

First ASTRON/LOFAR steps towards the VO standards

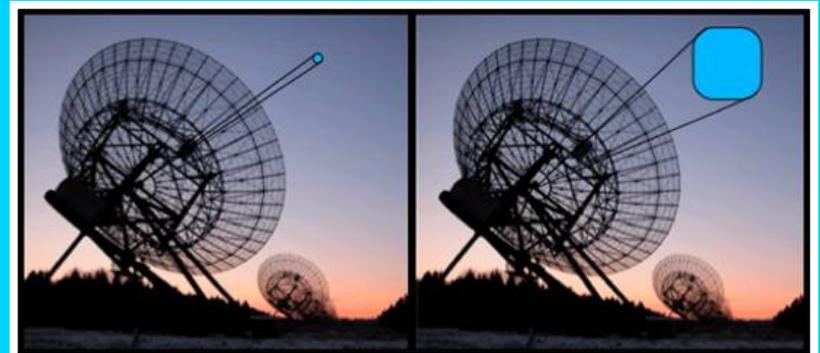
Marco Iacobelli
LOFAR telescope scientist

Trieste, December 13th 2017

ASTRON priorities & DADI



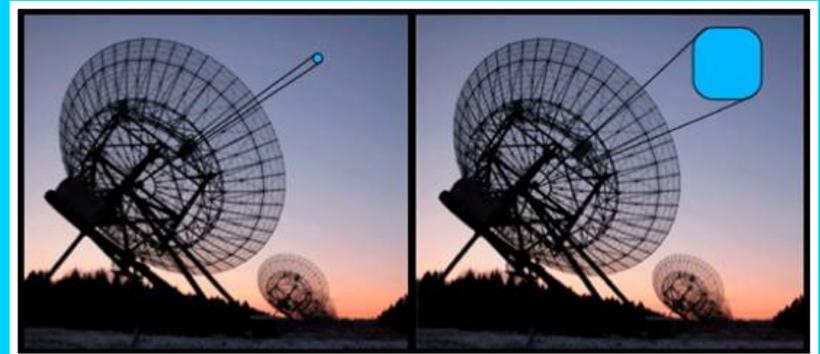
- The Netherlands Institute for Radio Astronomy is an institute of the Netherlands Organisation for Scientific Research (NWO).
- Overall priorities:
 - International LOFAR Telescope (SKA pathfinder),
 - SKA (leading role in technology, science & policy),
 - APERTIF project
 - Maximise scientific return



ASTRON priorities & DADI



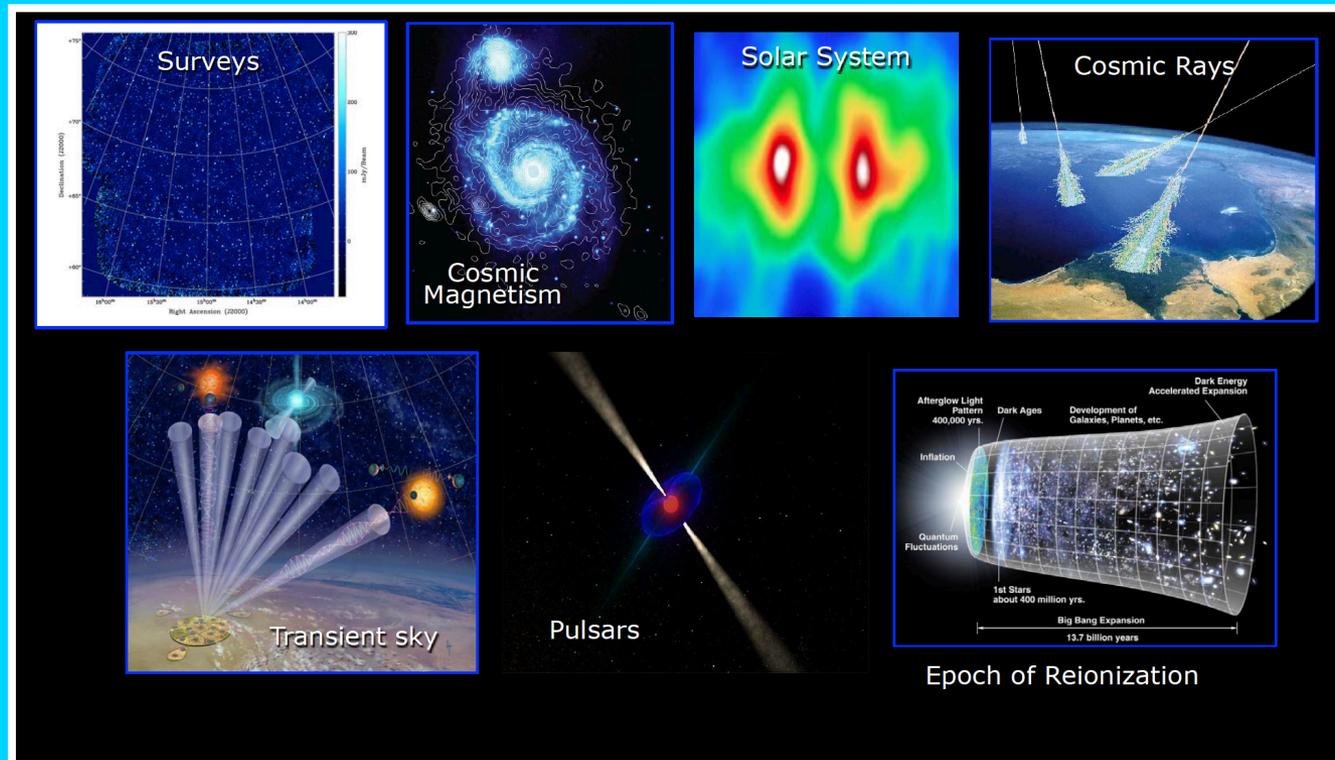
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ASTRON data collections



