

LSC@LIGO, Hanford  
14-17, August 2005

# LCGT project

Kazuaki Kuroda  
LCGT Collaboration  
LIGO-G050412-00-Z

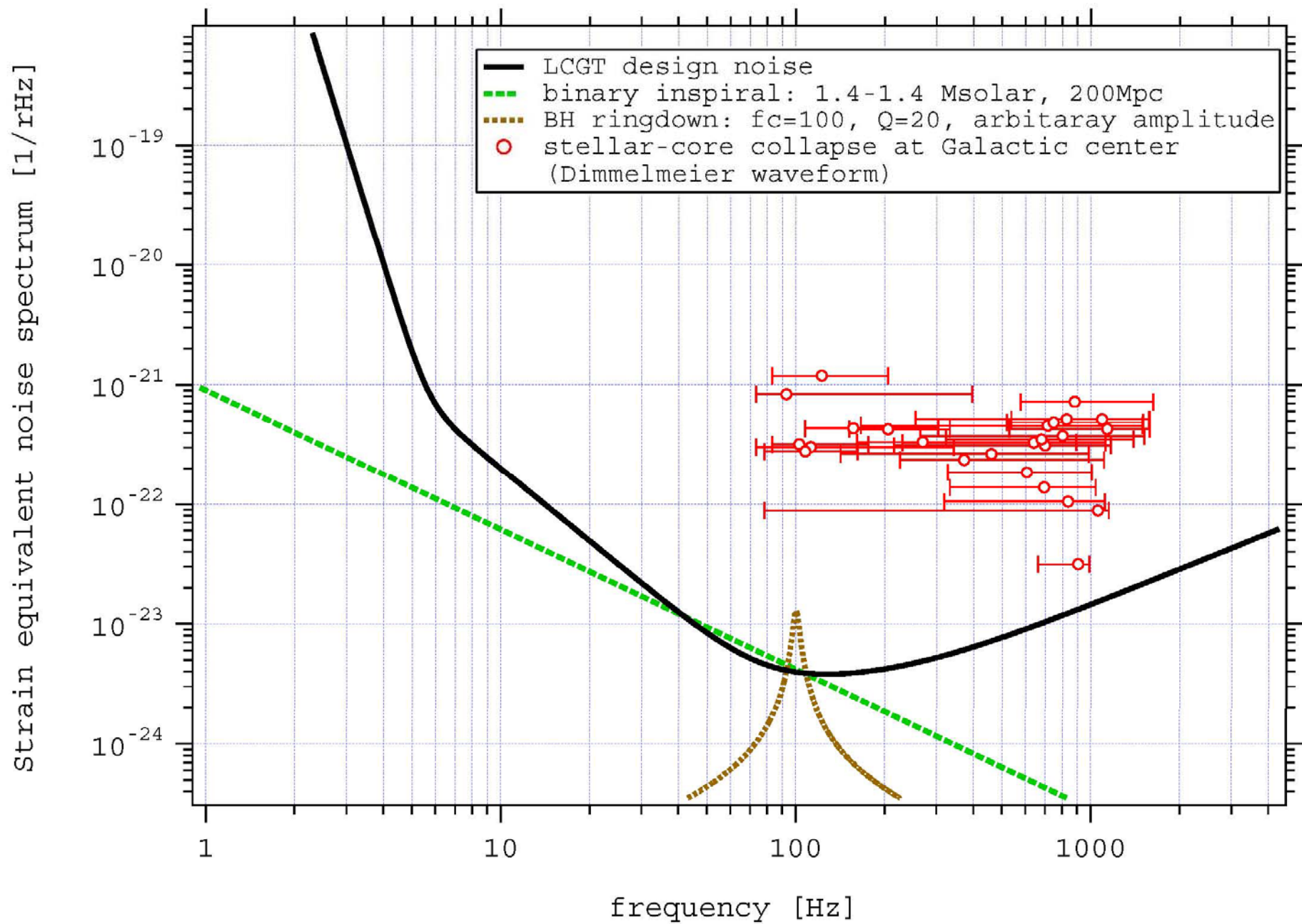


# Summary of LCGT

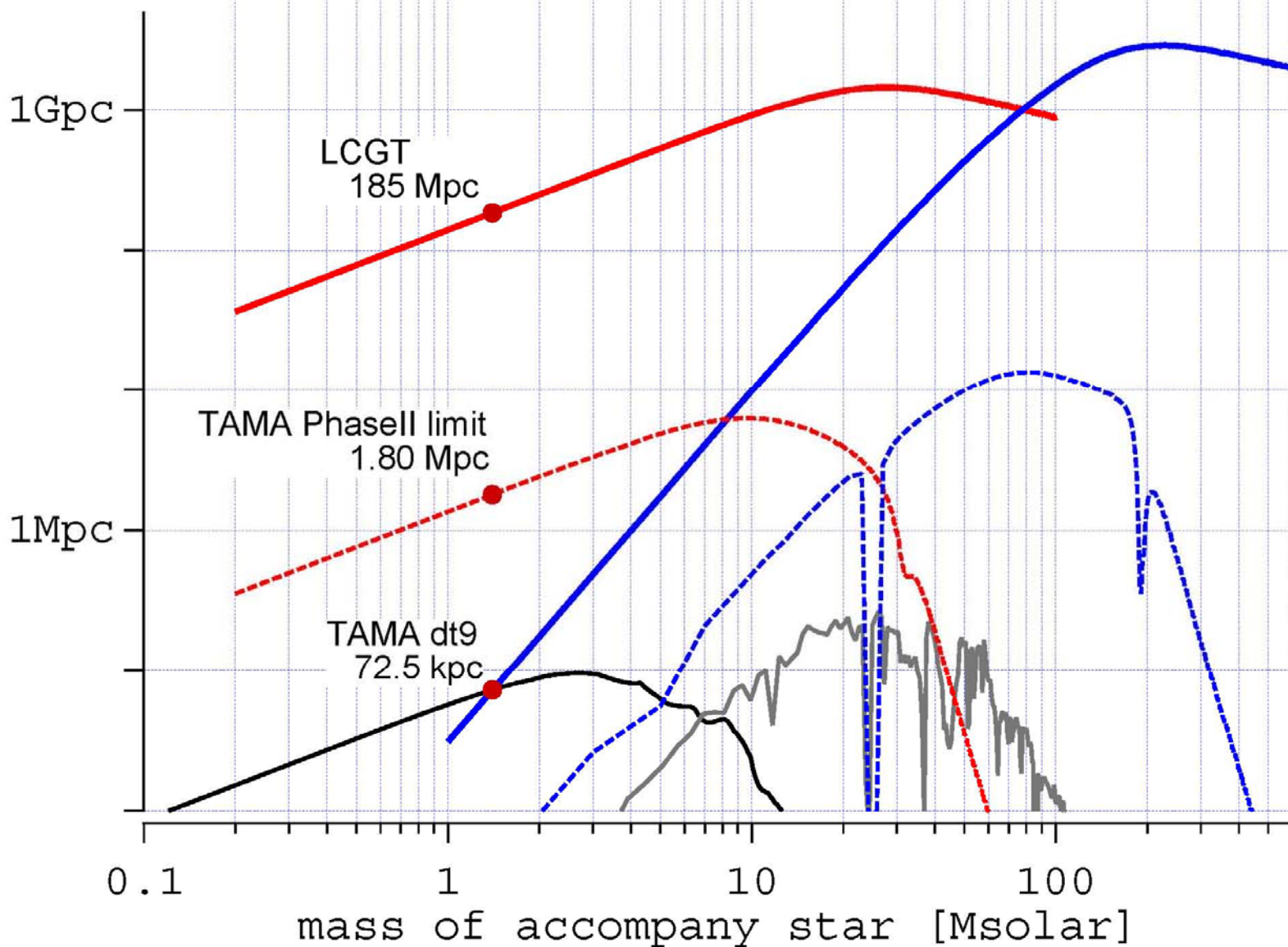
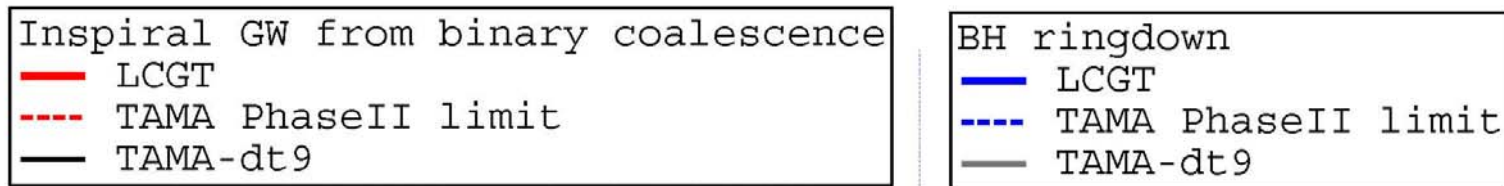
- It is a 3km Fabry-Perot MI with a power recycling scheme and equipped with a broadband RSE. The laser power is **150W**
- Main mirrors made of **sapphire** are cooled at **20K**. A SPI impedes the refrigerator- vibration.
- It is built underground in Kamioka.
- Two independent interferometers are installed in the vacuum system.
- The main target is the coalescence of BNS, which can be detected **1.2-27.8** events per year **at confidence level of 95%** for mass 1.4Msun and S/N=10.



