



ASTRON

Netherlands Institute for Radio Astronomy

LoTSS DR2

Publication of a LOFAR Data Release

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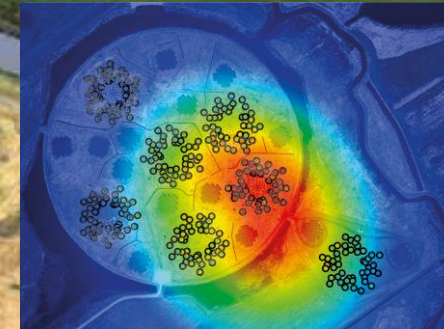
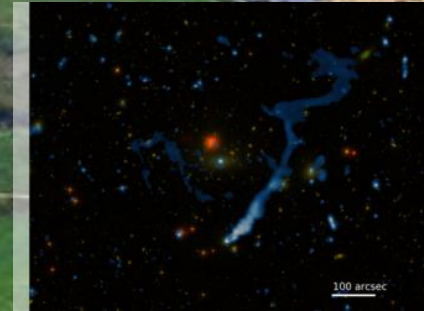
LOFAR: Data intensive science at European scale

European scale Radio Interferometer Instrument

Collaboration of multiple national consortia

Becoming an ERIC soon

Distributed data archive: 50 PB



The International LOFAR Telescope

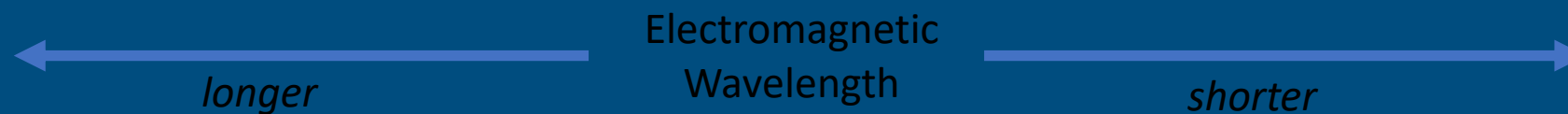
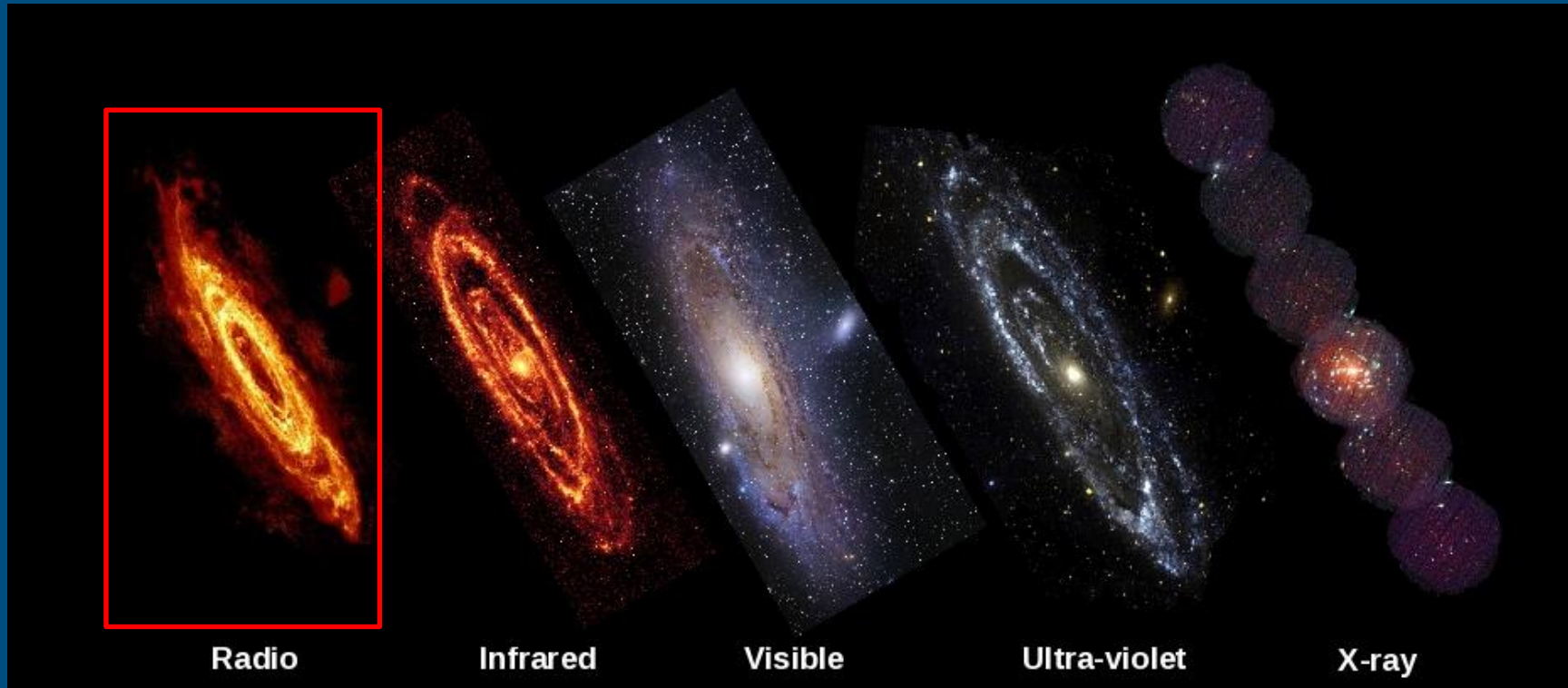


