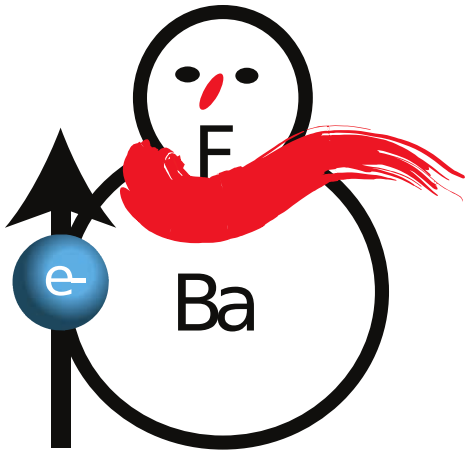
Measuring the electron electric dipole moment with BaF molecules

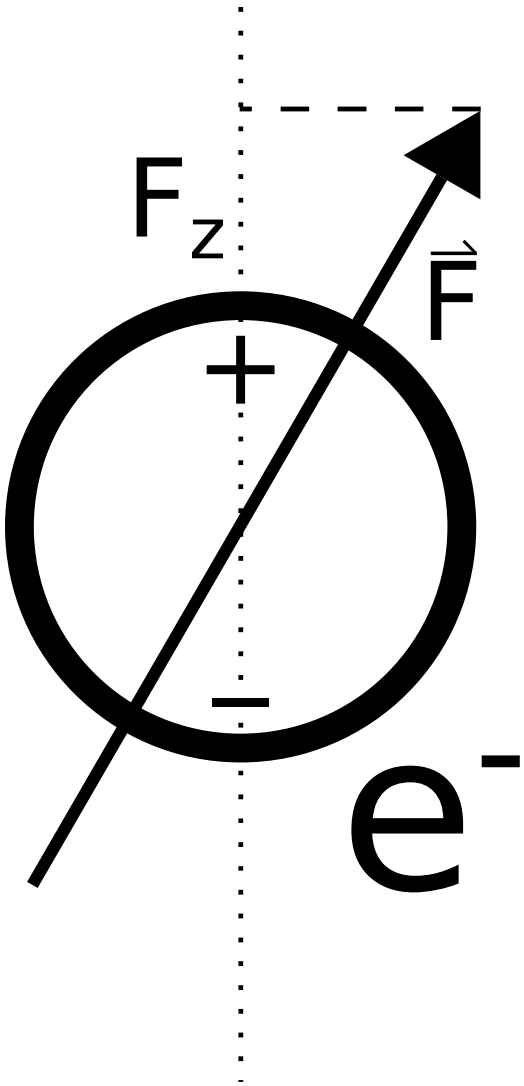
Thomas Meijknecht

NL-*e*EDM collaboration

2-11-18



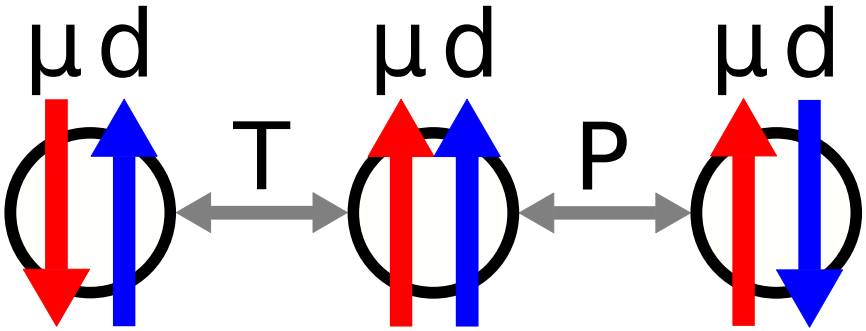
The electron electric dipole moment



The electron electric dipole moment

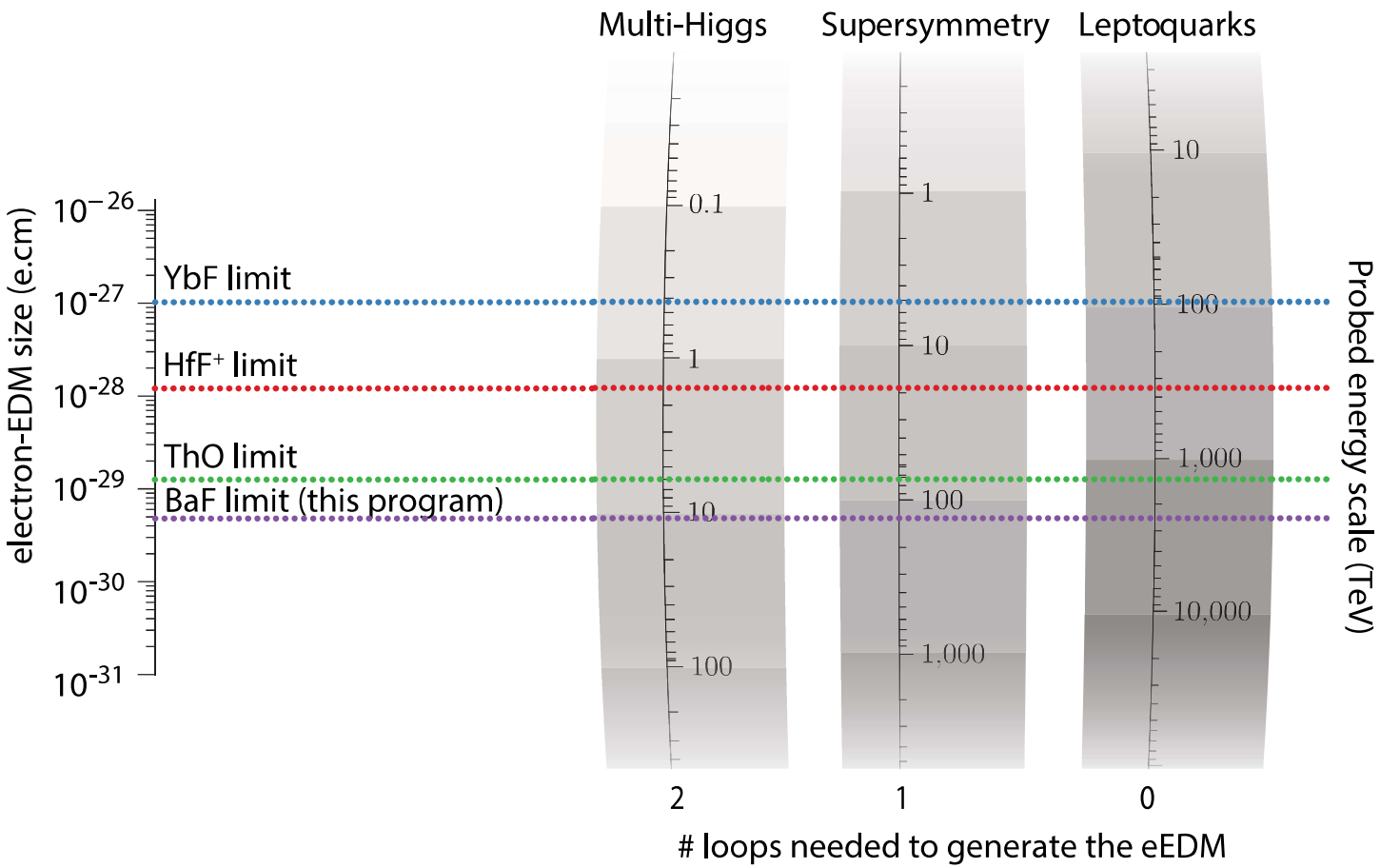
$$H = -(\mu\vec{B} + d\vec{E}) \cdot \frac{\vec{F}}{|\vec{F}|} \tag{1}$$