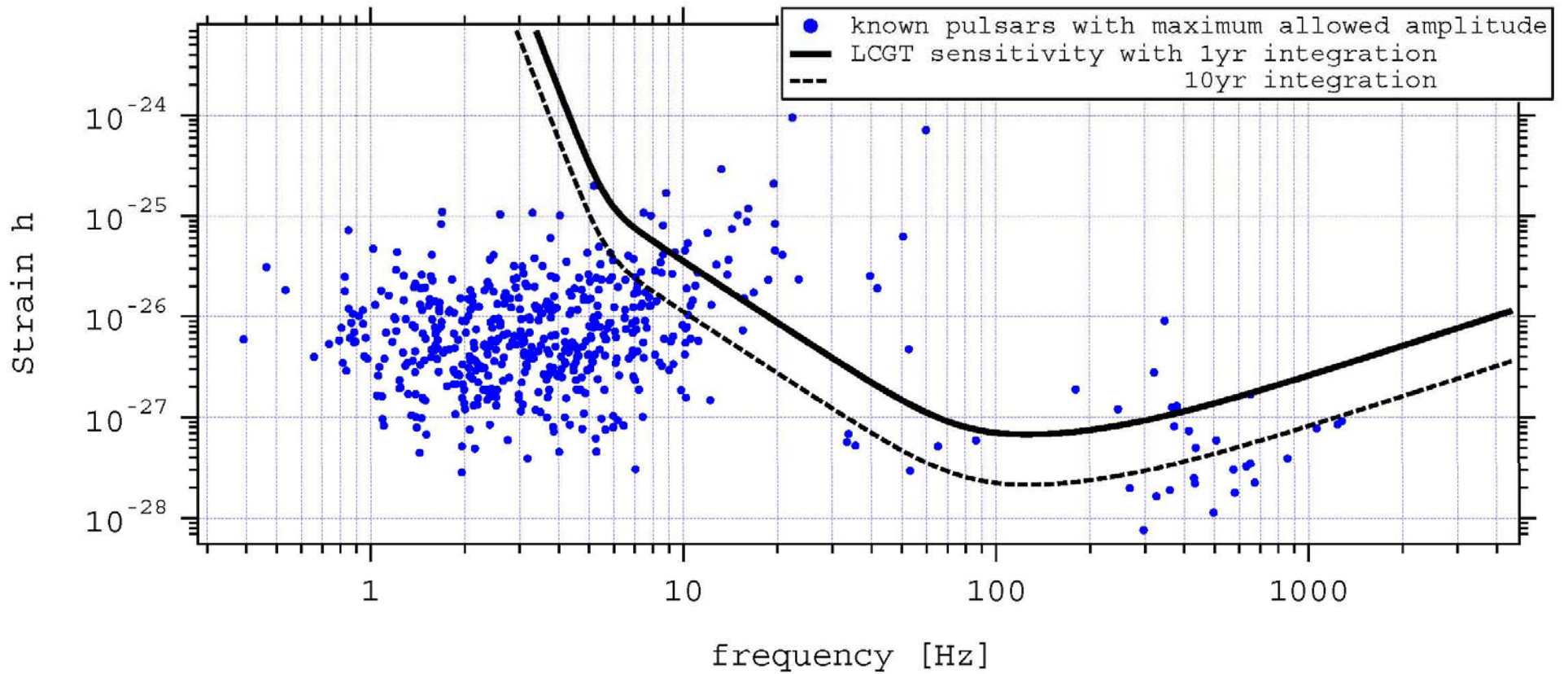
# Expected sources of LCGT (1)



Range for Single Detector with SNR=10

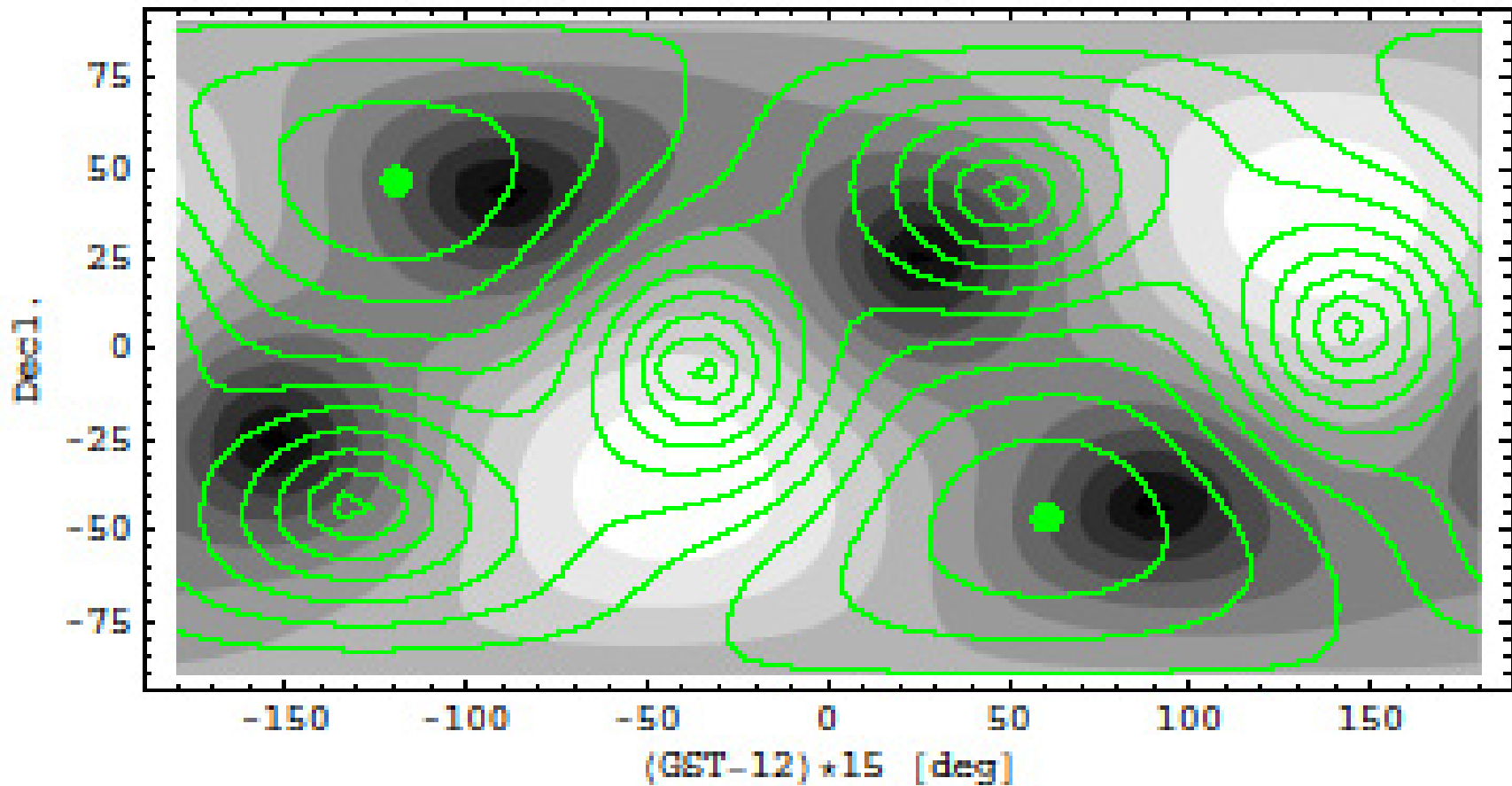


## Expected sources of LCGT (2)



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LCGT contributes the international observation by the coverage of a complimentary sky to other detectors:  
LCGT, grey scale, LIGO (Hanford), green contour curves.



