HiPS generation news

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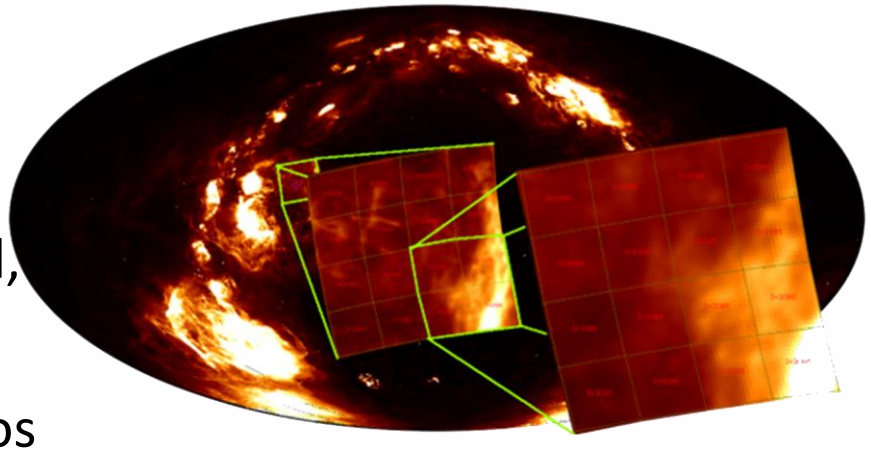
HiPS - what is it ?

- The **Hierarchical Progressive Survey** method
- Standardized by **IVOA in 2019**
- Based on HEALpix resampling
- Makes a **sky survey accessible, displayable and even processable, whatever the size of the survey, the quality of the network and the computing power** available to the astronomer.

- A response to the challenge of big data, (next big surveys Rubin or SKA…)
- **Implemented** by several scientifical, amateur and popular visualization tools: Aladin, hips2fits, ESAsky, ESO portal, Firefly, DIGISTAR, RSACosmos Stellarium…



What kind of HiPS?

- Today, 3 types of HiPS have been standardized by the IVOA:
  - HiPS image -> for an image collections
  - HiPS cube -> for a cube collections
  - HiPS catalog -> for a large catalog

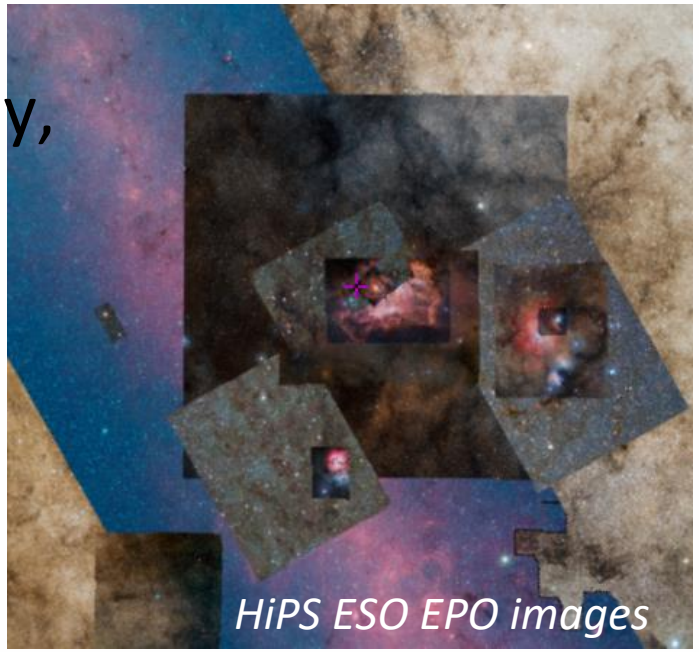
- In this presentation, we will focus solely on **image and cube HiPS** (see Hipscat, HATS talks for catalogs)

Hipsgen – what is it?

- ~1300 HiPS images & cubes currently available
- **99.3% generated by a unique tool: Hipsgen**,
- Developed and maintained by CDS since the invention of HiPS.
- Able to generate a HiPS of several terabytes of data in a few hours/days.

New features

1. **Contrast management by region** - Dynamic range of pixels to be displayed determined by region, rather than globally. Particularly useful for pointed surveys (HST, JWST…)
2. **More efficient iterative construction** - HiPS built iteratively, by specifying the operation to be applied to merge the new images added to a pre-existing HiPS (replacement, averaging, other algebraic operation).

