

Current status of Japanese gravitational wave detectors

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for LCGT project (including TAMA collaboration / CLIO collaboration)

LCGT Project

Large Cryogenic Gravitational wave Telescope

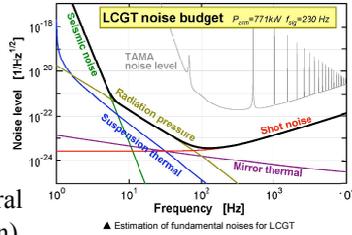
Key features of LCGT

- **Cryogenic mirrors (T~20K)**
=> suppression of thermal noises
- **Underground site at Kamioka**
=> quiet seismic activity
- **km-class baseline**
=> 3km arm length



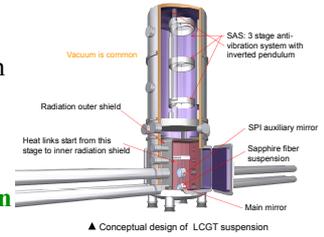
LCGT interferometer

- **150W laser source**
- **Optical configuration:**
Resonant Sideband Extraction
- **Expected binary range**
185Mpc for NS-NS binary inspiral (SNR10, from optimum direction)



LCGT suspension

- **Sapphire cryogenic mirrors**
=> m~30kg, heat transfer by sapphire monolithic suspension
- **Suspension Point Interferometer**
=> isolation from heat link vibration
- **Seismic Attenuation System for the room temp vibration isolation**



LCGT development

Task sharing by **two prototype interferometers**

TAMA300: Interferometer technologies, Sensitivity at kHz-band
SAS development, Digital control system

CLIO: Displacement sensitivity, Thermal noise reduction
Cryogenic technologies

TAMA Interferometer

TAMA interferometer

- Located at Mitaka near Tokyo
- 300m arm length
- Fabry-Perot Michelson with power recycling

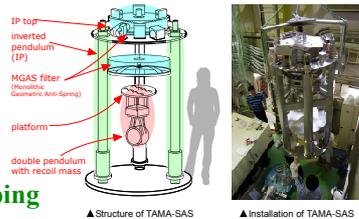


TAMA target

- **Development of TAMA-SAS**
=> International collaboration with LIGO / Univ of Pisa
- **Establishment of interferometer technologies**
=> Interferometer sensing and control

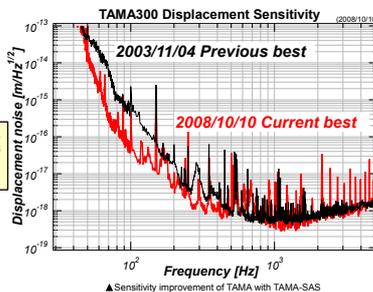
TAMA-SAS

- **Low freq vibration isolation**
Inverted pendulum
Vertical filters (MGAS)
Double pendulum suspension
- **Passive isolation + active damping**



TAMA sensitivity

- **Sensitivity improvement**
=> $4 \times 10^{-19} \text{m/rtHz}$ @1kHz

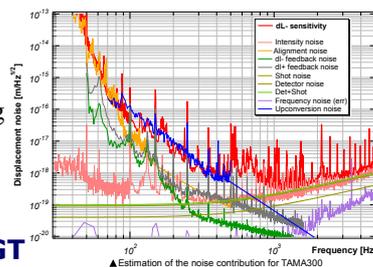


- Achieved reduction of alignment control noise with TAMA-SAS

=> owing to reduced angular motion of the test mass in the 1Hz-10Hz band

- Noise contribution estimated

=> low freq. excitation experiment revealed upconversion noise is limiting the sensitivity at 100~500Hz



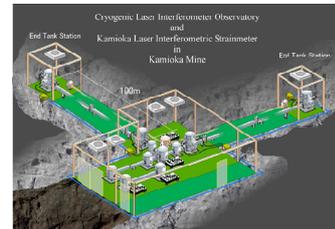
Future plan toward LCGT

- **Implement of Resonant Sideband Extraction**
=> Establishment of length/alignment control scheme

CLIO Interferometer

CLIO interferometer

- Located at Kamioka mine
- 100m arm length
- two orthogonal Fabry-Perot arms
- Sapphire mirror cooled at 20K

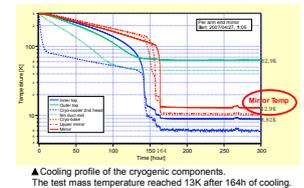
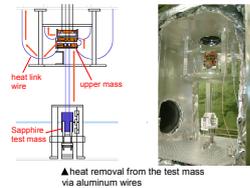


CLIO target

- **Demonstration of mirror cooling**
=> heat link design / suspension design
- **Demonstration of thermal noise reduction by mirror cooling**
=> pursue of displacement sensitivity
- **Experience of underground site operation**
=> infrastructures / working time limitation / safety

Mirror cooling

- **Heat link to an upper suspension stage** => 5N Al wire heat contact
- **Al fiber suspension (0.5mm in dia.)**
- **Low vibration PT refrigerators**
- **Mirror successfully cooled up to 12-14K**



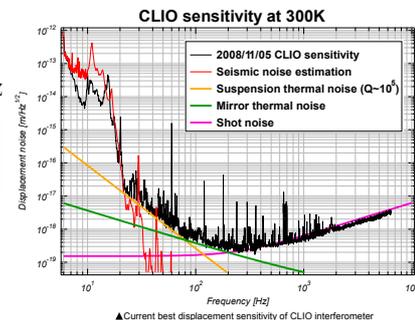
CLIO sensitivity

- **Sensitivity at 300K**
=> $2.5 \times 10^{-19} \text{m/rtHz}$ @250Hz

- 300K goal achieved: close to the sensitivity limit

- mirror thermal noise

=> thermoelastic damping is dominant at 300K



Future plan toward LCGT

- **Realize noise reduction by cooling of the mirror**

=> Now being carrying out:

Refinement of the cryogenic suspension and the interferometer system