6th Edoardo Amaldi Conference on Gravitational Waves
Okinawa, June 20-24, 2005

Approaching the quantum limit with a new read-out on EXPLORER and NAUTILUS

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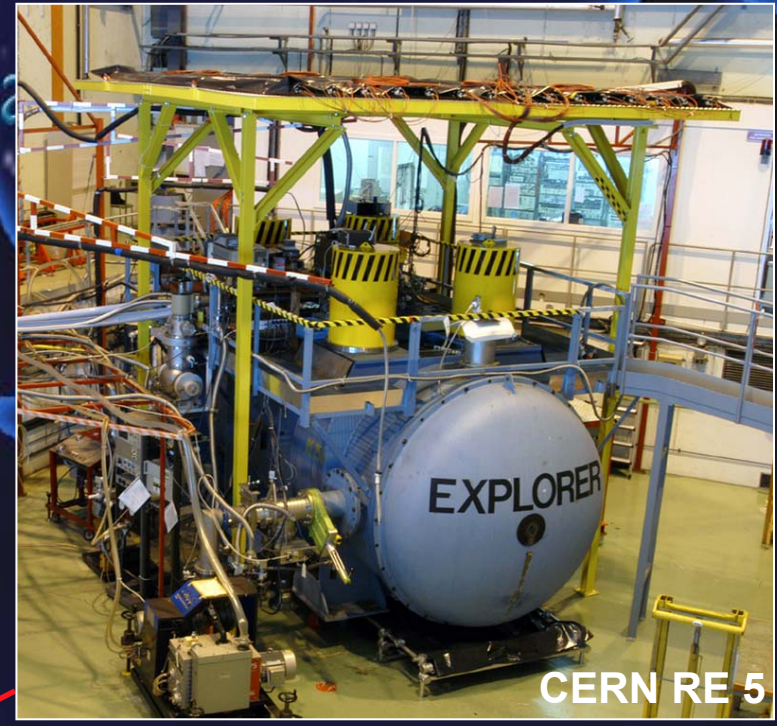
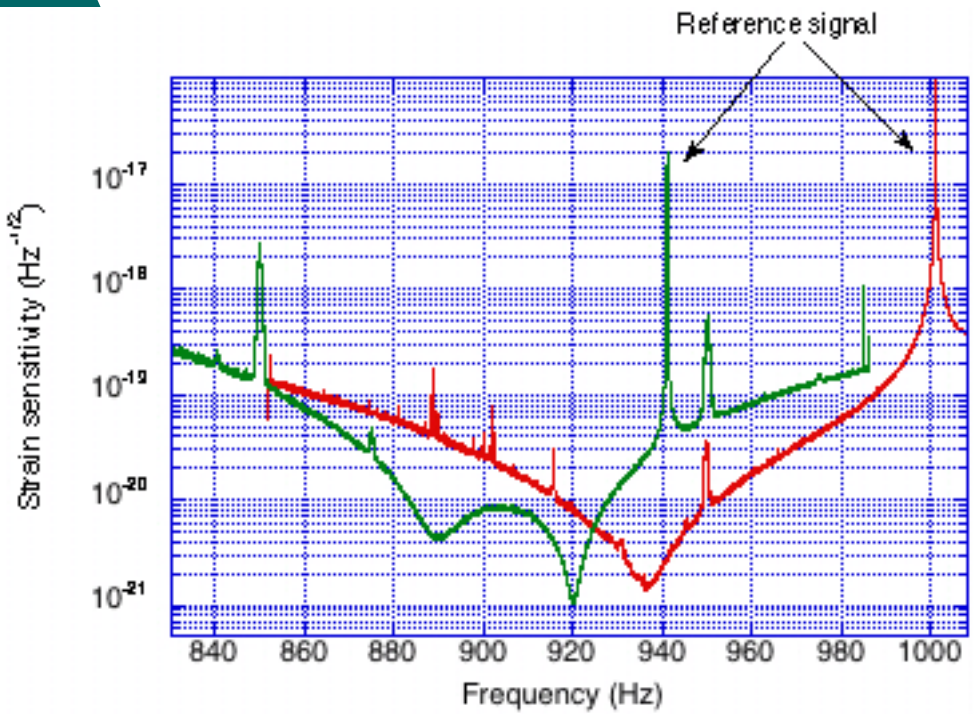
Interferometer
Resonant-Mass
MiniGrail
GEO
EXPLORER
AURIGA
VIRGO
NAUTILUS


