VLA data reduction – part 1: 
*Post-observing, pre-calibration*

Loránt Sjouwerman, NRAO
Outline

• After the observations:
  – Obtaining your data from the archive
    • Which CPU processes the data? (Home or NRAO)
  – Examine your data
    • Structure and potential issues: all expected data present, RFI, calibrators, reference antenna…
  – Prepare for calibration steps
    • Use examination to flag bad data upfront

Better preparation eases the process!
Assumptions (for all these lectures)

This presentation assumes that you are familiar with the basics of:

- radio interferometry
- flux density calibration, *antenna-based* calibration (complex gain, bandpass), and self-calibration
- imaging and deconvolution

For references on the above, please check:

- The lectures of the 2014 or 2016 synthesis imaging workshop
  https://science.nrao.edu/science/meetings/2014/14th-synthesis-imaging-workshop/
  https://science.nrao.edu/science/meetings/2016/15th-synthesis-imaging-workshop/lectures
- Synthesis Imaging for Radio Astronomy II
  (eds. Taylor, Carilli, and Perley).
- Interferometry and Synthesis in Radio Astronomy
  (by Thompson, Moran, and Swenson).
NRAO versus Local/home computing

• Note that NRAO offers computing facilities for demanding projects upon request
  – Registered user
  – Limited capacity, compete with others, no guarantee
  – See computing policy page
    https://science.nrao.edu/facilities/vla/docs/manuals/computing-resources

• Here assume processing at home institute
  – Data transfer over internet (up to ~ 100 GB)
  – Data shipped on disk (purchase, up to 1.8 TB/disk)
Obtaining data from the NRAO archive

Peek at using the new archive tool

*(still a work in progress)*

Here: using the current archive tool
<table>
<thead>
<tr>
<th>Project</th>
<th>Instrument</th>
<th>Title</th>
<th>Observation Stop</th>
<th>Execution Blocks</th>
</tr>
</thead>
<tbody>
<tr>
<td>10B-147</td>
<td>VLA</td>
<td>Testing the requirements for jet production in accreting black holes</td>
<td>2010-12-09 20:56 – 23:56</td>
<td>1 execution blocks</td>
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<tr>
<td>10B-133</td>
<td>VLA</td>
<td>The magnetic field and the structure of a disk in a massive young star</td>
<td>2011-08-01 13:31 – 15:30</td>
<td>7 execution blocks</td>
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<td>10B-123</td>
<td>VLA</td>
<td>Zeeman observations of 44 GHz Class I Methanol Masers</td>
<td>2010-11-03 06:20 – 08:20</td>
<td>6 execution blocks</td>
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<td>10B-137</td>
<td>VLA</td>
<td>Broad-band spectra of the lobes of FRII radio galaxies</td>
<td>2010-10-17 15:26 – 19:55</td>
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<tr>
<td>10B-119</td>
<td>VLA</td>
<td>Low Frequency Spectra of Radio Sources Detected by the Planck Satellite</td>
<td>2010-08-03 07:23 – 08:23</td>
<td>16 execution blocks</td>
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<td>10B-113</td>
<td>VLA</td>
<td>Testing the emission model of the Ultra Compact Binary RX J0806+15</td>
<td>2010-10-31 12:55 – 16:32</td>
<td>3 execution blocks</td>
</tr>
<tr>
<td>10B-143</td>
<td>VLA</td>
<td>A Radio Study of Flaring Be Disks</td>
<td>2010-11-05 00:45 – 01:46</td>
<td>19 execution blocks</td>
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<tr>
<td>10B-102</td>
<td>VLA</td>
<td>Dust properties in a massive disk in the Orion Nebula</td>
<td>2010-11-22 21:13 – 21:51</td>
<td>5 execution blocks</td>
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<tr>
<td>Project</td>
<td>Instrument</td>
<td>Title</td>
<td>Observation Stop</td>
<td>Execution Blocks</td>
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<td>14B-292</td>
<td>VLA</td>
<td>Search of M31 and M33 for Radio Signals in the 21-cm Band</td>
<td>2015-01-30 01:04 – 01:43</td>
<td>8 execution blocks</td>
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<td>19B-054</td>
<td>VLA</td>
<td>Finding the Missing Baryons with Dispersion of Transients in M31</td>
<td>2014-01-21 01:06 – 03:11</td>
<td>12 execution blocks</td>
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<td>15A-175</td>
<td>VLA</td>
<td>Resolving the Cold, Star Forming Atomic Gas in M31</td>
<td>2016-02-20 10:30 – 22:00</td>
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<td>2017-08-09 05:58 – 08:04</td>
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<td>12A-454</td>
<td>VLA</td>
<td>Does the nearest ultraluminous X-ray source have a radio counterpart?</td>
<td>2012-03-17 23:27 – 23:57</td>
<td>3 execution blocks</td>
</tr>
</tbody>
</table>

