Exploring large catalogues with HiPS and MOCs

ESCAPE
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ESCAPE 2nd VO school

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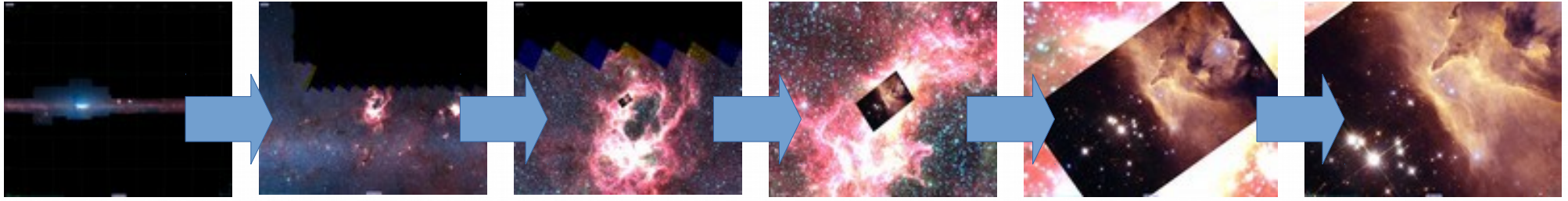
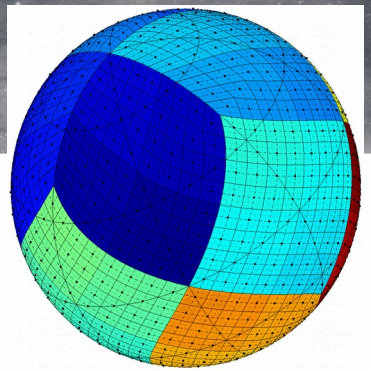
What is HiPS ?

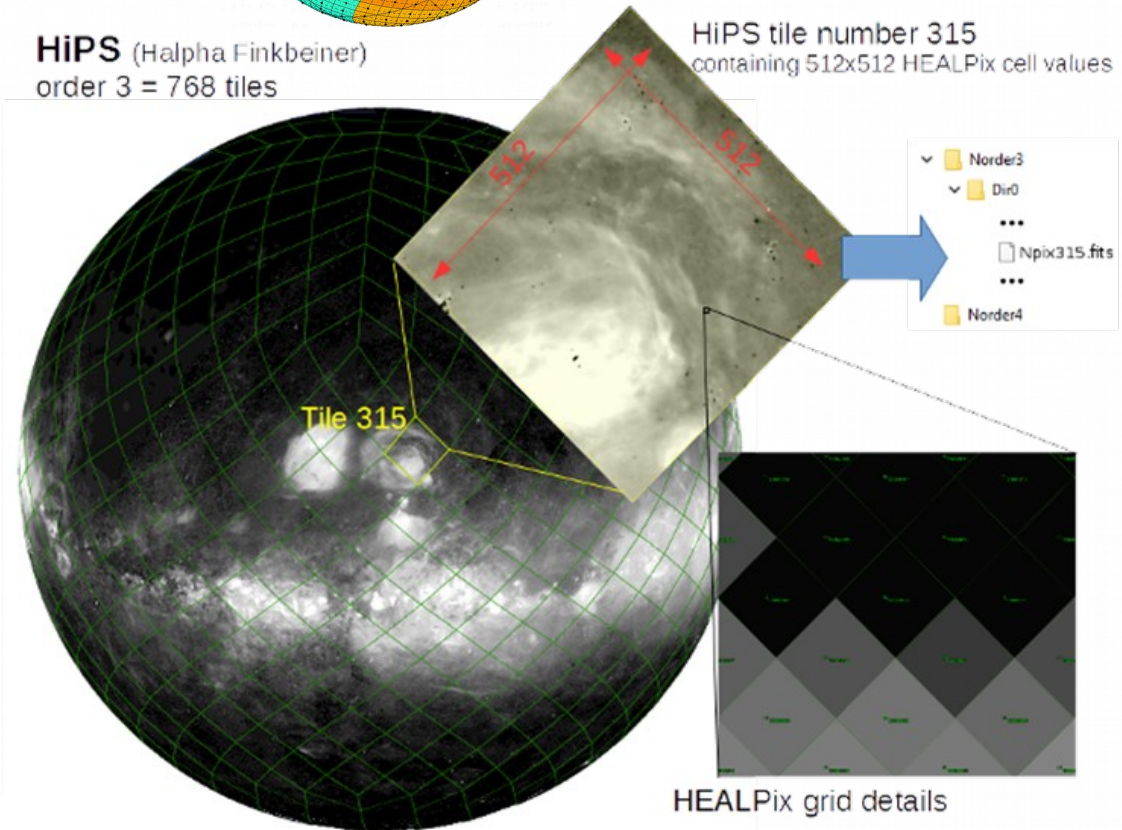
- Hierachical Progressive Survey
  "The more you zoom in on a particular area, the more details show up"
- Multi-resolution HEALPix data structure
  for Images, Catalogues, 3-dimensional data cubes, ...
- Conserves scientific data properties alongside visualisation considerations
- No databases or servers, just HTTP



What is HiPS ?

