An image reconstruction workflow @ JMMC

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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
◉ **G^{R}** (GRAVITY col., 2022)	python

Reconstruction algorithms in a nutshell

Most algorithms follow a MAP framework:

- Reconstructed image

$$\boldsymbol{o}^{+} = \arg\min_{\boldsymbol{o}\in\mathbb{D}^N} \mathcal{L}(\boldsymbol{o}) + \mu\,\mathcal{R}(\boldsymbol{o})$$

- Strict priors (eg non-negativity)
- Regularization: enforces priors
- Likelihood: measures the compatibility of the image with the data
- Hyper-parameter: balances priors and likelihood

Reconstruction algorithms in a nutshell

Likelihood Most algorithms use Gaussian likelihood for the three main measured quantities

- Visibilities
- Squared-visibilities
- Closure phase

Regularizations One of the following:

- Quadratic smoothness

$$f_{\text{prior}}(\boldsymbol{x}) = \|\mathbf{D} \cdot \boldsymbol{x}\|^2$$

- Soft support

$$f_{\text{prior}}(\boldsymbol{x}) = \sum_j x_j^2 / x_j^{\text{prior}}$$

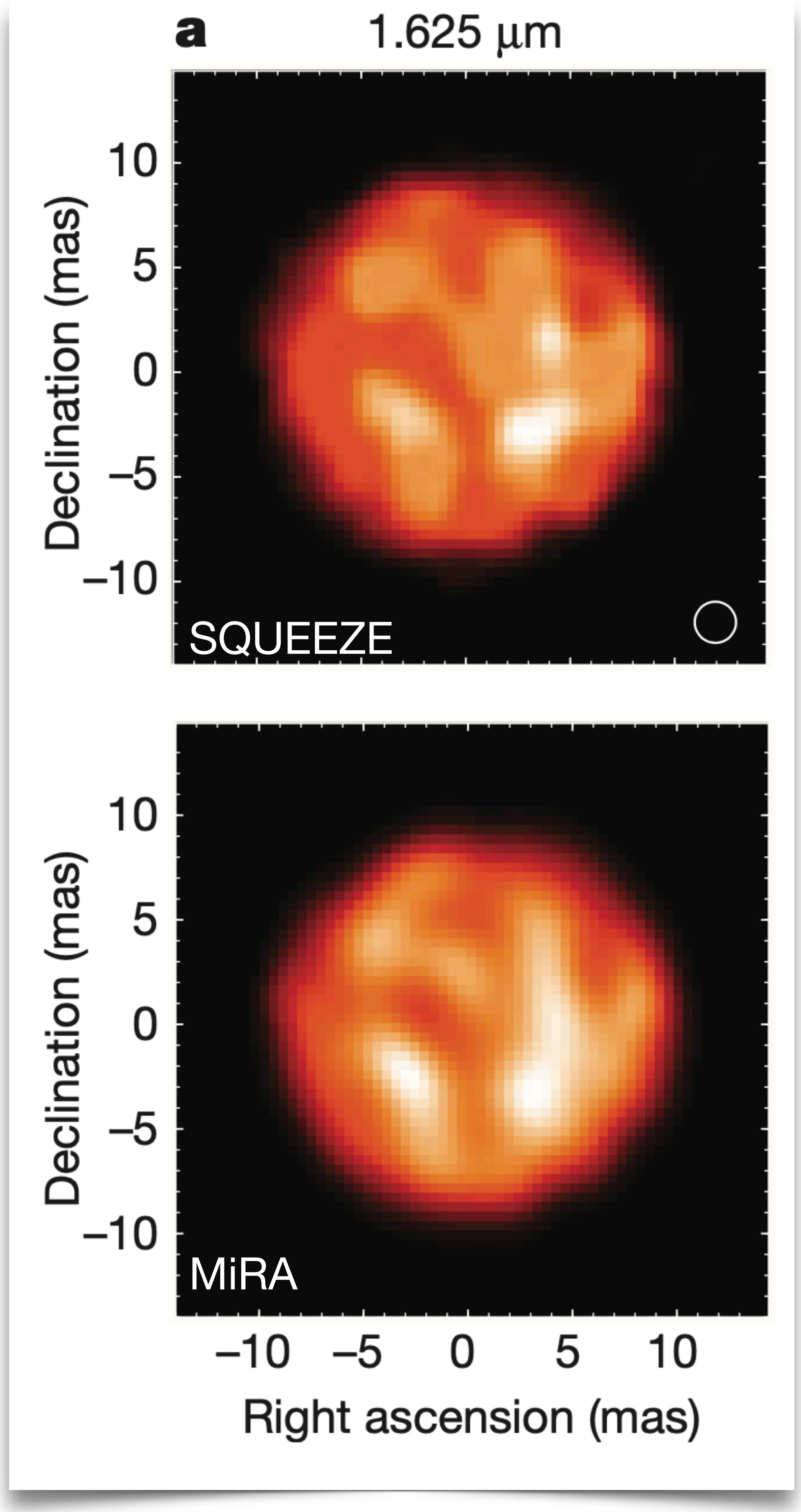
- Edge preserving smoothness

$$f_{\text{prior}}(\boldsymbol{x}) = \mu \sum_{j,k} \left(\sqrt{(\mathbf{D}_j \cdot \boldsymbol{x})_k^2 + \epsilon^2} - \epsilon \right)$$

