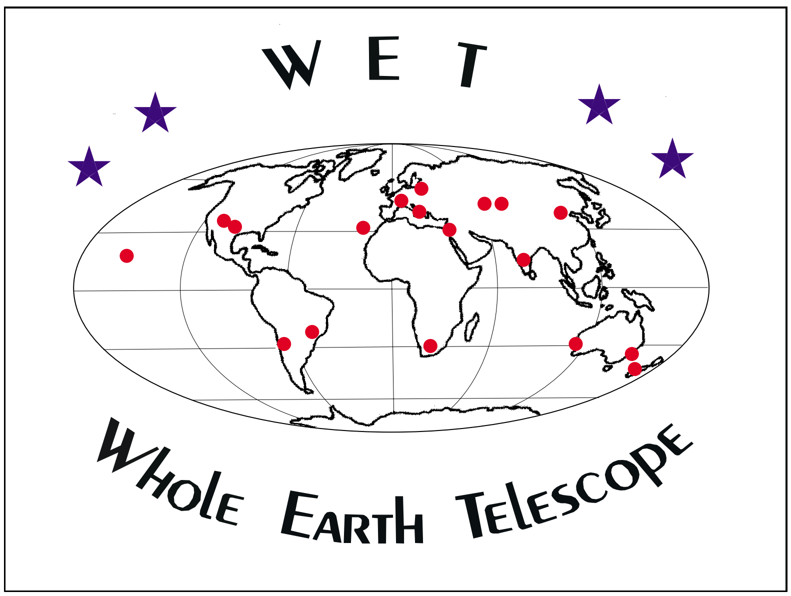
ASTRONOMICAL OBSERVATORY OF VILNIUS UNIVERSITY

HIGH-SPED THREE-CHANNEL PHOTOMETER
HSTCP

USER'S GUIDE

(To Molėtai version)



Edited by
E. G. Meištas

Vilnius, 2002

TABLE OF CONTENTS

PART A PHOTOMETER DESCRIPTION

PART USER'S MANUAL

PART A

PHOTOMETER DESCRIPTION

1. INTRODUCTION

General purpose high-speed three-channel photometer (HSTCP) is designed for the time series photometry of variable stars as well as for the multicolor photometry using UBVR and Vilnius photometric systems. Other photometric systems as Stromgren or others could be used in the photometer. The photometer conforms to main requirements of observations according to "Whole Earth Telescope" program as well as to ones of the photometry of variable stars as well as according to usual observational programs of multicolor photometry. Abbreviations and markings used in the pictures are given at the end of the paper in the **Appendix 2**, and technical data of the HSTCP - in **Appendix 3**. This photometer and the software was made at Vilnius University in Laboratory of astrophotometry of Astronomical Observatory in fruitful collaboration with people from Institute of Theoretical physics and Astronomy: R. Kalytis was the project manager, R. Skipitis - the main designer of mechanical and optical parts and many parts were machined by him too, E. Šiaučiūnas, developed main electronics and R. Janulis created the software.

2. SHORT INTRODUCING TO THE PHOTOMETER

The photometer HSTCP consists of five main parts: 1) optical-mechanical module; 2) box of electronics; 3) =24 V power supply; 4) manual control handpaddle and 5) GPS receiver. There are only few functions possible to access before the special software (AURIGA or CORVUS) are activated. Most of the adjustments are possible to make with the step-motors via the handpaddle only, which is active only when the software is loaded and initialization of the photometer is completed.

Optical-mechanical module of the HSTCP contains all necessary optical and mechanical controls to find the target and the comparison stars, to center their images in the apertures, and to apply the light of both stars and of the sky background to the photocathodes of the appropriate photomultipliers (PMTs).

The flange of the photometer attachment to the telescope contains very important mechanical device - the rotational bearing with the position limb **RL** (see this and the next features in Figs. 2, 4-6). It makes possible to use this photometer even with the telescopes which do not have their own positioning bearing. The handle **RH** is for the fine rotation of the bearing and handle **RF** is to stop the bearing in the required position for the fine rotation with the **RH**, or to release the bearing for free raw rotation by hand.

The main principle of the optical design is shown in the Fig.1. When telescope is pointed to the target star and it is centered in the aperture, photometer optical axis is on the optical axis of the telescope. To see this star in the main viewfinder (**FL** in Figs 2, 4-5) field center (on its croshair), this radially movable viewfinder position pointer **RP** must be at "0" on the position ruler **R1** (see them in Fig.5). The comparison (Ch2) star may be selected in the hatched

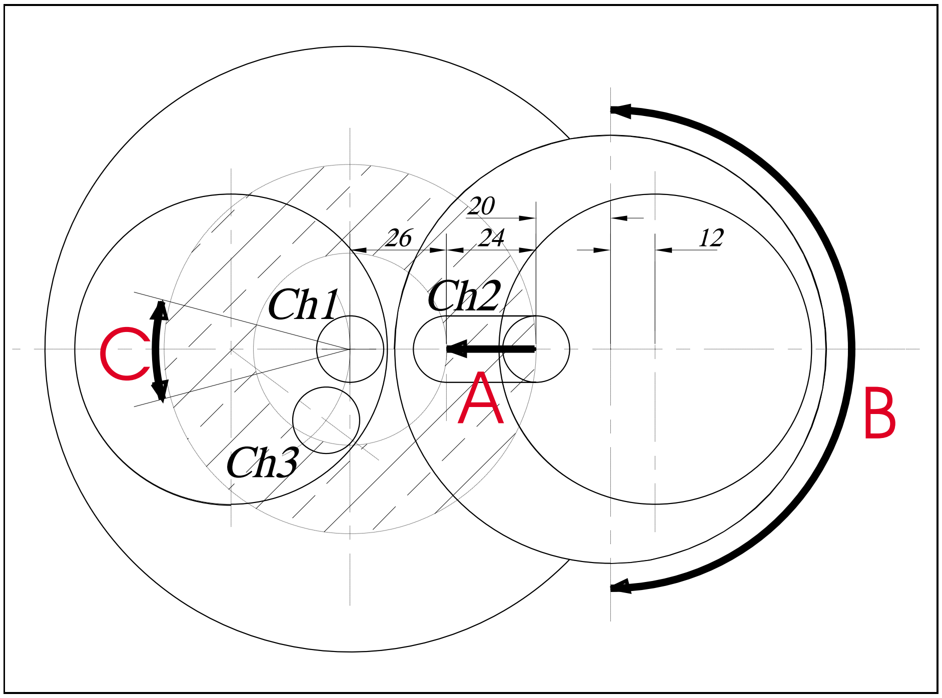


Fig. 1. The principle of the HSTCP optical design.

area, which may be searched moving the main viewfinder radially from 26 mm position till the 50 mm position of the ruler **R1** (this path is marked with thick arrow "A" in Fig.1) and the same time rotating all photometer around its optical axis using above mentioned rotator. And Ch2 optical axis can be positioned on the selected star beam rotating all Ch2 housing around its 12 mm offset axis to the same value on its limb as pointer **RP** showed on the main viewfinder ruler **R1** This possibility is showed with thick arrow "B" in Fig.1.

