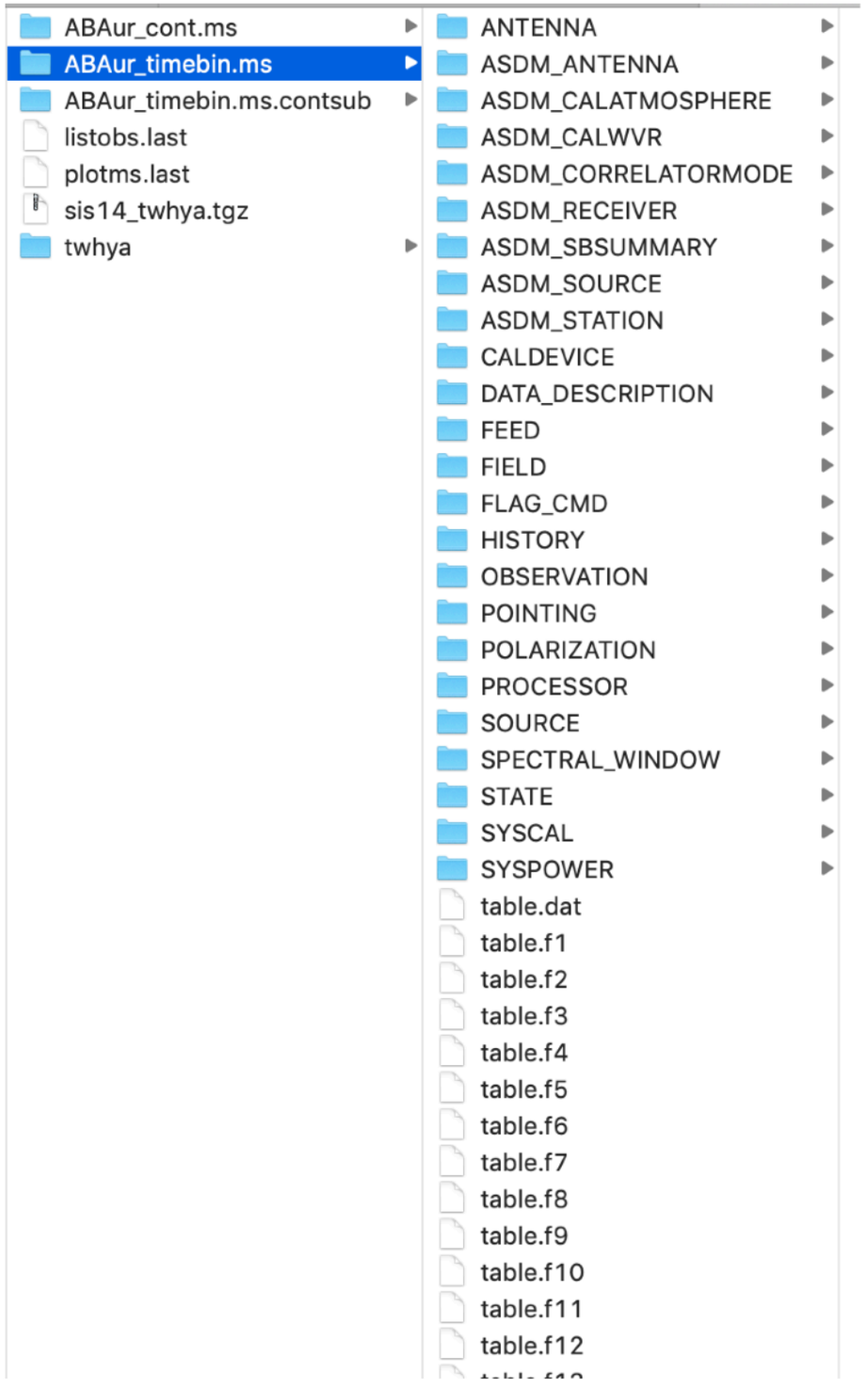
CASA inspection

- Measurement set: folder structure which can only be read/edited with CASA!

