JMMC Tools

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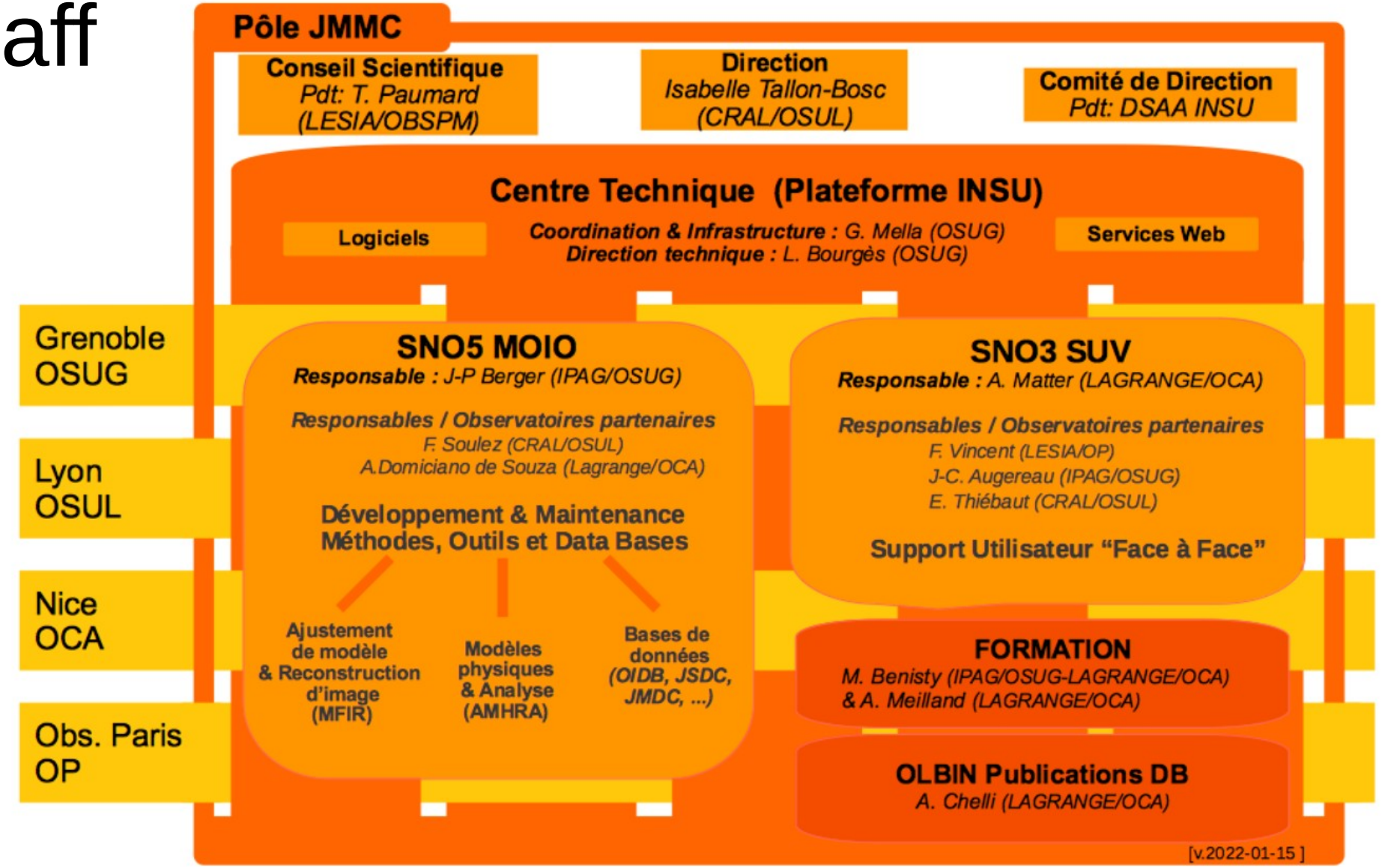
& JMMC Working groups Grenoble / Lyon / Nice / Paris

Outline

- JMMC overview
- It’s software and services suite
- Focus on
  - Observation preparation tools
  - Modelfitting tool
- Demo
- Conclusion

JMMC staff

~20 researcher
& 2 engineers
part time
< 3 or 4 FTE



JMMC overview

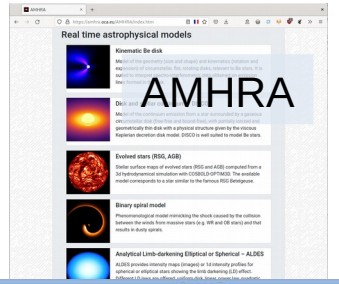
The **Jean-Marie Mariotti Center** coordinates the efforts of French Partner Laboratories with interferometric expertise to offer all the potential users of interferometric facilities the best operational environment.

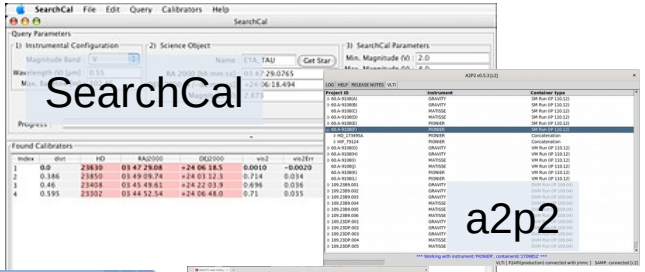
The mission of JMMC is threefold and consists in:

- develop, produce, document and maintain the software necessary for the exploitation and the follow-up of new interferometric equipments, especially the VLTI,
- stimulate and coordinate the academic formation of non specialists,
- participate to the prospective around new interferometric instruments.

Service overview

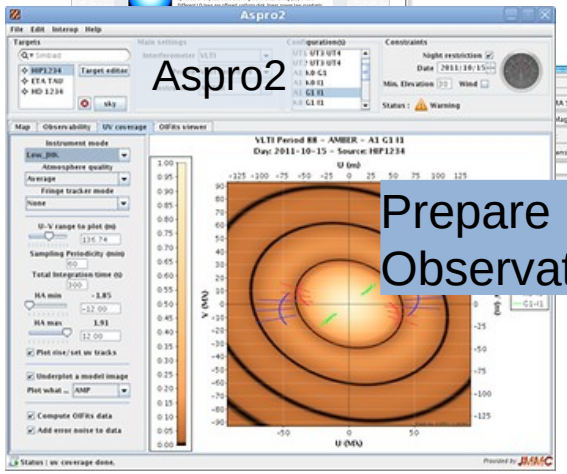
+ Expertise Center
  User Support
+ Training
+ OLBIN publications

