Current status of the TAMA300 interferometer

Masaki Ando

Department of Physics, Faculty of Science, University of Tokyo.

S. Nagano[B], K. Arai[A], S. Taniguchi, Gerhard Heinzel[A], R. Takahashi[A],
S. Kawamura[A], D. Tatsumi[B], S. Telada[A], A. Okutomi[B], S. Moriwaki[C], T. Kanda[E],
M. Fukushima[A], T. Yamazaki[A], M. Ohashi[A], N. Mio[C], K. Kawabe, A. Araya[D], M. Musha[F],
K. Tochikubo, N. Ohishi, K. Yamamoto, A. Takamori, A. Sekiya, K. Numata, S. Ohtsuka,
A.Ueda[A], S. Miyoki[B], S. Sato[B], K.Ueda[F], M.-K. Fujimoto[A], K. Tsubono, K. Kuroda[B],
and TAMA collaboration[F,G]

Department of Physics, University of Tokyo, NAO[A], ICRR[B],
Department of Advanced Materials Science, University of Tokyo[C], ERI[D],
Miyagi University of Education[E], UEC[F], KEK[G]

2nd TAMA Workshop (October 20, 1999, Tokyo, Japan)

Contents

Introduction (1)

300

. **TAMA300**

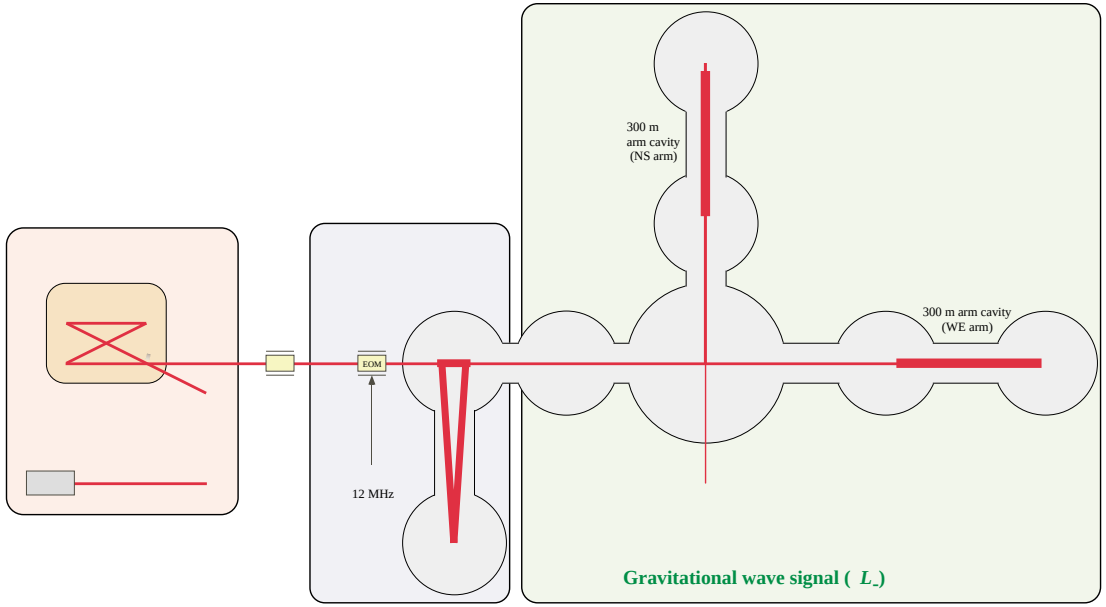
× **National Astronomical Observatory** , .

× - - **300m**.

× **10 W**.

×10 - .

× .



Introduction (2)

300

- (**Phase I**).
  - × .
    - ×10 W laser source with 10 m mode cleaner.
    - ×Main interferometer with 300 m arm cavities.
    - ×Without power recycling.
    - ×Data taking and analysis.
  - × 3 10 ^{20}.

    ($_{\text{obs}}$ = 300 Hz, Δ $_{\text{obs}}$ = 300 Hz)

    Displacement noise 5 10 ^{19} m $\overline{\text{Hz}}$.

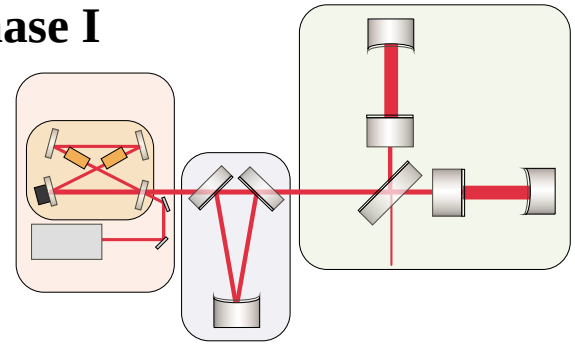
    Laser frequency noise 1 10 ^{6} Hz $\overline{\text{Hz}}$.

- (**Phase II**).
  - × .
  - × 3 10 ^{21}.

    ($_{\text{obs}}$ = 300 Hz, Δ $_{\text{obs}}$ = 300 Hz)

    Displacement noise 5 10 ^{20} m $\overline{\text{Hz}}$.

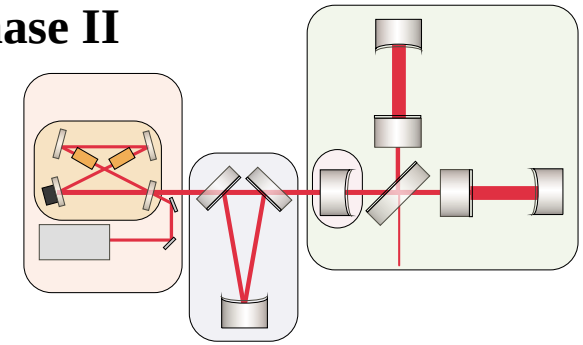
Phase I



300m Fabry-Perot-Michelson interferometer with 10W laser source and mode cleaner

$h \sim 3 \times 10^{-20}$

Phase II



Power-recycled interferometer

$h \sim 3 \times 10^{-21}$

Introduction (3)

