



HiPS Mixer

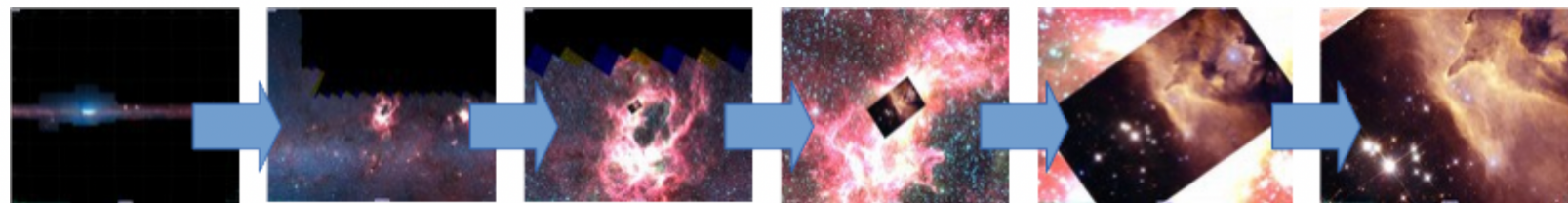
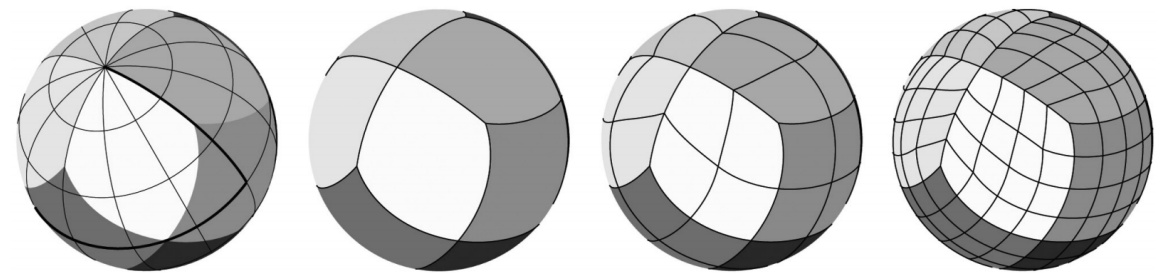
Combine HiPS at your will!



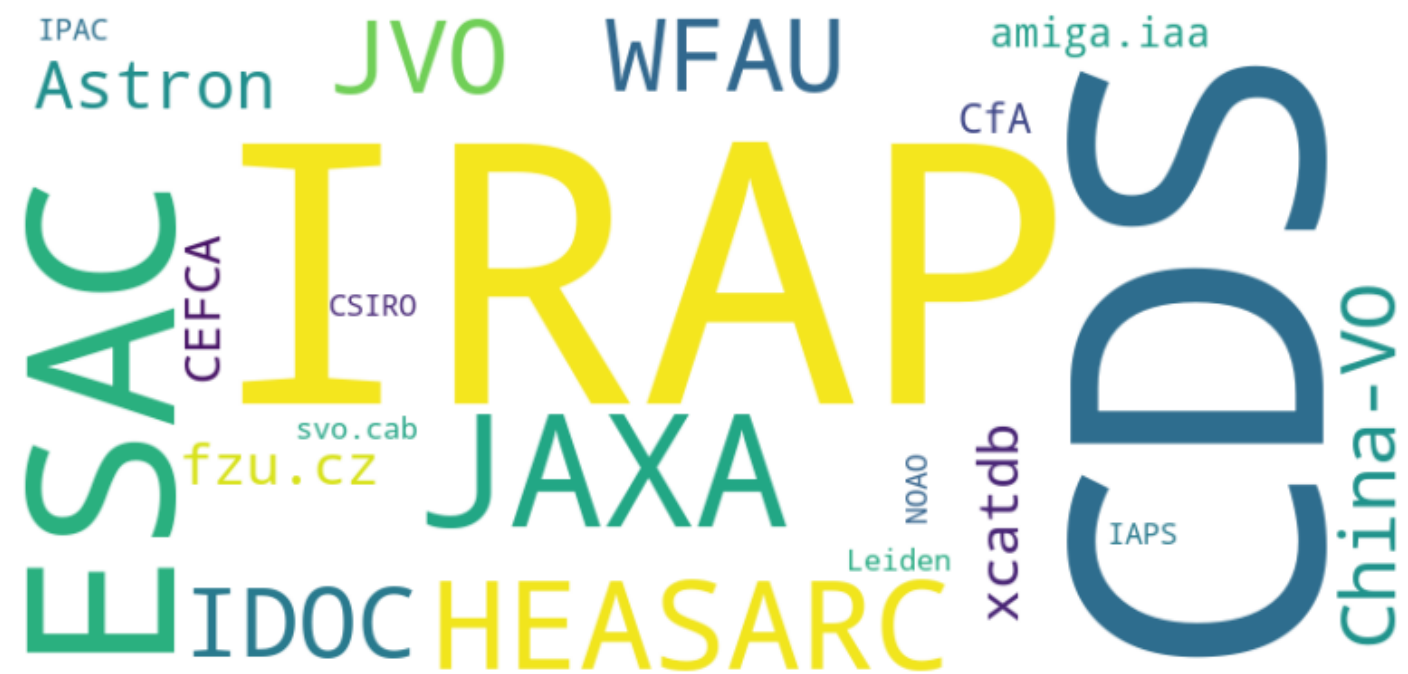
Thomas Boch
IVOA Apps 2 - June 5 2025

□ HiPS: the format

- Hierarchical Progressive Surveys
- CDS implementation of slippy maps suited for astronomy
 - started in 2009
- HEALPix-based
 - no singularity at poles
 - minimal deformation overall
- preserves original dynamic range (FITS tiles)
- Described in [2015A&A...578A.114F](#)
- IVOA standard since 2017



- 1400+ published HiPS
- By 24 publishers
- 820 TB
 - 2 billion tiles



☐ Motivations

- Benefit from the best of each individual HiPS dataset
 - Extend coverage
 - Resolution
- Without loading each HiPS client-side
 - Features available in each client
 - Save bandwidth
- In one new resulting HiPS product
 - Conform to HiPS standard

