Active Stabilization Studies at DESY

C. Montag, DESY

November 2000

1 Introduction and Motivation

2 Mechanical Feedback

3 Electronic Feedforward

4 Conclusion

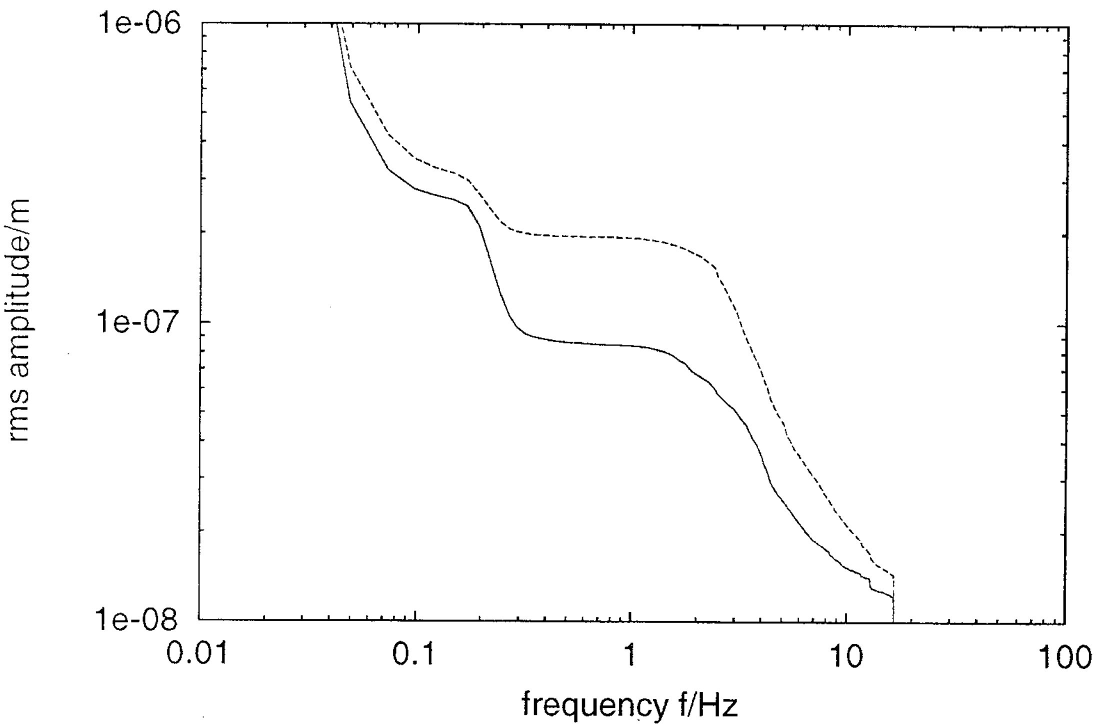
1 Introduction and Motivation

Vibration tolerances for the S-Band Linear Collider SBLC:

$$
\begin{aligned}
\sigma_q &= 0.25 \cdot \sqrt{\frac{\epsilon_{\text{end}} \cdot \overline{\beta}_{\text{end}}}{N_{\text{quads}}}} \cos \frac{\mu}{2} \\
&\approx \begin{cases} 85\,\text{nm}, & E_{\text{cm}} = 500\,\text{GeV} \\ 40\,\text{nm}, & E_{\text{cm}} = 1\,\text{TeV} \end{cases}
\end{aligned}
$$

Tolerances correspond to 3% luminosity degradation

RMS amplitudes of vertical ground motion in the HERA tunnel, under noisy and quiet conditions:



→ tolerances exceeded for frequencies below some 5 Hz

→ compensation required

2 Mechanical Feedback

Concepts of compensation:

- Beam-based orbit correction

→ not feasible for vibration frequencies above $\approx \frac{1}{25} \cdot f_{\mathrm{rep}} = 2\,\mathrm{Hz}$ for SBLC

