Variable Stars

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VARIABLE STARS

- *What are the goals of this talk:*

Outline the main reasons for variability.

Examples of what science can be achieved by large numbers of amateur observations.

What is necessary in order to measure the brightness of a star accurately.

Tools and systems for observing and finding variables

Organisations that collect data and produce plots.

Quick example of the process I use.

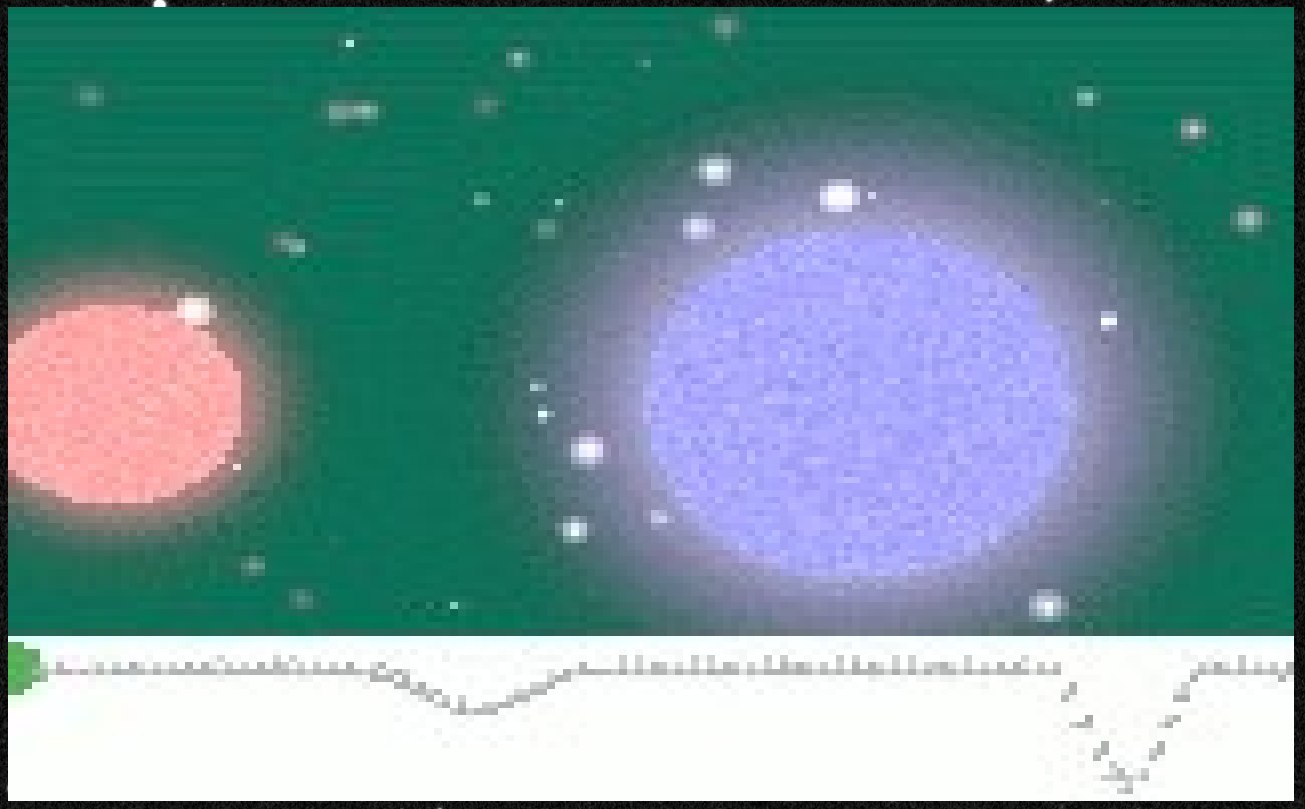
Not: Science of Photometry or Imaging and Image processing or the science of the variable types.

First – just a bit about star names

- Some cryptic notations are used to name variables and in fact stars may have many names!
- Most common -
  - "AM Cas"
    - First two letters or just one, are an identifier
    - Second three are the constellation – Cassiopeia
- Another common form-
  - V0245 Cas
    - The identifier is just V for variable and a 4 digit number.

Why are some stars variable?

- Two common reasons:
  - The star itself is changing (*intrinsic*)
  - The star is rotating or is in a binary pair (*extrinsic*)



Why are some stars variable?

Variable stars are frequently divided into five main classes:

intrinsic

pulsating,

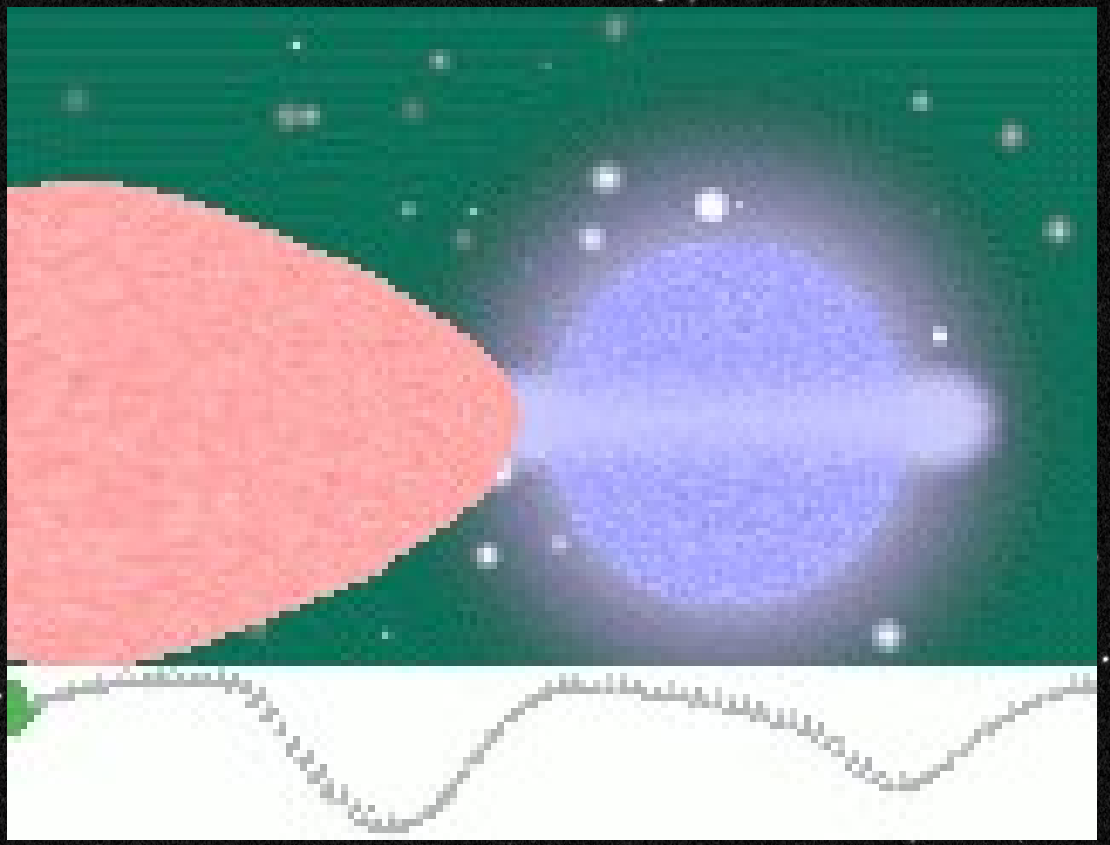
cataclysmic,

eruptive variables,

extrinsic

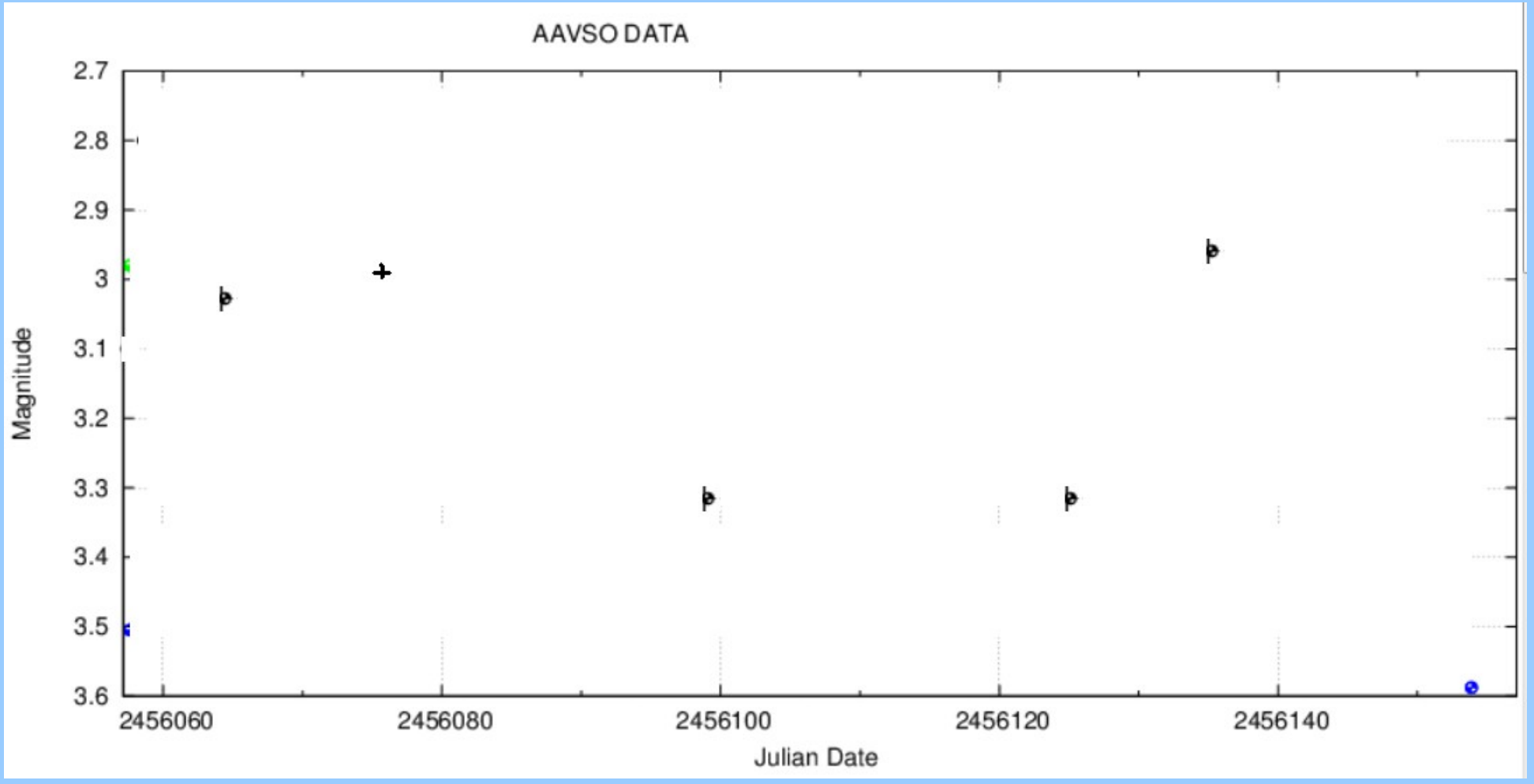
eclipsing binary

rotating stars.



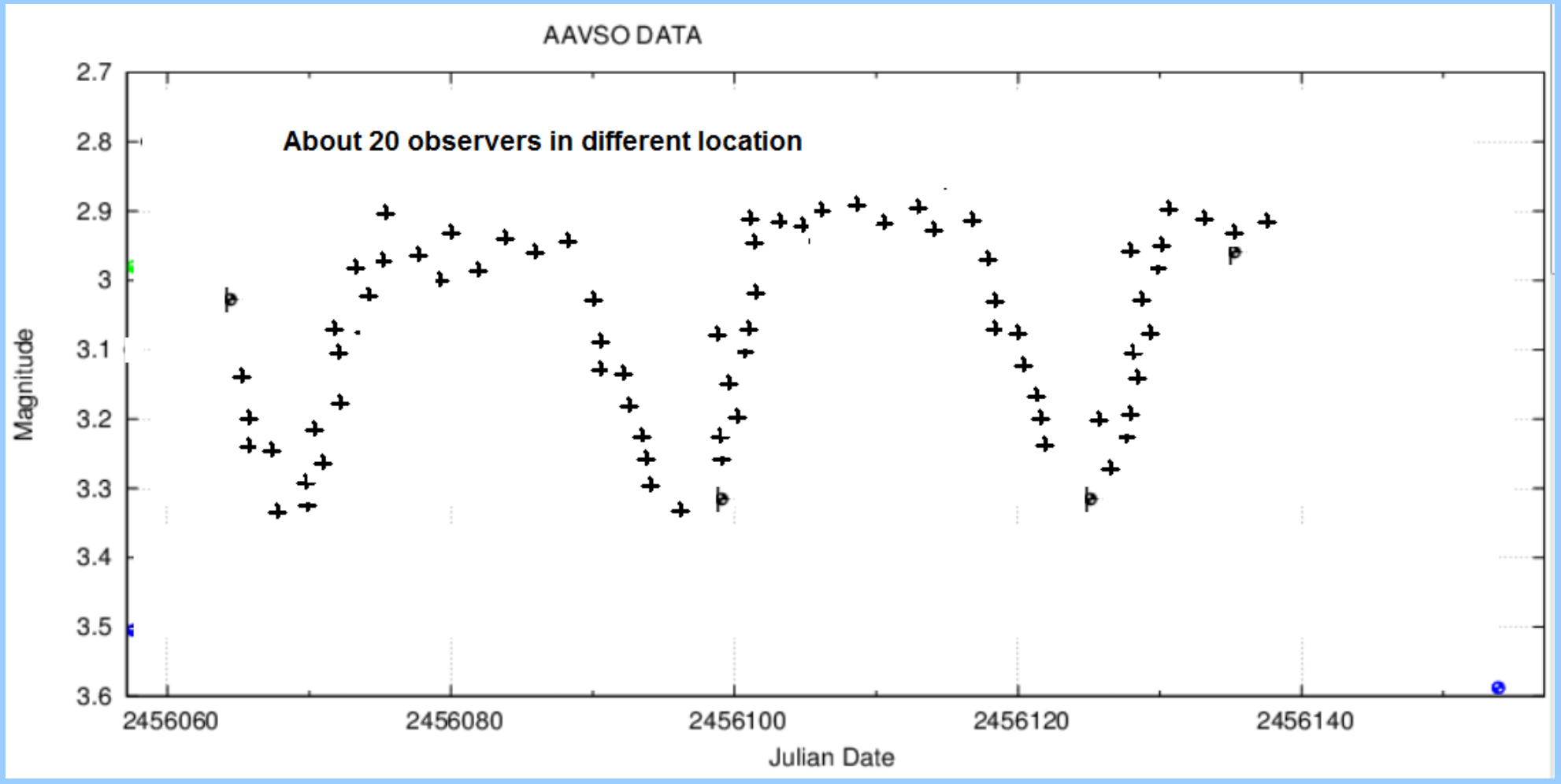
How important are amateur measurements?

What the readings of one observer look like?.



Volume of data is critical to science

The understanding of the mechanics of binary systems can be calculated from this data.

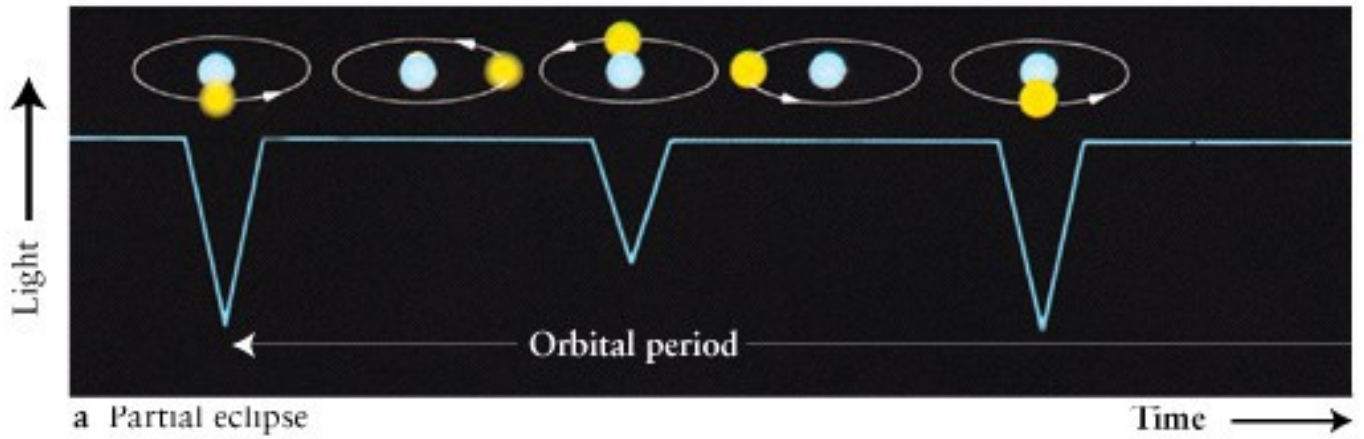


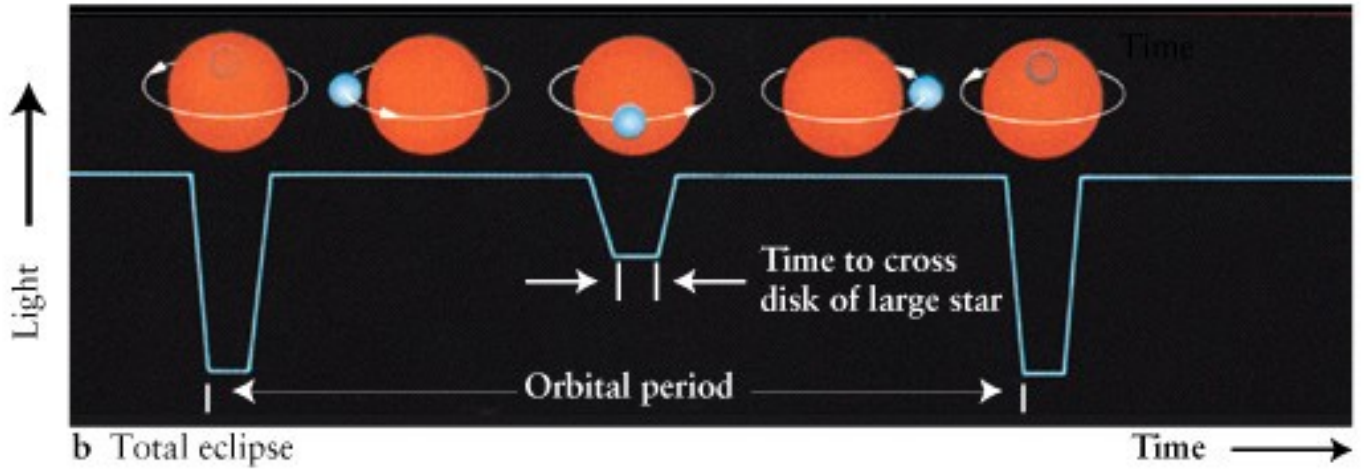
What can we derive from light curves?

