Characterization of GW150914 by RMSMon

2016/2/15 Tuesday @DetChar meeting, Yuzurihara

o Today's topic

- About RMSMon
- Result of GW150914 by RMSMon with several frequency ranges
  * LIGO Hanford
  * LIGO Livingston
- Comments to the results.
- Toward data quality flag

Definition of RMSMon

[Classical and Quantum Gravity, Volume 21, Number 5]

RMSMon : RMS monitor tool
RMSMonitor can find the time affected by non-stationary transient noise.

$$RMS = \left(\int_{f1}^{f2} |\tilde{s}(f)|^2 df \right)$$

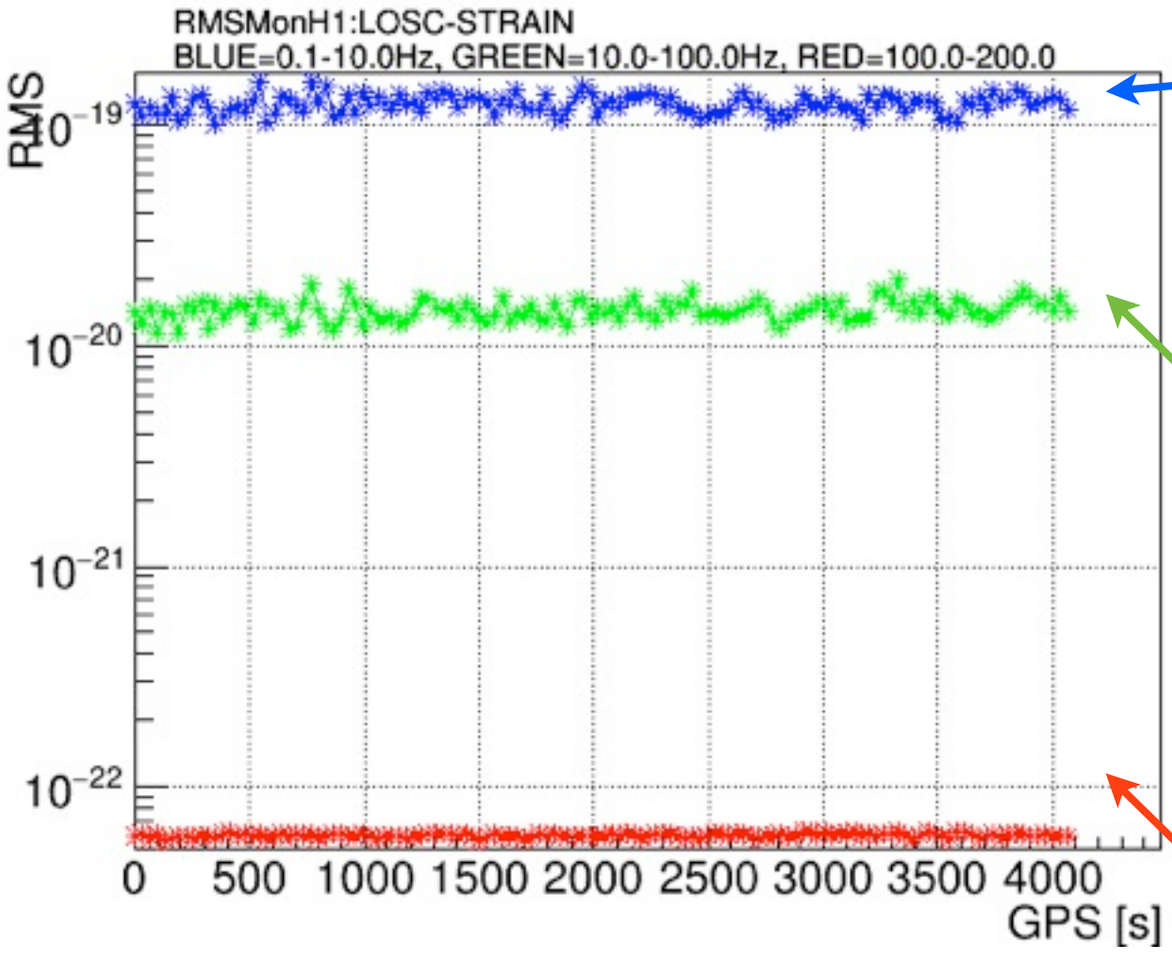
1. calculate the spectrum s(f)
 from the time series s(t)

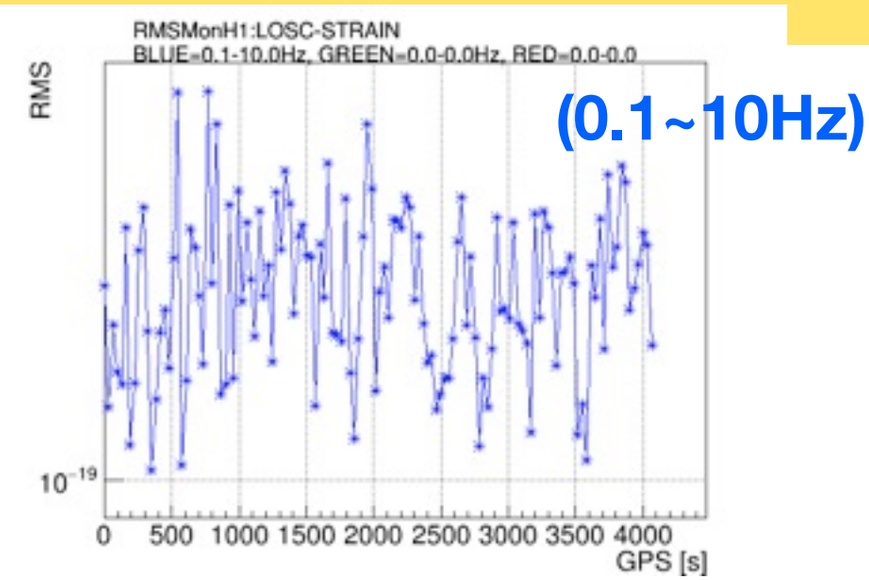
2. sum up the squared spectrum
between the frequency band

In following result, I calculated RMS from the data of GW150914.
The sampling rate of data is 4096[Hz].
The duration of data is 4096[s].
The duration of chunk is fixed as 32[s].
 => The number of samples is 4096/32 = 128 samples.

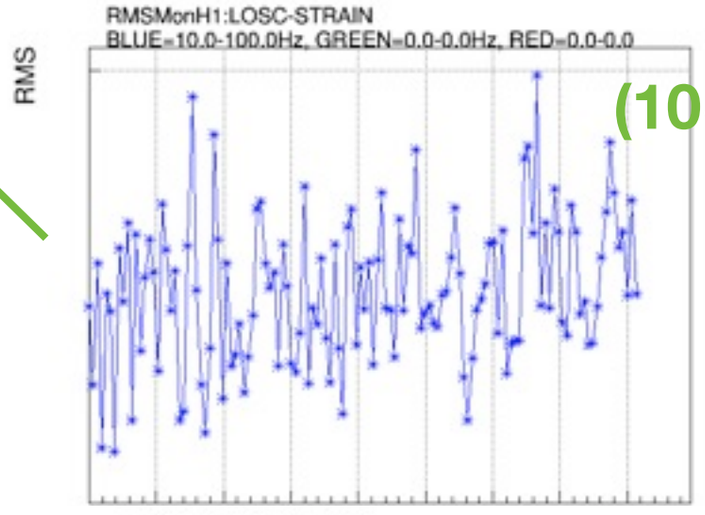
Result of RMSMon with LIGO Hanford data

Result 0.1~10Hz, 10~100Hz, 100~200Hz (LIGO Hanford)

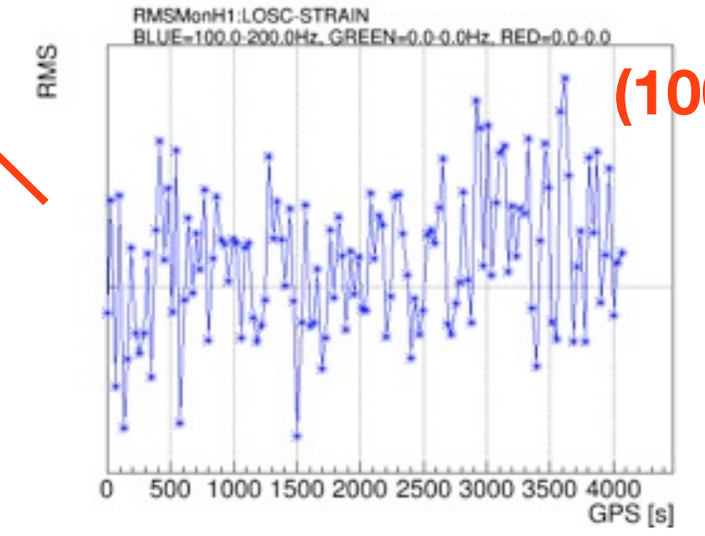




(0.1~10Hz)