But Ch3 - the sky background channel is hard-positioned in the same housing together with the Ch1. Because their distance is not changeable, after Ch1 and Ch2 positions are fixed, Ch3 is looking to some accidental area of the sky, which may be with some "contamination". To make possible to escape from some problematic place, it is made possible rotate a bit all Ch1-3 around the Ch1 optical axis, the same time deviating Ch3 from the previous area, and selecting some more acceptable Ch3 position (this feature is demonstrated with the arrow "C" in Fig.1).

The box of the electronics could be seen at the left side of the Fig.4 (marked **PB** in Fig. 4). It contains all electric circuitry necessary for the power supply to all units of the photometer, for their control and for the data acquisition. It includes microprocessor and computer interface, step motor drivers, electronics of cooling system, low and high voltage power supplies.

=24 V power supply is standard AC/DC converter (converting ≈220 V to =24 V) operating as a main power supply of the photometer.

In the pictures (Figs. 2, 4-8) one can introduce to all controls of the photometer: starting from the rotator bearing, through the field lens (the main viewfinder) and aperture microscopes, and finishing with the signal outputs at the amplifiers-discriminators.

It is very important even at the first introduction already to locate the handles **SH1** and **SH2** (shown in Fig.7) of the shutters on both Ch1-3 and Ch2 housings. These shutters must be closed at all adjustments of the telescope and of the photometer units, and must be opened only when the photometer is ready for the safe measurements.

The special attention must be paid to the three housings of the amplifiers-discriminators of this photometer **A1, A2, A3**. They are most prominent and not-too-strong mechanically units and they may be damaged by the accidental banging even with the comparatively modest force.

There is separate handpaddle (Fig.9), which may be used for the manual control of the photometer features, when observer is at the telescope.

GPS receiver is the standard receiver of signals from the Global Positioning System (GPS) and is providing standard information coming from GPS, including one PPP (pulse per second) signals for synchronization of the photometer to the Universal Time (UT).

In enlarged flange-close-pictures of the photometer (Figs. 4-7) are shown more clearly above mentioned and some other important controls to be used at the observations. They will be addressed when it will be needed in this user guide at the description of the observers actions at the positioning of the stars into the appropriate channels and at the observations.

The main measuring channel (first channel – Ch1) of the photometer is designed for the light measurement of a target star.

The second channel (Ch2) is used for the light measurement of a comparison star and can be moved and positioned in the ring field around the first channel.

The third channel (Ch3) is designated for the light measurement of the sky background and it is in one mechanical-optical unit with the first channel. It is located at the constant distance (with the possibility of small rotational deviations) from the first channel.

Light beams of all three channels can be observed with the large field eyepiece unit **FL** - the main viewfinder of the photometer. All these beems are passing 130 mm diameter central hole of rotational bearing. These light beams might directed either to this movable large field viewfinder (when the big flip-mirror **FM** is "IN" or to two diaphragm wheels (to apertures of all three channels) when the flip mirror is "OUT".

Movable large field eyepiece could be moved linearly into any position till the distance of 50 mm perpendicularly to the main axis of the telescope. Combining this movement and rotation of all photometer around the optical axis of the telescope it is possible to survey the sky field around the target star (the first channel) and to select a comparison star for the second channel in a ring-shape-field accessible for the Ch2 unit.

When the flip mirror is withdrawn, the light beams of all three channels is directed to the diaphragm wheels. The focal plane of the telescope lies at the plane of two motorized diaphragm wheels from which a field from 0.4 to 8.0 mm can be selected. Though there are three channels in the photometer, but there

