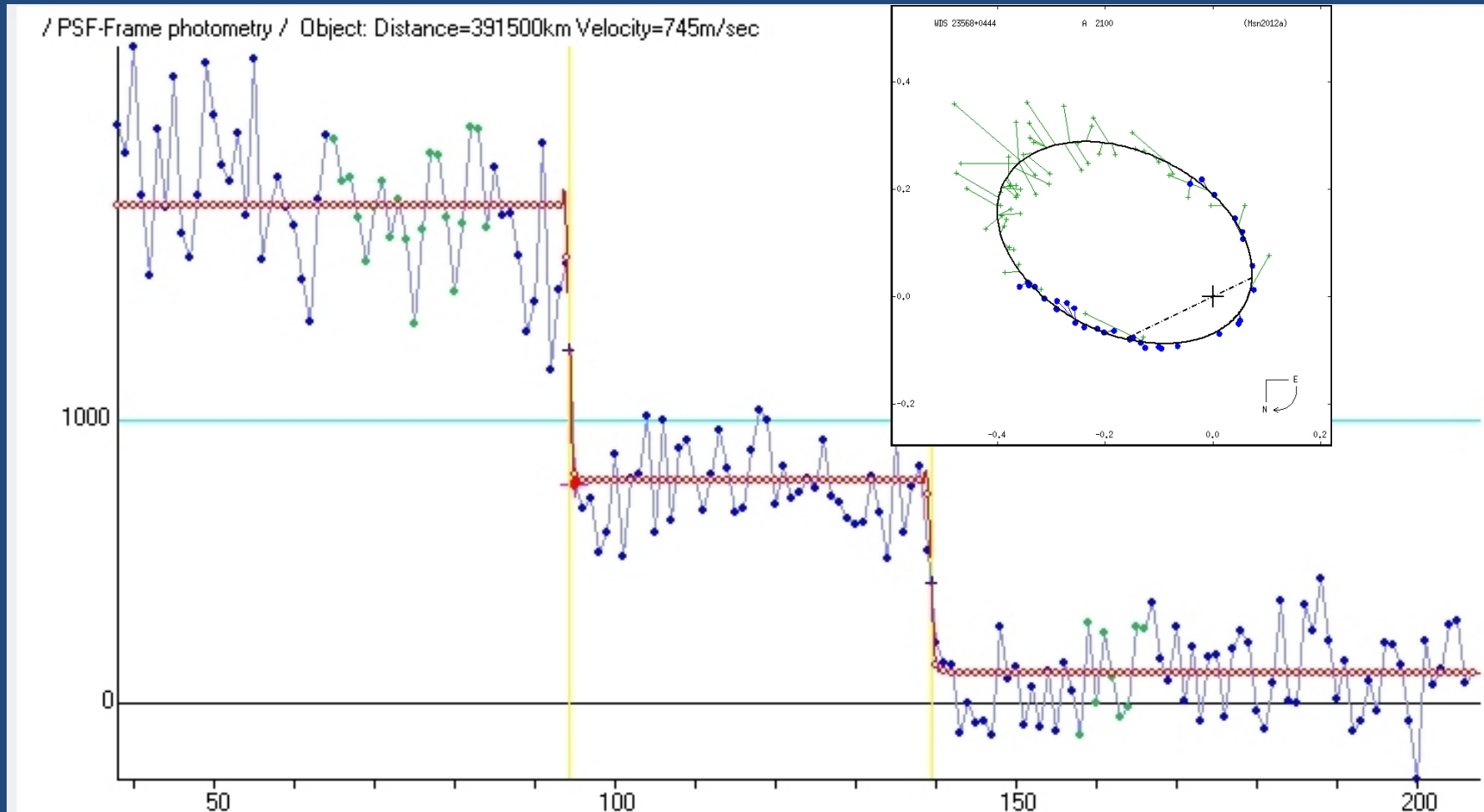


Video recording and analysing lunar occultations of double stars



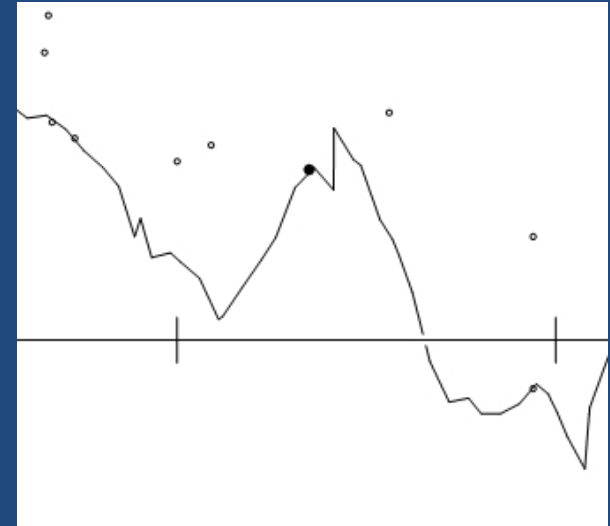
32nd European Symposium on Occultation Projects
(ESOP)

International Occultation Timing Association - European Section



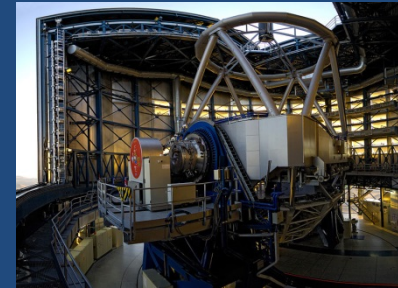
IOTA's lunar occultations programme

- Time occultations of single and multiple stars
- Determine the lunar limb profile (Kaguya)
- Estimate uncertainties in the stellar reference frame
- Double stars – Position Angle, separation, magnitude difference
- Discover new double stars



Recommended hardware

- Long focal length telescope – good contrast
- Sturdy mount and good quality drive
- Barlow lens
- Video camera – 25 fps – integration OFF (not colour)
- Video time and date inserter – GPS 1PPS receiver
- Computer with PC video card or USB capture device



Recommended software

- *VirtualDub*
- *AAVrec*
- *Lossless Codec (Lagarith)*
- *Occult*
- *OccultWatcher*
- *IOTA-ES Lunar Occultations add-in*
- *Tangra*
- *LiMovie*
- *AviSynth*

Occultation predictions

- *Occult*
- *OccultWatcher* (IOTA-ES Lunar Occultations add-in)
- Known and suspected double stars

Lunar Occultations

<input type="checkbox"/>	2233 D	Wed 14 Aug, 21:09	5.5	100	-	07 Aug, 10:04 new
<input type="checkbox"/>	184579 d	Thu 15 Aug, 23:11	7.9	100	-	07 Aug, 10:04 new
<input type="checkbox"/>	2733 d	Sun 18 Aug, 00:29	6.8	100	-	07 Aug, 10:04 new
<input type="checkbox"/>	163087 d	Mon 19 Aug, 01:21	8.5	100	-	07 Aug, 10:04 new
<input type="checkbox"/>	163899 d	Mon 19 Aug, 22:30	8.8	100	-	07 Aug, 10:04 new

Occultation prediction for OW.LunarOcc

E. Longitude - 1 36 27.9, Latitude 53 50 15.5, Alt. 164m; Telescope dia 20cm; dMag 3.0

day	Time	P	Star	Sp	Mag	Mag	%	Elon	Sun	Moon	CA	PA	VA	AA	Libration	A	B	RV	Cct	durn	R.A. (J2000)	Dec	Mdist	SV									
y	m	d	h	m	s	No	D	v	r	V	ill	Alt	Alt	Az	o	o	o	o	L	B	m/o	m/o	"/s	o	sec	h	m	s	o	m	s	Mm	m/s
13	Aug	14	20	9	47	D	2233cG8	5.5			54+	95	-5	13	208	19S	174	157	160	-5.1	-0.8	+1.5-3.6	.103	-76.7		15	38	54.6	-19	18	7	371.1	806.9
R2233 = 41 Librae																																	
2233 is double: AB 5.57 8.80 0.44" 107.2																																	
2233 is a close double. Observations are highly desired																																	

Recording an occultation

- Switch on VTI
- Locate star (D) or lunar limb (R)
- Check VTI
- Check *VirtualDub* 'Autoincrement after capture'
- Run *VirtualDub* Capture (Lossless Codec)
- Check for any dropped frames
- Backup the recording!

