Study of the electronics architecture for the mechanical stabilization of the quadrupoles of the CLIC linear accelerator

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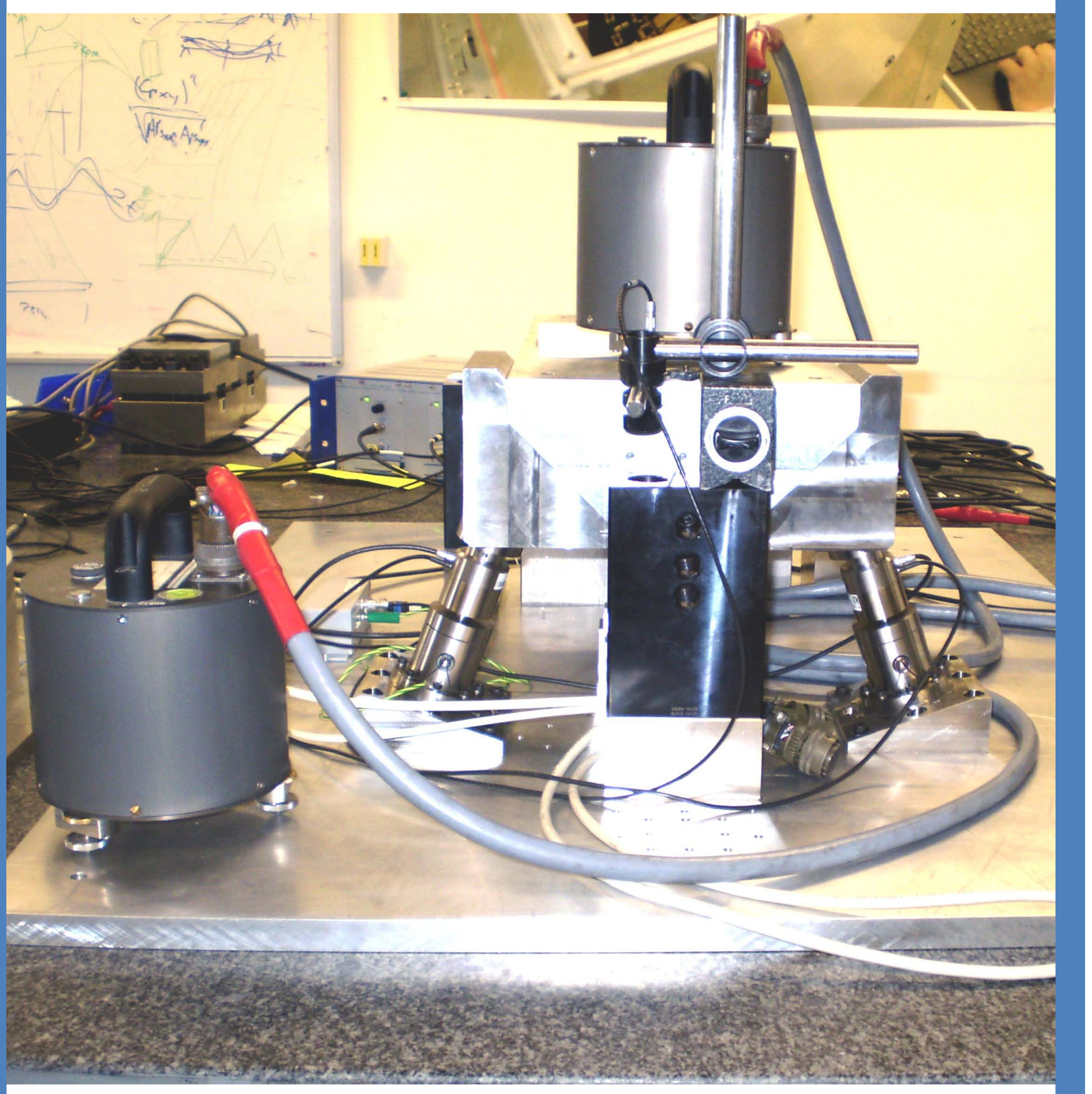
Abstract