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LOFAR

Astronomy - Wavelengths

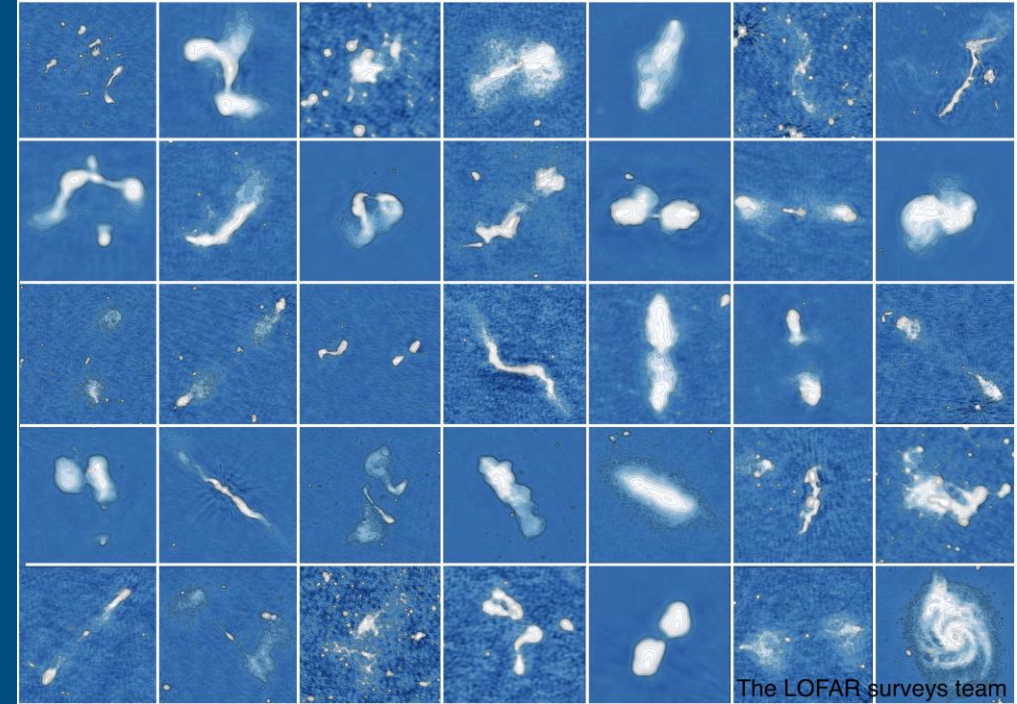
Andromeda Galaxy (Multi-wavelength View)



LoTSS

- The **LOFAR Two-metre* Sky Survey**
- aims to survey the whole northern sky
 - at the full resolution of Dutch LOFAR (6 arcseconds)
 - declination-dependent sensitivity which will typically be around $100 \mu\text{Jy}/\text{beam}$
- Prefactor direction-independent and DDF direction-dependent calibration pipeline
- Preliminary Data Release (PDR): 2017
- First Data Release (DR1): 2019
- Second Data Release (DR2): 2022