EXPLORER
CERN RE 5


INFN Frascati

EXPLORER and NAUTILUS
Duty cycle more than 90%

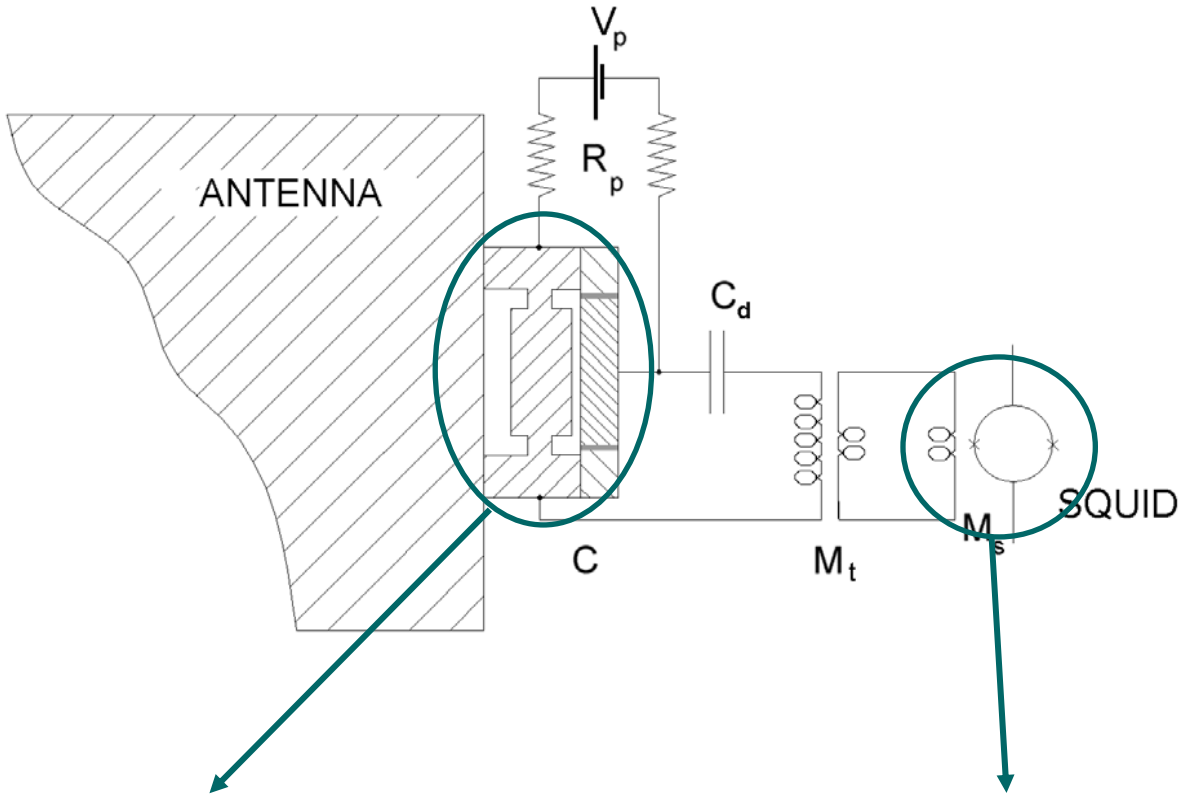
Talk by M. Visco this morning



Strain sensitivity of EXPLORER and NAUTILUS

$\langle T_{noise} \rangle_{NAU} = 2$ mK ⟶ $h = 3\ 10^{-19}$ for $10^{-4}\ M_o$ at Galactic Centre

Single gap transducers (gap ≈ 10μm) and single-stage dc SQUIDS (ε ≈ few thousand ħ)



β, transduction efficiency

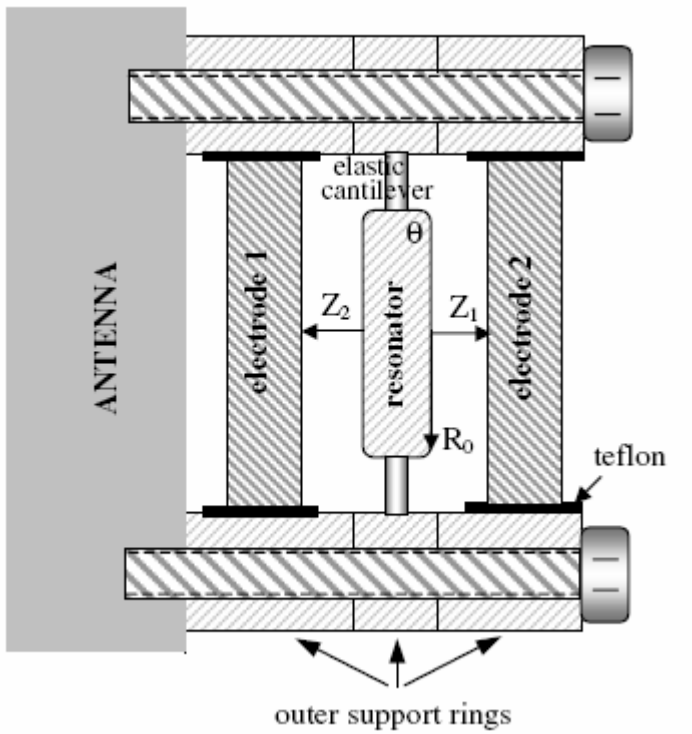
T_n, noise temperature

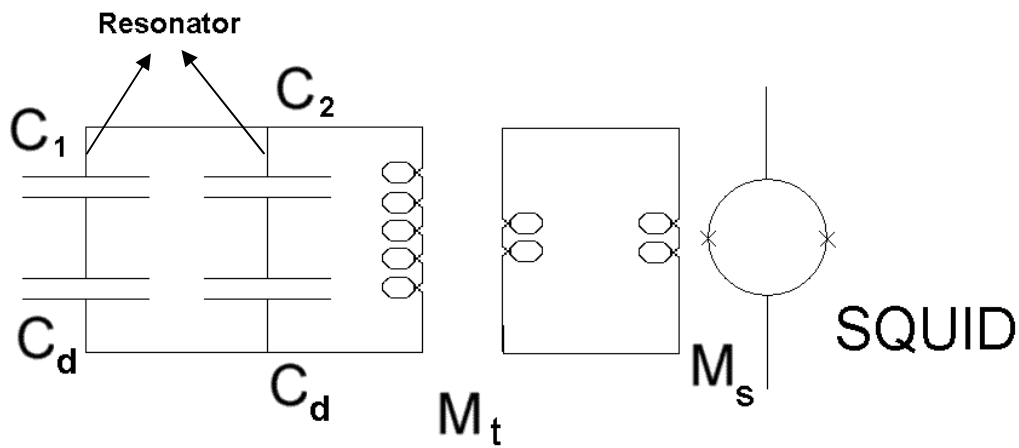
$$\Delta f \propto \sqrt{\frac{\beta}{T_n}}$$

