A VO service for the European VLBI Network

Mark Kettenis

IVOA Interop, May 2021

JIVE
Joint Institute for VLBI
ERIC

ESCAPE - The European Science Cluster of Astronomy & Particle Physics ESFRI Research Infrastructures has received funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement n° 824064.

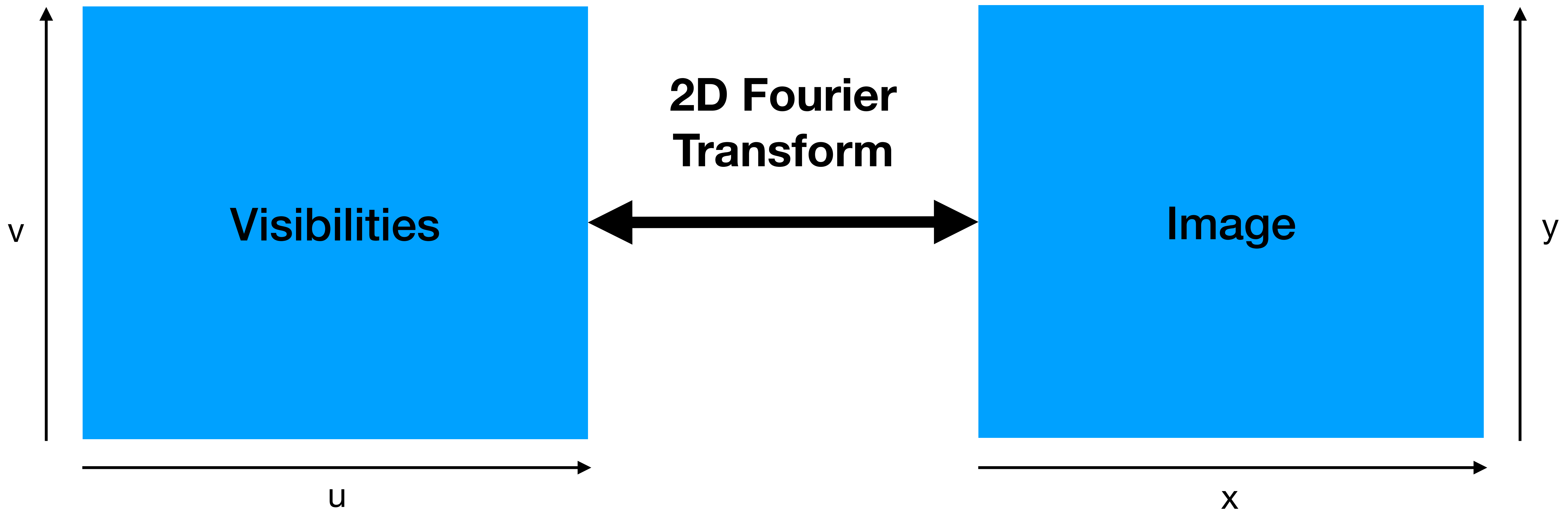
EVN & JIVE

- EVN: European VLBI Network
    - Collaboration between radio observatories in Europe and beyond (South-Africa, Puerto-Rico, China, Korea)
    - Heterogeneous array
    - PI driven
- JIVE: Joint Instutute for VLBI ERIC
    - Support institute for the EVN
    - Operates the EVN correlator and hosts the EVN data archive

Data products

- Visibility data (“UV data”; FITS-IDI)
  - No in-beam calibrators -> Multiple sources per observation
  - Continuum and spectral line data
  - Pulsar observations: multiple bins
  - MPC observations: multiple field centers
- Filterbank data (Pulsars, FRBs; PSR-FITS, not yet archived)
  - Time-series
- Calibration data
  - Flagging, amplitude calibration, observation schedule, observation logs
- Diagnostic plots (from pipeline)

Visibilities & Images



- UV plane is not completely filled
- Visibilities have to be (partly) self-calibrated
- Imaging algorithm choices depend on scientific goal

VO use case

1. Access historic data ("before picture") for high-resolution follow-up of:
    - Gravitational Wave events
    - Gamma Ray Bursts
    - Fast Radio Bursts

