DADI

All-sky astrophysics
indexing the sky

Data Access, Discovery and Interoperability (DADI)

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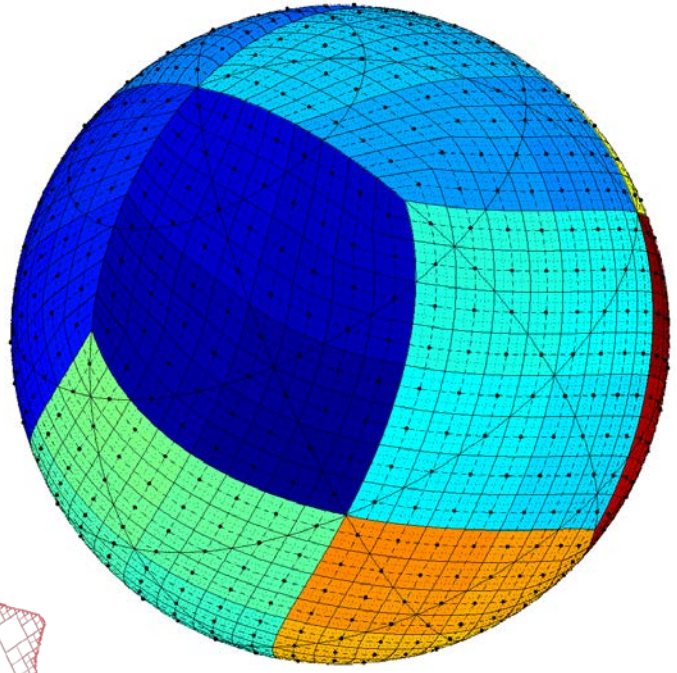
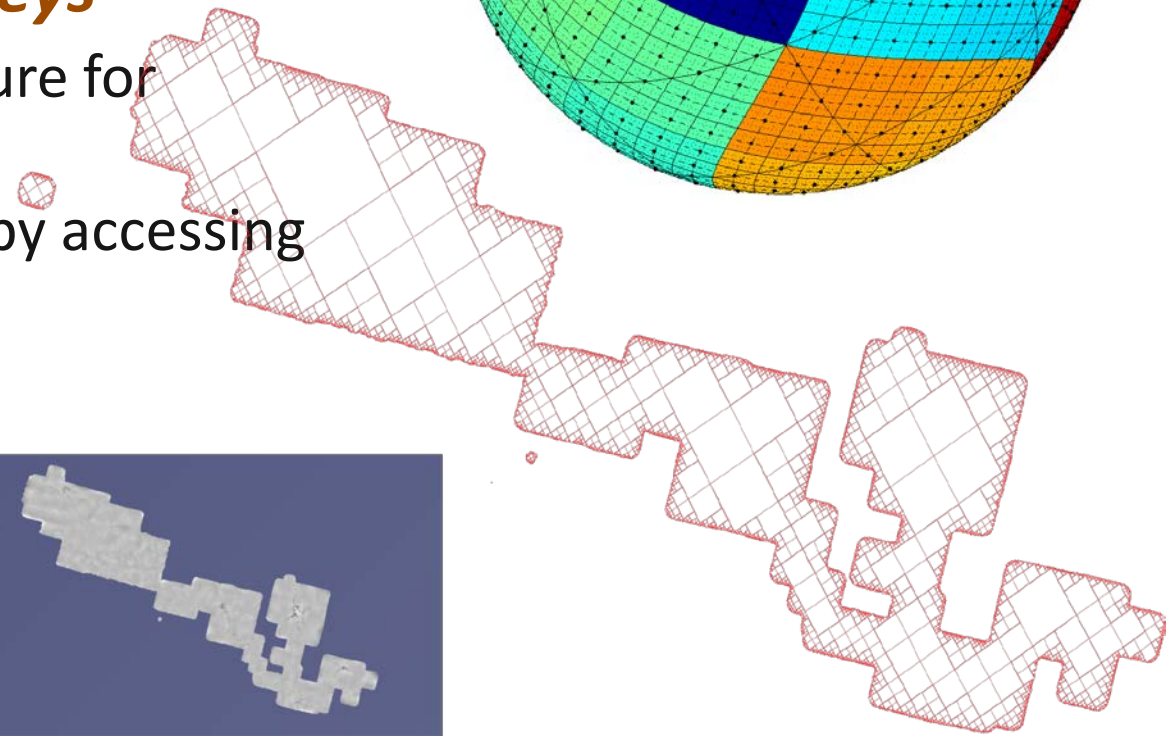
27 March 2019

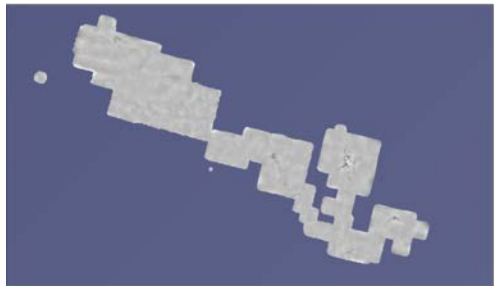
Hierarchical multi-resolution approach



- **HiPS*: *Hierarchical Progressive Surveys***
  - multi-resolution HEALPix** data structure for
    - images, 3-d image cubes, catalogues
  - the more you zoom, the more you see by accessing higher and higher resolution tiles



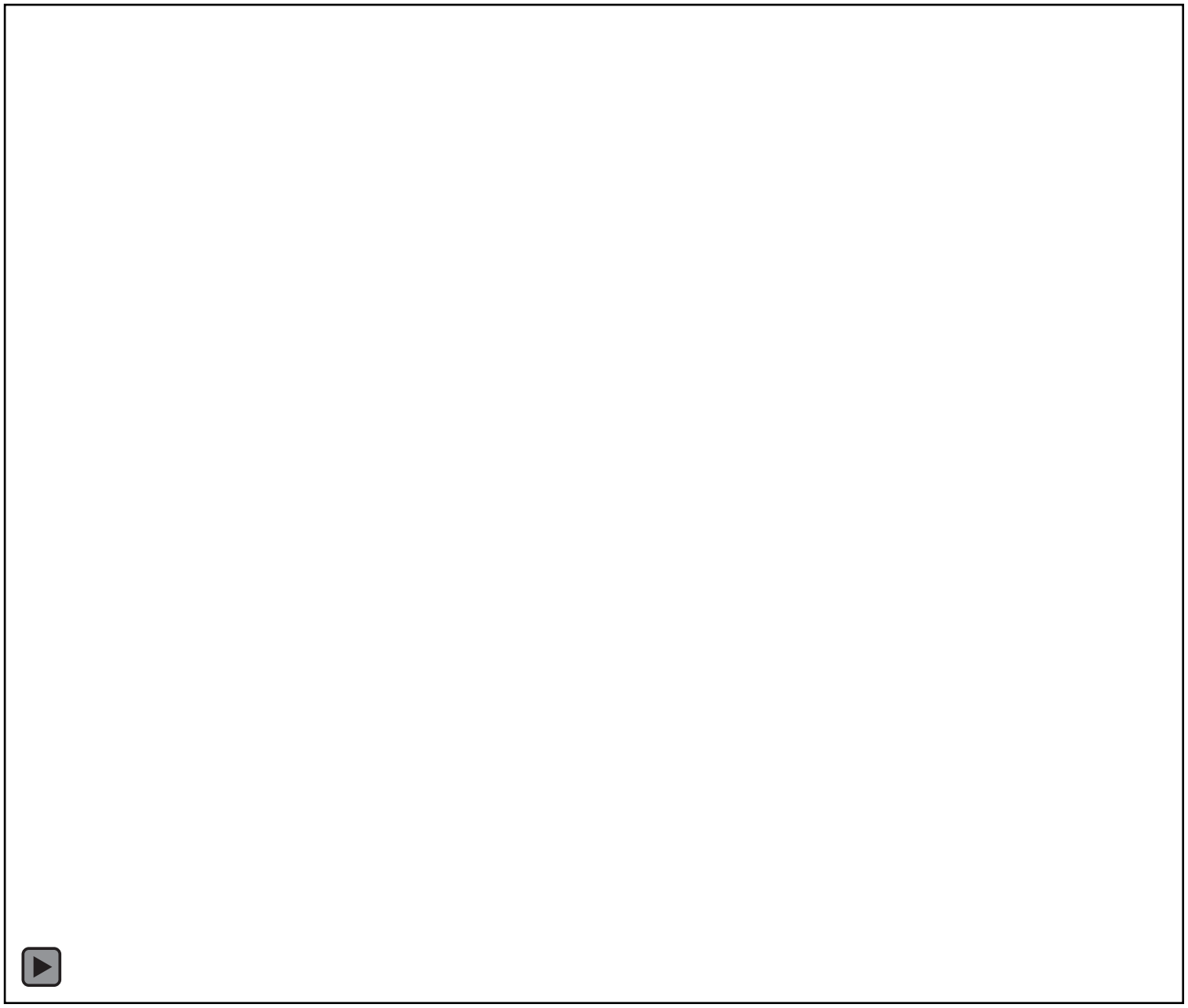
- **MOC: *Multi-Order Coverage maps***
  - HEALPix tiles at multiple orders
  - describe arbitrary regions on the sky



