UV-data analysis in practice

Cinthya Herrera Contreras
image plane

brightness \((x,y)\)

What we want

\[ \mathcal{F} \]

\[ \mathcal{I} \]

uv plane

visibility \((u,v)\)

What we obtain with an interferometer
General Picture

image plane

\[ \text{brightness } (x,y) \]

uv plane

\[ \text{visibility } (u,v) ^{\text{instr}} \]

Calibration

\[ \text{IPB data} \]

(raw data)

\[ \text{hpb files} \]

\[ \text{visibility } (u,v) ^{\text{obs}} \]

Gridding

\[ \text{Imv}^* (\text{gdf}) \]

\[ \text{brightness } (x,y)^{uv} \]

FFT

Cleaning

\[ \text{uv-table} \]

- Data processed enough to have removed all instrumental contribution

- Data raw enough to access to observational characteristics: baseline, scan, weight, etc.

- Data not yet affected by the ‘imaging process’: assumptions, interpolations, computations, etc.
Summary

1. Let’s create a uv-table, in CLIC
2. Data analysis, in MAPPING
   - Data analysis in the $uv$-plane
   - An inspection of the $uv$-data needed
Let’s create a table ("mytable".uvt),
in CLIC
Creating a uv-table; CLIC
Creating a *uv*-table; CLIC
Creating a uv-table; CLIC

Low resolution units

Some high resolution units

Spectral Units
Creating a uv-table; CLIC

PolyFix

Lower sideband
7.744GHz
HLO HLI

Upper sideband
7.744GHz
HUI HUO

3.872GHz
VLO VLI

3.872GHz
VUI VUO

more about PolyFiX on Friday morning
Creating a uv-table; CLIC

PolyFix

Lower sideband: 7.744GHz
- L1
- L2

Upper sideband: 7.744GHz
- L3
- L4

polar H
- L1
- L2

polar V
- L5
- L6

Radio Frequency (RF)

3.872GHz
- Inner baseband
- Inner baseband

- Outer baseband
- Outer baseband

F_{LO1}

... more about PolyFiX on Friday morning
Creating a *uv*-table; CLIC

<table>
<thead>
<tr>
<th>Line Number</th>
<th>Band Used</th>
<th>Continuum</th>
</tr>
</thead>
<tbody>
<tr>
<td>L01</td>
<td>Yes</td>
<td>LINE</td>
</tr>
<tr>
<td>L02</td>
<td>Yes</td>
<td>LSB</td>
</tr>
<tr>
<td>L03</td>
<td>No</td>
<td>LSB</td>
</tr>
<tr>
<td>L04</td>
<td>No</td>
<td>LSB</td>
</tr>
<tr>
<td>L05</td>
<td>Yes</td>
<td>LSB</td>
</tr>
<tr>
<td>L06</td>
<td>Yes</td>
<td>LSB</td>
</tr>
<tr>
<td>L07</td>
<td>No</td>
<td>LSB</td>
</tr>
<tr>
<td>L08</td>
<td>No</td>
<td>LSB</td>
</tr>
<tr>
<td>L09</td>
<td>No</td>
<td>LSB</td>
</tr>
<tr>
<td>L10</td>
<td>No</td>
<td>LSB</td>
</tr>
<tr>
<td>L11</td>
<td>No</td>
<td>LSB</td>
</tr>
<tr>
<td>L12</td>
<td>No</td>
<td>LSB</td>
</tr>
</tbody>
</table>

*Units:*
Creating a uv-table; CLIC

CLIC> header /plot
Creating a *uv*-table; CLIC

```
CLIC> header /plot
```

The image displays a UV table for a radio astronomical survey. The table represents data at different frequencies and spectral windows, with intermediate frequencies (IF1) and spectral line positions indicated. The survey details include the rest frequency (97.900 GHz), LSR (Local Standard of Rest) frequency, and reference frequency (RF). The image also includes a diagram with spectral windows and frequency bands, showing the distribution of data points and spectral lines across different zones (LO2).
Creating a uv-table; CLIC

- Use atm. phase correction: Yes
- Input Data File Name: 10-May-2018-hpb
- Output UV Table Name: table-NGC7027
- Source Name: NGC7027
- R.A. & Dec. Offsets (for Mosaics): 0 0
- First and last scan: 0 10000
- Receiver number: 1
- Line or Continuum: LINE
- Band Used: LSB
- L01: Yes
- L02: Yes
- L03: No
- L04: No
- L05: Yes
- L06: Yes
- L07: No
- L08: No
- L09: No
- L10: No
- L11: No
- L12: No
- Change line parameters: No
- Resample spectral data: No

Spectral Units

Go Close
Creating a *uv*-table; CLIC
Creating a *uv*-table; CLIC

![Resampling parameters dialog box showing resampling settings.]

