



Multi-object Instrument for Occultations
in the SOLar system and TransitorY Systems

The search for trans- Neptunian stellar occultations with MIOSOTYS,

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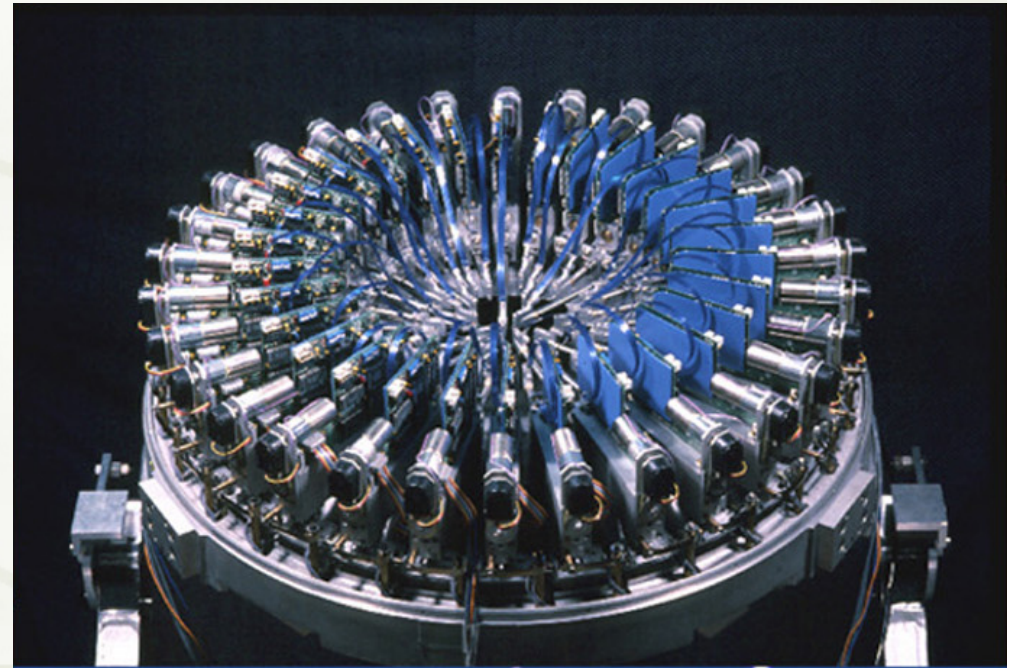
The instrument

- ★ MIOSOTYS: Multi-object Instrument for Occultations in the SOlar system and TransitorY Systems

MIOSOTYS is a multi-fiber positioner coupled with a fast photometry camera.

It is an arm positioner using 29 arms in a 26 arc-minute field.

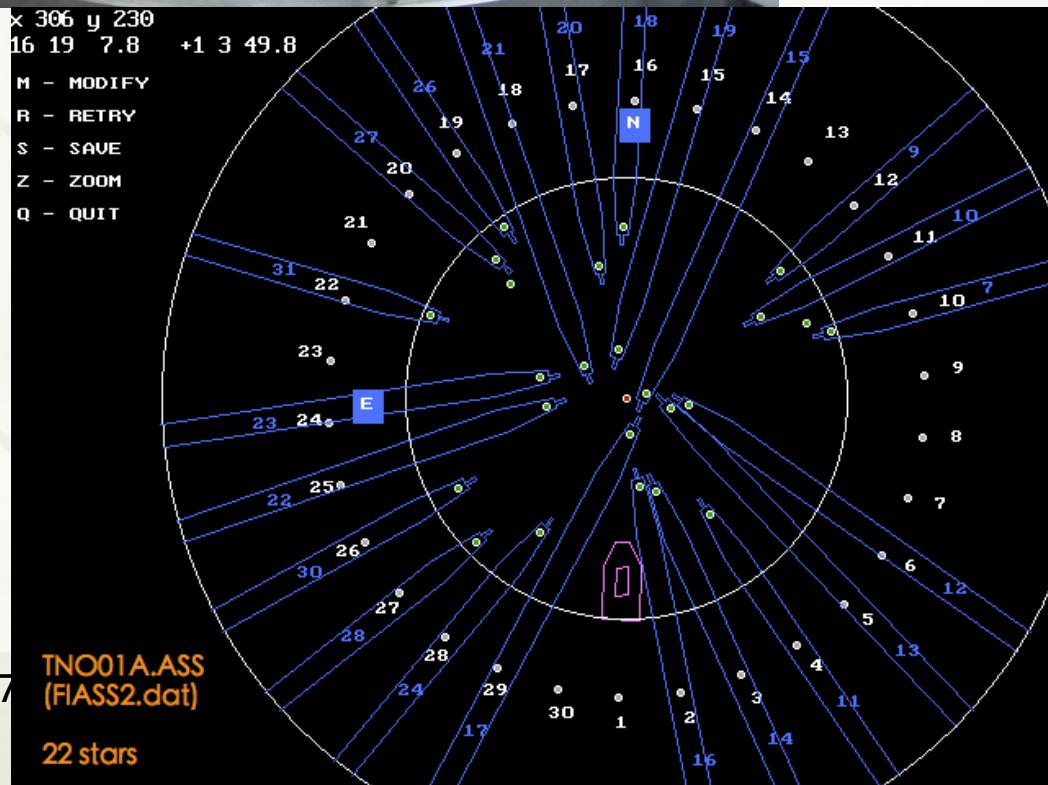
The system is set in a circle like 'fisherman around a pool'.





