Expected ground motion at ATF2 and resulting effects at IP

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Guidelines

1. Ground motion modeling and measurements
   - Andrei Seryi's ground motion model
   - Measurement at KEK (Courtesy of R. Sugahara et Al.)
2. Evaluation and use of the GM
   - Results with Andrei's parameters
   - Last update on parameters
3. Effects of GM on the ATF2 beam at IP
   - Effects on medium time scale
   - Effects on long time scale
   - Influence of feedback
4. Conclusion & Prospects

Outlines

Quick description of the model

3 types of motions parametrized in ground motion generator[1] :

Frequency range	Type of motion
Up to 1e-5 Hz	Systematic motion
From 1e-5 up to 0.1 Hz	ATL (diffusion) motion
From 0.1 Hz	Wave-like (propagation) motion

Measurements at KEK from 0.1 to 50 Hz $\Rightarrow$ check wave-like motion in generator.

[1] A. Seryi, O. Napoly, Phys. Rev. E53, 5323, (1996)

Differences between absolute and relative motion

- If all element of the lattice move together, there will not be any effect. What is relevant is not absolute but relative ground motion.
- The coherence $C(L,\omega)$ is a time average of $\cos(\phi)$ where ϕ is phase at frequency ω between 2 points distant by L. It allows to link absolute and relative motion between two points :

$$P_{rel}(L,\omega) = P_{abs} \times (1 - C(L,\omega)) \quad (1)$$

- For propagating surface waves : $C(L,\omega) = J_0(\frac{\omega.L}{v})$.

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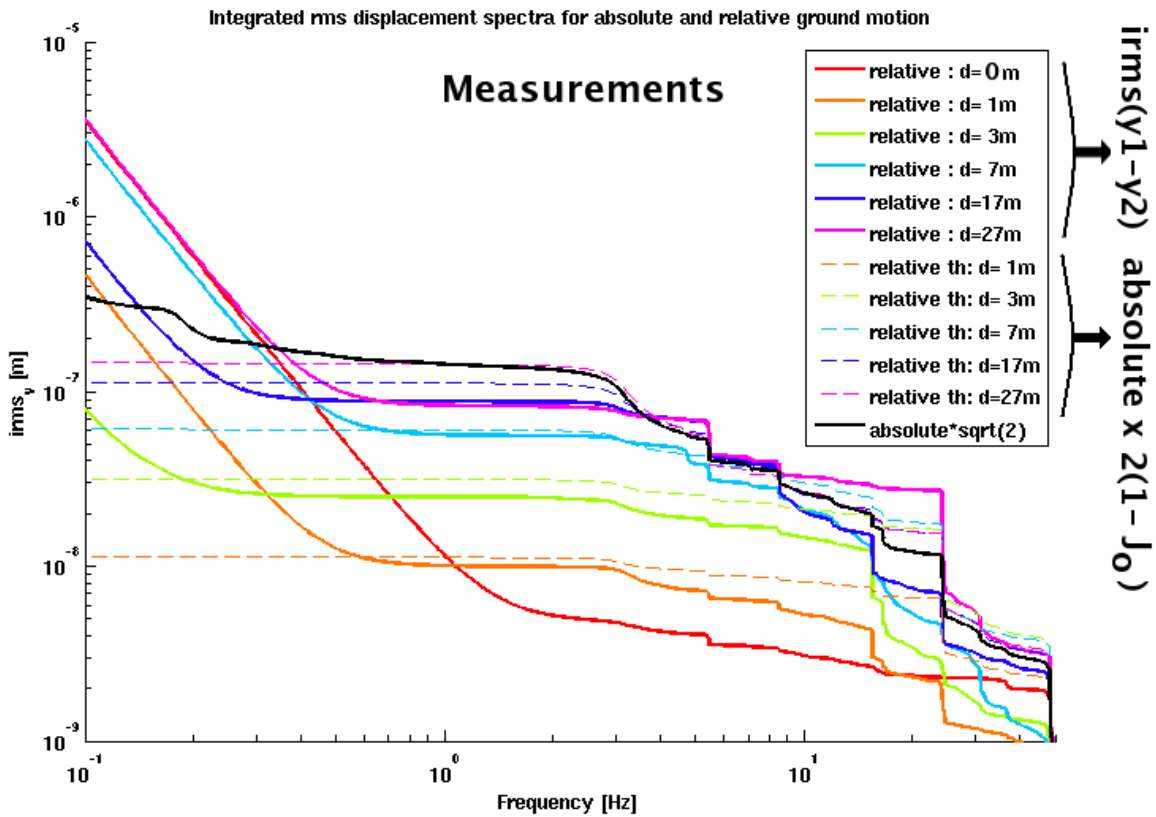
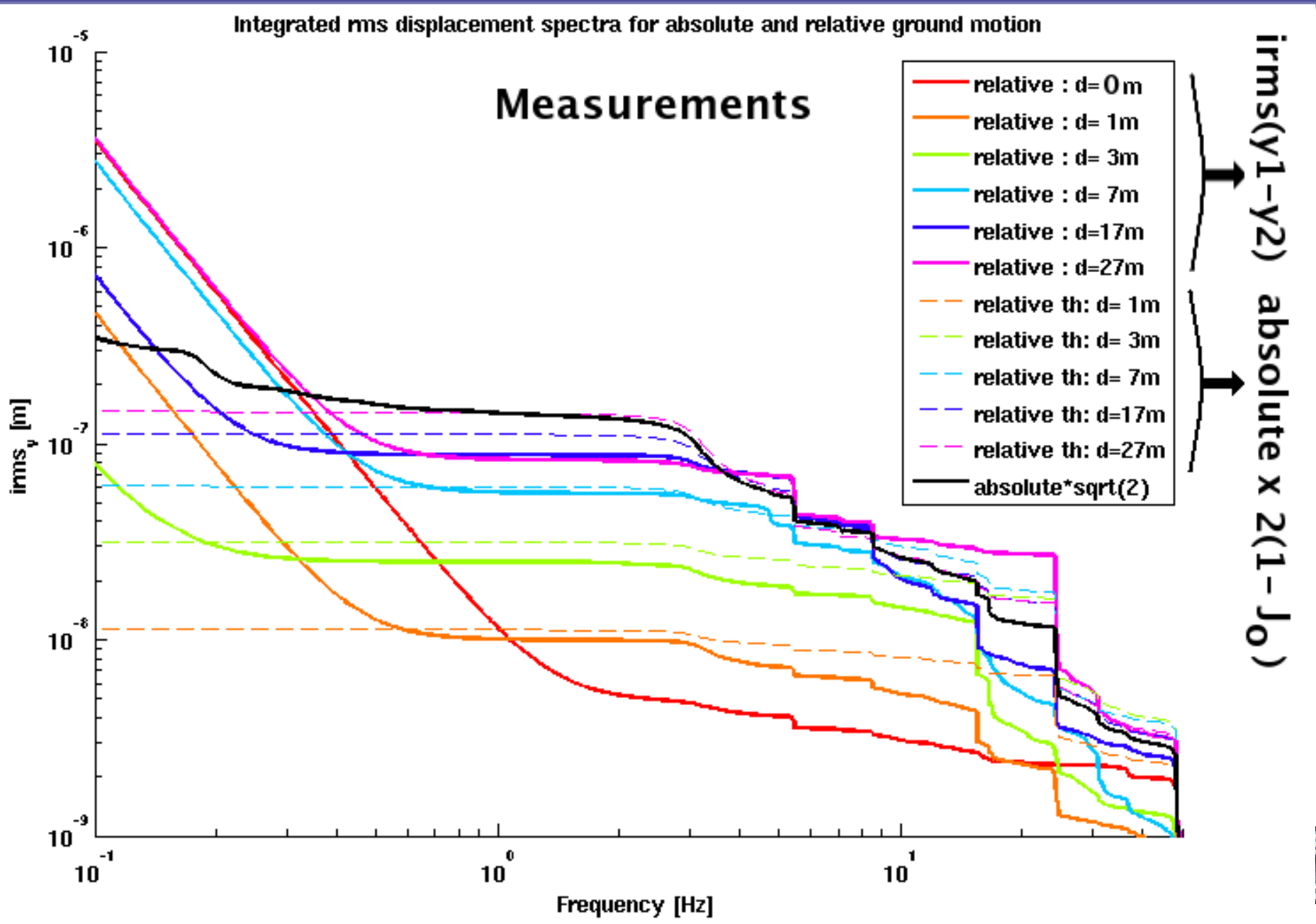
Outlines

