VLA data reduction – part 1:

Post-observing, pre-calibration

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NRAO

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

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 synthesis imaging workshop
  https://science.nrao.edu/science/meetings/2014/14th-synthesis-imaging-workshop/
- 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)

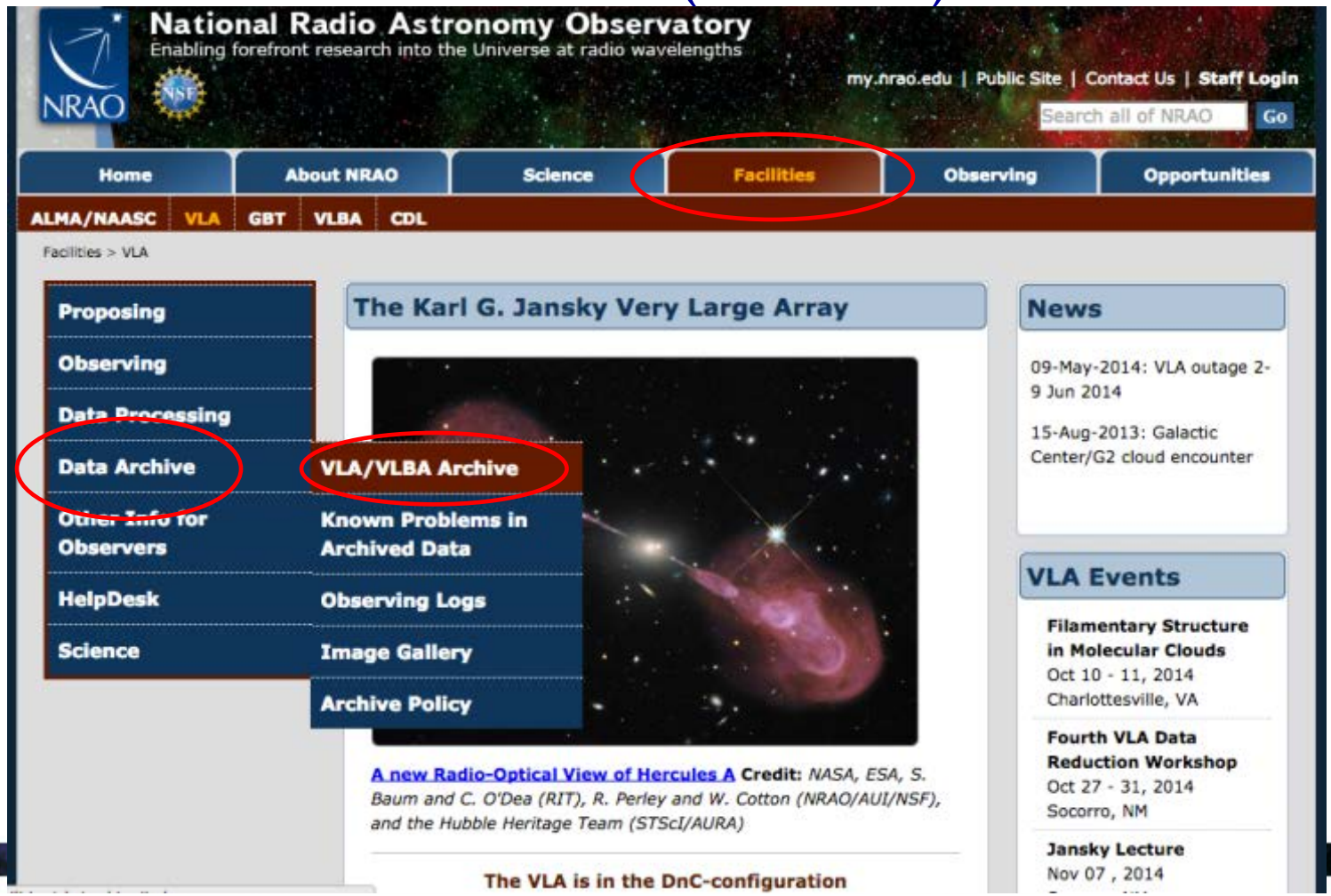
Obtaining data from the NRAO archive

(using the *current* archive tool)

The NRAO Data Archive Tool

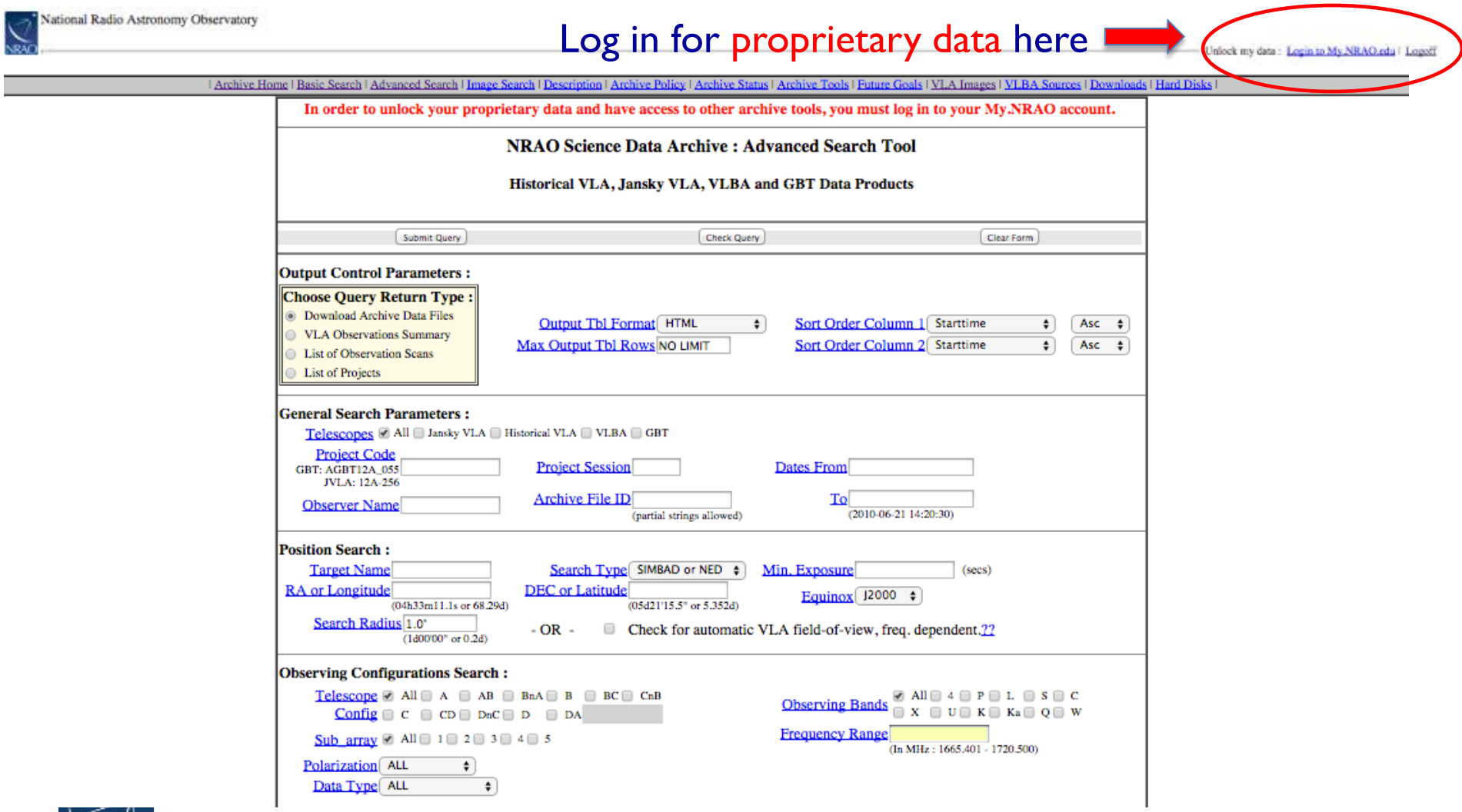
https://science.nrao.edu/

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

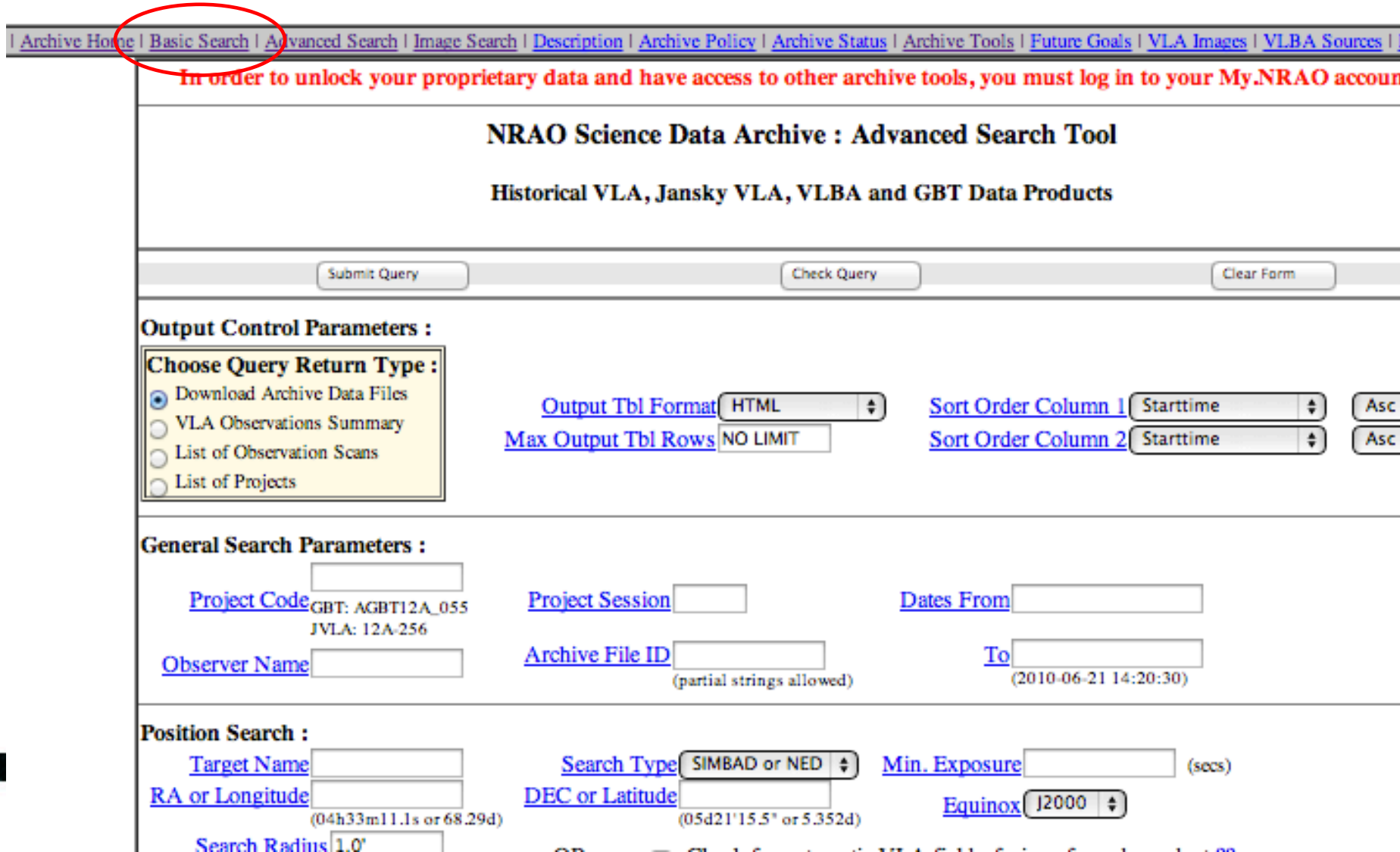


The Archive Tool

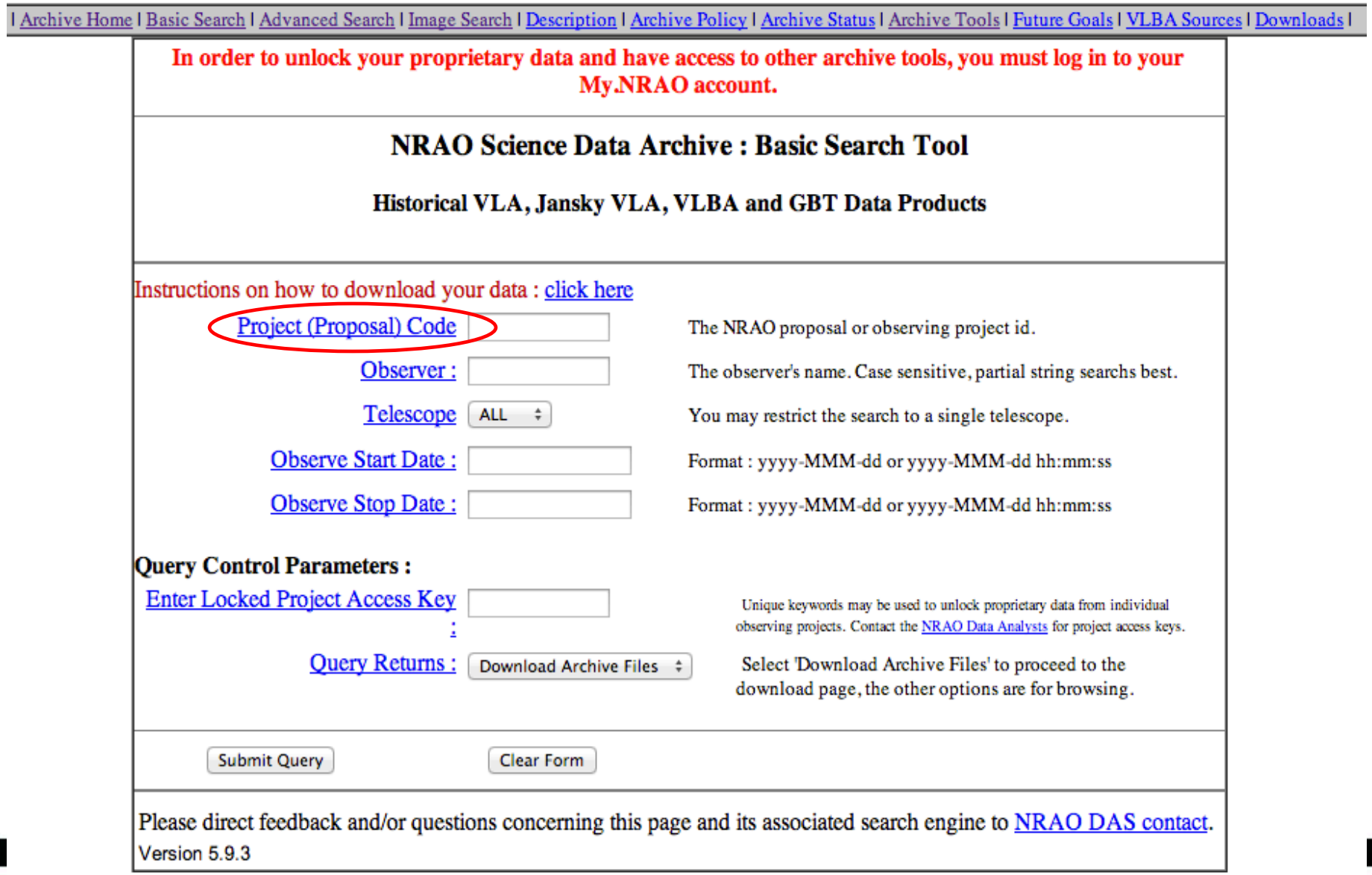
Also https://archive.nrao.edu/



The Archive Tool



Basic Search: simpler interface



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)