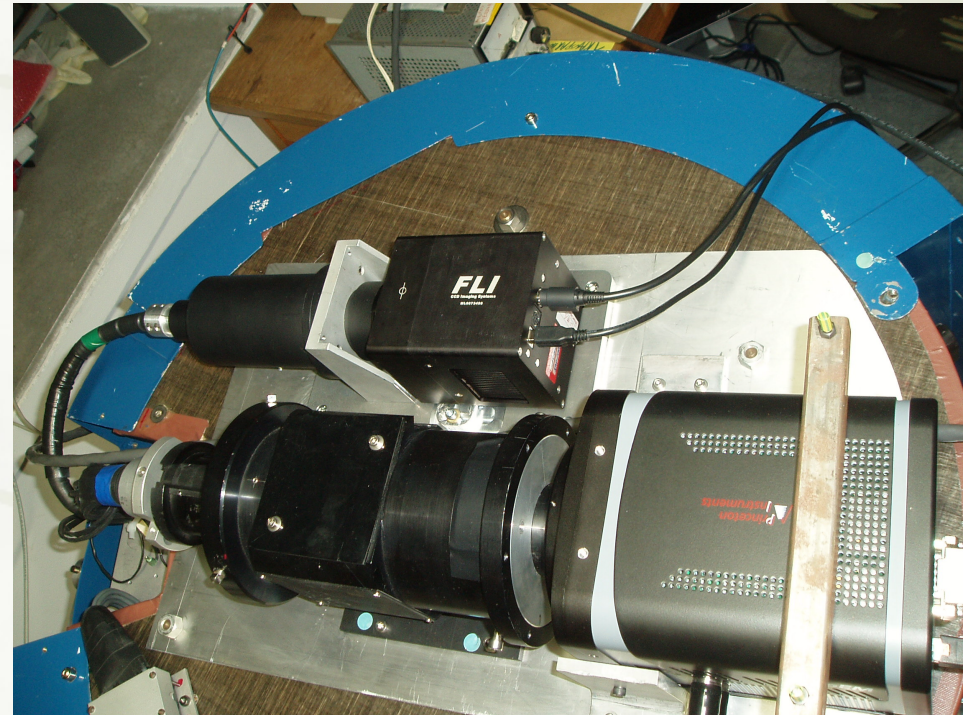
The instrument

- ◆ Each arm is equipped with an individual viewing system for accurate setting and carries one individual fiber that intercept 13" arcsec on the sky.



The instrument

- ◆ All the 29 fibers are aligned on an CCD for fast photometry acquisition.
- ◆ PROEM Princeton Instrument
- ◆ frame-transfer EMCCD: very low noise and fast acquisition



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Observatoire de Haute-Provence

- ★ **OHP** is situated in southeast France on a plateau at 650m altitude
- ★ Cassegrain (f/15) focus at the 193-cm telescope
- ★ Seeing around 2-2.5 arcsec

Longitude = $5^{\circ} 42' 44''$ E
Latitude = $+43^{\circ} 55' 54''$

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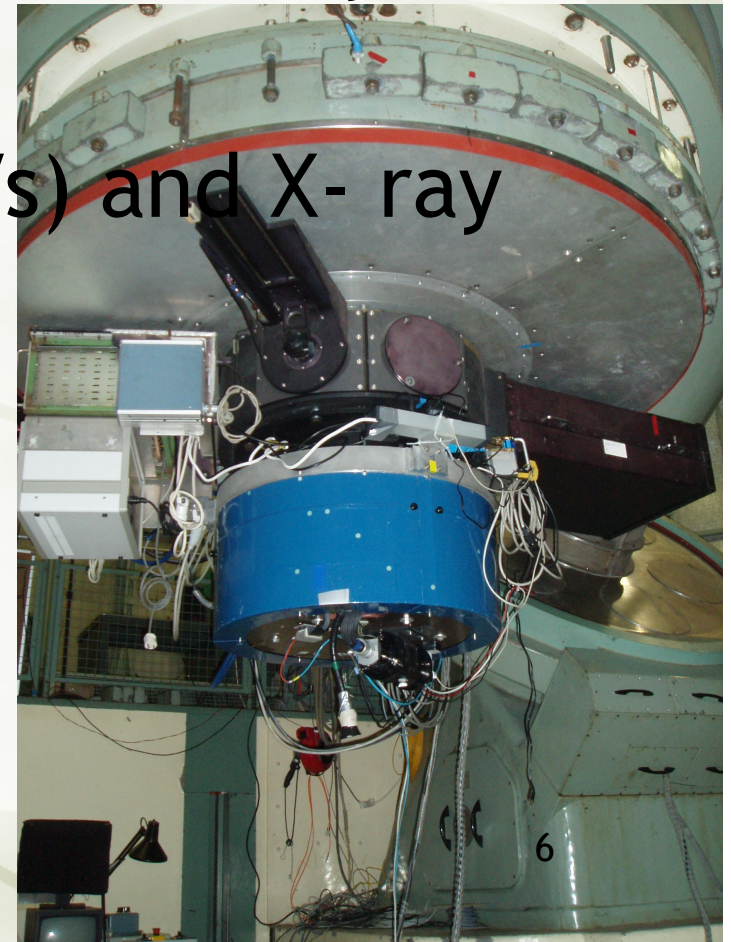


Science Case

- ★ Serendipitous stellar occultation by Trans-Neptunian objects
- ★ Cataclysmic Variables (CVs) and X-ray Binaries (XRBs)
- ★ Transiting exoplanets
- ★

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The method : *serendipitous stellar occultations*

The aim :