- 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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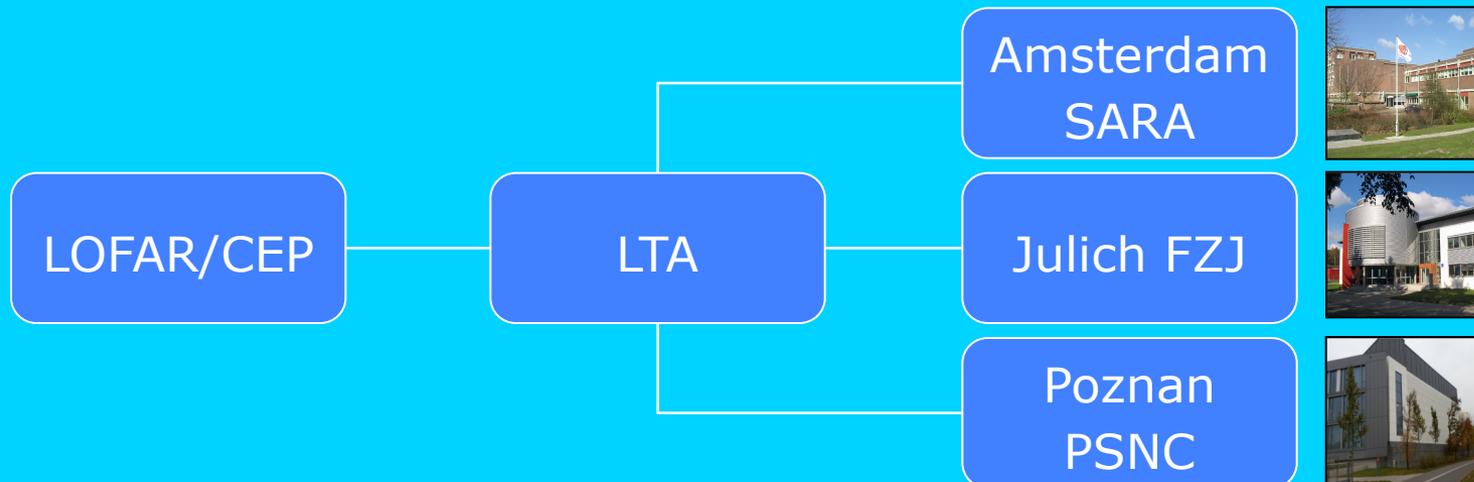


- LOFAR data collection: the world largest astronomical data collection with 31PB!
 - >1 billion of files / >6 millions of data products.

