COMSOL simulations for nTMM and optical potential calculation

Linus Persson, linus.persson@fysik.lu.se

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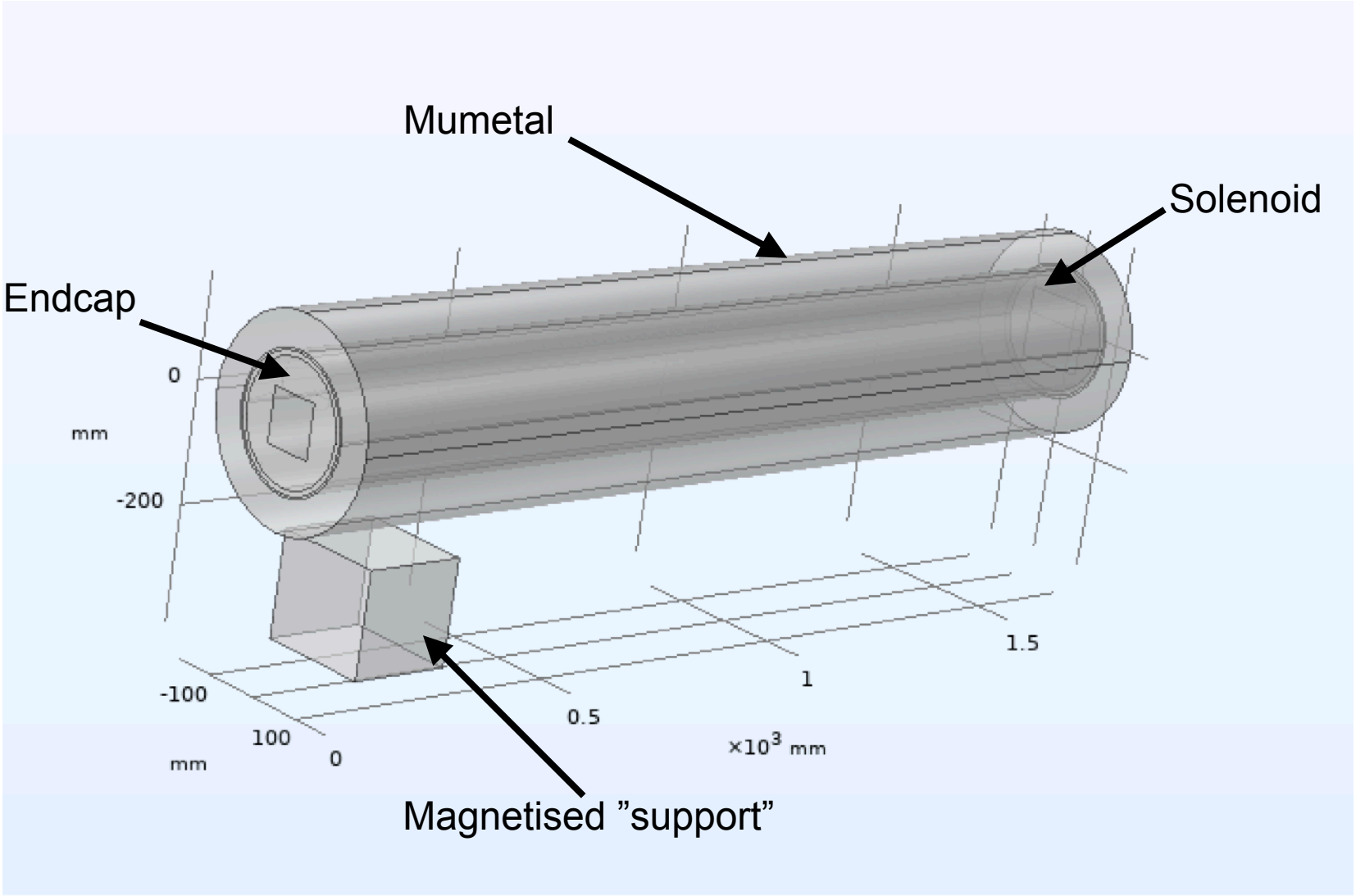
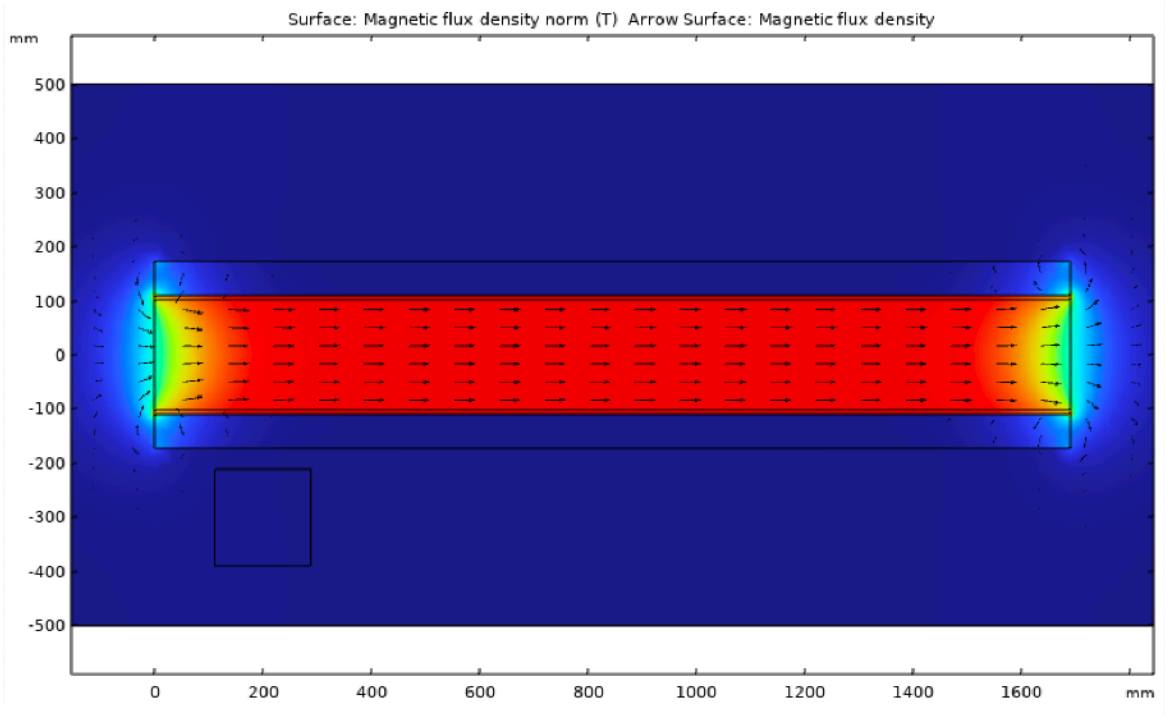
COMSOL configuration