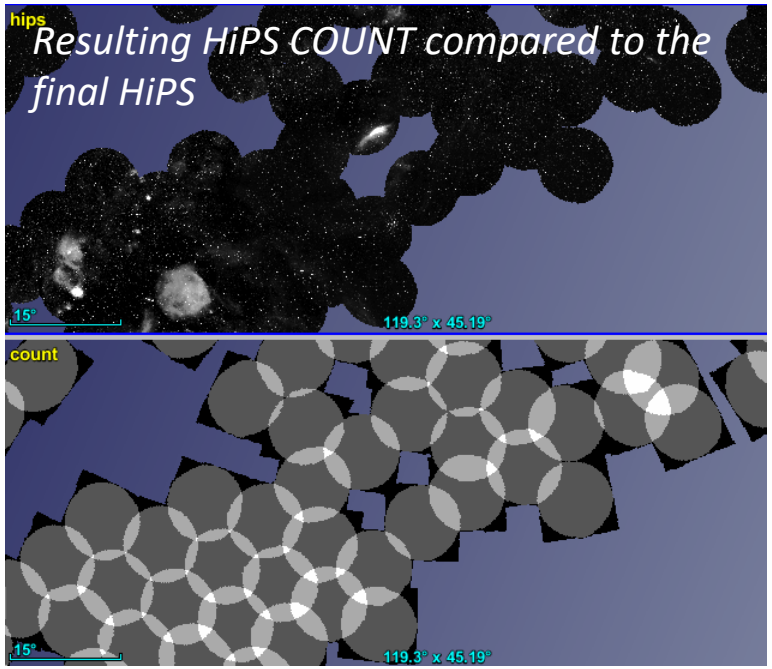


HiPS ESO EPO images

New features (cont.)

3. **Alternative packing for HiPS tiles** - To simplify HiPS storage management, Hipsgen has added two new commands, PACK and UNPACK, to assemble individual tiles into large "pack" files. The server can then use a small front-end script to dynamically extract the required tiles.

4. **Progenitor density** HiPS generation - COUNT command used to generate a HiPS representing, for each pixel, the number of images that contributed to its calculation.



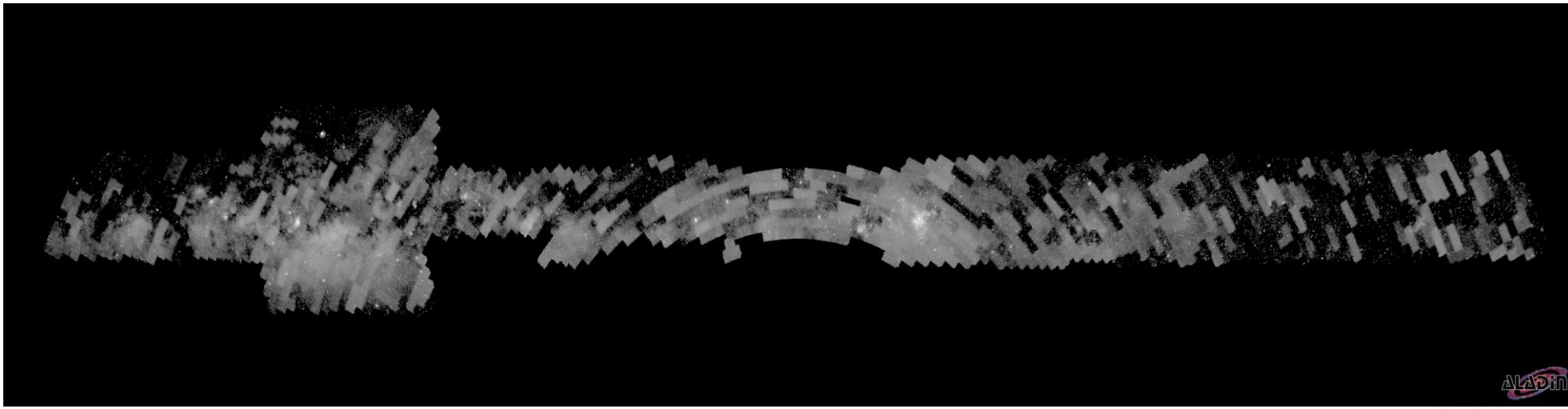
Resulting HiPS COUNT compared to the final HiPS

An alternative to Hipsgen

HiPS generation with Montage

VPHAS+ survey

- ESO survey of southern galactic plane
  - 5 bands: H-alpha, g, r, i, u
  - 2000 sq. degrees
  - 0.213 arcsec / pixel
- Images backgrounds are not homogeneous