Integrated RMS displacement (IRMS)

Definition

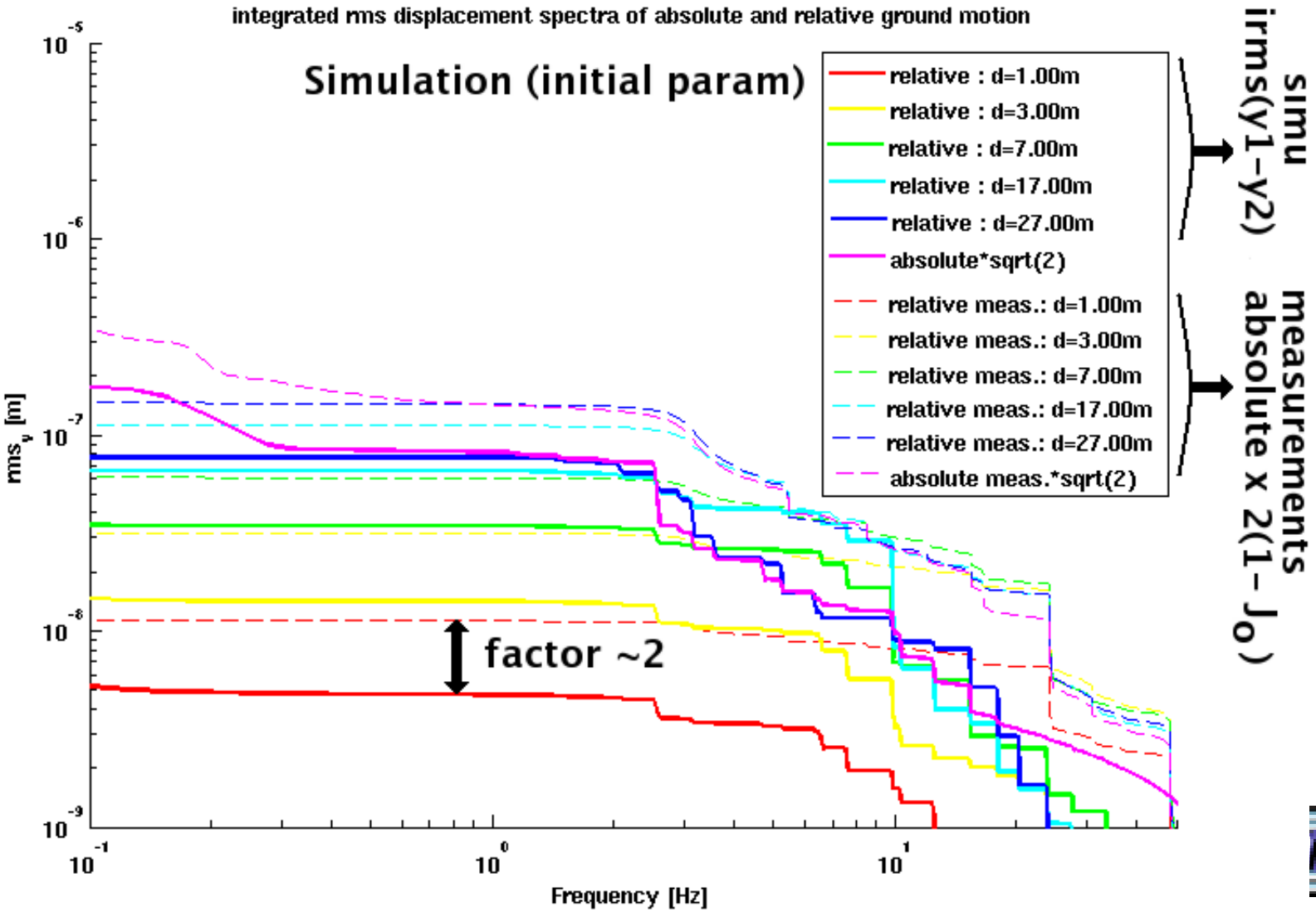
IRMS(ω) corresponds to RMS of displacements considering only frequencies above ω.




Integrated rms displacement spectra for absolute and relative ground motion
Measurements
relative : d= 0m
relative : d= 1m
relative : d= 3m
relative : d= 7m
relative : d=17m
relative : d=27m
relative th: d= 1m
relative th: d= 3m
relative th: d= 7m
relative th: d=17m
relative th: d=27m
absolute*sqrt(2)
irms(y1-y2)
absolute x 2(1-Jo)
irms_y [m]
Frequency [Hz]

Outlines

Integrated RMS displacement



Outlines

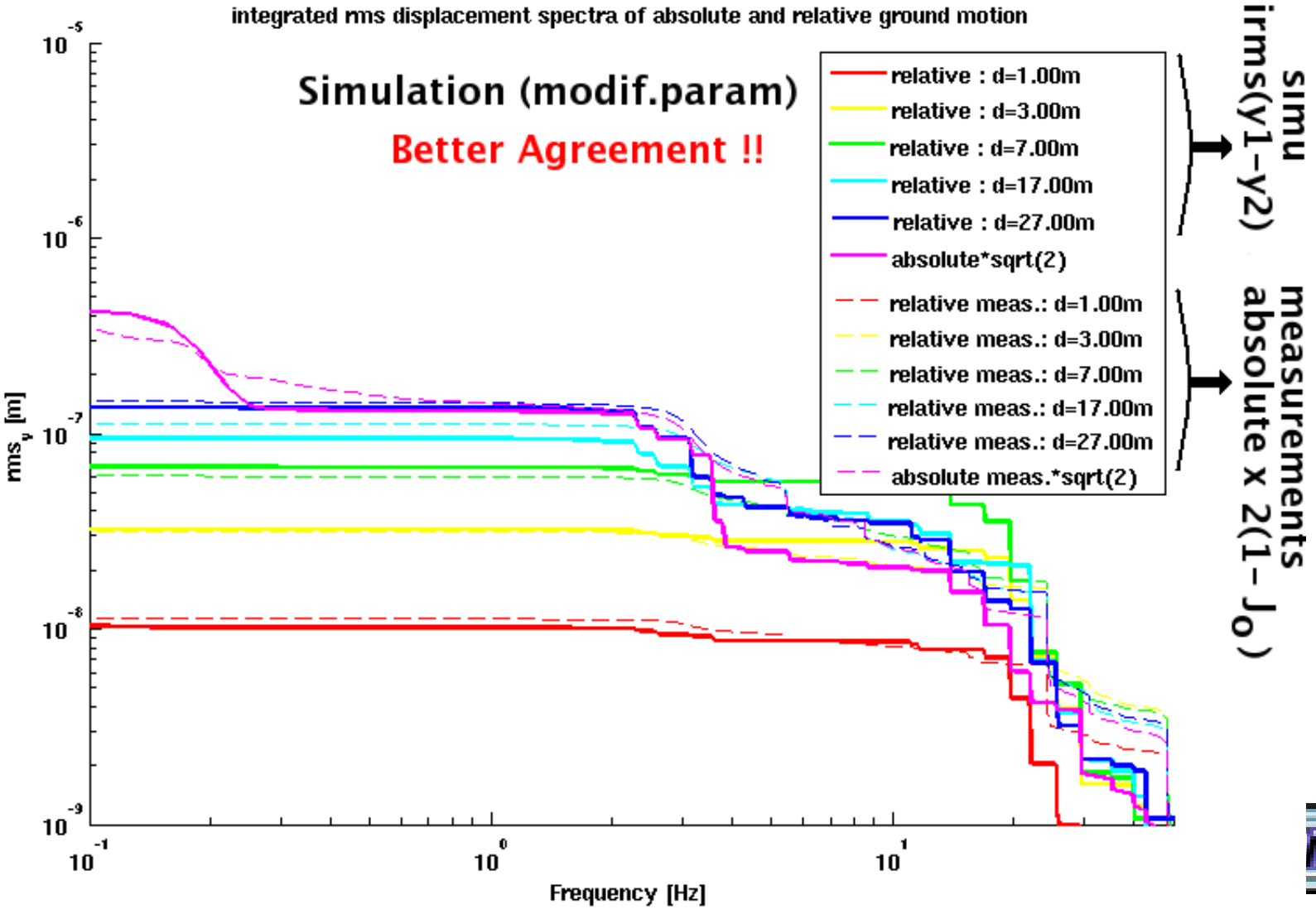
New parameters for wave-motions parameters

