Generating HiPS Catalogues

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Generalities about HiPS

HiPS Definition

- HiPS stands for **Hi**erachical **P**rogressive **S**urvey
- HiPS is based on HEALPix
  - **H**ierachical **E**qual **A**rea [...] **Pix**elisation of the sphere
  - At a given depth, all tiles have the same surface area and a similar shape
- Basic idea (à la Google Earth, ...):
  - Global view over a large amount of data
  - Summarized/Most important information at low resolutions (low levels)
  - Finer details at higher resolution (deeper levels)
- A user friendly way to access astronomical data
  - Browse the sky without performing any query
  - Pan to find a region of interest (ROI)
  - Zoom to obtain more details in your ROI
  - No overload of your machine, i.e.:
    - no full resolution images of 1/10th of the sky
    - no Cone Search returning >1 000 000 objects

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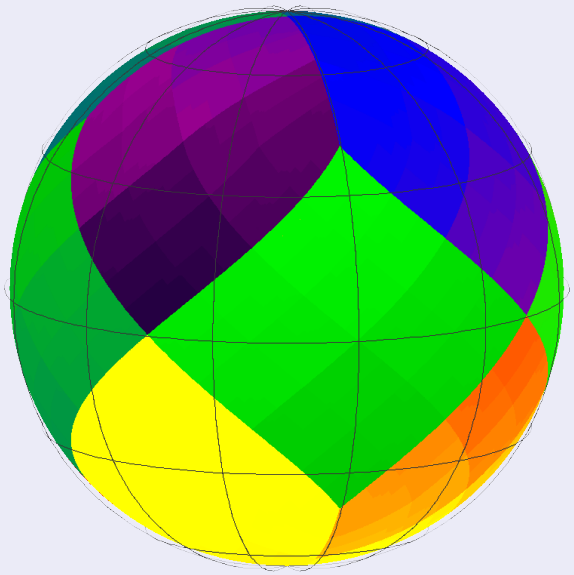

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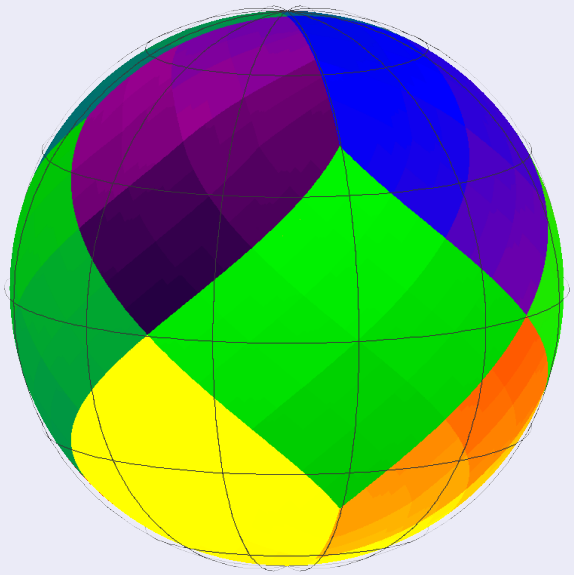

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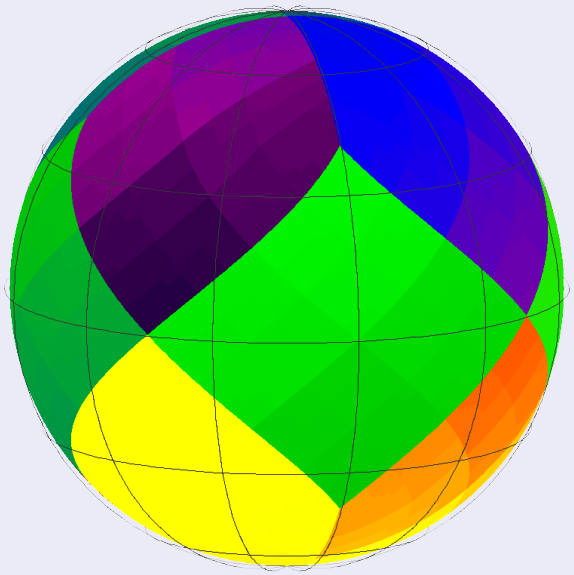
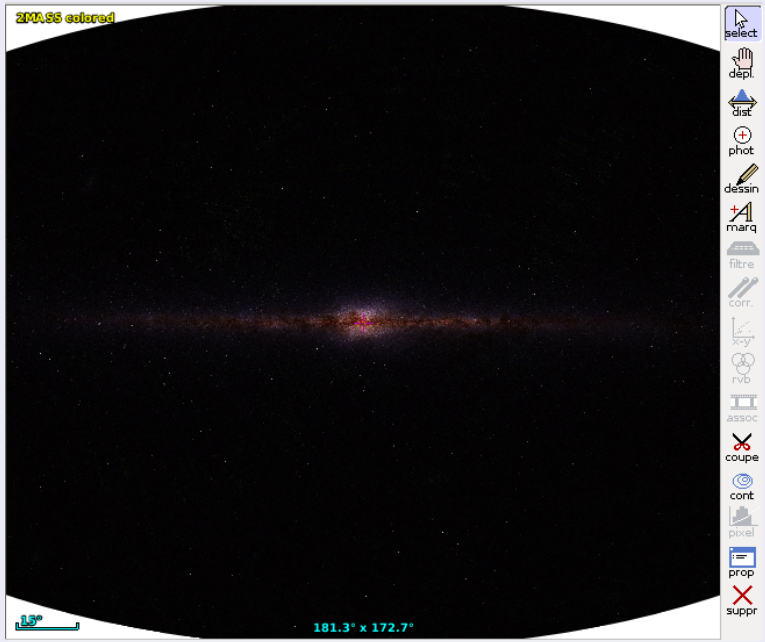


Several possible HiPS types

Existing HiPS types

- Image based HiPS
  - Resolution depends on zoom depth
    - Constant number of pixels on display
    - ⇒ better angular resolution zooming in
    - Low depth pixel summarizes the information its sub-pixels contain (e.g. mean value)
  - Global view of the sky (low level): large structures
  - Deepest level: individual fainter objects
  - Implemented in:



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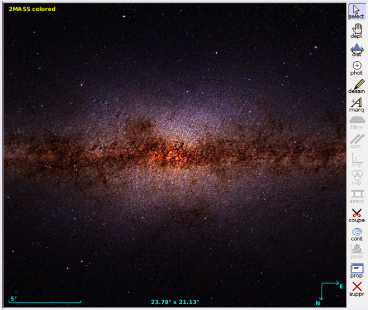

- Catalogue based HiPS (this talk)
- $HiPS^2$ (HiPS Cubes): see next talk by Pierre Fernique