- Passive damping

Assumption: Attenuation factor 5 needed at 2 Hz

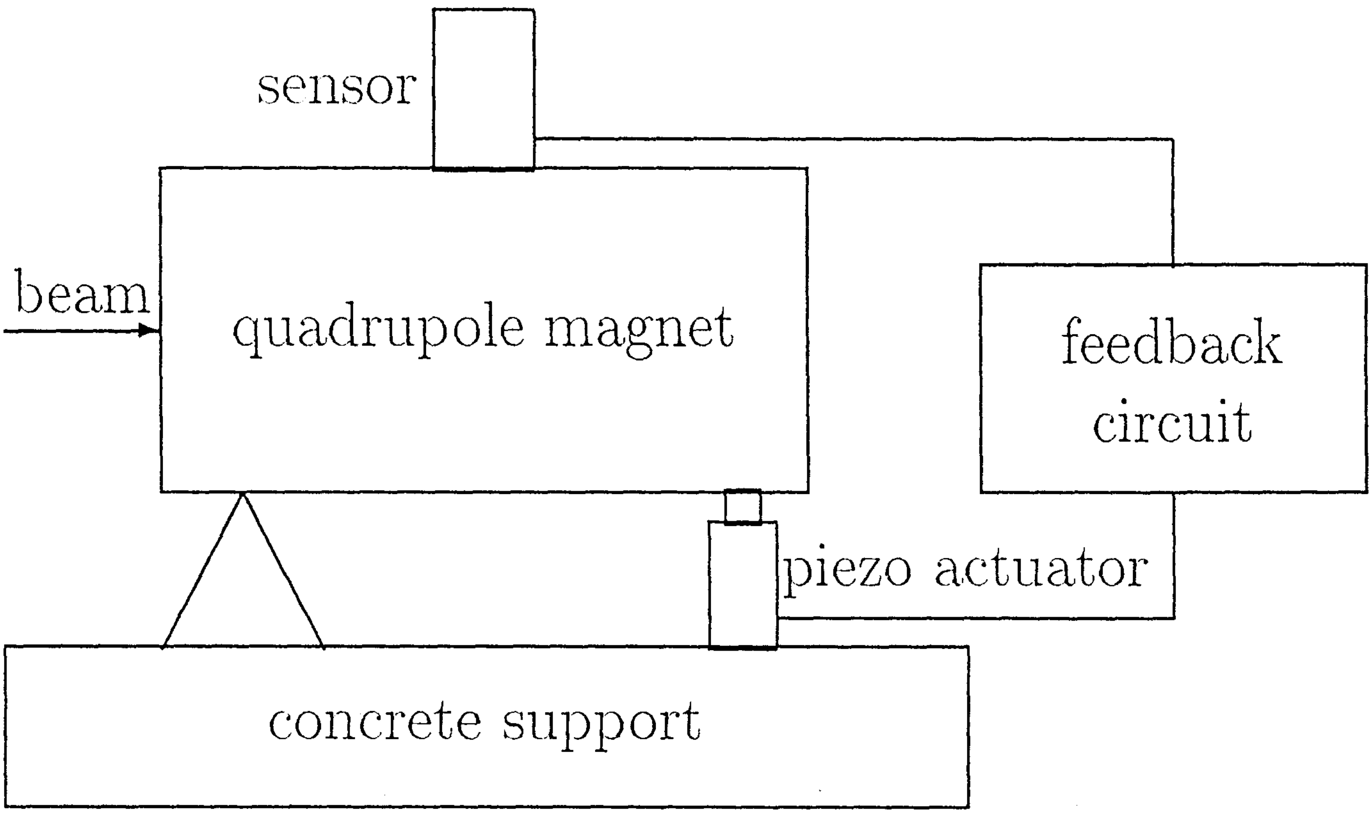
→ resonance frequency ≈ 1 Hz

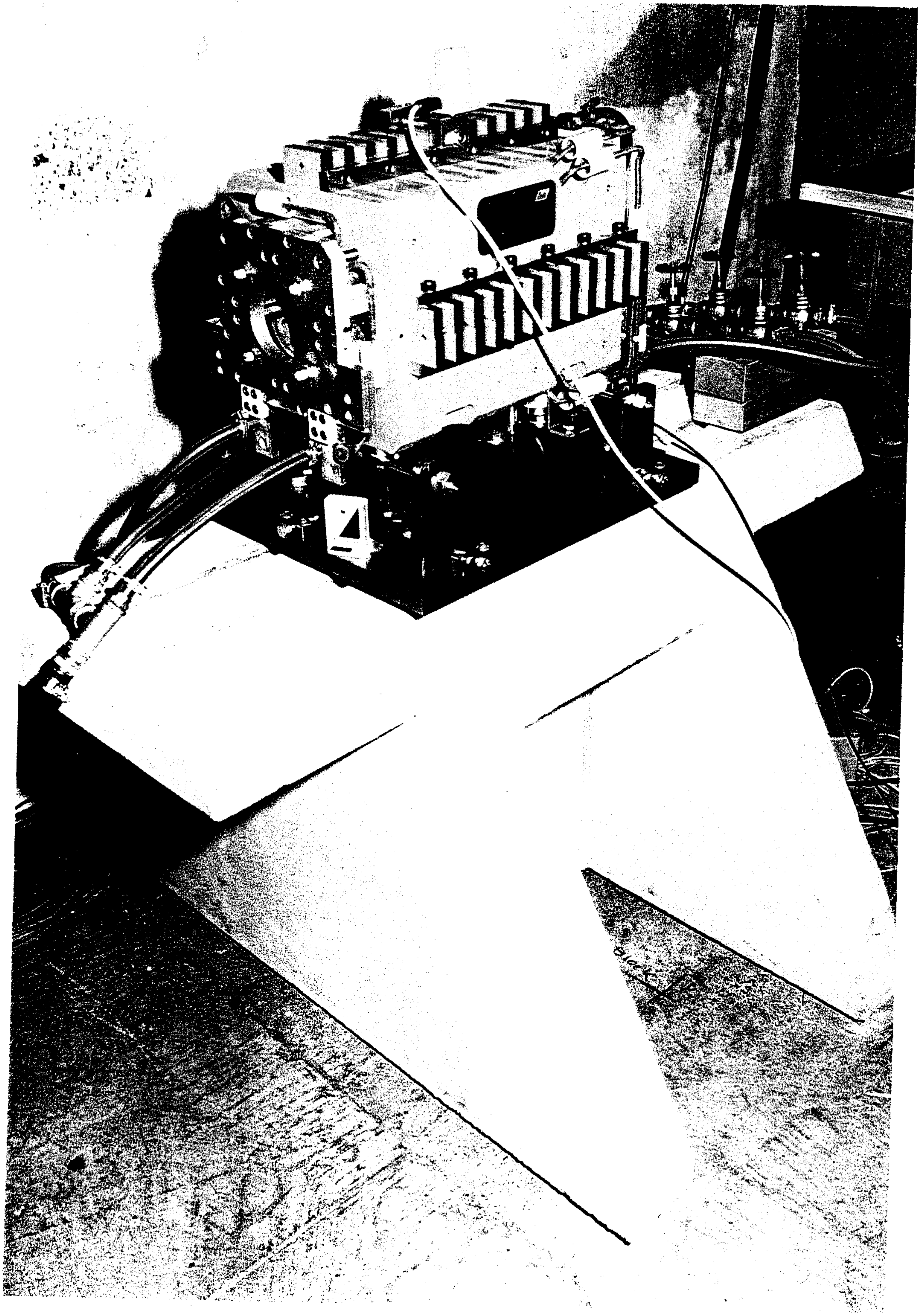
→ "spring" compression by 25 cm due to magnet mass