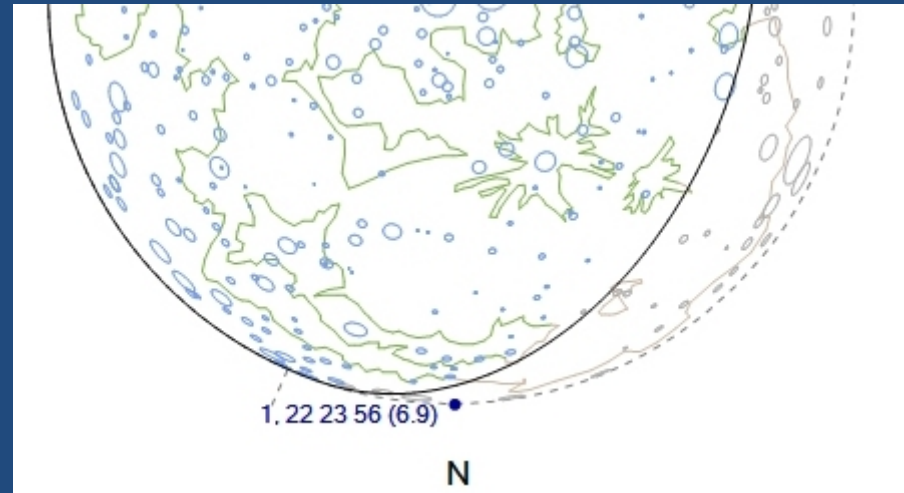


Image Saturation

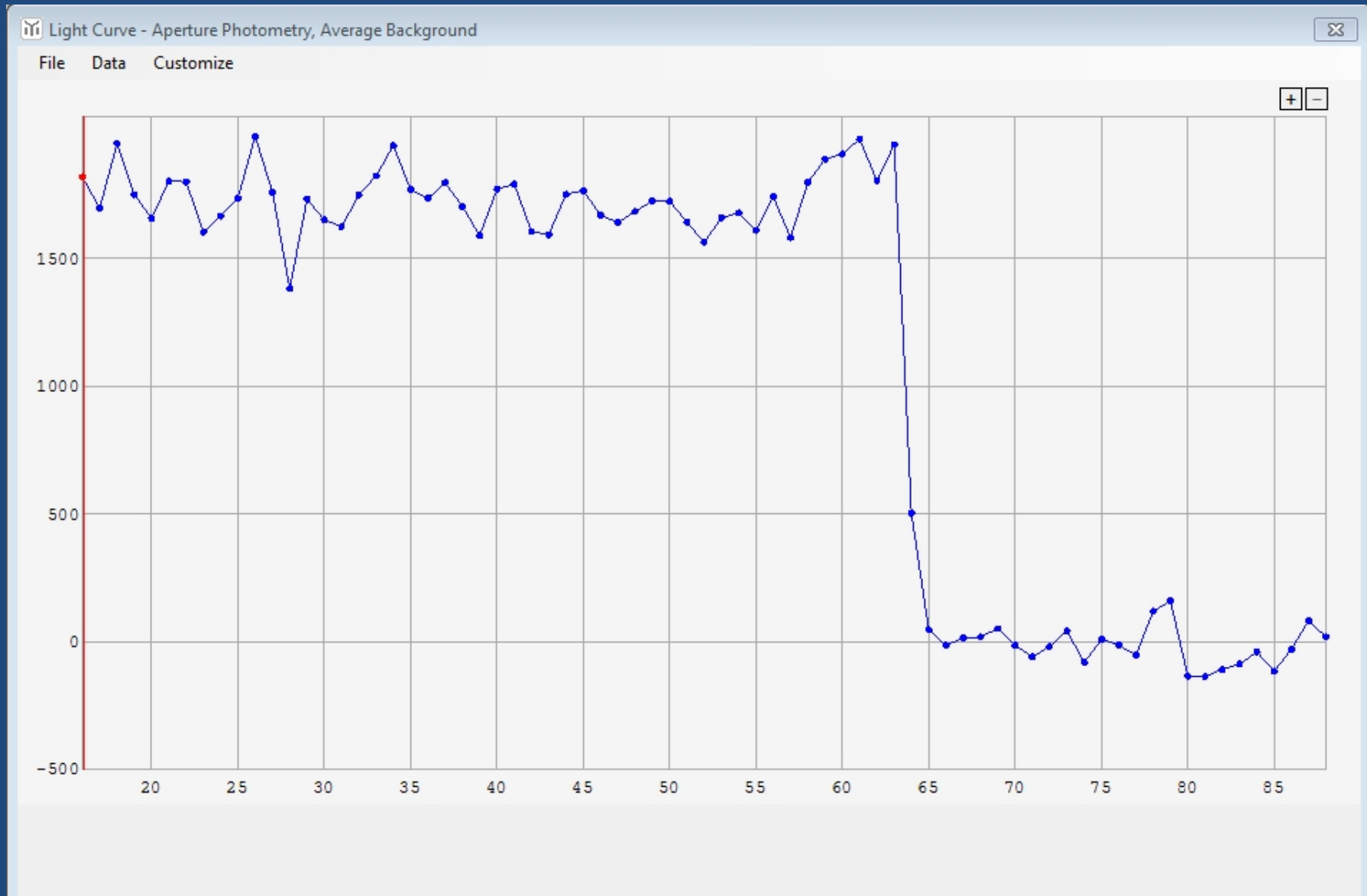
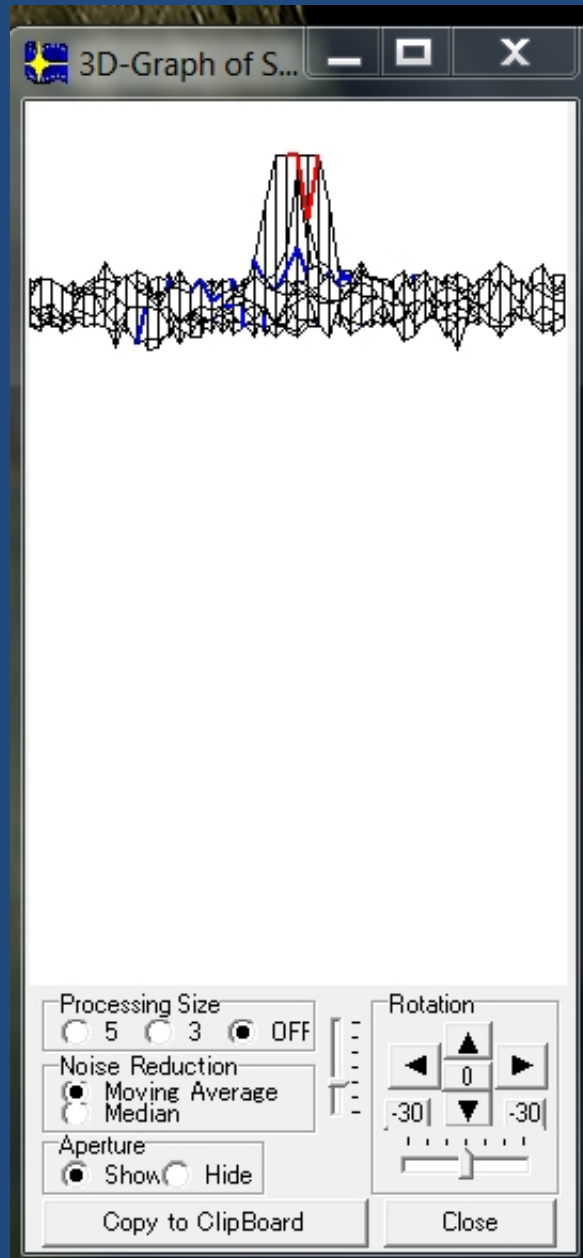


Image Saturation



Add Object

Add selected object as:

- Guiding/Comparison Star
- Occulted Star

PSF Fit Area: 11 px

Tolerance: 3.5 px

Aperture: 5.10 px

Auto-Centered

5.10 px = 1.12 FWHM

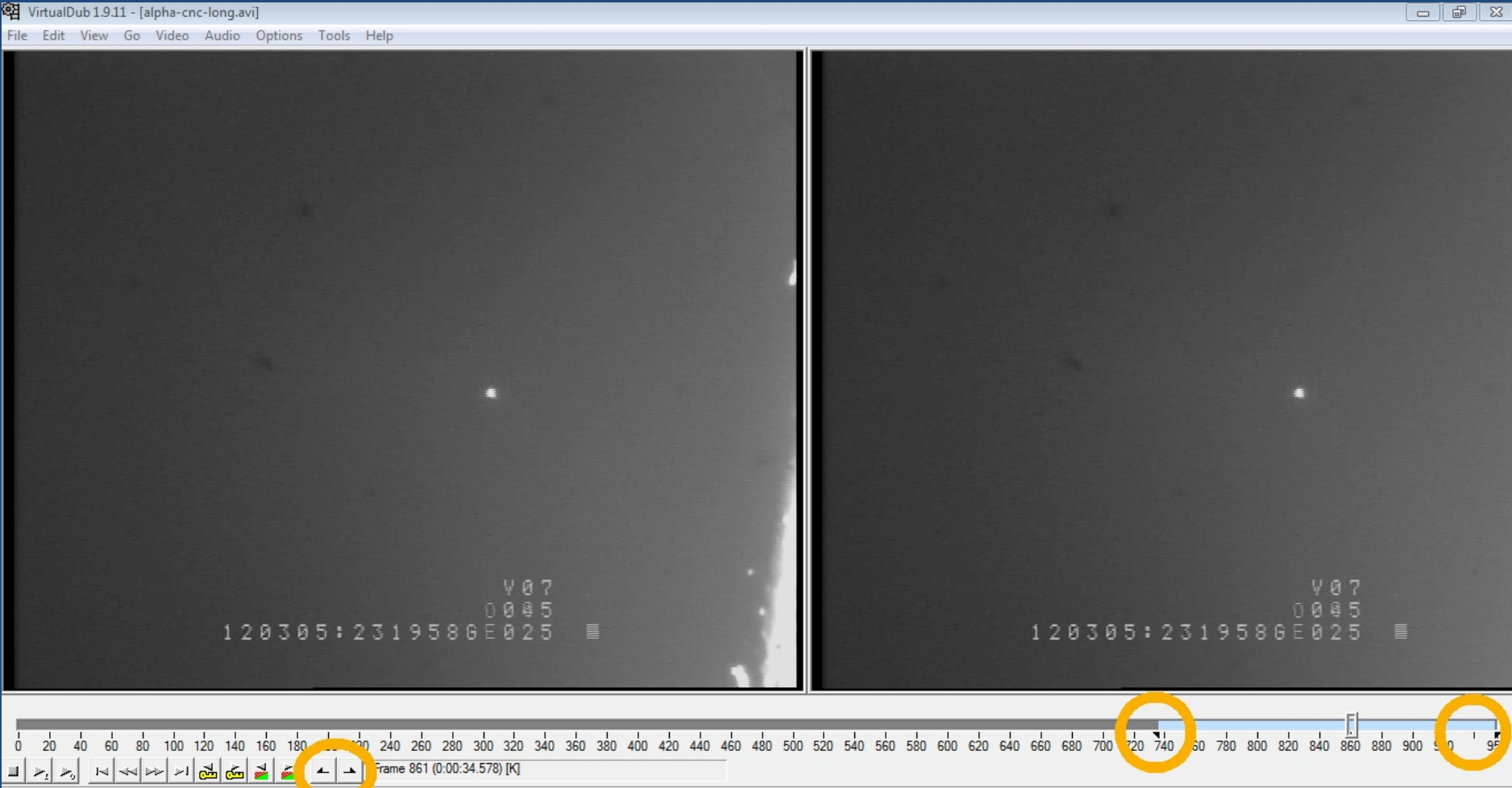
Add Don't Add

The "Add Object" dialog box is used to configure the analysis of a selected object. It includes options for adding the object as a "Guiding/Comparison Star" or an "Occulted Star". The "PSF Fit Area" is set to 11 px and the "Tolerance" is 3.5 px. The "Aperture" is set to 5.10 px, which is equivalent to 1.12 FWHM. The "Auto-Centered" option is selected. The dialog also features a "Processing Size" section with options for 5, 3, or OFF, and a "Noise Reduction" section with options for "Moving Average" or "Median". The "Aperture" section has "Show" and "Hide" options. The "Rotation" section includes a central value of 0 and two side values of -30. The dialog concludes with "Add" and "Don't Add" buttons.

Image Saturation

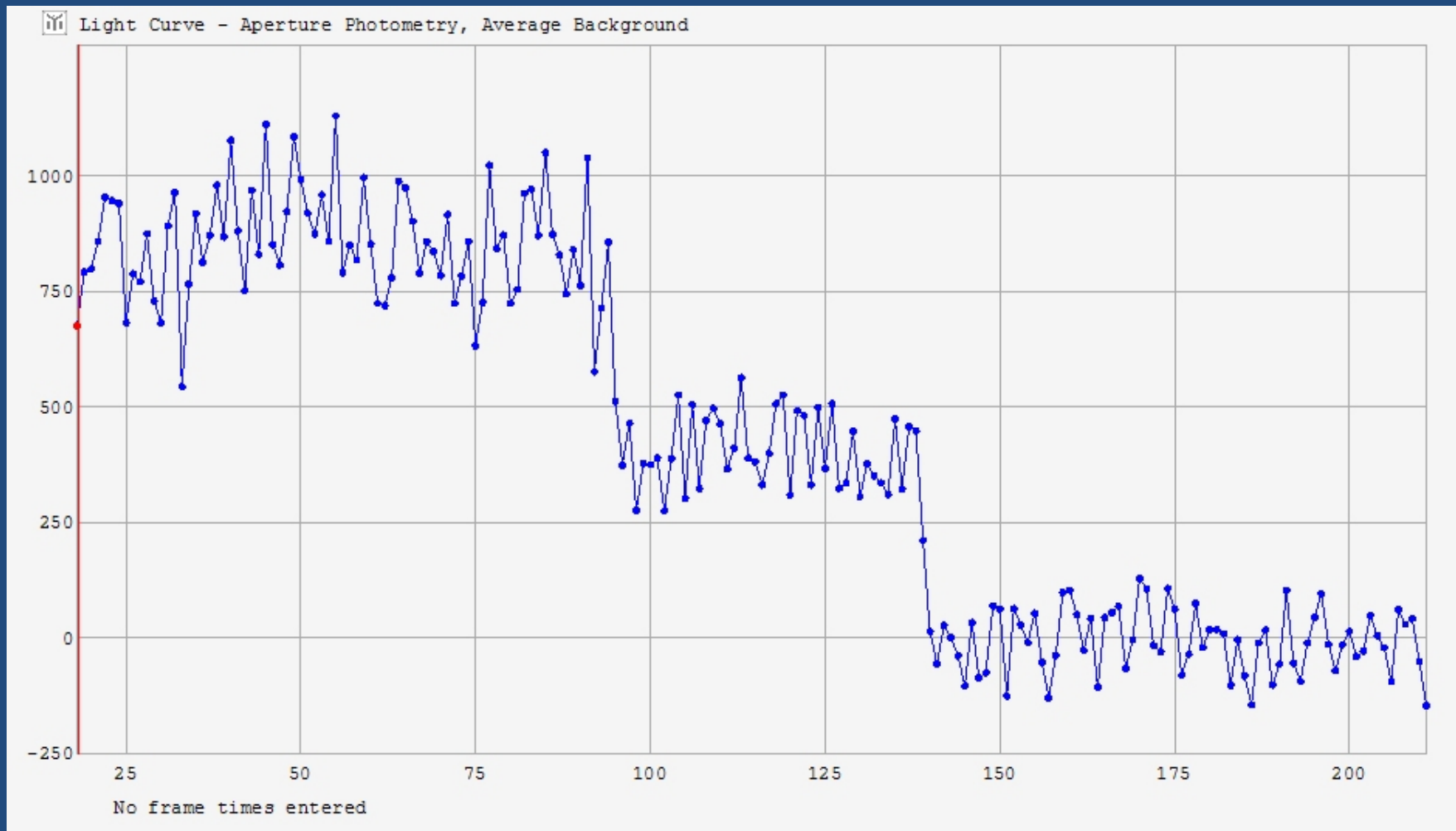
- The step might not be detected
- Take a short test recording and check with *LiMovie* or *Tangra*
- Reduce the gain setting on the video camera
- Stop down the telescope aperture