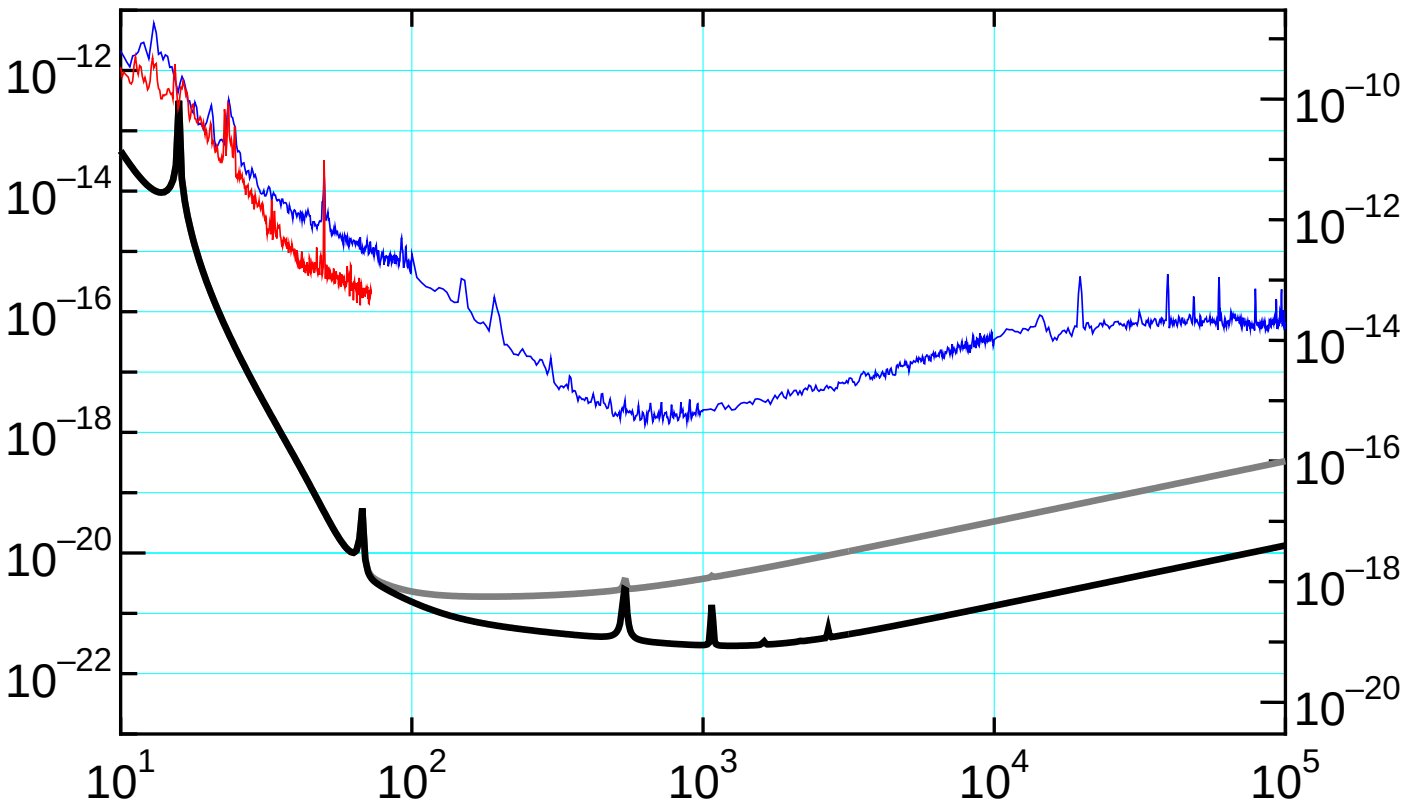
- 300
  - **Operated with** .
    - 7 10 ^{18} .
    - **7 hours**.
  - **Improve sensitivity and stability**.
    -
-
  - 1 (06) 1 10 ^{16} .
  - 2 (17 - 20) 1 10 ^{17} .

Data analysis.

Introduction (4)

300

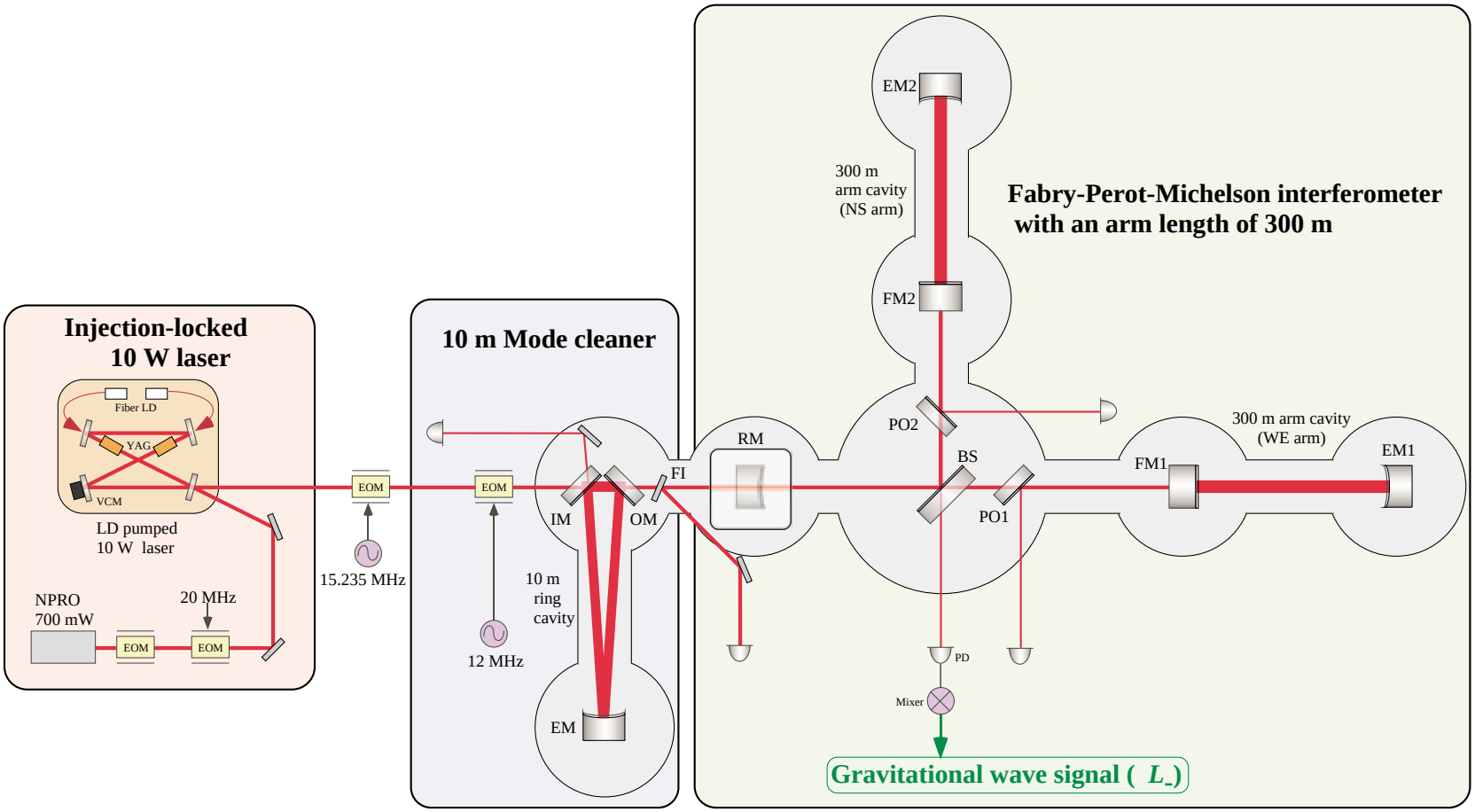
. 7 10 18 (2 10 20 1)



