



Netherlands Institute for Radio Astronomy

First ASTRON/LOFAR steps towards the VO standards

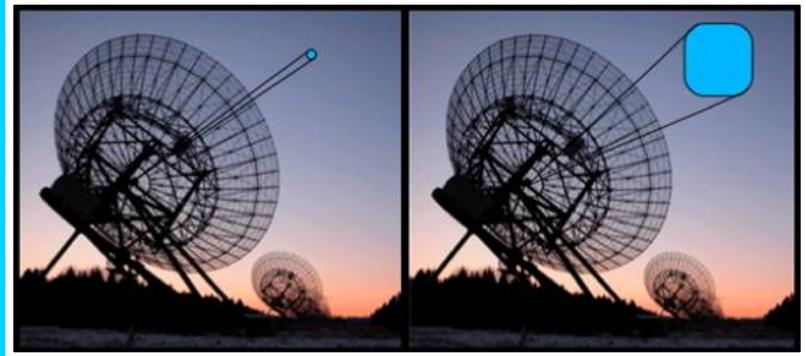
Marco Iacobelli
LOFAR telescope scientist

Trieste, December 13th 2017

ASTRON priorities & DADI



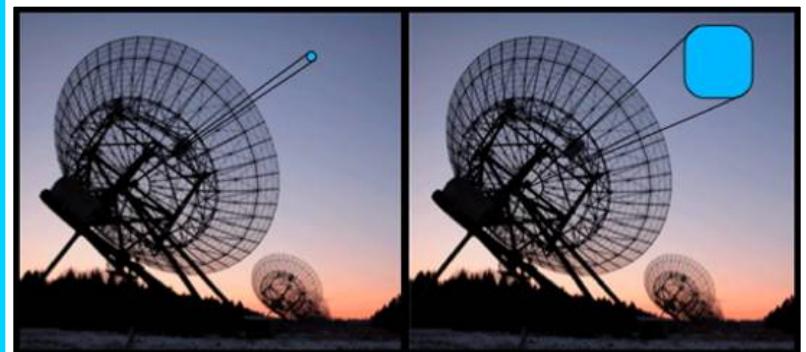
- The Netherlands Institute for Radio Astronomy is an institute of the Netherlands Organisation for Scientific Research (NWO).
- Overall priorities:
 - International LOFAR Telescope (SKA pathfinder),
 - SKA (leading role in technology, science & policy),
 - APERTIF project
 - Maximise scientific return



ASTRON priorities & DADI



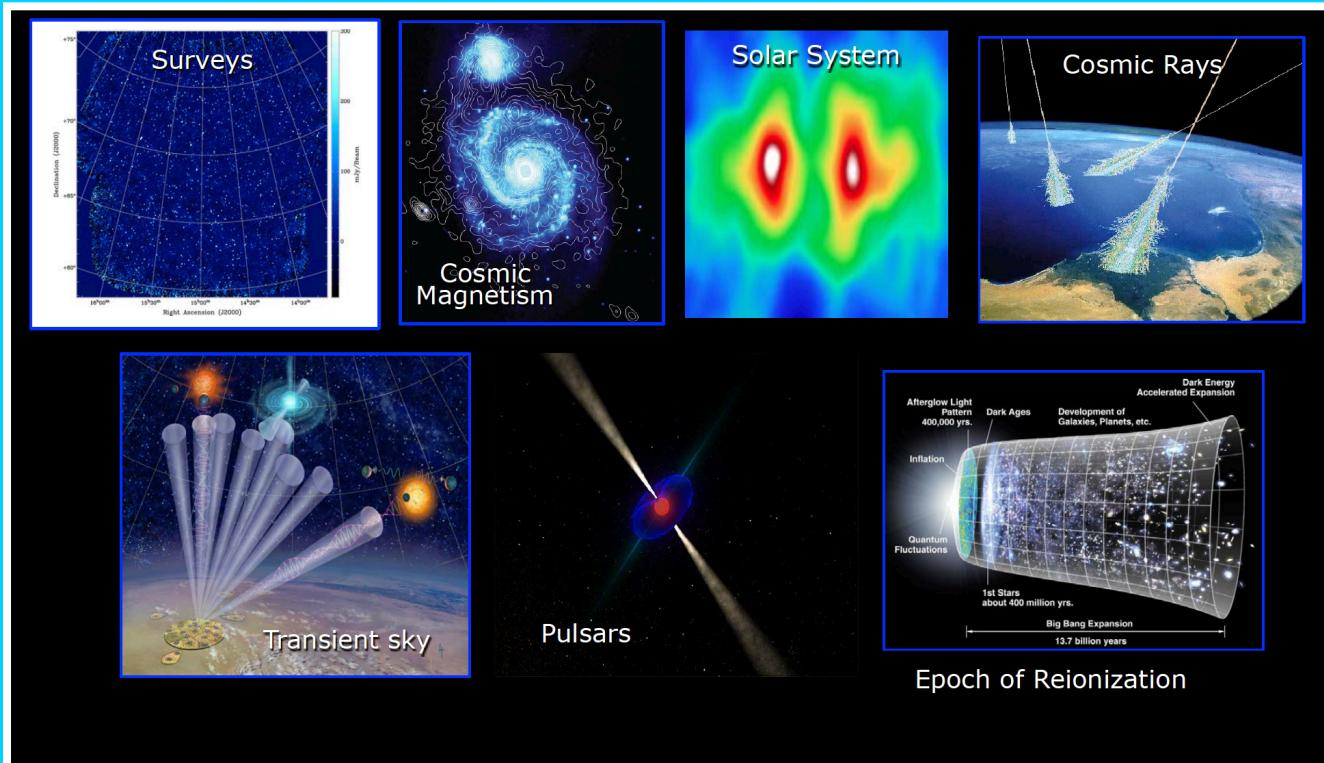
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ASTRON data collections