Archive File	Status	Project	Seg	Obs. Data Starts	Obs. Data Stops	File Size	Telescope: config:sub"	Bands	Format	Type	Data Qual	View Scans	Logs etc.
11A-291.sb4911125.eb4924302.55782.00136674769	public	11A-291	x	11-Aug-09 00:02:01	11-Aug-09 01:01:45	42.46GB	VLA:A:0	L	SDMset	raw	OK	Scans	Logs
11A-291.sb4911125.eb4944094.55784.99251239583	public	11A-291	x	11-Aug-11 23:50:07	11-Aug-13 02:14:44	30.29GB	VLA:A:0	L	SDMset	raw	OK	Scans	Logs
11A-291.sb4910900.eb4947827.55787.6933925	public	11A-291	x	11-Aug-14 16:39:27	11-Aug-14 18:39:07	78.96GB	VLA:A:0	L	SDMset	raw	info	Scans	Logs
11A-291_sb4911125_2.55795.922649976856	public	11A-291	x	11-Aug-22 22:08:44	11-Aug-22 23:08:30	36.44GB	VLA:A:0	L	SDMset	raw	OK	Scans	Logs
11A-291_sb4911125_3_000.55804.894766516205	public	11A-291	x	11-Aug-31 21:28:29	11-Aug-31 22:28:18	39.47GB	VLA:A:0	L	SDMset	raw	OK	Scans	Logs

Scan listing:

Scan details (source, date, setup, etc)

Project	Scan :sub	Source	Cal Code	Start Time	Stop Time	Sys	TOS (sec)	Intrvl (sec)	Scan Intent	Spect Win	Obs_Freq (MHz)	Bandw (MHz)	Polar	Spect chans	Corr Mode	Tele:config :sub:nants	RA(J2000)	DEC(J2000)	Archive File
11A-291	1:1	J1120+1420		11-Aug-09 00:02:01	11-Aug-09 00:02:54	UTC	53.5	1	OBS	CD_0:SW_0	958.000000	64.000	RR,LL	128	WIDR	EVLA:A:1:27	11h20m27.807s	+14d20'54.99"	11A-291.sb4911125.eb4924302.55782.00136674769 uid___evla_bdf_1312848123251.bdf
										CD_0:SW_1	1062.000000	64.000	RR,LL	128	WIDR				
										CD_0:SW_2	1126.000000	64.000	RR,LL	128	WIDR				
										CD_0:SW_3	1190.000000	64.000	RR,LL	128	WIDR				
										CD_0:SW_4	1254.000000	64.000	RR,LL	128	WIDR				
										CD_0:SW_5	1318.000000	64.000	RR,LL	128	WIDR				
										CD_0:SW_6	1382.000000	64.000	RR,LL	128	WIDR				
										CD_0:SW_7	1446.000000	64.000	RR,LL	128	WIDR				
										CD_0:SW_8	1506.000000	64.000	RR,LL	128	WIDR				
										CD_0:SW_9	1570.000000	64.000	RR,LL	128	WIDR				
										CD_0:SW_10	1634.000000	64.000	RR,LL	128	WIDR				
										CD_0:SW_11	1698.000000	64.000	RR,LL	128	WIDR				
										CD_0:SW_12	1762.000000	64.000	RR,LL	128	WIDR				
										CD_0:SW_13	1826.000000	64.000	RR,LL	128	WIDR				
										CD_0:SW_14	1890.000000	64.000	RR,LL	128	WIDR				
										CD_0:SW_15	1954.000000	64.000	RR,LL	128	WIDR				
11A-291	2:1	J1120+1420		11-Aug-09 00:02:54	11-Aug-09 00:03:54	UTC	59.8	1	CAL	CD_0:SW_0	958.000000	64.000	RR,LL	128	WIDR	EVLA:A:1:27	11h20m27.807s	+14d20'54.99"	11A-291.sb4911125.eb4924302.55782.00136674769 uid___evla_bdf_1312848123257.bdf
										CD_0:SW_1	1062.000000	64.000	RR,LL	128	WIDR				
										CD_0:SW_2	1126.000000	64.000	RR,LL	128	WIDR				
										CD_0:SW_3	1190.000000	64.000	RR,LL	128	WIDR				
										CD_0:SW_4	1254.000000	64.000	RR,LL	128	WIDR				
										CD_0:SW_5	1318.000000	64.000	RR,LL	128	WIDR				
										CD_0:SW_6	1382.000000	64.000	RR,LL	128	WIDR				
										CD_0:SW_7	1446.000000	64.000	RR,LL	128	WIDR				
										CD_0:SW_8	1506.000000	64.000	RR,LL	128	WIDR				
										CD_0:SW_9	1570.000000	64.000	RR,LL	128	WIDR				
										CD_0:SW_10	1634.000000	64.000	RR,LL	128	WIDR				
										CD_0:SW_11	1698.000000	64.000	RR,LL	128	WIDR				
										CD_0:SW_12	1762.000000	64.000	RR,LL	128	WIDR				
										CD_0:SW_13	1826.000000	64.000	RR,LL	128	WIDR				
										CD_0:SW_14	1890.000000	64.000	RR,LL	128	WIDR				
										CD_0:SW_15	1954.000000	64.000	RR,LL	128	WIDR				
11A-291	3:1	J1120+1420		11-Aug-09 00:03:54	11-Aug-09 00:05:24	UTC	89.8	1	CAL	CD_0:SW_0	958.000000	64.000	RR,LL	128	WIDR	EVLA:A:1:27	11h20m27.807s	+14d20'54.99"	11A-291.sb4911125.eb4924302.55782.00136674769 uid___evla_bdf_1312848174961.bdf
										CD_0:SW_1	1062.000000	64.000	RR,LL	128	WIDR				
										CD_0:SW_2	1126.000000	64.000	RR,LL	128	WIDR				
										CD_0:SW_3	1190.000000	64.000	RR,LL	128	WIDR				
										CD_0:SW_4	1254.000000	64.000	RR,LL	128	WIDR				
										CD_0:SW_5	1318.000000	64.000	RR,LL	128	WIDR				
										CD_0:SW_6	1382.000000	64.000	RR,LL	128	WIDR				
										CD_0:SW_7	1446.000000	64.000	RR,LL	128	WIDR				
										CD_0:SW_8	1506.000000	64.000	RR,LL	128	WIDR				
										CD_0:SW_9	1570.000000	64.000	RR,LL	128	WIDR				
										CD_0:SW_10	1634.000000	64.000	RR,LL	128	WIDR				
										CD_0:SW_11	1698.000000	64.000	RR,LL	128	WIDR				
										CD_0:SW_12	1762.000000	64.000	RR,LL	128	WIDR				
										CD_0:SW_13	1826.000000	64.000	RR,LL	128	WIDR				
										CD_0:SW_14	1890.000000	64.000	RR,LL	128	WIDR				
										CD_0:SW_15	1954.000000	64.000	RR,LL	128	WIDR				

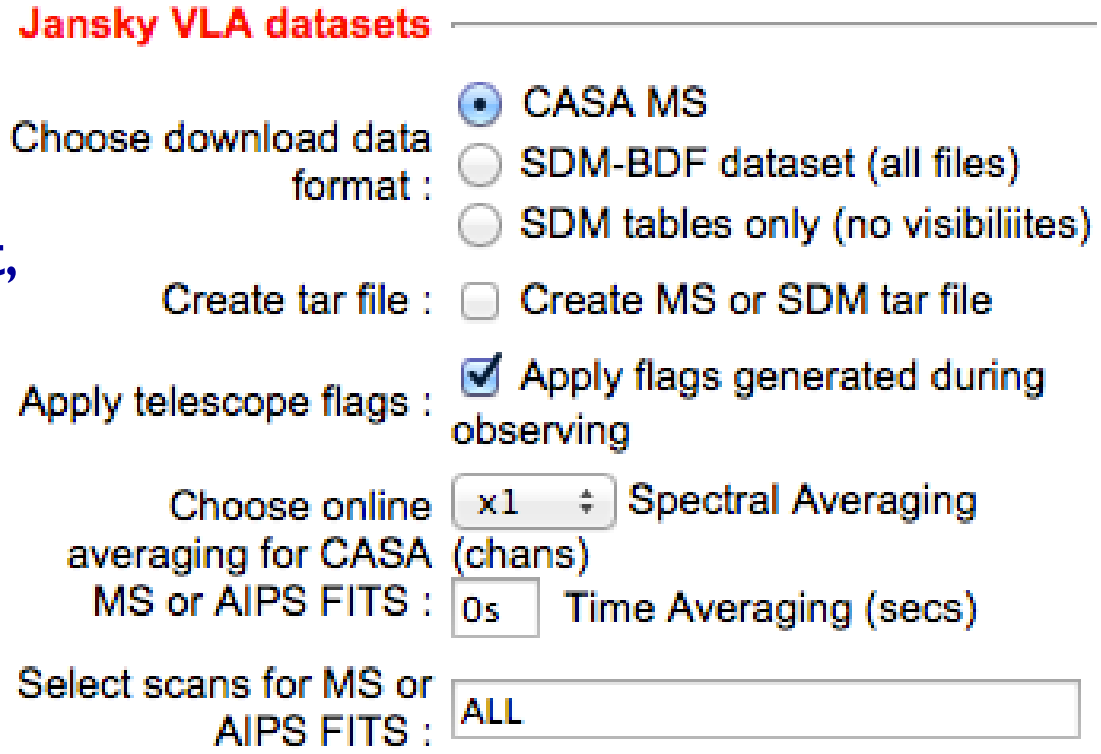
Scan listing

FYI: reference pointing and OTF have subscans

11A-258	42:1	0542+498=3C147		11-Jun-01 01:26:47	11-Jun-01 01:27:07	UTC	19.4	1	POINT	CD_1:SW_16 CD_1:SW_17	8332.000000 8460.000000	128.000 128.000	RR,RL,LR,LL RR,RL,LR,LL	64 64	WIDR WIDR	EVLA:BnA->A:1:25	05h42m36.138s	+49d51'07.23"	11A-258.sb4139176.eb4258095.55713.0339549537 uid___evla_bdf_1306891607524.bdf
11A-258	42:2	0542+498=3C147		11-Jun-01 01:27:07	11-Jun-01 01:27:27	UTC	20	1.1	POINT	CD_1:SW_16 CD_1:SW_17	8332.000000 8460.000000	128.000 128.000	RR,RL,LR,LL RR,RL,LR,LL	64 64	WIDR WIDR	EVLA:BnA->A:1:25	05h42m36.138s	+49d51'07.23"	11A-258.sb4139176.eb4258095.55713.0339549537 uid___evla_bdf_1306891608043.bdf
11A-258	42:3	0542+498=3C147		11-Jun-01 01:27:27	11-Jun-01 01:27:47	UTC	20	1.1	POINT	CD_1:SW_16 CD_1:SW_17	8332.000000 8460.000000	128.000 128.000	RR,RL,LR,LL RR,RL,LR,LL	64 64	WIDR WIDR	EVLA:BnA->A:1:25	05h42m36.138s	+49d51'07.23"	11A-258.sb4139176.eb4258095.55713.0339549537 uid___evla_bdf_1306891627503.bdf
11A-258	42:4	0542+498=3C147		11-Jun-01 01:27:47	11-Jun-01 01:28:07	UTC	20	1.1	POINT	CD_1:SW_16 CD_1:SW_17	8332.000000 8460.000000	128.000 128.000	RR,RL,LR,LL RR,RL,LR,LL	64 64	WIDR WIDR	EVLA:BnA->A:1:25	05h42m36.138s	+49d51'07.23"	11A-258.sb4139176.eb4258095.55713.0339549537 uid___evla_bdf_1306891647507.bdf
11A-258	42:5	0542+498=3C147		11-Jun-01 01:28:07	11-Jun-01 01:28:27	UTC	20	1.1	POINT	CD_1:SW_16 CD_1:SW_17	8332.000000 8460.000000	128.000 128.000	RR,RL,LR,LL RR,RL,LR,LL	64 64	WIDR WIDR	EVLA:BnA->A:1:25	05h42m36.138s	+49d51'07.23"	11A-258.sb4139176.eb4258095.55713.0339549537 uid___evla_bdf_1306891667503.bdf
11A-258	42:6	0542+498=3C147		11-Jun-01 01:28:27	11-Jun-01 01:28:47	UTC	20	1.1	POINT	CD_1:SW_16 CD_1:SW_17	8332.000000 8460.000000	128.000 128.000	RR,RL,LR,LL RR,RL,LR,LL	64 64	WIDR WIDR	EVLA:BnA->A:1:25	05h42m36.138s	+49d51'07.23"	11A-258.sb4139176.eb4258095.55713.0339549537 uid___evla_bdf_1306891687511.bdf
11A-258	42:7	0542+498=3C147		11-Jun-01 01:28:47	11-Jun-01 01:29:07	UTC	20	1.1	POINT	CD_1:SW_16 CD_1:SW_17	8332.000000 8460.000000	128.000 128.000	RR,RL,LR,LL RR,RL,LR,LL	64 64	WIDR WIDR	EVLA:BnA->A:1:25	05h42m36.138s	+49d51'07.23"	11A-258.sb4139176.eb4258095.55713.0339549537 uid___evla_bdf_1306891707505.bdf
11A-258	42:8	0542+498=3C147		11-Jun-01 01:29:07	11-Jun-01 01:29:27	UTC	20	1.1	POINT	CD_1:SW_16 CD_1:SW_17	8332.000000 8460.000000	128.000 128.000	RR,RL,LR,LL RR,RL,LR,LL	64 64	WIDR WIDR	EVLA:BnA->A:1:25	05h42m36.138s	+49d51'07.23"	11A-258.sb4139176.eb4258095.55713.0339549537 uid___evla_bdf_1306891727505.bdf
11A-258	42:9	0542+498=3C147		11-Jun-01 01:29:27	11-Jun-01 01:29:47	UTC	20	1.1	POINT	CD_1:SW_16 CD_1:SW_17	8332.000000 8460.000000	128.000 128.000	RR,RL,LR,LL RR,RL,LR,LL	64 64	WIDR WIDR	EVLA:BnA->A:1:25	05h42m36.138s	+49d51'07.23"	11A-258.sb4139176.eb4258095.55713.0339549537 uid___evla_bdf_1306891747507.bdf
11A-258	42:10	0542+498=3C147		11-Jun-01 01:29:47	11-Jun-01 01:30:07	UTC	20	1.1	POINT	CD_1:SW_16 CD_1:SW_17	8332.000000 8460.000000	128.000 128.000	RR,RL,LR,LL RR,RL,LR,LL	64 64	WIDR WIDR	EVLA:BnA->A:1:25	05h42m36.138s	+49d51'07.23"	11A-258.sb4139176.eb4258095.55713.0339549537 uid___evla_bdf_1306891767505.bdf
11A-258	42:11	0542+498=3C147		11-Jun-01 01:30:07	11-Jun-01 01:30:27	UTC	20	1.1	POINT	CD_1:SW_16 CD_1:SW_17	8332.000000 8460.000000	128.000 128.000	RR,RL,LR,LL RR,RL,LR,LL	64 64	WIDR WIDR	EVLA:BnA->A:1:25	05h42m36.138s	+49d51'07.23"	11A-258.sb4139176.eb4258095.55713.0339549537 uid___evla_bdf_1306891787507.bdf
11A-258	42:12	0542+498=3C147		11-Jun-01 01:30:27	11-Jun-01 01:30:42	UTC	15.4	1.2	POINT	CD_1:SW_16 CD_1:SW_17	8332.000000 8460.000000	128.000 128.000	RR,RL,LR,LL RR,RL,LR,LL	64 64	WIDR WIDR	EVLA:BnA->A:1:25	05h42m36.138s	+49d51'07.23"	11A-258.sb4139176.eb4258095.55713.0339549537 uid___evla_bdf_1306891807506.bdf