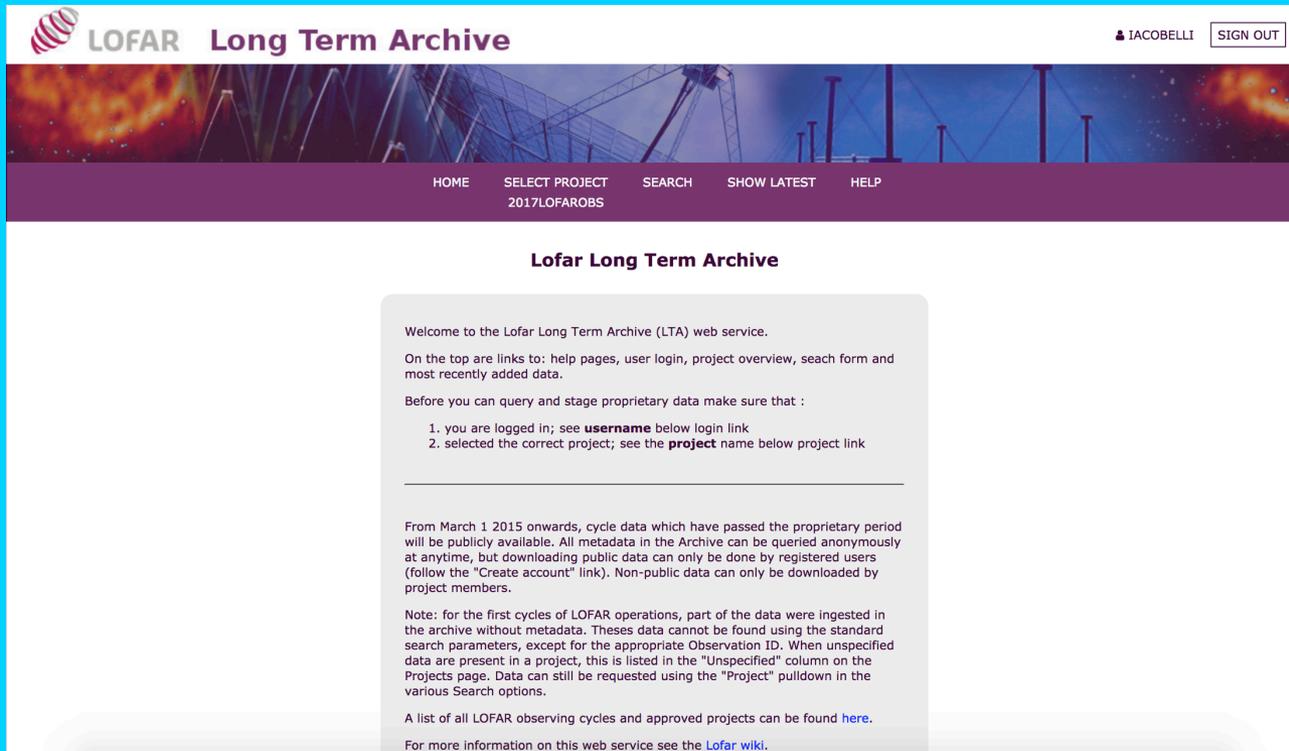
ASTRON data collections



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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.



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



The screenshot shows the Lofar Long Term Archive (LTA) web service interface. At the top, there is a header with the Lofar logo and the text "LOFAR Long Term Archive". On the right side of the header, there is a user profile icon for "IACOBELLI" and a "SIGN OUT" button. Below the header is a navigation bar with links for "HOME", "SELECT PROJECT", "SEARCH", "SHOW LATEST", and "HELP". The main content area is titled "Lofar Long Term Archive" and contains a welcome message and instructions for using the service. The text includes a list of steps for logging in and selecting a project, and a note about data availability and search options.

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

On the top are links to: help pages, user login, project overview, search 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.

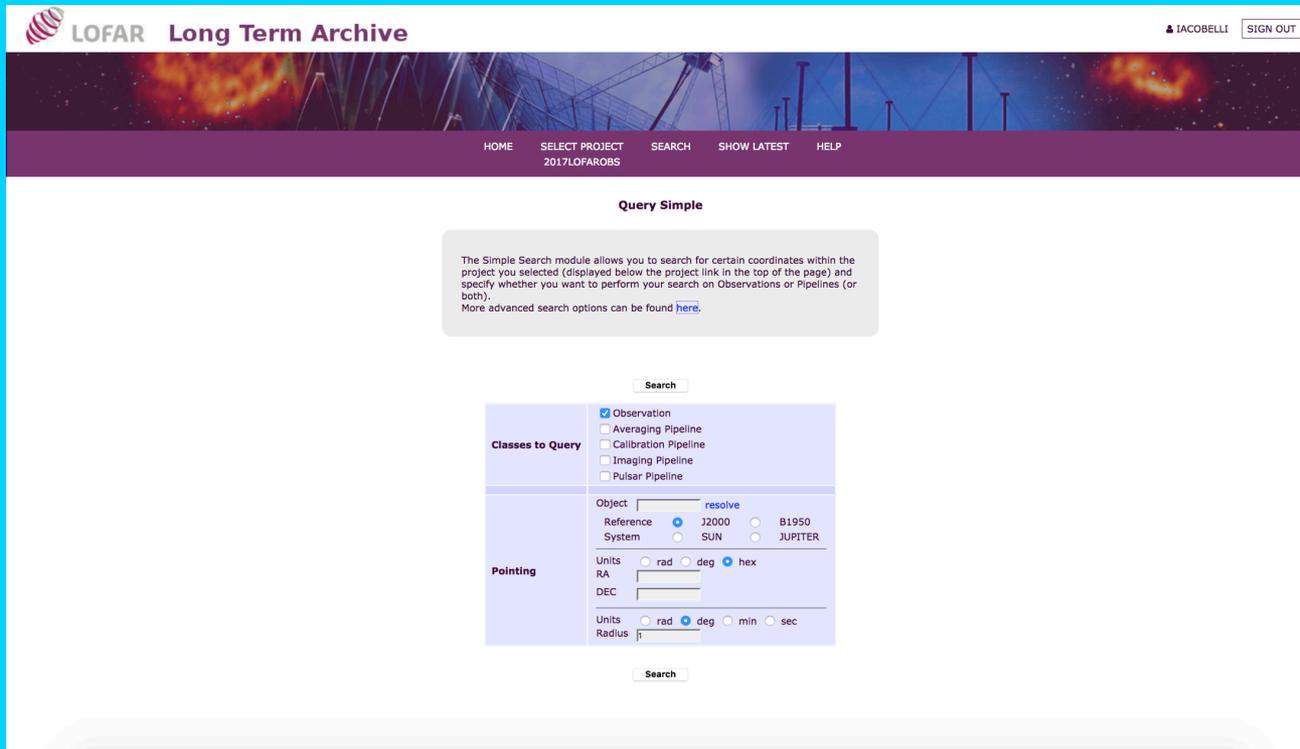
Note: for the first cycles of LOFAR operations, part of the data were ingested in the archive without metadata. These data cannot be found using the standard search parameters, except for the appropriate Observation ID. When unspecified data are present in a project, this is listed in the "Unspecified" 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

- 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

Help

Service info

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.