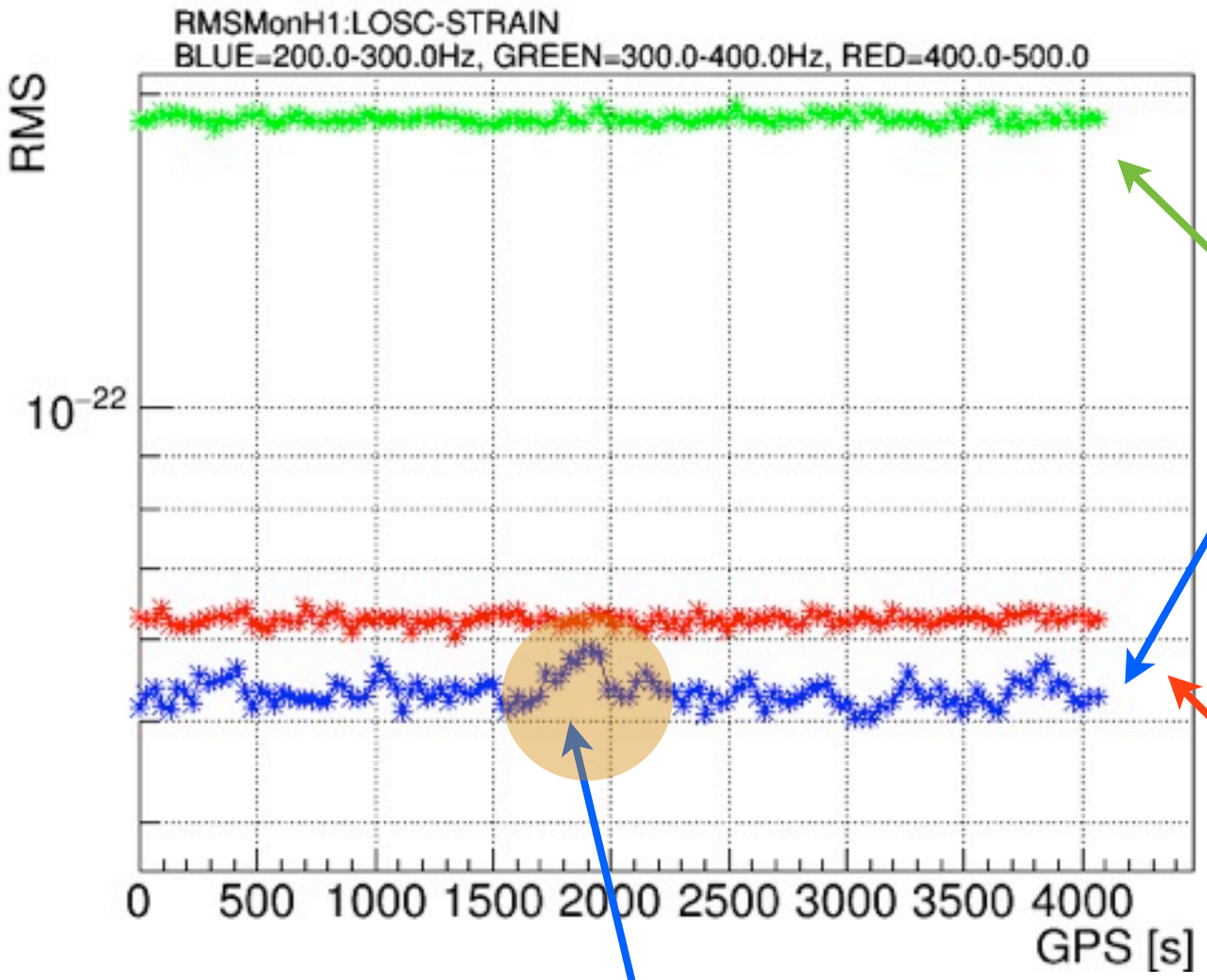
(10~100Hz)



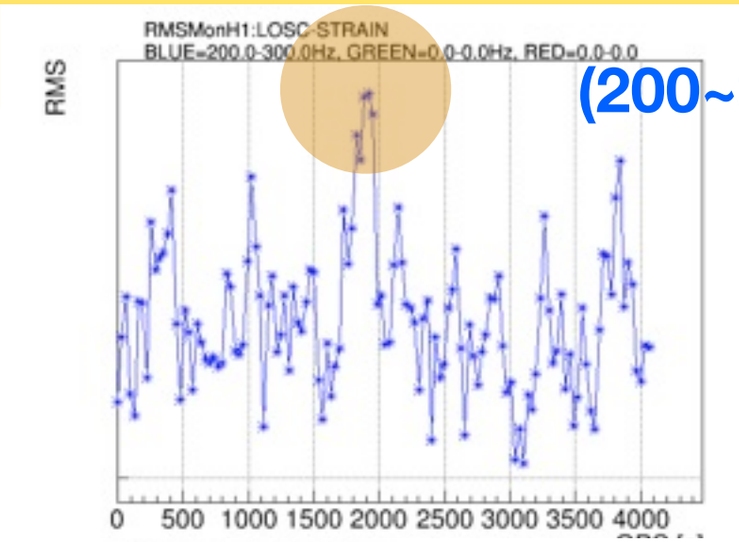
(100~200Hz)

・The RMS of these frequency bands looks almost stationary.

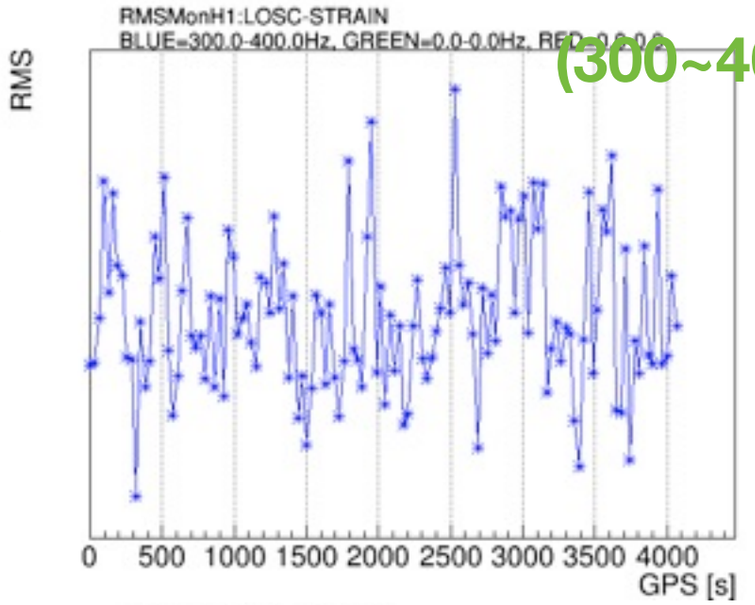
Result 200~300Hz, 300~400Hz, 400~500Hz (LIGO Hanford)



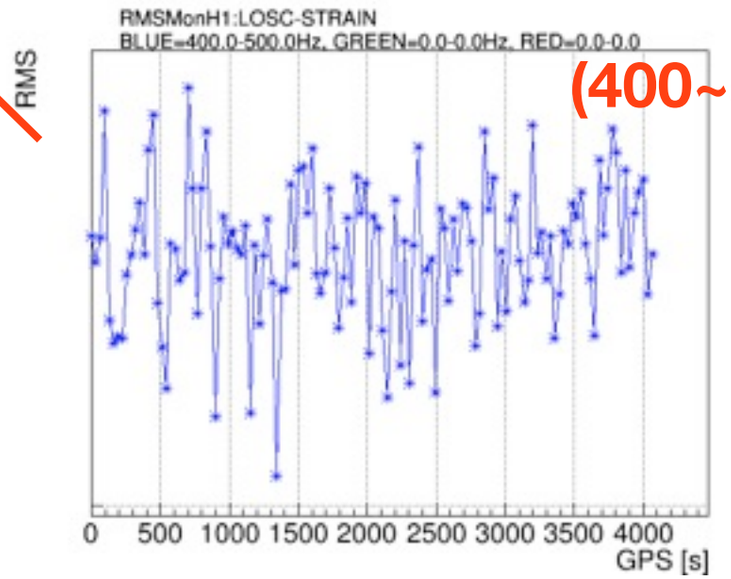
This looks the effect of glitch?



(200~300Hz)



(300~400Hz)

