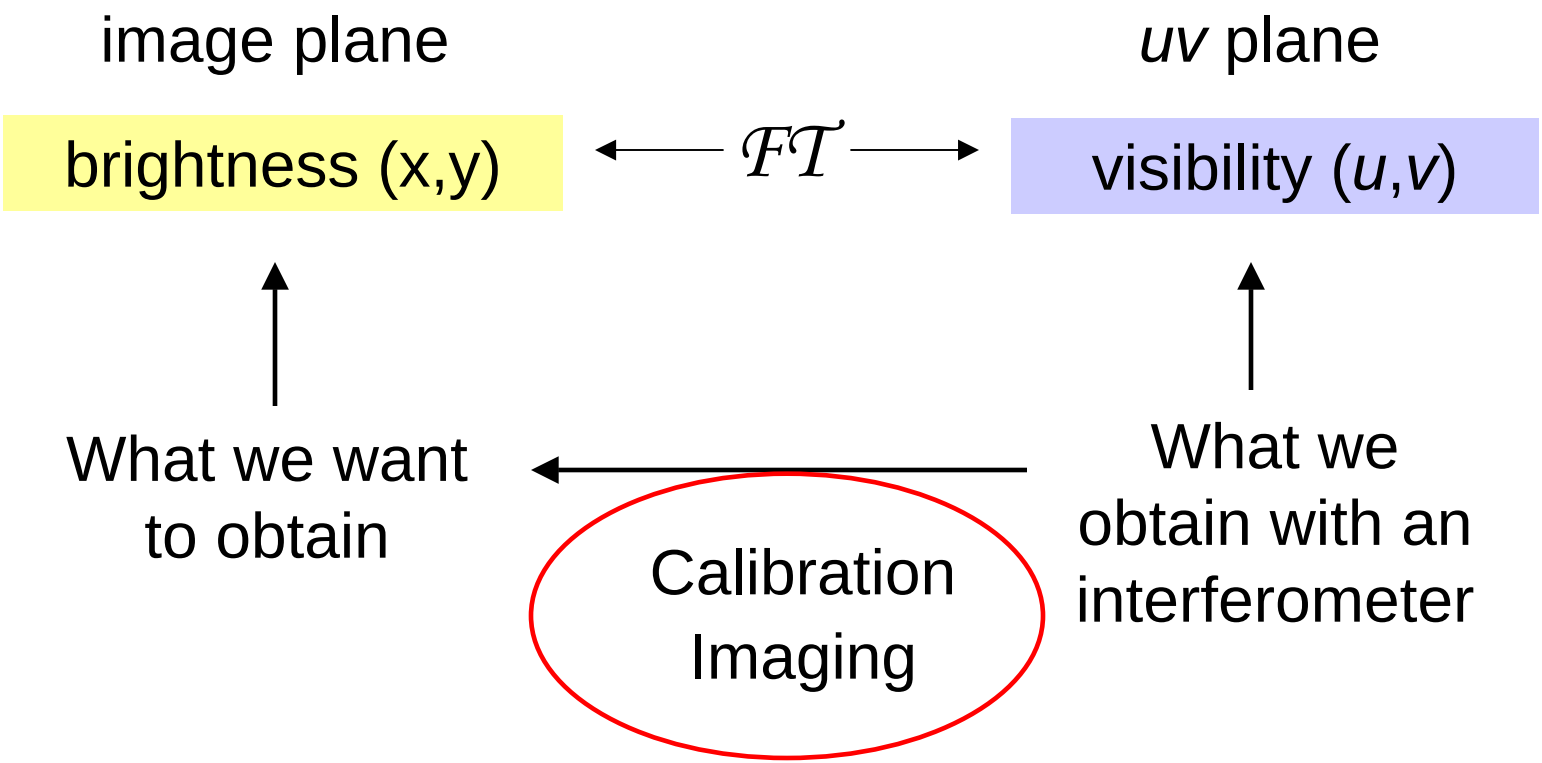
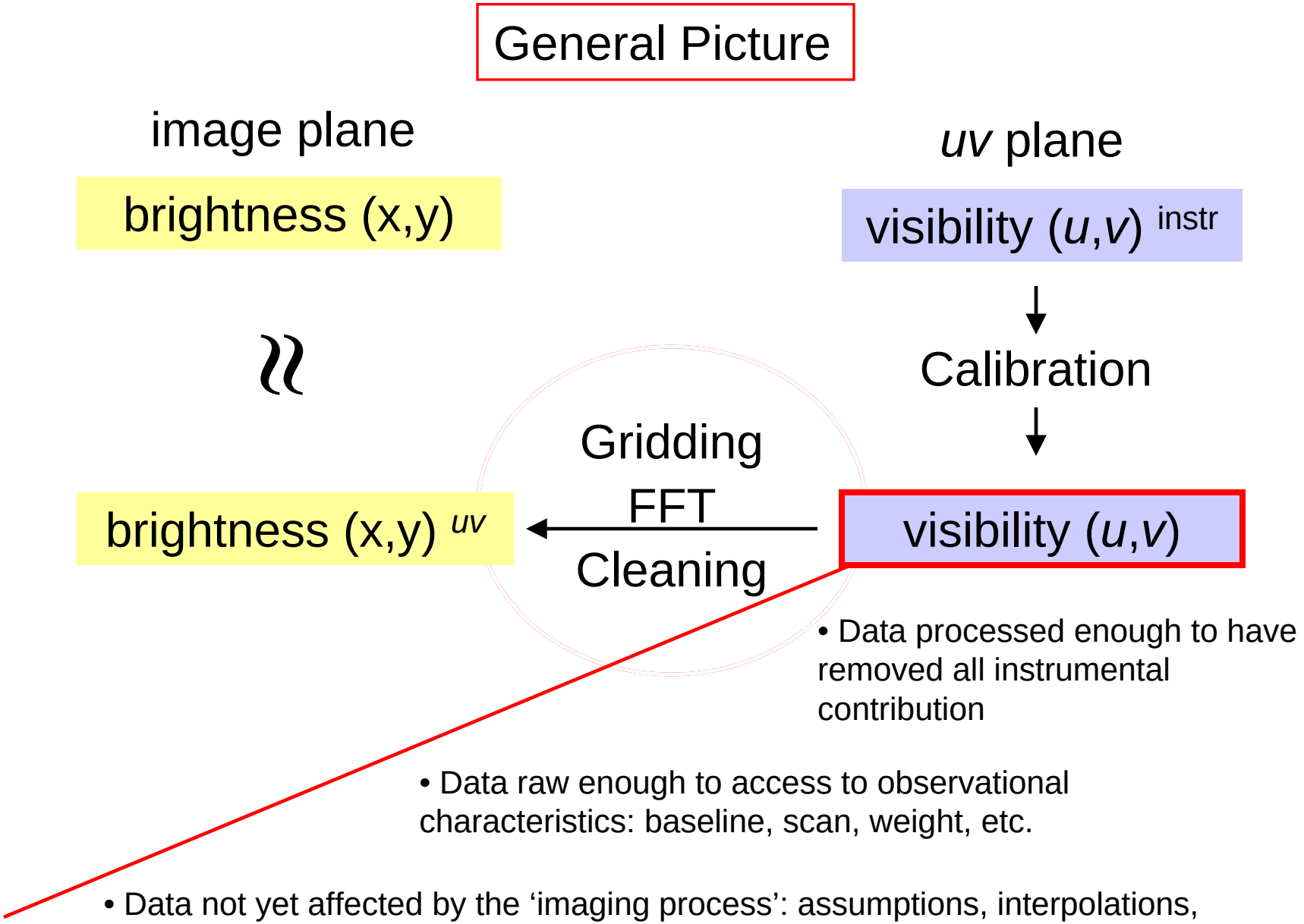
PdBI *UV*-Data Analysis and Imaging in practice

Arancha Castro-Carrizo

General Picture




General Picture
image plane
brightness (x,y)
≈
brightness (x,y) uv
uv plane
visibility (u,v) instr
Calibration
Gridding
FFT
Cleaning
visibility (u,v)
• 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

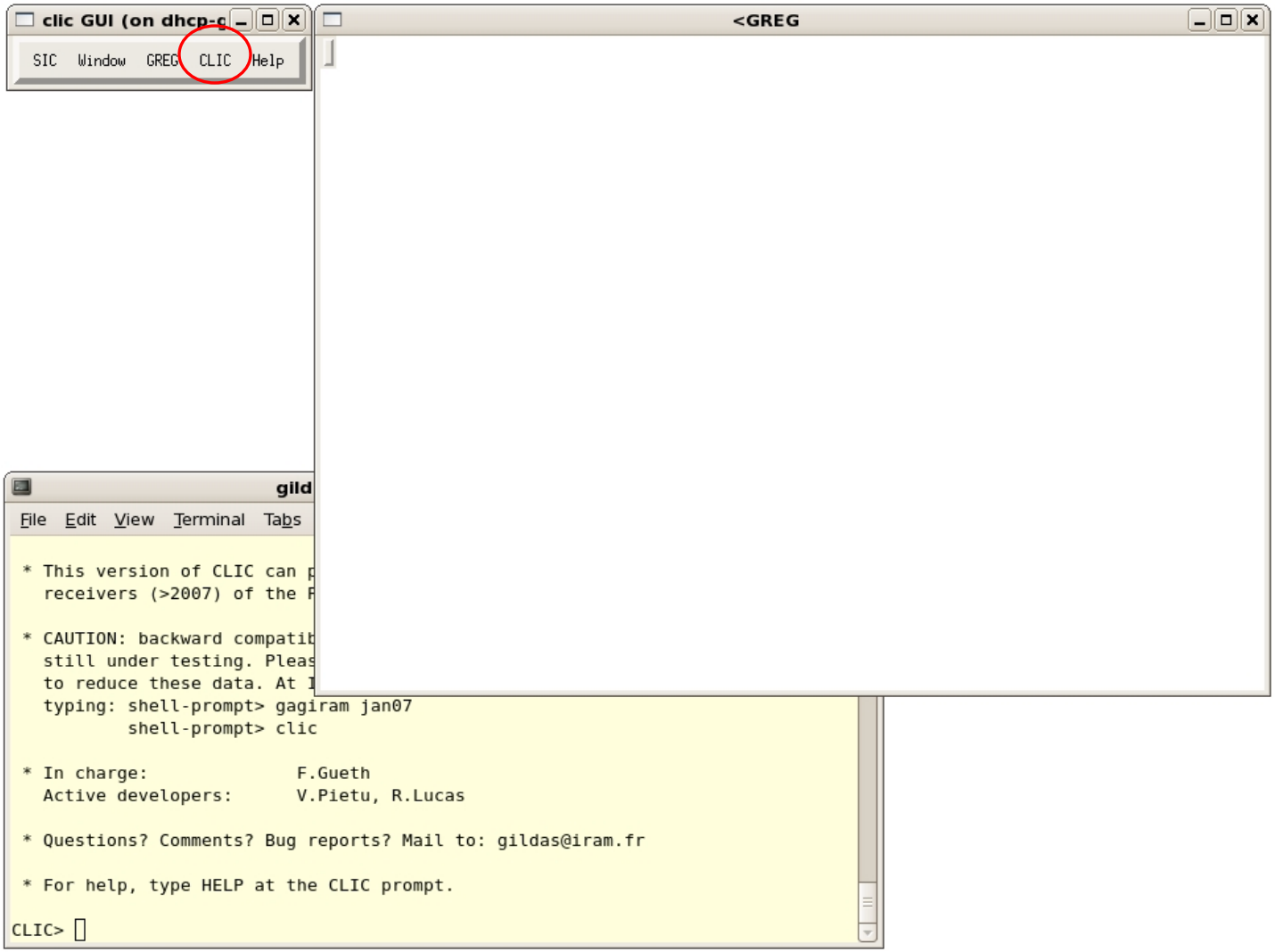
1. Let’s create a uv-table, in CLIC
2. Data analysis, in MAPPING

- Data analysis in the *uv*-plane
- Imaging in practice (demo tb followed)
- An inspection of the *uv*-data needed

