# Mesurer le diamètre des étoiles variables

Aller plus loin que la simple prise de données lors des collaborations Pro-Amateur

David Antao

# Les différents côtés de l'astronomie

- Observation du ciel
- L'instrumentation
- Astrophoto
- Dessin
- Actualité
- Les connaissances scientifiques
- Participer à la recherche
- L'Histoire
- …

# Participer à la recherche

Collaboration à des programmes de recherche professionnels

- Spectroscopie
- Photométrie
- Déclaration des observations


# Spectroscopie


- Aider les nouveaux à démarrer

Me contacter pour plus de renseignements

# Atelier débutants

# Introduction à la spectroscopie astronomique

Si vous voulez connaitre tout ce que l'on peut faire en spectroscopie avec des moyens amateurs, qu'est ce que l'on peut utiliser comme matériel, les divers spectroscopes, on organise un atelier en ligne via Zoom le **mardi 24 mai à 20h30** heure française (18h30 UTC).

Pour vous inscrire et afin de recevoir le lien zoom de l'atelier, merci de renseigner votre adresse e-mail sur le lien suivant :

https://framadate.org/R2LOt9aULxJcw3b3


https://framadate.org/R2LOt9aULxJcw3b3

# Photométrie et analyse des données


Aller plus loin que la simple prise de données lors des collaborations Pro-Amateur

Président : Antoine Cailleau

Référent Pro : Alain Klotz


AMERICA
1776


100 AUX ASTRES CITOYENS

# SAISISSEZ LA LUMIÈRE QUI POURSUIT LES ONDES GRAVITATIONNELLES

**Dans le sillage des professionnels, un réseau mondial d'astronomes amateurs se forme pour dénicher la prochaine kilonova, la lueur rare qui émane dans la foulée des ondes gravitationnelles. Le projet Kilonova Catcher recrute !**

Guillaume Langin

*"C'est un peu comme jouer au loto. Un participant seul a une faible chance de gagner. Mais si l'on est nombreux à jouer, il devient probable que quelqu'un empoche la mise !"* Si Alain Klotz, astrophysicien à l'observatoire Midi-Pyrénées, emploie la métaphore des jeux de hasard, c'est pour illustrer à quel point l'expérience d'astronomie participative qu'il a lancée en 2018 avec l'astrophysicienne Sarah Antier est une affaire collective. Le projet Kilonova Catcher, qui réunit des observatoires amateurs, est une

KILONOVA CATCHER

Alain Klotz (à gauche) et Antoine Cailleau comptent parmi les initiateurs du projet Kilonova Catcher, depuis la région de Toulouse. DR

# Photométrie et analyse des données


Création de l'association en 2020

Objectif :

Faire une école de photométrie à l'automne 2022

# Réunion du 13 nov. 2021

Analyse d'une série d'images prises au cours d'une seule nuit.

Cible : DY Peg une étoile variable

Etoile de type SX Phoenicis

Magnitude visuelle apparente de 9,95 à 10,62

Période de 1,75 heures

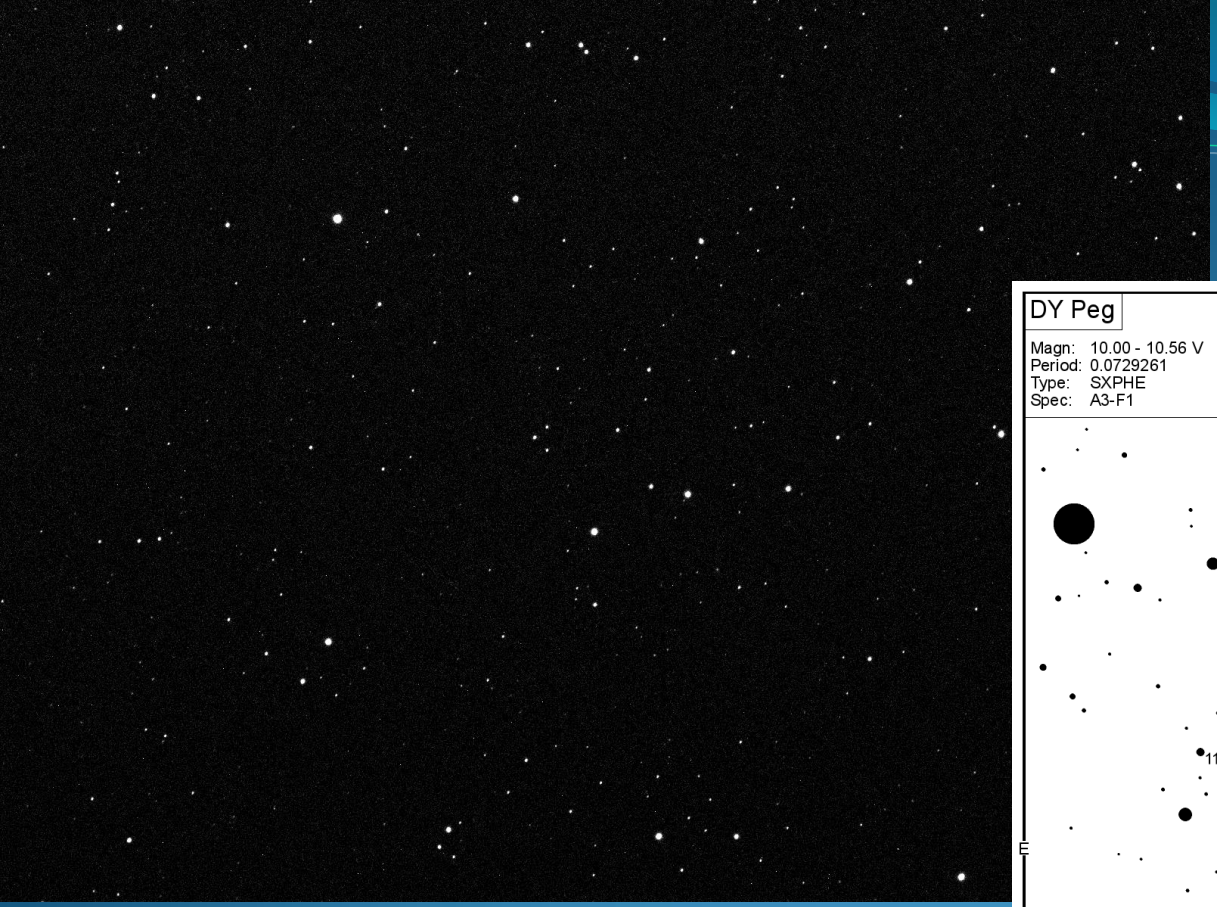
ASSOCIATION MIDI PYRENEES - GROUND ASTROPHYSICS ADDICTS MP-G2A

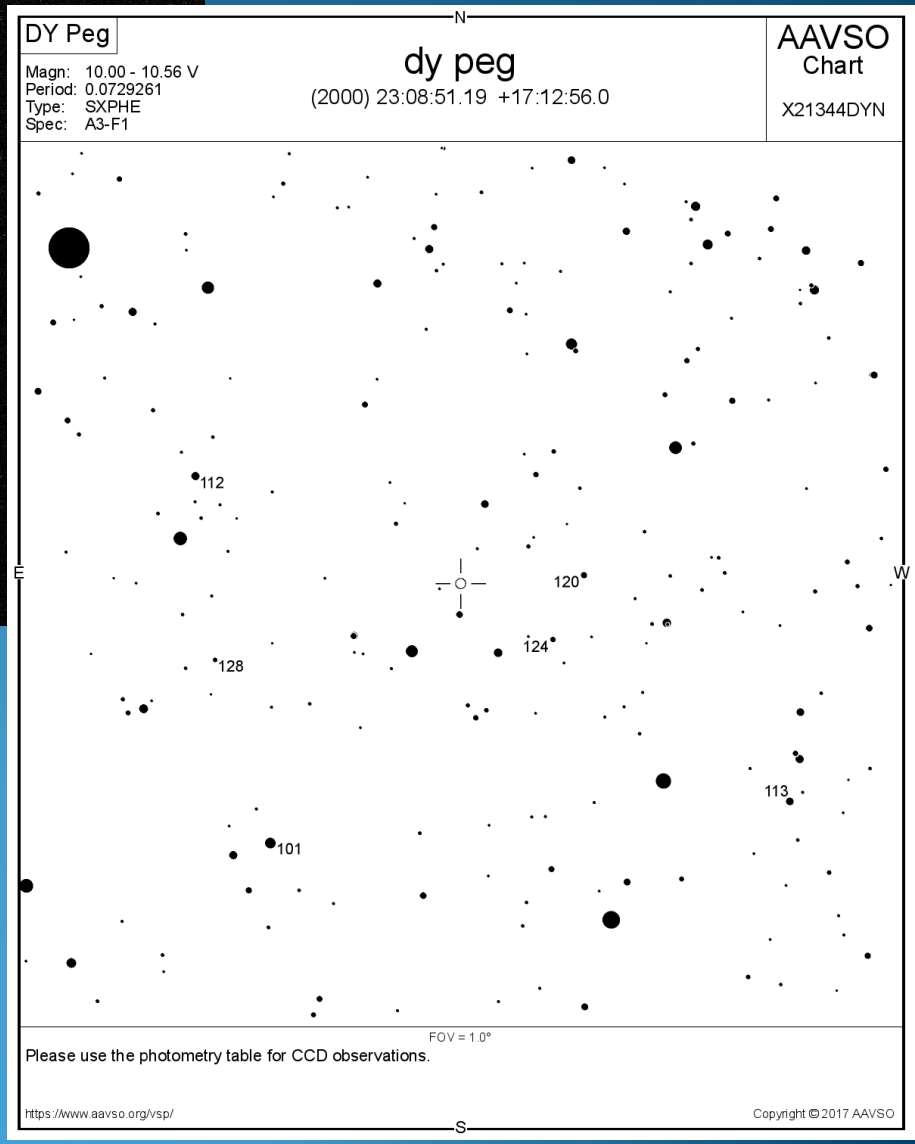
# Réunion du 13 nov. 2021

Objectif de la rencontre :

## Détermination des variations de rayon et de température

ASSOCIATION MIDI PYRENEES - GROUND ASTROPHYSICS ADDICTS
MP-G2A



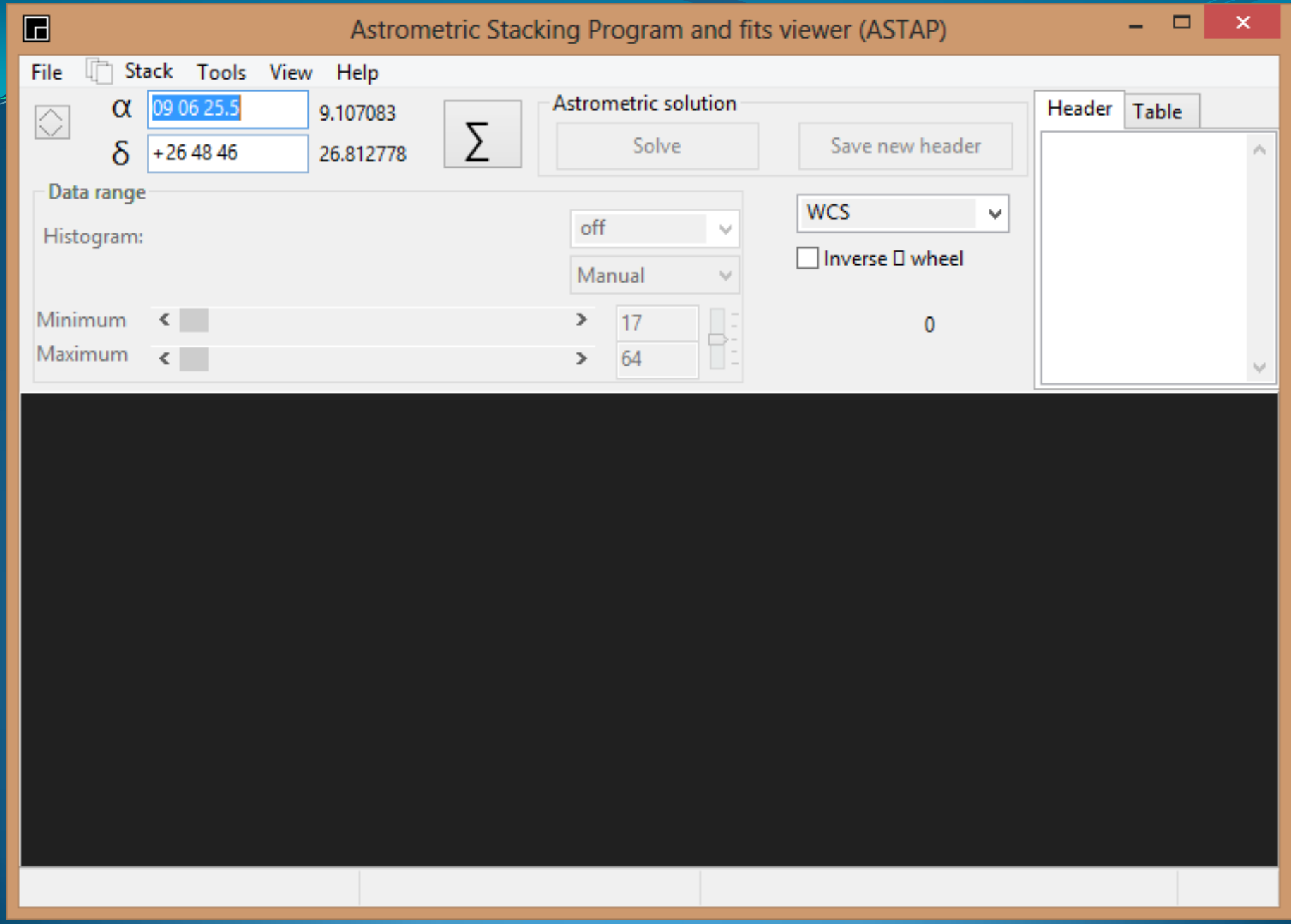

DY Peg
Magn: 10.00 - 10.56 V
Period: 0.0729261
Type: SXPHE
Spec: A3-F1
dy peg
(2000) 23:08:51.19 +17:12:56.0
AAVSO
Chart
X21344DYN
N
E
W
S
112
120
124
128
113
101
FOV = 1.0°
Please use the photometry table for CCD observations.
https://www.aavso.org/vsp/
Copyright © 2017 AAVSO