Metadata

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

Description Field size in decimal degrees (e.g., 0.2 or 1,0.1)

Keywords

Creator

Created

Data updated

Source

Reference URL

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

Limit to items.

Output format

[Try ADQL to query our data.](#)

Please report errors and problems to the [site operators](#). Thanks.

[Privacy](#) | [Disclaimer](#)

[Log in](#)



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...

- [LBGS Calibrator Search](#) [i](#) [q](#)
LBGS Calibrator Search
- [LOFARTIER 1 Image Archive](#) [i](#) [q](#)
The LOFAR HBA Tier-1 preliminary data release contains images and catalogs that characterise the low-frequency radio emission in the region of the HETDEX Spring Field. In excess of 40,000 sources are detected in the images that cover an area of over 350 square degrees, have a resolution of 25 arcsec, and typical noise levels of less than 0.5 mJy/beam.
- [LOFARTIER 1 Image Cutout Service](#) [i](#) [q](#)
- [LOFARTIER 1 Source Catalogue](#) [i](#) [q](#)
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M...

- [\[P\] MSSS catalogue](#) [i](#) [q](#)
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](#) [i](#) [q](#)
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- [MSSS Verification Field Images](#) [i](#) [q](#)
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](#) [i](#) [q](#)
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](#) [i](#) [q](#)
Download the TGSS Alternative Data Release mosaic images (5 deg square mosaics).
- [TGSSADR Image Cutout Service](#) [i](#) [q](#)
Download the TGSS Alternative Data Release image cutouts (up to 1 deg square).
- [TGSSADR Source Catalogue](#) [i](#) [q](#)
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.