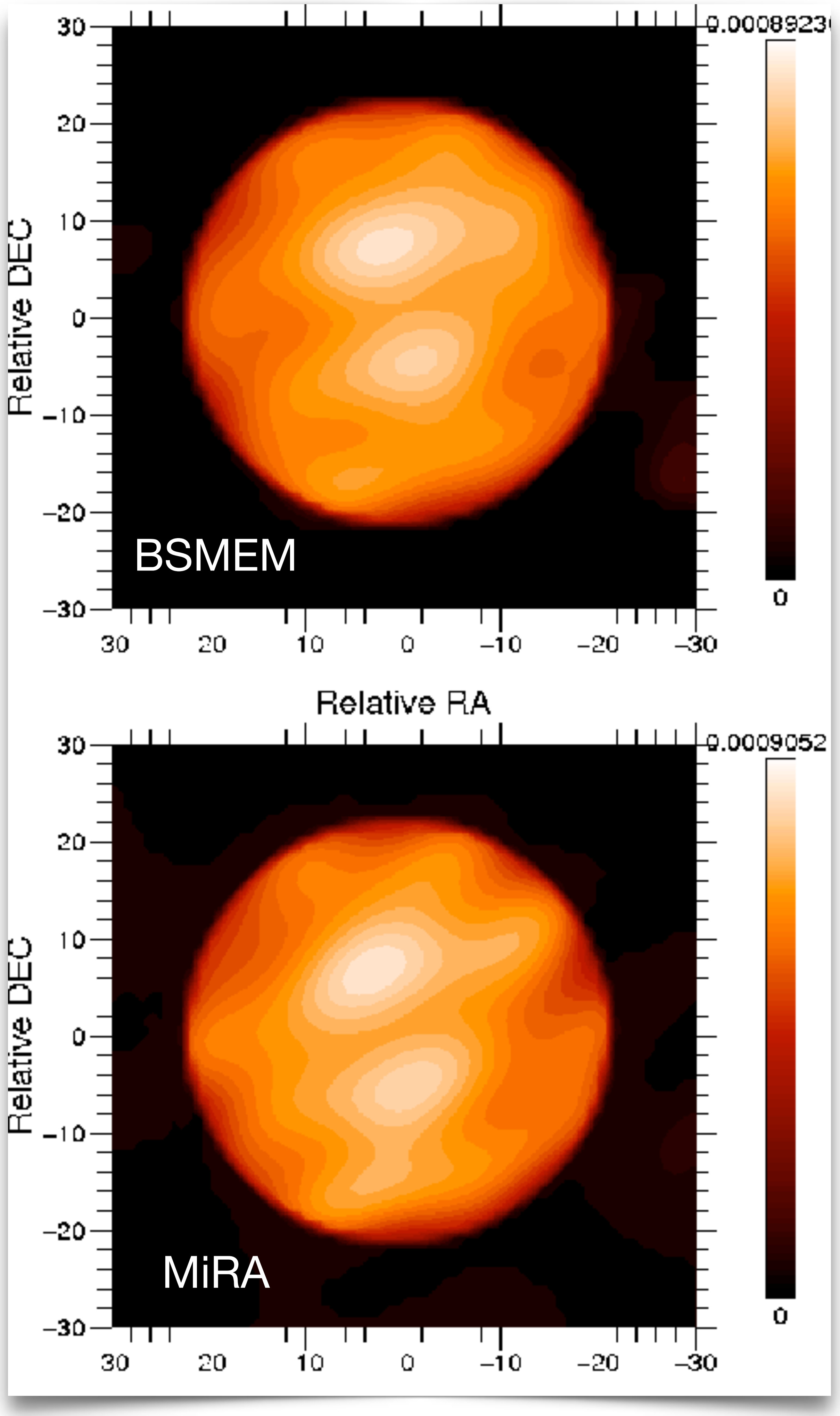
- Entropy

$$f_{\text{ent5}}(\boldsymbol{x}; \boldsymbol{x}_{\text{prior}}) = \sum_j \left[x_j^{\text{prior}} - x_j + x_j \log \left(x_j / x_j^{\text{prior}} \right) \right]$$

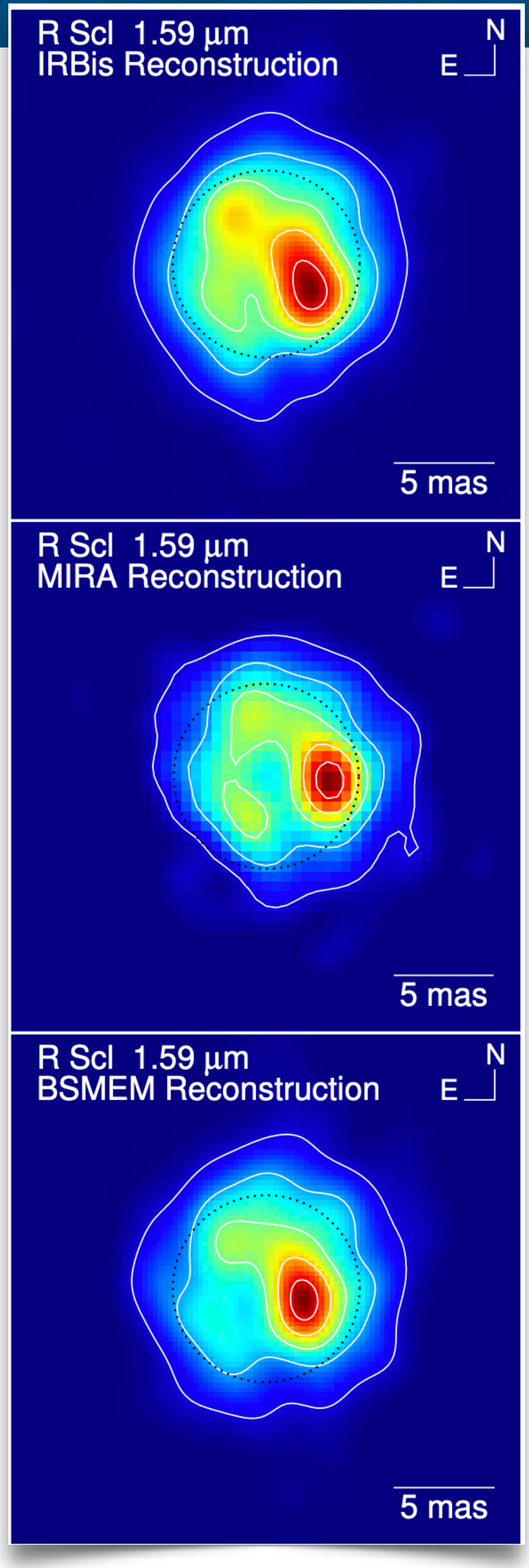
"Classical" softwares give similar results



π^1 Gruis (Paladini, 2018)



Betelgeuse (Haubois, 2009)



R Sculptoris (Wittkowski, 2017)

Reconstruction algorithms in a nutshell

Input:

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

reconstruction algorithm →

Output:

