Status of gravitational wave detection in Japan

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on behalf of

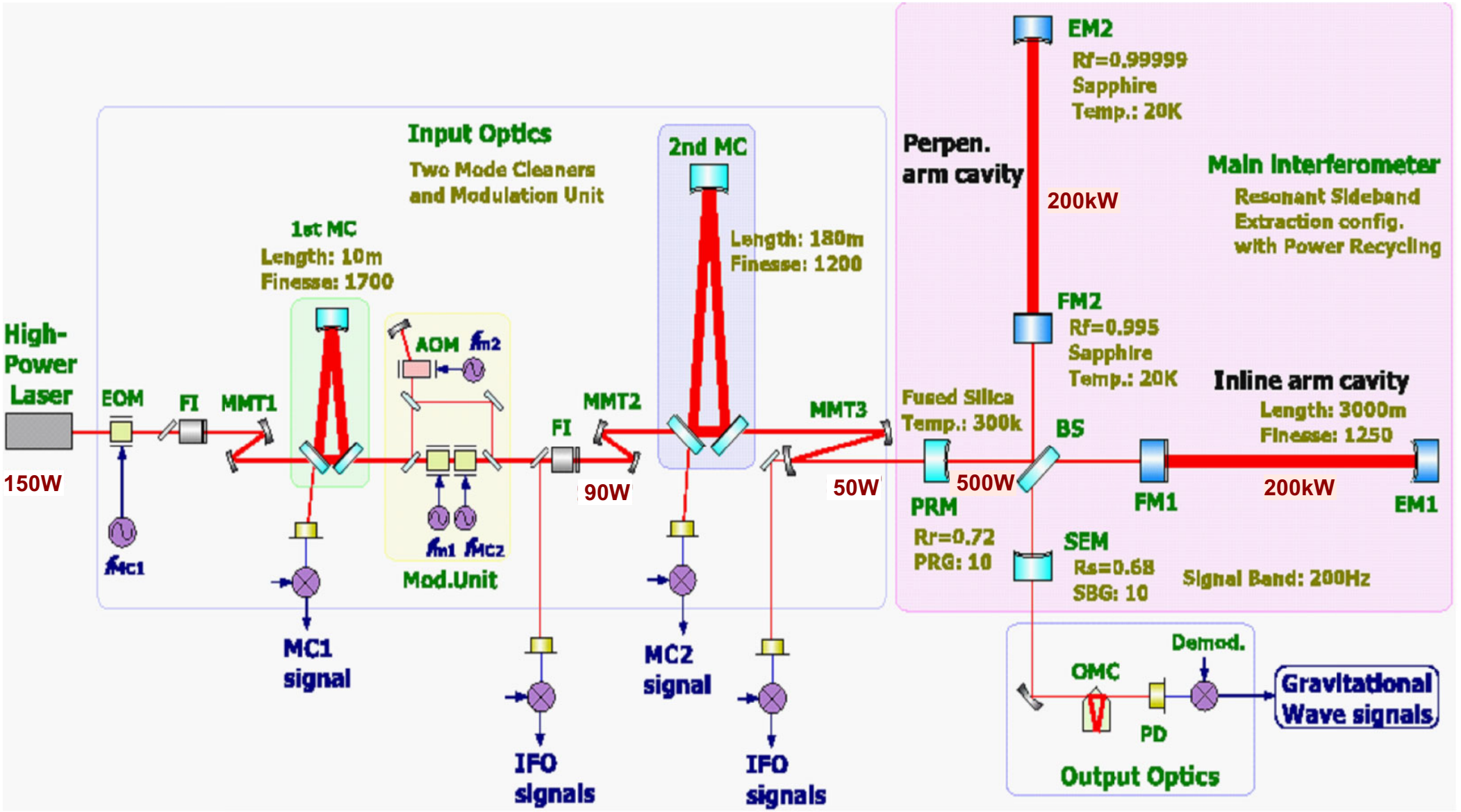
TAMA Collaboration and LCGT Collaboration

LCGT Project

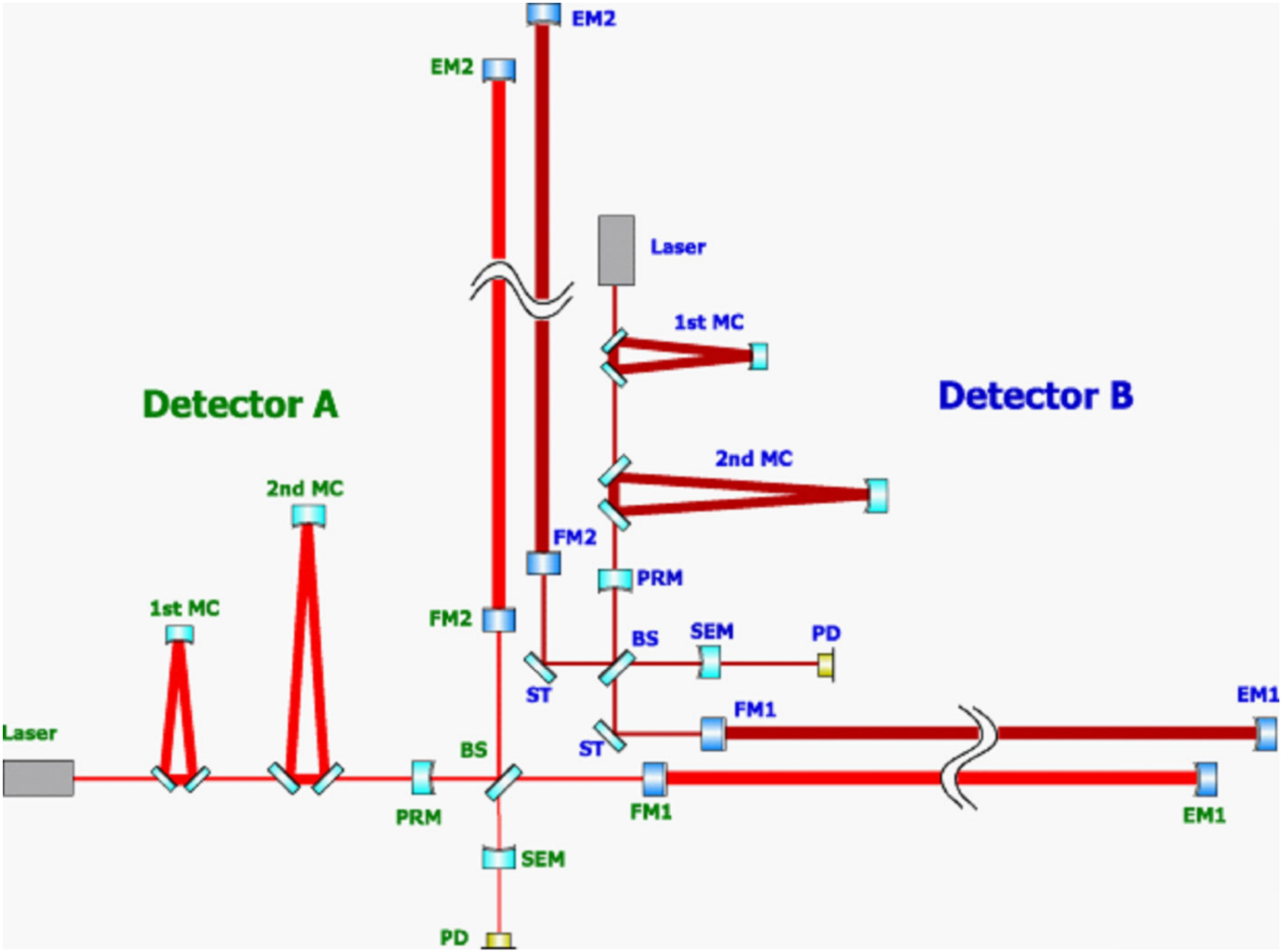
- Japanese advanced interferometer for GW detection
  - 3-km Fabry-Perot Michelson interferometer
  - with power recycling
  - resonant sideband extraction (RSE)
  - laser power of 150W
- Sapphire test masses
  - cooled up to 20K
  - suspension point interferometer (SPI)
- Sited at Kamioka mine
  - underground mine
  - two independent interferometers to reject fake events
- Main target ~ the coalescence of BNS
  - expected 1.2-27.8 events per year
    (C.L. of 95% for 1.4Msolar with S/N=10)

