JIVE partner report: CASA

Mark Kettenis, Des Small, Aard Keimpema,
Marjolein Verkouter, Ilse van Bemmel

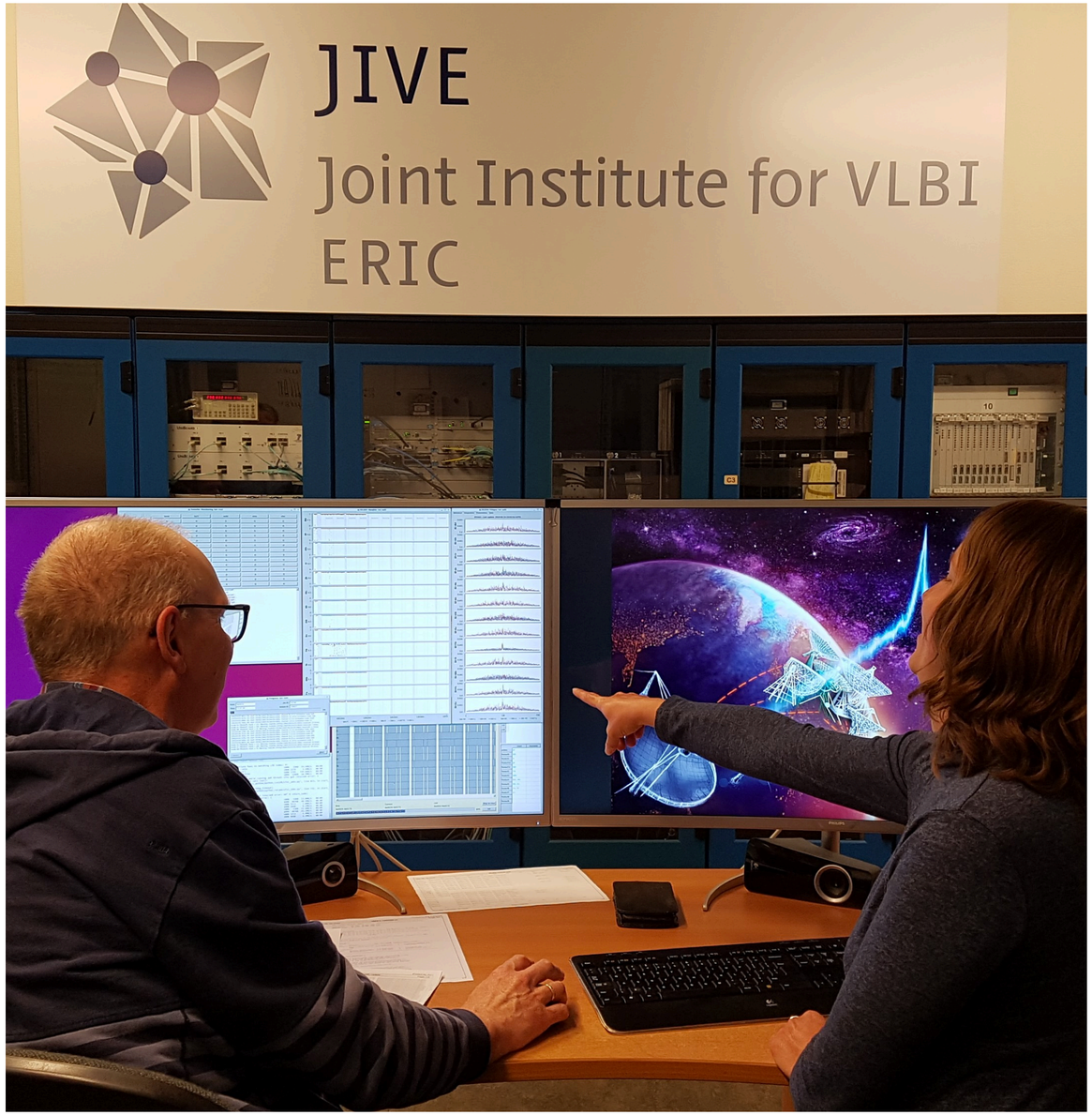
OSSR final workshop, FAU Erlangen-Nürnberg, November 2022

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.

