

# HiPS catalogue implementation at CDS

IVOA Interoperability Meeting

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## HiPS – Hierarchical Progressive Survey

### Version 1.0

### *IVOA Proposed Recommendation* *6<sup>rd</sup> April 2017*

**This version:**

1.0: Proposed Recommendation 2017-04-06

**Previous version(s):**

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>

# □ What is a HiPS?

- <http://www.ivoa.net/documents/HiPS/>
- Fernique et al, 2015. Ref. [2015A&A...578A.114F](#)
- *"HiPS [is] 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 panning. HiPS uses the **HEALPix** tessellation of the sky as the basis for the scheme and is implemented as a simple file structure [...]."*
- Purpose: **navigate through all-sky data** (image surveys, catalogues, ...) **à la Google Maps**
  - Explore the sky by zooming and panning, **no explicit query**
  - **The more you zoom, the more finer details you get**

# □ Make and explore your own HiPS

- CDS offers **2 tools** allowing users to build their own HiPS  
See <http://aladin.u-strasbg.fr/hips/>
  - **Hipsgen** for images:  
<http://aladin.u-strasbg.fr/hips/HipsIn10Steps.gml>
  - **Hipsgen-cat** for catalogues:  
<http://aladin.u-strasbg.fr/hips/HipsCat.gml>
- and 2 HiPS visualizers: **Aladin** and **Aladin Lite**
- (other visualizers: **Mizar** and **prototype extension of the MAST portal**)

# Example of directory structure in output of the Hipsgen-cat tool (public)

```
> ls -l MyHiPS

metadata.xml      # Std: metadata in VOTable format
Moc.fits         # Std: MOC of the table at order max
Moc.json         # Not Std: MOC in JSON format
Norder1         # Std: dir containing order 1 tiles
Norder2         # Std: dir containing order 2 tiles
Norder3         # Std: dir containing order 3 tiles
Norder4         # Std: dir containing order 4 tiles
Norder5         # Std: dir containing order 5 tiles
properties       # Std: HiPS meta information
index.html      # Std: webpage embedding AladinLite
arguments        # Not Std: HiPSgen-cat input args
densmap_o0.fits # Not Std: order 0 HEALPix density map
densmap_o1.fits # Not Std: order 1 HEALPix density map
densmap_o2.fits # Not Std: order 2 HEALPix density map
densmap_o3.fits # Not Std: order 3 HEALPix density map
densmap_o4.fits # Not Std: order 4 HEALPix density map
densmap_o5.fits # Not Std: order 5 HEALPix density map
```



# □ Example of a HiPS catalogue tile

```
> more MyHiPS/Norder1/Dir0/Npix4.tsv
```

```
# Completeness = 1969 / 2031
```

_RAJ2000	_DEJ2000	HIP	RAhms	DEdms	Vr
138.723590	4.442900	45383	091453.72		+0
133.781760	1.546508	43790	085507.60		+0
135.582844	8.468490	44376	090219.52		+0
135.209707	5.241545	44263	090050.47		+0
142.114170	9.056778	46454	092827.38		+0
142.645828	10.599953	46634	093035.11		+1
137.443434	11.564377	44984	090946.45		+1
145.287637	9.892308	47508	094109.12		+0
130.685548	9.556699	42748	084244.40		+0
130.717620	9.553099	42762	084252.10		+0
129.961632	11.522672	42499	083950.86		+1
128.963632	6.622776	42173	083551.34		+0
134.269528	11.646984	43948	085704.71		+1
135.322818	15.265768	44295	090117.55		+1

# Example of HiPS in Aladin V10

Aladin v9.6 \*\*\* PROTOTYPE VERSION (based on v9.621) \*\*\*

Fichier Edition Image Catalogue Graphique Couverture Outil Vue Interop Aide

Data access → 171 / 19697 Position 357.45336 -01.92762 Référentiel Gal Projection Aitoff

