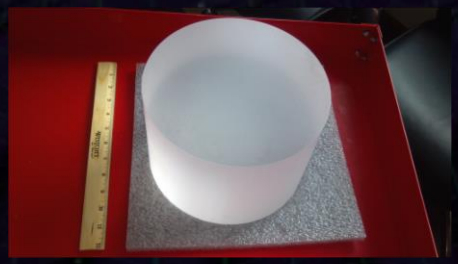
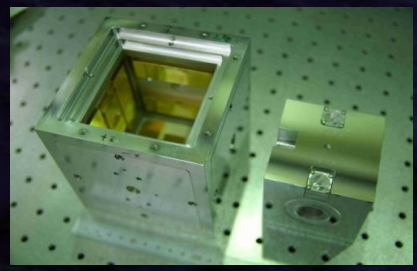


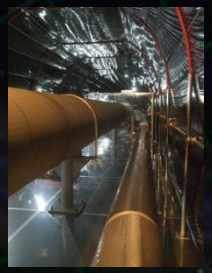


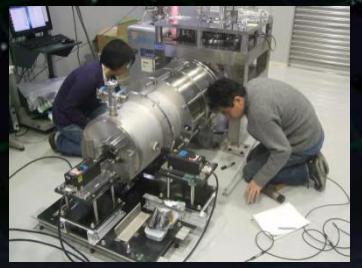



重力波プロジェクト推進室
Gravitational-Wave Project Office

安東 正樹 Masaki Ando







Outline

- Members and Activities
- KAGRA Overview and Status
- Activities of GW group
- Summary

GW Project Office

Purpose of GW Project Office

- Goal : Opening and Expansion of the field of Gravitational-Wave Astronomy.

- Current Activities
  - Large-scale cryogenic GW antenna : KAGRA
    - * Promotion of the project as a core institute.
    - * GW astronomy.
  - Research and development for future detectors
    - * Advanced technologies for ground-based detector.
    - * Space GW antenna.

Project, Research Achievement, Education

Members

Total : 21 Members

- Research Staff
  - Professor
    - New! Raffaele Flaminio
  - Associate Prof.
    - Masaki Ando (U. Tokyo)
    - New! (Yoichi Aso from April 2014)
  - Research Associate
    - Ryutaro Takahashi (ICRR)
    - Daisuke Tatsumi
    - Akitoshi Ueda (50%)
    - Naoko Ohishi (ICRR)
    - Tomotada Akutsu
- Engineer Staff
  - Hideharu Ishizaki
  - Yasuo Torii
  - Nobuyuki Tanaka
- Postdoctoral Fellow
  - Kouji Nakamura
  - New! Fabian Peña Arellano
  - New! Daniel Friedrich (from Sept.30)
- Support Staff
  - Mihoko Kondo
  - Mizuho Yoshizumi
  - New! Ramsey Lundock
- Professor Emeritus
  - Masa-Katsu Fujimoto
- Special Guest Researcher
  - Kazuhiro Hayama
- Students
  - Ayaka Shoda (D2, U. Tokyo)
  - New! Koki Okutomi (M1, Sokendai)
  - New! Mizuki Nikaido (B4, Ochanomizu U.)

Changes in Members

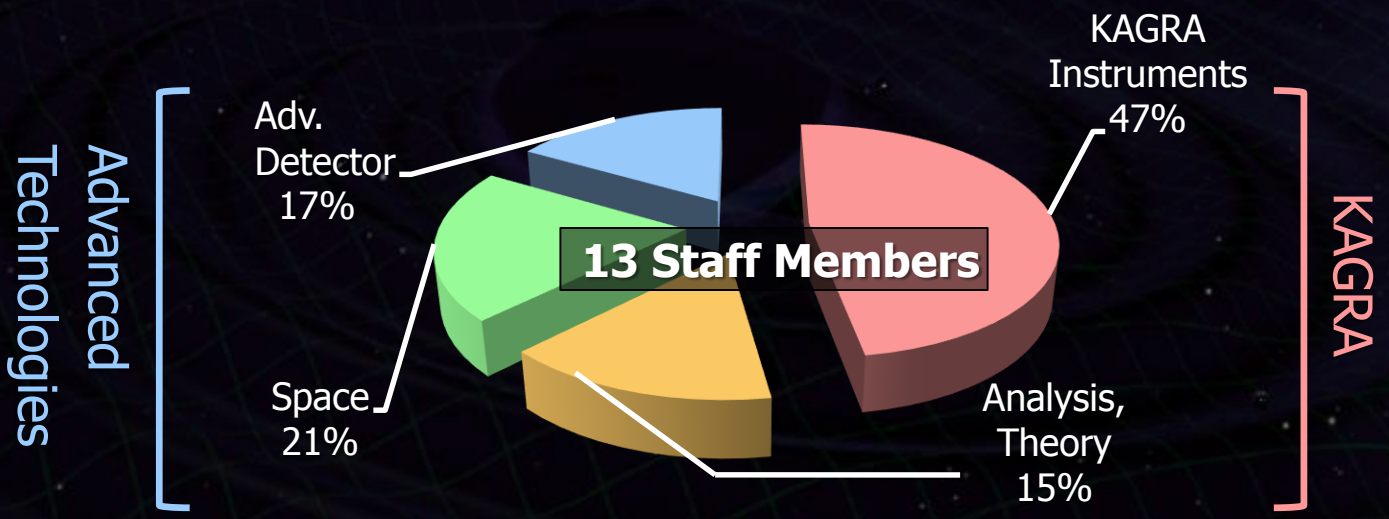
- Staffs
  - * New Professor, R.Flaminio has come (Sept. 1st -) !
  - * A. Prof. M.Ando moved to UT, but still support GW office under an agreement between NAOJ and UT.
  - * New A. Prof. Y.Aso will come in the next April.

- Pos-doc fellows
  - * Agatsuma finished his term, and moved to NIKEF.
  - * One additional project fellow post was newly assigned.
    - → Two new Pos-docs: F. P. Arellano and D. Friedrich.

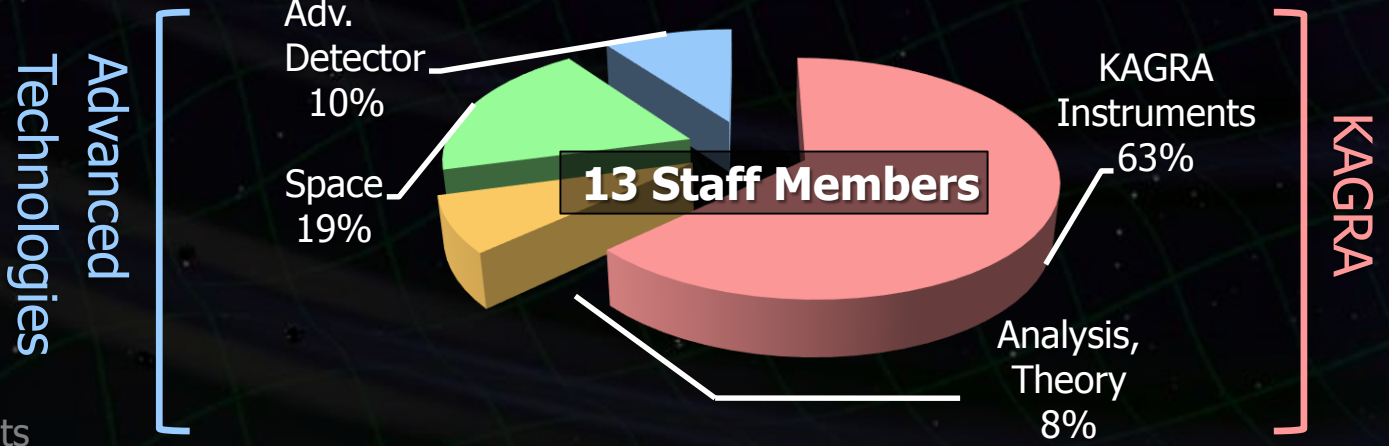
- Support Member : R.Lundock (AIC)
- New students: Okutomi (SOKENDAI), Nikaido (Ochanomizu)

Research Activities

- FY2012



- FY2013



※ Sum of Individual efforts
Students are not included

Research Activities

- First priority : Success of KAGRA and GW astronomy.
  - ⇨ As one of core institute, promote the project.
    - Members of management teams (EO and SEO).
    - Chiefs / Sub-chief of key subsystems.
    - Astronomical achievements.
- Fundamental research is also important
  - ⇨ Continuous growth of the GW field, with achievement and education of next-generation researchers.
    - Novel and challenging scientific value.
    - Appealing research activities for nearby field.

Balance the Activities with Broad Outlook

Overview of KAGRA

Gravitational-Wave Telescope

KAGRA (かぐら)

2nd Generation Large-scale Gravitational-Wave Telescope at Kamioka underground site

(Funded 2010-, Obs. : 2017-)

Open a new field of 'Gravitational-Wave Astronomy'

KAGRA Collaborations

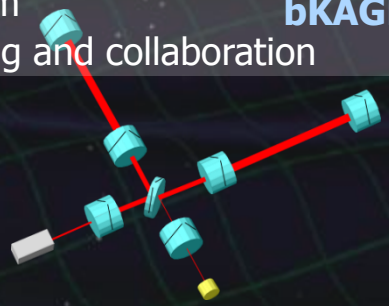
219 Collaborators from more than 60 institutes

※ on April 2013

- Host:
  ICRR/U-Tokyo
- Co-host :
  NAOJ and KEK
- Collaborations
  U-Tokyo, ERI/U-Tokyo, Osaka-CU, TITEC, Osaka-U, Kyoto-U, NICT, AIST, UEC, Hosei-U, Ochanomizu-U, Niigata-U, Kyusyu-U, Nihon-U, Toyama-U, Caltech, MPQ, UWA, LSU, …

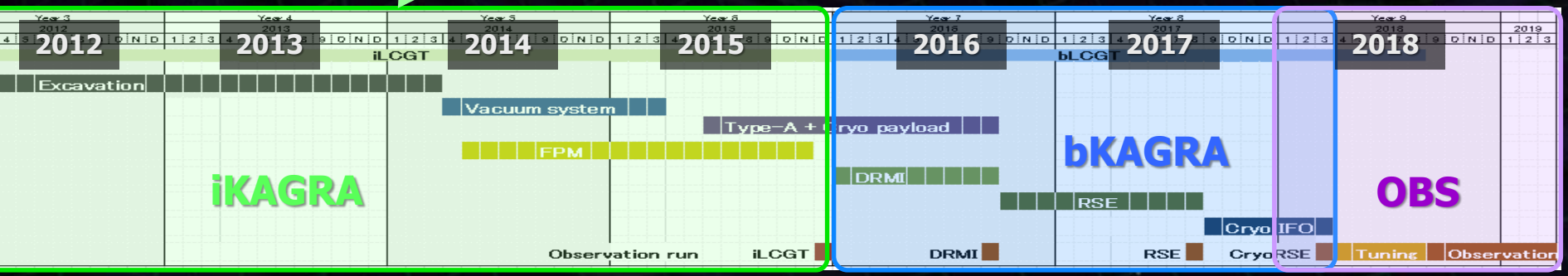
Schedule and Budget

	FY2010	FY2011	FY2012	FY2013	FY2014	FY2015	FY2016	FY2017
Budget	'Leading-edge Research Infrastructure' program (~$98M) for iKAGRA				'Specially Promoted Research' program (~$5M) for detector upgrade			
	Budget from MEXT (~$37M) for excavation				Budget from MEXT (~$20M) for detector upgrade			
	Scientific Research on Priority Areas (~$8M, ~$3M for GW) for multi-messenger astronomy							
KAGRA configuration	iKAGRA •KAGRA facility •3km simple room-temp. interferometer				Core-to-core program (<$1M) for traveling and collaboration Upgrade		bKAGRA •Cryogenic mirrors •Full-power RSE configuration	
Purpose	Preparation of infrastructure						GW detection and astronomy	



KAGRA Schedule

- **iKAGRA** (2010.10 – 2015.12)
  3-km FPM interferometer
  - Baseline 3km room temp.
  - Operation of total system with simplified IFO and VIS.



- **bKAGRA** (2016.1 – 2018.3)
  Operation with full config.
  - Final IFO+VIS configuration
  - Cryogenic operation.

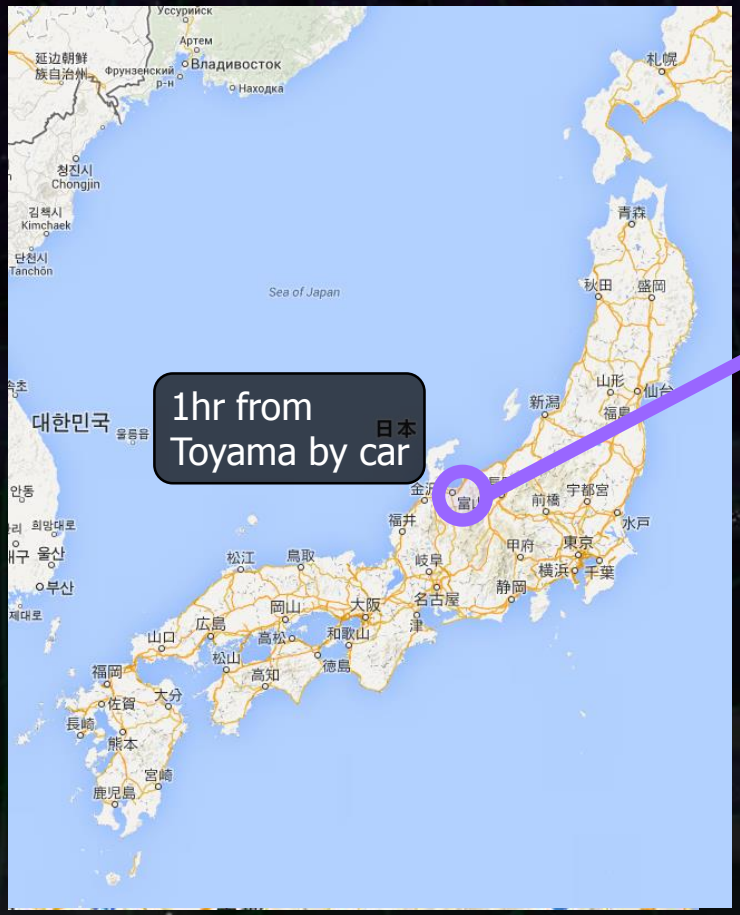
Construction Status of KAGRA

- Infrastructure and large systems mostly finished.
  - Tunnel : ~700m to be finished.
  - Facility : Kamioka office open.
    New building under construction.
  - Vacuum : Arm ducts delivered.
    Vacuum tanks under construction.
  - Cryostat : All of four have been completed.

KAGRA Site

Underground site at Kamioka, Gifu

Facility of the Institute of Cosmic-Ray Research (ICRR), Univ. of Tokyo.



Map by Google

Tunnel Excavation

- Excavation of Y arm to be completed by the end of November.
- As of November 20, remaining lengths are 63m (Y-arm) and 627m (X arm).

⇨ Will be finished by the next March.

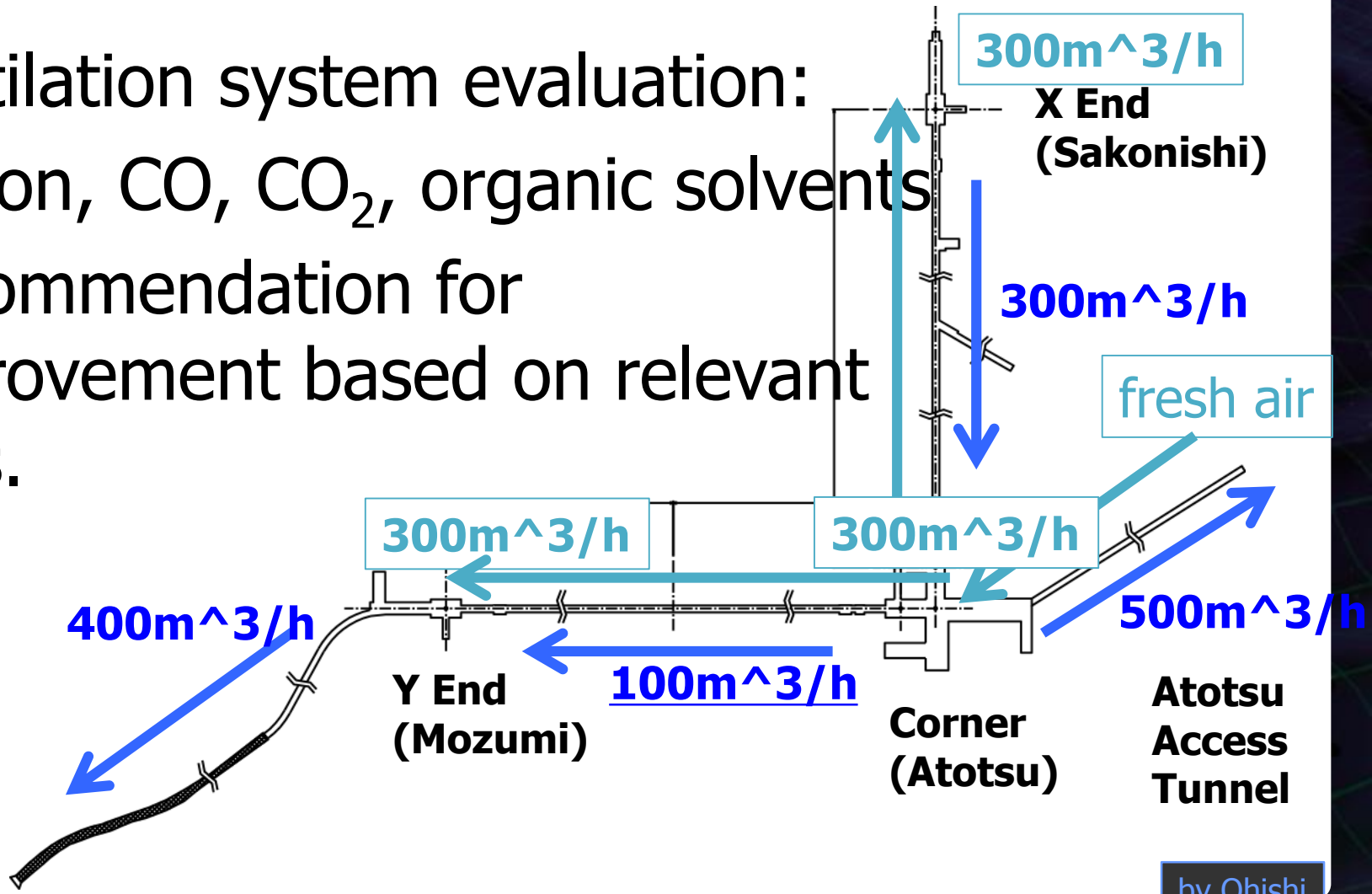
Center Room

Y arm tunnel

BS position

Facility : Safety Management of KAGRA

- Ventilation system evaluation:
  radon, CO, CO_2, organic solvents
- Recommendation for improvement based on relevant laws.



by Ohishi

Surface building

by Ohishi

- Office and Laboratory at the Kamioka site.
- The framework of the data-analysis building next to the existing building is completed.

