Hands-on activity on CUORE's cryostat

Gran Sasso Summer Institute

22nd Sept. - 3rd Oct.

Laboratori Nazionali del Gran Sasso

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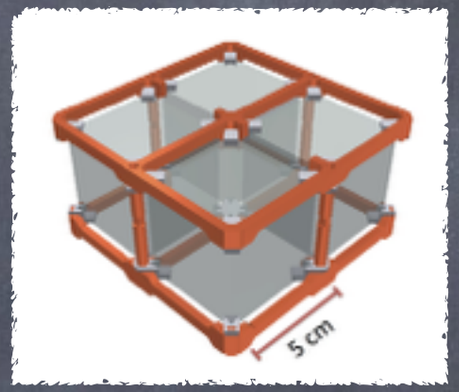
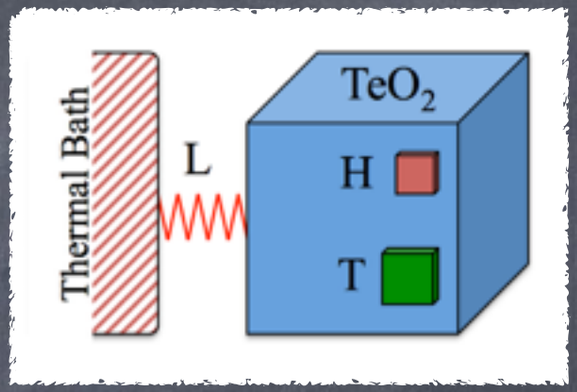
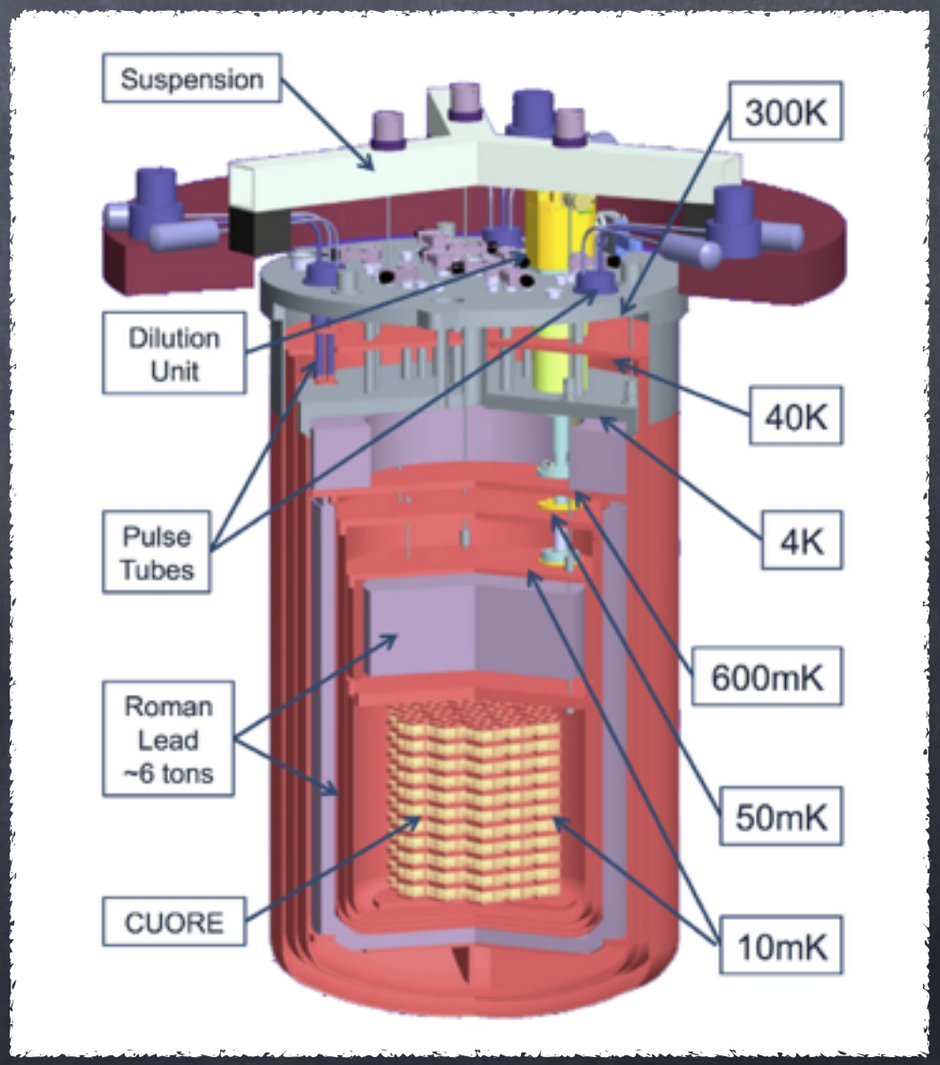
the CUORE experiment

- Looking for $0\nu\beta\beta$ signal from ^{130}Te
- Bolometric technique with 988 TeO_2 crystals (206 kg of ^{130}Te)
- 5 keV average energy resolution
- 1σ half-life sensitivity goal:
  ~ 1.6×10^{26} yr (5yr live time)
- Cryogenics needed because
  - $\Delta T = \Delta E/C \sim \Delta E/T^3$
  - $\Delta T/\Delta E \sim 10\text{–}20\ \mu K/MeV$

T ~ 10 mK !!