Collections → 171 / 19697  
Image → 8 / 301  
Infrared → 8 / 82  
2MASS → 8  
2MASS color J (1.23 micro)  
2MASS J (1.23 micro)  
2MASS H (1.66 micro)  
2MASS K (2.16 micro)  
2MASS6X → 4  
2MASS6X color  
2MASS6XJ (1.23 micro)  
2MASS6XH (1.66 micro)  
2MASS6XK (2.16 micro)  
Catalog → 124 / 17224  
II-Photometric Data → 3 / 3  
2MASS All-sky Catalog  
2MASS 6X Point Source  
2MASS Catalog Interm  
VII-Non-stellar Objects →  
The 2MASS Extended  
2MASS-selected Isola  
Journal table → 119 / 157  
A+A → 17 / 4151  
AKARI/HIP and AKAF  
AKARI/HIP and AKAF  
2MASS IR star clust  
OGLE+2MASS-DEN  
Extinctions at 7um  
New ultra-cool dw  
HI observations of:  
HI observations of:  
Extended red(dens)  
OGLE+2MASS-DEN  
Infrared study of IR  
Galactic globular cl  
Galactic globular cl  
Fornax Cluster Spe  
Fornax Cluster Spe  
The Magellanic Bric  
2MASS J16042165-2  
AJ → 39 / 2615  
2MASS galaxy group  
2MASS galaxy group  
2MASS galaxy group  
QSOs in 2MASS sec  
QSOs in 2MASS sec  
MSX and 2MASS crc  
MSX and 2MASS crc  
MSX and 2MASS crc  
2MASS6x survey of  
2MASS photometry  
2MASS-Selected sa  
2MASS-Selected sa  
2MASS-Selected sa  
2MASS-Selected sa  
2MASS-Selected sa  
2MASS-Selected sa  
2MASS counterpart  
Unbiased census of  
2MASS observation

select 2MASS  
from - All collections -

filter red dedart scan  
grille exam.cligne nord.hdr multivues unit

0 sel / 8984 src 48fps / 703Mo

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# Example of HiPS in Aladin V10

Aladin v9.6 \*\*\* PROTOTYPE VERSION (based on v9.621) \*\*\*

Fichier Edition Image Catalogue Graphique Couverture Outil Vue Interop Aide

Data access → 171 / 19697 Position [358.99898 +00.20991] Référentiel Gal Projection Aitoff

Contrôle par la souris:

- Gauche: sélection des sources.
- Milieu: déplacement du champ.
- Droite: ajustement du contraste.
- Molette: zoom sur le réticule.
- Simple-clic: déplace le réticule
- Double-clic: recentre la vue.

Pour découvrir les informations Simbad sur un objet, laissez dessus qq secondes le peinteur.

select: 2MASS  
from: All collections

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0 sel / 16250 src 67fps / 656Mo



# □ HiPS catalogue available at CDS

- 24 HiPS so far: <http://axel.u-strasbg.fr/HiPSCatService/hiplist>

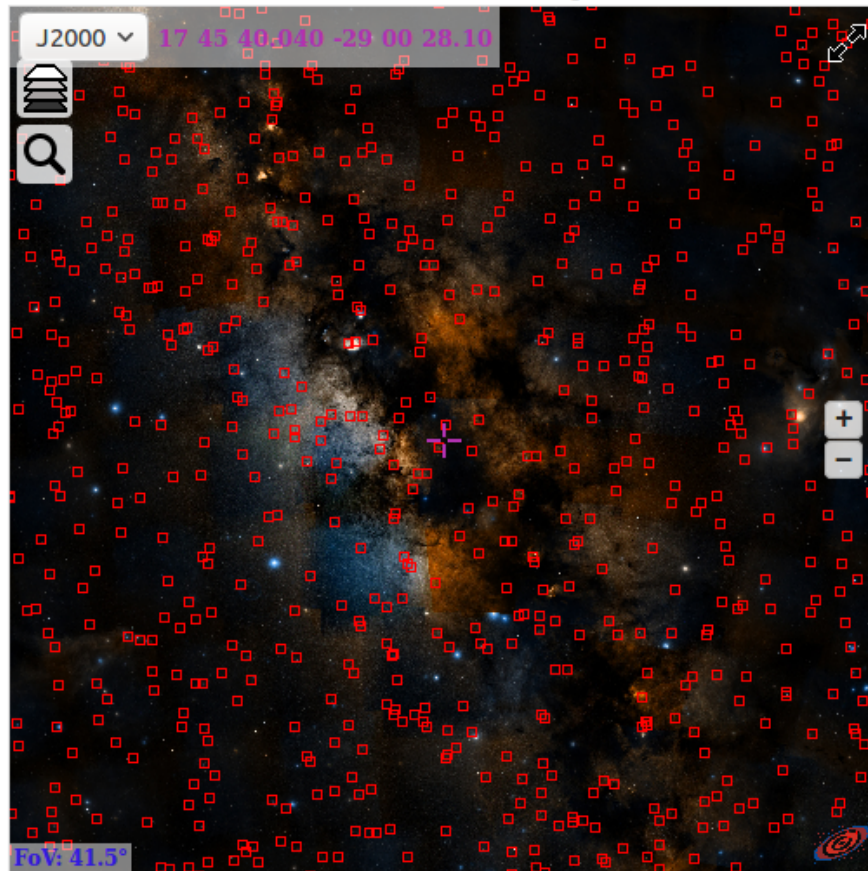
```
creator_did          = ivo://CDS/II/341/vphasp
dataprodct_type     = catalog
obs_collection      = VPHAS+
obs_description     = The VPHAS+ catalogue
hips_service_url    = http://axel.u-strasbg.fr/HiPSCatService/
hips_release_date   = 2016-10-16T21:04Z
hips_status         = public master unclonable
hips_tile_format    = tsv
hips_order          = 11
hips_frame          = equatorial
client_category     = Catalog
client_application  = AladinDesktop
client_sort_key     = 02-341-06
```

...