LOFAR MSSS Verification Field Images

Parameters

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

Result

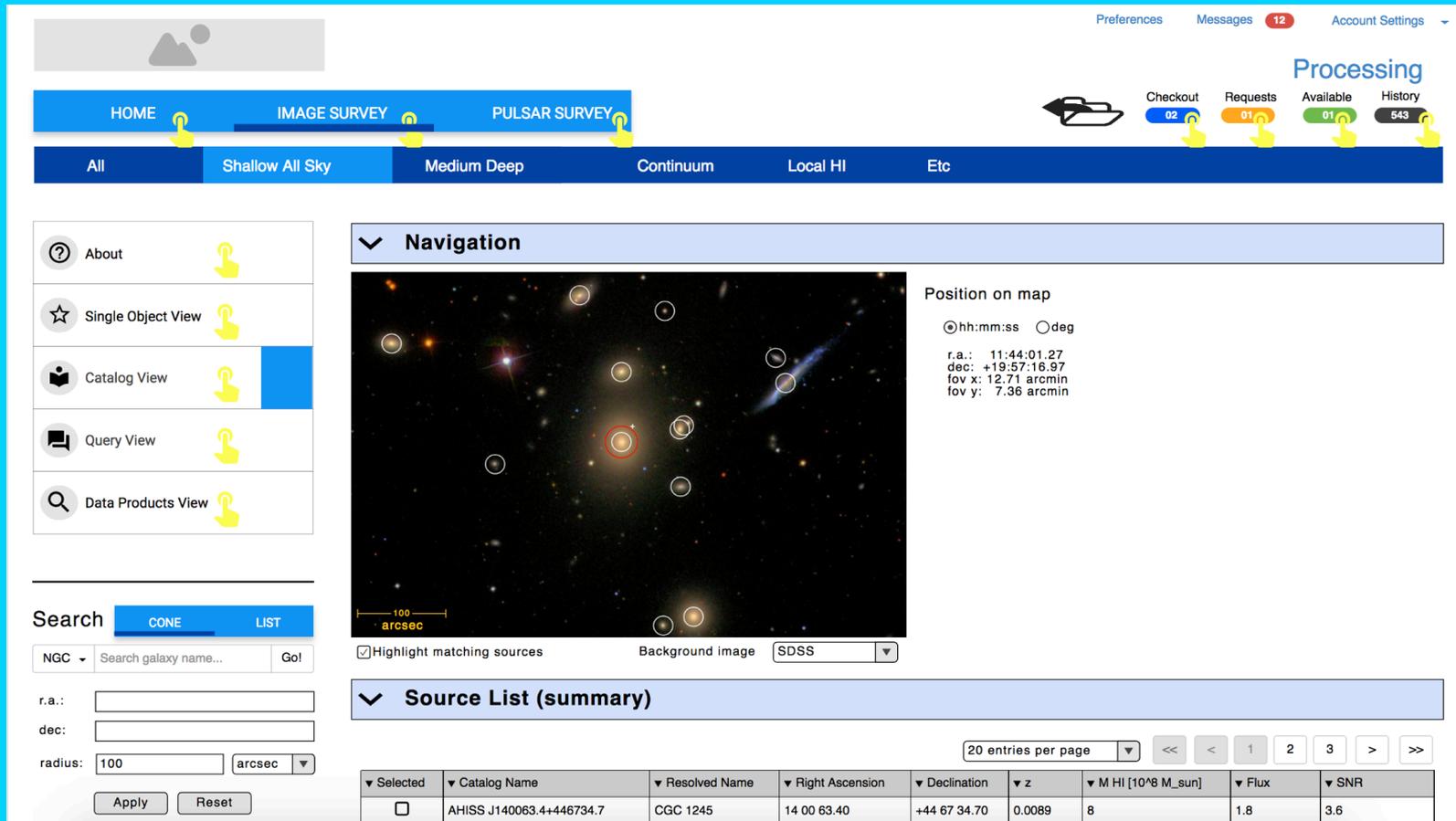
Matched: 18

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 [yr]	Proj.	Ref. pixel [pix]	Ref. values [deg]	CD matrix [deg/pix]	Bandpass	Bandpass unit	Band Ref. [m]	Band lower [m]	Band upper [m]	P. Flags	Coverage [deg]	Obs. Freq.
MSSSVF-HBA-averaged_map_sub.fits	N/A	N/A	image/fits	12.4MIB	225.01	69.00	MSSSVF-HBA-averaged_map_sub	LOFAR	N/A	4	[1799, 1799, 1, 1]	[0.005556, 0.005556]	ICRS	N/A	SIN	[900.0, 900.0]	[225.0, 69.0]	[-0.005556, 0.0, 0.0, 0.005556]	N/A	m	N/A	N/A	N/A	N/A	Polygon ICRS 236.2812401563 63.536321454 242.6341526395 73.2755034328 207.3658473605 73.2755034328 213.7187598437 63.536321454	HBA Average
MSSSVF-HBA-mosaic:band0_sub.fits	N/A	N/A	image/fits	12.4MIB	225.01	69.00	MSSSVF-HBA-mosaic-band0_sub	LOFAR	N/A	4	[1799, 1799, 1, 1]	[0.005556, 0.005556]	ICRS	N/A	SIN	[900.0, 900.0]	[225.0, 69.0]	[-0.005556, 0.0, 0.0, 0.005556]	N/A	m	N/A	N/A	N/A	N/A	Polygon ICRS 236.2812401563 63.536321454 242.6341526395 73.2755034328 207.3658473605 73.2755034328 213.7187598437 63.536321454	120 MHz
MSSSVF-HBA-mosaic:band1_sub.fits	N/A	N/A	image/fits	12.4MIB	225.01	69.00	MSSSVF-HBA-mosaic-band1_sub	LOFAR	N/A	4	[1799, 1799, 1, 1]	[0.005556, 0.005556]	ICRS	N/A	SIN	[900.0, 900.0]	[225.0, 69.0]	[-0.005556, 0.0, 0.0, 0.005556]	N/A	m	N/A	N/A	N/A	N/A	Polygon ICRS 236.2812401563 63.536321454 242.6341526395 73.2755034328 207.3658473605 73.2755034328 213.7187598437 63.536321454	125 MHz

- 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).