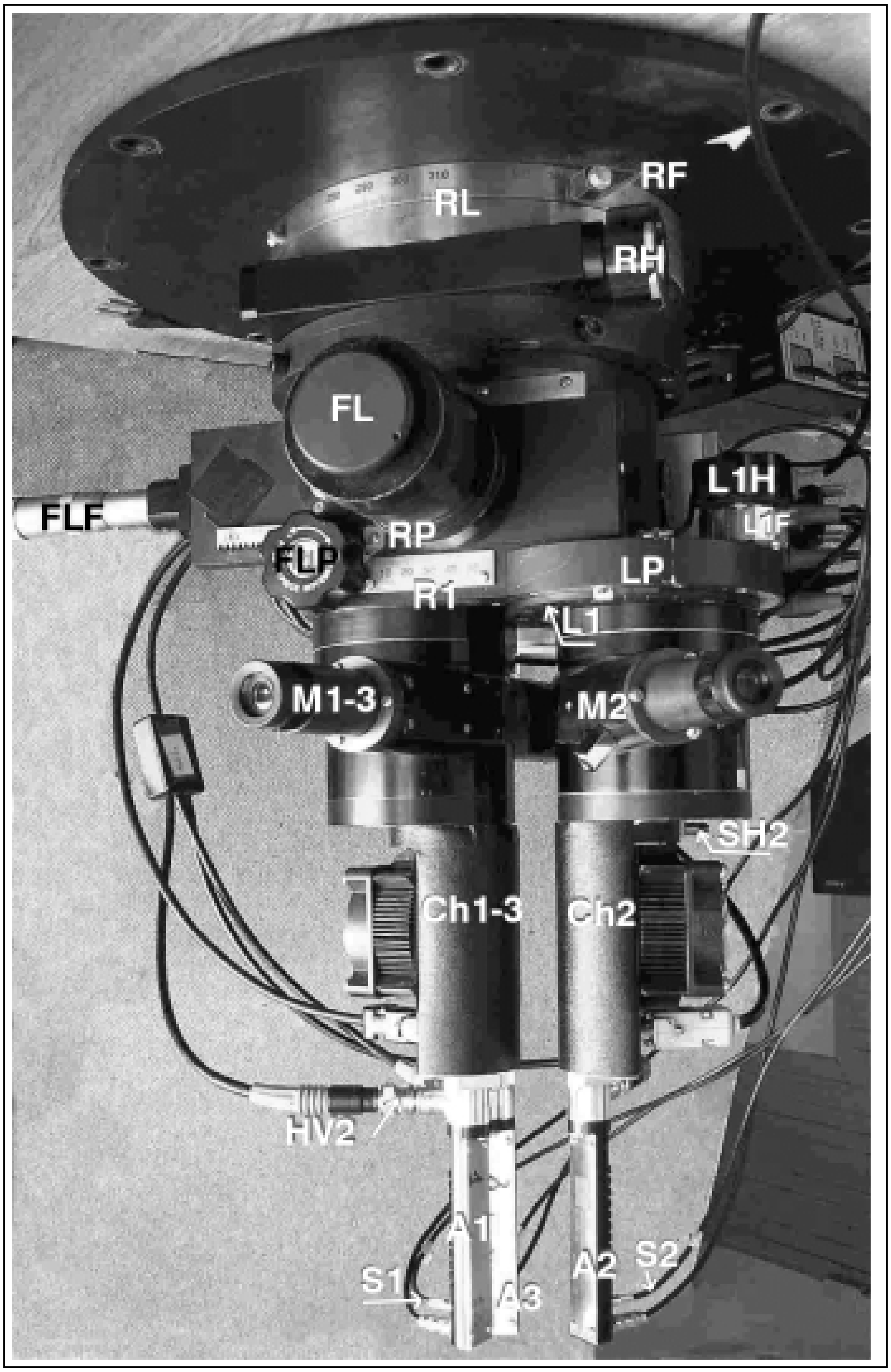


Fig. 2. The main picture of the photometer

are two diaphragm wheels only. The first one contains apertures placed in pairs for both Ch1 and Ch3, because these channel units are too close to each other to have two separate wheels, and for the movable Ch2 the second – separate diaphragm wheel is used.

After passing the apertures, the light beams of the stars are directed to the Fabry lenses of the channel units if the prism of the aperture microscope **M1-3** is not inserted. When the prism is "IN", the star light is directed to the aperture microscope. For the Ch1 and Ch3 one motorized movable prism is used. It could be set in three positions: " Ch1". "Ch3." and "withdrawn".

When the star is centered in the selected aperture, above mentioned prism is moved to the "OUT" position, and the star light beam passes to Fabry lens. After the Fabry lens star light in each channel unit is transformed into parallel light beam, which passes filters placed in two filter wheels and, at the end, as the images of the primary mirror are projected onto the photocathodes of the photomultiplier of the each channel.

PART B

(USER'S MANUAL)

3. BEFORE THE OBSERVATIONS

3.0. Controlling the instrumentation

It is recommended that the dark counts in all three channels as well as light counts from standard sources would be checked before observations. The sense of this checking is that observer must be sure that dark counts and sensitivity of the channels are the same or similar to the ones received in previous days. If the large difference in those values are observed, the reason of those differences must be found and fixed. Test of long-time (several hours) stability of both: dark and light signals should be measured, especially after instrument was not used for some time, after transportation in hard conditions, etc.

3.1. Starting the system

First of all! – it must be checked whether both shutters of Ch1-3 and Ch2 (**SH1** and **SH2** in Fig.8) are closed. At the first exercises, when studying the photometer The Low Voltage (**24 V** in Fig.4) power must be "ON", but High Voltage (**HV** in Fig.4) must be "OFF".

On the contrary, at the normal observations High Voltage (HV) stays "ON" all the time: day and night, usually. In that case the handling of the photometer must be especially careful, looking that the photomultipliers would not get too bright illumination - they can be totally damaged.

Aperture wheels, filter wheels and reflecting prisms of both microscopes are "motorized“, equipped with the step motors (five of them). It is possible to handle them only via operational computer or via the handpaddle when the data acquisition program AURIGA (for WET style time-series observations), or

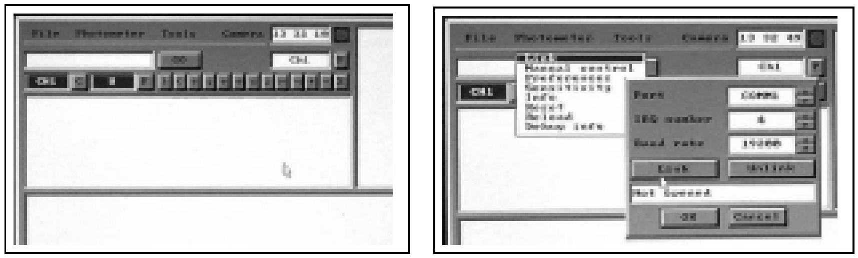


Fig. 3. Auriga's starting panel and submenu "Photometer".

CORVUS (for multicolor observations) is launched, working properly, and photometer is initialized. Except that, GPS unit must be launched too - otherwise system will use computer initial time (it is OK if exact time is not necessary, e.g. at photometer investigations).

3.2. Initialization

After the AURIGA.EXE is started, all actions of photometer initialization in the opened window must be performed via the menu and submenu commands.

First - click menu "Photometer", then submenu "Link" (Fig.3). After the linear window is on, check if everything – the port number, IRQ number, and communication speed are correct in it. Then give the command to link computer to the photometer and initialize it clicking button "Link".

If everything - the cables and powering is correct, then the progress bar appears and after it is filled in, if everything went smoothly, the software gives message "READY" in the window. To accept and to finish initialization click "OK" button.

After these actions, photometer is "alive", all systems and illuminations are working.

If something would went wrong in time of initialization, then: "Photometer" – "Link" – "Unlink" would return the system to the starting point and initialization may be restarted.

3.3. Positioning of the Ch1 and Ch2 stars and checking the Ch3

ACTION 1 - **Set the field mirror (FM in Fig.4) of the photometer to "IN" position.**

After that all star beams in the field are reflected 90° and may be watched via the main viewfinder (**FL** in Figs.1, 4-7), which can be relocated in the field in two ways — linearly with the Field Lens Position handle **FLP** and circularly, rotating all photometer around the optical axis of the telescope when the stop handle of the rotator **RF** is released.

ACTION 2 - **After the telescope is pointed to the program-star (Ch1 star) its image must be centered in the viewfinder (FL in Figs.1, 4-7)**.

But before that the ruler pointer **RP** at the viewfinder croshair position ruler **R1** must be set to the "0" value; that means that the center

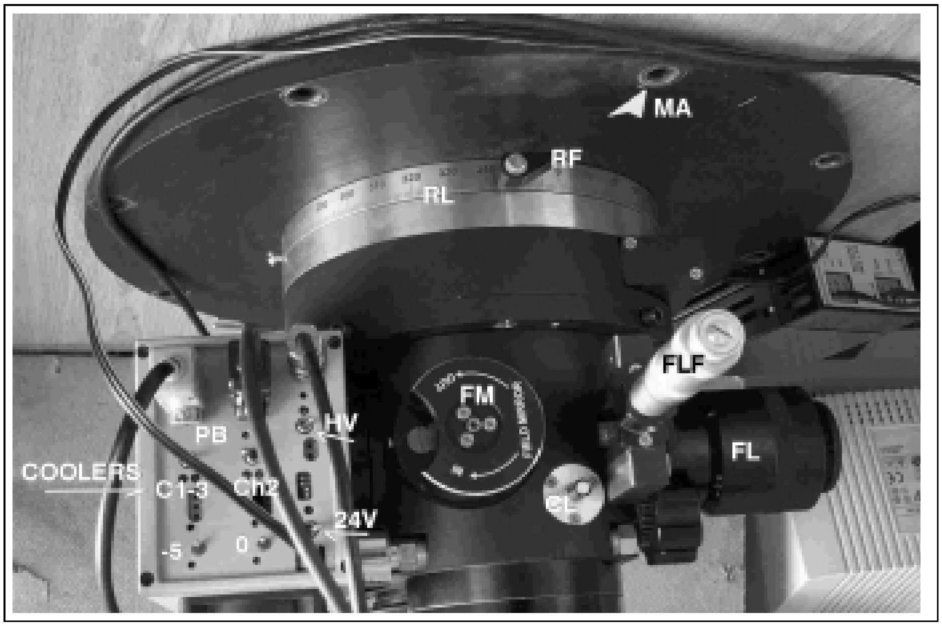


Fig. 4. The top part of the photometer (the Field Mirror Handle side).

