PSI Center for Accelerator Science and Engineering

Radiation damage to MHP45/46 magnetically coupled linear drive

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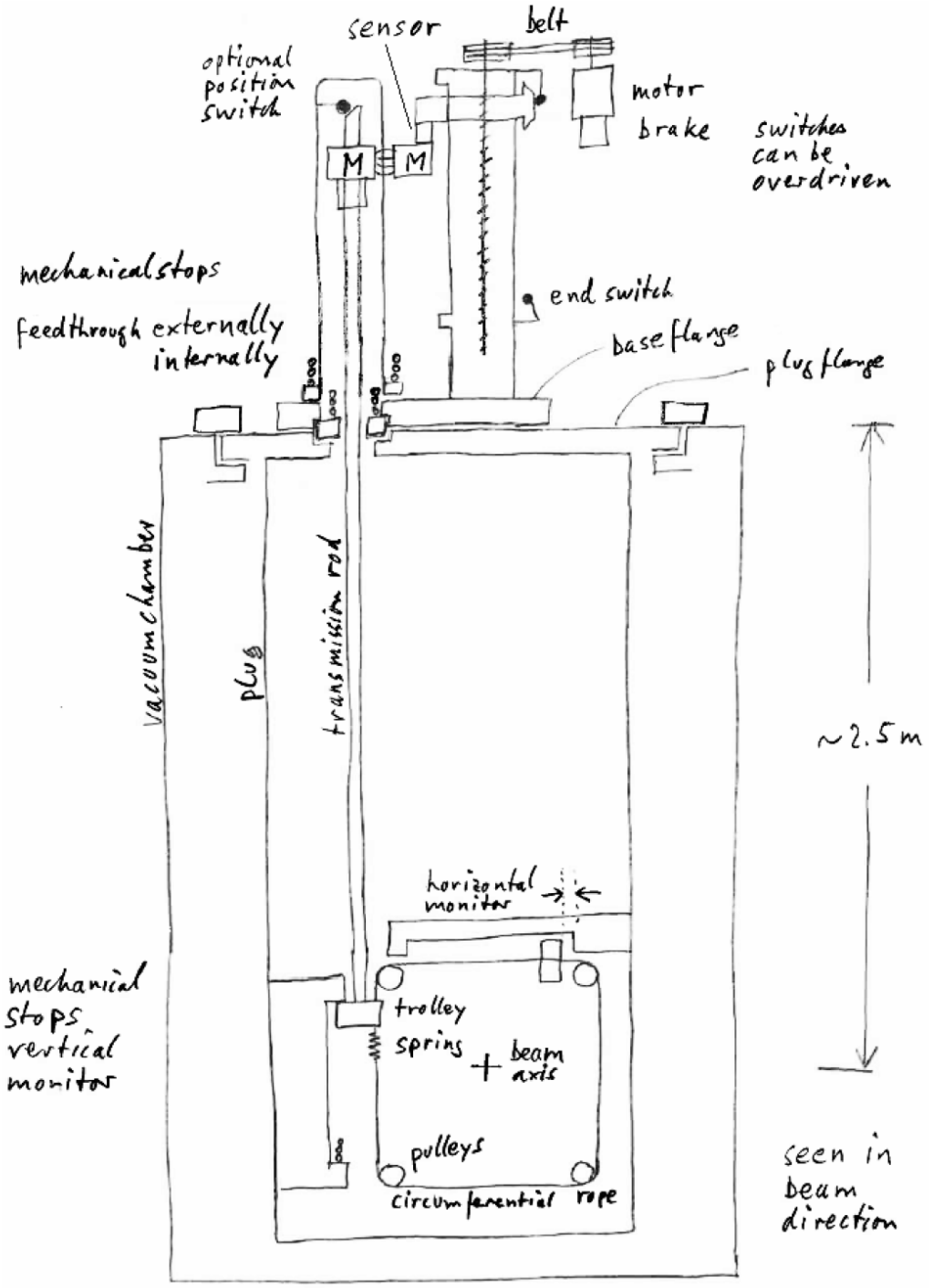
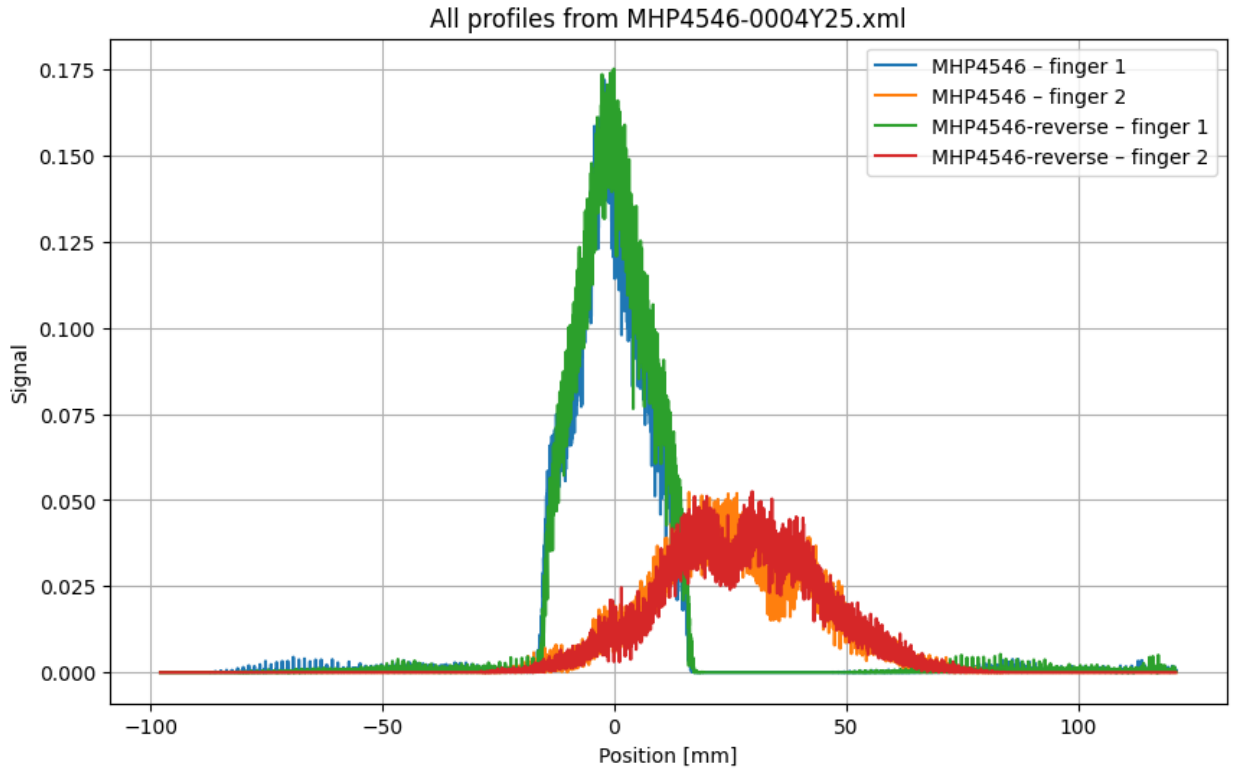
Magnetically coupled linear drive