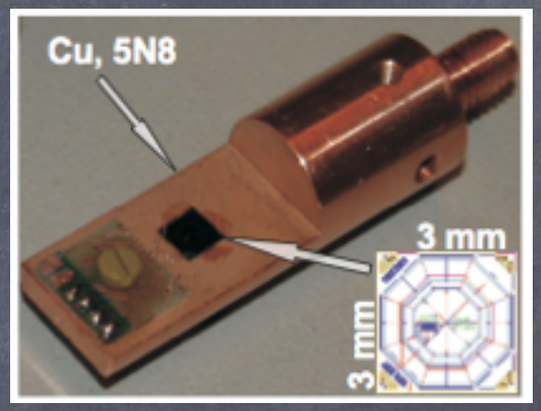


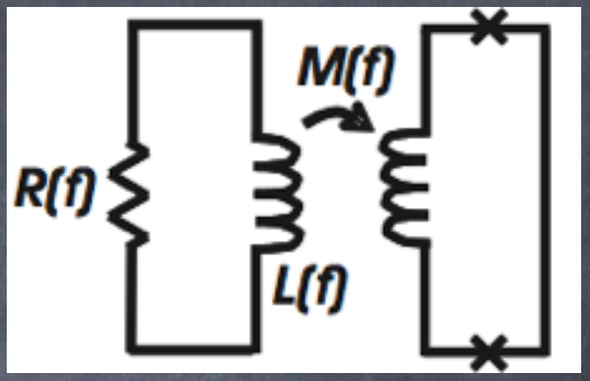


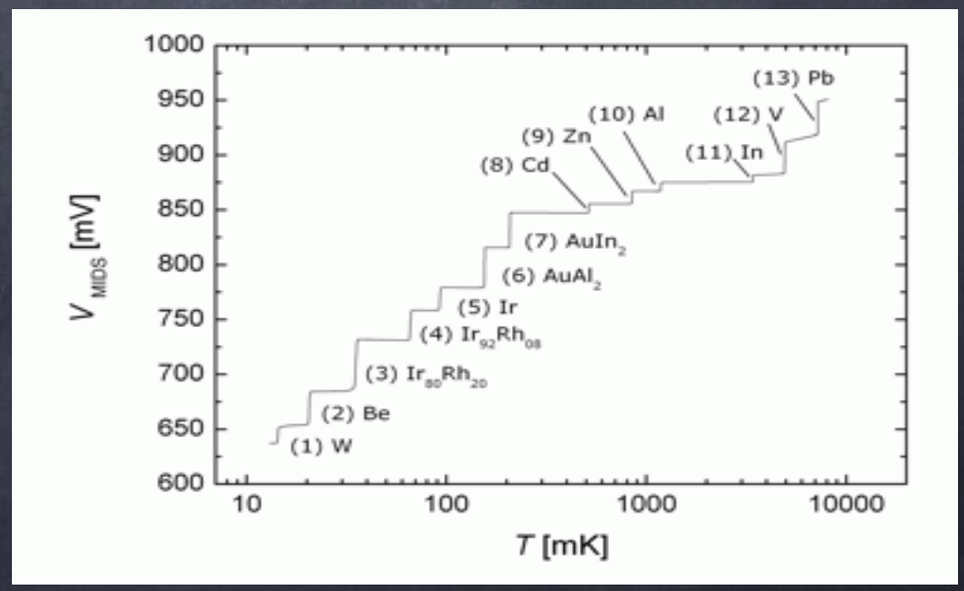


nK thermometry

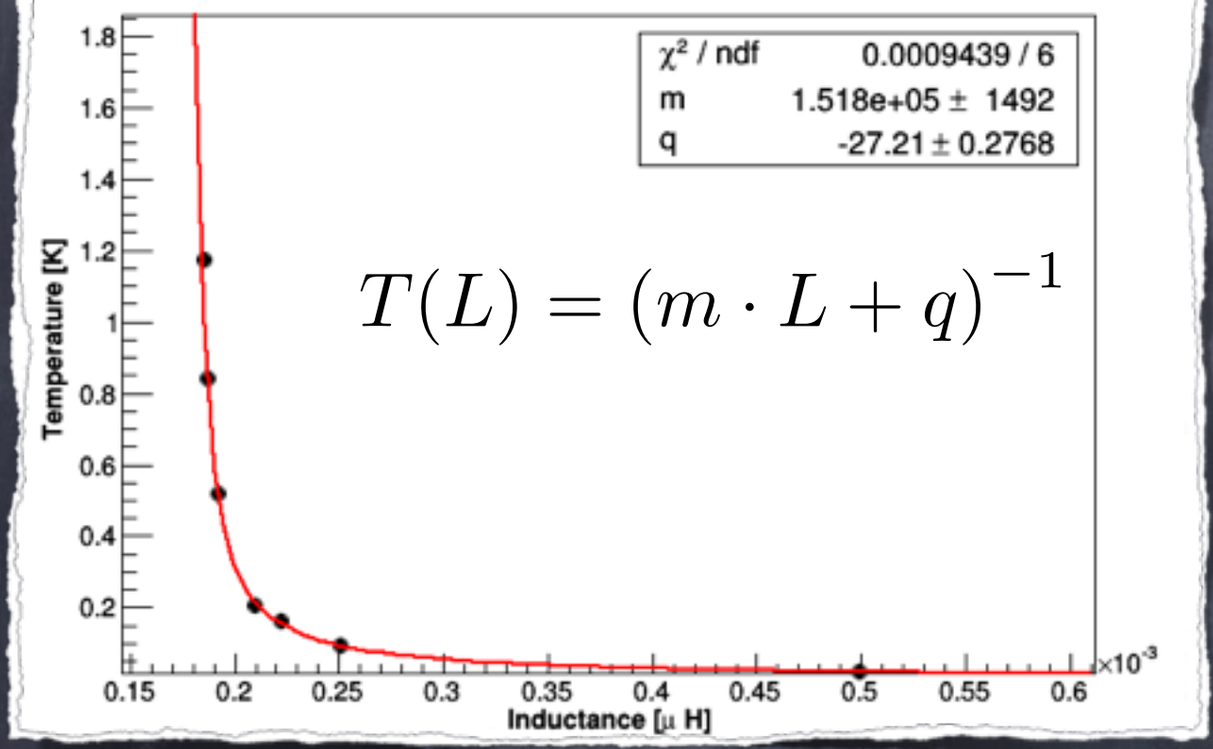
- Cerium Magnesium Nitrate (CMN) thermometer
- Magnetic Field Fluctuations Thermometer (thermal noise SQUID-based)
- Superconductive reference point sensor (SRD, suitable calibration device for the CMN and for the MFFT)