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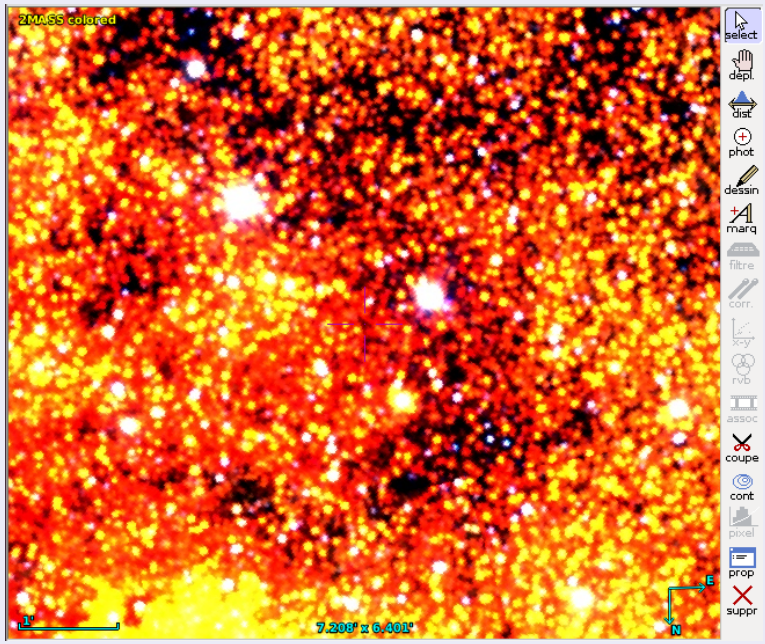

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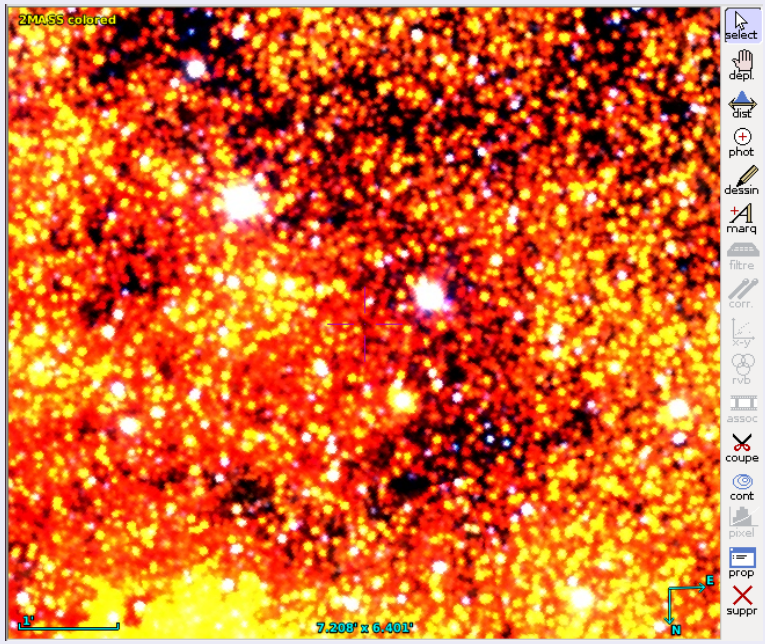

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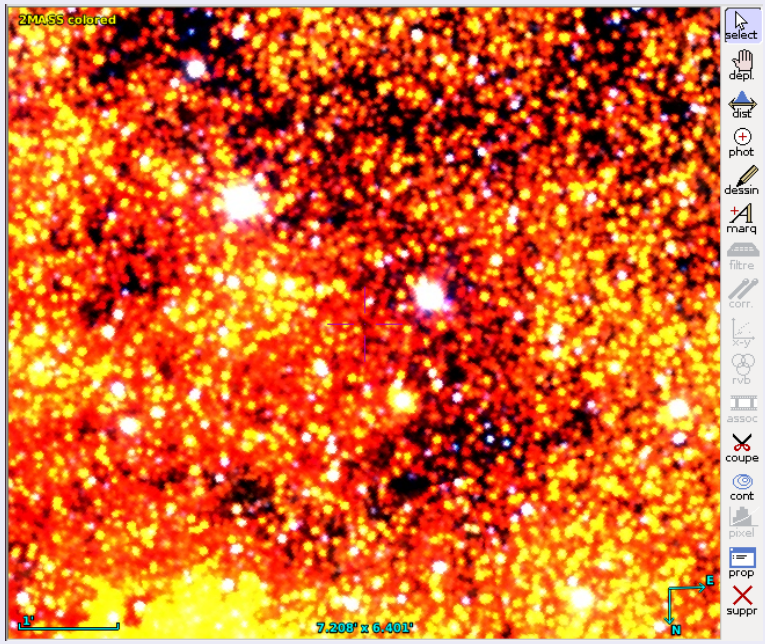

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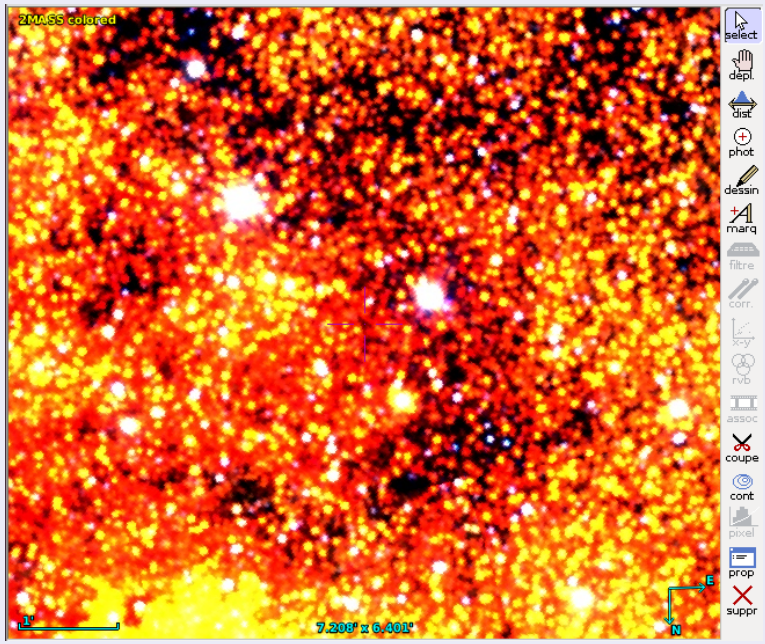