TAMA300 interferometer (1)

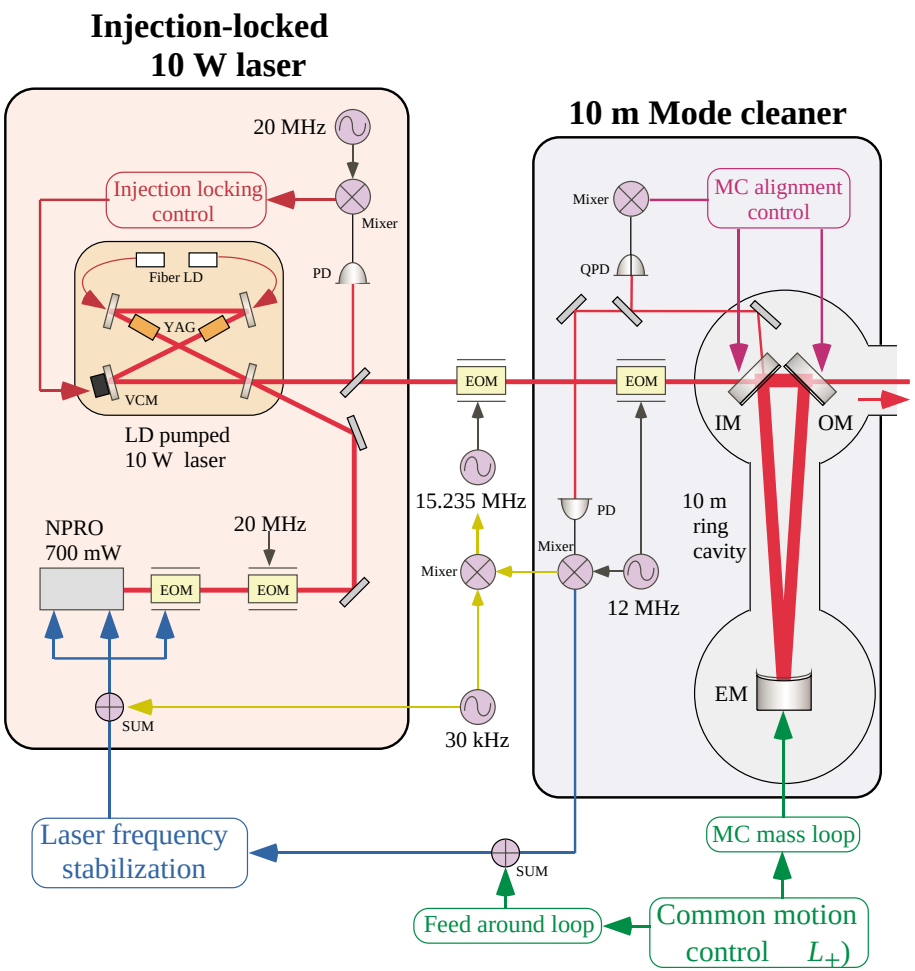
300

- - (10 10).
- (300 - -).



TAMA300 interferometer (2)

- **Injection-locked Nd:YAG laser.**
  - ×Output power of 10 W.
  - ×Master laser
    - ×LD-pumped Nd:YAG laser (700 mW).
  - ×Slave laser
    - ×Fiber LD-pumped ring laser.
    - ×Injection-locked to the master laser.
- **10-m ring cavity.**
  - ×Three mirrors — Independently suspended.
  - ×Finesse — 1,700.
  - ×Transmissivity — 54%.
  - ×Transmission of modulation sidebands.
-
  - ×MC end mirror (1kHz).
  - ×Feed around (1 kHz 20 kHz)
- .



TAMA300 interferometer (3)

300-

300- -

×Finesse — 516.

×Cut-off frequency — 480 Hz.

× signal front mirrors (diff.).

× signal beam splitter.

× + signal laser and MC.

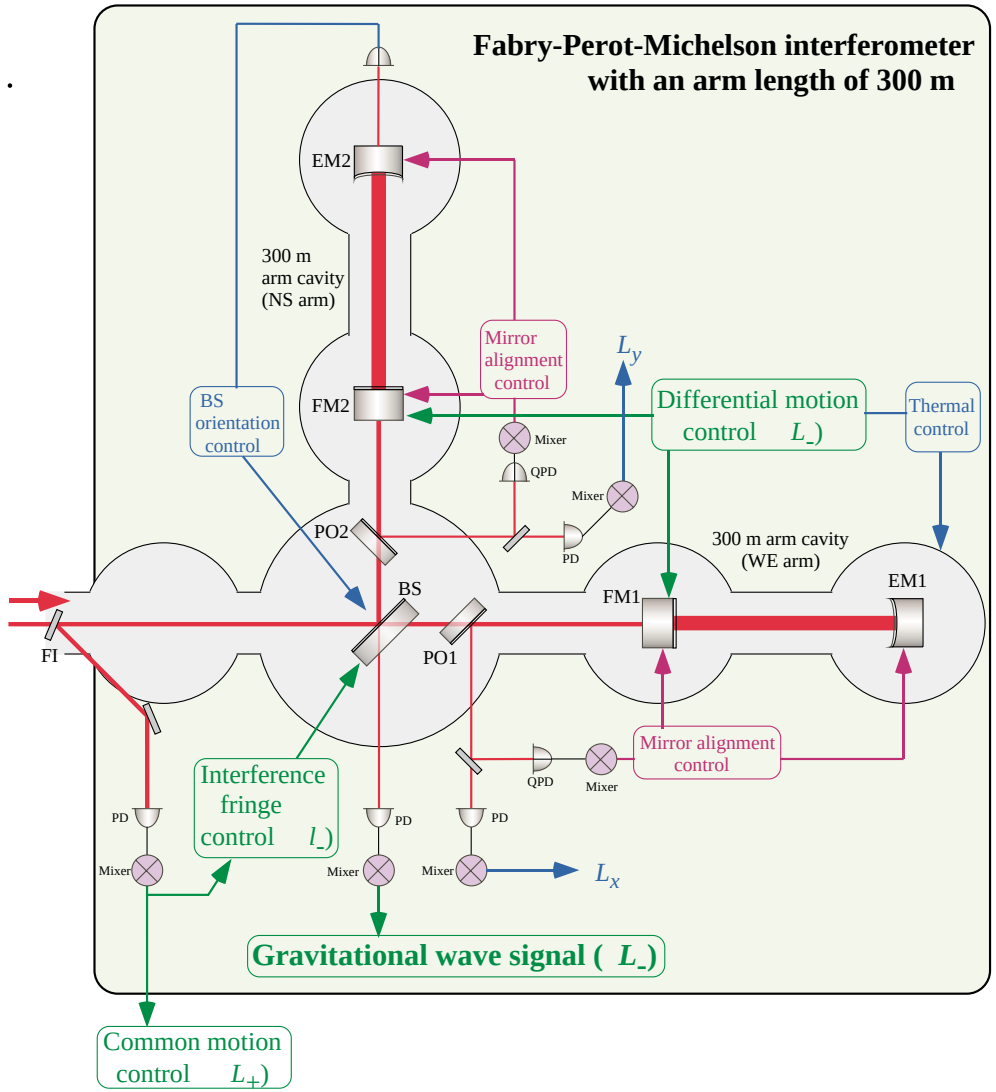
×Wave-front sensing scheme.

