Karlsruhe Institute of Technology

ET EINSTEIN TELESCOPE

Experimental plans to validate the He-II based payload cooling

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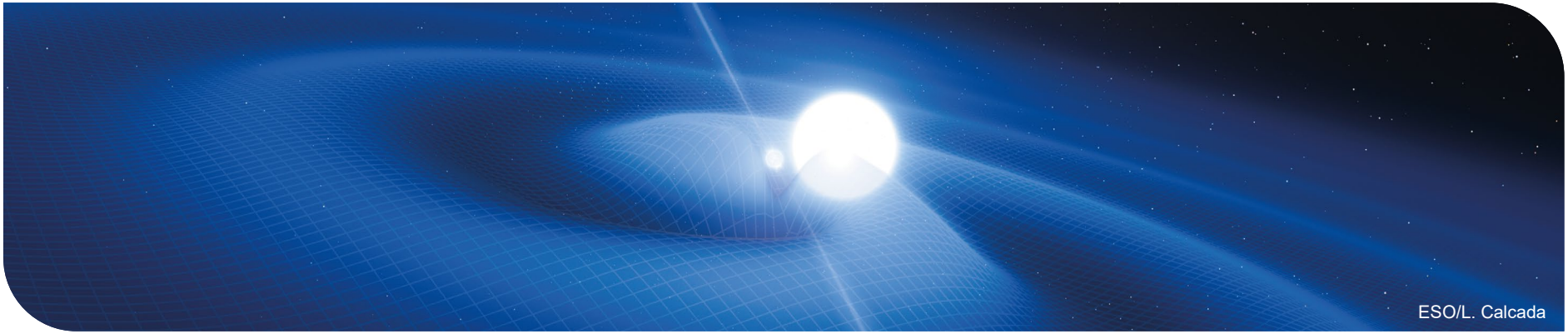
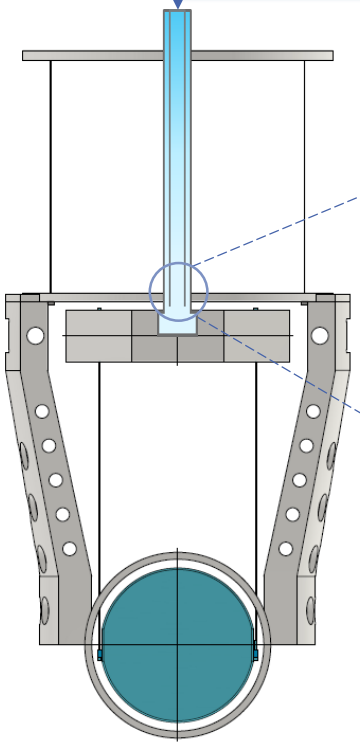
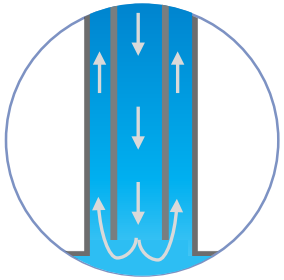
28-30 September 2022
GWD Vac'22 (Elba)



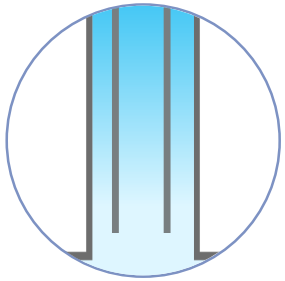
He-II based payload cooling for ET-LF

Cooling via He-II suspension tube

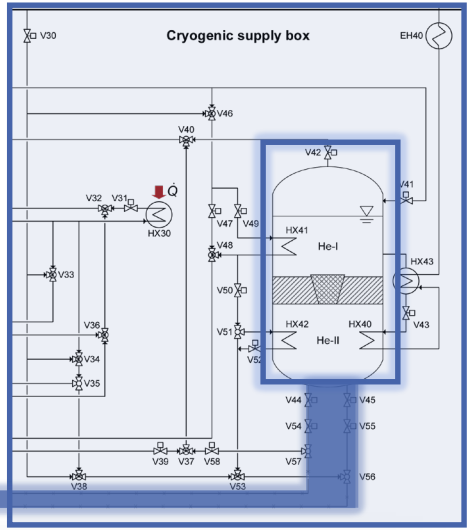




- He-I flow for cool-down



- He-II (no macroscopic flow) for steady-state operation



L. Busch (KIT, 2021)

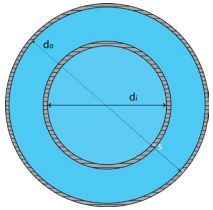
He supply capillaries:

- Cryogenic supply box ↔ Payload (i.e. suspension capillary) connection
- Length ~ 10-20 m → cryogenic supply box away from cryostat tower to reduce vibration input

X. Koroveshi (2022) - Feasibility of He-II suspensions based on thermal noise modelling

Status of He-II suspension concept

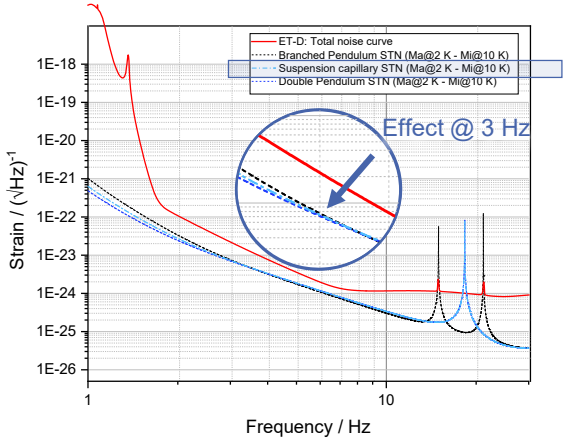
Mechanical

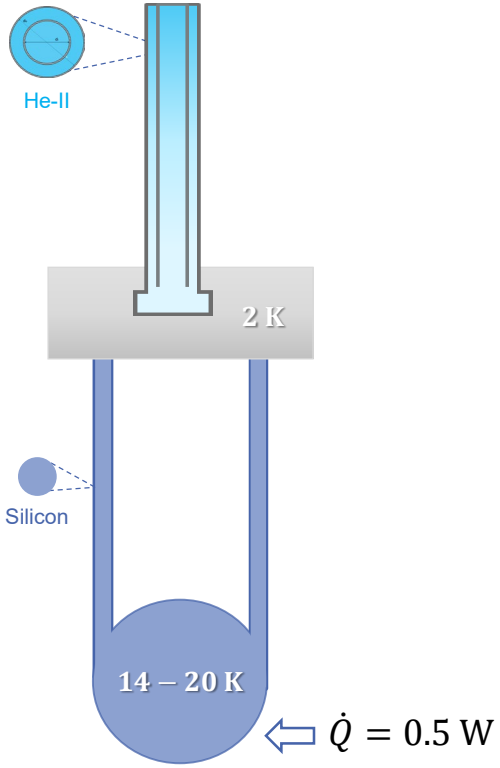


Thermal

Suspension thermal noise

- Feasibility shown theoretically
- Experimental proof of concept: **Open**





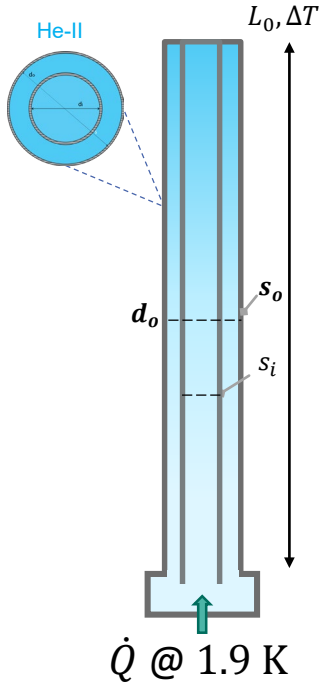
Experimental validation of concept

Experimental setup requirements

- Mechanical losses in suspensions (theoretical):

$$\Phi_{\text{fiber}}(\omega) = \Phi_{\text{bulk}} + \Phi_{\text{thermoelastic}}(\omega) + \Phi_{\text{surface}} + (\Phi_{\text{clamping}})$$

