

Description, Discovery, Access of Multi-Dimensional Data in the Virtual Observatory ASTERICS contributions



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acknowledges extensive collaborative work with DAL WG, DM WG,
ASTERICS DADI collaborators, Strasbourg CDS and SVOM teams



Summary

- Data multi-D Discovery
 - ObsCore 1.1
 - SIAP 2.0
- Link Resource
 - DataLink 1.0
 - DataLink 1.1
- Cutouts
 - SODA 1.0
 - hints of virtual data generation
- HiPS
 - discovery, description and access
- Interface within Aladin, TOPCAT
 - SIAP ? DataLink, SODA interface
 - TAP interface
- Virtual data generation
 - New SODA parameters → SODA next
 - Direct access in SIAP2 or via DataLink (SIAP2 next)
 - Implemented thanks to HipS at CDS (HiPStoFITS)



Multi-dimensional data

IVOA science priority since 2013

- Radio datacubes (ALMA, LOFAR, ASKAP, -->SKA)
- Xray cubes
- Time dimensions (work in progress)
- Polarisation (tackled)
- Visibility data (?)



Data discovery : ObsTAP

- data discovery by selecting criteria on description attributes (metadata)
- ObsCore 1.1 (addition to ObsCore 1.0):
 - size in pixels
 - Polarisation
- Served by TAP → ObsTAP
- ObsTAP : allows to select datasets on criteria such as `dataprodct_type= cube` and characterisation of axes
- **REC May 2017**



Data Discovery : SIAP 2.0

- SIAP 2 : allows queries for images and cubes with PARAMETERS such as DPTYPE = cube
- POS = « some shape » BAND = 0.0005 0.0006
TIME = 52618 53700 etc.
- REC December 2015



SIAV2/ObsTAP response (ObsCore)

Aladin v9.0 *** BETA VERSION (based on v9.039) ***

File Edit Image Catalog Overlay Coverage Tool View Interop Help

Location 344.57835 -55.91674

DSS SDSS 2MASS WISE GALEX PLANCK AKARI XMM Fermi Gaia Simbad NED +

DSS colored

Server selector

Others **HIPS** File all VO Watch FoV... CASDA Tools...

Image servers

- Aladin images
- SkyView
- UKIDSS
- Sloan
- DSS...
- VLA...
- Archives...
- Others...

Catalog servers

- All VizieR
- Surveys
- Missions
- Simbad
- NED
- MOC
- TAP
- SkyBot
- Gaia
- Others..

CASDA SIAV2 implementation

POS: CIRCLE 340.4567 -64.4194 2

BAND: 0.25 0.30

TIME:

POL:

FOV:

SPATRES:

EXPTIME:

ID:

COLLECTION:

Reset Clear **SUBMIT** Close ?

9.707' x 4.352'

grid wink north hdr multiview match

obs publ...	access url	target n...	s ra	s dec	s fov	s region	t min	Observat...	t max	Observat...	t exptime	t resolu...	em min	Spectral...	em max	Spectral...	em res p...	o ucd	pol sta
cube-24	https://		344.6289...	-55.9409...	153.5149...	FoV	0.0	1858-11-...	0.0	1858-11-...	0.0	0.319074...	939,5931...	0.347154...	863,5912...	11.86275...	phot.flu...	/I/	
cube-25	https://		344.6230...	-55.9411...	158.5882...	FoV	0.0	1858-11-...	0.0	1858-11-...	0.0	0.347157...	863,5854...	0.380658...	787,5834...	10.86267...	phot.flu...	/I/	
cube-26	https://		344.6258...	-55.9394...	164.6950...	FoV	0.0	1858-11-...	0.0	1858-11-...	0.0	0.380660...	787,5776...	0.421318...	711,5757...	9.862602...	phot.flu...	/I/	

Towards Access : SIAP 2.0 and ProvTAP - HiPS

- Full Data Retrieval via `access_reference` field
- Or access to DataLink ... and SODA (cutouts)
- Discovery , Representation and View via HiPS for cubes (see later)



