

Planning (VLA) observations

14th Synthesis Imaging Workshop (May 2014)



Loránt Sjouwerman

National Radio Astronomy Observatory (Socorro, NM)



Atacama Large Millimeter/submillimeter Array

Karl G. Jansky Very Large Array

Robert C. Byrd Green Bank Telescope

Very Long Baseline Array



Outline

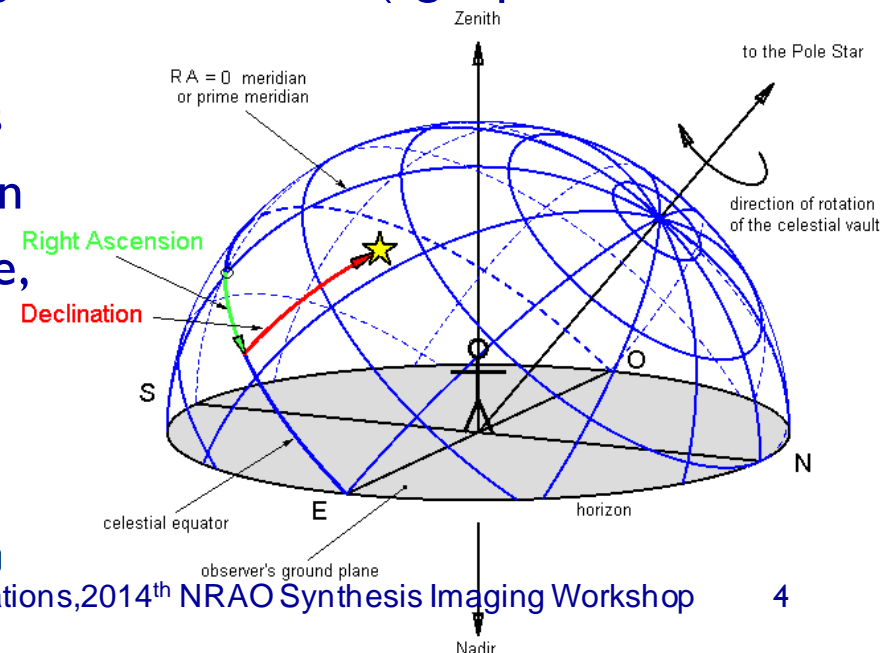
- General advice on planning any (ground based) observation
- NRAO telescopes: the GBT, ALMA, VLBA, and in particular the VLA
 - VLA, VLBA and ALMA are radio frequency interferometers, GBT is a single radio dish
 - ALMA is a joint endeavor (i.e. somewhat special with its own rules)
- Specific advice for planning VLA observations (I): Proposing
 - Planning starts before proposing/applying for time
- Introduction to the web-based tool to apply for NRAO telescope time
 - Proposal Submission Tool (PST) found at <https://my.nrao.edu>
- Specific advice for planning VLA observations (II): Scheduling
 - Operations and logistics: dynamic scheduling and scheduling priorities
 - Creating observing schedules is about determining the optimum trade-offs (for **YOUR** science case)
- Introduction to the web-based tool to schedule VLA observations
 - Observation Preparation Tool (OPT) through PST or via <https://obs.vla.nrao.edu/opt>



Planning observations

Planning any (ground based) observation

- Location of the telescope
 - Determines what part of the sky is visible
 - Declination range, e.g., for the VLA: -44° to $+90^\circ$
 - Determines the dry/wet seasons and other weather and atmospheric related issues (e.g., troposphere and ionosphere)
 - Determines the level of interfering human activities (light pollution, radio frequency interference)
- Particular telescope may have closures (e.g., maintenance) or instrumentation may be unavailable for periods of time, usually well announced



Planning any (ground based) observation

- Scientific and technical justification
 - Operating telescopes costs money; observing time is precious!
 - Time is available for well justified (scientific) projects on a competitive basis
 - Scientific justification (next slide) should clearly outline the broader scientific relevance and define goals that outline why only (new) telescope time using this particular instrument on a specific target will achieve that goal and contribute to the general knowledge of the research topic
 - Technical justification is to demonstrate that the choice of instrumentation, the observing time and the proposed methodology will yield the result using the requested resources in the most optimal way (i.e., within reason)
 - Projects are ranked by committees based on scientific and technical merit but even a top-notch scientific case may end up without observing time if the justification is poorly argued or technically not feasible
 - Conditional to constraints known to the TAC (time/resources available, day/night and other operational conditions, competition)



Scientific and technical justification

- **Why?**
 - Science context and motivation: what makes this subject scientifically interesting for the field?
 - Outline the broader impact of the science topic and the importance for astrophysics
- **What?**
 - Specific science questions: what missing but obtainable knowledge is furthering the field?
- **How?**
 - Specific science goals: how are these observations, resulting observables, going to answer the questions above and how will the science goals be achieved by this program?



Scientific and technical justification

- **Must appeal to non-expert astrophysicist reviewer** (try to avoid all jargon!)
- Who?
 - Target selection criteria: why are these object chosen for the observations, can the sample be smaller, can it instead be done with similar sources at less popular LST ranges?
- When and where?
 - Should this wait for a better opportunity, hosted by another telescope, that is, why now and why this telescope?
- What is needed?
 - Resources such as instrumental setups, observing time, operational conditions, data reduction requirements
 - *Show it can be done!*



NRAO telescopes



NRAO telescope gallery

- *Robert C. Byrd* **Green Bank Telescope (GBT)**
 - Fully steerable single dish antenna in WV
 - 100 meter diameter
 - Unblocked view
 - About 100 MHz to 100 GHz
- Not an interferometer (often used as an array element)
- Single dish school next year...



