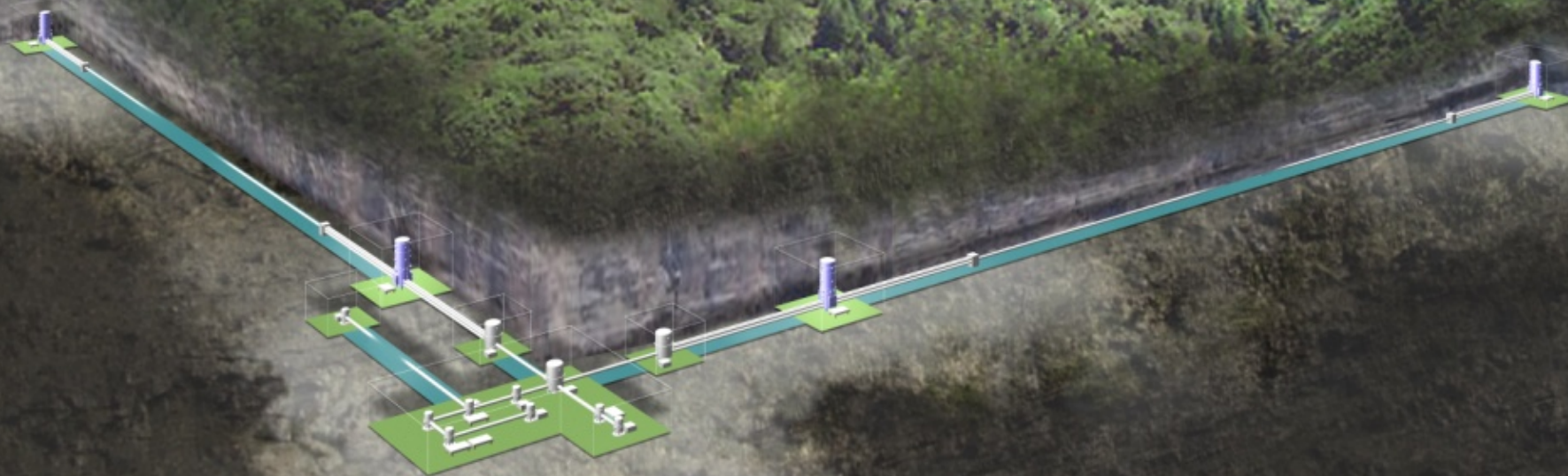




Gravitational Waves: New Frontier
January 16 – 18, 2013
Seoul National University, Seoul, KOREA

The Current Status of KAGRA



Seiji Kawamura (ICRR)

Outline:

- Design
- Schedule, organization, and collaboration
- Current status
- Summary

Key features of KAGRA

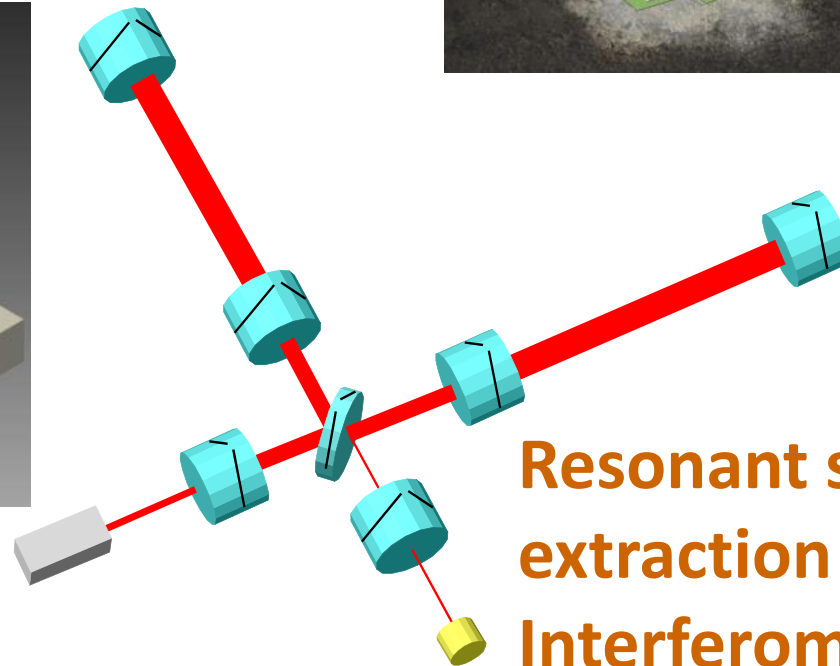
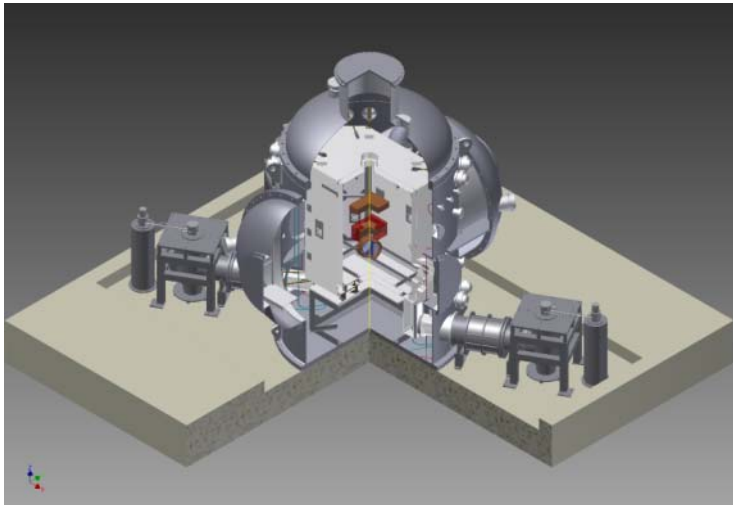
Underground