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

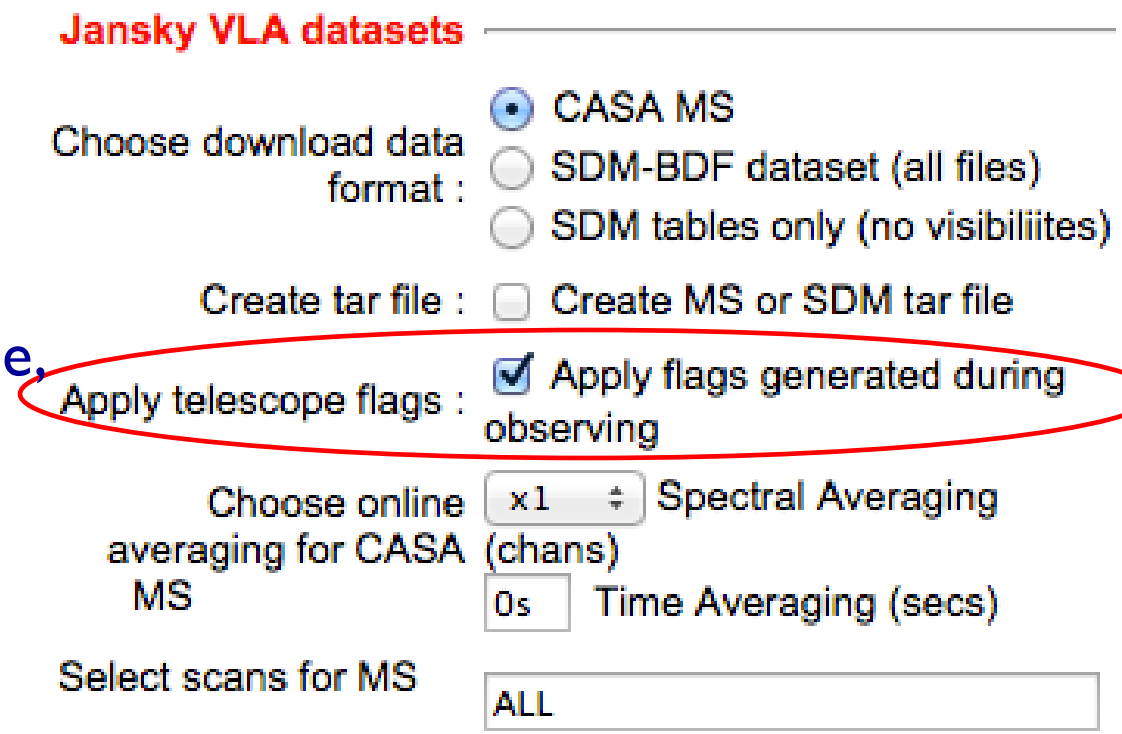


- If CASA MS is requested, the native SDM-BDF is converted to MS using CASA's *importevla* task (which allows flagging and averaging)

Download options: flagging

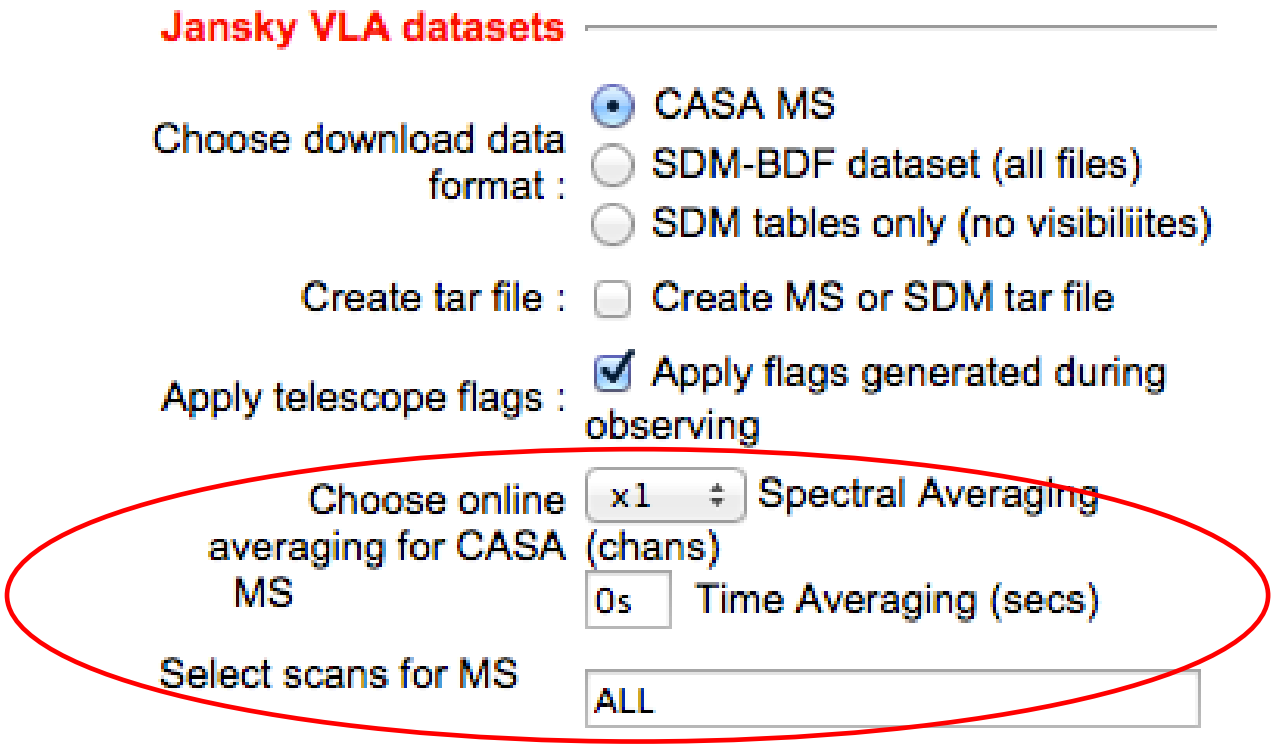
'Telescope flags'

- 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



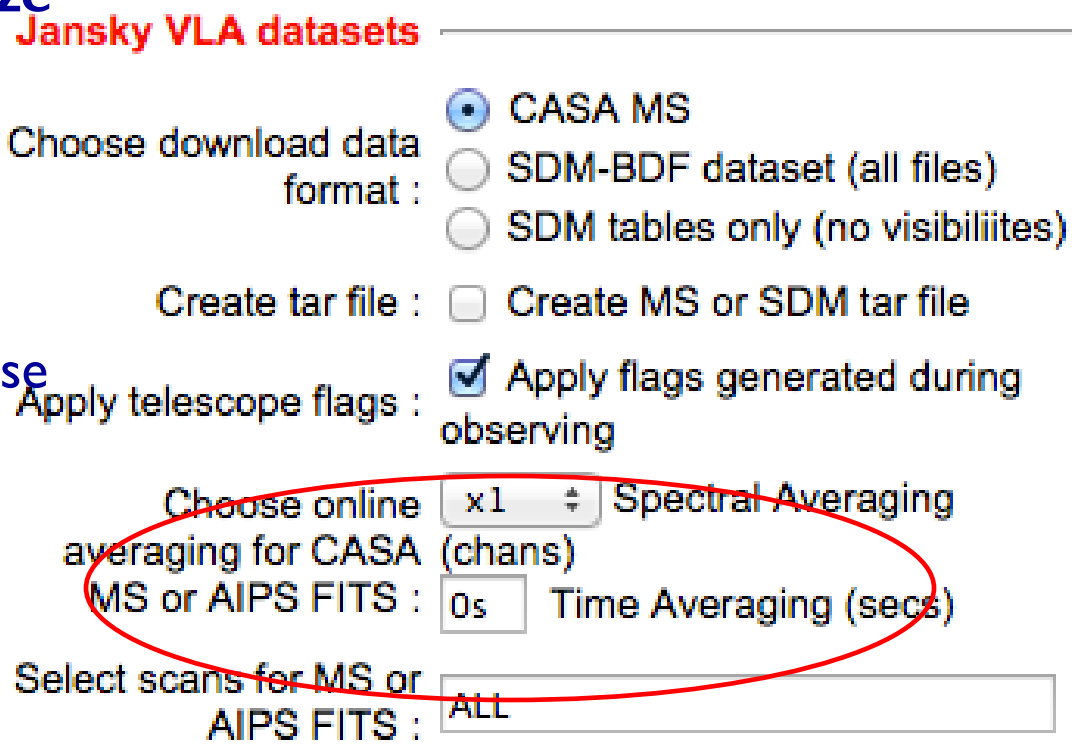
- Possible to average MS data in time and/or in frequency
- Selection of scan numbers (use scan listing mentioned before)
- For these, the archive tool uses the CASA task *split*

Notes on averaging

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

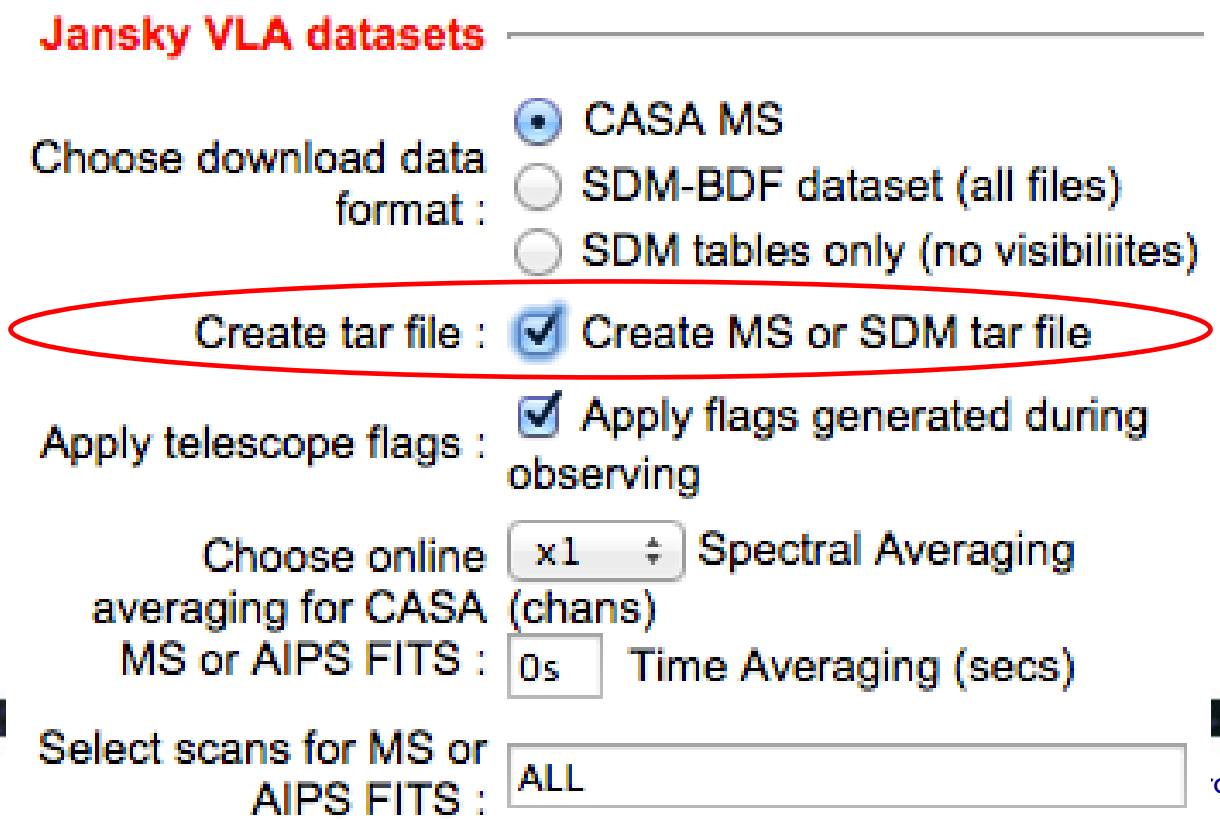
When averaging:

- 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"



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 holds1.8 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

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 4.5.2 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:
  http://casa.nrao.edu/ → 'Using CASA' → 'User Reference and 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 : *listobs*
  (sources, scans, spectral windows, antennas, etc…)
- Plotting the antenna positions: *plotants*
- Plotting/displaying data: *plotms*, and *msview* or *viewer*

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

Observing Summary: *listobs*

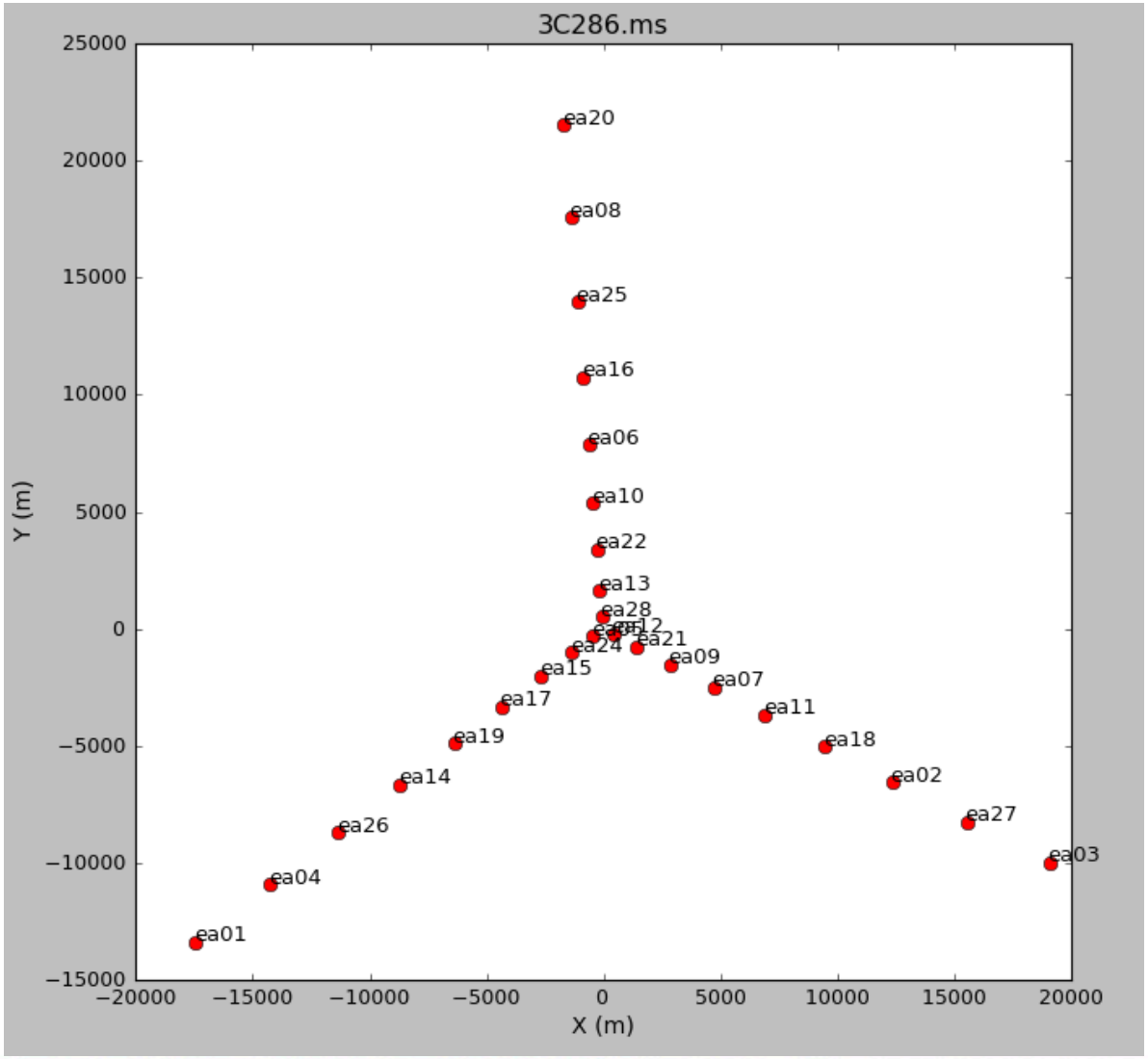
```
vis             = 'my.ms'
verbose         =  True     (or False)
listfile        = 'file_with_listobs_output'
```

```
listobs:… ================================================================================
listobs:…            MeasurementSet Name:  /lustre/aoc/users/emomjian/zeeman/StokesV_50Hz_
listobs:… ================================================================================
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:…    Observed from   12-Jul-2011/10:22:38.6   to   12-Jul-2011/11:22:25.5 (UTC)
listobs:… Fields: 3
listobs:…   ID   Code Name          RA              Decl            Epoch   SrcId
listobs:…   0    D    J1851+0035   18:51:46.7217 +00.35.32.4140 J2000   0
listobs:…   1    NONE G37.40+1.52* 18:54:14.2627 +04.41.41.4167 J2000   1
listobs:…   2    E    0137+331=3C* 01:37:41.2994 +33.09.35.1330 J2000   2
listobs:…    (nVis = Total number of time/baseline visibilities per field)
listobs:… Spectral Windows:  (1 unique spectral windows and 1 unique polarization setups)
listobs:…   SpwID  #Chans Frame Ch1(MHz)    ChanWid(kHz) TotBW(kHz)  Ref(MHz)    Corrs
listobs:…   0        256 TOPO  6667.85673  0.9765625    250         6667.85673  RR  LL
listobs:… Sources: 3
listobs:…   ID   Name          SpwId RestFreq(MHz)  SysVel(km/s)
listobs:…   0    J1851+0035    0     6668.518       41
listobs:…   1    G37.40+1.52*  0     6668.518       41
listobs:…   2    0137+331=3C*  0     6668.518       41
listobs:… Antennas: 27 'name'='station'
listobs:…    ID=   0-3: 'ea01'='W72', 'ea02'='E56', 'ea03'='E72', 'ea04'='W64',
listobs:…    ID=   4-7: 'ea05'='W08', 'ea06'='N40', 'ea07'='E32', 'ea08'='N64',
listobs:…    ID=  8-11: 'ea09'='E24', 'ea10'='N32', 'ea11'='E40', 'ea12'='E08',
listobs:…    ID= 12-15: 'ea13'='N16', 'ea14'='W48', 'ea15'='W24', 'ea16'='N48',
listobs:…    ID= 16-19: 'ea17'='W32', 'ea18'='E48', 'ea19'='W40', 'ea20'='N72',
listobs:…    ID= 20-23: 'ea22'='N24', 'ea23'='E16', 'ea24'='W16', 'ea25'='N56',
listobs:…    ID= 24-26: 'ea26'='W56', 'ea27'='E64', 'ea28'='N08'
```

