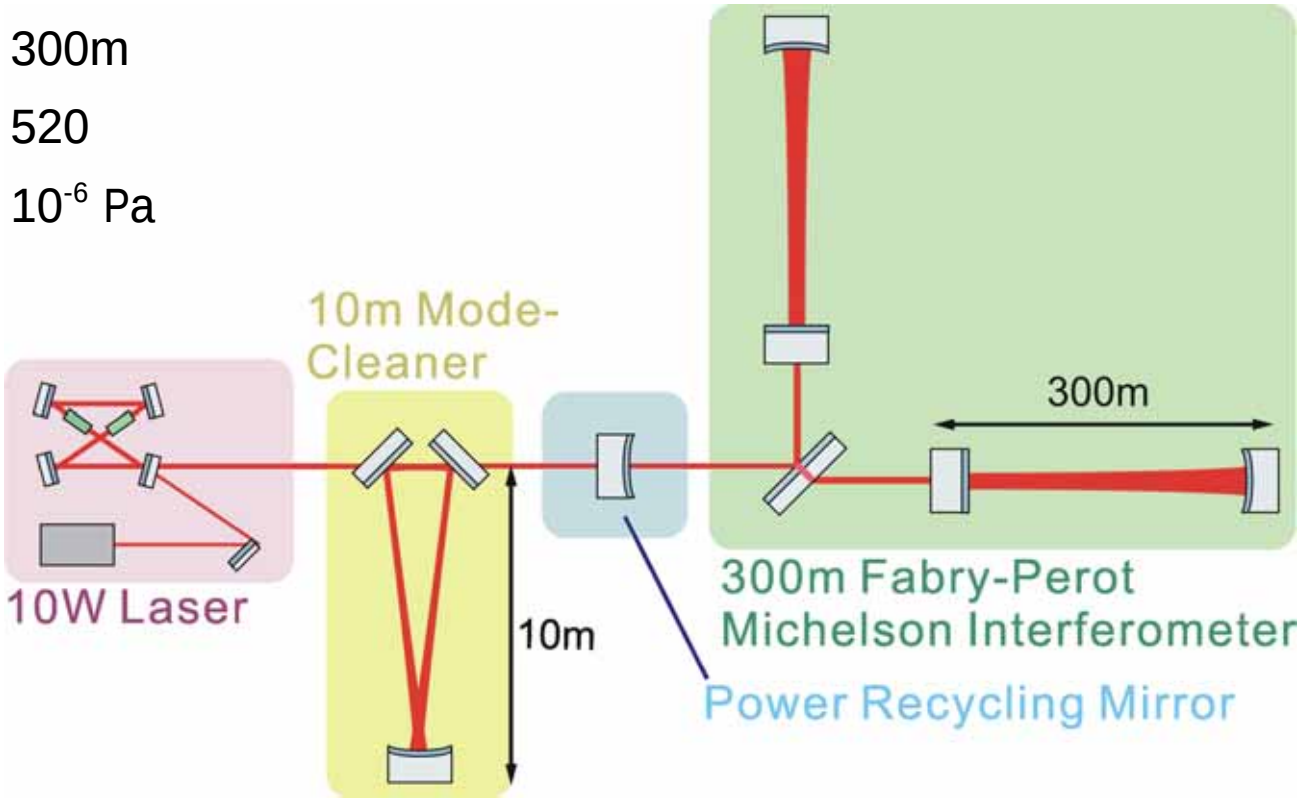
Status of TAMA300

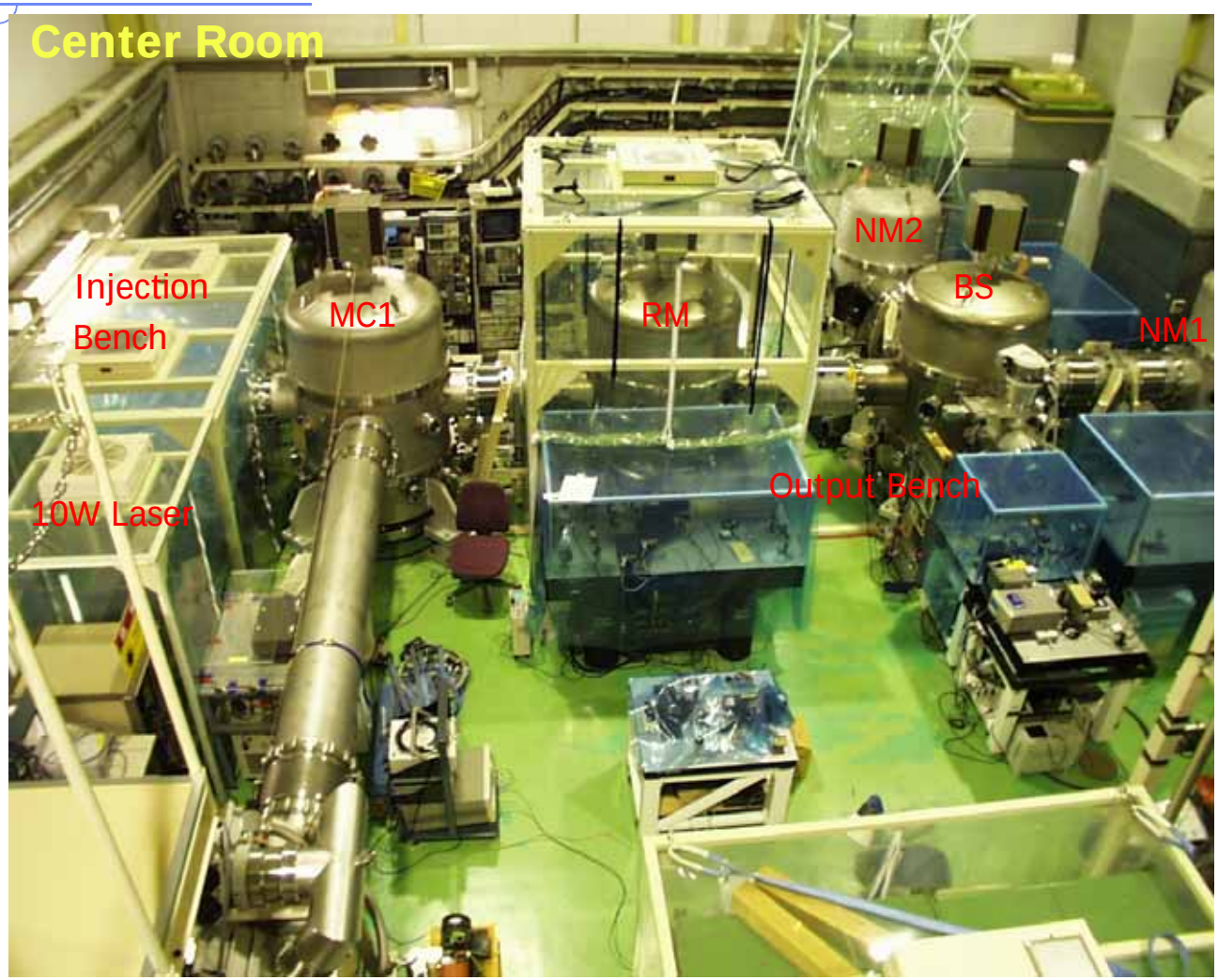
National Astronomical Observatory, The University of Tokyo,
The Institute for Cosmic Ray Research, Institute for Laser Science,
KEK-High Energy Accelerator Research Organization,
Osaka City University, Osaka University,
Yukawa Institute of Theoretical Physics

Specification

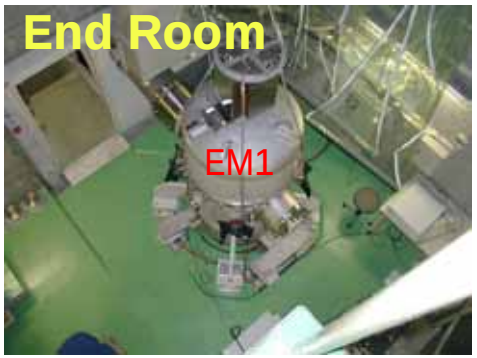
Location	Mitaka campus of NAO (E139.32.21 N35.40.25)
Aimed sensitivity	h=3x10^{-21} @300Hz (BW 300Hz)
Type	Recycled Fabry-Perot Michelson Interferometer
Laser	Injection-lock Nd:YAG (λ=1062nm), 10W
Baseline length	300m
Finesse of cavity	520
Vacuum	10^{-6} Pa