Reduce seismic noise



Cryogenic Mirror

Reduce thermal noise

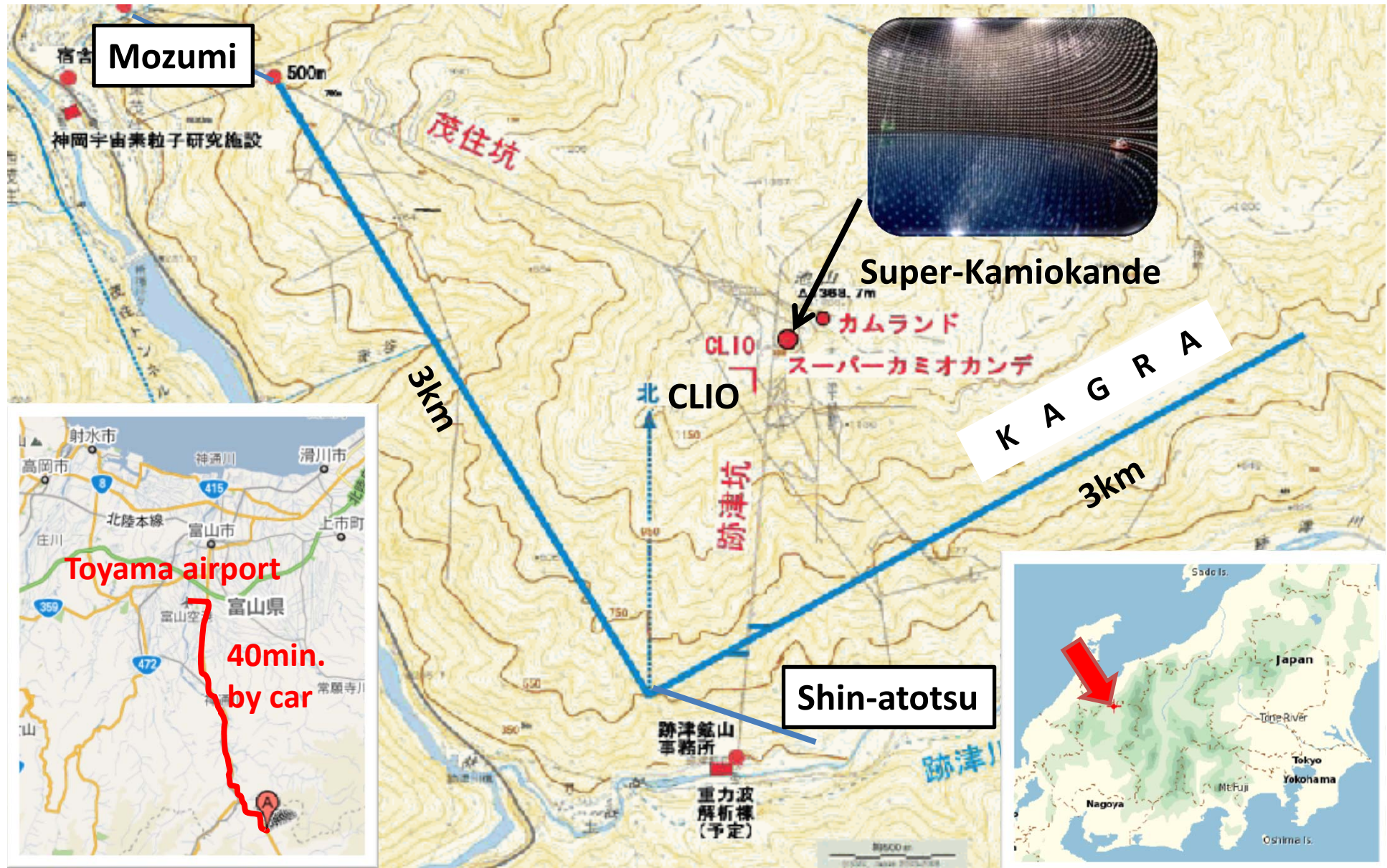


**Resonant sideband
extraction (RSE)**

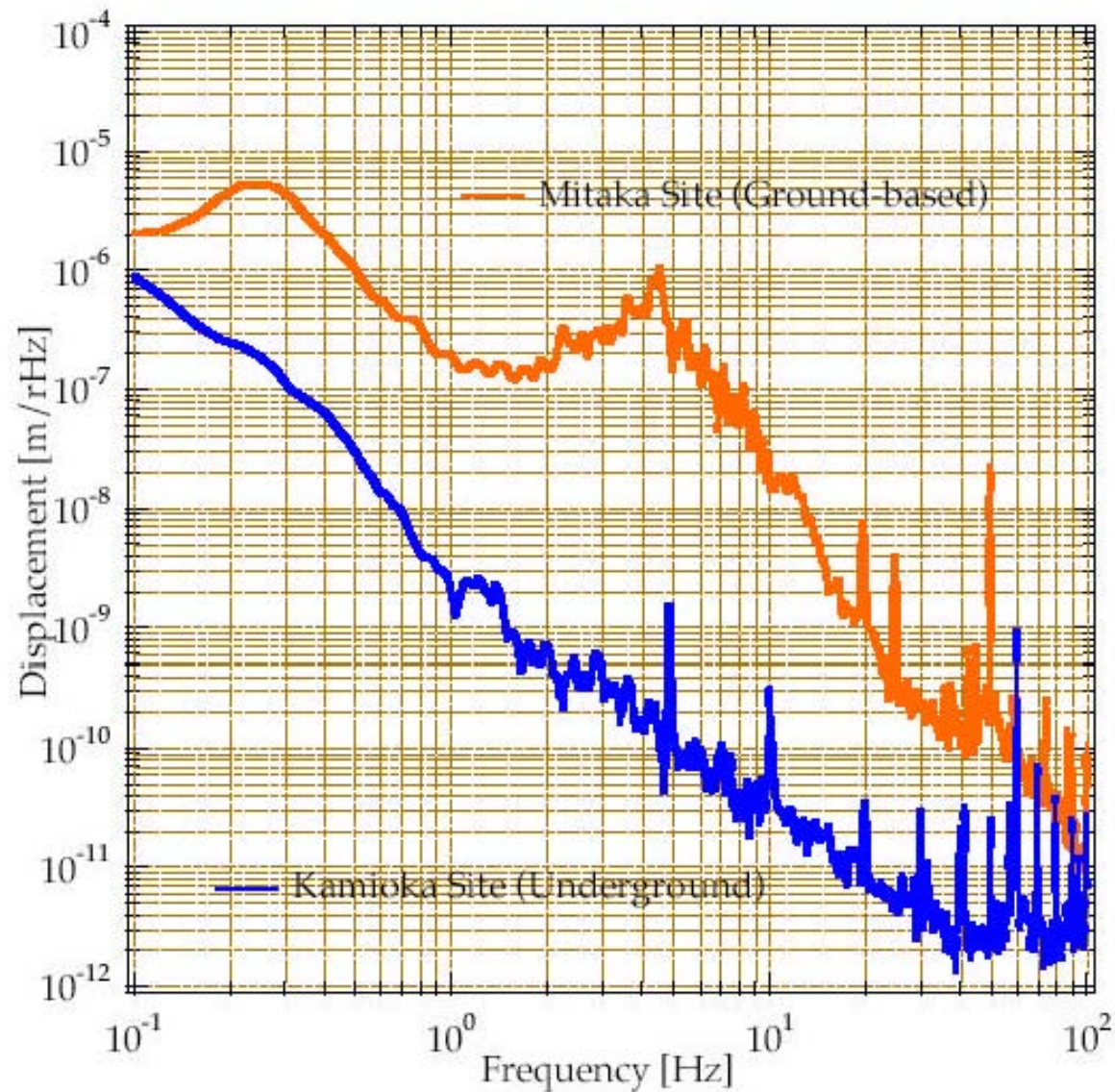
Interferometer

Optimize quantum noise

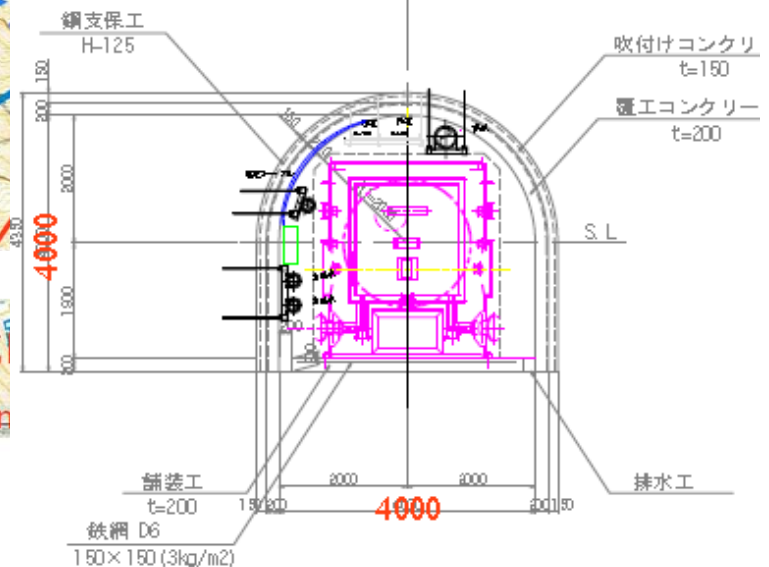
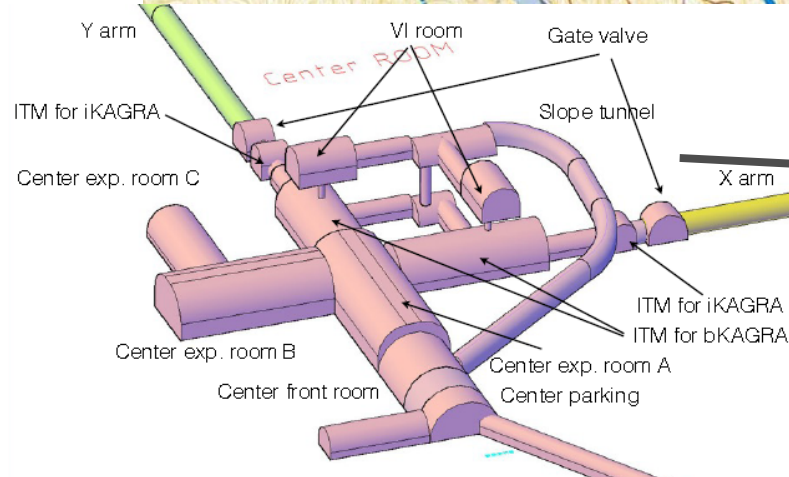
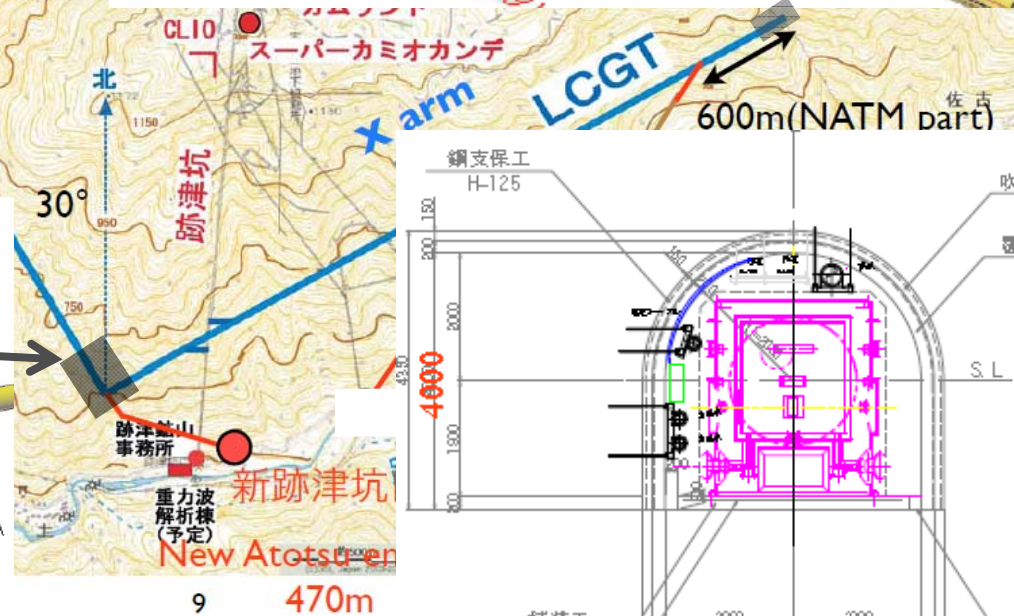
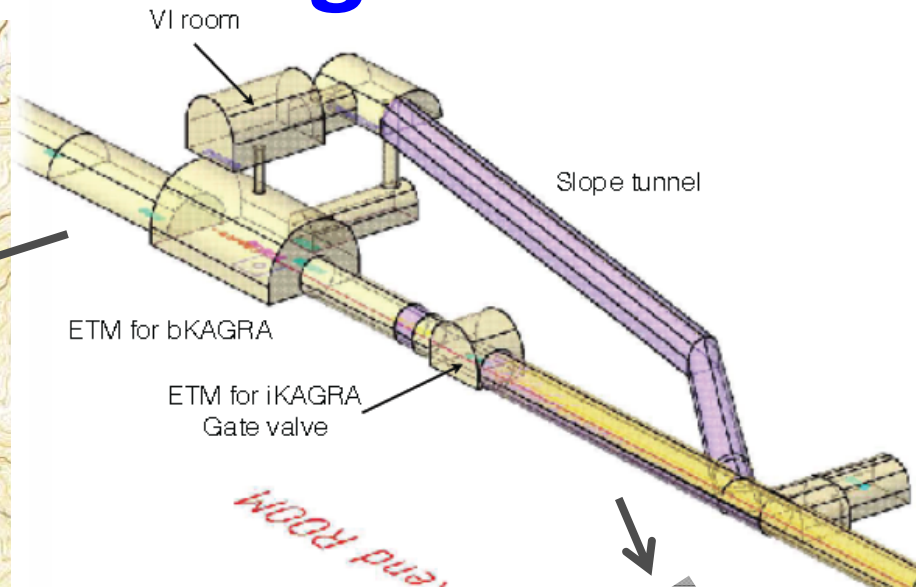
Location (Kamioka)



