Thin glass mirrors for the Pierre Auger project

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Abstract

Joint Laboratory of Optics produce mirrors for fluorescence optical detector of the Pierre Auger Project placed in Argentina. We want resume our manufacturing quality measurements and compare first two made telescopes with the prototype one. We measure radius of curvature, spot size and reflectivity in ultra-violet region.

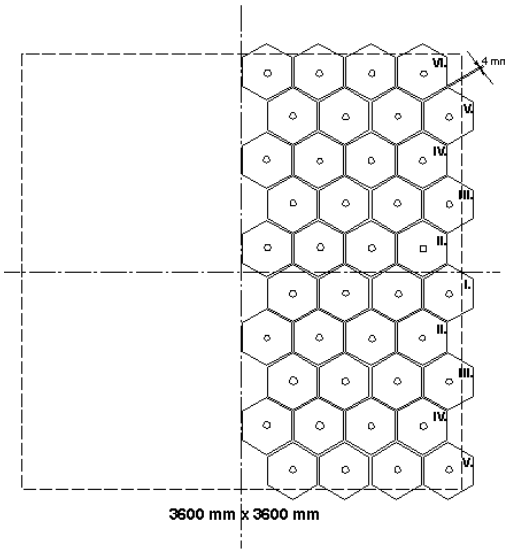
Introduction

We produce in Joint Laboratory of Optics mirror segments for the Pierre Auger Project. This project is placed in Argentina near village called Mallargue. There will be 30 fluorescence telescopes distributed in 3 or 4 buildings. Construction started in 1999 and whole project will be done probably in 2005. Our task in this project is produce 12 telescopes for fluorescence detector.

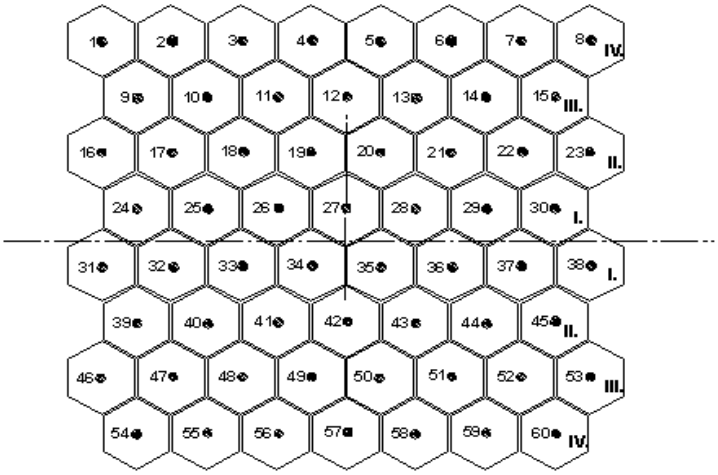
At the beginning we had to prove that we are able to produce mirrors in sufficient quality for this type of measurement and that our mirrors have good parameters. So we produced prototype of fluorescence telescope together with colleagues from Forschungszentrum in Karlsruhe. Half of prototype telescope was covered with our glass hexagonal mirrors and second half with aluminum rectangle mirrors from Karlsruhe and we set up this telescope prototype in October 2000 in Karlsruhe and during the spring 2001 in Argentina and we measured all reasonable parameters for testing quality of mirrors.

Our and German mirrors pass all conditions required from Pierre Auger collaboration and we have started production of mirror segments according to the final telescope design. Basic telescope parameters are follows:

- Center of curvature 3400 millimeters
- Surface area 3600 x 3600 millimeters
- Inclination 16 degrees
- 80 mirror segments for whole telescope in prototype (40 mirrors for our half – Picture 1.)
- 60 mirror segments for whole telescope in the final design – Picture 2.



Picture 1. – Prototype of fluorescence detector.