- Rotation rates of the binary pair.
- Size of each of the stars or planets
- Separation distance
- Relative mass
- Possible exchange of material between the components

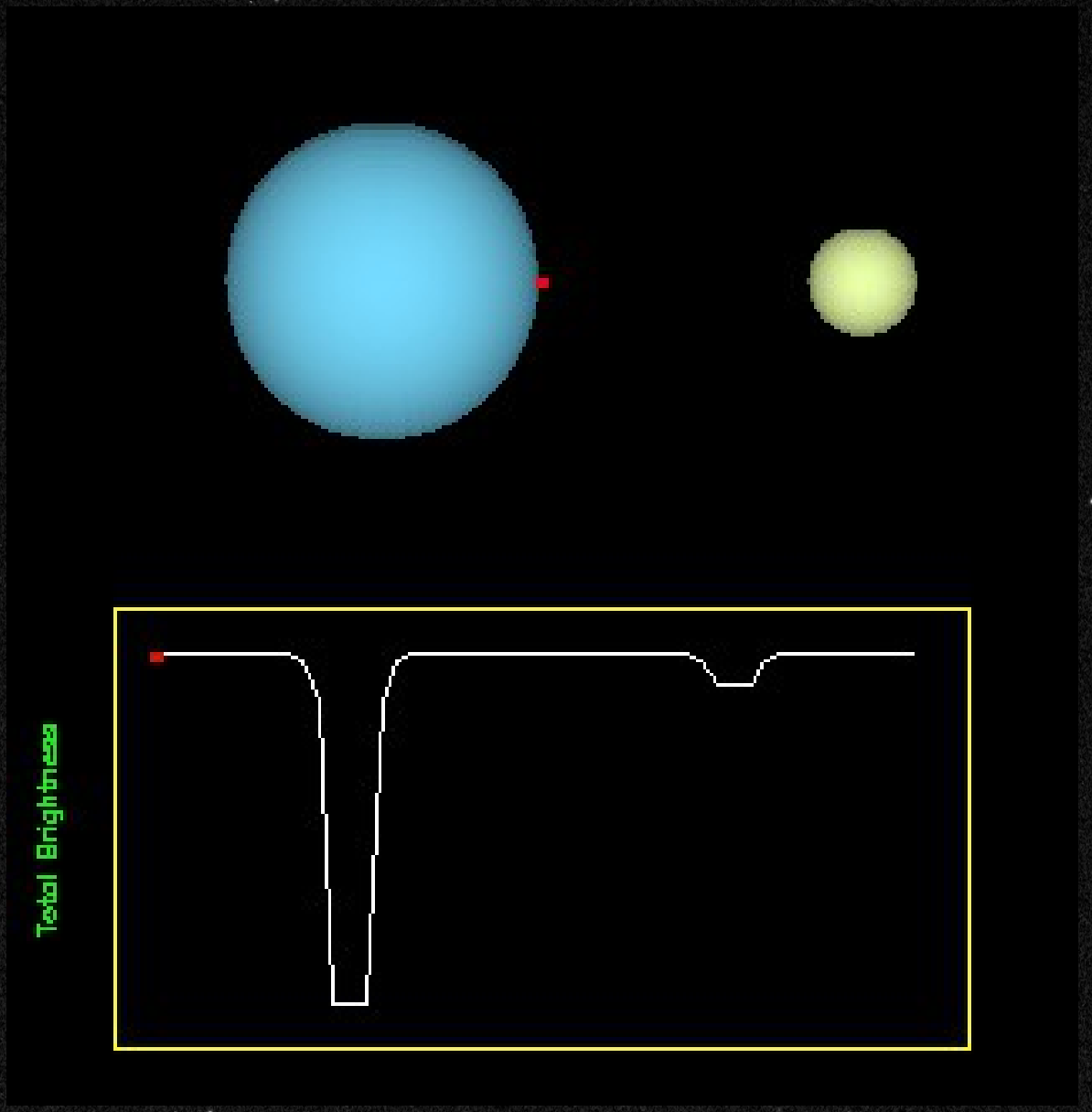
My particular interest, binaries

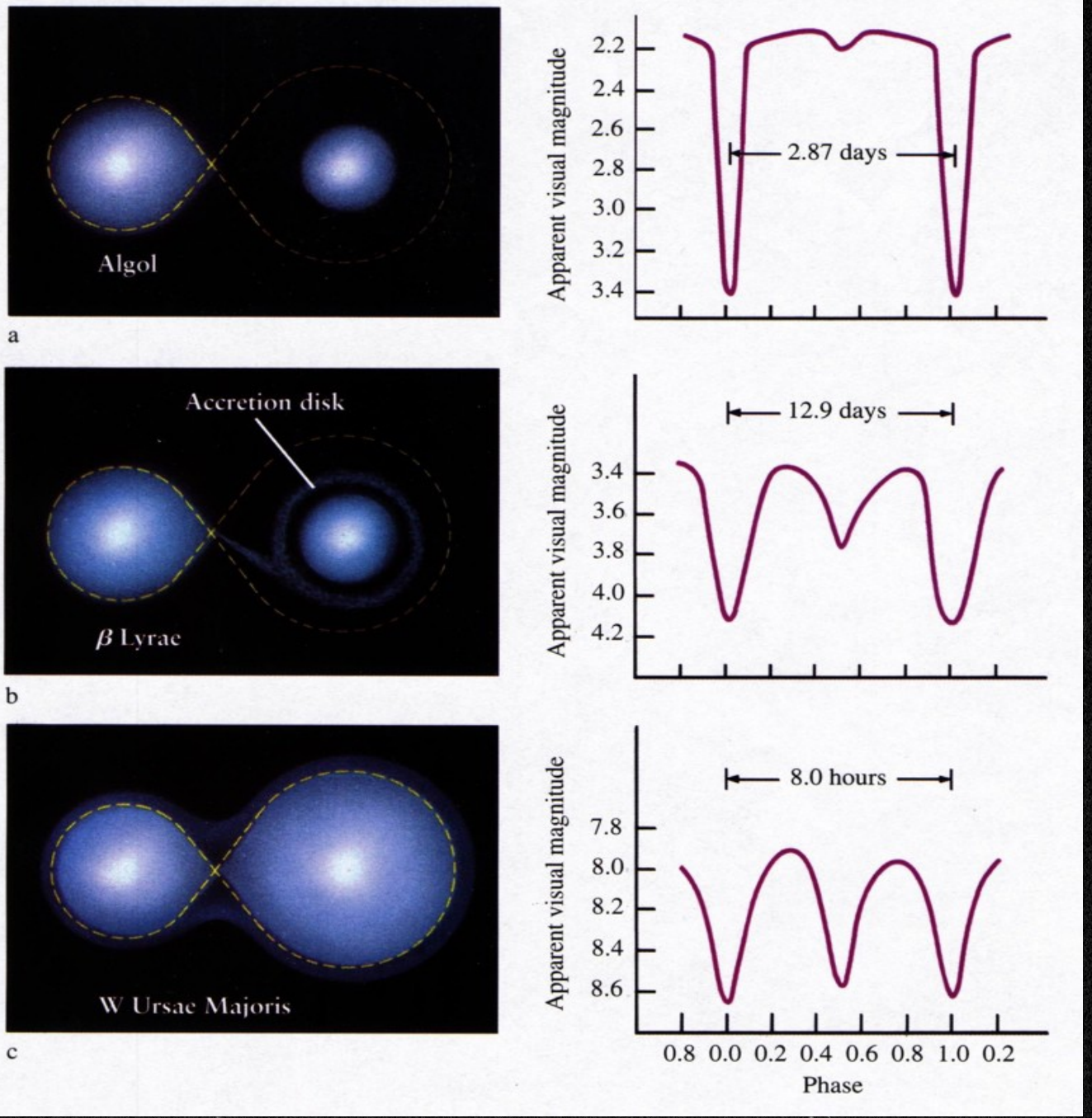
Type EA EB & EW





Type EA Binary




Algol
a
Apparent visual magnitude
2.2
2.4
2.6
2.8
3.0
3.2
3.4
2.87 days
Accretion disk
β Lyrae
b
12.9 days
3.4
3.6
3.8
4.0
4.2
W Ursae Majoris
c
8.0 hours
7.8
8.0
8.2
8.4
8.6
0.8 0.0 0.2 0.4 0.6 0.8 1.0 0.2
Phase

How easy is it to take measurements?

