Noise Experience of the 20m Run 1km Underground in the Kamioka Mine

– Stable operation of LISM antenna –

Shuichi Sato
National Astronomical Observatory of Japan

LISM project (1) – *Objectives* –

- To demonstrate stable operation
  - *IFO stability : continuous lock, live rate*
  - *Data stability : keep best spectrum sensitivity*

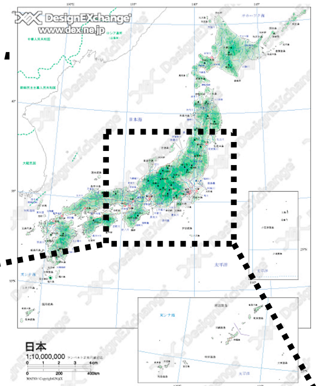
- To obtain high quality data
  - *Gaussianity of noise spectrum etc...*

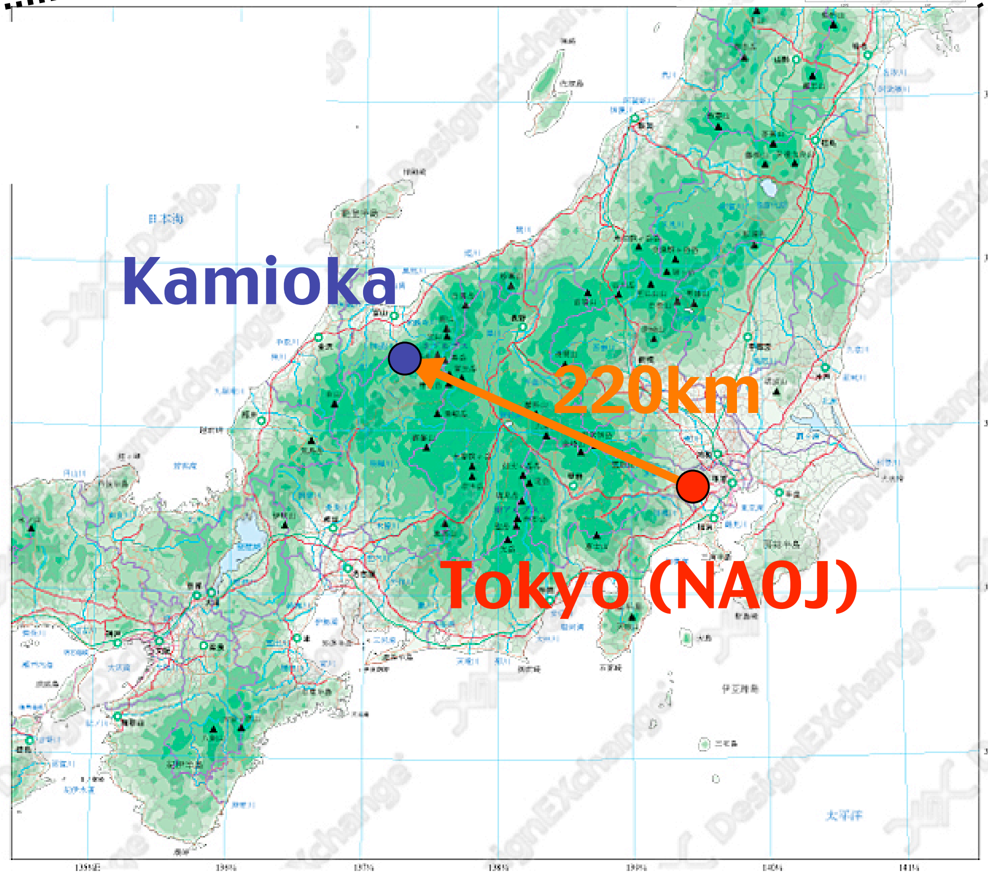
- To develop coincidence analysis methods
  - *Obtain coincident real IFO data*
  - *Results for TAMA-LISM coincidence analysis*

LISM project (2)

Kamioka (LCGT, CLIO site)