Picture 2. – Final fluorescence telescope design

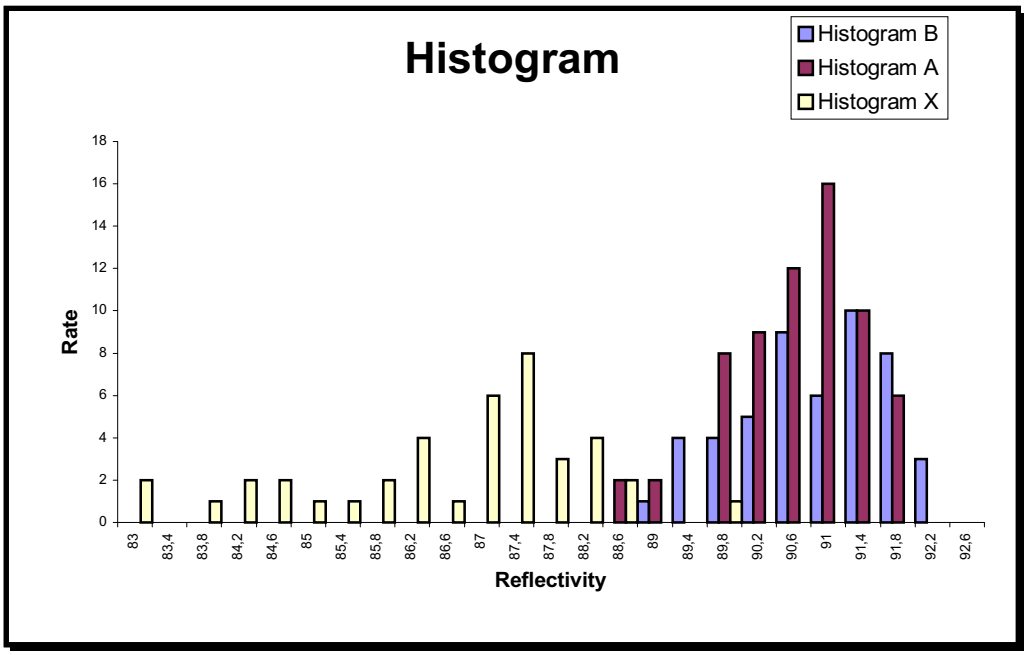
The final fluorescence detector design

In final fluorescence telescope design we enlarge the mirror surface from 500 millimeters circumscribed circle to 623 millimeters circumscribed circle. Center of curvature varies from 3400 millimeters to 3420 millimeters for prototype and from 3400 millimeters to 3412 millimeters for now produced mirrors along the final design. The quality of the spherical shape of mirrors is controlled and measured by Ronchi test. Next very important parameter, which we have to measure, is reflectivity on the UV wavelength. Our mirrors are coated by aluminum and this layer is protected by silicon dioxide layer. On the thickness of this layer depends mainly the reflectivity. We measure reflectivity of mirrors by comparative reflectometer which was made in Karlsruhe. In fact we compare reflectivity of measured mirror with sample whose reflectivity is known. This sample is calibrated and reflectivity at 370 nanometers is 90,6%. Measured data of reflectivity for prototype telescope are in Table 1.

mirror number	reflectivity at 370 nm [%]	mirror number	reflectivity at 370 nm [%]
I - 03	88,3	IV - 01	87,2
I - 10	86,7	IV - 03	85,7
I - 13	87,2	IV - 04	87,3
II - 01	87,7	IV - 05	88,5
II - 02	84,9	IV - 06	83,9
II - 05	87,5	IV - 10	83,7
II - 11	85,6	IV - 12	86,2
II - 15	74,9	IV - 13	86,1
II - 16	87,7	V - 01	86,6
II - 18	86,9	V - 02	87,4
II - 19	84,6	V - 03	88,0
III - 10	89,6	V - 04	86,8
III - 11	85,9	V - 06	87,1
III - 12	83,0	V - 07	87,2
III - 13	88,1	V - 08	87,9
III - 14	84,2	V - 09	87,2
III - 15	84,4	VI - 01	88,0
III - 16	87,0	VI - 02	86,7
III - 17	86,1	VI - 03	85,3
III - 18	87,1	VI - 04	86,9