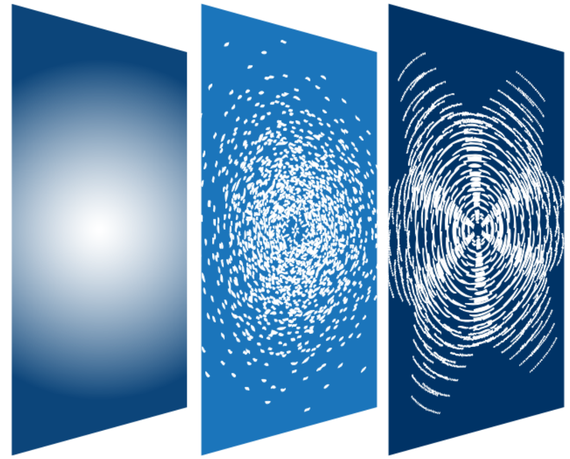
JIVE and the EVN

JIVE and the EVN

- JIVE is an ERIC
- Supports the European VLBI Network (EVN)
  - Operates the EVN correlator
  - Maintains corelator software (SFXC)
  - Provides user support (including data reduction support)



Why CASA?



CASA

Common Astronomy Software Applications

JIVE

CASA

- Can’t break ALMA (nor the VLA); rigorous code review (JIRA) and CI (Bamboo)
- Source code available in Bitbucket
- No more support for self-hosted installation of Atlassian Suite?

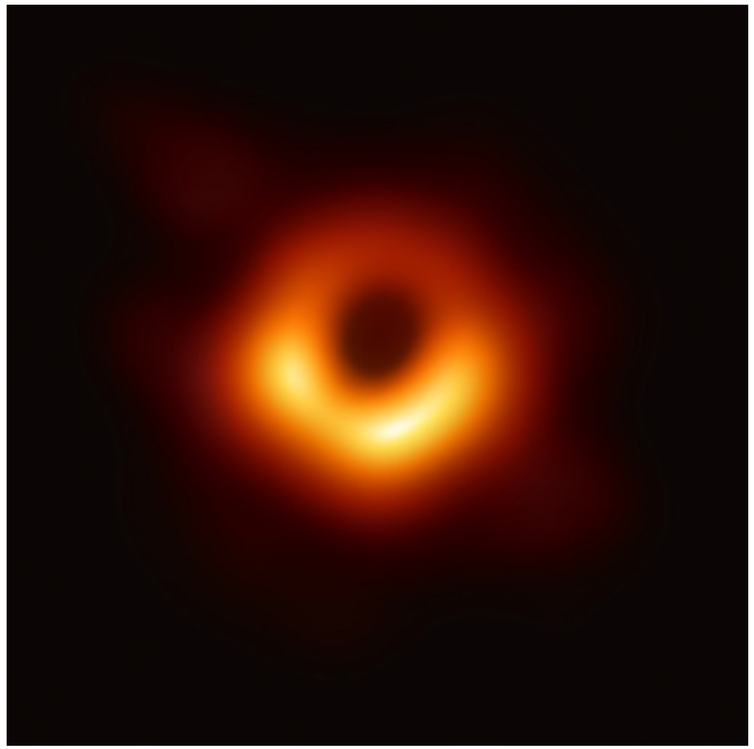
VLBI support in CASA

Make CASA viable for generic VLBI data reduction

- New functionality:
  - importfitsidi: Import data in FITS-IDI format; includes more calibration metadata now
  - fringefit: wide-band fringe fitting, memory usage optimisations
  - General calibration infrastructure improvements
    - per-scan interpolation
    - better handling of partially flagged data
- Under development:
  - EOP calibration