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- HiPS $\Rightarrow$ no explicit queries
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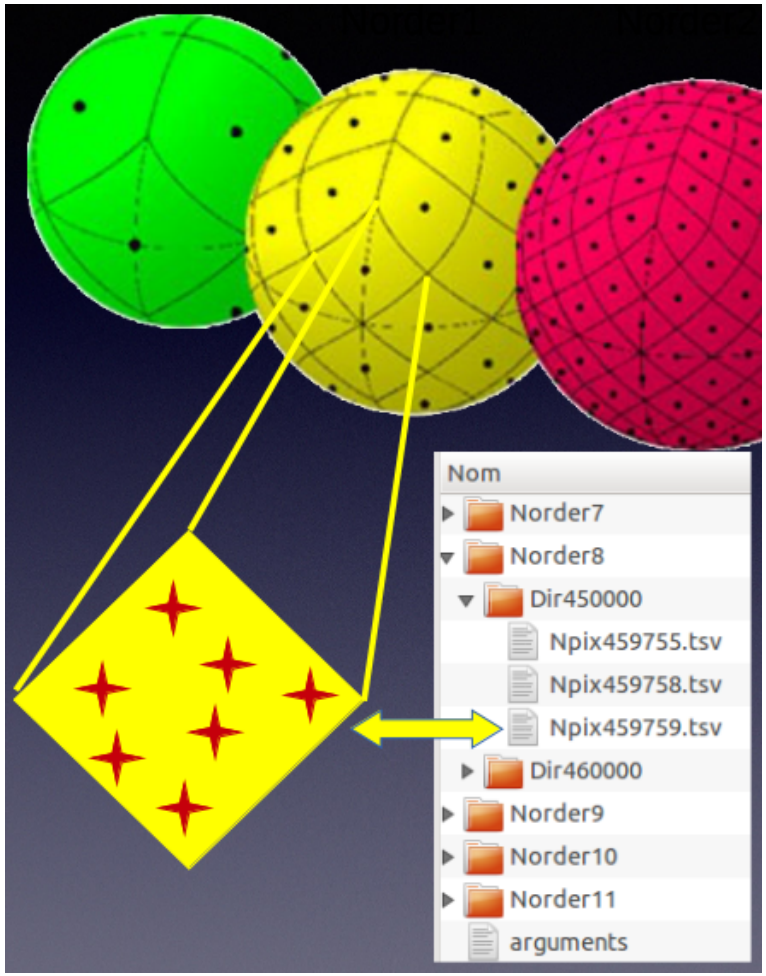

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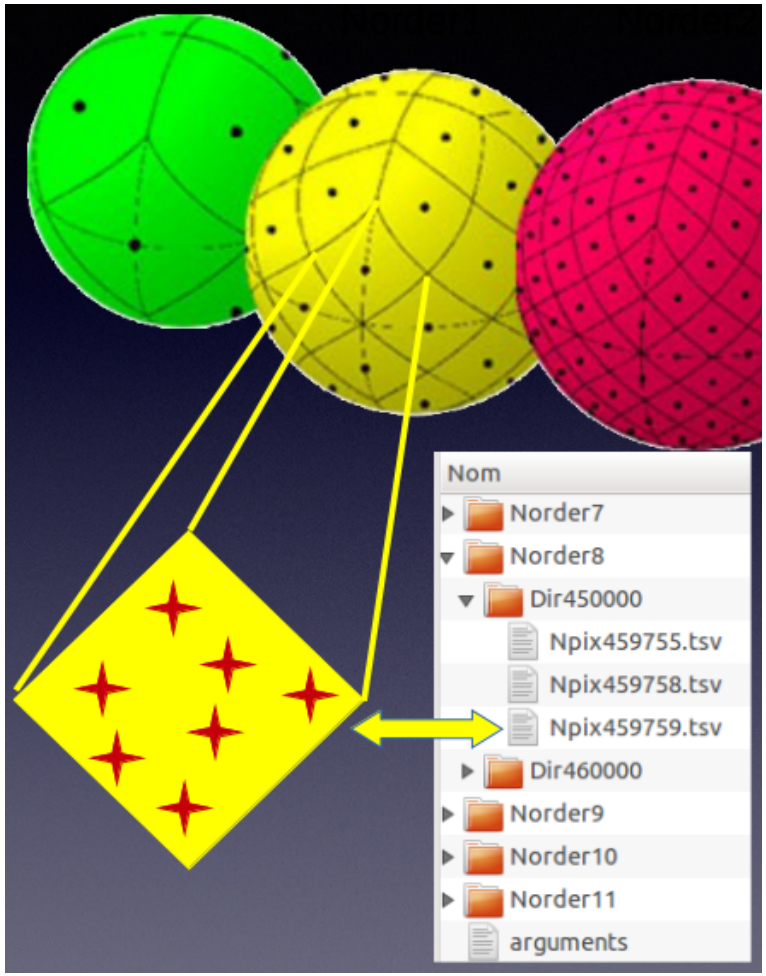

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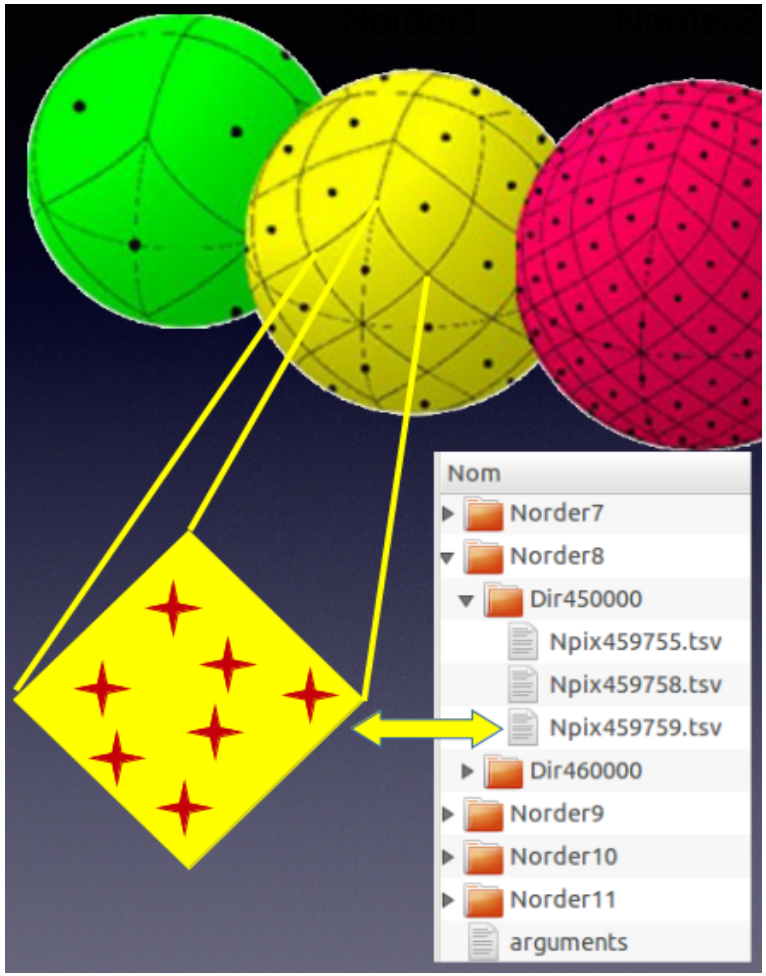

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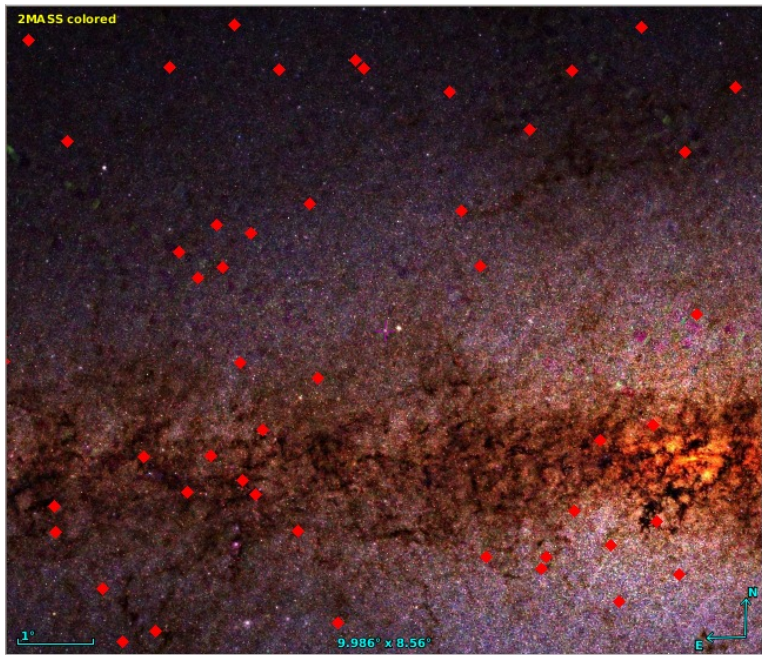