×Sample small power with pick-off mirrors.

– .

×BS orientation control.

× thermal control.



TAMA300 interferometer (4)

- .

  ×Two arm cavities — Resonate with input laser beam.

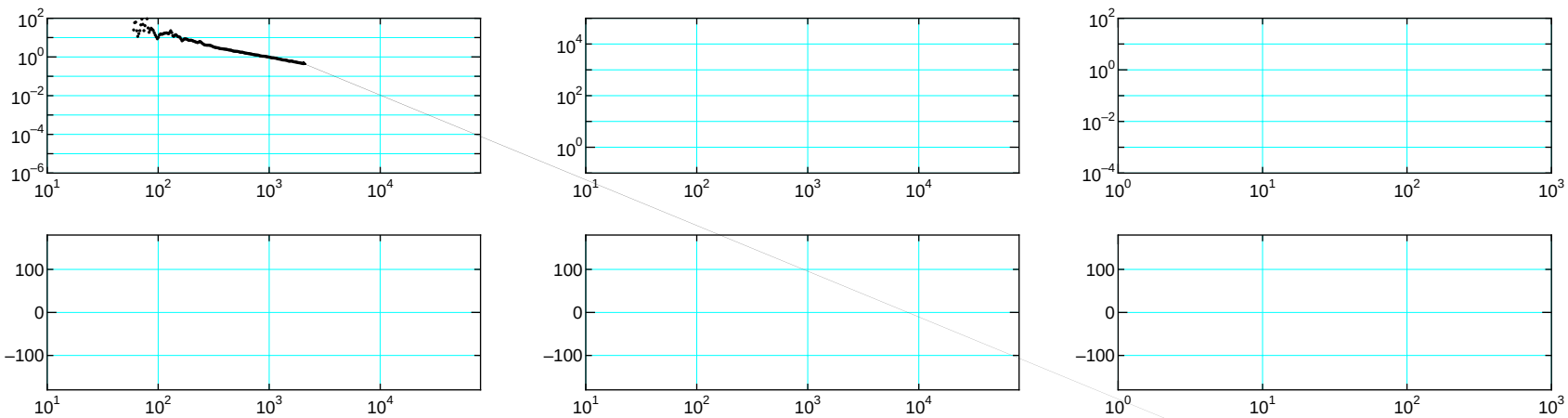
  ×Interference fringe — Dark at the detection port.

- . . . .

  ×Arm cavity differential motion ( ) Front Mirror coil-magnet actuators (differential).

  ×Arm cavity common motion ($_+$) Laser source (MC and feed around).

  ×Michelson fringe motion ( ) BS coil-magnet actuator.



TAMA300 interferometer (5)

- **Alignment control**

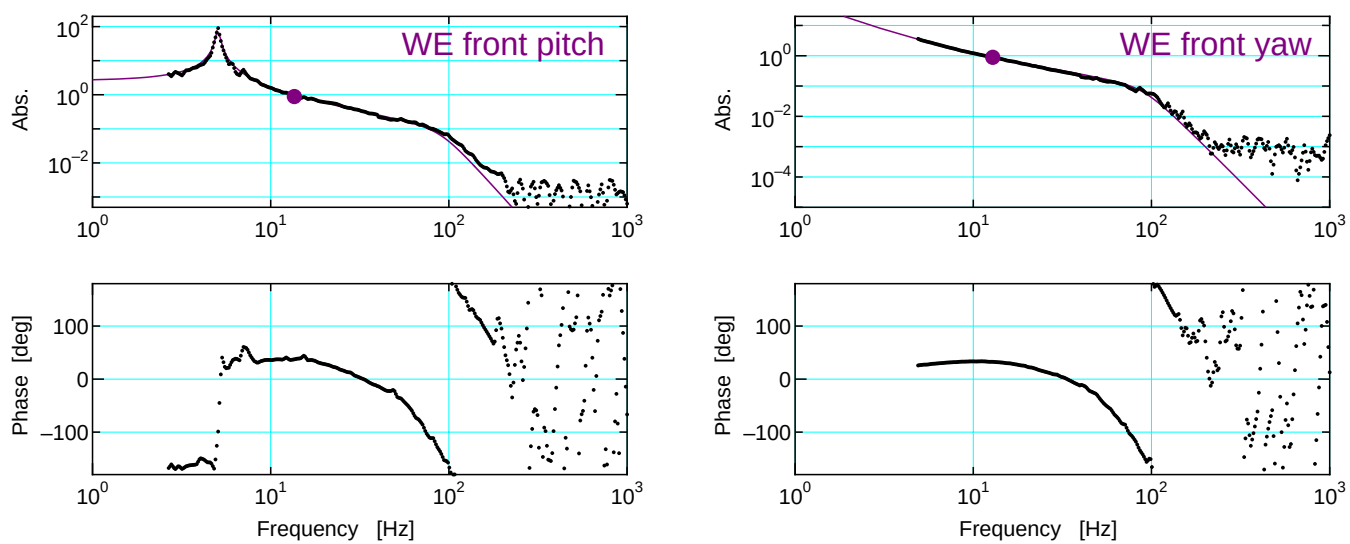
- 8

  ×Signals are extracted from picked-off beams.