*Fernique et al. 2015, 2017, **Gorski et al. 2005

HiPS

- Multi-resolution
- Enables:
  - Visualisation
  - Scalability
  - Interoperability
- Science data values maintained by use of FITS
- Easy to implement

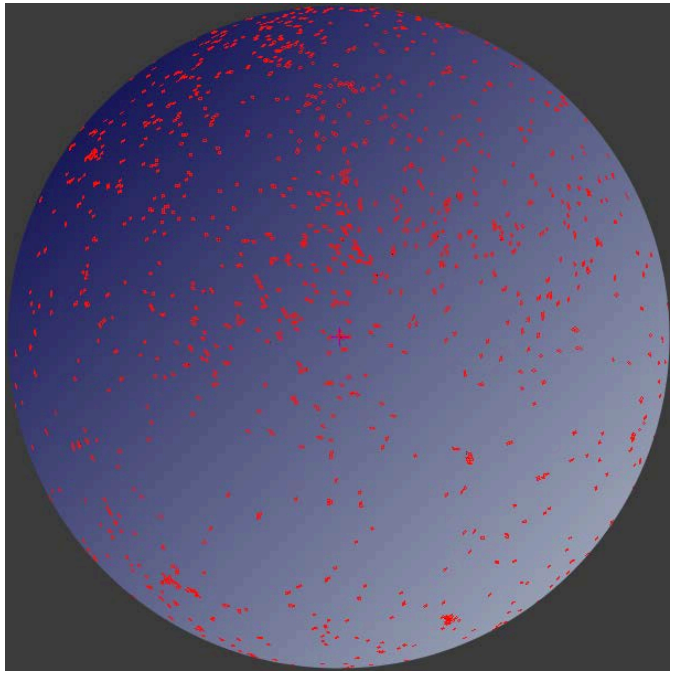


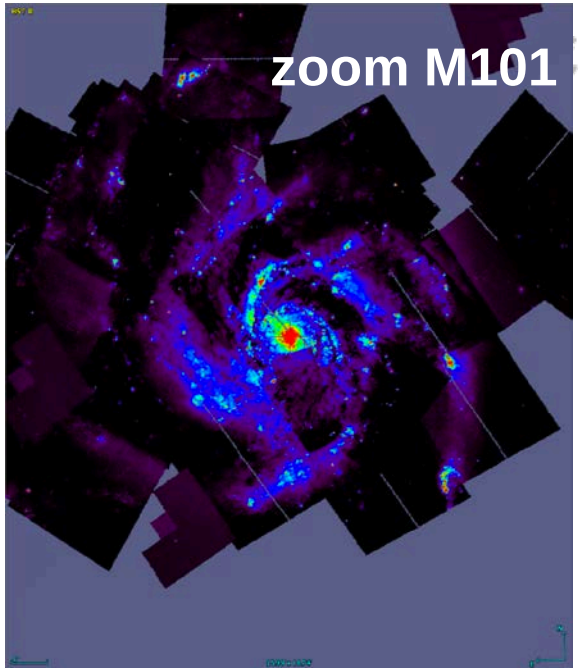
Pointed observations, fine angular res.

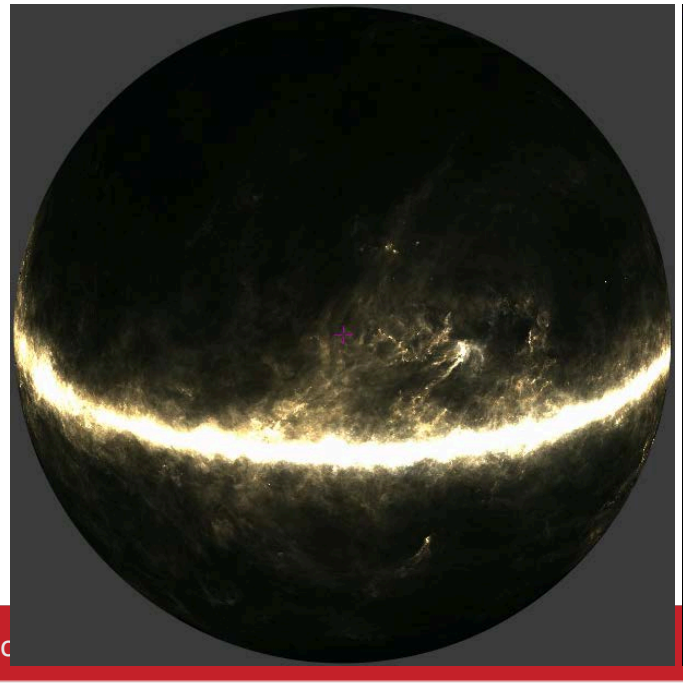
- e.g. HST

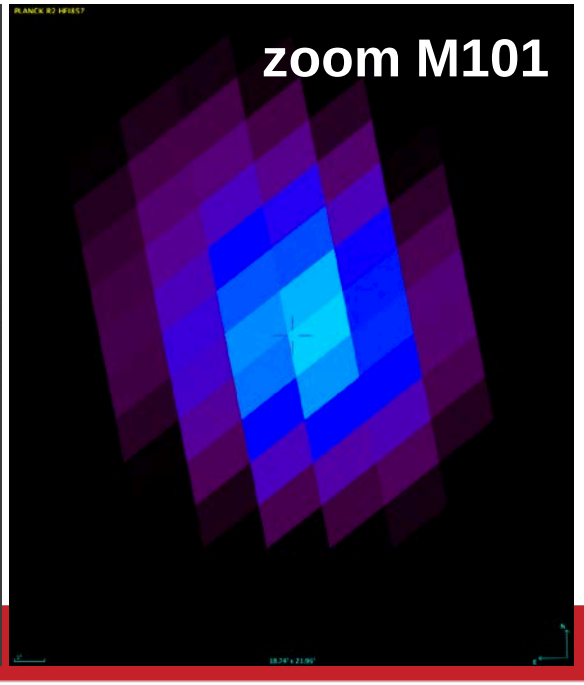
All-sky surveys, typically lower angular res.

