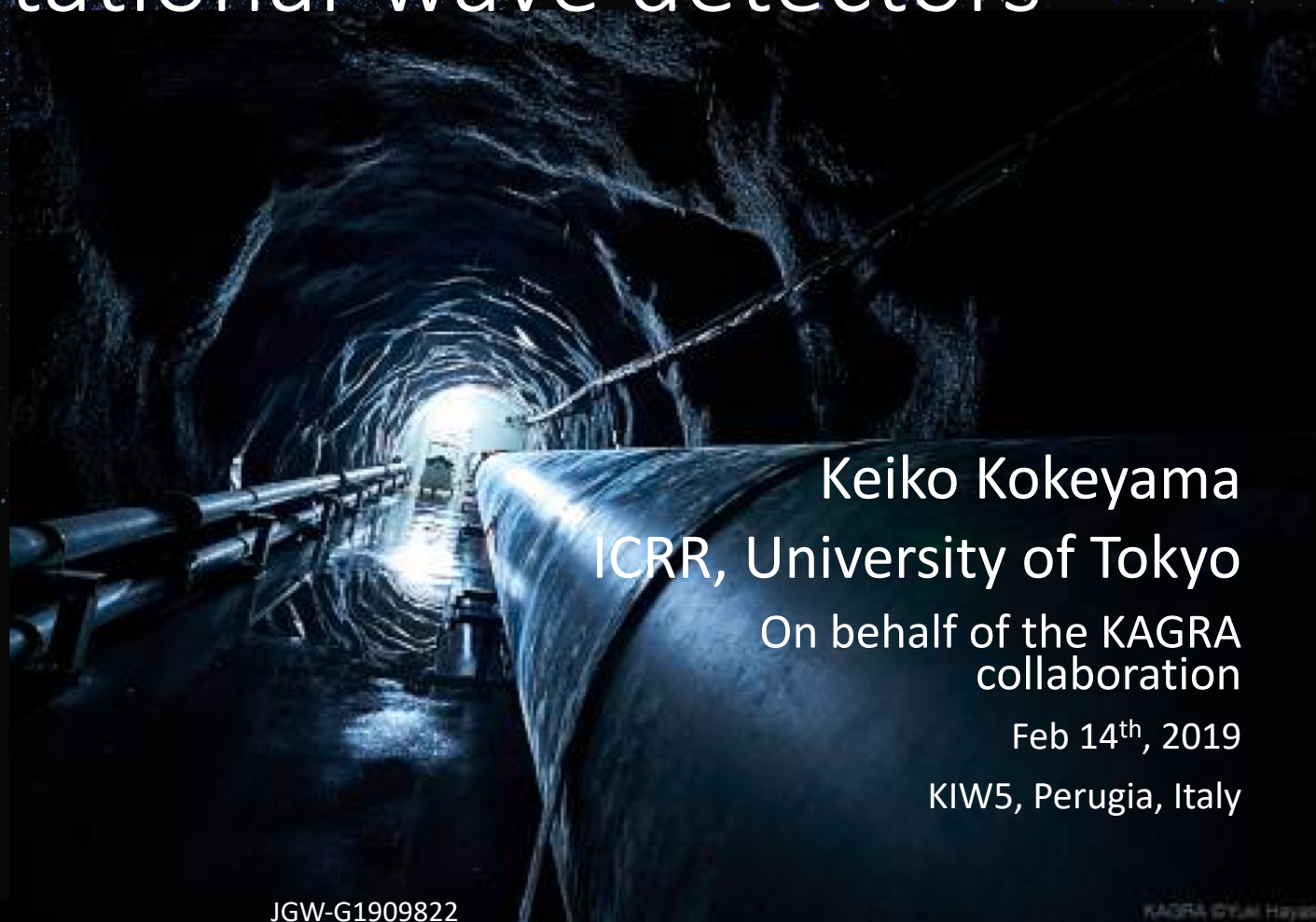


Status of KAGRA: the underground- and cryogenic gravitational-wave detectors



Keiko Kokeyama
ICRR, University of Tokyo
On behalf of the KAGRA
collaboration

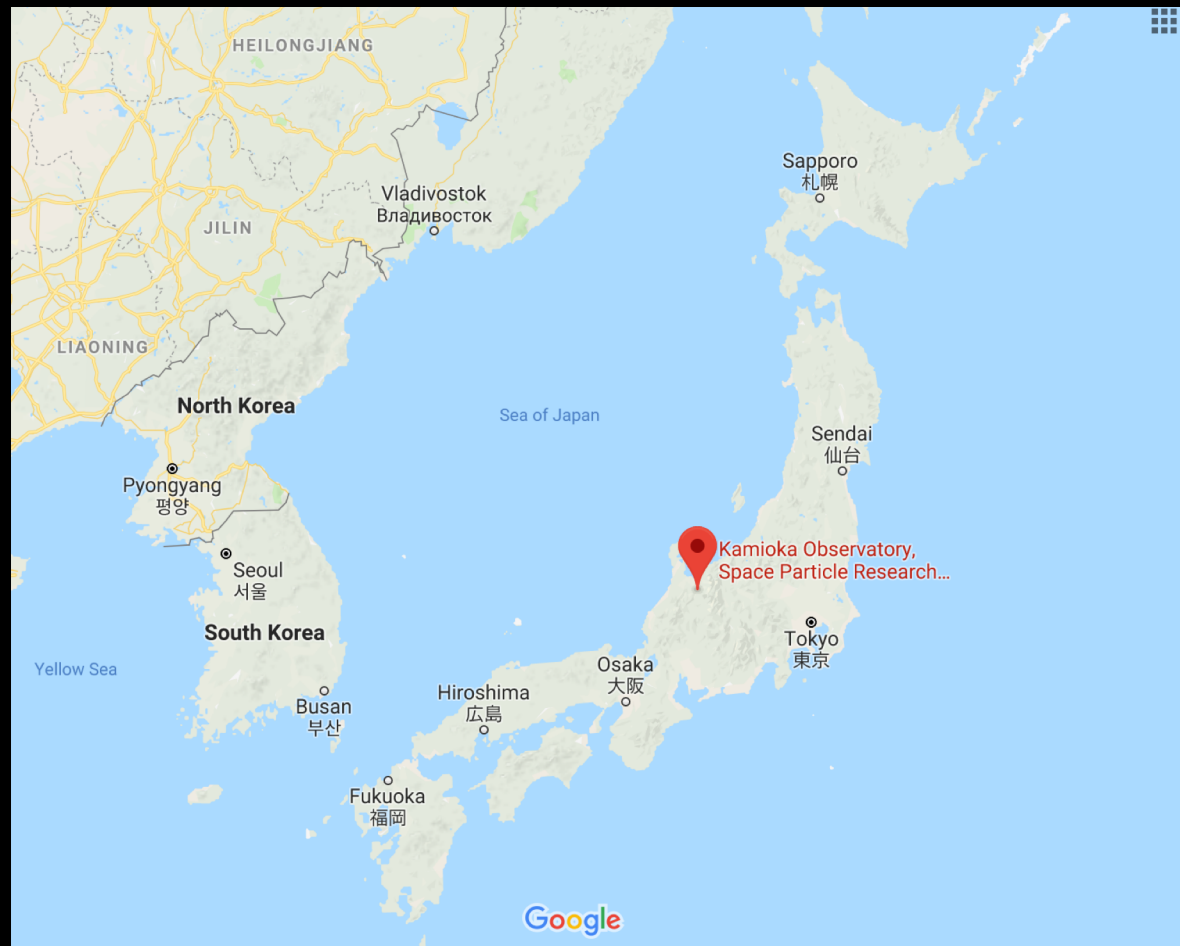
Feb 14th, 2019

KIW5, Perugia, Italy

KAGRA Project

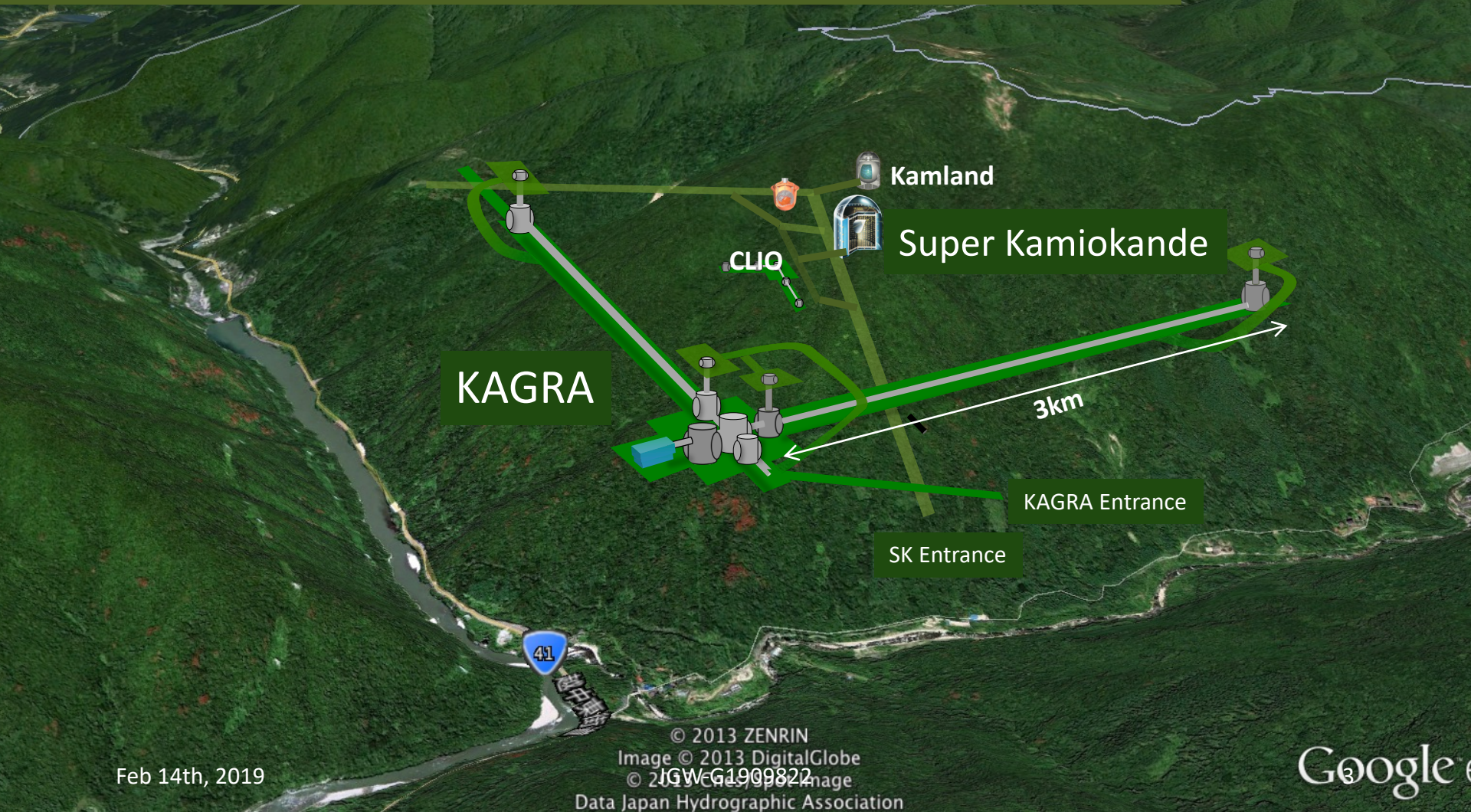
- **Underground** and **Cryogenic** interferometric gravitational-wave detector
- Project started in 2010, funded by MEXT, Japan
- International collaboration (97 institutions, 13? countries, 470 members)
- Rapidly being prepared to join the next LIGO-VIRGO observation, O3

Location of the KAGRA Observatory



Toyama Bay
Toyama City

KAGRA in Kamioka, Japan



Feb 14th, 2019

© 2013 ZENRIN
Image © 2013 DigitalGlobe
© 2013 CNES/Airbus Image
Data Japan Hydrographic Association

