CASA VLBI

WORKSHOP 2020

2-6 NOVEMBER 2020

LECTURE 2: PLOT TOOLS IN CASA

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Common Astronomy Software Applications

JIVE
Joint Institute for VLBI ERIC

RadioNet

JUMPING JIVE
Joint Institute for VLBI ERIC

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Plot tools in CASA

- ☑ Why plotting?
- ☑ *plotms*
- ☑ *viewer*
- ☑ *plotcal*
- ☑ Other tools…

Why plotting is important?

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Why plotting is important?

- ☑ Best approach to check how your data look like, and how it is being calibrated.
- ☑ Calibration of radio data (specially VLBI) still requires an important fraction of manual supervision.
- ☑ Most of the plotting stages will be done during ***data reduction***, not during ***data analysis***.
- ☑ Only way to make sure that the data reduction goes in the right direction.

Don’t trust blindly your (automatic) data reduction!

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Why plotting is important?

- You will know better your data.
- Is the easiest way to identify bad data.
  - Times where an antenna stopped recording properly.
  - Times where an antenna was still moving towards the source.
  - Radio frequency interference (RFI).
  - De-correlation of the signal due to external elements.
  - A long etc.
- Always check the solutions after running a calibration step.
  Do they make sense?
- Only then, continue to the next step.

How look at the data?

We also need to know what to expect…

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What should we look at?

- ☑ Actual (visibility) data or calibration solutions.
- ☑ Antenna- or baseline-based data.
- ☑ Multi-dimensional data:
  baselines, source, times, frequencies (subbands, channels), polarizations,…

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What should we expect?

Wait for:

- ☑ ***EVN Calibration Basics***

  Lecture 4 tomorrow at 8:30 UTC (me).

- ☑ ***Typical data problems***

  Lecture 6 tomorrow at 13:30 UTC (Ivan Martí-Vidal).

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What should we expect?

Typical considerations on VLBI data:

- ☑ Homogeneous (VLBA) vs inhomogeneous (EVN) arrays.

  Significantly different sensitivities.
  Most automatic flagging tasks do not work!

- ☑ Short VS long baselines.

  Source fluxes may vary with length and orientation.
  Most of them are resolved to some extend!

plotms

Both from inside the CASA prompt:
plotms(vis="n14c3.ms", xaxis="u",yaxis="v", coloraxis='field')

Or outside (for CASA 5.7-):
casaplotms vis="n14c3.ms", xaxis="u",yaxis="v", coloraxis='field'

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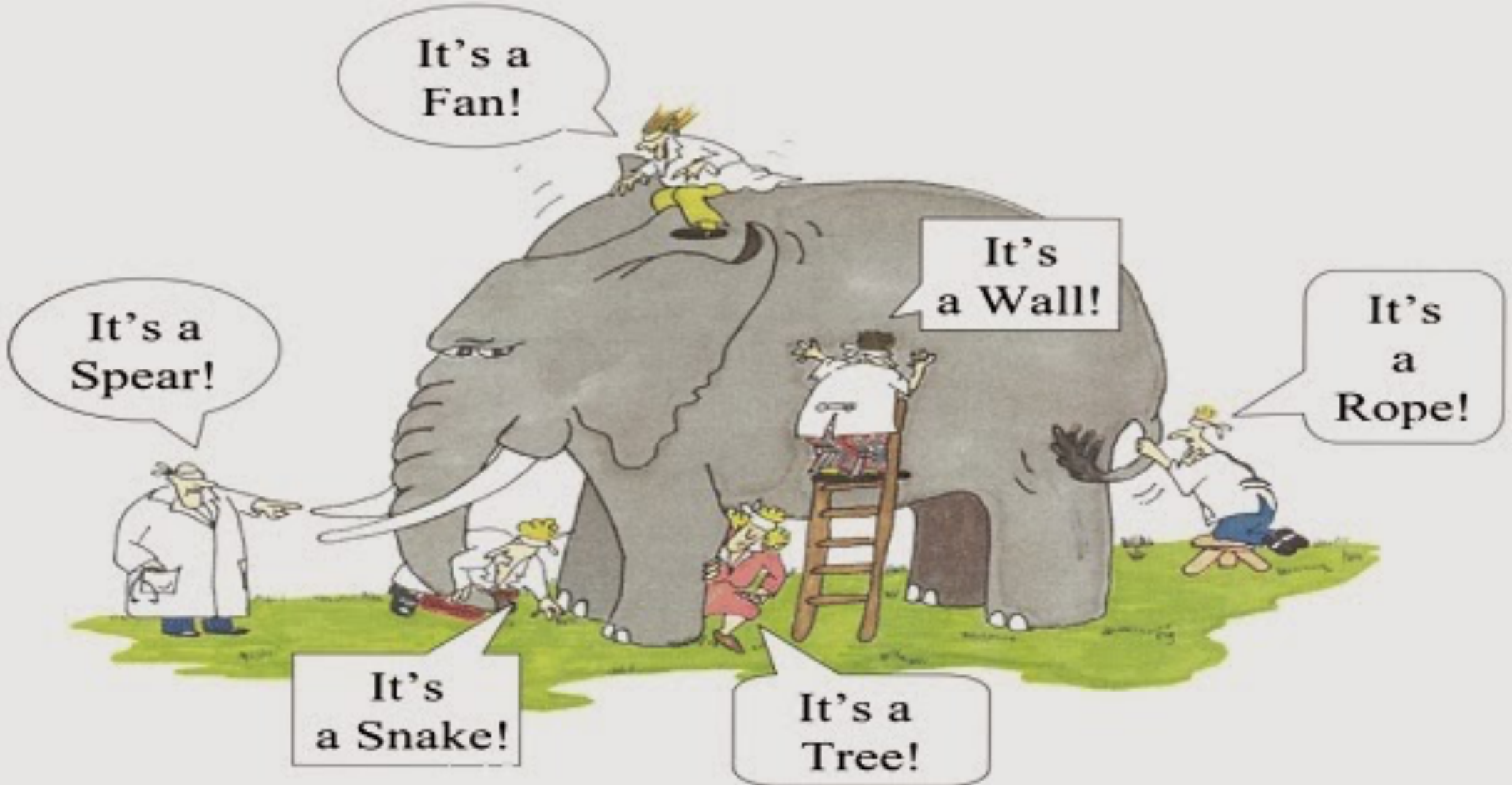
Looking the same data in different ways



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plotms

plotms?

plotms(vis="n14c3.ms",
xaxis="u",yaxis="v", coloraxis='field')

default(plotms)

vis="n14c3.ms"

xaxis="u"

yaxis="v"

coloraxis='field'

inp
plotms()

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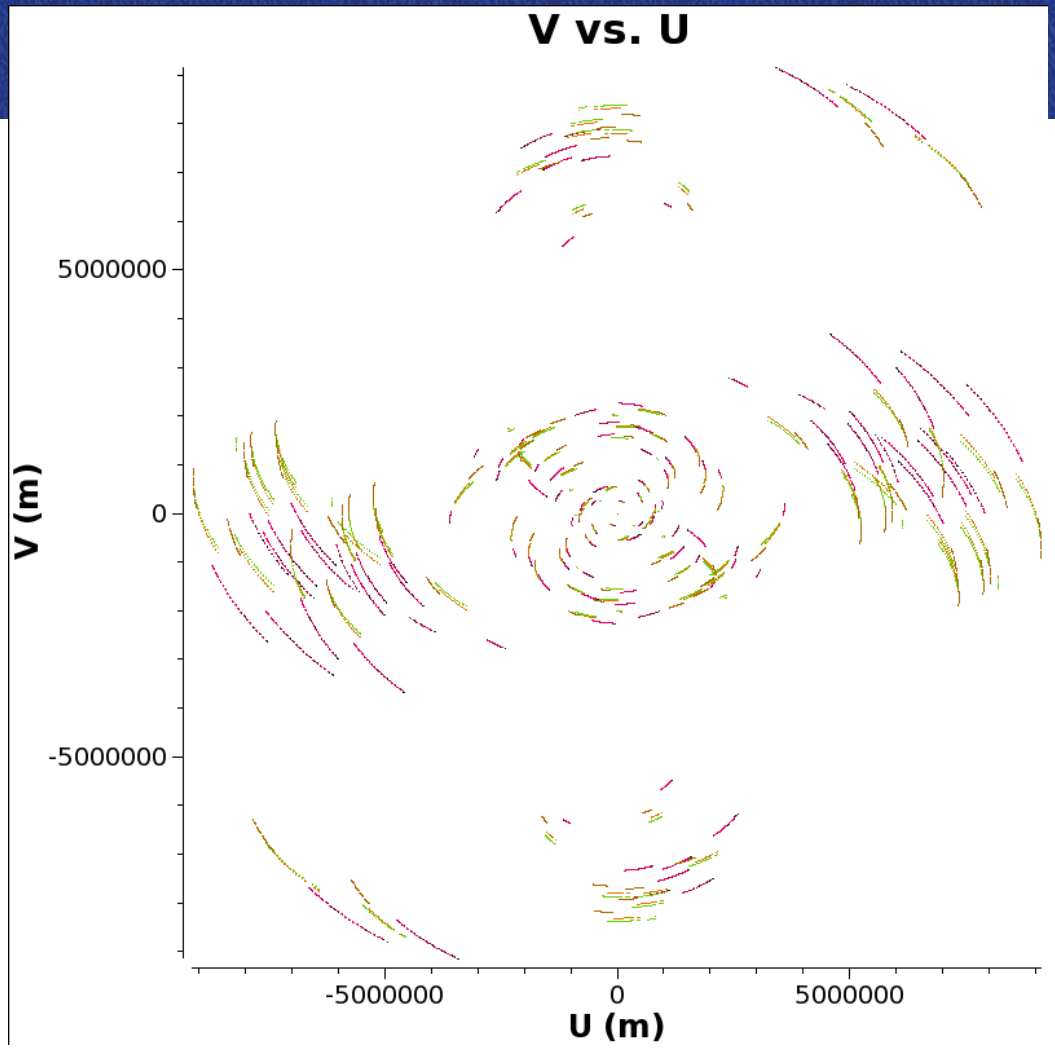
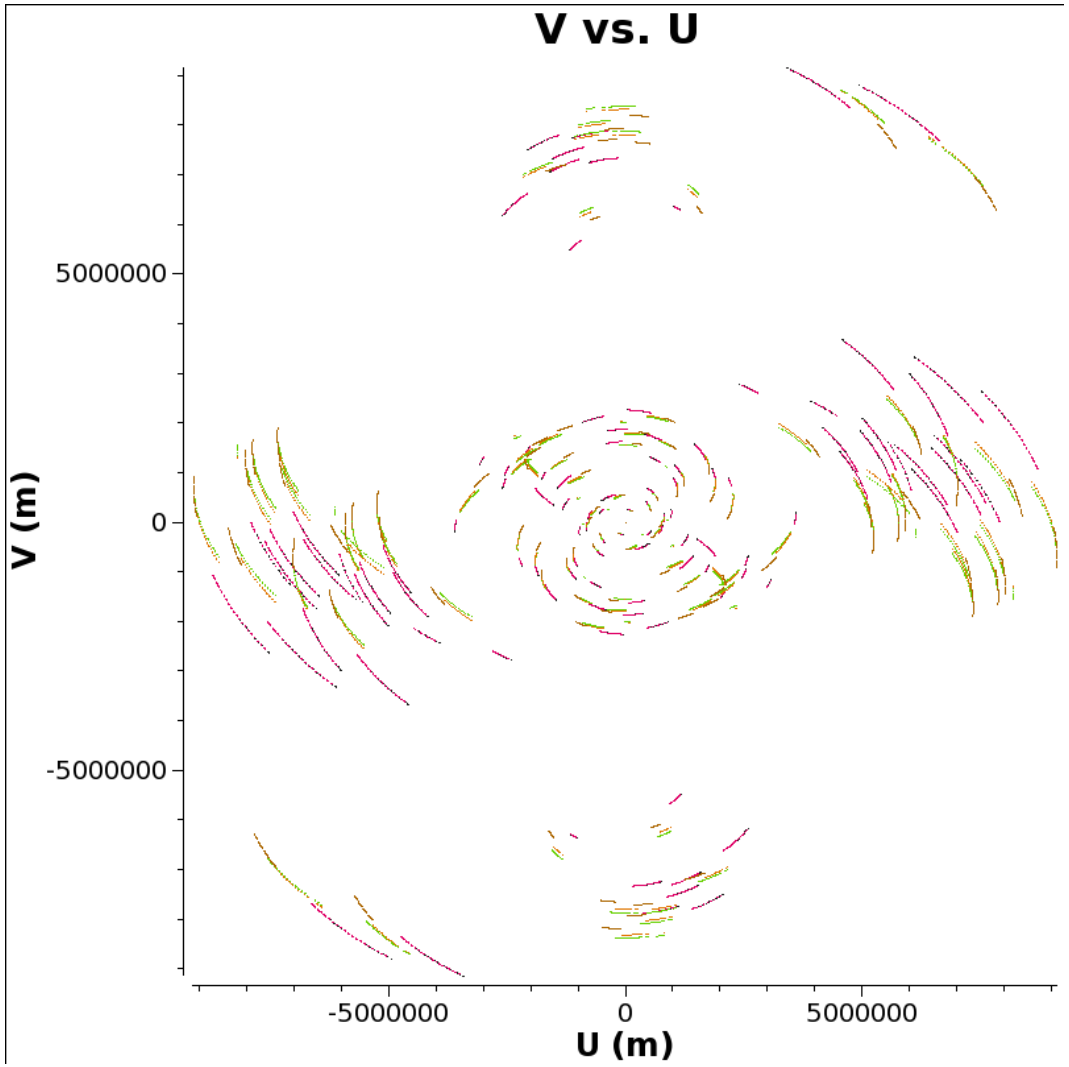
(u,v) plane

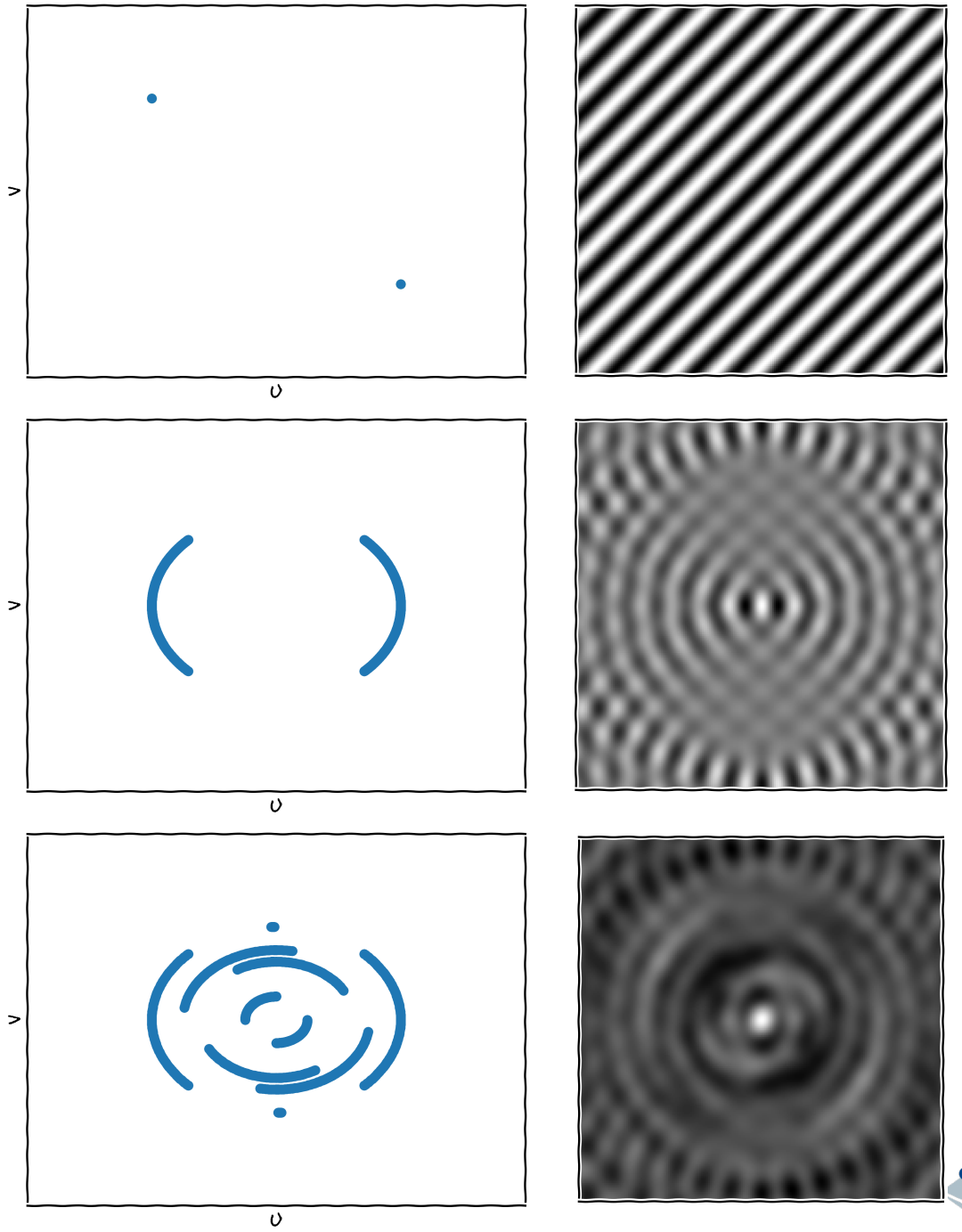
How are you filling the (u,v) plane?

- ☑ Maximum (uv) distance:
  Resolution of the final image
- ☑ Minimum (uv) distance:
  Larger angular scales you are sensitive to.
- ☑ Recovered angular scales on the final image

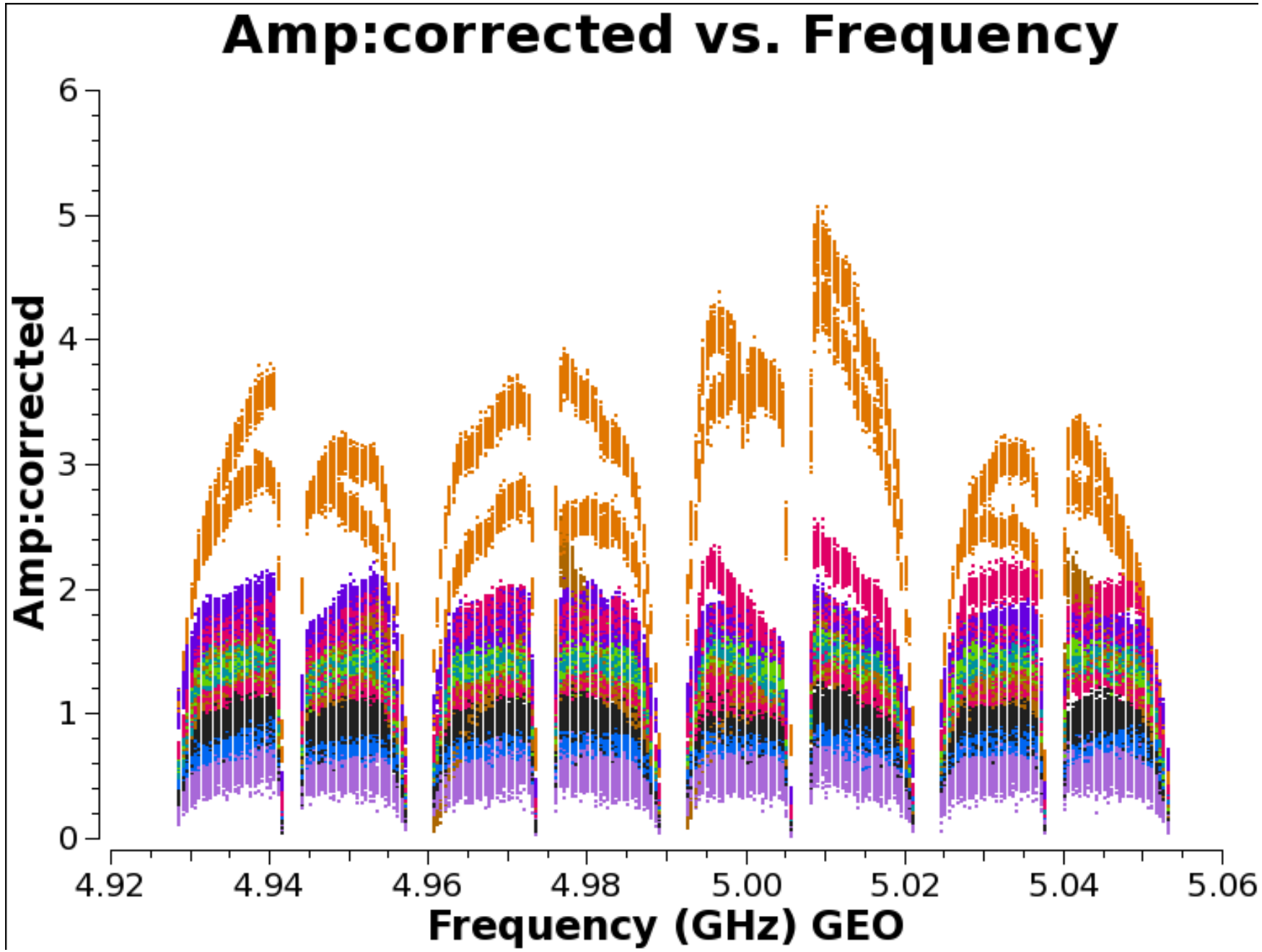


plotms(vis="ms-dataset", xaxis="u",yaxis="v", field='target')


V vs. U
5000000
0
-5000000
V (m)
-5000000
0
5000000
U (m)

