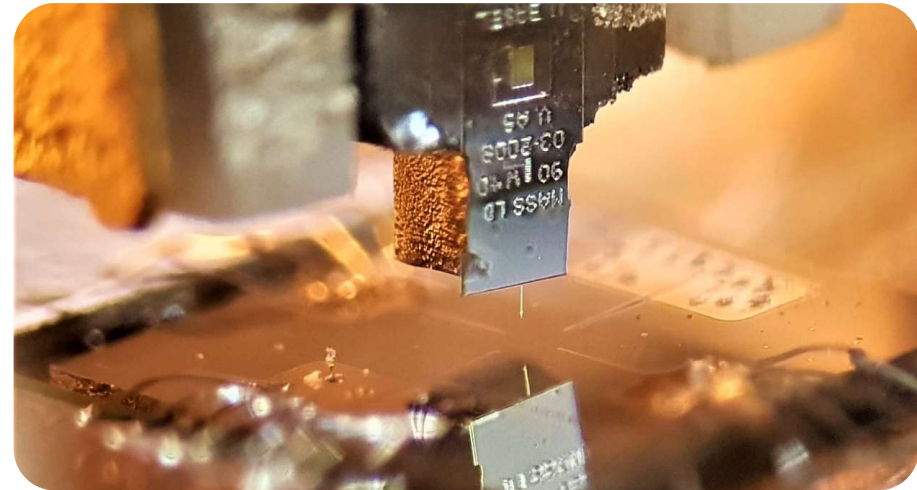


Cryogene start-ups en cryogeen onderzoek aan de Universiteit Leiden



Martin de Wit, Gesa Welker, Freek
Hoekstra, Jaimy Plugge, Tim Fuchs
Koen van Deelen, Dennis Uitenbroek

Tjerk Oosterkamp

Leiden University, the Netherlands

SRON cryo symposium

19-04-2022



Bedrijven in en om Leiden cryogene techniek (niet compleet)

- Leiden Cryogenics (1992)
- Leiden Probe Microscopy (2004)
- Leiden Spin Imaging (2014)
- Onnes Technologies (2018)
- Quantamap (2022)
- Hightech Development Leiden
- milliKelvin Technologies
- Cryolinks

Press this button
to add one

e.g. cosine, several in the space area

milliKelvins, positionering, vibratie isolatie, kabels, thermometrie,
nieuwe microscopie, integratie

Leiden Cryogenics

- Giorgio Frossati



Acknowledgements

Benard van Heck , Koen van Deelen
Jaimy Plugge, Gesa Welker, Tim Fuchs, Dennis Uitenbroek



Finemechanics/Electronics

Gert Koning, Merlijn Camp,
Kier Heeck



Companies: Leiden Cryogenics, Leiden Spin Imaging, Leiden Probe Microscopy,
Onnes Technologies, Delft Circuits, Hightech Development Leiden

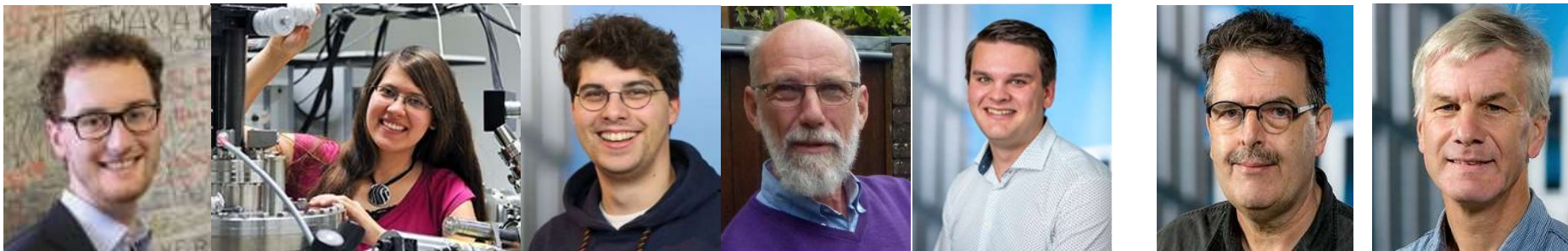
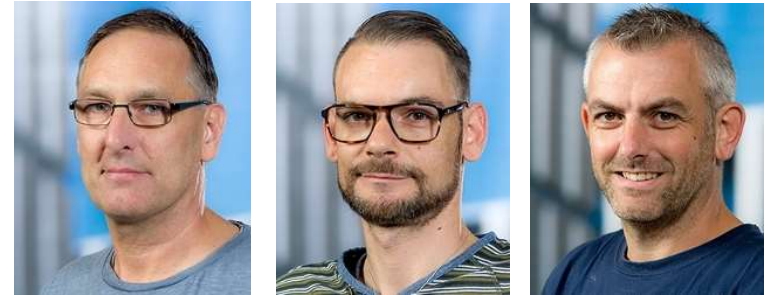
Acknowledgements

Martin de Wit, Jelmer Wagenaar, Tom van der Reep, Freek Hoekstra, Dirk Bouwmeester
Koen van Deelen, Jaimy Plugge, Gesa Welker, Tim Fuchs, Kier Heeck, Dennis Uitenbroek

Plus many undergraduate
students

Technical Support

Gert Koning, Merlijn Camp, Fred Schenkel
Ko Koning, Bert Crama

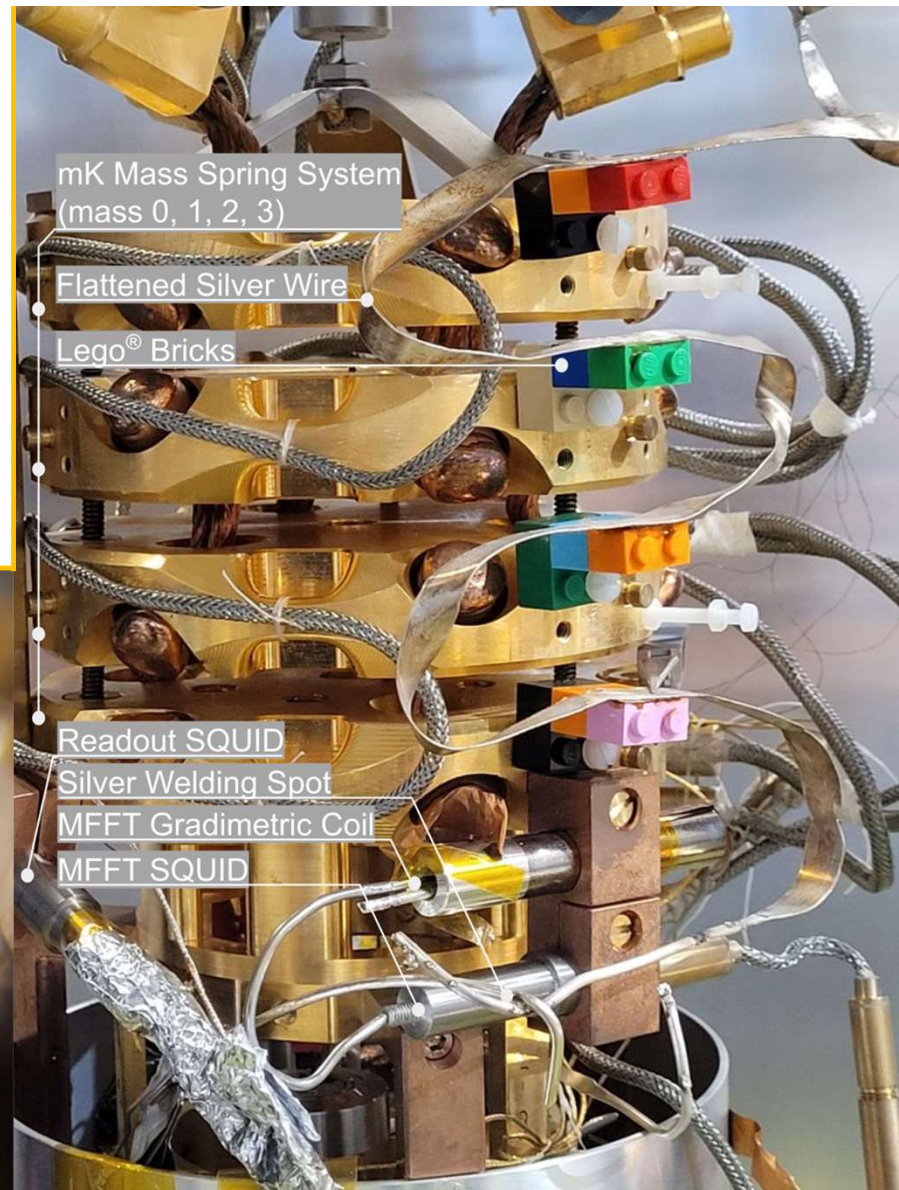
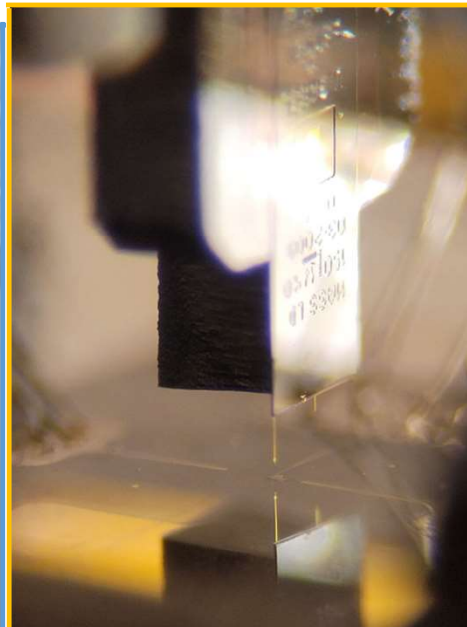


Companies: Leiden Cryogenics, Leiden Spin Imaging, Leiden Probe Microscopy,
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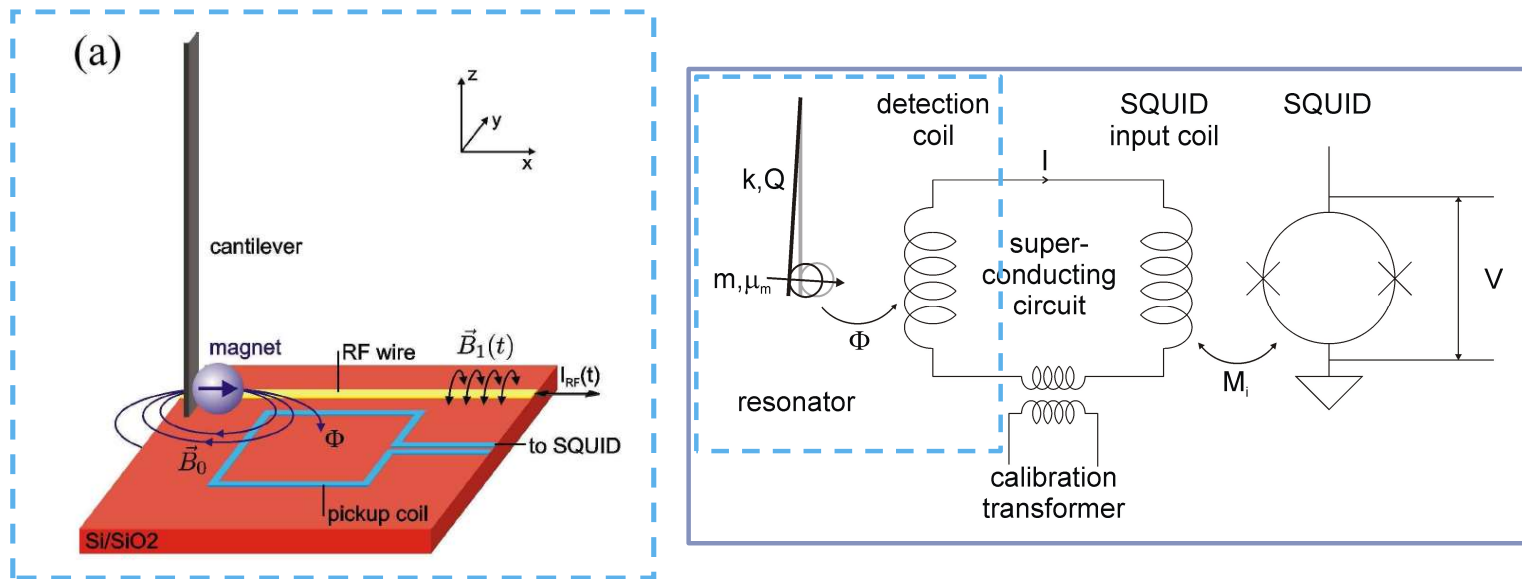
We meten zwaartekracht tussen
kleine objecten en
We proberen objecten op twee
plaatsen te laten zijn.

