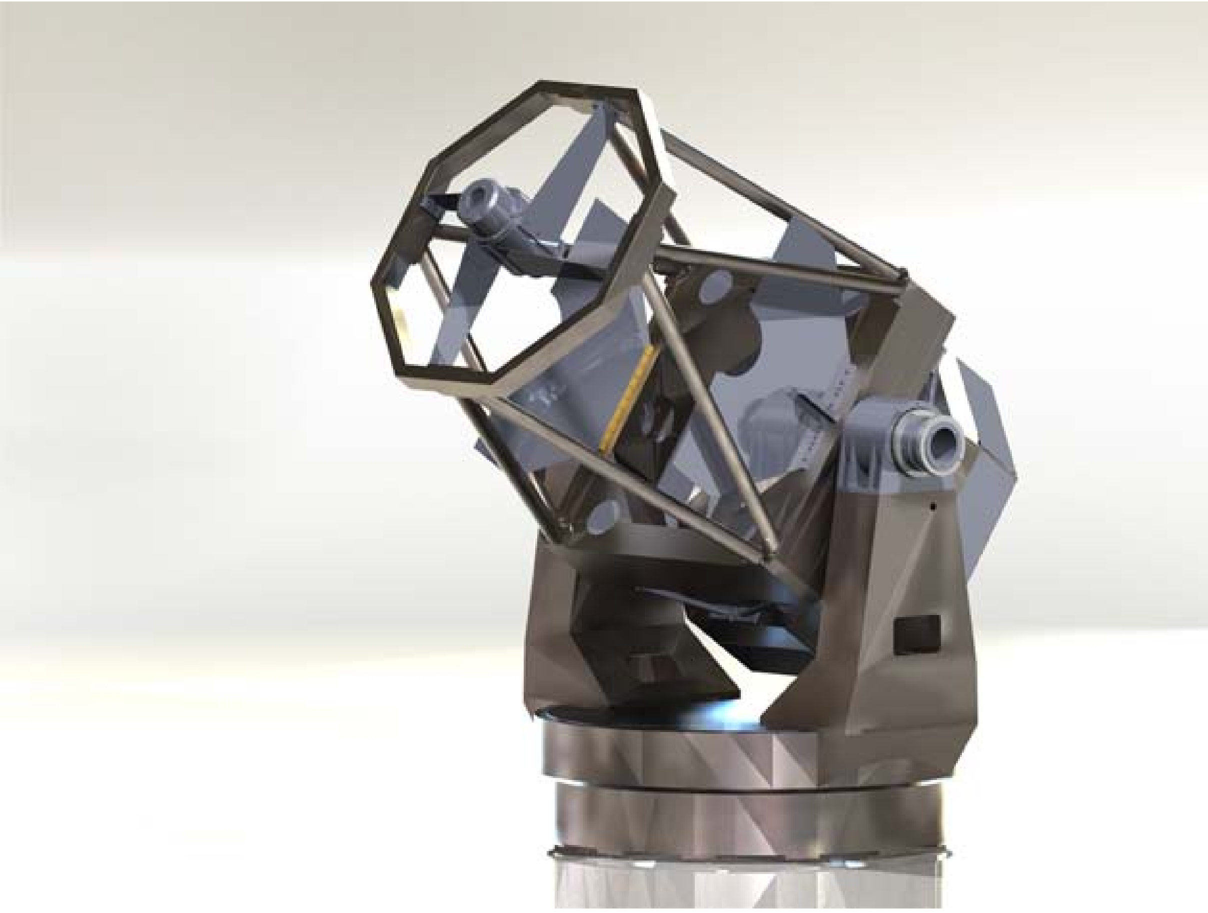
Document Establishing Good's Eligibility and Conformity to Bidding Documents



3. Specifications I

We are hereby confirming all asked specifications of the **1m Wide-Field Astronomical Telescope**. We have put some additional comments below each specification where further explanation or better than specified quality has made this necessary. Specifications that will be reached but did not need any further detailed comments have been marked "**OK**" only. Some specifications where we think there is a simple mistyping have been marked RED. In these cases we have changed the specification to what we think was intended from the author.

Effective diameter: >960mm

The clear aperture of the offered Cervit mirror will be 970mm

Prime focal length: less than 2200mm

The prime mirror focal length is 2032 mm, the corrector increases the effective focal length to 2159mm.

FOV at prime focus: >=1.5 degree x 1.5 degree

We have found a 4-lens corrector design that will cover even 2.4 degree diameter with exceptional quality (1.7 degree x 1.7 degree). Even bigger diameters will be possible with reduced quality and additional vignetting. All following curves and calculations are made for 1.7 degree x 1.7 degree. The quality for the minimum 1.5 degree square field is of course even better

Optical quality at prime focus: 80% within 2" diameter (1.5degree x 1.5degree FOV, 400-700nm)

We will demonstrate with the following calculations that the quality even of the 1.7x1.7degree field will be well within the demanded specifications.

A) Design considerations.

With more than 200 prime focus correctors produced we have an unequaled experience on the field. We had to learn in the beginning, that the theoretical performance reached with raytracing is very often not the same as can be found later in real imaging. One of the most important factors here is the glass quality. The problem with this corrector is the large diameter of the first 1 or 2 lenses which exceeds the diameter of the usual glass blocks made from Schott (due to quality reasons regarding glass homogeneity we have only limited out research on their glasses). Hot forming glass discs by pressing them in suitable shape from different sized blocks has the risk involved of a change in crystallization and thus a change in index of refraction or dispersion. A better method would be to order a special melt from Schott but this can require to melt 1 ton of the equivalent glass with the according costs involved. These considerations have let us focus on a design that uses BK7 glass for the big lenses, which is a glass that is also produced in mass sizes and therefore exceptional well controlled regarding homogeneity and optical properties. The final design was a 4-lens design with the 2 large lenses facing the main mirror made of BK7 and the other 2 lenses made of ED glasses.

The final tuning of the radius and glass thickness will include:

- CCD cover glass thickness
- Filter thickness
- Real measured glass data (nd and vd) of the used melt
- Final main mirror focal length and measured residual spherical errors (if rotational symmetric)