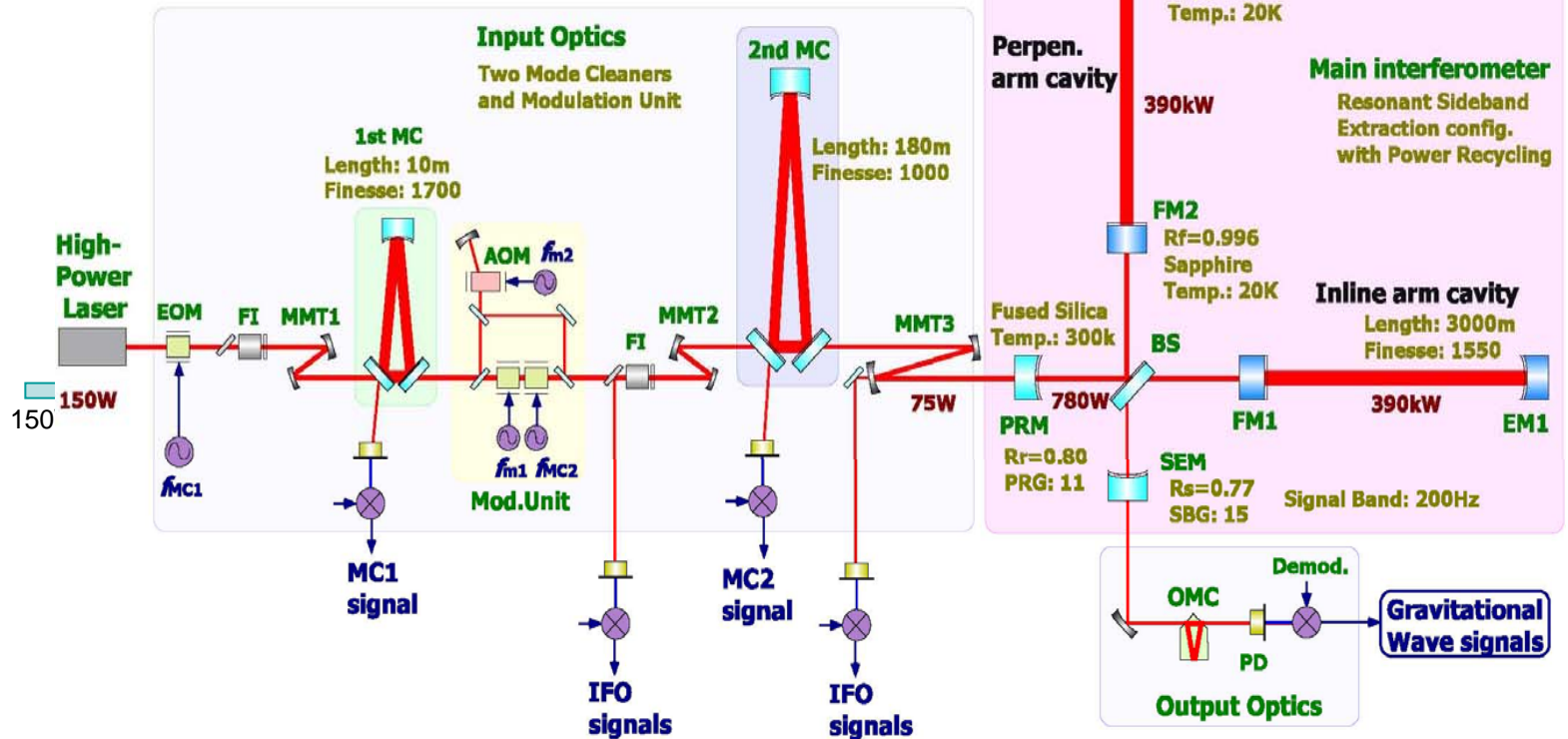
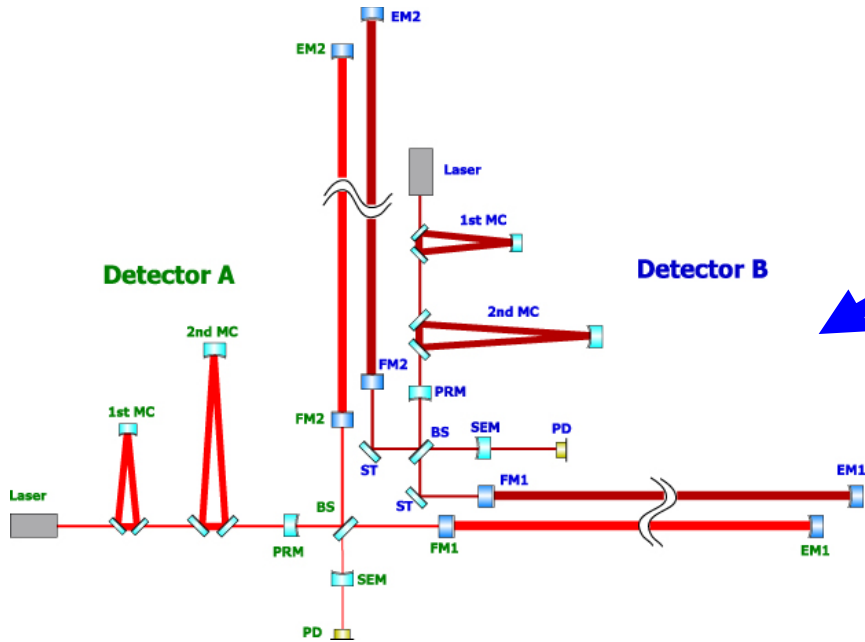
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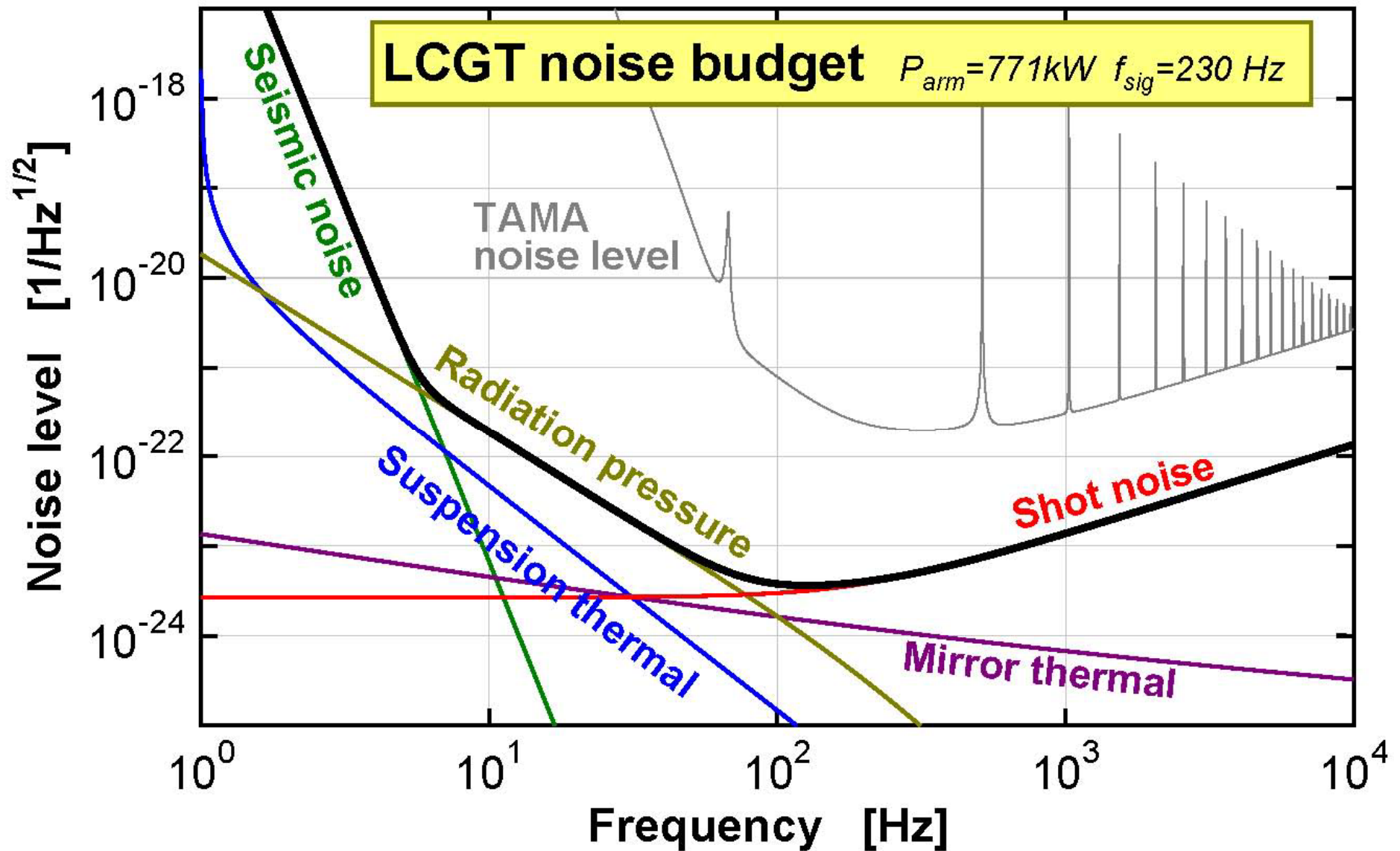
# Optical design of LCGT