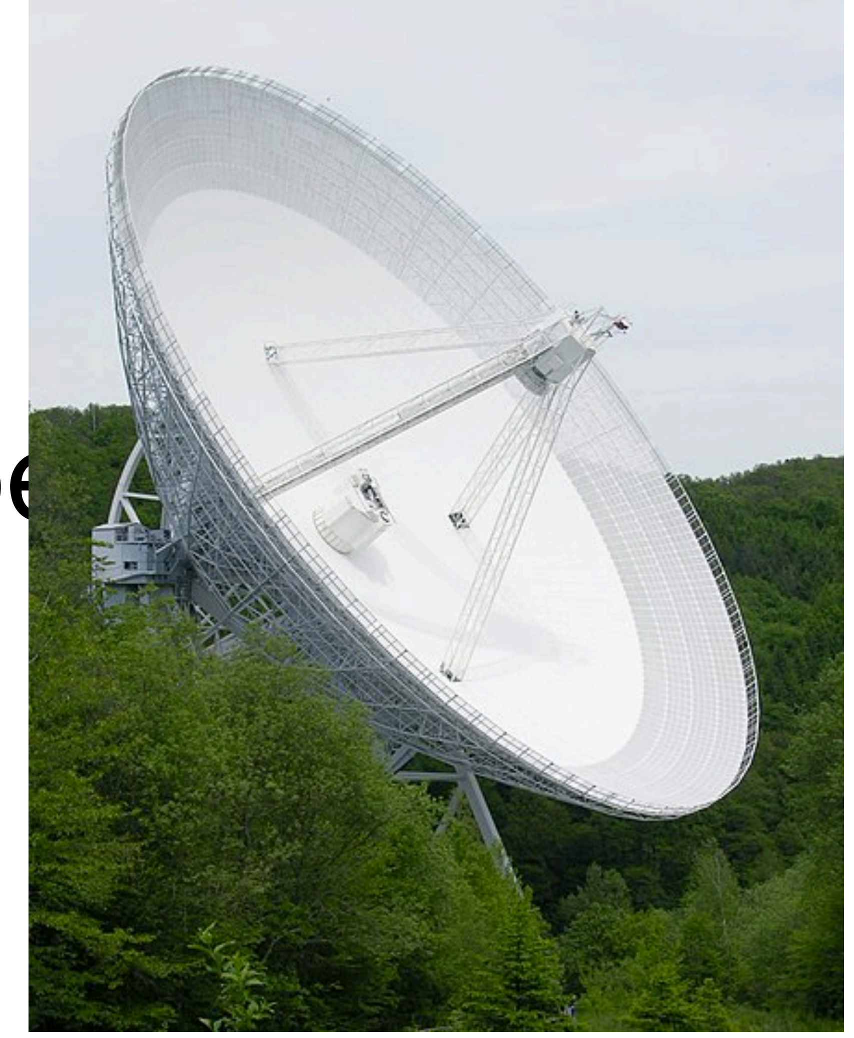
2. Standardized acces to archive data for science platform
    - JupiterLab environment

VO protocols that match: ObsTAP and Datalink

Implementation using DaCHS

- Why DaCHS?
  - Some in-house knowledge (at ASTRON)
  - Python
  - Visit by Markus (to ASTRON)
  - Implements TAP and Datalink service
- DaCHS runs alongside existing Archive interface
  - Linking to data products in Existing archive
- DaCHS ingests CSV data generated by separate Python “fitscrawler” Tool
  - FITS-IDI stores Important metadata in (large) binary tables

ObsCore representation of visibility data



- Spatial extent determined by several factors:
  - FoV of individual telescopes (in particular the largest telescope
  - Time and frequency smearing
  - Projected longest baseline (distance between telescopes)
- Approximated assuming maximal amplitude loss of 50% and ignoring projection effects

ObsCore representation of visibility data

JIVE

- **s_resolution** based on longest baseline
  - Approximation; should be based on synthesised beam (from UV coverage)
- **t_exptime** is calculated by summing integration time
  - Each source in the observation becomes separate ObsCore dataset
- **em_min** and **em_max** calculated based on minimum and maximum observed frequency
  - Dual S/X band observations should probably be split into separate ObsCore datasets

