Planning (VLA) observations

Loránt Sjouwerman, NRAO
Outline

• General advice on planning any (ground based) observation
• AUI telescopes: the GBT, ALMA, VLBA, and in particular the VLA
  – VLA, VLBA and ALMA are radio frequency interferometers, GBT is a single radio dish
  – VLA is NRAO operated, VLBA is LBO operated (soon NRAO?) and GBT is GBO operated
  – ALMA is a joint endeavor (i.e. somewhat special with its own rules); for ALMA see next talk

• Specific advice for planning VLA observations (I): Proposing
  – Planning starts before proposing/applying for time

• Introduction to the web-based tool to apply for AUI 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 portal 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°
  - 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 objects 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!*
AUI operated telescopes
AUI telescope gallery

- Robert C. Byrd Green Bank Telescope (GBT) operated by GBO
  - 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)
- Separate single dish workshops elsewhere
AUI telescope gallery

- Atacama Large Millimeter Array (ALMA) operated by JAO
  - 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)
- Shared instrument (East-Asia, Europe, North America)
- Separate talk here
AUI telescope gallery

- **Very Long Baseline Array (VLBA)** operated by LBO
  - 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)
AUI telescope gallery

- Karl G. Jansky **Very Large Array (VLA)** operated by NRAO
  - 27 (+1) movable antennas near Socorro NM!
  - 25 meter diameter
  - Baselines up to 36 km
  - About 70 MHz to 50 GHz

- Site tour on Sunday…
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
  - Configuration change every ~4 months
    - “Any” array configuration includes regular 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)

- Frequency bands
- Field-of-view & mosaicking
- 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 resolve 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, special instructions

• **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 receiver band
  – Specify the frequency to observe and why
  – Field-of-view at this frequency
    • Need mosaicking?
• VLA array 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?
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VLA Exposure Calculator

<table>
<thead>
<tr>
<th>Array Configuration</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Antennas</td>
<td>25</td>
</tr>
<tr>
<td>Number of Polarizations</td>
<td>Single, Dual</td>
</tr>
<tr>
<td>Type of Weighting</td>
<td>Natural, Robust</td>
</tr>
<tr>
<td>Frequency</td>
<td>7.0000 GHz</td>
</tr>
<tr>
<td>Receiver Band</td>
<td>C</td>
</tr>
<tr>
<td>Approximate Beam Size</td>
<td>1.372821°</td>
</tr>
<tr>
<td>Digital Samplers</td>
<td>Automatic, 3 bit, 8 bit</td>
</tr>
<tr>
<td>Elevation</td>
<td>Medium (25-50 degrees)</td>
</tr>
<tr>
<td>Average Weather</td>
<td>Summer</td>
</tr>
<tr>
<td>Calculation Type</td>
<td>Time, BW, Noise/Tb</td>
</tr>
<tr>
<td>Time on Source</td>
<td>4.7090s</td>
</tr>
<tr>
<td>Total Time</td>
<td>5.9381s</td>
</tr>
<tr>
<td>Bandwidth (Frequency)</td>
<td>2.000.000 MHz</td>
</tr>
<tr>
<td>Bandwidth (Velocity)</td>
<td>85,654.9860 km/s</td>
</tr>
<tr>
<td>RMS Noise (units/beam)</td>
<td>100.0000 μJy</td>
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<tr>
<td>RMS Brightness (temp)</td>
<td>1.8000 K</td>
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Planning VLA observations: Proposing

- Observing time request
  - Use **exposure calculator** to estimate sensitivity, image RMS
    - [https://obs.vla.nrao.edu/ect](https://obs.vla.nrao.edu/ect)
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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

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](https://my.nrao.edu) (ALMA portal: almascience.org depends on region)
  - Things change, please read the CfP and on-line documentation!
  - Helpdesk ([https://help.nrao.edu/](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
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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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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/](https://science.nrao.edu/facilities/vla/)
    - Observational Status Summary
    - Guide to VLA observing
    - OPT manual
- **Ask for help!**
  - [https://help.nrao.edu/](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/
- 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!
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- 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
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OPT “hands-on” tutorial

- Using the OPT, login and navigate, “look and feel”
- Create project SB (scheduling block) from scratch
- Hypothetical project to observe PN
  - Lines and continuum
- Experiencing the use of
  - SCT, source catalog tool
    - Search for calibrators, create a new source
  - RCT, resource (instrument setup) catalog tool
    - Default continuum setups, create a line setup
  - OPT, observation preparation (scan sequence) tool
    - Change (re)source, scan sequence, play with conditions
- Validate and “submit”
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  - Lines and continuum
- Experiencing the use of
  - SCT, source catalog tool
    - Search for calibrators, create a new source
  - RCT, resource (instrument setup) catalog tool
    - Default continuum setups, create a line setup
  - OPT, observation preparation (scan sequence) tool
    - Change (re)source, scan sequence, play with conditions
- Validate and “submit”
Questions?