- LOFAR, WSRT + others (MSSS, LBCS, LOTSS, TGSS)
 - different data format (raw telemetry, uv data, beam-formed data, FITS maps/cubes, light-curves, catalogues, etc.),
 - different sizes $10^{-4} - 10^2$ TB.



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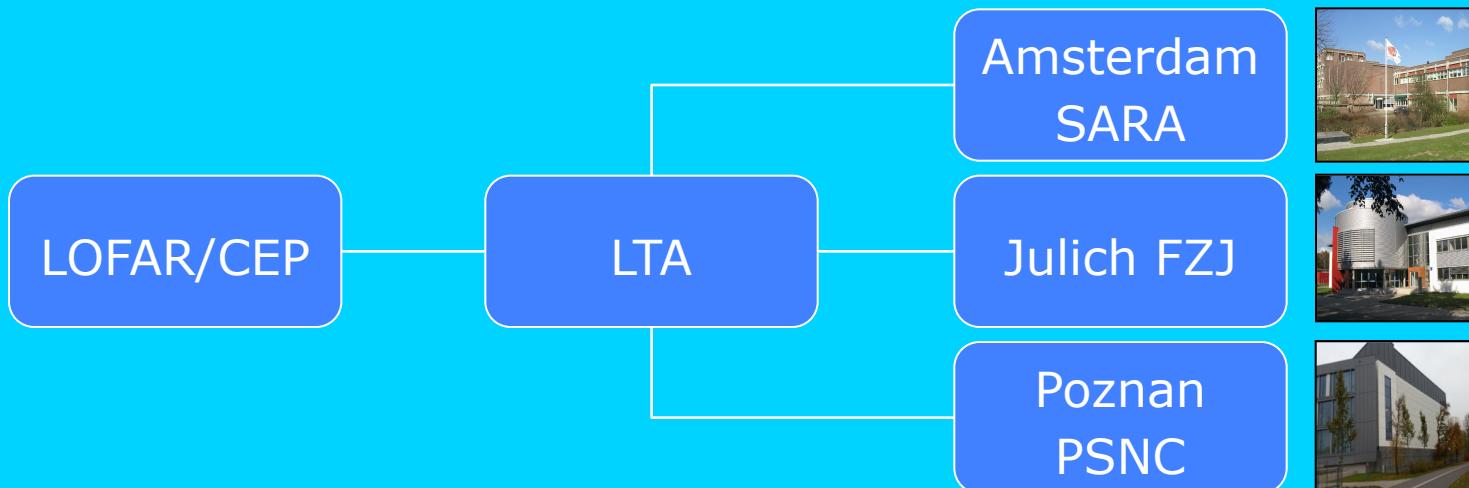


- LOFAR data collection: the world largest astronomical data collection with 31PB!
 - >1 billion of files / >6 millions of data products.

ASTRON data collections



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 - different data format (raw telemetry, uv data, beam-formed data, FITS maps/cubes, light-curves, catalogues, etc.),
 - different sizes $10^{-3} - 10^2$ TB.
- LOFAR data collection: the world largest astronomical data collection with 31PB!
 - Data shared with the users community via the LTA.



ASTRON data collections



- Query, browse and retrieval of LTA database via ASTROWISE interface:
 - need for substantial improvements (chance for new algorithms)

Welcome to the Lofar Long Term Archive (LTA) web service.

On the top are links to: help pages, user login, project overview, seach form and most recently added data.