220km west from Tokyo

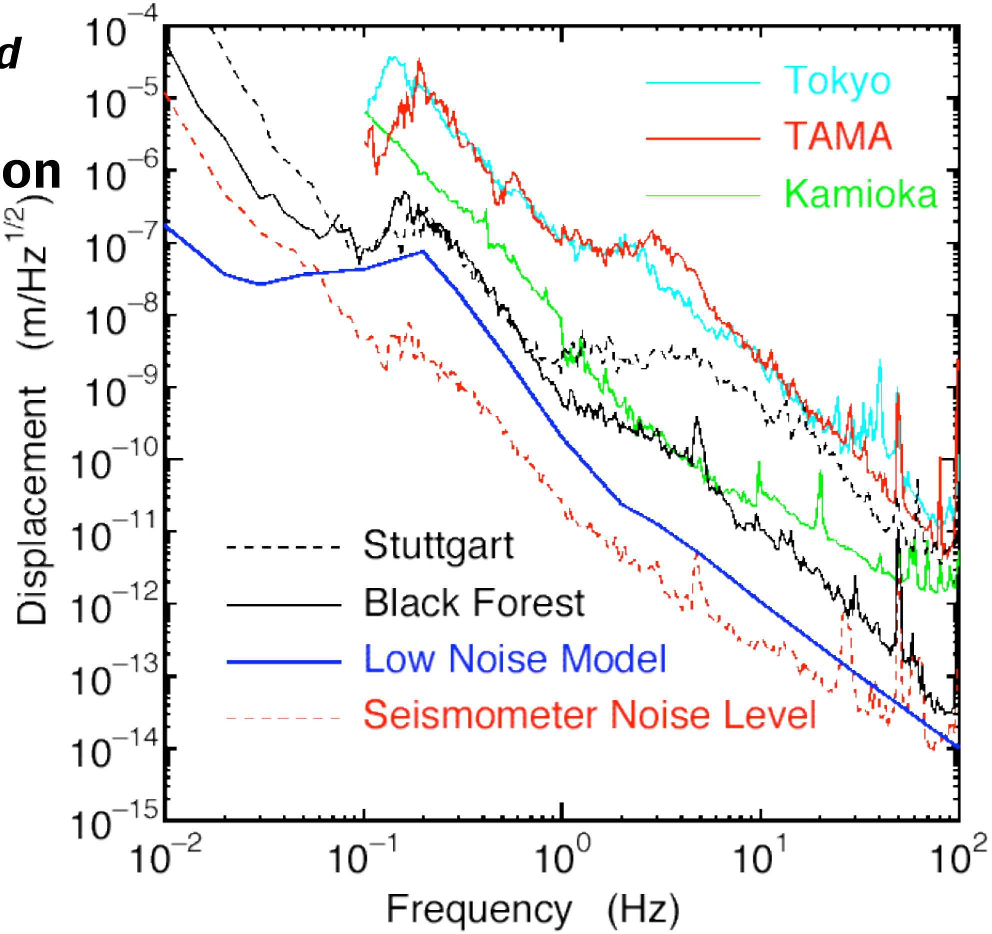




LISM project (3) – *Merit of Kamioka, underground* –

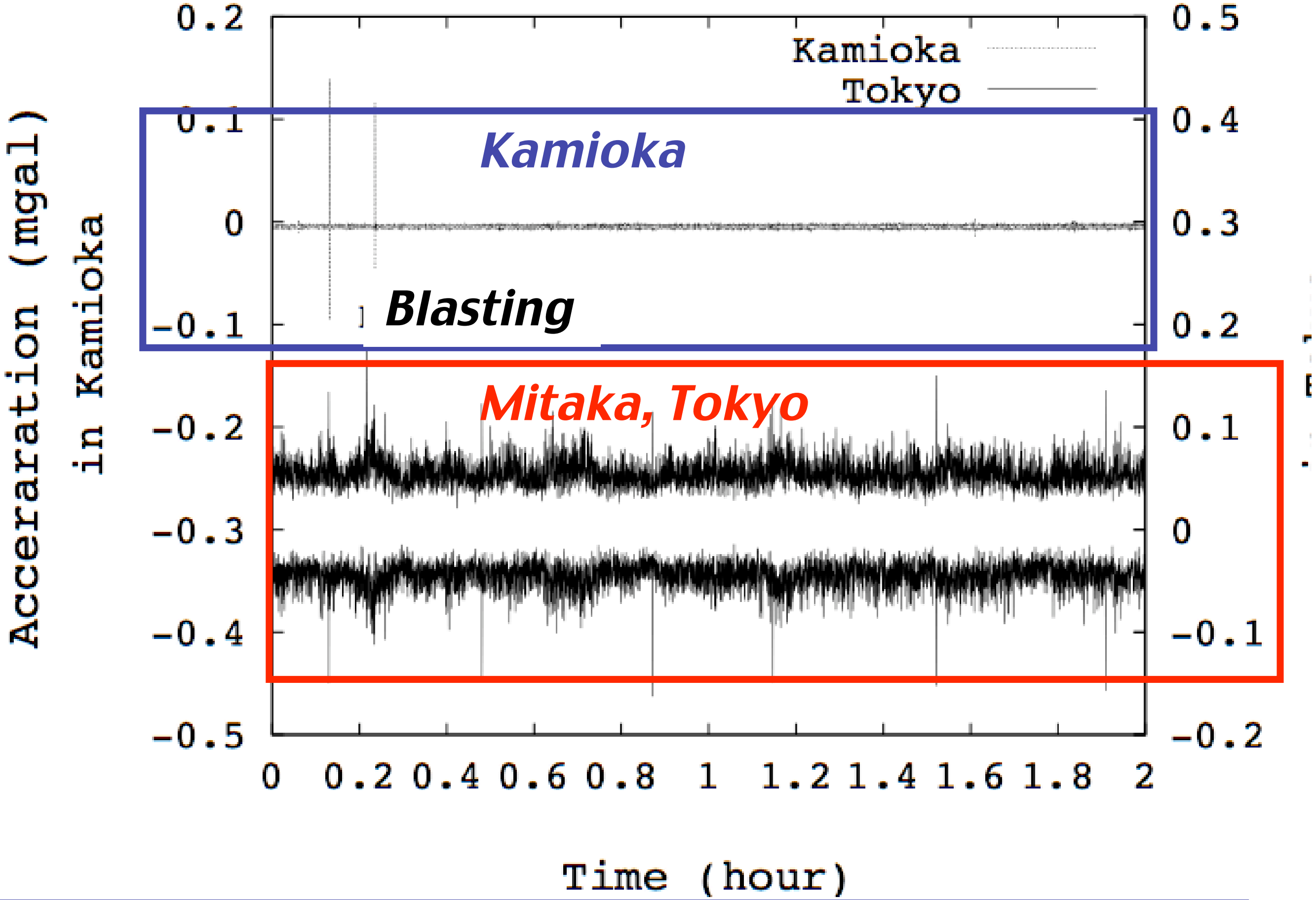
- **Low seismic noise level**
  - ***Great** in lower frequency Region*
  - ***2–3 orders merit**@ a few [Hz]*
  - ***Close to Tokyo** in observation band*

- **"Indispensable" for stable operation**



LISM project (3) – *Merit of Kamioka, underground* –

- **Small acceleration**
  - ***~1/100** at Kamioka site*
  - ***Blasts are equivalent** to Tokyo level*