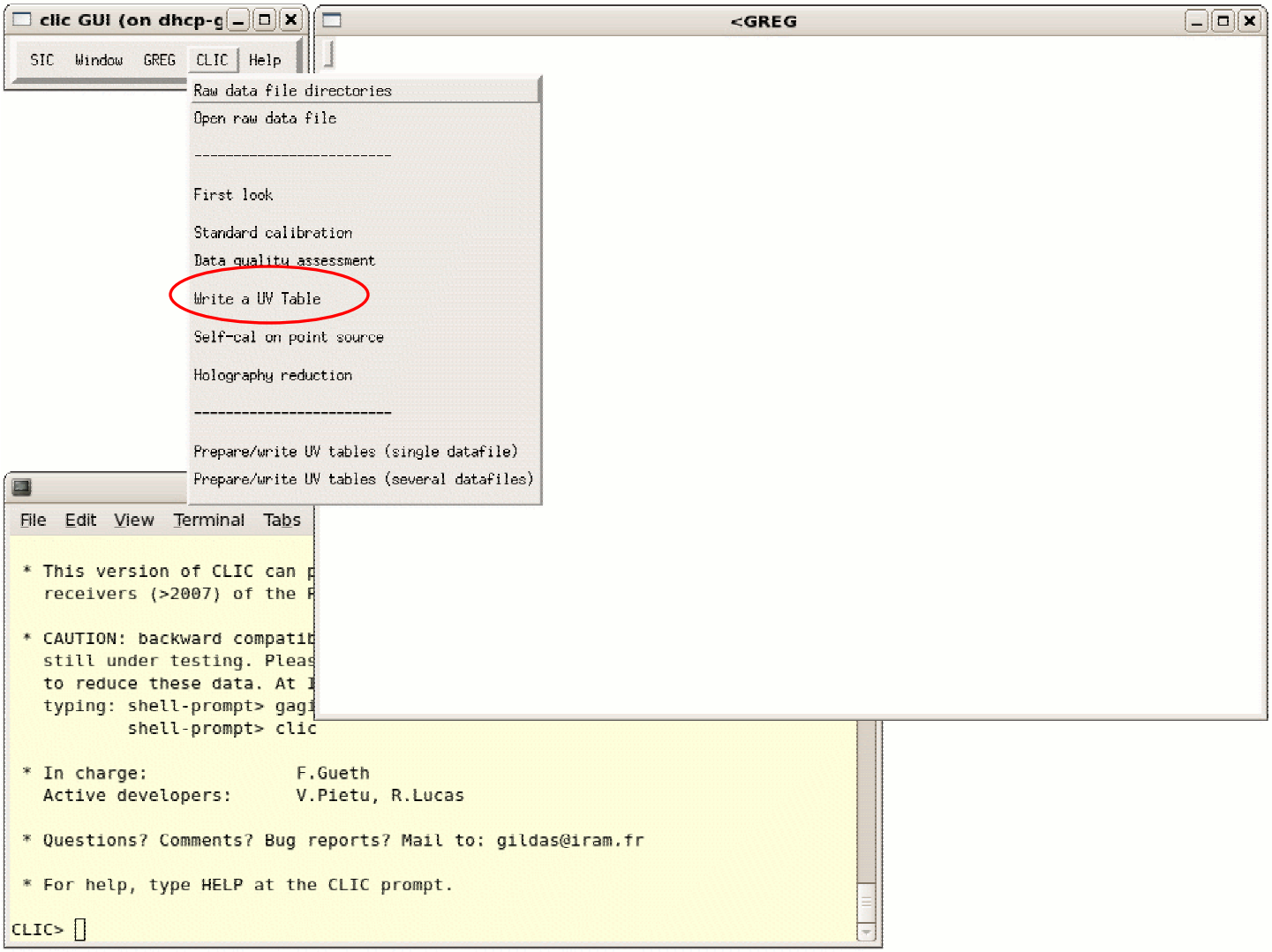
Let’s create a table (“mytable”.uvt),

in CLIC

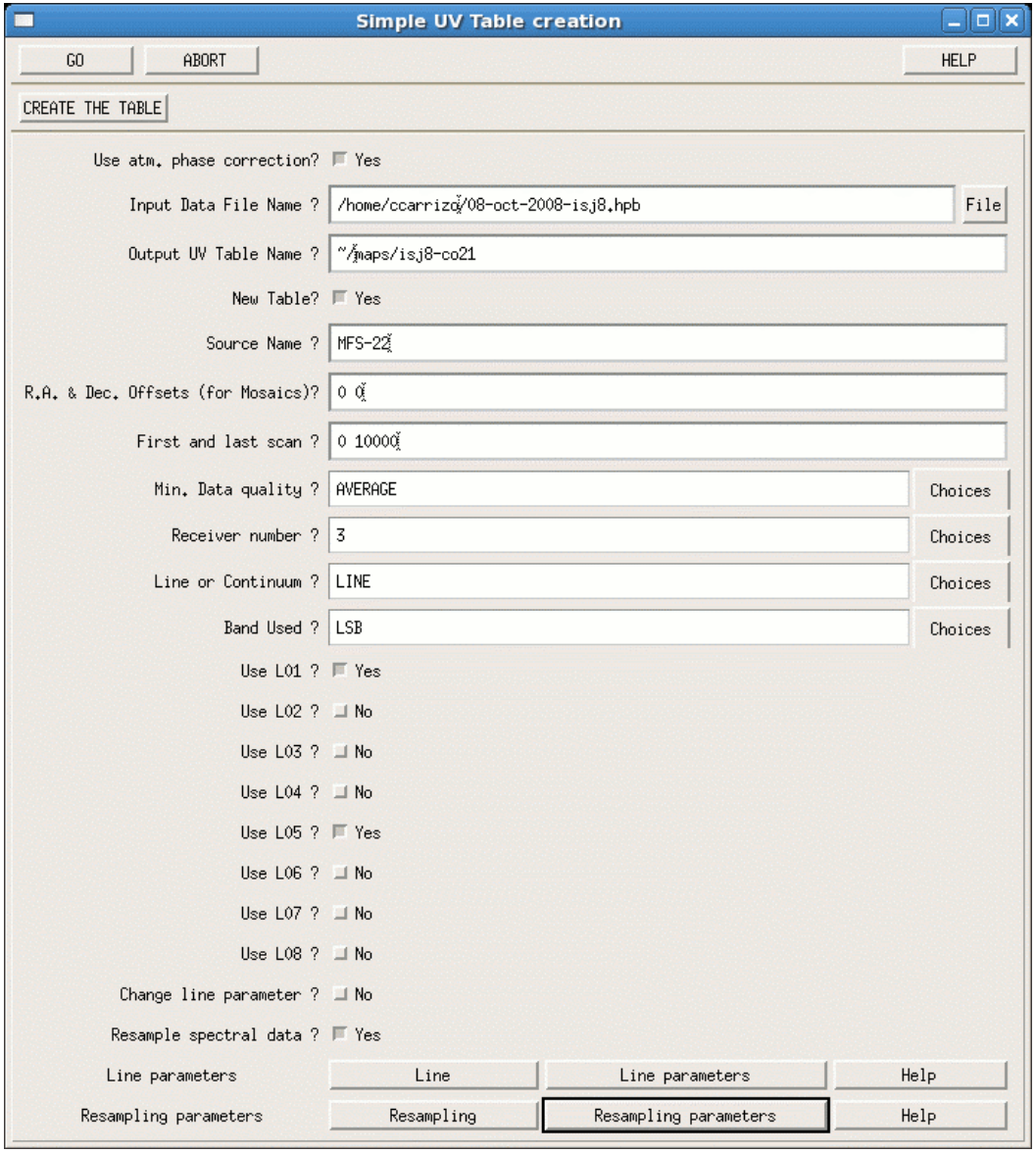
Creating a *uv*-table; **CLIC**



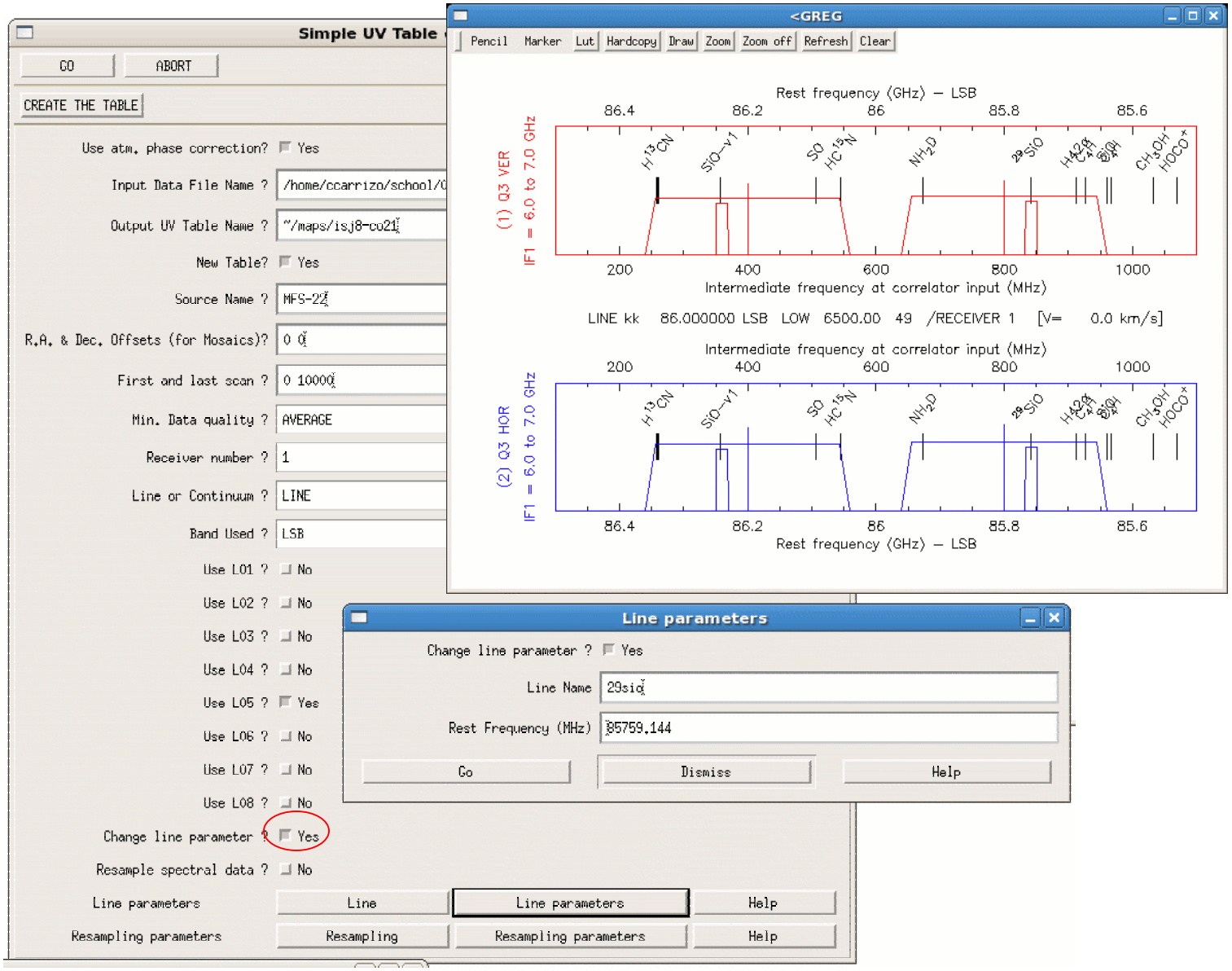
Creating a *uv*-table; CLIC



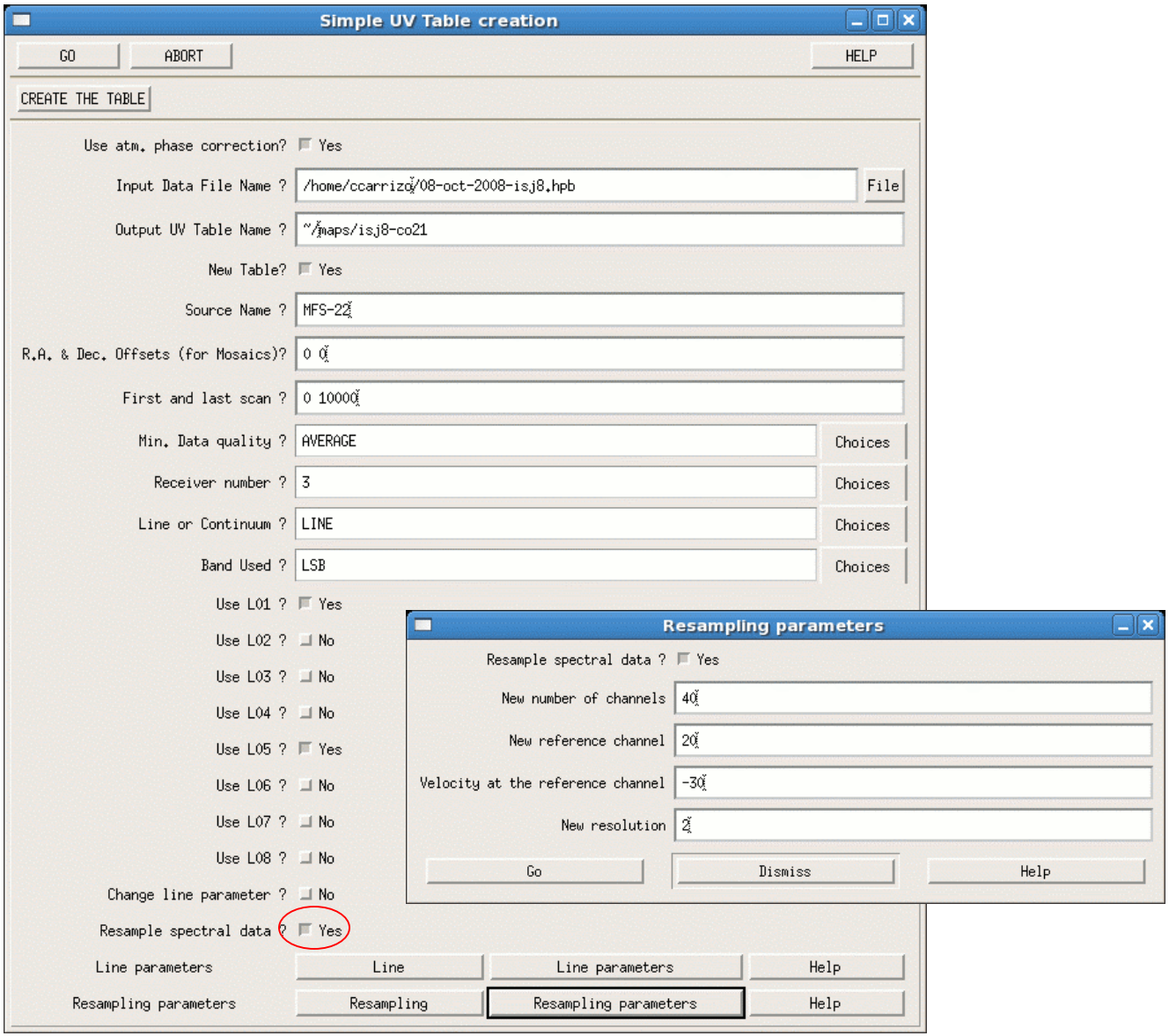
Creating a *uv*-table; CLIC

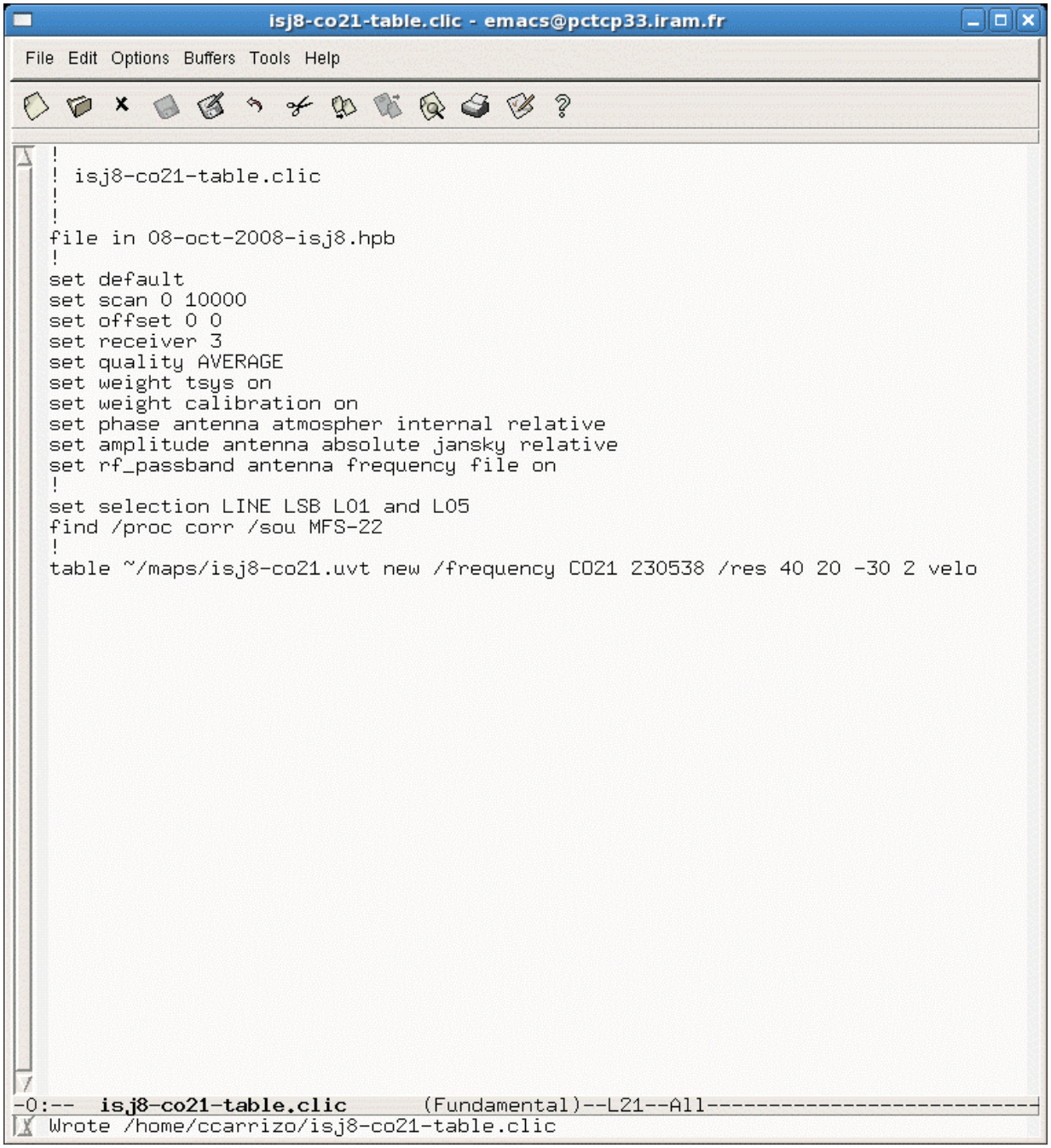


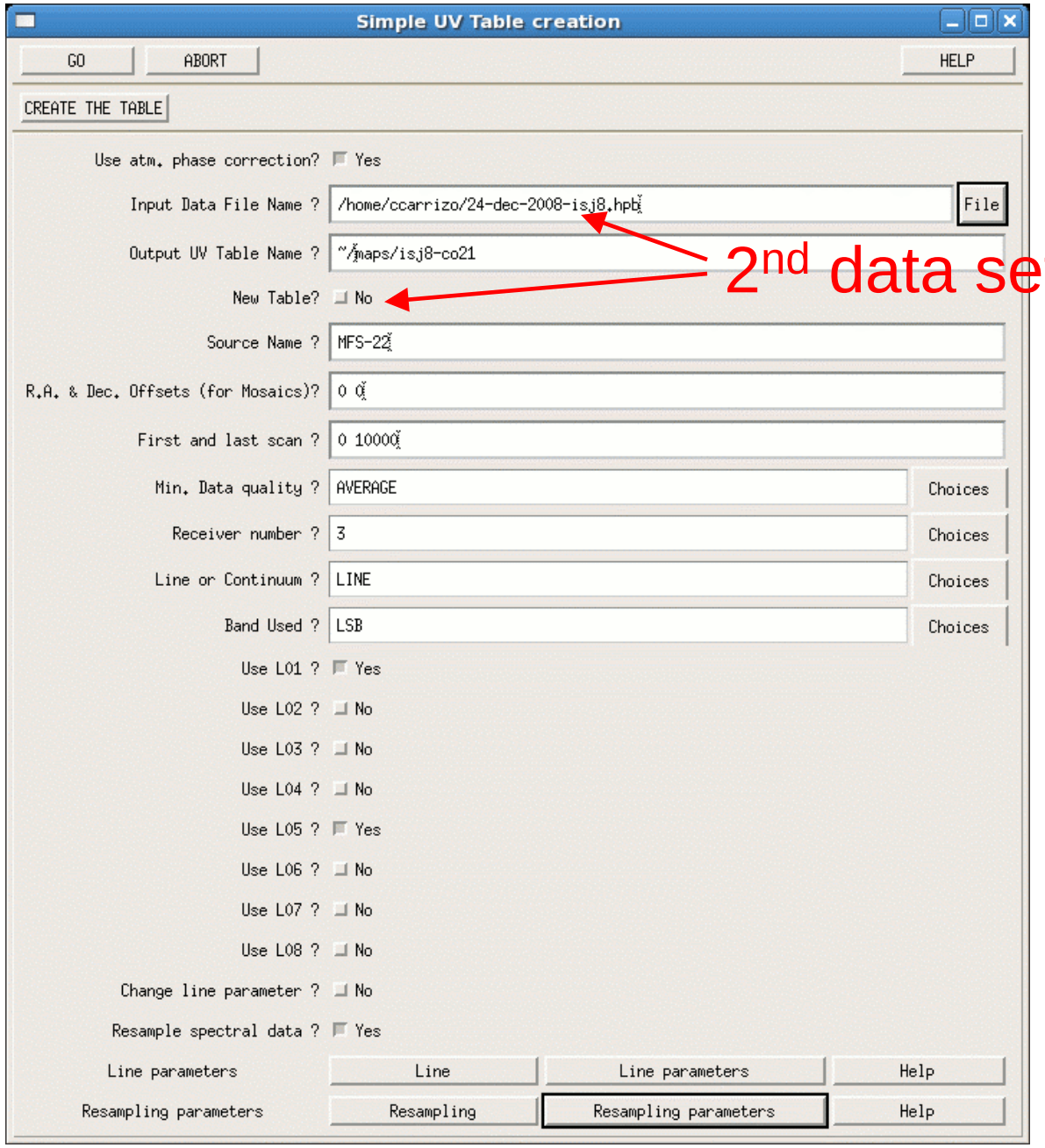
Creating a *uv*-table; CLIC

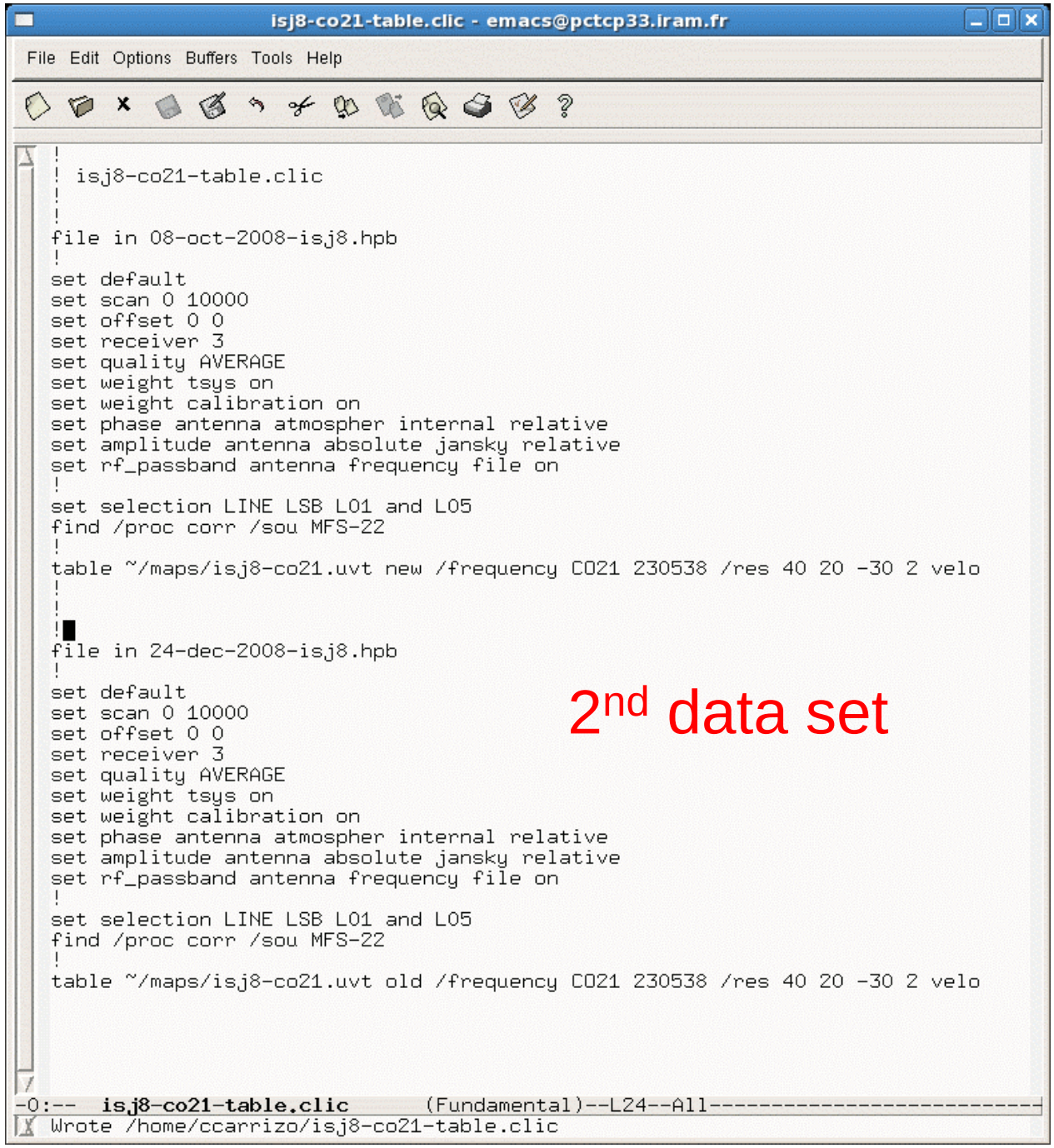


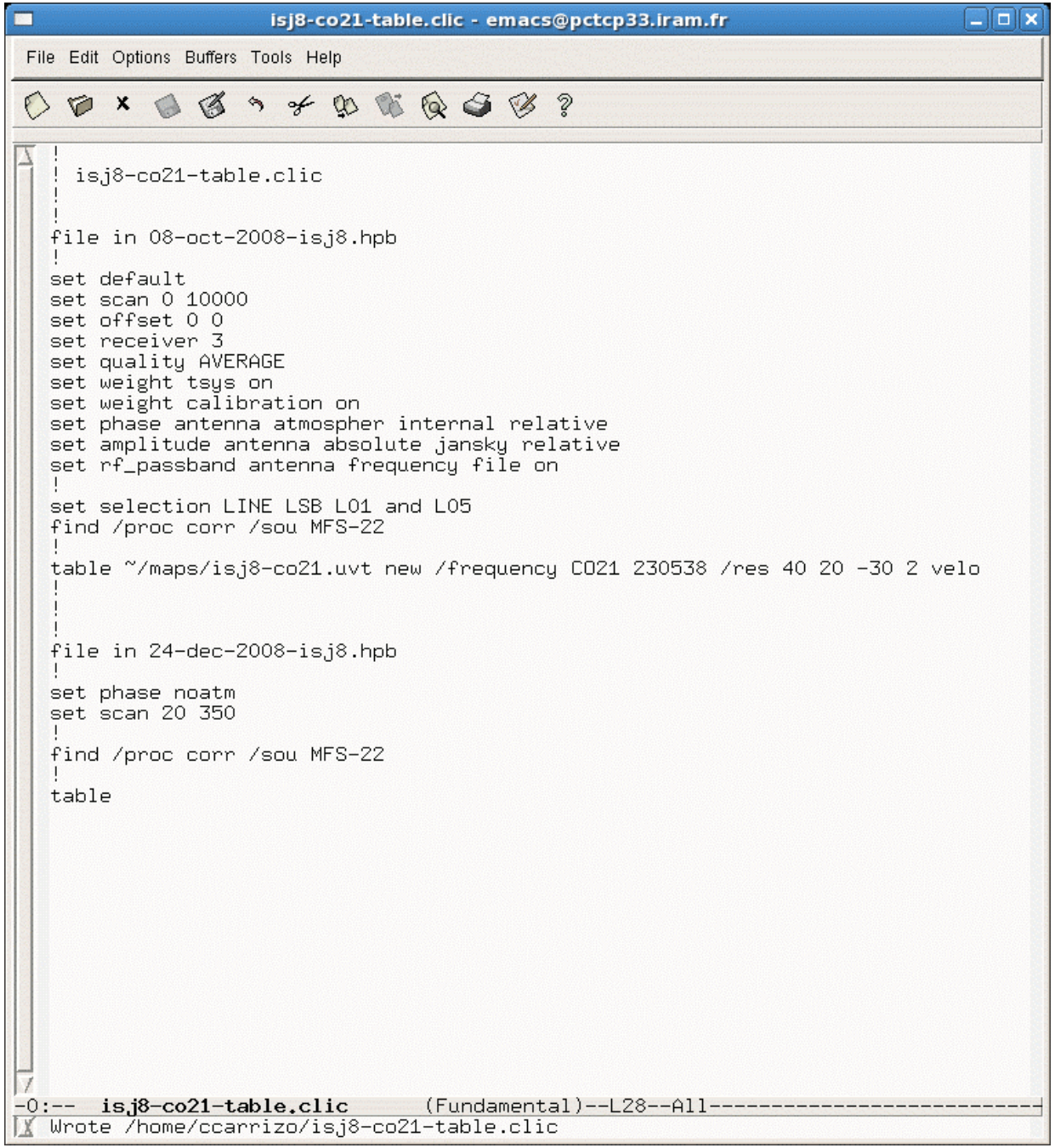
Creating a *uv*-table; CLIC

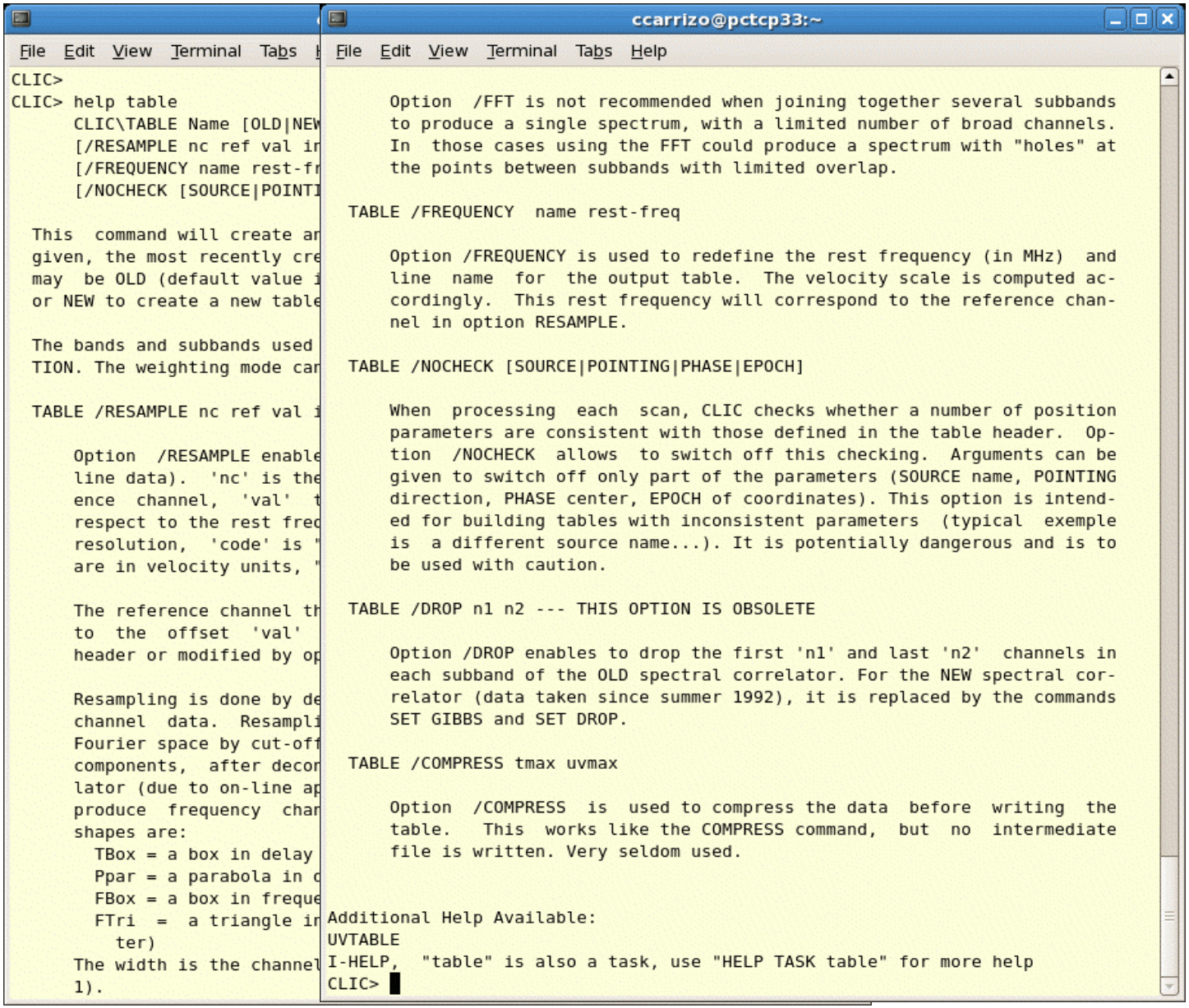


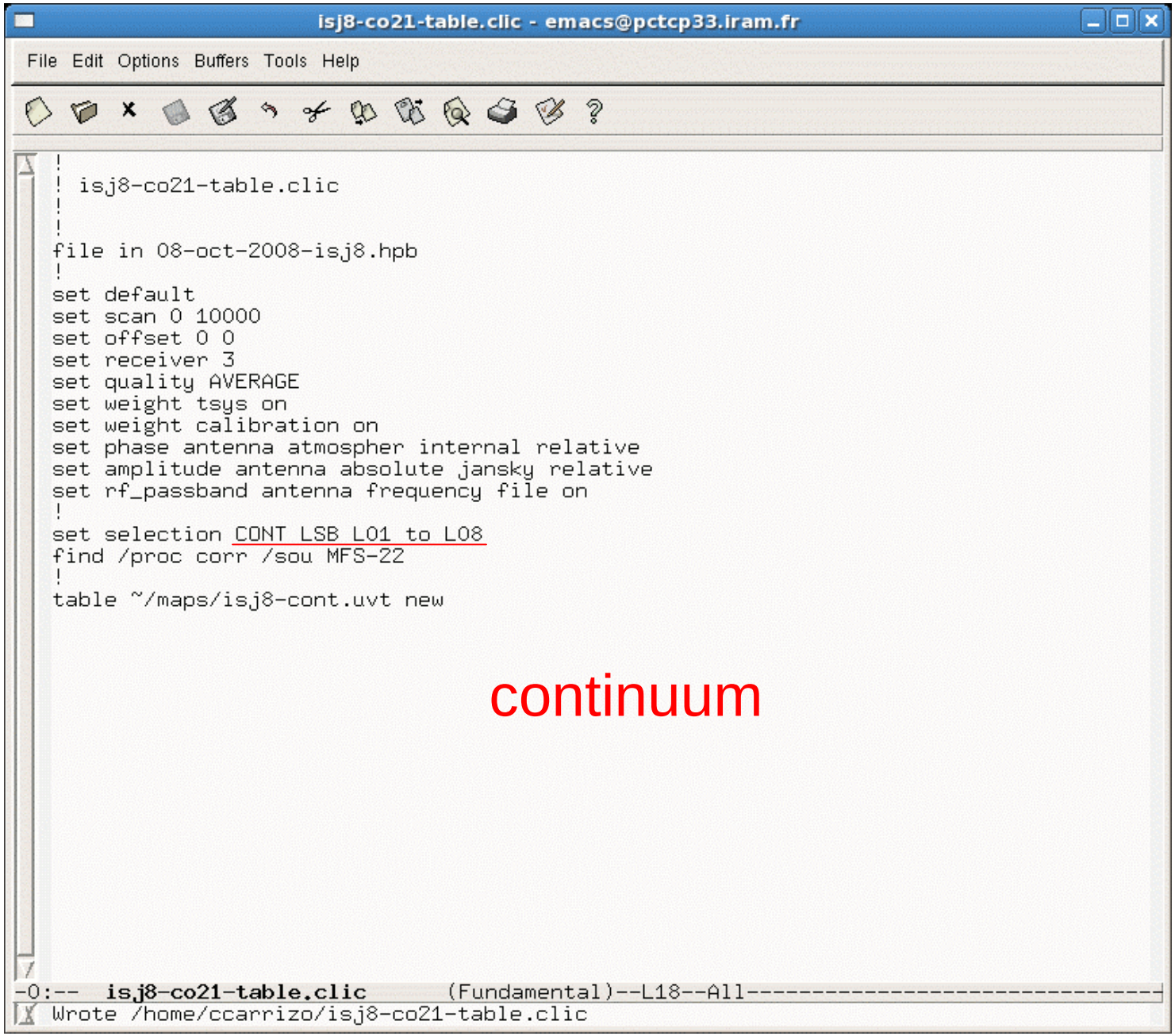

isj8-co21-table.clic - emacs@pctcp33.iram.fr
File Edit Options Buffers Tools Help
!
! isj8-co21-table.clic
!
!
file in 08-oct-2008-isj8.hpb
!
set default
set scan 0 10000
set offset 0 0
set receiver 3
set quality AVERAGE
set weight tsys on
set weight calibration on
set phase antenna atmospher internal relative
set amplitude antenna absolute jansky relative
set rf_passband antenna frequency file on
!
set selection LINE LSB L01 and L05
find /proc corr /sou MFS-22
!
table ~/maps/isj8-co21.uvt new /frequency CO21 230538 /res 40 20 -30 2 velo
-0:-- isj8-co21-table.clic (Fundamental)--L21--All
Wrote /home/ccarrizo/isj8-co21-table.clic

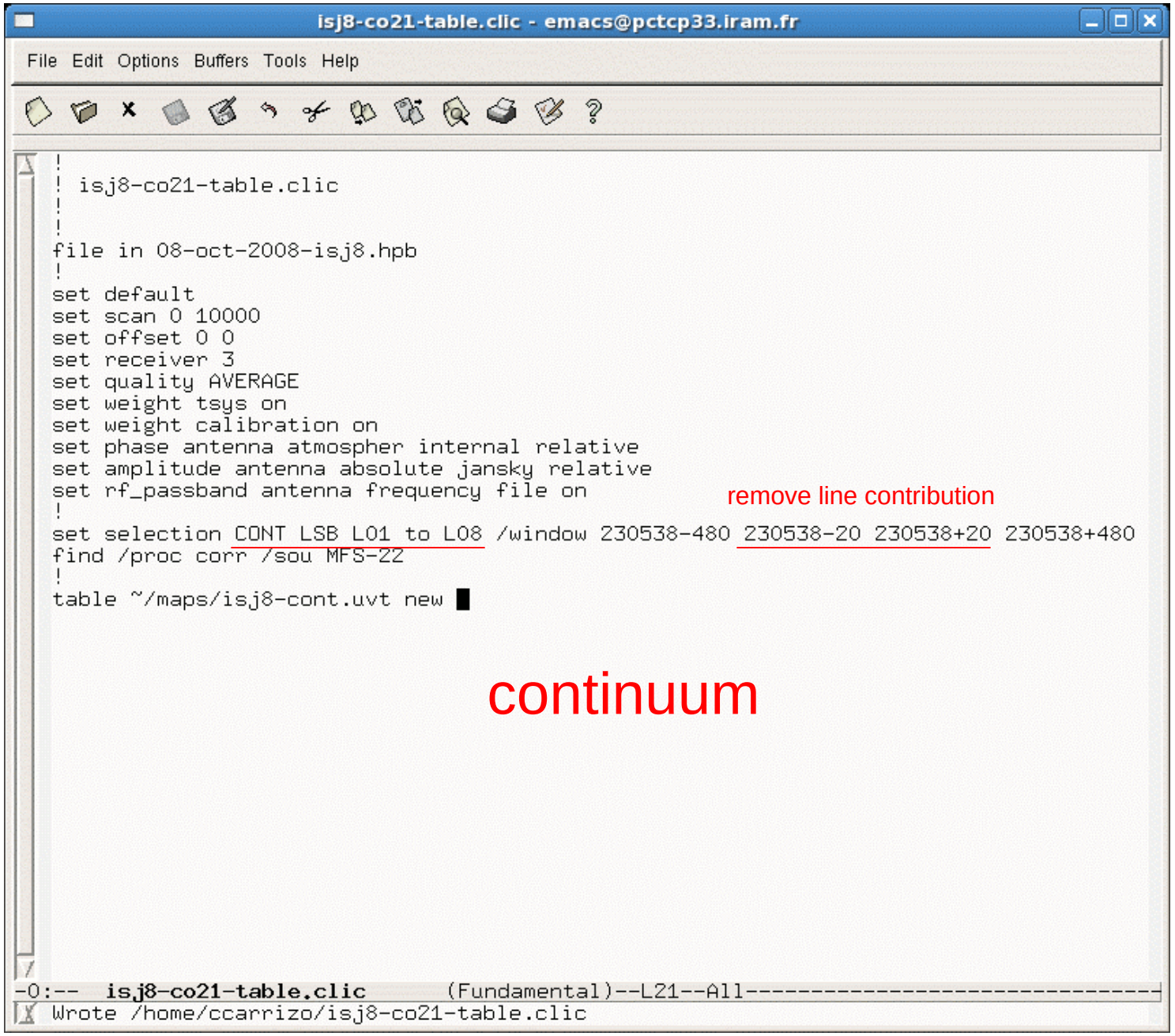

Simple UV Table creation
GO
ABORT
HELP
CREATE THE TABLE
Use atm. phase correction? Yes
Input Data File Name ? /home/ccarrizo/24-dec-2008-isj8.hpb
File
Output UV Table Name ? ~/maps/isj8-co21
New Table? No
Source Name ? MFS-22
R.A. & Dec. Offsets (for Mosaics)? 0 0
First and last scan ? 0 10000
Min. Data quality ? AVERAGE
Choices
Receiver number ? 3
Choices
Line or Continuum ? LINE
Choices
Band Used ? LSB
Choices
Use L01 ? Yes
Use L02 ? No
Use L03 ? No
Use L04 ? No
Use L05 ? Yes
Use L06 ? No
Use L07 ? No
Use L08 ? No
Change line parameter ? No
Resample spectral data ? Yes
Line parameters
Line
Line parameters
Help
Resampling parameters
Resampling
Resampling parameters
Help
2nd data set