Facilities


Center Room
Injection
Bench
MC1
RM
NM2
BS
NM1
Output Bench
10W Laser

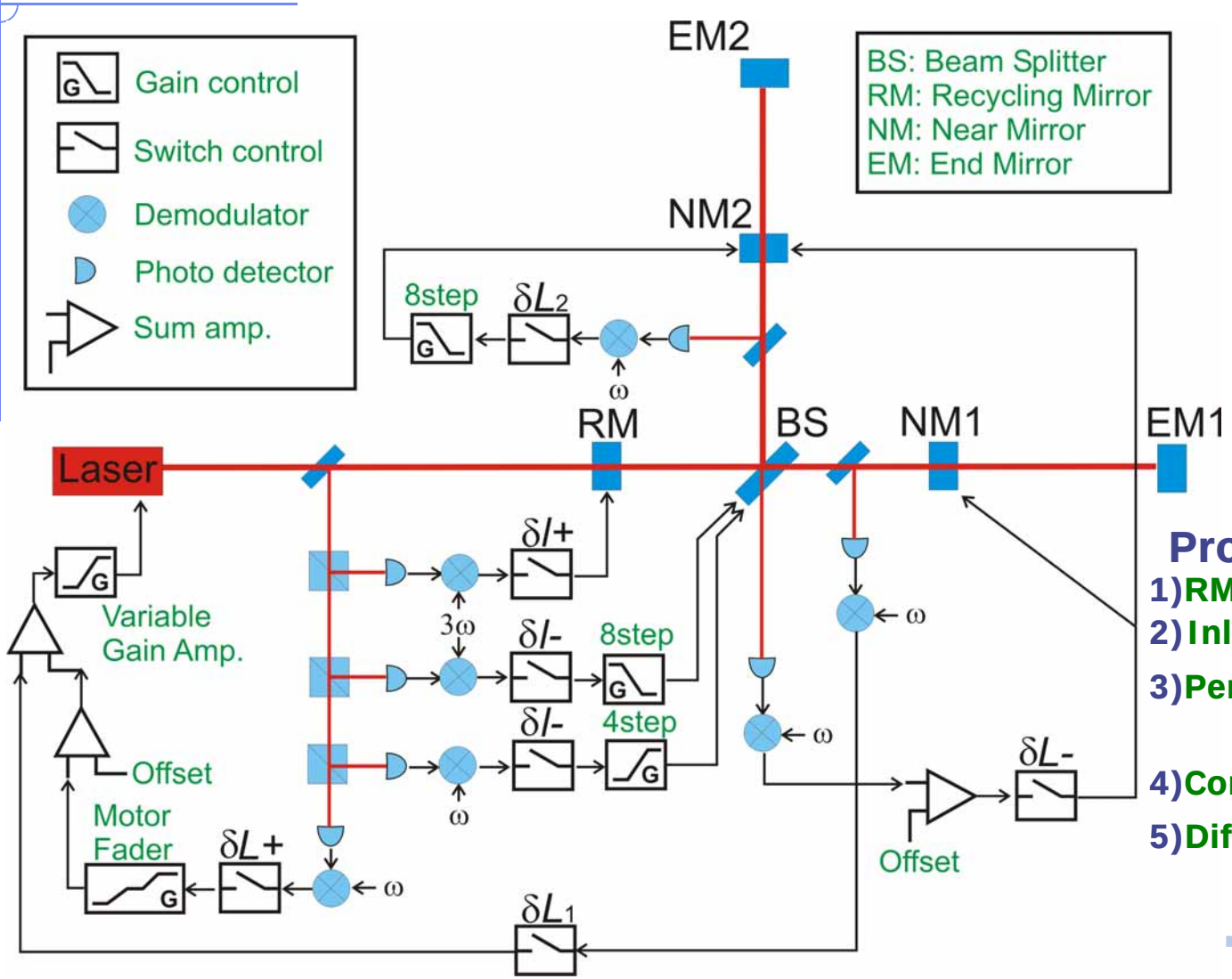

Tunnel
300m Tube


End Room
EM1

Past data taking (DT)

	Period	Obs. Time	Main Target
DT1	1999 8/6 ~ 8/7	11h	Establishment of calibration
DT2	1999 9/17 ~ 9/20	31h	First event search
DT3	2000 4/20 ~ 4/23	13h	Improved sensitivity
DT4	2000 8/21 ~ 9/4	167h	100-h data
DT5	2001 3/2 ~ 3/10	111h	24-h full-time observation
DT6	2001 8/1 ~ 9/20	1038h	1000-h data
DT7	2002 8/31 ~ 9/2	25h	Recycling
DT8	2003 2/14 ~ 4/14	1158h	International coincidence run

Lock system for recycled FPMI

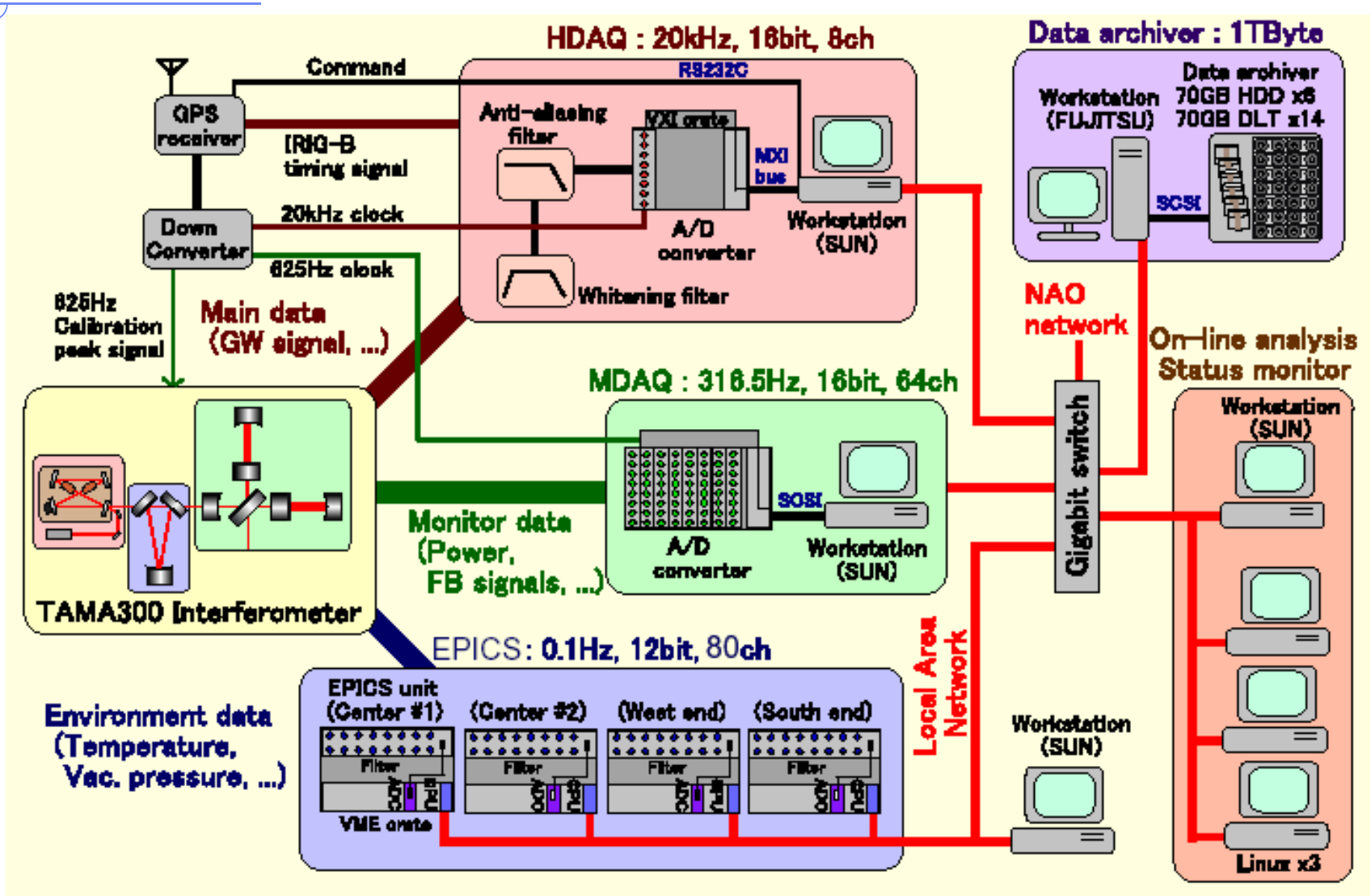


Procedure

1) **RMI ($\delta l+$, $\delta l-$)**
2) **Inline arm (δL_1)**
3) **Perpendicular arm (δL_2)**