Towards a Unified Theory:

Small Scale Gravity, Large Scale Quantum Mechanics



SQUID provides a cantilever detection system compatible with mK-temperatures

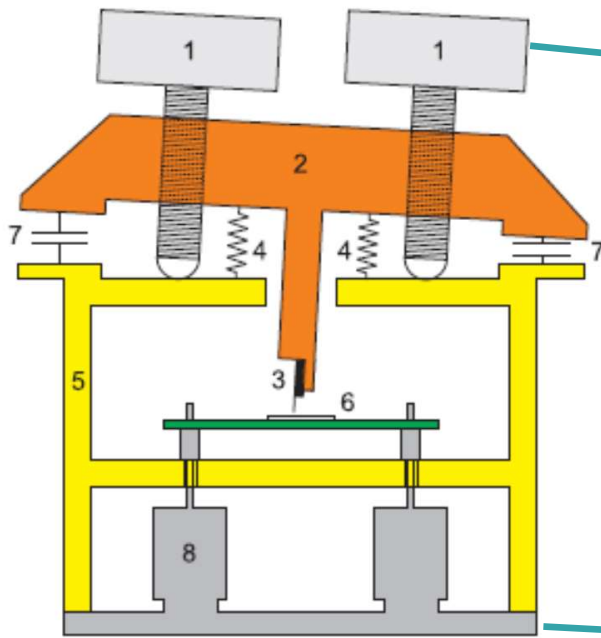


SQUID: Superconducting Quantum Interference Device

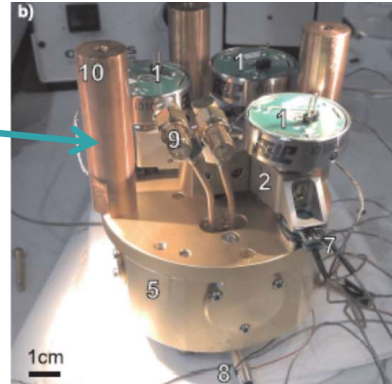
Flux noise: $\sim 0.6 \mu\Phi_0/\sqrt{Hz}$

10^{-21} T m^2 is a really small number!

The MRFM microscope



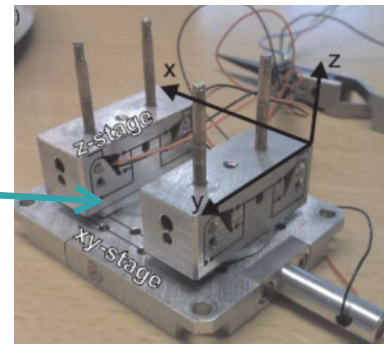
The experimental chamber



The coarse approach

- mm range
- nm precision

Janssen Precision
Engineering B.V.

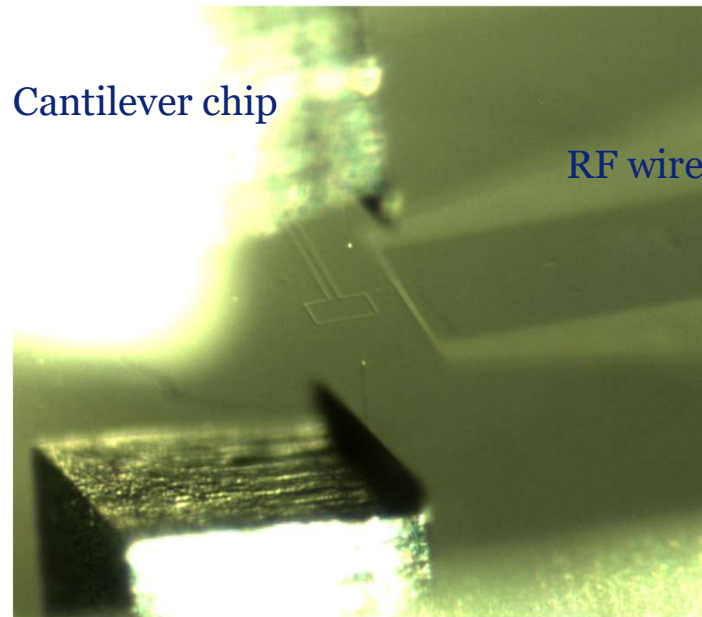


The fine stage (3x3 μm)

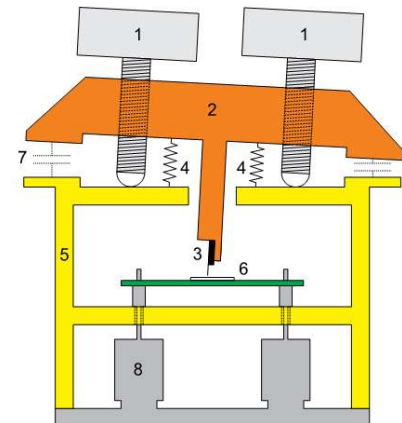
Home-made
FMD



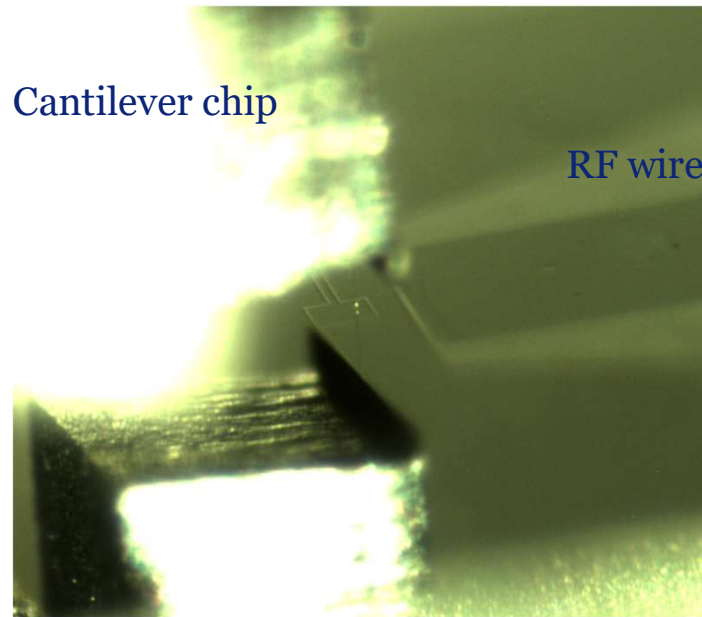
The coarse approach



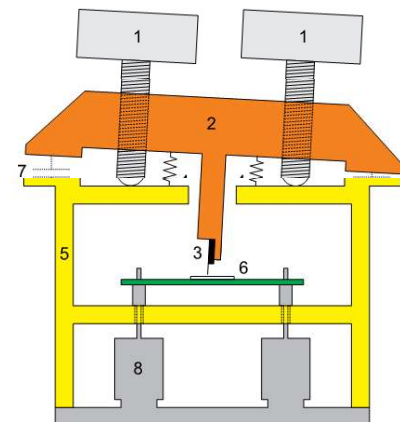
Cantilever chip (mirrored reflection)

