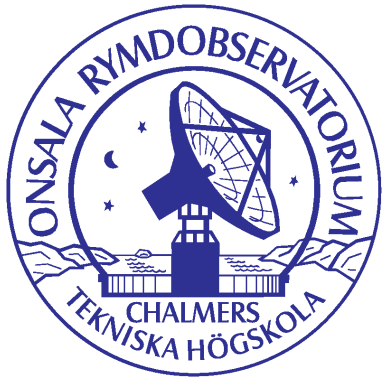


DIAS

Institiúid Ard-Léinn | Dublin Institute for
Bhaile Átha Cliath | Advanced Studies

BeamModelTester: analysing models of radio interferometer beam variation

Oisín Creaner (Astronomy and Astrophysics Section, Dublin Institute of Advanced Studies, Ireland)

Tobia Carozzi (Onsala Space Observatory/Chalmers University, Gothenberg, Sweden)

github.com/creaneroDIAS/beamModelTester

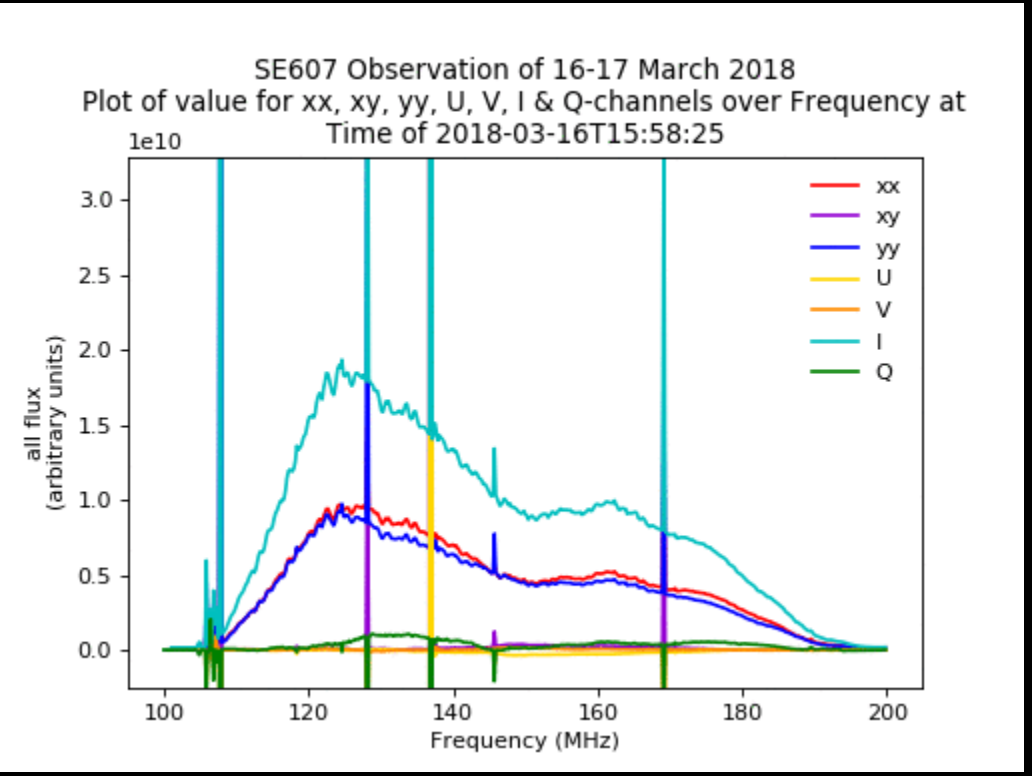
This presentation has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730562 [RadioNet]

The Instruments

- Fixed Antenna radio telescopes
- Photometric response for each antenna element varies significantly with orientation of Antenna and Source
- Apparent Polarisation varies significantly with Azimuth

(I-LOFAR, 2017)