- *It can be as easy or hard as you want:*
  - Visual by just comparing two or three stars using binoculars or a telescope
  - Using a SLR or CCD camera or webcam on your telescope
  - Using one of the many robotic telescopes like:
    - Faulkes
    - Liverpool telescope
    - Bradford robotic scope

Faulkes South

Siding Spring, Australia

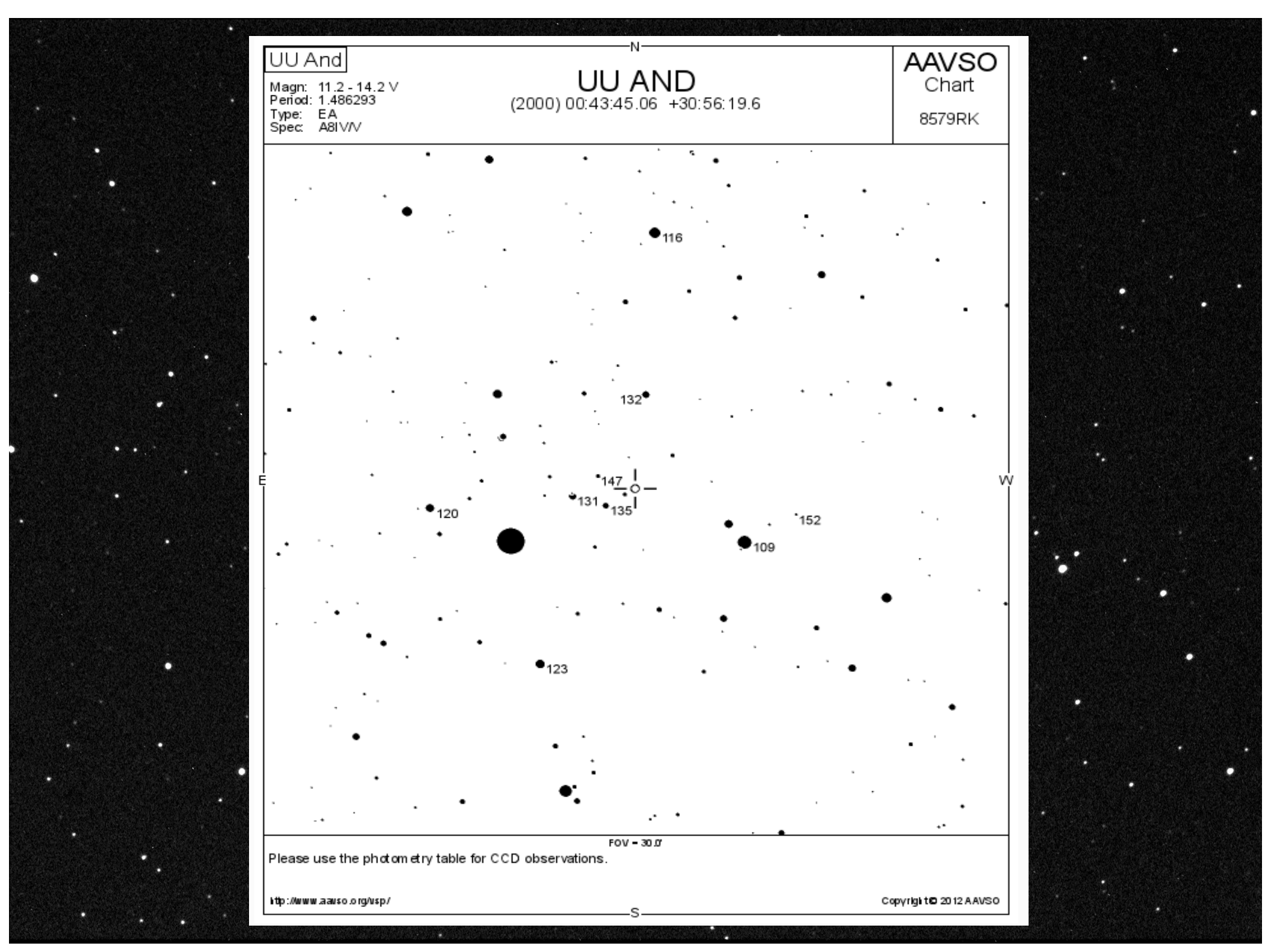
+9 hrs

Basics of magnitude measurement

- Photometry is the collective term for measurement of star brightness
- *What is important:*
  - To decide what sort of measurement you will make in what colour spectrum
    - **Visual by eye**
    - **Camera**: what colours and what optical response
      - Filters – filters compliance with a standard
      - CCD response
      - Telescope non linearities
      - Calibration
- Decide on a small selection of variable stars to study
- Decide if you just want to produce your own light curve or contribute to science as a wider group.

Information sources

- BAA has a variable star section
- AAVSO has a complete automated data collection and display process.
  - To obtain access to existing data
  - To get well calibrated reference stars
  - To manage your input data


UU And
Magn: 11.2 - 14.2 V
Period: 1.486293
Type: EA
Spec: A8IV/V
N
UU AND
(2000) 00:43:45.06 +30:56:19.6
AAVSO
Chart
8579RK
116
132
E
147
W
131
135
120
152
109
123
FOV = 30.0'
Please use the photometry table for CCD observations.
http://www.aavso.org/vsp/
Copyright© 2012 AAVSO
S

Variable Star Plotter (VSP)

- Printable Version
- Return & Replot

Field Photometry for UU AND From the AAVSO Variable Star Database

Data includes all comparison stars within 0.25000° of RA: 0:43:45.06 (10.93775) & Decl.: 30:56:19.61 (30.93878).

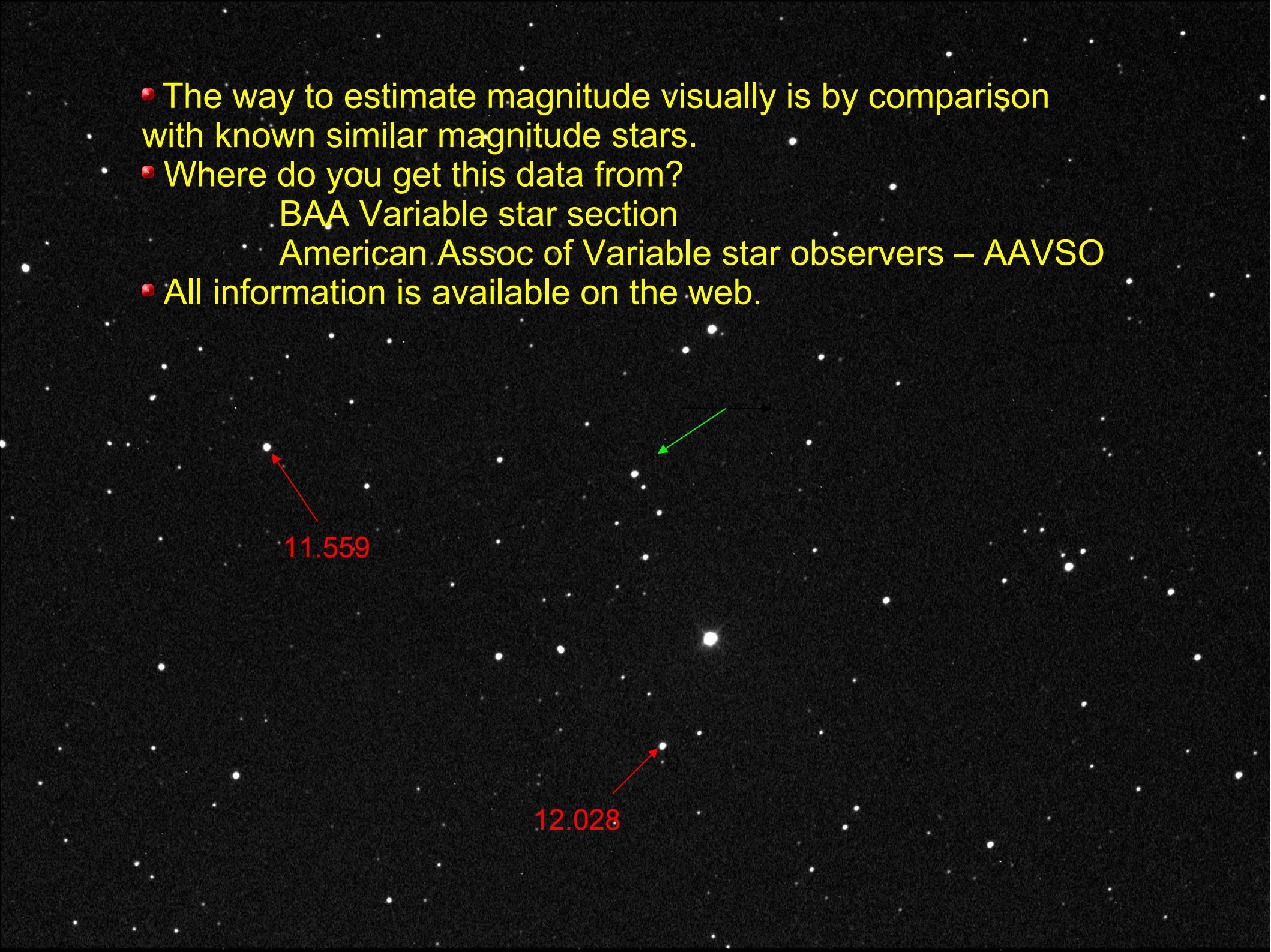
AUID	RA.	Dec.	Label	U	B	V	B-V	Rc	Ic	J	H	K	Comments
000-BKJ-952	0:43:24.52 [10.85217d]	30:53:59.7 [30.89992d]	**109**	-	11.407 (0.111) [29]	10.888 (0.061) [29]	0.519 (0.127)	10.510 (0.091) [29]	10.155 (0.113) [29]	-	-	-	
000-BKJ-953	0:43:41.33 [10.92221d]	31:07:26.9 [31.12414d]	**116**	-	12.312 (0.156) [29]	11.559 (0.079) [29]	0.753 (0.175)	11.084 (0.131) [29]	10.640 (0.167) [29]	-	-	-	
000-BKJ-954	0:44:23.60 [11.09833d]	30:55:27.6 [30.92433d]	**120**	-	12.650 (0.095) [29]	12.028 (0.046) [29]	0.622 (0.106)	11.624 (0.072) [29]	11.245 (0.090) [29]	-	-	-	
000-BKJ-	0:44:02.90	30:48:42.4	**123**		12.899 (0.087)	12.347 (0.041)	0.552	11.968 (0.069)	11.612 (0.089)				


Making the first step!