Ground motion in Kamioka mine



Tunnel Design



Vibration isolation system

Type A for test masses

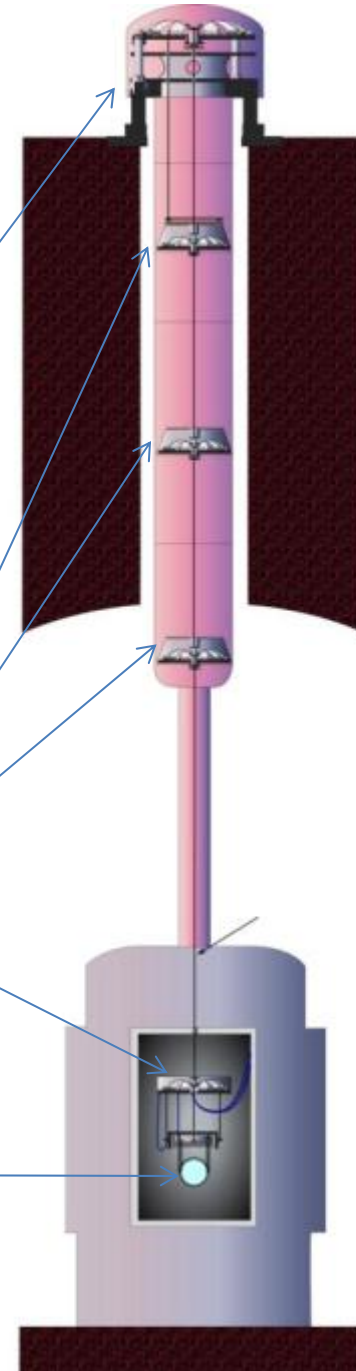
2nd floor

Inverted pendulum

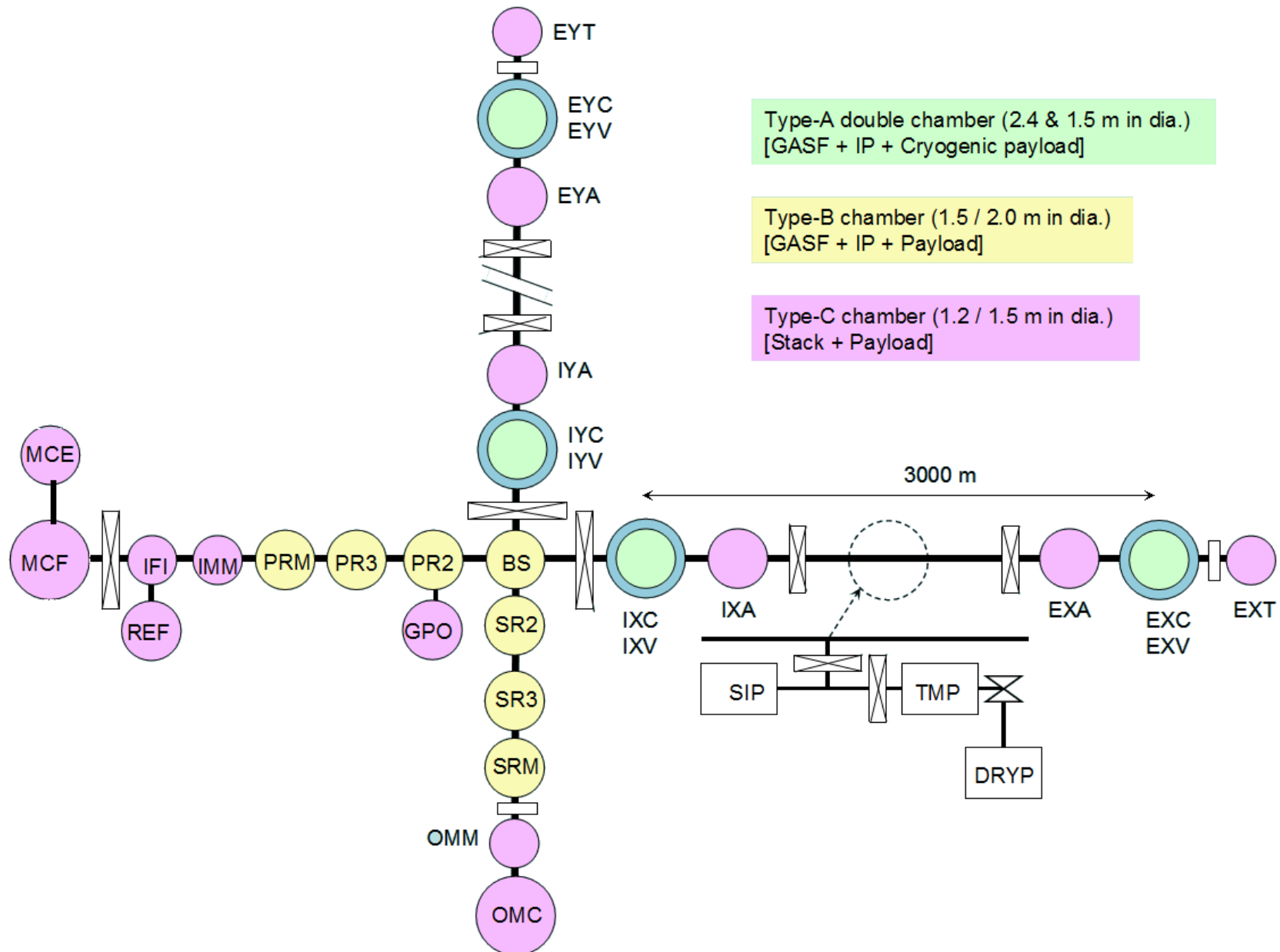
Geometrical antispring filter

Mirror