$$\Delta E_{\min} = k_B T_{eff} \approx \frac{k_B T}{\beta Q} + 2 k_B T_n$$

Double-gap transducer

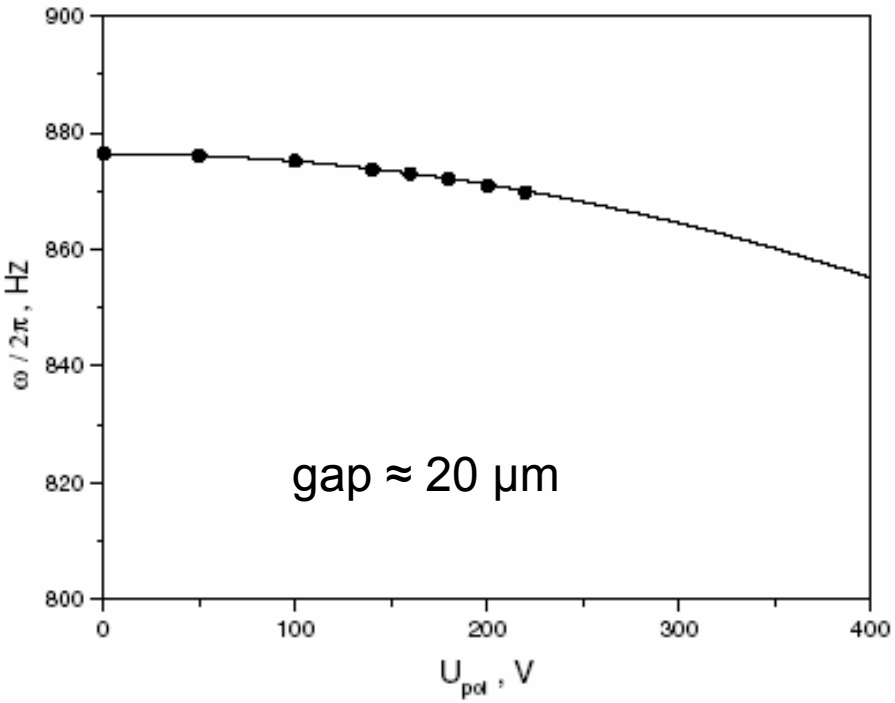
Actual gap on NAUTILUS transducer ≈ 9μm





Preliminary results on the Double-gap transducer

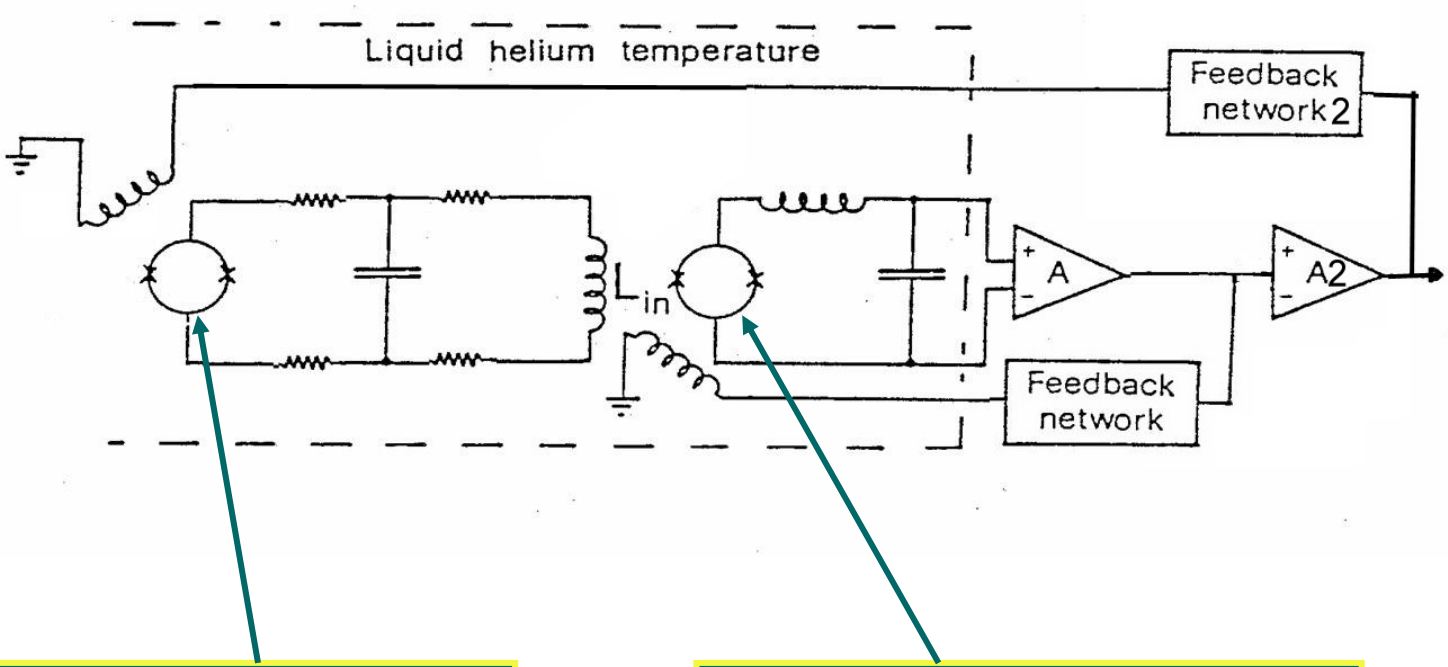
Minenkov, J. Phys. D: Appl. Phys. **33,** 1134–1136 (2000)