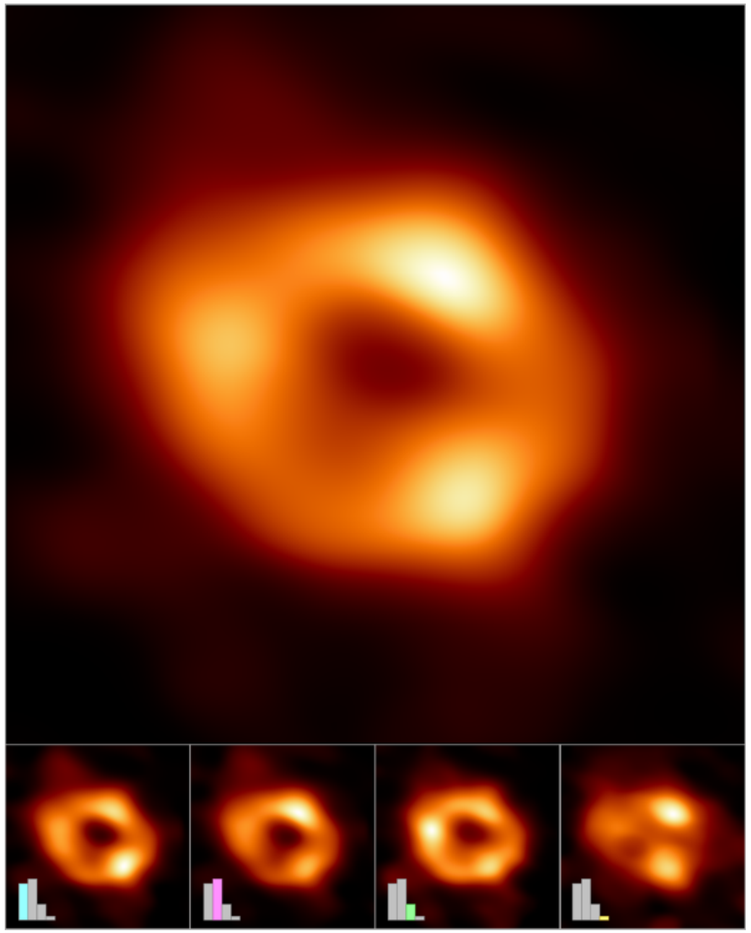
VLBI with CASA

2019



Credit: EHT Collaboration

2022

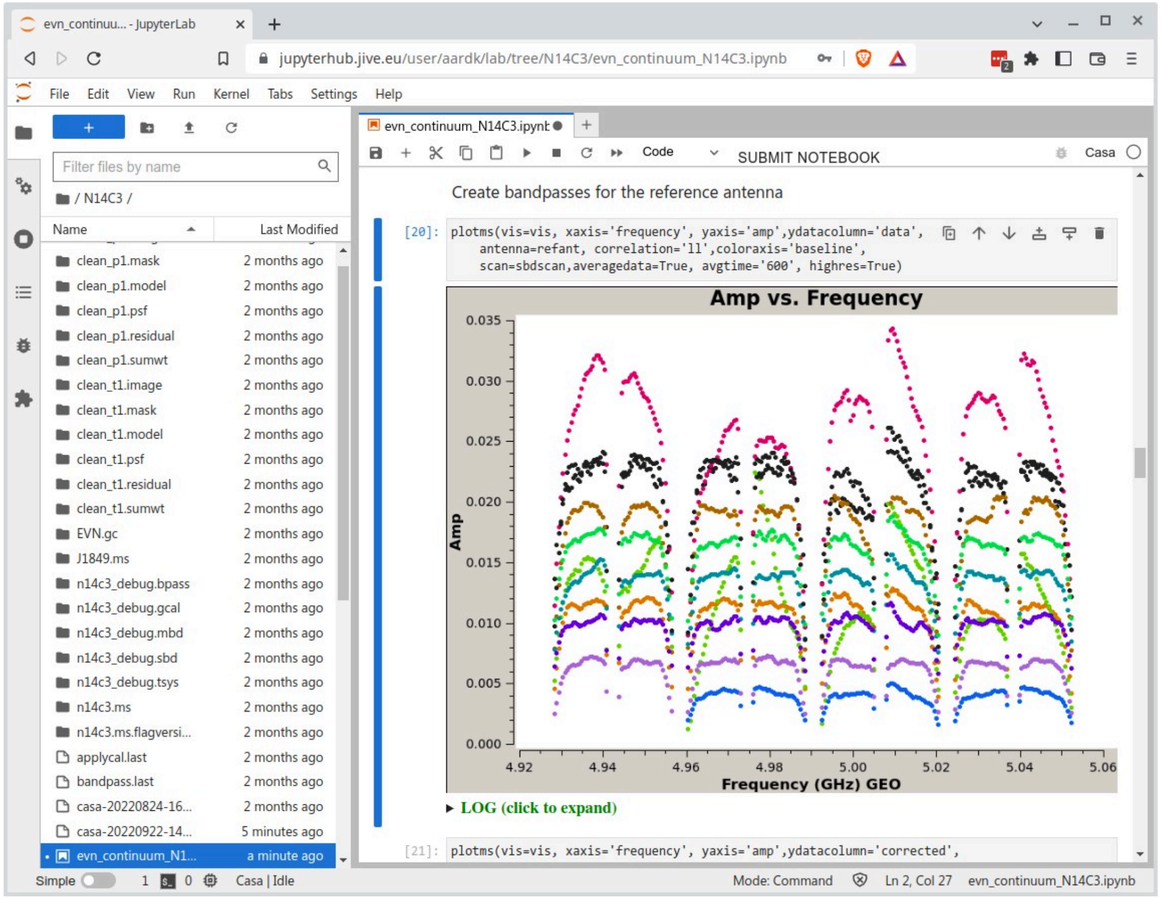


Credit: EHT Collaboration

Our OSSR contribution

Jupyter-CASA

- Software behind the JupyterLab-based Science Platform (WP5)