Optical configuration of LCGT

- *Power recycling gain of 10*
- *Signal gain of 10 by RSE (fc=200Hz)*

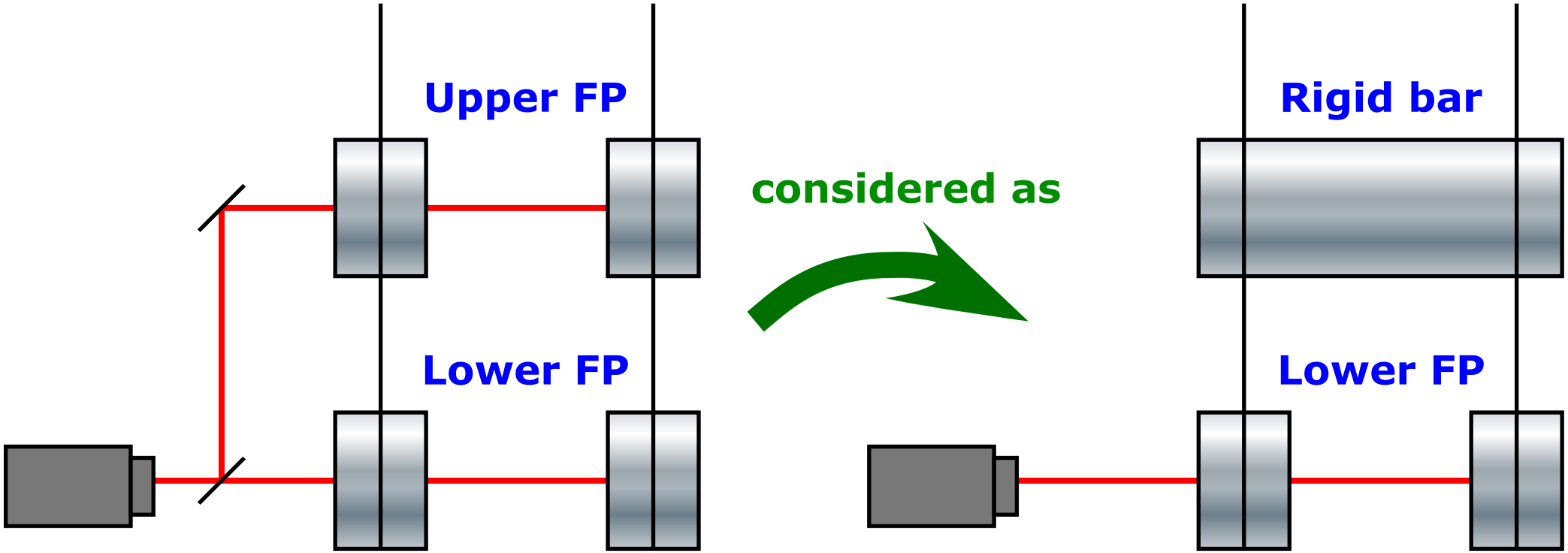


Two detector at a place

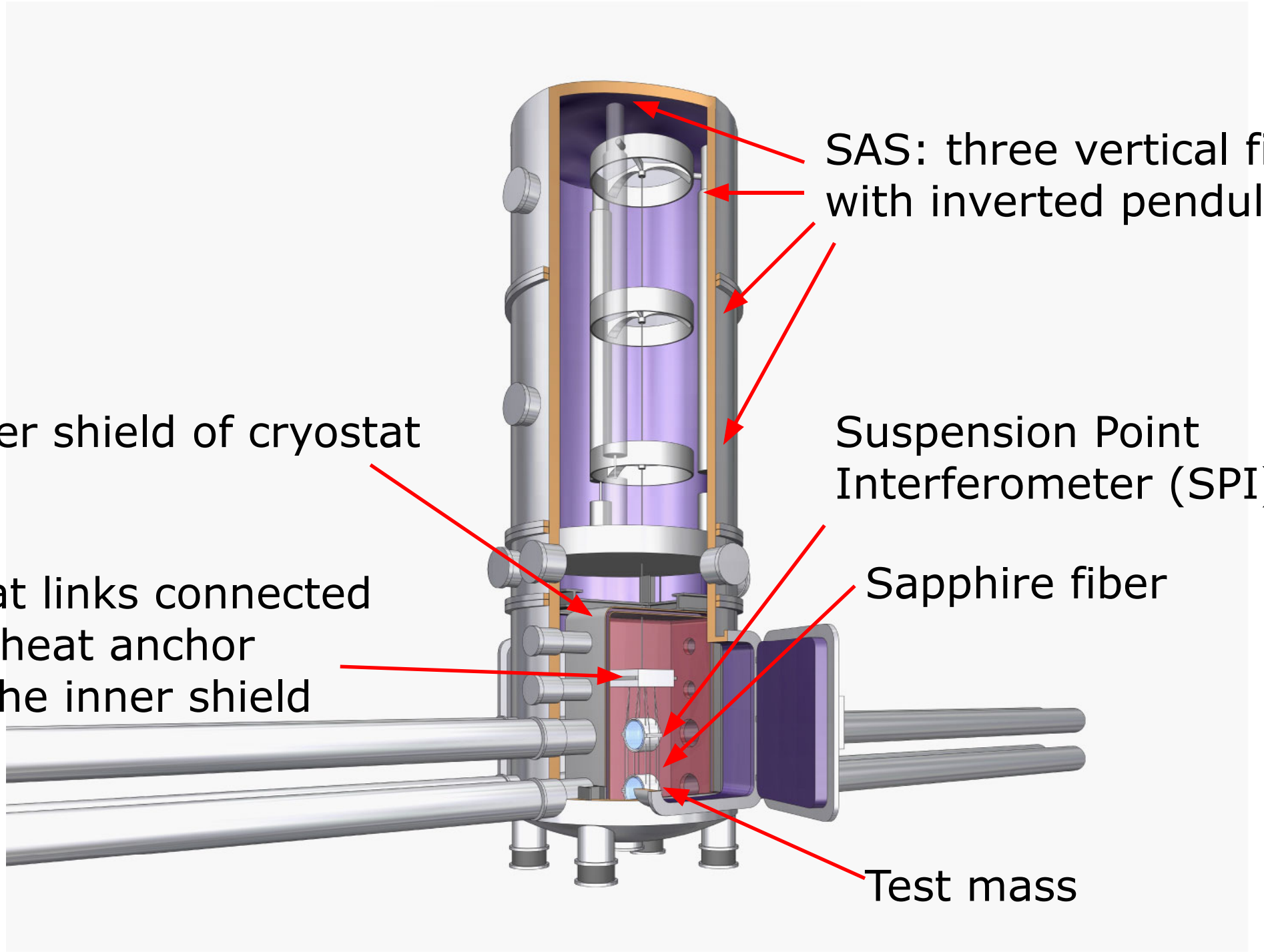


SPI: Suspension Point Interferometer

- ***A sort of active isolation system***
  Attenuate vibrations introduced through heat links
- ***Assist lock acquisition***
- ***Actuators with smaller range for the test masses***
  => smaller noise