□ 2 combinations modes

- **By order of priority**
- **Color HiPS from 3+ HiPS**

☐ By order of priority

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□ By order of priority

- We consider JPEG/PNG tiles

```
from PIL import Image
import numpy as np

tile = np.zeros((512, 512, 4), dtype=np.uint8)
for idx, hips in enumerate(hips):
    mask = (tile[..., 3] == 0)
    if np.sum(mask)==0: # all done?
        return tile

    tile_format = hips_params[hips]['format']
    if 'png' in tile_format:
        tile_format = 'png'
    else:
        tile_format = 'jpg'

    root = hips_params[hips]['root']

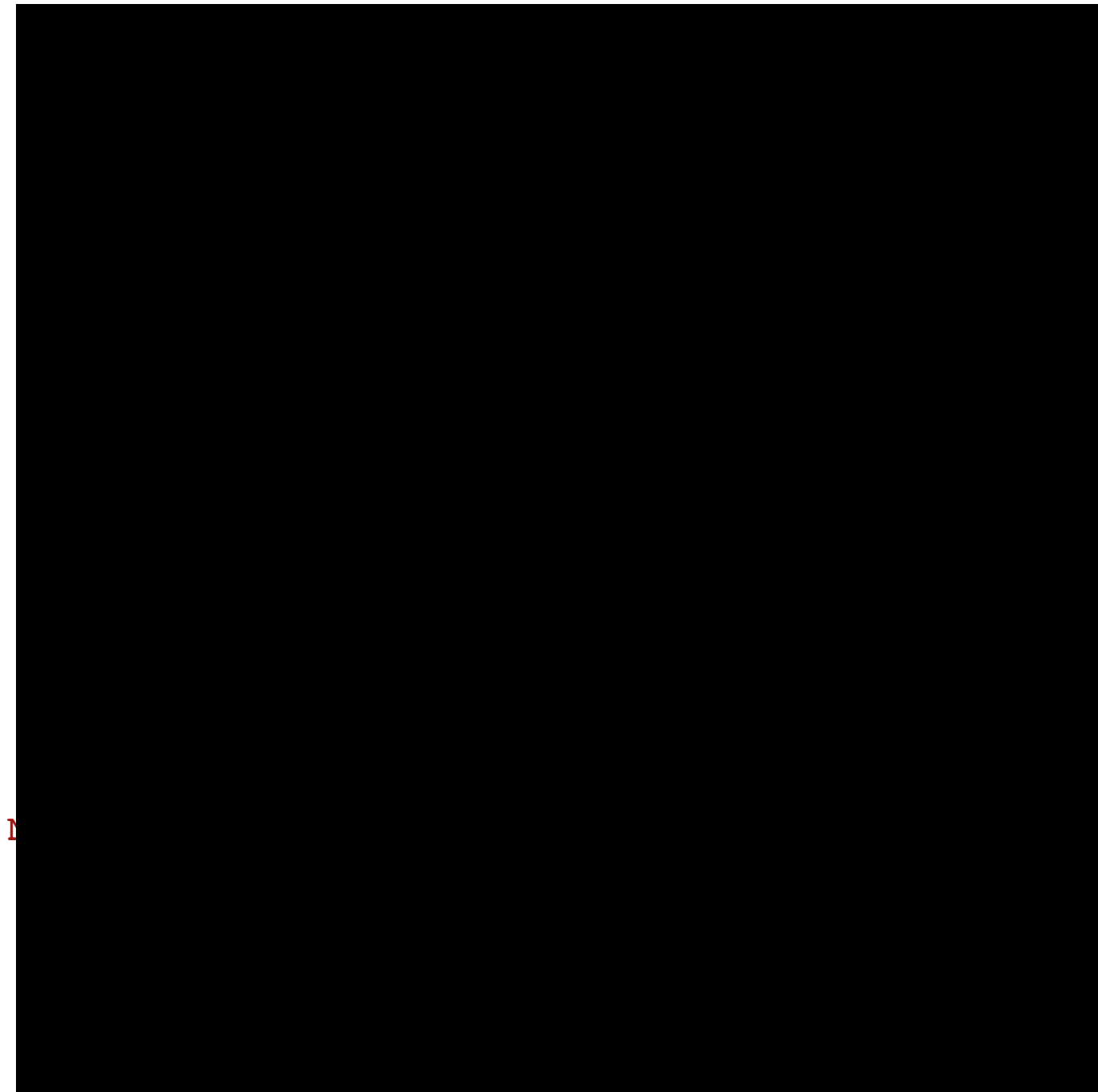
    tile_path = f'{root}/Norder{order}/Dir{int(10000 * (ipix//10000))}/
Npix{ipix}.{tile_format}'

    cur_tile = np.array(Image.open(tile_path).convert('RGBA'))

    tile[mask] = cur_tile[mask]
```

□ By order of priority

- We consider JPEG/PNG tiles



```
(10000 * (ipix//10000))}/
```

```
.convert('RGBA'))
```

□ By order of priority

- We consider JPEG/PNG tiles

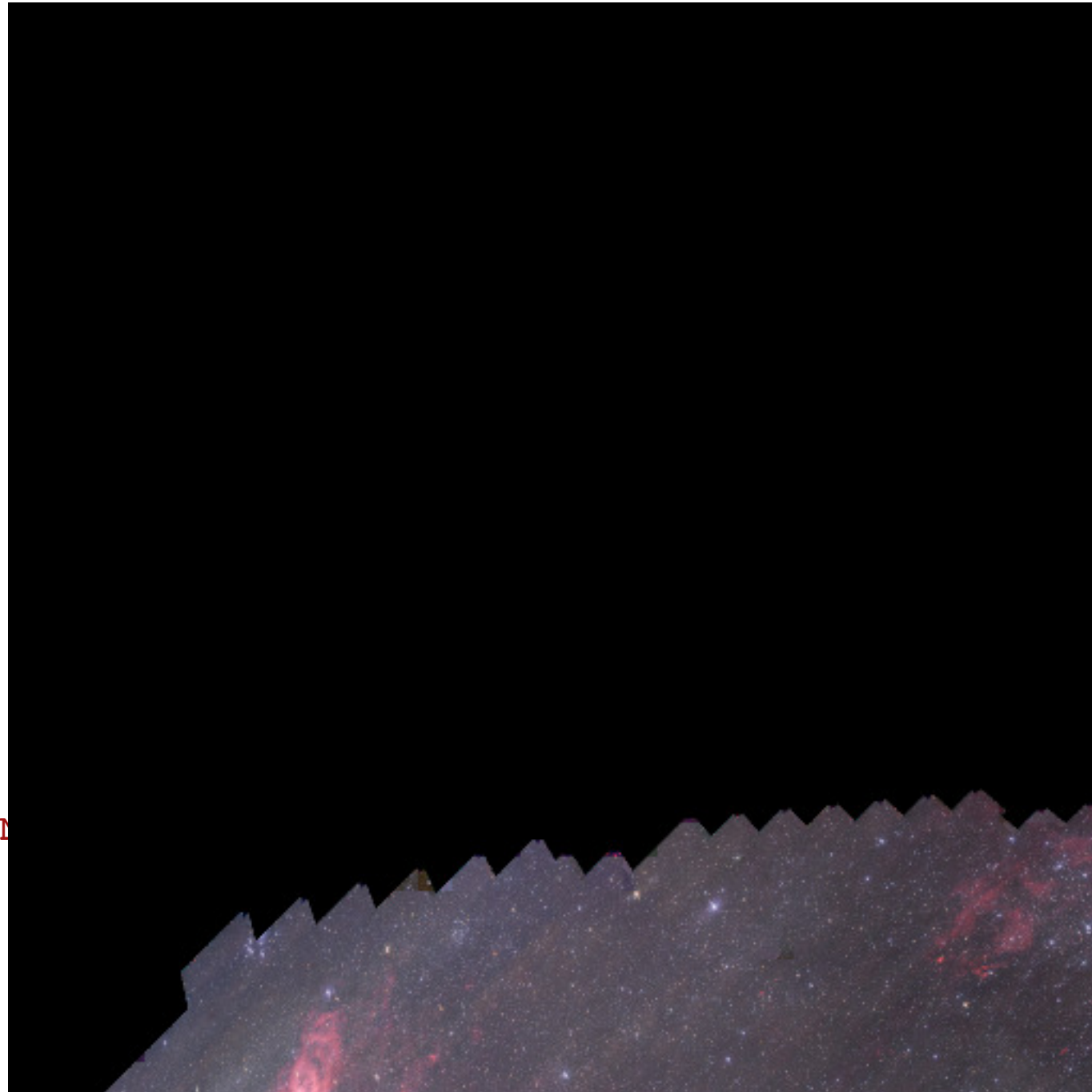
VPHAS
DECaPS
DES DR2
DESI
SkyMapper
DSS2

```
(10000 * (ipix//10000))}/
```

