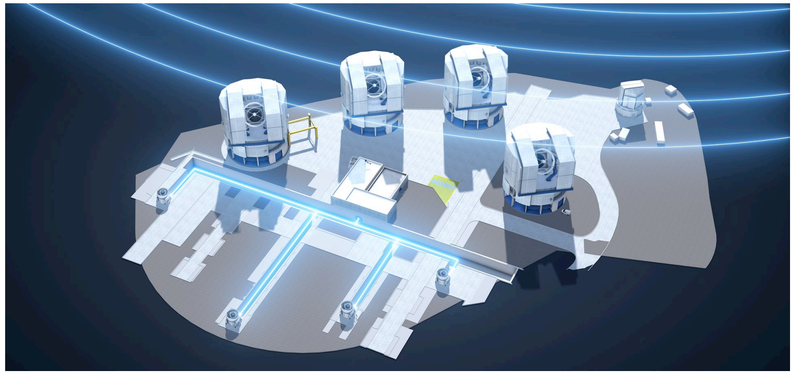
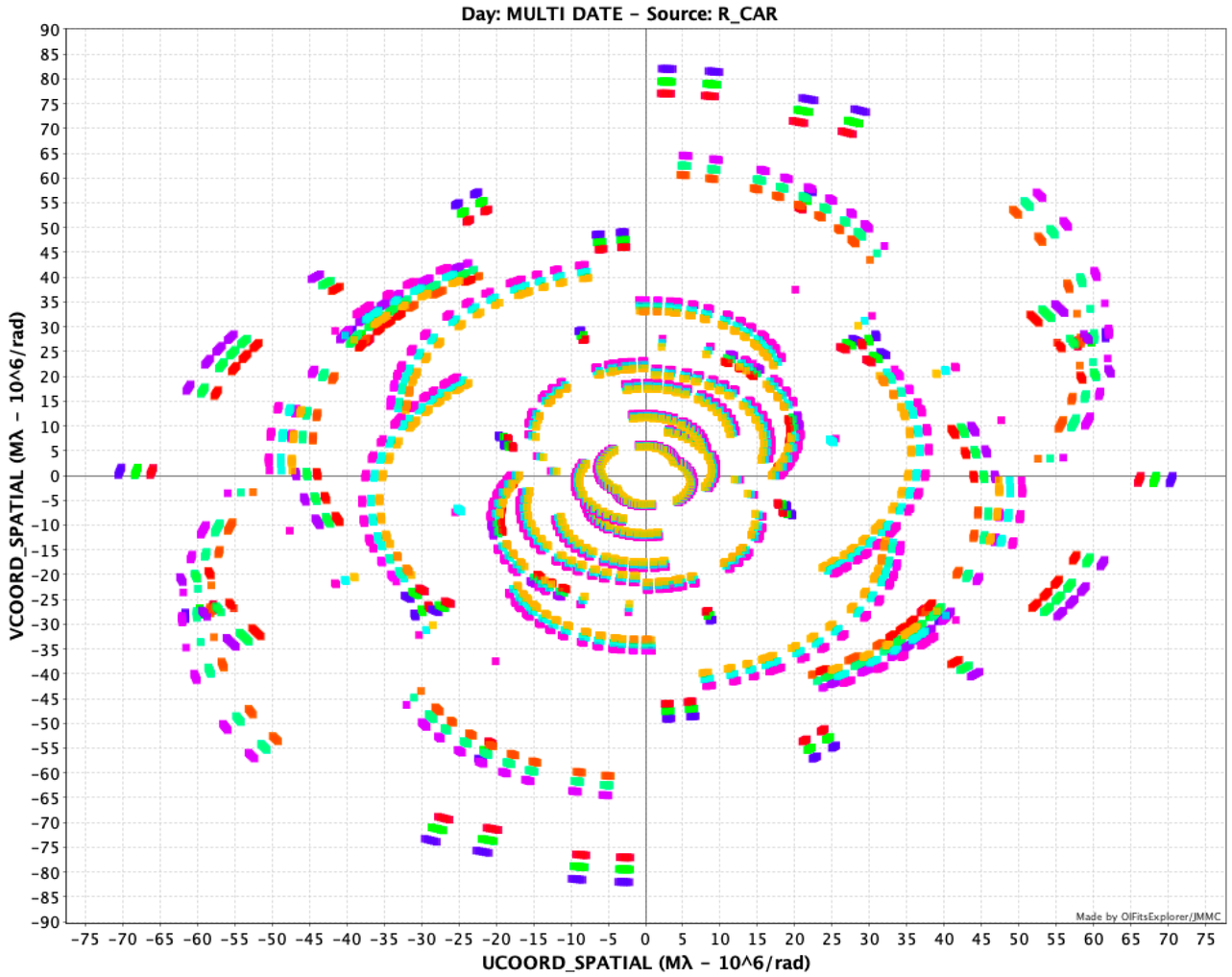
Image Reconstruction and Model Fitting tools for Optical Interferometry