Initial Observations

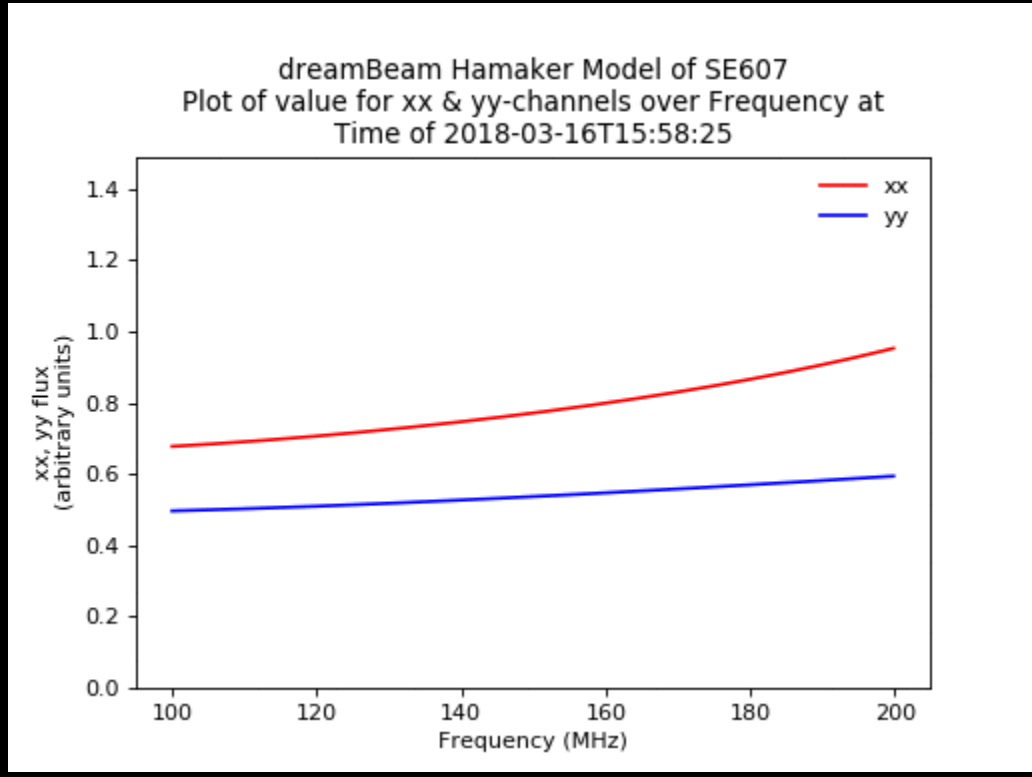


Initial observed spectrum of CasA

- Observations carried out at LOFAR Stations SE607 and IE613 in March 2018
- Significant variation observed
- Significant frequency dependence
- Strong RFI to be removed