**Title:** Does the nearest ultraluminous X-ray source have a radio counterpart?

**Abstract:** Ultraluminous X-ray sources (ULXs) are a well studied X-ray phenomenon that may be associated with either extreme accretion rates onto stellar mass black holes or more typical, sub-Eddington accretion onto a new class of intermediate mass black holes (IMBH). Distinguishing which solution is correct is difficult due mainly to their distance which has prevented successful multi-wavelength campaigns. In particular, the limiting radio luminosity of these sources has prevented observations which could readily distinguish the difference in outflows associated with other accretion regime. A new ULX has recently been discovered in M31 which provides an unprecedented opportunity to make the first radio detection of such an object and an unambiguous identification of the compact object driving the luminous emission. We request two 1 hour ToOs, initially to determine the presence and strength of a radio counterpart and then obtain a more comprehensive radio spectrum in the follow-up ToO in order to make direct comparisons to the jet emission from sub-Eddington and super-Eddington XRBs/AGN. The EVLA is the only instrument that can perform this analysis and provide this potentially groundbreaking result.

**PI:** [Name]
Title: BAaDE: Bulge Asymmetries and Dynamic Evolution (V)

Abstract: Our 13A-16A proposals (below) targeted ∼14000 color selected MSX sources for SiO masers. Results show that we indeed obtain a very high detection rate (>50%) with our calibration scheme in a random sample of the Bulge sources. With demonstrated feasibility and our observing schedule preparation and data reduction pipelines, we are ready to complete the survey by observing the remaining ∼5000 sources. We therefore propose to continue the largest ever survey of Galactic SiO maser (red giant) sources in the Galactic plane, bulge and inner Galaxy as tracers of the population and gravitational potential of the Galaxy. The detection of >10,000 SiO masers yields numbers comparable to optical surveys, but the proposed survey would extend coverage to the highly obscured lowest Galactic latitudes. Our survey exposes luminous SiO masers suitable for orbit and parallax determination using VLBA. The velocity structure of these tracers will relate the kinematic structures to those seen in the CO gas, highlight kinematically coherent (possibly younger) structures, complex orbit structure in the bar, or infalling systems. As SiO masers are detectable both near the obscured plane and Center as well as in regions with less optical extinction, there will be a solid connection to optical studies.

PI: Lorent Sijweewman

Proposal: Click to search

### Execution Blocks

<table>
<thead>
<tr>
<th>Obs ID</th>
<th>Obs Start</th>
<th>Obs Stop</th>
<th>Cal Status</th>
</tr>
</thead>
<tbody>
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<td>2017-05-07T03:02:38.40Z</td>
<td>2017-05-07T06:36.649Z</td>
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<tr>
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<td>2017-05-07T03:03:350Z</td>
<td>2017-05-07T14:59:01.349Z</td>
<td>Do Not Calibrate</td>
</tr>
</tbody>
</table>

Total Items: 37
The NRAO Data Archive Tool

https://science.nrao.edu/

→ Facilities → VLA, Data Archive (left menu), VLA/VLBA Archive
The Archive Tool

Log in for proprietary data here

Also https://archive.nrao.edu/

In order to unlock your proprietary data and have access to other archive tools, you must log in to your My.NRAO account.
### The Archive Tool

**NRAO Science Data Archive: Advanced Search Tool**

**Historical VLA, Jansky VLA, VLBA and GBT Data Products**

#### Output Control Parameters:

- **Choose Query Return Type**:
  - Download Archive Data Files
  - VLA Observations Summary
  - List of Observation Scans
  - List of Projects

- **Output Tbl Format**: HTML
- **Max Output Tbl Rows**: NO LIMIT
- **Sort Order Column 1**: Starttime
- **Sort Order Column 2**: Starttime

#### General Search Parameters:

- **Project Code**: GBT: AGBT12A_055, JVLA: 12A-256
- **Observer Name**
- **Project Session**
- **Dates From** (2010-06-21 14:20:30)
- **Archive File ID**: (partial strings allowed)
- **To**

#### Position Search:

- **Target Name**
- **RA or Longitude**: (04h33m11.1s or 68.29d)
- **DEC or Latitude**: (05d21'15.5" or 5.352d)
- **Search Radius**: 1.0'
- **Search Type**: SIMBAD or NED
- **Min. Exposure**: (secs)
- **Equinox**: J2000

In order to unlock your proprietary data and have access to other archive tools, you must log in to your My.NRAO account.
Basic Search: simpler interface

In order to unlock your proprietary data and have access to other archive tools, you must log in to your My.NRAO account.