- Quality factor (Q) measurements define the actual losses
  - Ring-down method as measurement concept
  - Identification of the specific contributions to the total measured Q_{tot} is non-trivial:
    - Sensitive measurements → Step-by-step complexity increase of measurements



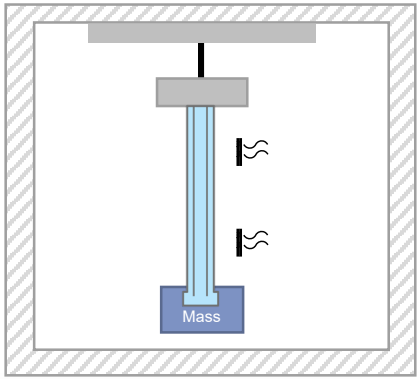
Possible stages of experimental validation

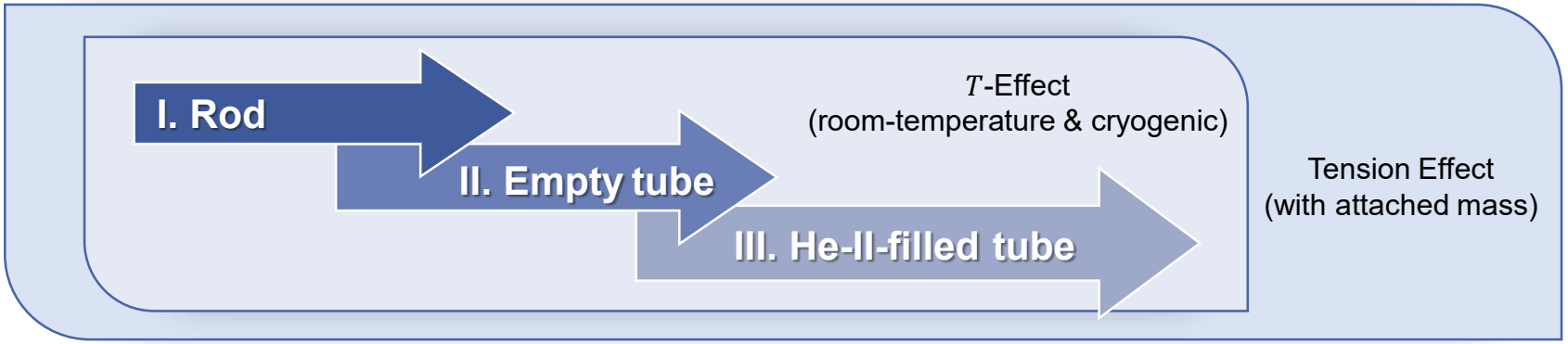
- Q-Measurements of suspension:

  I. As a simple suspension rod (room-temperature & cryogenic)

  II. As an empty suspension tube (room-temperature & cryogenic)

  III. As a He-II-filled suspension tube





Q-Measurements stages

I. Rod

- Comparison with literature data
- Various materials
- Influence of T and tension on Q

II. Empty tube

- Surface effects crucial (machining of tube)
- Identification of tube‘s modes
- Influence of T and tension on modes & Q