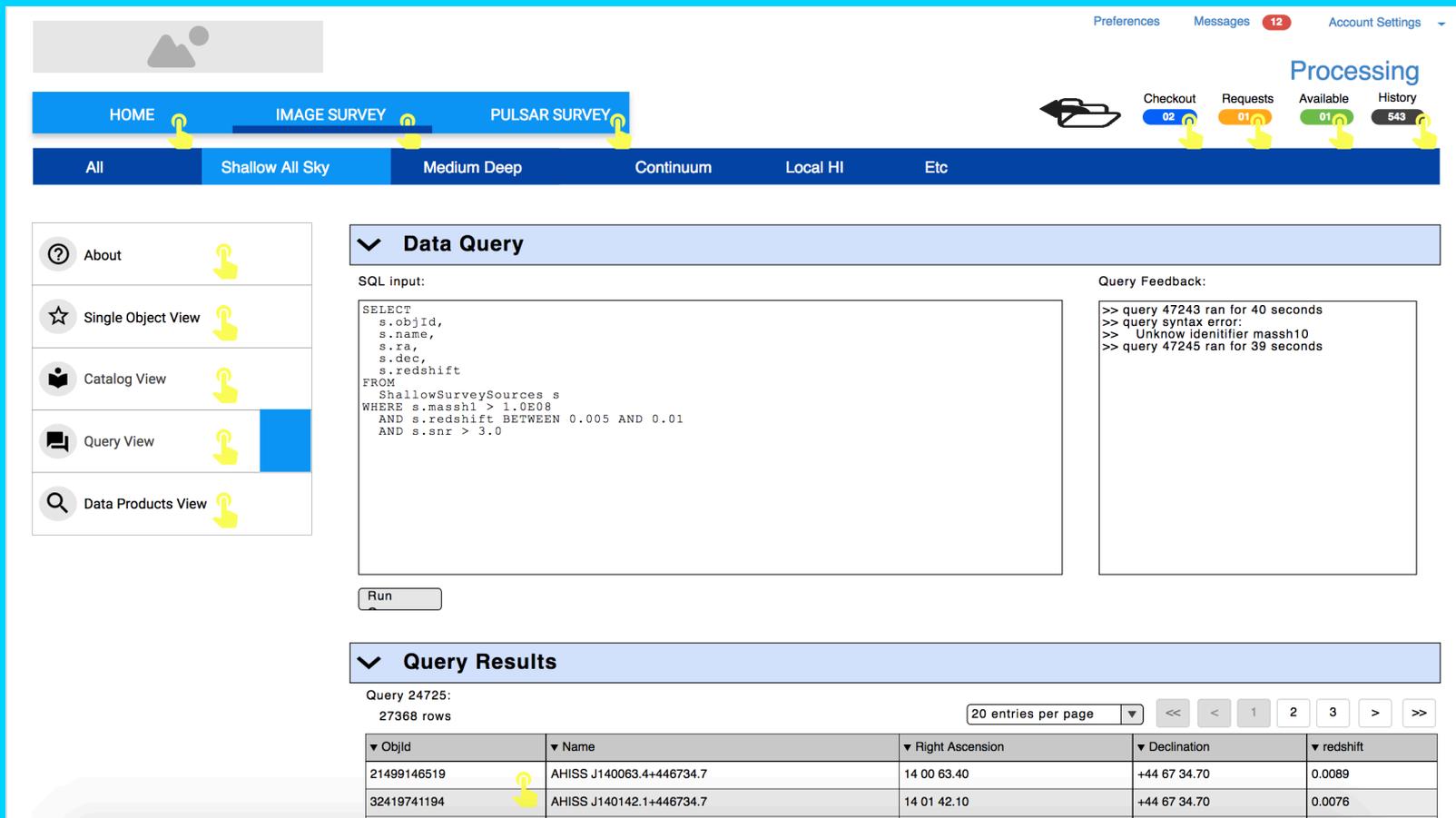
- Status of the project: system design / system requirements specification.
 - Design inspired by the ALTA (in progress) and ESA Sky 2.0 portals



The screenshot displays the ASTRON Data Portal interface. At the top right, there are links for Preferences, Messages (12), and Account Settings. Below this is a 'Processing' status bar with 'Checkout' (02), 'Requests' (01), 'Available' (01), and 'History' (543) indicators. The main navigation bar includes 'HOME', 'IMAGE SURVEY', and 'PULSAR SURVEY'. Below this is a filter bar with 'All', 'Shallow All Sky', 'Medium Deep', 'Continuum', 'Local HI', and 'Etc'. On the left, there is a sidebar with 'About', 'Single Object View', 'Catalog View', 'Query View', and 'Data Products View'. The main content area features a 'Navigation' section with a star map and 'Position on map' details: r.a.: 11:44:01.27, dec: +19:57:16.97, fov x: 12.71 arcmin, fov y: 7.36 arcmin. Below the map is a search bar with 'CONE' and 'LIST' tabs, and a search input field. The 'Source List (summary)' section shows a table with 20 entries per page.

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

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The screenshot displays the ASTRON Data Portal interface. At the top right, there are links for 'Preferences', 'Messages' (with a red notification badge showing '12'), and 'Account Settings'. Below this is a 'Processing' section with a folder icon and four status indicators: 'Checkout' (02), 'Requests' (01), 'Available' (01), and 'History' (543). The main navigation bar includes 'HOME', 'IMAGE SURVEY', and 'PULSAR SURVEY'. Below this is a filter bar with 'All', 'Shallow All Sky', 'Medium Deep', 'Continuum', 'Local HI', and 'Etc'. On the left, a sidebar contains navigation options: 'About', 'Single Object View', 'Catalog View', 'Query View', and 'Data Products View'. The central area is titled 'Data Query' and shows an SQL input field with the following query:

```
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
```