- **Resample spectral data**: Yes
- **New number of channels**: 400
- **New reference channel**: 200
- **Velocity at the reference channel**: 26
- **New resolution**: 0.4
Creating a *uv*-table; CLIC

UV resampling can be also done in mapping

**MAPPING** > uv_resample
Creating a *uv*-table; CLIC
Creating a **uv-table**; CLIC

<table>
<thead>
<tr>
<th>File</th>
<th>Edit</th>
<th>View</th>
<th>Search</th>
<th>Terminal</th>
<th>Help</th>
</tr>
</thead>
</table>

RF Passband Calibration is applied

RF Passband Calibration is frequency dependent

RF Passband Calibration is antenna-based

RF Passband Calibration from input file

Selection is LINE, LSB, L001 L002 L005 L006

All frequencies selected.

I-FIND,[1645] New generation receivers data

I-FIND,[1645] 417 observations found

I-GET,[2324] Entry 935 Observation 935; 26

I-SET_DATA,[2324] Displaying 61386 points in each of 72 boxes

I-CLIC, Primary beam size 52.3908539

I-GET,[2323] Entry 934 Observation 934; 26

**W-TABLE,[2323]** Spectrum resampling is needed, obs. # 934 Scan 2323

<table>
<thead>
<tr>
<th>W-TABLE,[2323] Frequency resolutions: 1.9999642372131348</th>
<th>-0.12835546574489437</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>W-TABLE,[2323]</strong> Reference channels: 1951.9847154268400</td>
<td>200.000000000000000</td>
</tr>
<tr>
<td><strong>W-TABLE,[2323]</strong> Number of channels: 3859</td>
<td>400</td>
</tr>
</tbody>
</table>

I-GET,[2322] Entry 933 Observation 933; 26

I-GET,[2321] Entry 932 Observation 932; 29

I-GET,[2320] Entry 931 Observation 931; 32

I-GET,[2319] Entry 930 Observation 930; 32

I-GET,[2318] Entry 929 Observation 929; 32

I-GET,[2317] Entry 928 Observation 928; 27

I-GET,[2316] Entry 927 Observation 927; 27
Creating a *uv*-table; CLIC

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-GET,[1655]</td>
<td>Entry 103 Observation 103; 12</td>
</tr>
<tr>
<td>I-SET_PASS,[1655]</td>
<td>RF recomputation not needed</td>
</tr>
<tr>
<td>I-GET,[1654]</td>
<td>Entry 102 Observation 102; 12</td>
</tr>
<tr>
<td>I-SET_PASS,[1654]</td>
<td>RF recomputation not needed</td>
</tr>
<tr>
<td>I-GET,[1653]</td>
<td>Entry 101 Observation 101; 12</td>
</tr>
<tr>
<td>I-SET_PASS,[1653]</td>
<td>RF recomputation not needed</td>
</tr>
<tr>
<td>I-GET,[1652]</td>
<td>Entry 100 Observation 100; 12</td>
</tr>
<tr>
<td>I-SET_PASS,[1652]</td>
<td>RF recomputation not needed</td>
</tr>
<tr>
<td>I-GET,[1651]</td>
<td>Entry 99 Observation 99; 12</td>
</tr>
<tr>
<td>I-SET_PASS,[1651]</td>
<td>RF recomputation not needed</td>
</tr>
<tr>
<td>I-GET,[1650]</td>
<td>Entry 98 Observation 98; 12</td>
</tr>
<tr>
<td>I-SET_PASS,[1650]</td>
<td>RF recomputation not needed</td>
</tr>
<tr>
<td>I-GET,[1649]</td>
<td>Entry 97 Observation 97; 12</td>
</tr>
<tr>
<td>I-SET_PASS,[1649]</td>
<td>RF recomputation not needed</td>
</tr>
<tr>
<td>I-GET,[1648]</td>
<td>Entry 96 Observation 96; 12</td>
</tr>
<tr>
<td>I-SET_PASS,[1648]</td>
<td>RF recomputation not needed</td>
</tr>
<tr>
<td>I-GET,[1647]</td>
<td>Entry 95 Observation 95; 12</td>
</tr>
<tr>
<td>I-SET_PASS,[1647]</td>
<td>RF recomputation not needed</td>
</tr>
<tr>
<td>I-GET,[1646]</td>
<td>Entry 94 Observation 94; 12</td>
</tr>
<tr>
<td>I-SET_PASS,[1646]</td>
<td>RF recomputation not needed</td>
</tr>
<tr>
<td>I-TABLE,[1646]</td>
<td>11598 visibilities written (out of 15012 possible)</td>
</tr>
<tr>
<td>I-TABLE,[1646]</td>
<td>Old size 15012 New 11598</td>
</tr>
</tbody>
</table>

**CLIC>**
Creating a *uv*-table; CLIC

```
$cat table-NGC7027-table.clic
!
! table-NGC7027-table.clic
!
file in "10-may-2018.hp"
!
set default
set scan 0 10000
set offset 0 0
set receiver 1
set quality AVERAGE
set weight tsys on
set weight calibration on
set phase antenna atmosphere internal relative
set amplitude antenna absolute jansky relative
set rf_passband antenna frequency file on
!
set selection LINE LSB l01 and l02 and l05 and l06
find /proc corr /sou NGC7027
table table-NGC7027 new /freq lsb 96200 /res 400 200 26 0.4 velo
```