ObsCore representation of visibility data

- Multiple targets per observation
    - Multiple ObsCore “rows” with the same **access_url** and **obs_publisher_did**
- Some observations are correlated multiple times with different parameters
    - “continuum” and “spectral line” get its own **obs_publisher_did**
- MPC correlations result in multiple sets of output file
    - Each phase centre gets its own **obs_publisher_did**
- Pulsar binning/gating
    - Each bin gets its own **obs_publisher_did** (including “off-pulse” bin)
- **access_url** is a Datalink

Datalink for FITS-IDI

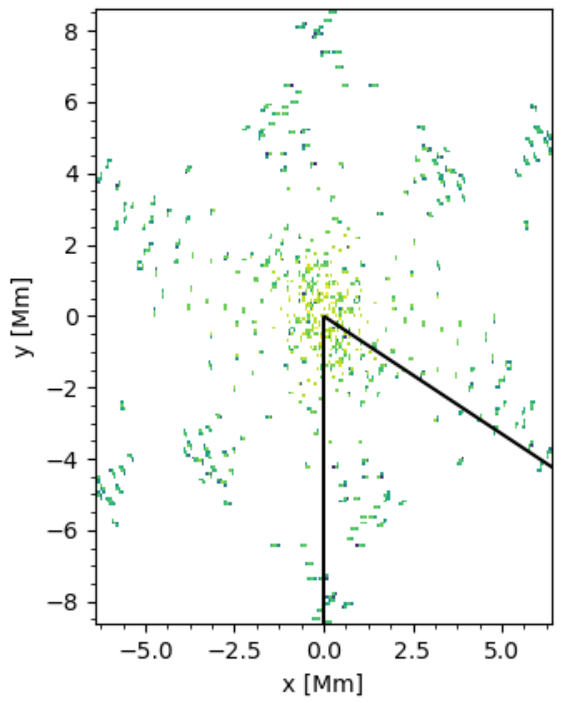
- Single observation split into several FITS-IDI files of ~2GB
  - Return Datalink table with rows for each chunk
- Calibration data will be added in the future
- Considering adding pipeline images as previews
  - These are often very rough!
- Considering adding diagnostic plots as secondary datalink

