Archive Access / Data Inspection

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: (these 5 are web links…)

- The lectures of the synthesis imaging workshops:
  https://science.nrao.edu/science/meetings/2014/14th-synthesis-imaging-workshop/
  https://science.nrao.edu/science/meetings/2016/15th-synthesis-imaging-workshop/
  https://science.nrao.edu/science/meetings/2018/16th-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 (portal https://my.nrao.edu)
  - Limited capacity, compete with others, no guarantee
  - See computing policy page https://info.nrao.edu/computing/guide/cluster-processing/

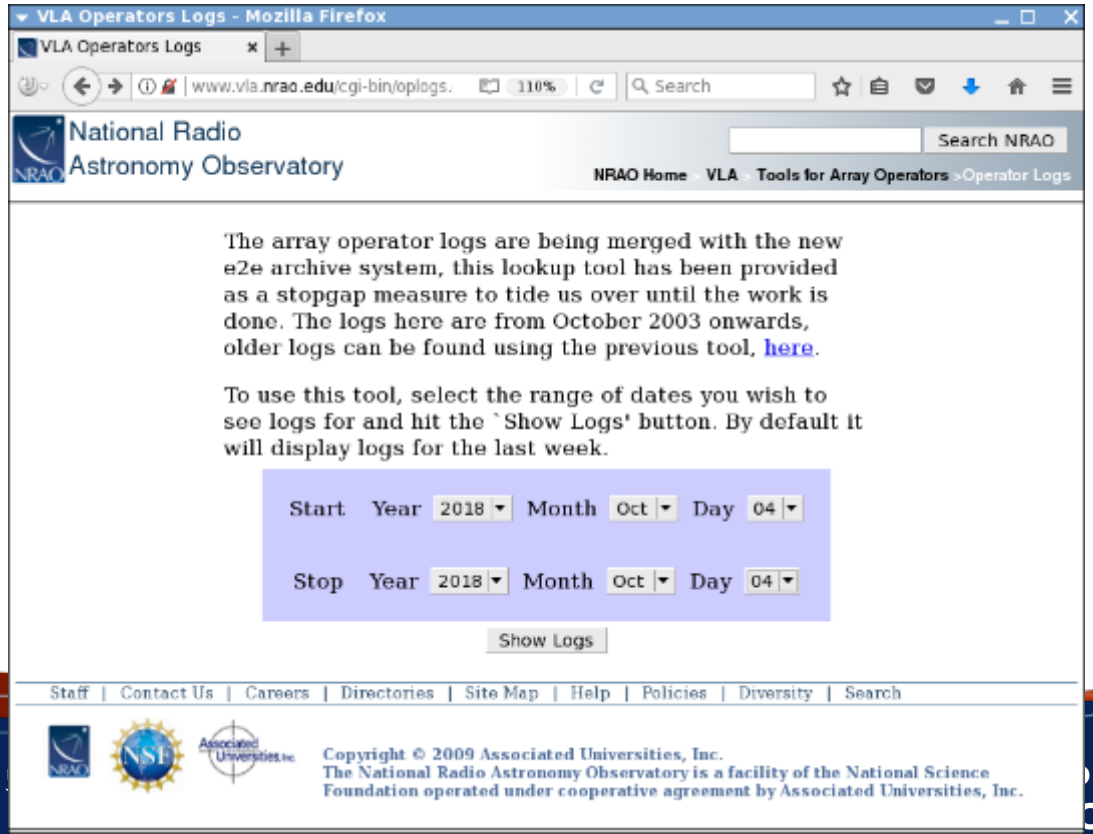
- Here assume **processing at home institute**
  - Data transfer over internet (up to couple of 100 GB)
  - Data shipped on disk (purchase, up to 1.8 TB/disk)

Observing operator logs are available

Sent by email to proposers directly after observation

Stored on web servers:

http://www.vla.nrao.edu/cgi-bin/oplogs.cgi



Date	Time	Code	File
2018-10-04	13:57	SOFTWARE	pdf
2018-10-04	13:21	18A-498	pdf
2018-10-04	12:03	18A-342	pdf
2018-10-04	09:32	18A-131	pdf
2018-10-04	08:32	18A-389	pdf
2018-10-04	05:41	TDRW0001	pdf
2018-10-04	04:59	18A-146	pdf
2018-10-04	03:41	18A-342	pdf
2018-10-04	03:12	STARTUP	pdf
2018-10-04	02:12	18A-354	pdf

Observing operator logs are available

Sent by email to proposers directly after observation

Stored on web servers:

http://www.vla.nrao.edu/cgi-bin/oplogs.cgi

VLA OBSERVING LOG **2018-10-04_0541_TDRW0001**

Observing Date:	04-Oct-2018		
Configuration:	D		
Decommissioned:	27		
Project:	TDRW0001	# Subarrays:	1
Observer(PI):	Dr Emmanuel Momjian	Observation Type:	Test
SBID(s):	35624494	Band(s) Used:	C S
Source File(s):	TDRW0001_sb35624494_1_1		
Observer E-mail:	emomjian@nrao.edu		
Operator(s):	Kenneth Gibson		

Adobe PDF version of this log is located at: https://www.vla.nrao.edu/operators/logs/

Visibility data is updated every hour in AIPS LATEST nickname and is available from the online archive at: https://archive.nrao.edu

Time (UTC)	Dew Point (C)	Temp. (C)	Wind Speed & Direction (avg)	Bar. Pressure (mbars)	API RMS Phase (degs)	Remarks
04Oct 5:44:10	6.2	17.2	SW at 6.7 m/s	789.7	4.3	Sky cover 20%. Cumuliform clouds.
04Oct 6:46:11	7.0	14.3	SW at 4.7 m/s	789.4	4.7	Sky cover 10%. Stratiform clouds.

Number of antennas used: 27

Start Time	End Time	Comments/Outages	Form #	#Ants	Down Time (in minutes)
04Oct 5:41:30		Starting project TDRW0001.			
04Oct 5:41:30		The band(s) used is(are): C S.			
04Oct 5:44:06		On source 0137+331=3C48 with all available antennas.			
04Oct 5:41:30		To access your data from the NRAO archive visit:			
		https://science.nrao.edu/facilities/vla/archive.			
		All VLA science data are processed through the VLA calibration pipeline. Details			
		are at: https://science.nrao.edu/facilities/vla/data-processing/pipeline.			
		For further questions please use the NRAO helpdesk at:			
		https://science.nrao.edu/observing/helpdesk.			
04Oct 5:41:30		Note: To support our ongoing RFI monitoring efforts, any feedback from your			
		program on RFI can be sent to: nrao-rfi@nrao.edu.			
		The key information to provide is:			
		- Observation/project code			
		- Frequency and Time of the observations			
		- The characteristics of the RFI signal, in particular if it is continuous or			

VLA OBSERVING LOG **2018-10-04_0541_TDRW0001**

		intermittent?			
		- If possible, a spectrum of the RFI should be included in the e-mail.			
		Thanks very much for your support; this information will be continuously			
		updated on the EVLA science pages at:			
		https://science.nrao.edu/facilities/vla/docs/manuals/obsguide/modes/rfi			
04Oct 5:41:30		Antennas in the D-array may be shadowed at low elevations. If shadowing			
		occurs, sensitivity will be affected.			
04Oct 5:41:30		NOTE: The VLA is still [illegible] power outage, and these data may			
		have [illegible] artifacts, missing antennas or IFs, ect., in them. NRAO staff will			
		examine the data closely after observing to determine if they meet the criteria for			
		a successful observation.			
04Oct 5:41:30	04Oct 8:32:51	Antenna(s) 5 (Data: Corrupted): FRONT END	WO-959	0.97	165.4
		S-band receiver cooling after work performed, currently 65/177K			
04Oct 5:41:30	04Oct 8:32:51	Antenna(s) 12 (Data: Corrupted): CRYOGENICS	PM	0.03	5.8
		C-band receiver warm for cold head replacement			
04Oct 5:57:00		Your new operator(s) is(are): Sam Gilmore			

Antenna 5 (&12) potential issues

Project End Time		Total Project Time (minutes x 27 ants)	Down Time % of Total Time	Total Down Time
04Oct 8:32:51	End of project TDRW0001	4626.0	3.7%	171.2

Obtaining data from the NRAO archive

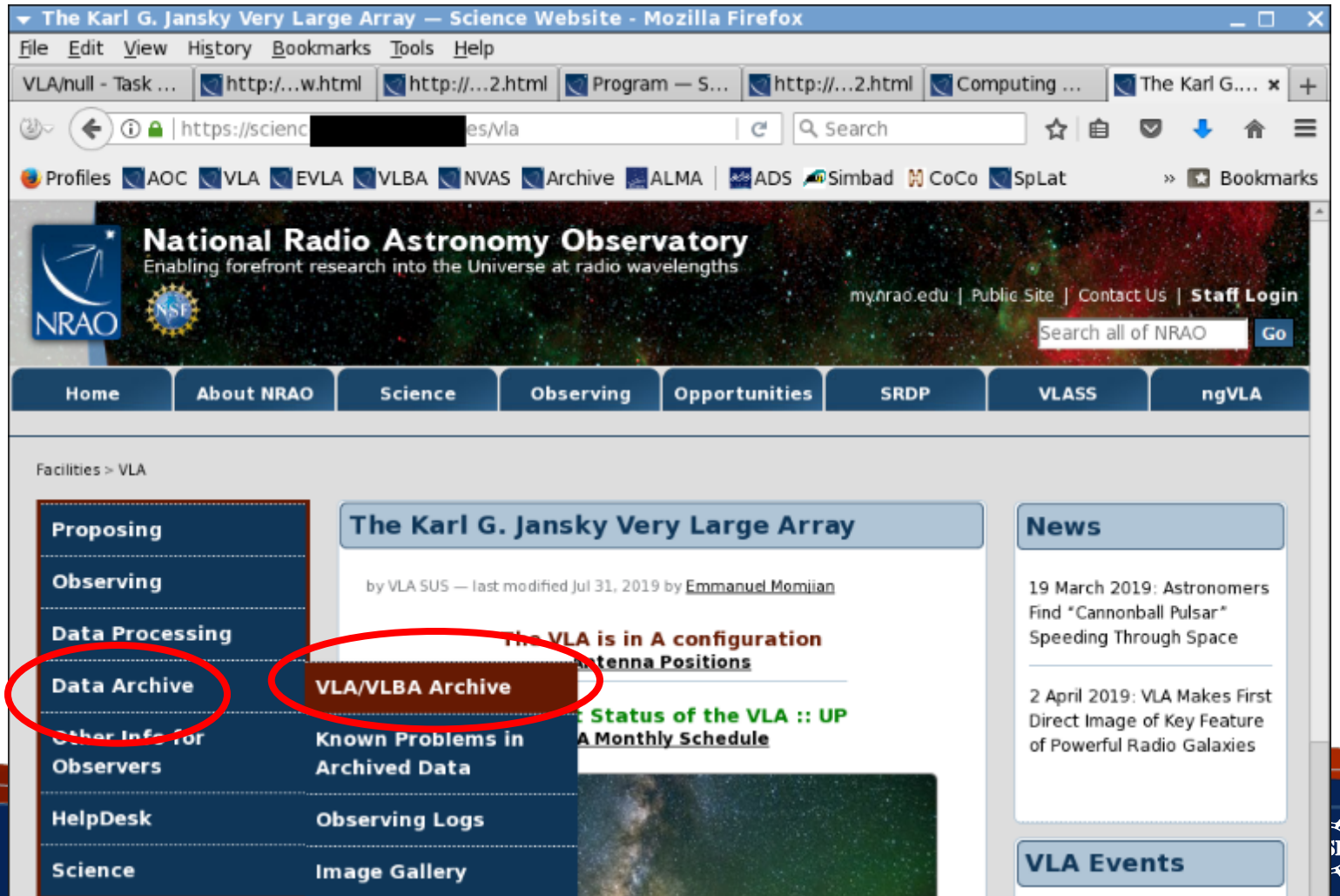
The *current* archive tool and the *new* archive tool

(improvements in progress)