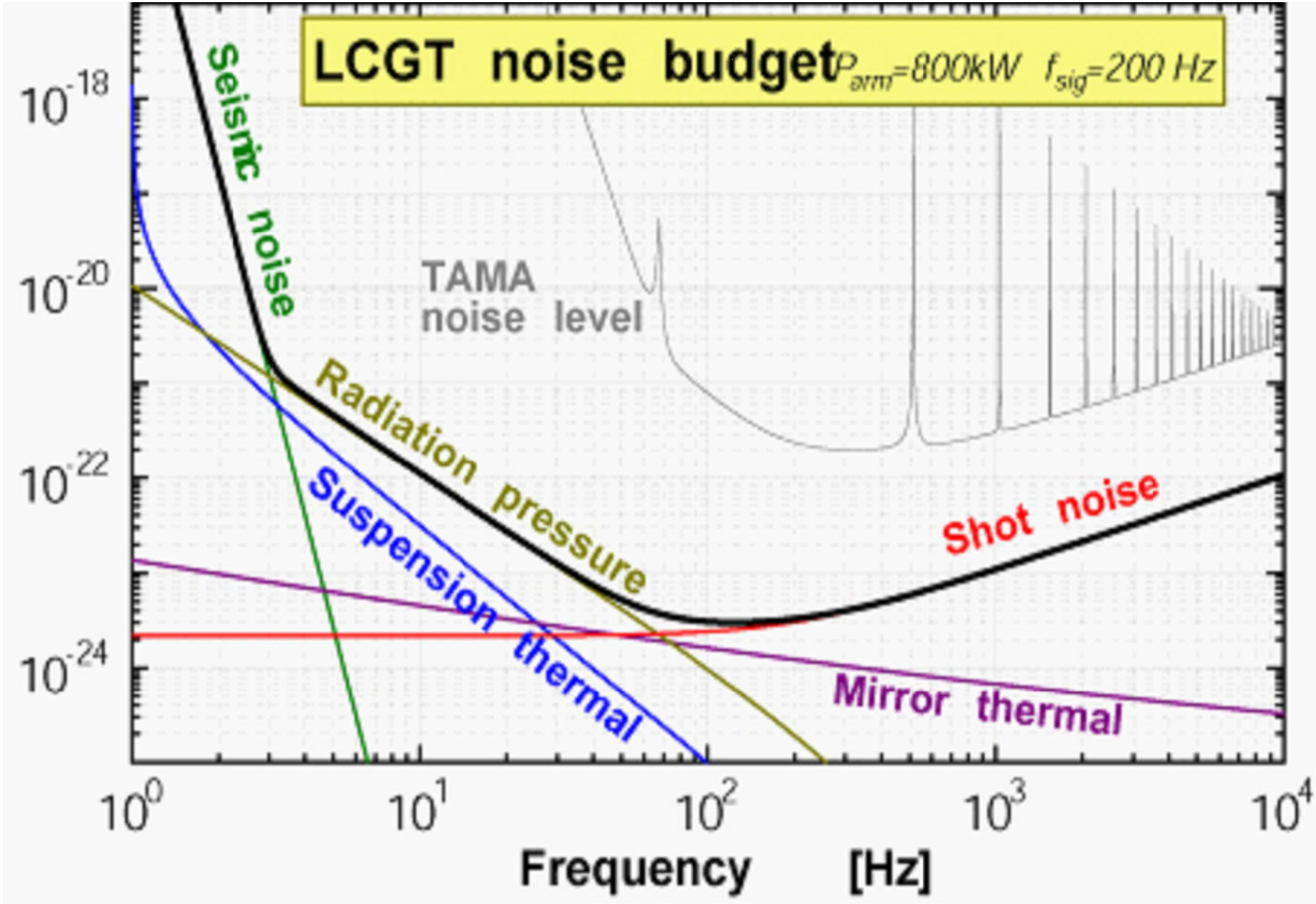


Suspension and vacuum system

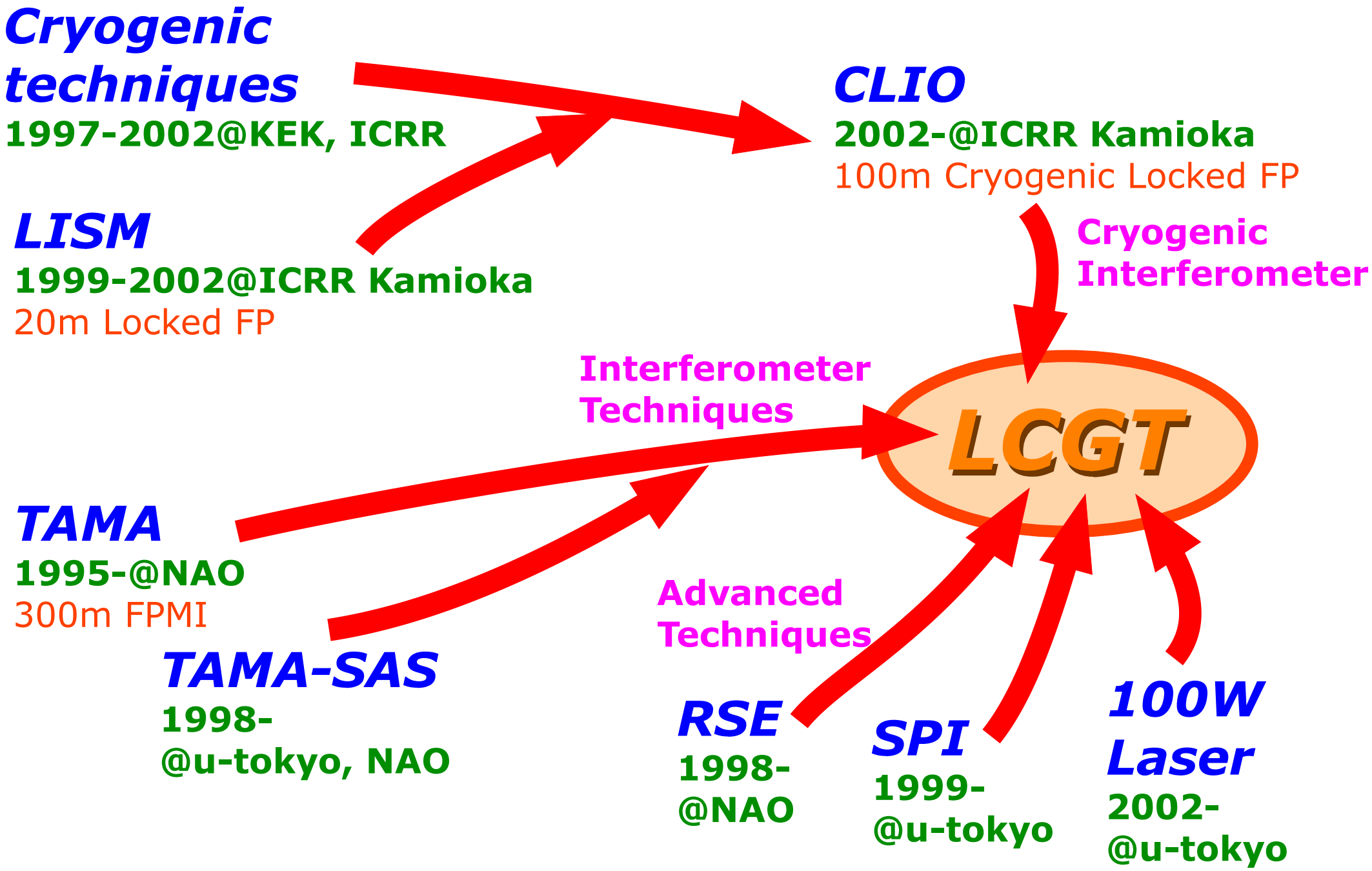


LCGT sensitivity

To be limited only by quantum noises in the obs. band



Technical foundations of LCGT



TAMA300

- ***Laser interferometric GW detector***