- Comes with a Jupyter notebook implementing EVN calibration pipeline
- Integration with EVN Archive (through VO service from WP4)
- Code at: https://github.com/aardk/jupyter-casa
- Docker/Singularity images on Zenodo



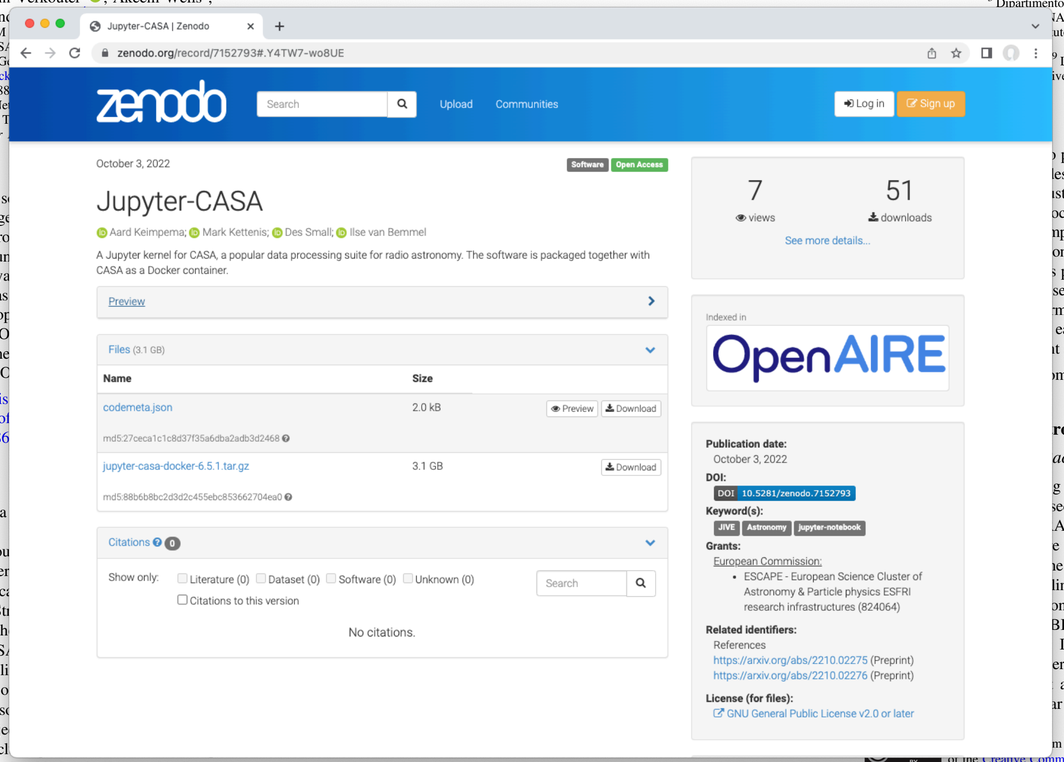
New CASA papers for added FAIRness!

