



# ASTRON

Netherlands Institute for Radio Astronomy

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# ARTS DR1

Bringing FRB data to the VO

Yan Grange

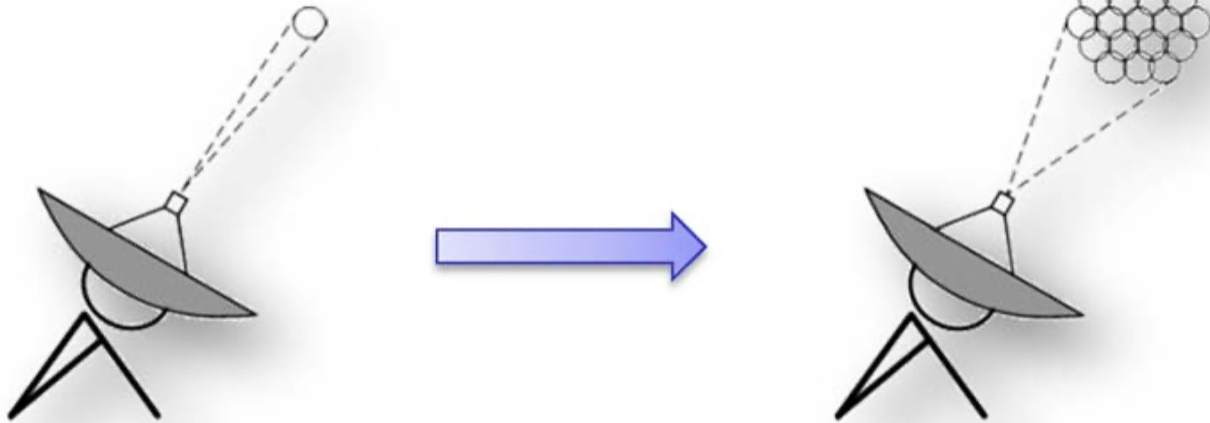
*(many people involved! Notably: Mattia Mancini, Emanuella Orru', Hanno Holties, Joeri van Leeuwen, Leon Oostrum, also lots of input from Markus and Baptiste)*

IVOA May interop 2011



# Apertif, Phased Array Feeds for the WSRT

- Transform the WSRT into an efficient 21-cm survey facility
  - 17x Survey speed increase
  - SKA Pathfinder



# ARTS



Image courtesy: Joeri van Leeuwen

# ARTS - system

The Apertif Radio Transient System (ARTS) is:

Real-time system:

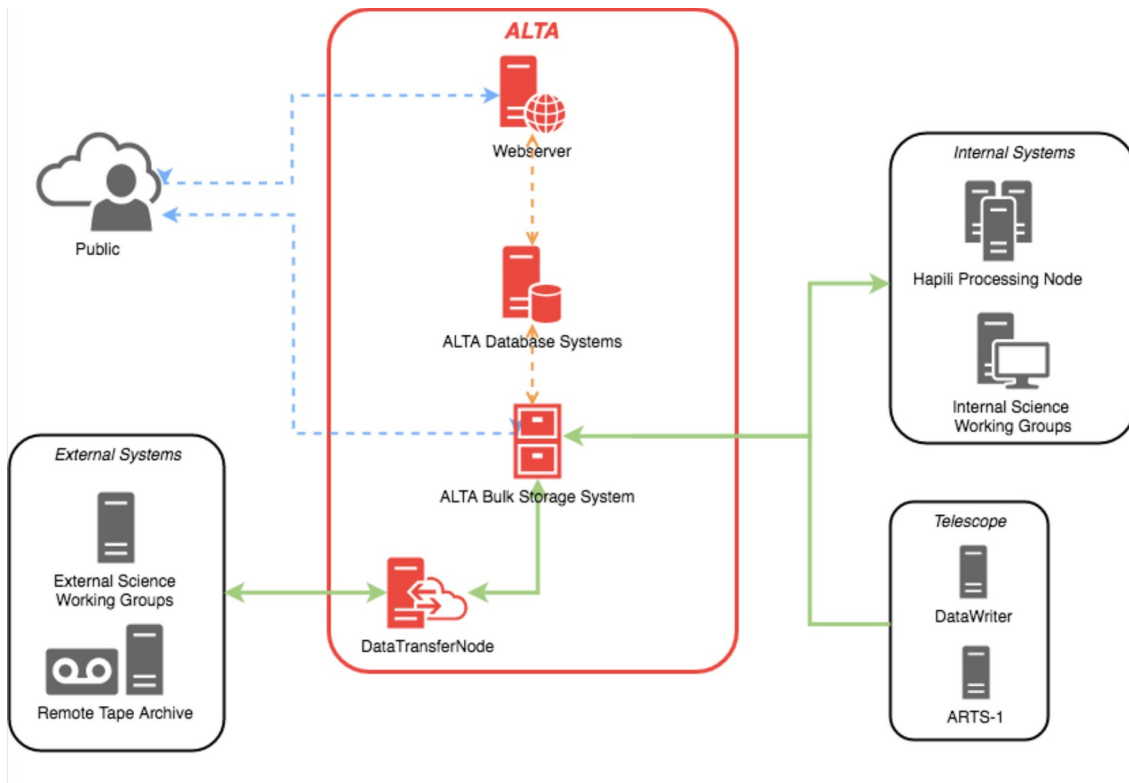
- Hybrid supercomputer (2019 Top 100 Equiv.) of
  - Two FPGA-based beam formers
  - GPU cluster