Modified parameters describe propagating waves, in this modelisation 3 waves can be defined with given frequency f_i and amplitude a_i, spectral width d_i and propagating speed v_i.

Wave-related parameters of gm_model_ATF_v1b.data

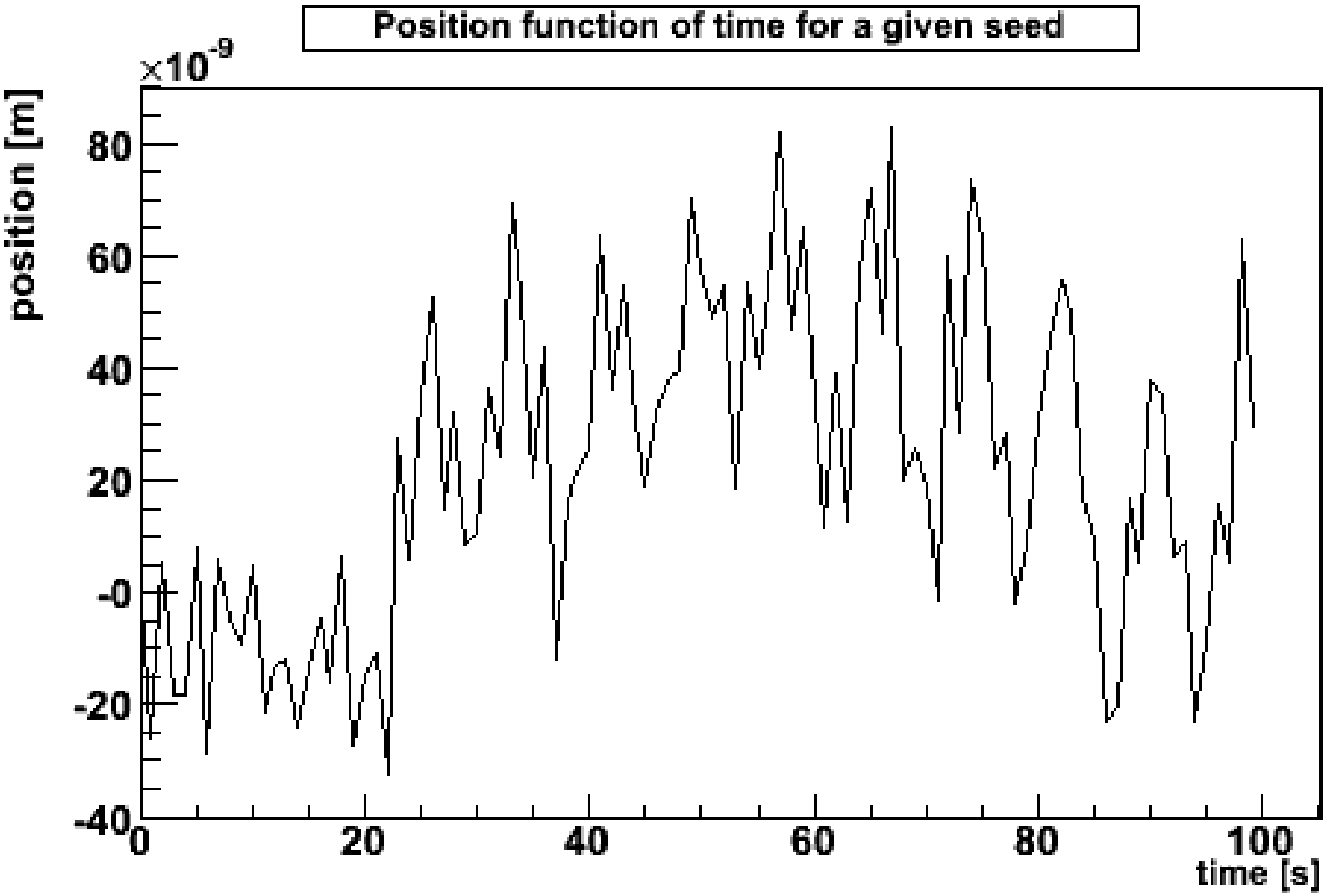
Description		New Value	Old Value
'Frequency of 1-st peak in PWK,	f1 [Hz]	' 1.60000E-01	1.60000E-01
'Amplitude of 1-st peak in PWK,	a1 [m**2/Hz]	' 2.00000E-12	4.00000E-13
'Width of 1-st peak in PWK,	d1 [1]	' 5.00000E+00	5.00000E+00
'Velocity of 1-st peak in PWK,	v1 [m/s]	' 1.0000E+03	1.0000E+03
'Frequency of 2-nd peak in PWK,	f2 [Hz]	' 2.50000E+00	2.50000E+00
'Amplitude of 2-nd peak in PWK,	a2 [m**2/Hz]	' 5.00000E-15	3.00000E-15
'Width of 2-nd peak in PWK,	d2 [1]	' 3.00000E+00	3.00000E+00
'Velocity of 2-nd peak in PWK,	v2 [m/s]	' 3.0000E+02	3.0000E+02
'Frequency of 3-rd peak in PWK,	f3 [Hz]	' 1.50000E+01	9.00000E+00
'Amplitude of 3-rd peak in PWK,	a3 [m**2/Hz]	' 3.00000E-17	3.00000E-17
'Width of 3-rd peak in PWK,	d3 [1]	' 2.80000E+00	2.80000E+00
'Velocity of 3-rd peak in PWK,	v3 [m/s]	' 2.5000E+02	2.5000E+02