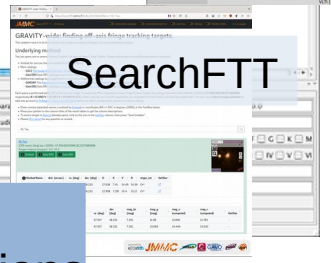


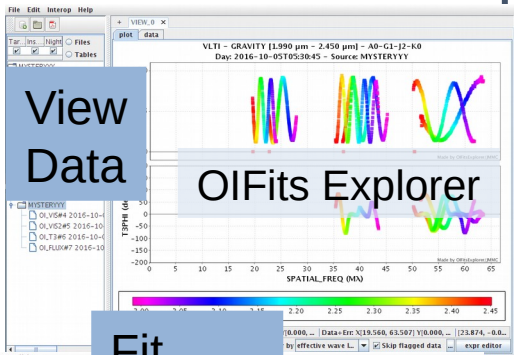


Reduce data

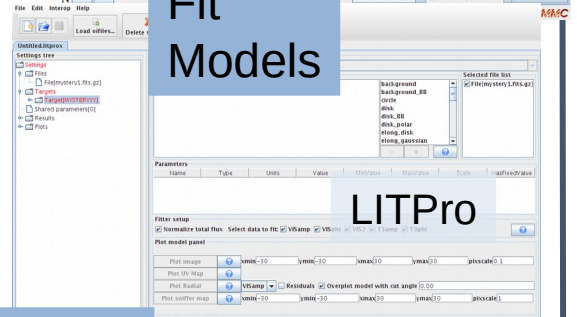
- amdlib
- pndrs

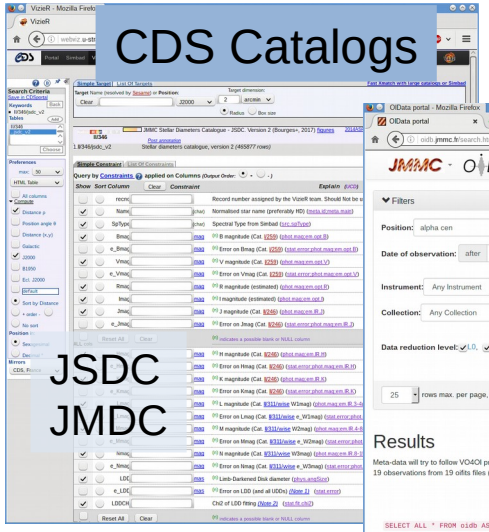


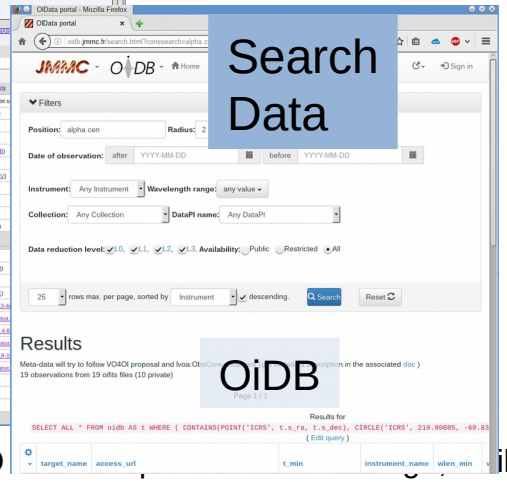


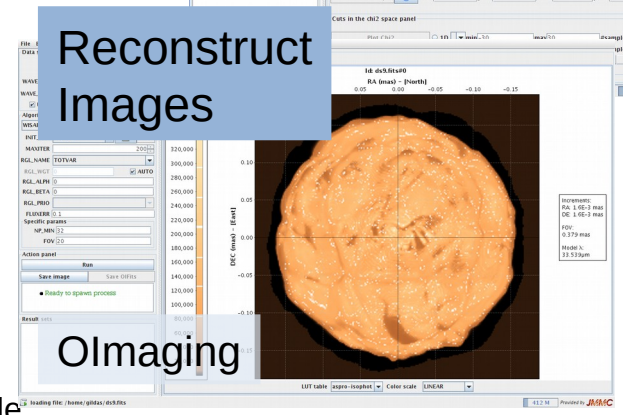


VO SAMP









Observation / Proposal preparation tools

Aspro2, AMHRA, SearchCal/JSDC, SearchFTT, a2p2

ASPRO 2: Feature overview

Observation preparation = VLTI / CHARA / NPOI

Target & calibrator list with their models and groups

Target observability, UV coverage

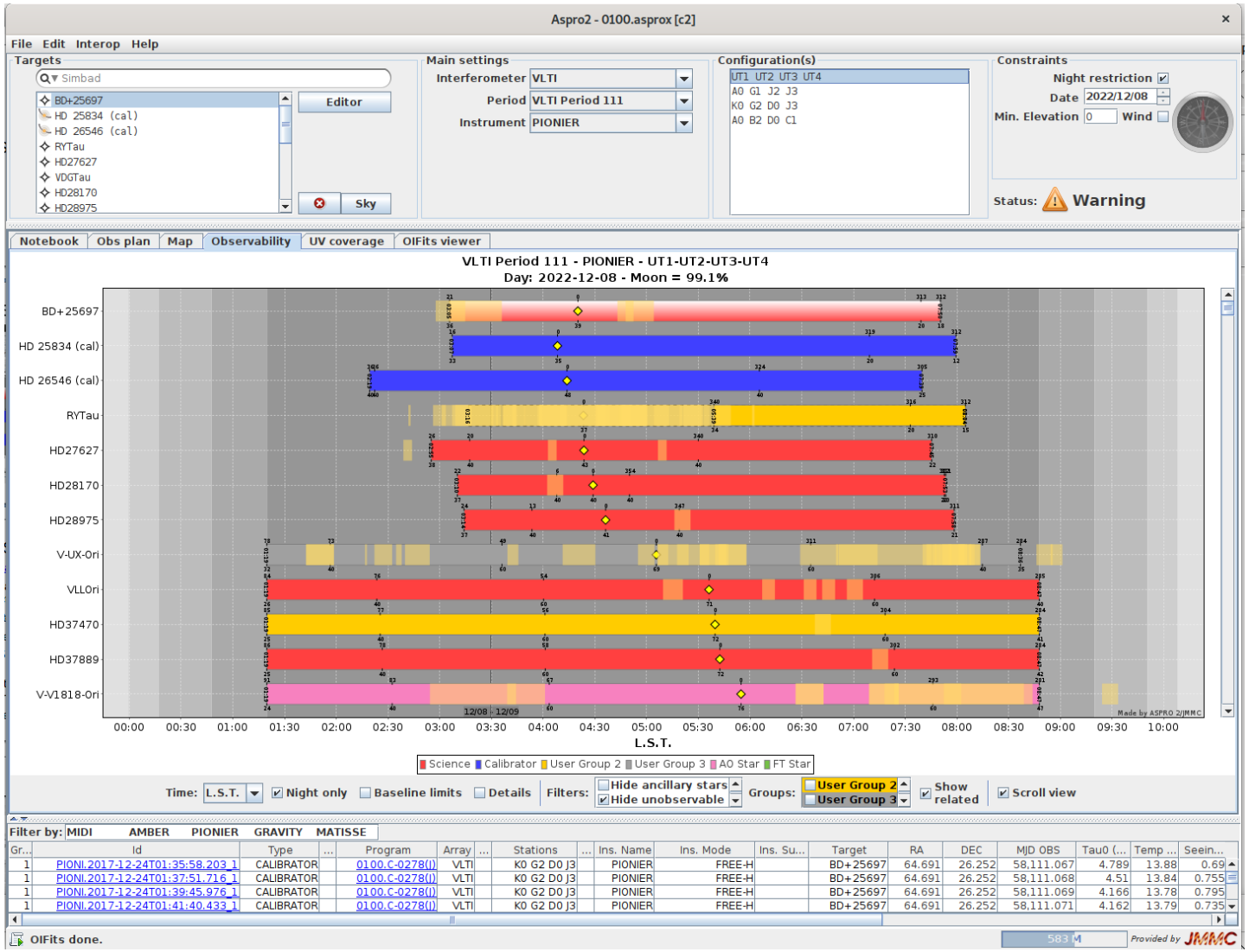
Instrument modes + noise modeling => **OIFITS data**

Noise modeling & OIFits simulator: see SPIE 2016

Interoperability :

- AMHRA
- GetStar, SearchCal, Vizier / Simbad (flux)
- OiDB, OIFits Explorer, LITpro or OImaging …
- a2p2

ASPRO 2: Observability



Observation = Targets, array & instrument setup, baselines…

SCI / CAL

Horizon / Delay Line constraints

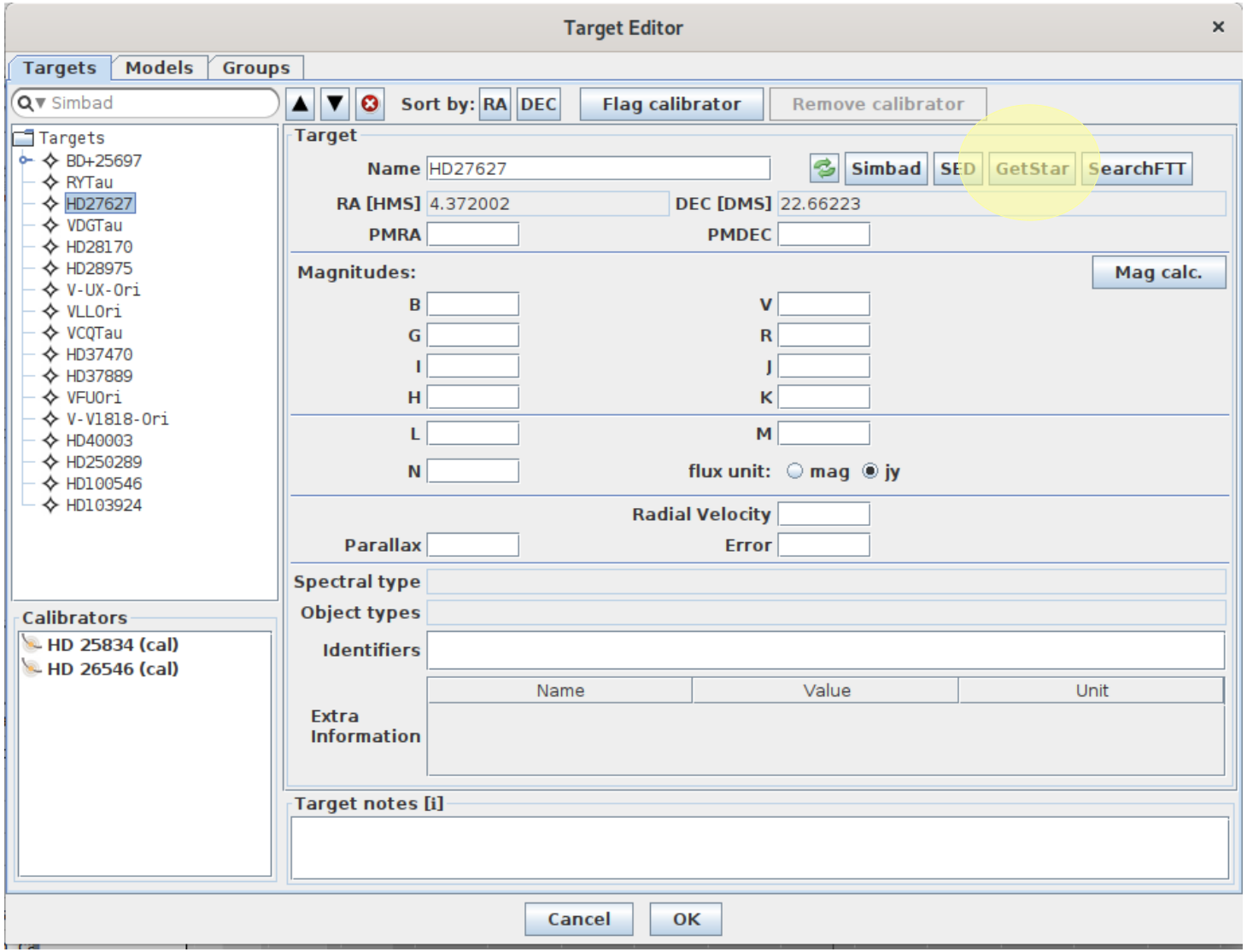
Configuration comparison

Groups (AO, FT star + user)

Time markers (night mode)