Before you can query and stage proprietary data make sure that :

1. you are logged in; see **username** below login link
2. selected the correct project; see the **project** name below project link

From March 1 2015 onwards, cycle data which have passed the proprietary period will be publicly available. All metadata in the Archive can be queried anonymously at anytime, but downloading public data can only be done by registered users (follow the "Create account" link). Non-public data can only be downloaded by project members.

Note: for the first cycles of LOFAR operations, part of the data were ingested in the archive without metadata. Theses data cannot be found using the standard search parameters, except for the appropriate Observation ID. When unspecified data are present in a project, this is listed in the "Unspecified" column on the Projects page. Data can still be requested using the "Project" pulldown in the various Search options.

A list of all LOFAR observing cycles and approved projects can be found [here](#).

For more information on this web service see the [Lofar wiki](#).

- limited capabilities to browse data and metadata

ASTRON data collections



- Query, browse and retrieval of LTA database via ASTROWISE interface:
 - need for substantial improvements (chance for new algorithms)

- basic capabilities to search data

- A first attempt to make available some data products to the VO community: VO@ASTRON, a site to enable data discovery (FITS images/cubes, catalogues) and offer VO-enabled services.

MSSS Verification Field Images

The Multifrequency Snapshot Sky Survey (MSSS) is the first major observing program to be carried out with LOFAR during its ongoing commissioning phase. This service queries the archive of both LBA and HBA images.

Position [deg]
ICRS Position, RA,DEC, or Simbad object (e.g., 234.234,-32.45)

Field size [deg] 0.5
Size in decimal degrees (e.g., 0.2 or 1.0.)

Intersection type
 Image overlaps Rol
 Image covers Rol
 Rol covers image
 The given position is shown on image
Relation of image and specified Region of Interest.

Obs. Freq.

LBA Average	No selection matches all, multiple values legal.
HBA Average	
31 MHz	
37 MHz	
43 MHz	
49 MHz	
54 MHz	
60 MHz	
66 MHz	
74 MHz	

Table Sort by ASC DESC
 Limit to 100 items.

Output format

LOFAR **The VO @ ASTRON**

Welcome to the ASTRON VO data center.
 In addition to the services listed below, on this site you probably can access numerous tables using [TAP](#) or [form-based ADQL](#).
 Please check out our [site help](#).

Services available here

[By Title](#) [By Subject](#)

L...

- [LBCS Calibrator Search](#)
- [LOFARTIER 1 Image Archive](#)
- [LOFARTIER 1 Image Cutout Service](#)
- [LOFARTIER 1 Source Catalogue](#)

M...

- [\[P\] MSSS catalogue](#)
 The Multifrequency Snapshot Sky Survey (MSSS) is the first major observing program to be carried out with LOFAR during its ongoing commissioning phase. This service queries the unified source catalogue database for the MSSS survey.
- [\[P\] MSSS Image Archive](#)
 The Multifrequency Snapshot Sky Survey (MSSS) is the first major observing program to be carried out with LOFAR during its ongoing commissioning phase. This service queries the archive of both LBA and HBA images.
- [MSSS Verification Field Images](#)
 The Multifrequency Snapshot Sky Survey (MSSS) is the first major observing program to be carried out with LOFAR during its ongoing commissioning phase. This service queries the archive of both LBA and HBA images.
- [MSSS Verification Field Sources](#)
 The Multifrequency Snapshot Sky Survey (MSSS) is the first major observing program to be carried out with LOFAR during its ongoing commissioning phase. This service queries the unified source catalogue database for the MSSS survey.

T...

- [TGSSADR Image Archive](#)
 Download the TGSS Alternative Data Release mosaic images (5 deg square mosaics).
- [TGSSADR Image Cutout Service](#)
 Download the TGSS Alternative Data Release image cutouts (up to 1 deg square).
- [TGSSADR Source Catalogue](#)
 Query the TGSS Alternative Data Release 7-sigma source catalog.

- A first attempt to make available some data products to the VO community: VO@ASTRON, a site to enable data discovery (FITS images/cubes, catalogues) and offer VO-enabled services.
- General features:
 - published services available through web browsers,
 - in addition to web-based services, the data center also provides services accessible through IVOA standard protocols.

MSSSVF Verification Field Images

Help

Service info

Metadata

Identifier

Cite this

Description

Keywords

Creator

Created

Data updated

Source

Reference URL

Try ADQL to query our data.

Please report errors and problems to the data operator. Thanks.