- Usual extension .ms but can be anything: convenient

- Do NOT change any of data or names inside folder or it becomes unreadable



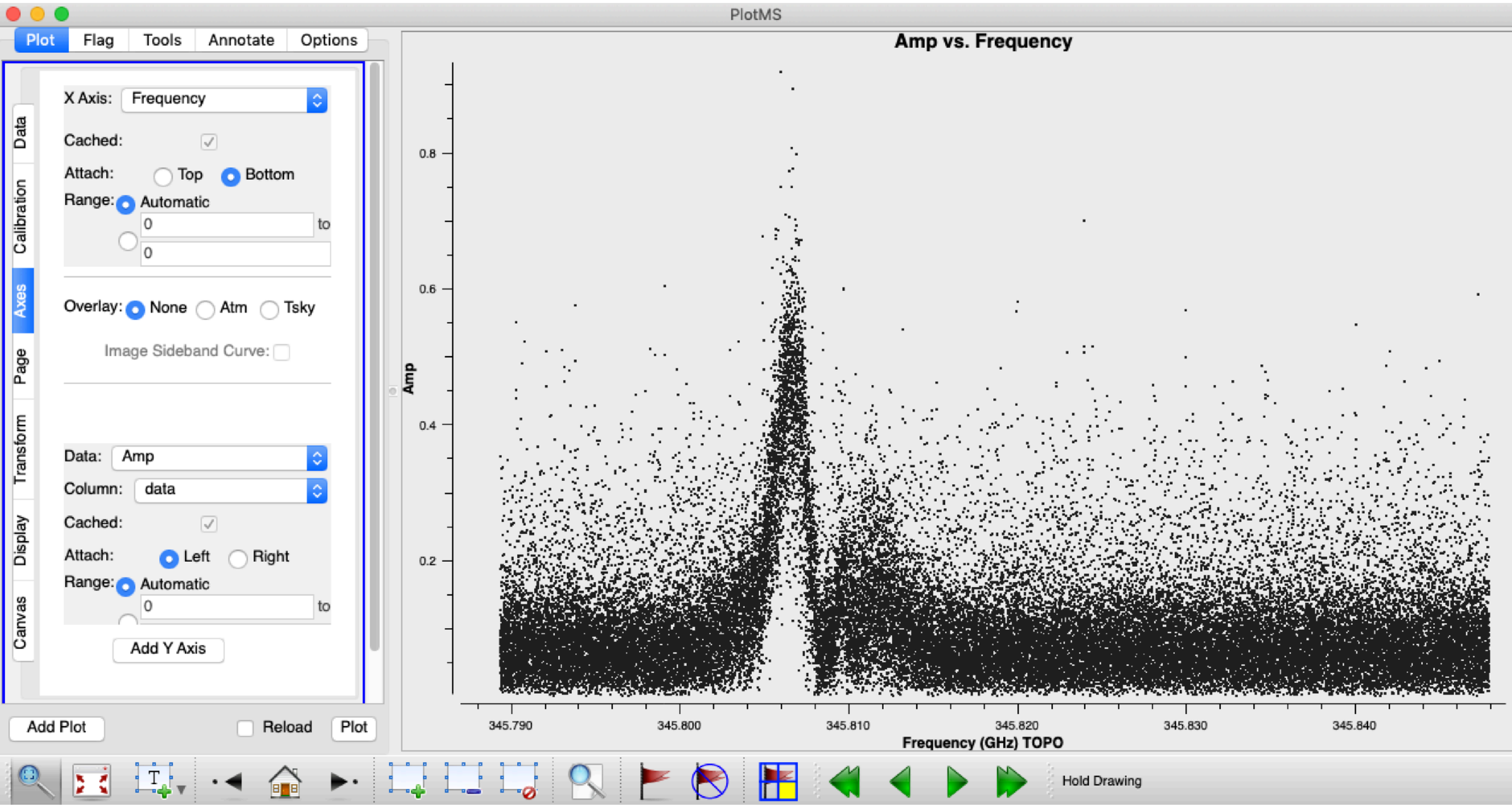
CASA inspection

- listobs(vis='mydata.ms') => basic observational data in logger

```
Time                    Priority  Origin          Message
2020-09-22 23:51:55  INFO       listobs::::
2020-09-22 23:51:55  INFO       listobs::::+  ##########################################
2020-09-22 23:51:55  INFO       listobs::::+  ##### Begin Task: listobs             #####
2020-09-22 23:51:55  INFO       listobs::::   listobs(vis="ABAur_timebin.ms",selectdata=True,spw="",field="",antenna="",
2020-09-22 23:51:55  INFO       listobs::::+         uvrange="",timerange="",correlation="",scan="",intent="",
2020-09-22 23:51:55  INFO       listobs::::+         feed="",array="",observation="",verbose=True,listfile="",
2020-09-22 23:51:55  INFO       listobs::::+         listunfl=False,cachesize=50,overwrite=False)
2020-09-22 23:51:55  INFO       …ms::summary  ================================================================================
2020-09-22 23:51:55  INFO       …s::summary+            MeasurementSet Name:  /Users/nienke/Documents/ALMA/Demo-ABAur/ABAur_timebin.ms      MS Version 2
2020-09-22 23:51:55  INFO       …s::summary+  ================================================================================
2020-09-22 23:51:55  INFO       …s::summary+     Observer: yawentang     Project: uid://A001/Xa0/X612
2020-09-22 23:51:55  INFO       …s::summary+  Observation: ALMA
2020-09-22 23:51:55  INFO       …s::summary+
2020-09-22 23:51:55  INFO       …s::summary+    Telescope Observation Date    Observer       Project
2020-09-22 23:51:55  INFO       …s::summary+    ALMA      [                   4.91456e+09, 4.91456e+09]yawentang      uid://A001/Xa0/X612
2020-09-22 23:51:55  INFO       …s::summary+    ALMA      [                   4.94376e+09, 4.94377e+09]yawentang      uid://A001/Xa0/X612
2020-09-22 23:51:55  INFO       …Properties   Computing scan and subscan properties...
2020-09-22 23:51:55  INFO       …ms::summary  Data records: 130584       Total elapsed time = 2.92084e+07 seconds
2020-09-22 23:51:55  INFO       …s::summary+     Observed from   12-Aug-2014/10:38:53.1   to   16-Jul-2015/12:06:13.4 (UTC)
2020-09-22 23:51:55  INFO       …ms::summary
2020-09-22 23:51:55  INFO       …s::summary+     ObservationID = 0         ArrayID = 0
2020-09-22 23:51:55  INFO       …s::summary+    Date        Timerange (UTC)          Scan  FldId FieldName             nRows     SpwIds   Average Interval(s)    ScanIntent
2020-09-22 23:51:55  INFO       …s::summary+    12-Aug-2014/10:38:53.1 - 10:44:41.1    11      0 ab_aurigae              15120  [0,1,2,3]  [56.7, 56.7, 56.7, 56.7] [OBSERVE_TARGET#ON_SOURCE]
2020-09-22 23:51:55  INFO       …s::summary+                10:45:47.0 - 10:52:38.6    13      0 ab_aurigae              17640  [0,1,2,3]  [57.5, 57.5, 57.5, 57.5] [OBSERVE_TARGET#ON_SOURCE]
2020-09-22 23:51:55  INFO       …s::summary+                10:56:30.0 - 11:02:18.0    18      0 ab_aurigae              15120  [0,1,2,3]  [56.7, 56.7, 56.7, 56.7] [OBSERVE_TARGET#ON_SOURCE]
2020-09-22 23:51:55  INFO       …s::summary+                11:03:24.1 - 11:10:15.7    20      0 ab_aurigae              17640  [0,1,2,3]  [57.5, 57.5, 57.5, 57.5] [OBSERVE_TARGET#ON_SOURCE]
2020-09-22 23:51:55  INFO       …s::summary+                11:13:53.3 - 11:19:41.3    25      0 ab_aurigae              15120  [0,1,2,3]  [56.7, 56.7, 56.7, 56.7] [OBSERVE_TARGET#ON_SOURCE]
2020-09-22 23:51:55  INFO       …s::summary+                11:20:46.3 - 11:21:48.3    27      0 ab_aurigae               2520  [0,1,2,3]  [62, 62, 62, 62] [OBSERVE_TARGET#ON_SOURCE]
2020-09-22 23:51:55  INFO       …ms::summary
2020-09-22 23:51:55  INFO       …s::summary+     ObservationID = 1         ArrayID = 0
2020-09-22 23:51:55  INFO       …s::summary+    Date        Timerange (UTC)          Scan  FldId FieldName             nRows     SpwIds   Average Interval(s)    ScanIntent
2020-09-22 23:51:55  INFO       …s::summary+    16-Jul-2015/11:45:40.0 - 11:50:56.2    28      0 ab_aurigae              14820  [4,5,6,7]  [62, 62, 62, 62] [OBSERVE_TARGET#ON_SOURCE]
2020-09-22 23:51:55  INFO       …s::summary+                11:52:02.9 - 11:58:54.4    30      0 ab_aurigae              20748  [4,5,6,7]  [57.4, 57.4, 57.4, 57.4] [OBSERVE_TARGET#ON_SOURCE]
2020-09-22 23:51:55  INFO       …s::summary+                12:02:32.5 - 12:06:13.4    35      0 ab_aurigae              11856  [4,5,6,7]  [54.1, 54.1, 54.1, 54.1] [OBSERVE_TARGET#ON_SOURCE]
2020-09-22 23:51:55  INFO       …ms::summary             (nRows = Total number of rows per scan)
2020-09-22 23:51:55  INFO       …ms::summary  Fields: 1
2020-09-22 23:51:55  INFO       …s::summary+    ID   Code Name                RA               Decl           Epoch   SrcId      nRows
2020-09-22 23:51:55  INFO       …s::summary+    0    none ab_aurigae          04:55:45.848188 +30.33.03.92532 J2000   0          130584
2020-09-22 23:51:55  INFO       …ms::summary  Spectral Windows:  (8 unique spectral windows and 1 unique polarization setups)
2020-09-22 23:51:55  INFO       …s::summary+    SpwID  Name                           #Chans   Frame   Ch0(MHz)  ChanWid(kHz)  TotBW(kHz) CtrFreq(MHz) BBC Num  Corrs
2020-09-22 23:51:55  INFO       …s::summary+    0      ALMA_RB_07#BB_1#SW-01#FULL_RES   3840   TOPO  345789.363        15.259     58593.8 345818.6522        1  XX  YY
2020-09-22 23:51:55  INFO       …s::summary+    1      ALMA_RB_07#BB_2#SW-01#FULL_RES    960   TOPO  342585.556      1953.125   1875000.0 343522.0798        2  XX  YY
2020-09-22 23:51:55  INFO       …s::summary+    2      ALMA_RB_07#BB_3#SW-01#FULL_RES   3840   TOPO  330629.728       -15.259     58593.8 330600.4391        3  XX  YY
2020-09-22 23:51:55  INFO       …s::summary+    3      ALMA_RB_07#BB_4#SW-01#FULL_RES    128   TOPO  333004.681    -15625.000   2000000.0 332012.4935        4  XX  YY
2020-09-22 23:51:55  INFO       …s::summary+    4      ALMA_RB_07#BB_1#SW-01#FULL_RES   3840   TOPO  345770.042        15.259     58593.8 345799.3317        1  XX  YY
2020-09-22 23:51:55  INFO       …s::summary+    5      ALMA_RB_07#BB_2#SW-01#FULL_RES    960   TOPO  342575.939      1953.125   1875000.0 343512.4623        2  XX  YY
2020-09-22 23:51:55  INFO       …s::summary+    6      ALMA_RB_07#BB_3#SW-01#FULL_RES   3840   TOPO  330620.449       -15.259     58593.8 330591.1593        3  XX  YY
2020-09-22 23:51:55  INFO       …s::summary+    7      ALMA_RB_07#BB_4#SW-01#FULL_RES    128   TOPO  332995.386    -15625.000   2000000.0 332003.1983        4  XX  YY
2020-09-22 23:51:55  INFO       …ms::summary  Sources: 4
```

