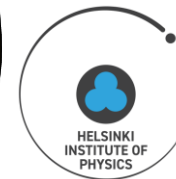


Vibration decoupling in the COSINUS underground facility

DPG Frühjahrstagung 2023
Dresden, 20.03.2023

Speaker: **Moritz Kellermann**



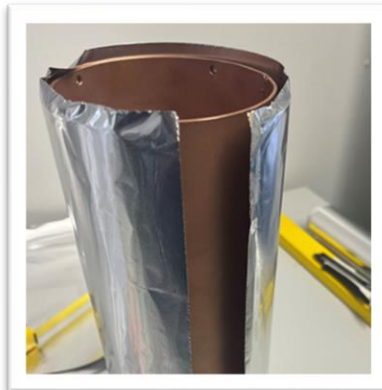
COSINUS @ DPG 2023

COSINUS Overview

See talk of
Martin S.
(Mon. 17:15)



See talk of
Maximilian H.
(Mon. 17:30)



Magnetic shielding

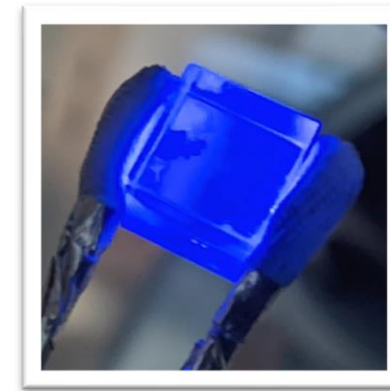
Facility & Vibration decoupling



This talk !

Moritz Kellermann – 20.03.2022

Quenching factors

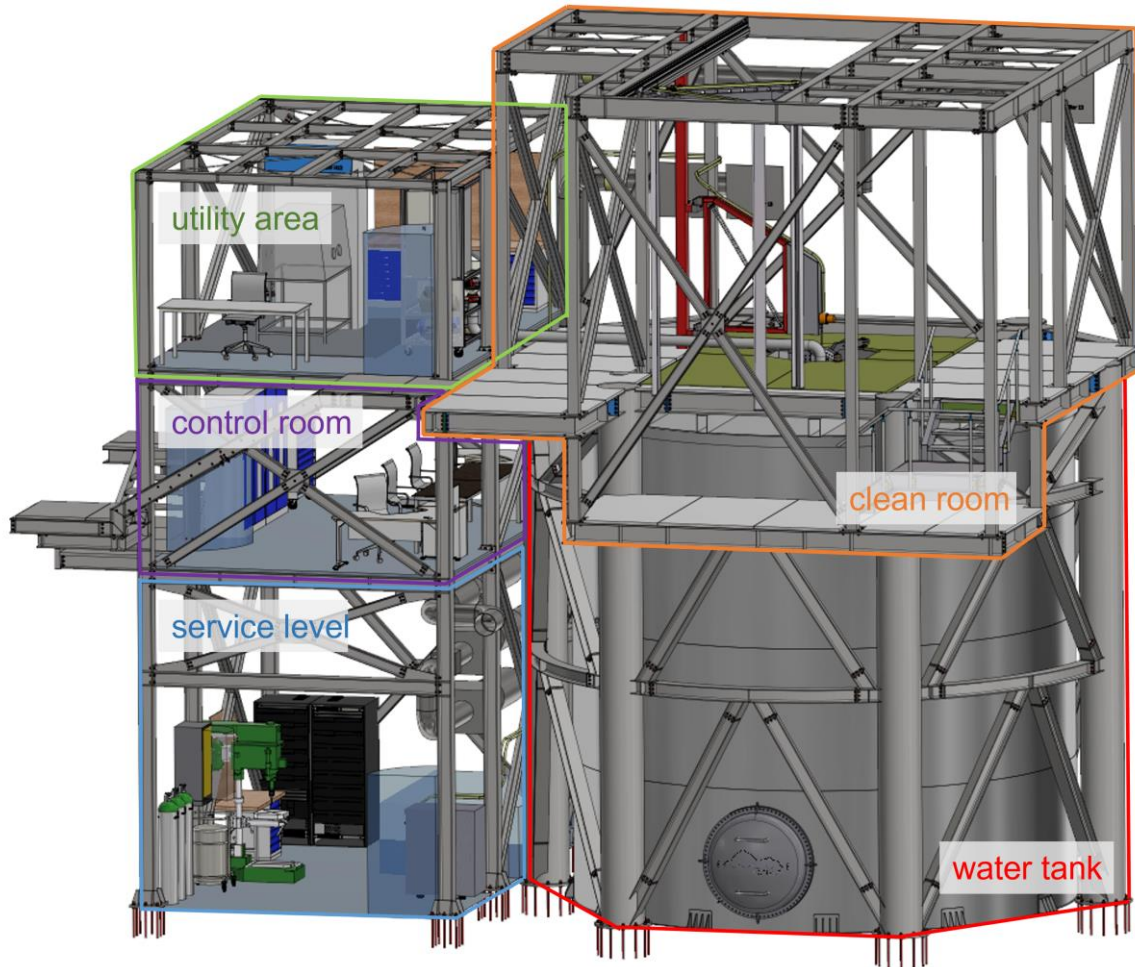


See talk of
Mukund R.B.
(Wed. 16:20)



remoTES detectors

See talk of
Kumrie S.
(Wed. 15:50)



The COSINUS facility consists of 5 areas:

1-3. Utility area | Control room | Service level

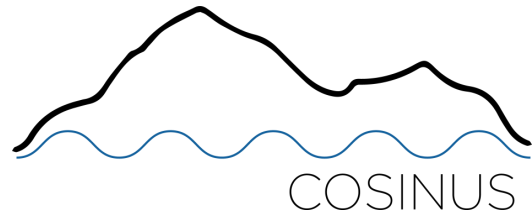
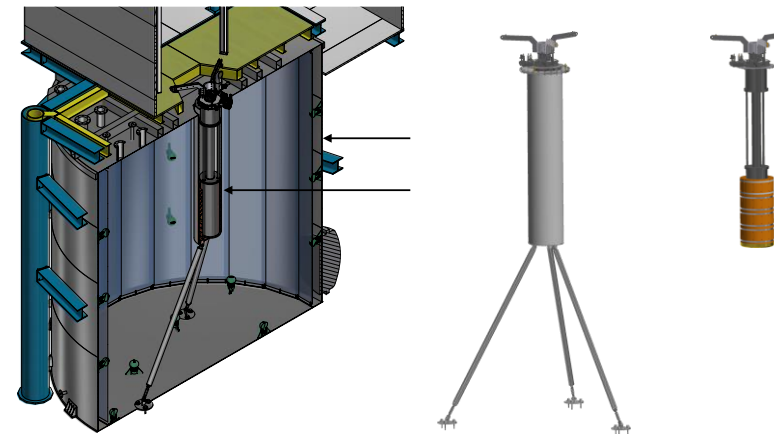
- Equipped with necessary infrastructure to operate the experiment

4. Clean room


- Access to cryogenic refrigerator
- Clean environment for mounting + dismounting detectors

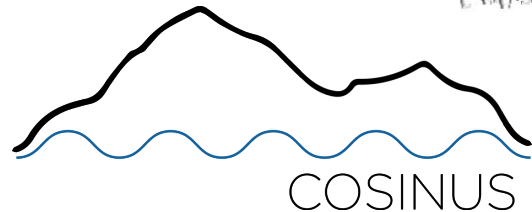
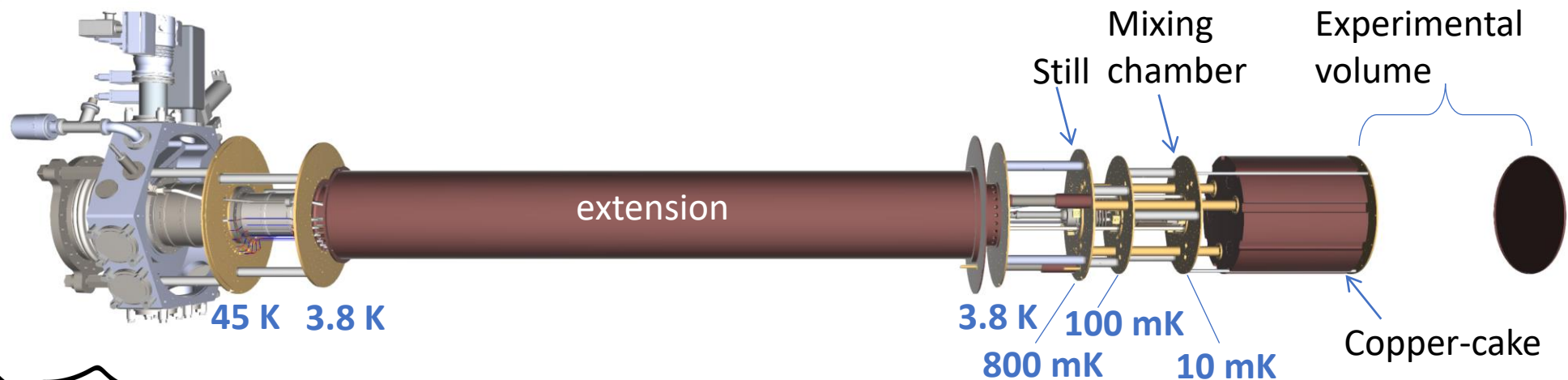
5. Water tank

- 270 m³ water as passive neutron shield
- ~30 PMTs for active muon veto

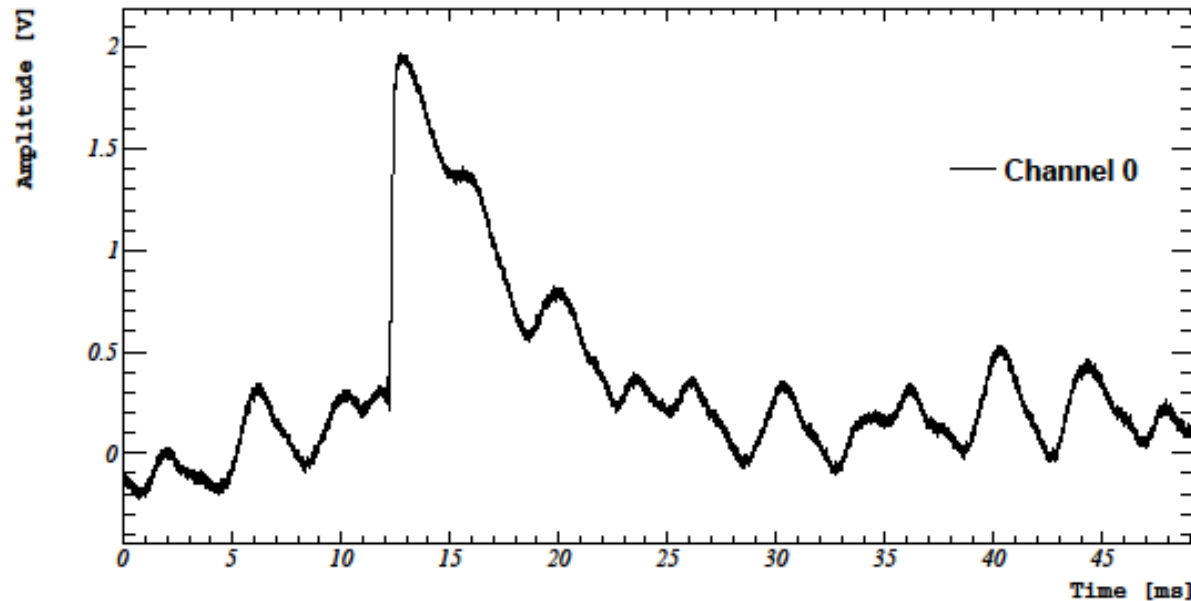


Refrigerator specifications

- **Dry dilution refrigerator** manufactured by CryoConcept 
- Base temperature around **~15 mK**
- Custom-made with a **1.5 m extension at 3.8 K**
- **$3 \times 10^4 \text{ cm}^3$** available experimental volume at base temperature
- **190 kg “copper-cake”** at 800 mK for radiation shielding
- Equipped with **48 Superconducting Quantum Interference Devices (SQUIDs)**

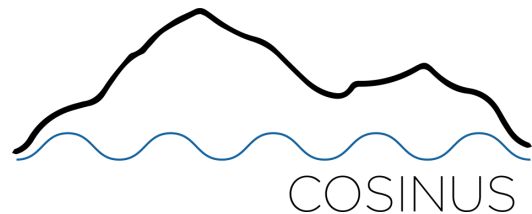


Vibrational noise is a dominating noise source for a cryogenic detector!