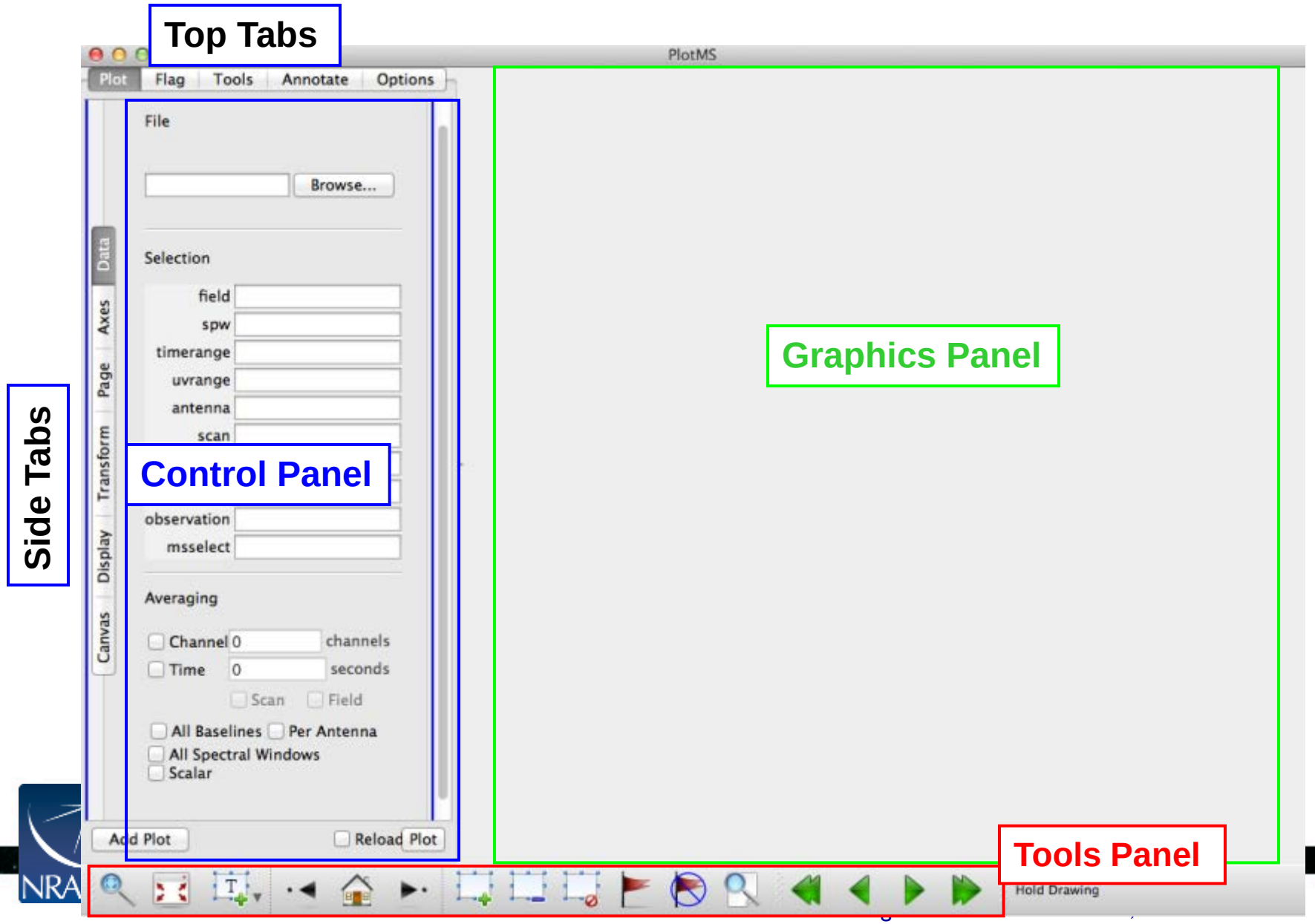
Plotting the antennas: *plotants*

```
vis   = 'my.ms'
```

- 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***)

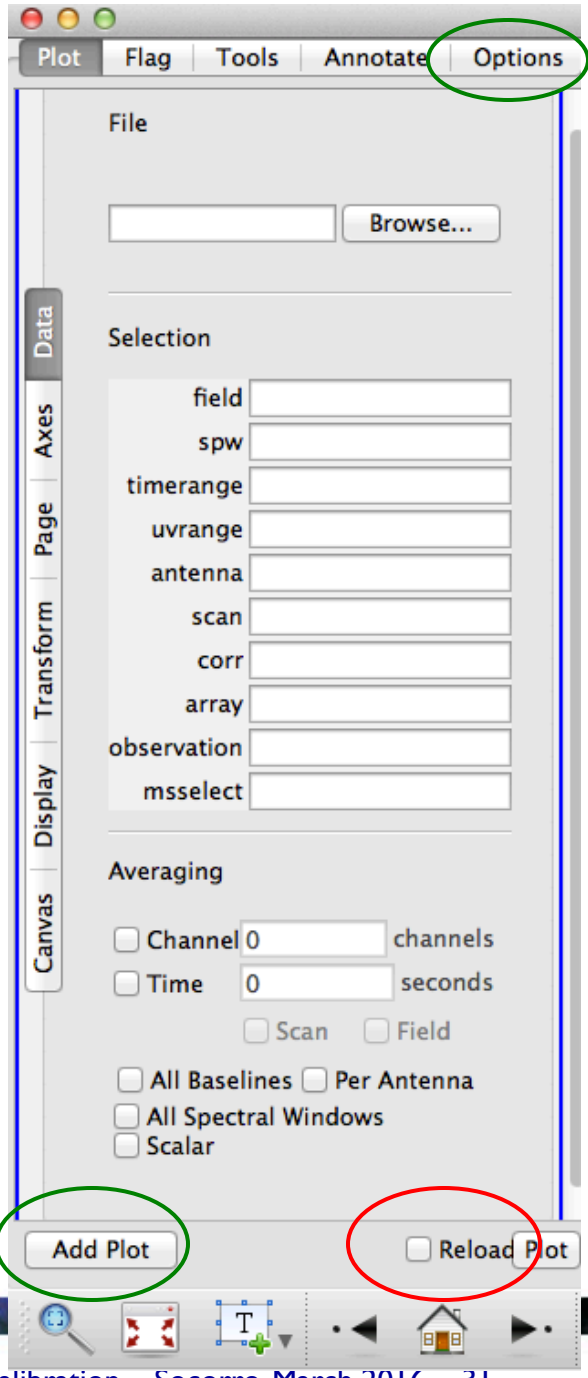


Data Review: *plotms*

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*

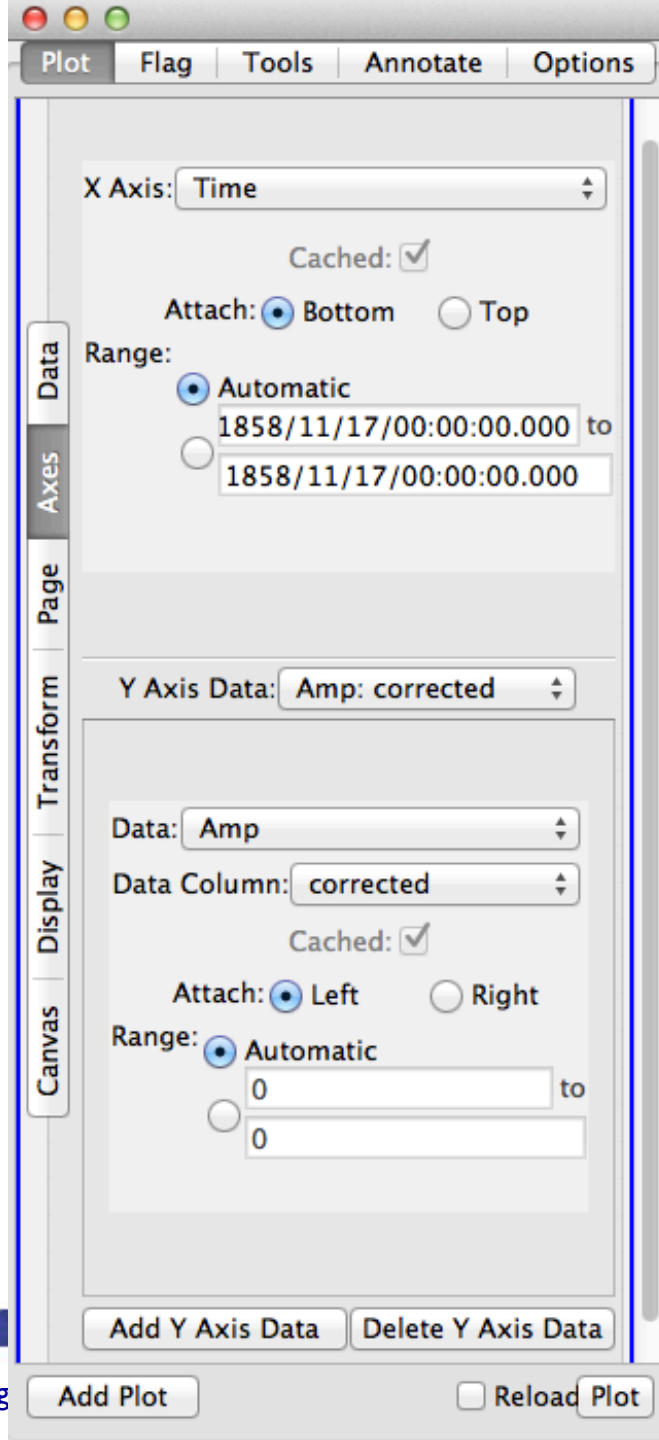
Axes

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' (absoute row Id from the MS)

Visibility values, flags:

'amp'='amplitude'
'phase' (deg)
'real'
'imag'='imaginary'
'wt'='weight'
'flag'
'flagrow'



Data Review: *plotms*

Axes

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)

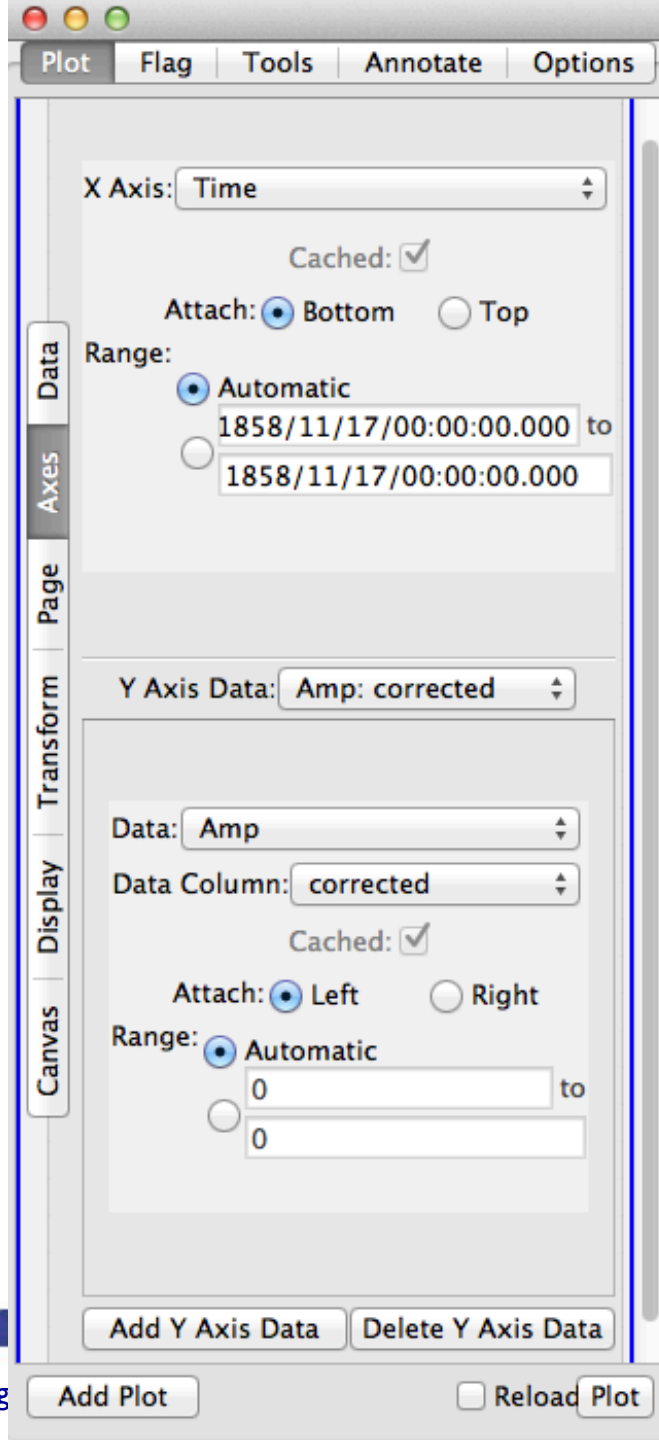
Antenna-based (only works vs. data Ids):

'ant'='antenna'

'ant-azimuth'

'ant-elevation'

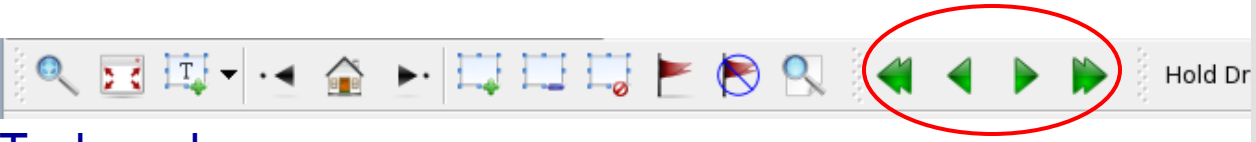
'ant-parang'='ant-parangle'



