E U R O P E A N S O U T H E R N O B S E R V A T O R Y

Organisation Européenne pour des Recherches Astronomiques dans l'Hémisphère Austral

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ESO - LA SILLA

LA SILLA OBSERVATORY

LED / Optics

FEROS on 2p2 Telescope

Final ADC Design

Technical Report

LSO-TRE-ESO-75441-005

Issue 3.0

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Change Record

Issue/Rev.	Date	Section/Page affected	Reason/Initiation/Document/Remarks
Issue 1.0	Feb, 2003		
Issue 2.0	May 2003	All	New design using a double prisms
Issue 3.0	Sept.2003	All	Final Design (with requirements)

1 Purpose.

After moving the Feros instrument from the 1m50 telescope to the 2m20, the instrument will use a sky aperture of 2.0 arcsec equivalent to 0.17 mm (available drill). For larger telescope Zenithal Distance (ZD) the atmospheric dispersion effect is important and part of the star light will be lost in a chromatic dependence. The instrument wavelength range response will be ZD dependant. An Atmospheric Dispersion Corrector (ADC) is required and we present on this document the selected final design.

2 Requirements

From the recently released user requirements documents the summary of the needs is:

- Maximum image decentering of 0.2 arcsec for a wavelength range of 350-920 nm up to 60 deg ZD
- Maximum light loss in the ADC of 10% across the full spectral range
- Tolerance in parallactic angle positioning of 1 deg up to 5 max.
- No WFI vignetting when ADC is parked
- Tracking of the ADC continuous, maximum speed is 2.5 deg/min
- Presetting ADC speed of 90deg/min
- Overhead less than 2min
- Three mode control software as OUT, IN (preset to mean parallactic angle), IN (continuous tracking)
- Compatible with object calibration mode if possible.

Implicit requirements:

- not degrading the telescope image quality as far as 0.2 arcsec

3 Design

3.1 How.

For ZD larger than 35 deg, the dispersed light of the star is as long as the aperture diameter and losses will occur forward. Adding the seeing effect will even degrade the throughput with relative chromatic contributions. A double prisms ADC has been defined. A rotation ability on both prisms must be performed to match the telescope parallactic and the zenith distance angles. The ADC correction range will concern ZD angles from 30 deg to 65 deg.
Due to a reduced available space for the ADC mounting, the prisms must be as small as possible correcting only the chromatic dispersion for the science aperture of the fiber head.
The prism will require three functions to be added on the present adapter, an in/out and the two prism rotations.

3.2 Constraints.

Three constraints on the design:

- smaller size: 12.5mm diameter for a F/8 beam of 8mm not covering the second aperture hole at 16mm
- small distance from the fiber head: 48.3 mm from the exit prism surface.
- telescope defocus compensated to avoid telescope focus correction for in/out ADC.

Several ADC prism designs have been done in the past and the glass combination selected has been fully tested on existing designs. The instrument wavelength range is not reduced by the glass selected, the UBK7 and

LLF6.
The prism position angles are to be adjusted according the parallactic and zenith distance angles of the telescope available on the TCS. A tracking in rotation is required following the angle variations according the Zenithal Distance and the Parallactic angle. Close to zenith observations will not require the ADC.

3.3 Additional Parameters

The telescope image quality has been measured at the Feros focus position. The Feros focus position corresponds to the WFI one slightly out of the nominal telescope focal plane location.
The spherical aberration at the new location has been found around 0.1 arcsec d80%, under corrected sign.
The design of the ADC is including this small amount of spherical aberration.
The ADC design is done for a temperature of 20degC with an Atmospheric Pressure 780 mbar as standard condition for la Silla.

4 Design

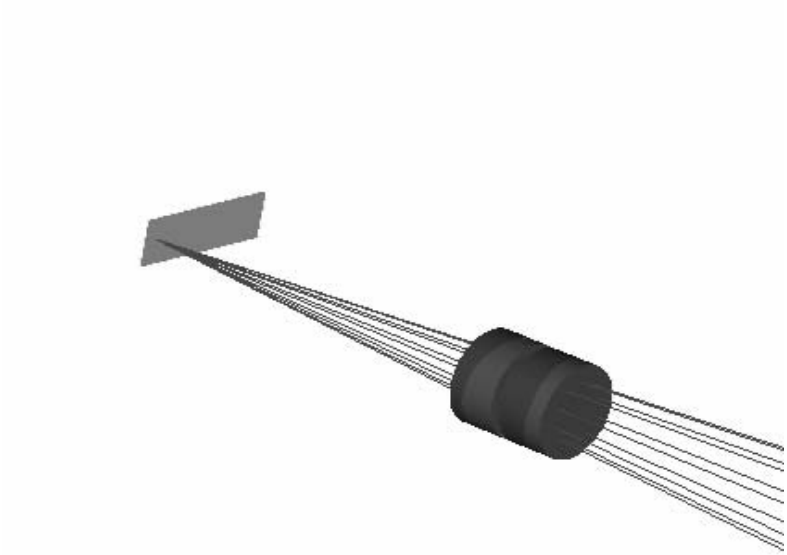
The prism sizes 12.5 mm diameter with an on axis thickness of 6mm. The “back focal “position is 48.3 mm from the fiber head (from the exit surface). The two prism separation is 1mm. The last surface is curved with a radius of 386.89 mm to compensate the prisms defocus. This radius has been proposed by the manufacturer as available tooling. The both prism angle is 10.758 deg.
The prism is decentered by 8mm to fit the science aperture of the fiber head. The corresponding field offset is 1 arcmn 34 arcsec.
The opto-mechanical design must be with a minimum obstruction on the Prism area and not produce vignetting on the optical beam from M3 as well as the beam reflected towards the Technical CCD. The WFI field must be also un-vignetted when the ADC support will be in park position.

