

Offer for 1.2m Cassegrain azimuthal mounted with Primefocus

Position	Short Description
1. 1.2m Telescope	
Optics	<ul style="list-style-type: none"> - Lomo Sitall optic - 1160 mm free diameter - 1200 mm mechanical diameter - Primary focal ratio f/3, f=appr. 3500mm - RMS Spot Size below 8 micron for 400nm<math><\lambda</math><math><1000</math> for prime focus - 70mm field diameter = 1.15 degree for prime focus - f/10 Nasmyth-Focus (11600 mm focal length) dual Focus design - 2-lens field corrector afocal for Nasmyth-focus, 100mm field diameter - System accuracy L/25 RMS wavefront or better - Al+SiO₂ coating on mirrors - All refractive elements coated with an Multilayer-AR coating of R<math><0.5\%</math> for 400-700nm and R<math><1\%</math> for 400nm to 1100nm per surface
Tube	<ul style="list-style-type: none"> - Truss Tube - Lasalle main mirror support - Direct prime focus with field Derotator - Dual Nasmyth focus design with computer controlled selector. - Both foci allow the easy attachment of instrumentation to the field de-rotators at the focal planes - 2 field de-rotators on both Nasmyth-foci, capable to carry 50kg - computer controlled focusing in both Nasmyth foci and primefocus, temperature compensated - Main mirror covers motorically - Baffle light shielding to avoid direct stray light in CCD sensor
Mount	<ul style="list-style-type: none"> - AltAz mount - high accuracy friction servo-drives - external Heidenhain-Encoders with <math><0.06''</math> resolution - Servomotor Encoders with <math><0.08''</math> resolution - 3 degree per second maximum slew rate in Azimut - 3 degree per second maximum slew rate in Altitude - Eigen frequency above 10 Hz

Telescope control system and software	<ul style="list-style-type: none"> - Industrial PC, > 2,4 GHz with all necessarily PC cards, mouse and keyboard, Monitor for the TCS Autoslew - 32bit Win controll software Autoslew - Windows XP - Full vb-scripting via ActiveX possible for telescope, rotator, focus-switch and guide-camera - <4 arc seconds RMS pointing for >15 and <75 degree zenith distance (after calibration with pointing model) - <10 arc sec RMS pointing for 75<Z<85 - 85<Z<88 is possible but not advised for serious work - <0.15 arc second RMS blind guiding for >10 degree and <75 degree zenith distance over 10 seconds in 95% of all test intervals. - <0.5 arc second RMS blind guiding for >10 degree and <75 degree zenith distance over 10 minutes in 90% of all test intervals. - Software limit switch and hardware limite switch for rotation (against cable break) - Hardware limit switch for altitude (horizon limit, zenith limit) - Dome control Ascom compatible - TheSky software package (or Starry Night) - ACP Internet version for complete internet control of telescope (and camera, if MaximDL compatible driver) - Focusing, autofocus possible for supported cameras - Temperature compensation of the focus drift - large object database (NGC, IC; UGC, PK) - RA, DE input
	<ul style="list-style-type: none"> - ACL (Astronomical Command Language) for external remote control of the telescope, with RS232 or LAN - LCD-Hand-Box with integrated Micro-Controller - Automatic initialisation of the telescope - Remote controll possible via ACL-protocoll and RS232 - Compatible with all major Ascom software
Backup Electronics for fast System restore	<ul style="list-style-type: none"> - Complete and ready installed backup PC> 2.3GHz, identical to above control PC for fast change on any PC related problems - Heidenhain IK220 Card (ready installed) - Servo-Card (ready installed) - RS232 expansion card (ready installe) - Autoslew-Software installed - Backup Servoamplifier (1x) - Backup Powersupplies (48V and 12V) - Spare Motor Encoder
4. Installation	<ul style="list-style-type: none"> - Packaging - Without shippment costs - Installation of telescope - 2 weeks at customers observatory for testing and fine tuning the system to achieve the final specifications - costs without crane costs

Delivery time: 17 months

Payment details: 40% on order, 40% at shippment date, rest after installation and testing

Further description and comments

1. System Layout – AltAz Design suggestions



Some of our AltAz telescope are shown here:
90cm Uppsala (upper left)
80cm Munich (upper right)
80cm Korea Yanggu (left)

The design is mainly based on our first prototype, the Pollux 0.8m telescope which we are running now since August 2001 with great success. Now we made more AltAz telescopes which are running even better.