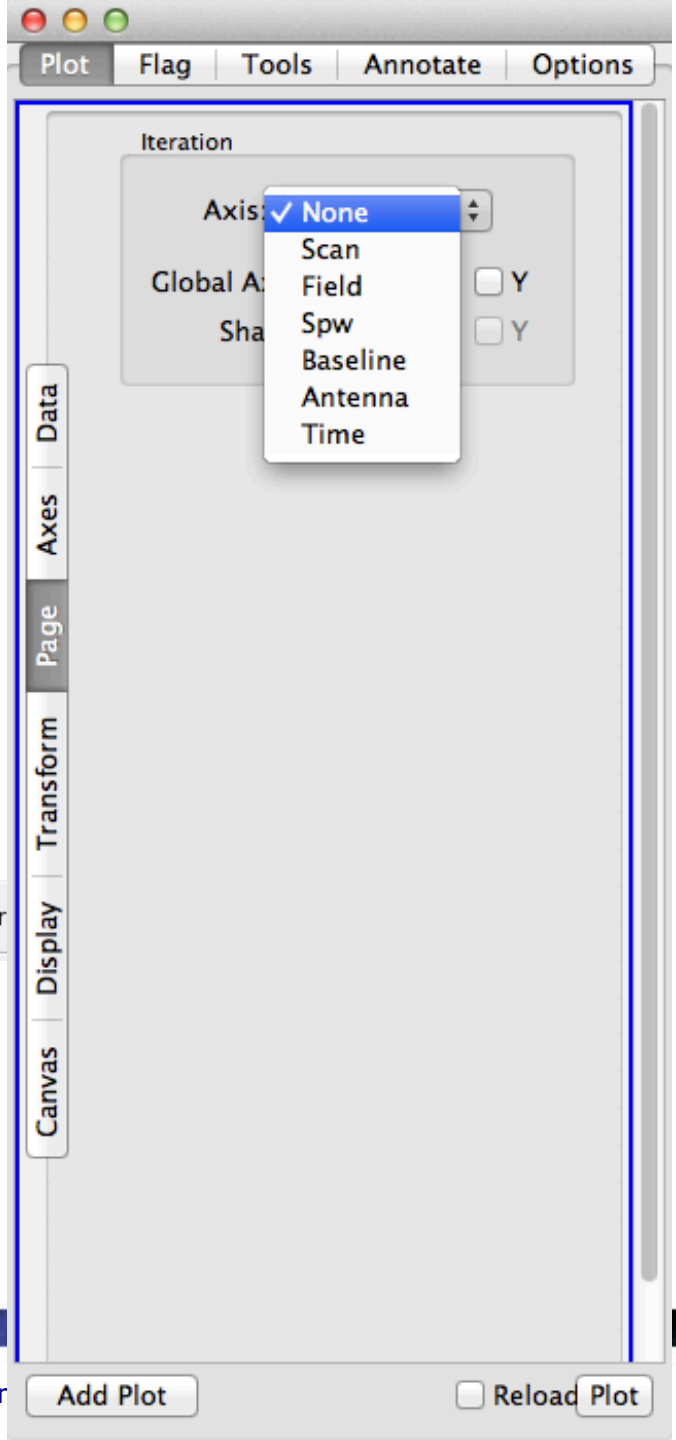
Data Review: *plotms*

Page: to iterate on

Scan
Field
Spw
Baseline
Antenna
Time



Tool panel

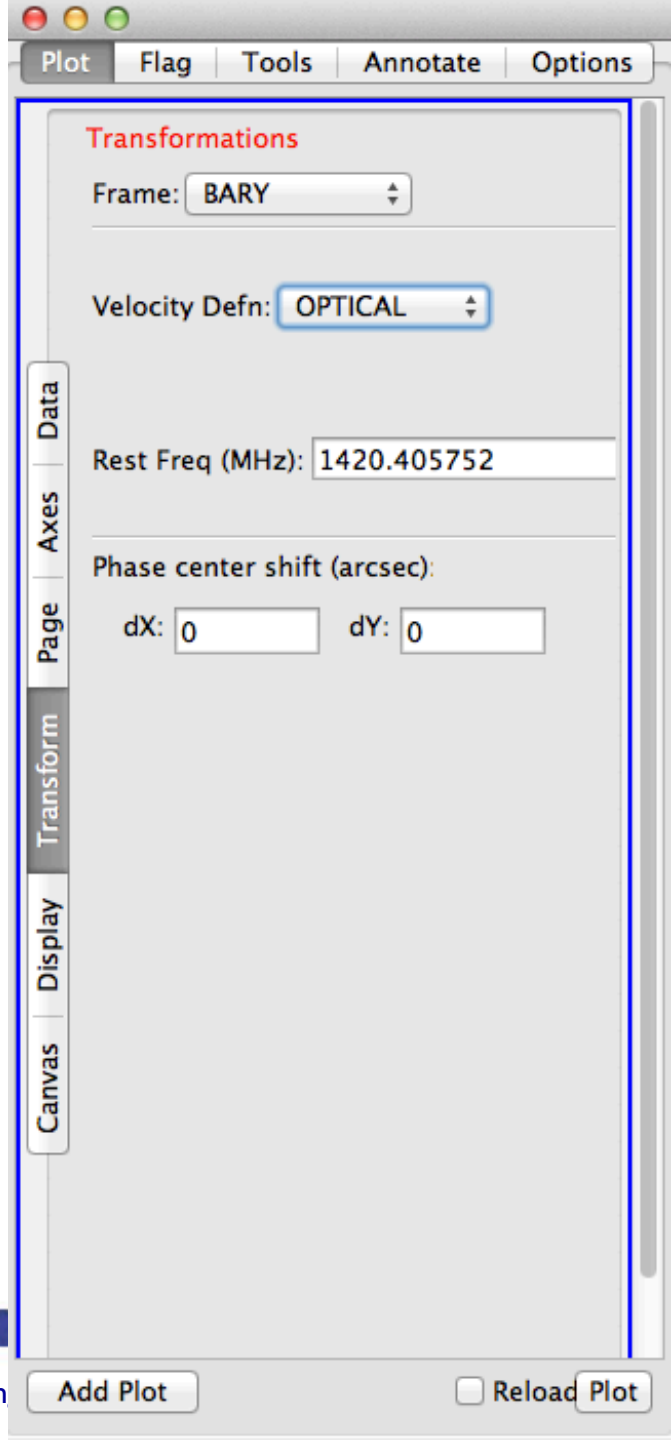


Data Review: *plotms*

Transformations

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

(While examining your data you probably want to keep the data in channel or frequency)

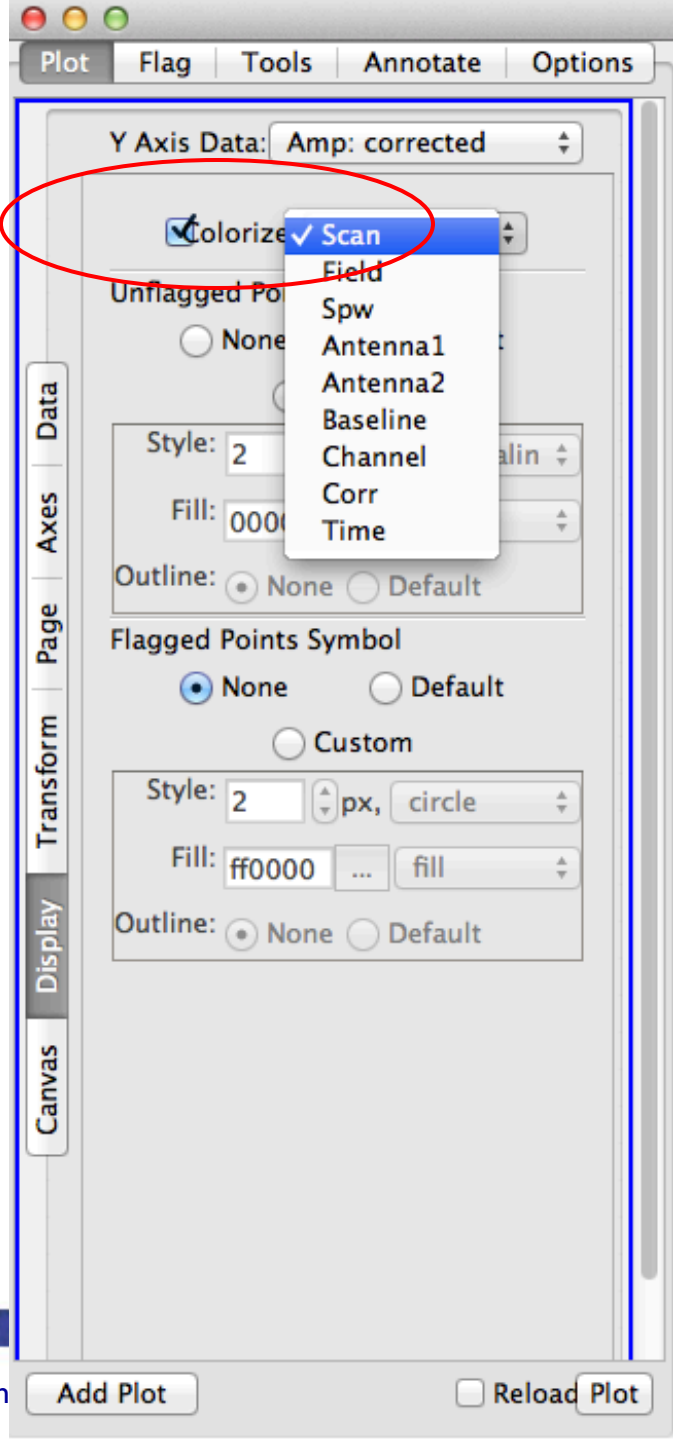


Data Review: *plotms*

Display

Colorize by:

- Scan
- Field
- Spw
- Antenna1
- Antenna2
- Baseline
- Channel
- Correlation
- Time



What are we looking for?

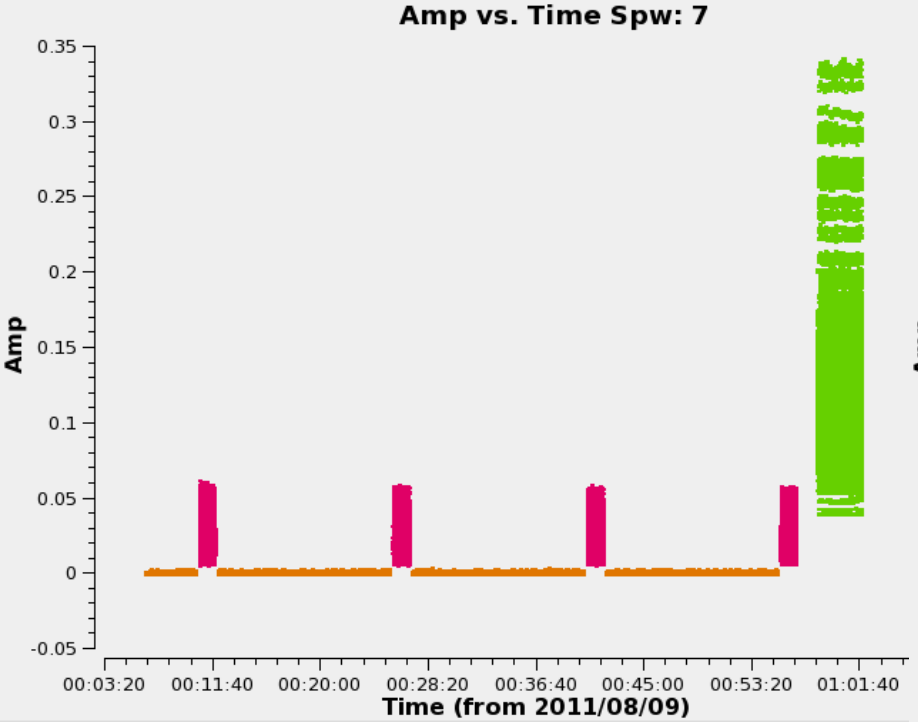
- A feel of the overall structure of the data
  (see also the OPT schedule):
  - Calibrators and target visibilities, frequency setup
  - Observing conditions, instrumental response

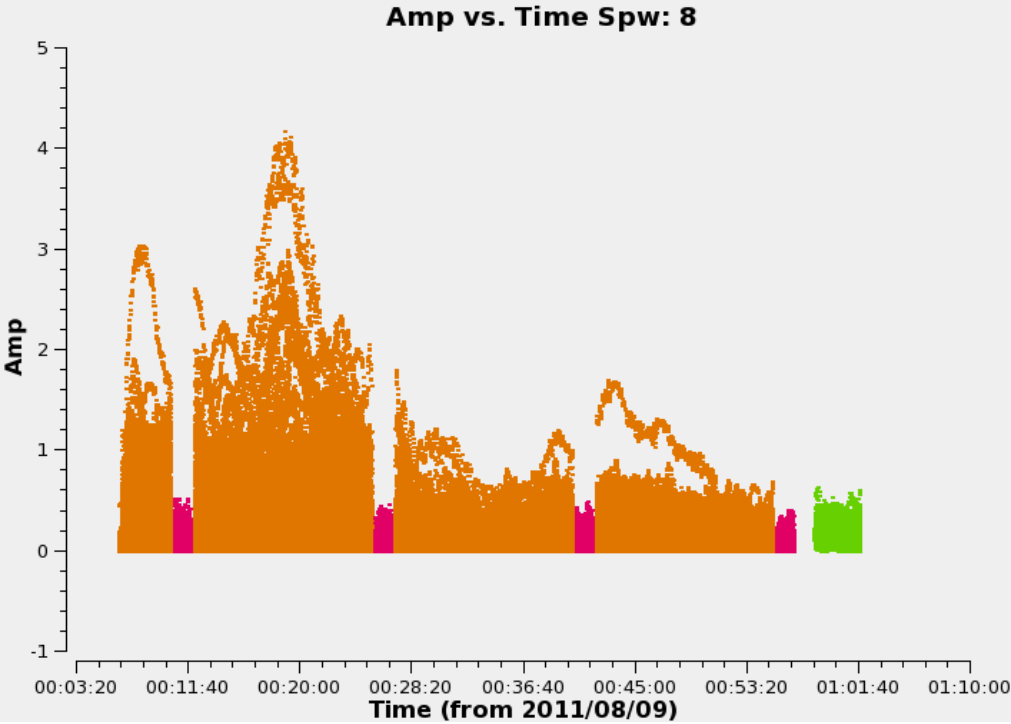
- Where to expect bad data
  - Specific ill-performing antennas/baseline(boards)
  - In time
    - Start of scans
    - Bad weather/pointing (observing conditions)
  - In frequency
    - Bandpass, subband edges
    - RFI – not your line!