  with arm length of 300m

  Site: National Astronomical Observatory of Japan, (Mitaka, Tokyo)

- ***Objects of the project***

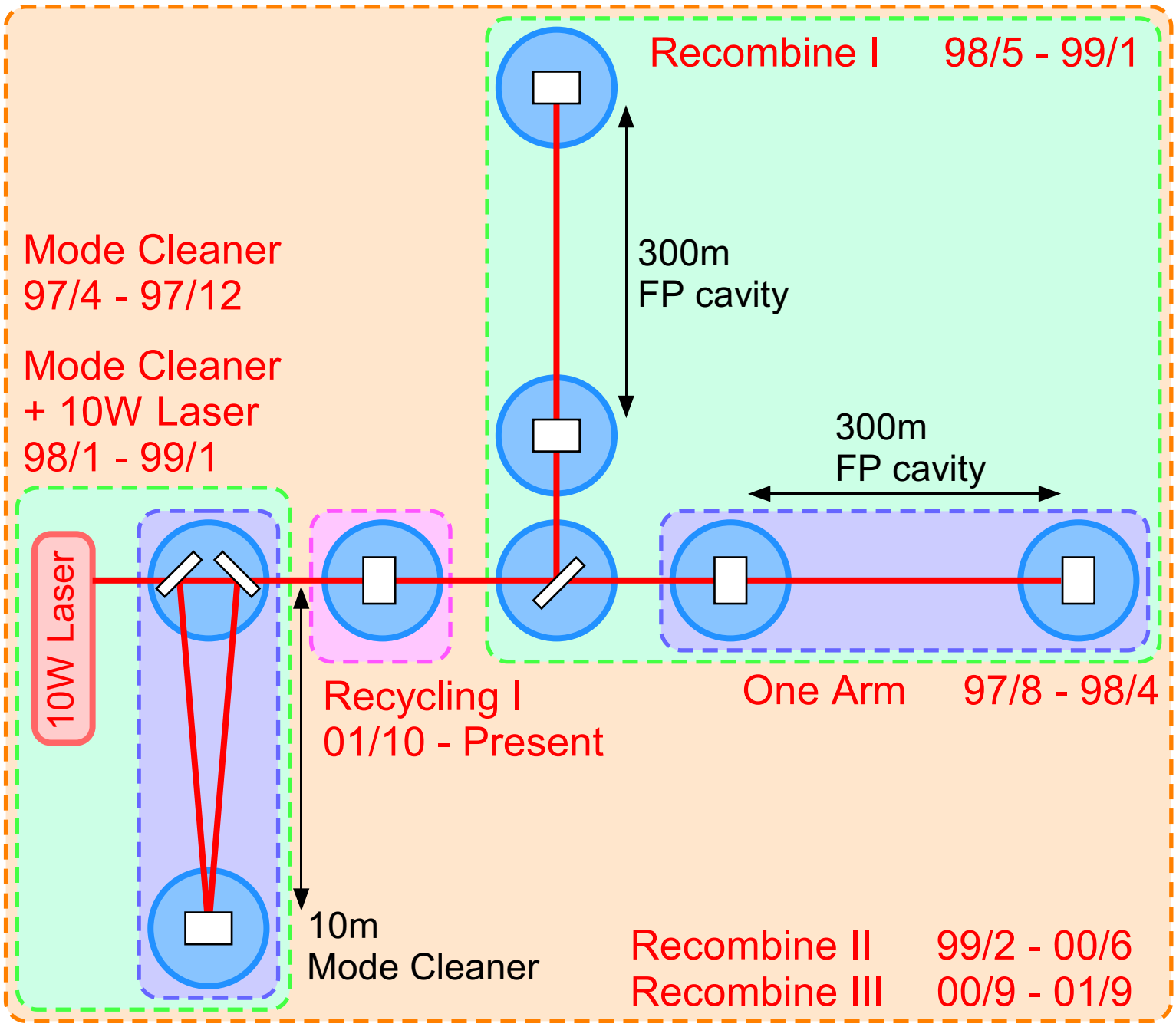
  To develop a detector capable to detect GW events in nearby galaxies.