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

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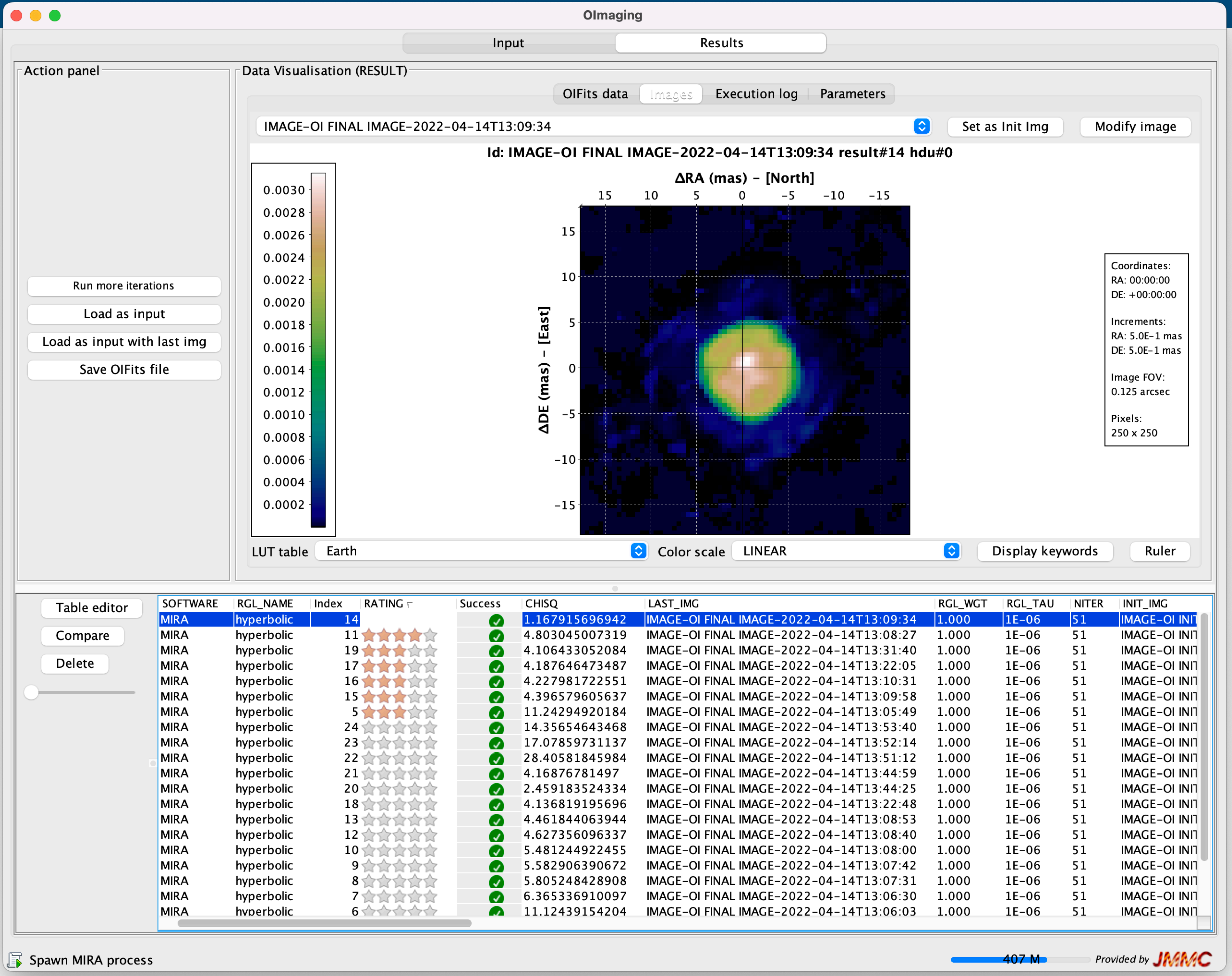
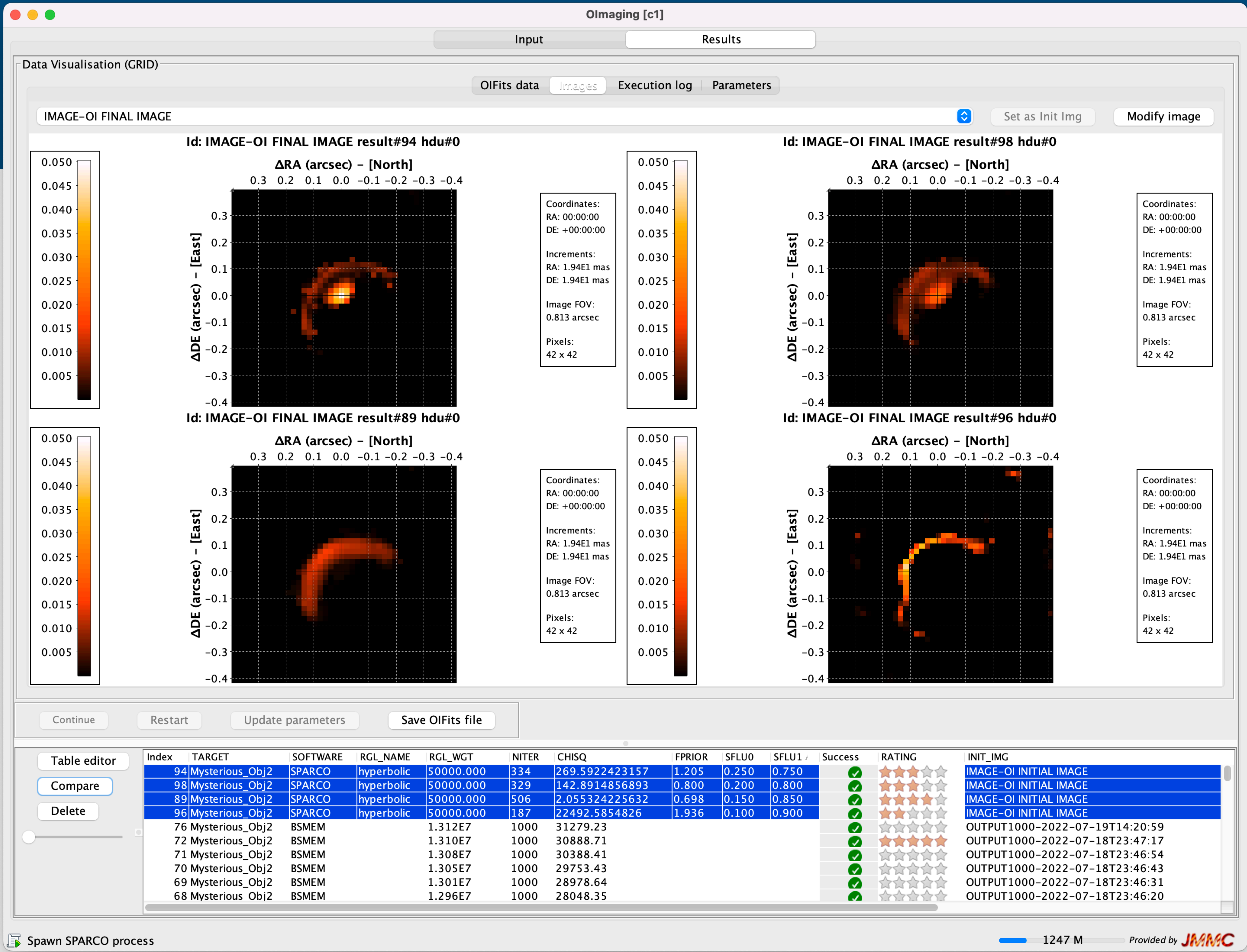
JMMC