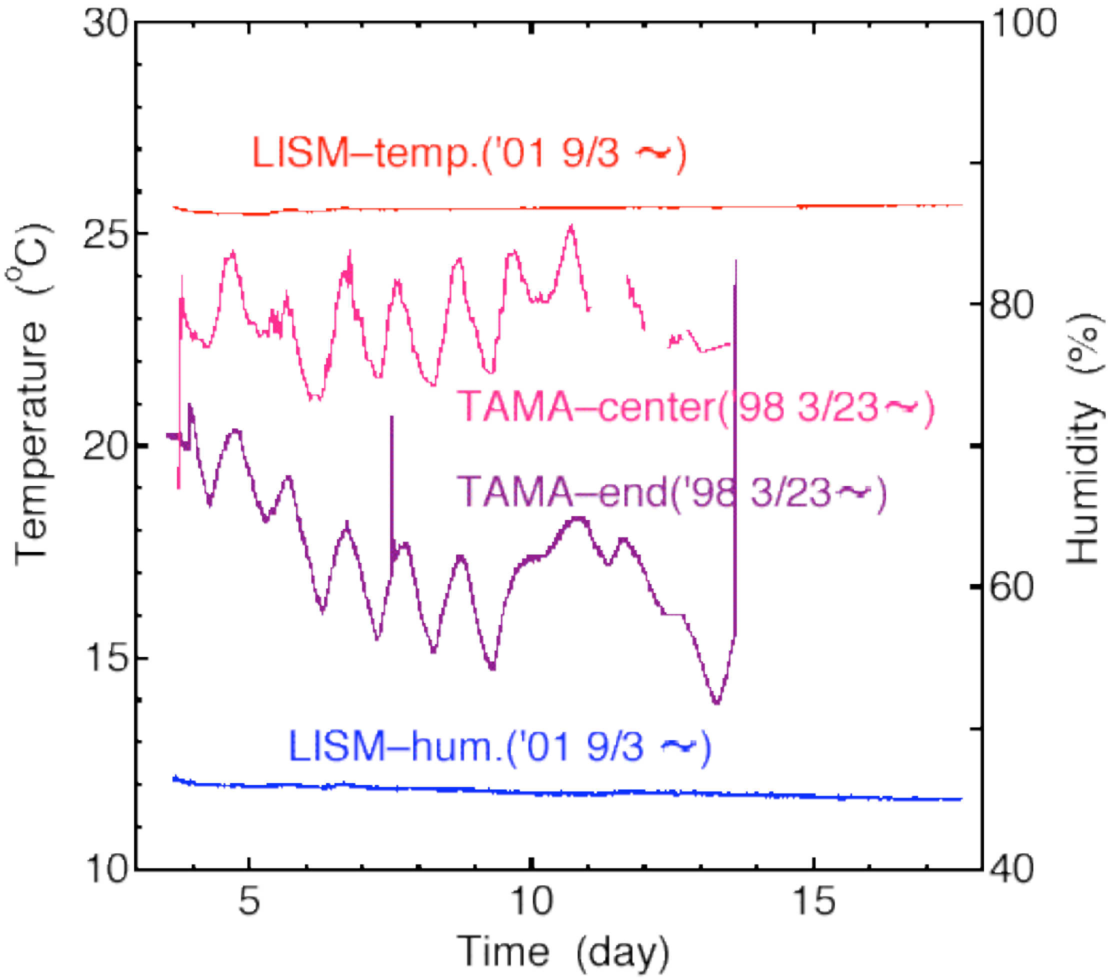


LISM project (4) *–Merits of Kamioka, underground–*

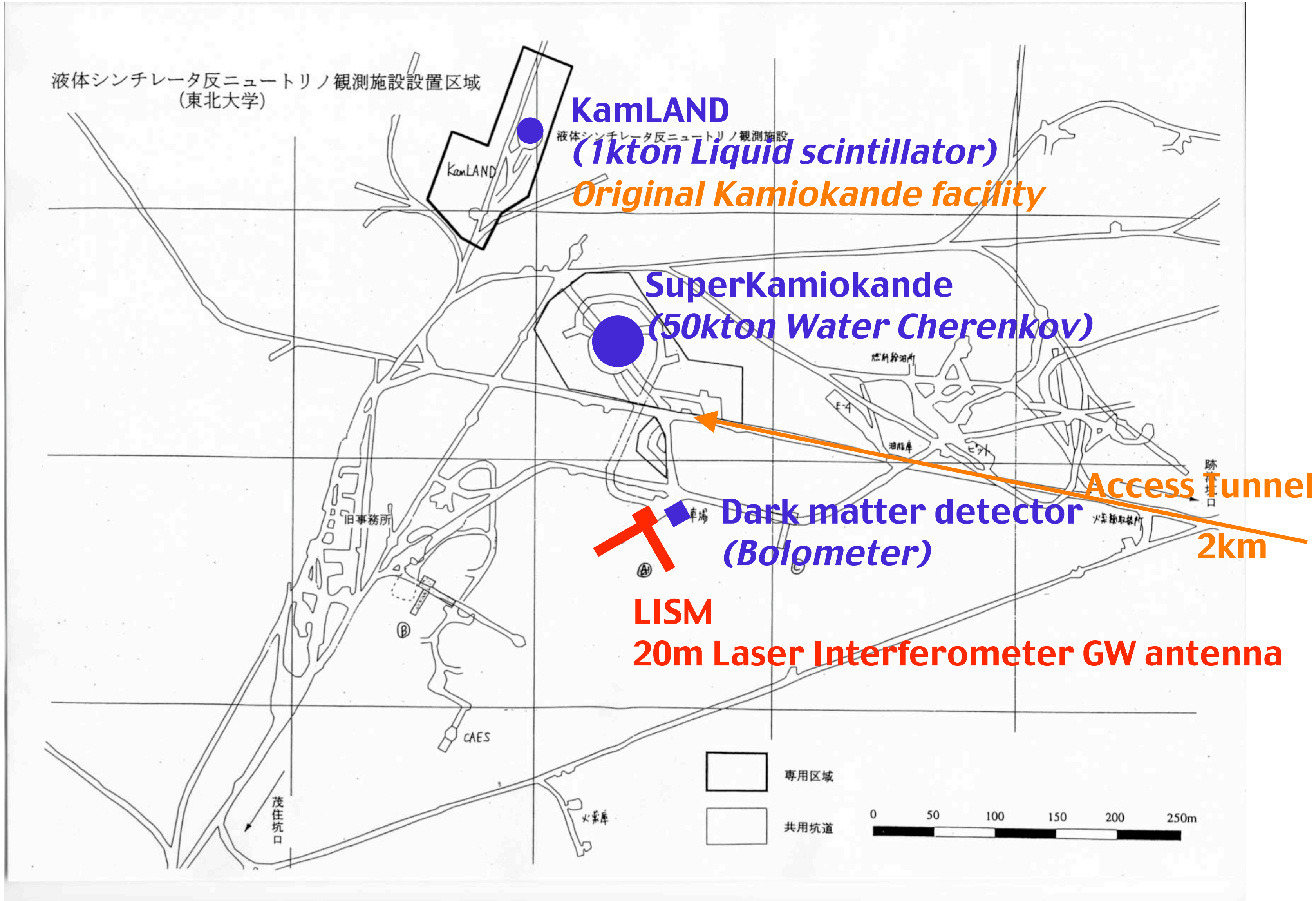
- **Environmental stability**
  - ***Strong merit for long term, stable operation***

- **Temperature variation**
  - ***+/–0.1Degree/week***
  - ***Very small drift***