Google

Kamioka Site



Feb 14th, 2019

JGW-G1909822

3km arm tunnel



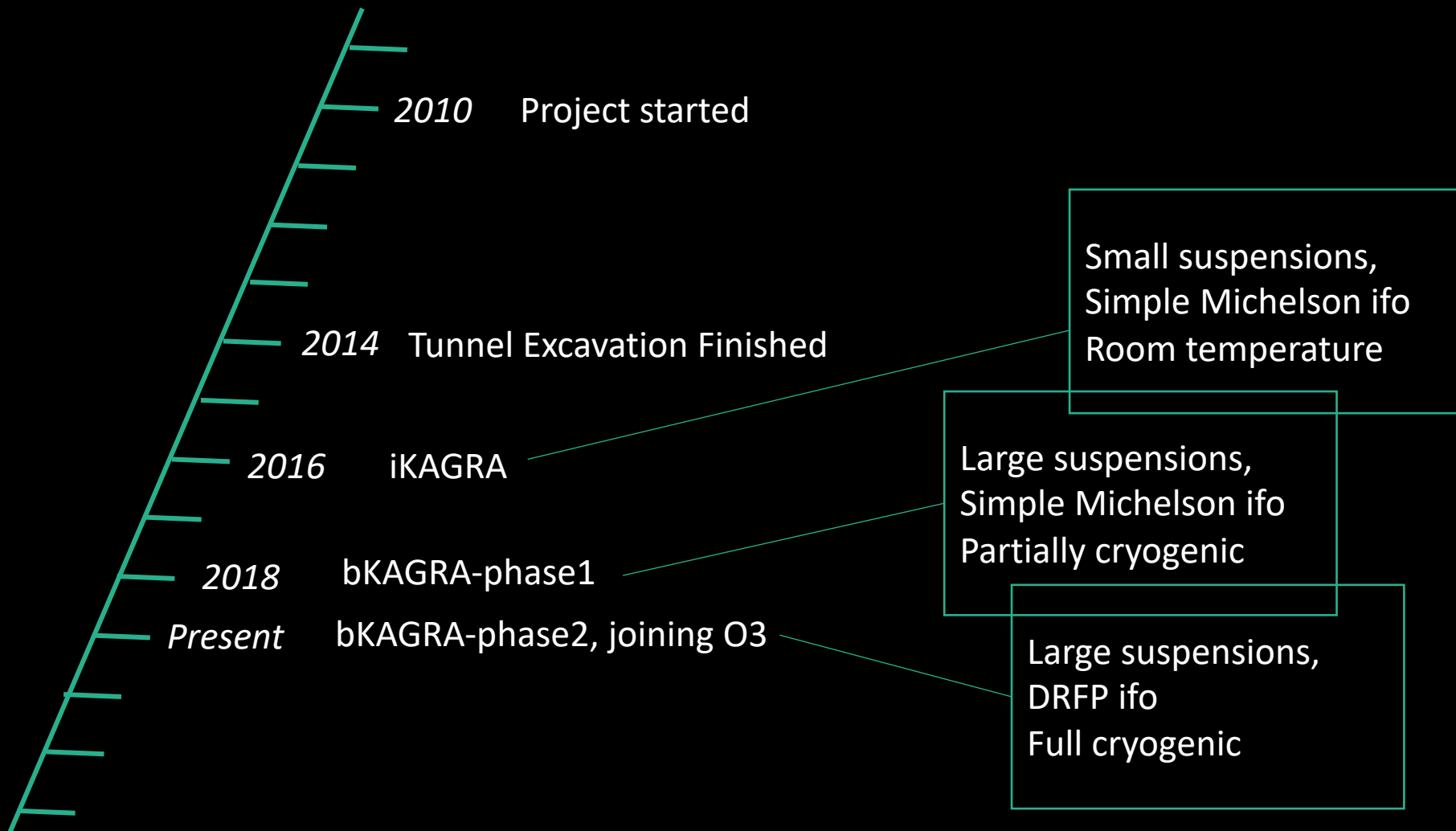
Credit:NAOJ



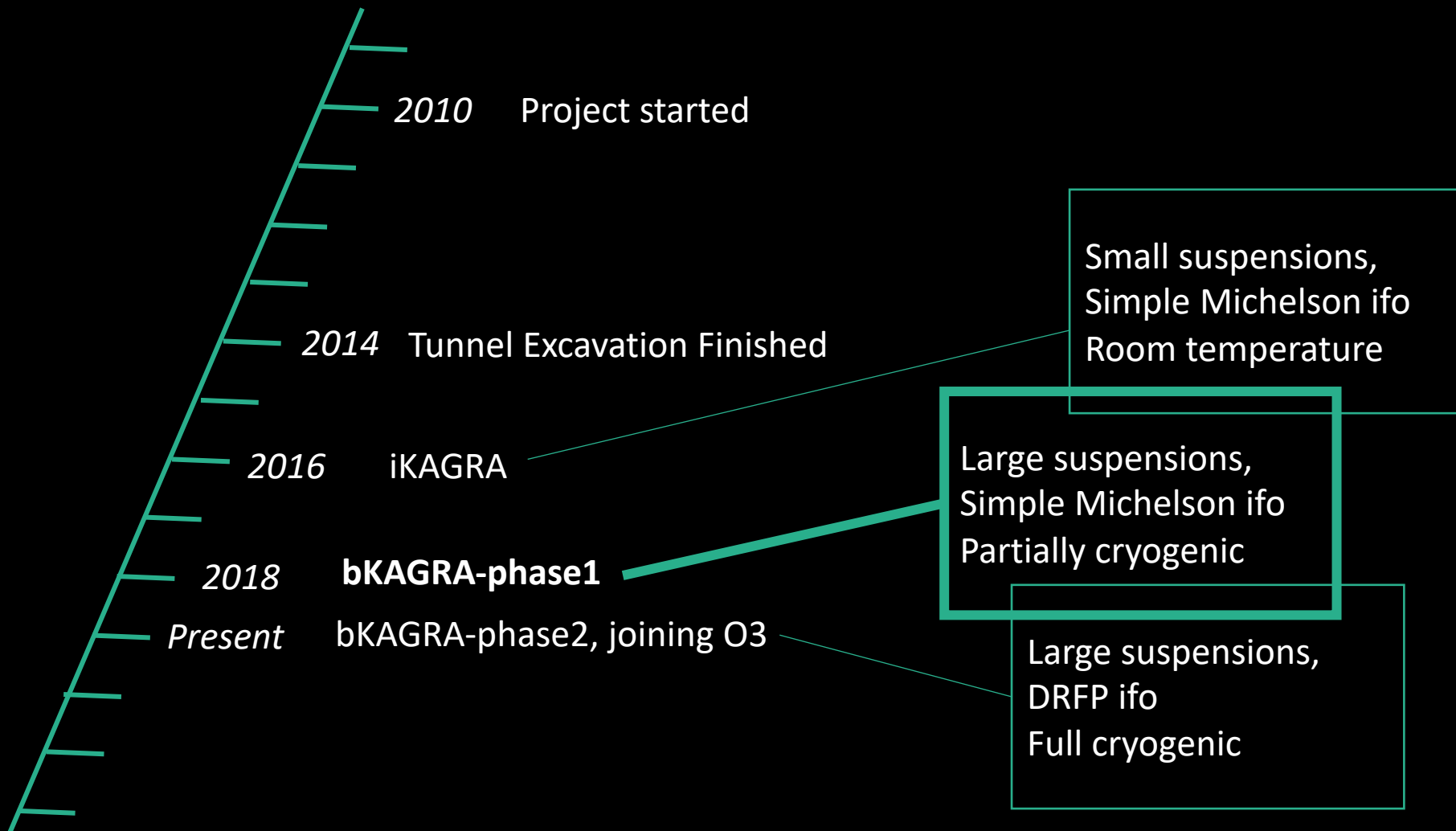
Corner Station



Timeline of the Project



Timeline of the Project

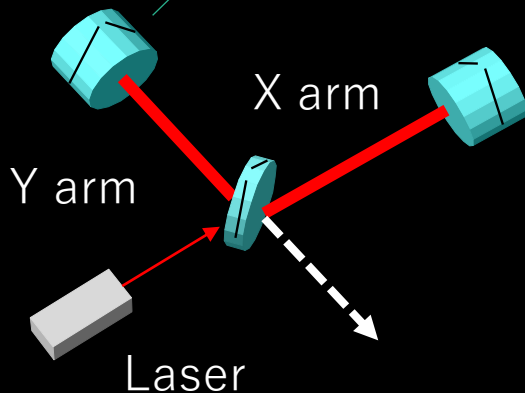


bKAGRA-Phase1 Operation

April 28th – May 6th 2018

Y end

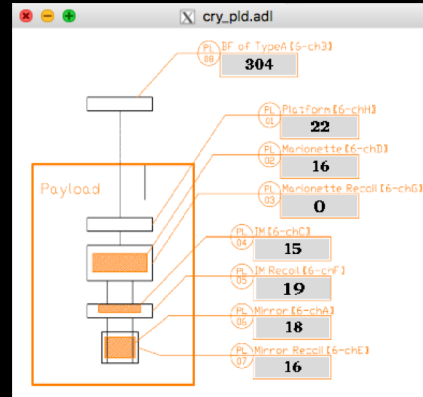
Cryogenic (18K)
Type-A suspension
Spare sapphire mirror