* LOFAR High Band Antenna's: 1.8 - 2.4 m wavelength

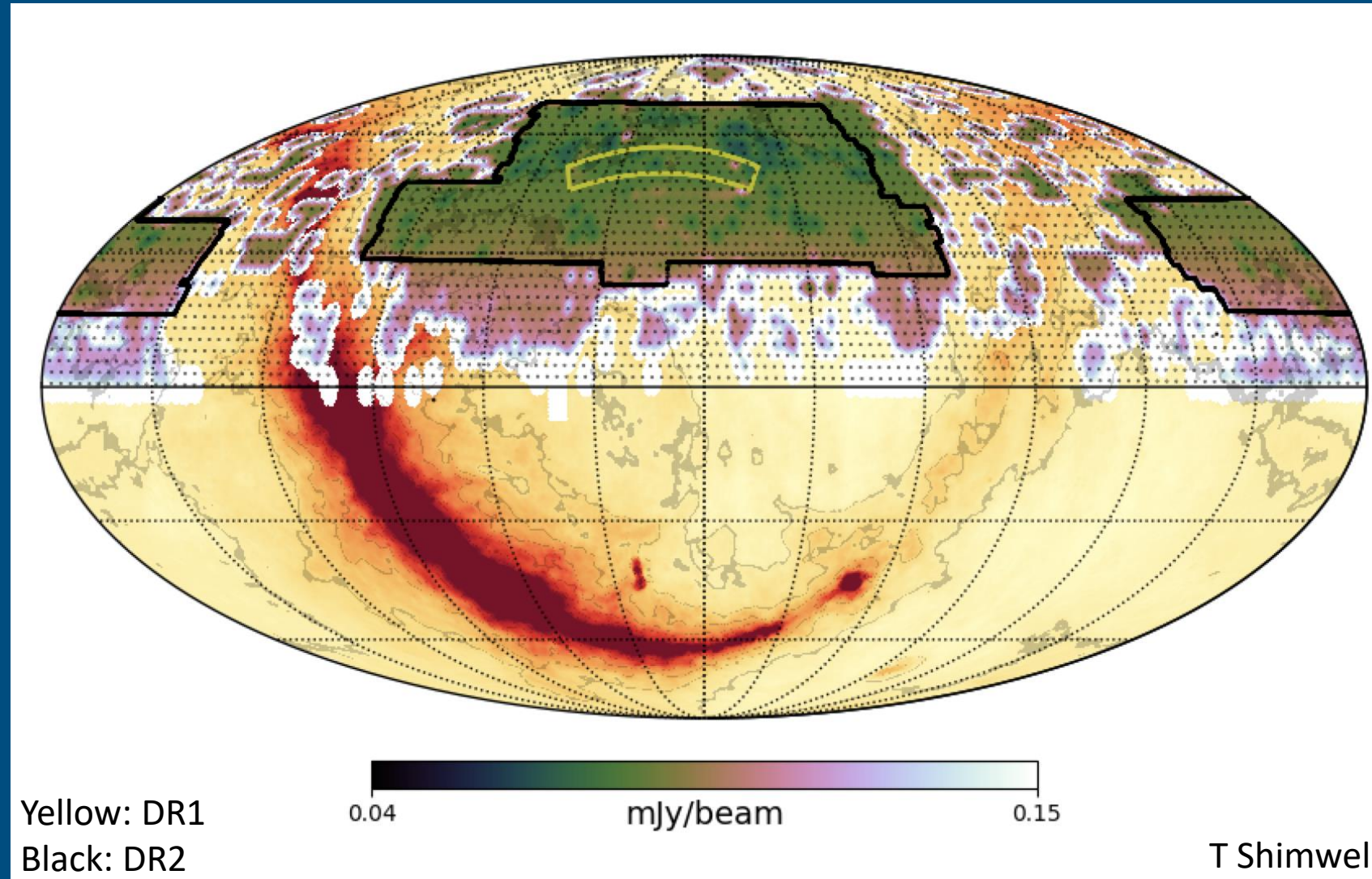


LoTSS – DR1

- Feb 2019
- 424 deg²
- 2% of sky (N)
- 58 pointings
- 325 694 sources

LoTSS – DR2

- Feb 2022
- 5634 deg²
- 27% of sky (N)
- 841 pointings
- 4 395 448 sources

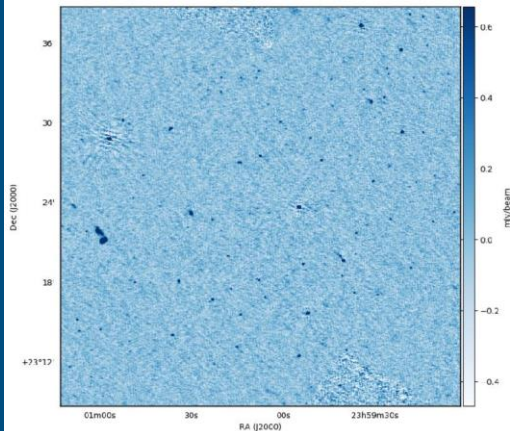




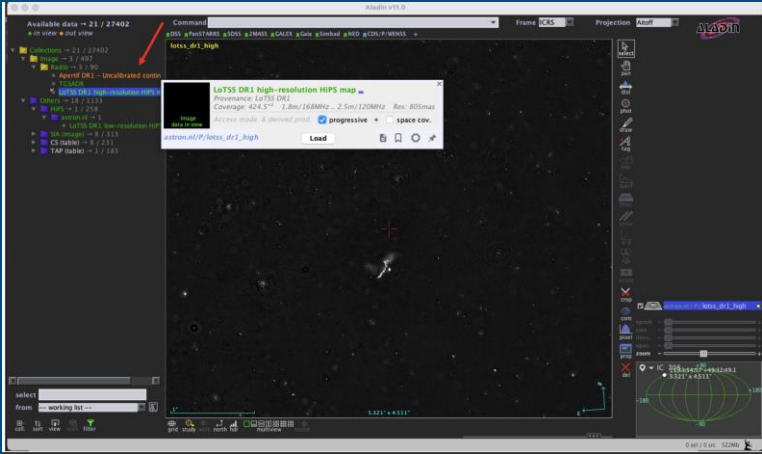
Community Data Standard: VO

- “The Virtual Observatory (VO) is the vision that astronomical datasets and other resources should work as a seamless whole.”
- The VO defines the standards (schemas and protocols), not the tools.
 - Similar to the www, which does not implement websites or browsers, but tells them how to share information.
 - Tools are available for access (TOPCAT, Aladin, ESASky, pyvo,...) and sharing (ASTRON hosts DaCHS VO & HiPS servers).

Table links



Where?	Description	What?
Link (609.5 MiB)	6" resolution Stokes I 120-168MHz mosaic image (fits format)	#this ivo://astron.nl/~7LoTSS-DR2/P000+23
Link (117.2 kiB)	Preview of the observed area	#preview ivo://astron.nl/~7LoTSS-DR2/P000+23
Link (71.53 MiB)	20" resolution Stokes I 120-168MHz mosaic image (fits format)	#coderived ivo://astron.nl/~7LoTSS-DR2/P000+23



Product key	Type	File size [byte]	Ctr. RA	Ctr. Dec	Title	Instrument	Obs. date
			[deg]	[deg]			
P000 23	image/fits	609.5MiB	0.03	23.40	P000+23_mosaic-blanked.fits	LOFAR.HBA	2018-11-30T15:14:35Z



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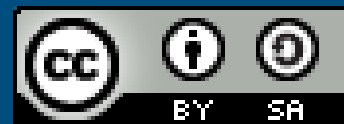
LOFAR

LoTSS DR2 – Making it FAIRer

- The VO covers most of the FAIR standard specifications by design. However this can be improved by adding:

- Licensing

- Default license: CC-BY-SA for ASTRON-VO



- PIDs

- ePIC PIDs for each data product in the release,
 - for each pointing (observation of a patch of the sky)
 - and for the release itself (and one for the documentation)
 - Also a DOI for the release
 - Linked Community and Data center PID's

the SURF data repository

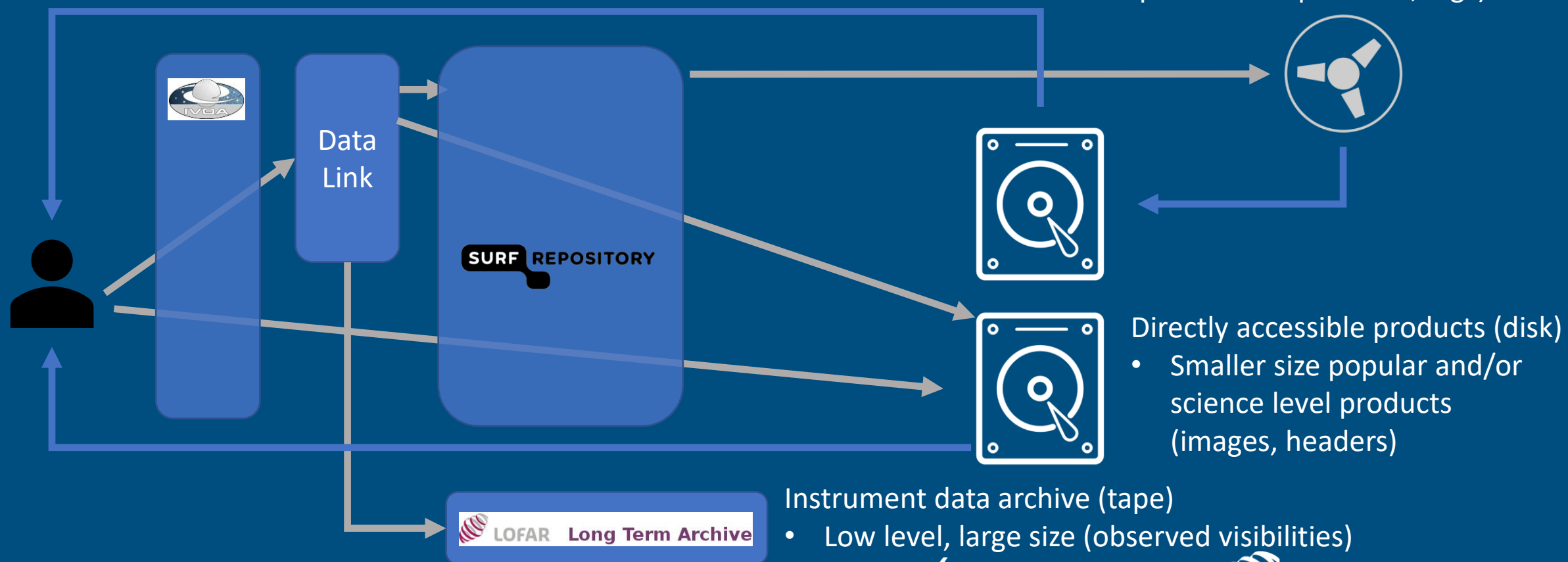
- Publication platform for research data sets
- Links directly to the SURF storage
- Also makes data findable outside of astronomy
- Makes access to data on tape easier (staging through the platform)

The image displays three overlapping screenshots of the SURF Repository website. The top screenshot shows the main navigation bar with links for HOME, USER GUIDE, FAQ, and CONTACT, along with a search icon and a 'Log in' button. The middle screenshot shows a data release page for 'The LOFAR Two-metre Sky Survey (LoTSS) V. Second data release', featuring a small image of a radio galaxy and a list of authors. The bottom screenshot shows a file listing table with columns for File name, Size, Status, and Action, listing various data files like 'images.tar' and 'misc.tar'.

LoTSS DR2 – Repository Design

Publicly requestable products (tape)

- Medium size and/or intermediate level products (Pre-mosaiced images, calibrated visibilities, polarization products, logs)



Directly accessible products (disk)

- Smaller size popular and/or science level products (images, headers)

Instrument data archive (tape)

- Low level, large size (observed visibilities)

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LoTSS DR2 – Data collection

Type		Locality
Mosaicked astrometric corrected Stokes I 6'' and 20'' resolution images	1.5 TB	Disk
Individual Stokes I 6'' and 20'' (with and without astrometric correction) resolution restored images with associated DDFacet model, residual and mask images	7.5 TB	Disk
Catalogue of the 4,395,448 radio sources	2 GB	Disk
Stokes I 6'' and 20'' HiPS files	2 TB	Disk*
Individual observation Stokes QU 20' and 3' resolution undeconvolved 480-plane image cubes	34 TB	Tape
Individual observation Stokes V 20'' resolution 120-168MHZ continuum dirty images	400 GB	Tape
DI calibrated visibilities and DD calibration solution, facet layout and astrometric corrections	100 TB	Tape
Raw data in the LOFAR Long Term Archive (only linked through the VO, not exposed via SDR)	12 PB	LTA (tape)

*HiPS files are stored separately on a web server.

