Status of CANGAROO-III

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Abstract

Status of the CANGAROO-III project and hardware performance of the second telescope is reported.

1. Introduction

The scope of CANGAROO (Collaboration for a GAmma-Ray Observatory in the Outback) project is to observe very high energy gamma-ray objects in the southern sky using atmospheric Cherenkov telescopes. The project started in 1990 with a single 3.8m diameter telescope, and the history and results so far are presented in Ref.[1] or elsewhere.

At present the project steps into the third phase –CANGAROO-III, whose goal is to construct four 10m diameter telescopes and achieve observation with lower energy threshold($\sim$200 GeV) and higher angular resolution. The first 10m telescope has been completed in 2000 and its observational results are summarized in Refs.[2],[3]. The 2nd telescope whose hardware performance is reported here was constructed in 2002 March and its tune-up work is scheduled in Nov 2002.

Table 1. CANGAROO-III construction schedule

2000 Mar	completion of the 1st telescope(T1)
	production of the 2nd telescope(T2)
2002 Mar	T2 construction
2002 Nov	T2 tune-up
	construction of the 3rd telescope(T3)
2002 Dec	start stereo observation with T1 and T2
	production of the 4th telescope (T4)
2003 Apr	T3 tune-up
	T4 construction
2004	all the four telescopes would be in operation

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Stereo observation with these two telescopes will be started until the end of the year 2002. All the four telescopes will be in operation in the year 2004.

2. performance of the 2nd telescope

Hardware performance of the seconnd telescope of CANGAROO-III is significantly improved compared with the first one. There are some subgroups in developmental work and results should be shown by each, and as for the PMT camera and electronics groups their results are reported elsewhere(Refs.[5],[6]), so the report here could be rather brief.

2.1. Optical reflector

Grand design of the reflector

All the four telescopes of CANGAROO-III project have basically the same design, which was inherited from the existing radio telescope(Ref.[4]). The main mirror is tessellated parabola with 8m focal length ,whose area reaches 5.73×10^4 cm ^{2}. F/d value is 0.8. 114 mirror segments are spherical and 80cm in diameter. Their curvature radii are distributed between 16.0 to 17.2m according to the position on the main mirror. Due to the tessellation total Point Spread Function of the telescope is finite as $0^\circ.027$ in RMS(Root Mean Square) even if the all the mirrors are ideal. Since required focusing power for the Atmospheric Cherenkov Telescope is about less than 0.1degree in FWHM that can separate gamma/cosmic-ray induced showers, it is acceptable.

Fig. 1. CANGAROO-III 10m telescope(T1).

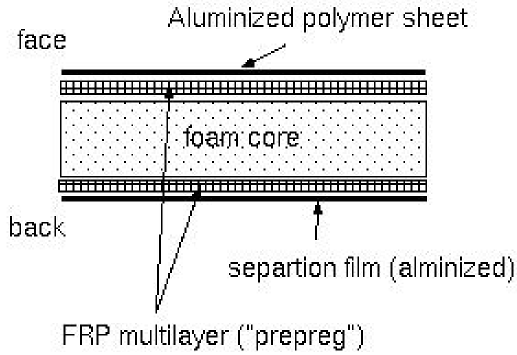

Fig. 2. FRP composite layer.

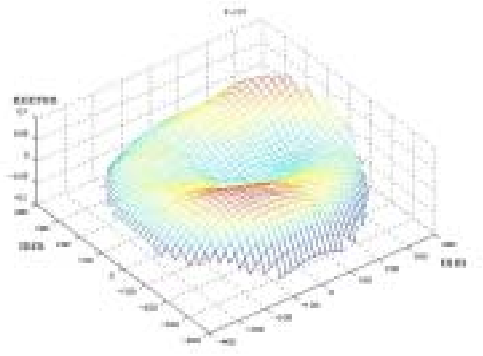

Fig. 3. 3D surface measurement. Deviation from the ideal sphere is shown.

Spherical mirror segments

- surface accuracy Especially for large area telescopes, weight-saving of the mirrors is quite a point of interest. We adopted FRP (Fiber Reinforced Plastic) as the material of the mirror from this point of view. This plastic mirror is relatively light-weight (6.7kg itself) and extremely rigid compared with a conventional glass mirror of the same size.
  Our FRP mirror is in reality a composite, consisting of multi-layer of different materials(Fig.2.). A rigid foamed core is pintched by the FRP layers and this structure is placed on the mold and curved in an auto-clave. This is the only forming procedure and no subsequent surface tuning like grinding is available in return of its stiffness. So the improvement of surface accuracy control and productivity has long been our main concern.