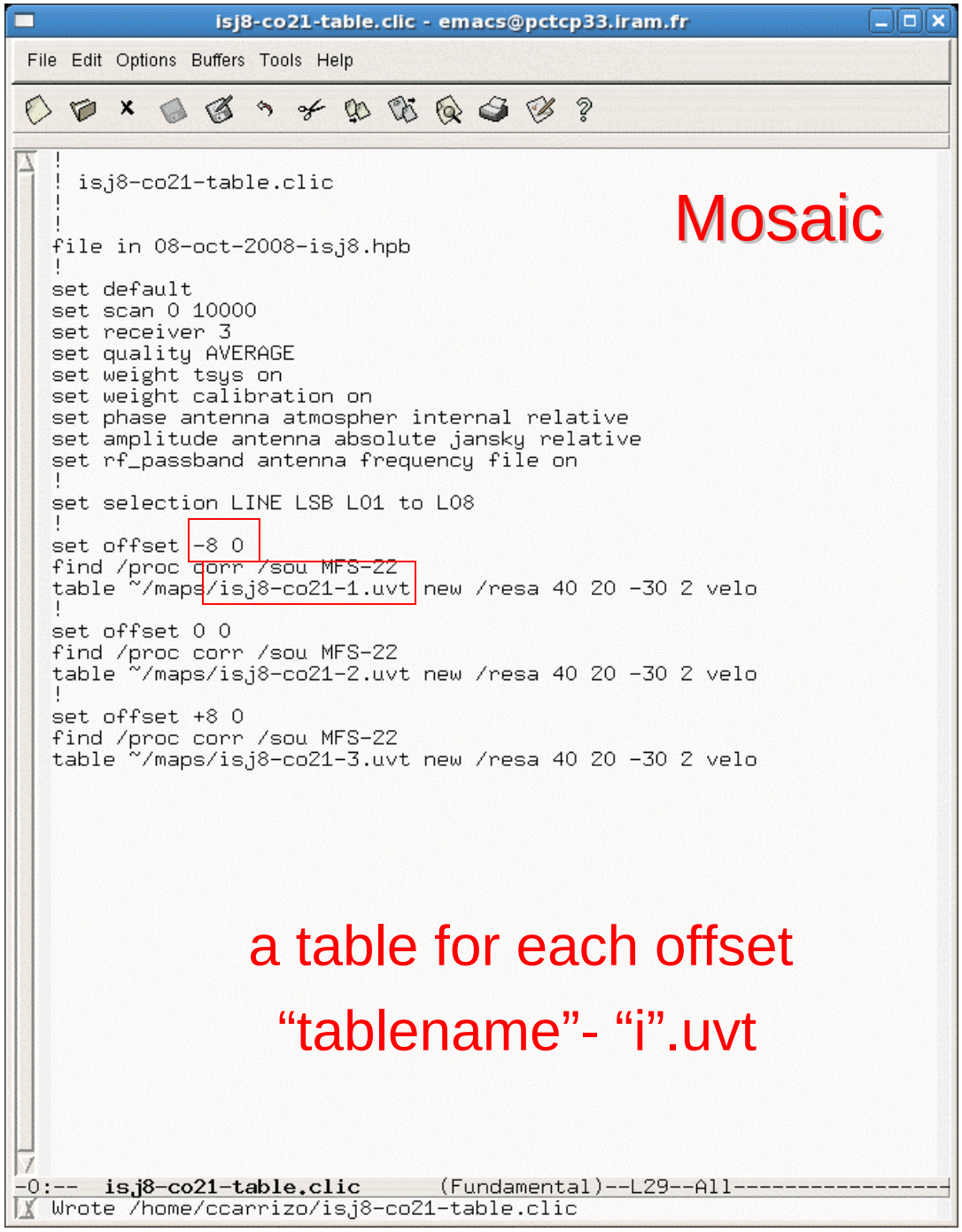

isj8-co21-table.clic - emacs@pctcp33.iram.fr
File Edit Options Buffers Tools Help
!
! isj8-co21-table.clic
!
!
file in 08-oct-2008-isj8.hpb
!
set default
set scan 0 10000
set offset 0 0
set receiver 3
set quality AVERAGE
set weight tsys on
set weight calibration on
set phase antenna atmospher internal relative
set amplitude antenna absolute jansky relative
set rf_passband antenna frequency file on
!
set selection LINE LSB L01 and L05
find /proc corr /sou MFS-22
!
table ~/maps/isj8-co21.uvt new /frequency CO21 230538 /res 40 20 -30 2 velo
!
!
!
file in 24-dec-2008-isj8.hpb
!
set default
set scan 0 10000
set offset 0 0
set receiver 3
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 L05
find /proc corr /sou MFS-22
!
table ~/maps/isj8-co21.uvt old /frequency CO21 230538 /res 40 20 -30 2 velo
2nd data set
-0:-- isj8-co21-table.clic (Fundamental)--L24--All
Wrote /home/ccarrizo/isj8-co21-table.clic

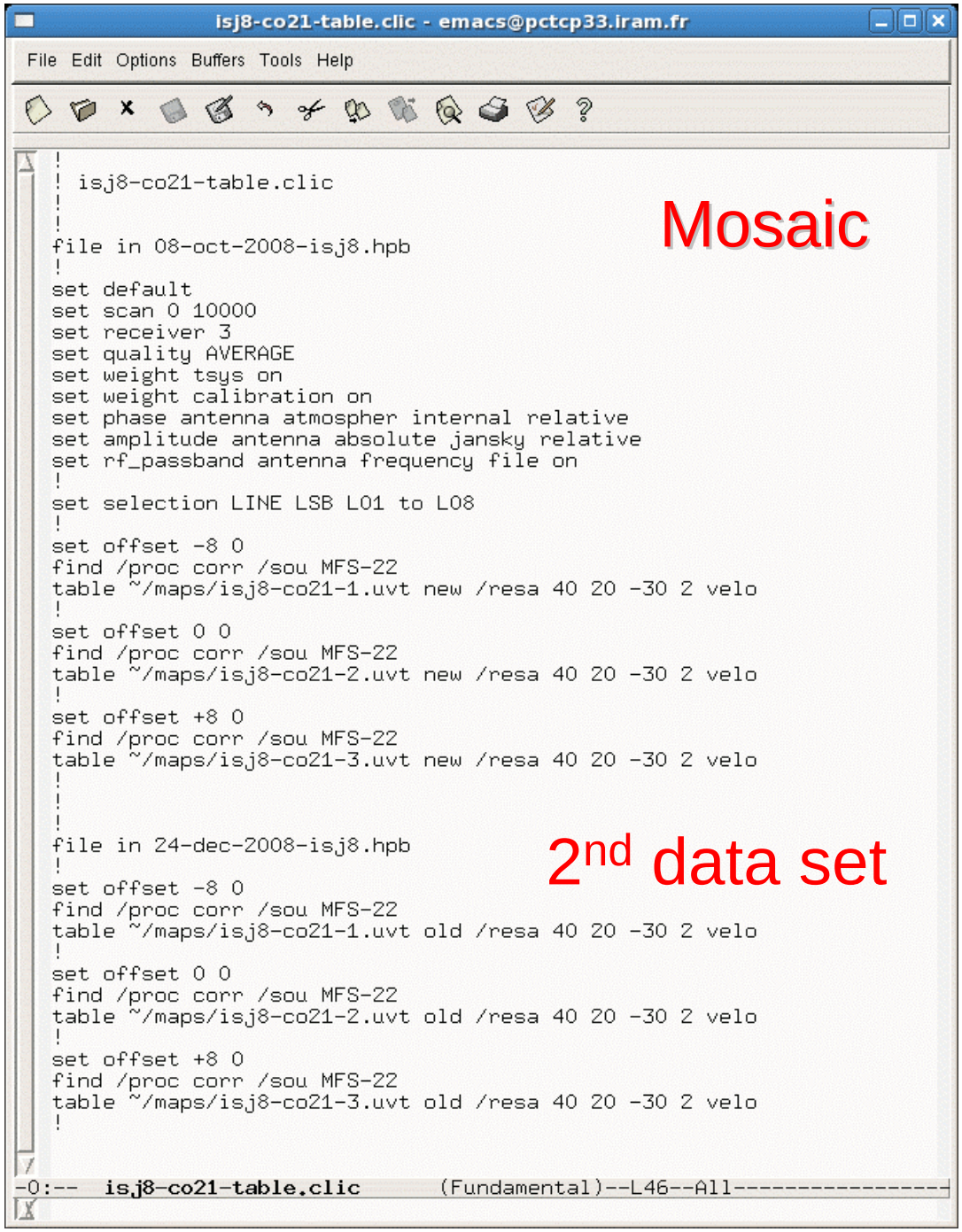

isj8-co21-table.clic - emacs@pctcp33.iram.fr
File Edit Options Buffers Tools Help
!
! isj8-co21-table.clic
!
!
file in 08-oct-2008-isj8.hpb
!
set default
set scan 0 10000
set offset 0 0
set receiver 3
set quality AVERAGE
set weight tsys on
set weight calibration on
set phase antenna atmospher internal relative
set amplitude antenna absolute jansky relative
set rf_passband antenna frequency file on
!
set selection LINE LSB L01 and L05
find /proc corr /sou MFS-22
!
table ~/maps/isj8-co21.uvt new /frequency CO21 230538 /res 40 20 -30 2 velo
!
!
!
file in 24-dec-2008-isj8.hpb
!
set phase noatm
set scan 20 350
!
find /proc corr /sou MFS-22
!
table
-0:-- isj8-co21-table.clic (Fundamental)--L28--All
Wrote /home/ccarrizo/isj8-co21-table.clic


File Edit View Terminal Tabs
CLIC>
CLIC> help table
CLIC\TABLE Name [OLD|NEW
[/RESAMPLE nc ref val in
[/FREQUENCY name rest-fr
[/NOCHECK [SOURCE|POINTI
This command will create ar
given, the most recently cre
may be OLD (default value i
or NEW to create a new table
The bands and subbands used
TION. The weighting mode car
TABLE /RESAMPLE nc ref val i
Option /RESAMPLE enable
line data). 'nc' is the
ence channel, 'val' t
respect to the rest freq
resolution, 'code' is "
are in velocity units, "
The reference channel th
to the offset 'val'
header or modified by op
Resampling is done by de
channel data. Resampli
Fourier space by cut-off
components, after decor
lator (due to on-line ap
produce frequency char
shapes are:
TBox = a box in delay
Ppar = a parabola in d
FBox = a box in freque
FTri = a triangle in
ter)
The width is the channel
1).
ccarrizo@pctcp33:~
File Edit View Terminal Tabs Help
Option /FFT is not recommended when joining together several subbands
to produce a single spectrum, with a limited number of broad channels.
In those cases using the FFT could produce a spectrum with "holes" at
the points between subbands with limited overlap.
TABLE /FREQUENCY name rest-freq
Option /FREQUENCY is used to redefine the rest frequency (in MHz) and
line name for the output table. The velocity scale is computed ac-
cordingly. This rest frequency will correspond to the reference chan-
nel in option RESAMPLE.
TABLE /NOCHECK [SOURCE|POINTING|PHASE|EPOCH]
When processing each scan, CLIC checks whether a number of position
parameters are consistent with those defined in the table header. Op-
tion /NOCHECK allows to switch off this checking. Arguments can be
given to switch off only part of the parameters (SOURCE name, POINTING
direction, PHASE center, EPOCH of coordinates). This option is intend-
ed for building tables with inconsistent parameters (typical exemple
is a different source name...). It is potentially dangerous and is to
be used with caution.
TABLE /DROP n1 n2 --- THIS OPTION IS OBSOLETE
Option /DROP enables to drop the first 'n1' and last 'n2' channels in
each subband of the OLD spectral correlator. For the NEW spectral cor-
relator (data taken since summer 1992), it is replaced by the commands
SET GIBBS and SET DROP.
TABLE /COMPRESS tmax uvmax
Option /COMPRESS is used to compress the data before writing the
table. This works like the COMPRESS command, but no intermediate
file is written. Very seldom used.
Additional Help Available:
UVTABLE
I-HELP, "table" is also a task, use "HELP TASK table" for more help
CLIC>


isj8-co21-table.clic - emacs@pctcp33.iram.fr
File Edit Options Buffers Tools Help
!
! isj8-co21-table.clic
!
!
file in 08-oct-2008-isj8.hpb
!
set default
set scan 0 10000
set offset 0 0
set receiver 3
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 CONT LSB L01 to L08
find /proc corr /sou MFS-22
!
table ~/maps/isj8-cont.uvt new
continuum
-0:-- isj8-co21-table.clic (Fundamental)--L18--All
Wrote /home/ccarrizo/isj8-co21-table.clic


isj8-co21-table.clic - emacs@pctcp33.iram.fr
File Edit Options Buffers Tools Help
!
! isj8-co21-table.clic
!
!
file in 08-oct-2008-isj8.hpb
!
set default
set scan 0 10000
set offset 0 0
set receiver 3
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 CONT LSB L01 to L08 /window 230538-480 230538-20 230538+20 230538+480
find /proc corr /sou MFS-22
!
table ~/maps/isj8-cont.uvt new
remove line contribution
continuum
-0:-- isj8-co21-table.clic (Fundamental)--L21--All
Wrote /home/ccarrizo/isj8-co21-table.clic


isj8-co21-table.clic - emacs@pctcp33.iram.fr
File Edit Options Buffers Tools Help
!
! isj8-co21-table.clic
!
!
file in 08-oct-2008-isj8.hpb
!
set default
set scan 0 10000
set receiver 3
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 to L08
!
set offset -8 0
find /proc corr /sou MFS-22
table ~/maps/isj8-co21-1.uvt new /resa 40 20 -30 2 velo
!
set offset 0 0
find /proc corr /sou MFS-22
table ~/maps/isj8-co21-2.uvt new /resa 40 20 -30 2 velo
!
set offset +8 0
find /proc corr /sou MFS-22
table ~/maps/isj8-co21-3.uvt new /resa 40 20 -30 2 velo
Mosaic
a table for each offset
“tablename”- “i”.uvt
-0:-- isj8-co21-table.clic (Fundamental)--L29--All
Wrote /home/ccarrizo/isj8-co21-table.clic

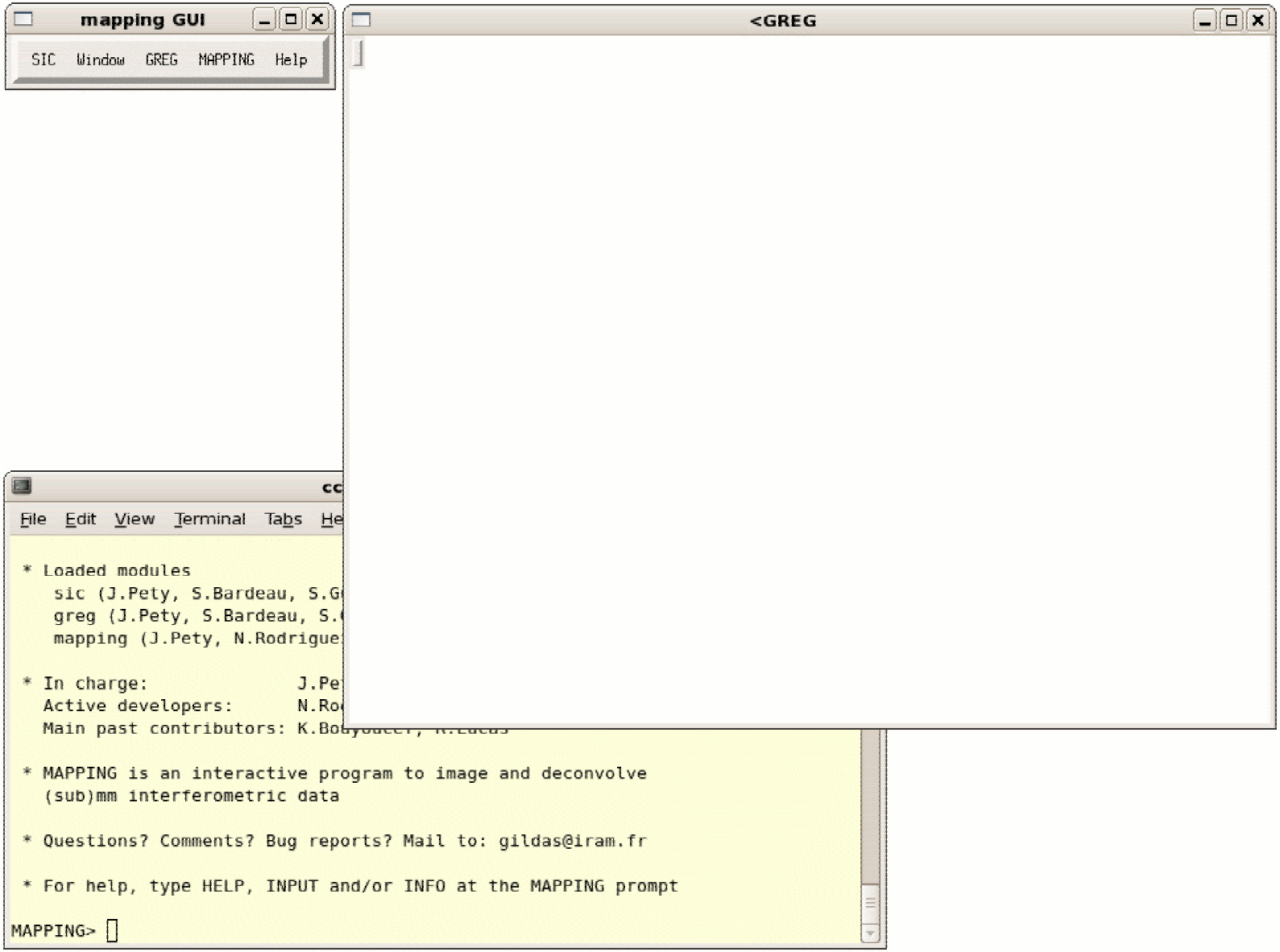

isj8-co21-table.clic - emacs@pctcp33.iram.fr
File Edit Options Buffers Tools Help
! isj8-co21-table.clic
!
file in 08-oct-2008-isj8.hpb
!
set default
set scan 0 10000
set receiver 3
set quality AVERAGE
set weight tsys on
set weight calibration on
set phase antenna atmospher internal relative
set amplitude antenna absolute jansky relative
set rf_passband antenna frequency file on
!
set selection LINE LSB LO1 to LO8
!
set offset -8 0
find /proc corr /sou MFS-22
table ~/maps/isj8-co21-1.uvt new /resa 40 20 -30 2 velo
!
set offset 0 0
find /proc corr /sou MFS-22
table ~/maps/isj8-co21-2.uvt new /resa 40 20 -30 2 velo
!
set offset +8 0
find /proc corr /sou MFS-22
table ~/maps/isj8-co21-3.uvt new /resa 40 20 -30 2 velo
!
!
!
file in 24-dec-2008-isj8.hpb
!
set offset -8 0
find /proc corr /sou MFS-22
table ~/maps/isj8-co21-1.uvt old /resa 40 20 -30 2 velo
!
set offset 0 0
find /proc corr /sou MFS-22
table ~/maps/isj8-co21-2.uvt old /resa 40 20 -30 2 velo
!
set offset +8 0
find /proc corr /sou MFS-22
table ~/maps/isj8-co21-3.uvt old /resa 40 20 -30 2 velo
!
-0:-- isj8-co21-table.clic (Fundamental)--L46--All
Mosaic
2nd data set

Created “mytable”.uvt, in CLIC

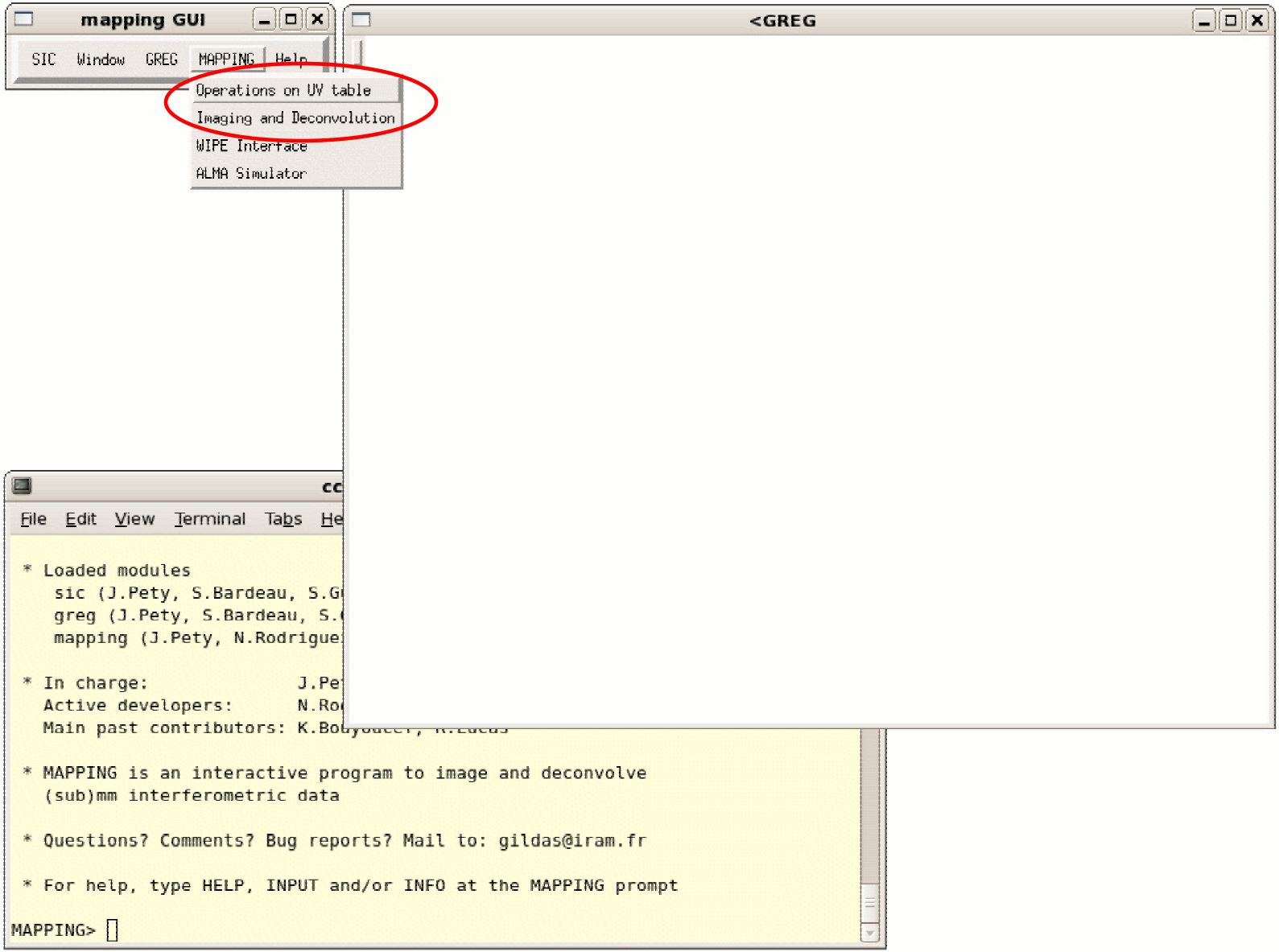
Analyze the data, in MAPPING

1. Data analysis in the *uv*-plane

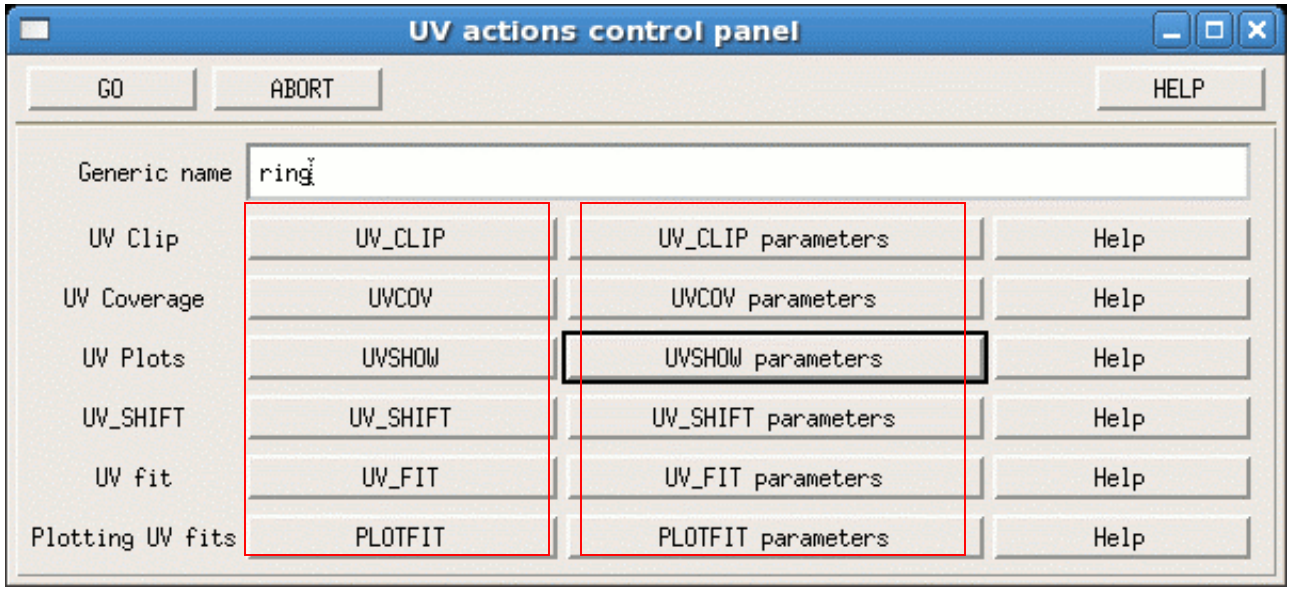
Data analysis in the *uv*-plane; **MAPPING**