KAGRA Vacuum duct

- 12m, Φ800mm ducts for 3km x 2 arms→ Delivered.

Press to form a duct

Bellows for each duct

Presentation
By Y.Saito (KEK)

Transportation to Kamioka

Baking at MIRAPRO Co.
Noda/MESCO, Kamioka

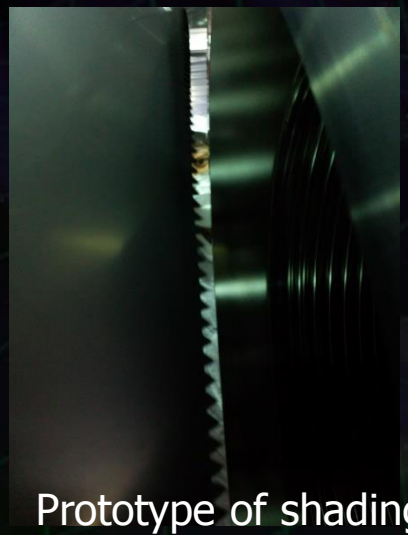
Test at MIRAPRO Co. Noda

Production of vacuum system for KAGRA

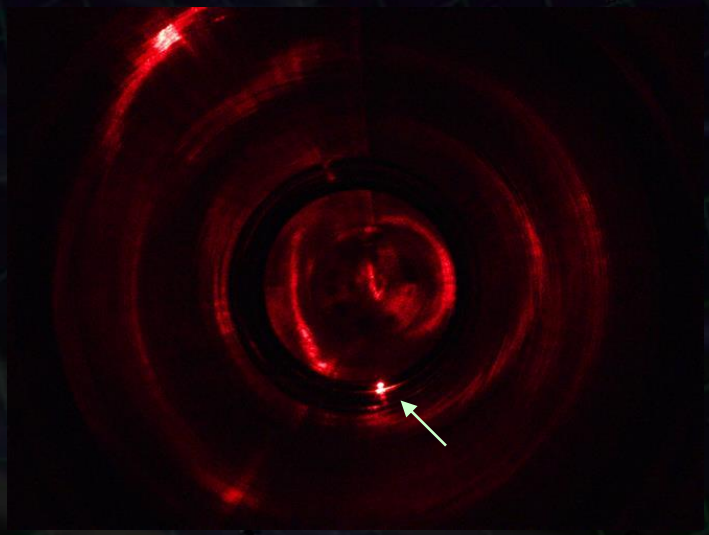
- Production of 19 vacuum chambers is on going.
  One of them is used for a prototype test of the vibration isolation system in TAMA.
- Production of 250 baffles is on going.
  Solblack (a kind of Nickel plating) was employed as surface treatment for shading baffles.

by Takahashi

Leak test of the f1500 chamber in which the pre-isolator is put away.Metal O-rings are used to seal the flanges.



Prototype of shading baffle inserted into f800 tube. The baffle has saw shape edge.



A beam spot on the baffle inside the f800 tube. DLC and Solblack are tested as surface treatment.

Cryostat Construction and Test

Construction and cooling tests were finished!

Inside the Rad. Shield

Cryostat #1 in preparation for installation of radiation shield.

Cryostat #2 under leak test.

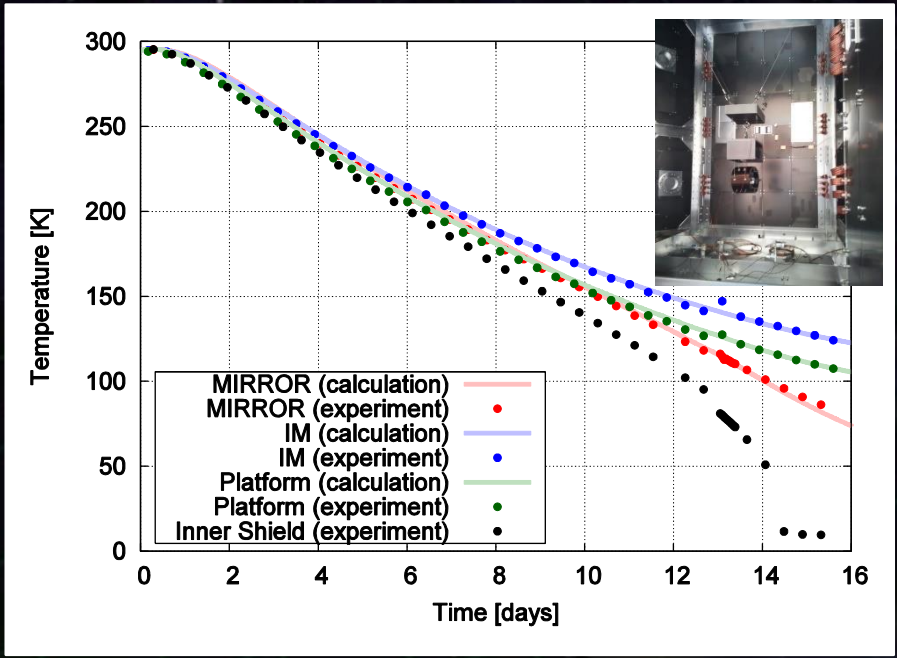
Toshiba Keihin Factory (Oct 31, 2012)

Cryo-cooler unit

Cooling Test and Delivery

Cooling test with dummy payload
→ Cooling time ~ 2weeks.

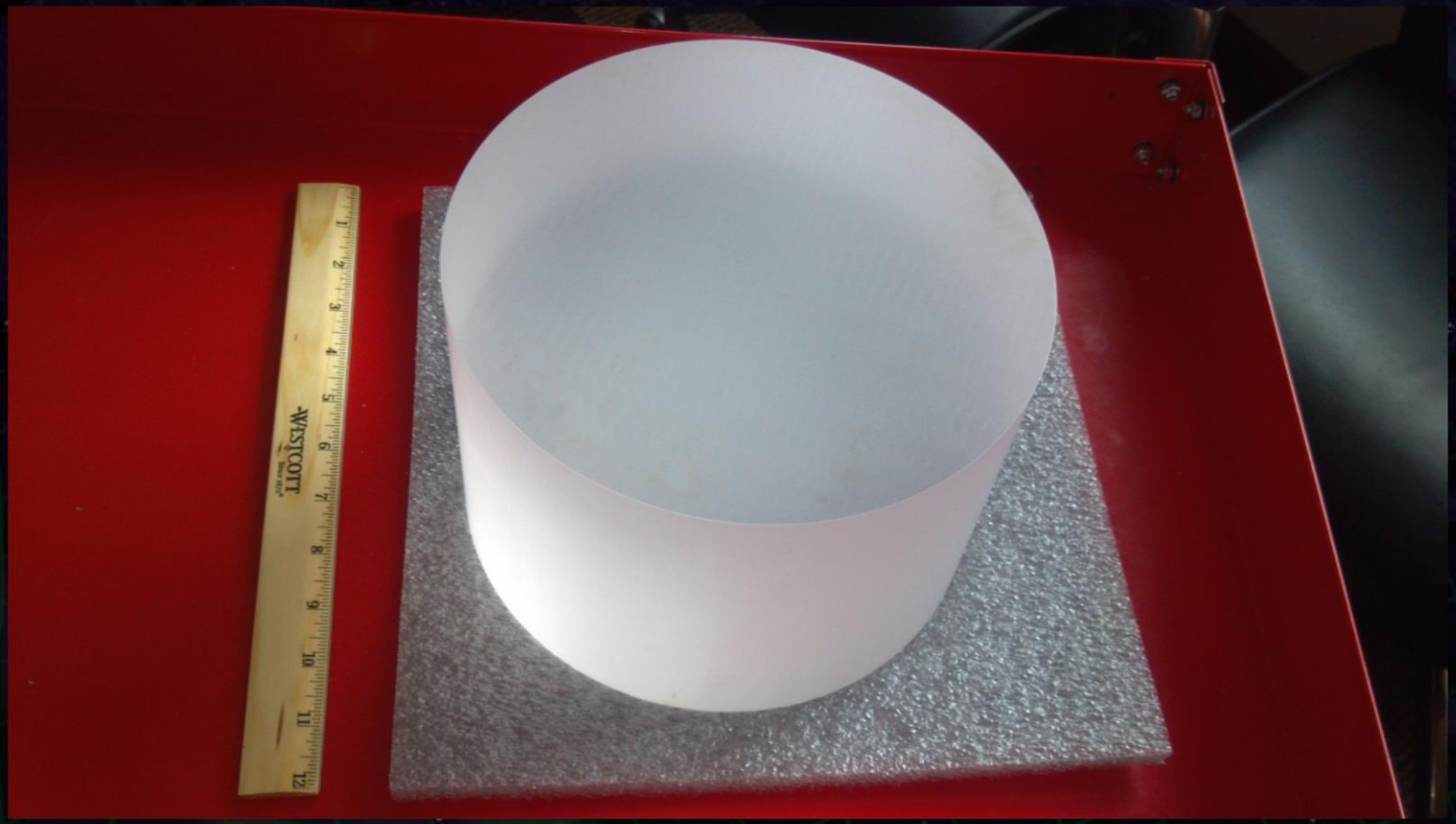
All of 4 cryostats were
in storage near the site (2013.7)



Presentation by N.Kimura at Amaldi10 (2013.7)

Photo by C.Tokoku

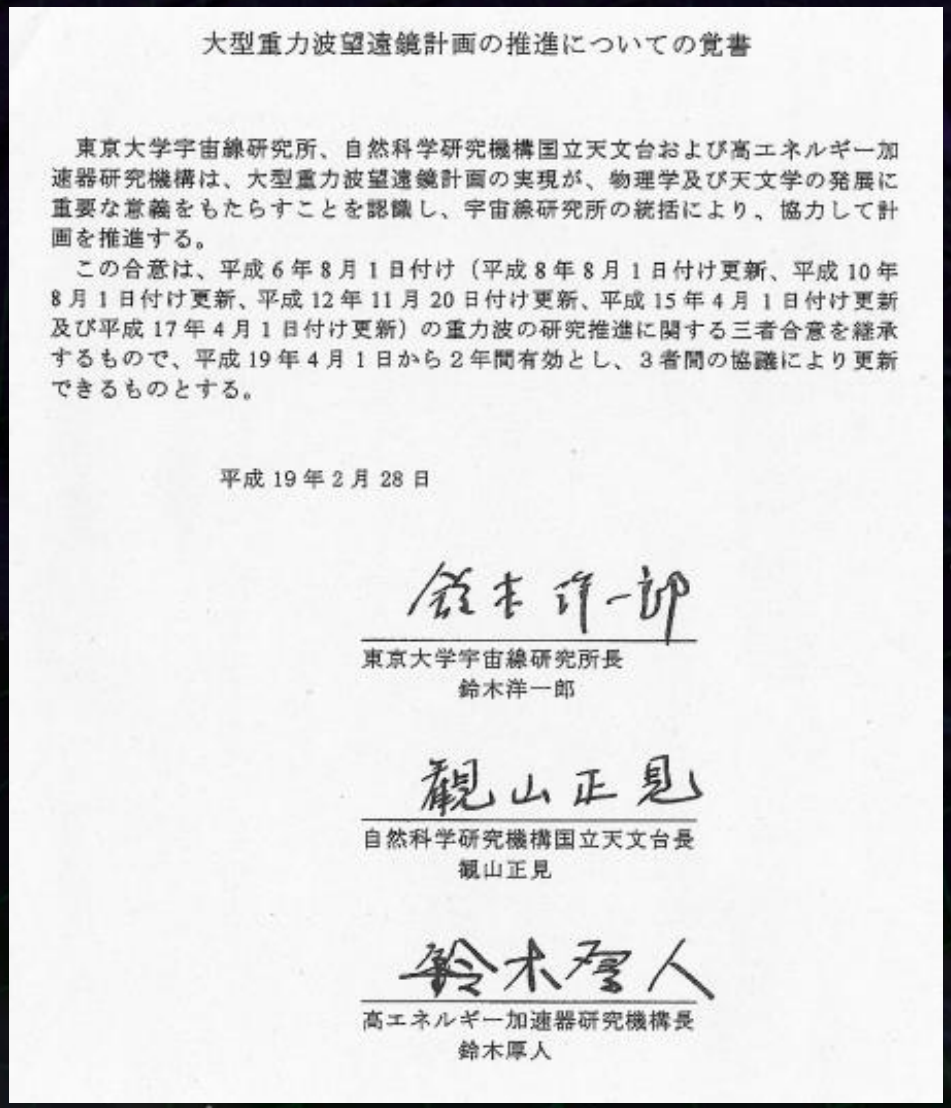
Sapphire Mirror



2 Sapphire substrates were delivered
(Φ220mm, t 150mm, c-axis)

NAOJ Activities for KAGRA

Agreement between 3 institutes



大型重力波望遠鏡計画の推進についての覚書

東京大学宇宙線研究所、自然科学研究機構国立天文台および高エネルギー加速器研究機構は、大型重力波望遠鏡計画の実現が、物理学及び天文学の発展に重要な意義をもたらすことを認識し、宇宙線研究所の統括により、協力して計画を推進する。

この合意は、平成6年8月1日付け（平成8年8月1日付け更新、平成10年8月1日付け更新、平成12年11月20日付け更新、平成15年4月1日付け更新及び平成17年4月1日付け更新）の重力波の研究推進に関する三者合意を継承するもので、平成19年4月1日から2年間有効とし、3者間の協議により更新できるものとする。

平成19年2月28日

東京大学宇宙線研究所長
鈴木洋一郎

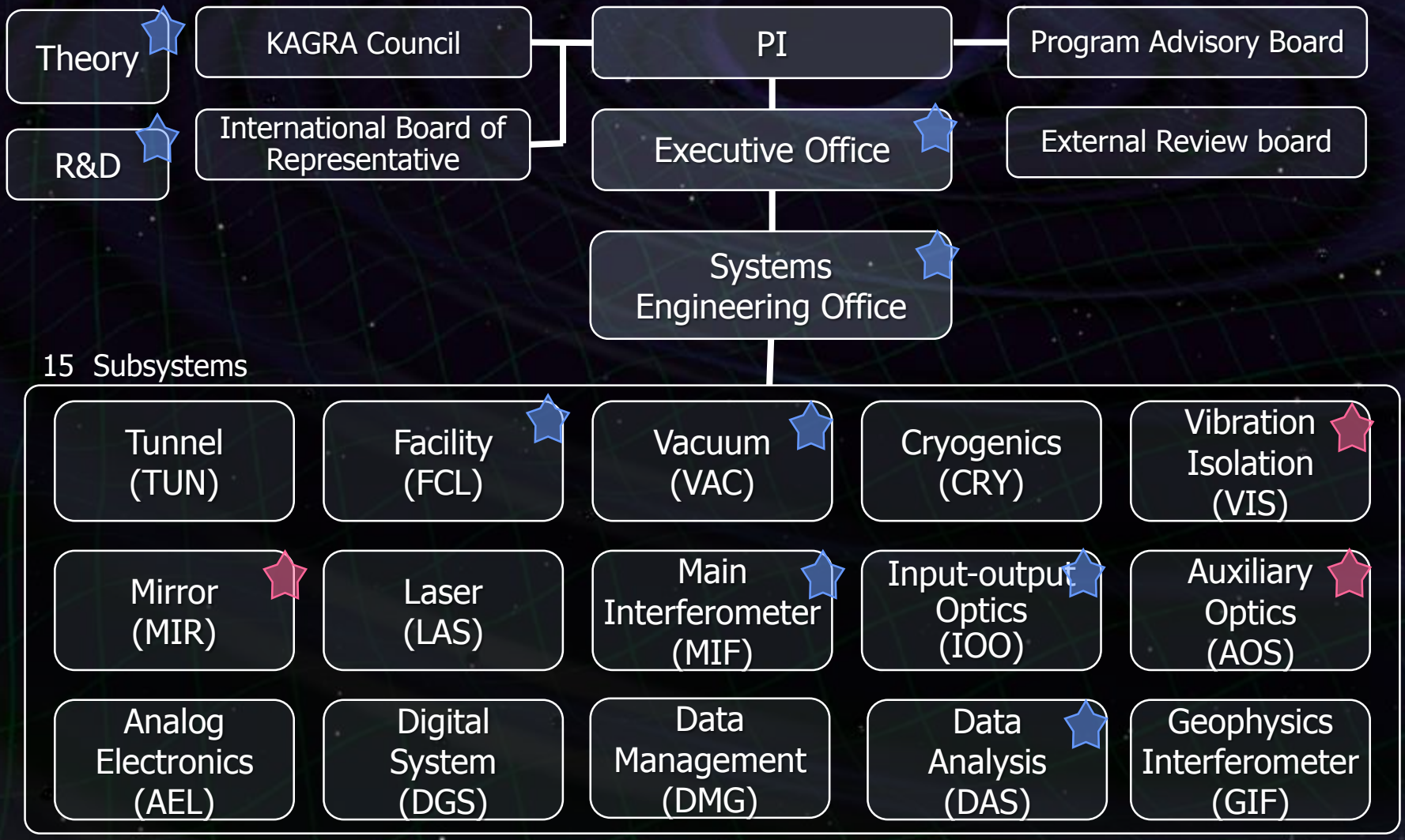
自然科学研究機構国立天文台長
観山正見

高エネルギー加速器研究機構長
鈴木厚人

- Agreement between 3 institutes: ICRR-KEK-NAOJ (3**機関覚書**) for promotion of KAGRA project.
  - Concluded in August 1994 (**平成6年8月**)
  - Extension of terms in 1996, 1998, 2000, 2003, 2005, 2007, 2009, 2011, and 2013.
- KAGRA Council Meeting (KAGRA**協議会**) every year.

Organization of KAGRA

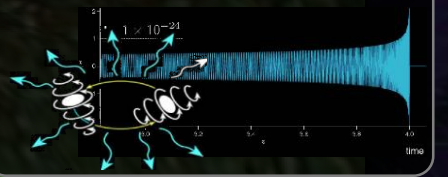
KAGRA Organization PI: T.Kajita (ICRR), PM: Y.Saito (KEK)



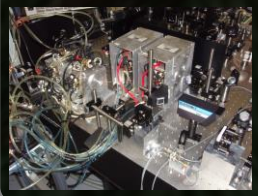
KAGRA 15 Subsystems

- Tunnel
- Facility
- Vacuum system


- Data Management
- Data Analysis
- Geophys. IFO

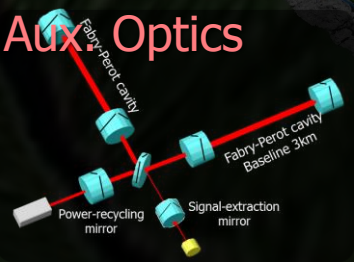


- Laser source
- Mirror




- Seismic iso.
- Cryogenic sys.

- Main IFO.
- In/Output Opts.
- Aux. Optics



- Analog Elec.
- Digital Elec.