### NRAO Science Data Archive: Basic Search Tool

#### Historical VLA, Jansky VLA, VLBA and GBT Data Products

<table>
<thead>
<tr>
<th>Instructions on how to download your data:</th>
<th>click here</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Project (Proposal) Code</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Observer</strong>:</td>
<td></td>
</tr>
<tr>
<td><strong>Telescope</strong>:</td>
<td>ALL</td>
</tr>
<tr>
<td><strong>Observe Start Date</strong>:</td>
<td></td>
</tr>
<tr>
<td><strong>Observe Stop Date</strong>:</td>
<td></td>
</tr>
</tbody>
</table>

**Query Control Parameters:**

- **Enter Locked Project Access Key**
- **Query Returns**: Download Archive Files

The NRAO proposal or observing project id.
The observer's name. Case sensitive, partial string searches best.
You may restrict the search to a single telescope.
Format: yyyy-MMM-dd or yyyy-MMM-dd hh:mm:ss
Format: yyyy-MMM-dd or yyyy-MMM-dd hh:mm:ss

Unique keywords may be used to unlock proprietary data from individual observing projects. Contact the NRAO Data Analysts for project access keys.
Select 'Download Archive Files' to proceed to the download page, the other options are for browsing.

Please direct feedback and/or questions concerning this page and its associated search engine to [NRAO DAS contact](#).
Query return

- For each match, the archive query return presents per observation (i.e. per row):
  - The observing run identifier (i.e., the SB name)
  - Any data quality issues (highlighted in yellow/red)
  - The SDM-BDF set (content of the SDM directory)
  - The individual scans with their details – see next
  - The operator log (usually, also sent by email)
## Scan listing:

Scan details (source, date, setup, etc)

<table>
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<tbody>
<tr>
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<td>1.1</td>
<td>J120+1420</td>
<td></td>
<td>11-Aug-09 00:02:01</td>
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</table>
### Scan Listing

**FYI: reference pointing and OTF have subscans**

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</table>

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**VLA data reduction - Part 1: observing to calibration – Socorro, October 2017**
Download options: data format

- **Data formats:**
  - SDM-BDF
  - CASA measurement set, i.e., CASA MS (default)
  - SDM tables only
- **Flagging and averaging options only apply to CASA MS format**
- If CASA MS is requested, the native SDM-BDF is converted to MS using CASA’s `importevla` task (which allows flagging and averaging)
Download options: flagging

‘Telescope flags’

- Online flags, e.g., antenna not on source, sub-reflector error
- Shadowing flags, and
- Zero flags (pure zero’s)

- If the “apply flags” option is not checked, the flags are written to a FLAG_CMD MS table. They can later be applied by using the CASA task `flagcmd`
- If checked, flags are applied to the data in the MS conversion
Download options: averaging

- Possible to average MS data in time and/or in frequency
- Selection of scan numbers (use scan listing mentioned before)
- For these, the archive tool uses the CASA task `split`
Notes on averaging

Averaging decreases data size which helps in the transfer and data reduction speed.

When averaging:
- Apply the flags!
- Frequency averaging may cause coherence loss. Check that delays are small before frequency averaging.
- Amount of allowable time averaging depends on the science goal. The VLA Observational Status Summary discusses amplitude loss due to time averaging.
Transfer of SDM and MS directories:

- The SDM-BDF and MS are data directories!
  - For downloading over internet, “tar” is recommended (but requires twice the disk space)
  - Alternatively, use “wget”
Some final archive notes

• The native SDM-BDF data is always good:
  • May take a while to convert to MS at home
  • Should be usable for any CASA version available
  • Can also be used for AIPS
• Archive processed (averaged/flagged MS) data may need the same CASA version to proceed
  • Version used should be listed in a file in the download directory in *__asdm2MS.log or *__casalog.log
• Pipeline processed (MS) data and/or products may need the same CASA version to proceed
  • Calibration tables specific to CASA version
Requesting data on a hard disk

• NRAO can ship data on hard disks upon request, e.g.:
  – when the size of the data is large (over a few 100 GB)
  – when the internet connection cannot handle the request

• This disk-ordering process is done through the archive tool.
• Data is shipped on a 2 TB disk (which holds 1.8 TB of data)
• Cost: **USD 125** per disk, potentially plus shipping cost

• Disk shipment information and policies are posted at
  [https://science.nrao.edu/facilities/vla/archive/shipment](https://science.nrao.edu/facilities/vla/archive/shipment)
Getting CASA Pipeline Calibrated Data

• Upcoming VLA CASA pipeline talks…

• Note that VLA CASA calibration pipeline products are not yet available through the archive (work is in progress)

• Request pipelined data products through the VLA Pipeline department of the NRAO help desk (https://help.nrao.edu/)
  Download through the internet or ask for a hard disk (purchase)
Loading data into AIPS

- Conversion from the native SDM into UV FITS format is no longer supported through the archive.
  - Download the native SDM-BDF from the archive.
  - Use OBIT to load into AIPS using task ’bdf2aips’.
    http://www.cv.nrao.edu/~bcotton/Obit.html
  - For more details on the VLA data archive, see https://science.nrao.edu/facilities/vla/archive/index
Examine the visibility data (in CASA)
CASA

• Web site: http://casa.nrao.edu/
• Available for both Linux and Mac OS

• Make sure to subscribe to the CASA mailing lists:
  – casa-announce: announcements of new releases, workshops, etc…
  – casa-users: critical bugs and code updates

http://casa.nrao.edu/ → Getting Help → Mailing lists
CASA

• Documentation is available at http://casa.nrao.edu/ → ‘Using CASA’
• Training material is available at http://casaguides.nrao.edu
• For help, use the NRAO help desk at: http://help.nrao.edu