Integrated RMS displacement

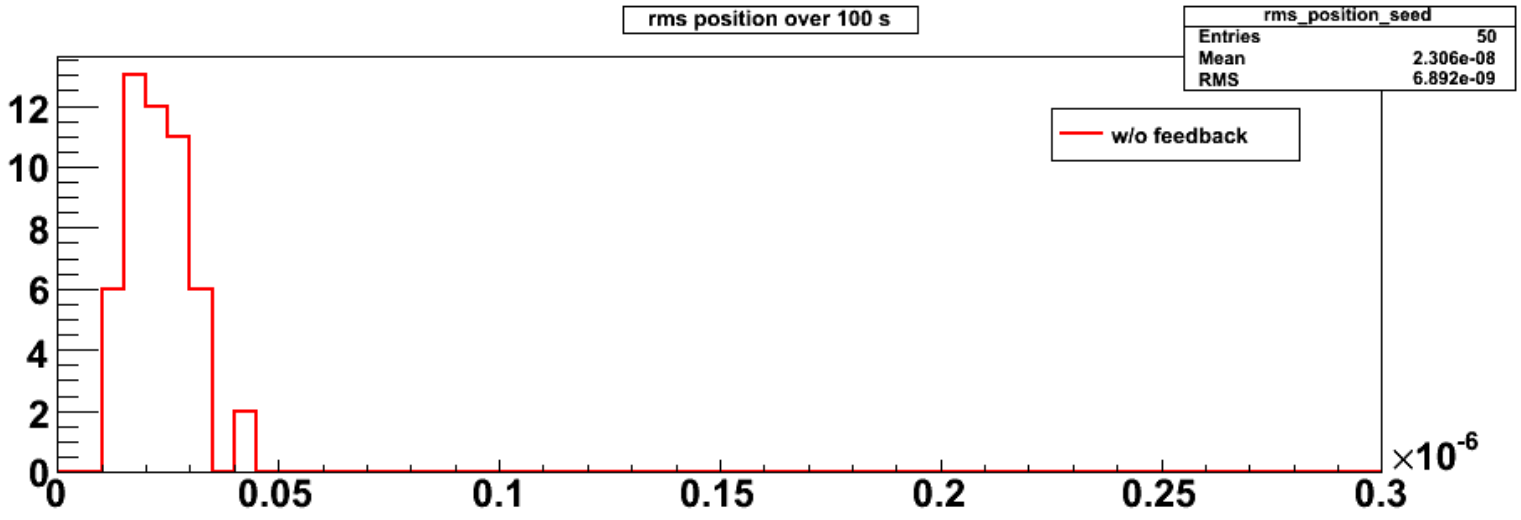


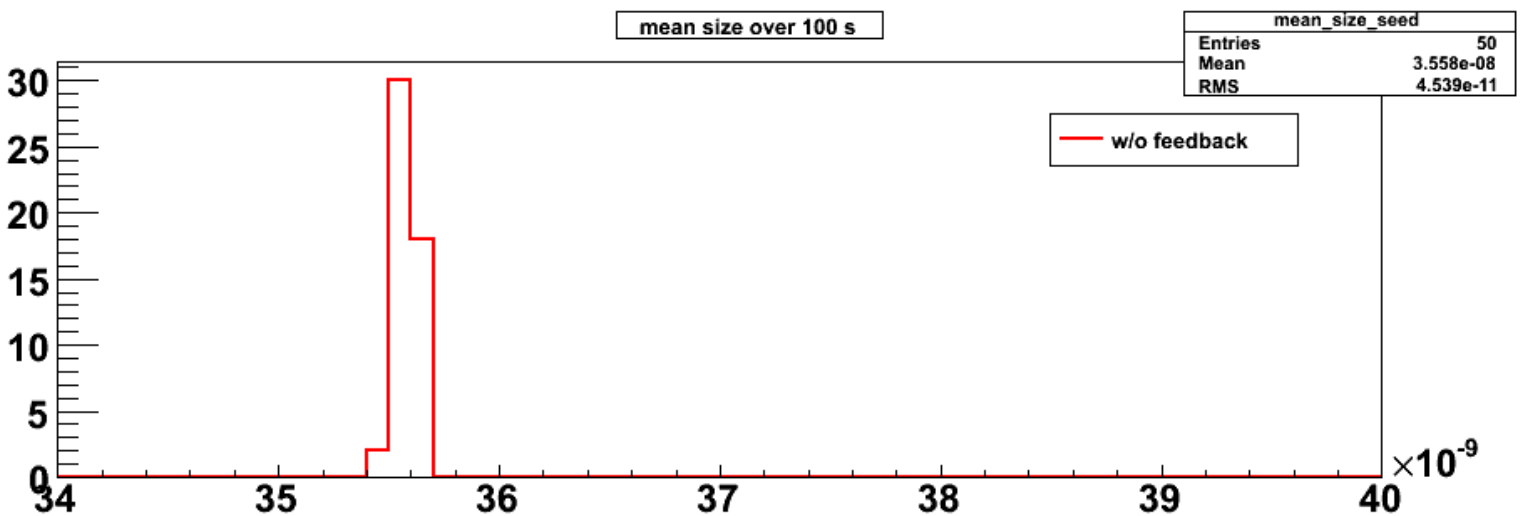
Outlines

Displacement over 100 s for 1 seeds



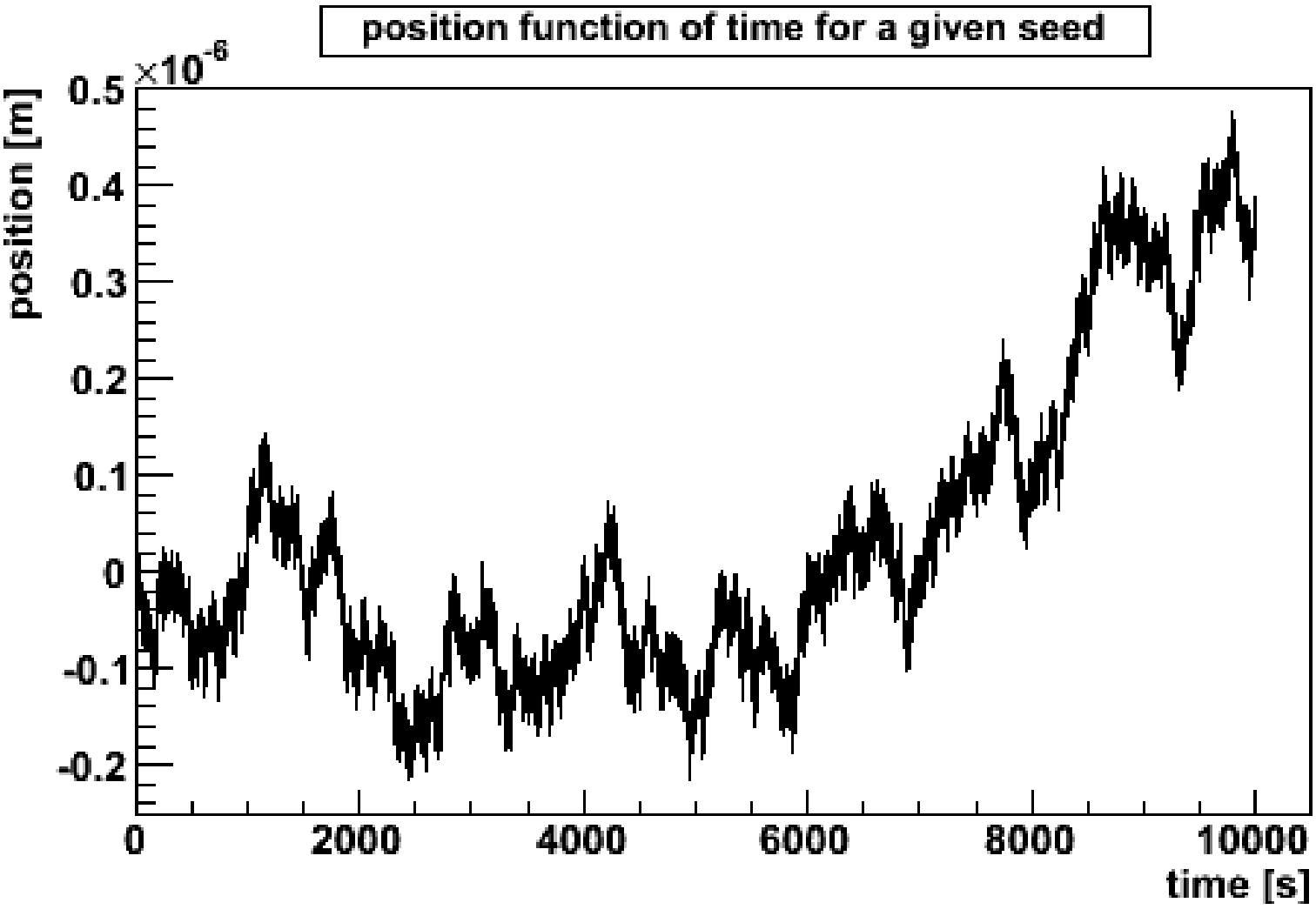
IP position and size over 100 s for 49 seeds