Crop the video with *VirtualDub*



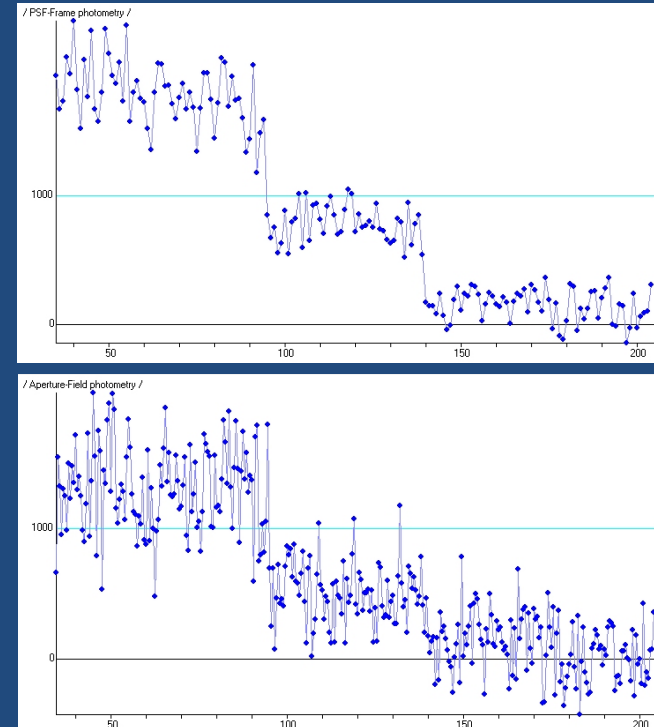
Analysing the disappearance of double star XZ 13791 and XZ 113062 2013 Apr 19

Magnitudes 9.9 and 10.2, separation 0.8", PA 136.6



Video frames, fields and gamma

- 25 frames per second (0.04s)
- 50 fields per second (0.02s)
- Signal to Noise ratio (SNR)
- Gamma 0.45 to 1.0
- *AviSynth*



Video field order (Even – Odd)

Light Measurement tool for Occultation bservation using Video Recorder [Limovie 0.9.97.3i]

File Edit Option Tools Software Update

Limovie File Format (for Ver.0.9.26 later)
"FileName : C:\Users\Alex\Documents\BAA - Lun-
"Video System : PAL , FrameRate=25.00"
"Time" "" "Centre of" , "End of" "" "Result" "" "" "Object
"Detect" "" "VTI" "" "Frame" "" "Frame" "" "Sound" "" "Mea
"No." "" "Signal1" "" "Signal2" "" "H" "" "M" "" "S" "" "" /Frame"

Gamma Reverse Correction
 OFF Measure Field 1.00 More Fast

End Time of Field Exposure (Field1=Centre of Frame)
h m s [Field1] [Field2] Threshold S1 S2
h m s[Field1] s[Field2] 80 KIWI

C:\Users\Alex\Documents\BAA - Lunar Section#

Current Frame: 0

Measurement: 1Frame D2L

START STOP DataRemove SaveToCSV-File Capture Open AVI Load CSV Exit

Measurement Value: BKG/Frame Star Even Odd Frame 5637.2 Color Value

Position Center Tracking X= 50 Y= 50

Linked Tracking Link Passed- Frame1 Frame2 Rotate Point Set Clr Set Clr

PSF Tracking Photometry

Form of BKG-Area Standard Avoid Sunlit Face Meteor/Lunar Limb

Number of Pixels / Radius Aperture Background Even Odd Frame

Direction Setting Width Gap

Star Tracking Anchor Drift OFF CSV Estimated track Radius Threshold Frame1 Frame2

Passed Point (Frame.)

Set radius to memoried Radius Inner Outer

Star Image [3D] Update Setting Items

Measurement / View Option Show Field Interval Frame Rate

Field Order Even first Odd first

Current Object A B C

Analysing the disappearance of double star XZ 13791 and XZ 113062

Light Measurement tool for Occultation bserveration using Video Recorder [Limovie 0.9.97.3i]

File Edit Option Tools Software Update

P7 21:54:06 4447 4647 44635

Operation guide

Select type of observed occultation.

- Analyzer for occulted star
- Base star for tracking Delete
- Link Analyzer to Base
- Comparison star Delete

Preview Stop Back to Starting point
Measure Stop Graph

End Time of Field Exposure (Field1=Centre of Frame)
h m s [Field1] [Field2] Threshold S1 S2
h m s(Field1) s(Field2) 80 KIWI

C:\Users#Alex#Documents#BAA - Lunar Section#

Current Frame 0 Measurement 1Frame DEL START STOP DataRemove SaveToCSV-File Capture Open AVI Load CSV Exit