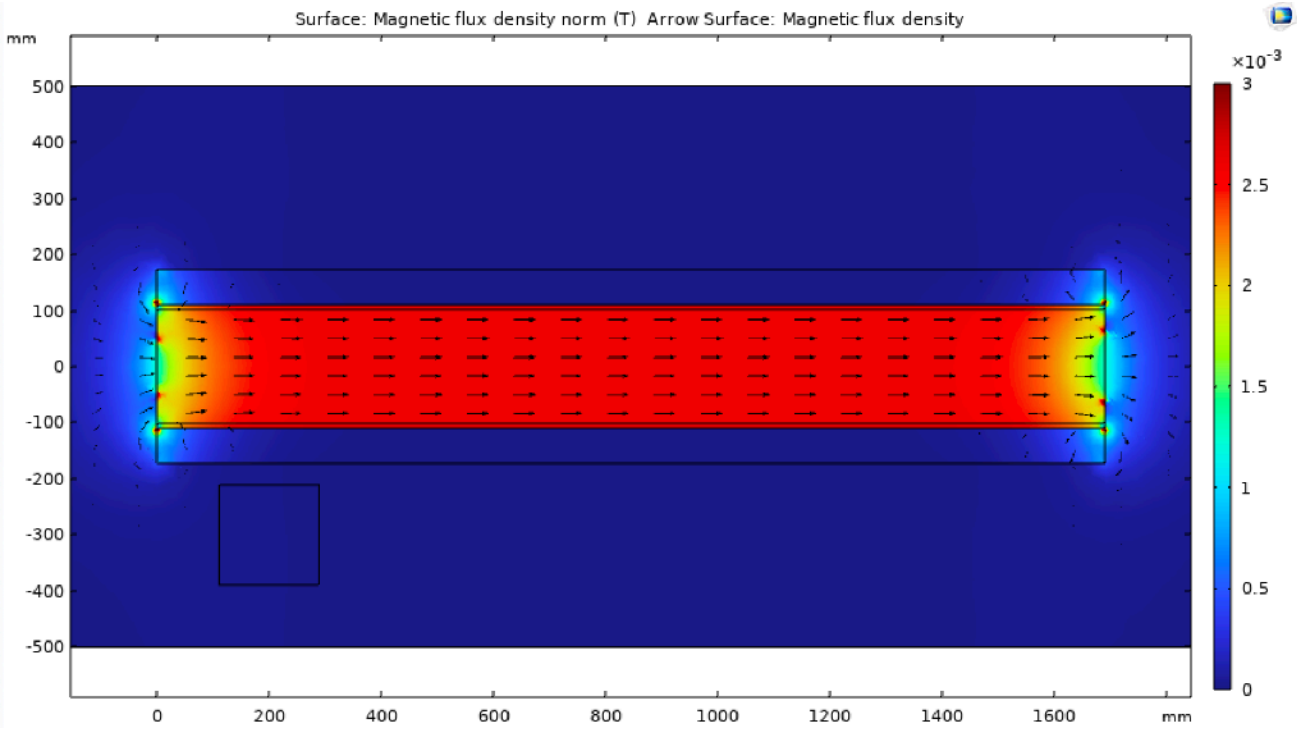


Flux density maps with/without endcap

Without endcap



With endcap