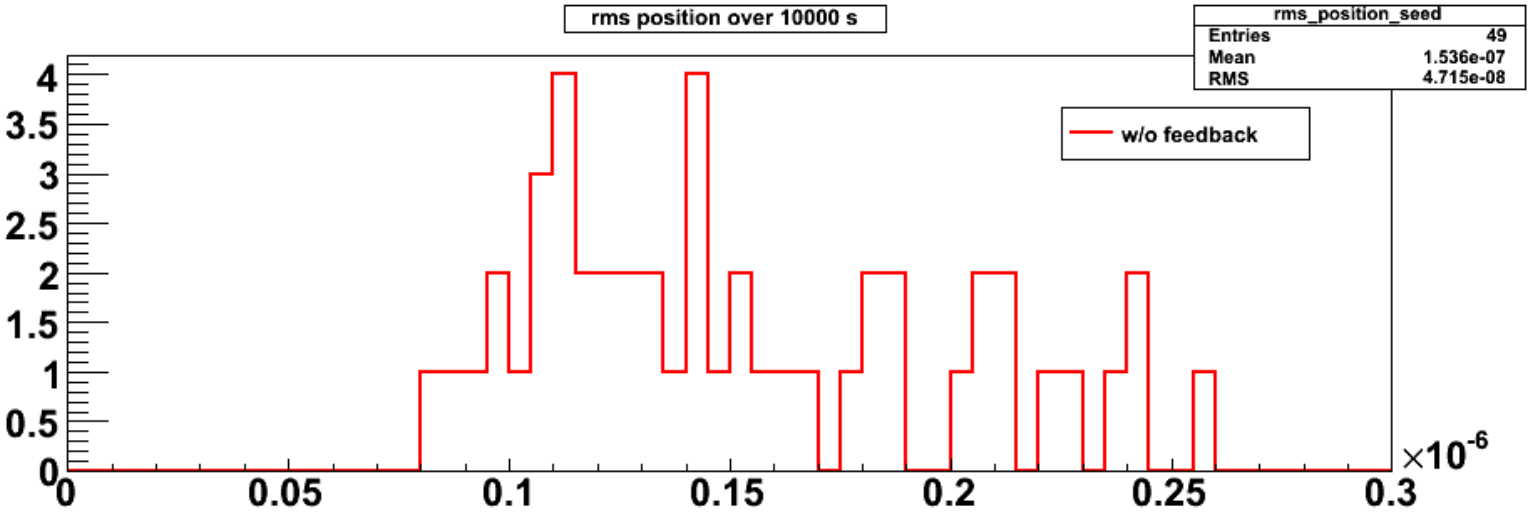


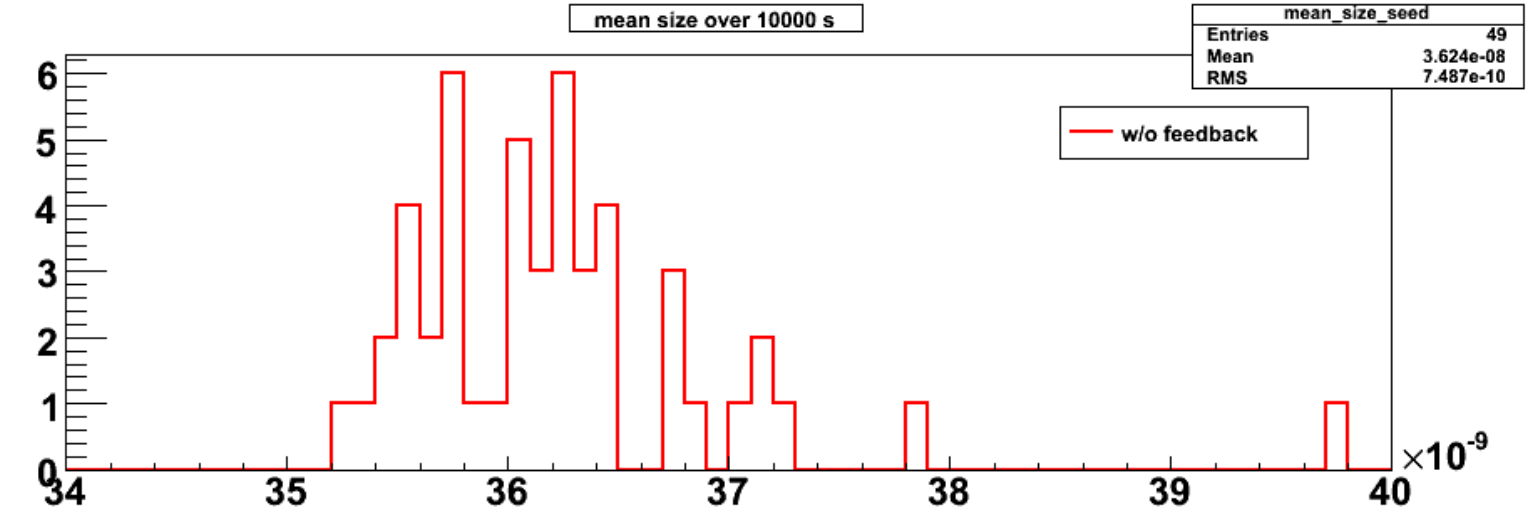
Outlines

Displacement over 10000 s for 1 seeds

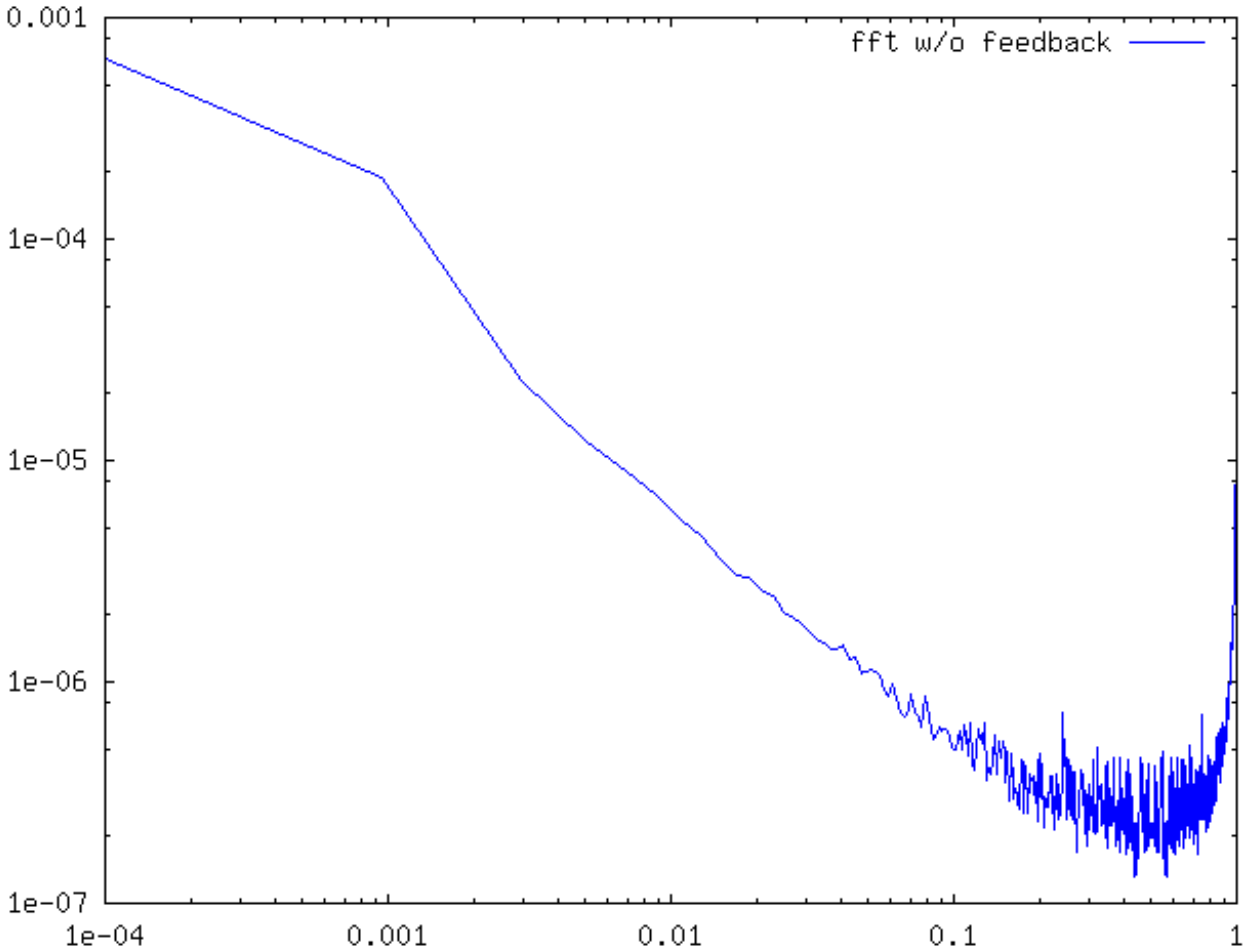


IP position and size over 10000 s for 49 seeds



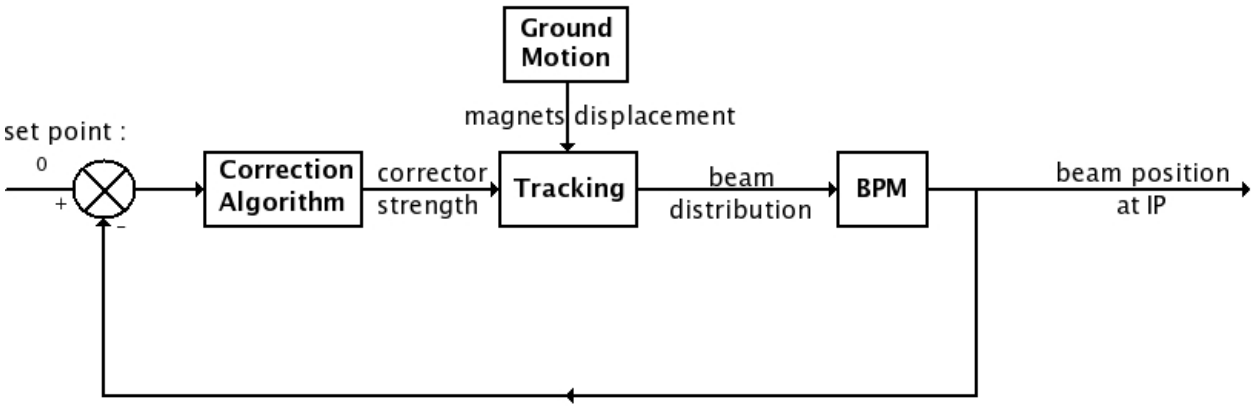


FFT of beam position



Outlines

Description of the feedback