- Typical sources for vibrations: Machines, Traffic, People, Nature
- In a dry dilution refrigerator: Pulse Tube Noise

Decoupling is necessary

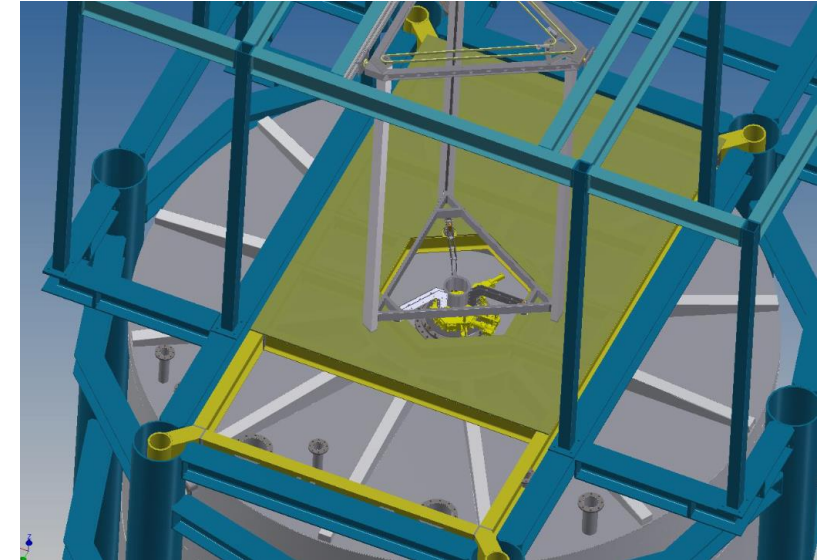


Decoupling stages

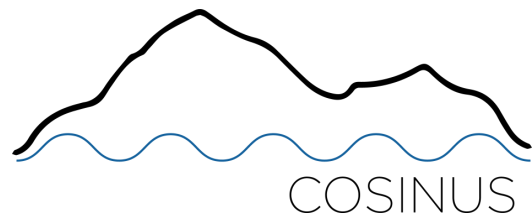
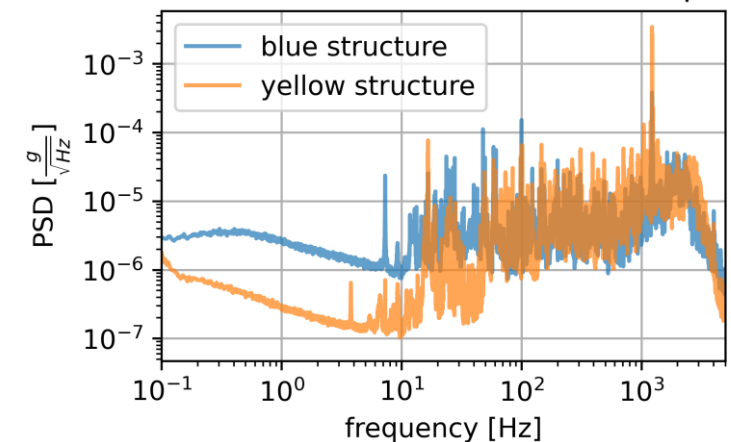
Vibration decoupling happens in 3 stages:

1. Double frame structure of the COSINUS setup

- “yellow structure” houses the dilution refrigerator
- “blue structure” houses necessary infrastructure
- Minimized contacts between frames for low transmission
- Granular damping by sand filled in yellow pillars



Vibrations in the COSINUS setup




Decoupling stages

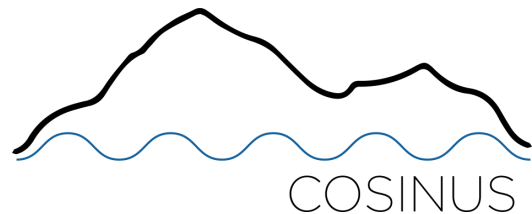
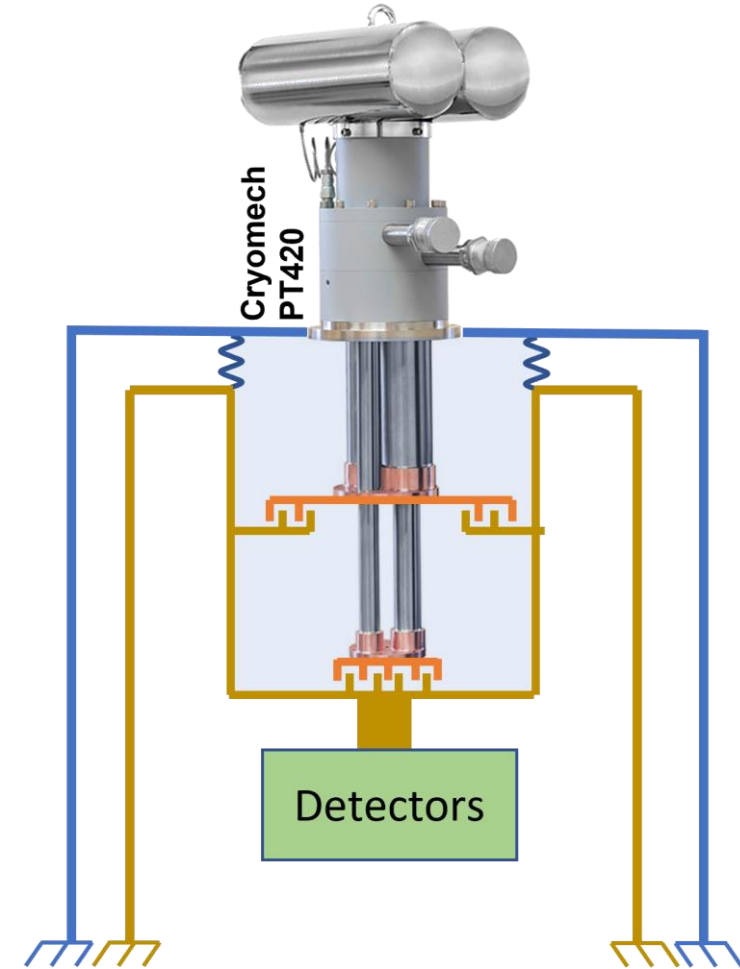
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1. Double frame structure of the COSINUS setup