*Sclocco et al. 2016; @Yogesh Maan & van Leeuwen 2017*



# ALTA – the Apertif Long-Term Archive

- ALTA is the main source of Apertif data.

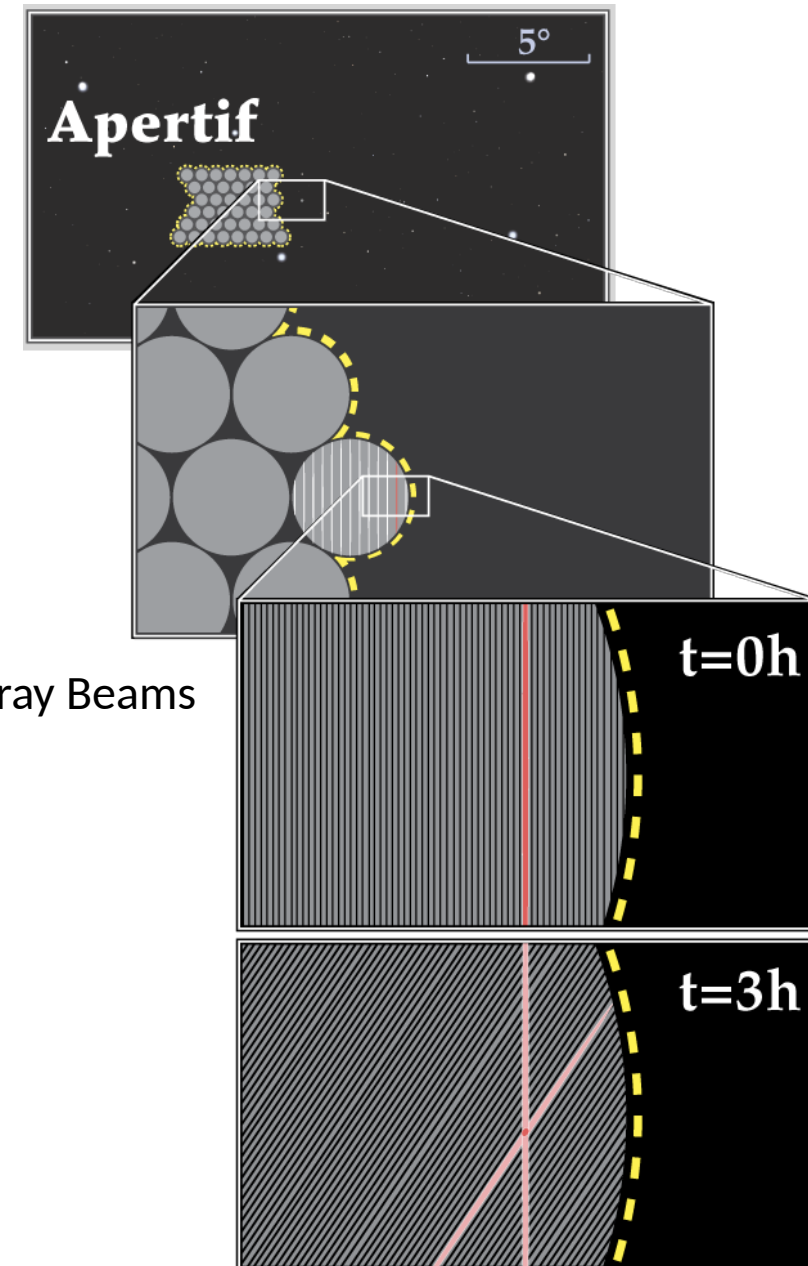
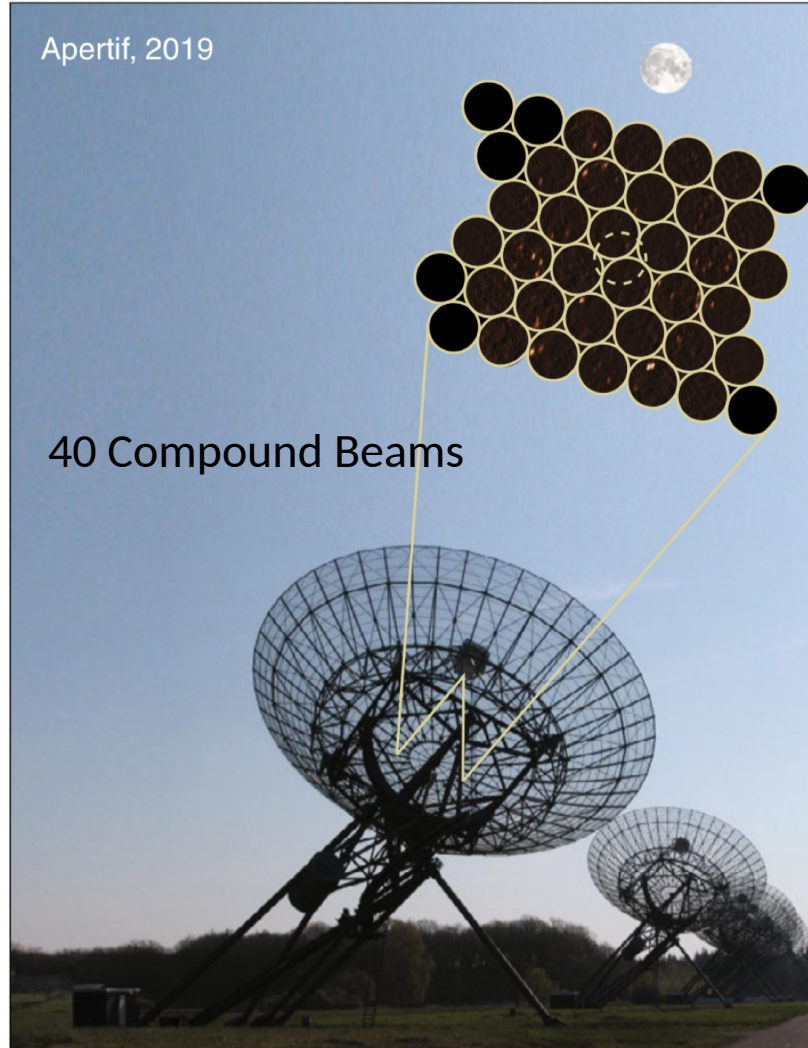


- ASTRON (Dwingeloo): Online storage (including 'nearline' object store)
- SURFsara (Amsterdam): Offline storage (including online cache & staging)
- Using IRODS for internal data management