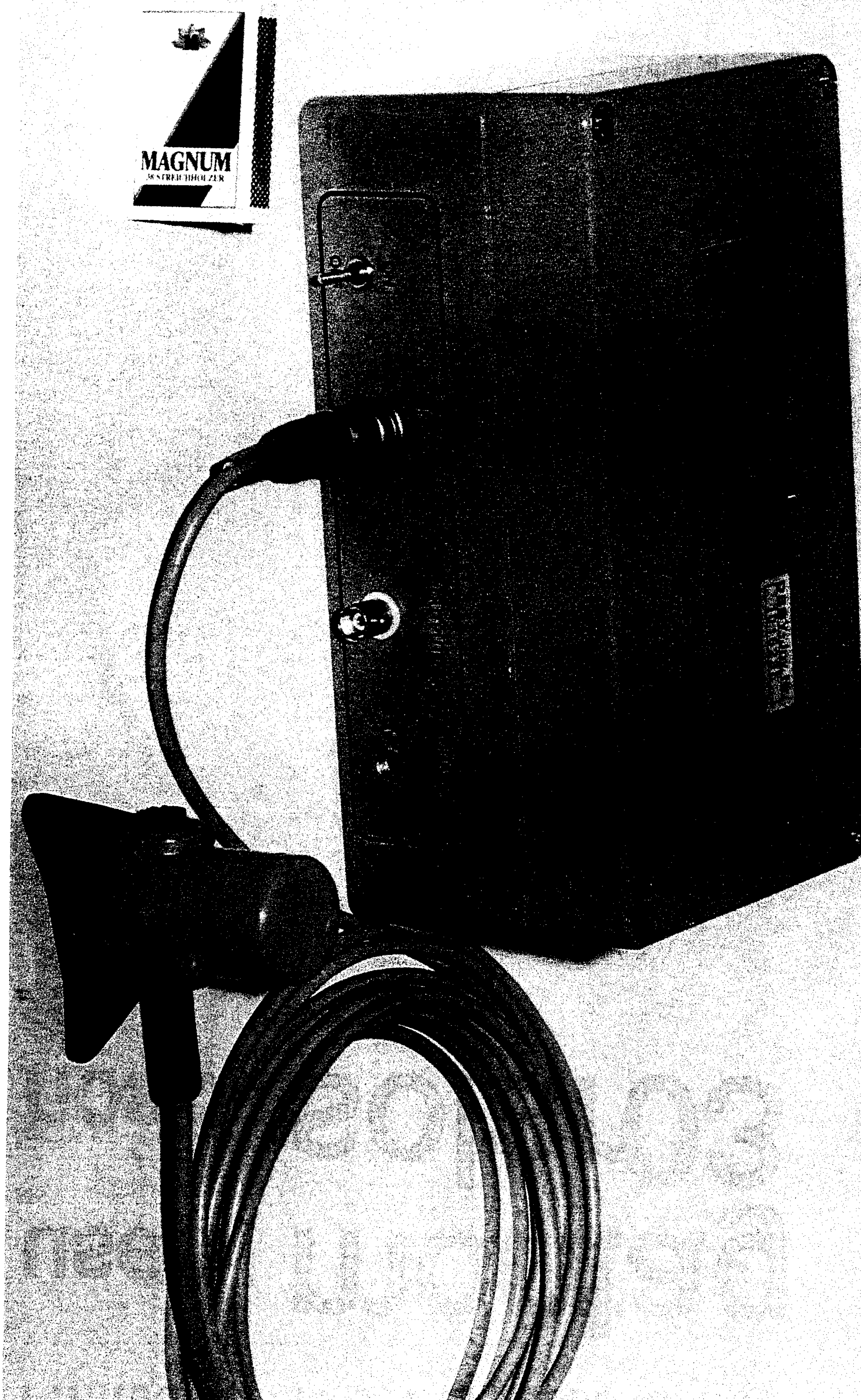
→ extreme sensitivity to direct excitation of the magnet (cooling water, air flow, ...)