Publications of the Astronomical Society of the Pacific, 134:114501 (17pp), 2022 November https://doi.org/10.1088/1538-3873/ac9642

OPEN ACCESS

CASA, Common Astronomy Software Applications for Radio Astronomy

The CASA Team, Ben Bean[1], Sanjay Bhatnagar[2], Sandra Castro[3], Jennifer Donovan Meyer[4], Bjorn Emonts[4,8], Enrique Garcia[3], Robert Garwood[4], Kumar Golap[2], Justo Gonzalez Villalba[3], Pamela Harris[2], Yohei Hayashi[5], Josh Hoskins[4], Mingyu Hsieh[2], Preshanth Jagannathan[2], Wataru Kawasaki[5], Aard Keimpema[6], Mark Kettenis[6], Jorge Lopez[4], Joshua Marvil[2], Joseph Masters[4], Andrew McNichols[4], David Mehringer[4], Renaud Miel[5], George Moellenbrock[2], Federico Montesino[3], Takeshi Nakazato[5], Juergen Ott[2], Dirk Petry[3], Martin Pokorny[2], Ryan Raba[4], Urvashi Rau[2], Darrell Schiebel[4], Neal Schweighart[4], Srikrishna Sekhar[2,7], Kazuhiko Shimada[5], Des Small[6], Jan-Willem Steeb[4], Kanako Sugimoto[5], Ville Suoranta[4], Takahiro Tsutsumi[2], Ilse M. van Bemmel[6], Marjolein Verkouter[6], Akeem Wells[4], Wei Xiong[1], Arpad Szomoru[6], Morgan Griffith[4], Brian Glendenning[2], and
[1] National Radio Astronomy Observatory, 800 Bradbury Dr., SE Ste 235, Albuquerque, NM
[2] National Radio Astronomy Observatory, P.O. Box O, Socorro, NM 87801, USA
[3] European Southern Observatory, Karl Schwarzschild Strasse 2, D-85748 Garching, G
[4] National Radio Astronomy Observatory, 520 Edgemont Road, Charlottesville, VA 22903, USA; casa-feedback
[5] National Astronomical Observatory of Japan, 2-21-1 Osawa, Mitaka, Tokyo 181-8588
[6] Joint Institute for VLBI ERIC, Oude Hoogeveensedijk 4, 7991 PD Dwingeloo, The Ne
[7] Inter-University Institute for Data Intensive Astronomy, University of Cape Town, Rondebosch, Cape T
Received 2022 June 14; accepted 2022 September 27; published 2022 November



Abstract

CASA, the Common Astronomy Software Applications, is the primary data processing s
Large Millimeter/submillimeter Array (ALMA) and the Karl G. Jansky Very Large
frequently used also for other radio telescopes. The CASA software can handle data fro
synthesis, and Very Long Baseline Interferometry (VLBI) telescopes. One of its core fun
the calibration and imaging pipelines for ALMA, VLA, VLA Sky Survey, and the Nobeya
paper presents a high-level overview of the basic structure of the CASA software, as
calibrating and imaging astronomical radio data in CASA. CASA is being develop
consortium of scientists and software engineers based at the National Radio Astronomy O
European Southern Observatory, the National Astronomical Observatory of Japan, and the
European Research Infrastructure Consortium (JIV-ERIC), under the guidance of NRAC

Unified Astronomy Thesaurus concepts: Single-dish antennas (1460); Aperture synthesis (1338); Radio interferometry (1346); Long baseline interferometry (932); Astronomy sof source software (1866); Software documentation (1869); Astronomy data reduction (186 analysis (1858)

1. Introduction

Radio astronomy is a discipline that heavily relies on computational resources to image the sky at wavelengths ranging from roughly 10 m to 300 μm (e.g., Condon & Ransom 2016; Thompson et al. 2017). The Common Astronomy Software Applications (CASA)[9] (McMullin et al. 2007) is a software package that enables the calibration, imaging, and analysis of data telescopes.