1st floor

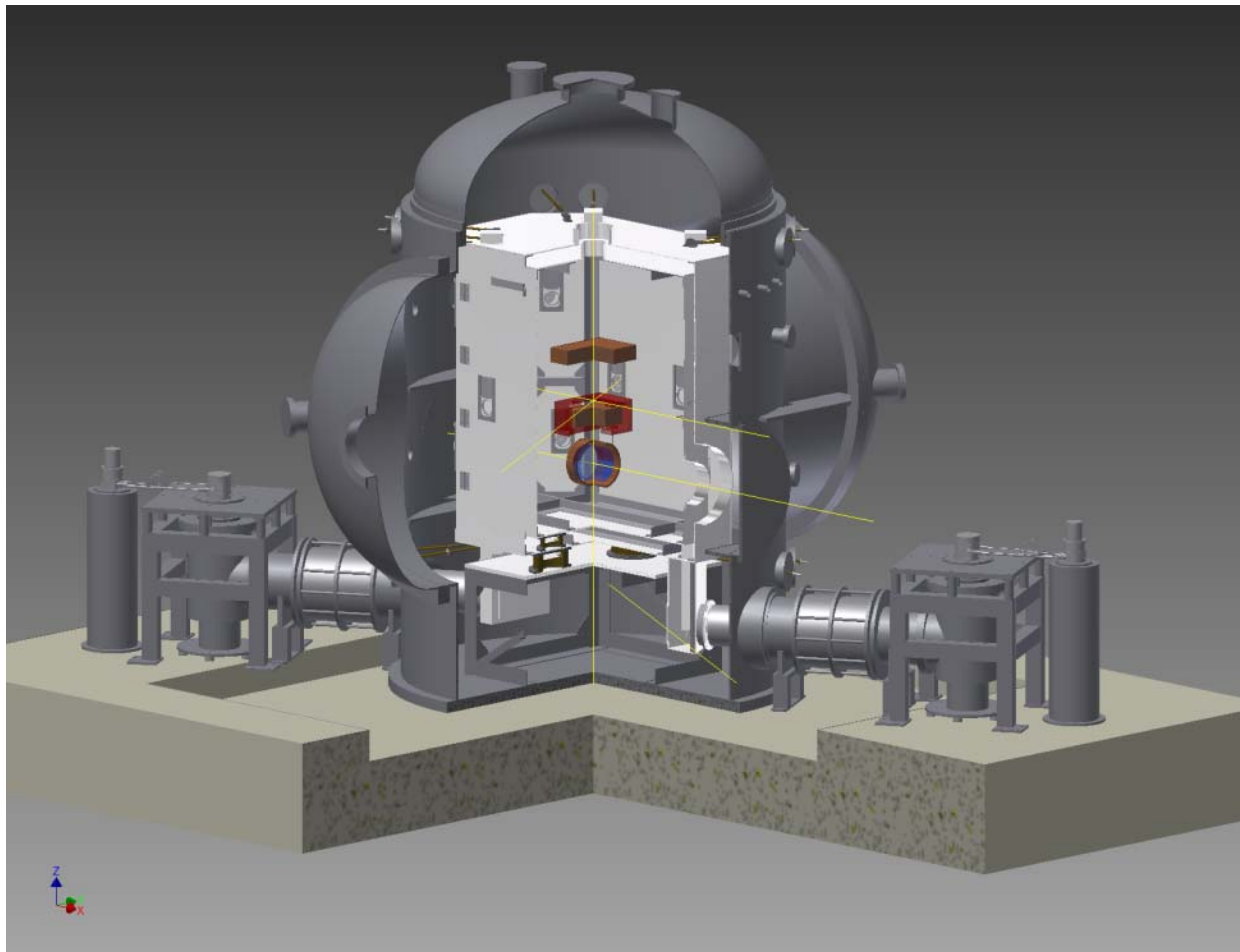


Vacuum chamber configuration

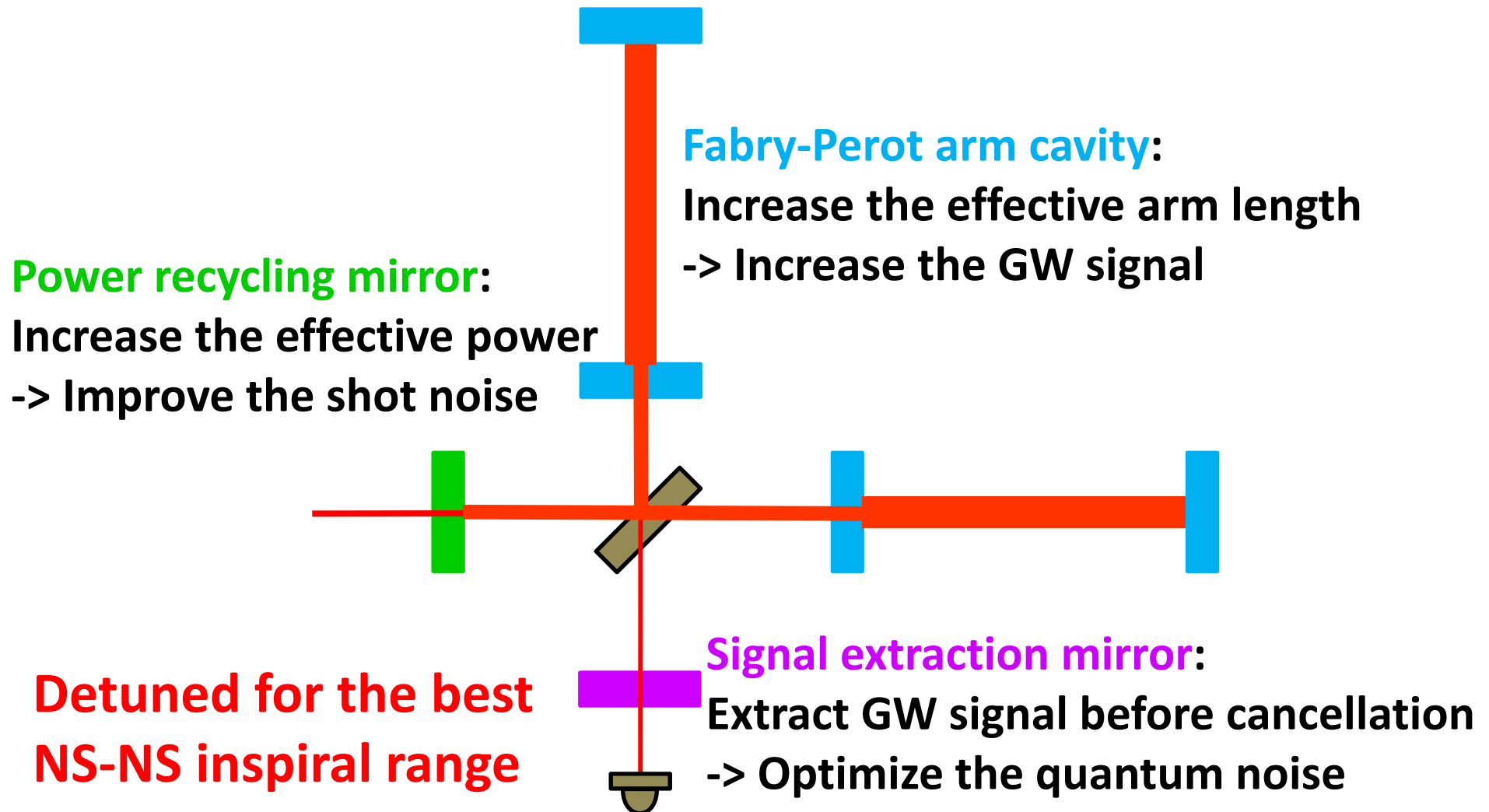


Cryogenic System

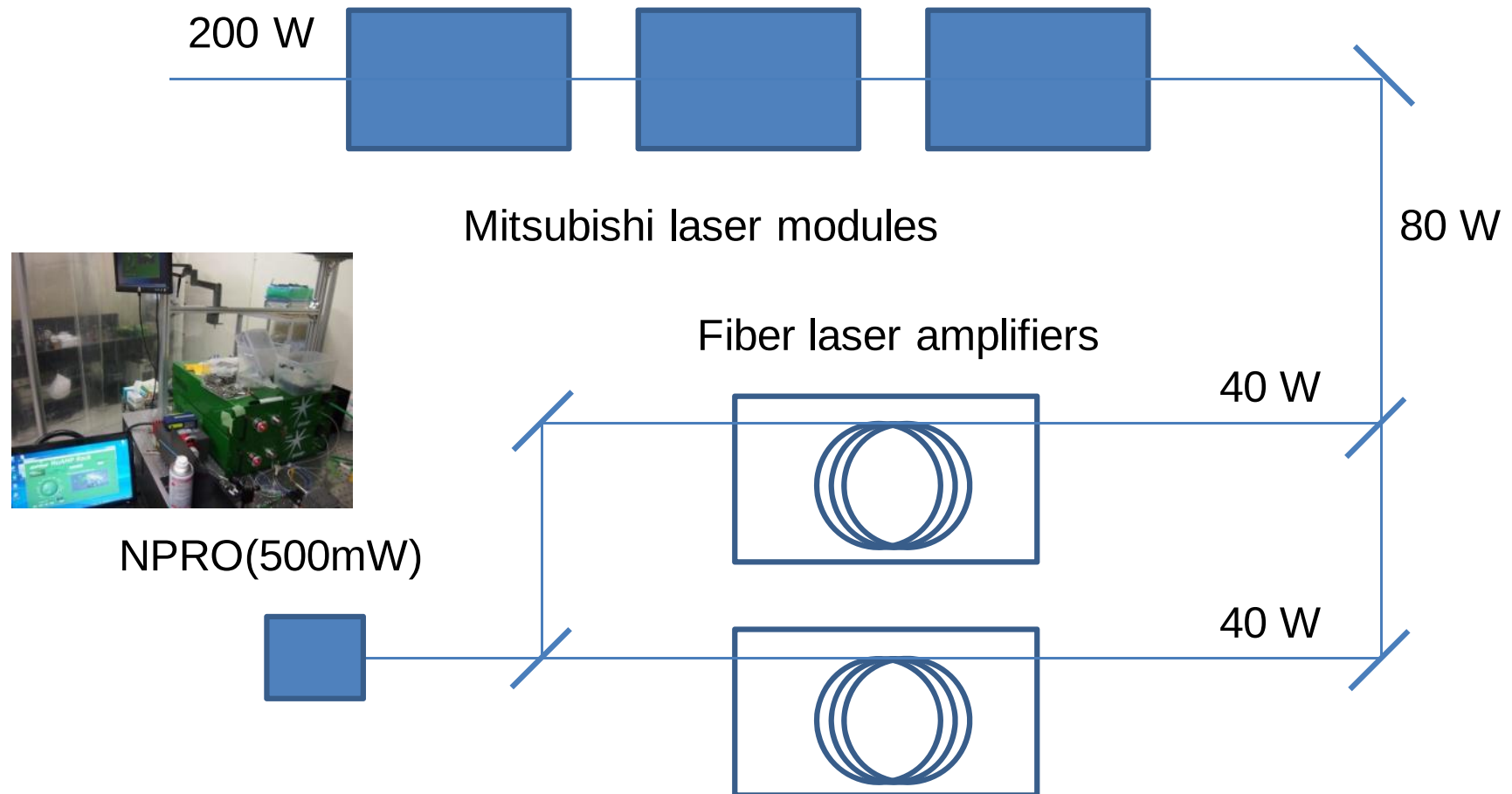
Suzuki-san will give a detailed presentation about the KAGRA cryogenics.