Two interferometers are arranged not to interfere in the same vacuum system.

Optical design of the basic interferometer



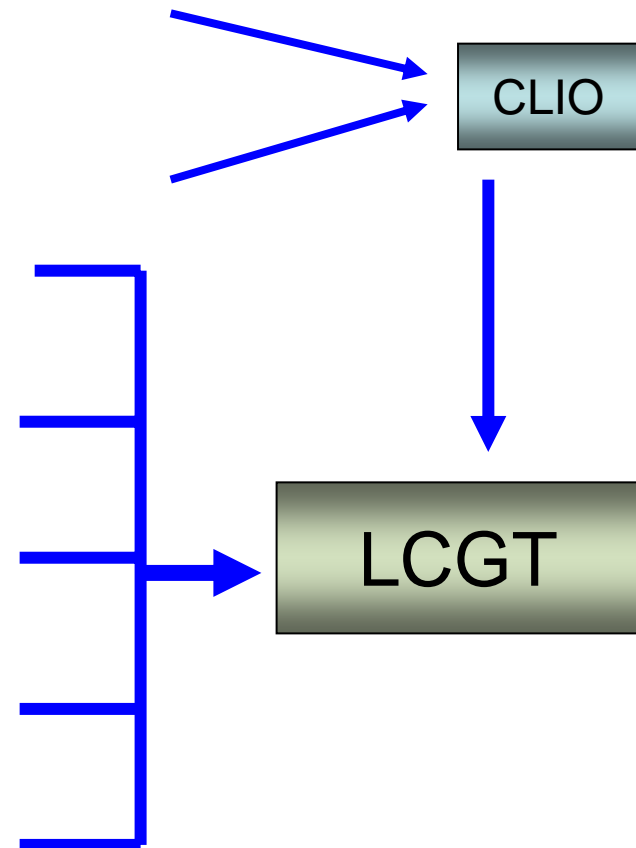
Sensitivity is limited only by quantum noises around at observational frequency band.



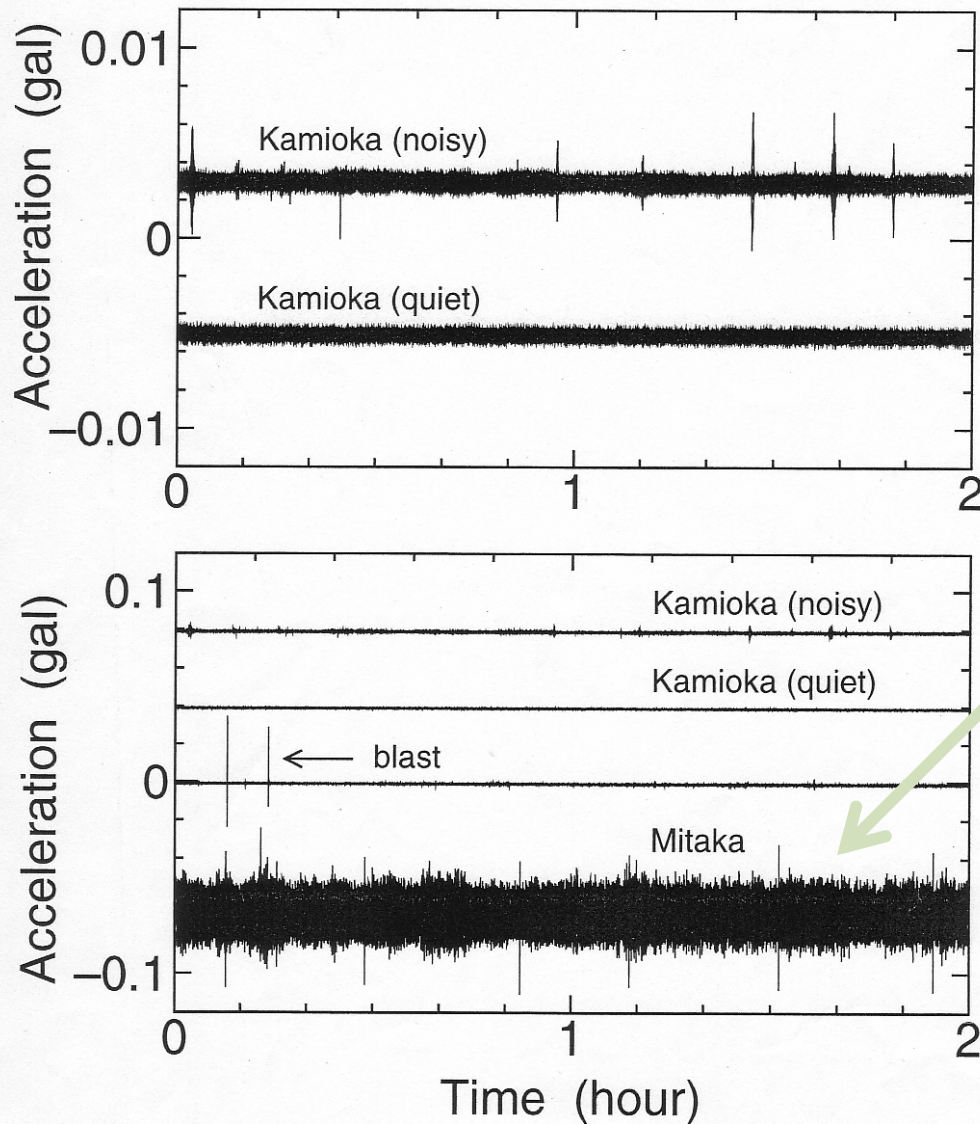


# Technical foundation of LCGT is established by a prototype and an intermediate size interferometer with challenging techniques

- 20m interferometer
  - Kamioka mine 1999-2002
- Cryogenic experiments
  - KEK-ICRR 1997-2002
- TAMA advancement
  - NAO 1995-
- RSE adoption
  - NAO 1998-
- SPI installation
  - Phys. Dept. UT 1999-
- Lasers
  - Dept. AMS UT 2003-
- SAS
  - Phys. Dept. & NAO 1998-  
(CALTECH)