- For the moment, tracking (and GM modeling) is only done on FF ATF2 line.
- Corrector used is the sweeper magnet after FD used for SM.
- PID Correction Algorithm: $C(p) = k_p + \frac{k_i}{p} + k_d \cdot p$

Tuning of the PID corrector

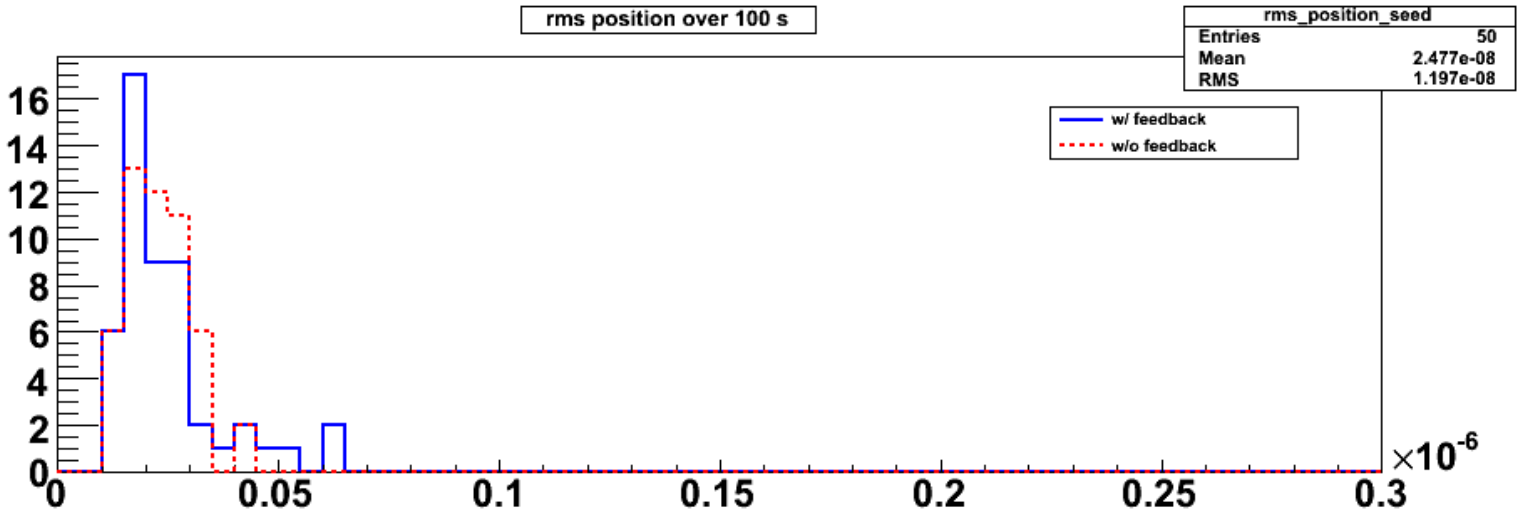
As it minimizes the error without any other constraint, Takahashi's method was first tried ...