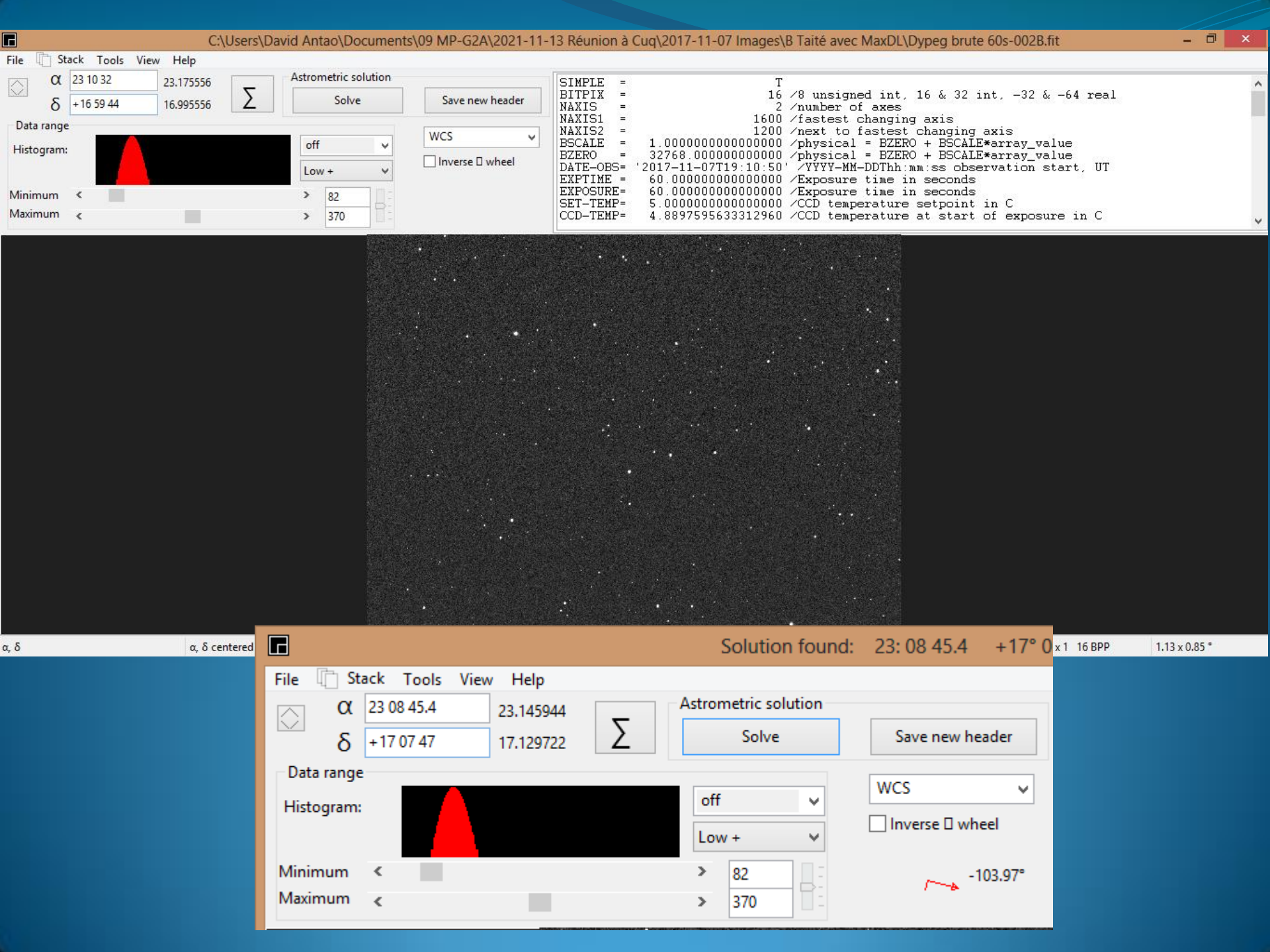
# Réunion du 13 nov. 2021

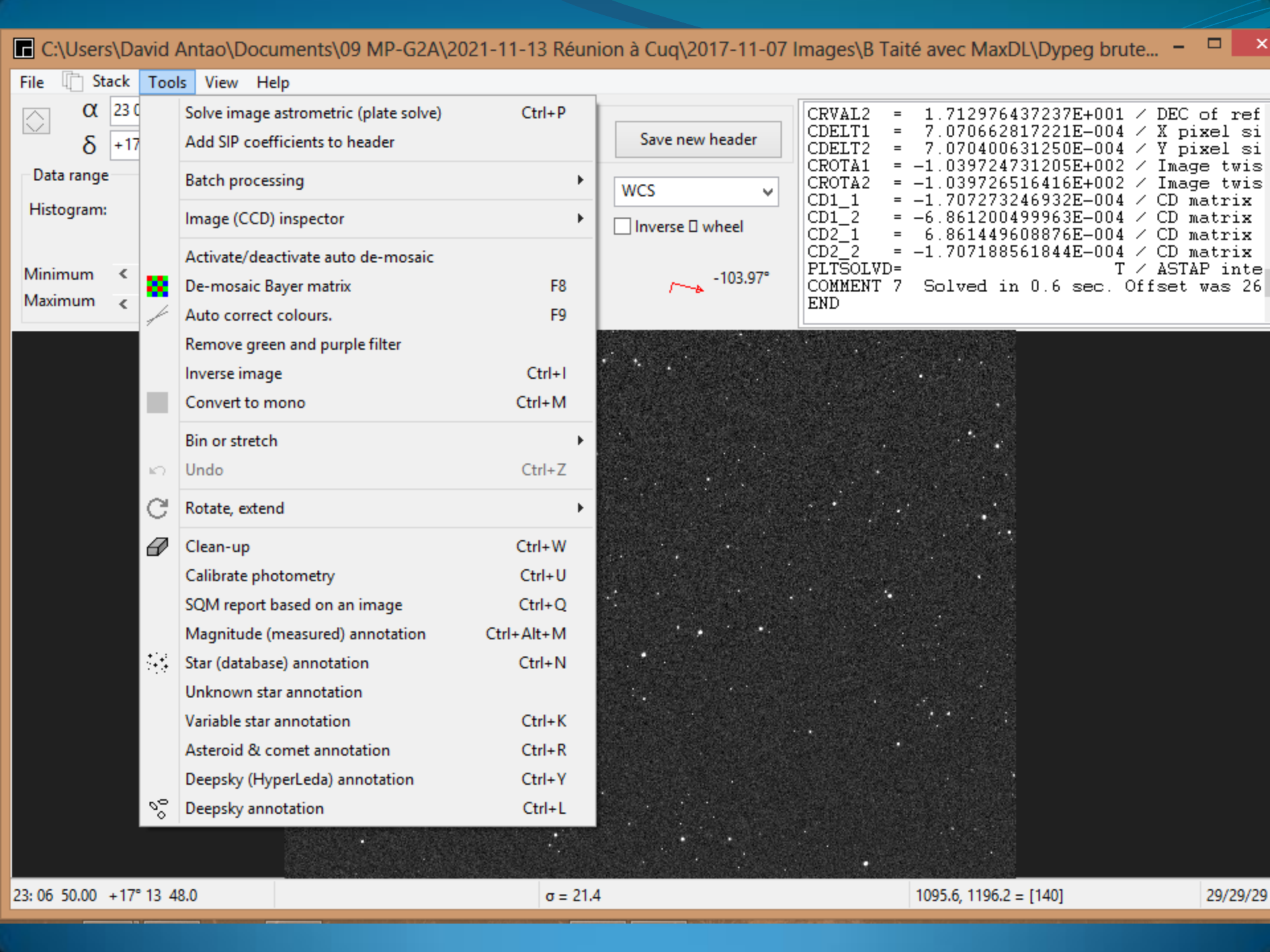
Découverte de nouveaux outils


Logiciel ASTAP

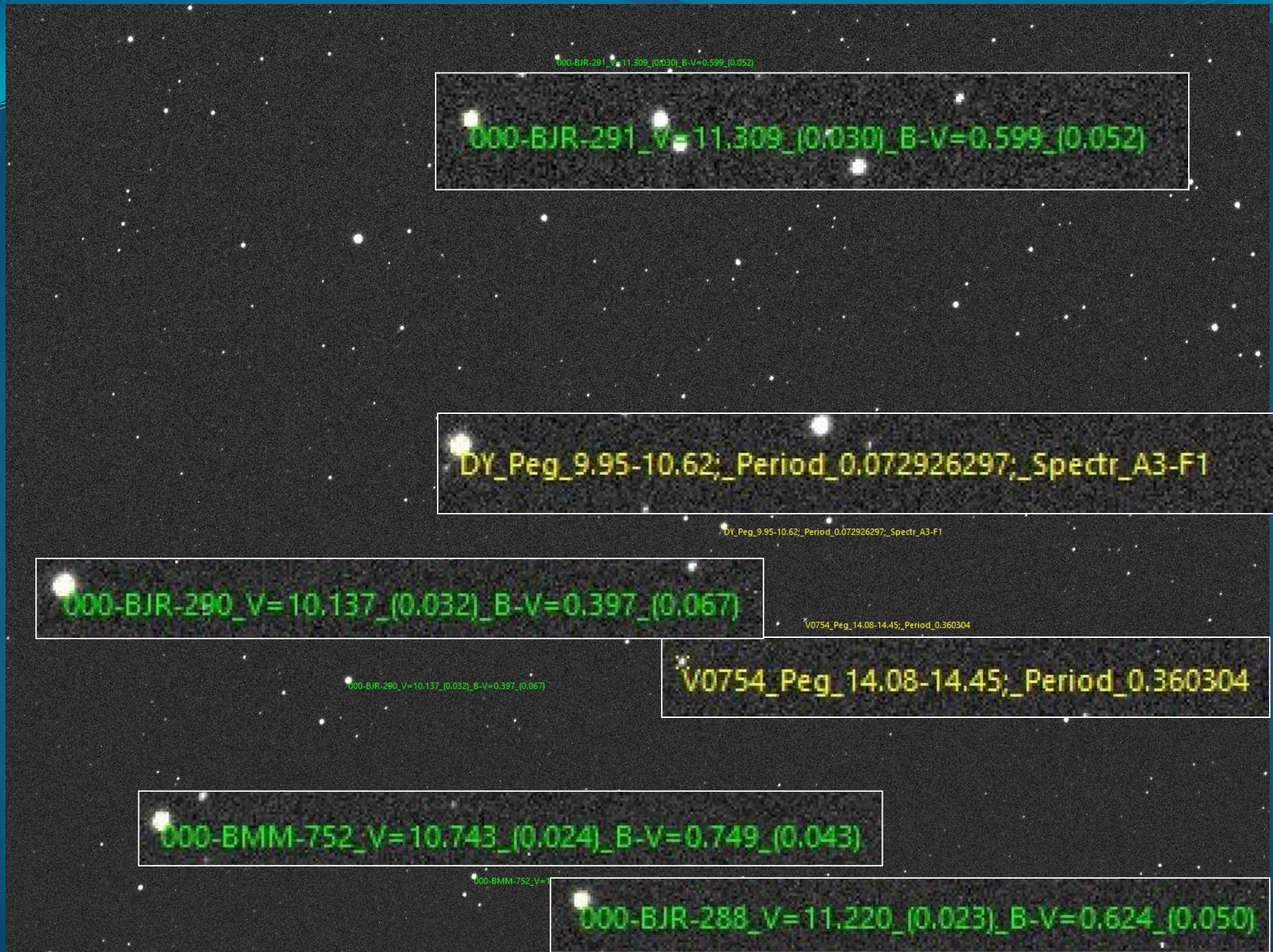
ASSOCIATION MIDI PYRENEES - GROUND ASTROPHYSICS ADDICTS
MP-G2A


Astrometric Stacking Program and fits viewer (ASTAP)
File
Stack
Tools
View
Help
α
09 06 25.5
9.107083
δ
+26 48 46
26.812778
∑
Astrometric solution
Solve
Save new header
Header
Table
Data range
Histogram:
off
Manual
Minimum
Maximum
17
64
WCS
Inverse wheel
0