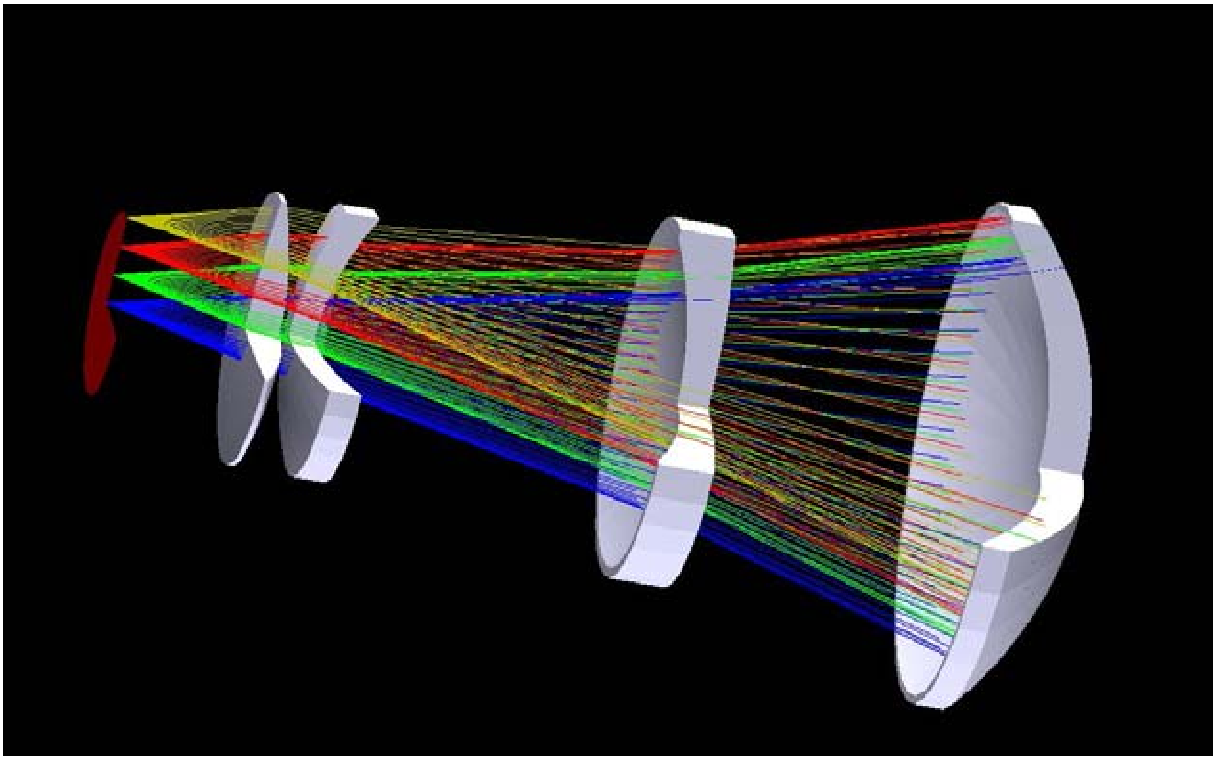


Image 1: optical design of the prime focus corrector

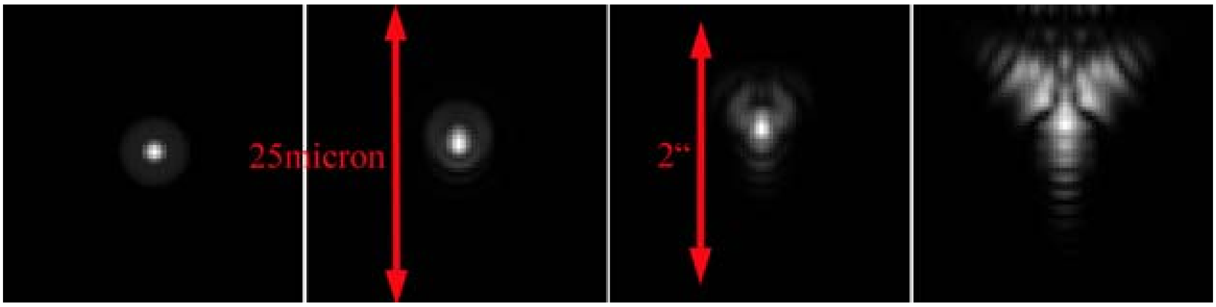


Image 2: FFT calculated spot diagrams for 400-700nm (incl. diffraction effects) shown for (from left to right) field center, 0.4°, 0.8° and 1.2° field RADIUS