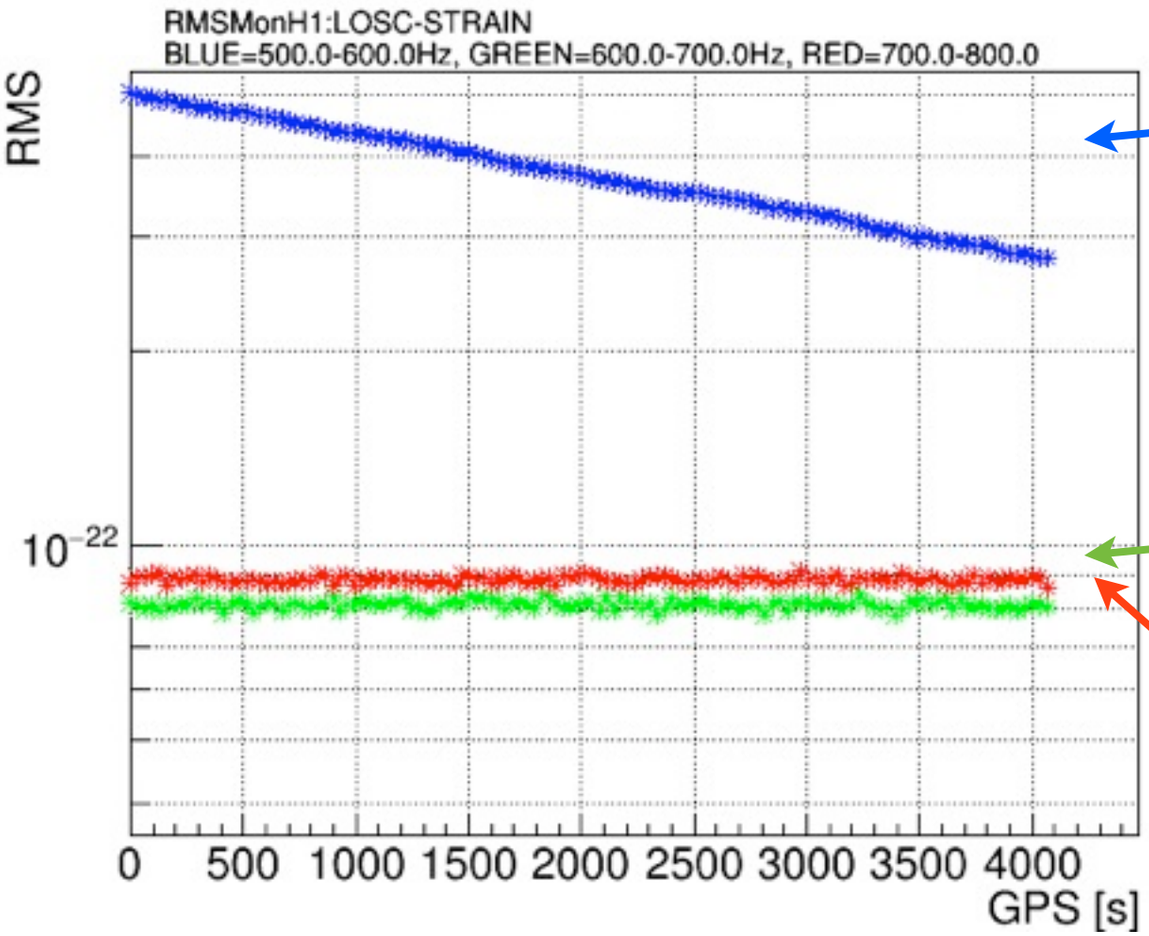


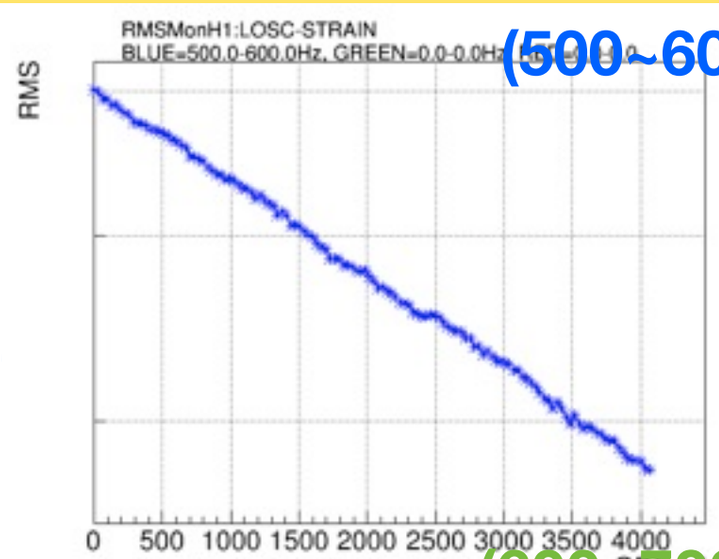
(400~500Hz)

- The RMS of other frequency bands and other time looks stationary.

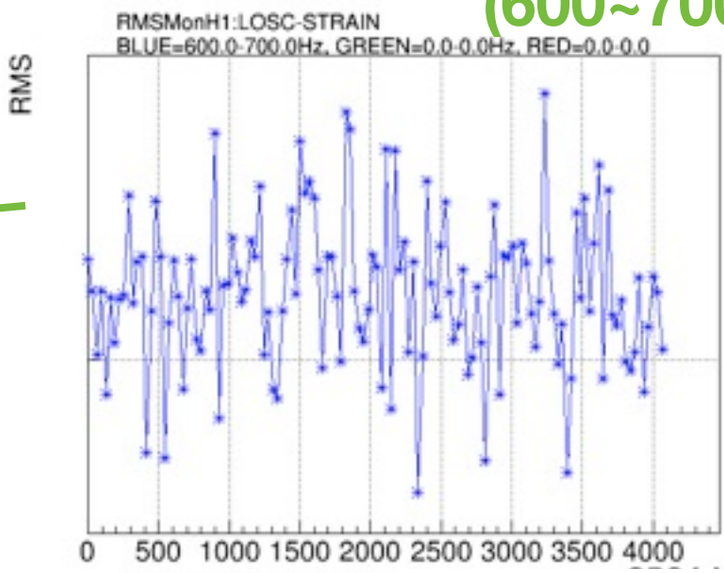
Result 500~600Hz, 600~700Hz, 700~800Hz (LIGO Hanford)

RMS(500~600Hz) looks continuously decreasing.
The excitation of violin mode is attenuating?

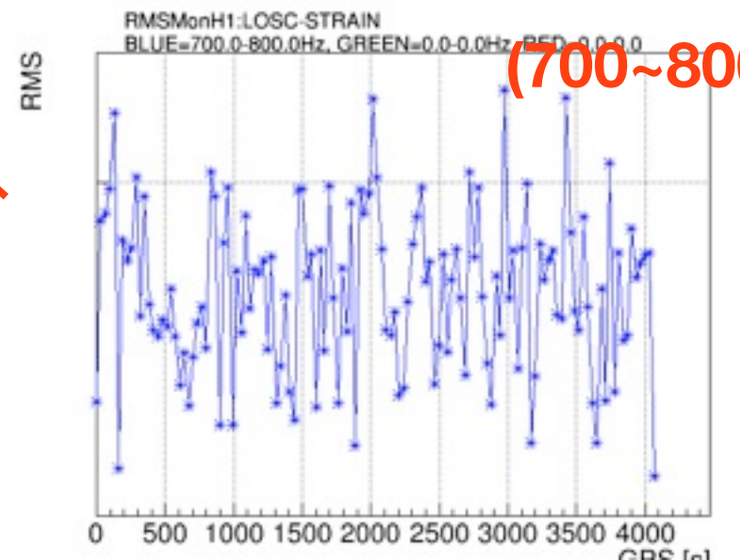




(500~600Hz)



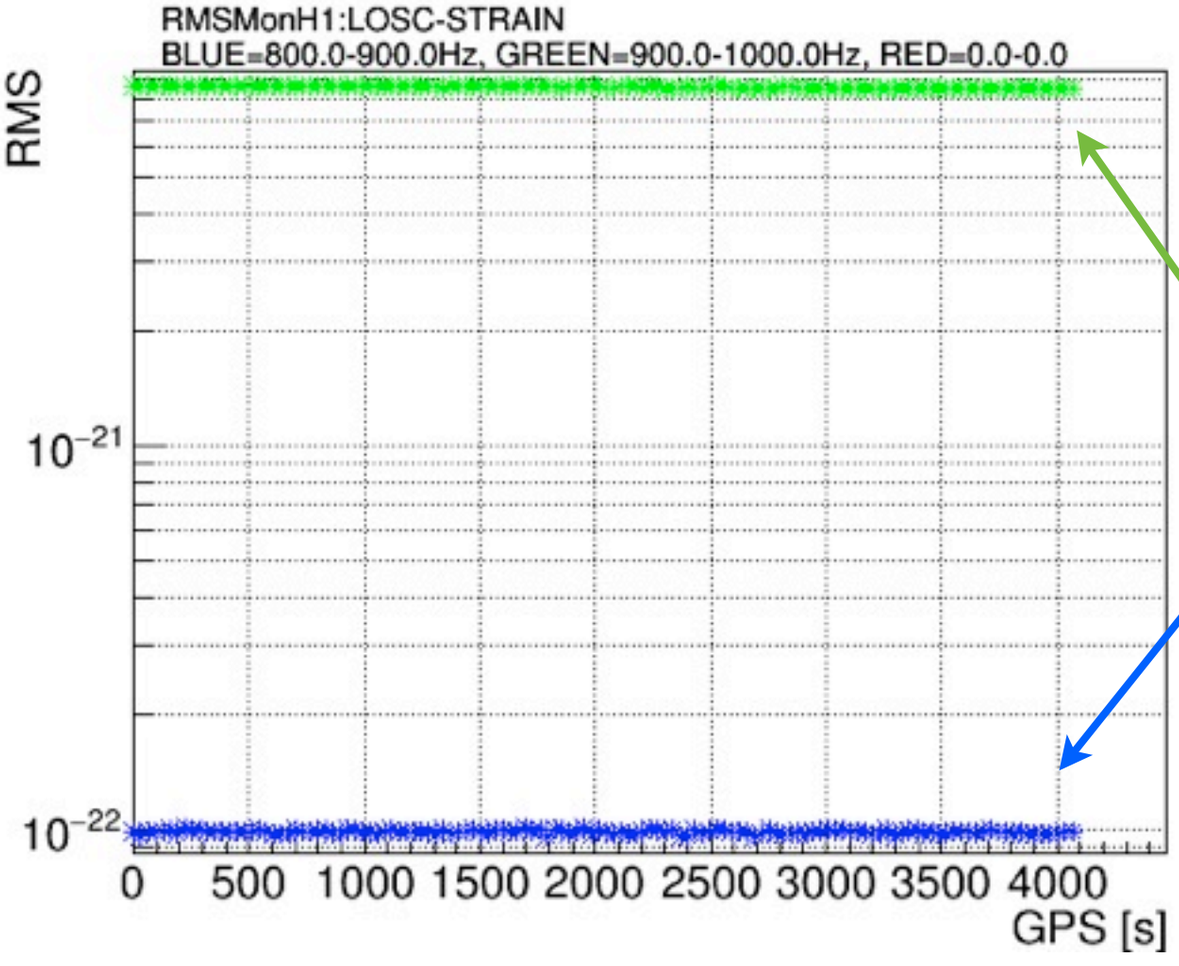
(600~700Hz)



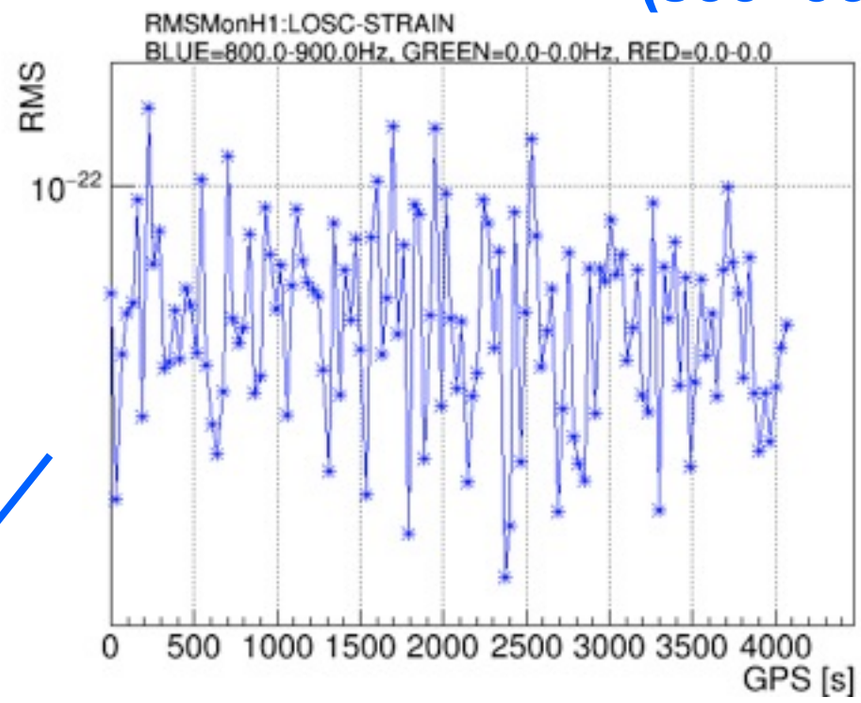
(700~800Hz)