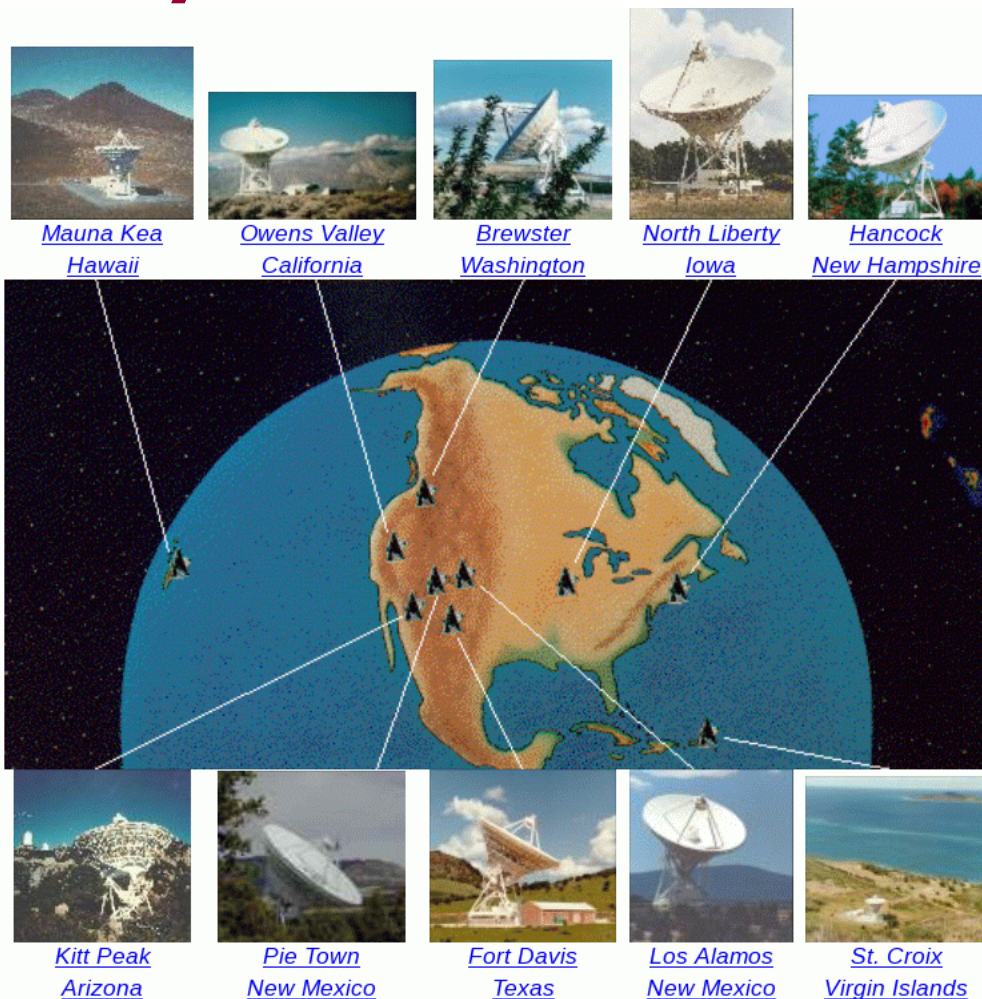
NRAO telescope gallery

- **Atacama Large Millimeter Array (ALMA)**
 - 66 (50 movable and 4+12 stationary) antennas in Chile
 - 12 & 7 meter diameter
 - Baselines up to 16 km
 - About 50 GHz to 1 THz (1000 GHz, 300 μm)
- Almost end of construction...
- Shared instrument (East-Asia, Europe, North America)
- [Separate talk here](#)



NRAO telescope gallery

- **Very Long Baseline Array (VLBA)**
 - 10 stationary antennas spread across the US
 - 25 meter diameter
 - Baselines up to 8500 km
 - About 300 MHz to 90 GHz
- Frequently combined with others (US, Europe, Asia, etc)



NRAO telescope gallery

- *Karl G. Jansky* **Very Large Array (VLA)**
 - 27 (+1) movable antennas near Socorro NM!
 - 25 meter diameter
 - Baselines up to 36 km
 - About 70 MHz to 50 GHz
 - New instrument!
- Site tour on Sunday...
(in A array configuration ☺)



Karl G. Jansky Very Large Array (VLA)

- Movable antennas: compact (“D” configuration) through spread out (“A”)
 - Baseline coverage 35 m to ~1 km (D), 3 km (C), 11 km (B), 36 km (A)
Highest angular resolution in A, best surface brightness sensitivity in D – for a given frequency
 - “Hybrid” configurations: extended north arm for southern sources
 - Configuration change every 4 months: 3 months regular, 1 month hybrid
“Any” array configuration includes regular, hybrid and “move” time configurations
- Every antenna currently has 8 permanent receiver feeds
 - Continuous frequency coverage from 1 to 50 GHz (working on < 1 GHz)
 - Continuum bandwidth of 2 or up to 8 GHz dual polarization (L: 1 GHz)
 - Switching between feeds takes 10-20 seconds, setups 10-40 seconds
- Extremely flexible WIDAR correlator
 - Up to 64 independent “spectral windows”, 31 kHz to 128 MHz (< 8 GHz)
 - Frequency channels of 2 MHz down to 122 Hz (single pol, without recirculation)



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Karl G. Jansky Very Large Array (VLA)