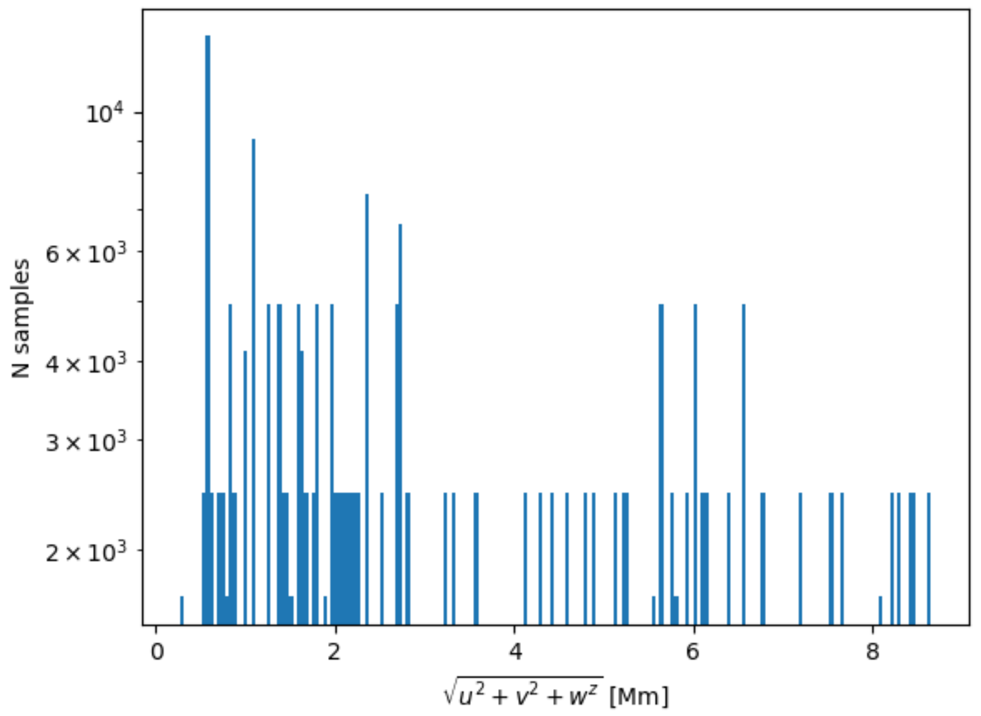
Some initial feedback

- em_min, em_max and em_res_power given in wavelengths
  - This is unatural for radio astronomy
  - Posible solution: add f_min, f_max and f_resolution?