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

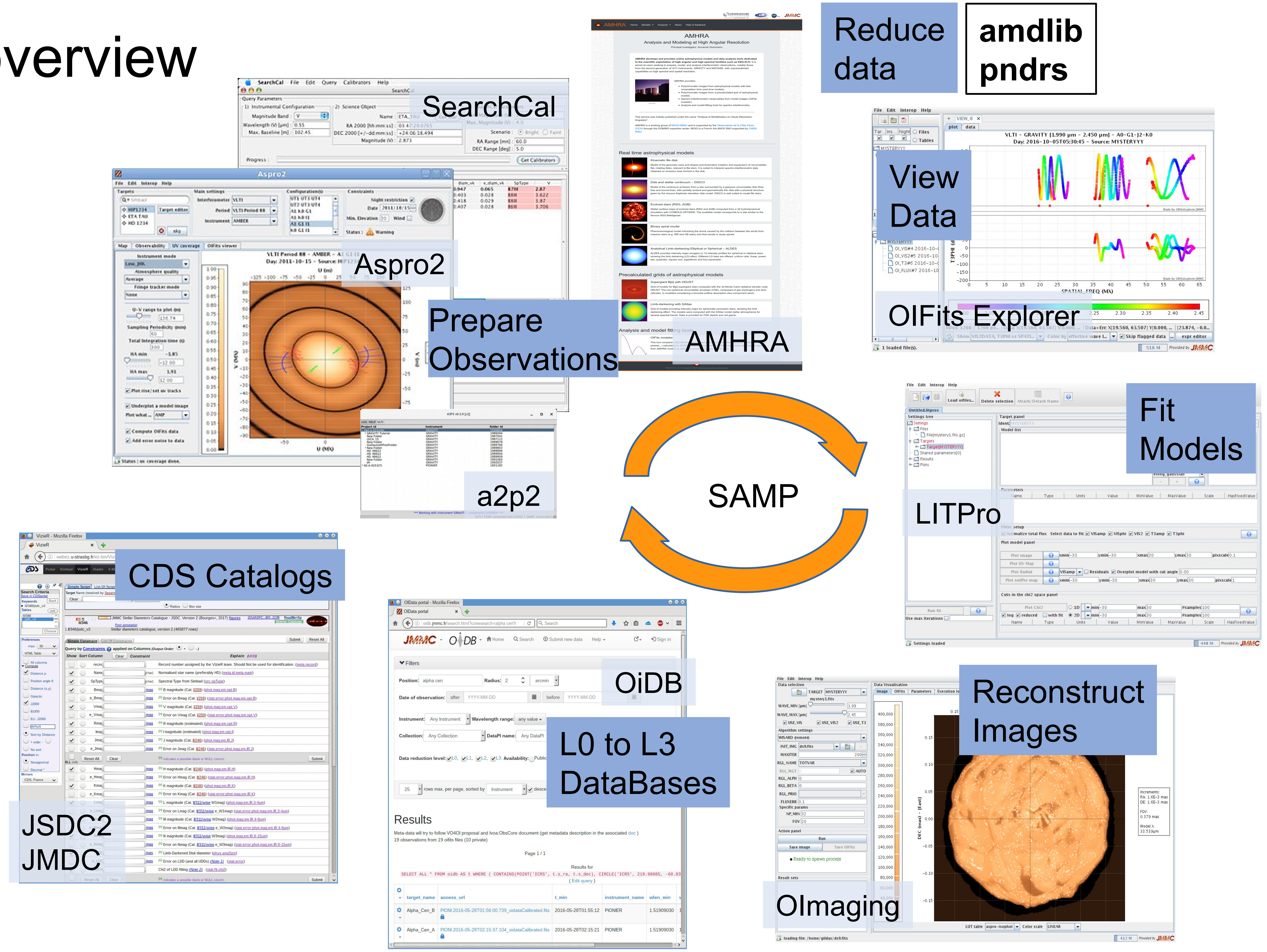


OImaging

Comparing results



JMMC Service overview

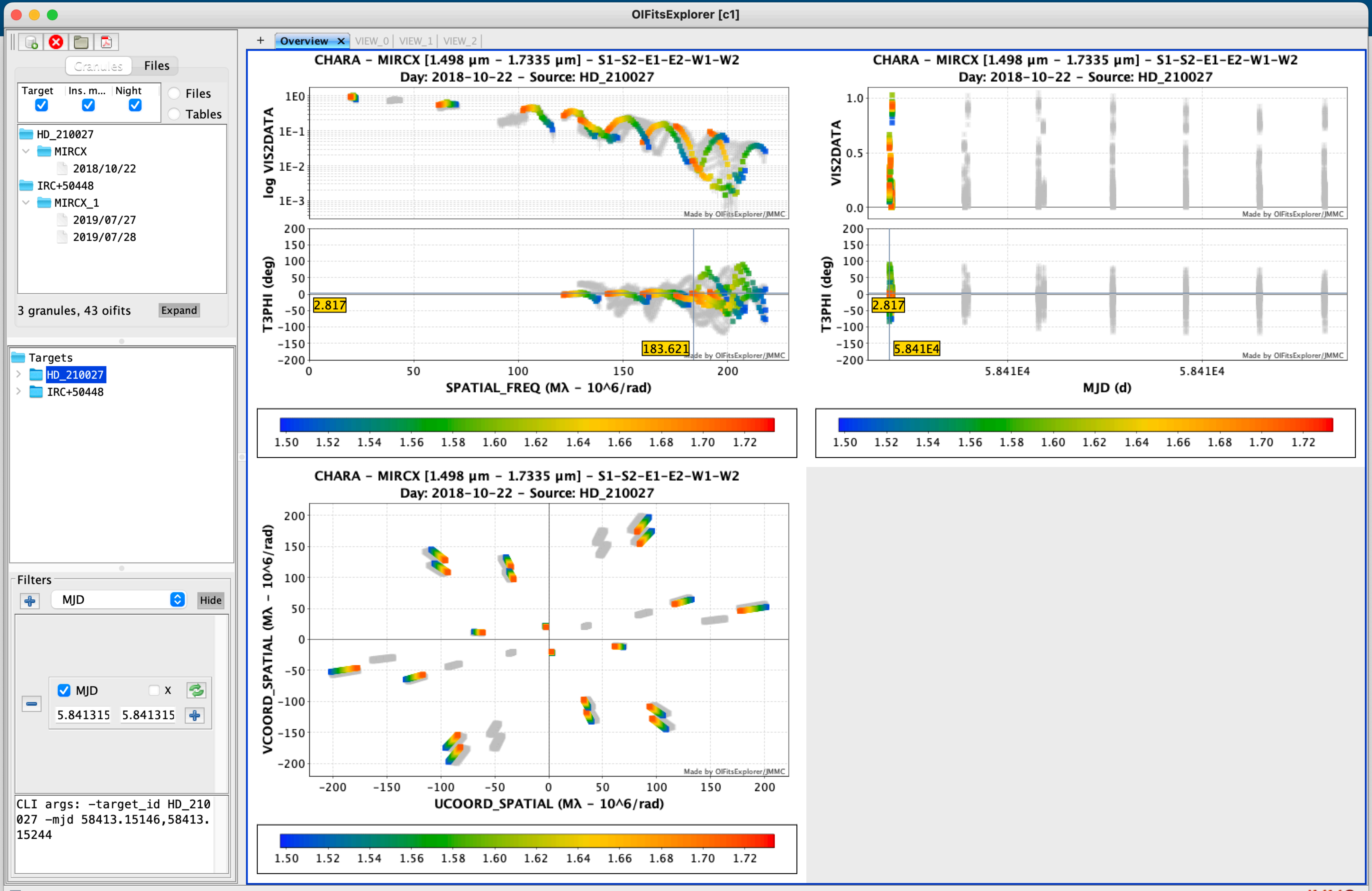


SUV (VLTI Center):