   $\delta l-$: $3\omega \rightarrow \omega$
4) **Com. mode ($\delta L_1 \rightarrow \delta L+$)**
5) **Diff. mode ($\delta L_2 \rightarrow \delta L-$)**

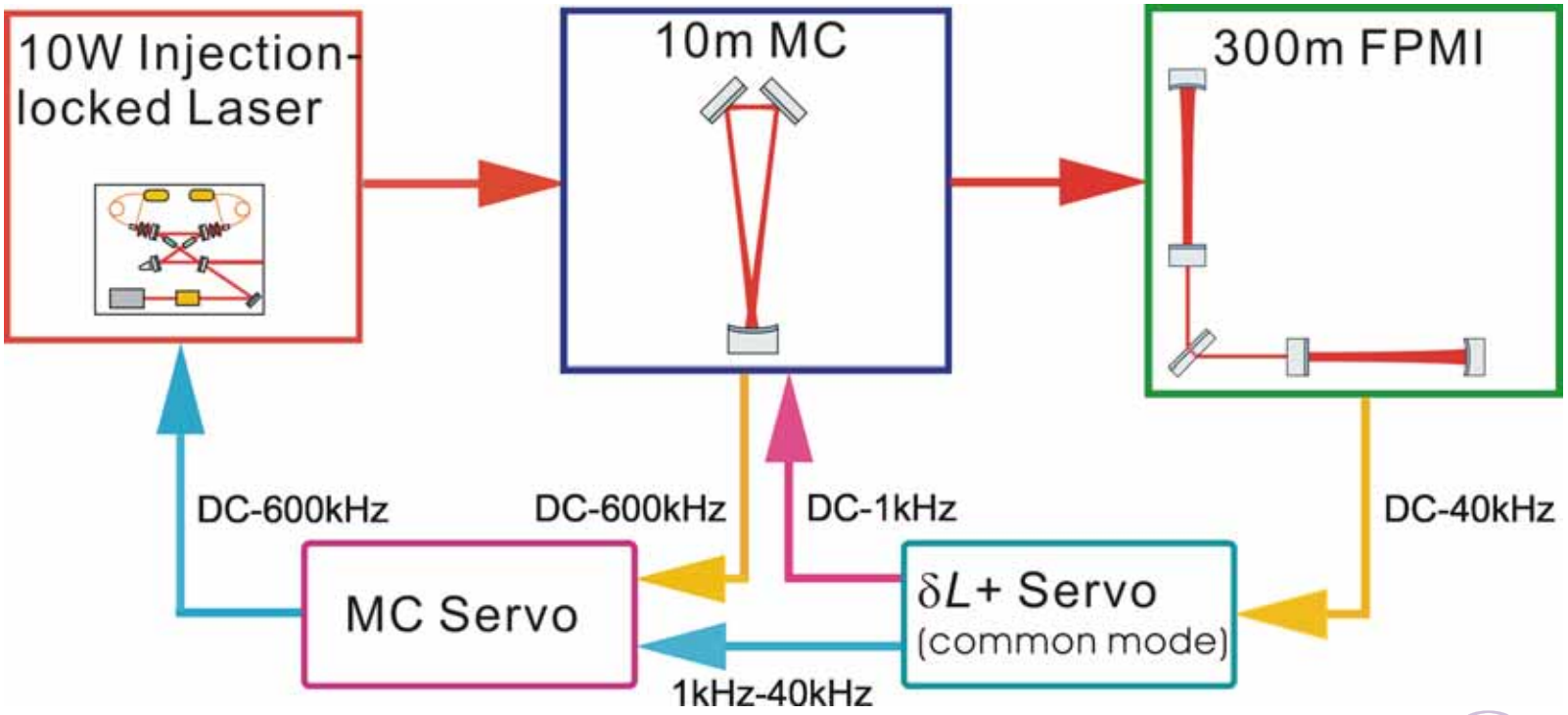
DAQ system


HDAQ : 20kHz, 16bit, 8ch
Data archiver : 1TByte
Command
RS232C
GPS receiver
IRIG-B timing signal
Anti-aliasing filter
VXI crate
MXI bus
Workstation (FUJITSU)
Data archiver 70GB HDD x6 70GB DLT x14
SCSI
Down Converter
20kHz clock
A/D converter
Workstation (SUN)
625Hz clock
Whitening filter
625Hz Calibration peak signal
Main data (GW signal, ...)
NAO network
On-line analysis Status monitor
MDAQ : 316.5Hz, 16bit, 64ch
Gigabit switch
Workstation (SUN)
SCSI
Monitor data (Power, FB signals, ...)
A/D converter
Workstation (SUN)
TAMA300 Interferometer
EPICS : 0.1Hz, 12bit, 80ch
Local Area Network
EPICS unit (Center #1)
(Center #2)
(West end)
(South end)
Environment data (Temperature, Vac. pressure, ...)
Filter
VME crate
Workstation (SUN)
Linux x3

Frequency stabilization

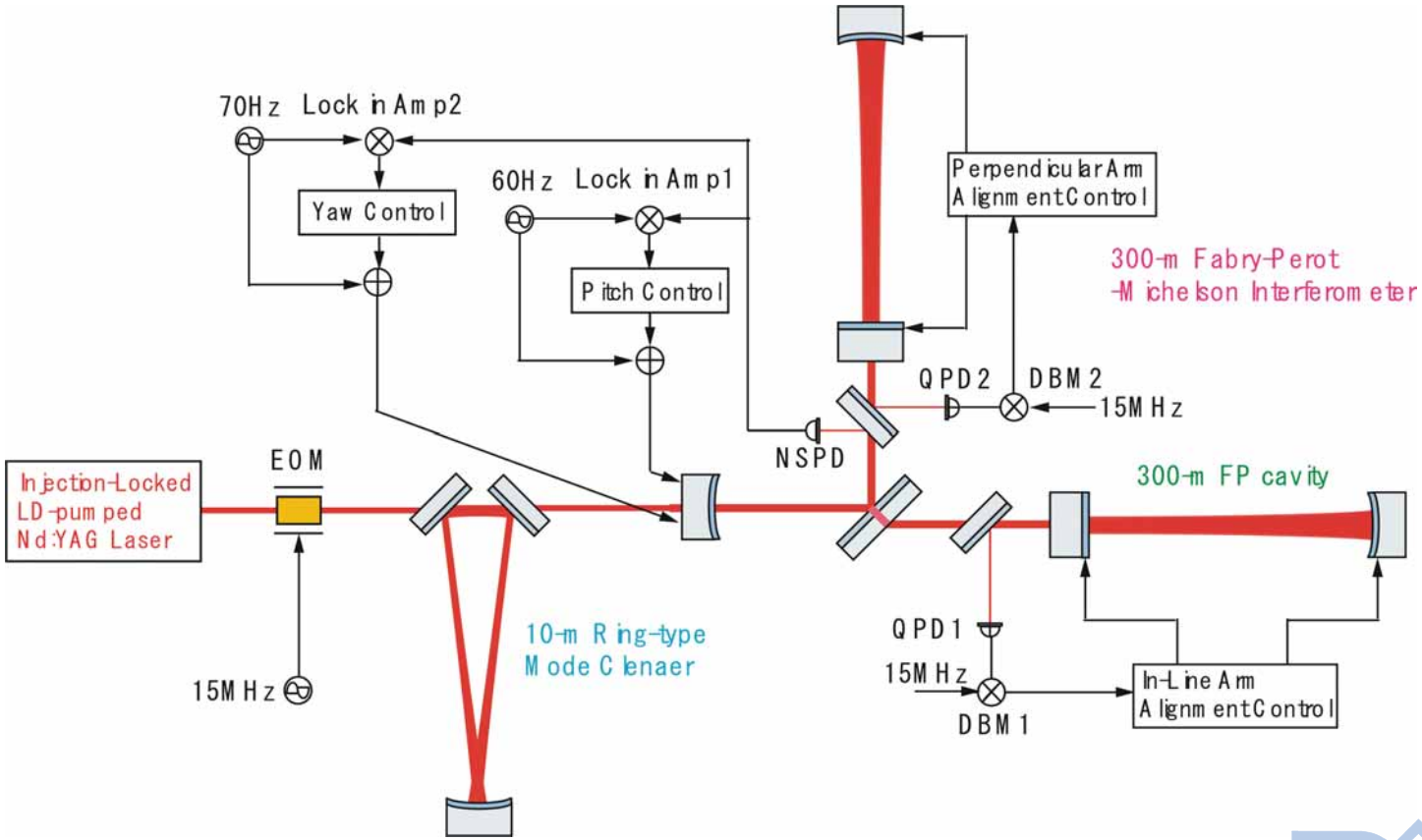
Extended BW of MC servo 300kHz → 600kHz (~2002/10)