- Datalink acess_url initially surprises users

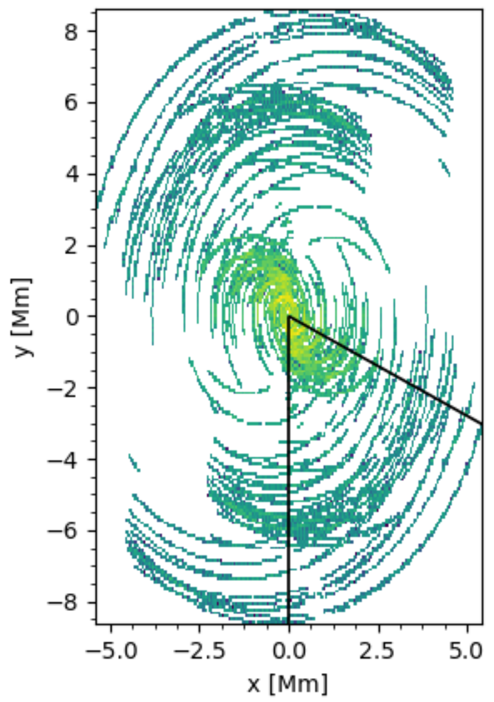
UV space characterization

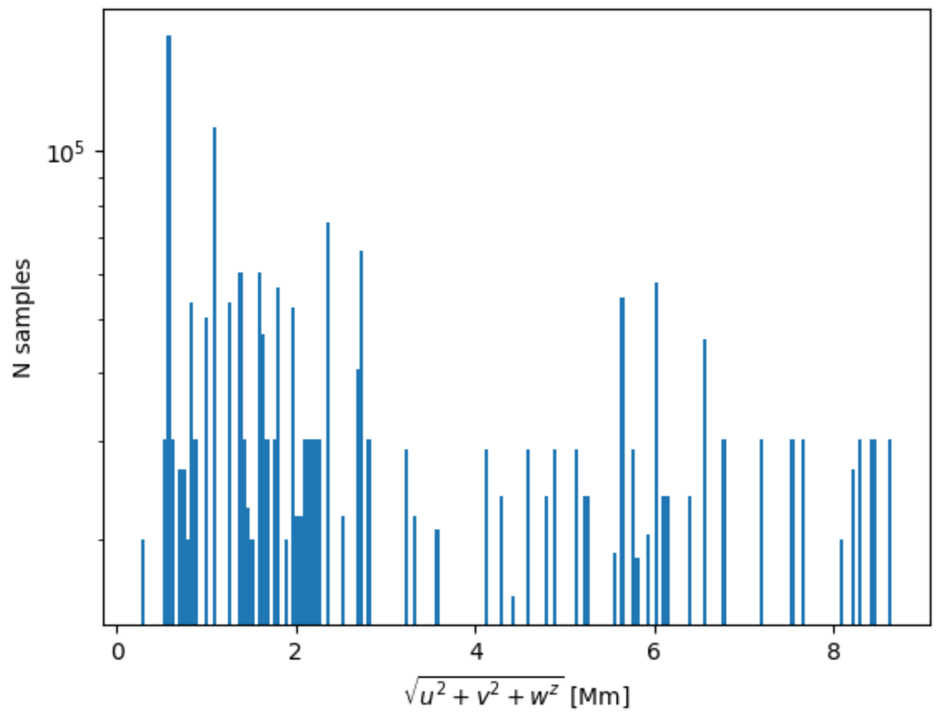




$e = 0.74$
$f = 0.03$

calibrator source