Measurement Value
BKG./Frame
Star Even
Odd
Frame 1609.2
Color Value

Position Center Tracking
X= 355 355
Y= 246 246

FWHM 7.58
 Fixed

Position Set
 Star
 Signal1
 Signal2
 TIVi

Linked Tracking
 Link Passed-
 Rotate Point

Star Tracking
 Anchor
 Drift
 OFF
 CSV

Estimated track
Radius Threshold 8 95

Passed Point (Frame.)
Frame1 Frame2

Form of BKG-Area
 Standard
 Avoid Sunlit Face
 Meteor/Lunar Limb

Direction Setting
Width Gap 5 0

Number of Pixels / Radius
Aperture Background
Even
Odd
Frame

Set radius to memoried
Radius Inner Outer
8 16 25

Star Image (3D) Update Setting Items

Measurement / View Option
Show Field Interval
 Field Measure 1

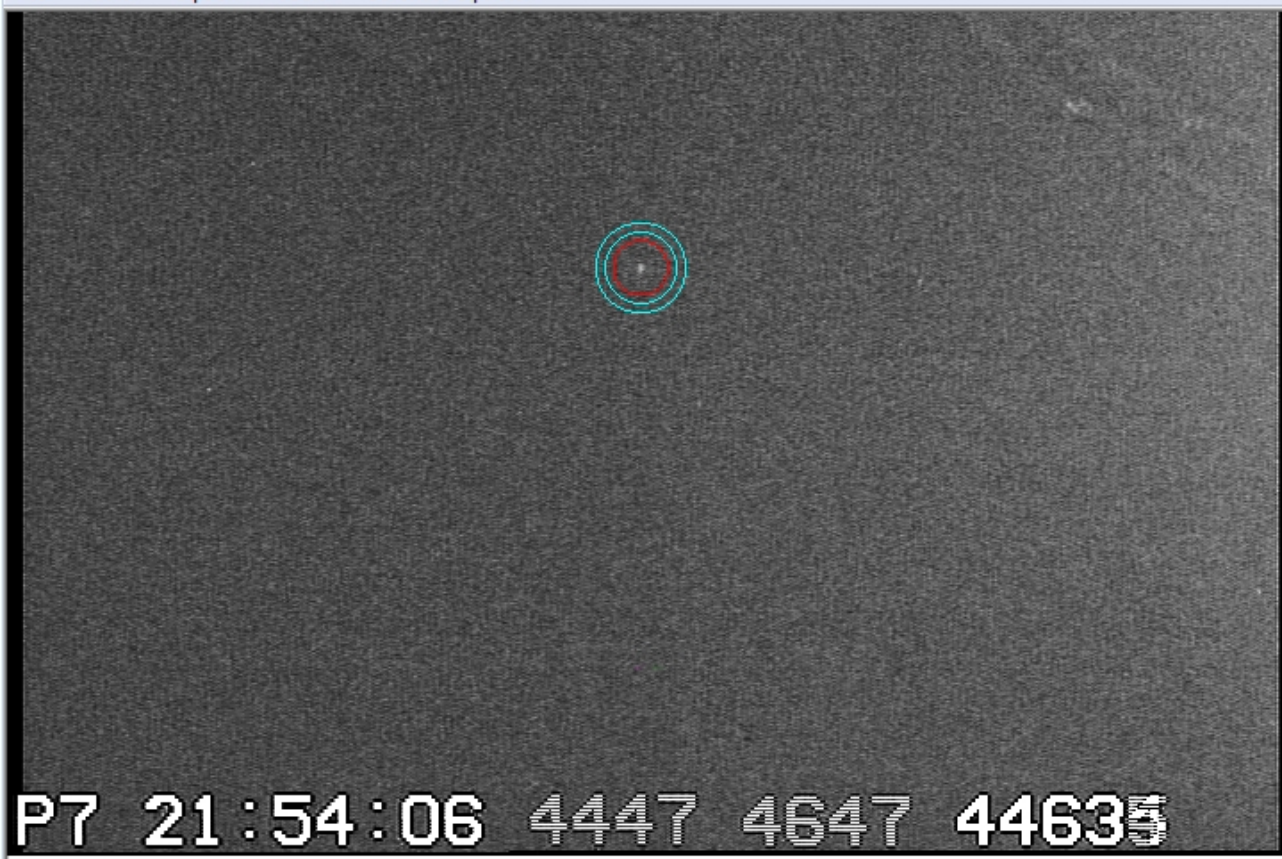
Field Order
 Even first
 Odd first

Current Object
Graph A B C

Analysing the disappearance of double star XZ 13791 and XZ 113062

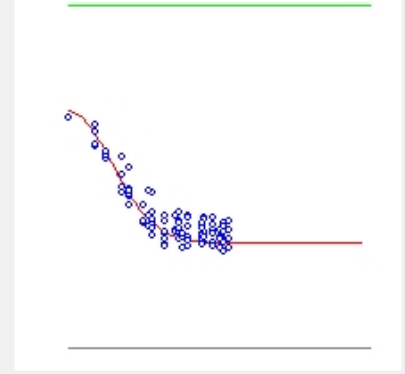
Light Measurement tool for Occultation bservation using Video Recorder [Limovie 0.9.97.3i]

File Edit Option Tools Software Update



P7 21:54:06 4447 4647 44635

Operation guide



Select type of observed occultation.

- Analyzer for occulted star
- Base star for tracking
- Comparison star

Buttons: Preview, Stop, Back to Starting point, Measure, Stop, Graph

End Time of Field Exposure (Field1=Centre of Frame)

h	m	s	[Field1]	[Field2]	Threshold	S1	S2
h	m	s	[Field1]	[Field2]	80	<input type="checkbox"/>	KlWl