ASTRON Astron Help Center  
Radio Observatory Helpdesk

# ARTS - beams



# ARTS - Survey strategy

*Detection -localization -characterization*

## **Field priorities:**

(a) Known fields for localization + new detections

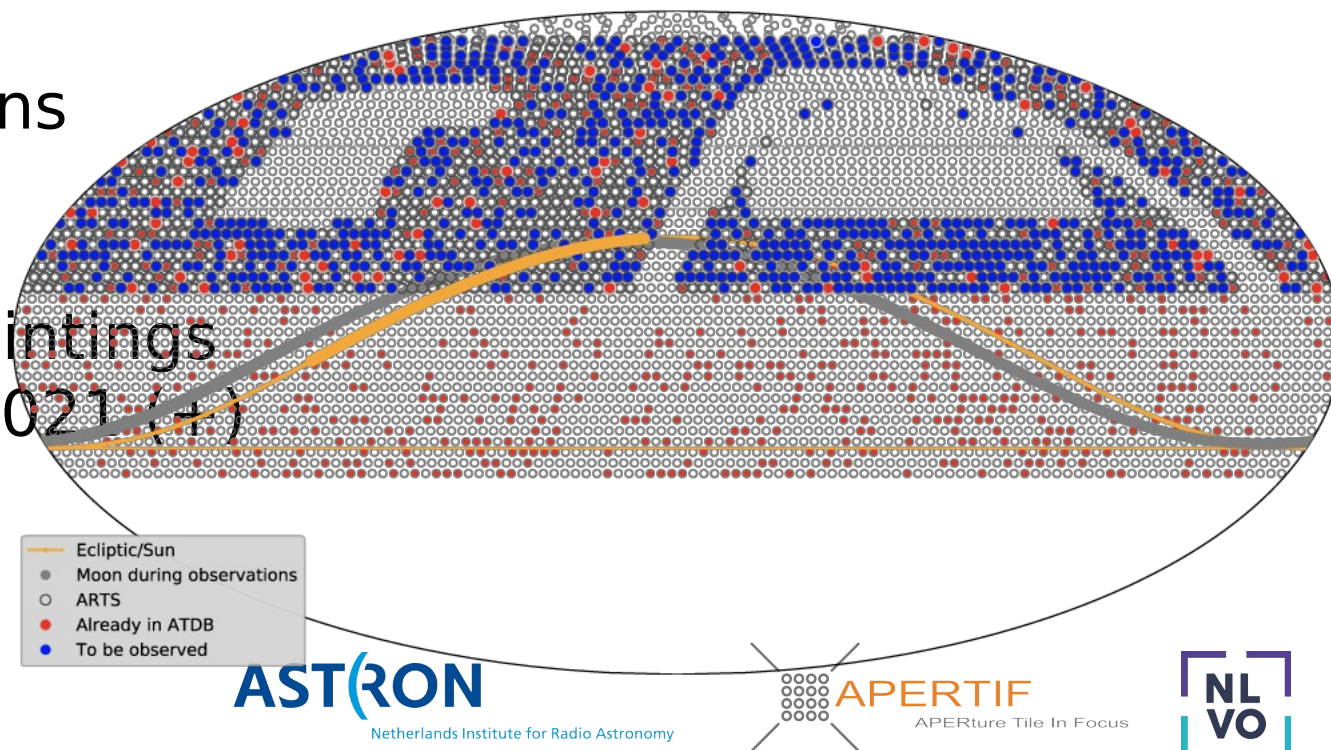
(b) Known fields for characterization + new detections

(c) Blank fields for new detections

1 week on, 4 weeks off ; 3 hr pointings

Operation 2 (+) years, 2019 .. 2021 (+)

DR1 only covers the 2019 data.







# ARTS DR1

- Apertif detecting 1 FRB every 5 days of observing.
  - Over 20 one-off FRBs discovered so-far, with good localization.
- DR1 covers all data of 2019, June – Dec; preliminary numbers:
  - ~23k observation files
    - Each is a timing observation of one pointing (i.e. one tied array beam and compound beam combination).
  - ~1k files from detections
  - For each observation:
    - 40 CB
    - 12 TAB
    - So max 480 files per sky scan.
  - Format: PSRFITS

# Data access

Data and instrument metadata in the Apertif Long-Term Archive (ALTA)

- ALTA design was based on VO standards to ease data releases through VO (and because standards have been thought through)
- Data owners would like to be able to see a table of only detections, but also all observations go in a table for obscure.
  - one table is a view :)
- psrfits format
- Detections on disk 
- non-detections on tape 

