



**Damage mechanisms and limits in superconducting
strands induced by instantaneous beam impact**

Cryostat specifications

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Scientific goals

- Investigation of the damage mechanisms and limits of superconducting magnet components due to instantaneous beam impact
 - Experiment at room temp. see HRMT31
 - At cryogenic temperature (LHe temp.) HRMT37
- Expose strands to beam in order to reach varying hot-spot temperatures from 400K to 1300K
- Superconducting strand short samples with length of 10cm
- In-Situ observations
 - Hot-spot temperature via resistance measurement,
 - critical temperature measurement
- Post mortem analysis
 - Magnetization
 - Critical transport current
 - Insulation degradation of surrounding Polyimide films

HiRadMat

Irradiation facility provides 440 GeV/p proton beams towards fixed targets

- 1.2×10^{11} p.p. bunch
- Max. 288 bunches
- 25 ns bunch spacing

Maximum pulse parameters:

- 7.2 μ s pulse length
- 3.4 MJ stored beam energy

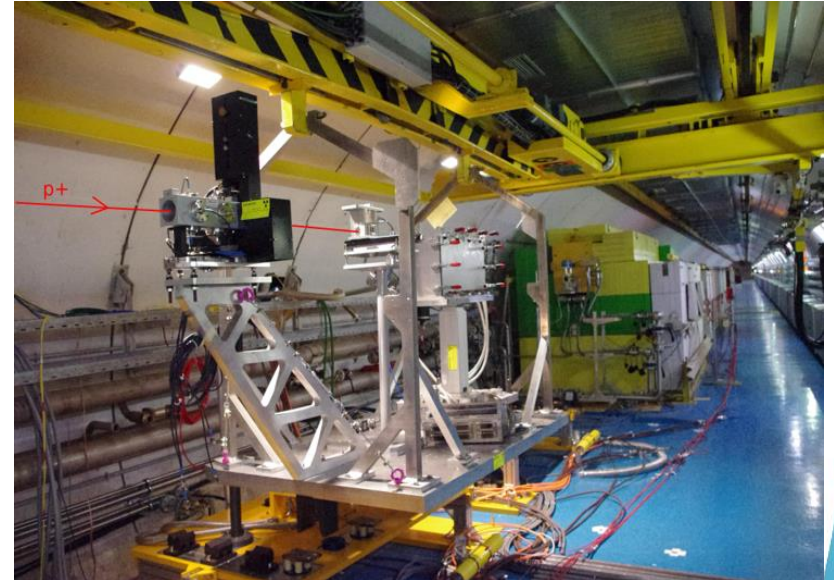
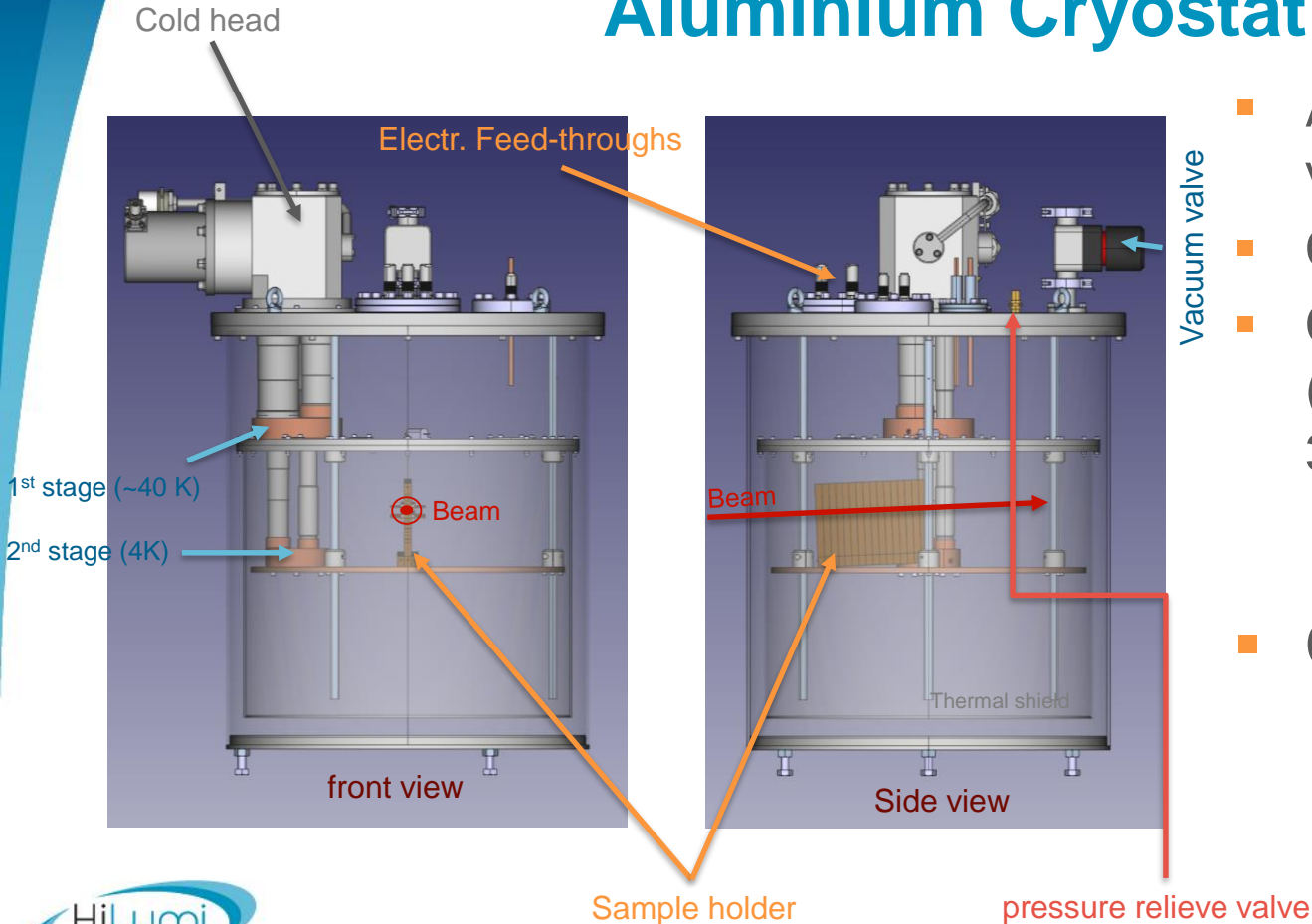