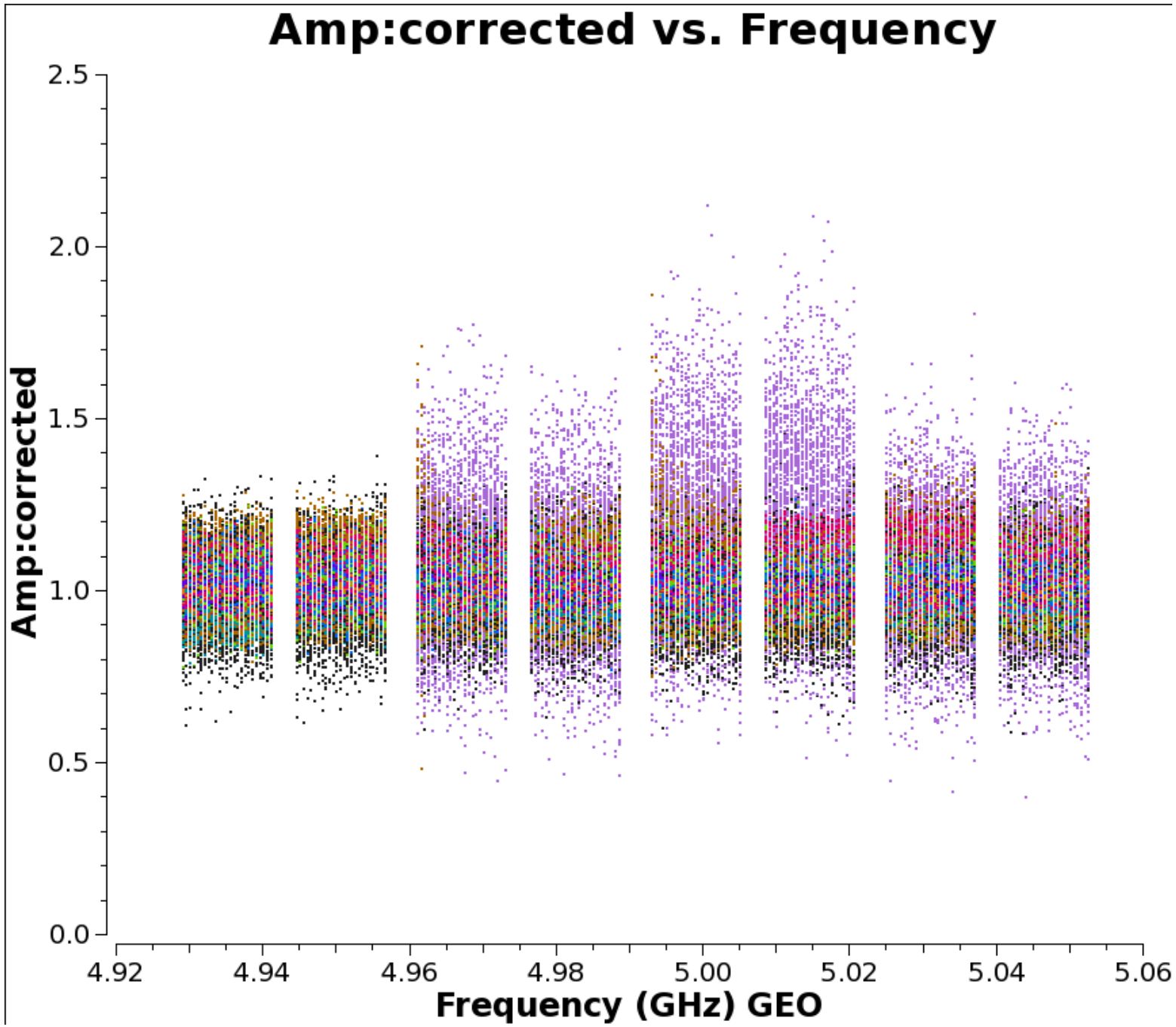

v
u
v
u
v
u

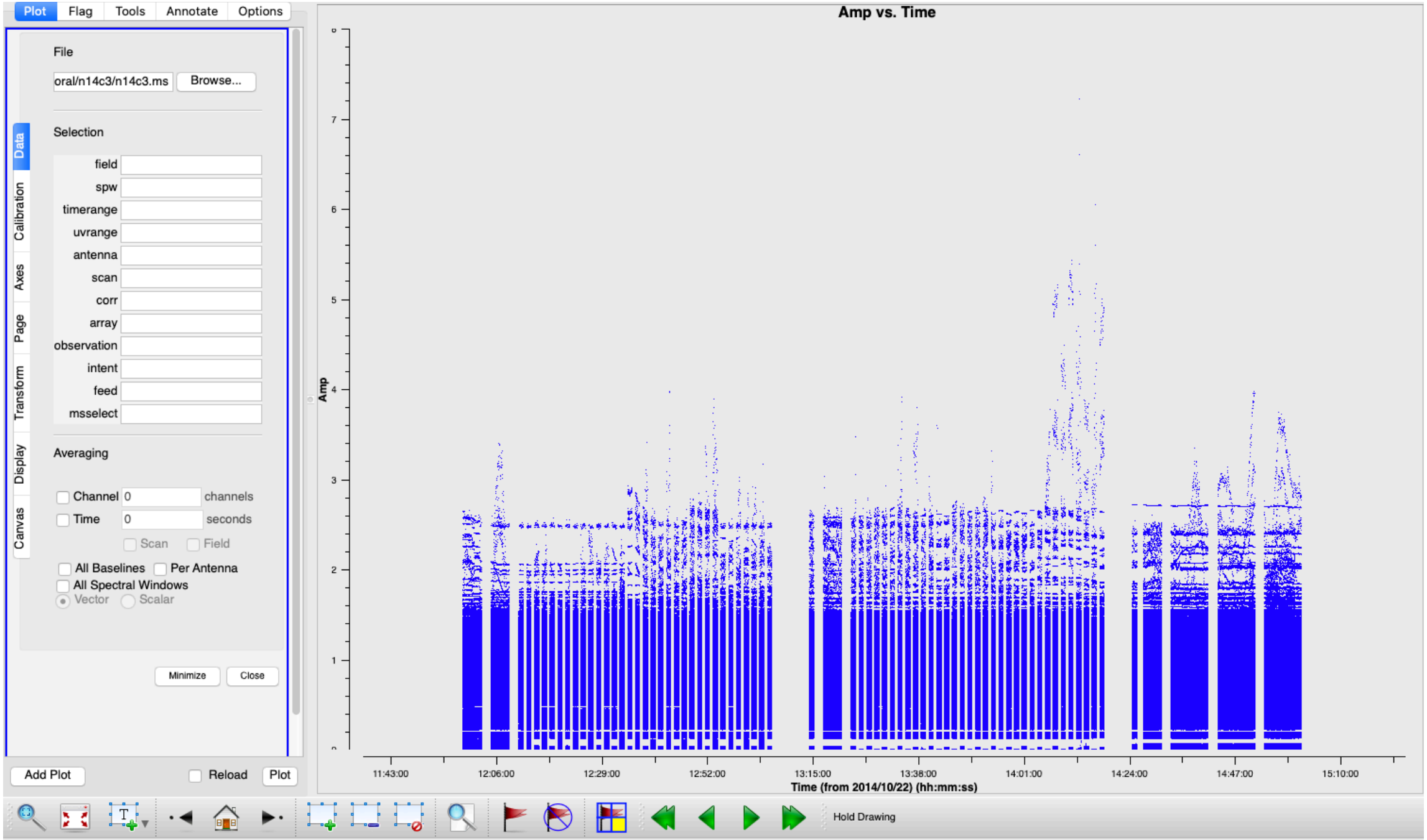
```
plotms(
vis="n14c3.ms",
xaxis="frequency",
yaxis="amp",
field='1848+283',
avgtime='3600',
# Will only average within scans unless additionally told to average scans too
antenna='EF&*',
# All baselines to EF
correlation='RR,LL',
coloraxis='antenna2'
)
```

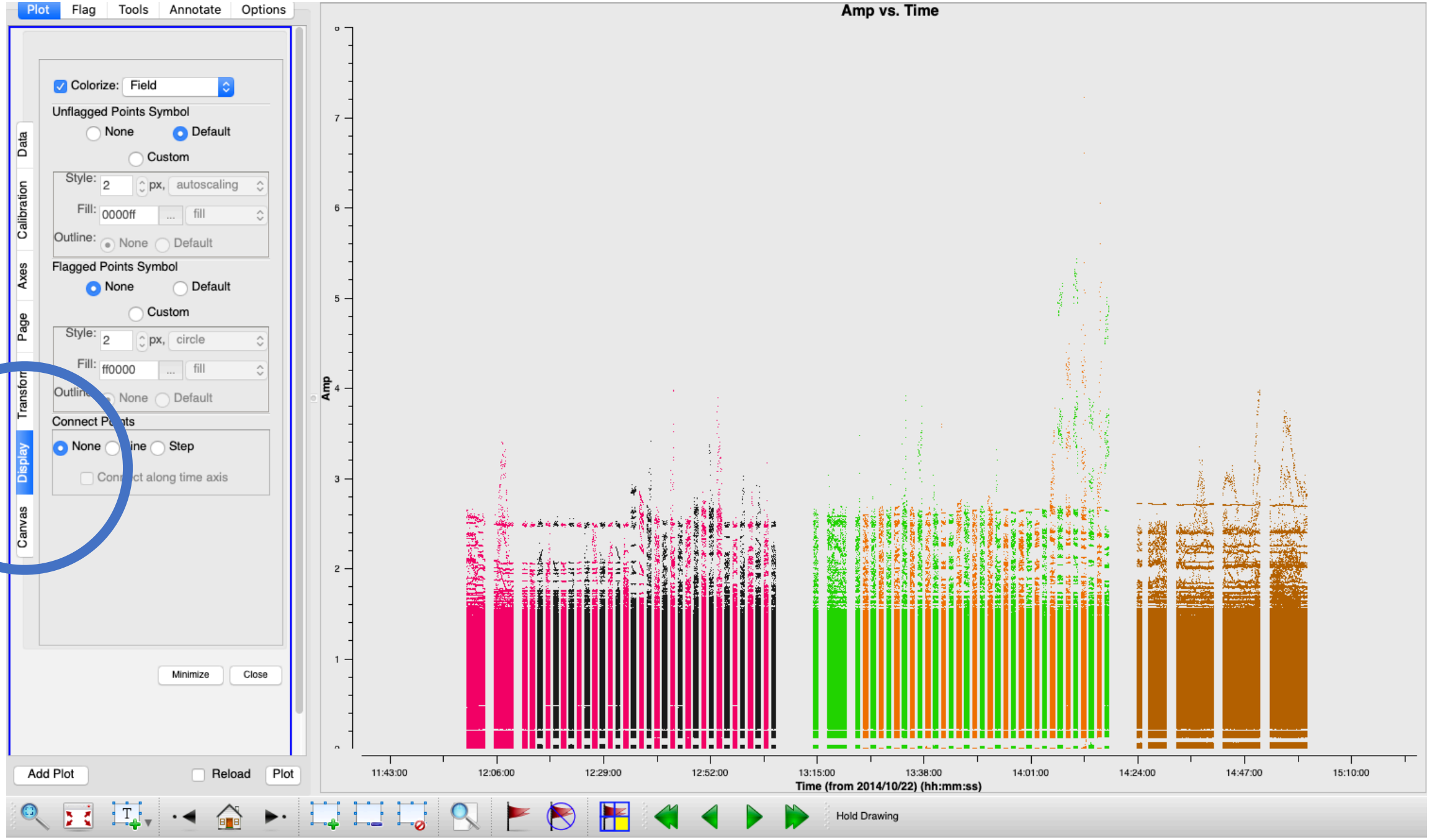


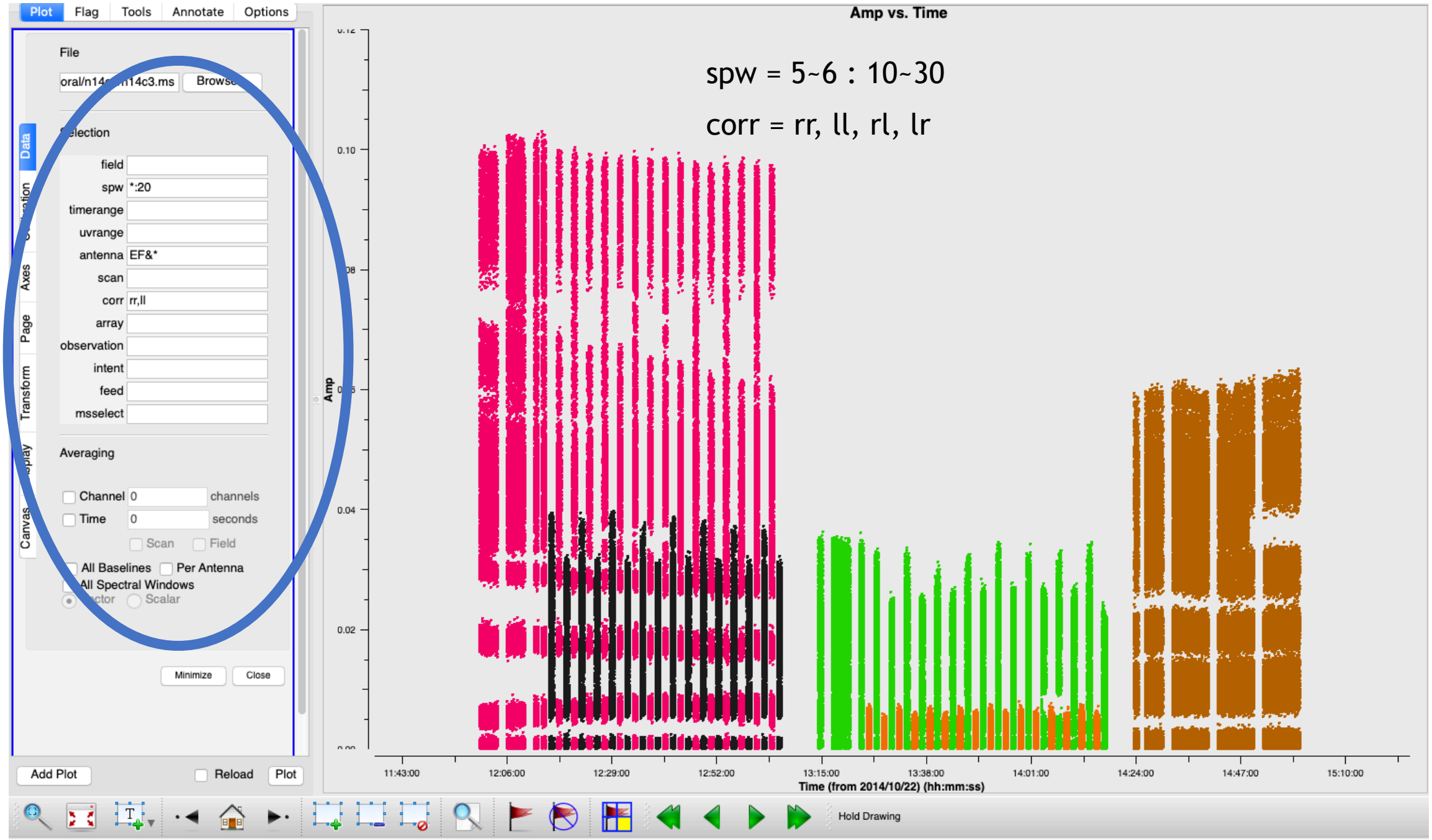
After bandpass calibration:

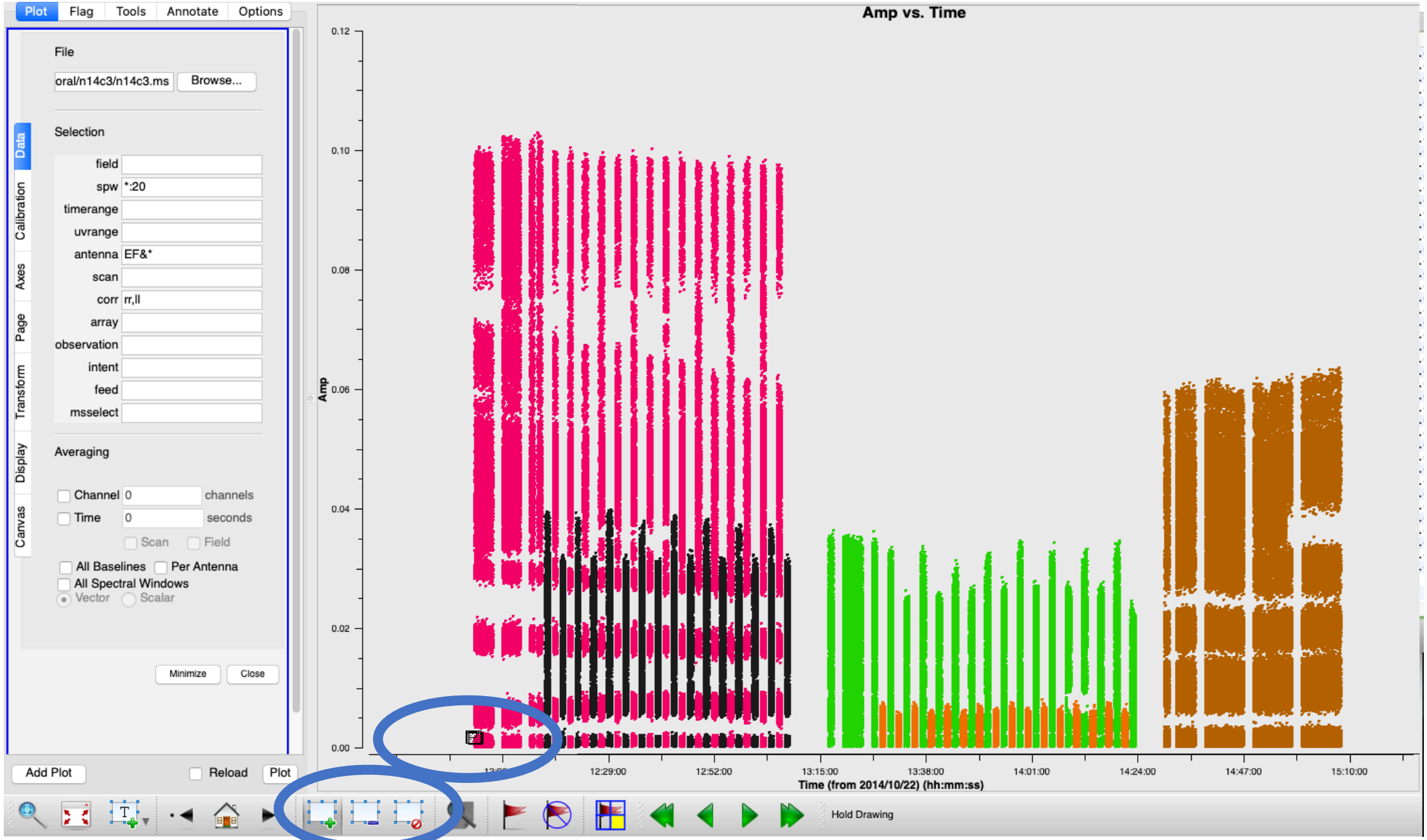
ydatacolumn='corrected'

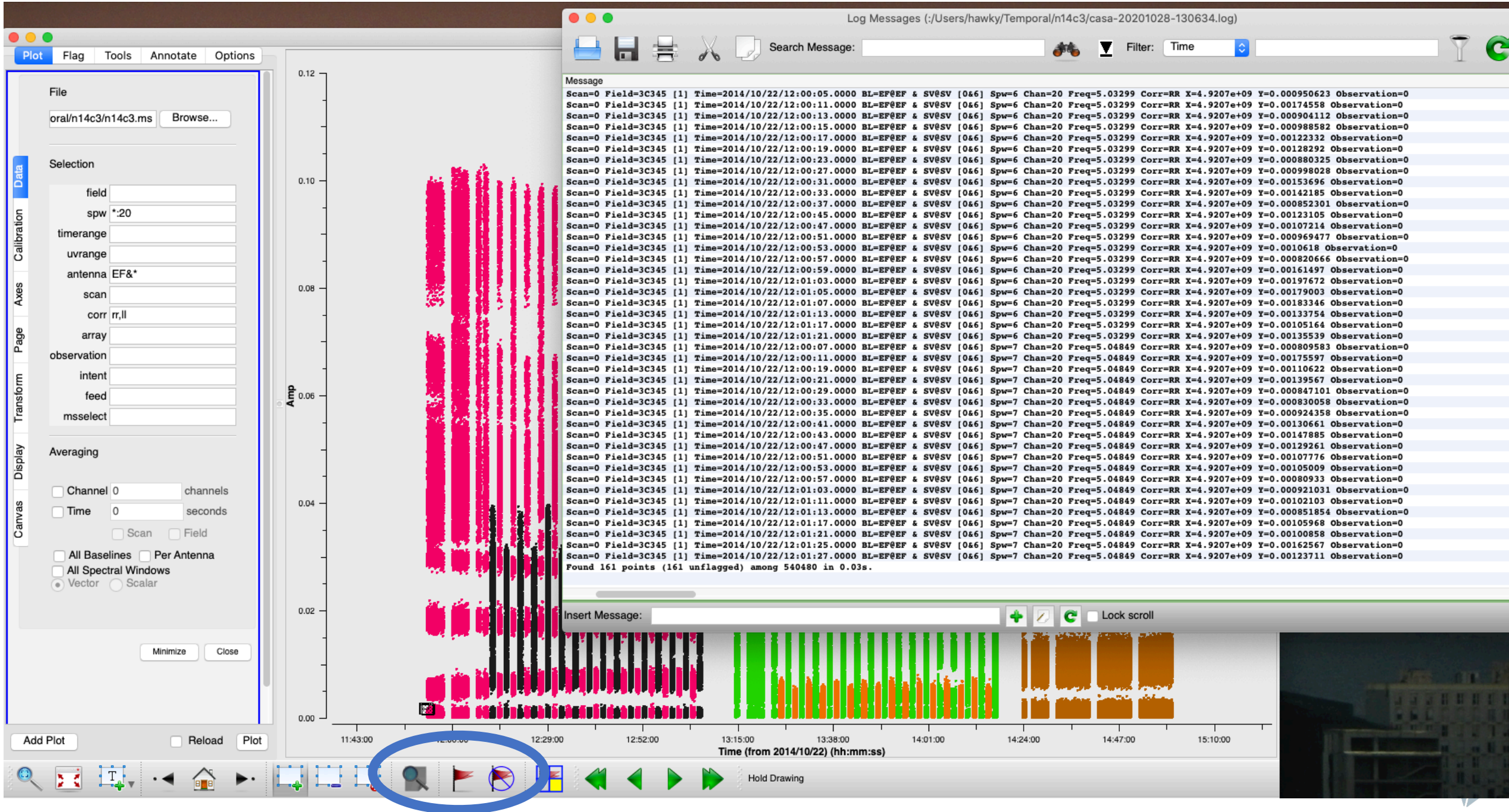


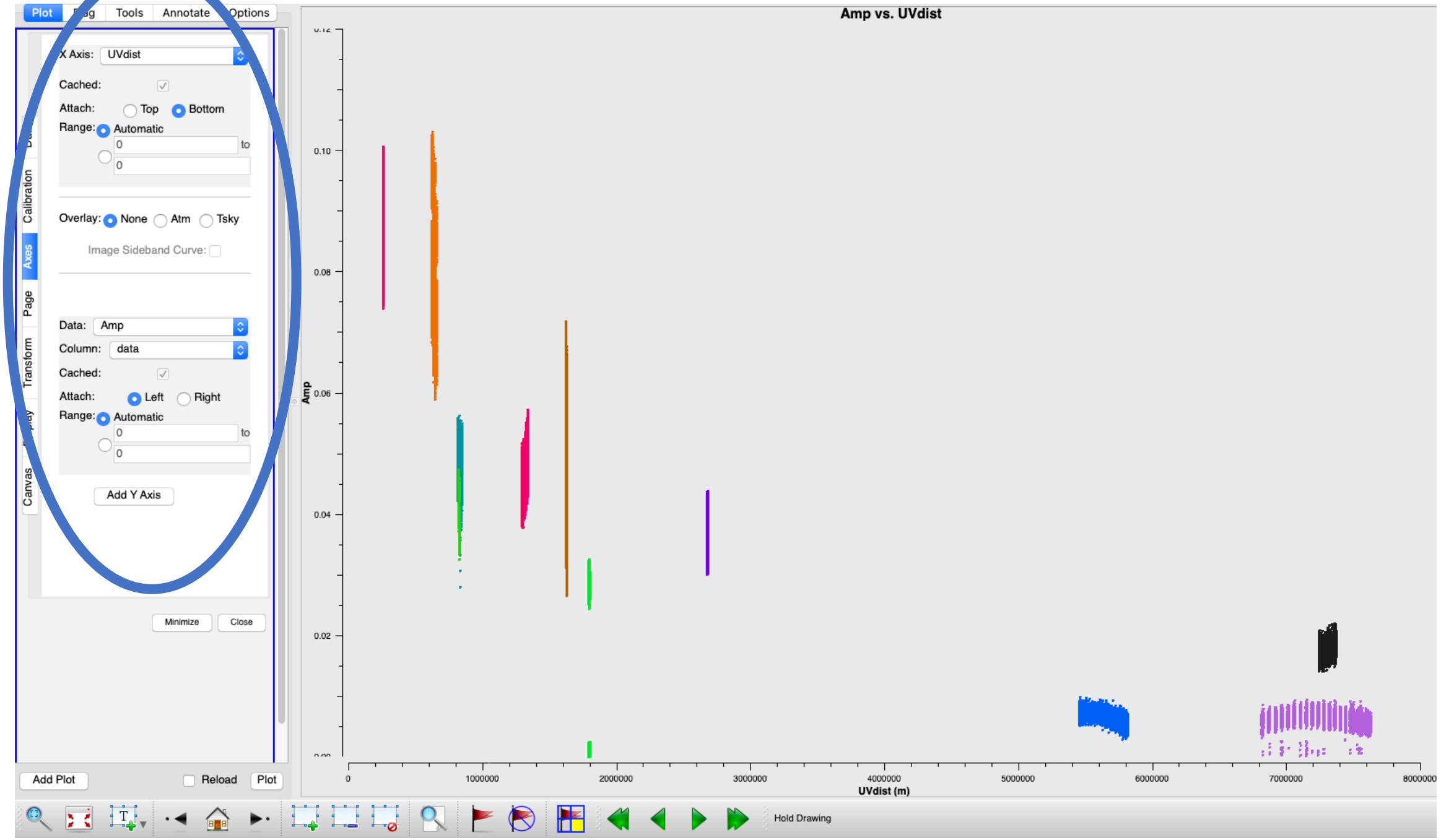

Plot
Flag
Tools
Annotate
Options
File
oral/n14c3/n14c3.ms
Browse...
Selection
field
spw
timerange
uvrange
antenna
scan
corr
array
observation
intent
feed
msselect
Averaging
Channel
0
channels
Time
0
seconds
Scan
Field
All Baselines
Per Antenna
All Spectral Windows
Vector
Scalar
Minimize
Close
Data
Calibration
Axes
Page
Transform
Display
Canvas
Add Plot
Reload
Plot
Amp vs. Time
Amp
Time (from 2014/10/22) (hh:mm:ss)
11:43:00
12:06:00
12:29:00
12:52:00
13:15:00
13:38:00
14:01:00
14:24:00
14:47:00
15:10:00
Hold Drawing