- MBPT1 and MHP45/46 use magnetically-coupled linear drive with NdFe permanent magnets.
- This is an elegant solution (motor does not have to counteract atmospheric pressure).
- But permanant magnets suffer from radiation damage. Literature shows that after 10^{17} n/cm^2 magnets may completly loss their properties.
- SmCo magnets withstand much higher dose, but they contain Cobalt, which becomes very radioactive.



MHP45/46 usage

- In 2024 MHP34/46 was used 126 Times (commissioning phase).
- In 2025 we have used it only 4 times, last time December 18th, 2025.



Reading of activation foils

Two activation foils installed, weighting 15.8 g each in 2024:

- On the linear drive
- On the protective shield

Composition: Permendur samples, proposed by Roman Galeev, main components Fe and Co.

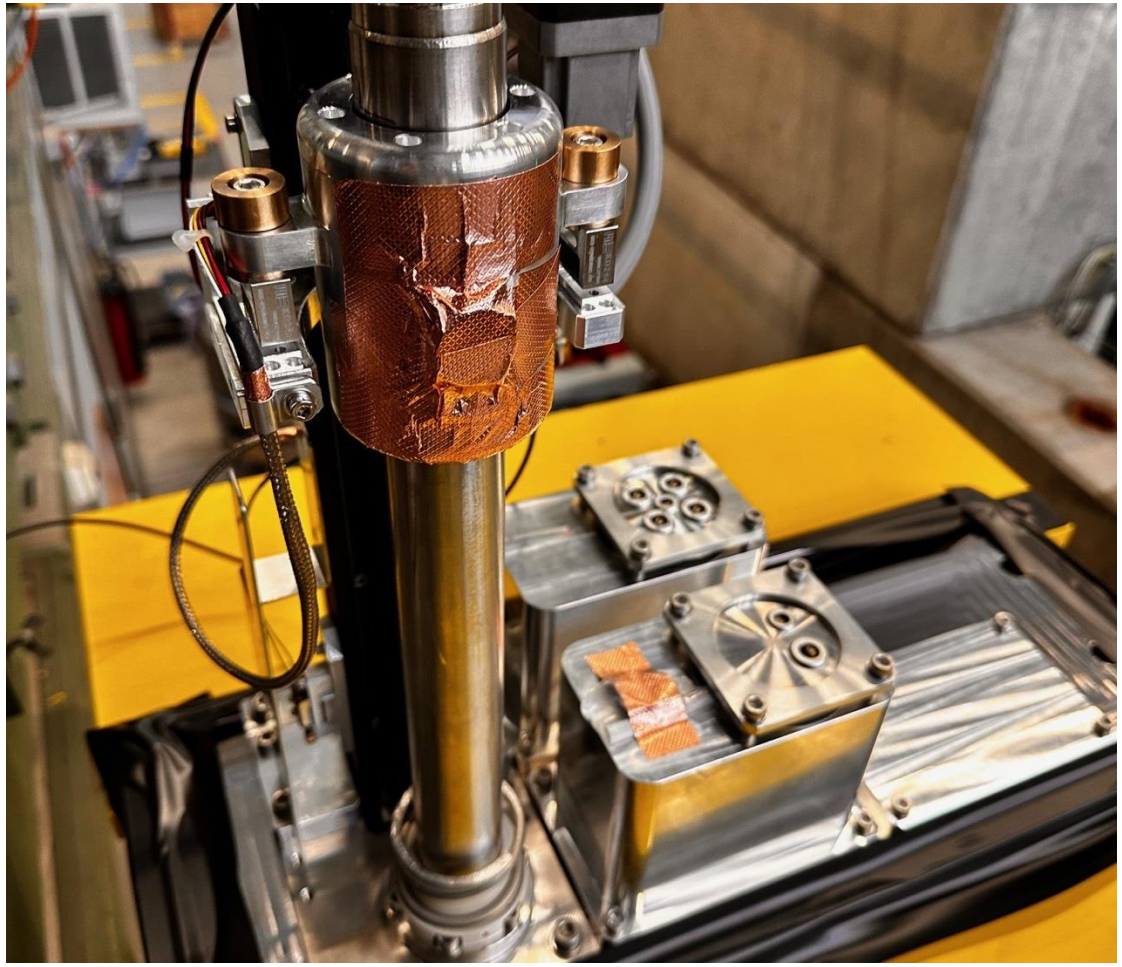
Roman is gone, nobody seems to understand why he has chosen this material. They become cobalt-sources.

Activation after removal on March 17, 2026:

- 1.3 mSv/h (Oberflasche) for foil on the shield.
- 0.91 mSv/h for the linear drive.

Back of an envelope calculation gives 10^{13}-10^{14} n/cm^2

To do: obtain neutron fluence from this.



Magnet strength measurements

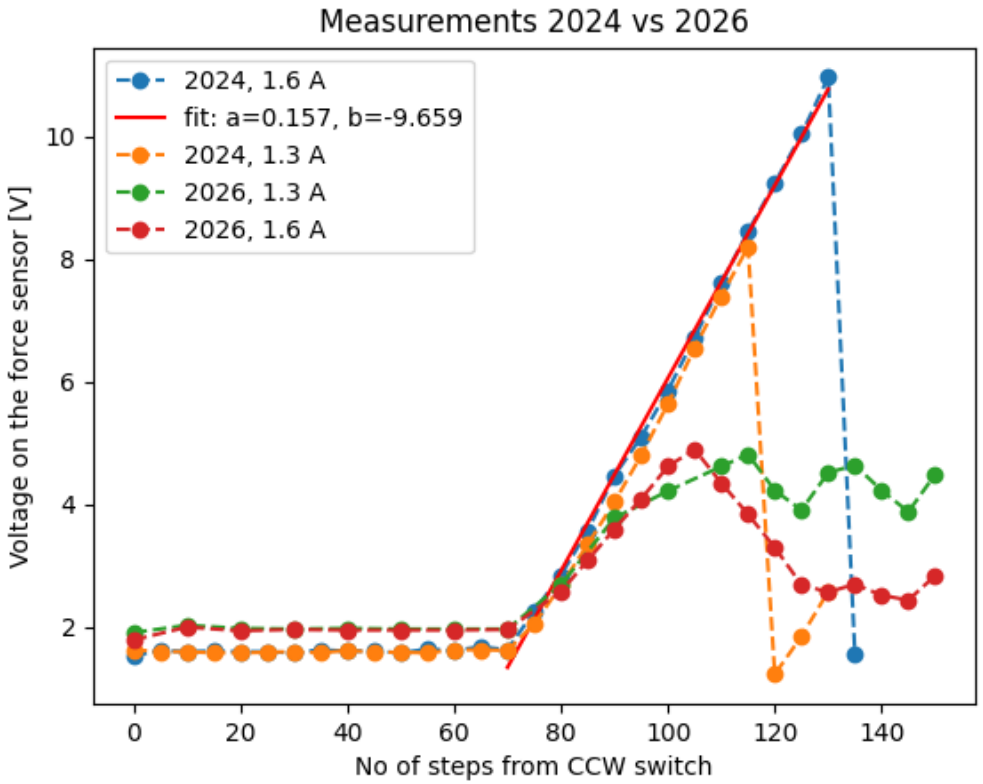
The magnet strength measurement procedure:

1. Use manual drive.
2. Override CCW limit switch.
3. Observe the force sensor as the motor tries to decouple the magnets of the linear drive.