Data analysis softwares proposed in Expertise Centers

Ferréol Soulez, G. Mella, A. Matter, A. Kaszczyc and L. Bourges

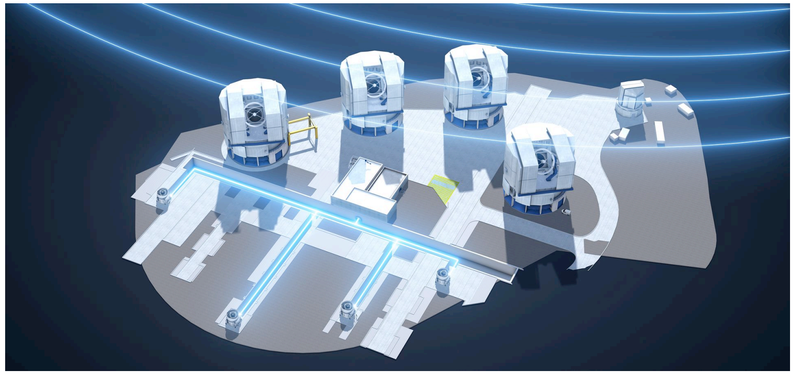
Interferometric data

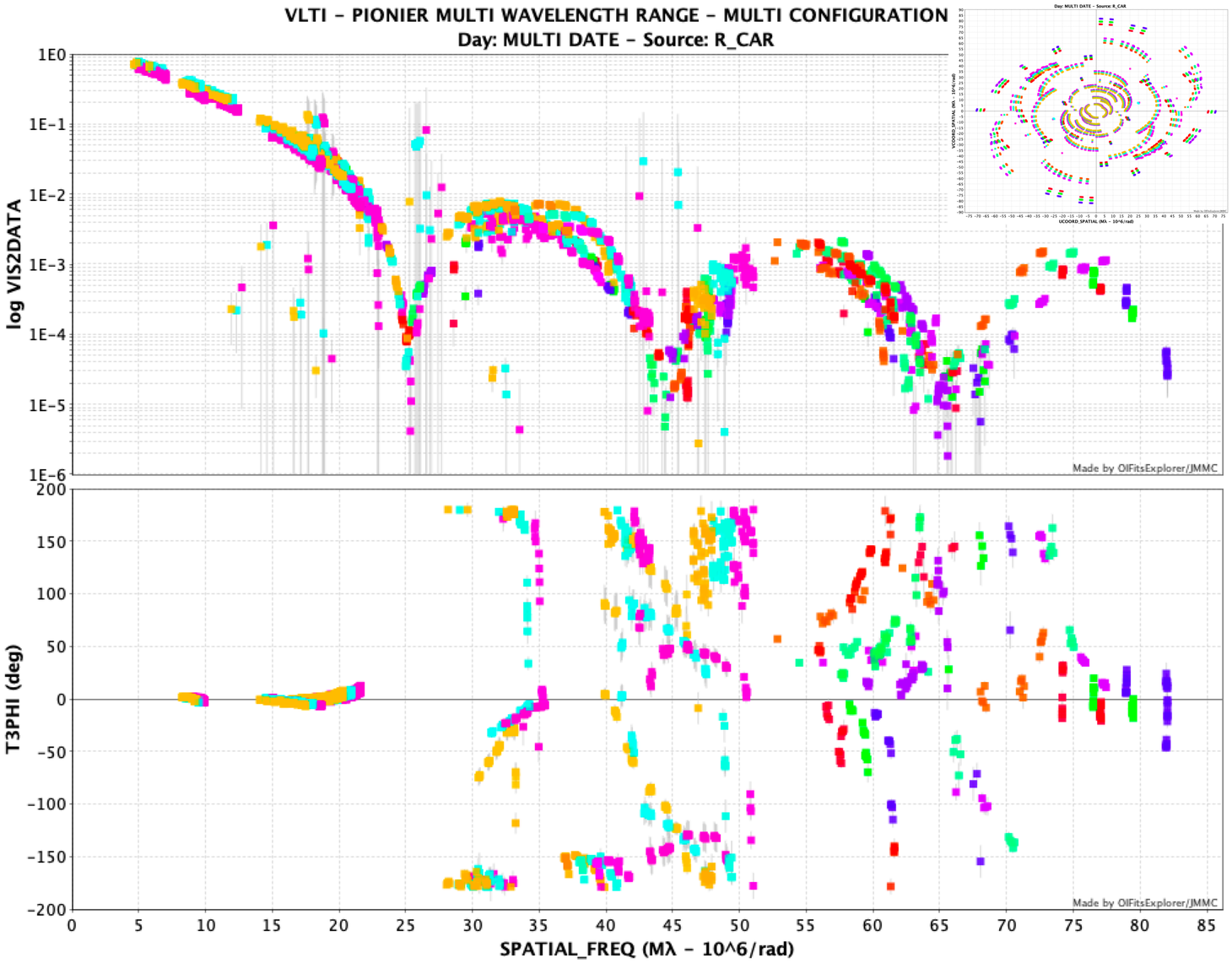




- Interferometric data:
  - Fourier domain
  - few measurements

Interferometric data





- Interferometric data:
  - Fourier domain
  - few measurements
  - (differential) visibilities,
  - squared visibilities,
  - bispectra

difficult to interpret

Interferometric data analysis

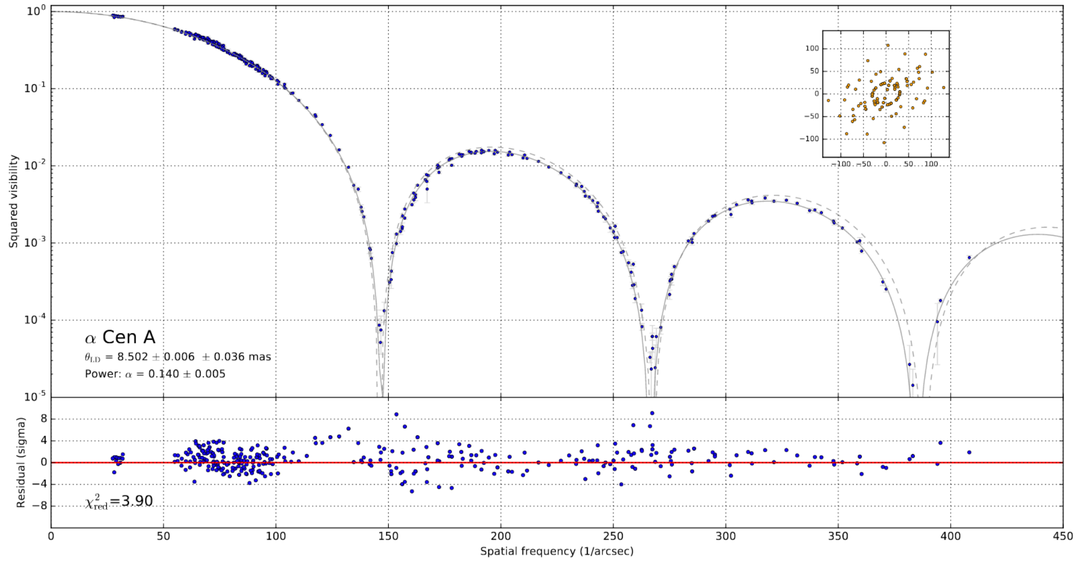
Model Fitting

Parametric model
- separation,
- diameter,
- limb-darkening,
- temperature,
- …

- need few data points
- priors in the model definition
- error bars & covariance
- no parameter to tune

review: (Baron, 2020)