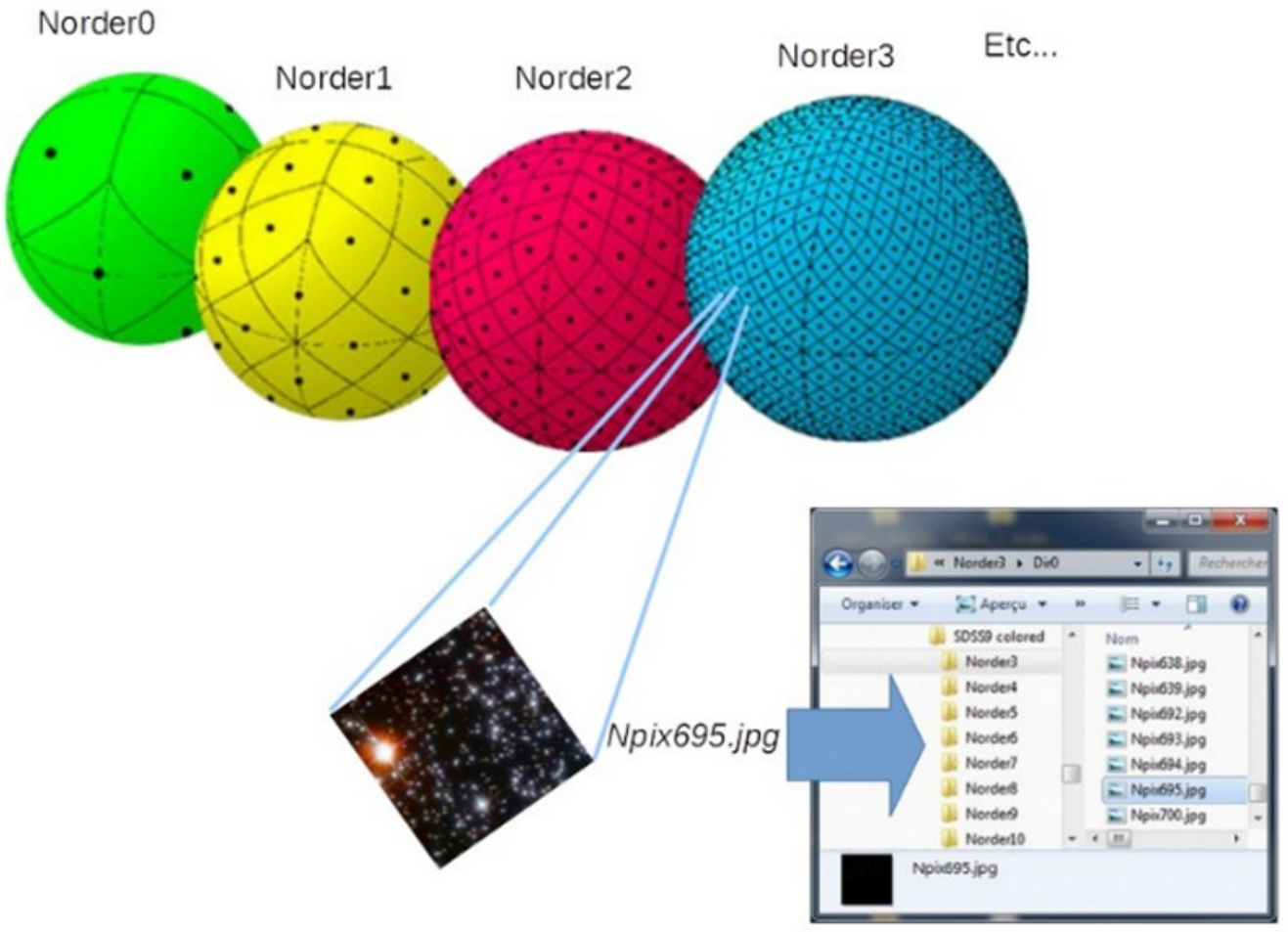


- HEALPix (Gorski et al. 2005)
  - **12 quadrilateral pixels**
  - 2x2 division at each level
  - **Equal area,** Iso-latitude
- HiPS = Mosaic of HEALPix tiles (HEALPix pixel geometry)



What is HiPS ?

