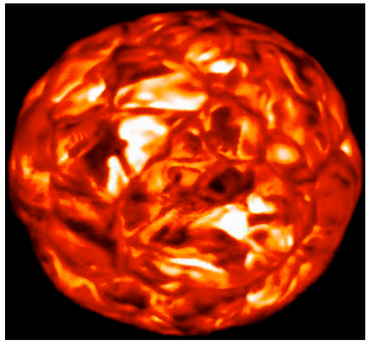
IMAGE-OI: an OIFITS extension for image reconstruction algorithms

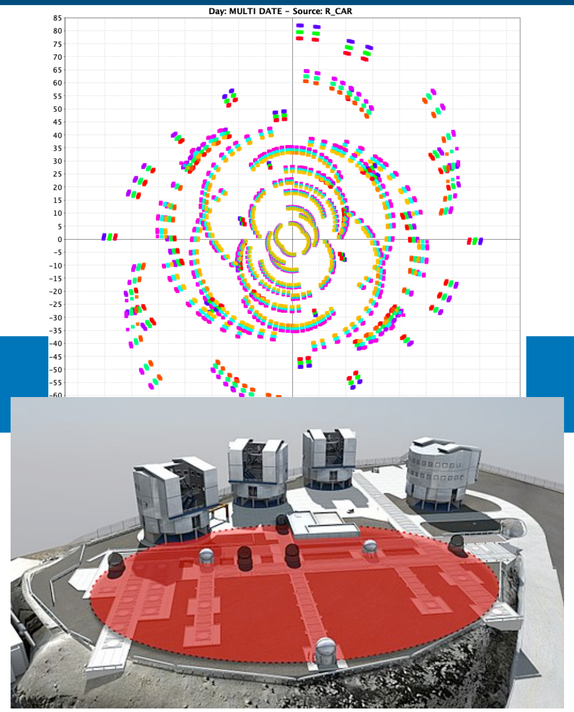
Application to OImaging

F. Soulez, L. Bourgès, A. Kaszczyc, G. Mella, M. Pratoussy, G. Duvert, J. Kluska, E. Thiébaut and J. Young

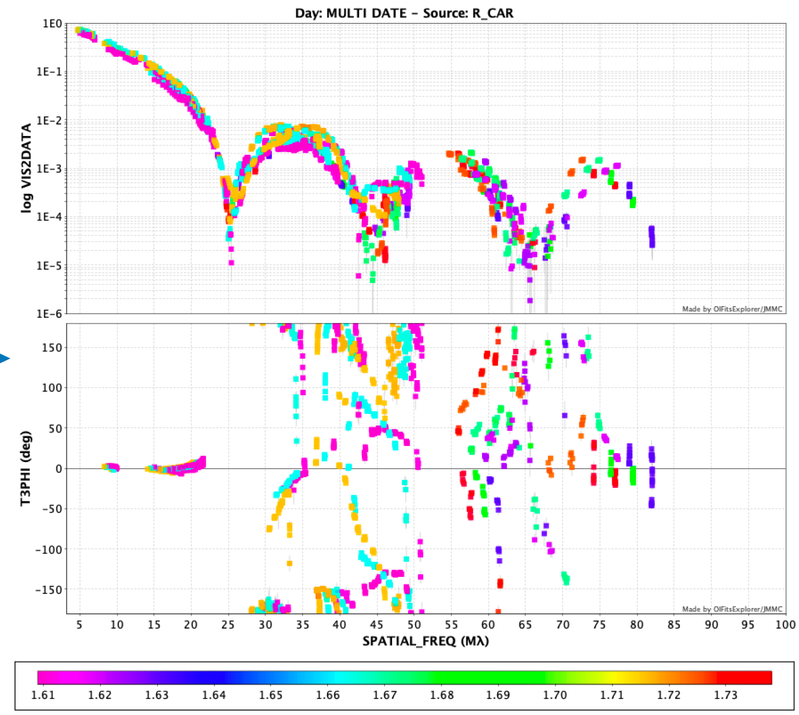
Image reconstruction in interferometry



Object



Interferometric instrument



Measurements

Image reconstruction

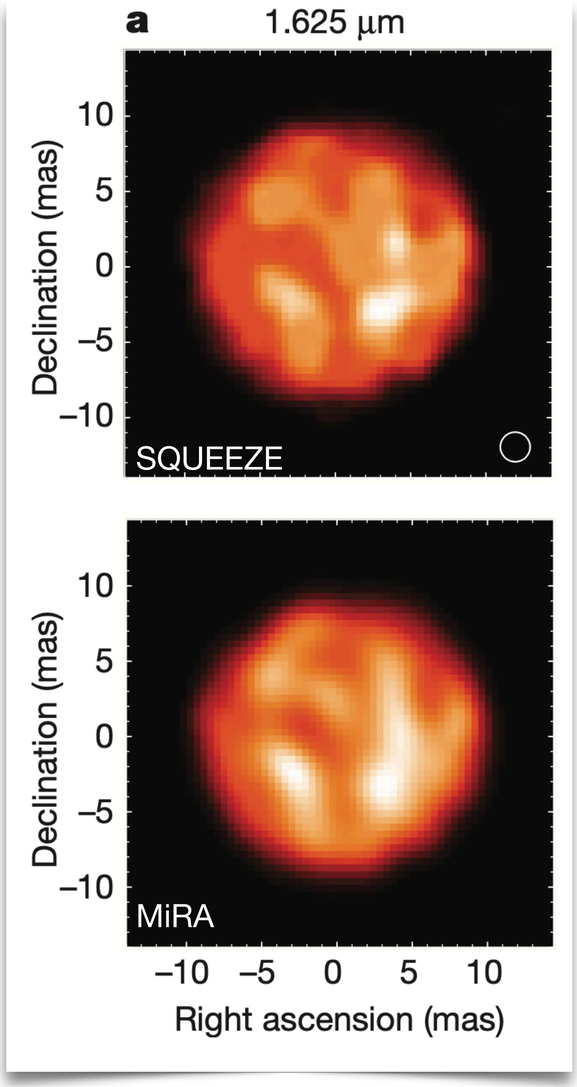
Image reconstruction softwares

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

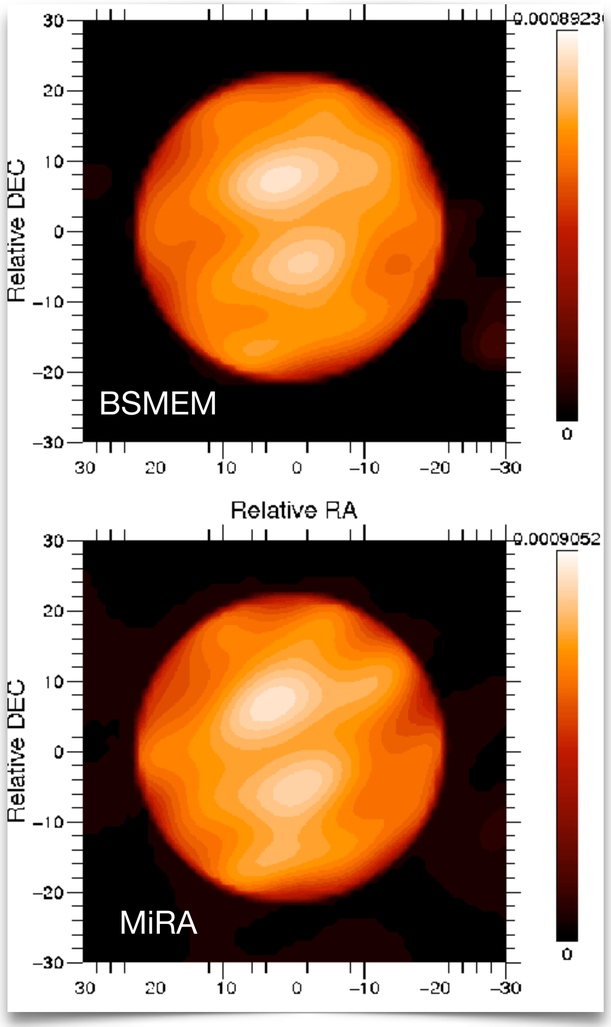
Image reconstruction softwares

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

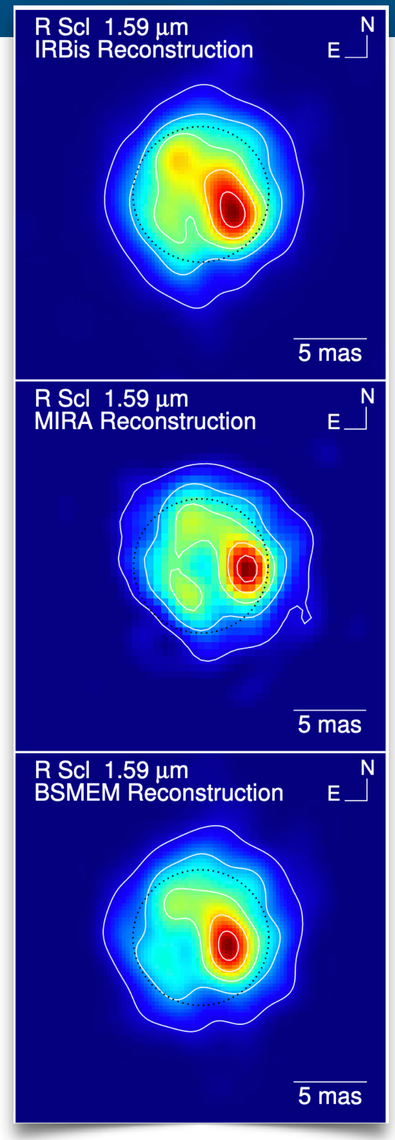
Needs: comparing reconstructions softwares



π^1 Gruis (Paladini, 2018)