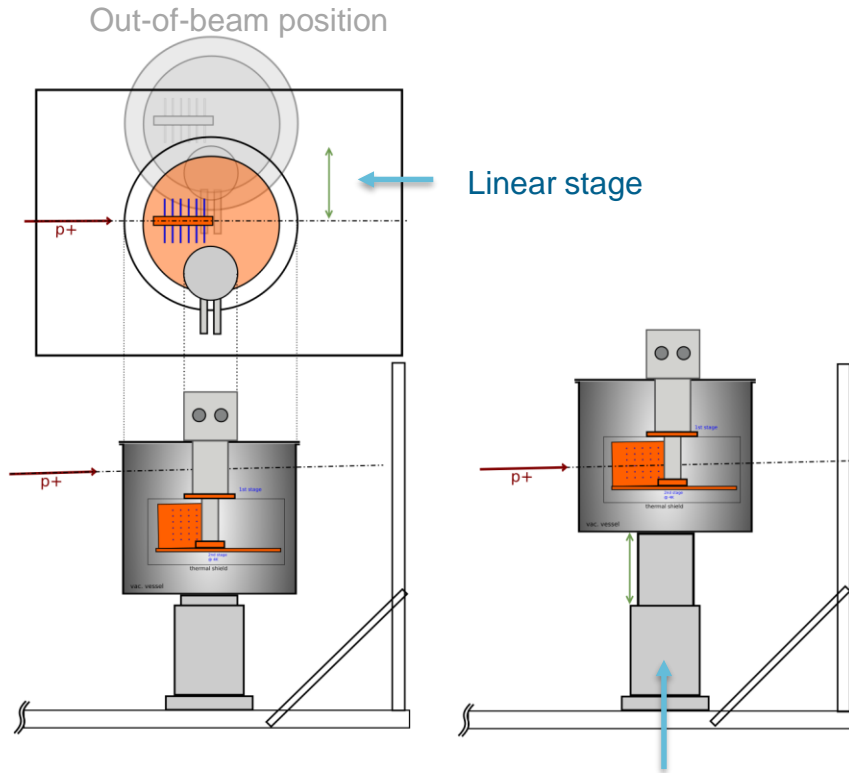
Image courtesy V.Raginel

Aluminium Cryostat



- Aluminium Vacuum vessel
- Cryocooler cold head
- Copper sample holder (taking 16 Nb-Ti and 30 Nb₃Sn strands)
- Cryogen free