LoTSS DR2 – Metadata

Main source of data is the VO following the community schema. SDR is provisioned from VO.

SDR provides ePIC PIDs and checksums which are entered into the VO tables.

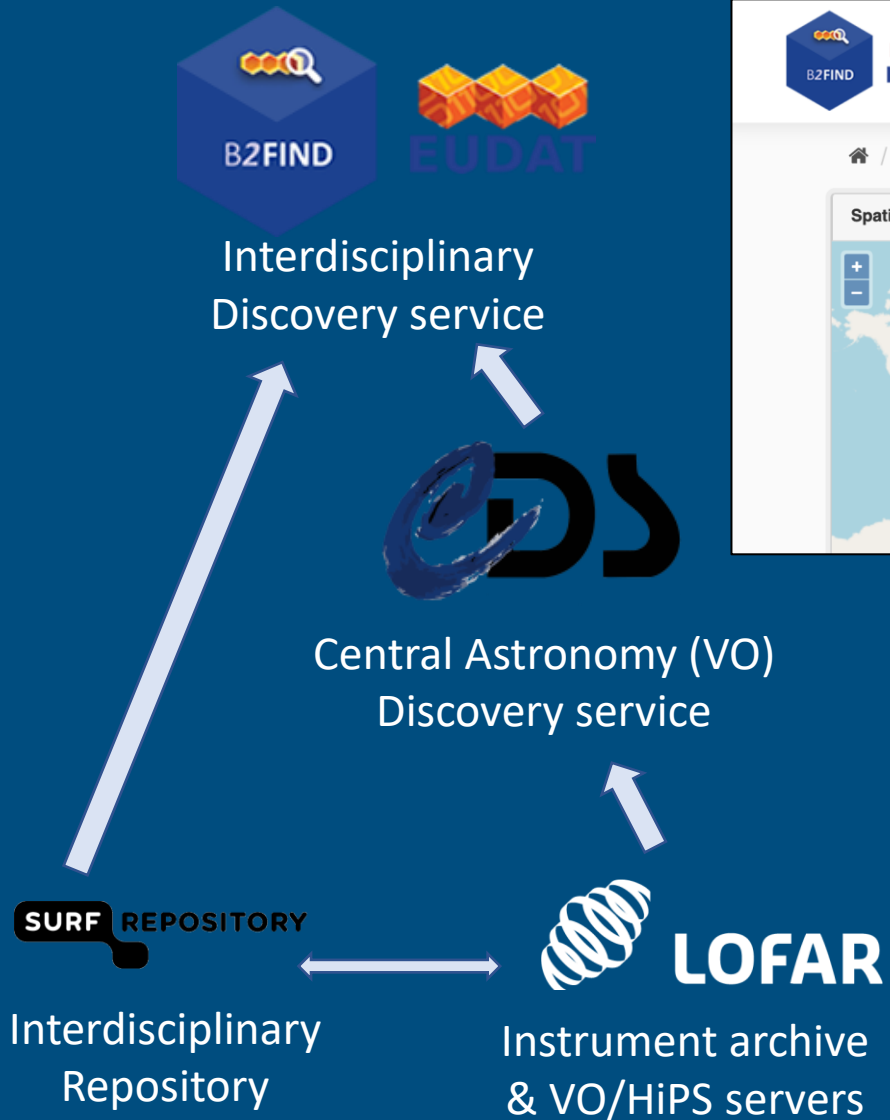
The screenshot displays the LoTSS DR2 metadata interface. On the left, there is a 'FILES' tab with a search bar and a table of files. The table has columns for 'File name', 'Size', 'Status', and 'Action'. The files listed include 'images.tar', 'misc.tar', 'stokes_large.tar', 'stokes_small.tar', 'uv.tar', 'fits_headers.tar', 'low-mosaic-blanked.fits', 'low-mosaic-weights.fits', 'mosaic-blanked.fits', and 'mosaic-blanked.png'. The 'Status' column shows 'online' for most files and 'external' for others. The 'Action' column contains 'Download' buttons and checkboxes. Below the table, it says 'Showing 1 to 10 of 14 entries' with pagination controls.