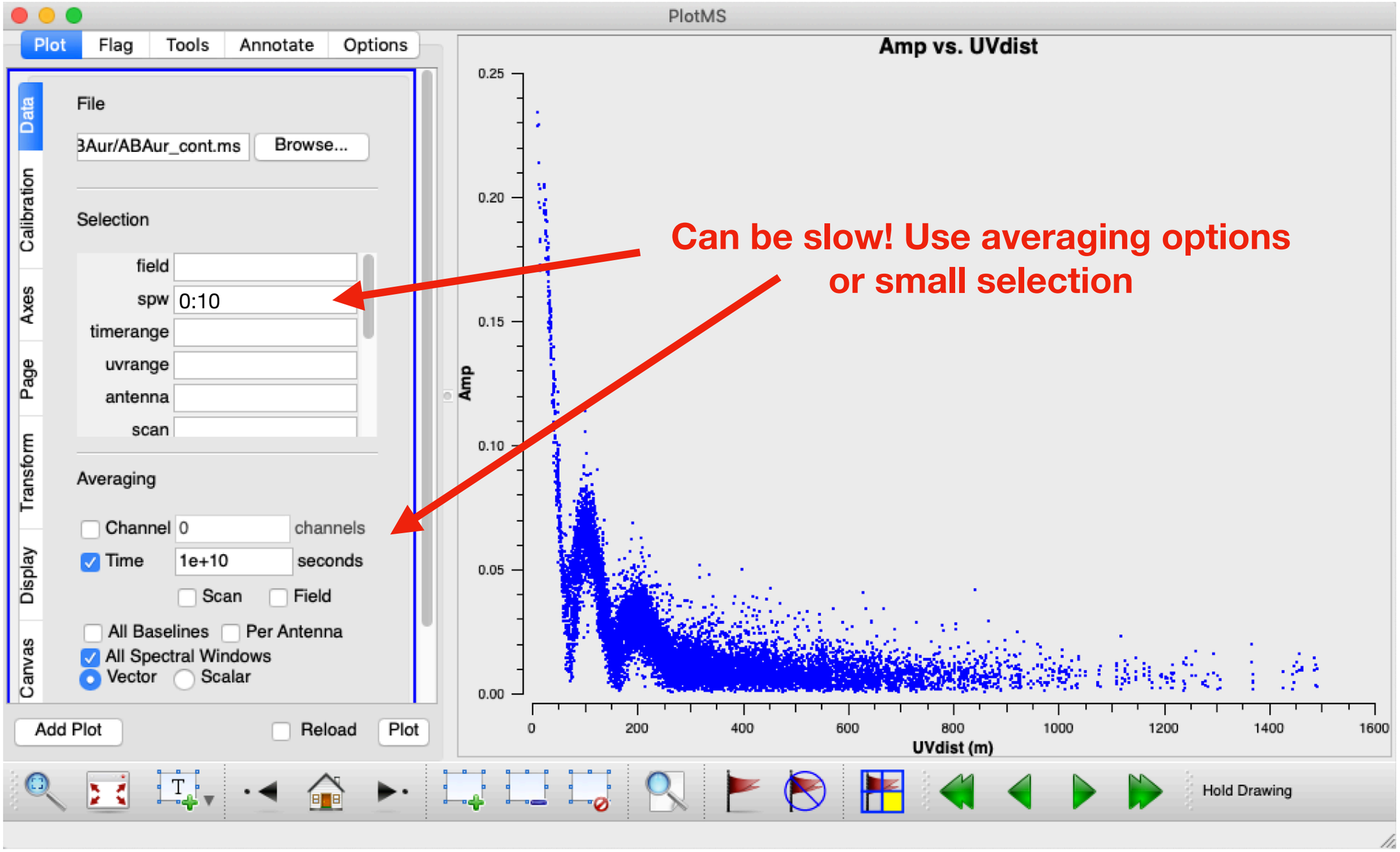
CASA inspection

- plotms(vis='mydata.ms') => plot visibility data



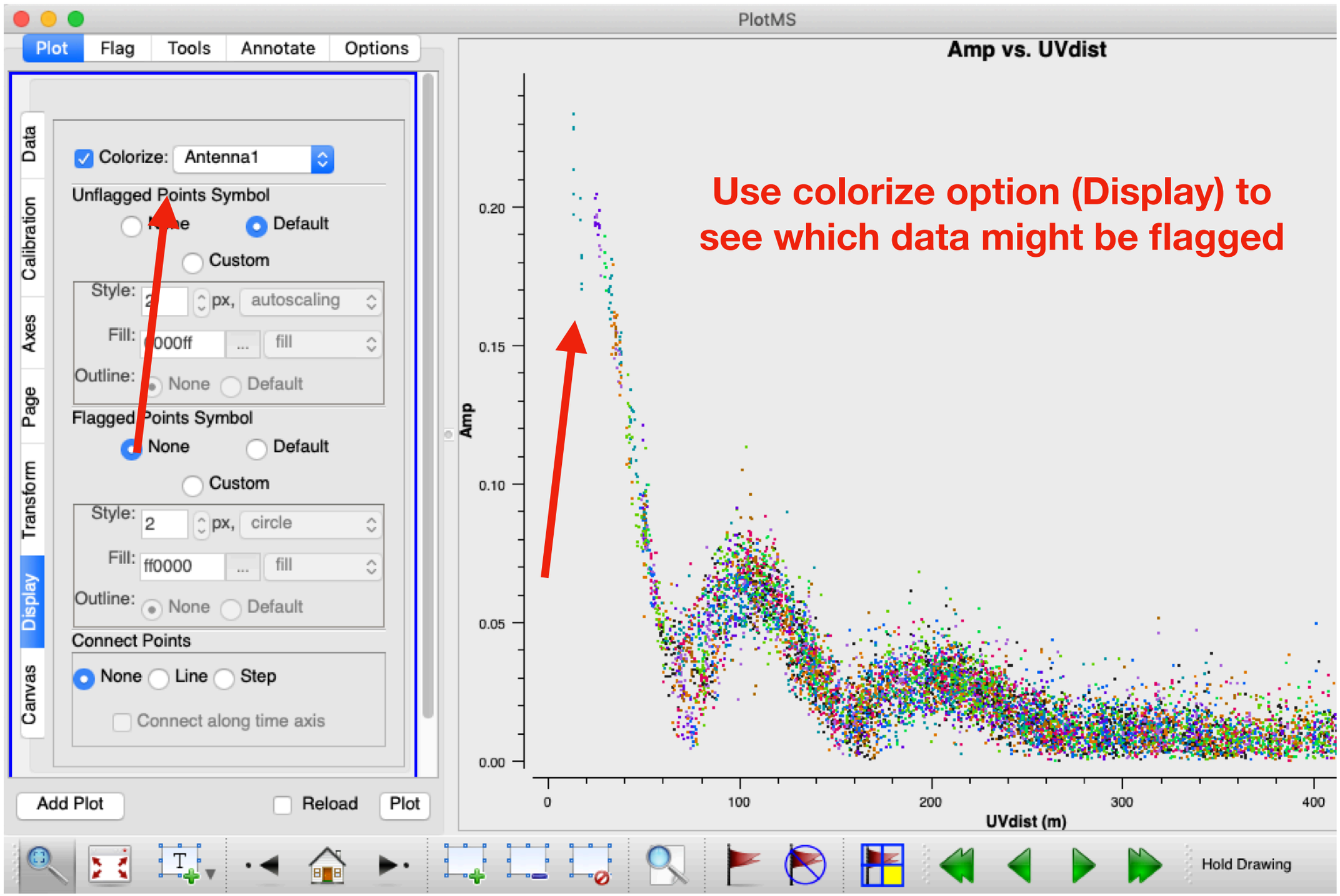
CASA inspection

- plotms(vis='mydata.ms') => plot visibility data

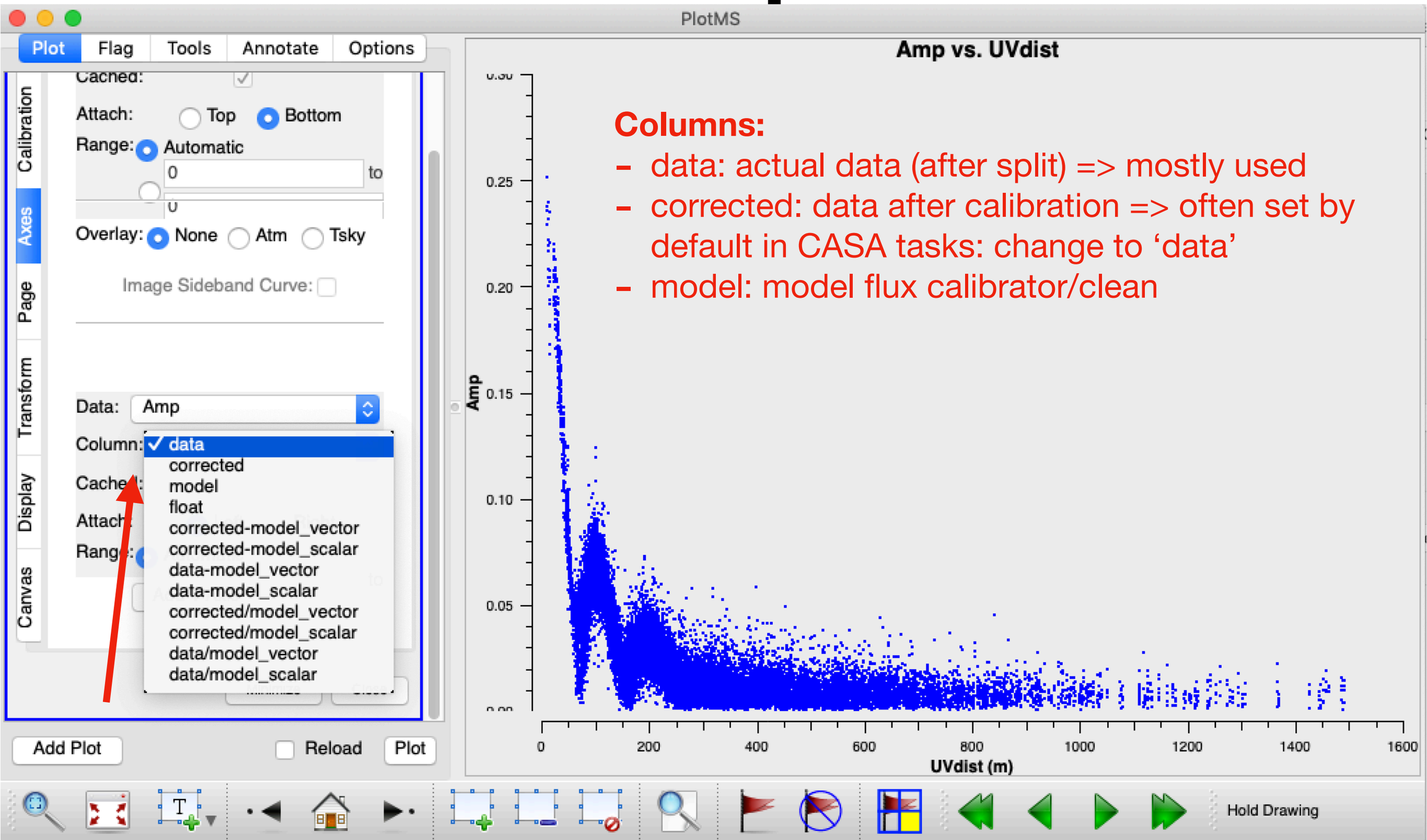


CASA inspection

- plotms(vis='mydata.ms') => plot visibility data



CASA inspection



Columns:

- data: actual data (after split) => mostly used
- corrected: data after calibration => often set by default in CASA tasks: change to ‘data’
- model: model flux calibrator/clean

CASA inspection

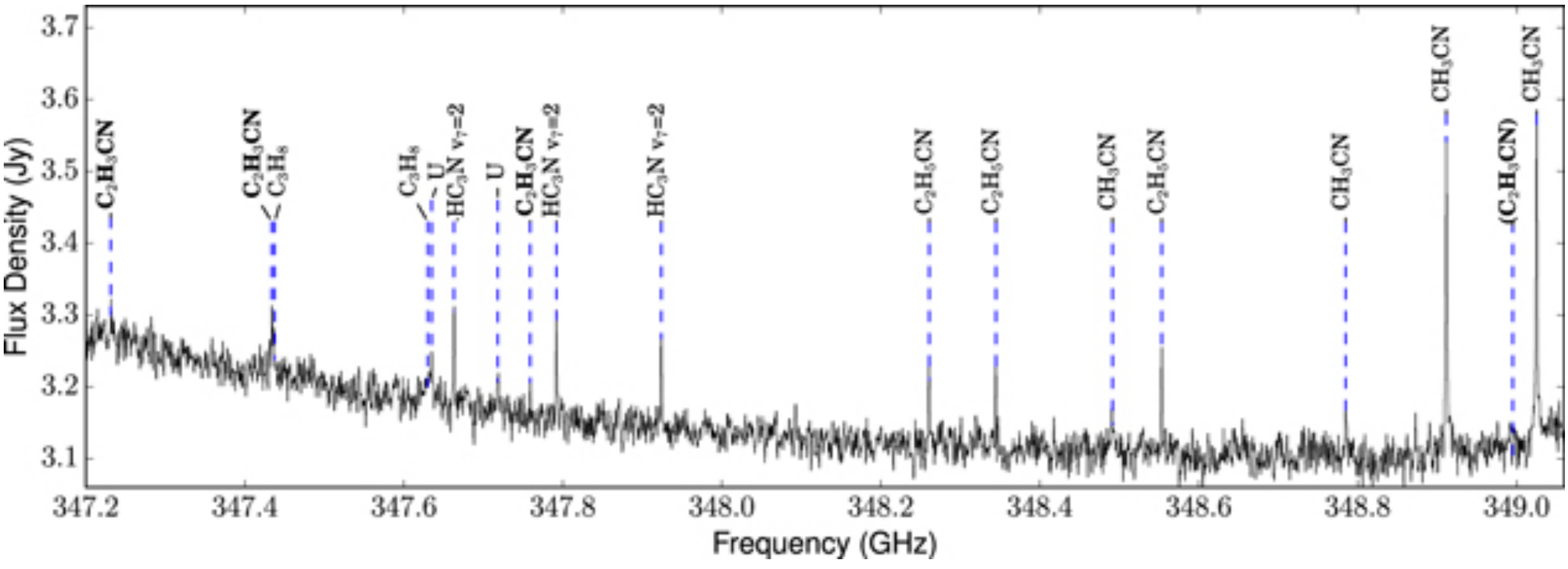
- Datasets can be huge: some tips to reduce (before imaging/plotms)
  - Split out what you need (field, spectral window, channels)
  - Bin in frequency (for continuum)
  - Bin in time domain (if no visibility analysis)

```
[CASA <76>: inp
 ---------> inp()
#  split :: Create a visibility subset from an existing visibility set
vis                 = 'ABAur_timebin.ms' #  Name of input visibility file
outputvis           =         ''         #  Name of output visibility file
keepmms             =       True         #  If the input is a Multi-MS the output
                                         #   will also be a Multi-MS.
field               =        '3'         #  Select field using field id(s) or
                                         #   field name(s)
spw                 = '1:100~1000'       #  Select spectral window/channels
scan                =         ''         #  Scan number range
antenna             =         ''         #  Select data based on antenna/baseline
correlation         =         ''         #  Select data based on correlation
timerange           =         ''         #  Select data based on time range
intent              =         ''         #  Select observing intent
array               =         ''         #  Select (sub)array(s) by array ID
                                         #   number.
uvrange             =         ''         #  Select data by baseline length.
observation         =         ''         #  Select by observation ID(s)
feed                =         ''         #  Multi-feed numbers: Not yet
                                         #   implemented.
datacolumn          = 'corrected'        #  Which data column(s) to process.
keepflags           =       True
width               =       3840         #  Number of channels to average to form
                                         #   one output channel
timebin             =       '30s'        #  Bin width for time averaging
     combine        =         ''         #  Span the timebin across scan, state
                                         #   or both
```