DataLink

- `{links}` RESOURCE :
Link a list of RESOURCES (metadata, other formats, associated data, services...) to a DataSet via a small votable giving url, media type, semantics, etc..
- DataLink service descriptor
A resource to describe a service (included in main DAL service or `{links}` resource response)
- REC June 2015
- DataLink 1.1 proposal (January 2019)= extending scope, better recognition, extended vocabulary etc



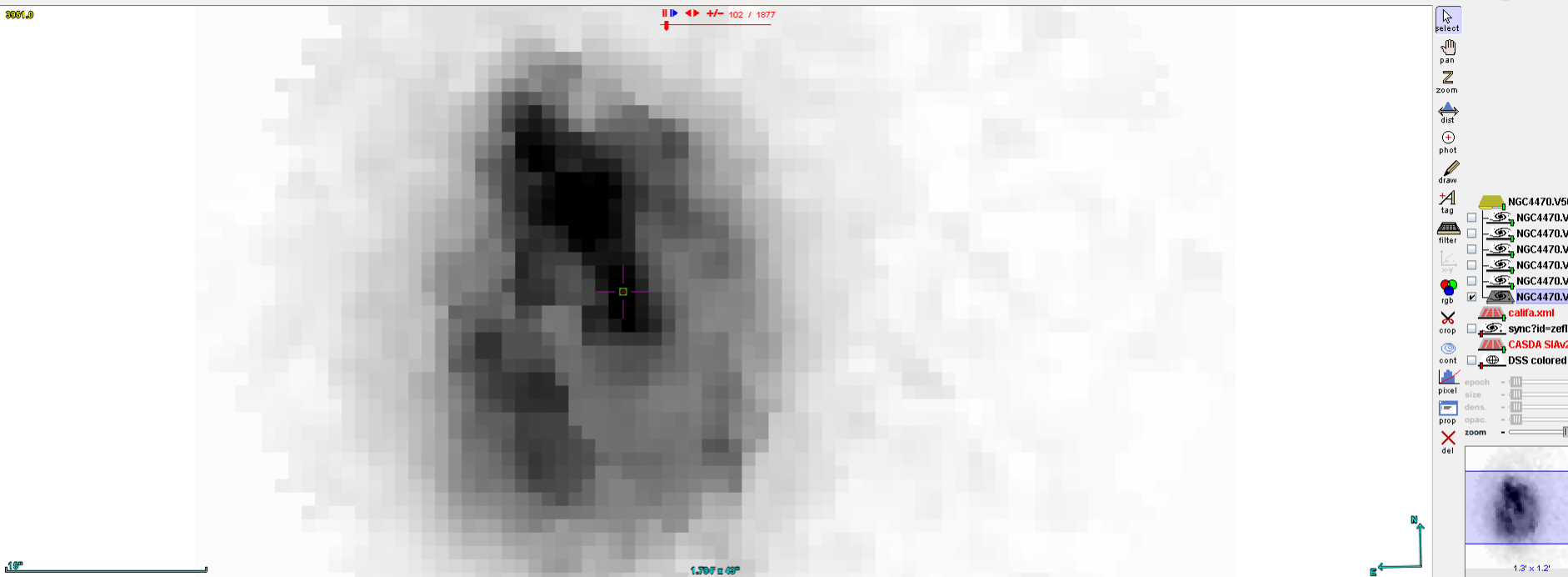
{links} response display

Aladin v9.0 *** BETA VERSION (based on v9.039) ***

File Edit Image Catalog Overlay Coverage Tool View Interop Help

Location 12:29:37.78 +07:49:27.1

DSS SDSS 2MASS WISE GALEX PLANCK AKARI XMM Fermi Gaia Simbad NED +



3001.0

102 / 1877

1.3" x 1.2"

obscore - target_name - Object a targeted observation targeted

dataproduct	obs title	obs publ...	obs crea...	access url	target n...	target c...	s ra	s dec	s fov	s region	t min	Observat...	t max	Observat...	t exptime
	CALIFA V...	1v01//02...		http://...											5400.0
	CALIFA V...	1v01//02...		http://...											2700.0

TIP: Double clic on the catalog name in the stack for selecting all its sources

2 sel / 422 src 165Mb

FR 15:30 31/10/2016

Data access

- data access : extracting useful data from the datasets
 - full retrieval cumbersome
 - Cutouts : SODA 1.0 **REC May 2017**
 - eventually regridding, reprocessing ? SODA -next.
 - need for detailed data (metadata) representation further than ObsCore....