C:\Users\David Antao\Documents\09 MP-G2A\2021-11-13 Réunion à Cuq\2017-11-07 Images\B Taité avec MaxDL\Dypeg brute 60s-002B.fit
File
Stack
Tools
View
Help
α 23 10 32
23.175556
δ +16 59 44
16.995556
Astrometric solution
Solve
Save new header
Data range
Histogram:
off
Low +
WCS
Inverse wheel
Minimum
82
Maximum
370
SIMPLE = T
BITPIX = 16 /8 unsigned int, 16 & 32 int, -32 & -64 real
NAXIS = 2 /number of axes
NAXIS1 = 1600 /fastest changing axis
NAXIS2 = 1200 /next to fastest changing axis
BSCALE = 1.0000000000000000 /physical = BZERO + BSCALE*array_value
BZERO = 32768.000000000000 /physical = BZERO + BSCALE*array_value
DATE-OBS= '2017-11-07T19:10:50' /YYYY-MM-DDThh:mm:ss observation start, UT
EXPTIME = 60.000000000000000 /Exposure time in seconds
EXPOSURE= 60.000000000000000 /Exposure time in seconds
SET-TEMP= 5.0000000000000000 /CCD temperature setpoint in C
CCD-TEMP= 4.8897595633312960 /CCD temperature at start of exposure in C
α, δ
α, δ centered
Solution found: 23: 08 45.4 +17° 0
x 1 16 BPP
1.13 x 0.85 °
File
Stack
Tools
View
Help
α 23 08 45.4
23.145944
δ +17 07 47
17.129722
Astrometric solution
Solve
Save new header
Data range
Histogram:
off
Low +
WCS
Inverse wheel
Minimum
82
Maximum
370
-103.97°


C:\Users\David Antao\Documents\09 MP-G2A\2021-11-13 Réunion à Cuq\2017-11-07 Images\B Taité avec MaxDL\Dypeg brute...
File
Stack
Tools
View
Help
Solve image astrometric (plate solve) Ctrl+P
Add SIP coefficients to header
Batch processing
Image (CCD) inspector
Activate/deactivate auto de-mosaic
De-mosaic Bayer matrix F8
Auto correct colours. F9
Remove green and purple filter
Inverse image Ctrl+I
Convert to mono Ctrl+M
Bin or stretch
Undo Ctrl+Z
Rotate, extend
Clean-up Ctrl+W
Calibrate photometry Ctrl+U
SQM report based on an image Ctrl+Q
Magnitude (measured) annotation Ctrl+Alt+M
Star (database) annotation Ctrl+N
Unknown star annotation
Variable star annotation Ctrl+K
Asteroid & comet annotation Ctrl+R
Deepsky (HyperLeda) annotation Ctrl+Y
Deepsky annotation Ctrl+L
Save new header
WCS
Inverse wheel
-103.97°
CRVAL2 = 1.712976437237E+001 / DEC of ref
CDELT1 = 7.070662817221E-004 / X pixel si
CDELT2 = 7.070400631250E-004 / Y pixel si
CROTA1 = -1.039724731205E+002 / Image twis
CROTA2 = -1.039726516416E+002 / Image twis
CD1_1 = -1.707273246932E-004 / CD matrix
CD1_2 = -6.861200499963E-004 / CD matrix
CD2_1 = 6.861449608876E-004 / CD matrix
CD2_2 = -1.707188561844E-004 / CD matrix
PLTSOLVD= T / ASTAP inte
COMMENT 7 Solved in 0.6 sec. Offset was 26
END
Data range
Histogram:
Minimum
Maximum
23: 06 50.00 +17° 13 48.0
σ = 21.4
1095.6, 1196.2 = [140]
29/29/29


000-BJR-291_V=11.309_(0.030)_B-V=0.599_(0.052)
DY_Peg_9.95-10.62;_Period_0.072926297;_Spectr_A3-F1
V0754_Peg_14.08-14.45;_Period_0.360304
000-BJR-290_V=10.137_(0.032)_B-V=0.397_(0.067)
000-BMM-752_V=10.743_(0.024)_B-V=0.749_(0.043)
000-BJR-288_V=11.220_(0.023)_B-V=0.624_(0.050)


000-BJR-291_V=11.309_(0.030)_B-V=0.599_(0.052)
DY_Peg_9.95-10.62;_Period_0.072926297;_Spectr_A3-F1
000-BJR-290_V=10.137_(0.032)_B-V=0.397_(0.067)
V0754_Peg_14.08-14.45;_Period_0.360304
000-BMM-752_V=10.743_(0.024)_B-V=0.749_(0.043)
000-BJR-288_V=11.220_(0.023)_B-V=0.624_(0.050)

C:\Users\David Antao\Documents\09 MP-G2A\2021-11-13 Réunion à Cuq\2017-11-07 Images\B Taité avec MaxDL\Dypeg brute...

File Stack Tools View Help

α 23 08 45.4 23.145944

δ +17 07 47 17.129722

Astrometric solution

Solve Save new header

Data range

Histogram:

off

Low +

WCS

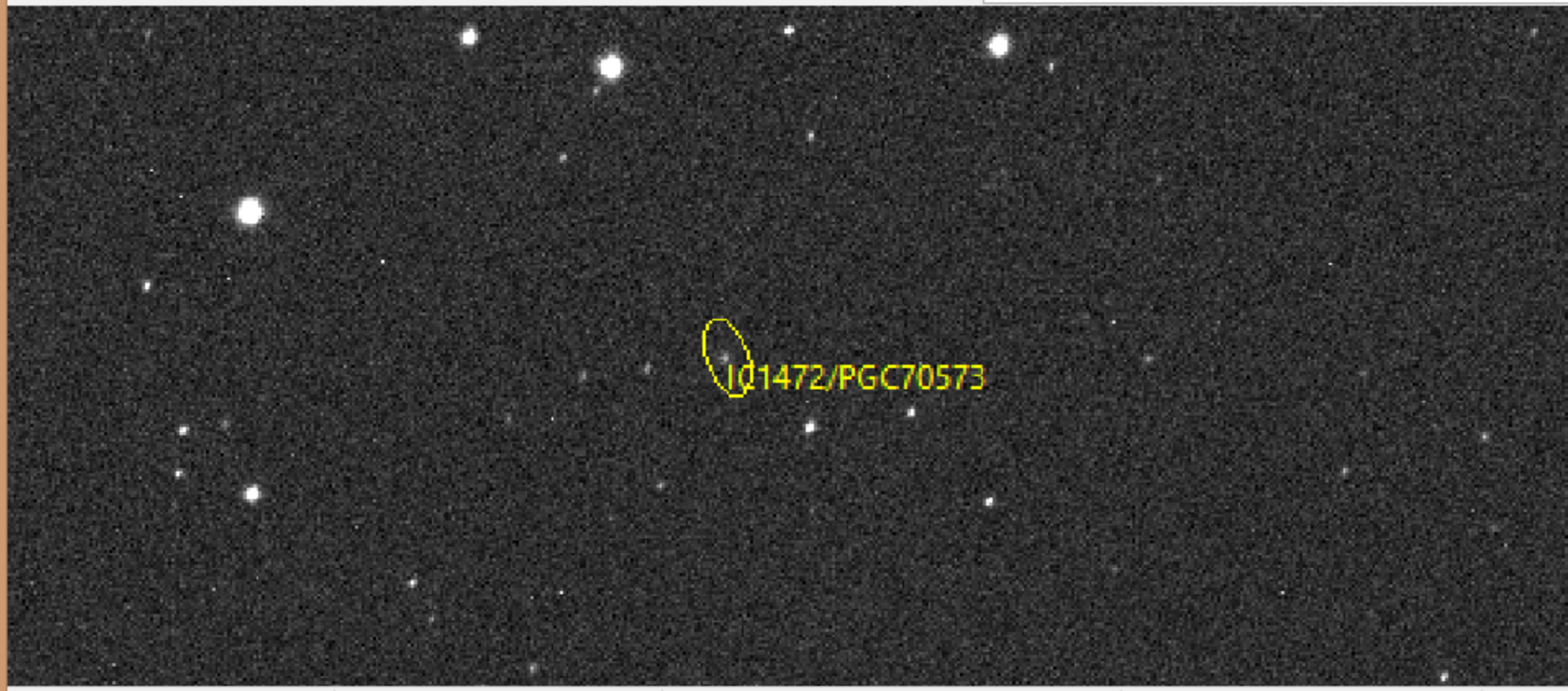
Inverse wheel

Minimum 82

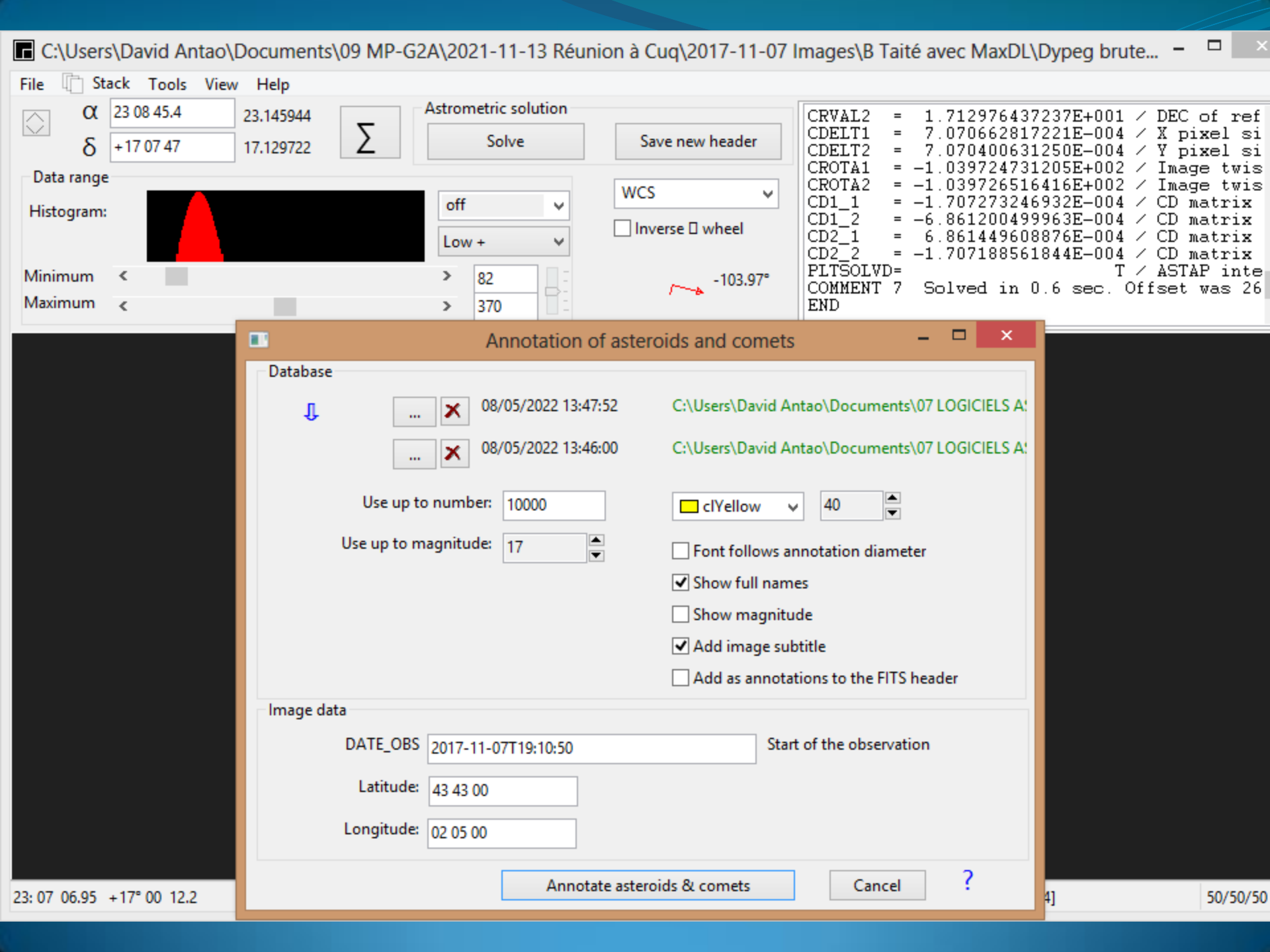
Maximum 370

-103.97°

```
CRVAL2  =  1.712976437237E+001 / DEC of ref
CDELT1  =  7.070662817221E-004 / X pixel si
CDELT2  =  7.070400631250E-004 / Y pixel si
CROTA1  = -1.039724731205E+002 / Image twis
CROTA2  = -1.039726516416E+002 / Image twis
CD1_1   = -1.707273246932E-004 / CD matrix
CD1_2   = -6.861200499963E-004 / CD matrix
CD2_1   =  6.861449608876E-004 / CD matrix
CD2_2   = -1.707188561844E-004 / CD matrix
PLTSOLVD=                    T / ASTAP inte
COMMENT 7  Solved in 0.6 sec. Offset was 26
END
```




α, δ | α, δ centered | Local standard deviation or star values | X, Y = [pixel value(s)] | RGB valu


C:\Users\David Antao\Documents\09 MP-G2A\2021-11-13 Réunion à Cuq\2017-11-07 Images\B Taité avec MaxDL\Dypeg brute...
File
Stack
Tools
View
Help
α 23 08 45.4
23.145944
δ +17 07 47
17.129722
Astrometric solution
Solve
Save new header
Data range
Histogram:
off
Low +
WCS
Inverse wheel
Minimum
Maximum
82
370
-103.97°
CRVAL2 = 1.712976437237E+001 / DEC of ref
CDELT1 = 7.070662817221E-004 / X pixel si
CDELT2 = 7.070400631250E-004 / Y pixel si
CROTA1 = -1.039724731205E+002 / Image twis
CROTA2 = -1.039726516416E+002 / Image twis
CD1_1 = -1.707273246932E-004 / CD matrix
CD1_2 = -6.861200499963E-004 / CD matrix
CD2_1 = 6.861449608876E-004 / CD matrix
CD2_2 = -1.707188561844E-004 / CD matrix
PLTSOLVD= T / ASTAP inte
COMMENT 7 Solved in 0.6 sec. Offset was 26
END
Annotation of asteroids and comets
Database
08/05/2022 13:47:52
C:\Users\David Antao\Documents\07 LOGICIELS A
08/05/2022 13:46:00
C:\Users\David Antao\Documents\07 LOGICIELS A
Use up to number: 10000
clYellow
40
Use up to magnitude: 17
Font follows annotation diameter
Show full names
Show magnitude
Add image subtitle
Add as annotations to the FITS header
Image data
DATE_OBS 2017-11-07T19:10:50
Start of the observation
Latitude: 43 43 00
Longitude: 02 05 00
Annotate asteroids & comets
Cancel
23: 07 06.95 +17° 00 12.2
50/50/50

C:\Users\David Antao\Documents\09 MP-G2A\2021-11-13 Réunion à Cuq\2017-11-07 Images\B Taité avec MaxDL\Dypeg brute...