Easy and faster editable script
! table-NGC7027-table.clic
!
!
file in "10-may-2018.hp"b"
!
set default
set scan 0 10000
set offset 0 0
set receiver 1
set quality AVERAGE
set weight tsys on
set weight calibration on
set phase antenna atmospher internal relative
set amplitude antenna absolute jansky relative
set rf_passband antenna frequency file on
!
set selection LINE LSB l01 and l02 and l05 and l06
find /proc corr /sou NGC7027
table table-NGC7027 new /freq lsb 96200 /res 400 200 26 0.4 velo
**Create the Table**

- **Use atm. phase correction?**: Yes
- **Input Data File Name**: 19-feb-2018.hpb
- **Output UV Table Name**: table-NGC7027
- **New Table**: No

**Source Name**: NGC7027

- **R.A. & Dec. Offsets (for Mosaics)**: 0 0
- **First and last scan**: 0 10000
- **Receiver number**: 1

**Line or Continuum**: LINE

**Band Used**: LSB

- **L01**: Yes
- **L02**: Yes
- **L03**: No
- **L04**: No
- **L05**: Yes
- **L06**: Yes
- **L07**: No
- **L08**: No
- **L09**: No
- **L10**: No
- **L11**: No
- **L12**: No

**Change line parameter**: No

**Resample spectral data**: No

---

**Line parameters**

<table>
<thead>
<tr>
<th>Line parameters</th>
<th>Line parameters</th>
<th>Help</th>
</tr>
</thead>
</table>

**Resampling parameters**

<table>
<thead>
<tr>
<th>Resampling parameters</th>
<th>Resampling parameters</th>
<th>Help</th>
</tr>
</thead>
</table>

---

*2nd data set!*
1st data set!

file in "10-may-2018.hp"n
set default
set scan 0 10000
set offset 0 0
set receiver 1
set quality AVERAGE
set weight tsys on
set weight calibration on
set phase antenna atmosphere internal relative
set amplitude antenna absolute jansky relative
set rf_passband antenna frequency file on
set selection LINE LSB l01 and l02 and l05 and l06
find /proc corr /sou NGC7027
table table-NGC7027 new /freq lsb 96200 /res 400 200 26 0.4 velo

2nd data set!

file in "19-feb-2018.hp"
set default
set scan 0 10000
set offset 0 0
set receiver 1
set quality AVERAGE
set weight tsys on
set weight calibration on
set phase antenna atmosphere internal relative
set amplitude antenna absolute jansky relative
set rf_passband antenna frequency file on
set selection LINE LSB l01 and l02 and l05 and l06
find /proc corr /sou NGC7027
table table-NGC7027
! table-NGC7027-table.clic

file in "10-may-2018-.hpb"

1st data set!

set default
set scan 0 10000
set offset 0 0
set receiver 1
set quality AVERAGE
set weight tsys on
set weight calibration on
set phase antenna atmosphere internal relative
set amplitude antenna absolute jansky relative
set rf_passband antenna frequency file on

set selection LINE LSB l01 and l02 and l05 and l06
find /proc corr /sou NGC7027
table table-NGC7027
new /freq lsb 96200 /res 400 200 26 0.4 velo

file in "19-feb-2018.hp" 2nd data set!

set selection LINE LSB l01 and l02 and l05 and l06
find /proc corr /sou NGC7027
table table-NGC7027

file in "01-mar-2018.hp" 3rd data set!

set selection LINE LSB l01 and l02 and l05 and l06
find /proc corr /sou NGC7027
table table-NGC7027

-**: table-NGC7027-table.clic  All L37  (F90)
Creating a uv-table; CLIC

CLIC> help table

CLIC\TABLE Name [OLD\NEW] [/COMPRESS tmax uvmax]
[/RESAMPLE nc ref val inc code shape width] [/FFT]
[/FREQUENCY name rest-freq] [/DROP n1 n2]
[/NOCHECK [SOURCE\POINTING|PHASE|EPOCH]]

This command will create an UV data Table from the current index. is
not given, the most recently created table will be extended. Next argu-
ment may be OLD (default value if not specified) to extend and existing
table, or NEW to create a new table.

The bands and subbands used must have been given by the command SET SE-
LECTION. The weighting mode can be modified by the command SET WEIGHTS.

TABLE /RESAMPLE nc ref val inc code [shape width /FFT]

Option /RESAMPLE enables to resample data on a new spectral grid
(for line data). 'nc' is the output number of channels, 'ref' the
reference channel, 'val' the value of velocity or frequency offset
(with respect to the rest frequency) at the reference channel, 'inc'
the resolution, 'code' is "V" if the value 'val' and the resolution
... Press RETURN for more ...
For mosaics:
find /proc corr /source SourceName
table mosaic-source.uvt new /freq lsb 96200 /mosaic

set selection LINE LSB l01 and l02 and l05 and l06
find /proc corr /sou NGC7027
table table-NGC7027 new /freq lsb 96200 /res 400 200 26 0.4 velo

file in "19-feb-2018.hp"b

set selection LINE LSB l01 and l02 and l05 and l06
find /proc corr /sou NGC7027
table table-NGC7027

file in "01-mar-2018.hp"b

set selection LINE LSB l01 and l02 and l05 and l06
find /proc corr /sou NGC7027
table table-NGC7027