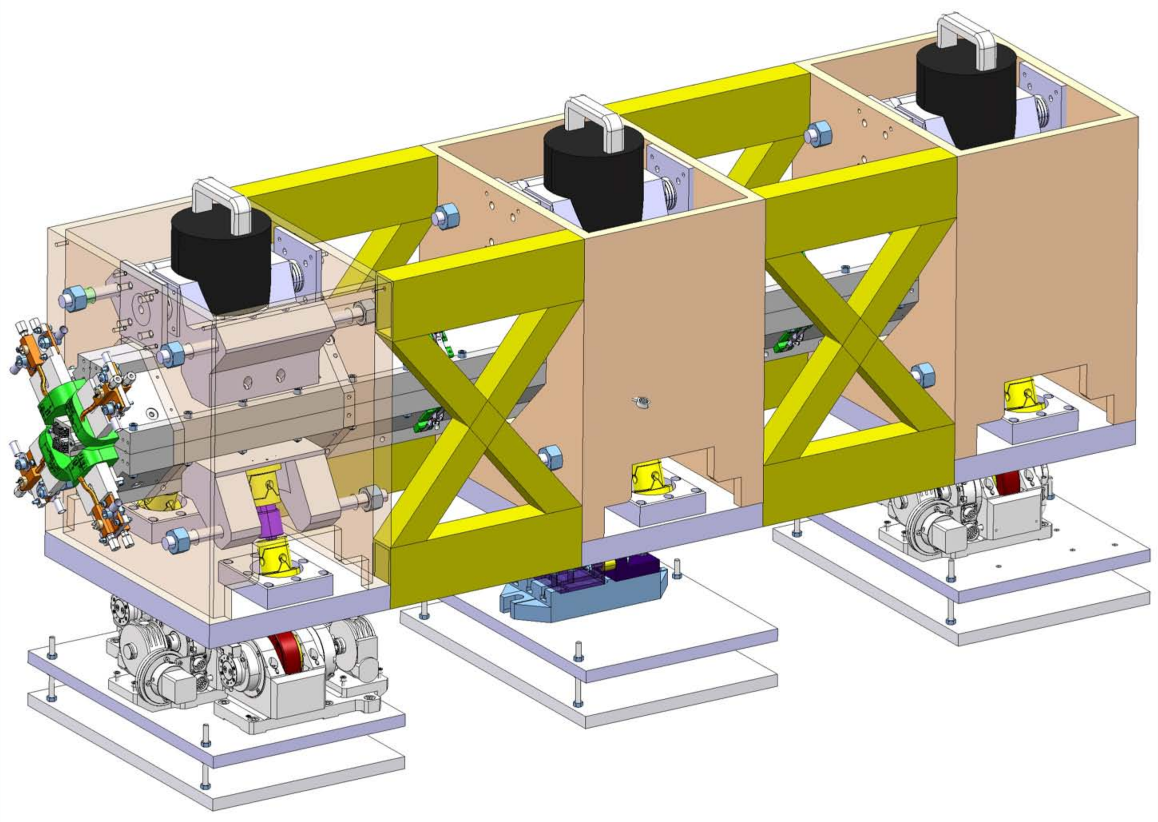
To reach a sufficient luminosity, the transverse beam sizes and emittances in future linear particle accelerators should be reduced to the nanometer level. Mechanical stabilization of the quadrupole magnets is of the utmost importance for this. The piezo actuators used for this purpose can also be used to make fast incremental orientation adjustments with a nanometer resolution. The main requirements for the CLIC stabilization electronics is a robust, low noise, low delay, high accuracy and resolution, low band and radiation resistant feedback control loop.