of the viewfinder field and its croshair is pointed to the optical axis of the telescope, and if the field mirror **FM** would be "OUT" the star image would be on its way to the Ch1 aperture. If the croshair is badly or too much illuminated, there is potentiometer **CL** (Fig.4), to adjust it. It is good idea at the beginning of the observations to adjust the telescope guider so, that, when the star image is on its croshair, it is close to the viewfinder center too. This action saves lots of time at the future observations;

ACTION 3 - **When the program (Ch1) star is centered, the next step is to locate and set the comparison (Ch2) star**.

It could be done when observer is searching the suitable star manually, rotating the handle (**FLP** in Figs.2, 4-7) and the same time rotating all photometer around the optical axis of the telescope. The stop handle of the rotator **RF** must be released at that. But, if precalculated values of ruler **R1** and rotator limb **RL** are available, then much less time is necessary to set the viewfinder to the Ch2 star.

ACTION 4 - **Ch2 star setting**.

After action "3" the Ch2 star is on the crosshair of the main field viewfinder, but not on its way to the Ch2 of the photometer, if the field mirror (**FM**) would be switched to **"OFF"**. To make the final setting one must read the value of the viewfinder ruler **R1** scale at the ruler pointer **RP**, and releasing the stopper **L1F** rotate the handle of the Ch2 unit position **L1H** till the limb **L1** pointer **LP** will point to exactly the same

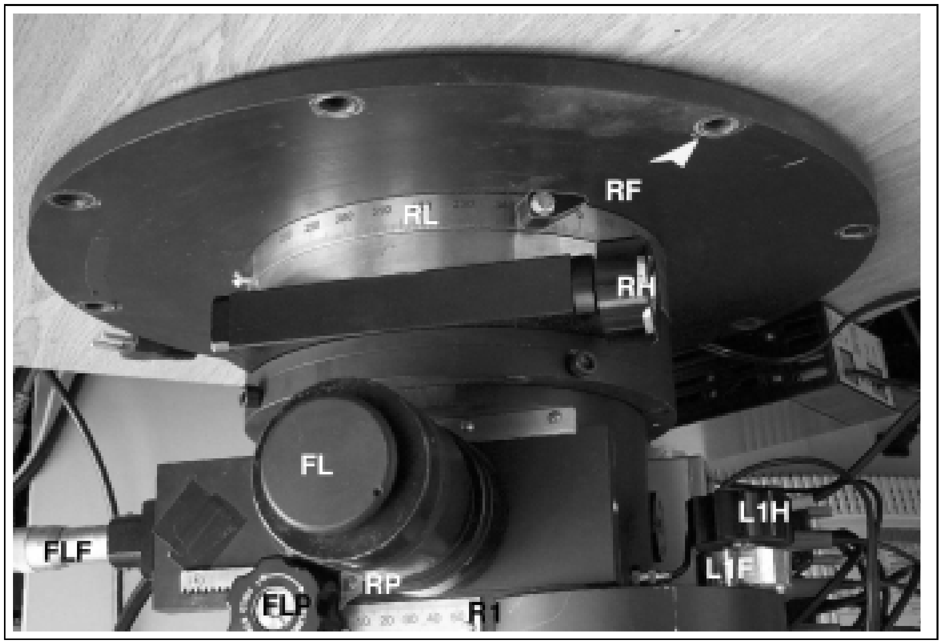


Fig. 5. The top part of the photometer (the Viewfinder side).

value as it was read on the ruler **R1**. After this action the Ch1 and Ch2 stars are set into their positions, and it is time to go to the next step - to set/center the images of the stars into appropriate apertures of Ch1 and Ch2.

It is completed job from here with the field mirror "IN". From now it must be made "OFF" with the handle **FM** (Fig. 4), to let the beams of the stars to the apertures.

3.4. Setting the apertures, centering Ch1 and Ch2 stars in them, and checking Ch3

Since the data acquisition program is working and photometer initialization is completed, it is possible to continue setting of the photometer - the aperture sizes, centering stars into them, and setting of the filters. The next few actions must be performed manually via the handpaddle (Fig.8), and the first step is to take control from the computer to the handpaddle - to press button "**ON**" of it. If interface is prepared to work with the handpaddle, indicators at "MOTOR" and "POSITION" will show some numbers in their windows. If interface is not ready for some reason (e.g. it might be still busy with some measurements) then both indicators will show "—" (dashes).

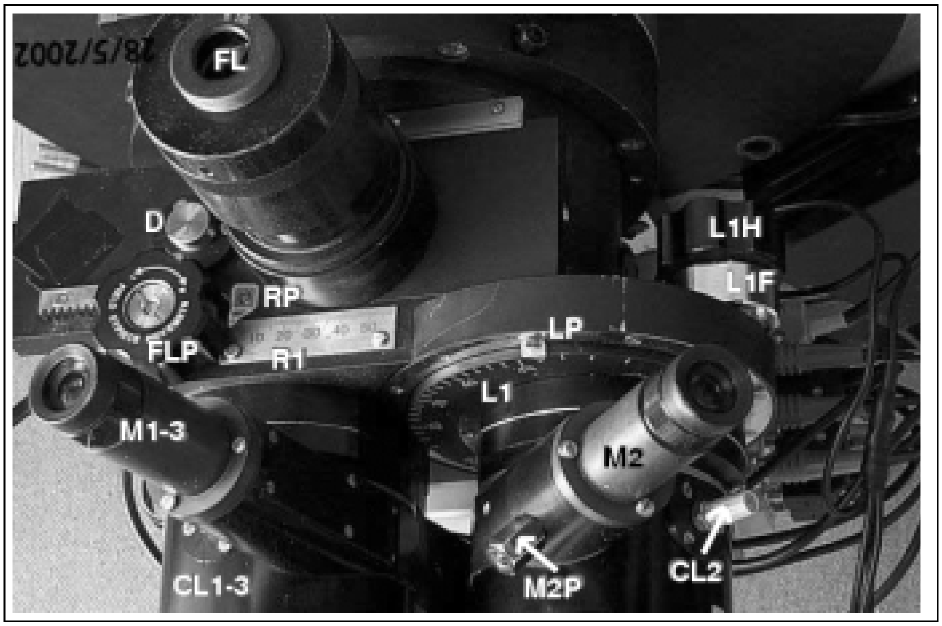


Fig. 6. The middle part of the photometer (the Viewfinder position controls).