  ×Use the WFS scheme for each arm cavity.

  ×Feed back to coil-magnet actuators of each mirror.

  × UGF 10 Hz.



TAMA300 interferometer (6)

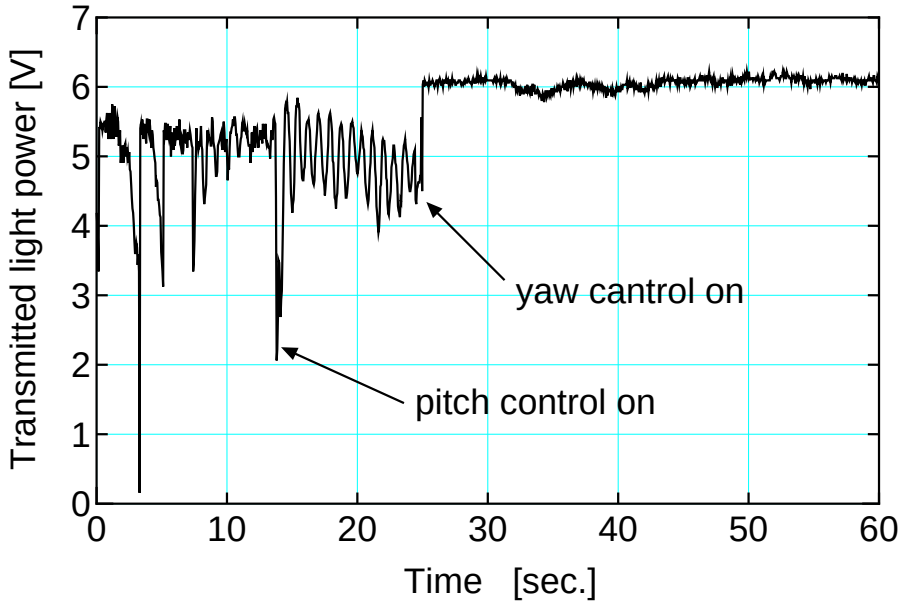
.

× .

.

× -

× 7 .



TAMA300 interferometer (7)

-

- .

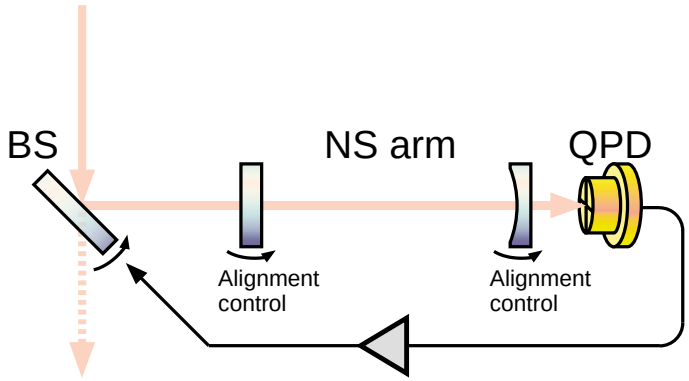
×Sensitivity is degraded by BS orientation drift.
(Arm cavity transmissivity, Contrast.)

×BS orientation is controlled with QPD at the end room.

×Detect beam position of transmitted beam.

×Fed back to BS
(coil-magnet actuator, PZT at suspension point).

× UGF 0.3 Hz.



- .

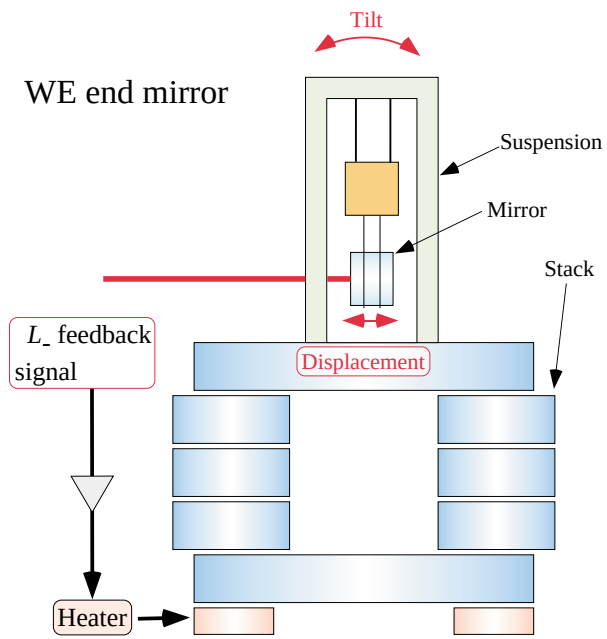
×Finite dynamic range for actuator (50 m).

× is dragged by .

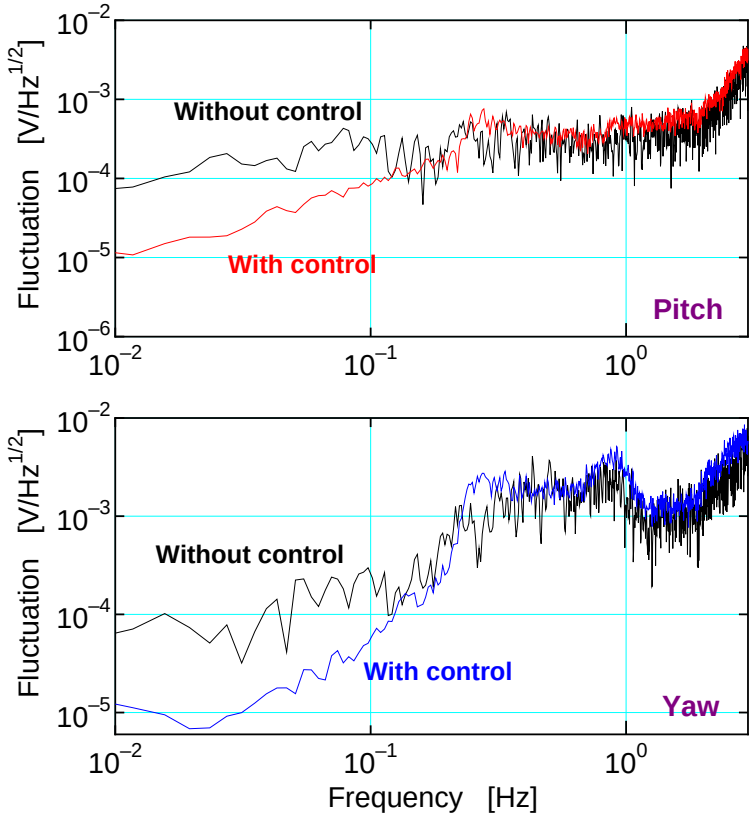
×Cancel feedback signal by the tilt of the isolation system.