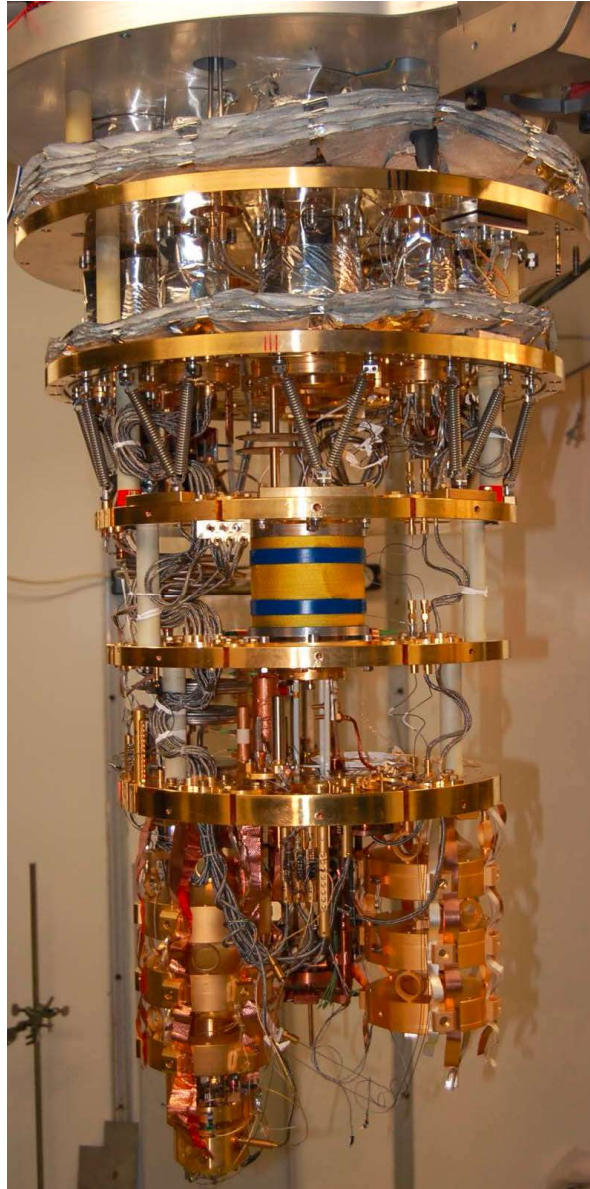


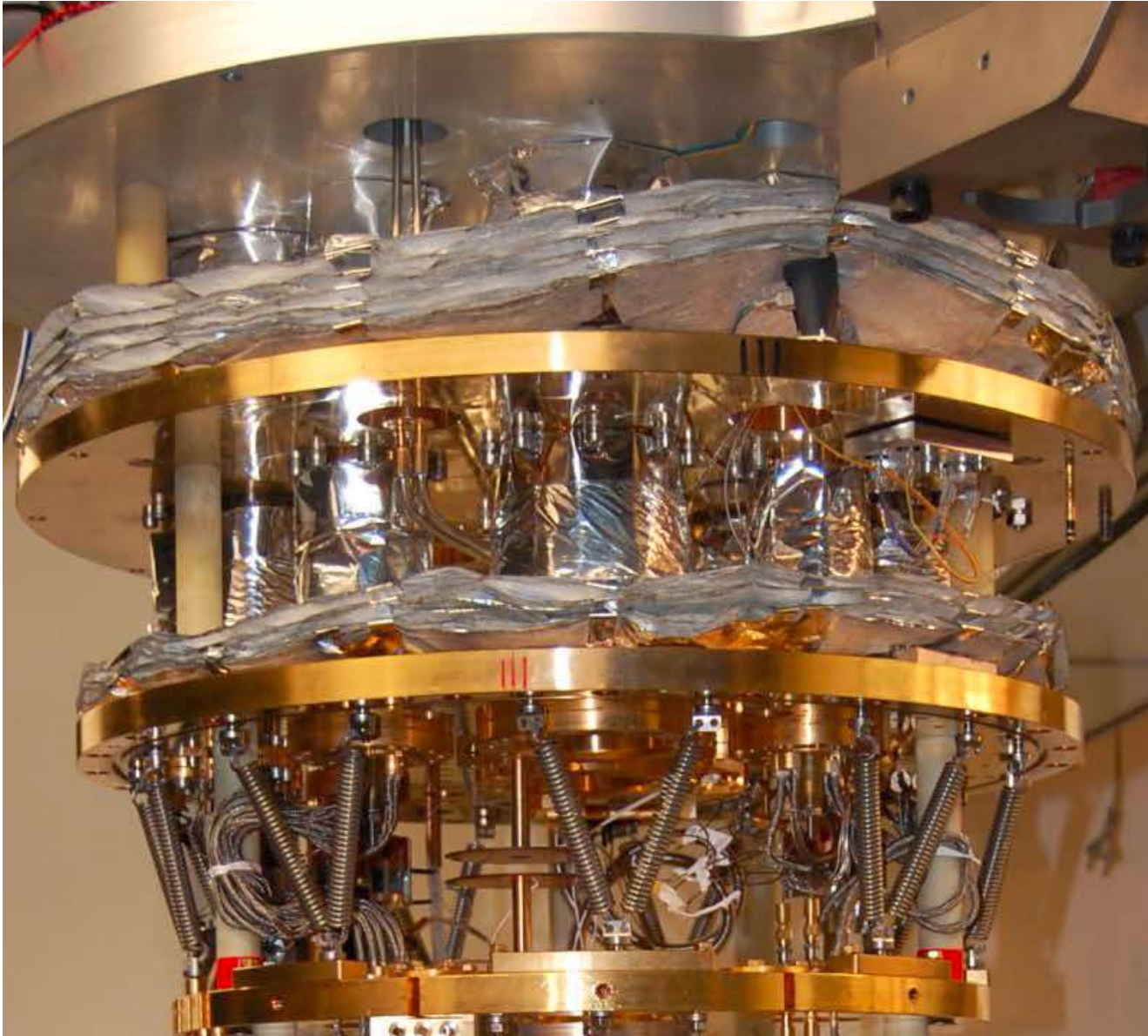
The coarse approach

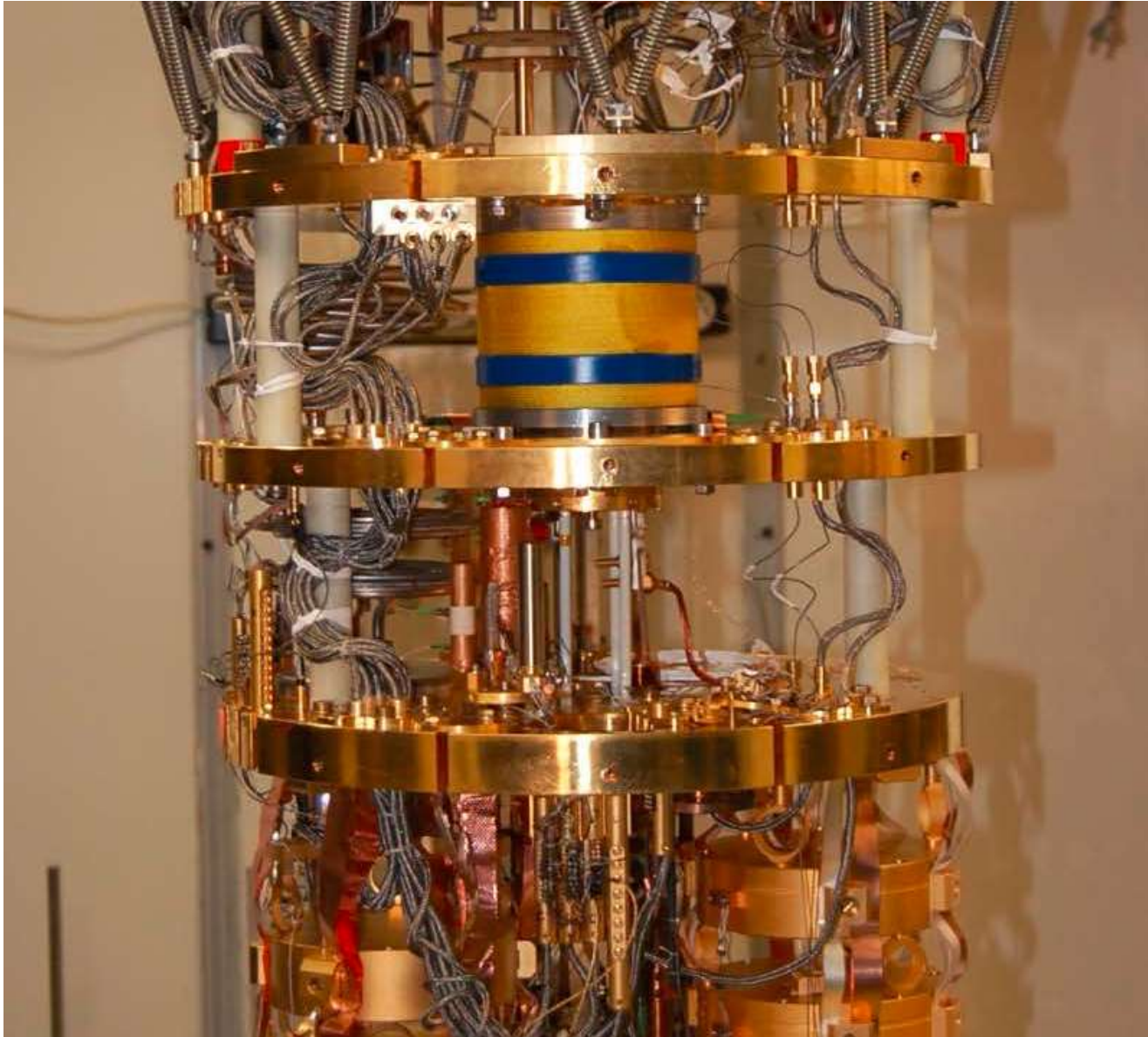


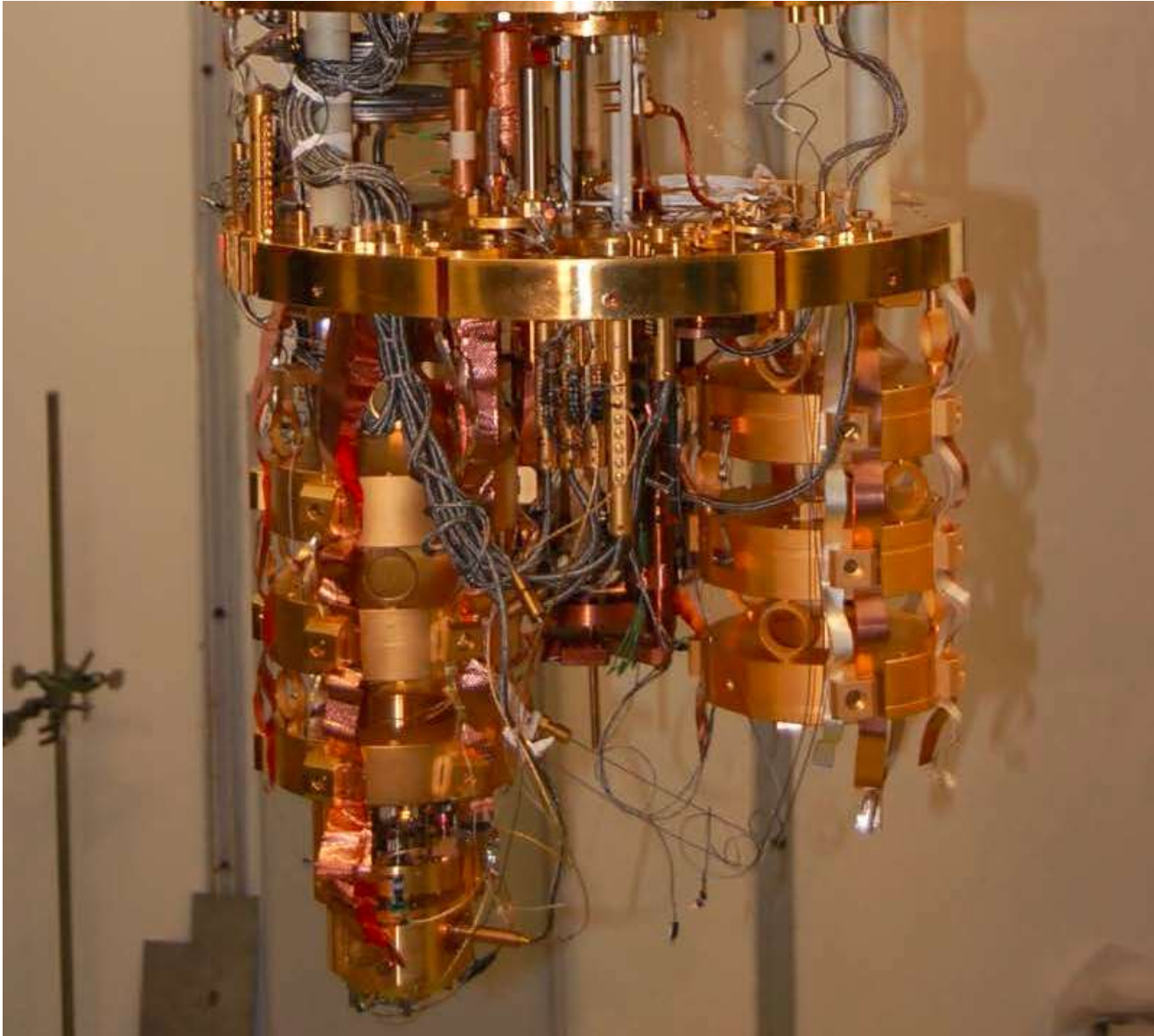
Cantilever chip (mirrored reflection)











Vibration isolation

thermal motion at 10mK, $k=3E-5N/m$ is 60pm.
If $Q=60.000$ you can allow only ...
... 1 femtometer of motion...