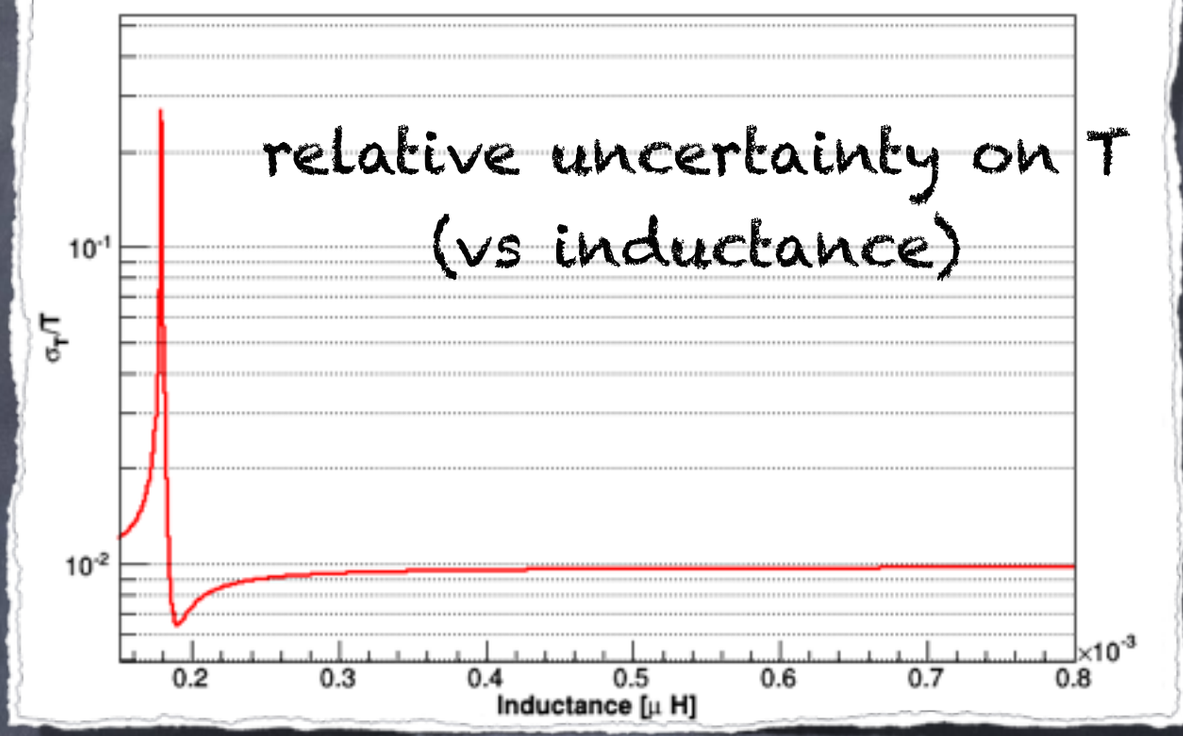




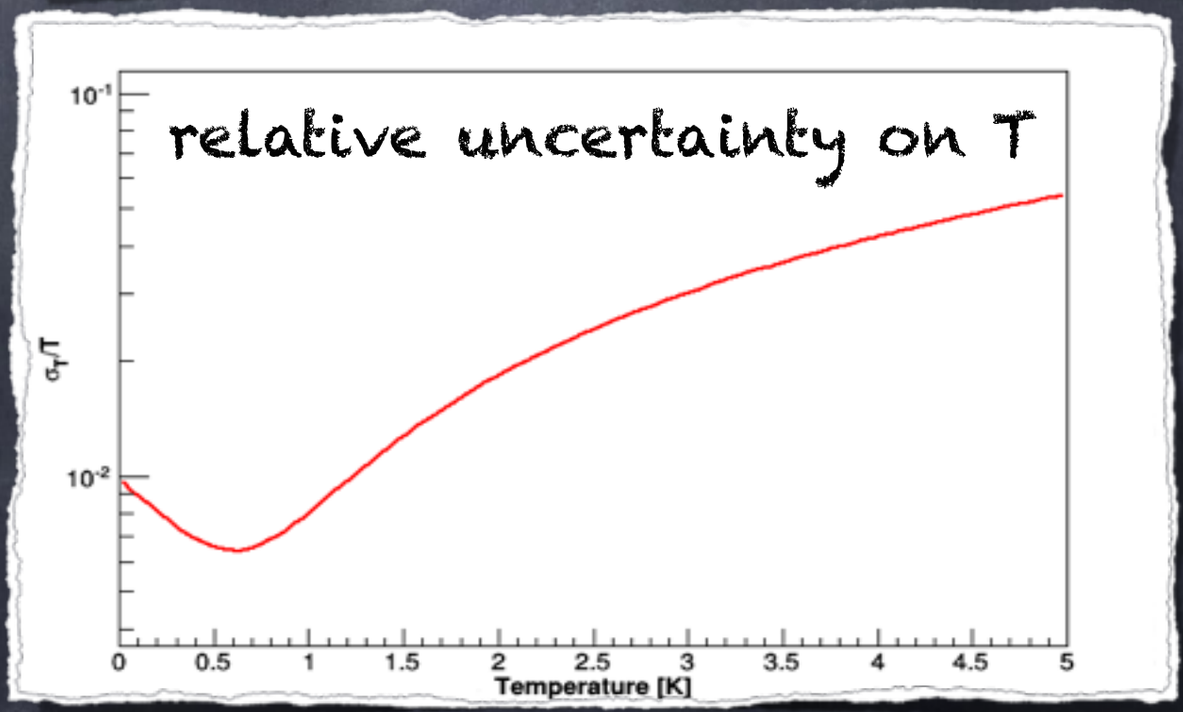


CMN calibration

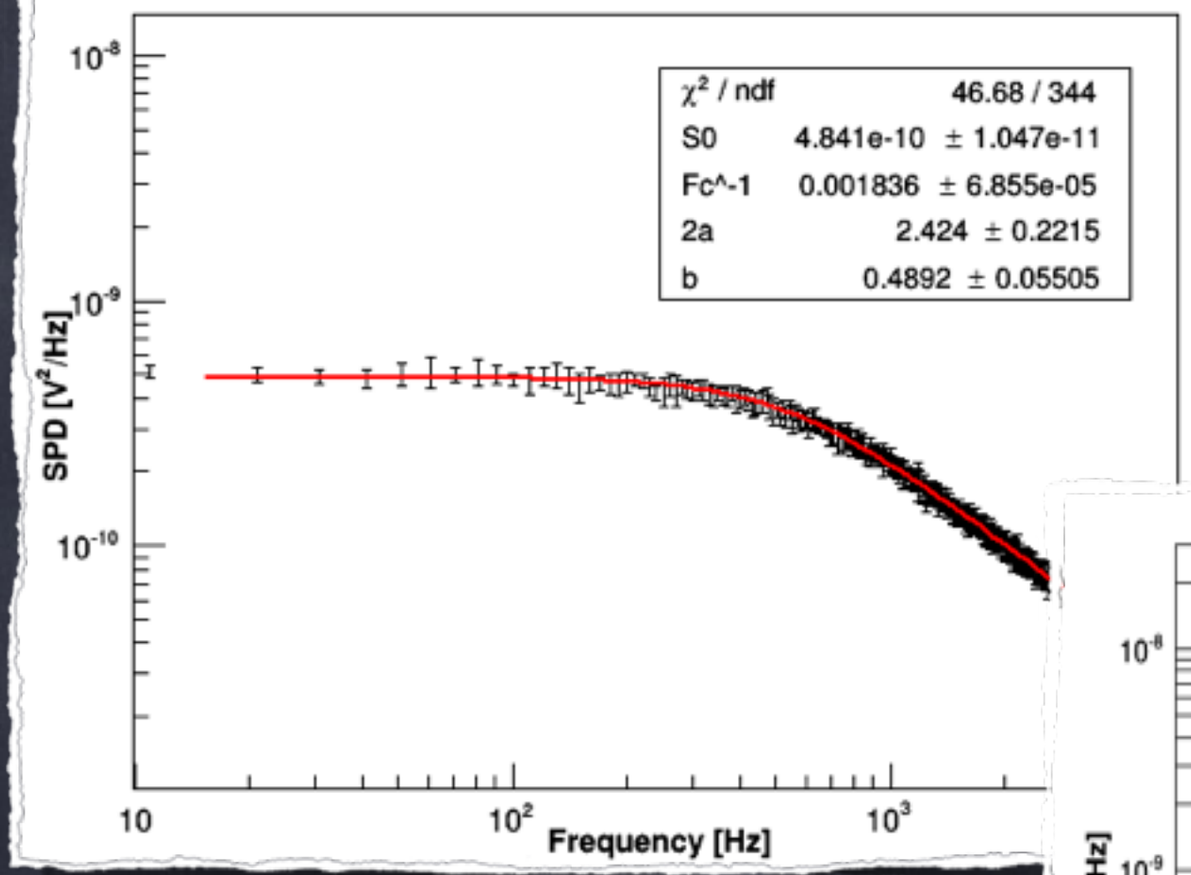




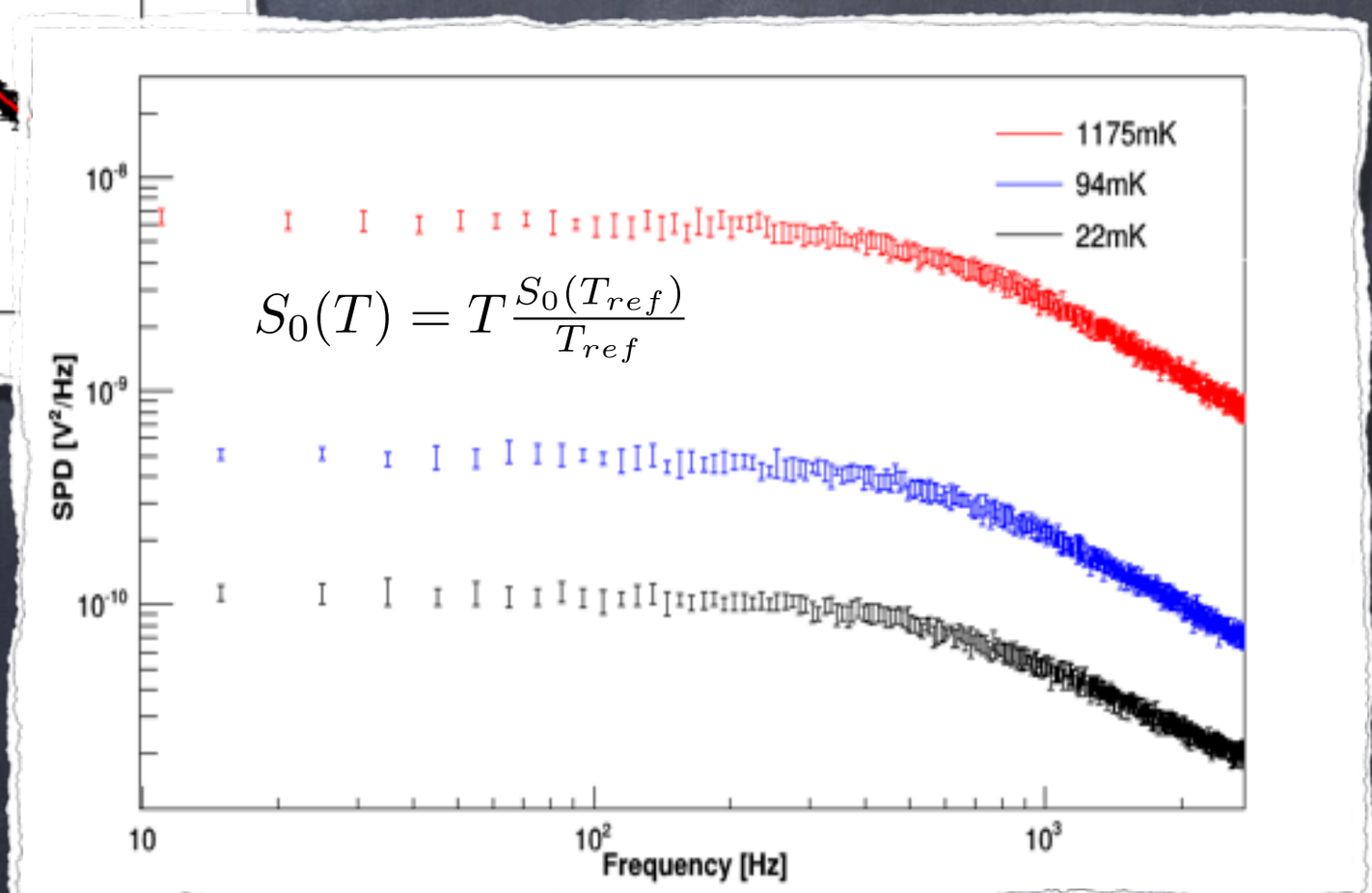
- CMN susceptibility X below 3 K scales as $1 / (T - \theta)$
- the output voltage V_{MIDS} of the system is proportional to X, so: $V_{MIDS} (T) = A + B / (T - \Delta)$
- constants A, B and Δ to be calibrated for each sensor.