- e.g. Planck



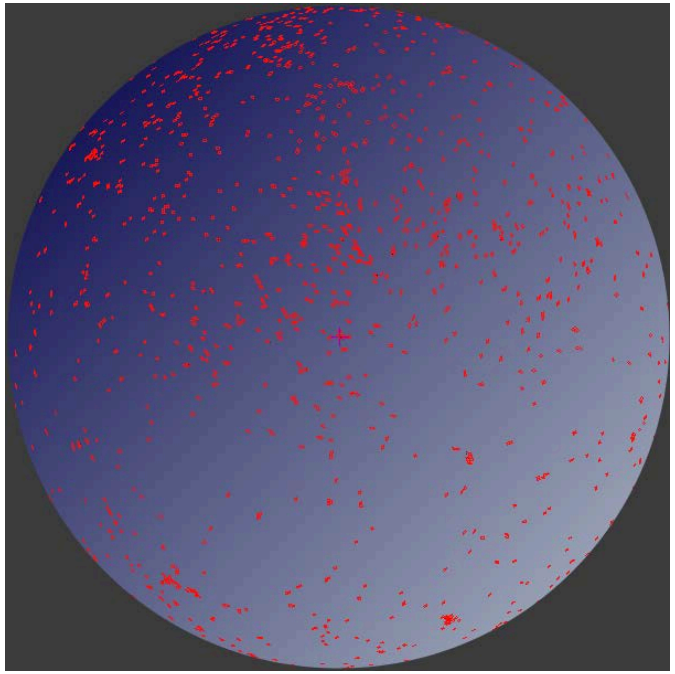


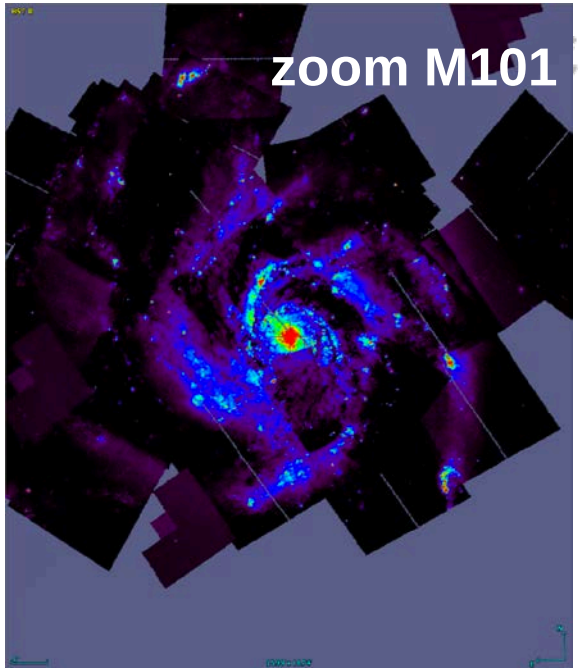




Pointed observations, fine angular res.

- e.g. HST
- Standard rectangular image, FITS header with WCS



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CDELT2  =             0.00277778
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NAXIS2  =                      7
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CRVAL2  =                30.6599
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CTYPE2  = 'DEC--TAN'
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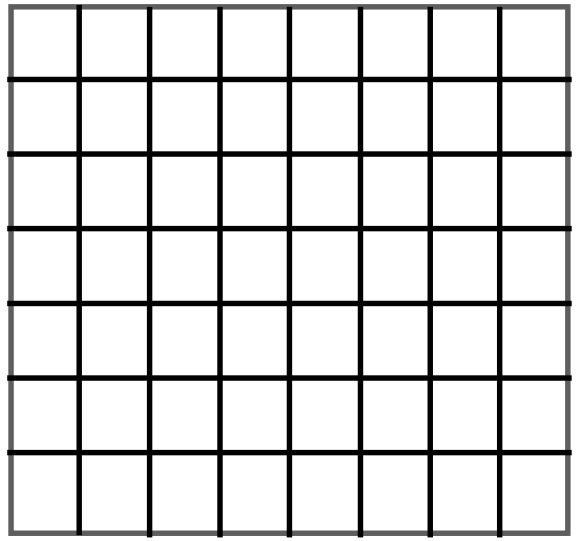
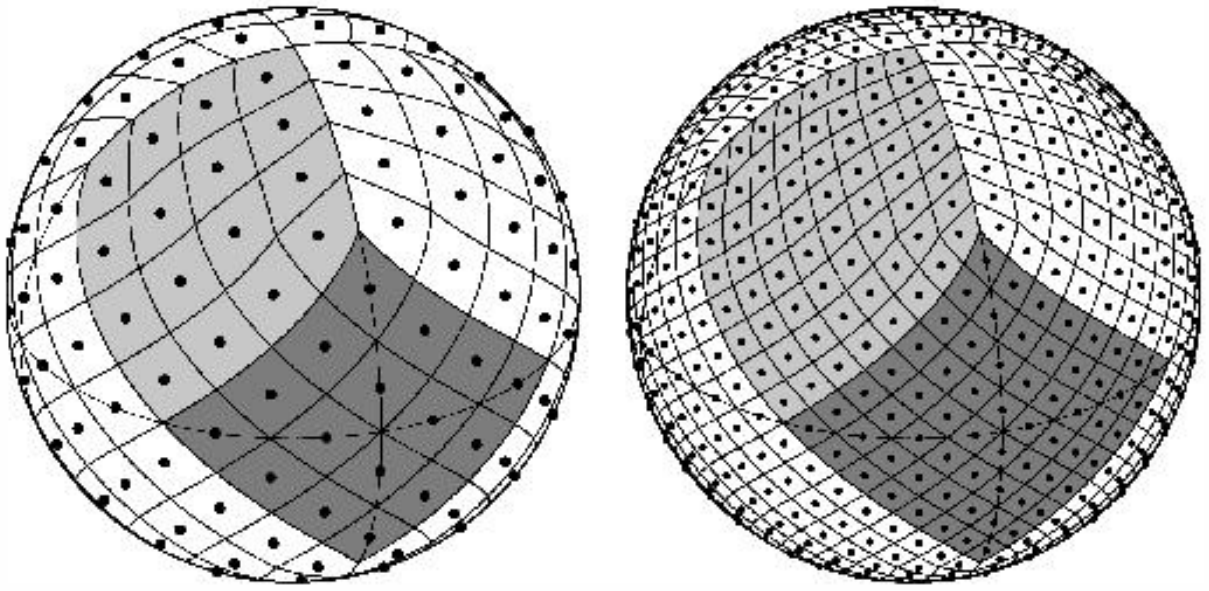
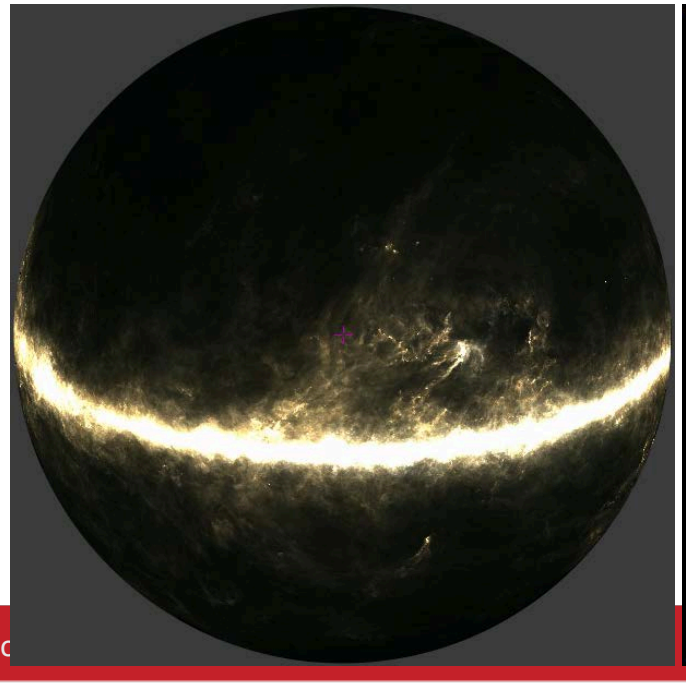


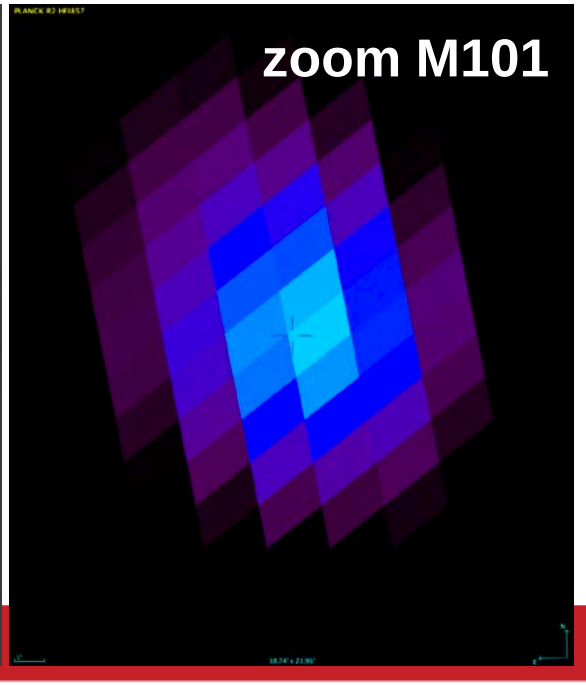
- All-sky formats e.g. HEALPix



All-sky surveys, typically lower angular res.