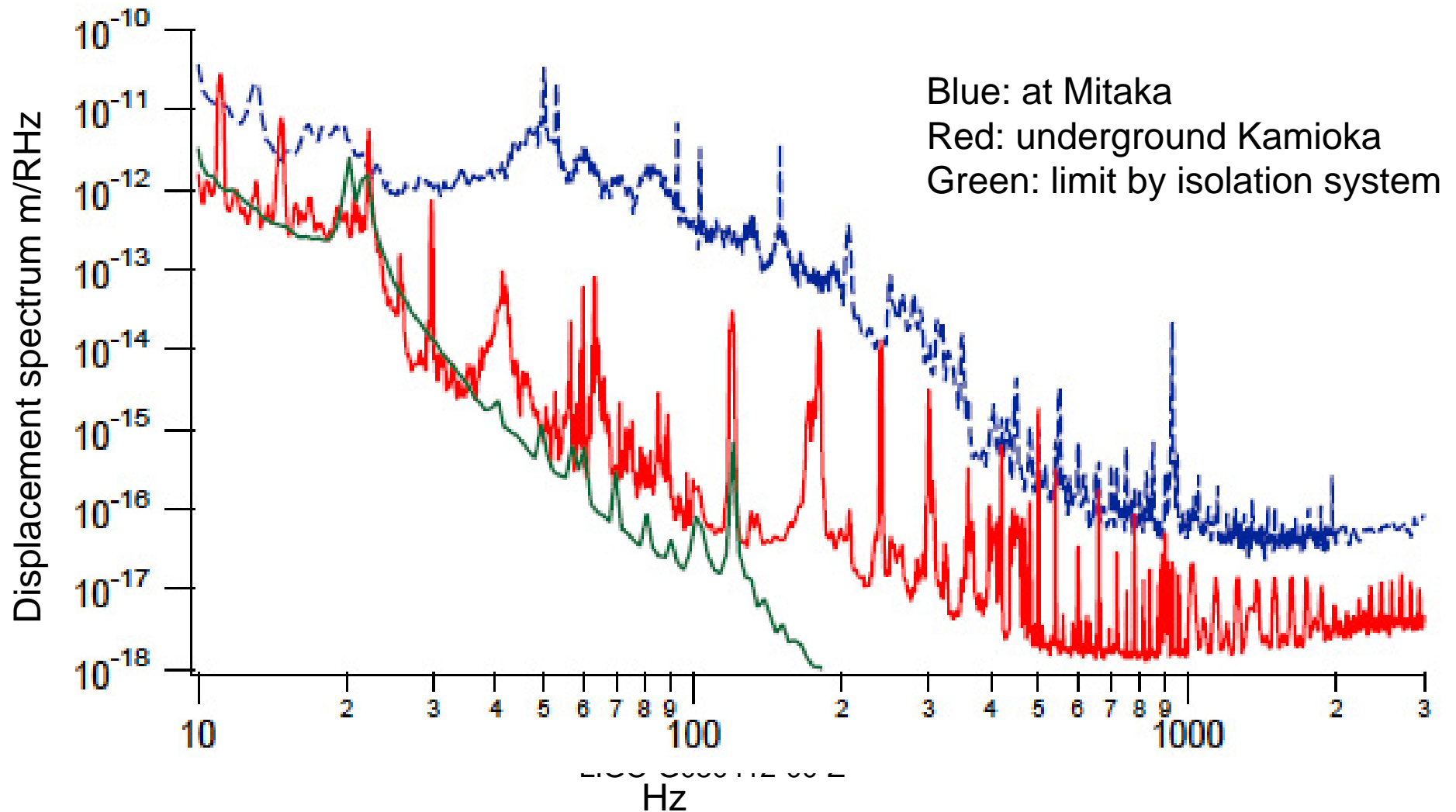


Why do we go underground? In Kamioka low frequency noise is less than Mitaka by 30 times.



The seismic noise of Mitaka is equivalent to continuous blasting in Kamioka underground.

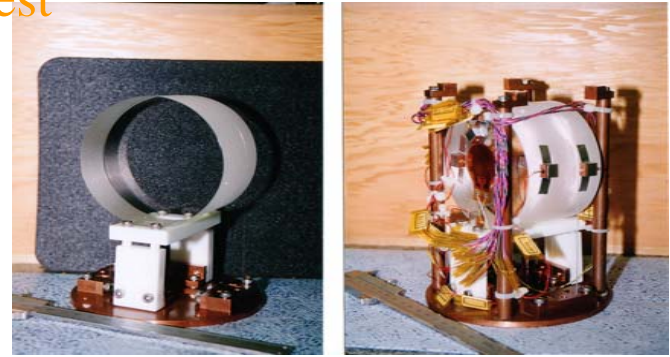
When the 20 m interferometer was moved from Mitaka to Kamioka mine, the noise at 100Hz was decreased by 4 orders and the spectrum limit by the anti-vibration system was achieved at frequencies less than 100Hz.