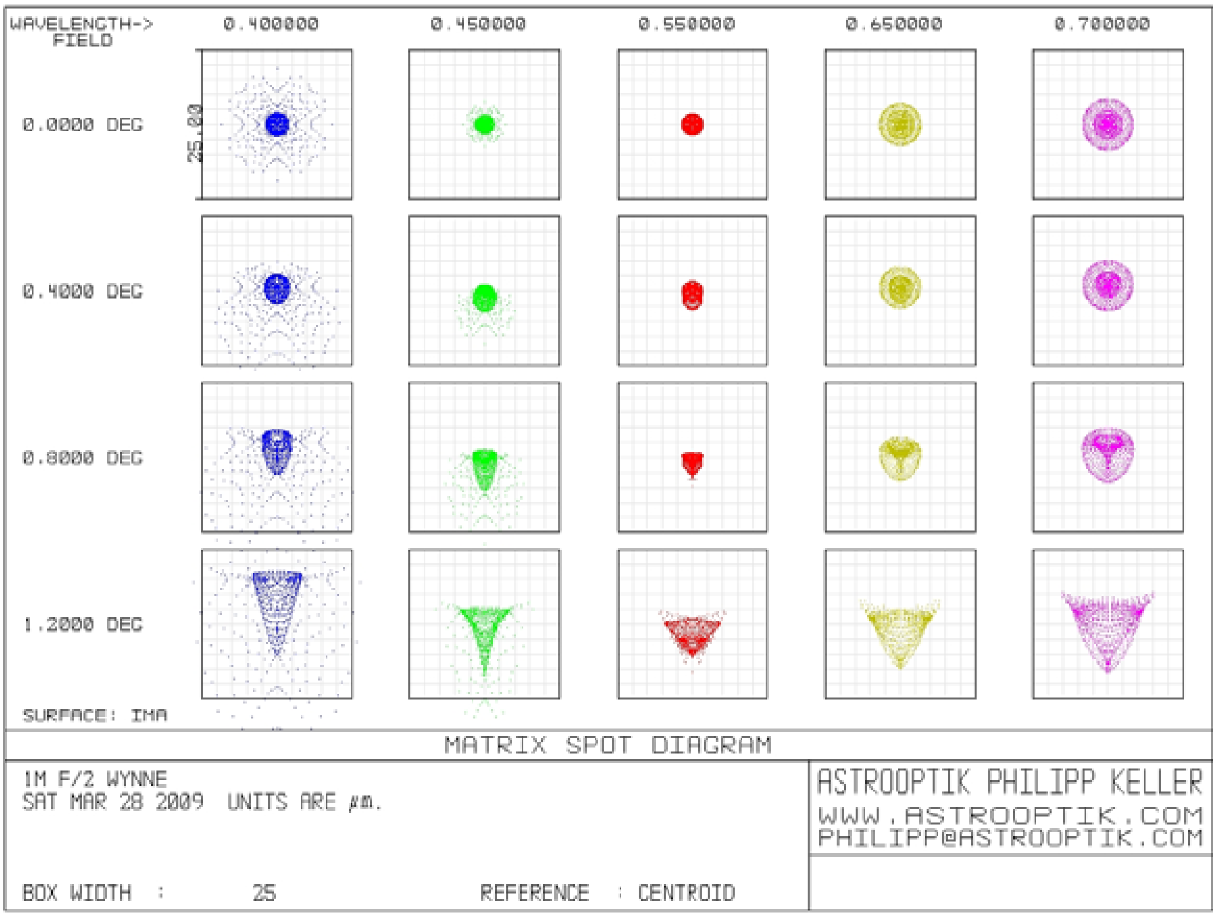


Image 3: Spot diagrams for different wavelengths

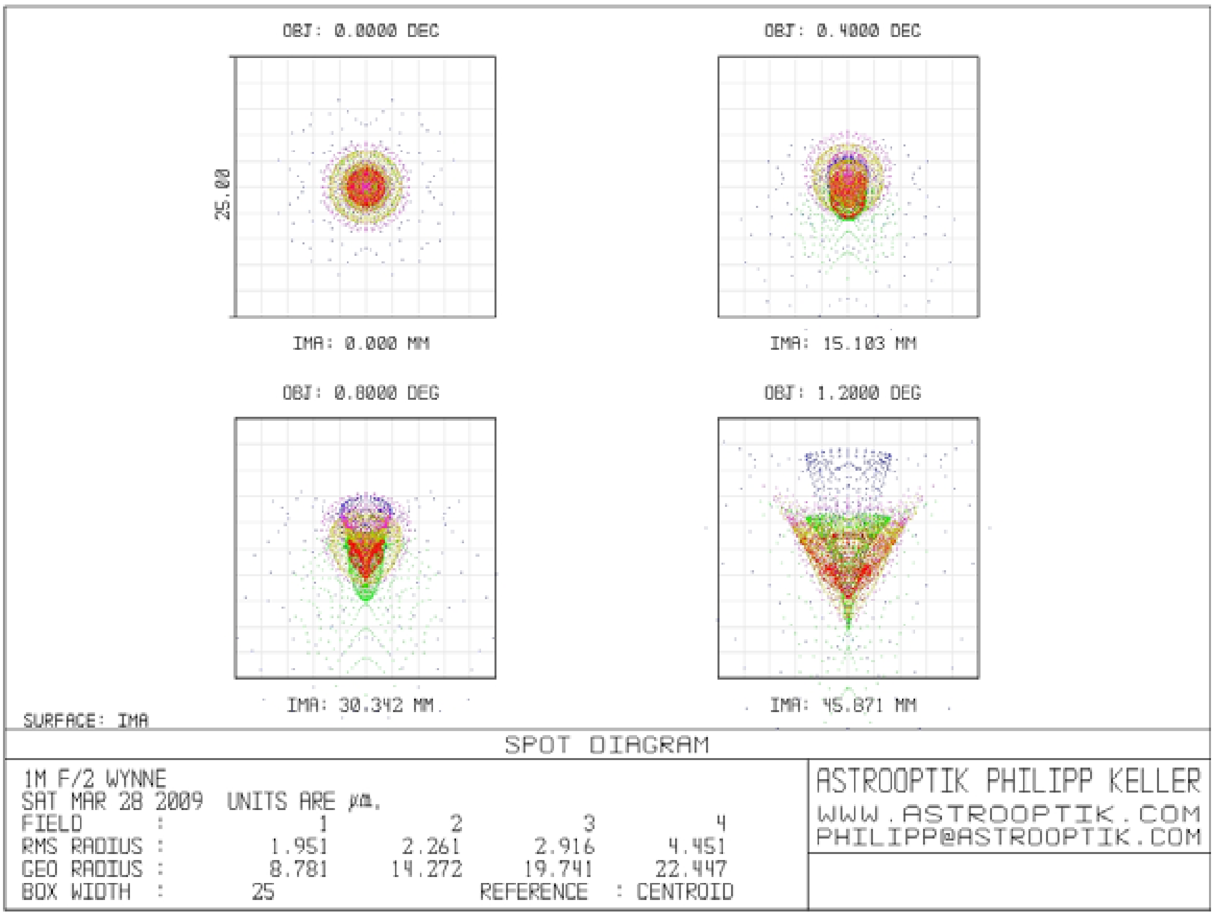


Image 4: combined spot diagrams for 400nm-700nm and 2.4 degree diameter field

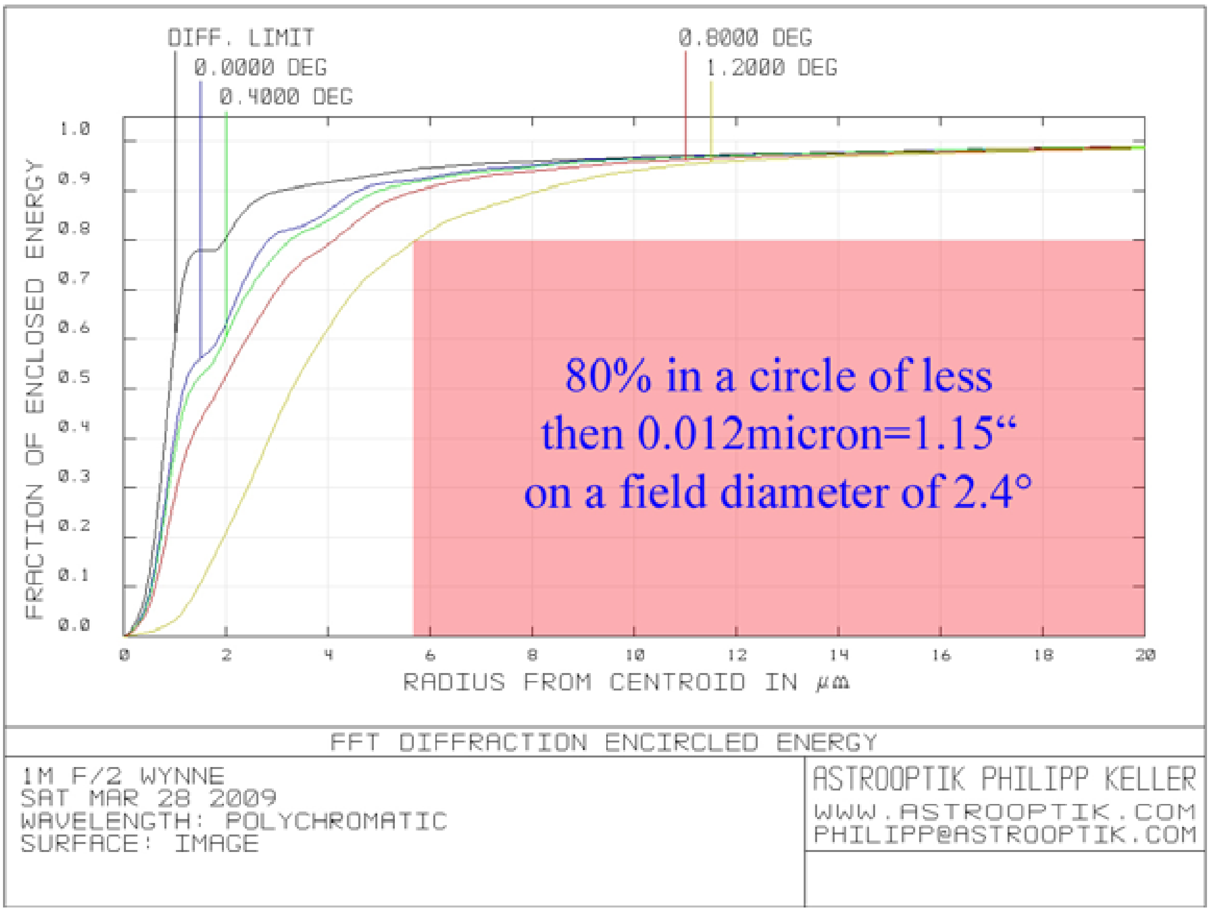


Image 5: Encircled Energy for all field points which clearly shows that the expected performance is much better than the demanded 80% in 2“ (arc sec) criterion.