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VPHAS
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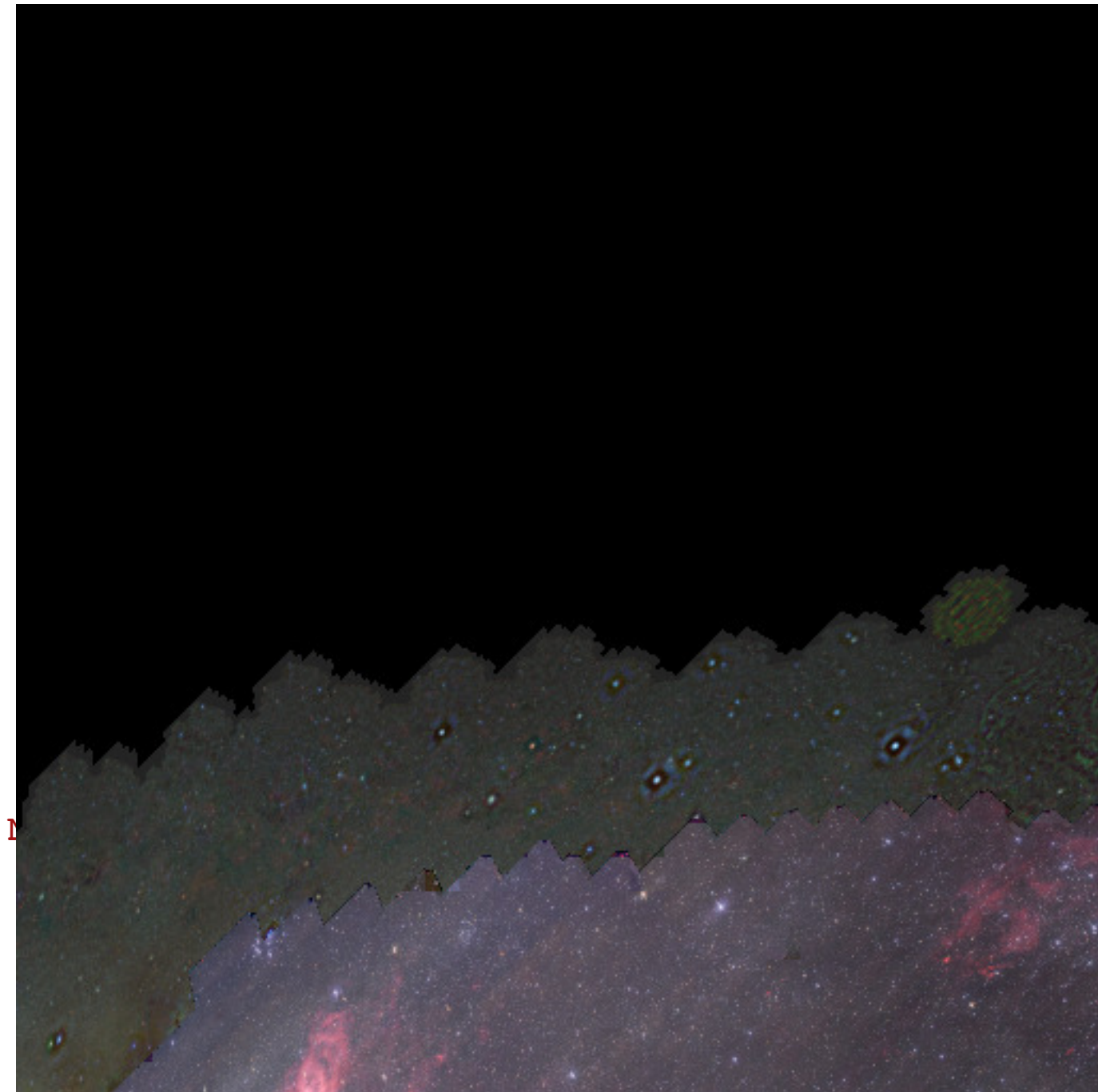
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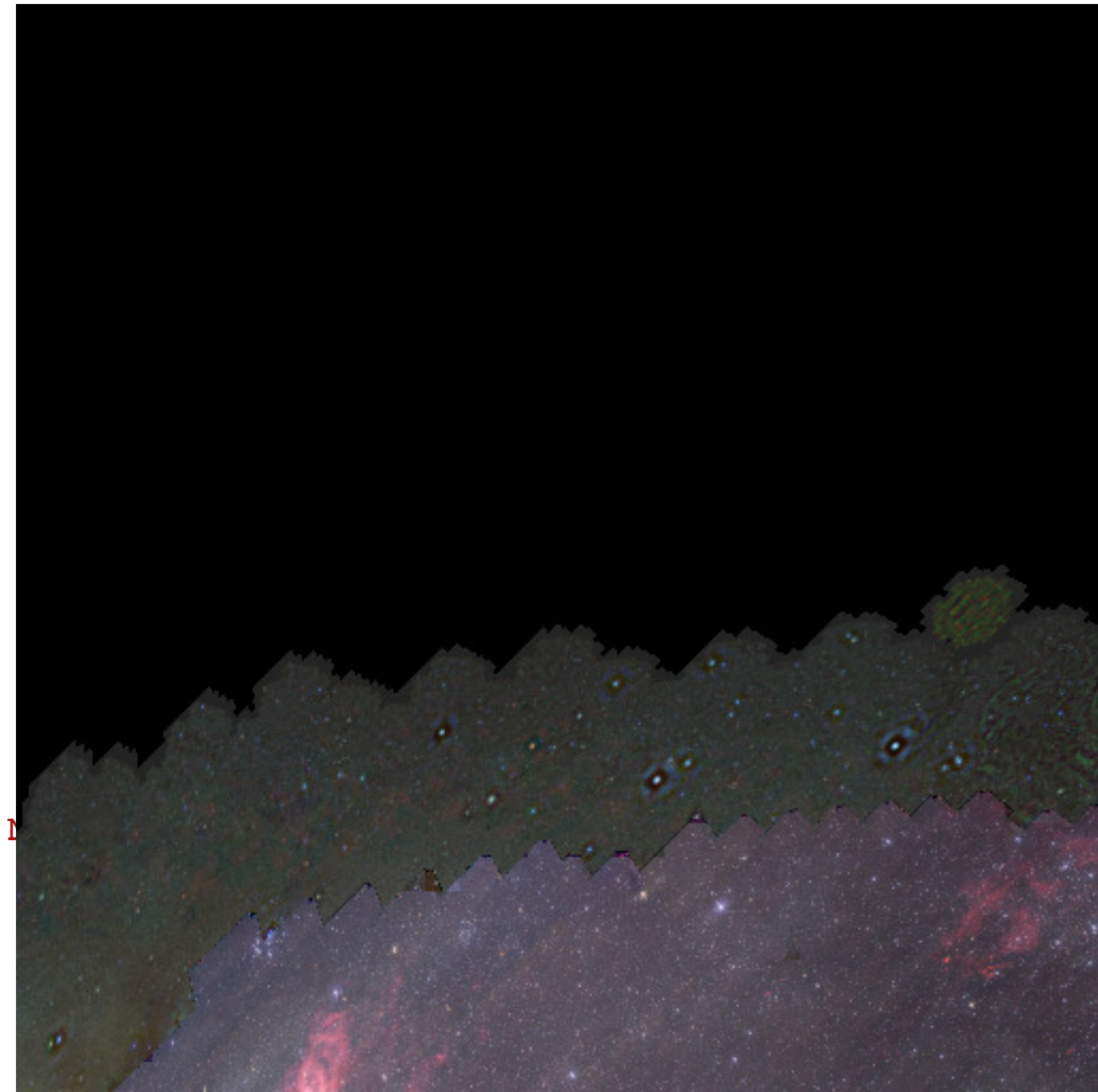
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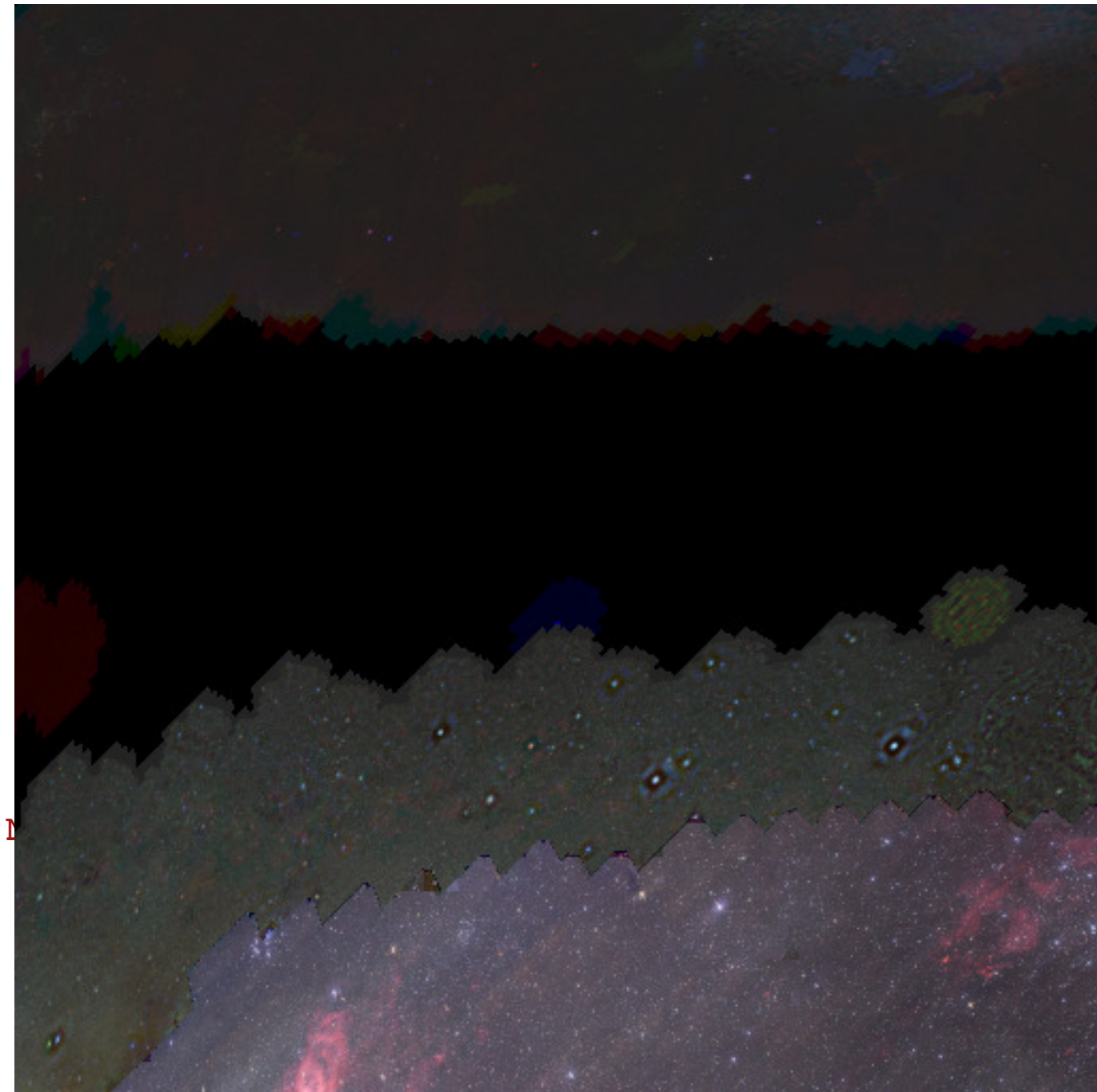
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(10000 * (ipix//10000))}/
```

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```

□ By order of priority

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VPHAS
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→ DESI
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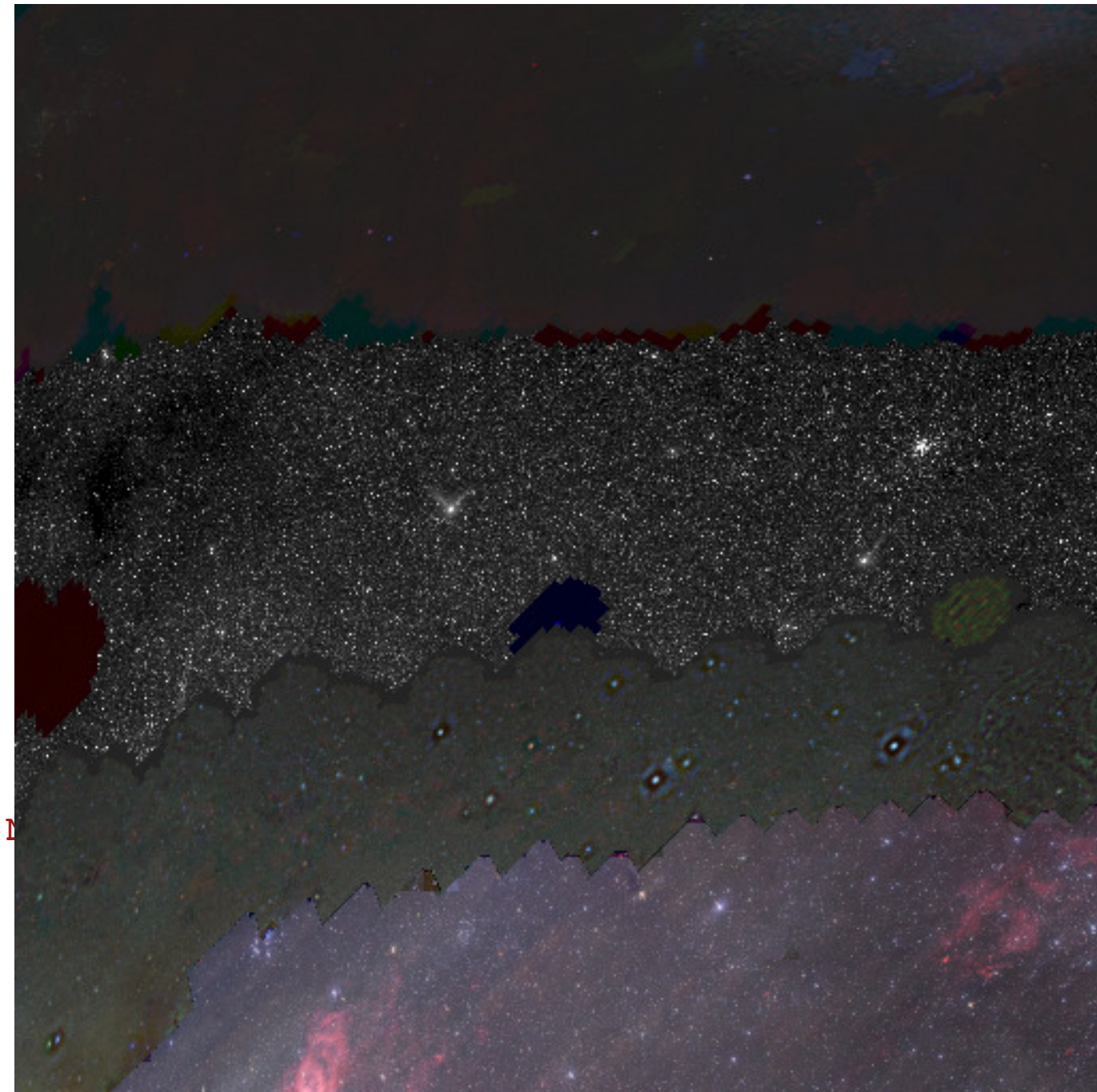
```
(10000 * (ipix//10000))}/
```