Continuum vs line

Example full spectrum

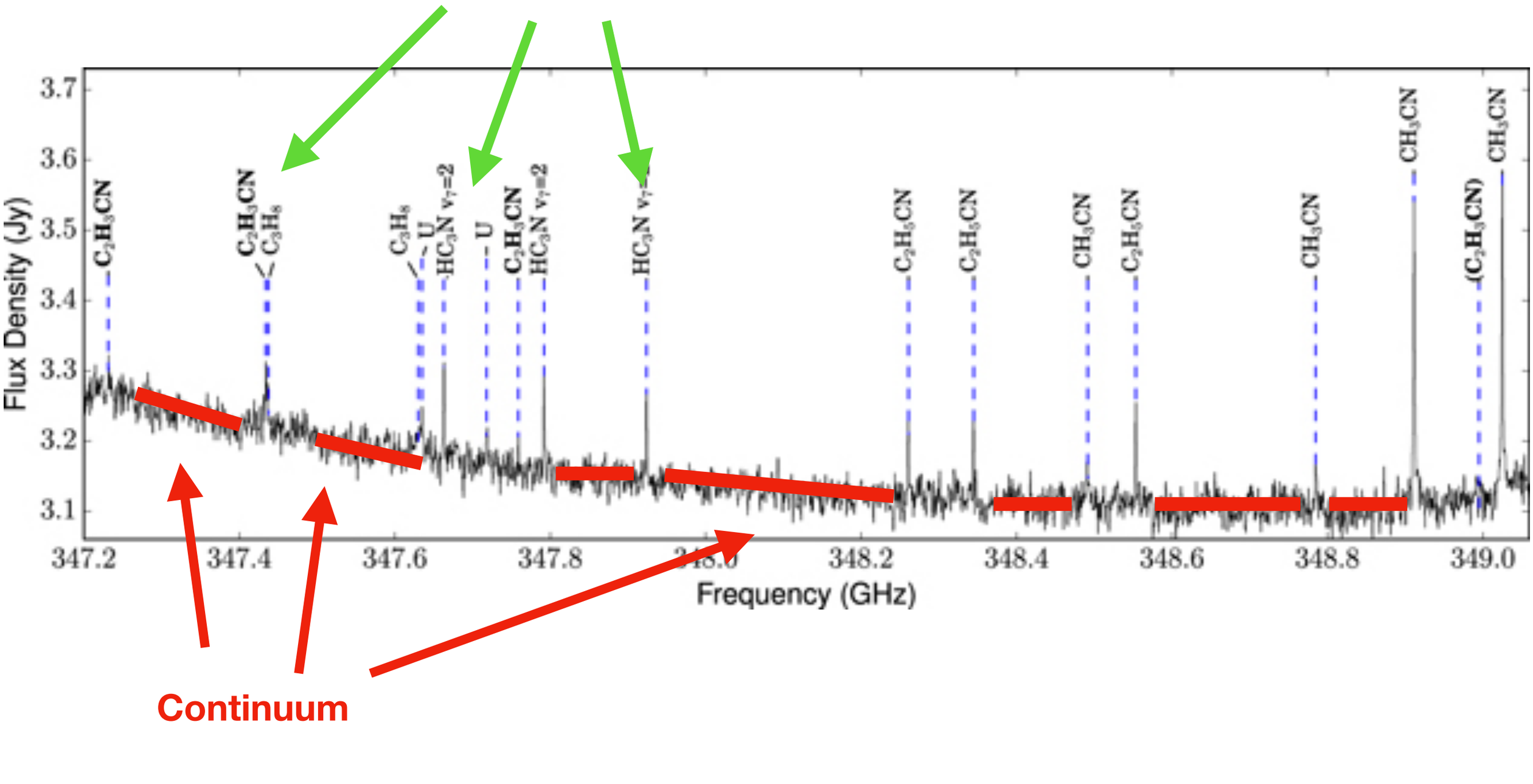
Molecular lines



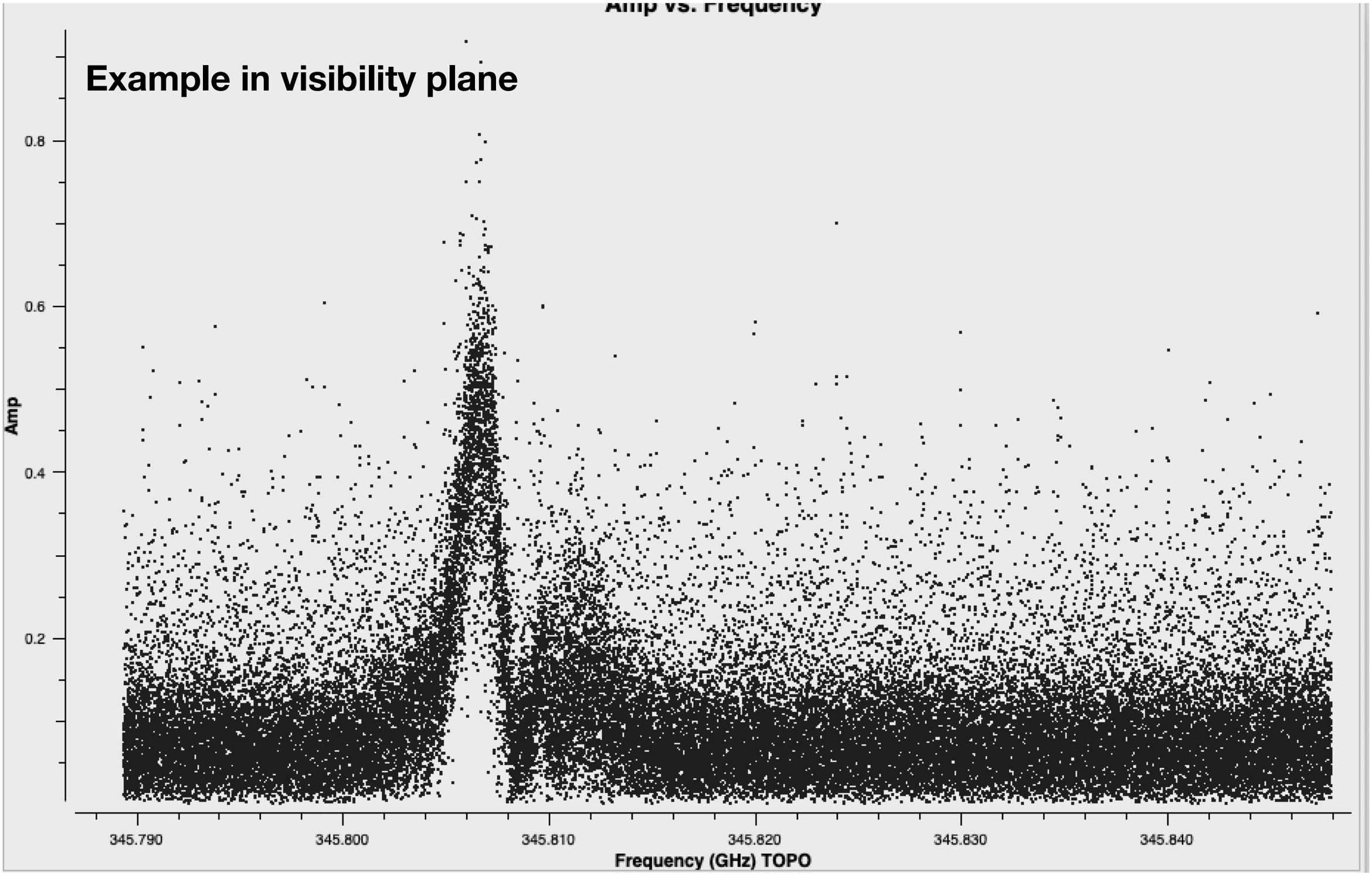
Continuum

Continuum vs line

Example full spectrum



Continuum vs line



Continuum vs line

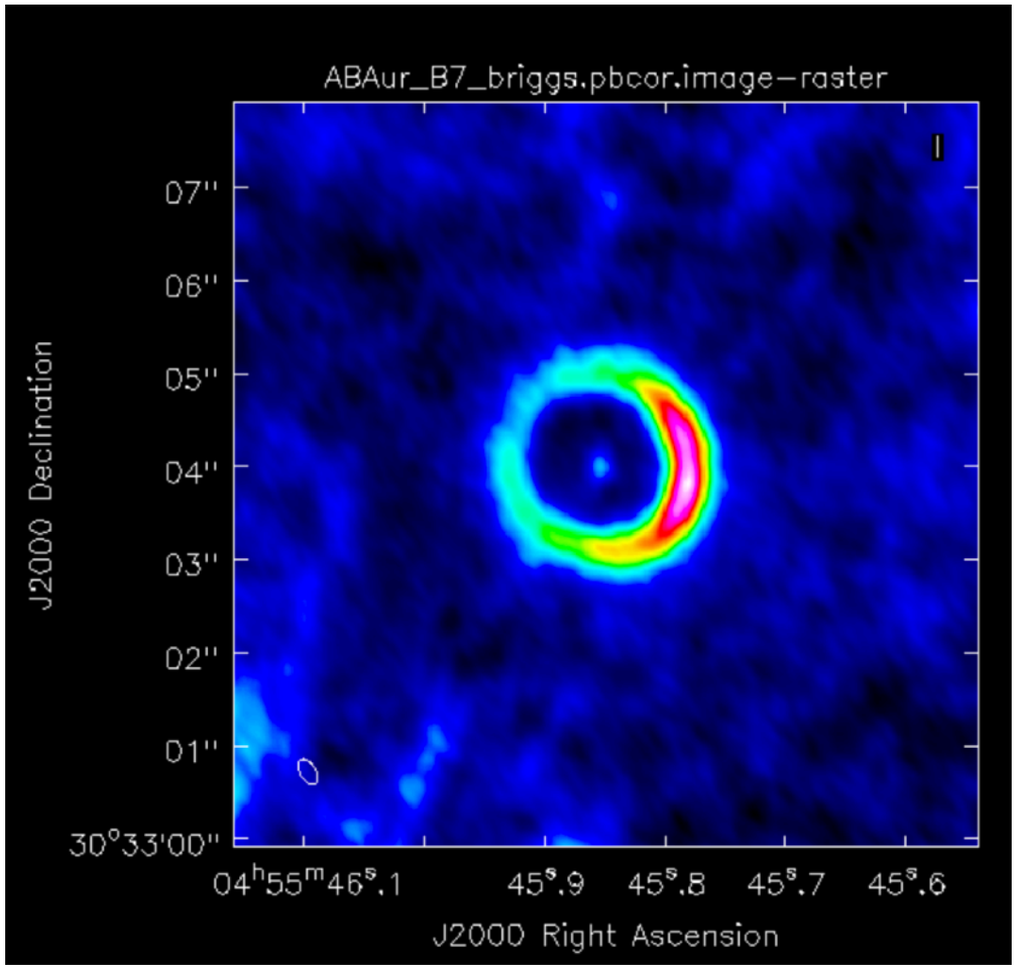
- **<u>Continuum</u>**
  - Thermal dust emission
  - Select channels without line emission and average them using split() command
  - Averaging results in much higher SNR
  - Clean using specmode='mfs'
- **<u>Line</u>**
  - Molecular line
  - Subtract the continuum in the visibility plane using the uvcontsub() command, by specifying channels without line emission
  - Clean using specmode='cube'
  - Velocity mode: set outframe='LSRK'!
  - Set velocity resolution and rest frequency