@ T=4.2 K, $Q = 1.5 \cdot 10^6$, $U_{pol} \approx 200$ V
gap ≈ 10 μm

The ROG 2-stage SQUID amplifier

Carelli *et al*., Appl. Phys. Lett. **72**, 115 (1998)

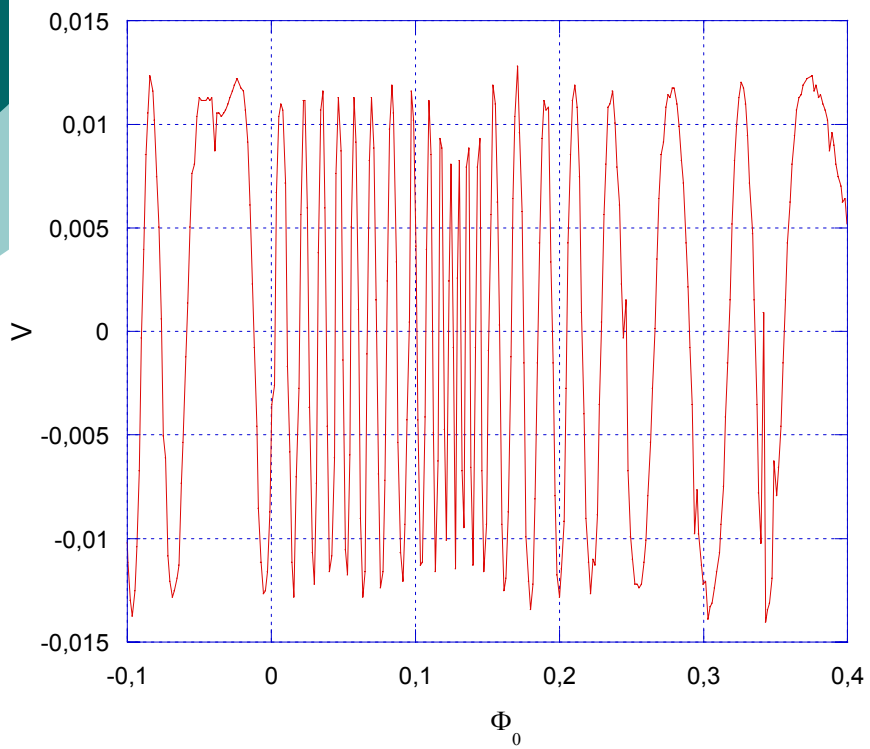


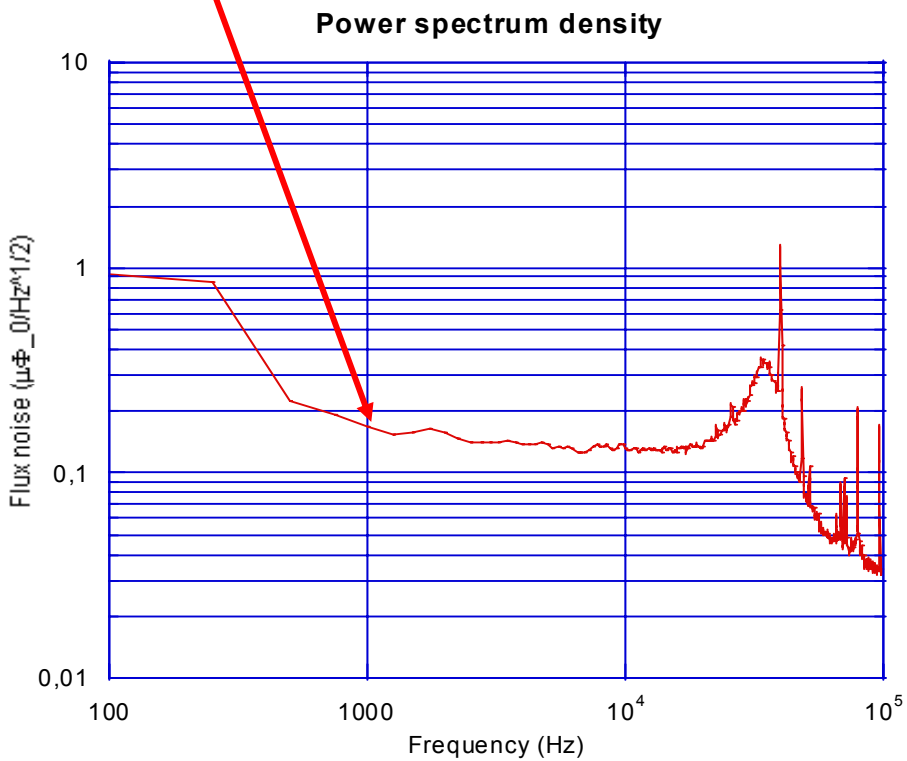
ROG dc SQUID