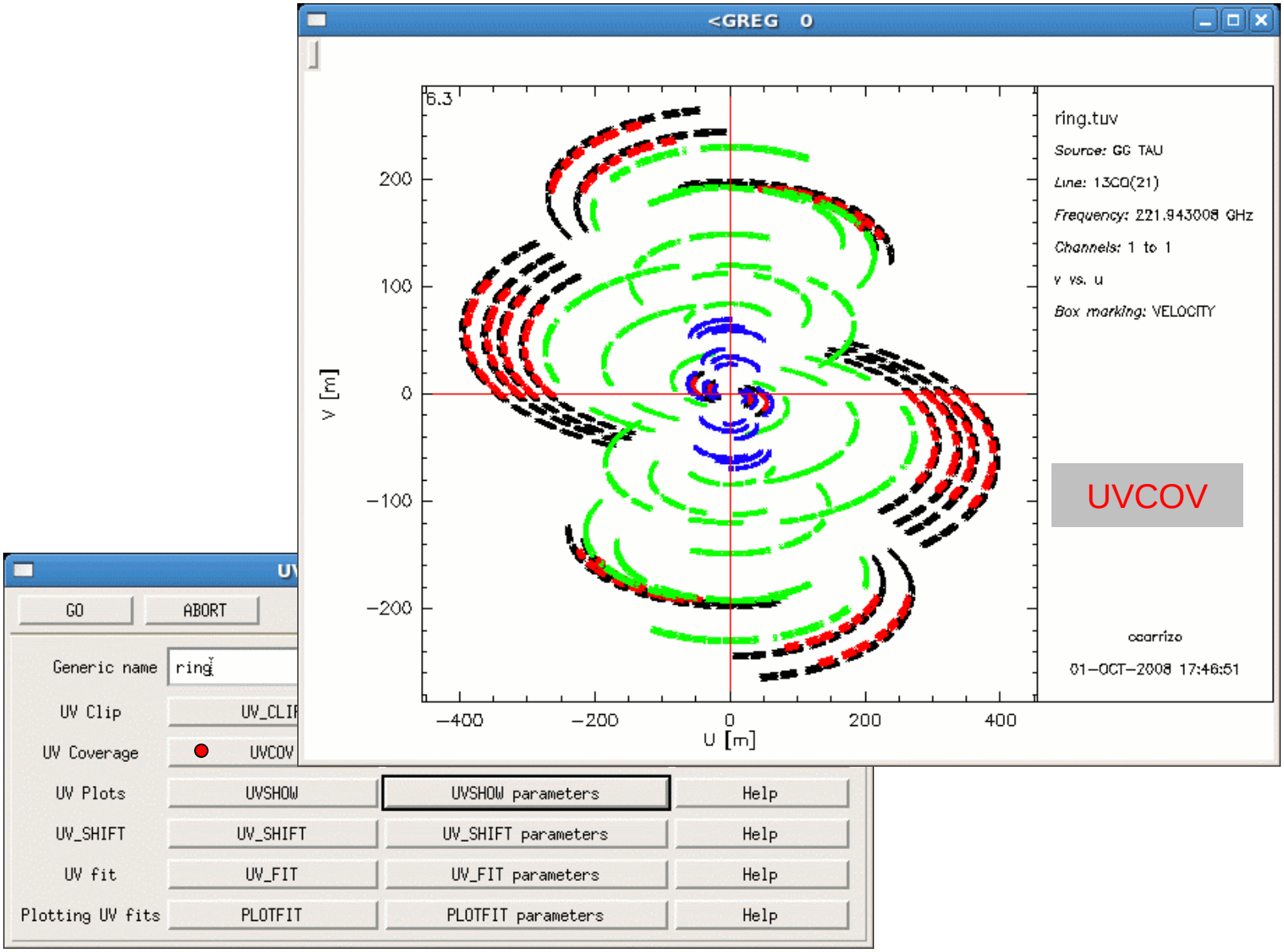
Data analysis in the *uv*-plane



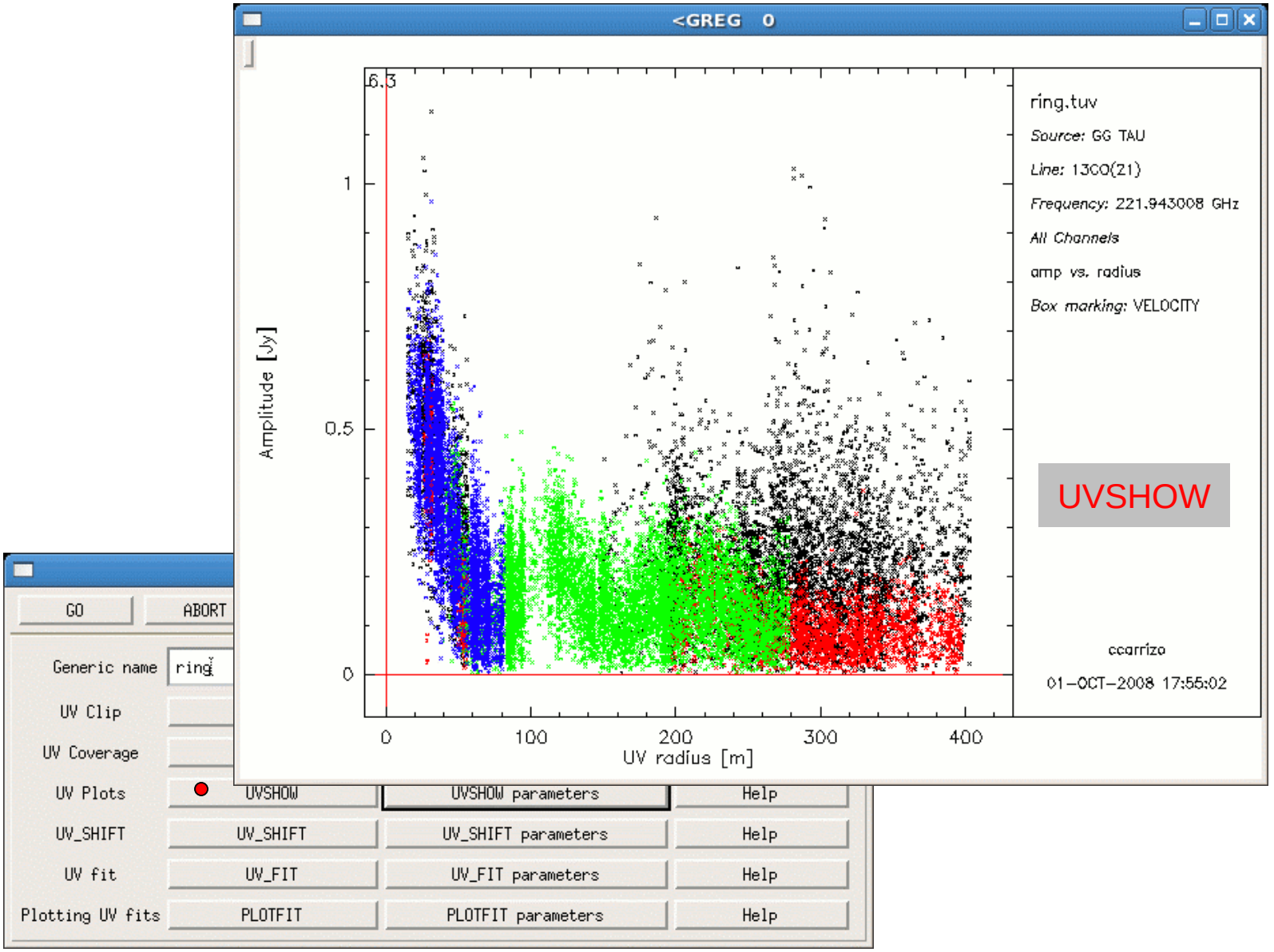
Data analysis in the *uv*-plane



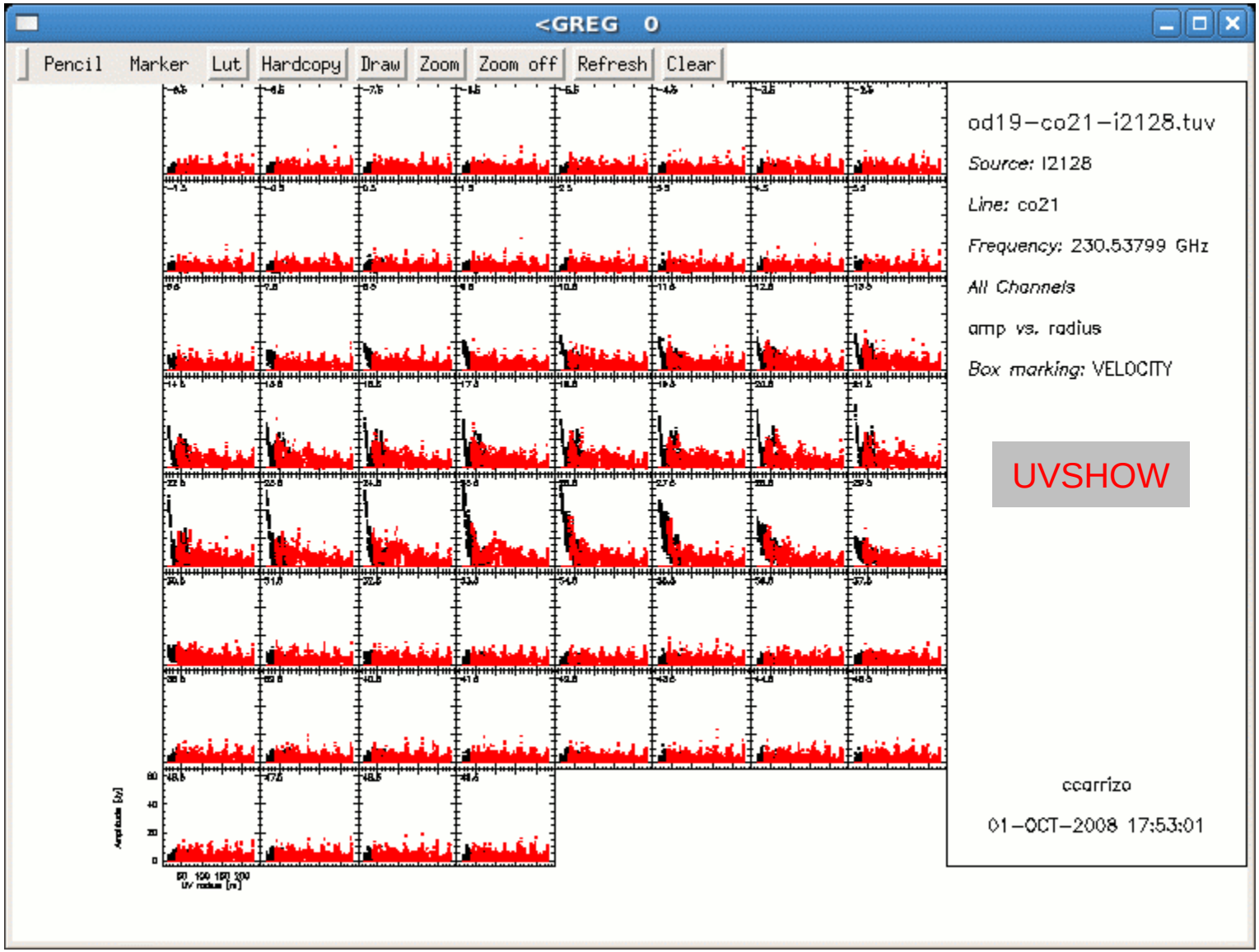
Data analysis in the *uv*-plane



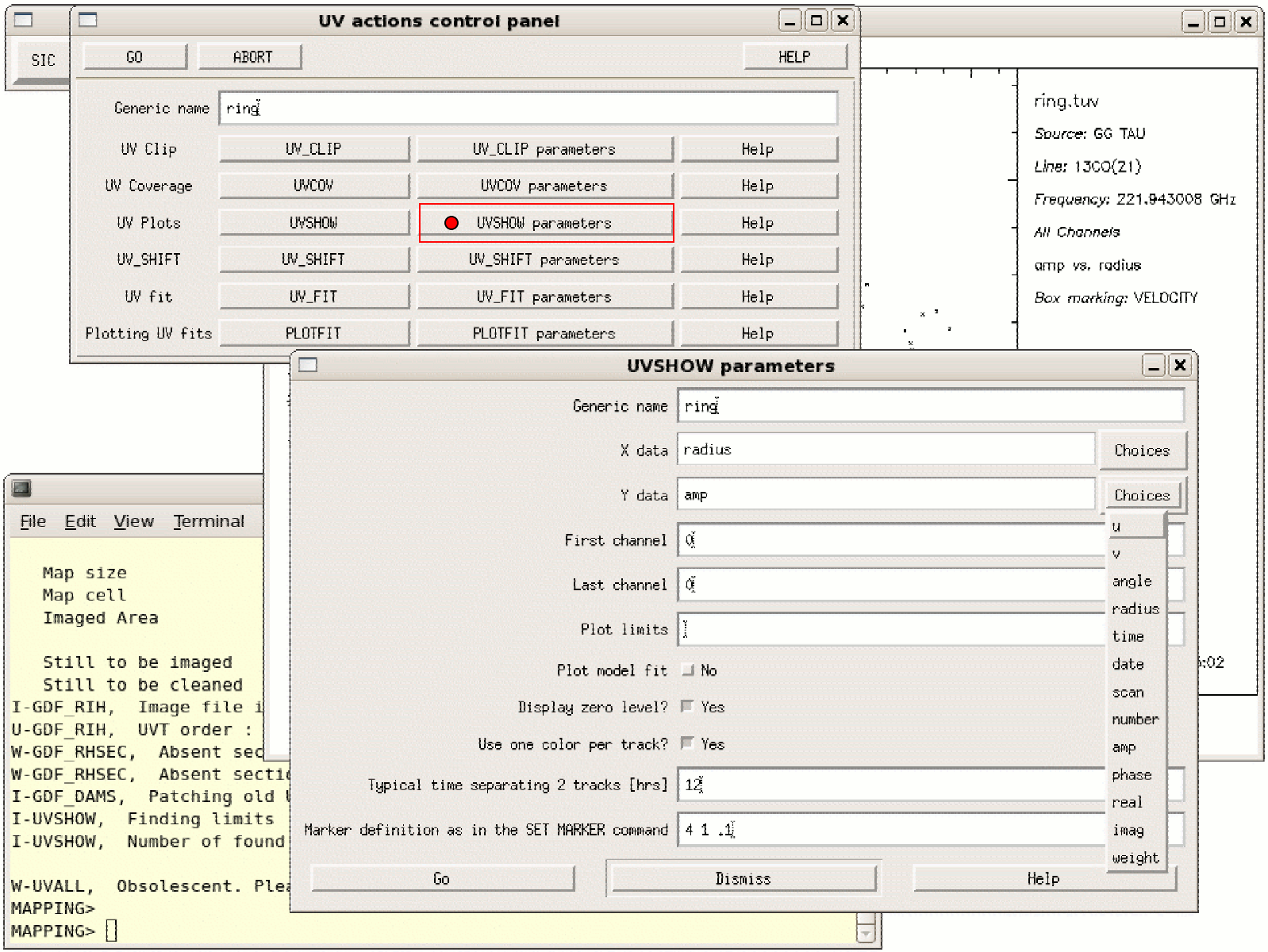
Data analysis in the *uv*-plane



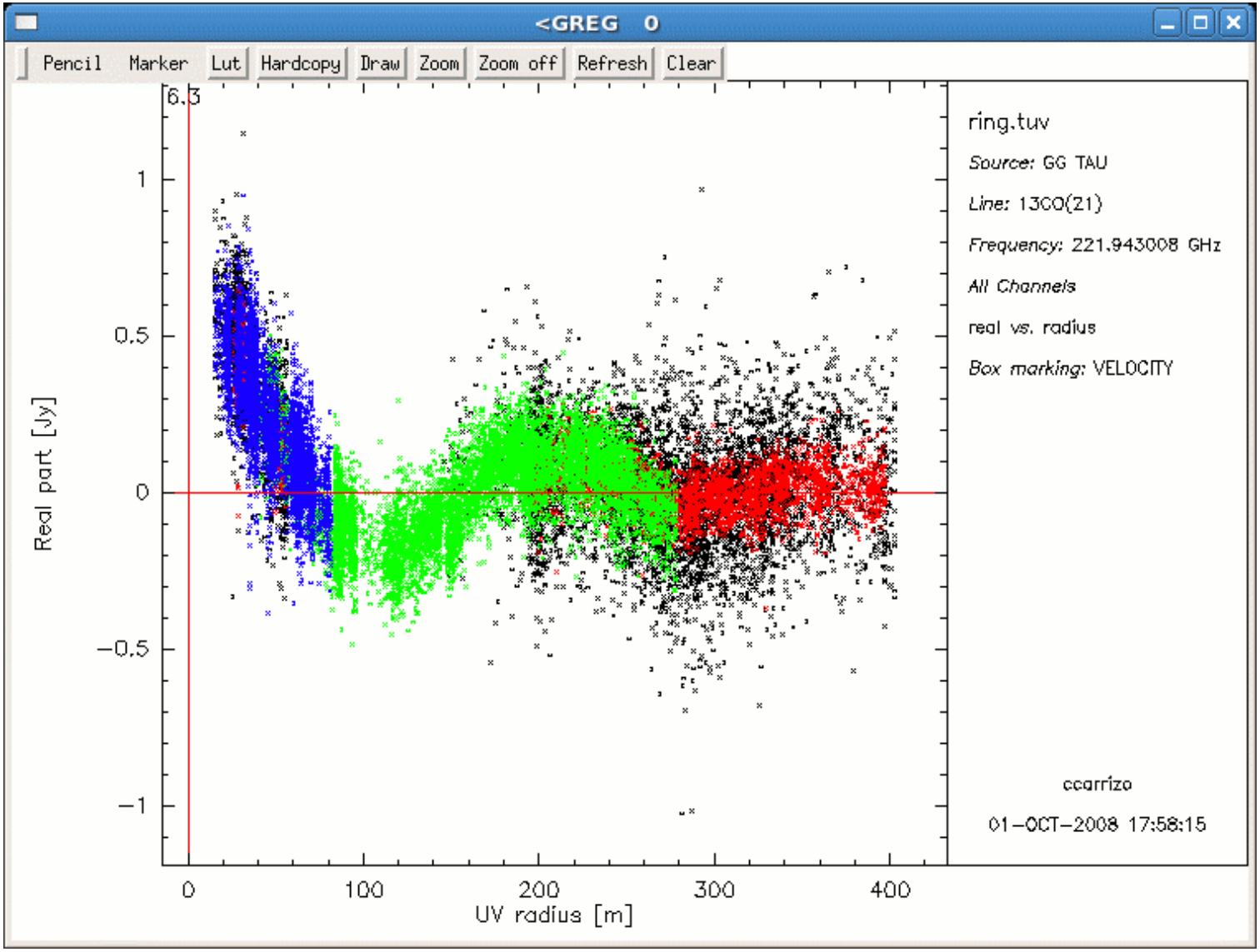
Data analysis in the *uv*-plane



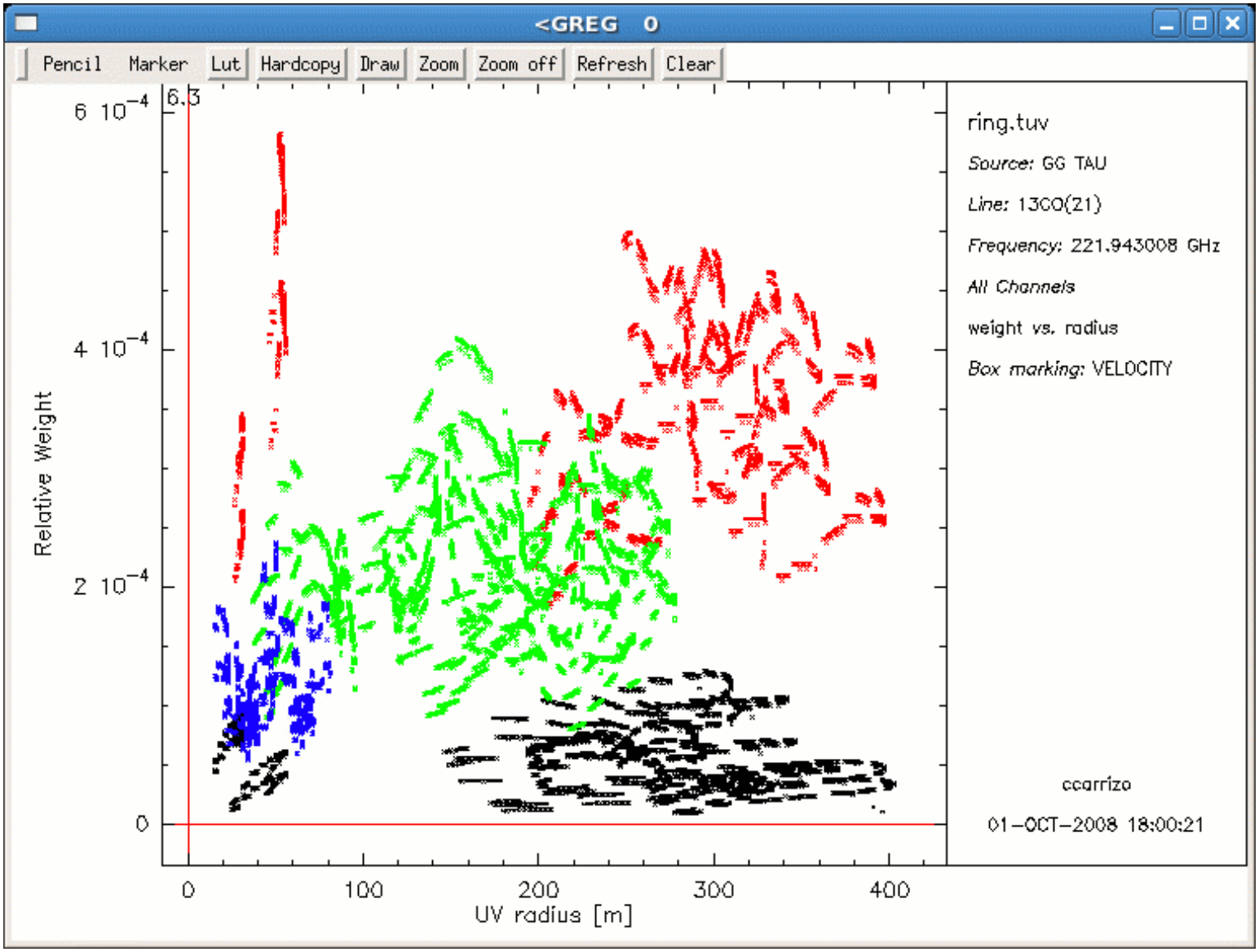
Data analysis in the *uv*-plane



Data analysis in the *uv*-plane



Data analysis in the *uv*-plane



Data analysis in the *uv*-plane

With commands:

MAPPING> let first 12

MAPPING> let last 12

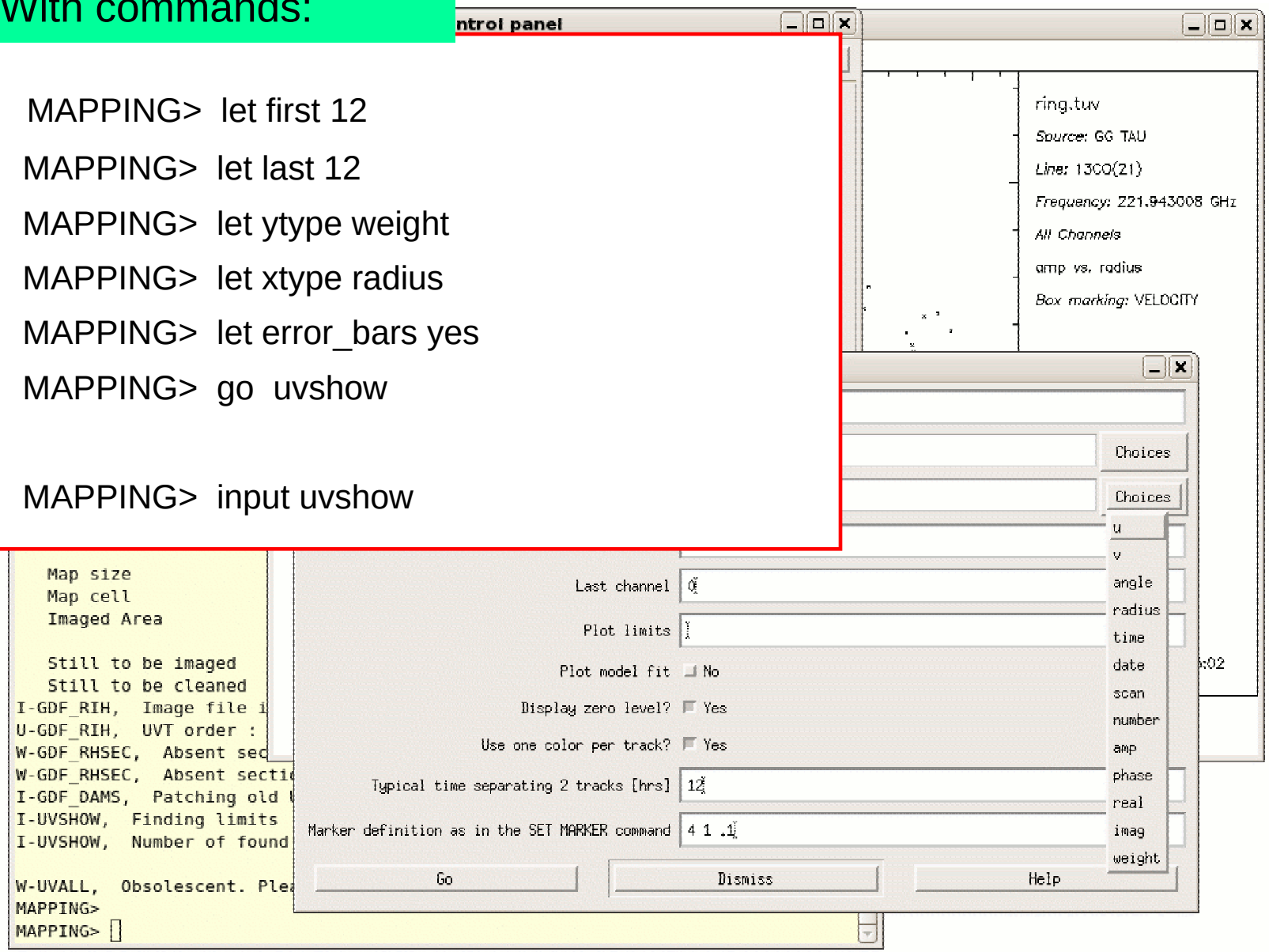
MAPPING> let ytype weight

MAPPING> let xtype radius

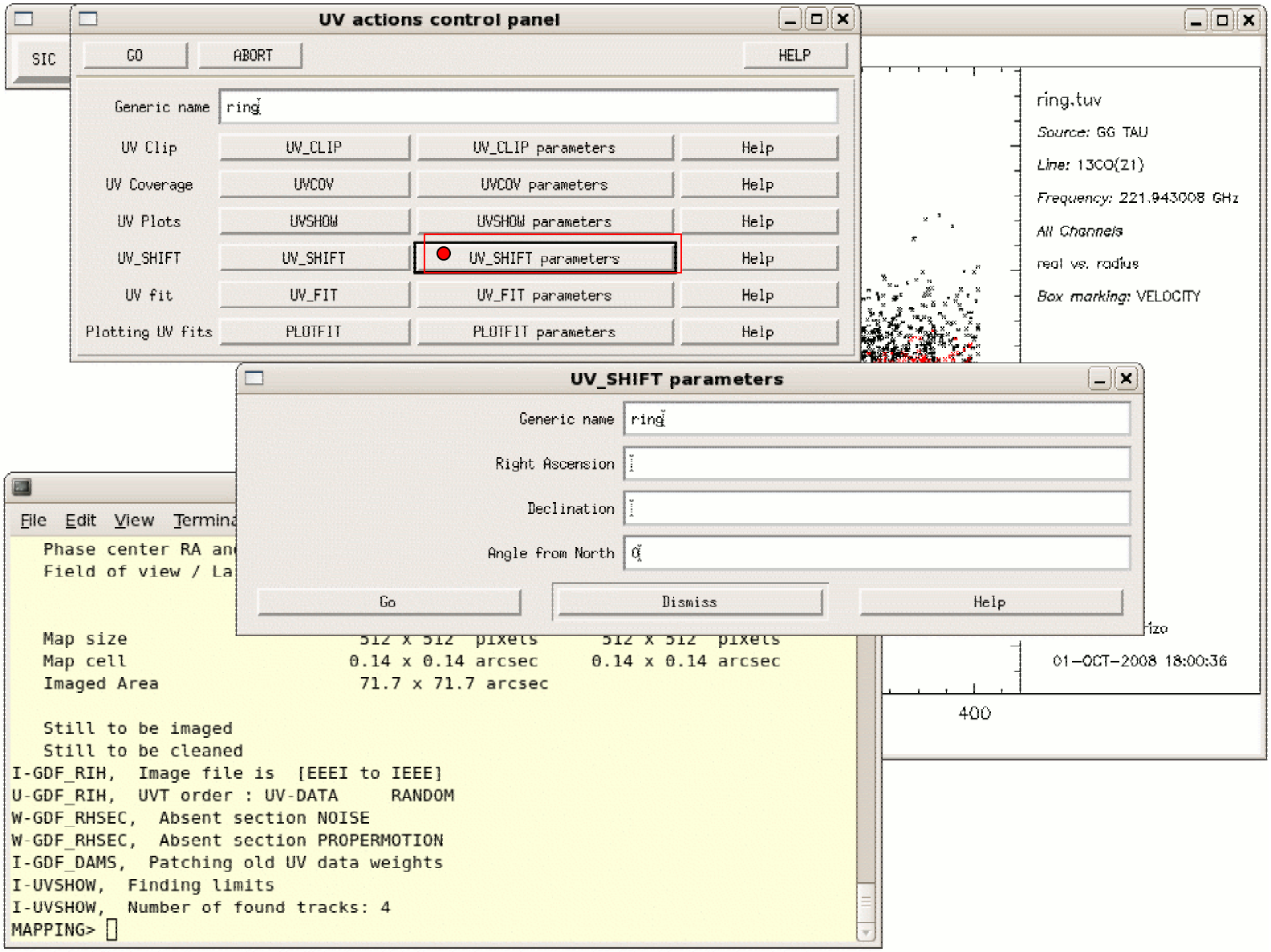
MAPPING> let error_bars yes

MAPPING> go uvshow

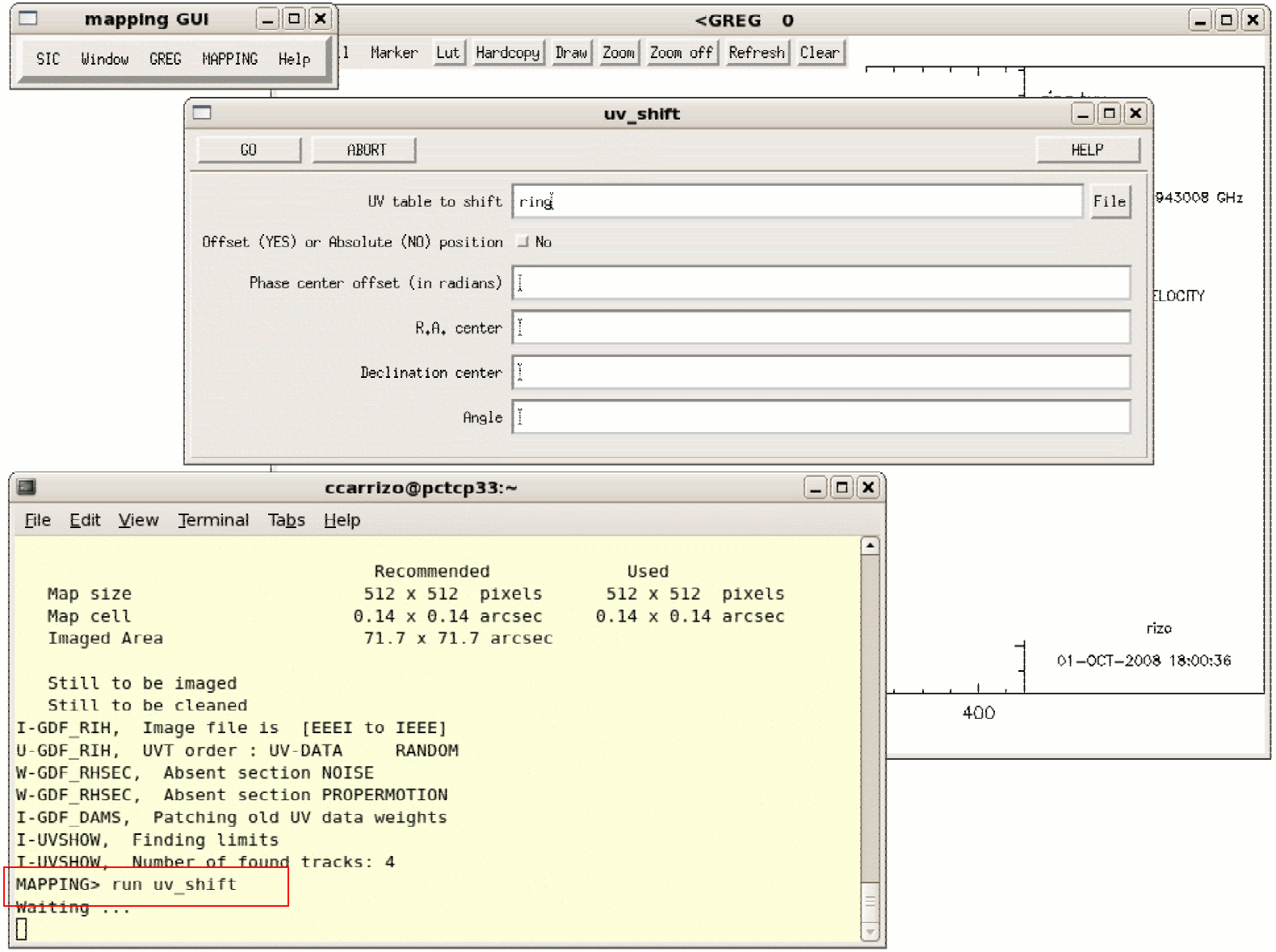
MAPPING> input uvshow



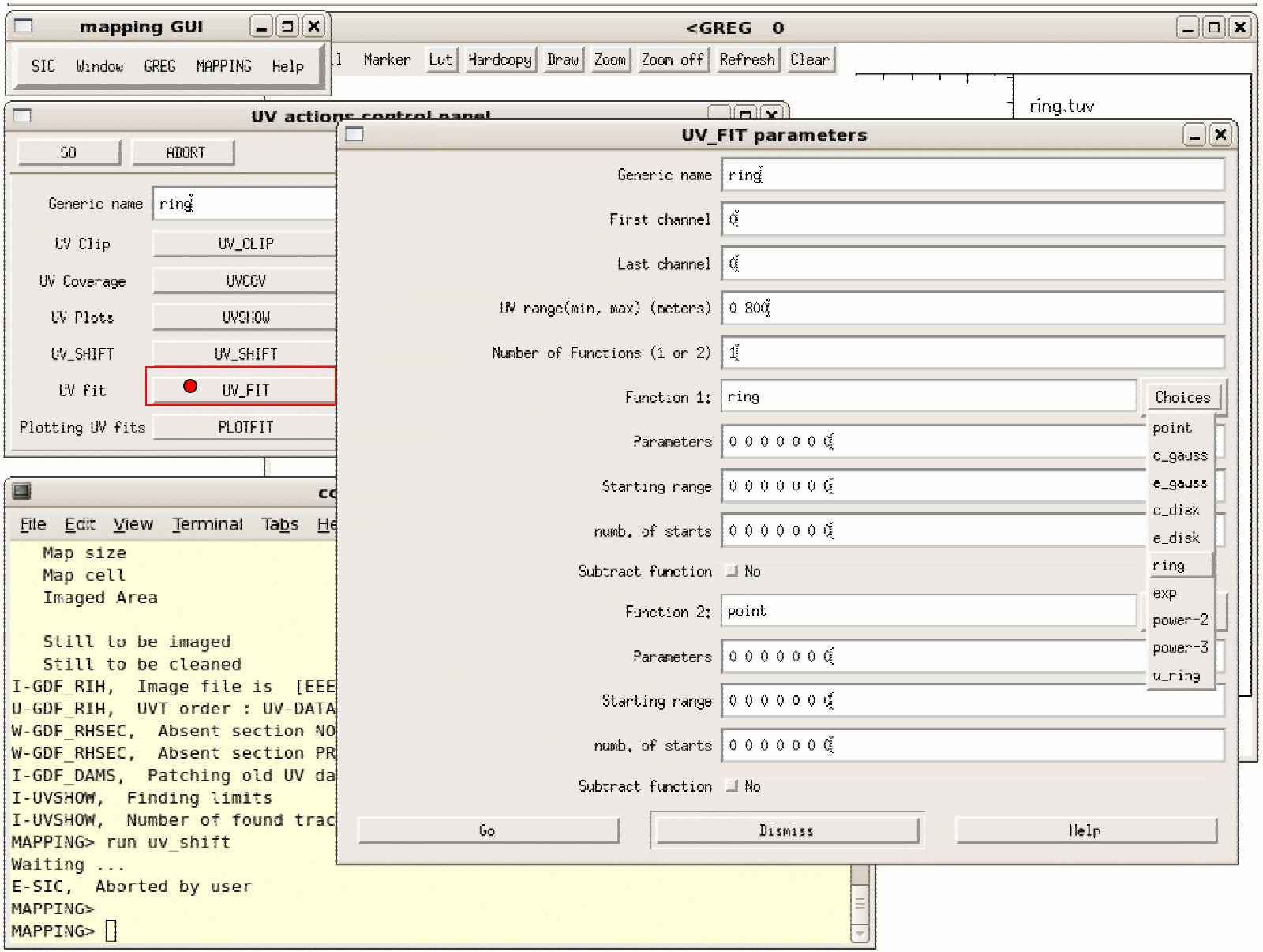
Data analysis in the *uv*-plane



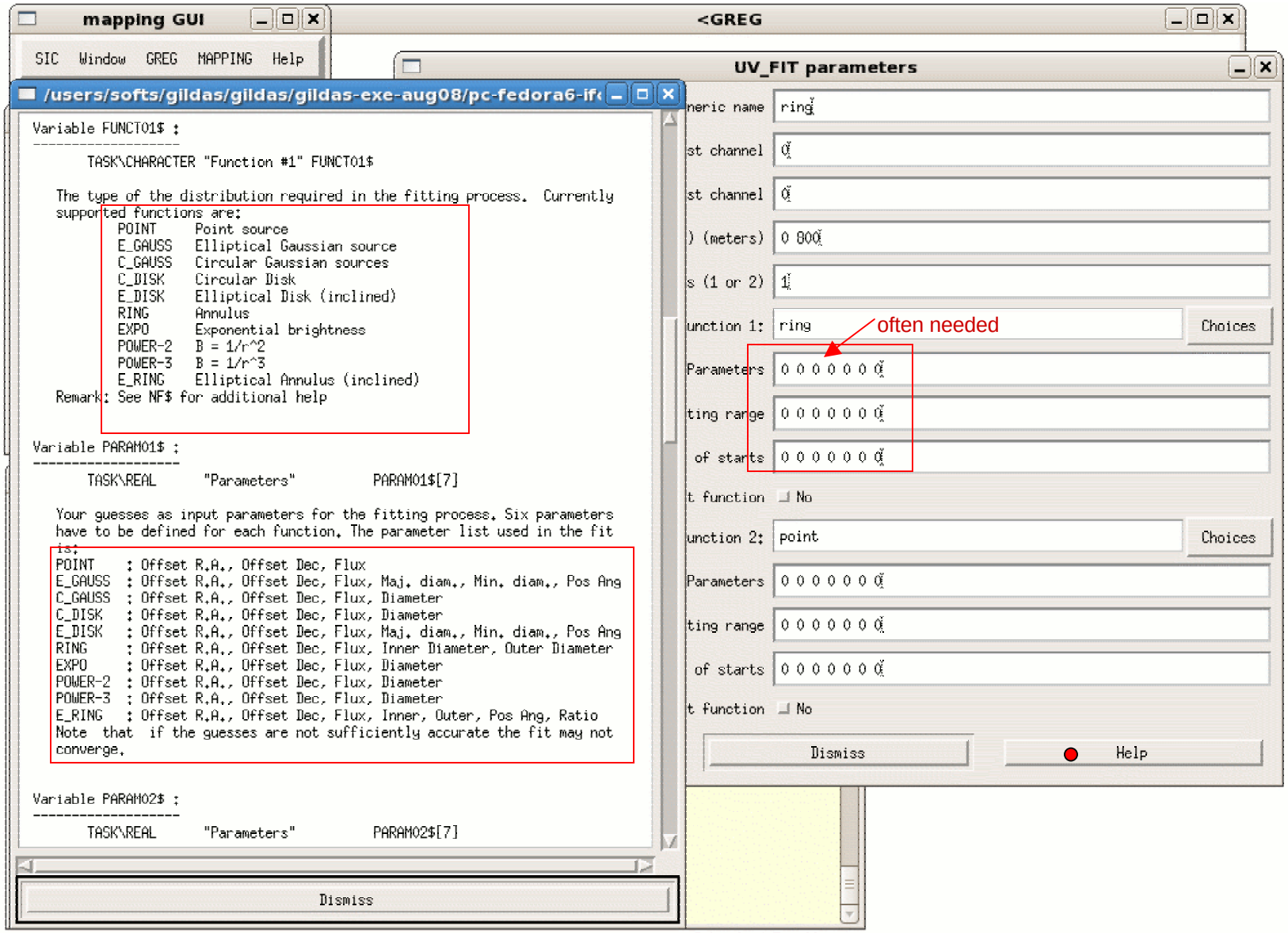
Data analysis in the *uv*-plane



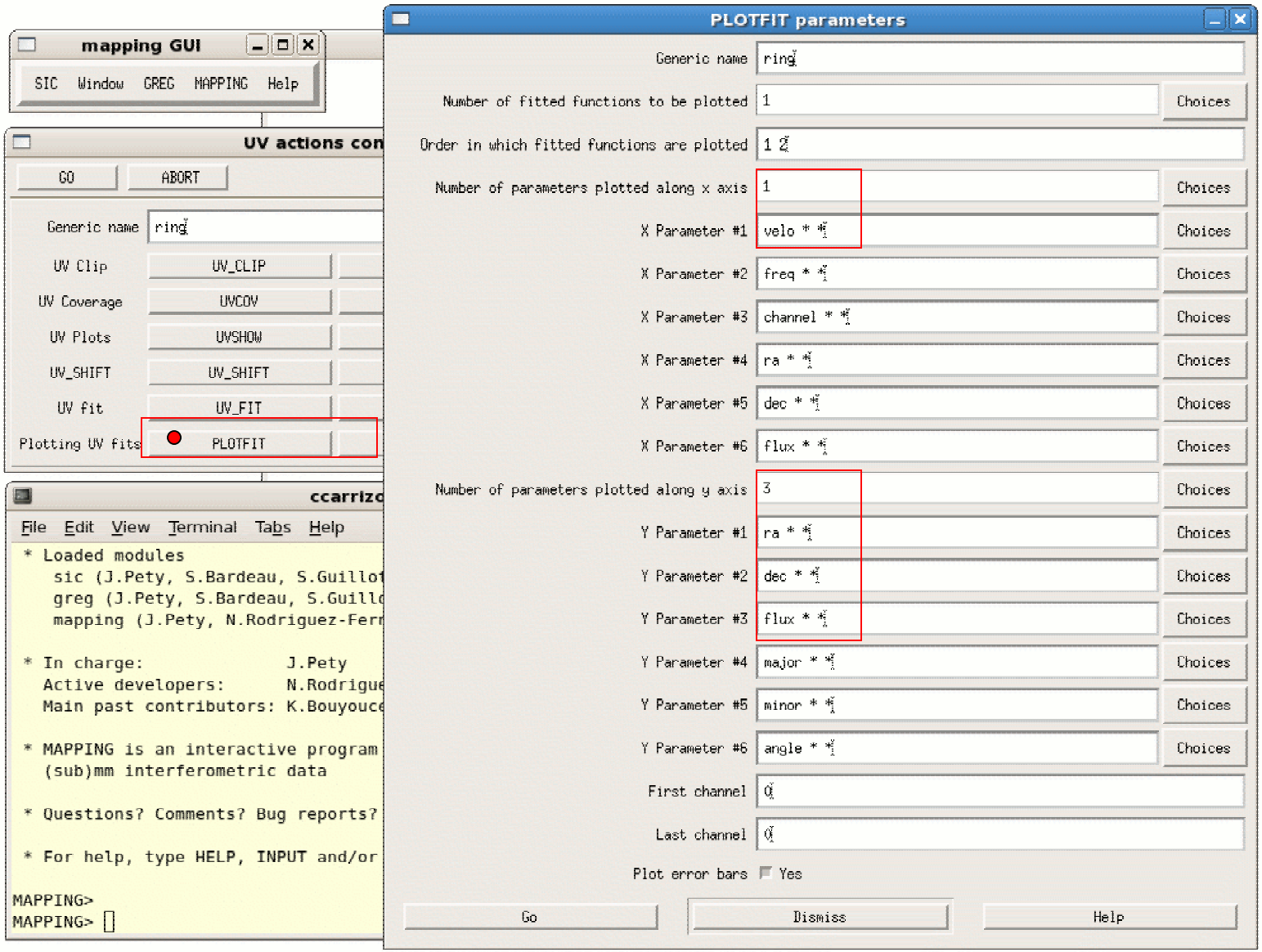
Data analysis in the *uv*-plane



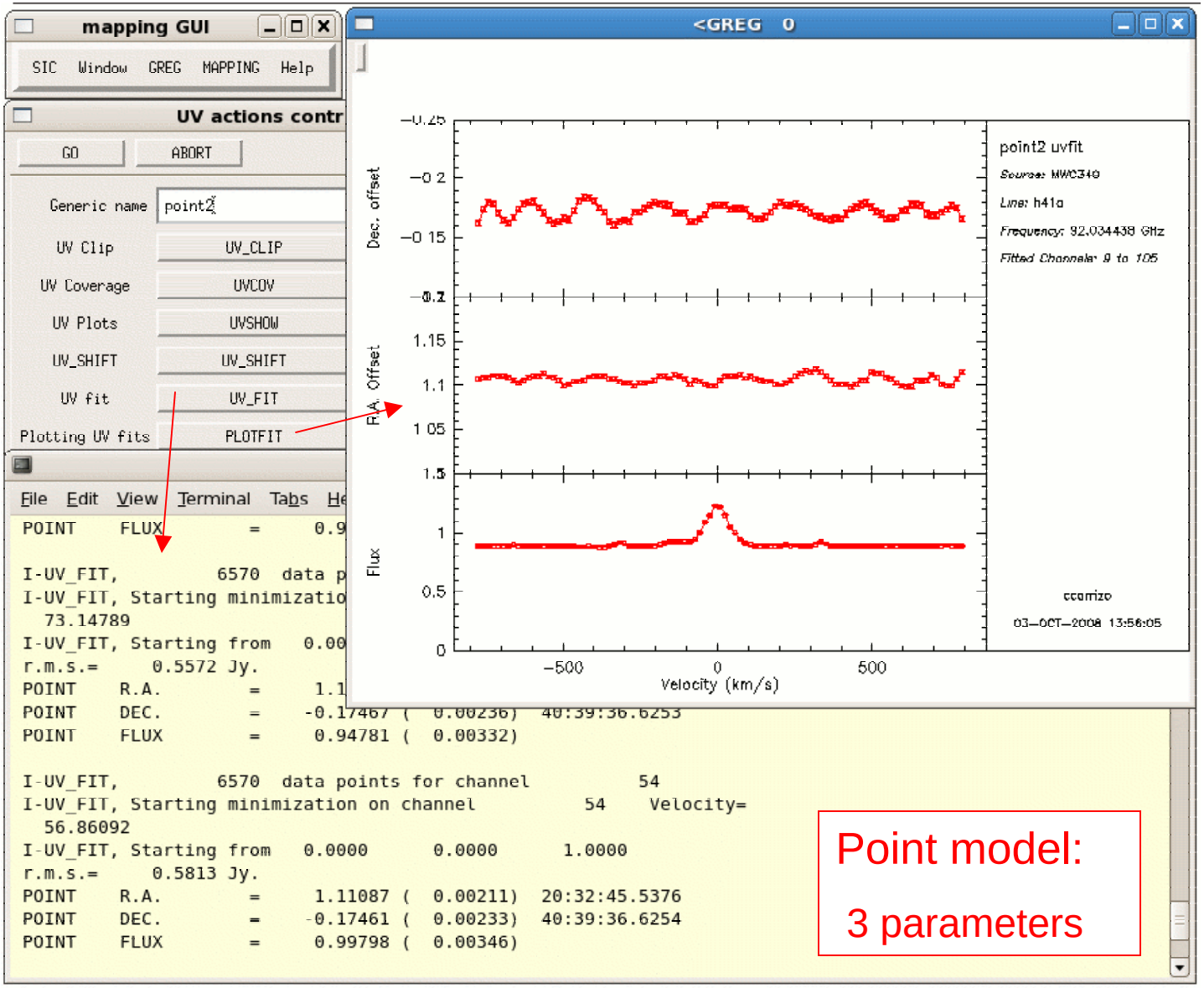
Data analysis in the *uv*-plane



Data analysis in the *uv*-plane



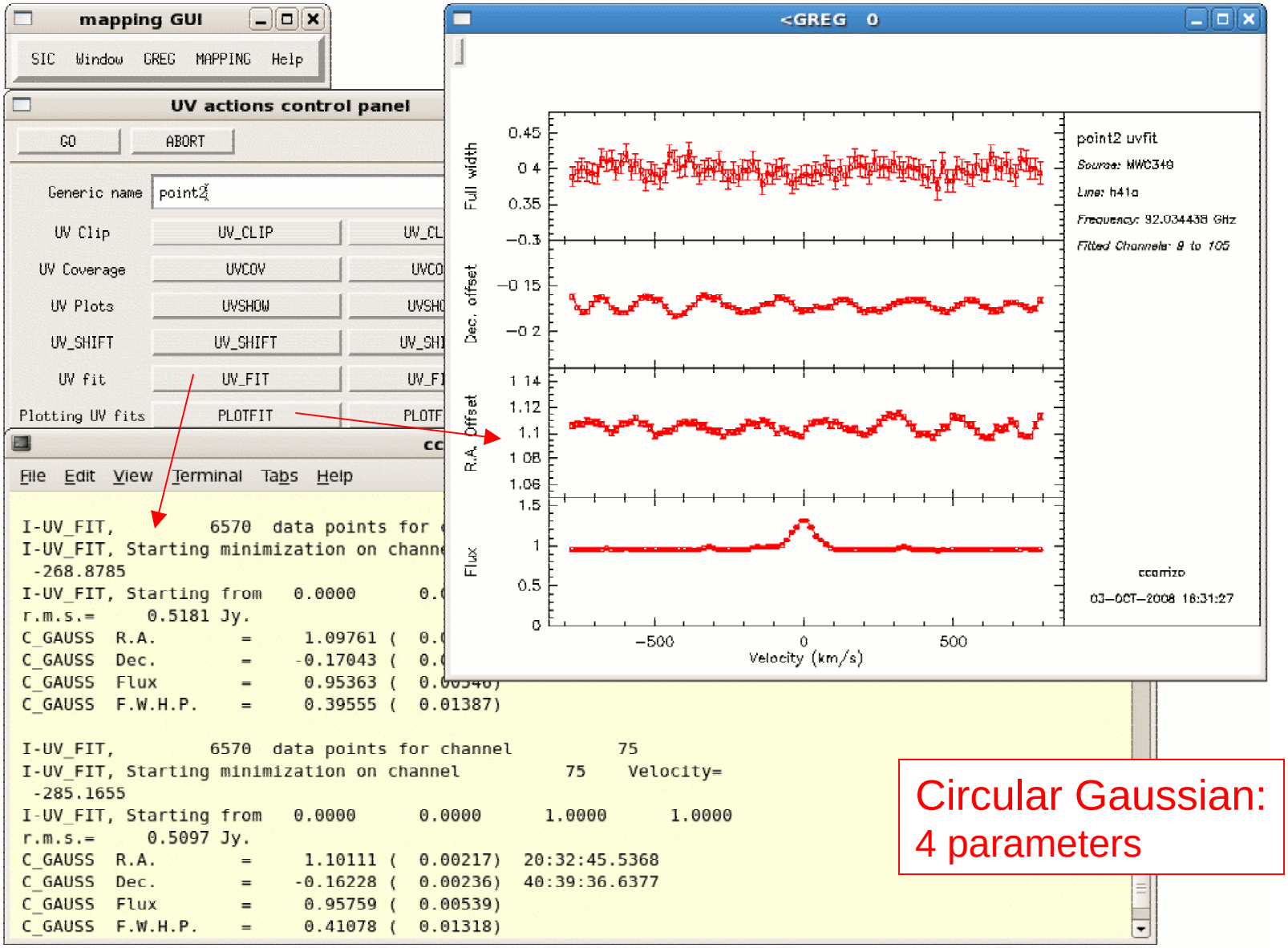
Data analysis in the *uv*-plane



Point model:

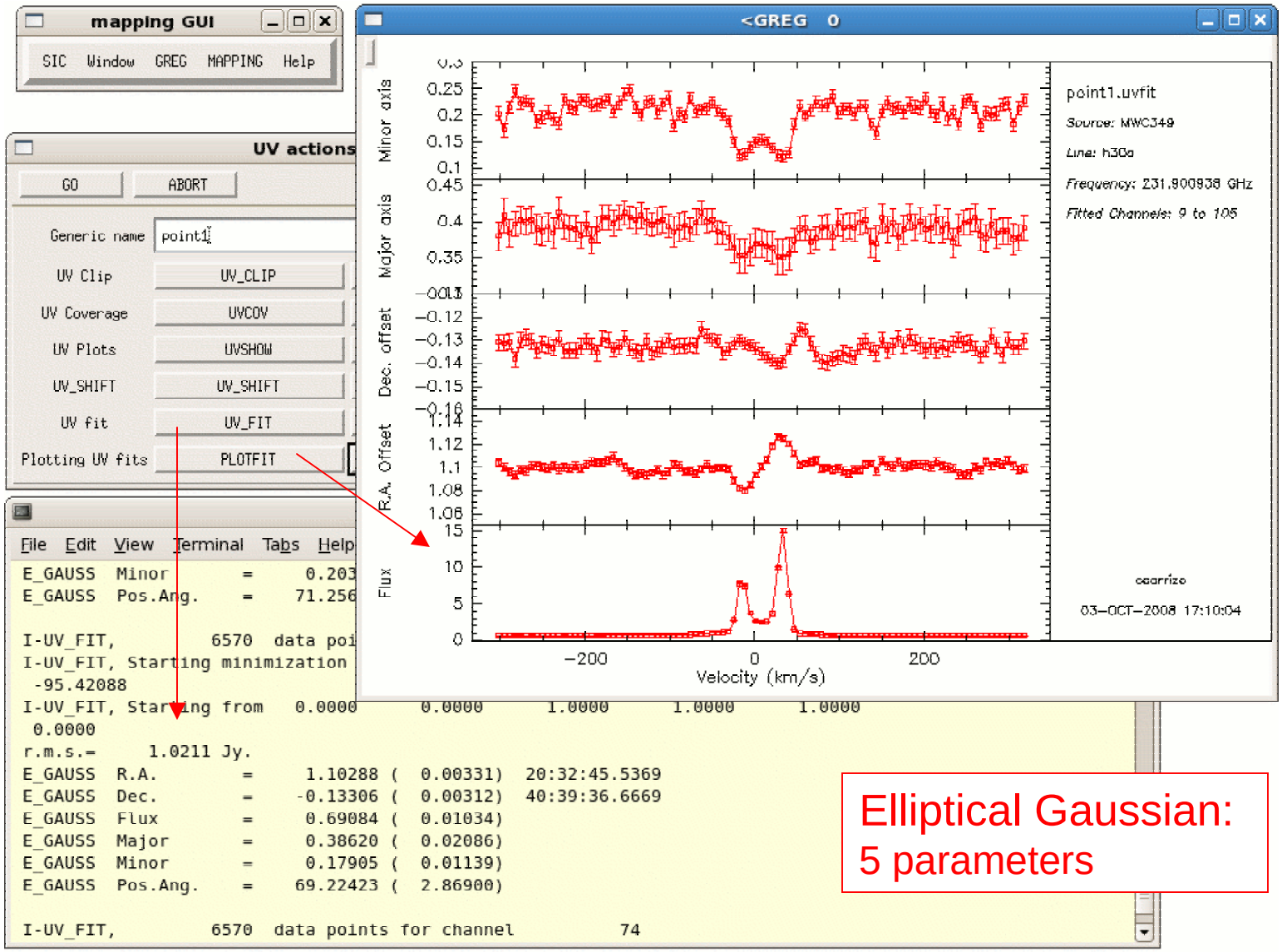
3 parameters

Data analysis in the *uv*-plane



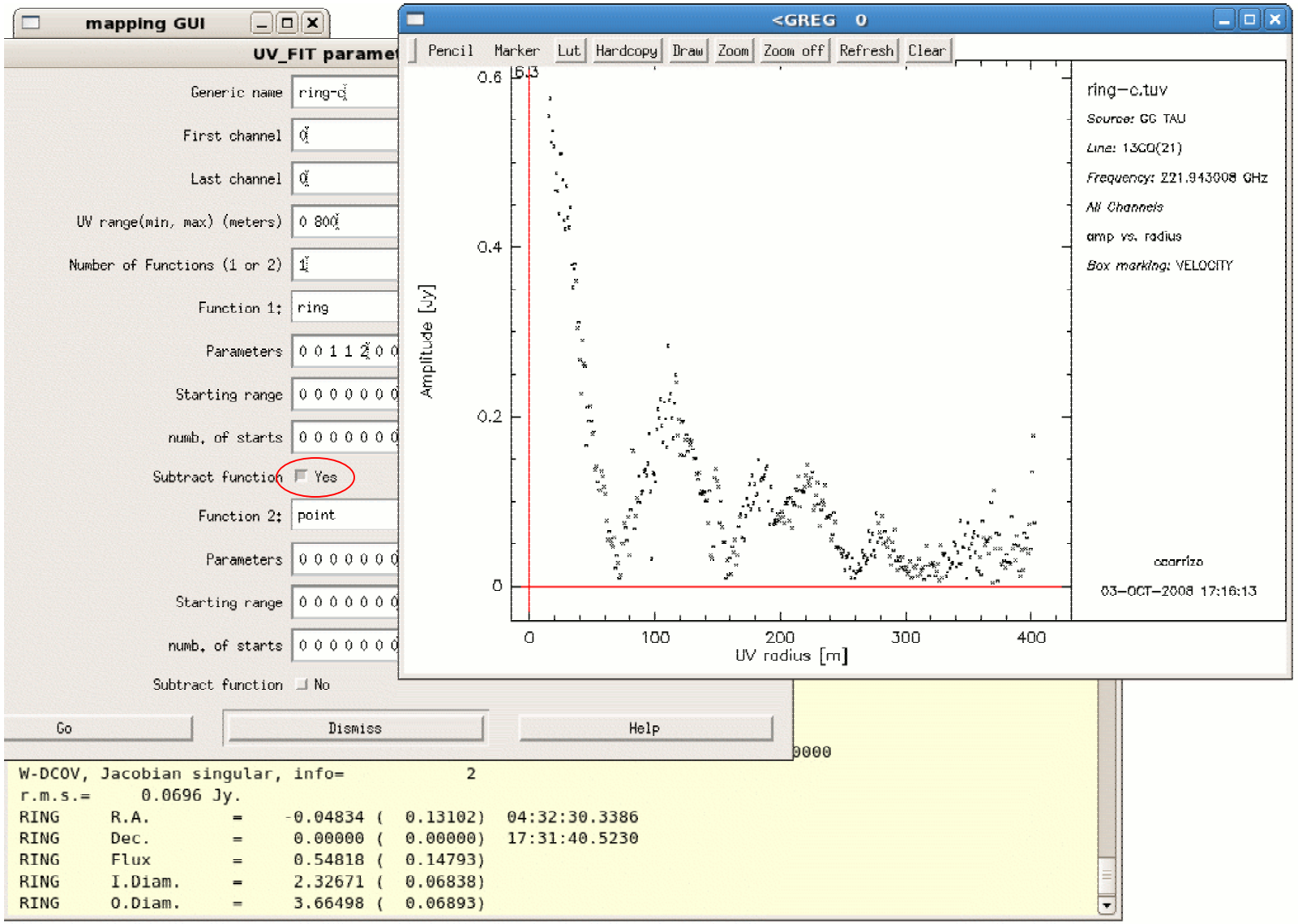
Circular Gaussian:
4 parameters

Data analysis in the *uv*-plane

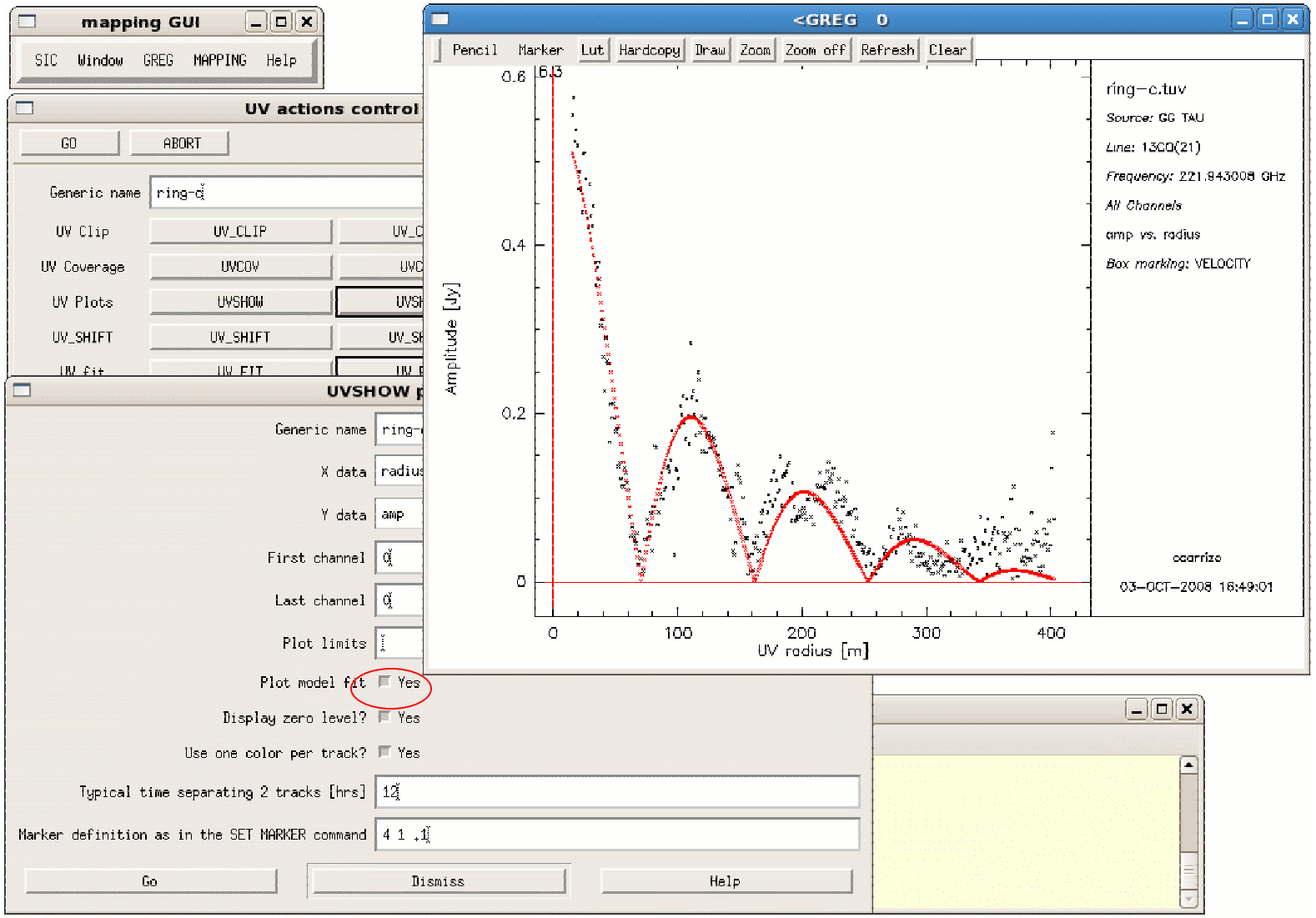


Elliptical Gaussian:
5 parameters

Data analysis in the *uv*-plane



Data analysis in the *uv*-plane



MAPPING procedures / tasks

```
MAPPING>  go …
MAPPING>  input …
```

also

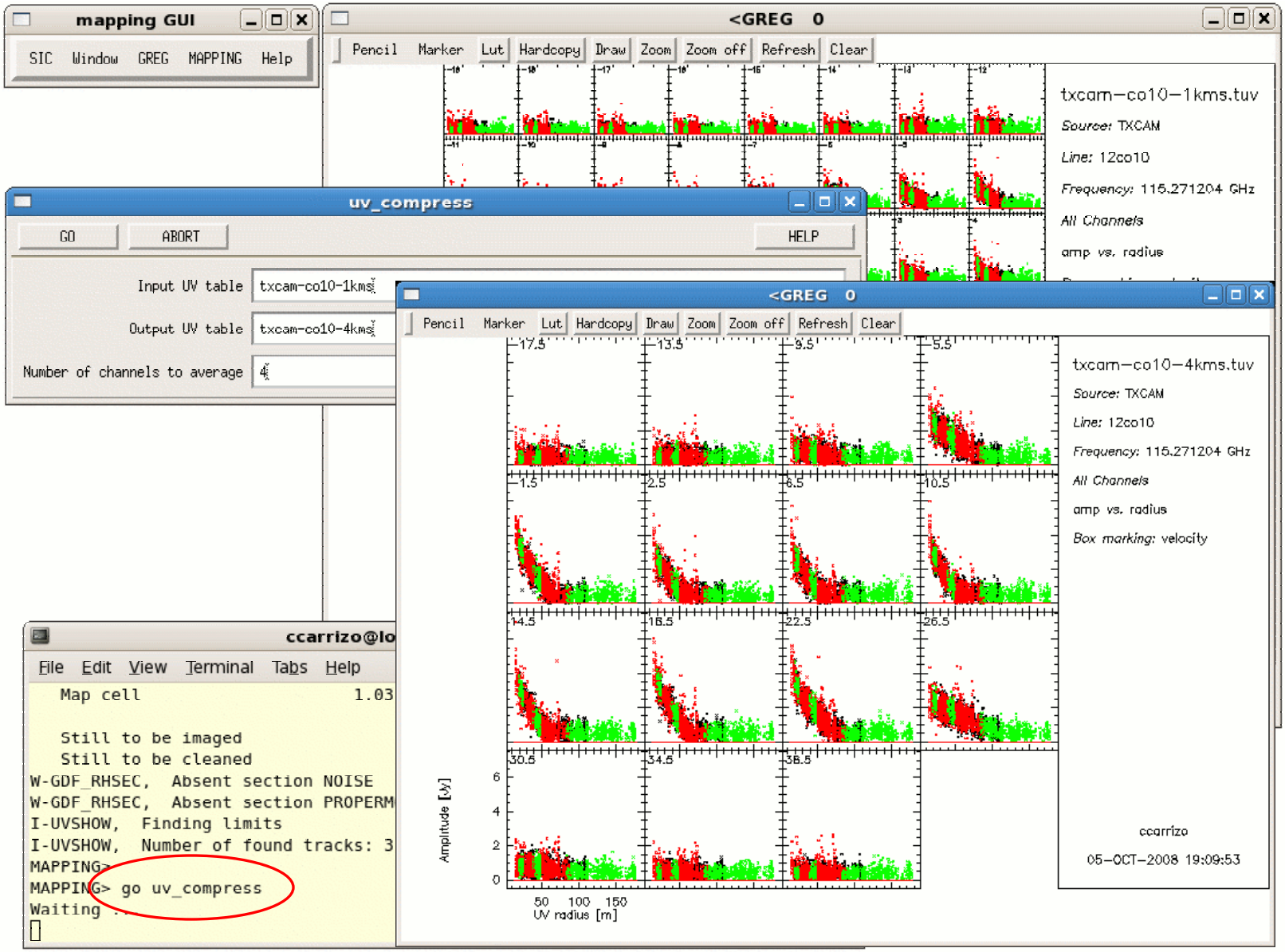
```
MAPPING>  run …
MAPPING>  help …
```

Data analysis in the *uv*-plane

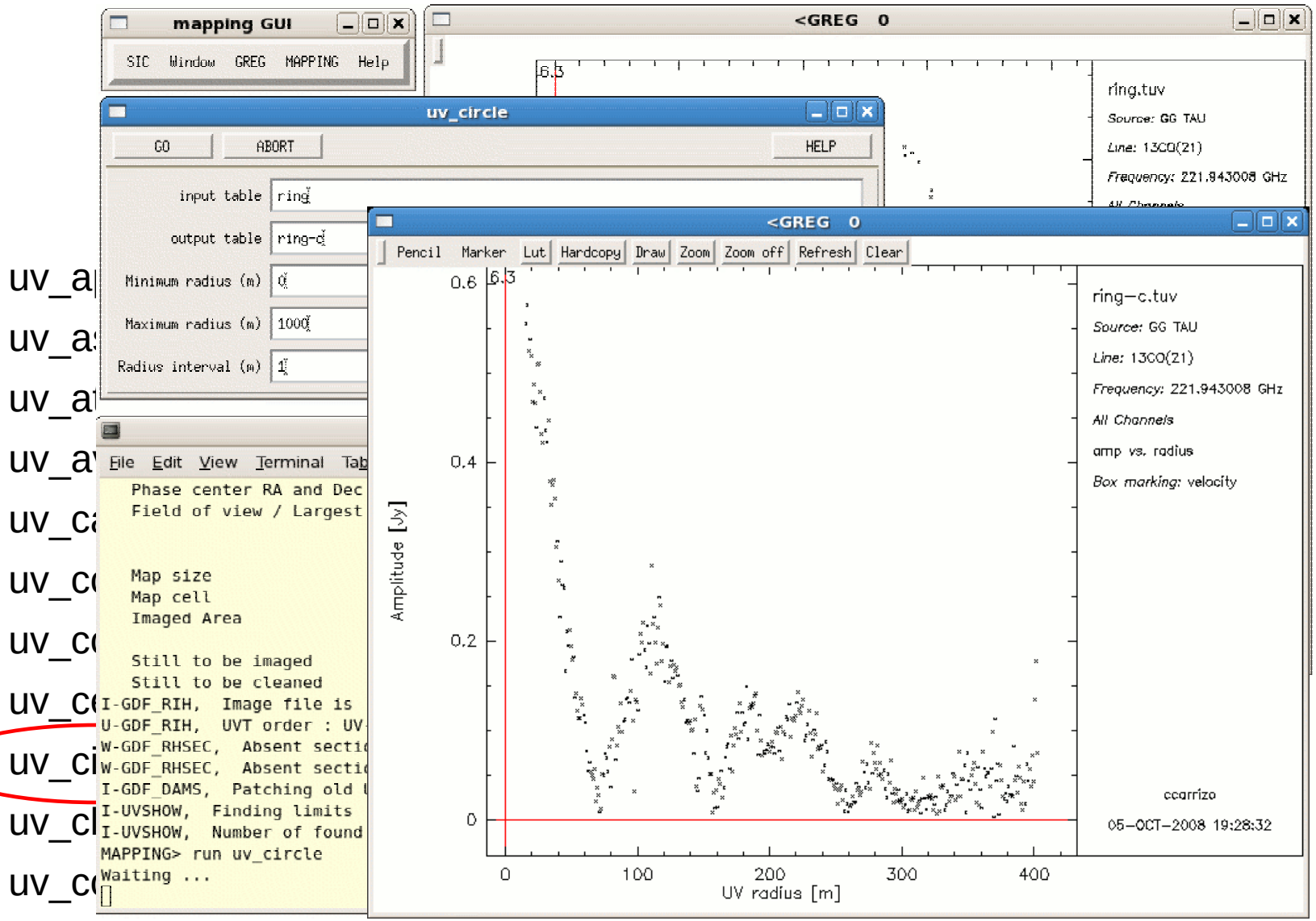
```
MAPPING>  go  …     or     run  …
MAPPING>  input  … or     help  …
```

uv_applyphase	uv_dft	uv_merge	uv_solve
uv_ascal	uv_extract	uv_mflag	uv_sort
uv_atm	uv_fidelity	uv_model	uv_splitfield
uv_average	uv_fit-s	uv_mult	uv_stat
uv_cal	uv_flag	uv_noise	uv_substract
uv_ccmodel	uv_fmodel	uv_observe	uv_table
uv_cct	uv_gain	uv_pointing	uv_timeaverage
uv_center	uv_hanning	uv_selfcal	uv_timebase
uv_circle	uv_hybrid	uv_shift	uv_track
uv_clip	uv_list	uv_short	uv_track_phase
uv_compress	uv_map	uv_single	uv_zero
uv_cuts	uv_mcal	uv_sinusphase	

Data analysis in the *uv*-plane



Data analysis in the *uv*-plane



uv_a

uv_a

uv_a

uv_a

uv_c

uv_c

uv_c

uv_c

uv_c

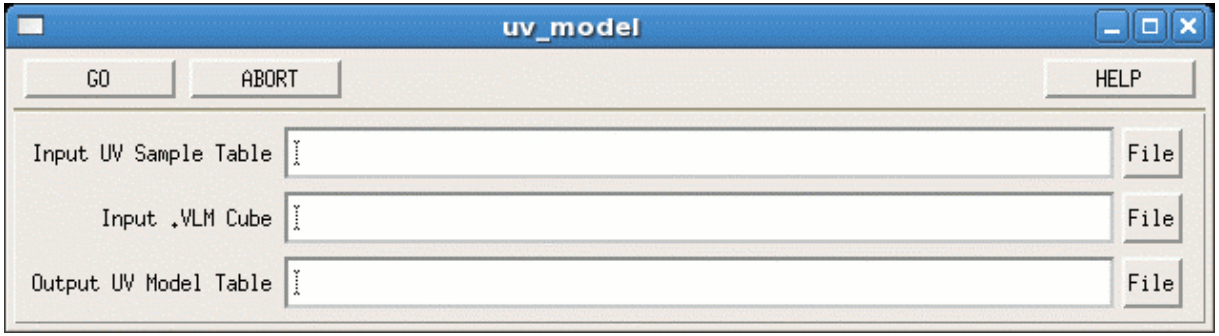
uv_c

uv_cuts uv_mcal uv_sinusphase

Data analysis in the *uv*-plane

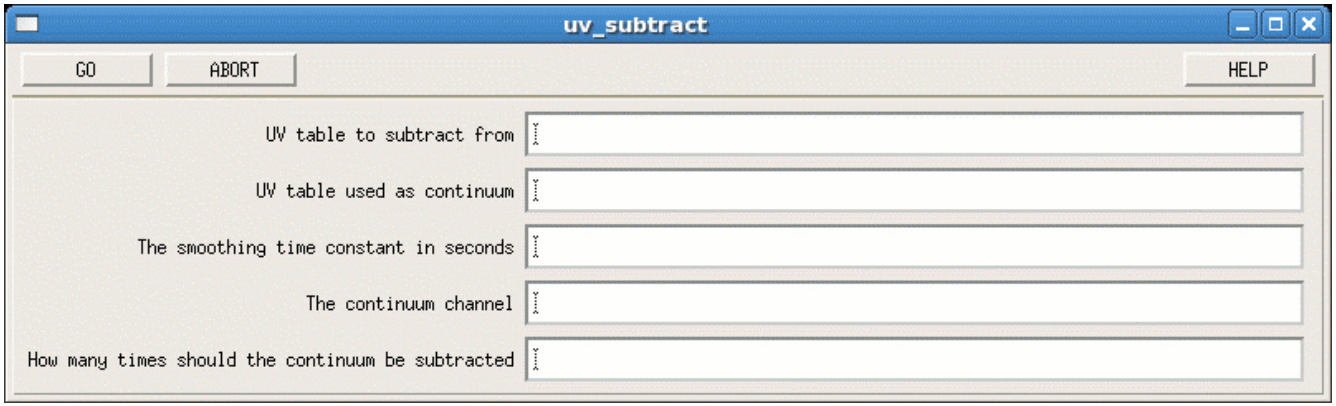
MAPPING> go …		or	run …
MAPPING> input …		or	help …

uv_applyphase	uv_dft	uv_merge	uv_solve
uv_ascal	uv_extract	uv_mflag	uv_sort
uv_atm	uv_fidelity	uv_model	uv_splitfield
uv_avera			
uv_cal			
uv_ccmod			
uv_cct			
uv_center			
uv_circle			
uv_clip			
uv_compress	uv_map	uv_single	uv_zero
uv_cuts	uv_mcal	uv_sinusphase	



To create a *uv* table from an image, e.g. a model

Data analysis in the *uv*-plane



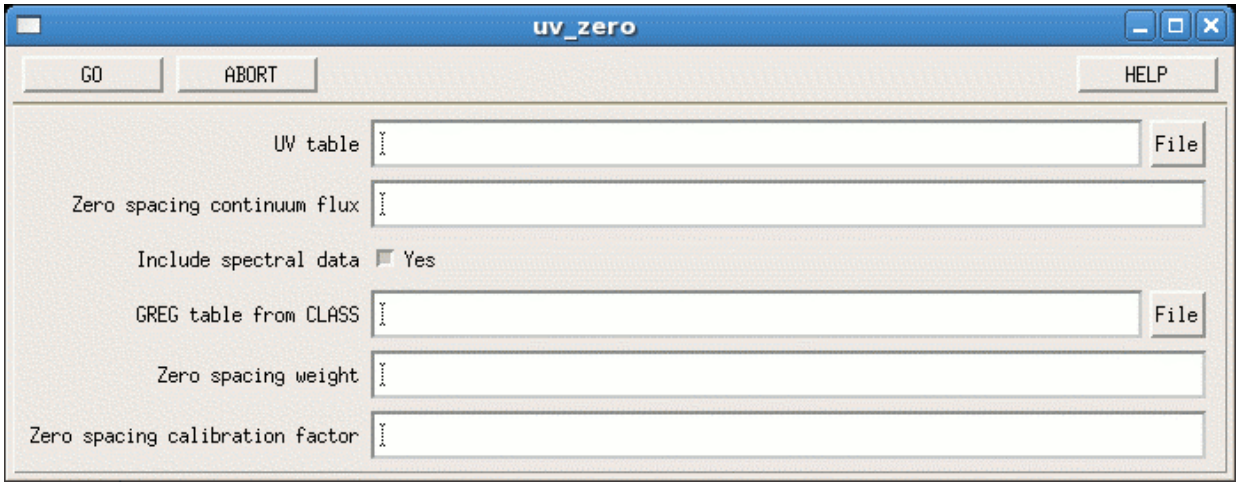
To substract a time-averaged continuum *uv* table

d

uv_cal	uv_flag	uv_noise	uv_subtract
uv_ccmodel	uv_fmodel	uv_observe	uv_table
uv_cct	uv_gain	uv_pointing	uv_timeaverage
uv_center	uv_hanning	uv_selfcal	uv_timebase
uv_circle	uv_hybrid	uv_shift	uv_track
uv_clip	uv_list	uv_short	uv_track_phase
uv_compress	uv_map	uv_single	uv_zero
uv_cuts	uv_mcal	uv_sinusphase	

Data analysis in the *uv*-plane

MAPPING> go … or run …
MAPPING> input … or help …



To add a single-dish zero-spacing spectrum

_solve
_sort
_splitfield
_stat
_subtract
_table
_timeaverage
_timebase
_track
uv_clip uv_list uv_short uv_track_phase
uv_compress uv_map uv_single uv_zero
uv_cuts uv_mcal uv_sinusphase

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

- real part fo
- imaginary part
- weight

- real part for 2nd channel
- imaginary part 2nd channel
- …

uv table [visib dimension, # visibilities]

visib dimension = 7 + 3 x (# channels)

7 visib. characteristics

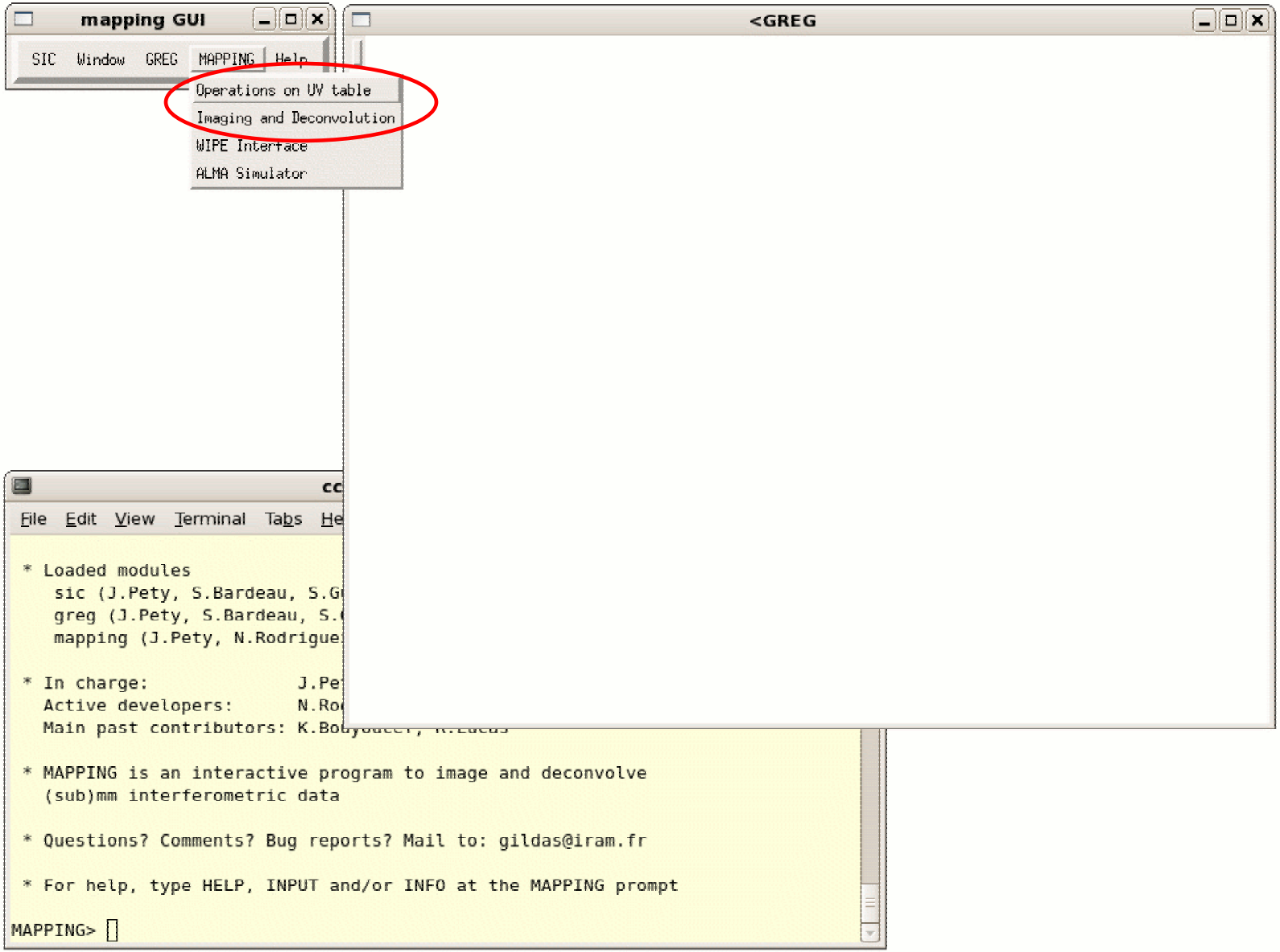
```
mapping>  define table aa mytable.uvt write
mapping>  let  aa[8,2380]  6000
mapping>  delete /variable aa
```

data at 2nd channel

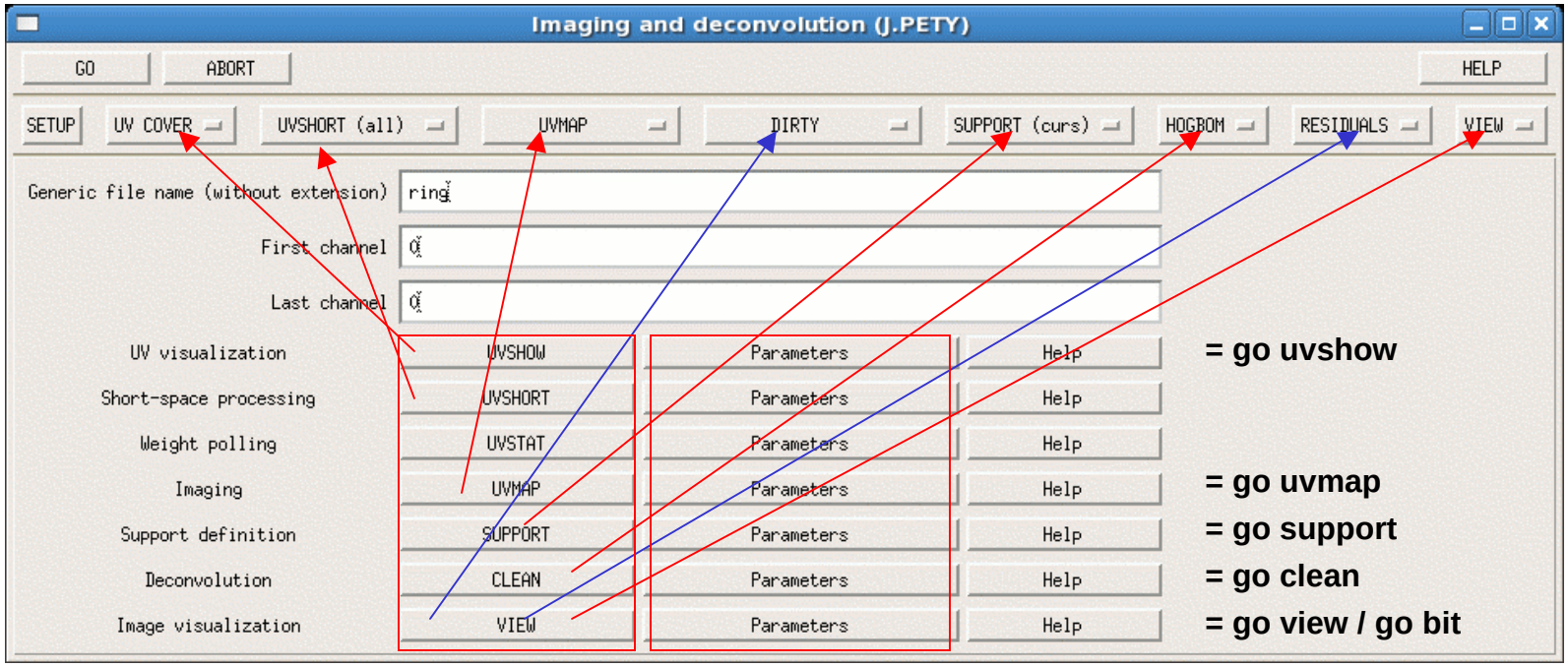
2. Imaging in practice

(demo this afternoon)