Molecular lines

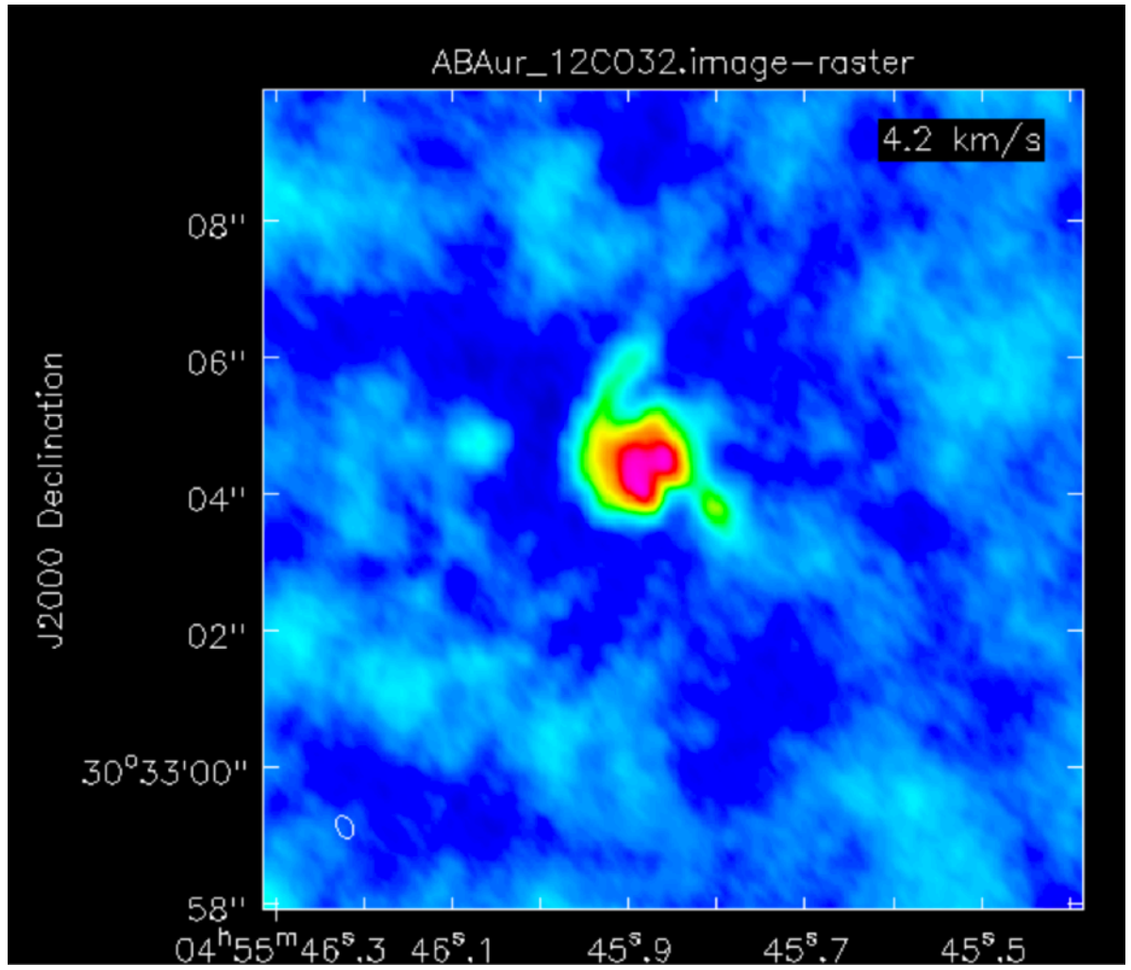
- Molecular line spectroscopy
  - Each molecule emits through a number of transitions, depending on local density and temperature
  - Each transition has a unique frequency (fingerprint): the *rest frequency*
- Molecular lines are broadened by kinematics:
  - Shift by source velocity: few km/s for nearby disks
  - Broadened profile by disk rotation
- Velocity resolution ALMA can be very high (10 m/s)! Depends on user settings (proposal)
- Rest frequencies and more: **https://splatalogue.online//**

Continuum vs line

Continuum

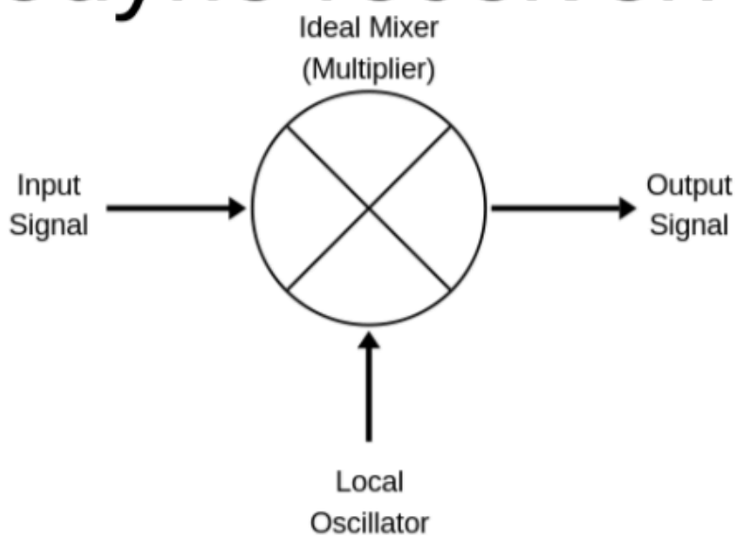


Cube



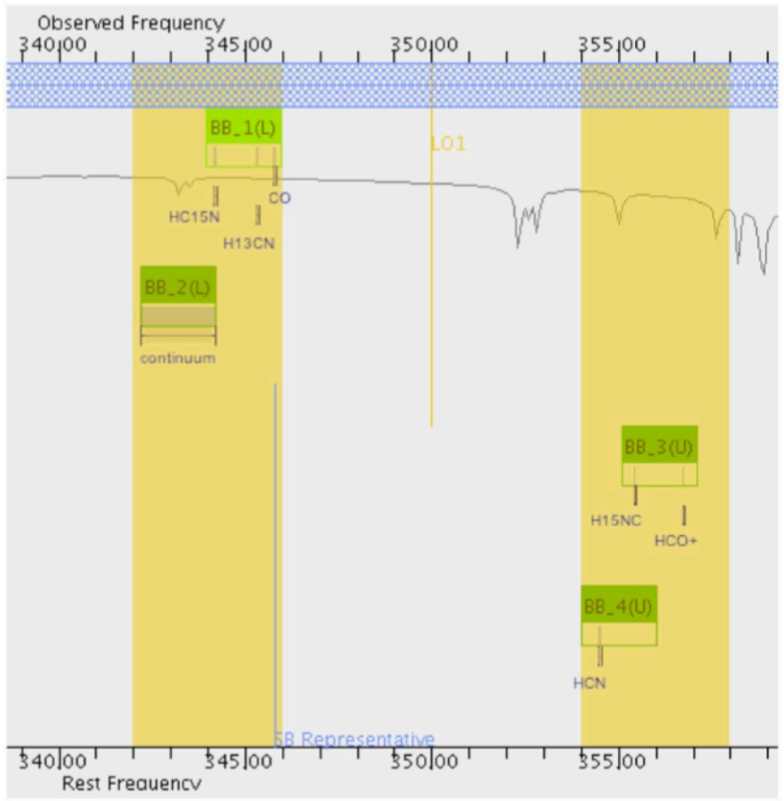
About spectral windows

- Heterodyne receiver: mixing local oscillator

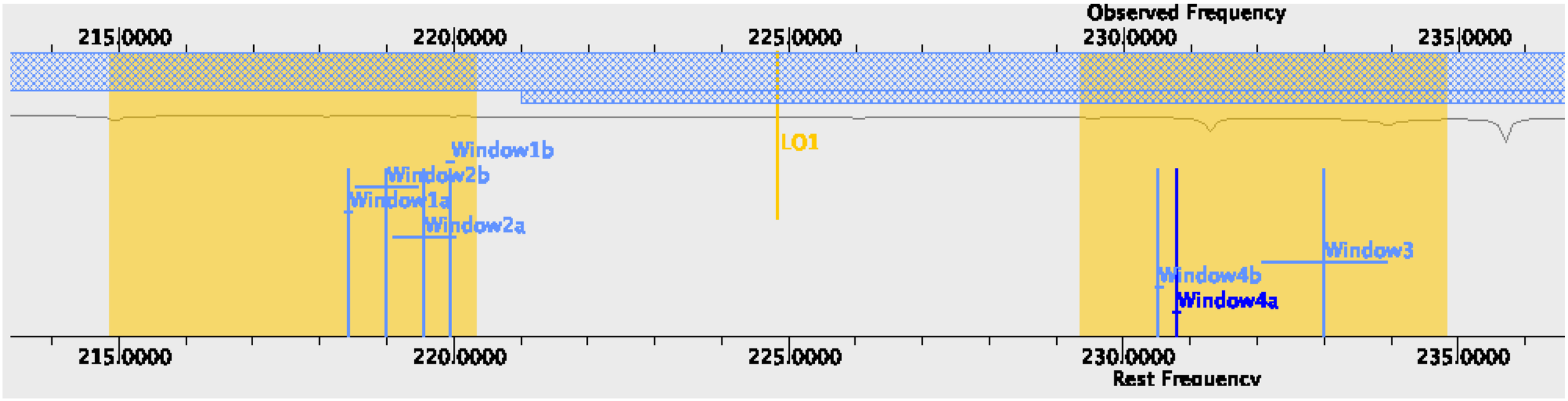


- Frequency spectral windows always within USB and LSB: LO +/- IF (IF~4-8 GHz)
- ALMA: B9 double, other bands dual SB: freedom in frequency range

About spectral windows



- Basic setup: 4 basebands of 3840 channels each around LO frequency
- Max 4 spectral windows within each baseband
- Compromise: bandwidth (line width, multi-line coverage, continuum bandwidth) or spectral resolution (velocity resolution)
- Observing frequency: depends on Earth velocity at time of observing, so sometimes multiple spectral windows when observed multiple times