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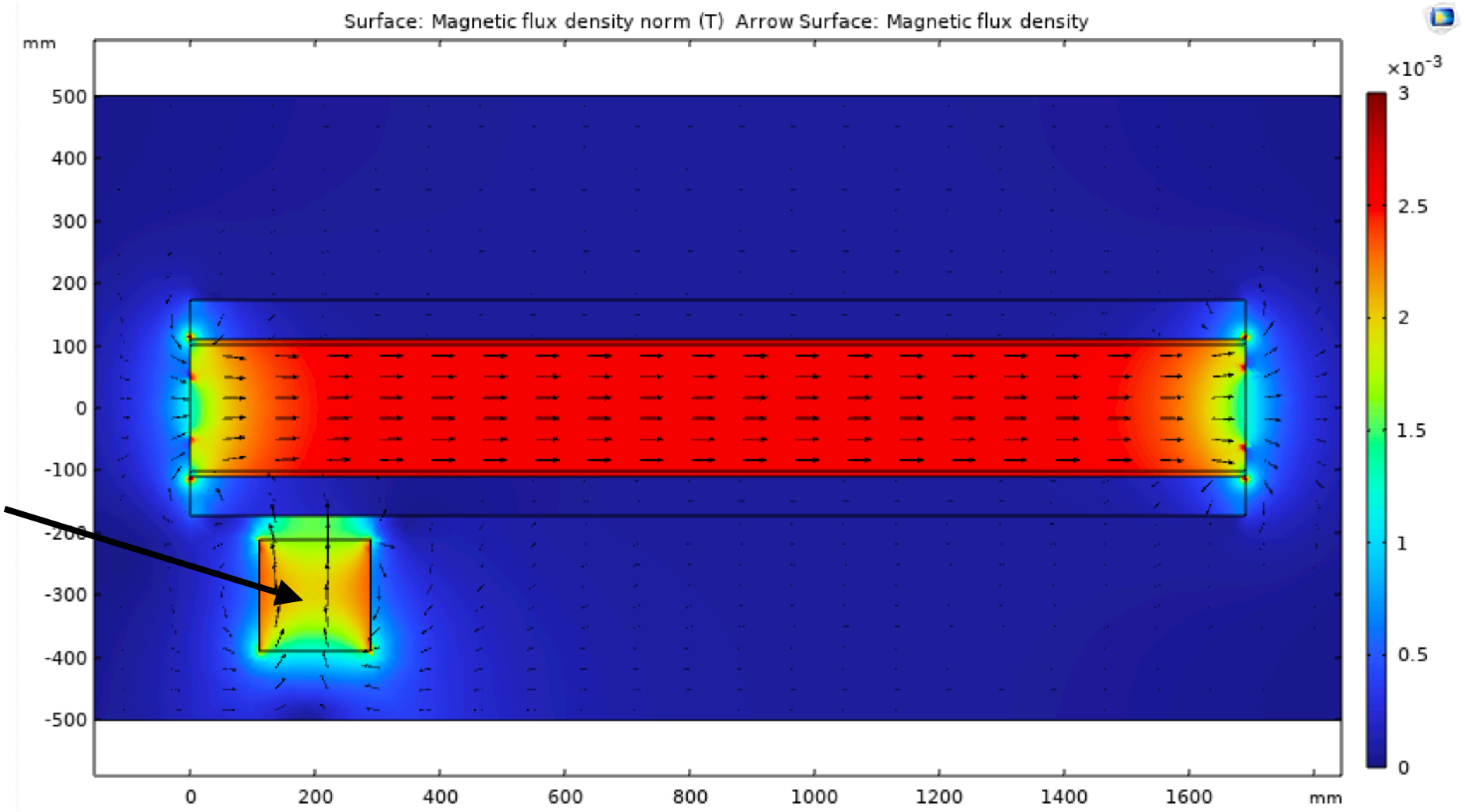
