CLASS tutorial: Dealing with cubes in CLASS

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Opening a cube

Opening a cube: I. Prerequisite

From LMV: cubes are usually Position-Position-Velocity (lmv): efficient for plane (image) access and use in GREG

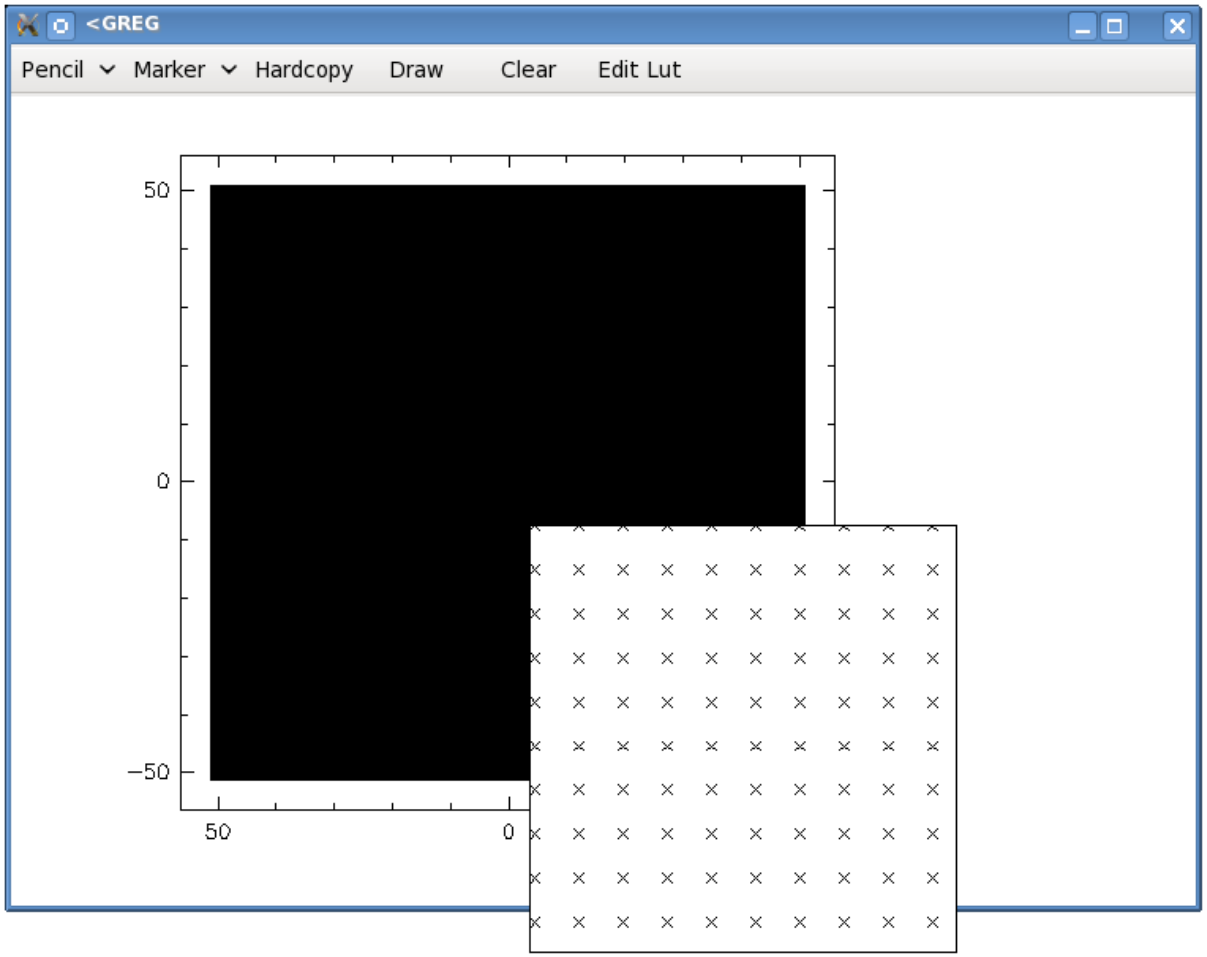
To VLM: spectrum access in CLASS needs Velocity-Position-Position (vlm) cubes ⇒ need transposition

```
LAS> TRANSPOSE lj-meth1.lmv-clean lj-meth1.vlm-clean 312
```

⊕ Efficient access,
⊖ Redondant files, double disk usage.