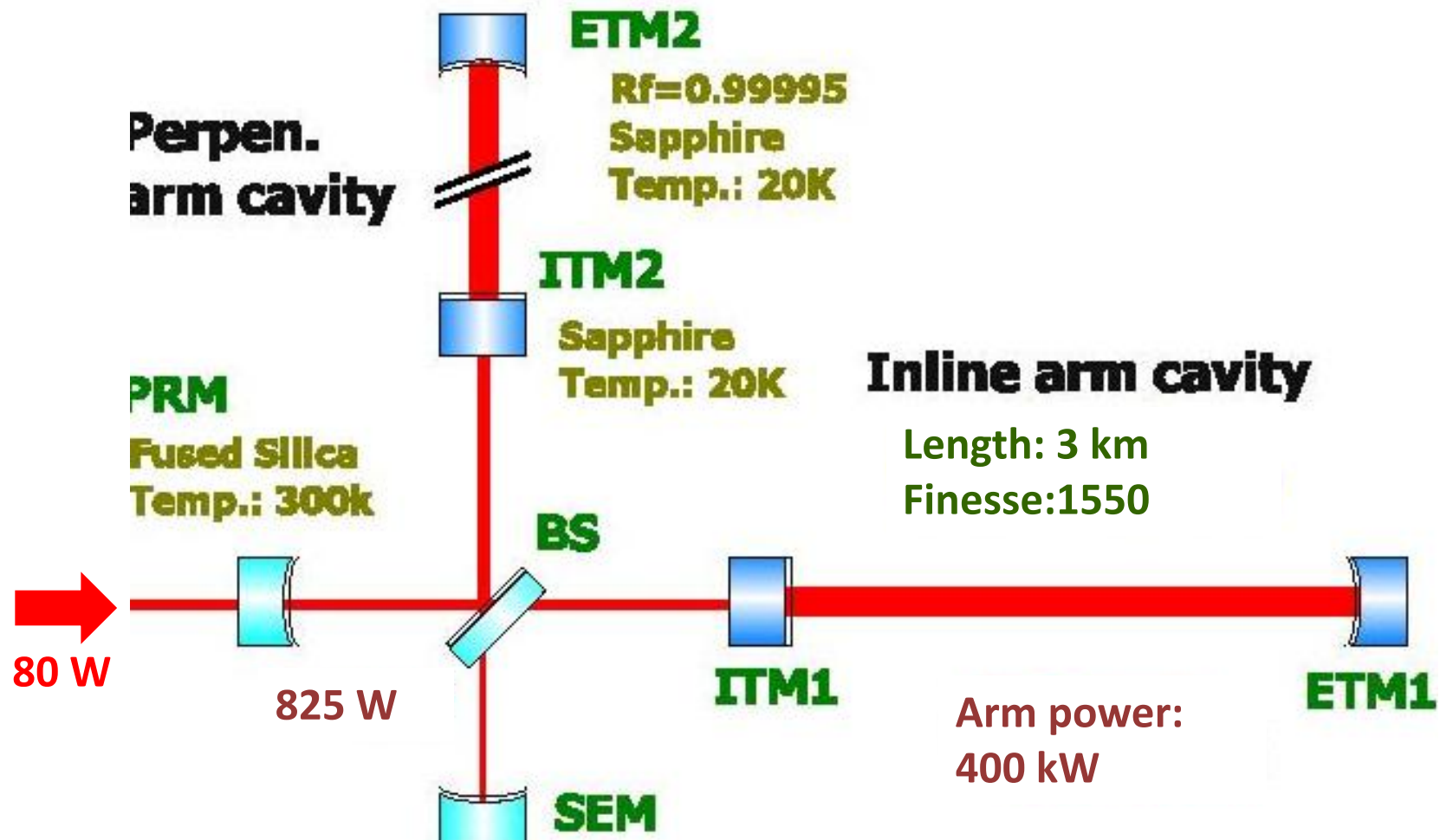
RSE interferometer



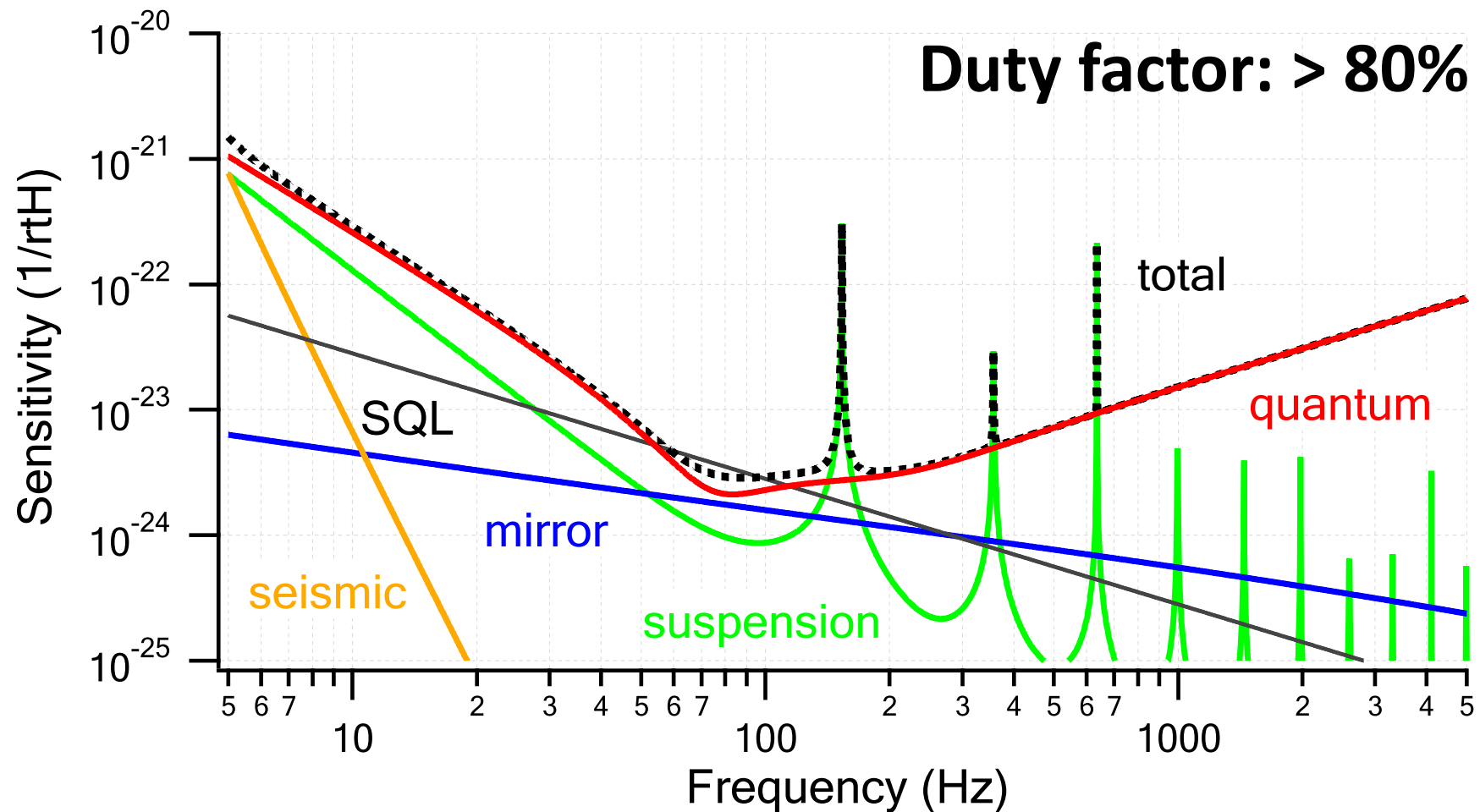
Laser system



Interferometer specifications



Target sensitivity of KAGRA



Expected event rate for NS-NS coalescence

Inspiral range: 167 Mpc
(the same definition as LIGO/Virgo)

Inspiral rate per galaxy $118^{+174}_{-79} \text{ Myr}^{-1}$

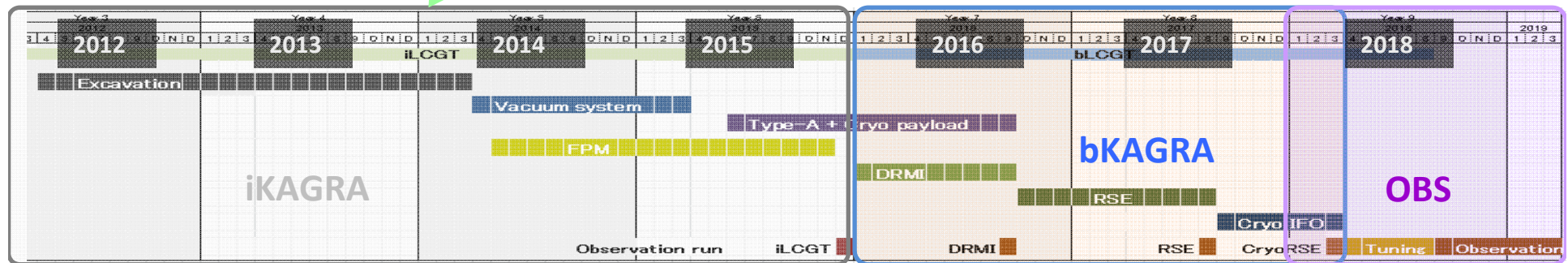
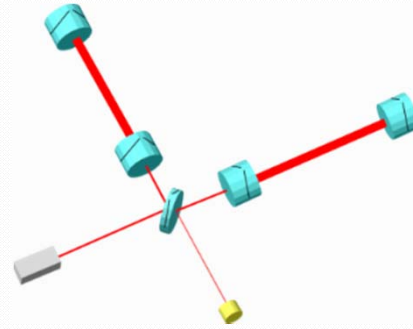


Expected event rate $9.8^{+14}_{-6.6} \text{ yr}^{-1}$

KAGRA Schedule

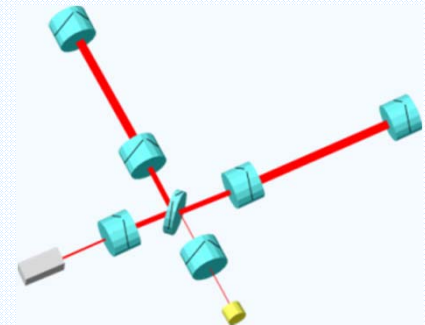
iKAGRA (2010.10 – 2015.12)

- Fabry-Perot Michelson interferometer
- Room temperature
- Fused silica mirror
- Simplified vibration isolation system

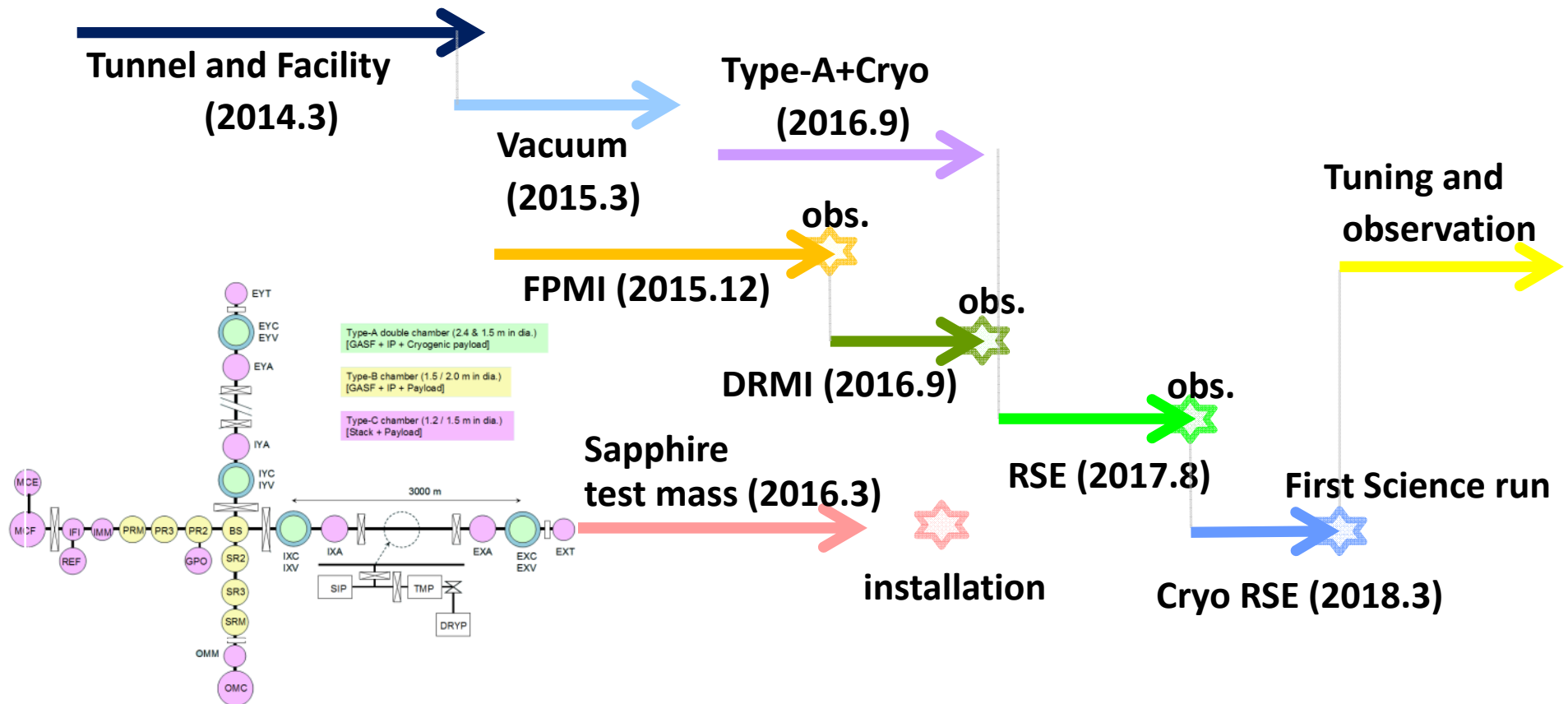
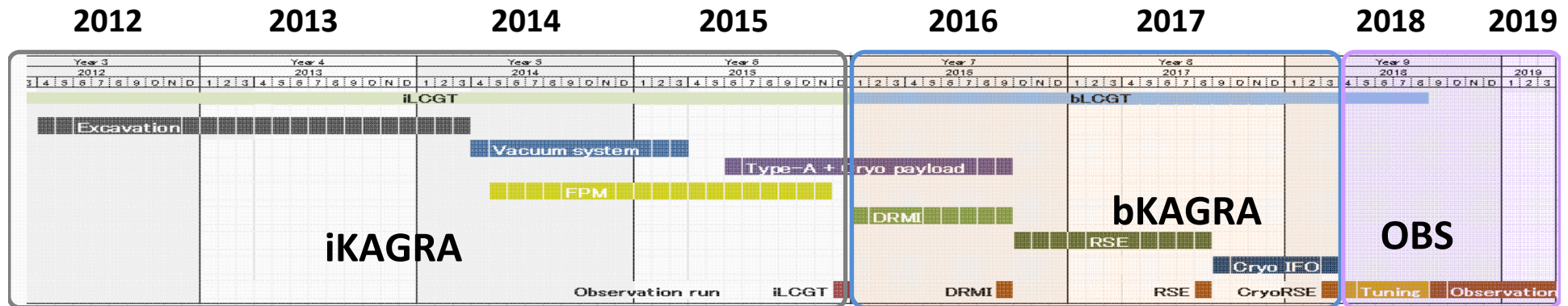


bKAGRA (2016.1 – 2018.3)