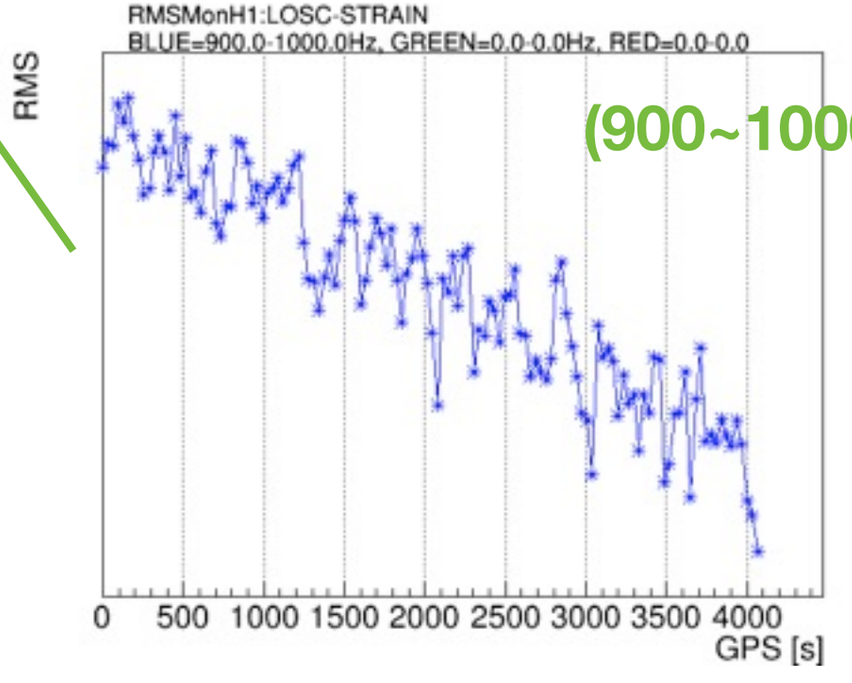
- The RMS of other frequency bands and other time looks stationary.

Result 800~900Hz, 900~1000Hz (LIGO Hanford)



(800~900Hz)

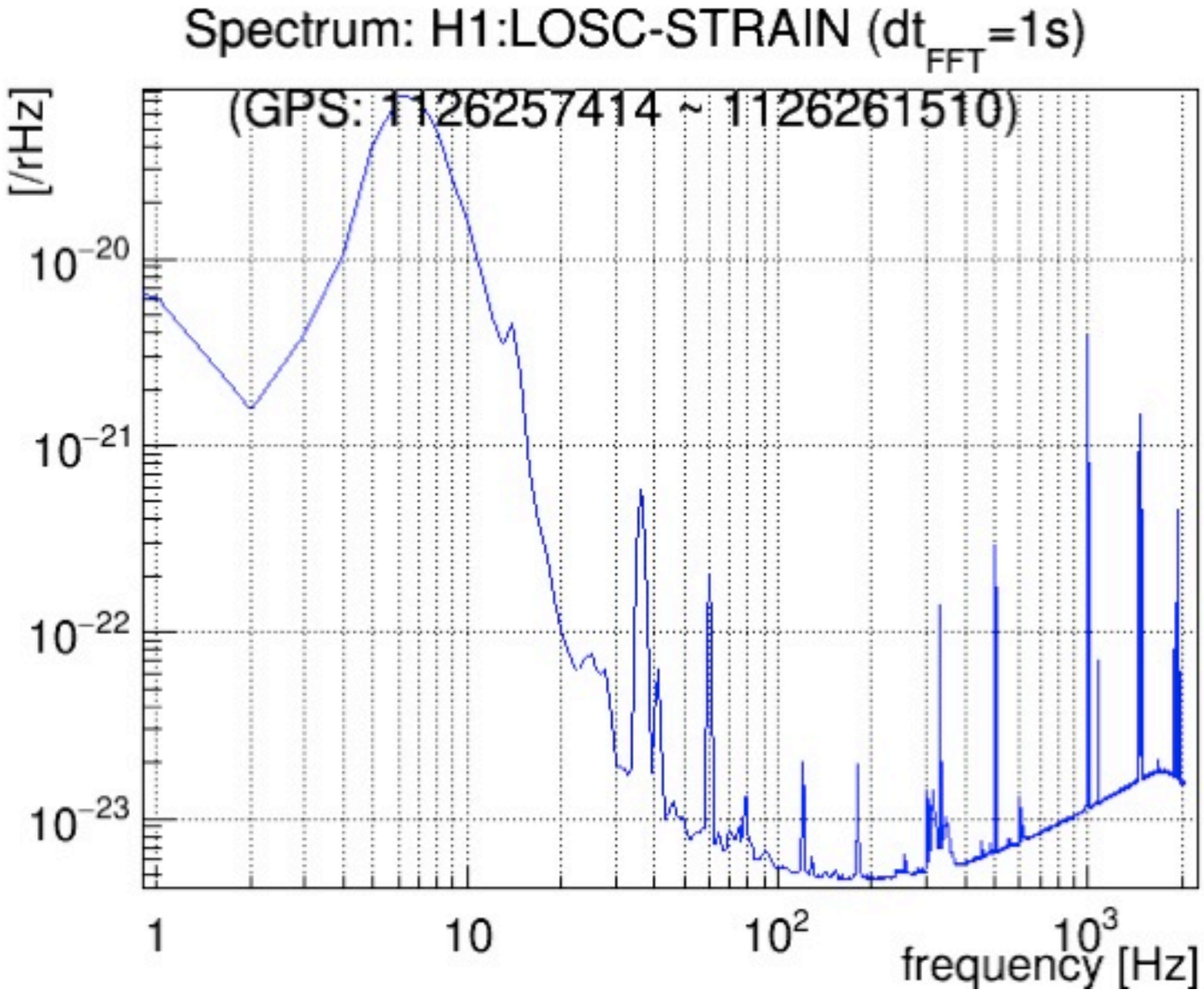




(900~1000Hz)

- The RMS of other frequency bands and other time looks stationary.