Setup on table



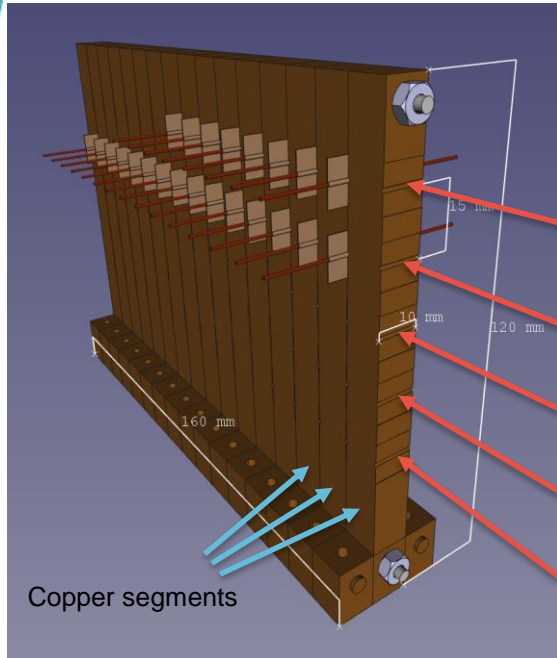
Movable pillar, SKF telemag
(compare HRMT31)

- 46 strand samples to be irradiated at LHe temp.
- Cryogen-free Aluminium vacuum vessel
- Vertical movement to irradiate different batches of samples
 - 5 batches at diff. vertical positions
 - 8-10 strands per batch
 - Irradiate one batch per pulse
- Horizontal movement to allow out-of-beam position
- Total weight **100 kg**
- Dimensions
 - Diameter Cryostat: **d=525 mm**
 - Height: **632 mm**
 - + cold head: **188 mm**