Noise thermometer

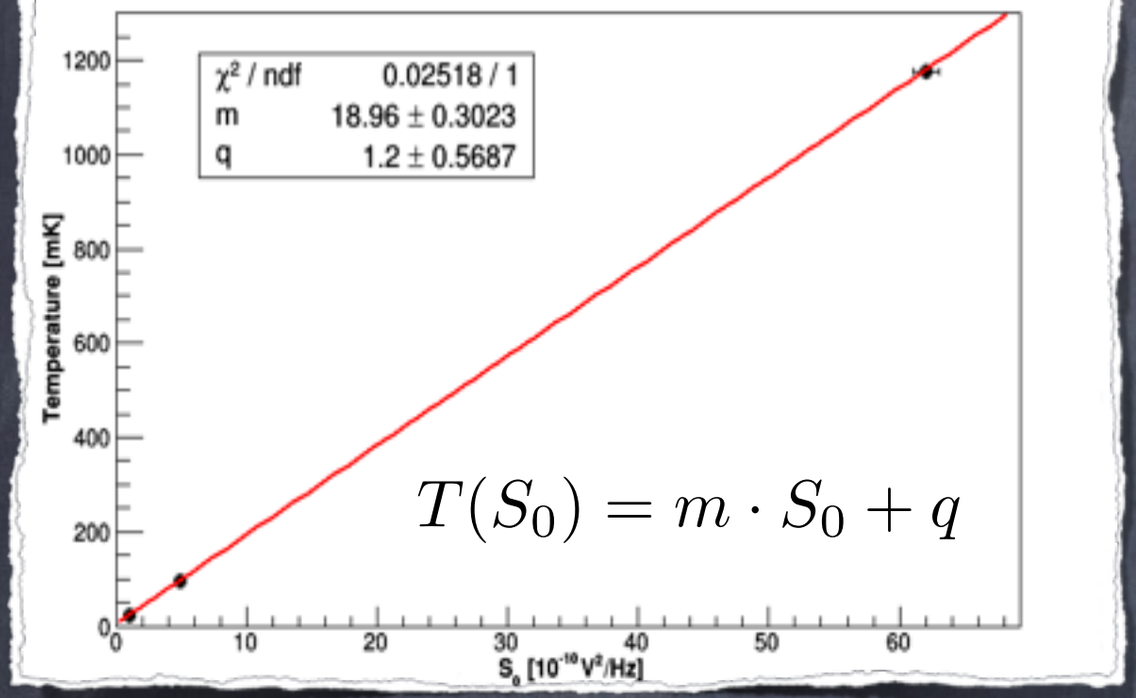


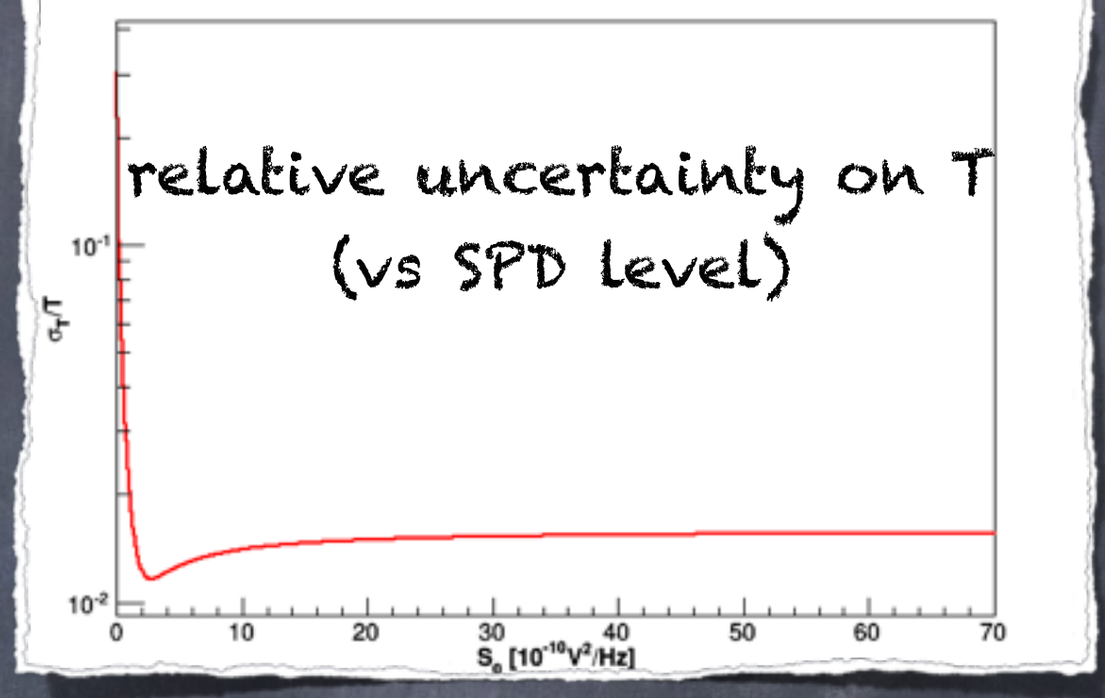
$$S(f,T) = \frac{S_0(T)}{(1+(f/f_0)^{2a})^b}$$



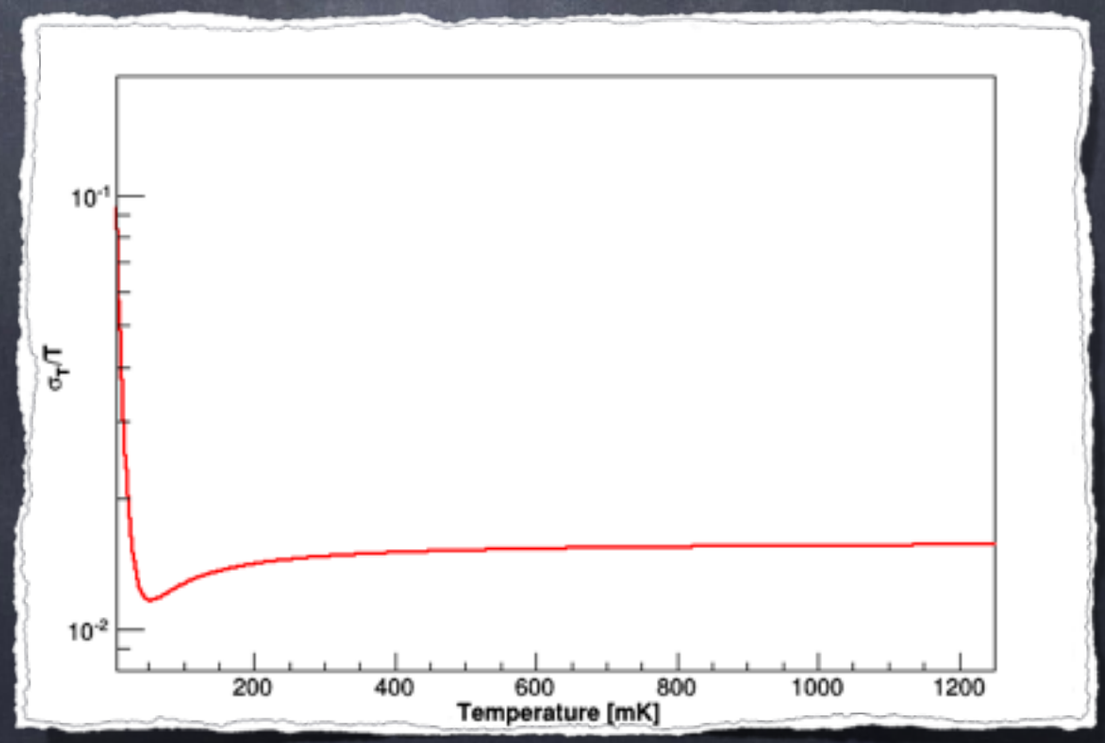
Power Spectrum Density of noise is proportional to the thermodynamic temperature