Extended BW of δL+ servo 20kHz → 40kHz

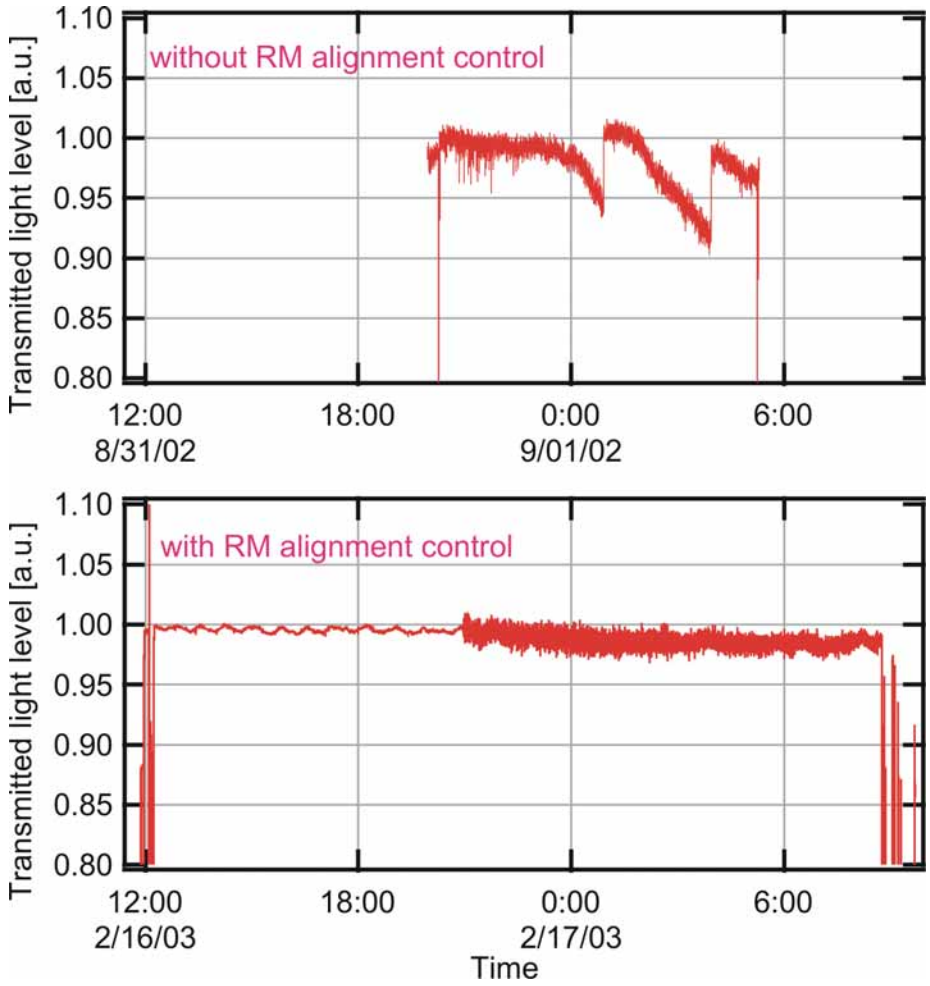


Alignment control

Test mass mirrors: Wave front sensing at 15MHz (BW 60Hz)
Recycling mirror: Mechanical modulation at 60Hz & 70Hz (BW 1Hz)



Alignment control for recycling mirror



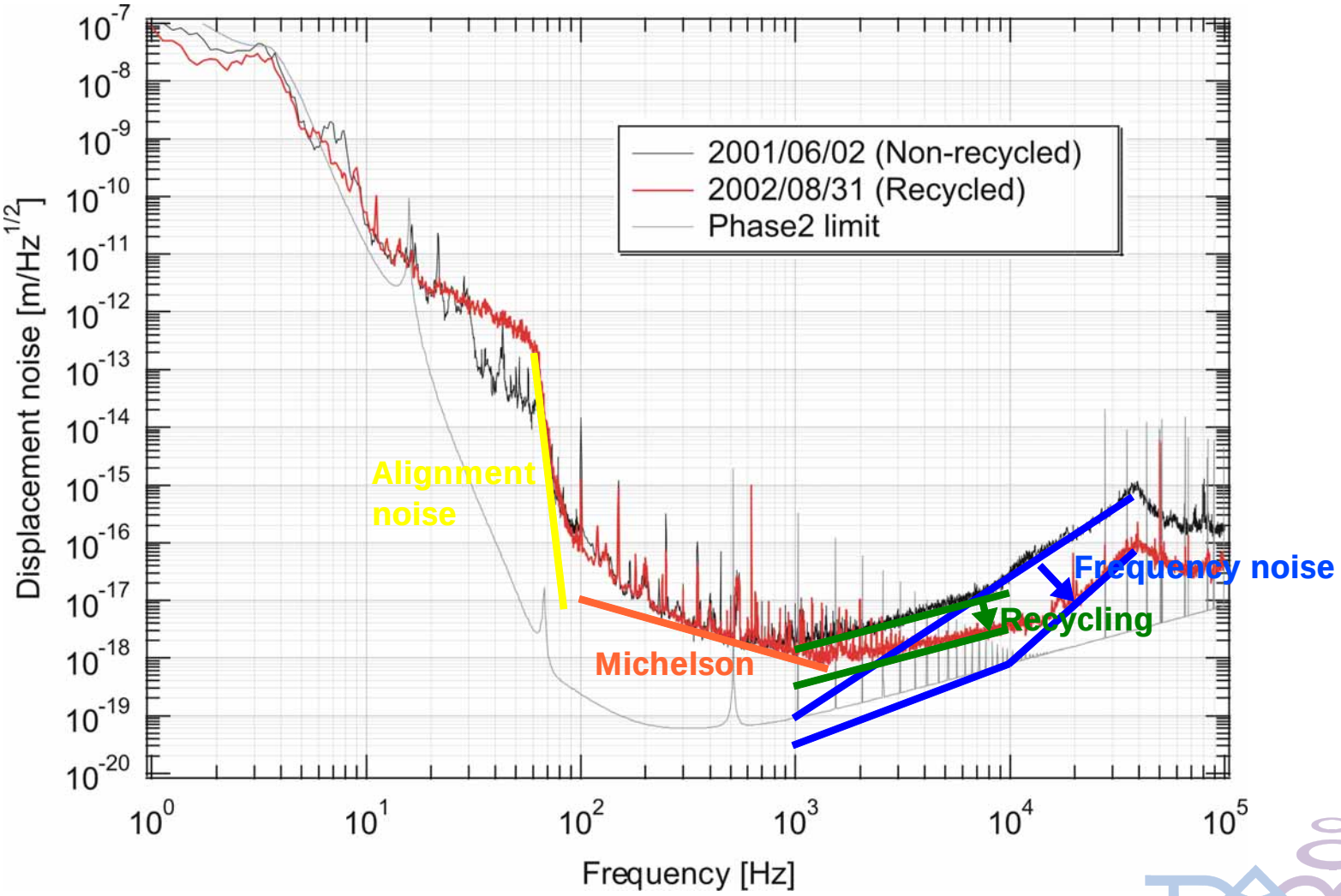
Without RM alignment control

- Fluctuation of transmitted light: >9%
- Decreased light power due to drift of recycling mirror
- Longest lock time: 8h38m

