/BBC: 256	Full Polarization <input type="checkbox"/> Pulsar Gate <input type="checkbox"/> Output Format Conversion to Mark4 <input type="checkbox"/>
HSA <input type="checkbox"/> GBT <input type="checkbox"/> AR <input type="checkbox"/> EB <input type="checkbox"/> VLA-Y27 <input type="checkbox"/>	Baseband Channels: 4 Polarization: Dual	No. of Phase Centers per Pointing: 1	
VLA <input type="checkbox"/> Y1 <input type="checkbox"/>	Agg. Bit Rate (Mbits/sec): 2048		
Geodetic <input type="checkbox"/>			

Save Delete Cancel

Correlation Parameters

Number of Correlator Passes	1
Integration Period(sec)	2.0
Spectral Points/BBC	256
No. of Phase Centers per Pointing	1

If both wide bandwidth and spectral zooming are desired, this would be 2

Up to 32768 spectral channels

For multi-field imaging

VLBA/HSA Sessions in the PST

SESSIONS

Sessions << < > >>

Session	Number of Sessions	Separation	Min. Start GST	Max. End GST
<input type="text"/>	<input type="text" value="1"/>	<input type="text" value="0"/> day(s)	<input type="text" value="00:00:00"/> (HH:MM:SS)	<input type="text" value="24:00:00"/> (HH:MM:SS)

EVN Exposure Calculator

Constraints: <input type="text"/>	Comments: <input type="text"/>	Save Cancel
--------------------------------------	-----------------------------------	----------------

Source Groups	Resources	Time/Session (hrs)	RMS Noise (mJy/beam)
<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

Note: Adding Source Groups to a session will automatically associate all sources, within the group, to the session.

VLBA/HSA Sessions in the PST

SESSIONS

Sessions << >>

Session	Number of Sessions	Separation	Min. Start GST	Max. End GST
<input type="text"/>	<input type="text" value="1"/>	<input type="text" value="0"/> day(s)	<input type="text" value="00:00:00"/> (HH:MM:SS)	<input type="text" value="24:00:00"/> (HH:MM:SS)
Constraints: <input type="text"/>		Comments: <input type="text"/>		EVN Exposure Calculator Save Cancel

Source Groups	Resources	Time/Session (hrs)	RMS Noise (mJy/beam)
<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

Note: Adding Source Groups to a session will automatically associate all sources, within the group, to the session.