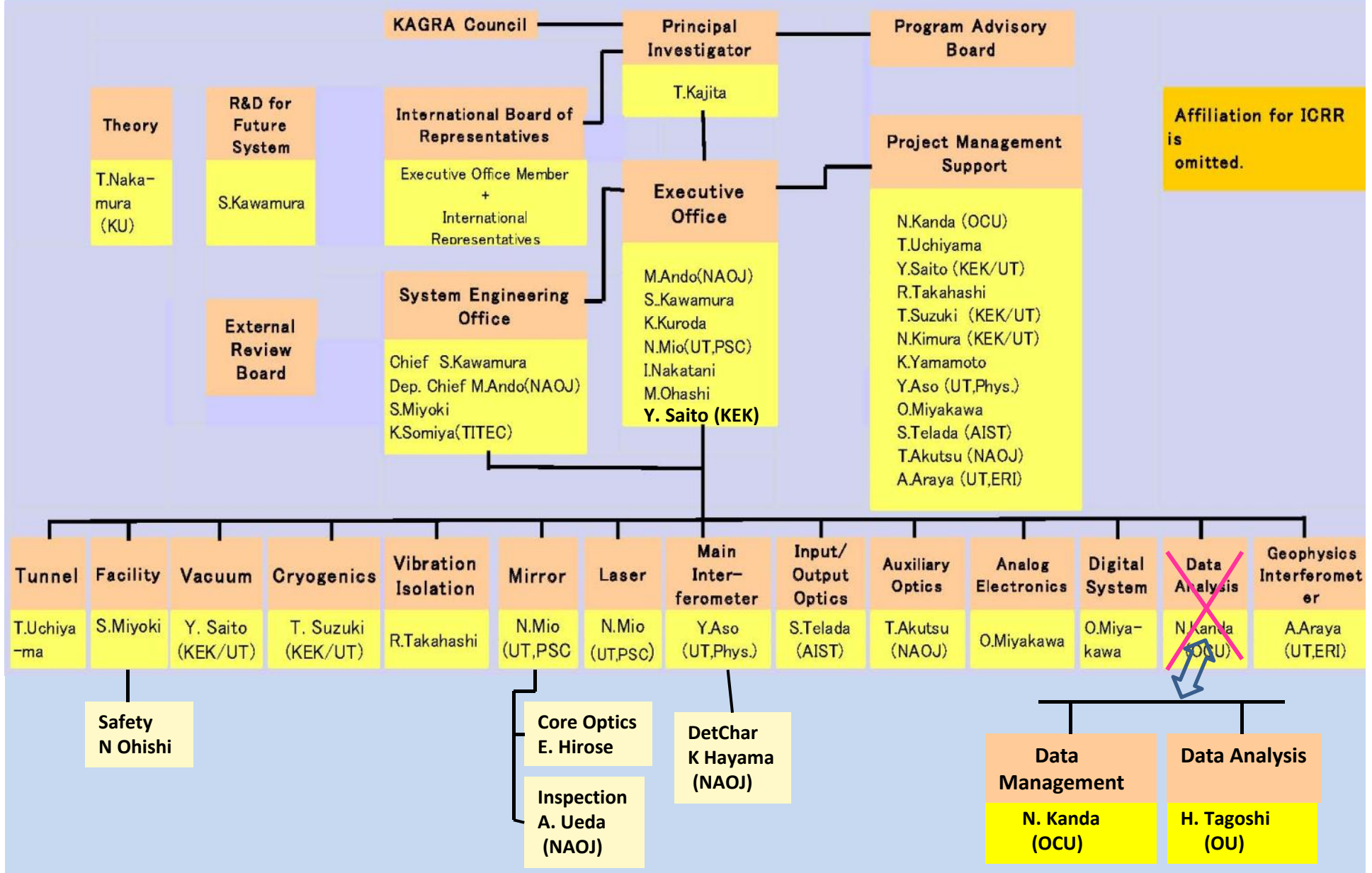
- RSE interferometer
- Cryogenic temperature
- Sapphire mirror
- Full vibration isolation system



Major Milestones of KAGRA



Organization



KAGRA collaboration

190 members from the following institutes/universities

The University of Tokyo, National Astronomical Observatory of Japan, the Graduate University for advanced studies, High Energy Accelerator Research Organization , Tokyo Institute of Technology, Osaka City University, Kyoto University, University of Electro-Communications, Hosei University, National Institute of Advanced Industrial Science and Technology, Osaka University, Ochanomizuu University, Nihon University, Niigata University, Yamanashi Eiwa College , Nihon University, Hirosaki University, Tohoku University, Rikkyo University, Hiroshima University, University of the Ryukyus, Waseda University, Teikyo University, Japan Student Service Organization, Institute for Molecular Science, Max-Planck-Institut, California Inst. Technology, University of Western Australia, Louisiana State University, Beijing Normal University, Inter University Center for Astronomy & Astrophysics, Moscow University, LATMOS, CNRS, University of Science and Technology of China, Tsinghua University, Industrial Technology Research Institute, University of Maryland, Columbia University, University of Glasgow, University of Sannio, Fulbright Fellow, INFN Student Fellow, Univ. of Basilicata, Univ. of Salerno, Shanghai Normal University, National Tsing Hua University, **Korea University, Inje University, Seoul National University, Myongii National University, Korea Atomic Energy Research Institute, Hanyang University, Pusan National University, Korea Institute of Science and Technology Information, National Institute for Mathematical Sciences, Kyungpook National University, Gunsan National University, Korea Institute for Advanced Study, Sogang University**, Chinese Academy of Sciences, The Pennsylvania State University, Montana State University

Collaboration with the Korean GW group

- Had a meeting to discuss the possibility of collaboration in January 2011 at Seoul National Univ.
- Some KGWG members joined KAGRA in August 2011.
- Collaboration started.
- Three workshops held so far.
- Collaboration on Laser, interferometer, data analysis, and data characterization going on



1st workshop (Jan. 2012 @ Korean Univ.)



2nd workshop (May 2012 @ ICRR)



3rd workshop (Dec. 2012 @ Sogang Univ.)

MoU with LSC and VIRGO

KAGRA-M1201313-v1
LIGO-M1200326-v1
VIR-0371A-12

- **MOU signed**
 - **General part (K-L-V)**
 - **Attachment A (K-L)**
Technical collaboration
 - **Attachment B (K-L-V)**
Data sharing and analysis
- **MOU to be signed very soon**
 - **Attachment C (K-V)**
Technical collaboration

Memorandum of Understanding
between
KAGRA, LIGO and Virgo Scientific Collaborations

A. Purpose of the agreement:

The purpose of this Memorandum of Understanding (MOU) is to establish a collaborative relationship between the signatories who are seeking to discover gravitational waves and pursue the new field of gravitational wave astronomy. The main scientific motivation is that the maximum return from gravitational wave observations is through simultaneous joint measurements by several instruments.

This MOU provides for joint work between the scientific collaborations of KAGRA, LIGO and Virgo. We enter into this agreement in order to lay the groundwork for decades of world-wide collaboration. When sensitive detectors are in operation, we intend to carry out the search for gravitational waves in a spirit of teamwork.

Details and extensions to this MOU will be provided in Attachments agreed by the parties.

B. Parties to the agreement:

1. KAGRA

KAGRA, previously called LCGT (Large-scale Cryogenic Gravitational-wave Telescope), is a 3-km laser interferometric gravitational wave antenna built at Kamioka underground site in Japan. One of its characteristic features is to be a cryogenic interferometer; the test-mass mirrors that form 3-km Fabry-Perot arm cavities are cooled down to cryogenic temperature of around 20K, so as to reduce the effect of thermal noises. Stable environment of the underground site and

ELiTES

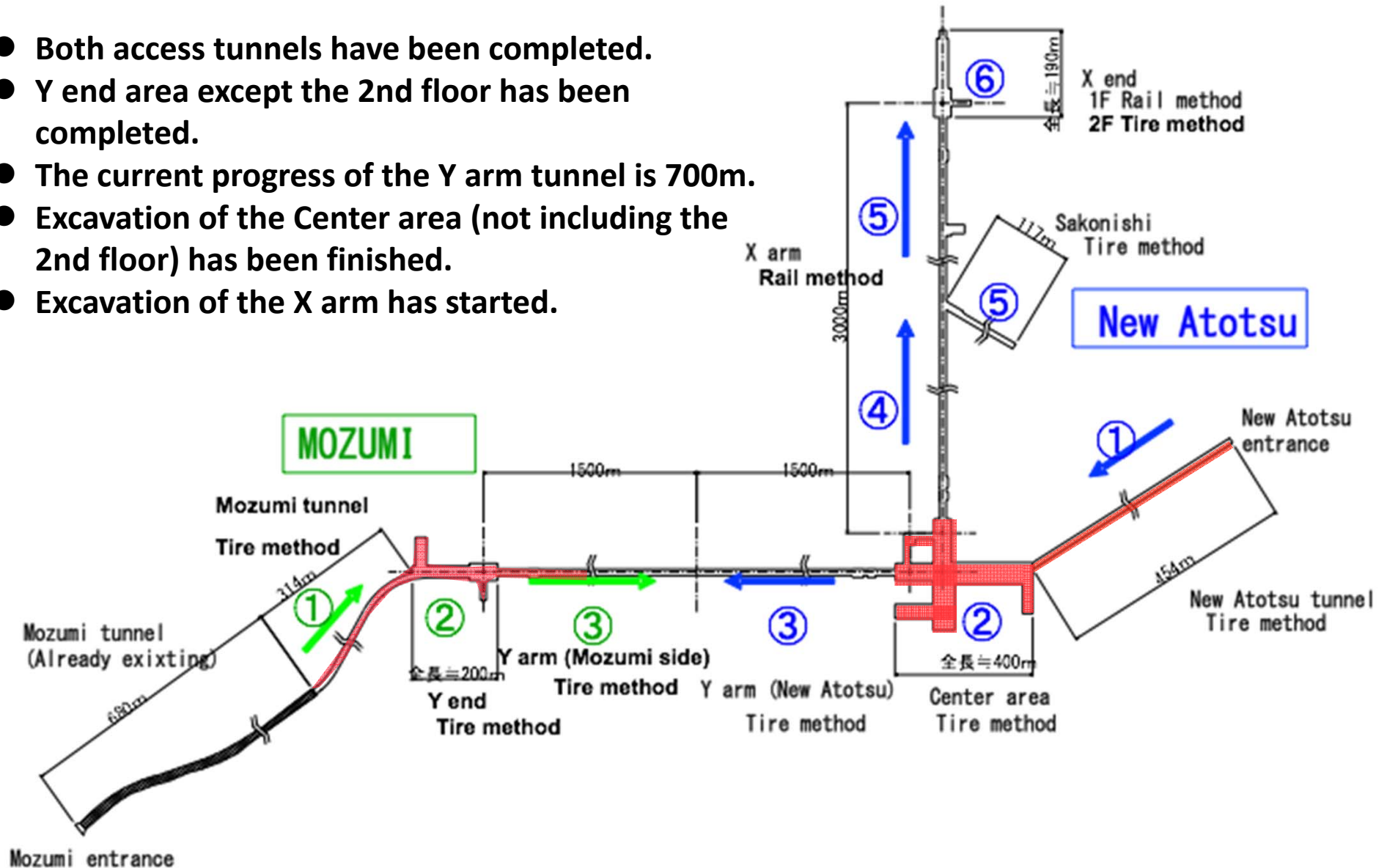
- ET-KAGRA collaboration program
mainly on underground site and cryogenics.
- 1st general meeting in Oct. 2012 at Tokyo



PAC33, The 3rd
Advisory Committee Meeting
(November 8th 2012,
Hanford, USA)

Tunnel excavation

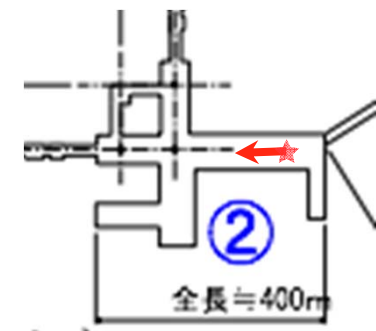
- Both access tunnels have been completed.
- Y end area except the 2nd floor has been completed.
- The current progress of the Y arm tunnel is 700m.
- Excavation of the Center area (not including the 2nd floor) has been finished.
- Excavation of the X arm has started.