The NRAO Data Archive Tool

https://science.nrao.edu/facilities/vla/

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



The NRAO Data Archive Tool

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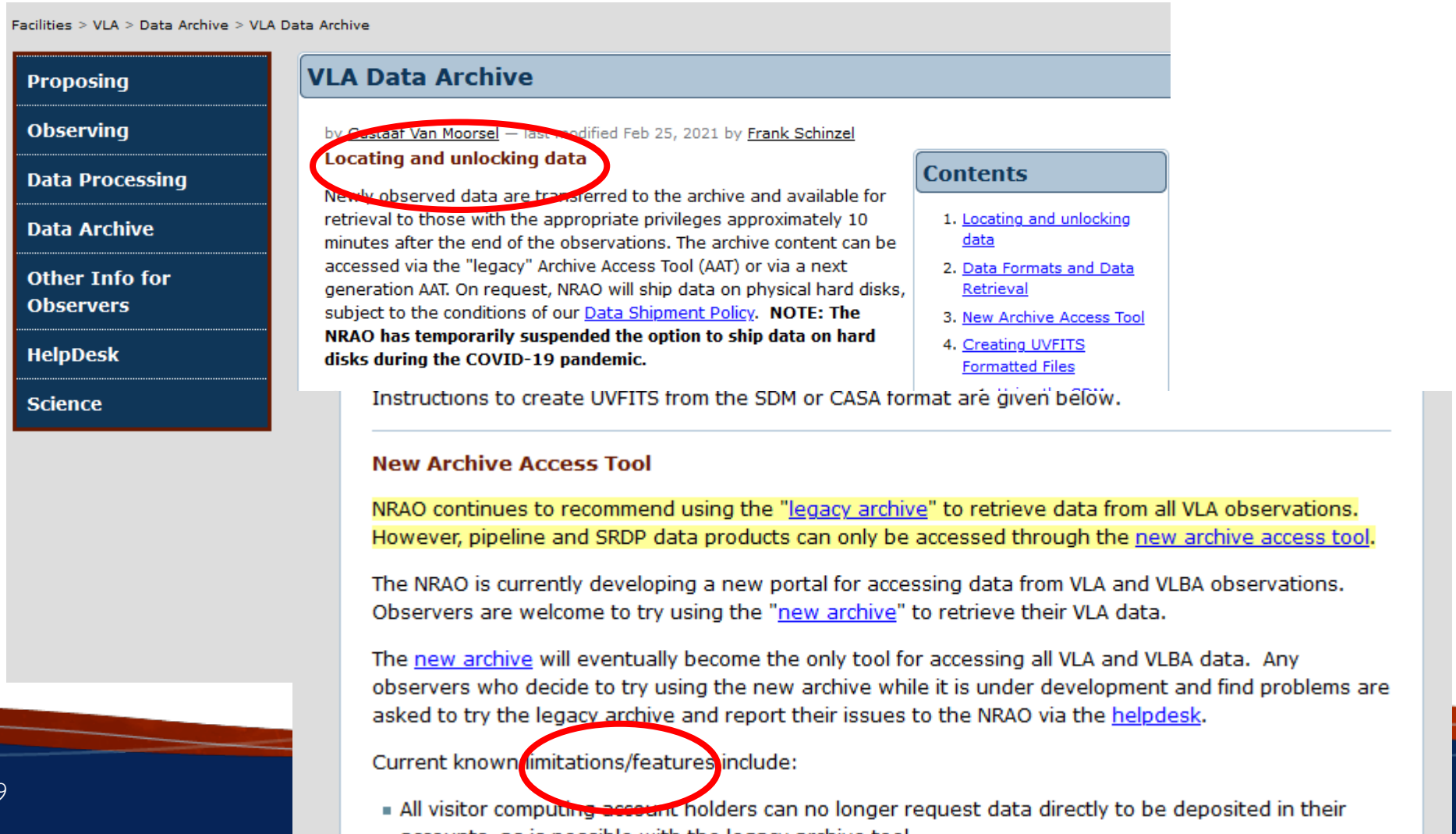
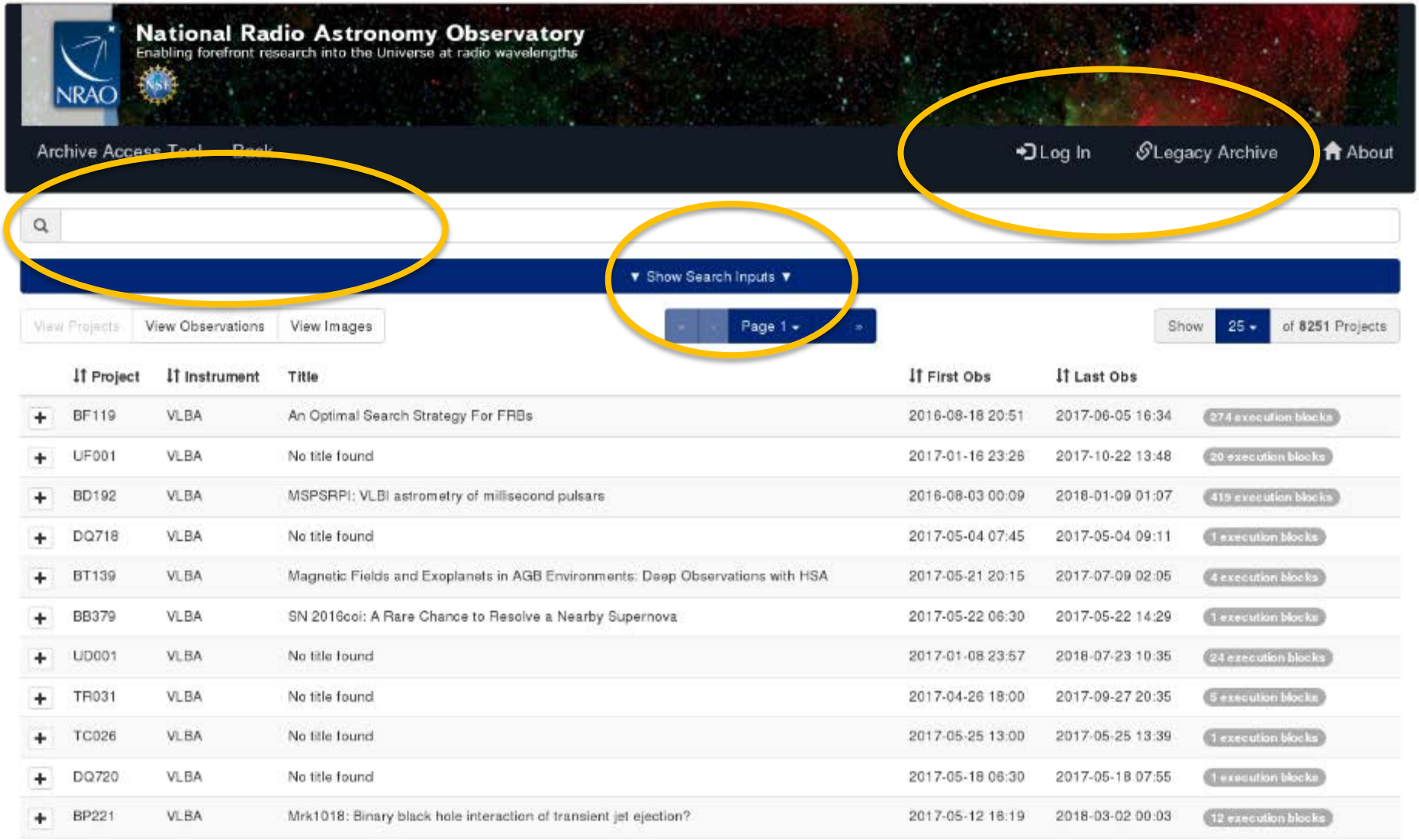
→ Data Archive (left menu), VLA/VLBA Archive

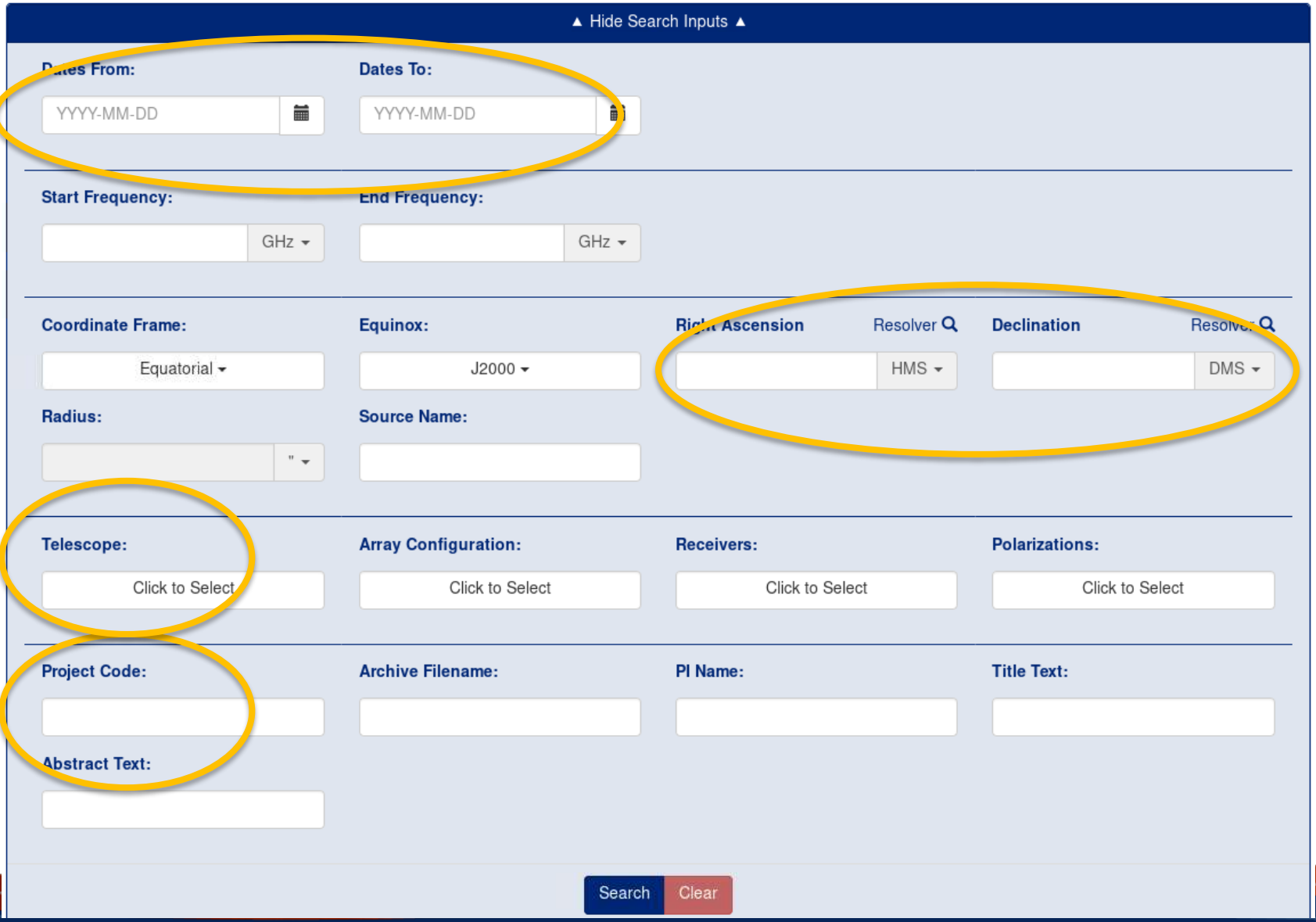


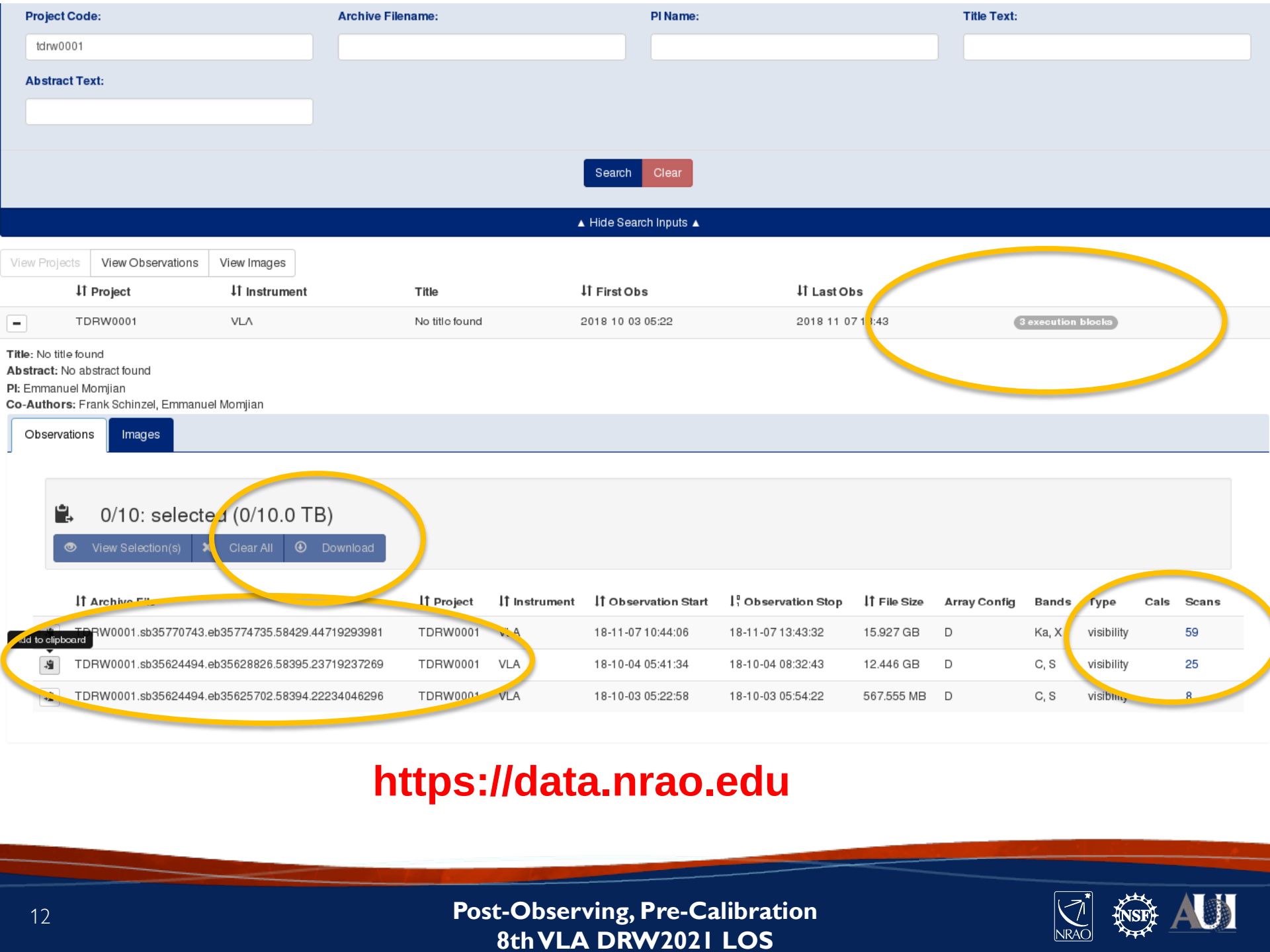
https://data.nrao.edu



Project	Instrument	Title	First Obs	Last Obs	
BF119	VLBA	An Optimal Search Strategy For FRBs	2016-08-18 20:51	2017-06-05 16:34	274 execution blocks
UF001	VLBA	No title found	2017-01-16 23:28	2017-10-22 13:48	20 execution blocks
BD192	VLBA	MSPSRPI: VLBI astrometry of millisecond pulsars	2016-08-03 00:09	2018-01-09 01:07	419 execution blocks
DQ718	VLBA	No title found	2017-05-04 07:45	2017-05-04 09:11	1 execution blocks
BT139	VLBA	Magnetic Fields and Exoplanets in AGB Environments: Deep Observations with HSA	2017-05-21 20:15	2017-07-09 02:05	4 execution blocks
BB379	VLBA	SN 2016coi: A Rare Chance to Resolve a Nearby Supernova	2017-05-22 06:30	2017-05-22 14:29	1 execution blocks
UD001	VLBA	No title found	2017-01-08 23:57	2018-07-23 10:35	24 execution blocks
TR031	VLBA	No title found	2017-04-26 18:00	2017-09-27 20:35	5 execution blocks
TC026	VLBA	No title found	2017-05-25 13:00	2017-05-25 13:39	1 execution blocks
DQ720	VLBA	No title found	2017-05-18 06:30	2017-05-18 07:55	1 execution blocks
BP221	VLBA	Mrk1018: Binary black hole interaction of transient jet ejection?	2017-05-12 18:19	2018-03-02 00:03	12 execution blocks