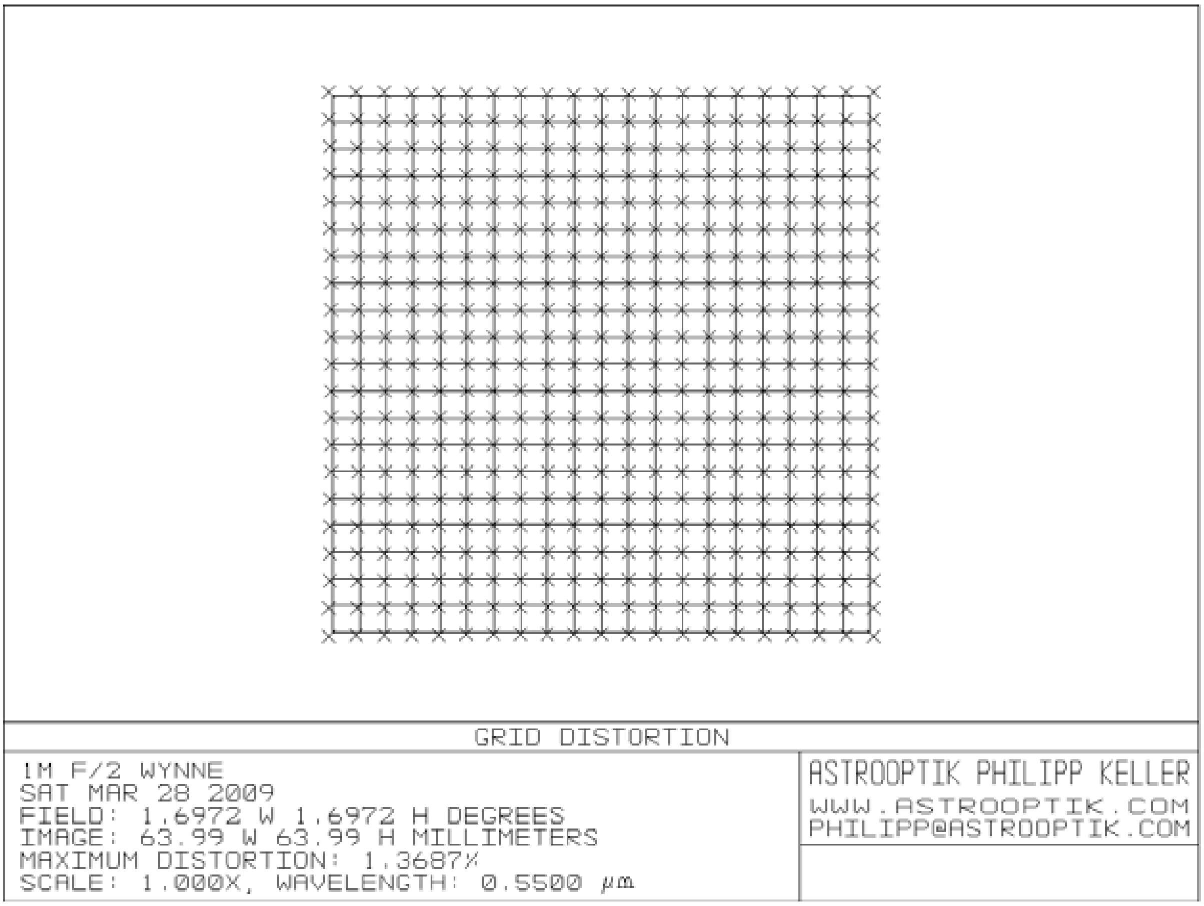


Image 6: Distortion shown for the 2.4 degree field

Although we have optimized the corrector design for best possible energy concentration it can be noted that the distortion also is well within an acceptable range and can be easily covered and compensated with modern astrometric software.

All lenses will be coated with a rave coating

Efficiency of prime focus: >70% (the efficiency of CCD and/or filters not included)

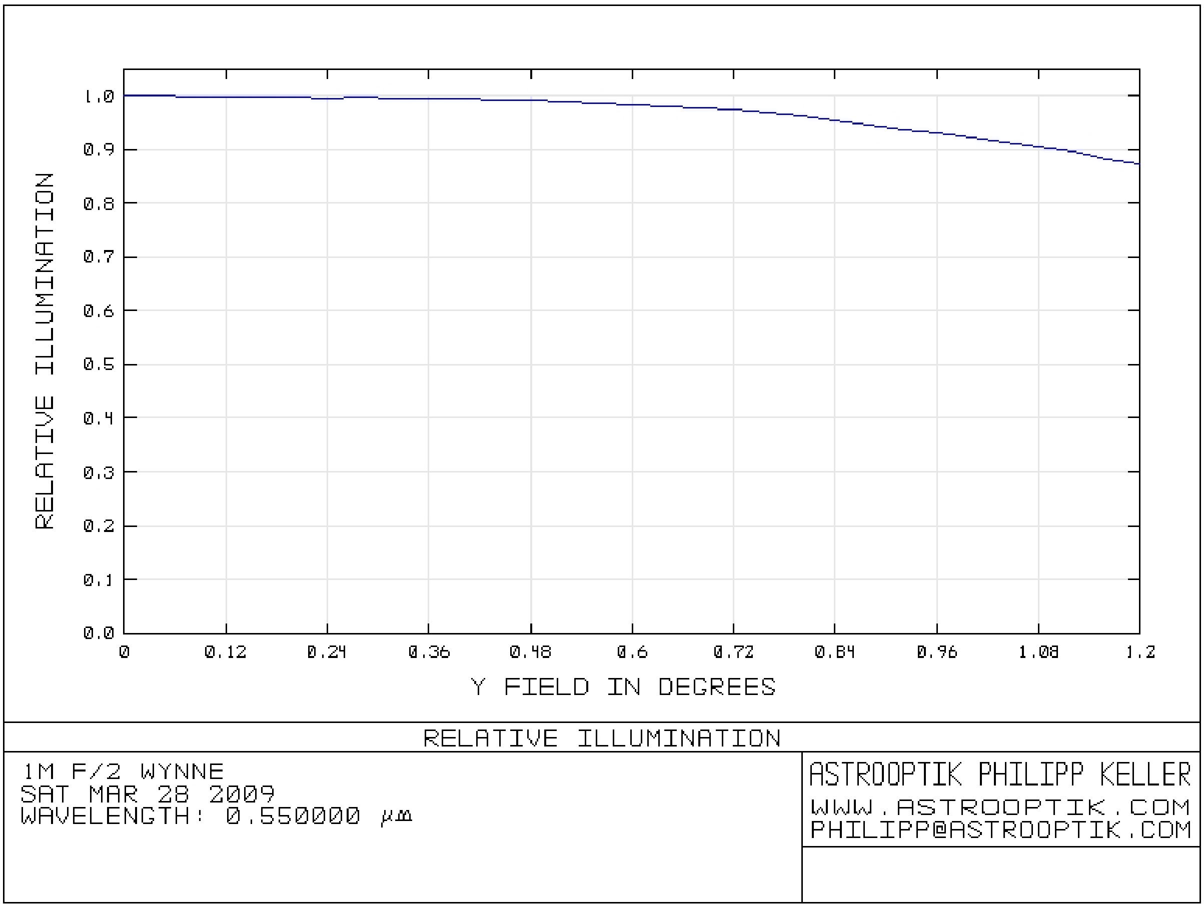


Image 7: Vignetting plot in prime focus

The efficiency is determined by the following factors:

- Reflectivity loss of the primary mirror (Al+SiO2) 10%
- Obscuration loss due to the size of the used camera and filter slider 9%
- Reflection loss on the surfaces of the corrector (8 surfaces) 4%
- Absorption loss within the glasses of the corrector 3%
- Vignetting occurring outside the field center 12%

For the field center the expected efficiency (without filters, CCD QE) will be 76%. The edge of the 2.4 degree will still have an efficiency of appr. 67%. Even with the multilayer AR coating we are using on the lenses and only using glasses that have very good transmission we think that getting much better values than above estimations is difficult. The main mirror could be coated with a higher reflective coating but this would involve higher costs and the coating may be difficult to remove without polishing.

Mount: high accuracy Alt-Az mount

OK

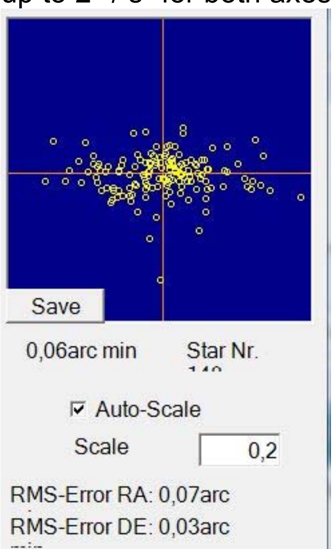
Maximum Slew Speed: >6° / s (both axes)

Since we will be using direct drive (torque motors) the maximum slewing speed can be set to any rate although we recommend slewing speeds below 10° / s. The Azimuth speed can also be set to be depending on the telescope altitude, allowing for faster maximum azimuth speeds if the telescope is close to zenith (a telescope pointing towards horizon slewing with 10° per second is un-safer than a telescope pointing towards zenith with the same rate).

Our Torque motors are made in Germany by a company that makes special windings for these low speed applications that have a maximum Torque/Ampere factor. The motors used have a permanent Torque of 200NM (Peak 400NM) that can be reached with 48V and less than 20A. We wanted to avoid having 200V applied to the telescope (unsafe in humid environments).

Maximum acceleration 1°/s^2 (both axes)

Our torque motors have 200NM permanent torque thus allowing the telescope to easy accelerate with enough excessive torque. The value for the acceleration can be set by user up to 2° / s^2 for both axes. Faster rates are possible due to the peak torque of 400NM but not recommended.



Pointing accuracy: better than 5” RMS for each axis after pointing model correction (20degree > elevation<75degree)

Image 8: Pointing errors measured with a 90cm AltAz telescope

With our latest 90cm AltAz telescope we reached a pointing accuracy of 4” RMS in Azimuth and 2” RMS in Altitude. This was with a Cassegrain Design used in Nasmyth focus. The prime focus design is much less prone to pointing errors since there is only 1 instead of 3 mirrors involved. Thus we are sure we can get much better with the prime focus design. Also the mentioned 90cm was a very reasonable priced Amateur class telescope and not the professional design we will use for the 1m Wide Field.

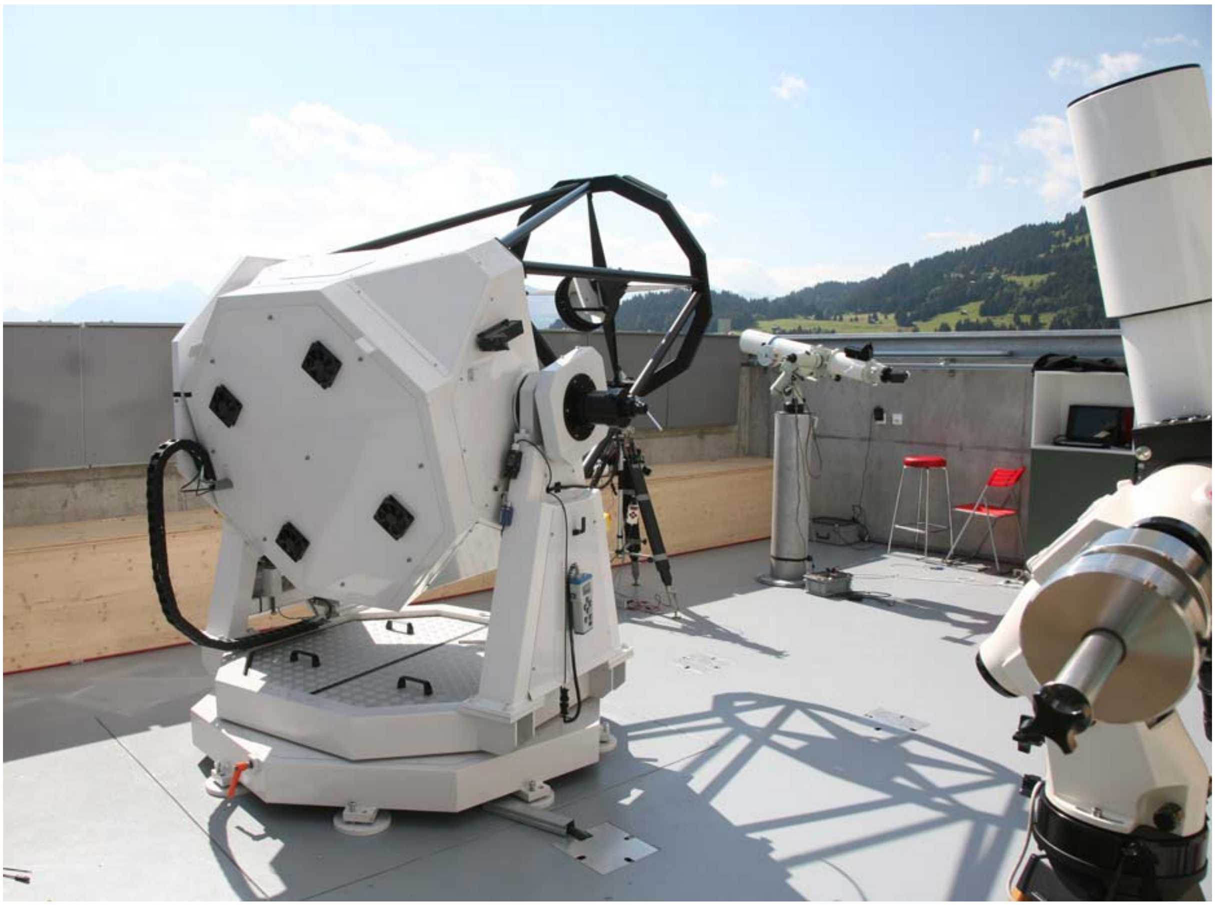


Image 9: Alt Az Telescope Amateur design with already 4" RMS pointing

Image 10: Recent more professional design (example 1.2m Ural telescope)