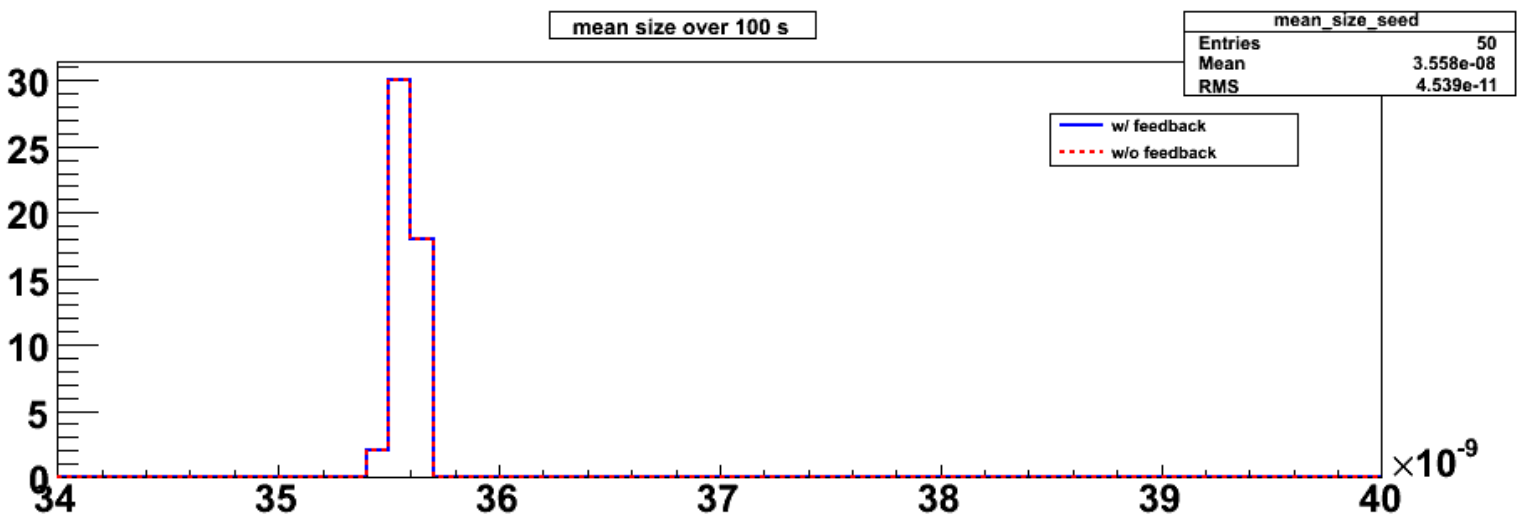
Takahashi's method

1. Start with all coefficients to 0.
2. Increase k_p up to auto-oscillation. Take :
   - T_0 : The period of auto-oscillation.
   - k_0 : k_p at this moment.
3. Use following coefficients (T is repetition rate):

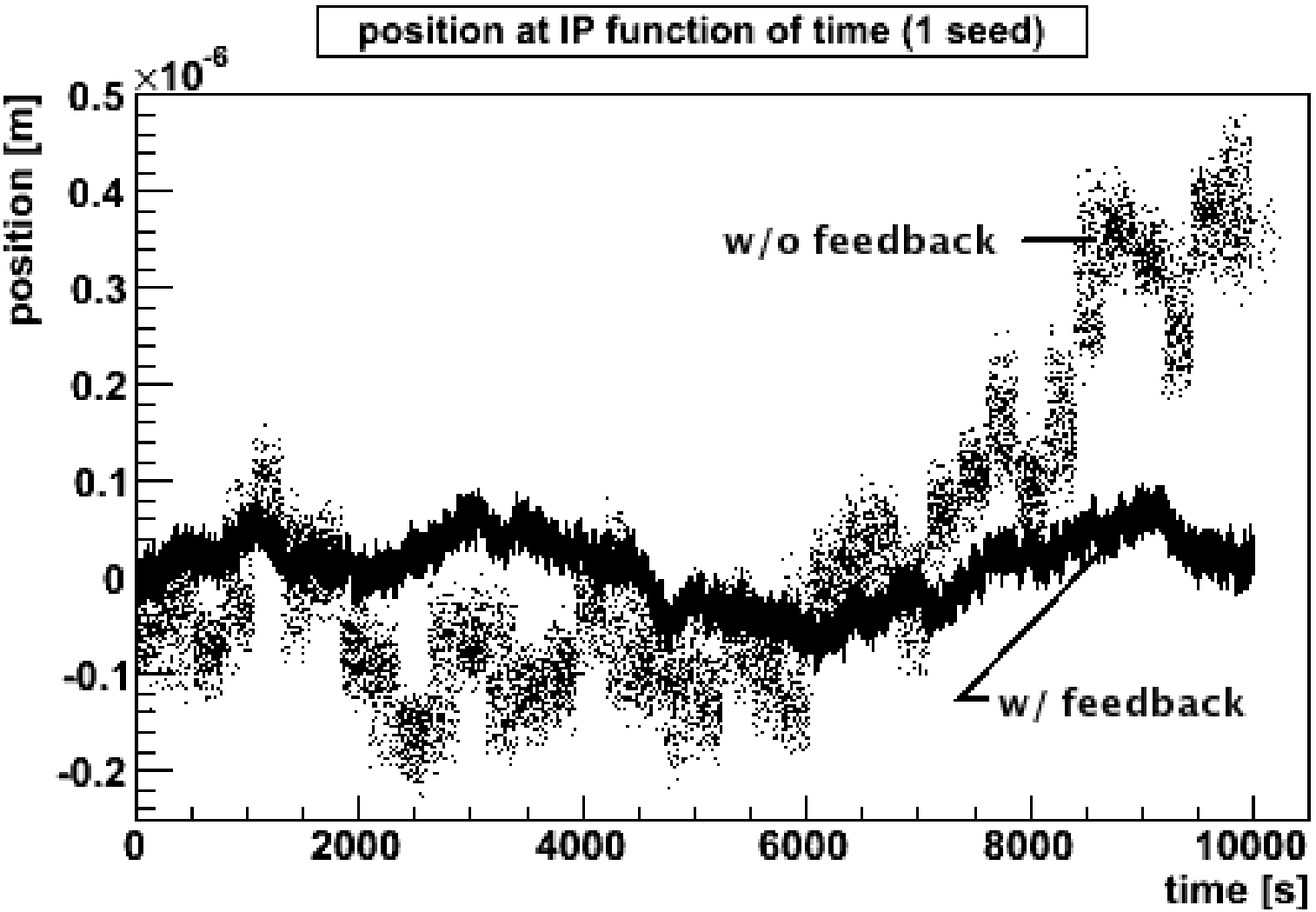
k_p	k_i	k_d
$0.6k_0 - 0.5k_iT$	$1.2\frac{k_0}{T_0}$	$\frac{3}{40}k_0T_0$
0.5533	1.1067	0.2767