```
.convert('RGBA'))
```

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- We consider JPEG/PNG tiles

VPHAS
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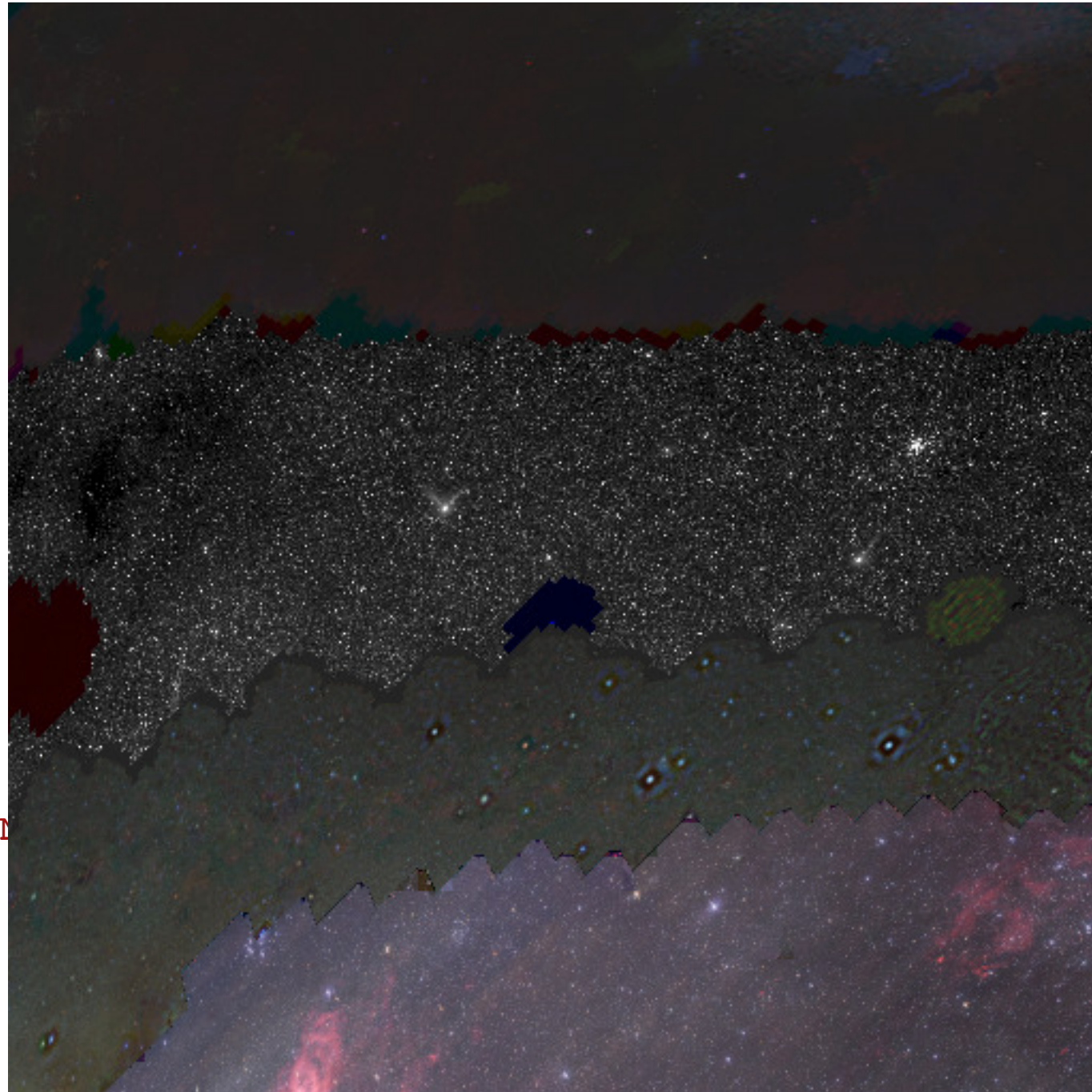