The latest Alt Az telescopes incorporate an even more precise design and bearings and a much stiffer azimuth ring allowing better pointing with less pointing stars involved

Tracking accuracy: (20degree > elevation < 75 degree, open-loop) 0.2” RMS in 10 seconds, 1” RMS in 60 minutes

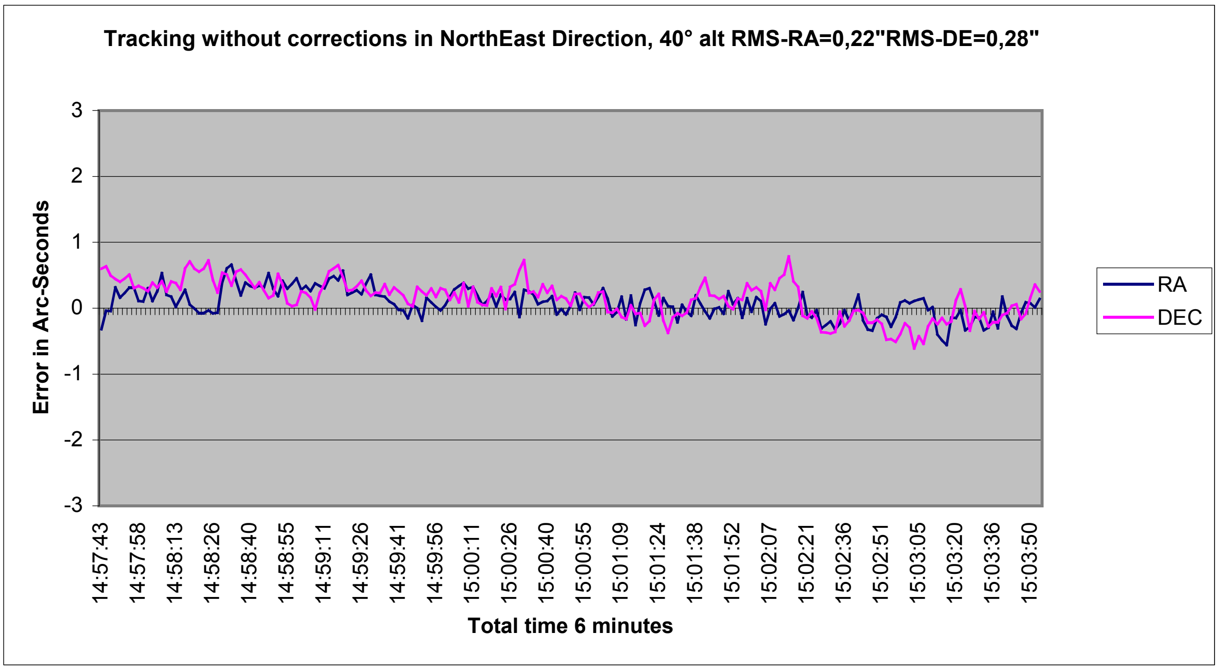


Image 11: Tracking errors of 1m telescope

The above measurement included seeing and was obtained with a 1m telescope. It is always difficult to distinguish between seeing and real telescope errors if it comes to accuracies better than 0.5” RMS. But with an estimated all sky pointing of 3” RMS we will be able to reach or exceed the specified tracking.

Tracking accuracy: (75degree < elevation < 85 degree, open-loop) 0.4” RMS in 10 seconds, 3” RMS in 60 minutes

OK

Zenith blind hole: 2.5° radius

OK

4. Specifications II

4.1 Optical System

Primary mirror material: BK7 or low expansion (Zerodur, Astrosital, Cervit, etc.)

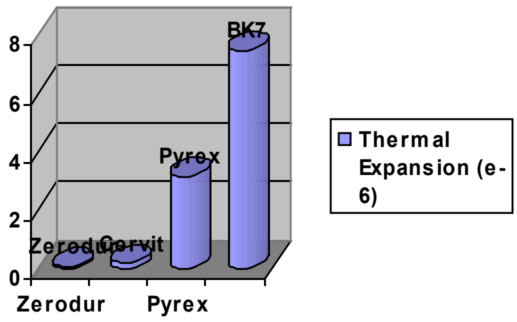


Image 12: Comparison of different mirror materials

We think that a high precision telescope should make use of one of the following mirror materials:
Quartz, Zerodur, AstroSital, Cervit, ULE. All of these materials will not change shape during a change of temperature because the thermal coefficient is less than 1e-6 per degree Celsius. Pyrex (or Duran) both has a thermal coefficient of 3.2e-6 and BK7 is even twice as worse. BK7 or crown glass already causes trouble in small sized amateur telescopes with 30cm aperture and should not be considered as cheap alternative to ULE glasses for a 1m class telescope. We offer a Cervit mirror here.

Coating Aluminium, over coated with SiO2 (mirror)

OK

4.2 Telescope control

Rotation angle on Azimuth : ±270º（from center of rotation)

OK. We will install a limit switch (software and hardware) that prevents the telescope from over-rotating

Rotation angle on Elevation : 0-95º

Although we could fulfill this requirement we suggest to limit the max. altitude to 89°. Otherwise, if the telescope could reach a point near zenith either by slewing through Azimut or by slewing through Altitude there is a coordinate problem in the pointing models used like in case of a German Mount where a point on the Meridian can be reached through West and East Position.

maximum slew speed : >6º/s (both axes)

OK

maximum accelerations : 1º/s^2 （both axes)

OK

emergency stop : in case of emergency during fast slew, the telescope should be able to stop immediately without hurting the optical and mechanical parts.

OK. We have a software emergency stop and a hardware emergency stop. Excessive breaking voltage from the direct drive is consumed by proper breaking chopper device resistors.

4.3 field de-rotator

Maximum load : 20kg

OK

Rotation range : 360º

OK, with limit switch provided to avoid over rotation (cable problem).

Maximum rotation speed : 5º/s

OK

Accuracy : 0.1"/600second on the edge of the FOV

The encoder will be an analog Renishaw encoder with 36.000 lines interpolated to an angular resolution of 0.02 arc sec. Since the edge of the field (1.2 degree radius) is 45mm in radius this resolution corresponds to a linear readout error of far below the micron range. The according arc second field error will be much better than 0.01".

4.4 filter wheel

Five positions, manual or motorized switch, moving with the CCD. The size of the filters should be large enough for unvigneted imaging over the 1.5degx1.5deg FOV.