CASA consists of open-sou single-dish and radio interfer consists of a suite of applic programming language (St through an Interactive Pyth 2007). The origin of CAS (Glendenning 1996; McMulli in 1992 as the successor o Processing System (AIPS) s The original AIPS++ proje astronomical institutes, incl National Facility (ATNF), the National Center for Super-computing Applications (NCSA) at the University of Illinois,

[8] Author to whom any correspondence should be addressed.
[9] https://casa.nrao.edu

Publications of the Astronomical Society of the Pacific, 134:114502 (11pp), 2022 November

OPEN ACCESS

CASA on the Fringe—Development of VI for CASA

Ilse M. van Bemmel[1], Mark Kettenis[1], Des Small[1], Michael Janssen[2], George A. Moellenbrock[3], Dirk Petry[4], Ciriaco Goddi[5,6], Justin D. Linford[3], Kazi L. J. Rygl[7], Elisabetta Liuzzo[7], Benito Marcote[1], Olga S. Bayandina[1,8], Neal Schweighart[3], Marjolein Verkouter[1], Aard Keimpema[1], Arpad Szomoru[1], and Huib Jan van Langevelde[1,9,10]
[1] Joint Institute for VLBI ERIC (JIVE), Oude Hoogeveensedijk 4, 7991 PD Dwingeloo, The Netherlands
[2] Max-Planck-Institut für Radioastronomie, Auf dem Hügel 69, D-53121 Bonn, Germany
[3] National Radio Astronomy Observatory, P.O. Box O, Socorro, NM 87801, USA
[4] European Southern Observatory, Karl-Schwarzschild-Strasse 2, D-85748 Garching, Germany
[5] Dipartimento di Fisica, Universitá degli Studi di Cagliari, SP Monserrato-Sestu km 0.7, I-09042 Monserrato, Italy
AF—Osservatorio Astronomico di Cagliari, via della Scienza 5, I-09047 Selargius (CA), Italy
uto di Radioastronomia & Italian ALMA Regional Centre, Via P. Gobetti 101, I-40129 Bologna, Italy
[8] INAF—Osservatorio Astrofisico di Arcetri, Largo E. Fermi 5, I-50125 Firenze, Italy
[9] Leiden Observatory, Leiden University, Postbus 2300, 9513 RA Leiden, The Netherlands
iversity of New Mexico, Department of Physics and Astronomy, Albuquerque, NM 87131, USA
Received 2022 June 7; accepted 2022 July 18; published 2022 November 15

Abstract

process Very Long Baseline Interferometry (VLBI) data has been implemented in the CASA
es two new tasks to handle fringe fitting and VLBI-specific amplitude calibration steps. Existing
sted to handle VLBI visibility data and calibration meta-data properly. With these updates, it is
ocess VLBI continuum and spectral line observations in CASA. This article describes the
nplementation, and presents an outline for the workflow when calibrating European VLBI
ong Baseline Array data in CASA. Though the CASA VLBI functionality has already been
part of the Event Horizon Telescope data processing, in this paper we compare results for the
sed in CASA and AIPS. We find identical results for the two packages and conclude that CASA
ms better, though it cannot match AIPS for single-core processing time. The new functionality
easy development of pipelines or Jupyter notebooks, and thus contributes to raising VLBI data
t day standards for accessibility, reproducibility, and reusability.

my software – Very long baseline interferometry – Radio astronomy

roduction

ackground

g Baseline Interferometry (VLBI)
sed data using the National Radio
AO) Astronomical Image Proces-
e package (Greisen 2003). How-
e Common Astronomy Software
lin et al. 2007) has replaced AIPS
ons in radio astronomy. Requiring
BI observations to learn AIPS is a
In addition, with the changing
er growing data volumes, AIPS is
are increasingly harder to over-
r challenge was the calibration of high-frequency, global VLBI observations carried out with the Event Horizon Telescope (EHT; Event Horizon Telescope Collaboration 2019b). To overcome this challenge the ERC-funded *BlackHoleCam* project (Goddi et al. 2017), initiated the development of the CASA-VLBI functionality which led to the development of the first CASA-based calibration pipeline for VLBI data (Janssen et al. 2019; Event Horizon Telescope Collaboration 2019a).