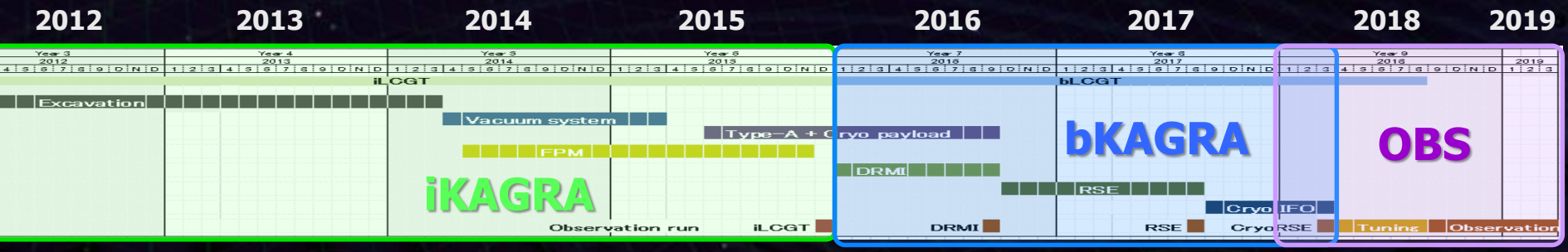
NAOJ Responsibilities

- Project Management : Flaminio, Ando (EO and SEO)

- Vibration Isolation (VIS) : Takahashi (chief)
  Ishizaki, Arellano
- Auxiliary Optics (AOS) : Akutsu (Chief), Friedrich
- Mirror (MIR) : Ueda (Sub-chief), Tatsumi

- Vacuum System (VAC) : Takahashi
- Facility and Safety (FCL) : Ohishi
- Data analysis (DAS) and
  Data Management (DMG) : Tatsumi, Hayama, Nakamura
- Interferometer (MIF, IOO) : Ando, Tatsumi, Akutsu, Hayama

KAGRA Schedule



Tunnel (2014.3)

FPMI (2015.12)

obs.

Facility and Vacuum (2015.3)

DRMI (2016.9)

obs.

RSE (2017.8)

obs.

First Science run

Tuning and observation

Cryo RSE (2018.3)

VIS

Prototype test

Type-C

Type-A

Type-A+Cryo (2016.9)

Type-B

AOS

Baffle, BR Telescope

installation

Duct Baffle

2 Installation timings for iKAGRA and bKAGRA.

MIR

Silica Mirror (2014.6)

Installation Start

Sapphire test mass (2016.3)

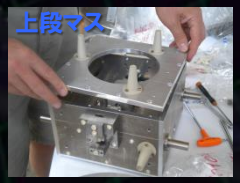
installation

VIS Subsystem

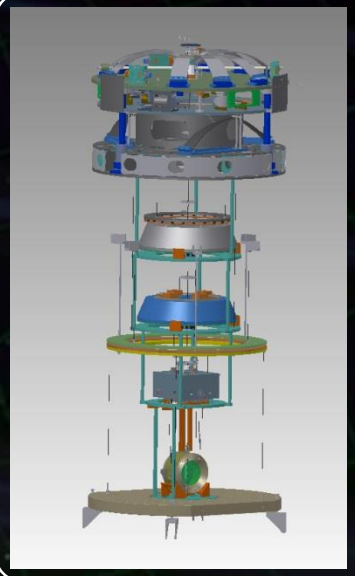
- VIS
  - Pre-isolator prototype test with digital control system at ICRR.
  - Assembly of the payload prototype at NAOJ.
  - Production of 6 top filters has been finished.

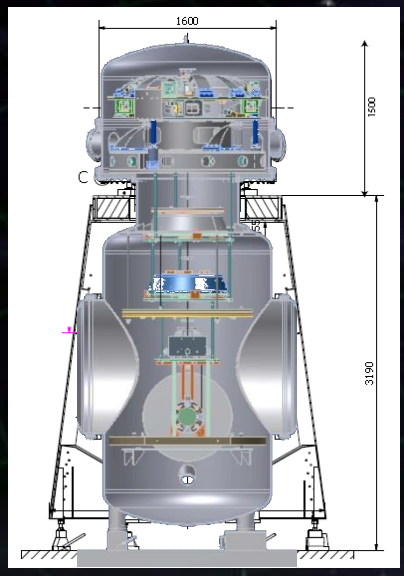
⇩

Full prototype test at TAMA300.



⇨



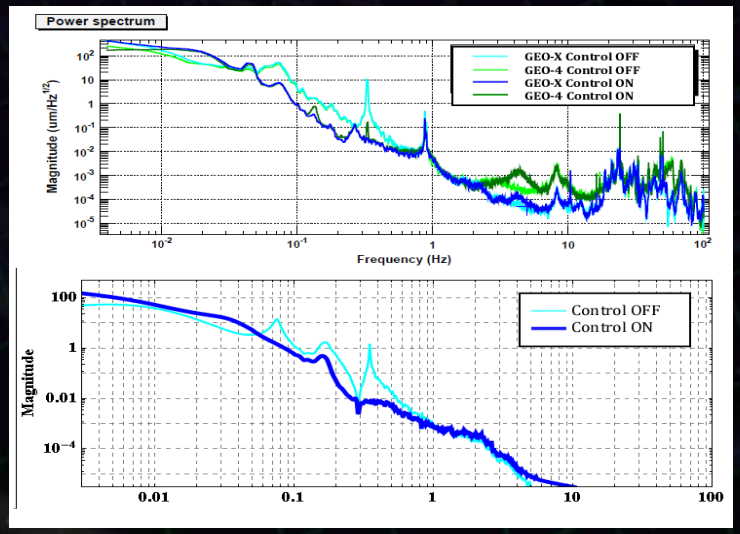


Production and test for VIS

by Takahashi

- Production of 6 top filters have been finished.
- Prototype tests are on going in NAOJ and ICRR.
- Full prototype test using TAMA300 is planed.

Tuning of the top filter. The natural frequencies were tuned to 0.2Hz.

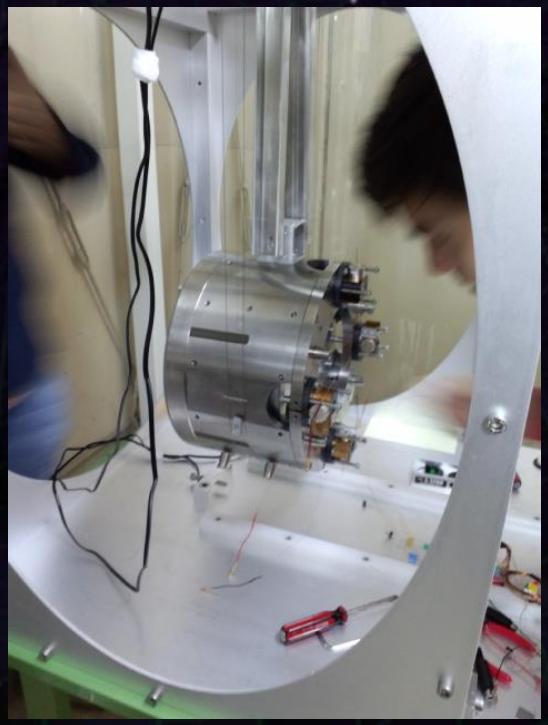


Result of damping control for the inverted pendulum. 3-DOF (X, Y, YAW) motion was controlled using inertial sensors successfully.

Control test of the pre-isolator prototype. The motion of the pre-isolator is controled by the digital system mountd in the rack.

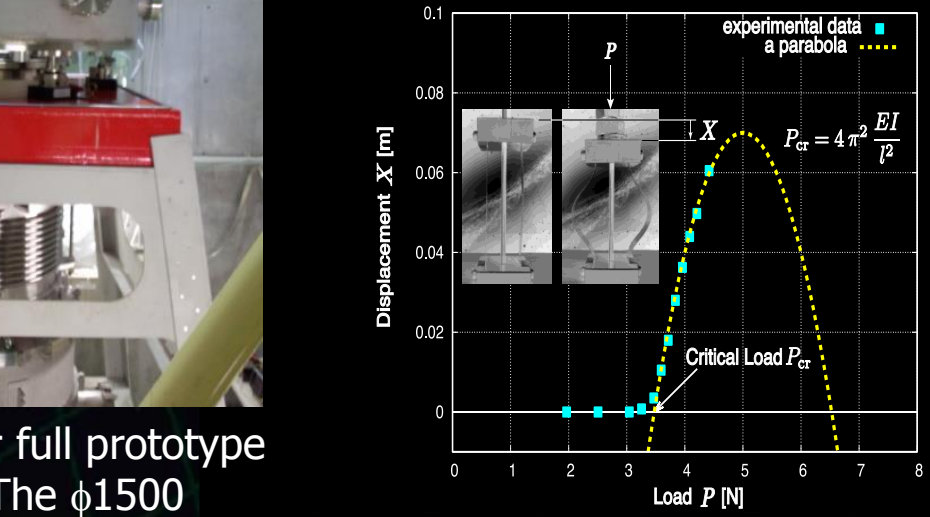
Production and test for VIS

by Takahashi, Ishizaki



Assembly and test of the payload prototype. The test mass and the recoil mass were suspended by tungsten wires. Optical sensor and electro manetic actuators (OSEMs) are used to control the test mass.

Preparation for full prototype test in TAMA. The ϕ1500 chamber is connected to the TAMA chamber with an outer frame in the west-end room.

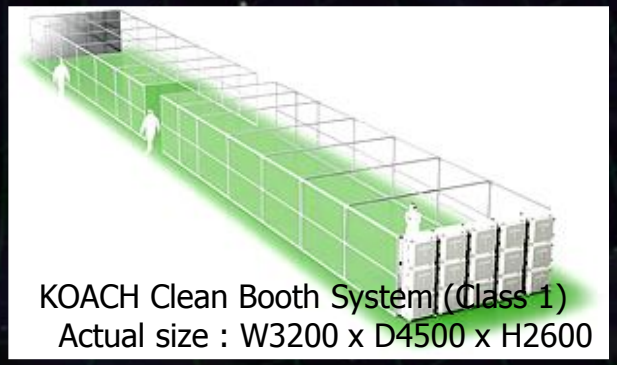


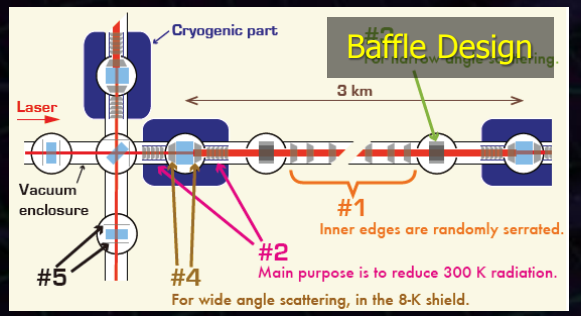
Development of cryogenic vertical spring. A spring using post-buckling phenomena is tested. Fundamental behavior was confirmed.

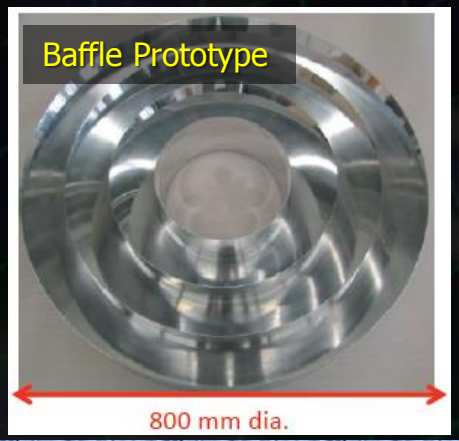
Scope of AOS

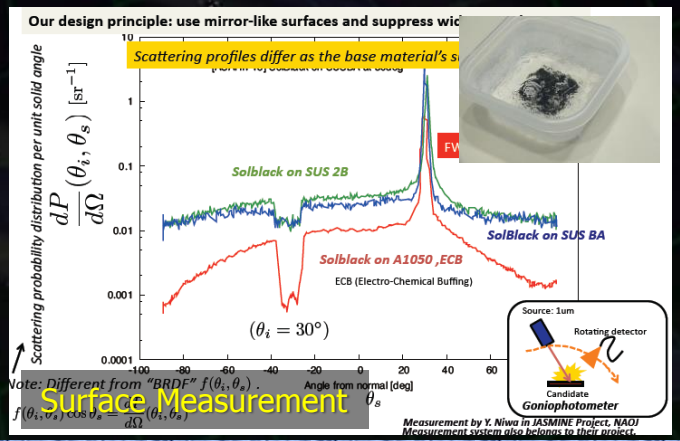
by Akutsu

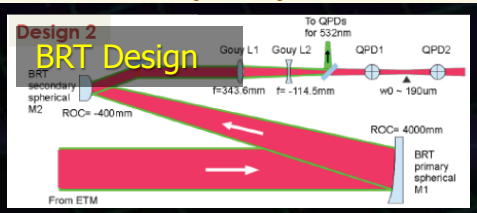
- AOS
  - Stray Light Control (SLC)
  - Beam Reducing Telescopes (BRT)
  - Optical Levers (OpLevs)
  - Viewports
  - Monitors and Illumination
  - Automatic Targets
  - Other tools for commissioning (e.g. Beam Profiler, …)

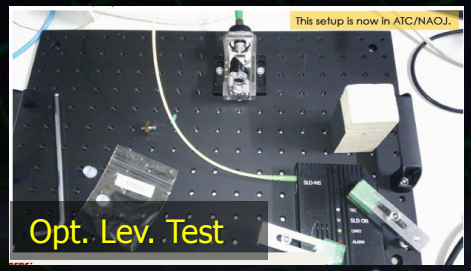

KOACH Clean Booth System (Class 1)
Actual size : W3200 x D4500 x H2600







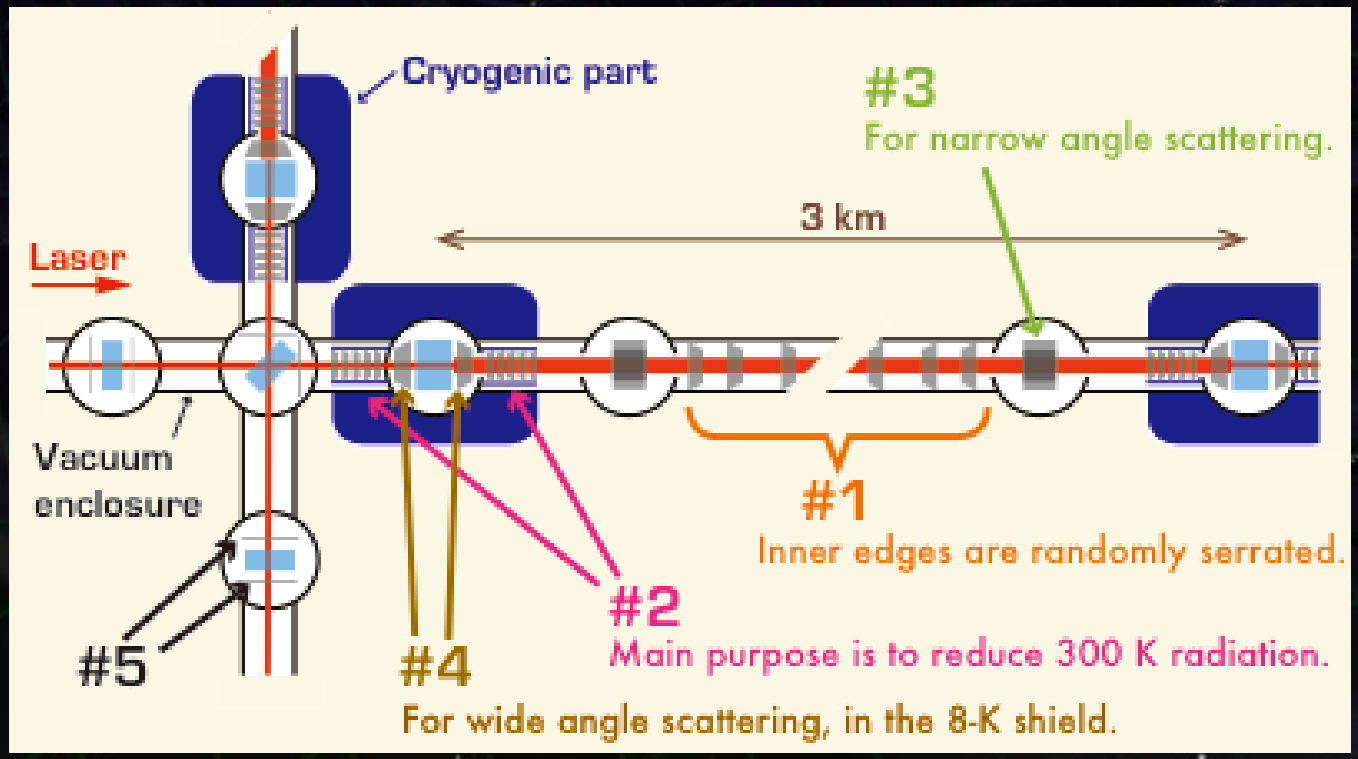




KAGRA Stray-light Control

by Akutsu

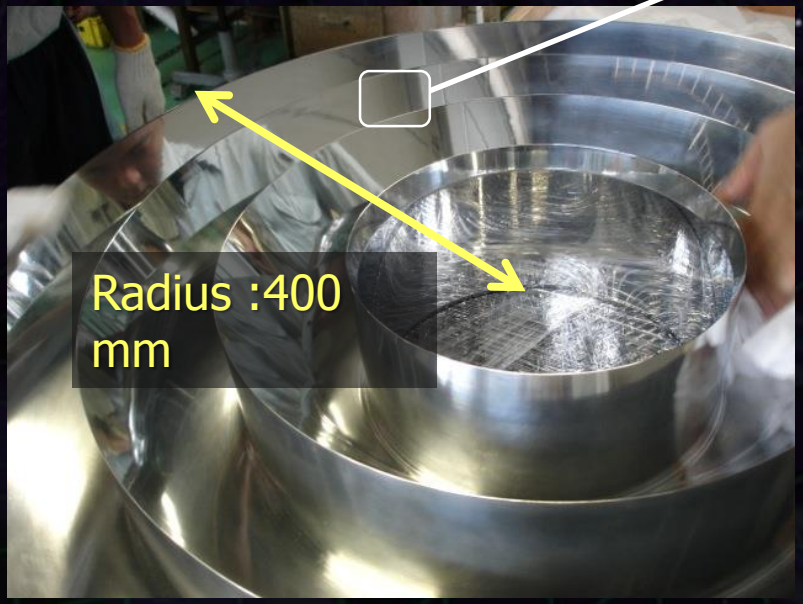
- Five types of Baffle
  - #1 : Arm duct baffles → In production (VAC)
  - #2 : Cryo-duct Shield → In production (CRY)
  - #3 : Narrow-angle Baffle
  - #4 : Wide-angle Baffles
  - → Prototype test (AOS)
  - #5 : Other