https://data.nrao.edu





https://data.nrao.edu

Archive Access Tool Back Log In Legacy Archive About

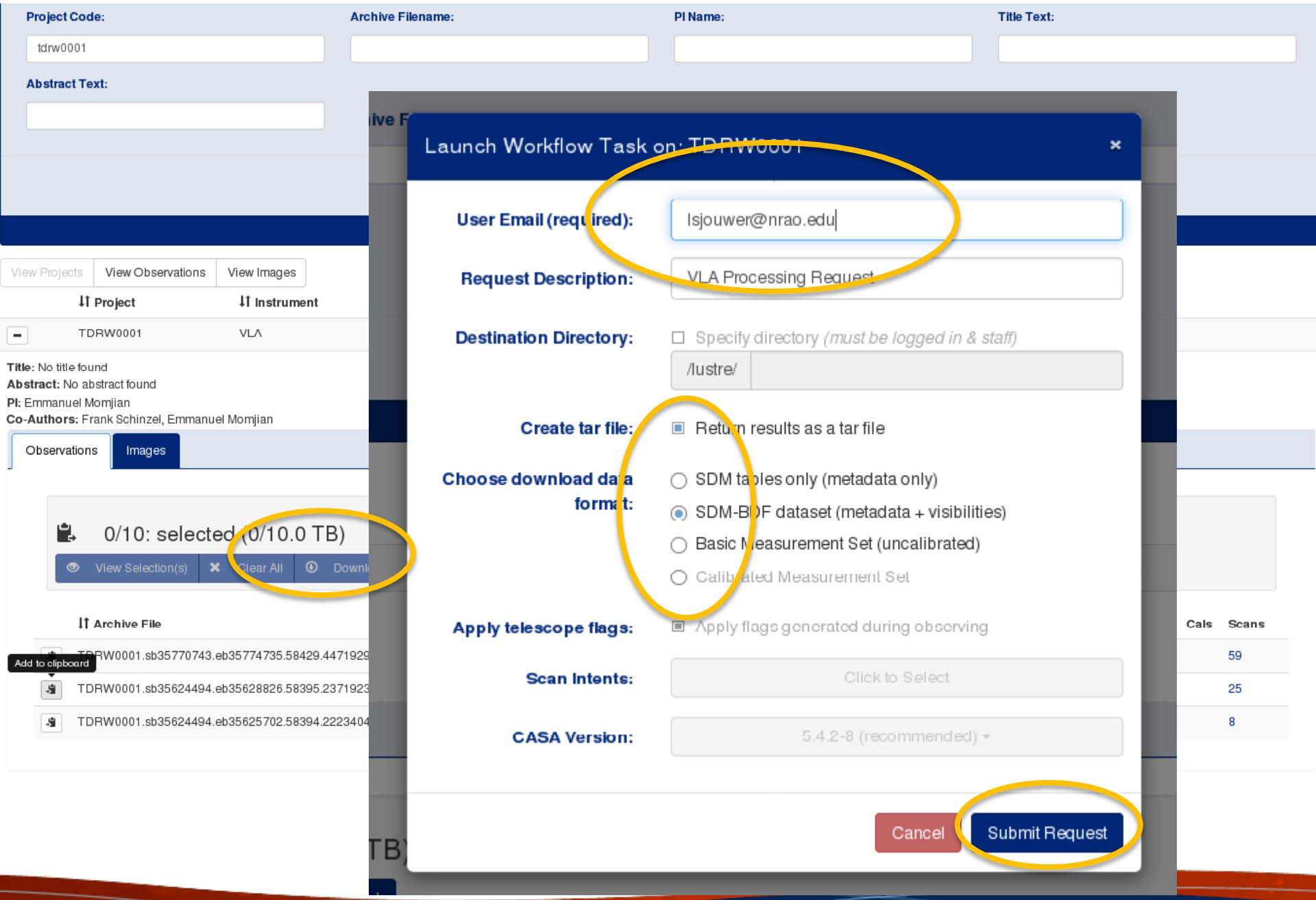
Observation ID: TDRW0001.sb35770743.eb35774735.58429.44719293981

Obs ID: TDRW0001.sb35770743.eb35774735.58429.44719293981
Project Code: TDRW0001
Estimated Size: 15.927 GB
Obs Release Date: 2018-11-07T13:43:32.001Z
Data Product Type: visibility
Receiver Band: Ka, X
Array Configuration: D

Request Data

Longitude	Latitude	Target Name	Min Frequency	Max Frequency	Scan Intent	Polarizations	Temporal Res
13h31m8.288s	30°30'32.959"	1331+305=3C286	8.3320000 GHz	8.4600000 GHz	["CALIBRATE_POINTING"]	["RR, RL, LR, LL"]	1.044
9h54m56.824s	17°43'31.222"	J0954+1743	8.3320000 GHz	8.4600000 GHz	["CALIBRATE_POINTING"]	["RR, RL, LR, LL"]	1.053
9h47m57.382s	13°16'40.660"	IRC+10216	36.3115447 GHz	36.8677209 GHz	["OBSERVE_TARGET"]	["RR, RL, LR, LL"]	3.053
9h47m57.382s	13°16'40.660"	IRC+10216	36.3115447 GHz	36.8677209 GHz	["OBSERVE_TARGET"]	["RR, RL, LR, LL"]	3.022
9h54m56.824s	17°43'31.222"	J0954+1743	36.3115447 GHz	36.8677209 GHz	["SYSTEM_CONFIGURATION"]	["RR, RL, LR, LL"]	3.322
9h47m57.382s	13°16'40.660"	IRC+10216	36.3115447 GHz	36.8677209 GHz	["OBSERVE_TARGET"]	["RR, RL, LR, LL"]	3.022
9h54m56.824s	17°43'31.222"	J0954+1743	36.3115447 GHz	36.8677209 GHz	["CALIBRATE_AMPLI","CALIBRATE_PHASE"]	["RR, RL, LR, LL"]	3.095
9h47m57.382s	13°16'40.660"	IRC+10216	36.3115447 GHz	36.8677209 GHz	["OBSERVE_TARGET"]	["RR, RL, LR, LL"]	3.022
9h47m57.382s	13°16'40.660"	IRC+10216	36.3115447 GHz	36.8677209 GHz	["OBSERVE_TARGET"]	["RR, RL, LR, LL"]	3.053
9h54m56.824s	17°43'31.222"	J0954+1743	36.3115447 GHz	36.8677209 GHz	["CALIBRATE_AMPLI","CALIBRATE_PHASE"]	["RR, RL, LR, LL"]	3.095
9h54m56.824s	17°43'31.222"	J0954+1743	36.3115447 GHz	36.8677209 GHz	["CALIBRATE_AMPLI","CALIBRATE_PHASE"]	["RR, RL, LR, LL"]	3.097
9h47m57.382s	13°16'40.660"	IRC+10216	36.3115447 GHz	36.8677209 GHz	["OBSERVE_TARGET"]	["RR, RL, LR, LL"]	3.053