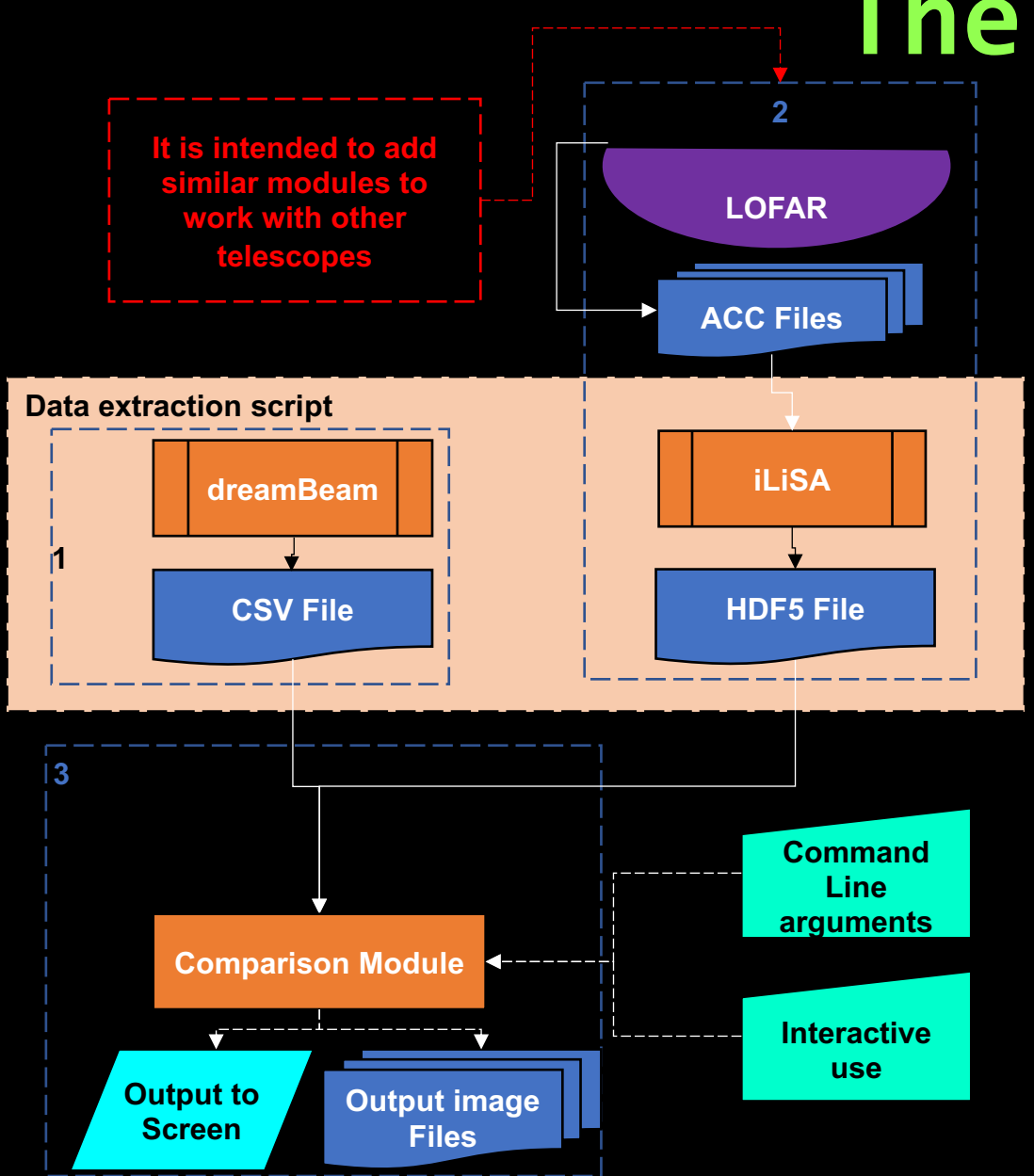
The Challenge

- Existing models such as Hamaker are designed with limited scope
- Need to compare Model with Observation to calibrate
- Need to be able to compare models with each other
- Solution must be able to handle multiple scenarios



Hamaker model implemented through dreamBeam (Carozzi)