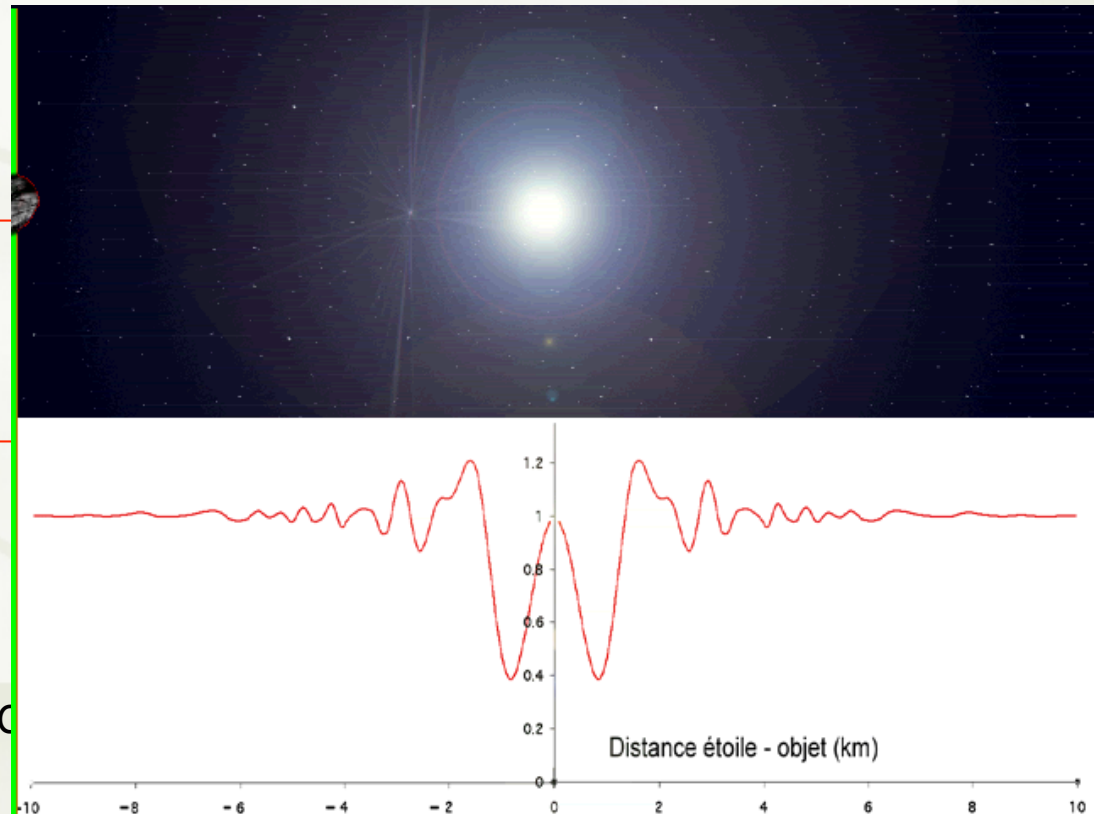
- Detection of the diffraction shadow of small (numerous) TNOs
- Simulations : hundreds meters TNOs detectable (Roques et Moncuquet, 2000)

Principles of the method :

- Fast photometry (> 20 Hz)
- small size stars

Observations :

- Constraint on the size distribution
- Three events (Roques et al, 2006)

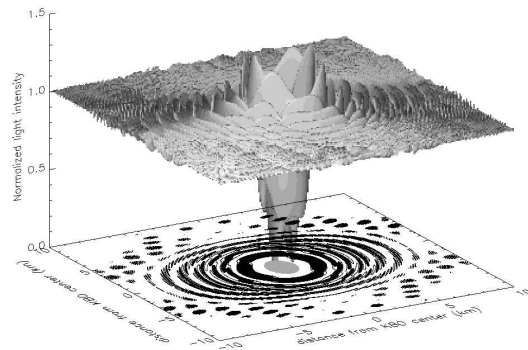
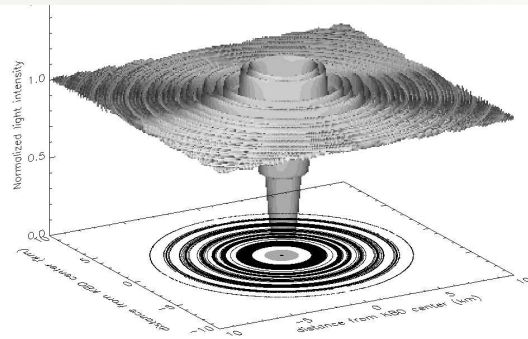


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The Fresnel scale

The Fresnel scale is the scaling factor of the occultation



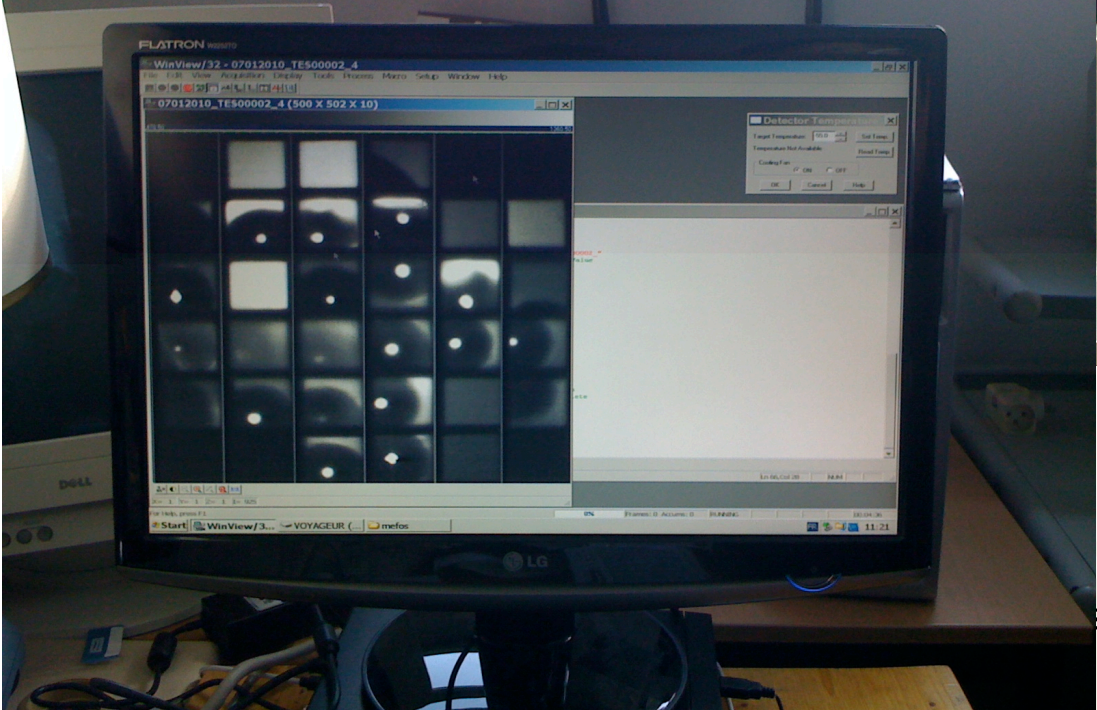
Roques et Moncuquet, 2000

$$F = \sqrt{\lambda \cdot R / 2}$$

λ : wavelength

R: distance of the TNO

- R = 3 AU, $F_s = 245$ m
- R = 40 AU, $F_s = 1.1$ km
- R = 10^5 AU, $F_s = 55$ km



Miosotys source selection software

- Automatically downloads catalogs and model of the Galaxy.
- Selects stars with small angular diameter, via reduced proper motions and magnitudes.
- Finds fields to be observed by MIOSOTYS with various settings.