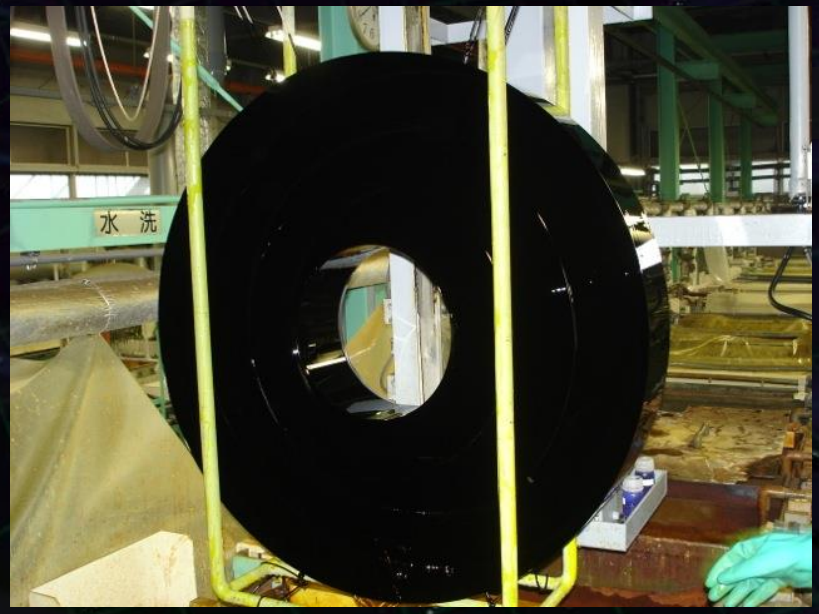
Prototype of a Large Baffle

by Akutsu

#3 Narrow-angle baffle
Material: A5052



Smooth surface treatment by ECB



Blackened surface: Solblack

- ECB: low scattering
- Solblack: Vacuum Compatibility (10^{-7} Pa) - Cryogenic compatibility (<8K)
- Low reflectivity (~2%@1064nm)
- Applicable for a large work

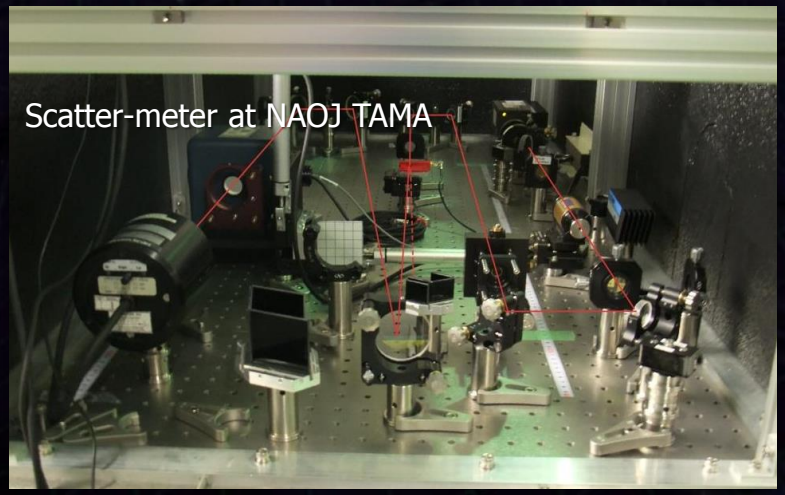
AOS plan in the next year

by Akutsu

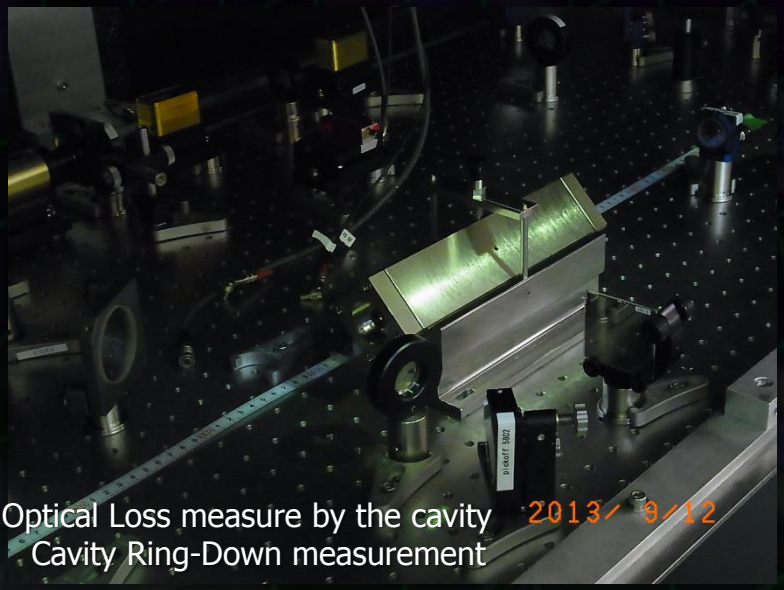
- Stray-light control
  - Production of #3 (4pcs) & #4 (4pcs) baffles
- Beam reducing telescope (BRT)
  - Fabrication of large mirror holders for iKAGRA BRT (3pcs)
  - Fabrication of bKAGRA BRTs (2pcs)
- Optical levers
  - Optical design and procurements
- Viewports
  - Procurements

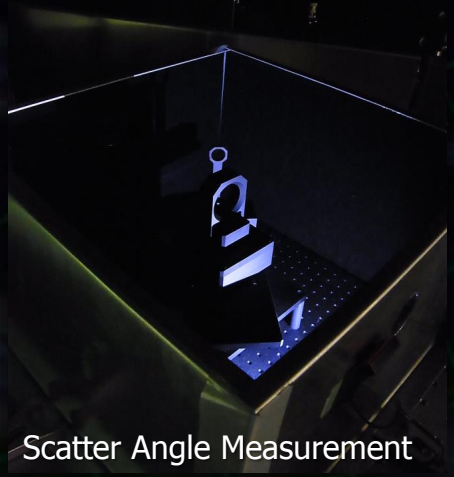
Mirror Quality Evaluation

by Tatsumi, Ueda


Scatter-meter at NAOJ TAMA

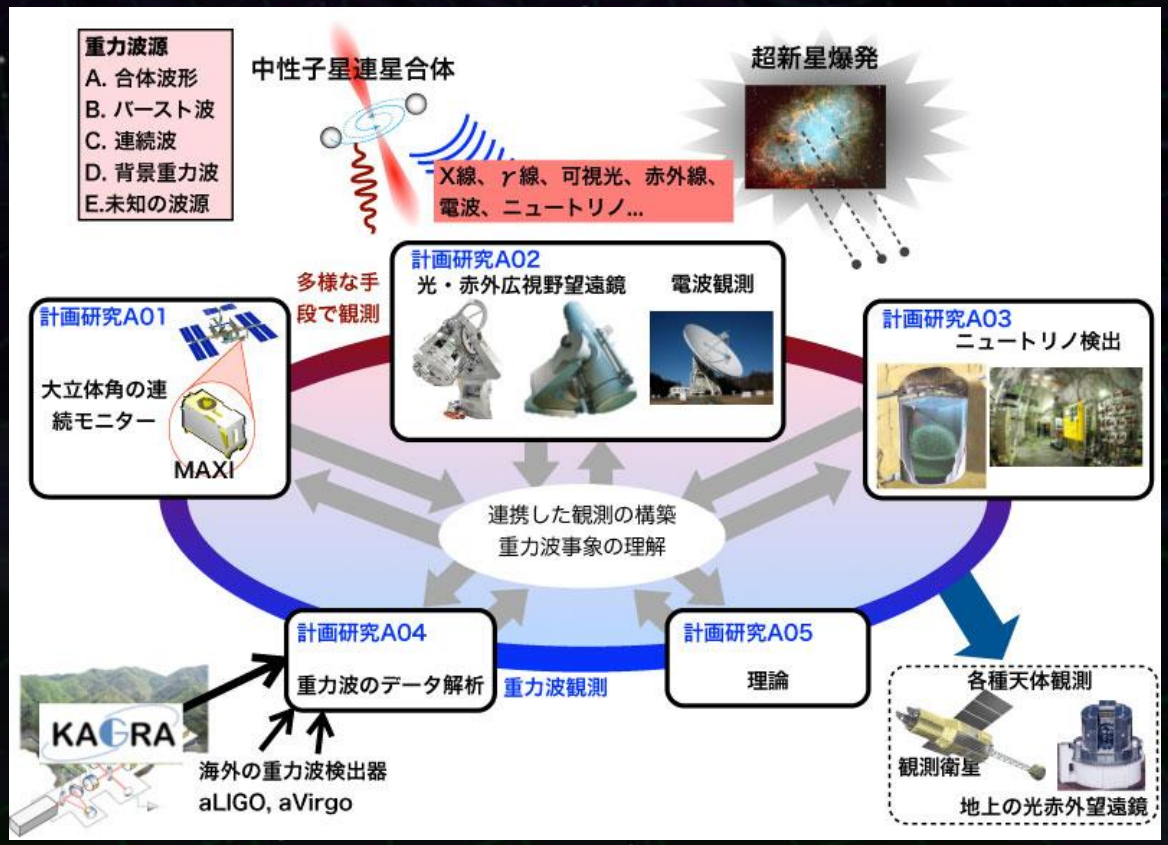
- MIR
  - Mirror qualities investigation by NAOJ (Ueda Tatsumi), UEC (Yoneda, Musha), and ATC NAOJ.
  - Ability to measure <10ppm quality mirror for KAGRA core optics.
  - High-quality mirrors for input optics.


Optical Loss measure by the cavity
Cavity Ring-Down measurement


Scatter Angle Measurement

Multi-messenger Astronomy

- Based on the approved Grants-in-Aid for Scientific Research: 'Scientific Research on Priority Areas' → 4.5-yr project.
- GW theory, GW data analysis, EM transients, and Neutrino. (KAGRA and other GW experiment are not included.)



by Tatsumi, Hayama

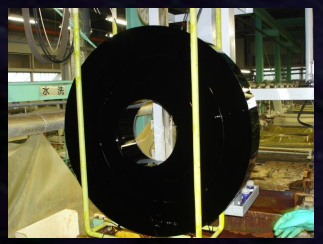
Collaboration with ATC

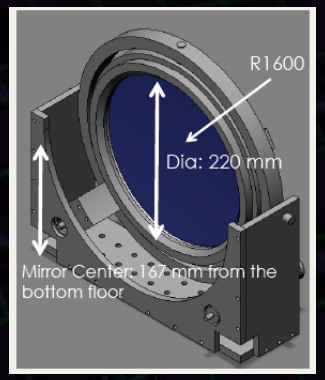
- KAGRA is one of key project for ATC

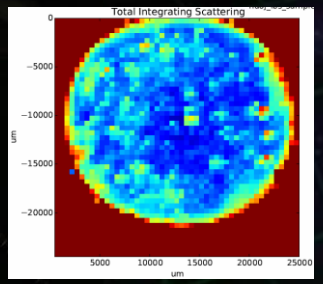
  - Collaborative work from 2012 on AOS
    * Design and prototype production of large-angle baffle.
    * Design and production of primary mirror holder for BRT.

  - Newly starting activities:
    Regular meetings for VIS and MIR.
    * Collaborative works to produce bottom filters for VIS.
    * Test coating using IBS machine
      → Quality measurement.

⇨ Covering AOS, VIS and MIR.







by Akutsu, Tatsumi

Clarification of the Role of NAOJ

- For NAOJ
  - Explanations at executive meetings in NAOJ.
  - KAGRA council meeting (Sept. 17th , 2013).
  - Invitation to Program Advisory Board (Nov. 2nd-3rd, 2013).

- For KAGRA
  - Flaminio and Ando are members of management team (EO and SEO).
  - Takahashi and Akutsu are subsystem chiefs.
  - Ueda became a sub-chief of the MIR subsystem, redefining the tasks.

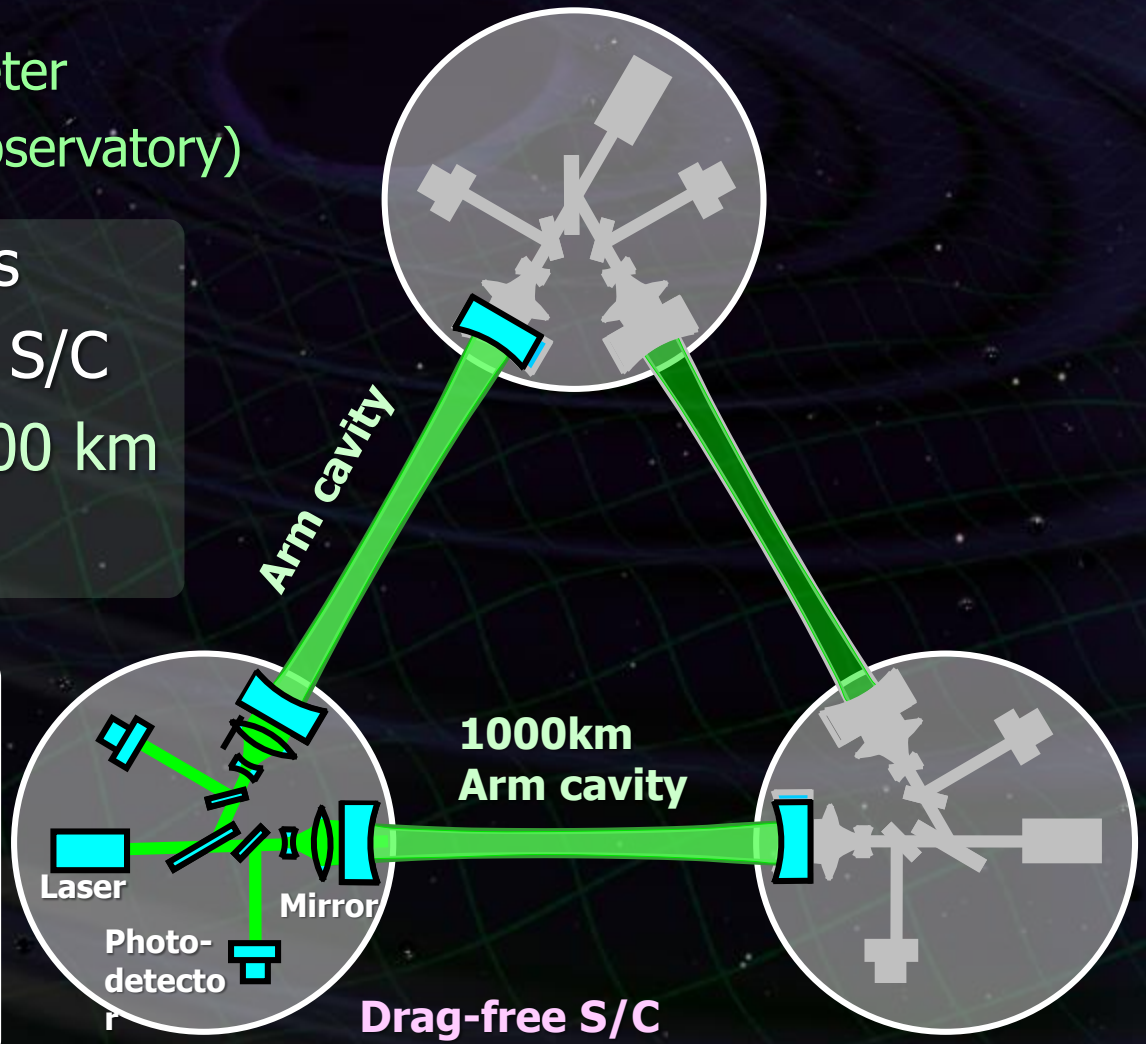
Advanced R&Ds

DECIGO

(Deci-hertz interferometer
Gravitational wave Observatory)

- 3 FP interferometers by formation flight S/C
- Baseline length: 1000 km
- Drag-free control

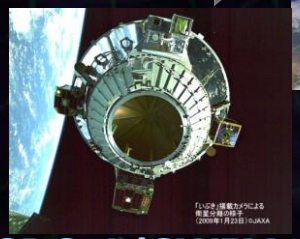
Arm length:	1000 km
Finesse:	10
Mirror diameter:	1 m
Mirror mass:	100 kg
Laser power:	10 W
Laser wavelength:	532 nm

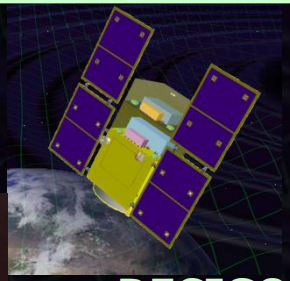


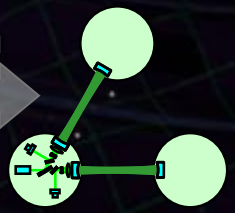
Roadmap

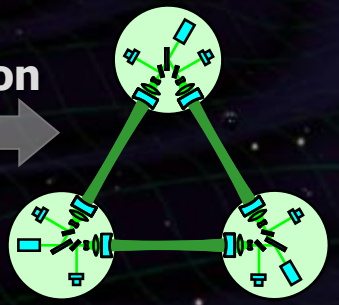
Figure: S.Kawamura

	2010 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29		
Mission	R&D Fabrication → SDS-1/SWIM; DECIGO Pathfinder (DPF)	R&D Fabrication → Pre-DECIGO	R&D Fabrication → DECIGO
Objective	Space test of key tech. GW observation	Detect GW with min. spec FP between S/C	GW astronomy
Design	Single small satellite Short FP interferometer	3 S/C 1 interferometer unit	3 S/C x 3-4 units





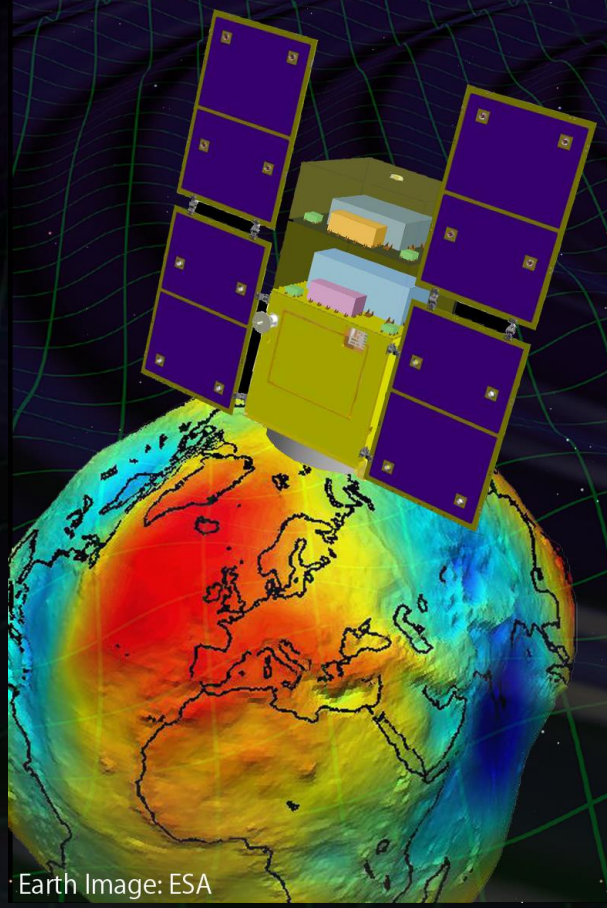




Targets of DPF

DECIGO

DPF
Weight ~400kg
Orbit : 500km LEO



Earth Image: ESA

Scientific observations

Gravitational Waves form BH mergers
→ BH formation mechanism
Gravity of the Earth
→ Geophysics, Earth environment