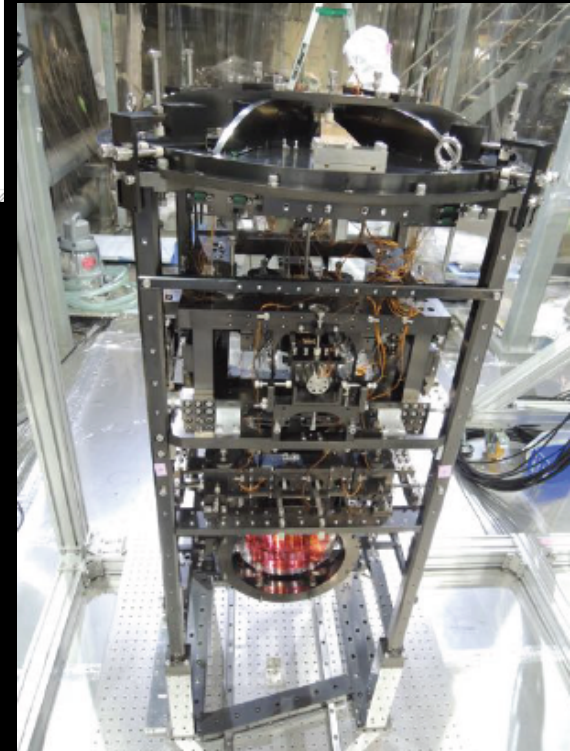
X end

Type-A suspension
Sapphire mirror

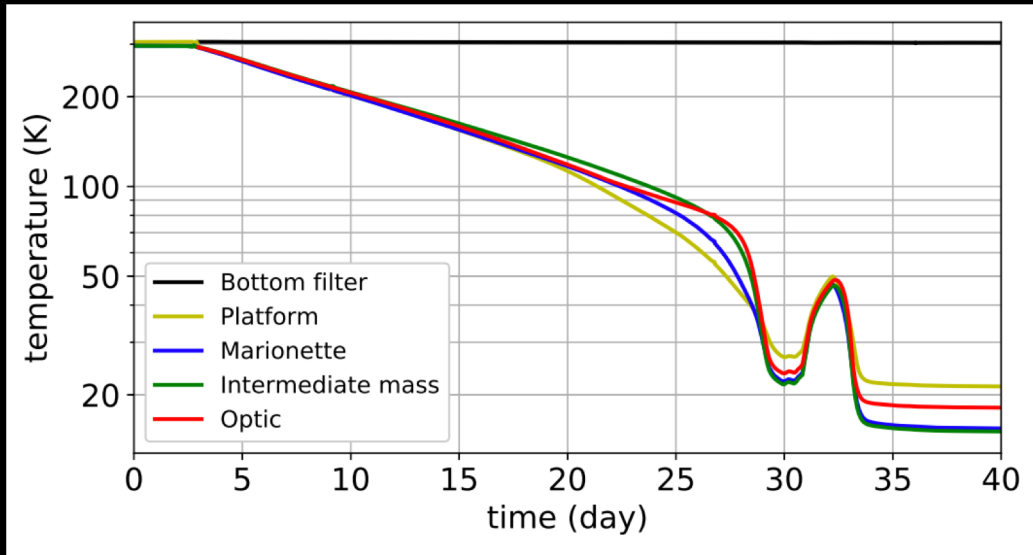
PRM (misaligned), PR2,
PR3, BS were also in place



Cryo-payload



Temperature of ETMY

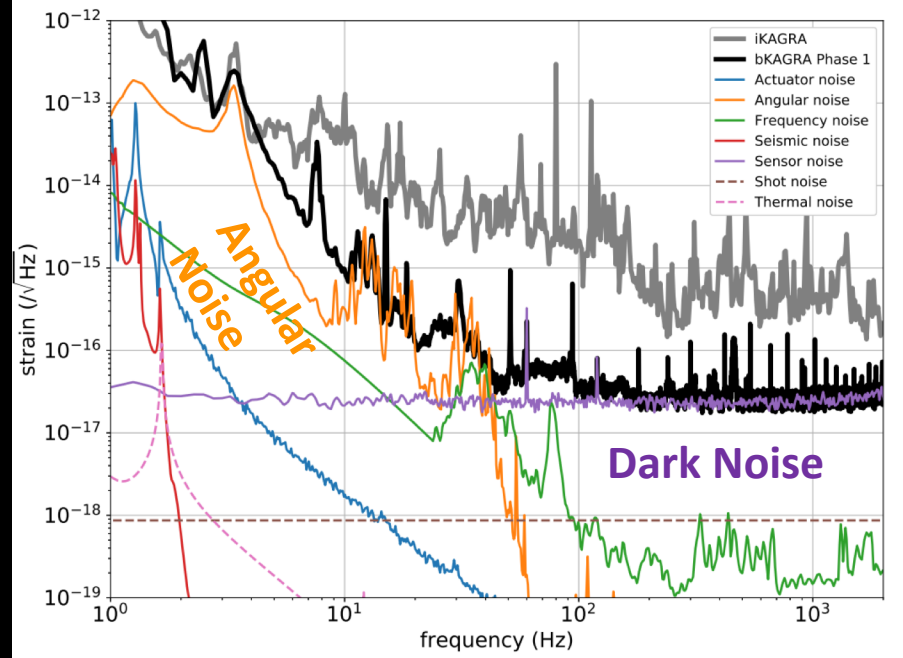


Phase-1 Sensitivity
 $\sim 3e-17$ /rtHz at 100Hz

<https://arxiv.org/pdf/1901.03569.pdf>

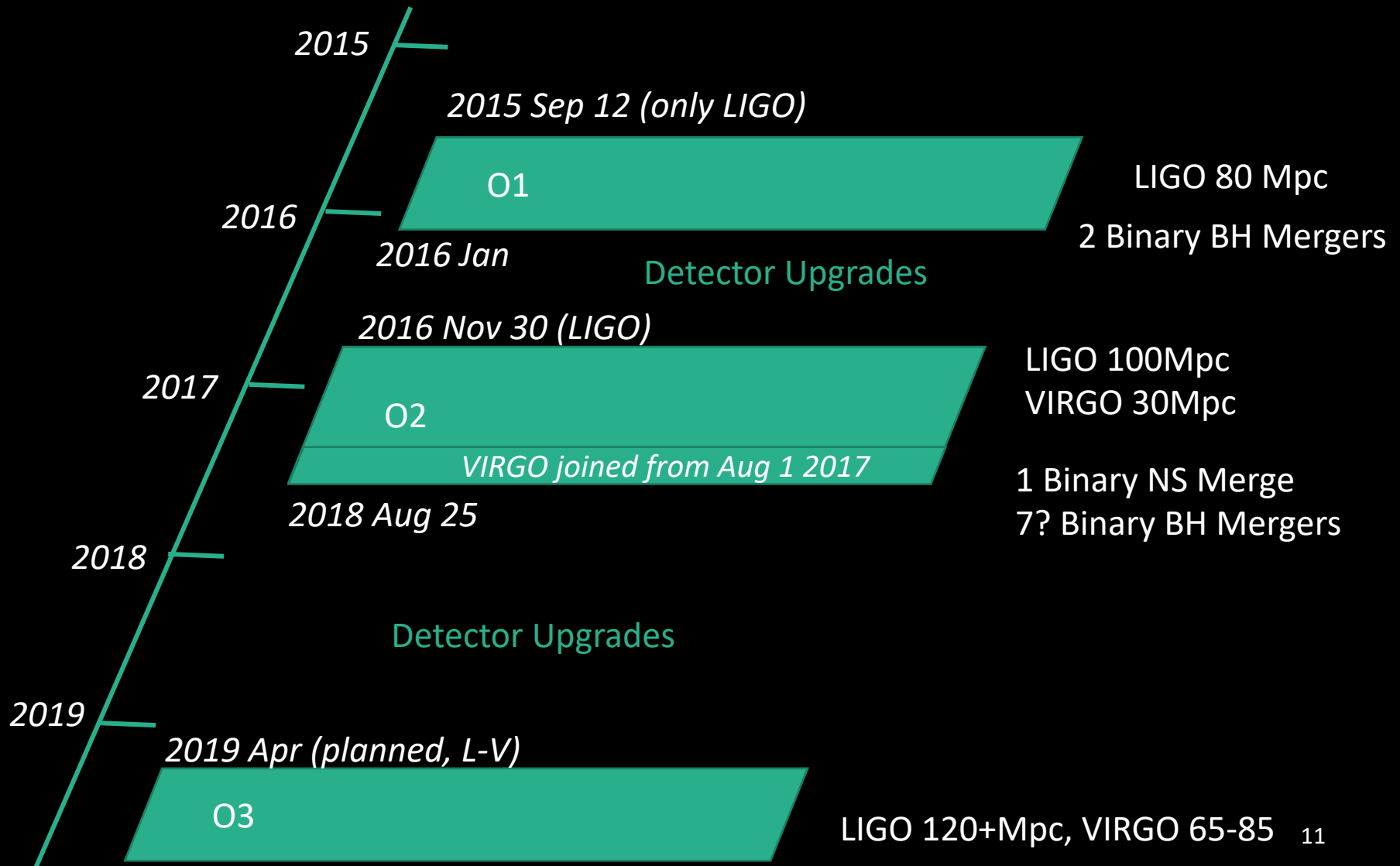
We gained the experiences of...