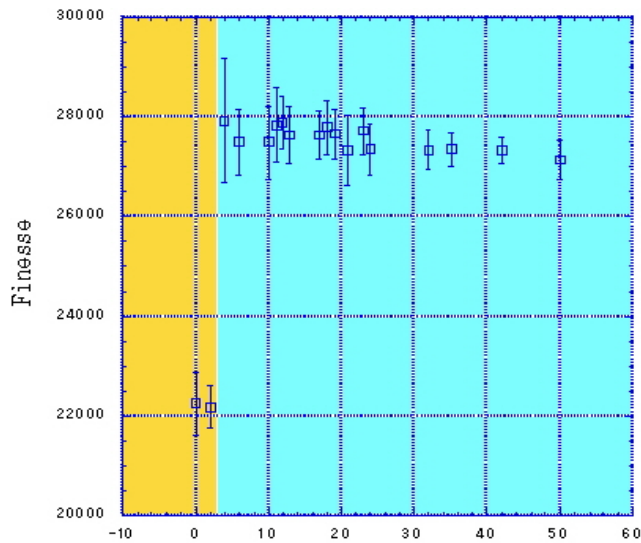


## Cooling test

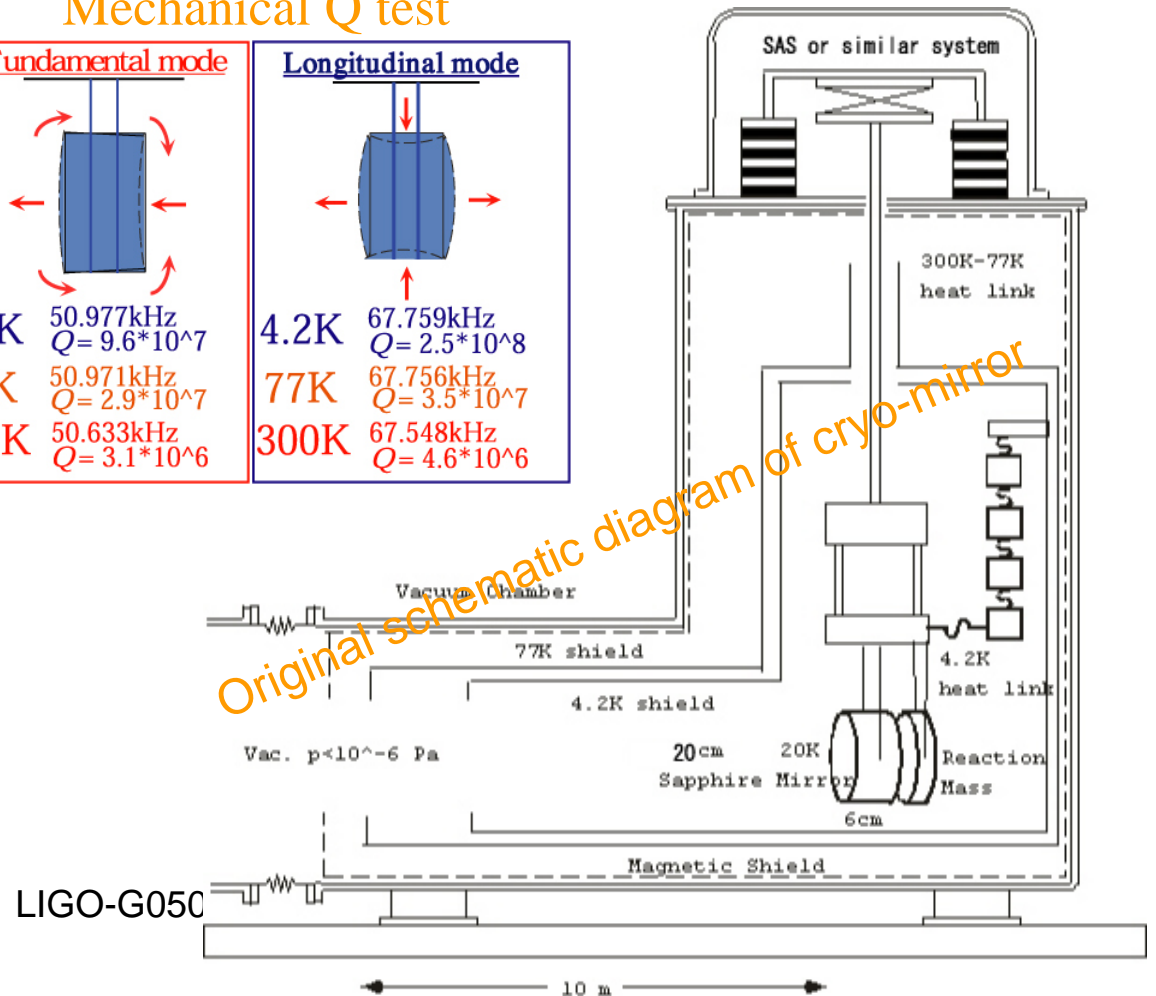
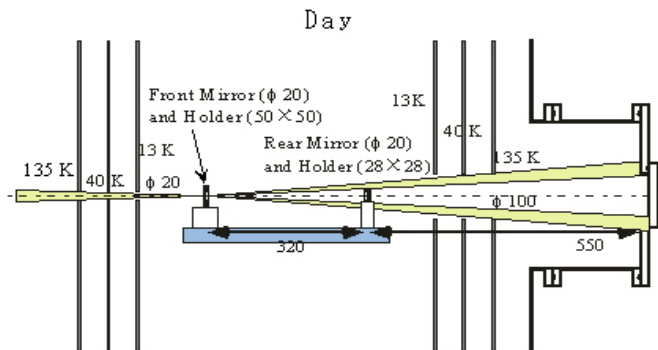
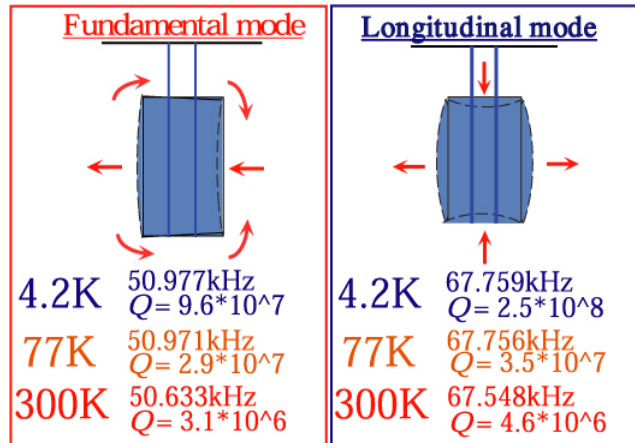
Cryogenic mirror was established by several basic experiments.



## Contamination test

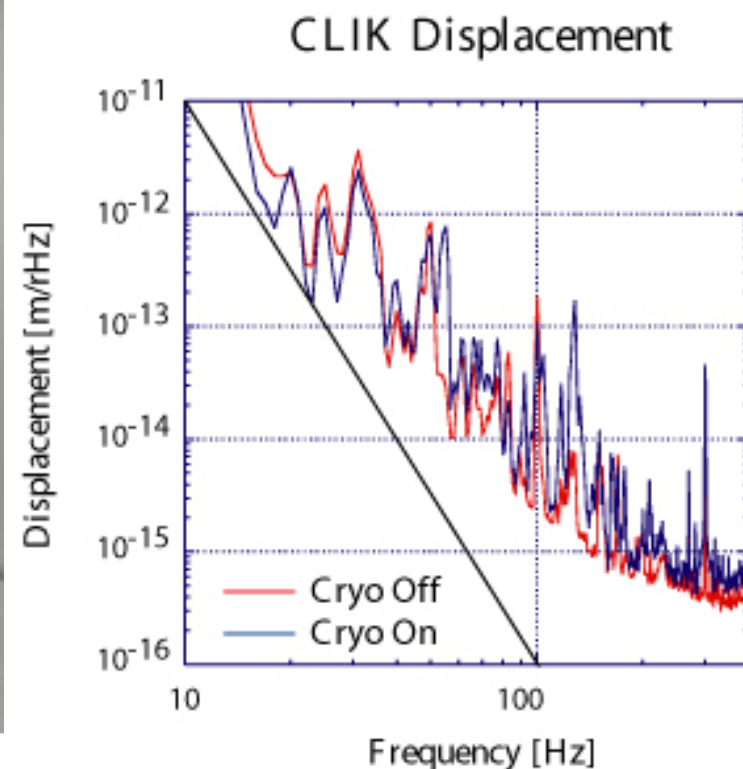
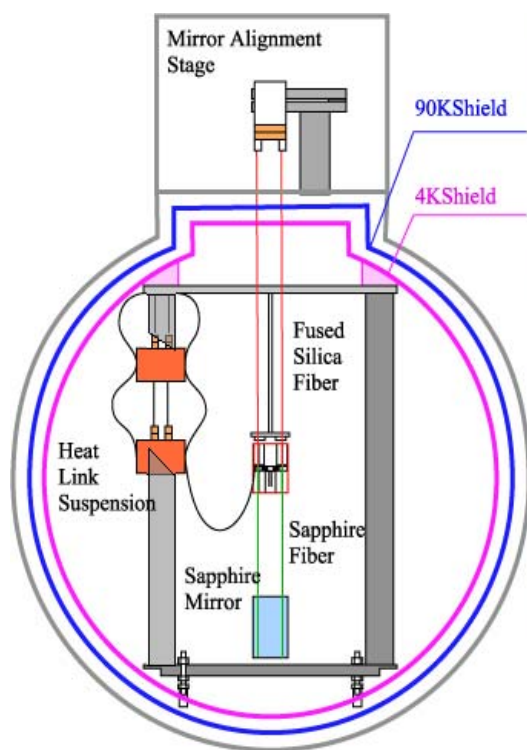


## Mechanical Q test



Suspension prototype was tested in Kashiwa campus in ICRR, in 2001.

Fabry-Perot cavity was locked at cryogenic temperature and requirements on refrigerator were studied.