The spectrum estimated by Yamamoto-san

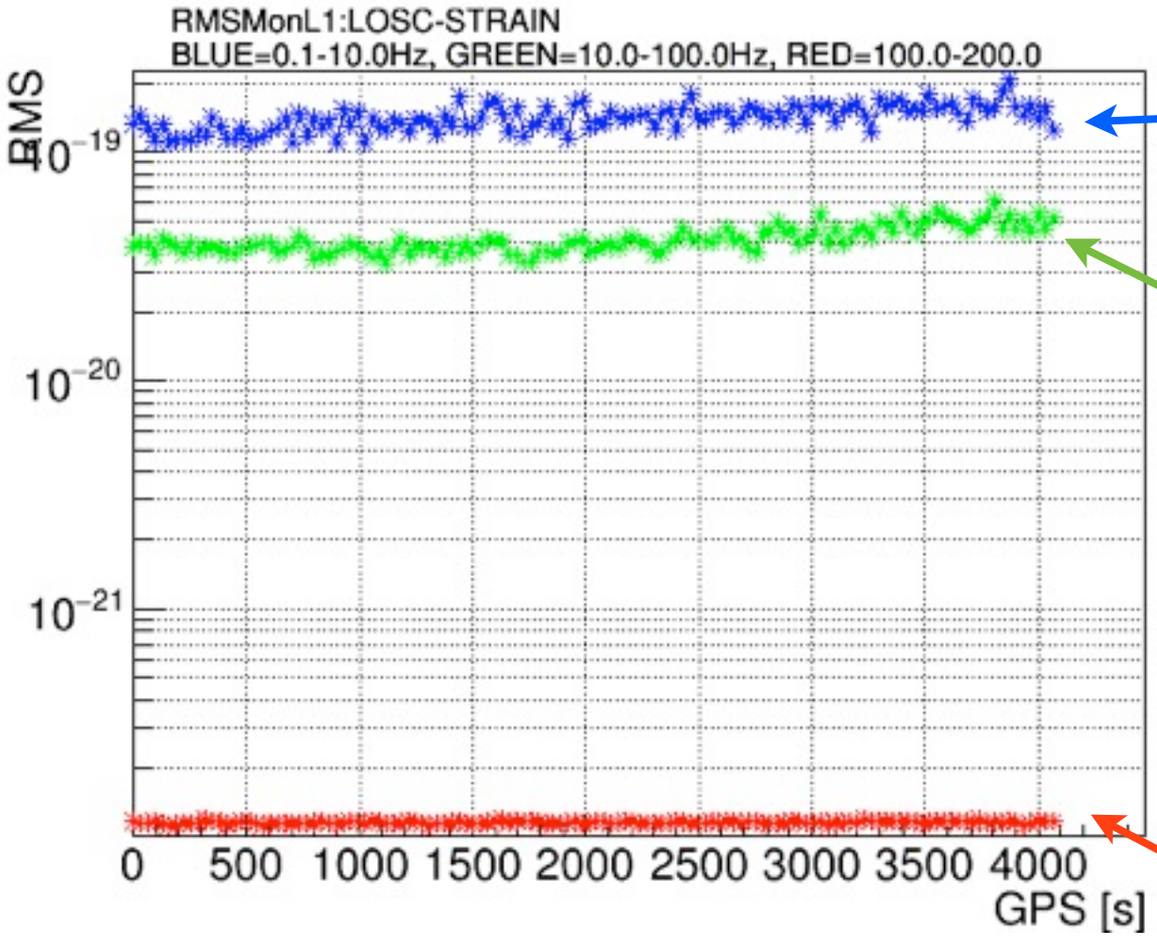


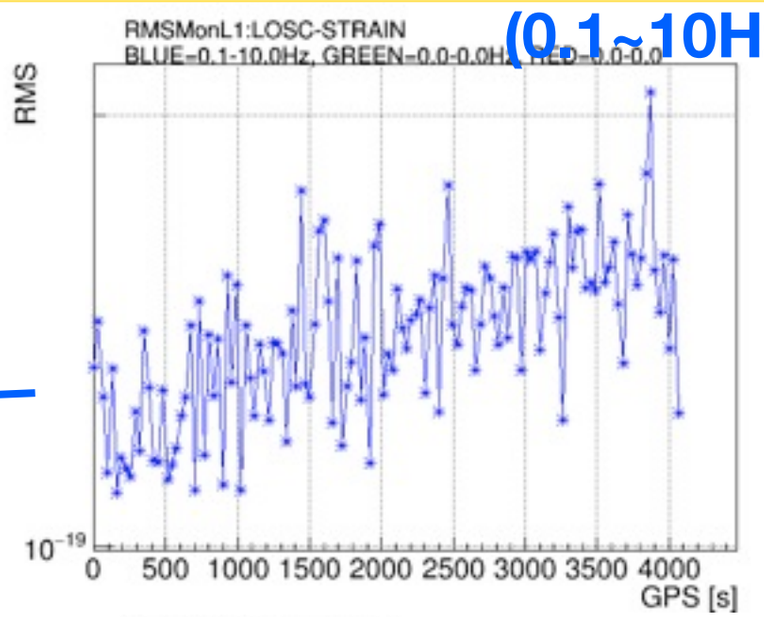
The duration and the sampling frequency of the whole data is 4096[s] and 4096[Hz].
This spectrum is estimated by taking the average(mean) of 4096chunk data (chunk duration is 1[s]).

Result of RMSMon with LIGO Livingston data

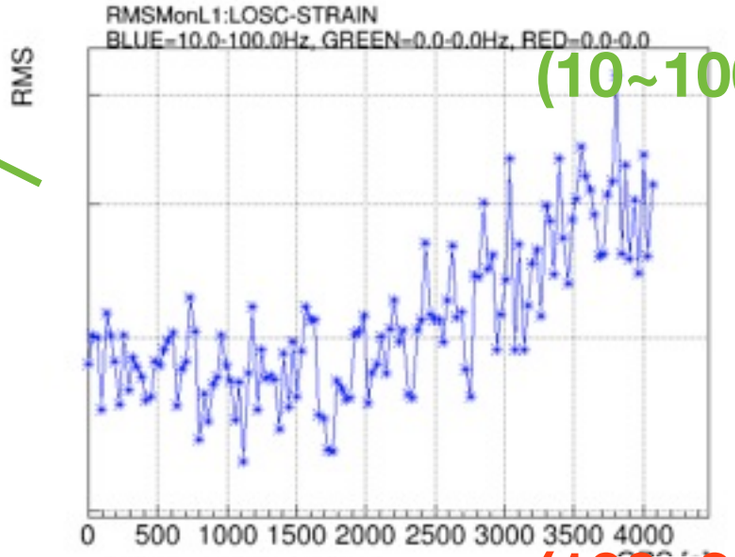
Result 0.1~10Hz, 10~100Hz, 100~200Hz (LIGO Livingston)

RMS(10~100Hz) looks continuously increasing.

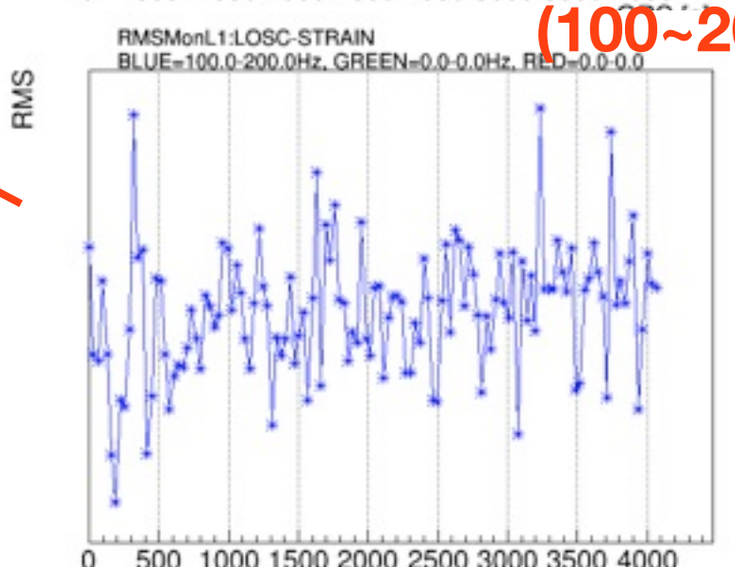




(0.1~10Hz)



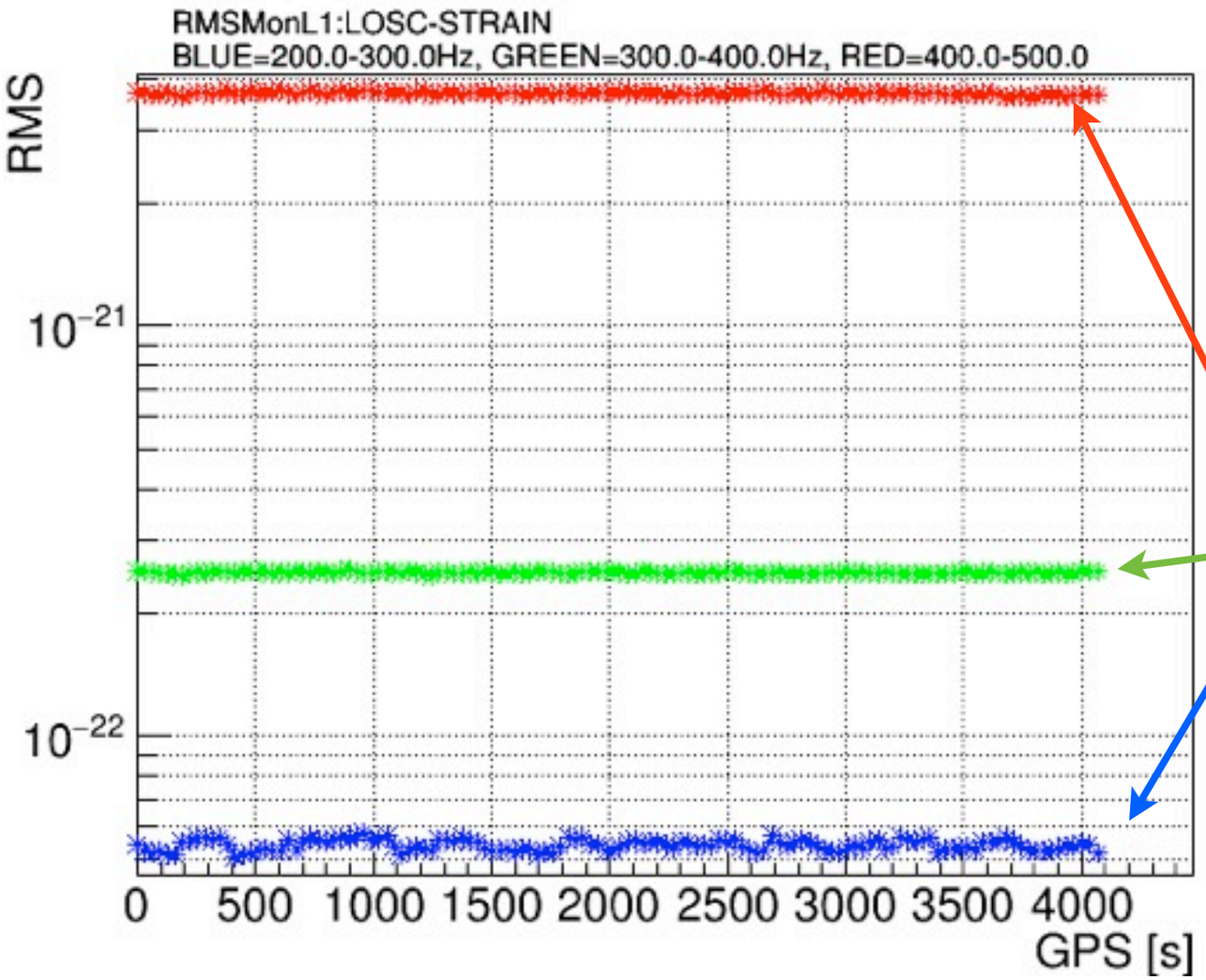
(10~100Hz)