This development was preceded by a detailed comparative study among the main radio-interferometric data processing software packages currently in use. The comparison scored each package on its suitability to build a pipeline for VLBI observations by comparing reliability, flexibility, sustainability, user access and support. From this exercise, CASA and AIPS were found to be the best options, with CASA being the prime choice due to continuous and future software development and extensive support for users of large observatories such as ALMA and VLA (see Appendix). The development of the CASA VLBI functionality has in the meantime matured into a

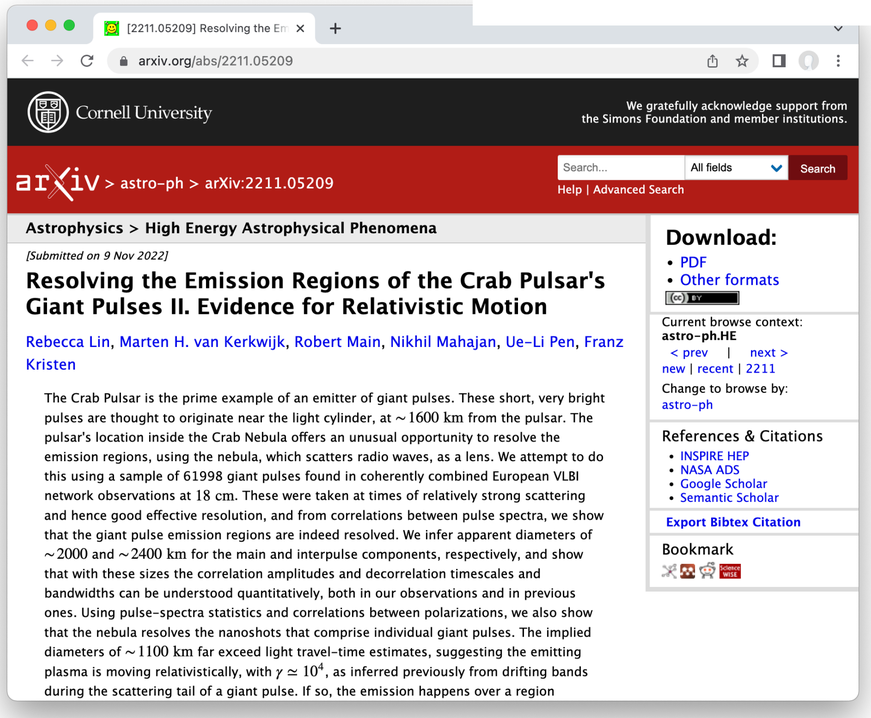
Future of CASA

- Scalability of CASA is not great
- CNGI prototype
  - Uses Dask, xarray, …
  - To replace casacore in ngCASA (to go with ngVLA)
  - More Python instead of C++
- EU Infratech RADIOBLOCKS project: use these technologies to speed up fringefit task
- NRAO hired a developer for developing VLBI (for VLBA/ngVLA)
- JIVE will continue VLBI development in CASA (in collaboration with NRAO)

Future of Jupyter-CASA

- CASA 6 replaced CASA 5
  - Includes a Python wheel-based installation
- CASA in Jupyter is now a priority for NRAO
  - Offering several Jupyter-based tutorials (including one for VLBA)
  - Does not offer a JupyterLab environment
- JIVE offering continues to serve as basis for our Science Platform

Some thoughts on OSSR



- Could contribute more software to OSSR:
  - SFXC software correlator
  - ParselTongue
- OSSR not main entry point for Radio Astronomers
  - CASA already widely known within community
  - Science Platform likely more important
  - But could play a role for Multi-wavelength/Multi-messenger community?
- JIVE can probably help with continued curation of OSSR contributions