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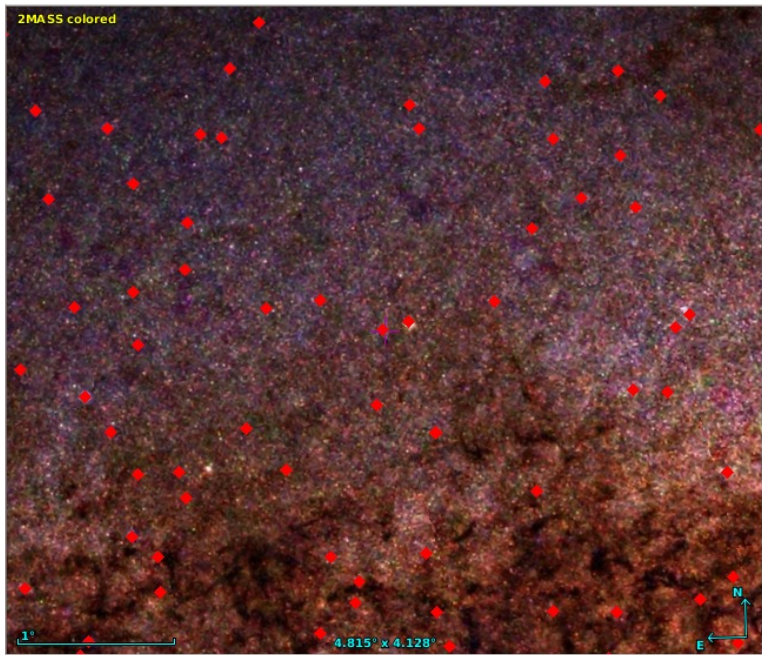

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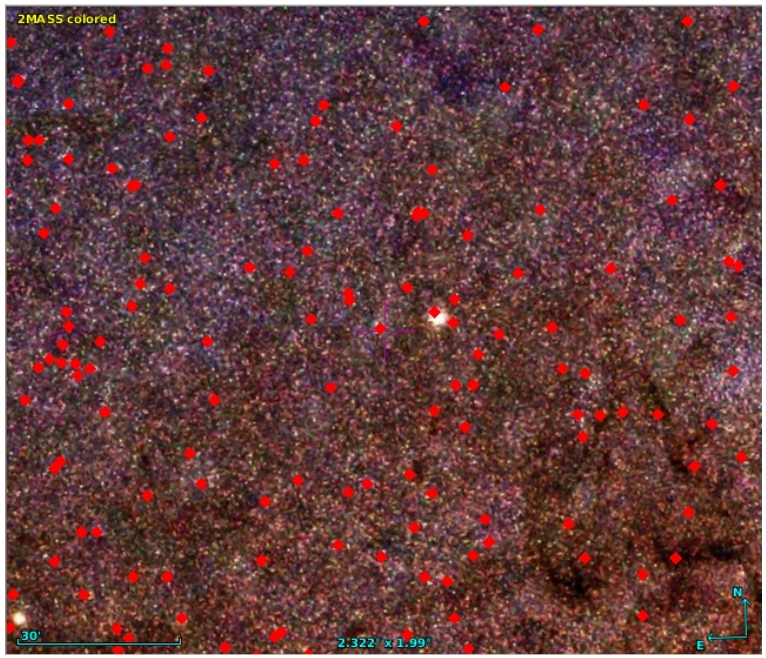

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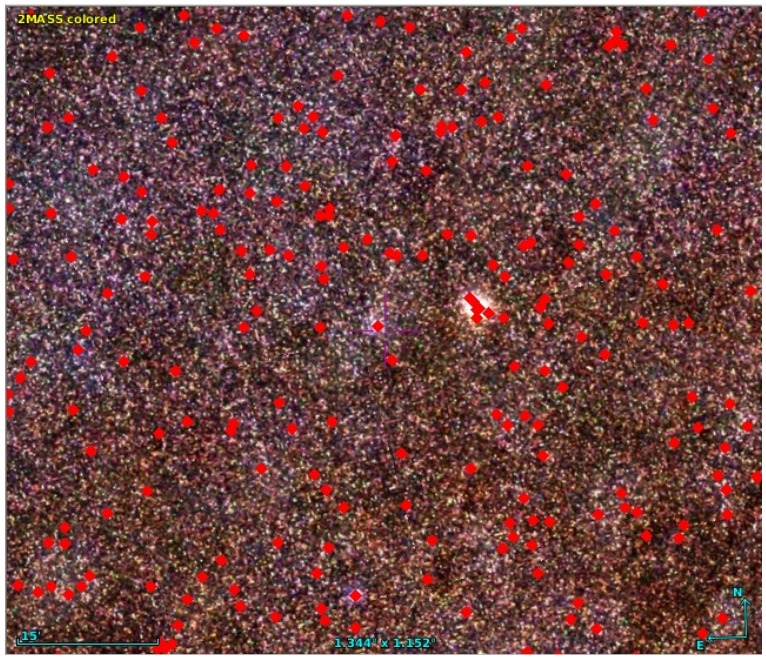

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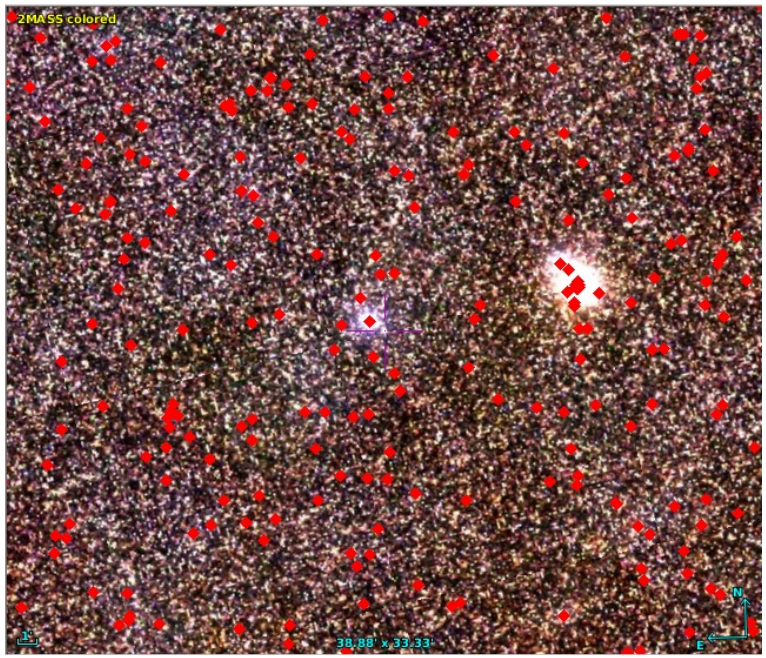