  To establish necessary interferometer techniques for LCGT

- ***Designed sensitivity***

  $h_{RMS} = 3 \times 10^{-21}$ @300Hz (BW300Hz)

Progress of TAMA300 development



1995 Project started

1997 Arm cavity locked

1999 FPMI operation
DT1(11h)
DT2(31h)
2000 DT4(167h)
2001 DT6(1038h)
Power Recycling

2002 Coincidence Run
with LIGO(S1)
and GEO600

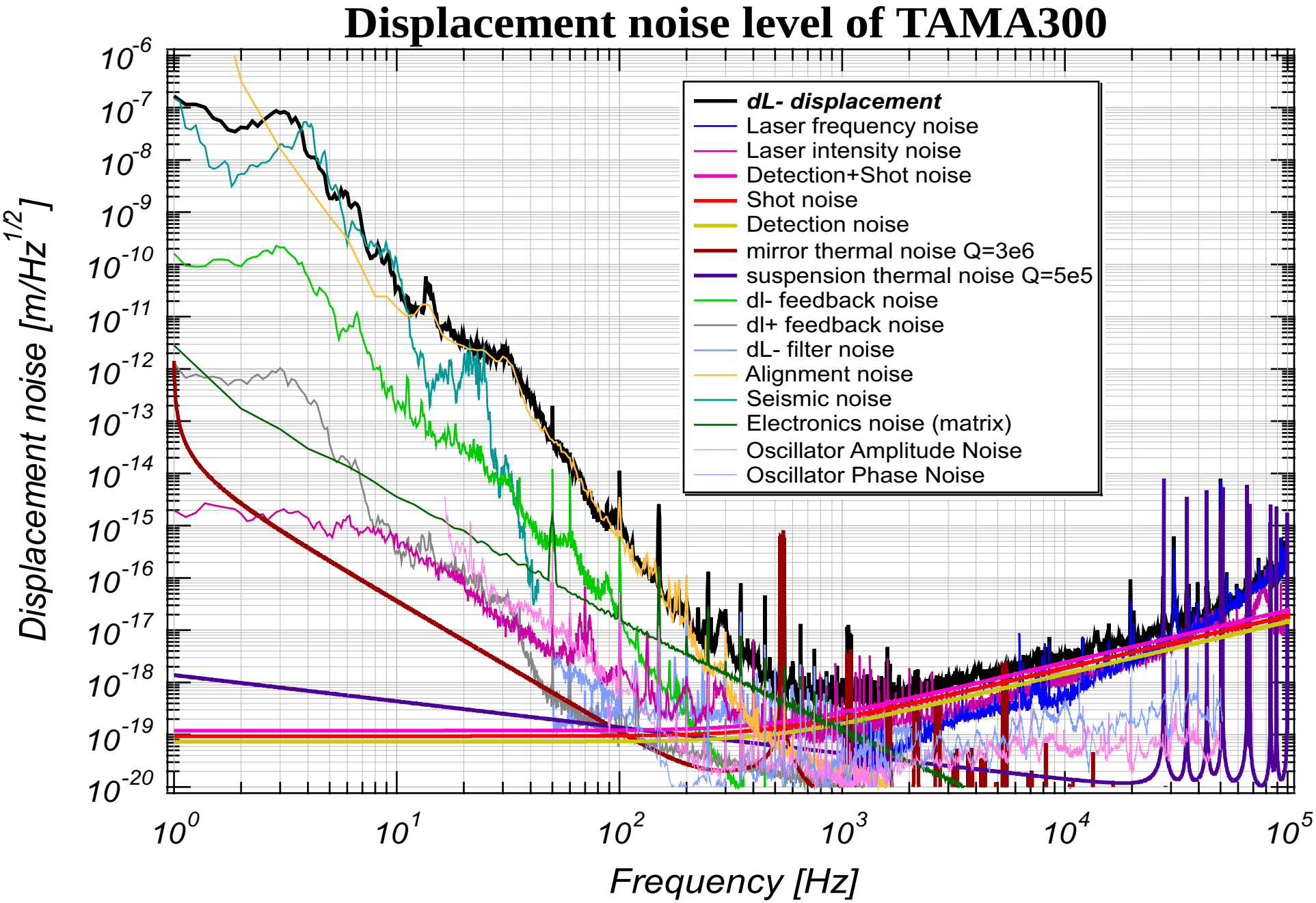
2003 DT8(1158h)
with LIGO(S2)
2003~4
DT9
with LIGO(S3)
and GEO600
Full Automatic Operation
2004~5 Noise hunting
TAMA-SAS

Observation runs: DT1~DT9

Data Taking		Objective	Observation time	Typical strain noise level	Total data (Longest lock)
DT1	August, 1999	Calibration test	1 night	3×10^{-19} /Hz $^{1/2}$	10 hours (7.7 hours)
DT2	September, 1999	First Observation run	3 nights	3×10^{-20} /Hz $^{1/2}$	31 hours
DT3	April, 2000	Observation with improved sensitivity	3 nights	1×10^{-20} /Hz $^{1/2}$	13 hours
DT4	Aug.-Sept., 2000	100 hours' observation data	2 weeks (night-time operation)	1×10^{-20} /Hz $^{1/2}$ (typical)	167 hours (12.8 hours)
DT5	March, 2001	100 hours' observation with high duty cycle	1 week (whole-day operation)	1.7×10^{-20} /Hz $^{1/2}$ (LF improvement)	111 hours
DT6	Aug.-Sept., 2001	1000 hours' observation	50 days	5×10^{-21} /Hz $^{1/2}$	1038 hours (22.0 hours)
DT7	Aug.-Sept., 2002	Full operation with Power recycling	2 days		25 hours
DT8	Feb.-April., 2003	1000 hours Coincidence (S2)	2 months	3×10^{-21} /Hz $^{1/2}$	1157 hours (20.5 hours)
DT9	Nov.-Jan. 2003-2004	Automatic operation Coincidence (S3)	44 days (night-time in weekdays)	2×10^{-21} /Hz $^{1/2}$	557 hours (28.1 hours)