Fit



Kervella et al, 2017

Image reconstruction

Image reconstruction
- one parameter per pixel
- **Fourier transform**

- need more data points
- prior enforced by regularization
- some parameters to tune

review: (Thiébaut &Young, 2017)

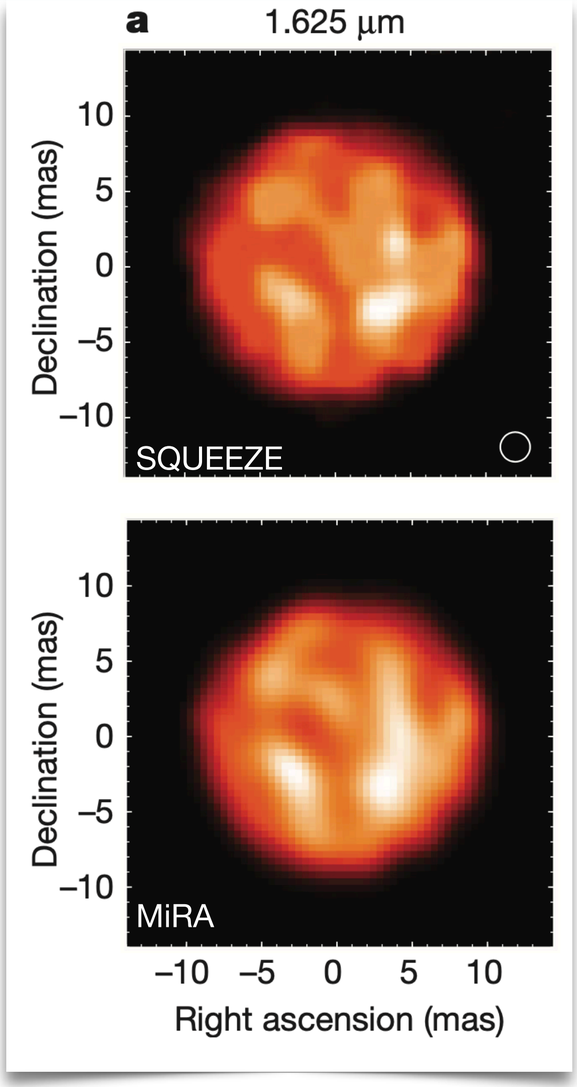
Model fitting tools

- **Custom scripts**
- **LITPro** (Tallon-Boc et al, 2008)
- **MFIT** (Young, 2010)
- **PMOIRED** (Mérand)
- **OITOOLS.jl** (Baron et al, 2019)

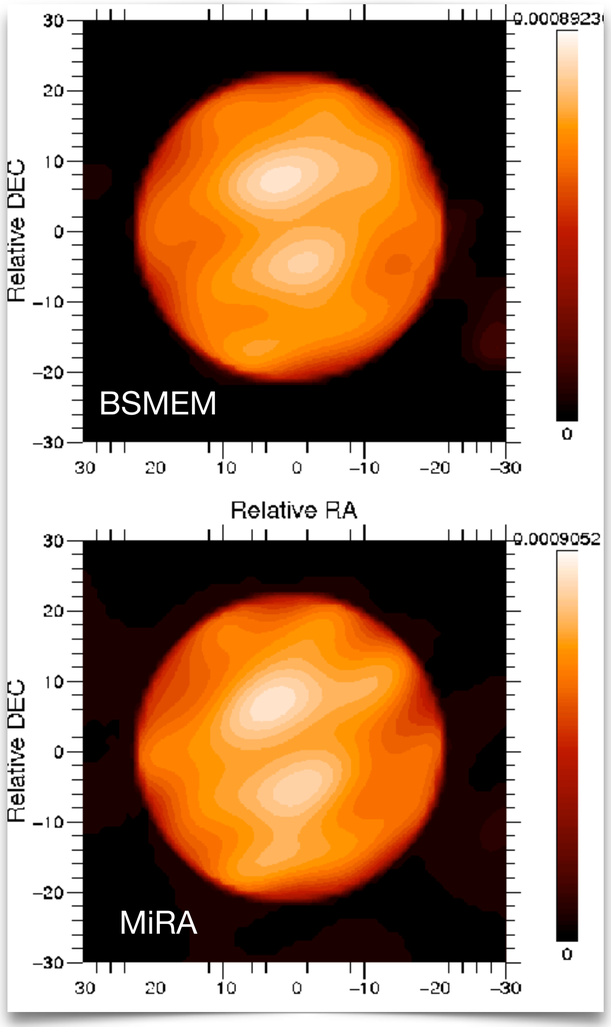
Image reconstruction softwares

BSMEM (Buscher et al, 1994)	C
MACIM (Ireland et al, 2006)	C
MiRA (Thiébaut, 2008)	yorick
WISARD (Mugnier et al 2008)	IDL
SQUEEZE (Baron et al, 2010)	C
IRBIS (Hoffman et al, 2014)	C
SPARCO (Kluska et al, 2014)	yorick or C
ORGANIC (Claes et al 2020)	python
GR (GRAVITY col., 2022)	python