File Stack Tools View Help

α 23 08 45.4 23.145944

δ +17 07 47 17.129722

Astrometric solution

Solve Save new header

Data range

Histogram:

off

Low +

WCS

Inverse wheel

Minimum 82

Maximum 370

-103.97°

```
CRVAL2  =  1.712976437237E+001 / DEC of ref
CDELT1  =  7.070662817221E-004 / X pixel si
CDELT2  =  7.070400631250E-004 / Y pixel si
CROTA1  = -1.039724731205E+002 / Image twis
CROTA2  = -1.039726516416E+002 / Image twis
CD1_1   = -1.707273246932E-004 / CD matrix
CD1_2   = -6.861200499963E-004 / CD matrix
CD2_1   =  6.861449608876E-004 / CD matrix
CD2_2   = -1.707188561844E-004 / CD matrix
PLTSOLVD=                    T / ASTAP inte
COMMENT 7  Solved in 0.6 sec. Offset was 26
END
```

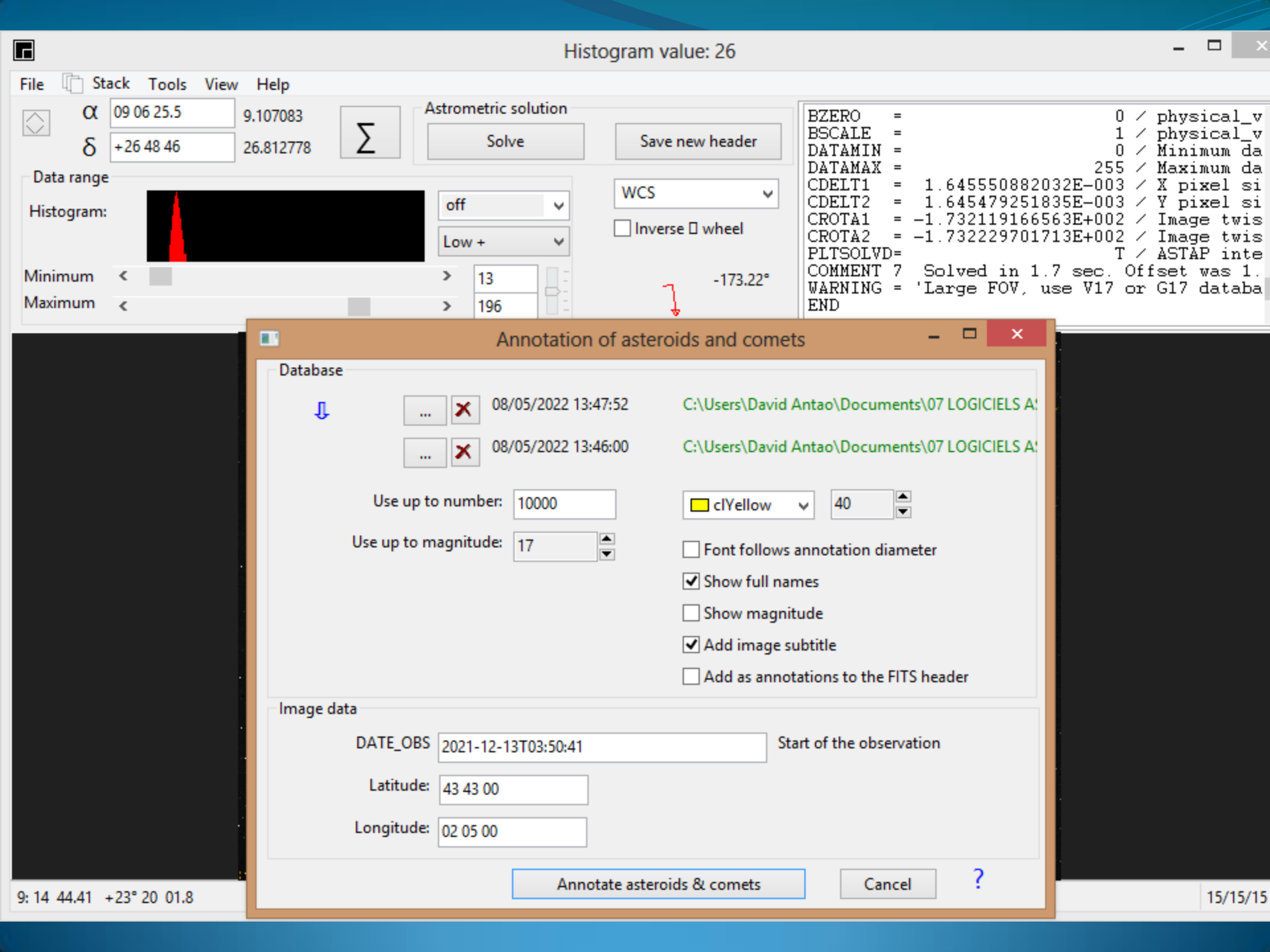
α, δ | α, δ centered | Local standard deviation or star values | X, Y = [pixel value(s)] | RGB valu

# Logiciel très utile dans d'autres occasions …

Mail de Jean-Pierre S.

Bonjour à tous,
je n'ai pas réussi à voir la comète Léonard hier soir, par contre j'ai photographié par hasard une comète dans le Cancer en recherchant une variable, comète que je n'ai pas pu encore identifier…

Association Midi Pyrenees - Ground Astrophysics Addicts
MP-G2A


Histogram value: 26
File
Stack
Tools
View
Help
α 09 06 25.5
9.107083
δ +26 48 46
26.812778
Astrometric solution
Solve
Save new header
Data range
Histogram:
off
Low +
WCS
Inverse wheel
Minimum
Maximum
13
196
-173.22°
BZERO = 0 / physical_v
BSCALE = 1 / physical_v
DATAMIN = 0 / Minimum da
DATAMAX = 255 / Maximum da
CDELT1 = 1.645550882032E-003 / X pixel si
CDELT2 = 1.645479251835E-003 / Y pixel si
CROTA1 = -1.732119166563E+002 / Image twis
CROTA2 = -1.732229701713E+002 / Image twis
PLTSOLVD= T / ASTAP inte
COMMENT 7 Solved in 1.7 sec. Offset was 1.
WARNING = 'Large FOV, use V17 or G17 databa
END
Annotation of asteroids and comets
Database
08/05/2022 13:47:52
C:\Users\David Antao\Documents\07 LOGICIELS A
08/05/2022 13:46:00
C:\Users\David Antao\Documents\07 LOGICIELS A
Use up to number:
10000
clYellow
40
Use up to magnitude:
17
Font follows annotation diameter
Show full names
Show magnitude
Add image subtitle
Add as annotations to the FITS header
Image data
DATE_OBS
2021-12-13T03:50:41
Start of the observation
Latitude:
43 43 00
Longitude:
02 05 00
Annotate asteroids & comets
Cancel
9: 14 44.41 +23° 20 01.8
15/15/15

C:\Users\David Antao\Documents\# Parallaxe 81\03 - Les réunions\2022\Comète de Jean-Pierre S\01b-new-image (3) en nivea...

File Stack Tools View Help

α 09 06 25.5 9.107083

δ +26 48 46 26.812778

Σ

Astrometric solution

Solve | Save new header

Data range

Histogram:

off

Low +

WCS

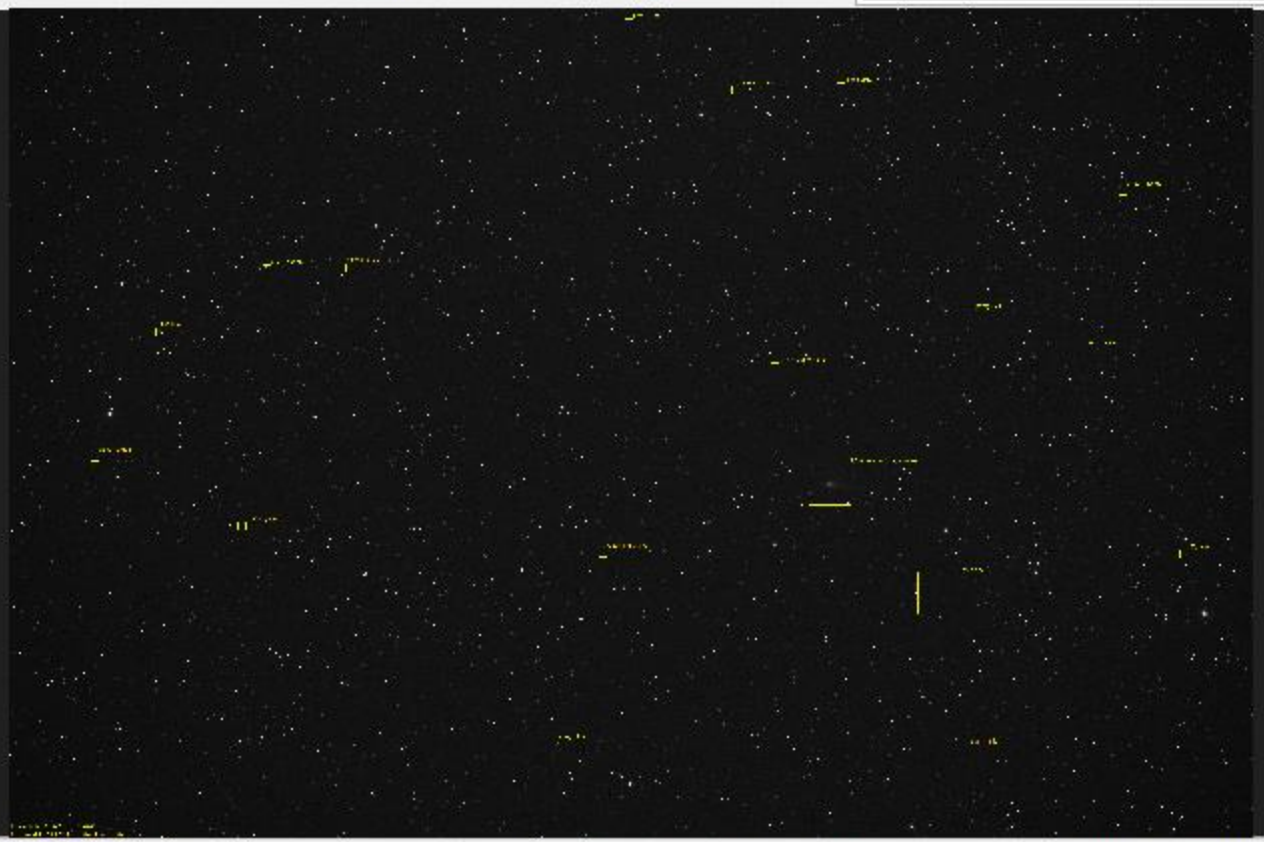
Inverse wheel

Minimum 13

Maximum 196

-173.22°

```
BZERO   =                    0 / physical_v
BSCALE  =                    1 / physical_v
DATAMIN =                    0 / Minimum da
DATAMAX =                  255 / Maximum da
CDELT1  =  1.645550882032E-003 / X pixel si
CDELT2  =  1.645479251835E-003 / Y pixel si
CROTA1  = -1.732119166563E+002 / Image twis
CROTA2  = -1.732229701713E+002 / Image twis
PLTSOLVD=                    T / ASTAP inte
COMMENT 7  Solved in 1.7 sec. Offset was 1.
WARNING = 'Large FOV, use V17 or G17 databa
END
```



α, δ | α, δ centered | Local standard deviation or star values | X, Y = [pixel value(s)] | RGB valu

C:\Users\David Antao\Documents\# Parallaxe 81\03 - Les réunions\2022\Comète de Jean-Pierre S\01b-new-image (3) en nivea...