- First cryogenic operation
- First operation with large suspensions

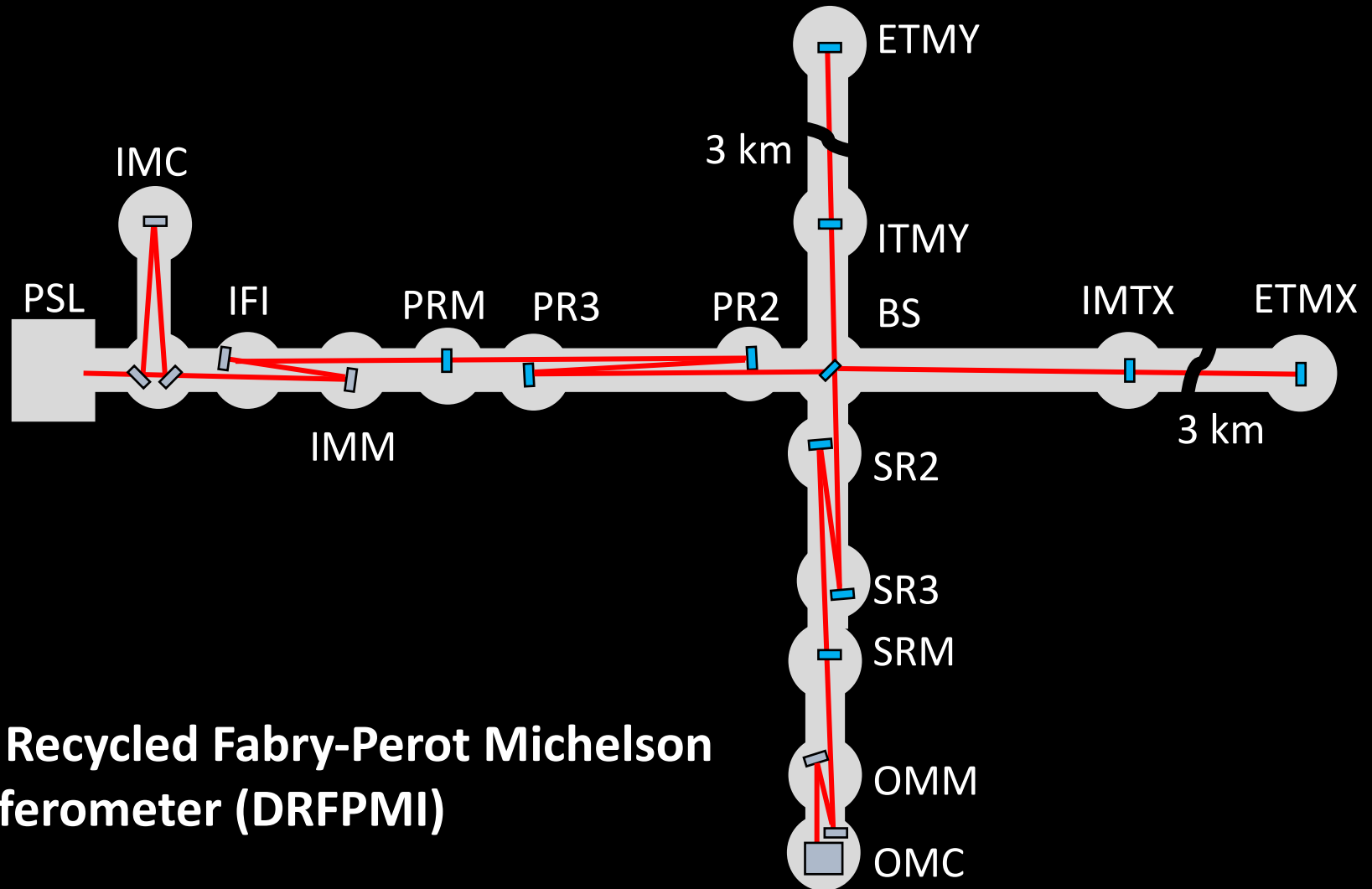


Before going to the current status...

LIGO-VIRGO Obs. Timeline



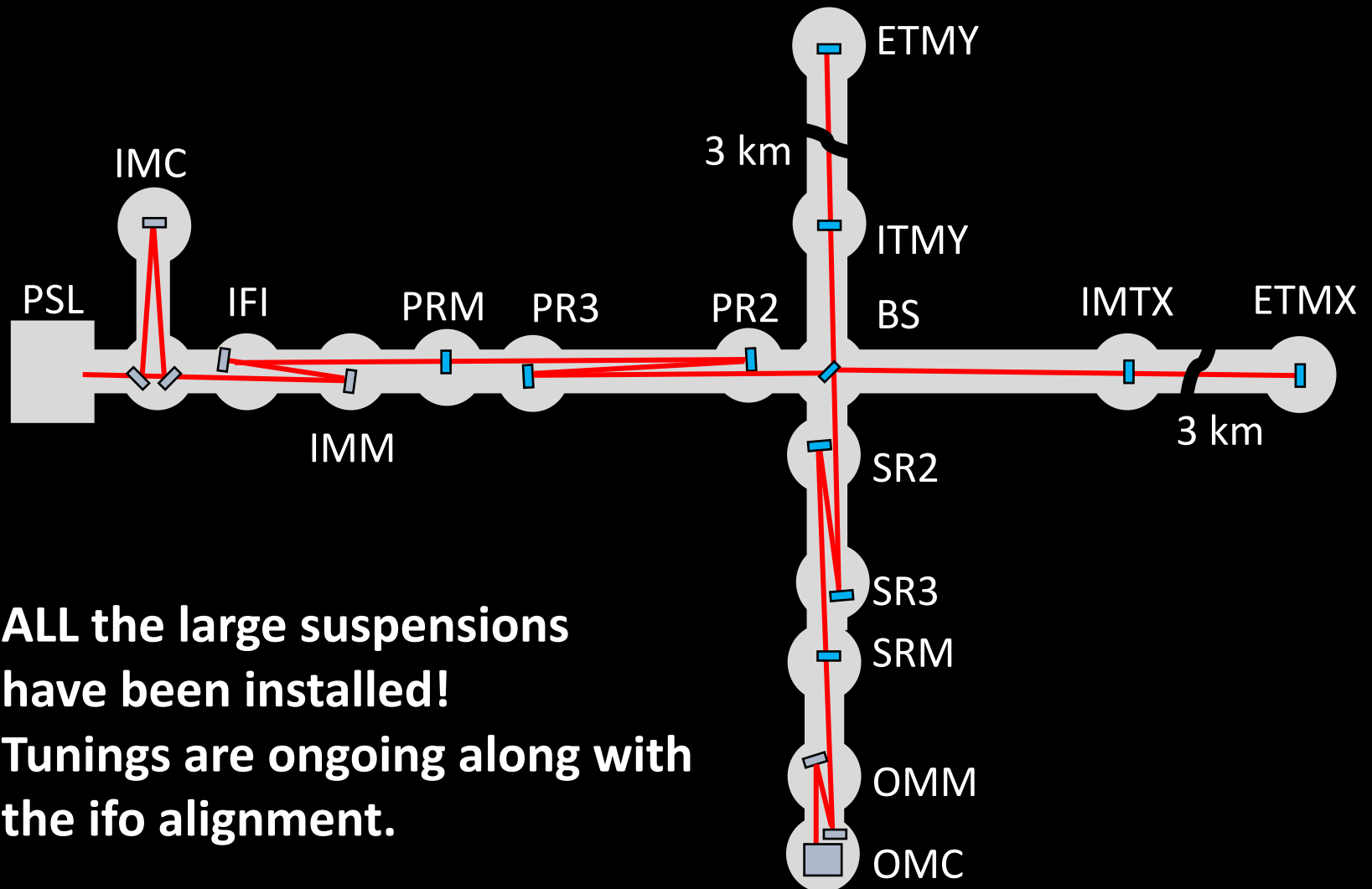
bKAGRA-Phase2



Dual Recycled Fabry-Perot Michelson Interferometer (DRFPMI)