Measurements in 2024 show clear linear dependence and force reaching 270 N (10 V).

Data from last week look very much degraded. Is that magnet damage? I see also polarity flip (negative voltages) at high step count.

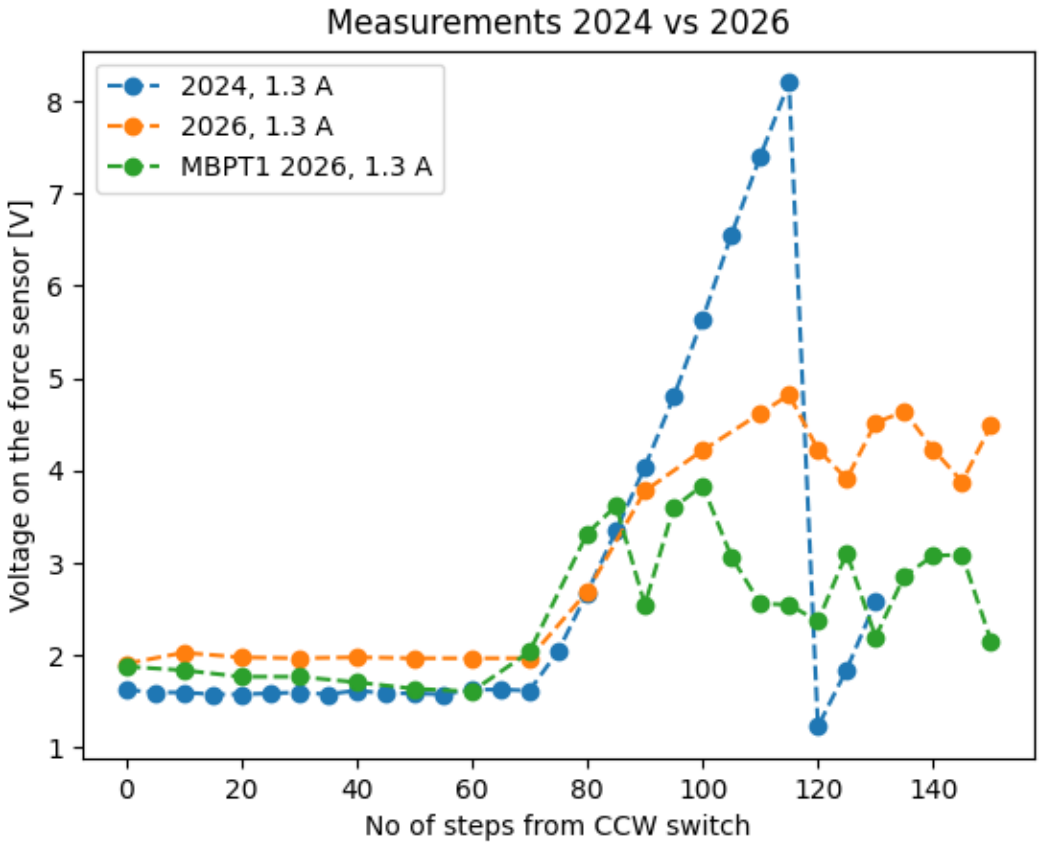
Also: at 1.3 A we lost about 30 steps,
at 1.6 A no steps were lost.



MBPT1 Magnet strength measurements

Same procedure as for MHP45/46.

- Puzzling outcome.
- MBPT1 is installed since 2023.
- In 2025 no scan was done with this test monitor. Last scan: October 2024.



Summary

1. The fluence registered on the outside of the linear drive seems to be ~10^{14} n/cm^2, so far away from level of 10^{17} n/cm^2 at which NbFe magnets loose their magnetisation. Both numbers have to be confirmed.

2. MHP45/46 performed correctly in December 2025.

3. Magnet strength measurements were difficult, but several sessions gave similar results suggesting degradation of the magnets. Or maybe problem with measurement procedure?

4. Piezzoelectric sensors are also sensitive to radiation. Radiation damage can also affect the sensor. Typical effect is baseline drift which we probably see in the initial „plateau”.

What to do? HIMB linear drives are ordered, construction of the two scanners start later this year.