Privacy | Disclaimer

Logout

Parameters

- Field size: 0.5
- Output format: image/fits

Result

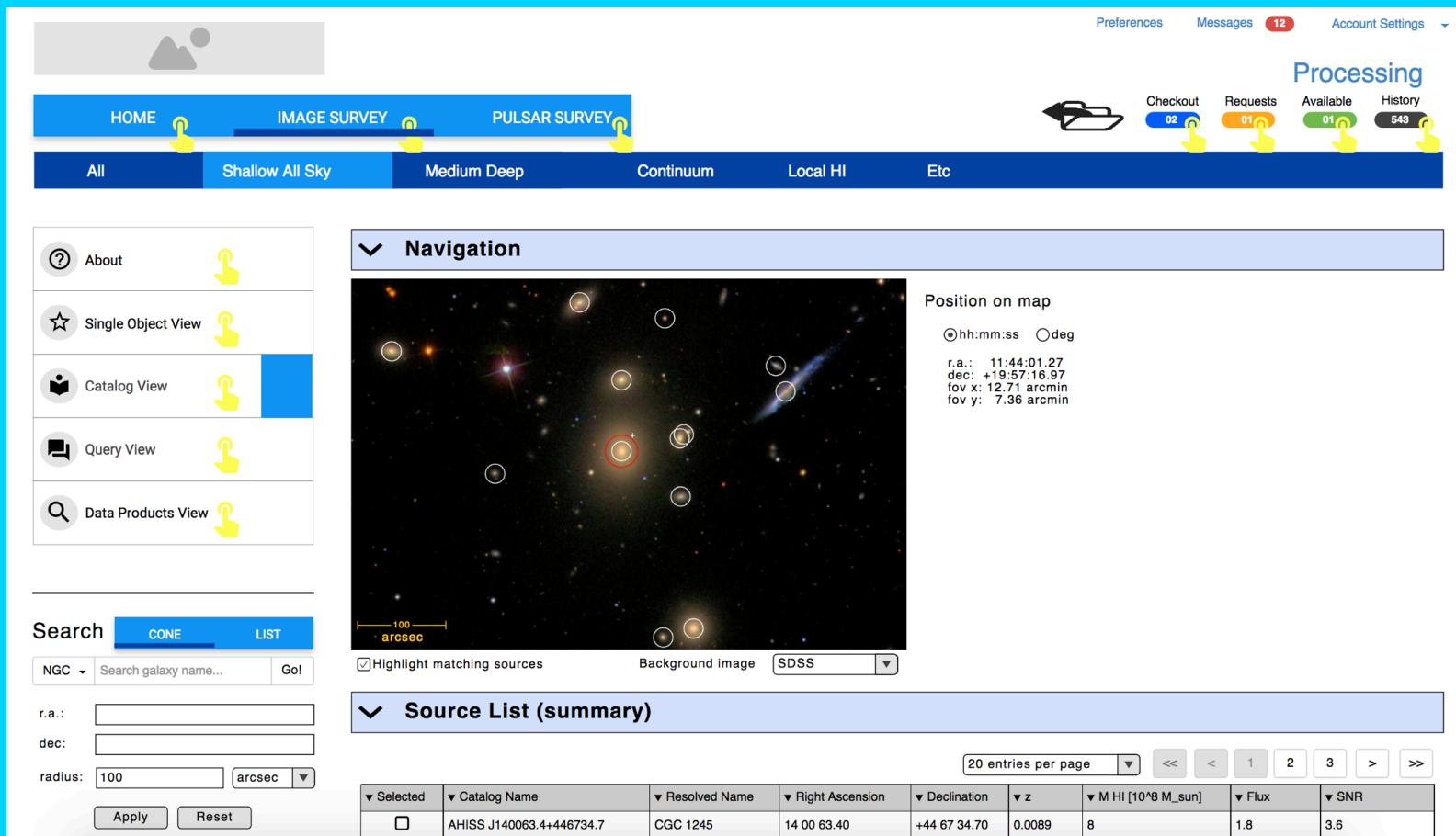
Matched: 18

Product key	Owner	Embargo ends	Type	File size [byte]	Ctr. RA [deg]	Ctr. Dec [deg]	Title	Instrument	Obs. date	#axes	Axes Lengths [pix]	Scales [deg/pix]	Ref. Frame	Equinox	Proj.	Ref. pixel [pix]	Ref. values [deg]	CD matrix [deg/pix]	Bandpass unit	Band	Band	P. Ref. [m]	upper [m]	lower [m]	Coverage [deg]	Obs. Freq.
MSSSVF-HBA-averaged_map_sub.fits	N/A	N/A	image/fits	12.4MB	225.01	69.00	MSSSVF-HBA-averaged_map_sub	LOFAR	N/A	4	[1799, 1, 1]	[0.005556, 0.005556]	ICRS	N/A	SIN	[900.0, 69.0]	[225.0, 0.0, 0.0]	[0.005556, 0.0, 0.0, 0.005556]	m	N/A	N/A	N/A	N/A	Polygon	ICRS	
MSSSVF-HBA-mosaic-band0_sub.fits	N/A	N/A	image/fits	12.4MB	225.01	69.00	MSSSVF-HBA-mosaic-band0_sub	LOFAR	N/A	4	[1799, 1, 1]	[0.005556, 0.005556]	ICRS	N/A	SIN	[900.0, 69.0]	[225.0, 0.0, 0.0]	[0.005556, 0.0, 0.0, 0.005556]	m	N/A	N/A	N/A	N/A	Polygon	ICRS	
MSSSVF-HBA-mosaic-band1_sub.fits	N/A	N/A	image/fits	12.4MB	225.01	69.00	MSSSVF-HBA-mosaic-band1_sub	LOFAR	N/A	4	[1799, 1, 1]	[0.005556, 0.005556]	ICRS	N/A	SIN	[900.0, 69.0]	[225.0, 0.0, 0.0]	[0.005556, 0.0, 0.0, 0.005556]	m	N/A	N/A	N/A	N/A	Polygon	ICRS	

- A first attempt to make available some of data products to the VO community: VO@ASTRON, a site to enable data discovery (FITS images/cubes, catalogues) and offer VO-enabled services.
- General features:
 - published services available through web browsers,
 - in addition to web-based services, the data center also provides services accessible through IVOA standard protocols.
- Work in progress:
 - Limited data exploitation capability
 - A major challenge is having a suited visibility model for including the bulk of data products (i.e. uv ...)

- In view of an European Science and Data Centre, ASTRON has the ambition to set up a science data portal to support the exchange of data by scientists and maximise scientific return from existing data collections.
- Main goals:
 - Access to data collections of LOFAR, WSRT and APERTIF
 - Added value services: pipelines, analytics and visualization