$$\text{where} \quad \vec{\mu} = \mu\vec{F} \quad \text{and} \quad \vec{d} = d\vec{F}. \tag{2}$$



Connection to theories: CP symmetry, CPT symmetry, ...

Electron electric dipole moment limits



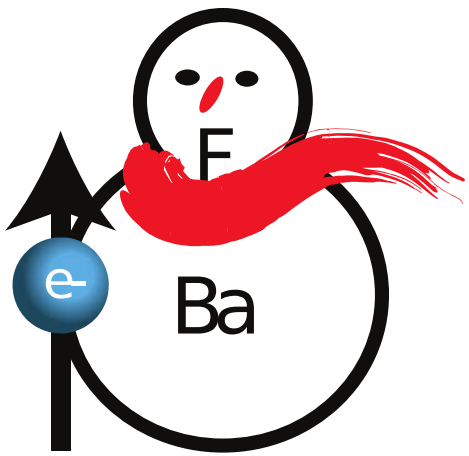
YbF, Imperial College London, 2011
HfF^+, Boulder Colorado, 2017

ThO, ACME, Yale, 2018

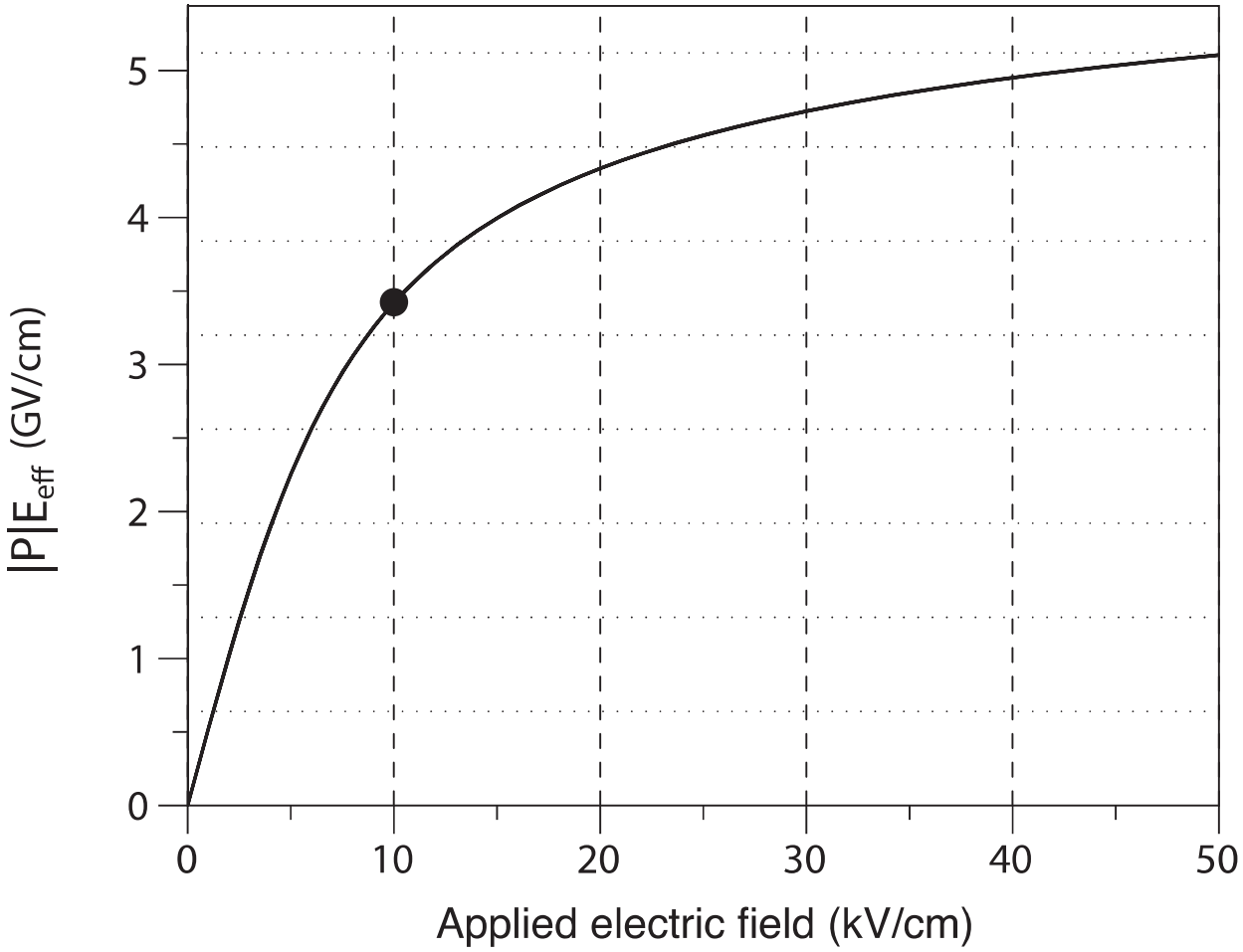
electron-EDM sensitivity

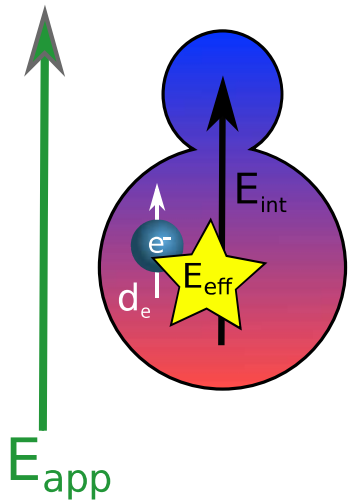
$$\sigma_d = \frac{\hbar}{2e} \frac{1}{|P|\, E_{eff}\, \tau \sqrt{\dot{N}\, T}}$$