- **Humidity variation**
  - ***+/–1%/week***

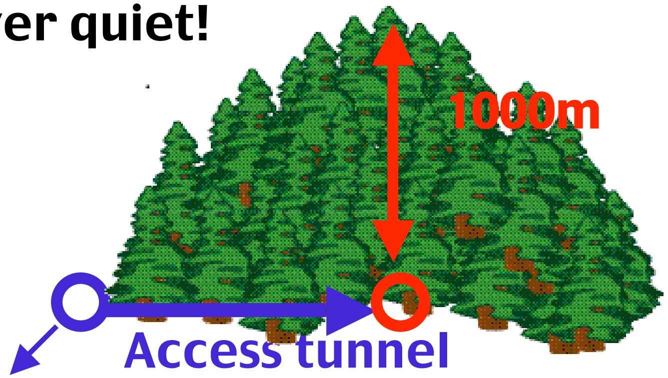


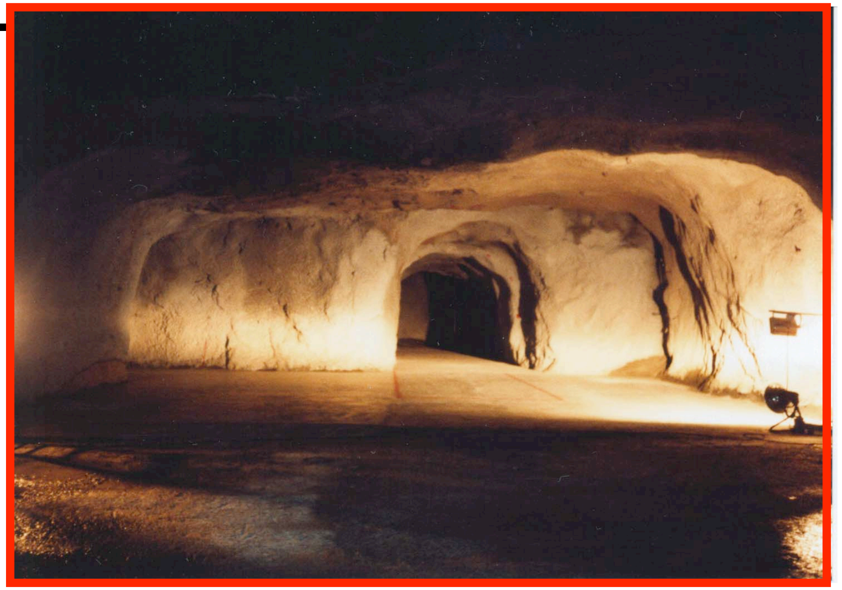
LISM project (5) *–Pit Map–*



LISM project (6) – *Lab* –

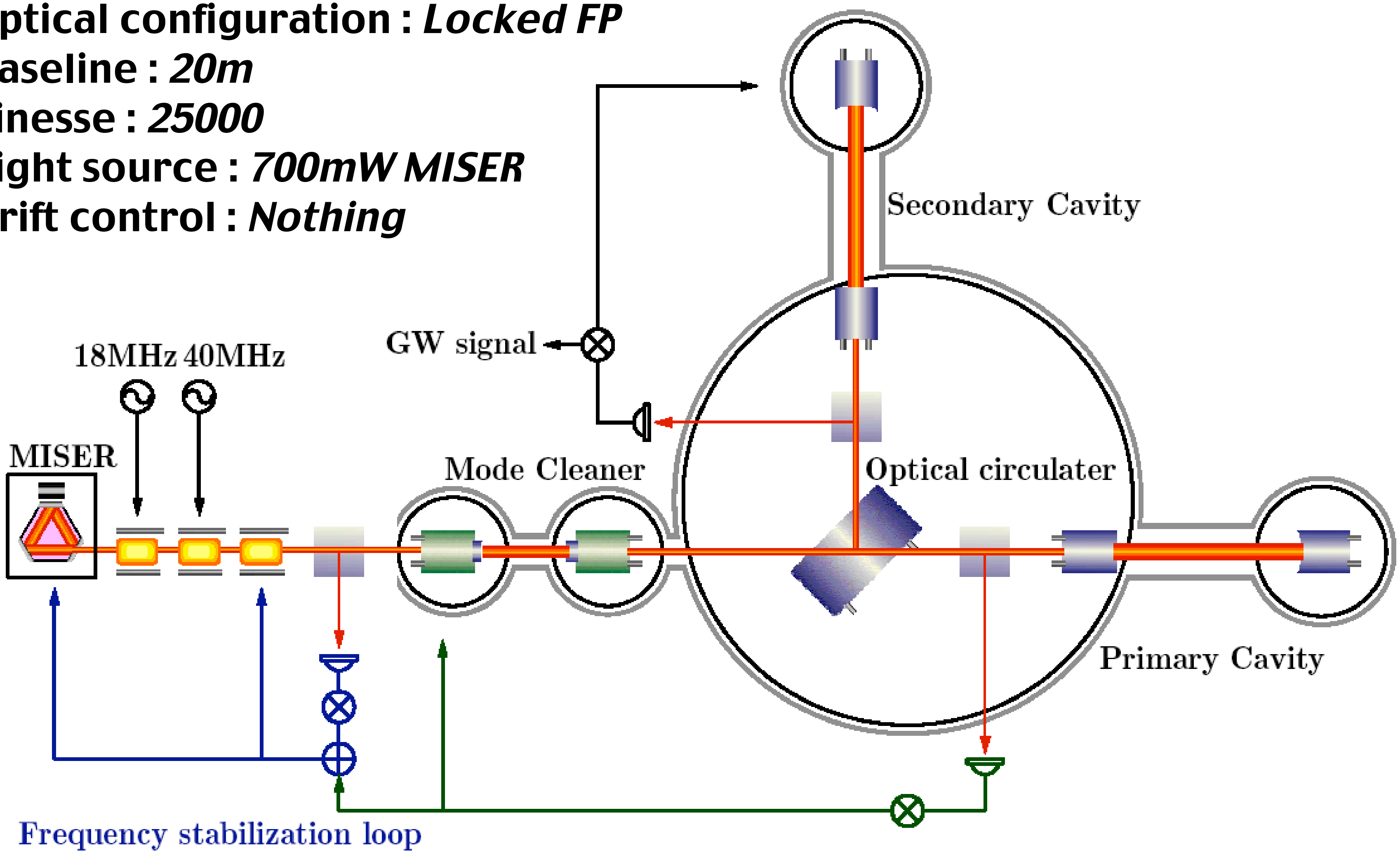
- 1000m "*underground*"
- Nature of the soil is "hard rock"
- However quiet!