## Services available here

By Title By Subject By Author

- ▶ [FRB detection cone search](#)  
- ▶ [FRB observation cone search](#)  

# VO table creation

- Since most data is on tape, and staging all of it is just no option, need obtain data from (postgres) DB dump (joining csv files using pandas...)
  - Some values not in db, but are constant over files
  - Number of time steps computed based on duration and fixed time resolution
- FRB field set up their own global catalogue(s) of events ( [frbcat.org](http://frbcat.org) / [wis-tns.weizmann.ac.il/](http://wis-tns.weizmann.ac.il/) ). So little interest in actual physical parameters through VO (the 'source catalog').
- Thanks a lot **Baptiste** and **Markus** for discussions <sup>^^</sup>

[Help](#)[Service info](#)

## Metadata

## Identifier

ivo://ASTRONSDCv/arts.

## Cite this

[Advice on citing this res](#)

## Description

This service provides th

## Keywords

sky-surveys

## Creator

Joeri et al

## Created

2021-03-03T13:38:11Z

## Data updated

2021-04-29

## Copyright

ARTS DR1 is licensed ur

## Source

## Reference URL

[Service info](#)[Try ADQL](#) to query our data.[Privacy](#) | [Disclaimer](#)[Log out vobev](#) (give an empty user name in the dialog popping up)

This service provides the FRB catalog cone search.

Position/Name

*Coordinates (as h m s, d m s or decimal degrees), or SIMBAD-resolvable object*

Search radius

*Search radius in arcminutes*

Target Name

*Name of the target. Matches also partial input (e.g. T1403+5324 or 1403+5324).*

Observation

[\[?date expr.\]](#)

start time

Compound  
Beam

No selection matches all, multiple values legal.

Tied Array  
Beam

No selection matches all, multiple values legal.

Detection

 Yes No

Table

Sort by

Dist.



ASC



Limit to

100



items.

Output  
format

HTML

[More output fields](#)ARTS DR1 is licensed under the [Creative Commons Attribution 3.0 License](#)[/static/img/ccby.png](#)Please report errors and problems to the [site operators](#). Thanks.

Help

Service info

## Result

Matched: 100

Send via SAMP

Quick Plot

The query limit was reached. Increase it to retrieve more matches. Note that unsorted truncated queries are not reproducible (i.e., might return a different result set at a later time).

Metadata

Identifier  
ivo://ASTRONSDCv/arts.