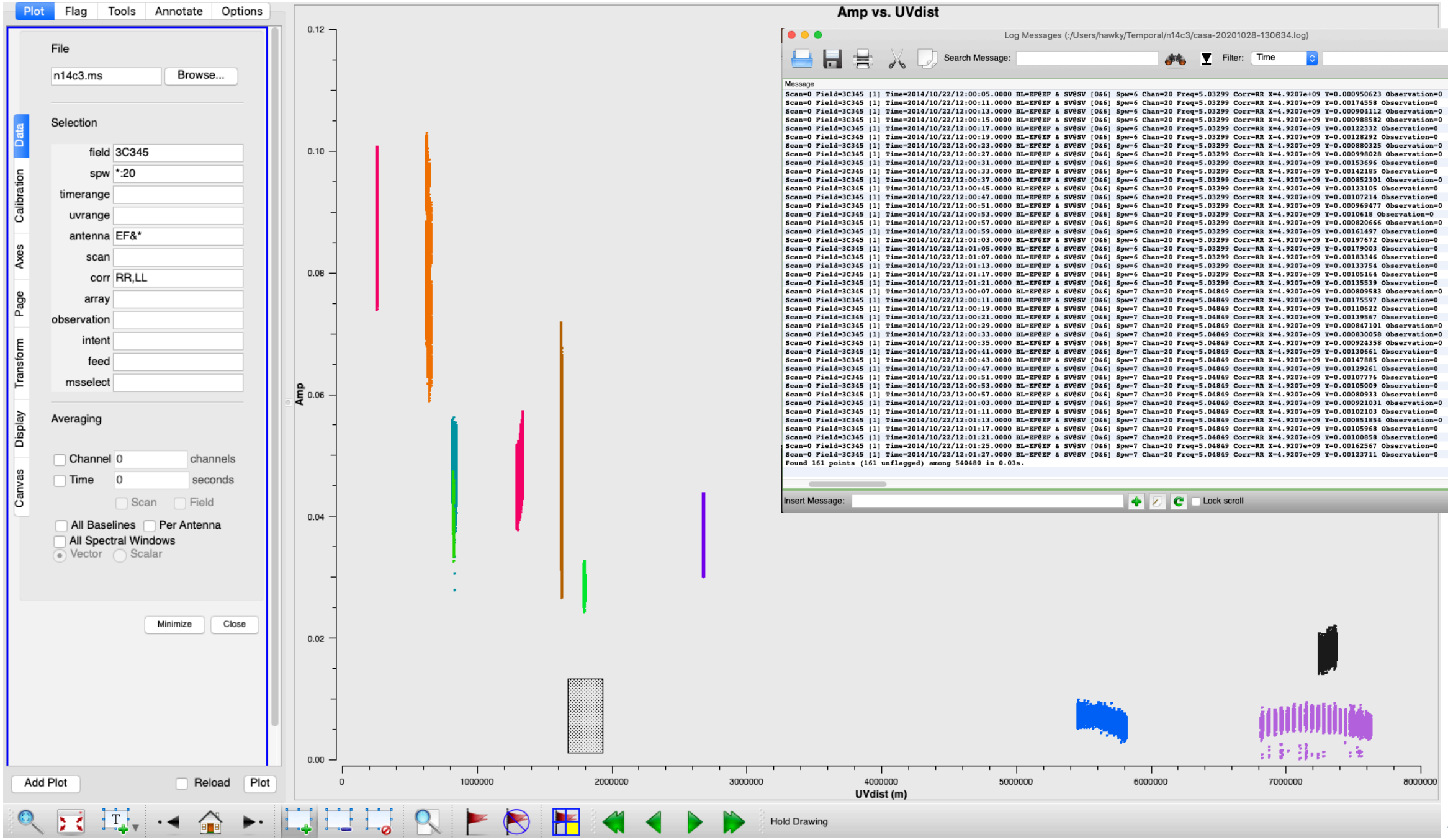

Plot
Flag
Tools
Annotate
Options
Data
Calibration
Axes
Page
Transform
Display
Canvas
Colorize:
Field
Unflagged Points Symbol
None
Default
Custom
Style:
2
px,
autoscaling
Fill:
0000ff
fill
Outline:
None
Default
Flagged Points Symbol
None
Default
Custom
Style:
2
px,
circle
Fill:
ff0000
fill
None
Default
Connect Points
None
Step
Minimize
Close
Add Plot
Reload
Plot
Amp vs. Time
Amp
Time (from 2014/10/22) (hh:mm:ss)
11:43:00
12:06:00
12:29:00
12:52:00
13:15:00
13:38:00
14:01:00
14:24:00
14:47:00
15:10:00
Hold Drawing

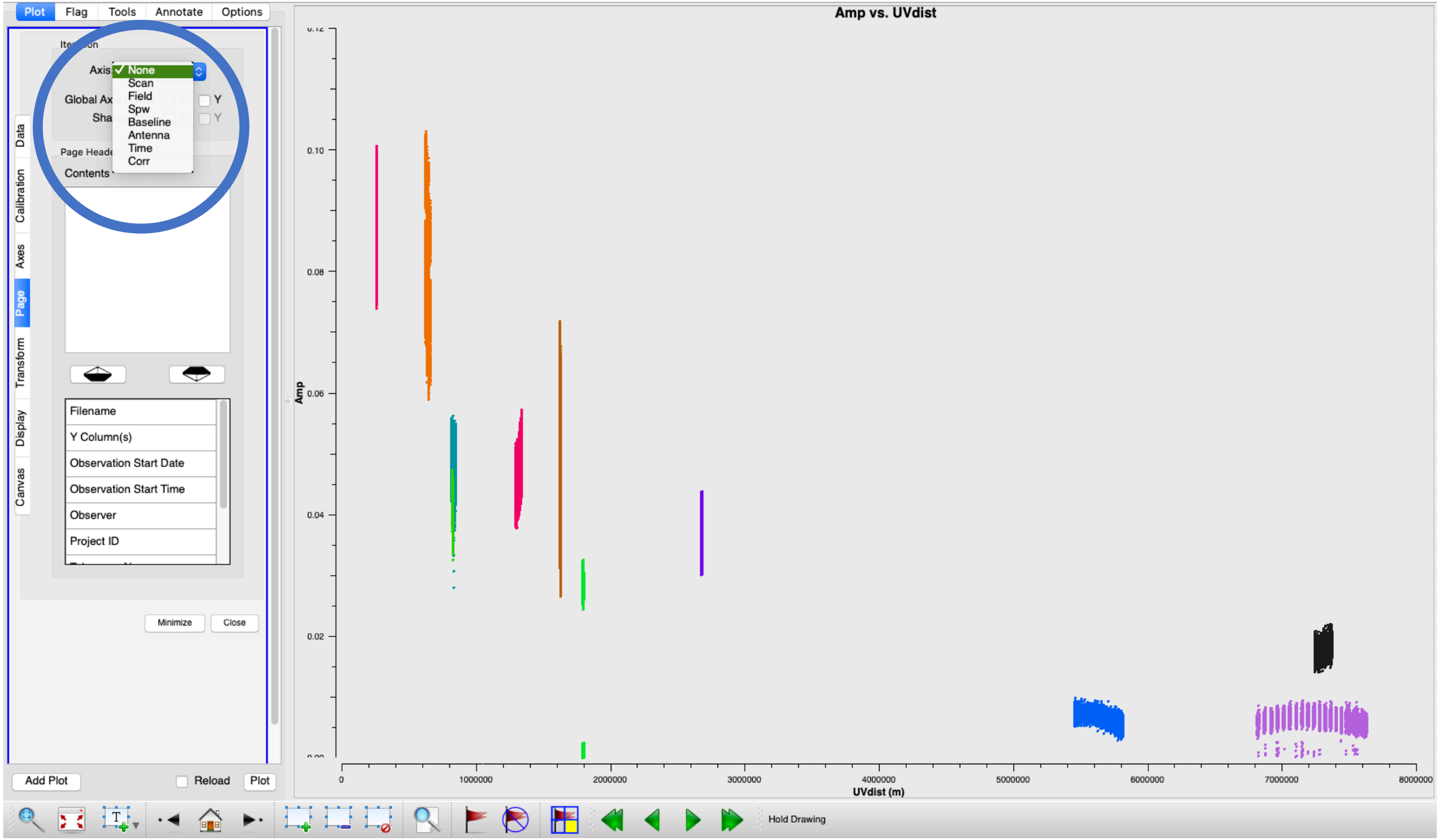

Plot
Flag
Tools
Annotate
Options
File
Browse
Selection
field
spw *:20
timerange
uvrange
antenna EF&*
scan
corr rr,ll
array
observation
intent
feed
msselect
Averaging
Channel 0 channels
Time 0 seconds
Scan
Field
All Baselines
Per Antenna
All Spectral Windows
Scalar
Minimize
Close
Data
Axes
Page
Transform
Canvas
Add Plot
Reload
Plot
Amp vs. Time
spw = 5~6 : 10~30
corr = rr, ll, rl, lr
Amp
0.10
0.04
0.02
11:43:00
12:06:00
12:29:00
12:52:00
13:15:00
13:38:00
14:01:00
14:24:00
14:47:00
15:10:00
Time (from 2014/10/22) (hh:mm:ss)
Hold Drawing

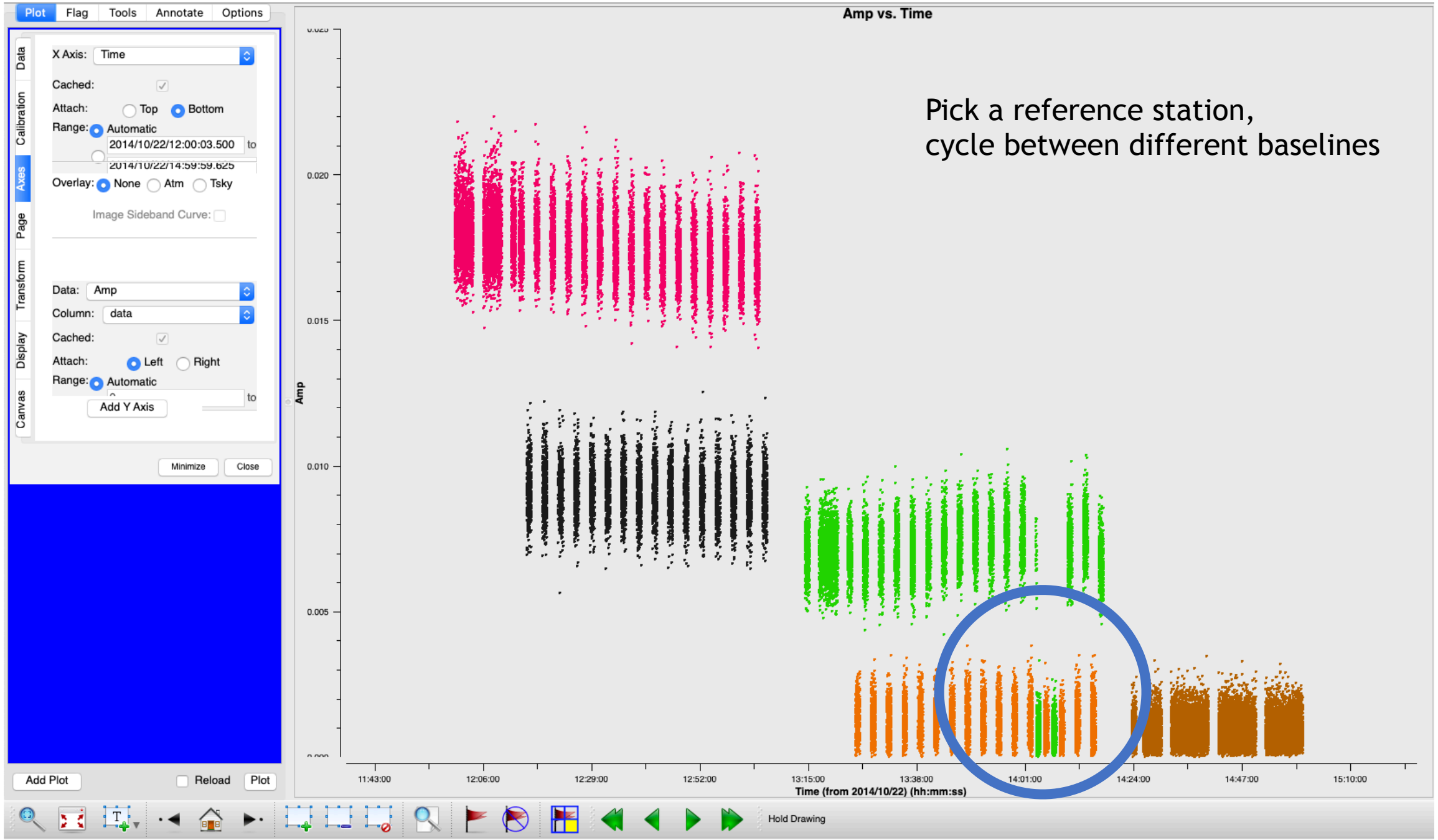

Plot
Flag
Tools
Annotate
Options
File
oral/n14c3/n14c3.ms
Browse...
Selection
Data
Calibration
Axes
Page
Transform
Display
Canvas
field
spw *:20
timerange
uvrange
antenna EF&*
scan
corr rr,ll
array
observation
intent
feed
msselect
Averaging
Channel 0 channels
Time 0 seconds
Scan
Field
All Baselines
Per Antenna
All Spectral Windows
Vector
Scalar
Minimize
Close
Add Plot
Reload
Plot
Amp vs. Time
Amp
0.12
0.10
0.08
0.06
0.04
0.02
0.00
12:29:00
12:52:00
13:15:00
13:38:00
14:01:00
14:24:00
14:47:00
15:10:00
Time (from 2014/10/22) (hh:mm:ss)
Hold Drawing

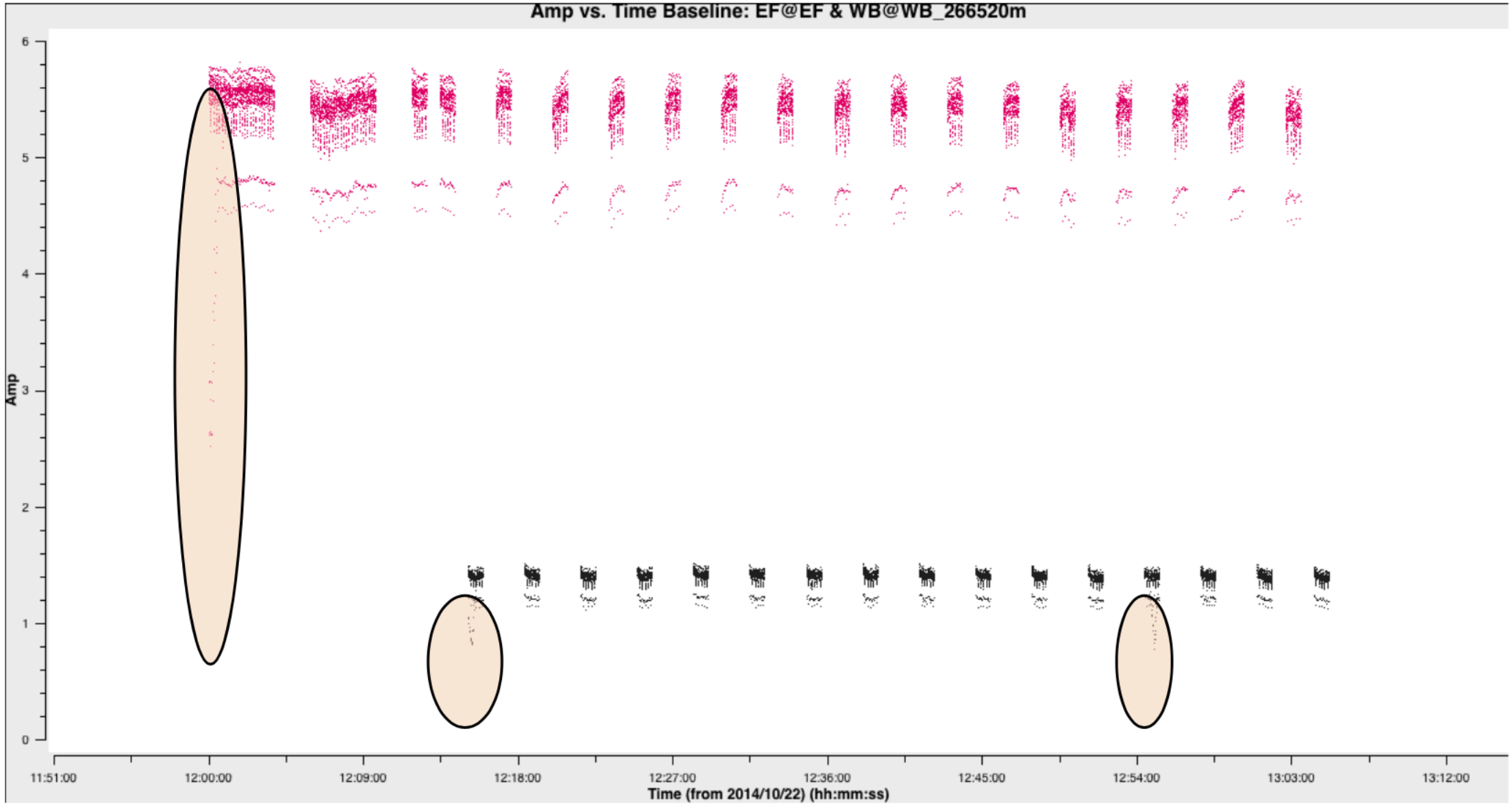

Log Messages (:/Users/hawky/Temporal/n14c3/casa-20201028-130634.log)
Search Message:
Filter:
Time
Message
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:05.0000 BL=EF@EF & SV@SV [0&6] Spw=6 Chan=20 Freq=5.03299 Corr=RR X=4.9207e+09 Y=0.000950623 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:11.0000 BL=EF@EF & SV@SV [0&6] Spw=6 Chan=20 Freq=5.03299 Corr=RR X=4.9207e+09 Y=0.00174558 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:13.0000 BL=EF@EF & SV@SV [0&6] Spw=6 Chan=20 Freq=5.03299 Corr=RR X=4.9207e+09 Y=0.000904112 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:15.0000 BL=EF@EF & SV@SV [0&6] Spw=6 Chan=20 Freq=5.03299 Corr=RR X=4.9207e+09 Y=0.000988582 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:17.0000 BL=EF@EF & SV@SV [0&6] Spw=6 Chan=20 Freq=5.03299 Corr=RR X=4.9207e+09 Y=0.00122332 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:19.0000 BL=EF@EF & SV@SV [0&6] Spw=6 Chan=20 Freq=5.03299 Corr=RR X=4.9207e+09 Y=0.00128292 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:23.0000 BL=EF@EF & SV@SV [0&6] Spw=6 Chan=20 Freq=5.03299 Corr=RR X=4.9207e+09 Y=0.000880325 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:27.0000 BL=EF@EF & SV@SV [0&6] Spw=6 Chan=20 Freq=5.03299 Corr=RR X=4.9207e+09 Y=0.000998028 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:31.0000 BL=EF@EF & SV@SV [0&6] Spw=6 Chan=20 Freq=5.03299 Corr=RR X=4.9207e+09 Y=0.00153696 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:33.0000 BL=EF@EF & SV@SV [0&6] Spw=6 Chan=20 Freq=5.03299 Corr=RR X=4.9207e+09 Y=0.00142185 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:37.0000 BL=EF@EF & SV@SV [0&6] Spw=6 Chan=20 Freq=5.03299 Corr=RR X=4.9207e+09 Y=0.000852301 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:45.0000 BL=EF@EF & SV@SV [0&6] Spw=6 Chan=20 Freq=5.03299 Corr=RR X=4.9207e+09 Y=0.00123105 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:47.0000 BL=EF@EF & SV@SV [0&6] Spw=6 Chan=20 Freq=5.03299 Corr=RR X=4.9207e+09 Y=0.00107214 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:51.0000 BL=EF@EF & SV@SV [0&6] Spw=6 Chan=20 Freq=5.03299 Corr=RR X=4.9207e+09 Y=0.000969477 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:53.0000 BL=EF@EF & SV@SV [0&6] Spw=6 Chan=20 Freq=5.03299 Corr=RR X=4.9207e+09 Y=0.0010618 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:57.0000 BL=EF@EF & SV@SV [0&6] Spw=6 Chan=20 Freq=5.03299 Corr=RR X=4.9207e+09 Y=0.000820666 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:59.0000 BL=EF@EF & SV@SV [0&6] Spw=6 Chan=20 Freq=5.03299 Corr=RR X=4.9207e+09 Y=0.00161497 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:01:03.0000 BL=EF@EF & SV@SV [0&6] Spw=6 Chan=20 Freq=5.03299 Corr=RR X=4.9207e+09 Y=0.00197672 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:01:05.0000 BL=EF@EF & SV@SV [0&6] Spw=6 Chan=20 Freq=5.03299 Corr=RR X=4.9207e+09 Y=0.00179003 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:01:07.0000 BL=EF@EF & SV@SV [0&6] Spw=6 Chan=20 Freq=5.03299 Corr=RR X=4.9207e+09 Y=0.00183346 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:01:13.0000 BL=EF@EF & SV@SV [0&6] Spw=6 Chan=20 Freq=5.03299 Corr=RR X=4.9207e+09 Y=0.00133754 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:01:17.0000 BL=EF@EF & SV@SV [0&6] Spw=6 Chan=20 Freq=5.03299 Corr=RR X=4.9207e+09 Y=0.00105164 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:01:21.0000 BL=EF@EF & SV@SV [0&6] Spw=6 Chan=20 Freq=5.03299 Corr=RR X=4.9207e+09 Y=0.00135539 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:07.0000 BL=EF@EF & SV@SV [0&6] Spw=7 Chan=20 Freq=5.04849 Corr=RR X=4.9207e+09 Y=0.000809583 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:11.0000 BL=EF@EF & SV@SV [0&6] Spw=7 Chan=20 Freq=5.04849 Corr=RR X=4.9207e+09 Y=0.00175597 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:19.0000 BL=EF@EF & SV@SV [0&6] Spw=7 Chan=20 Freq=5.04849 Corr=RR X=4.9207e+09 Y=0.00110622 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:21.0000 BL=EF@EF & SV@SV [0&6] Spw=7 Chan=20 Freq=5.04849 Corr=RR X=4.9207e+09 Y=0.00139567 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:29.0000 BL=EF@EF & SV@SV [0&6] Spw=7 Chan=20 Freq=5.04849 Corr=RR X=4.9207e+09 Y=0.000847101 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:33.0000 BL=EF@EF & SV@SV [0&6] Spw=7 Chan=20 Freq=5.04849 Corr=RR X=4.9207e+09 Y=0.000830058 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:35.0000 BL=EF@EF & SV@SV [0&6] Spw=7 Chan=20 Freq=5.04849 Corr=RR X=4.9207e+09 Y=0.000924358 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:41.0000 BL=EF@EF & SV@SV [0&6] Spw=7 Chan=20 Freq=5.04849 Corr=RR X=4.9207e+09 Y=0.00130661 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:43.0000 BL=EF@EF & SV@SV [0&6] Spw=7 Chan=20 Freq=5.04849 Corr=RR X=4.9207e+09 Y=0.00147885 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:47.0000 BL=EF@EF & SV@SV [0&6] Spw=7 Chan=20 Freq=5.04849 Corr=RR X=4.9207e+09 Y=0.00129261 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:51.0000 BL=EF@EF & SV@SV [0&6] Spw=7 Chan=20 Freq=5.04849 Corr=RR X=4.9207e+09 Y=0.00107776 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:53.0000 BL=EF@EF & SV@SV [0&6] Spw=7 Chan=20 Freq=5.04849 Corr=RR X=4.9207e+09 Y=0.00105009 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:57.0000 BL=EF@EF & SV@SV [0&6] Spw=7 Chan=20 Freq=5.04849 Corr=RR X=4.9207e+09 Y=0.00080933 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:01:03.0000 BL=EF@EF & SV@SV [0&6] Spw=7 Chan=20 Freq=5.04849 Corr=RR X=4.9207e+09 Y=0.000921031 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:01:11.0000 BL=EF@EF & SV@SV [0&6] Spw=7 Chan=20 Freq=5.04849 Corr=RR X=4.9207e+09 Y=0.00102103 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:01:13.0000 BL=EF@EF & SV@SV [0&6] Spw=7 Chan=20 Freq=5.04849 Corr=RR X=4.9207e+09 Y=0.000851854 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:01:17.0000 BL=EF@EF & SV@SV [0&6] Spw=7 Chan=20 Freq=5.04849 Corr=RR X=4.9207e+09 Y=0.00105968 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:01:21.0000 BL=EF@EF & SV@SV [0&6] Spw=7 Chan=20 Freq=5.04849 Corr=RR X=4.9207e+09 Y=0.00100858 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:01:25.0000 BL=EF@EF & SV@SV [0&6] Spw=7 Chan=20 Freq=5.04849 Corr=RR X=4.9207e+09 Y=0.00162567 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:01:27.0000 BL=EF@EF & SV@SV [0&6] Spw=7 Chan=20 Freq=5.04849 Corr=RR X=4.9207e+09 Y=0.00123711 Observation=0
Found 161 points (161 unflagged) among 540480 in 0.03s.
Insert Message:
Lock scroll
Plot
Flag
Tools
Annotate
Options
File
oral/n14c3/n14c3.ms
Browse...
Selection
field
spw *:20
timerange
uvrange
antenna EF&*
scan
corr rr,ll
array
observation
intent
feed
msselect
Averaging
Channel 0 channels
Time 0 seconds
Scan
Field
All Baselines
Per Antenna
All Spectral Windows
Vector
Scalar
Minimize
Close
Data
Calibration
Axes
Page
Transform
Display
Canvas
Add Plot
Reload
Plot
Amp
0.12
0.10
0.08
0.06
0.04
0.02
0.00
11:43:00
12:29:00
12:52:00
13:15:00
13:38:00
14:01:00
14:24:00
14:47:00
15:10:00
Time (from 2014/10/22) (hh:mm:ss)
Hold Drawing