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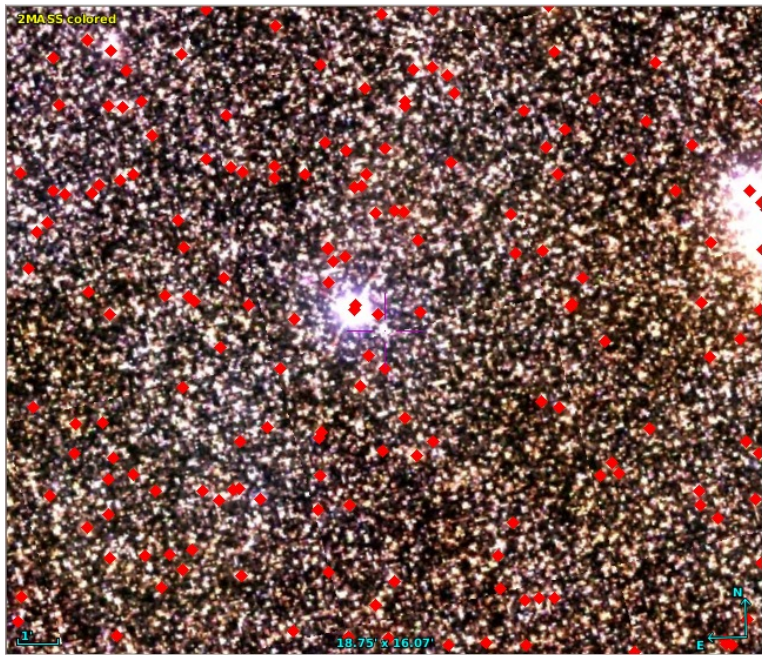

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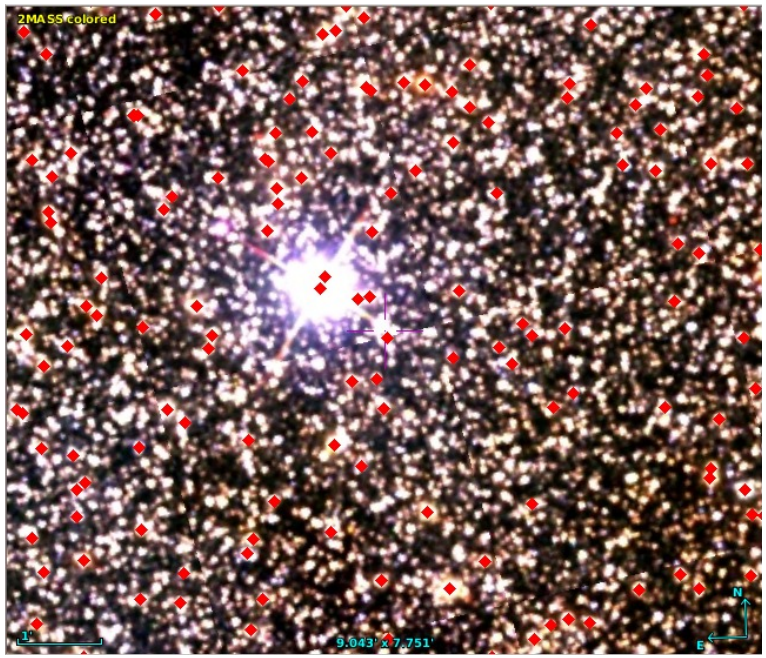

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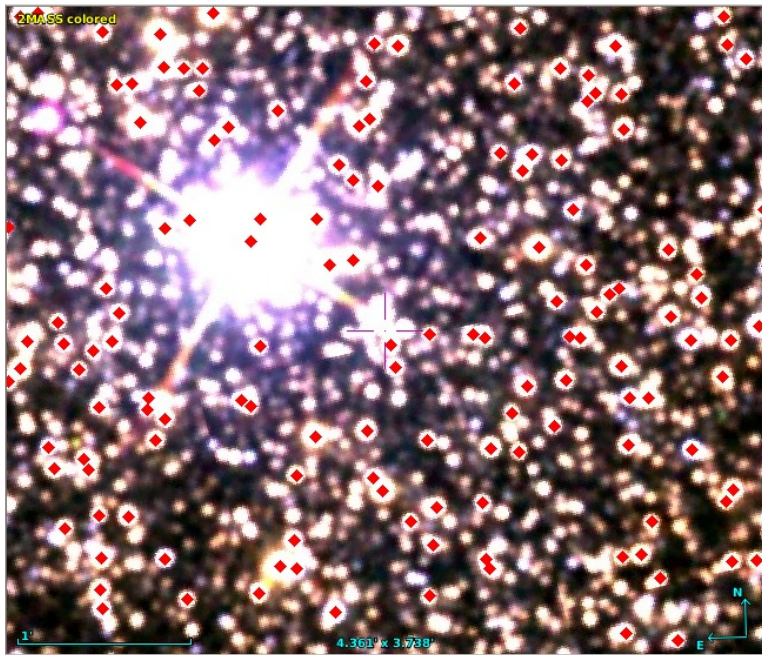

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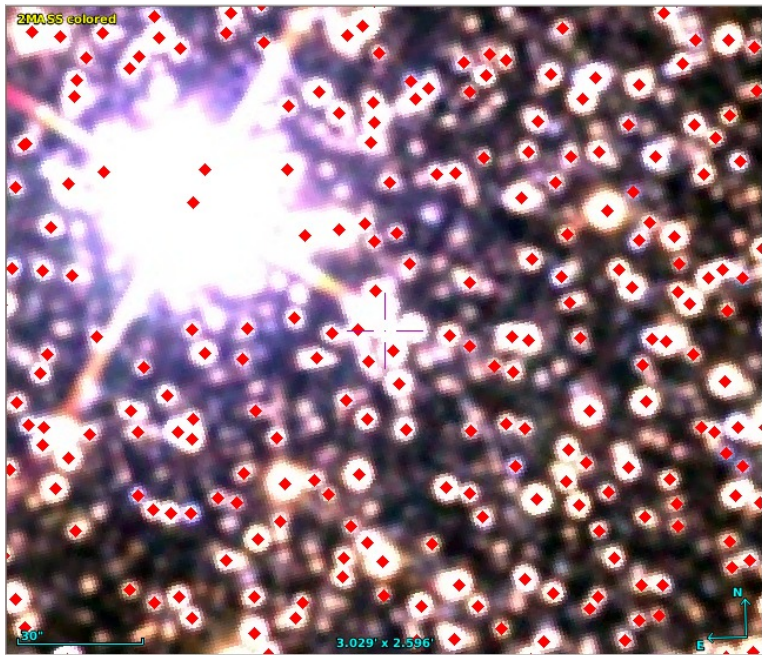

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HiPS catalogues: data structure