- The portal can grow wider by including data collections of future instruments (MeerKat, NCLE, SKA).

- Status of the project: system design / system requirements specification.
 - Design inspired by the ALTA (in progress) and ESA Sky 2.0 portals



The screenshot shows the ASTRON Data Portal interface. At the top, there is a navigation bar with tabs: HOME, IMAGE SURVEY (highlighted with a yellow arrow), and PULSTAR SURVEY. Below the tabs are sub-navigation buttons: All, Shallow All Sky, Medium Deep, Continuum, Local HI, and Etc. On the right side of the top bar, there are links for Preferences, Messages (with 12 notifications), Account Settings, and a Processing section showing metrics for Checkout (02), Requests (01), Available (01), and History (543). A large yellow arrow points to the 'Checkout' button.

On the left, there is a sidebar with links: About, Single Object View, Catalog View, Query View, and Data Products View. A yellow arrow points to the 'Data Products View' link.

The main content area features a 'Navigation' section with a map showing several celestial objects. A yellow arrow points to the 'Background image' dropdown menu, which is set to SDSS. Another yellow arrow points to the 'Highlight matching sources' checkbox, which is checked. A scale bar indicates a distance of 100 arcsec. To the right of the map, there is a 'Position on map' section displaying coordinates: r.a.: 11:44:01.27, dec: +19:57:16.97, fov x: 12.71 arcmin, and fov y: 7.36 arcmin.

Below the map is a 'Source List (summary)' section. It includes a search bar for 'CONE' and 'LIST' modes, and fields for 'r.a.', 'dec.', and 'radius: 100 arcsec'. Buttons for 'Apply' and 'Reset' are also present. A yellow arrow points to the 'radius' input field. The source list table has columns: Selected, Catalog Name, Resolved Name, Right Ascension, Declination, z, M HI [10^8 M_sun], Flux, and SNR. The first row of the table is shown:

Selected	Catalog Name	Resolved Name	Right Ascension	Declination	z	M HI [10 ⁸ M _{sun}]	Flux	SNR
<input type="checkbox"/>	AHISS J140063.4+446734.7	CGC 1245	14 00 63.40	+44 67 34.70	0.0089	8	1.8	3.6