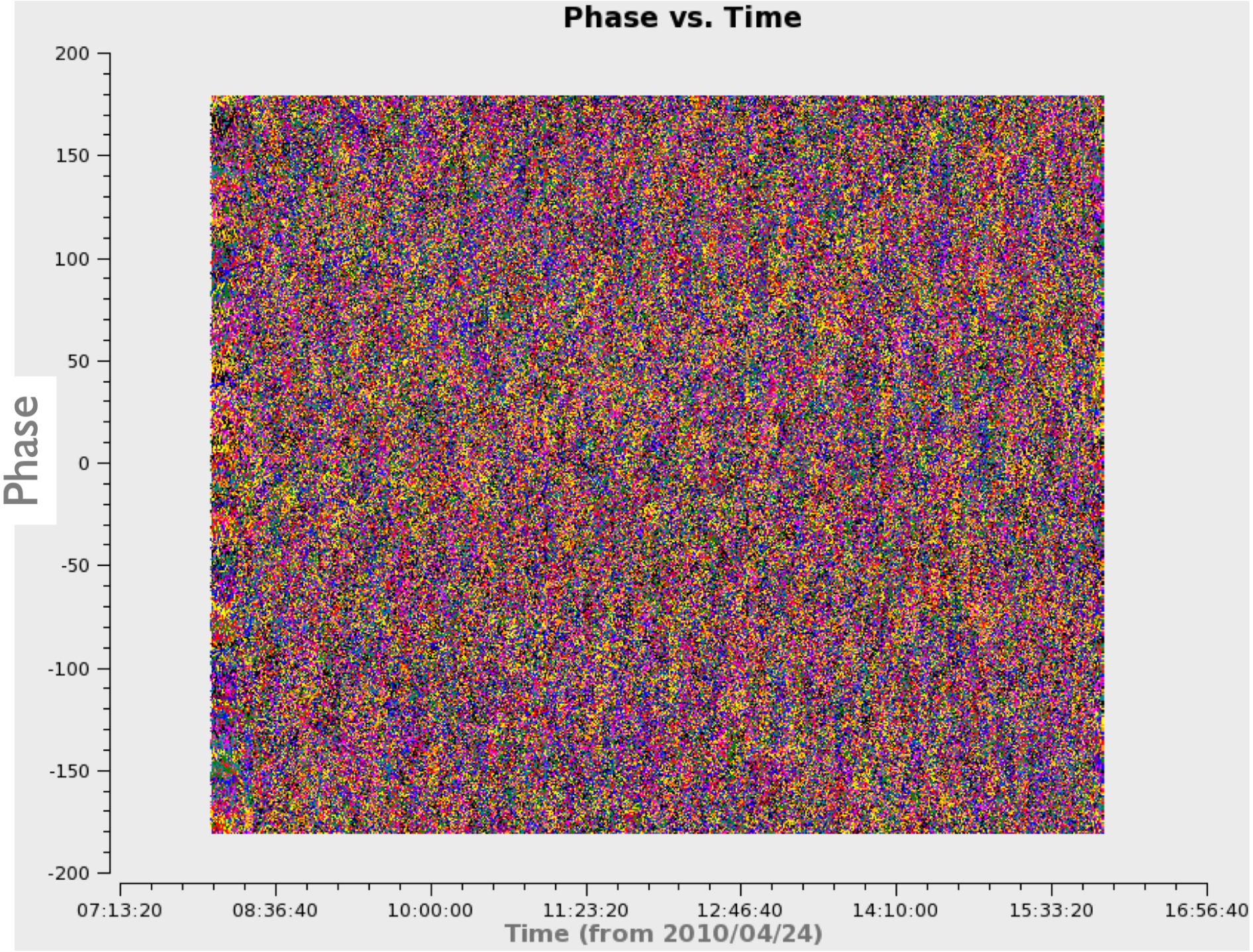

Plot
Tools
Annotate
Options
X Axis: UVdist
Cached:
Attach: Top Bottom
Range: Automatic
0
to
0
Overlay: None Atm Tsky
Image Sideband Curve:
Data: Amp
Column: data
Cached:
Attach: Left Right
Range: Automatic
0
to
0
Add Y Axis
Calibration
Axes
Page
Transform
Canvas
Minimize
Close
Add Plot
Reload
Plot
Amp vs. UVdist
Amp
0.10
0.08
0.06
0.04
0.02
0
1000000
2000000
3000000
4000000
5000000
6000000
7000000
8000000
UVdist (m)
Hold Drawing

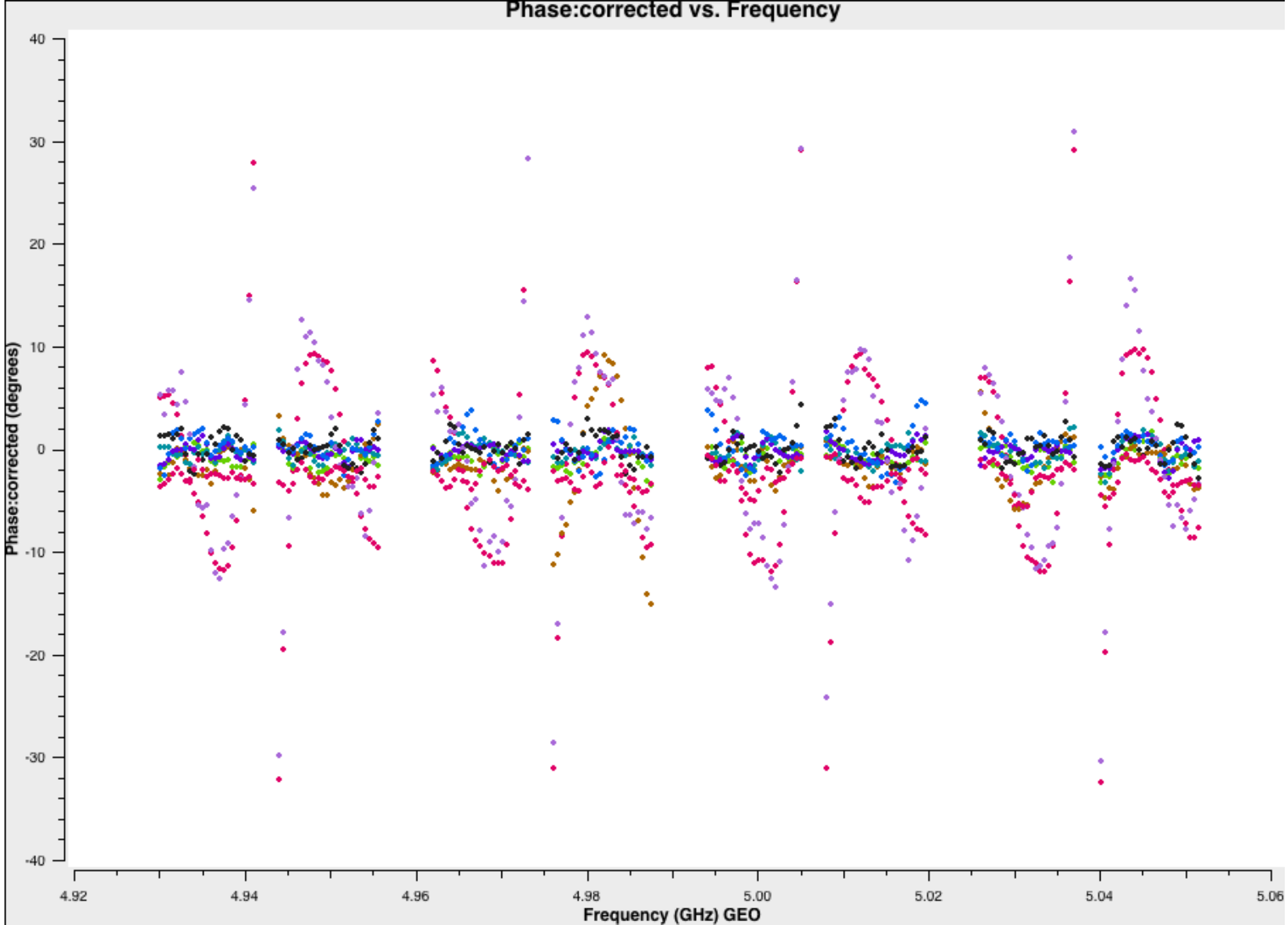

Plot
Flag
Tools
Annotate
Options
File
n14c3.ms
Browse...
Selection
field 3C345
spw *:20
timerange
uvrange
antenna EF&*
scan
corr RR,LL
array
observation
intent
feed
msselect
Averaging
Channel 0 channels
Time 0 seconds
Scan
Field
All Baselines
Per Antenna
All Spectral Windows
Vector
Scalar
Minimize
Close
Data
Calibration
Axes
Page
Transform
Display
Canvas
Add Plot
Reload
Plot
Amp vs. UVdist
Amp
UVdist (m)
0.12
0.10
0.08
0.06
0.04
0.02
0.00
0
1000000
2000000
3000000
4000000
5000000
6000000
7000000
8000000
Log Messages (:/Users/hawky/Temporal/n14c3/casa-20201028-130634.log)
Search Message:
Filter:
Time
Message
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:05.0000 BL=EF@EF & SV@SV [0&6] Spw=6 Chan=20 Freq=5.03299 Corr=RR X=4.9207e+09 Y=0.000950623 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:11.0000 BL=EF@EF & SV@SV [0&6] Spw=6 Chan=20 Freq=5.03299 Corr=RR X=4.9207e+09 Y=0.00174558 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:13.0000 BL=EF@EF & SV@SV [0&6] Spw=6 Chan=20 Freq=5.03299 Corr=RR X=4.9207e+09 Y=0.000904112 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:15.0000 BL=EF@EF & SV@SV [0&6] Spw=6 Chan=20 Freq=5.03299 Corr=RR X=4.9207e+09 Y=0.000988582 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:17.0000 BL=EF@EF & SV@SV [0&6] Spw=6 Chan=20 Freq=5.03299 Corr=RR X=4.9207e+09 Y=0.00122332 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:19.0000 BL=EF@EF & SV@SV [0&6] Spw=6 Chan=20 Freq=5.03299 Corr=RR X=4.9207e+09 Y=0.00128292 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:23.0000 BL=EF@EF & SV@SV [0&6] Spw=6 Chan=20 Freq=5.03299 Corr=RR X=4.9207e+09 Y=0.000880325 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:27.0000 BL=EF@EF & SV@SV [0&6] Spw=6 Chan=20 Freq=5.03299 Corr=RR X=4.9207e+09 Y=0.000998028 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:31.0000 BL=EF@EF & SV@SV [0&6] Spw=6 Chan=20 Freq=5.03299 Corr=RR X=4.9207e+09 Y=0.00153696 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:33.0000 BL=EF@EF & SV@SV [0&6] Spw=6 Chan=20 Freq=5.03299 Corr=RR X=4.9207e+09 Y=0.00142185 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:37.0000 BL=EF@EF & SV@SV [0&6] Spw=6 Chan=20 Freq=5.03299 Corr=RR X=4.9207e+09 Y=0.000852301 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:45.0000 BL=EF@EF & SV@SV [0&6] Spw=6 Chan=20 Freq=5.03299 Corr=RR X=4.9207e+09 Y=0.00123105 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:47.0000 BL=EF@EF & SV@SV [0&6] Spw=6 Chan=20 Freq=5.03299 Corr=RR X=4.9207e+09 Y=0.00107214 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:51.0000 BL=EF@EF & SV@SV [0&6] Spw=6 Chan=20 Freq=5.03299 Corr=RR X=4.9207e+09 Y=0.000969477 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:53.0000 BL=EF@EF & SV@SV [0&6] Spw=6 Chan=20 Freq=5.03299 Corr=RR X=4.9207e+09 Y=0.0010618 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:57.0000 BL=EF@EF & SV@SV [0&6] Spw=6 Chan=20 Freq=5.03299 Corr=RR X=4.9207e+09 Y=0.000820666 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:59.0000 BL=EF@EF & SV@SV [0&6] Spw=6 Chan=20 Freq=5.03299 Corr=RR X=4.9207e+09 Y=0.00161497 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:01:03.0000 BL=EF@EF & SV@SV [0&6] Spw=6 Chan=20 Freq=5.03299 Corr=RR X=4.9207e+09 Y=0.00197672 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:01:05.0000 BL=EF@EF & SV@SV [0&6] Spw=6 Chan=20 Freq=5.03299 Corr=RR X=4.9207e+09 Y=0.00179003 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:01:07.0000 BL=EF@EF & SV@SV [0&6] Spw=6 Chan=20 Freq=5.03299 Corr=RR X=4.9207e+09 Y=0.00183346 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:01:13.0000 BL=EF@EF & SV@SV [0&6] Spw=6 Chan=20 Freq=5.03299 Corr=RR X=4.9207e+09 Y=0.00133754 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:01:17.0000 BL=EF@EF & SV@SV [0&6] Spw=6 Chan=20 Freq=5.03299 Corr=RR X=4.9207e+09 Y=0.00105164 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:01:21.0000 BL=EF@EF & SV@SV [0&6] Spw=6 Chan=20 Freq=5.03299 Corr=RR X=4.9207e+09 Y=0.00135539 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:07.0000 BL=EF@EF & SV@SV [0&6] Spw=7 Chan=20 Freq=5.04849 Corr=RR X=4.9207e+09 Y=0.000809583 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:11.0000 BL=EF@EF & SV@SV [0&6] Spw=7 Chan=20 Freq=5.04849 Corr=RR X=4.9207e+09 Y=0.00175597 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:19.0000 BL=EF@EF & SV@SV [0&6] Spw=7 Chan=20 Freq=5.04849 Corr=RR X=4.9207e+09 Y=0.00110622 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:21.0000 BL=EF@EF & SV@SV [0&6] Spw=7 Chan=20 Freq=5.04849 Corr=RR X=4.9207e+09 Y=0.00139567 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:29.0000 BL=EF@EF & SV@SV [0&6] Spw=7 Chan=20 Freq=5.04849 Corr=RR X=4.9207e+09 Y=0.000847101 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:33.0000 BL=EF@EF & SV@SV [0&6] Spw=7 Chan=20 Freq=5.04849 Corr=RR X=4.9207e+09 Y=0.000830058 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:35.0000 BL=EF@EF & SV@SV [0&6] Spw=7 Chan=20 Freq=5.04849 Corr=RR X=4.9207e+09 Y=0.000924358 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:41.0000 BL=EF@EF & SV@SV [0&6] Spw=7 Chan=20 Freq=5.04849 Corr=RR X=4.9207e+09 Y=0.00130661 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:43.0000 BL=EF@EF & SV@SV [0&6] Spw=7 Chan=20 Freq=5.04849 Corr=RR X=4.9207e+09 Y=0.00147885 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:47.0000 BL=EF@EF & SV@SV [0&6] Spw=7 Chan=20 Freq=5.04849 Corr=RR X=4.9207e+09 Y=0.00129261 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:51.0000 BL=EF@EF & SV@SV [0&6] Spw=7 Chan=20 Freq=5.04849 Corr=RR X=4.9207e+09 Y=0.00107776 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:53.0000 BL=EF@EF & SV@SV [0&6] Spw=7 Chan=20 Freq=5.04849 Corr=RR X=4.9207e+09 Y=0.00105009 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:00:57.0000 BL=EF@EF & SV@SV [0&6] Spw=7 Chan=20 Freq=5.04849 Corr=RR X=4.9207e+09 Y=0.00080933 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:01:03.0000 BL=EF@EF & SV@SV [0&6] Spw=7 Chan=20 Freq=5.04849 Corr=RR X=4.9207e+09 Y=0.000921031 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:01:11.0000 BL=EF@EF & SV@SV [0&6] Spw=7 Chan=20 Freq=5.04849 Corr=RR X=4.9207e+09 Y=0.00102103 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:01:13.0000 BL=EF@EF & SV@SV [0&6] Spw=7 Chan=20 Freq=5.04849 Corr=RR X=4.9207e+09 Y=0.000851854 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:01:17.0000 BL=EF@EF & SV@SV [0&6] Spw=7 Chan=20 Freq=5.04849 Corr=RR X=4.9207e+09 Y=0.00105968 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:01:21.0000 BL=EF@EF & SV@SV [0&6] Spw=7 Chan=20 Freq=5.04849 Corr=RR X=4.9207e+09 Y=0.00100858 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:01:25.0000 BL=EF@EF & SV@SV [0&6] Spw=7 Chan=20 Freq=5.04849 Corr=RR X=4.9207e+09 Y=0.00162567 Observation=0
Scan=0 Field=3C345 [1] Time=2014/10/22/12:01:27.0000 BL=EF@EF & SV@SV [0&6] Spw=7 Chan=20 Freq=5.04849 Corr=RR X=4.9207e+09 Y=0.00123711 Observation=0
Found 161 points (161 unflagged) among 540480 in 0.03s.
Insert Message:
Lock scroll
Hold Drawing


Plot
Flag
Tools
Annotate
Options
Axis
None
Scan
Field
Spw
Baseline
Antenna
Time
Corr
Global Ax
Y
Sha
Y
Page Heade
Contents
Data
Calibration
Axes
Page
Transform
Display
Canvas
Filename
Y Column(s)
Observation Start Date
Observation Start Time
Observer
Project ID
Minimize
Close
Add Plot
Reload
Plot
Amp vs. UVdist
Amp
0.10
0.08
0.06
0.04
0.02
0
1000000
2000000
3000000
4000000
5000000
6000000
7000000
8000000
UVdist (m)
Hold Drawing


Plot
Flag
Tools
Annotate
Options
Data
Calibration
Axes
Page
Transform
Display
Canvas
X Axis: Time
Cached:
Attach: Top Bottom
Range: Automatic
2014/10/22/12:00:03.500 to
2014/10/22/14:59:59.625
Overlay: None Atm Tsky
Image Sideband Curve:
Data: Amp
Column: data
Cached:
Attach: Left Right
Range: Automatic
to
Add Y Axis
Minimize
Close
Add Plot
Reload
Plot
Amp vs. Time
Amp
0.020
0.015
0.010
0.005
11:43:00
12:06:00
12:29:00
12:52:00
13:15:00
13:38:00
14:01:00
14:24:00
14:47:00
15:10:00
Time (from 2014/10/22) (hh:mm:ss)
Hold Drawing
Pick a reference station,
cycle between different baselines


Amp vs. Time Baseline: EF@EF & WB@WB_266520m
Amp
0
1
2
3
4
5
6
11:51:00
12:00:00
12:09:00
12:18:00
12:27:00
12:36:00
12:45:00
12:54:00
13:03:00
13:12:00
Time (from 2014/10/22) (hh:mm:ss)


Phase vs. Time
Phase
200
150
100
50
0
-50
-100
-150
-200
07:13:20
08:36:40
10:00:00
11:23:20
12:46:40
14:10:00
15:33:20
16:56:40
Time (from 2010/04/24)


Phase:corrected vs. Frequency
Phase:corrected (degrees)
40
30
20
10
0
-10
-20
-30
-40
4.92
4.94
4.96
4.98
5.00
5.02
5.04
5.06
Frequency (GHz) GEO

viewer

Both from inside the CASA prompt:
viewer(vis="n14c3.ms")

Or outside:
casaviewer vis="n14c3.ms"

Not only for images!

CASA
VLBI

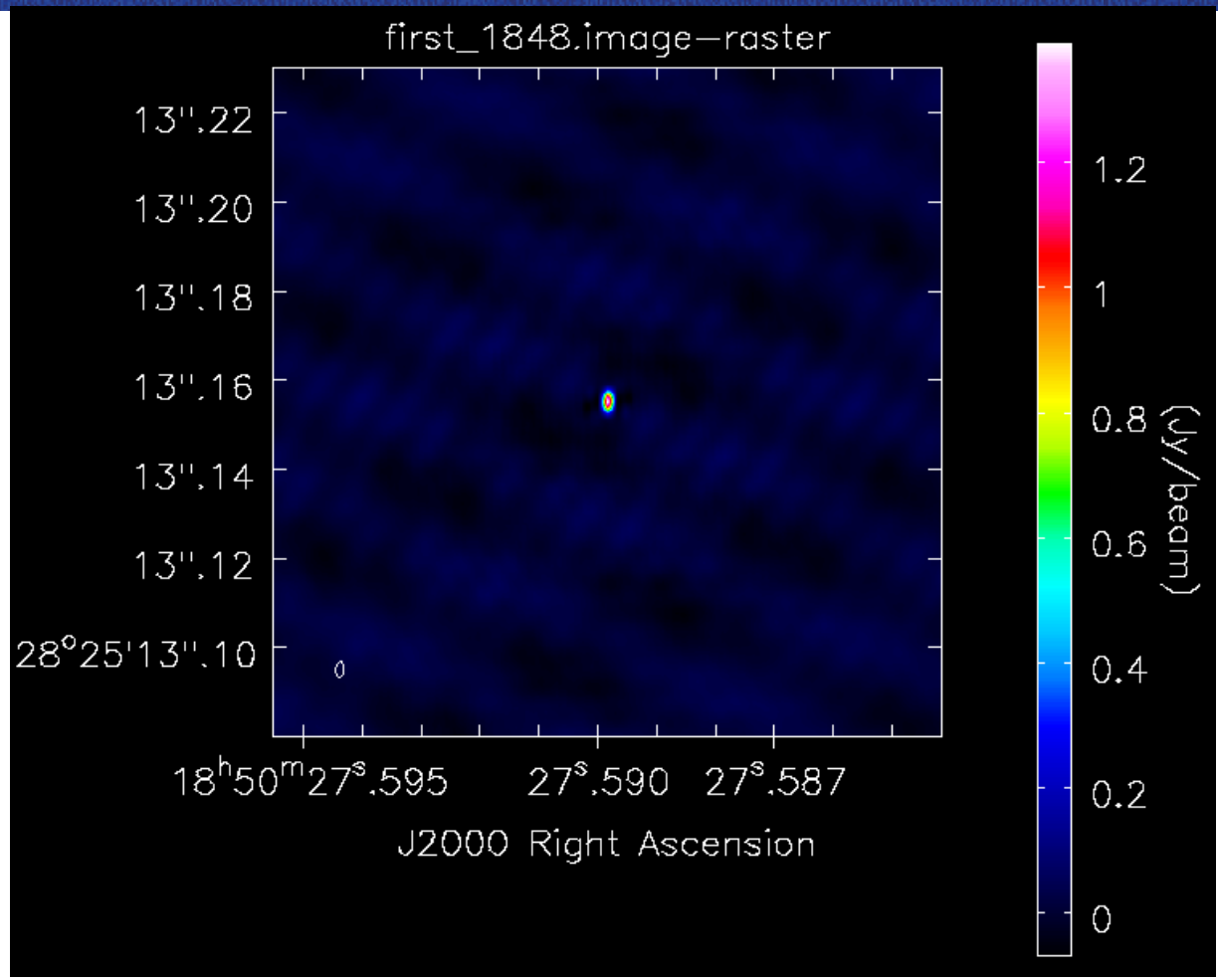
viewer

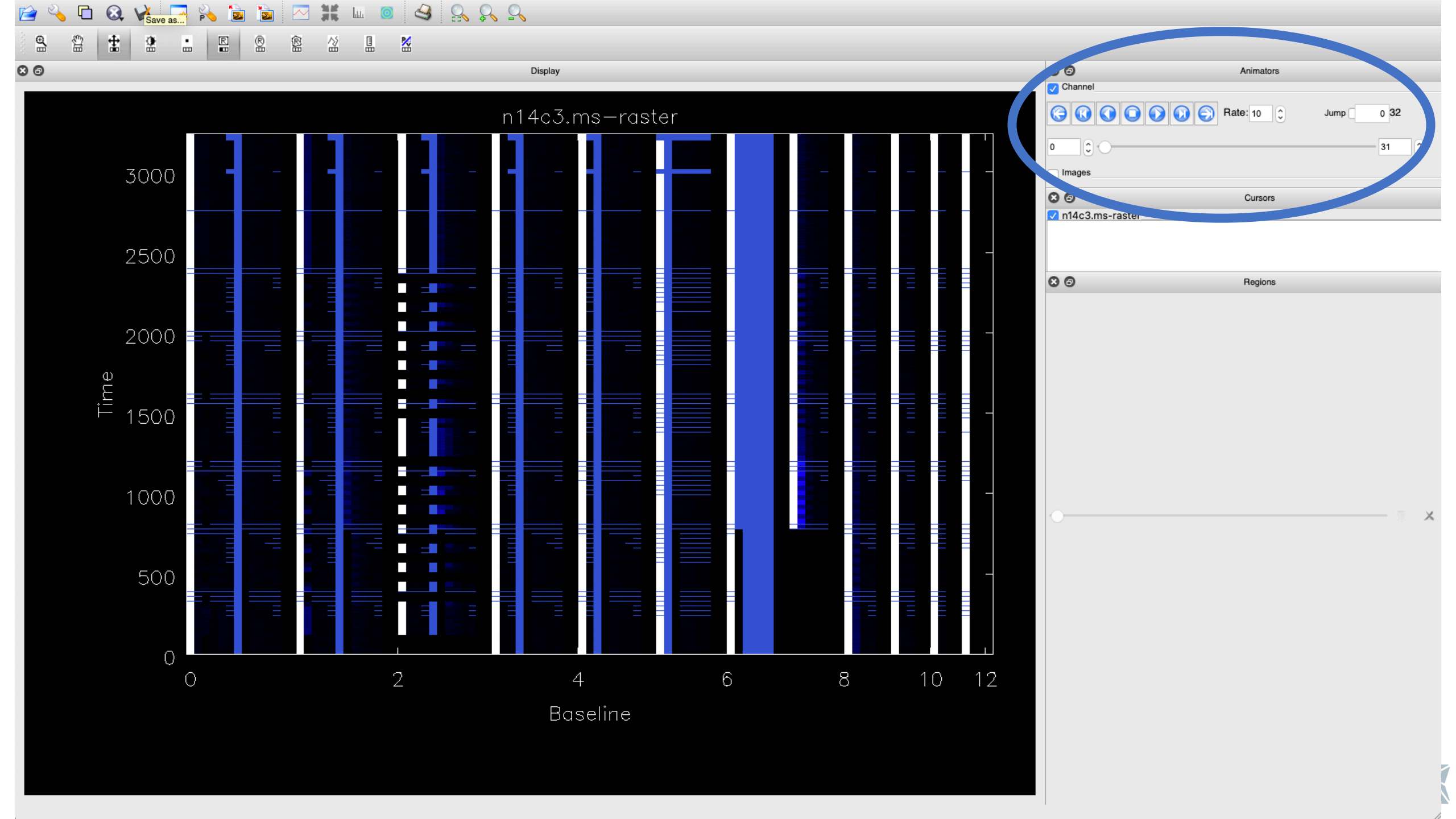
- viewer is often used only to show images (after CLEANing)