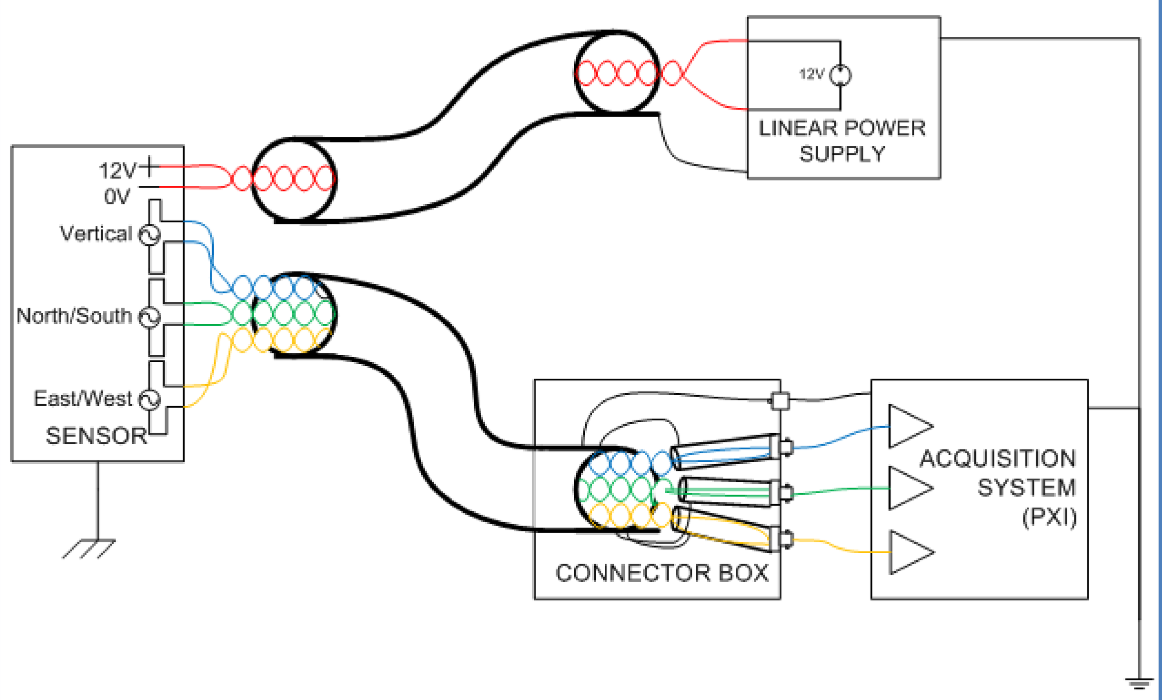
Requirements Stability CLIC

	Final Focus quadrupoles	Main beam quadrupoles
Vertical	0.2 nm > 4 Hz	1 nm > 1 Hz
Lateral	5 nm > 4 Hz	5 nm > 1 Hz