On the right, the 'Object properties' section is expanded, showing the following details:

- Number of files: 14
- Data size: 183.6 GB
- Access level: Open
- Updated: 31 January 2022
- Object identifiers: EPIC PID 11112/C00807BF-1E6A-46BC-8ECF-75D9813C27E8
- Conditions of use: License Creative Commons Attribution-ShareAlike (CC-BY-SA)
- Metadata details: General, Collection
- Using schema: LOFAR LoTSS-DR2 metadata schema
- Access key: <https://sdc-dev.astron.nl/vodev/getproduct/LoTSS-DR2/P9Hetdex01>
- Image center RA: 170.437 deg
- Image center declination: 45.3324 deg

Image center RA	170.437 deg
Image center declination	45.3324 deg
Instrument identifier	LOFAR.HBA
Epoch	56816.666666666665 d
Axis count	2
Image dimensions	10750, 10750 pix
Pixel scale	0.0004166669968981296, 0.0004166669968981296 deg/pix
Reference frame	ICRS
Equinox	2000.0 yr
Projection type	SIN
Reference pixel	5375.0, 5375.0 pix
Reference pixel coordinates	170.437, 45.3324 deg
Matrix	-0.0004166669968981296, 0.0, 0.0, 0.0004166669968981296 deg/pix
Bandpass name	120-168MHz
Bandpass unit	m
Bandpass quantity	2.08189 m

LoTSS DR2 Discovery



The screenshot shows the EUDAT/B2FIND website interface. The search bar contains 'lotss dr2', and the results show '854 datasets found for "lotss dr2"'. The 'Order by' dropdown is set to 'Relevance'. A 'Spatial Coverage' map is visible on the left.