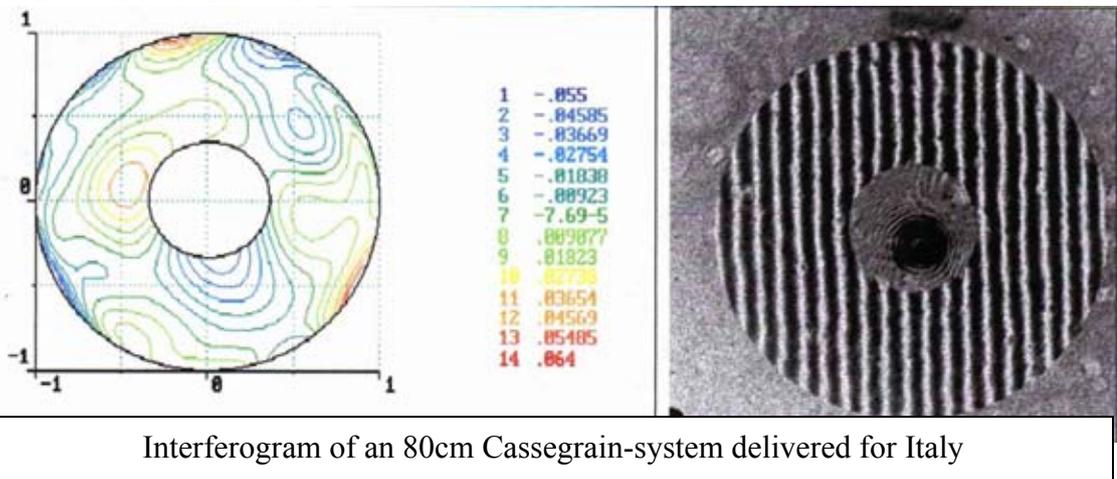
Currently we are building 2 more AltAz telescopes, a 1m for Stockholm, Sweden and a 90cm for Falera, Swiss.

The images that we made indicate, that the performance of this instrument is only limited to seeing. You can check out a lot of images with this instrument here:

<http://www.astrooptik.com/Bildergalerie/PolluxGallery/PolluxGallery.htm>

2. Optical quality

Lomo is the supplier of the optic set. We have already delivered many large sized optics (1.1m, 4x 1.2m, several 0.8m and 0.9m and many 0.6m). Lomo according to our opinion is one of the best manufacturer of large Cassegrain optics and is unbeatably regarding the price performance ratio. Both the main mirror and the complete



Interferogram of an 80cm Cassegrain-system delivered for Italy

Cassegrain-System are interferometrically tested. We think this is a superior method compared to the testing of the main mirror and secondary mirror separately. The encircled energy will be better than 80% in 0.5 arc seconds. The used material is Sitall, which is the Russian equivalent to Zerodur. There is a slight disadvantage with Sitall, which we do not want to conceal. There are nearly always some bubbles in the blank and sometimes it happens, that some small bubbles are open in the optical surface. The total area of the bubbles is so small, that it does not affect the optical performance.

3. Tube

The telescope is build in a Serrurier truss tube design. The **mirror support** is a very important point of a telescope. Our cell is made with a Lasalle-system which uses 24 points on the back side of the mirror that are all resting on small counter-weights on roller-bearings. The force of each point is optimized with FEM calculations. The residual surface error is less than 15nm. The lateral forces on the mirror are also caught by Lasalle-counterweights.