The lens data prescription of the ADC is presented below:

SURFACE DATA SUMMARY:

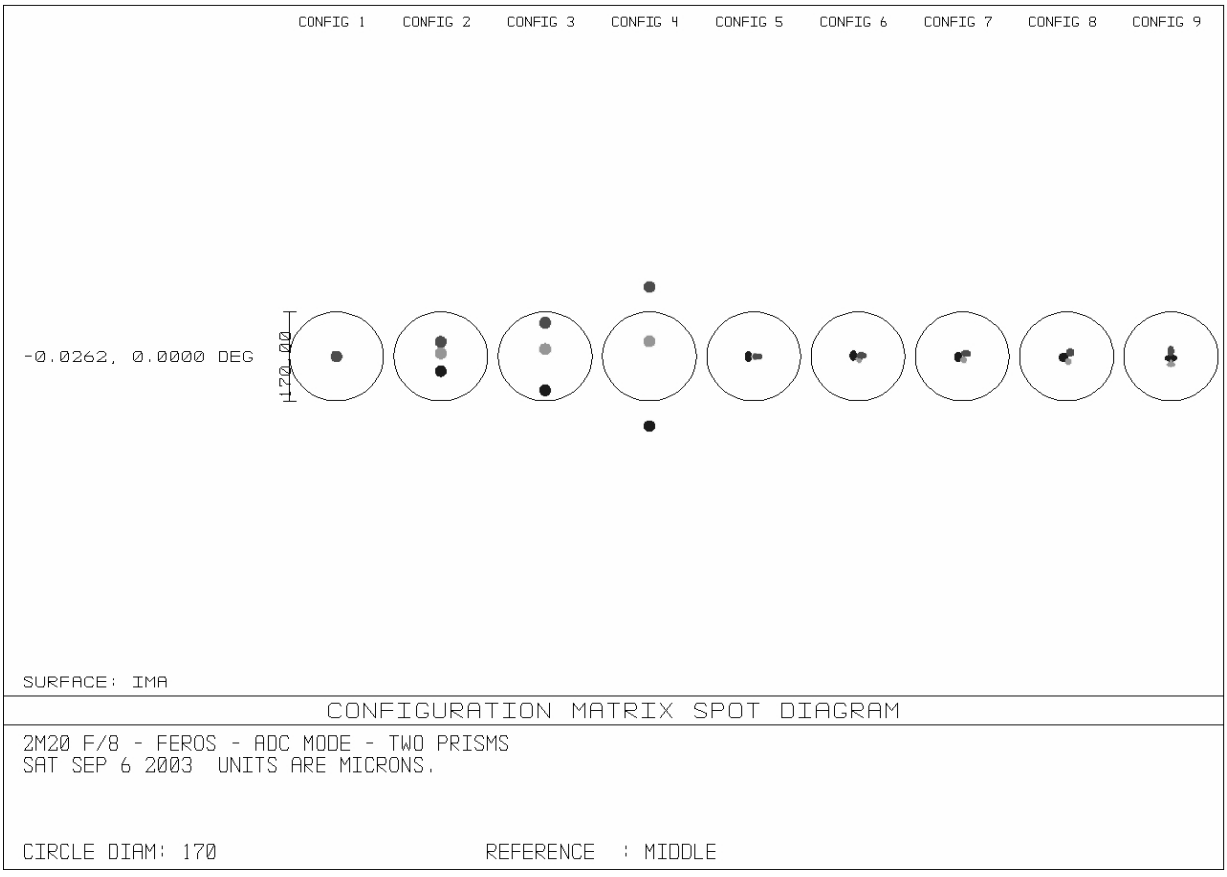
Surf	Type	Comment	Radius	Thickness	Glass	Diameter	Conic
OBJ	STANDARD		Infinity	Infinity		0	0
1	ATMOSPHR	ATMOSP. DISP	Infinity	0		2204.564	0
2	STANDARD		Infinity	5000		800	0
STO	STANDARD	MAIN MIRROR	-13200	-4471.592	MIRROR	2210	-1.134444
4	STANDARD	M2	-6816	5107.555	MIRROR	800	-6.5379
5	STANDARD	NEW SPACER	Infinity	20		0	0
6	STANDARD	M3	Infinity	-470	MIRROR	100	0
7	STANDARD	DUMMY	Infinity	-10		24.8585	0
8	COORDBRK	DECENTER A	-	0		-	-
9	COORDBRK	ROTATION PRISM 1	-	0		-	-
10	STANDARD	ADC PRISM 1	Infinity	-3	UBK7	12	0
11	TILTSURF	PRISM ANGLE	-	-3	LLF6	12	-
12	STANDARD		386.89	0		12	0
13	COORDBRK		-	-1		-	-
14	COORDBRK	ROTATION PRISM 2	-	0		-	-
15	STANDARD	ADC PRISM 2	Infinity	-3	UBK7	12	0
16	TILTSURF	PRISM ANGLE	-	-3	LLF6	12	-
17	STANDARD		Infinity	0		12	0
18	COORDBRK		-	0		-	-
19	COORDBRK	DECENTER -A	-	-48.3		-	-
IMA	STANDARD		Infinity			16.06895	0