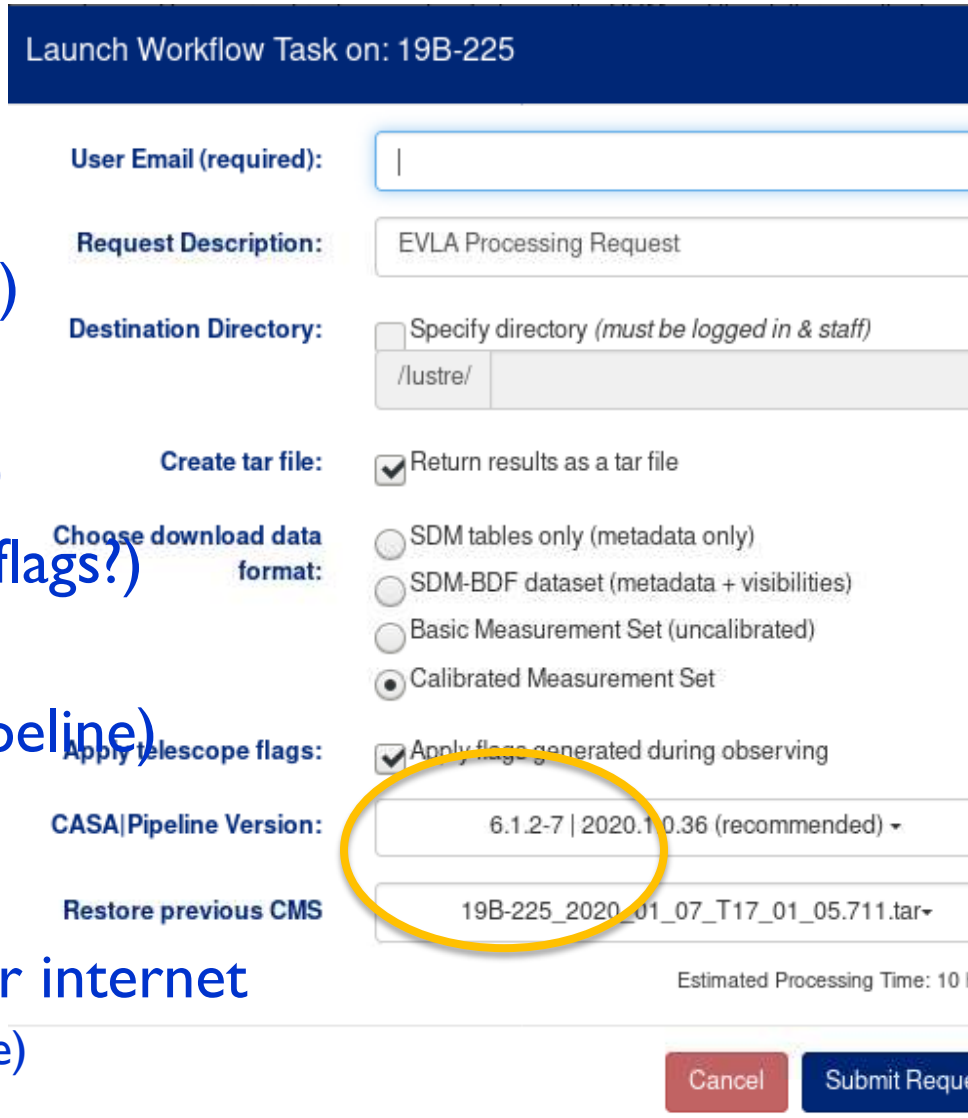
https://data.nrao.edu



Post-Observing, Pre-Calibration
8th VLA DRW2021 LOS

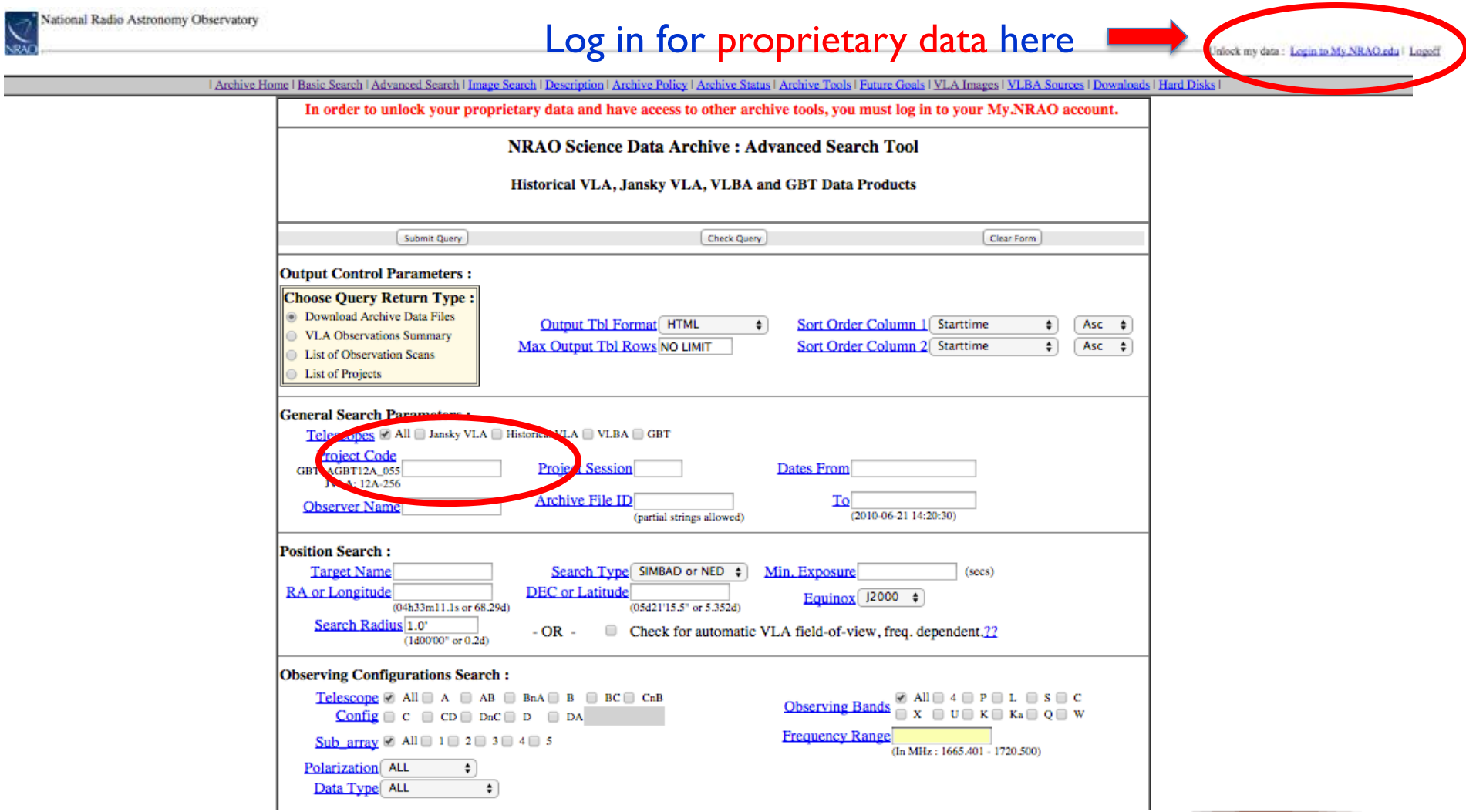
Science Data Model

- SDM native VLA data format
  - Header tables (XML, meta)
  - Scan data (BDF, binary)
- CASA Measurement Set (MS)
  - Basic (SDM ⟹ MS, with flags?)
    - Online, Shadow, Zero
  - Calibrated (VLA CASA pipeline)
    - CASA version dependent !
- SDM/MS are data directories
  - "tar" for downloading over internet
    (but requires twice the disk space)
  - Alternatively, use "wget"



The Archive Tool

https://archive.nrao.edu/



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
  - 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	Dat Qua	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

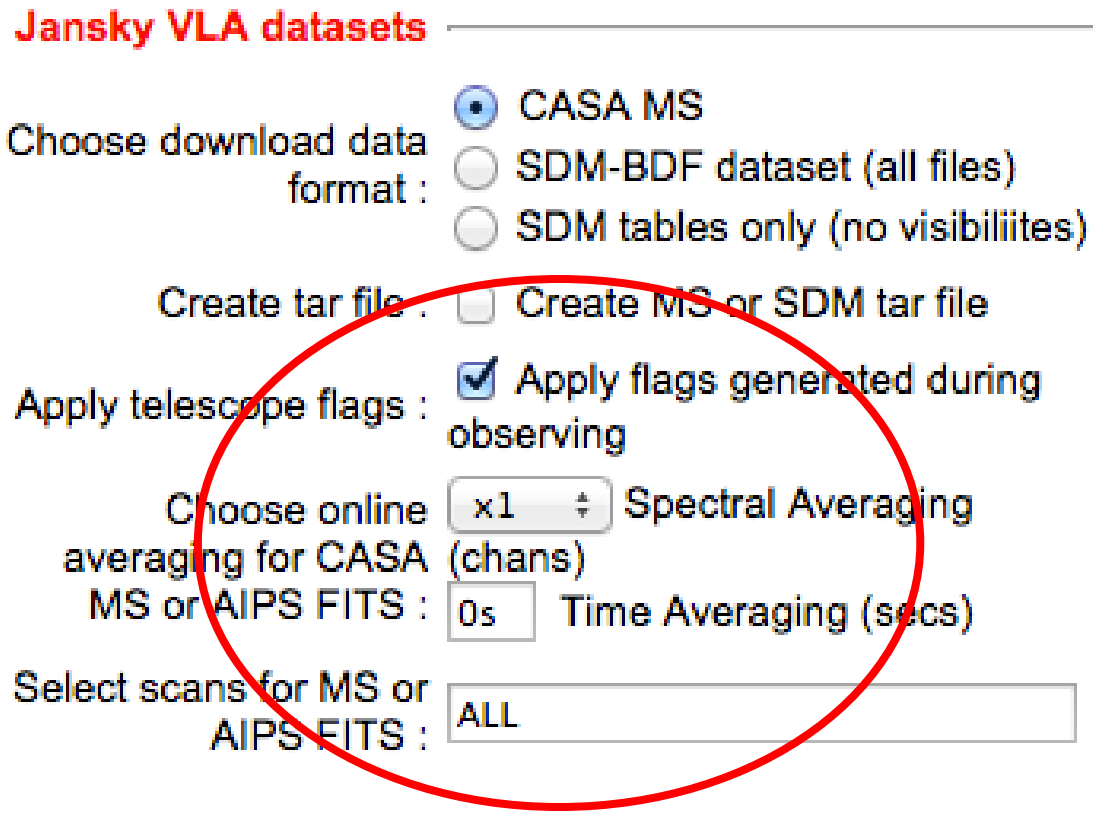
Scan listing:

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				

Download options: data format

- Same data formats:
  - SDM or MS, tar?
- Flagging and averaging options only apply to CASA MS format
  - Decreases data size
  - Apply the flags!
  - May cause coherence loss: See discussion in VLA Observational Status Summary (OSS)



Some final archive notes

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

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

- Disk-ordering process is done through the archive/helpdesk
- 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

Getting CASA Pipeline Calibrated Data

- Upcoming VLA CASA pipeline talks…
- Note that VLA CASA calibration pipeline products are only available through the new archive
- 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

- See previous lecture..
- 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 6.1.2-7 will be used at this workshop

- Type "*casa –ls*" to find the exact string
- Then "*casa [–r <version-string>]*" to start

Loading The Data: *importasdm*

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

- Task *import**asdm*** converts the SDM-BDF to MS
- *importasdm* only understands VLA online flags:
  - It converts the data into a MS while applying flags.

```
> default importasdm
> inp
> asdm              =  'archive_sdm_directory_name'
> vis               =  'output MS name'
> ocorr_mode        =  'co'    (or load ca, ao)
> applyflags        =   True
> inp
> go
```

Loading The Data: *flagdata*

Additional flags for VLA data:

- Note that if `applyflags = False` (the default in *importasdm*), the flags are written to a FLAG_CMD MS table. They can be examined (listed, plotted) and applied by using the task *flagcmd*

- VLA data needs additional flags for shadowing and pure zero data; these flags are applied using the *flagdata* task:

```
> default flagdata
> vis                 =       'drw.ms'
> mode                =       'shadow'
> inp
> go
> mode                =       'clip'
> correlation         =       'ABS_ALL'
> clipzeros           =       True
> go
```

Examining Your Data

- Operator observing log (email, posted on web)
- Plotting the antenna positions: *plotants*

  (potential reference antennas)
- Observing summary: *listobs*

  (sources, scans, spectral windows, antennas, etc…)
- Plotting/displaying/editing data: *plotms*

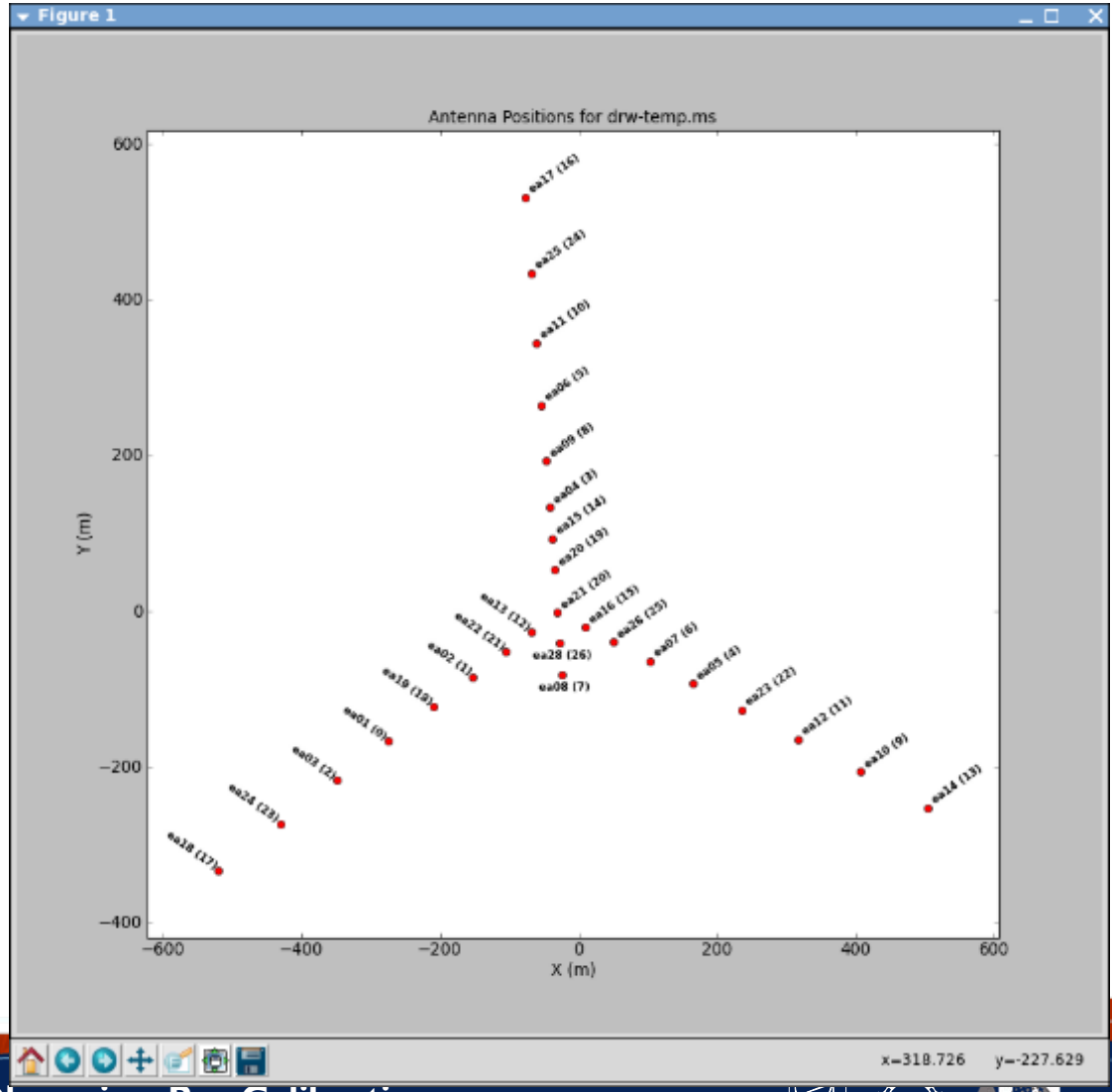
Examine your data carefully before flagging:

That is, know your data content

Plotting the antennas: *plotants*

```
> default plotants
> inp
> vis = 'drw.ms'
> antindex = True
> inp
> go
```

Find a reference antenna for use in data processing



Choosing the reference antenna

Hints:

- Must have good data on **all calibrator** sources (target scans irrelevant)
  - No antenna "issues"
  - Clean from RFI
- Baselines not too long
  - **Near** physical center of array

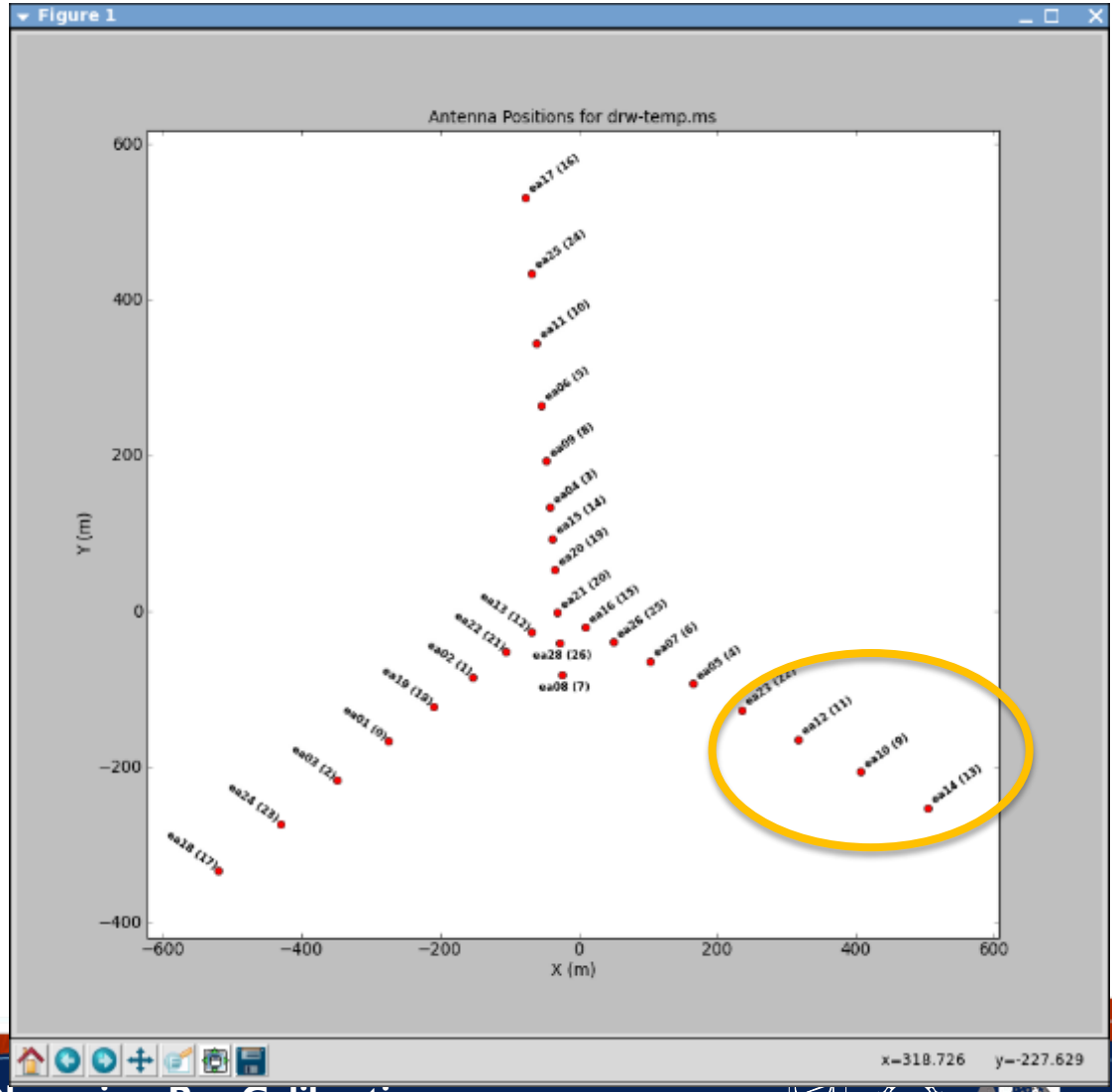
    (use *listobs/vishead*)
  - e.g. 08-pad [WNE]