Betelgeuse (Haubois, 2009)

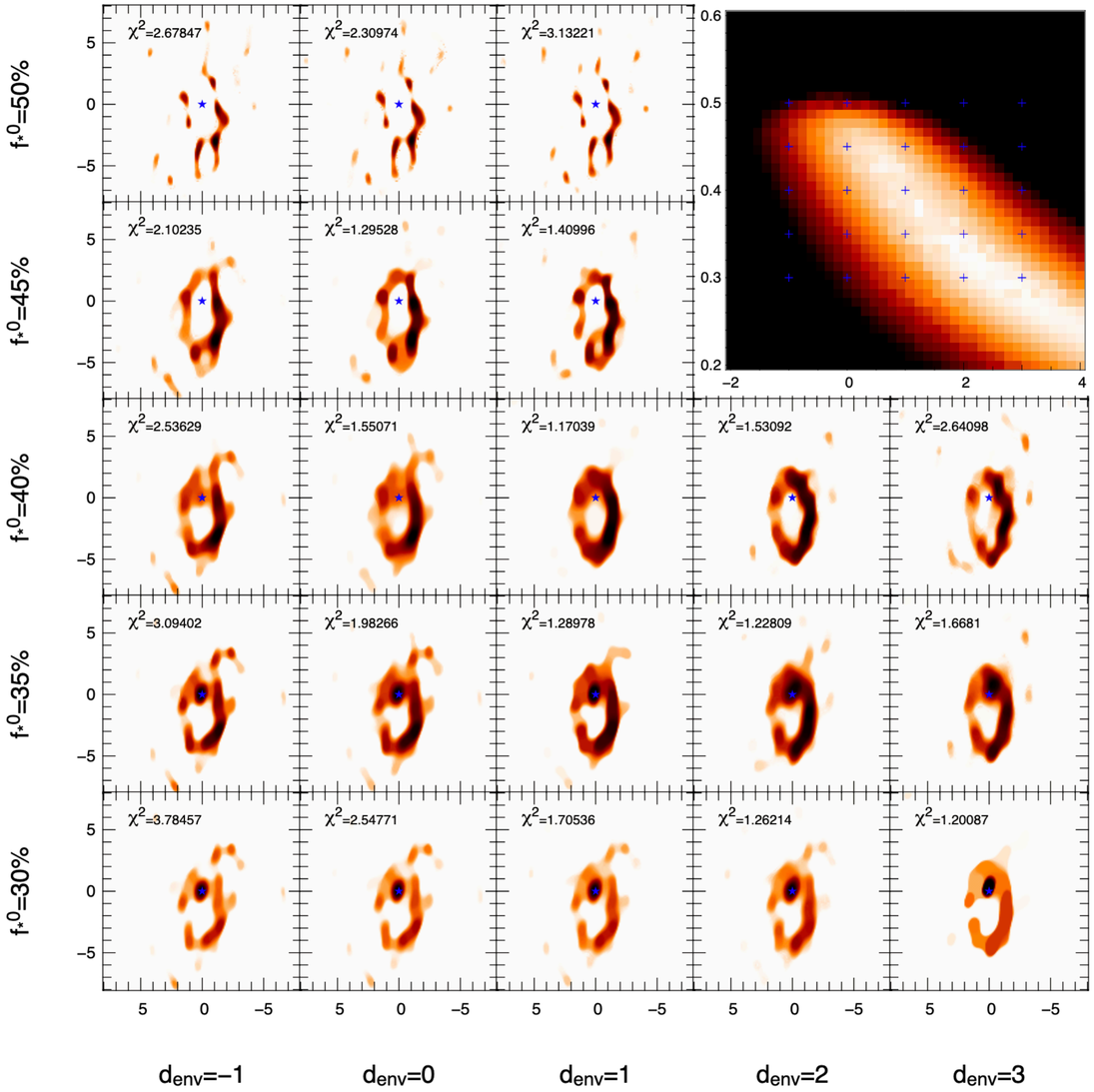


R Sculptoris (Wittkowski, 2017)

Needs: benchmarking parameters

Comparing results with different

- Priors
- Parameters
- Initialization



(Kluska, 2014)

Reconstruction algorithm in a nutshell

Input:

- Initial image
  - size
  - sampling
- Data
  - selection parameters
- Parameters
  - priors
  - hyper-parameters
  - number of iterations
  - …

Output:

- Reconstructed image
- Model of the data
- Output parameters
  - Chi-square
  - cost function value
  - …

Image-OI: an OIFITS extension for image reconstruction algorithms

Reconstructed image

OIFITS data

Initial image

Input parameters

Output parameters

Index	Extension	Type
0	Primary	Image
1	OI_TARGET	Binary
2	OI_ARRAY	Binary
3	OI_WAVELENGTH	Binary
4	OI_VIS2	Binary
5	OI_T3	Binary
6	IMAGE-OI INITIAL IMAGE	Image
7	IMAGE-OI INPUT PARAM	Binary
8	IMAGE-OI OUTPUT PARAM	Binary

Input parameters

Input parameters stored in the header of 'IMAGE-OI INPUT PARAM' HDU.

Data Selection (mandatory)		
Keyword	Type	Description
TARGET	string	Identifier of the target object to reconstruct
WAVE_MIN	real	Minimum wavelength to select (in meters)
WAVE_MAX	real	Maximum wavelength to select (in meters)
USE_VIS	string	Complex visibility data to consider if any†
USE_VIS2	logical	Use squared visibility data if any
USE_T3	string	Bispectrum data to consider if any†
† value can be: 'NONE', 'ALL', 'AMP' or 'PHI'.		

Algorithm Settings		
Keyword	Type	Description
INIT_IMG	string	Identifier of the initial image
MAXITER	integer	Maximum number of iterations to run
RGL_NAME	string	Name of the regularization method
AUTO_WGT	logical	Automatic regularization weight
RGL_WGT	real	Weight of the regularization
RGL_PRIO	string	Identifier of the HDU with the prior image
FLUX	real	Assumed total flux (1 is the default)
FLUXERR	real	Error bar for the total flux (0 means strict constraint)
HDUPREFX	string	Prefix that specifies the leading text to use in the HDUNAME of the final image

More complex inputs can be stored in the HDU itself

Initial image

Initial image set the field of view and the pixel size of the reconstruction

Image Parameters

Keyword	Type	Description
HDUNAME	string	Unique name for the image within the FITS file
NAXIS1	integer	First dimension of the image
NAXIS2	integer	Second dimension of the image
CTYPE1	string	Coordinate name 'RA---TAN' for 1st axis
CTYPE2	string	Coordinate name 'DEC--TAN' for 2nd axis
CDELT*i*	real	Physical increment along *i*-th dimension of the image (for *i* = 1 or 2)
CUNIT*i*	string	Physical units for CDELT*i* and CRVAL*i*; defaults to 'deg' if omitted
CRPIX*i*	real	Index of reference pixel along *i*-th dimension (for *i* = 1 or 2); defaults to the geometric center of the field of view if omitted
CRVAL*i*	real	Physical coordinate of reference pixel along *i*-th dimension (for *i* = 1 or 2) and relative to the center of the field of view; defaults to 0 if omitted

Can be a simple shape or a more complex object generated by model fitting tool

Reconstructed image and output parameters

Reconstructed image is stored in the primary HDU

- Most FITS viewer opens the primary by default

Reconstructed image and output parameters

Reconstructed image is stored in the primary HDU

Most FITS viewer opens the primary by default

Output parameters are stored in the header of 'IMAGE-OI OUTPUT PARAM' HDU

Algorithm Results		
Keyword	Type	Description
LAST_IMG	string	Identifier of the final image
NITER	integer	Total iterations done in the current program run
CHISQ	real	Reduced chi-squared
FPRIOR	real	Regularization penalty
FLUX	real	Total image flux
PROCSOFT	string	Software name and version number
CONVERGE	boolean	Set to 'T' if the algorithm stopped because it has converged

Modeled data

Extra column next to the data containing the model and optionally its errors

New columns in OI_VIS tables		
Label	Format	Description
NS_MODEL_VISAMP	D(*NWAVE*)	Model of the visibility amplitude
NS_MODEL_VISAMPERR	D(*NWAVE*)	Model of the error in visibility amplitude (optional)
NS_MODEL_VISPHI	D(*NWAVE*)	Model of the visibility phase in degrees
NS_MODEL_VISPHIERR	D(*NWAVE*)	Model of the error in visibility phase in degrees (optional)