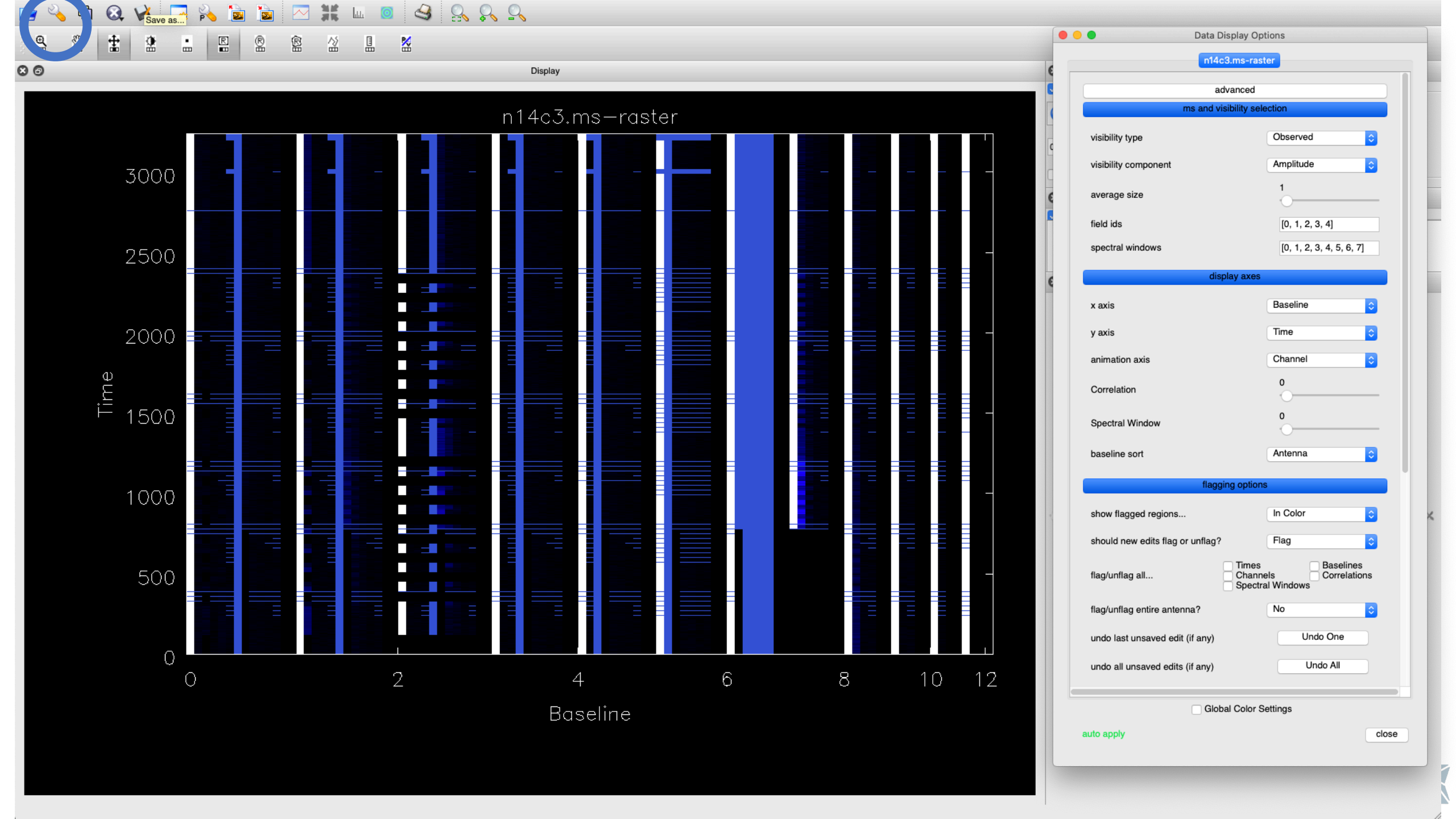
```
viewer(vis="n14c3.ms.first_1848.image")
```

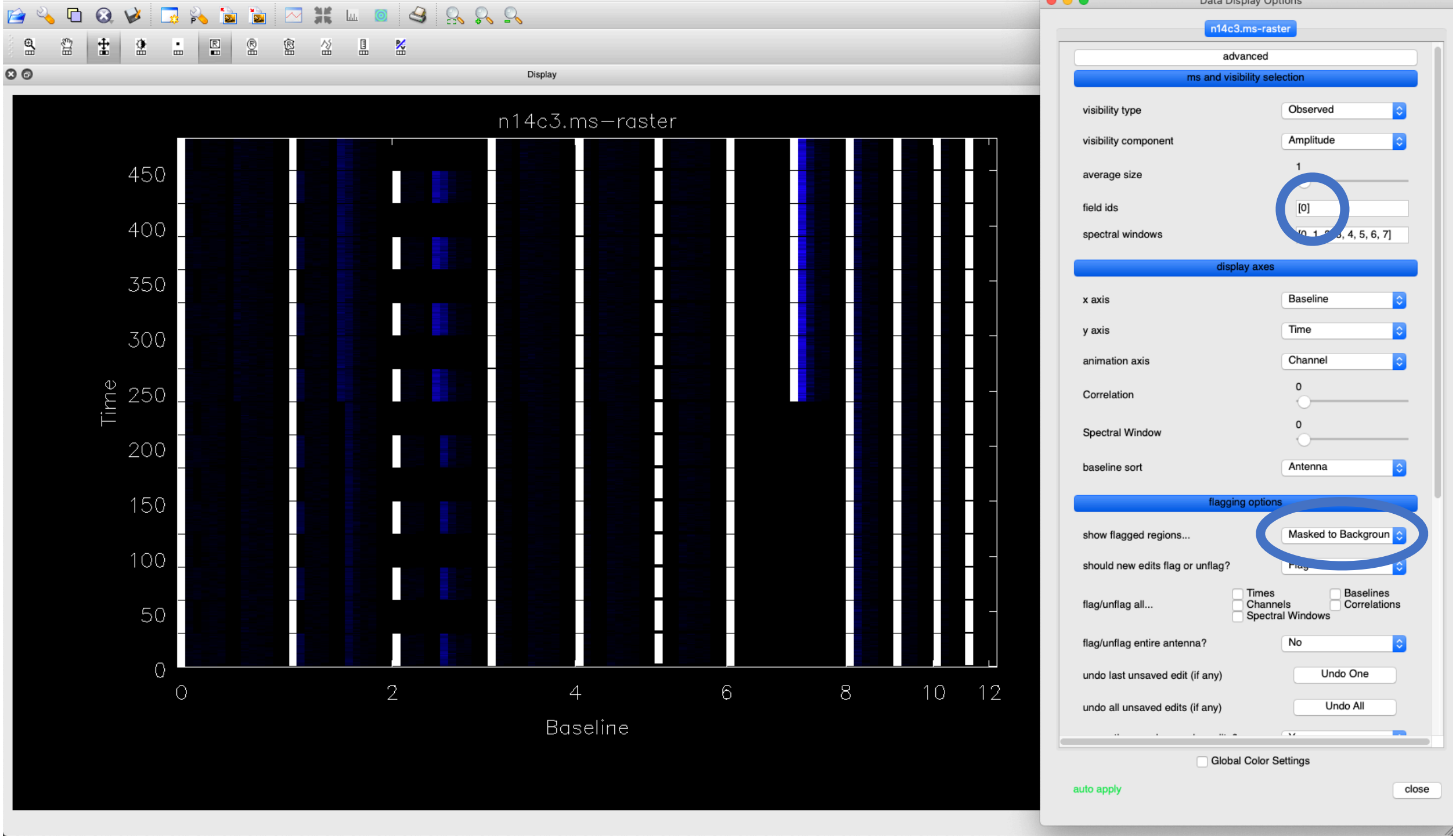
- Can also be used to show visibilities.

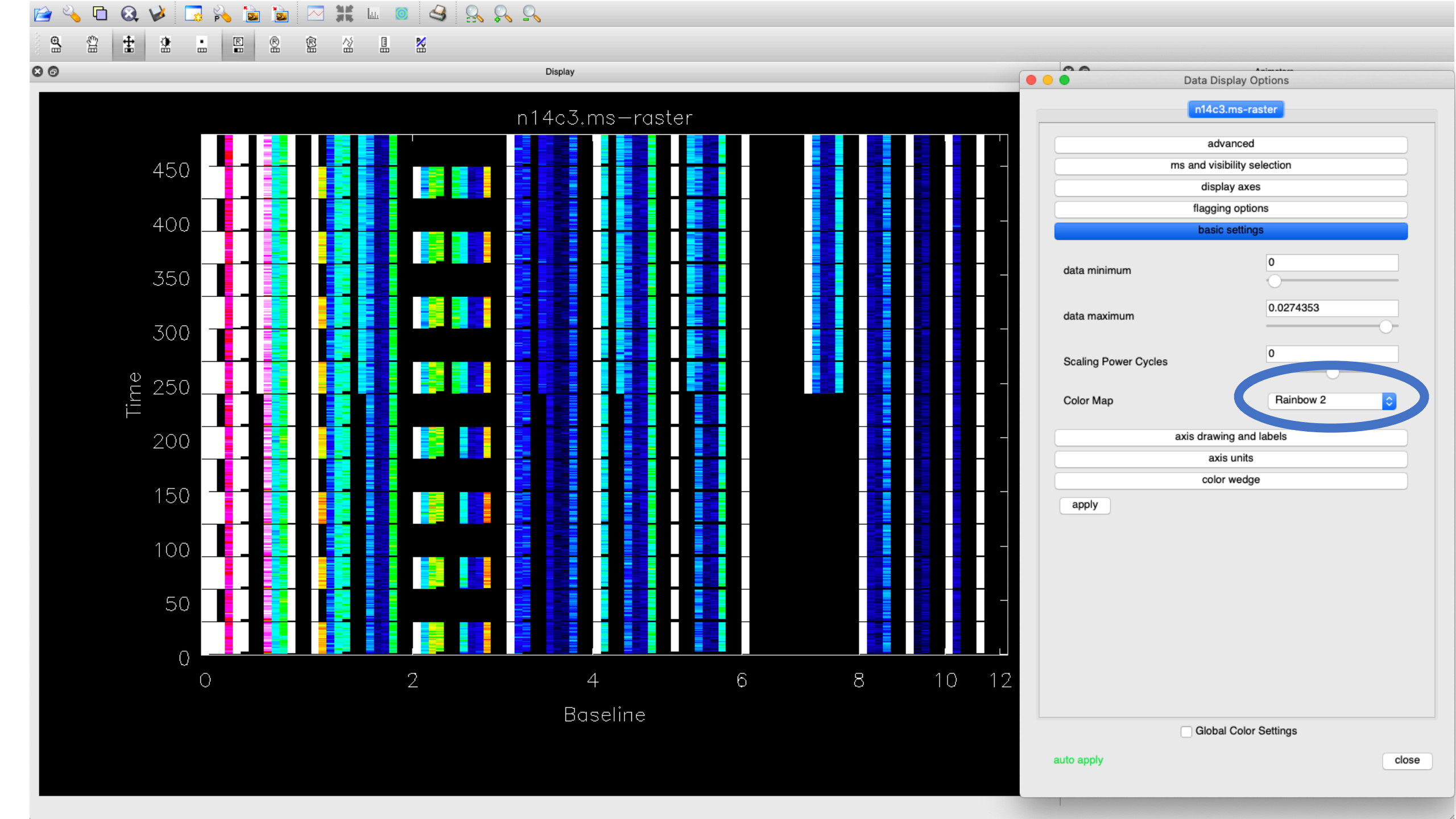
  It allows an extra dimension compared to ***plotms***.

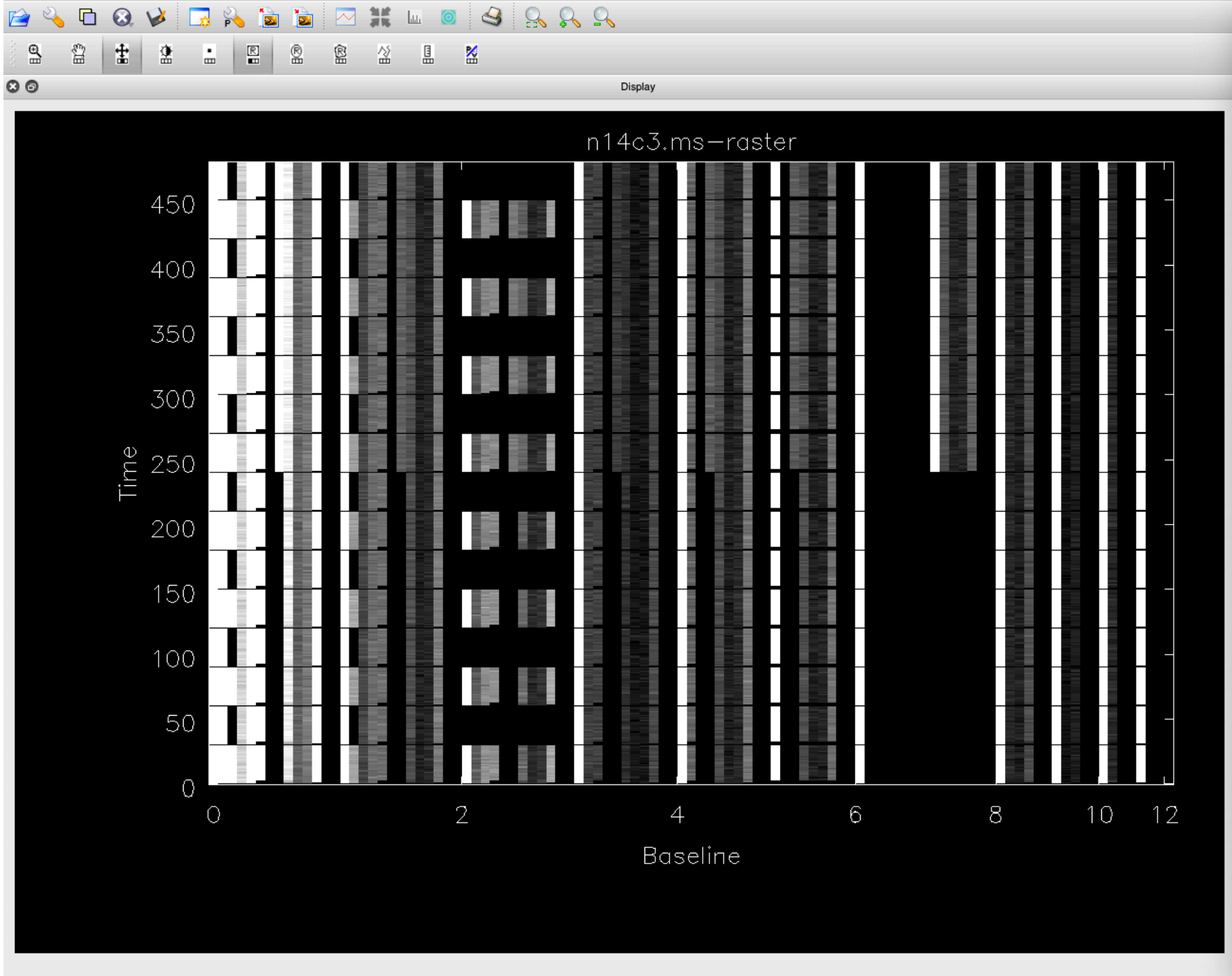



Save as...
Display
n14c3.ms–raster
3000
2500
2000
1500
1000
500
0
Time
0
2
4
6
8
10
12
Baseline
Animators
Channel
Rate: 10
Jump
0
32
0
31
Images
Cursors
n14c3.ms-raster
Regions


Save as...
Display
n14c3.ms—raster
3000
2500
2000
1500
1000
500
0
Time
0
2
4
6
8
10
12
Baseline
Data Display Options
n14c3.ms-raster
advanced
ms and visibility selection
visibility type
Observed
visibility component
Amplitude
average size
1
field ids
[0, 1, 2, 3, 4]
spectral windows
[0, 1, 2, 3, 4, 5, 6, 7]
display axes
x axis
Baseline
y axis
Time
animation axis
Channel
Correlation
0
Spectral Window
0
baseline sort
Antenna
flagging options
show flagged regions...
In Color
should new edits flag or unflag?
Flag
flag/unflag all...
Times
Baselines
Channels
Correlations
Spectral Windows
flag/unflag entire antenna?
No
undo last unsaved edit (if any)
Undo One
undo all unsaved edits (if any)
Undo All
Global Color Settings
auto apply
close


Display
n14c3.ms-raster
Data Display Options
n14c3.ms-raster
advanced
ms and visibility selection
visibility type
Observed
visibility component
Amplitude
average size
1
field ids
[0]
spectral windows
4, 5, 6, 7]
display axes
x axis
Baseline
y axis
Time
animation axis
Channel
Correlation
0
Spectral Window
0
baseline sort
Antenna
flagging options
show flagged regions...
Masked to Backgroun
should new edits flag or unflag?
flag/unflag all...
Times
Baselines
Channels
Correlations
Spectral Windows
flag/unflag entire antenna?
No
undo last unsaved edit (if any)
Undo One
undo all unsaved edits (if any)
Undo All
Global Color Settings
auto apply
close
Time
Baseline
0
50
100
150
200
250
300
350
400
450
0
2
4
6
8
10
12


Display
n14c3.ms—raster
Time
Baseline
0
50
100
150
200
250
300
350
400
450
0
2
4
6
8
10
12
Data Display Options
n14c3.ms-raster
advanced
ms and visibility selection
display axes
flagging options
basic settings
data minimum
0
data maximum
0.0274353
Scaling Power Cycles
0
Color Map
Rainbow 2
axis drawing and labels
axis units
color wedge
apply
Global Color Settings
auto apply
close



Data Display Options

n14c3.ms-raster

x axis	Baseline
y axis	Time
animation axis	Channel
Correlation	0
Spectral Window	0
baseline sort	Antenna

flagging options

show flagged regions...	Masked to Backgroun
should new edits flag or unflag?	Flag
flag/unflag all...	Times, Baselines, Channels, Correlations, Spectral Windows
flag/unflag entire antenna?	No
undo last unsaved edit (if any)	Undo One
undo all unsaved edits (if any)	Undo All
use entire ms when saving edits?	Yes
save edits to disk	Save Edits

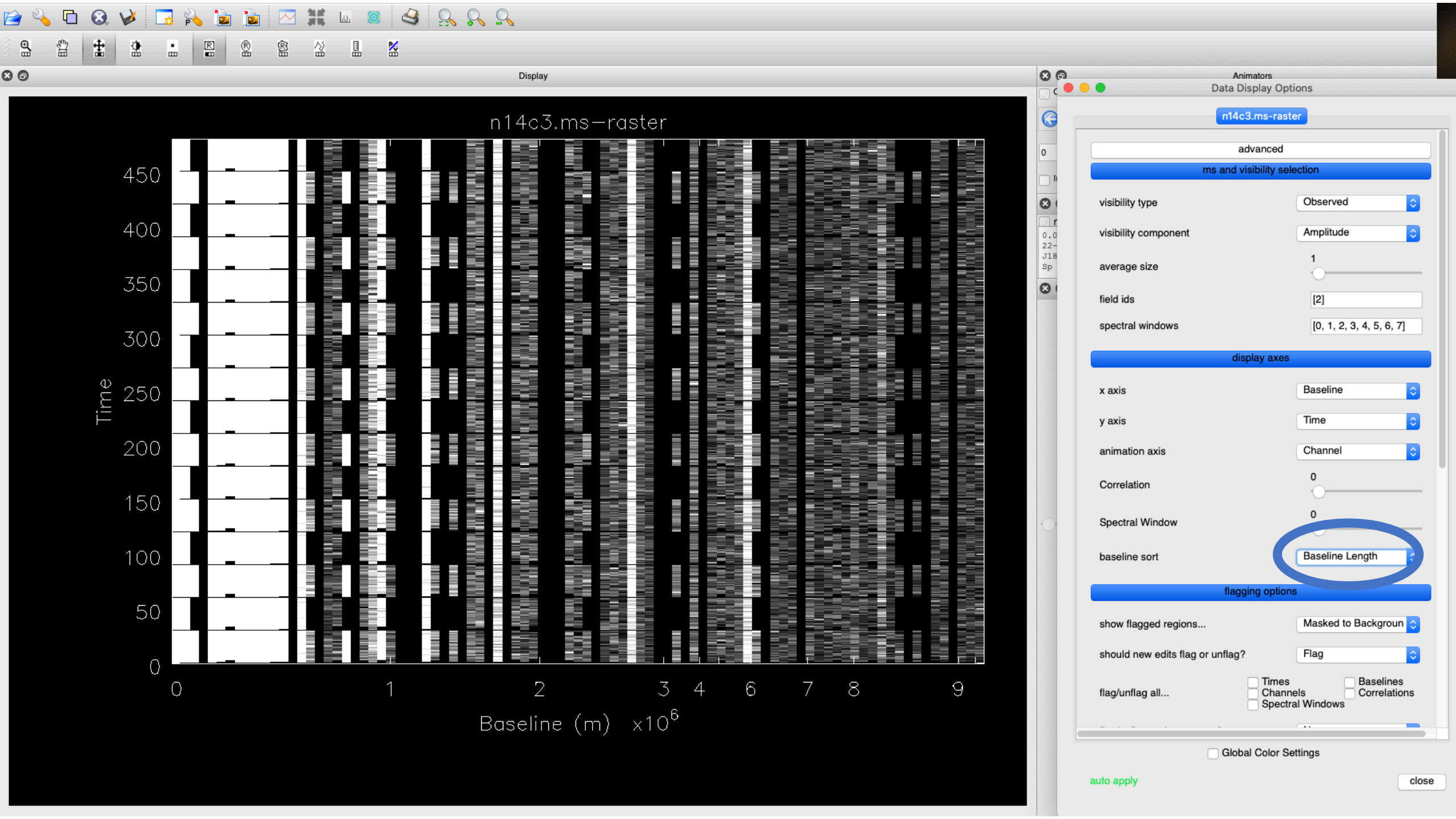
basic settings

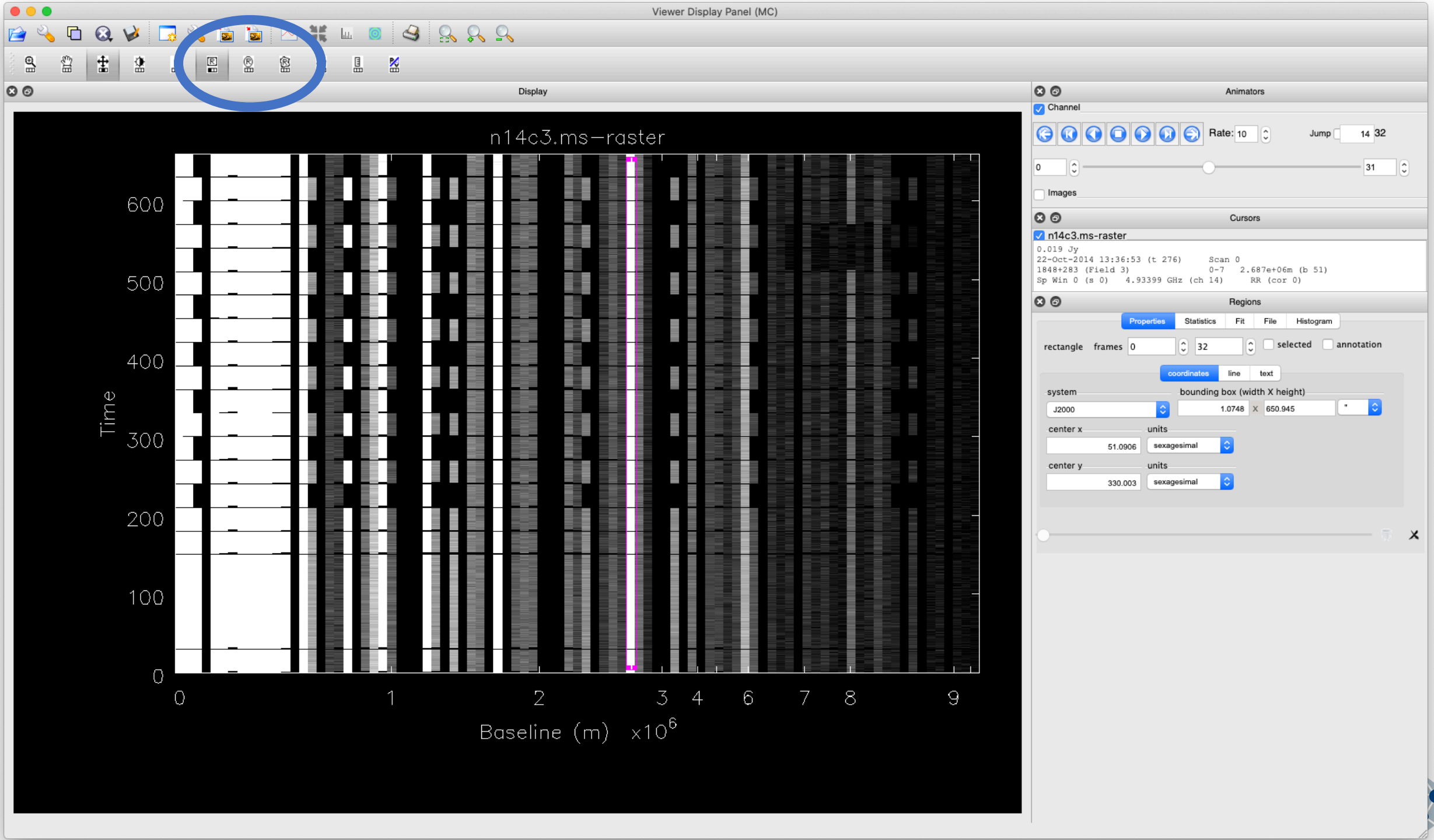
data minimum	0
data maximum	0.0195434
Scaling Power Cycles	0
Color Map	Greyscale 1