- + User Support
- + Training

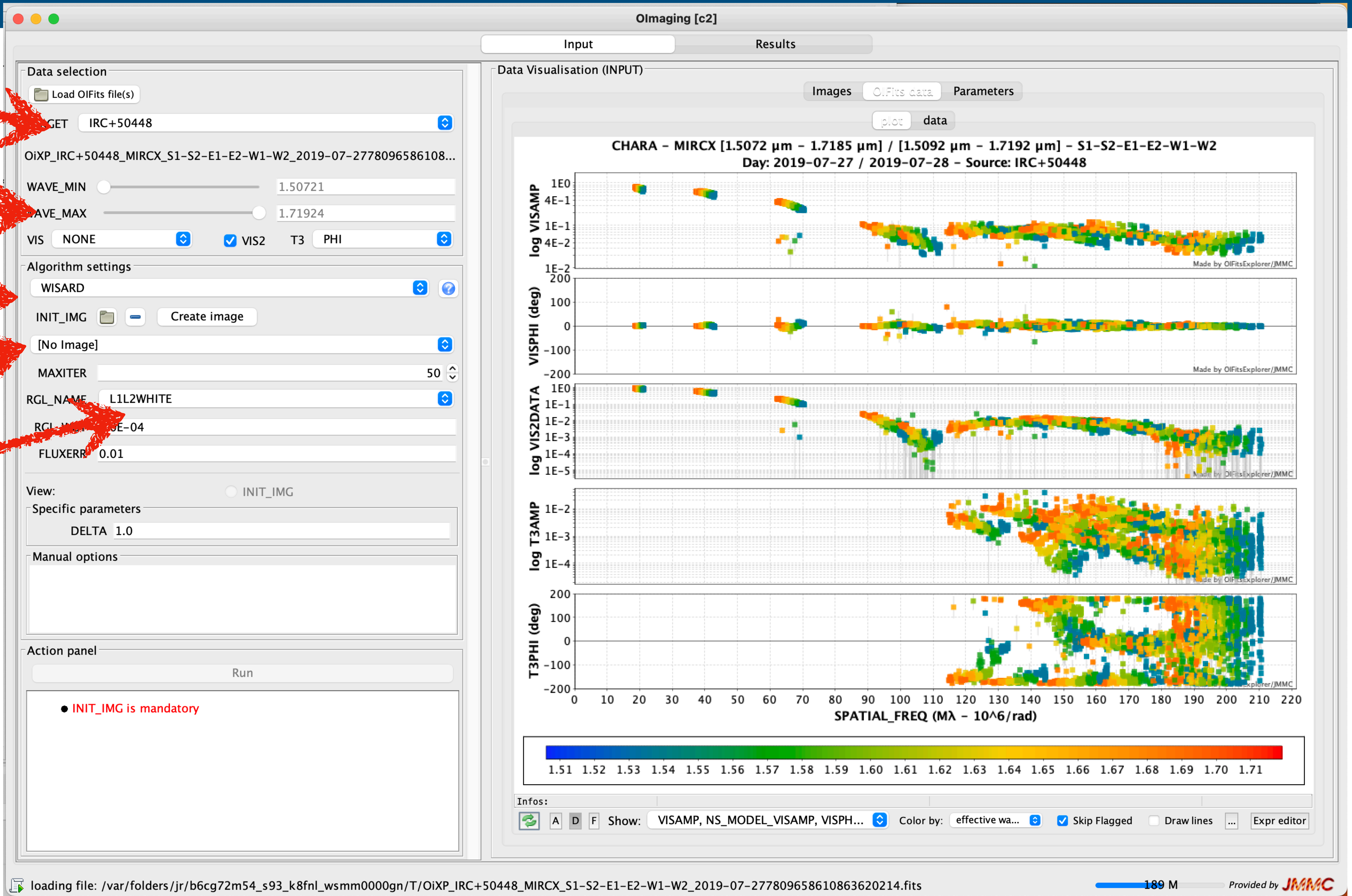
OIFitsExplorer

- inspect
- merge files
- filter



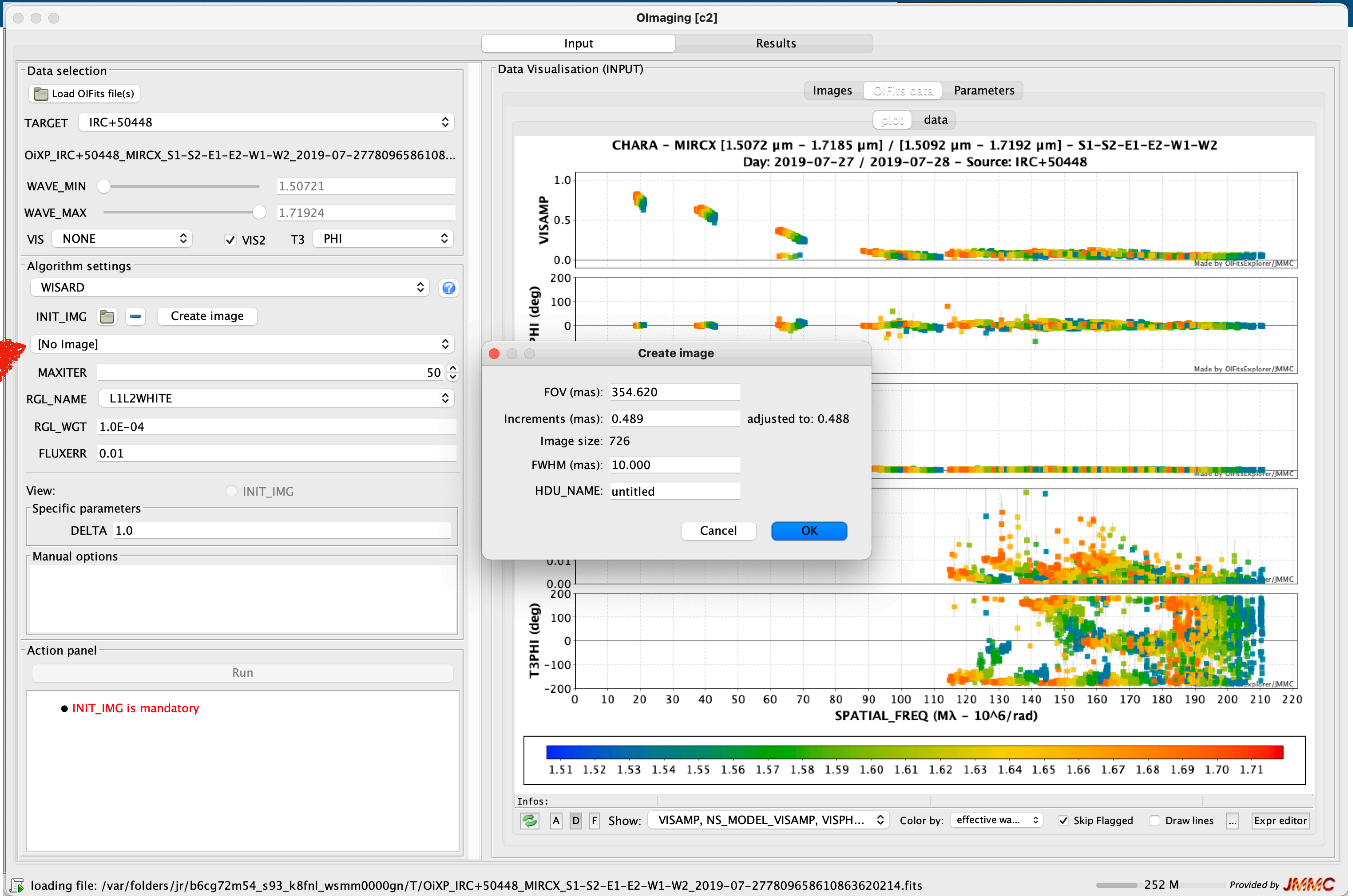
Workflow example: CL Lac

- (single) outfits file
- selection
- algorithm
- initial image
- parameter



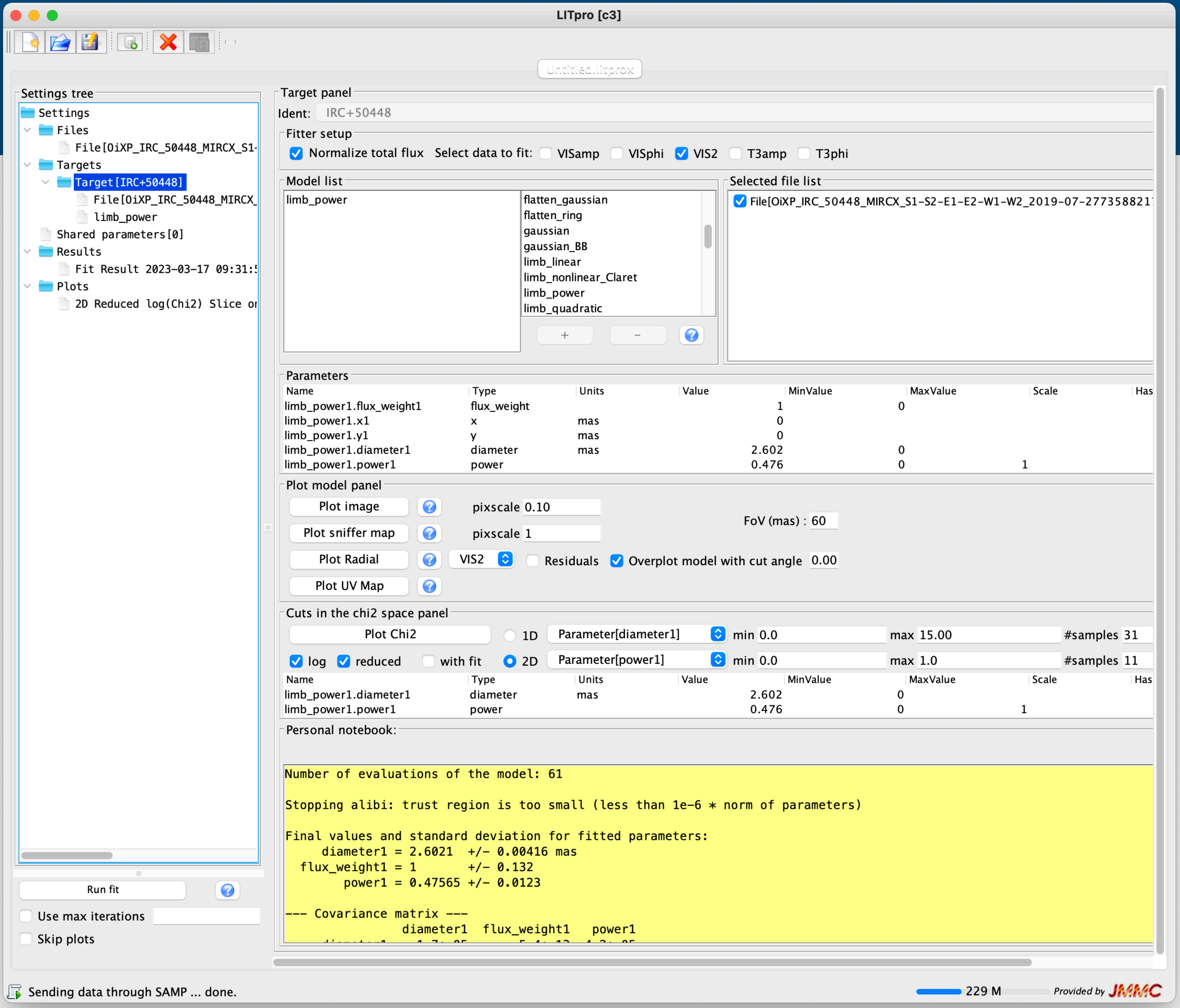