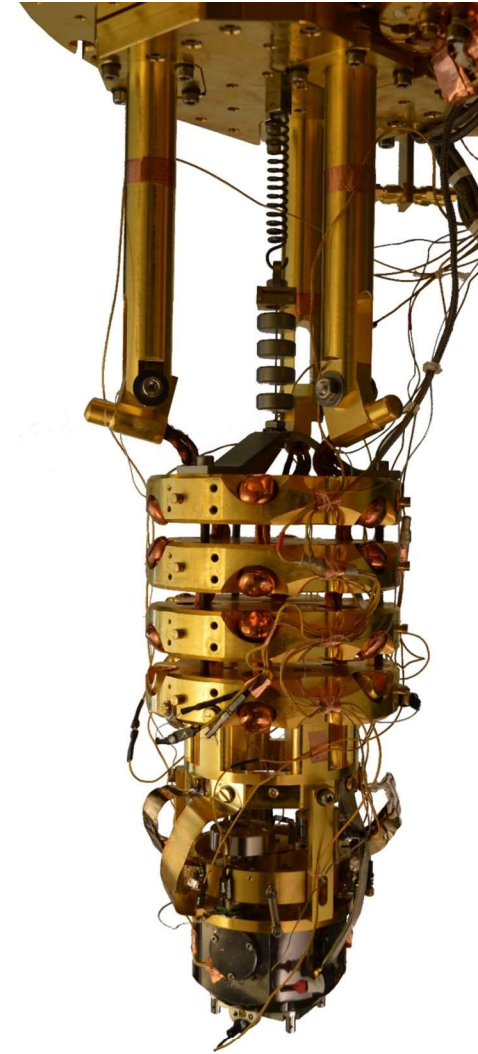
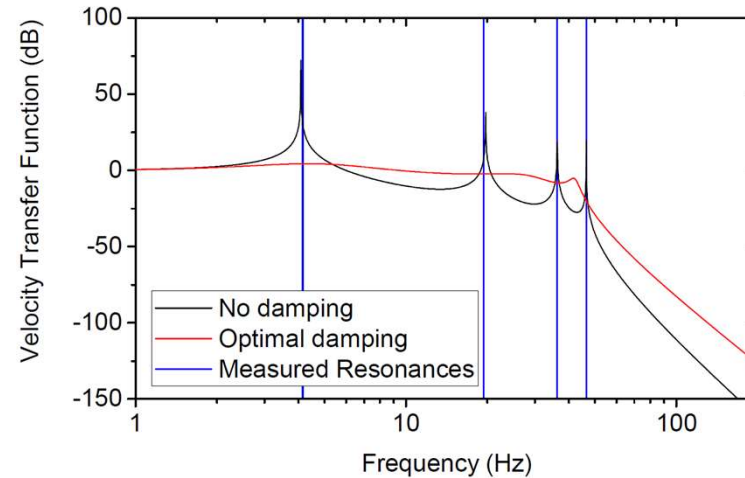
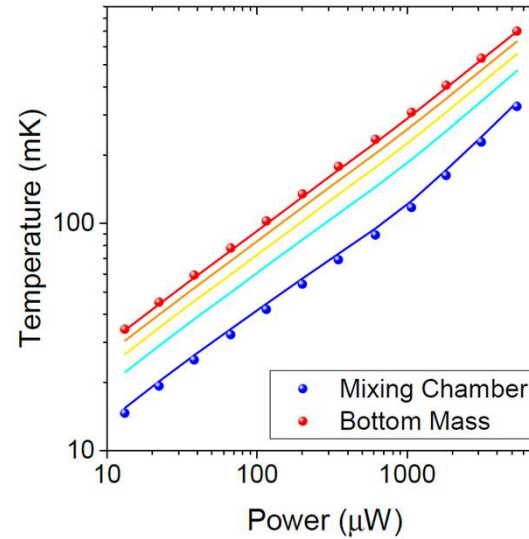
Cooling power 113 μW at 100 mK