- Root directory

  properties : property file for HiPS clients
  Metadata.xml : VOTable containing catalogue Metadata
  NorderX : directories containing data files
  NpixYY.tsv : tile data in TSV format
  ⋮

- Example of TSV file

```
# Completeness = 271 / 14616
2MASS RAJ2000 DEJ2000 Jmag Hmag Kmag
16580813-3039504 254.533899 -30.664015 10.785 9.961 9.797
16581040-3040000 254.543334 -30.666691 11.232 10.464 10.270
16581465-3038453 254.561069 -30.645926 11.396 10.390 10.088
16580765-3037537 254.531886 -30.631590 10.196 9.399 9.203
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- First solution:
  - Select a criterion (e.g. total flux)
  - Sort the full catalogue, brighter objects first
  - At each level l, select the remaining n_l brightest objects
- Second solution:
  - Also take into account density of sources in the sky!!
- Third solution:

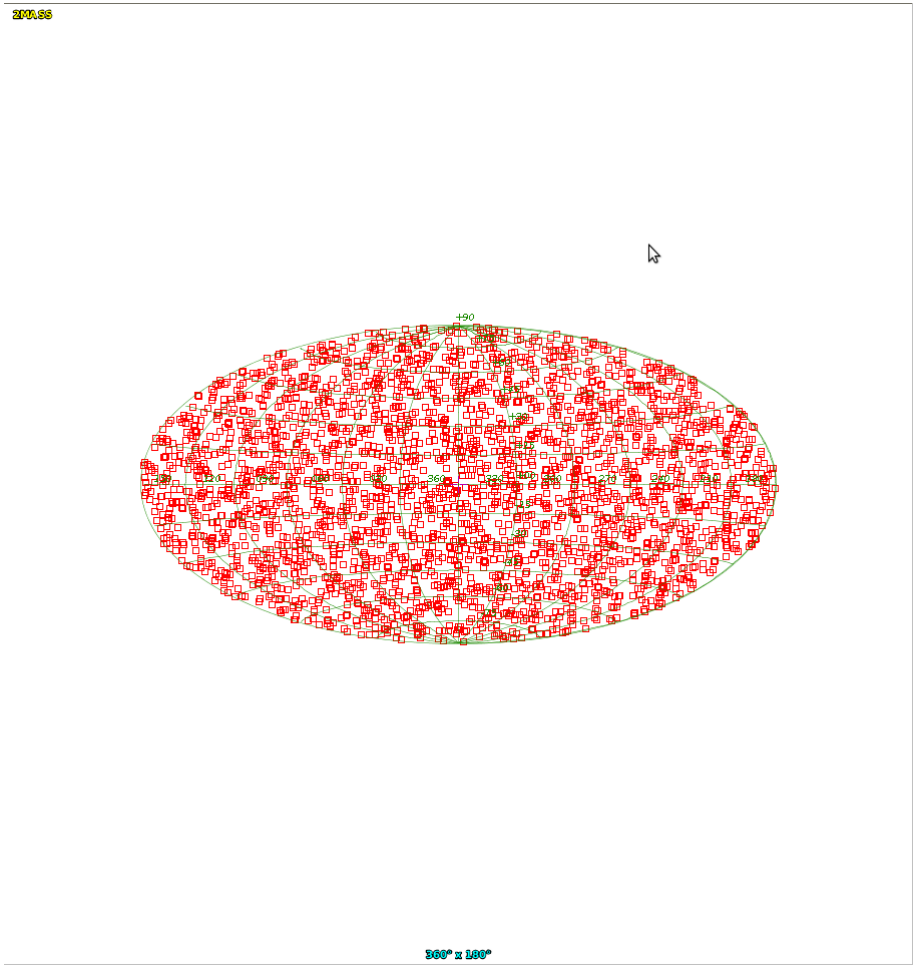

Figure: 2MASS HiPS: first attempt

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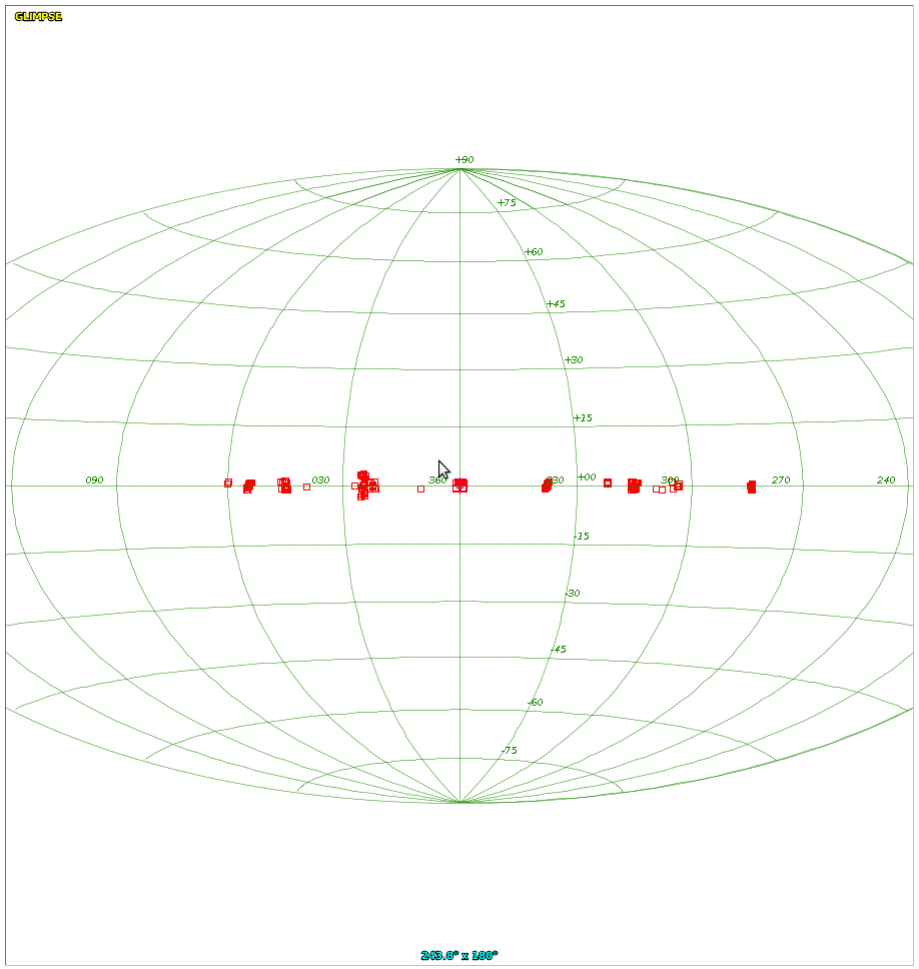

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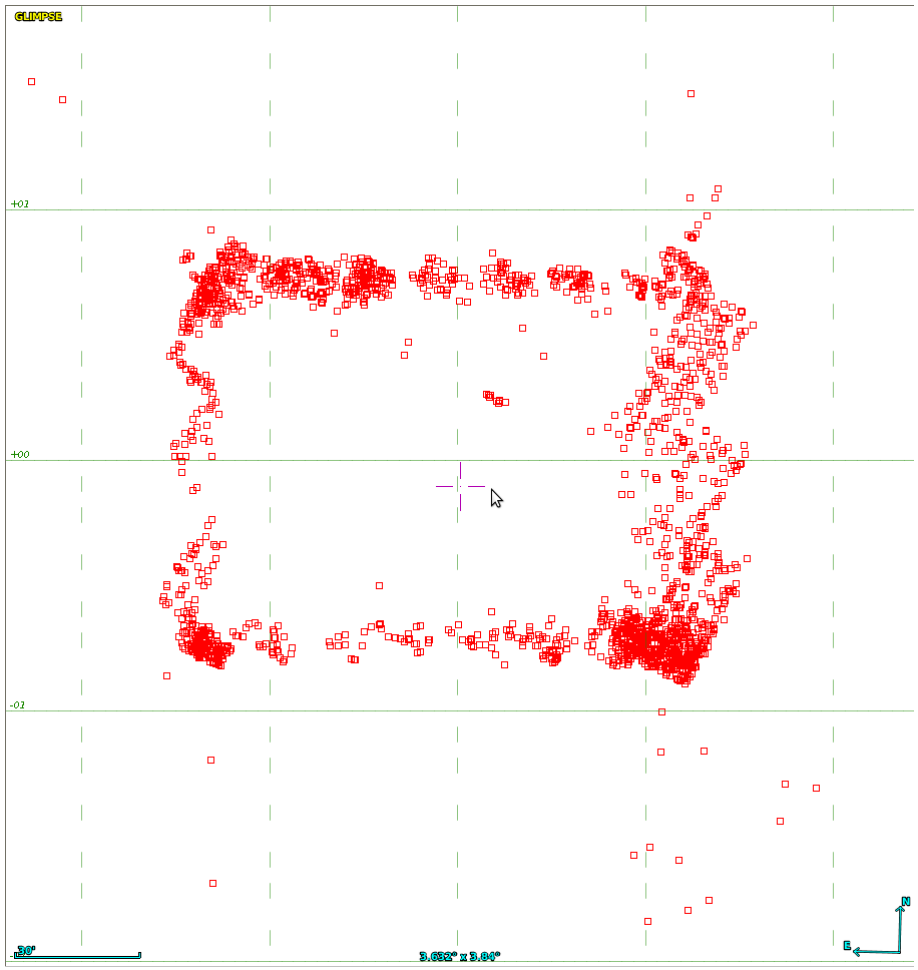

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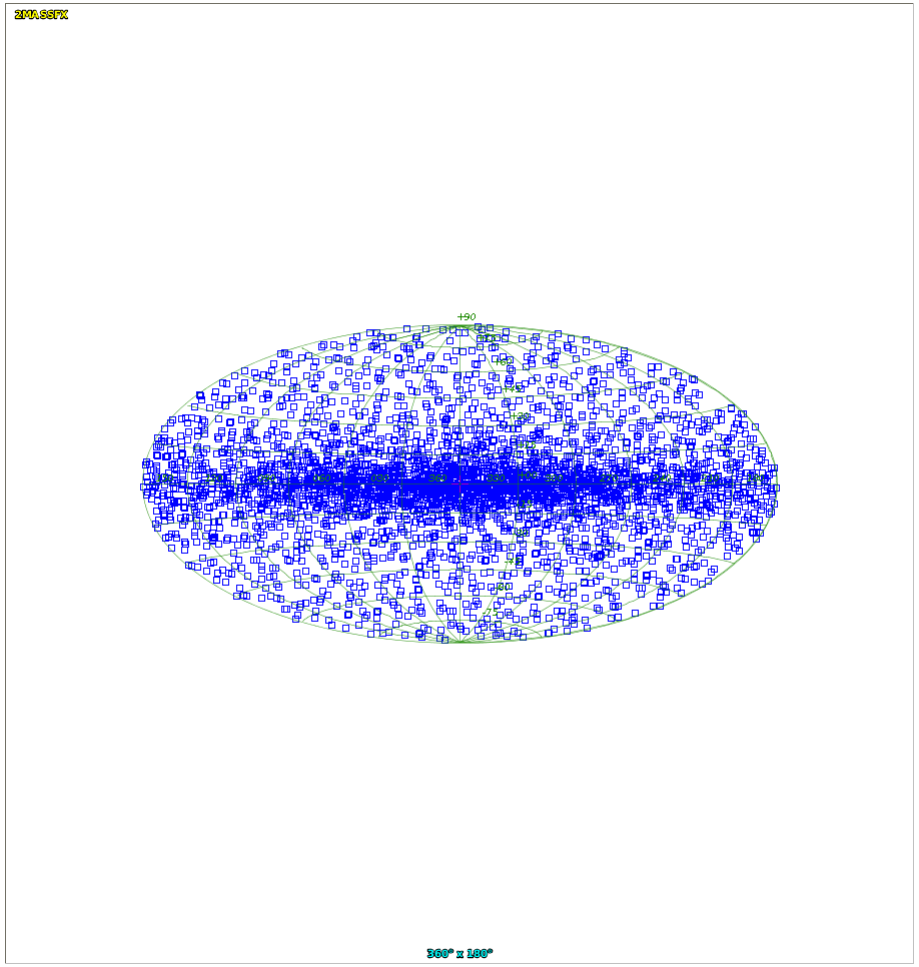

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- Third solution:
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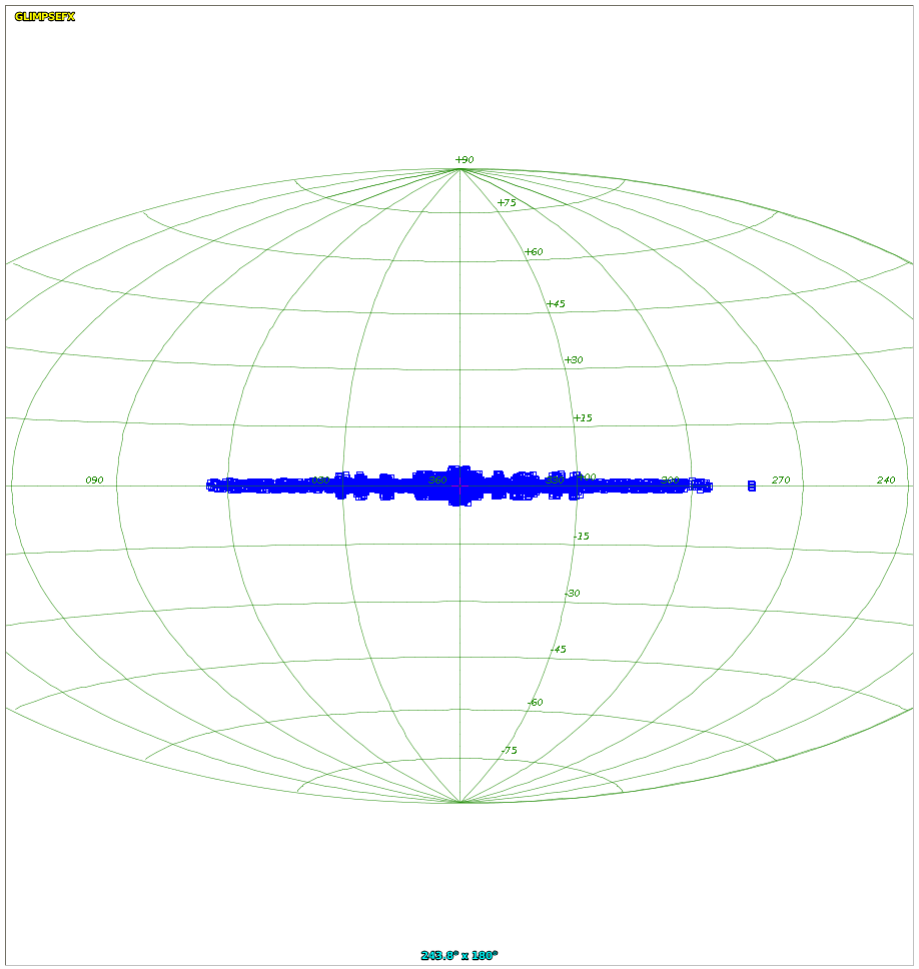

Figure: GLIMPSE HiPS: third attempt

Generating HiPS catalogues

- First solution:
  - Select a criterion (e.g. total flux)
  - Sort the full catalogue, brighter objects first