h=820 mm

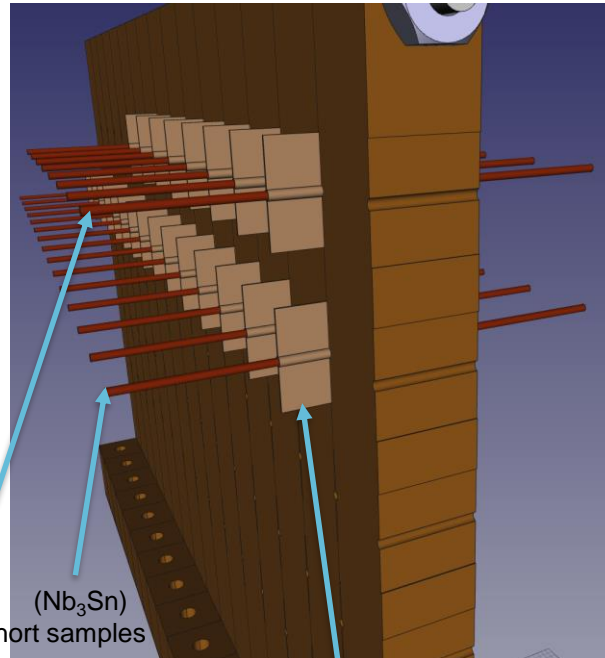
Sample holder

5 (vertical) x 15 (horizontal) Samples can be inserted



Beam pulses

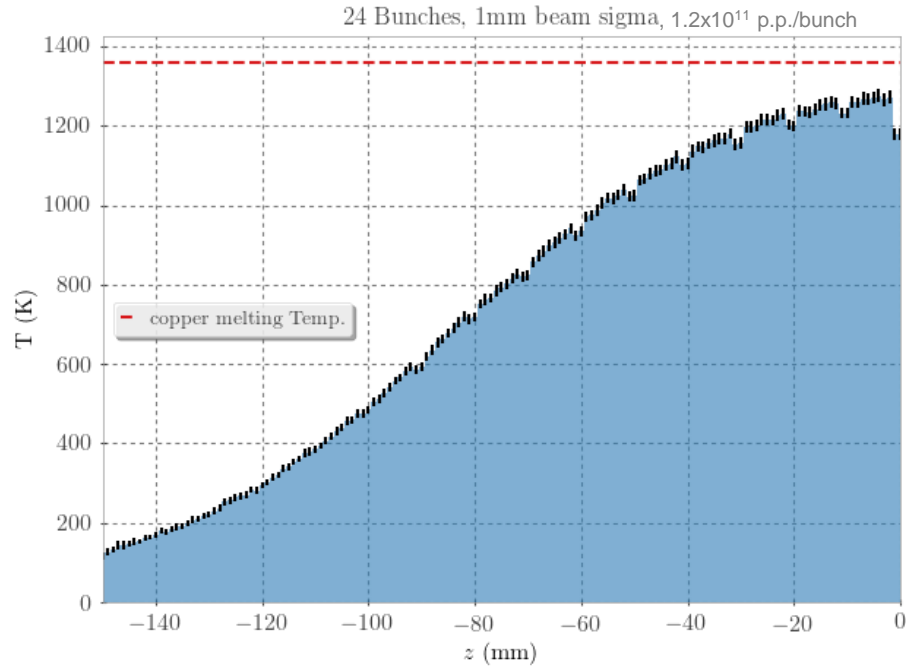
(Nb-Ti) Strand short samples
(Nb₃Sn)



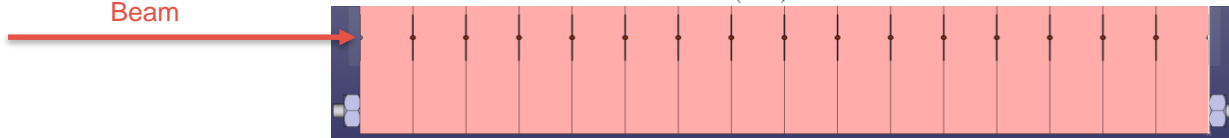
Thin Polyimide sheets

- Pulse list
- 80 pilot bunches for beam based alignment
 5×10^{10} p.p./bunch
- 6x24 bunches with
 1.2×10^{11} p.p./bunch