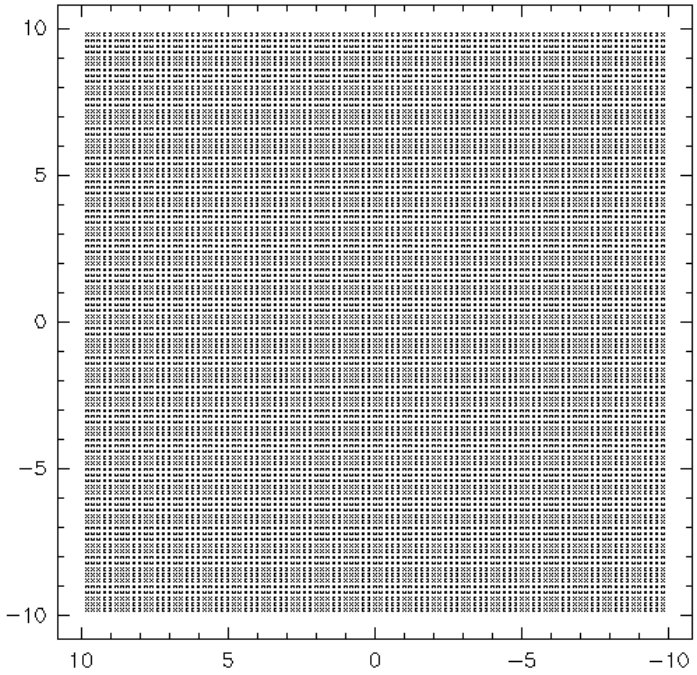
Opening a cube: II. Selecting all pixels

```
LAS> file in lj-meth1.vlm-clean  ! Open the file
I-GIO_RIH,  GDFBIG re-allocation      2
I-INPUT,  lj-meth1.vlm-clean successfully opened
LAS> find                        ! Select all the spectra/pixels
I-FIND,  262144 observations found
LAS> go where                    ! Where are the selected pixels?
```

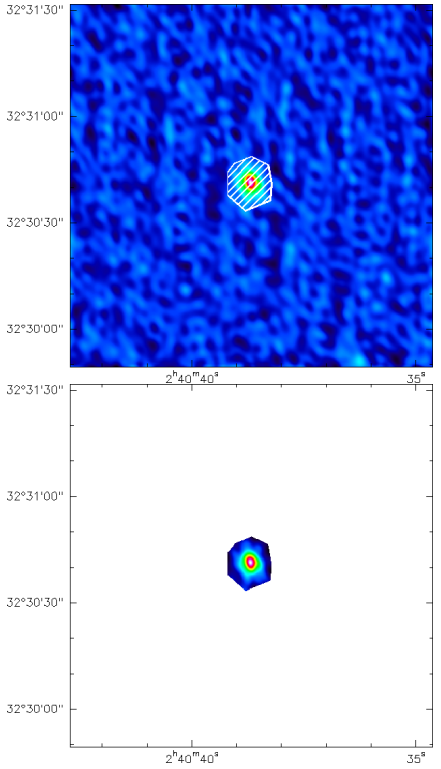


Opening a cube: III. Selecting a subset

```
LAS> set angle sec      ! Set angle unit (second is the default)
LAS> set match 10       ! Matching tolerance, in current angle unit
LAS> find /offset 0 0   ! Find spectra/pixels at the source center, with above tolerance
I-FIND,  9801 observations found
LAS> go where           ! Check selection
```



Opening a cube: IV. Selecting with custom mask

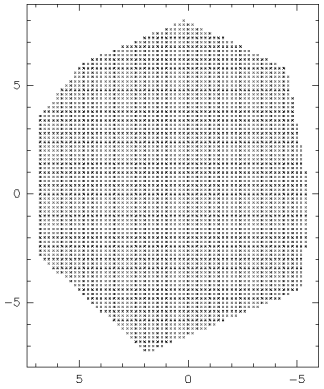


Use GREG commands (g\...) to create a mask file:

```
LAS> g\clear
LAS> g\set /def
LAS> g\image lj-meth1.lmv-clean /plane 135
LAS> g\limits /rg
LAS> g\set box match
LAS> g\plot
LAS> g\box /absolute
LAS> g\polygon /plot /hatch  ! Custom selection with cursor

LAS> g\mask out  ! Mask pixels out of the polygon
LAS> g\clear
LAS> g\plot
LAS> g\box /absolute

LAS> let rg 1 /where rg.ne.blanking[1]  ! Enable pixels in the polygon
LAS> g\write image lj-meth1-mask.lm     ! Save the mask in image file
```



