Research Report
ICRR Inter-University Research Program 2021

Research Subject:

G02-Intermediate stage for future cryogenic payload development

Principal Investigator:

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Participating Researchers:

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Summary of research results:

The proposal aimed to continue the collaborative work started in recent years and focused on the design of a cryogenic payload and monolithic silicon suspensions. In particular, the project was focused on the optimization of the intermediate stage of a cryogenic payload (present and future) and specifically on the production of an intermediate silicon mass, on the design of the upper clamping system for silicon fibers and on the development of new sapphire blades. Due to the impossibility to travel in Japan for COVID restrictions, the collaboration decided to focus all efforts on the only topic that could have been produced in Japan and tested in Italy during this pandemic year, namely the new sapphire blade.

We designed a new sapphire blade adapted to the size of KAGRA mirror and suitable to be installed in an updated version of the cryogenic payload.

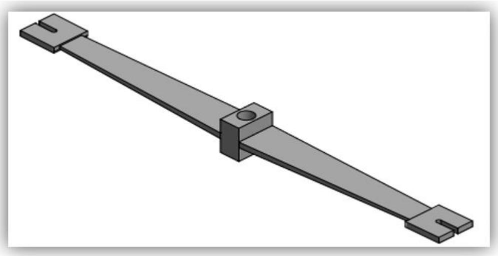
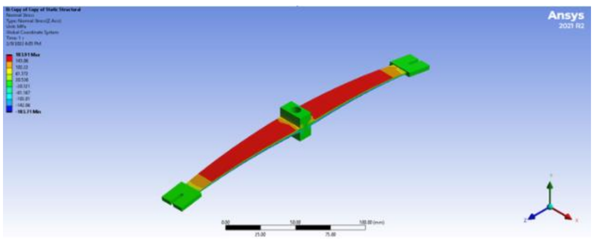

Fig.1: A preliminary design meant to compute the stress distribution along the blade and its modes. The requirement was to guarantee at least the features of KAGRA blade concerning frequency and max stress peak.

KAGRA blades had been tested in Rome in a small cryogenic facility, the same that served in past to study the quality factor of 1.6 mm rods, with nail heads (anchors) meant to hook the test mass suspension. During the campaign of measurement with the actual KAGRA bades, and comparing the quality factor performance with different configurations, we outlined the possible measures one should adopt to improve the system in order to reduce the mechanical losses. We implemented most of them in a new design. A double blade meant to hook two mirror suspension rods and designed to be fixed at the center of the intermediate mass. We spent a given amount of time to deal with the feasibility of the machining, with the wanted features.

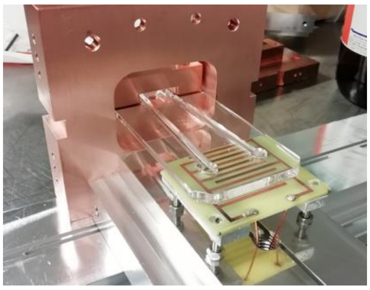

Fig.2: Assembling the measurement jig in Rome during the KAGRA blade tests (T. Yamada)

The prototype design was finally realized in Japan through a very fruiful deal with Shinkosha engineers. In parallel, we completely redesigned the jig for the cryogenic test, whose construction starts in June 2022. The tests will be initially done with the jig, with no load anchored to the slots at the end of the blade, oriented vertically and properly fixed inside the jig case (5 kg).

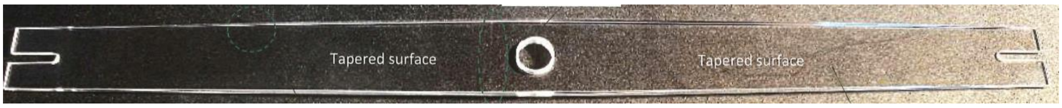

Fig.3: The prototype blade. Notice that the two heels at the center, in this version are not present. The two blockets that constitute the heels, mant to optimize the Q, have been constructed too, but they will be attached to the blade by meants of HCB (Perugia).

The jig, with sensor and and actuator is suspended with two wires into the cryostat. Once the full campaign on quality factor will be finished, a test campaign with the butterfly blade, have been planned in Japan will be done in Japan.

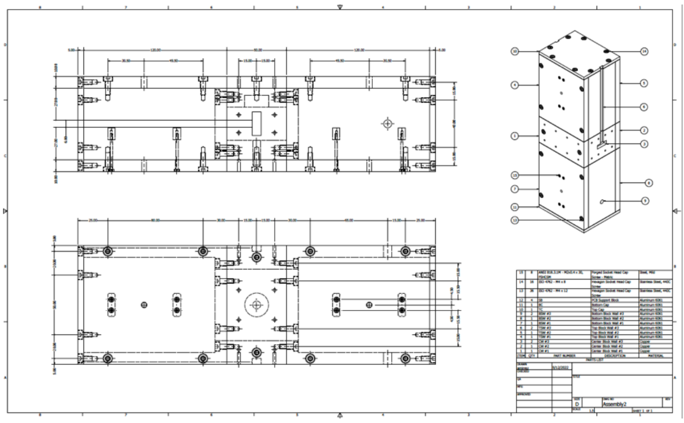

Fig.4: The test jig designed in Rome, it wil be built thanks to local co-funding at Sapienza Univ.

In the long term, if the design turns to be successful, we can proceed towards an improved version with the monolithic heels athe center. Also, we started to project the design requirements of Einstein Telescope cryogenc payload. Such a perspective appears to us quite interesting as we could gradually furher develop KAGRA know, merging it with the experience of large mass payloads foreseen in ET design.

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