    A: inner antennas

    D: no shadowing

    Also don't move..
- Here: **ea10**

  (D array, E08, #=9)



Observing summary: *listobs*

```
> Default listobs
> vis = 'drw-temp.ms'
> inp
> go

Note:
> listfile =
```

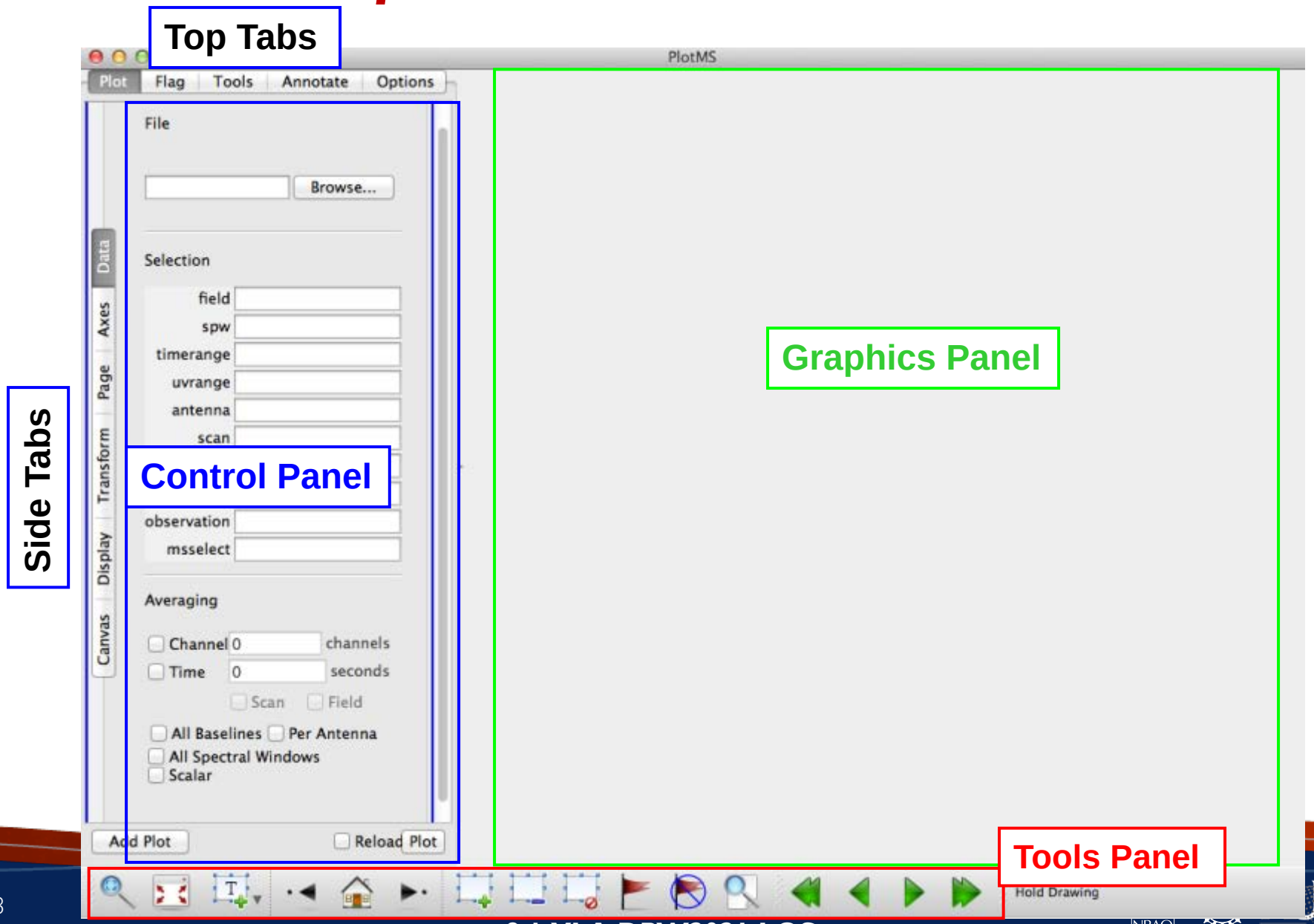
```
   ObservationID = 0         ArrayID = 0
  Date        Timerange (UTC)          Scan  FldId FieldName             nRows     SpwIds   Average Interval(s)
  04-Oct-2018/05:41:35.0 - 05:42:31.0     1      0 0137+331=3C48          39312   [0,1]   [1, 1] [SYSTEM_CONFIG
              05:42:32.0 - 05:47:30.0     2      0 0137+331=3C48         209196   [0,1]   [1, 1] [SYSTEM_CONFIG
              05:47:35.0 - 05:48:30.0     3      0 0137+331=3C48          30888   [2,3,4,5,6,7,8,9]   [5, 5, 5,
              05:48:35.0 - 05:49:00.0     4      0 0137+331=3C48          14040   [2,3,4,5,6,7,8,9]   [5, 5, 5,
              05:49:05.0 - 05:53:25.0     5      0 0137+331=3C48         146016   [2,3,4,5,6,7,8,9]   [5, 5, 5,
              05:53:30.0 - 05:57:55.0     6      1 J2355+4950            148824   [2,3,4,5,6,7,8,9]   [5, 5, 5,
              05:58:00.0 - 06:03:55.0     7      2 J0259+0747            199368   [2,3,4,5,6,7,8,9]   [5, 5, 5,
              06:04:00.0 - 06:18:55.0     8      3 3C75                  502632   [2,3,4,5,6,7,8,9]   [5, 5, 5,
              06:19:00.0 - 06:20:10.0     9      2 J0259+0747             39312   [2,3,4,5,6,7,8,9]   [5, 5, 5,
              06:20:15.0 - 06:35:05.0    10      3 3C75                  499824   [2,3,4,5,6,7,8,9]   [5, 5, 5,
              06:35:10.0 - 06:36:20.0    11      2 J0259+0747             39312   [2,3,4,5,6,7,8,9]   [5, 5, 5,
              06:36:25.0 - 06:51:20.0    12      3 3C75                  502632   [2,3,4,5,6,7,8,9]   [5, 5, 5,
              06:51:25.0 - 06:52:30.0    13      2 J0259+0747             36504   [2,3,4,5,6,7,8,9]   [5, 5, 5,
              06:52:35.0 - 07:07:30.0    14      3 3C75                  502632   [2,3,4,5,6,7,8,9]   [5, 5, 5,
              07:07:35.0 - 07:08:45.0    15      2 J0259+0747             39312   [2,3,4,5,6,7,8,9]   [5, 5, 5,
              07:08:50.0 - 07:23:40.0    16      3 3C75                  499824   [2,3,4,5,6,7,8,9]   [5, 5, 5,
              07:23:45.0 - 07:26:25.0    17      2 J0259+0747             89856   [2,3,4,5,6,7,8,9]   [5, 5, 5,
              07:26:30.0 - 07:41:25.0    18      3 3C75                  502632   [2,3,4,5,6,7,8,9]   [5, 5, 5,
              07:41:30.0 - 07:42:40.0    19      2 J0259+0747             39312   [2,3,4,5,6,7,8,9]   [5, 5, 5,
              07:42:45.0 - 07:57:35.0    20      3 3C75                  499824   [2,3,4,5,6,7,8,9]   [5, 5, 5,
              07:57:40.0 - 07:58:50.0    21      2 J0259+0747             39312   [2,3,4,5,6,7,8,9]   [5, 5, 5,
              07:58:55.0 - 08:13:50.0    22      3 3C75                  502632   [2,3,4,5,6,7,8,9]   [5, 5, 5,
              08:13:55.0 - 08:15:05.0    23      2 J0259+0747             39312   [2,3,4,5,6,7,8,9]   [5, 5, 5,
              08:15:10.0 - 08:30:00.0    24      3 3C75                  499824   [2,3,4,5,6,7,8,9]   [5, 5, 5,
              08:30:05.0 - 08:32:45.0    25      2 J0259+0747             89856   [2,3,4,5,6,7,8,9]   [5, 5, 5,
          (nRows = Total number of rows per scan)
Fields: 4
  ID   Code Name                RA               Decl           Epoch   SrcId      nRows
  0    NONE 0137+331=3C48       01:37:41.299431 +33.09.35.13299 J2000   0         439452
  1    NONE J2355+4950          23:55:09.458169 +49.50.08.34001 J2000   1         148824
  2    NONE J0259+0747          02:59:27.076633 +07.47.39.64322 J2000   2         651456
  3    NONE 3C75                02:57:42.630000 +06.01.04.80000 J2000   3        4512456
Spectral Windows:  (10 unique spectral windows and 1 unique polarization setups)
  SpwID  Name           #Chans   Frame   Ch0(MHz)   ChanWid(kHz)   TotBW(kHz)  CtrFreq(MHz)  BBC Num  Corrs
  0      EVLA_C#A0C0#0      64   TOPO    4832.000       2000.000     128000.0     4895.0000       12  RR  RL  LR  LL
  1      EVLA_C#B0D0#1      64   TOPO    4960.000       2000.000     128000.0     5023.0000       15  RR  RL  LR  LL
  2      EVLA_S#A0C0#2      64   TOPO    2488.000       2000.000     128000.0     2551.0000       12  RR  RL  LR  LL
  3      EVLA_S#A0C0#3      64   TOPO    2616.000       2000.000     128000.0     2679.0000       12  RR  RL  LR  LL
  4      EVLA_S#A0C0#4      64   TOPO    2744.000       2000.000     128000.0     2807.0000       12  RR  RL  LR  LL
```

Observing summary: *listobs*

Summary, for example:

- Four sources:
  - 0137+331=3C48
    - 5 scans of which 4 are setup, i.e. 1 scan on Flux calibrator
  - J2355+4950, 1 scan, some calibrator
  - J0259+0747, 10 scans, Gain/phase calibrator
  - **3C75**, 9 scans, source with the most time on source, has the most visibilities so this would be the **target source**
- 8 spectral windows (spw), full polarization products (RR,RL,LR,LL)
  - Ranging 2488 to (3384+128=) 3512 MHz, centered at 3000 MHz
  - 64 channels per spw/pol, each 2 MHz wide
- Using 27 antennas (ea27 is not used)
  - Highest numbered antenna pad is E09/N09/W09: D-array

Data Review: *plotms*



Data Review: *plotms*

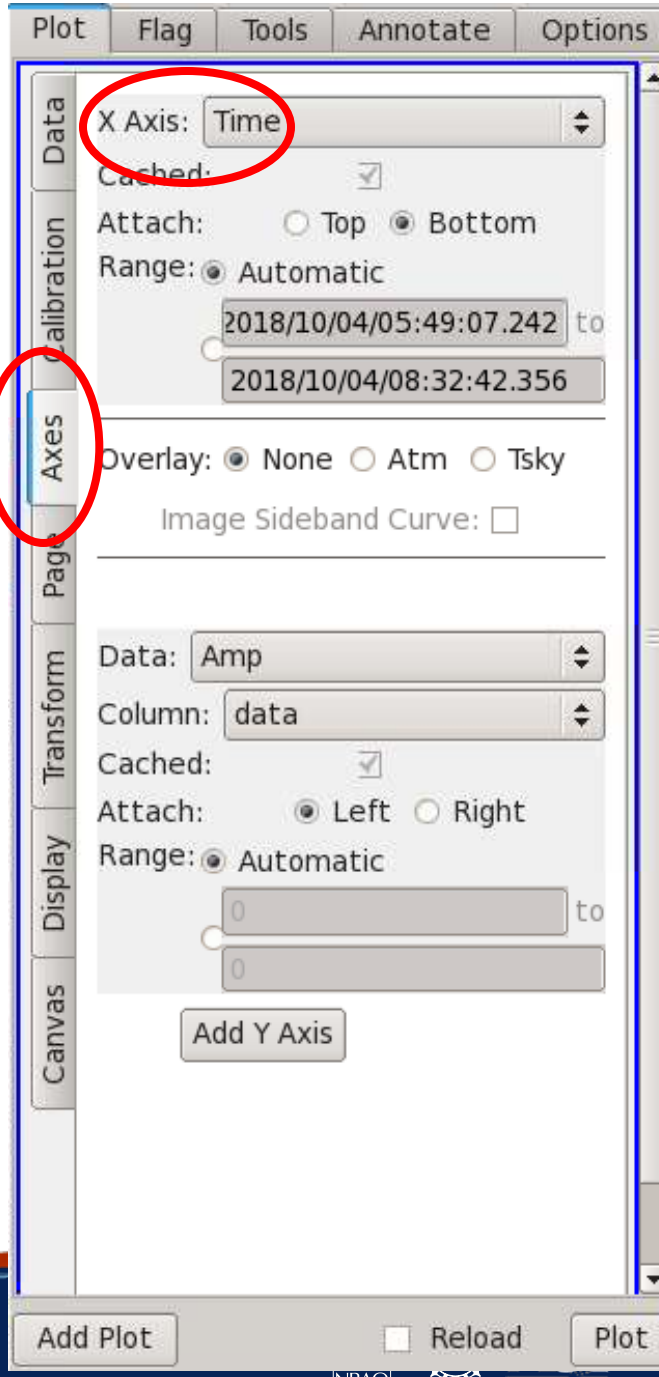
Axes

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'