Making the first step!

You look through your telescope and find the star
you have selected to measure. You may need to find it
In a finder scope in low power first by star hopping.

- The way to estimate magnitude visually is by comparison with known similar magnitude stars.
- Where do you get this data from?
  BAA Variable star section
  American Assoc of Variable star observers – AAVSO
- All information is available on the web.



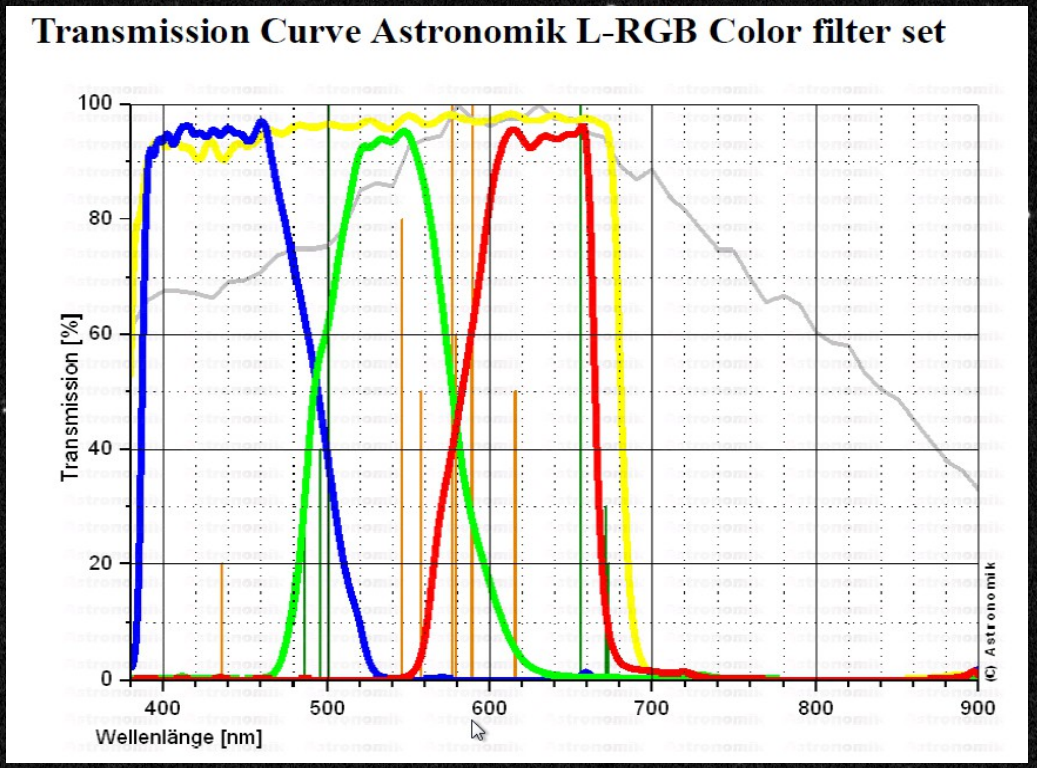
CCD or Camera measurements

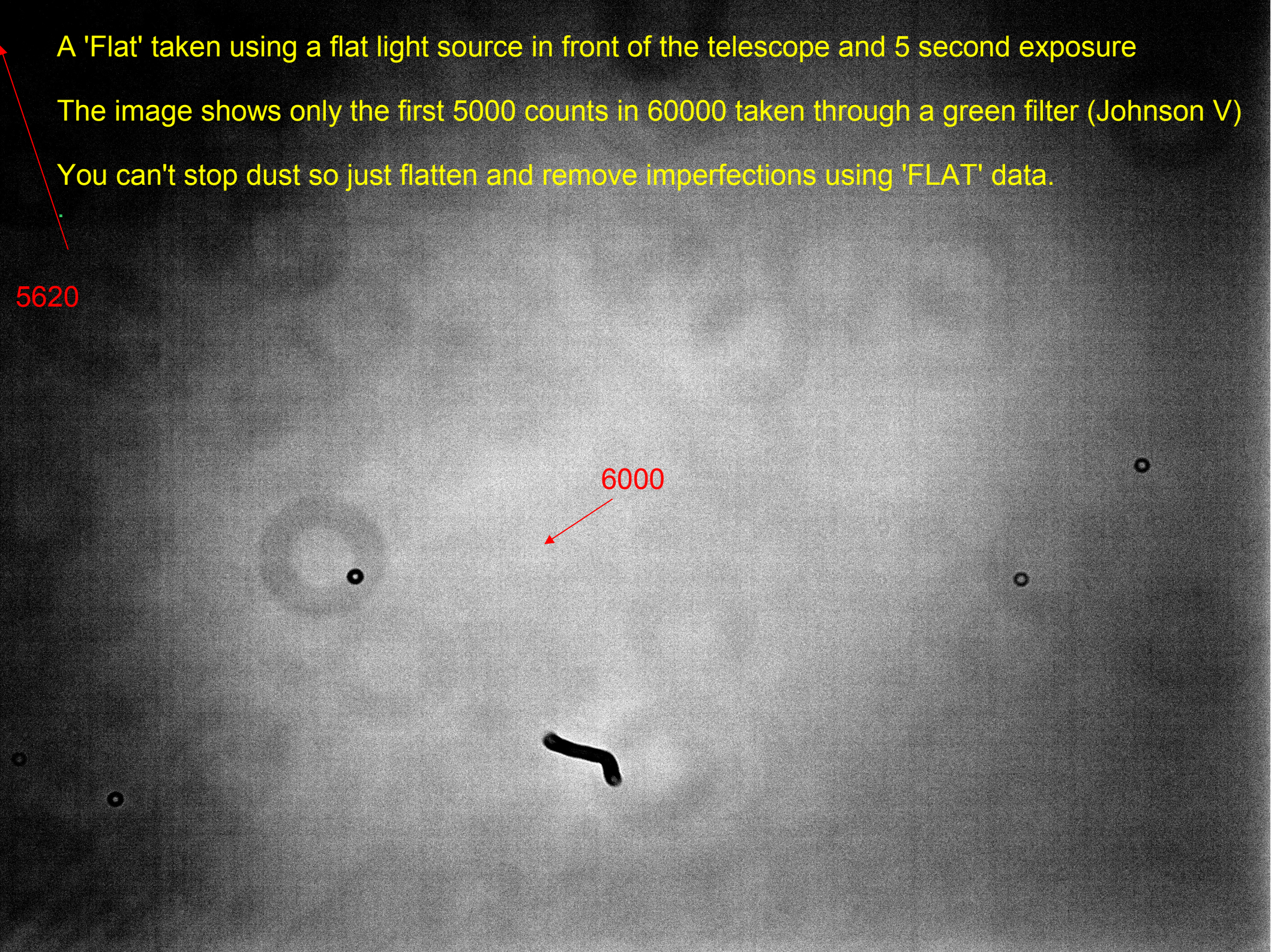
- Much more sensitive than the human eye.
- Stars are all different colours:
  - Comparing stars of different colour will require a correction
  - CCD images are never completely flat across the chip
  - If filters are used they need to match the reference star filter colour (Called Johnson V)
  - The thickness of the atmosphere needs to be taken into account if reference stars are far apart or < 30deg.
- Standard correction processes are used to ensure accuracy.