$$\sigma_x(1) = \sqrt{\int_1^{\infty} \Phi_x(f)\,df}$$

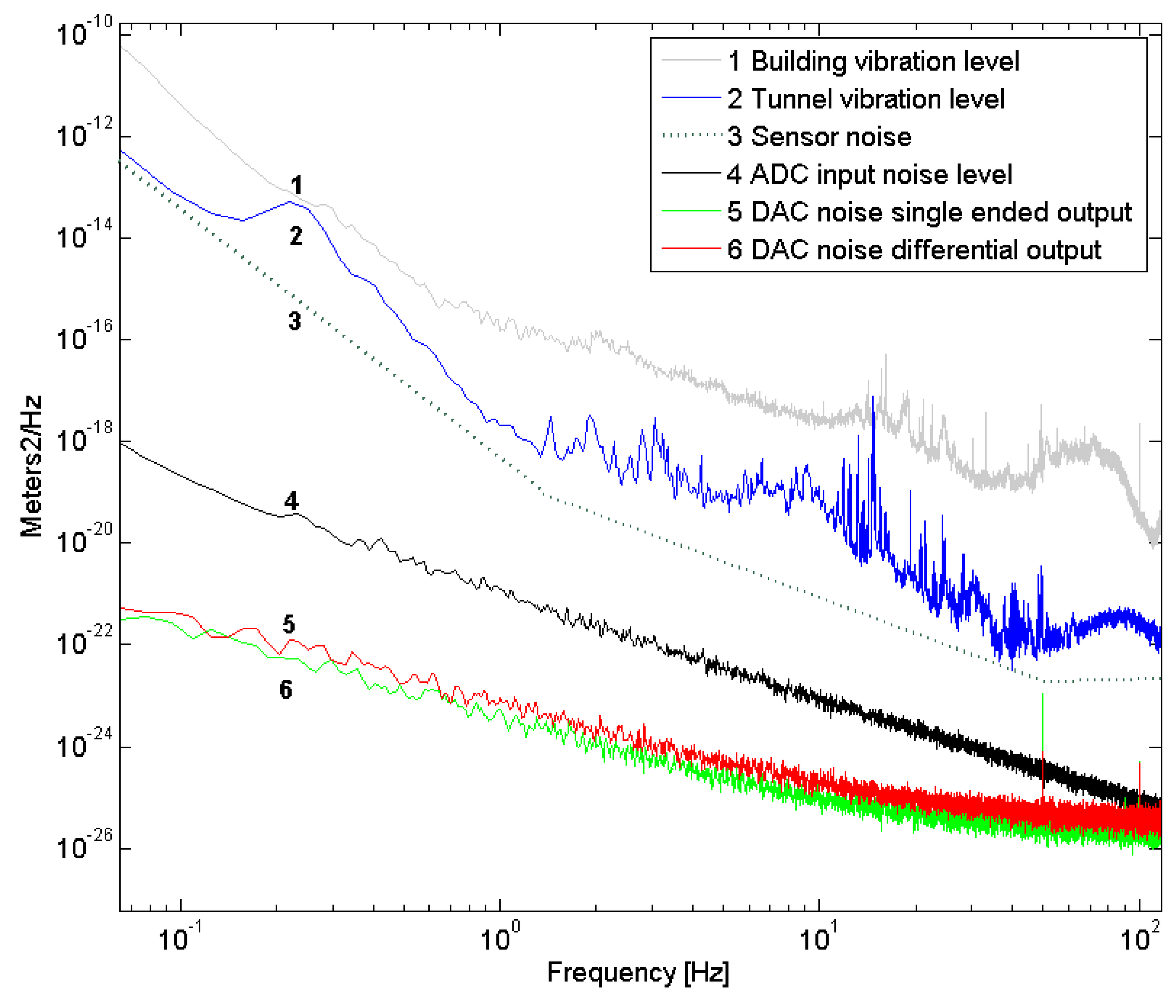


Stabilised magnet concept drawing

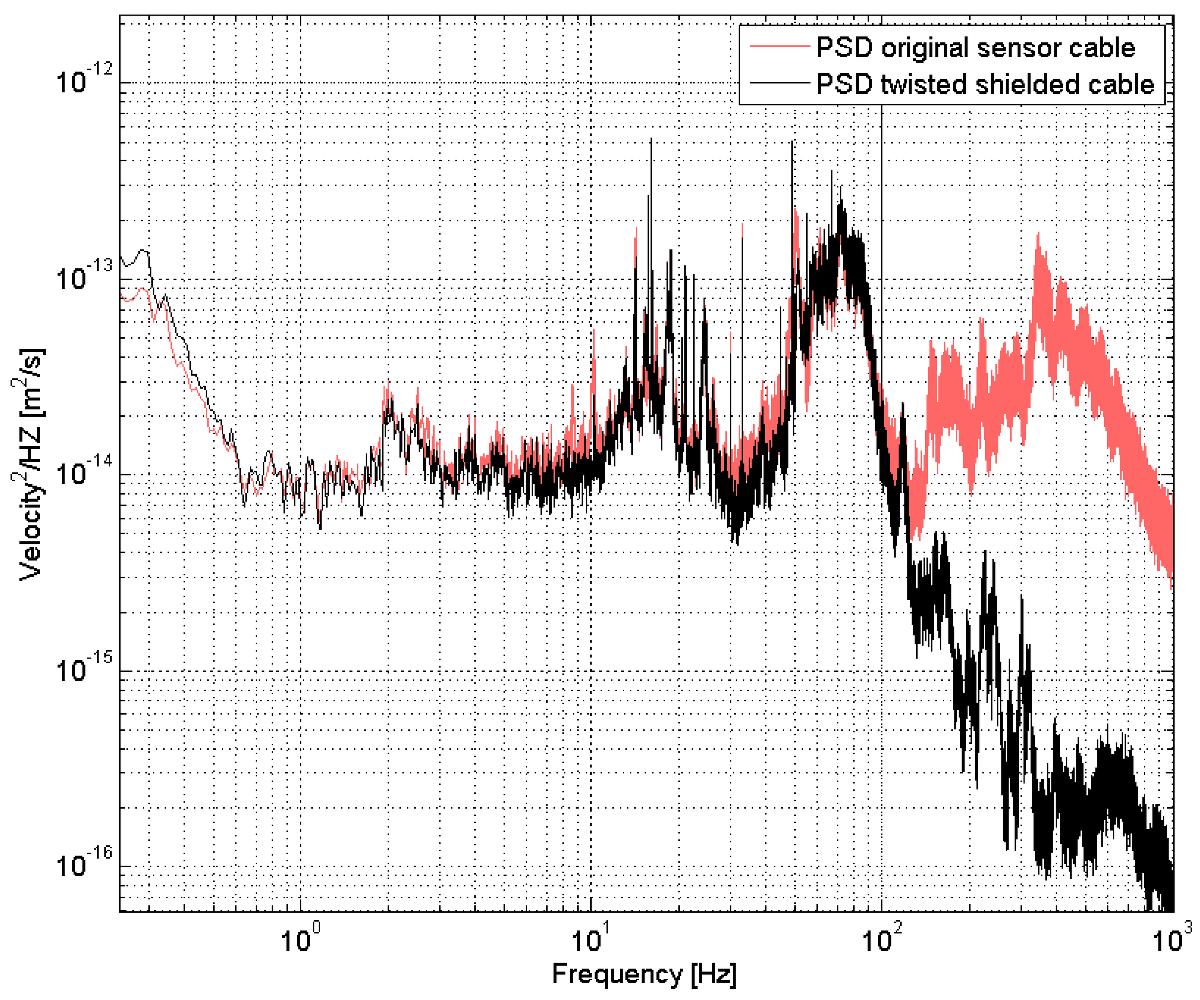