<http://www.evlbi.org/cgi-bin/EVNcalc>

EVN Calculator

<input type="button" value="EVN"/> <input type="button" value="e-EVN"/> <input type="button" value="VLBA"/> <input type="button" value="GLOBAL"/> <input type="button" value="GMVA"/>	<input type="button" value="RESET"/> <input type="button" value="GO"/>
Observing band & data rate [Mbit/s]	On-source integration time [min]
<input type="text" value="L - 18cm"/> <input type="text" value="2048"/>	<input type="text" value="150"/>
<input type="checkbox"/> Ef <input type="checkbox"/> W1 <input type="checkbox"/> Hh <input type="checkbox"/> Ka <input type="checkbox"/> Gb <input checked="" type="checkbox"/> Kp <input type="checkbox"/> Mc <input type="checkbox"/> Nt <input type="checkbox"/> My <input type="checkbox"/> Ny <input type="checkbox"/> Y1 <input checked="" type="checkbox"/> Pt <input type="checkbox"/> On <input type="checkbox"/> Sh <input type="checkbox"/> Km <input type="checkbox"/> Tc <input type="checkbox"/> Y27 <input checked="" type="checkbox"/> Ov <input type="checkbox"/> Tr <input type="checkbox"/> Ur <input type="checkbox"/> Sv <input type="checkbox"/> Pv <input checked="" type="checkbox"/> Sc <input checked="" type="checkbox"/> Br <input type="checkbox"/> Jb1 <input type="checkbox"/> Mh <input type="checkbox"/> Zc <input type="checkbox"/> Ro70 <input checked="" type="checkbox"/> Hn <input checked="" type="checkbox"/> Mk <input type="checkbox"/> Jb2 <input type="checkbox"/> Ys <input type="checkbox"/> Bd <input type="checkbox"/> Ro34 <input checked="" type="checkbox"/> Nl <input type="checkbox"/> Cm <input type="checkbox"/> Sr <input type="checkbox"/> Wz <input type="checkbox"/> Pb <input checked="" type="checkbox"/> Fd <input type="checkbox"/> Wb <input type="checkbox"/> Ar <input type="checkbox"/> Sm <input type="checkbox"/> Go <input checked="" type="checkbox"/> La	<p>The image thermal noise is estimated to be 21.27 uJy/beam (1 sigma) using natural weighting.</p>
Number of spectral channels, integration time [s], and maximum baseline length	Number of polarizations, subbands per polarizations, and bandwidth of a subband [MHz]
<input type="text" value="16 ch"/> <input type="text" value="2s"/> <input type="text" value="10000 km (Full EVN)"/>	<input type="text" value="2 pols"/> <input type="text" value="8 sb"/> <input type="text" value="32 MHz"/>
<p>The field of view limited by bandwidth-smearing is 2.475 arcseconds (assuming 10000.0 km for the maximum baseline).</p> <p>The field of view limited by time-smearing is 16.70 arcseconds. These values are calculated for 10% loss in the response of a point source, and they give the FoV radius from the pointing center.</p>	<p>32 MHz subbands are not available operationally at the EVN yet. The resulting FITS file size will be about 427.24 MBytes.</p> <p>This combination of channels and polarizations results in an aggregate bit rate of 2048 Mbps, assuming 2 bit sampling.</p>
	<input type="button" value="RESET"/> <input type="button" value="GO"/>

VLBA/HSA Technical Justification

My Proposals Available Authors Available Organizations Monday 06 January 2014

Validate Print Submit Save Help

TECHNICAL JUSTIFICATION

« < Technical Justification > »

Options

- My Proposals
 - VLBA/2014-00-003
 - General
 - Authors
 - Science Justification
 - Technical Justification**
 - Sources
 - Resources
 - Sessions
 - Print Preview
 - GBT/13B-443
 - VLBA/14A-428
 - GBT/14A-230
 - GBT/14A-363
 - GBT/2013-01-040
 - VLA/13B-184
 - VLA/13B-340
 - GBT/13B-157
 - VLA/13A-234
 - VLBA/13A-235
 - GBT/13A-236
 - GBT/13A-239
 - GBT/12B-052
 - GBT/12B-325
 - VLA/12B-282
 - VLBA/12B-276
 - VLA/12A-283
 - VLA/12A-294
 - GBT/12A-297
 - VLA/12A-377
 - VLBA/12A-293
 - VLBA/12A-284