Note: a bug was found in version sep18.
You should use version oct18 (or later)
For **mosaics**: 
find /proc corr /source SourceName 
table mosaic-source.uvt new /freq lsb 96200 /mosaic

For **continuum**: 
Go to MAPPING and: 
MAPPING>uv_continuum
Created “mytable”.uvt, in CLIC

Analyze the data, in MAPPING
1. Data analysis in the $uv$-plane
Data analysis in the uv-plane

GILDAS Version: 27sep (27sep18 02:04 cest) (x86_64-centos7.4-gfortran81-openmp)
executable tree

* Welcome to MAPPING

* Loaded modules
  sic (J.Pety, S.Bardeau, S.Guilloteau, E.Reynier)
  greg (J.Pety, S.Bardeau, S.Guilloteau, E.Reynier)
  mapping (J.Pety, S.Guilloteau, F.Gueth, N.Rodriguez-Fernandez)

* In charge: J.Pety
Active developers: V.deSouzaMagalhaes, S.Bardeau, S.Guilloteau
Main past contributors: N.Rodriguez-Fernandez, F.Gueth, K.Bouyoucef, R.Lucas

* MAPPING is an interactive program to image and deconvolve
  (sub)mm interferometric data

* Questions? Comments? Bug reports? Mail to: gildas@iram.fr

* For help, type HELP, INPUT and/or INFO at the MAPPING prompt

MAPPING>
Data analysis in the *uv*-plane

| Generic name | UV Clip      | UV_CLIP | UV_CLIP parameters | Help | UV Coverage | UVCOV | UVCOV parameters | Help | UV Plots | UVSHOW | UVSHOW parameters | Help | UV SHIFT | UV_SHIFT | UV_SHIFT parameters | Help | UV fit | UV_FIT | UV_FIT parameters | Help | Plotting UV fits | PLOTFIT | PLOTFIT parameters | Help |
Data analysis in the *uv*-plane

![UV actions control panel](image)
Data analysis in the $uv$-plane
With commands:

MAPPING> let name table-NGC7027
MAPPING> go uvcov

MAPPING> input uvcov ! To check the parameters
Data analysis in the *uv*-plane

<table>
<thead>
<tr>
<th>Generic name</th>
<th>UV_CLIP</th>
<th>UV_CLIP parameters</th>
<th>Help</th>
</tr>
</thead>
<tbody>
<tr>
<td>UV Coverage</td>
<td>UVCOV</td>
<td>UVCOV parameters</td>
<td>Help</td>
</tr>
<tr>
<td>UV Plots</td>
<td><strong>UVSHOW</strong></td>
<td>UVSHOW parameters</td>
<td>Help</td>
</tr>
<tr>
<td>UV_SHIFT</td>
<td>UV_SHIFT</td>
<td>UV_SHIFT parameters</td>
<td>Help</td>
</tr>
<tr>
<td>UV fit</td>
<td>UV_FIT</td>
<td>UV_FIT parameters</td>
<td>Help</td>
</tr>
<tr>
<td>Plotting UV fits</td>
<td>PLOTFIT</td>
<td>PLOTFIT parameters</td>
<td>Help</td>
</tr>
</tbody>
</table>
Data analysis in the \textit{uv}-plane

Continuum \textit{uv} table (1 channel)
Data analysis in the uv-plane

Line uv table (several channels)
Data analysis in the uv-plane

Generic name: cont-PNe
X data: radius
Y data: amp
First channel: 
Last channel: 
Plot limits: 
Plot model fit: No
Display zero level: Yes
Use one color per track: Yes
Typical time separating 2 tracks [hrs]: 12
Marker definition as in the SET MARKER command: 4 1.1
Data analysis in the uv-plane...
Source: NGC7027
Line: Isb
Frequency: 96.2 GHz
Channels: 80 to 91
real vs. radius
Box marking: VELOCITY
With commands:

MAPPPING> let name table-NGC7027
MAPPPING> let first 80
MAPPPING> let last 91
MAPPPING> let ytype real
MAPPPING> let xtype radius
MAPPPING> go uvshow

MAPPPING> input uvshow ! To check the parameters
Data analysis in the $uv$-plane
Data analysis in the *uv-plane*
Data analysis in the *uv*-plane
Data analysis in the \textit{uv-plane} \texttt{uv\_shift through commands:}

	exttt{MAPPING> help uv\_shift}

\begin{verbatim}
[CLEAN]\texttt{UV\_SHIFT}
[CLEAN]\texttt{UV\_SHIFT OffX OffY \{Angle\}}
[CLEAN]\texttt{UV\_SHIFT HH:MM:SS.SSS DDD:MM:SS.SSS \{Angle\}}
\end{verbatim}

Shift a UV table to a new phase center.