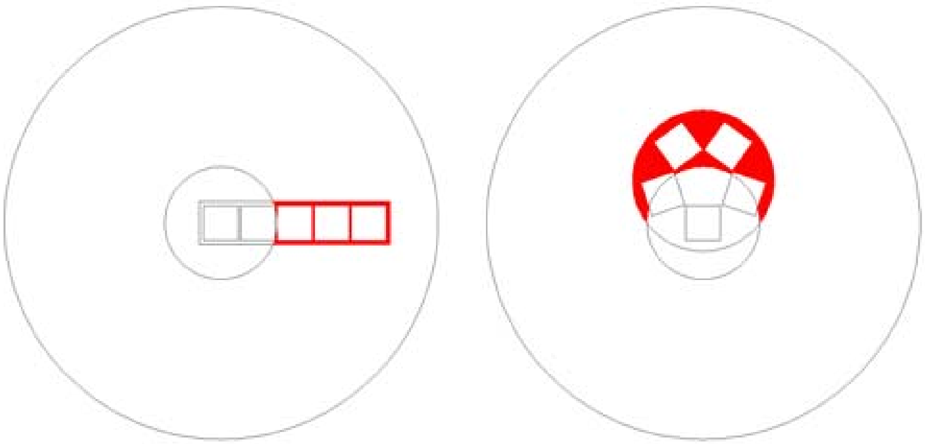


Image 13: Obscuration comparison between a linear or rotational 5 position filter wheel

The filter wheel for prime focus telescopes can be either rotational or linear. The advantage of the linear filter slider is less obscuration The drawing shows the approximate situation with these 2 options. The disadvantage of the linear slider is an additional diffraction spike because the filter slider will turn in respect to the spiders. We would leave it up to the decision of the customer which wheel to choose because the costs involved are the same. In case of the linear slider we would use a linear Renishaw encoder band with better than 0.005mm referencing and positioning and in the case of the wheel we would use a rotational encoder band with an equal resolution. A good referencing and positioning if crucial for removing dust donuts by applying flats. This only works well if the filter is exactly at the same position during the flat as during the real exposure.

4.5 telescope structure：

weight：　　<5500kg（including telescope base, excluding control cabinet and instruments）

estimated weight is appr. 3000kg

structural Resonance：　>10Hz (by analysis)

will be confirmed by FEM analysis with Solid works

recommended enclosure size: ：>6.5m（in diameter）

estimated minimum dome size is 4.3m

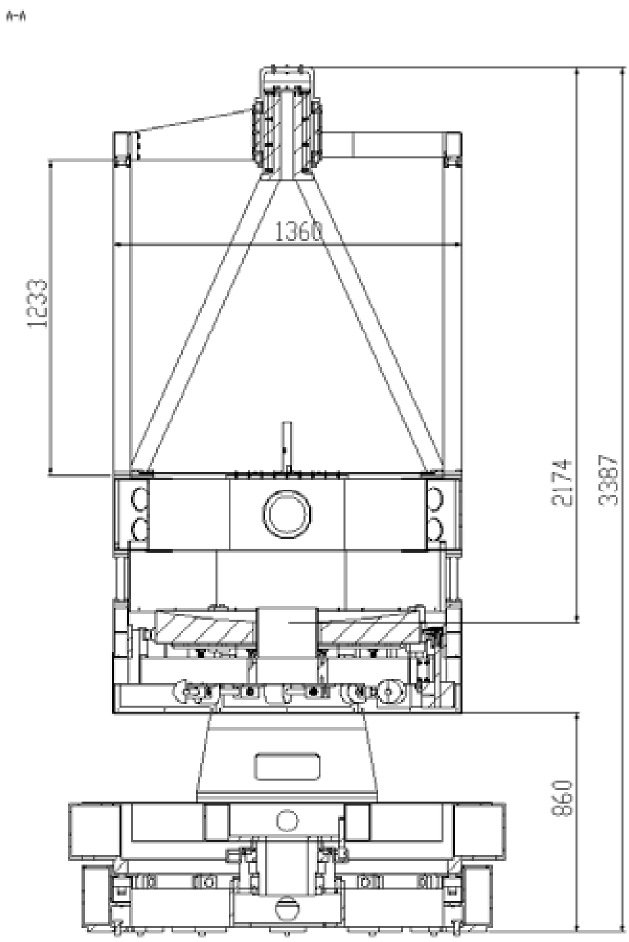


Image 14: Preliminary design of the Wide Field 1m

Focus compensation with temperature variations

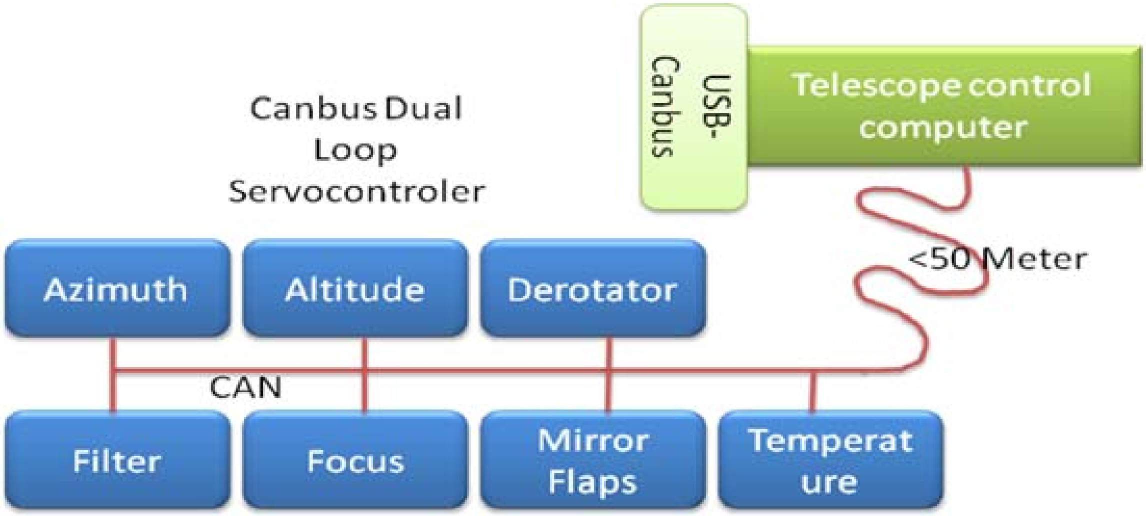
Temperature sensor will measure temperature and correct focus by theoretical calculated value or user set value (determined by measurement at different temperatures).

4.6 safety：The safety of operator and equipment should be greatly concerned in telescope design.

Mechanical limit switches for minimum altitude and maximum altitude. Limit switch in Azimuth against over-rotation. Limit switch on Rotator against over rotating. Limit switch on focus. All limit switches accompanied by software limit checks.