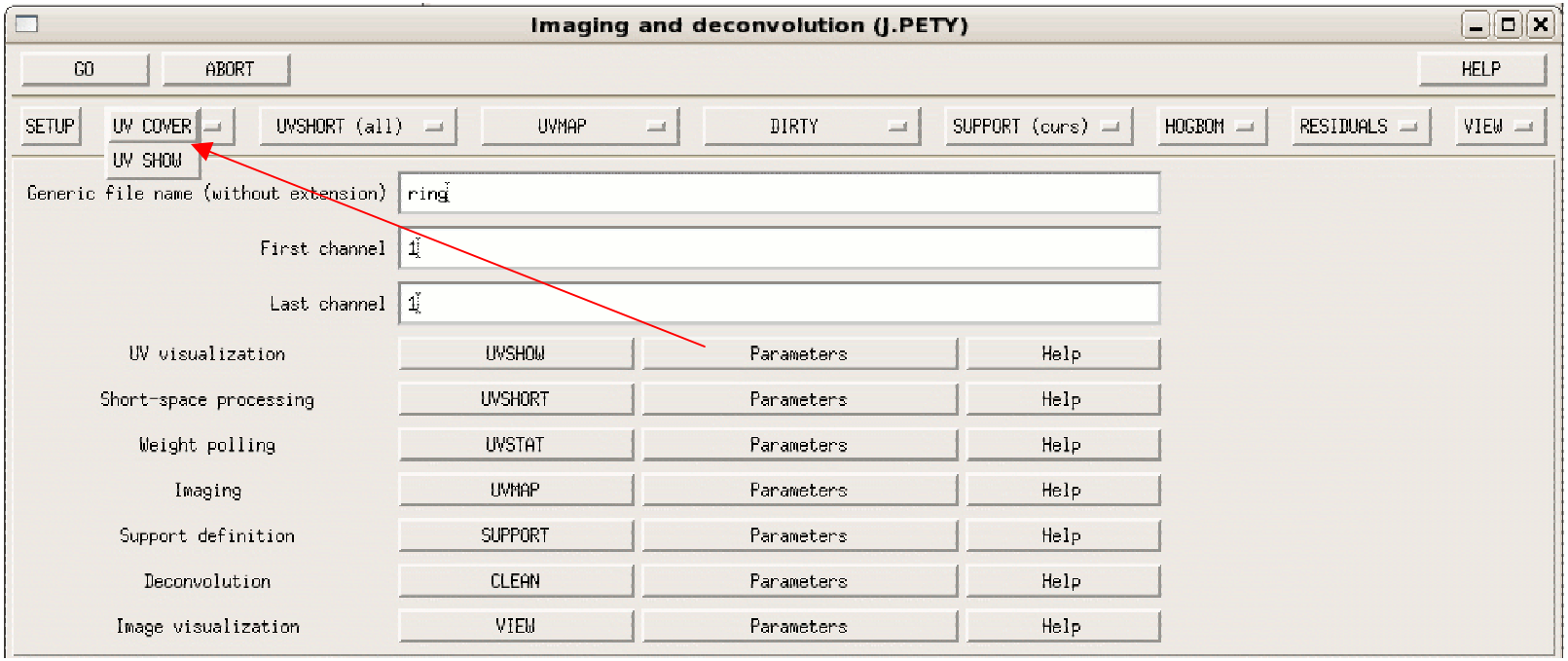
Imaging in practice



Imaging in practice



Imaging in practice



go uvshow

let name ring

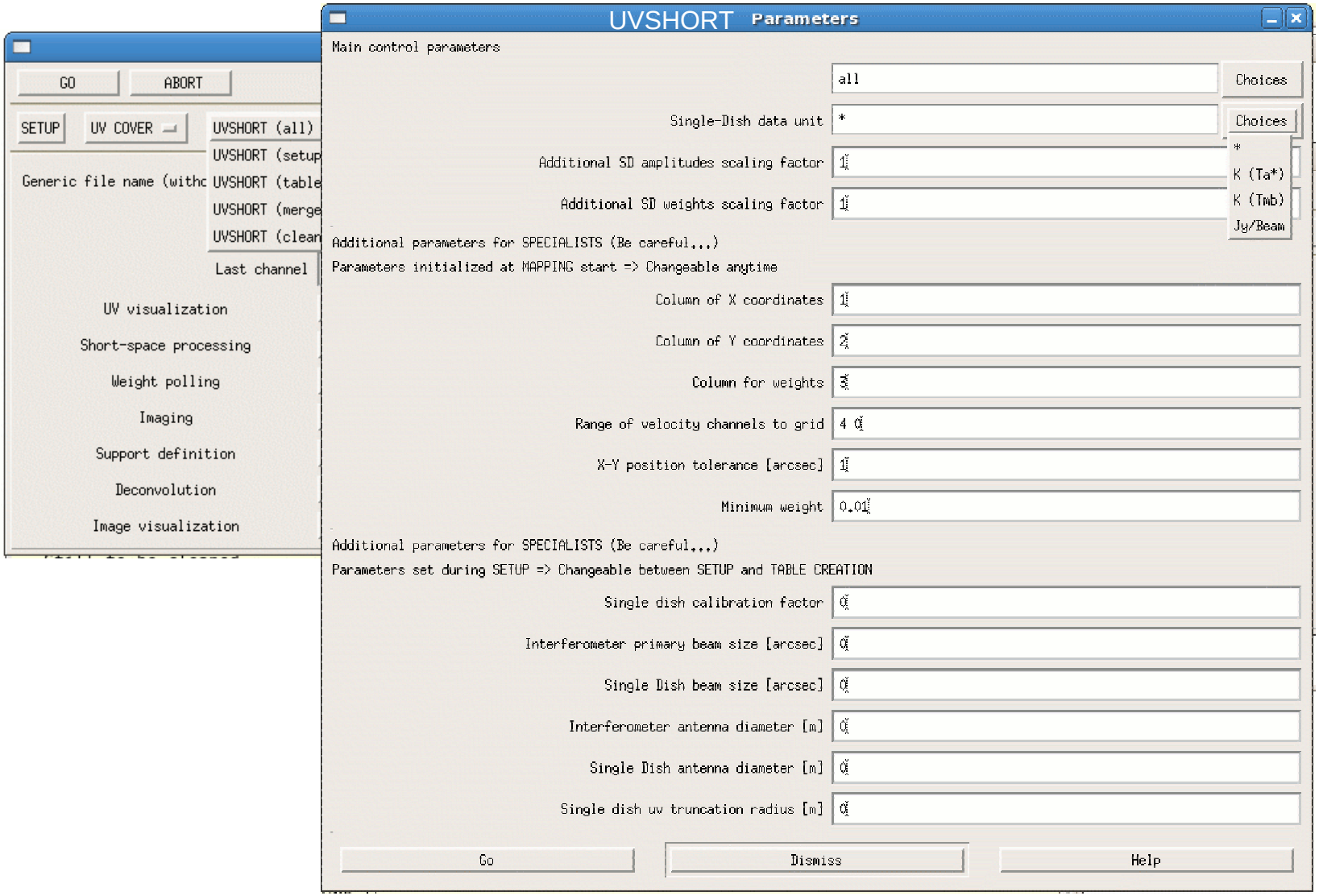
let first 1

let xtype radius

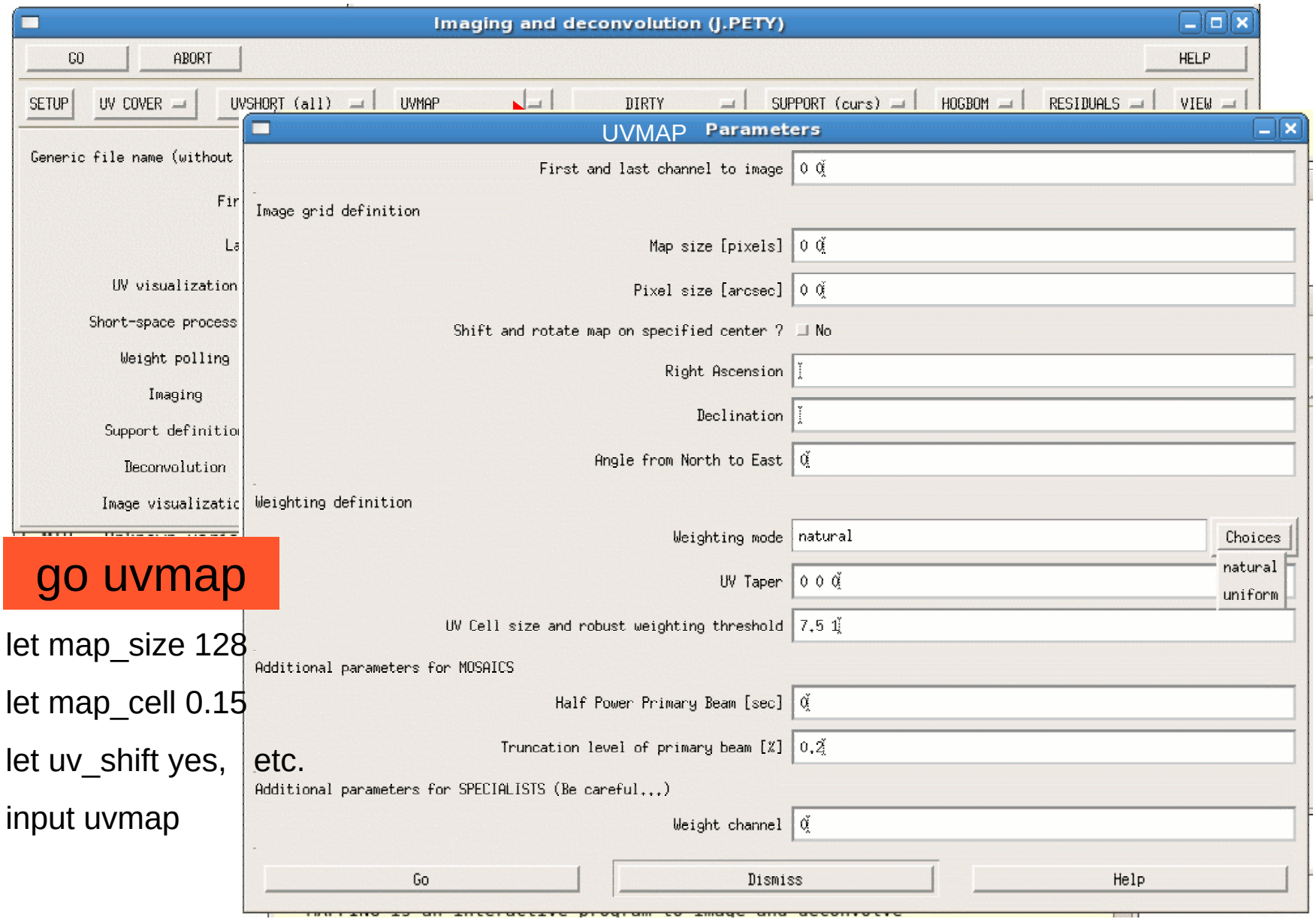
let ytype amp, etc.

input uvshow

Imaging in practice



Imaging in practice



go uvmap

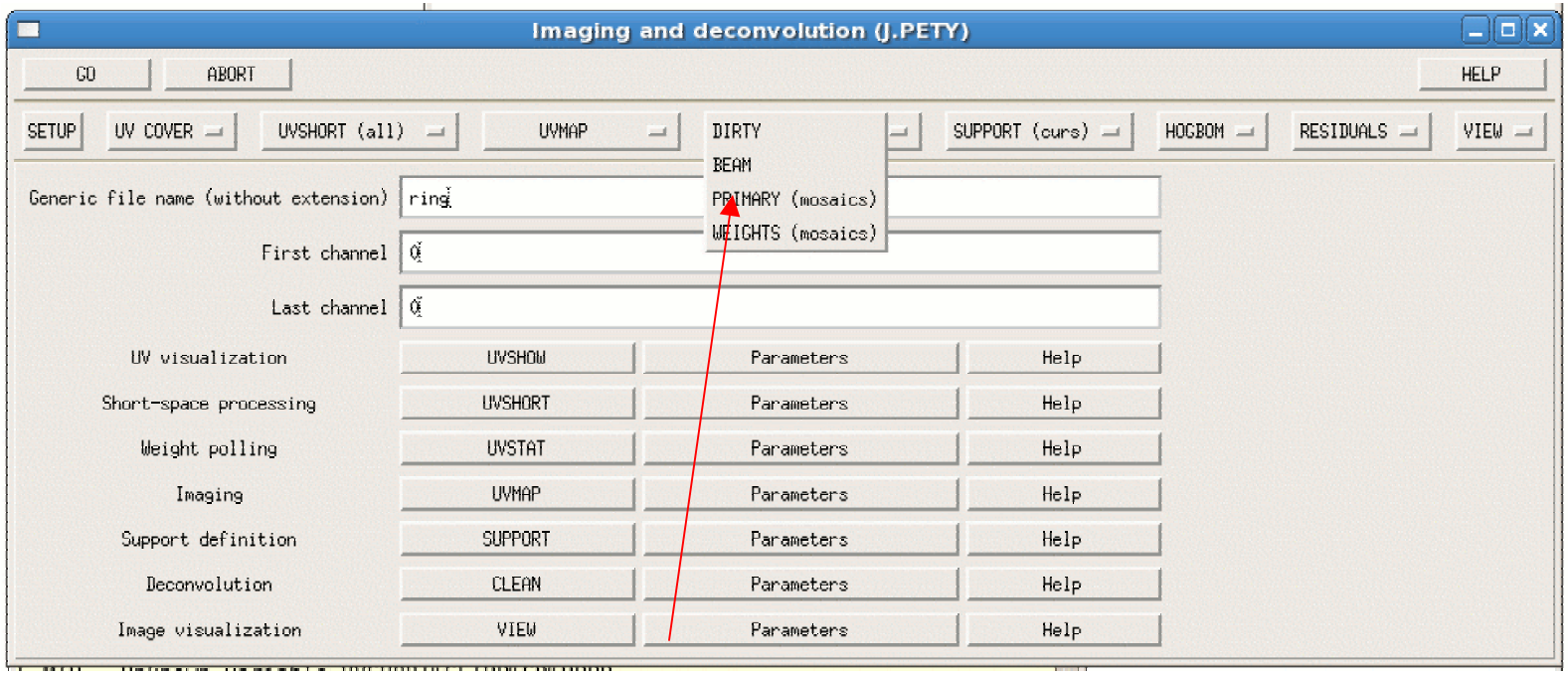
let map_size 128

let map_cell 0.15

let uv_shift yes, etc.