Star Colour

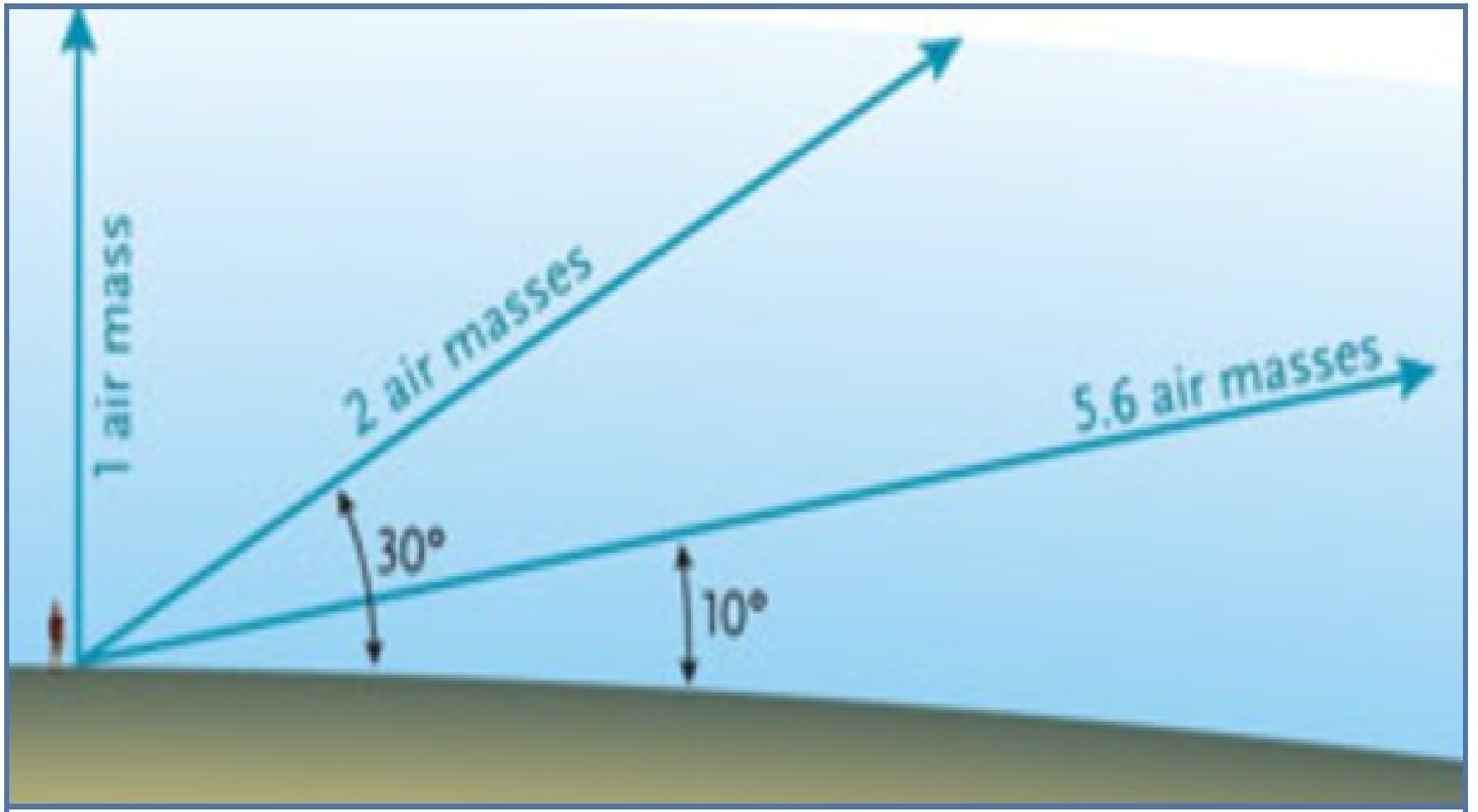
- Driven by star temperature

- Ranges from Blue to Red
- The reference V (Green) values are:
  - Johnson V filter
  - Close to the spectrum centre of the human eye



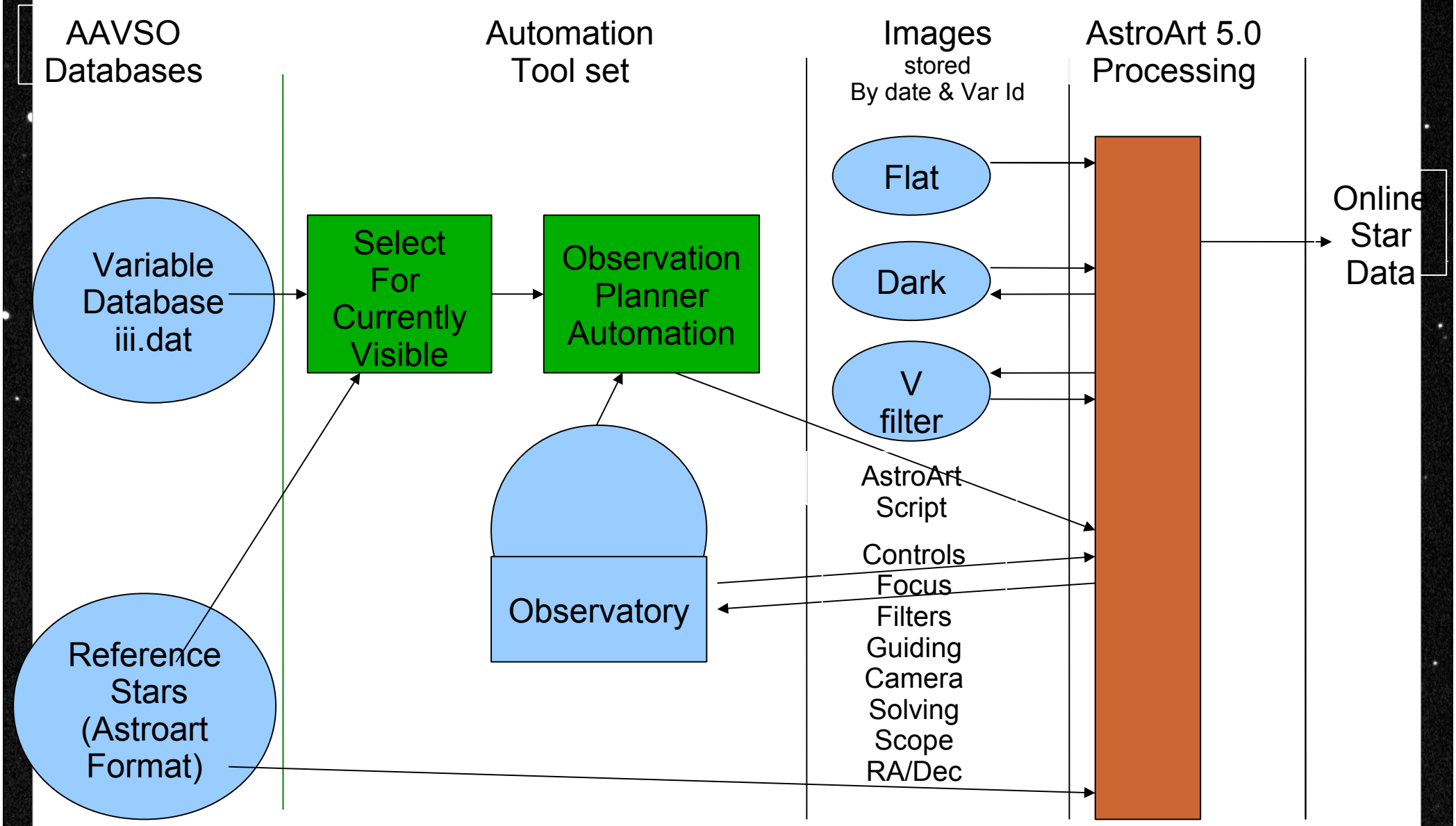

A 'Flat' taken using a flat light source in front of the telescope and 5 second exposure
The image shows only the first 5000 counts in 60000 taken through a green filter (Johnson V)
You can't stop dust so just flatten and remove imperfections using 'FLAT' data.
5620
6000