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Dist. [arcsec]	Observation target	Right ascension [deg]	Declination [deg]	Observation start time	Observation end time	Detection	Observation Title	Dataset ID	Compound Beam	Tied Array time Beam [s]	Exposure	Number of time bins	File size [kbyte]	PSRFITS file
N/A	3C147drift3339	345.849	49.4672	2019-10-01T03:23:35Z	2019-10-01T03:52:29Z		ARTS191001007_CB28_TAB05	191001007	28	5	1734.0	832054	51220	<a href="#">psrfitsaccess</a>
N/A	3C147drift3339	345.849	49.4672	2019-10-01T03:23:35Z	2019-10-01T03:52:29Z		ARTS191001007_CB28_TAB04	191001007	28	4	1734.0	832054	51220	<a href="#">psrfitsaccess</a>
N/A	3C147drift3339	345.849	49.4672	2019-10-01T03:23:35Z	2019-10-01T03:52:29Z		ARTS191001007_CB28_TAB02	191001007	28	2	1734.0	832054	51220	<a href="#">psrfitsaccess</a>
N/A	3C147drift3339	345.849	49.4672	2019-10-01T03:23:35Z	2019-10-01T03:52:29Z		ARTS191001007_CB28_TAB00	191001007	28	0	1734.0	832054	51220	<a href="#">psrfitsaccess</a>
N/A	3C147drift3339	346.569	49.4594	2019-10-01T03:23:35Z	2019-10-01T03:52:29Z		ARTS191001007_CB27_TAB07	191001007	27	7	1734.0	832054	51220	<a href="#">psrfitsaccess</a>
N/A	3C147drift3339	346.569	49.4594	2019-10-01T03:23:35Z	2019-10-01T03:52:29Z		ARTS191001007_CB27_TAB08	191001007	27	8	1734.0	832054	51220	<a href="#">psrfitsaccess</a>
N/A	3C147drift3339	346.569	49.4594	2019-10-01T03:23:35Z	2019-10-01T03:52:29Z		ARTS191001007_CB27_TAB03	191001007	27	3	1734.0	832054	51220	<a href="#">psrfitsaccess</a>
N/A	3C147drift3339	346.569	49.4594	2019-10-01T03:23:35Z	2019-10-01T03:52:29Z		ARTS191001007_CB27_TAB04	191001007	27	4	1734.0	832054	51220	<a href="#">psrfitsaccess</a>
N/A	3C147drift3339	346.569	49.4594	2019-10-01T03:23:35Z	2019-10-01T03:52:29Z		ARTS191001007_CB27_TAB05	191001007	27	5	1734.0	832054	51220	<a href="#">psrfitsaccess</a>
N/A	3C147drift3339	346.569	49.4594	2019-10-01T03:23:35Z	2019-10-01T03:52:29Z		ARTS191001007_CB27_TAB11	191001007	27	11	1734.0	832054	51220	<a href="#">psrfitsaccess</a>
N/A	3C147drift3339	346.569	49.4594	2019-10-01T03:23:35Z	2019-10-01T03:52:29Z		ARTS191001007_CB27_TAB10	191001007	27	10	1734.0	832054	51220	<a href="#">psrfitsaccess</a>
N/A	3C147drift3339	346.569	49.4594	2019-10-01T03:23:35Z	2019-10-01T03:52:29Z		ARTS191001007_CB27_TAB06	191001007	27	6	1734.0	832054	51220	<a href="#">psrfitsaccess</a>