  - At each level l, select the remaining n_l brightest objects
- Second solution:
  - Also take into account density of sources in the sky!!
  - Still problems with non all-sky catalogues
- Third solution:
  - Also take into account coverage!!

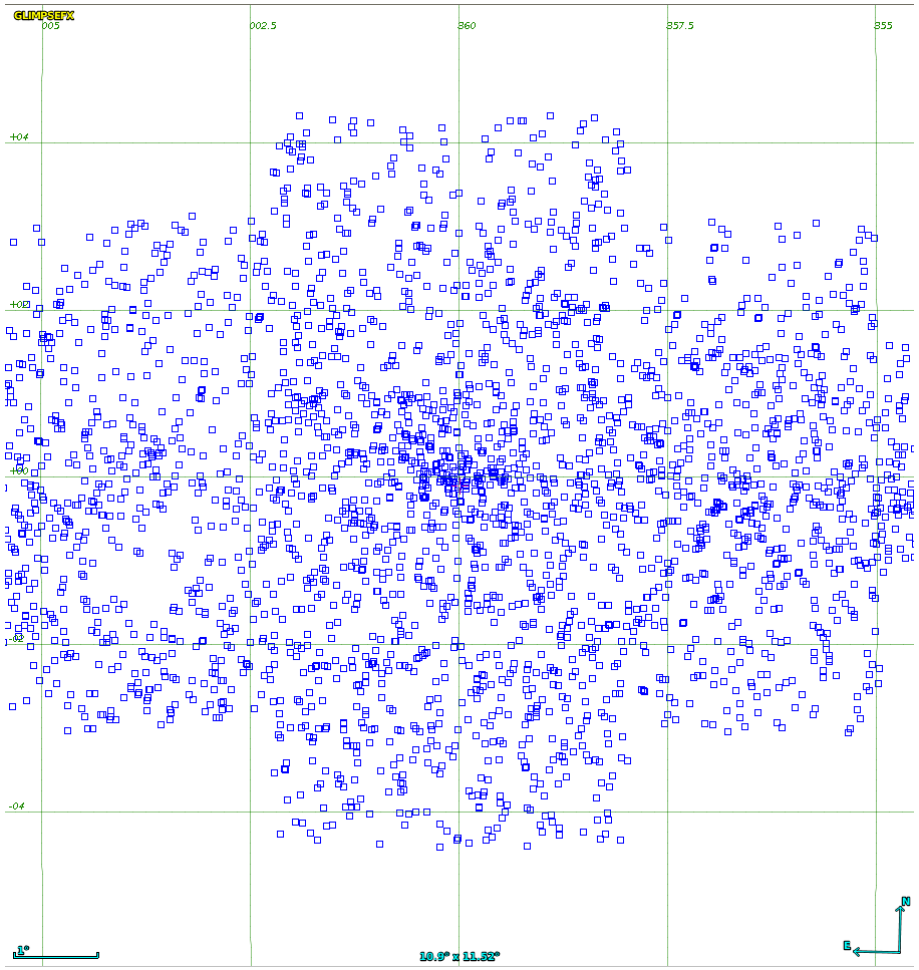

Figure: GLIMPSE HiPS: third attempt

Generating HiPS catalogues: algorithm

Basic algorithm

- 1 - Put catalogue sources into a HEALPix indexed data structure
  - can be one file sorted by HEALPix cell number + index
  - can be a hierarchy of files
- 2 - At the same time, compute:
  - Density maps from level 0 to level max
  - Coverage map at a given level
- 3 - Derive smoothing functions from nSrc min and max by pixel in HiPS
- 4 - For each of the low level cells, do recursively:
  - first pass to compute e.g. magnitude distribution
  - derive the magnitude upper limit
  - second pass to keep all sources with a magnitude $\leq$ upper limit (and $>$ than previous lower limit)
  - for each of the 4 sub-pixels, continue passing the new upper value (becoming a lower value)
- Remarks:
  - Multiple reads of each cell content ($\approx$2 times for each level)
  - But benefit from HDD cache at higher resolution

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Generating HiPS catalogues: Software

One internal to CDS, one public

- 2 ways to generate HiPS catalogues at CDS:
  - Public software from a CSV (or FITS, VOTable, ...) file
    - Produces a hierarchy of dirs and files
  - Dedicated software from CDS large catalogues file format (much faster!)
    - Produces intermediary indexed binary files