CASA 5.1.0 will be used at this workshop
CASA

• All CASA tasks can be listed by `tasklist`
• The tasks are grouped as:
  – Import/export
  – Information
  – Editing
  – Manipulation
  – Calibration
  – Modeling
  – Imaging
  – Analysis
  – Visualization
  – Simulation
  – Single dish
  – Utility

• AIPS(/MIRIAD/CLIC) to CASA dictionary in the CASA cookbook:
  

(see Appendix I)
Loading The Data: *importevla*

If one chooses to download the SDM-BDF (not CASA MS)

- **Task** *importevla* converts the SDM-BDF to MS
- *importevla* understands VLA online flags:
  - It converts the data into a MS while applying various types of flagging (online flags, pure zeros, shadowing).

```
> default importevla
> inp
> asdm = 'archive_sdm_directory_name'
> vis = 'output MS name'
> ocorr_mode = 'co' (or load ca, ao)
> scans = ''
```
Loading The Data: importevla

Flags:

- online = True
- tbuff = 0.0
- flagzero = True
- flagpol = True
- shadow = True
- tolerance = 0.0
- applyflags = False

- If applyflags = False (default) => the flags are written to a FLAG_CMD MS table. They can be examined (listed, plotted) and applied by using the task flagcmd [recommended]

- If applyflags = True => the flags are applied to the data
Examining Your Data

• Operator observing log (email, posted on web)

• Observing summary: \textit{listobs}
  (sources, scans, spectral windows, antennas, etc…)

• Plotting the antenna positions: \textit{plotants}

• Plotting/displaying data: \textit{plotms}, and \textit{msview} or \textit{viewer}

Examine your data carefully before flagging:
That is, know your data content
Observing Summary: listobs

vis = 'my.ms'
verbose = True (or False)
listfile = 'file_with_listobs_output'

listobs: MeasurementSet Name: /lustre/acq/users/edmondian/zeeman/StokesV_50Hz_
listobs: Observer: Dr. Emmanuel Momjian Project: T.B.D.
listobs: Observation: EVLA(27 antennas)
listobs: Data records: 1249911 Total integration time = 3586.94 seconds
listobs: Fields: 3

<table>
<thead>
<tr>
<th>ID</th>
<th>Code Name</th>
<th>RA</th>
<th>Decl</th>
<th>Epoch</th>
<th>SrcId</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>D</td>
<td>J1851+0035</td>
<td>18:51:46.7217</td>
<td>+00.35.32.4140</td>
<td>J2000</td>
</tr>
<tr>
<td>1</td>
<td>NONE</td>
<td>G37.40+1.52*</td>
<td>18:54:14.2627</td>
<td>+04.41.41.4167</td>
<td>J2000</td>
</tr>
<tr>
<td>2</td>
<td>E</td>
<td>0137+331=3C*</td>
<td>01:37:41.2994</td>
<td>+33.09.35.1330</td>
<td>J2000</td>
</tr>
</tbody>
</table>

nVis = Total number of time/baseline visibilities per field

listobs: Spectral Windows: (1 unique spectral windows and 1 unique polarization setups)

<table>
<thead>
<tr>
<th>SpwID</th>
<th>#Chans</th>
<th>Frame Ch1(MHz)</th>
<th>ChanWid(kHz)</th>
<th>TotBW(kHz)</th>
<th>Ref(MHz)</th>
<th>Corrs</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>256</td>
<td>TOPO 6667.85673</td>
<td>0.9765625</td>
<td>250</td>
<td>6667.85673</td>
<td>RR LL</td>
</tr>
</tbody>
</table>

listobs: Sources: 3

<table>
<thead>
<tr>
<th>ID</th>
<th>Name</th>
<th>SpwId</th>
<th>RestFreq(MHz)</th>
<th>SysVel(km/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>J1851+0035</td>
<td>0</td>
<td>6668.518</td>
<td>41</td>
</tr>
<tr>
<td>1</td>
<td>G37.40+1.52*</td>
<td>0</td>
<td>6668.518</td>
<td>41</td>
</tr>
<tr>
<td>2</td>
<td>0137+331=3C*</td>
<td>0</td>
<td>6668.518</td>
<td>41</td>
</tr>
</tbody>
</table>

listobs: Antennas: 27 'name'='station'