File Stack Tools View Help

α 09 06 25.5 9.107083

δ +26 48 46 26.812778

Σ

Astrometric solution

Solve | Save new header

Data range

Histogram:

off

Low +

WCS

Inverse wheel

Minimum 13

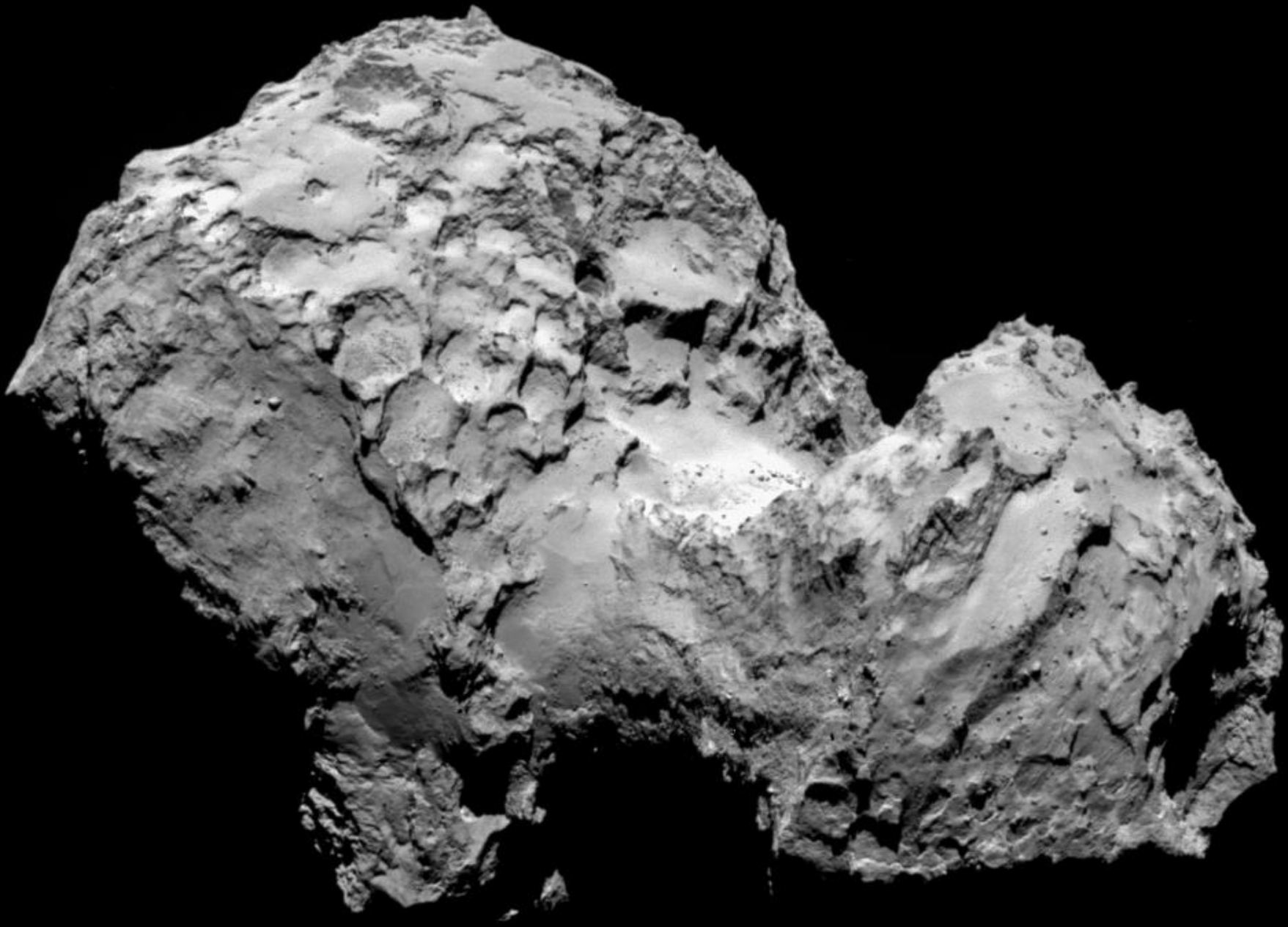
Maximum 196

-173.22°

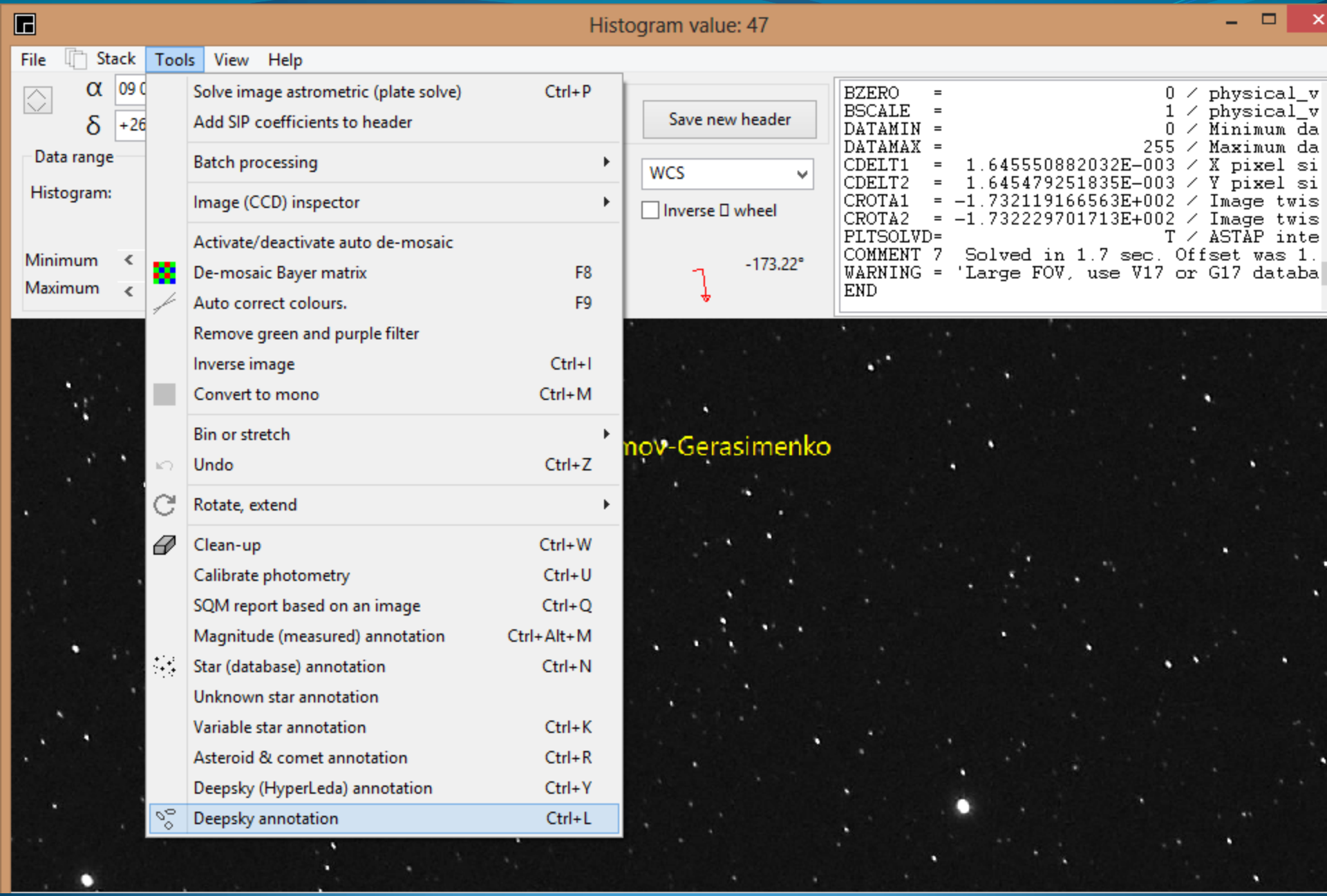
```
BZERO   =                    0 / physical_v
BSCALE  =                    1 / physical_v
DATAMIN =                    0 / Minimum da
DATAMAX =                  255 / Maximum da
CDELT1  =  1.645550882032E-003 / X pixel si
CDELT2  =  1.645479251835E-003 / Y pixel si
CROTA1  = -1.732119166563E+002 / Image twis
CROTA2  = -1.732229701713E+002 / Image twis
PLTSOLVD=                    T / ASTAP inte
COMMENT 7  Solved in 1.7 sec. Offset was 1.
WARNING = 'Large FOV, use V17 or G17 databa
END
```

67P/Churyumov-Gerasimenko

α, δ | α, δ centered | Local standard deviation or star values | X, Y = [pixel value(s)] | RGB valu




67P/Churyumov-Gerasimenko
15P/Finlay


Histogram value: 47
File
Stack
Tools
View
Help
Solve image astrometric (plate solve) Ctrl+P
Add SIP coefficients to header
Batch processing
Image (CCD) inspector
Activate/deactivate auto de-mosaic
De-mosaic Bayer matrix F8
Auto correct colours. F9
Remove green and purple filter
Inverse image Ctrl+I
Convert to mono Ctrl+M
Bin or stretch
Undo Ctrl+Z
Rotate, extend
Clean-up Ctrl+W
Calibrate photometry Ctrl+U
SQM report based on an image Ctrl+Q
Magnitude (measured) annotation Ctrl+Alt+M
Star (database) annotation Ctrl+N
Unknown star annotation
Variable star annotation Ctrl+K
Asteroid & comet annotation Ctrl+R
Deepsky (HyperLeda) annotation Ctrl+Y
Deepsky annotation Ctrl+L
Save new header
WCS
Inverse wheel
-173.22°
Data range
Histogram:
Minimum
Maximum
BZERO = 0 / physical_v
BSCALE = 1 / physical_v
DATAMIN = 0 / Minimum da
DATAMAX = 255 / Maximum da
CDELT1 = 1.645550882032E-003 / X pixel si
CDELT2 = 1.645479251835E-003 / Y pixel si
CROTA1 = -1.732119166563E+002 / Image twis
CROTA2 = -1.732229701713E+002 / Image twis
PLTSOLVD= T / ASTAP inte
COMMENT 7 Solved in 1.7 sec. Offset was 1.
WARNING = 'Large FOV, use V17 or G17 databa
END
noV-Gerasimenko

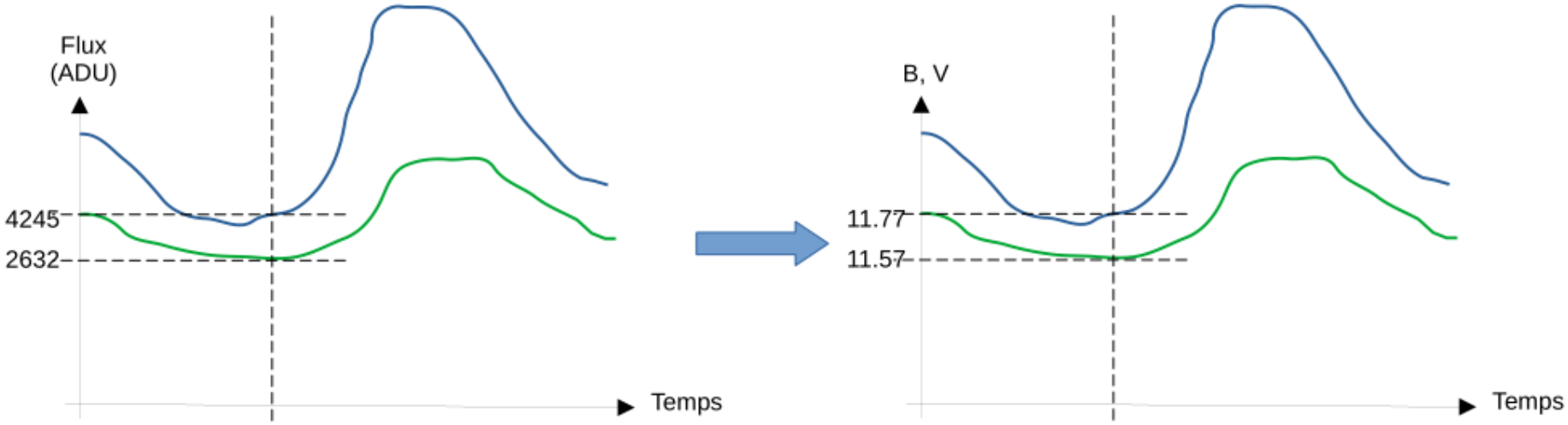
# Réunion du 13 nov. 2021

Objectif de la rencontre :

## Détermination des variations de rayon et de température

ASSOCIATION MIDI PYRENEES - GROUND ASTROPHYSICS ADDICTS
MP-G2A

# Calibration des adu en magnitude




**Principe de la calibration:**

Sur l'image filtré g, L'étoile de référence (label 101) V = 10.137 génère un Flux = 9851 adu

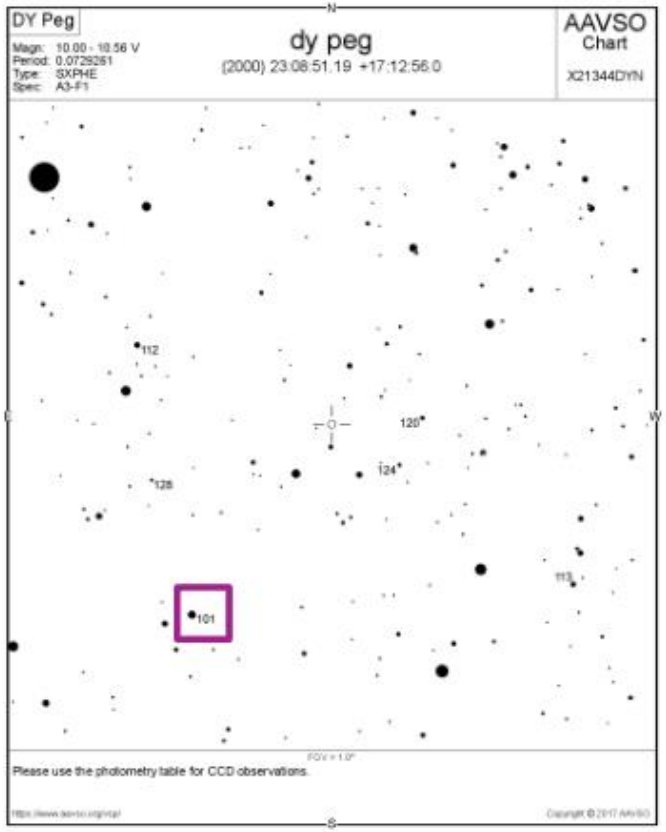
On en déduit le point zéro des magnitudes : zmag = mag + 2.5 * log10( flux ) = 10.137 + 2.5*log10(9851) = 20.121

On peut calculer la magnitude V de l'étoile variable : V = zmag - 2.5 * log10( flux ) = 20.121 - 2.5*log10(2632) = 11.57

**Dans la vraie vie:**

Pour chaque image, on calcule zmag avec toutes étoiles de références et on prend le zmag médian.