Cable shielding and grounding

Noise, signal and interferences

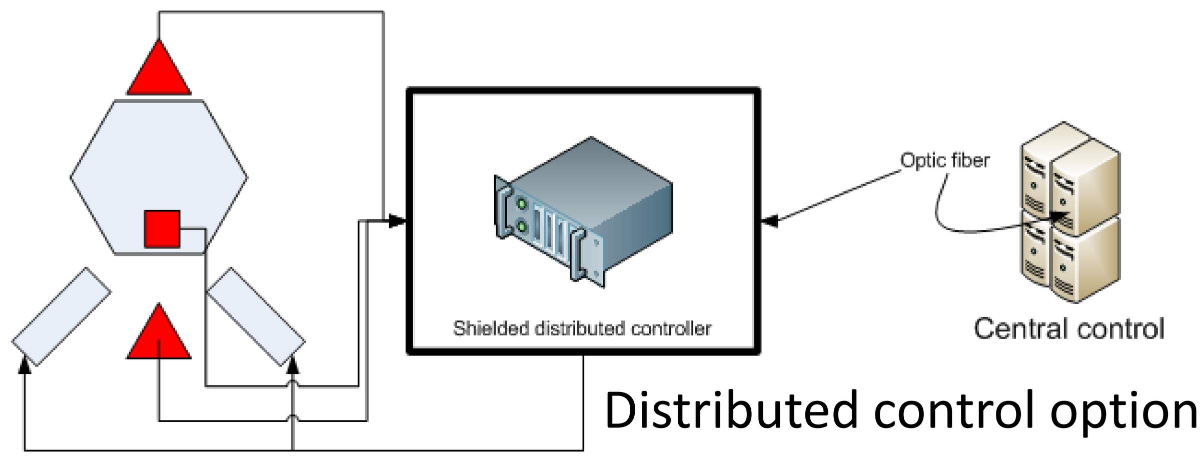


PSD of the vibration levels and main noise sources.