Noise thermometer fit





- Linearity over ~3 decades
- Relative uncertainty at 1% level in the mK region
- ~10% discrepancy with CMN at transition points



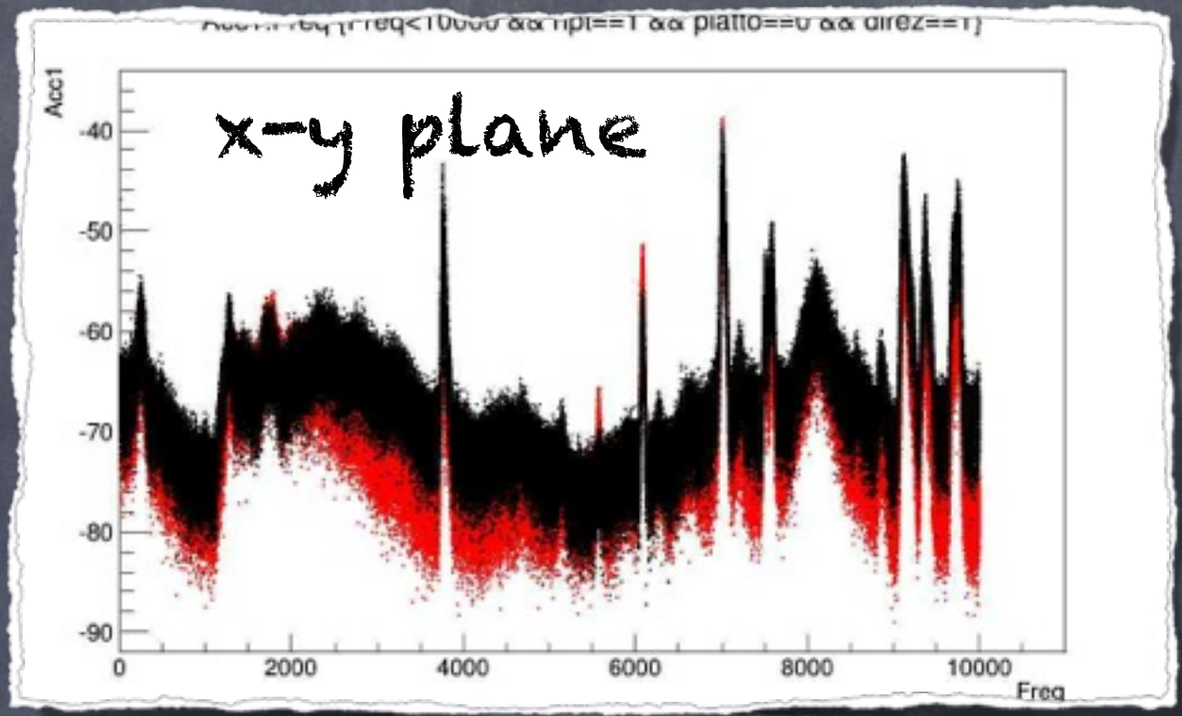
Study of vibrations

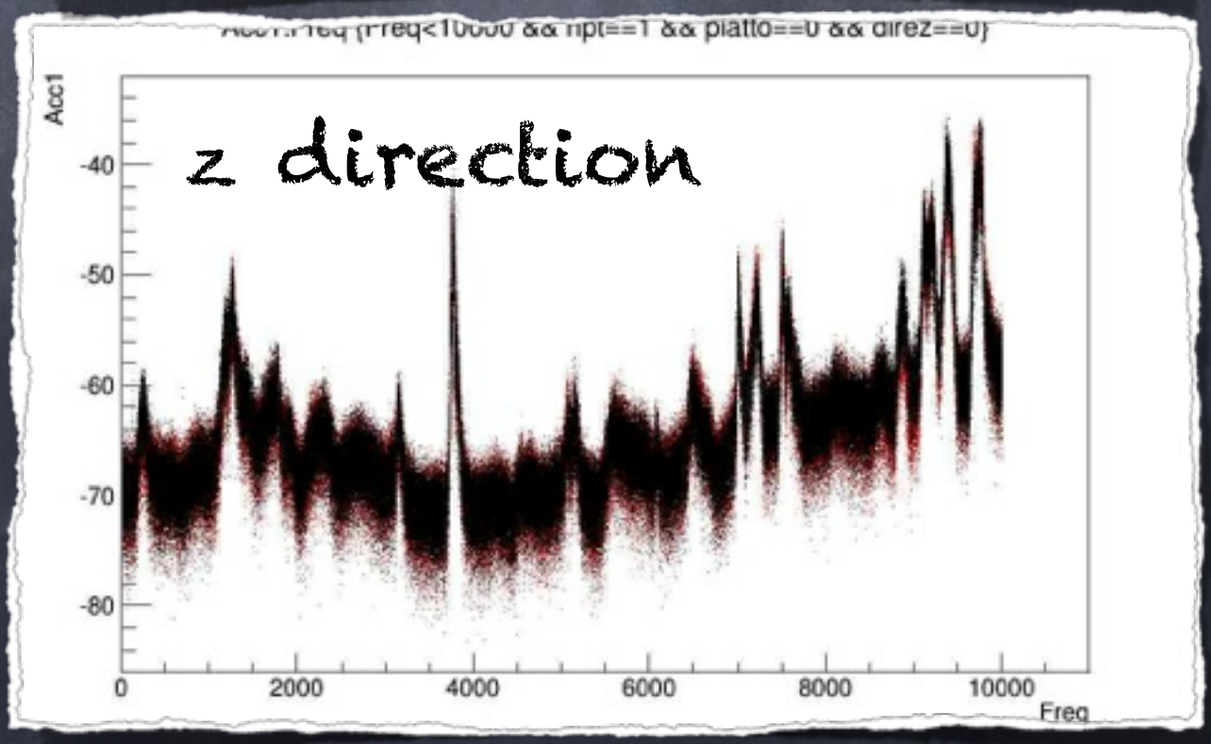
- 3 movable accelerometers
- 2 geophones inside the cryostat on 4K plate
- we implemented a simple DAQ system to acquire data in order to study the effects of:
  - Pulse Tubes
  - Blockage of the cryostat

Blockage of the plate (1)