CADC example : « cutout » SODA service (in Aladin)

The screenshot displays the Aladin web interface. At the top, the location is set to `05:32:35.25 -11:09:55.8`. The main view shows a star field with a zoomed-in cutout of a star. A 'Server selector' dialog box is open, showing the following fields:

- Target (ICRS, name): `05 32 57.25 -11 57 20.5`
- Radius: `2.904°`
- Time: (empty)
- Band: `8.424999999999999E-5 1.1576E-4`
- Pol: `I`
- Pol: `Q`
- Pol: `U`
- ID: `adIRIS/1170B4H0`

The dialog also includes 'Reset', 'Clear', 'SUBMIT', and 'Close' buttons. The main window shows a star field with a zoomed-in cutout of a star. The 'Server selector' dialog box is open, showing the following fields:

Location: `05:32:35.25 -11:09:55.8`

Frame: `ICRS` Projection: `Sinus`

Data access: `DSS` `SDSS` `2MASS` `WISE` `GALEX` `PLANCK` `AKARI` `XMM` `Fermi` `Gala` `Sirius` `NED`

CDS/P/DSS2/color

Basic controls:

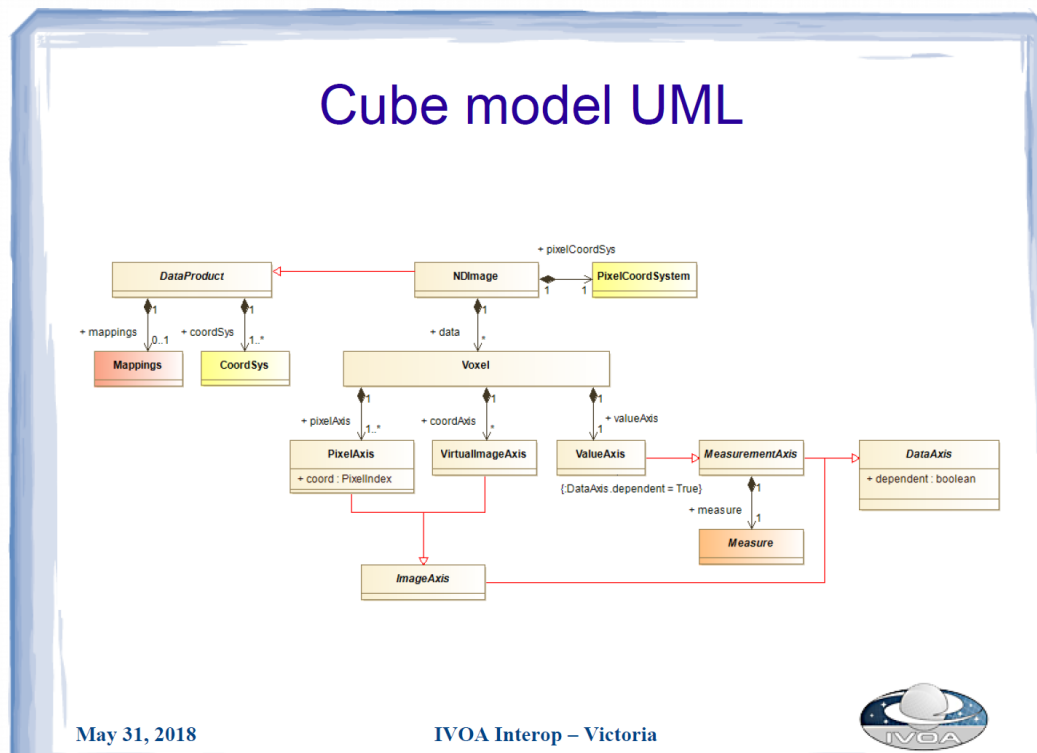
- select: Type any object name or coordinates for moving on it.
- edit: Select catalog sources for displaying associated data measurements.
- draw: SODA sync, CADC SIAV2, 1170B4H0?runid=u2wmyfstck, CDS/P/DSS2/color
- zoom: 28.03° x 16.05°