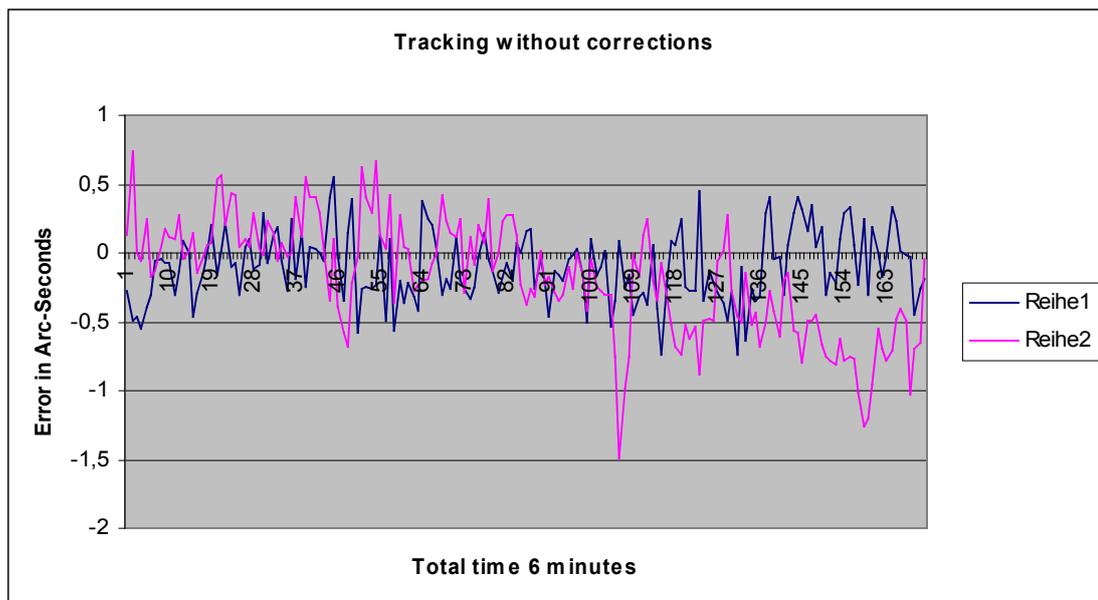
We removed a major error source now by moving the lateral supports in linear bearings. We found out, that otherwise, the mirror can be tilted by the lateral supports and decrease performance in pointing and tracking.

The field derotator is driven by means of DC-Servomotors. The derotator is driven by a large worm gear, is nearly back-lash free and the accuracy is better than 20'' (less than 10 microns for the specified field diameter).

The cleaning of the mirror can be done with the mirror left inside the tube. All the side metal sheets can be removed so you will be able to have an easy access to the mirror. This method is to be preferred in relation to other methods because you will not need to adjust the optics after cleaning. For the removal of the optics the lower part of the tube can be unscrewed and the optic can be removed with belts and a pulley-block.

4. Mount

The mount uses an Alt-Az design. The great advantage is that the fork can be made much smaller and the total telescope weight is decreased. We use a combination of friction drive together with a worm-gear to get the final reduction for the Servomotors. A slip-clutch is used to prevent any damage on the friction drive. Contrary to other manufacturers the problem to drive both axis with the right speed during tracking has been solved. The mount of Pollux has been optimized by means of FEM calculations. The measured eigen-frequency was about 15Hz. A high eigen frequency is desirably for a telescope because it means that the telescope is very rigidly. We can guarantee at least 10 Hz.



Typical tracking performance (measured with CCD, 1s update frequency, 0.9m AltAz). Most of the observed errors here is seeing. The total RMS error including seeing was 0.45 arc sec., so the instrument performance was probably much better.

To find out if the telescope is in equilibrium the drive can be de-coupled. Then counterweights can be added to put the telescope in equilibrium.

We use DC-Servomotors with 48V/10A maximum power. The electronic that drives the Servomotors uses a PID-controller that is specially modified to make a very smooth tracking even at very low frequencies.

Limiting switches are directly connected to the electronics, so even a PC-failure cannot cause any accidents. If a certain torque is exceeded (if the telescope hits any resistance) there is also an emergency stop of the Servomotors. The average power output to the motors is less than 15 Watt during tracking.

Another safety method we use is to compare the Heidenhainencoder position with the Motor-Encoder position. If the software detects a certain difference the telescope is shut down because the telescope will probably have hit some resistance.

We use a total of 2 encoders per axis to control the telescope and guarantee a safe operation:

a) Encoders at the Servo-axis

In the Pollux telescope we have used 8000 counts encoders. To achieve the high slew-rate of 8 degrees/s we have to decrease the gearing and we have to increase the encoder resolution to still have smooth tracking. Especially with the AltAz design a very high resolution at the Servomotors is crucial because of the variable tracking rates in both axes.

So in this design we will use a 16000 counts encoder and a 2500 total gearing. We will have 0.03 arc seconds per count and a maximum tracking error of about 0.09 arc seconds and a RMS value of less than 0.05 arc seconds.