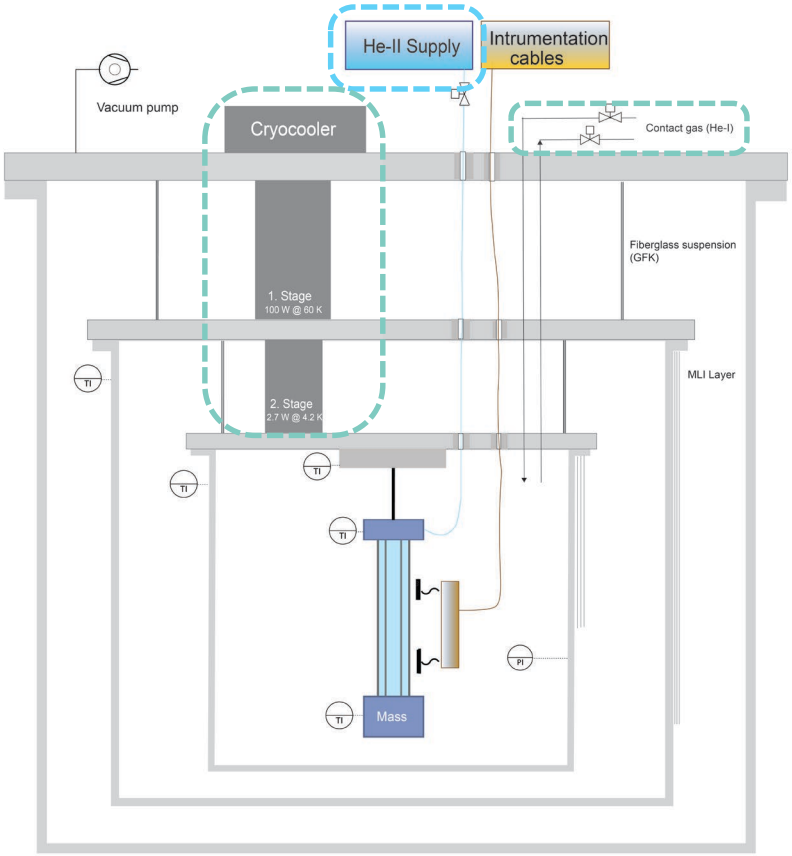
III. He-II-filled tube

Open questions:

- $\dot{M}_{\mathrm{He-II}} = 0$, but investigation whether noise transmission in He-II as in metals/crystals?
- He-II effect on Q, extra/no dissipation?
- Influence of supply capillary ↔ suspension tube interface on Q?

Q-Measurement experimental setup

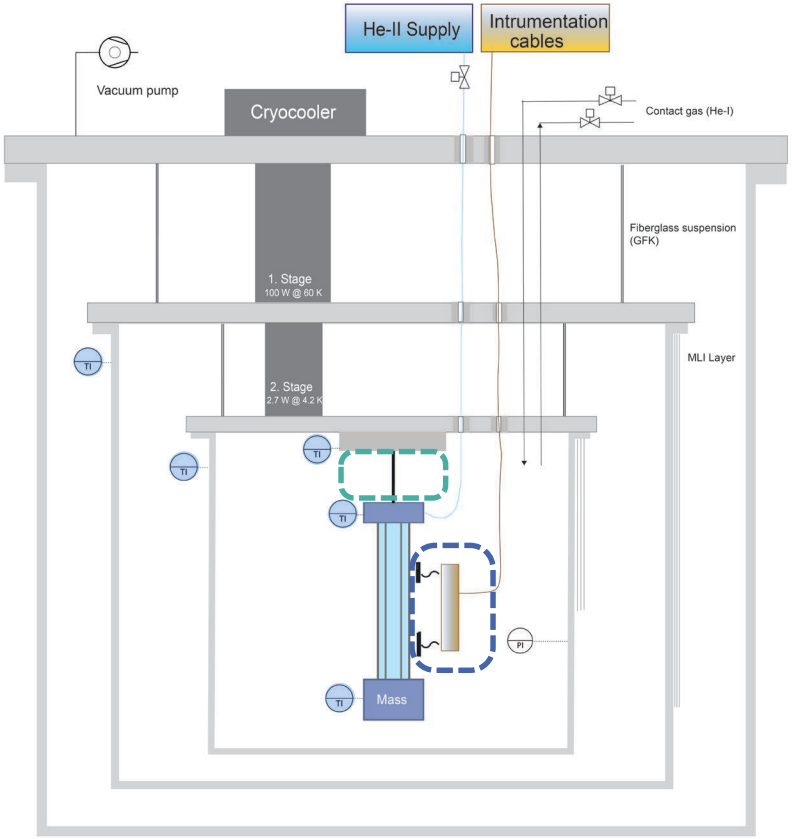
Q-Measurement Cryostat



Properties:

- Mechanical design
  - Same cryostat (test stand) for Stages I-III
    - At RT
    - Cryogenic
  - Bottom-to-top design to facilitate He-II experiments (Stage III)