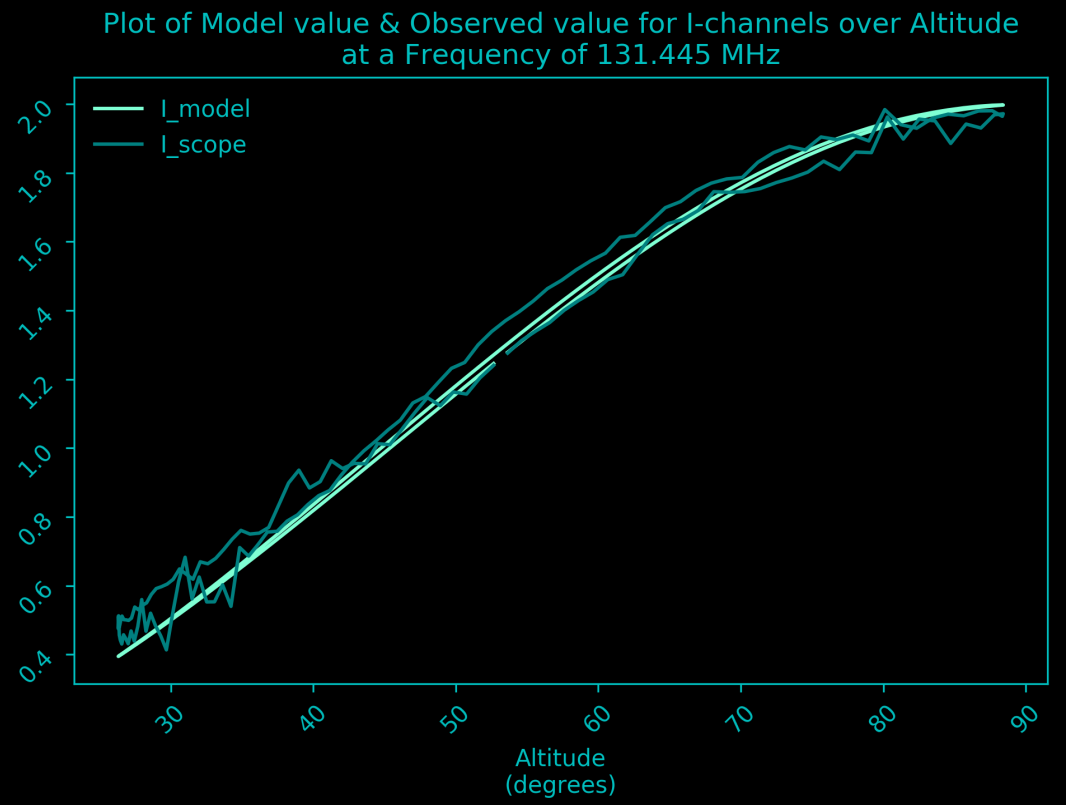
The Solution



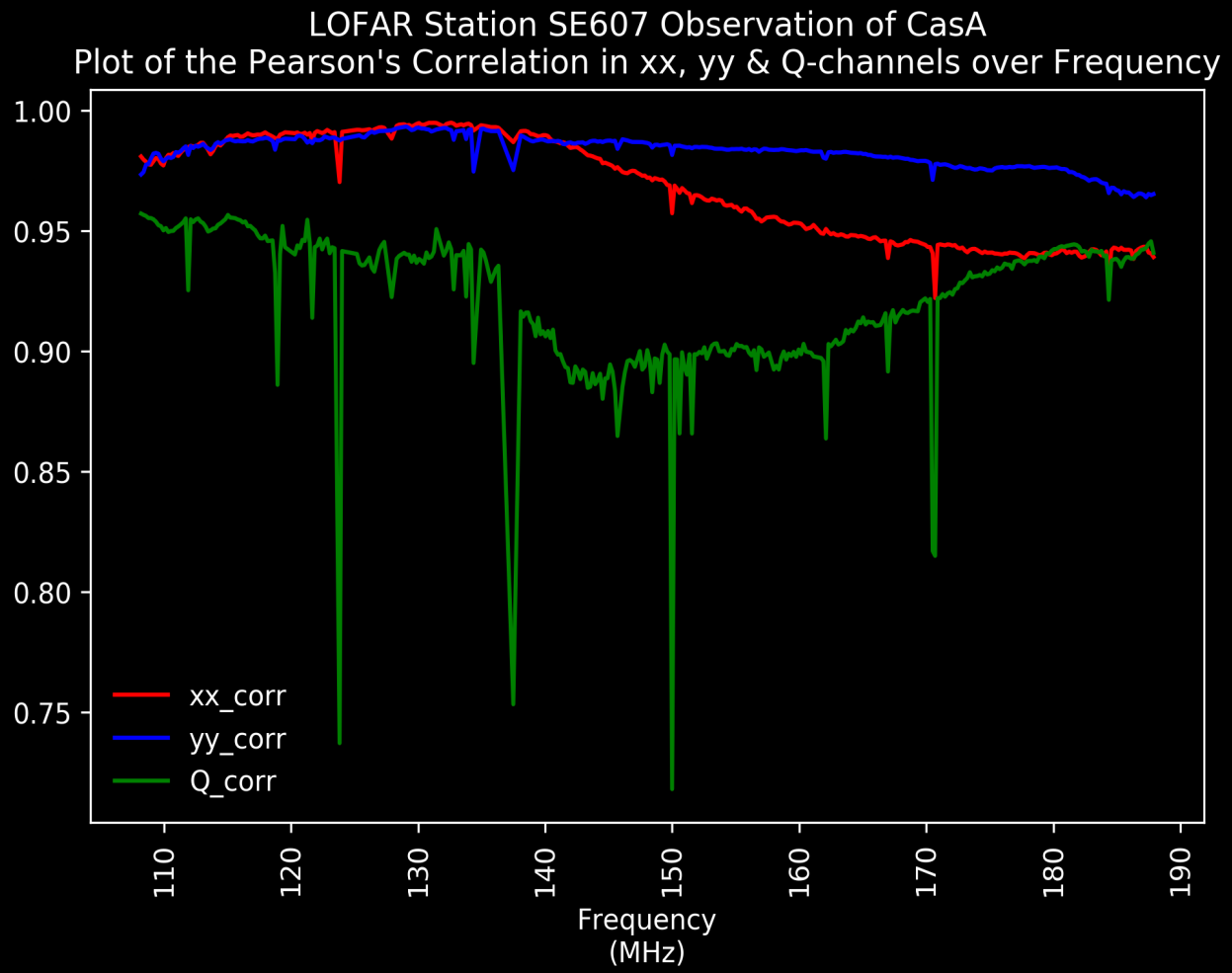
- Flexible analysis packages to allow comparison of model with observation across multiple telescopes using API
- Automated merger of related data by matching parameters
- Consistent visual design for at-a-glance interpretation
- GUI and CLI interfaces with in-depth tutorials for users

The Solution

- Filtering, Cropping and Normalisation to remove RFI
- Consistent visual design for at-a-glance interpretation
- RMSE and Correlation used as Figures of Merit for model performance overall and across parameter space



The Results



- User-oriented system is available at github
- Hamaker Model's known limitations are confirmed
- Frequency dependence not accounted for
- Dependence over time well modelled at many **but not all** frequencies