- HiPS = Collection of tiles as files.



Different kinds of HiPS

- HiPS images : progressive image survey
  - HiPS nodes contain FITS (full pixel dynamics), JPG or PNG (used for web browsing / Aladin Lite) tiles : images at different resolutions
- HiPS cubes
  - 3D datasets : 2 spatial dimensions + 1 other
  - For example radio frequencies, spectral cube (MUSE, …)
- HiPS catalogues
  - Progressive catalogue display, useful for very large catalogues
  - Associate a « score » to each source, and sort by score (could be brightness, distance, number of citations, …)
  - Store sources with highest scores in top-level nodes ; sources with lower scores are associated to nodes deeper in the hierarchy

What is MOC ? → sky « footprint »

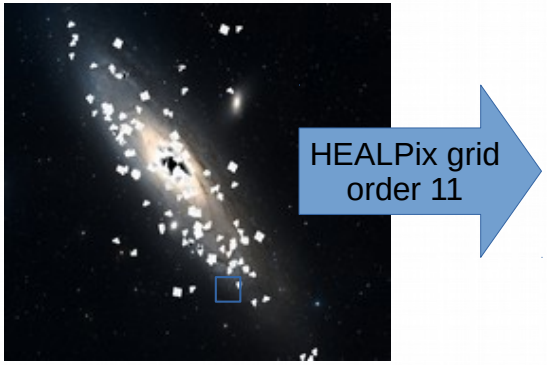
- Multi-Order Coverage map

  “Combine sky regions in few milliseconds”

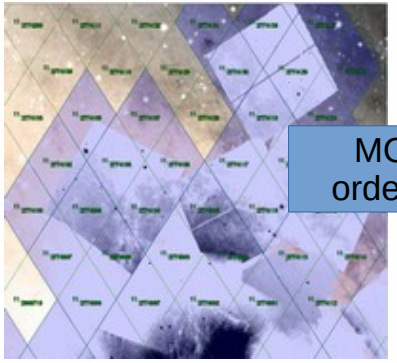
- A simple and efficient method to specify any kind of sky regions
- Based on HEALPix tessellation
- Existing libraries: Java, C, python
- Used in VO tools (Aladin, TOPcat, …)

What is MOC ?

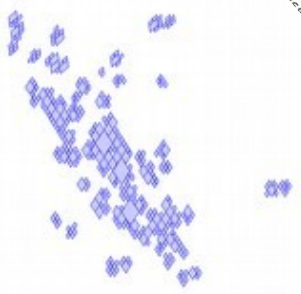
- “Just” the list of HEALPix cell numbers covering a region



HEALPix grid order 11



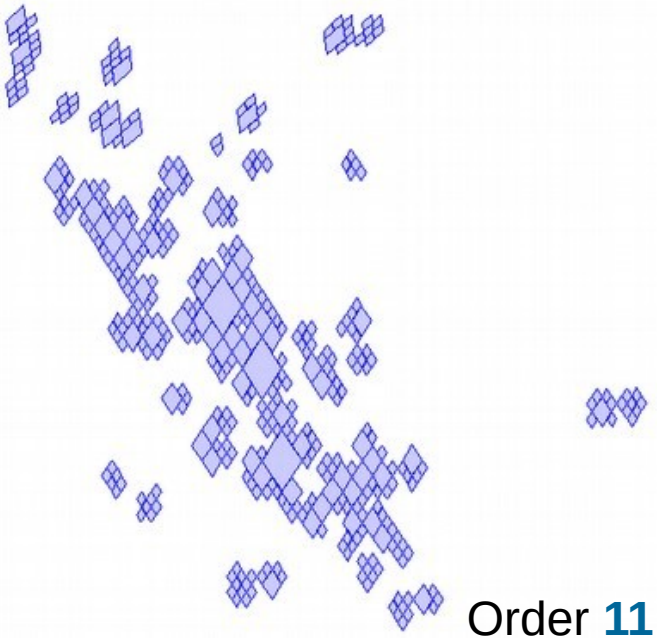
MOC order 11



- 4 adjacent cells are replaced by the parent, recursively
  → intrinsic compression
- Store as a FITS table (or JSON)

What is MOC ?