Workflow example: initial image

- simple gaussian
- use models
- use LITPro



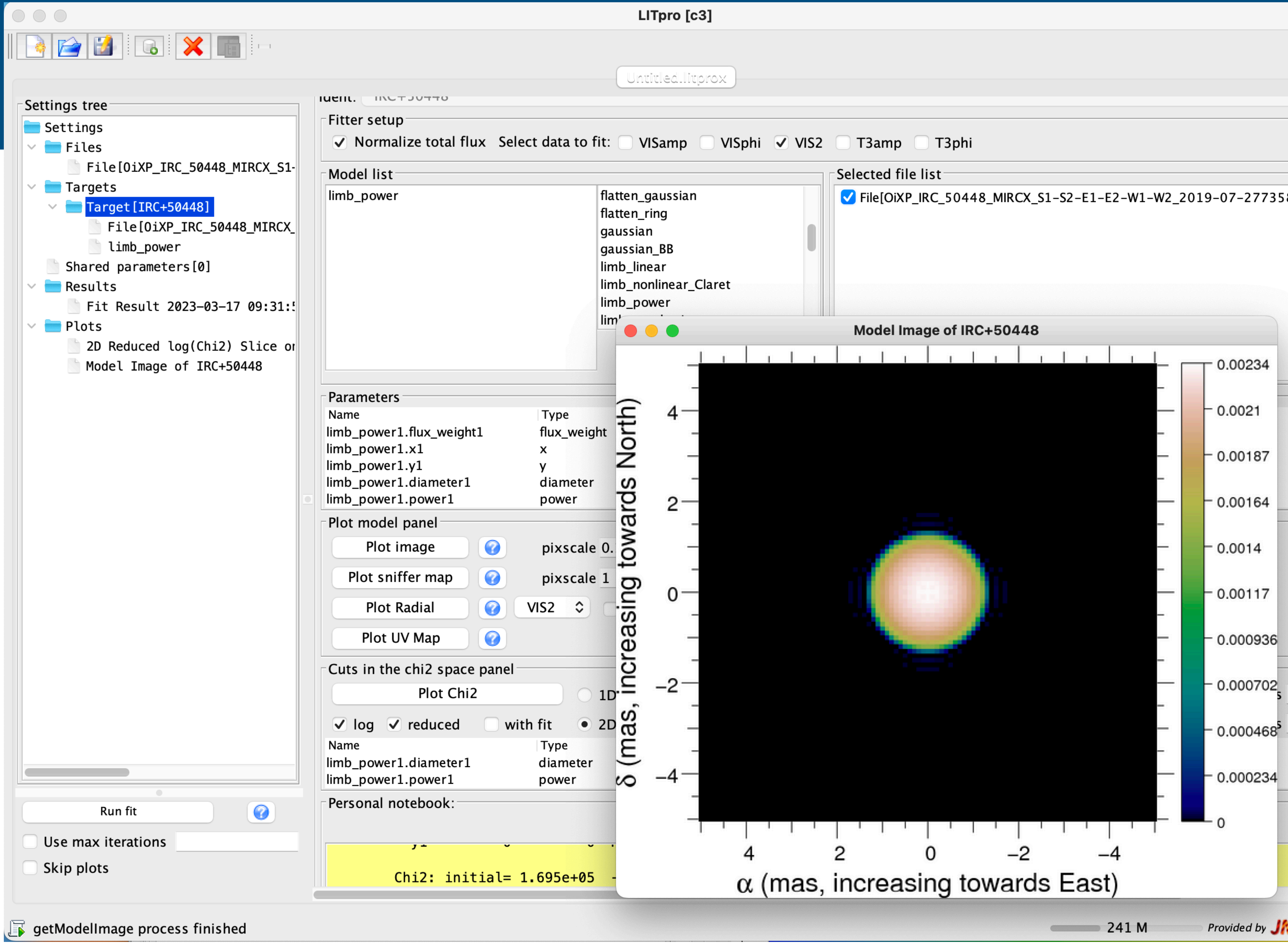
initial image

- Fit a coarse model using LITpro (eg limb darkened disk)



initial image

- Fit a coarse model using LITpro (eg limb darkened disk)
- export image to OImaging