Data Review: *plotms*

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

Page: iterating on spw (with all channels averaged)





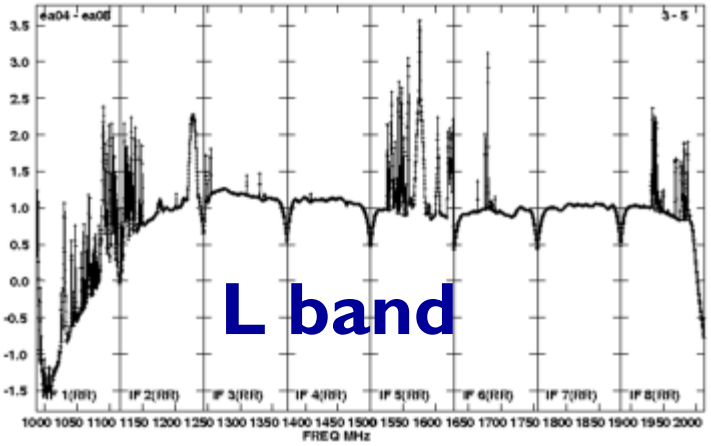
Radio Frequency Interference (RFI)

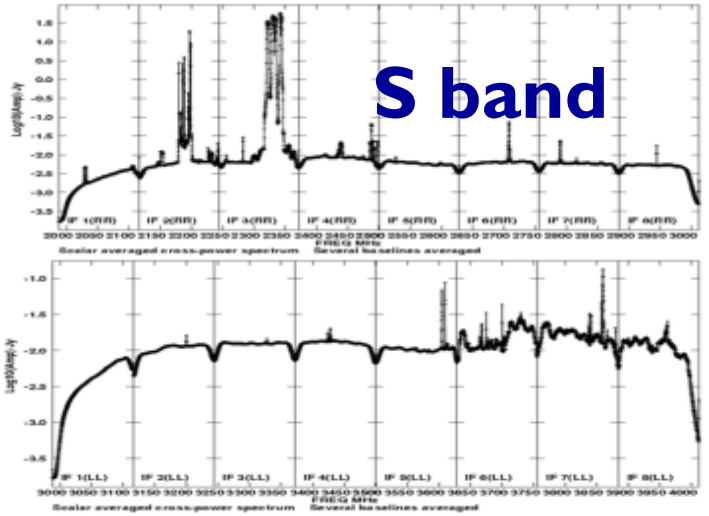
1. VLA observations, particularly at the lower frequency bands, will be severely affected by RFI.
2. VLA RFI information is available at:

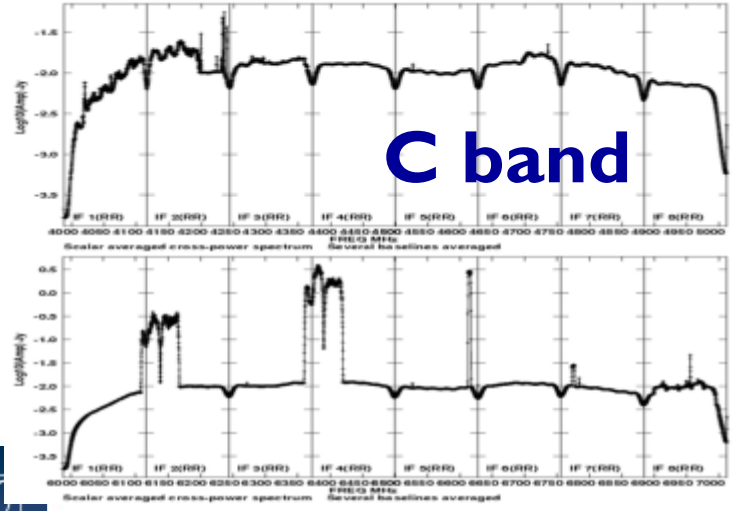
   https://science.nrao.edu/ → Facilities → VLA → Observing → Guide to VLA Observing → Radio Frequency Interference

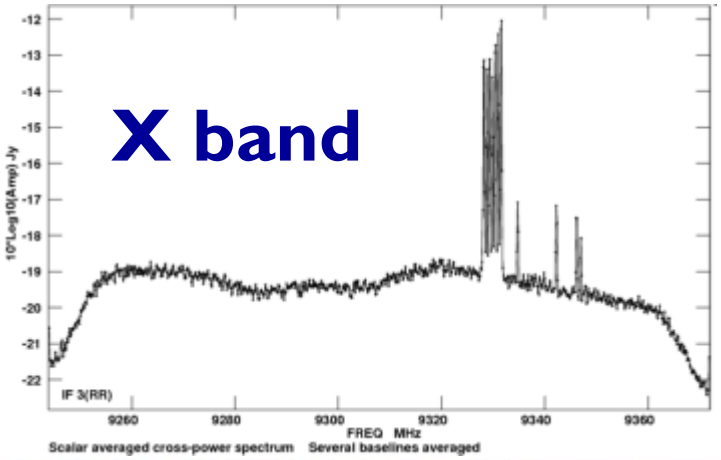
   - RFI listings per frequency band.
   - Spectra of various RFI sweeps between 1-50 GHz.

RFI is present at lower frequency bands

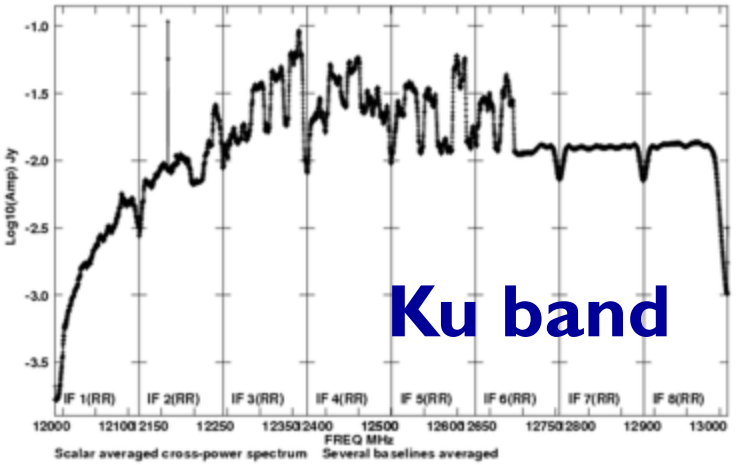


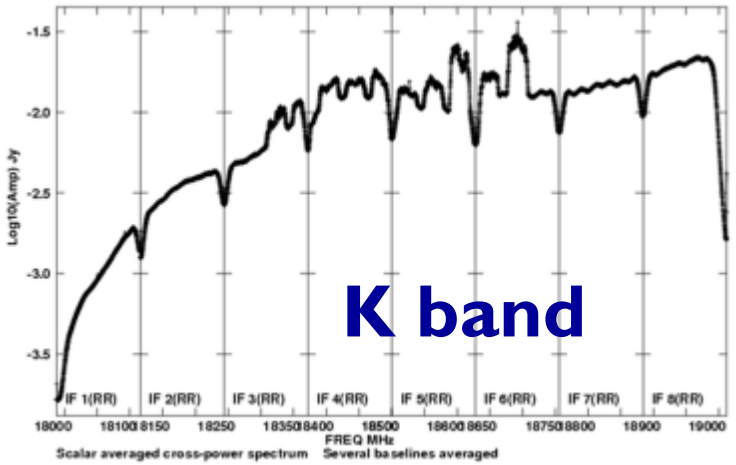


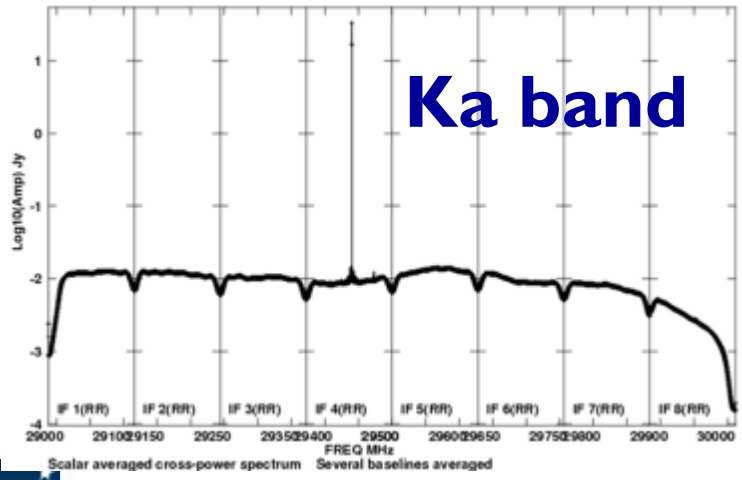


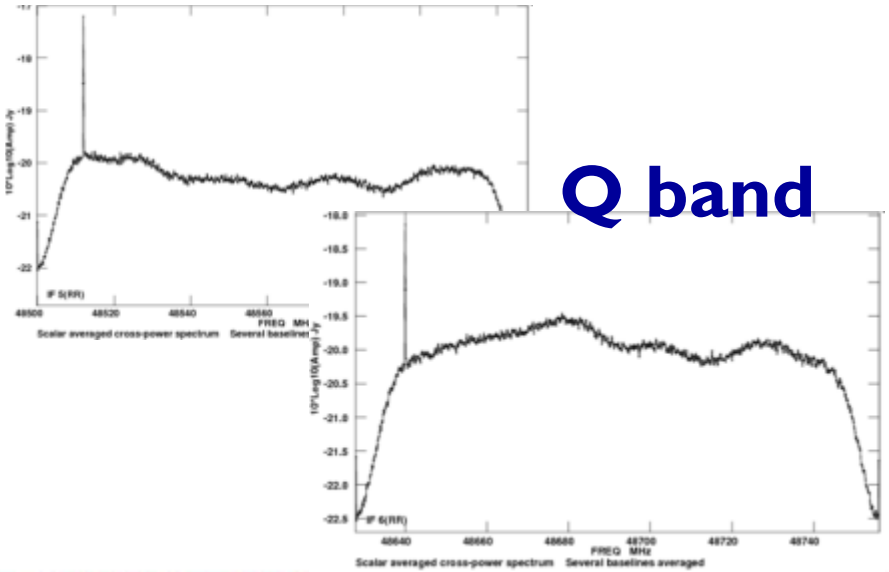


RFI/birdies at the higher frequency bands





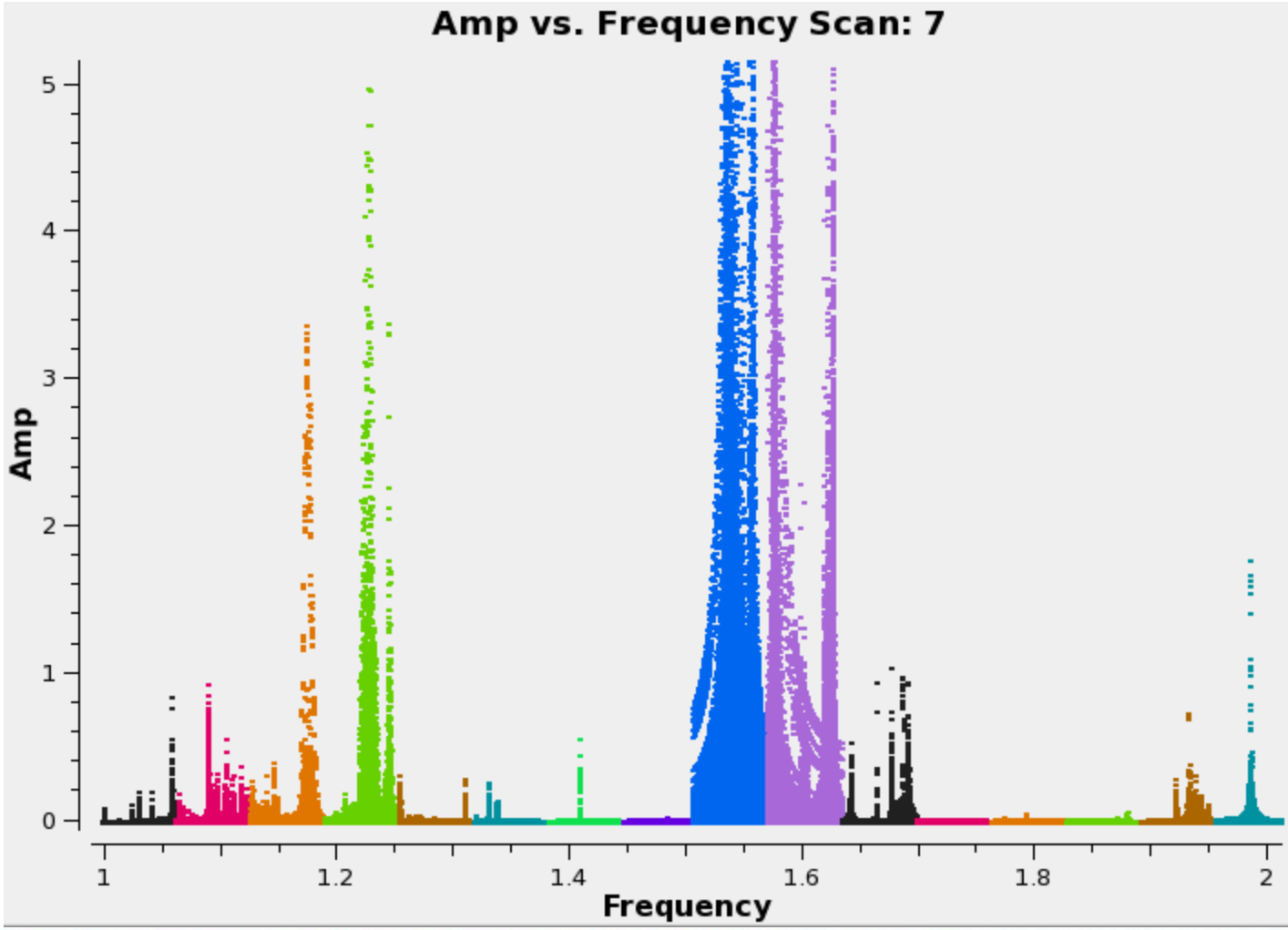




Data Review: *plotms*

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 (`inpmode`) 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.