Attenuation > 100 dB @ 100 Hz

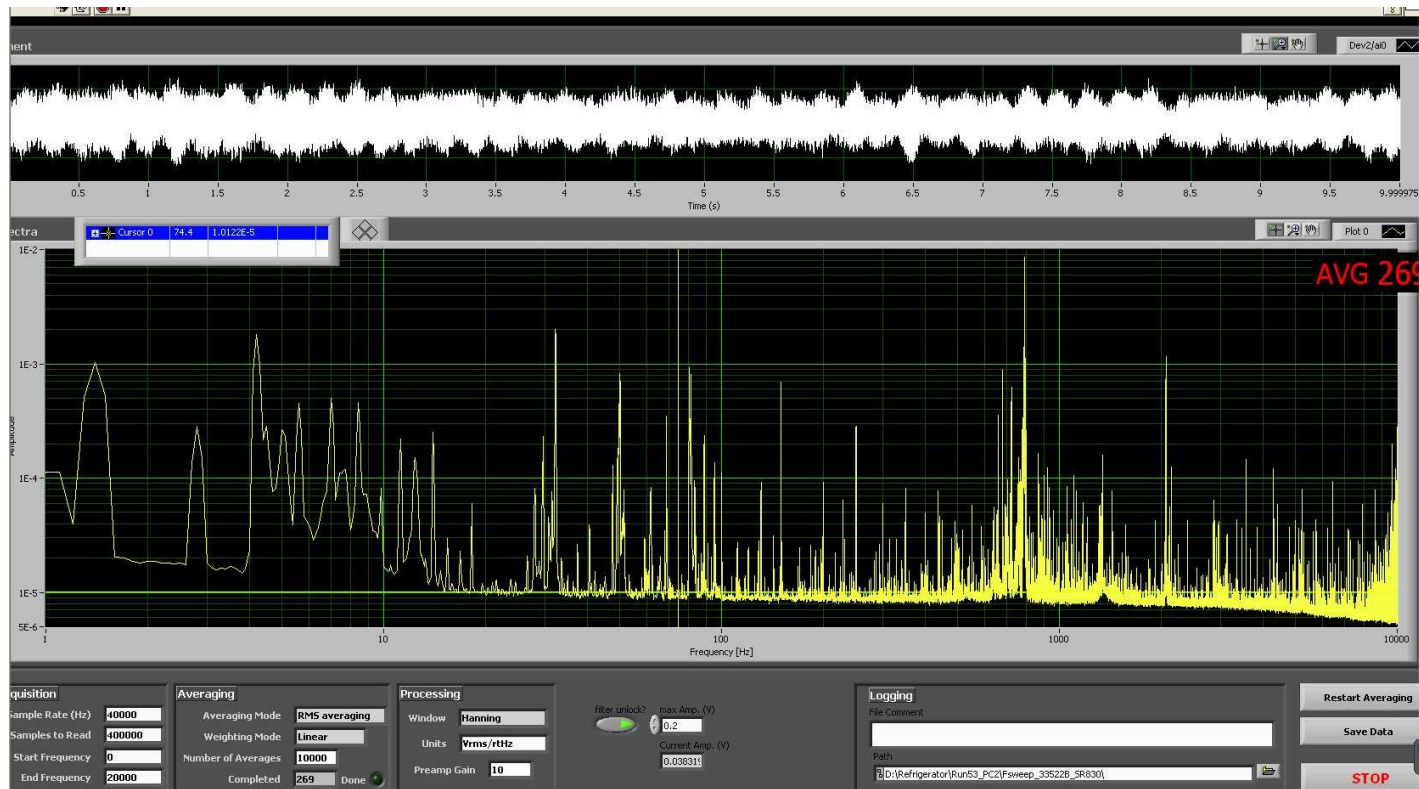
Base temperature 10.5 mK

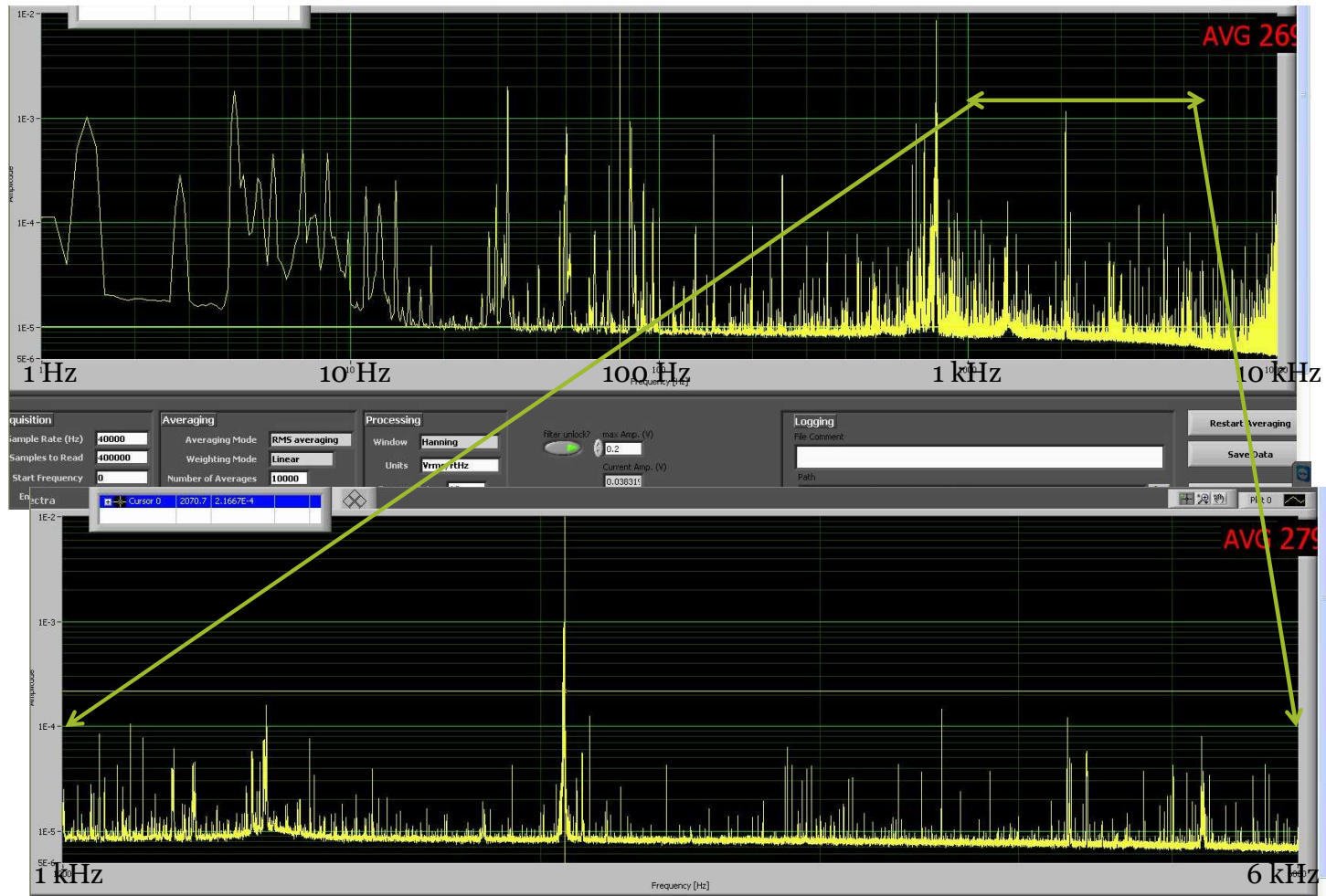
Modular design, easy to adapt

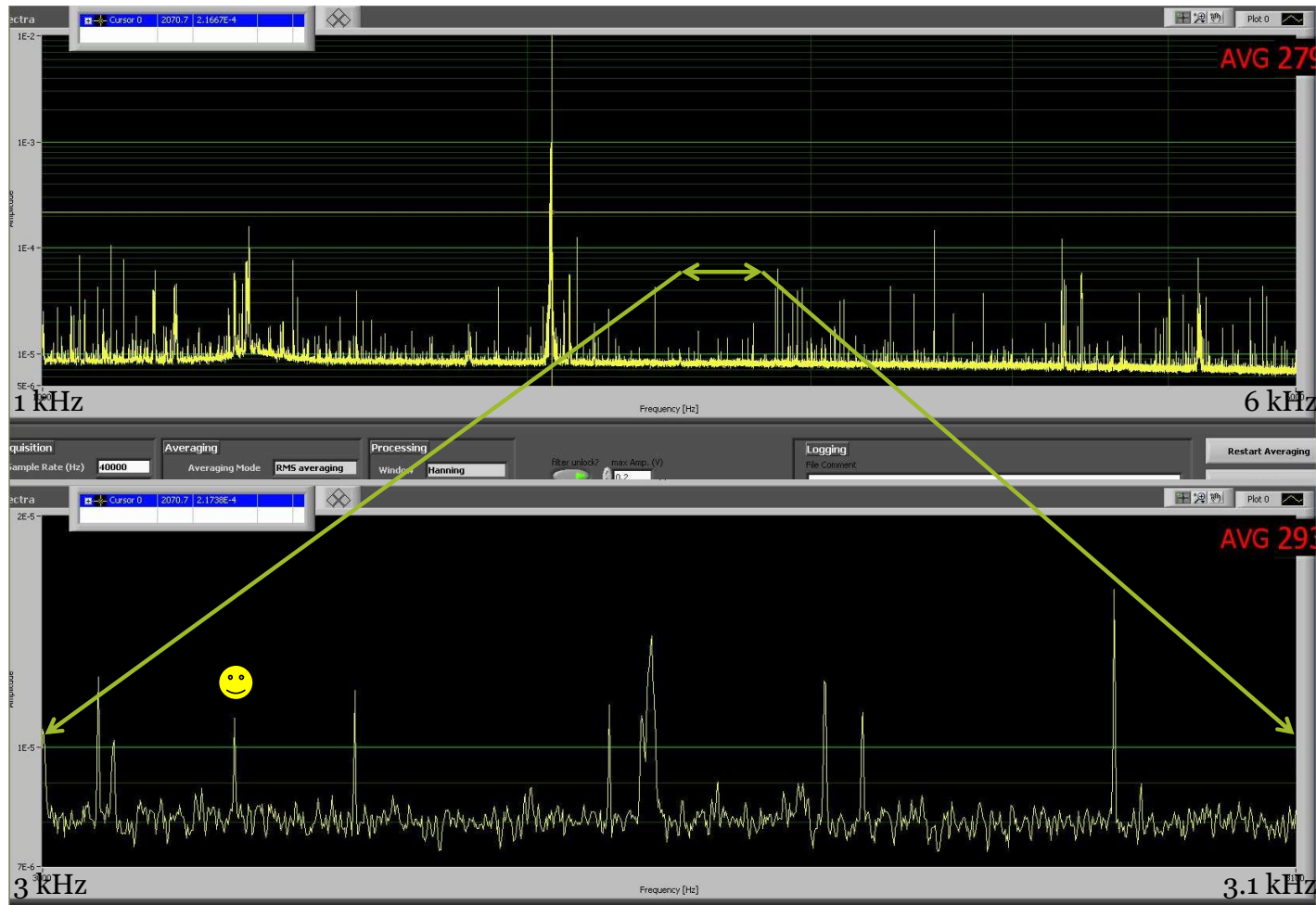
e.g. softer springs
for lower freq force sensor



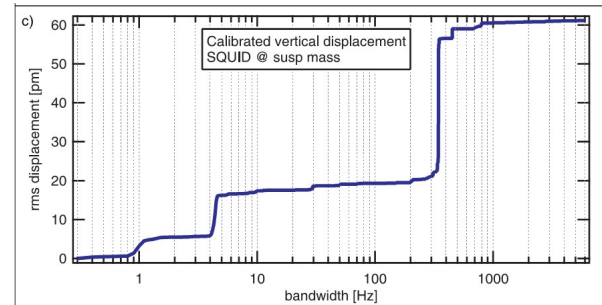
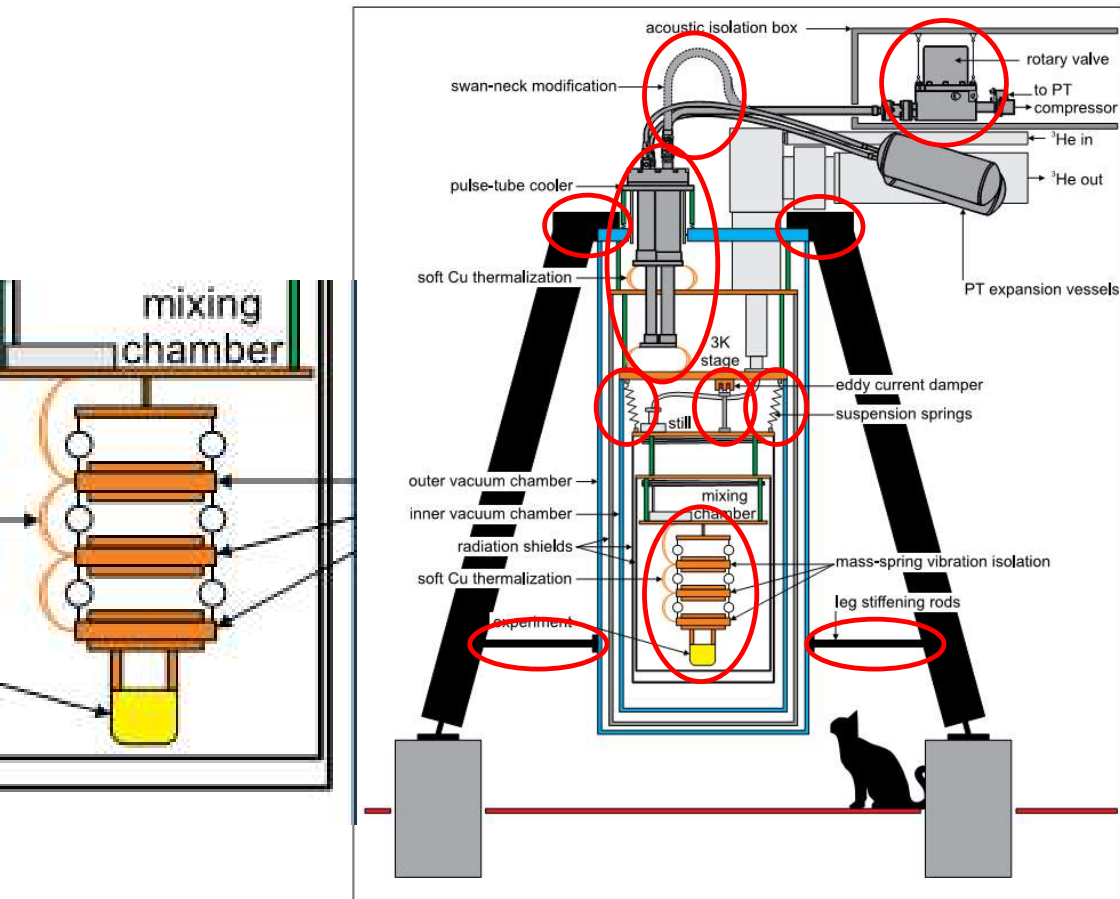
10 seconds of data in the early days of SQUID detection



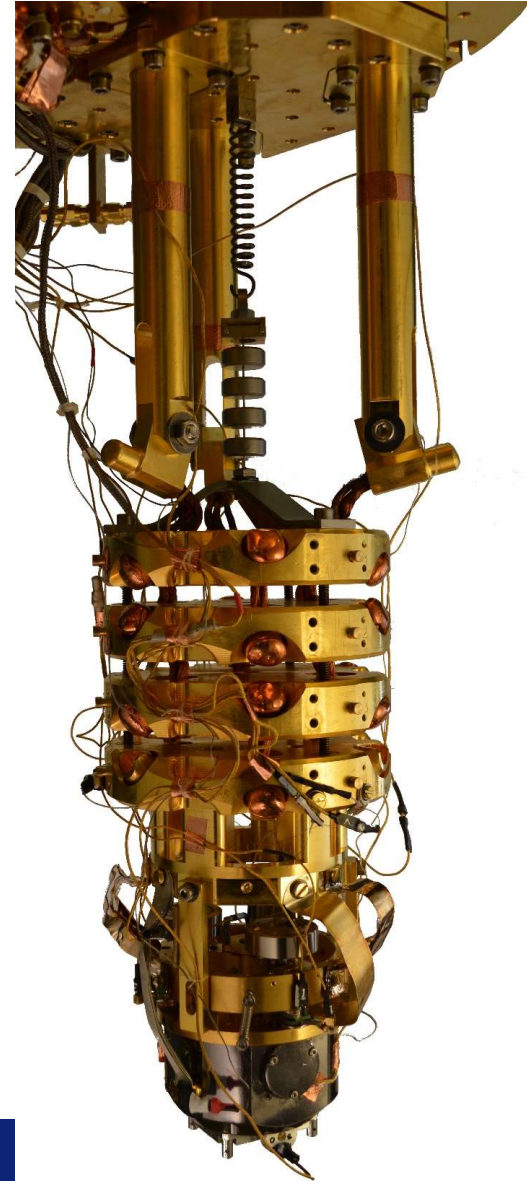
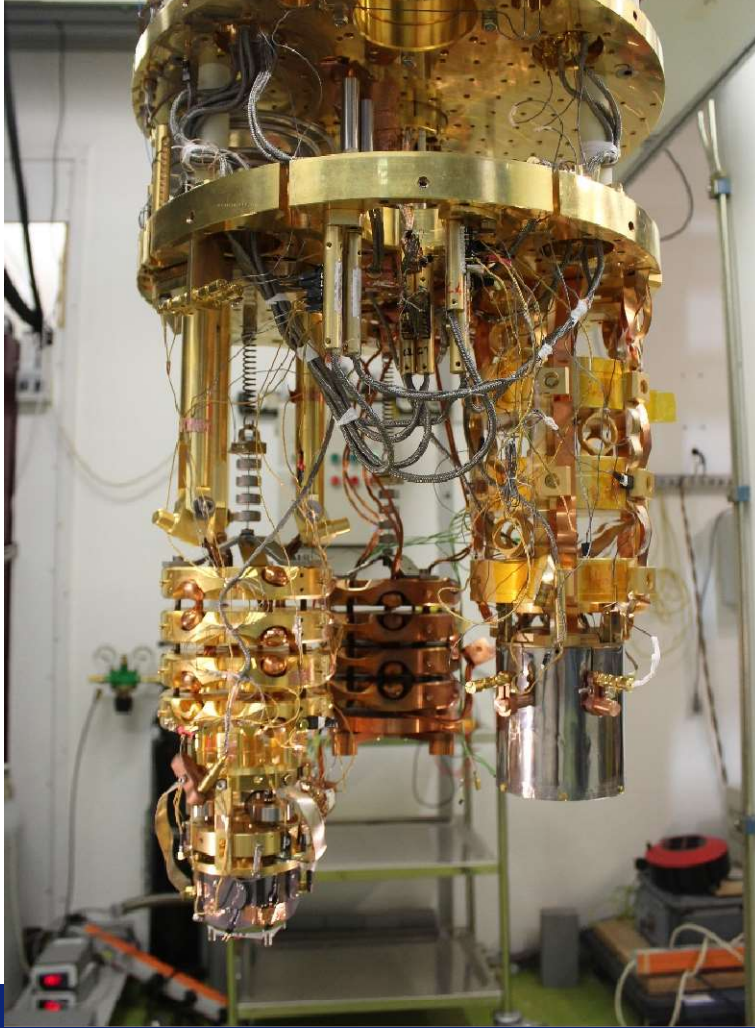