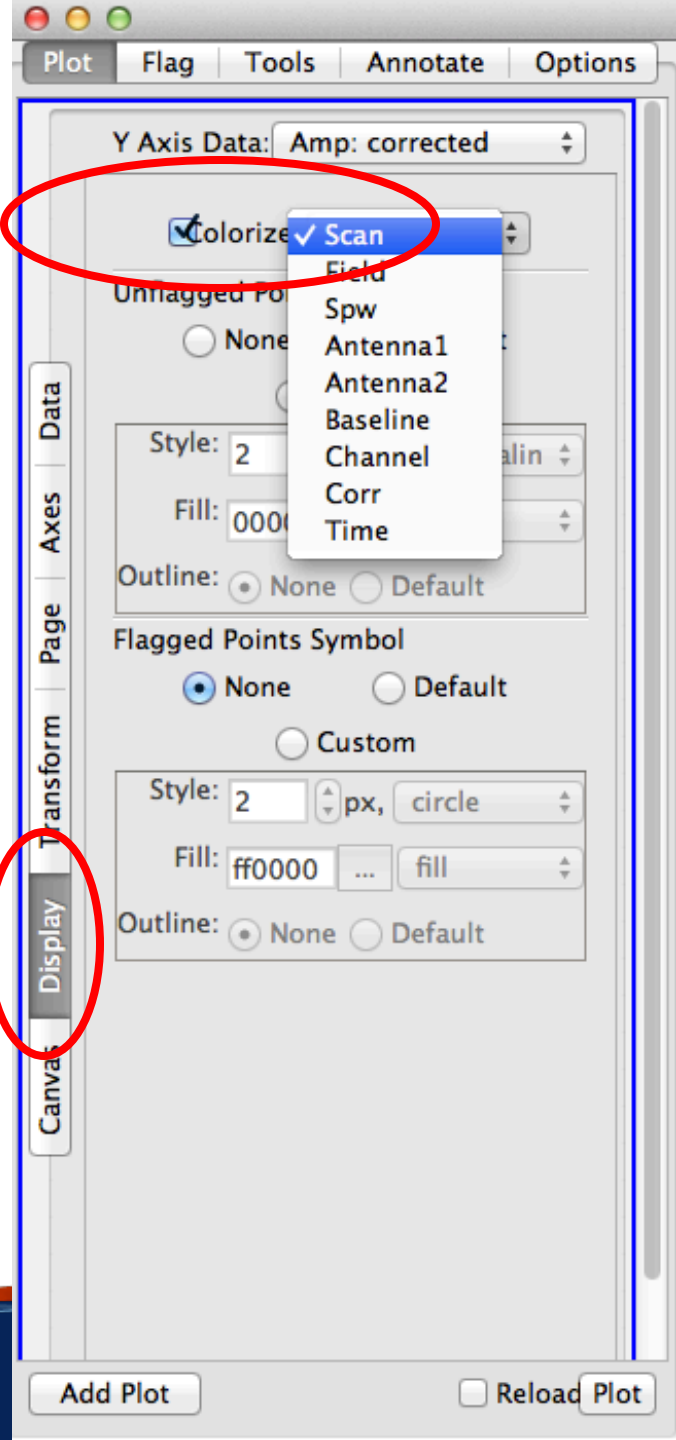


Data Review: *plotms*

Display

Colorize by:

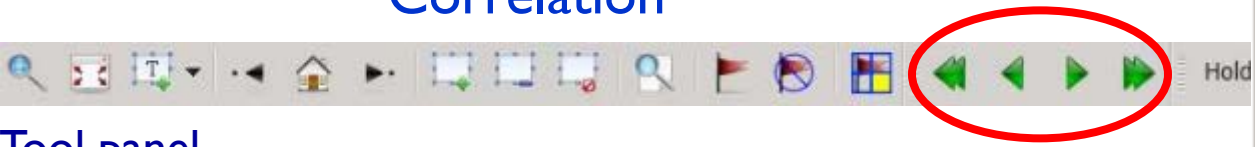
- Scan
- Field
- Spw
- Antenna1
- Antenna2
- Baseline
- Channel
- Correlation
- Time
- Observation
- Intent



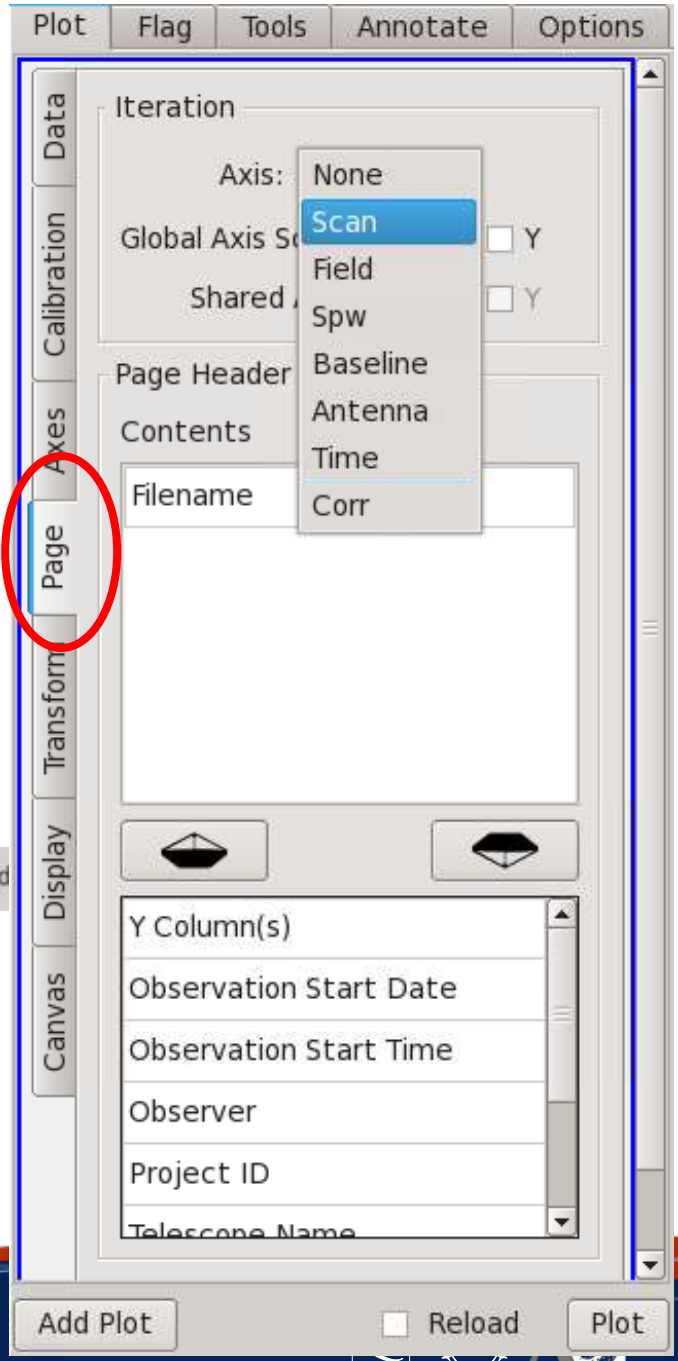
Data Review: *plotms*

Multi-page, cycling through/iterate

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



Tool panel



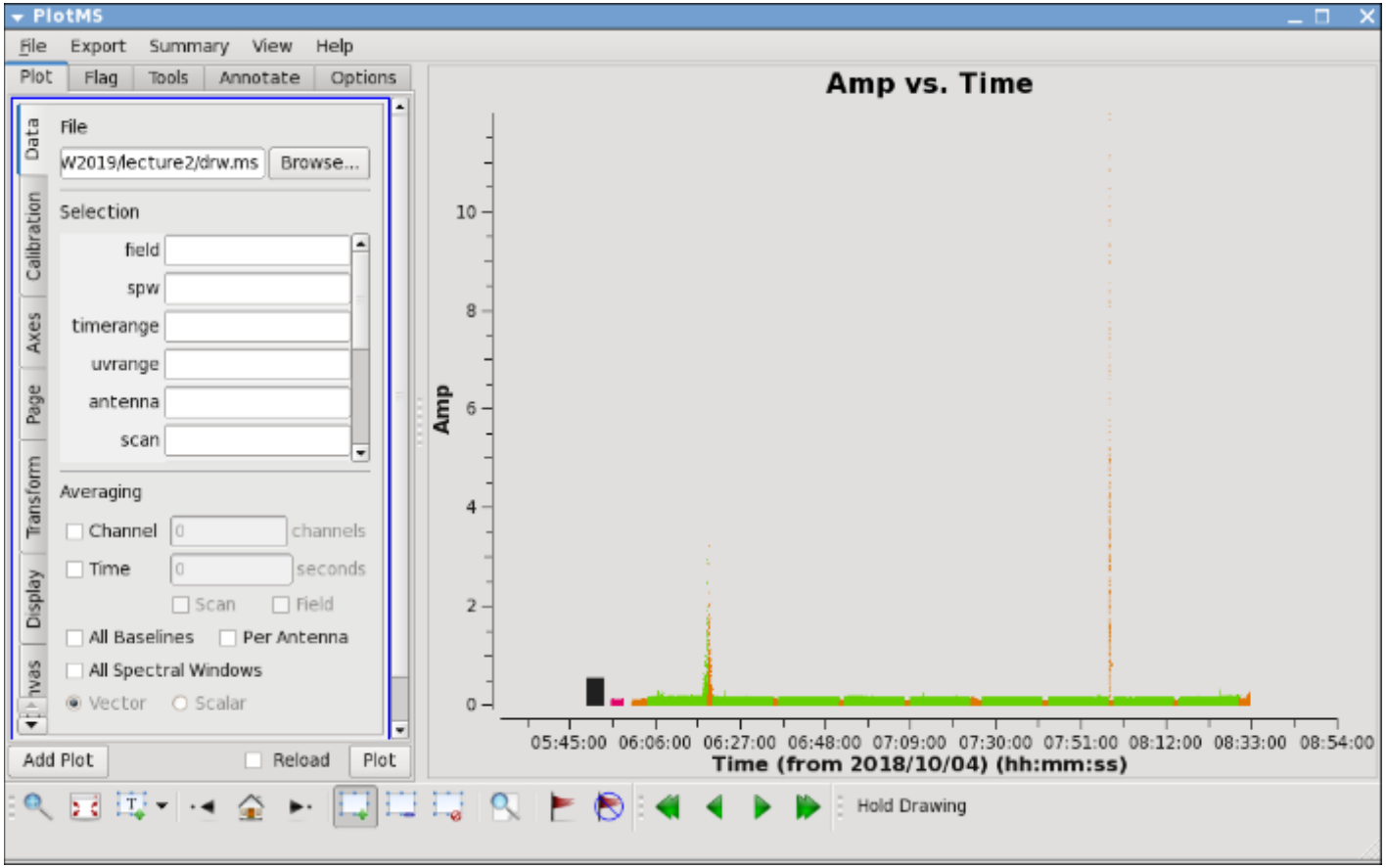
What are we looking for?

- 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/RFI (observing conditions)
  - In frequency
    - Bandpass, subband edges
    - RFI – not your line!