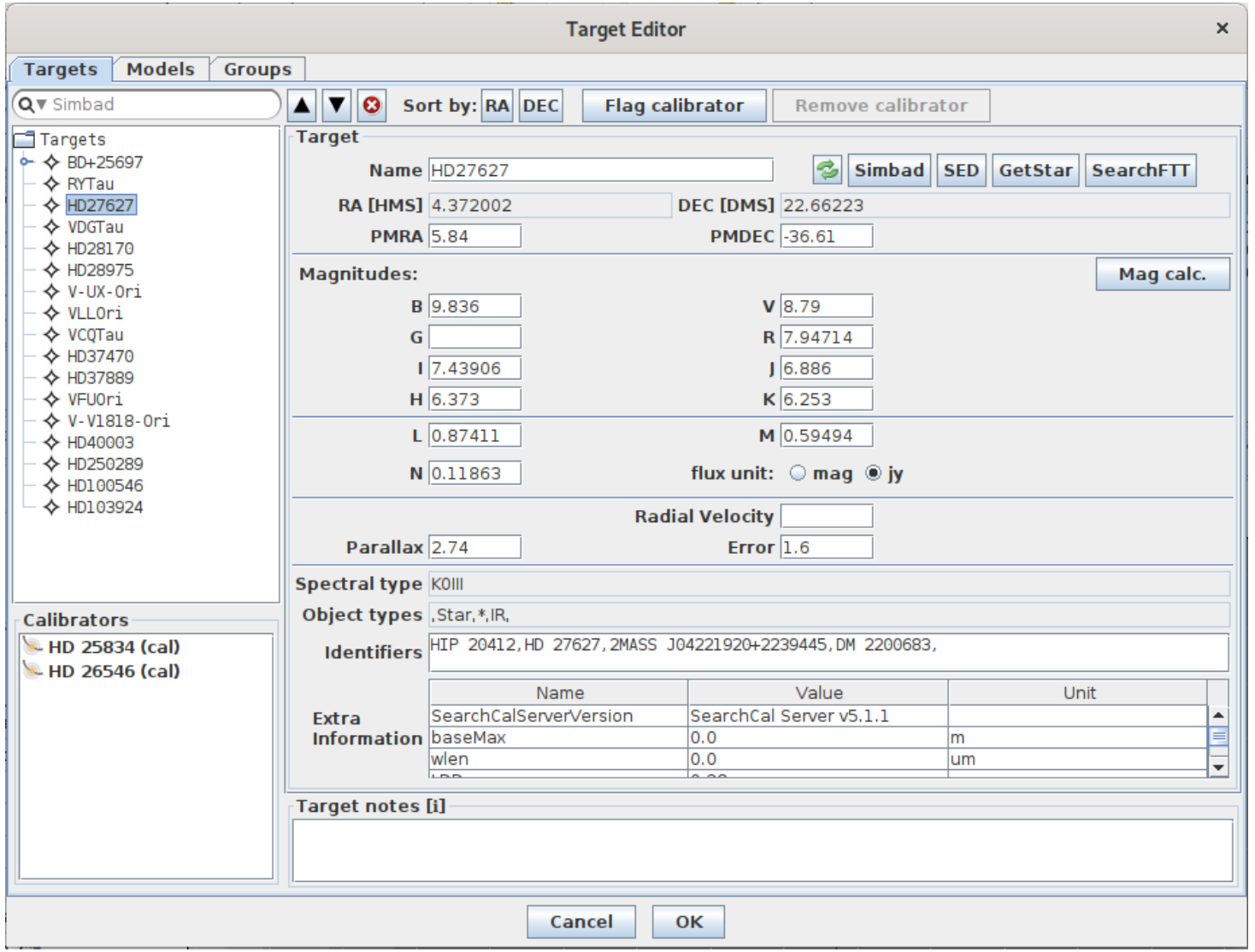
ASPRO 2: Target Editor

- Fluxes (mag) use GetStar



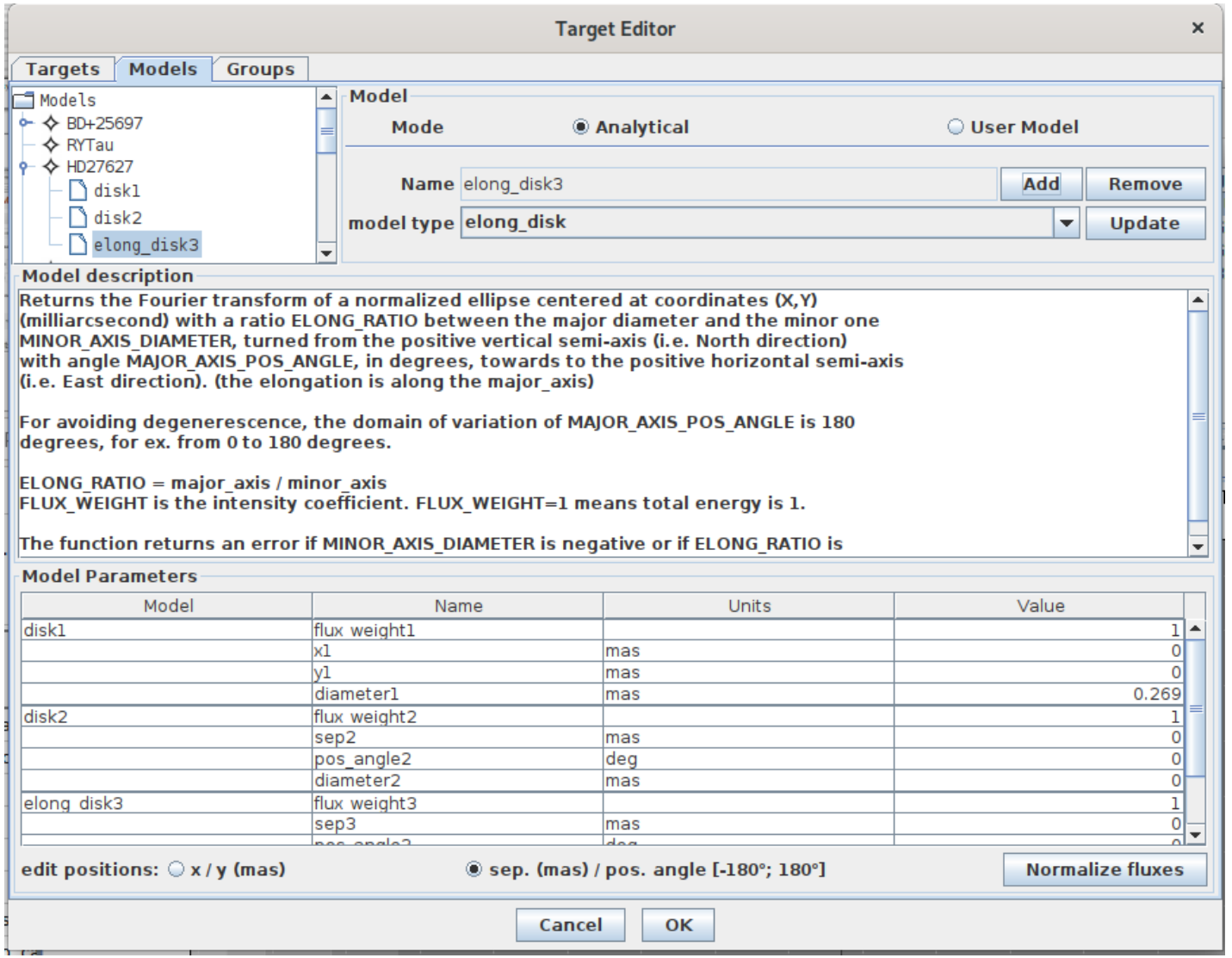
ASPRO 2: Target Editor

- Fluxes (mag) use GetStar
- (try with firefox
- if send VOTable does not work)



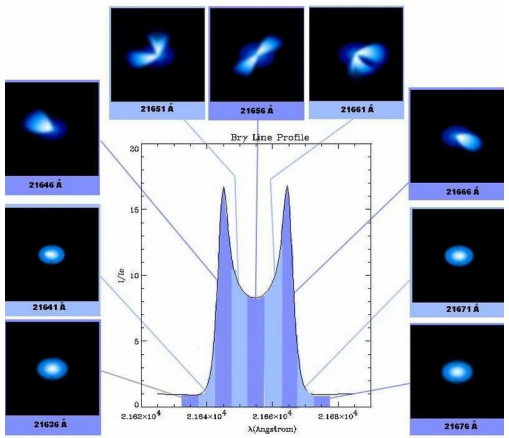
ASPRO 2: Target Editor

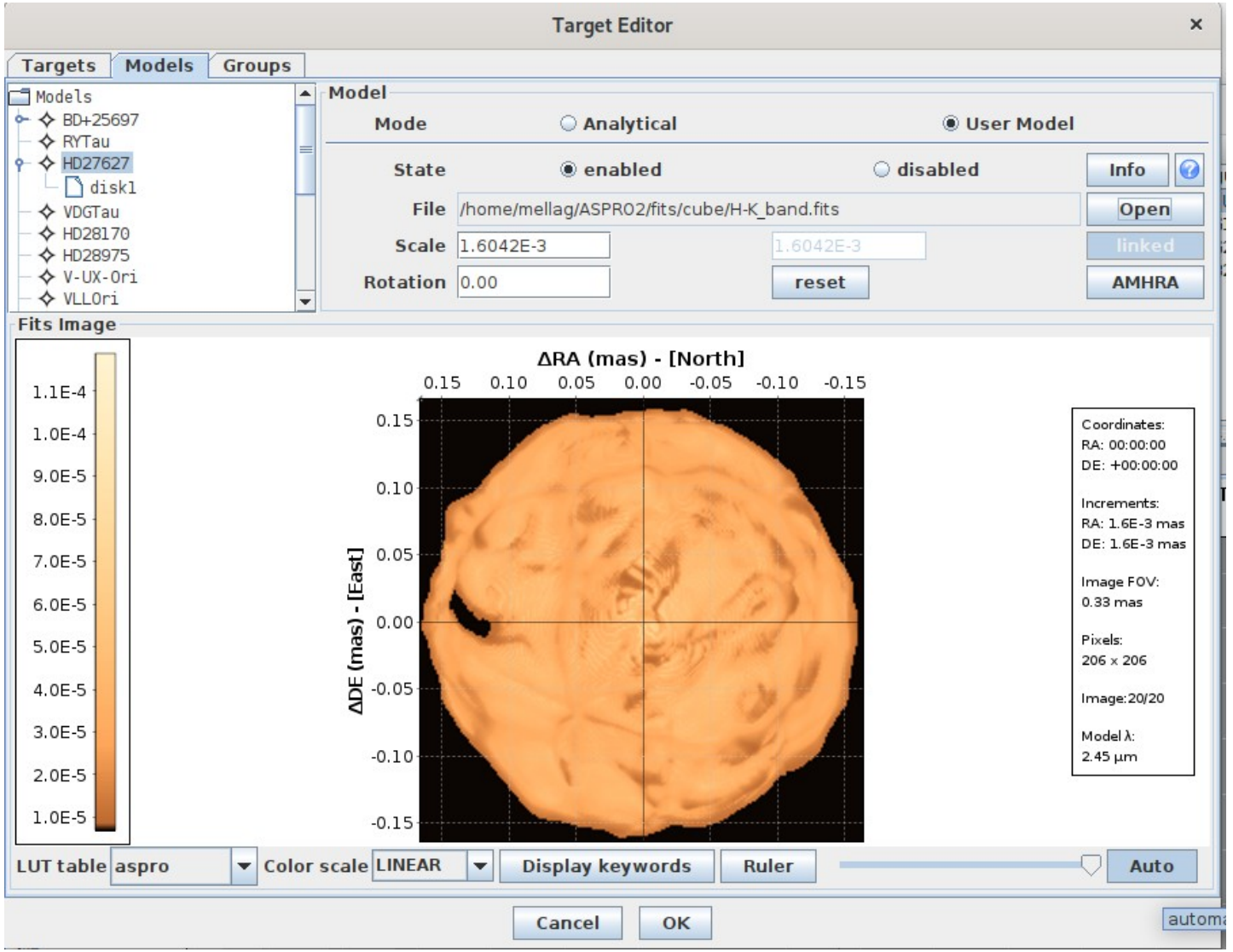
- Fluxes (mag) use GetStar
- Models
  - Analytical