Global Color Settings

auto apply

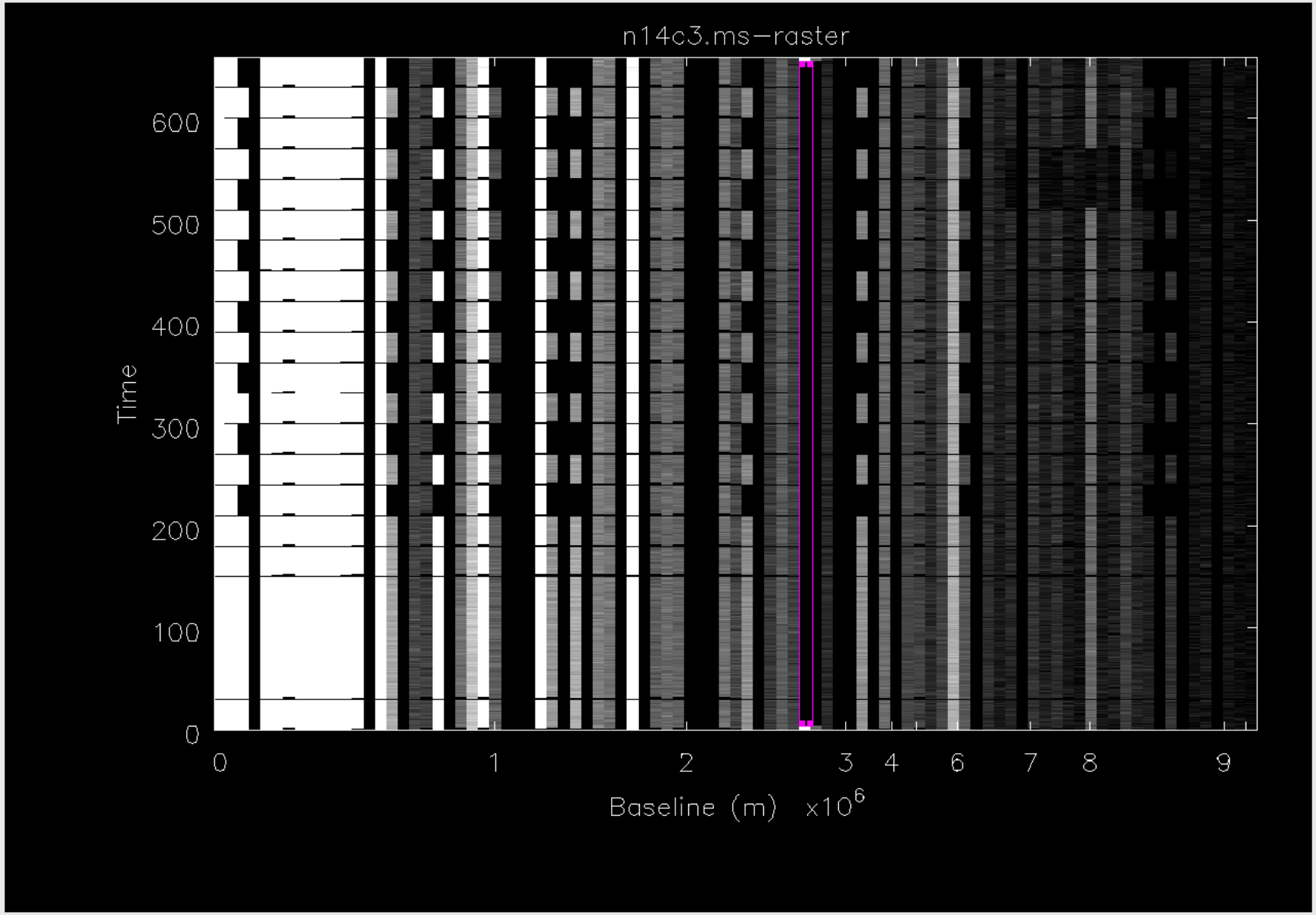
close


Display
n14c3.ms–raster
Time
450
400
350
300
250
200
150
100
50
0
0
1
2
3
4
6
7
8
9
Baseline (m) x10^6
Animators
Data Display Options
n14c3.ms-raster
advanced
ms and visibility selection
visibility type
Observed
visibility component
Amplitude
average size
1
field ids
[2]
spectral windows
[0, 1, 2, 3, 4, 5, 6, 7]
display axes
x axis
Baseline
y axis
Time
animation axis
Channel
Correlation
0
Spectral Window
0
baseline sort
Baseline Length
flagging options
show flagged regions...
Masked to Backgroun
should new edits flag or unflag?
Flag
flag/unflag all...
Times
Channels
Spectral Windows
Baselines
Correlations
Global Color Settings
auto apply
close


Viewer Display Panel (MC)
Display
n14c3.ms–raster
Time
600
500
400
300
200
100
0
0
1
2
3
4
6
7
8
9
Baseline (m) x10^6
Animators
Channel
Rate: 10
Jump 14 32
0
31
Images
Cursors
n14c3.ms-raster
0.019 Jy
22-Oct-2014 13:36:53 (t 276) Scan 0
1848+283 (Field 3) 0-7 2.687e+06m (b 51)
Sp Win 0 (s 0) 4.93399 GHz (ch 14) RR (cor 0)
Regions
Properties
Statistics
Fit
File
Histogram
rectangle
frames 0 32
selected
annotation
coordinates
line
text
system
J2000
bounding box (width X height)
1.0748 X 650.945
"
center x
51.0906
units
sexagesimal
center y
330.003
units
sexagesimal

Viewer Display Panel (MC)

Display



Animators

Channel

Rate: 10 Jump 14 32

0 31

Images

Cursors

n14c3.ms-raster

```
0.019 Jy
22-Oct-2014 13:36:53 (t 276)      Scan 0
1848+283 (Field 3)                0-7   2.687e+06m (b 51)
Sp Win 0 (s 0)   4.93399 GHz (ch 14)     RR (cor 0)
```

Regions

Properties | Statistics | Fit | File | Histogram

rectangle frames 0 32 selected annotation

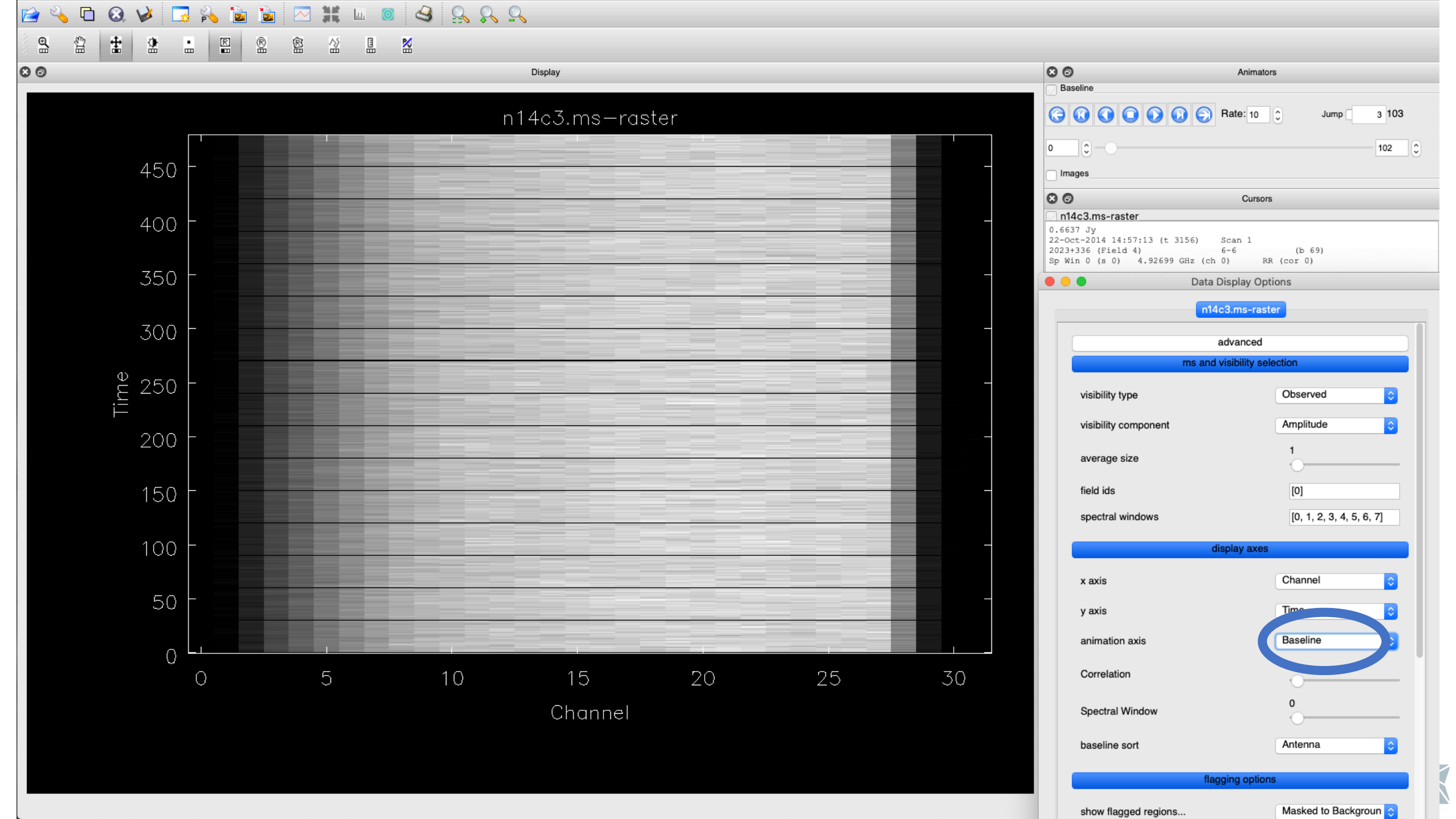
coordinates | line | text

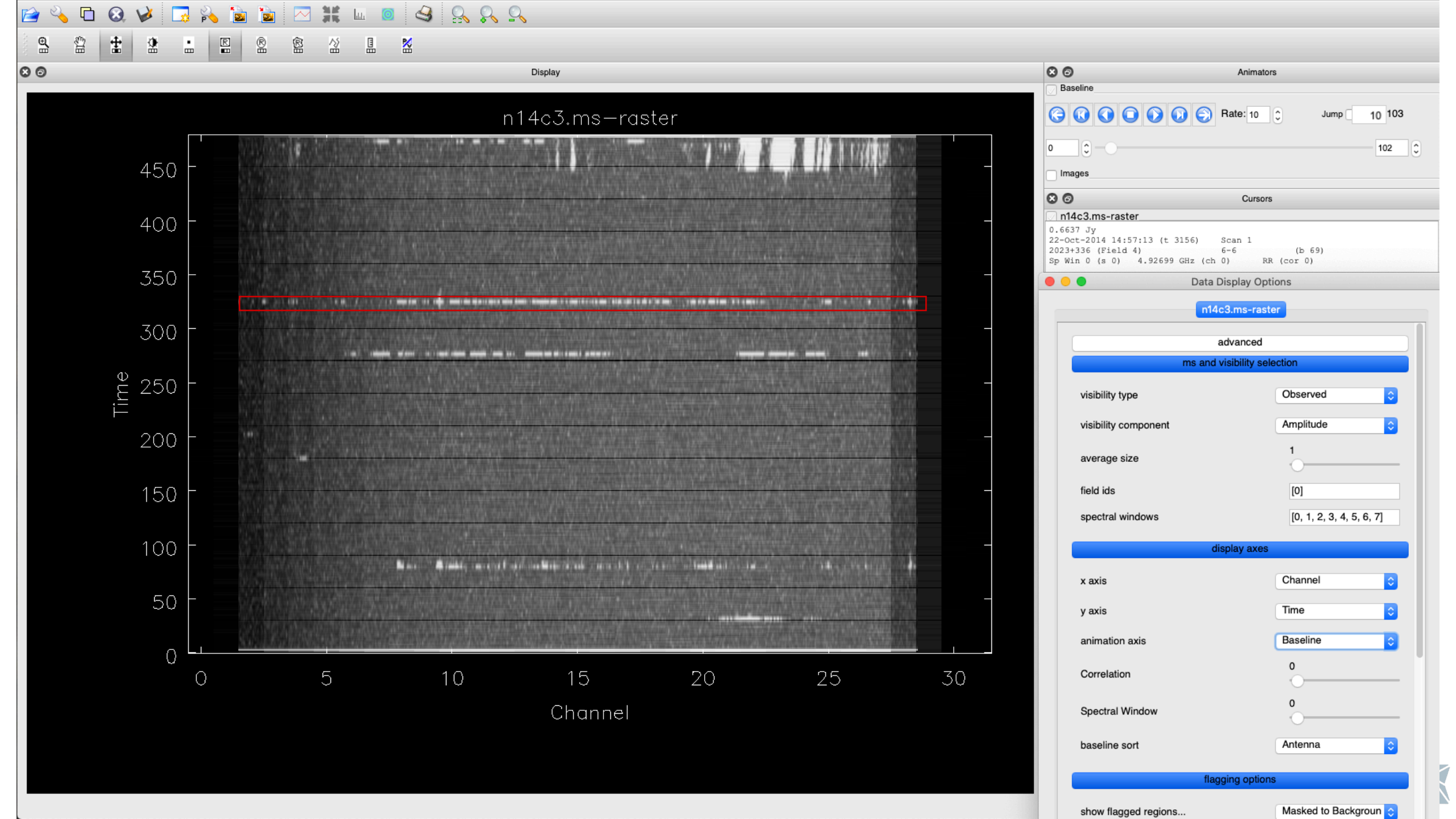
system: J2000

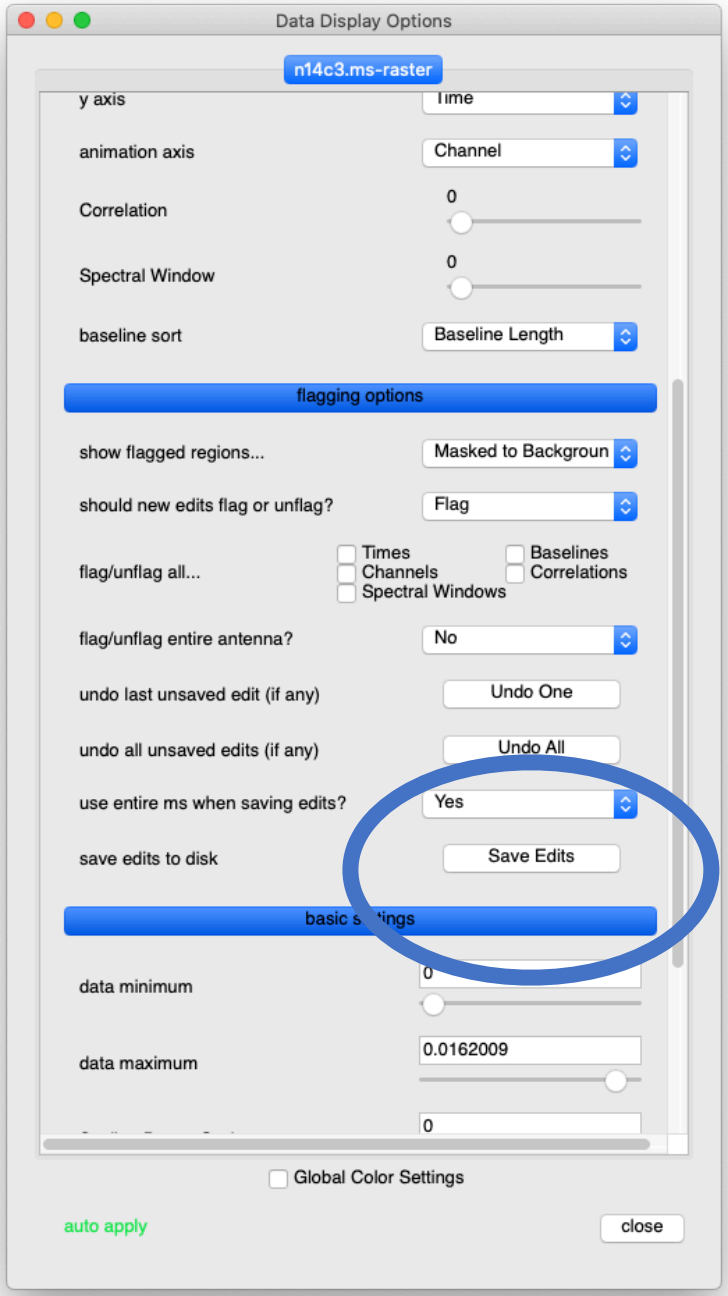
bounding box (width X height): 1.0748 X 650.945 "

center x: 51.0906 units: sexagesimal

center y: 330.003 units: sexagesimal


Display
n14c3.ms—raster
Time
Channel
0
50
100
150
200
250
300
350
400
450
0
5
10
15
20
25
30
Animators
Baseline
Rate: 10
Jump 3 103
0
102
Images
Cursors
n14c3.ms-raster
0.6637 Jy
22-Oct-2014 14:57:13 (t 3156) Scan 1
2023+336 (Field 4) 6-6 (b 69)
Sp Win 0 (s 0) 4.92699 GHz (ch 0) RR (cor 0)
Data Display Options
n14c3.ms-raster
advanced
ms and visibility selection
visibility type
Observed
visibility component
Amplitude
average size
1
field ids
[0]
spectral windows
[0, 1, 2, 3, 4, 5, 6, 7]
display axes
x axis
Channel
y axis
Time
animation axis
Baseline
Correlation
Spectral Window
0
baseline sort
Antenna
flagging options
show flagged regions...
Masked to Backgroun


Display
n14c3.ms—raster
Time
Channel
0
50
100
150
200
250
300
350
400
450
0
5
10
15
20
25
30
Animators
Baseline
Rate: 10
Jump 10 103
0
102
Images
Cursors
n14c3.ms-raster
0.6637 Jy
22-Oct-2014 14:57:13 (t 3156) Scan 1
2023+336 (Field 4) 6-6 (b 69)
Sp Win 0 (s 0) 4.92699 GHz (ch 0) RR (cor 0)
Data Display Options
n14c3.ms-raster
advanced
ms and visibility selection
visibility type
Observed
visibility component
Amplitude
average size
1
field ids
[0]
spectral windows
[0, 1, 2, 3, 4, 5, 6, 7]
display axes
x axis
Channel
y axis
Time
animation axis
Baseline
Correlation
0
Spectral Window
0
baseline sort
Antenna
flagging options
show flagged regions...
Masked to Backgroun


Data Display Options
n14c3.ms-raster
y axis
Time
animation axis
Channel
Correlation
0
Spectral Window
0
baseline sort
Baseline Length
flagging options
show flagged regions...
Masked to Backgroun
should new edits flag or unflag?
Flag
flag/unflag all...
Times
Channels
Spectral Windows
Baselines
Correlations
flag/unflag entire antenna?
No
undo last unsaved edit (if any)
Undo One
undo all unsaved edits (if any)
Undo All
use entire ms when saving edits?
Yes
save edits to disk
Save Edits
basic s ings
data minimum
0
data maximum
0.0162009
0
Global Color Settings
auto apply
close

