Lunar Grazing Observations

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(National Astronomical Observatory of Japan)

2023 IOTA Annual Meeting

Jul 15 and 16, 2023

Grazes Observed in 2021 (17 grazes 25 stations 280 contacts)

YR MN DY	Star	Mag	Country	Sta	Cont
2021 01 25	SAO 077355	7.5	Japan	2	20
2021 02 04	ZC 2060	6.2	Austria	1	8
2021 02 17	ZC 0315	7.3	Japan	1	8
2021 02 18	SAO 093181	8.9	Japan	1	7
2021 02 20	ZC 0670	7.7	Japan	1	16
2021 03 02	SAO 139567	7.8	Japan	1	6
2021 03 05	SAO 184044	9.3	Poland	1	12
2021 08 04	SAO 077746	8.7	Japan	1	14
2021 08 28	SAO 093238	7.8	Japan	3	24
2021 08 31	ZC 0835	7.0	Japan	2	33
2021 09 02	ZC 1049	6.8	Belgium	2	36
2021 09 25	ZC 0510	6.8	Japan	1	6
2021 09 27	ZC 0709	4.3	Italy, Russia	3	46
2021 10 10	SAO 184461	9.1	Australia	1	3
2021 10 28	SAO 080235	8.6	Japan	2	24
2021 11 29	SAO 119422	8.7	Japan	1	9
2021 12 27	ZC 1875	6.7	Japan	1	8

Grazes Observed in 2022 (16 grazes 25 stations 226 contacts)

YR MN DY	Star	Mag	Country	Sta	Cont
2022 01 08	ZC 0025	7.4	Japan	2	8
2022 01 25	ZC 2061	7.7	Japan	2	40
2022 02 24	ZC 2455	6.6	Japan	1	5
2022 03 09	ZC 0660	4.3	Japan	1	6
2022 03 09	ZC 0693	6.0	Poland	1	1
2022 03 23	SAO 184725	8.5	Japan	2	30
2022 04 05	SAO 076398	8.8	Japan	1	8
2022 04 06	ZC 0740	6.3	Japan	2	18
2022 05 06	SAO 079253	7.6	Japan	1	23
2022 07 19	ZC 0076	5.9	U.K.	1	8
2022 07 20	SAO 110215	8.3	Japan	2	12
2022 08 21	ZC 0869	7.4	Japan	2	26
2022 09 04	ZC 2480	5.2	Japan	3	10
2022 09 04	ZC 2488	6.9	Japan	2	19
2022 09 23	ZC 1484	3.5	Hungary	1	8
2022 09 23	SAO 099255	8.5	Japan	1	4

Grazes Observed in 2023 (10 grazes 15 stations 133 contacts)

YR MN DY	Star	Mag	Country	Sta	Cont
2023 01 03	ZC 0599	4.4	Japan	3	16
2023 01 10	SAO 099030	8.8	Japan	1	12
2023 01 11	SAO 099421	8.1	Japan	1	8
2023 02 01	ZC 0849	6.5	Japan	1	4
2023 02 14	ZC 2317	6.6	Canada	1	13
2023 02 25	SAO 093076	8.7	Japan	1	2
2023 02 28	ZC 0849	6.5	Germany	2	35
2023 03 13	SAO 184267	7.7	Japan	1	2
2023 04 28	ZC 1373	6.5	Japan	1	12
2023 05 22	ZC 0890	4.6	U.S.A.	3	29

ZC 2061 (mag 7.7) graze on 2022 Jan 25 in Japan

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Place name     Otsu, Shiga, Japan
Representative Masayuki Ishida

TA  CAD   20   200  +1355619.0  +345814.7  84  140  M

OA  M. Ishida

202201251650      R  2061 S G    EG G0.04            22    AA
20220125165052.76 R  2061 DDG    EG G0.04 1   B      22    AA
20220125165054.0  R  2061 DDG    EG G0.04 1   F      22    AA
20220125165255.39 R  2061 RDG    EG G0.04 1   F      22    AA
20220125165258.13 R  2061 DDG    EG G0.04 1   F      22    AA
20220125165308.44 R  2061 RDG    EG G0.04 1   F      22    AA
20220125165309.18 R  2061 DDG    EG G0.04 1   F      22    AA
20220125165315.79 R  2061 RDG    EG G0.04 1   F      23    AA
20220125165317.58 R  2061 RDG    EG G0.04 1   B      22    AA
20220125165320.12 R  2061 DDG    EG G0.04 1   B      22    AA
20220125165325.32 R  2061 RDG    EG G0.04 1   B      22    AA
20220125165325.71 R  2061 DDG    EG G0.04 1   B      22    AA
20220125165325.79 R  2061 RDG    EG G0.04 1   B      22    AA
20220125165409.64 R  2061 DDG    EG G0.04 1   B      22    AA
20220125165411.06 R  2061 DDG    EG G0.04 1   F      22    AA
20220125165412.42 R  2061 RDG    EG G0.04 1   F      22    AA
20220125165414.25 R  2061 RDG    EG G0.04 1   B      22    AA
20220125165447.44 R  2061 DDG    EG G0.04 1   B      22    AA
20220125165450.22 R  2061 DDG    EG G0.04 1   F      22    AA
20220125165453.28 R  2061 RDG    EG G0.04 1   F      22    AA
20220125165455.22 R  2061 RDG    EG G0.04 1   B      22    AA
202201251656      R  2061 E G    EG G0.04            22    AA
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Place name     Otsu, Shiga, Japan
Representative Hidehito Yamamura