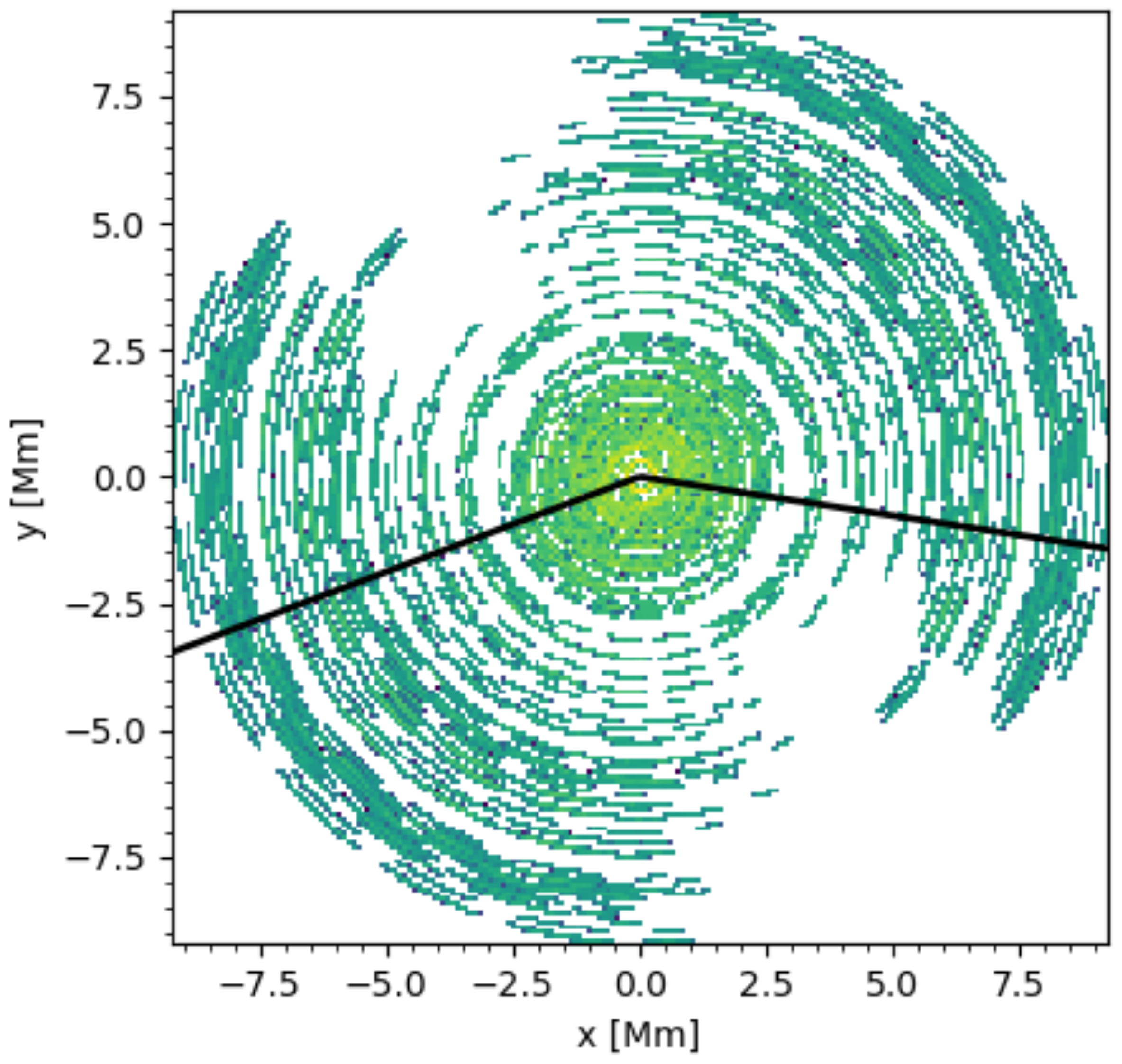




$e = 0.63$
$f = 0.25$

target source

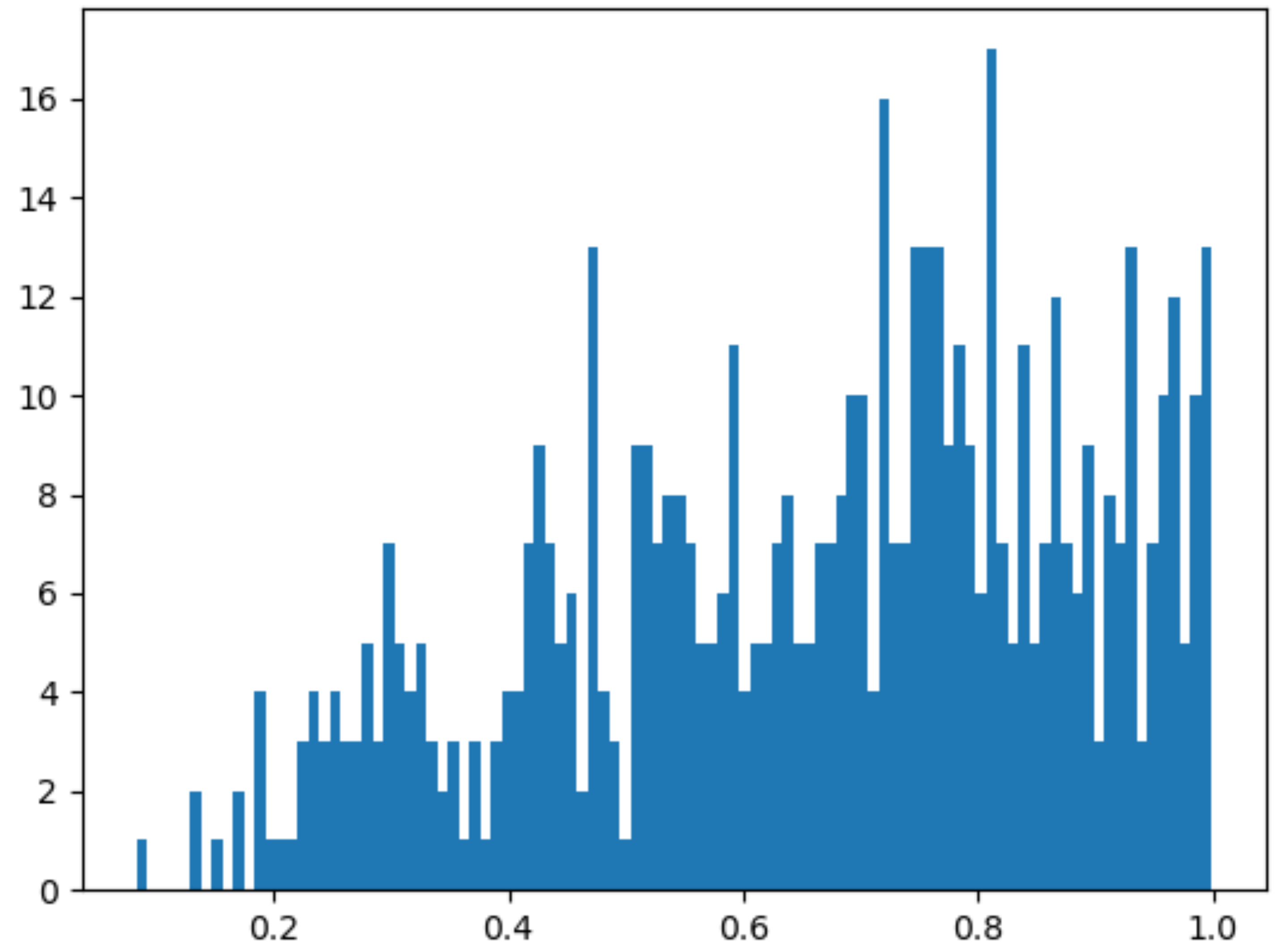
Plots derived from software developed by Mattia Mancini (ASTRON)