$\lvert P \rvert$	Molecule Polarization
E_{eff}	Effective Electric Field
τ	Coherence Time
$\dot{N}$	Molecule Rate
T	Measurement Time



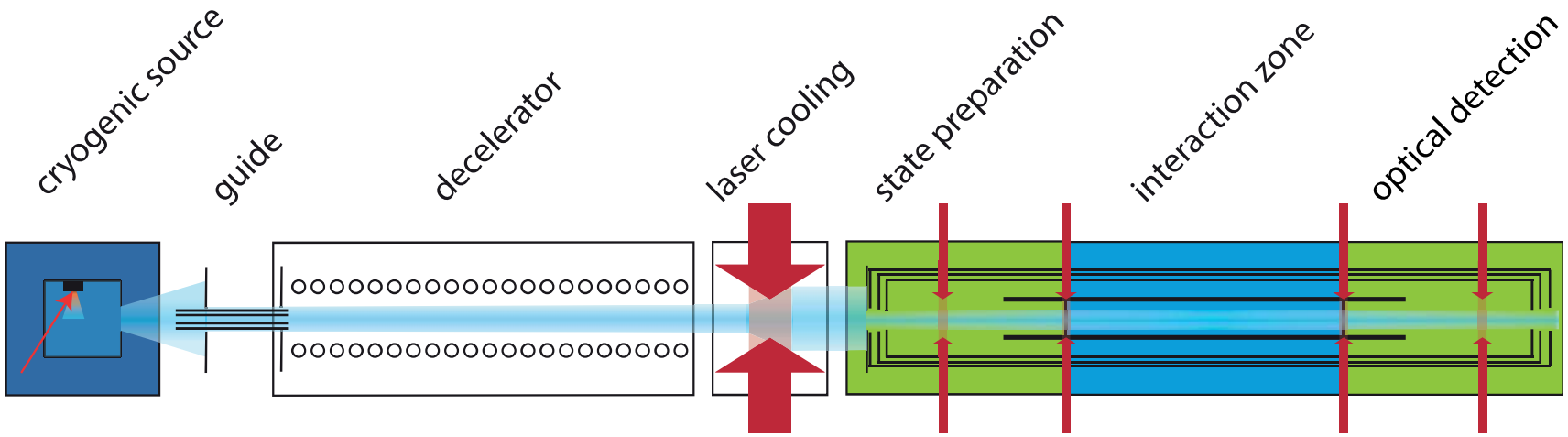
BaF: large E_{eff}



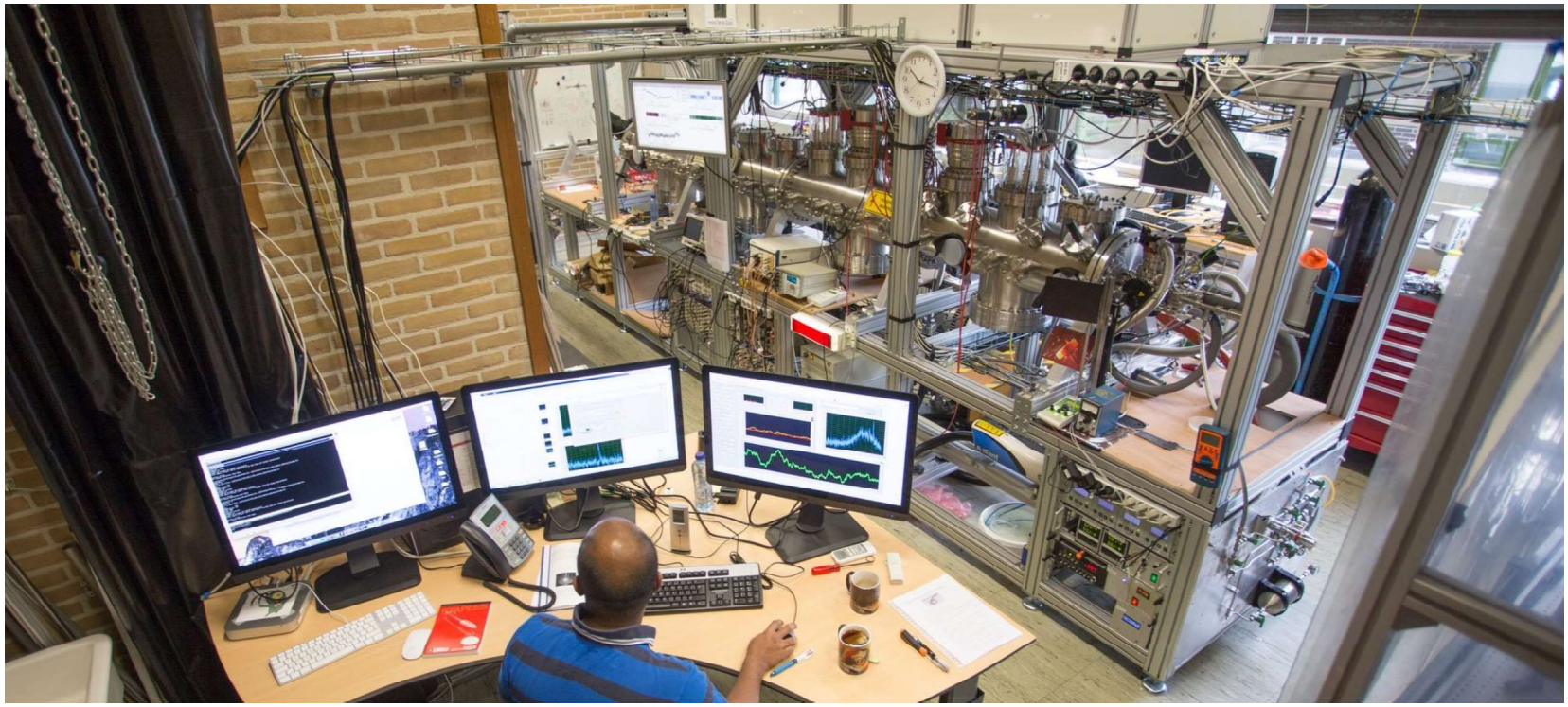


Steven, Pi