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2. “Ultra-Quiet Technology” (UQT)

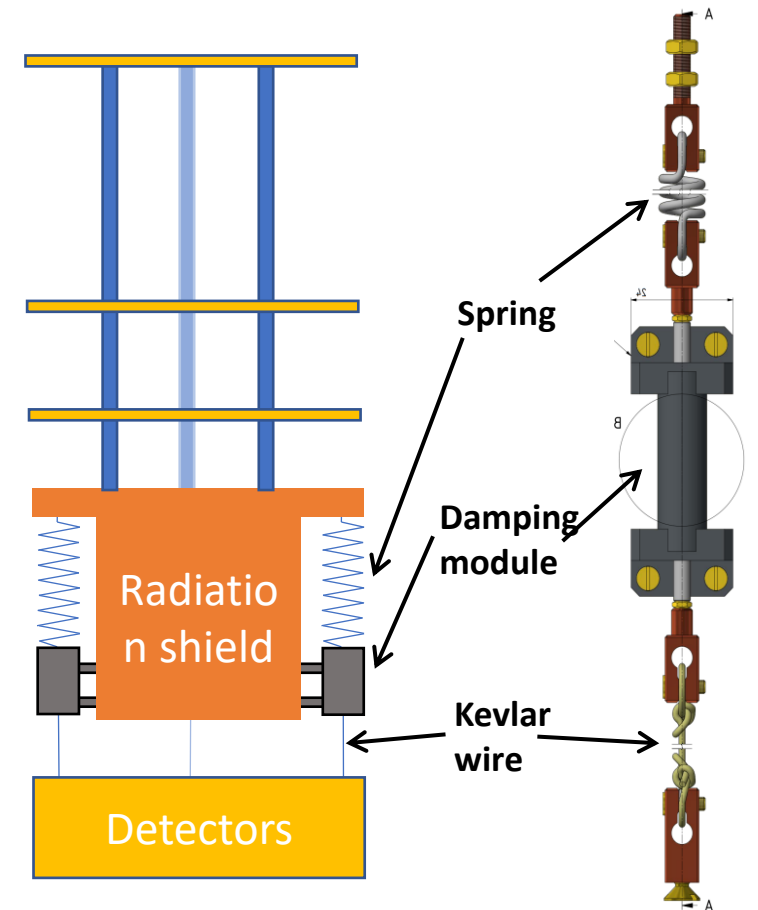
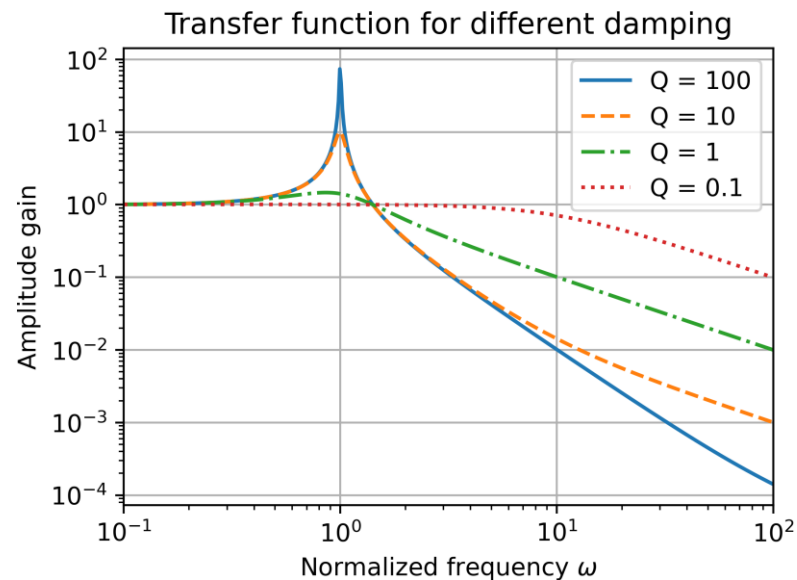
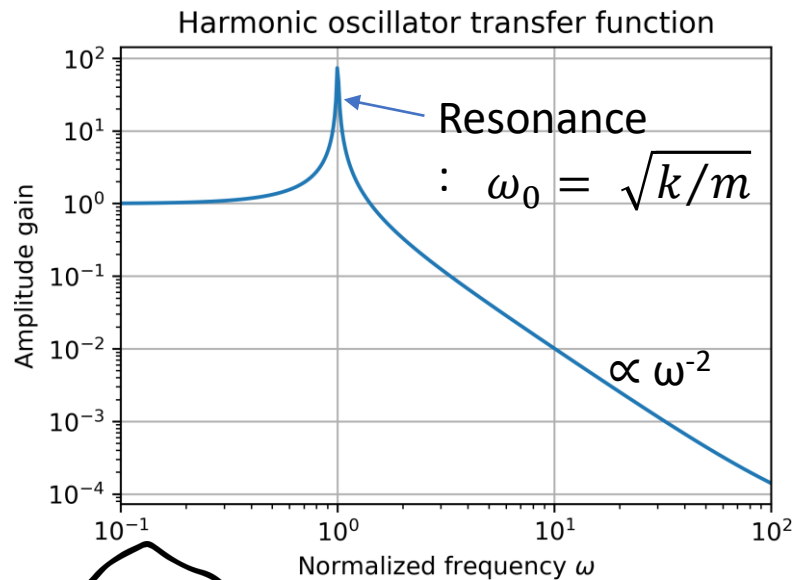
- Developed by Cryoconcept 
- 2 frame structure within the cryostat
- Cold head coupled to one frame
- Detectors coupled to other frame with minimized contact
- Heat transfer up to 4 K via exchange gas