With RM alignment control

- Fluctuation of transmitted light: <3%
- Recycling gain: 4.5±0.14
- Longest lock time: 20h31m

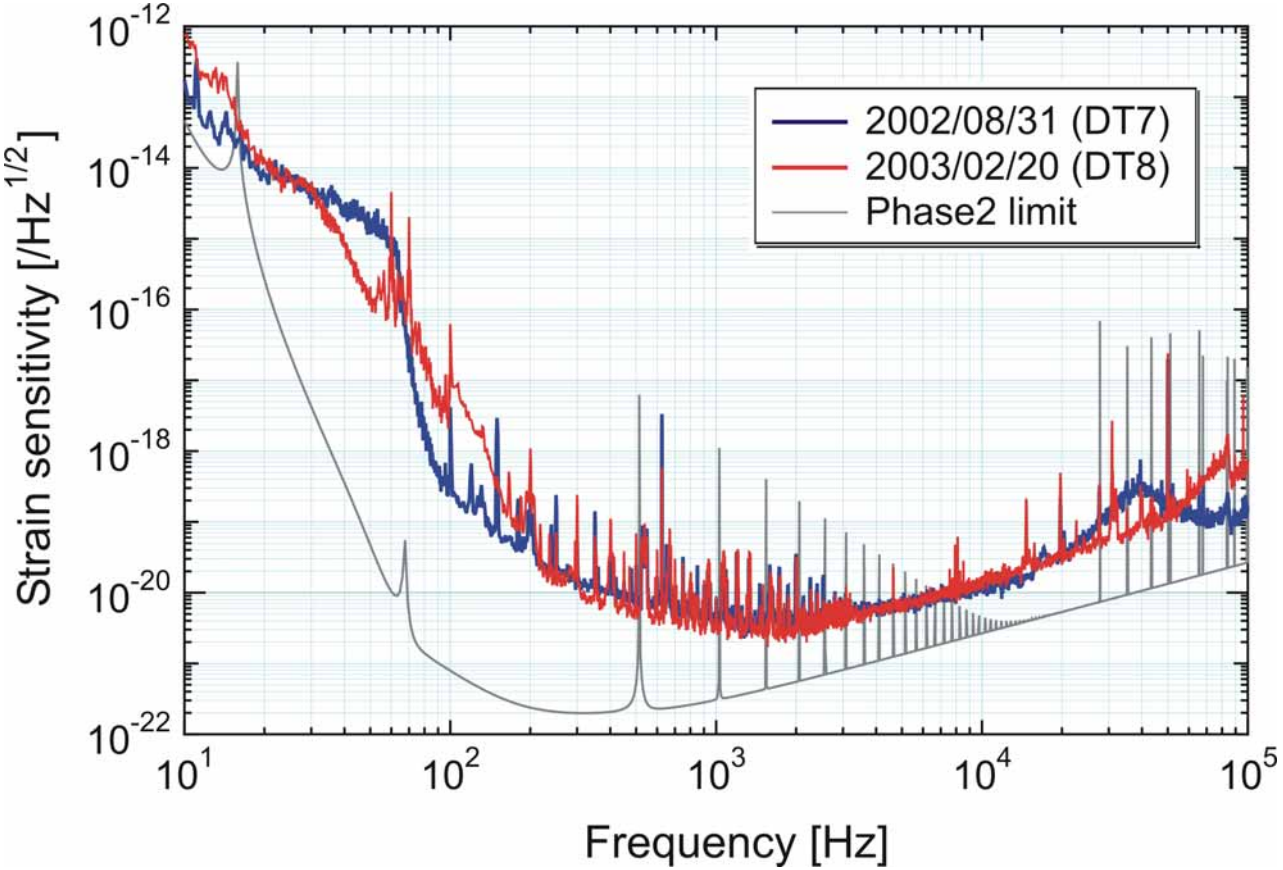
Improvement of sensitivity



Sensitivity in DT8

Reduced non-stationary fluctuation owing to wide band filters for the alignment control

Improved strain sensitivity: $h = 2.7 \times 10^{-21}$ /Hz$^{1/2}$ @2kHz



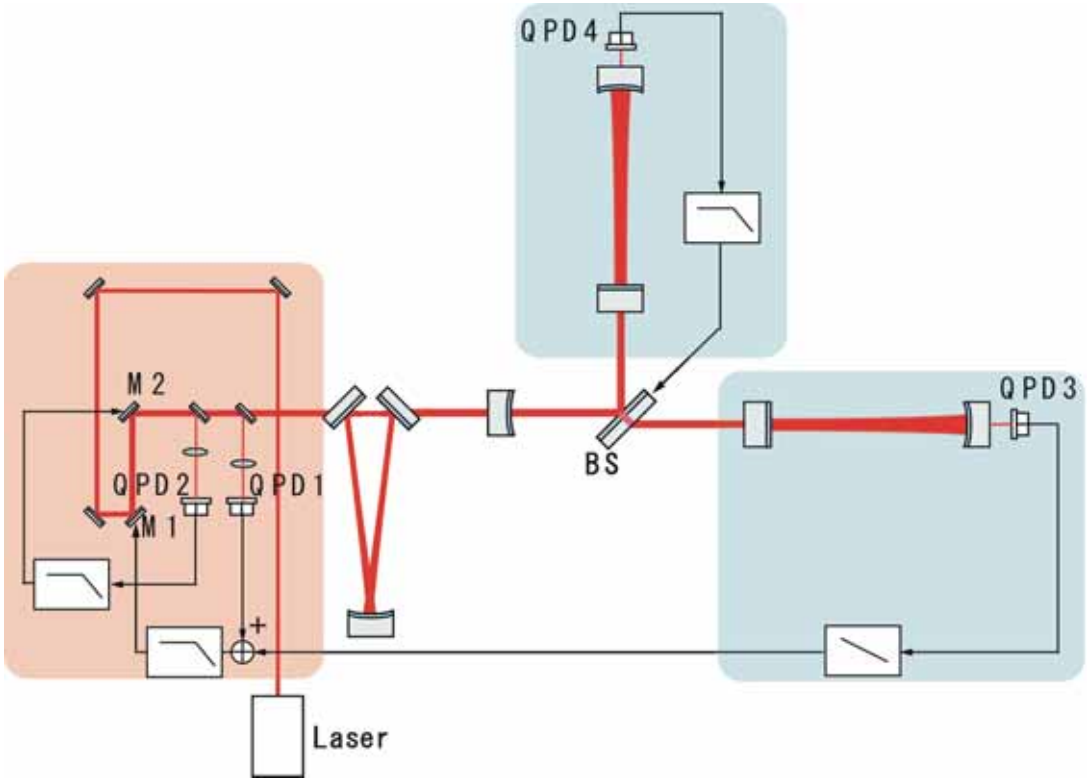
Orientation control

Local control on the injection bench (QPD1, 2)

to keep the incident beam to MC

Grobal control using the transmitted lights (QPD3, 4)

to keep the beam centering of arms



Automation

Self-switching sub-system (Laser & MC)

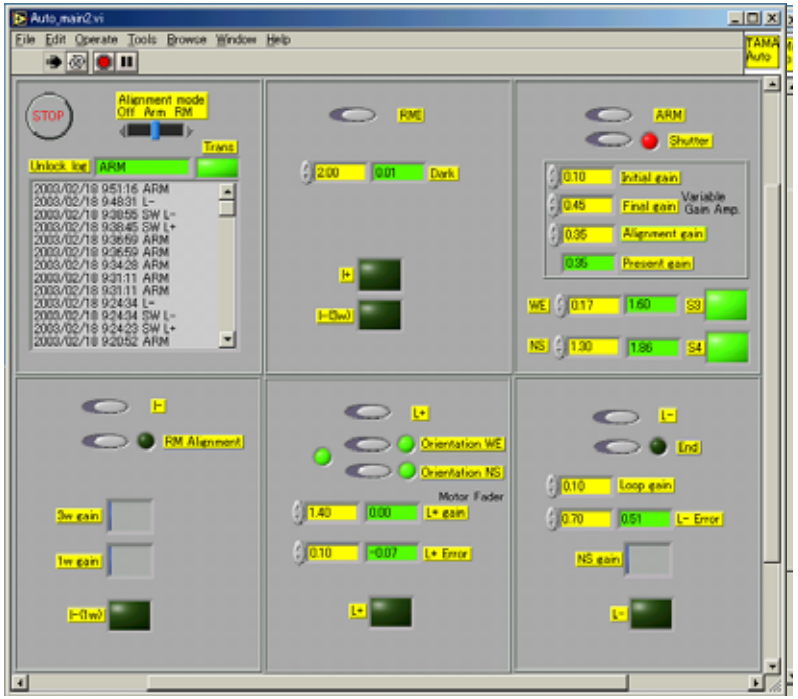
- MC frequency stabilization
- MC alignment control
- Laser intensity stabilization
- Orientation control
- Injection-lock servo of laser