```
(10000 * (ipix//10000))}/
```

```
.convert('RGBA'))
```

□ By order of priority

- We consider JPEG/PNG tiles



VPHAS
DECaPS
DES DR2
DESI
SkyMapper
~~DSS2~~

```
(10000 * (ipix//10000))}/
```

```
.convert('RGBA'))
```

□ MOC (spatial coverage)

- Union of spatial coverages

```
moc = MOC.new_empty(max_order)
for hips in hipses:
    cur_moc =
MOCServer.query_region(return_moc="smoc",
criteria=f'ID={hips}')
    moc = moc.union(cur_moc)
```

□ Properties file

```
obs_title           = HiPS combined
hips_frame          = equatorial
hips_order          = 13
hips_tile_width     = 512
hips_initial_ra     = 266.416817
hips_initial_dec    = -29.0078249
hips_initial_fov    = 360
dataprodct_type     = image
hips_tile_format    = png
dataprodct_subtype  = color
obs_description     = Created from HiPS CDS/P/Euclid/Q1/NISP.H,CDS/P/Euclid/
Q1/NISP.J,CDS/P/Euclid/Q1/NISP.Y,CDS/P/Euclid/Q1/VIS
```

□ Heterogeneous orders

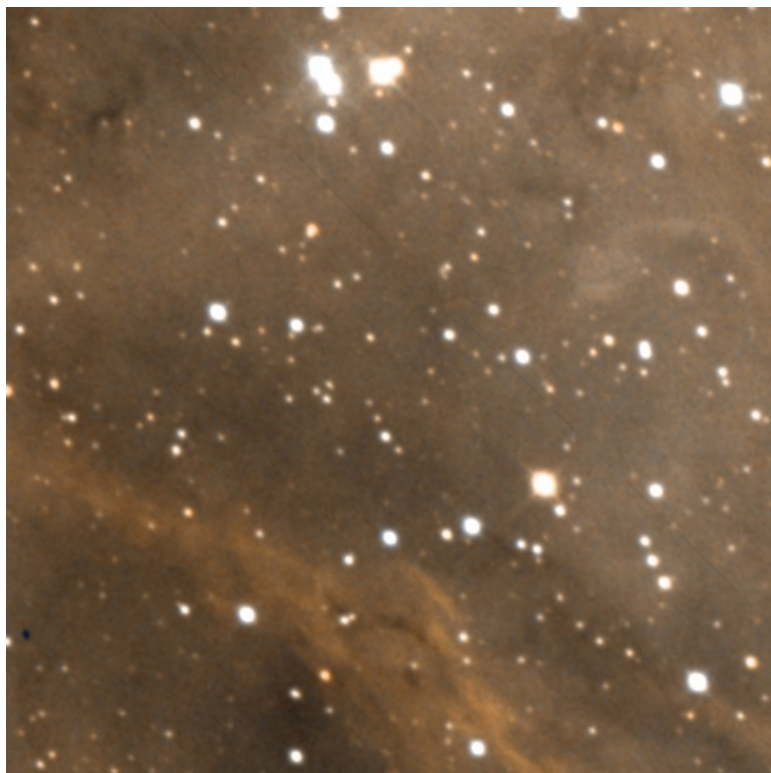
- $\text{order_combined} = \max(\text{order_hips1}, \dots, \text{order_hips}n)$

If order HiPS < order max

DSS2 ==> request tile *12345* at order *11*

Retrieve tile *12345//16* at DSS2 max order (9)

Cut the needed part and expand it



□ Heterogeneous orders

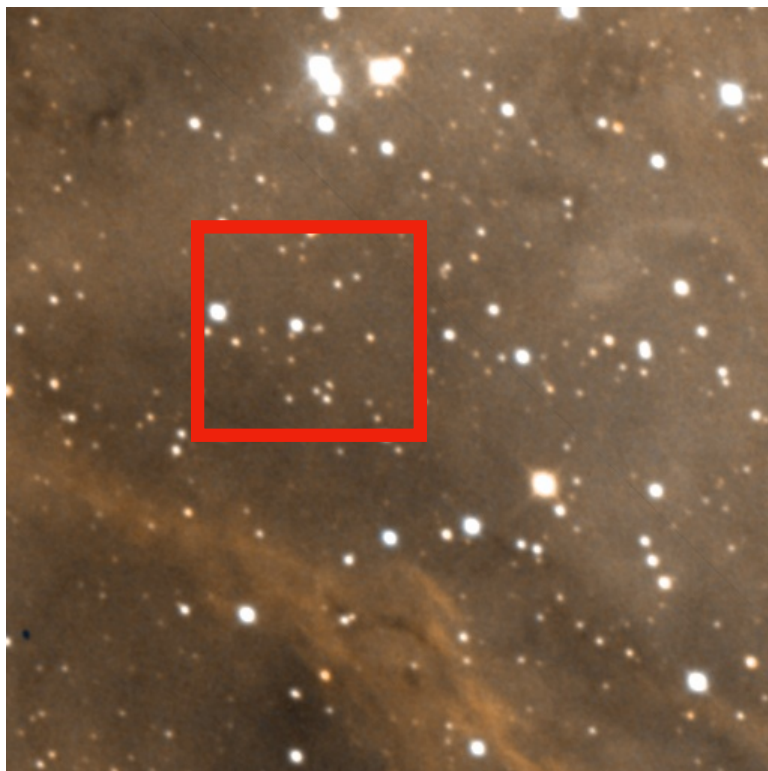
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□ Heterogeneous orders

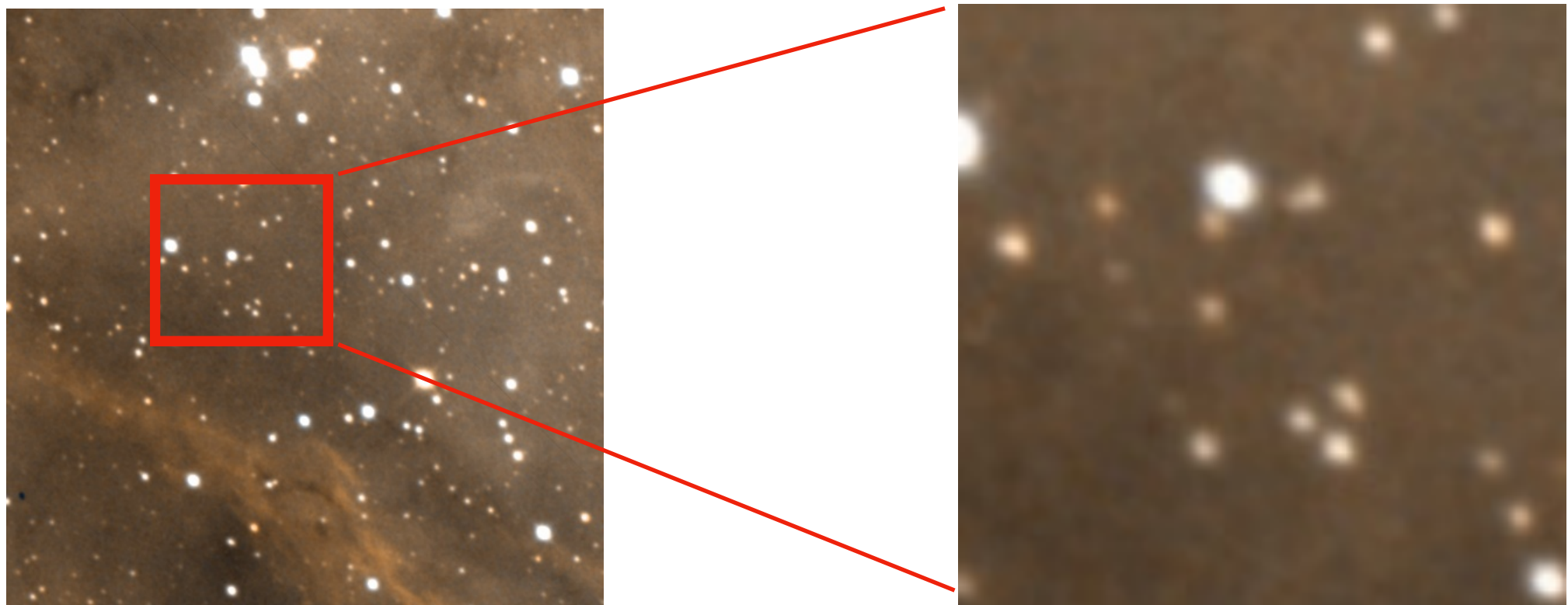
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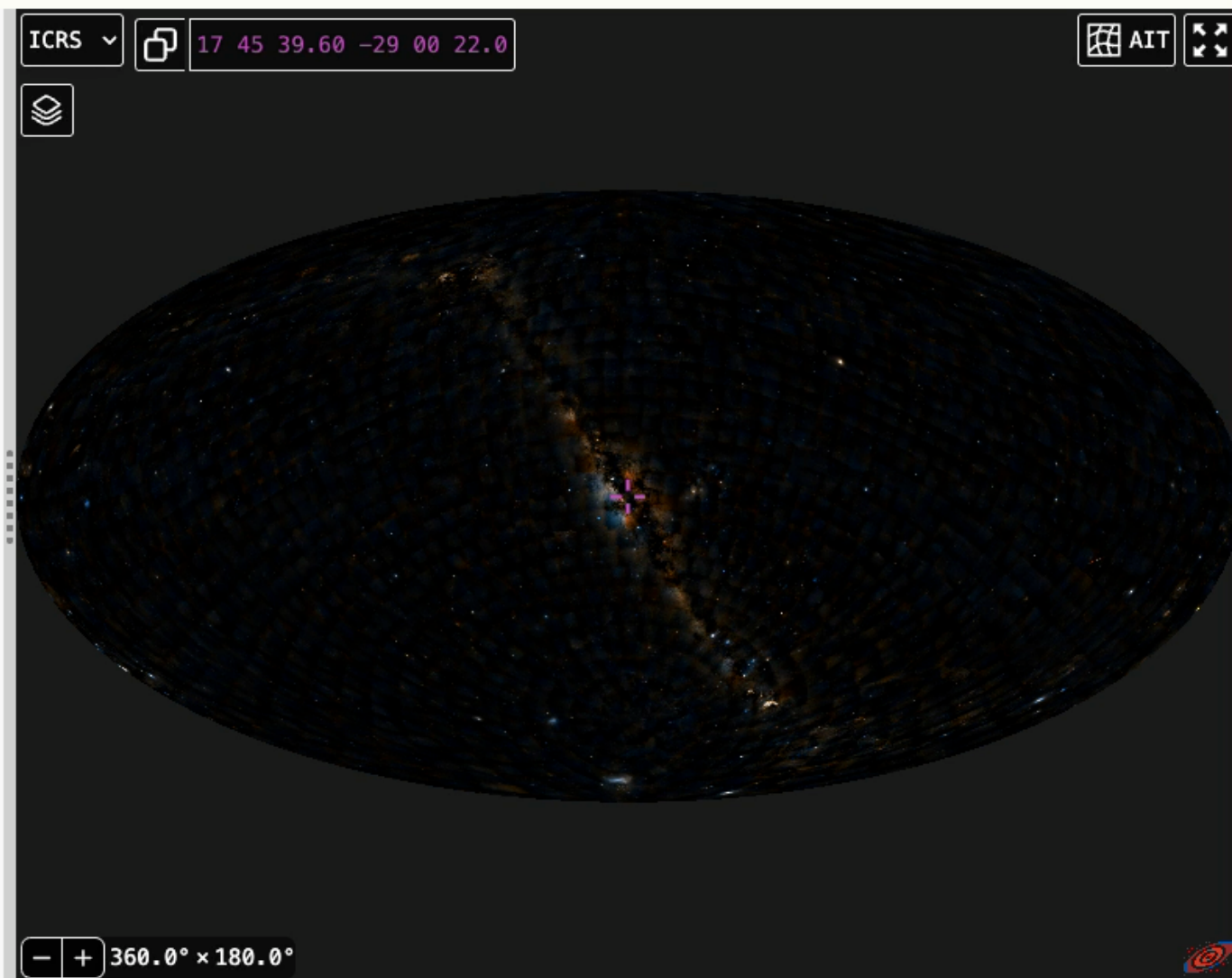
Virtual color HiPS

HiPS Mixer - 🌈 Create a color HiPS from 3+ HiPS

- ☐ Reduce green noise
- ☐ Add luminance channel
- ☐ Use Lupton method

Preview your HiPS

Copy HiPS root URL



Virtual color HiPS

HiPS Mixer - 🌈 Create a color HiPS from 3+ HiPS



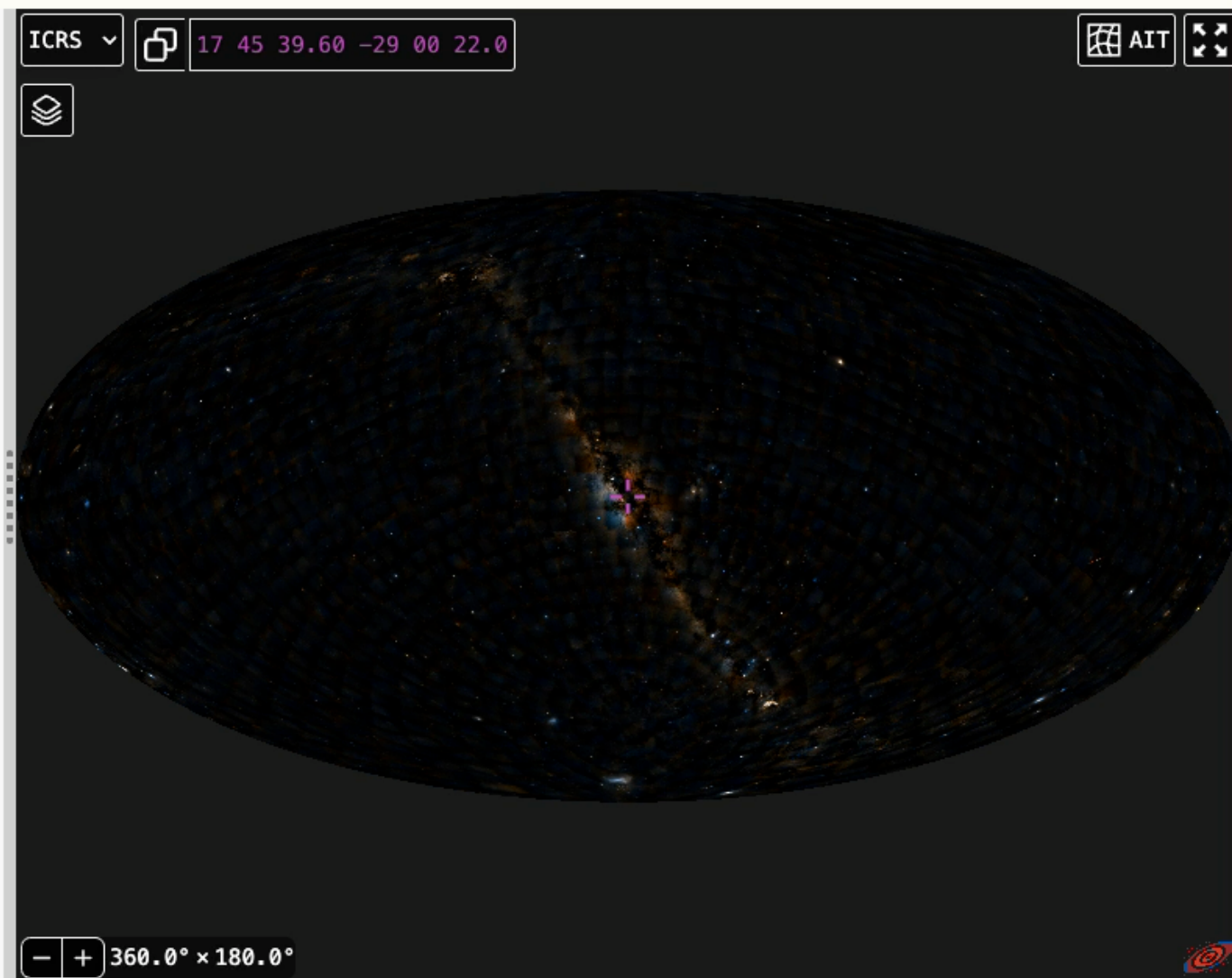
 

- ☐ Reduce green noise
- ☐ Add luminance channel
- ☐ Use Lupton method

[Preview your HiPS](#)

 [Copy HiPS root URL](#)



□ Color HiPS creation

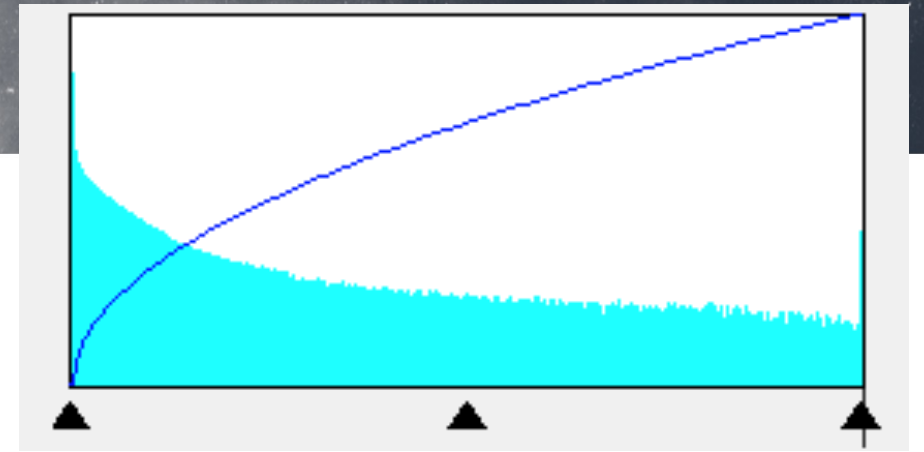
- We work from FITS files
- Compute contribution of each channel

HiPS	Red	Green	Blue
2MASS/K	1.0	0.0	0.0
2MASS/H	0.0	1.0	0.0