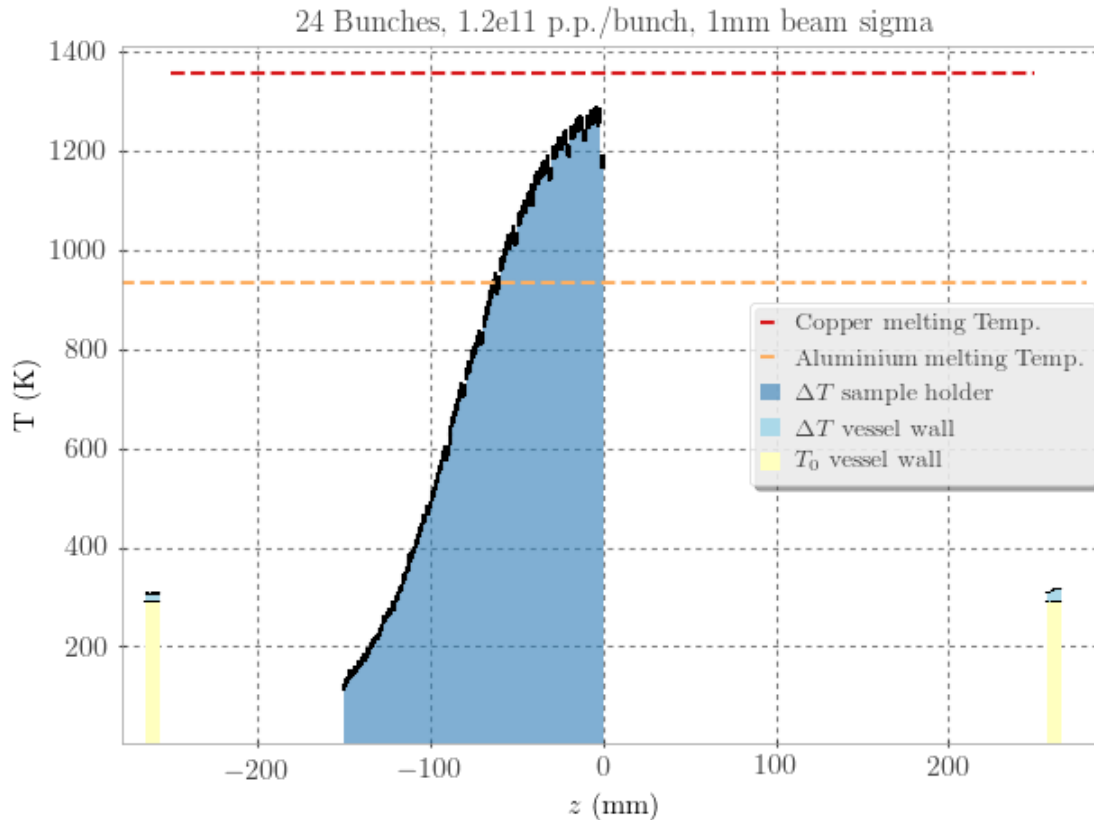
Sample holder - energy deposition



Beam



Energy deposition in the vessel wall



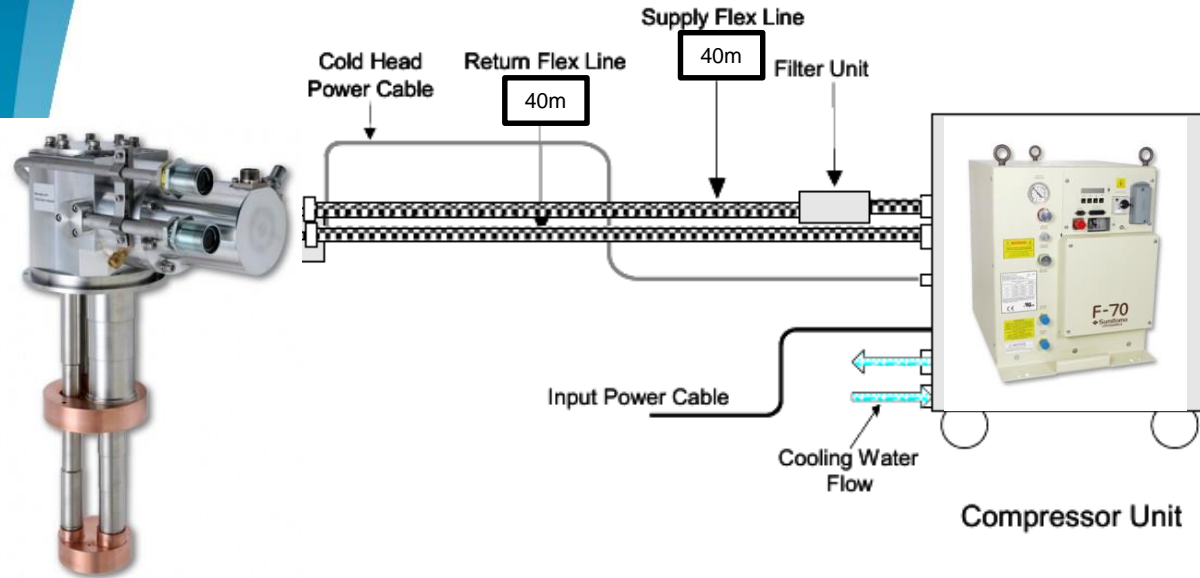
Conclusion

- HRMT37 as a follow-up of HRMT31
 - Stronger focused on Nb₃Sn
 - At cryogenic temperatures (4K) to understand and verify the observed degradation mechanisms
 - 6x24 bunches with 1.2×10^{11} p.p./bunch + pilots for alignment → total $\sim 2.2 \times 10^{13}$ protons
 - Cool-down 3-6 months
 - Cryogen-free
 - No risk of Melting vessel or sample holder



Thank you for your attention!

Cryocooler unit (Sumitomo RP-082B2 4K Pulse Tube)



- Cooling power
 - 1W at 4K on the 2nd stage
- 40 m compressed He flex lines and motor cable, from compressor to cold head

Schematics, drawings and images from Sumitomo compressor unit datasheet and webpage
<http://www.shicryogenics.com/products/pulse-tube-cryocoolers/>