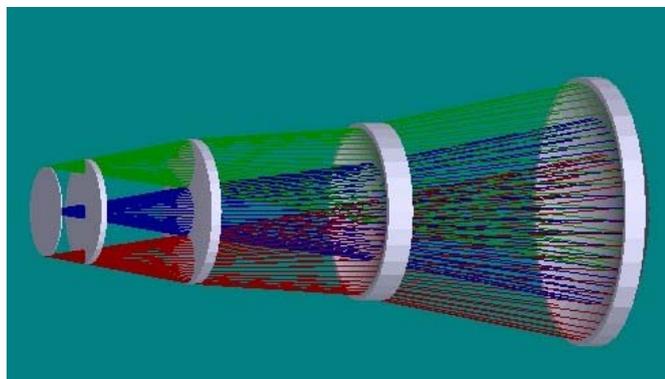
b) Heidenhain Encoder ERA 880C

These Encoders with 920mm diameter are directly attached to the telescope axis and are the same that are used in the big-size professional ESO-telescopes. These encoders have 90.000 sin-waves that are further subdivided by a factor of 4000. This gives a theoretical resolution of 0.0036 arc second. These encoders are used to make realtime-corrections of back-lash, wind-load and all gearing errors. Therefore, PEC or other software approaches are not needed (though possible)

The encoders have distance-coded reference marks in 5° distances. If the telescope is moved through 2 reference marks the telescope knows the exact Altitude and Azimuth and therefore can calibrate its position together with the exact time that is given by a DCF clock attached to the parallel port of the computer. We run through the reference mark from both directions and can calibrate the position without any star-calibration to better than 3 arc seconds. This self-alignment process takes about 1 minute.