- e.g. Planck





Pointed observations, fine angular res.

- e.g. HST

All-sky surveys, typically lower angular res.

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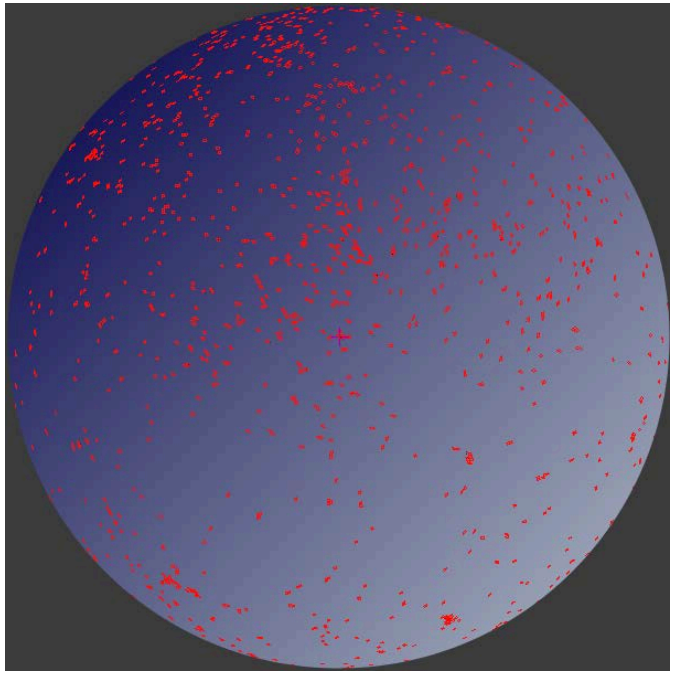
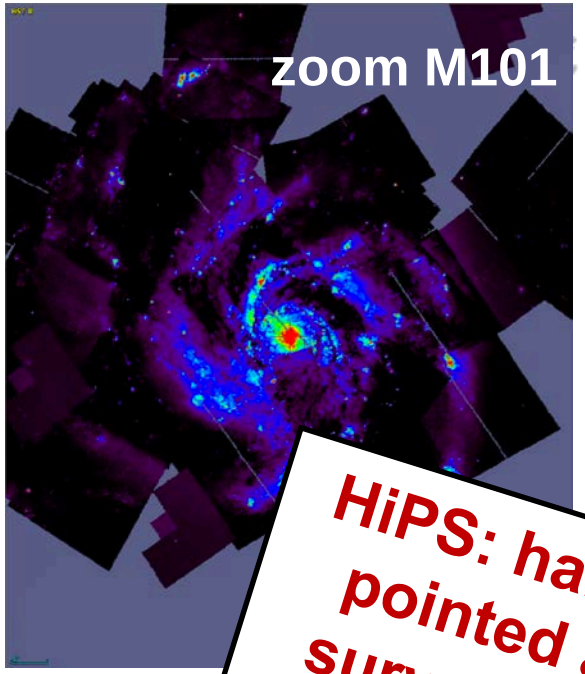
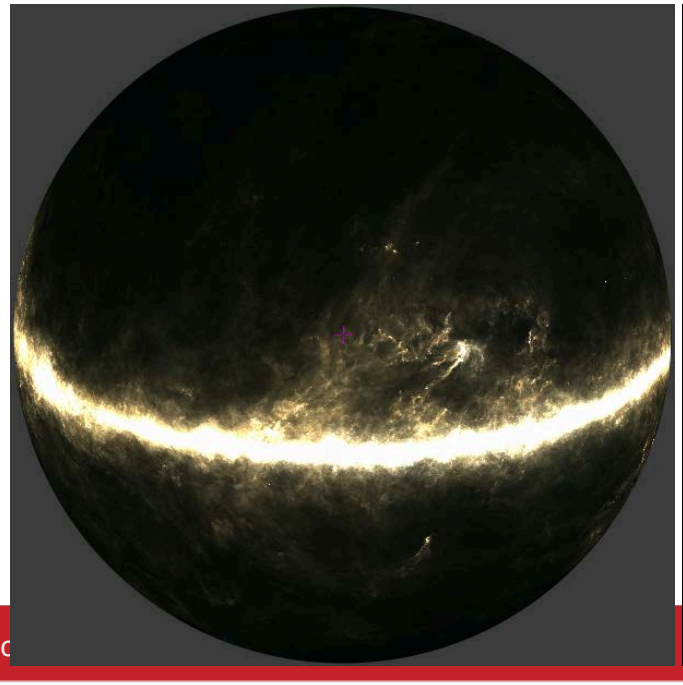
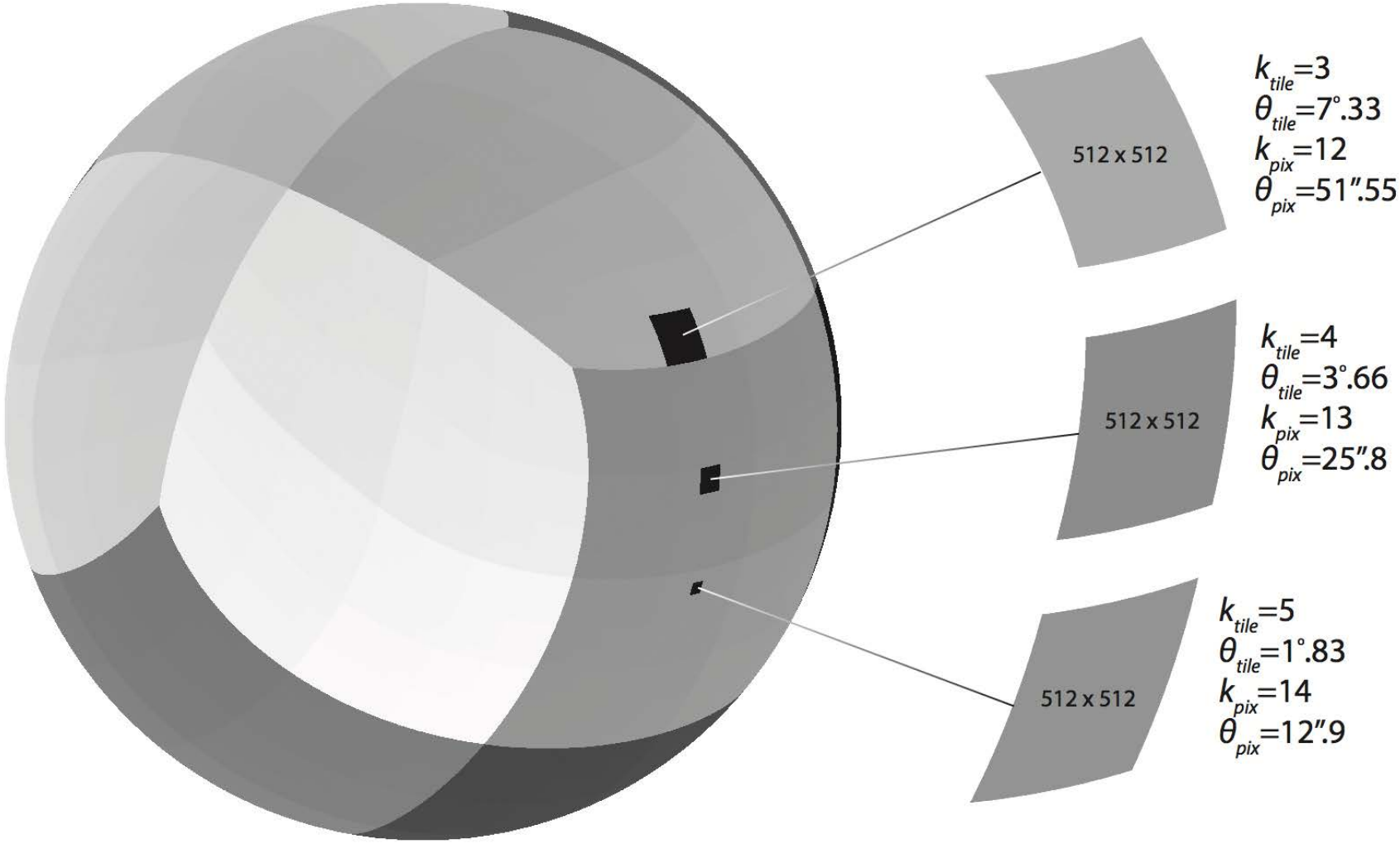