ASPRO 2: Target Editor

- Fluxes (mag) use GetStar Models
  - Analytical
  - User models (Fits cubes)



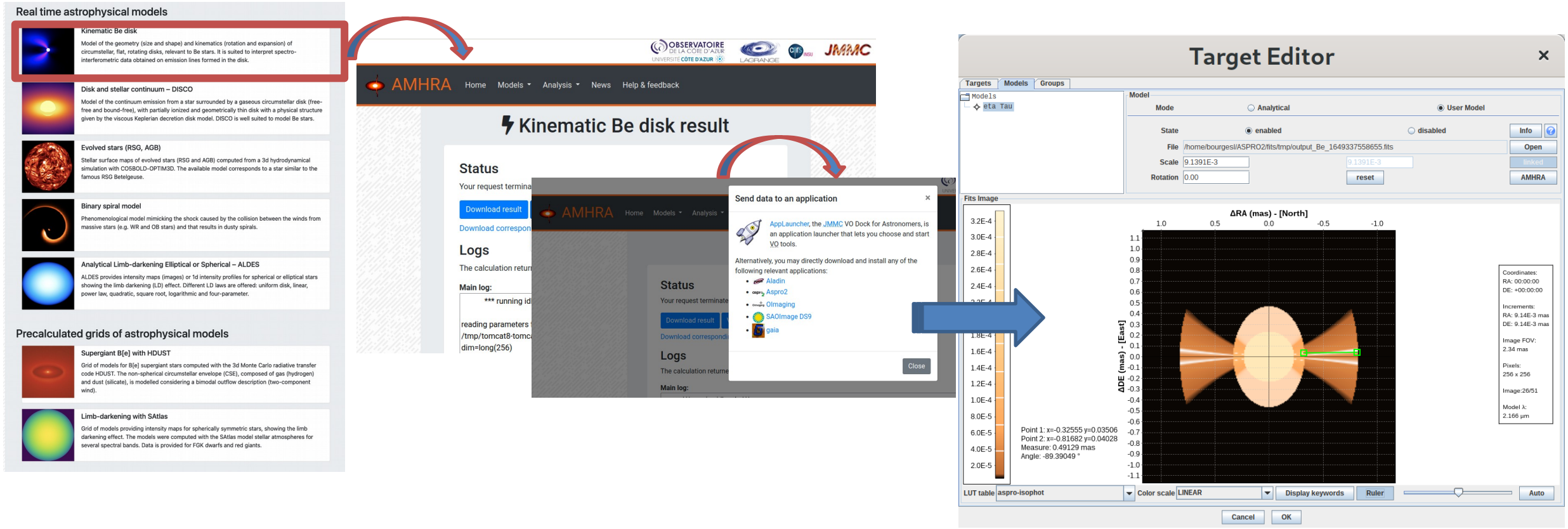


AMHRA Service

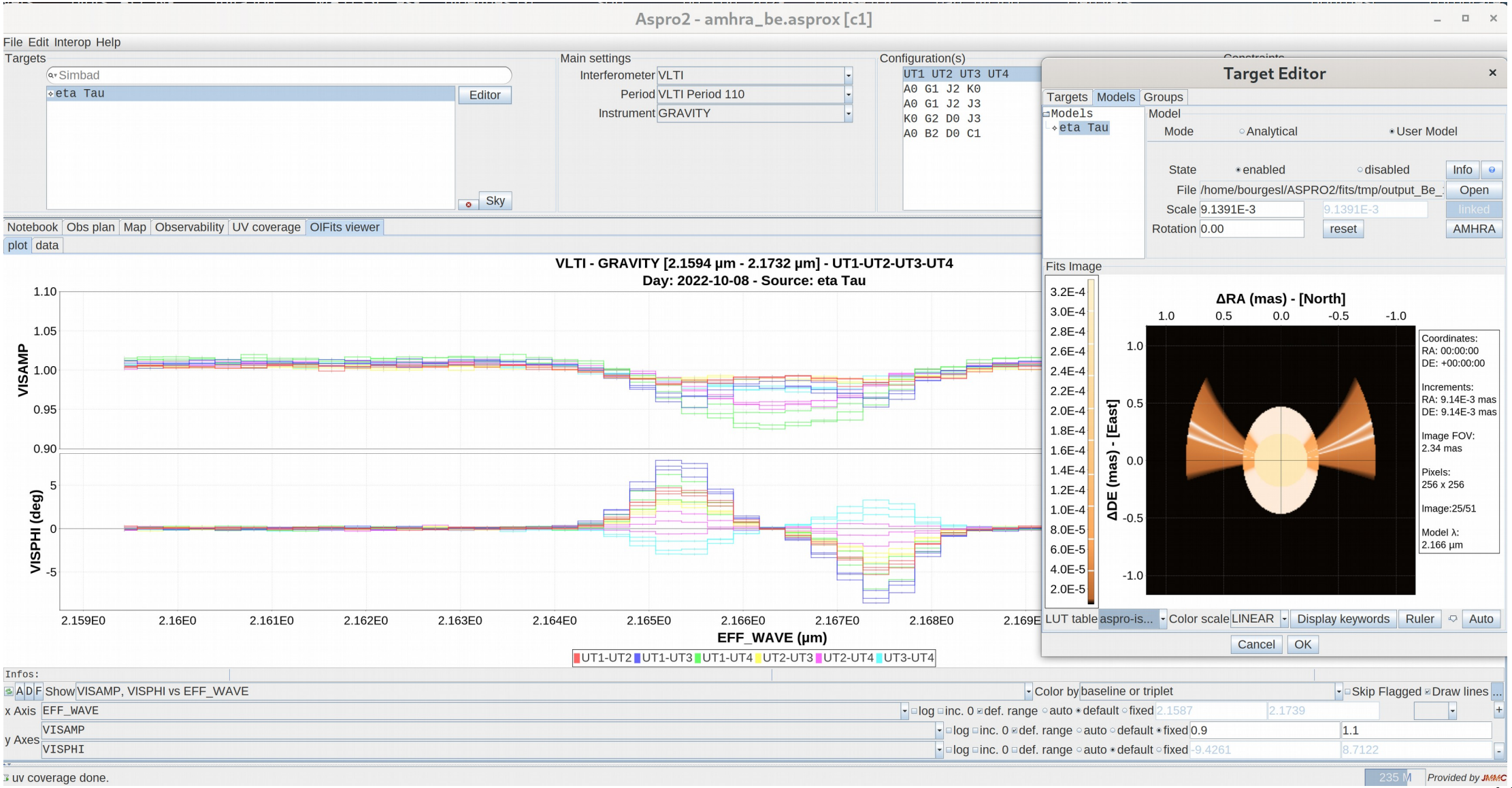
AMHRA develops and provides online astrophysical models and data analysis tools dedicated to the scientific exploitation of high angular and high spectral facilities such as ESO-VLTI

