Optica Applicata, Vol. XXXIII, No. 4, 2003

Thin glass mirrors for the Pierre Auger Project

Martin Vlček, Petr Schovánek, Miroslav Palatka, Miroslav Hrabovský

Joint Laboratory of Optics of Palacký University and Institute of Physics of the Academy of Sciences of the Czech Republic, Tř. 17. listopadu 50, 77207 Olomouc, Czech Republic.

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

Keywords: Pierre Auger Project, fluorescence telescope, glass mirror, mirror segment, reflectivity.

1. Introduction

In the Joint Laboratory of Optics we produce mirror segments for the Pierre Auger Project. This project is situated in Argentina near a village called Mallargue. There will be 30 fluorescence telescopes distributed in 3 or 4 buildings. The construction started in 1999 and the whole project will be accomplished probably by 2005. Our task in this project is to produce 12 telescopes for fluorescence detector.

At the beginning we had to prove that we were able to produce mirrors of quality which was sufficient for that type of measurements and that our mirrors had good parameters. So, we produced a prototype of fluorescence telescope together with our colleagues from Forschungszentrum in Karlsruhe. One half of the prototype telescope was covered with our glass hexagonal mirrors and the other half with aluminum rectangle mirrors from Karlsruhe. We set up this telescope prototype in October 2000 in Karlsruhe and during the spring of 2001 in Argentina, and we measured more essential parameters for testing the quality of mirrors.

Both the German mirrors and ours met all the conditions imposed by Pierre Auger collaboration and we started production of mirror segments according to the final telescope design. The basic telescope parameters are as follows:

– Radius of curvature 3400 mm;

– Surface area ca. 3600×3600 mm;

– Inclination 16 deg;

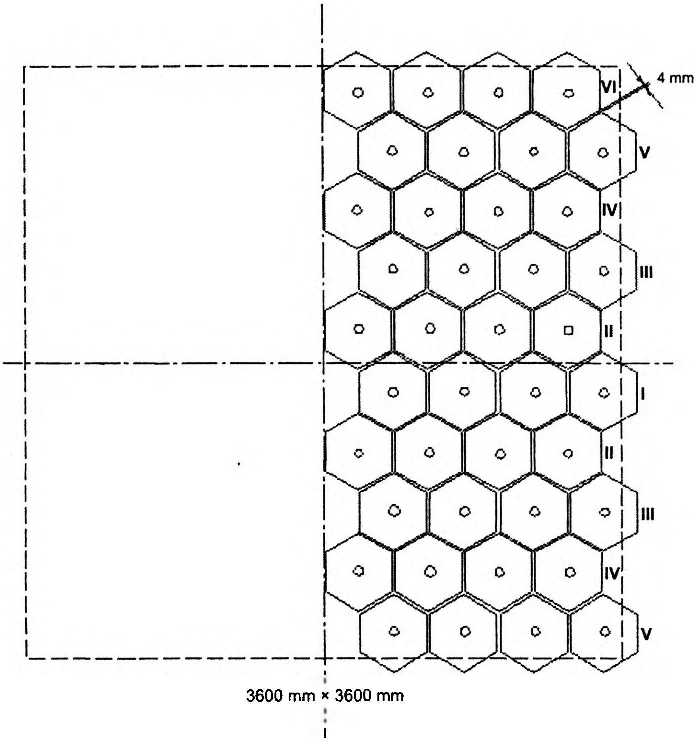

Fig. 1. Prototype of the fluorescence detector.

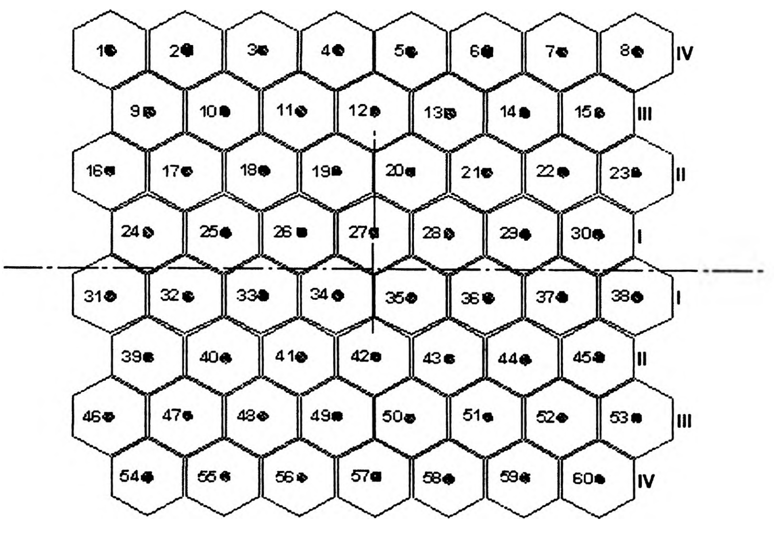

Fig. 2. Final fluorescence telescope design.

– 80 mirror segments for the whole telescope in prototype (40 mirrors for our half, see Fig. 1);

– 60 mirror segments for the whole telescope in final design (see Fig. 2).

2. Final fluorescence detector design

In the final design of fluorescence telescope we enlarge the mirror surface from 500 mm circumscribed circle to 623 mm circumscribed circle. The center of curvature varies from 3400 to 3420 mm for the prototype and from 3400 to 3412 mm for mirrors being now produced according to the final design. The quality of the spherical shape of mirrors is controlled and measured by Ronchi test. Another very important parameter we have to measure is reflectivity in the UV wavelength range. Our mirrors are coated by aluminum and this layer is protected by silicon dioxide layer. It is the thickness of this layer that reflectivity mainly depends. We measure the reflectivity of mirrors by a comparative reflectometer which was made in Karlsruhe. In fact, we compare the reflectivity of the mirror being measured with sample one whose

Table. Reflectivity of prototype mirrors.