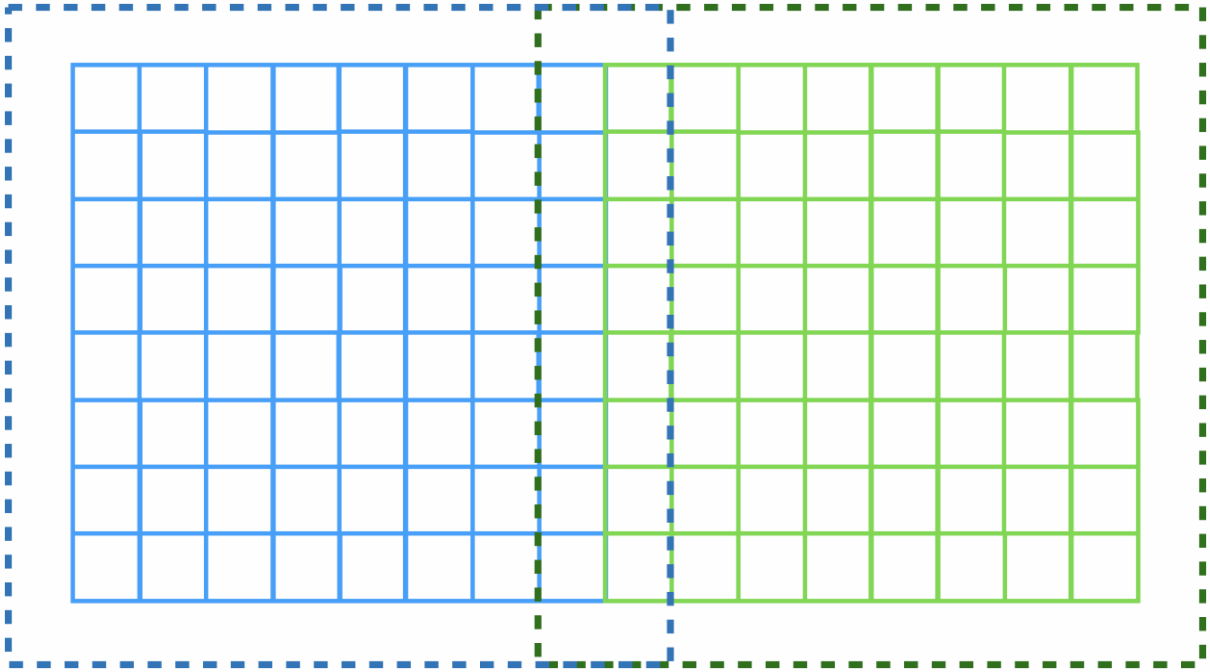


WCS for HiPS tile

```
SIMPLE  =                    T
BITPIX  =                  -32
NAXIS   =                    2
NAXIS1  =                  512
NAXIS2  =                  512
CPYRIGHT= 'See HiPS properties file'
COMMENT = 'HiPS FITS tile generated by Aladin/Hipsgen v11.023'
ORDER   =                    8
NPIX    =                12345
CRPIX1  =              29696.5
CRPIX2  =             101376.5
CD1_1   = -3.4332275390625E-04
CD1_2   = -3.4332275390625E-04
CD2_1   =  3.4332275390625E-04
CD2_2   = -3.4332275390625E-04
CTYPE1  = 'RA---HPX'
CTYPE2  = 'DEC--HPX'
CRVAL1  =                    0.
CRVAL2  =                    0.
PV2_1   =                    4
PV2_2   =                    3
```