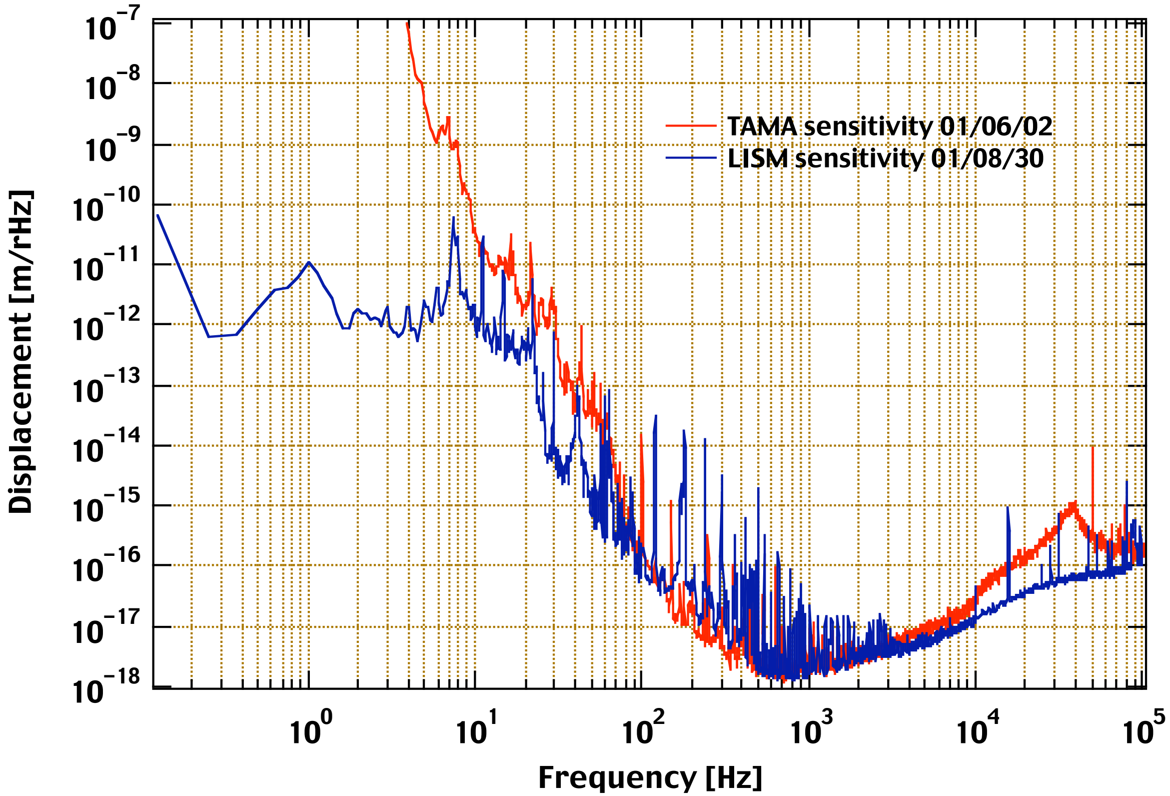
LISM project (7) – *Configuration* –

- Optical configuration : *Locked FP*
- Baseline : *20m*
- Finesse : *25000*
- Light source : *700mW MISER*
- Drift control : *Nothing*

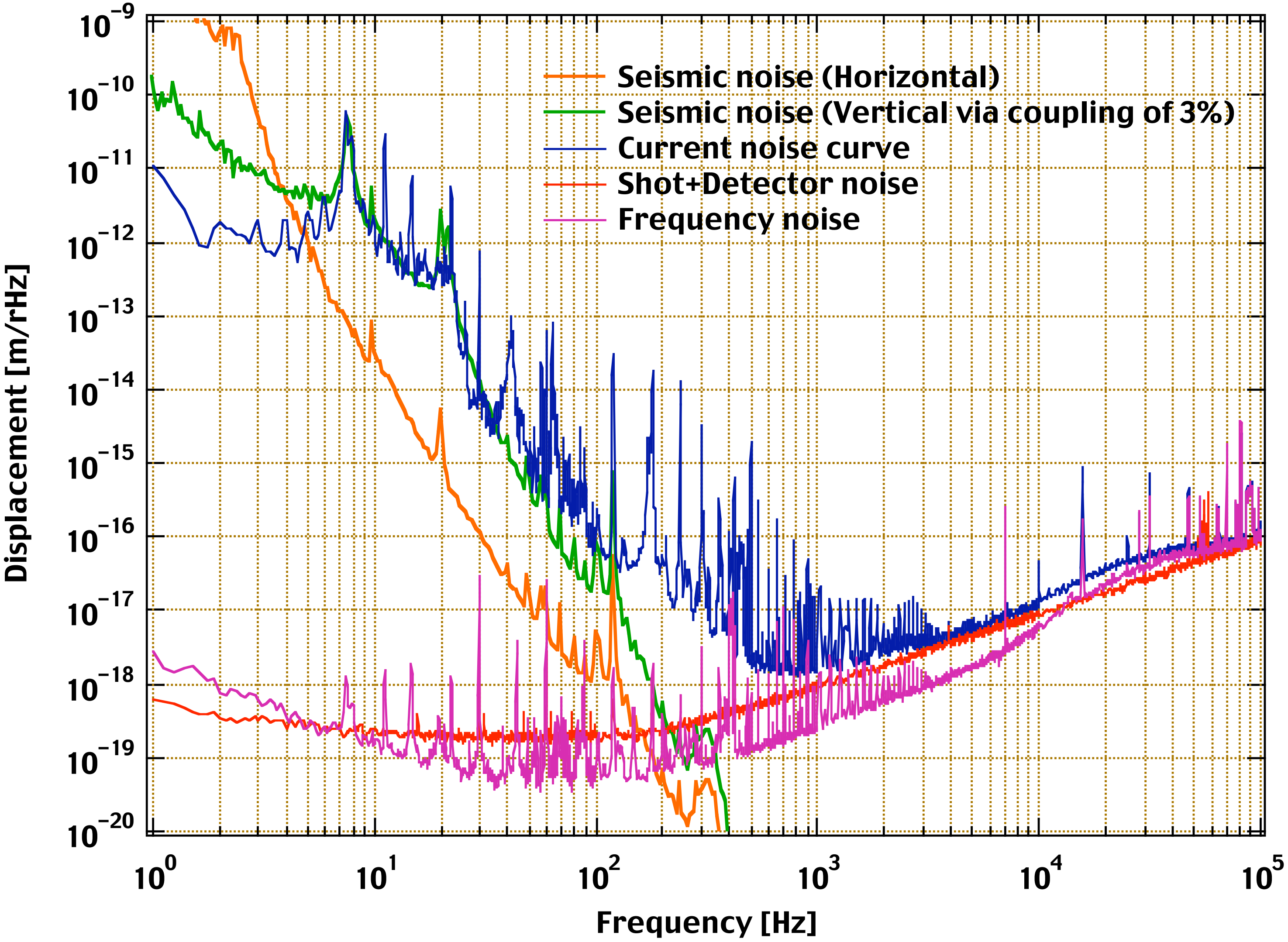


LISM project (8) – *IFO Sensitivity* –

- 1.5×10^{-18}[m/rHz]@800[Hz]
- Comparable with TAMA FPMI best sensitivity
- MUCH Better in lower frequency region
- Residual RMS displacement (integrated down to 0.1[Hz])
  - : ~10^{-10}[m_{rms}] *LISM*
  - : ~10^{-6}[m_{rms}] *TAMA*