- M

- E

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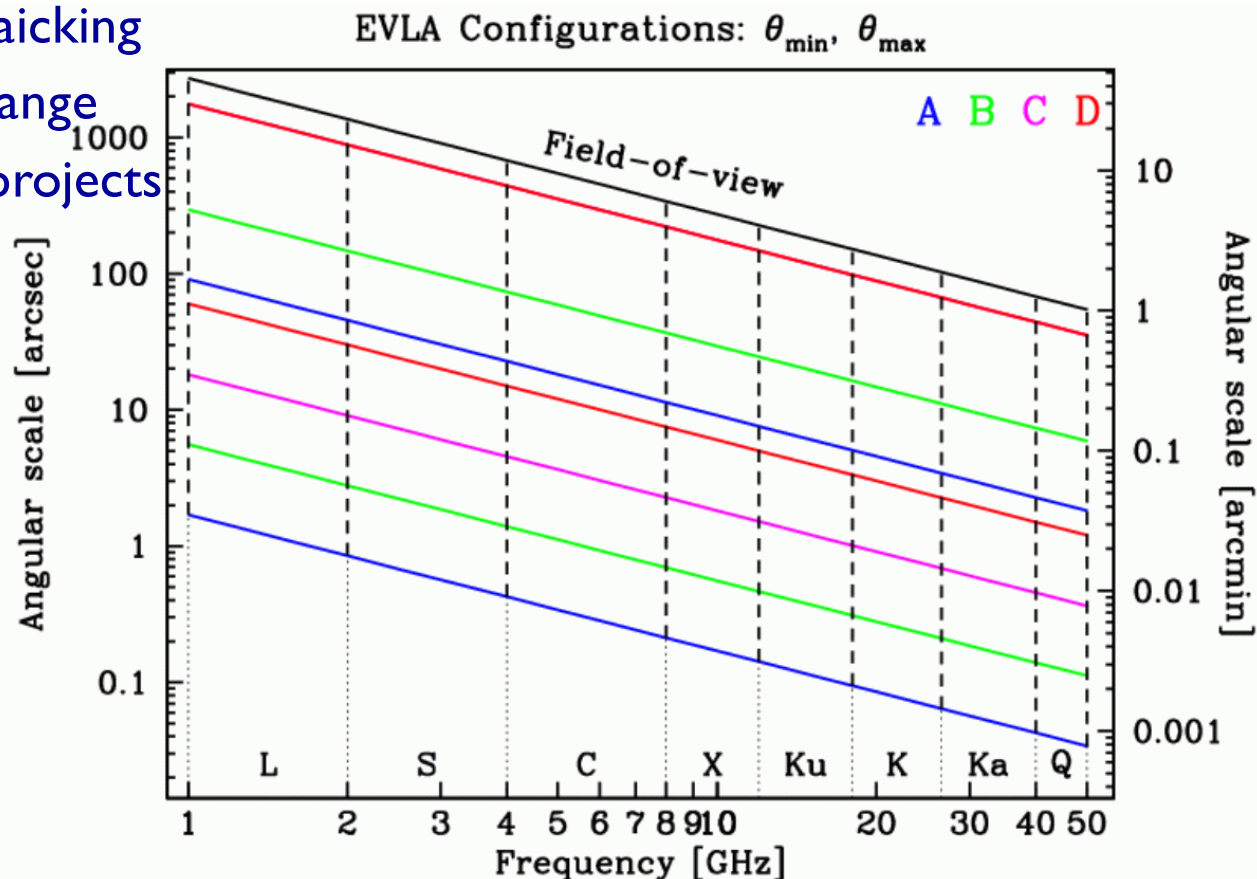
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Karl G. Jansky Very Large Array (VLA)

- Frequency bands
- Field-of-view & mozaicking
- Angular resolution range
- Multi-configuration projects



Proposing for VLA observations

Planning VLA observations: Proposing

- Two proposal rounds per year
 - Deadlines near February 1st and August 1st
 - Both for Regular and Large proposals
- DDT: exploratory/target of opportunity
 - Small amount of time (typically couple of hours)
 - Must argue why the normal deadline could not be met
- Scientific justification should be clear and to the point
 - See a previous slide
- Technical justification should address and solve all potential issues
 - Includes setup, sources, data size and reduction, analysis, logistics, etc.

Planning VLA observations: Proposing

- **Read the Call for Proposals (CfP)**
 - Changes, new opportunities
- **Read the on-line documentation!**
 - Instructions and restrictions change
 - Suggestions and hints for higher success rate
- Helpdesk (<https://help.nrao.edu>) is available
 - Do not wait until just before the deadline, response may be delayed!
 - Best to start asking for help about 2-3 weeks before the deadline
 - i.e., just after the CfP is issued

Planning VLA observations: Proposing

- VLA frequency band
 - Specify the frequency to observe and why
 - Field-of-view at this frequency
 - Need mozaicking?
- VLA configuration (A-D):
 - What angular resolution for the smallest details?
 - What angular scale for the largest structure?
 - Need multi-configuration?
 - B and C configurations less oversubscribed, can those be used instead?
- Need for subarrays? Use less antennas in “move” time?

Planning VLA observations: Proposing

- VLA frequency setup
 - Standard continuum observations?
 - In C, X, Ku bands, use 8-bit or 3-bit?
 - Multi-frequency synthesis?
 - Spectral line, with continuum or complex correlator configuration?
 - Bandwidth per spectral window
 - up to 64 independently configurable
 - Channel separation within each spectral window
 - Polarization within each spectral window
 - Other details like rest frequencies, velocities/redshifts
- Data rate for the setup within the limits?



Planning VLA observations: Proposing

- Observing time request
 - Use **exposure calculator** to estimate sensitivity, image RMS
 - <https://obs.vla.nrao.edu/ect>
 - Signal-to-noise needed for science, self-calibration?
 - Dynamic range limited or detection experiment?
 - Include overhead for calibration, special processing needs
 - (u,v) coverage considerations (snapshot, full polarization tracks)
 - Specific LST ranges that the sources are above the elevation limit (8°)
 - How many blocks of observing time versus available?
- Is the total project data volume realistic?
 - Data reduction resources (cpu, disks, people, clock time) available?



