

HiPS catalogue implementation at CDS

IVOA Interoperability Meeting

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International

Virtual

Observatory

Alliance

HiPS – Hierarchical Progressive Survey

Version 1.0

IVOA Proposed Recommendation *6rd 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/>
- *"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/
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

select displ dist phot dessin marq moc speed filtre corr xxy rrb assoc coupe cont pixel prop supp

CDS/II/246/out

CDS/II/246/out
CDS/P/2MASS/color

eprog... taille dens. opac. zoom

Frame: G2
RA: 357.45336 -01.92762
11.08° x 11.77°

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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

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/
2MASS All-Sky Catalog
2MASS 6XPoint Sourc
2MASS Catalog Intern
VII-Non-stellar Objects -
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AKARI/HIP and AKAF
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Extinctions at 7um
New ultra-cool dw
HI observations of :
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Extended red(dens
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Infrared study of IR
Galactic globular cl
Galactic globular cl
Fornax Cluster Spe
Fornax Cluster Spe
The Magellanic Bric
2MASS J16042165-2
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2MASS galaxy group
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2MASS galaxy group
QSOs in 2MASS sec
QSOs in 2MASS sec
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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 dedant scan grille exam.clique nord. hd multivues unit

358.99898 00.20991
2.8" x 2.975"

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.

CDS/II/246/out

CDS/II/246/out=1
CDS/II/246/out
CDS/P/2MASS/color

taille dens. opac. zoom

Frame: G2
358.99898 -00.20991
2.8" x 2.975"

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□ HiPS catalogue available at CDS

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

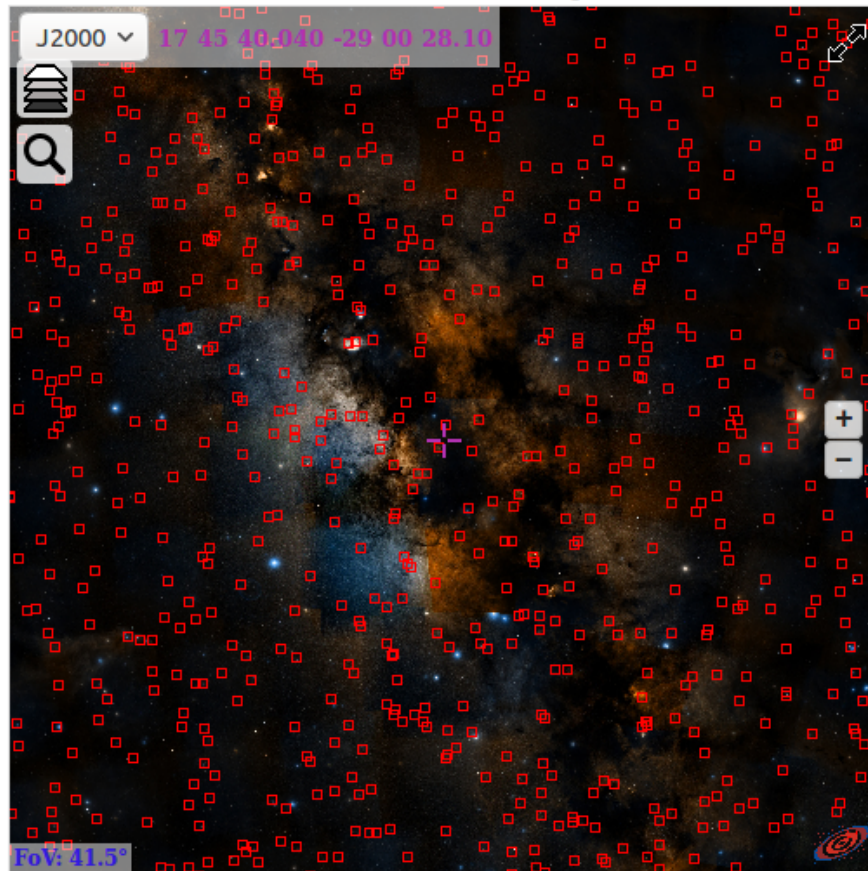
```
creator_did          = ivo://CDS/II/341/vphasp
dataprodect_type     = catalog
obs_collection       = VPHAS+
obs_description      = The VPHAS+ catalogue
hips_service_url     = http://axel.u-strasbg.fr/HiPSCatService/
hips_release_date    = 2016-10-16T21:04Z
hips_status          = public master unclonable
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 (1.23 micr)", "2MASS6XJ (1.23 micr)", "2MASS6XJ (1.23 micr)", "Cat", "II", "V", "J", "2MASS IR star cluste", "OGLE+2MASS+DEN", "Extinctions at 7um", "New ultra-cool dw", "HI observations of 2", "HI observations of 2", "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 grou", "2MASS galaxy grou", "2MASS galaxy grou", "QSOs in 2MASS sec", "QSOs in 2MASS sec", "MSX and 2MASS cro", "MSX and 2MASS cro", "MSX and 2MASS cro", "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".

A modal window is open in the center, titled "2MASS All-Sky Catalog of Point Sources (more...)". It indicates the provenance as "CDS" and provides statistics: "Sky coverage: 89.529%", "Nb rows: 470 992 970", and "Pub.year: 2003". Below this, there are search options: HiPS, Cone search, MOC search, Xmatch, TAP, and Coverage. At the bottom of the modal are "Load" and "Close" buttons.

At the bottom of the main interface, there is a search bar with "select 2MASS" and "from -- All collections --". The status bar at the very bottom shows "© 2017 Université de Strasbourg/CNRS - by CDS - Distributed under GNU GPL v3" on the left and "0 sel / 0 src 21fps / 256Mo" on the right.

□ 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

Position: [input field] Référentiel: Gal Projection: Aitoff

Data access

- 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 (1.25 micr)
 - 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 Catalog
 - 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

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 [input field]
from -- All collections --

taille - dens. - opac. - zoom

350 74077 +00 39005
1.755' x 1.778'

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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
Light for the file-system	More complex access (need a specific tool)
Fast copy on another machine	Harder to debug
Output columns can be chosen on-the-fly (not in the std)	Less rich metadata (to be solved)
Very fast generation: 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!