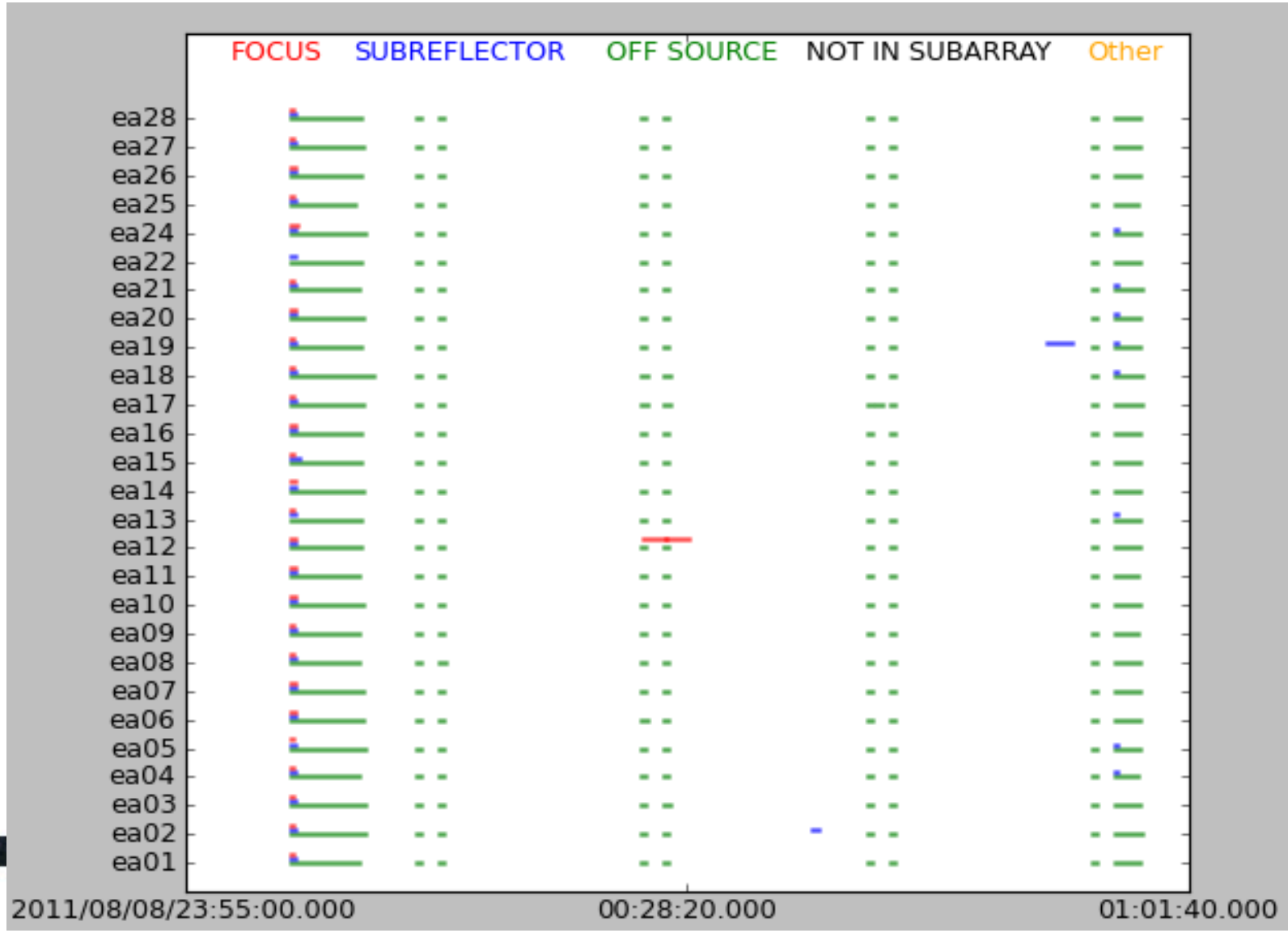
Examining the flags with *flagcmd*

list

Key	FlagID	Antenna	Reason	Timerange
0	0	ea28	SUBREFLECTOR_ERROR	2011/08/09/00:02:00.401~2011/08/09/00:02:15.300
1	1	ea26	SUBREFLECTOR_ERROR	2011/08/09/00:02:00.435~2011/08/09/00:02:15.274
2	2	ea21	SUBREFLECTOR_ERROR	2011/08/09/00:02:00.478~2011/08/09/00:02:15.093
3	3	ea08	SUBREFLECTOR_ERROR	2011/08/09/00:02:00.478~2011/08/09/00:02:15.300
4	4	ea22	SUBREFLECTOR_ERROR	2011/08/09/00:02:00.487~2011/08/09/00:02:14.946
5	5	ea27	SUBREFLECTOR_ERROR	2011/08/09/00:02:00.487~2011/08/09/00:02:15.594
6	6	ea20	SUBREFLECTOR_ERROR	2011/08/09/00:02:00.522~2011/08/09/00:02:15.343
7	7	ea03	ANTENNA_NOT_ON_SOURCE	2011/08/09/00:02:00.548~2011/08/09/00:06:58.537
8	8	ea03	SUBREFLECTOR_ERROR	2011/08/09/00:02:00.548~2011/08/09/00:02:15.551
9	9	ea18	ANTENNA_NOT_ON_SOURCE	2011/08/09/00:02:00.573~2011/08/09/00:07:31.533
10	10	ea18	SUBREFLECTOR_ERROR	2011/08/09/00:02:00.573~2011/08/09/00:02:15.084
11	11	ea04	ANTENNA_NOT_ON_SOURCE	2011/08/09/00:02:00.573~2011/08/09/00:06:30.586
12	12	ea04	SUBREFLECTOR_ERROR	2011/08/09/00:02:00.573~2011/08/09/00:02:15.179
13	13	ea19	ANTENNA_NOT_ON_SOURCE	2011/08/09/00:02:00.591~2011/08/09/00:06:42.907
14	14	ea19	SUBREFLECTOR_ERROR	2011/08/09/00:02:00.591~2011/08/09/00:02:16.069
15	15	ea28	ANTENNA_NOT_ON_SOURCE	2011/08/09/00:02:00.599~2011/08/09/00:06:42.397
16	16	ea07	ANTENNA_NOT_ON_SOURCE	2011/08/09/00:02:00.608~2011/08/09/00:06:46.907
17	17	ea16	ANTENNA_NOT_ON_SOURCE	2011/08/09/00:02:00.591~2011/08/09/00:06:39.658
18	18	ea07	SUBREFLECTOR_ERROR	2011/08/09/00:02:00.608~2011/08/09/00:02:15.663
19	19	ea16	SUBREFLECTOR_ERROR	2011/08/09/00:02:00.591~2011/08/09/00:02:15.706
20	20	ea10	ANTENNA_NOT_ON_SOURCE	2011/08/09/00:02:00.608~2011/08/09/00:06:45.810
21	21	ea01	ANTENNA_NOT_ON_SOURCE	2011/08/09/00:02:00.591~2011/08/09/00:06:30.301
22	22	ea10	SUBREFLECTOR_ERROR	2011/08/09/00:02:00.617~2011/08/09/00:02:15.706
23	23	ea01	SUBREFLECTOR_ERROR	2011/08/09/00:02:00.591~2011/08/09/00:02:15.430
24	24	ea02	ANTENNA_NOT_ON_SOURCE	2011/08/09/00:02:00.625~2011/08/09/00:06:59.098

Examining the flags with *flagcmd*

plot



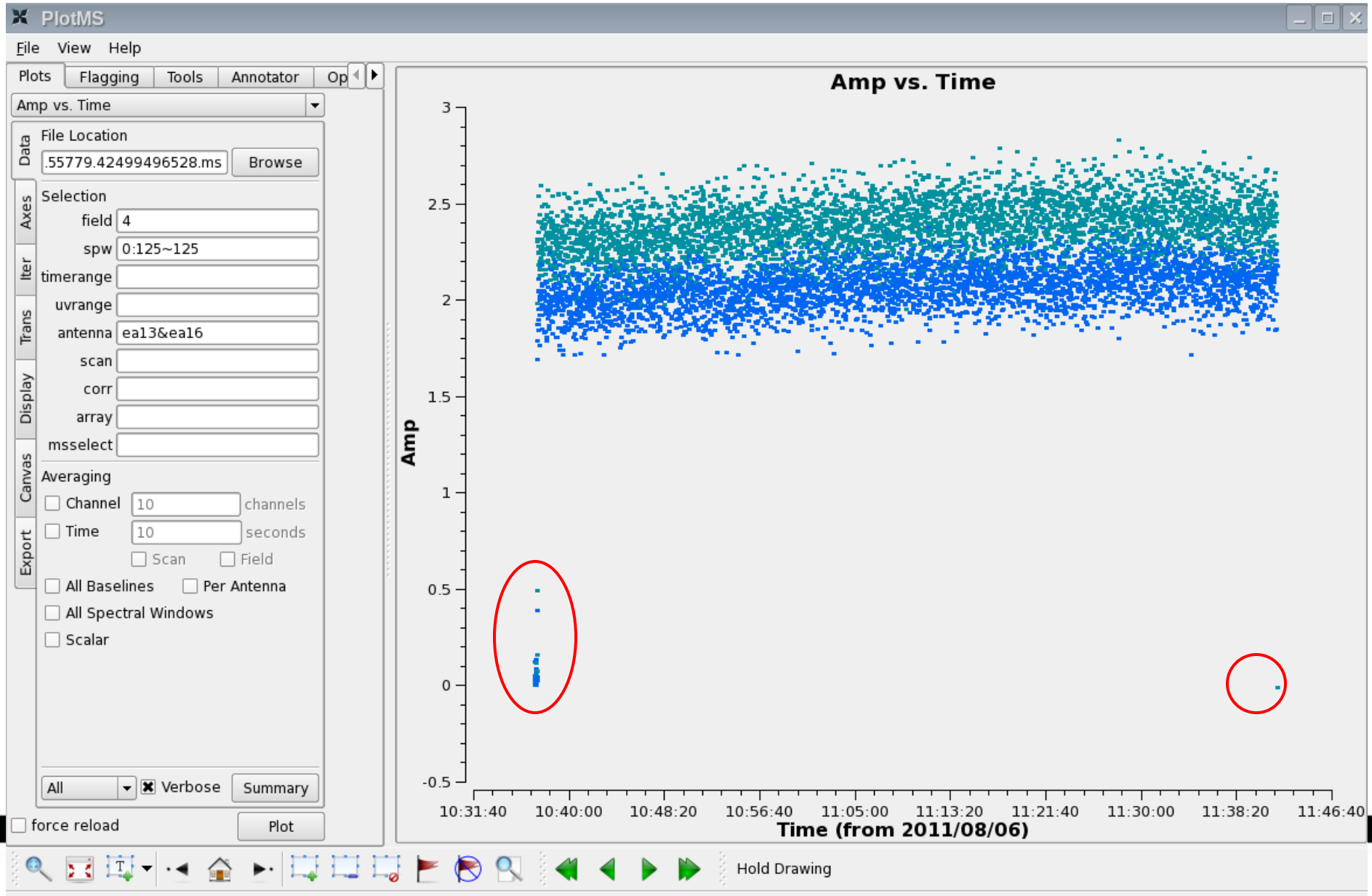
Flagging Data: *flagdata vs. flagcmd*

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

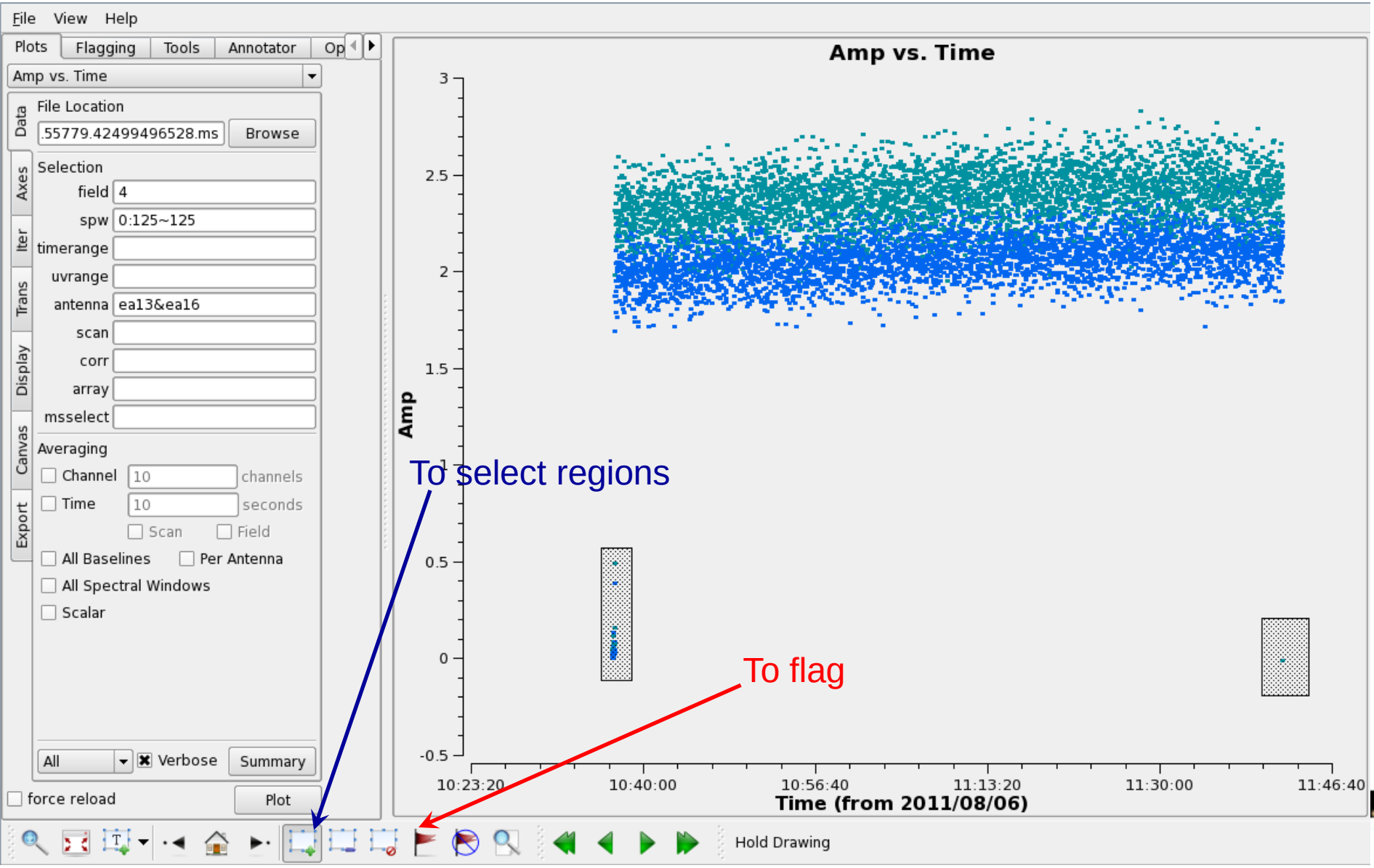
Flagdata	Flagcmd
RFI flagging (tfcrop, rflag)*	Access to the Flag.xml
Runtime displays* (before and after flagging)	Apply the online (and other) flags in FLAG_CMD MS table
	Plot Flags

* More details on Tuesday (RFI talk)