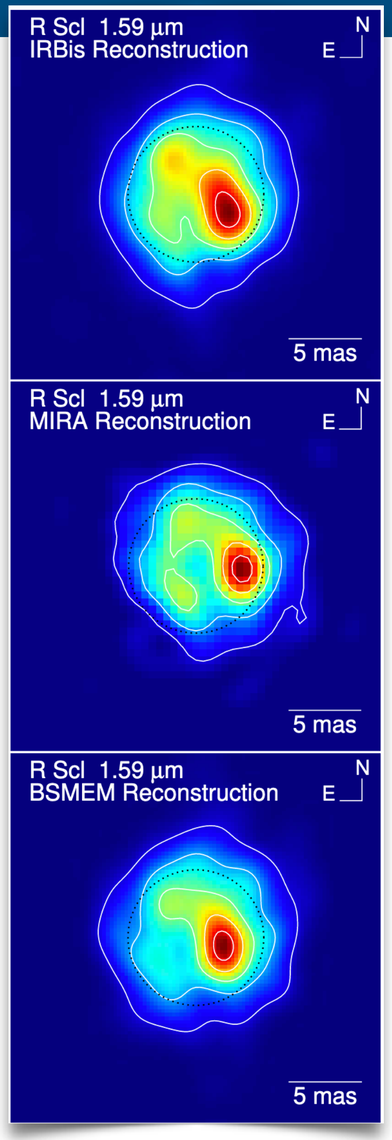
Comparing reconstructions softwares



π^1 Gruis (Paladini, 2018)



Betelgeuse (Haubois, 2009)



R Sculptoris (Wittkowski, 2017)

You’ll never walk alone

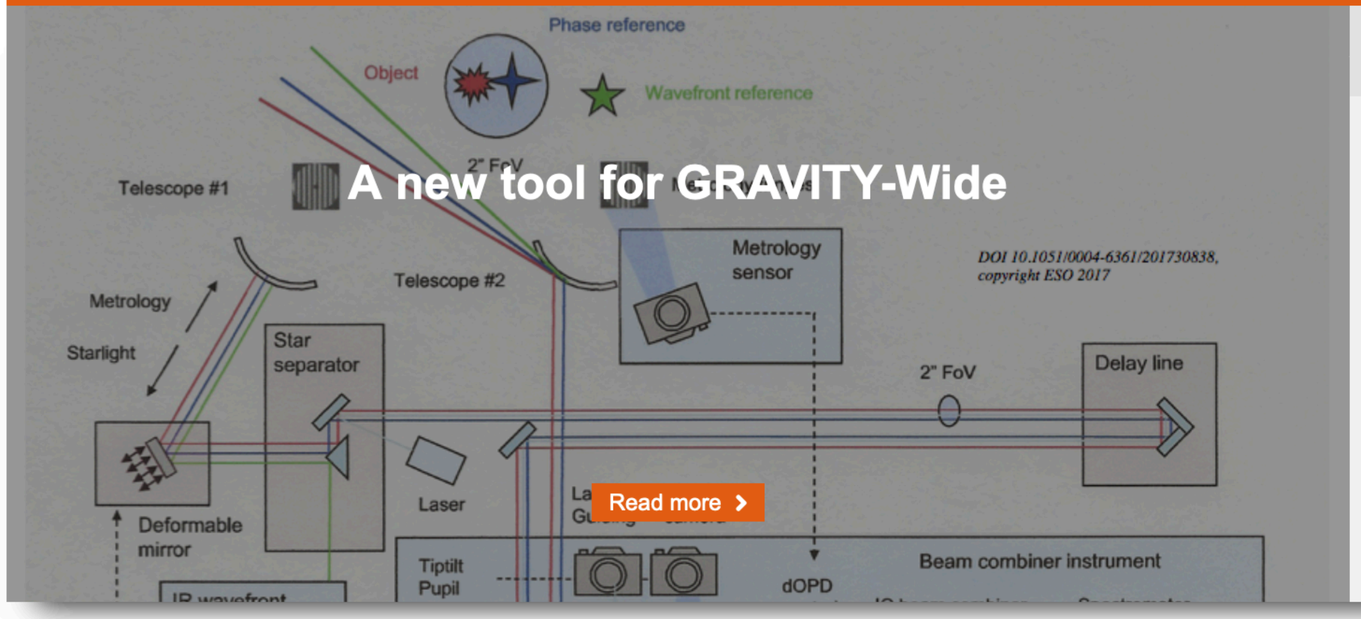
VLTI Expertise Center

European Interferometry Initiative

JMMC

We interfere constructively

PÔLE / SNO | TOOLS | USER SUPPORT | PUBLICATIONS | TRAINING | NEWS



A new tool for GRAVITY-Wide

Read more ›

The Mission

The JMMC is the french center for optical interferometry. It aims at providing support for the users of the stellar interferometers currently in operation. This support is possible thanks to the development of efficient and using friendly tools for preparing the observations, analysing the data or archiving the results. The tools are accessible through the web site and linked to a **"Face to Face" help**, especially for the preparation of observations, the PIONIER, GRAVITY and MATISSE data reduction, and the data analysis.

Who are we? ›

JMMC User Support

The JMMC is commited to provide support to the users of the VLTI and other interferometers. For this purpose, a single contact e-mail address has been created. You can also fill the dedicated feedback form. Access by click on "Read more".