N/A	3C147drift3339	346.569	49.4594	2019-10-01T03:23:35Z	2019-10-01T03:52:29Z		ARTS191001007_CB27_TAB02	191001007	27	2	1734.0	832054	51220	<a href="#">psrfitsaccess</a>
N/A	3C147drift3339	346.569	49.4594	2019-10-01T03:23:35Z	2019-10-01T03:52:29Z		ARTS191001007_CB27_TAB00	191001007	27	0	1734.0	832054	51220	<a href="#">psrfitsaccess</a>
N/A	3C147drift3339	346.569	49.4594	2019-10-01T03:23:35Z	2019-10-01T03:52:29Z		ARTS191001007_CB27_TAB01	191001007	27	1	1734.0	832054	51220	<a href="#">psrfitsaccess</a>
N/A	3C147drift3339	346.569	49.4594	2019-10-01T03:23:35Z	2019-10-01T03:52:29Z		ARTS191001007_CB27_TAB09	191001007	27	9	1734.0	832054	51220	<a href="#">psrfitsaccess</a>
N/A	3C147drift0814	347.174	49.4538	2019-11-12T00:55:13Z	2019-11-12T01:24:06Z	✓	ARTS191112003_CB07_TAB00	191112003	7	0	1734.0	832054	51220	<a href="#">ARTS191112003_CB07_TAB00.fits</a>
N/A	3C147drift0814	347.174	49.4538	2019-11-12T00:55:13Z	2019-11-12T01:24:06Z	✓	ARTS191112003_CB07_TAB06	191112003	7	6	1734.0	832054	51220	<a href="#">ARTS191112003_CB07_TAB06.fits</a>
N/A	3C147drift0814	347.174	49.4538	2019-11-12T00:55:13Z	2019-11-12T01:24:06Z	✓	ARTS191112003_CB07_TAB10	191112003	7	10	1734.0	832054	51220	<a href="#">ARTS191112003_CB07_TAB10.fits</a>
N/A	3C147drift0814	347.174	49.4538	2019-11-12T00:55:13Z	2019-11-12T01:24:06Z	✓	ARTS191112003_CB07_TAB11	191112003	7	11	1734.0	832054	51220	<a href="#">ARTS191112003_CB07_TAB11.fits</a>
N/A	3C147drift0814	347.174	49.4538	2019-11-12T00:55:13Z	2019-11-12T01:24:06Z	✓	ARTS191112003_CB07_TAB08	191112003	7	8	1734.0	832054	51220	<a href="#">ARTS191112003_CB07_TAB08.fits</a>
N/A	3C147drift0814	347.174	49.4538	2019-11-12T00:55:13Z	2019-11-12T01:24:06Z	✓	ARTS191112003_CB07_TAB01	191112003	7	1	1734.0	832054	51220	<a href="#">ARTS191112003_CB07_TAB01.fits</a>
N/A	3C147drift0814	347.174	49.4538	2019-11-12T00:55:13Z	2019-11-12T01:24:06Z	✓	ARTS191112003_CB07_TAB02	191112003	7	2	1734.0	832054	51220	<a href="#">ARTS191112003_CB07_TAB02.fits</a>
N/A	3C147drift0814	347.174	49.4538	2019-11-12T00:55:13Z	2019-11-12T01:24:06Z	✓	ARTS191112003_CB07_TAB03	191112003	7	3	1734.0	832054	51220	<a href="#">ARTS191112003_CB07_TAB03.fits</a>
N/A	3C147drift0814	347.174	49.4538	2019-11-12T00:55:13Z	2019-11-12T01:24:06Z	✓	ARTS191112003_CB07_TAB04	191112003	7	4	1734.0	832054	51220	<a href="#">ARTS191112003_CB07_TAB04.fits</a>