TA  CAD   24   235  +1355733.7  +345748.8  84  108  M

OA  H. Yamamura

20220125165001.02 R  2061 S G    EG G                           AA
20220125165053.14 R  2061 DDG    EG G0.01 1   B      32     AA
20220125165054.08 R  2061 DDG    EG G0.01 1   F      32     AA
20220125165256.24 R  2061 RDG    EG G0.01 1   F      32     AA
20220125165258.31 R  2061 DDG    EG G0.01 1   F      32     AA
20220125165317.10 R  2061 RDG    EG G0.01 1   F      32     AA
20220125165319.23 R  2061 RDG    EG G0.02 1   B      32     AA
20220125165319.69 R  2061 DDG    EG G0.02 1   B      32     AA
20220125165323.05 R  2061 DDG    EG G0.01 1   F      32     AA
20220125165324.26 R  2061 RDG    EG G0.03 1   F      32     AA
20220125165327.36 R  2061 RDG    EG G0.01 1   B      32     AA
20220125165348.96 R  2061 DDG    EG G0.01 1   B      32     AA
20220125165351.52 R  2061 RDG    EG G0.01 1   B      32     AA
20220125165409.89 R  2061 DDG    EG G0.01 1   B      32     AA
20220125165410.95 R  2061 DDG    EG G0.01 1   F      32     AA
20220125165413.85 R  2061 RDG    EG G0.01 1   F      32     AA
20220125165415.39 R  2061 RDG    EG G0.01 1   B      32     AA
20220125165447.04 R  2061 DDG    EG G0.01 1   B      32     AA
20220125165449.71 R  2061 DDG    EG G0.01 1   F      32     AA
20220125165454.63 R  2061 RDG    EG G0.01 1   F      32     AA
20220125165456.72 R  2061 RDG    EG G0.01 1   B      32     AA
20220125165811.43 R  2061 EDG    EG G                           AA
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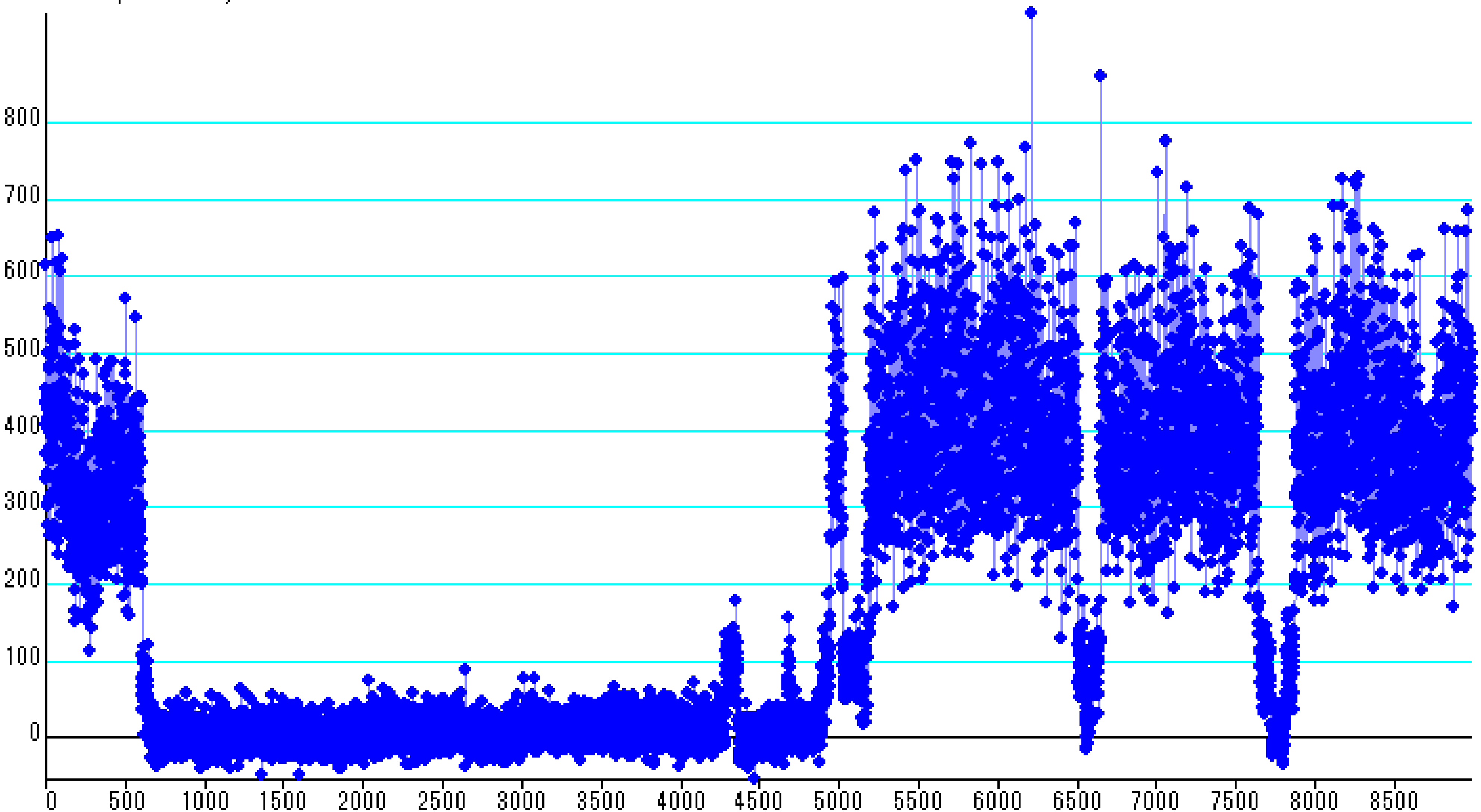
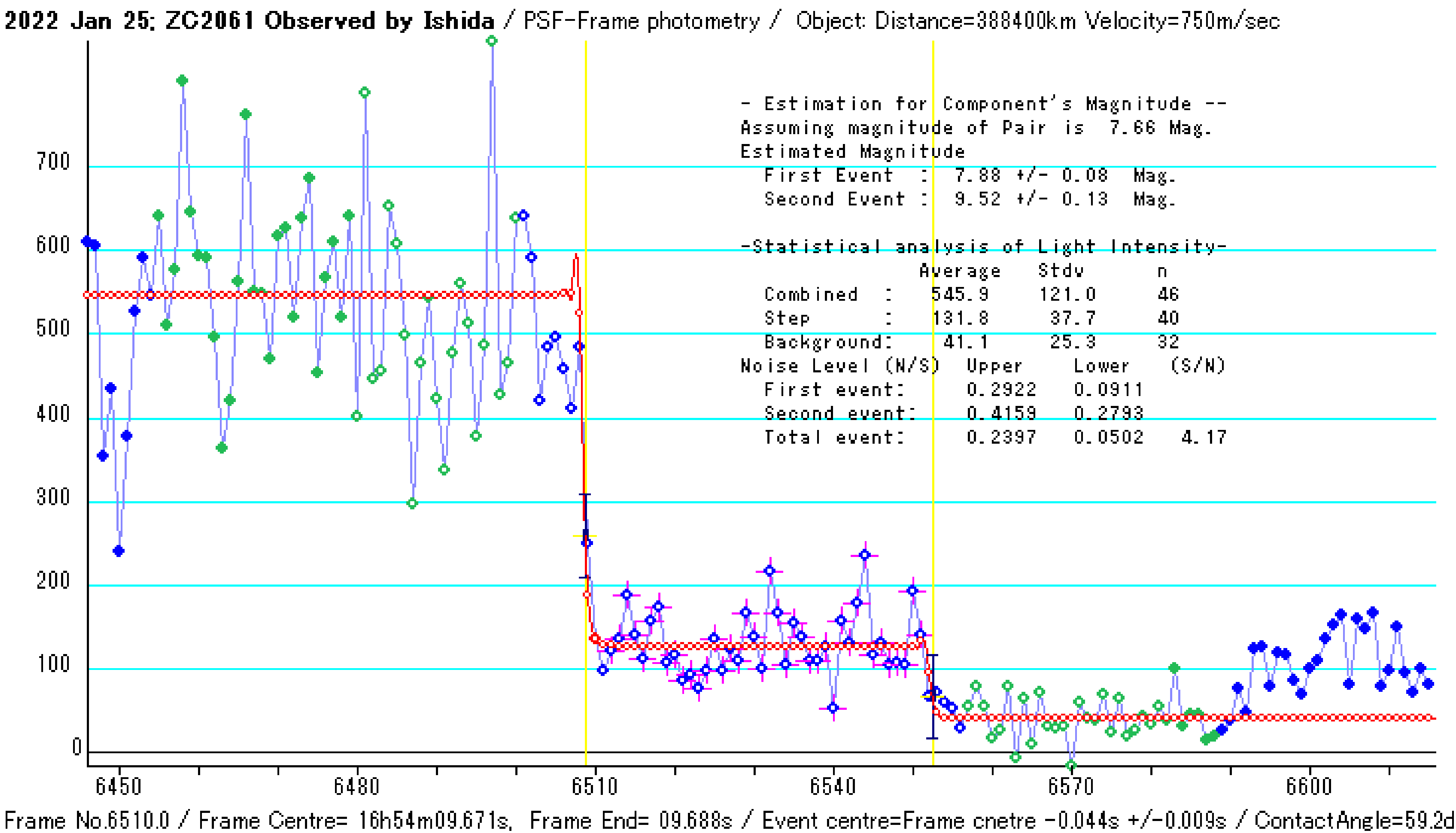
M. Ishida's observation