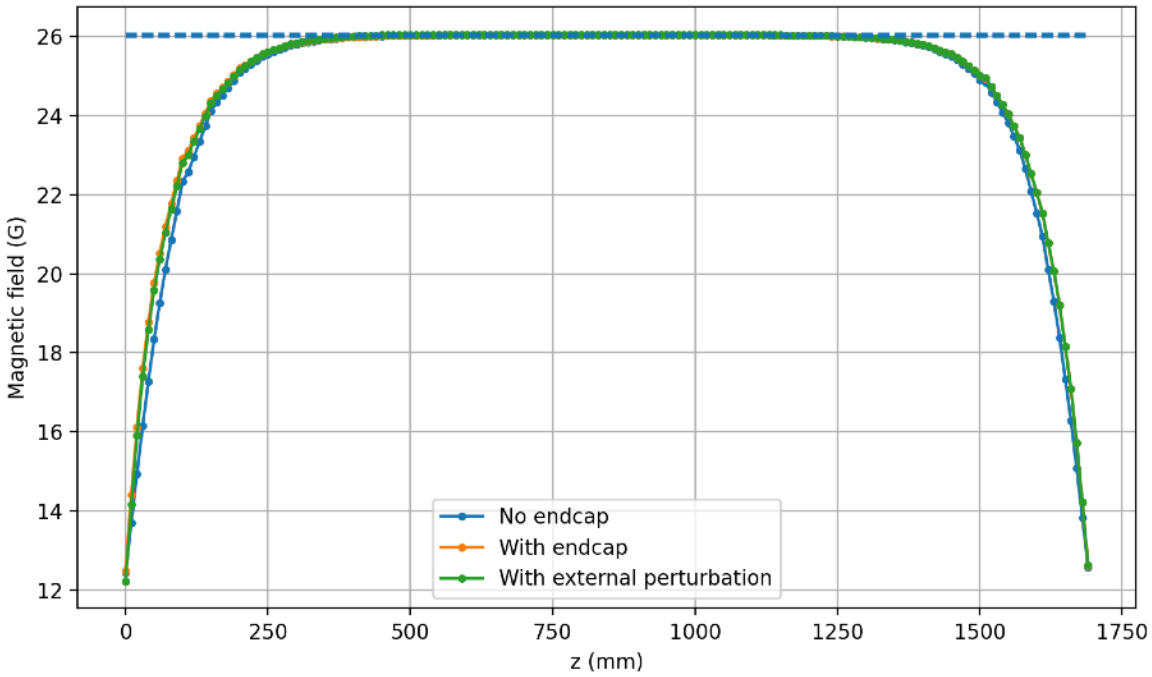
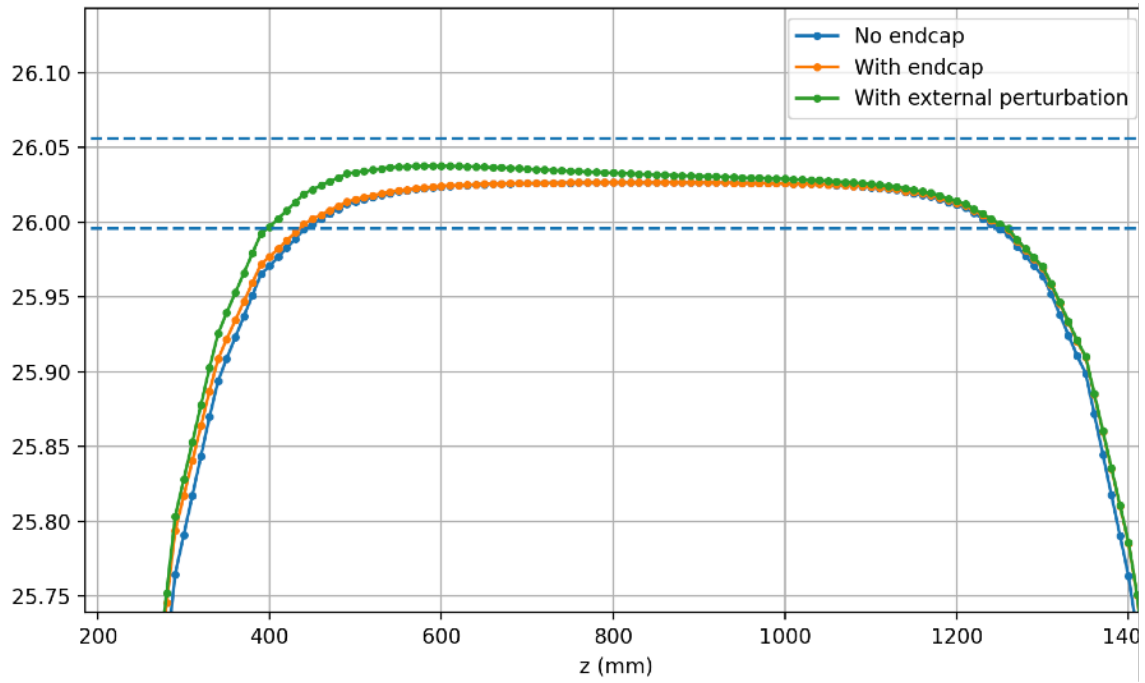
Flux density map with external perturbation