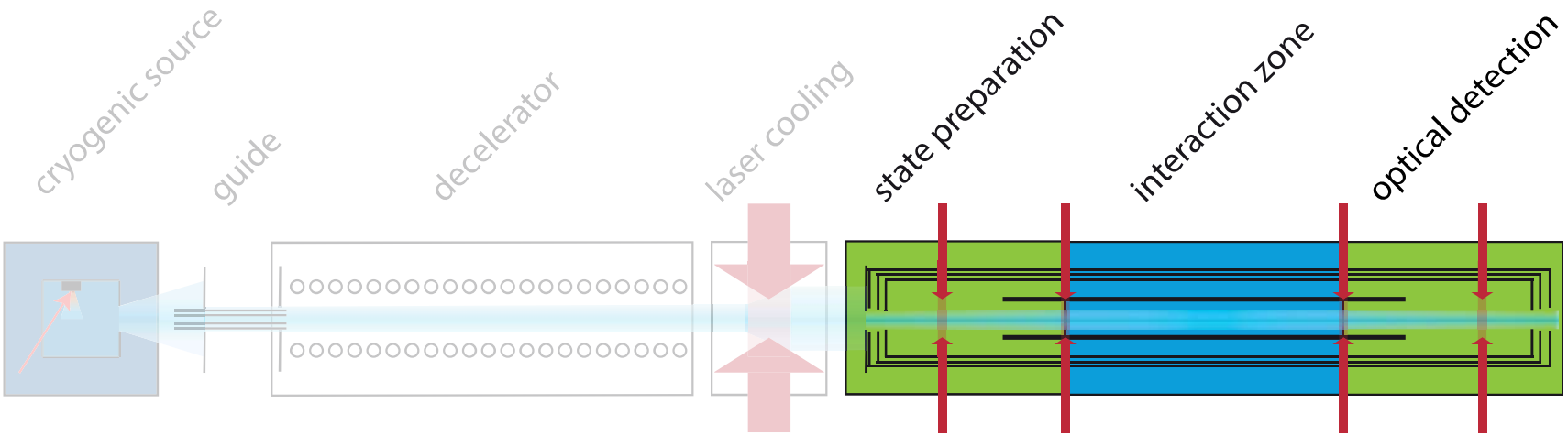
Experimental Setup



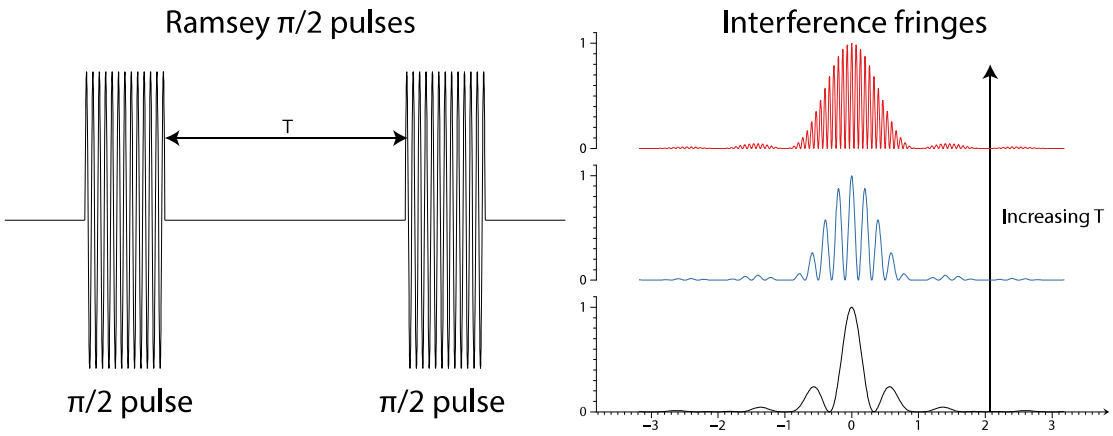
Experimental Setup



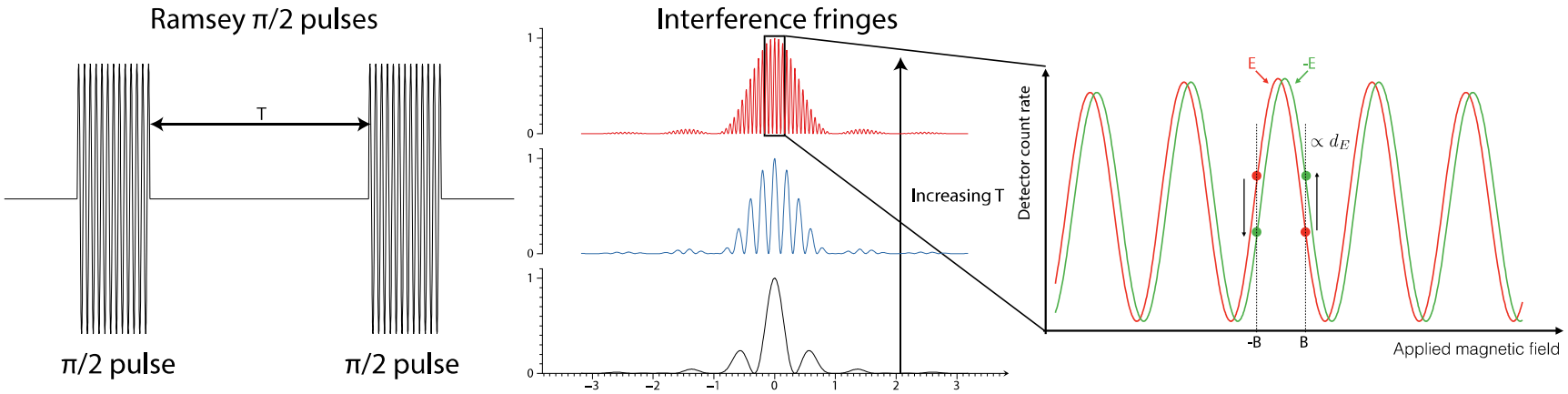
Experimental Setup: Interaction Zone



How to measure: Ramsey interferometry



How to measure an electron-EDM?