Digital switching using PC & LabVIEW

- Lock acquisition
- Manual mirror alignment
- IFO status monitoring

MC Lock

MC Alignment



LabVIEW

Data Taking 8

Target

Full-scale coincidence run with LIGO

More than 1000-h data (>70%)

Period

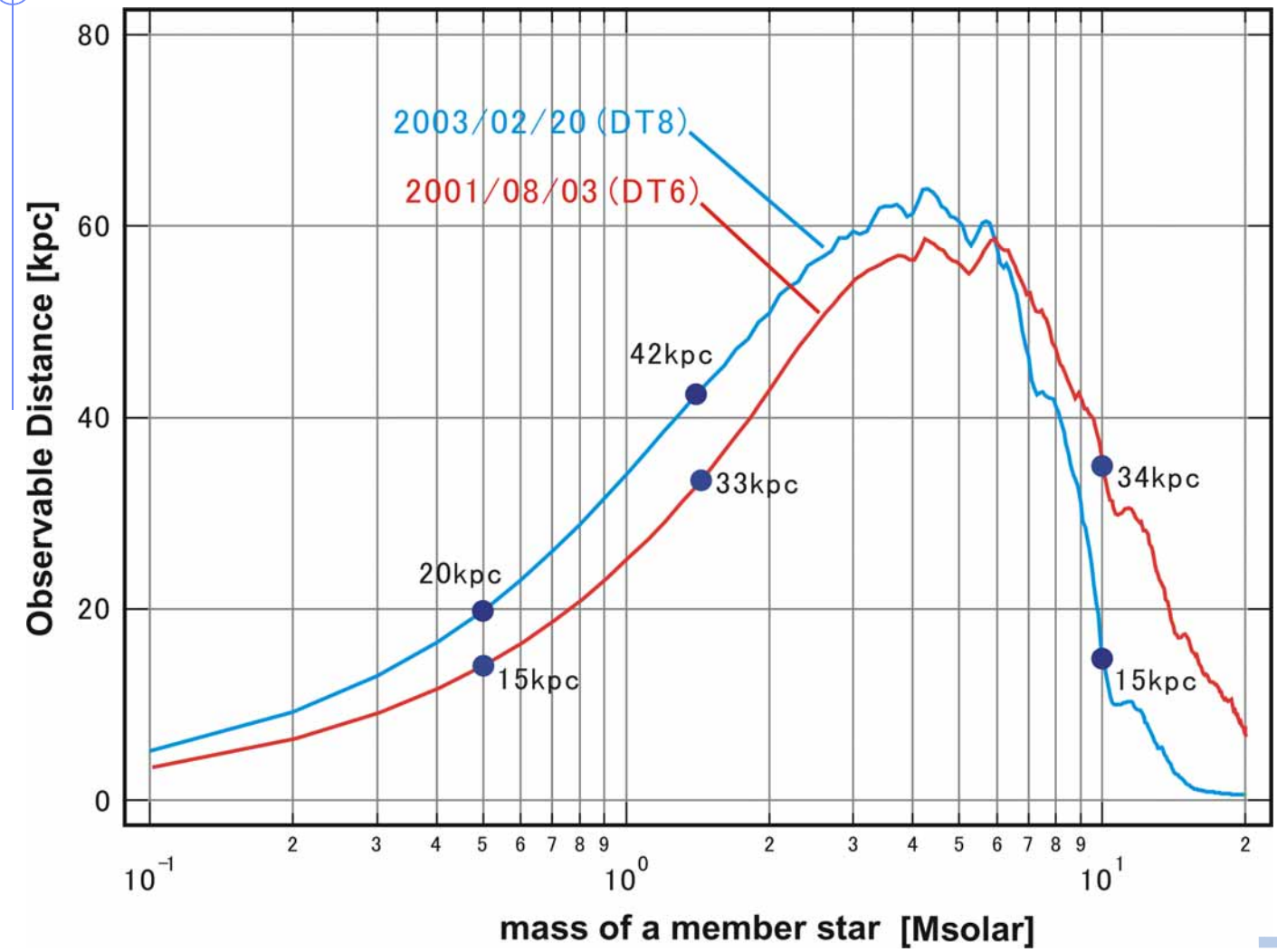
Feb. 14 14:00 ~ Apr. 14 22:00 (1424h)

Shift

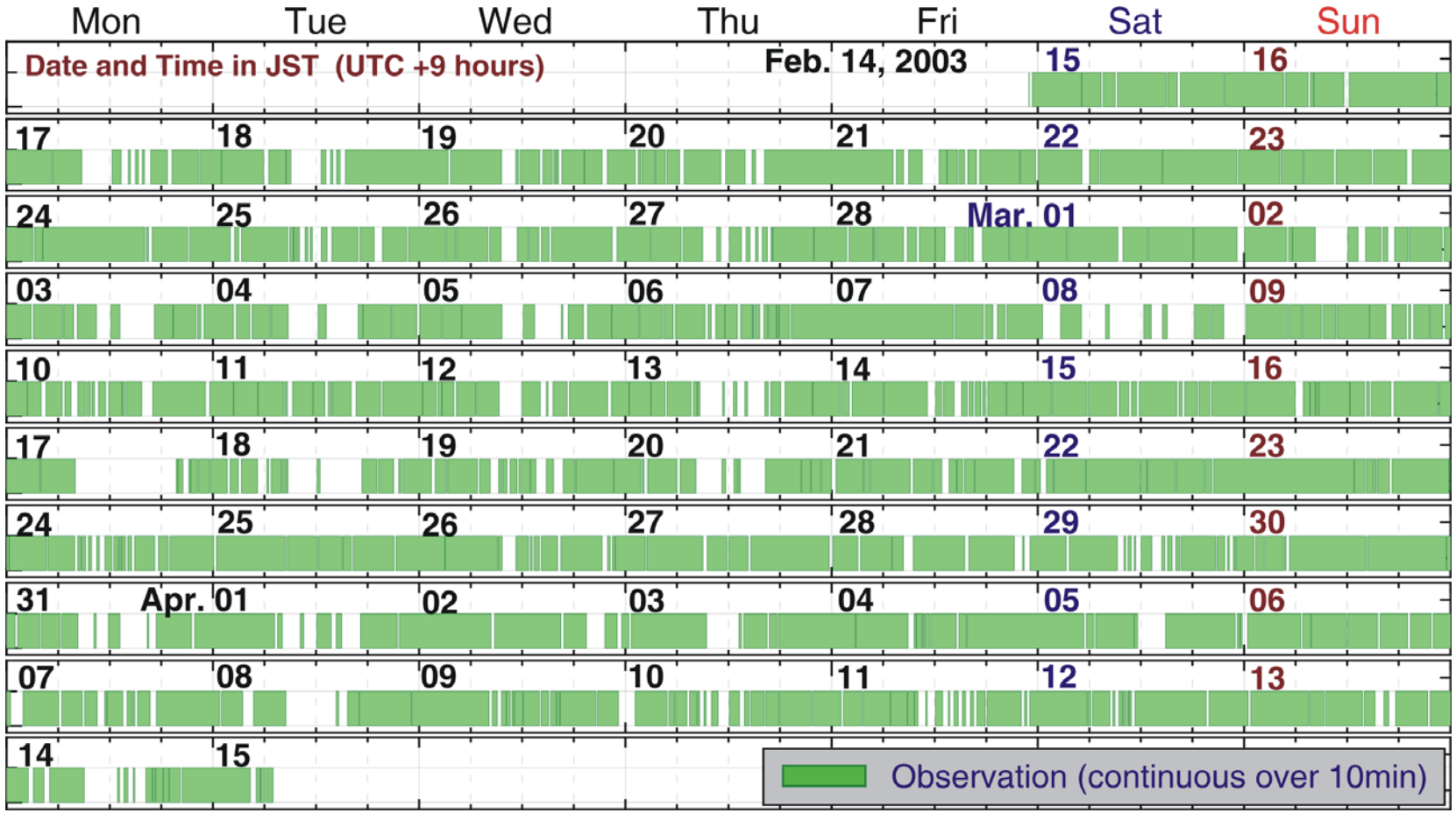
94 people (2 people×3 shift /day)