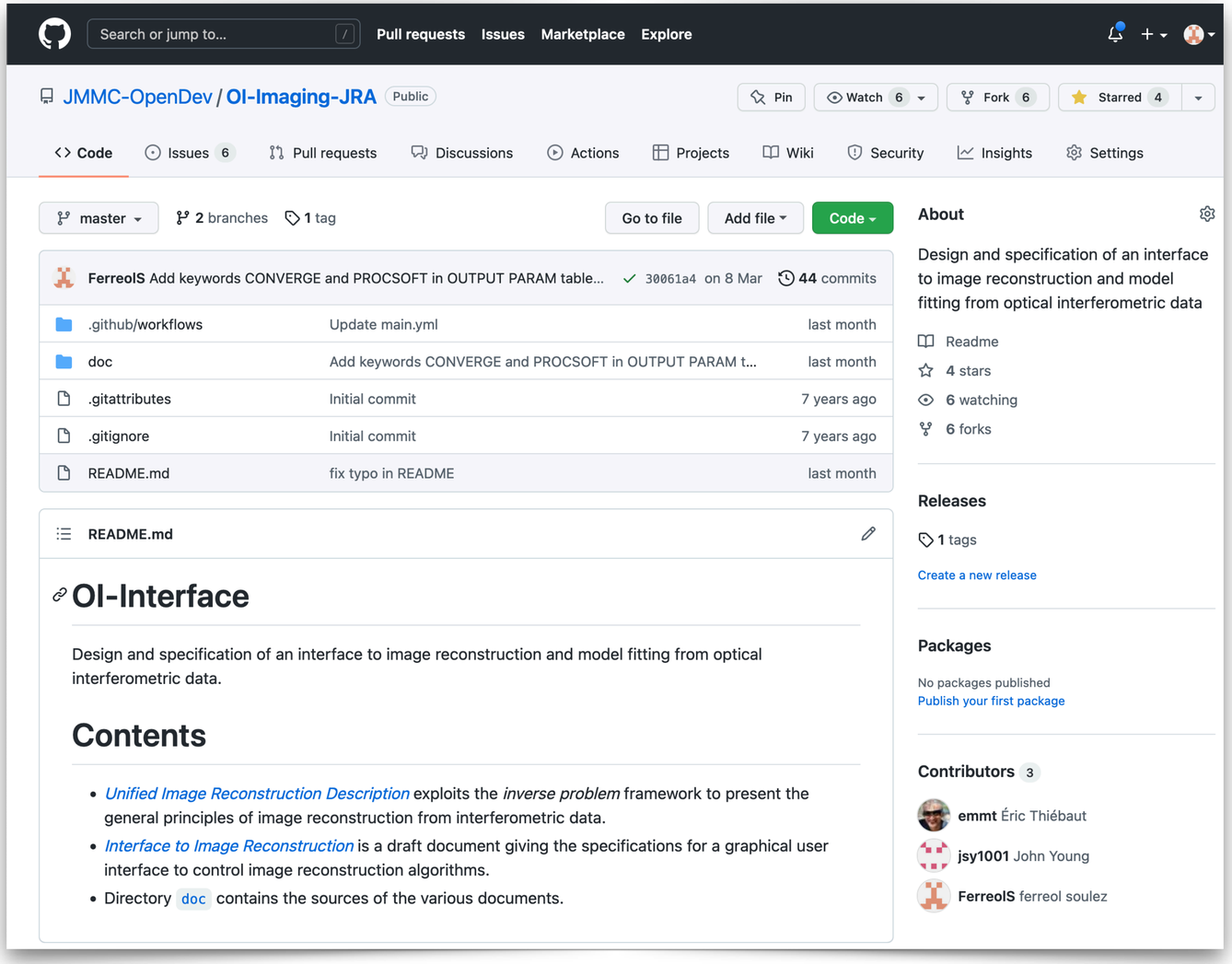
New columns in OI_VIS2 tables		
Label	Format	Description
NS_MODEL_VIS2	D(*NWAVE*)	Model of the squared visibility
NS_MODEL_VIS2ERR	D(*NWAVE*)	Model of the error in squared visibility (optional)

New columns in OI_T3 tables		
Label	Format	Description
NS_MODEL_T3AMP	D(*NWAVE*)	Model of the triple-product amplitude
NS_MODEL_T3AMPERR	D(*NWAVE*)	Model of the error in triple-product amplitude (optional)
NS_MODEL_T3PHI	D(*NWAVE*)	Model of the triple-product phase in degrees
NS_MODEL_T3PHIERR	D(*NWAVE*)	Model of the error in triple-product phase in degrees (optional)

Image-OI: a common extension to connect them all

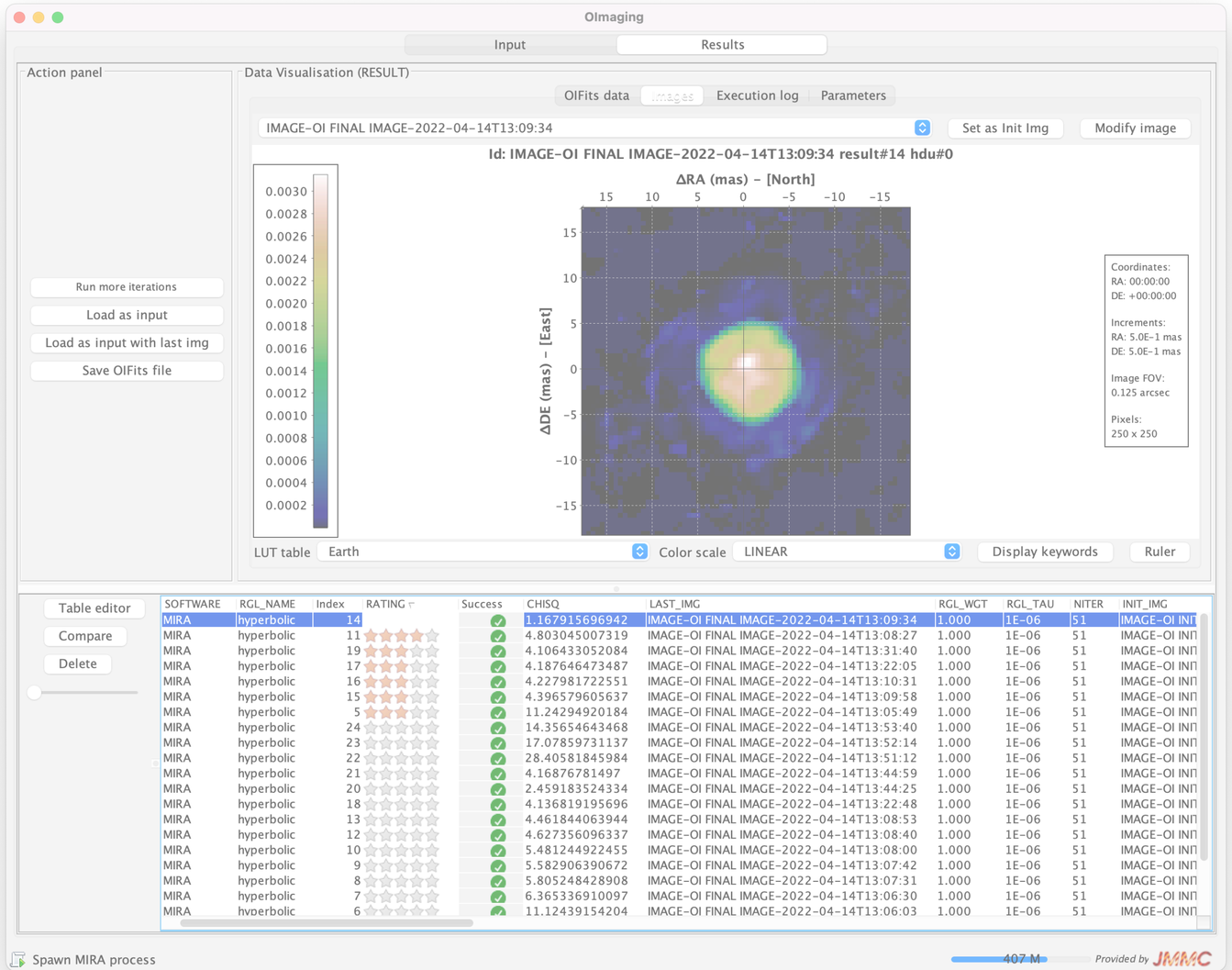
A unified way to call reconstruction softwares

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



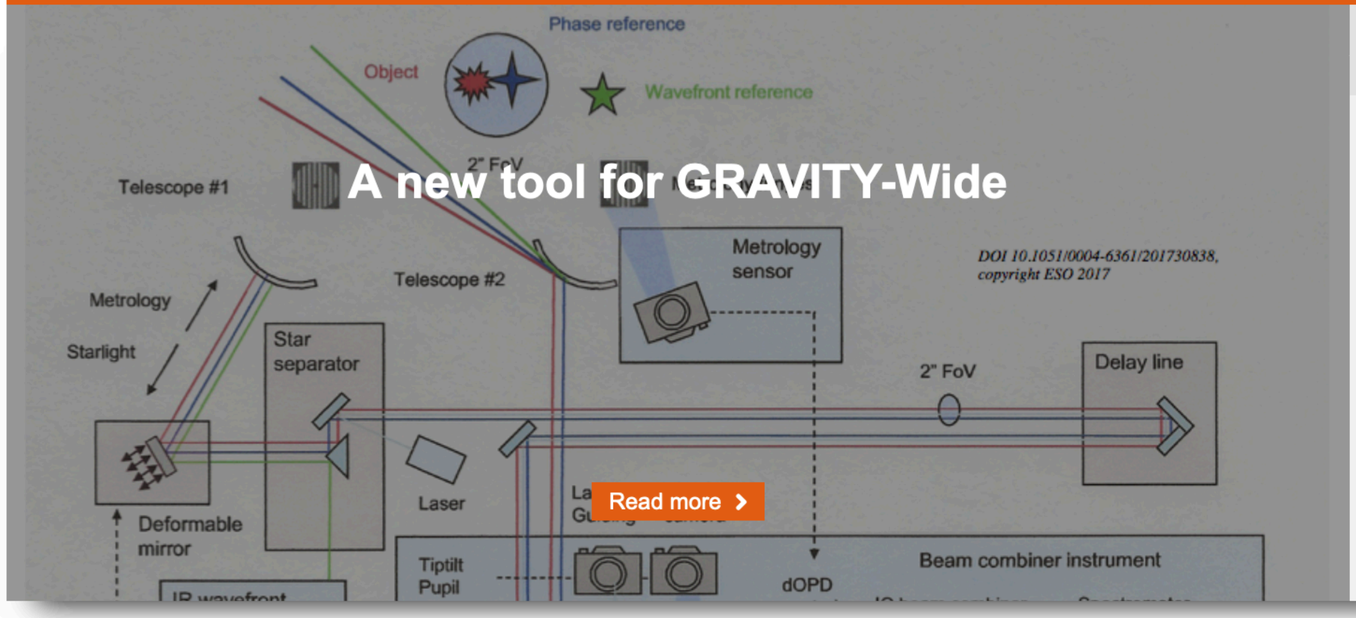
OImaging

A single graphical user interface for image reconstruction algorithms



JMMC

We interfere constructively



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 ›

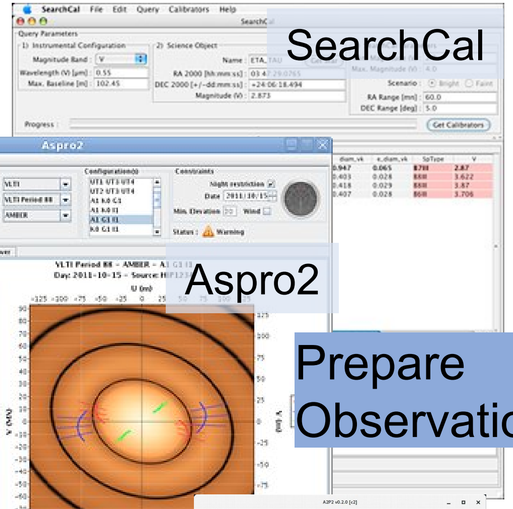
ASPRO SEARCHCAL LITPRO OIFITSEXPLORER OIMAGING OIDB

JMMC Service overview

SUV (VLTI Center):