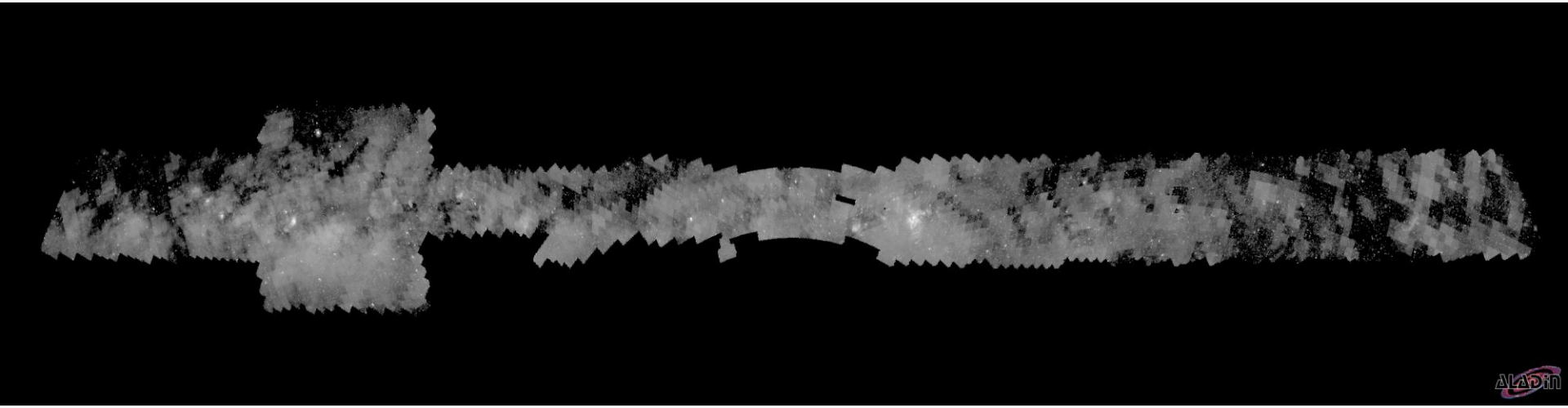
Super-tiles creation

- A super-tile is made of 32x32 regular tiles + 512 pixels border for tiles overlap (17408 x 17408 pixels)
- One VPHAS+ HiPS : 2700 super-tiles



HiPS from super tiles

- Homogeneous background within each super-tile



Background correction between super-tiles

- compute difference between each pair of overlapping super-tiles (**mDiffExec**)
- create a model of the differences (**mFitExec**)
- compute individual super-tiles corrections to be applied (**mBgModel**)
- apply corrections (**mBgExec**)

Rinse & repeat

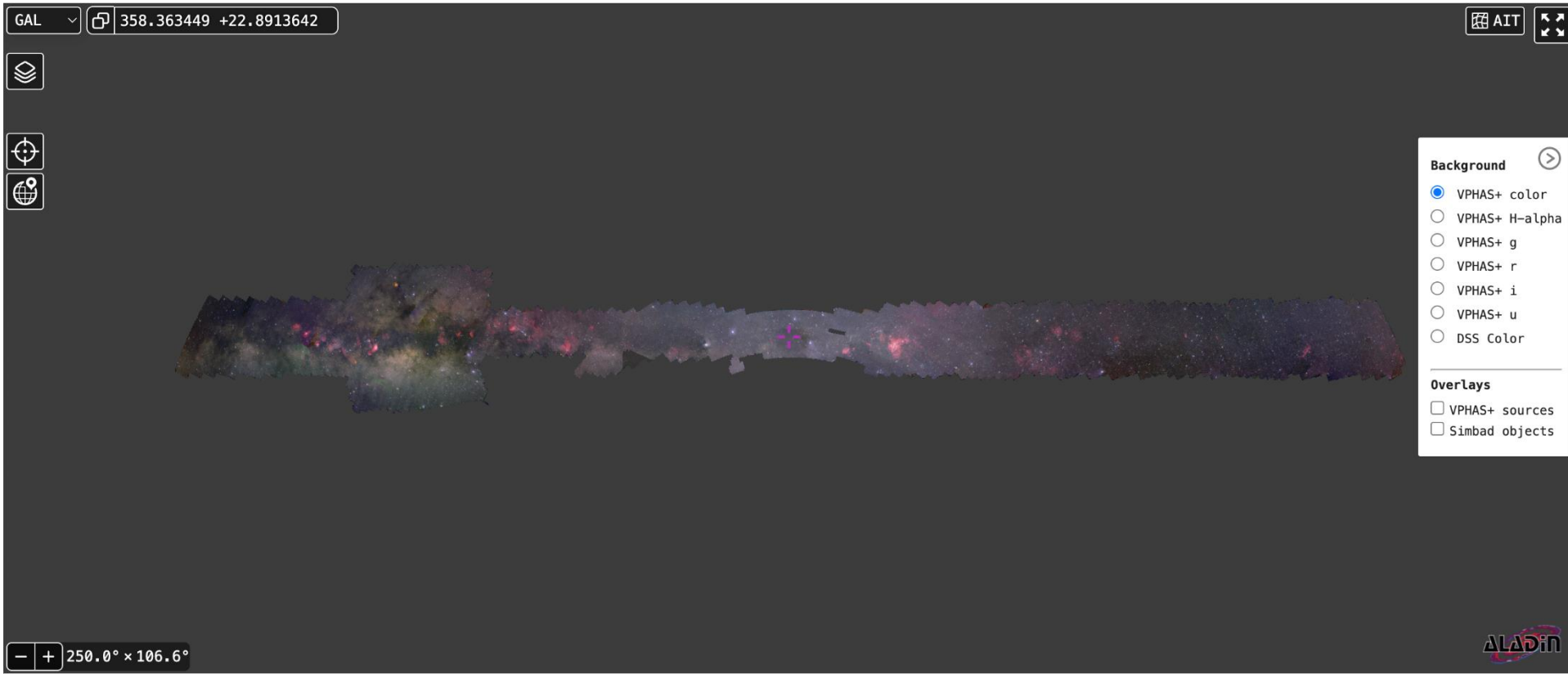
- Same process for 5 VPHAS+ bands
- Color VPHAS+ HiPS
  - Mixing the 5 bands:

```
# 1st step
red   = (  0.5 * i + 0.33 * u) / 0.83
green = r
blue  = (g + 0.66 * u) / 1.66

# 2nd step: add and boost H-alpha
mask = ha > threshold
red[mask] = np.maximum(1.2 * ha[mask], red[mask])
```