Miosotys Software

What do you want to do?


Find a field for TNOs | Reduce data

Source Selection Software | Data Reduction Software

View an image data file | Concatenate light curves

Quick View Software | Light Curve Viewer

Visit Beyond Neptune website



Multi-object Inst in the SOLAR syste

Author : Yannick Boisse.

7-11 March 2011

Miosotys Source Selection Software V2.4

MSSS MENU

1. CATALOGUES AND MODEL

This area is for the download or search of catalogues and model data files, needed to run the software.

- For a new search, give position of field on the sky and Av max, then click on Download. This will download the catalog files from VizierR and the model files from Besancon Observatory.

- If you want to use previously downloaded files, click on BROWSE. See help for more information.

Position of the field, in degrees :

RA : 267,057 DEC : 16,0735

Av max : 2 E[1,4]

DOWNLOAD | Download READY

BROWSE | Browse READY

/Data/yboisse/working_directory/MIOSOTYS_86_4050_

What I am doing right now :

I found the folder. Please go and speak to my twin on the right.

2. STARS SELECTION

START | Star selection READY

Stars max sizes (Fresnel scales): 0.5

Distance of TNOs (AU): 40 OK

What I am doing right now :

Field number 11/50

3. FIELD SEARCH

AUTO | MANUAL | Field search AUTO

Previous field | Next field | Save information on this field | Show this field on real sky | ATTENTION : always press return after giving values to me

28 arcmin field

FIELD CENTER: 5h 43m 42.31s 28d 9m 15.76s

STAR MAGNITUDES :

+ Vmag < 8.0	+ 12.5 <= Vmag < 13.0
+ 8.0 <= Vmag < 10.0	+ 13.0 <= Vmag < 13.5
+ 10.0 <= Vmag < 10.5	+ 13.5 <= Vmag < 14.0
+ 10.5 <= Vmag < 11.0	+ 14.0 <= Vmag < 14.5
+ 11.0 <= Vmag < 11.5	+ 14.5 <= Vmag < 15.0
+ 11.5 <= Vmag < 12.0	+ 15.0 <= Vmag < 15.5
+ 12.0 <= Vmag < 12.5	+ 15.5 <= Vmag < 16.0

Crasses : selected stars (74) Dist of TNOs : 40 AU
Dots : non selected stars (822) Stars max size : 0.50 Fres
White circle : MIOSOTYS field
25 arcmin diameter

DEC (deg) vs RA (deg) plot showing a circular field of stars.

V mag of selected stars plot showing the distribution of magnitudes.

4. ANTI-SOLAR DIRECTION

Date (YYYYMMDDHH) : ... CHECK

A-S at Date : ...

A-S +20d : ...

A-S -20d : ...

AUTOMATIC MODE SETTINGS

Minimum nb of stars in fields : 30

Vmin : 12 Vmax : 14 OK

Vmax must be <= 16.0

MANUAL MODE SETTINGS

Target position, in degrees :