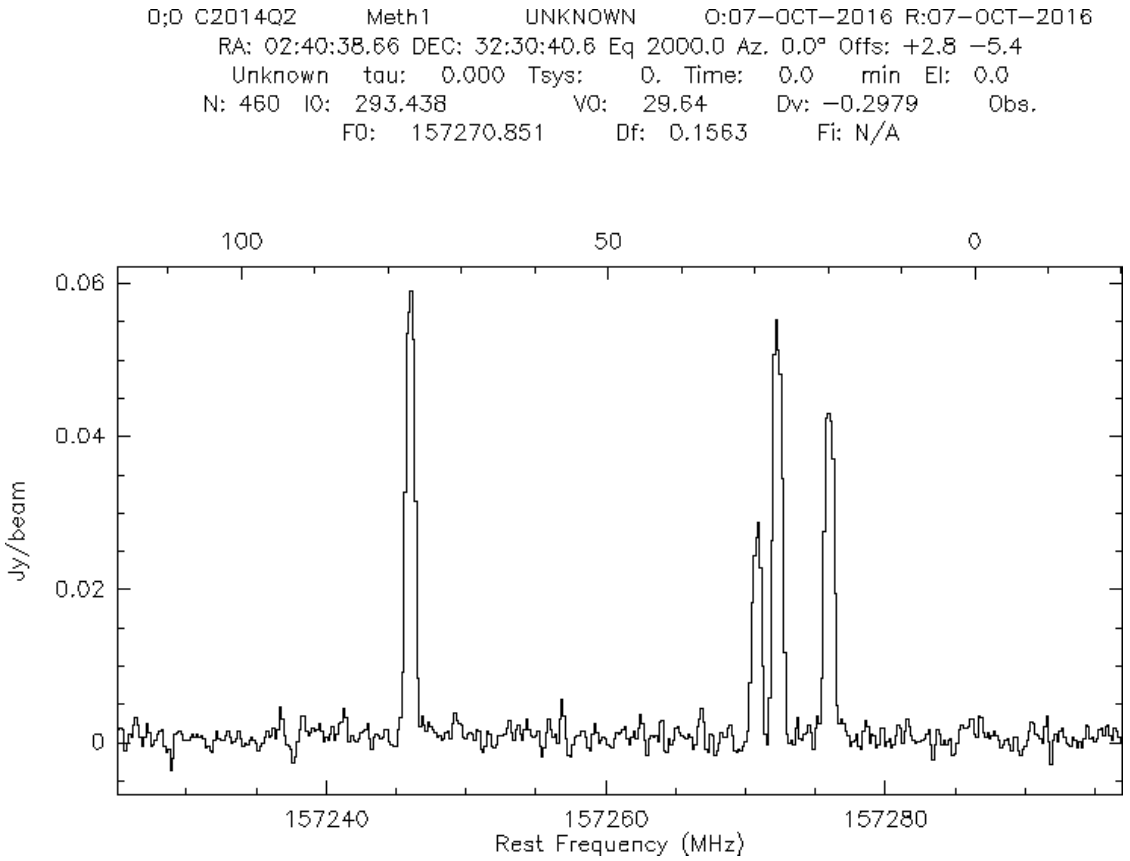
Use this mask file in CLASS for custom selection:

```
LAS> file in lj-meth1.vlm-clean
LAS> find /mask lj-meth1-mask.lm  ! Use the mask image file
LAS> go where
```