Third decoupling stage

3. Spring-based passive decoupling inside the refrigerator

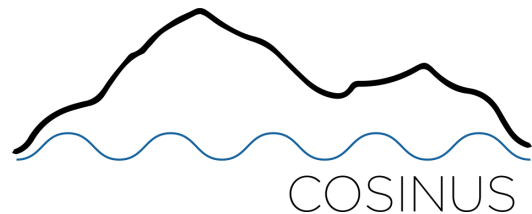
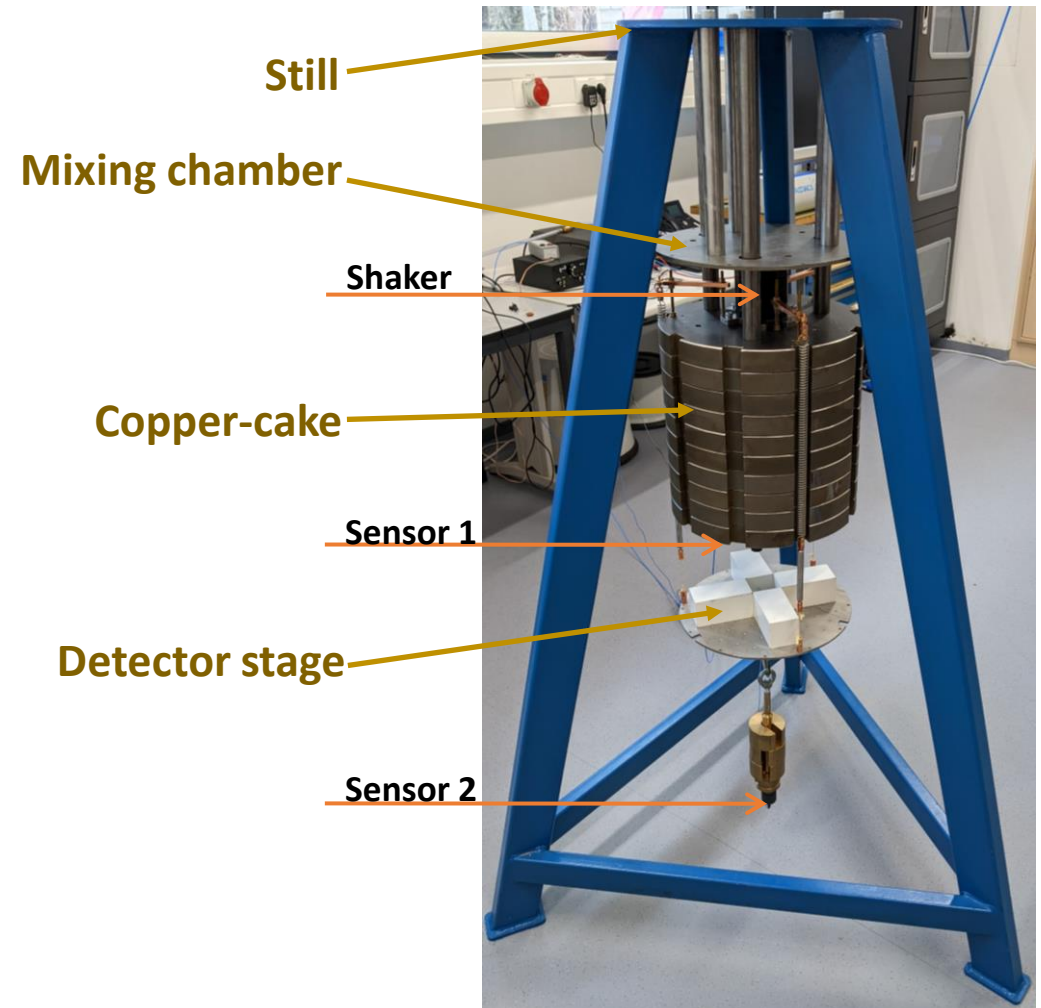
- Currently under development at MPP
- Concept: Hang box with detectors on 3 „decoupling-strings“
- Springs in use: **CuSn6, stainless steel, spring steel**
- Resonance frequencies determine decoupling capabilities



COSINUS

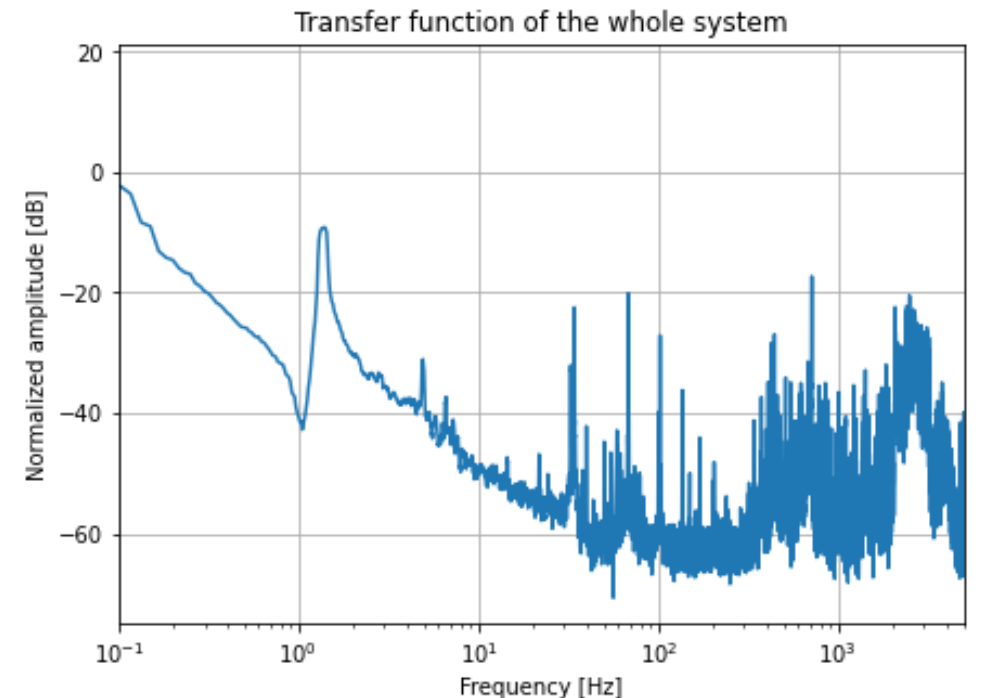
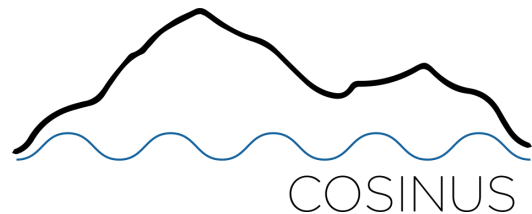
Testing the system