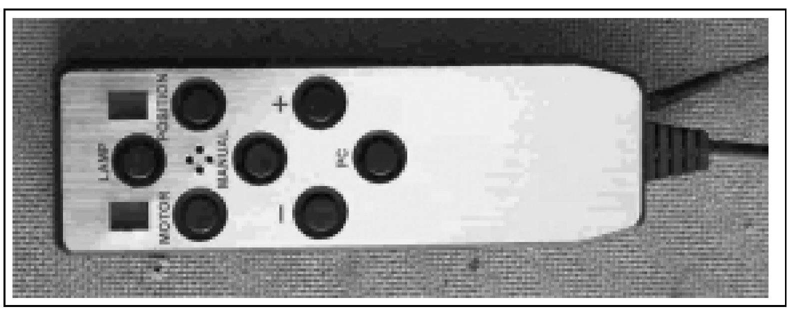


Fig. 8. The handpaddle for manual adjustments at the photometer.

In that case it is possible to force the interface to give priority to the handpaddle pressing "**OFF**", and few seconds later "**ON**". This will force interface to stop what it was doing and after some time (which it might use e.g., to save the data of the activity) and it will show some numbers in above mentioned indicators, announcing that it is ready for the manual commands. Then, with the handpaddle buttons "–" or "+" the needed step motor number could be set (numbers from 1 to 5 in the indicator), and after that, when the right button "POSITION" is pressed, with the same "–" or "+" buttons necessary position of the unit to which this engine is attached can be selected.

In Fig.9 are shown numbers of the step motors and the units, which they are handling. All meanings of the numbers in the indicator "POSITION" are

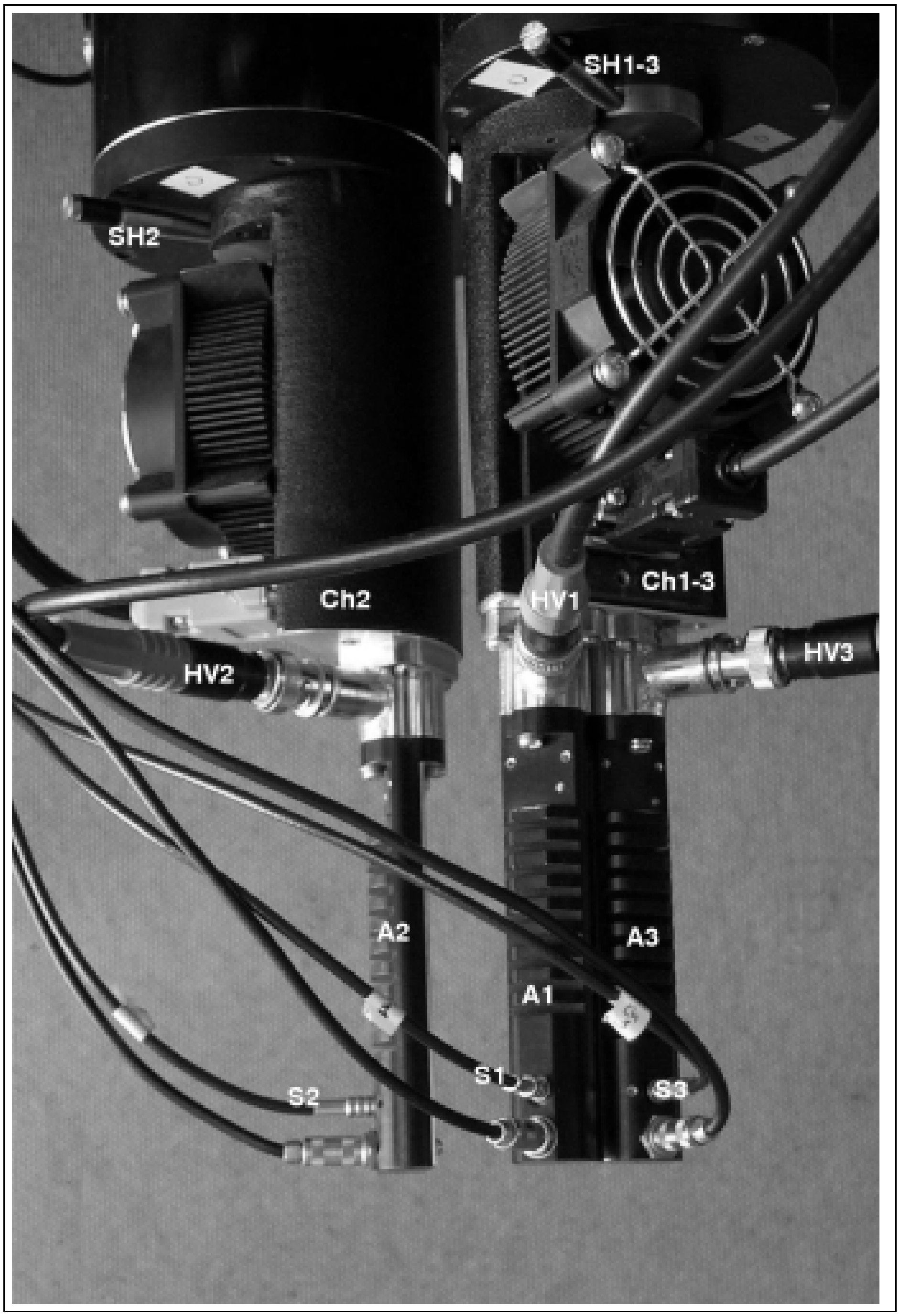


Fig. 7. The lower part of the photometer (the Channel Units).

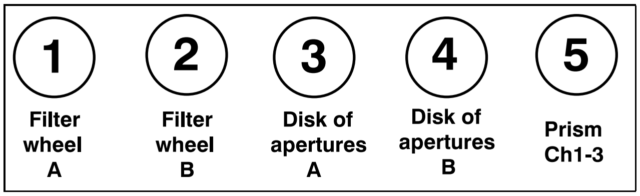


Fig. 9. The motor numbers and units, which they are controlling.

given in the tables at the end of this manual (APPENDIX 1: Position values)

The next actions assume that handpaddle is in active (”ON”) state.

ACTION 5 - **Setting the Ch1-3 microscope (M1-3 in Fig.6) prism for the centering of Ch1 (the target) star**.