Science technology

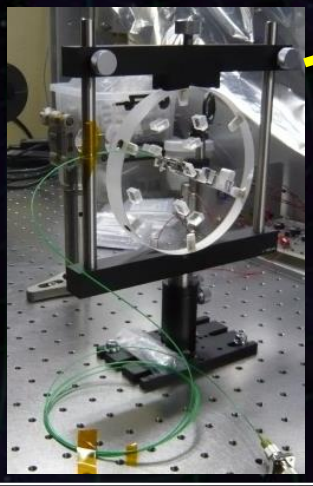
Space demonstration for DECIGO
→ Most tech. with single satellite
(IFO, Laser, Drag-free)
Precision measurement in orbit
→ IFO measurement
under stable zero-gravity

R&D for DPF Interferometer

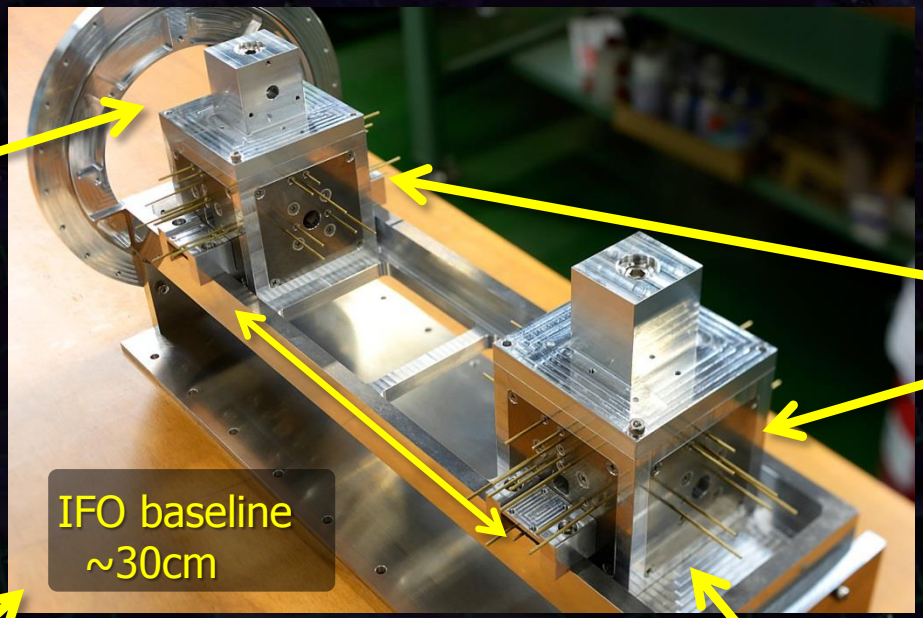
DECIGO

Optical Bench

Monolithic optics for PDH + WFS

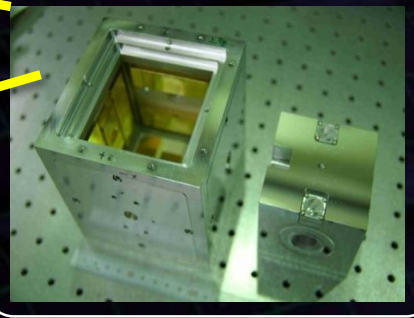


Interferometer Module



Test-mass module

Test mass, ES sensor/actuator, Launch lock, …



Quadrant RF Photo Detector

QPD + Demodulator for IFO signal sensing

SpW signal-processing board

SpW FPGA + 16bit AD/DA for IFO Control

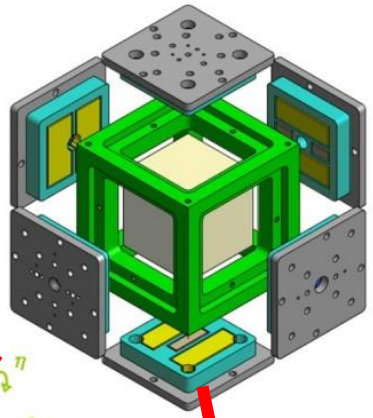
DPF Interferometer module

Components in the interferometer module

- 2 test-mass modules (i.e. inertial sensors)
- Input optics (monolithic)
- Evacuation system
- Launch lock system
- Clamp & release system

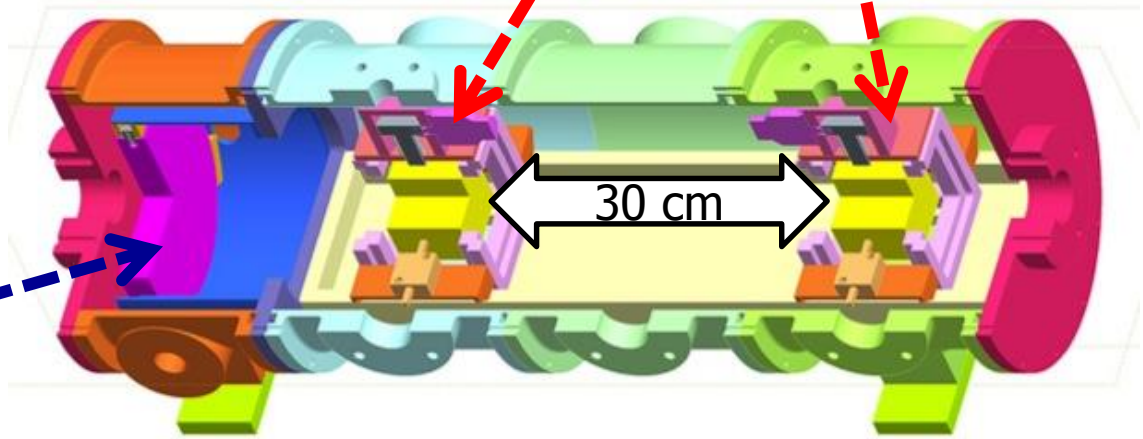
N_2 will be purged after it launched

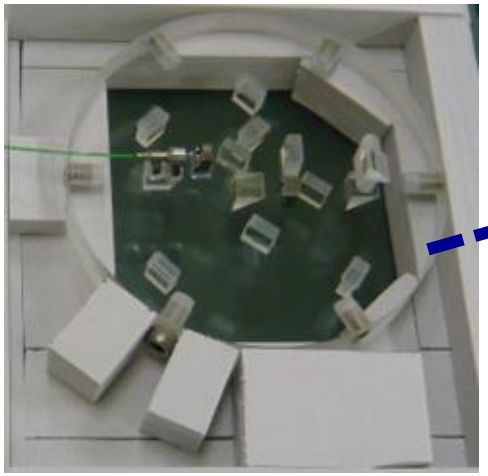
Test-mass module



Characteristics

- Rigid structure
- Vacuum: 10^{-6} Pa
- 30cm cavity arm length

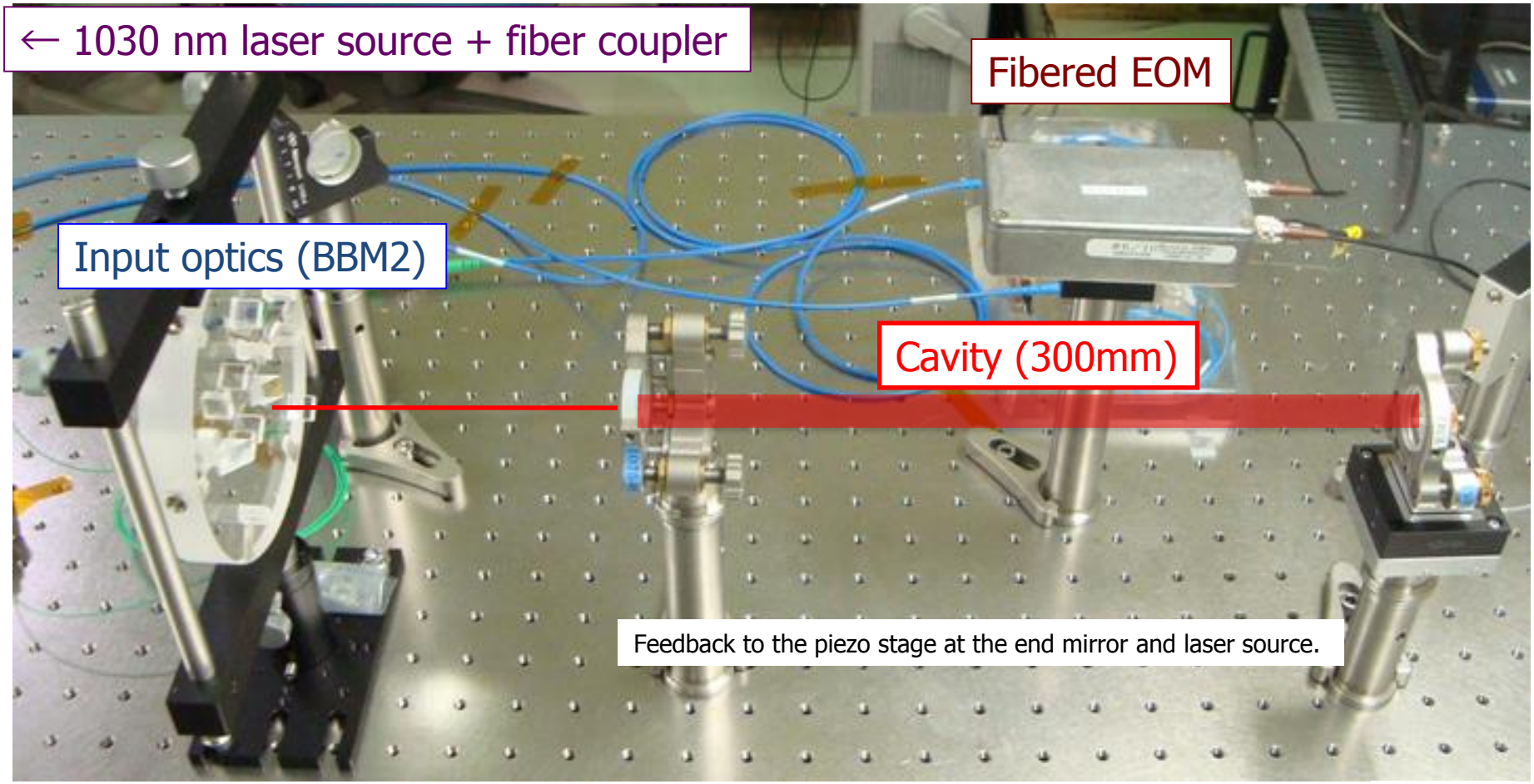




Input optics (BBM2) by A. Ueda

Experimental setup for optical parts

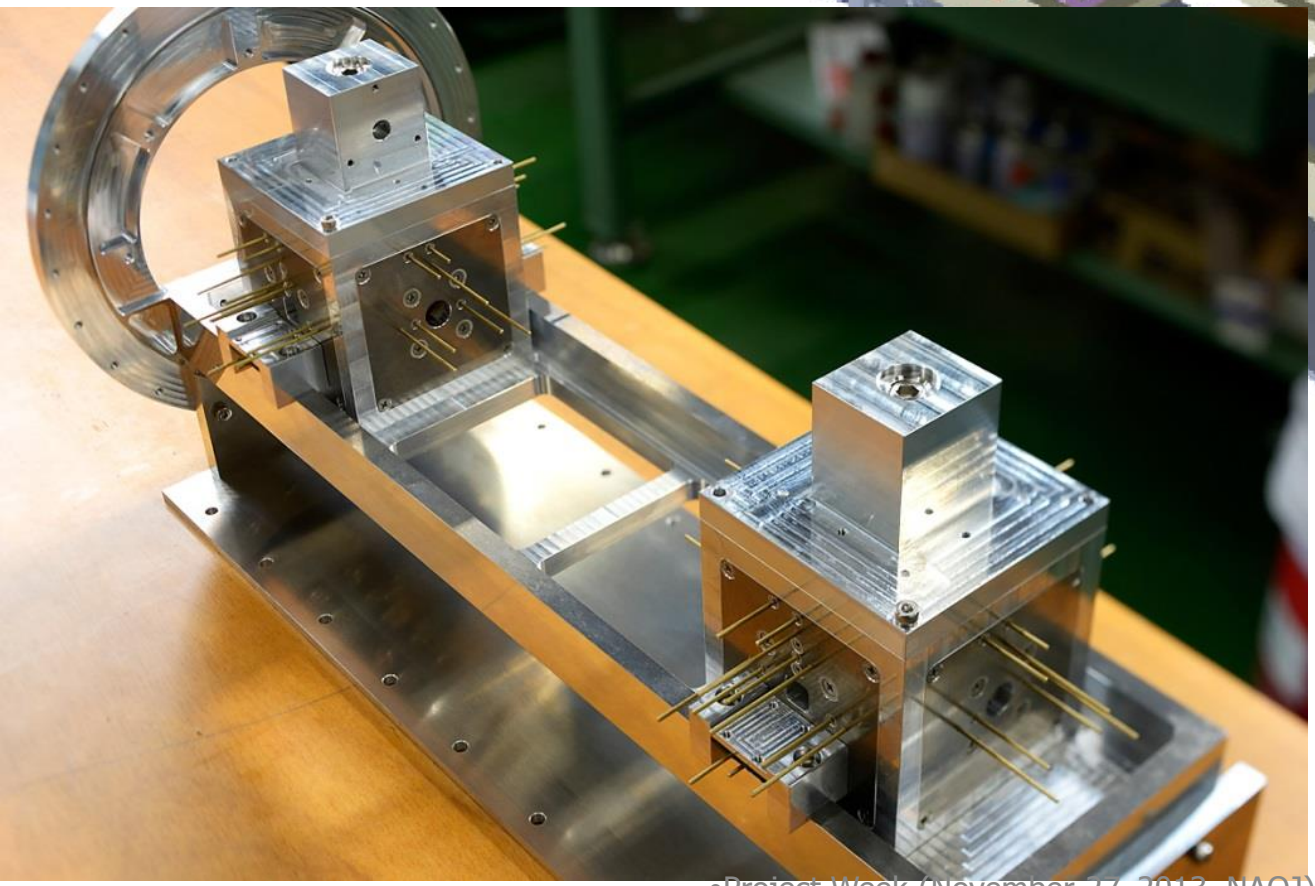
A test of the optics of the gravitational-wave detector (a Fabry-Perot cav

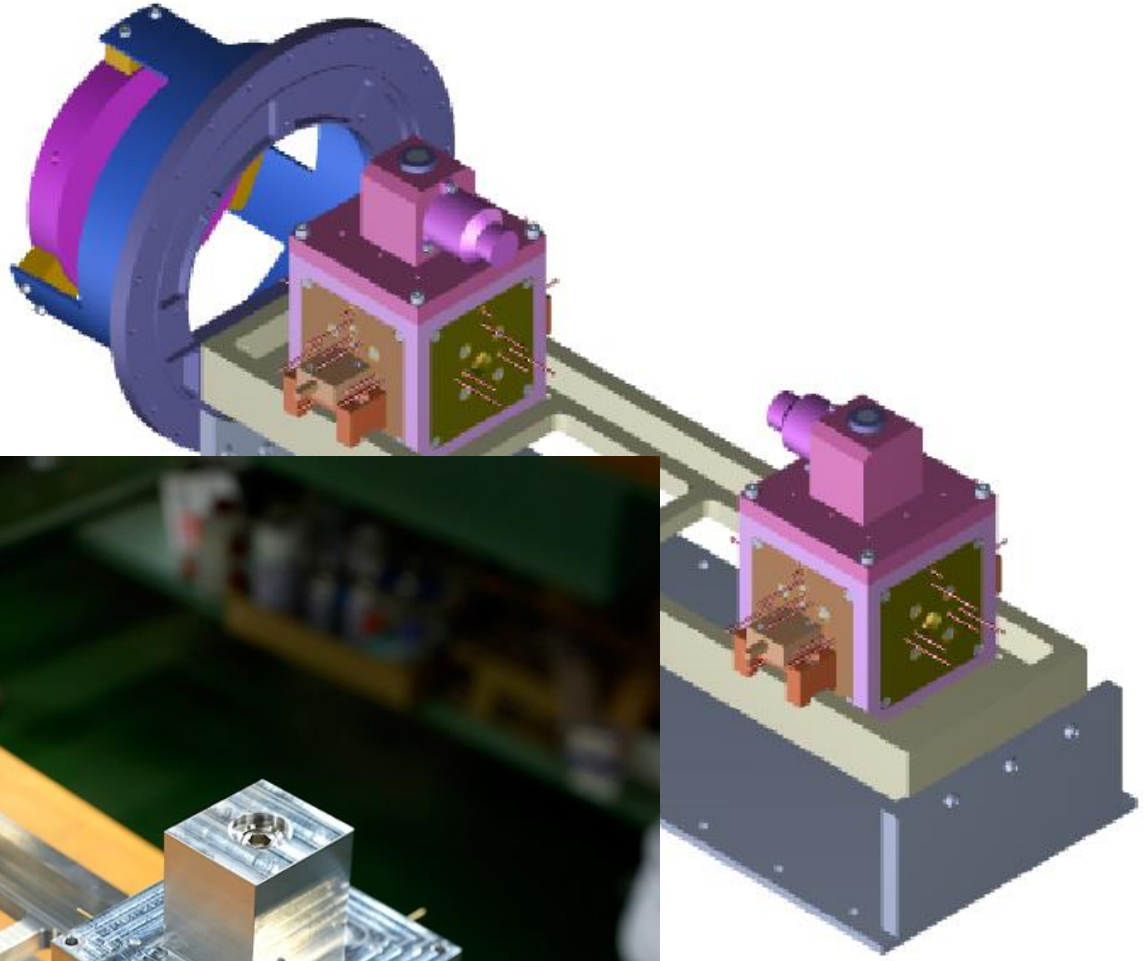


The cavity can be operated.

by Kasuga

by Akutsu





by Akutsu

Works in the next year

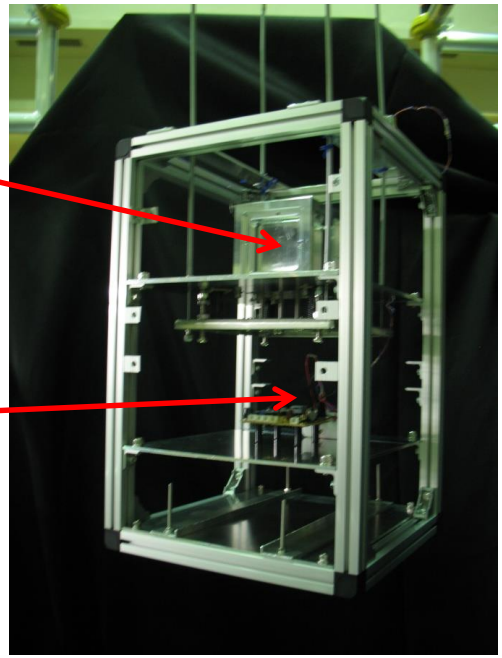
- Tests for vibration, impact, and thermal shock
- Validation of the new design of inner wall of a test-mass module (for the reduction of a force noise by the squeezed-film damping)
- Validation of the Interferometer module
- Noise reduction

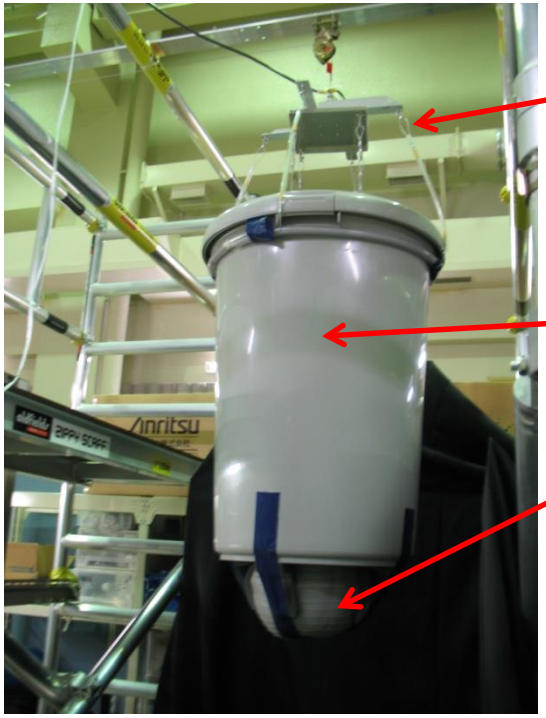
by Akutsu

Free fall experiment for DECIGO Path Finder

We made equipment to experiment control the test mass position for free fall from 3m high in ATC facility.