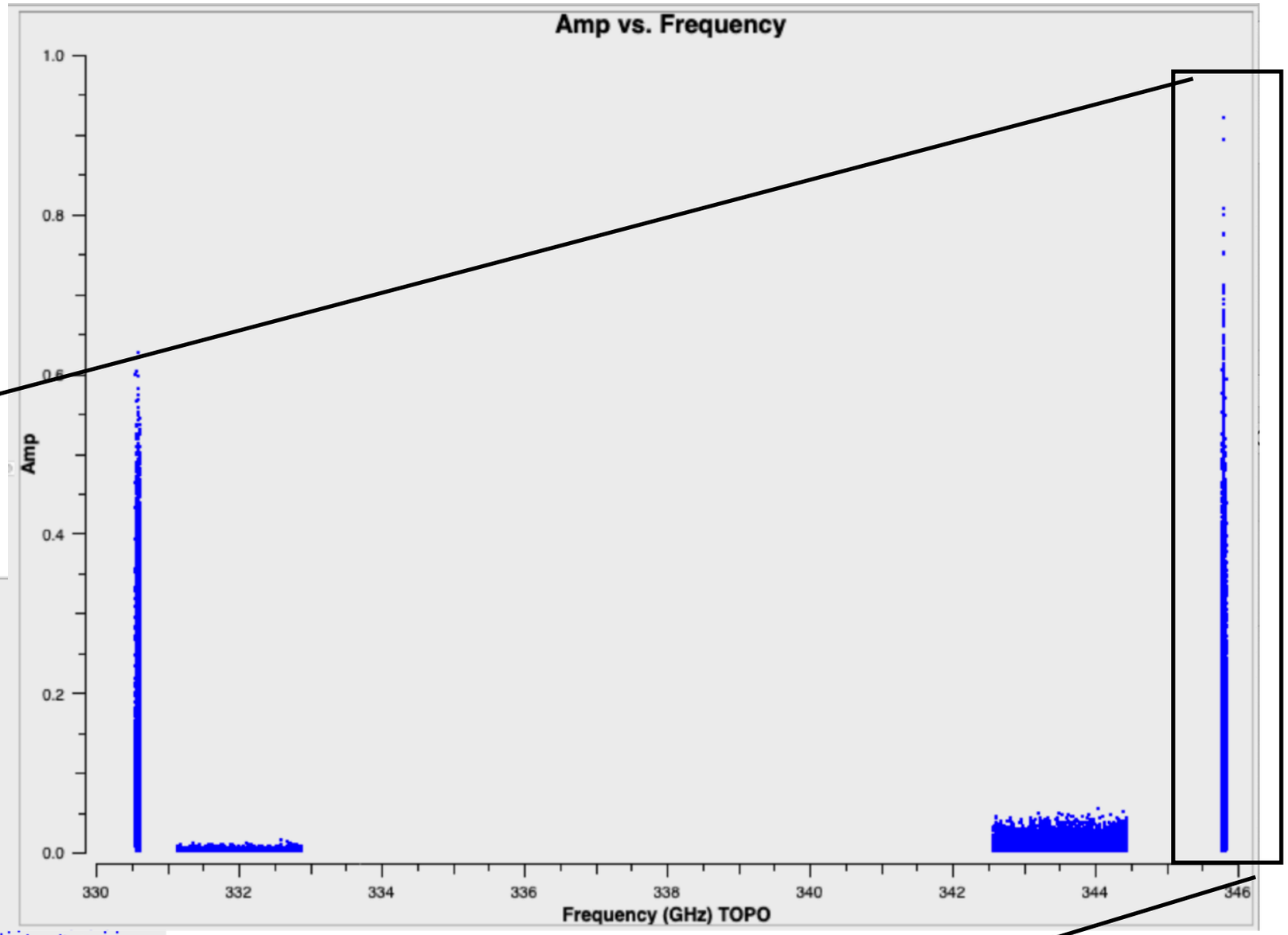
About spectral windows

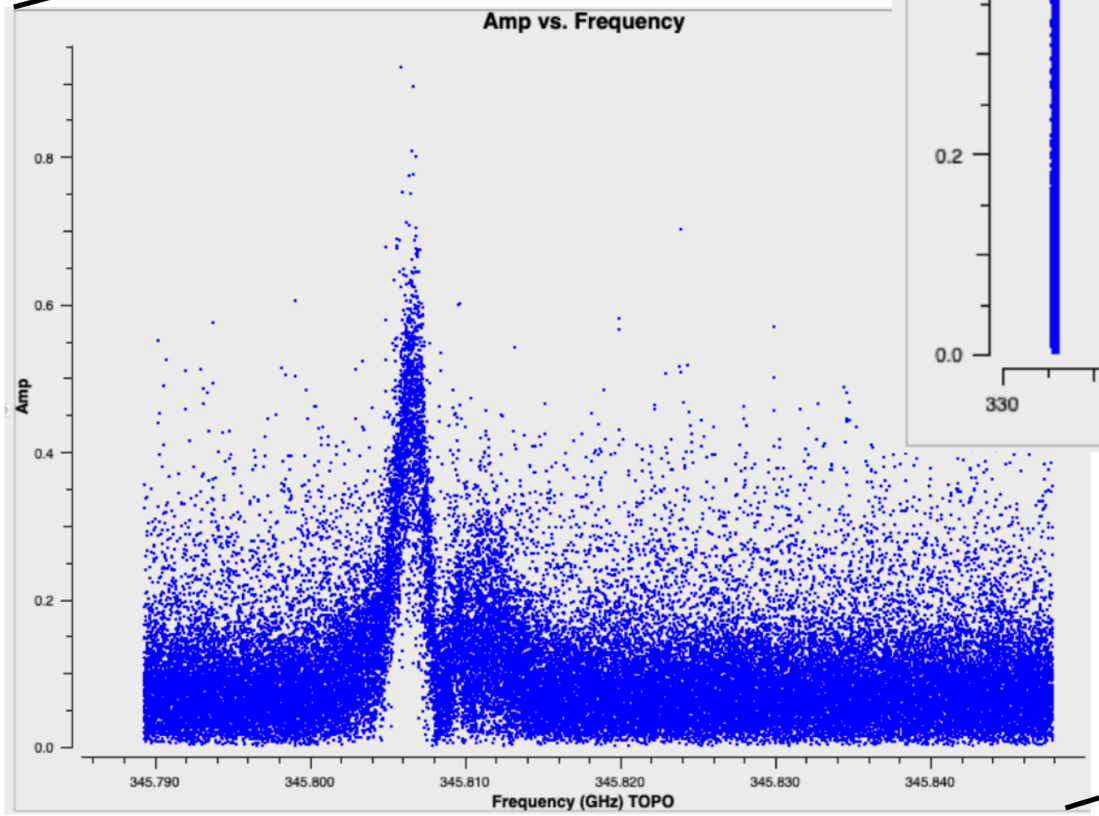
Practice: output listobs ()

```
ummary  Spectral Windows:  (16 unique spectral windows and 1 unique polarization setups)
mary+     SpwID  Name                                          #Chans   Frame   Ch0(MHz)  ChanWid(kHz)  TotBW(kHz) CtrFreq(MHz)
mary+     19     X1135923343#ALMA_RB_06#BB_2#SW-01#FULL_RES     128   TOPO  233201.518     15625.000   2000000.0 234193.7059
mary+     23     X1135923343#ALMA_RB_06#BB_4#SW-01#FULL_RES     128   TOPO  218493.923    -15625.000   2000000.0 217501.7354
mary+     25     X1135923343#ALMA_RB_06#BB_1#SW-01#FULL_RES    1920   TOPO  230522.724       976.562   1875000.0 231459.7354
mary+     27     X1135923343#ALMA_RB_06#BB_3#SW-01#FULL_RES    1920   TOPO  220396.747      -976.562   1875000.0 219459.7354
mary+     47     X1135923343#ALMA_RB_06#BB_2#SW-01#FULL_RES     128   TOPO  233198.091     15625.000   2000000.0 234190.2783
mary+     51     X1135923343#ALMA_RB_06#BB_4#SW-01#FULL_RES     128   TOPO  218490.620    -15625.000   2000000.0 217498.4328
mary+     53     X1135923343#ALMA_RB_06#BB_1#SW-01#FULL_RES    1920   TOPO  230519.421       976.562   1875000.0 231456.4328
mary+     55     X1135923343#ALMA_RB_06#BB_3#SW-01#FULL_RES    1920   TOPO  220393.445      -976.562   1875000.0 219456.4328
mary+     75     X1135923343#ALMA_RB_06#BB_2#SW-01#FULL_RES     128   TOPO  233194.079     15625.000   2000000.0 234186.2664
mary+     79     X1135923343#ALMA_RB_06#BB_4#SW-01#FULL_RES     128   TOPO  218486.755    -15625.000   2000000.0 217494.5673
mary+     81     X1135923343#ALMA_RB_06#BB_1#SW-01#FULL_RES    1920   TOPO  230515.556       976.562   1875000.0 231452.5673
mary+     83     X1135923343#ALMA_RB_06#BB_3#SW-01#FULL_RES    1920   TOPO  220389.579      -976.562   1875000.0 219452.5673
mary+     103    X1135923343#ALMA_RB_06#BB_2#SW-01#FULL_RES     128   TOPO  233193.692     15625.000   2000000.0 234185.8796
mary+     107    X1135923343#ALMA_RB_06#BB_4#SW-01#FULL_RES     128   TOPO  218486.382    -15625.000   2000000.0 217494.1946
mary+     109    X1135923343#ALMA_RB_06#BB_1#SW-01#FULL_RES    1920   TOPO  230515.183       976.562   1875000.0 231452.1946
mary+     111    X1135923343#ALMA_RB_06#BB_3#SW-01#FULL_RES    1920   TOPO  220389.206      -976.562   1875000.0 219452.1946
mmary  Sources: 17
```

About spectral windows

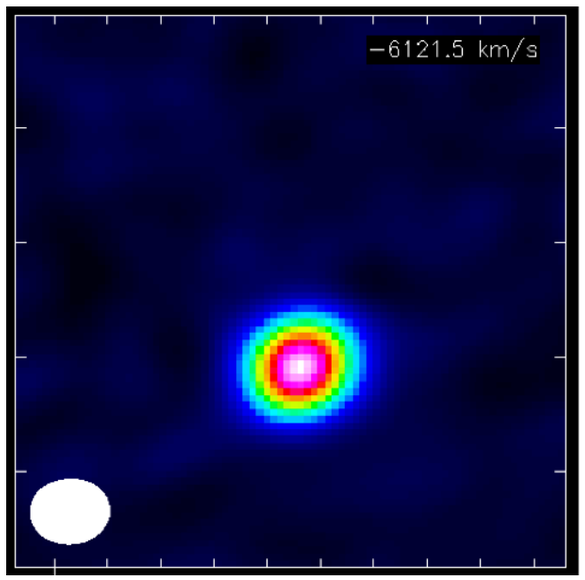
In practice:
output plotms ()