# Etablir l'équation entre l'indice de couleur (B-V) et la température des étoiles de référence




Il y a bien (B-V) dans la liste AAVSO

Mais il manque la valeur de la température (Teff)

## Variable Star Plotter

Plot Another Chart  Star Chart for this Table

Field photometry **for dy peg** from the AAVSO Variable Star Database

Data includes all comparison stars within 0.5° of RA: **23:08:51.19 [347.21329167°]** & Dec: **17:12:56.0 [17.21555556°]**

Report this sequence as **X21373CD** in the chart field of your observation report.

| AUID | RA | Dec | Label | V | B-V |
|---|---|---|---|---|---|
| 000-BJR-290 | 23:09:45.07 [347.43780518°] | 16:55:20.7 [16.92241669°] | **101** | 10.137 (0.032)[28] | 0.397 (0.067) |
| 000-BJR-288 | 23:10:06.45 [347.52688599°] | 17:20:11.0 [17.33638954°] | **112** | 11.220 (0.023)[28] | 0.624 (0.050) |
| 000-BJR-291 | 23:07:18.00 [346.82501221°] | 16:58:08.0 [16.96888924°] | **113** | 11.309 (0.030)[28] | 0.599 (0.052) |
| 000-BJR-294 | 23:08:16.24 [347.06765747°] | 17:13:28.3 [17.22452736°] | **120** | 12.041 (0.039)[28] | 0.692 (0.121) |
| 000-BJR-292 | 23:08:25.08 [347.10449219°] | 17:09:04.6 [17.15127754°] | **124** | 12.435 (-0.039)[28] | 0.552 (0.084) |
| 000-BJR-289 | 23:10:00.76 [347.50317383°] | 17:07:43.6 [17.12877846°] | **128** | 12.793 (0.010)[28] | 0.735 (0.023) |

# Extraire la température des étoiles de référence à partir du catalogue GAIA

```
from astroquery.vizier import Vizier
import astropy.units as u
from astropy.coordinates import SkyCoord

def gaia_teff(ra, dec):
    vizier = Vizier(columns=["all"], catalog=["I/345/gaia2"])
    skyobj = SkyCoord(ra=ra, dec=dec, frame="icrs", unit=(u.deg, u.deg))
    tables = vizier.query_region(skyobj, radius=2*u.arcsec)
    if len(tables)==0:
        Teff = 0
    else:
    table = tables[0]
    colnames = table.colnames
    data = table.as_array()[0]
    idx = colnames.index("Teff")
    Teff = data[idx]
    return Teff
```

```
ref_stars = []
ref_stars.append([101, 347.437805, 16.92241, 10.137, 0.397,0])
ref_stars.append([112, 347.526886, 17.33638, 11.220, 0.624, 0])
ref_stars.append([113, 346.825012, 16.96888, 11.309, 0.599, 0])
ref_stars.append([120, 347.067657, 17.22452, 12.041, 0.692, 0])
ref_stars.append([124, 347.104492, 17.15127, 12.435, 0.552, 0])
ref_stars.append([128, 347.503173, 17.12877, 12.793, 0.735, 0])

for k in range(len(ref_stars)):
        label, ra, dec, v , bmv, teff = ref_stars[k]
        teff = gaia_teff(ra, dec)
        print(f"{label} Teff={teff}")
        ref_stars[k][5] = teff
```

## Variable Star Plotter

Plot Another Chart  Star Chart for this Table

Field photometry **for dy peg** from the AAVSO Variable Star Database

Data includes all comparison stars within 0.5° of RA: **23:08:51.19 [347.21329167°]** & Dec: **17:12:56.0 [17.21555556°]**

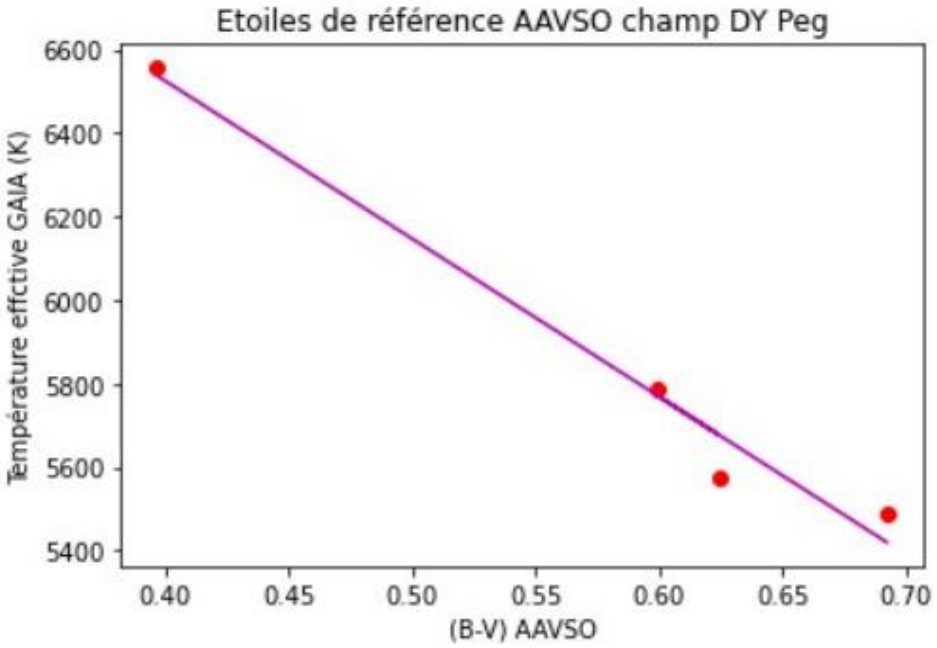
Report this sequence as **X21373CD** in the chart field of your observation report.

| AUID | RA | Dec | Label | V | B-V |
|---|---|---|---|---|---|
| 000-BJR-290 | 23:09:45.07 [347.43780518°] | 16:55:20.7 [16.92241669°] | **101** | 10.137 (0.032)[28] | 0.397 (0.067) |
| 000-BJR-288 | 23:10:06.45 [347.52688599°] | 17:20:11.0 [17.33638954°] | **112** | 11.220 (0.023)[28] | 0.624 (0.050) |
| 000-BJR-291 | 23:07:18.00 [346.82501221°] | 16:58:08.0 [16.96888924°] | **113** | 11.309 (0.030)[28] | 0.599 (0.052) |
| 000-BJR-294 | 23:08:16.24 [347.06765747°] | 17:13:28.3 [17.22452736°] | **120** | 12.041 (0.039)[28] | 0.692 (0.121) |
| 000-BJR-292 | 23:08:25.08 [347.10449219°] | 17:09:04.6 [17.15127754°] | **124** | 12.435 (-0.039)[28] | 0.552 (0.084) |
| 000-BJR-289 | 23:10:00.76 [347.50317383°] | 17:07:43.6 [17.12877846°] | **128** | 12.793 (0.010)[28] | 0.735 (0.023) |

101 Teff=6555.79
112 Teff=5573.0
113 Teff=5789.0
120 Teff=5488.67
124 Teff=0
128 Teff=0

## Etablir l'équation entre l'indice de couleur (B-V) et la température des étoiles de référence

```
import numpy as np
x = np.array([ ])
y = np.array([ ])
for k in range(len(ref_stars)):
        label, ra, dec, v , bmv, teff = ref_stars[k]
        if teff ==0:
                continue
        x = np.append(x, bmv)
        y = np.append(y, teff)

import matplotlib.pyplot as plt
plt.plot(x, y, 'ro')
plt.xlabel("(B-V) AAVSO")
plt.ylabel("Température effctive GAIA (K)")
plt.title("Etoiles de référence AAVSO champ DY Peg")

coefs = np.polyfit(x, y, 1)
yt = np.polyval(coefs, x)
plt.plot(x, yt, 'm-')

msg = f"Equation : Teff = {coefs[0]:.3f}(B-V) + {coefs[1]:.3f}"
print(msg)
```




Equation : Teff = -3786.948(B-V) + 8040.471

# Extraire la distance de l'étoile variable à étudier à partir du catalogue GAIA

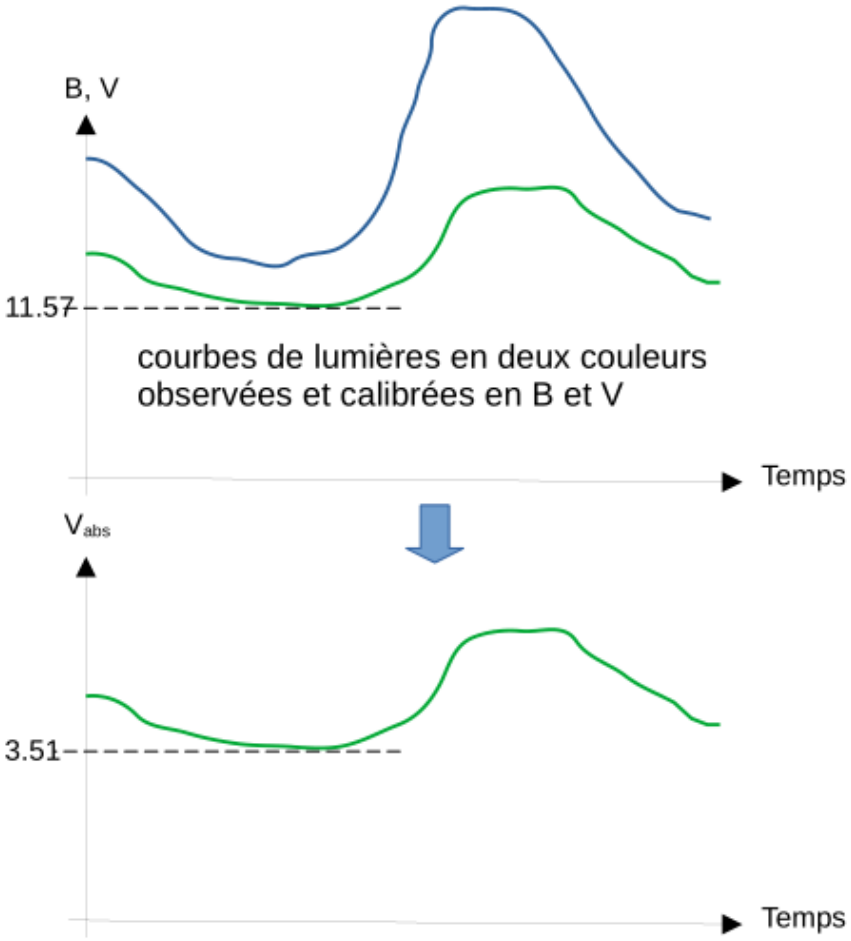
```
from astroquery.vizier import Vizier
import astropy.units as u
from astropy.coordinates import SkyCoord

def gaia_dist(ra, dec):
    vizier = Vizier(columns=["all"], catalog=["I/345/gaia2"])
    skyobj = SkyCoord(ra=ra, dec=dec, frame="icrs", unit=(u.deg, u.deg))
    tables = vizier.query_region(skyobj, radius=2*u.arcsec)
    if len(tables)==0:
        dist = 0
        ddist = 0
    else:
        table = tables[0]
        colnames = table.colnames
        data = table.as_array()[0]
        idx = colnames.index("Plx")
        Plx = data[idx]
        idx = colnames.index("e_Plx")
        e_Plx = data[idx]
        dist_max = 1e3/(Plx-e_Plx)
        dist_min = 1e3/(Plx+e_Plx)
        dist = (dist_min+dist_max)/2.
        ddist = dist- dist_min
    return dist, ddist
```

```
ra = 347.21329
dec = 17.215555
dist, ddist = gaia_dist(ra, dec)
msg = f"Distance = {dist:.1f} +/- {ddist:.1f} pc"
print(msg)
```

▼

Distance = 408.8 +/- 11.9 pc

# Convertir la courbe de lumière V de l'étoile variable en magnitude absolue




dist = 408.8 (pc)

MD : Le module de Distance

```
import math
MD = 5*math.log10(dist) - 5
print(f"MD={MD:.2f}")
```

→ MD=8.06

Magnitude absolue

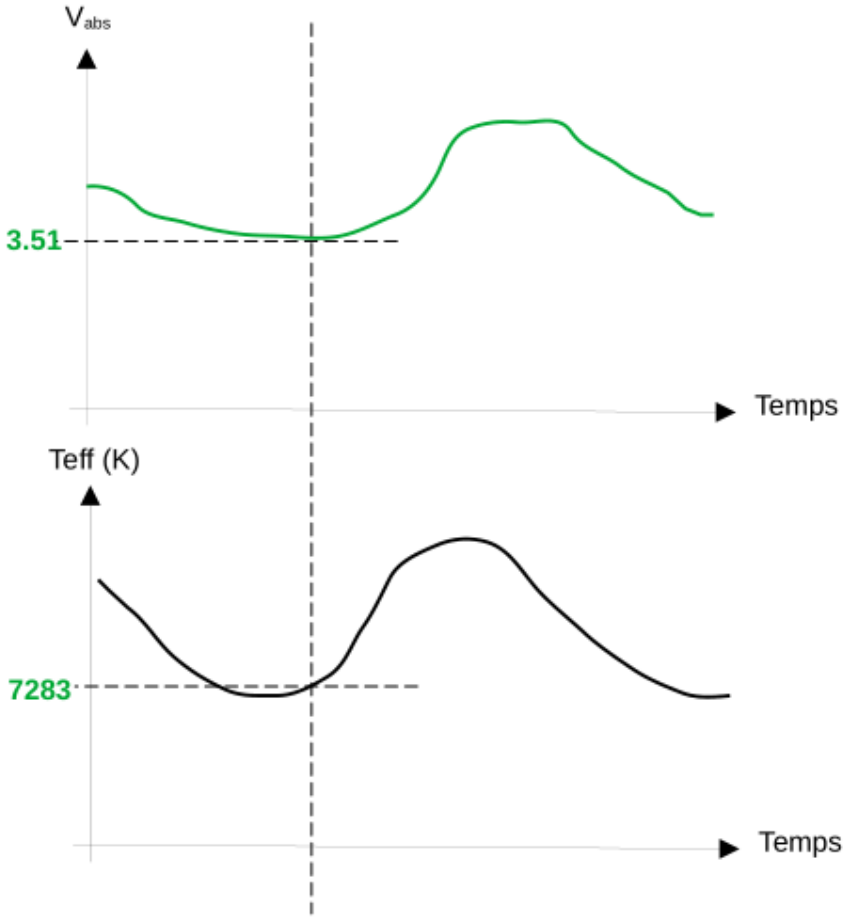
$V_{abs} = V_{app} - MD$

Exemple avec Vapp = 11.57

Vabs = 11.57 - 8.06 = 3.51

3.51 est la magnitude apparente
si l'étoile était située à 10 pc.