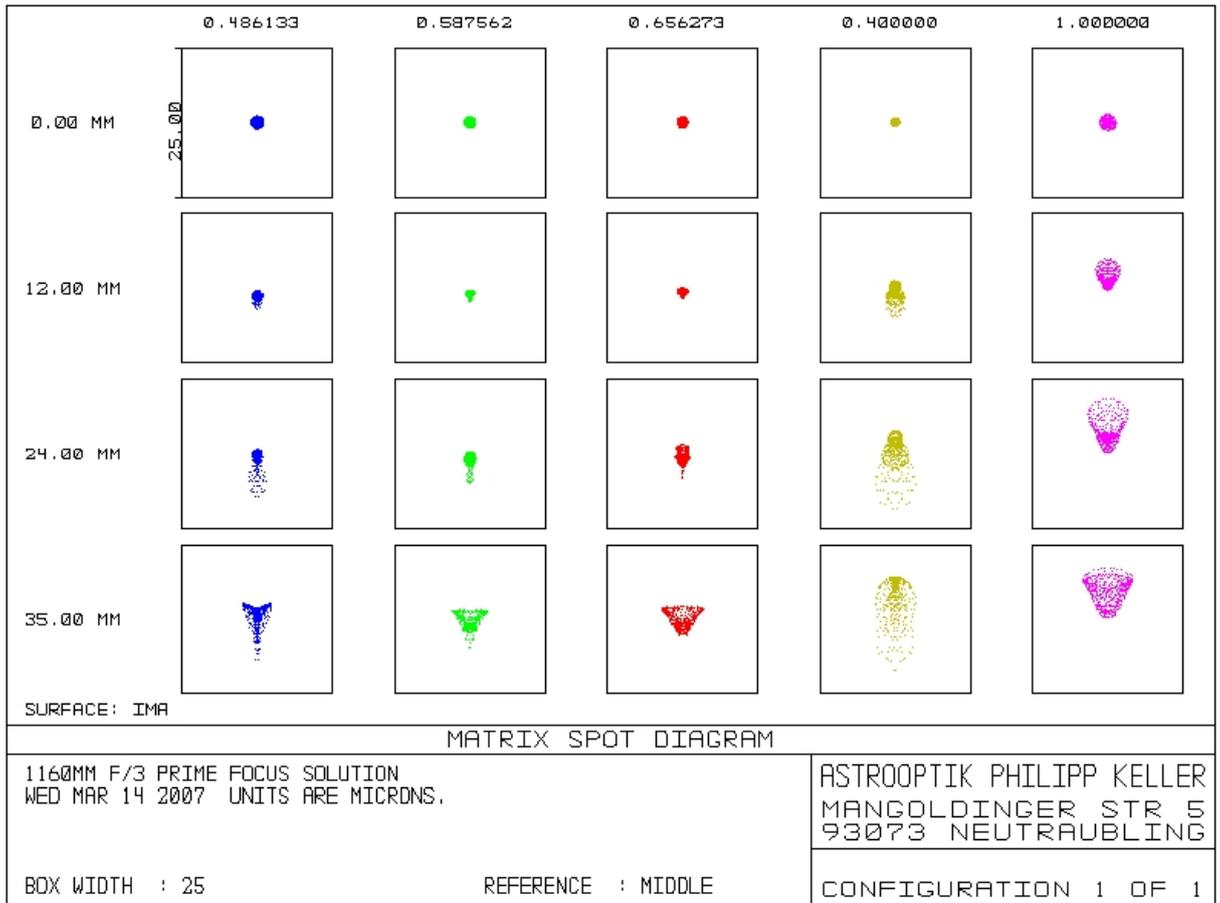
5. Optical Design

The design we want to present here is a suggestion we found that may be easier to make compared to the design proposal from the customer. Our design reaches also a pixel limited performance but it does this with one lens less (less ghosting and reflection loss) and has also a smaller corrector mount (easier mounting, looser tolerances on the mirror holder, cheaper production costs).



Optical design shown with the 3-lens corrector, Filter and CCD cover slip

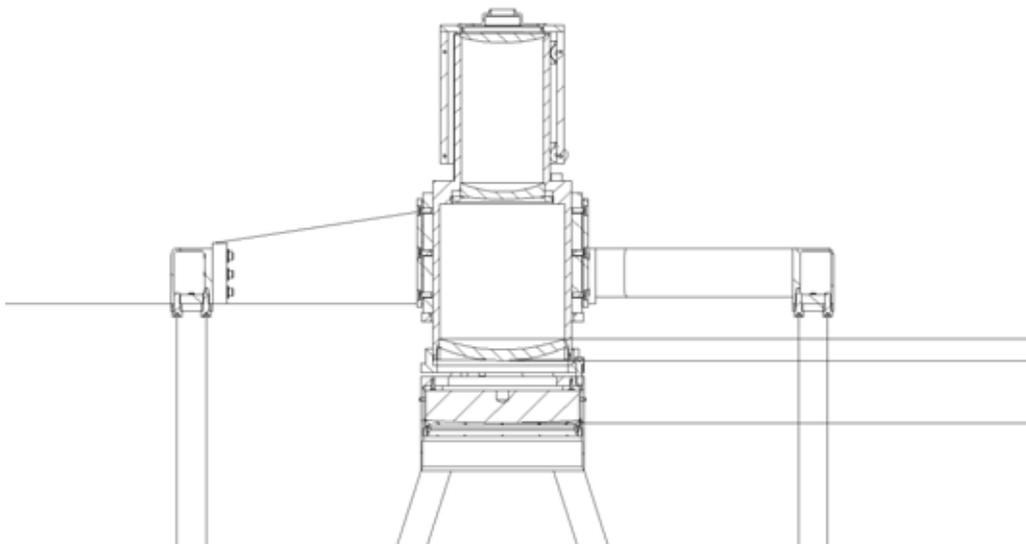
The optical design is not a final design (time was too short here) but it is the same design we already use in several prime focus telescopes. It will be pixel- and seeing-limited in most conditions.



Spot diagrams shown for wavelengths from 400nm to 1000nm for this design proposal.

The corrector consists of a 3-element in 3 groups. The maximum useful format is $D=70\text{mm}$ (even larger diameter can be used with some vignetting), which is 1.15 degree in diameter. The corrector has a very good performance through a wavelength interval of 400 to 1000nm.

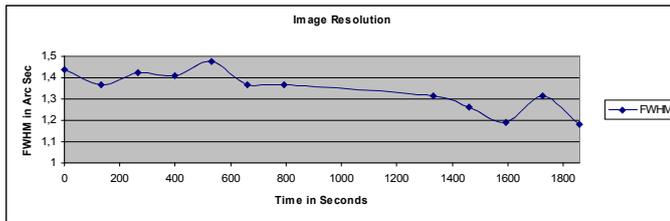
The current design gives 117mm back focus, which is enough for the filter wheel and typical CCD camera.