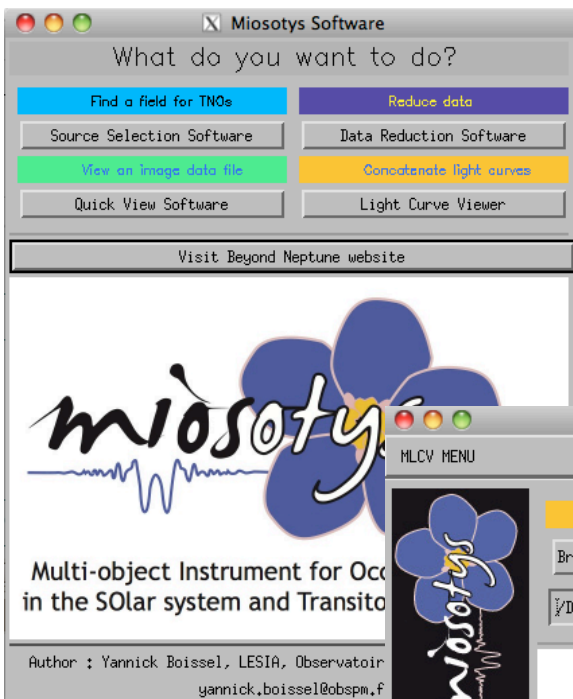
RA : 0.00000 DEC : 0.00000

Position must be within 5 deg^2

target Vmag : 0.00 name : I

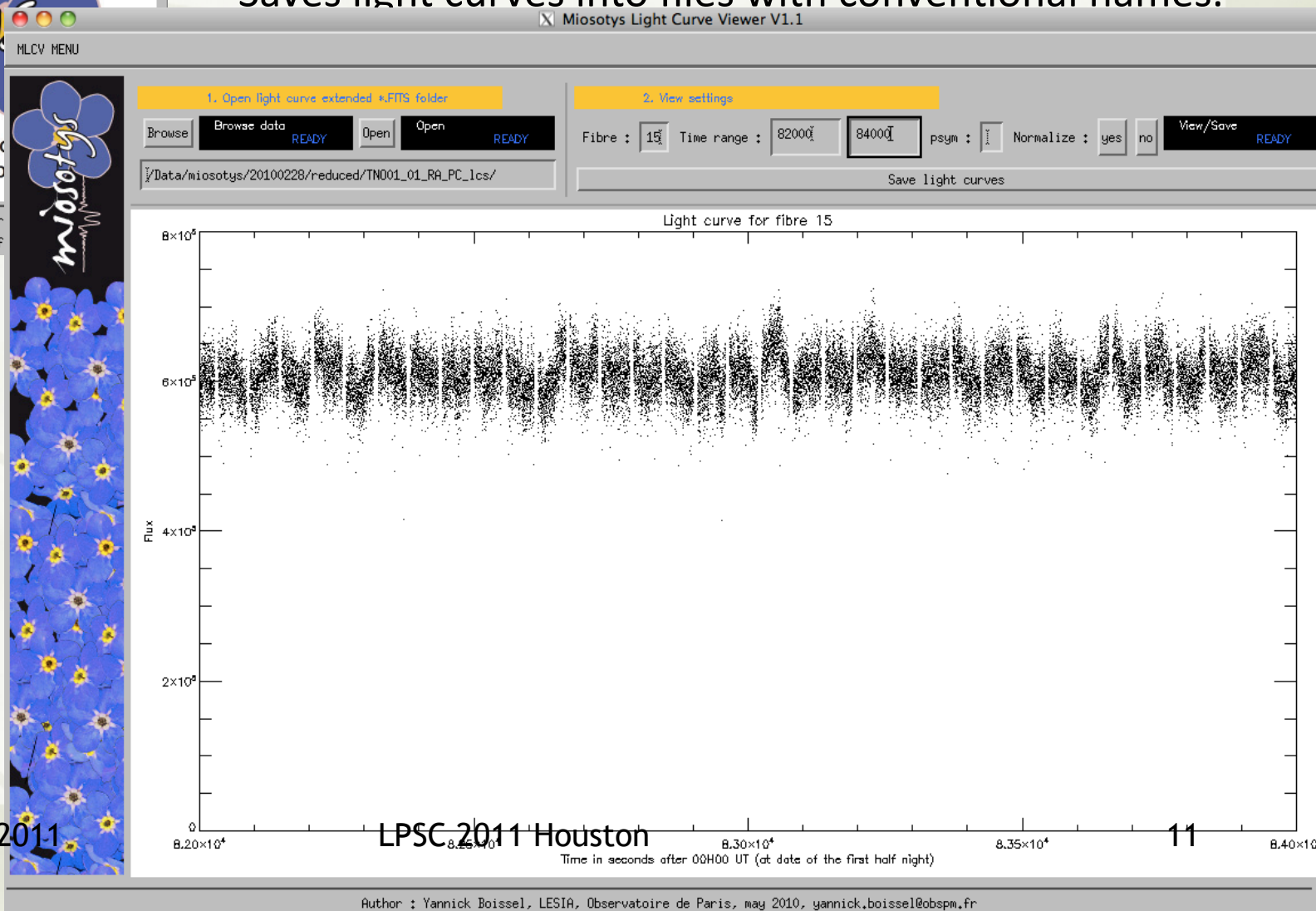
Vmin : 0. Vmax : 0. OK

Vmax must be <= 16.0



Miosotys light curve viewer

- Concatenates all elements of light curve of a run into a long one.
- Provides a few visualization tools.
- Saves light curves into files with conventional names.