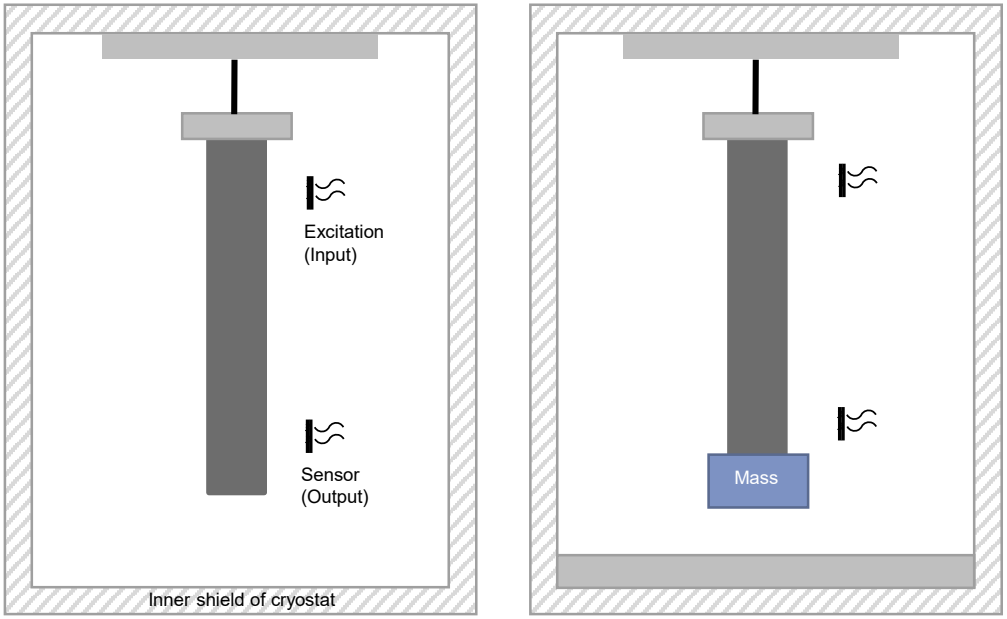
Q-Measurement Cryostat



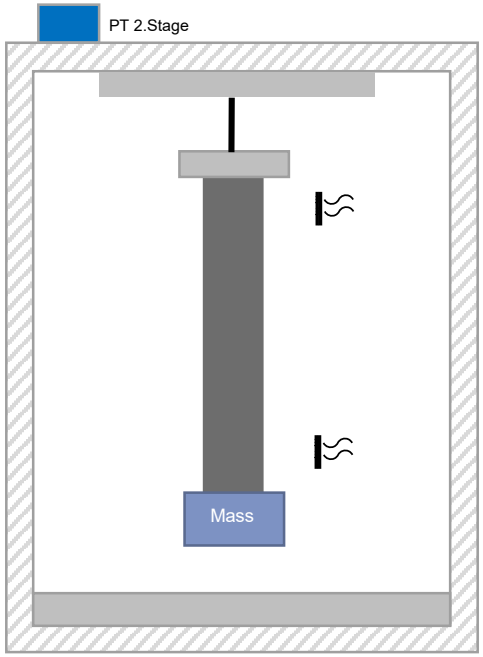
- Instruments
  - Excitation/sensing :
    - Combination: PZCs (contact) and contactless concept
    - Excitation of the flexural mode of the tube

Q-Measurement experiments - Stage I

- Bulk suspension tube (RT)
  - Measurements without and with load (300-400 kg)
  - Determination of load‘s effect on dissipation