2MASS/J	0.0	0.0	1.0
VPHAS H α	1.0	0.75	0.8

$$\begin{aligned}\text{Red} &= \frac{1 \cdot 2\text{MASS/K} + 1 \cdot \text{VPHAS H}\alpha}{2} \\ \text{Green} &= \frac{1 \cdot 2\text{MASS/H} + 0.75 \cdot \text{VPHAS H}\alpha}{1.75} \\ \text{Blue} &= \frac{1 \cdot 2\text{MASS/J} + 0.8 \cdot \text{VPHAS H}\alpha}{1.8}\end{aligned}$$

- Weighted mean
(⚠ taking NaN/missing into account)

□ Cuts and stretch



- Providing *good defaults* cut values
 - Pre-compute percentiles on all pixels for tiles at order 2
(at most: $192 \times 512 \times 512 = 50\text{M}$ pixels)
- Default min_cut = percentile 0.5
- Default max_cut = percentile 99.9

□ Other options

- Green noise reduction
- Lupton method vs classical RGB
- Luminance channel



□ Video: Lupton method

HiPS Mixer - 🌈 Create a color HiPS from 3+ HiPS

Type HiPS ID

Type HiPS ID

Type HiPS ID

☐

Reduce green noise

☐

Add luminance channel

☐

Use Lupton method

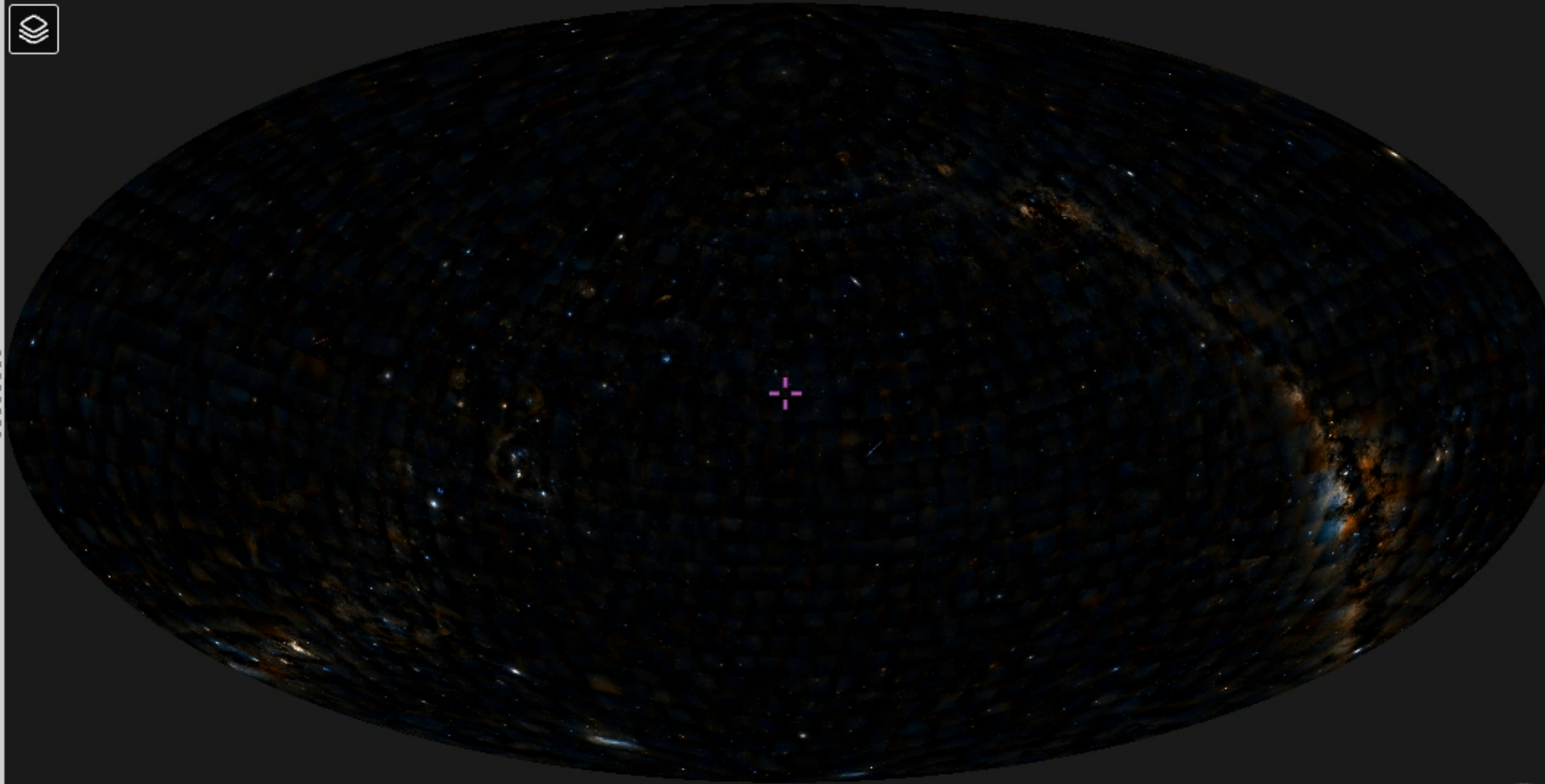
Preview your HiPS

Copy HiPS root URL

ICRS  01 59 20.78 +19 00 37.2





  360.0° × 180.0°



□ Video: Lupton method

HiPS Mixer - 🌈 Create a color HiPS from 3+ HiPS

Type HiPS ID

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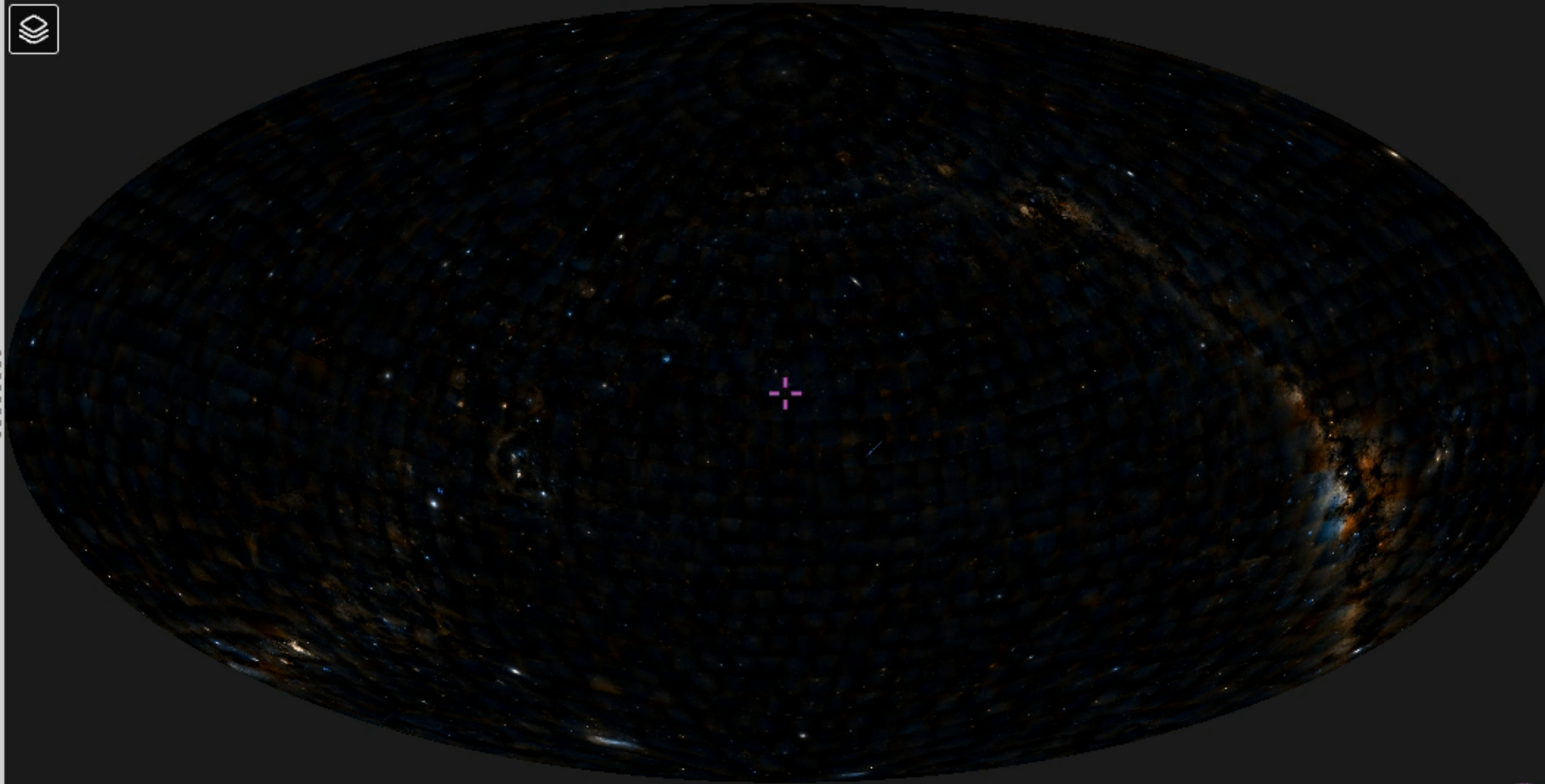
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  360.0° × 180.0°



□ Video: luminance channel

HiPS Mixer - 🌈 Create a color HiPS from 3+ HiPS

The screenshot displays the HiPS Mixer web application. On the left, there are three input fields for HiPS IDs, each with a color-coded icon (red, green, blue). Below these are three checkboxes: "Reduce green noise", "Add luminance channel", and "Use Lupton method". At the bottom left are two buttons: "Preview your HiPS" and "Copy HiPS root URL". The main area shows a large, dark, oval-shaped visualization of a HiPS, likely a mosaic of astronomical images. Above the visualization, there is a search bar with the coordinates "00 20 23.75 -49 14 47.5" and a dropdown menu set to "ICRS". In the top right corner, there are icons for "AIT" and a full-screen button. At the bottom left of the visualization, there are zoom controls and the text "360.0° x 180.0°". The "ALADIN" logo is visible in the bottom right corner.