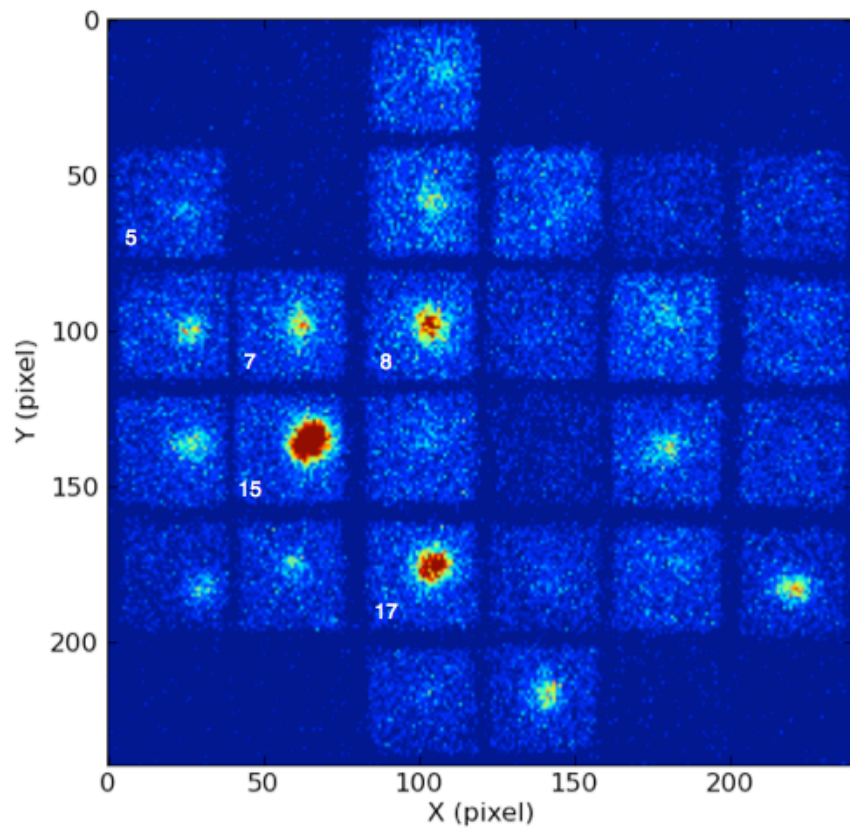


7-11 March 2011

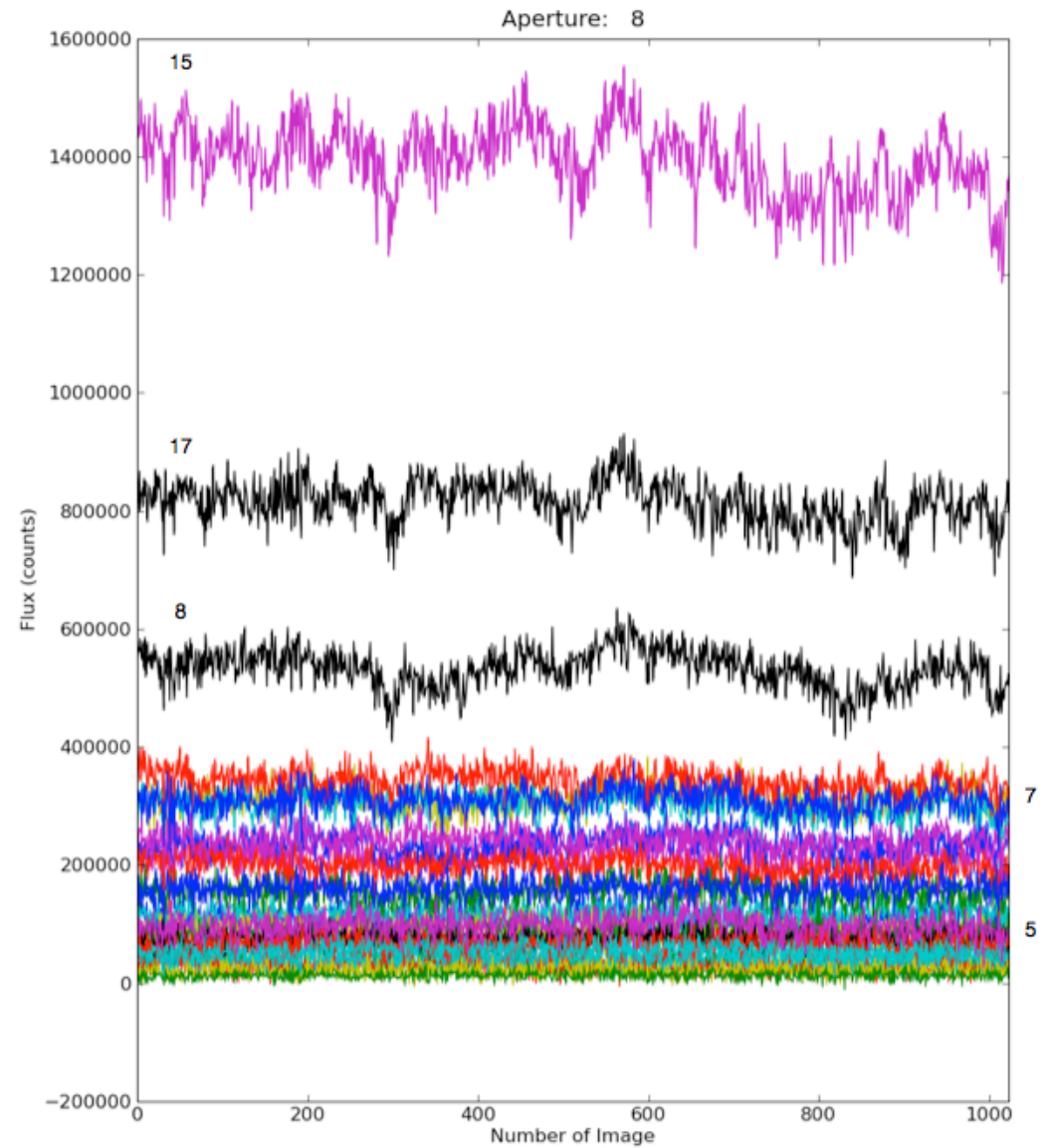
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11

First light in March 2010



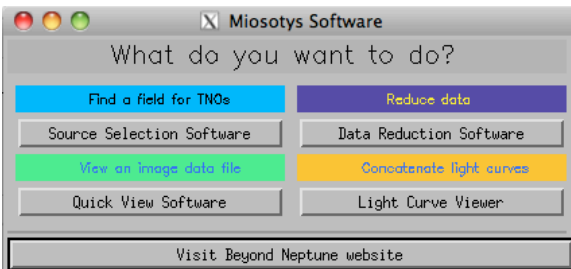
R.A. (centre)	07:10:15.3
Dec. (centre)	+22:44:12.8
Exposure time	0.1 sec
EM gain stage	500
V Magnitude (NOMAD)	12.2 - 14.5





Summary and perspectives

- ◆ New promising instrument
- ◆ First « dedicated » fiber instrument
- ◆ Expected performances:
 - ◆ S/N=10-30 @ 20 Hz
 - ◆ 12-13 mag stars
- ◆ Detection of 0.09 event per night



Miosotys data reduction software

- Converts CCD owned formats to *.FITS.
- Detects stars in each fibre, for all frames via calculation of photocenters.
- Produces light curves via aperture photometry.



Multi-object Instru
in the SOLar system

Author : Yannick Boissel,
yanni

MIRS MENU



1. Browse data

Browse directory: OFF

Directory: /Data/yboissel/working_directory/MIOSOTYS/20100228/

Target (TNO01_01, EX004_04 ...):

2. SPE files conversion to FITS format

Reduction level: FLAT configuration:

(0:none, 1:BIAS, 2:BIAS & FLAT, 3:BIAS & FLAT & DAFL) DAFL configuration:

BIAS configuration:

OFF

Reduction ID:

What I am doing right now :

Hello, I am the MIOSOTYS data reduction software. Please give the path of the mother directory (YYYYMMDD), and target. Then choose between SPE files conversion and aperture photometry processes. See help for more information.