Planning VLA observations: Proposing

- Observing time request
 - Use **exposure calculator** to estimate
 - <https://obs.vla.nrao.edu/ect>
 - Signal-to-noise needed for source
 - Dynamic range limited or desired
 - Include overhead for calibration
 - (u,v) coverage considerations (source position)
 - Specific LST ranges that the source is visible
 - How many blocks of observing time
- Is the total project data volume realistic
 - Data reduction resources (cpu, storage)

VLA Exposure Calculator	
Array Configuration	B
Number of Antennas	25
Number of Polarizations	<input type="radio"/> Single <input checked="" type="radio"/> Dual
Type of Weighting	<input checked="" type="radio"/> Natural <input type="radio"/> Robust
Frequency	7.0000 GHz
Receiver Band	C
Approximate Beam Size	1.372821"
Digital Samplers	<input checked="" type="radio"/> Automatic <input type="radio"/> 3 bit <input type="radio"/> 8 bit
Elevation	Medium (25-50 degrees)
Average Weather	Summer
Calculation Type	<input checked="" type="radio"/> Time <input type="radio"/> BW <input type="radio"/> Noise/Tb
Time on Source	4.7090s
Total Time	5.9381s
Bandwidth (Frequency)	2,000.0000 MHz
Bandwidth (Velocity)	85,654.9880 km/s
RMS Noise (units/beam)	100.0000 μ Jy
RMS Brightness (temp)	1.8000 K
<input type="button" value="Help"/> <input type="button" value="Save"/>	



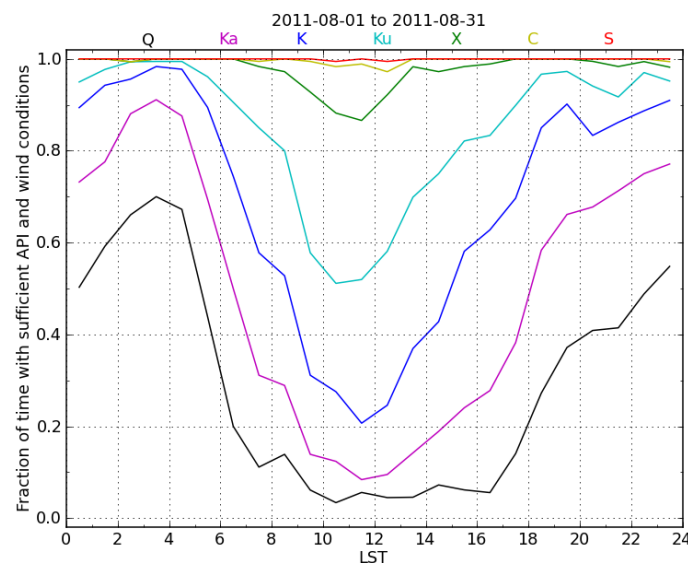
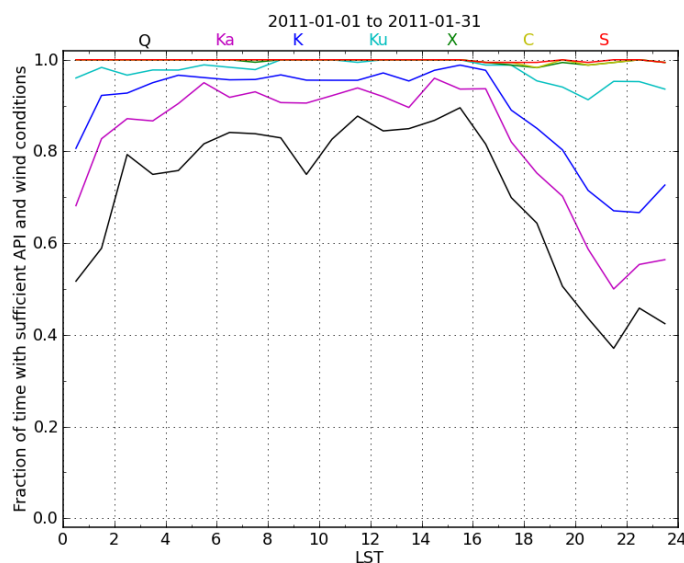
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Planning VLA observations: Proposing

- Is source logistically observable?
 - Weather, e.g., decreased time for high frequencies in late summer



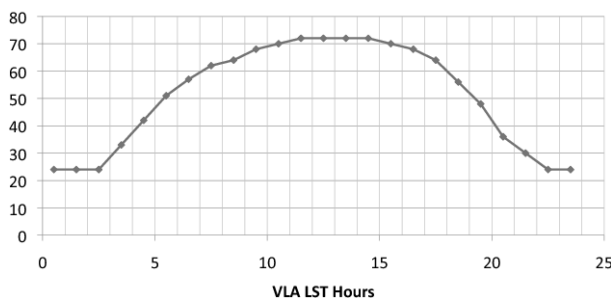
High-frequency observing in January mostly okay, even at LST 22-24h

Mostly poor high-frequency observing conditions in August LST 6-22h

Planning VLA observations: Proposing

- Is source logistically observable?
 - Weather, e.g., decreased time for high frequencies in late summer
 - Time of day, e.g., maintenance during working hours, less RFI at night
 - Available time function of LST, e.g., Galactic LST at 18h in high demand
 - Solar activity, twilight observing, proximity to the Sun

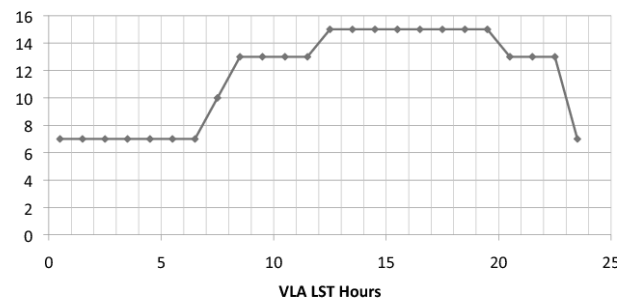
D Configuration in Semester 2013A
2013 Jan 25 – 2013 Apr 22



— Estimate of the Hours of Science Time Available per LST Hour

jwrobel 7/8/12

DnC Configuration in Semester 2013A
2013 Apr 26 – 2013 May 13



— Estimate of the Hours of Science Time Available per LST Hour

jwrobel 7/8/12

Available time as function of LST: daytime used for maintenance and tests!