/ PSF-Frame photometry /



M. Ishida’s first D of primary and companion



The star’s duplicity was found in 2014 through lunar occultations by Dave Gault and Dave Herald in Australia. They showed the double star’s data as

PA=$206^{o}.28 \pm 2^{o}.06$, Sep=$0''.208 \pm 0''.009$.

These data are given in the current WDS.

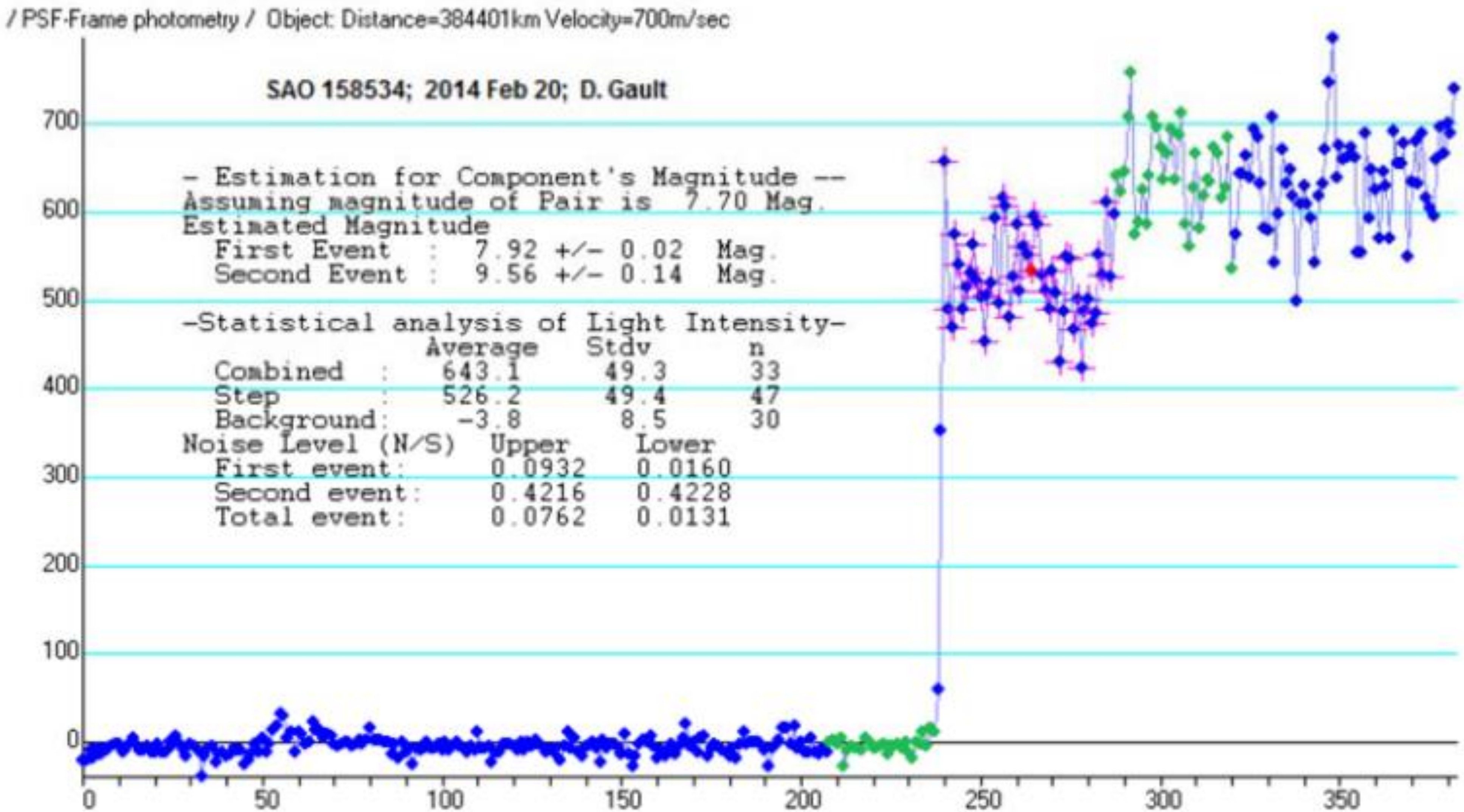
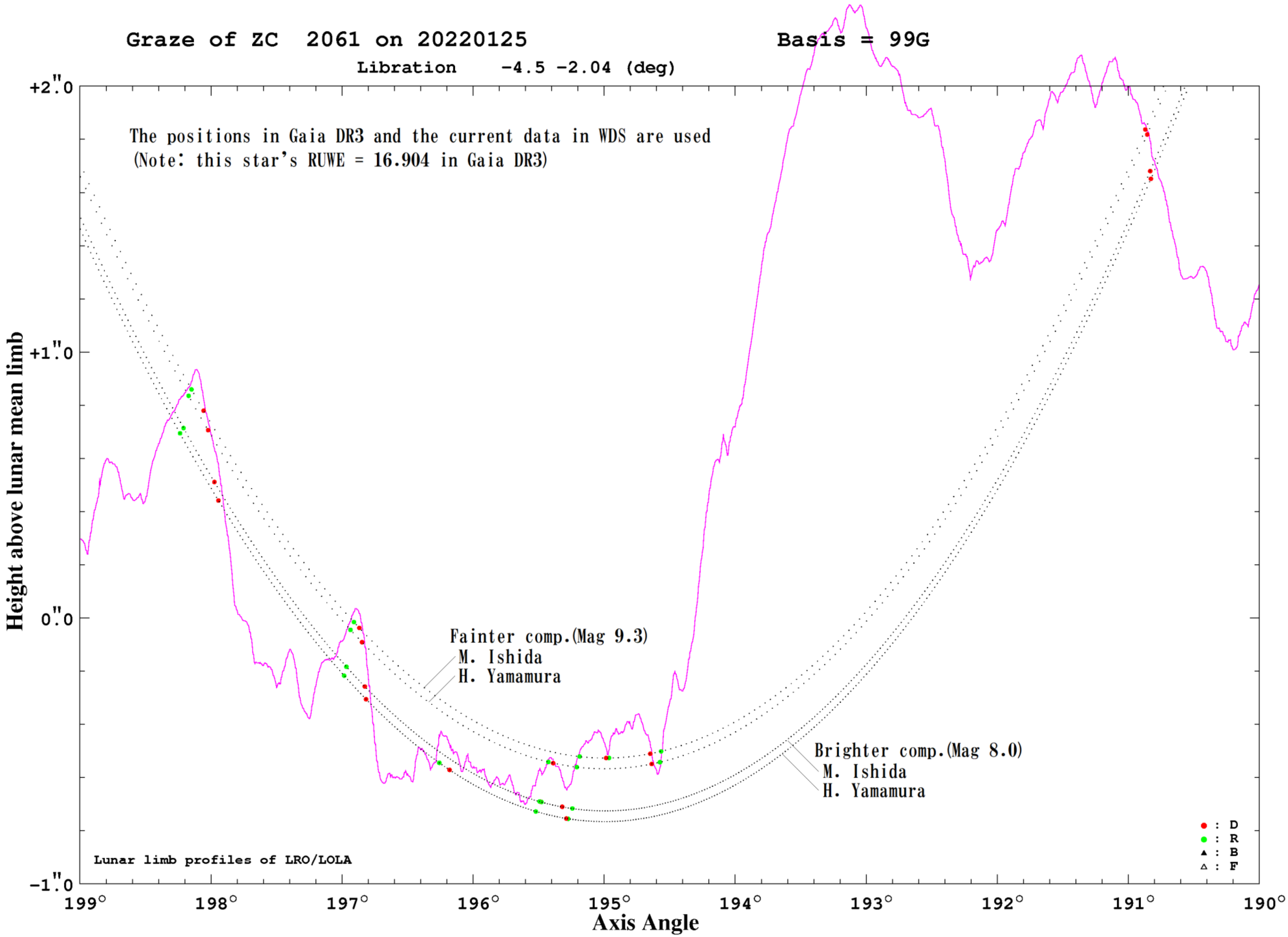


Figure 1: *Light curve for the occultation reappearance of SAO 158534 (ZC2061) obtained by D. Gault.*


Graze of ZC 2061 on 20220125
Basis = 99G
Libration -4.5 -2.04 (deg)
The positions in Gaia DR3 and the current data in WDS are used
(Note: this star's RUWE = 16.904 in Gaia DR3)
+2."0
+1."0
0."0
-1."0
Height above lunar mean limb
Fainter comp.(Mag 9.3)
M. Ishida
H. Yamamura
Brighter comp.(Mag 8.0)
M. Ishida
H. Yamamura
: D
: R
: B
: F
Lunar limb profiles of LRO/LOLA
199°
198°
197°
196°
195°
194°
193°
192°
191°
190°
Axis Angle

From analyses of the graze observations the following results about the positions of the stars were obtained:

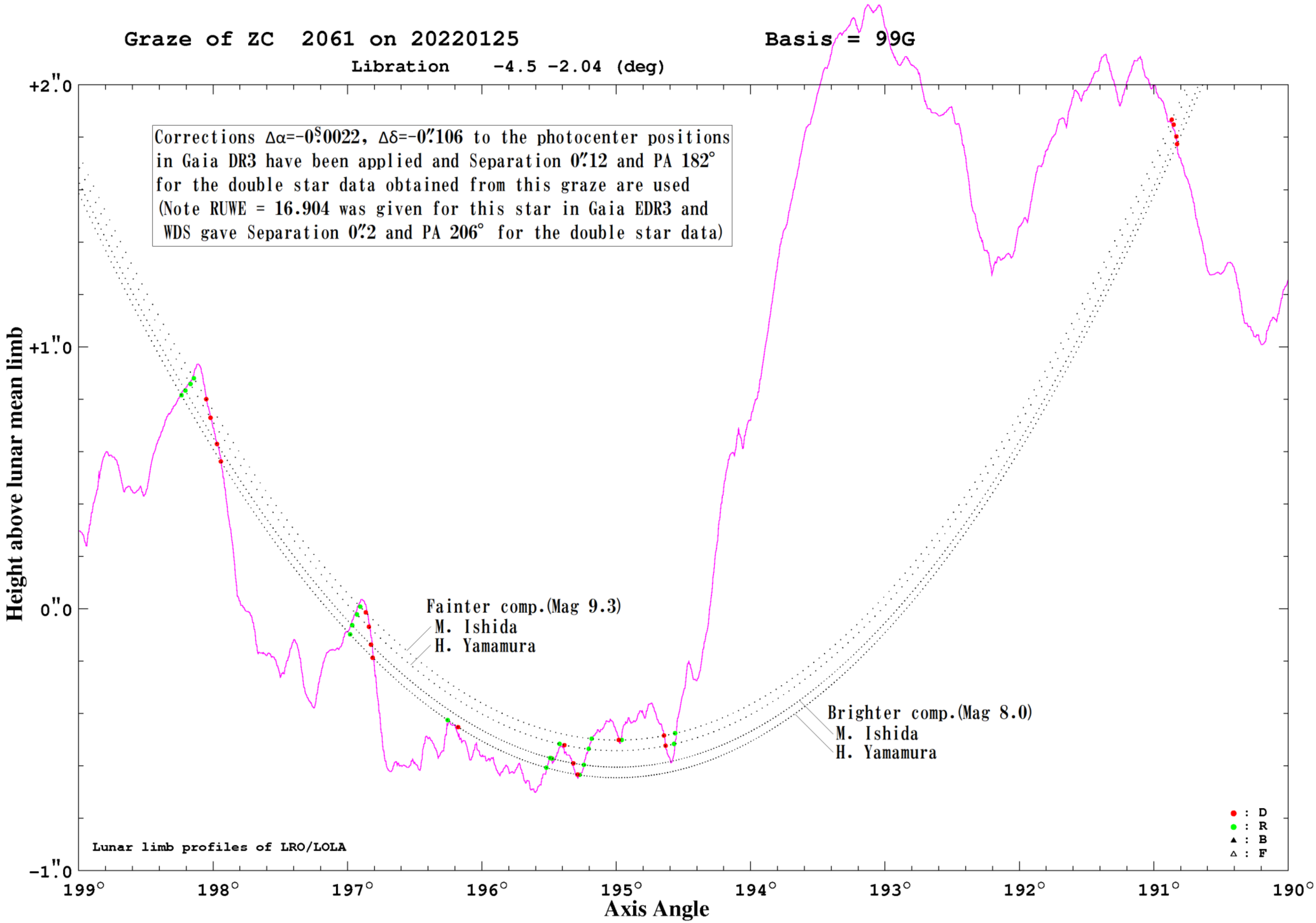
Correction to the photocenter position in Gaia DR3

$\Delta\alpha = -0^{s}.0022s \pm 0^{s}.0013$, $\Delta\delta = -0''.106 \pm 0''.009$

Double star data

PA=182$^{o} \pm 10^{o}$, Sep=0''.118$\pm$0''.011

(cf. PA=206$^{o} \pm 2^{o}$,   Sep=0''.208$\pm$0''.009 in 2014)


Graze of ZC 2061 on 20220125
Basis = 99G
Libration -4.5 -2.04 (deg)
Corrections Δα=-0ˢ.0022, Δδ=-0″.106 to the photocenter positions in Gaia DR3 have been applied and Separation 0″.12 and PA 182° for the double star data obtained from this graze are used (Note RUWE = 16.904 was given for this star in Gaia EDR3 and WDS gave Separation 0″.2 and PA 206° for the double star data)
Fainter comp.(Mag 9.3)
M. Ishida
H. Yamamura
Brighter comp.(Mag 8.0)
M. Ishida
H. Yamamura
Height above lunar mean limb
+2″.0
+1″.0
0″.0
-1″.0
Axis Angle
199°
198°
197°
196°
195°
194°
193°
192°
191°
190°
Lunar limb profiles of LRO/LOLA
: D
: R
: B
: F

ZC 1049 (mag 6.8) graze on 2021 Sept 2 in Belgium

Place name Arlon, Belgium
Representative Jean Bourgeois

TA	CED	20	200	+	55134.9	+493858.9	84	350	M
TB	NED	25	150	+	55131.7	+4939 1.5	84	353	M

OA J. Bourgeois
OB B. Goffin

2021	9	2	41917.41	R	1049	DDG	EG	0	1	S	T11	10AA
2021	9	2	41917.73	R	1049	DDG	EG	0	1	N	T11	10AA
2021	9	2	41919.37	R	1049	RDG	EG	0	1	N	T11	10AA
2021	9	2	41919.97	R	1049	DDG	EG	0	1	N	T11	10AA
2021	9	2	41930.09	R	1049	RDG	EG	0	1	N	T11	10AA
2021	9	2	41930.25	R	1049	RDG	EG	0	1	S	T11	10AA
2021	9	2	41935.89	R	1049	DDG	EG	0	1	S	T11	10AA
2021	9	2	41936.09	R	1049	DDG	EG	0	1	N	T11	10AA
2021	9	2	41939.09	R	1049	RDG	EG	0	1	N	T11	10AA
2021	9	2	41939.57	R	1049	RDG	EG	0	1	S	T11	10AA
2021	9	2	41939.93	R	1049	DDG	EG	0	1	S	T11	10AA
2021	9	2	41940.93	R	1049	RDG	EG	0	1	S	T11	10AA
2021	9	2	41942.01	R	1049	DDG	EG	0	1	S	T11	10AA
2021	9	2	41942.49	R	1049	RDG	EG	0	1	S	T11	10AA
2021	9	2	41942.89	R	1049	DDG	EG	0	1	S	T11	10AA
2021	9	2	41944.41	R	1049	RDG	EG	0	1	S	T11	10AA
2021	9	2	41947.57	R	1049	DDG	EG	0	1	S	T11	10AA