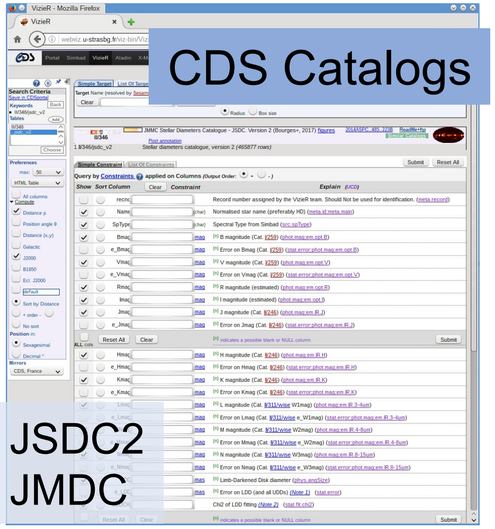
+ User Support

+ Training

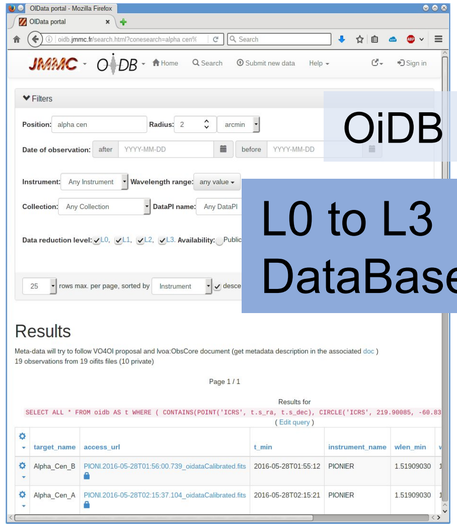


Prepare Observations

SAMP



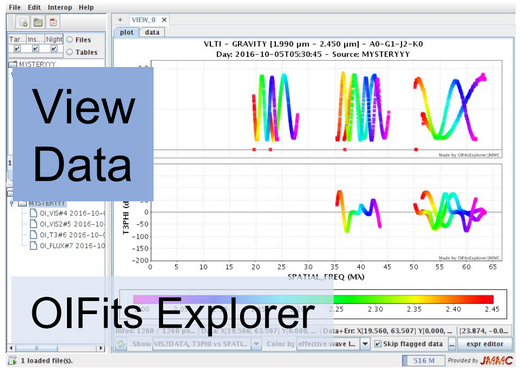
JSDC2
JMDC

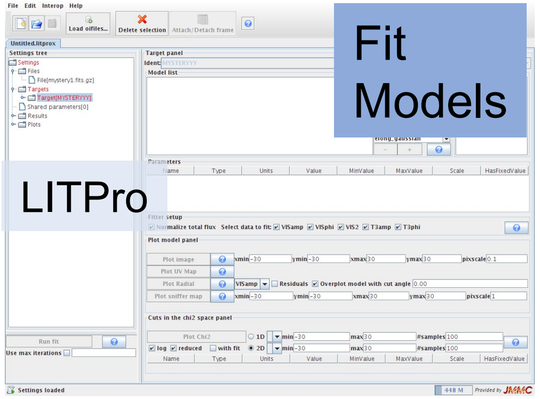


L0 to L3
DataBases

Reduce data

amdlib
pndrs





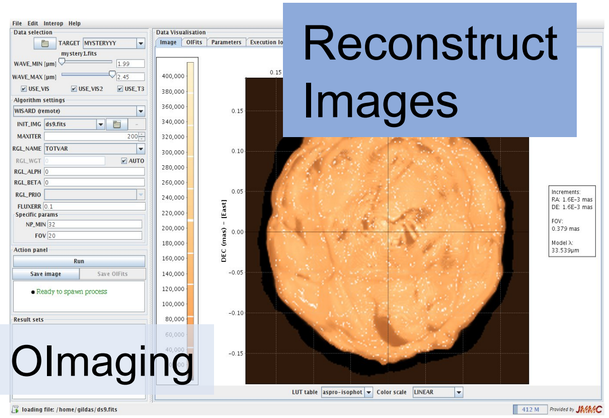
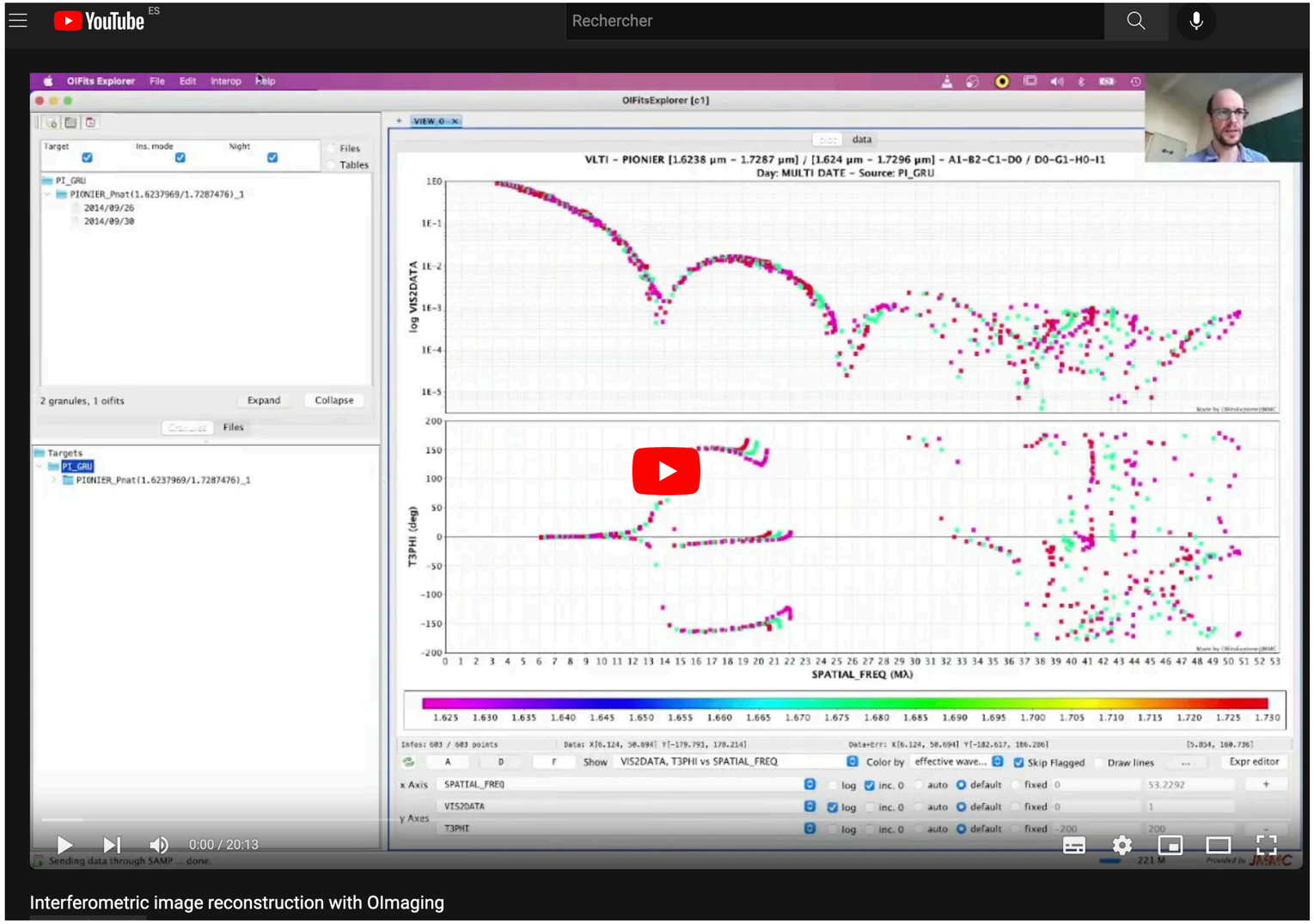