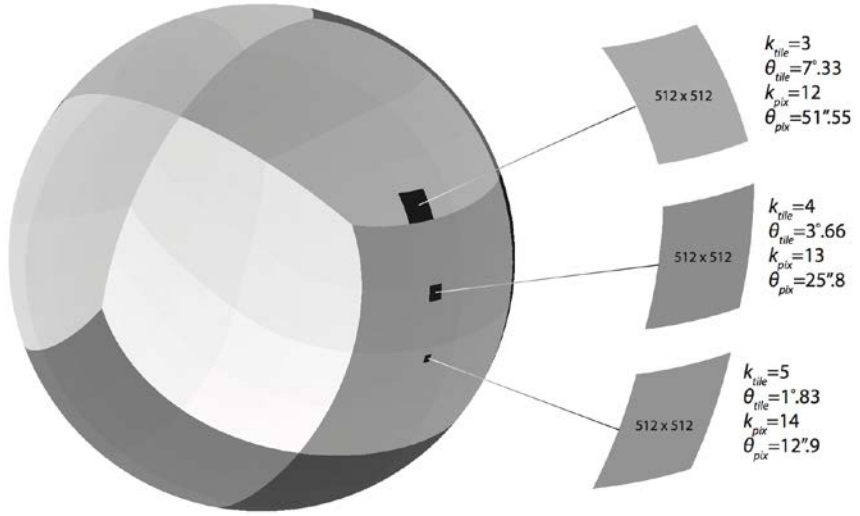


HiPS: handles pointed and survey in the same system

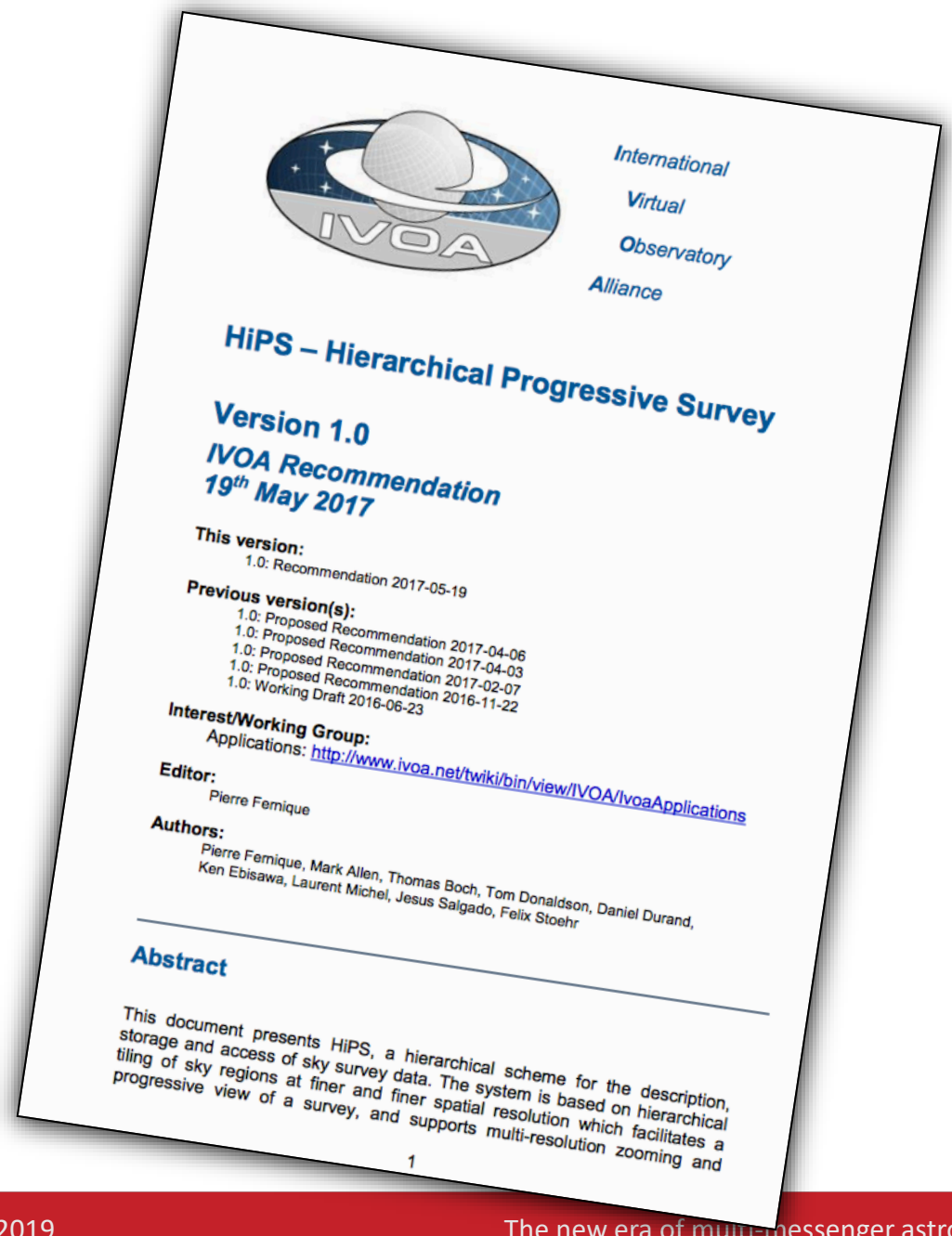

512 x 512
k_{tile}=3
θ_{tile}=7°.33
k_{pix}=12
θ_{pix}=51″.55
512 x 512
k_{tile}=4
θ_{tile}=3°.66
k_{pix}=13
θ_{pix}=25″.8
512 x 512
k_{tile}=5
θ_{tile}=1°.83
k_{pix}=14
θ_{pix}=12″.9

k	$N_{side} = 2^k$	N_{pix}	θ_{pix}	$k_{tile,512}$	$N_{tile,512}$	$\theta_{tile,512}$
0	1	12	58.6			
1	2	48	29.3			
2	4	192	14.7			
3	8	768	7.33			
4	16	3072	3.66			
5	32	12,288	1.83			
6	64	49,152	55.0			
7	128	196,608	27.5			
8	256	786,432	13.7			
9	512	3,145,728	6.87	0	12	58.6
10	1024	12,582,912	3.44	1	48	29.3
11	2048	50,331,648	1.72	2	192	14.7
12	4096	201,326,592	51.″5	3	768	7.33
13	8192	805,306,368	25.″8	4	3072	3.66
14	2^{14}	3.22×10^9	12.″9	5	12288	1.83
15	2^{15}	1.29×10^{10}	6.″44	6	49152	55.0
16	2^{16}	5.15×10^{10}	3.″22	7	196608	27.5
17	2^{17}	2.06×10^{11}	1.″61	8	786432	13.7
18	2^{18}	8.25×10^{11}	0.″81	9	3,145,728	6.87
19	2^{19}	3.30×10^{12}	0.″40	10	12,582,912	3.44
20	2^{20}	1.32×10^{13}	0.″20	11	50,331,648	1.72
21	2^{21}	5.28×10^{13}	0.″10	12	201,326,592	51.″5
22	2^{22}	2.11×10^{14}	50.3 mas	13	805,306,368	25.″8
23	2^{23}	8.44×10^{14}	25.1 mas	14	3.22×10^9	12.″9
24	2^{24}	3.38×10^{15}	12.6 mas	15	1.29×10^{10}	6.″44
25	2^{25}	1.35×10^{16}	6.29 mas	16	5.15×10^{10}	3.″22
26	2^{26}	5.40×10^{16}	3.15 mas	17	2.06×10^{11}	1.″61