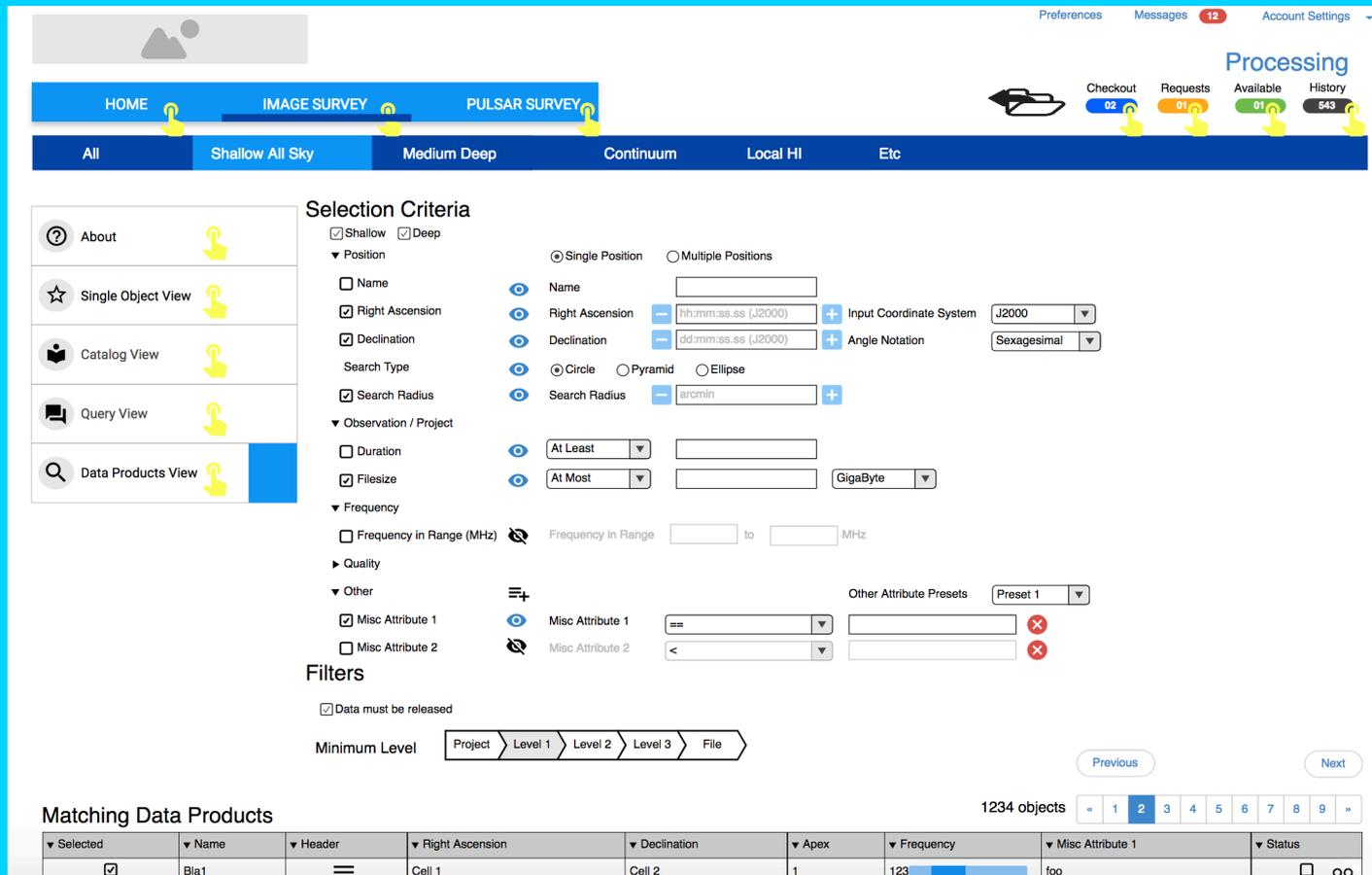
Below the SQL input is a 'Run' button. To the right, the 'Query Feedback' section shows the execution results:

```
>> query 47243 ran for 40 seconds
>> query syntax error:
>>   Unknow identifier massh10
>> query 47245 ran for 39 seconds
```

Below the feedback is the 'Query Results' section, showing 'Query 24725: 27368 rows'. It includes a pagination control set to '20 entries per page' and a table of results:

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

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The screenshot displays the ASTRON Data Portal interface. At the top, there are navigation tabs for HOME, IMAGE SURVEY, and PULSAR SURVEY. Below these are sub-tabs for All, Shallow All Sky, Medium Deep, Continuum, Local HI, and Etc. The main content area is titled "Selection Criteria" and includes various search options such as Position (Shallow/Deep), Name, Right Ascension, Declination, Search Type (Circle, Pyramid, Ellipse), Search Radius, Observation / Project (Duration, Filesize), Frequency (Frequency in Range), and Other (Misc Attribute 1, Misc Attribute 2). There are also "Filters" and "Matching Data Products" sections. The "Matching Data Products" section shows a table with columns for Selected, Name, Header, Right Ascension, Declination, Apex, Frequency, Misc Attribute 1, and Status. The table contains one row with the name "Bla1" and status "foo".

Processing: Checkout 02, Requests 01, Available 01, History 543

Selection Criteria

- Shallow Deep
- Position
 - Name
 - Right Ascension
 - Declination
- Search Type
 - Circle Pyramid Ellipse
- Search Radius: arcmin
- Observation / Project
 - Duration
 - Filesize
- Frequency
 - Frequency in Range (MHz)
- Other
 - Misc Attribute 1
 - Misc Attribute 2