The drawing shows the lens corrector for the prime focus together with the holder for the secondary (example 80cm). To use the prime focus all you have to do is remove the secondary mirror. This may be easy in case of 80cm, but it is too heavy to do it by hands in case of 1.2m telescope. In this case, we have to find a solution together with the customer to use a small crane (for example attached to the dome) to exchange the secondary mirror.



The above image was made with the 80cm dual focus telescope in Brittheim (see left image) in the prime focus at $f/3.3$. The image was made by stacking 12 unguided ! luminance exposures with exposure time of 2m each and also some color images.



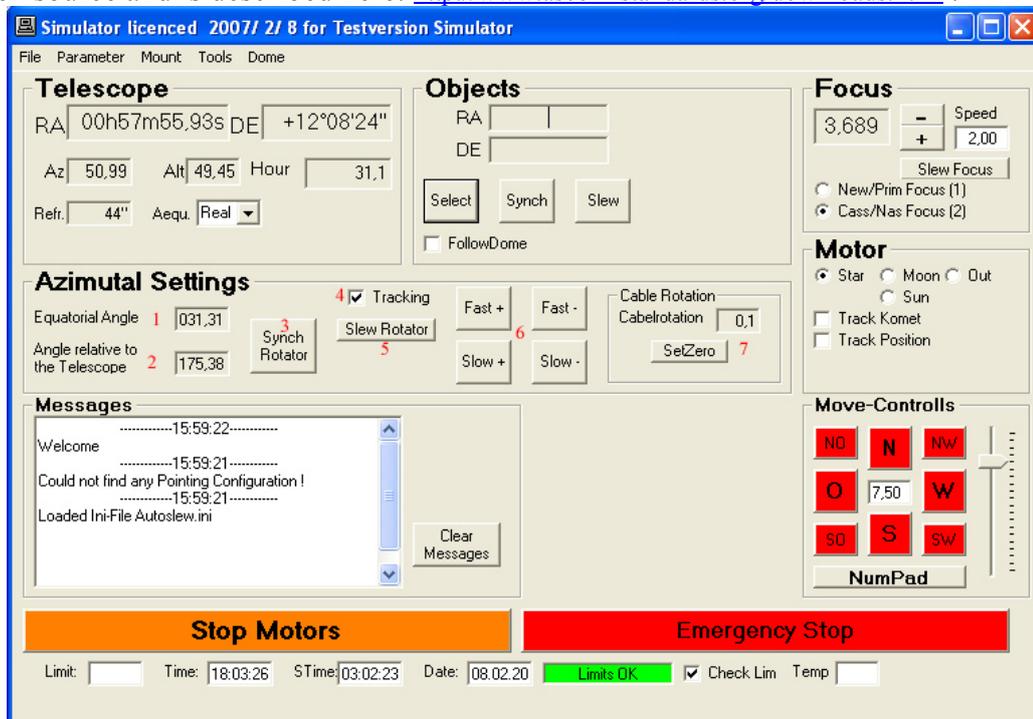
We measured the image resolution which was down to 1.2 arc seconds for the best exposures which is an exceptional value for German conditions. For the secondary focus a seeing limited 2-lens corrector is offered and sufficient.

6. Telescope Control System

We use Autoslew, a software package that has been developed the last 5 years and is now in use on all of our large telescopes.

Autoslew is installed on the control computer. The control computer is industrial PC with some PC cards (2 PCI cards for the Heidenhainencoder, 1 ISA card for the Servocontrol, 1 RS232x4 +LPT expansion card etc) installed. The operating system is Windows. You can remote control the Autoslew computer with other computers by RS232 or network (TCP/IP) connection.