Search: [input field]



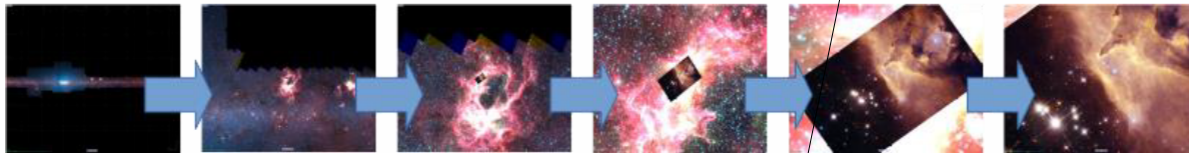
Data representation

- Cube data model → serialisation : still in discussion
- in the meantime FITS or native format



□ HiPS ? What is it ?

- **H**ierachical **P**rogressive **S**urvey
“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 dedicated servers are required, just http



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View, Access, Discovery of DataCube



Interface : Aladin

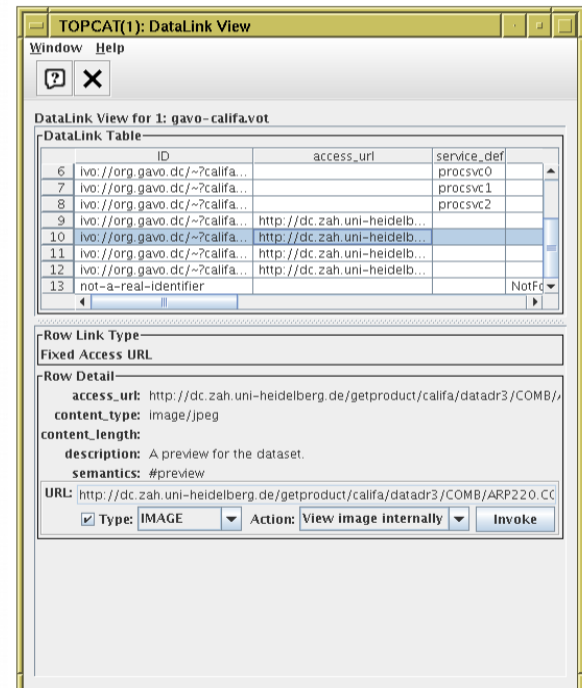
- ASTERICS developments : discovery tree, SIA interface, DataLink interface and SODA interface (see above)
- ASTERICS development :
 - TAP interface
 - ADQL control and assistance
 - Synchronous, asynchronous
 - JOIN
 - UPLOAD

The screenshot displays the Aladin web interface. A 'Server selector' window is open, showing a query execution interface. The query is: `Select TOP 9999 main_id, ra, dec, pmra, pmdec, SQRT(POWER(pmra,2)+POWER(pmdec,2)) as pm from basic WHERE SQRT(POWER(pmra,2)+POWER(pmdec,2)) > 20`. Below the query, a table of results is shown with columns: main_id, ra, dec, pmra, pmdec, pm.

main_id	ra	dec	pmra	pmdec	pm
UCAC2 33429...	269.990821	4.598942	-1.47	-1.41	20.369094
TYC 994-1499...	266.809109	8.844841	-1.799	-39.197	39.238262
TYC 994-240.1	266.814408	8.847392	-5.633	-43.158	43.524058
2MASS J1812558	273.231008	11.602548	-29.3	24.1	34.941379
2MASS J1846107	281.544764	10.551941	-1.64	-27.4	31.933055
2MASS J1846209	281.587148	10.503709	-1.94	-33.1	38.366261
2MASS J1846460	281.681769	11.098897	-21.2	-16.8	27.049584
UGCS J174207.6	265.531882	5.172271	9.85	-38.68	39.91447
UGCS J174348.2	265.951045	5.703928	-18.43	-8.57	21.23605
UGCS J174349.1	265.954572	4.976473	-2.0	-22.0	22.090722
UGCS J174355.1	285.979948	4.743094	-12.24	-26.21	28.927175
UGCS J174433.3	286.13878	6.001072	-20.22	-51.9	55.699716
UGCS J174519.0	266.329346	5.335037	-11.53	-26.56	28.954697

Interface : TOPCAT

- TOPCAT is an interface to ObsTAP
 - Discovery, SAMP to other Tools
- TOPCAT takes into account DataLink
 - Feedback
 - Improvement proposals



Virtual data: why give access to standalone FITS and JPEG images in the age of HiPS ?