Publication

- 5 bands HiPS published + HiPS color
- https://alasky.cds.unistra.fr/VPHAS/

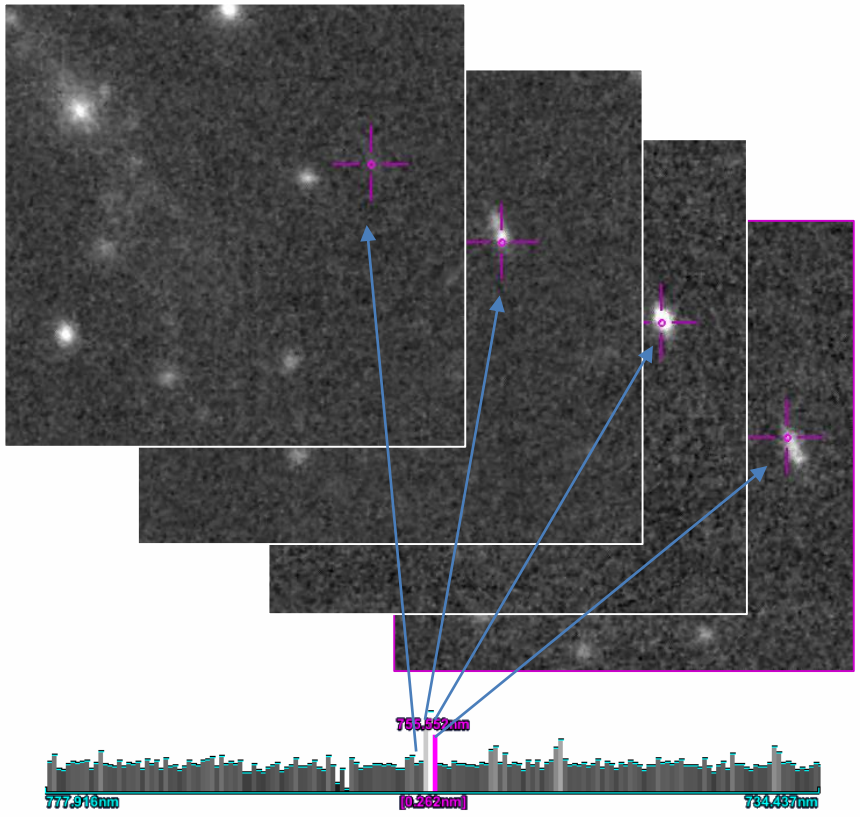


Acknowledgments

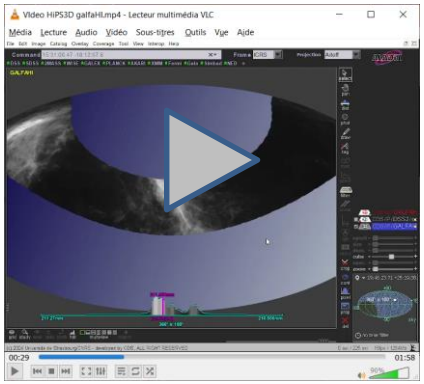
- Thank you to John Good (IPAC, Montage) for his valuable help in creating VPHAS+ HiPS.

The next step – HiPS 3D ?

- We are face to an avalanche of data not 'images' but 'cubes‘
- The idea: third dimension (time or frequency) must be also ‘Hipsilized’
- We are developing a new version of Hipsgen(+Aladin)
  - **capable of generating 3D HiPS** still based on the main HiPS ideas (resampling, tile packaging, hierarchy at different pre-calculated resolutions),
  - **operating simultaneously in all physical dimensions**.