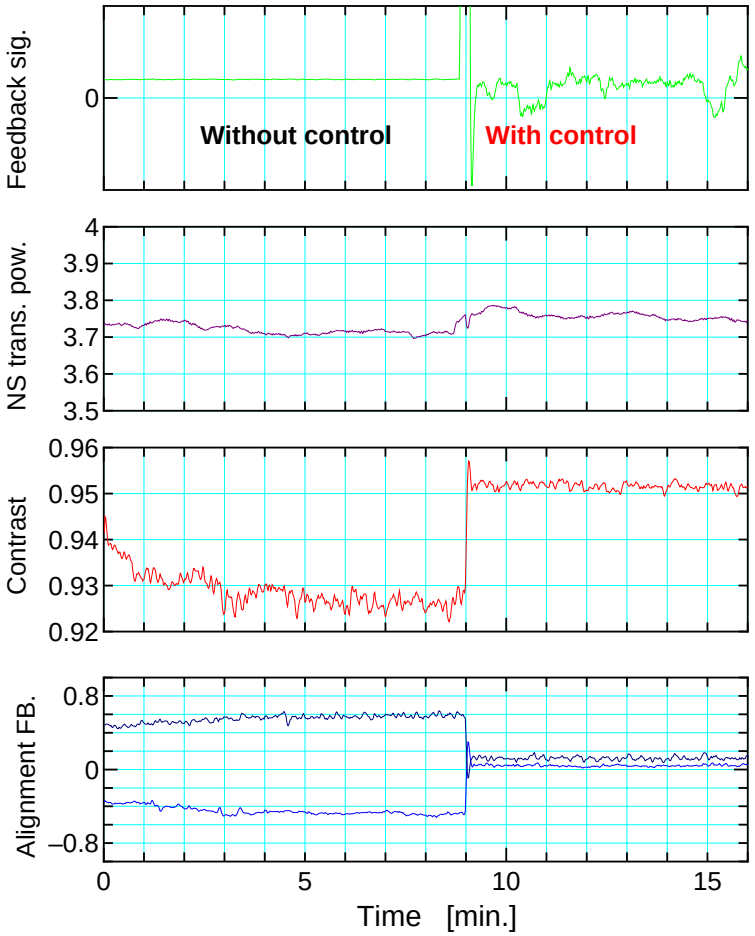
×Heater is attached at the bottom of WE-end VIS.

× UGF 3 mHz.



TAMA300 interferometer (8)

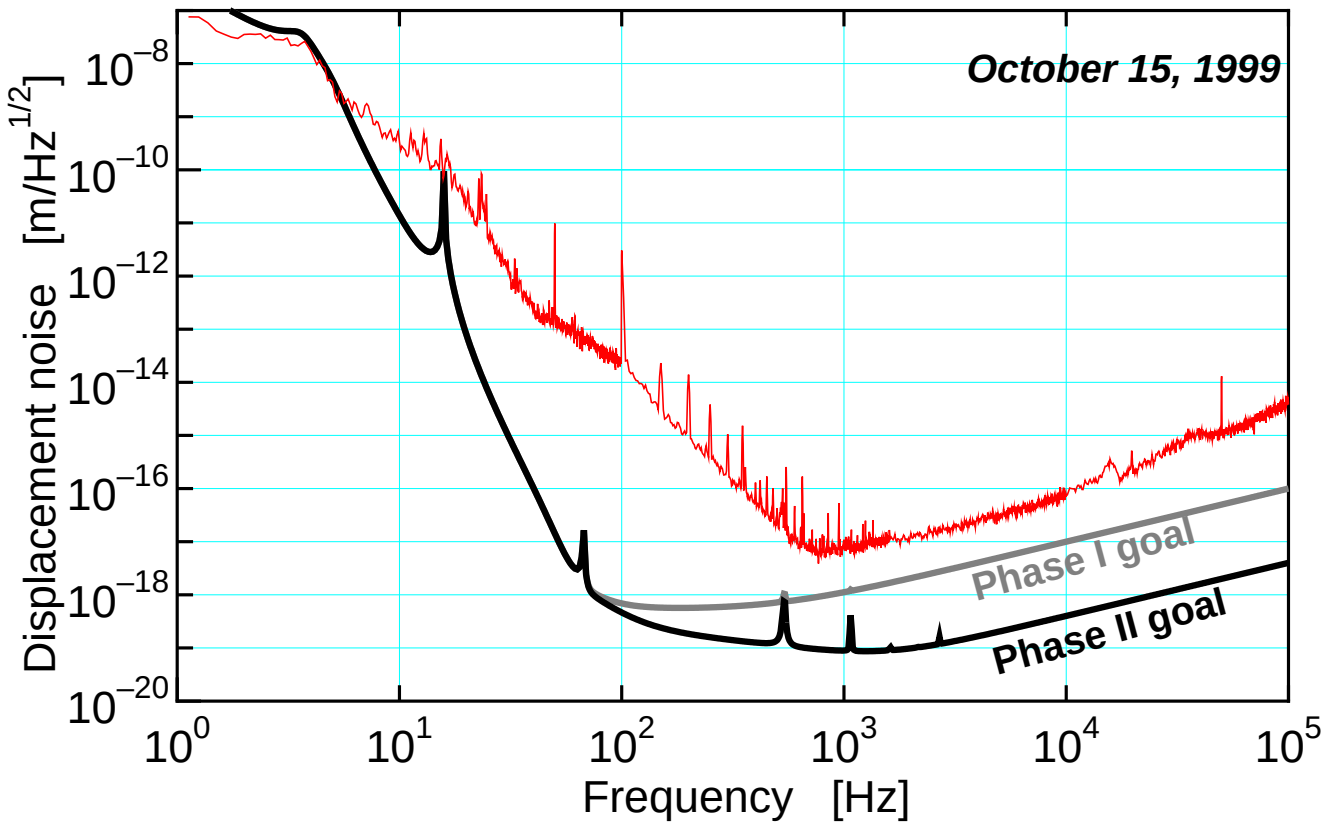




Sensitivity of the TAMA300 interferometer (1)

. 7 10 18 . (700 900).