------ Tiles -----



- **WMAP**
- **PLANCK HFI**
- **IRAS**
- **NVSS**
- **SCUBA**
- **DSS**
- **SDSS**
- **CFHTLS**
- **HST ACS**



International Virtual Observatory Alliance

HiPS – Hierarchical Progressive Survey

Version 1.0
IVOA Recommendation
19th May 2017

This version:
1.0: Recommendation 2017-05-19

Previous version(s):
1.0: Proposed Recommendation 2017-04-06
1.0: Proposed Recommendation 2017-04-03
1.0: Proposed Recommendation 2017-02-07
1.0: Proposed Recommendation 2016-11-22
1.0: Working Draft 2016-06-23

Interest/Working Group:
Applications: http://www.ivoa.net/twiki/bin/view/IVOA/IvoaApplications

Editor:
Pierre Fernique

Authors:
Pierre Fernique, Mark Allen, Thomas Boch, Tom Donaldson, Daniel Durand, Ken Ebisawa, Laurent Michel, Jesus Salgado, Felix Stoehr

Abstract

This document presents HiPS, a hierarchical scheme for the description, storage and access of sky survey data. The system is based on hierarchical tiling of sky regions at finer and finer spatial resolution which facilitates a progressive view of a survey, and supports multi-resolution zooming and

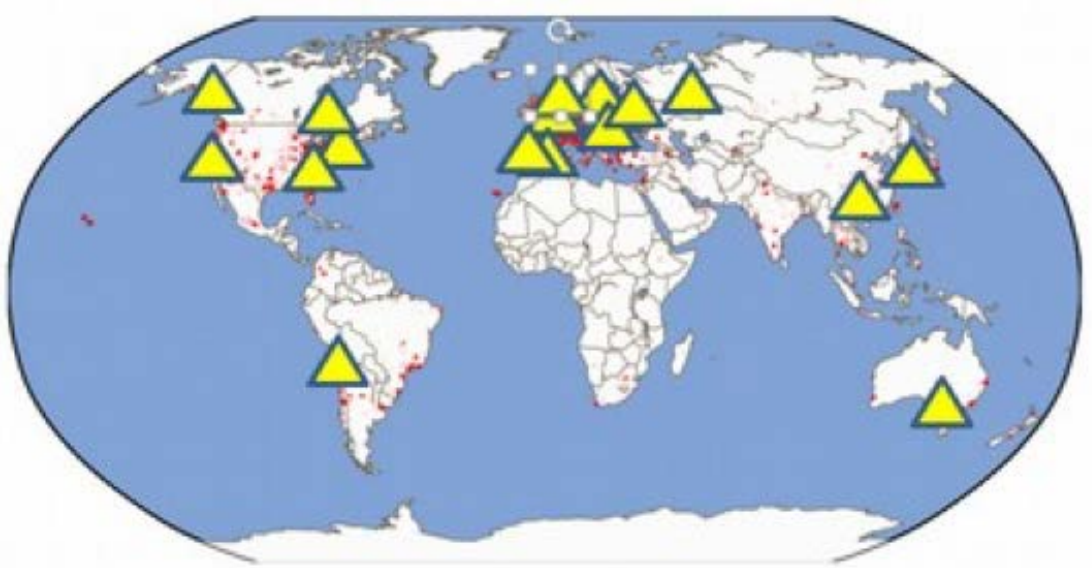
1

- **20 HiPS nodes**
  - ~8 new in 2018

- **Independent HiPS clients**
  - Aladin Desktop (JAVA)
  - Aladin Lite + derived (javascript)
  - CNES/MIZAR (javascript + WebGL)
  - Firefly/IPAC (javascript)
  - Stellarium (C), Kstars (C)
  - + 40 Aladin Lite implementations

- **Libraries:** astropy — Hipspy, MOCpy

- **HiPS/MOC adopted by LSST (RFC-441)**

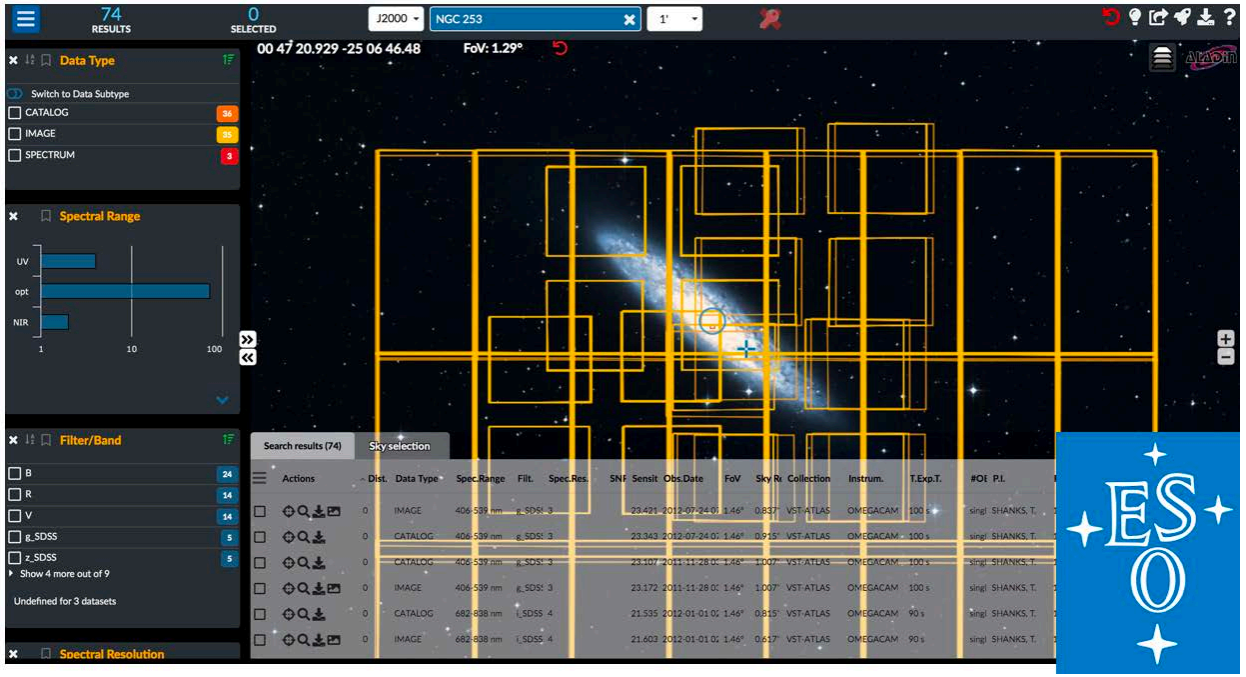


HiPS Nodes:

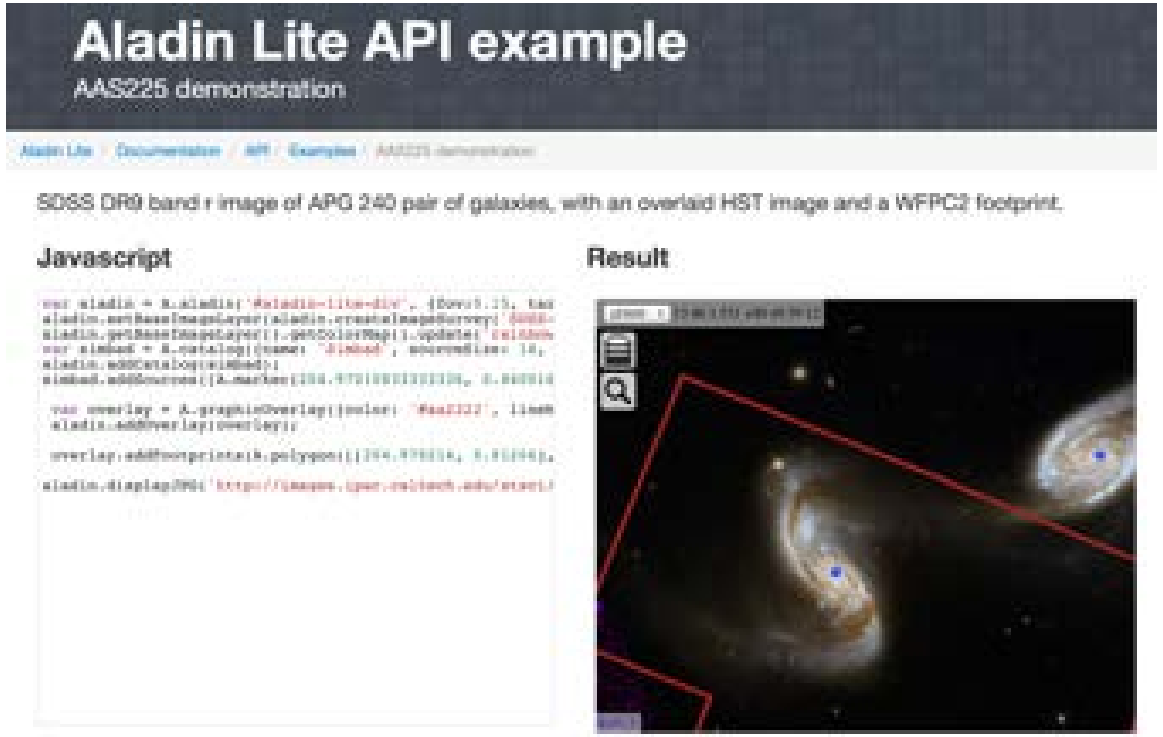
Leiden, IRAP, SSC, 3xCDS, AMIGA, svo.cab, IAS, ESAC, JAXA ,IPAC, ANU, 2xCADC, HEASARC, China-VO, MPIK, PADC

Coming soon:

ESO, Stellarium AWS/S3, Chile-VO

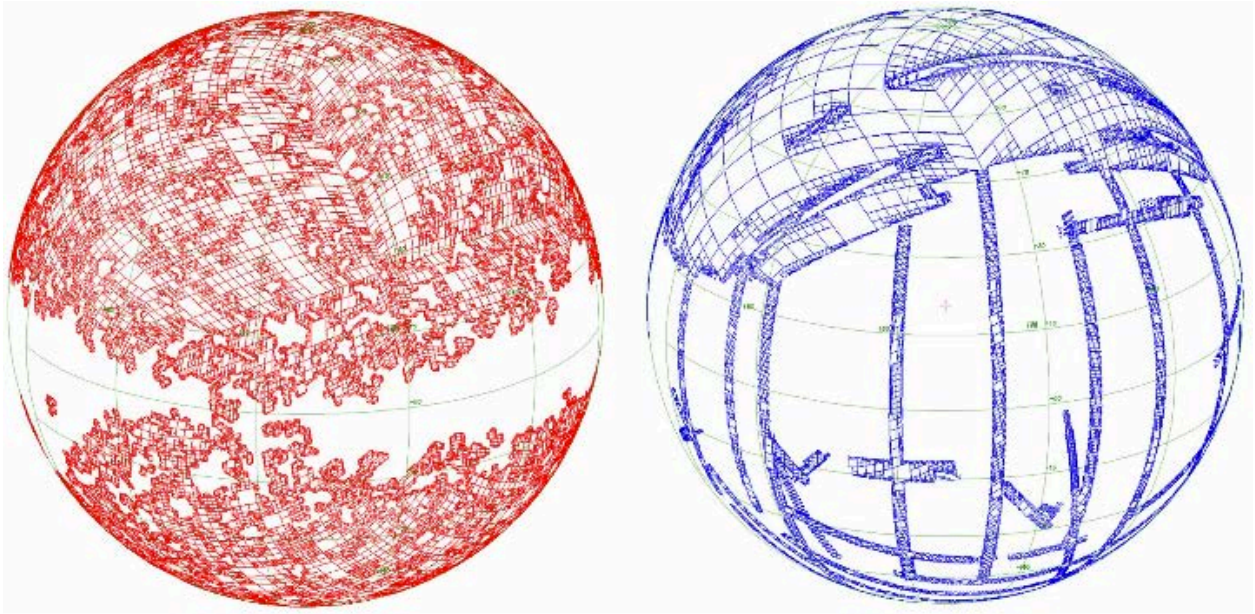

74
RESULTS
0
SELECTED
J2000
NGC 253
00 47 20.929 -25 06 46.48
FoV: 1.29°
Data Type
Switch to Data Subtype
CATALOG
IMAGE
SPECTRUM
Spectral Range
UV
opt
NIR
Filter/Band
B
R
V
g_SDSS
z_SDSS
Show 4 more out of 9
Undefined for 3 datasets
Spectral Resolution
Search results (74)
Sky selection
Actions
Data Type
Spec.Range
Filt.
Spec.Res.
Sensit
Obs.Date
FoV
Collection
Instrum.
T.Exp.T.
P.I.
ESO

esa


Aladin Lite API example
AAS225 demonstration
SDSS DR9 band r image of APG 240 pair of galaxies, with an overlaid HST image and a WFPC2 footprint.
Javascript
Result