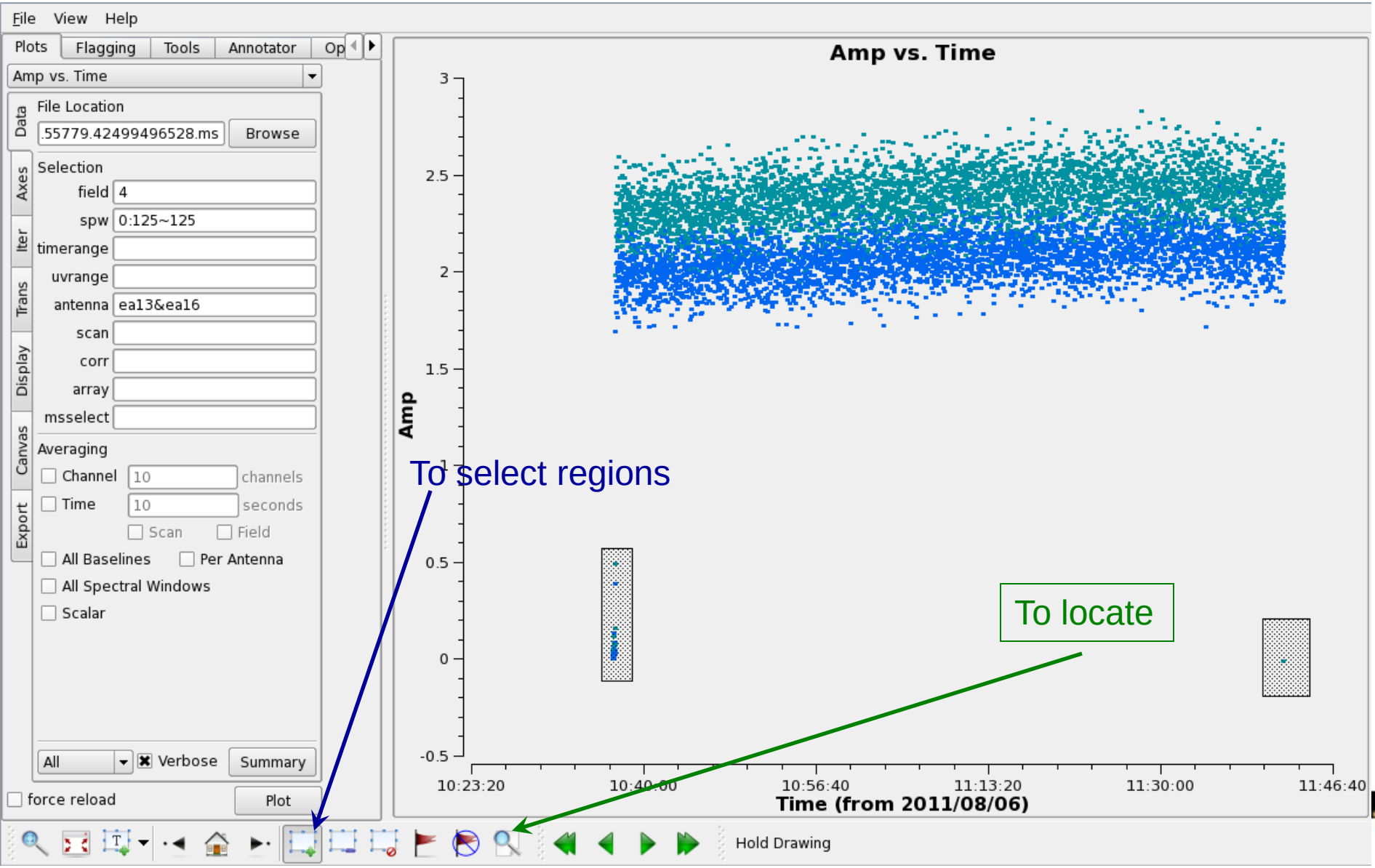
Flagging Data: *plotms*



Flagging Data: *plotms*



Flagging Data: *plotms*

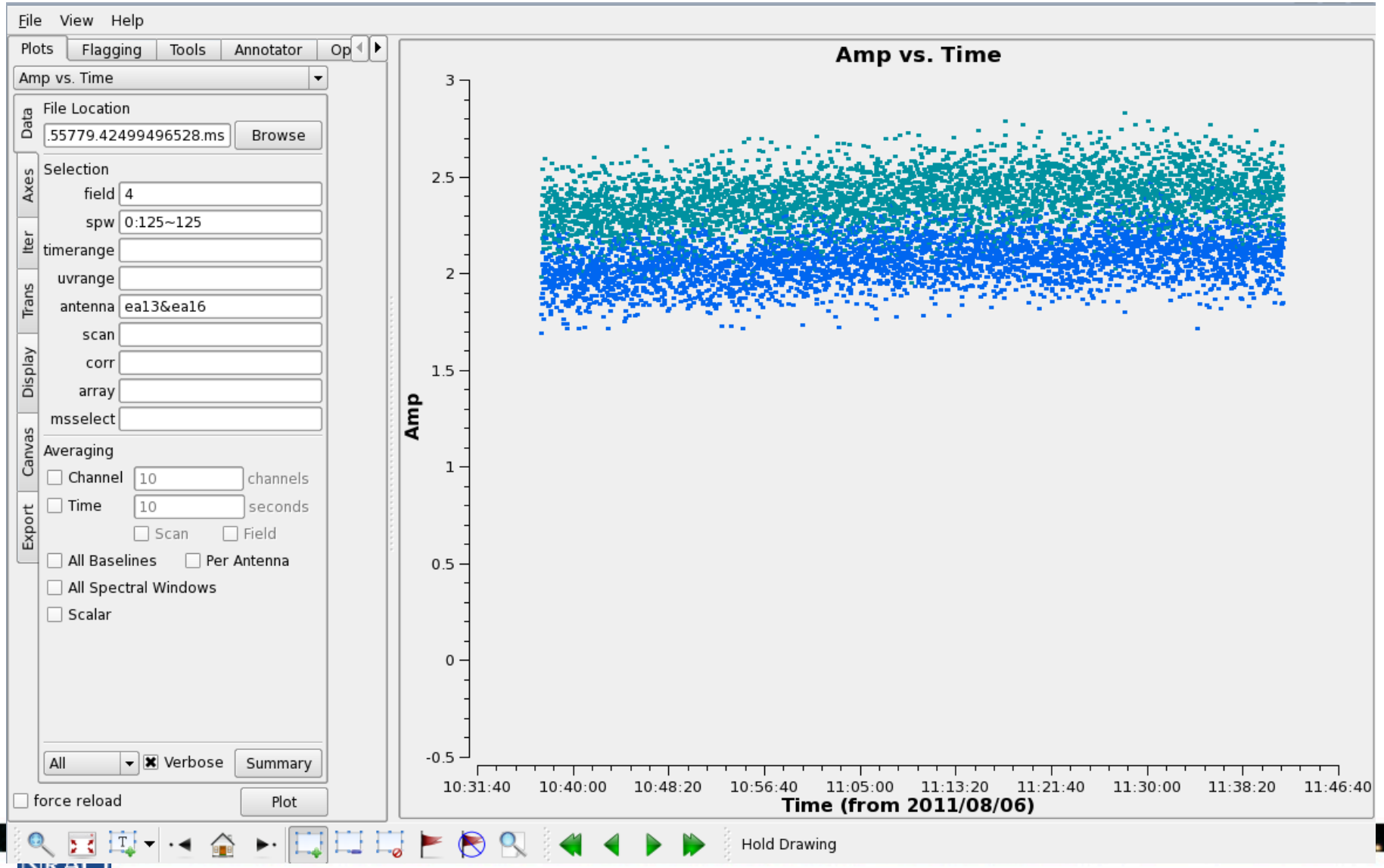


Flagging Data: *plotms*

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

```
Scan=9 Field=W3IRS5[4] Time=2011/08/06/10:36:57.3 BL=ea13&ea16[11&14] Spw=0 Chan=125 Freq=22.2398 Corr=RR
Scan=9 Field=W3IRS5[4] Time=2011/08/06/10:36:57.3 BL=ea13&ea16[11&14] Spw=0 Chan=125 Freq=22.2398 Corr=LL
Scan=9 Field=W3IRS5[4] Time=2011/08/06/10:36:58.3 BL=ea13&ea16[11&14] Spw=0 Chan=125 Freq=22.2398 Corr=RR
Scan=9 Field=W3IRS5[4] Time=2011/08/06/10:36:58.3 BL=ea13&ea16[11&14] Spw=0 Chan=125 Freq=22.2398 Corr=LL
Scan=9 Field=W3IRS5[4] Time=2011/08/06/10:36:59.3 BL=ea13&ea16[11&14] Spw=0 Chan=125 Freq=22.2398 Corr=RR
Scan=9 Field=W3IRS5[4] Time=2011/08/06/10:36:59.3 BL=ea13&ea16[11&14] Spw=0 Chan=125 Freq=22.2398 Corr=LL
Scan=9 Field=W3IRS5[4] Time=2011/08/06/10:37:00.3 BL=ea13&ea16[11&14] Spw=0 Chan=125 Freq=22.2398 Corr=RR
Scan=9 Field=W3IRS5[4] Time=2011/08/06/10:37:00.3 BL=ea13&ea16[11&14] Spw=0 Chan=125 Freq=22.2398 Corr=LL
Scan=9 Field=W3IRS5[4] Time=2011/08/06/10:37:01.3 BL=ea13&ea16[11&14] Spw=0 Chan=125 Freq=22.2398 Corr=RR
Scan=9 Field=W3IRS5[4] Time=2011/08/06/10:37:01.3 BL=ea13&ea16[11&14] Spw=0 Chan=125 Freq=22.2398 Corr=LL
Scan=9 Field=W3IRS5[4] Time=2011/08/06/10:37:02.3 BL=ea13&ea16[11&14] Spw=0 Chan=125 Freq=22.2398 Corr=RR
Scan=9 Field=W3IRS5[4] Time=2011/08/06/10:37:02.3 BL=ea13&ea16[11&14] Spw=0 Chan=125 Freq=22.2398 Corr=LL
Scan=9 Field=W3IRS5[4] Time=2011/08/06/10:37:03.3 BL=ea13&ea16[11&14] Spw=0 Chan=125 Freq=22.2398 Corr=RR
Scan=9 Field=W3IRS5[4] Time=2011/08/06/10:37:03.3 BL=ea13&ea16[11&14] Spw=0 Chan=125 Freq=22.2398 Corr=LL
Scan=9 Field=W3IRS5[4] Time=2011/08/06/10:37:04.3 BL=ea13&ea16[11&14] Spw=0 Chan=125 Freq=22.2398 Corr=RR
Scan=9 Field=W3IRS5[4] Time=2011/08/06/10:37:04.3 BL=ea13&ea16[11&14] Spw=0 Chan=125 Freq=22.2398 Corr=LL
Scan=9 Field=W3IRS5[4] Time=2011/08/06/10:37:05.3 BL=ea13&ea16[11&14] Spw=0 Chan=125 Freq=22.2398 Corr=RR
Scan=9 Field=W3IRS5[4] Time=2011/08/06/10:37:05.3 BL=ea13&ea16[11&14] Spw=0 Chan=125 Freq=22.2398 Corr=LL
Scan=9 Field=W3IRS5[4] Time=2011/08/06/10:37:06.3 BL=ea13&ea16[11&14] Spw=0 Chan=125 Freq=22.2398 Corr=RR
```

Flagging Data: *plotms*



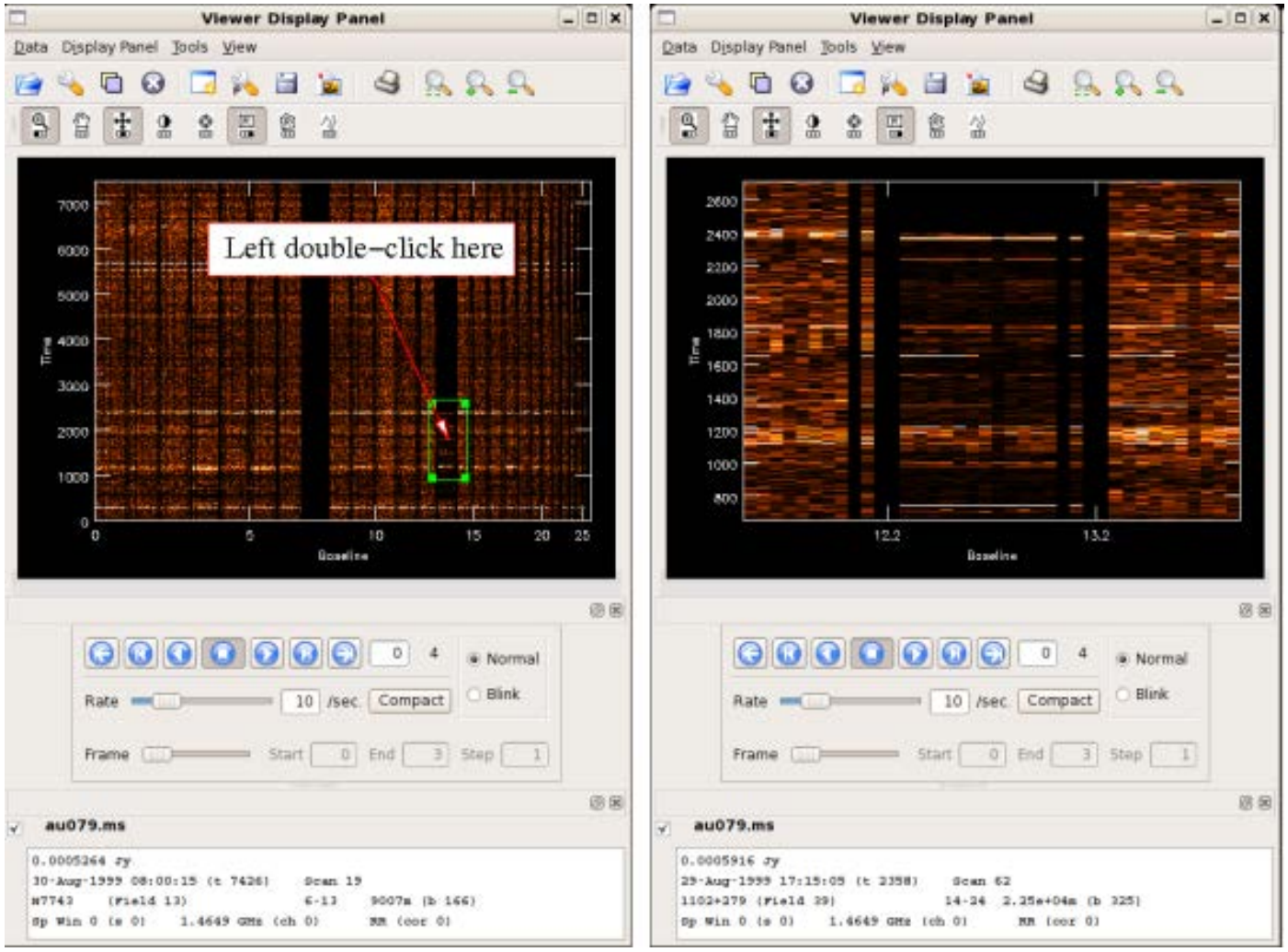
Flagging Data: *plotms*
A few important notes

- 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: *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*

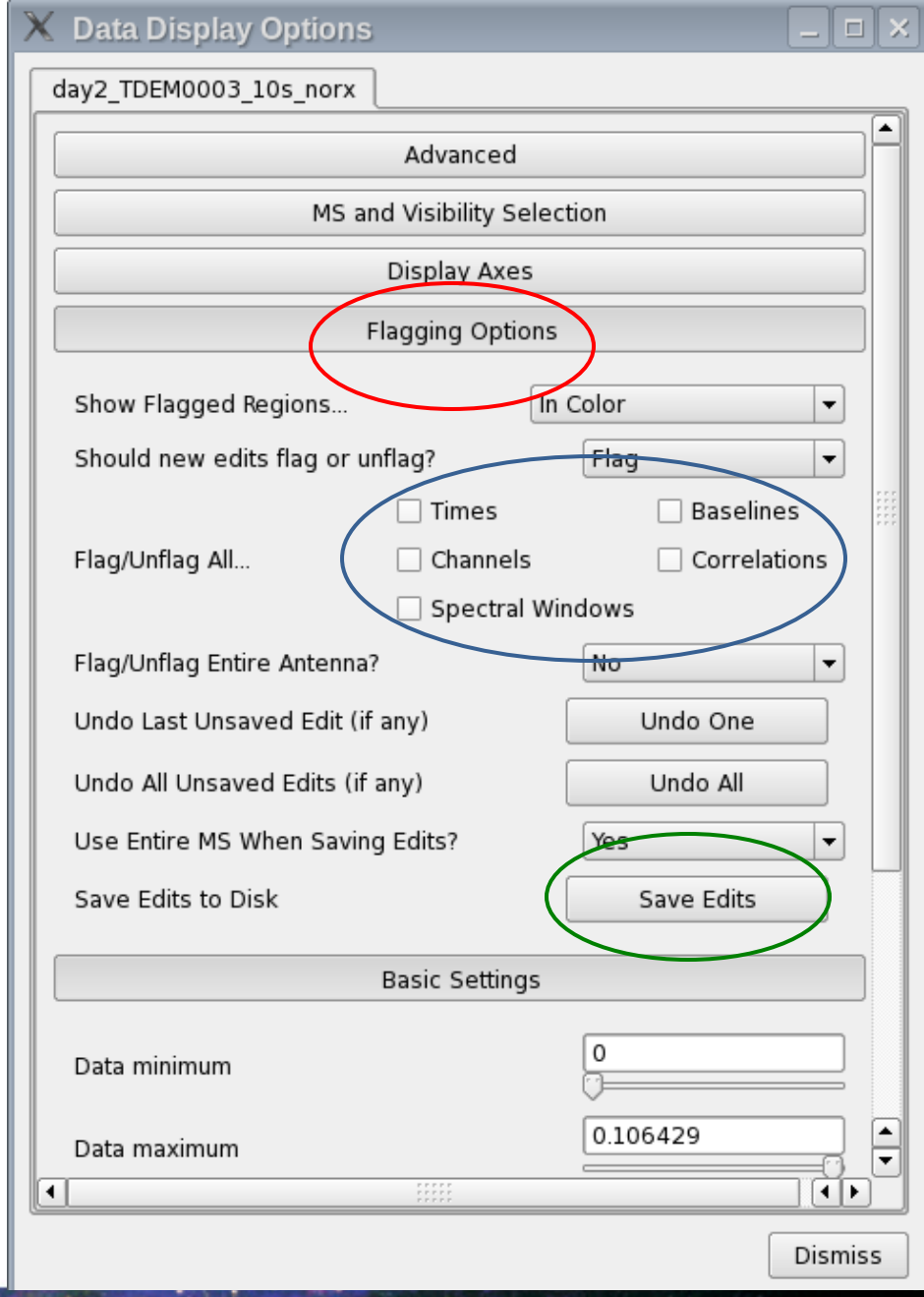


http://casaguides.nrao.edu/ → Data flagging with viewer

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…