- If the table is an observed mosaic with phase and pointing described by the same offsets, the visibilities are aligned to a common phase center and the offsets are replaced by pointing offsets only, with pointing reference matching the phase center.
- If the table is already a phase-shifted mosaic with pointing offsets, the visibilities are realigned to the new phase center, and the pointing offsets are recomputed so that the pointing reference matches the phase center.
- If the table is single field UV table (i.e. with no offsets), the visibilities are realigned to the new phase center. The pointing reference is left unchanged.

If a new phase center (absolute or relative coordinates) is provided on the command line, it is used as new center. Without argument, \texttt{UV\_SHIFT} rely on the variables \texttt{MAP\_RA}, \texttt{MAP\_DEC}, and \texttt{MAP\_ANGLE} if \texttt{MAP\_RA} is non-... Press RETURN for more ...
Data analysis in the $uv$-plane

With commands:

```
MAPPING> read uv "mytable"
MAPPING> uv_shift Xoff Yoff
MAPPING> write uv table-name-shift

MAPPING> help uv_shift ! To check the parameters
```

```
MAPPING> read uv table-NGC7027
W-READ, File not modified and same range -- not reloaded
W-READ, Reading enforced by user
W-GDF_READ_UVDATASET, Producing a UVT order
MAPPING> uv_shift -2.25 -1.25
I-UV_SHIFT, UV table is a single field
MAPPING> write uv table-NGC7027-shift
MAPPING> ...
```
Data analysis in the *uv*-plane
Data analysis in the *uv*-plane

- **Generic name**
- **UV Clip**
- **UV Coverage**
- **UV Plots**
- **UV SHIFT**
- **UV fit**
- **Plotting UV fits**
Data analysis in the *uv-plane*

[Image of a software interface with parameters listed for data analysis.]
Data analysis in the uv-plane

Variable PARAM01$:
   TASK$REAL "Parameters" PARAM01$[7]

Your guesses as input parameters for the fitting process. Six parameters have to be defined for each function. The parameter list used in the fit is:

- POINT: Offset R.A., Offset Dec, Flux
- E_GAUSS: Offset R.A., Offset Dec, Flux, Maj. diam., Min. diam., Pos Ang
- C_GAUSS: Offset R.A., Offset Dec, Flux, Diameter
- C_DISK: Offset R.A., Offset Dec, Flux, Diameter
- E_DISK: Offset R.A., Offset Dec, Flux, Maj. diam., Min. diam., Pos Ang
- RING: Offset R.A., Offset Dec, Flux, Inner Diameter, Outer Diameter
- EXPO: Offset R.A., Offset Dec, Flux, Diameter
- POWER-2: Offset R.A., Offset Dec, Flux, Diameter
- POWER-3: Offset R.A., Offset Dec, Flux, Diameter
- E_RING: Offset R.A., Offset Dec, Flux, Inner, Outer, Pos Ang, Ratio

Note that if the guesses are not sufficiently accurate the fit may not converge.

Variable PARAM02$:
   TASK$REAL "Parameters" PARAM02$[7]

Same as PARAM01$
Generic name: table-NGC7027-shift
First channel: 3308
Last channel: 3430
UV range(min, max) (meters): 0 800
Number of Functions (1 or 2): 1
Function 1: ring
Parameters: 0 0 200 1 0 0 0
Starting range: 0 0 0 0 0 0 0
Number of starts: 0 0 0 0 0 0
Subtract function: No
Function 2: point
Parameters: 0 0 0 0 0 0
Starting range: 0 0 0 0 0 0
Number of starts: 0 0 0 0 0 0
Subtract function: No

Variable PARAM01$:
TASK\REAL = "Parameters" PARAM01$[76]
Your guesses as input parameters for the fitting procedure have to be defined for each function. The parameter list is:
- POINT: Offset R.A., Offset Dec, Flux
- E_GAUSS: Offset R.A., Offset Dec, Flux, Maj. diameter
- C_GAUSS: Offset R.A., Offset Dec, Flux, Diameter
- C_DISK: Offset R.A., Offset Dec, Flux, Diameter
- E_DISK: Offset R.A., Offset Dec, Flux, Maj. diameter
- RING: Offset R.A., Offset Dec, Flux, Inner Diameter
- EXPO: Offset R.A., Offset Dec, Flux, Diameter
- POWER-2: Offset R.A., Offset Dec, Flux, Diameter
- POWER-3: Offset R.A., Offset Dec, Flux, Diameter
- E_RING: Offset R.A., Offset Dec, Flux, Inner Diameter
Note that if the guesses are not sufficiently accurate, the fit may not converge.