- Sensors are on PT1's head on top of the 300K plate
- Black = plate blocked
- Red = plate free

on PT1's head, vibrations are horizontal

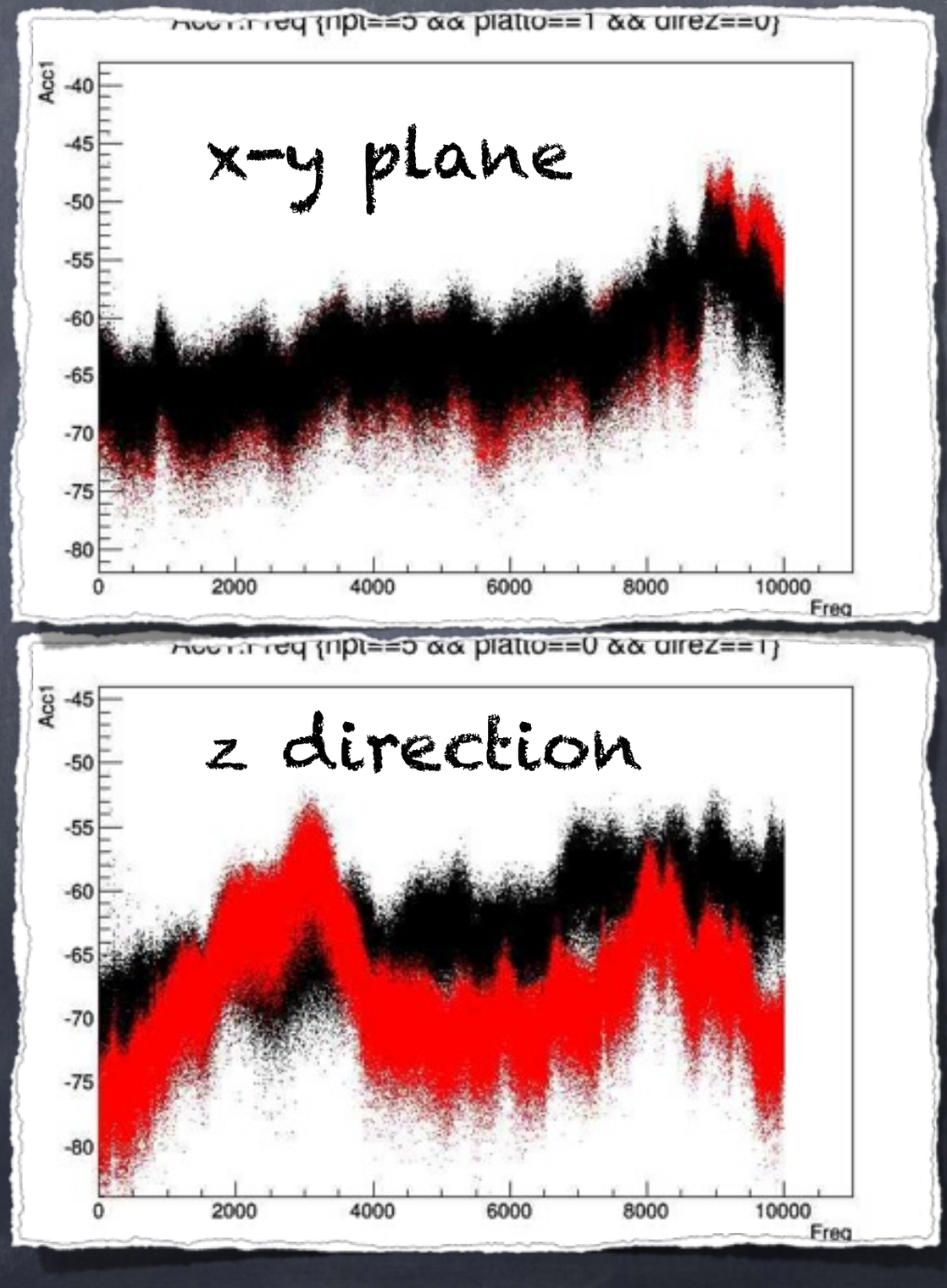




Blockage of the plate (2)

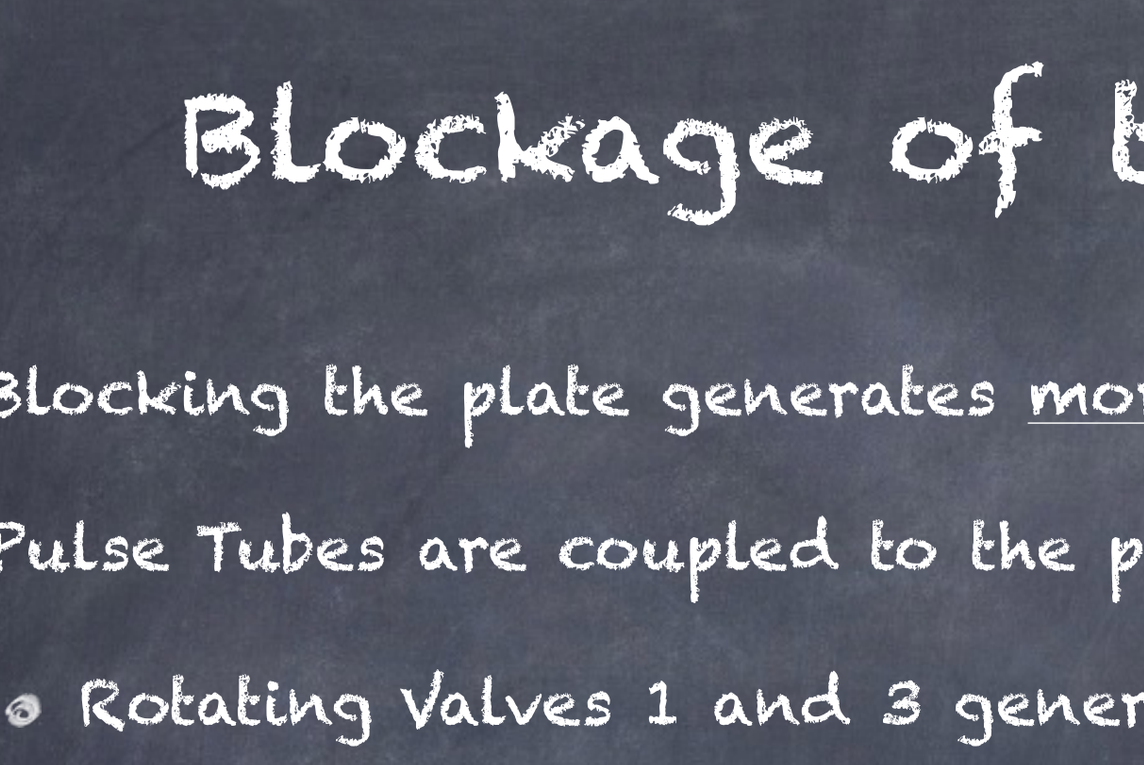
- Sensors are on PT5's head on top of the 300K plate
- Black = plate blocked
- Red = plate free

on PT5's head, vibrations are vertical



Blockage of the plate (3)