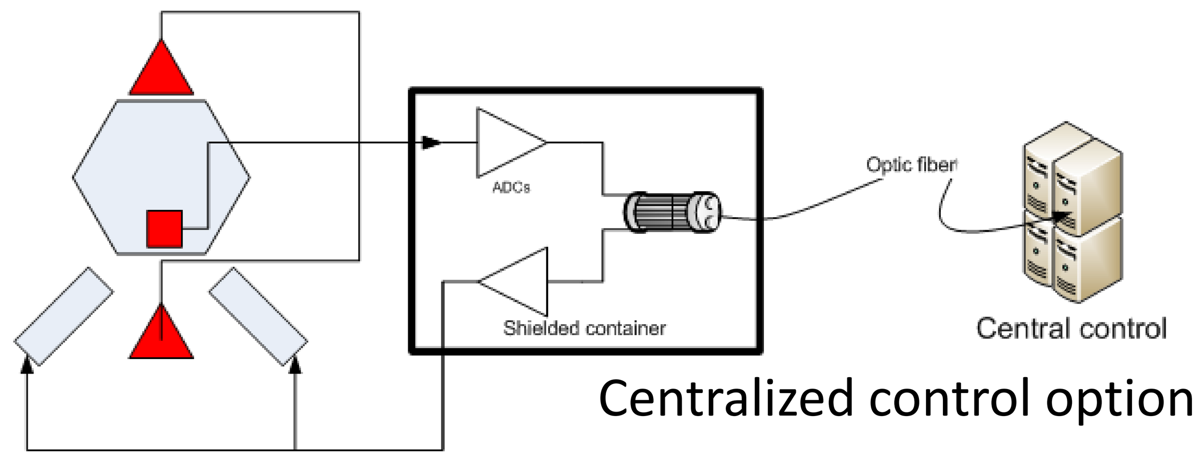


Effect of different cables against EM interferences.

Timing analysis

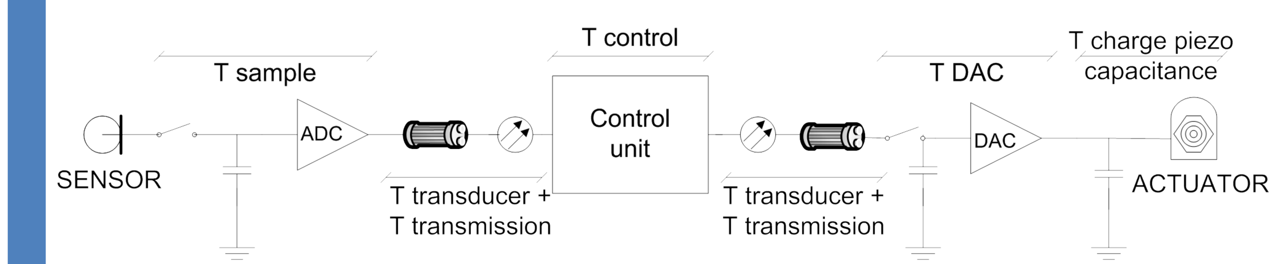


Distributed control option



Centralized control option

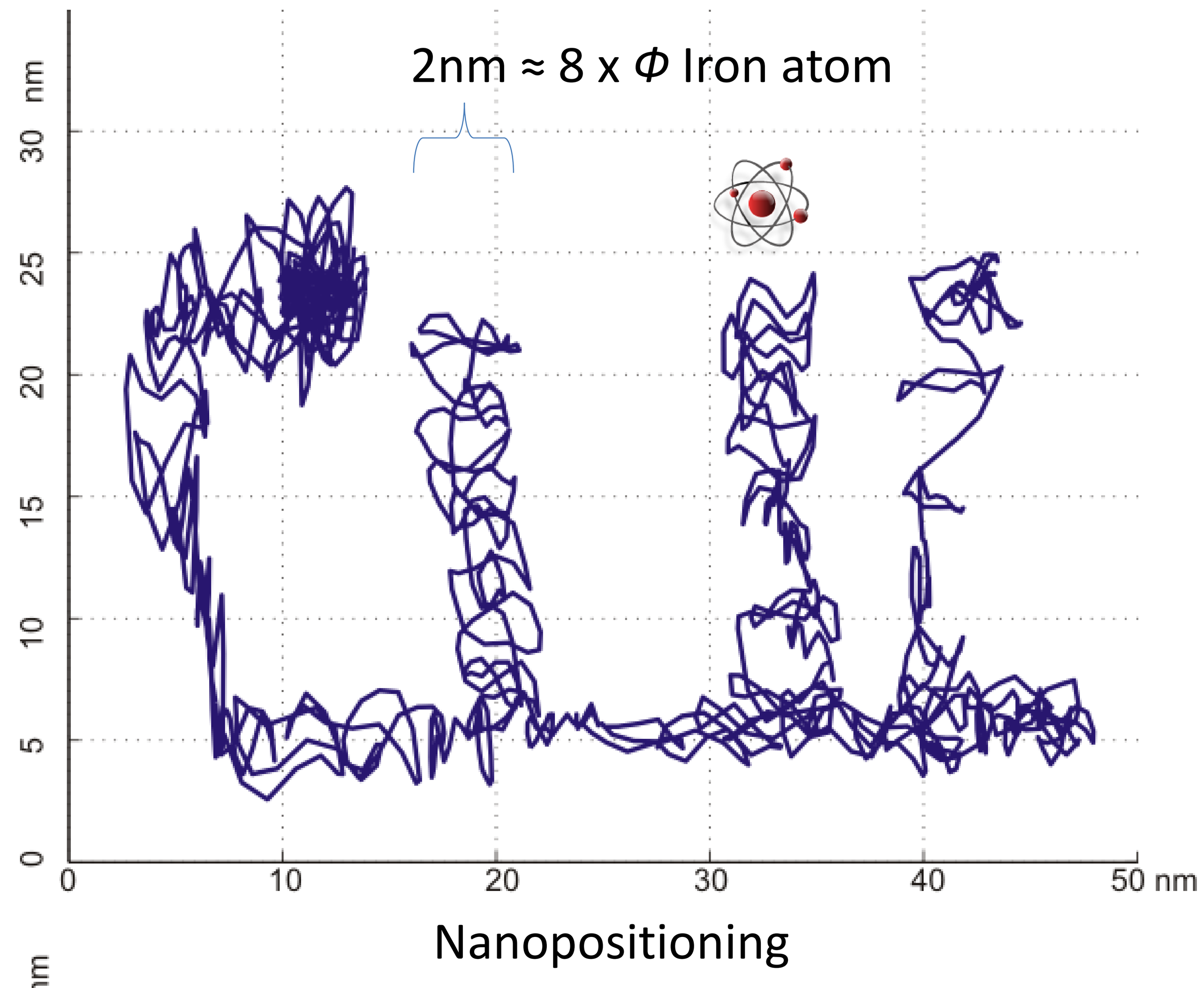
Control loop delay	Stabilization performance
43µs	100%
80 µs	90%
90 µs	80%
100 µs	60%
130 µs	30%