- Active damping

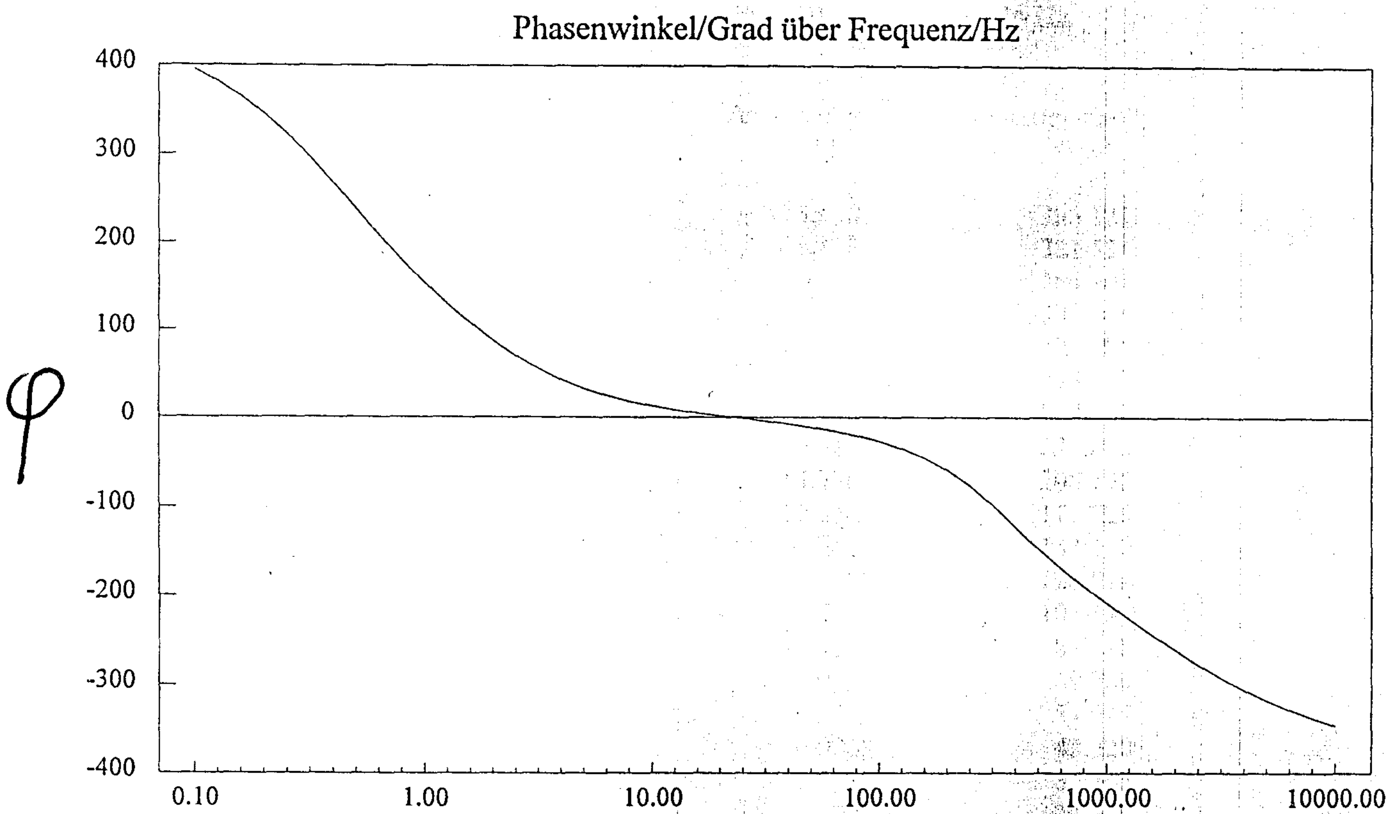
Active damping concept:

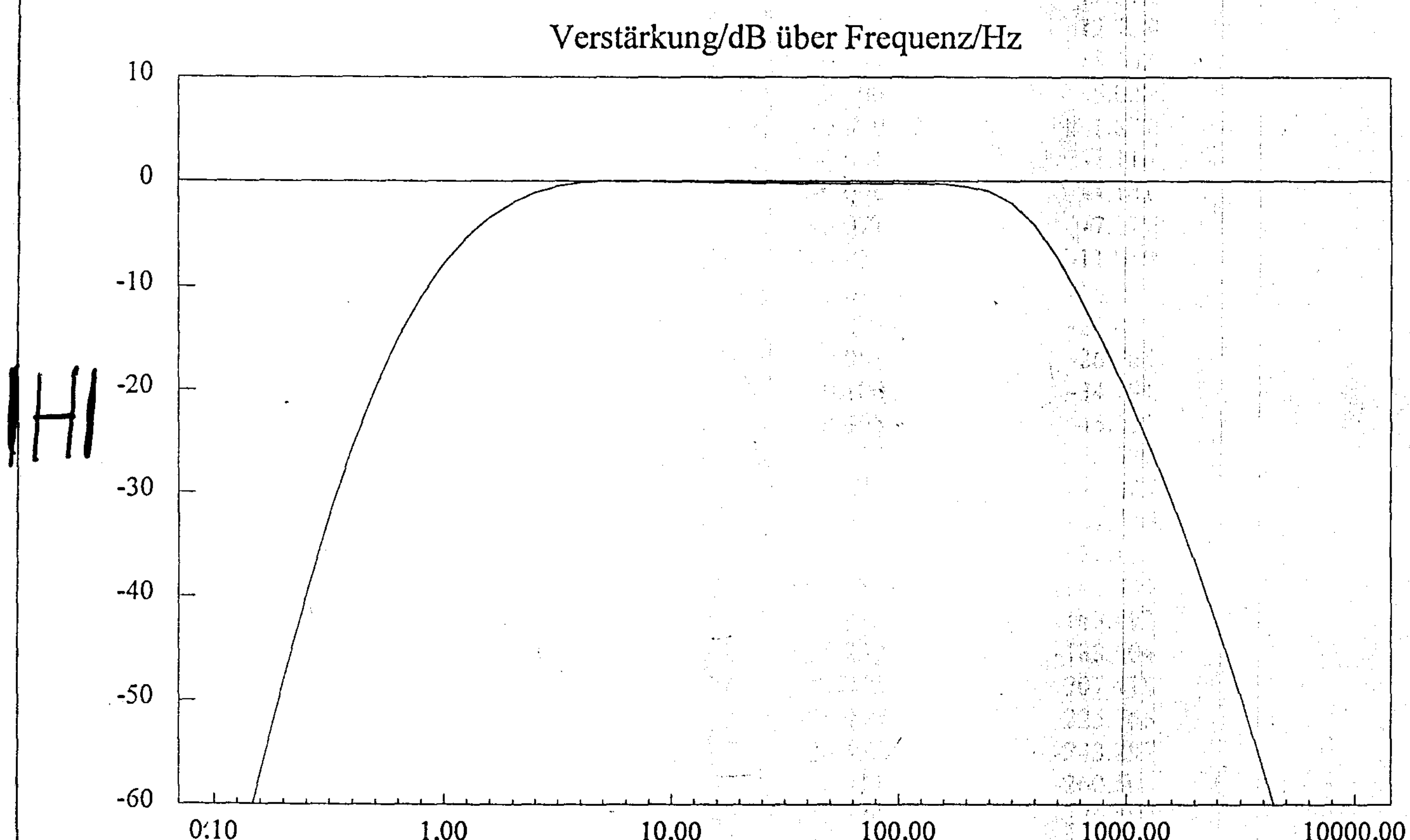





MAGNUM

Sensor Transfer Function

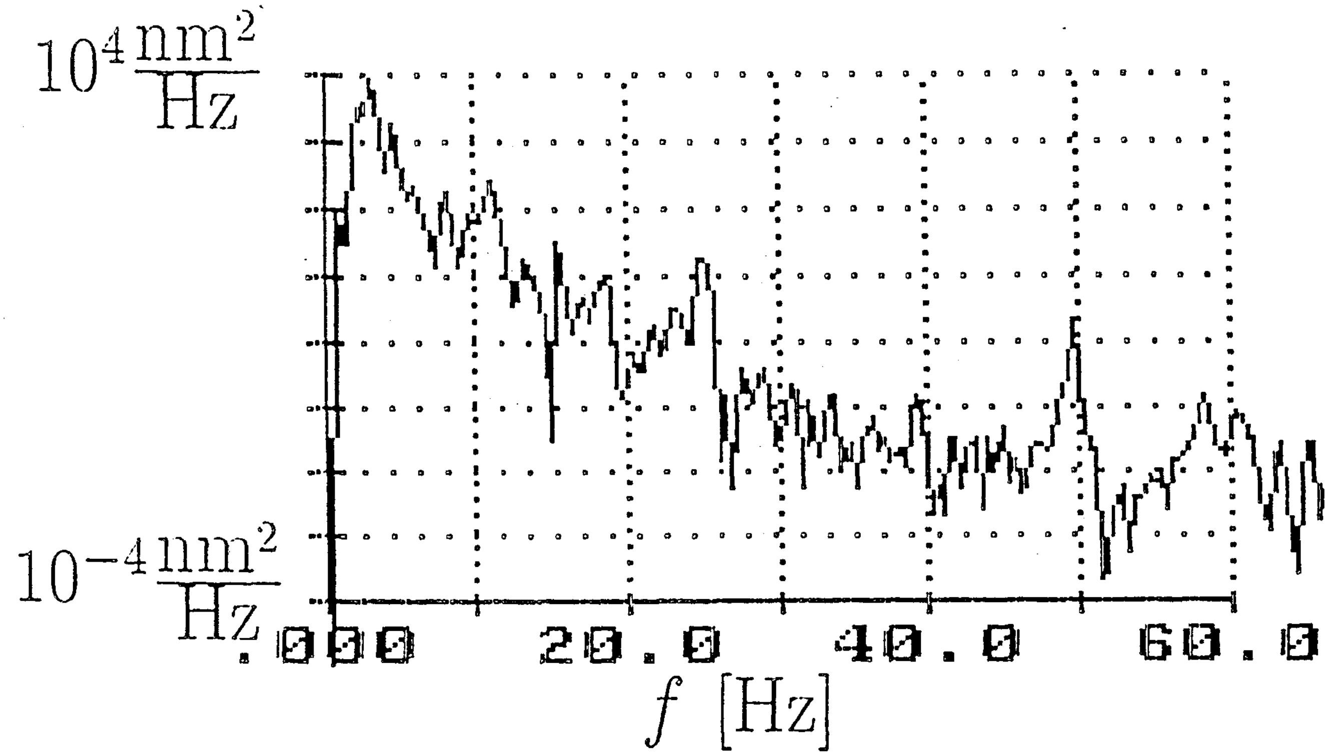