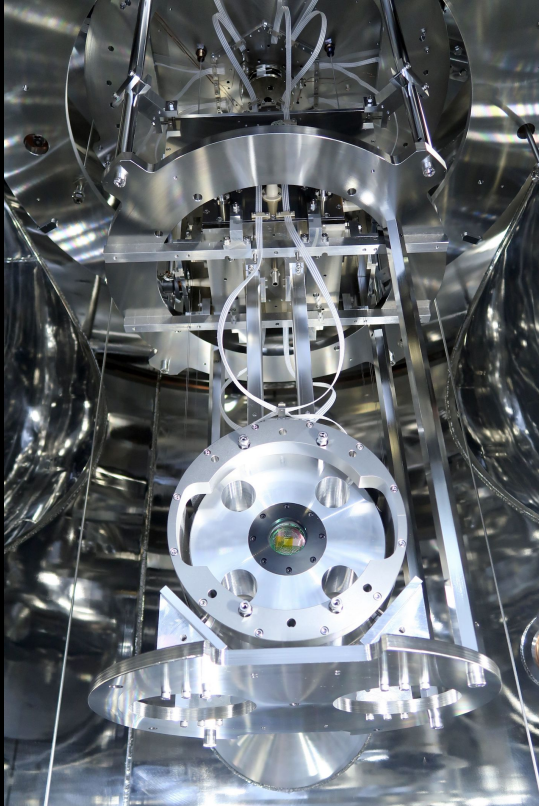
Recent Achievements and News

VIS

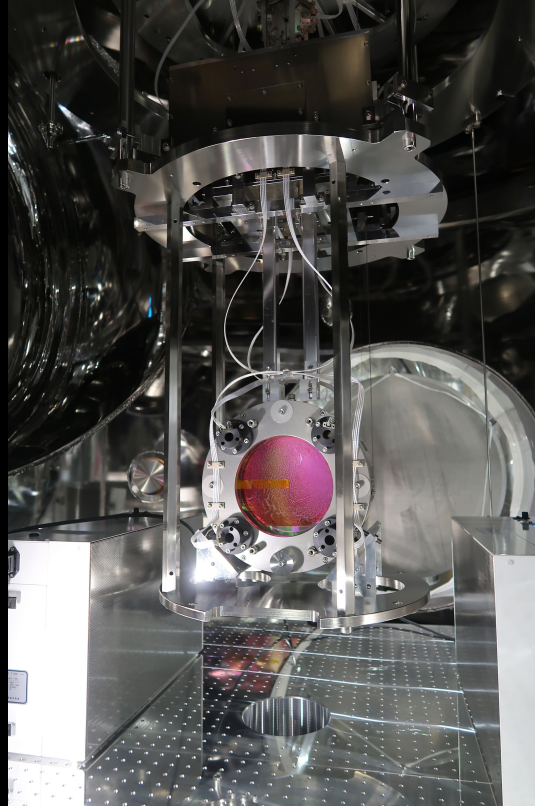


Most recently, all SRs have been installed!

SRM



SR2



SR3

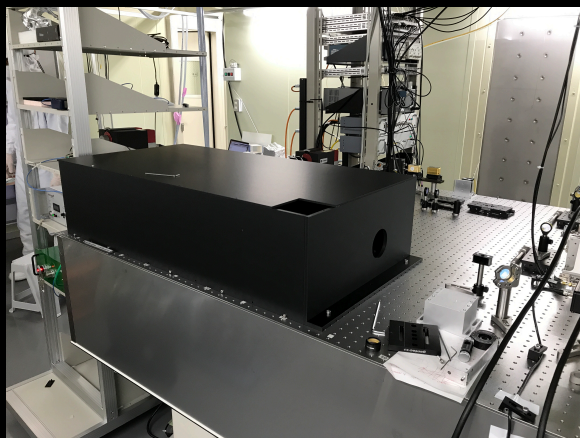


* SRM has a temporary 2-inch mirror

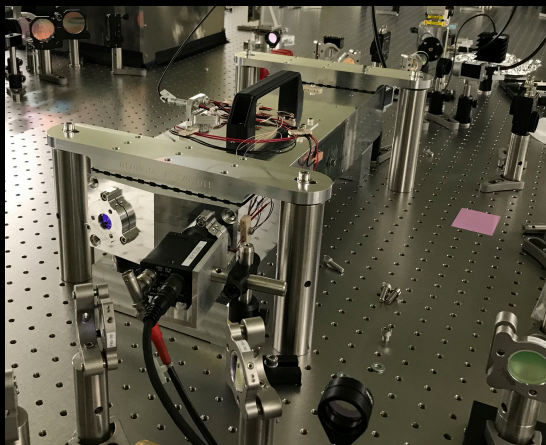
→ See, Burton, Tapia, Fujii, Kozu's talks

Input Optics

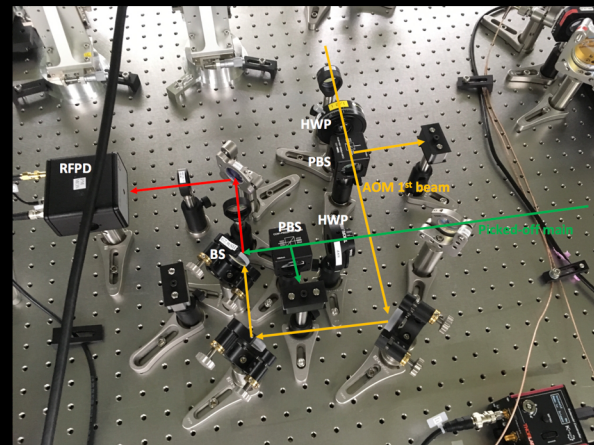
40W laser installed



PMC installed



Mach-Zehnder ifo type
modulation system,
PM&AM monitor system



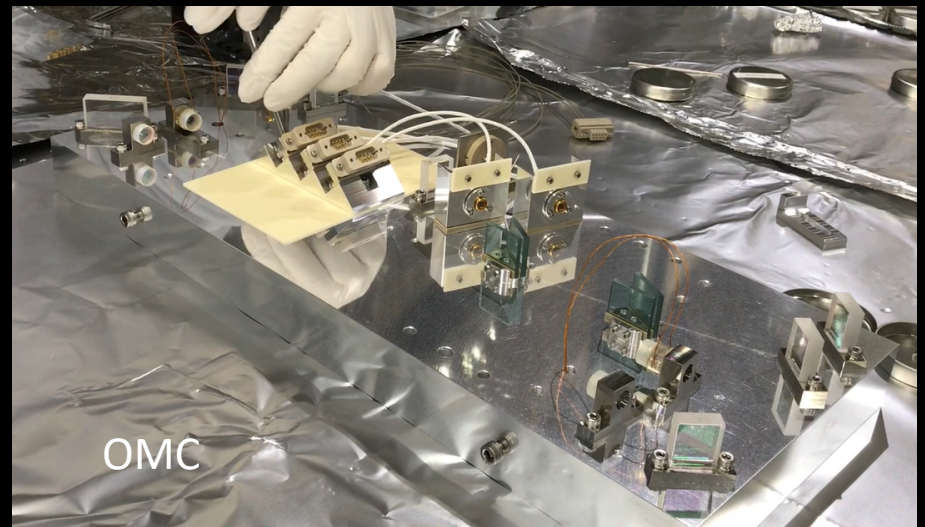
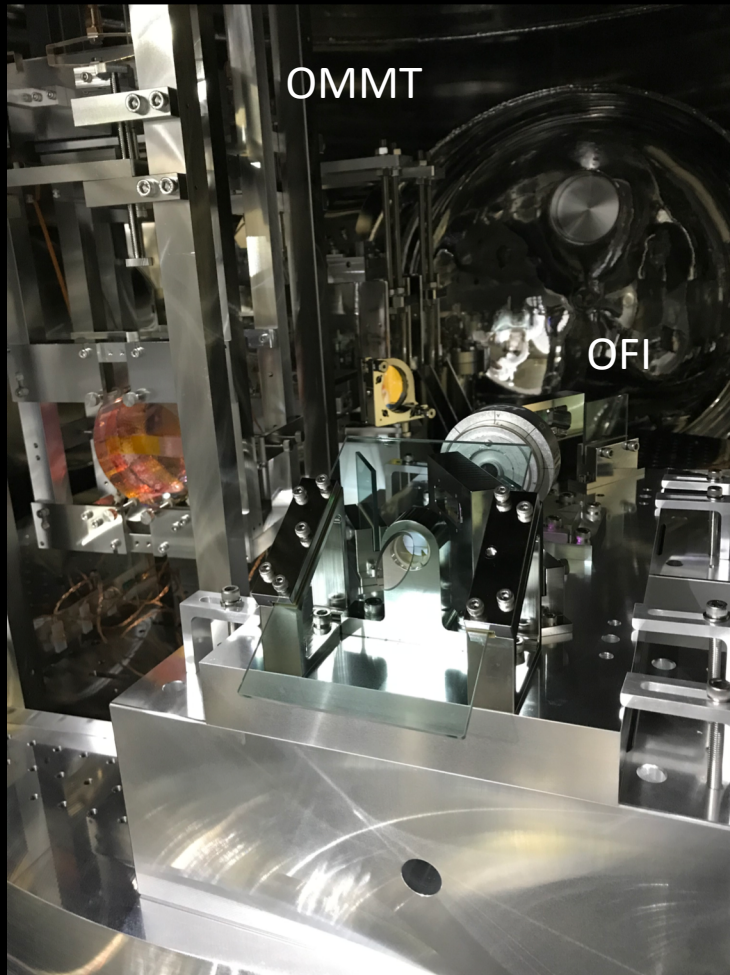
- Input mode cleaner was tested with 10W
- Intensity stabilization is being commissioned
- Frequency stabilization (mode cleaner & reference cavity) has been operating since phase1

→ See, Nakano's talk

Output Optics

- Output mode cleaner (OMC)
- Output Faraday Isolator (OFI)
- Output mode-matching telescopes (OMMTs) installed!