Read more ›

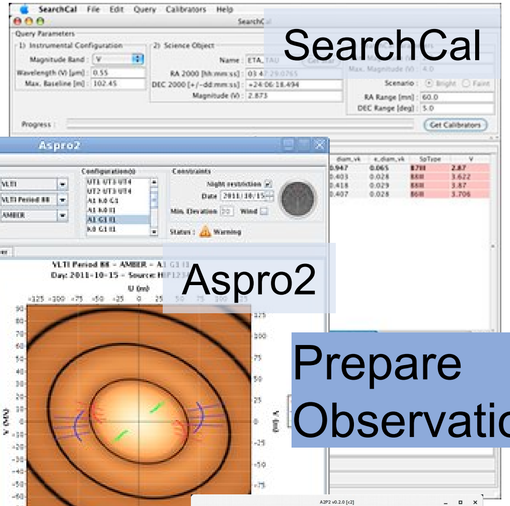
ASPRO | SEARCHCAL | LITPRO | OIFITSEXPLORER | OIMAGING | OIDB

JMMC Service overview

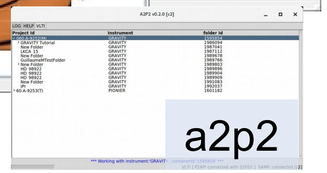
SUV (VLTI Center):