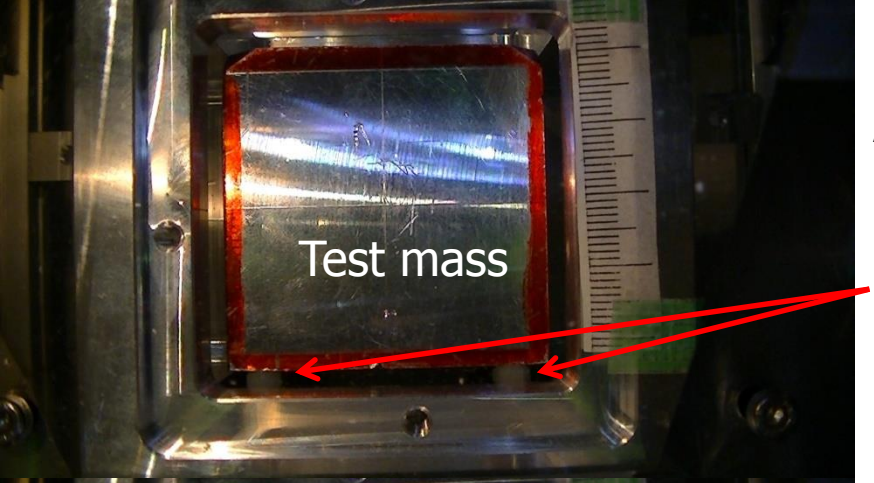
We could confirm to make free fall condition and preparing to control the test mass position. The way of the test mass control is used magnets, electro magnets and photo sensors for measuring displacement.





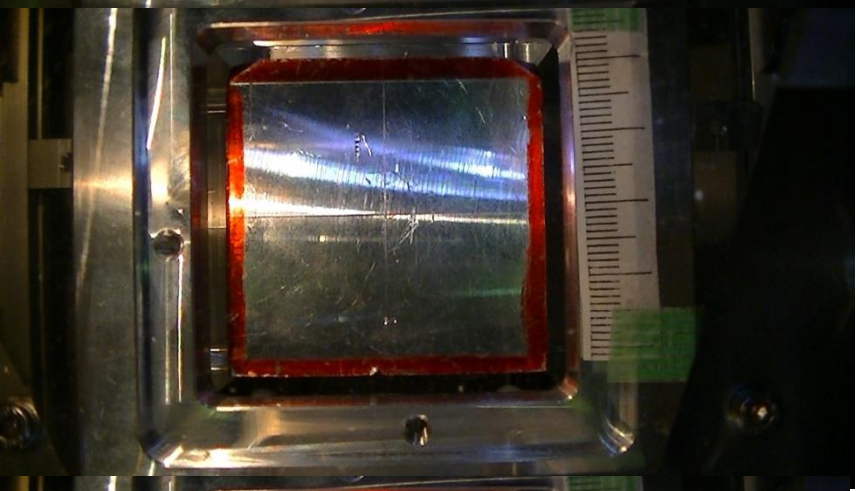
by Torii

Test mass for free fall

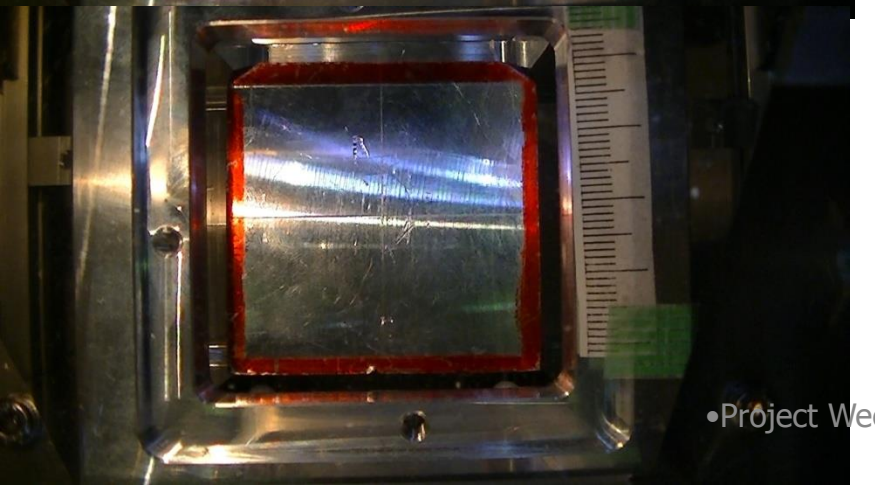


After releasing
0 sec. (Start)

Test mass on the holding finger

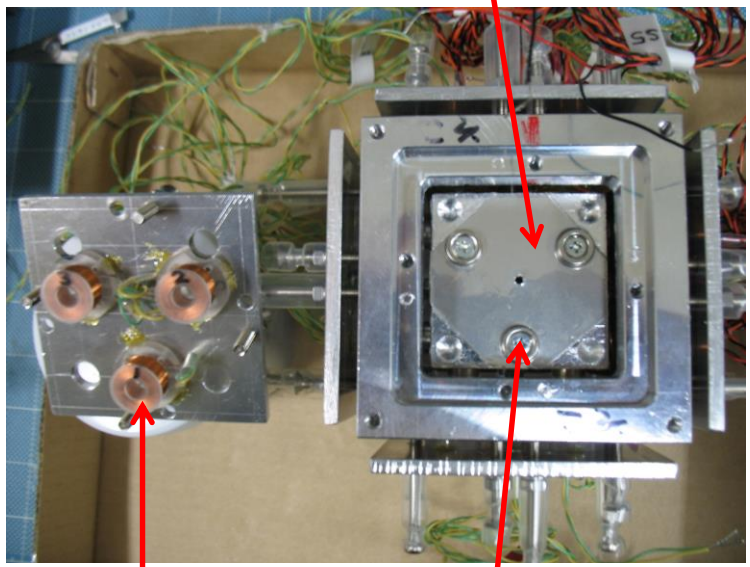


After 1/15sec.



2/15 sec.

Test mass and the housing on a table



by Torii

Theoretical Researches (1)

Researches on quantum measurements (Akutsu, Nakamura)

- Quantum Non-Demolition (QND) techniques for GW telescopes.
- Monthly seminar is held to discuss QND theories and experiments.

  Participants are from NAOJ, TITECH, Kyoto Univ., Keio Univ., IMS., Tokyo Univ., KEK, Hiroshima Univ. … . (Members are increasing...)

- Main Achievement :

  Theoretical results discussed in this seminar agree with the experiment by Hiroshima Univ.

  [K. Nakamura and M. Iinuma, PRA**88** (2013), 042106.]

- Prospect :

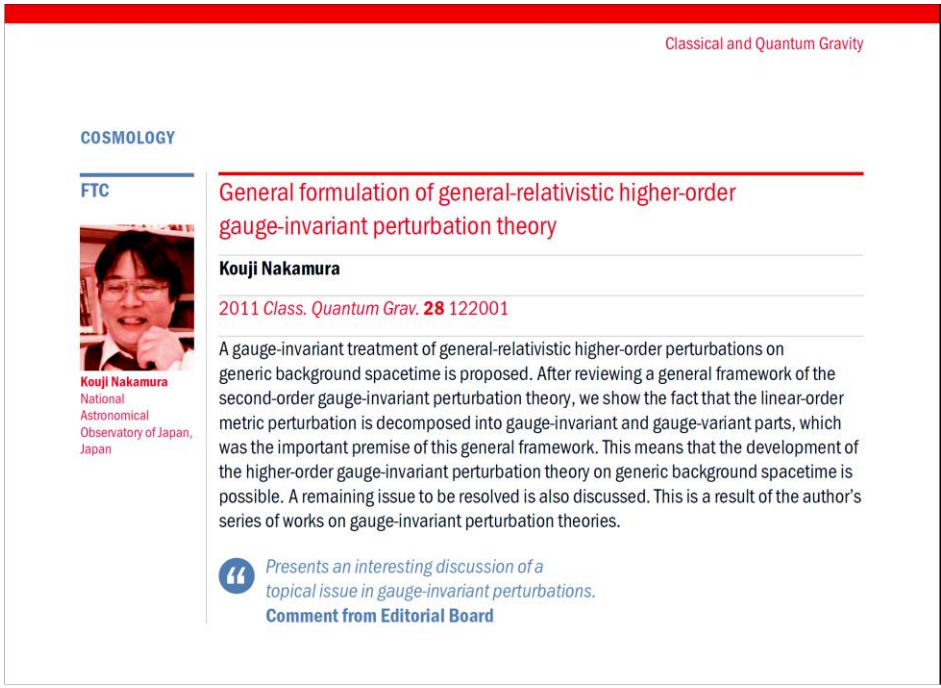
  We are now trying to apply our understanding on quantum measurements to GW detectors.

by Nakamura

Theoretical Researches (2)

■ General-relativistic higher-order gauge-invariant perturbation theory and its applications (Nakamura)

- Developments of the general framework of the theory
- Classical and Quantum Gravity Highlight letter (last year) was advertized in the CQG brochure :


Classical and Quantum Gravity

COSMOLOGY

FTC

General formulation of general-relativistic higher-order gauge-invariant perturbation theory

Kouji Nakamura

2011 *Class. Quantum Grav.* **28** 122001

A gauge-invariant treatment of general-relativistic higher-order perturbations on generic background spacetime is proposed. After reviewing a general framework of the second-order gauge-invariant perturbation theory, we show the fact that the linear-order metric perturbation is decomposed into gauge-invariant and gauge-variant parts, which was the important premise of this general framework. This means that the development of the higher-order gauge-invariant perturbation theory on generic background spacetime is possible. A remaining issue to be resolved is also discussed. This is a result of the author's series of works on gauge-invariant perturbation theories.

Presents an interesting discussion of a topical issue in gauge-invariant perturbations.
Comment from Editorial Board

Kouji Nakamura
National Astronomical Observatory of Japan, Japan

- Main Achievement :

  The full paper version of this letter is published.

  [K. Nakamura, PTEP**2013** (2013), 043E02.]

- Prospect :

  We are now trying to apply our theory to black hole perturbations and cosmology.

by Nakamura

Summary

Summary

- KAGRA is under construction. Large part (tunnel, vacuum system, cryogenic system, facility) are completed or will be finished soon. Installation will start in the next year.
- NAOJ GW Project Office is playing a key role in KAGRA. The activities on KAGRA is increasing.
- Increased collaborative activities with ATC for KAGRA.
- We appreciate the support from NAOJ.

End

Supplementary Slides

Surface building

- The framework of the data-analysis building next to the existing building is completed.

Nov 19, 2013

Nov 20, 2013

by Ohishi

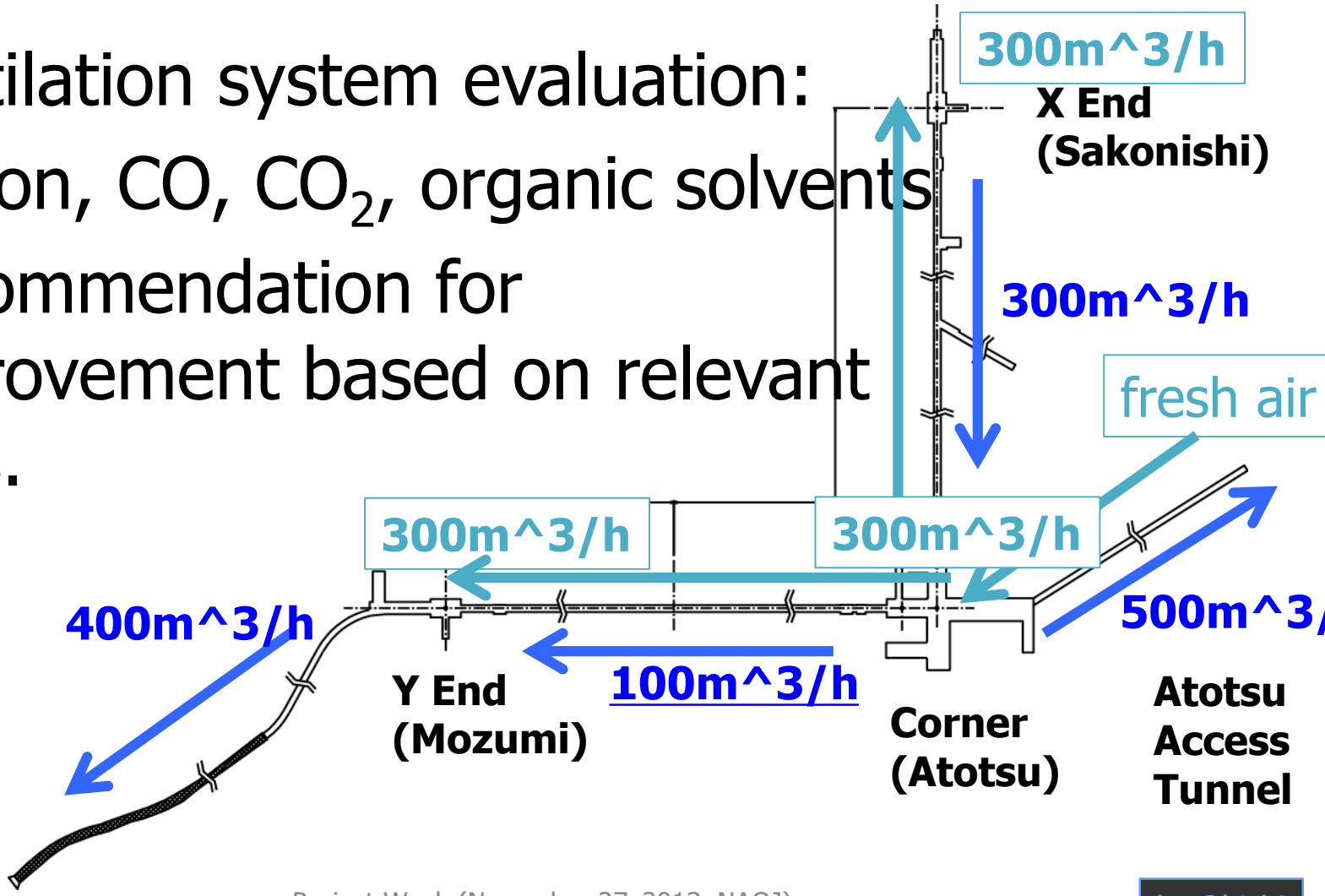
Tunnel excavation

- Excavation of Y arm is expected to be completed by the end of November.
- As of November 20, the remaining length of Y arm is 63m and that of X arm is 627m.

by Ohishi

Safety Management of KAGRA

- Ventilation system evaluation:
  radon, CO, CO_2, organic solvents
- Recommendation for improvement based on relevant laws.

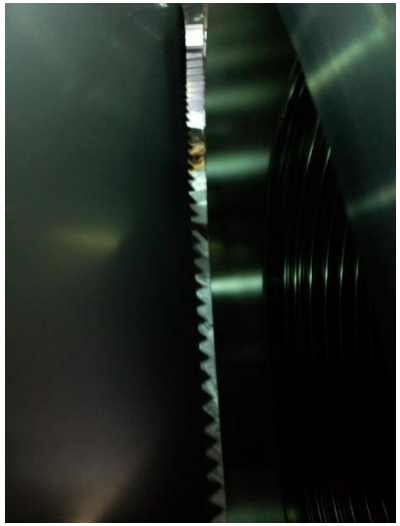


by Ohishi

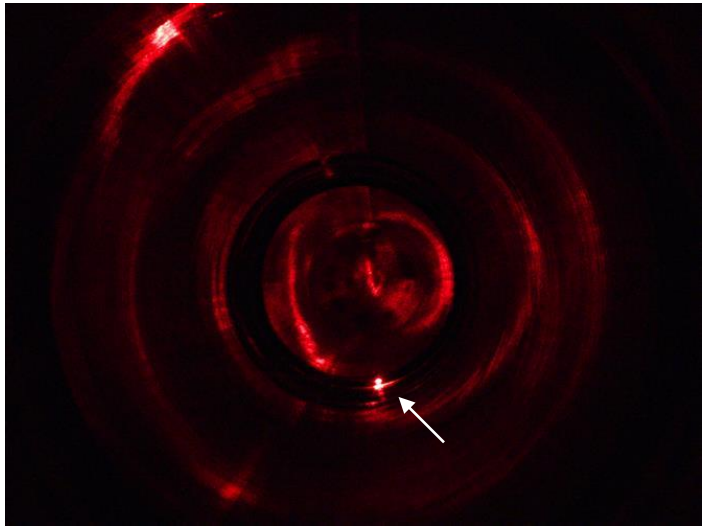
Production of vacuum system for KAGRA

- Production of 19 vacuum chambers is on going.
- One of them is used for a prototype test of the vibration isolation system in TAMA.
- Solblack (a kind of Nickel plating) was employed as surface treatment for shading baffles.
- Production of 250 baffles is on going.

Leak test of the ϕ1500 chamber in which the pre-isolator is put away.Metal O-rings are used to seal the flanges.



Prototype of shading baffle inserted into ϕ800 tube. The baffle has saw shape edge.



A beam spot on the baffle inside the ϕ800 tube. DLC and Solblack are tested as surface treatment.