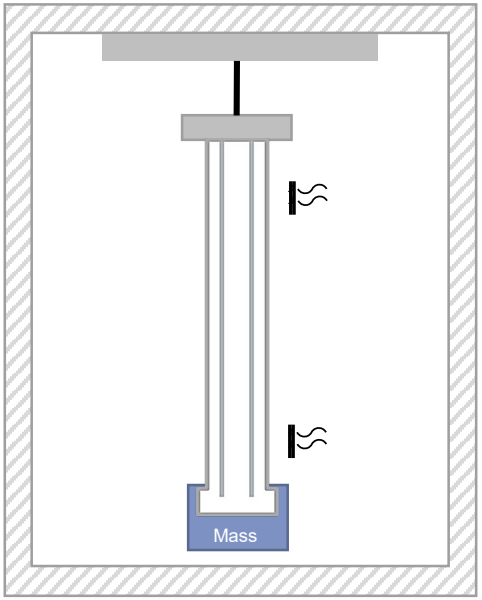


- Bulk suspension tube (cryogenic)
  - Measurements without and with load

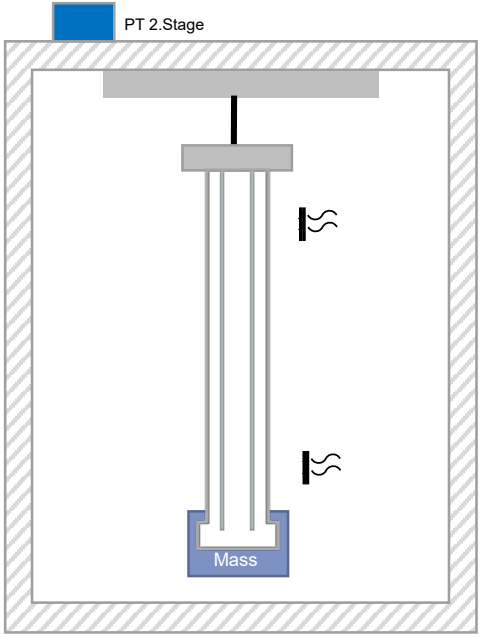


Q-Measurement experiments - Stage II

- Hollow suspension tube (RT)
  - Determination of hollow tube‘s effect
  - Measurements without/with load

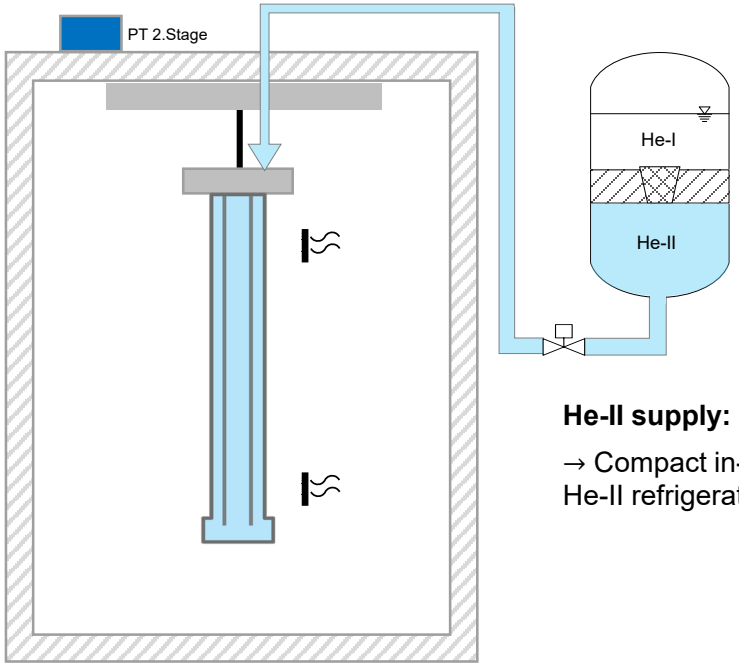


- Hollow suspension tube (cryogenic)
  - Determination of temperature‘s effect
  - Measurements without/with load



Q-Measurement experiments - Stage III

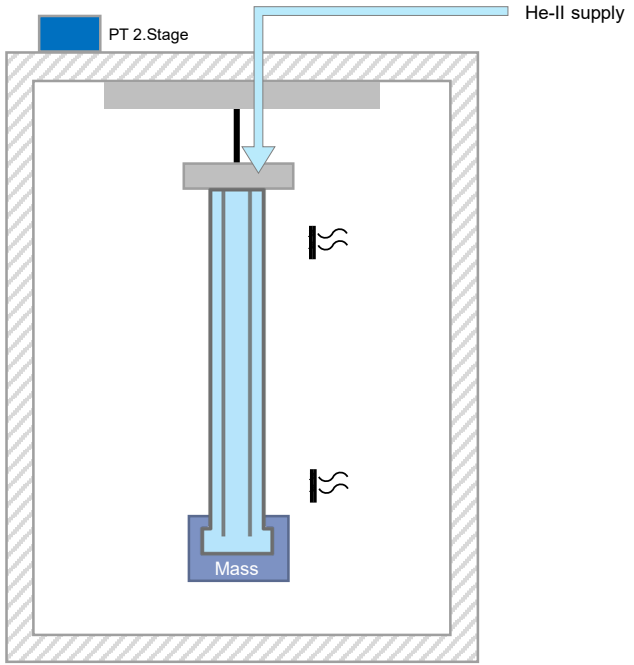
- He-II-filled suspension tube
  - Effect of He-II and of the clamping of He-II supply path