Set the handpaddle motor ”5” and position ”1”. The deviating prism will reflect to the microscope small region around the optical axis of the telescope. Set the biggest (8mm) aperture: Motor ”3”, Position ”1”. Looking to the microscope ocular the target star must be seen in the field. If aperture perimeter is not enough or to much illuminated, adjust it using the potentiometer **CL1-3** (Fig.6). Move image of the star to the approximate center of this — all-microscope-field aperture. Change to 1.6mm aperture (the usual working aperture for observations with 1.65m Molėtai telescope): Motor ”3”, Position ”2”. Center the target star in this aperture too.

ACTION 6 - **Checking Ch3 if there is good (clean) background**.

Set Ch1-3 microscope prism to see the Ch3 field: Motor ”5”, Position ”2”. Looking to the microscope ocular one must investigate whether there is no obvious star in the field. The aperture there must be 1.6mm, as it was left for Ch1, because apertures in this disc are made in twine-pairs. Aperture illumination can be adjusted with the same handle as for the Ch1 aperture - **CL1-3**. If there is some obvious star, it is possible to move Ch3 slightly to the neighboring position - rotating the special deviation knob (”D” in Fig.6). But this background checking is only the starting measure. The final checking must be done at the observations — moving the telescope slightly around the region and looking to the data, whether there is no obvious changes in Ch3 readings. Do not forget to withdraw the prism from the Ch3 light path: Motor ”5”, Position ”0”.

ACTION 7 - **Centering the comparison star in Ch2**.

This channel has no motorized prism in front of the aperture microscope **M2**. It has the special handle **M2P** in Fig.6 in the housing, which may be used to set beam-deviation prism ”IN” and ”OUT” manually. For the centering of Ch2 star this prism must be ”IN”, and the Ch2 aperture wheel must be set to the biggest 8mm aperture for the beginning: on the handpaddle - Motor ”4”, Position ”1”. If there was no mistake performing ”Action 4”, the selected comparison star must be in the field. Aperture illumination may be adjusted with the potentiometer **CL2** (Fig.6) After

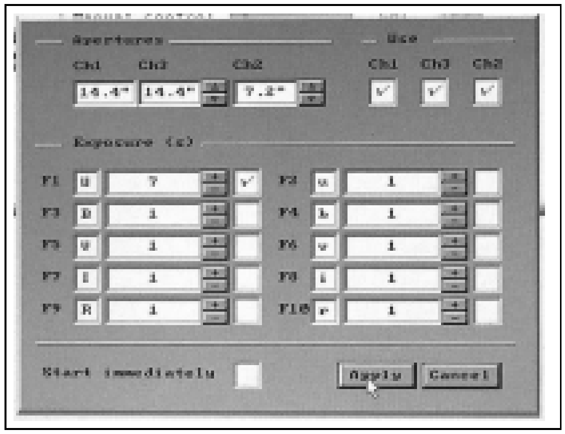


Fig. 10. The preferences set before the start of the observations.

moving it to the center of this big aperture, the aperture wheel must be changed to the same size working aperture, as it was set for the Ch1-3, to 1.6mm in our case. To have this aperture in Ch2 too, on the handpaddle must be: Motor "4", Position "5" (Table 2a in the Appendix 1). Do the final centering of the star in this aperture too. Withdraw the prism from the Ch2 light path with **M2P**

After this action photometer is ready for the time-series photometry of the selected stars.

3.5. Continuing "Auriga" program settings and data recording

Program "AURIGA" preparation for the observations:

Step 1 - The next step in preparations is setting the preferences for the data recording. Click "Photometer" – "Preferences". The panel of preferences pops down and one must fill-in the data in it according the plans of observations (Fig.10).

Step 2 - Here must be set sizes of the work-apertures for every channel, and marked the holes of the 10-hole-disk of the photometer, where the filters for this observation were placed. Even if observations were planned in the integral light, through one hole, this hole box must be marked and some name (letter) must be there. Then system will know that the filter disk must stay still at this hole and data in the data file will be marked with this fake filter letter too.

Step 3 - Computer data and time should be checked to be the recent one. If there are problems with the GPS system, then it is possible to make photometry counting on computers initial clock. Actually, the system accepted computer time after the linking and initialization procedure already. And, if computer time will be used, it should have been set to the correct time as exactly as possible before the initialization.

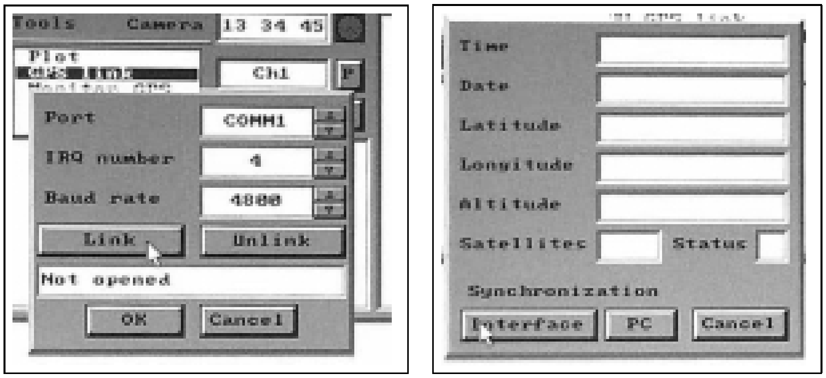


Fig. 11. Auriga's panel for the system linking to the GPS unit and the panel of the GPS preferences.

Step 4 - Much better timing may be reached if computer clock is synchronized with the GPS time signals. This may be done from the AURIGA main window: menu "Tools" – submenu "GPS Link". The "GPS Link" window shows Port number, IRQ number and communication speed. They are set according the system requirements and are accepted as they are, usually. Clicking "Link" button starts the process of computer linking to the GPS unit. When everything went smoothly message "Port ready" appears, and after "OK" the panel of GPS preferences pops down. In this panel observer can see the GPS data. If data is acceptable, and receiver "sees" enough (not less than three) satellites, then button "Interface" finishes the linking process - after ≈10s system gives the sound signal, and the blue clock icon in the right upper corner of the main Auriga's panel changes into the "happy" one with the GPS letters in it. After this procedure, it is possible to adjust computers initial clock with the GPS system too – click the "PC" button in the same panel for that. All this process may be repeated if for some reasons the linkage failed, but before that: "Tools" – "GPS Link" – "Unlink" must be performed.

Step 5 - In the AURIGA's "Notes" file must be written all necessary information related to the recent observations. It must contain the information about: the site (observatory), the telescope, the photometer, observers, weather conditions, as well as the main technical information – instrumentation operating modes (values of high voltage, cooling mode,), photomultipliers, software used etc.

4. AT THE OBSERVATIONS

If the above mentioned procedures are performed, then it is time to check if the Ch1 and Ch2 stars are still in their apertures and centered (use handpaddle again – as it was explained above, in actions 5 and 7).

If High Voltage is not "ON" yet, it is time to start it – the switch **HV** on the Power Box **PB** in the Fig.4.