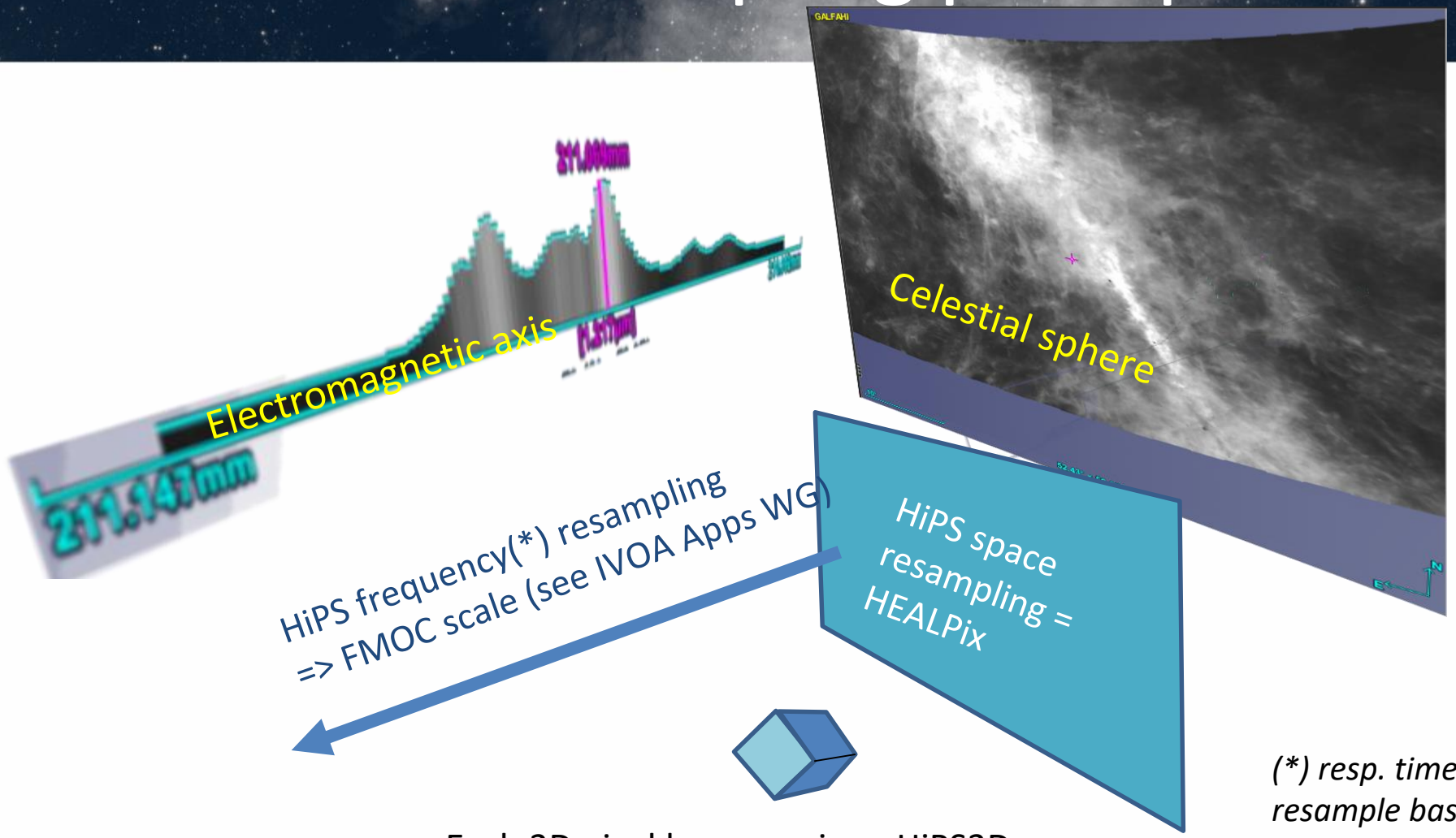


HiPS3D proof-of-concept



A 1mn demo/video to catch the idea

HiPS3D resampling principle



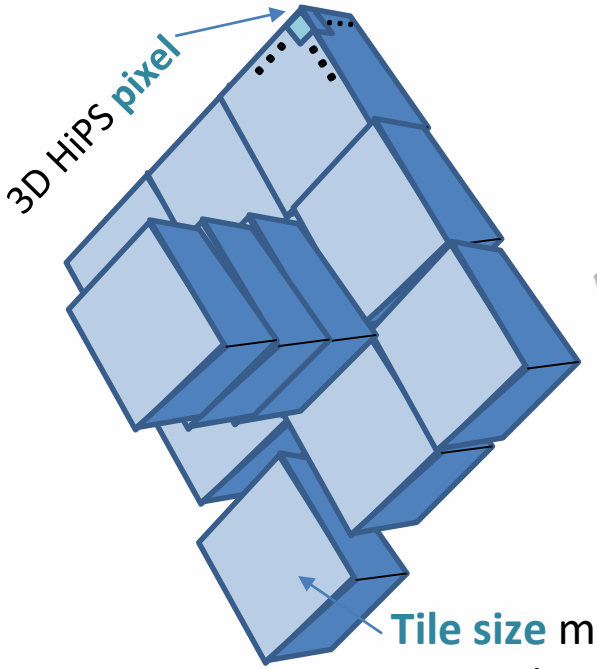
Each 3D pixel has an unique HiPS3D address = (OrderS/NpixS, OrderF/NpixF)