Plotcal

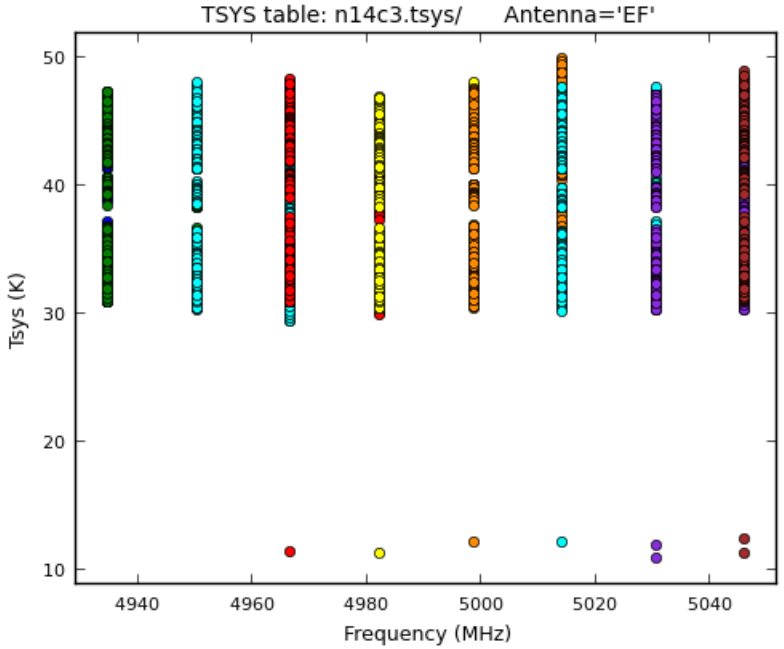
Only in CASA 5.7-

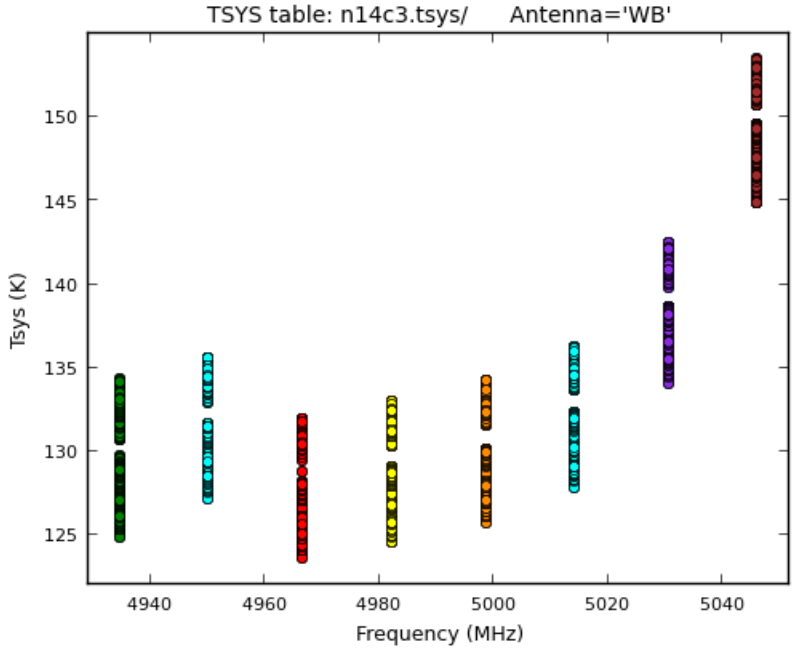
CASA
VLBI

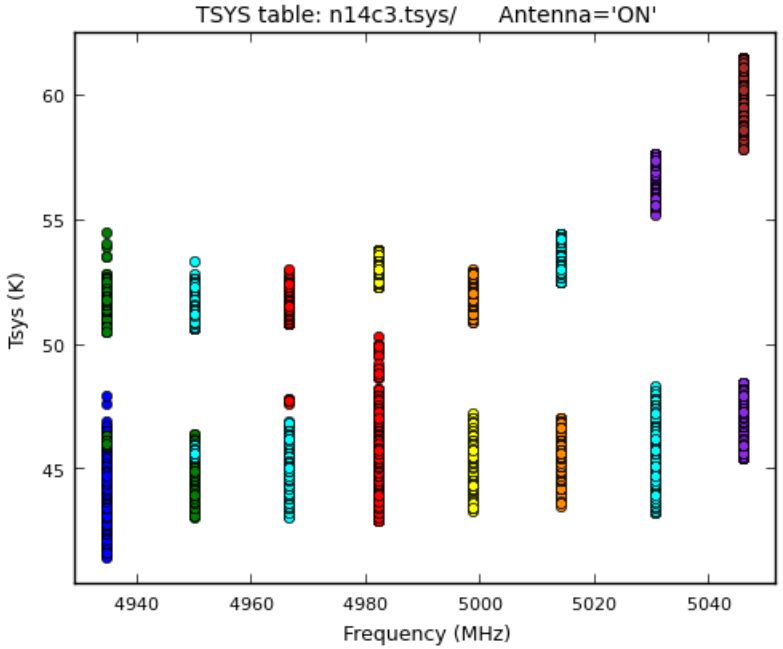
Plot cal

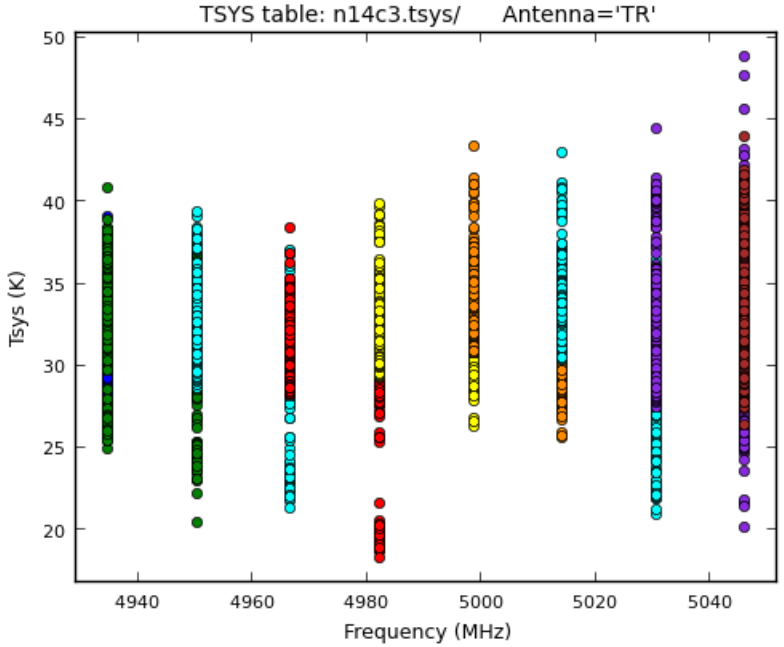
- Each calibration CASA task will create a calibration table (external file).
- Before applying it to the actual data, it is

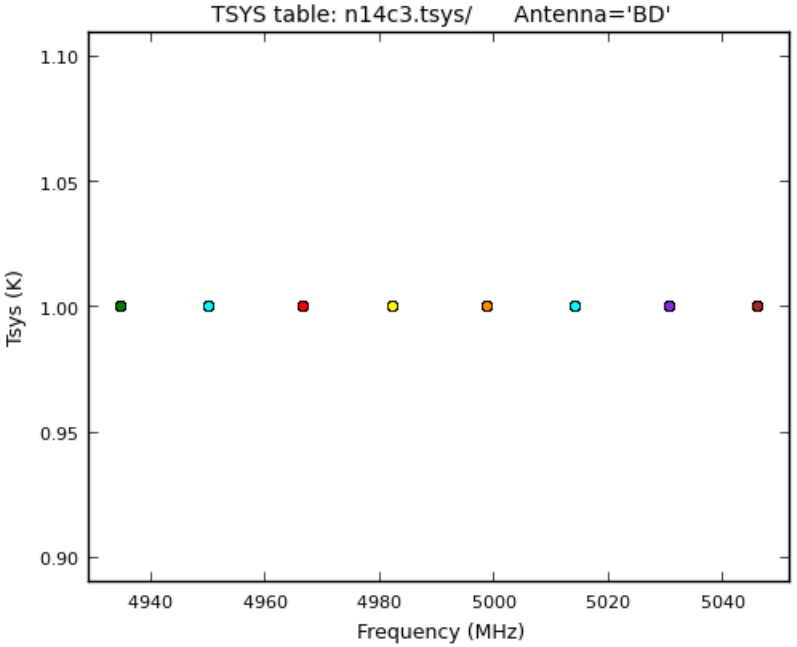
```
plotcal(caltable='n14c3.tsys',
        xaxis='freq',  yaxis='tsys',
        subplot=321, iteration='antenna')
```

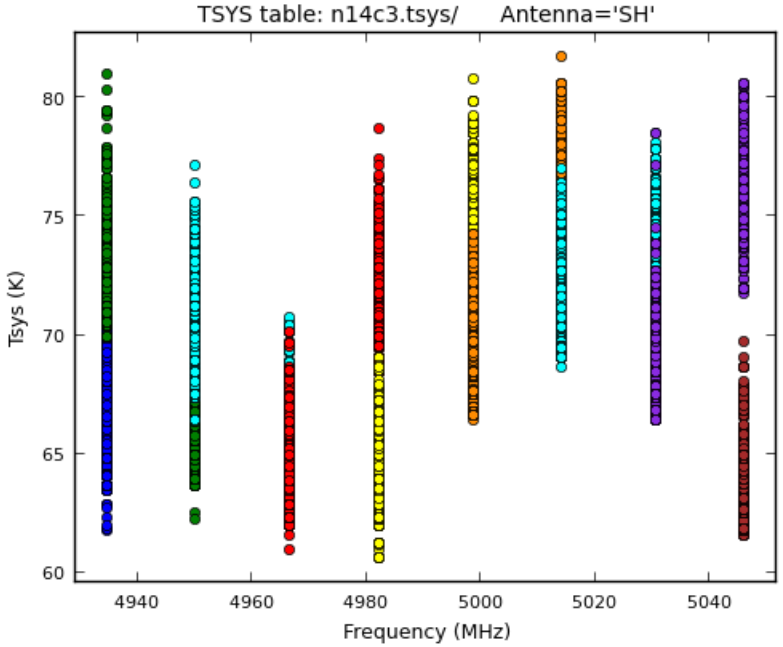

TSYS table: n14c3.tsys/ Antenna='EF'
Tsys (K)
Frequency (MHz)

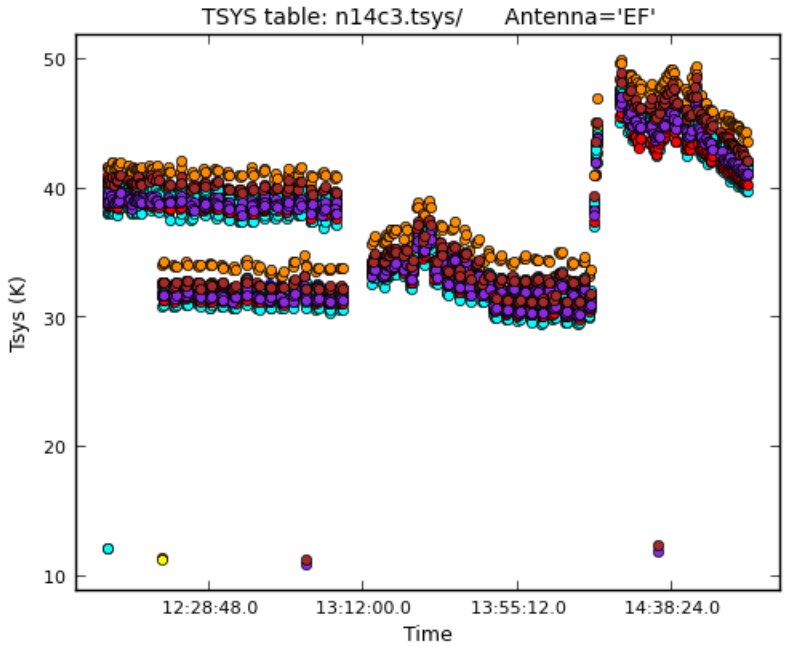

TSYS table: n14c3.tsys/ Antenna='WB'
Tsys (K)
Frequency (MHz)

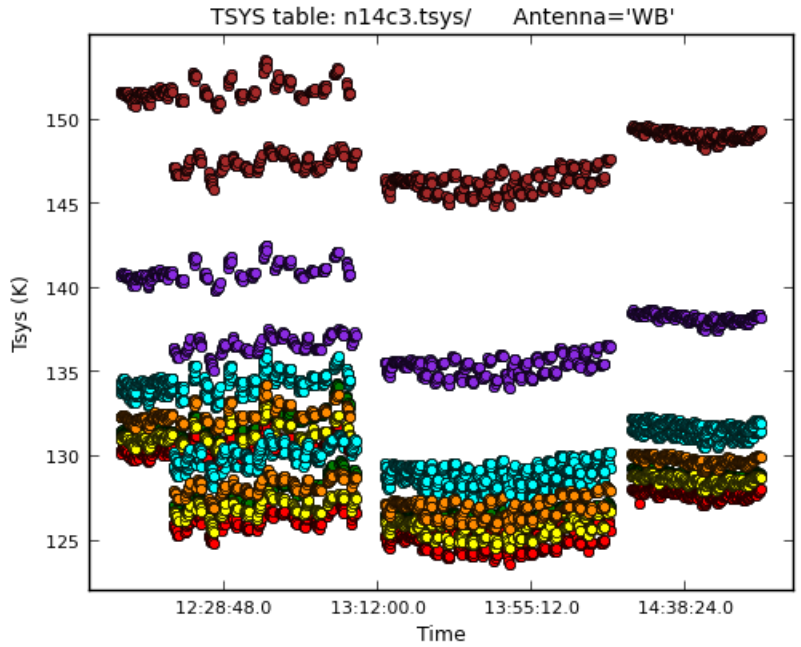

TSYS table: n14c3.tsys/ Antenna='ON'
Tsys (K)
Frequency (MHz)

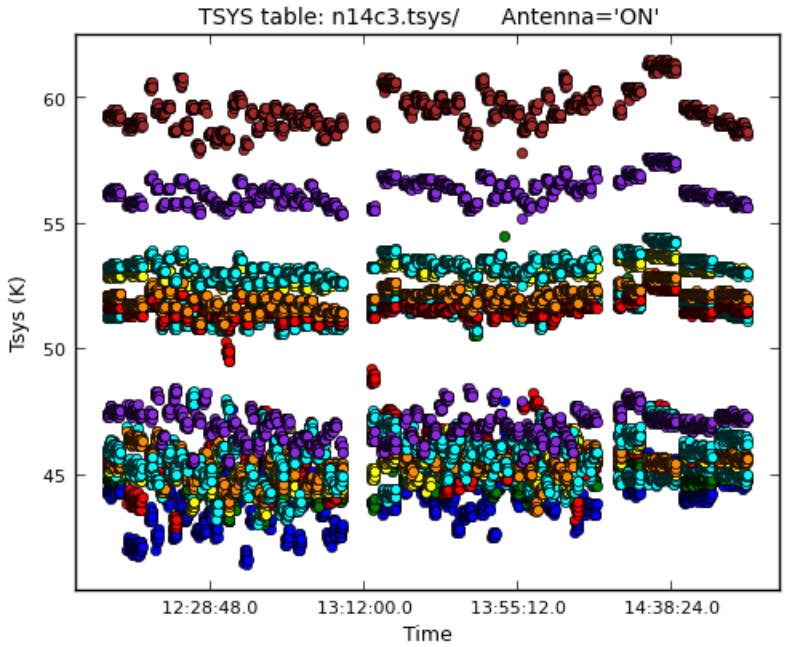

TSYS table: n14c3.tsys/ Antenna='TR'
Tsys (K)
Frequency (MHz)

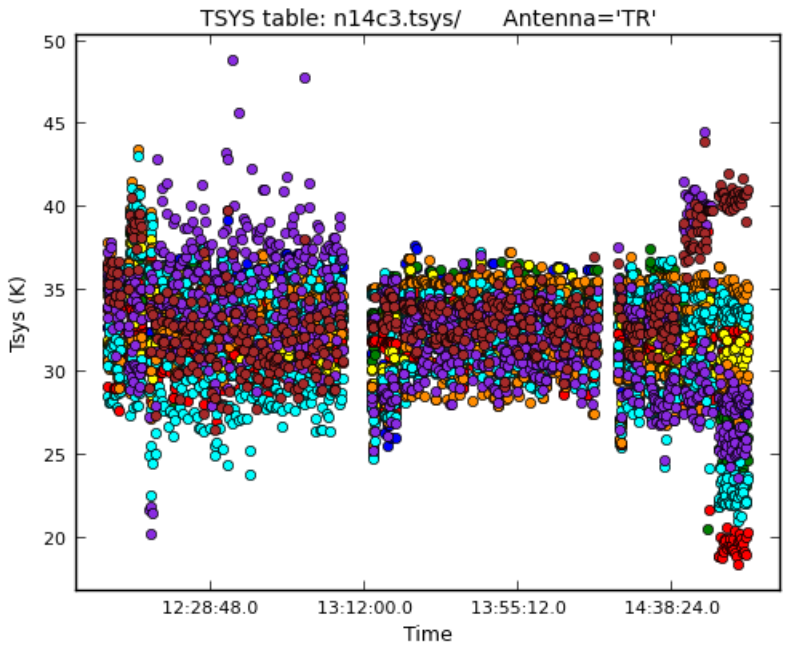

TSYS table: n14c3.tsys/ Antenna='BD'
Tsys (K)
Frequency (MHz)

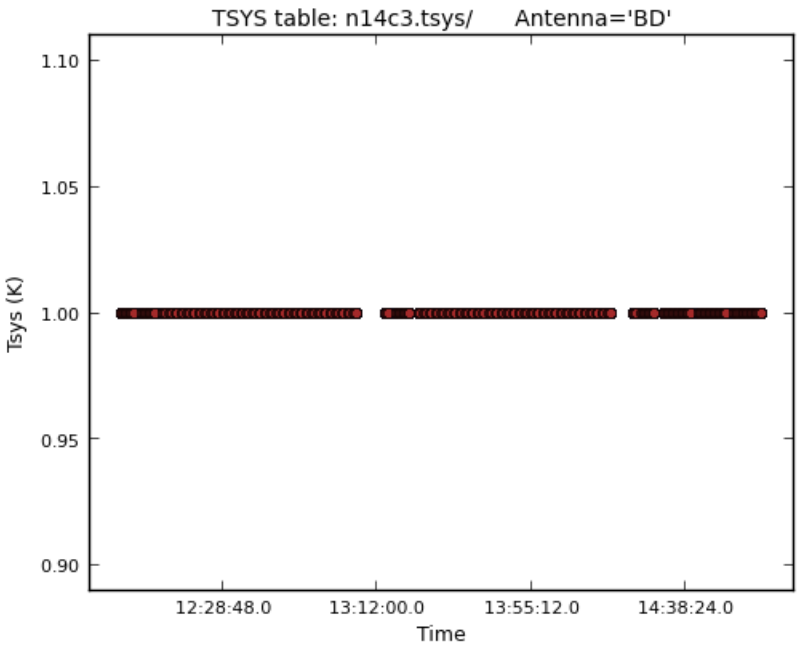

TSYS table: n14c3.tsys/ Antenna='SH'
Tsys (K)
Frequency (MHz)

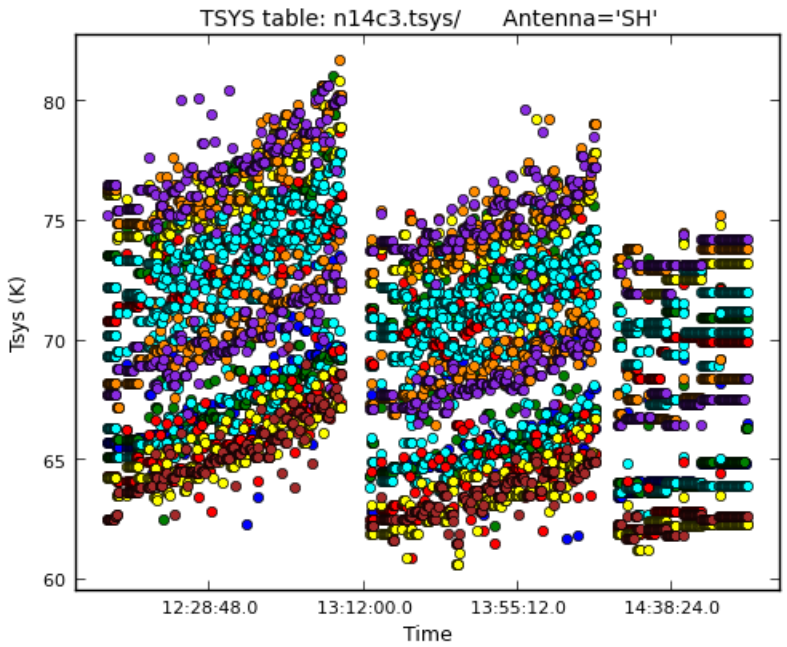

TSYS table: n14c3.tsys/ Antenna='EF'
Tsys (K)
Time
12:28:48.0
13:12:00.0
13:55:12.0
14:38:24.0

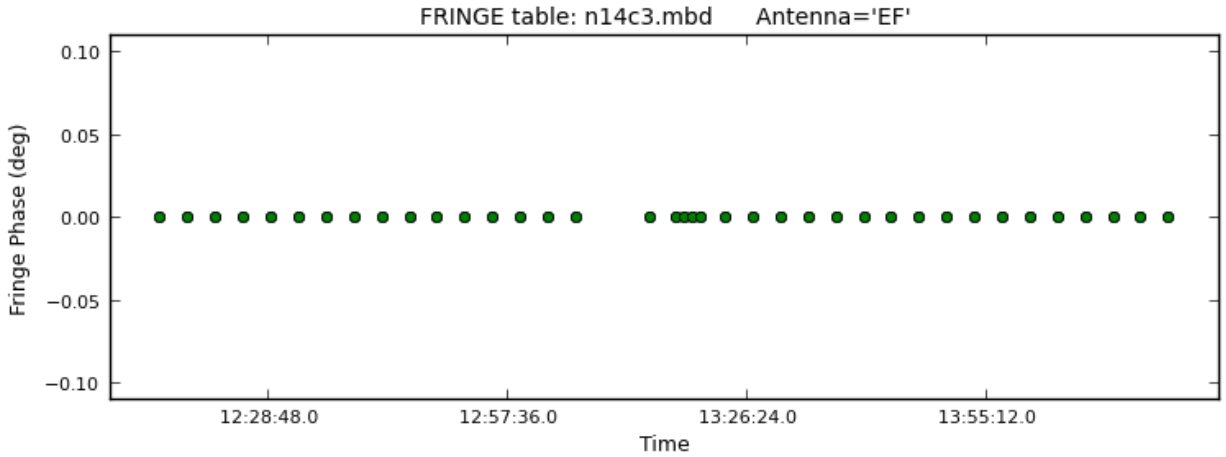

TSYS table: n14c3.tsys/ Antenna='WB'
Tsys (K)
Time
12:28:48.0
13:12:00.0
13:55:12.0
14:38:24.0

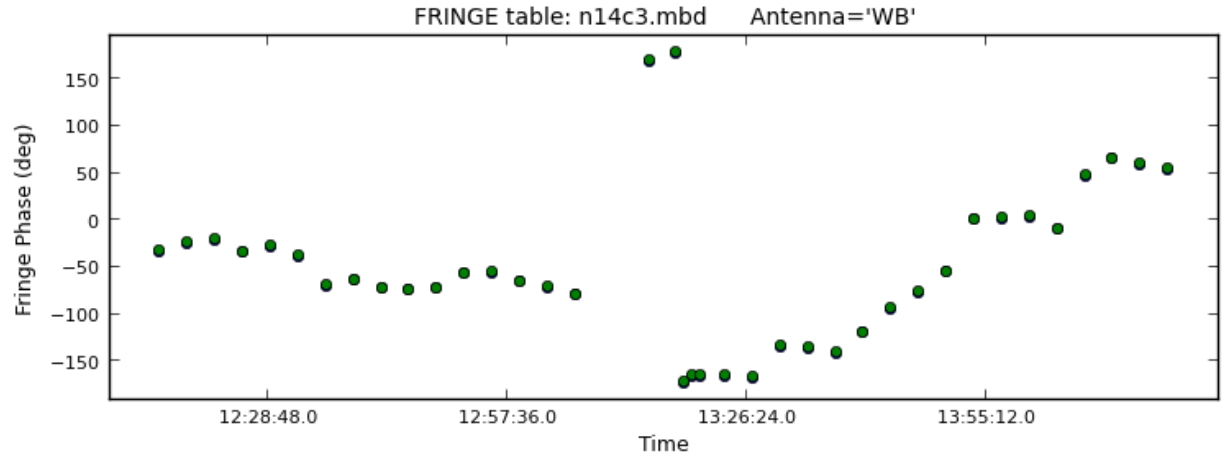

TSYS table: n14c3.tsys/ Antenna='ON'
Tsys (K)
Time
12:28:48.0
13:12:00.0
13:55:12.0
14:38:24.0

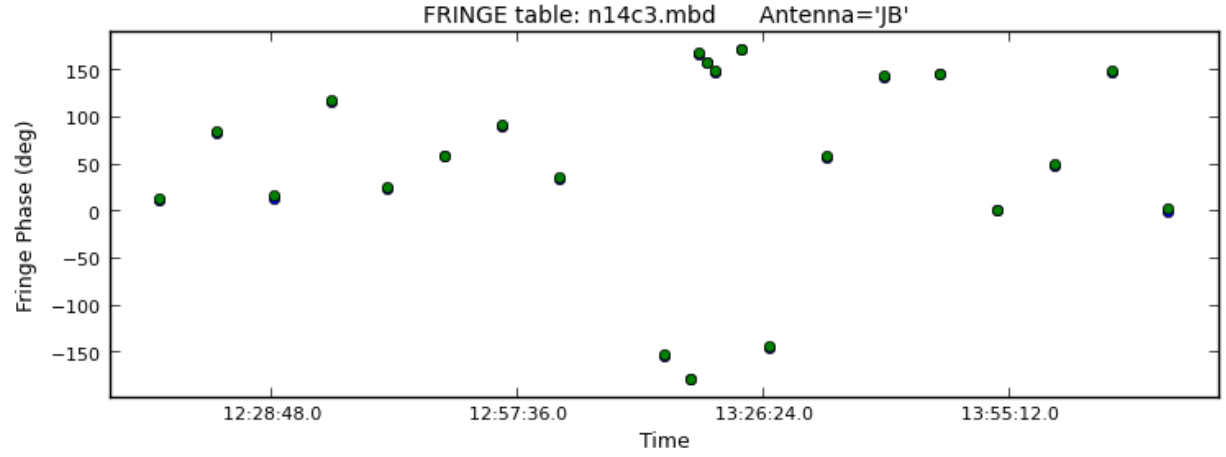

TSYS table: n14c3.tsys/ Antenna='TR'
Tsys (K)
Time
12:28:48.0
13:12:00.0
13:55:12.0
14:38:24.0

