

**To:**  
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**Subject: Customer reference on 5.3-meter fiberglass reinforced polyester observatory dome (up and over shutter -type)**

**Background:**

Finnish Geospatial Research Institute (FGI, formerly known as the Finnish Geodetic Institute) of the National Land Survey of Finland is operating a geodetic research station at Metsähovi, Kirkkonummi, Finland (60.2N, 24.4E). Metsähovi is one of a few geodetic core sites worldwide where all major space-geodetic measurement systems, including satellite laser ranging, are co-located.

Satellite laser ranging (SLR) is a measurement technique where ultra-short laser pulses are transmitted through a telescope that is tracking a satellite equipped with retroreflecting mirrors and then subsequently received back at a receiver attached to the telescope. With precise measurement of the time of flight of the laser pulse, several important geodetic parameters can be obtained including: variations in Earth's gravity field, location of the center of the mass of the Earth, and scale of the terrestrial reference frame. SLR is also used in validation of orbits of several types of satellites including navigation and remote sensing satellites.

FGI has build a new, modern, SLR system in Metsähovi in 2013-2016. As part of that project a new observatory building was built to house the new SLR system and a state-of-the-art observatory dome was required. Requirements for the dome were strict. Here I list some of the requirements for the dome:

- The dome needs to be able to operate in all weather conditions where SLR operations can be performed. This includes operating during daytime, when the dome is used as a sun-shield for the telescope.
- It needs to have low maintenance needs
- It needs to have a long lifetime
- It needs to turn fast (SLR also tracks low-flying satellites)

- For added safety it needs to be able to autonomously (and with its own power) close in case of rain and/or heavy winds
- It needs to be tightly sealed while closed to allow fast resumption of operations after the weather improves.

We talked to several manufacturers of observatory domes and also to other SLR observatories about their experiences with different manufacturers. It soon became clear that Baader Planetarium GmbH produces the domes best suited for our requirements.

We selected from Baader's products a 5.3-meter fiberglass reinforced polyester observatory dome (up and over shutter -type) with geared tooth drive. The dome was built and installed in 2014. In addition to the dome itself, we also ordered, e.g., an integrated weather station working together with a dehumidifier system. Before describing our experiences with the Baader dome, it is important to summarize the operating environment of the dome at Metsähovi as the dome's main purpose is to protect the telescope against the environment.

Metsähovi is located in the southern Finland approximately 20 km from the sea, at an altitude of 60 m above the sea level, in a rural environment. The weather conditions at Metsähovi show characteristics of both maritime and continental climate: summer is humid and relatively warm and winter is cold. The temperature normally varies annually between  $-25^{\circ}$  to  $+30^{\circ}$  Celsius, with a yearly average temperature around  $6^{\circ}$  Celsius. Seasonal snow normally covers the station from December to April and yearly precipitation is around 700 mm with approximately 170 days with rain. Supercooled water rain can occur during late autumn and each summer Metsähovi receives a few hailstorms, mainly together with thunderstorms. The mean relative humidity for an average year in Metsähovi is  $\sim 80\%$ . Fog arising from the nearby small bog and from the Baltic Sea is relatively frequent during cold summer mornings as well as during the sea-ice forming and melting season. The station sees a few storms each year with gust wind speeds up to 25 m/s, but mostly winds are around 0-10 m/s. Dust and pollen from the surrounding pine forest, especially during spring, has the tendency to cover all surfaces.

### Customer experience:

FGI is very pleased with its choice of Baader Planetarium GmbH as the provider for the observatory dome at Metsähovi Geodetic Research Station. The level of collaboration with Baader during the design, manufacturing and installation processes as well as the communication and support after the installation are to be commended. The craftsmanship of the dome is superior and the installation was smooth and professional. Here are some comments about the dome:

- We have tested and operated the dome in different weather conditions at Metsähovi for a more than a year now and have had no problems with the dome whatsoever. The weather conditions have included, e.g., ice and snow on top of the dome, temperatures from +25°C to -25°C.
- The weather station/autonomous weather protection system is working well to prevent unwanted opening of the dome when weather is bad (precipitation being the main problem in Metsähovi). From the weather station we also get a nice quantitative picture of the conditions outside the dome.
- The dehumidifier is working perfectly keeping the inside of the dome in a desired level of relative humidity. There has been no condensation of water inside the skin of the dome, probably also due to the good thermal-insulation characteristics of the dome skin and structure.
- The dome is very air- and watertight. We've had no water leaks inside the dome even during heavy rains. No insect have found their way inside the dome. Even though Metsähovi is surrounded by a forest, there is virtually no pollen or any other dust deposited inside the dome after one year (of which most of the time the dome has been closed as the SLR system was being built).
- The temperature inside the dome does not rise high even during hottest summer days. The IR-reflecting coating of the dome skin seems to be working very well in keeping heat outside. It is also noteworthy to mention here that the observatory building itself is thermally insulated from the dome so that there is no heat flux from the building but also no active cooling of the dome.
- The shutter and flap of the dome have worked perfectly in all weather conditions.

As a general note, I want to also mention that the construction of the dome is very sturdy. We expect for it to easily handle all conceivable snow and ice loads. We can even use the shutter to lift ~150kg objects inside the dome and the flap as a stepping platform to access the roof of the observatory! The mechanical and electrical components are of the highest build quality and meet all of our requirements. I can without reservations recommend Baader domes to anyone looking for a top-quality high-performance observatory dome.

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