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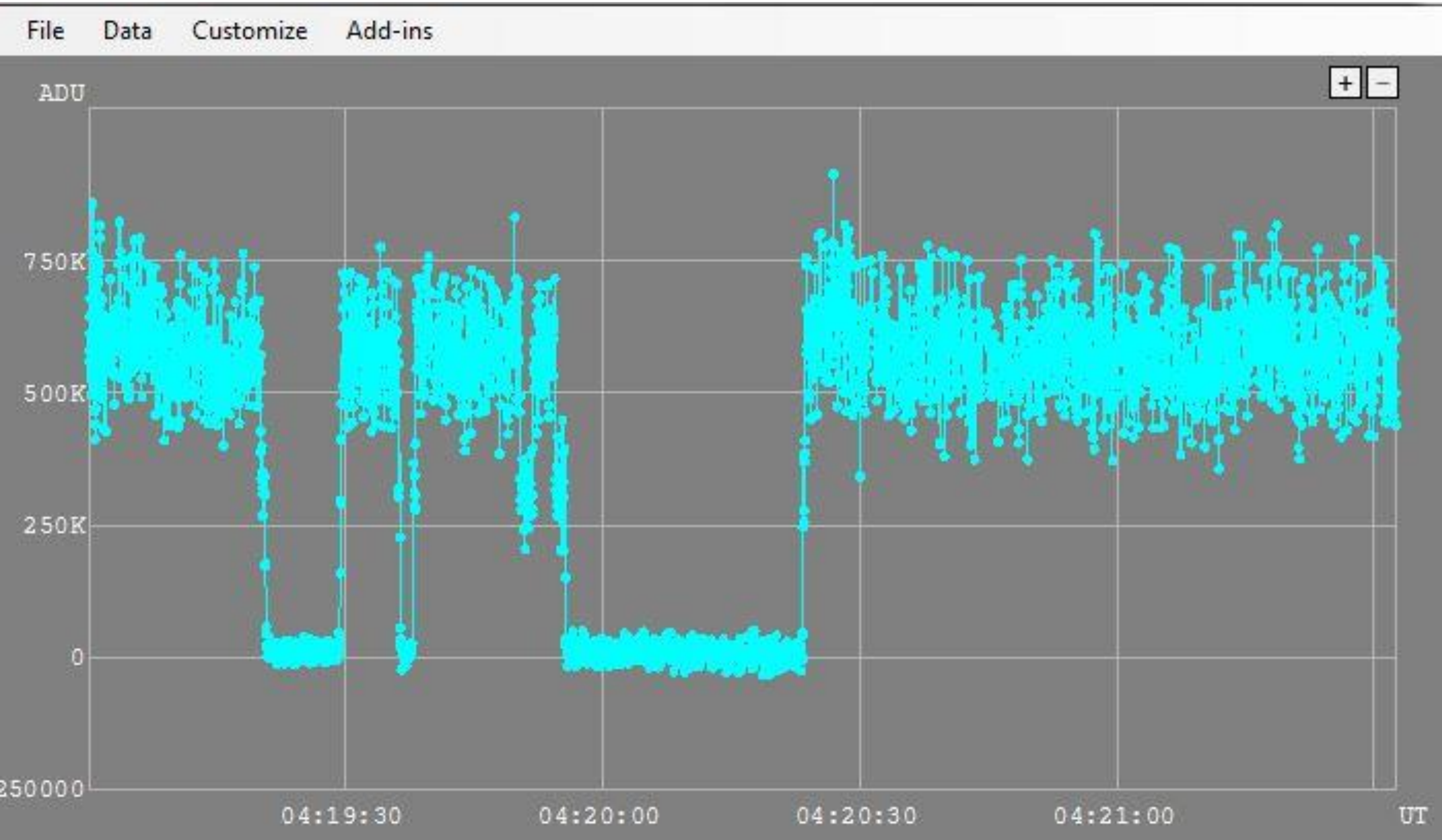
ZC 1049 (mag 6.8) graze on 2021 Sept 2
B. Goffin's light curve



ZC 1049 (mag 6.8) graze on 2021 Sept 2
Part of J. Bourgeois's light curve

Analyses gave the following results
(light curves were analyzed by Hidehito Yamamura, Hayato Watanabe, and Hidetoshi Yoshida):

Mag. N=7.29, S=7.78 (combined mag 6.75 assumed)

Correction to the photocenter position in Gaia DR3

$\Delta\alpha = -0^{s}.0012s \pm 0^{s}.0013$, $\Delta\delta = -0''.059 \pm 0''.004$

Double star data

PA=118°, Sep=0”.037

ZC 709 (mag 4.3 and 7.0) graze on 2021 Sept 27 observed in Italy and Russia

(2,290km apart; PAs of central graze differ by about $7^o.3$)