Rationale of virtual standalone images distribution :

- Mosaics
- Comparison with external standard image servers (with same WCS)
- CDS : Follow-ups of previous functionalities for non HiPS clients
 - JPEG thumbnails for CDS portal (replacing Aladin preview..)
 - Local usage for XMM ACDS cross identification pipe-line (originally done with legacy Aladin image server)
- Etc...



How to give access to standard FITS and JPEG images in the age of HiPS ?

- HiPS-based solution : create images on the fly by reprojecting HiPS pixels on a 2D grid of pixels
→ HiPStoFITS !!

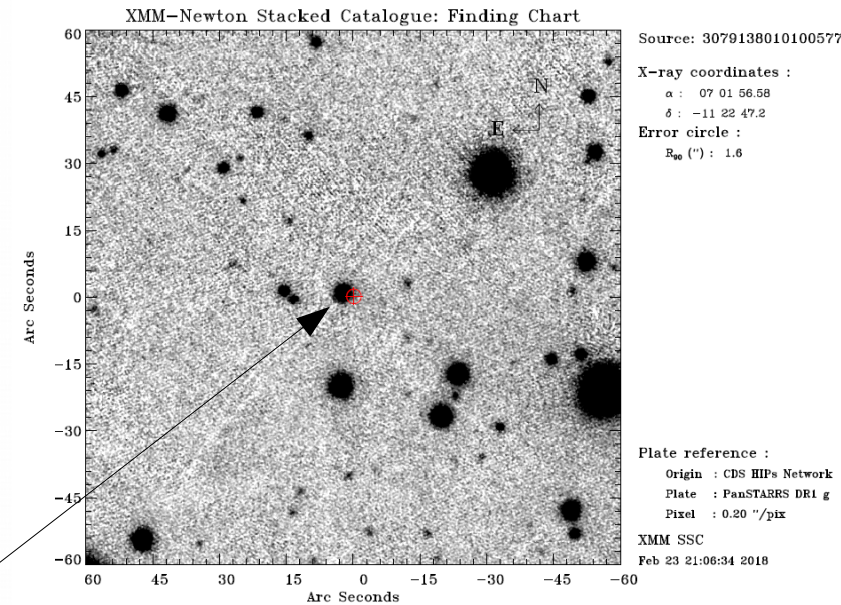
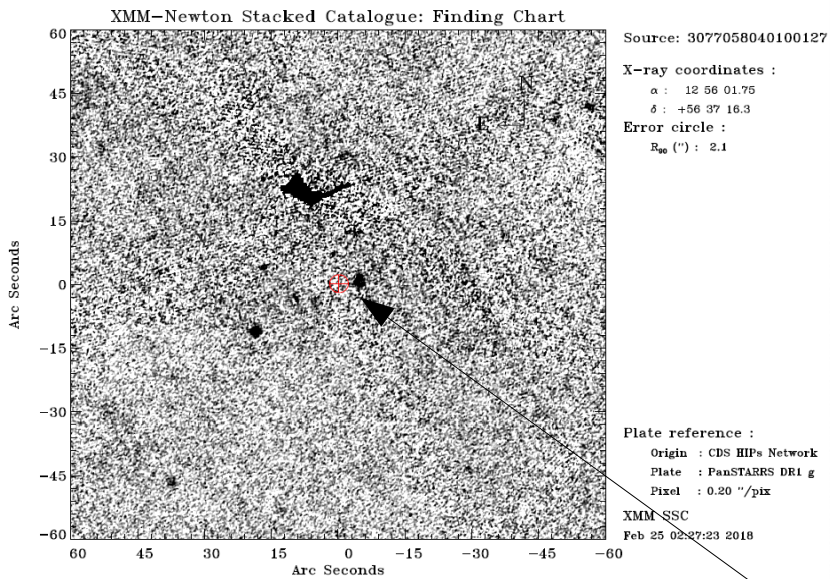