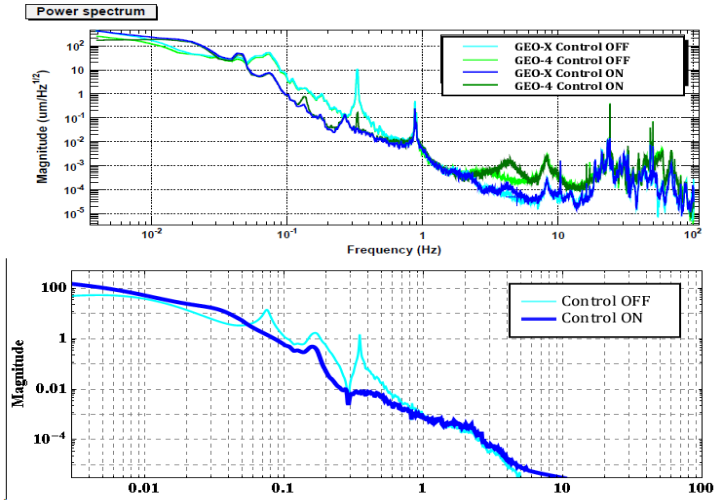
•Project Week (November 27, 2013, NAOJ)

by Takahashi

Production and test of vibration isolation system for KAGRA (1)

- Production of 6 top filters have been finished.
- Prototype tests are on going in NAOJ and ICRR.
- Full prototype test using TAMA300 is planed.

Tuning of the top filter. The natural frequencies were tuned to 0.2Hz.



Result of damping control for the inverted pendulum. 3-DOF (X, Y, YAW) motion was controlled using inertial sensors successfully.

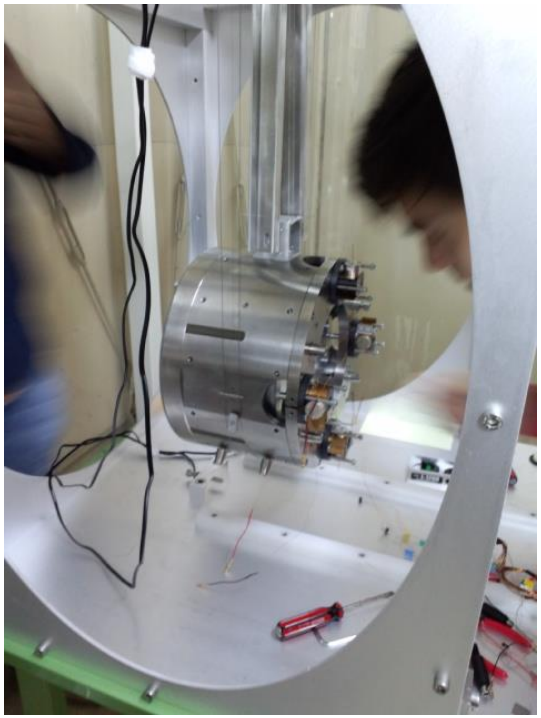
•Project Week (November 27, 2013, NAOJ)

Control test of the pre-isolator prototype. The motion of the pre-isolator is controled by the digital system mountd in the rack.

by Takahashi

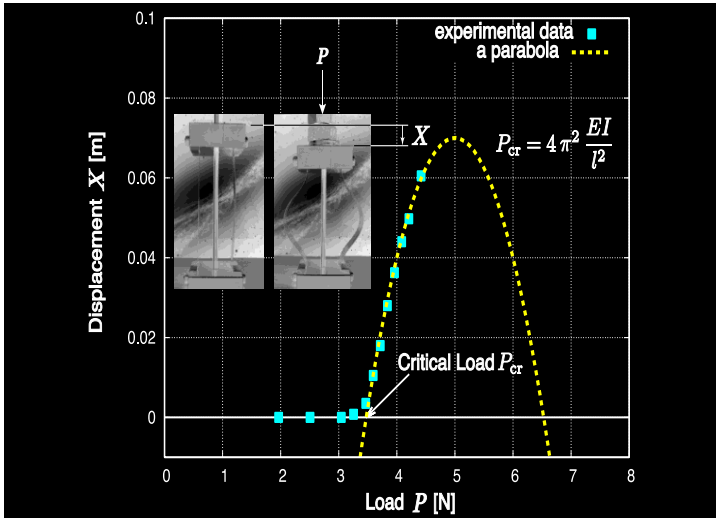
Production and test of vibration isolation system for KAGRA (2)

by Takahashi



Assembly and test of the payload prototype. The test mass and the recoil mass were suspended by tungsten wires. Optical sensor and electro manetic actuators (OSEMs) are used to control the test mass.

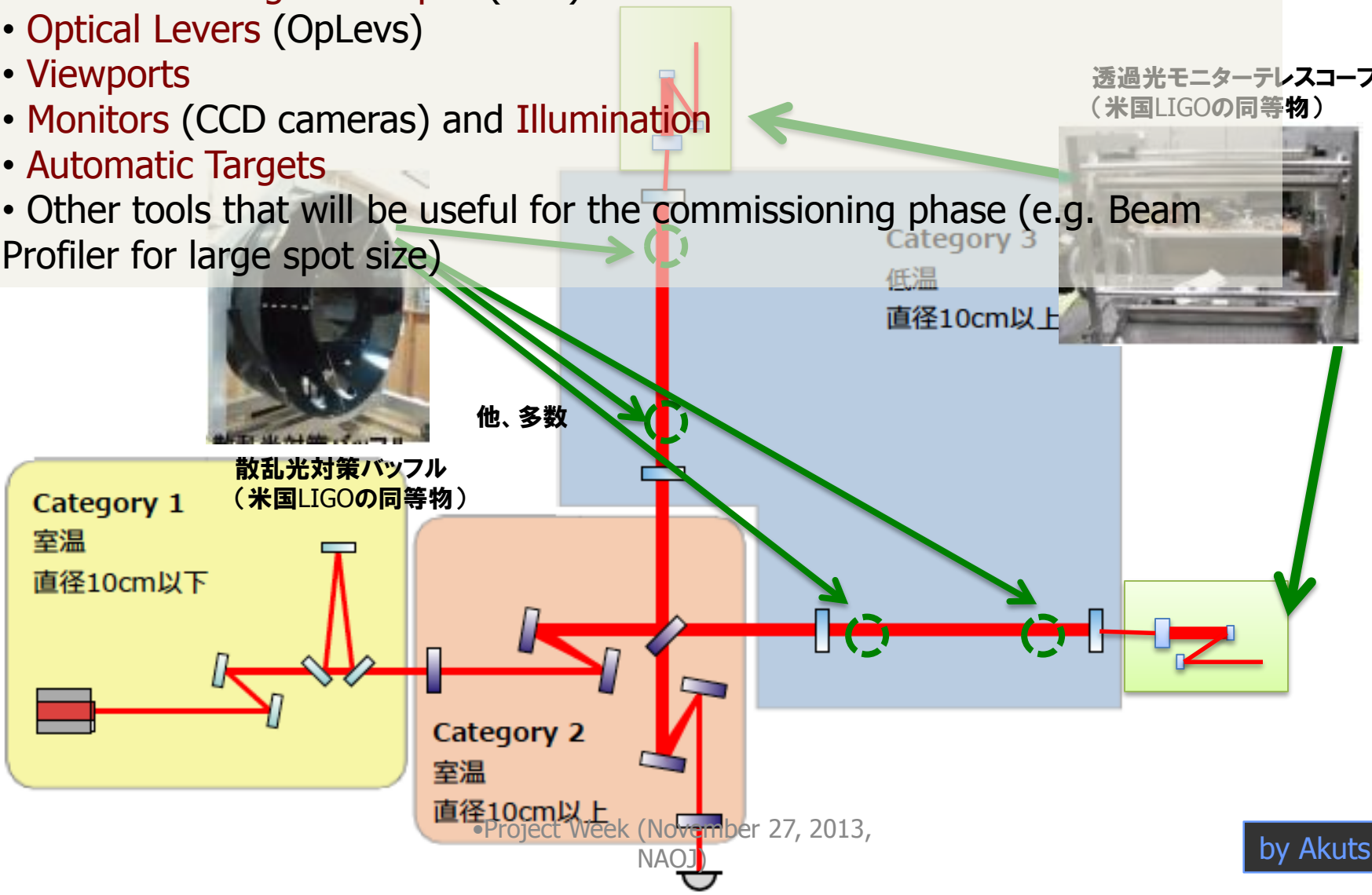
Preparation for full prototype test in TAMA. The ϕ1500 chamber is connected to the TAMA chamber with an outer frame in the west-end room.



Development of cryogenic vertical spring. A spring using post-buckling phenomena is tested. Fundamental behavior was confirmed.

AOS tasks

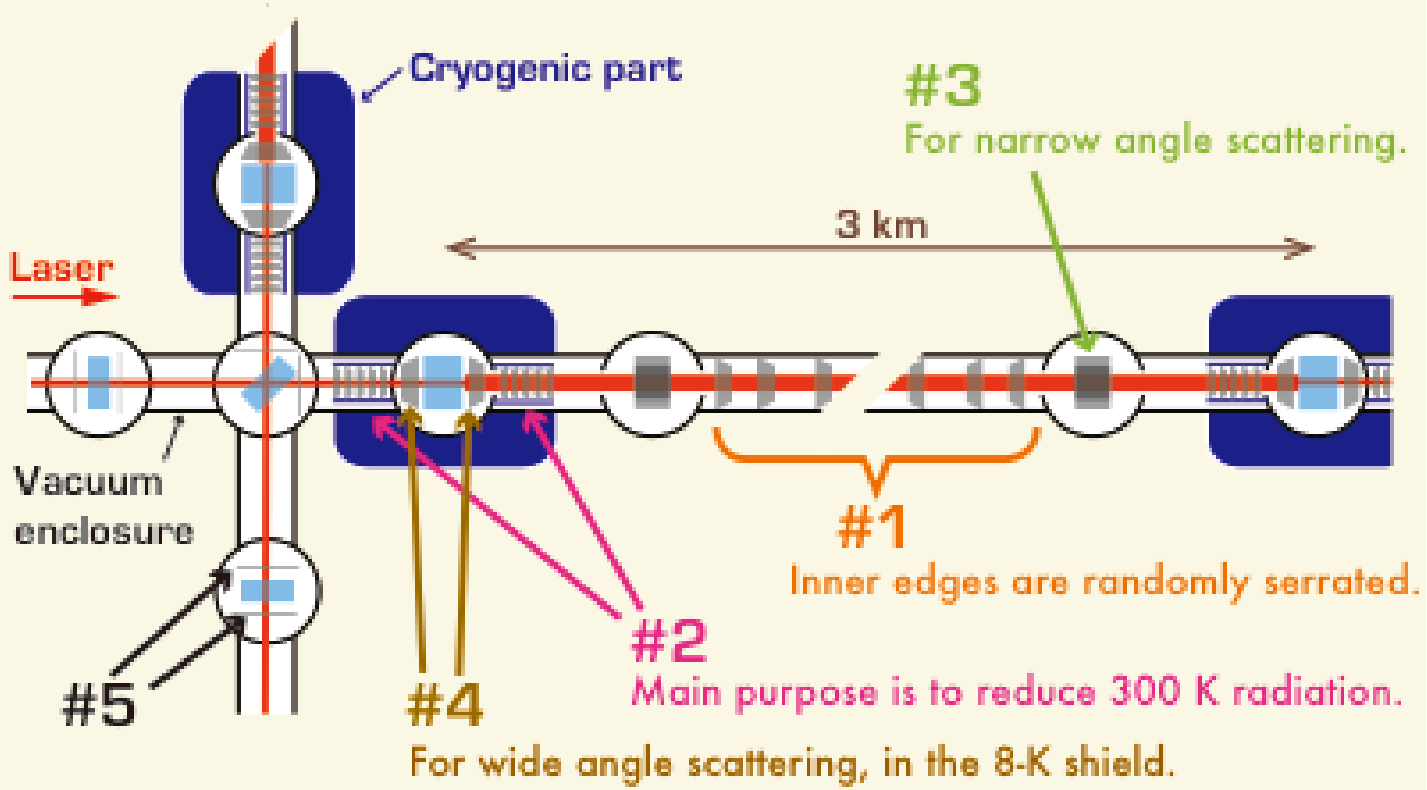
- Stray Light Control (SLC)
- Beam Reducing Telescopes (BRT)
- Optical Levers (OpLevs)
- Viewports
- Monitors (CCD cameras) and Illumination
- Automatic Targets
- Other tools that will be useful for the commissioning phase (e.g. Beam Profiler for large spot size)



by Akutsu

KAGRA Baffle system

#1 Arm duct baffles -- 125 baffles per each 3-km arm
#2 Cryo-duct shield -- 5 m long, cooled down to about 80 K
#3 Narrow-angle baffles
#4 Wide-angle baffles -- cooled down to about 8 K
#5 Others

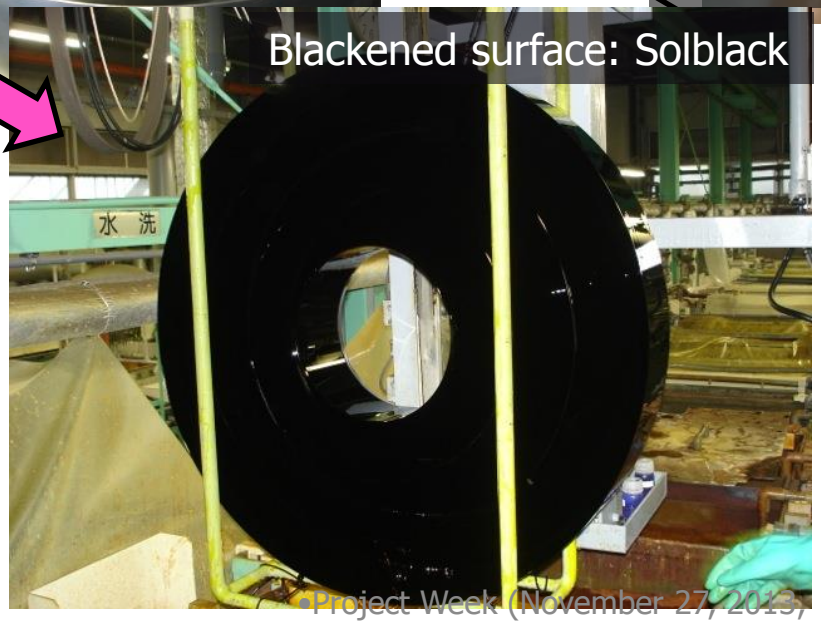


Schematic view of the main interferometer of KAGRA and its baffles

by Akutsu

Example of a large baffle

#3 Narrow-angle baffle
Material: A5052



ECB: low scattering
Solblack: Vacuum Compatibility (10^{-7} Pa), Cryogenic compatibility (<8K), Low reflectivity (~2%@1064nm), Applicable for a large work

by Akutsu

Works in the next year

- Stray-light control
  - Production of #3 (4pcs) & #4 (4pcs) baffles
- Beam reducing telescope (BRT)
  - Fabrication of large mirror holders for iKAGRA BRT (3pcs)
  - Fabrication of bKAGRA BRTs (2pcs)
- Optical levers
  - Optical design and procurements
- Viewports
  - Procurements

by Akutsu

KAGRA補助光学系サブシステム

- 干渉計内で生じた迷光の処理
  - KAGRAの最終感度を決める。
  - 大型(Φ800程度)のバッフルの設計、製造が必要
- 3km 光軸をモニターするテレスコープ
  - KAGRAの3km光軸のリファレンスとなる。
  - テレスコープ光学系の設計、製造が必要

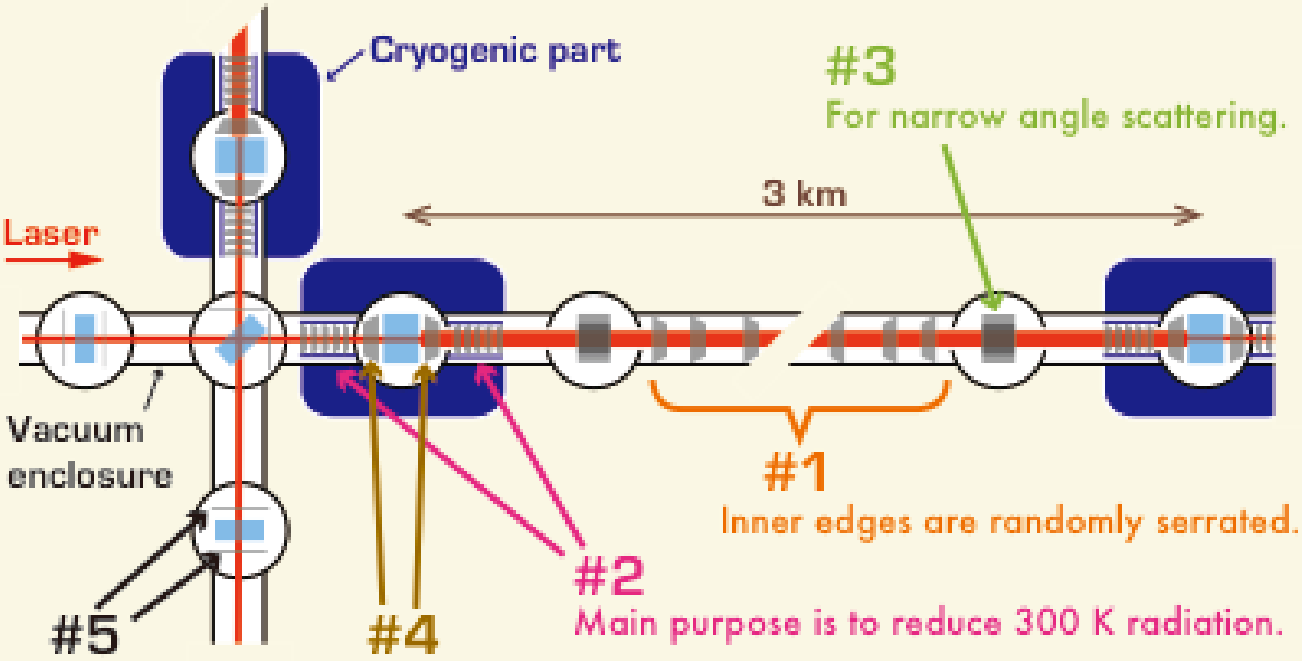
- 技術的チャレンジ
  - 高真空、低温の環境で振動を抑える構造でこれらを達成すること。
- 人員
  - 重力波P推進室: 阿久津(ATC併任)、D. Friedrich
  - MEショップ: 大渕、池之上、浦口…

by Akutsu

迷光処理

#3と#4について
- **機械設計**: ATC MEショップ
- **光学設計**: ATCのノウハウ(外部企業との連携含む)

#1 Arm duct baffles – 125 baffles per each 3-km arm
#2 Cryo-duct shield – 5 m long, cooled down to about 80 K
#3 Narrow-angle baffles
#4 Wide-angle baffles – cooled down to about 8 K
#5 Others