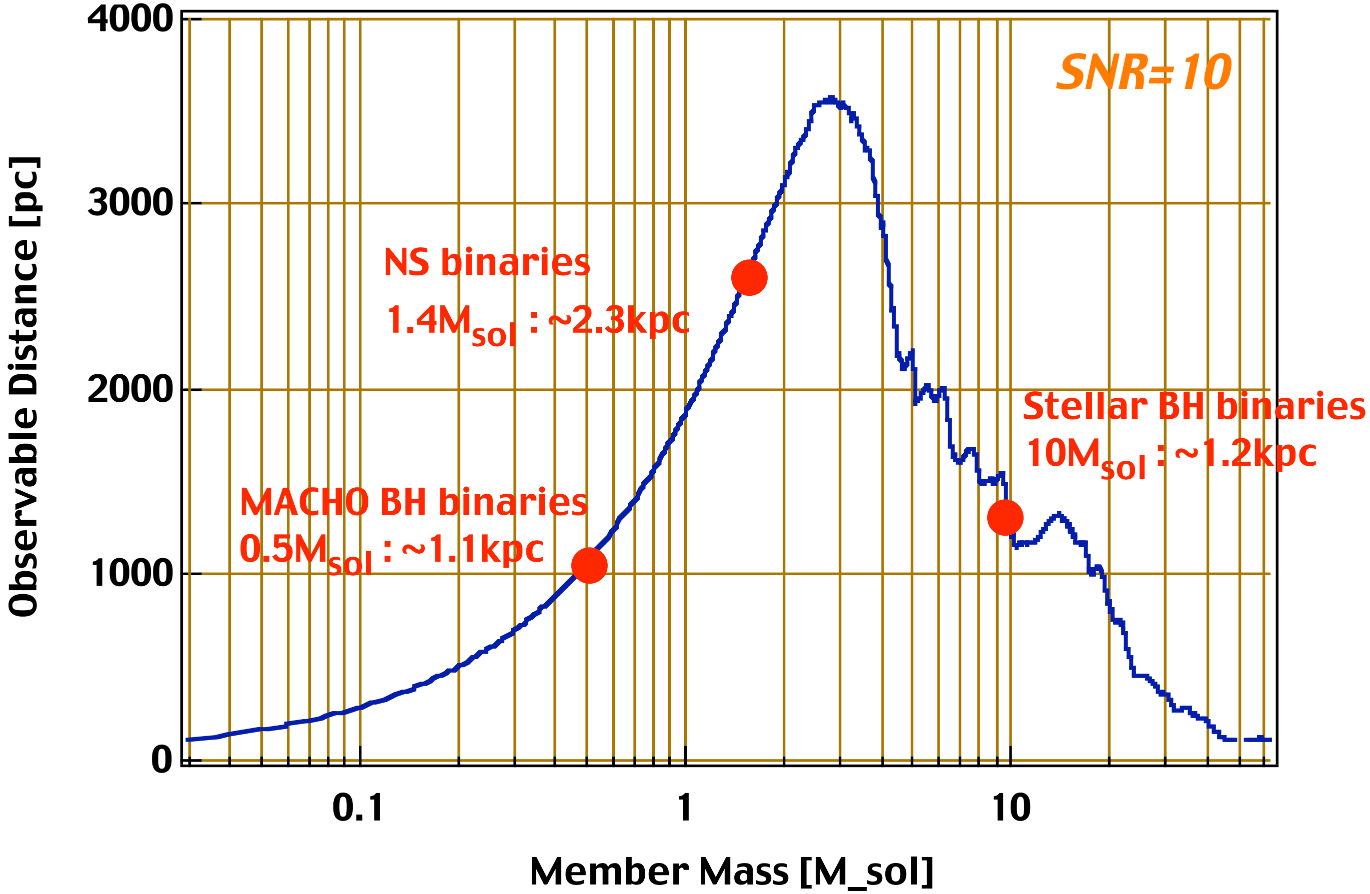
LISM project (9) – *IFO Noise Budget* –



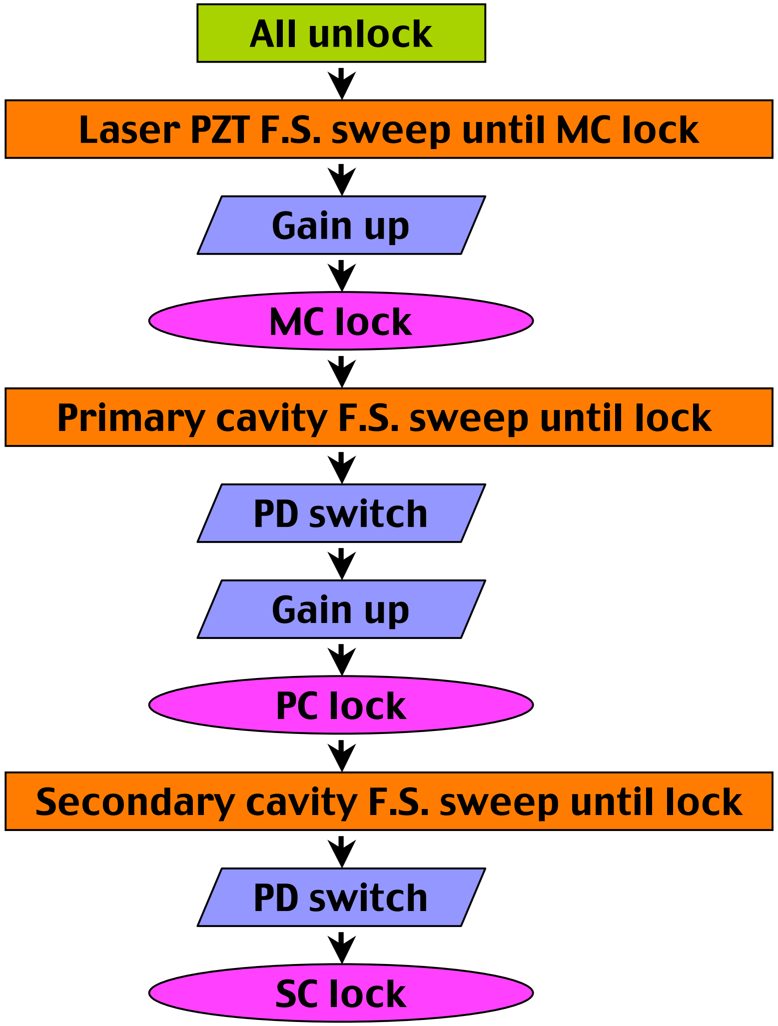
LISM project (10) – *Expected Binary Range* –