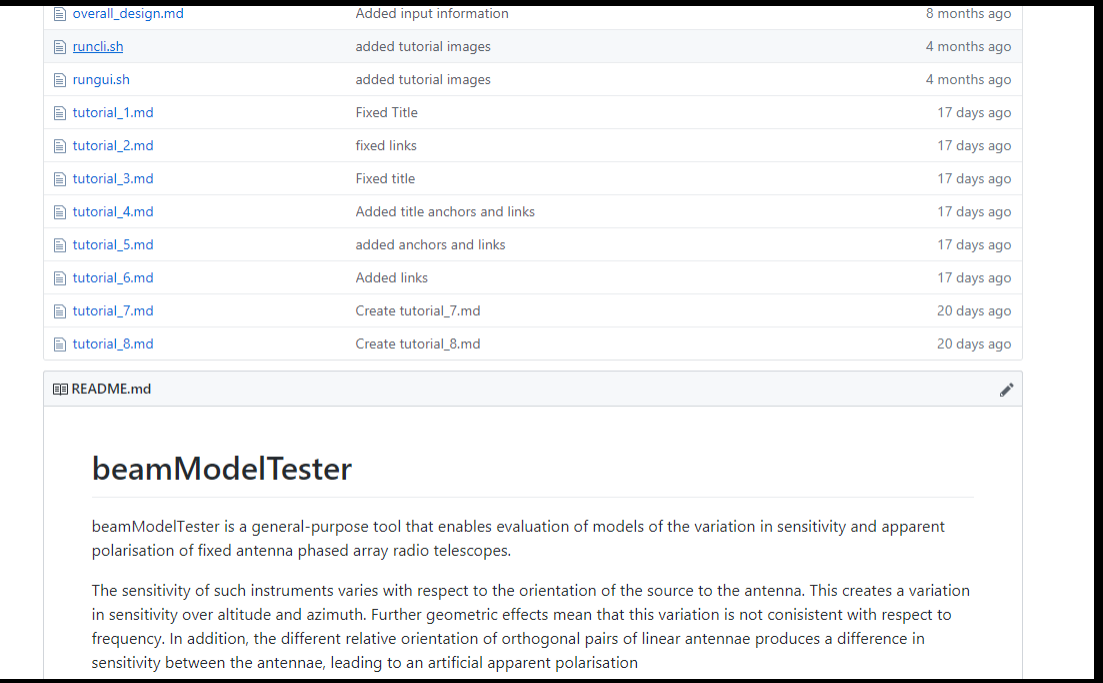
The Implications

- Hamaker Model must be combined with frequency
- Sidelobe image demixing not accounted for in many implementations
- Certain frequencies show closer agreement with model than others
- Refinements to model can be tested using this system

Channel	RMSE	Correlation
xx	22.5%	62.8%
xy	14.6%*	21.7%
yy	23.1%	67.9%
U	14.6%*	48.2%
V	.162%*	11.8%
I	22.6%	65.4%
Q	6.27%**	56.0%

*percentage relative to xy absolute value
**percentage relative to xx & yy absolute value

Software Release



overall_design.md	Added input information	8 months ago
runcli.sh	added tutorial images	4 months ago
rungui.sh	added tutorial images	4 months ago
tutorial_1.md	Fixed Title	17 days ago
tutorial_2.md	fixed links	17 days ago
tutorial_3.md	Fixed title	17 days ago
tutorial_4.md	Added title anchors and links	17 days ago
tutorial_5.md	added anchors and links	17 days ago
tutorial_6.md	Added links	17 days ago
tutorial_7.md	Create tutorial_7.md	20 days ago
tutorial_8.md	Create tutorial_8.md	20 days ago

README.md

beamModelTester

beamModelTester is a general-purpose tool that enables evaluation of models of the variation in sensitivity and apparent polarisation of fixed antenna phased array radio telescopes.

The sensitivity of such instruments varies with respect to the orientation of the source to the antenna. This creates a variation in sensitivity over altitude and azimuth. Further geometric effects mean that this variation is not conisistent with respect to frequency. In addition, the different relative orientation of orthogonal pairs of linear antennae produces a difference in sensitivity between the antennae, leading to an artificial apparent polarisation

- Software available on github.com/creaneroDIAS/BeamModelTester
- README available with instructions for installation and use
- Tutorial for users to employ it for graphing and analysis
- APIs can be implemented for other telescopes and use-cases as needed.

Publications

Recent Submission to Astronomy and Computing

BeamModelTester: software framework for testing radio telescope beams

Further Publications

Modelling and model implementation (Carozzi, Creaner & Hamaker)

Model assessment results (Creaner & Carozzi)

BeamModelTester: software framework for testing radio telescope beams

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Abstract

The flux, polarimetric and spectral response of phased array radio telescopes such as LOFAR is known to vary considerably with orientation of source to the receivers. Calibration models exist for this dependency such as that used in the LOFAR pipeline. Presented here is a system for comparing models with observation, thus making it possible to calibrate and propose refinements to models and to compare models with one another in a robust framework.

Keywords: LOFAR, Beam Modelling, Radio Flux, Radio Polarimetry

Thank you

- This presentation has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 730562 [RadioNet]

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