HiPStoFITS for XMM ACDS (Chaitra+Laurent Michel + Pierre

- Based on an extension of Aladin java code
 - Web Server = servlet technolog.
 - Generates FITS images from HiPS for a preselected list of HiPS
 - All WCS projections available
 - flexibility in the interface parameters (Polygon, Circle, resolution...)
 - Works for any spatial extent by adapting resolution
 - Force output via input WCS
 - HiPStoFITS becomes a testbed fo IVOA protocol prototype for virtual data generation (« SODA »)
- Operational in SSC XMM since 2018 January



HiPStoFITS for XMM ACDS (Laurent Michel)



XMM source

Pan-Starrs finding charts for Stacked XMM Catalogue (3XMMdr7s catalogue, Iris Traulsen et al. A&A submitted)



Proposal for SODA-next interface parameters, access modes

- Proposal based on HiPStoFITS experience
 - Non spatial parameters as in SODA1.0 (selection on the axis)
 - ID = may be an image identifier or a HiPS identifier/url
 - POS = as in SODA1.0 .
 - SPATRES = spatial resolution (or HiPS order as non standard parameter)
 - PROJECTION = sky projection
 - PA = position angle of the North direction
- OR alternatively to above
 - WCS = wcs fits header keywords list
- Can be accessed in several ways :
 - direct URL in SIAP2.0 consistent with SIAP2.0 Parameters (POS, SPATRES, etc ...)
 - Or via DataLink and a dedicated interface



Mode 1 : SIAP2 HiPStoFITS Pan-STARRS retrieved image

Aladin v10.0 *** BETA VERSION (based on v10.098) ***

File Edit Image Catalog Overlay Coverage Tool View Interop Help

Command: 20:34:52.80000 +60:09:00.0000

Frame: ICRS Projection: Aitoff

Available data → 22055 / 22059

Server selector

Image servers: Aladin Images, SkyView, Sloan, DSS..., VLA..., Se..., Others...

Catalog servers: All VizieR, SIMBAD, TAP, Gaia, SkyBot, VO, Others...

HIPS CDS SIAv2 virtual data prototype

Fill in all these fields and press the SUBMIT button

POS: 308.72 60.15 0.1

BAND: []

TIME: []

FORMAT: application/fits

RESPONSEFORMAT: VOTable

Buttons: Reset, Clear, SUBMIT, Close

Selected image

access url	dataproduc...	calib level	obs collecti...	obs id	obs publisher ...	access format	access estsize	target name	s ra	s d
http://localhost	image	1	PLANCK R2 HF1...	CDS/P/PLANCK/R2...	ivo://CDS/P/PLANCK	image/fits	-32768	308.72000000...	60.1499	
http://localhost	image	1	PLANCK R2 HF1...	CDS/P/PLANCK/R2...	ivo://CDS/P/PLANCK	image/fits	-32768	308.72000000...	60.1499	
http://localhost	image	1	PLANCK R2 HF1...	CDS/P/PLANCK/R2...	ivo://CDS/P/PLANCK	image/fits	-32768	308.72000000...	60.1499	
http://localhost	image	1	PLANCK R2 HF1...	CDS/P/PLANCK/R2...	ivo://CDS/P/PLANCK	image/fits	-32768	308.72000000...	60.1499	
http://localhost	image	1	PLANCK R2 LF1...	CDS/P/PLANCK/R2...	ivo://CDS/P/PLANCK	image/fits	-32768	308.72000000...	60.1499	
http://localhost	image	1	PLANCK R2 LF1...	CDS/P/PLANCK/R2...	ivo://CDS/P/PLANCK	image/fits	-32768	308.72000000...	60.1499	
http://localhost	image	1	PLANCK R2 LF1...	CDS/P/PLANCK/R2...	ivo://CDS/P/PLANCK	image/fits	-32768	308.72000000...	60.1499	
http://localhost	image	1	PanSTARRS DR...	CDS/P/PanSTARR...	ivo://CDS/P/PanS	image/fits	-32768	308.72000000...	60.1499	
http://localhost	image	1	Planck HF1 100	ESA/VO/P/PLANCK...	ivo://ESA/VO/P/PL	image/fits	-32768	308.72000000...	60.1499	
http://localhost	image	1	Planck HF1 143	ESA/VO/P/PLANCK...	ivo://ESA/VO/P/PL	image/fits	-32768	308.72000000...	60.1499	
http://localhost	image	1	Planck HF1 143	ESA/VO/P/PLANCK...	ivo://ESA/VO/P/PL	image/fits	-32768	308.72000000...	60.1499	
http://localhost	image	1	Planck HF1 217	ESA/VO/P/PLANCK...	ivo://ESA/VO/P/PL	image/fits	-32768	308.72000000...	60.1499	
http://localhost	image	1	Planck HF1 545	ESA/VO/P/PLANCK...	ivo://ESA/VO/P/PL	image/fits	-32768	308.72000000...	60.1499	
http://localhost	image	1	Planck HF1 657	ESA/VO/P/PLANCK...	ivo://ESA/VO/P/PL	image/fits	-32768	308.72000000...	60.1499	