ICRS AIT

Type HiPS ID
Type HiPS ID
Type HiPS ID

☐ Reduce green noise
☐ Add luminance channel
☐ Use Lupton method

Preview your HiPS Copy HiPS root URL

360.0° x 180.0° ALADIN

□ Video: luminance channel

HiPS Mixer - 🌈 Create a color HiPS from 3+ HiPS

The screenshot displays the HiPS Mixer web application. On the left, there is a control panel with three color-coded input fields (red, green, and blue) for entering HiPS IDs. Below these are three checkboxes: 'Reduce green noise', 'Add luminance channel', and 'Use Lupton method'. At the bottom of the control panel are two buttons: 'Preview your HiPS' and 'Copy HiPS root URL'. The main area on the right shows a large, dark, oval-shaped visualization of a HiPS, which is a mosaic of astronomical images. The visualization is centered on a bright star. Above the visualization, there is a search bar with the coordinates '00 20 23.75 -49 14 47.5' and a dropdown menu set to 'ICRS'. In the top right corner, there are icons for 'AIT' and a full-screen button. In the bottom right corner, there is a logo for 'ALADIN'.

ICRS AIT

Type HiPS ID
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☐ Reduce green noise
☐ Add luminance channel
☐ Use Lupton method

Preview your HiPS Copy HiPS root URL

360.0° × 180.0° ALADIN

□ Limitations

- Heterogeneous frames (equatorial vs galactic)
 - Not supported
 - Would need time-consuming reprojections
- Only HiPS hosted at CDS
 - Created by CDS or mirrored at CDS

□ Future developments

- **Cache** for MOC, Allsky, properties, tiles at order ≤ 3
- Support **remote HiPS**
 - Huge distributed datasets, eg SKA
- Virtual HiPS from **arithmetic combination**
 - Eg: color HiPS from 2 flux maps HiPS
- **Stacking** HiPS
 - Hard, need to have compatible quantities
- HiPS cubes, **HiPS 3D** support
 - Combine cube slices

□ Implementation : Falcon Web framework

- Definition of *routes* associated to class methods
 - Parameter mapping
 - Example :