Image reconstruction workflow

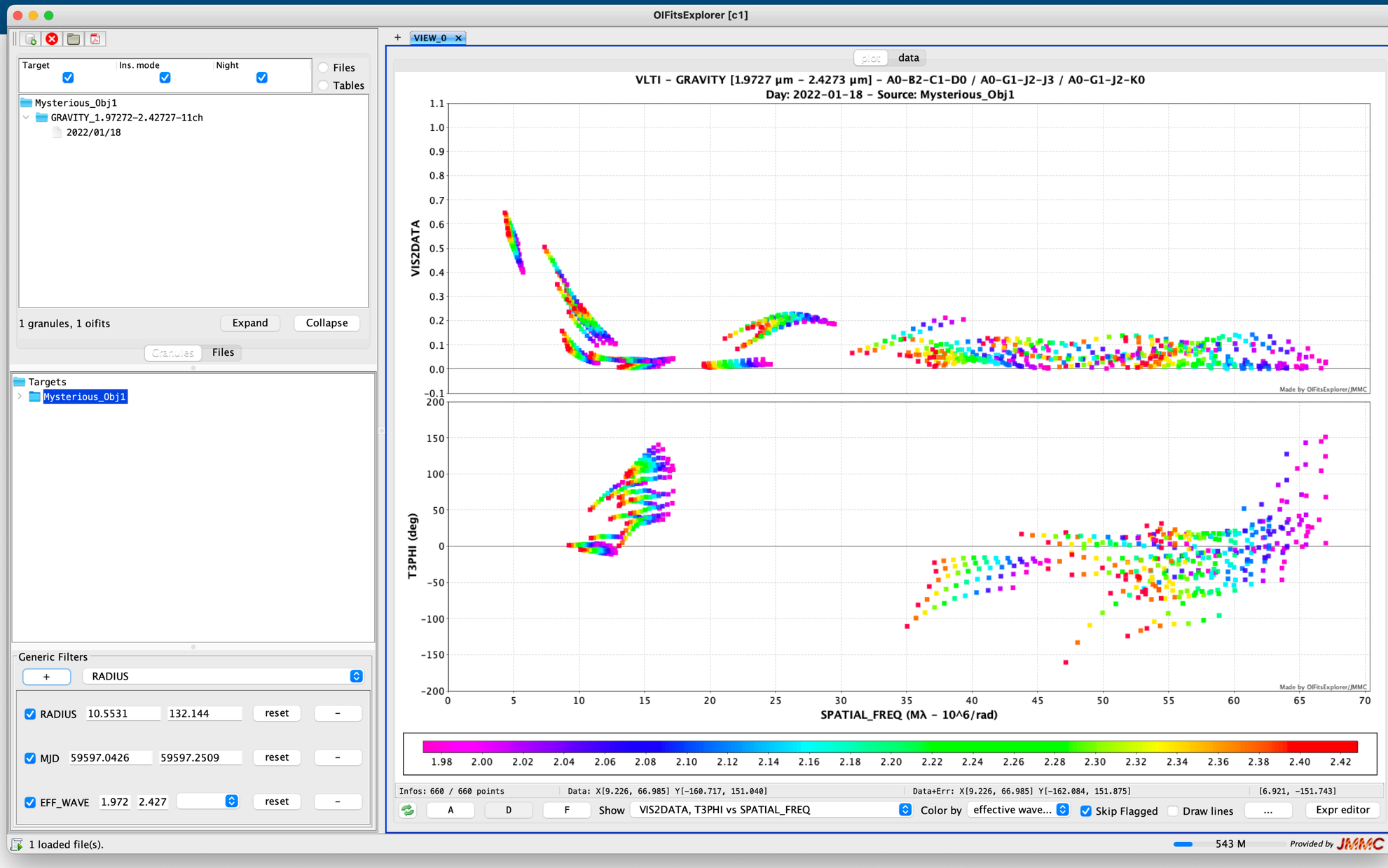
https://youtu.be/YA3hvs_sOfE



Interferometric image reconstruction with OImaging

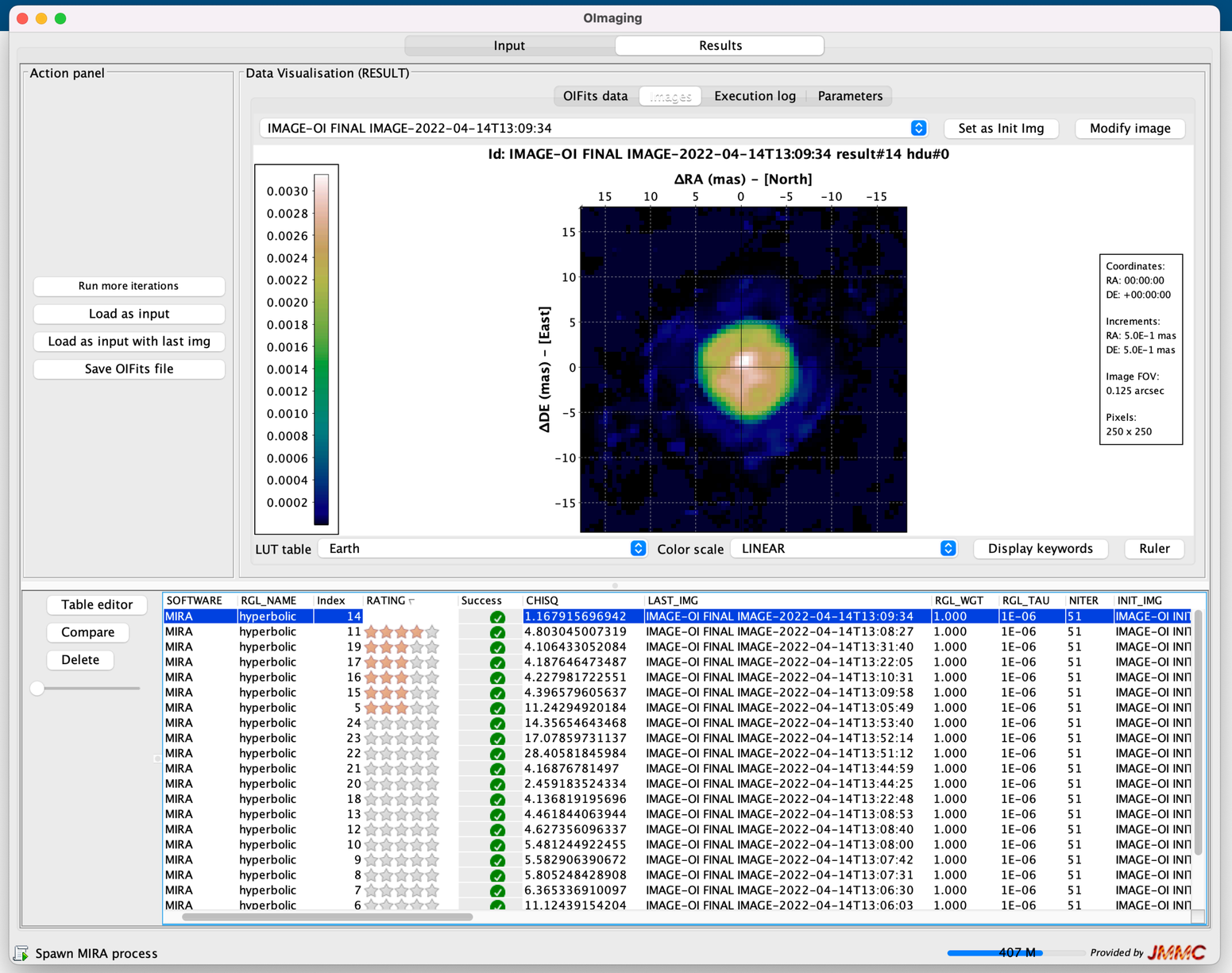
OIFitsExplorer: data handling tool

New version today!



OImaging

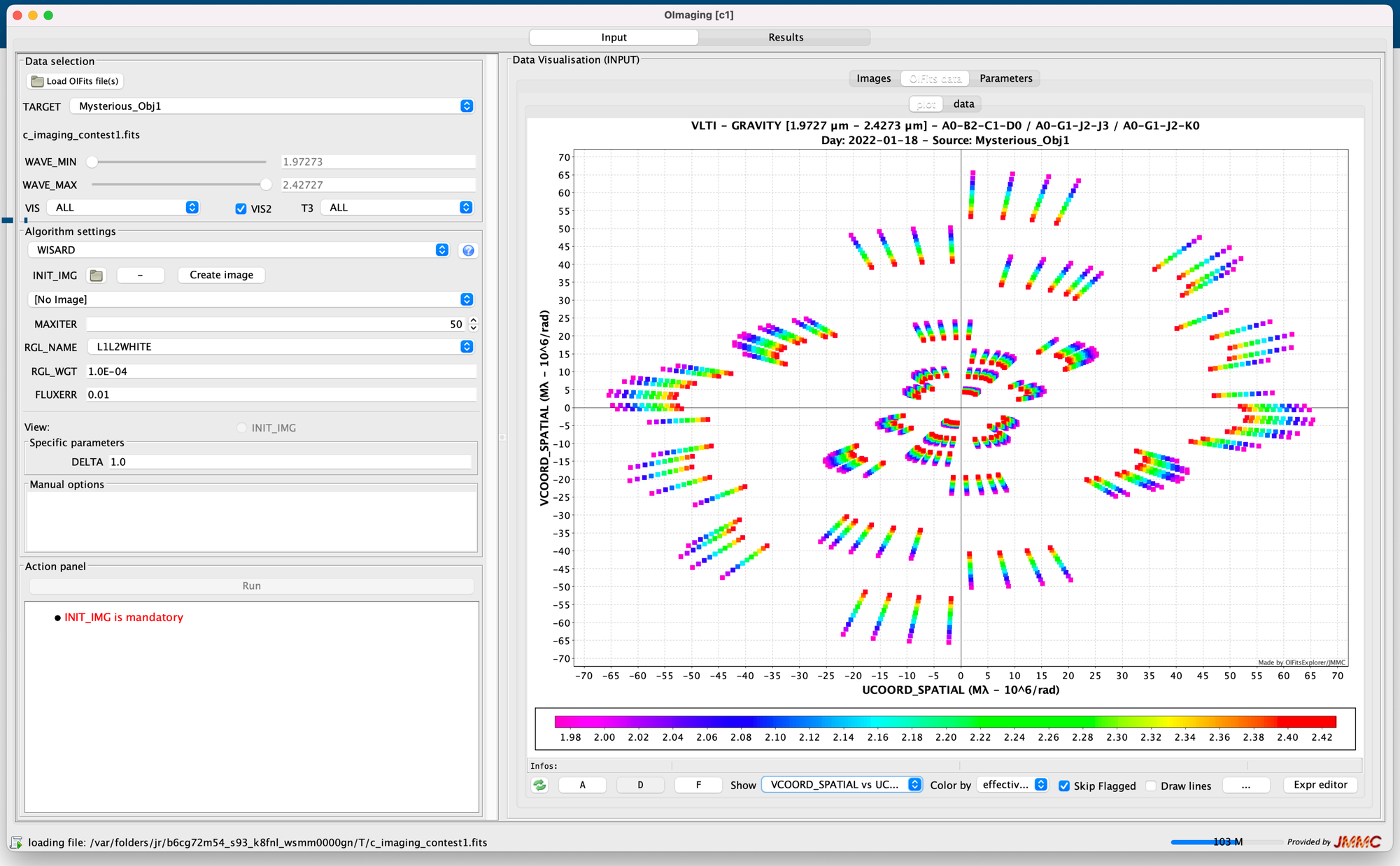
- **A single interface**
  - 4 softwares: BSMEM, MiRA, SPARCO,WISARD
  - results in a single table
  - rating, comparing,…
  - saving reconstruction parameters with the image