<table>
<thead>
<tr>
<th>ID=</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-3</td>
<td>'ea01'='W72', 'ea02'='E56', 'ea03'='E72', 'ea04'='W64',</td>
</tr>
<tr>
<td>4-7</td>
<td>'ea05'='W08', 'ea06'='N40', 'ea07'='E32', 'ea08'='N64',</td>
</tr>
<tr>
<td>8-11</td>
<td>'ea09'='E24', 'ea10'='N32', 'ea11'='E40', 'ea12'='E08',</td>
</tr>
<tr>
<td>12-15</td>
<td>'ea13'='N16', 'ea14'='W48', 'ea15'='W24', 'ea16'='N48',</td>
</tr>
<tr>
<td>16-19</td>
<td>'ea17'='W32', 'ea18'='E48', 'ea19'='W40', 'ea20'='N72',</td>
</tr>
<tr>
<td>20-23</td>
<td>'ea22'='N24', 'ea23'='E16', 'ea24'='W16', 'ea25'='N56',</td>
</tr>
<tr>
<td>24-26</td>
<td>'ea26'='W56', 'ea27'='E64', 'ea28'='N08',</td>
</tr>
</tbody>
</table>
Plotting the antennas: \textit{plotants}

\begin{verbatim}
vis = 'my.ms'
\end{verbatim}

- **Reference antenna:**
  - Pick a few, need baselines to all other antennas (to be checked)
  - Keep in mind when examining data (use the one with in the end least data flagged)
Data Review: `plotms` (unix command line `casaplotms`)
Data Review: *plotms*

**Control Panel: Data**

Check the ‘Reload’ box if the MS has been modified through another task.

Use the ‘Options’ to divide the screen into multiple panels, and ‘Add plot’ to be able make plots of multiple data sets (or one data set but using different axes) onto the graphic panel.
Data Review: **plotms**

**MS IDs and other meta info:**
- 'scan' (number)
- 'field' (index)
- 'time',
- 'interval'='timeint'='timeinterval'='time_interval'
- 'spw' (index)
- 'chan'='channel' (index)
- 'freq'='frequency' (GHz)
- 'vel'='velocity' (km/s)
- 'corr'='correlation' (index)
- 'ant1'='antenna1' (index)
- 'ant2'='antenna2' (index)
- 'baseline' (a baseline index)
- 'row' (absolute row ID from the MS)

**Visibility values, flags:**
- 'amp'='amplitude'
- 'phase' (deg)
- 'real'
- 'imag'='imaginary'
- 'wt'='weight'
- 'flag'
- 'flagrow'
Data Review: plotms

Observational geometry:
'uvdist' (meters)
'uvwave'='uvdistl'='uvdist_l' (wavelengths, per channel)
'u' (meters)
'v' (meters)
'w' (meters)
'azimuth' (at array reference; degrees)
'elevation' (at array reference; degrees)
'hourang'='hourangle' (at array reference; hours)
'parang'='parangle'='parallacticangle' (at array reference; degrees)

Antenna-based (only works vs. data Ids):
'ant'='antenna'
'ant-azimuth'
'ant-elevation'
'ant-parang'='ant-parangle'
Data Review: *plotms*

Page: to iterate on

- Scan
- Field
- Spw
- Baseline
- Antenna
- Time

Tool panel
Data Review: *plotms*

Transformations

Frame: TOPO, GEO, BARY, LSRK, LSRD, etc..

(While examining your data you probably want to keep the data in channel or frequency)
Data Review: *plotms*

Display

Colorize by:
- Scan
- Field
- Spw
- Antenna1
- Antenna2
- Baseline
- Channel
- Correlation
- Time
What are we looking for?

• A feel of the overall structure of the data
  (see also the OPT schedule):
    – Calibrators and target visibilities, frequency setup
    – Observing conditions, instrumental response

• Where to expect bad data
  – Specific ill-performing antennas/baseline(boards)
  – In time
    • Start of scans
    • Bad weather(pointing) (observing conditions)
  – In frequency
    • Bandpass, subband edges
    • RFI – not your line!
Data Review: *plotms*

Example: `xaxis='time', yaxis='amp,' coloraxis='field'`

Page: iterating on spw (with all channels averaged)
Radio Frequency Interference (RFI)

1. VLA observations, particularly at the lower frequency bands, will be severely affected by RFI.

2. VLA RFI information is available at:


   - RFI listings per frequency band.
   - Spectra of various RFI sweeps between 1-50 GHz.
RFI is present at lower frequency bands

![Graphs showing RFI at different frequency bands: L band, S band, C band, X band.](image)
RFI/birdies at the higher frequency bands

Ku band

K band

Ka band

Q band
Data Review: `plotms`

Example: `xaxis='frequency', yaxis='amp', coloraxis='spw'`

Iterating on scan
RFI: feedback from observers

• The VLA has opened the full 1 to 50 GHz frequency range.
  • Also the 230-470 MHz range.
• This exposed us to all types of RFI.
• RFI is direction dependent.
• User feedback is critical for our ongoing RFI identification and monitoring efforts.
• Observers are asked to email nrao-rfi@nrao.edu and provide:
  – Observation/project code
  – Frequency and time of the observations
  – The characteristics of the RFI signal (e.g., continuous, intermittent)
  – A spectrum
RFI: spectral (Gibbs) ringing

- Strong RFI will introduce disturbing spectral ringing.
- Hanning-smoothing should be applied on such data sets before attempting any spectral flagging, or calibration.
- In CASA, the task to use is `hanningsmooth`.
- **Probably want to flag this affected data after HS** (bad antennas, etc., you probably want to flag before smoothing)
Preparing for calibration: flagging
Flagging (or unflagging) Data

1. **flagdata**: All purpose flagging task based on selection.
   - Includes RFI flagging capabilities (RFLAG, TFCROP).