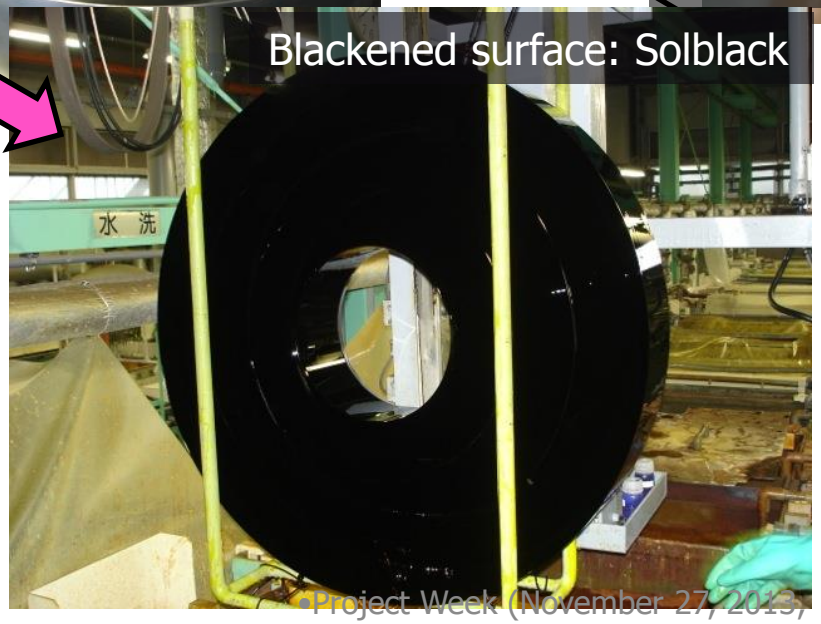


Schematic view of the main interferometer of KAGRA and its baffles

by Akutsu

#3 狭角散乱バッフル(プロトタイプ)

#3 Narrow-angle baffle
Material: A5052



ECB: low scattering
Solblack: Vacuum Compatibility (10^{-7} Pa), Cryogenic compatibility (<8K), Low reflectivity (~2%@1064nm), Applicable for a large work

by Akutsu

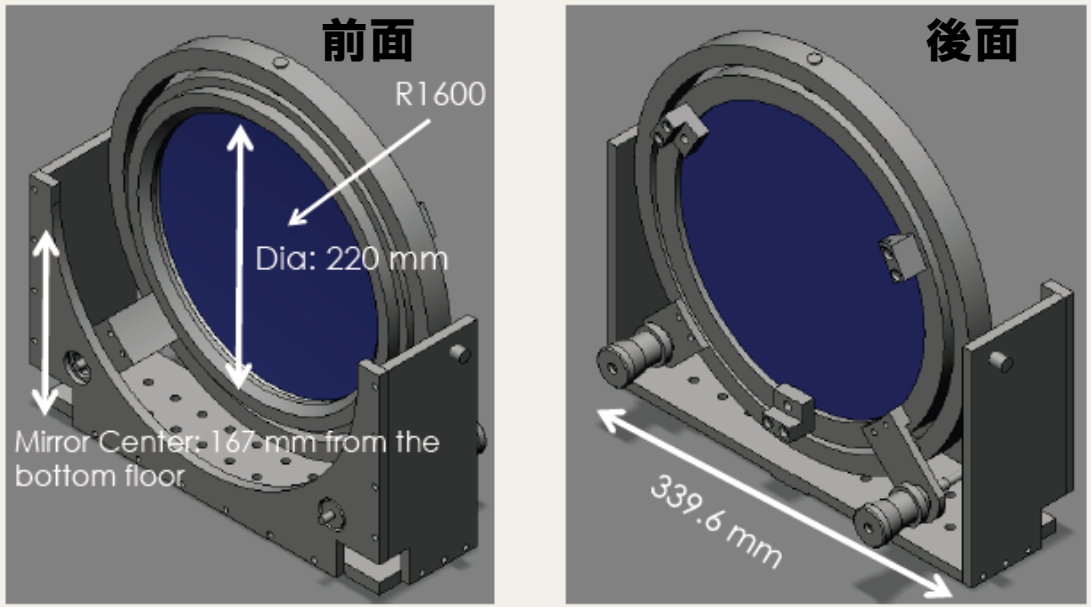
Initial KAGRA用の Beam Reducing Telescopeの主鏡ホルダー

by Akutsu

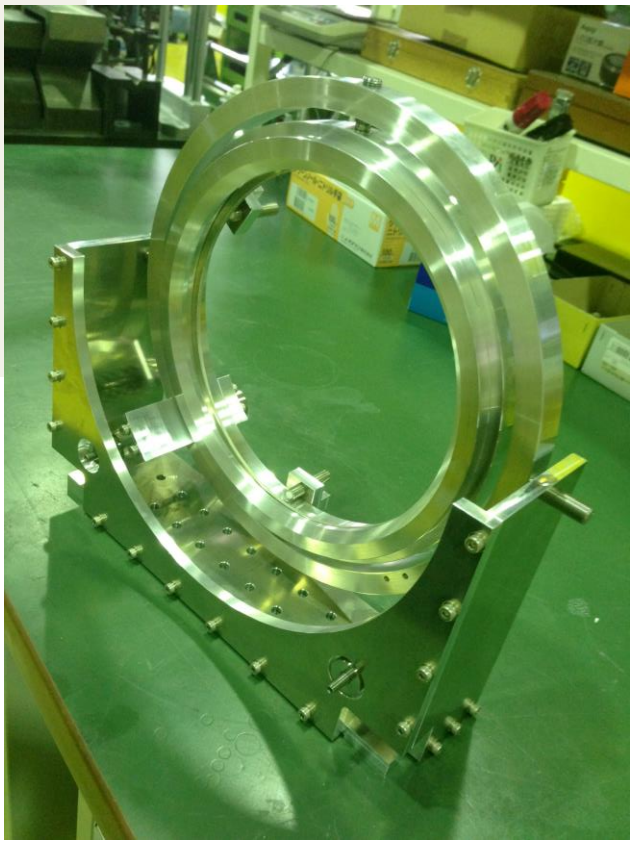
Primary mirror holder (vacuum compatible) should be prepared.

Design is finished by NAOJ-ATC. The **first product** will be brought in the **end of this month**.

This design is based on Sigma Koki's MHD-254 (it is not vacuum compatible).



ATCにて設計



•Project Week (November 27, 2013, NAOJ) ATCにて製作

by Tatsumi, Ueda

Progress report of NAOJ Mirror group

Akitoshi UEDA	NAOJ
Daisuke TATSUMI	NAOJ
Hitoki YONEDA	ILS, UEC
Mitsuru MUSHA	ILS, UEC

We **succeed to develop low-loss mirror** of the world's top quality.
At least two domestic companies provide us the mirror.

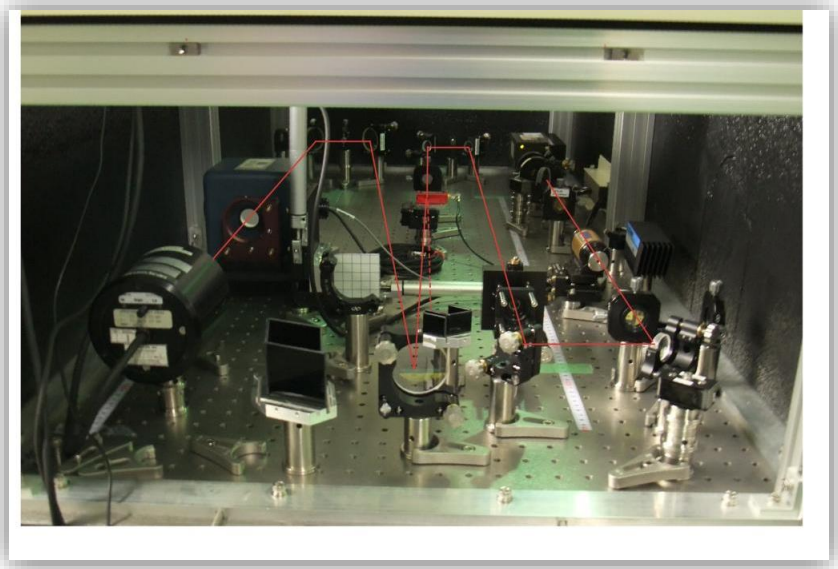
Mirror qualities are investigated by NAOJ Mirror group collaborated with the University of Electro-Communication, the University of Tokyo, and Advanced Technology Center in NAOJ.

High quality mirror for **KAGRA Pre-Mode Cleaner** will be delivered within this year.

Figure 1: High quality mirror for KAGRA

Figure 2: A picture of coating cross-section

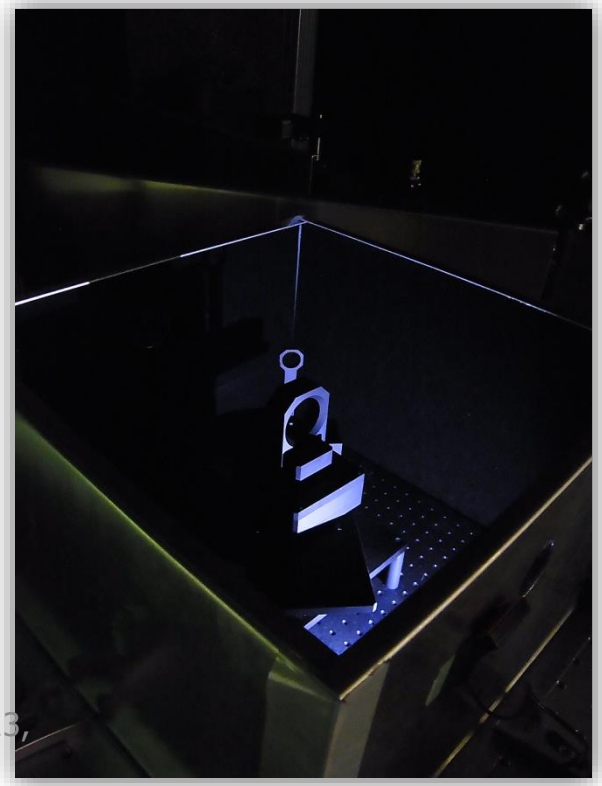
by Tatsumi, Ueda



Mirror qualities are investigated at TAMA by NAOJ Mirror group.

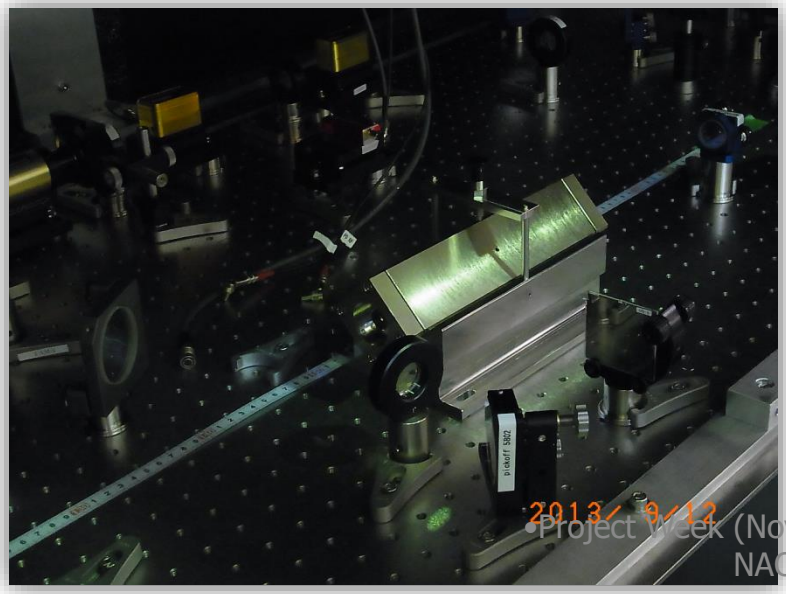
Picture 1: Scatter-meter at NAOJ TAMA

Picture 2: Scatter Angle Measurement



Picture 3: Optical Loss measure by the cavity

Cavity Ring-Down measurement



Preparations for Multi-messenger Analysis

Daisuke Tatsumi
Kazuhiro Hayama

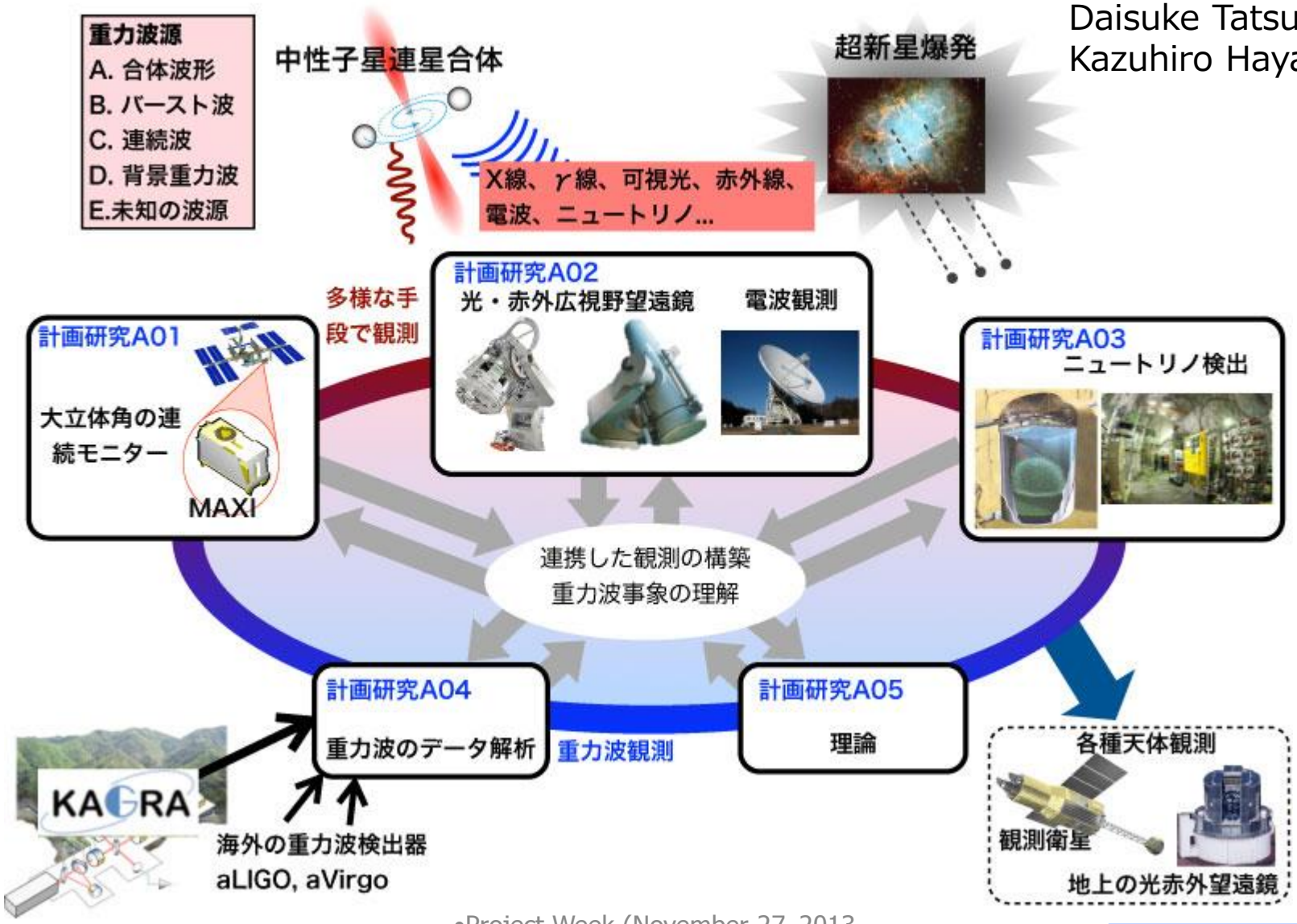
Background

Together with construction of the KAGRA detector, preparations for multi-messenger analysis are in progress. The multi-messenger means collaborative observation with infra-red light, neutrino, gamma-ray and X-ray detectors.

This activity was adopted as
Grant-in-Aid for Scientific Research on Innovative Areas "New Developments in Astrophysics Through Multi-Messenger Observations of Gravitational Wave Sources"

Preparations for Multi-messenger Analysis

Daisuke Tatsumi
Kazuhiro Hayama



by Tatsumi, Hayama

Preparations for Multi-messenger Analysis

Daisuke Tatsumi
Kazuhiro Hayama

It is very important to reduce the false alerts for such multi-messenger observations.
Our target value is less than 1 events per month.
To realize it we are developing the following systems.

* **Detector Charcterization System (with online veto system)**

* **Investigation of cryogenic system induced noises**

by Tatsumi, Hayama

Detector Characterization

Kazuhiro Hayama

By referring back to TAMA experience of long-term observations, it is very important to know detector conditions and status. As a sub-subgroup leader of KAGRA detector characterization collaboration with Korea group is leading.

[Recent activities]

*** Systemization of multivariate correlated analysis**

*** Evaluation of effects from magnetic propagation modes in the earth**

*** Glitch monitoring**

and so on.

[Talk]

4th Korea-Japan Workshop on KAGRA, at Osaka Univ., 2013 June

•Project Week (November 27, 2013, NAOJ)

by Hayama

Reduction of cryogenics induced burst noises

Daisuke Tatsumi

KAGRA is a unique cryogenic detector in the world. Therefore we need to reduce burst noises induced by cryogenic systems.

Goal

To reduce false alarm rate less than 1 event per month is out target value.

Budget

Grant-in-Aid for Scientific Research on Innovative Areas
"New Developments in Astrophysics Through Multi-Messenger Observations of Gravitational Wave Sources"

Recent Activity

By referring back to TAMA experience of long-term observations, it is very important to know detector conditions and status.
We have experience to construct such online analysis system for TAMA300 detector. Together with that, the world's first cryogenic GW detector CLIO was also developed as a prototype of KAGRA.
Therefore we put these experiences to make monitoring (vetoing) system for cryogenic system induced noises.

The left picture is noise monitoring system developed at TAMA site.
We have plan to install the system together with a vibration sensor for cryogenic part.

[Talk]
Boot Camp 2013 for A04 project, at Osaka City Univ. Satellite Campus, 28 -29 June 2013

Effective Use of TAMA facility

- Current status
  - No observation run after the damage in optics by the earthquake in 2011.
  - Center room is used for high-quality mirror development.
  - West end room is used for prototype test of Type-B vibration isolation system.

- Plans
  - Two vacuum tanks (BS and RM) will be moved to KAGRA.
  - One vacuum tank will be upgraded to cryostat, used as cryogenic test facility for KAGRA.
  - Small optical components are ready for use in KAGRA.
  - Considering a good usage of 300-m baseline facility.

研究計画：低温施設整備

- KAGRA低温部に収められる装置を試験・評価するための設備.
  - 防振系・補助光学系：最終的に低温部(20K)にインストール.
  - 現在、重力波P推進室には試験設備が無い.
    → KEK, ICRRなどに出向いてコンポーネント試験.
  - 重力波分野の基礎・応用研究では低温設備は必須になる.
    → 国内・国際的な競争力の維持.

- 2年計画で整備 (設計, 冷凍機 / 防振, 輻射シールド, 組上げ).
  基本的にはKAGRAと同構成. ただし真空槽など現有物を
  利用し, コスト削減をはかる.