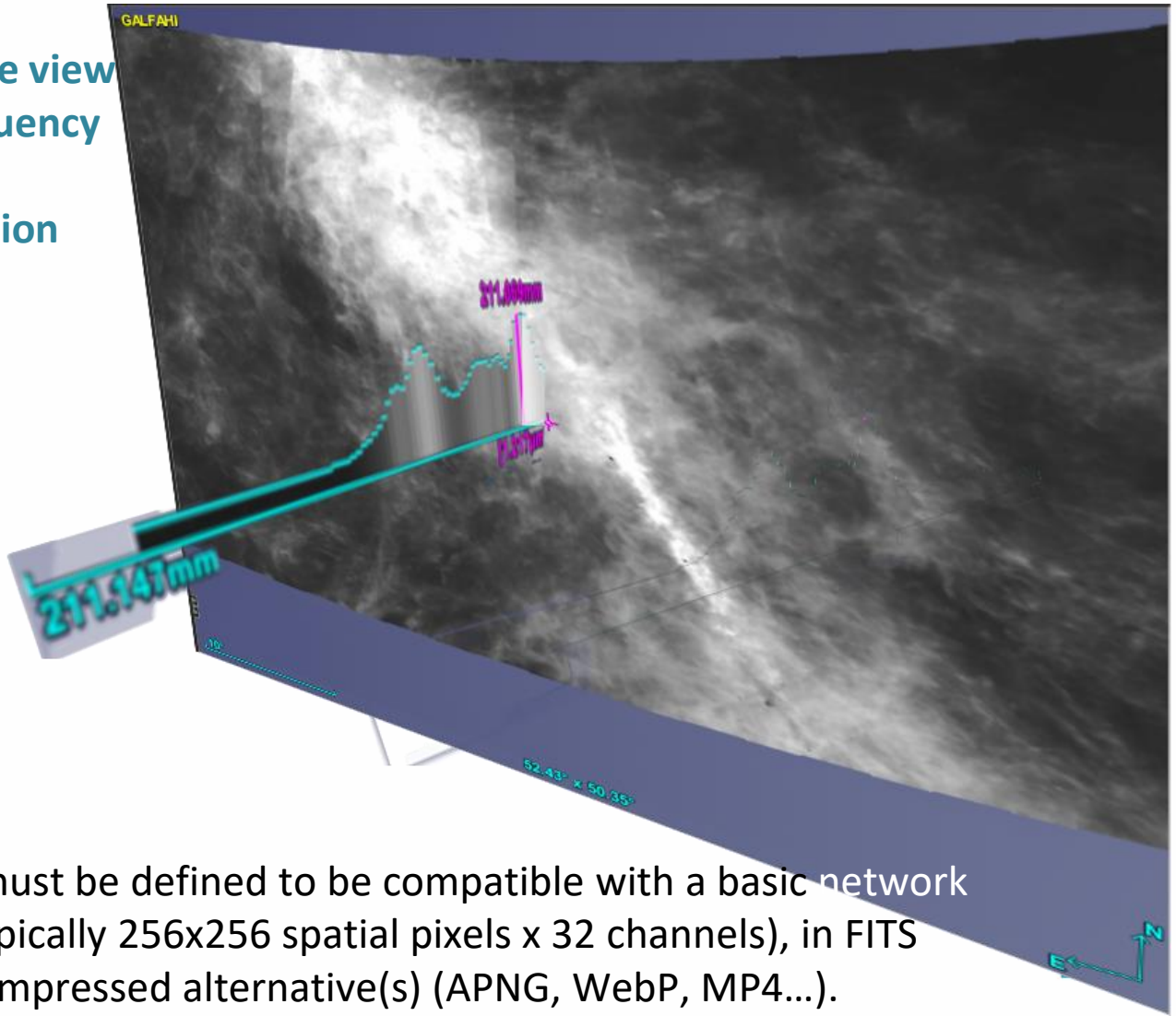
(*) resp. time resample based on TMOC scale

HiPS3D tile client ‘paving’ principle

The HiPS3D client loads:

- the tiles covering the **space view**
- the tiles covering the **frequency view**
- at **the appropriate resolution**