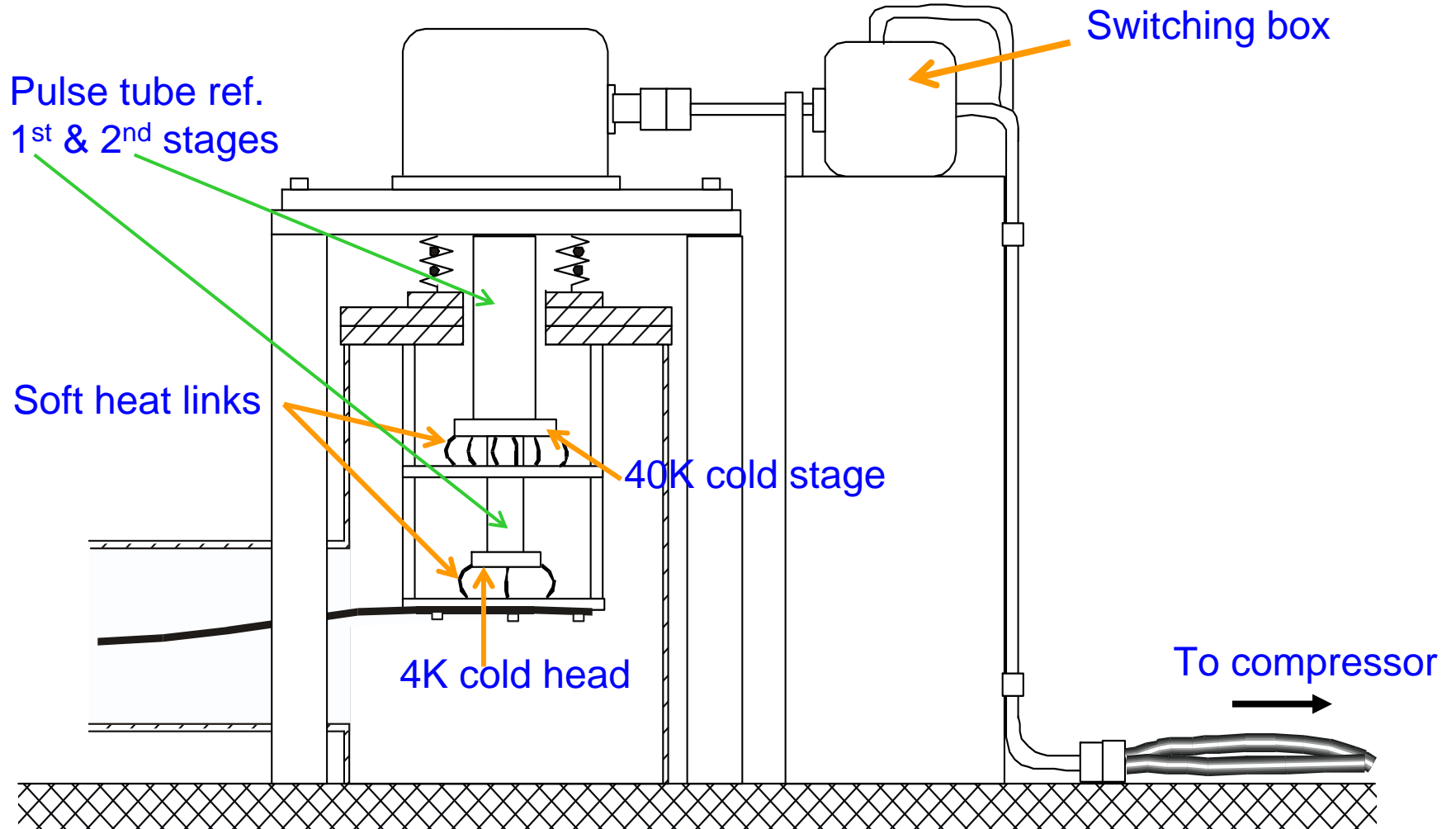


This result makes us to develop quieter refrigerator and softer heat link design.

LIGO-G050412-00-Z

# Quiet refrigerator was developed ( design in 2003)

F-6: Class. Quantum Grav. (Accepted), Pr-1: Proc. 28th ICRC (2003),  
patent: Pa-3 Tomaru et al., 2003; Suzuki et al., 2003.



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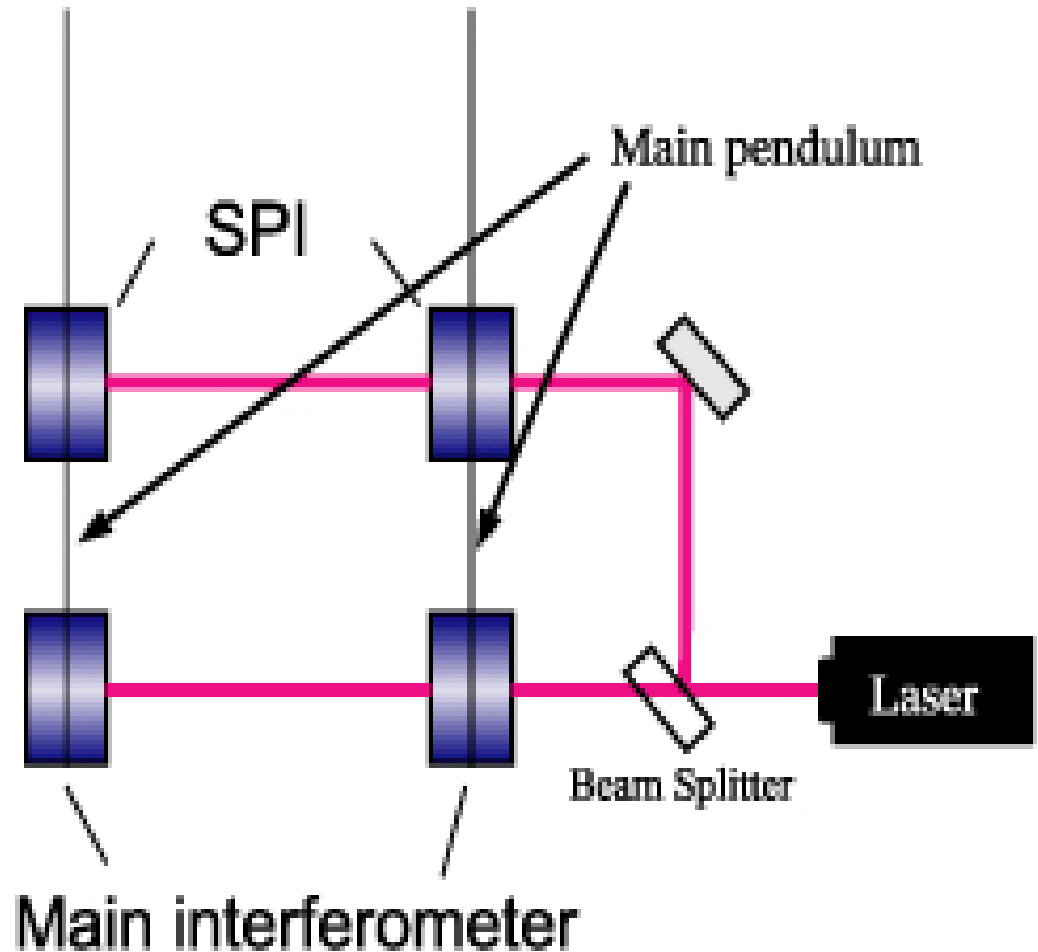


# Large heat production is avoided by RSE

- Broad band RSE is applied.
- Power recycling gain is set 11.
- Finesse of the cavity is 1550, which means that observational band becomes to be lower than required.
- RSE keeps the frequency band unchanged.