Proposal Submission Tool

NRAO Proposal Submission Tool (PST)

- NRAO portal at <https://my.nrao.edu> (ALMA portal depends on region)
 - Things change, please read the CfP and on-line documentation!
 - Helpdesk (<https://help.nrao.edu>) is available, allow for response time
- Create new proposal and select instrument: VLA, VLBA, GBT (& GMVA)
- Follow the tree on the left to construct the proposal
- Submit (and wait)
- Disposition letters 3-4 months later



NRAO Proposal Submission Tool (PST)

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The screenshot shows the NRAO PST dashboard in a Mozilla Firefox browser window. The address bar displays <https://my.nrao.edu/nrao-2.0/secure/Home.htm>. The page header includes the NRAO logo and the text "National Radio Astronomy Observatory". Navigation tabs are labeled "Dashboard", "Proposals", "Data Processing", "Obs Prep", "Helpdesk", and "Profile". The user is logged in as "Hi, TestUse" with a "Sign Out" link. The date "Wednesday 14 May 2014" and a "Help" button are also visible.

The main content area is divided into two sections:

- Options:** A sidebar menu with a tree structure:
 - Dashboard
 - News & General Information
 - Information for Astronomers
 - Documentation
 - Release Notes
 - Policies
 - My Information
 - My Data
- DASHBOARD:** A central area with several announcements:
 - User Accounts:** "Please remember to update your user profile, especially if you have moved to a new institution. Do not create a new account."
 - Telescope News:** "We are aware that many proposals submitted before the 3 February, 2014 5 PM EST (22 hours UT) deadline were incorrectly assigned a 15A proposal ID code. We will change these proposal IDs from 15A to 14B and inform you of your new proposal ID code."
 - Next Proposal Deadline In 79 Days - **August 01, 2014 5 PM EDT (21 hours UT)**
 - New Proposal Finder Tool** - Search cover sheets of approved NRAO telescope proposals.
 - Important:** All proposal authors must be registered users
 - Important:** Information for VLA/GBT/VLBA/HSA/VLBI Proposers - January 3, 2014
 - VLA Configuration Plans and Proposal Deadlines - January 3, 2014

The footer contains logos for NRAO, NSF, and Associated Universities, Inc., along with the text: "The National Radio Astronomy Observatory is a facility of the National Science Foundation operated under cooperative agreement by Associated Universities, Inc." and a "Proposal Help Desk" link.

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• Create

• Follow

• Submit

• Display

NRAO - Mozilla Firefox (on gygax)

Firefox ▾ NRAO

https://my.nrao.edu/nrao-2.0/secure/Helpdesk.htm

NRAO Source Catalog Mana... ▾

NRAO National Radio Astronomy Observatory

Dashboard Proposals Data Processing Obs Prep Helpdesk Profile

Hi, TestUse | Sign Out

Wednesday 14 May 2014

Options

- Helpdesk
- General Information

NRAO Help Desk

Welcome to the new NRAO helpdesk.

Please use the helpdesk for questions concerning EVLA, VLBA, AIPS, CASA, Archive Access, and Proposal Submission.

[Login to the NRAO Helpdesk.](#)

For questions concerning ALMA/NAASC use the [ALMA helpdesk](#).

We also offer a platform for community discussions on NRAO related topics such as project planning, observing, data reduction, and science, the [NRAO Science Forums](#).

Proposal Help Desk

NRAO NSF Associated Universities, Inc.

The National Radio Astronomy Observatory is a facility of the National Science Foundation operated under cooperative agreement by Associated Universities, Inc.

<https://help.nrao.edu>

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- Create new proposal and select instrument: VLA, VLBA, GBT (& GMVA)

NRAO: Proposals - Mozilla Firefox (on gygax)

Firefox ▾ NRAO: Proposals

https://my.nrao.edu/nrao-2.0/secure/ProposalList.htm

NRAO National Radio Astronomy Observatory

Dashboard Proposals Data Processing Obs Prep Helpdesk Profile

Hi, TestUse | Sign Out

My Proposals Available Authors Available Organizations

Wednesday 14 May 2014

New Proposal Help

Problem finding your proposal? Try sorting a column by clicking on the column header or by changing the filters to the left.

« Records: 1 Page: 1 of 1 »

Options	Proposal ▾	Legacy ID ▾	Title ▾	PI. Name ▾	Created ▾	Submitted ▾	Status ▾
Status: ALL ▾ Telescope: ALL ▾ Trimester / Semester: ALL ▾ Year: ALL ▾	VLA/2013-06-007 This is an old draft proposal and it may contain components that are no longer valid (e.g., resources).		This is a blank proposal created on Thursday July 4, 2013	TestUse Lor.man	07/04/2013		DRAFT

NRAO Proposal Submission Tool (PST)

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- Follow
- Submit
- Dispo



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- Disposition letters
3-4 months later

NRAO: Cover Sheet - Mozilla Firefox (on gygax)

NRAO: Cover Sheet

<https://my.nrao.edu/nrao-2.0/secure/CoverSheetPage.htm>

NRAO National Radio Astronomy Observatory

Dashboard Proposals Data Processing Obs Prep Helpdesk Profile

Hi, TestUse | Sign Out

Wednesday 14 May 2014

My Proposals Available Authors Available Organizations

Validate Print Submit

Options

- My Proposals
 - VLA/2013-06-007
 - General
 - Authors
 - Science Justification
 - Technical Justification
 - Sources
 - Resources
 - Sessions
 - Print Preview

GENERAL

NRAO Observing Proposal

Status: DRAFT
Create Date: 07/04/2013
Modify Date: 07/04/2013
Submit Date:
Total Time: 0.0

Title
This is a blank proposal created on Thursday July 4, 2013

Type
Regular

Sponsored Proposal
Not Sponsored

Scientific Category

Abstract

Joint
Not a Joint Proposal

Scheduling of VLA observations

Planning VLA observations: Scheduling

- VLA is dynamically scheduled and uses scheduling priorities
 - A: most likely to be completed
 - C: filler, i.e., when time available and schedule appropriate
- Typically not known when a particular observation takes place
 - For a given array configuration and LST, select from the list of available observing schedules:
 - Highest priority at the top of the list
 - Scheduling priority
 - Science priority (i.e., competition from other PIs)
 - Deselected if science conditions (weather) unfavorable
 - Deselected if operational constraints unfavorable