- Expected SNR for coalescence of equal mass binary system

$$\mathrm{SNR} \propto \left(\int_{f_0}^{f_c} \frac{f^{-7/3}}{S_n(\mathrm{f})} df \right)^{1/2}$$



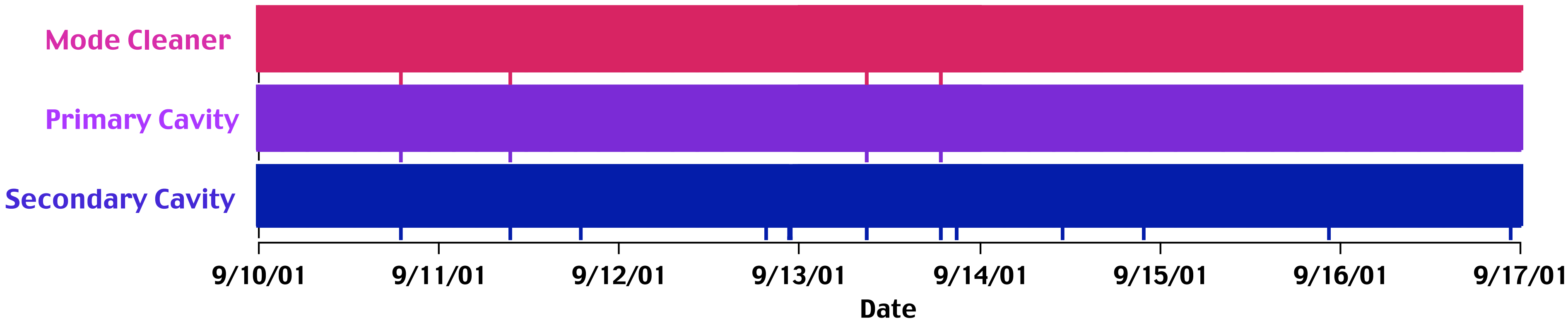
LISM project (11) – *Automated Lock Acquisition* –



- Make lock acquire by the order
  - *MC >> PC >> SC >> Final state*
- Actively sweep FS for lock acquisition
  - *No resonance flush without sweep*

LISM project (11) – *Operational Stability* –

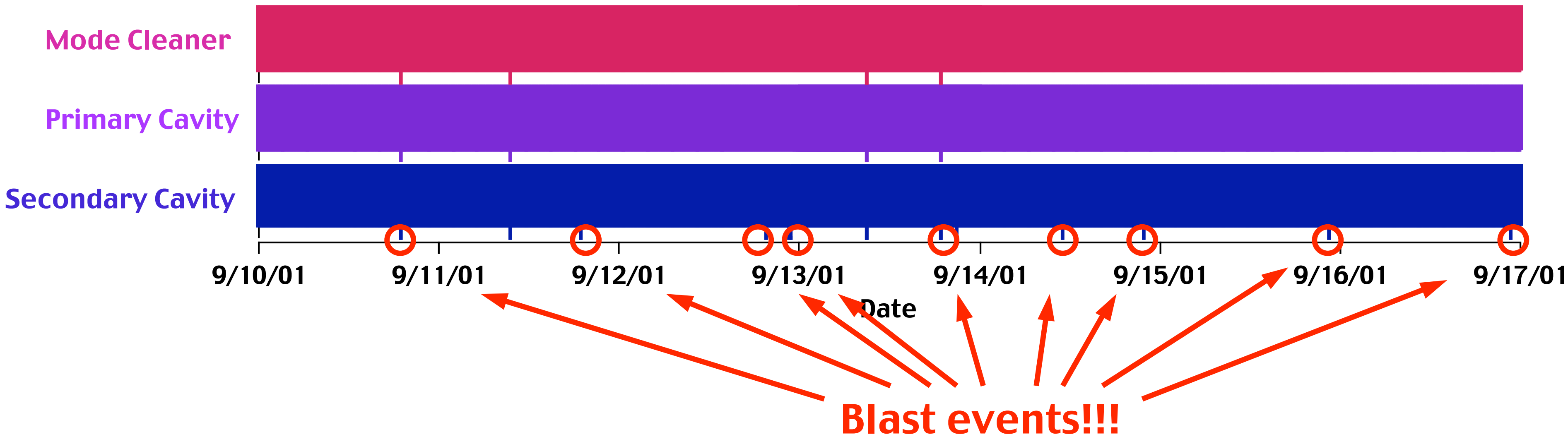
- Longest stretch of lock : 24h in this period
  - *Lock lost due to blasting !*
  - *Record : 170h in 2001spring*