3. Aperture photometry

Radius: Sky from radius: Reduction ID:

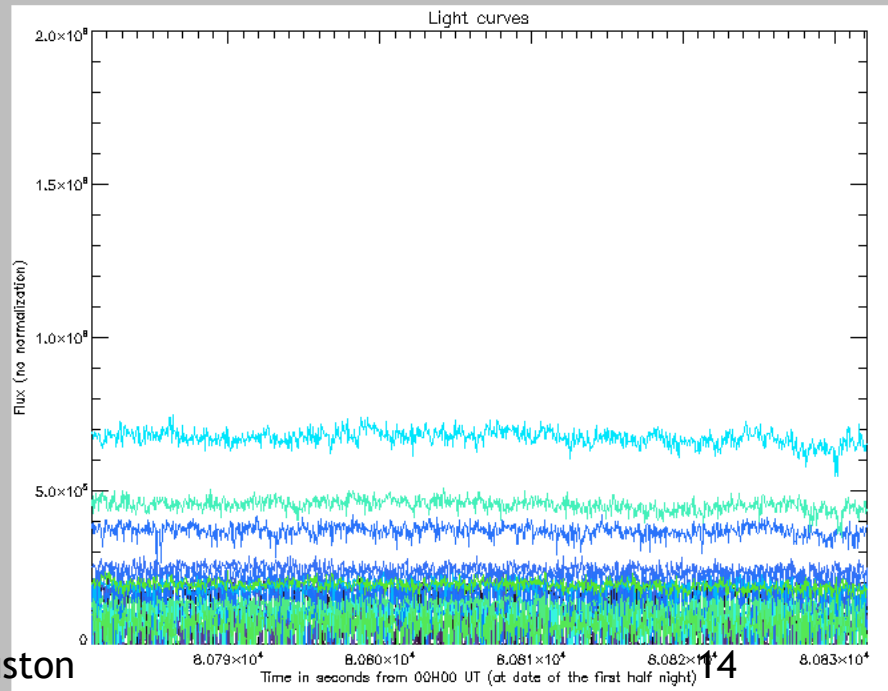
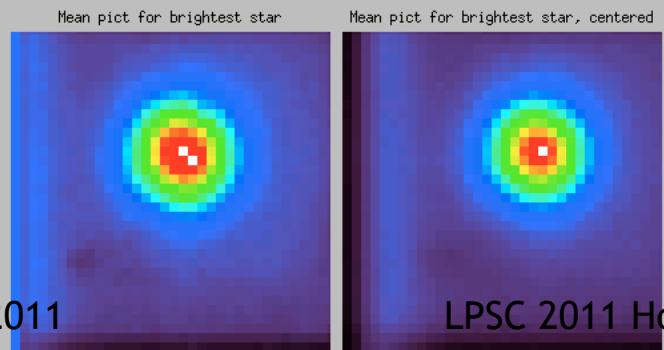
ACTIVE

Photometry ID:

What I am doing right now :

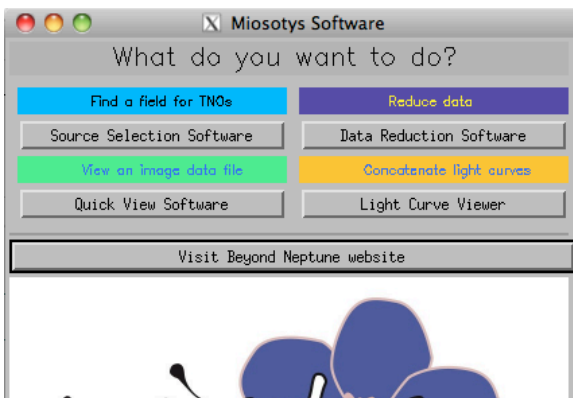
```
Processing FITS cube 2/2 ...
/Data/yboissel/working_directory/MIOSOTYS/20100228/reduced/TN
001_01_AA_images/20100228_2_TNO01_01_2.fits
Processing extension 18/26 (fibre 21) ...
```

ext 28	/	non assigned
ext 26	/	non assigned
ext 27	/	non assigned
ext 26	/	fibre 30
ext 25	/	fibre 28
ext 24	/	fibre 28
ext 23	/	fibre 26
ext 22	/	fibre 24
ext 21	/	fibre 24
ext 20	/	fibre 23
ext 19	/	fibre 22
ext 18	/	fibre 21
ext 17	/	fibre 20
ext 16	/	fibre 18
ext 15	/	fibre 18
ext 14	/	fibre 17
ext 13	/	fibre 16
ext 12	/	fibre 16
ext 11	/	fibre 14
ext 10	/	fibre 13
ext 9	/	fibre 10
ext 8	/	fibre 9
ext 7	/	fibre 8
ext 6	/	fibre 7
ext 5	/	fibre 6
ext 4	/	fibre 5
ext 3	/	fibre 4
ext 2	/	fibre 3
ext 1	/	fibre 2



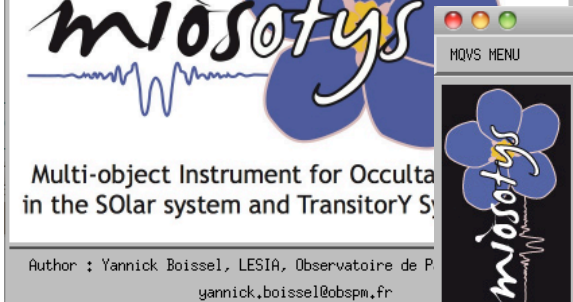
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Miosotys quick view software

- Can read MIOSOTYS data cubes at any stage of reduction.
- Can show any frame of any fibre cube.
- Shows header.



MIOSOTYS Quick View Software V1.3

1. Open *.SPE or reduced *.FITS file

Browse file

~/Data/yboissel/working_directory/MIOSOTYS/20100523/reduced/CV001_01_RA_im...

What I am doing right now :

I found the *.FITS file.