Mirror no.	Reflectivity at 370 nm [%]	Mirror no.	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

reflectivity is known. This sample is calibrated and its reflectivity at 370 nm is 90.6%. The data of reflectivity measured for prototype telescope are collected in the Table.

The mean value of reflectivity for prototype mirrors is 86.3%. The mean values of reflectivity for the first two telescopes already made which are labelled A and B, are

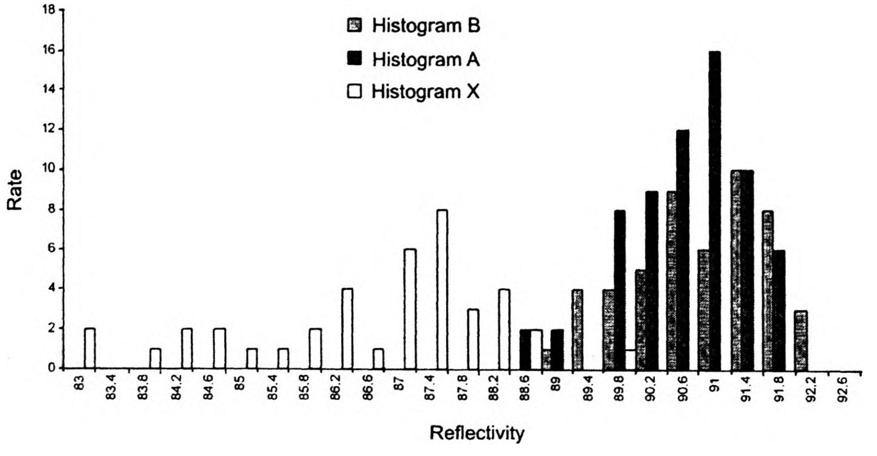

Fig. 3. Histogram of reflectivity distribution.

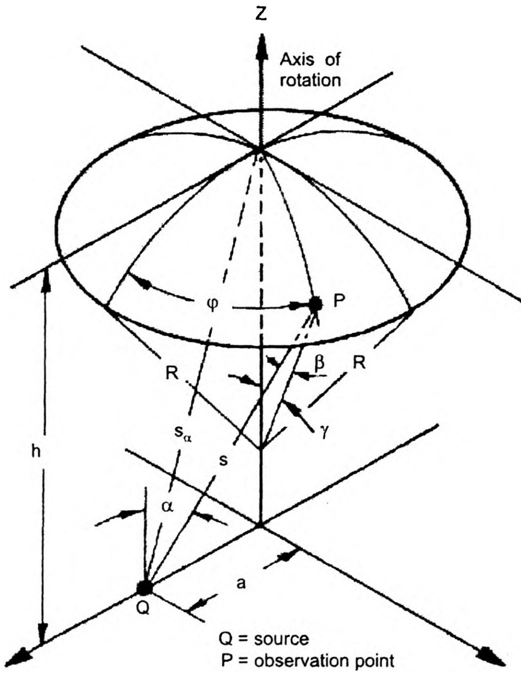

Fig. 4. Evaporation characteristic for a rotating mirror segment.

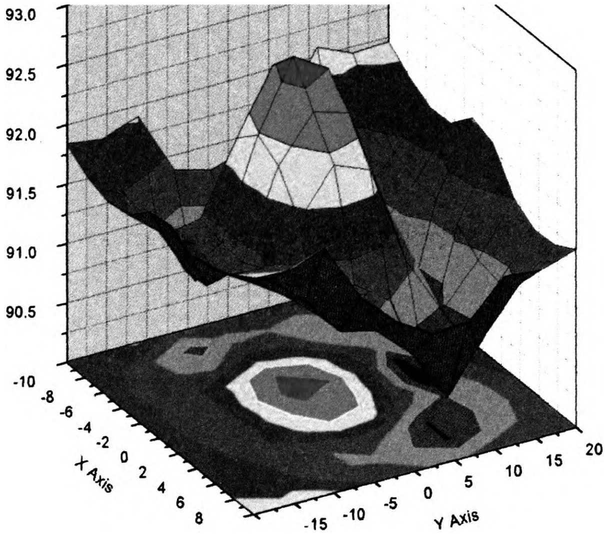

Fig. 5. Changes of reflectivity on mirror surface.

90.5% for telescope A and 90.7% for telescope B. In Figure 3, a histogram of reflectivity distribution for prototype (label Telescope X) and telescopes A and B is given.

The reflectivity along the mirror surface varies a little bit. This is caused by the evaporation point source of silicon dioxide and rotation of mirror segment during evaporation. We achieve minimization of these changes in reflectivity by optimizing the parameters h and a, as shown in Fig. 4.

These changes of reflectivity are now less than 2.5% as you can see from Fig. 5. We also measure the spot size of our mirrors to see what percentage of reflected light from the point source in the center of curvature lies inside the circle of radius less than 1 mm. All mirror segments undoubtedly reflect more than 95% of light in this 2 mm circle (mostly 98% or 99%).

3. Conclusions

The mirror segments now produced in their final design prove to have better parameters, such as reflectivity or center of curvature than prototype mirrors. They satisfy all requirements specified by Pierre Auger Collaboration, despite on the fact that we dramatically enlarge the mirror surface even by 56% in comparison with prototype mirrors.

Acknowledgments – We thank the Ministry of Education of the Czech Republic for financial support under the grants LN00A006, Ingo LA 134 and the Grant Agency of Academy of Sciences of the Czech Republic for project A1010928.

Received September 20, 2002