- astrophysical models (parametric and grids) https://amhra.oca.eu

PI: Armando Domiciano de Souza

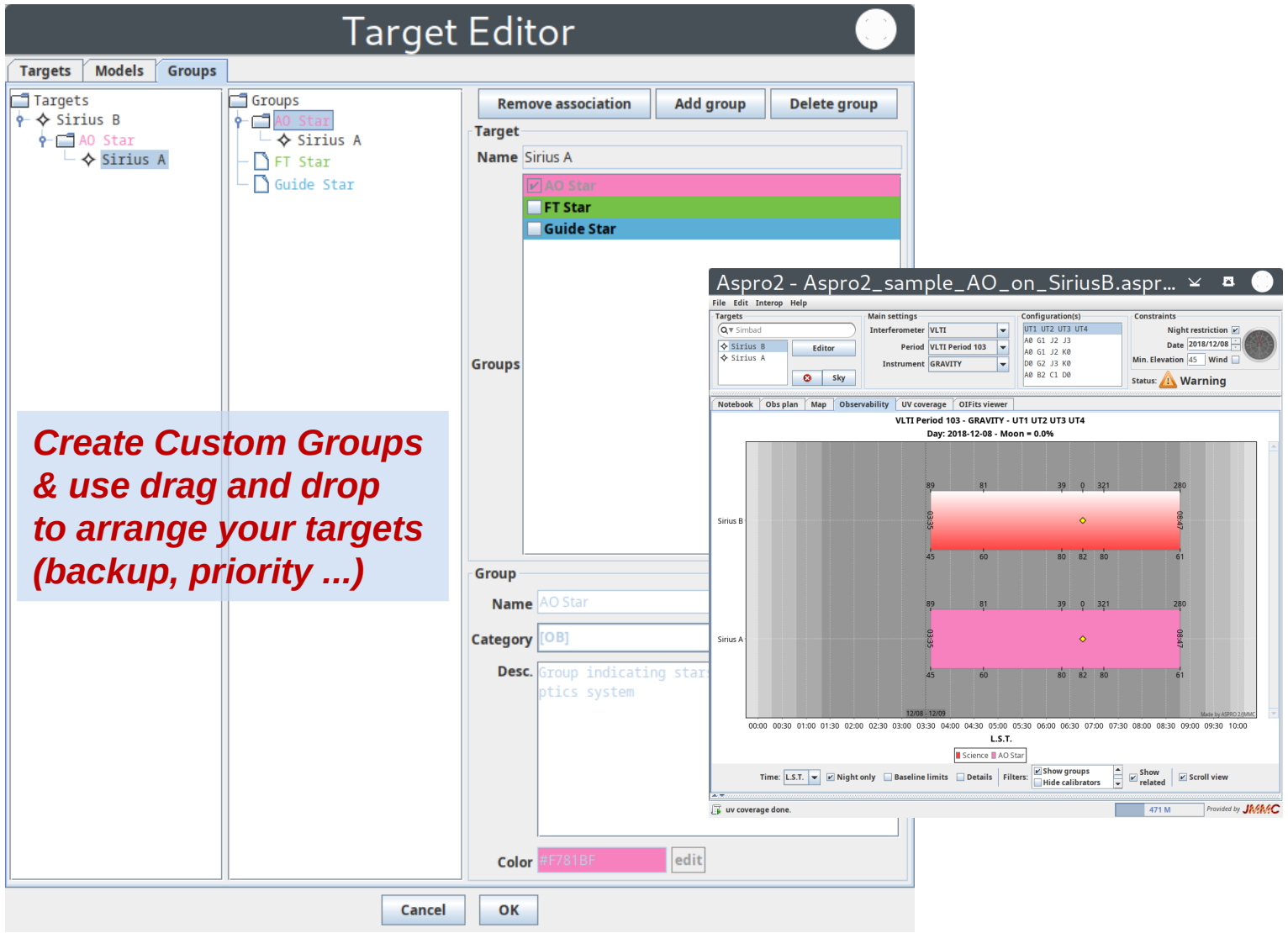


Simulated data – e.g. : GRAVITY HIGH

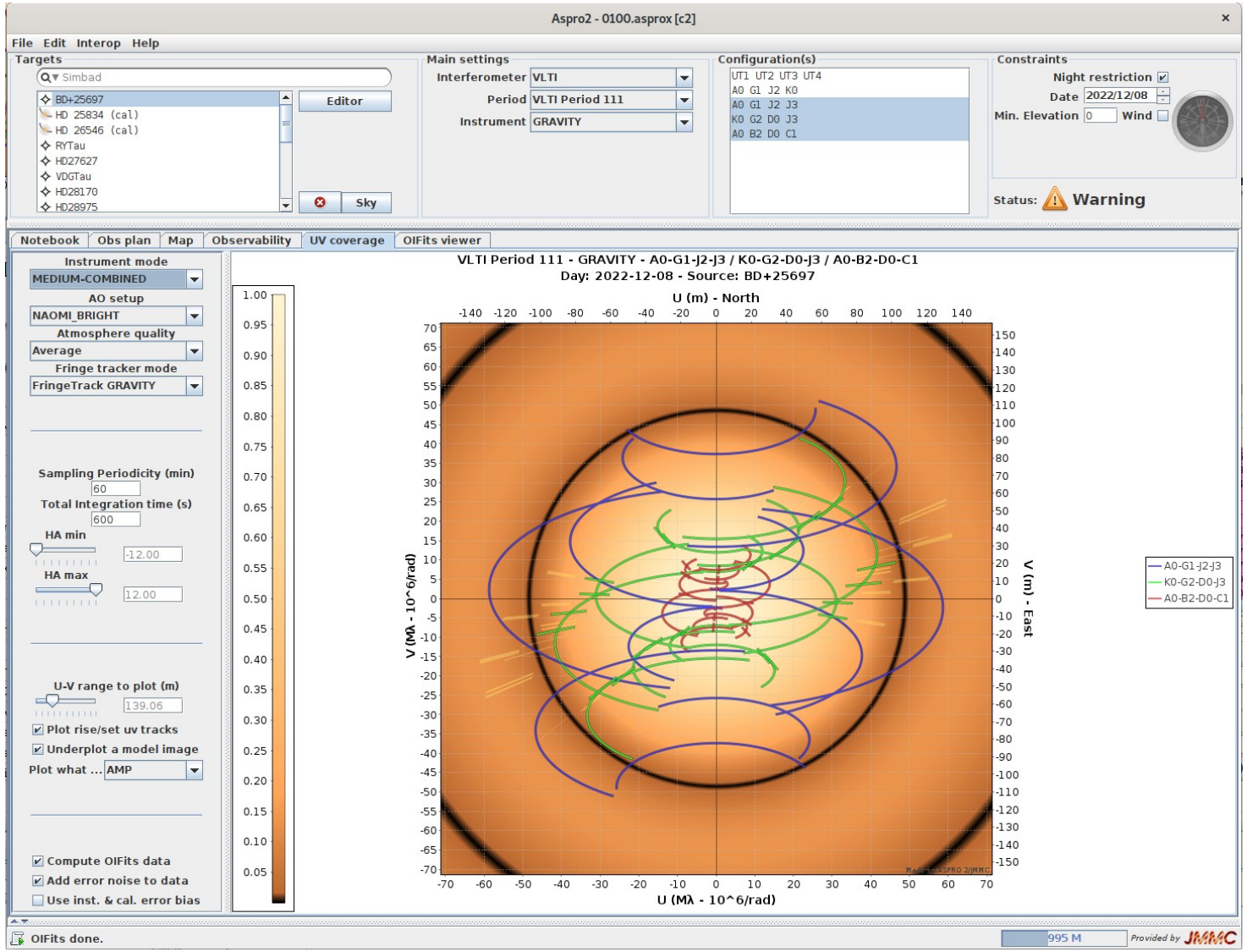


ASPRO 2: Target Editor

- Fluxes (mag) use GetStar Models
  - Analytical
  - User models (Fits cubes)
- Groups
  - Guide Star
  - Adaptive Optic Star
  - Frindge Tracking Star
  - Custom...



ASPRO 2: UV Coverage



UV Plot for GRAVITY MEDIUM-COMBINED mode with a disk model

Instrument mode:

Wavelength range / spectral channels

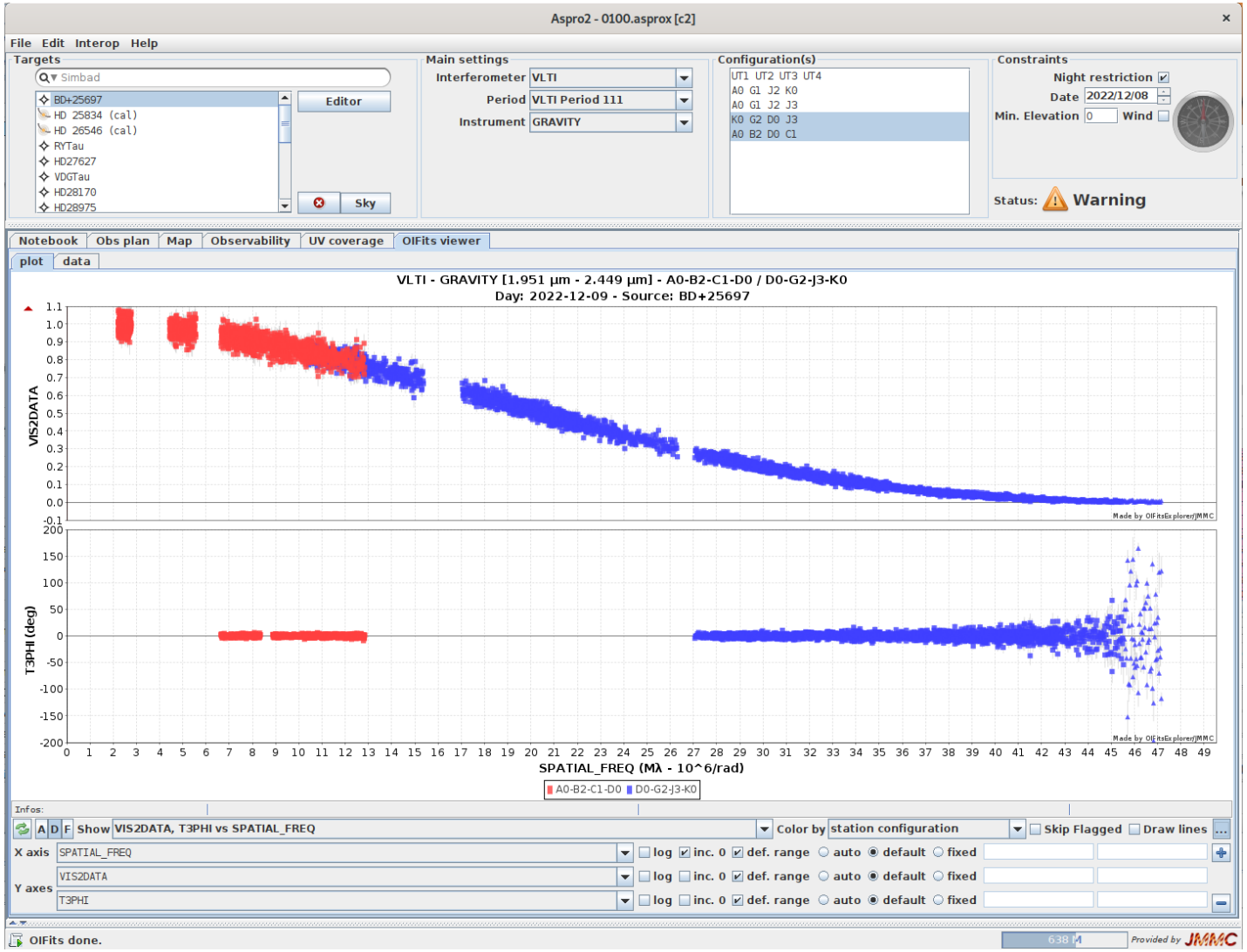
Transmission, camera parameters

Seeing (atm quality)

Total integration time (s) on SCI

Select baselines adapted to your model (scaling)

ASPRO 2: OIFits simulator



Exact Fourier Transform from user model images

Click 'Skip flagged data' to hide data with low SNR

Noise modelling:

- Target photometry
- Atm. transmission
- Instrument parameters

SearchCal / JSDC 2

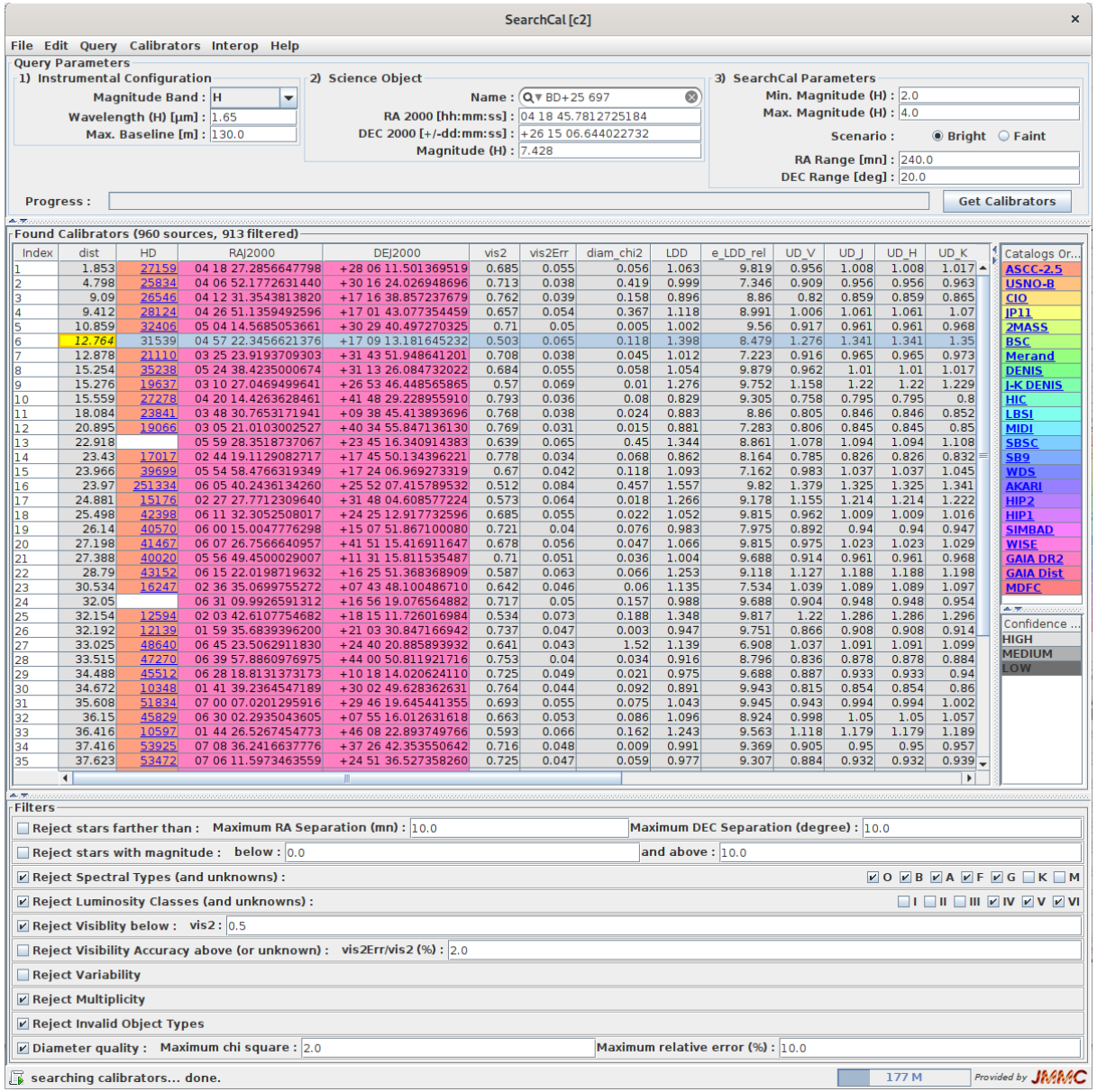
Search Calibrators close to your target object and phot.

Filter results (SP type, luminosity, V2 …)

Interoperability with ASPRO2, Aladin

Query JSDC 2: [Vizier II/346]

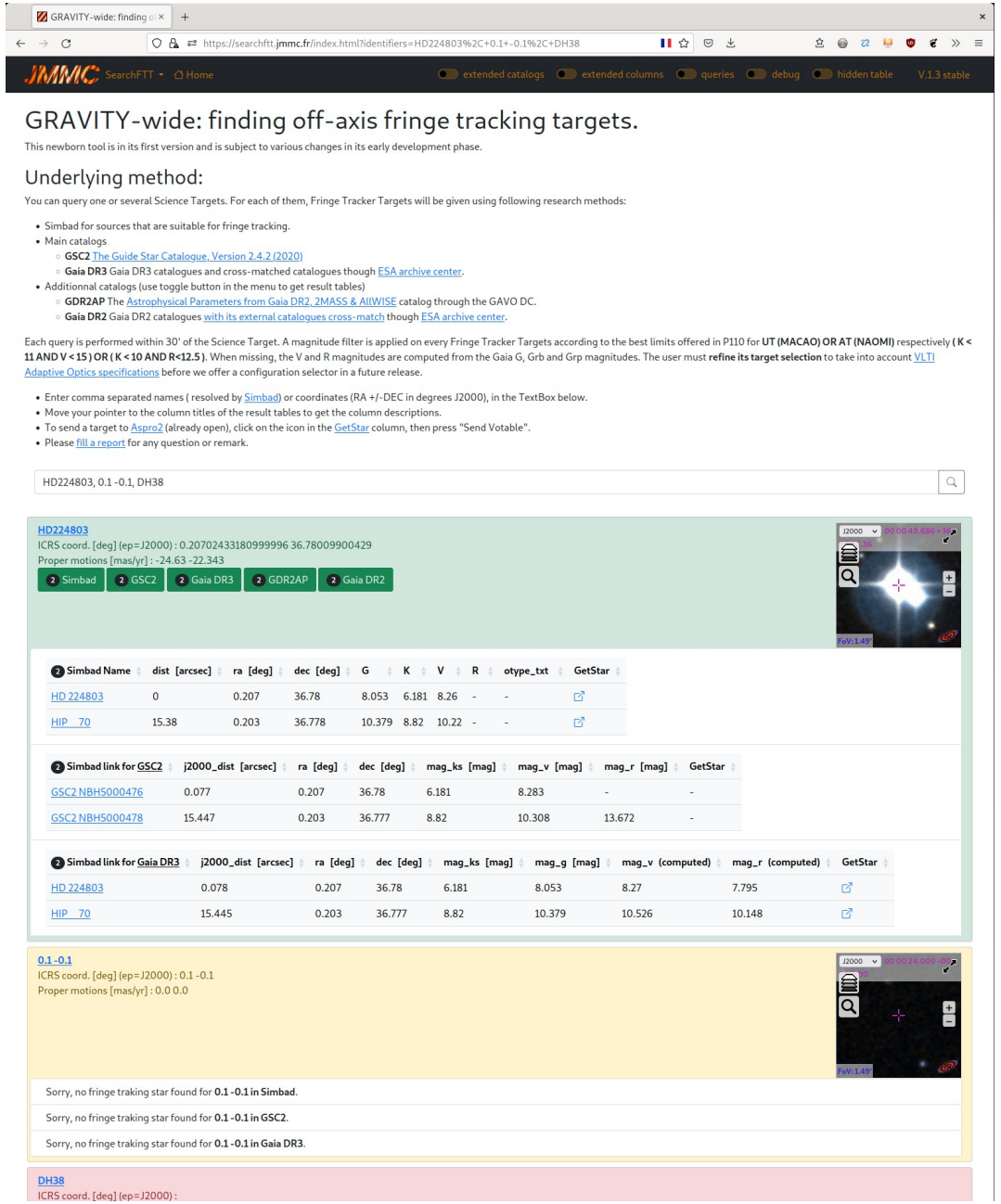
~400 000 stellar diameters



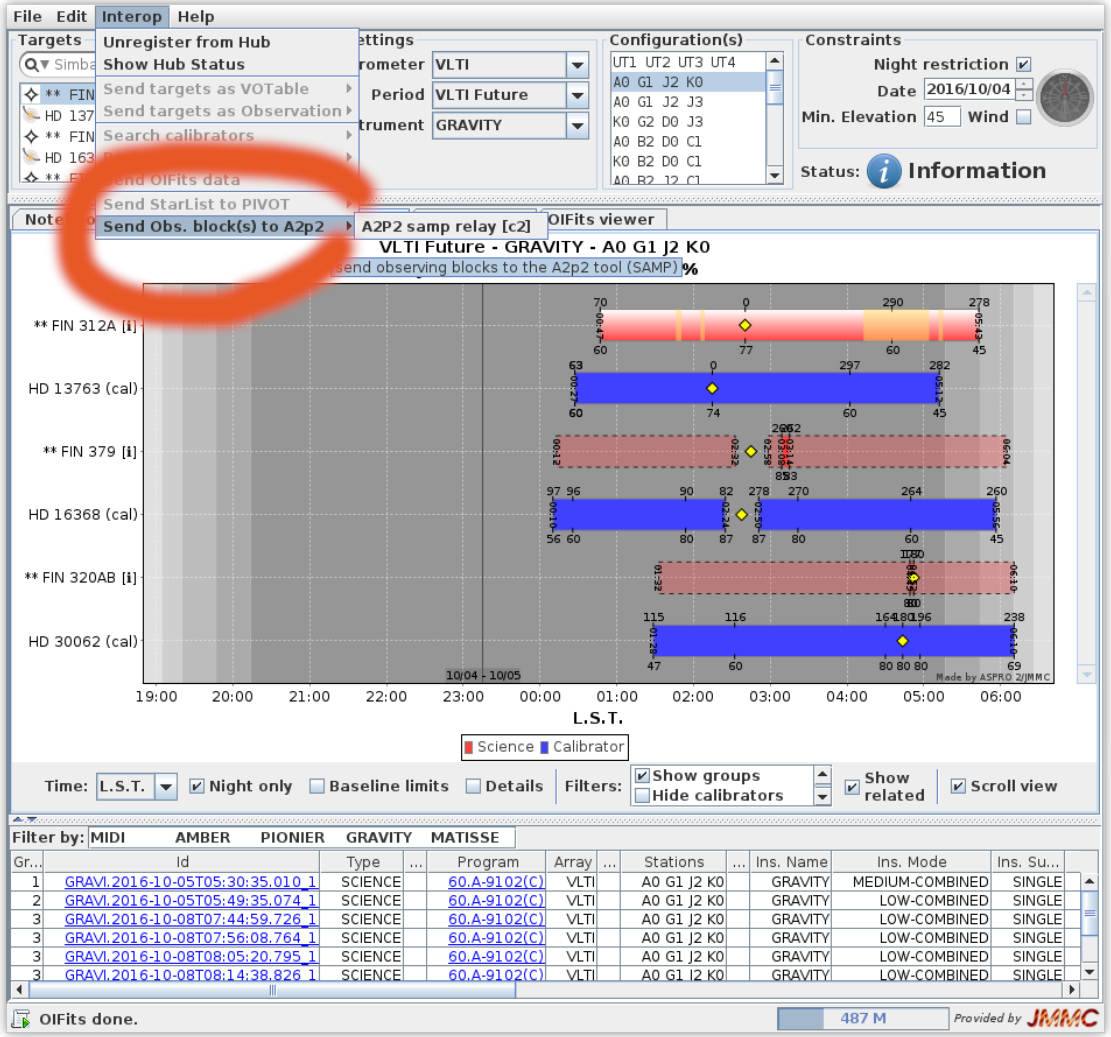
SearchFTT

Search Fringe Tracker Targets within 30” for VLTI/GRAVITY wide Dynamic queries to get candidates:

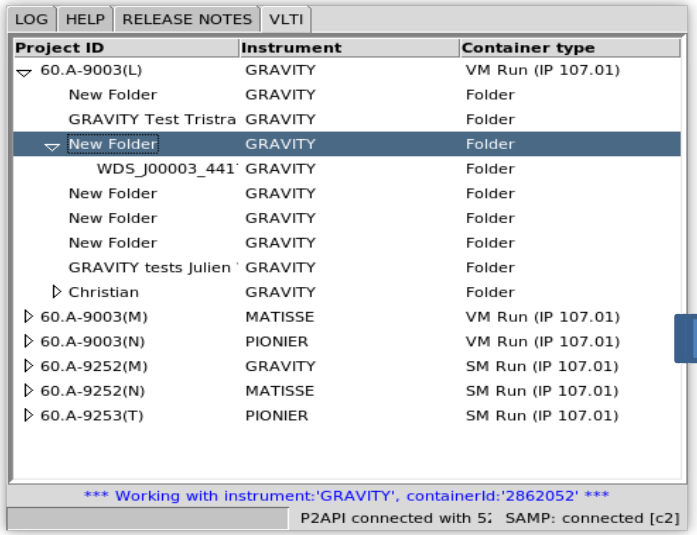
- Simbad
- GAIA : GAVO & ESAC
- GSC2 : VizieR
- Display table results & FOV image (AladinLite)

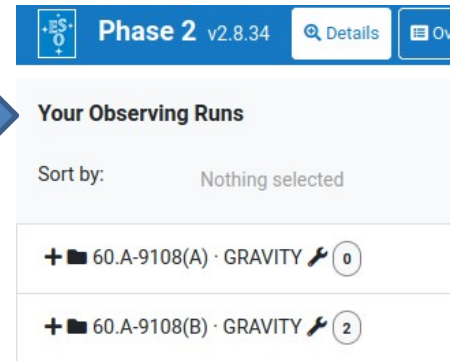


A2P2, the ASPRO2 companion tool in Python



Send your VLTI OB (SCI & ancillary stars) from ASPRO2 to ESO p2: PIONIER, GRAVITY & MATISSE





https://www.eso.org/p2

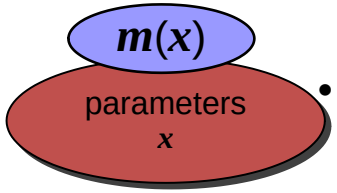
Try A2P2:

```
pip install -U a2p2
```

Model fitting with LITpro

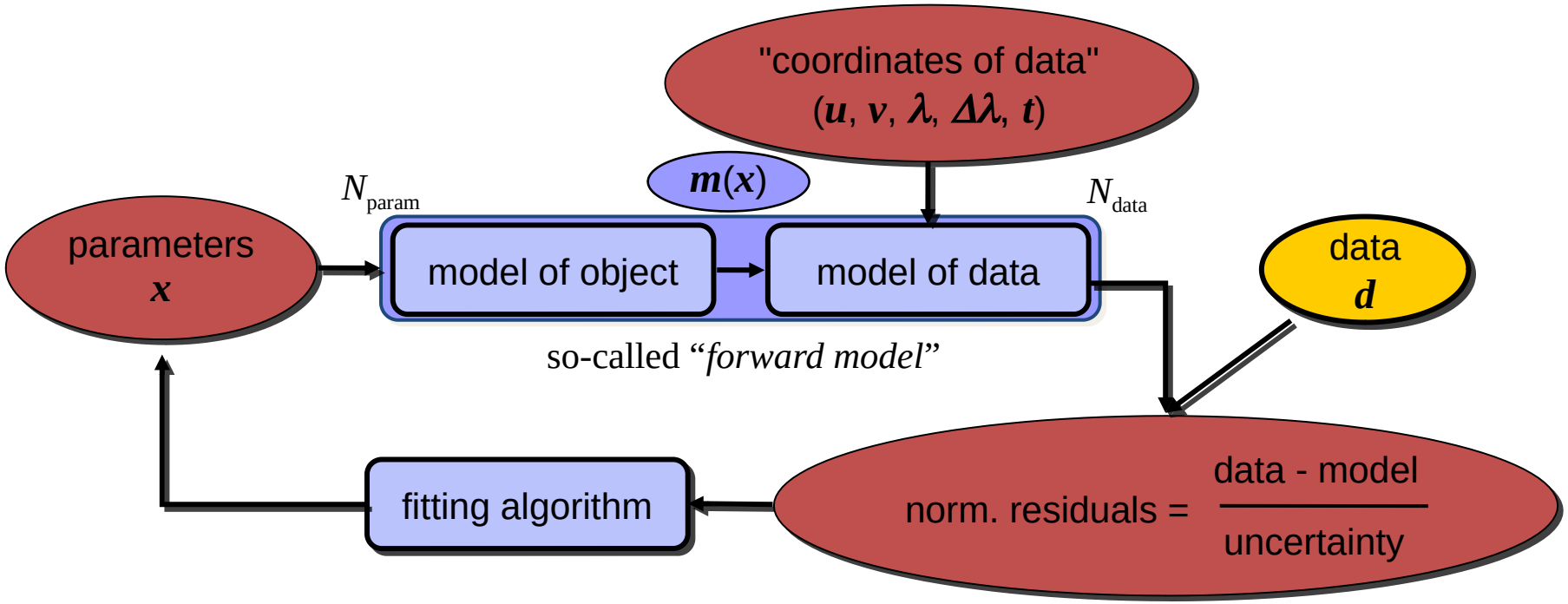
Model fitting principle

- What we have in hand
  - interferometric data (here OIFITS) ***and*** **uncertainties on data**
    - OI_VIS2 squared visibility amplitude
    - OI_T3 triple product (amplitude and phase)
    - OI_VIS complex visibility (amplitude and phase)
  - other data :
    - OI_FLUX calibrated or uncalibrated spectrum (OIFITS2)
    - absolute photometry, etc.
  - priors: all possible models of object



- What we want
  - identify the observed object seen by the instrument with a (forward) model ***m(x)***
  - estimate parameters ***x***, ***and*** **uncertainties on the parameters**

Model fitting principle



Model fitting principle

- The ***best* parameters** maximize the probability of the data (*knowing the model*)

$$\boldsymbol{x}_{\text{best}} = \arg\max_{\boldsymbol{x}} \text{Pdf}\left(\boldsymbol{d} \,\middle|\, \boldsymbol{m}(\boldsymbol{x})\right)$$

where ***d*** data (**random quantities, known statistics**)

x parameters

***m*(x)** model (of data): ~ *expected values of data*

Assumptions: data have **Gaussian statistics** and are **statistically independent**

$$\mathrm{x}_{\text{best}} = \arg\min_{\boldsymbol{x}} \sum_{i=1}^{N_{\text{data}}} \left(\frac{d_i - m_i(\boldsymbol{x})}{\sigma_i} \right)^2$$

σ_i error on d_i

$$= \arg\min_{\mathrm{x}} [\, \chi^2(\boldsymbol{x}) \,]$$

Model fitting principle

- What we have in hand
  - interferometric data (here OIFITS) ***and*** **uncertainties on data**
    - OI_VIS2 squared visibility amplitude
    - OI_T3 triple product (amplitude and phase)
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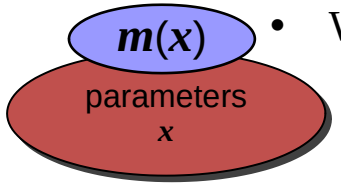
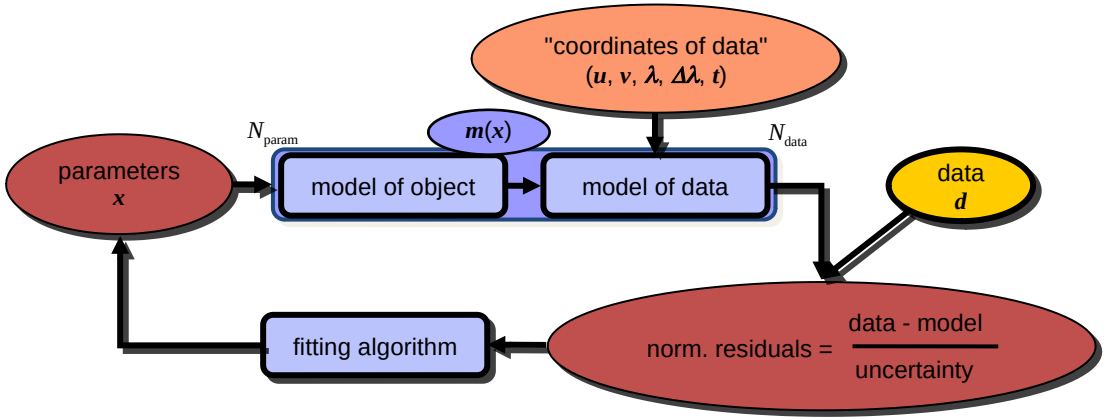
    - absolute photometry, etc.
  - priors: all possible models of object → ***m(x)***



- What we want
  - identity the observed object with a model ***m(x)***
  - estimate object parameters ***x***, ***and*** **uncertainties on the parameters**

- **What we need**
  - tools for minimizing $\chi^2(\boldsymbol{x})$ → **fitting algorithm**
  - there are several methods on the "market" → different softwares accessible
  - PMoired, OITOOLS, ... and **LITpro**.