2. File header

```

SIMPLE =          T / conforms to FITS standard
BITPIX =         -32 / array data type
NAXIS =           2 / number of array dimensions
NAXIS1 =          240
NAXIS2 =          240
EXTEND =          T
FILENAME= '20100523_2_CV001_01_5'
TELESCOP= 'OHP 1.93m'
INSTRUME= 'MEFOS'
OBSERVER=         / P.I.
OBJECT = 'CVO' / Type of scientific objective
DATE-OBS= '2010-05-24T22:18:13' / Beginning date and time of
observation.
LST-OBS = '00:18:13' / Local time
JD = 2455341.42931713 / Julian Date/Time (still under test!)
NUMSHOT = 5120 / Number of shots
BINSIZE = 2 / Binning
BPIXELX = 40 / X axis size of fibre image
BPIXELY = 40 / Y axis size of fibre image
EXPTIME = 0.05000000074505806 / second
READOUT = 30.24990081787109 / millisecond
CCDTEMP = -55.0 / Celsius
READNOI = 39.52 / readout noise (e- rms)
GAIN = 2.47 / Conversion gain (e-/ADU)
DARK = 0.0074 / e-/pixel/sec at -55 degree Celsius
EMGAIN = 400 / EM gain stages
FIBREACT= 18 / Number of active fibres
EXTEN_01= '3' / fibre arm
RA_01 = '17:12:52.1'
DEC_01 = '+33:25:0.9'
MAG_01 = 13.9
EXTEN_02= '4' / fibre arm
RA_02 = '17:12:45.2'
DEC_02 = '+33:25:42.1'
MAG_02 = 13.0
EXTEN_03= '5' / fibre arm
RA_03 = '17:12:18.0'
DEC_03 = '+33:21:29.8'

```

3. View data

Average

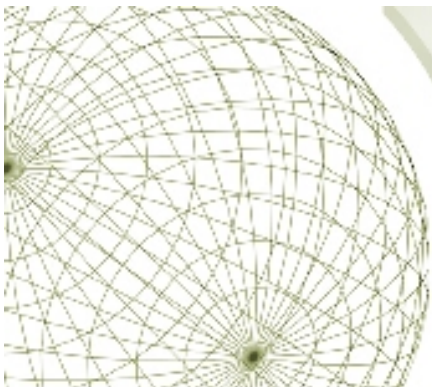
Single frame

Grid of 30 frames (1-30) showing data cubes.

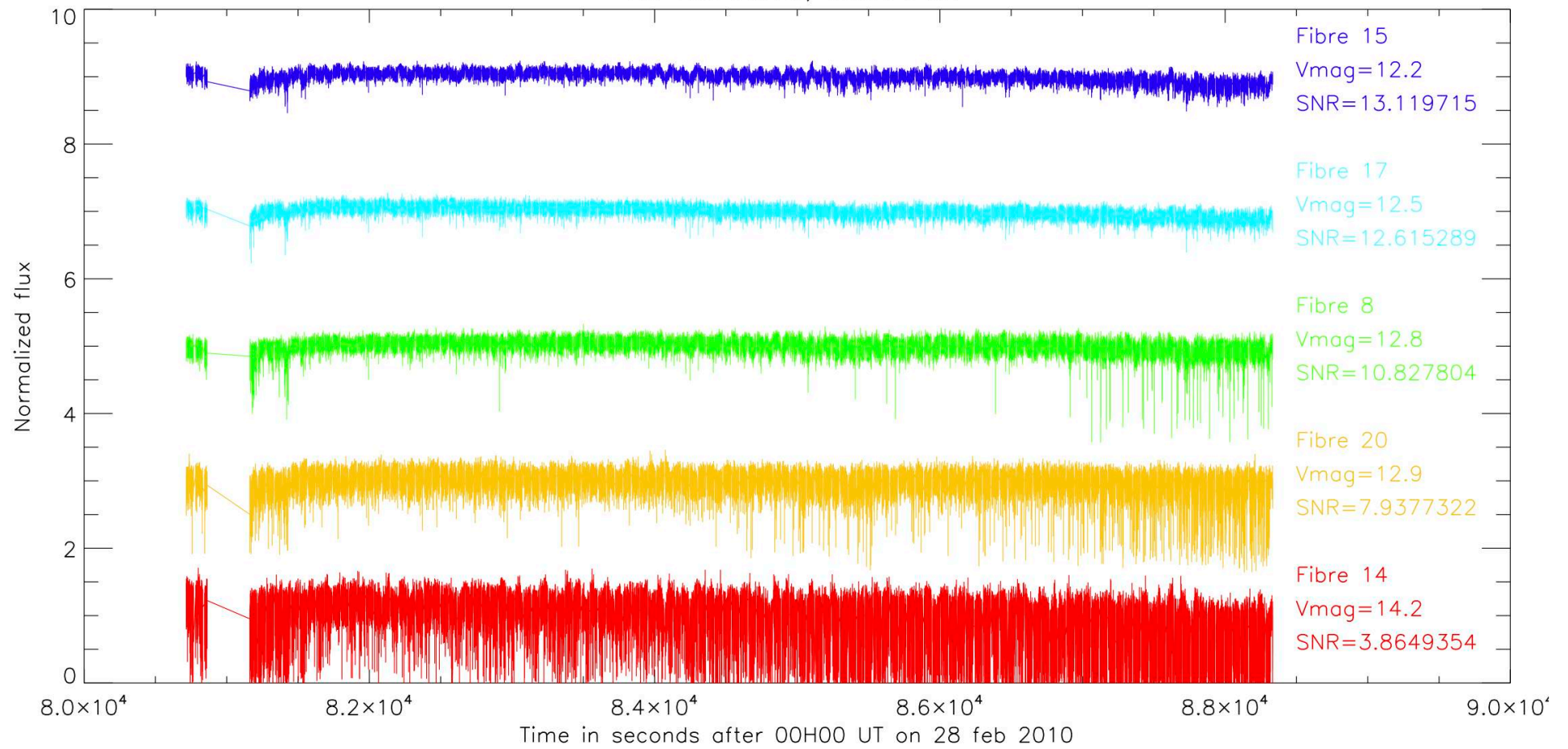
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15



28 feb 2010, TNO01_01



Variability index : example on ULTRACAM/VLT observations (2005)

- Two filters : green (g' : 0.47 μm) and red (r' : 0.62 μm).
- 19 hours of data at frequency 61 to 64 Hz.

$$VI_w(i) = \frac{\sigma_w(i) - \langle \sigma_o \rangle}{\sigma(\sigma_o)}$$

Calculated in a running window on light curves.