- Natural extension of HiPS — unique representation of a region on the sky

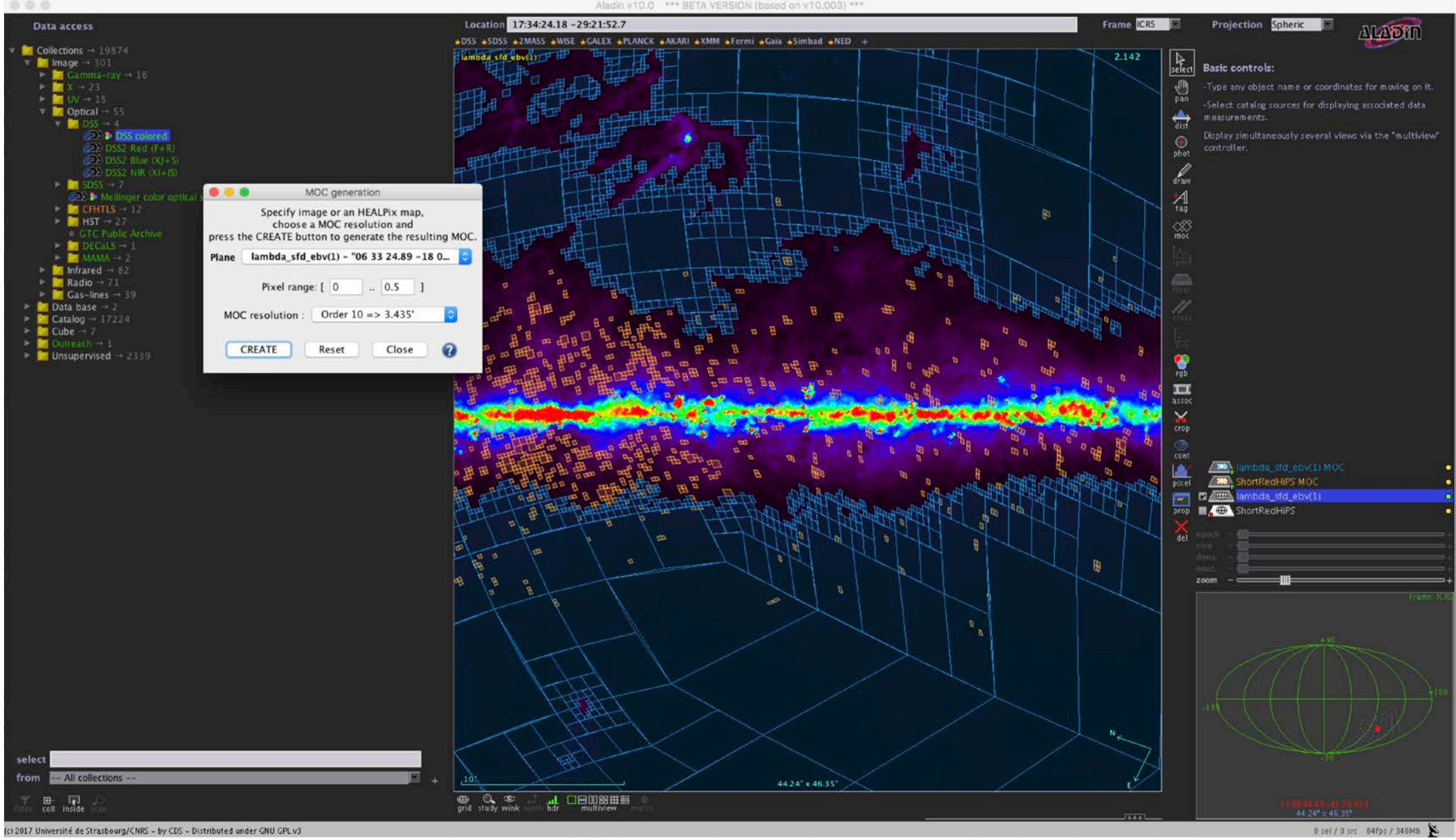
GALEX



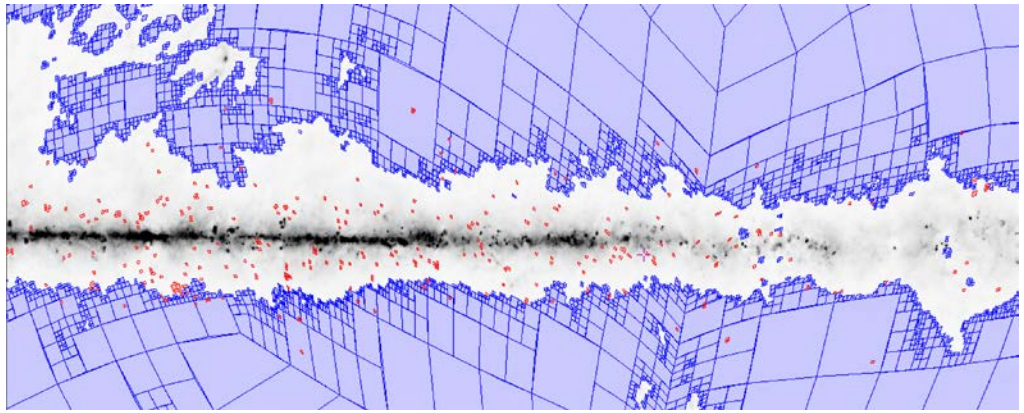
SDSS

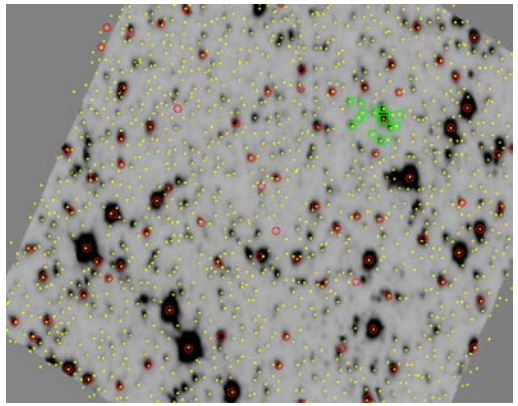
- Very easy logical operations (intersections, unions,…)

- Query a database or service by MOC (“*catalogue XXX in MOC YYY*”)


Aladin v10.0 *** BETA VERSION (based on v10.003) ***
Data access
Location 17:34:24.18 -29:21:52.7
Frame ICRS
Projection Spheric
ALADIN
Collections → 19874
Image → 301
Gamma-ray → 16
X → 23
UV → 15
Optical → 55
DSS → 4
DSS colored
DSS2 Red (F+R)
DSS2 Blue (XJ+S)
DSS2 NIR (XI+IS)
SDSS → 7
Mellinger color optical
CFHTLS → 12
HST → 27
GTC Public Archive
DECaLS → 1
MAMA → 2
Infrared → 82
Radio → 71
Gas-lines → 39
Data base → 2
Catalog → 17224
Cube → 7
Outreach → 1
Unsupervised → 2339
MOC generation
Specify image or an HEALPix map,
choose a MOC resolution and
press the CREATE button to generate the resulting MOC.
Plane lambda_sfd_ebv(1) - "06 33 24.89 -18 0...
Pixel range: [0 .. 0.5]
MOC resolution : Order 10 => 3.435'
CREATE
Reset
Close
Basic controls:
-Type any object name or coordinates for moving on it.
-Select catalog sources for displaying associated data measurements.
Display simultaneously several views via the "multiview" controller.
lambda_sfd_ebv(1) MOC
ShortRedHiPS MOC
lambda_sfd_ebv(1)
ShortRedHiPS
select
from -- All collections --
(c) 2017 Université de Strasbourg/CNRS - by CDS - Distributed under GNU GPL v3

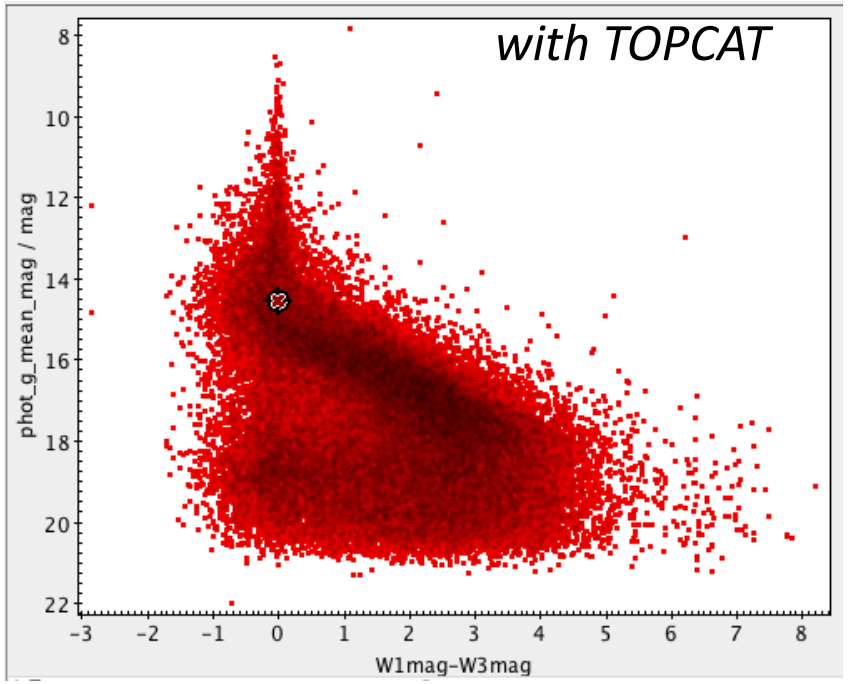
- *"I have a set of observations (survey MASH, Parker et al). I want to find the regions with low extinction, and find the sources detected by both Gaia DR2 and WISE, and extract various quantities, e.g. a colour-colour diagram"*





X-match Gaia-WISE

Visualisation with TOPCAT



Tutoral available on the ASTERICS and Euro-VO pages:
http://www.euro-vo.org/?q=science/scientific-tutorials

Summary

- HiPS and MOC – hierarchical approach to big/complex data on the sky
- ASTERICS DADI fostered the development and standardization
- Implemented in a distributed network of HiPS nodes
- MOC/HiPS/Catalogues – new levels of interoperability

- Tools for generation of HiPS/MOC - in Aladin, and Astropy
- Implementable widgets for web pages / portals / note books etc.
- Scalable to the biggest data sets…