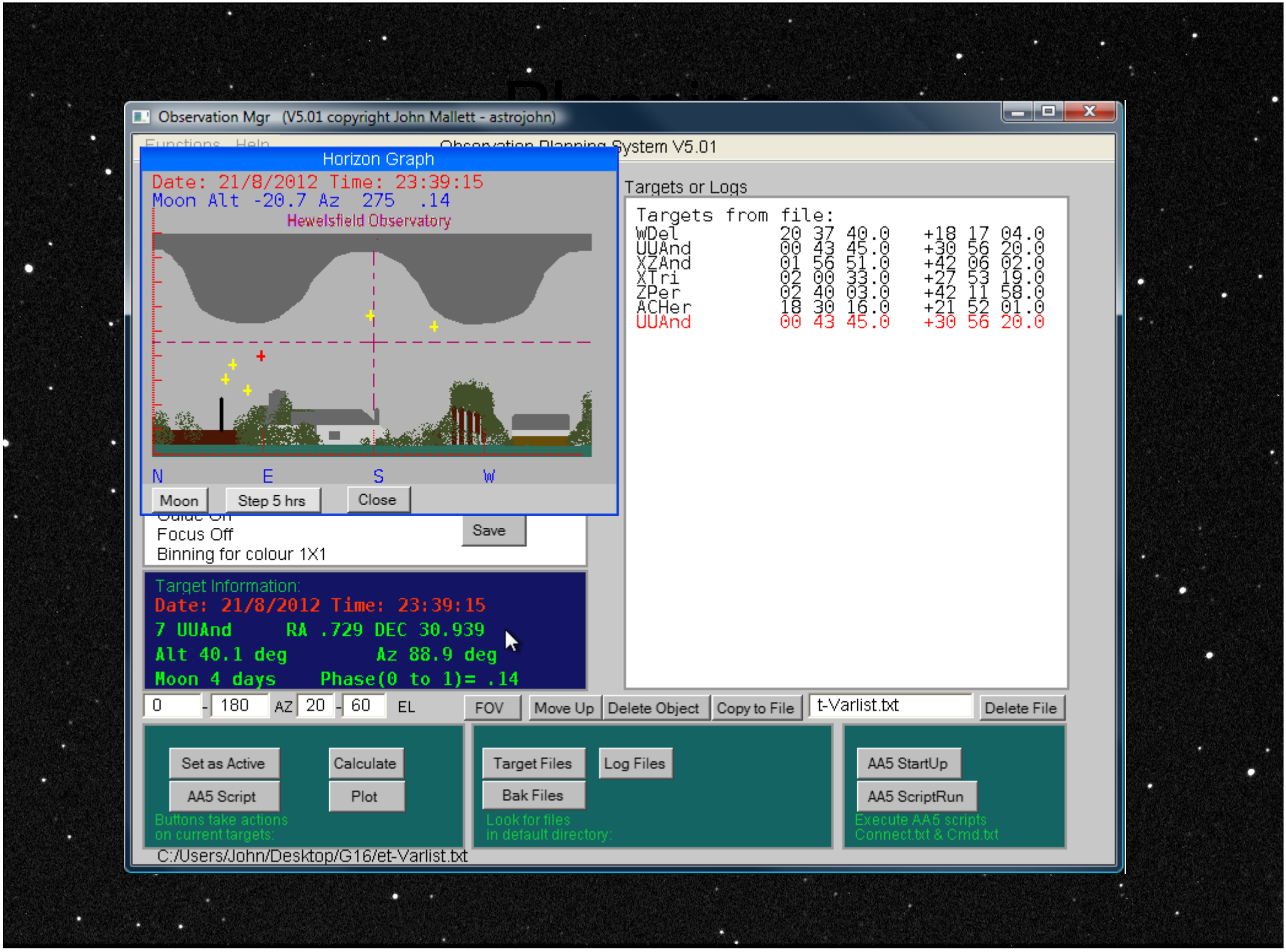
Atmosphere

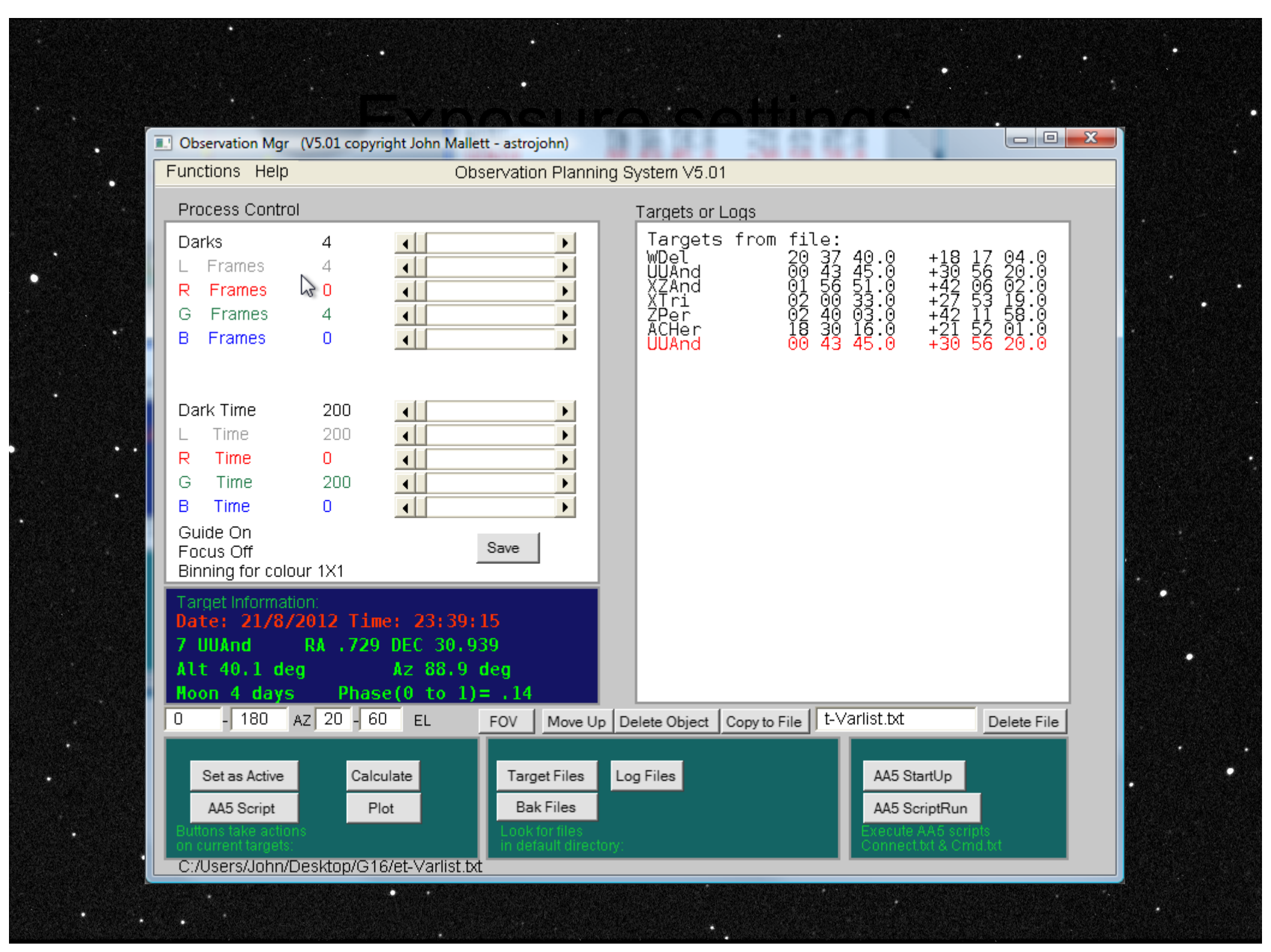


S&T Illustration

My methodology




Observation Mgr (V5.01 copyright John Mallett - astrojohn)
Functions Help
Observation Planning System V5.01
Horizon Graph
Date: 21/8/2012 Time: 23:39:15
Moon Alt -20.7 Az 275 .14
Hewelsfield Observatory
N
E
S
W
Moon
Step 5 hrs
Close
Focus Off
Binning for colour 1X1
Save
Target Information:
Date: 21/8/2012 Time: 23:39:15
7 UUAnd RA .729 DEC 30.939
Alt 40.1 deg Az 88.9 deg
Moon 4 days Phase(0 to 1)= .14
Targets or Logs
Targets from file:
WDel 20 37 40.0 +18 17 04.0
UUAnd 00 43 45.0 +30 56 20.0
XZAnd 01 56 51.0 +42 06 02.0
XTri 02 00 33.0 +27 53 19.0
ZPer 02 40 03.0 +42 11 58.0
ACHer 18 30 16.0 +21 52 01.0
UUAnd 00 43 45.0 +30 56 20.0
0 - 180 AZ 20 - 60 EL
FOV
Move Up
Delete Object
Copy to File
t-Varlist.txt
Delete File
Set as Active
Calculate
AA5 Script
Plot
Buttons take actions on current targets:
Target Files
Log Files
Bak Files
Look for files in default directory:
AA5 StartUp
AA5 ScriptRun
Execute AA5 scripts Connect.txt & Cmd.txt
C:/Users/John/Desktop/G16/et-Varlist.txt


Exposure settings
Observation Mgr (V5.01 copyright John Mallett - astrojohn)
Functions Help
Observation Planning System V5.01
Process Control
Darks 4
L Frames 4
R Frames 0
G Frames 4
B Frames 0
Dark Time 200
L Time 200
R Time 0
G Time 200
B Time 0
Guide On
Focus Off
Binning for colour 1X1
Save
Target Information:
Date: 21/8/2012 Time: 23:39:15
7 UUAnd RA .729 DEC 30.939
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Targets or Logs
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wDel 20 37 40.0 +18 17 04.0
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ZPer 02 40 03.0 +42 11 58.0
ACHer 18 30 16.0 +21 52 01.0
UUAnd 00 43 45.0 +30 56 20.0
0 - 180 AZ 20 - 60 EL
FOV
Move Up
Delete Object
Copy to File
t-Varlist.txt
Delete File
Set as Active
Calculate
AA5 Script
Plot
Buttons take actions on current targets:
Target Files
Log Files
Bak Files
Look for files in default directory:
AA5 StartUp
AA5 ScriptRun
Execute AA5 scripts Connect.txt & Cmd.txt
C:/Users/John/Desktop/G16/et-Varlist.txt

MSB Astroart 5.0

File Edit View Image Filters Arithmetic Color Tools Plug-in Window Help

#1 uuANDSTFLBIN.fit [50%]