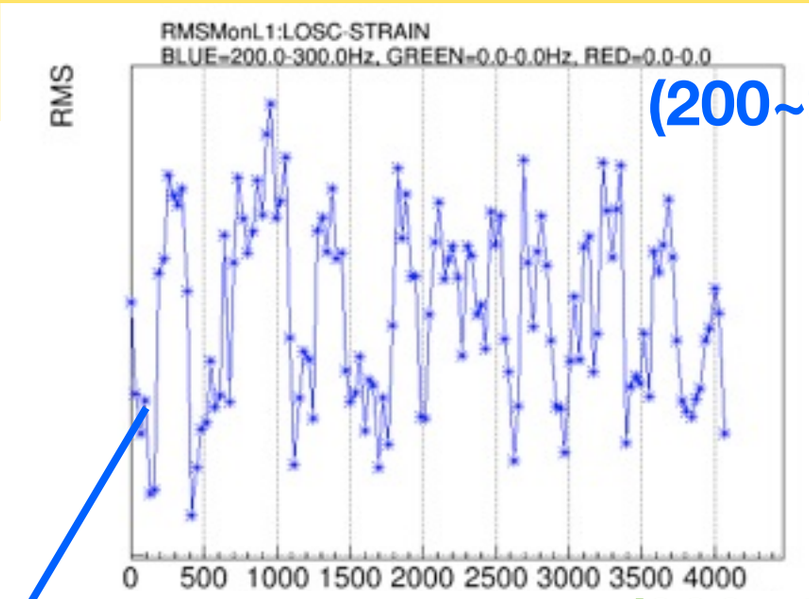


(100~200Hz)

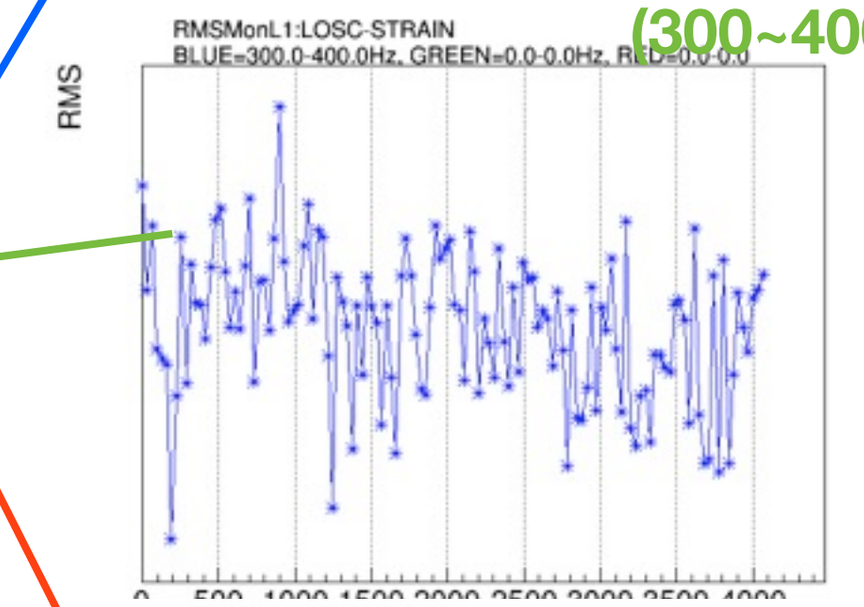
- The RMS of other frequency bands and other time looks stationary.

Result 200~300Hz, 300~400Hz, 400~500Hz (LIGO Livingston)

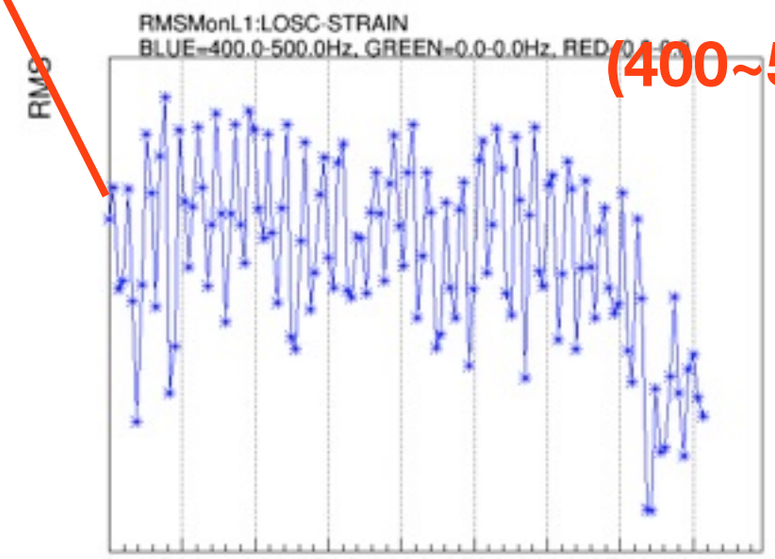




(200~300Hz)



(300~400Hz)

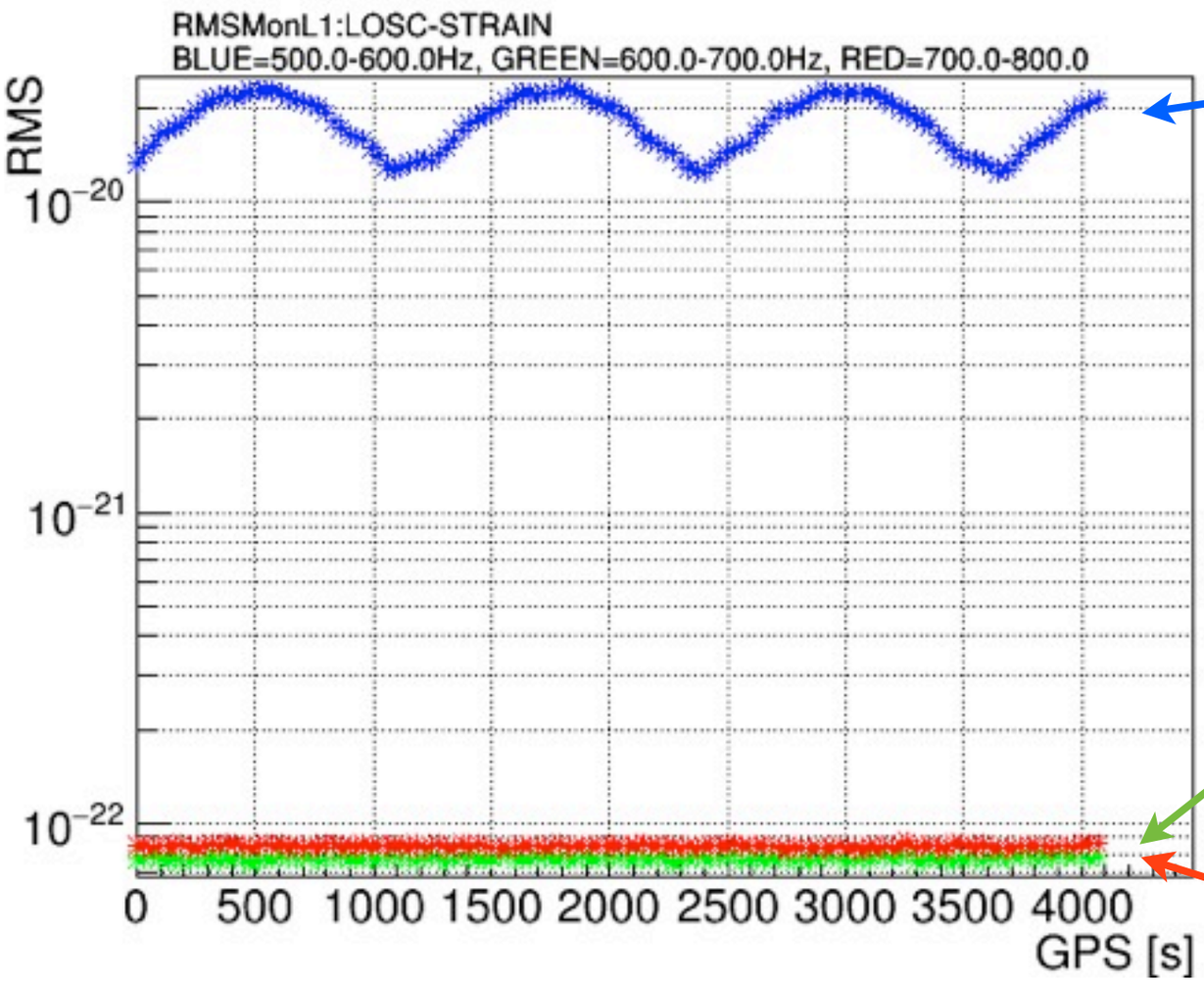


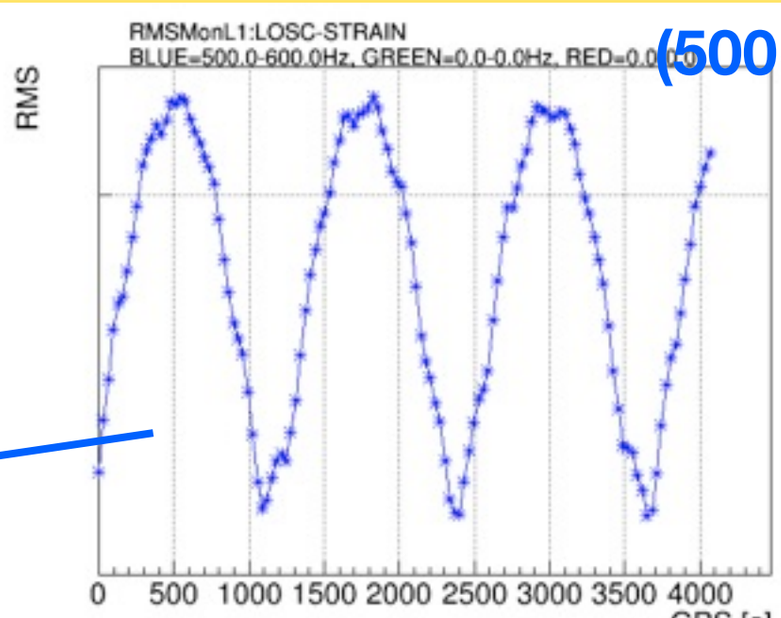
(400~500Hz)

- The RMS of other frequency bands and other time looks stationary.