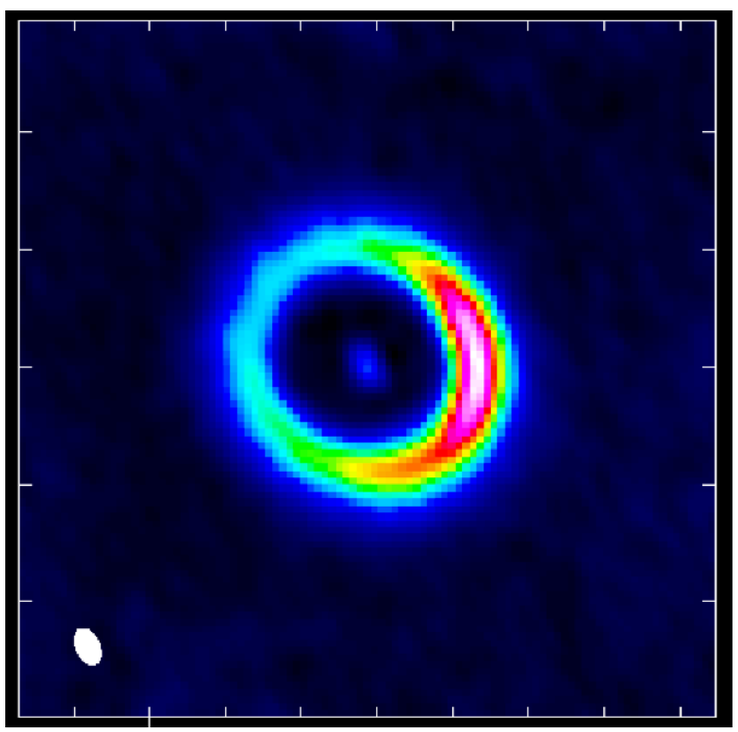


Detections and non-detections

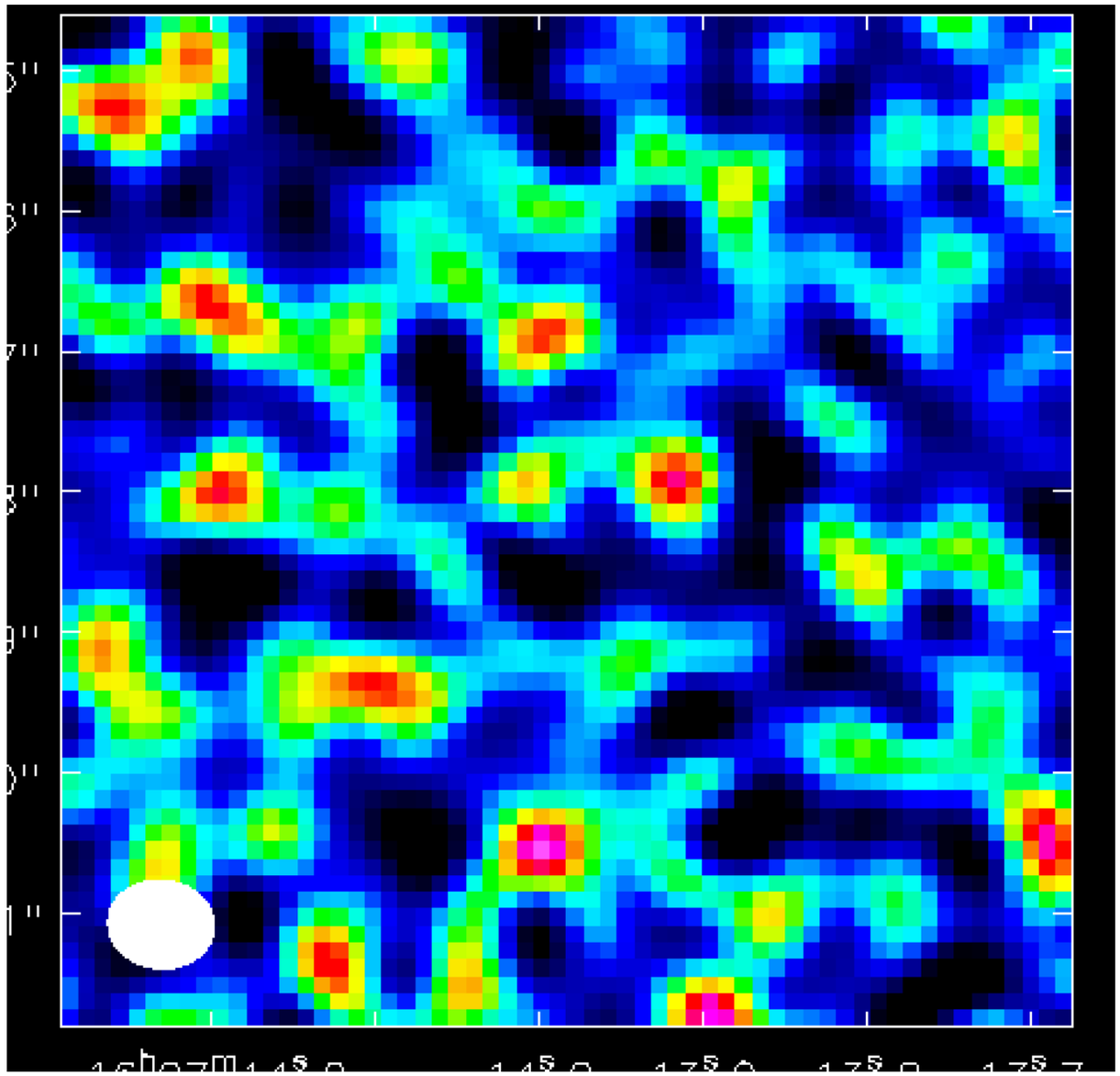
Detection point-source



Detection extended source

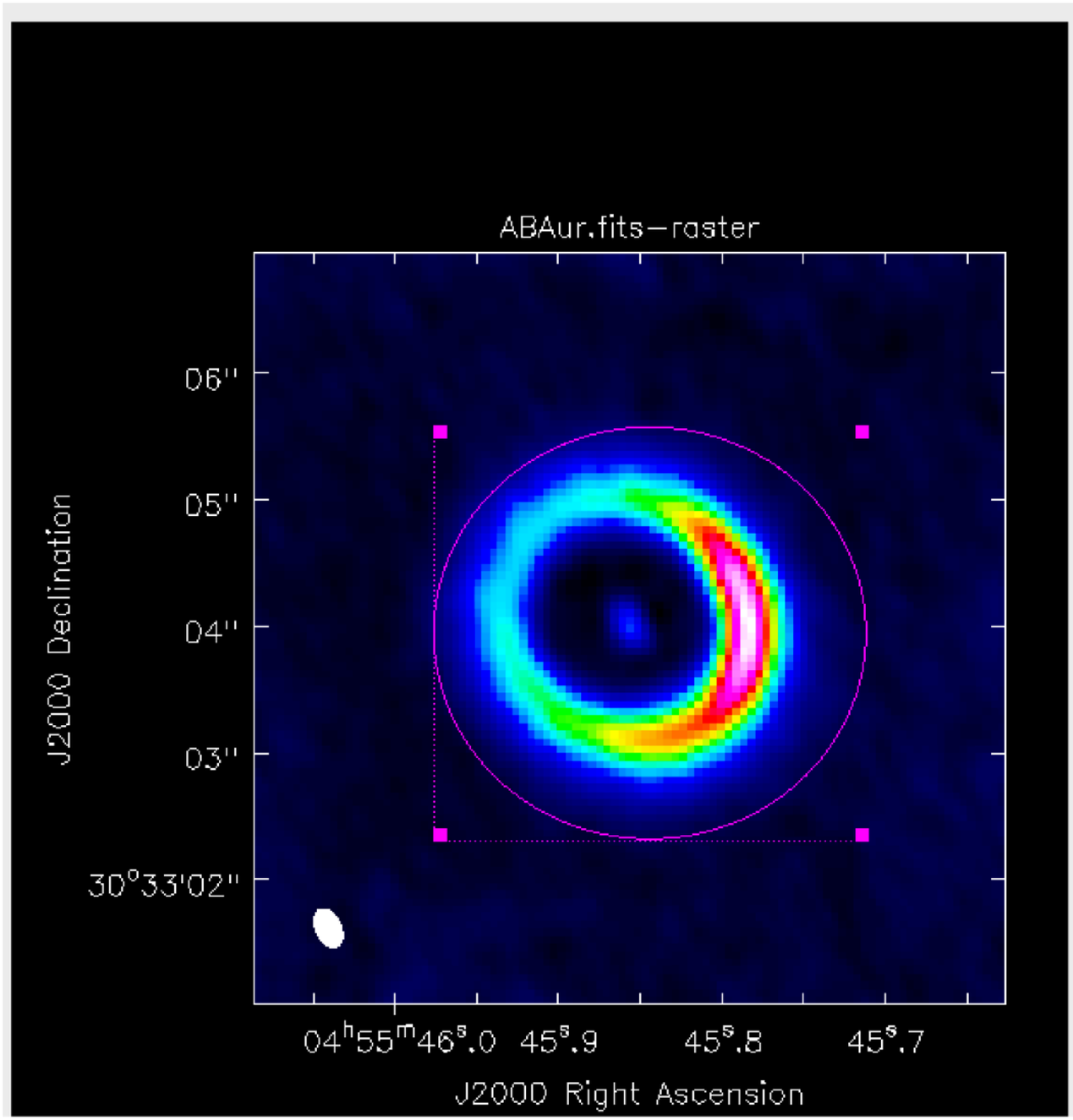


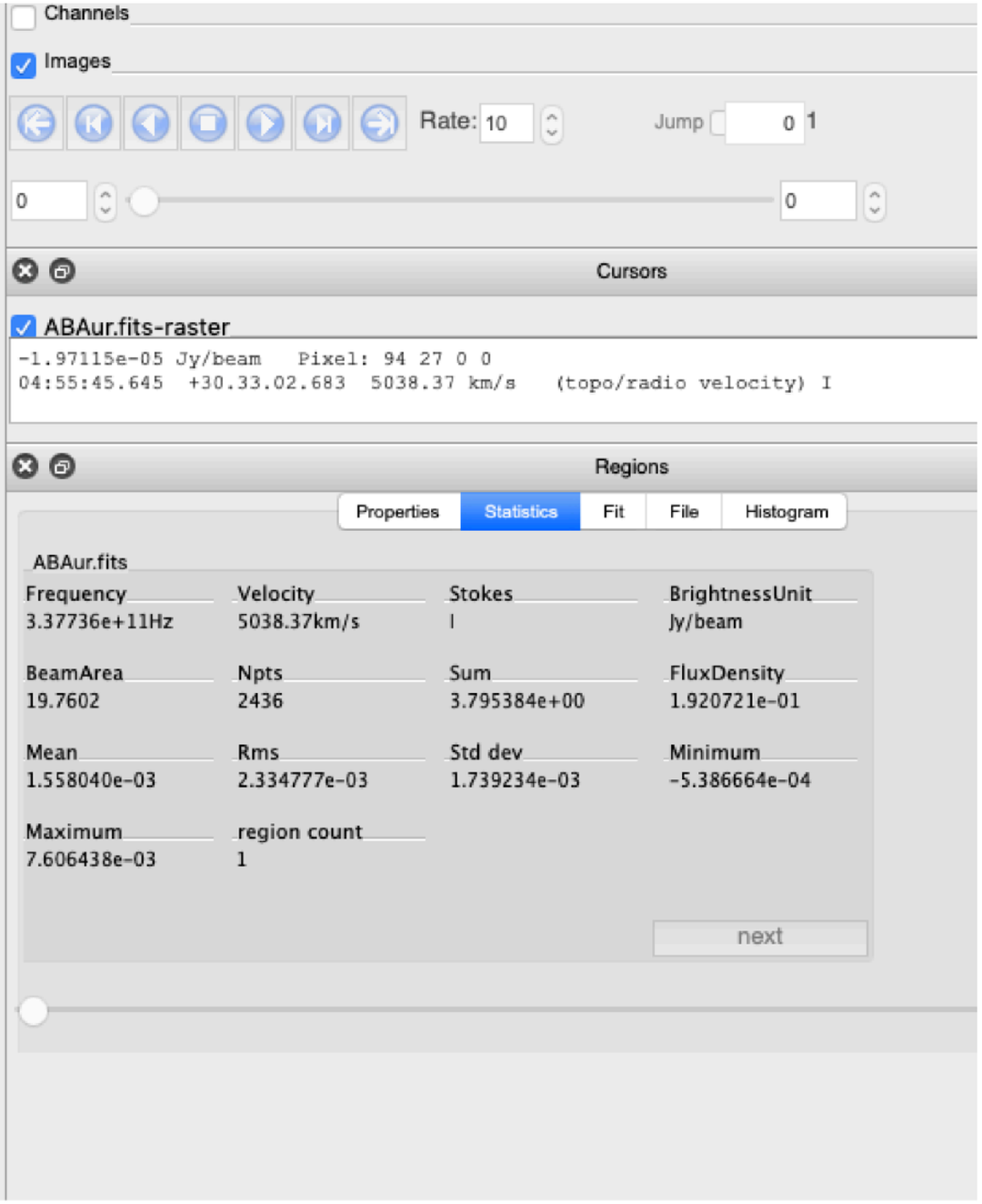
Non-detection



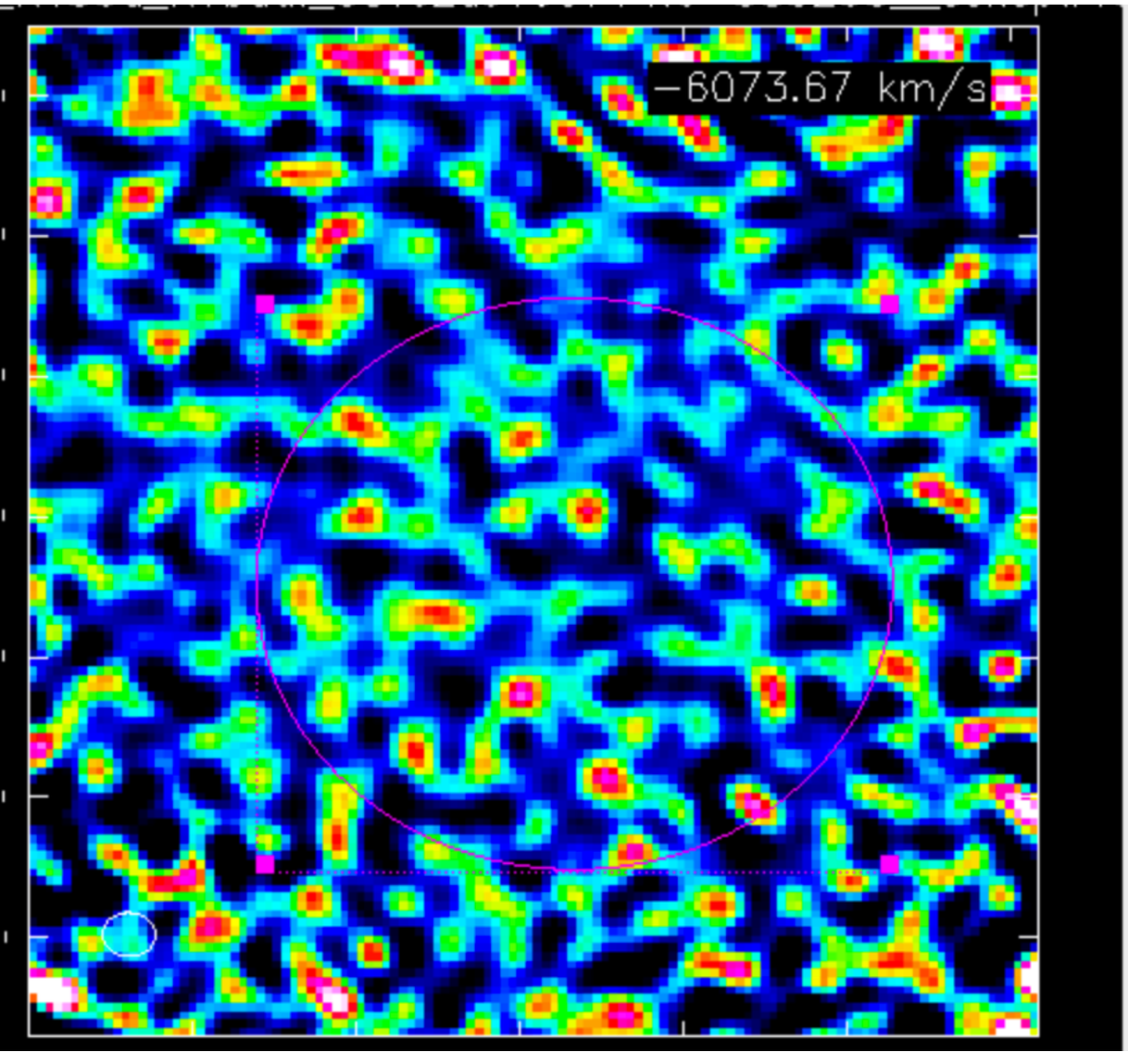
Detections

Get information about flux, size, etc. either with viewer or using imfit()





Non-detections/noise



Regions

Properties | Statistics | Fit | File | Histogram

member.uid___A001_X133d_X1bad._SSTc2dJ160714.0-385238__sci.spw19_21_23_25.cont.

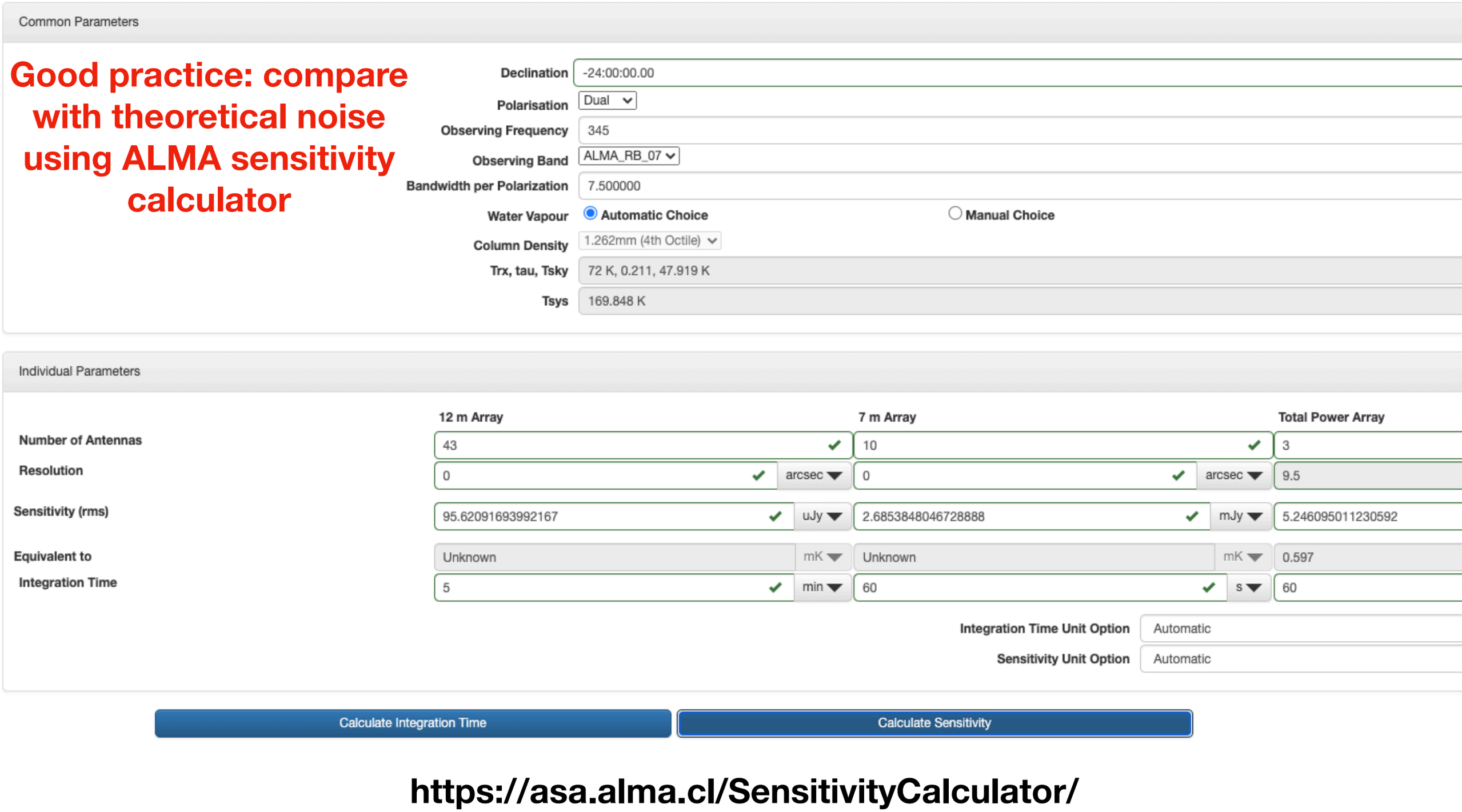
Frequency	Velocity	Stokes	BrightnessUnit
3.50153e+11Hz	-6073.67km/s	I	Jy/beam
BeamArea	**Npts**	**Sum**	**FluxDensity**
36.8425	4068	8.961256e-03	2.432313e-04
Mean	**Rms**	**Std dev**	**Minimum**
2.202865e-06	3.732565e-05	3.726517e-05	-1.160252e-04
Maximum	**region count**		
1.320873e-04	1		

next

Measure noise in emission-free region

Non-detections/noise

Good practice: compare with theoretical noise using ALMA sensitivity calculator



https://asa.alma.cl/SensitivityCalculator/

Import/export

- For operations outside CASA, export your images to a fitsfile using exportfits()

- For most operations in CASA and CASA viewer, import your images to an image file using importfits() if not yet in fits format

More information

- ALMA proposer's guide: https://almascience.nrao.edu/proposing/proposers-guide

- ALMA CASA tutorials: https://casaguides.nrao.edu/index.php/ALMAguides

- NRAO 17th Synthesis Imaging Workshop 2020: http://www.cvent.com/events/virtual-17th-synthesis-imaging-workshop/agenda-0d59eb6cd1474978bce811194b2ff961.aspx (online lectures)