Variable PARAM02$:
TASK\REAL = "Parameters" PARAM02$[76]
Same as PARAM01$
Data analysis in the \textit{uv}-plane

```
W-DCOV, Jacobian singular, info=  2
r.m.s.=  30.6978 Jy.
RNG  R.A.  =  -0.18724 ( 0.35419)  21:07:01.75054
RNG  Dec.  =   0.18611 ( 0.34386)  42:14:09.6361
RNG  Flux  =  203.57039 ( 0.04314)  Jy
RNG  I.Diam.  =  9.67553 ( 0.27221)
RNG  O.Diam.  =   0.00000 ( 0.00000)

I-UV\_FIT, 18078 data points for channel3430
I-UV\_FIT, Starting minimization on channel3430  Velocity= -9.186E+03
I-UV\_FIT, Starting from  0.00000  0.00000  200.00  1.0000  0.0000

W-DCOV, Jacobian singular, info=  2
r.m.s.=  30.6410 Jy.
RNG  R.A.  =  -0.19016 ( 0.35428)  21:07:01.75028
RNG  Dec.  =   0.19305 ( 0.34393)  42:14:09.6430
RNG  Flux  =  203.45130 ( 0.04316)  Jy
RNG  I.Diam.  =  9.66825 ( 0.27228)
RNG  O.Diam.  =   0.00000 ( 0.00000)

I-UV\_FIT,  Successful completion

I-RUN,  Elapsed 24.4, User 1633.7, System 5.3
I-RUN,  Task uv\_fit completed successfully
```

MAPPING>
Data analysis in the *uv*-plane

![UV actions control panel](image)
Data analysis in the *uv-plane*

**PLOTFIT parameters (on reducv2.iram.fr)**

<table>
<thead>
<tr>
<th>Generic name</th>
<th>table-NGC7027-shift</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of fitted functions to be plotted</td>
<td>1</td>
</tr>
<tr>
<td>Order in which fitted functions are plotted</td>
<td>1 2</td>
</tr>
<tr>
<td>Number of parameters plotted along x axis</td>
<td>1</td>
</tr>
<tr>
<td>X Parameter #1</td>
<td>velo **</td>
</tr>
<tr>
<td>X Parameter #2</td>
<td>freq **</td>
</tr>
<tr>
<td>X Parameter #3</td>
<td>channel **</td>
</tr>
<tr>
<td>X Parameter #4</td>
<td>ra **</td>
</tr>
<tr>
<td>X Parameter #5</td>
<td>dec **</td>
</tr>
<tr>
<td>X Parameter #6</td>
<td>flux **</td>
</tr>
<tr>
<td>Number of parameters plotted along y axis</td>
<td>3</td>
</tr>
<tr>
<td>Y Parameter #1</td>
<td>ra **</td>
</tr>
<tr>
<td>Y Parameter #2</td>
<td>dec **</td>
</tr>
<tr>
<td>Y Parameter #3</td>
<td>flux **</td>
</tr>
<tr>
<td>Y Parameter #4</td>
<td>major **</td>
</tr>
<tr>
<td>Y Parameter #5</td>
<td>minor **</td>
</tr>
<tr>
<td>Y Parameter #6</td>
<td>angle **</td>
</tr>
<tr>
<td>First channel</td>
<td>3308</td>
</tr>
<tr>
<td>Last channel</td>
<td>3430</td>
</tr>
<tr>
<td>Plot error bars</td>
<td>No</td>
</tr>
</tbody>
</table>

**Note:**
- The X parameters include velocity (velo), frequency (freq), channel, right ascension (ra), declination (dec), and flux.
- The Y parameters include right ascension, declination, flux, major axis, minor axis, and angle.
- The channel range is from 3308 to 3430.
Data analysis in the *uv*-plane

Table: NGC7027-shift.uvf
Source: N007027
Line: Isb
Frequency: 96.2 GHz
Channels: 3308 to 3430

Imiss@reducv2.iram.fr
27-SEP-2018 14:32:07
Data analysis in the $uv$-plane

**MAPPING procedures / commands**

MAPPING> input “command” or help “command”
MAPPING> let name uvtable-name
MAPPING> go “command”

Type: INPUT command-name for further information on a command
Type: GO command-name to execute a command
Data analysis in the uv-plane

MAPPING procedures / commands

MAPPING> input “command” or help “command”
MAPPING> go “command”

These can be also found in the widgets:

- go setup
- go uvclip
- go uvcov
- go uvshow
- go uv shift
- go uvfit
- go plotfit
- go uvshort
- go uvstat
- go uvmap
- go clean
- go support
- go view
- go flux
- go noise
- go moments
- go velocity
Data analysis in the \textit{uv-plane}

\textbf{MAPPING} procedures / commands

\begin{enumerate}
\item MAPPING\textgreater{} input “command” or help “command”
\item MAPPING\textgreater{} go “command”
\end{enumerate}

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Data analysis in the *uv*-plane

**MAPPING procedures / commands**

MAPPING> input “command” or help “command”
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These can be also found in the widgets:

- go setup
- go uvclip
- **go uvcov**
- go uvshow
- go uvshift
- **go uvfit**
- go plotfit
- go uvshort
- go uvstat
- **go uvmap**
- go clean
- **go support**
- go view
- go flux
- go noise
- **go moments**
- go velocity
Data analysis in the uv-plane

MAPPING> input

INPUT & GO possibilities:

Commands for multichannel viewing:
- VIEW interactive viewing of spectra data cube
- 3VIEW interactive viewing of position/velocity diagrams
- BIT plot a color map of all or selected channels
- MAP plot a contour map of all or selected channels
- XV plot x-axis/velocity diagrams
- VY plot velocity/y-axis diagrams
- SPECTRE plot spectra from a data cube
- VELOCITY plot mean, velocity and width maps
- OVER Overlay bitmaps and contours of several images
- COLOR, LUT Fiddle Color Table