C:\Users#Alex#Documents#BAA - Lunar Section#

Current Frame: 0

Measurement: 1Frame DEL **START** STOP DataRemove SaveToCSV-File

Measurement Value: BKG/Frame, Star Even, Star Odd, Frame 1606.0, Color Value

Position Center Tracking: X=355, Y=246

FWHM: 7.58

Position Set: Star, Signal1, Signal2, TIVi

Linked Tracking: Link, Passed, Rotate, Point

Star Tracking: Anchor, Drift, OFF, CSV, Estimated track, Radius, Threshold

Form of BKG-Area: Standard, Avoid Sunlit Face, Meteor/Lunar Limb

Direction Setting: Width, Gap

Number of Pixels / Radius: Aperture, Background, Even, Odd, Frame

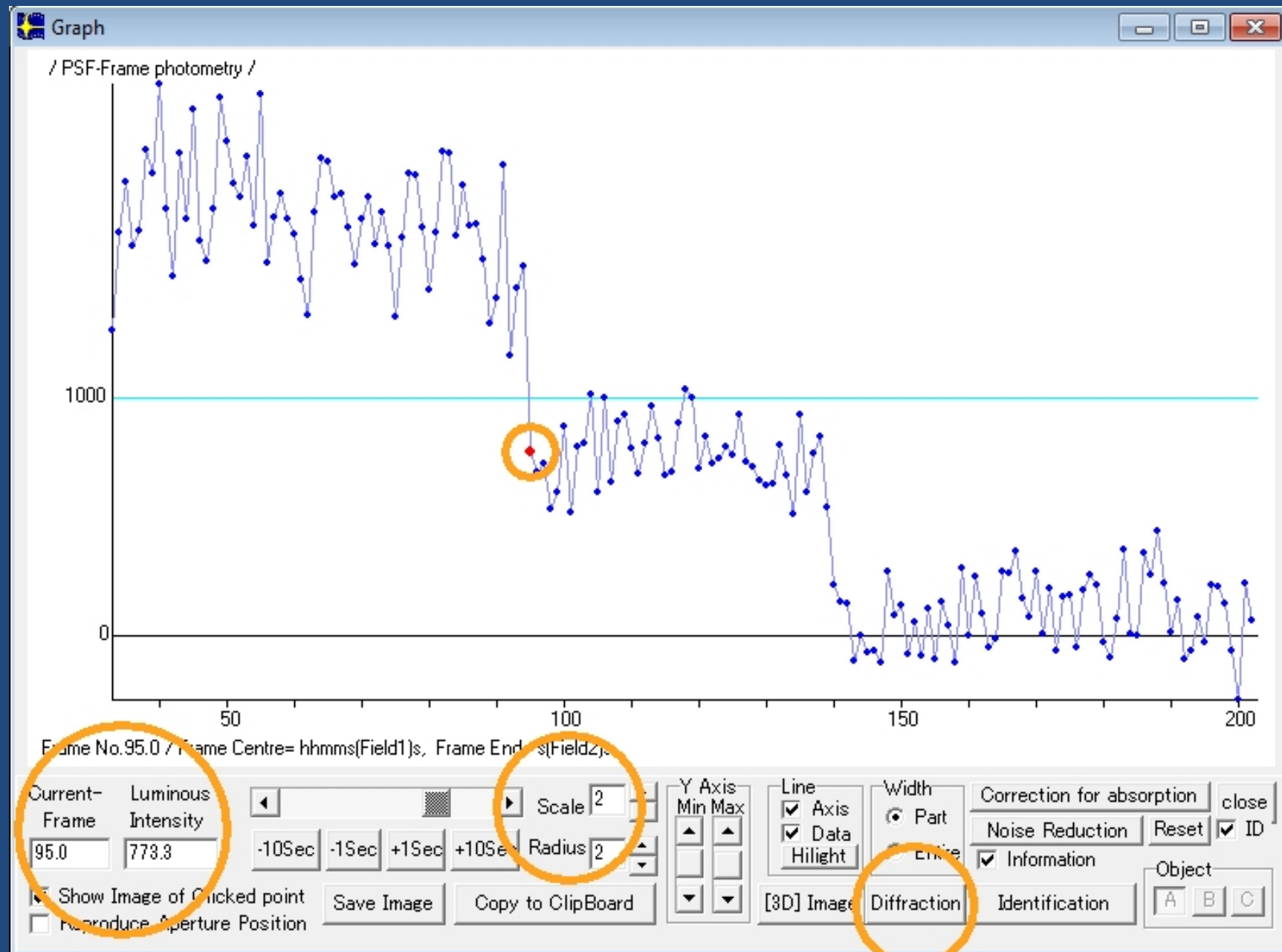
Star Image [3D], Update Setting Items

Measurement / View Option: Show Field, Interval, Field Measure, Field Order

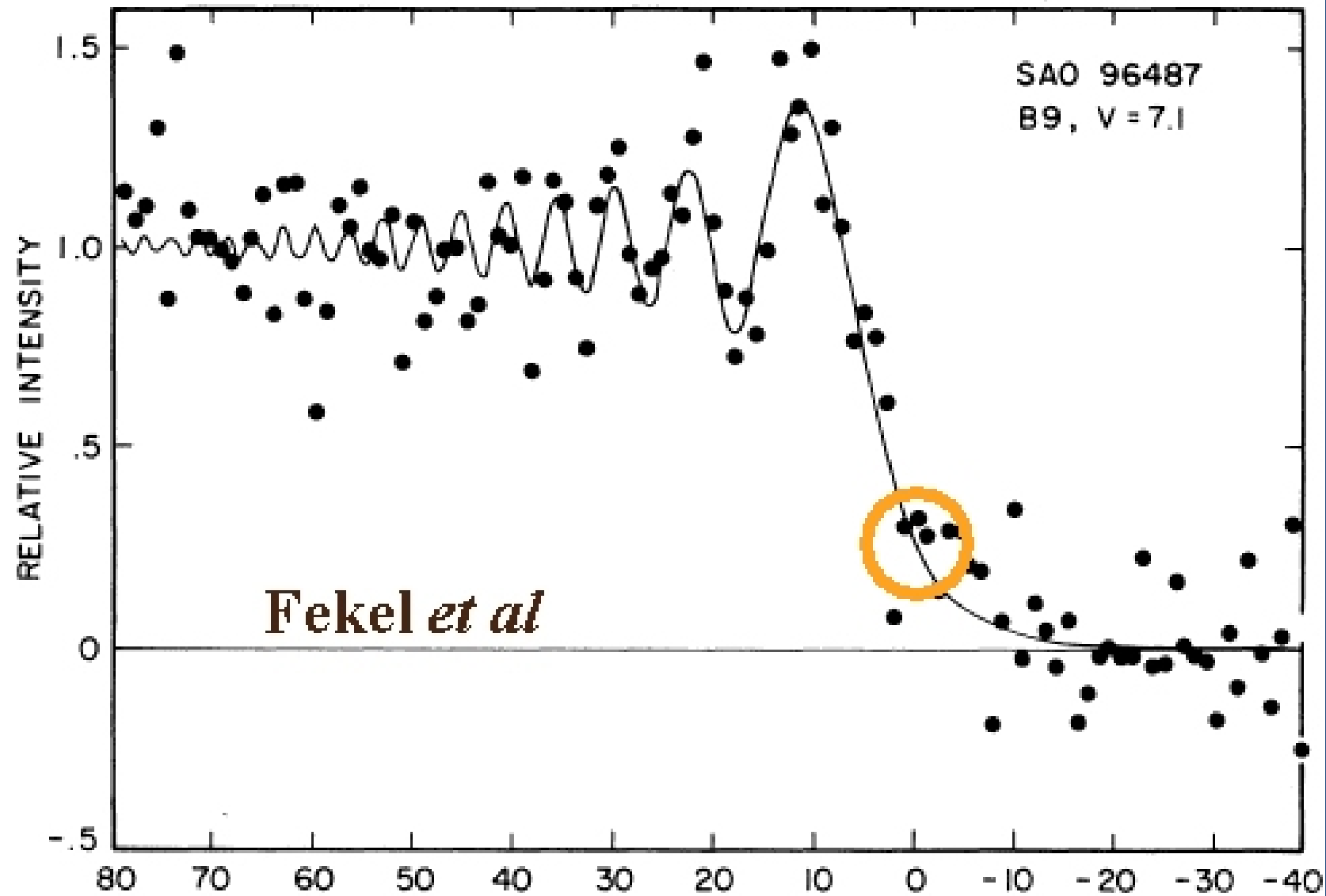
Current Object: A, B, C

Graph

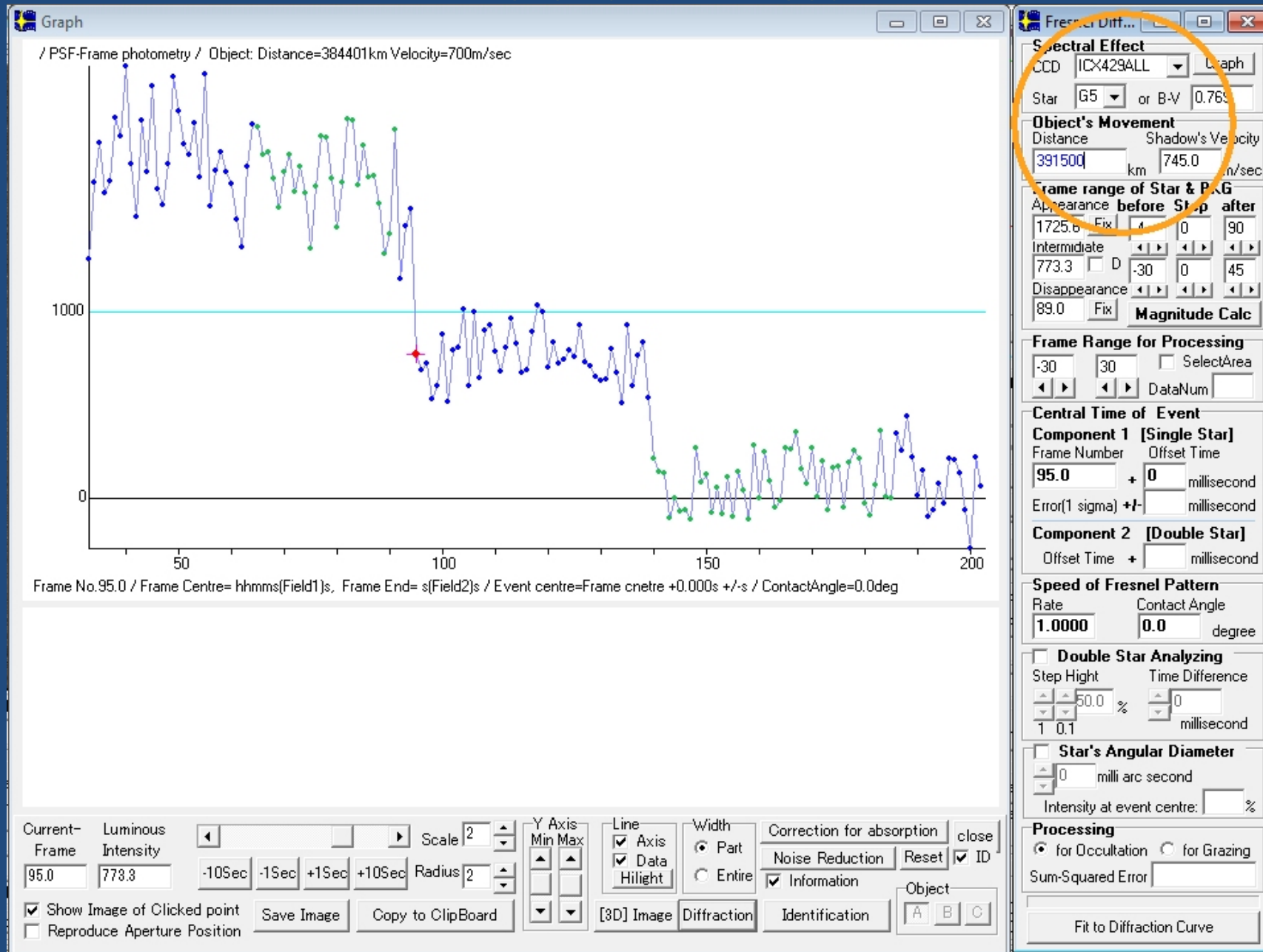
Analysing the disappearance of double star XZ 13791 and XZ 113062