Remanent flux density 30 G



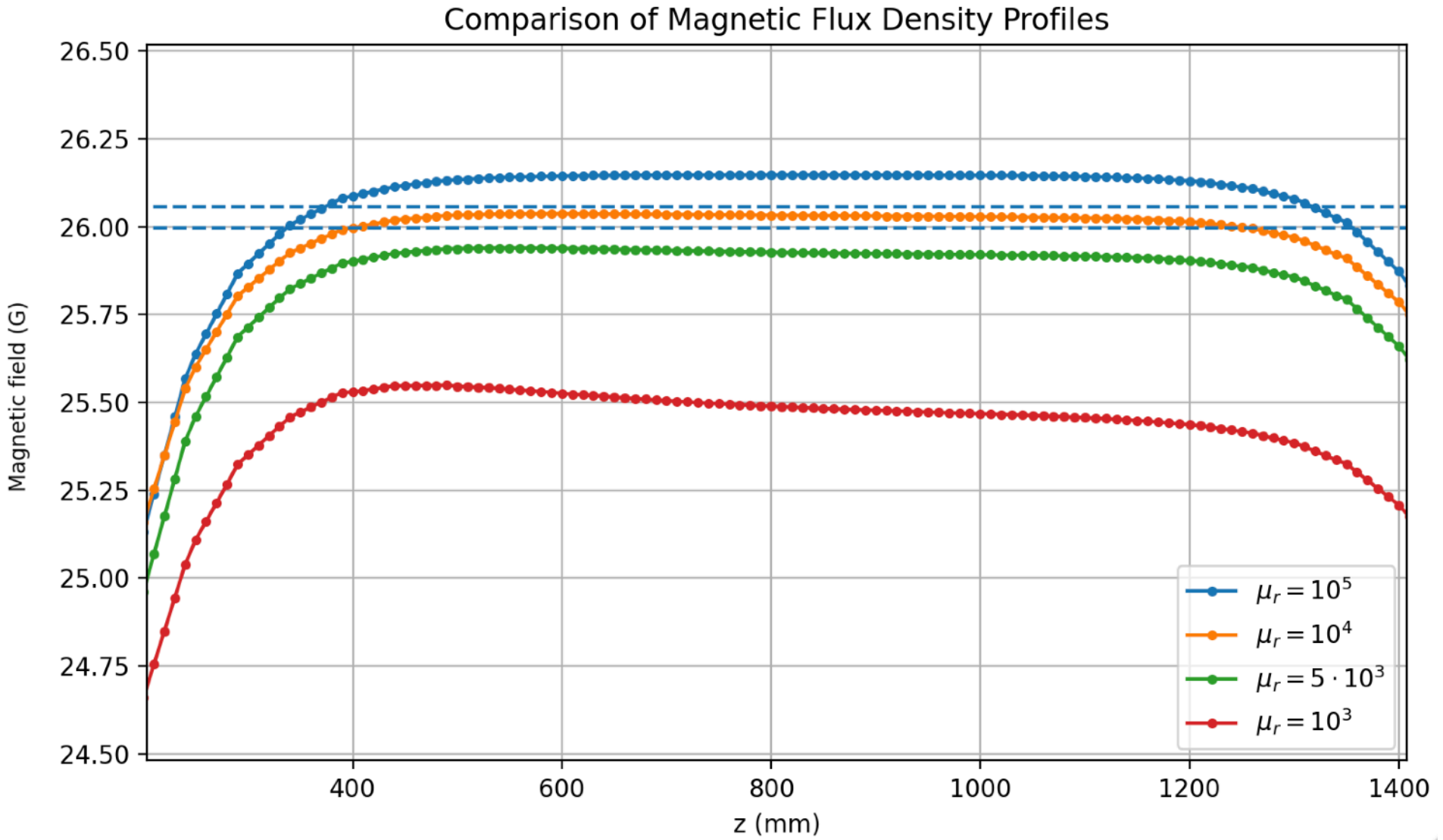
Total magnetic field along cylinder axis