14 Phase I.

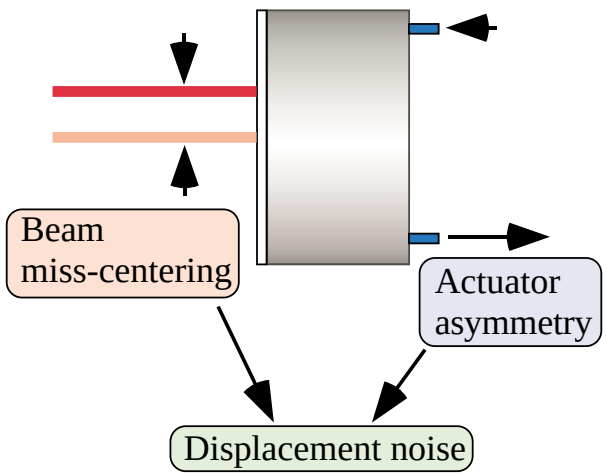


Sensitivity of the TAMA300 interferometer (2)

- $\left({}_{\text{obs}} \quad 300 \quad , \Delta \; {}_{\text{obs}} \quad 300 \quad \right),$

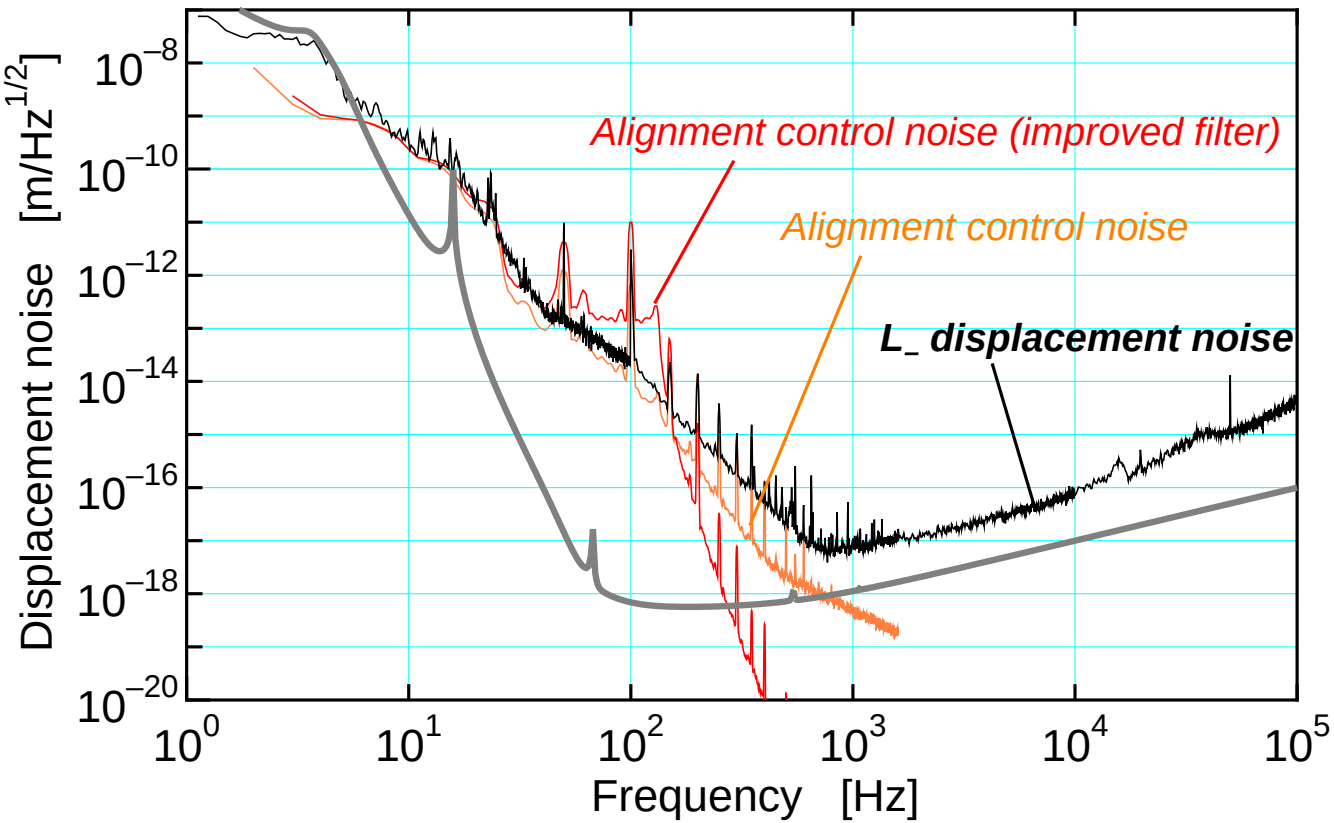
  .

  - ×Asymmetry in actuator efficiencies.
  - ×Beam miss-centering on mirrors.
  - × .
  - × – .
  - × .



Sensitivity of the TAMA300 interferometer (3)

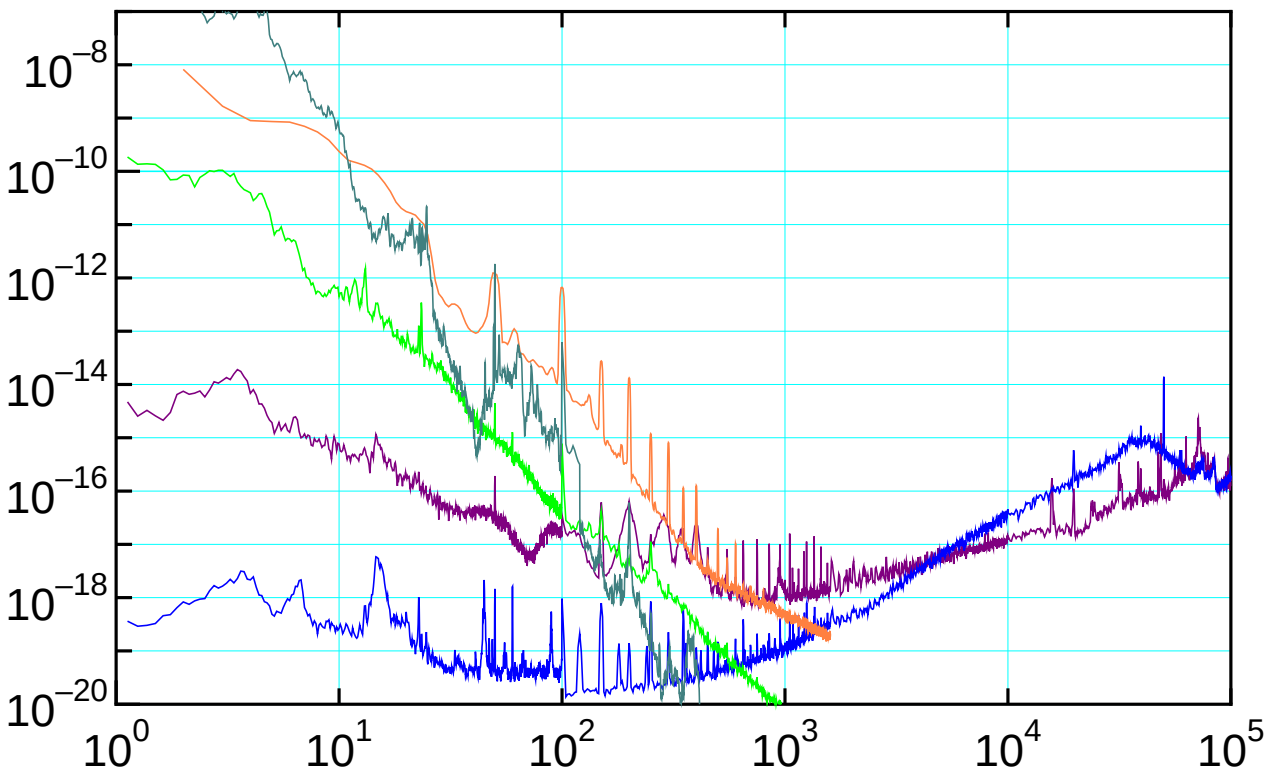
(with steep LPF with 10-pole Chebyshev low-pass filter.)