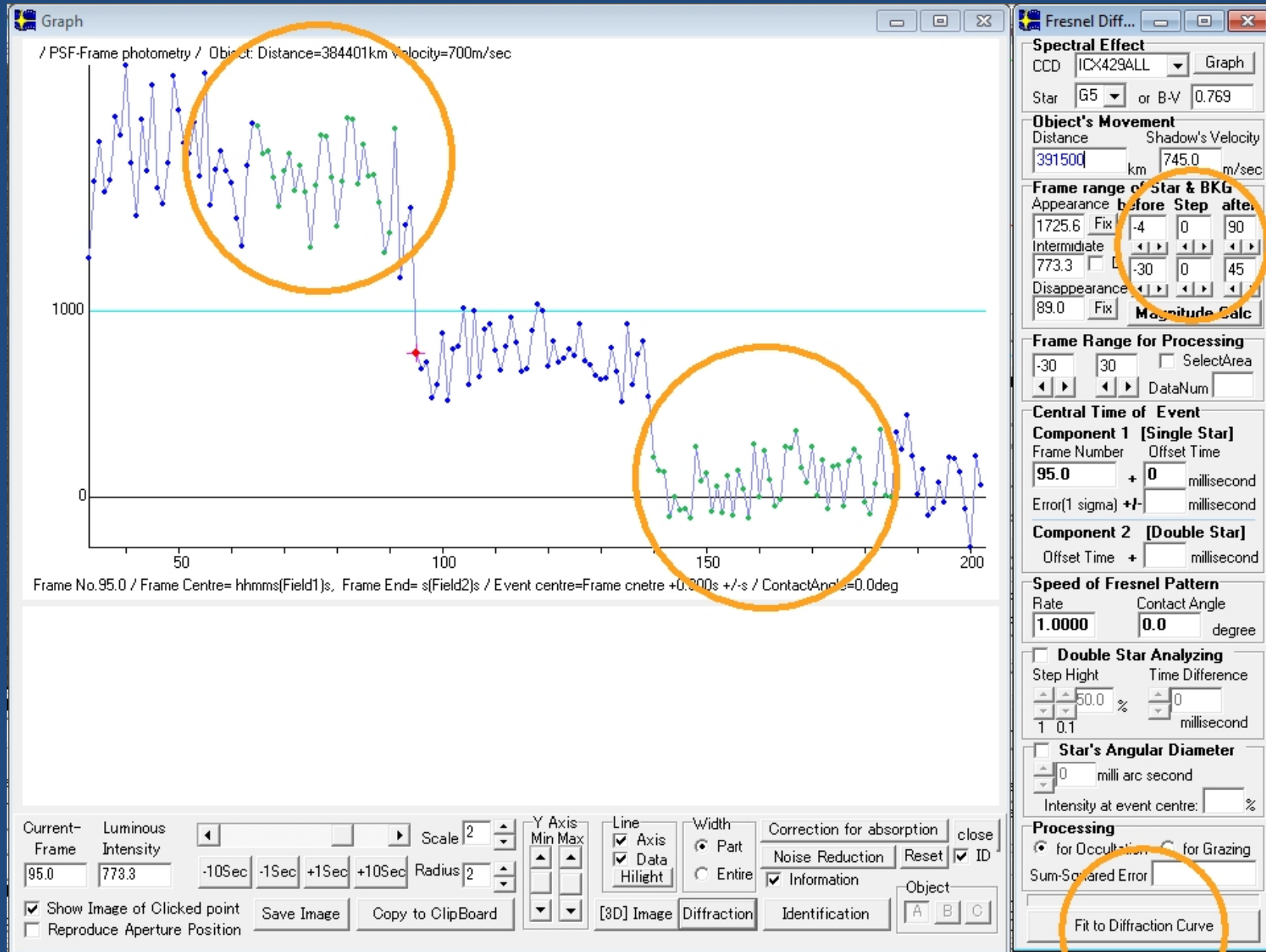
Fresnel Diffraction



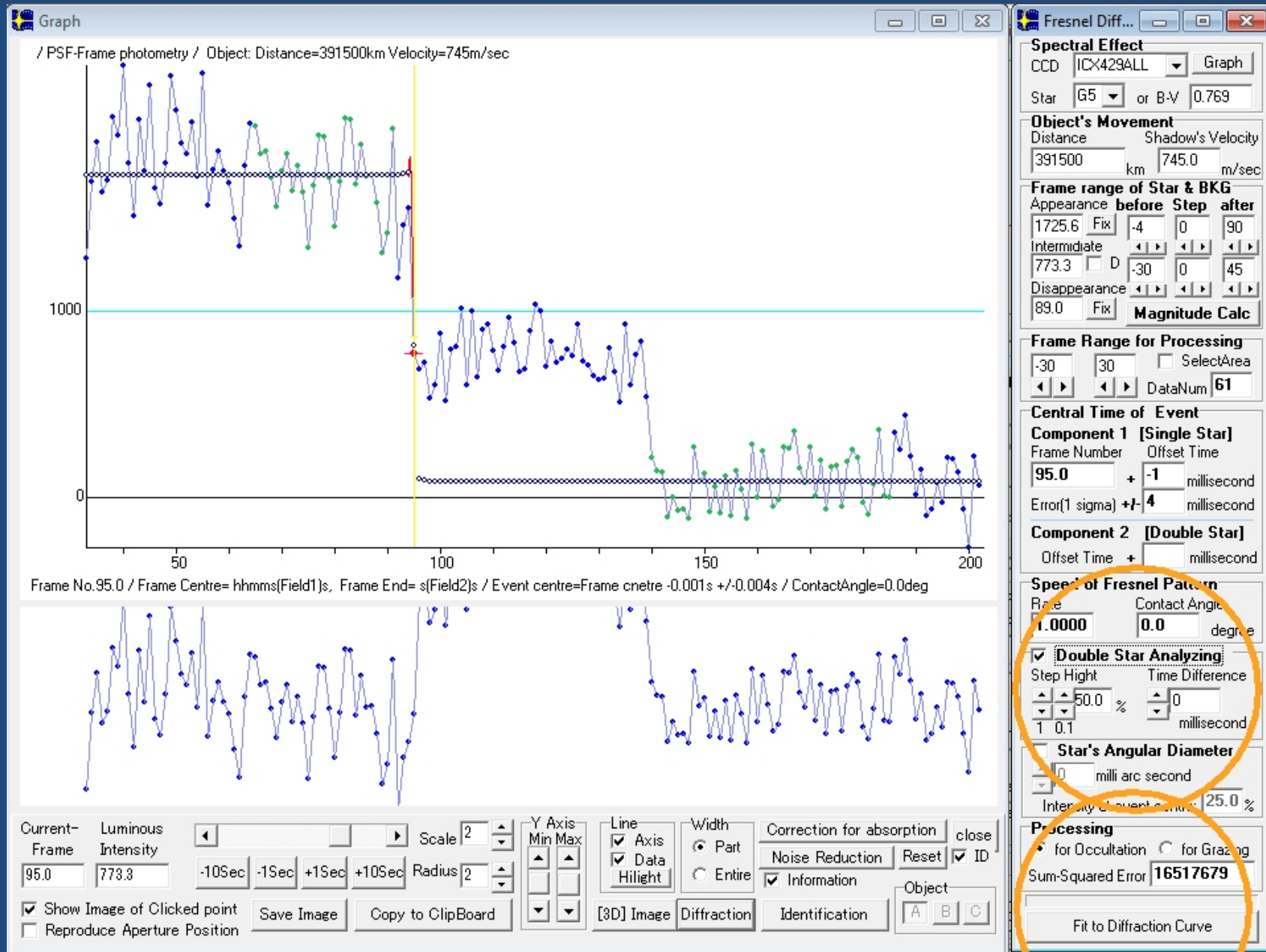
Analysing the disappearance of double star XZ 13791 and XZ 113062



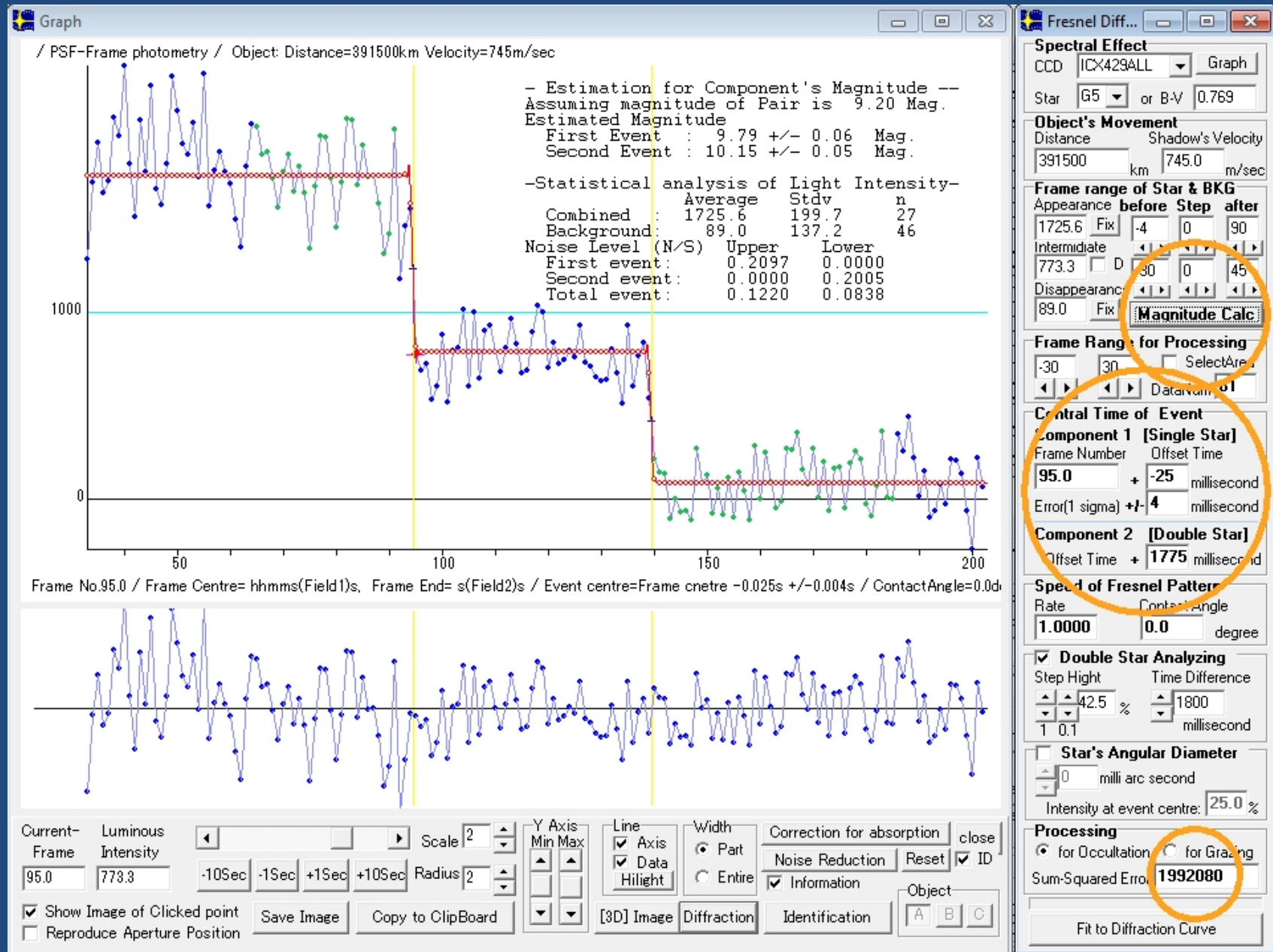
Analysing the disappearance of double star XZ 13791 and XZ 113062