More than 3000 hours data

Noise budget



SAS: Seismic Attenuation System

- ***Development of SAS***

Collaboration with

Caltech and **Universita' di Pisa**

- ***Installation***

'05 summer:

1 SAS for one of the end mass

'05 autumn/winter:

The other 3 SASs

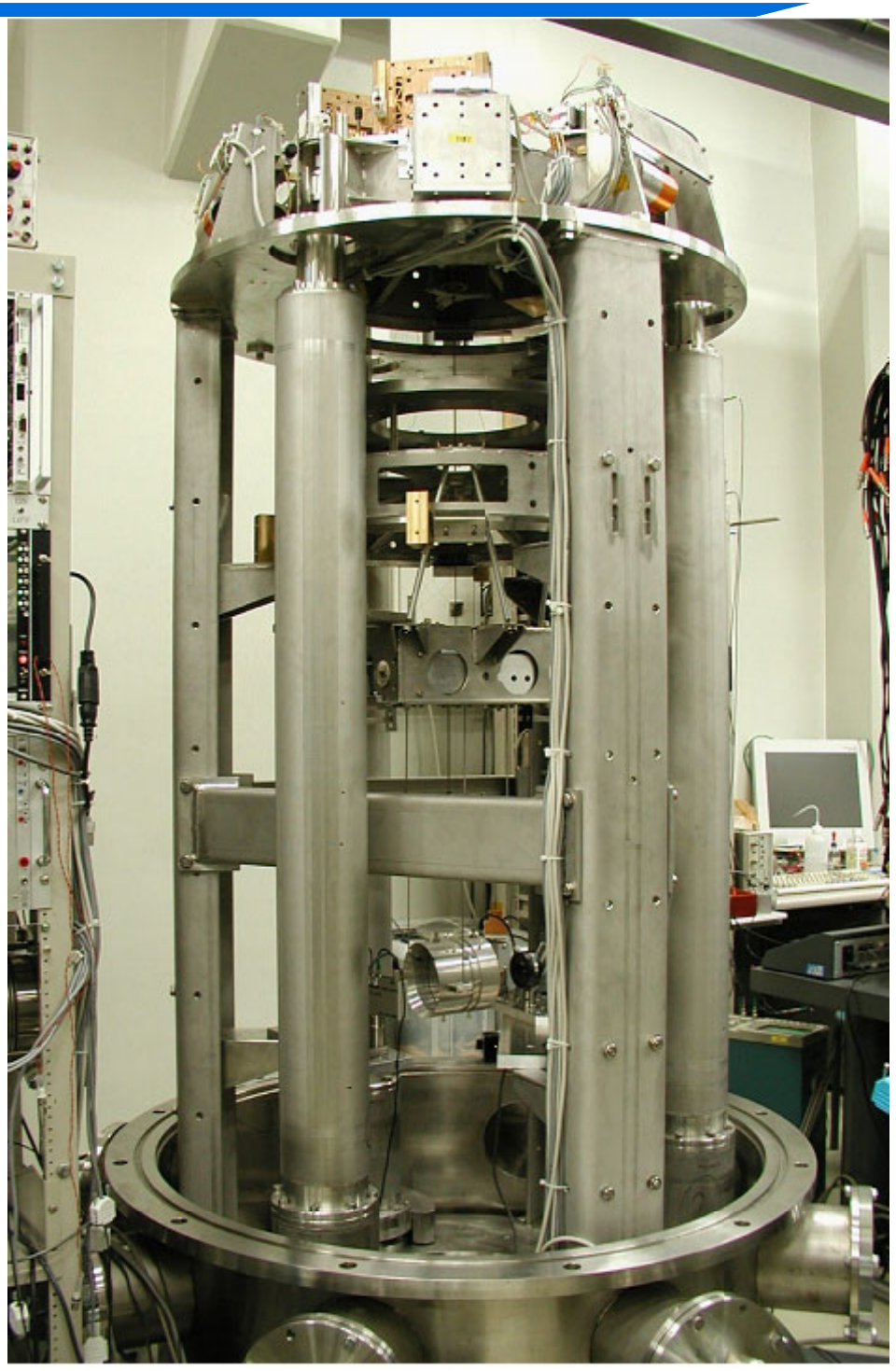
- ***Target***

To improve seismic-related noise

direct or indirect noise couplings