Commands for analysis
- NOISE Compute noise histogram of data cubes
- MOMENT Compute mean, velocity and width maps

Commands for UV-visibility analysis:
- UVSHOW plot UV data for all or selected channels

Commands for multichannel mapping:
- UVMAP compute an image from UV data
- CLEAN clean a dirty image
- SUPPORT define a deconvolution support
- IMAGE compute an image from UV data and clean it
- CCT [Ncc] display Clean Components up to Ncc

Commands for self-calibration:
- SELFCAL compute phase gains using self calibration
Data analysis in the uv-plane

MAPPING procedures / commands

MAPPING> input “command” or help “command”
MAPPING> go “command”

go uv_applyphase
go uv_average
go uv_cal
go uv_ccmodel
go uv_cct
go uv_center
go uv_circle
go uv_clip
go uv_compress
go uv_cuts
go uv_dft
go uv_extract
go uv_fidelity
go uv_flag
go uv_fmodel
go uv_gain
go uv_hanning
go uv_hybrid
go uv_list
go uv_merge
go uv_mflag
go uv_model
go uv_mult
go uv_noise
go uv_observe
go uv_pointing
go uv_short
go uv_sinusphase
go uv_solve
go uv_sort
go uv_splitfield
go uv_substract
go uv_table
go uv_timeaverage
go uv_timebase
go uv_track
go uv_track_phase
go uv_zero
Data analysis in the uv-plane

go uv_circle

MAPPING> help uv_circle

Compute the azimuthal average of the visibilities around the UV plane center. The output UV table gives for each bin one visibility associated to one UV radius. This radius is the actual average of \( \sqrt{U^2+V^2} \) of the visibilities in the bin (i.e. it is not the theoretical bin center). Flagged visibilities are ignored. If no input visibility is found inside a bin, then it is skipped in the output table.

Additional Help Available: UVTABLE$ OUTABLE$ QM

MAPPING> go uv_circle

Note: use only in symmetrical sources.
Data analysis in the *uv*-plane

**go uv_circle**
Data analysis in the uv-plane

`go uv_circle`

This is half of the antenna diameter (to not oversample your plot). However, you could use a smaller number depending on the source.
Data analysis in the \textit{uv-plane}

\texttt{go uv\_circle}
Data analysis in the uv-plane

go uv_circle
Data analysis in the $uv$-plane

MAPPING procedures / commands

```
MAPPING> help "command"
MAPPING> READ UV uvtable-name
MAPPING> "command" [Arg]
MAPPING> WRITE UV uvtable-name-output
```

uv_baseline  uv_map  uv_shift
uv_check    uv_resample  uv_sort
uv_compress  uv_residual  uv_stat
uv_continuum uv_restore  uv_time
uv_flag      uv_reweight uv_truncate
uv_filter
Data analysis in the *uv*-plane

**uv_compress**
Data analysis in the *uv*-plane

**uv_compress**

[MAPPING]> help uv_compress
    [CLEAN]\]UV_COMPRESS Nc

Resample the UV data loaded by READ UV by averaging NC adjacent channels. All other UV commands except UV_RESAMPLE work on the "Resampled" UV table.

The "Resampled" UV table is a simple copy of the original one after a READ UV command, or after a UV_RESAMPLE or UV_COMPRESS commands without arguments.

[MAPPING]> read uv usb
W-GDF_READ_UVDATASET, Producing a UVT order
I-PAUSE, Generated by pressing ^C
[MAPPING]> uv_compress 15
I-UV_COMPRESS, Averaging by chunks of 15 channels
[MAPPING]> write uv usb-comp
[MAPPING]> $ls usb-comp.uvt
usb-comp.uvt
Data analysis in the *uv*-plane

**uv_compress**
Data analysis in the *uv*-plane

How to create a continuum uv table from a cube?

1. **uv_filter**: to filter channels with line emission

```
MAPPING> help uv_filter
[CLEAN]UV_FILTER [/ZERO] [/CHANNELS Channel_List] [/FREQUENCY List
Of Frequencies] [/WIDTH Width]
```

"Filter" line emission, by flagging the corresponding channels. The
channels can be specified either by the /CHANNEL option or by the /FRE-
QUENCY and /WIDTH options.

2. **uv_continuum**: to create uv table from the filtered one

```
MAPPING> help uv_continuum
[CLEAN]UV_CONTINUUM Naver [First Last]
```

Transform the (presumably spectral line) UV data set loaded by READ UV
into a "continuum" data set.

The transformation selects line channels from First to Last, average
them by groups of Naver contiguous channels, and concatenate the result-
ing visibilities into a "continuum" UV table.