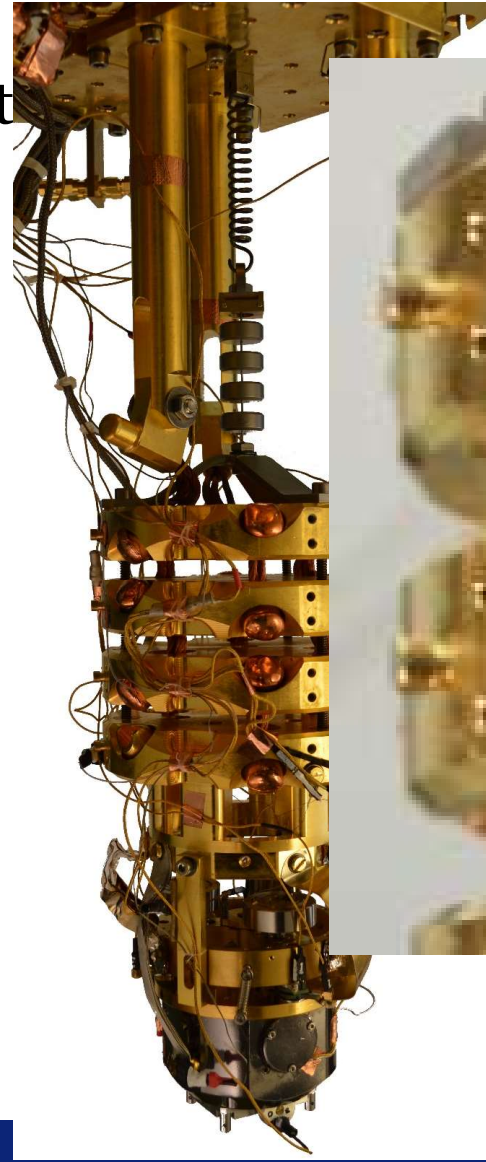
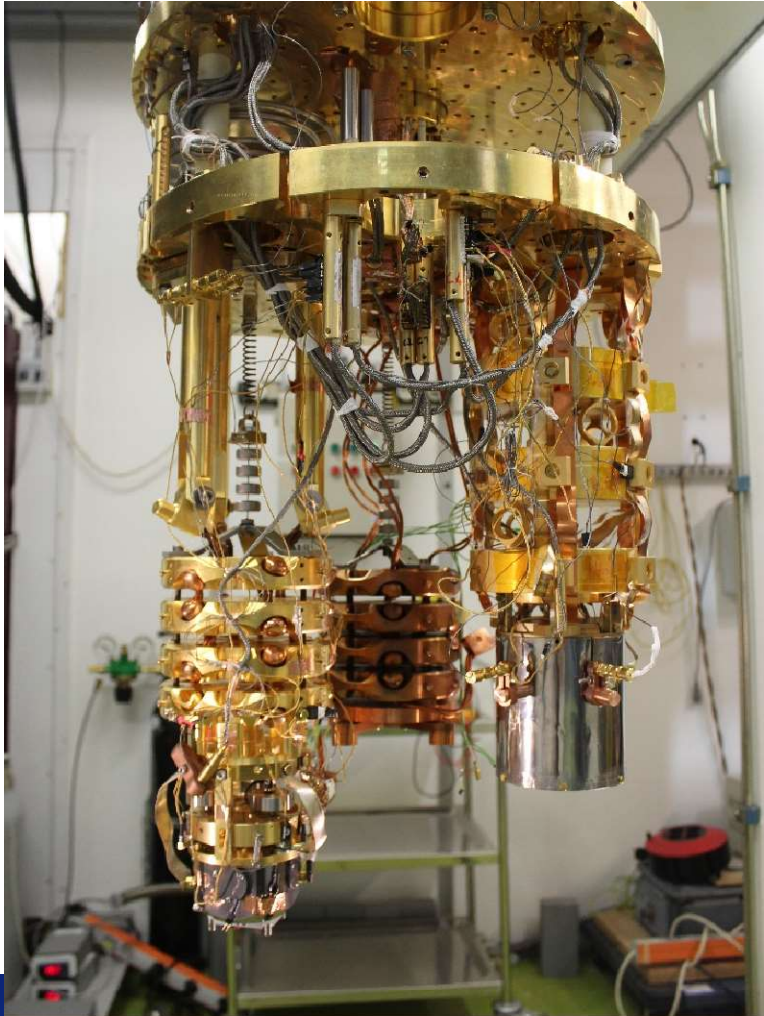
Vibration reduction: still suspension and lifting of pulsetube



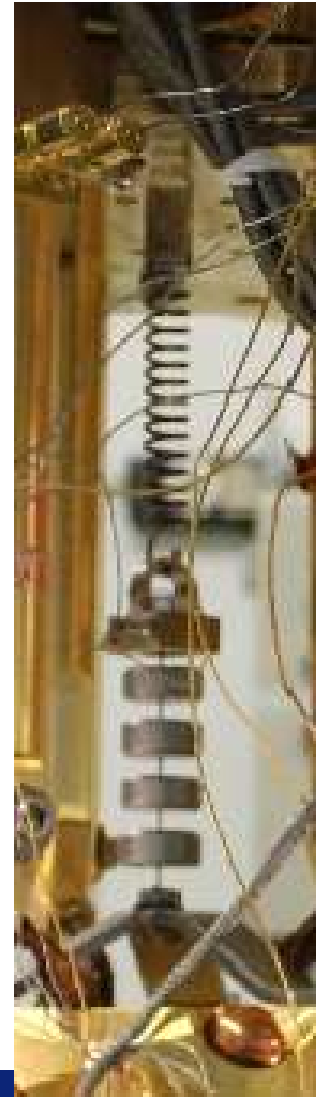
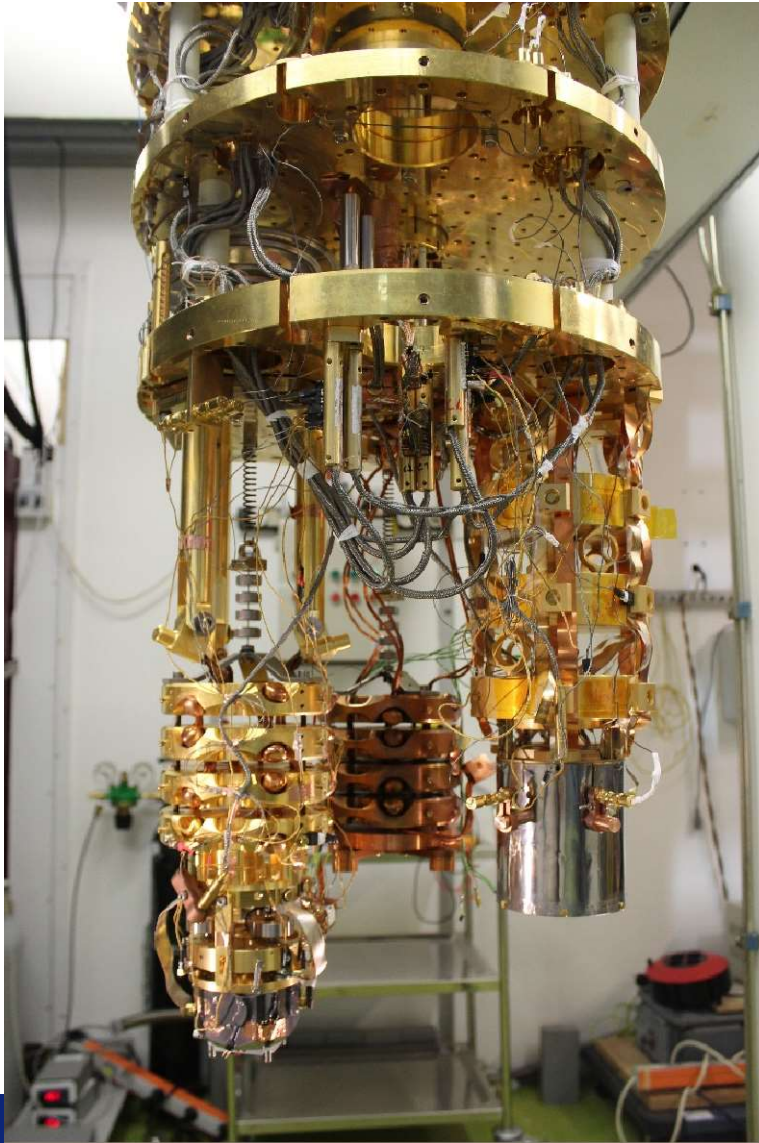
So we were motivated to do a better job