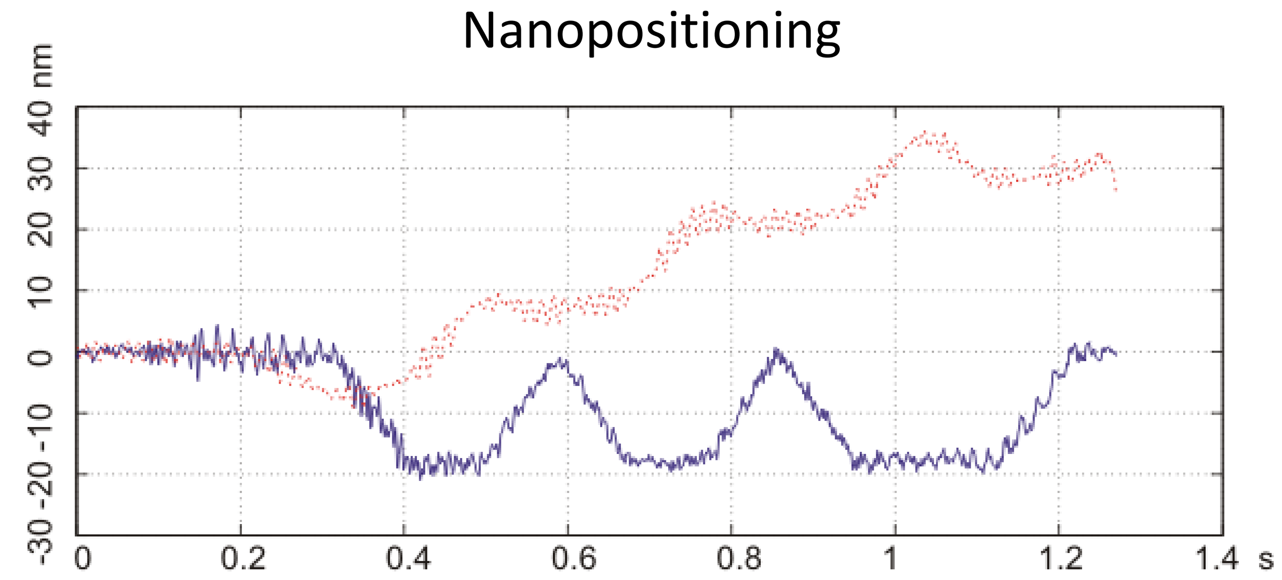
Component	Delay
ADC	8 µs
Electro-optic transducer	100 ns
Optic fiber transmission	5 µs/Km !!!
Opto-electric transducer	120 ns
DAC	3 µs
Actuator (20nm single step)	1 µs