Search

epoch - size - dens. - opac. - zoom -

20:34:52.66749 +60:09:00.00000

16.04' x 8.658'

Same interface, Pan-STARRS, driven by WCS header

Survey **Pan STARRS g** ▼

Cutout constraints:

Direct input

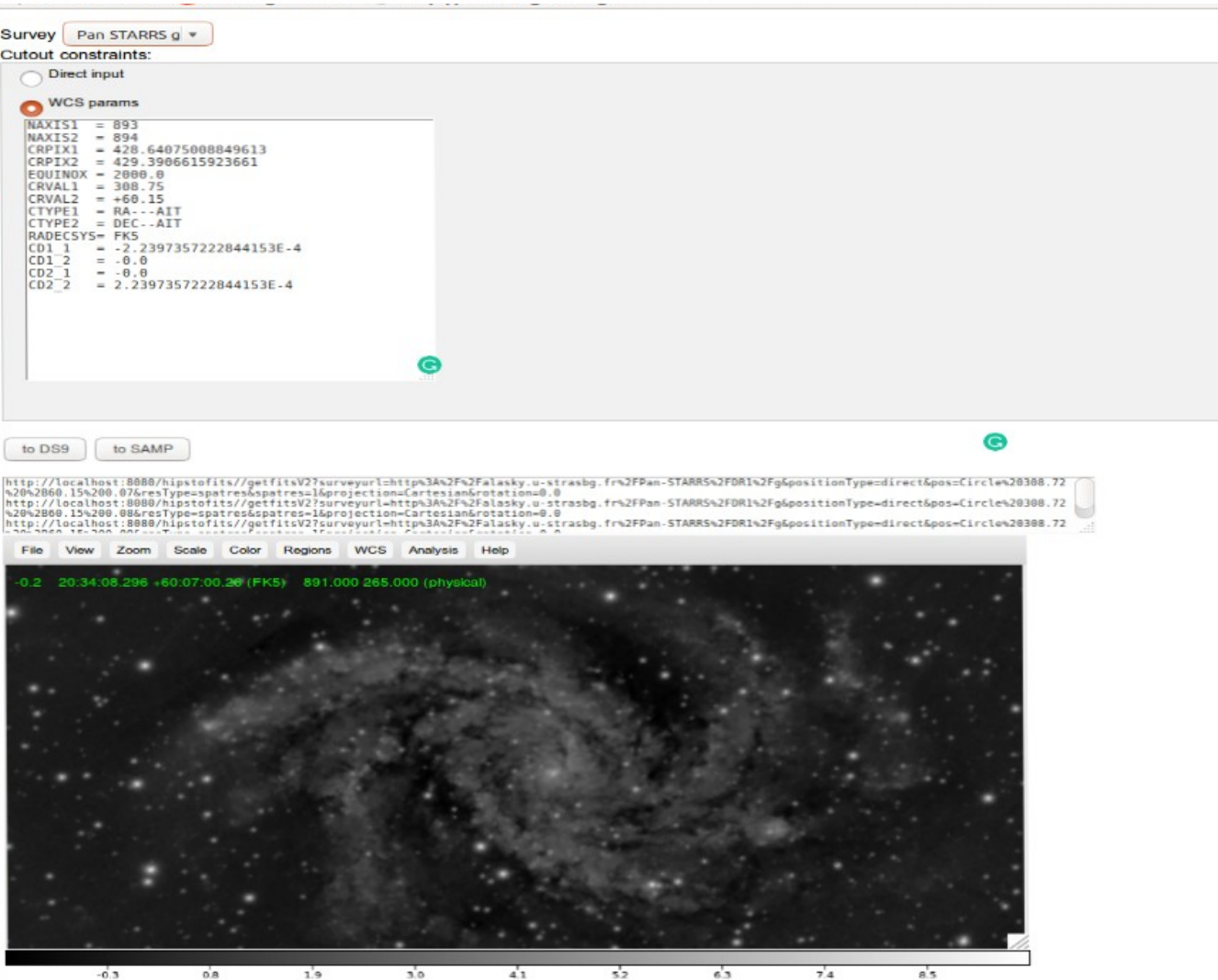
WCS params

```
NAXIS1 = 893
NAXIS2 = 894
CRPIX1 = 428.64075008849613
CRPIX2 = 429.3906615923661
EQUINOX = 2000.0
CRVAL1 = 308.75
CRVAL2 = +60.15
CTYPE1 = RA---AIT
CTYPE2 = DEC--AIT
RADECSYS= FK5
CD1_1 = -2.2397357222844153E-4
CD1_2 = -0.0
CD2_1 = -0.0
CD2_2 = 2.2397357222844153E-4
```

```
http://localhost:8888/hipstofits//getfitsV2?surveyurl=http%3A%2F%2Falasky.u-strasbg.fr%2FPan-STARRS%2FDR1%2Fg&positionType=direct&pos=Circle%20308.72%20%2060.15%200.07&resType=spatres&spatres=1&projection=Cartesian&rotation=0.0
http://localhost:8888/hipstofits//getfitsV2?surveyurl=http%3A%2F%2Falasky.u-strasbg.fr%2FPan-STARRS%2FDR1%2Fg&positionType=direct&pos=Circle%20308.72%20%2060.15%200.08&resType=spatres&spatres=1&projection=Cartesian&rotation=0.0
http://localhost:8888/hipstofits//getfitsV2?surveyurl=http%3A%2F%2Falasky.u-strasbg.fr%2FPan-STARRS%2FDR1%2Fg&positionType=direct&pos=Circle%20308.72%20%2060.15%200.09&resType=spatres&spatres=1&projection=Cartesian&rotation=0.0
```

File View Zoom Scale Color Regions WCS Analysis Help

-0.2 20:34:08.296 +60:07:00.26 (FK5) 891.000 265.000 (physical)



-0.3 0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0

HiPStoFITS version 2 and SIAP2 next steps

- Complete integration in SIAP2 CDS service
- Release SIAP2 and HiPStoFITS external access next year (before next interop)



Further discussion. Acknowledgments

Hackathon late today (after provenance)?

TimeDomain is reusing a lot of Multi-D : hackathon today

Radio data in the VO : workshop on Thursday.

Contributors in ASTERICS context : a major involvement of europeans

(not all of them funded by ASTERICS, but they all discuss in ASTERICS meetings)

M.Demleitner (SODA, DataLink, services)

M.Louys, A.Micol ; C.Rodrigo (Obscore, feedback, use cases)

Chaitra, P.Fernique, L.Michel, T Boch (development)

M.Taylor (TOPCAT development, feedback)

M.Molinaro, F.Bonnarel (miscelaneous inputs as DAL WG vice-chair, chair, ex-chair)

+ CADC (Canada), CFA SAO (USA), CASDA (ASKAP Australia)