Here $\mu_r = 10^4$ and thickness 0.6 mm is assumed

Varying the relative permeability of the shield



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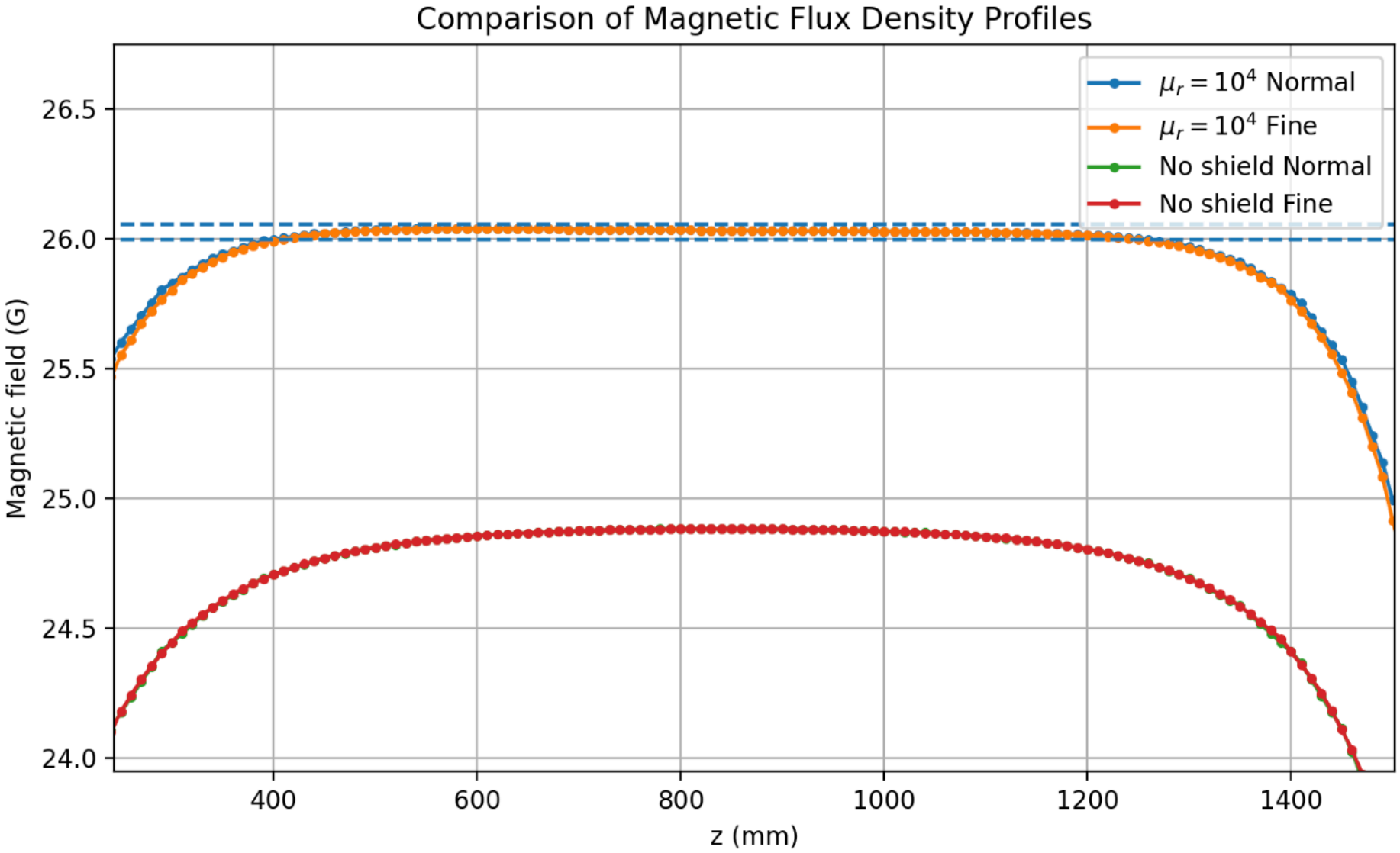
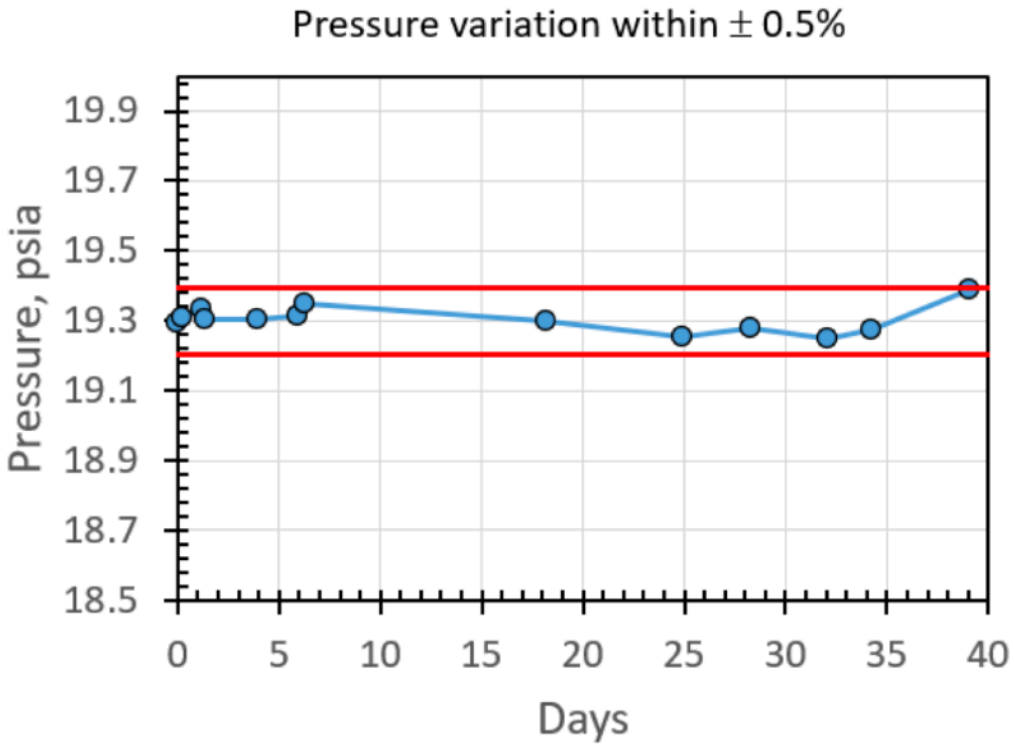
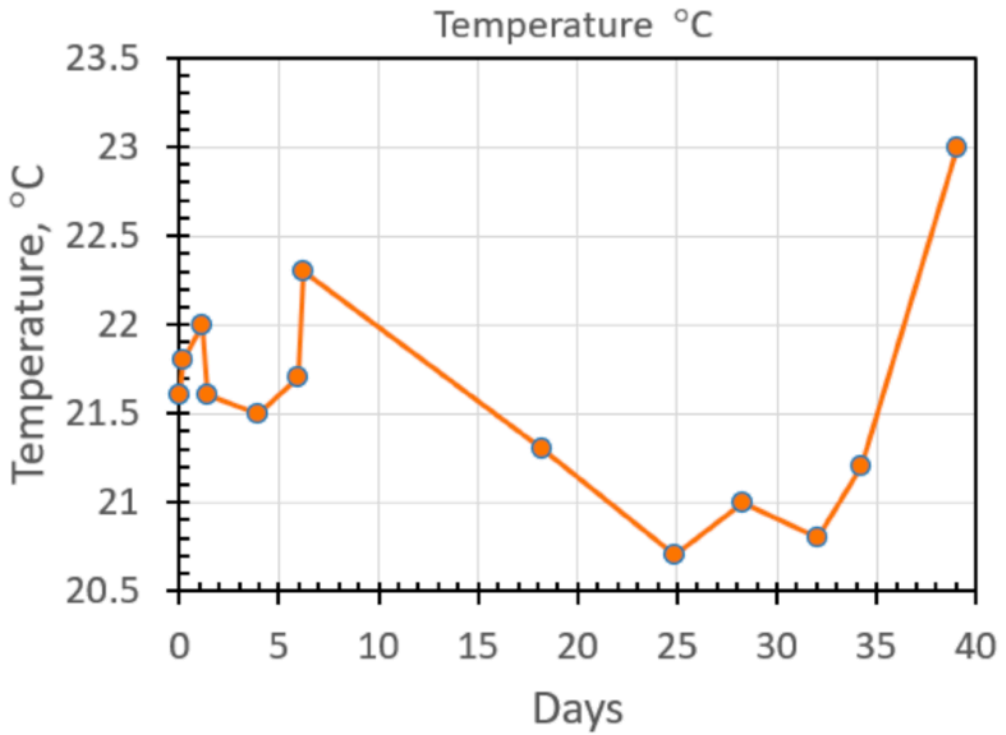
With/without shield (no perturbation) and varying mesh size