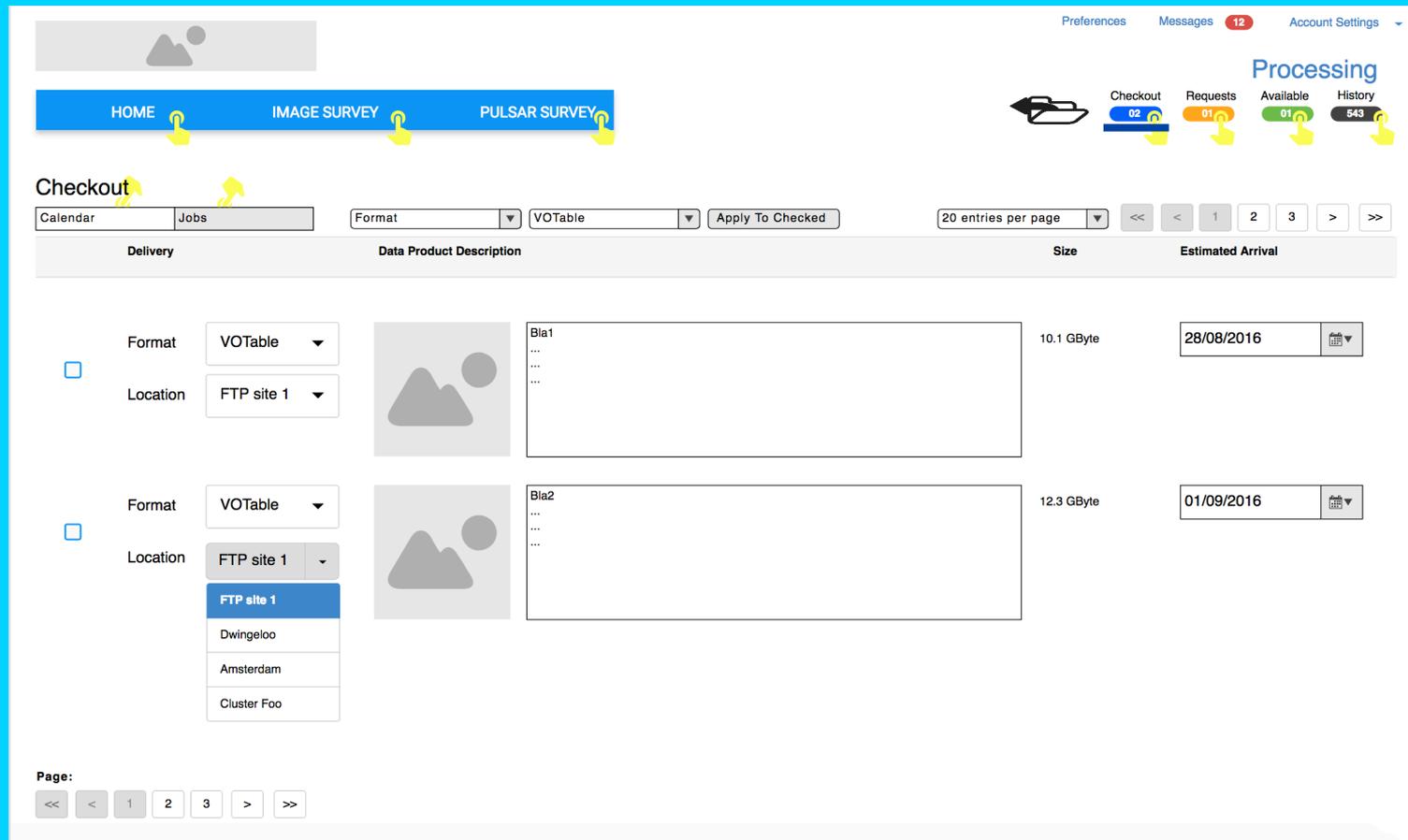
Filters

- Data must be released
- Minimum Level: Project > Level 1 > Level 2 > Level 3 > File

Matching Data Products

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

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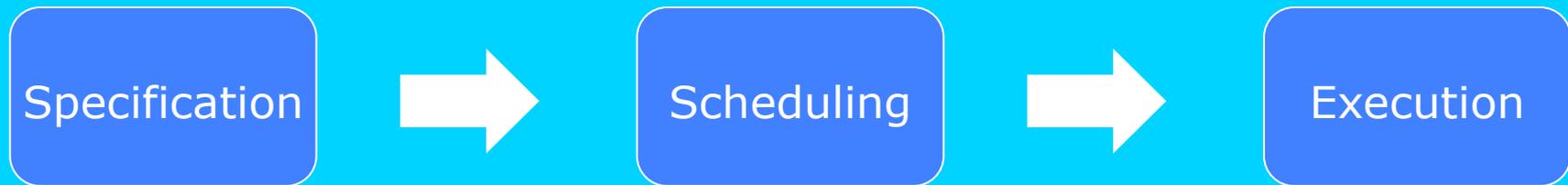
Delivery	Data Product Description	Size	Estimated Arrival
<input type="checkbox"/>	Format: VOTable Location: FTP site 1 Description: Bla1	10.1 GByte	28/08/2016
<input type="checkbox"/>	Format: VOTable Location: FTP site 1 Description: Bla2	12.3 GByte	01/09/2016

At the bottom, there is a 'Page:' section with navigation controls for page 1, 2, and 3.

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 become 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), 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