Cold at extremely low vibrat



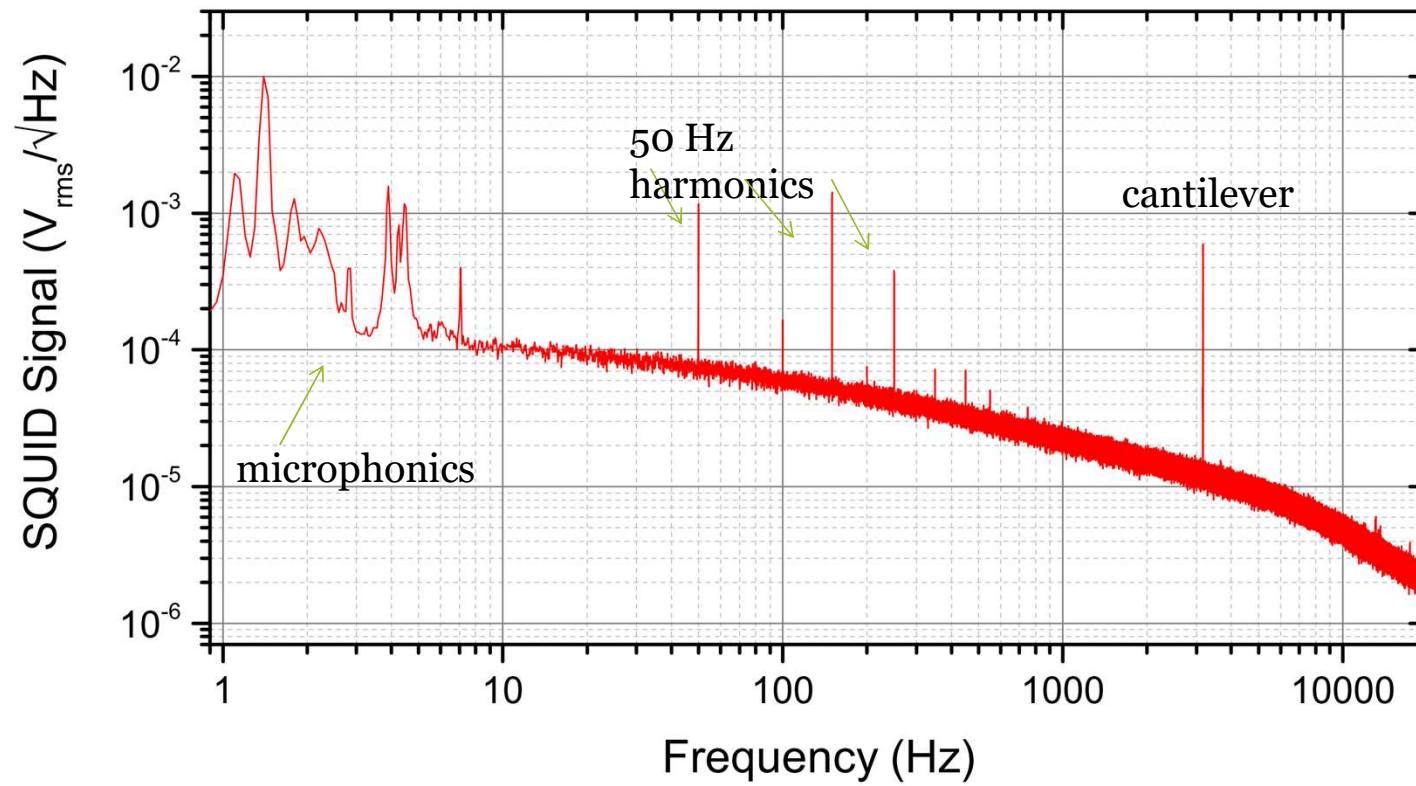
Kier Heeck
Harmen
vdMeer



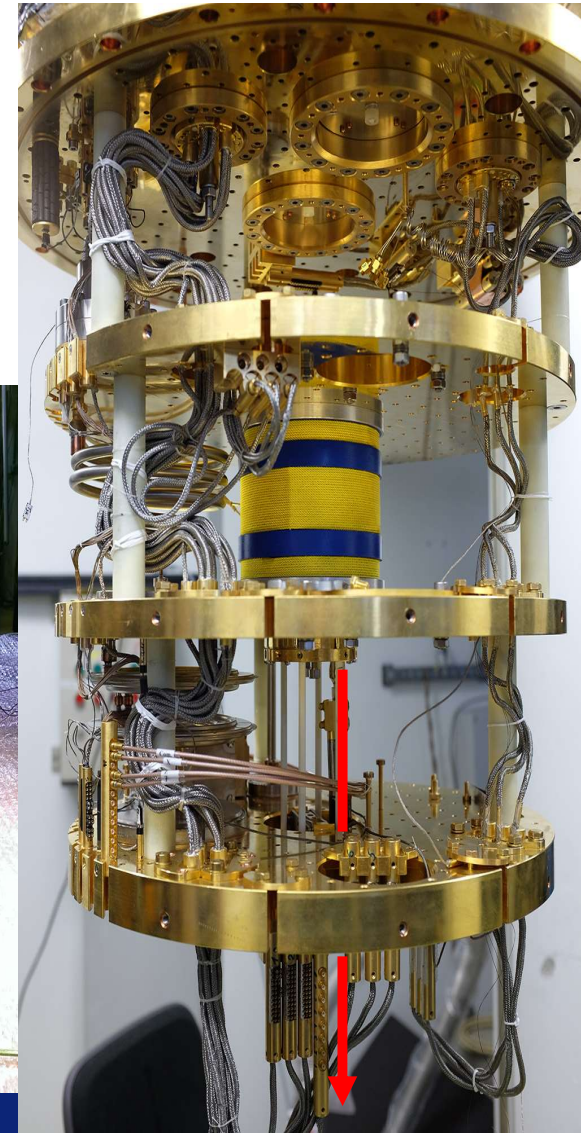
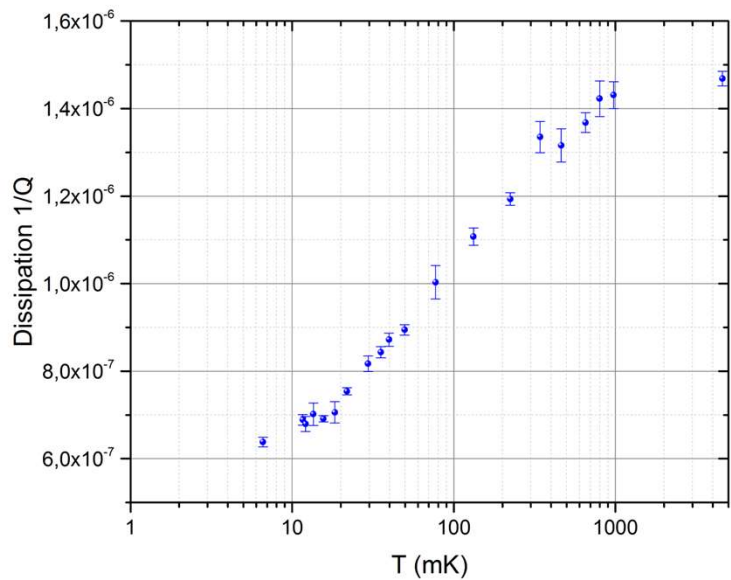
ArXiv Wit, Welker,
Oosterkamp

Kier Heeck
Harmen vdMeer

Things have been cleaned up

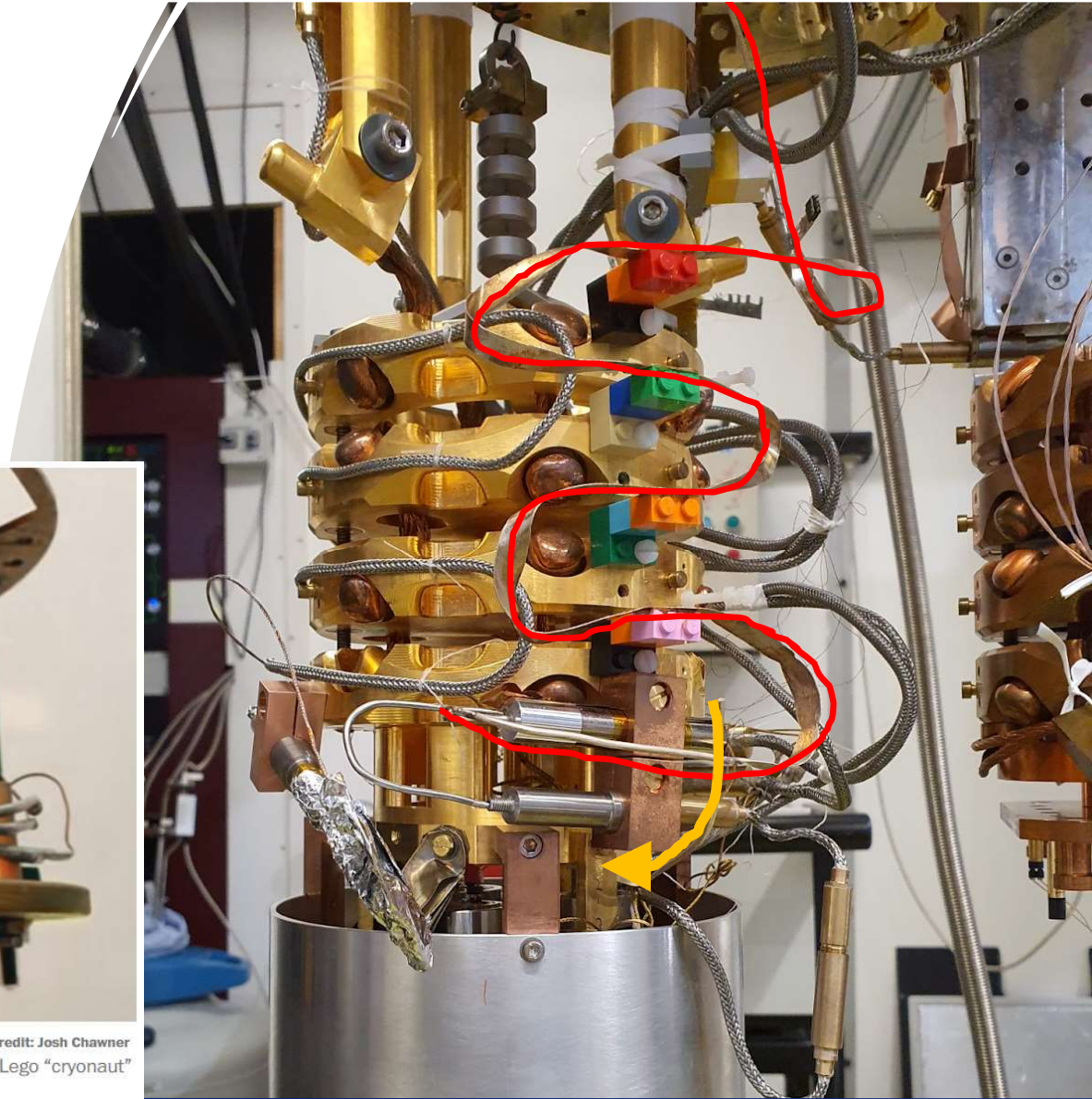


Lower temperatures.
<1 mK with PrNi₅
demagnetization.
Connect to expt?



Bring <1 mK to the expt

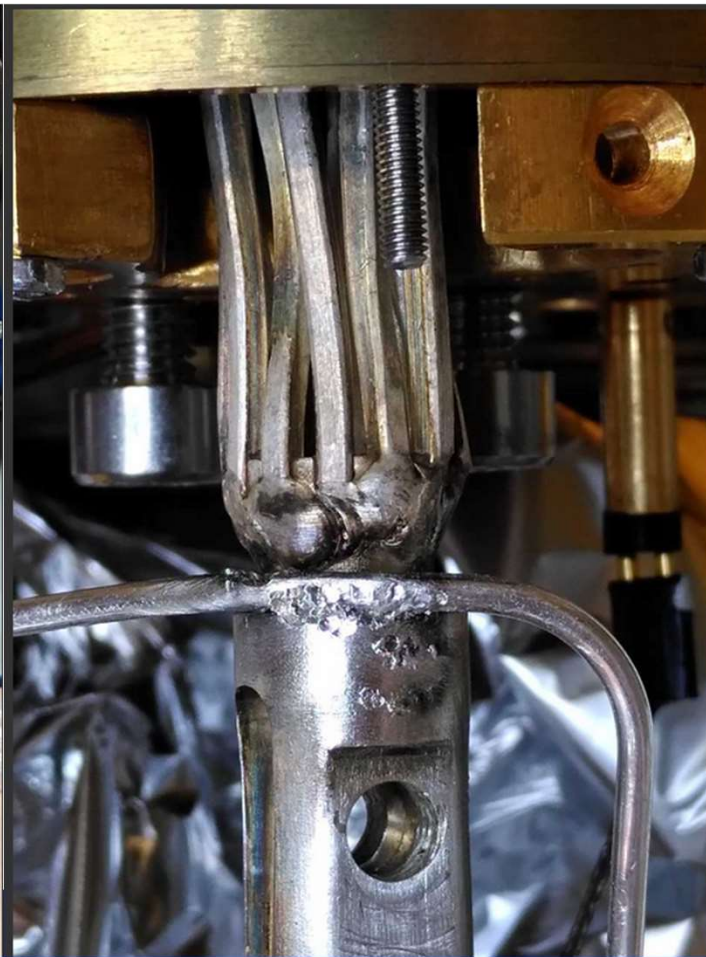
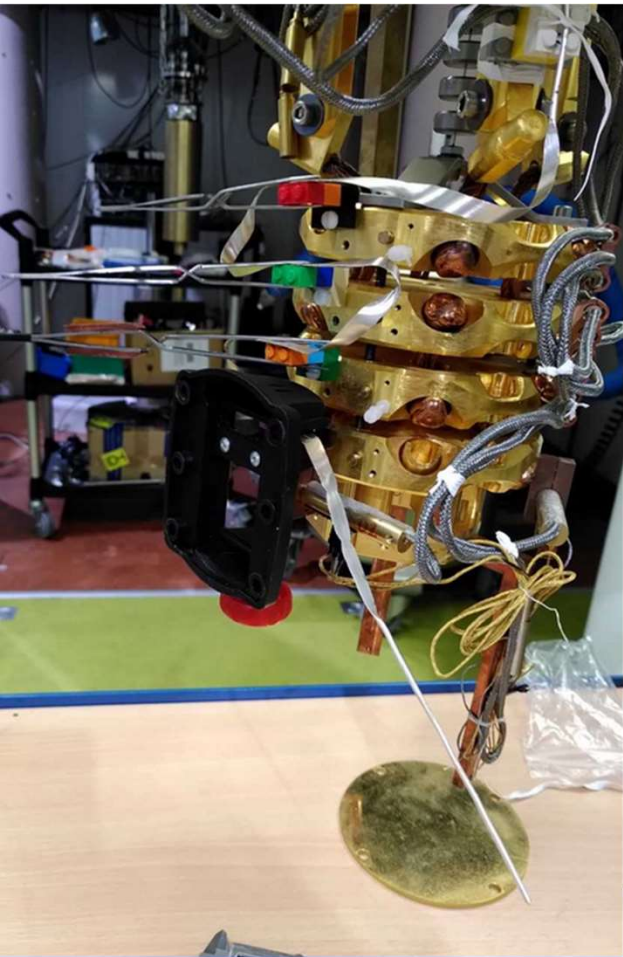
A big thankyou to George Pickett!



Credit: Josh Chawner

Chilled out: Researchers measured the thermal conductivity of Lego bricks near absolute zero, with a Lego "cryonaut" along for the ride.