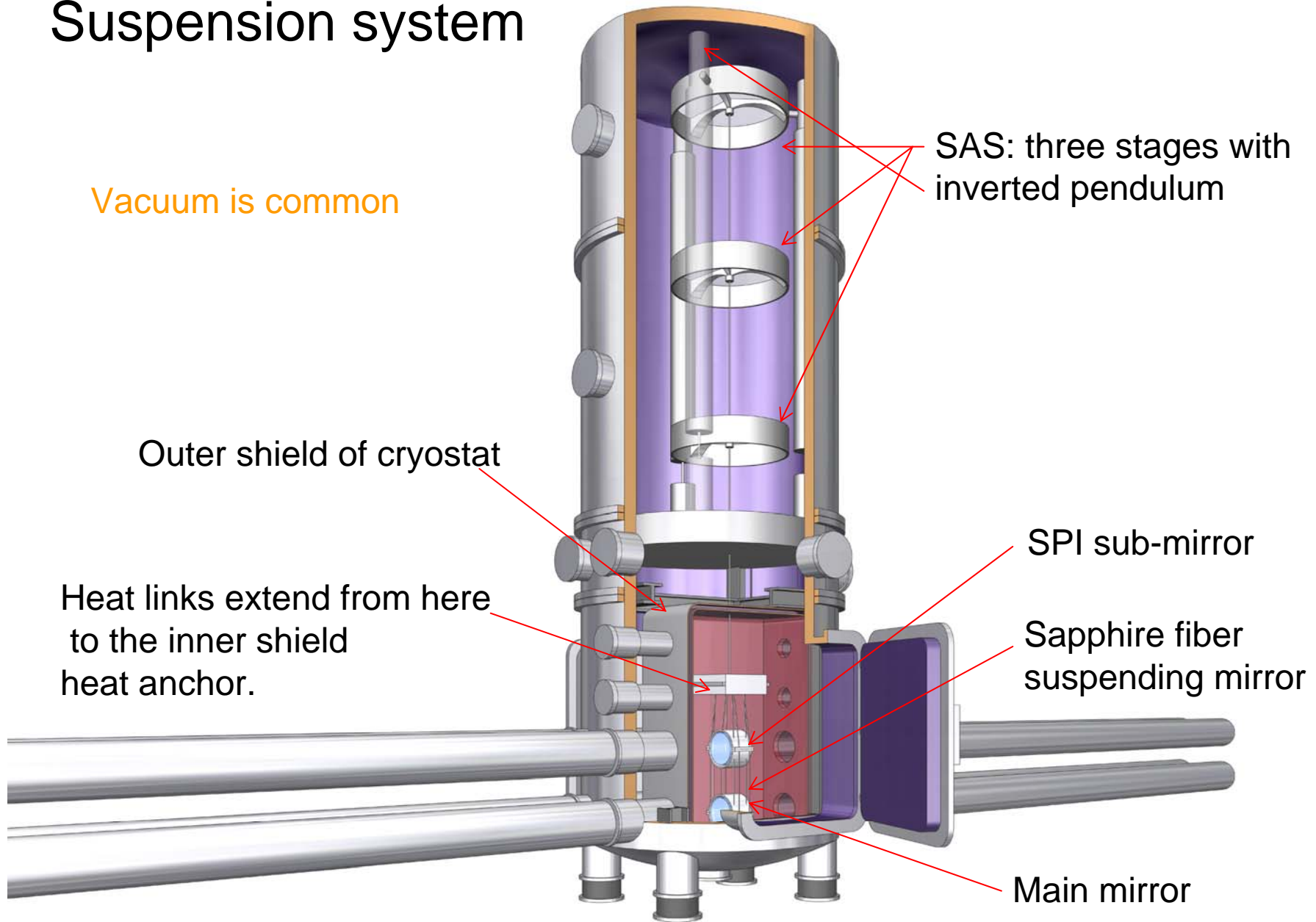
# Refrigerator noise is avoided by SPI

Test mass of LCGT is connected to a cooling system by a heat link that introduces mechanical noise. A **suspension point interferometer (SPI)** is introduced to maintain high attenuation of seismic and mechanical noise without degrading high heat conductivity.



# Suspension system

Vacuum is common





# Schedule and Budget

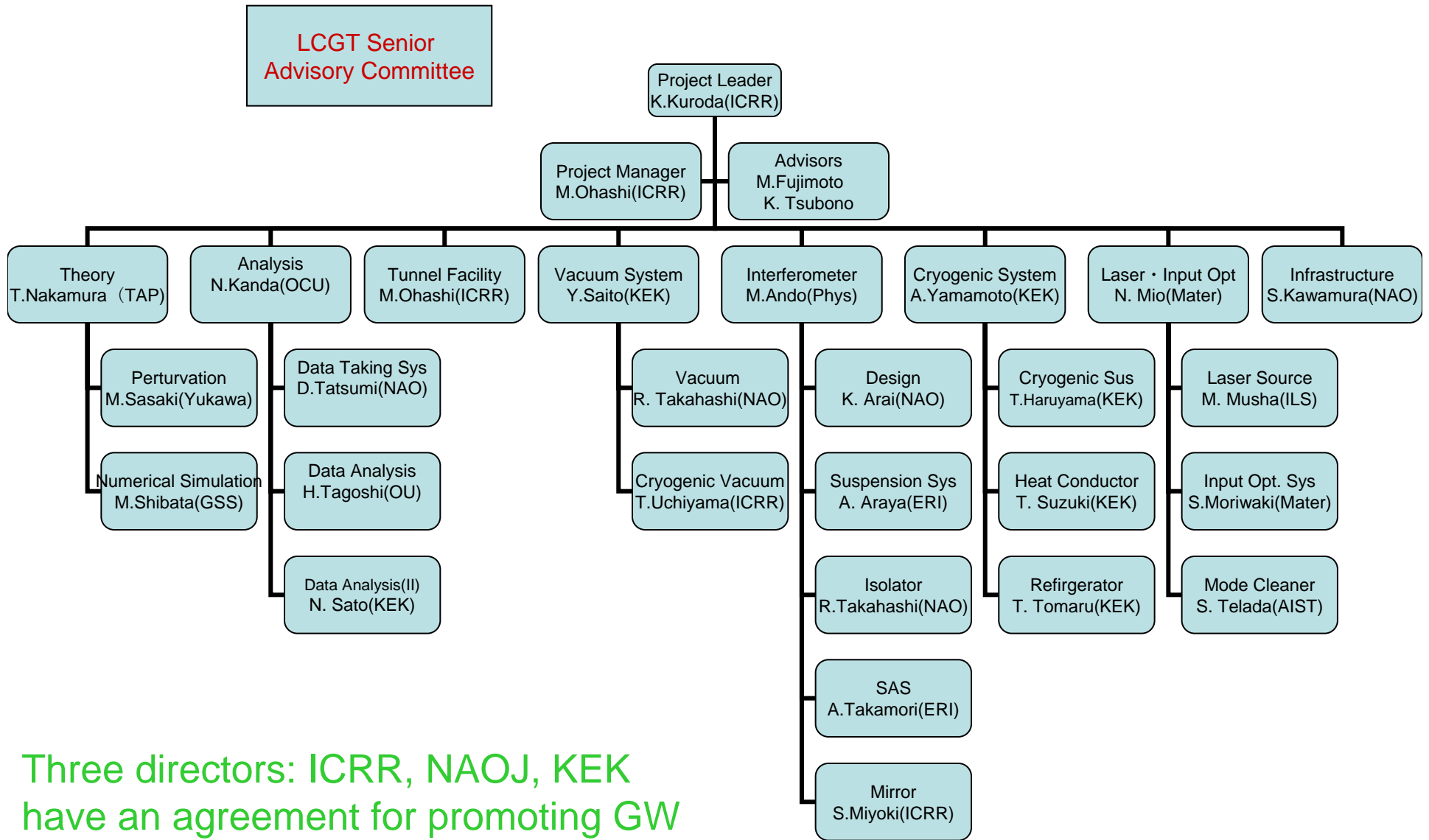
112 JpnYen=1 US\$

Item	2006	2007	2008	2009	2010	2011	2012	Cost (Thousand Yen)
Tunnel	⇒⇒	⇒⇒	⇒					3,396,000
Buildings		⇒⇒	⇒					500,000
Vacuum	→	→	→⇒	⇒				5,250,000
Optics	→	→	→	→⇒	⇒			925,420
Laser	→	→	→	⇒				802,780
Cryo-Suspension	→	→	→	⇒				2,630,000
Anti-vibration	→	→	→	⇒				230,000
Main Mirror	→	→	→	→	⇒Install			300,000
Data-taking			→	→	⇒Install			200,000
Observation						⇒⇒	⇒⇒	600,000
							<b>Total</b>	<b>14,834,2000</b>

US\$ 132M

It does not include salaries & maintenances of facilities.

# LCGT Organization



Three directors: ICRR, NAOJ, KEK  
have an agreement for promoting GW  
experiment.

# International Collaborations

- Succeeding almost all MOUs exchanged under the name of TAMA
  - LIGO (GEO)
  - VIRGO
  - ROG, AURIGA, TWG
- Maintaining MOU with ACIGA
  - Laser, Cryogenic sapphire, etc.
- Initiating a new collaborative work
  - high quality sapphire



# Proposal of collaborative research with the LIGO sapphire group

- Exchange of scientific and/or technical information of sapphire development
  - Accumulated knowledge of sapphire in LIGO
  - Need of high quality sapphire in LCGT
- Application of annealing to sapphire samples
  - 1<sup>st</sup> step (reconfirmation of the effect, this year)
  - 2<sup>nd</sup> step (application to larger size, next year)

# Closing this talk

- Budget asking for FY2006 is ongoing in collaboration with ERI (geophysical strain meter project).
- Usually, this August is the most important in the decision making by the government.
  - Congress dissolved. Ministry renewed in this September. Determination process may delay.
- We have another chance in the next year even if disapproved.