## Convertir les courbes de magnitude absolue et température en rayon stellaire




F : Densité de flux à 500 nm (filtre g)
Unité = Jansky = W/m2/Hz
**F** = 3631*math.pow(10,-Mabs/2.5)

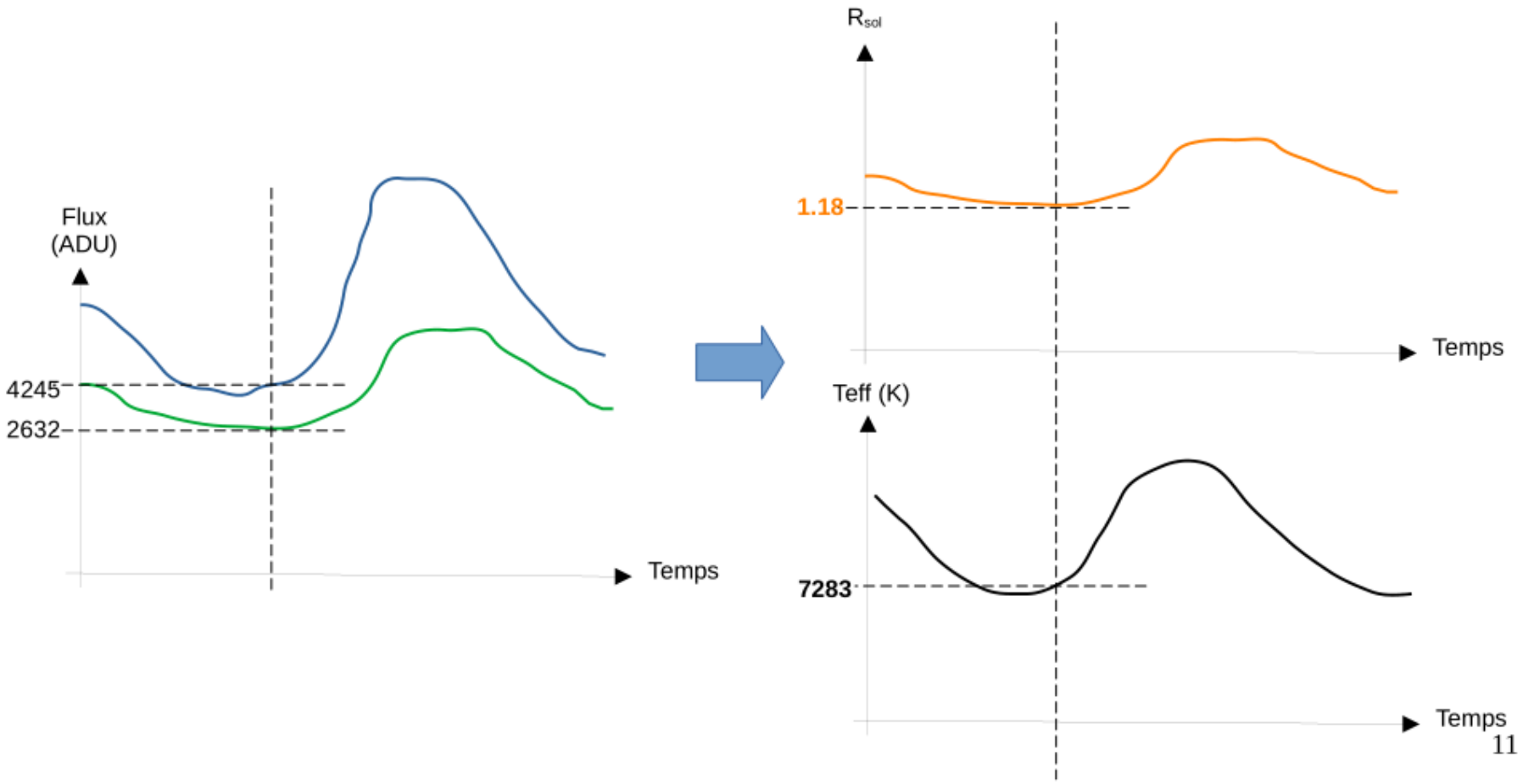
Le Soleil a une puissance P = 4e26 W
Le Soleil a une magnitude absolue Vabs = 4.83
Donc F = 42.46 Jansky à la distance de 10 pc
Le rapport **P/F** = 4e26/42.46 = 9.4e24 W/Jansky

Notre étoile : Vabs = **3.51**
Donc F = 143.2 Jansky à la distance de 10 pc
Sa puissance **P** = 9.4e24 * 143.2 = 1.35e27 W

Emittance M = 5.67e-8*math.pow(Teff,4) (W/m2)
**M** = 5.67e-8*math.pow(**7283**,4) = 1.60e8 W/m2

Rayon R = math.sqrt( P / (4*math.pi*M) ) (m)
R = math.sqrt( 1.35e27 / (4*math.pi*1.6e8) ) = 8.19e8 m
Le rayon solaire vaut Rsol = 6.9634e8 m
**R** = 8.19e8/6.9634e8 = **1.18 rayon solaire**

# De la mesure photométrique aux paramètres de physique stellaire



traitement_B-V.xlsx - Microsoft Excel

Fichier | Accueil | Insertion | Mise en page | Formules | Données | Révision | Affichage

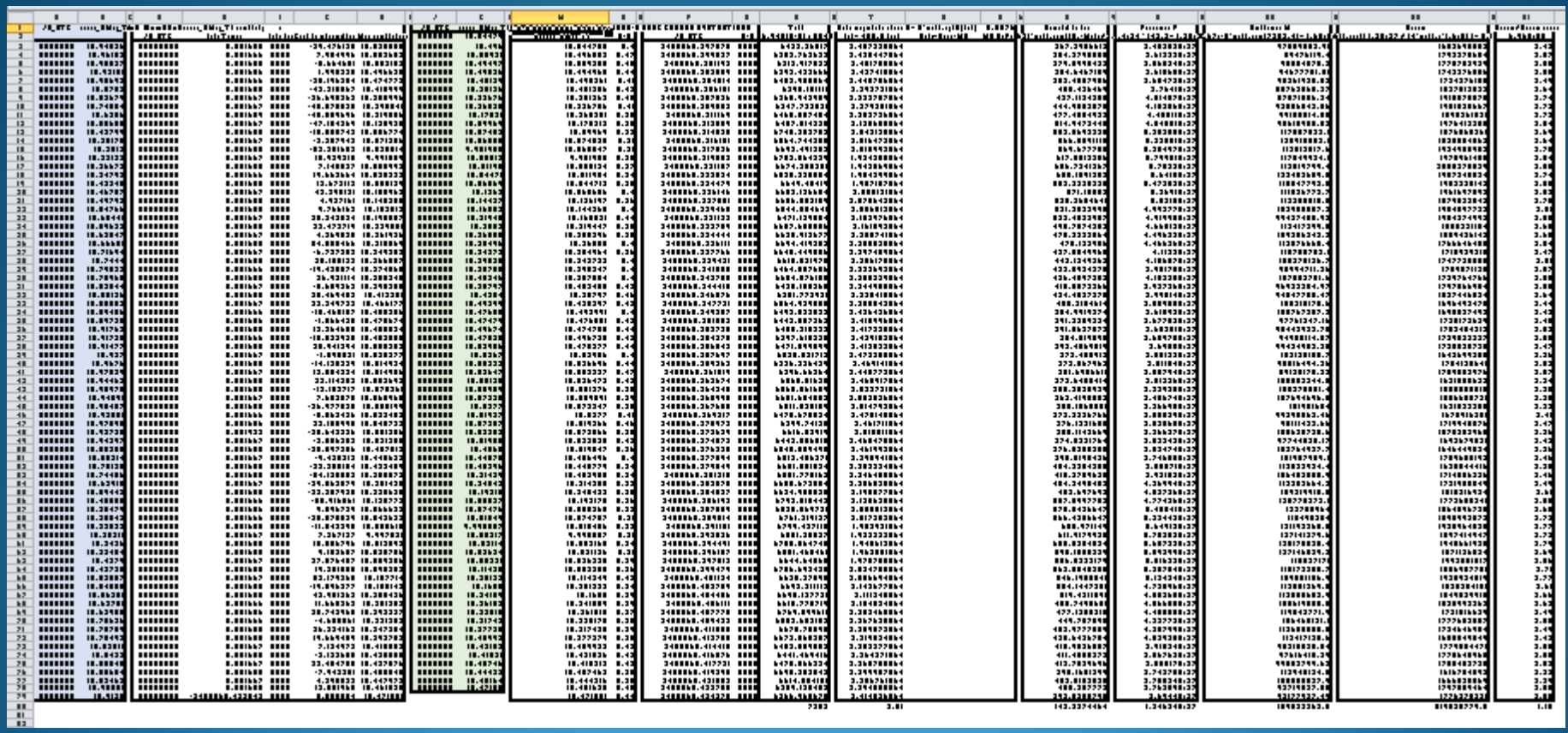
Coller | Calibri | 11 | Renvoyer à la ligne automatiquement | Standard | Fusionner et centrer | Mise en forme conditionnelle

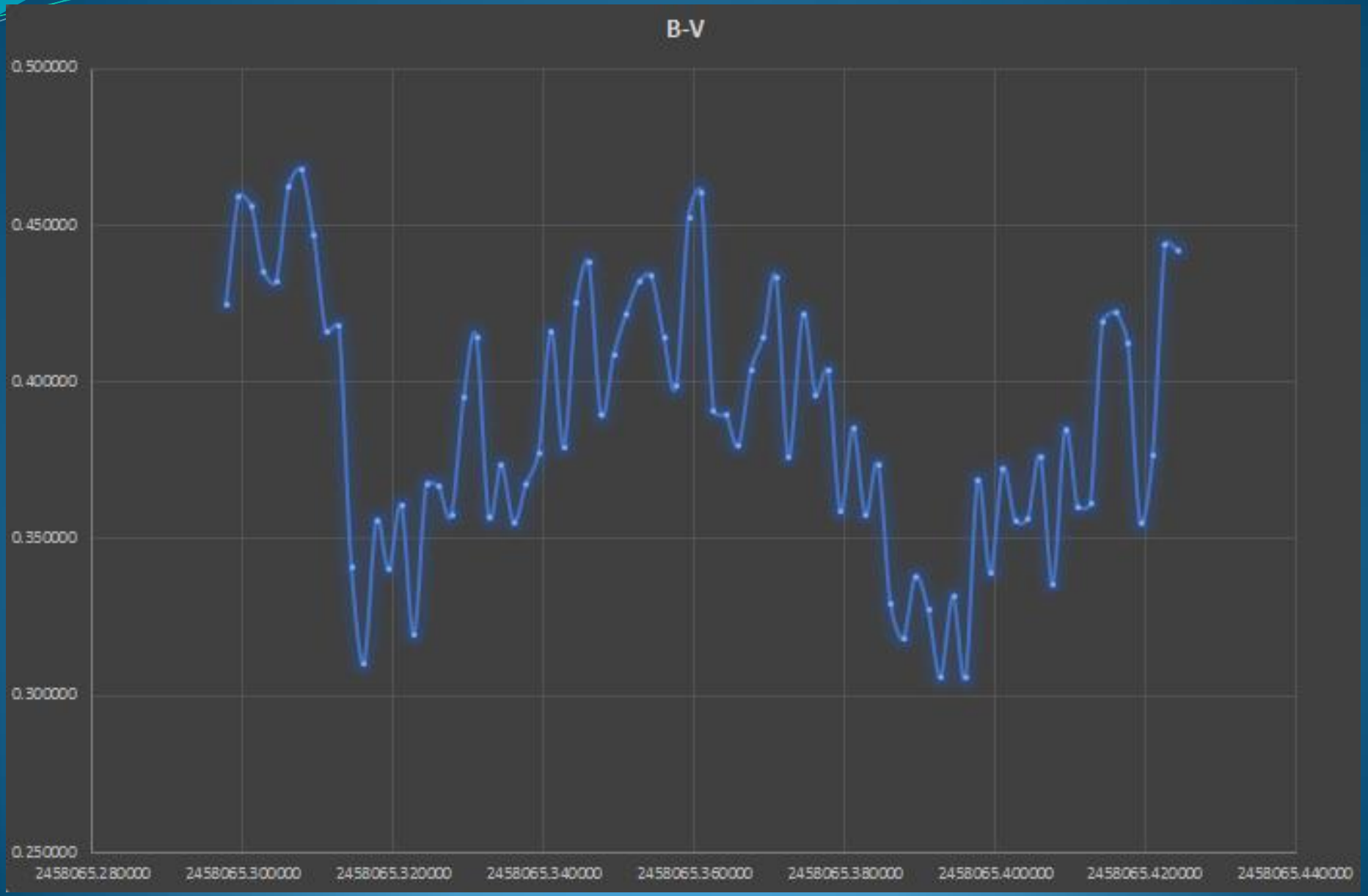
Presse-papi... | Police | Alignement | Nombre