+ User Support

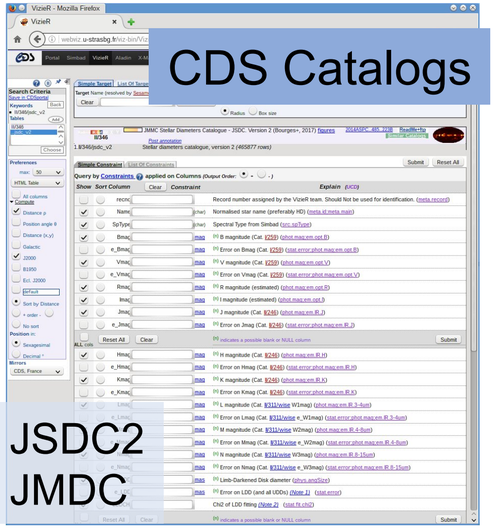
+ Training



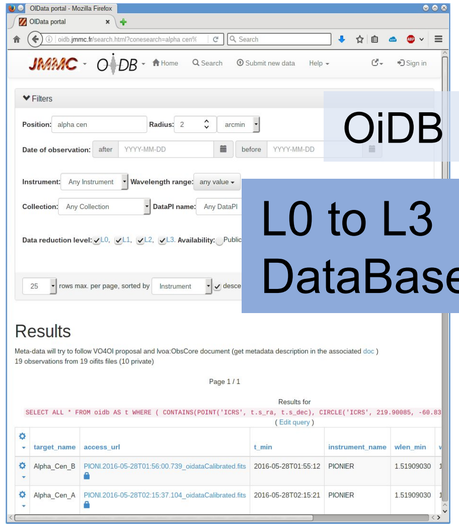
Prepare Observations



SAMP



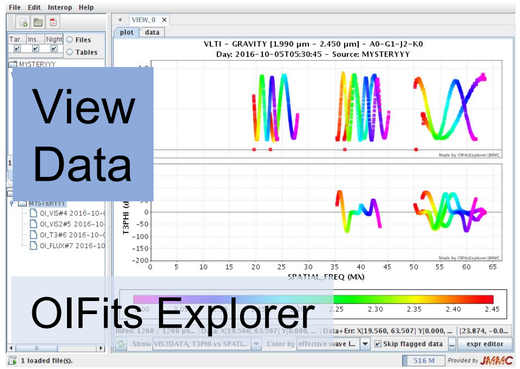
JSDC2
JMDC

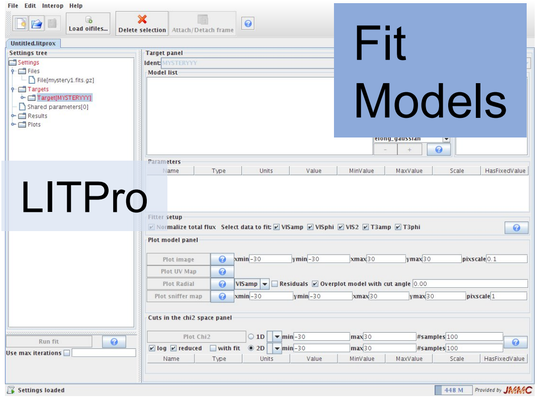


L0 to L3 DataBases

Reduce data

amdlib
pndrs





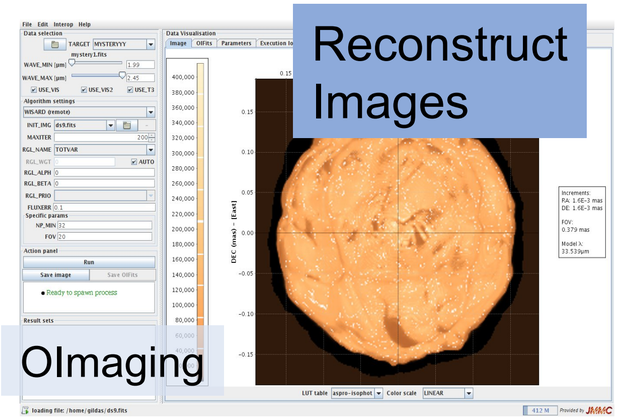
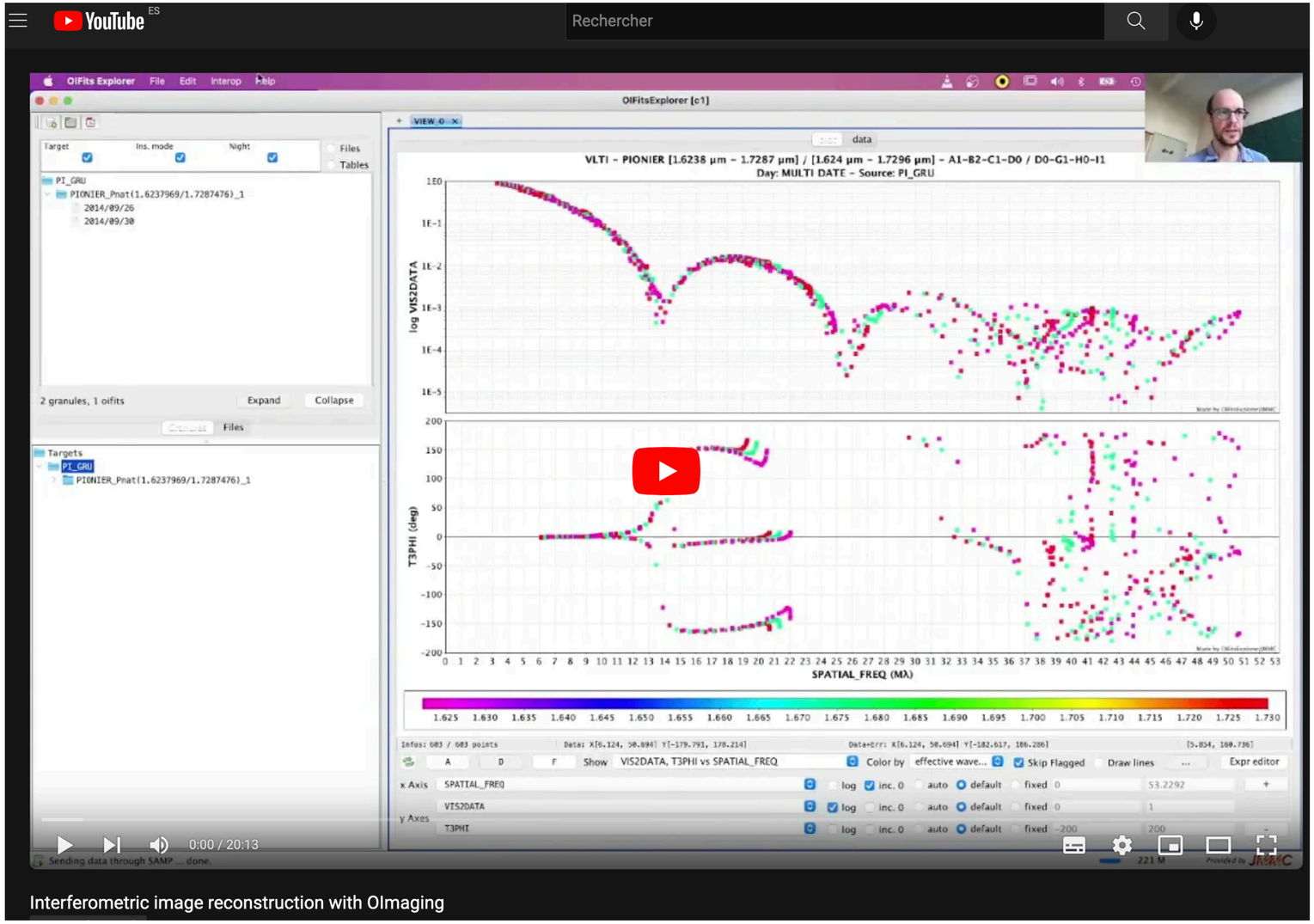