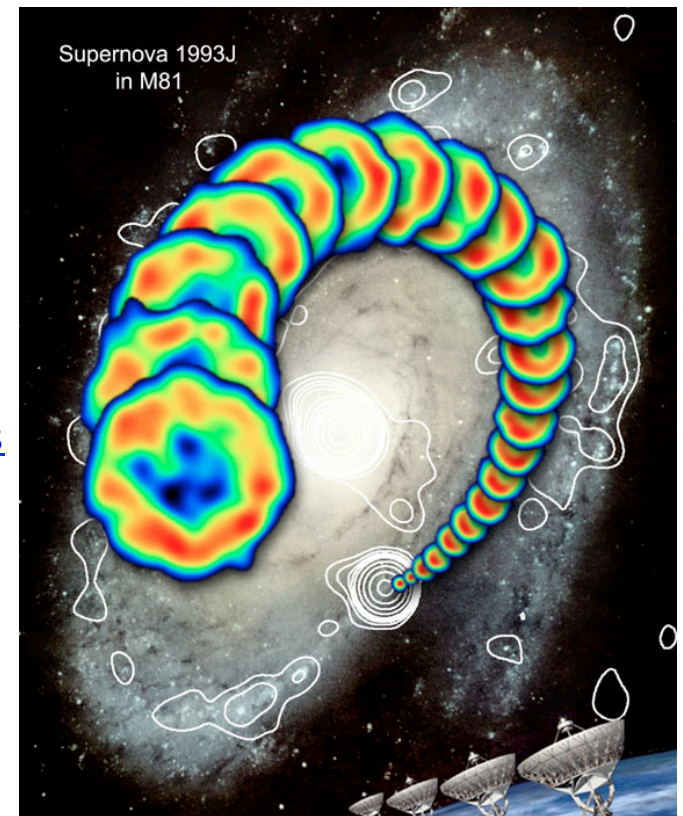
VLBA Technical Justification

Use this page to specify how the technical set-up requested for your proposal enables the scientific goals to be met. Input is required for all fields. If a field is not relevant for your proposal then enter "NA" into the textbox. The links within each box provide information concerning these technical questions.

Explain the reasons for the stations requested; specify minimum number acceptable, and note which stations are optional and/or required. If HSA observations are being requested, justify why the HSA is needed to achieve the science, and verify that all stations can sample/record with the same observing mode. https://science.nrao.edu/facilities/vlba/docs/manuals/oss/ang-res https://science.nrao.edu/facilities/vlba/docs/manuals/oss/prop-prep/vlba-plus	<input type="text"/>
Explain the choice of receiver(s) requested and whether or not dual polarization is required for each receiver: https://science.nrao.edu/facilities/vlba/docs/manuals/oss/bands-perf	<input type="text"/>
Explain scheduling issues including requested weather conditions, dates, and length of scheduling blocks. Specify the weather suitable for a given frequency band. For example - 'I request weather suitable for the 2cm band'. Note that this is not necessarily the observing frequency (since one may request lower or higher frequency weather). Specify preferred dates, or excluded dates, and/or if a series of observations with specified cadence, specify that cadence. Specify minimum length of scheduling blocks (blocks of observing time, which may be different than sessions) that can be observed and a start-time range in Pt_LST; note that shorter blocks are, in general, easier to schedule; if 24-hour blocks are required, indicate whether or not break-points may be installed in the schedule to allow different start times.	<input type="text"/>
Describe correlator set-up requested. Correlation parameters beyond those required for narrow-field continuum or spectral line observing should be justified. For example, use of pulsar processing, multiple phase centers, multiple correlator passes or wide-field phase centers should be explained. These capabilities, used in isolation or in combination, may have an impact on correlator throughput. Also justify the number of multiple phase centers if > 100. https://science.nrao.edu/facilities/vlba/docs/manuals/oss/correlator	<input type="text"/>
Note whether the target(s) can be self-calibrated and estimate their flux density. If phase-referencing is required, specify the phase-reference calibrators to be used and their expected flux densities, or whether extra time (on the VLBA or VLA) will be required to find calibrators: https://science.nrao.edu/facilities/vlba/docs/manuals/oss/bsin-sens http://www.vlba.nrao.edu/astro/calib	<input type="text"/>

Important Links

- NRAO Help Desk
<https://help.nrao.edu>
- VLBA Observational Status Summary
<https://science.nrao.edu/facilities/vlba/docs/manuals/oss>
- EVN Sensitivity Calculator
<http://www.evlbi.org/cgi-bin/EVNcalc>
- Proposal Submission Tool
<http://my.nrao.edu>
- SCHED – observation preparation software
<http://www.aoc.nrao.edu/software/sched/index.html>
- AIPS – data reduction software
<http://www.aips.nrao.edu/index.shtml>



SNI 1993J, Bartel et al.
Image courtesy Michael Rupen