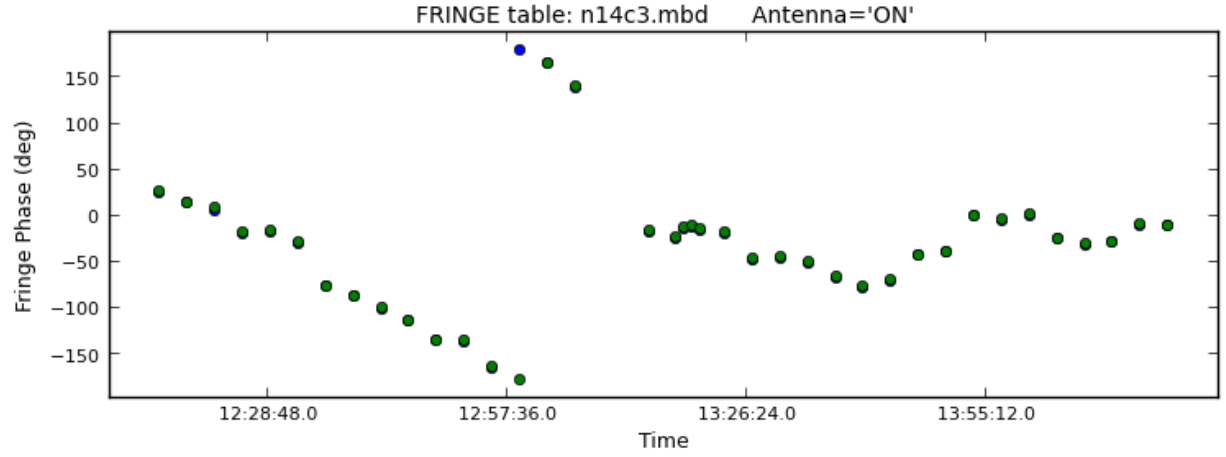

TSYS table: n14c3.tsys/ Antenna='BD'
Tsys (K)
Time
12:28:48.0
13:12:00.0
13:55:12.0
14:38:24.0

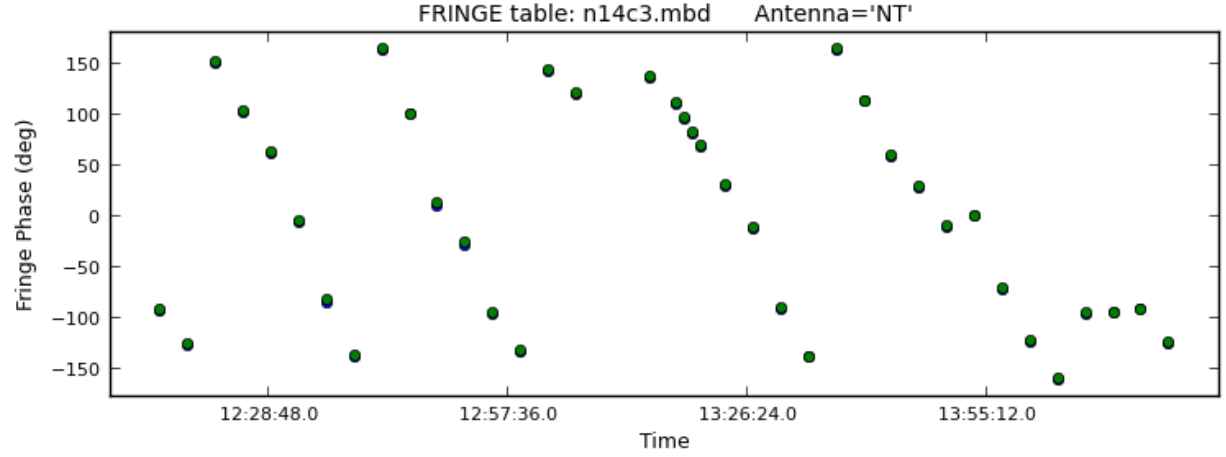

TSYS table: n14c3.tsys/ Antenna='SH'
Tsys (K)
Time
12:28:48.0
13:12:00.0
13:55:12.0
14:38:24.0

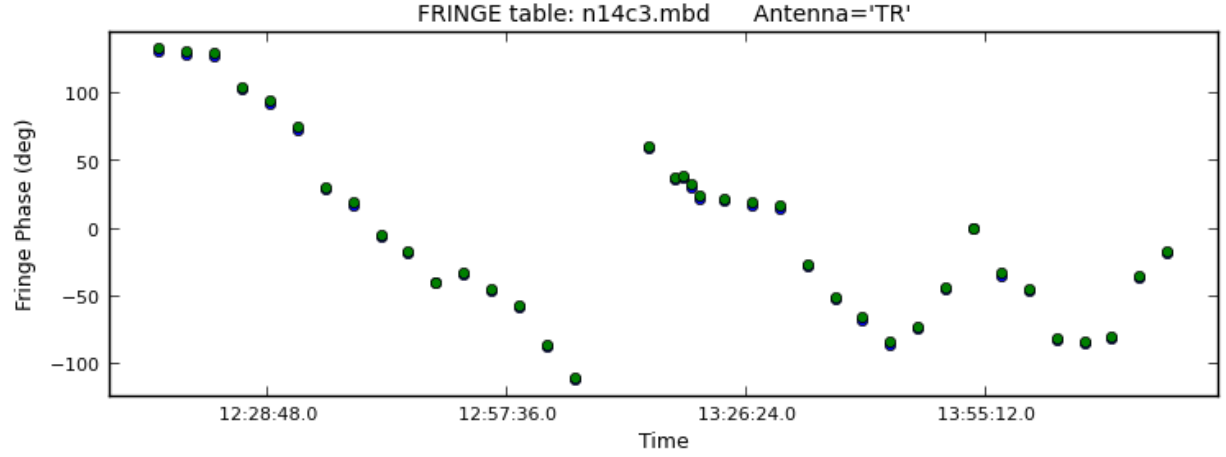

FRINGE table: n14c3.mbd Antenna='EF'
Fringe Phase (deg)
0.10
0.05
0.00
−0.05
−0.10
12:28:48.0
12:57:36.0
13:26:24.0
13:55:12.0
Time


FRINGE table: n14c3.mbd Antenna='WB'
Fringe Phase (deg)
150
100
50
0
−50
−100
−150
12:28:48.0
12:57:36.0
13:26:24.0
13:55:12.0
Time


FRINGE table: n14c3.mbd Antenna='JB'
Fringe Phase (deg)
150
100
50
0
−50
−100
−150
12:28:48.0
12:57:36.0
13:26:24.0
13:55:12.0
Time


FRINGE table: n14c3.mbd Antenna='ON'
Fringe Phase (deg)
150
100
50
0
−50
−100
−150
12:28:48.0
12:57:36.0
13:26:24.0
13:55:12.0
Time

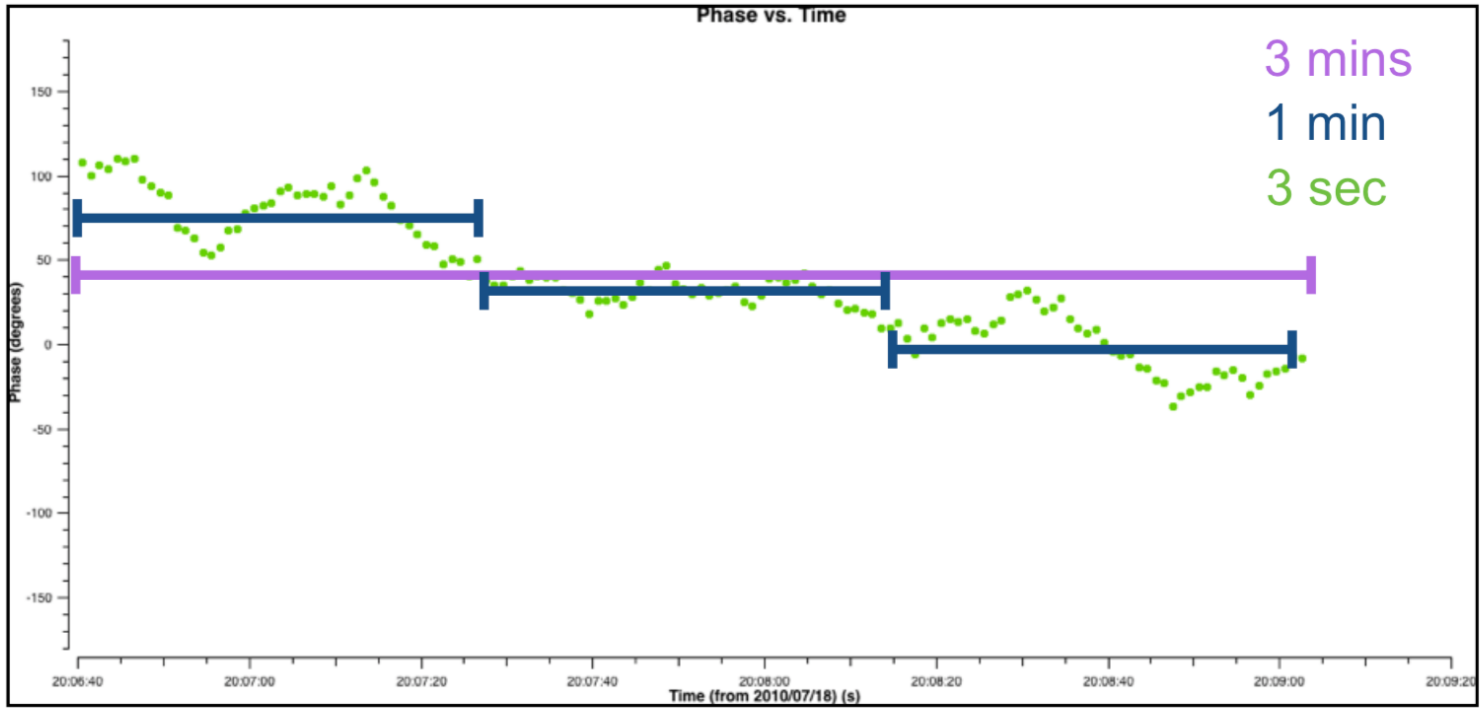

FRINGE table: n14c3.mbd Antenna='NT'
Fringe Phase (deg)
150
100
50
0
−50
−100
−150
12:28:48.0
12:57:36.0
13:26:24.0
13:55:12.0
Time


FRINGE table: n14c3.mbd Antenna='TR'
Fringe Phase (deg)
100
50
0
−50
−100
12:28:48.0
12:57:36.0
13:26:24.0
13:55:12.0
Time

CASA
VLBI

Plotcal

- You want to have:
  - Shortest possible solutions to track the variations.
  - Long enough to have enough signal-to-noise.



Credit: J. McKean ERIS 2017

Outside CASA…

Because there is life outside

CASA VLBI

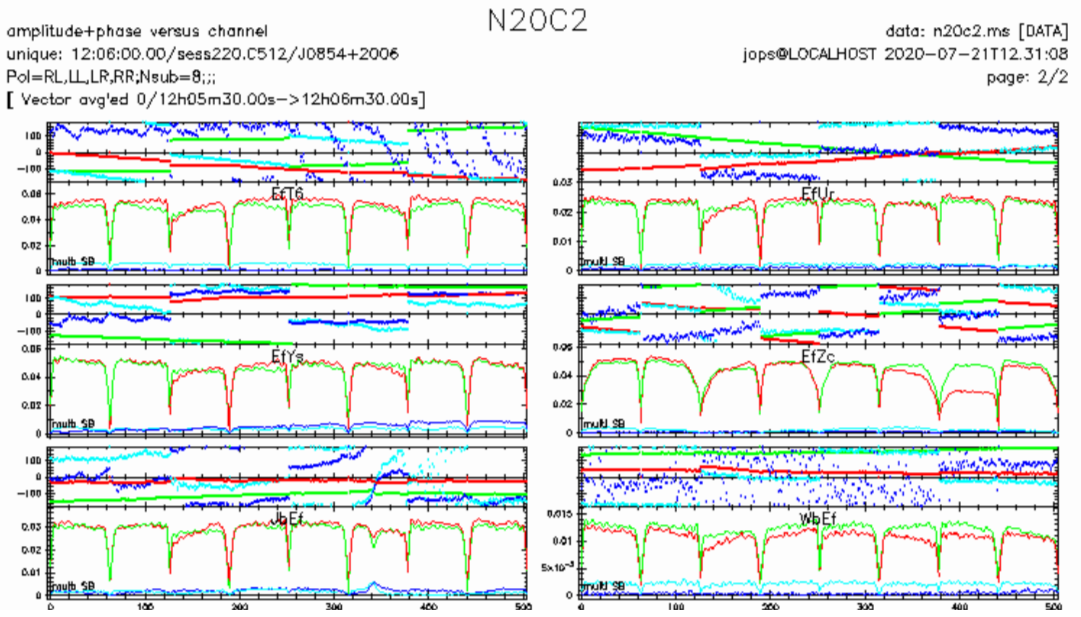
jplotter (jiveplot)

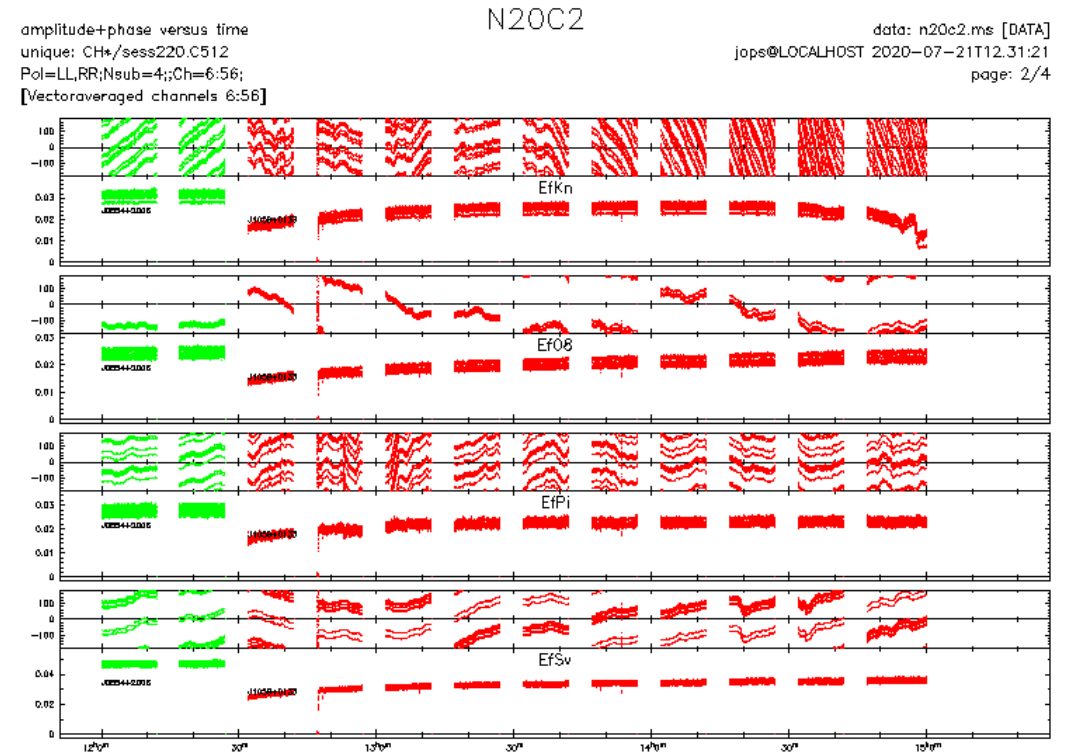
https://github.com/haavee/jiveplot

- ☑ Used internally at JIVE during the processing of an EVN observation.
- ☑ Quick visualizations of MS files.

jplotter

```
ms n14c3.ms
bl Ef*      # baselines to Ef
fq */p      #FreQuencies (all subbands, parallel pols)
pt amptime     # amplitude VS time plot
pl                  # do the plot
save n14c3-plot.ps          # multi-page file.
```



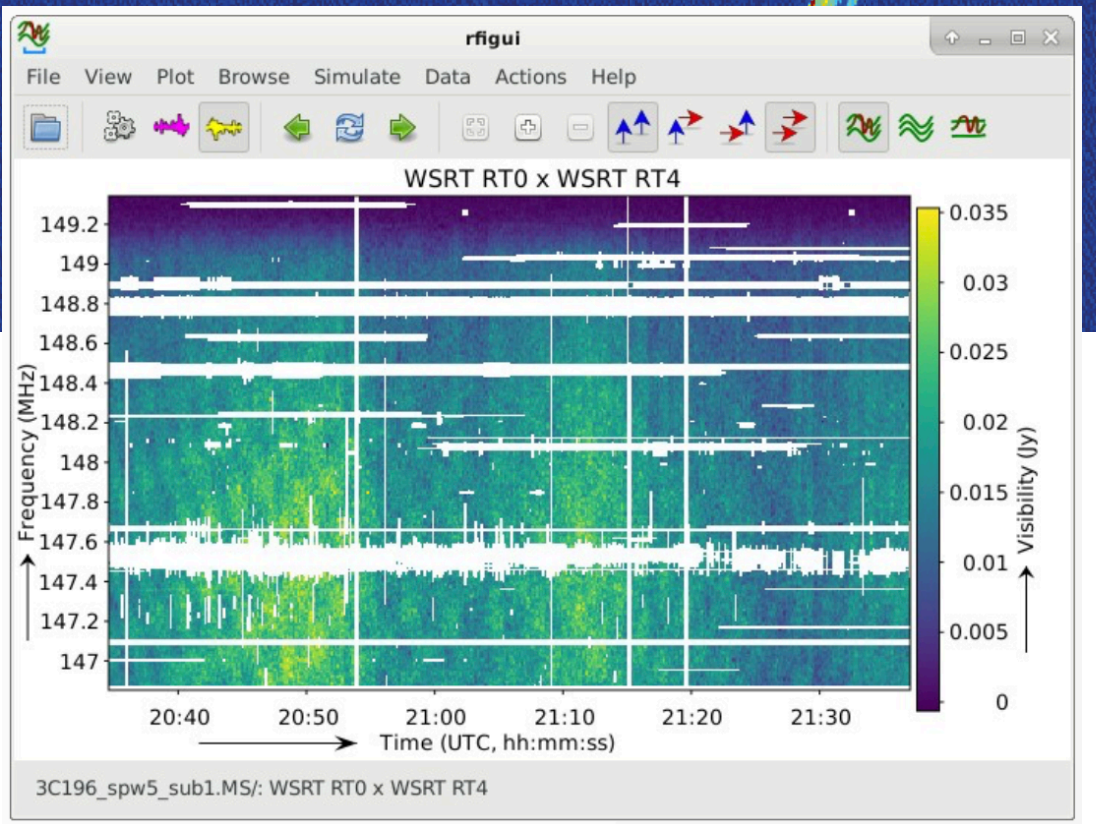


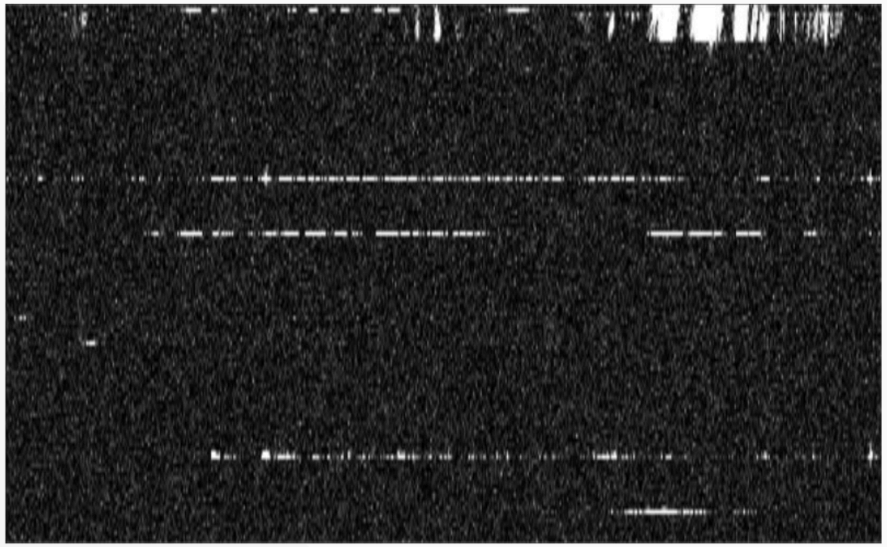
CASA
VLBI

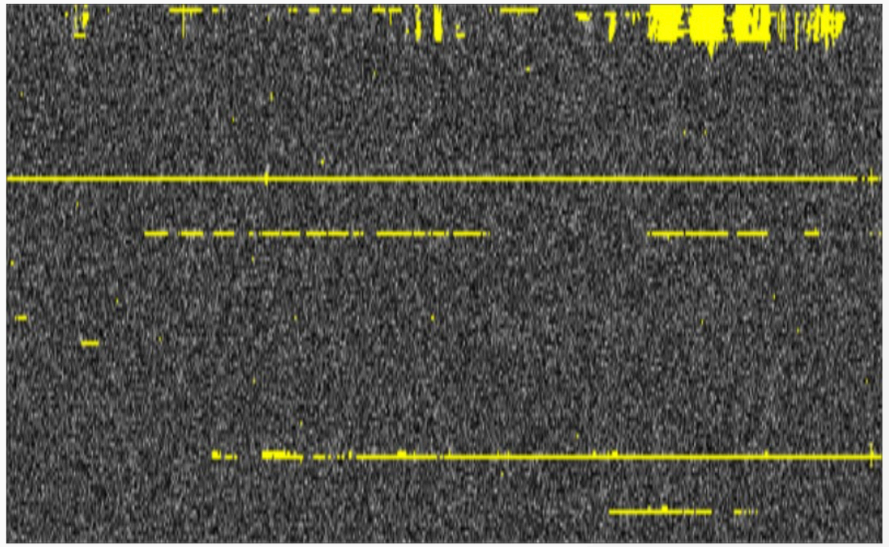
AOFlagger

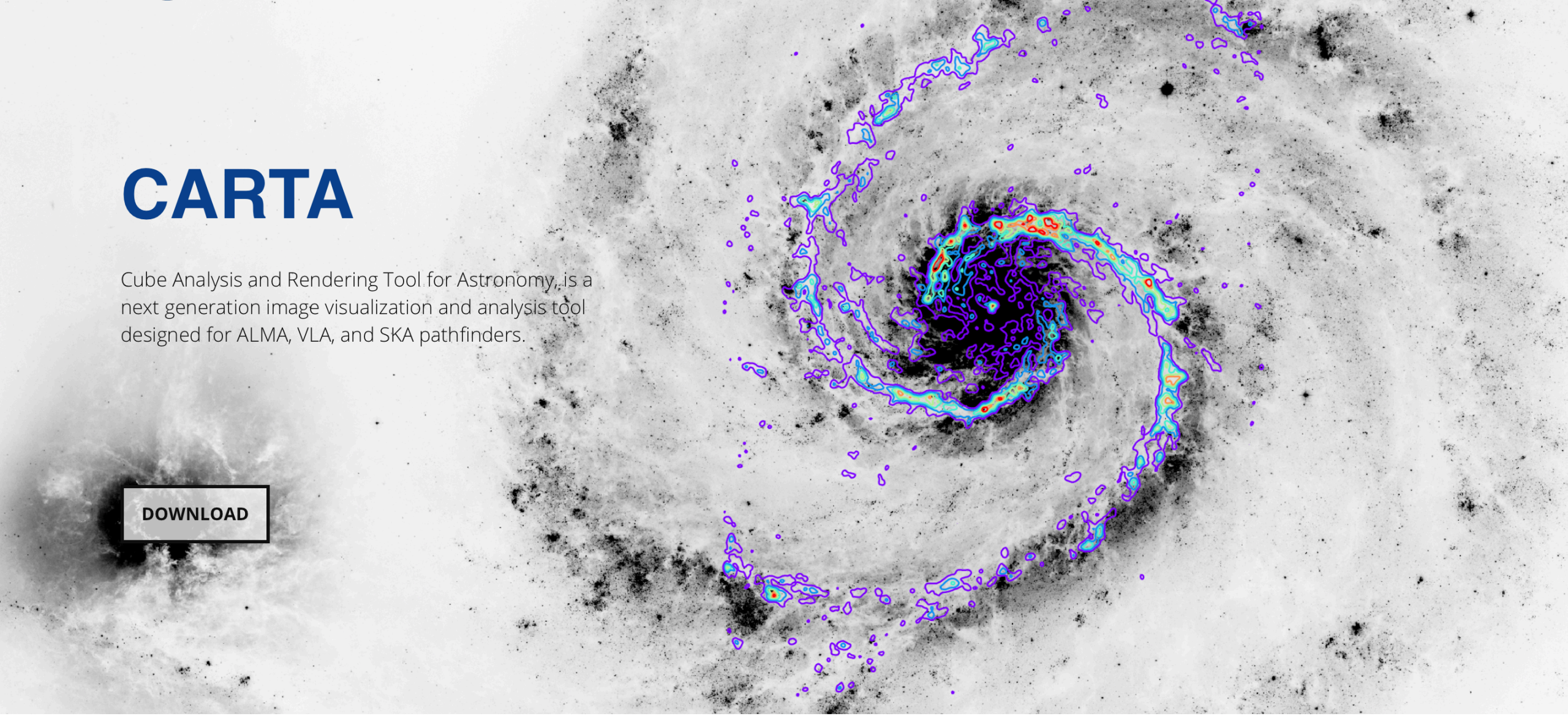
https://sourceforge.net/projects/aoflagger/

- ☑ Great Flagger program doing baseline-based statistics.
- ☑ Optimal performance for fine RFI (both in time or frequency).









https://cartavis.github.io

Possible future replacement for DS9, kvis (or casaviewer)

CASA VLBI

Thanks to our sponsors

JUMPING JIVE
Joint Institute for VLBI ERIC

RadioNet

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JIVE