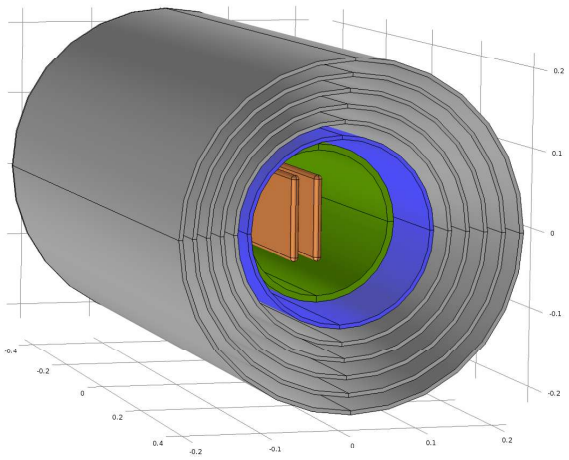


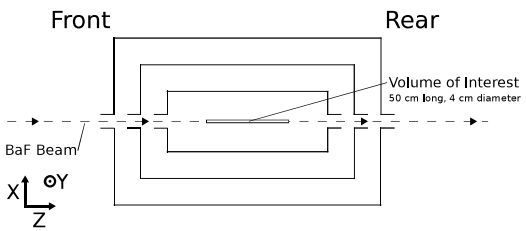
$$\text{Interferometer Phase: } \phi = (\pm d_E E + \mu B)\frac{T}{\hbar}$$

Desired fields:

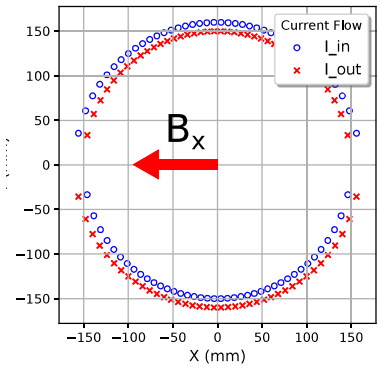
- $B = 600\,\text{pT} = 10^{-5} \times B_{\text{earth}}$
- $E_{\text{app}} = 10\,\text{kV/cm} \rightarrow E = E_{\text{eff}} = 3.4\,\text{GV/cm}$
- Small gradients: 1 % inhomogeneity