input uvmap

Imaging in practice



go bit

let type lmv

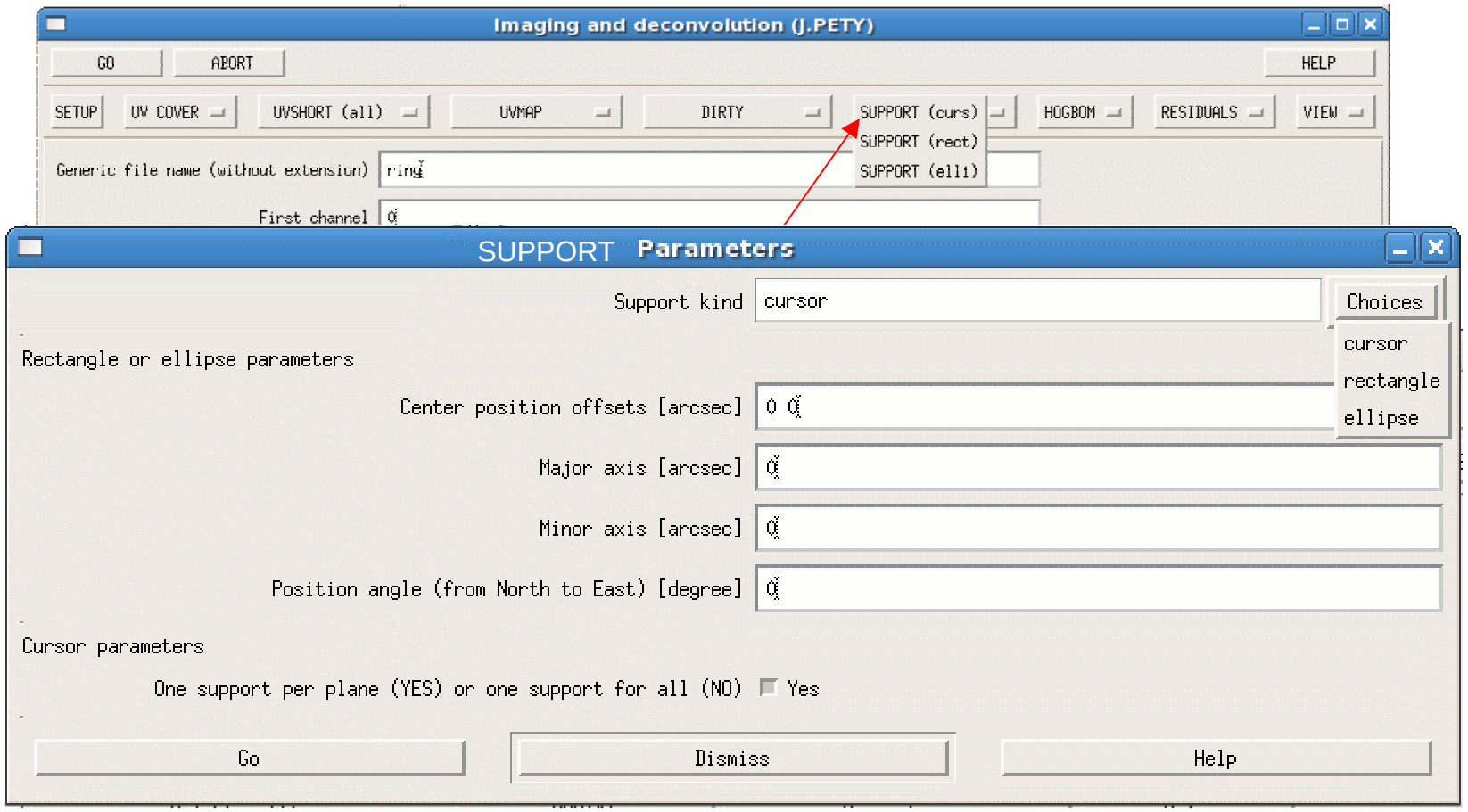
let type beam

let size 60

let spacing 0.02 , etc

input bit

Imaging in practice

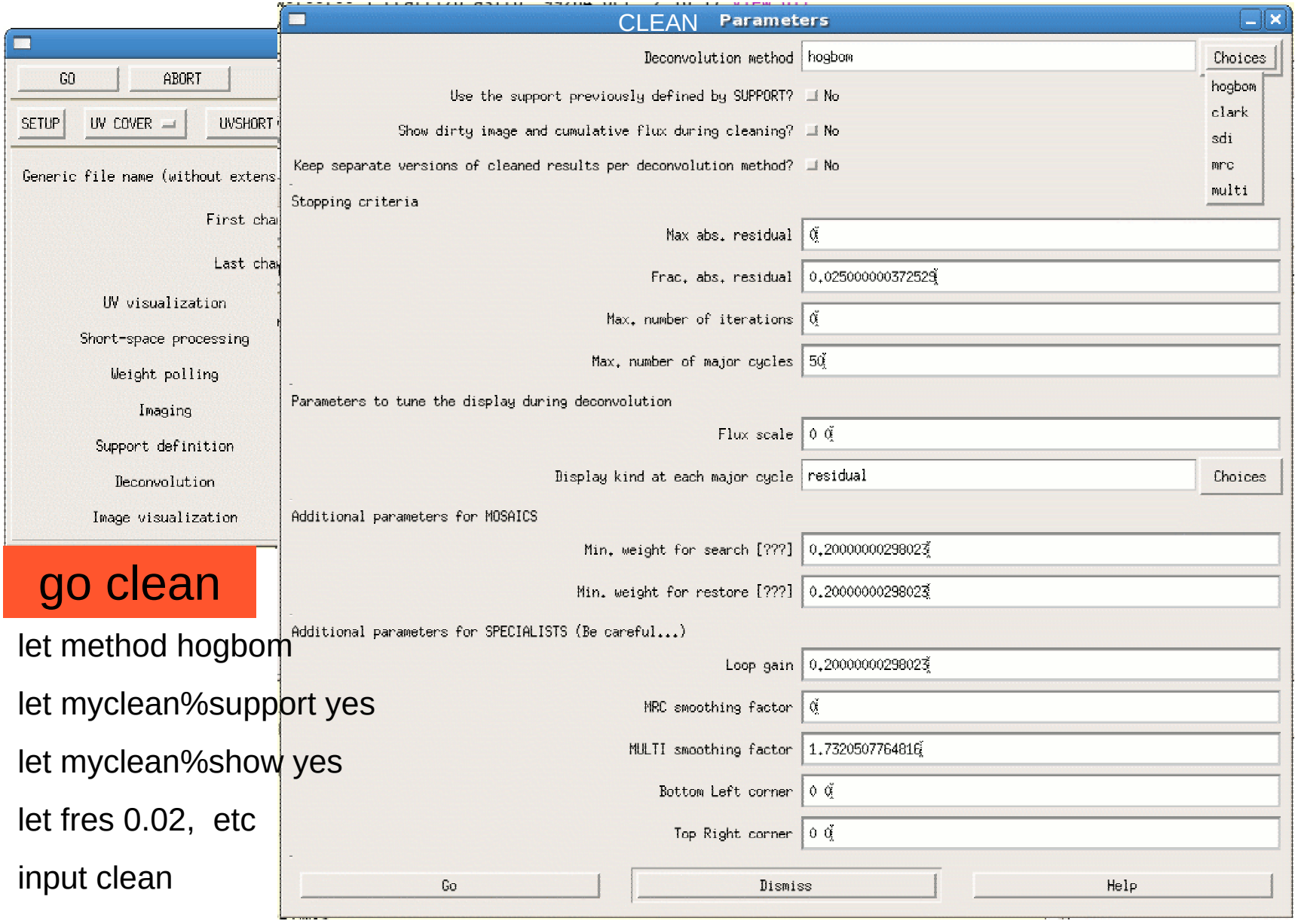


go support

let support%kind cursor

let support%oneperplane yes

Imaging in practice



go clean

let method hogbom

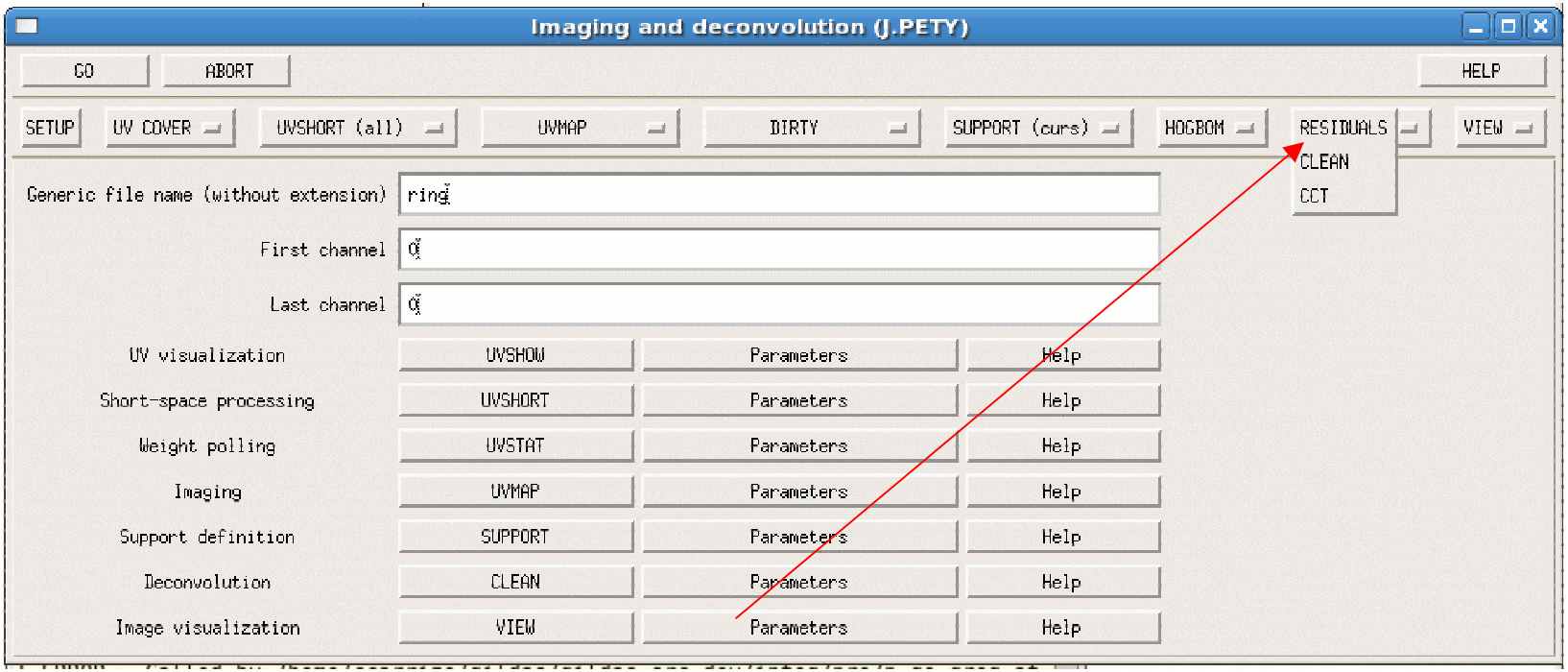
let myclean%support yes

let myclean%show yes

let fres 0.02, etc

input clean

Imaging in practice



go bit

let type lmv-res

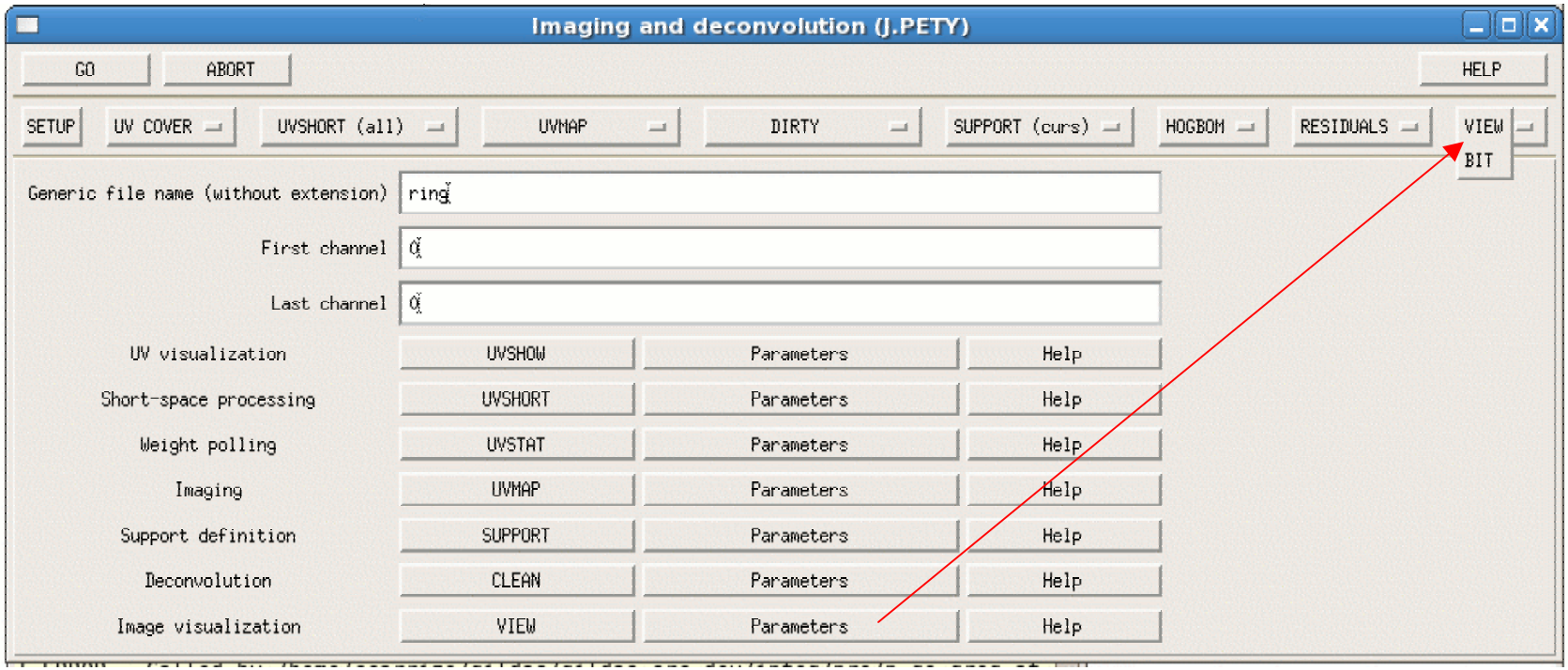
let type lmv-clean

let size 60

let spacing 0.02 , etc

input bit

Imaging in practice



go view
go bit

let name ring

let type lmv-clean

let size 60

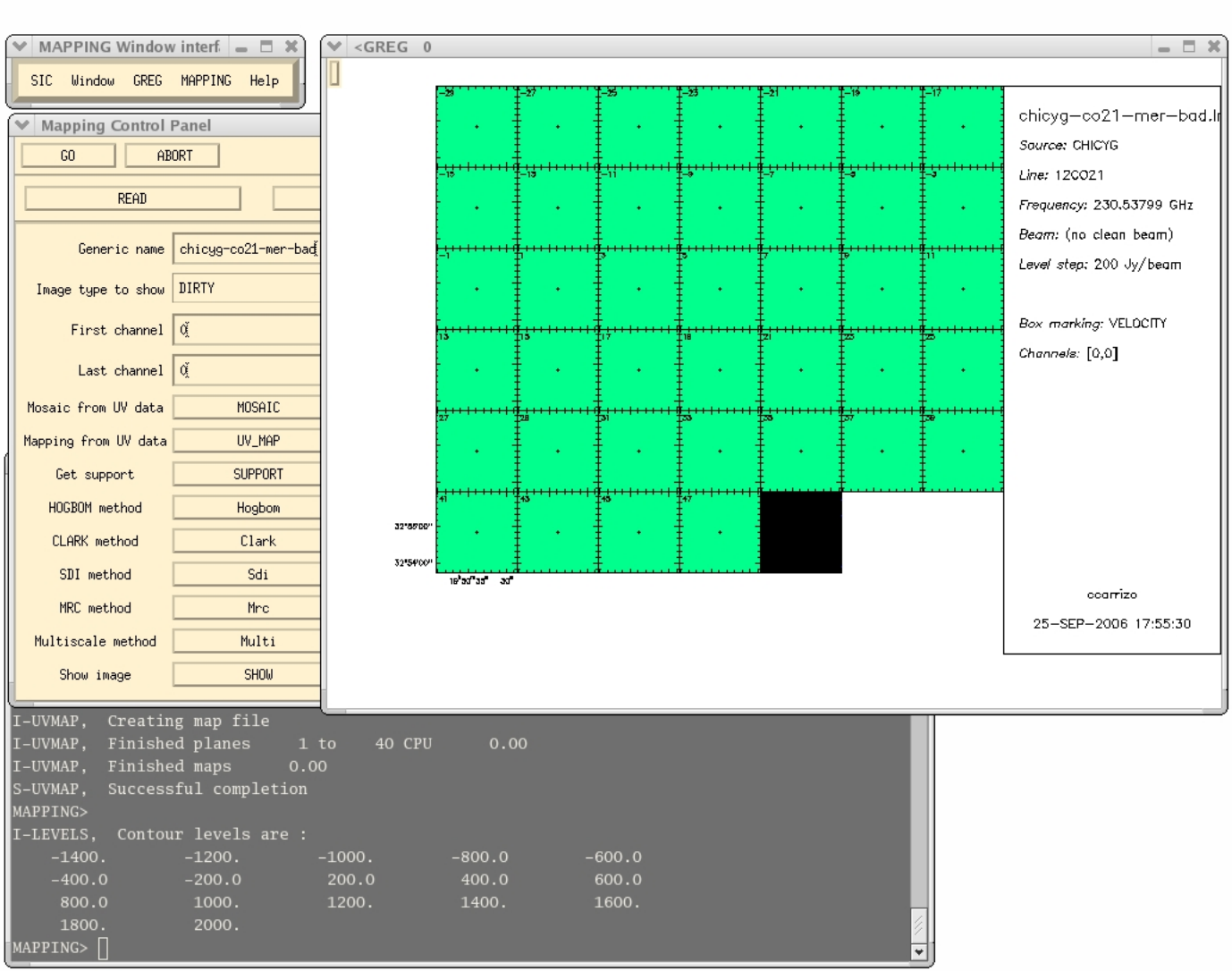
let spacing 0.02 , etc

input bit / input view

3. An inspection of the data in the *uv*-plane is recommended

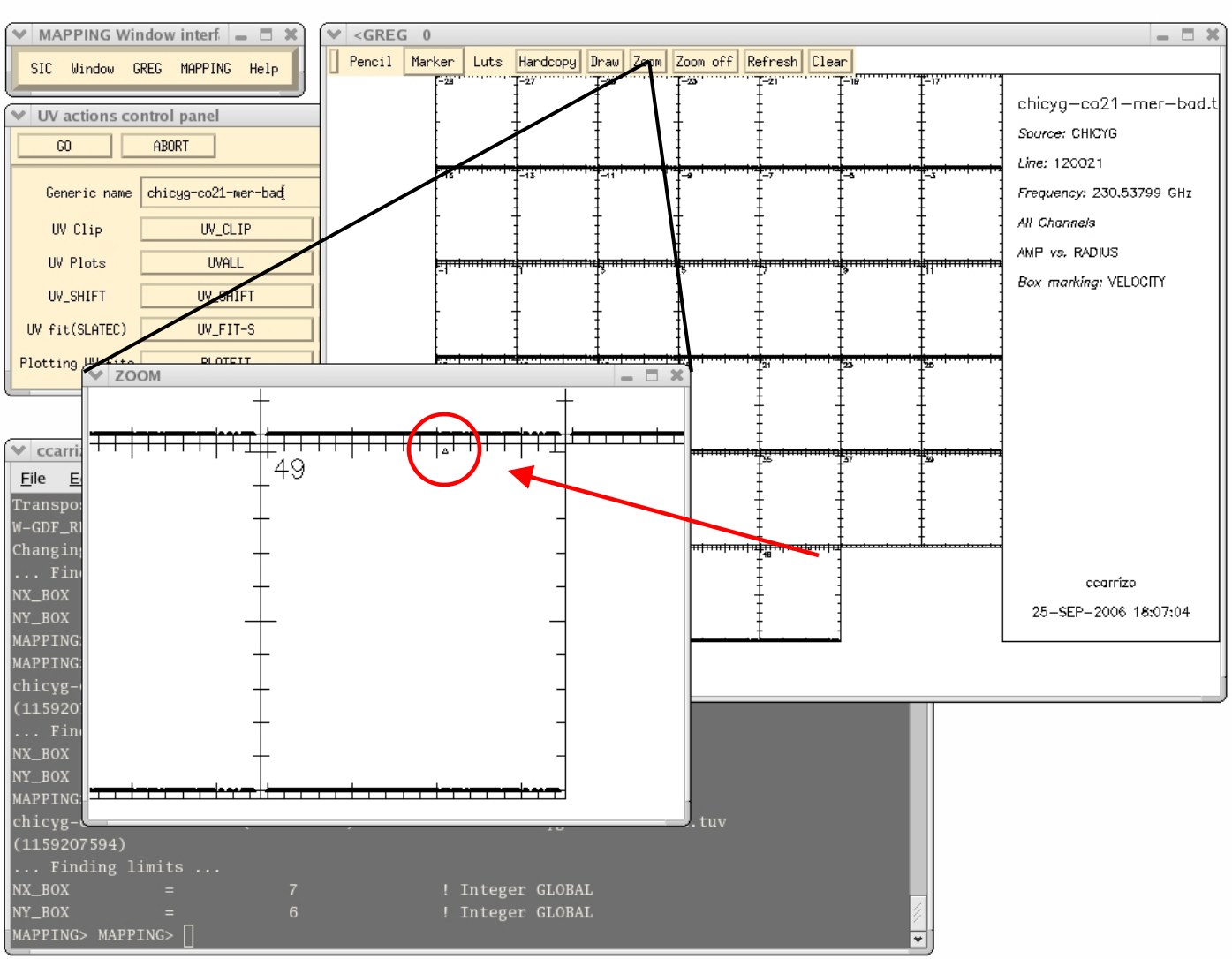
(1) Passing directly from hpb → mapping

It may happen…



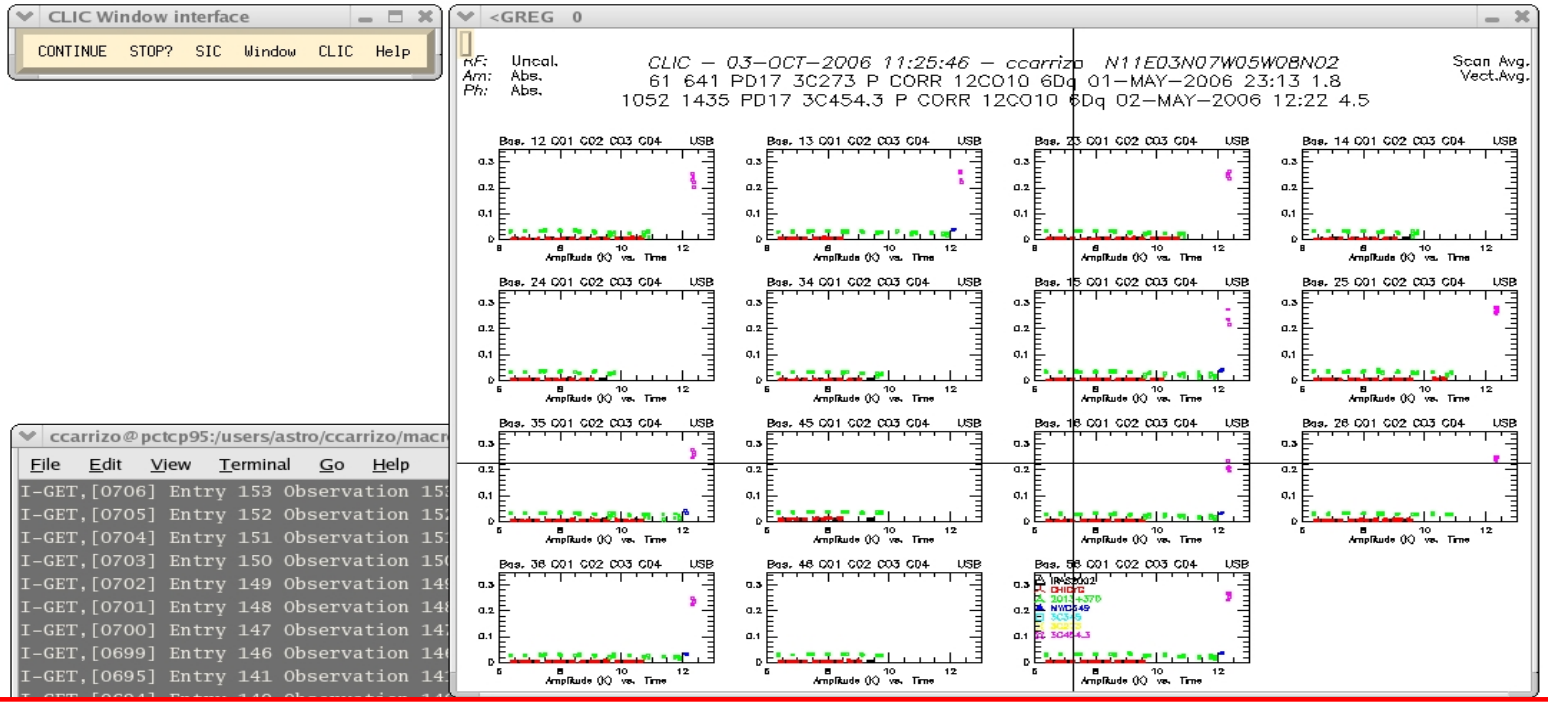
(1) Passing directly from hpb → mapping

It may happen…



(1) Passing directly from hpb → mapping

It may happen… that it remains a wrong visibility

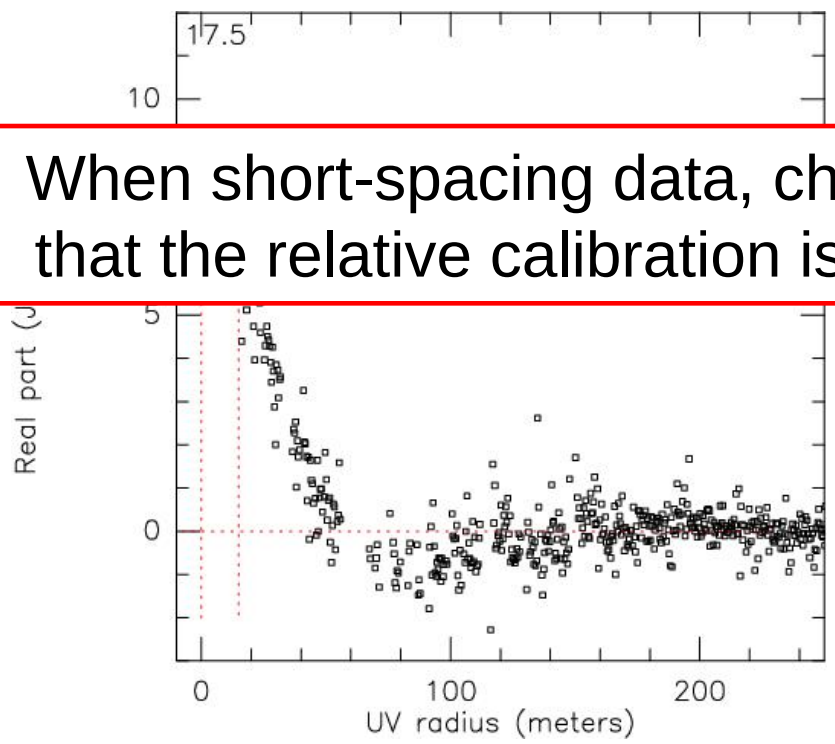


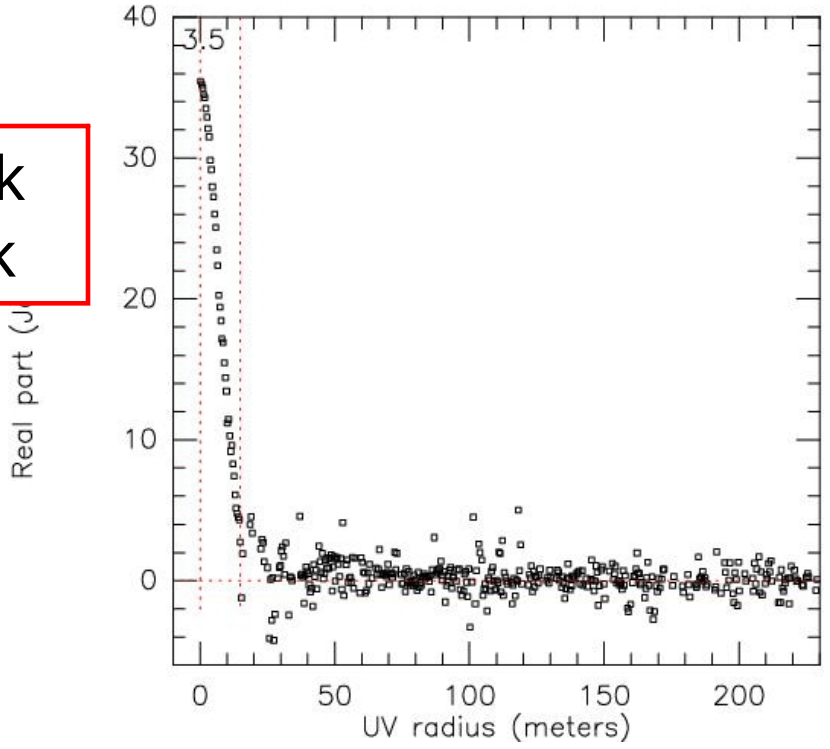
CLIC> find /proc corr /sou Betel /rece 2 /scans 1245 1255

CLIC> store quality 9

(2) Passing directly from hpb → mapping

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

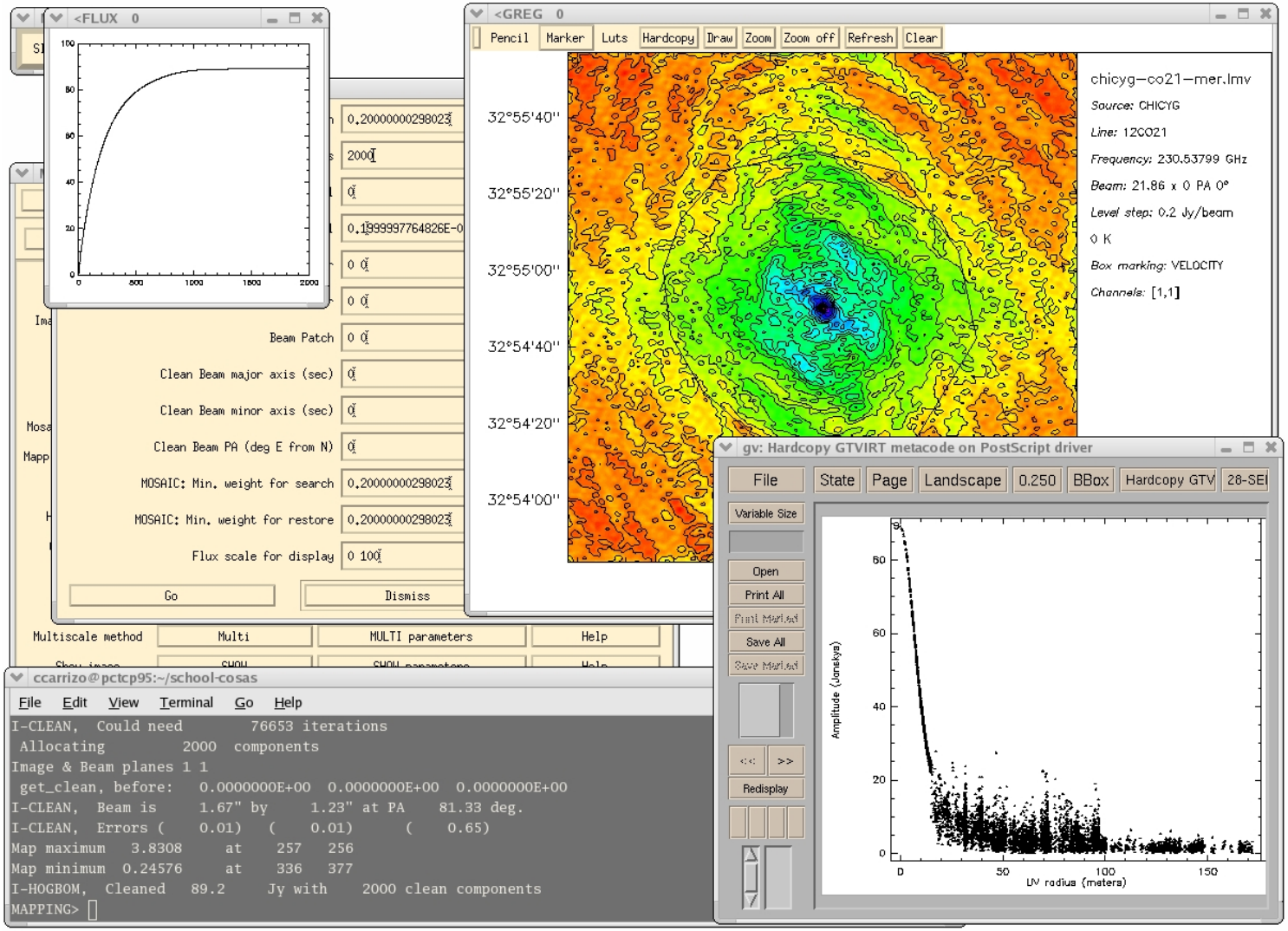




+ Short-spacing data

(3) Passing directly from hpb → mapping

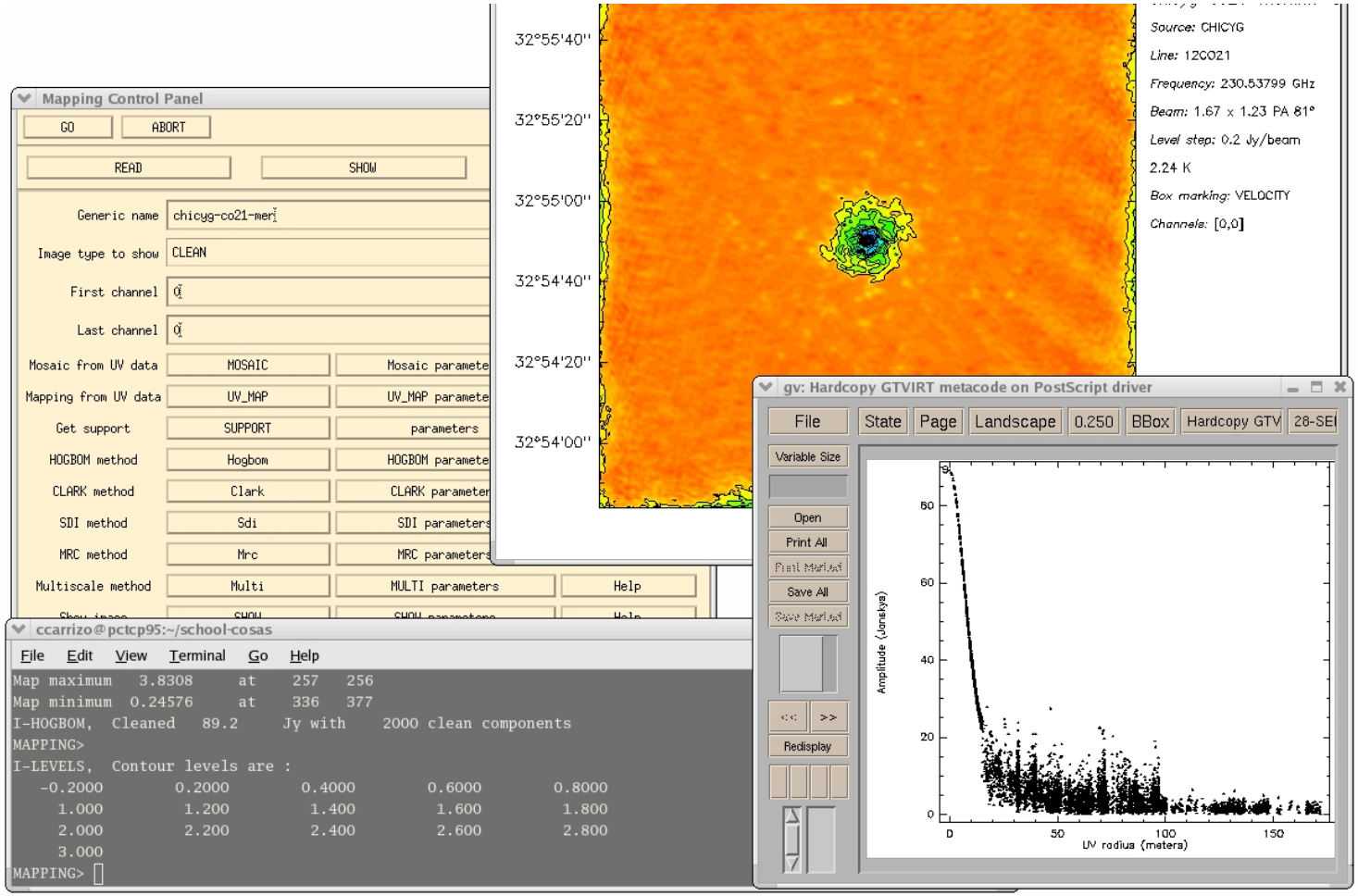
Good practice: When cleaning (extended sources)…



(3) Passing directly from hpb → mapping

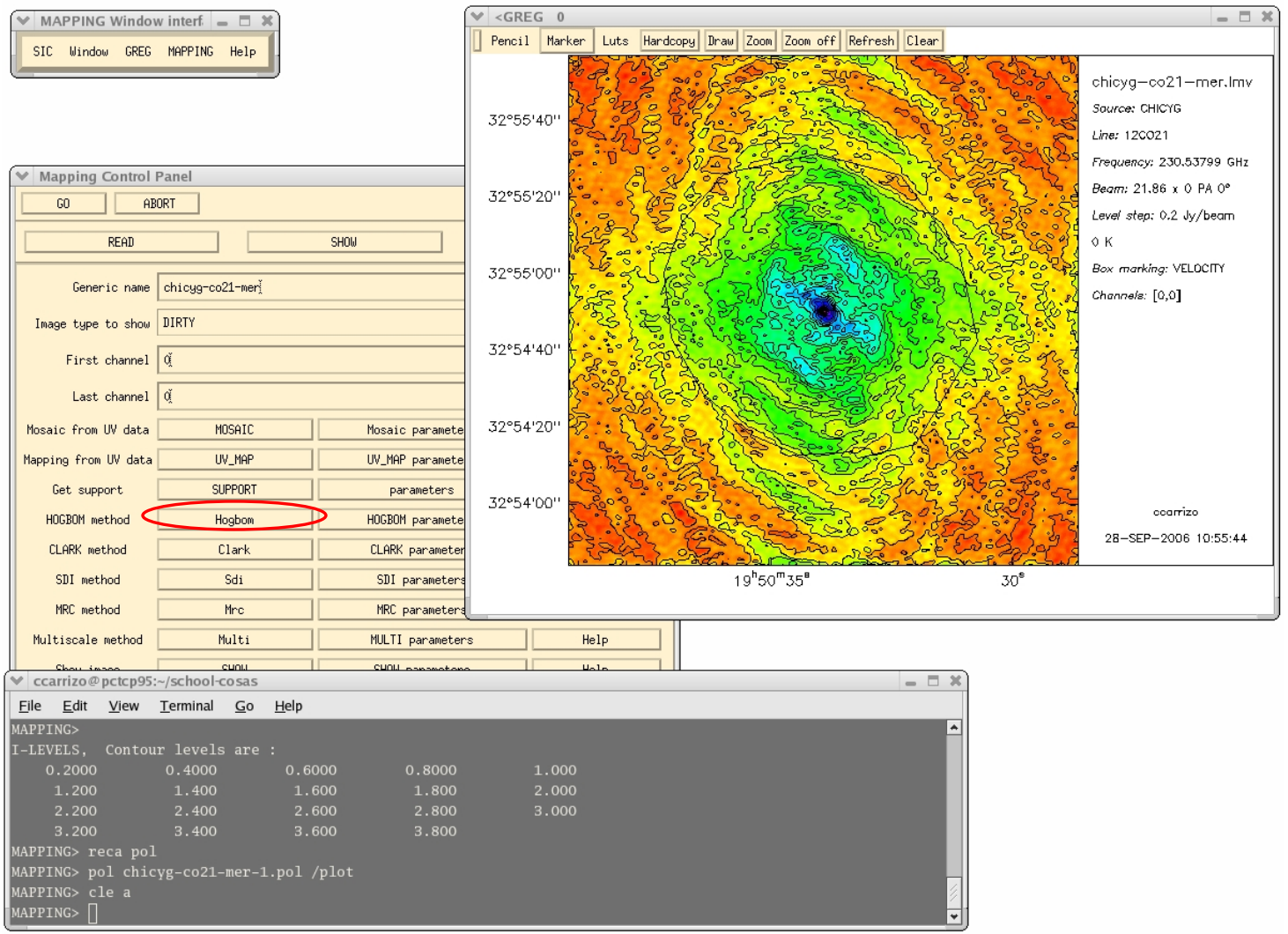
Good practice: When cleaning (extended sources)

verify that the flux obtained in the image plane coincides with that at the zero-spacing



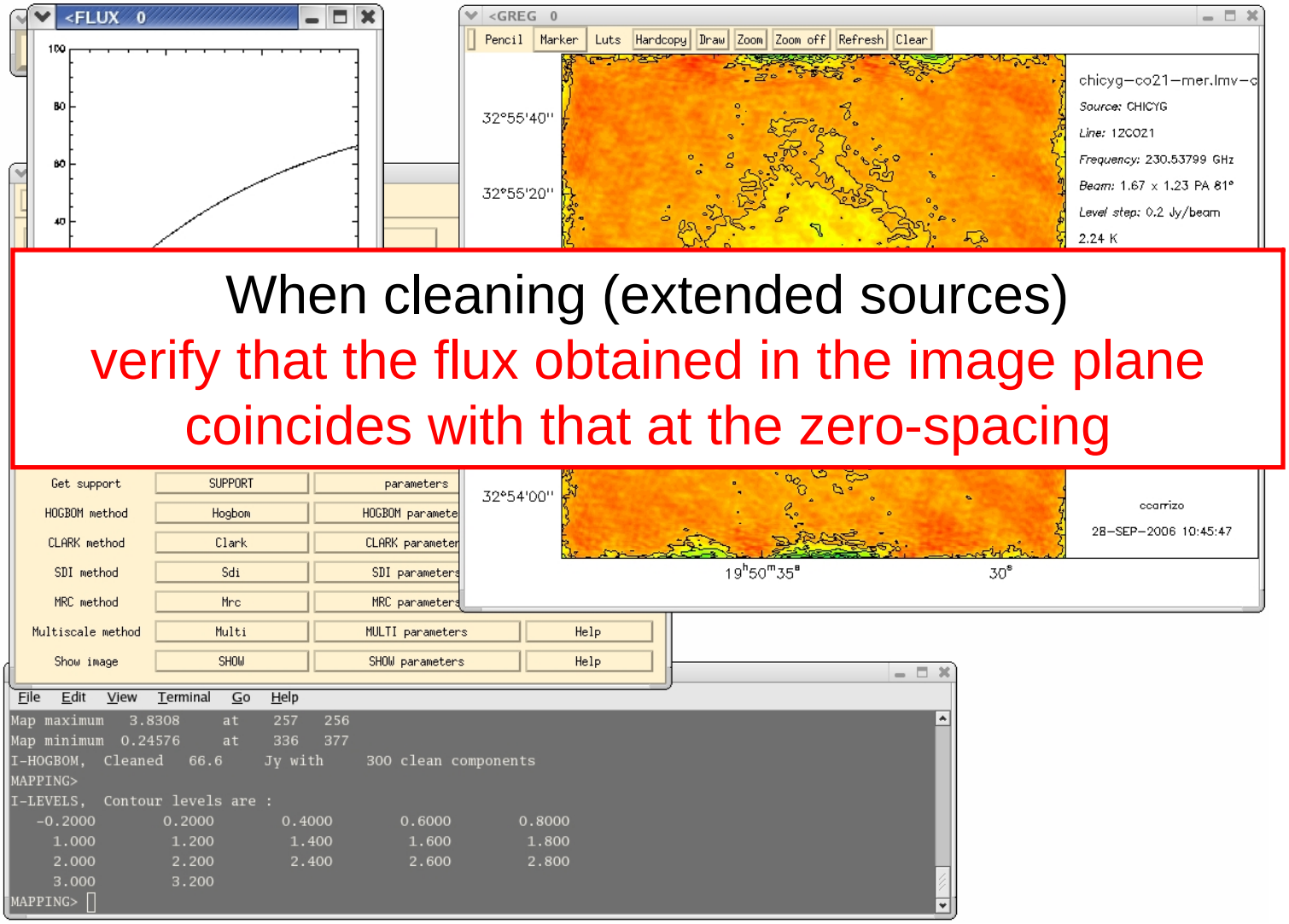
(3) Passing directly from hpb → mapping

If not, it may happen…



(3) Passing directly from hpb → mapping

It may happen…



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

- About imaging, this afternoon more…