LITpro model fitting software

M.Tallon, I. Tallon-Bosc, *conception, "expert layer"* *CRAL / Lyon Observatory*

G. Mella, *Graphical User Interface* *Grenoble Observatory*

Maintenance and improvement inside a working group

with F. Soulez, H. Beust, L. Bourgès, J.P. Berger

First public release Octobre 2009

LITpro main features

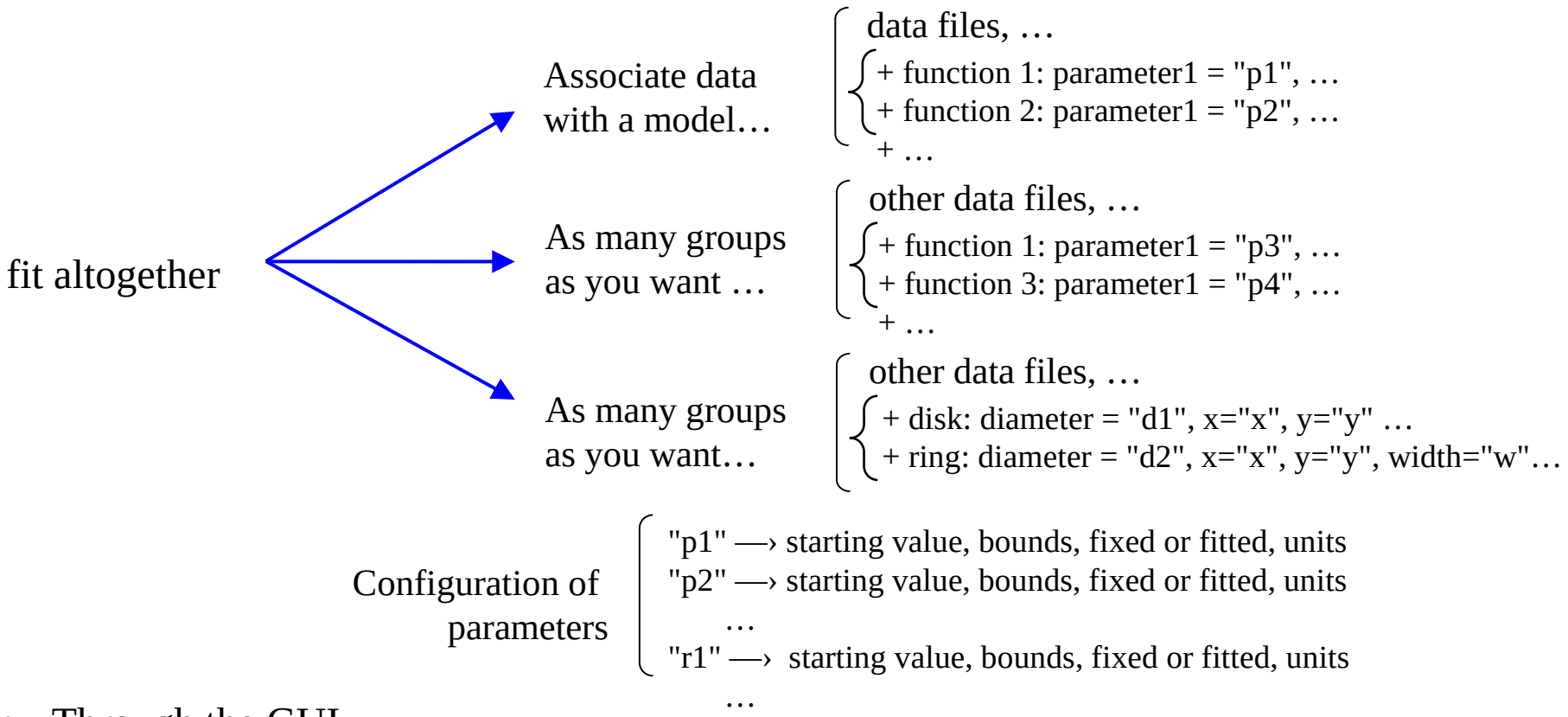
- a user-friendly accessibility via a GUI
  - implemented in JAVA
  - interoperability with other tools
  - (OIFitsExplorer, OiDB, Aspro2, OImaging, SAOimageds9)

- an easy Modeling builder
  - rich library of elementary functions combinable between them

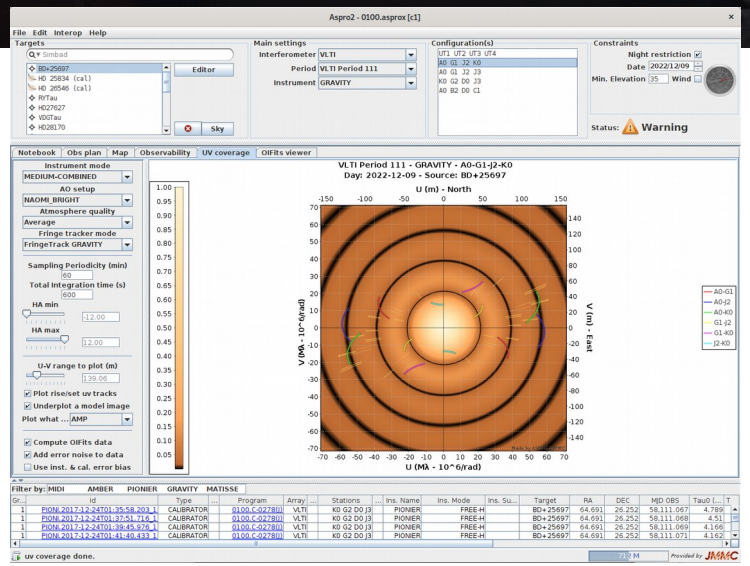
- a fast Fitter "engine": (modified) *Levenberg-Marquardt algorithm*
  - Combined with a Trust Region method
  - Bounds on the parameters
  - Partial derivatives of the model by finite differences

- some tools for analysis and help to conduct the fit
  exploration of the χ^2 space

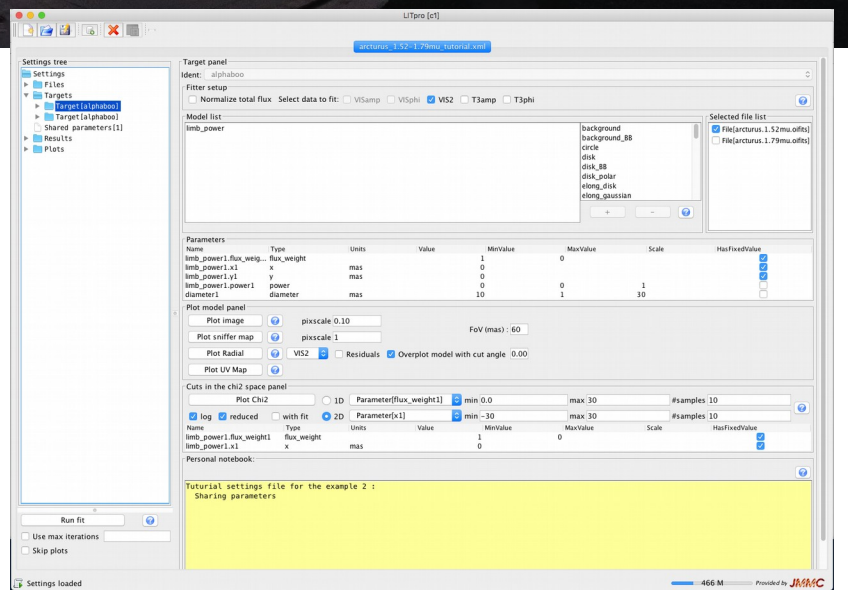
Setting up the fitting process / principle



- Through the GUI


Aspro2 - 0100.asprox [c1]
File Edit Interop Help
Targets
Main settings
Configuration(s)
Constraints
Night restriction
Date 2022/12/09
Min. Elevation 35 Wind
Status: Warning
Notebook Obs plan Map Observability UV coverage OIFits viewer
Instrument mode
MEDIUM-COMBINED
AO setup
NAOMI_BRIGHT
Atmosphere quality
Average
Fringe tracker mode
FringeTrack GRAVITY
Sampling Periodicity (min)
Total integration time (s)
HA min
HA max
U-V range to plot (m)
Plot rise/set uv tracks
Underplot a model image
Plot what ... AMP
Compute OIFits data
Add error noise to data
Use inst. & cal. error bias
VLTI Period 111 - GRAVITY - A0-G1-J2-K0
Day: 2022-12-09 - Source: BD+25697
U (m) - North
V (m) - East
U (MA - 10^6/rad)
V (MA - 10^6/rad)
Filter by: MIDI AMBER PIONIER GRAVITY MATISSE
uv coverage done.

Demo

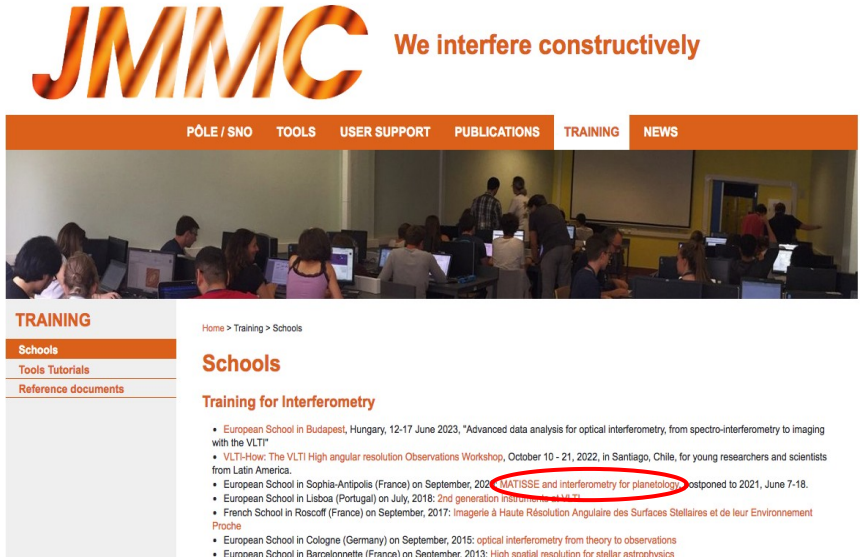

LITpro [c1]
Settings tree
Target panel
Fitter setup
Model list
Selected file list
Parameters
Plot model panel
Cuts in the chi2 space panel
Personal notebook:
Tuturial settings file for the example 2 :
Sharing parameters
Run fit
Skip plots
Settings loaded

Final words

Get tools & documentation : www.jmmc.fr

Find courses and practice sessions

of last VLTISchools...



Please report any problem, question or enhancement request to the JMMC User Support

at

www.jmmc.fr/support

Feedback always appreciated and useful !