Center experiment room A

2012/12/02



Panorama photo from BS position

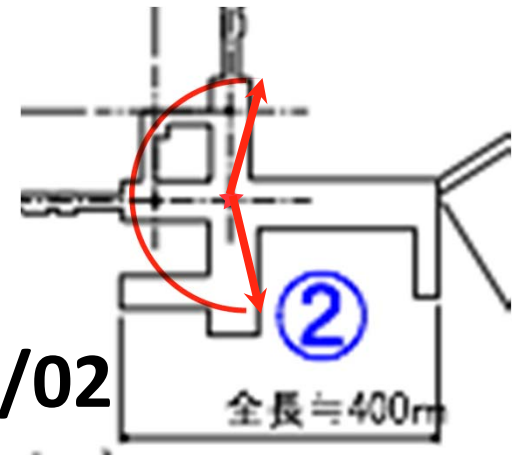
Direction of Yarm

Direction of Xarm



Direction of Laser booth
&
Mode Cleaner

2012/12/02

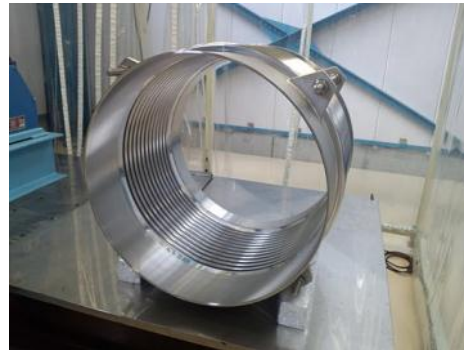


Beam tubes

- 12m, $\Phi 800$ mm for 3km x 2 arms
- 90% of 478 beam tubes have been delivered.



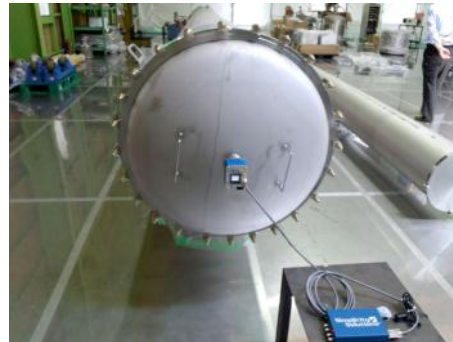
Press to form a tube



Bellows for each tube



**Baking at MIRAPRO Co.
Noda/MESCO, Kamioka**



Test at MIRAPRO Co. Noda



Transportation to Kamioka

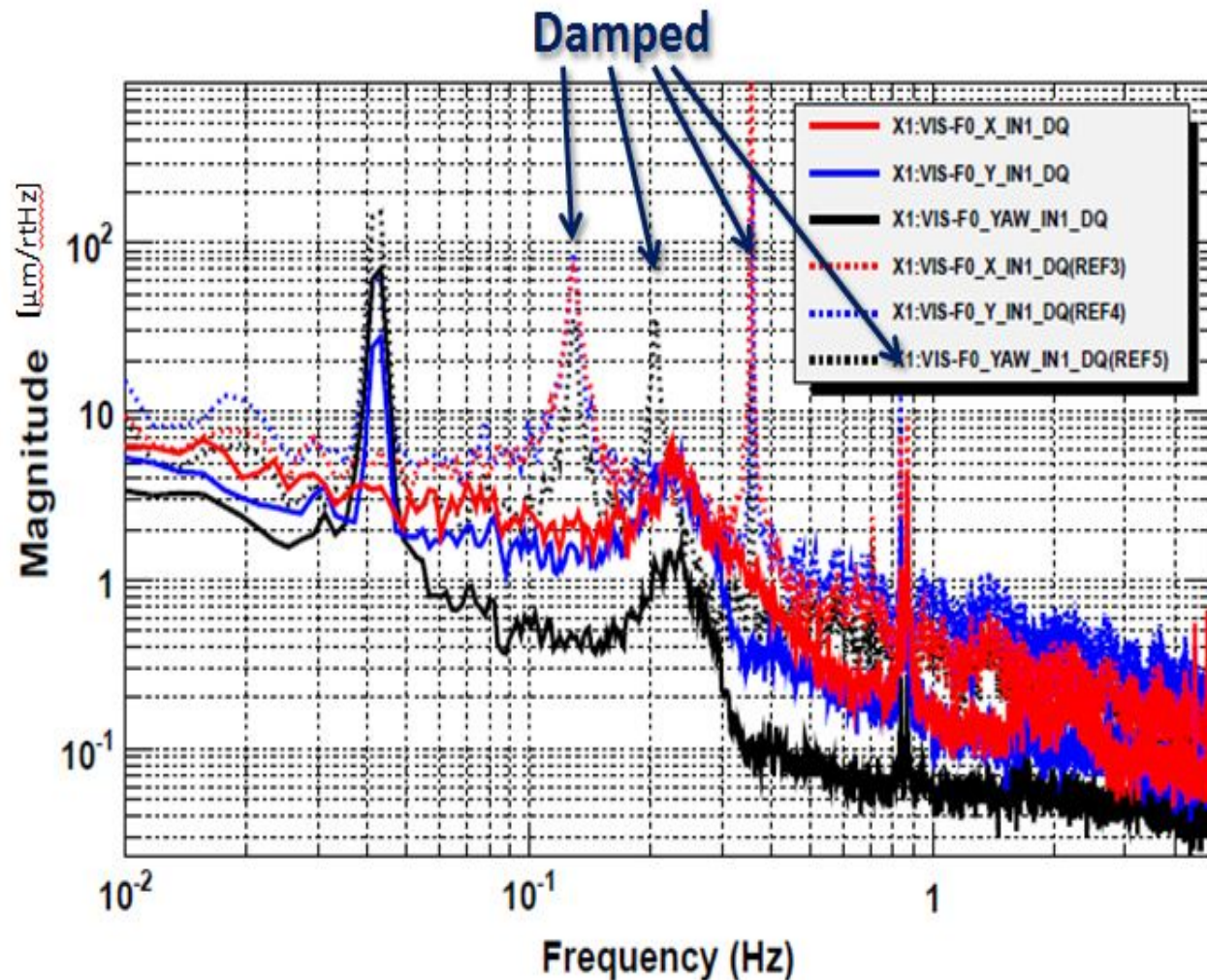
Isolator Prototypes



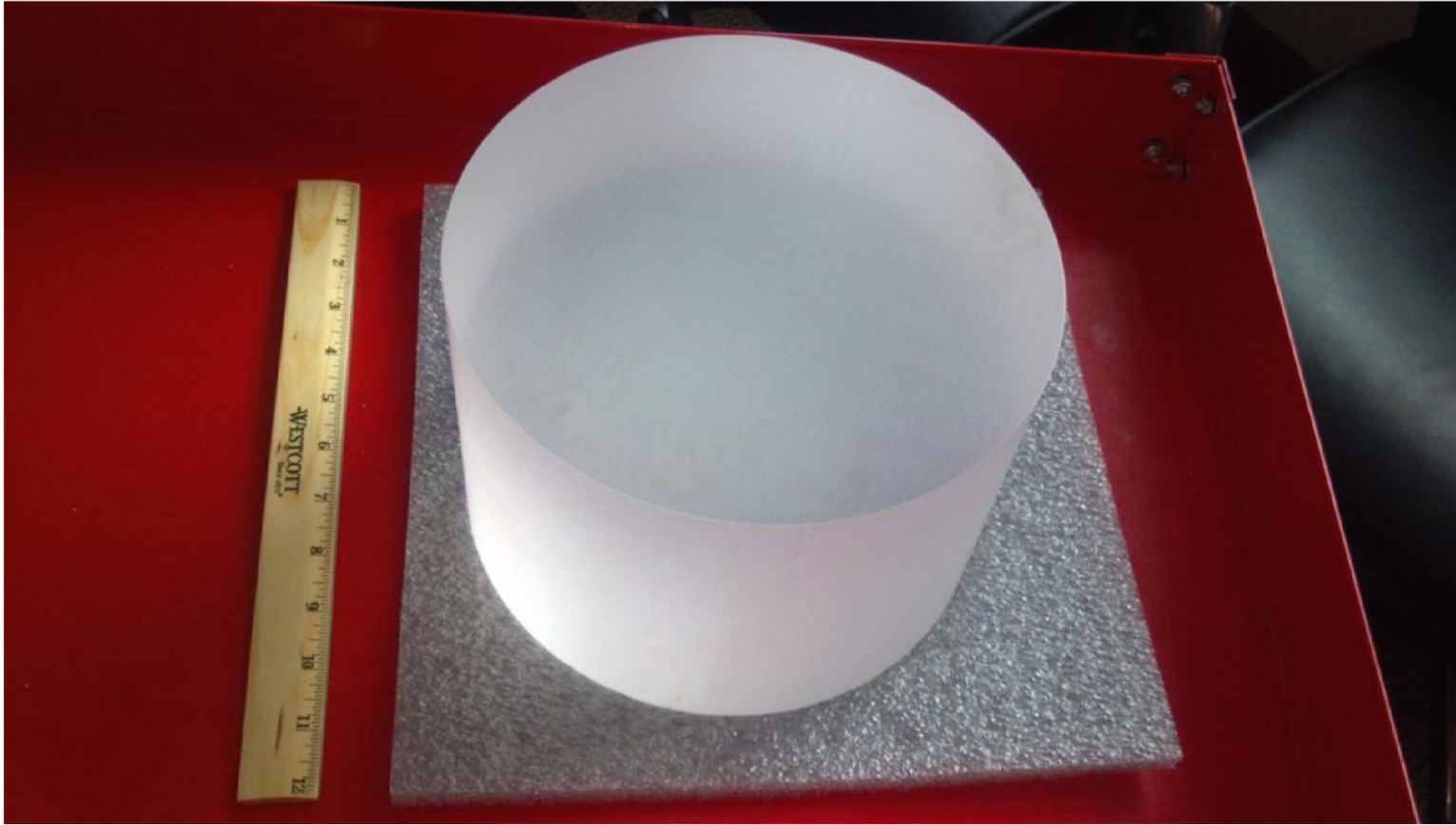
Pre-Isolator Prototype test (Kashiwa)