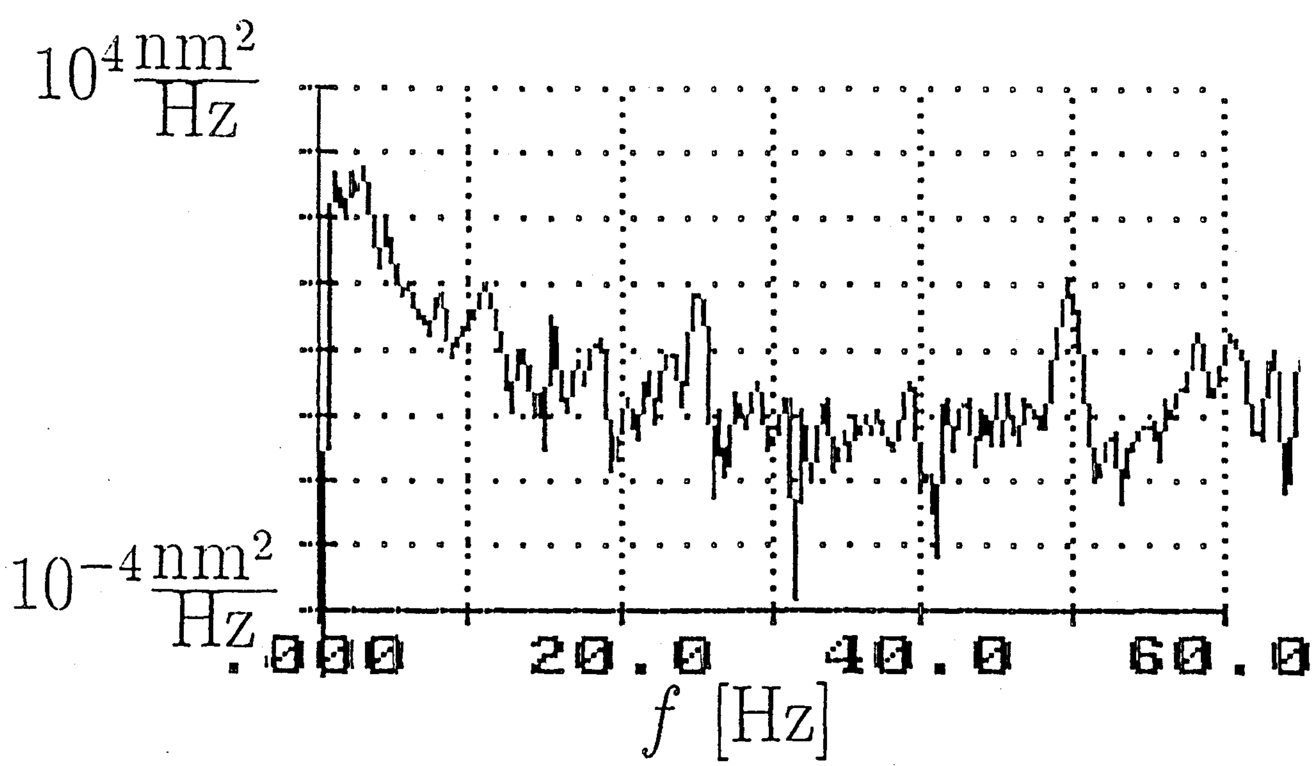
Results of Active Stabilization

Power spectrum densities