2. **flagcmd**: All purpose flagging task based on commands (alternative to **flagdata** for certain types of flagging).

3. **plotms**: Interactive flagging

4. **msview/viewer**: Interactive flagging

**Review the VLA operator’ s log carefully.**
**Certain issues (e.g., antennas without receivers), do not end up in the online flags, and may need to be flagged manually.**
Flagging (or unflagging) Data

A few important notes

1. Data in CASA are either flagged or not flagged.
   - Every MS has a flag column.
   - Every bit of data has its own flag (set either to true or false).
   - Applying flags means setting the flag column entries of the selected bits of data to true.

2. Most flagging tasks have the option of creating a flag backup.

3. A flag backup is an MS table made by a given flagging task and contains the state of the flags before running the flagging task.

4. With flagmanager flag back-ups can be restored (and made)
Flagging Data: *flagdata* - Modes

- **list** = apply a list of flagging commands
- **manual** = flagging based on specific selection parameters
- **clip** = clip data according to values
- **quack** = remove/keep specific time range at scan beginning/end
- **shadow** = remove antenna-shadowed data
- **elevation** = remove data below/above given elevations
- **tfcrop** = auto identification of outliers on the time-freq plane
- **rflag** = auto detection of outliers based on sliding-window RMS filters
- **extend** = extend and/or grow flags
- Also **summary** (per antenna, correlation, field, scan, total), and **unflag**.
- Can also flag calibration tables.
Flagging Data: *flagcmd*

- It allows listing, plotting, saving, applying, or un-applying flags.
- **Flagging modes** (*inp mode*) are:
  - *table*: uses the `FLAG_CMD` MS table (initially created by `importevla`)
  - *list*: uses an ASCII file that contains a set of flagging commands.
  - *xml*: uses the online flags from Flag.xml in the MS.
- It allows the user to save the flag records in the `FLAG_CMD` MS table or a file.
Examining the flags with `flagcmd` list