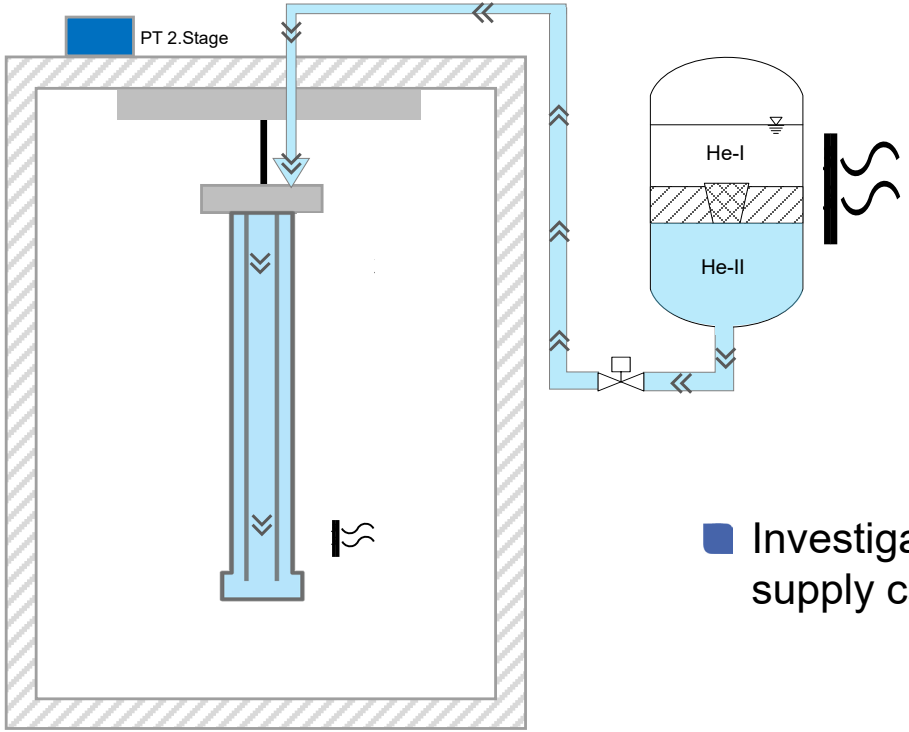
He-II supply:

→ Compact in-house
He-II refrigeration system

- He-II-filled suspension tube
  - Load end temperature and effect of tension on dissipation