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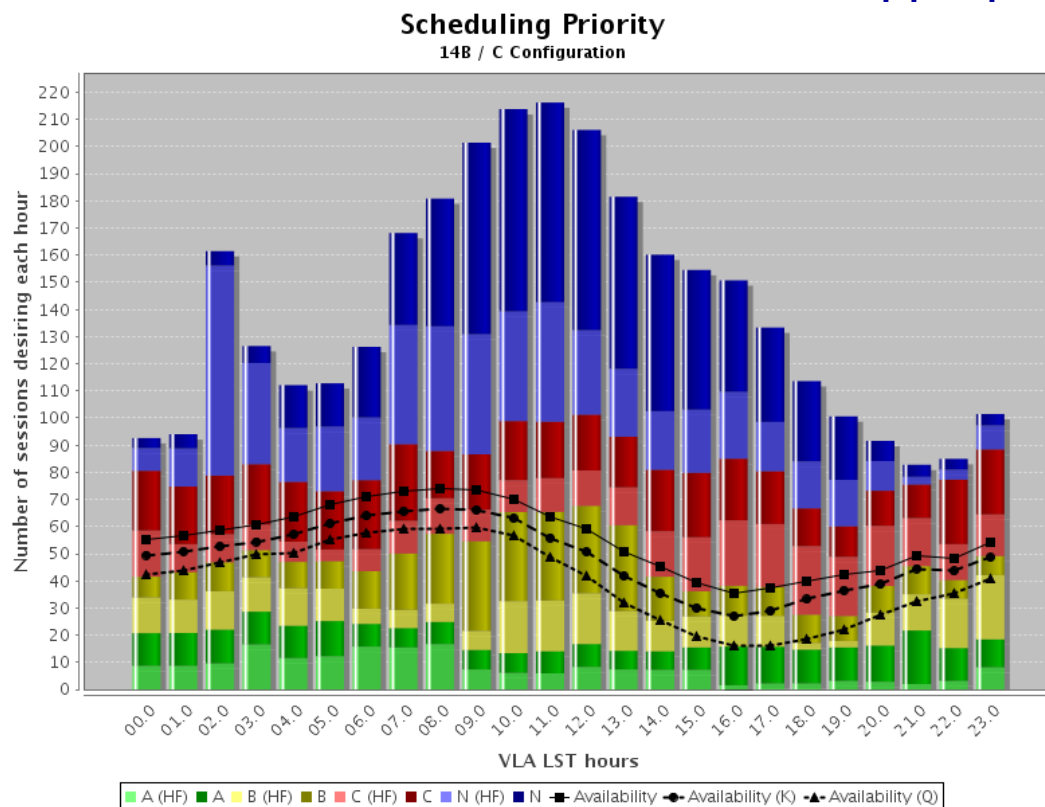
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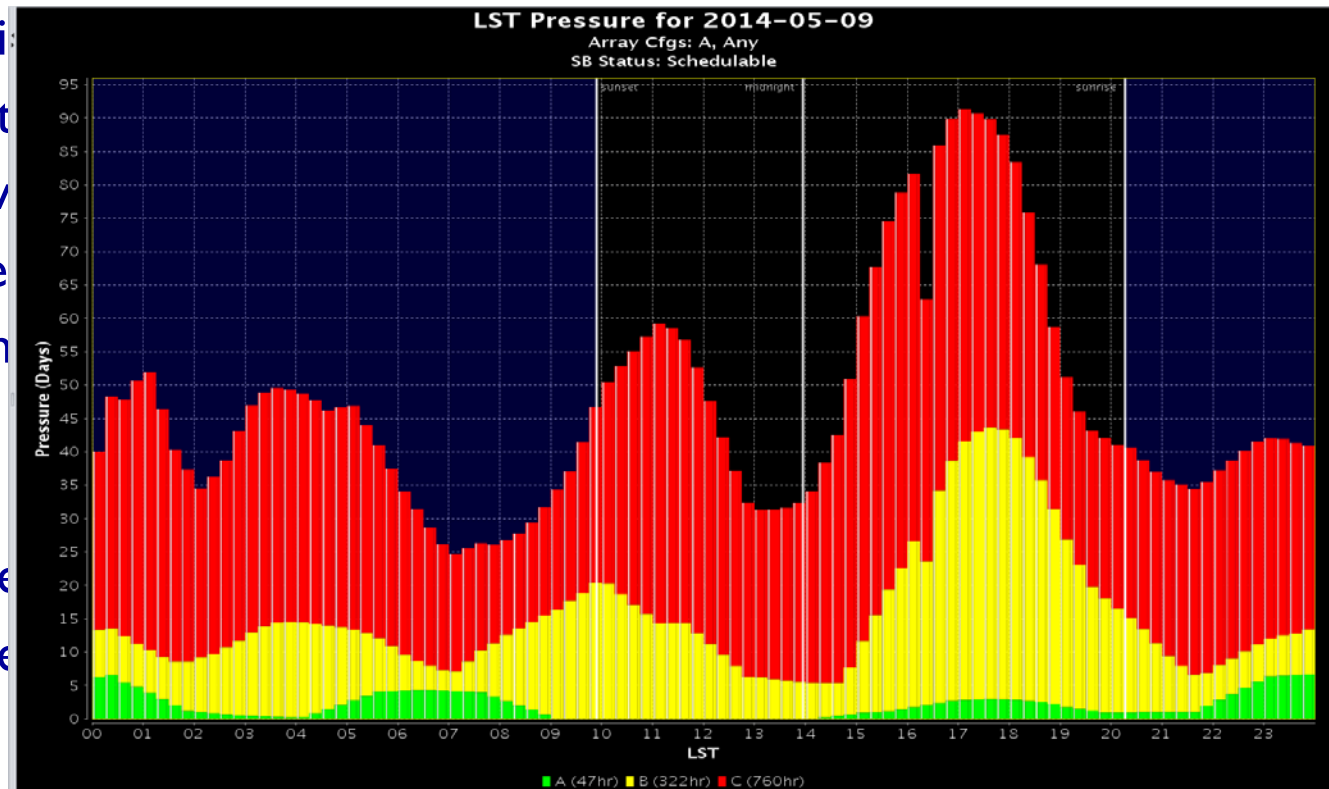
Is)
able