- Status of the project: system design / system requirements specification.
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The screenshot shows the ASTRON Data Portal's Processing section. At the top, there are three main survey tabs: HOME, IMAGE SURVEY (selected), and PULSTAR SURVEY. Below these are several data categories: All, Shallow All Sky (highlighted), Medium Deep, Continuum, Local HI, and Etc. On the right, there are buttons for Preferences, Messages (12), Account Settings, and processing status: Checkout (02), Requests (01), Available (01), and History (543). A sidebar on the left lists options like About, Single Object View, Catalog View, Query View, and Data Products View. The central area features a 'Data Query' section with a SQL input field containing the following code:

```

SELECT
    s.objId,
    s.name,
    s.ra,
    s.dec,
    s.redshift
FROM
    ShallowSurveySources s
WHERE
    s.masshl > 1.0E08
    AND s.redshift BETWEEN 0.005 AND 0.01
    AND s.snr > 3.0
  
```

Below the query is a 'Run' button. To the right, 'Query Feedback' shows error messages:

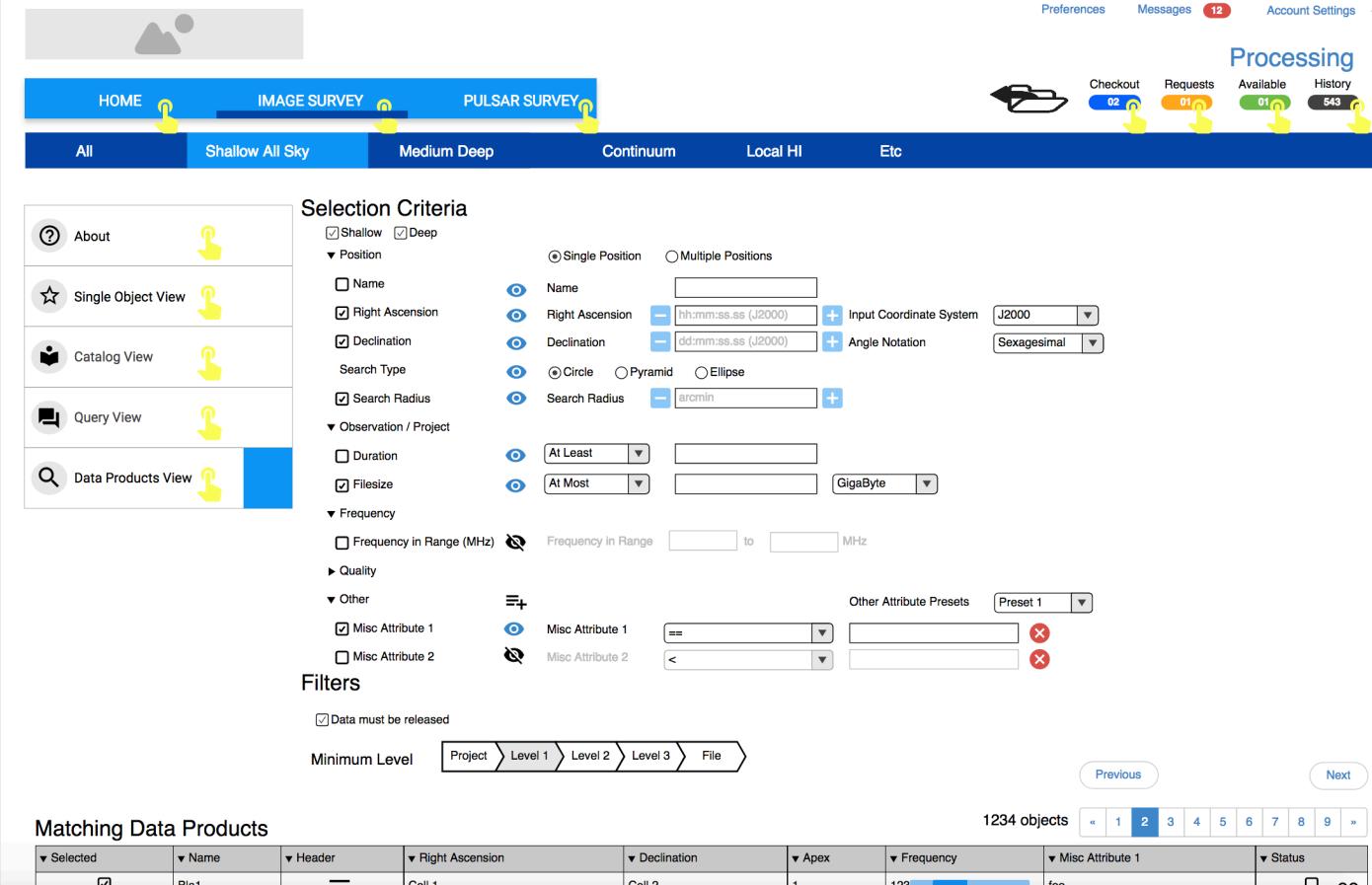
```

>> query 47243 ran for 40 seconds
>> query syntax error:
>> Unknown identifier masshl0
>> query 47245 ran for 39 seconds
  