- Refrigerator mockup model for tests at 300 K:
 - Same dimensions and similar masses to real refrigerator
 - Piezo-based accelerometers used for vibration measurements
 - Shaker used as signal emitter for transfer function measurements
- Power spectral density plots & transfer functions give information about noise sources and transmission
- Test stand to test spring properties at 77 K in use to characterize all springs



Status

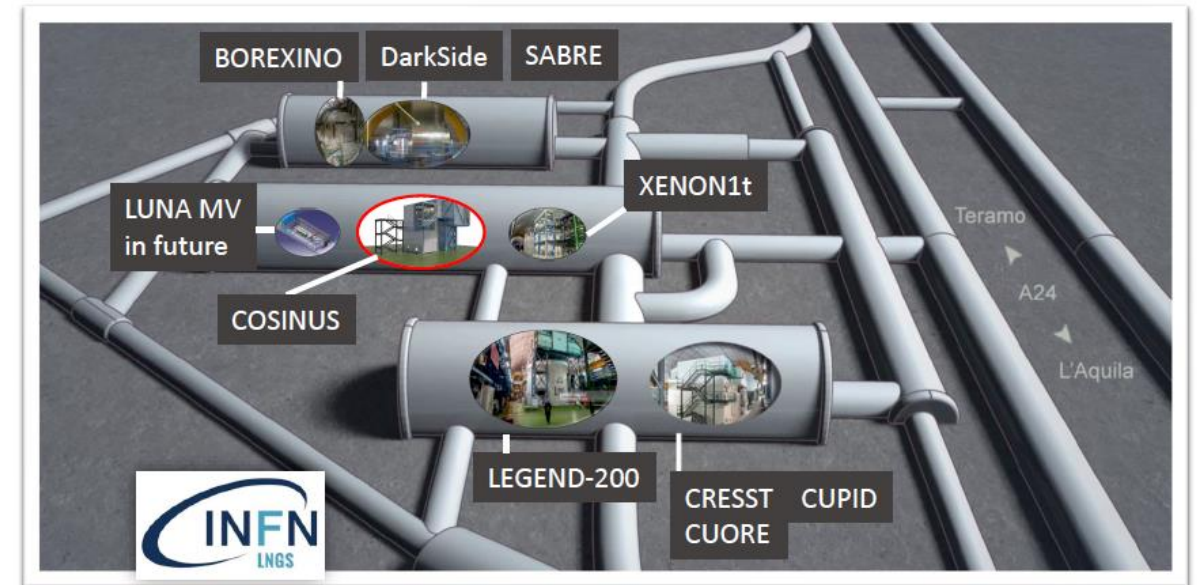
- The COSINUS facility is near completion.
- Decoupling concept in 3 stages was developed
- Vibration decoupling at the detector stage is currently investigated
 - Test with springs at room temperature done (on a mockup)
 - Test of springs at 77 K currently performed
- Next:
 - Investigate damping effect of cabling
 - Investigate thermalization of the whole system



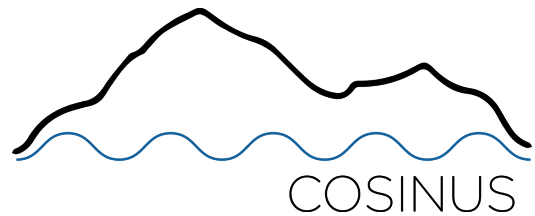
BACKUP

COSINUS @ LNGS

- Located at Laboratori Nazionali del Gran Sasso (LNGS)
- 3600 m.w.e overburden
- Direct neighbours of LUNA and XENON in hall B