Italy: 2 stations by B. Gaehrken

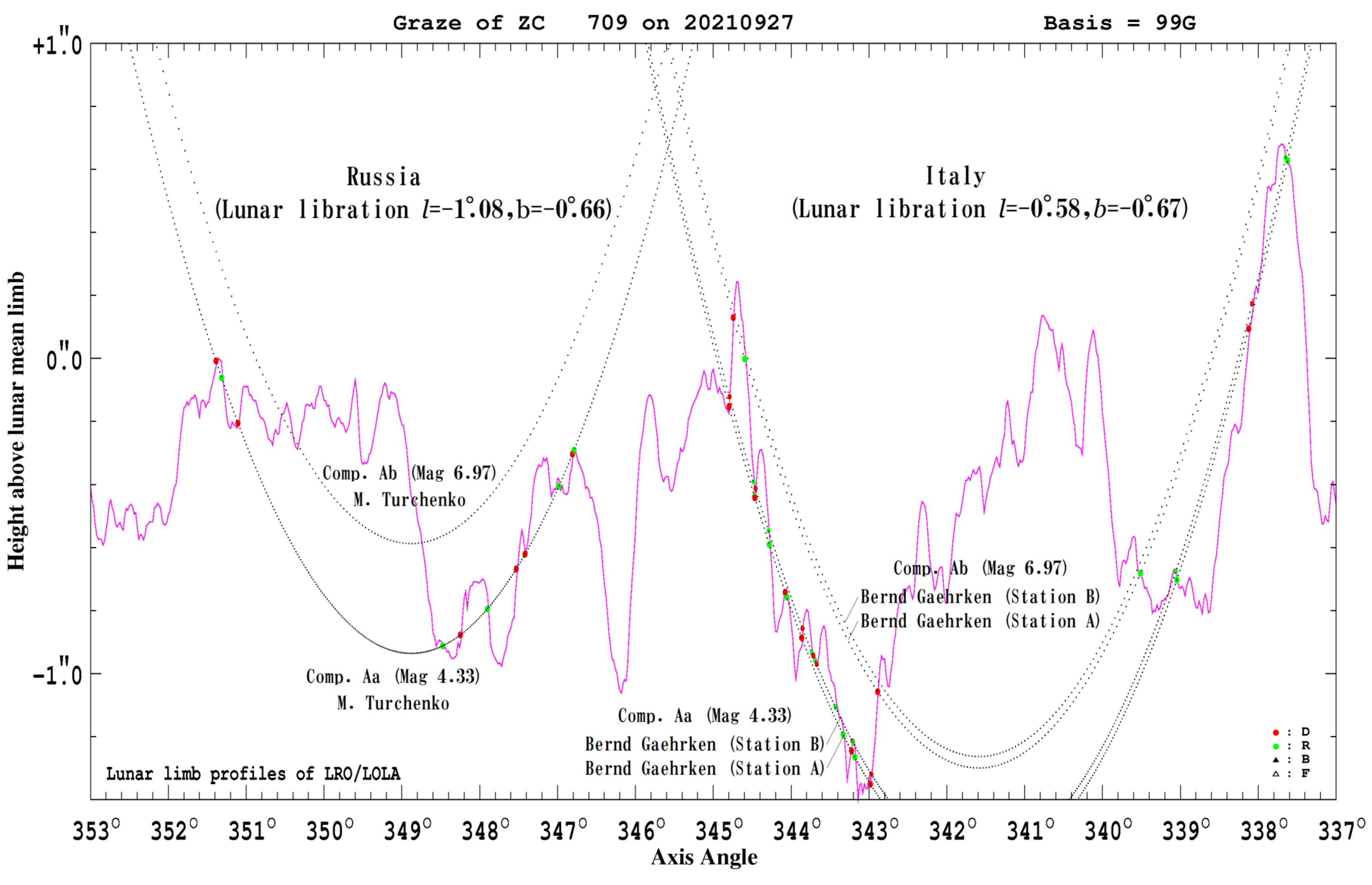
30 contacts for primary, 4 contacts for comp.

Russia: 1 station by M. Turchenko

12 contacts for primary

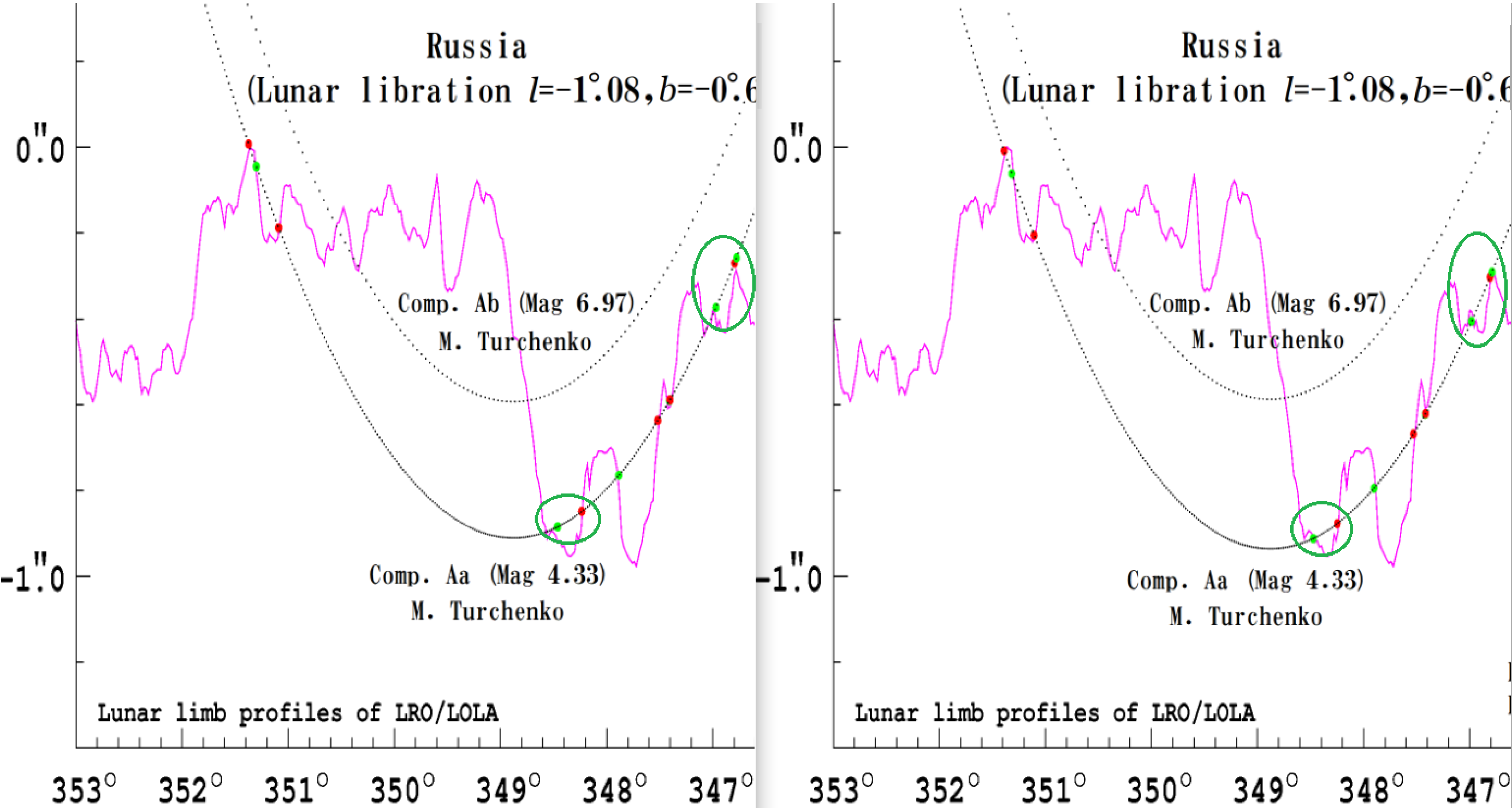
This binary's orbit is given in *"Sixth Catalog of Orbits of Visual Binary Stars"* which gives Sep 0".332, PA $359^o.8$ at the time of the graze. These data were found to be good.