Quantum Design dc SQUID

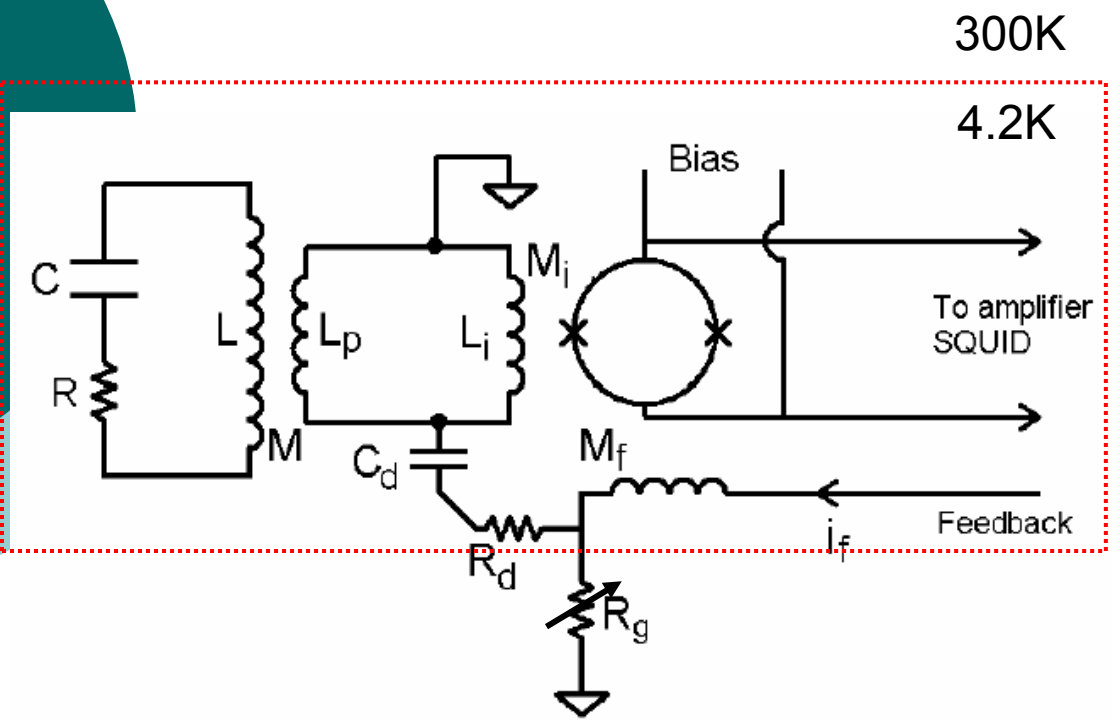
Open input noise measurement of the ROG 2-stage SQUID amplifier

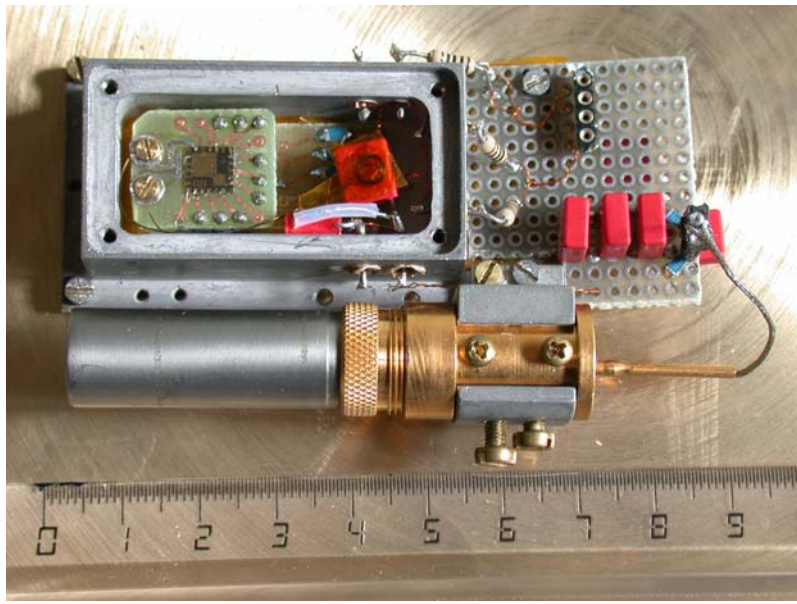
Energy resolution ≈ 30ħ around 1kHz @ 4.2K





Working point stabilization via cold-damping network[1]