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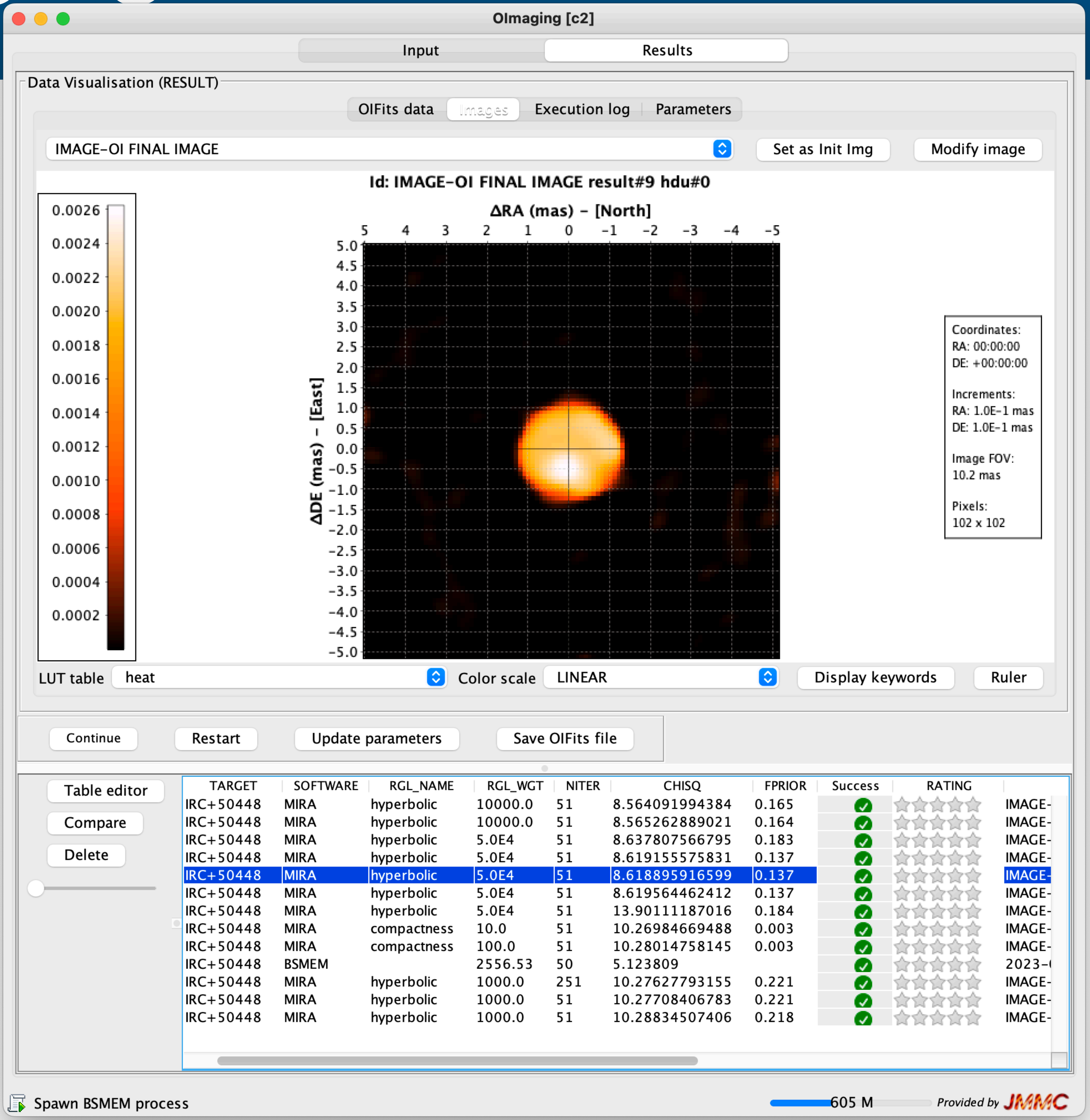
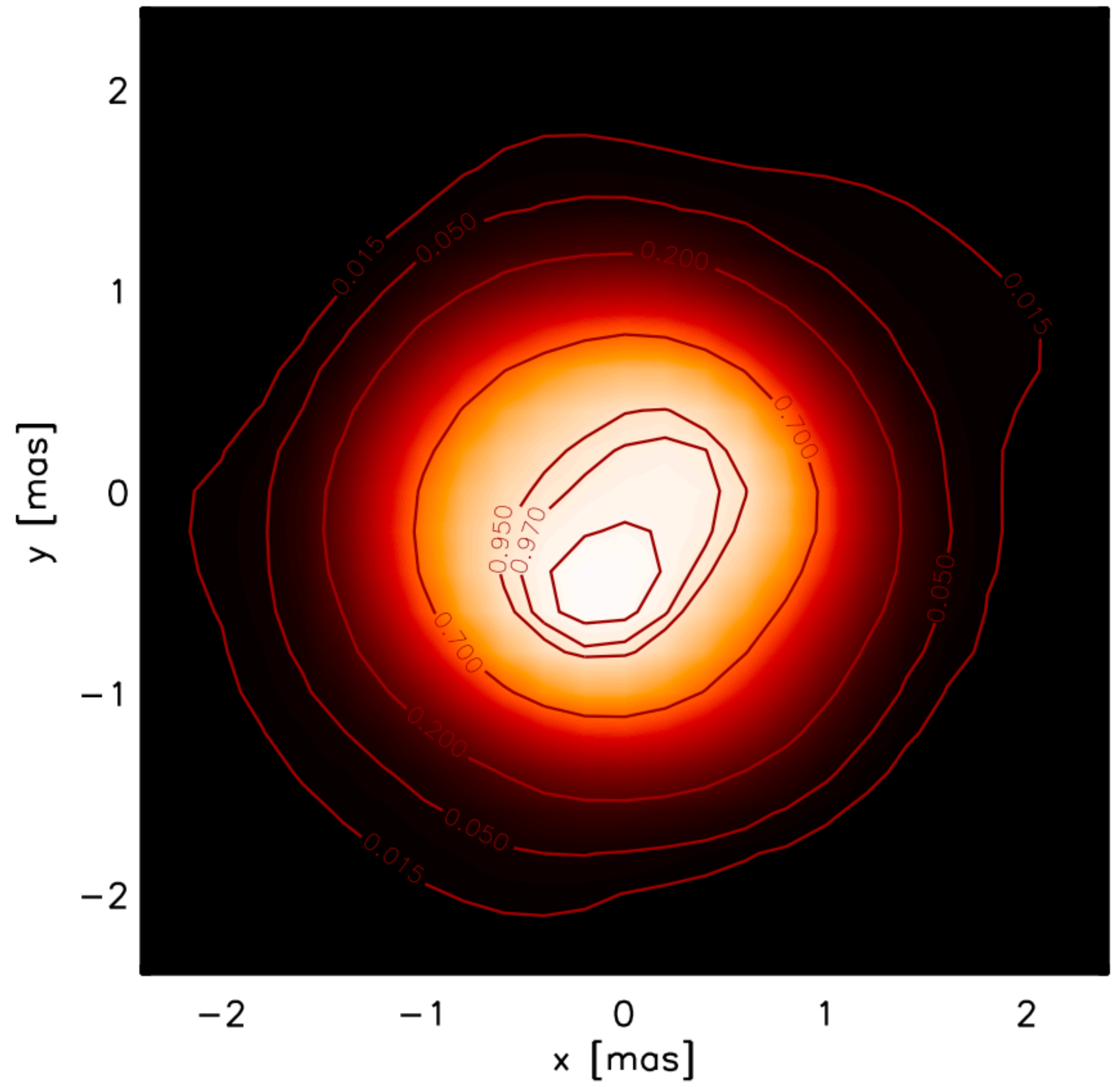
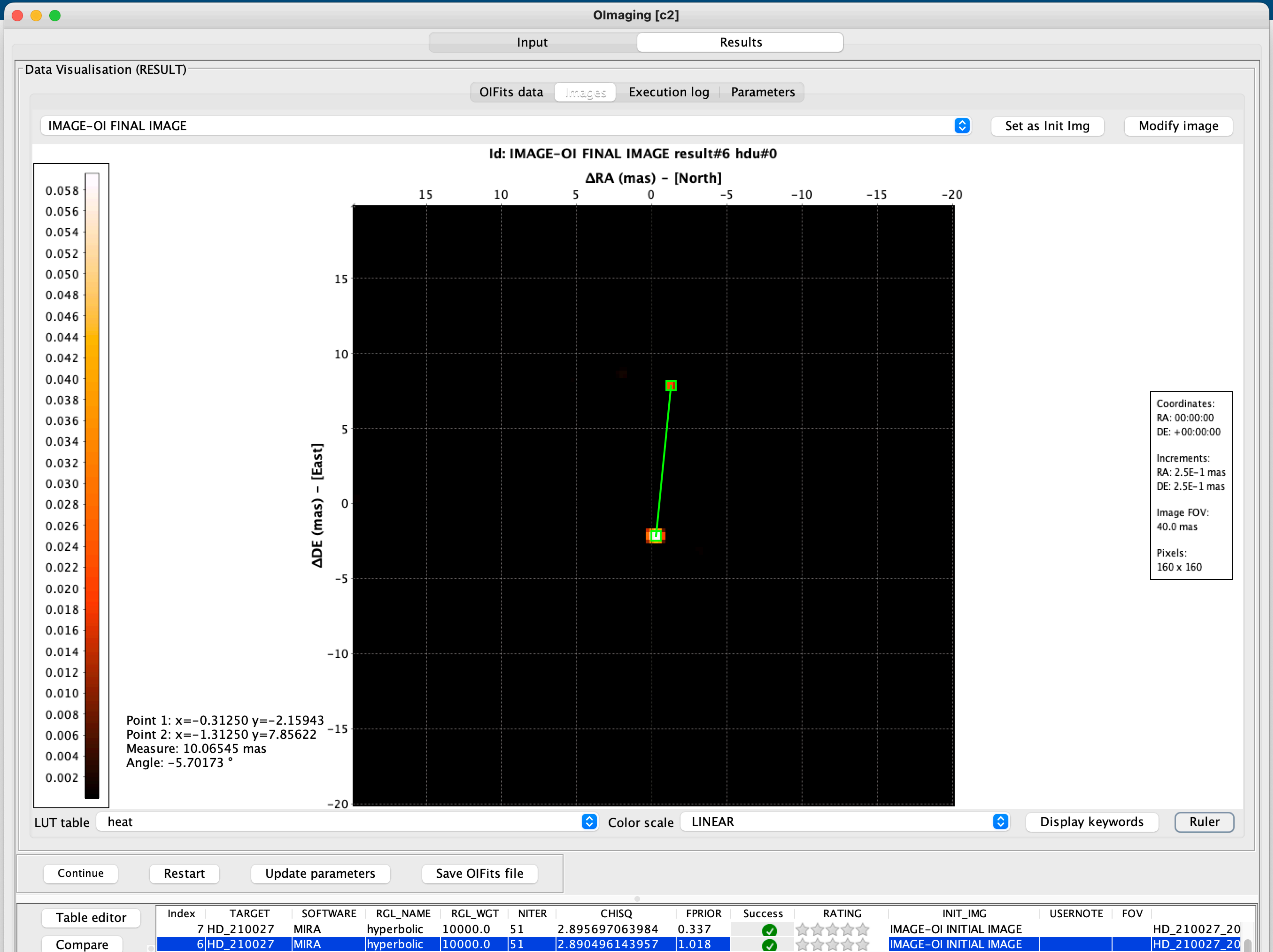