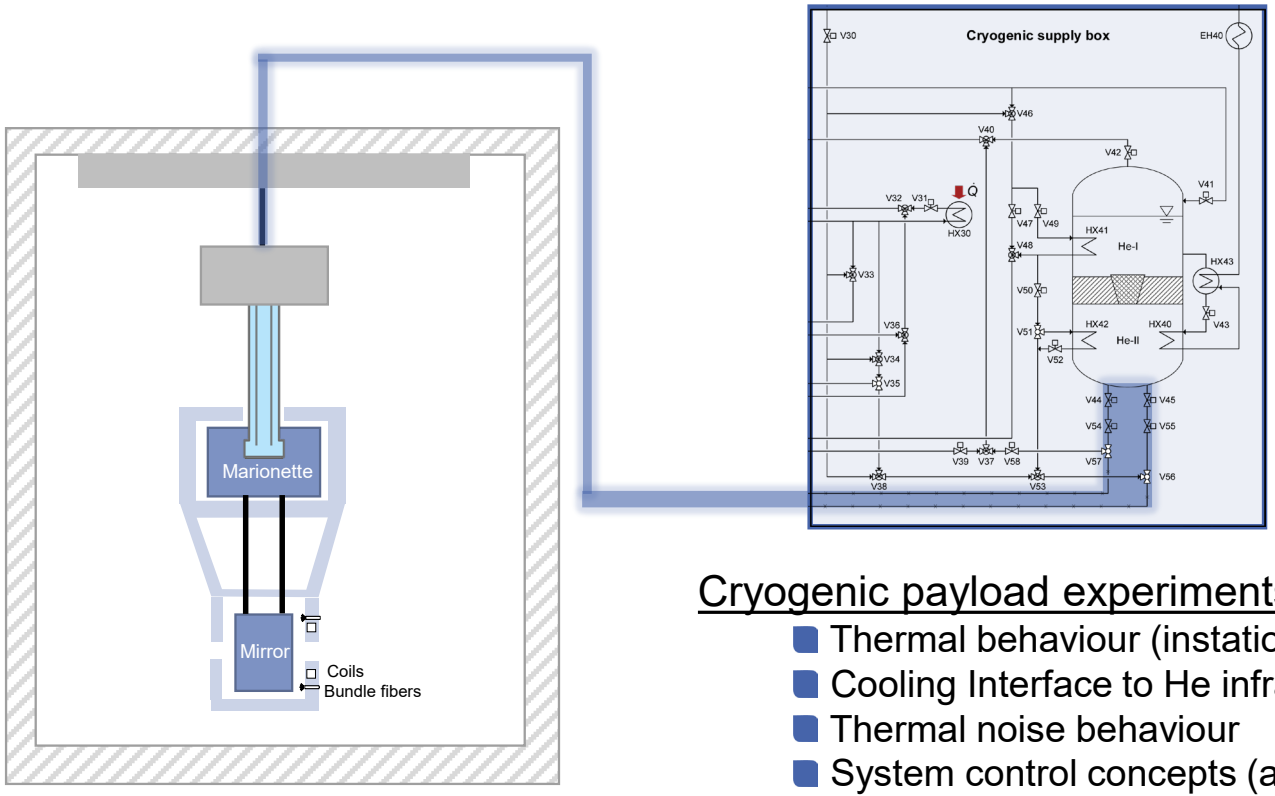
Additional vibration measurements



- Investigation of vibration propagation in He-II supply capillaries via external excitation

Prospects

Cryogenic payload experiments

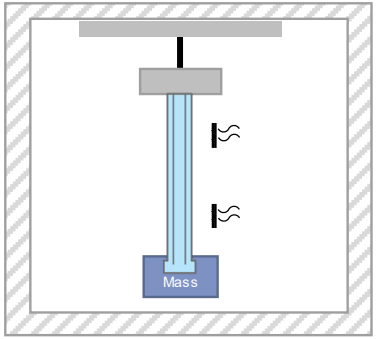


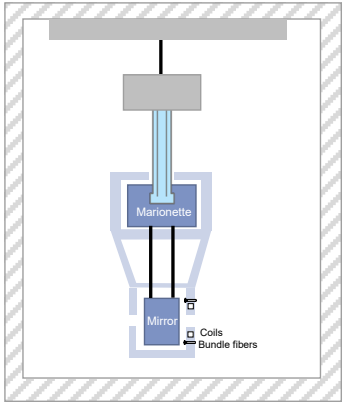
Cryogenic payload experiments for investigating:

- Thermal behaviour (instationary & stationary)
- Cooling Interface to He infrastructure
- Thermal noise behaviour
- System control concepts (actuation+sensing)

Conclusions

- 1) Q-Measurements of suspension
  - I. As a simple suspension rod (room-temperature & cryogenic)
  - II. As an empty suspension tube (room-temperature & cryogenic)
  - III. As a He-II-filled suspension tube
- 2) Cryogenic payload experiments for investigating:
  - Thermal behaviour (instationary & stationary)
  - Cooling Interface to He infrastructure
  - Thermal noise behaviour
  - System control concepts (actuation+sensing)
  - …





Thank you for your attention

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