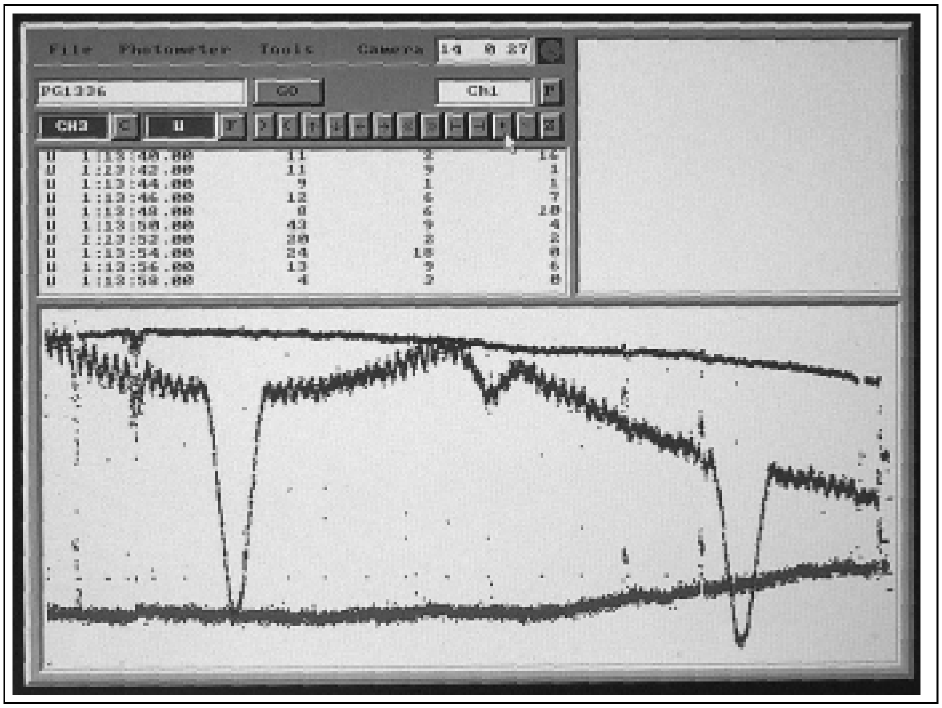


Fig. 12. Auriga's window as it is at the data floats in.

To start data counting and recording click button "**GO** in the main Auriga's panel under the menu bar. Lines of data numbers starts to show up in the upper left main panel window and the data points – in the lower window of it. If the Ch1-3 and Ch2 shutters are still closed, these numbers and point positions must be quite low - the dark counts. To start recording data of stars – open them (**SH1 and SH2** in Fig.7).

4.1. Continuous time series observations of the variable star should be executed in the following order:

Darks-1 Recording of the dark counts in all three channels (at the closed shutters of both channel units (**SH1, Sh2** in Fig.7). Must be recorded about 10 points.

Sky-1 First recording of the sky background in all three channels. Shutters - open, but stars moved ≈ 5 aperture sizes away. The best is to control this offset in the autoguiders monitor, where the size of the aperture is marked. Must be recorded about 10 points too. It is good idea to check if there were no changes in the background (Ch3 data), when images of stars were moving – it gives some understanding if there is good place for the background selected.

Stars Observations: return stars to the centers of their apertures and do recording of the data of the target star in Ch1, comparison star – in Ch2 and sky background in Ch3. Every problem with the sky or the instrumentation must be written in the log file.

Sky-2 Final recording of the sky background in all three channels. Star images must be moved approximately to the same place where they were at the first sky recording, and about 10 data points must be recorded again.

Darks-2 Final recording of the dark counts in all three channels. Close both shutters (SH1 and SH2) and record the final 10 points.

Stop Stop data recording by clicking the same **"GO"** button at the top of the Auriga's main panel. Actually this button has three functions - the mentioned start and stop of the data recording. But if after recording is stopped, and **"GO"** would be 'clicked' again, observations would be continued with the recording of the data into the same binary file which was used before. So, **"GO"** button can perform the PAUSE function too, making some gap in the recorded data.

The system records data into automatically made in-file continuously, after each integration and data does not disappear even at power failure. It is even possible to continue data writing - appending to the same file after new load and initialization of the system with menu commands: "File" – "Restore" and "GO"

5. AT THE END OF OBSERVATIONS

The binary data file, which was used for the data recording, was named by the Auriga automatically - with some letters and numbers. It is good idea to rename it at the final saving to something more informative, e.g. PG1336A.RAW. Do that with "File" – "Save As" in the Auriga's main panel, and make "File" – "Exit" to stop the Auriga.

The last action - the power switches. If it is the final observation of the campaign, or to leave power "ON" is not safe for some reason, then must be switched off the HV power and 24V power, as the last step of the observations (switches **HV, 24V** in the Fig.4).

6. RECOMMENDATIONS

1. Sky maps with the useful field circles drawn on them should be prepared — e.g. the field for finding of the accessible comparison star, all field of the viewfinder eyepiece.

2. The photometer should be switched on (high voltage and cooling selected for the season) two or three hours before the observations. It is necessary for stabilizing of the sensitivity of all detection channels. The best case is if high voltage and cooling are not switched off for all run of observation – all nights and days.

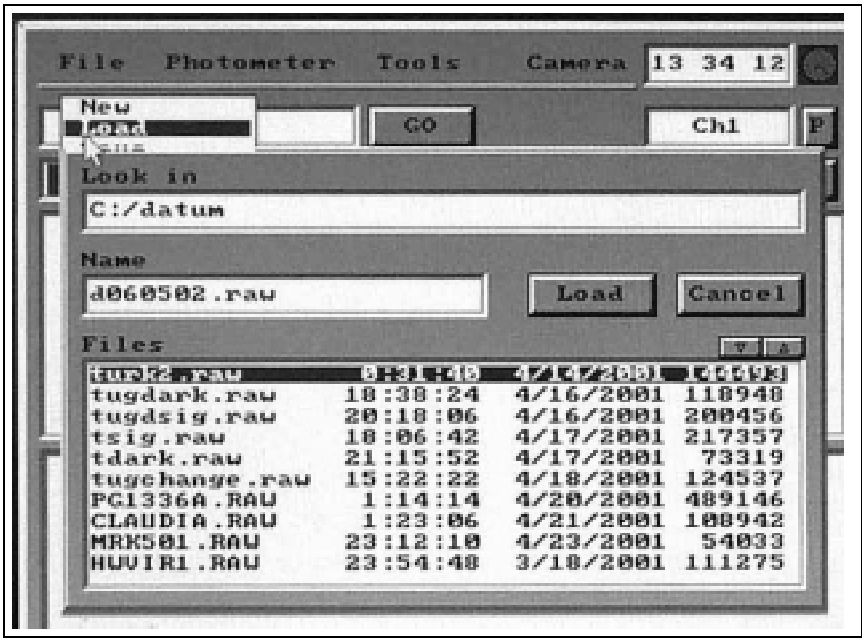


Fig. 13. Auriga's window with the final savings of the data.