Data reduction

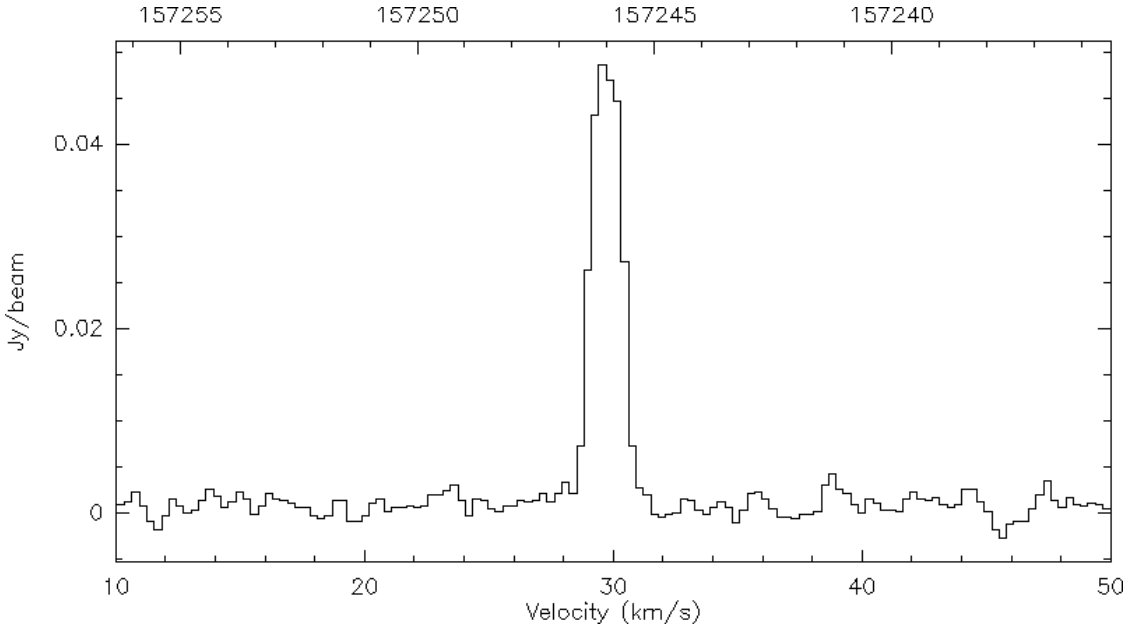
Data reduction: I. Averaging

```
LAS> set weight equal          ! Spectra have equal weight
LAS> average /nocheck offset   ! Average the selected spectra altogether, result in R buffer
...
Channel alignment, no resampling:
...
LAS> plot                      ! Plot the R buffer
```



Data reduction: II. Fitting a line on single spectrum

```
LAS> modify frequency 157246.056  ! Align velocity axis for analyzing this methanol line
LAS> set unit v f                 ! Lower axis velocity => fit results in velocity units
LAS> set mode x 10 50             ! Plot and fit only in range 10 to 50 km/s
LAS> plot
```



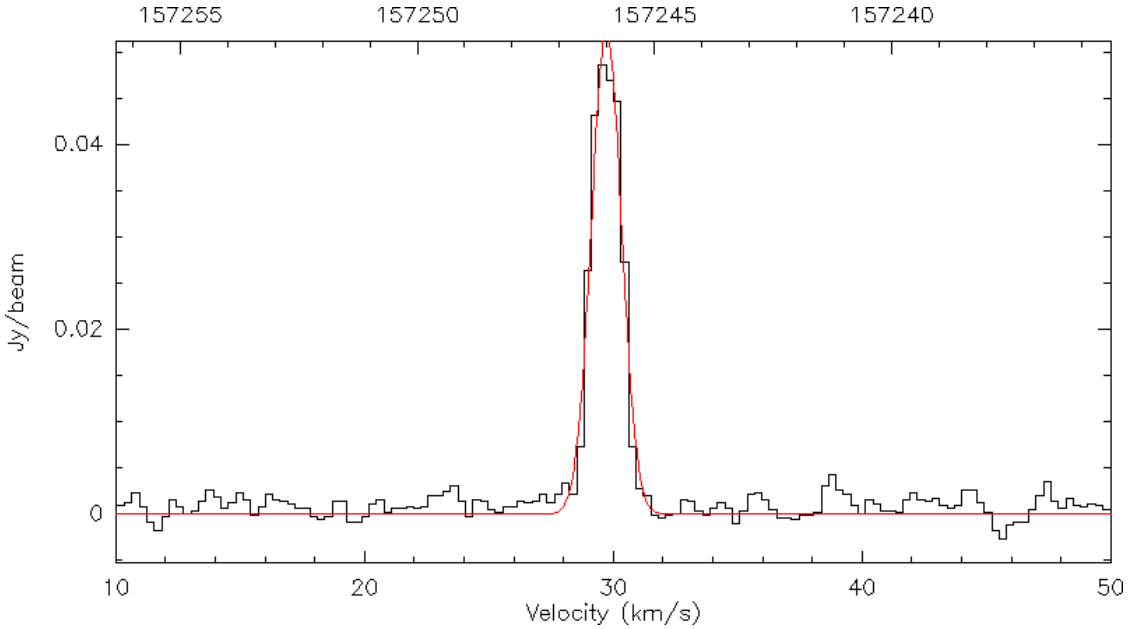

```
LAS> method gauss                 ! Will fit gaussian profile(s)
I-METHOD,   GAUSS        selected
LAS> lines 1 "0 0.1  0 30  0 2"   ! 1 gaussian, initial guesses for intensity, position, width
LAS> minimize /nocheck baseline   ! Minimization, assume there is no baseline to remove
...
 Line      Area                    Position           Width              Tpeak
 1    9.51483E-02 (  0.002)    29.717 (  0.012)     1.404 (  0.025)  6.36587E-02
```