LISM project (11) – *Operational Stability* –

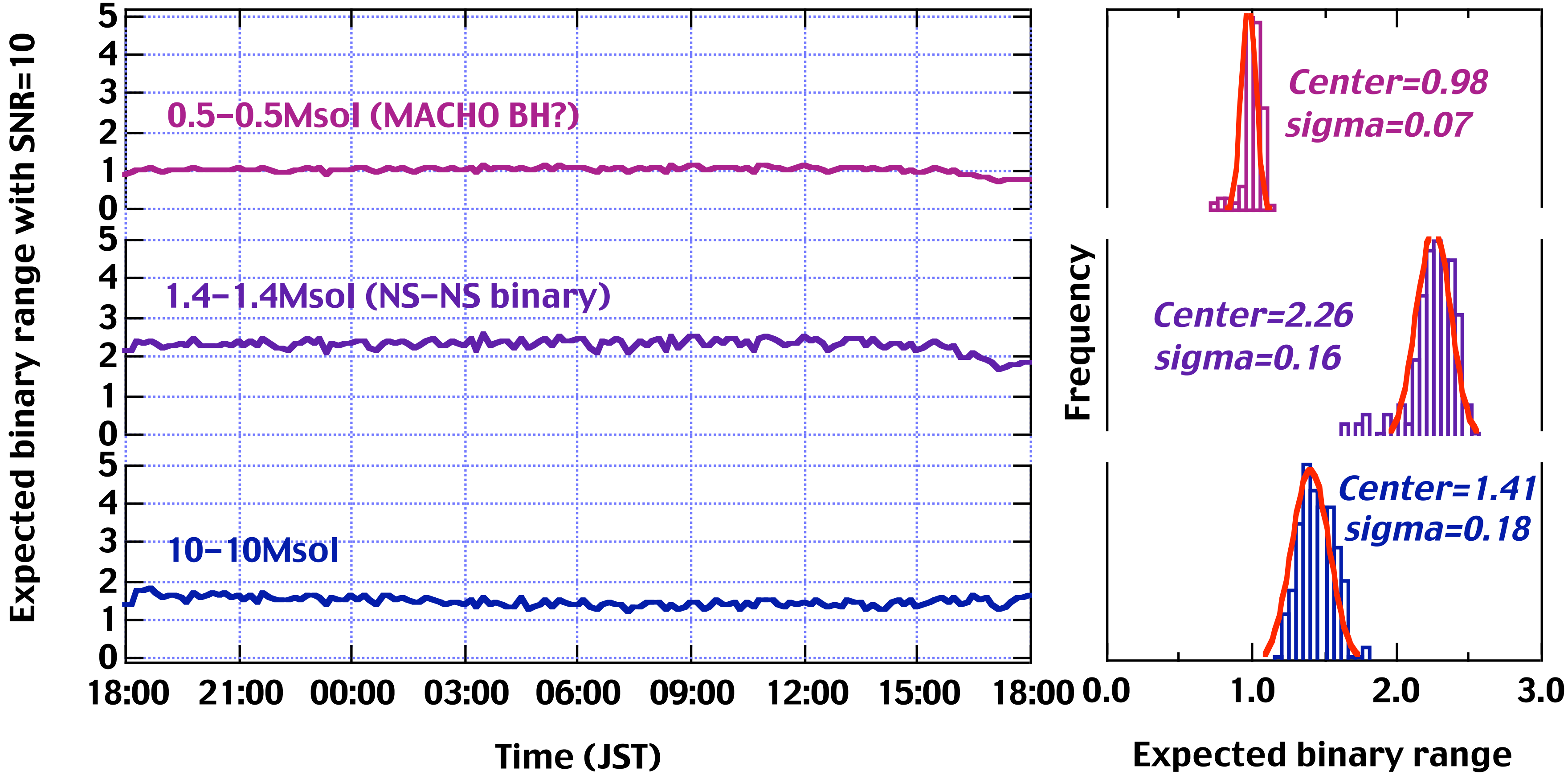
- Longest stretch of lock : 24h in this period
  - *Lock lost due to blasting !*
  - *Record : 170h in 2001spring*

- Live rate : 99.8%

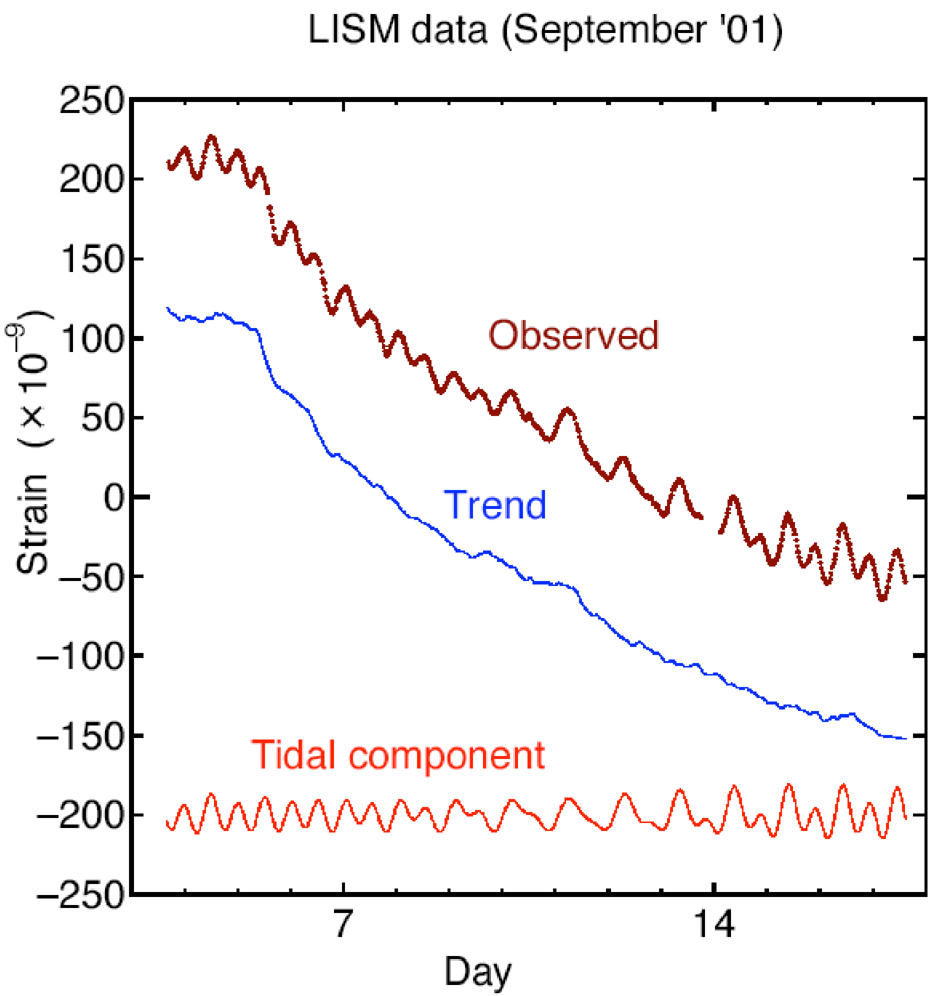


LISM project (12) – *Spectral Sensitivity Stability* –

- Sensitivity stability (*by use of binary range as reference*)
- No apparent "*day/night effect*"



LISM project (13) – *Tidal observation* –



- **Stretch of feedback signal**
  - ***Primary cavity (f-stab. loop)***
  - ***PZT feedback (No thermal path)***
- **Observed stretch includes**
  - ***FP length change***
  - ***Wave length change***
- **Observed−Trend=Tidal**
  - ***Response function of local land***
  - ***Characteristic parameters etc…***
  - ***Geophysical application***

Summary *– Invitation to the underground world–*

- Stable Environment (Seismic, Temperature and so on…)
  - *Stable operation of IFO*
  - *Lowering IFO sensitivity in low frequency region*

Summary – *Invitation to the underground world–*

- Stable Environment (Seismic, Temperature and so on...)
  - *Stable operation of IFO*
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- Going underground can be one of solutions