OImaging: Input panel

Data selection

Algorithm parameters

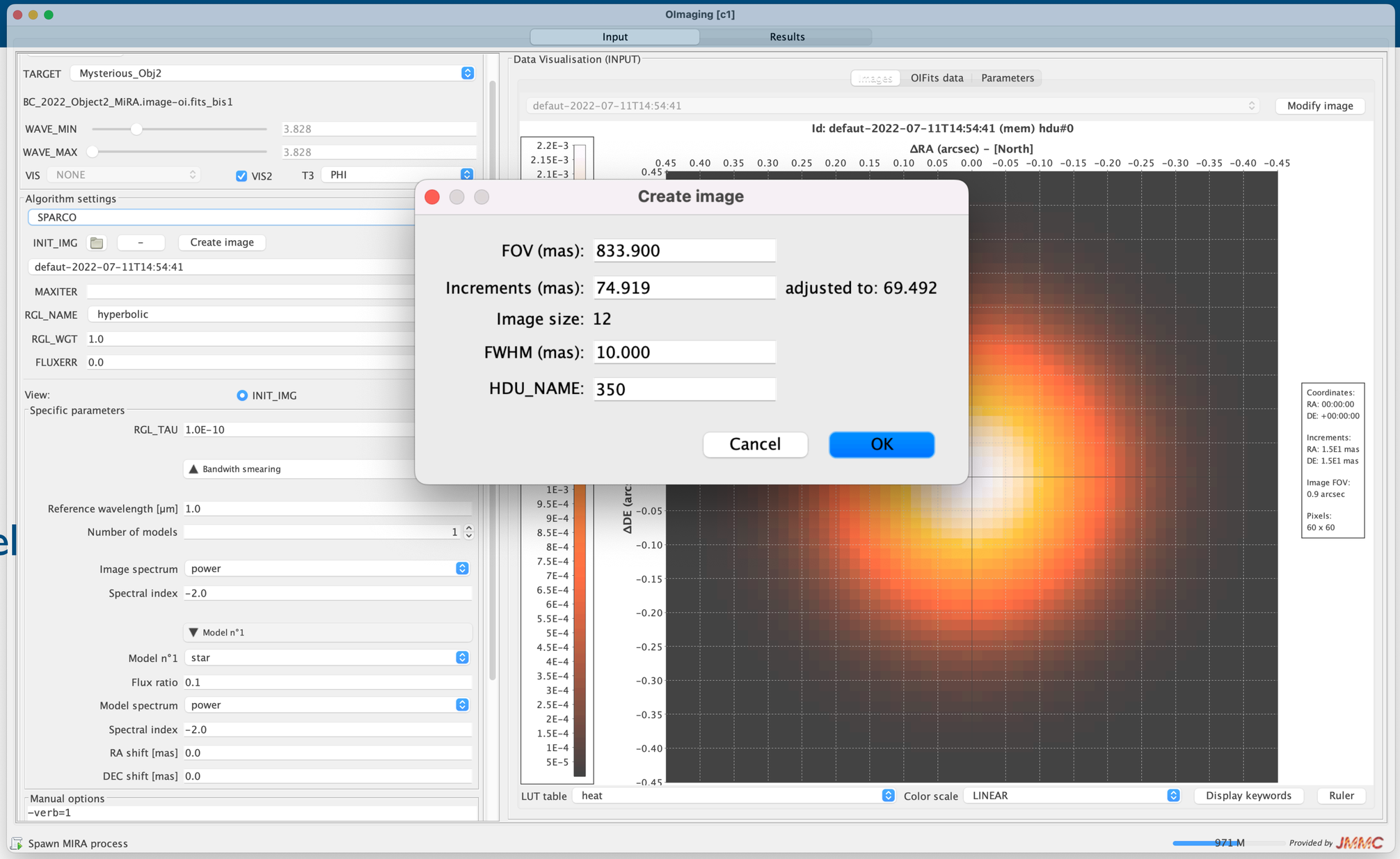


OImaging: Initial image

Set the field of view and the sampling of the reconstruction

Can be a

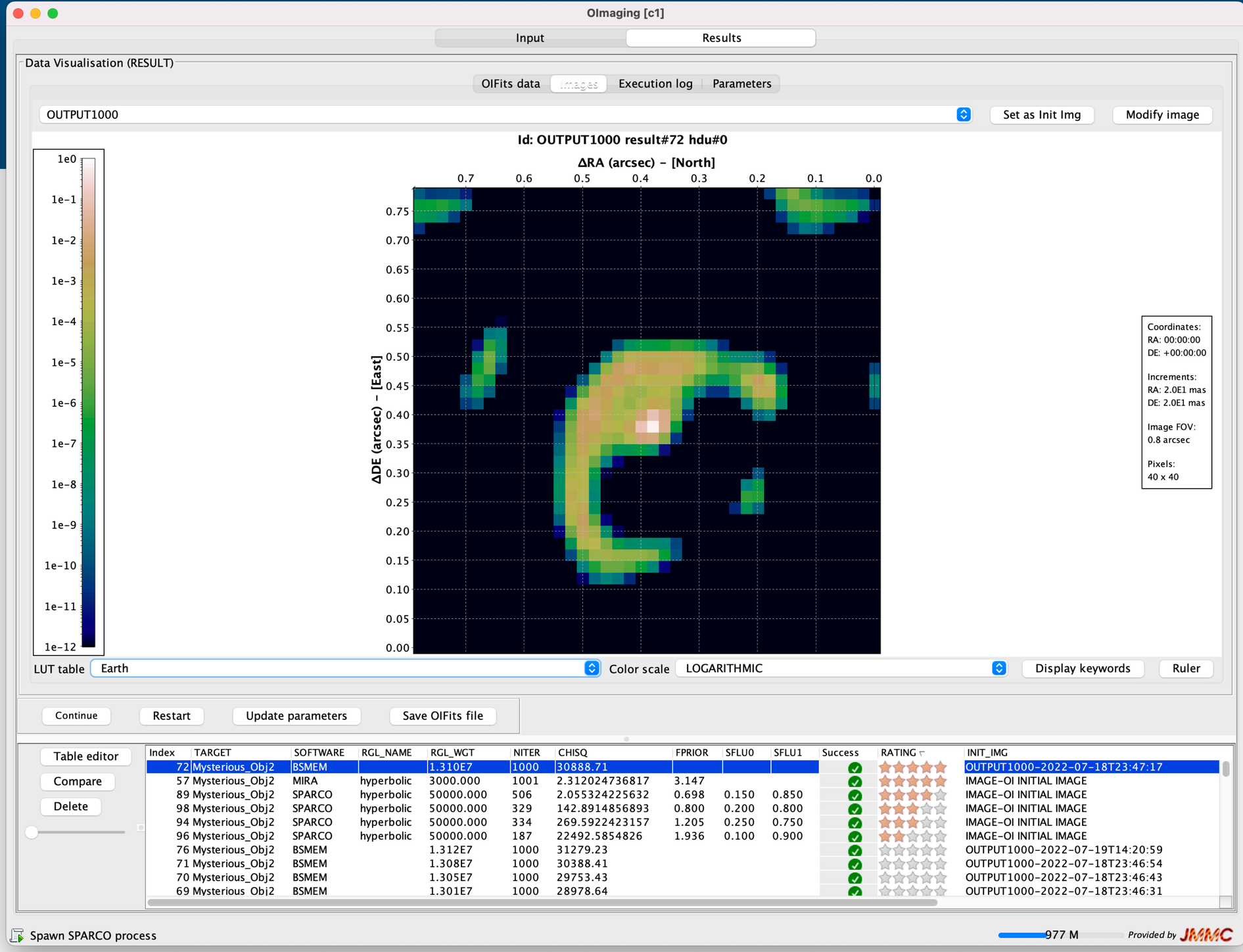
- FITS image
- Image from model fitting algorithms
- built from OImaging (Gaussian)