IP position and size over 100 s with feedback

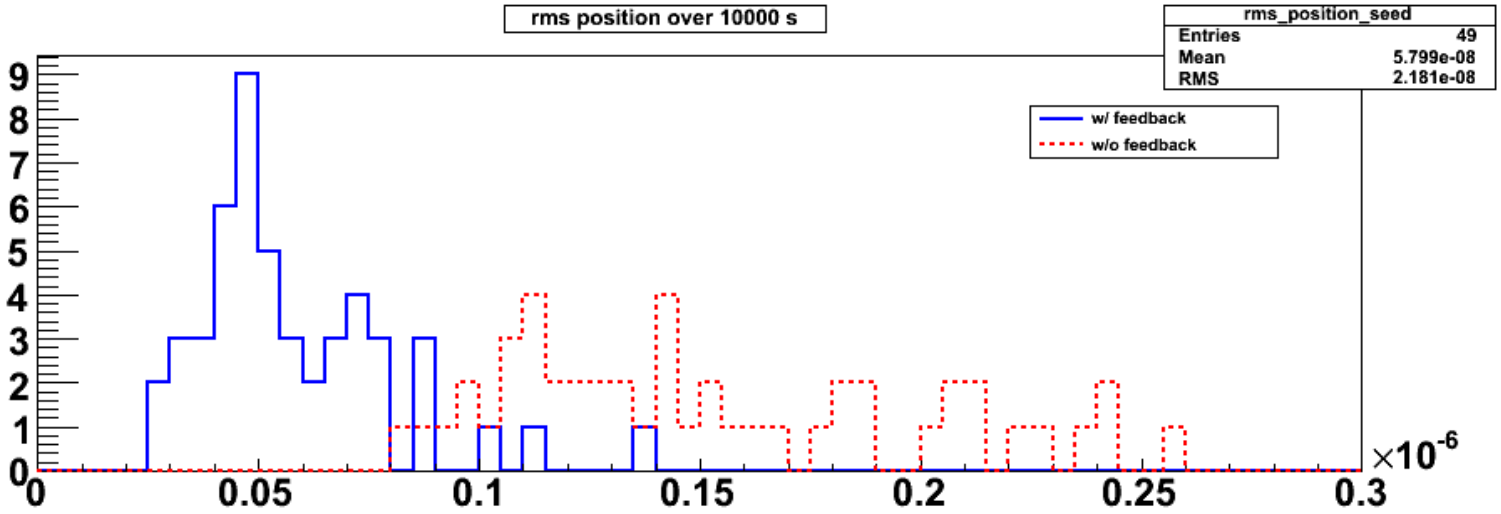


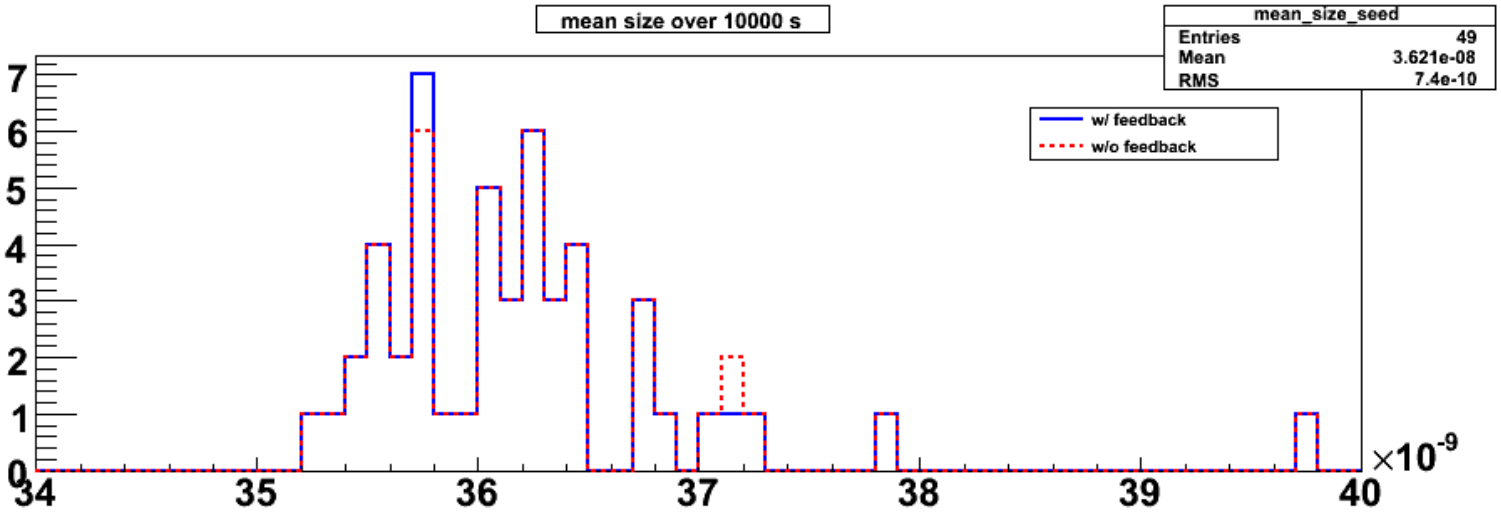


Displacement over 10000 s with feedback

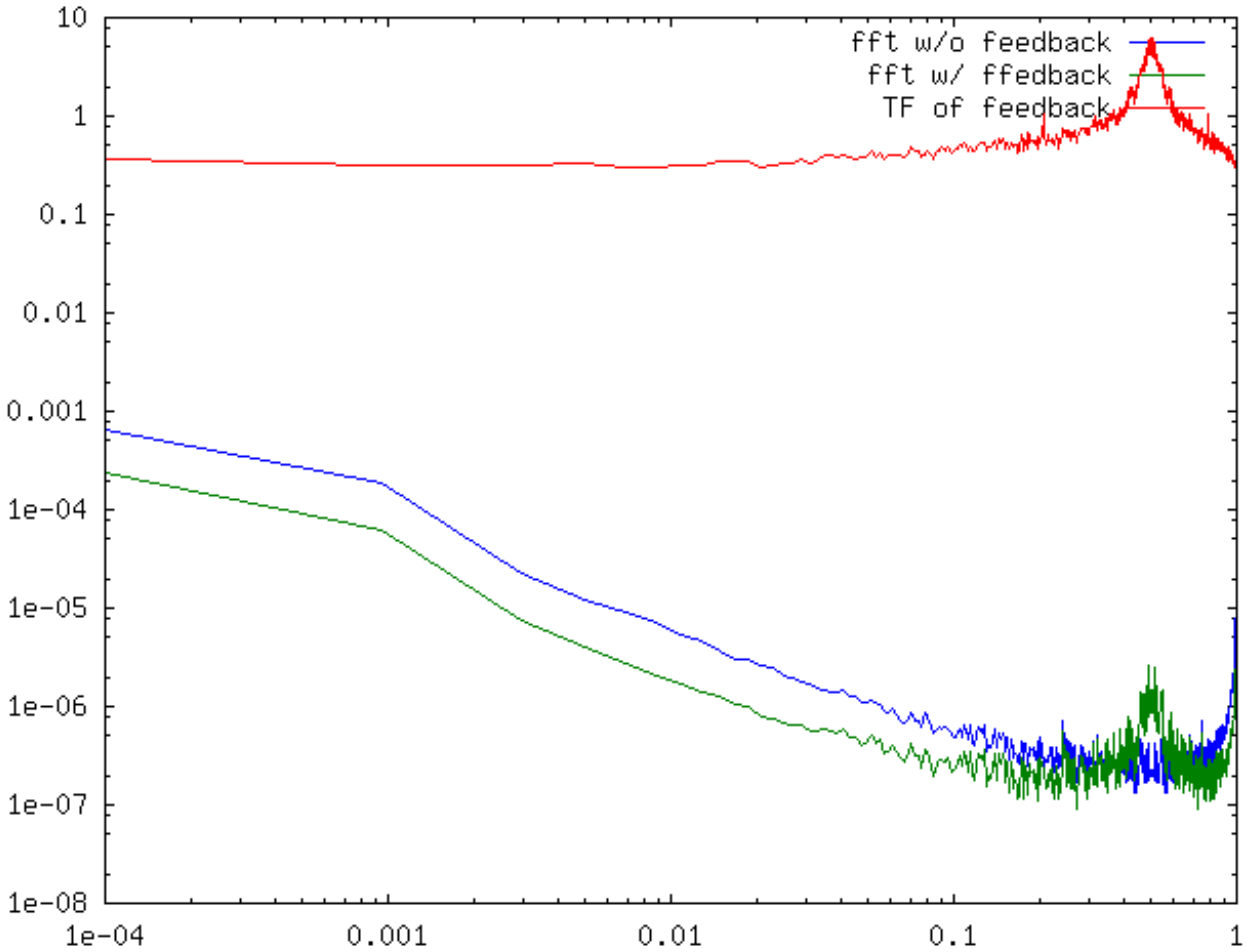


IP position and size over 10000 s with feedback





FFT of beam position



Conclusion

- ATF ground motion generator checked to be reliable from 0.1 up to 50 Hz
- Ground motion effect on beam studied on different timescales : <rms over 100s> = 20-25 nm
- Feedback needed to correct for slow drifts
- First implementation shows moderate improvements $\Rightarrow$ needs further study ...

Prospects

- Ground motion measurements on new floor needed to check ATL and "systematic" model parameters
- Include full ATF2 beam line and interaction with other feedbacks
- Impact of beam motion during Shintake measurememts
- Develop slow feedback controler $\Rightarrow$ understand IP BPM signal output and sweeper magnet input
- Long term impact on beam size and tuning