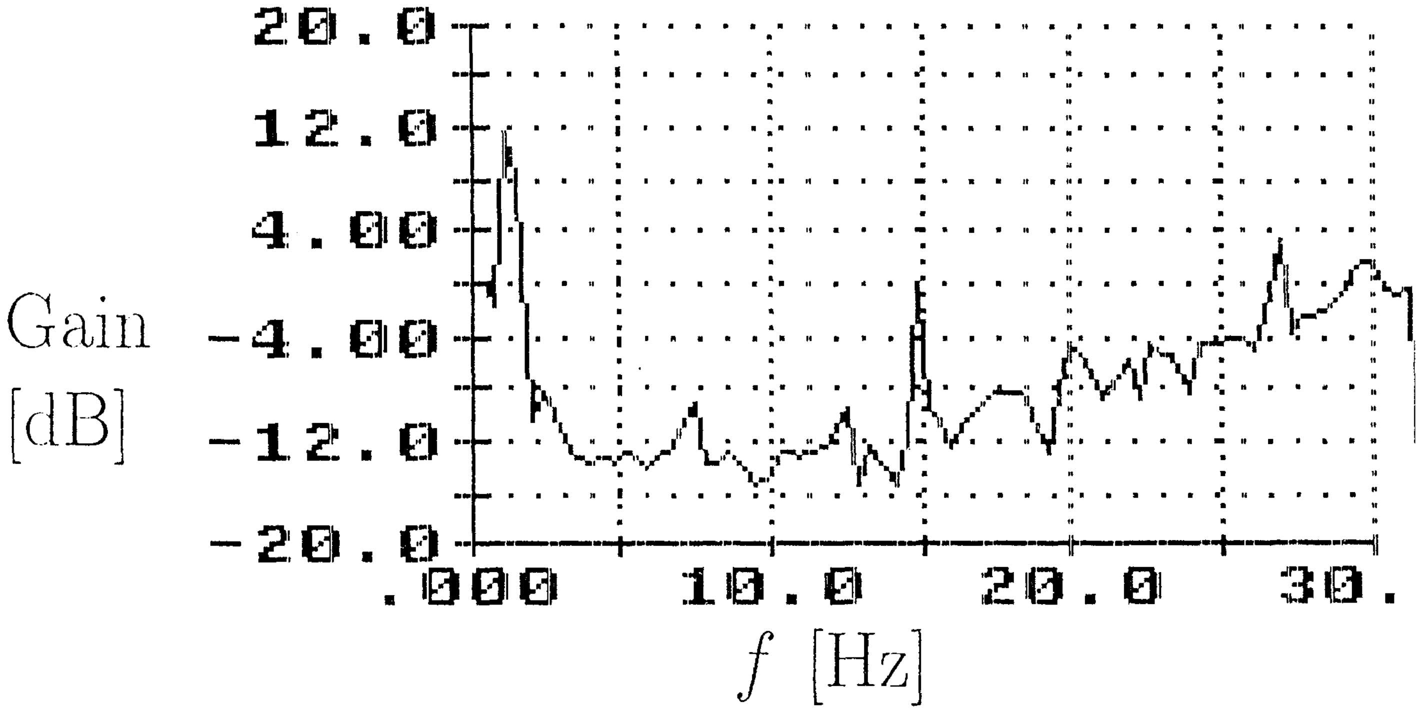
Feedback off: ≙ *floor motion*



Feedback on: ≙ *magnet motion*



Feedback gain:

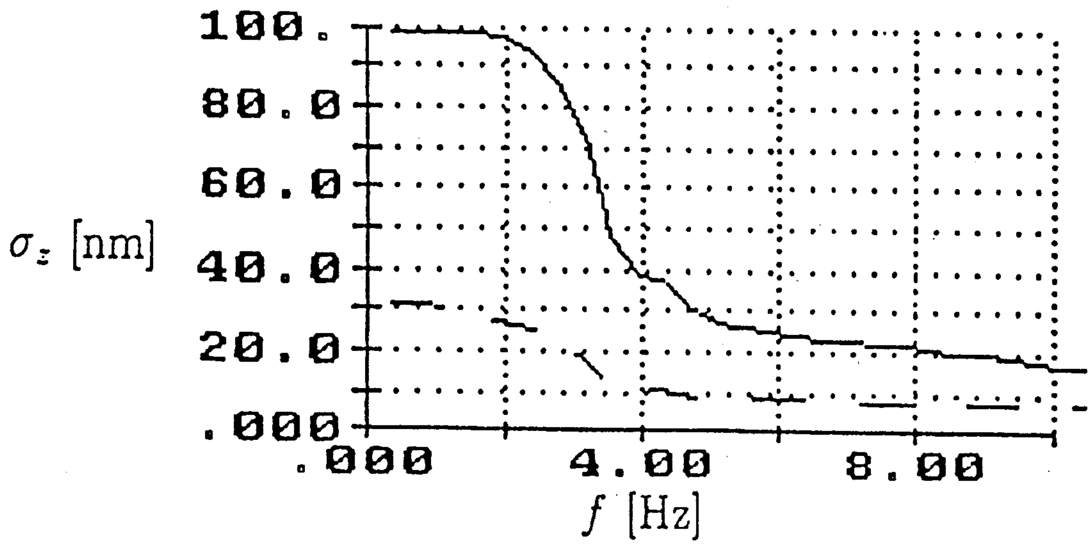


rms-value:

$$\sigma_z\big|_{\omega>\omega_0} = \sqrt{\int_{\omega_0}^{\infty} P_{zz}(\omega)d\omega}$$

solid: feedback off

dashed: feedback on



Noisy environment, cooling water on

3 Electronic Feedforward

Idea:

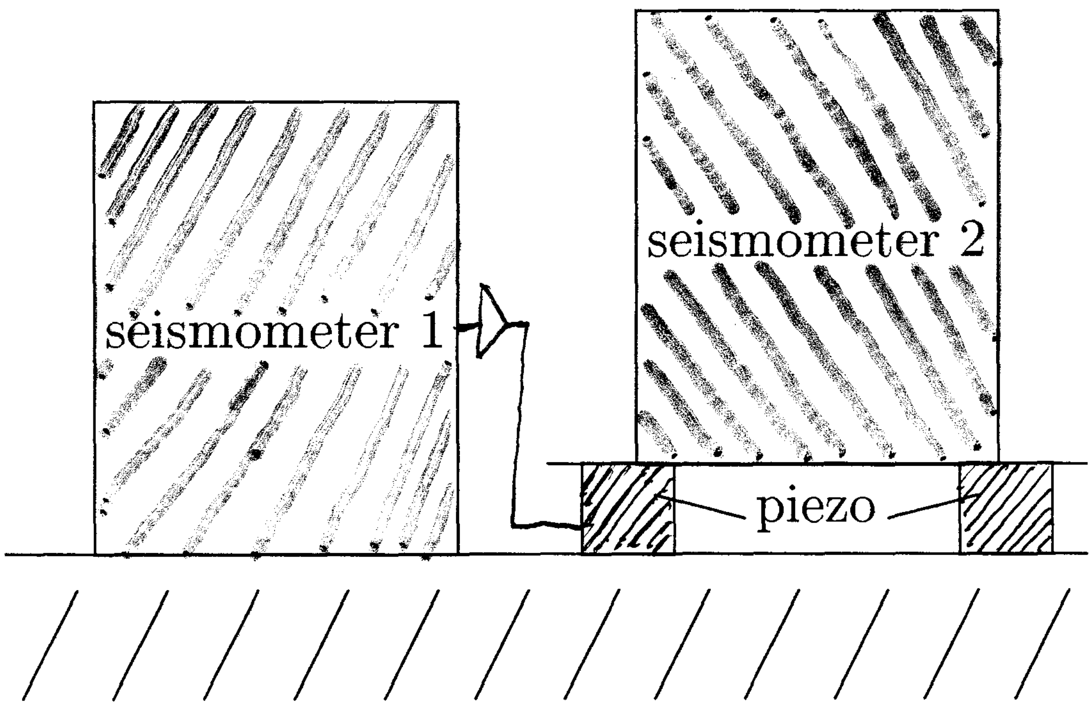
Direct application of sensor output to kicker magnets

Electronic feedforward requires flat amplitude transfer function and zero degree phase of the sensor within the desired frequency range

→ Broadband seismometers, not just geophones

Guralp CMG-40: 0.1 . . . 50 Hz

Mechanical feasibility test (to be done):



Apply output signal of seismometer 1 to piezos, measure remaining vibration by seismometer 2

4 Conclusion

- Active mechanical stabilization down to some 20 nm at 2 Hz successfully demonstrated

- Feedforward requires more sophisticated sensors (seismometers)

- Feedforward feasibility test remains to be done