OImaging

◉ Result panel

- Image
- model
- execution log
- parameters



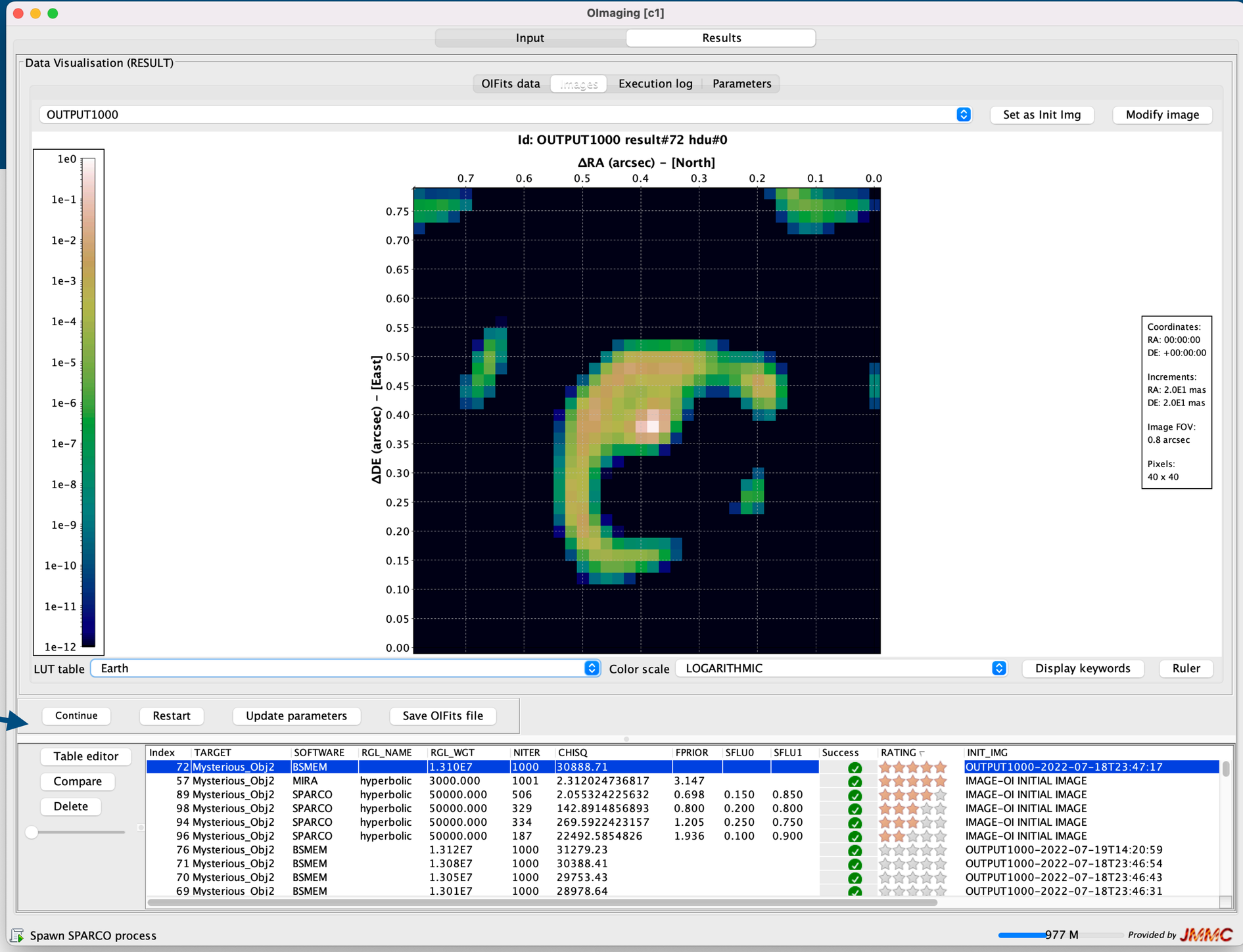
OImaging

◉ Result panel

- Image
- model
- execution log
- parameters

◉ Buttons

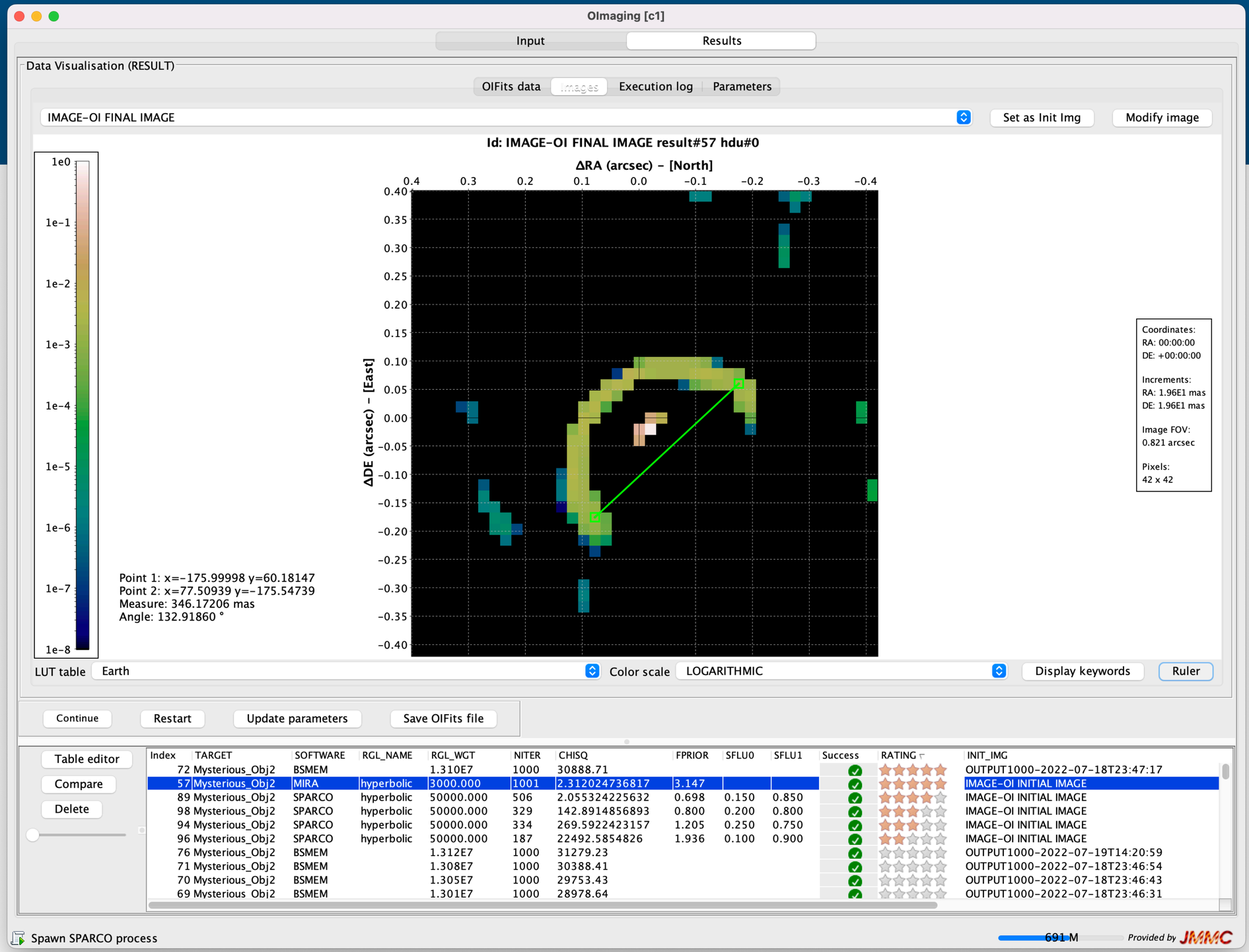
- Continue
- Restart
- Update
- Save



OImaging

◉ Tools

- ruler
- LUT table and scale



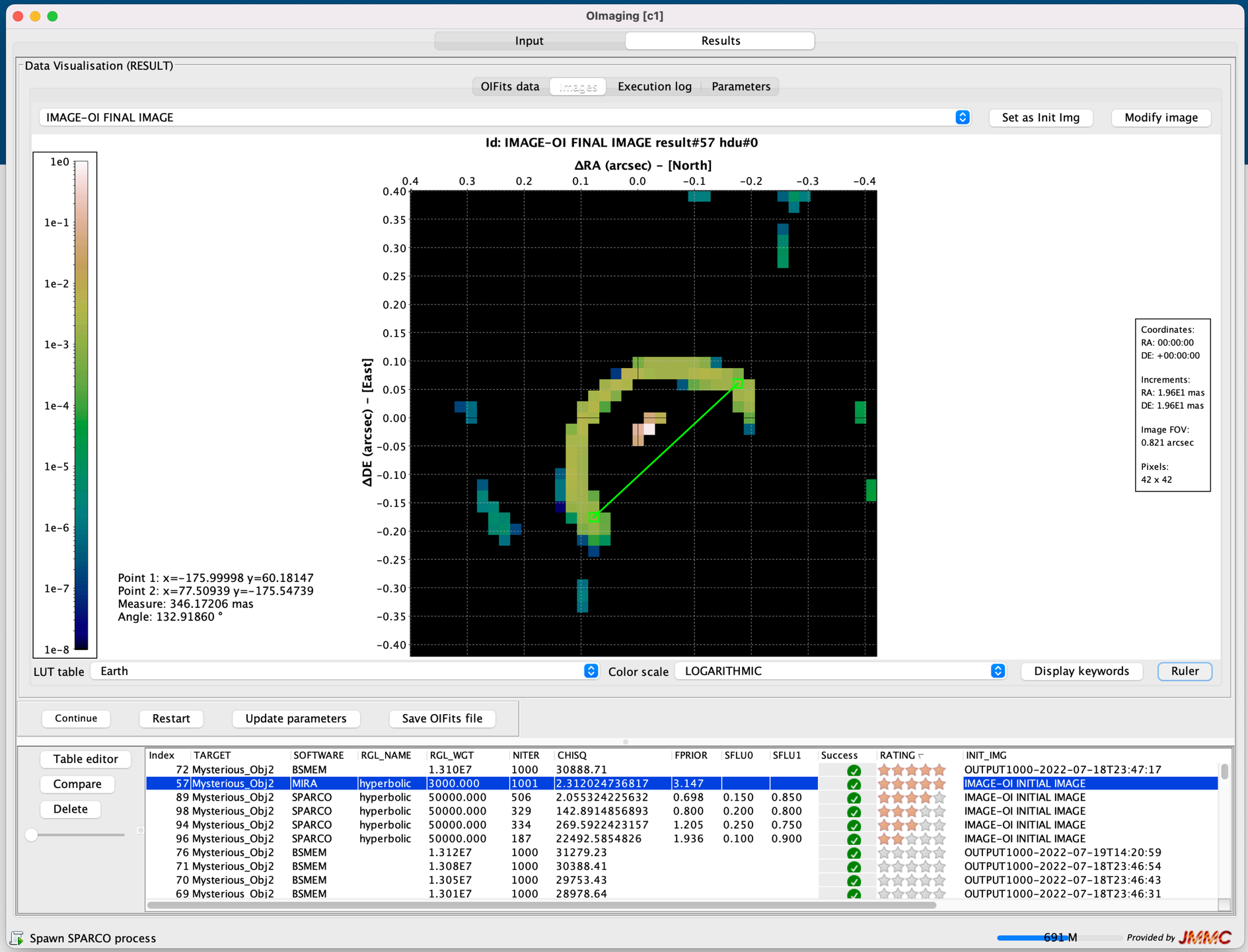
OImaging

◉ Tools

- ruler
- LUT table and scale

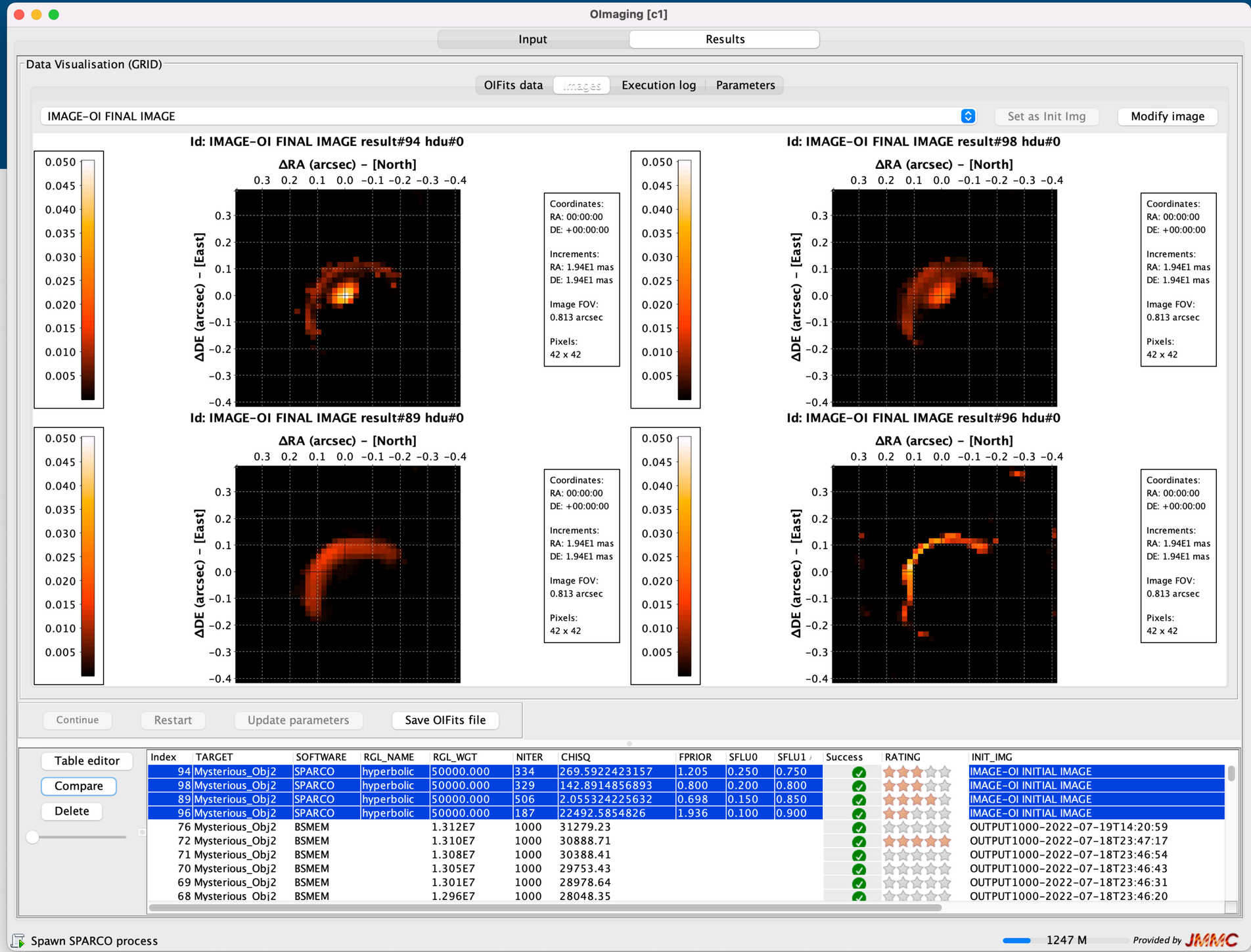
◉ Table panel

- All previous results
- sorting
- rating
- user notes



OImaging

Comparing results



You'll never walk alone

JMMC

European Interferometry Initiative

Past Activities | VLTI Expertise Centres | Dissemination & Training | Joint Activities | Fizeau Program | Getting start with the VLTI