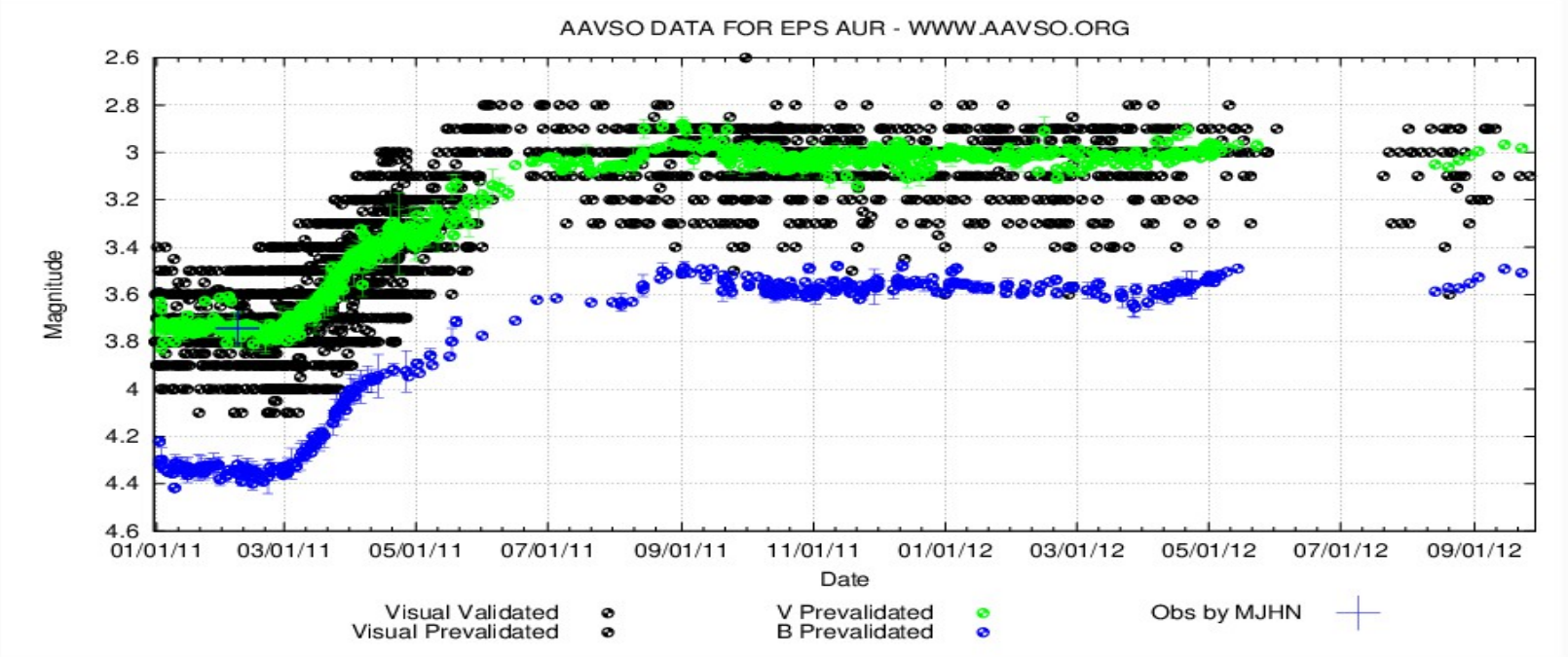
R=0 : 63491 B=457 V=410 : 1102 Lin

Stars #1 uuANDSTFLBIN.fit [1/4]

N#	Xc	Yc	ADU	A	P	R.A.°	DEC.°	R.A.	DEC	Mag.	O-C pos	O-C mag	Fwhm X	Fwhm Y	S/N	S-G-B
1	829.87	628.38	233908			10.937907	30.938754	00 43 45.098	+30 56 19.51	11.975			3.61	3.39	249.74	6-4-4
2	866.18	270.89	221612		REF	11.098590	30.924375	00 44 23.662	+30 55 27.75	12.028			3.17	3.83	241.27	6-4-4
3	348.83	663.79	358498		REF	10.922382	31.124251	00 43 41.372	+31 07 27.30	11.559			3.69	3.75	322.73	6-4-4
4	930.86	818.74	677897			10.852259	30.899936	00 43 24.542	+30 53 59.77	10.938			3.69	3.69	462.28	6-4-4

Light Curve Generator (LCG)

- Plot another light curve
- Search Quick Look for EPS AUR
- Create star chart for EPS AUR
- Search VSX for EPS AUR



The following observers have contributed to this light curve:

AALA	ABOUZAHR, ALESSANDRA	USA, AAVSO	AANB	ALTMAN, ANDREW	USA, AAVSO	AAP	ABBOTT, PATRICK	CANADA,
ABNA	ABU-EID, BADER	USA, AAVSO	ACMA	ALVAREZ, CRISTINA	USA, AAVSO	ADEA	AKTAS, DENIZ	USA, AAVSO
MJAD	MORRIS, JAMEELAH	USA, AAVSO	MJFA	MEE, JENNIFER	USA, AAVSO	MJHA	MCCAMMON, JOHN	USA, AAVSO
MJHN	MALLETT, JOHN	UK, BAA-VSS	MJOA	MACLENNAN, JOHN	USA, AAVSO	MJTA	MCLAUGHLIN, JOHN	USA, AAVSO
MKAA	MOSER, KATE	USA, AAVSO	MLIA	MERCHAN, LIZZETH	USA, AAVSO	MMAC	MCKINNON, MICHAEL	USA, AAVSO
MMGA	MILLER, MICHAEL	USA,	MMIA	MARTINEZ, MIKE	USA, AAVSO	MMKB	MAHER, MEAGAN	USA, AAVSO
MNAA	MILSTEIN, NATALIE	USA, AAVSO	MNIB	MARSHALL, NICHOLAS	USA, AAVSO	MNRA	MARCHAND, NATHANIEL	USA, AAVSO

A great example..

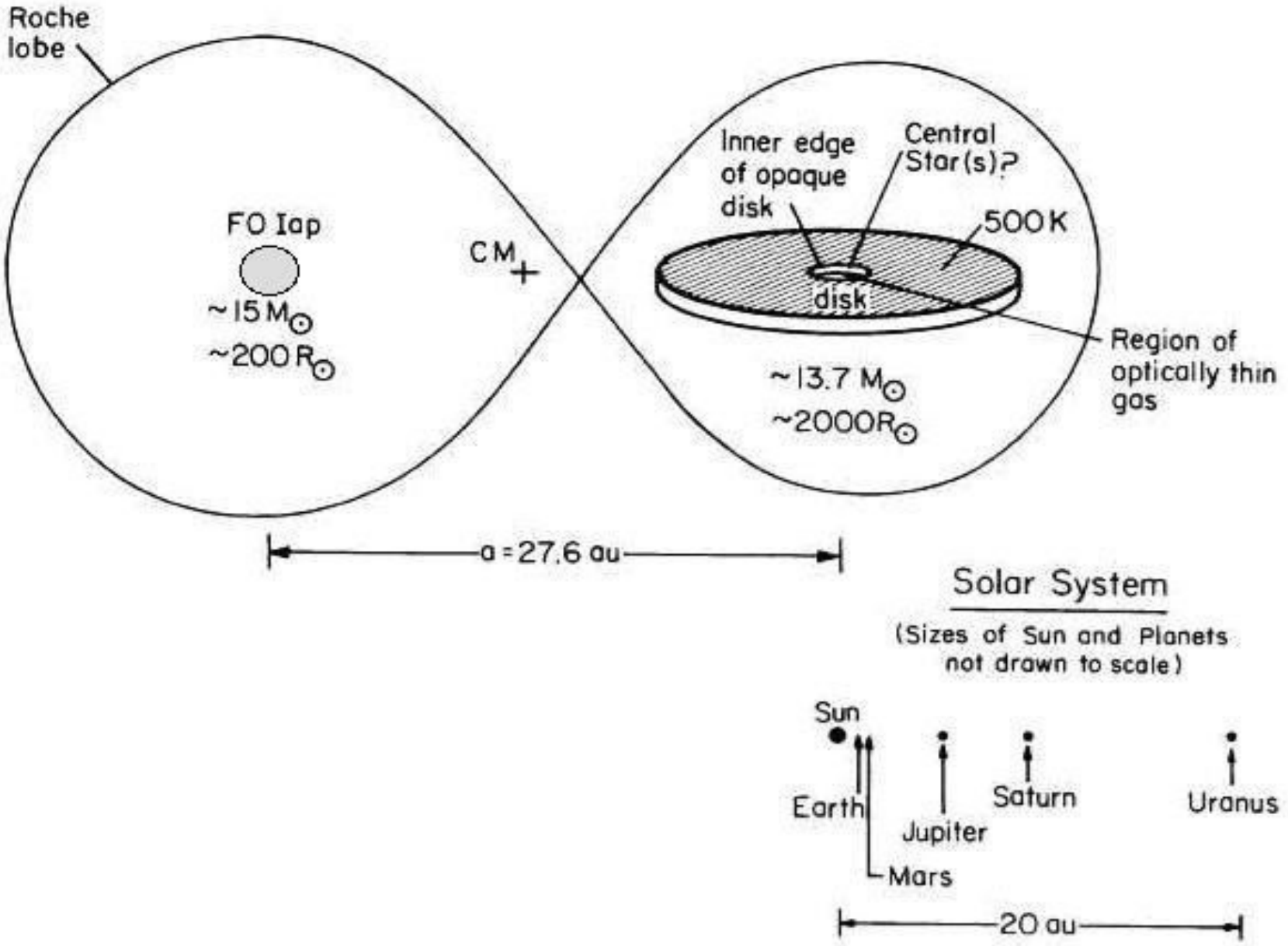
Des Loughney – October 2009

Made hundreds of measurements over 2 years to assist the discovery of the structure of Eps Aur binary.

Estimates of the 7/10/09
JD: 2455111.471
Camera Settings with an 85 mm lens:
Exposure-5 seconds, ISO 200, f5.

5 sets of ten images:
Analysed with AIP4WIN v2.3
(1) 3.294V
(2) 3.315V
(3) 3.292V
(4) 3.304V
(5) 3.285V

Average = 3.298V Standard Error = 0.005


Roche lobe
FO Iap
~15 M⊙
~200 R⊙
CM
Inner edge of opaque disk
Central Star(s)?
500 K
disk
Region of optically thin gas
~13.7 M⊙
~2000 R⊙
a = 27.6 au
Solar System
(Sizes of Sun and Planets not drawn to scale)
Sun
Earth
Mars
Jupiter
Saturn
Uranus
20 au