    - Easier to handle: less files, more compact
- Aladin access HiPS catalogues
  - From the root directory/the root URL
  - A service generating files on-the-fly
    - Uses intermediary indexed binary files
- Algorithms are the same in both cases

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Generating HiPS catalogues: Examples

Build your own HiPS catalogue

- Example of command line 1 (basic example)

```
java -Xmx1024m -jar cds.hips.cat.jar
     -in myfile.csv -cat 2mass
     -ra RAJ2000 -dec DEJ2000 -score Jmag
```

- Example of command line 2 (same example with explicit default values)

```
java -Xmx1024m -jar cds.hips.cat.jar
     -in myfile.csv -f ASCII -af CSV -head -cat 2mass
     -ra RAJ2000 -dec DEJ2000 -score Jmag -t 0.0+0.0
     -out HiPS_2MASS -n1 3000 -n2 6000 -m 10 -r 50 -fr false
     -r3 0.2 -nm 20 -nM 500 -method log -lM 11 -lC 10 -p
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HiPS catalogues: final words and perspective

Largest HiPS catalogue so far

- HiPS catalogue on GAIA_GUMS
  - $>$ 2 billion sources
  - 15 hours to generate (from CDS binary file)

Perspectives

- Generation of HiPS catalogues will be included in VizieR large survey ingestion pipeline
- May become the standard way to access catalogues in Aladin

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You can download the early version here:
`http://aladin.u-strasbg.fr/hips/`

Contact us for any trouble, bug, suggestion, ...

- francois-xavier.pineau@astro.unistra.fr
- thomas.boch@astro.unistra.fr
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