<table>
<thead>
<tr>
<th>Key</th>
<th>FlagID</th>
<th>Antenna</th>
<th>Reason</th>
<th>TimeRange</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>ea28</td>
<td>SUBREFLECTOR_ERROR</td>
<td>2011/08/09 00:02:00.401-2011/08/09 00:02:15.300</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>ea26</td>
<td>SUBREFLECTOR_ERROR</td>
<td>2011/08/09 00:02:00.435-2011/08/09 00:02:15.274</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>ea21</td>
<td>SUBREFLECTOR_ERROR</td>
<td>2011/08/09 00:02:00.478-2011/08/09 00:02:15.093</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>ea08</td>
<td>SUBREFLECTOR_ERROR</td>
<td>2011/08/09 00:02:00.478-2011/08/09 00:02:15.300</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>ea22</td>
<td>SUBREFLECTOR_ERROR</td>
<td>2011/08/09 00:02:00.487-2011/08/09 00:02:14.946</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>ea27</td>
<td>SUBREFLECTOR_ERROR</td>
<td>2011/08/09 00:02:00.487-2011/08/09 00:02:15.594</td>
</tr>
<tr>
<td>6</td>
<td>6</td>
<td>ea20</td>
<td>SUBREFLECTOR_ERROR</td>
<td>2011/08/09 00:02:00.522-2011/08/09 00:02:15.343</td>
</tr>
<tr>
<td>7</td>
<td>7</td>
<td>ea03</td>
<td>ANTEenna_NOT_ON_SOURCE</td>
<td>2011/08/09 00:02:00.548-2011/08/09 00:06:58.557</td>
</tr>
<tr>
<td>8</td>
<td>8</td>
<td>ea03</td>
<td>SUBREFLECTOR_ERROR</td>
<td>2011/08/09 00:02:00.548-2011/08/09 00:02:15.551</td>
</tr>
<tr>
<td>9</td>
<td>9</td>
<td>ea18</td>
<td>ANTEenna_NOT_ON_SOURCE</td>
<td>2011/08/09 00:02:00.573-2011/08/09 00:07:31.533</td>
</tr>
<tr>
<td>10</td>
<td>10</td>
<td>ea18</td>
<td>SUBREFLECTOR_ERROR</td>
<td>2011/08/09 00:02:00.573-2011/08/09 00:02:15.084</td>
</tr>
<tr>
<td>11</td>
<td>11</td>
<td>ea04</td>
<td>ANTEenna_NOT_ON_SOURCE</td>
<td>2011/08/09 00:02:00.573-2011/08/09 00:06:30.586</td>
</tr>
<tr>
<td>12</td>
<td>12</td>
<td>ea04</td>
<td>SUBREFLECTOR_ERROR</td>
<td>2011/08/09 00:02:00.573-2011/08/09 00:02:15.179</td>
</tr>
<tr>
<td>13</td>
<td>13</td>
<td>ea19</td>
<td>ANTEenna_NOT_ON_SOURCE</td>
<td>2011/08/09 00:02:00.591-2011/08/09 00:06:42.907</td>
</tr>
<tr>
<td>14</td>
<td>14</td>
<td>ea19</td>
<td>SUBREFLECTOR_ERROR</td>
<td>2011/08/09 00:02:00.591-2011/08/09 00:02:16.069</td>
</tr>
<tr>
<td>15</td>
<td>15</td>
<td>ea28</td>
<td>ANTEenna_NOT_ON_SOURCE</td>
<td>2011/08/09 00:02:00.599-2011/08/09 00:06:42.397</td>
</tr>
<tr>
<td>16</td>
<td>16</td>
<td>ea07</td>
<td>ANTEenna_NOT_ON_SOURCE</td>
<td>2011/08/09 00:02:00.608-2011/08/09 00:06:46.907</td>
</tr>
<tr>
<td>17</td>
<td>17</td>
<td>ea16</td>
<td>ANTEenna_NOT_ON_SOURCE</td>
<td>2011/08/09 00:02:00.591-2011/08/09 00:06:39.658</td>
</tr>
<tr>
<td>18</td>
<td>18</td>
<td>ea07</td>
<td>SUBREFLECTOR_ERROR</td>
<td>2011/08/09 00:02:00.608-2011/08/09 00:02:15.663</td>
</tr>
<tr>
<td>19</td>
<td>19</td>
<td>ea16</td>
<td>SUBREFLECTOR_ERROR</td>
<td>2011/08/09 00:02:00.591-2011/08/09 00:06:15.706</td>
</tr>
<tr>
<td>20</td>
<td>20</td>
<td>ea10</td>
<td>ANTEenna_NOT_ON_SOURCE</td>
<td>2011/08/09 00:02:00.608-2011/08/09 00:06:45.810</td>
</tr>
<tr>
<td>21</td>
<td>21</td>
<td>ea01</td>
<td>ANTEenna_NOT_ON_SOURCE</td>
<td>2011/08/09 00:02:00.591-2011/08/09 00:06:30.301</td>
</tr>
<tr>
<td>22</td>
<td>22</td>
<td>ea10</td>
<td>SUBREFLECTOR_ERROR</td>
<td>2011/08/09 00:02:00.617-2011/08/09 00:02:15.706</td>
</tr>
<tr>
<td>23</td>
<td>23</td>
<td>ea01</td>
<td>SUBREFLECTOR_ERROR</td>
<td>2011/08/09 00:02:00.591-2011/08/09 00:02:15.430</td>
</tr>
<tr>
<td>24</td>
<td>24</td>
<td>ea02</td>
<td>ANTEenna_NOT_ON_SOURCE</td>
<td>2011/08/09 00:02:00.625-2011/08/09 00:06:59.098</td>
</tr>
</tbody>
</table>
Examining the flags with `flagcmd`
Flagging Data: *flagdata vs. flagcmd*

- Complementary flagging tasks.
- Have several common features.
- Some of the important differences:

<table>
<thead>
<tr>
<th>Flagdata</th>
<th>Flagcmd</th>
</tr>
</thead>
<tbody>
<tr>
<td>RFI flagging (tfcrop, rflag)*</td>
<td>Access to the Flag.xml</td>
</tr>
<tr>
<td>Runtime displays* (before and after flagging)</td>
<td>Apply the online (and other) flags in FLAG_CMD MS table</td>
</tr>
<tr>
<td></td>
<td>Plot Flags</td>
</tr>
</tbody>
</table>

* More details on Tuesday (RFI talk)
Flagging Data: *plotms*
Flagging Data: `plotms`

To flag:
- Click on the flagging tool in the `plotms` interface.
- Select the regions you want to flag by clicking on them.

To select regions:
- Use the selection tools in the `plotms` interface to draw or select the regions you want to flag.

The `plotms` interface allows you to visualize and manage your data by flagging certain regions based on time, amplitude, and other parameters.
Flagging Data: plotms

