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MEMORANDUM

DATE: November 18, 2017

TO: Professor Takaaki Kajita

FROM: Program Advisory Board: G. Sanders (chair), S. Whitcomb, M. Iye, M. Sasaki, B. Sathyaprakash, J. van den Brand (not in attendance), A. Yamamoto, I. Han, J. Watanabe

SUBJECT: Report of the KAGRA Program Advisory Board meeting, September 28, 2017

The KAGRA PAB review this year was conducted as an electronic meeting. It was felt by both the PAB Chair and the KAGRA leadership that this provided sufficient review and discussion without the burden of preparing for a physical meeting at this very busy time for the KAGRA team. The PAB is thoroughly familiar with the KAGRA facility underground, and with the KAGRA team members. Therefore, an electronic meeting was deemed to be appropriate for this review.

The KAGRA team provided a status report, the proposed schedule and planning through commissioning in 2020 and responses to the 2016 PAB report. The PAB appreciates the thorough preparation and presentation of these subjects.

Summary

As we noted in our prior report, the field of ground-based gravitational wave detection has experienced a profound transformation with actual detection, already revealing new and surprising physics and astrophysics. Indeed, on the day of this review, one of our members, Jo van den Brand, was missing due to a press conference on the fourth detection of a binary black hole inspiral, notably the first coincident detection between LIGO and Virgo (in its first run), demonstrating the long-promised potential for spatial localization of sources. Since the PAB review, and as this report was being prepared, LIGO and Virgo have further announced the first neutron star-neutron star inspiral detection together with numerous detections of electromagnetic companion emissions by other astronomy facilities. These companion emissions were observed because the three detector LIGO/Virgo system guided observers to the location of the gravitational wave event in the sky. Once KAGRA joins the global network, even finer localization of sources will further spur an acceleration of this revolutionary new field of multi-messenger astronomy. Thus, it is most interesting to the PAB to see the progress and planning for KAGRA to join the global network.

Project Plan and Commissioning

The KAGRA project has built upon its successful initial run of the iKAGRA detector with significant progress in installing the required advanced optics and elements of the cryogenics system for bKAGRA. This review did not cover details of the optics installation, nor the impressive and unique work in cryogenics systems implementation and we suggest that a more detailed report be provided at the next PAB review. The team is wisely focused on the Spring 2018 milestone to operate the first version of bKAGRA as a Michelson interferometer with cryogenic end test masses (ETMs). This first step is a prudent choice in which the complexity of commissioning both the new interferometer and the cryogenic systems is aided by concentrating

on the simplified configuration. This approach is consistent with past advice (Recommendation 1) from the PAB 2016 review.

Furthermore, KAGRA has chosen to bypass the next intermediate step of operating a simple cryogenic Michelson with power recycling, moving directly to install and commission the full configuration with both power and signal recycling in 2019 (bKAGRA phase-II) and completing cryogenic commissioning in 2020. This, too, seems to be an appropriate and efficient plan.

KAGRA presented an overview of the funding that the project has received. From a variety of Japanese funding programs ranging from construction funds through operations funds and grants-in-aid for scientific use of KAGRA, the team has been most efficient in advancing the program with a very tight budget. KAGRA states that it should be able to complete KAGRA construction with the anticipated budget. However, the PAB continues to be concerned that the tight funding stream may limit KAGRA progress and scientific exploitation.

Recommendation 1: The PAB strongly recommends that KAGRA seek sufficient funding to assure timely observation and detection capability with LIGO and Virgo and to use KAGRA's role in contributing to the likely breakthrough observations with the global network as a key argument for such funding.

Management

Management Structure

The organization chart was presented and reviewed. Required functions are included and staffed, although with very tight responsibility loads on team members. The management structure is functioning reasonably well and is essentially unchanged since the last PAB review.

Total KAGRA manpower numbers approximately 270 with some growth from each of ICRR, NAOJ and KEK. Office space is due to increase in the neighboring Hokubu-Kaikan building and this is a welcome development given the growing effort in KAGRA. We congratulate the KAGRA team for their successful negotiations with Hida City for this additional space.