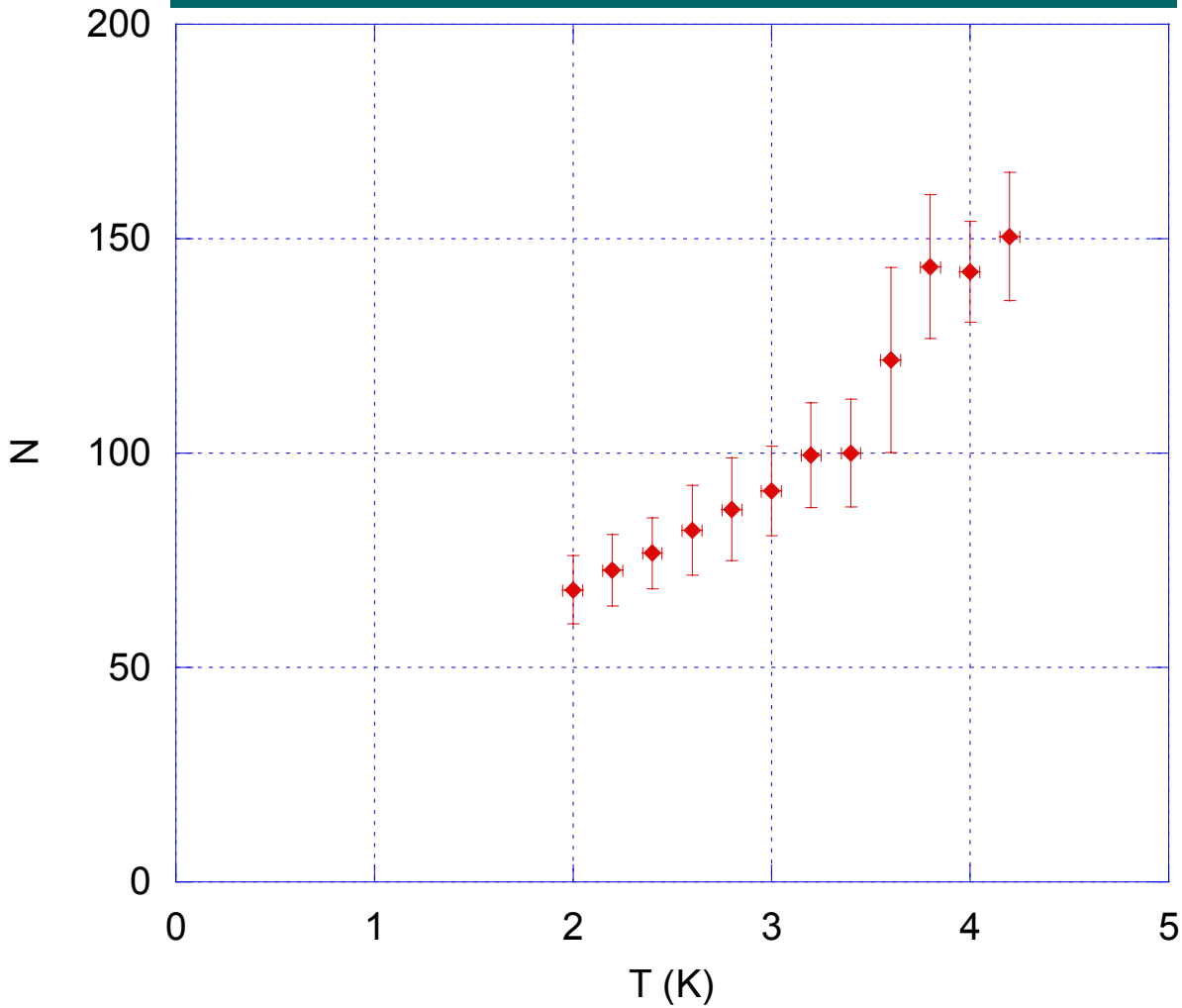




High-Q input circuit (L_0=96mH, Q_0=0.7·10^6, k=0.38).
f_0= 1740 Hz

1 see Vinante *et al.*, Physica C **368**, 176-180 (2002)