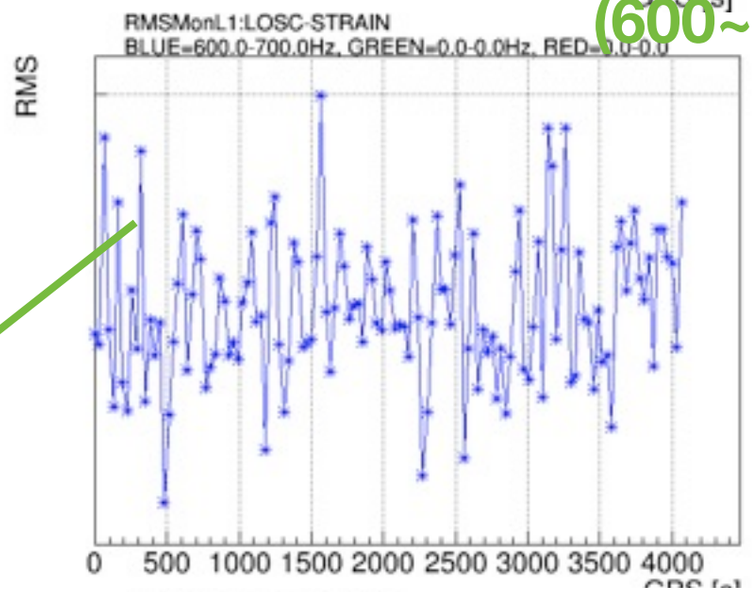
Result 500~600Hz, 600~700Hz, 700~800Hz (LIGO Livingston)

RMS(500~600Hz) looks oscillating.
The 3.5 cycles in 4096[s] => period is ~20min.

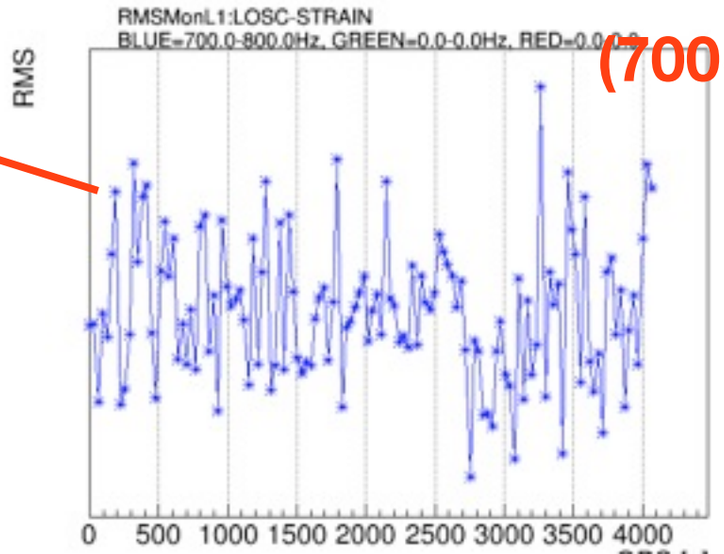




(500~600Hz)



(600~700Hz)

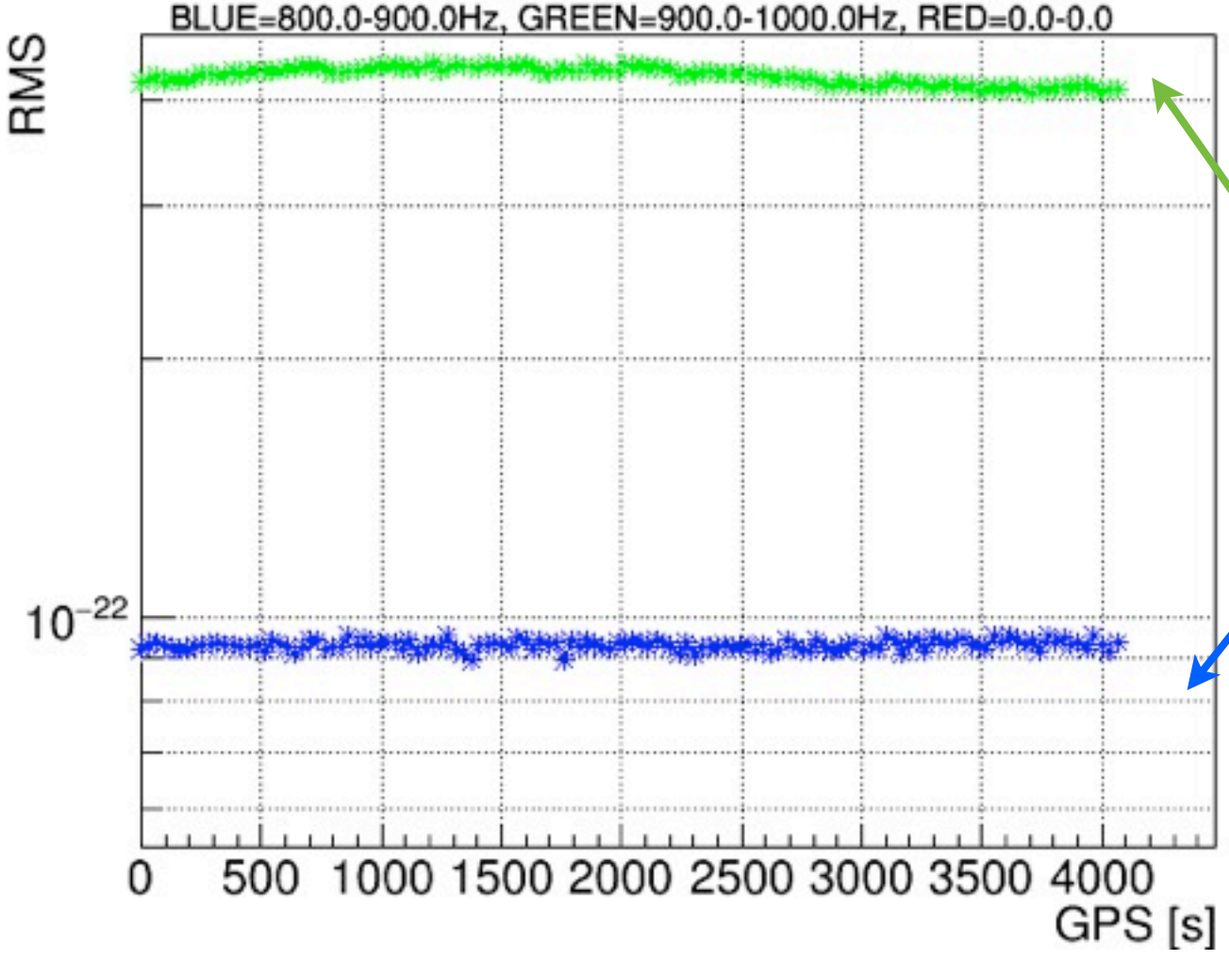


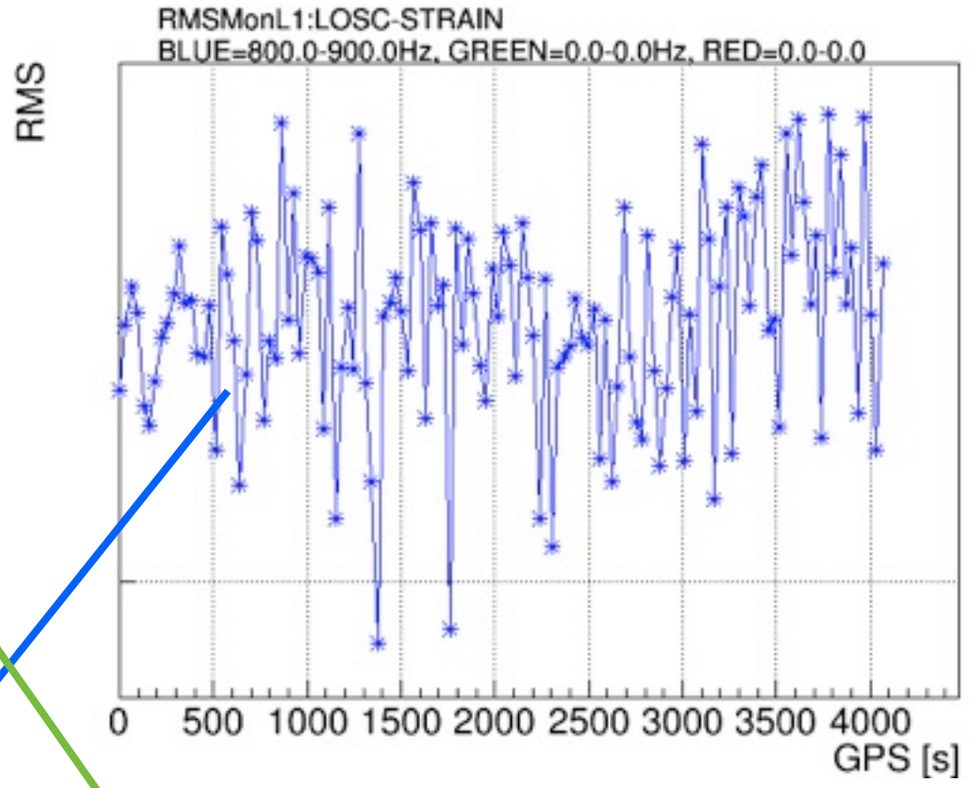
(700~800Hz)

- The RMS of other frequency bands and other time looks stationary.