```

The bottom section is titled 'Query Results' and displays a table for Query 24725, which found 27368 rows. The table has columns for ObjId, Name, Right Ascension, Declination, and redshift. Two rows are shown:

ObjId	Name	Right Ascension	Declination	redshift
21499146519	AHSS J140063.4+446734.7	14 00 63.40	+44 67 34.70	0.0089
32419741194	AHSS J140142.1+446734.7	14 01 42.10	+44 67 34.70	0.0076

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The screenshot shows the ASTRON Data Portal's user interface. At the top, there are navigation tabs: HOME (highlighted), IMAGE SURVEY, and PULSTAR SURVEY. Below these are sub-tabs: All, Shallow All Sky, Medium Deep, Continuum, Local HI, and Etc. On the right side, there are links for Preferences, Messages (with 12 notifications), and Account Settings.

Processing Tab:

- Checkout: 02
- Requests: 01
- Available: 01
- History: 543

Selection Criteria:

- Shallow Deep
- Position:**
 - Single Position Multiple Positions
 - Name:
 - Right Ascension: h:m:s.s (J2000) Input Coordinate System: J2000
 - Declination: d:m:s.s (J2000) Angle Notation: Sexagesimal
 - Circle Pyramid Ellipse
 - Search Radius: arcmin
 - At Least:
 - At Most: GigaByte
- Observation / Project:**
 - Duration
 - Filesize
- Frequency:**
 - Frequency in Range (MHz) Frequency in Range: to MHz
- Quality:**
- Other:**
 - Misc Attribute 1
 - Misc Attribute 2

Filters:

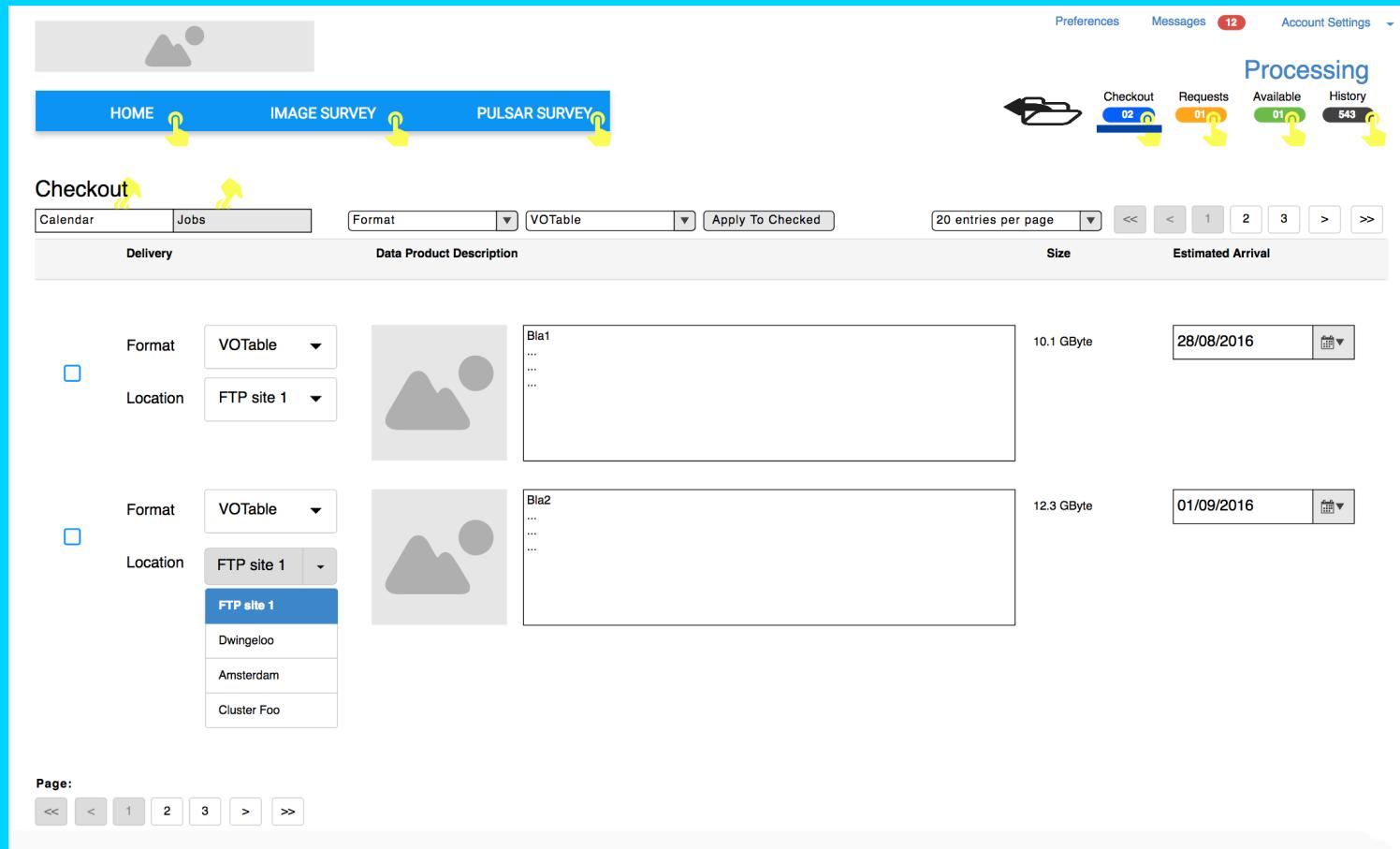
- Data must be released

Minimum Level: Project > Level 1 > Level 2 > Level 3 > File

Matching Data Products: 1234 objects

Selected	Name	Header	Right Ascension	Declination	Apex	Frequency	Misc Attribute 1	Status
<input checked="" type="checkbox"/>	Bla1	<input type="button"/>	Cell 1	Cell 2	1	123 	foo	<input type="checkbox"/> 

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The screenshot shows the ASTRON Data Portal interface with several user interactions highlighted by yellow arrows:

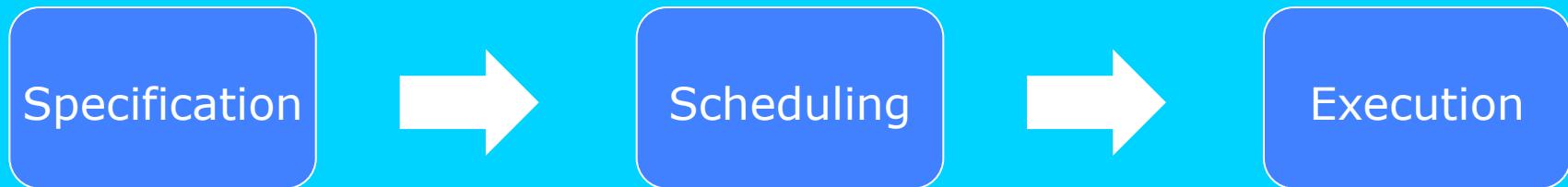
- Top Navigation:** HOME (highlighted), IMAGE SURVEY, PULSAR SURVEY.
- Right Sidebar:** Processing section with icons for Checkout (02), Requests (01), Available (01), and History (543).
- Checkout Section:** A "Checkout" button is highlighted. Below it, there are tabs for Calendar and Jobs, and dropdowns for Format (VOTable) and VOTable.
- Data Product Description:** A table listing two data products:

	Delivery	Data Product Description	Size	Estimated Arrival
<input type="checkbox"/>	Format: VOTable Location: FTP site 1	Bla1 ...	10.1 GByte	28/08/2016
<input type="checkbox"/>	Format: VOTable Location: FTP site 1	Bla2 ...	12.3 GByte	01/09/2016
- Bottom Navigation:** Page navigation buttons (<<, <, 1, 2, 3, >, >>) and a "20 entries per page" dropdown.

Responsive telescope project



- Innovative design of telescope makes LOFAR a good follow-up instrument.



- Make LOFAR able to quickly respond to events of other instruments.
 - Latency of <3 minutes (will be tuned and improved)
 - Basic feedback interfaces (will be improved iteratively)
 - Event / trigger specification generator will follow
- In production for the current observing cycle

Conclusions



- Enabling access and exploitation of data collections of LOFAR (as well as WSRT and APERTIF) has became an ASTRON RO high priority task.
 - VO@ASTRON pilot project (M.Sipior, sipior@astron.nl) to open access to ASTRON/LOFAR data collections,
 - ADP project (R.F.Pizzo, pizzo@astron.nl) will satisfy DADI goals (data access, exploitation and interoperability); design to be ready by end of April 2018 (to follow implementation phase).
- LOFAR telescope can now handle (VO) triggers.
 - Responsive telescope project (J.D.Mol, [mol@astron.nl](mailto/mol@astron.nl)), part of of the Cleopatra Work Package. Delivered functionality in 2017-10-16. Further optimization will be part of follow up projects.
- Ongoing work.
 - Working out a visibility model to include WSRT archive (A.Renting, renting@astron.nl) and upload through the VO. A LOFAR data model should be developed by April 2019. Tests are ongoing . .
 - Investigate new algorithms to access and browse LOFAR metadata