- Observation time: 1158h
- Duty cycle: 81.3%
- Best sensitivity: 8×10^{-19}m/rHz@1.5kHz
- Longest lock time：20.5h

Observable distance for GW from inspiral NS binaries (SNR=10)

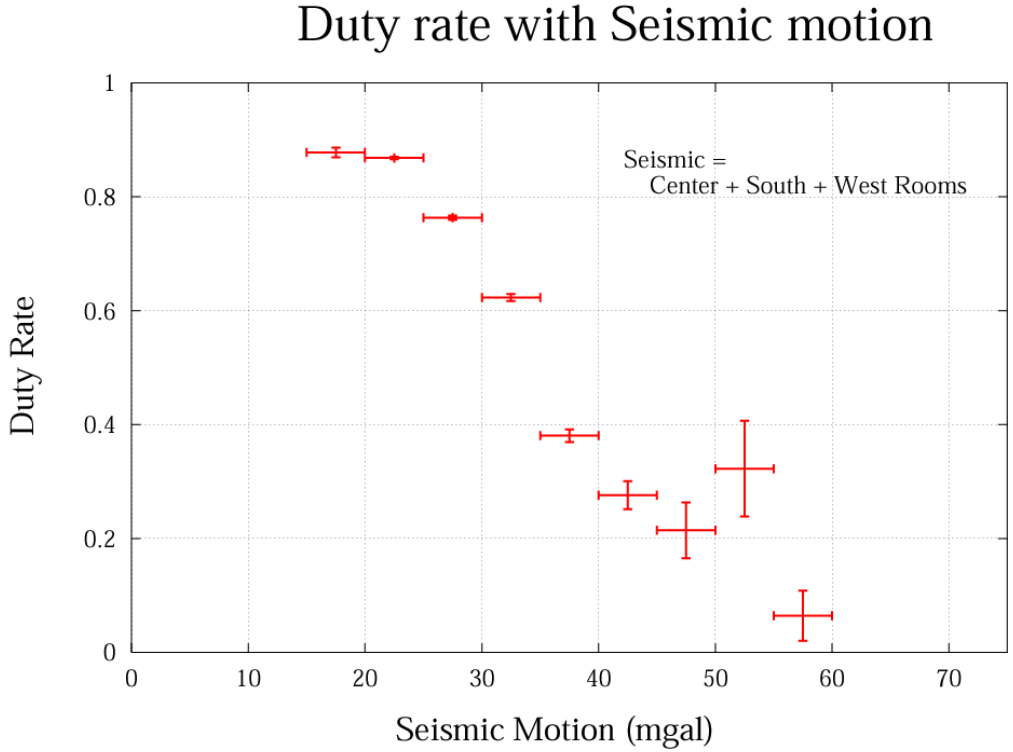


Time table in DT8



Disturbance of the observation

- Construction: Difficult to keep the lock
- Wave due to depression: Difficult to acquire the lock
- Laser: Sometimes to unstable mode
- Misc.: DAQ trouble, Electricity shutdown...