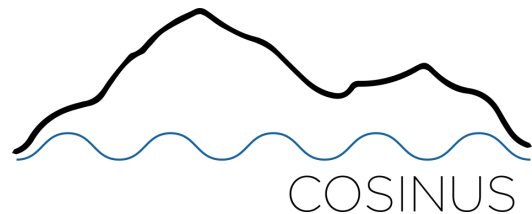
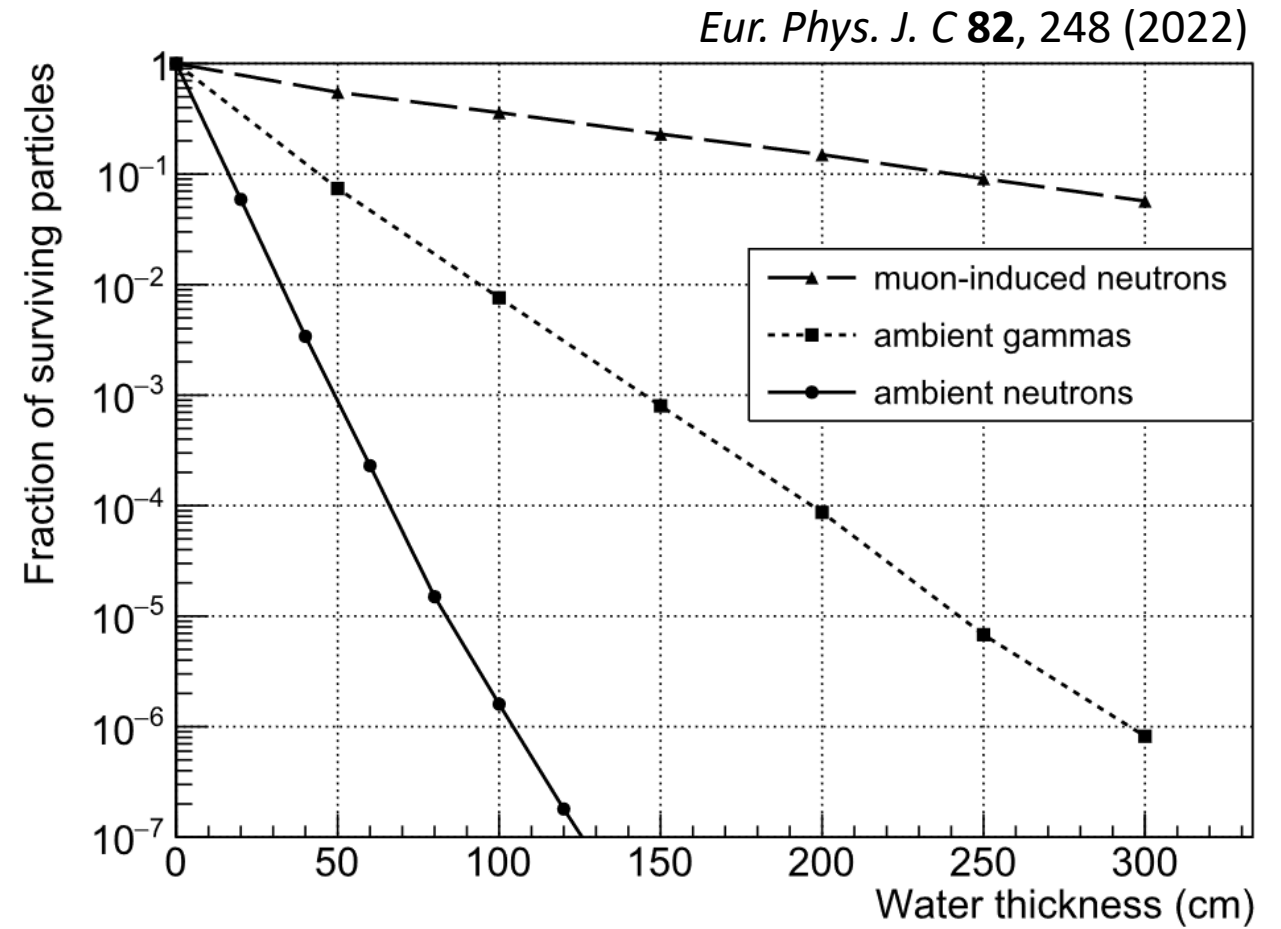