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Planning VLA observations: Scheduling

- VLA is dynamically scheduled and uses scheduling priorities
 - A: most likely to be completed
 - C: filler, i.e. low priority
- Typically not
 - For a given day, the amount of time available for observations is limited
- High priority observations
 - High priority observations are scheduled first
 - Low priority observations are scheduled last
- Desirable observations
 - Desirable observations are scheduled first
 - Undesirable observations are scheduled last
- Desirable observations
 - Desirable observations are scheduled first
 - Undesirable observations are scheduled last



Planning VLA observations: Scheduling

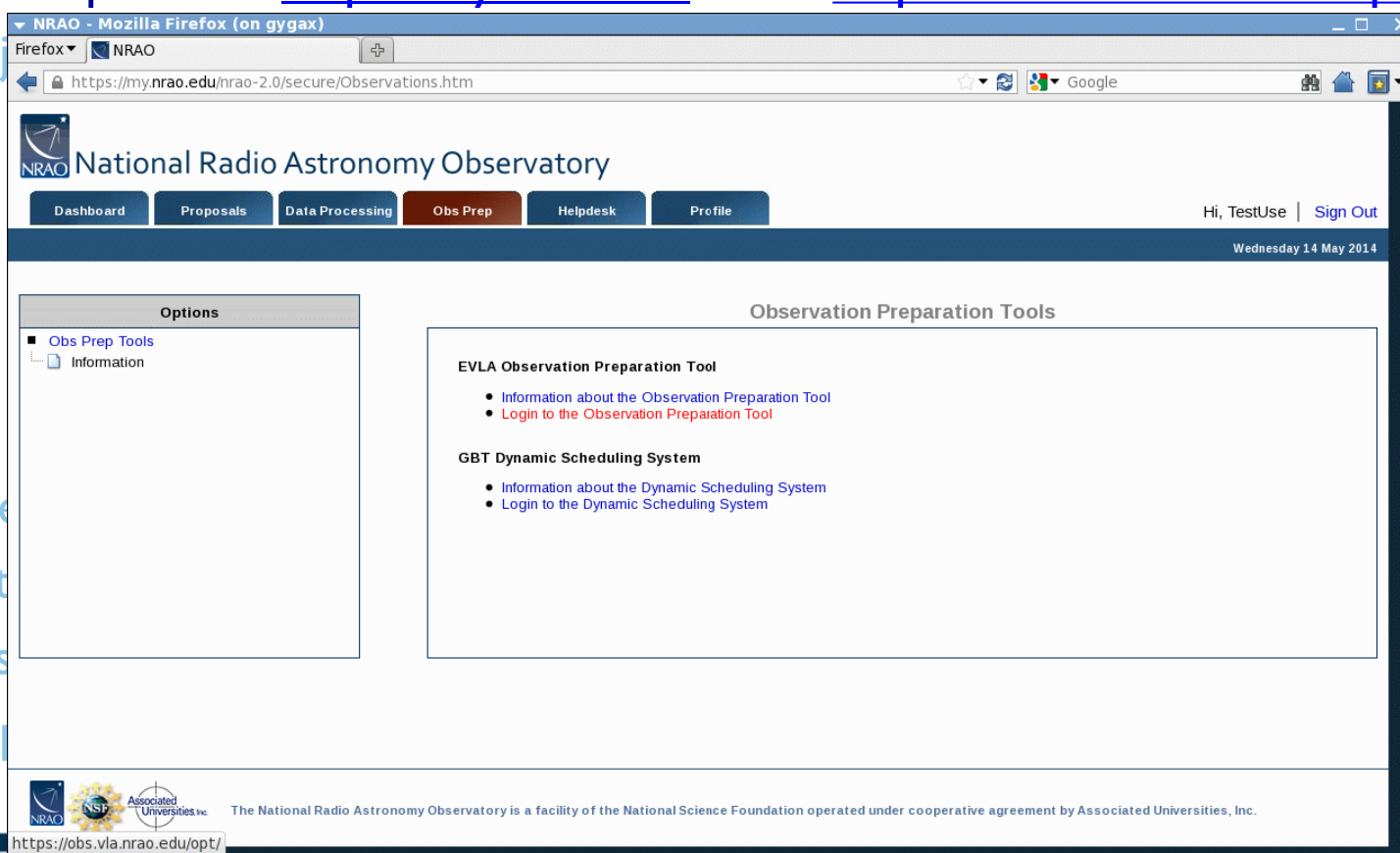
- Some PI control on trade-offs in the scheduling constraints for higher success rate, especially for scheduling priority B and C
- **Read the documentation:**
 - <https://science.nrao.edu/facilities/vla/>
 - Observational Status Summary
 - Guide to VLA observing
 - OPT manual
- Ask for help!
 - <https://help.nrao.edu/>



Observation Preparation Tool

Observation Preparation Tool (OPT)

- Use to create VLA observing schedules, a.k.a. “scheduling blocks (SBs)”
- NRAO portal at <https://my.nrao.edu> or via <https://obs.vla.nrao.edu/opt>



Observation Preparation Tool (OPT)

- Use to create VLA observing schedules, a.k.a. “scheduling blocks (SBs)”
- NRAO portal at <https://my.nrao.edu> or via <https://obs.vla.nrao.edu/opt>
- Project is created in the OPT a few weeks before the array configuration

— N

— P

Priority(!)

(LST, API,..)