Corrections to the photocenter position in Gaia DR3 were found to be $\Delta\alpha = +0^s.0159$, $\Delta\delta = +0''.045$.

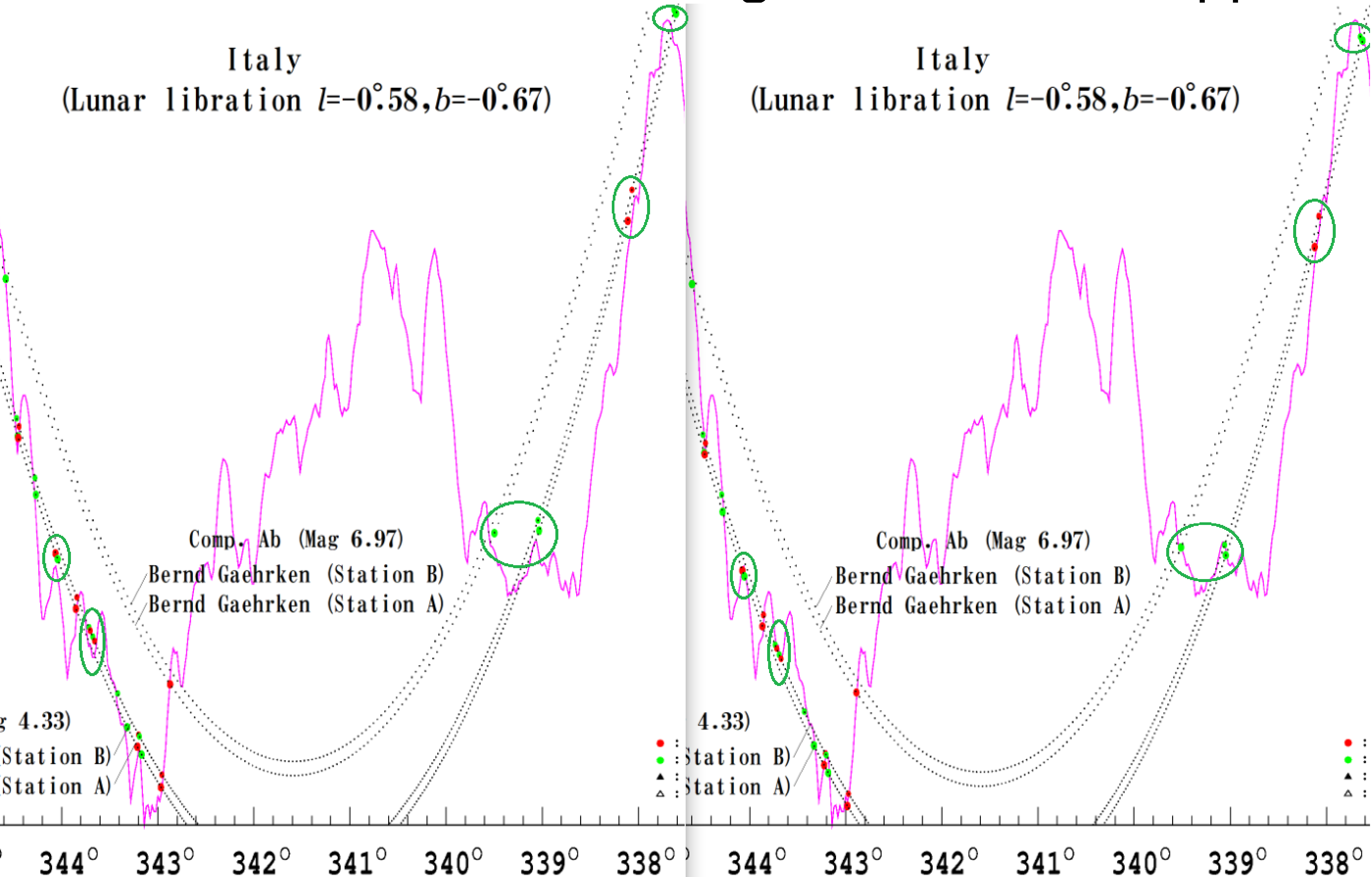


Graze of ZC 709 on 20210927
Basis = 99G
Russia
(Lunar libration l=-1°.08,b=-0°.66)
Italy
(Lunar libration l=-0°.58,b=-0°.67)
Comp. Ab (Mag 6.97)
M. Turchenko
Comp. Aa (Mag 4.33)
M. Turchenko
Comp. Ab (Mag 6.97)
Bernd Gaehrken (Station B)
Bernd Gaehrken (Station A)
Comp. Aa (Mag 4.33)
Bernd Gaehrken (Station B)
Bernd Gaehrken (Station A)
Lunar limb profiles of LRO/LOLA
: D
: R
: B
: F
Height above lunar mean limb
+1".0
0".0
-1".0
353° 352° 351° 350° 349° 348° 347° 346° 345° 344° 343° 342° 341° 340° 339° 338° 337°
Axis Angle

Left: Gaia DR3 Right: Corrections applied



Left: Gaia DR3   Right: Corrections applied



Summary

The 3 examples of graze analyses show that the positions of the stars in Gaia DR3 can have significant errors. All 3 stars showed here happen to be double, but our analyses show that positions of single stars can also have significant errors in Gaia DR3. Therefore observations of lunar occultations are still valuable not only to find and get double star data but also to analyze such positional errors.

Number of grazes since 2021 according to countries

Country	No. of grazes	Country	No. of grazes
Japan	32	Germany	1
Poland	2	Hungary	1
Australia	1	Italy	1
Austria	1	Russia	1
Belgium	1	U.K.	1
Canada	1	U.S.A.	1

(2021 January－2023 June)