- Blocking the plate generates more vibrations on the pulse tubes
- Pulse Tubes are coupled to the plate in 2 different ways, in fact:
  - Rotating Valves 1 and 3 generate horizontal oscillations
  - Rotating Valves 4 and 5 generate horizontal oscillations

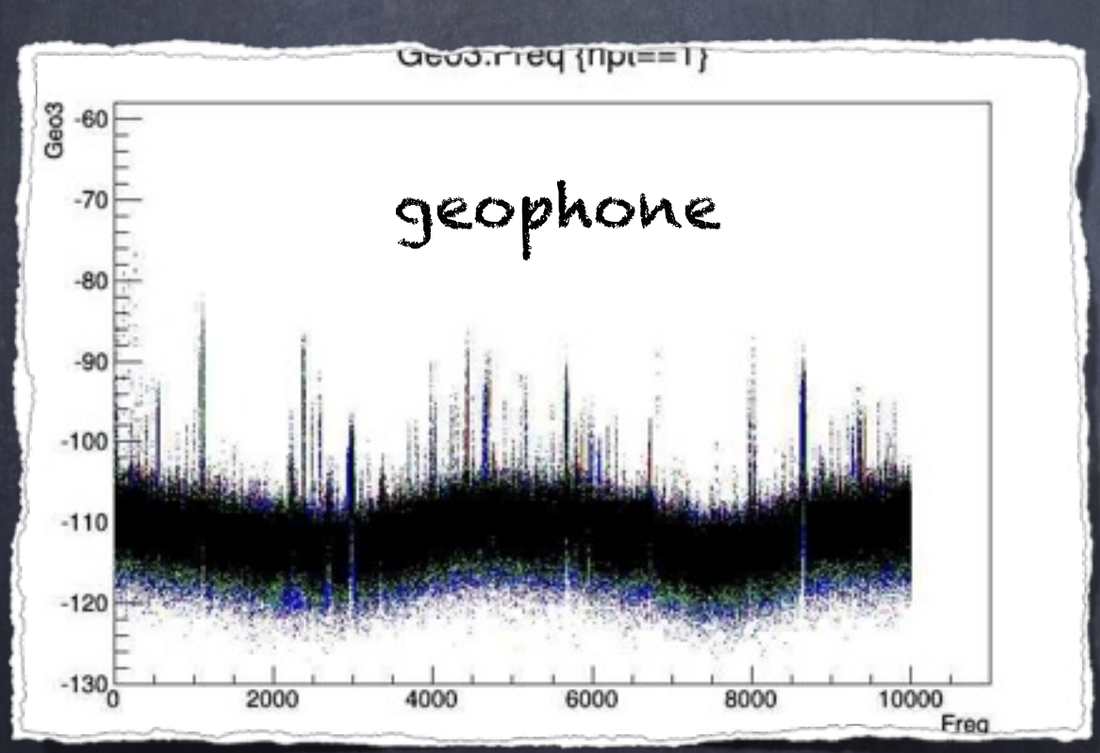


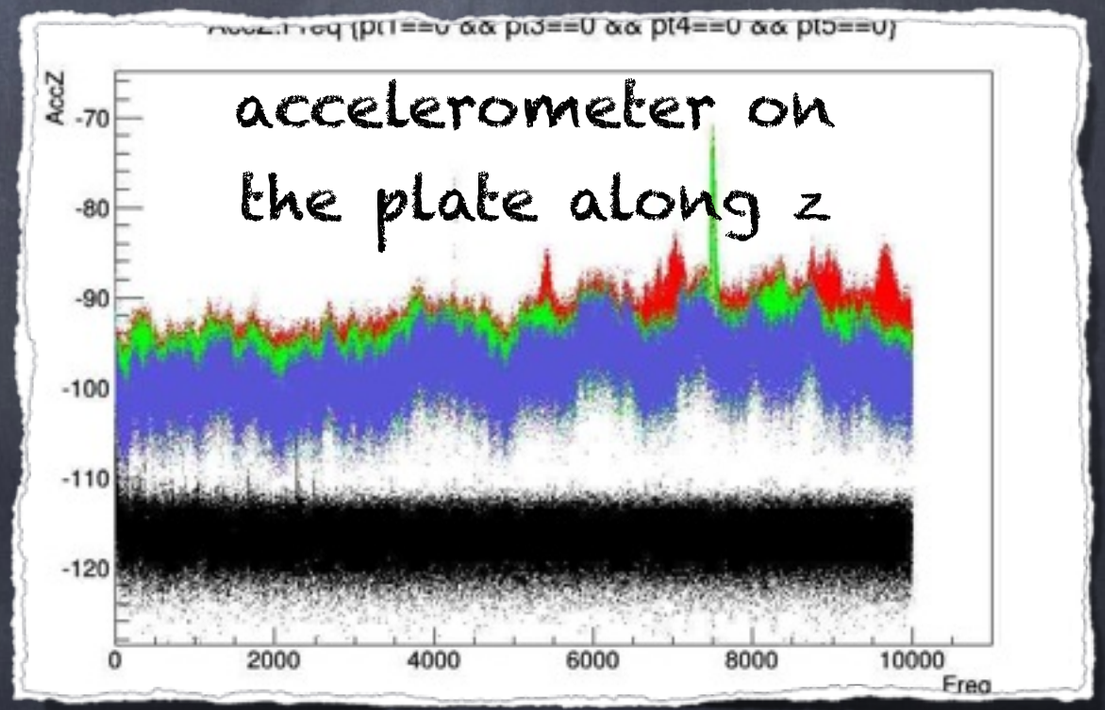
freeing the plate dumps the entire cryostat vibrations

red = free
black = blocked

Single Pulse Tube contributions to vibrations

- black = all PTs are off
- red = only PT3 off
- green = PT3 and PT4 off
- violet = only PT5 on





PT5 gives the biggest contribution

Conclusions

- We characterized the CMN and cross-checked with the noise thermometer
- We acquired and analyzed vibrations data:
  - positive indications from the suspensions
  - positive indications from rotating valves configuration

and we got new identities ...

...Paolo's Oompa-Loompas