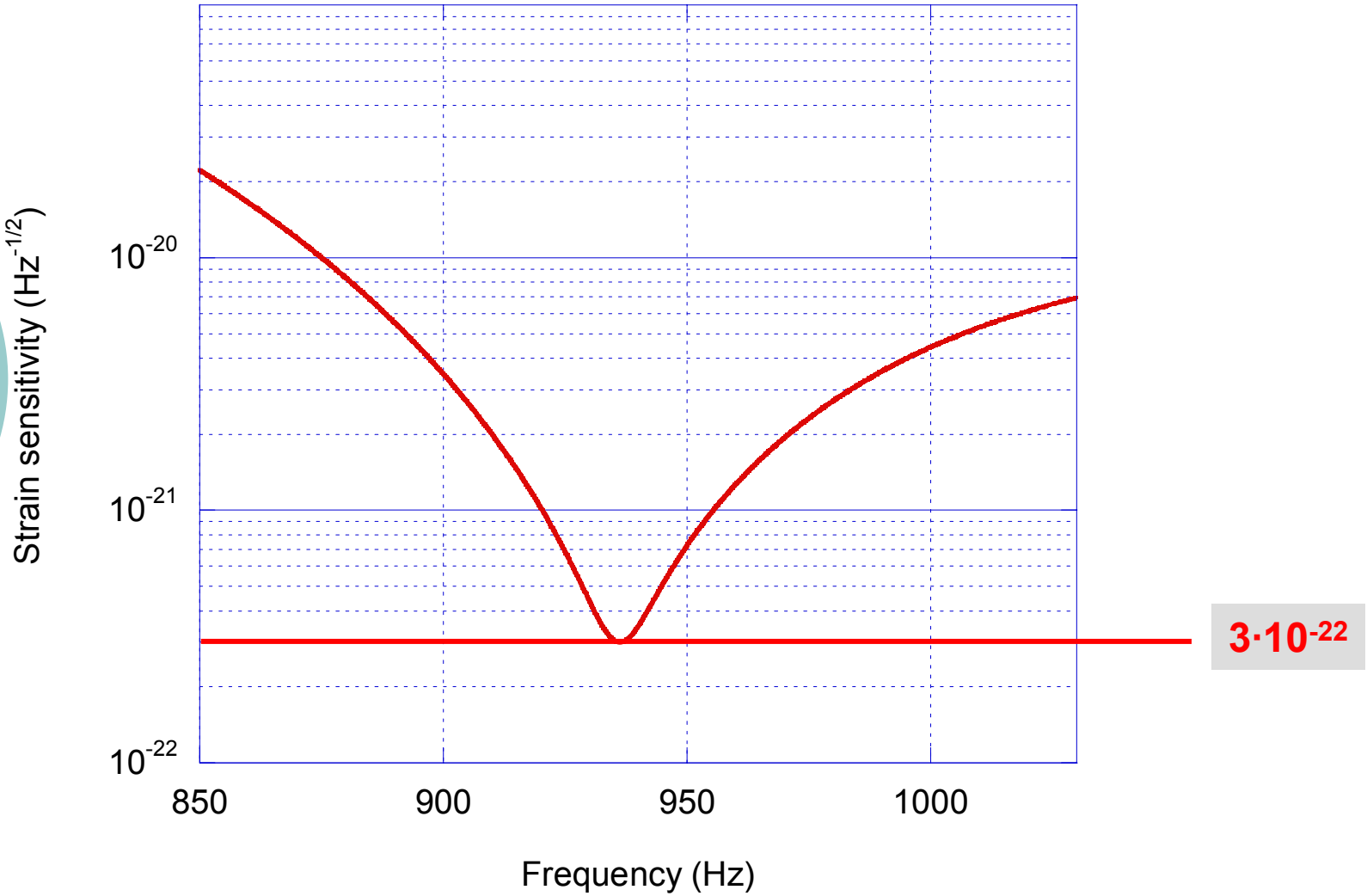
Energy resolution vs temperature



@ T=2.0 K, the flux noise is $0.21 \mu\Phi_0/\sqrt{Hz}$ corresponding to **70ħ**

Next Steps

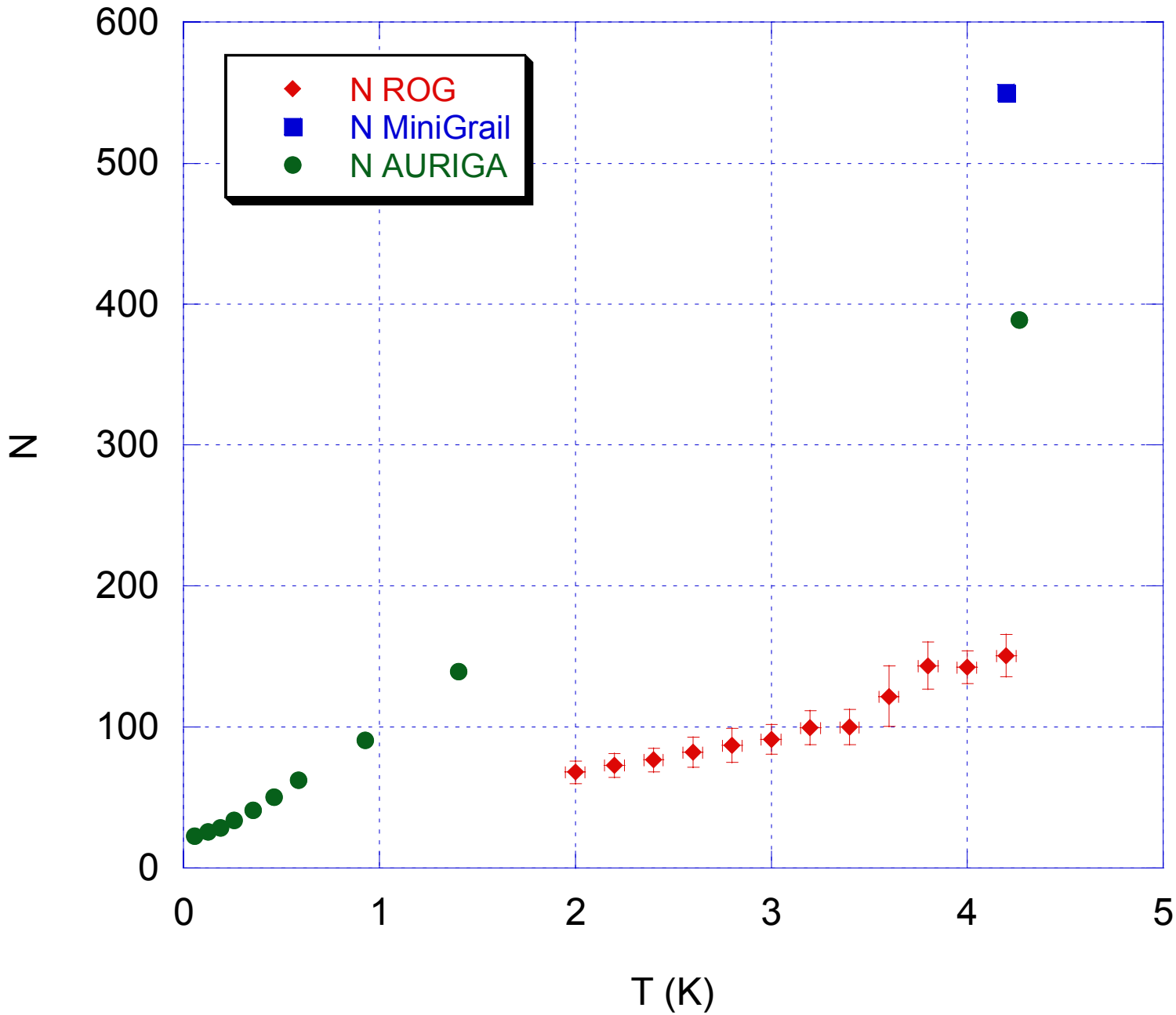
- Investigate temperatures below 2 K;
- Increase the transformer coupling;
- Measurement of back-action to estimate noise temperature T_n;
- Couple the system to the double gap transducer.