- Goal: put the 16000 VizieR tables in the HiPS format

## The I/339/hsoy progressive table

This Web resource contains HiPS(\*) components for the **I/339/hsoy** progressive table.



- **Label:** I/339/hsoy
- **Type:** HiPS table
- **Raw property file:** [properties](#)
- **Metadata:** [metadata.xml](#)
- **Associated coverage map:** [Moc.fits](#)
- **Base URL:** <http://axel.u-strasbg.fr/HiPSCatService/I/339/hsoy/>
- **Allsky level 1:** [allsky1.tsv](#)
- **Allsky level 2:** [allsky2.tsv](#)
- **Tiles URL format:** [http://axel.u-strasbg.fr/HiPSCatService/I/339/hsoy/Norder\[1-orderMax\]/Dir\[0-9\]\\*/Npix\[1-ipixMax\].tsv](http://axel.u-strasbg.fr/HiPSCatService/I/339/hsoy/Norder[1-orderMax]/Dir[0-9]*/Npix[1-ipixMax].tsv)

This progressive catalogue can be displayed by the [Aladin Desktop](#) client (just open the base URL) or any other HiPS aware clients.

(\*) The HiPS technology allows a dedicated client to access an astronomical table at any location and at any scale. HiPS is based on HEALPix sky tessellation and it is designed for astronomical scientific usages. HiPS technical documentation is available [here](#)

# Example of CDS HiPS in Aladin V10

The screenshot displays the Aladin V10 web interface. At the top, the title bar reads "Aladin v9.6 \*\*\* PROTOTYPE VERSION (based on v9.621) \*\*\*". Below it, a menu bar includes "Fichier", "Edition", "Image", "Catalogue", "Graphique", "Couverture", "Outil", "Vue", "Interop", and "Aide". The main interface features a dark background with a central view of a star field. On the left, a tree view shows the data hierarchy: "Data access → 171 / 19697", "Collections → 171 / 19697", "Image → 8 / 301", "Infrared → 8 / 82", "2MASS → 8", "2MASS color J (1.23 micr", "2MASS J (1.23 micr", "2MASS H (1.66 micr", "2MASS K (2.16 micr", "2MASS6X → 4", "2MASS6X color", "2MASS6XJ (1.23u", "2MASS6XJ (1.23u". A search bar at the top left contains "CDS/P/2MASS/color". A modal window is open in the center, titled "2MASS All-Sky Catalog of Point Sources (more...)", with "Provenance: CDS" and "Sky coverage: 89.52% Nb rows: 470 992 970 Pub.year: 2003". Below the title are search options:  HiPS,  Cone search,  MOC search,  Xmatch,  TAP, and  Coverage. At the bottom of the modal are "Load" and "Close" buttons. The bottom right of the interface shows a control panel for the current catalog, "CDS/P/2MASS/color", with sliders for "epog...", "taille", "dens.", "space", and "zoom". The status bar at the bottom indicates "0 sel / 0 src 21fps / 256Mo".



# CDS HiPS in Aldin V10 (animated gif)

Aladin v9.6 \*\*\* PROTOTYPE VERSION (based on v9.621) \*\*\*

Fichier Edition Image Catalogue Graphique Couverture Outil Vue Interop Aide

Data access Position Référentiel Gal Projection Aitoff

▼ Collections → 19589  
Image → 301  
  ▼ Gamma-ray → 16  
  X → 25  
  UV → 15  
  Optical → 55  
    DSS → 4  
    SDSS → 7  
      Mellinger color opt  
    CFHTLS → 12  
    HST → 27  
    GTC Public Archive  
    DECaLS → 1  
    MAMA → 2  
  Infrared → 82  
    2MASS → 8  
      2MASS color J (1.  
      2MASS J (1.23 micr  
      2MASS H (1.66 micr  
      2MASS K (2.16 micr  
    2MASS6X → 4  
    UltraVista → 6  
    WISE → 10  
    DIRBE → 20  
    IRIS → 5  
    Spitzer → 9  
    AKARI-FIS → 9  
    The ISOPHOT 170um  
    APEX → 2  
    HST → 6  
    VISTA → 1  
    HERSCHEL → 4  
    ISO → 1  
  Radio → 71  
  Gas-lines → 37  
  Data base → 2  
  Catalog → 17184  
    I-Astrometric Data → 254  
    II-Photometric Data → 30  
      2MASS All-Sky Catalo  
      AAVSO Photometric #  
      AllWISE Data Release  
      WISE All-Sky Data Rel  
      AKARI/IRC mid-IR all-sl  
      GALEX-DR5 (GR5) sou  
      GALEX-DR5 (GR5) sou  
      IRAS catalogue of Poi  
      2MASS 6XPoint Sourc  
      IRAS PSC/FSC Combin  
      IRAS Faint Source Cat  
      AKARI/FIS All-Sky Surv