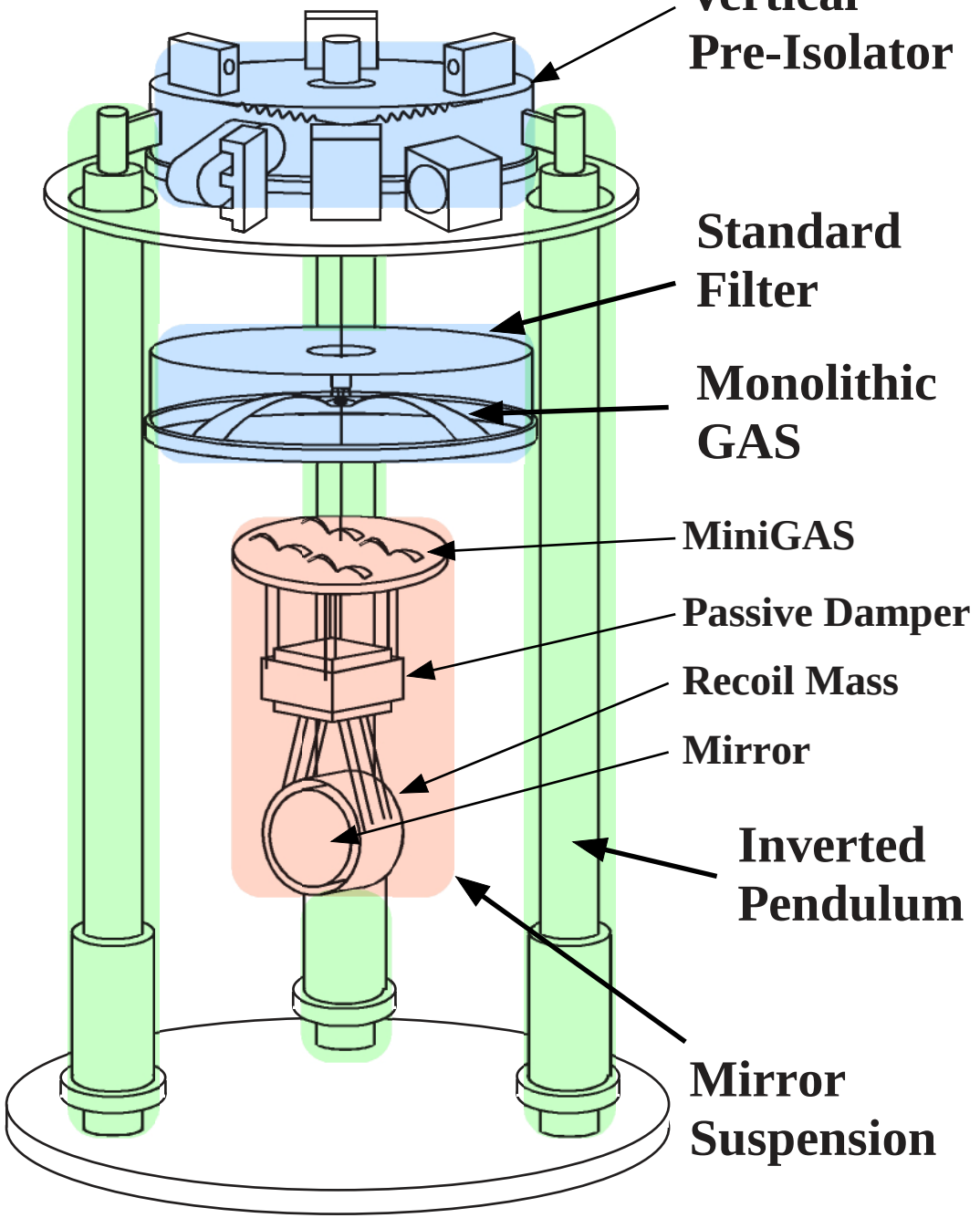
To stabilize the IFO operation

To ease lock acquisition



SAS: Seismic Attenuation System

- ***Inverted Pendulum***
  - Horizontal isolation
  - Resonant frequency:
    - Currently 70-80mHz
    - To be 30mHz
- ***MGAS***
  - Vertical isolation
  - Resonant frequency:
    - To be 0.4~0.5Hz



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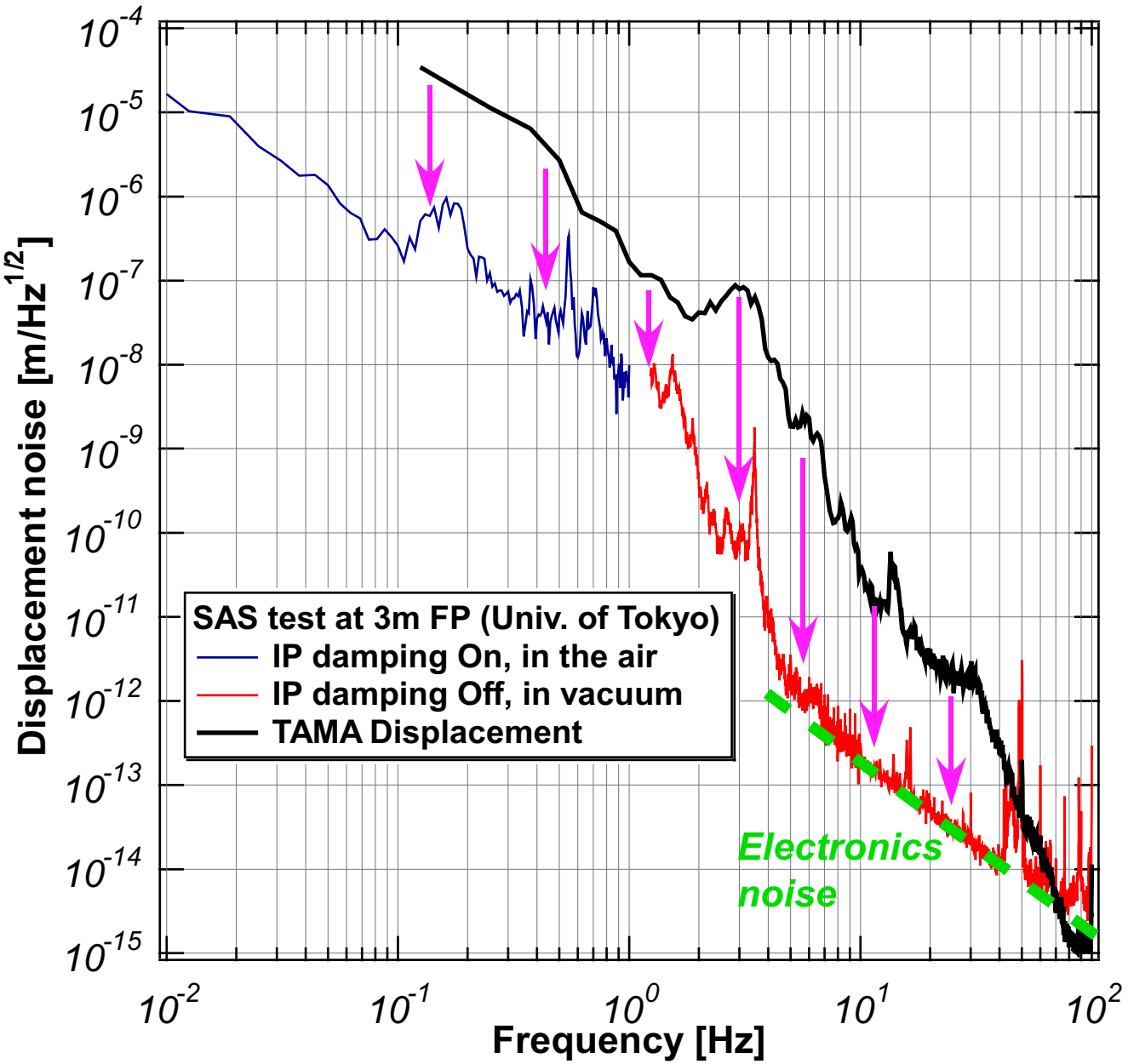