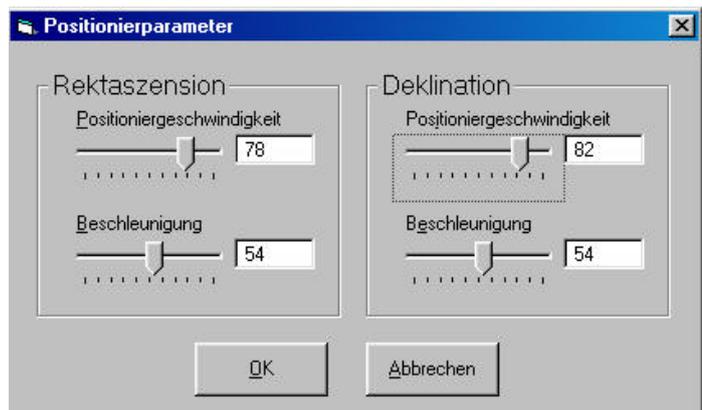
Typically, you will write an observation program on the computer where the image acquisition software (not included) is installed that will control the CCD-camera and will give slew-commands to the Autoslew-computer via RS232. It can also set the filter-wheels, focus position, read temperature, humidity, air-pressure, dome-status etc. Therefore, you can write your own observation program on computers with different operating systems. The communication can be done with the ACL-protocol. This is open source and is described here: <http://www.ascom-standards.org/downloads.html> .



This is a typical screen-shot of the Autoslew-Screen. We now also have a fully english version of course and with additional features like Dome-parameters, temperature display, humidity warning etc. On the upper left, the telescopes actual position is displayed. Also the Azimuth (which will be given to the dome) and the Altitude will permanently be updated. The rotation angle of the rotator is also displayed. The angle in respect to the Ra-Dec coordinates

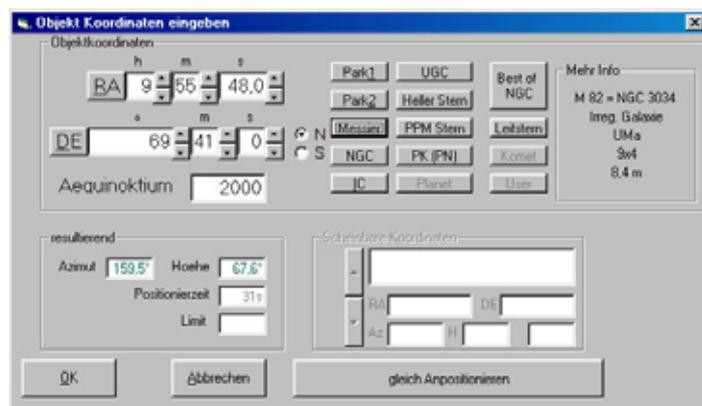
is shown as well as the angle in respect to the telescope tube. It is possible to slew the rotator to certain positions, for example to center a guide star. The coordinates and type of object of the last slewed object is shown in the object field. With the Move controls it is possible to move the telescope with a mouse-click. Errors and status reports are displayed in a Message-box.

All the parameters of the telescope can be easily changed by the observer. Some parameters can only be changed with a password. Changed parameters are saved in a ini-file.

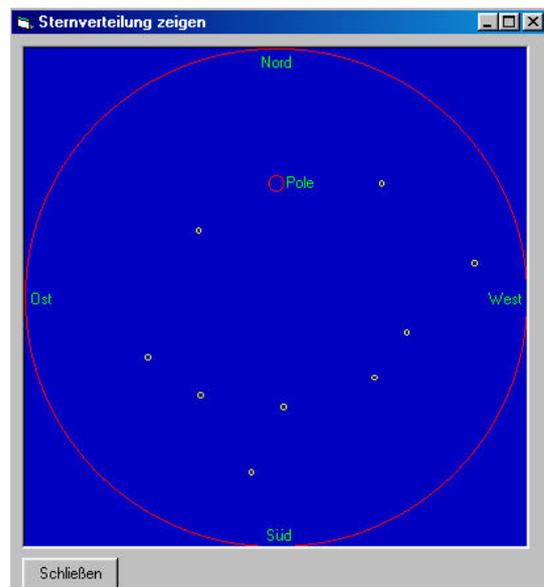


SOME SCREENSHOTS ARE GERMAN BUT SOFTWARE IS ENGLISH !

A lot of objects are in the database of Autoslew like all NGC and IC objects, Messier, UGC, PK and stars from the PPM catalogue. Recently we have added planets and comets where the user can input the ephemerides and Autoslew is not only able to slew to the right position but also can correct for the actual speed of the object.