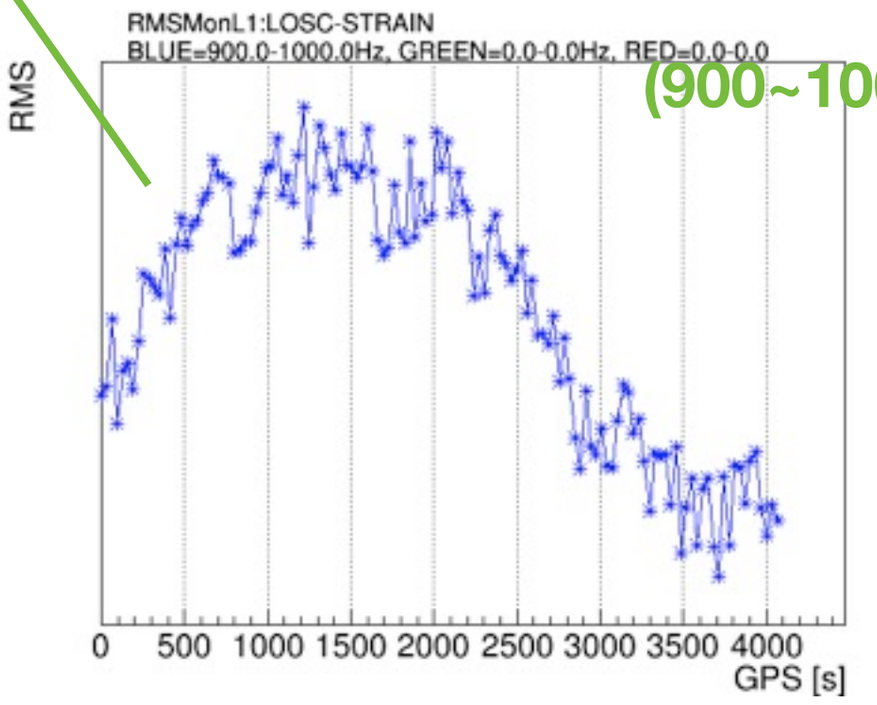
Result 800~900Hz, 900~1000Hz (LIGO Livingston)

RMS(800~900Hz) looks slowly changing.





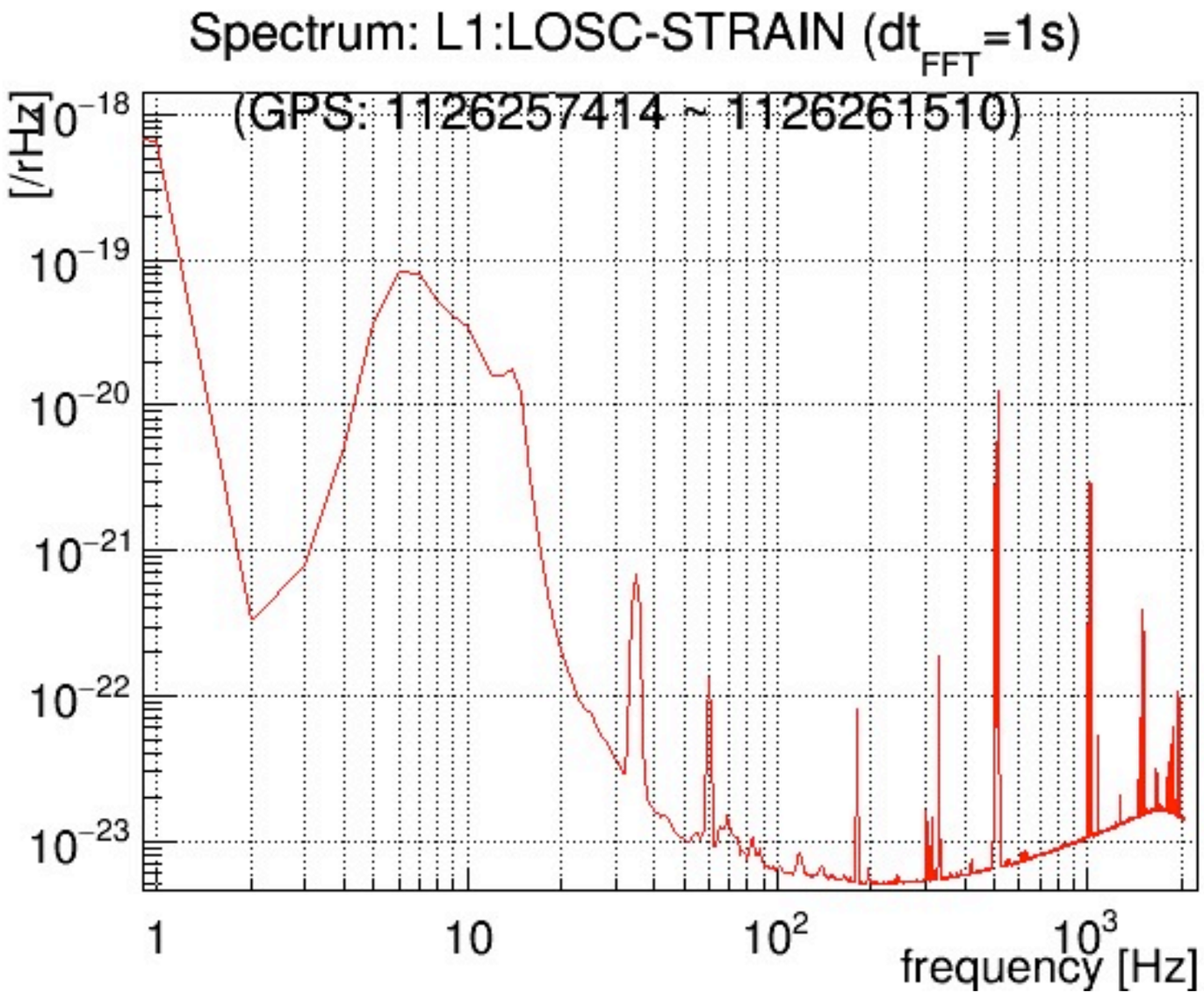
(800~900Hz)



(900~1000Hz)

- The RMS of other frequency bands and other time looks stationary.

The spectrum estimated by Yamamoto-san



The duration and the sampling frequency of the whole data is 4096[s] and 4096[Hz].
This spectrum is estimated by taking the average(mean) of 4096chunk data (chunk duration is 1[s]).

Identify the frequency of the line noise
and calculate the RMS
with the frequency band not affected by line noise

In my opinion,
the time variation of line noise should not be covered
by RMSMon.

Line Tracking(very simple definition)

If the S(f) meets following inequality, I define S(f) as the line noise.
This definition is very simple one.

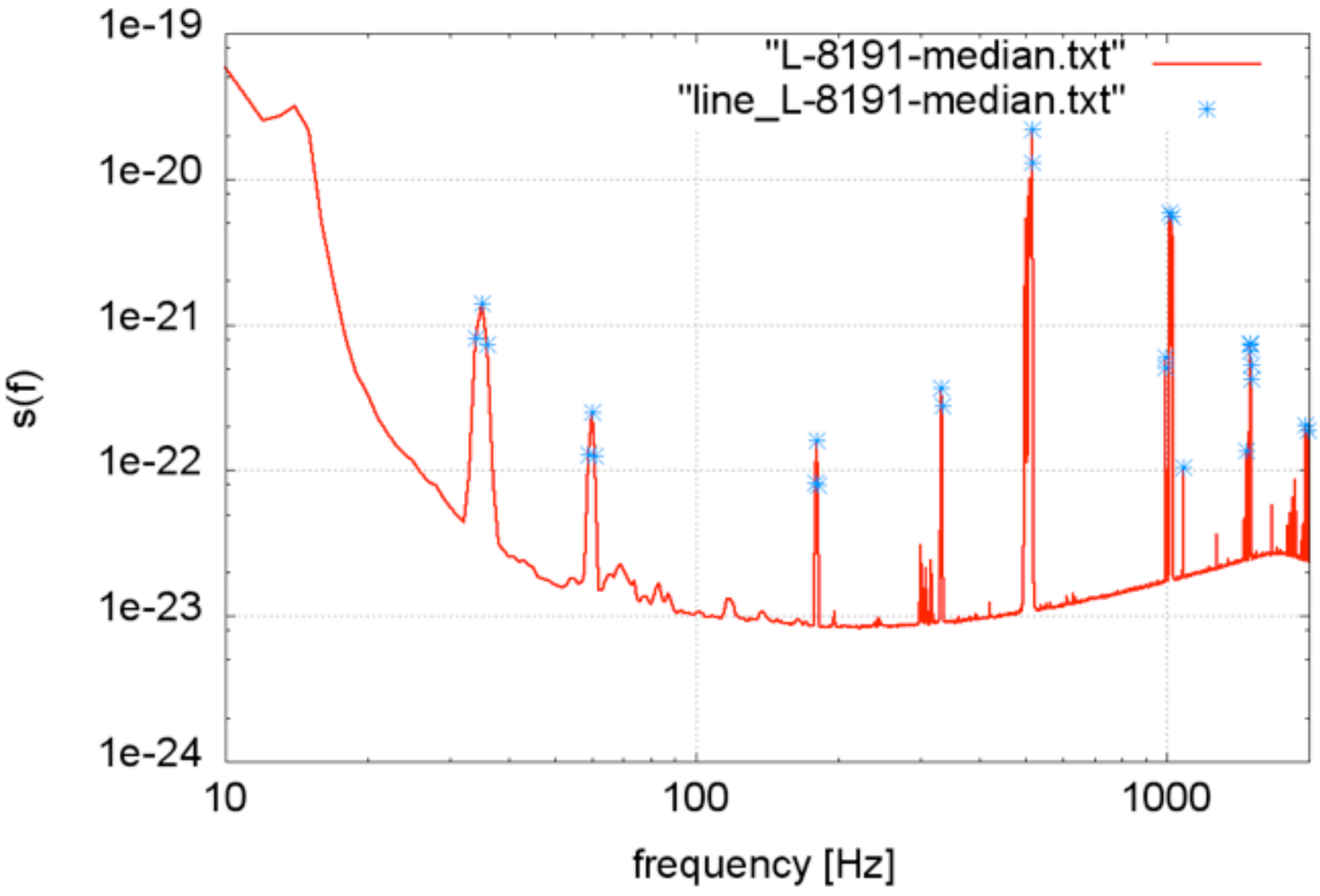
$$S(f_i) > 5 \times \frac{1}{2N+1} \sum_{k=i-N}^{i+N} S(f_k)$$

averaged spectrum

threshold
(arbitrary)

smoothing with 2N+1 samples around S(f_i)

Line Tracking(very simple definition)



The blue marks indicate the line noise.
The whole line noise are not identified... (the definition is not enough)

I propose the calculation of RMSMon with frequency band
not affected by line noise.