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:

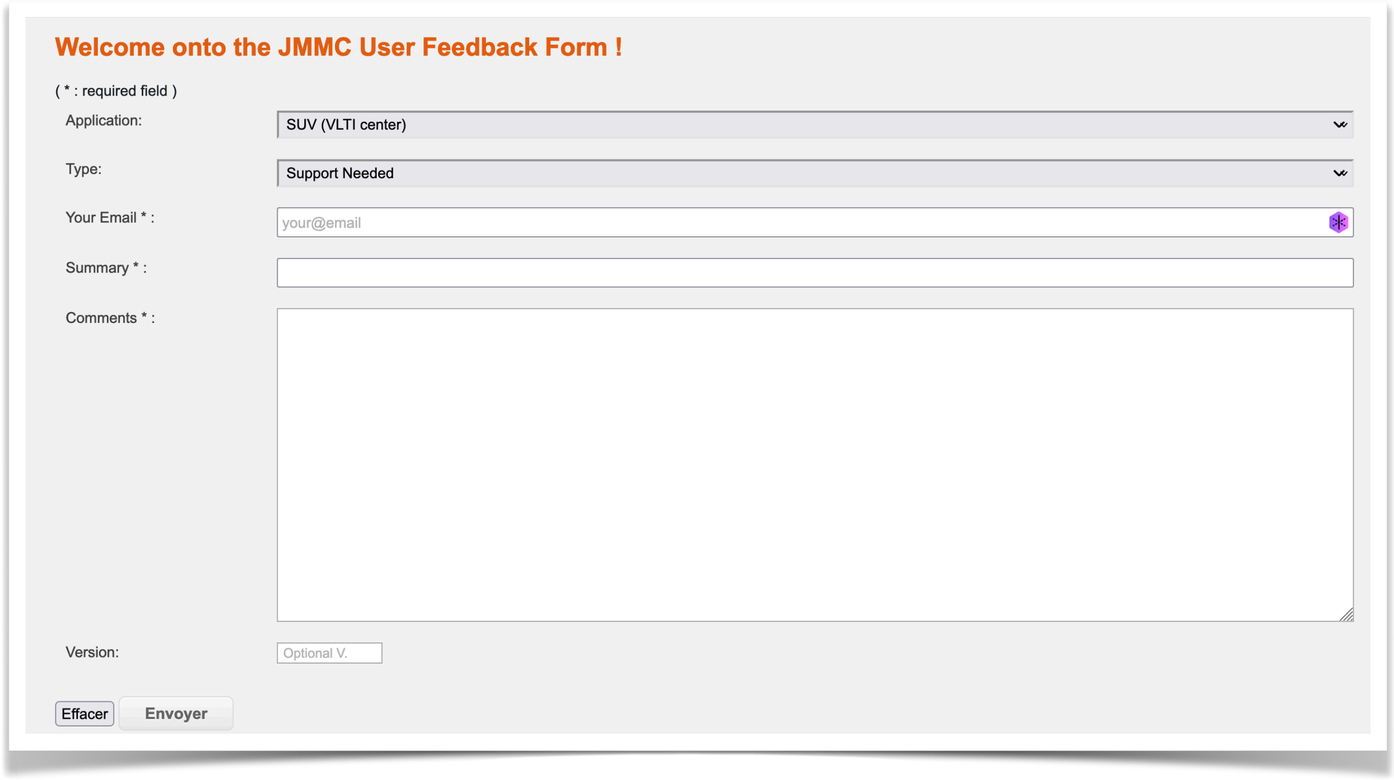
- Lagrange Laboratory/OCA, France
- KU Leuven, Belgium

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

OImaging

- Checkout new v1.0 release !!! www.jmmc.fr/releases/
- Still in progress
- Open source:  github.com/JMMC-OpenDev
- Need help to add new algorithms

OImaging

- Checkout new v1.0 release !!! www.jmmc.fr/releases/
- Still in progress
- Open source:  github.com/JMMC-OpenDev
- Need help to add new algorithms

Ask for help and give feedback !

- Expertise center gather experts that are willing to help
- 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