Data Review: *plotms*

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



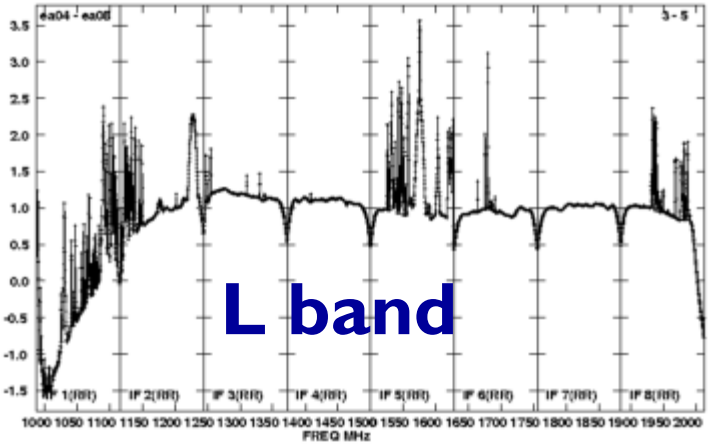
Radio Frequency Interference (RFI)

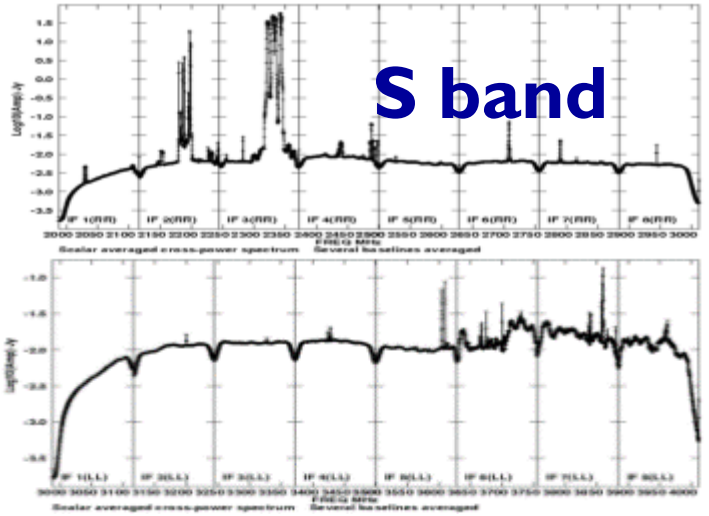
1. VLA observations, particularly at the lower frequency bands, will be severely affected by RFI.
2. VLA RFI information is available at:

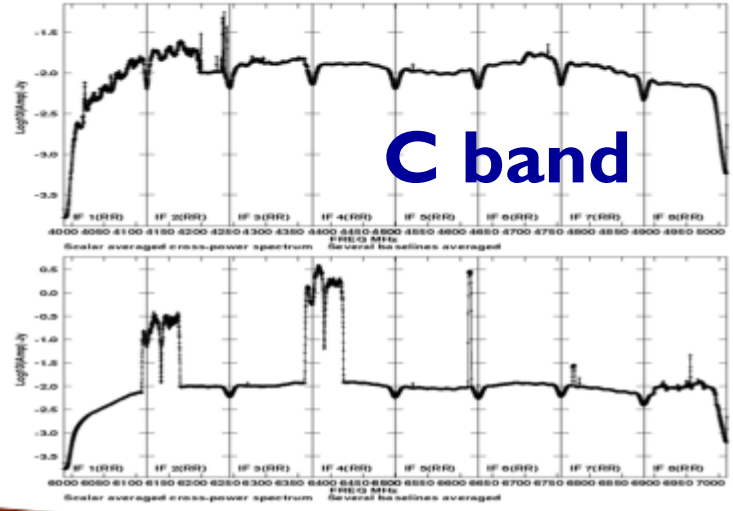
   https://science.nrao.edu/facilities/vla/ → Observing → VLA Observing Guide → #5: Radio Frequency Interference

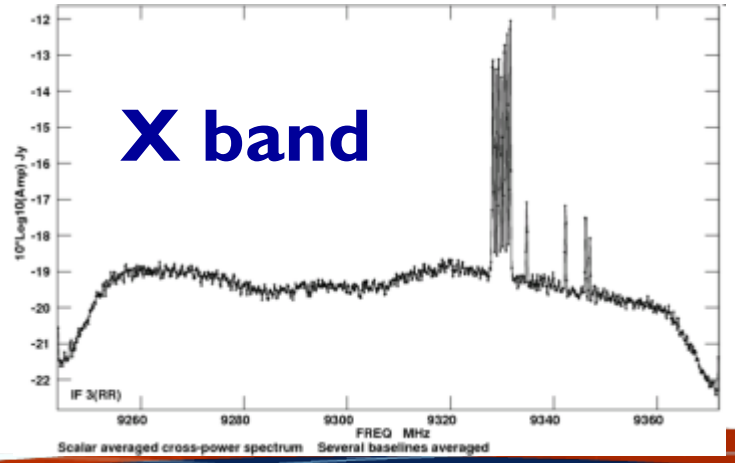
   - RFI listings per frequency band.
   - Spectra of various RFI sweeps between 1-50 GHz.

RFI is present at lower frequency bands



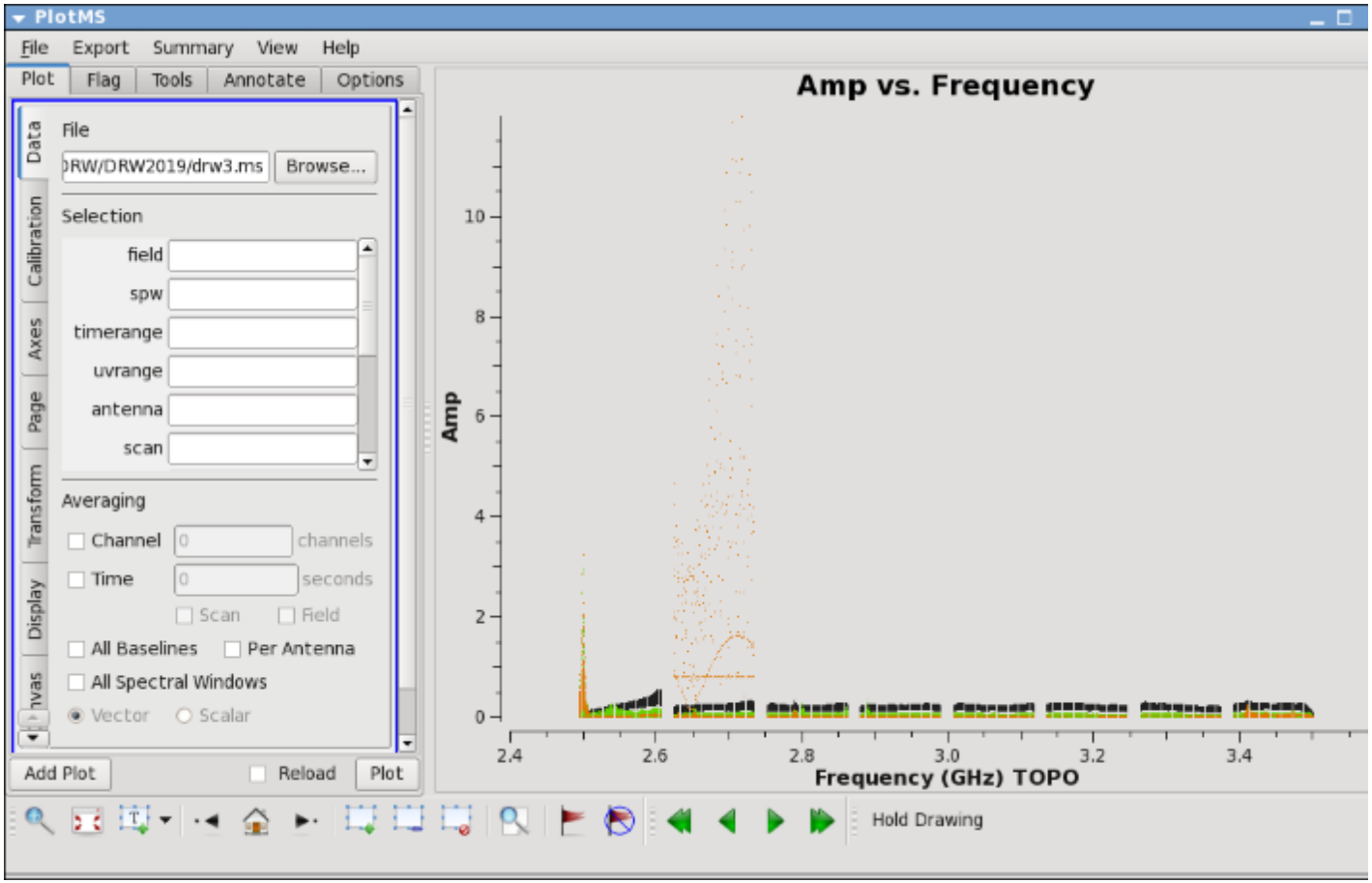






Data Review: *plotms*

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



Preparing for calibration: editing

Editing/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

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.

Editing/Flagging (or unflagging) Data
A few important notes

- 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 – there is no record of what it was before setting to True.
  - Unflagging sets it to Flase, *regardless* it's immediate previous setting
- ***Most*** flagging tasks have the option to create a flag backup.
  - In particular *plotms* does not have this option!
- A flag backup is an MS table and contains the state of the flags before running the flagging task.
- With *flagmanager* flag back-ups can be restored (and made)

Editing Data: *flagdata* - Modes

- *list* = apply a list of flagging commands
- *manual* = flagging based on specific selection parameters [default]
- *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.

Editing Data: *flagcmd*

- It allows listing, plotting, saving, applying, or un-applying flags.
- Flagging modes (`inpmode`) are:
  - *table*: uses the FLAG_CMD MS table (created by *importasdm*)
  - *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.