  The surface accuracy of a mirror is determined by the balance of rigidity of each layer component. In order to understand the tendency of the deformation, we had measured surface of all the product mirrors in 3-dimension with accuracy of 5 micron(Fig.3.) and obtained deformation from the ideal sphere. From these data, we repeated tunings of composite parameters and there seems to be some progress in surface accuracy control. The primary parameter change is that rigidity of the core is raised and Carbon FRP is replaced to Glass FRP accordingly. Now the surface "winding" RMS value is 0.030 micron as typical(Fig.4.),and each mirror's image size is about $0^\circ.13$ in FWHM. All the developmental work of FRP mirrors are carried out in cooperation with Mitsubishi Electric Corporation.

- Cherenkov photon collection efficiency Due to the strong wavelength depen-

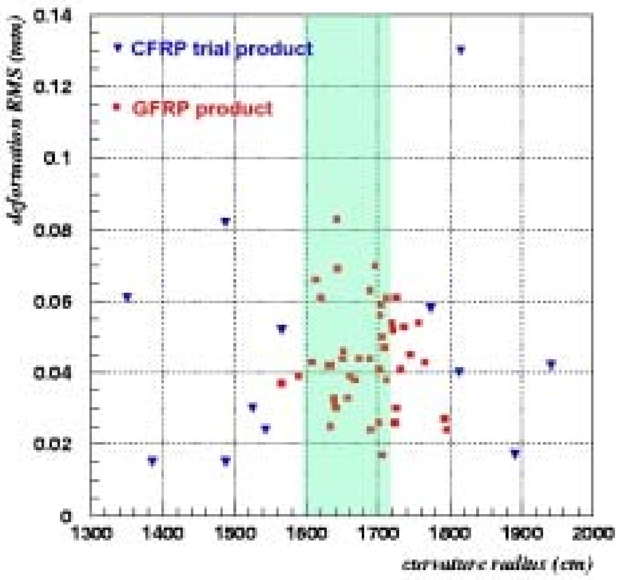

Fig. 4. Improvement in surface accuracy control. New products show concentraion.

dence of Cherenkov spectrum as $N(\lambda) \propto \lambda^{-2}$, high reflectance at the shorter wavelength band(300-400nm) is required. It is well known that aluminum has good reflectance at this wave-band, but some additional surface protection is needed to avoid decay of surface metal for outdoor use.
Fluoroplastic coating we selected has 80% reflectance at 400nm and it is confirmed to be kept at least two years(Fig5.).

- Alignment system of each segment
  Every mirror of CANGAROO-III telescopes is equipped a system that can control orientation of the mirror remotely. The mirror is cramped at the center and sustained by four shafts, two of them are linear actuators driven by stepping motors. Designed resolution is 1.43×10^{-4} degree and the performance of this system (recursiveness and smoothness of the motion) is checked before shipping, at the test assembly of the telescope.

2.2. Imaging camera

Cherenkov photon detector, the photomultiplier tubes(PMTs) arrayed camera of the second telescope has wider field of view($\sim 4^\circ.0$ in full angle) than the first one, which is suitable for the stereo observation. 3/4 inch PMT HAMAMATSU R3479 is adopted and each of them is accompanied with high-gain high-

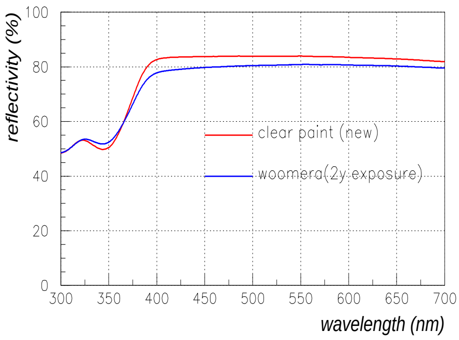

Fig. 5. Reflectance of fluoroplastic coated FRP mirror before/after exposure.

Fig. 6. Alignment system of each segment.

speed pre-amplifier. Their response are elaborately calibrated before the shipping. High voltage supply for the PMTs can be controlled individually ,which makes fine gain tuning and rejection of starlight effects easier. The PMTs are arranged in hexagonal close-packing and high-efficient Winston light collecting cones are attached just in front of the PMTs to compensate dead space. Total weight of the camera is about 100kg, small enough that the effect to the tracking accuracy is negligible.
Details about the imaging camera of CANGAROO-III the second is described in [5].

2.3. Electronics and data acquisition

Since lowering energy threshold leads to the increase of coincidence triggers induced by background photons, one of the concern of the electronics group is to achieve high-speed (low dead-time) data processing. As for CANGAROO-III standard of all the electronics modules(custom-built front-end including discriminator and scaler, commercial charge ADC and TDC) is unified into the VME system and at present with Linux OS and available data acquisition rate is raised up to 500Hz (with 20% deadtime level). Details about data acquisition and electronics are described in [6].

3. Summary

Construction of CANGAROO-III telescopes is proceeding and performance of its 2nd telescope is considerably improved. Until the end of the year 2002 we will start stereo observation with two 10m telescopes.

4. References

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4. Kawachi.A., et al. Astropart. Phys.**14**,261(2001).
5. Kabuki.S., 2002, T09 in this symposium, to appear in NIM.
6. Nishida.D., 2002, T17 in this symposium.