Sensitivity of the TAMA300 interferometer (4)

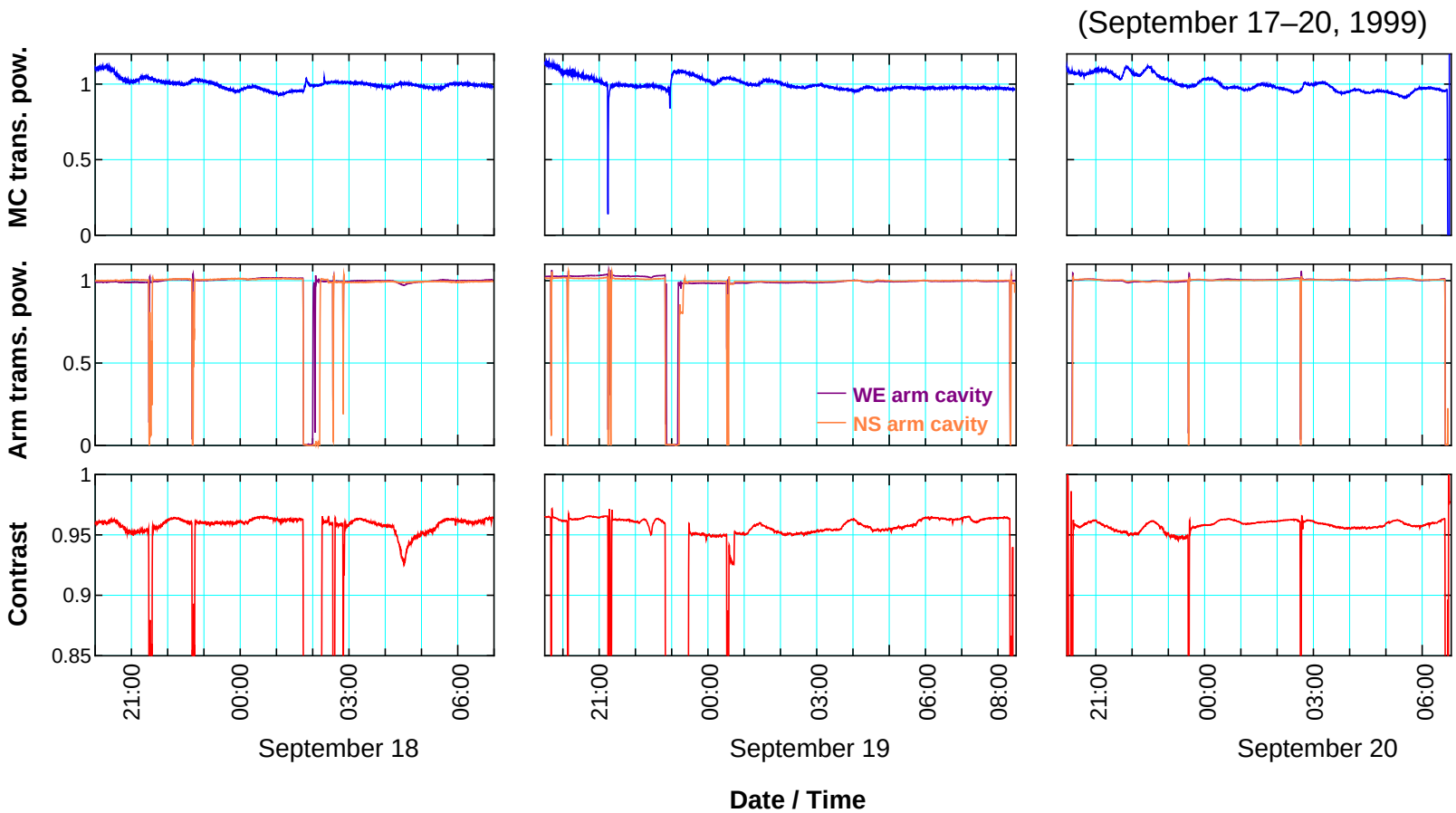
×Noise sources to be considered.

×Shot noise, Thermal noise, Seismic noise, Laser frequency noise,
Laser intensity noise, control noise, Detector noise, AC line noise, ...



Stability of TAMA300 interferometer (1)

- 2 (17 20).
- **31 hours**.



Stability of TAMA300 interferometer (2)

- .
  - × 31 3 .
  - × **7 hours 43 min.**.
- .
  - × 2 .
  - × 9 - 97 .
    - ×Arm cavity alignment control.
    - ×BS orientation control.
  - × 10
    - ×No alignment control at this time.
-
  - × - .

Summary and future works

- .

  .

  × 7 10 18 .

  × 7 .

- **Improve the sensitivity** 10 19 .

  ×Reduce alignment control system noise.

  ×Reduce detection system noise and the other noises.

- .

- **stable operation**.

- **of** .

Sensitivity of the TAMA300 interferometer

- ×Sensitivity is degraded coupling with
  - ×WFS noise.
  - ×Asymmetry in actuator efficiencies.
  - ×Beam miss-centering on mirrors.

×

×

×