Data reduction: II. Fitting a line on single spectrum (cont'd)

```
LAS> minimize /nocheck baseline      ! Minimization, assume there is no baseline to remove
...
 Line      Area                    Position            Width              Tpeak
 1    7.89793E-02 (  0.001)    29.720 (  0.012)     1.410 (  0.027)  5.26357E-02

LAS> examine r%head%gau%result[1:3]  ! Fitting results saved in R buffer
R%HEAD%GAU%RESULT[1:3] is a real Array     of dimensions  3
  7.8979328E-02   29.72018       1.409616
LAS> examine r%head%gau%error[1:3]   ! Fitting errors saved in R buffer
R%HEAD%GAU%ERROR[1:3] is a real Array     of dimensions  3
  1.3531410E-03  1.2194340E-02  2.6825795E-02

LAS> visualize /pen 1                ! Overplot the fitted profile
```



Data reduction: III. Fitting a line on all pixels

Same operation on each individual spectrum/pixel. Save results in a CLASS file.

```
LAS> file in lj-meth1.vlm-clean
LAS> set match 5
LAS> find /offset 0 0                  ! Square selection => will produce square maps

LAS> file out lj-meth1.bin single      ! Will save spectra + fitting results in this file
LAS> set unit v f                      ! Lower axis velocity => fit results in velocity units
LAS> set mode x 10 50                  ! Fit only in range 10 to 50 km/s
LAS> method gauss                      ! Will fit gaussian profile(s)

LAS> for i 1 to found                  ! Loop on all selected spectra
LAS>   get next                        ! Read next spectrum in index
LAS>   modify frequency 157246.056
LAS>   lines 1 "0 0.1  0 30  0 2"      ! 1 gaussian, initial guesses for intensity, position, width
LAS>   minimize /nocheck baseline
LAS>   write                           ! Write this spectrum + fitting results
LAS> next i

LAS> $ls -l lj-meth1.bin
-rw------- 1 bardeau astro 6148096 Oct 10 10:42 lj-meth1.bin
```

Data reduction: IV. Maps of parameters

```
LAS> file in lj-meth1.bin      ! Retrieve the fitted spectra
LAS> find
LAS> set weight equal          ! Spectra have equal weight

LAS> table lj-meth1 new /math R%HEAD%GAU%RESULT[1] R%HEAD%GAU%RESULT[2] R%HEAD%GAU%RESULT[3]

LAS> xy_map lj-meth1 /nogrid   ! Create cube from table, no gridding (spectra already inplace)
...
Field of View:     -10.0" x      10.0"
Pixel size:      -0.4" x       0.4"
Spatial resolution:       3.2"
Telescope Beam:       3.0" (from table header)
I-XY_MAP,  Creating file: lj-meth1.lmv
I-XY_MAP,  Creating file: lj-meth1.wei
```