Test@3mFP

Displacement

10^{-8} m/Hz$^{1/2}$

->

10^{-11} m/Hz$^{1/2}$

RMS Velocity

3.7 μm/s

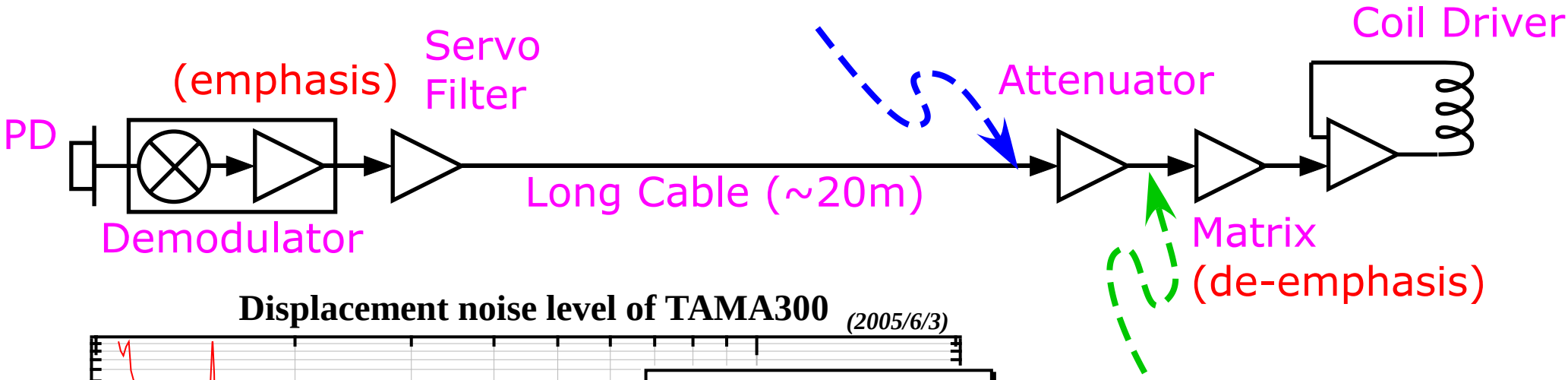
->

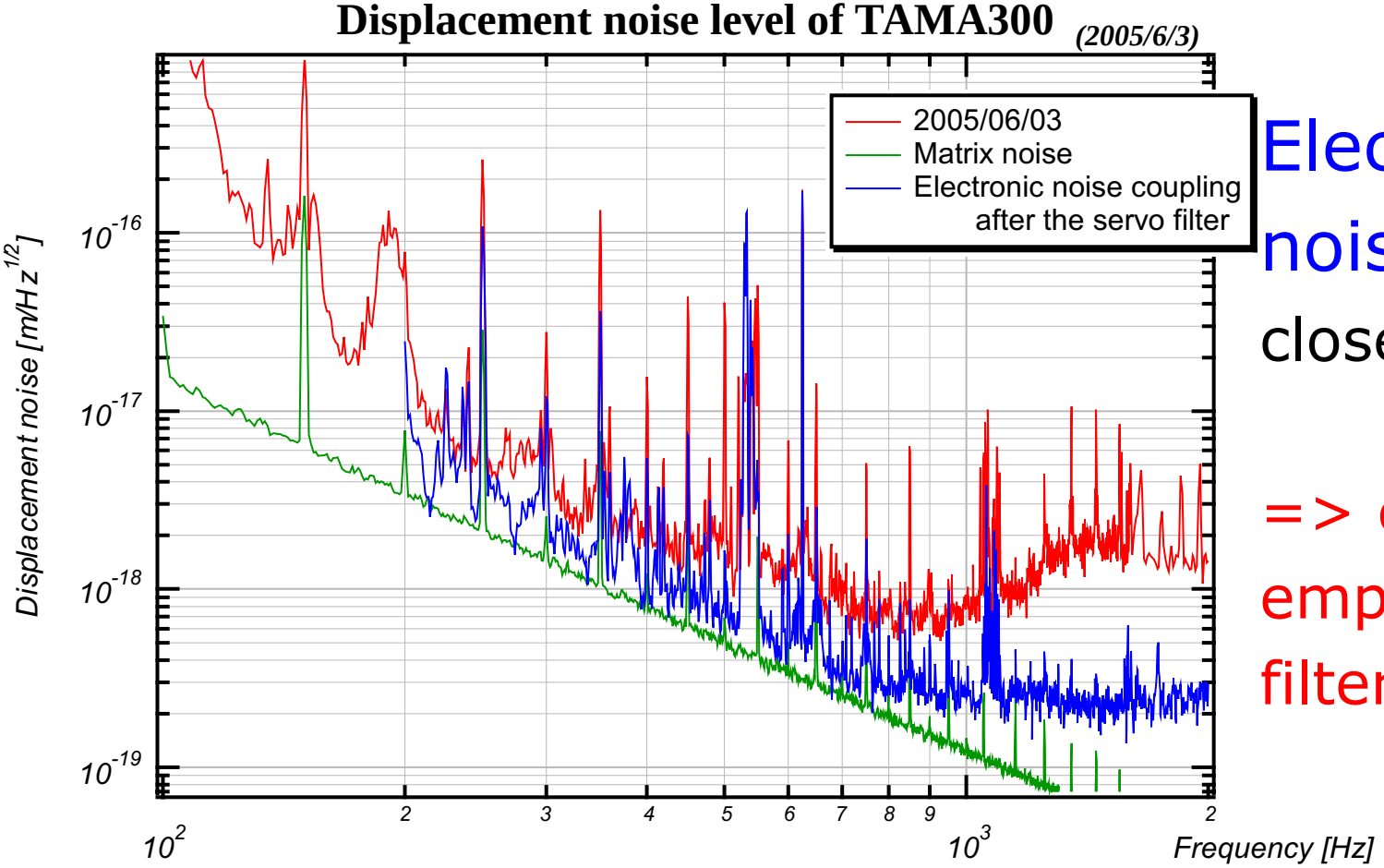
0.3 μm/s

Expected: lower seismic/alignment noise, easier lock acquisition

Electronic noise

- **dL- servo chain**





Electronic noise / noise coupling close to limit the sensitivity

=> currently trying emphasis/de-emphasis filters

Summary

- ***LCGT: Japanese future interferometer for GW detection***

- ***Interferometric GW detector TAMA300***

  To establish interferometer techniques for LCGT

- ***Current efforts focused on noise hunting***

- ***SAS: Seismic Attenuation System***

  Vibration isolation from 0.1Hz region

  Installation work on going

- ***Electronics noise***

  Trying to arrange the gain distribution