select  
from -- All collections --

grille exam.cligne nord. trac multivues unit

350 74077 +00 39005  
1.755' x 1.778'

CDS/P/2MASS/color

CDS/II/246/out

eproc...  
taille - dens. - opac. - zoom

Frame: 0/1

350 74077 +00 39005  
1.755' x 1.778'

Contrôle de la pile:  
● le logo: montre/cache le plan  
● taille: change la taille des objets  
● zoom: modifie l'agrandissement  
● opacité: ajuste la transparence.  
La vue est dessinée en fonction de la projection d'un plan de référence.  
Pour changer de plan de référence, cliquer sur sa coche.

select  
depl  
dist  
phot  
dessin  
marq  
moc  
spect  
filtre  
corr  
x-y  
rvb  
assoc  
coupe  
cont  
pixel  
prop  
suppr

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0 sel / 14091 src 148fps / 1106Mo

# □ HiPS: not necessarily physical files

- On page 8, [the standard](#) says:  
*"[T]he actual implementation of HiPS as directories and files is not an obligation, only the view as directories and files is required (see HiPS distribution section). Internally, a HiPS **may** be stored in a database, or any other appropriate packaging (tar or zip files...) rather than in a basic file system directory structure."*
- **Hipsgen-cat** = 2 tools in one
  - 1 public: FITS, VOTable, CSV, ... → Standard HiPS
  - 1 private: CDS Xmatch Binary file → HiPS binary files
    - **HTTP API** mimicking the file hierarchy
    - Access through **Tomcat Servlet + rewriting rules**
  - large parts of the code in common

# □ Structure of HiPS catalogues at CDS

```
> ls -l MyHiPS
```

```
header.bin  # Not Std: metadata in a proprietary format
Moc.fits    # Std: MOC of the table at order max
Moc.json    # Not Std: MOC in JSON format
l1.prg      # Not Std: binary file of order 1 tiles
l2.prg      # Not Std: binary file of order 2 tiles
l3.prg      # Not Std: binary file of order 3 tiles
l4.prg      # Not Std: binary file of order 4 tiles
l5.prg      # Not Std: binary file of order 5 tiles
l6.prg      # Not Std: binary file of order 6 tiles
arguments   # Not Std: HiPSgen-cat input args
```

- **.prg** file: index + concatenated tiles
  - index: tile number → (starting row, No. rows) + Tot. No. rows in the HEALPix cell
  - tiles: concatenated in a format similar to FITS BINTABLE



# □ Advantages of CDS HiPS catalogues

Pros	Cons
<b>Light for the file-system</b>	More complex access (need a specific tool)
<b>Fast copy</b> on another machine	Harder to debug
Output columns can be chosen on-the-fly (not in the std)	Less rich metadata (to be solved)
<b>Very fast generation:</b> few hours for largest tables	Same date for all tiles

- In practice, the Apache Tomcat Servlet is very robust
- Large parts of the code in common with CDS Xmatch / Vizier large catalogues

# □ CDS Algorithm: beyond basic ones

- Threshold on the source brightness
  - not fixed, depends on each tile
- Number of sources per tile:
  - not fixed,  $\in [50, 500]$  by default (from depth  $> 3$ )
  - depends on:
    - the number of sources in the HEALPix cell
    - the catalogue coverage in the HEALPix cell
  - specific treatment at level 1, 2, 3 to better mimic the density of sources
- $\Rightarrow$  The depth of the HiPS is variable
  - area of higher density  $\rightsquigarrow$  deeper hierarchy ( $\sim$  QuadTree)

# □ Last words

- Reminder:
  - main purpose: easy exploration of large dataset (no queries)
  - the users must understand how it works (which sources first?, when are all sources loaded?)
- Recent improvements from user feedbacks (JAXA, USA):
  - now **compatible with V1.0 of the standard.**
  - web page added (**index.html**) (but need to be access through an HTTP server for security reasons)
  - default positional column metadata for AladinLite
  - few bugs corrected
- Future plan:
  - public version of **Hipsgen-cat**: improve performances





Thank you!