One of the very powerful features of Autoslew is the ability to increase the pointing accuracy by means of pointing models. The first step is to point to about 4-5 stars. From this pointing, the Azimuth and Altitude tilt and the collimation error is corrected. This will already give you a pointing accuracy of about 30 arc seconds RMS. The next step to get an even higher accuracy is to point about 20, better 50 stars. We use a pointing model which models the errors with a Fourier development. All reproducibly errors that are slow can be simulated with this method. This will typically give you a final pointing of about 15 arc seconds RMS, depending on the number of stars. The pointing can be made manually now (you select a star, slew to the object and make a repositioning with a cross-hair eyepiece or by centering the star on the CCD). We are working now on a method where the picture of a CCD-Camera (you will be able to use our guiding CCD) is made automatically by the telescope and through a comparison with a star-catalogue the pointing error is determined. With this method you can let the telescope make the pointing file without any work on your side.





During this calibration process you can check the sky coverage of the selected stars.

We have developed a Hand-Control-Box with an integrated Micro-Controller that is connected to the Control-Computer with RS232.

With the Hand-Box you can not only move the telescope in the different directions with selectable speed but you can also control the focuser and the rotator. You can display current focus, telescope position and rotator angle on the illuminated display. Also you can make slewing with a large object database without the need to go to the control computer. It is also possible to synch the telescopes position.

The LCD-Display is a special version that is suited to low temperatures.



Electronics used to control the AltAz telescopes mounted in professional wall mounted enclosure

Supported ASCOM Commands

We checked with TheSky6.0, MaximDL, ACP, Focusmax, CCD Autopilot and it works with these programs. If you do your own programming, you may wish to know the supported features. Please check the ASCOM Telescope and Focuser Reference document if you need more information about the Telescope and Focuser properties and methods.

TELESCOPE:

PROPERTY	Read	Write	Comments
Alignmentmode	√		
Altitude	√		
AtHome	√		
Azimuth	√		
CanFindHome	√		
CanPark	√		
CanPulseGuide	√		
CanSetDeclinationRate	√		
CanSetGuideRates			
CanSetPark	√		
CanSetRightAscensionRate	√		
CanSetTracking	√		
CanSetGuideRates	√		
CanSetPierSide	√		
CanSlew	√		
CanSlewAsync	√		
CanSync	√		
CanUnPark	√		
Connected	√	√	
Declination	√		
DeclinationRate	√	√	
Description	√		
DoesRefraction	√		
DriverInfo	√		
IsPulseGuiding	√		
Name	√		
RightAscension	√		
RightAscensionRate	√	√	
SideOfPier	√	√	It will accept this Ascom command only if it can really flip the mount to the wished side. Mount limits set in Autoslew have always priority to this Ascom command. Otherwise it will do nothing
SiderialTime	√		
SiteElevation	√		
SiteLatitude	√		
SiteLongitude	√		
Slewing	√		
SlewSettleTime	√	√	
TargetDeclination	√	√	
TargetRightAscension	√	√	
Tracking	√	√	
UTCDate	√		
METHODS			
AbortSlew			
FindHome			
Park			In Autoslew you can set the covers to be

			automatically closed with Park
PulseGuide			Speed is currently 10arcsec per second
SetPark			
SetupDialog			
SlewToTargets			
SlewToTargetsAsync			
SlewToTarget			
SlewToTargetAsync			
SynchToCoordinates			
SynchToTarget			
Unpark			In Autoslew you can set the covers to be automatically opened with Unpark

FOCUSER

PROPERTY	Read	Write	
Absolute	√		
IsMoving	√		
Link	√	√	
MaxIncrement	√		You should set this in Autoslew
MaxStep	√		You should set this in Autoslew
Position	√		
StepSize	√		Normaly 1 micron
TempComp	√		Autoslew does all the compensation So ignore all these settings
TempCompAvailable	√		Autoslew does all the compensation So ignore all these settings
Temperature	√		
METHODS			
Halt			
Move			
SetupDialog			

Additional Telescope Commands not in Ascom-Standard

PROPERTY	Read	Write	
CanSetCovers	√	√	Read-only, Boolean
Epoch		√	Sets Epoch to 1950 or 2000 or other If Epoch=0 (default) that means Autoslew will expect current Epoch from ACL
Trackposition		√	Write only, Boolean Enables High Precision Tracking
GuideMoveRa		√	Write, Double Moves Mount with the amount in arc seconds in RA
GuideMoveDe			Write, Double Moves Mount with the amount in arc seconds in DE
METHODS			
CloseCover			Closes Cover if possible
OpenCover			Opens Cover if possible