Nov-Dec 2018

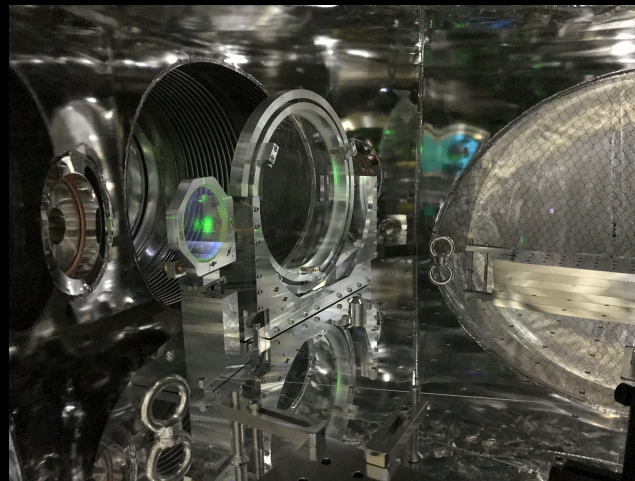


Auxiliary Optics

WAB EX



Transmon EX

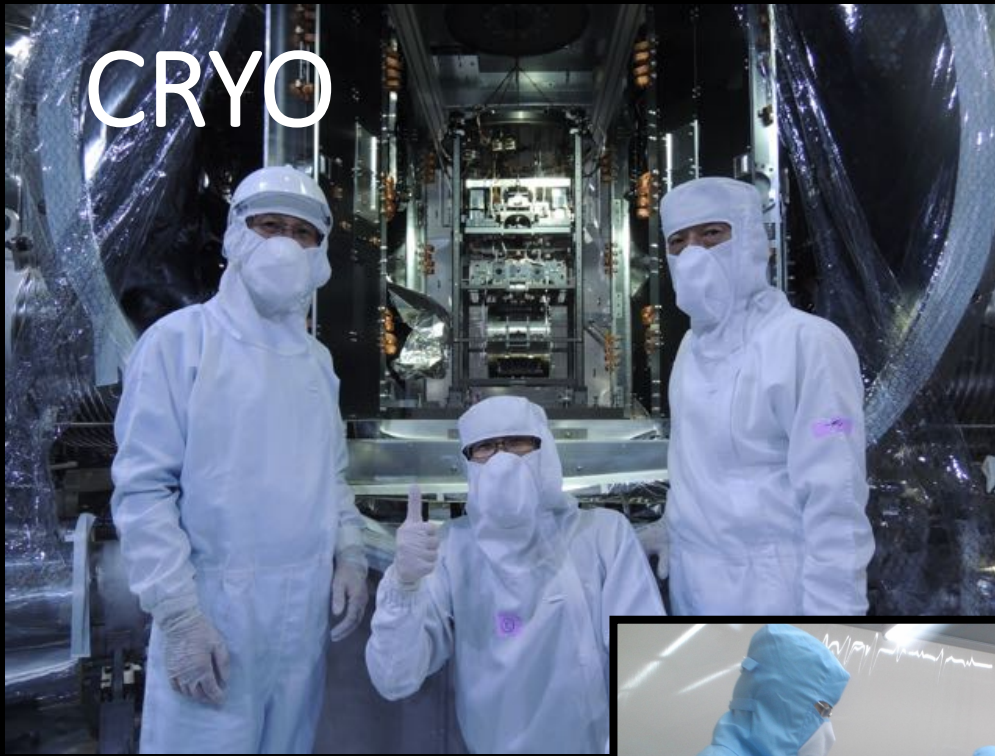


NAB IY



- WAB - 3 of 4 installed! The last one delivered at the X end
- Transmitting monitor (TRANSMON) installed in both of the X and Y ends!

CRYO



**All the sapphire mirrors
has installed
in Nov 2018**

ITMX and ITMY

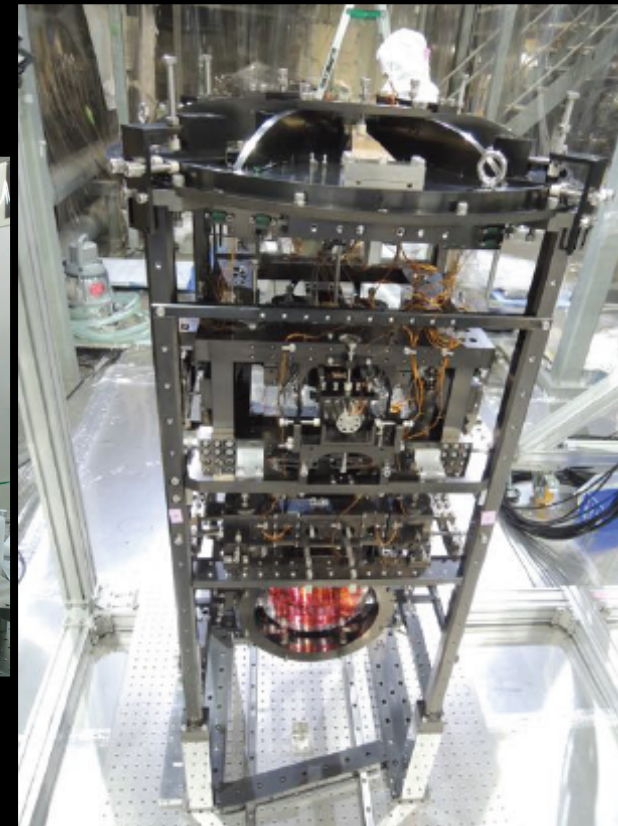
Pictures from K Yamamoto

→ See, Ushiba, Yamada,
Fukunaga's talks



Ears were bonded at Toyama U

Bonded mirror is integrated
Into the cryo-payload
And the type-C suspension
at the site



CAL

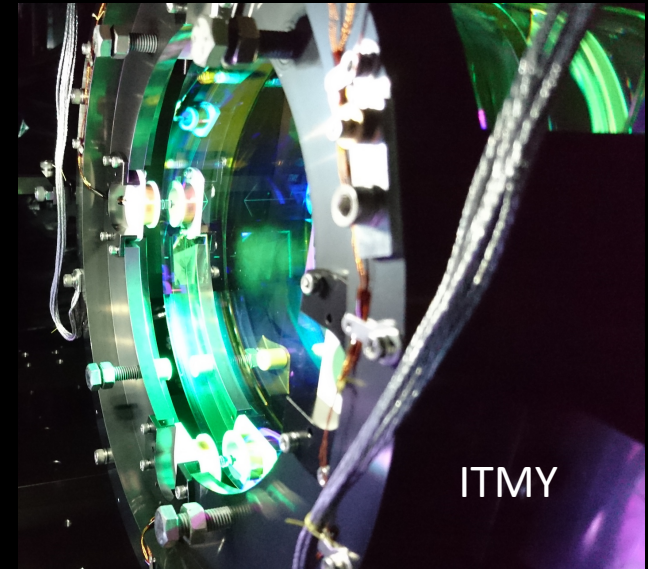
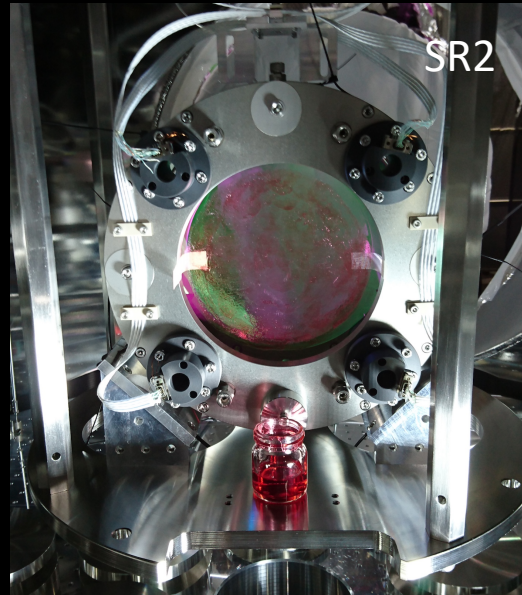
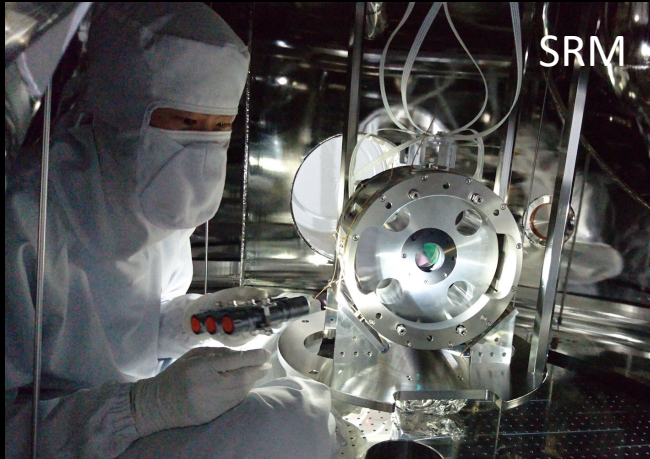
- Photon calibrator modules installed at the both ends
- Calibration pipelines are being constructed