KAGRA presented a brief summary of the organization chart during the operational era. The plan separates the engineering organization from a KAGRA Scientific Collaboration that is organized along scientific topic analysis efforts. This mirrors the approach used in the LIGO and Virgo scientific collaborations and seems quite appropriate at this early planning stage. However, the position of the PI above both the detector operation and the scientific collaboration parts of the organization is a departure from the LIGO and Virgo models. The PAB should continue to be updated on this organizational structure as it becomes more solid.

Commissioning

We have already commented on the overall phasing of commissioning. In additional detail, the PAB was presented with the detailed planned steps in achieving the commissioning program milestones. These seem to be well thought out though the schedule for the Spring 2018 milestone is tight and fragile.

The commissioning plan calls for KAGRA to join the LIGO-Virgo network in early 2020 with a binary neutron star range approaching 40 Mpc, increasing towards 140 Mpc the following year and running at length with that range capability starting in 2022. This is a most appropriate milestone goal and is properly aimed at achieving scientific results in what is likely to be a

surprising and transformational era. This plan should be vigorously pursued given the great scientific potential.

Responses to 2016 PAB Report

Planning and Manpower

KAGRA has followed the PAB advice to simplify planned goals to focus resources, to increase onsite presence at Kamioka, and to introduce enhanced system engineering and working to a plan. They have not succeeded in covering the shortage in shift manpower though they are beginning to outsource non-technical work which was advised by the PAB.

Safety

The previous PAB report commented on several significant safety issues and on issues identified in prior PAB reports. KAGRA has followed some of the recommendations in that report but much work remains to be done. The PAB continues to be concerned about the safety of operating in the underground location.

We are very pleased that KAGRA has held an external safety review as recommended. The external safety reviewers are an expert team and they were provided with the prior PAB reviews of safety. Their recommendations reflect a good understanding of the PAB comments and concurrence with our review though some of their "Yes" answers to posed questions at the summary level seem more lenient than their detailed comments. Readers of their report should focus on the detailed comments. Reading their report, it is clear that while some progress has been made by the KAGRA team, much remains to be done and there are still very significant safety concerns at the Kamioka site.

Breathing gas supplies in the shelter area have been increased but the PAB continues to be concerned about the duration during which safe breathing gas can be supplied. The external reviewers agree that breathing gas supplies are not adequate.

Robust communication means to the surface have not yet been provided. Useful and urgent suggestions were made by the external safety reviewers.

Safety drills have been conducted once in late 2016. The frequency of these drills should be increased as evacuation currency is essential for confident action by team members in a stressful emergency condition.

KAGRA has adopted the PAB recommendation to initiate installations in the safer y-arm where evacuation is facilitated.

No separate safety presentation was made at this PAB meeting though the safety review committee report was provided after a request was made. This should be a required practice at future PAB meetings.

*Recommendation 2: The PAB strongly recommends urgent attention to all items in the external safety review report. Their report states: "**Safety MUST take priority over the experiment."** The PAB endorses this as the overarching guidance with respect to safety*.

Technical

Technical recommendations from the PAB have been adopted in the ongoing and future work of KAGRA.

Data

As this review did not include discussions of data acquisition or analysis, the PAB recommends inclusion in the next PAB meeting of plans to test both the hardware systems such as data pipelines and the software systems to detect specific targets. These, too, are important parts of the commissioning effort.

Membership in the PAB

The table below summarizes the membership in the PAB over the years it has existed. The last column contains the PAB recommendations on replacement members.

	2011-2013	2014-2016	2017-2019
NAOJ	Masanori Iye	Masanori Iye	Junichi Watanabe (observer Satoshi Miyazaki)
ACIGA	David McClelland	David McClelland	Jesper Munch
Virgo	Benoit Mours	Jo van den Brand	Jo van den Brand
Theory	Takashi Nakamura	Misao Sasaki	Misao Sasaki
GEO	Bernard Schutz	Bangalore Sathyaprakash	Bangalore Sathyaprakash
External	Gary Sanders	Gary Sanders	new member
KEK	Akira Yamamoto	Akira Yamamoto	Akira Yamamoto
LIGO	Stan Whitcomb	Stan Whitcomb	Albert Lazzarini
Korea		Inwoo Han	someone from Korea