To select regions
To locate

Amp vs. Time
Flagging Data: `plotms`

The output of "locate" in the casalog – look for common lines

<table>
<thead>
<tr>
<th>Scan</th>
<th>Field</th>
<th>Time</th>
<th>BL = ea13 &amp; ea16</th>
<th>Spw</th>
<th>Chan</th>
<th>Freq</th>
<th>Corr</th>
</tr>
</thead>
<tbody>
<tr>
<td>9</td>
<td>W3IRS5</td>
<td>2011/08/06/10:36:57.3</td>
<td>ea13 &amp; ea16 [11 &amp; 14]</td>
<td>0</td>
<td>125</td>
<td>22.2398</td>
<td>RR</td>
</tr>
<tr>
<td>9</td>
<td>W3IRS5</td>
<td>2011/08/06/10:36:57.3</td>
<td>ea13 &amp; ea16 [11 &amp; 14]</td>
<td>0</td>
<td>125</td>
<td>22.2398</td>
<td>LL</td>
</tr>
<tr>
<td>9</td>
<td>W3IRS5</td>
<td>2011/08/06/10:36:58.3</td>
<td>ea13 &amp; ea16 [11 &amp; 14]</td>
<td>0</td>
<td>125</td>
<td>22.2398</td>
<td>RR</td>
</tr>
<tr>
<td>9</td>
<td>W3IRS5</td>
<td>2011/08/06/10:36:59.3</td>
<td>ea13 &amp; ea16 [11 &amp; 14]</td>
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<td>9</td>
<td>W3IRS5</td>
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<td>ea13 &amp; ea16 [11 &amp; 14]</td>
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<td>22.2398</td>
<td>LL</td>
</tr>
<tr>
<td>9</td>
<td>W3IRS5</td>
<td>2011/08/06/10:37:00.3</td>
<td>ea13 &amp; ea16 [11 &amp; 14]</td>
<td>0</td>
<td>125</td>
<td>22.2398</td>
<td>RR</td>
</tr>
<tr>
<td>9</td>
<td>W3IRS5</td>
<td>2011/08/06/10:37:00.3</td>
<td>ea13 &amp; ea16 [11 &amp; 14]</td>
<td>0</td>
<td>125</td>
<td>22.2398</td>
<td>LL</td>
</tr>
<tr>
<td>9</td>
<td>W3IRS5</td>
<td>2011/08/06/10:37:01.3</td>
<td>ea13 &amp; ea16 [11 &amp; 14]</td>
<td>0</td>
<td>125</td>
<td>22.2398</td>
<td>RR</td>
</tr>
<tr>
<td>9</td>
<td>W3IRS5</td>
<td>2011/08/06/10:37:01.3</td>
<td>ea13 &amp; ea16 [11 &amp; 14]</td>
<td>0</td>
<td>125</td>
<td>22.2398</td>
<td>LL</td>
</tr>
<tr>
<td>9</td>
<td>W3IRS5</td>
<td>2011/08/06/10:37:02.3</td>
<td>ea13 &amp; ea16 [11 &amp; 14]</td>
<td>0</td>
<td>125</td>
<td>22.2398</td>
<td>RR</td>
</tr>
<tr>
<td>9</td>
<td>W3IRS5</td>
<td>2011/08/06/10:37:02.3</td>
<td>ea13 &amp; ea16 [11 &amp; 14]</td>
<td>0</td>
<td>125</td>
<td>22.2398</td>
<td>LL</td>
</tr>
<tr>
<td>9</td>
<td>W3IRS5</td>
<td>2011/08/06/10:37:03.3</td>
<td>ea13 &amp; ea16 [11 &amp; 14]</td>
<td>0</td>
<td>125</td>
<td>22.2398</td>
<td>RR</td>
</tr>
<tr>
<td>9</td>
<td>W3IRS5</td>
<td>2011/08/06/10:37:03.3</td>
<td>ea13 &amp; ea16 [11 &amp; 14]</td>
<td>0</td>
<td>125</td>
<td>22.2398</td>
<td>LL</td>
</tr>
<tr>
<td>9</td>
<td>W3IRS5</td>
<td>2011/08/06/10:37:04.3</td>
<td>ea13 &amp; ea16 [11 &amp; 14]</td>
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<td>125</td>
<td>22.2398</td>
<td>RR</td>
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<td>W3IRS5</td>
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<td>125</td>
<td>22.2398</td>
<td>LL</td>
</tr>
</tbody>
</table>
Flagging Data: *plotms*
Flagging Data: `plotms`

A few important notes

- Use `plotms` carefully for flagging data.
- Keep in mind that flagging data with `plotms` often requires extending the flags (through the Flag tab).
- `plotms` does not produce a flag backup (`flagmanager` has to be used).
- Use `plotms` to identify bad data (through the locate option). Then flag the bad data using `flagcmd` or `flagdata`.
Flagging Data: \textit{msview}

- Shows gray scale (or colored) waterfall, plots.
- Plots Time vs. Baseline, or Time vs. Channel for
  - Amplitude (or amplitude diff or amplitude rms)
  - Phase (or phase diff or phase rms)
  - Real
  - Imaginary
- Provides interactive flagging tools (comparable to TVFLG and SPFLG in AIPS).
Flagging Data: msview

http://casaguides.nrao.edu/ → CASA Tips → Data flagging with viewer
Flagging Data: *msview*

Use the Flagging Options

- to expand the flags.
- to apply the flags.
Ready to calibrate the data?

✓ The data structure is understood, reference antenna picked
✓ Calibrators (flux density, bandpass, gain) are identified
✓ Bad antennas and bad basebands are flagged
✓ RFI is removed (as much as possible), hanning smooth?
✓ Bad individual visibilities/baselines/times are flagged

• Maybe inspect (some parts of) the data again to make sure
  Likely more flagging may need to be done during/after calibration steps

• Ready to start with data calibration
  Next lecture…