The back surface of the front prism is curved to compensate the ADC defocus unit. The correction is located on this surface instead of the last surface of the second prism to avoid any ghost reflection effect between the two prisms.
We also present below a shaded model view of the prism and fiber head area:



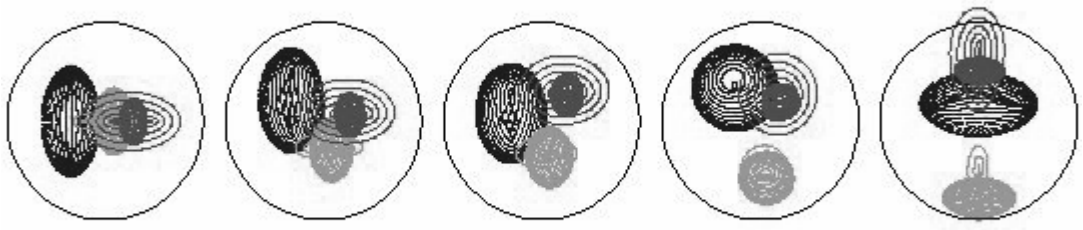
The two prisms are clearly presented above. Only the science beam reaching the science fiber aperture on the head is presented as specified.
The prism angle setting corresponds to a Zenithal Distance of 40 deg with respective angles of +- 29 deg.

On the next figure, the corrective effect of the prism is presented.



9 different configurations of the prism setting are presented with four without the ADC.
The first four show the star image at Zenith Distance 0, 20, 40 and 60 deg without the ADC prisms corrector.
The five next ones show the star image at ZD 0, 30, 40, 50 and 60 deg with the ADC inserted within the beam.

By the residual chromatic effect, the tolerance of 0.2 arcsec separation of the wavelength range edge images is not reached and not achievable on the space restriction.



On the above figure the scale of the image plane is reduced to 0.4 arcsec circle. At least 80% of Encircled Energy is within 0.020 mm or 0.25 arcsec at ZD 0 and 30, 0.022 mm or 0.26 arcsec at ZD 40 and 50 and finally 0.024 mm or 0.28 arcsec at ZD 60.
As expected a small spherical aberration is noticed on the images.

The four surfaces of the prisms will have a Anti-Reflection coating type Broadband MGF2. Around 10% of the light is expected to be lost with the ADC (glass absorption and 0.98% reflection on 4 surfaces)

5 Implications

5.1 Tolerances

The ADC surfaces position has been verified over optical degradation effects. Tilts, decenters and focus position has been used.
The tolerance in tilts and decenters are not critical and perfectly reachable.
The most critical effect is the position of two prisms. The back focal distance must be very precise as well as the first prism position with respect to the second prism.

5.2 Mechanical Requirements

We presents below the following requirements on the opto-mechanical mounting derived from the optical design:

- The possibility to choose during the integration which fiber will have the ADC. The object fiber will be selected during the new fiber bundle installation
- The ADC and the calibration switch mirror are located on the same back focal distance to the fiber head. The calibration mode is NOT possible using the ADC
- The ADC must not produce vignetting on the beam before M3.
- The ADC must not produce vignetting on the reflected beam towards the guiding technical CCD
- On park position the ADC must not produce vignetting on the WFI beam
- The ADC prisms size should be around 12 mm diameter minimum

- The rotation of the prisms requires only a precision of 2 deg.
- The tolerance on decenter position of both prism is up to 0.5 mm (prism diameter !)
- The tolerance on tilt angle of both prism is up to 1deg.
- The tolerance in focus position of both prism is up to 0.2 mm total (prism 1& 2 added effects)

The element position tolerance of the two prisms will require a precise laboratory adjustment. The “on site” adjustment is not possible for access limitations.

5.3 ADC Manufacture.

The cost of the two prisms with one curved surface including the coating process will amount 1300 Euros for two sets (with a spare).
A delivery time of 2 months must be expected.

6 Conclusion

The double ADC prisms can be used for the atmospheric dispersion correction. The reached quality is not the required one but enough good until a zenithal distance of 60 deg.
The integration of the two prisms with the required rotating functions will be quite difficult on the small available free space.
The early solution of one single prism already mentioned could an alternative choice. The sky aperture of 2 arcsec allows observations without vignetting up to 30 deg only and strongly dependant of the seeing quality and the guiding acquisition colour.

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