Resonance damping of SAS

Digital control of Inverted Pendulum for horizontal isolation 3 degrees of freedom using LVDT&voice coil (sensors of acceleration)



Sapphire Mirror

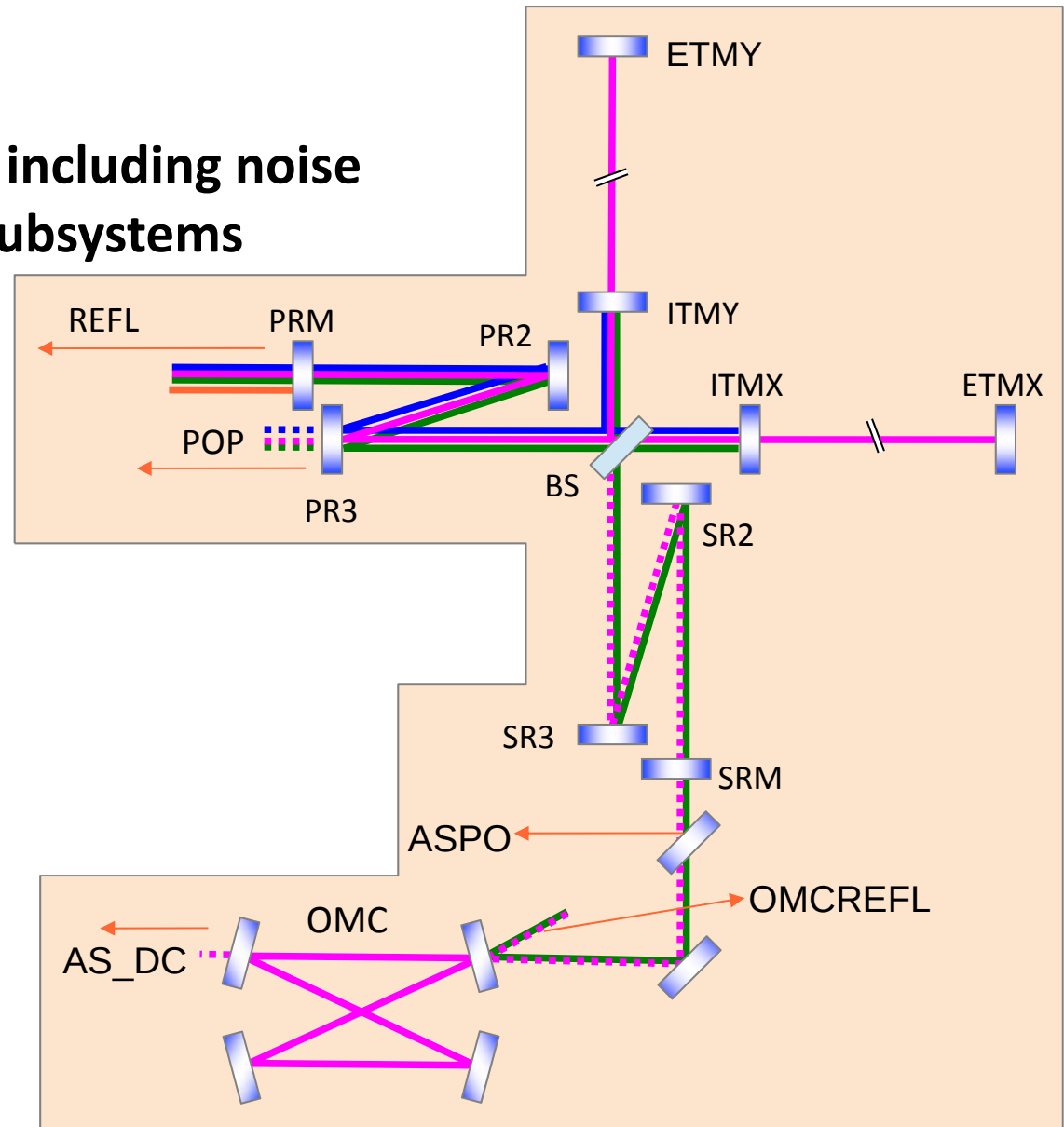


**Two Sapphire substrates have been delivered.
(Φ 220mm, t 150mm, c-axis)**

Main Interferometer

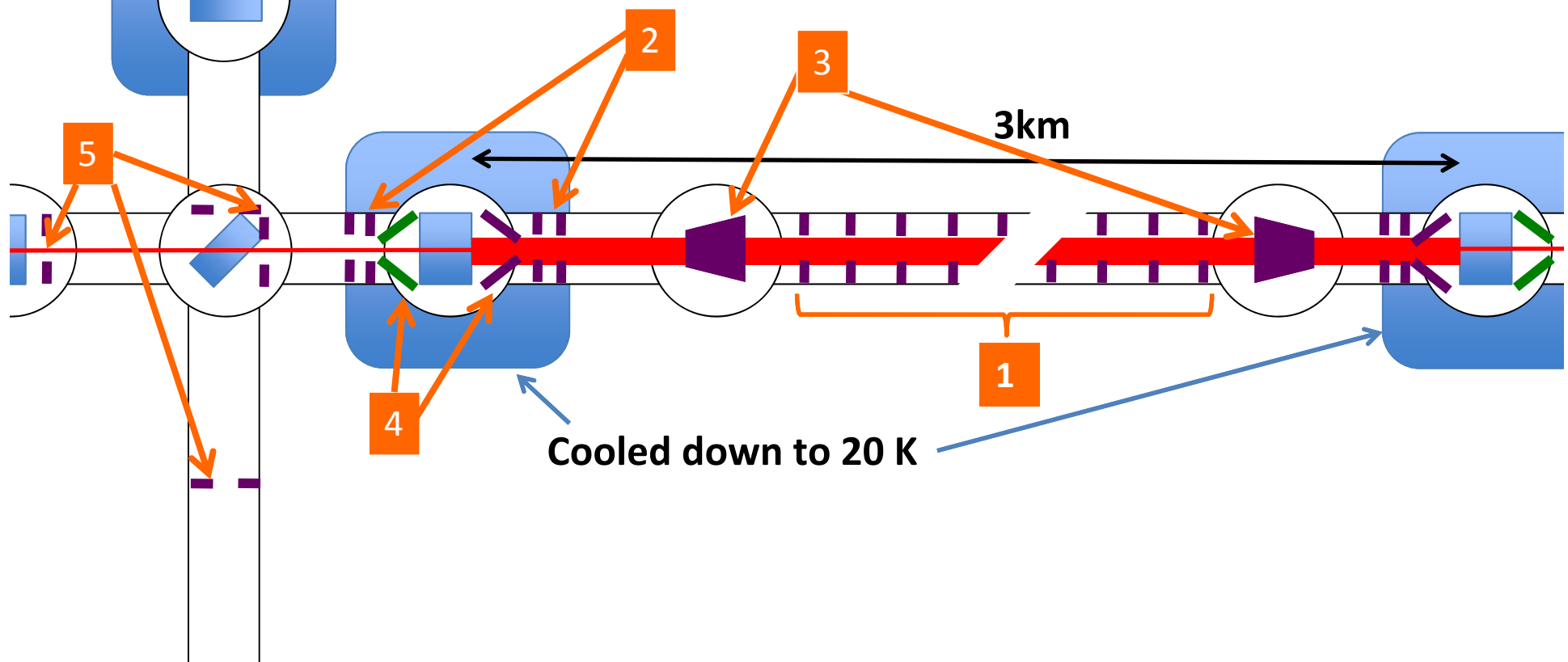
[Progress]

- Detailed design document including noise requirements for various subsystems
- A reasonable LSC scheme
- Preliminary ASC scheme
- Computer optimized optical layout



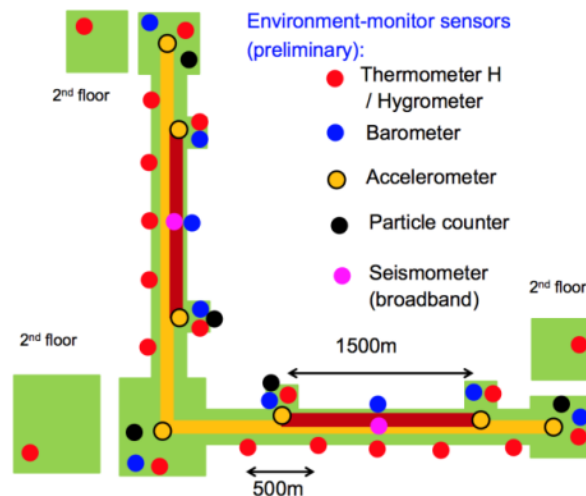
Stray-light Control

1. Baffle vanes in the 3-km beam tube (every 12 m)
2. **Cryo**-baffle vanes in the 17-m cryoshield
3. Baffles for narrow-angle scatters
4. **Cryo**-baffles for wide-angle scatters
5. Other baffles

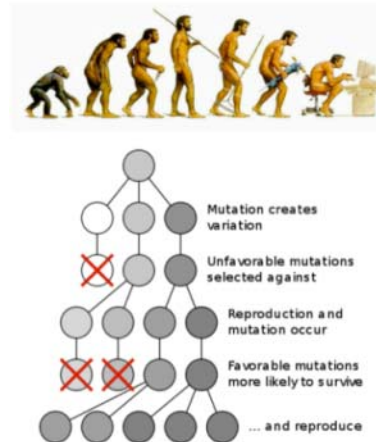


Detector Characterization

- to evaluate & improve **data quality**
Instrumental, environmental monitors
- to distinguish between **GW and GW-like noise**
Multi-monitor analysis (collaboration with KGWG)
- to perform **calibration**
From Observation to Science



various monitors



Neural Network (KGWG)

Summary

- **The tunnel excavation is going well.**
- **Design activities are also going well.**
- **We will start installation in April 2014.**
- **We have a challenging schedule and tight budget and human resources.**
- **International collaborations are extremely important.**