4.7 telescope control: telescope control hardware and software should be supplied with the telescope

Hardware



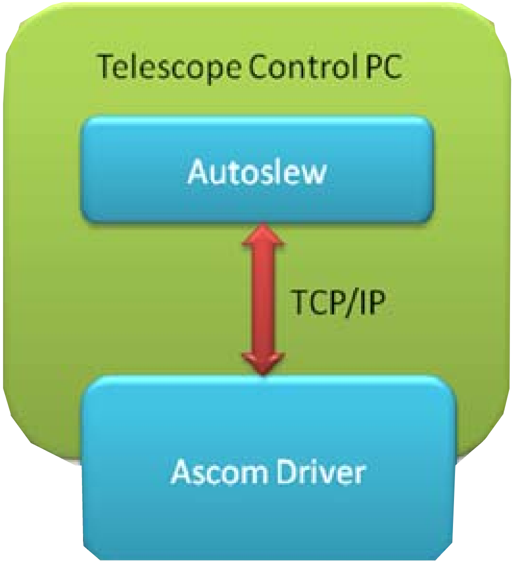
Most telescope control electronics should be installed in a cabinet away from the telescope. The cable length between telescope and cabinet should be longer than 20m

We are now using a completely new control design that is very modular and based on Can-Bus (Controller Ares Network) system that is also widely used in Automotive industry. The big advantage compared to earlier control systems is that the control is removed from the PC to the intelligent servo controllers. The PC thus can be any Windows PC (XP, Vista) that has an USB port as minimum requirement. Installation of Backup PC's is now much easier since there are no PC cards involved. Another advantage is the cable length from the telescope control computer to the servocontrollers. This distance can be up to 50m.

The servocontrollers in this setup are usually installed near the drive system to avoid noise in the analog encoder signals. It even makes sense to install them inside the telescope because the controllers are extremely small and dissipate nearly no heat. If there is no other option the cable length between the controllers and telescope can be 20m.

software

Telescope control software (TCP) should be compatible with ACL and/or ASCOM. TCP should have the following functions



The old Autoslew design used Microsoft Com Objects and ACL for Data exchange. Autoslew has now been completely renewed and programmed in managed code (Microsoft Visual Studio 2008). Autoslew still has a Com-Server for direct control of Ascom programs running on the same PC but we have now developed a new Socket based TCP/IP driver that has a Com-Objects Interface for all known Ascom compatible programs. The great thing about this setup is that the Ascom Driver can be installed on the Autoslew Telescope Control PC (then be talking to Autoslew via LocalHost and TCP/IP) but it can as well also be installed on any other PC in the network and even completely remotely if there is suitable Internet access (fixed IP address, Port Forwarding, Firewall etc.). The Interface is 100% compatible to the Ascom 2.0 standard where some additional functions have been added to allow better control for our telescopes.

·GUI environment, running in Windows XP and lower versions

Currently support is granted for XP, Vista. Since there is no driver issue any more regarding the PC upgrading to later Windows Version will be easy.

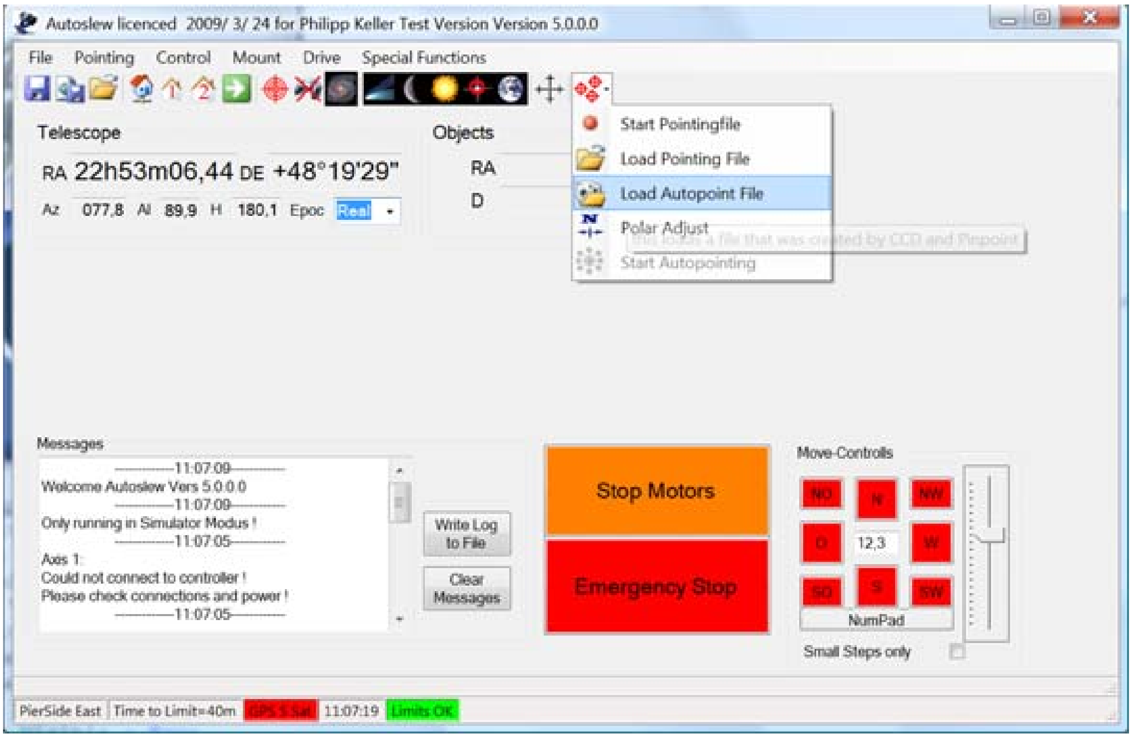


Image 15: Autoslew GUI with modern design and new features

Our software has now been completely recoded to Microsoft managed Code (Framework, .net) and runs on all Windows Versions higher than XP. The focus was to make the Autoslew more intuitive to use and easier to understand also for non-experienced observers. Toolbar menu has been added with icons. Some new features added:

- Automatic pointing file creation (with all MaximDL supported cameras)
- Automatic configuration calculation
- Joystick support (focus, both axis, user functions can be free defined)

·control all the standard telescope movements (including the dome)
Dome can be controlled via different standard interfaces (like Baader Dome, ACE, Ascom)

·coordinates convert, epoch convert, and tracking of non-sidereal objects
OK

·improve telescope pointing and tracking accuracy by using pointing model
OK

·safety alert
OK

·telescope malfunction diagnosis
OK

·remote control via LAN、WAN or Internet
OK (see above comments about TCP/IP Ascom Driver)

·custom software telescope control possible·
Via ACL or Ascom

4.8 temperature requirement：

Operating temperature：-20°C to 30°C
OK

Storage temperature：-30°C to 50°C
OK

4.9 maintenance：

Easy maintenance should be concerned in telescope design, primary mirror clean and removal of the primary mirror for re-aluminizing should be safe and easy. Custom made and special tools, spare parts should be provided by the manufacturer with the installation of the telescope.
OK

4.10 documents：

Hardware and software manuals, maintenance manual, diagrams and drawings (hardcopies and electronic files)

Additional Comments

Focuser

The focuser was not mentioned in the original specifications. We will use a ball screw spindle together with a linear Renishaw encoder band to achieve a reproducible and precise focusing. The encoder allows referencing and positioning to better than 0.001mm accuracy. The readhead of the Renishaw Encoder also allows the readout of limits on both sides of the focusing range.