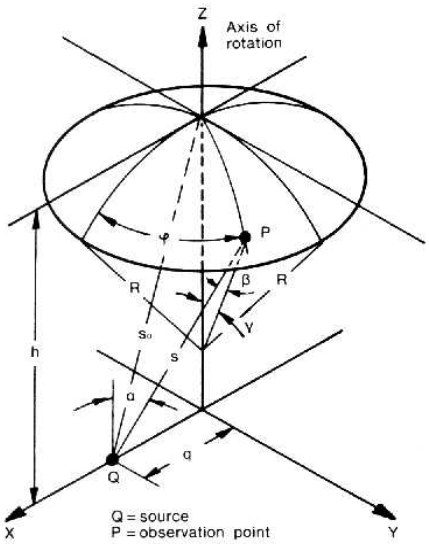
Table 1. – Reflectivity of prototype mirrors.

The mean value of reflectivity for prototype mirrors is 86,3%. Mean values of reflectivity for the first two already made telescopes which have label A and B are 90,5% for telescope A and 90,7% for telescope B. On the Picture 3. is histogram of reflectivity distribution for prototype (label Telescope X) and telescopes A and B.



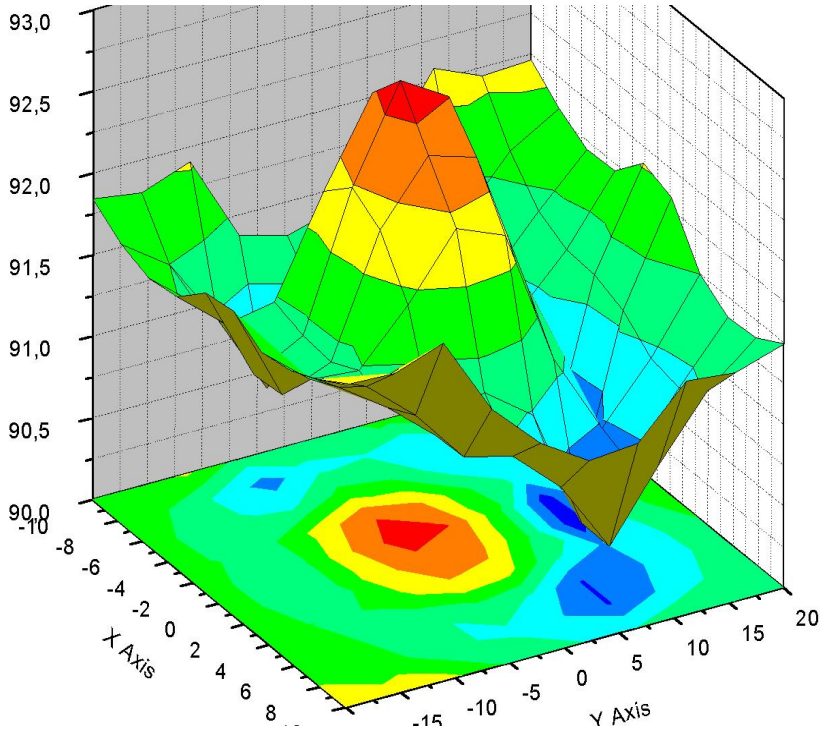
Picture 3. – Histogram of reflectivity distribution.

Reflectivity along the mirror surface little bit varies. This is caused by point evaporation source of silicon dioxide and rotation of mirror segment during evaporation. We achieve minimalization of these changes in reflectivity by optimalization of parameters *h* and *q* along Picture 4.



Picture 4. – evaporating characteristics for rotating mirror segment.

This changes of reflectivity are now less than 2,5% as you can see on the Picture 5.



Picture 5. – Changes of reflectivity on mirror surface.

We also measure the spot size of our mirrors. Measured parameter is how many percent of reflected light from point source in center of curvature lies inside the circle with diameter less than 1 millimeter again in center of curvature. All mirror segments undoubtedly reflect more than 95% of light in this 1 millimeter circle (mostly 98% or 99%).

Conclusion

Now produced mirror segments along the final design prove that they have better parameters like reflectivity or center of curvature than prototype mirrors, which pass all requirements requested by Pierre Auger Collaboration in despite of we dramatically enlarge the mirror surface of now produced mirrors by 56% in comparison with prototype mirrors.