Construction around the site

Stability of sensitivity

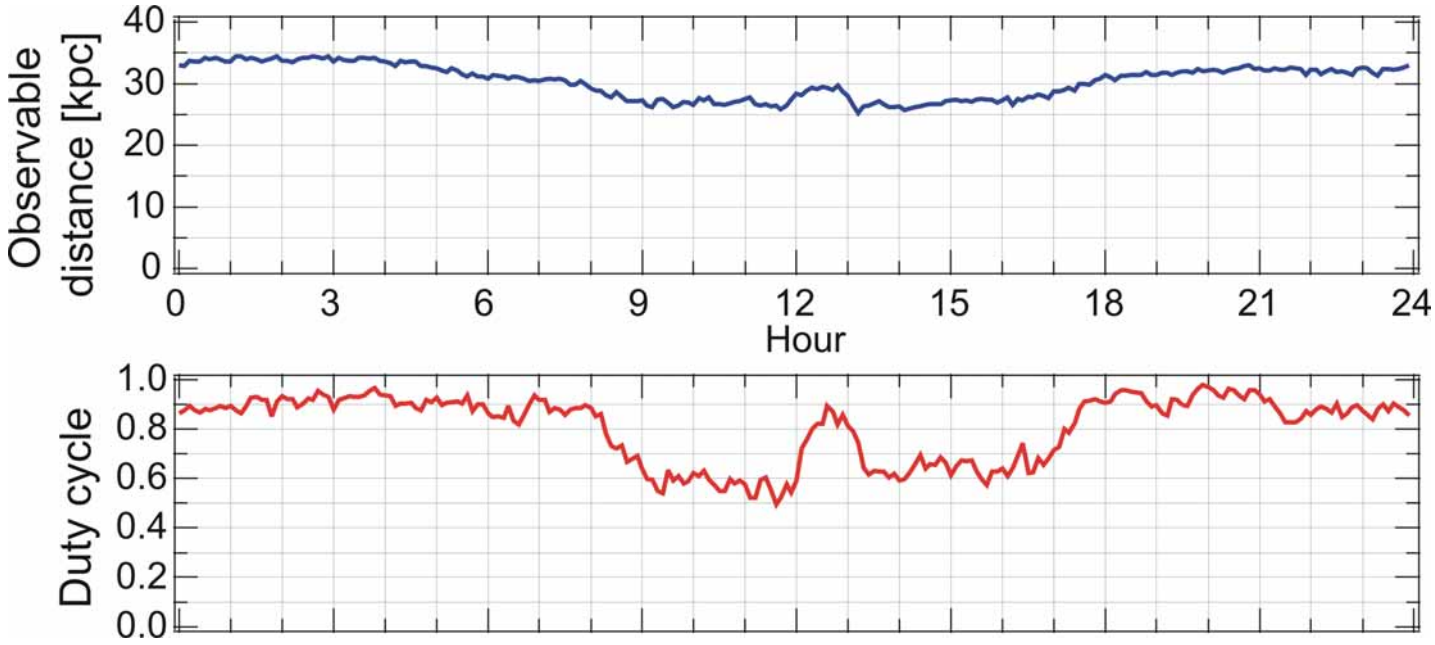
In the daytime

Reduction of duty cycle

90% → 60%

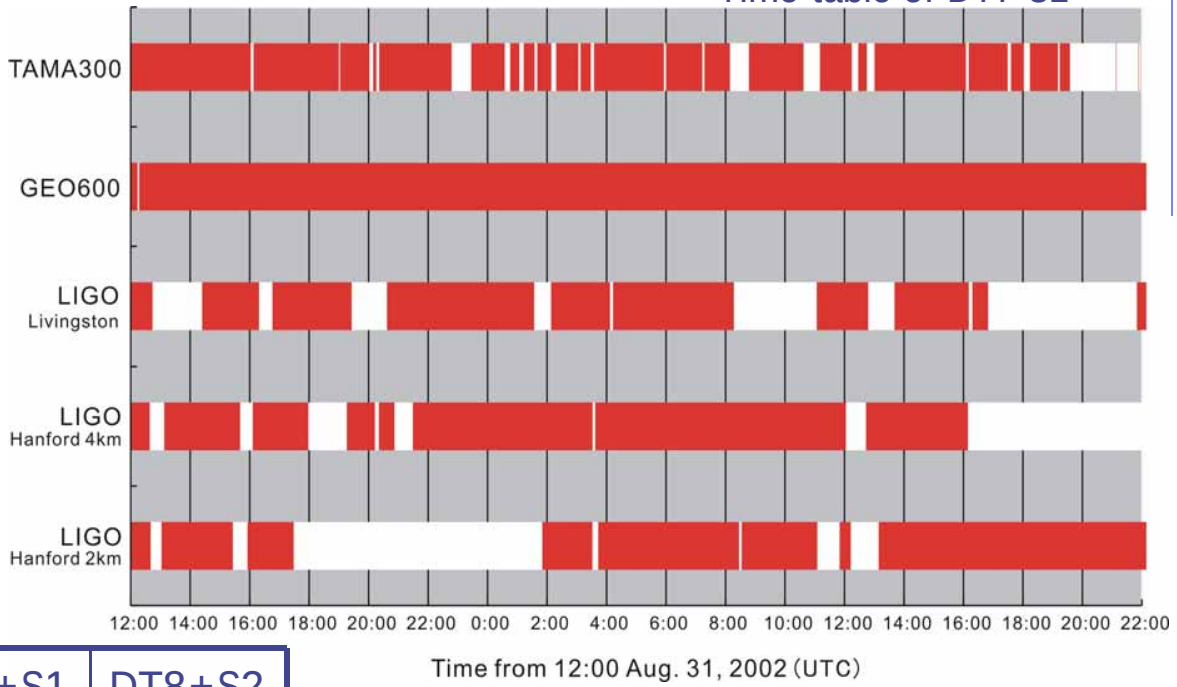
Reduction of sensitivity

10%~20%



International coincidence run

Time table of DT7-S1



	DT7+S1	DT8+S2
Year	2002	2003
Number of interferometers	5	4
Period [h]	34	1416
Common observation [h]	9.8	251
Common duty cycle [%]	28.8	17.7
Longest common lock [h]	2.4	4.9

Data analysis

Talk on Wednesday!

Inspiraling compact binaries
H. Takahashi

Black hole ring-downs
Y. Tsunesada

Burst waves
M. Ando

Future plan

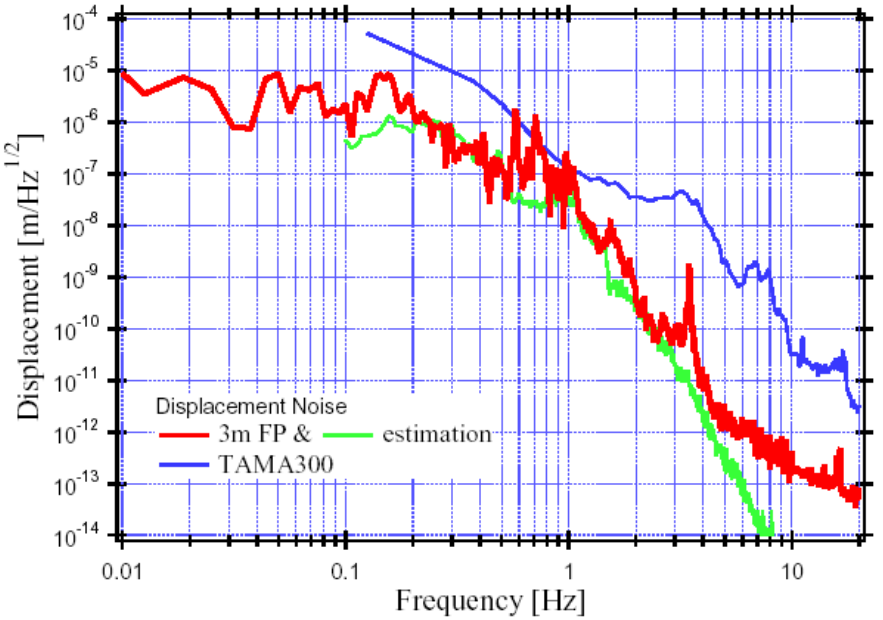
- Improvement of sensitivity
  - Investigation of the noise from Michelson part at <1kHz
- Power recycling
  - Alignment control of RM using WFS
  - High gain (G=10) recycling
- Seismic attenuation system (SAS)
  - For low frequency (0.1 ~ 10Hz)
  - R&D with Caltech and Univ. of Pisa
  - Installation in early 2005
- Observation
  - Shared run with experiments
  - Crewless operation
  - Online real-time analysis

R&D in Univ. of Tokyo

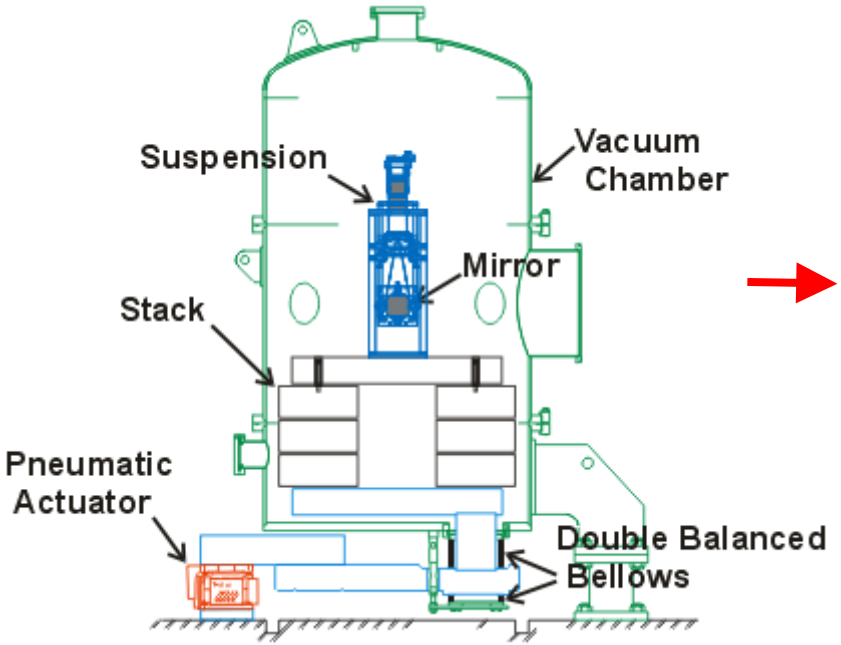
TAMA-SAS

Expected RMS velocity

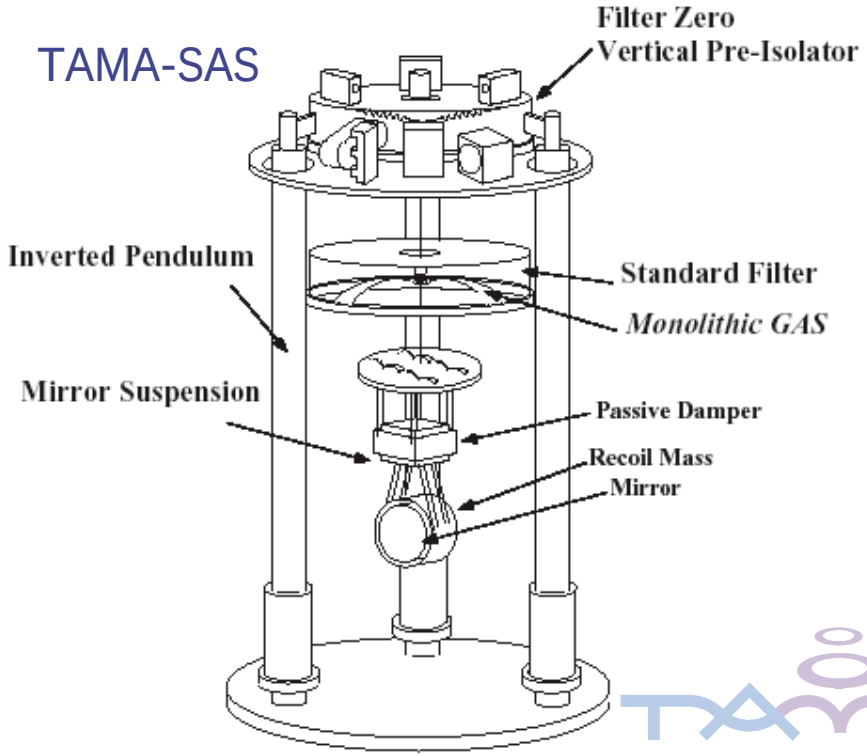
3.7μm/s → 0.3μm/s



Present system



TAMA-SAS



Summary

- Recycled FPMI with alignment control for RM
- Improved frequency stabilization: BW=600kHz (MC loop), 40kHz (δL+ loop)
- Improved sensitivity: $h=2.7\times10^{-21}$ /Hz$^{1/2}$ @2kHz
- Items for observation: auto lock, orientation control
- DT8: observation time=1158h, Duty cycle=81.3%
- SAS: Installation in early 2005