Pressure and temperature





$$N_{\text{ideal}} = \frac{p}{k_B T}$$

Magnet 1: 3.269(2) m^{-3}

Magnet 2: 3.271(2) m^{-3}

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Number density and coherent scattering length

Compressibility factor for CO_2 at (25°C, 1 atm) [1], (20°C, 1 atm) [2], (22°C, 1.3 atm) [3]: $Z = 0.994(2)$

$$N = \frac{N_{\text{ideal}}}{Z} = \frac{3.2709(13) \times 10^{25}\,\text{m}^{-3}}{0.994(2)} \approx 3.290(7) \times 10^{25}\,\text{m}^{-3}$$

Coherent scattering length [4]:

$$b_c = b_{\text{C}} + 2b_{\text{O}} = 6.6460(1)\,\text{fm} + 2 \cdot 5.803(1)\,\text{fm} = 18.252(2)\,\text{fm}$$

1. https://encyclopedia.airliquide.com/carbon-dioxide#properties
2. J. Hilsenrath et al. Tables of Thermal Properties of Gases. 1956.
3. https://www.peacesoftware.de/einigewerte/co2_e.html
4. NIST https://www.nist.gov/ncnr/neutron-scattering-lengths-list

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Optical potential and compensatory field strength

Optical Fermi potential:

$$V_F = \frac{2\pi\hbar^2}{m_n} N b_c = \frac{2\pi(1.054\,572 \times 10^{-34}\,\mathrm{Js})^2}{1.674\,928 \times 10^{-27}\,\mathrm{kg}} \cdot 3.290(7)\,\mathrm{m}^{-3} \cdot 18.252(2) \times 10^{-15}\,\mathrm{m}$$
$$\approx 2.505(5)\,\mathrm{J} \approx 0.1563(3)\,\mathrm{neV}$$

Compensatory magnetic field:

$$B = \frac{V_F}{\mu_n} = \frac{2.505(9)\,\mathrm{J}}{9.662\,365 \times 10^{-27}\,\mathrm{J/T}} \approx 2.592(5) \times 10^{-3}\,\mathrm{T} = 25.92(5)\,\mathrm{G}$$

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