Chiavassa et al 2020

OImaging: preparing model fitting

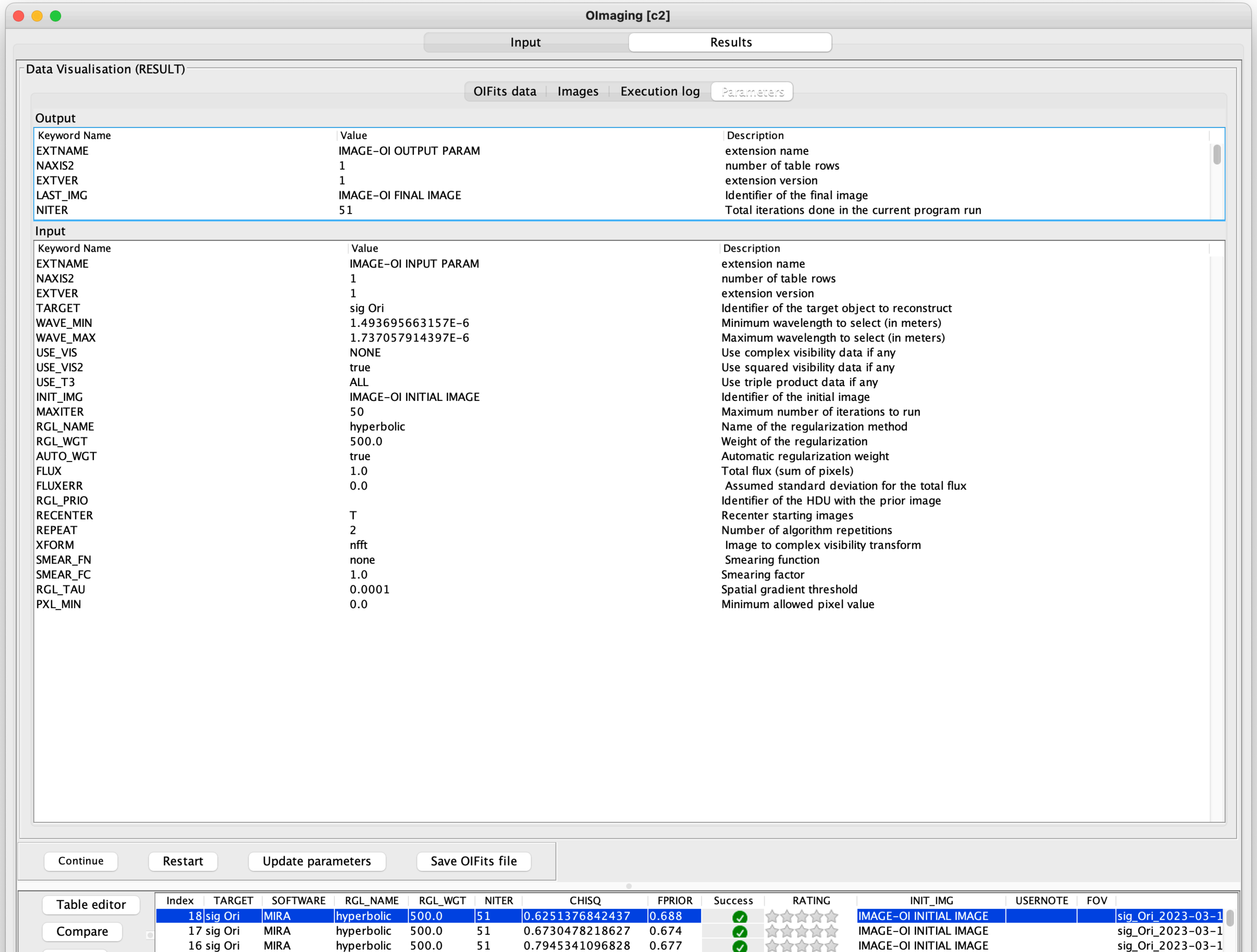


	squeeze + modeling		
UT date	$F_{pri/sec}$	sep, ρ (mas)	pos ang, PA (deg)
2018-10-22	4.55 ± 0.04	10.0352 ± 0.0176	354.7005 ± 0.019

Anugu et al 2020

OImaging: reproducibility enabled

Reconstructed image + data + all parameters in a single OIFits file



You’ll never walk alone

Eii European Interferometry Initiative | Past Activities | VLTI Expertise Centres | Dissemination & Training | Joint Activities | Fizeau Program | Getting started 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.

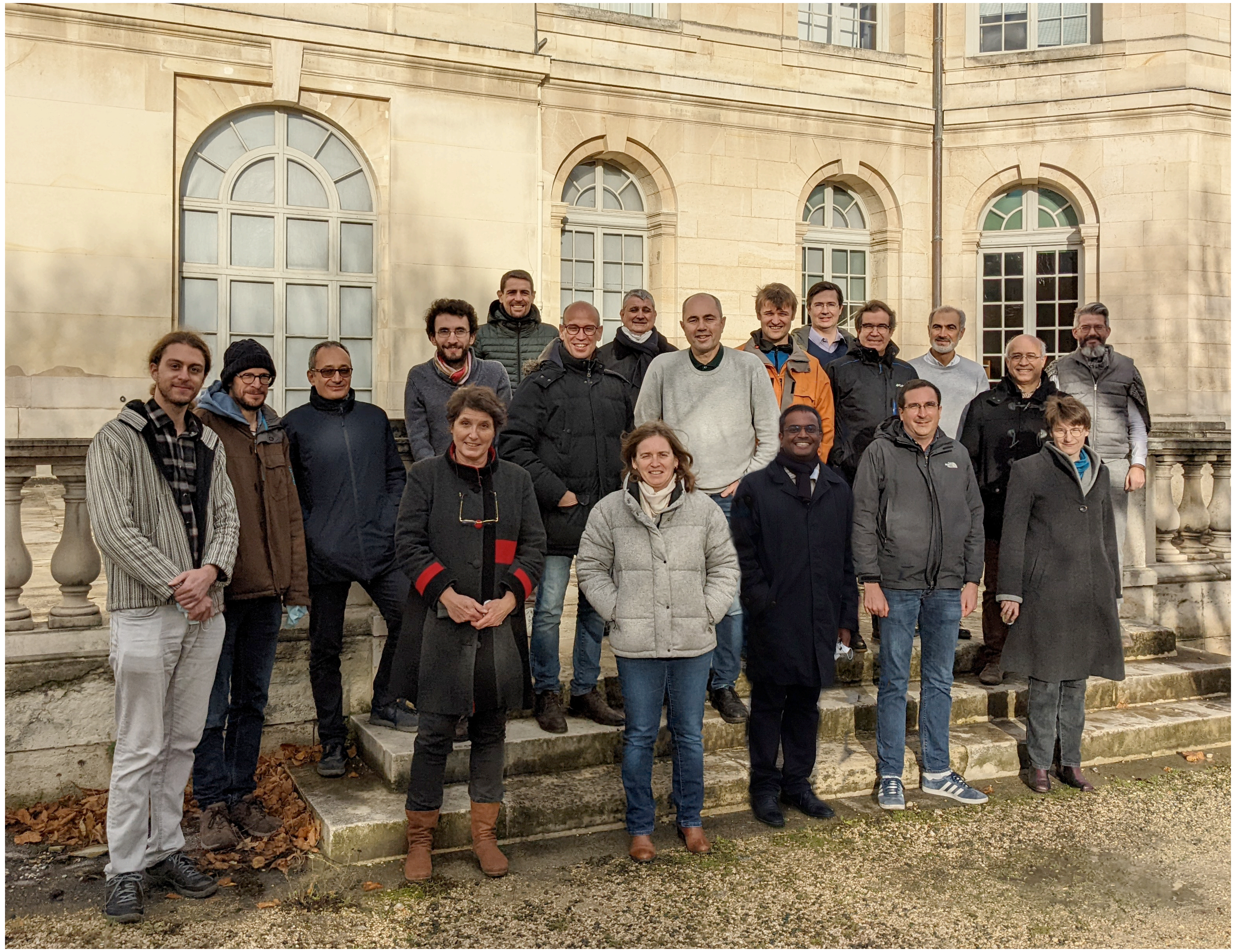
Effacer | Envoyer

- + video tutorial on JMMC website

OImaging: a collective project

- **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

OImaging: preparing model fitting