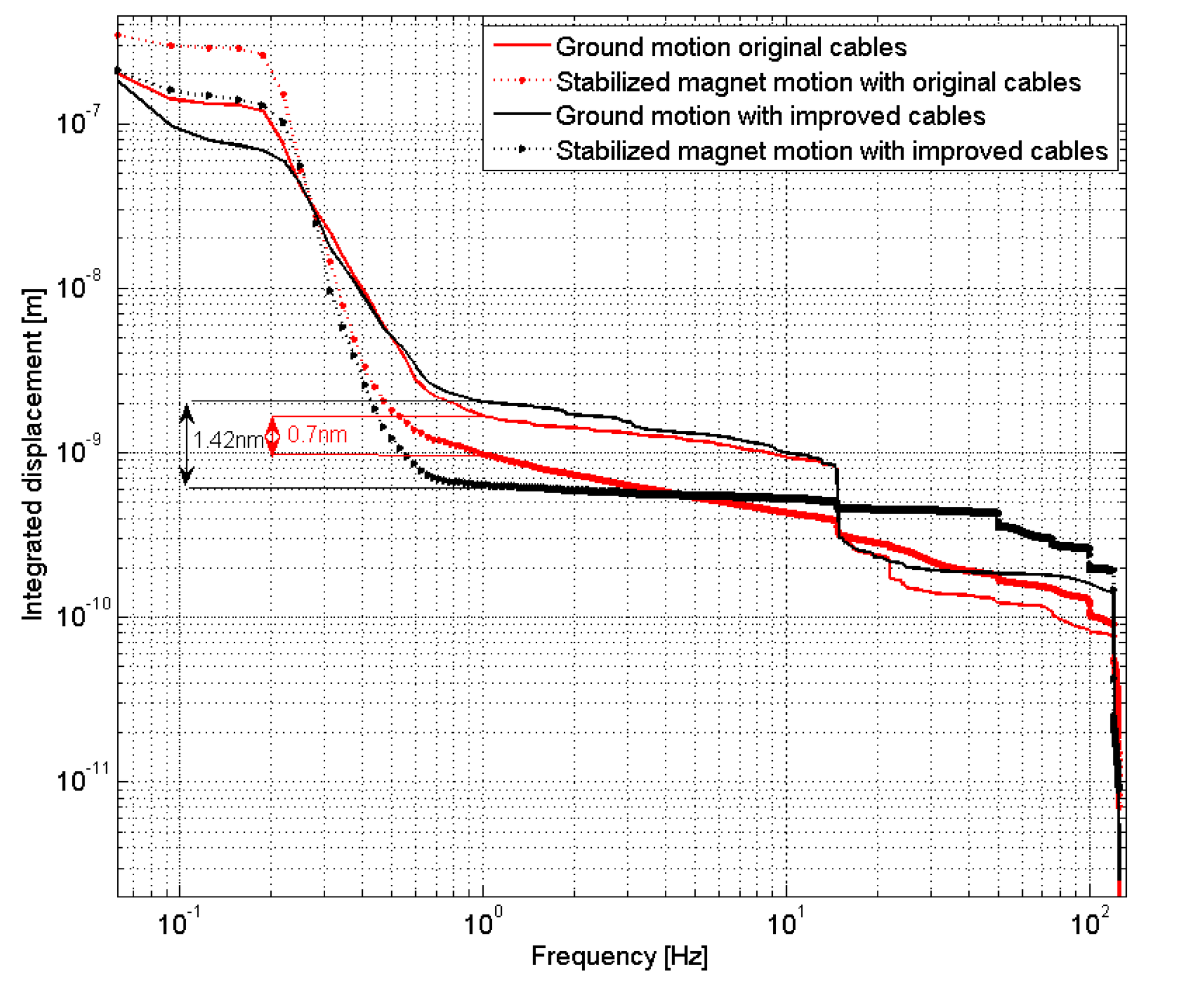
Typical catalog delay values for the components

Achievements



Nanopositioning





Stabilization

It is essential to highlight the importance of clean power supplies, adequate selection of cables, proper grounding and shielding and careful routing and placement of sensitive elements in relation to noise sources.
As prove of this, RMS stabilization results are compared on the figure above before and after the work.

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http://clic-stability.web.cern.ch/clic-stability