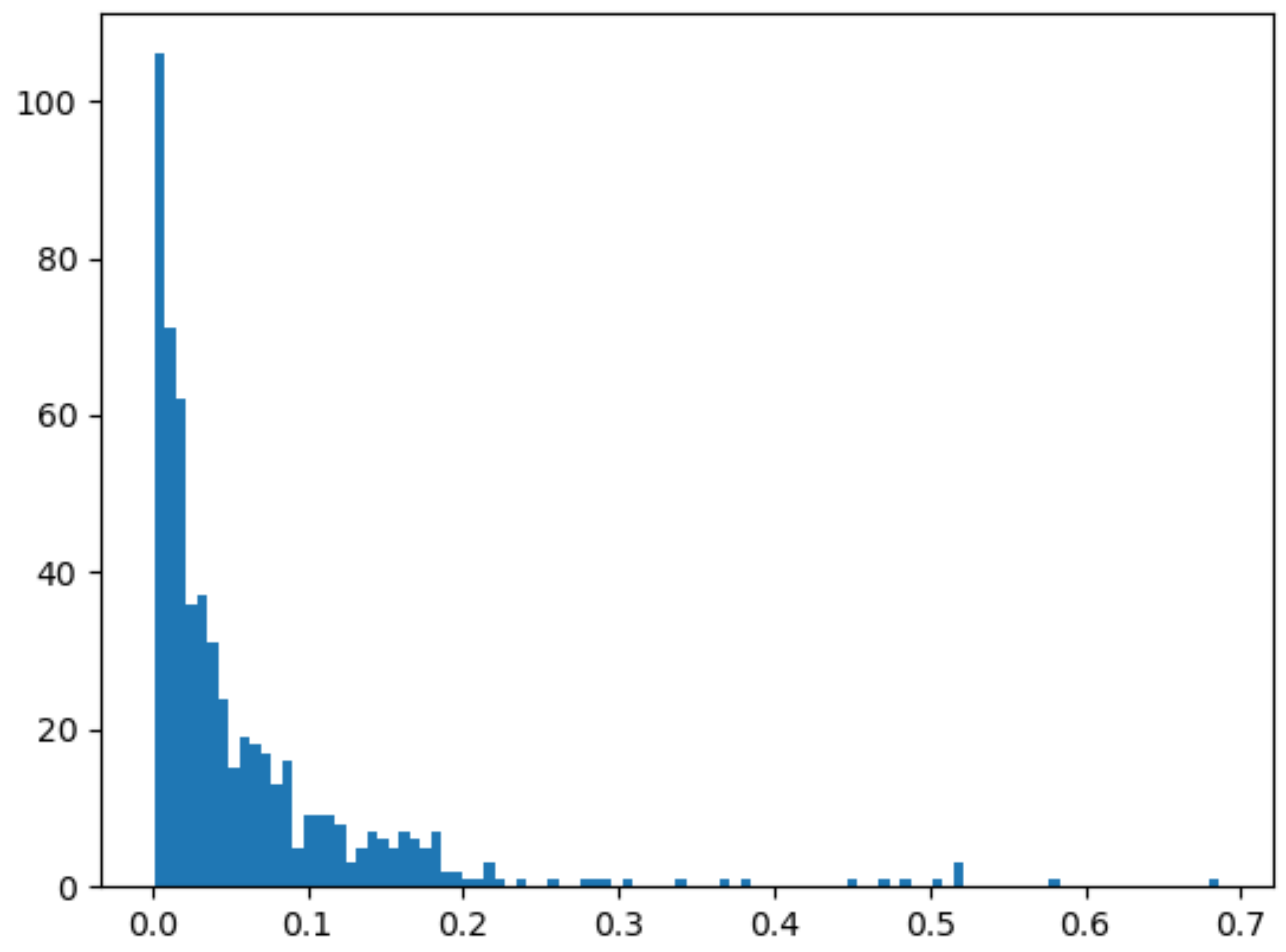
e = 0.97
f = 0.34

All EVN observations in 2017

eccentricity (e)



filling factor (f)



ESCAPE - The European Science Cluster of Astronomy & Particle Physics ESFRI Research Infrastructures has received funding from the European Union's Horizon 2020 research and innovation programme under the Grant Agreement n° 824064.