Prototyping of Hexagonal Light Concentrators for the Large-Sized Telescopes of the Cherenkov Telescope Array

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Reflective light concentrators with hexagonal entrance and exit apertures are frequently used at the focal plane of gamma-ray telescopes in order to reduce the size of the dead area caused by the geometries of the photodetectors, as well as to reduce the amount of stray light entering at large field angles. The focal plane of the large-sized telescopes (LSTs) of the Cherenkov Telescope Array (CTA) will also be covered by hexagonal light concentrators with an entrance diameter of 50 mm (side to side) to maximize the active area and the photon collection efficiency, enabling realization of a very low energy threshold of 20 GeV. We have developed a prototype of this LST light concentrator with an injection-molded plastic cone and a specular multilayer film. The shape of the plastic cone has been optimized with a cubic Bézier curve and a ray-tracing simulation. We have also developed a multilayer film with very high reflectance (>95%) along wide wavelength and angle coverage. The current status of the prototyping of these light concentrators is reported.

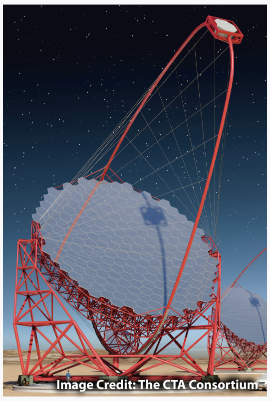
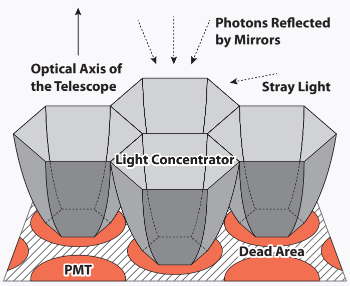


Image Credit: The CTA Consortium

Large-Sized Telescopes (LSTs)

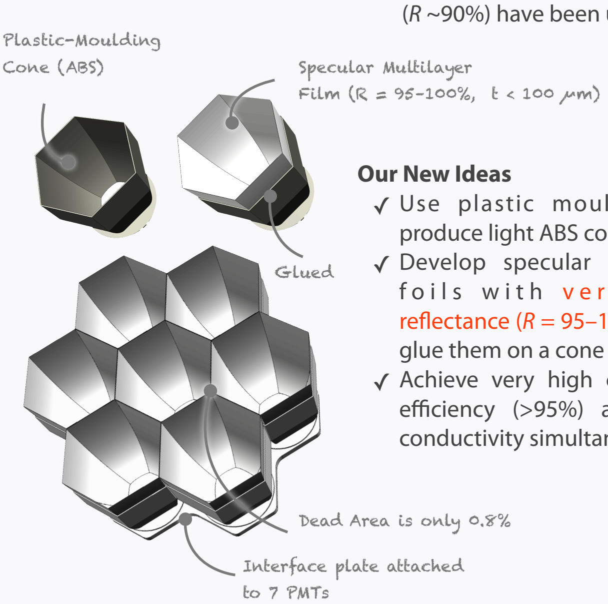
- ✓ Cover the low-energy band of the Cherenkov Telescope Array (CTA)
- ✓ Aims to achieve 20 GeV energy threshold
- ✓ Requires a large effective collection area
- ✓ 23-meter parabola mirror with 198 facets
- ✓ In addition to high-QE PMTs and high-reflectance mirrors, high collection efficiency is required for hexagonal light concentrators



Modified Fig. 1 in Okumura (2012)

Hexagonal Light Concentrators

- ✓ Often used for Cherenkov telescopes to reduce the dead area between PMTs
- ✓ Only photons reflected on the mirror are collected
- ✓ Stray light and night sky background entering at large field angles are cut
- ✓ A Winston cone (or compound parabolic cone) and aluminum coating (R ~90%) have been used

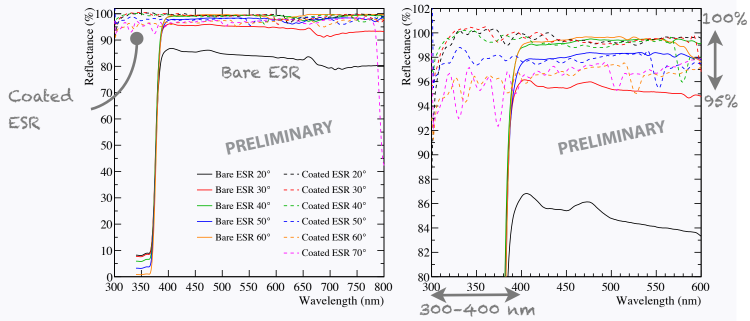


Our New Ideas

- ✓ Use plastic moulding to produce light ABS cones
- ✓ Develop specular reflective foils with very high reflectance (R = 95–100%) and glue them on a cone
- ✓ Achieve very high collection efficiency (>95%) and non-conductivity simultaneously

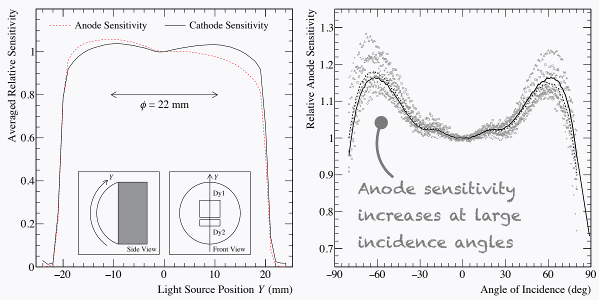
Newly Developed Specular Reflective Foil

- ✓ Use *Vikuiti ESR* film by 3M as a base material (R > 98% in 410–800 nm)
- ✓ Additional multilayer coating to enhance the reflectance in the UV region (95–100% in 300–400 nm) and to mitigate incidence angle dependence



Measurements of PMT Anode Sensitivity

- ✓ LST PMTs (R11920-100 by Hamamatsu) have position and incidence angle dependence of anode sensitivity
- ✓ The latter is because of the matte and spherical input window
- ✓ Simulations of an LST light concentrator are performed taking these measured response into account



Measured Performance of a Prototype Light Concentrator

- ✓ PMT anode sensitivity relative to that without a light concentrator is ~95% at 0° field angle, and higher than 100% around the cutoff angle
- ✓ Almost ideal collection efficiency has been achieved thanks to the newly developed film and the very small (0.8%) dead area