```
prioritize_hips_combiner = PrioritizeHiPSCombiner(...)
app.add_route('/prioritize/{params_str}/', prioritize_hips_combiner,
suffix='survey_hips_root')
app.add_route('/prioritize/{params_str}/properties',
prioritize_hips_combiner, suffix='survey_hips_properties')
app.add_route('/prioritize/{params_str}/Moc.fits',
prioritize_hips_combiner, suffix='survey_hips_moc')
```

```
app.add_route('/prioritize/{params_str}/Norder{order:int}/
Dir{dir_nb:int}/Npix{ipix:int}.{tile_format}',
prioritize_hips_combiner, suffix='survey_hips_tile')
```



```
def on_get_survey_hips_tile(self, req, resp, params_str, order, dir_nb, ipix
, tile_format):
    params = decode_params_string(params_str)
    hipses = params['hipses']
    tile = create_tile(order, ipix, tile_format, hipses, self.hips_params, s
elf.mapping_functions)
    buffer = io.BytesIO()
    mimg.imsave(buffer, tile, format='png', dpi=42)

    resp.content_type = f'image/png'
    resp.data = buffer.getvalue()
```

□ Conclusion

- HiPS mixer:
smart proxy, building virtual HiPS in various ways
 - Prototype at <https://alasky.cds.unistra.fr/hips-mixer/>
- Valid HiPS
 - use in any client
- Good performances
 - 30-50 tiles / second
- Advice to HiPS producers
 - Keep your FITS tiles
 - Equatorial frame if possible
 - Use PNG for partial coverage / pointed survey

□ Additional slides

□ Green noise reduction

- <https://siril.readthedocs.io/en/stable/processing/colors.html#remove-green-noise>

```
if reduce_green_noise:
    green_p = 0.5 * red + 0.5 * blue
    # this is SIRIL Average Neutral Protection
    mask = green > green_p
    green[mask] = green_p[mask]
```

- <https://alasky.cds.unistra.fr/hips-combiner/color/hips:CDS=P=2MASS=K,CDS=P=2MASS=H,CDS=P=2MASS=J;colors:red,green,blue;stretch:sqrt/?fov=10>

□ Lupton

$$I = \frac{r + g + b}{3}$$

$$f(I) = \frac{\sinh^{-1}(Q \cdot I)}{\sqrt{Q}}$$

$$R = \frac{F(I) \cdot r}{I + \varepsilon}$$

$$G = \frac{F(I) \cdot g}{I + \varepsilon}$$

$$B = \frac{F(I) \cdot b}{I + \varepsilon}$$

<https://alasky.cds.unistra.fr/hips-combiner/color/hips:CDS=P=DESI-Legacy-Surveys=DR10=i,CDLegacy-Surveys=DR10=r,CDS=P=DESI-Legacy-Surveys=DR10=g%3Bcolors:red,green,blue;stretch:logfov=0.2&ra=318.776309&dec=-47.2208105>

<https://alasky.cds.unistra.fr/hips-combiner/color/hips:CDS=P=DESI-Legacy-Surveys=DR10=i,CDLegacy-Surveys=DR10=r,CDS=P=DESI-Legacy-Surveys=DR10=g%3Bcolors:red,green,blue;method:lupfov=0.2&ra=318.776309&dec=-47.2208105>