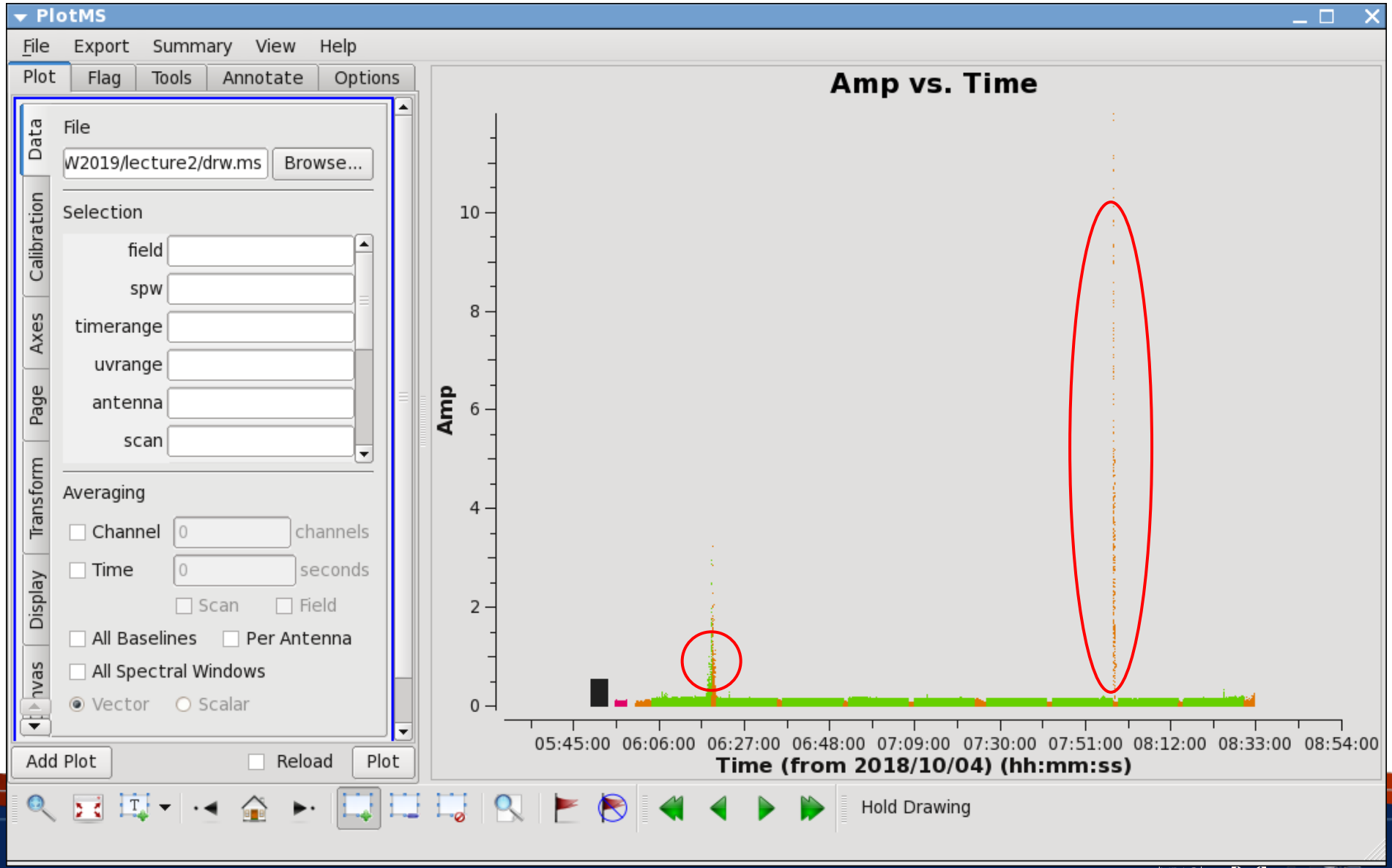
Editing Data: *flagdata vs. flagcmd*

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

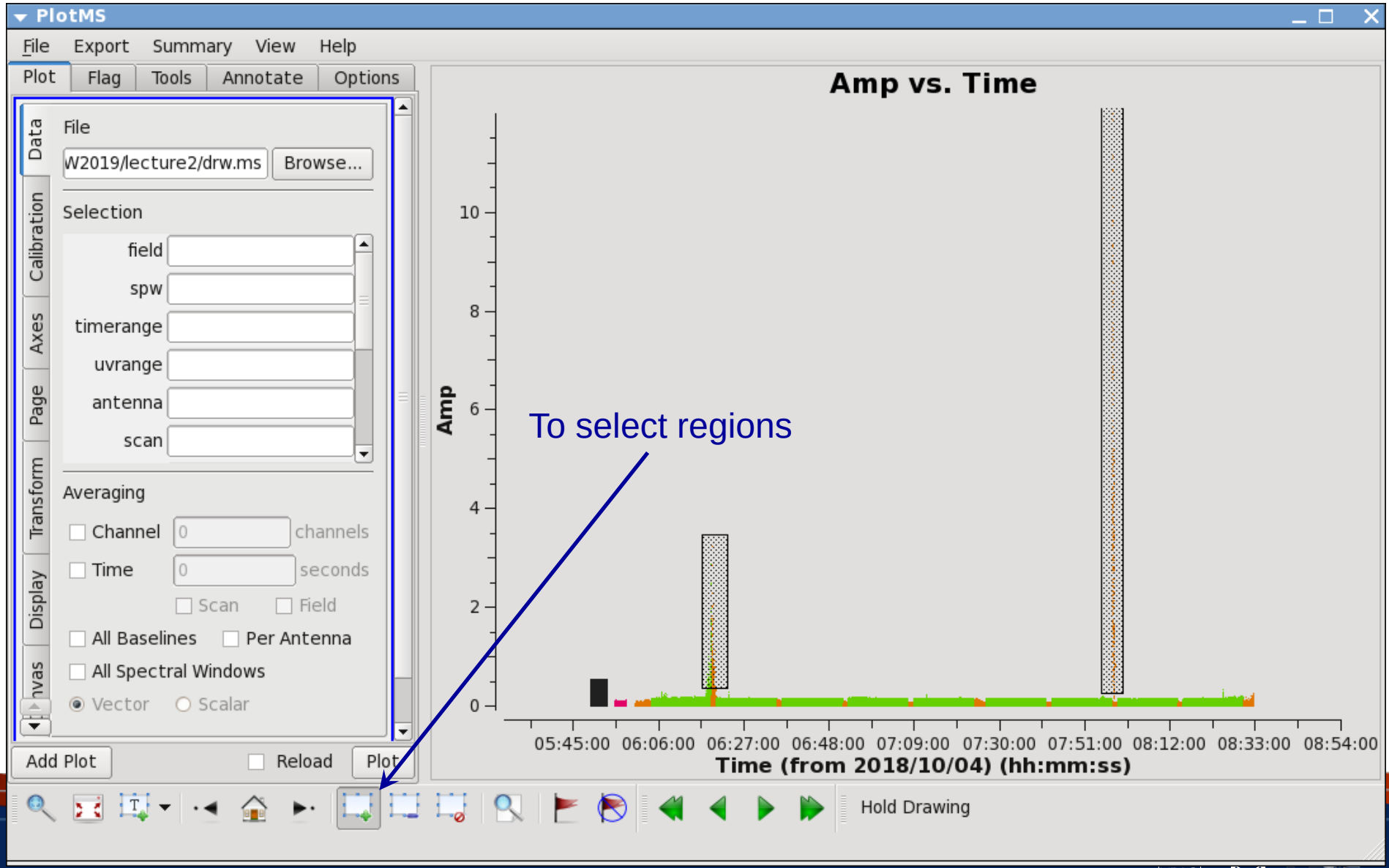
Flagdata	Flagcmd
RFI flagging (tfcrop, rflag)*	Access to the Flag.xml
Runtime displays* (before and after flagging)	Apply the online (and other) flags in FLAG_CMD MS table
	Plot Flags

* More details on Tuesday (RFI talk)

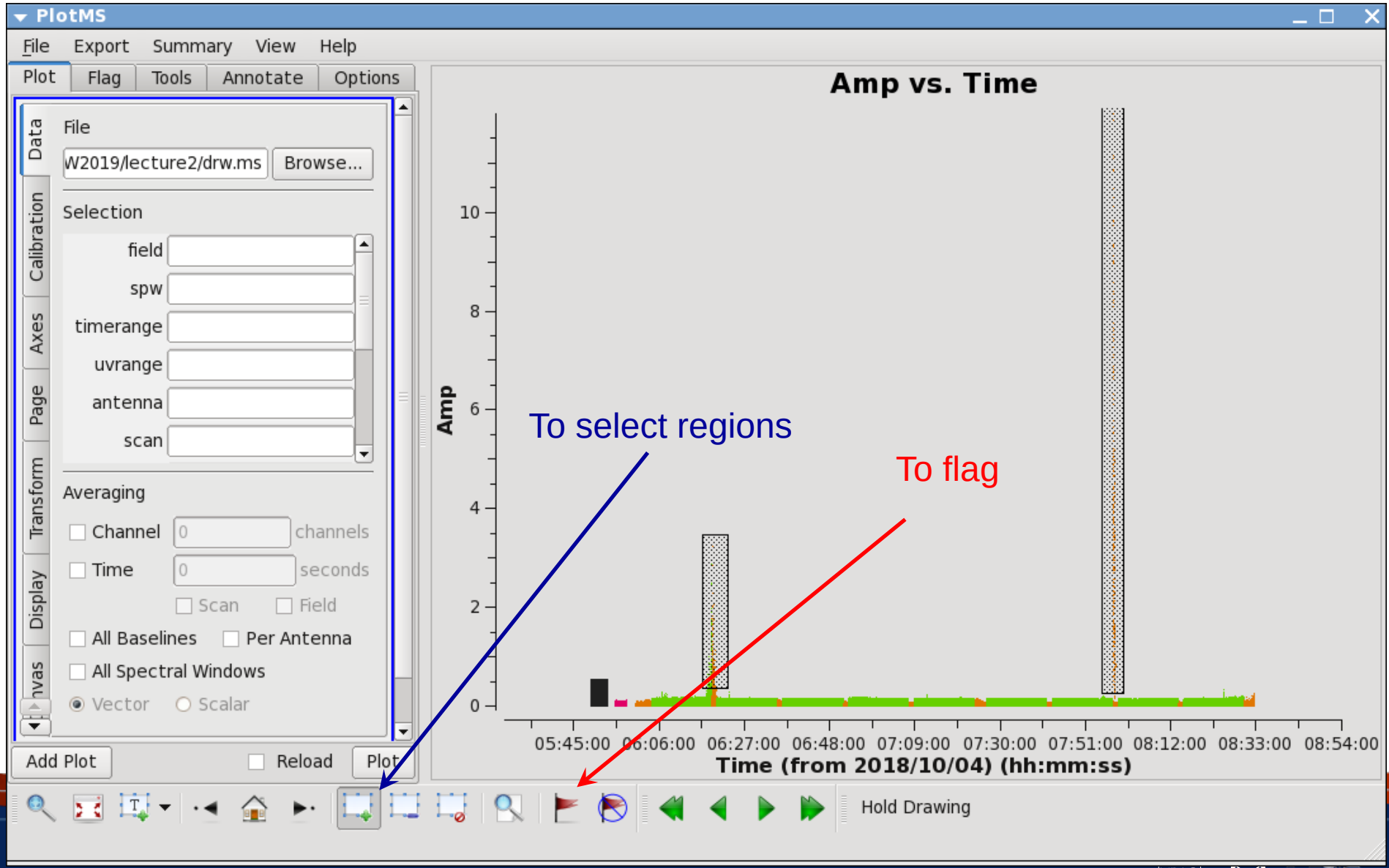
Editing Data: *plotms*



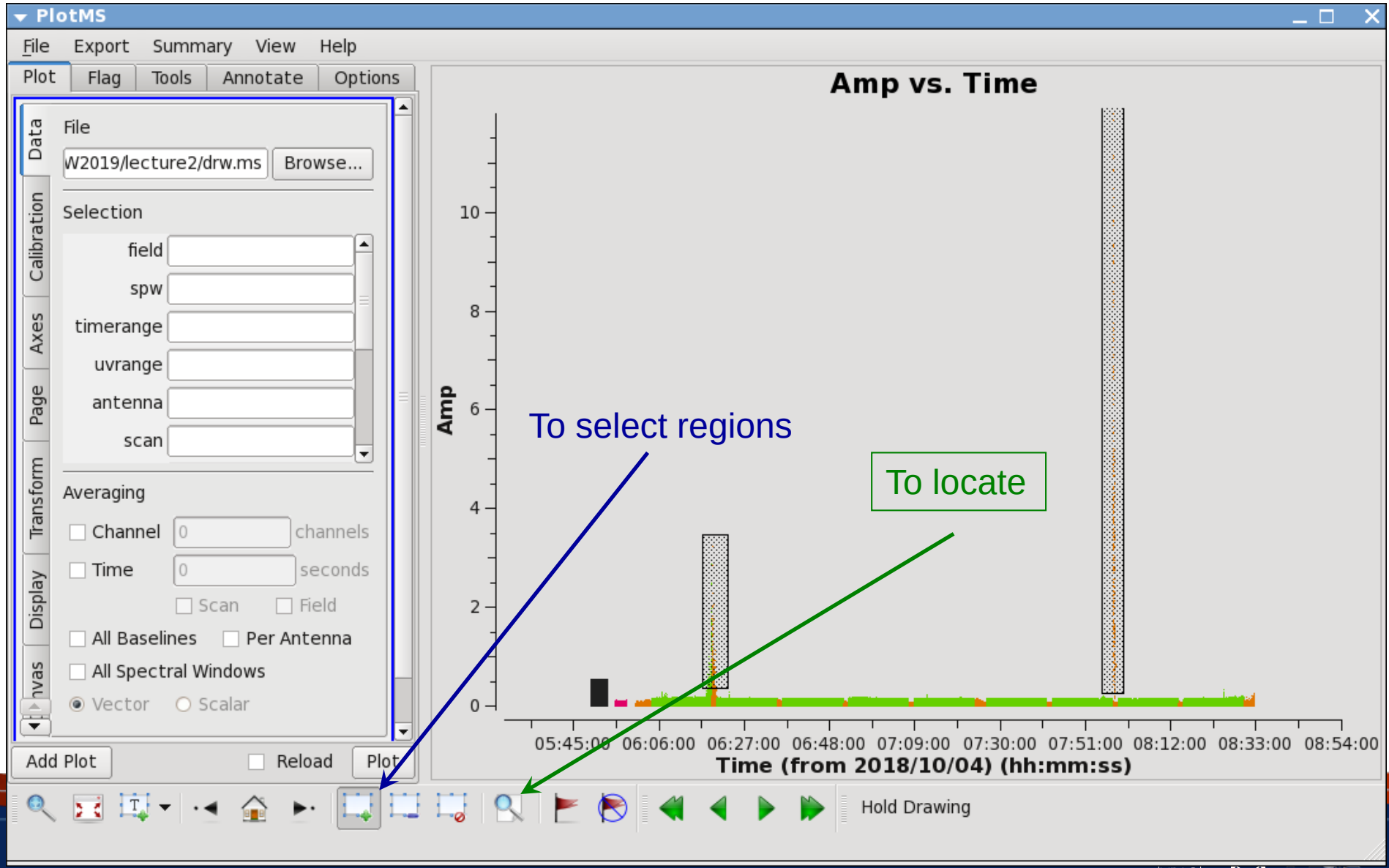
Editing Data: *plotms*



Editing Data: *plotms*

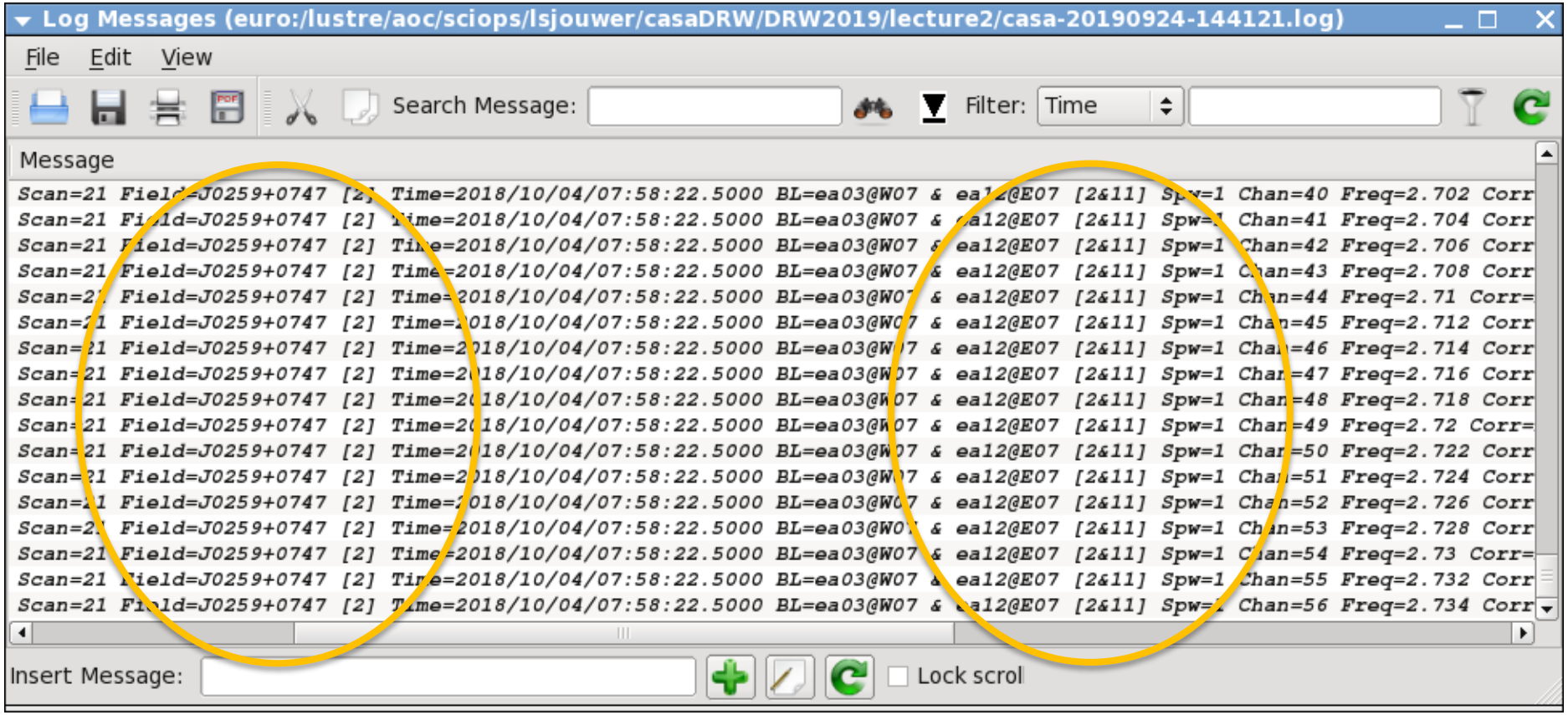


Editing Data: *plotms*



Editing Data: *plotms*

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



Editing Data: *plotms*
A few important notes

- Use *plotms* carefully for editing data.
- Keep in mind that editing 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*.

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…

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