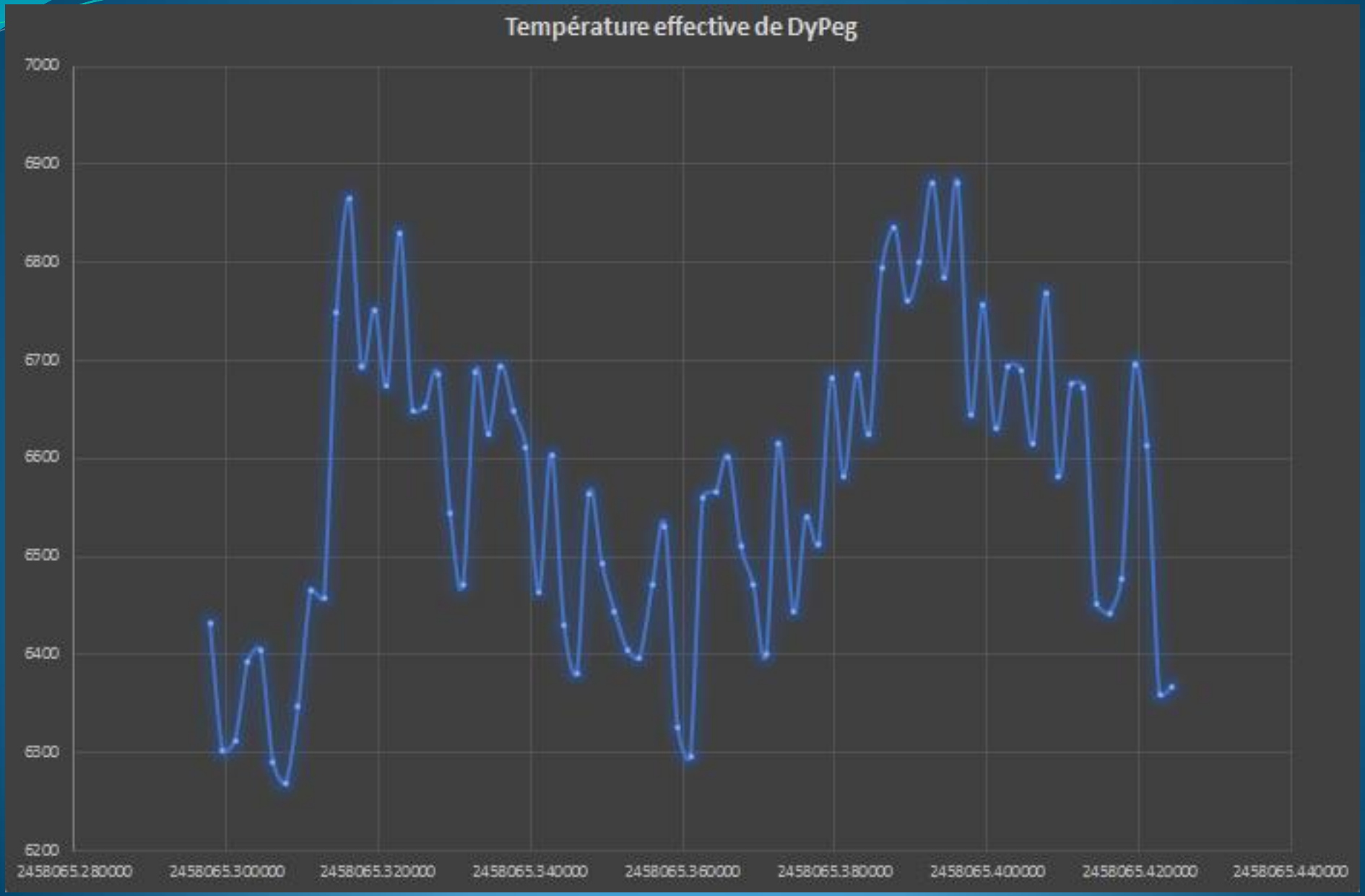
M1 | ESSAI B-V SANS VERT SYNTHETIQUE

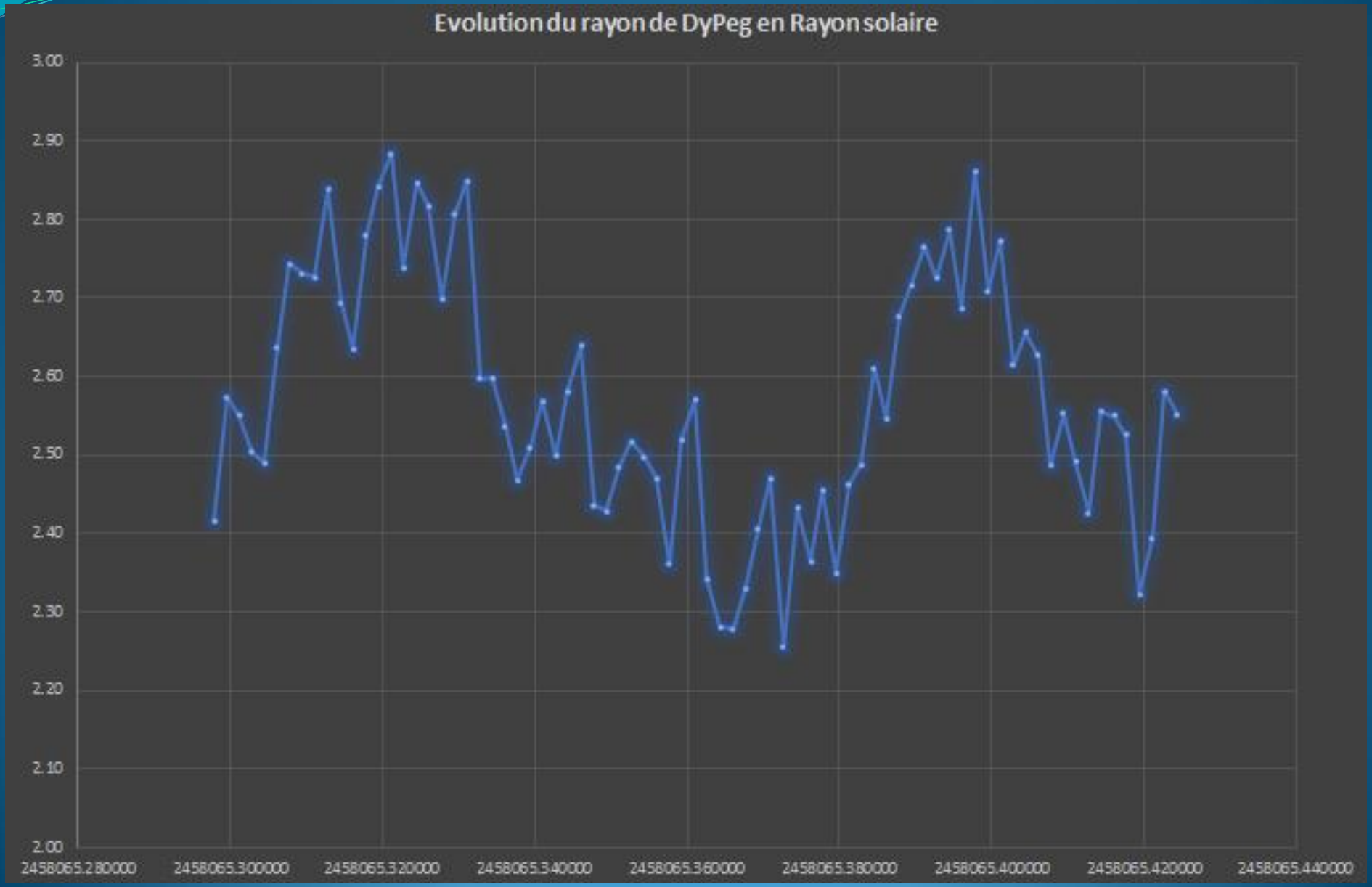
| | L | M | N | O | P | Q | R | S | T | |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | | ESSAI B-V SANS VERT SYNTHETIQUE | | | B-V AVEC COURBE SYNTHETIQUE | | Teff | | Vabs magnitude absolue | MD = 5*math |
| 2 | | Source_AMag_T1 | B-V | | JD_UTC | B-V | -3786.948(B-V) + 8040.471 | | dist = 408.8 (pc) | Vabs=V |
| 3 | | 10.544785 | 0.40047 | | 2458065.297870 | 0.424670 | 6432.26817 | | 2.487230564 | |
| 4 | | 10.496002 | 0.465519 | | 2458065.299537 | 0.458868 | 6302.763632 | | 2.438447564 | |
| 5 | | 10.509305 | 0.449064 | | 2458065.301192 | 0.456186 | 6312.917033 | | 2.451750564 | |
| 6 | | 10.494965 | 0.436849 | | 2458065.302859 | 0.435189 | 6392.432666 | | 2.437410564 | |
| 7 | | 10.498261 | 0.40866 | | 2458065.304514 | 0.432148 | 6403.950864 | | 2.440706564 | |
| 8 | | 10.451286 | 0.426911 | | 2458065.306181 | 0.462198 | 6290.151111 | | 2.393731564 | |
| 9 | | 10.381262 | 0.445532 | | 2458065.307836 | 0.467798 | 6268.942989 | | 2.323707564 | |
| 10 | | 10.336756 | 0.408781 | | 2458065.309502 | 0.446996 | 6347.722031 | | 2.279201564 | |
| 11 | | 10.260281 | 0.375317 | | 2458065.311169 | 0.415792 | 6465.887484 | | 2.202726564 | |
| 12 | | 10.178213 | 0.378639 | | 2458065.312859 | 0.417924 | 6457.814325 | | 2.120658564 | |
| 13 | | 10.09969 | 0.3283 | | 2458065.314525 | 0.341216 | 6748.302703 | | 2.042135564 | |
| 14 | | 10.074028 | 0.307726 | | 2458065.316181 | 0.310468 | 6864.744285 | | 2.016473564 | |
| 15 | | 10.068547 | 0.312657 | | 2458065.317836 | 0.355690 | 6693.491202 | | 2.010992564 | |
| 16 | | 9.981905 | 0.349327 | | 2458065.319502 | 0.340223 | 6752.064329 | | 1.924350564 | |
| 17 | | 10.000124 | 0.366603 | | 2458065.321157 | 0.360734 | 6674.388351 | | 1.942569564 | |
| 18 | | 10.011954 | 0.335961 | | 2458065.322824 | 0.319582 | 6830.230584 | | 1.954399564 | |
| 19 | | 10.044712 | 0.377736 | | 2458065.324479 | 0.367319 | 6649.45419 | | 1.987157564 | |
| 20 | | 10.065686 | 0.401887 | | 2458065.326146 | 0.366610 | 6652.136684 | | 2.008131564 | |
| 21 | | 10.136197 | 0.361726 | | 2458065.327801 | 0.357668 | 6686.002189 | | 2.078642564 | |
| 22 | | 10.144368 | 0.403296 | | 2458065.329468 | 0.395151 | 6544.054641 | | 2.086813564 | |
| 23 | | 10.160531 | 0.443881 | | 2458065.331123 | 0.414405 | 6471.139554 | | 2.102976564 | |
| 24 | | 10.219447 | 0.376784 | | 2458065.332789 | 0.357230 | 6687.658086 | | 2.161892564 | |
| 25 | | 10.258296 | 0.377175 | | 2458065.334444 | 0.373535 | 6625.912677 | | 2.200741564 | |
| 26 | | 10.26558 | 0.400434 | | 2458065.336111 | 0.355445 | 6694.419382 | | 2.208025564 | |
| 27 | | 10.354964 | 0.361972 | | 2458065.337766 | 0.367584 | 6648.449006 | | 2.297409564 | |

B et V | Comparaison V et V synthetique | B-Vsynth | Essai B-V SANS vert synthetique | Teff | R%Ro | Feuil1




B-V
0.500000
0.450000
0.400000
0.350000
0.300000
0.250000
2458065.280000
2458065.300000
2458065.320000
2458065.340000
2458065.360000
2458065.380000
2458065.400000
2458065.420000
2458065.440000


Température effective de DyPeg
7000
6900
6800
6700
6600
6500
6400
6300
6200
2458065.280000
2458065.300000
2458065.320000
2458065.340000
2458065.360000
2458065.380000
2458065.400000
2458065.420000
2458065.440000


Evolution du rayon de DyPeg en Rayon solaire
3.00
2.90
2.80
2.70
2.60
2.50
2.40
2.30
2.20
2.10
2.00
2458065.280000
2458065.300000
2458065.320000
2458065.340000
2458065.360000
2458065.380000
2458065.400000
2458065.420000
2458065.440000

# Réunion du 13 nov. 2021

But final de la réunion :

**Apprendre à coder ça en Python pour que cela se fasse tout en automatique**

**MERCI ALAIN !**

**MERCI ANTOINE !**

ASSOCIATION MIDI PYRENEES - GROUND ASTROPHYSICS ADDICTS
MP-G2A

# Mesurer le diamètre des étoiles variables

**Il n'y a plus qu'à se mettre au travail ……**

David Antao