- MOC accuracy depends of the MOC **order**
  = the smallest HEALPix cell level used in the MOC



Order **11**
=>1.718 arcsec

Order **20**
=>201.3mas

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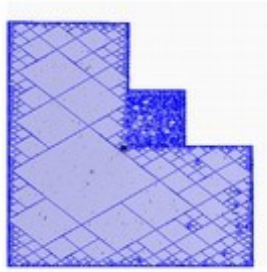
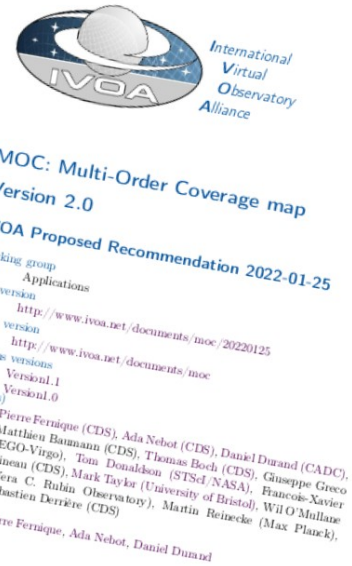


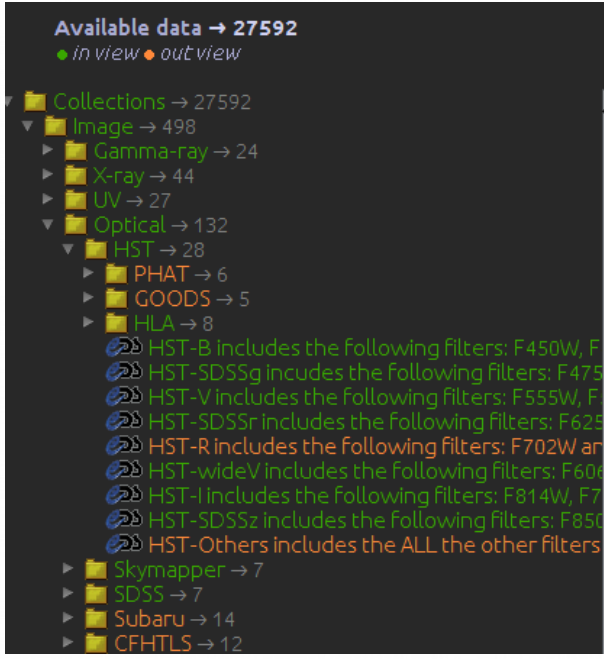
Order **29**
=>391 µas

IVOA standards



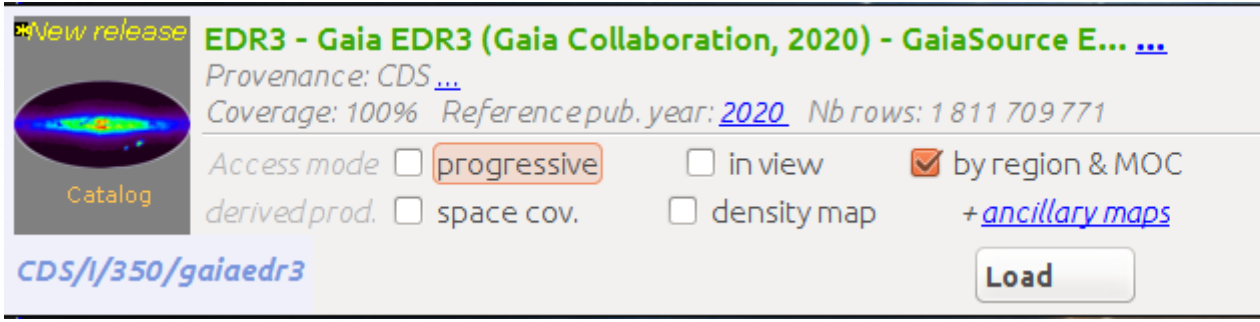
Usage of HiPS and MOCs

- Browse very large datasets without downloading the full data
  - PanSTARRS 1 band = 15TB
  - Gaia EDR3 1.8 billion sources
- MOC gives you a boolean value for sky coverage
  - See Aladin Data collections tree : orange/green colours
- Compute logical operations on coverage : intersection, union
  - What region of the sky is observed by SDSS, Galex and HST in the V band ?
- Create your own HiPS and MOCs
  - Hipsgen https://aladin.u-strasbg.fr/hips/HipsIn10Steps.gml



Usage of HiPS and MOCs

- Query catalogue by MOC



- Programmatic use
  - Mocpy https://github.com/cds-astro/mocpy
- Soon : new standard with STMOC : combined space-time coverage

Tutorial outline

1. Retrieve a sample of FITS images
2. Create the MOC for these images
3. Logical operations on spatial MOCs
4. Query catalogues by MOC
5. Cross-matching and analysis

Tutorial

- Let’s see this in practice !