See, T Yamamoto's talk

JGW-D1807705, JGW-G1909581



Mirror



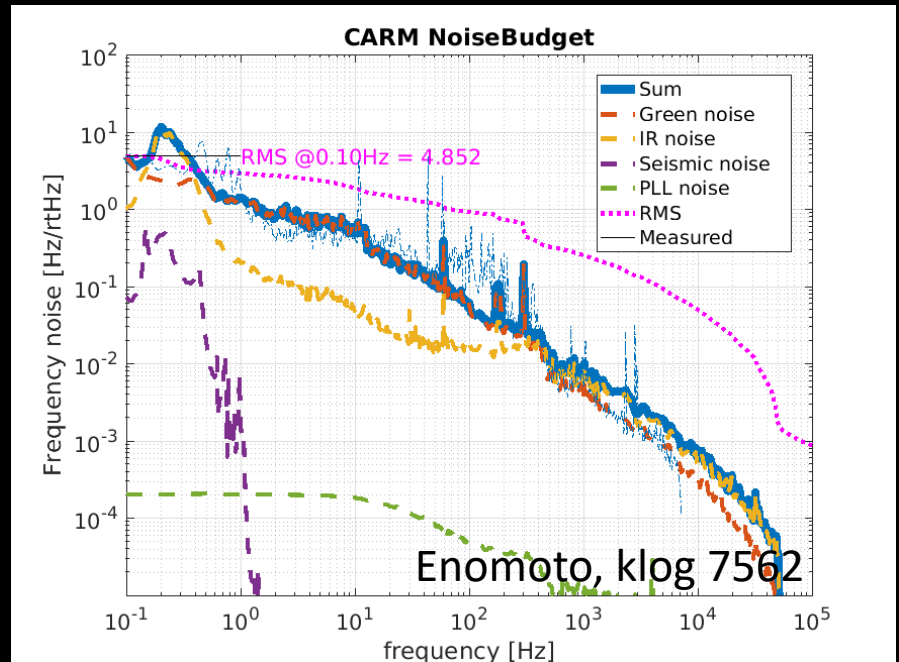
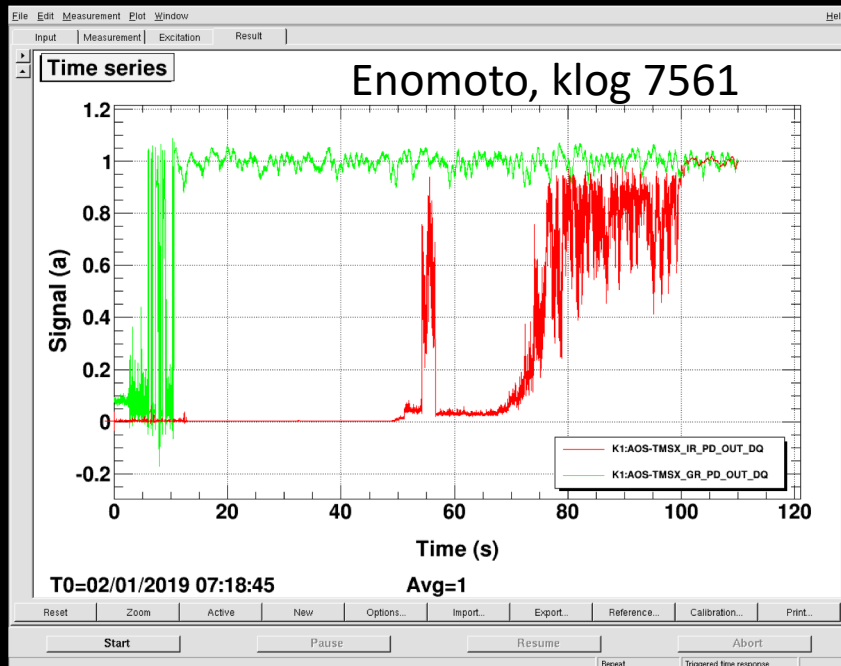
Many mirrors were cleaned with FC before starting the DRMI commissioning

- 3 IMC mirrors as preparation for the high power
- PR3 (condensation), SRM, SR2 (condensation), SR3 (dusts)

Test masses were found to have particles too

X-arm Locking Test

- X-arm test has completed
 - X-arm locked with the axillary (green) laser, then successfully handed off to the IR laser
 - Noise budgeting
- See, K Izumi's talk