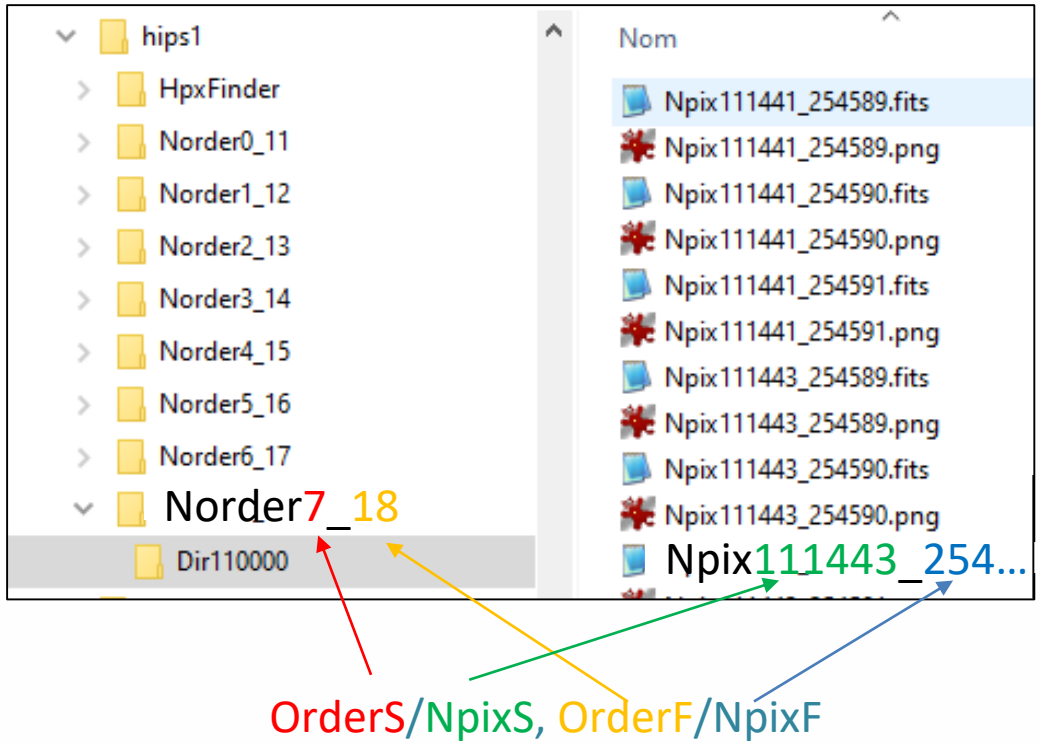




Tile size must be defined to be compatible with a basic network access (typically 256x256 spatial pixels x 32 channels), in FITS and/or compressed alternative(s) (APNG, WebP, MP4…).

HiPS3D directory structure/API

- **Allow all resolution** combinations (spatial vs freq)
- But intuition that generating only the 'diagonal' will be enough for discovery tool client = **simultaneously reducing spatial and frequency** resolution



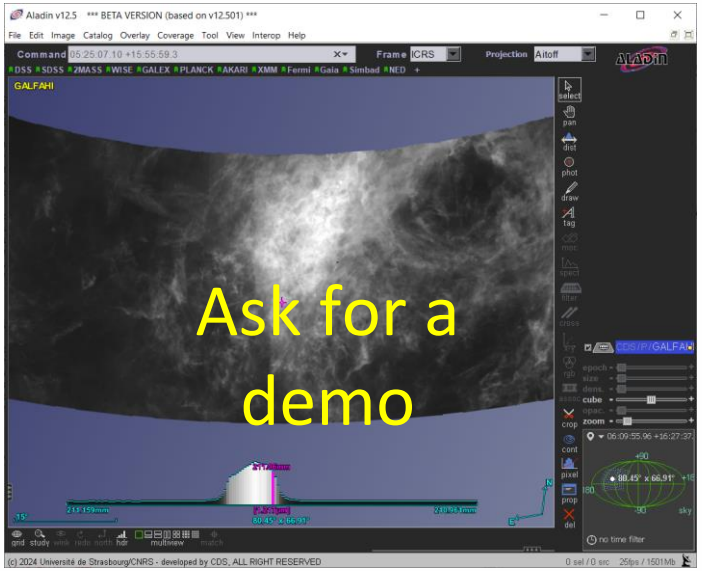
Hierarchy **adds only 15%** to HiPS volume (reduce by 8 for each suborder)

Promising prototyping phase

First results : it works well!

- **Divides the size** of the generated HiPS by **30** (pointed surveys), **the number of files** by **15**, and **processing time** by **11**.
- **Tested on several datasets**, in local and/or remote view (1GB cube, 40GB (ASKAP), 890GB (SKA CD2), 1200x2GB cubes (MUSE), large mosaic cube survey (GalfaHI DR2)
- Possibility of keeping/distributing only **compressed tiles** (=> a few percent of the original survey size)

- Very **easy to 'navigate' through huge cube** surveys, and discover a lot of interesting things



New versions soon:

- Hipsgen
- Aladin Desktop
- Aladin Lite

Thanks to everyone involved!

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Next steps?

- More tests, and more testers
- Towards an IVOA HiPS 2.0 standard?