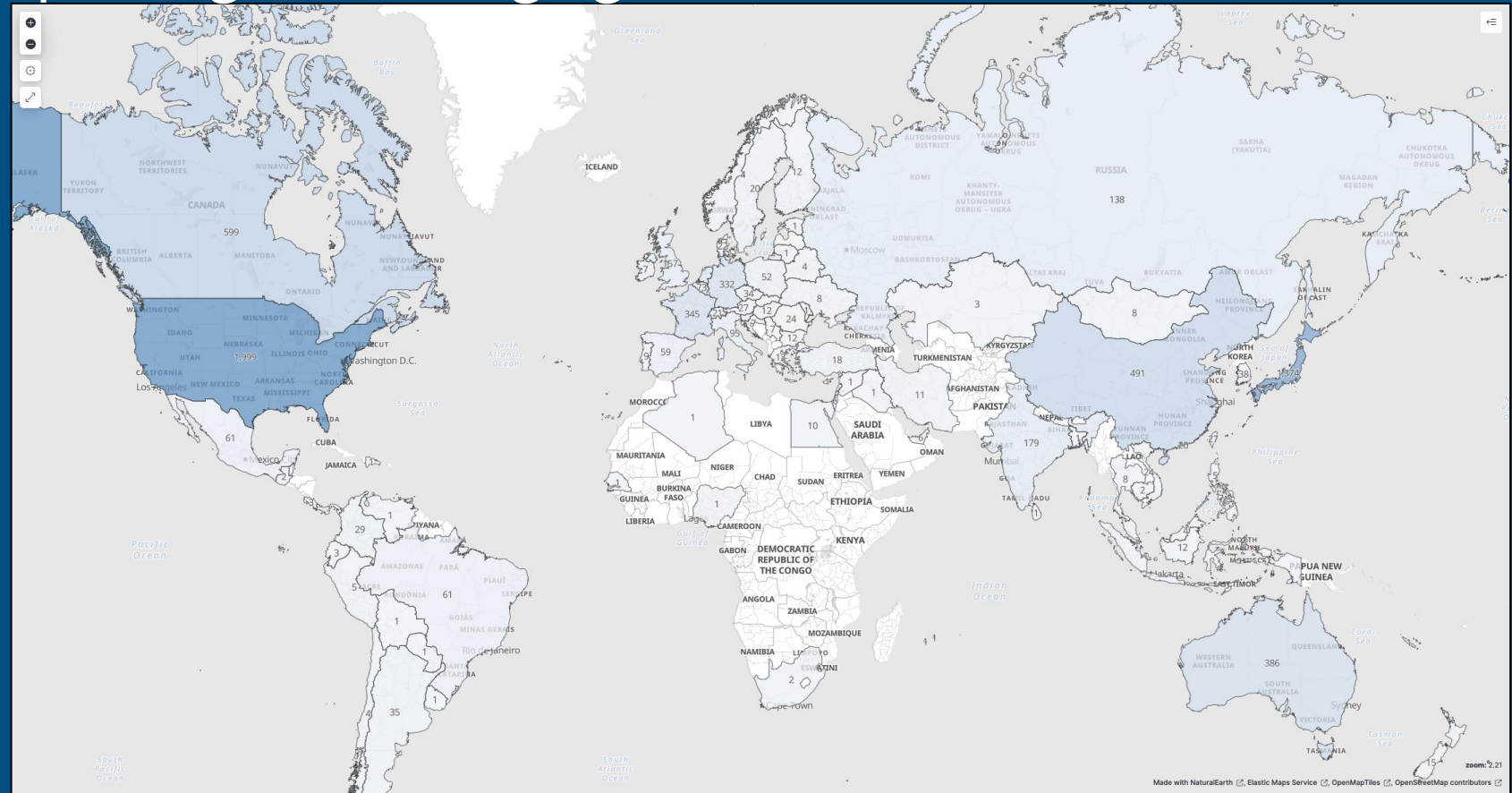
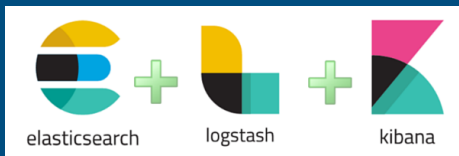
Identifier	
Source	https://cdsarc.cds.unistra.fr/viz-bin/cat/J/A+A/659/A1
Related Identifier	https://ui.adsabs.harvard.edu/abs/2022A&A...659A...1S
Metadata Access	http://dc.g-vo.org/rr/q/pmh/pubreg.xml?verb=GetRecord&metadataPrefix=oai_b2find&identifier=ivo://CDS.VizieR/J/A+A/659/A1

Identifier	
PID	https://hdl.handle.net/11112/8E4F1273-F6CB-4820-8AE8-FAE553EF7452
Source	https://repository.surfsara.nl/datasets/lotss-dr2/P13Hetdex12

Identifier	
Source	https://vo.astron.nl/lotss_dr2/q/query_mosaics/info
Related Identifier	https://ui.adsabs.harvard.edu/abs/2022A&A...659A...1S
Metadata Access	http://dc.g-vo.org/rr/q/pmh/pubreg.xml?verb=GetRecord&metadataPrefix=oai_b2find&identifier=ivo://astron.nl/lotss_dr2/q/query_mosaics

Measuring usage

- KPI monitoring & reporting to funding agencies
- Currently limited to ASTRON managed services
- Access logs captured through



LoTSS DR2 references

Main PID: [21.12136/95f9f5a9-406e-4270-ad8b-45e36c809561](https://hdl.handle.net/21.12136/95f9f5a9-406e-4270-ad8b-45e36c809561)

Corresponding paper: DOI [10.1051/0004-6361/202142484](https://doi.org/10.1051/0004-6361/202142484).

Surf Data Repository landing page DOI: [10.25606/SURF.lotss-dr2](https://doi.org/10.25606/SURF.lotss-dr2)

Acknowledgments:

*Yan Grange, Tim Shimwell, Mattia Mancini (ASTRON) for implementation & material
LOFAR Surveys (<https://lofar-surveys.org>) for realizing LoTSS DR2 science content
SURF for supporting the integration with SDR/Handle
DKRZ for harvesting by B2FIND*