Data Management

Tier-0
Steadily working

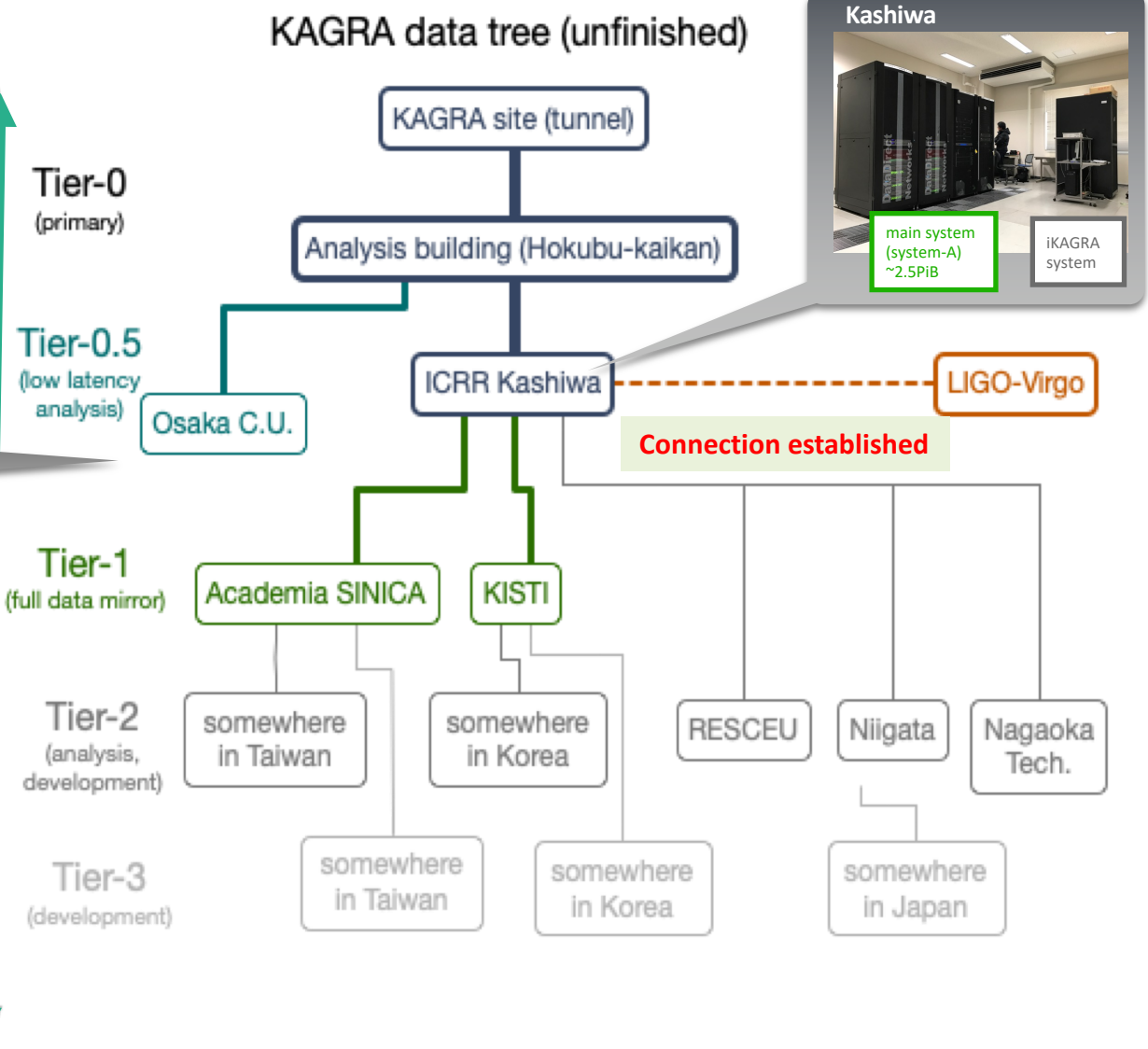
Tier-0.5
Under refurbishment

Tier-1
Steadily working

Tier-2/3
in preparation



Faster latency ↑
↓ Slower latency



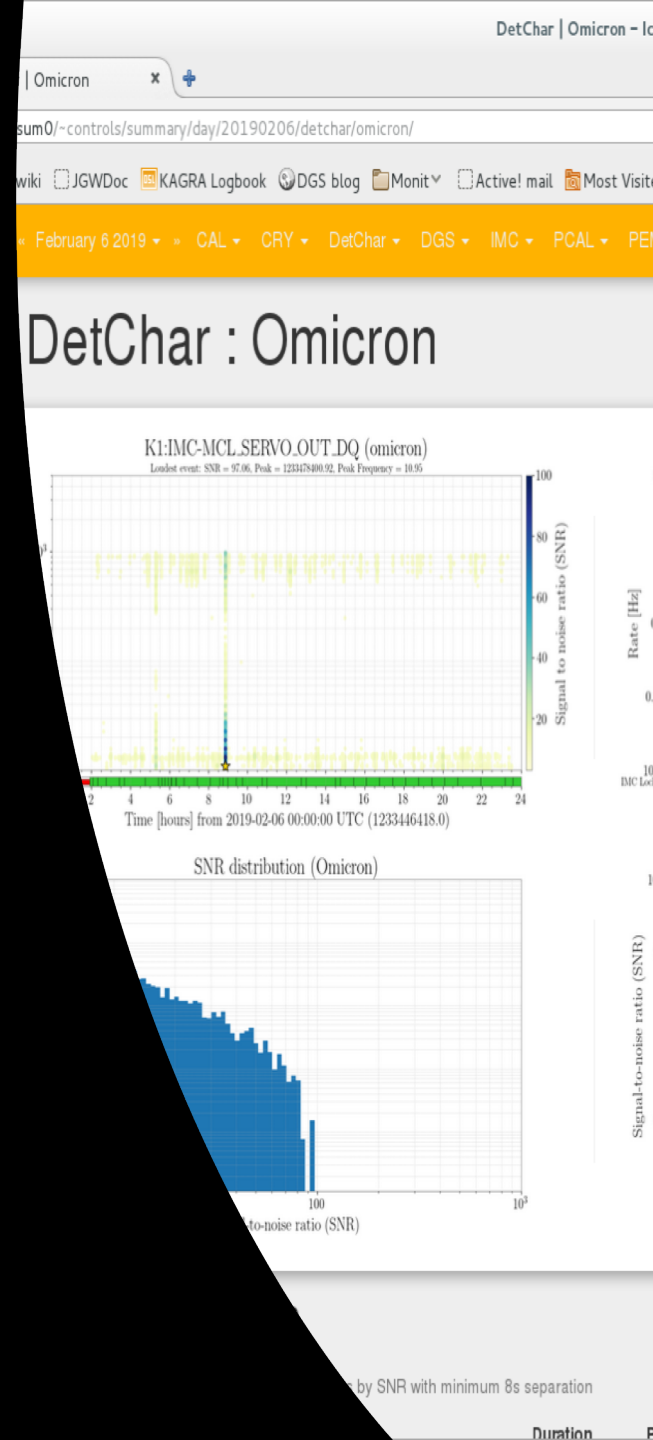
Data Management

Milestones to achieve by the end of Feb:

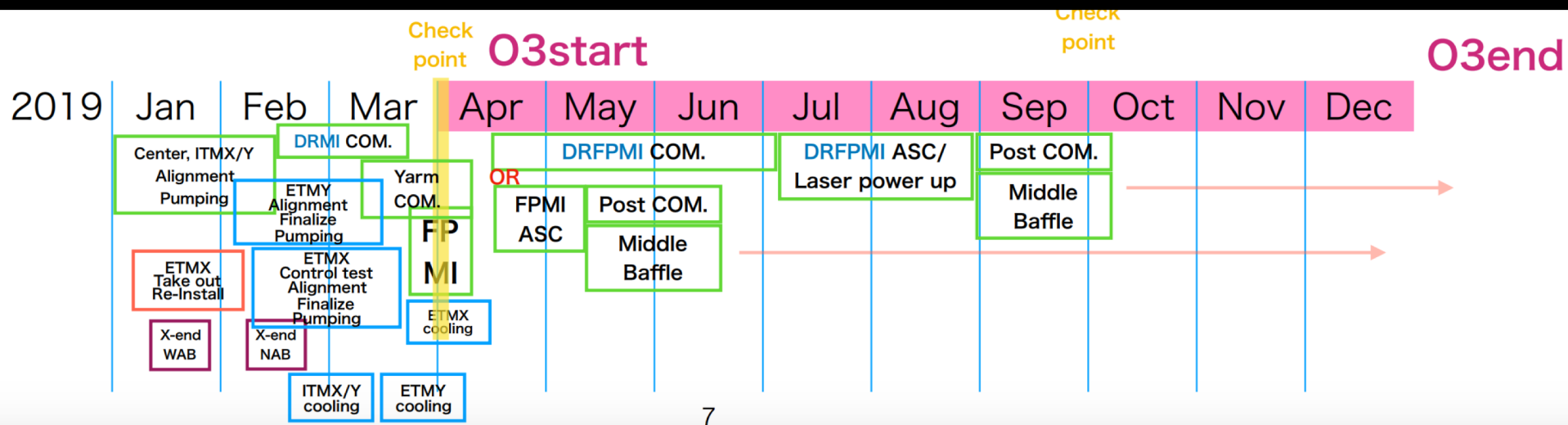
- Low Latency h(t) transfer
 - From KAGRA tunnel to the surface test : **OK**
 - From KAGRA tunnel to Kashiwa server : **Testing**
- Low Latency connection with LV
 - **The connection had established**
 - 6.2 sec from LLO to Kashiwa
 - Status information has been exchanged
- Bulk data connection with LV
 - Implementation of LDR (LIGO Data Replicator) software is on going

Detector Characterization

- Had a kick-off meeting with L-V Detchar teams
- A bunch of the Detchar tools were imported from L-V!
 - Summary Pages, Omicron, Bruco, Sus drift mon, ligoDV...
 - Line finding tools, ligoDV-web to be installed
 - iDQ by KGWG (see, Young-min's talk)
- Data quality generation and sharing to be discussed
- Strong collaboration with KGWG

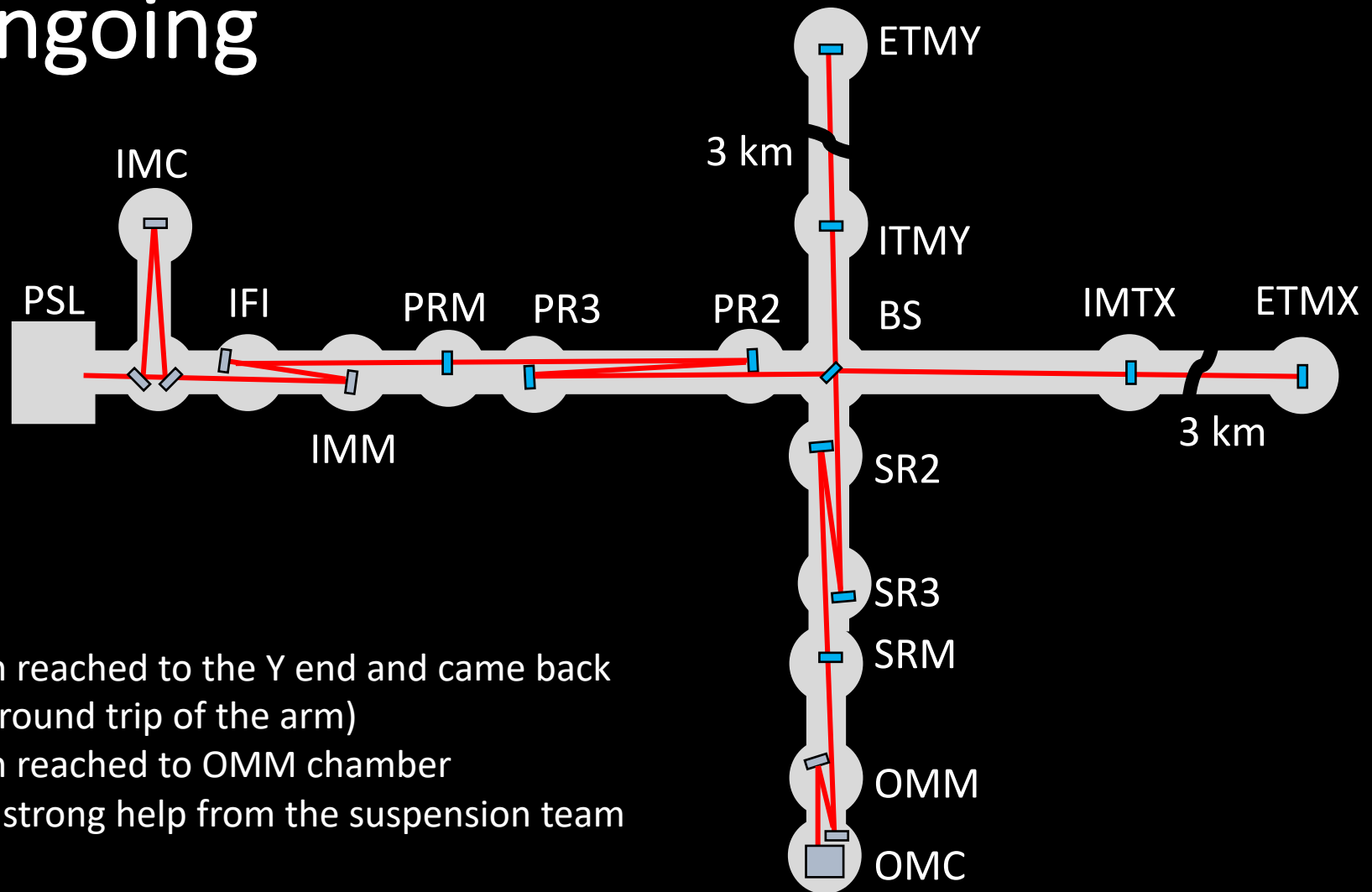


Commissioning Plans and Next IFO Checkpoint



Uchiyama, JGW-E1809209

Interferometer Initial Alignment Ongoing



Beam reached to the Y end and came back
(one round trip of the arm)
Beam reached to OMM chamber
With strong help from the suspension team

Prospects of joining O3

- Improves sky coverage (→ see, JGW- G1809082 by Tagoshi)
- Network duty factor
- source parameter estimation (→ see, JGW- G1808212 by Haino)
- Some parameter degeneracy can be resolved with four detectors (e.g. polarization, → see, PRD 98, 022008 by Takeda)

Summary

- KAGRA detector rapidly being integrated towards joining O3
- So far, no major delay happened
- Dual-recycled Michelson ifo commissioning is about to start, followed by the full ifo commissioning and noise hunting
- For O3, KAGRA will contribute for the source localization and the GW polarization studies