Image reconstruction workflow

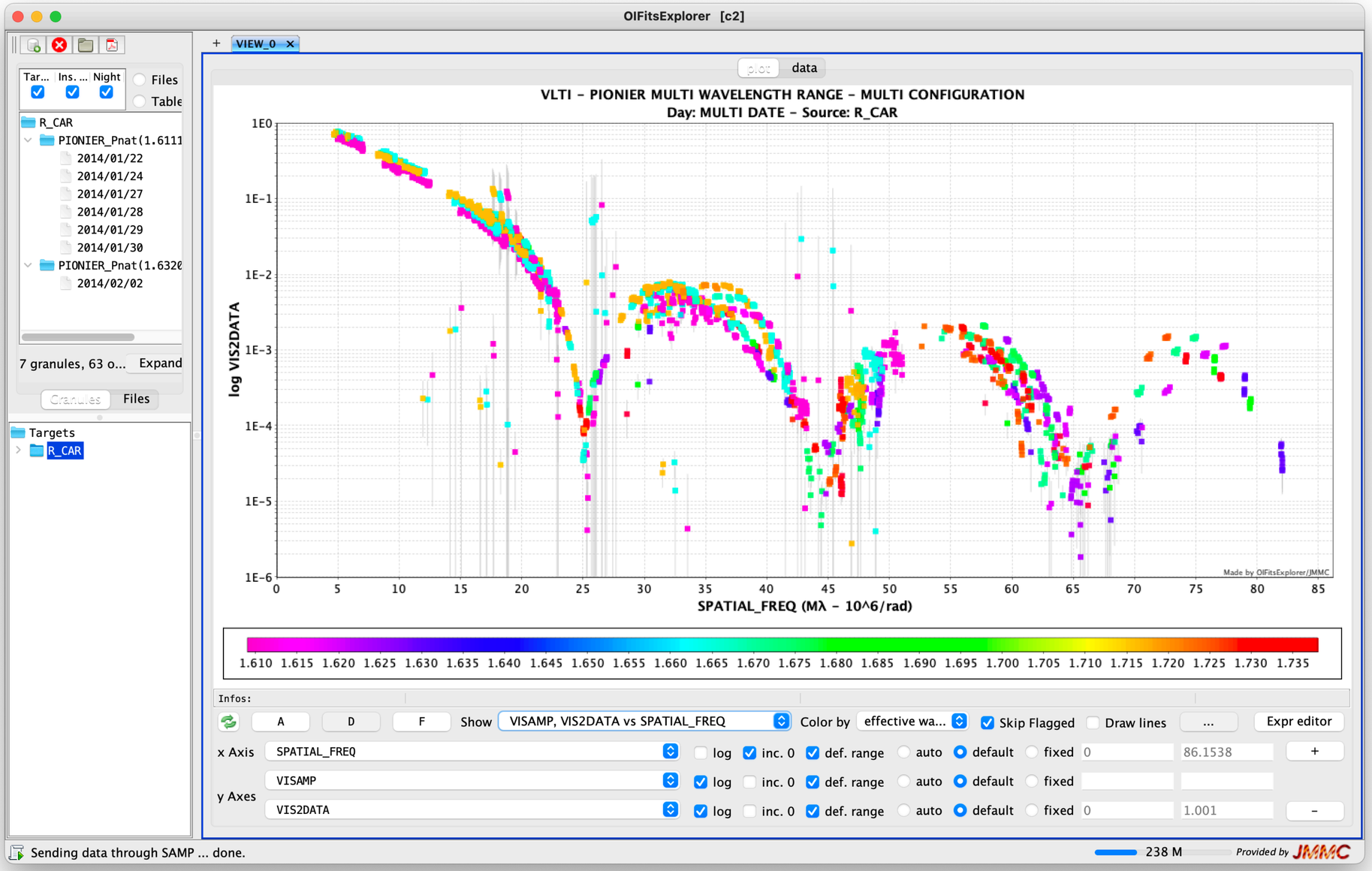
https://youtu.be/YA3hvs_sOfE



Interferometric image reconstruction with OImaging

OIFitsExplorer: data handling tool

Still in beta version



Model fitting

◉ LITpro

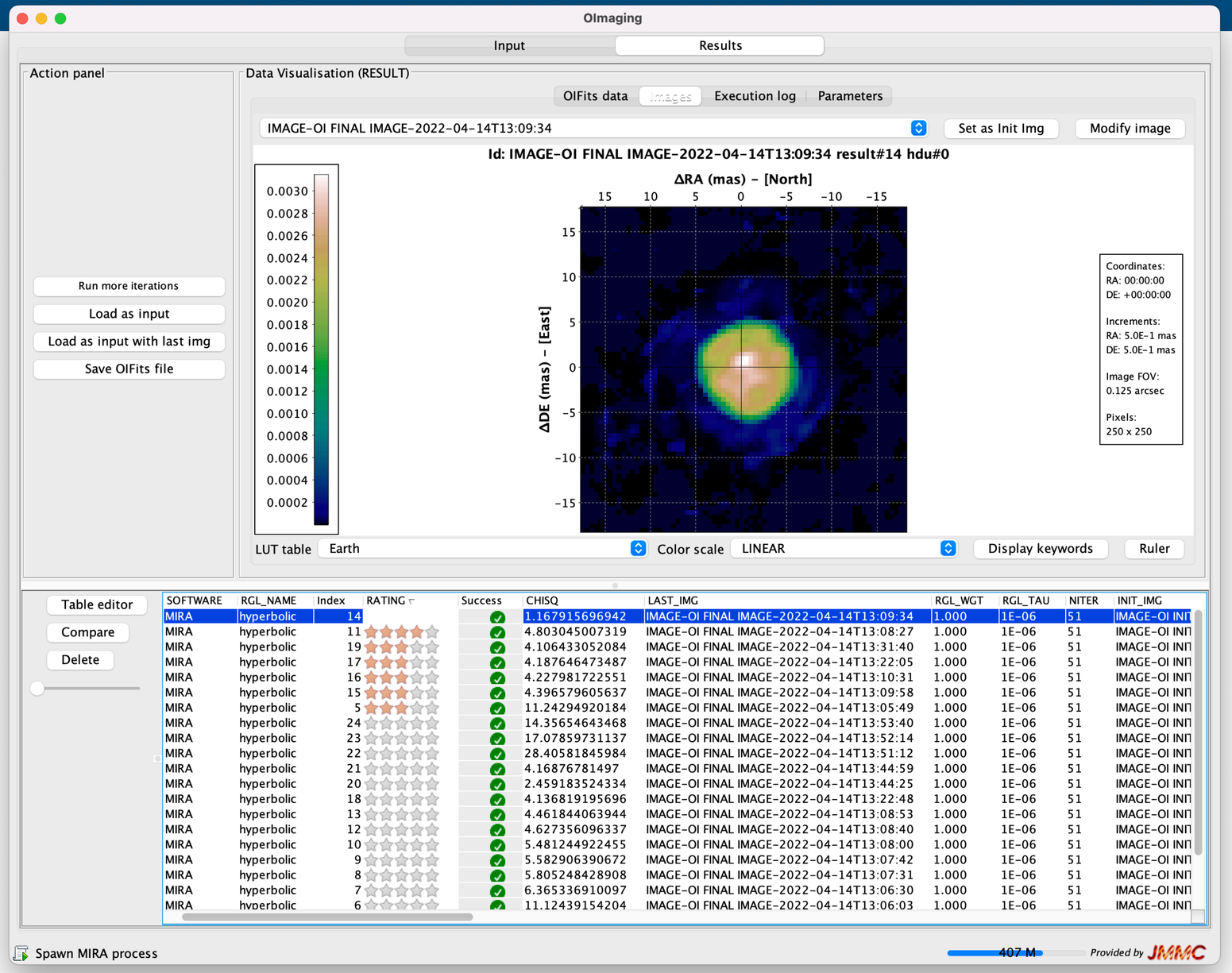
- GUI
- geometrical model
- temperature
- analytic estimate of uncertainties
- hidden features (ask for it)
- free to use (+citation)

◉ PMOIRED

- python notebook
- geometrical model
- more spectral and temporal model
- uncertainties via bootstrapping
- A. Mérand asks to be co-author