3. Dark counts without cooling and with cooling should be checked every evening after switching the photometer "ON", before the start of observations and after the observations. Comparing these values with the ones received in the previous days, makes possible to control the system stability.

4. It is good idea to check the signal counts from standard sources (SS) in all channels periodically.

APPENDIX 1: Position values

In the next few tables it is explained what means the position number in the right indicator above the word "POSITION" on the handpaddle.

When the "MOTOR" value is "1", then "POSITION" number means that in front of the Ch1 and Ch3 are placed such a filters of the filter wheel "A" (Table 1a.):

Table 1a. The positions and names of filters in filter wheel "A" of Ch1/Ch3

Position in the wheel	Filter name
1	U (Johnson)
2	B (Johnson)
3	B (Johnson)
4	V (Johnson) for S20
5	V (Johnson) for S20
6	R (Cosins) for S20
7	R (Cosins) for S20
8	–
9	–
10	U (Johnson)

When the "MOTOR" value is "2", then "POSITION" number means that in front of the Ch1 and Ch3 are placed such a filters of the filter wheel "B" (Table 1b.):

Table 1b. The positions and names of filters (UBVR filter set) in filter wheel "B" of Ch2

Position in the wheel	Filter name
1	U (Johnson)
2	–
3	B (Johnson)
4	–
5	V (Johnson) for S20
6	–
7	R (Cosins) for S20
8	–
9	–
10	–

When the "MOTOR" value is "3", then "POSITION" number means that in front of the Ch1 and Ch3 are placed apertures of such a size (Table 2a.):

Table 2a. Positions and diameters of apertures in aperture wheel "A" of Ch1/Ch3

Position in the wheel	Diameter (mm)	Diameter in arcunits 1.65 m Molėtai tel.
1	8.0	1'.4
2	1.6	16".8
3	1.6	16".8
4	1.1	11".5
5	1.1	11".5
6	0.8	8".4
7	0.8	8".4
8	0.6	6".3
9	0.6	6".3
10	Standard Light Source	

When the "MOTOR" value is "4", then "POSITION" number means that in front of the Ch2 are placed apertures of such a size (Table 2b.):

Table 2b. Positions and diameters of apertures in aperture wheel "B" of Ch2

Position in the wheel	Diameter in mm	Diameter in arcunits 1.65 m Molėtai tel.
1	8.00	1'.4
2	6.50	1'.1
3	3.25	34".1
4	2.25	23".6
5	1.60	16".8
6	1.10	11".5
7	0.80	8".4
8	0.60	6".3
9	0.40	4".2
10	Standard Light Source	

When the "MOTOR" value is "5", then:

"POSITION" number "1" means that the prism in the Ch1-3 microscope (**M1-3** in Fig.6) is positioned so, that in its ocular may be observed the Ch1 aperture picture (the target star);

"POSITION" number "2" means that the prism in the same Ch1-3 microscope (**M1-3** in Fig.6) is positioned so, that in its ocular may be observed the Ch3 aperture picture (the sky background);

APPENDIX 2: Abbreviations and markings in the pictures

Ch1	First Channel
Ch2	Second channel
Ch3	Third channel
RF	Rotator fixator
RL	Rotator limb
RH	Rotator fine movement handle
FL	Field lens - the main viewfinder
FLP	Field lens raw positioning
FLF	Field lens fine positioning
R1	Field lens position ruler
RP	Field lens position pointer
L1	Ch2 angular position limb
LP	Ch2 limb pointer
L1F	Ch2 limb rotation stopper
L1H	Ch2 angular positioning handle
M1-3	Aperture microscope for Ch1 and Ch3
M2	Aperture microscope for Ch2
SH1	Ch1 and Ch3 shutter
SH2	Ch2 shutter
HV1, HV2, HV3	Ch1, Ch2, Ch3 High voltage inputs
A1, A2, A3	Ch1, Ch2, Ch3 amplifiers
S1, S2, S3	Ch1, Ch2, Ch3 signal outputs-inputs
CL	Field lens croshair illumination regulator
FM	Field mirror IN-OUT handle
D	Ch3 slight deviation knob
CL1-3	Ch1, Ch3 aperture illumination regulator
CL2	Ch2 aperture illumination regulator
M2P	Ch2 microscope prism IN-OUT handle
HSTCP	High-Speed Three-Channel Photometer
HV	High Voltage output
PMT	photomultiplier Tube
SS	Standard Source
UBVR	names of passbands of Johnson's photometric system

APPENDIX 3: Technical specifications of the HSTCP

Number of channels	3 (Ch1 – target star. Ch2 – comparison star. Ch3 – sky background
Distance between Ch1 and Ch2	25.3 mm to 51.4 mm
Distance between Ch1 and Ch3	20 mm
Possible deviation of the Ch3	± 2 mm
Number of filter wheels	2 (one for Ch1+Ch3 and other for Ch2)
Number of filters in each filter wheel	10 in Ch2 and 5 pairs in Ch1+Ch3
Diameter of filters	13 mm
Number of aperture wheels	2 (one for Ch1+Ch3 and other for Ch2)
Number of apertures in each wheel	10 in Ch2 and 5 pairs in Ch1+Ch3
Diameters of apertures	0.4 to 8.0 mm (see Tables 1a and 1b)
Diameter of field eyepiece	40 mm
Number of aperture microscopes	2 (one for Ch1+Ch3 and other for Ch2)
Magnification of microscopes	$25\times$
Diameter of the field of microscopes	8 mm
Number of Fabry lenses	3
Diameter of Fabry lenses	14 mm
Focal length of Fabry lenses	34 mm
Time of the filter wheel turn:	
to the neighboring position	0.08 s
over 5 positions	0.20 s
Photomultiplier type	Hamamatsu R470P (S20)
spectral range	185 to 850nm
Photometric systems	UBVR and Vilnius
Detection mode	photon counting
Dead time of photon counters	22 ± 2 ns
PMTs cooling system	two one-stage thermoelectric coolers (one for Ch1+Ch3 and other for Ch2) with actively ventilated air heat absorber
Temperature of the PMTs	two stabilized temperatures: $-5°$C and $-15°$C which can be set according to the environmental temperature
Time synchronization system	using GPS receiver
accuracy of absolute timing	$\pm 2\mu$s
Maintenance of accuracy using only inner oscillator	± 5 ms per 12 hours

Technical specifications (cont.)

Communication between PC and interface	via RS232 port
Data transfer rate	19.2 kbd
Minimal integration time	20 ms
Power supply requirements	220 V
Dimensions of the photometer:	
height	410±5 mm
max. diameter (including microscope)	210±5 mm
max. diameter of the main frame	140±5 mm
Distance from the mounting plane of the rotational bearing to the focal plane of the photometer	200 mm
Weight	31 kg