...
Data analysis in the uv-plane

MAPPING procedures / commands

MAPPING> help “command”
MAPPING> READ UV uvtable-name
MAPPING> “command” [Arg]
MAPPING> WRITE UV uvtable-name-output

uv_baseline
uv_check
uv_compress
uv_continuum
uv_flag
uv_filter
uv_map
uv_resample
uv_residual
uv_restore
uv_reweight
uv_shift
uv_sort
uv_stat
uv_time
uv_truncate
Data analysis in the *uv*-plane

**MAPPING procedures / commands**

```
MAPPING> help "command"
MAPPING> READ UV uvtable-name
MAPPING> "command" [Arg]
MAPPING> WRITE UV uvtable-name-output
```

- `uv_baseline`
- `uv_check`
- `uv_compress`
- `uv_continuum`
- `uv_flag`
- `uv_filter`
- `uv_map`
- `uv_resample`
- `uv_residual`
- `uv_restore`
- `uv_reweigh`
- `uv_shift`
- `uv_sort`
- `uv_stat`
- `uv_time`

**MAPPING> type**
To see in the screen all commands that you have typed
Data analysis in the *uv*-plane

*uv* tables are fully editable

Each visibility contains:

- *u* in meters
- *v* in meters
- scan number
- observation date (CLASS number)
- time in seconds (since date above)
- start antenna in the baseline
- end antenna in the baseline
- real part
- imaginary part
- weight
- real part for 2\textsuperscript{nd} channel
- imaginary part
- ...

**uv** table [ visib dimension, # visibilities ]

visib dimension = 7 + 3 x (# channels)

7 visib. characteristics

mapping> define table aa mytable.uvt write
mapping> let aa[8,2380] 6000
mapping> delete /variable aa

Data at 2\textsuperscript{nd} channel
3. An inspection of the data in the $uv$-plane is recommended
(1) Passing directly from hp → mapping

It may happen...
(1) Passing directly from hpb → mapping

It may happen...
It may happen... that there remain some wrong visibilities
(1) Passing directly from hpb → mapping

It may happen... that there remain some wrong visibilities

MAPPING> uv_flag

Return to CLIC to identify the wrong visibilities and flag them in the hpb file

Bad data
(1) ______________ Passing directly from hpb → mapping

It may happen... that there remain some wrong visibilities

Returning to CLIC to flag the bad visibilities

```
File  Edit  View  Search  Terminal  Help

CLIC> set aver scan
CLIC> set y amp
I-SET_DATA,[0000] Displaying 122773 points in each of 36 boxes
Y axis : Amplitude, 0.00 to *
CLIC> set x time
I-SET_DATA,[0000] Displaying 122773 points in each of 36 boxes
X axis : Time, * to *
CLIC> find /proc corr /type o
I-FIND,[0000] New generation receivers data
I-FIND,[0000] 418 observations found
CLIC> plot /id col
I-GET,[2595] Entry 985 Observation 985; 12
I-SET_DATA,[2595] Displaying 122773 points in each of 36 boxes
I-GET,[2594] Entry 984 Observation 984; 11
```
(1) Passing directly from hpb → mapping
(1) Passing directly from hpb → mapping

CLIC> set Y axis:
I-SET_DATA
CLIC> set X axis:
I-SET_DATA
CLIC> find I-FIND,[000]
I-FIND,[000]
CLIC> plot I-GET,[259]
I-SET_DATA
I-GET,[259]

CLIC> cursor To define the scan range
(1) Passing directly from hpb → mapping

It may happen... that there remain some wrong visibilities

CLIC> set aver scan
CLIC> set y amp
I-SET_DATA,[0000] Displaying 122773 points in each of 36 boxes
  Y axis : Amplitude , 0.00 to *
CLIC> set x time
I-SET_DATA,[0000] Displaying 122773 points in each of 36 boxes
  X axis : Time , * to *
CLIC> find /proc corr /type o
I-FIND,[0000] New generation receivers data
I-FIND,[0000] 418 observations found
CLIC> plot /id col
I-GET,[2595] Entry 985 Observation 985; 12
I-SET_DATA,[2595] Displaying 122773 points in each of 36 boxes
I-GET,[2594] Entry 984 Observation 984; 11

CLIC> find /procedure corr /type object /scans 1245 1255
CLIC> store quality 9
(1) Passing directly from hpb → mapping

```
CLIC> set X axis: I-SET_DATA
CLIC> set Y axis: I-SET_DATA
CLIC> find X-FIND,[00]
CLIC> find Y-FIND,[00]
CLIC> plot I-GET,[259]
CLIC> I-SET_DATA I-GET,[259]
CLIC> store quality 9
```
(2) Passing directly from hpb → mapping

When short-spacing data, check that the relative calibration is ok

+ Short-spacing data
(3) Passing directly from hpb → mapping

Good practice: When cleaning (extended sources)…

Dirty image

Uvradius vs Amp
(3) Passing directly from hpb → mapping

Good practice: When cleaning (extended sources) verify that the flux obtained in the image plane coincides with that at the zero-spacing

Clean image
(3) Passing directly from hpb → mapping

If not, it may happen...

CCT

Clean image

When cleaning (extended sources)
verify that the flux obtained in the image plane
coincides with that at the zero-spacing
To conclude:

• An inspection of data in the $uv$-plane is recommended for all the projects

• A detailed analysis in the $uv$-plane: detection, modeling of simple shapes, to check relative calibration, etc…