Schedule

Not

Observed

Proposed

NRAO Observation Preparation Tool - Mozilla Firefox (on gygax)

Firefox | NRAO | NRAO Observation Preparat... | <https://obs.vla.nrao.edu/opt/MyProjects.jsf;jsessionid=90FD0569633EA2D9CA0AD52F997F21C5> | Google

File Edit View Help

NRAO > User Portal > Observation Preparation | Sources | Instrument Configurations | Hello, TestUse Lorman | Exit

Information | Reports | Validation and Submission | Bulk Scan Creation | Bulk Scan Edit | Executions

SCHEDULING BLOCK DETAILS

GENERATED ID: 3681193

NAME: 3c454.3 30m

STATUS: Not Submitted

COUNT: 8

COMPLETED: 0

TOTAL TIME: 04:00:00

TIME PER EXECUTION: 00:30:00

SCHEDULE TYPE: Dynamic

LST START RANGE: 20 : 00 - 03 : 30 Remove

NO CONSTRAINT: ☐

EARLIEST UT START DATE (OPTIONAL): 2011/03/15

AVOID SUNRISE: ☐

AVOID SUNSET: ☐

Diagram: A circular diagram showing the SB's orientation. The top is labeled 'N 360° 0°'. The diagram shows a clockwise (CW) right wrap from 275° to -85° and a counter-clockwise (CCW) left wrap from 85° to 445°. A 180° arc is shown at the bottom, labeled '265° - 265°'.

Description	Wind	Atmospheric Phase Limit
Lowest Frequencies (4, P, and L)	Any	Any
2.0GHz - 4.0GHz (S)	Any	60.0 degrees
4.0GHz - 8.0GHz (C)	Any	45.0 degrees
8.0GHz - 12.0GHz (X)	15.0 m/s	30.0 degrees

Observation Preparation Tool (OPT)

- Use to create VLA observing schedules, a.k.a. “scheduling blocks (SBs)”
- NRAO portal at <https://my.nrao.edu> or via <https://obs.vla.nrao.edu/opt>
- Project is created in the OPT a few weeks before the array configuration
 - NRAO fills in read-only details, e.g., PI, time, array, scheduling priority(!)
 - Proposers responsible for schedule and observing constraints (LST, API,...)
 - Things change, please read the on-line documentation!
 - Helpdesk (<https://help.nrao.edu>) is available, please use it
 - Schedule is checked for logistical issues, but not for science!
- Scheduling may require making trade-offs, depending on science goals
- Not all SBs will be completed (priority/competition, weather, constraints, operations)
- Observations are directly archived and pipelined, proprietary period
- Proposers may be contacted about the pipelined data products



OPT “hands-on” tutorial

- Using the OPT, login and navigate, “look and feel”
- Existing project SB (scheduling block) available
- Examine SB
 - Conditions, reports and validation
- Modify SB
 - SCT, source catalog tool
 - Search for calibrators, create a new source
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– Scheduling

– Resources

– Configuration

• Validation

SCHEDULING BLOCK DETAILS

GENERATED ID: 3681193
 NAME: 3c454.3 30m
 STATUS: Not Submitted
 COUNT: 8
 COMPLETED: 0
 TOTAL TIME: 04:00:00
 TIME PER EXECUTION: 00:30:00
 SCHEDULE TYPE: Dynamic
 LST START RANGE: 20:00 - 03:30
 EARLIEST UT START DATE (OPTIONAL): 2011/03/15

Description	Wind	Atmospheric Phase Limit
Lowest Frequencies (4, P, and L)	Any	Any
2.0GHz - 4.0GHz (S)	Any	60.0 degrees
4.0GHz - 8.0GHz (C)	Any	45.0 degrees
8.0GHz - 12.0GHz (X)	15.0 m/s	30.0 degrees

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NRAO Source Catalog Management Tool - Mozilla Firefox (on gygax)

Firefox | NRAO | NRAO Source Catalog Mana... | +

https://obs.vla.nrao.edu/sct/MyCatalogs.jsf

File Edit Help

NRAO > User Portal > Observation Preparation | Sources | Instrument Configurations

Hello, TestUse Lorman Exit

Sources Properties

SOURCES IN 'VLA FLUX CAL' (5)

Select All | None Show: 25 | 50 | 100 | 200 SELECT COORDINATE SYSTEM: Equatorial

	Name	Right Ascension	Declination	Velocity	Flux / Structure	Sky Map
<input type="checkbox"/>	0137+331=3C48	1h 37m 41.299431s	33d 9' 35.13299"		DETAILS	ALIASES
<input type="checkbox"/>	0542+498=3C147	5h 42m 36.137916s	49d 51' 7.23356"		DETAILS	ALIASES
<input type="checkbox"/>	1331+305=3C286	13h 31m 8.287984s	30d 30' 32.95885"		DETAILS	ALIASES
<input type="checkbox"/>	0521+166=3C138	5h 21m 9.886021s	16d 38' 22.05122"		DETAILS	ALIASES
<input type="checkbox"/>	1411+522=3C295	14h 11m 20.6477s	52d 12' 9.141"		DETAILS	ALIASES

Advanced Search

Search

☐ Search Aliases As Well

External Search

VLA

- RA Groups
- Dec Groups
- VLA Flux Cal
- Personal Catalog
- My Sources
- My project sources

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NRAO Instrument Configuration Tool - K64f3 wide 3s - Basics - Mozilla Firefox (on gygax)

Firefox | NRAO | NRAO Instrument Configura... | <https://obs.vla.nrao.edu/rct/secure/catalogs/1770/resources/600771/basics.xhtml?group=602265> | Google

NRAO | [NRAO](#) > [User Portal](#) > [Observation Preparation](#) | [Sources](#) | [Instrument Configurations](#) | Hello, TestUse Lor.man | [Exit](#)

NRAO Defaults » DCB/Any config » K64f3 wide 3s

Spectral Plot: 17.7 GHz to 26.8 GHz. The plot shows several colored bars (yellow, red, cyan, purple) representing different spectral components.

Total BI. BPs Used:	64 of 64
Total Data Rate:	15.79 MB/s or 56.86 GB/h
Total Spectral Points:	4096
Total Bandwidth:	8.192GHz
Capability Mode:	General observing

Basics | Lines | Basebands | Line Placement | Subbands | Validation

ID
600771

Name
K64f3 wide 3s

Receiver Band
K (18.0GHz - 26.5GHz)
3-dB range: 17.7GHz - 26.8GHz

Correlator Integration Time (s)
3.0

Comments
8 GHz (3 bit) Full polzn. 3s

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Questions ?