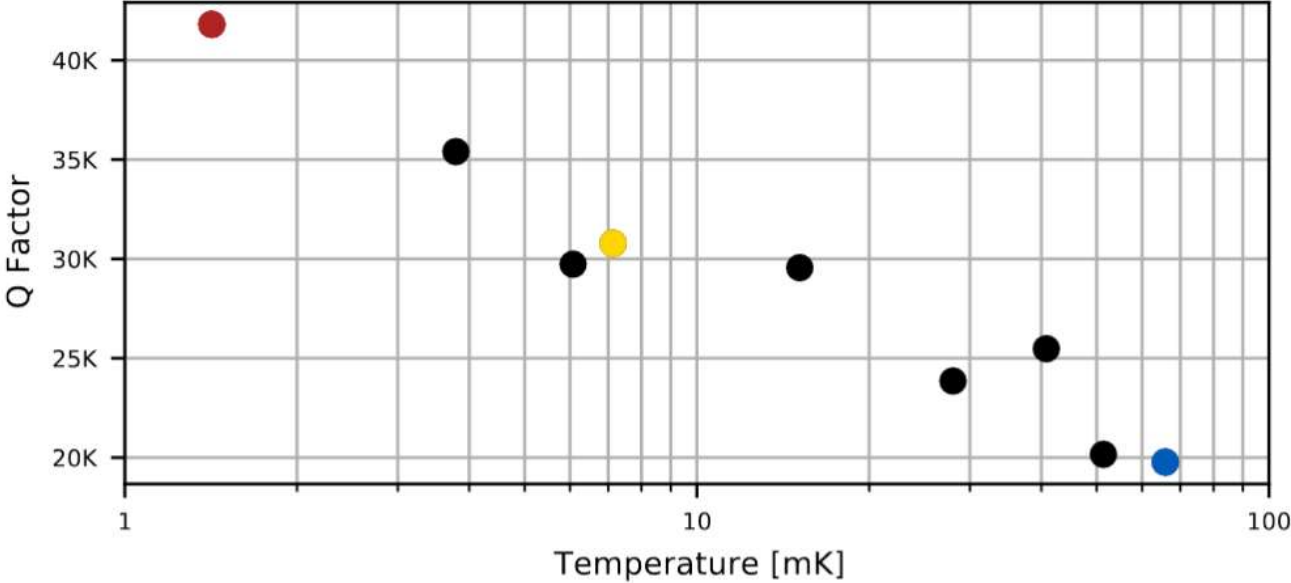
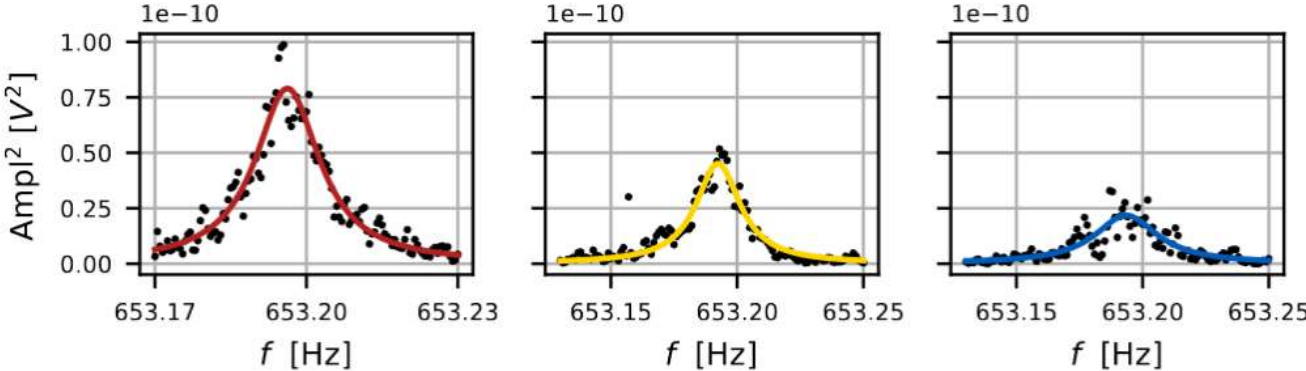
Welding on the cryostat. Not in the workshop





Temperature has an effect on Q-factor

- IBM style cantilever with large magnet (7 micrometer diameter)
- @ 1 mK: 0.06 aN/rtHz



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Press this button
to add

milliKelvins, positionering, vibratie isolatie, kabels, thermometrie,
nieuwe microscopie, integratie

MENSENWERK



Ontwikkelingen in technologisch-wetenschappelijk onderzoek samen met bedrijven

- Ontwikkelingen in de funding
 - Bedrijven waren een pré bij sommige aanvragen
 - Bedrijven werden een noodzaak bij sommige aanvragen
 - Bedrijf moet geld bijleggen om mee te doen met EU aanvraag
 - ...
 - Bedrijf krijgt geld van EU als het meedoet
 - Bedrijven krijgen geld voor ontwikkeling
- Samenwerking met Hogescholen / LIS
 - In toenemende mate ook in onderzoeksaanvragen

Field lab (QDNL)

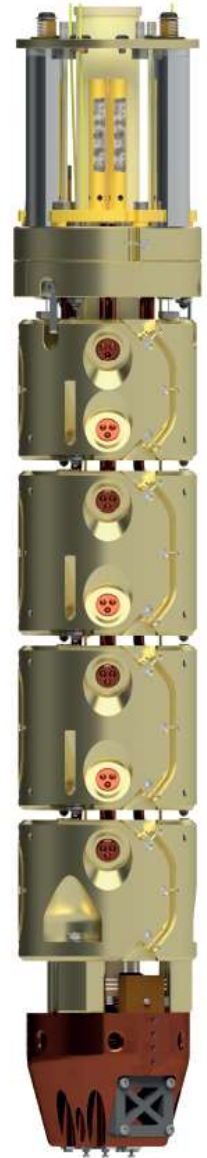
- Leiden Cryogenics (1992)
- Leiden Probe Microscopy (2004)
- Leiden Spin Imaging (2014)
- Onnes Technologies (2018)
- Quantamap (2022)



Field lab

Demo/test SPM systems at
< 100 mK

arQtika LCW X1



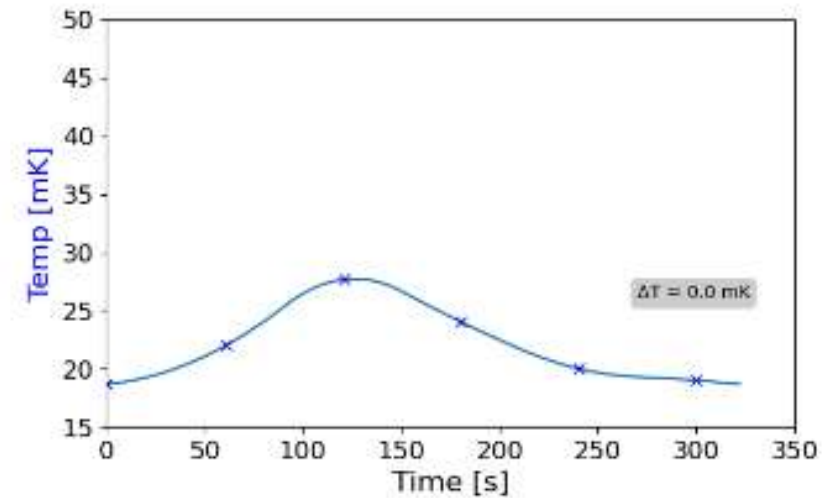
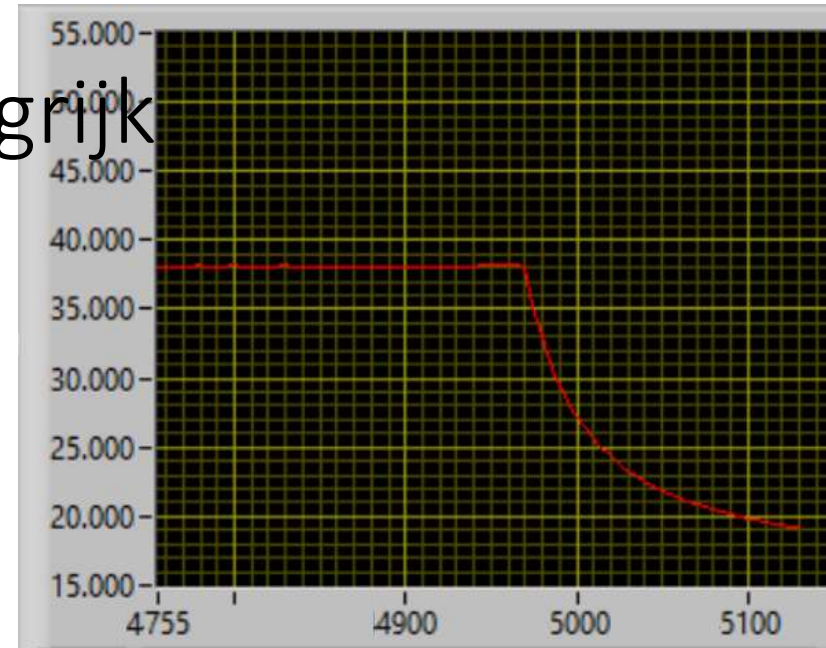
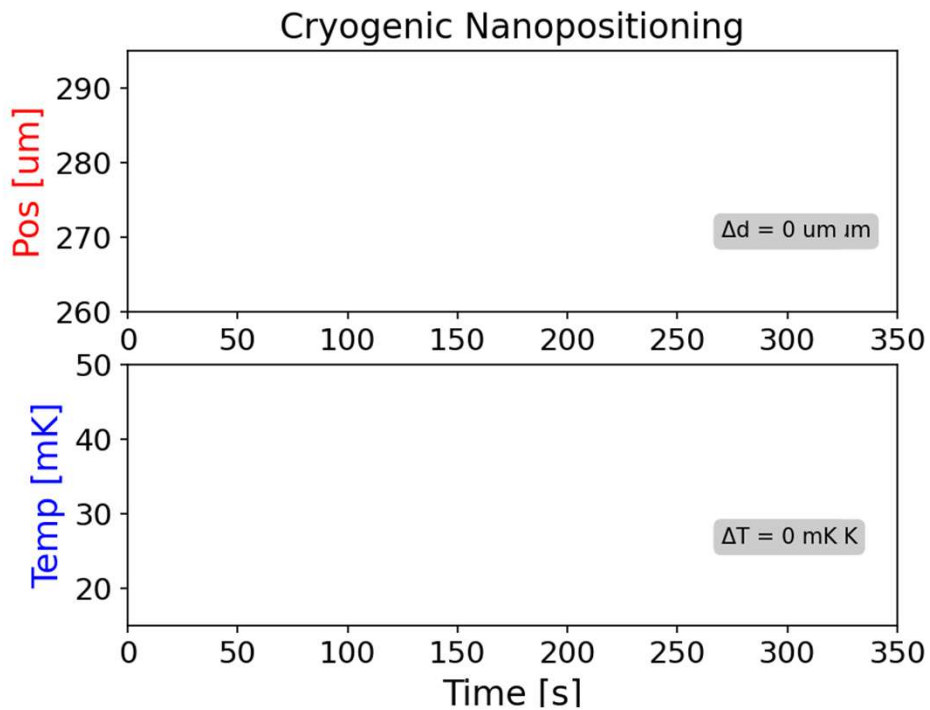
Field lab

- UHV
- Microscope transfer
- Sample transfer
- Optical fibers



Thermometrie is ook best belangrijk

- Hightech Development Leiden
Wim Bosch



Future

towards 100 microkelvin?

Combine:

- the vibration free platform
- the ability to precool to 1 mK
- miniature electro magnets that make 100mT in 1mm³ volume
at 10 mK

Can we make a miniature nuclear demagnetization stage ?