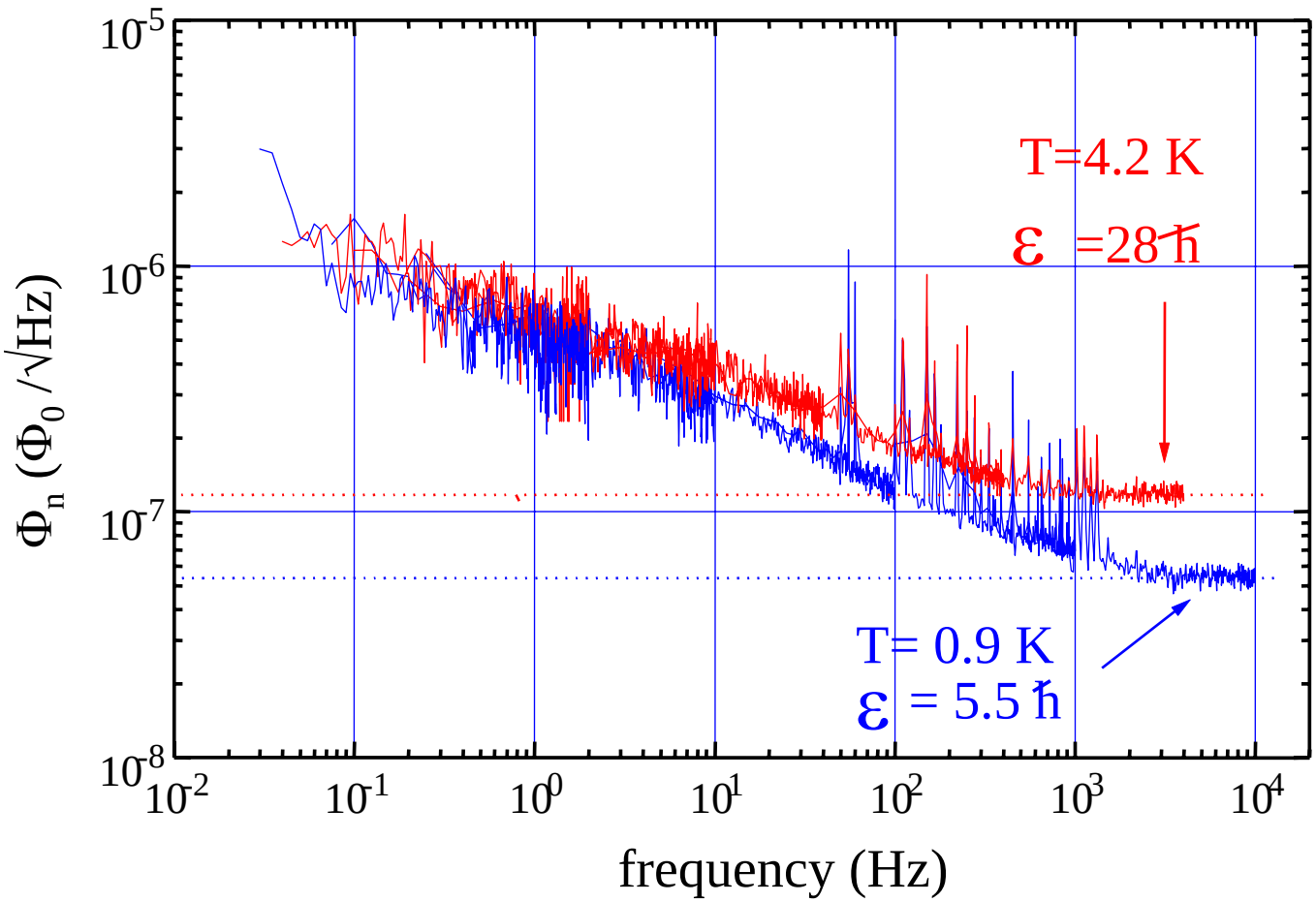
Expected S_h for NAUTILUS @ 0.12K, double gap transducer (11 μm and $Q=1.5 \cdot 10^6$) and double SQUID (L_0=2.5 H, k=0.7, $\Phi_n = 0.16 \mu\Phi_0/\sqrt{Hz}$).

$T_{eff} \approx 7\mu K$ (corresponding to **$h=2.1 \cdot 10^{-20}$**), sensitivity **$< 1 \cdot 10^{-21} / \sqrt{Hz}$** over **35Hz**.

The End


N ROG
N MiniGrail
N AURIGA
N
T (K)
0
100
200
300
400
500
600
0
1
2
3
4
5

Experimental flux noise spectral density of the Rome double stage SQUID amplifier



$$\varepsilon = \frac{L_{in}\Phi_n^2}{2M^2}$$

Carelli et al. 98