Help

Service info

**Metadata**

Identifier

ivo://ASTRONSDCv/arts\_d

Cite this

[Advice on citing this resource](#)

Description

ARTS is cool

Keywords

sky-surveys

Creator

Joeri et al

Created

2021-03-03T13:38:11Z

Data updated

2021-04-29

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Source

Reference URL

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Listed below are the properties of the requested file

<b>File reference</b>	191001007/CB27/ARTS191001007_CB27_TAB11.fits
<b>RA</b>	346.569
<b>DEC</b>	49.4594
<b>Obs ID</b>	191001007
<b>CB</b>	27
<b>TAB</b>	11
<b>File size [kB]</b>	51220
<b>Start time</b>	2019-10-01 03:23:35.000
<b>End time</b>	2019-10-01 03:52:29.000
<b>Exposure</b>	1734.0
<b>Pub. DID</b>	ivo://ASTRONSDCv/~?ARTS_DR1/191001007/CB27/ARTS191001007_CB27_TAB11.fits

**This data product is stored on tape and not directly accessible for download. Access can be requested via the helpdesk [helpdesk](#). The request will be processed on a best effort basis.**

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

# Forward look: LoTSS DR2

Yes, this is an imaging survey (but still radio :-)) but also here we will face a lot of files that are primarily stored on tape.

- Data size is challenging even for single images
  - users using e.g. Aladin may expect to be able to download single images in finite time).
  - Cutout services probably to the rescue!
- LOFAR staging service is being renewed (by Mattia Mancini) and has a REST API
- Means that we could maybe implement it using the VO UWS standard.
- *(Also: LOTAAS -> Timing with LOFAR)*

# Discussion on parameters

*I teamed up with **Baptiste Cecconi** on this, slide is mostly aimed at starting some discussion here :).*

## Data type:

- In ALTA, dataProductType is “*timeSeries*”, dataProductSubType is “*pulsarTimingTimeSeries*”
- However this is not really appropriate since it is not really a “data presenting some quantity as a function of time”
- We propose to add **dynamic spectrum** to the dataProductType vocabulary
  - is this appropriate if the ‘time’ axis is actually phase? (or should we also have e.g. **phase spectrogram**?)
  - Could we use the same terminology for the phase spectrum of rotating asteroids
- **Non-detections** and ObsCore. Probably too specific a parameter for ObsCore itself, but maybe if we propose a radio-specific extension it may fit in?
- Also one observation is not necessarily one file. Right now our table is pretty ignorant about this. This is a general Radio issue.



# Conclusions

- We have started putting timing/transient data in the VO
- It's still a bit crude, but awesome that we can see it
- Still some work needed to convince community of the usefulness (e.g. that having a 'source catalog' as an addition to having the data in e.g. frbcat.org could be useful).
  - Partially also due to lack in apps that can handle PSRFITS from transients directly from the VO