Interaction Zone

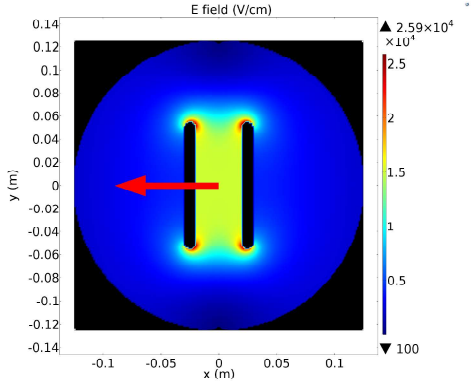




μ-metal magnetic shield

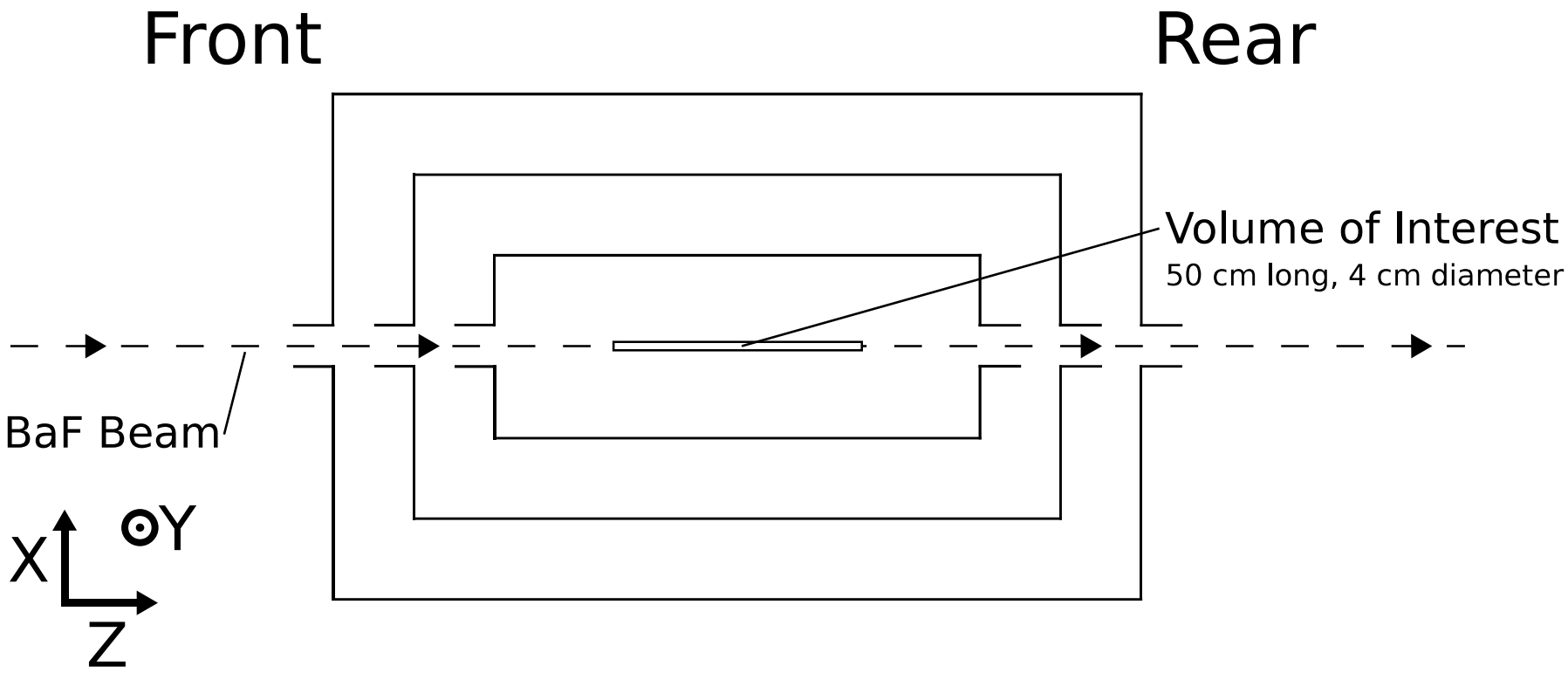


B field

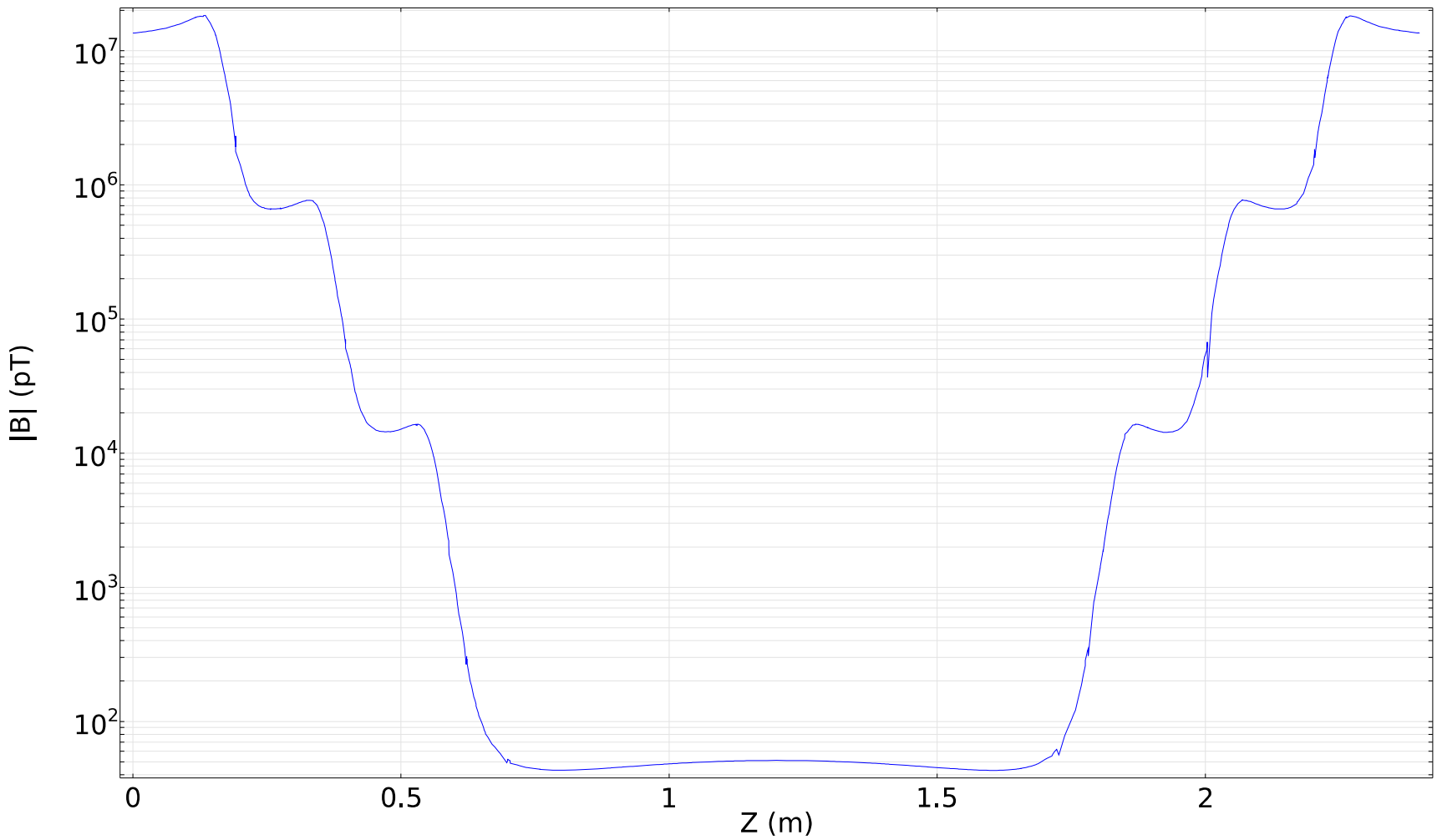


E field

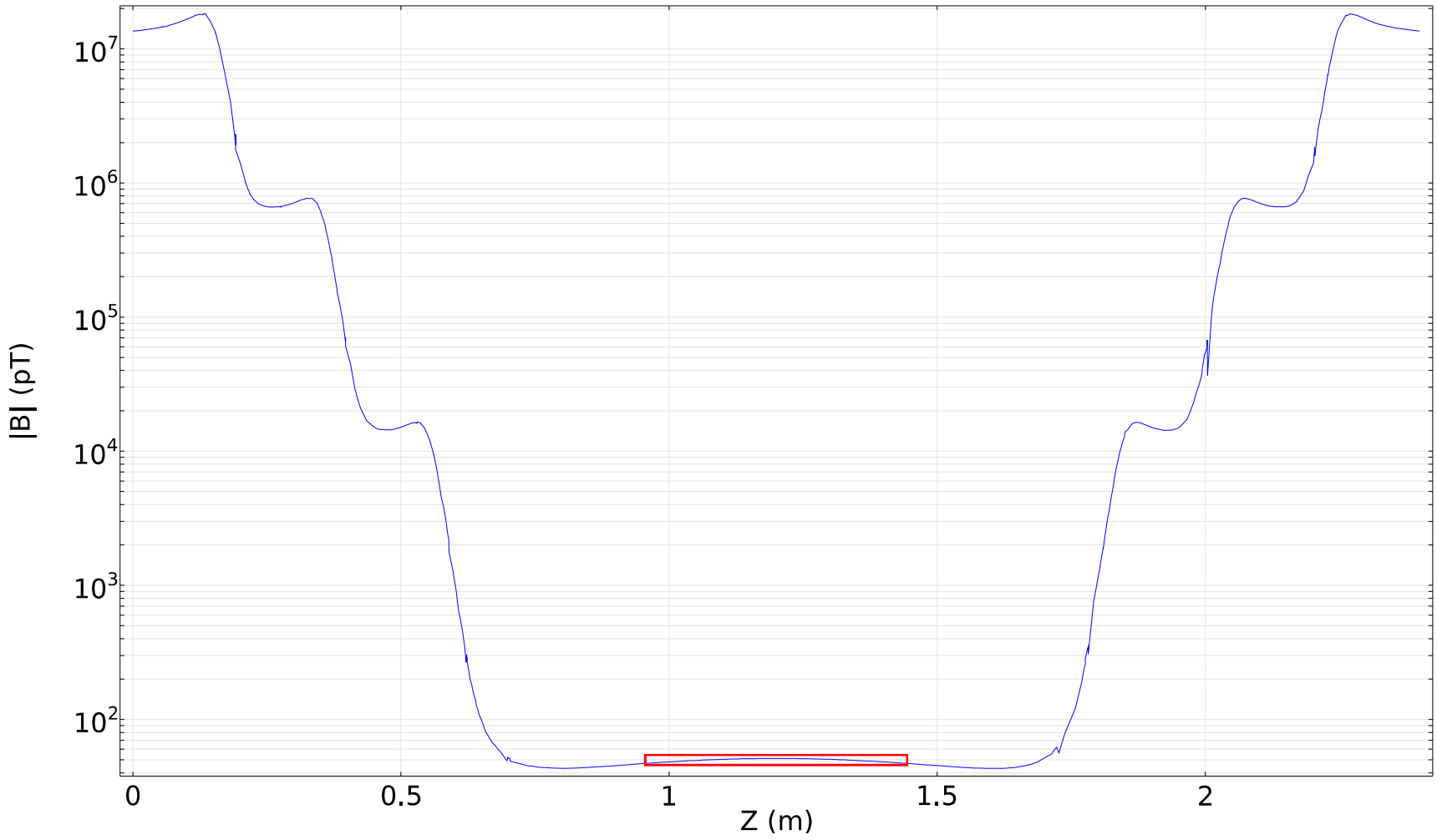
Suppress environmental B field



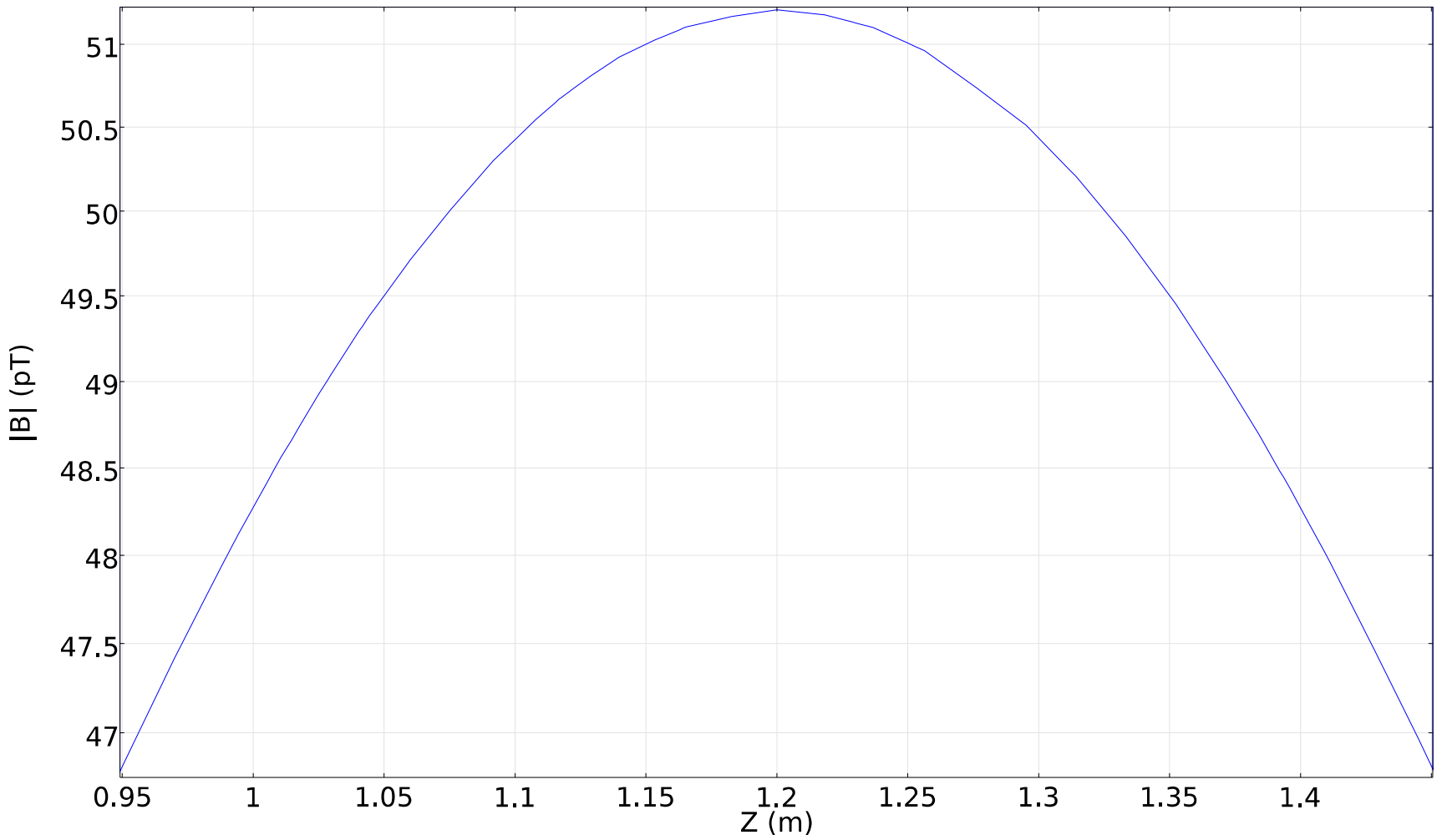
Shielding factor: 10^5



Volume of Interest

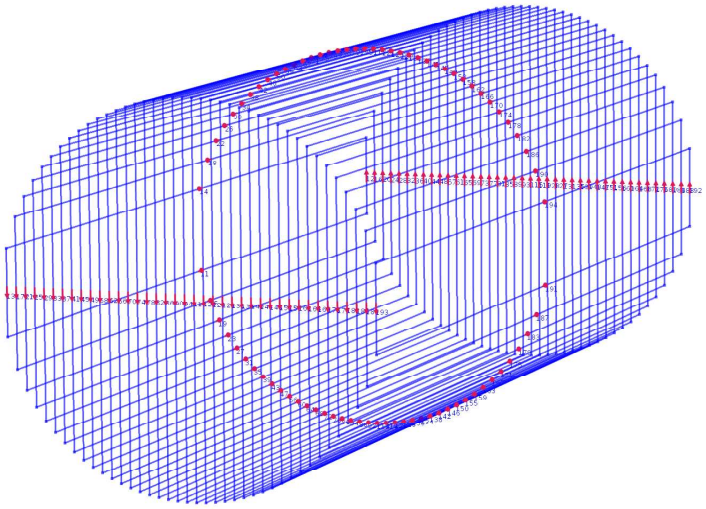