COSINUS @ LNGS

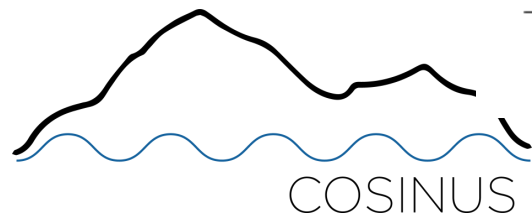
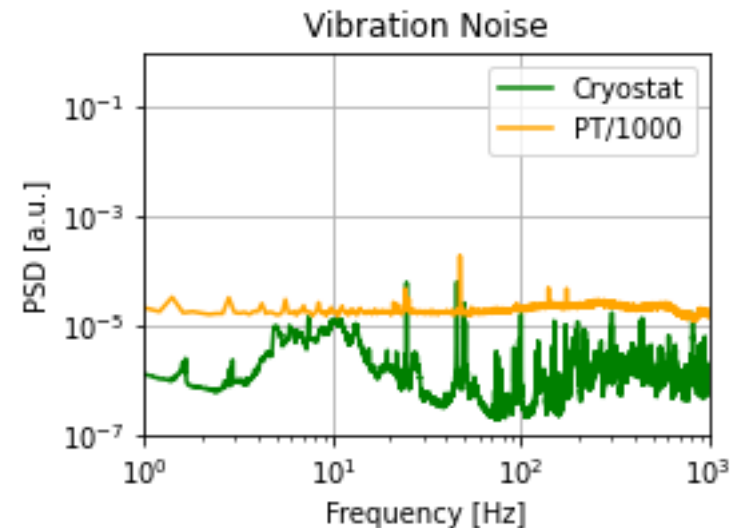
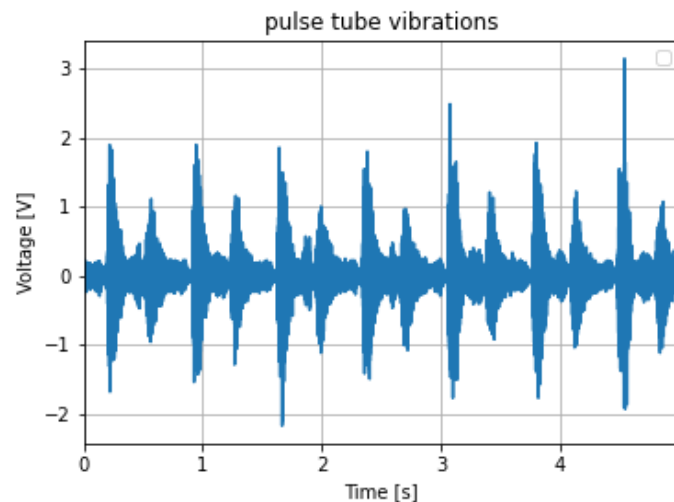
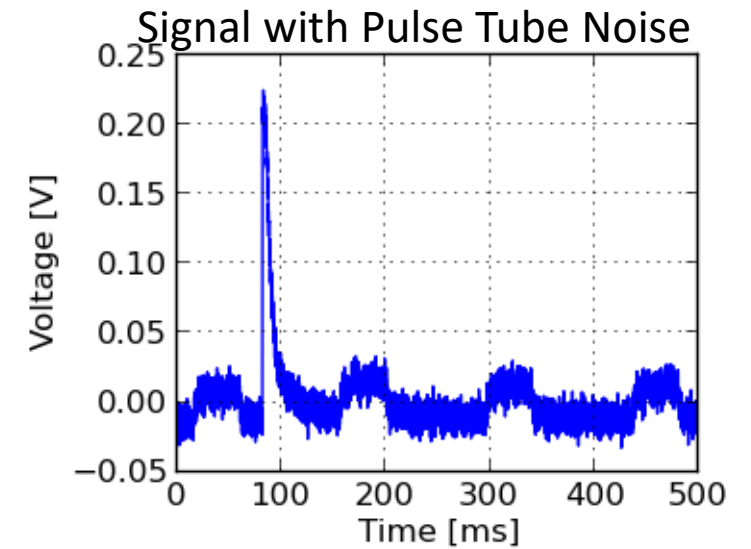
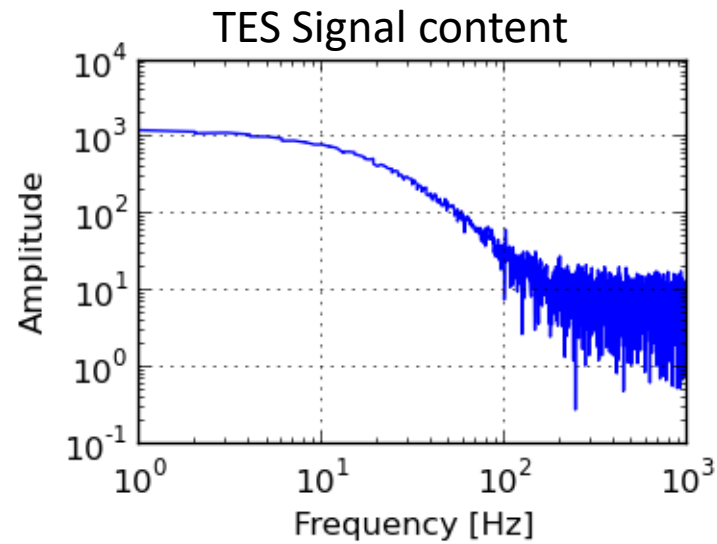
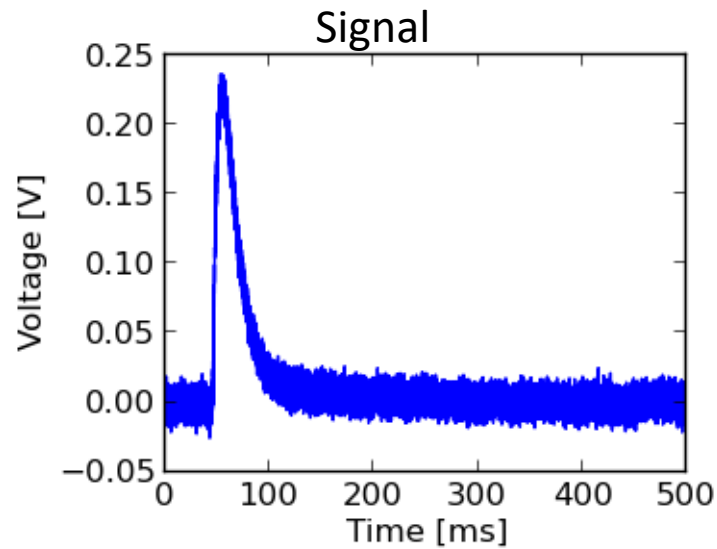


Watertank & Cleanroom

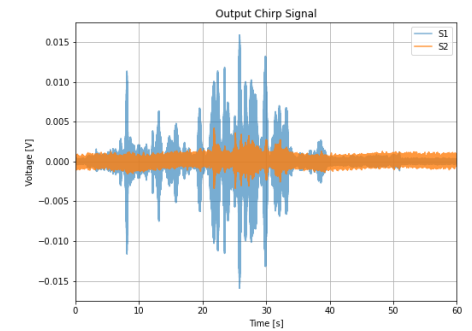
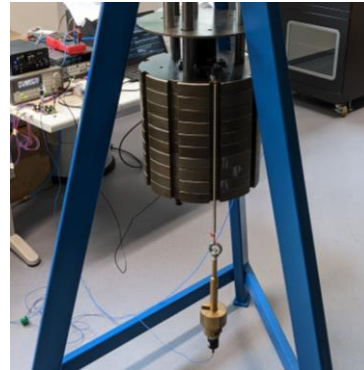
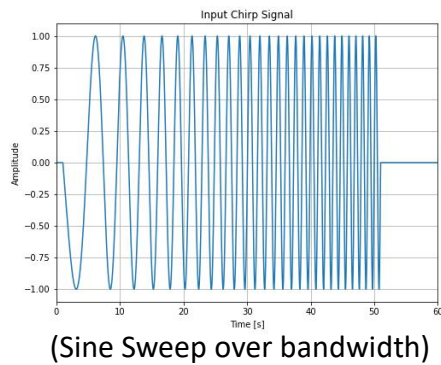
- Watertank + muon veto simulated in GEANT 4
 - Radiogenic neutrons are produced via spontaneous fission and interactions originating from natural radioactive contaminants
 - Cosmogenic neutrons are either produced by muon-induced spallation or by secondary particles generated in muon-induced cascades
- Detailed material screening campaign ongoing



PT Noise & Pulse



Transfer function analysis



Linear Time-invariant System

- Output signal is the convolution of the input signal with all blocks of the system
- A convolution in time domain is the same as a product in frequency domain

➤ The transfer function of the system can be calculated by $TF = \frac{fft(output)}{fft(input)}$