OImaging

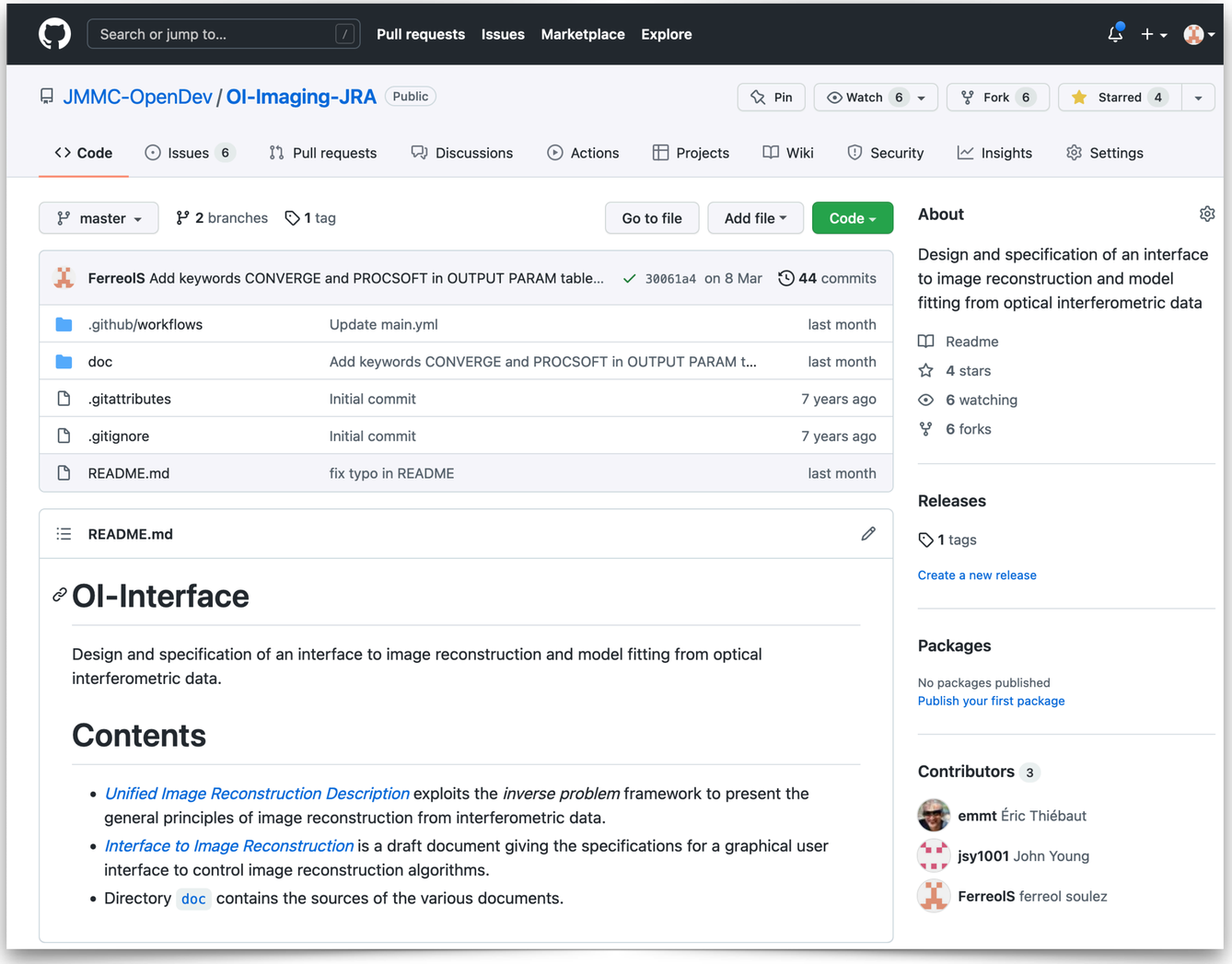
- **A single interface**
  - 4 softwares: BSMEM, MiRA, SPARCO,WISARD
  - results in a single table
  - rating, comparing,…
  - saving reconstruction parameters with the image



OI-Interface: a single format to connect them all

A unified way to call reconstruction softwares

- Every information in a single OI-FITS file
- Simpler interaction with softwares
- Reproducible results



You'll never walk alone

Subpages:

Overview VLTI Expertise Centre Support

VLTI Expertise Centres

Structured development of optical interferometry requires leaping towards a European network of VLTI Expertise Centres. These centres are the backbone of dissemination activities to new VLTI users, by organising observing preparation and data reduction schools, by co-organising with ESO VLTI open days, and being the end-points of the Fizeau staff exchange programme.

The leap aims at bringing the impact and return of the programme in spreading know-how in Europe to a new level. It follows at a smaller scale the successful experience of the ALMA Regional Centres, where researchers travel to the expertise centres to reduce their data. The centres will be the visible first contact point for astronomers interested in using VLTI.

The present network of VLTI Expertise Centres includes three partners from the OPTICON Horizon 2020 networking activity:

- Jean-Marie Mariotti Centre (JMMC) - Service aux Utilisateurs du VLTI, (SUV) France - a structure that aggregates manpower from different observatories:
  - Observatoire des Sciences de l´Univers de Grenoble (OSUG)
  - Observatoire des Sciences de l´Univers de Lyon (OSUL)
  - Observatoire de Paris-Meudon (OPM)
  - Observatoire de la Côte d'Azur (OCA)
- Portuguese VLTI Expertise Centre, Portugal
- University of Exeter, United Kingdom

two interferometry JRA (Joint Research Activities; WP8) lead partners:

- Lagrange Laboratory/OCA, France
- KU Leuven, Belgium

and two new nodes from the OPTICON/RadioNet Pilot (ORP) program:

- Leiden Observatory, The Netherlands
- Konkoly Observatory, Hungary

An overview of the support provided by each VLTI Expertise Centre and the data protection policy can be found here.

Visitors wishing to travel to the above centres to reduce their VLTI data or prepare observations are encouraged to use the Fizeau Programme.

Welcome onto the JMMC User Feedback Form !

(* : required field)

Application: SUV (VLTI center)

Type: Support Needed

Your Email * : your@email

Summary * :

Comments * :

Version: Optional V.

Effacer | Envoyer

Ask for help and give feedback

- Expertise center gather experts that are willing to help
- Use Fizeau program to travel to your expertise center
- Request features
- Knowing user needs help us to tailor softwares
- Research on methodology are fueled by requests

OImaging: a collective project

JMMC

- **The big chiefs:**
  - I. Tallon-Bosc
  - J-P. Berger
  - G. Duvert

- **The developers:**
  - L. Bourgès
  - A. Kaszczyc
  - G. Mella
  - M. Pratoussy

- **The reconstruction software fathers:**
  - G. Duvert
  - J. Kluska
  - L. Mugnier
  - E. Thiébaut
  - J. Young

- **The beta-testers:**
  - J. Kluska
  - M. Montargès