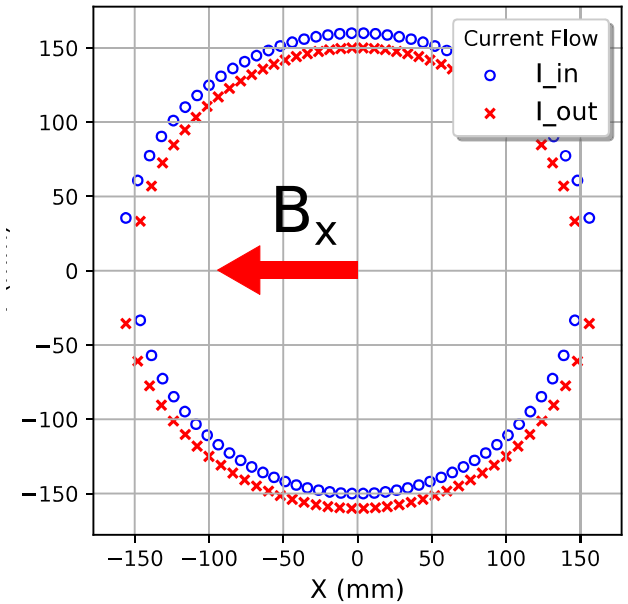
Volume of Interest



4 pT/600 pT <1% Inhomogeneity

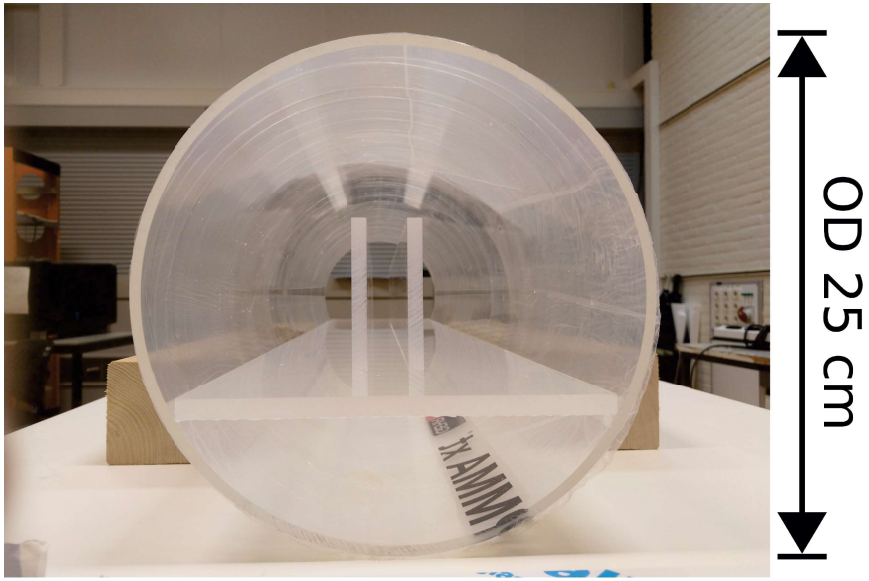
Generate homogeneous holding B field: 600 pT



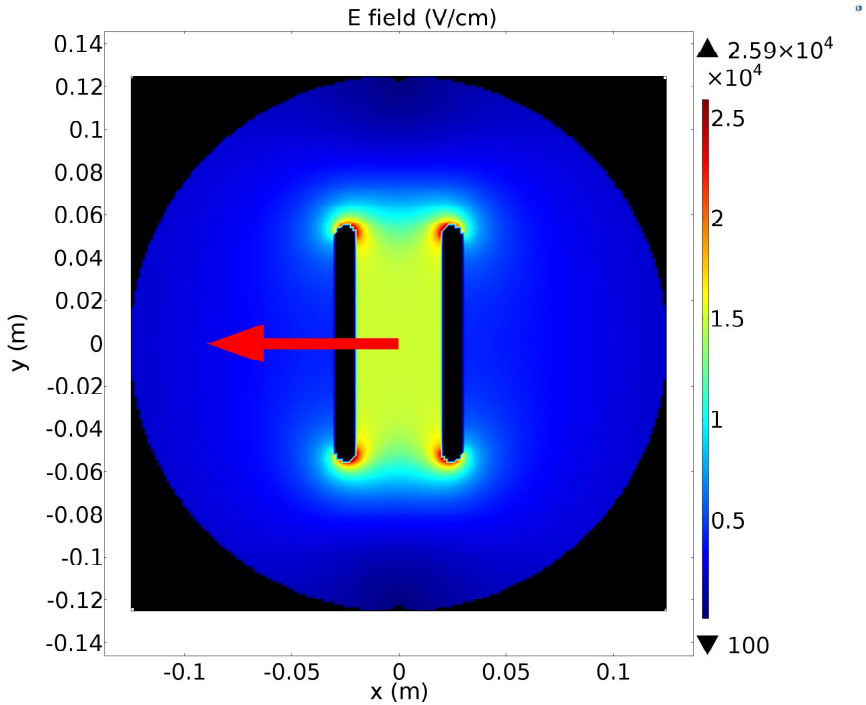


- Design finished: Double Cos θ coils
- Nikhef workshop works on implementation

Generate homogeneous E field: 10 kV/cm



Mockup



- Design finished: Use ITO coated glass plates
- From commercial company

Summary

- Measure electron-EDM with BaF molecules
- Requires well defined conditions for
  - E, B, etc.
  - With small gradients
- Current interaction zone design
  - Reach such conditions

For more general program information:

Measuring the electric dipole moment of the electron in BaF

arXiv:1804.10012, accepted by EPJD

NL-eEDM collaboration