Analysing the disappearance of double star XZ 13791 and XZ 113062



Analysing the disappearance of double star XZ 13791 and XZ 113062



Analysing the occultation of a double star

Timings

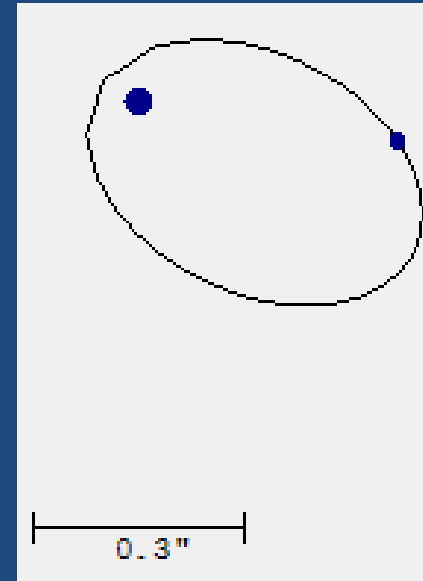
- Mid-point of frame
- 1st component: offset time (ms)
- 2nd component: offset time (ms) + interval
- Instrumental delay: Gerhard Dangl

Reporting the occultation of a double star

- Use Observations Report option in *Occult*
- Validate report with local coordinator
- Submit reports around Full Moon
- Total occultation report to lunoccult@iota-es.de
- Double star report to palbrl@clear.net.nz

Estimating the position angle (PA) and separation of a double star

- Combine observations from 2 or more locations
- Within the same lunation
- Within 12 months?
- *Occult* – ‘Solve for double star PA and separation’



Estimating the position angle (PA) and separation of a double star

Solve for double star PA and separation

File... with Observations ... Magnitude calculator Help Exit

Paste an observation Solve & Plot

Event
 Year Mth Day Star ID Show WDS & IF List Equivalents
 2012 5 27 S98347

Details of an observation
 T1 (secs) T2 (secs) PA rv cct limb slope
 (brighter) (fainter)
 10.22 12 92.58 0.3925 21.04 2.75
 T1 <> T2
 Year Mth Day Observer
 2013 4 19 A R Pratt
 Circumstances CA 77N %illum 63% Alt 37
 Add Replace Delete

Solution is not a 'best fit'. Change times by a small amount to estimate the error.
 Sep = $0.928 \pm 0.000''$ PA = $135.31 \pm 0.00^\circ$
 RMS fit: $0.00 \pm 0.00''$

Checked events are used for the solution

	T1	T2	T2-T1	P.A.	RV	CCT	slope	*	Year	M	D	Observer	C
<input checked="" type="checkbox"/>	14.65	17.56	2.91	174.92	0.2466	-60.48	0.25	1	2012	5	27	E. Edens	24
<input checked="" type="checkbox"/>	10.22	12.00	1.78	92.58	0.3925	21.04	2.75	1	2013	4	19	A R Pratt	77
<input type="checkbox"/>	0.00	0.00	0.00	0.00	0.0000	0.00	0.00		1600	1	1		
<input type="checkbox"/>	0.00	0.00	0.00	0.00	0.0000	0.00	0.00		1600	1	1		

Observations

Legend

- 0, 14.65, E. Edens
- 1, 10.22, A R Pratt
- 2, 0.00,
- 3, 0.00,

Limb plot, with current solution
 Plot scale Plot width = 1.93"
 S98347
 Occult 4.1.0.11
 1.93"

Estimating the position angle (PA) and separation of a double star

Double star XZ 13791 and XZ 113062

Occult

2012/05/27 – 2013/04/19

PA	Separation (arcsec)
135.3	0.924

USNO Fourth Interferometric Catalog of Binary Stars

Date	PA	Sep
1991.92	138.2	0.941

Washington Double star Catalog

Y1	Y2	N	PA	PA	Sep	Sep
1910	1995	21	139	137	0.8	0.8

Published result - example

Double star XZ 32105

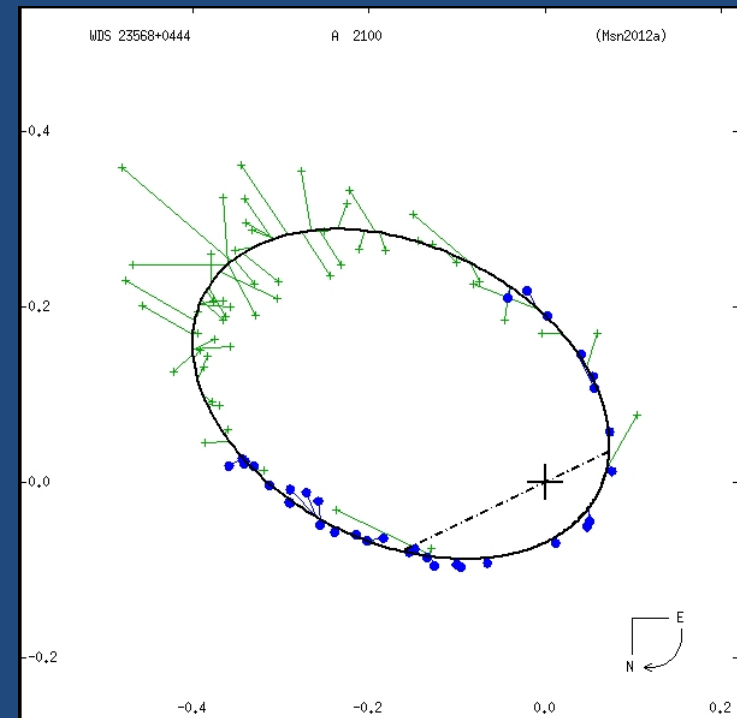
WDS name	XZ	RA Dec	PA	+/-	Sep.	+/-	Mag. diff.	Date	Observers	Note
A 2100	32105	23568+0444	260.67	1.42	0.366	0.010	1±0.3	2011.849 2011.924	AP DB	9

“Lunar Occultation Observations of Double Stars – Report #3” B. Loader *et al*
 (*Journal of Double Star Observations*, Vol 8, No 4, Oct 1, 2012)

Washington Double Star Catalog

Y1	Y2	N	PA	PA	Sep	Sep
1909	2011	91	289	261	0.2	0.4

Period 88.95 years



Summary

- Investigate known and suspected double stars
- Estimate PA, separation and magnitude differences
- Discover previously unknown double stars

With acknowledgements and grateful thanks to...

- Jan Manek (IOTA total occultations coordinator for Europe)
- Brian Loader (IOTA double star coordinator)
- Dave Herald (author of *Occult*)
- Hristo Pavlov (author of *OccultWatcher*)

"This research has made use of the Washington Double Star Catalog maintained at the U.S. Naval Observatory."