n2EDM Ramsey Chamber

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Introduction

The measurement of an electric dipole moment (EDM) probes new sources of **CP** violation and physics beyond the Standard Model. These measurements are typically done with Ultra-Cold Neutrons (UCN), whose energy is low enough that they can be stored. The sensitivity of the neutron EDM is given by:

$$\sigma_{d_n} \approx \frac{\hbar}{2\alpha\tau E\sqrt{N}}$$

where α is the signal visibility, τ the free precession period, E the applied electric field, and N the neutron count. The next generation neutron EDM experiment at PSI, n2EDM, aims for a sensitivity of $\sigma_{d_n} \sim 1 \times 10^{-27} e \cdot \mathrm{cm}$. This requires an improvement in operational electric field from 11 kV/cm (nEDM) to 15 kV/cm (n2EDM).

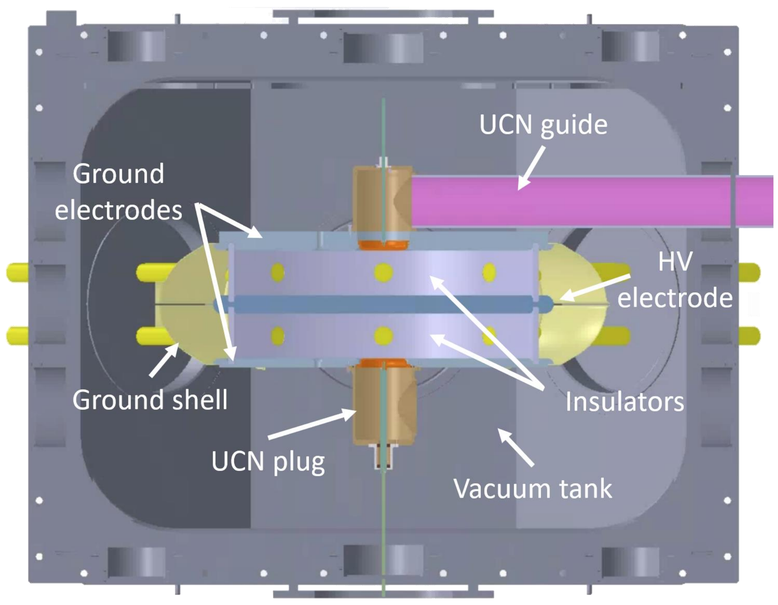

Figure 1: Schematic design of the n2EDM setup.

Validation

In the previous nEDM experiment at PSI, the maximum electric potential applied under ideal conditions was ±200 kV. Simulating the apparatus in a finite element analysis software (COMSOL) verified the experimentally achieved fields.

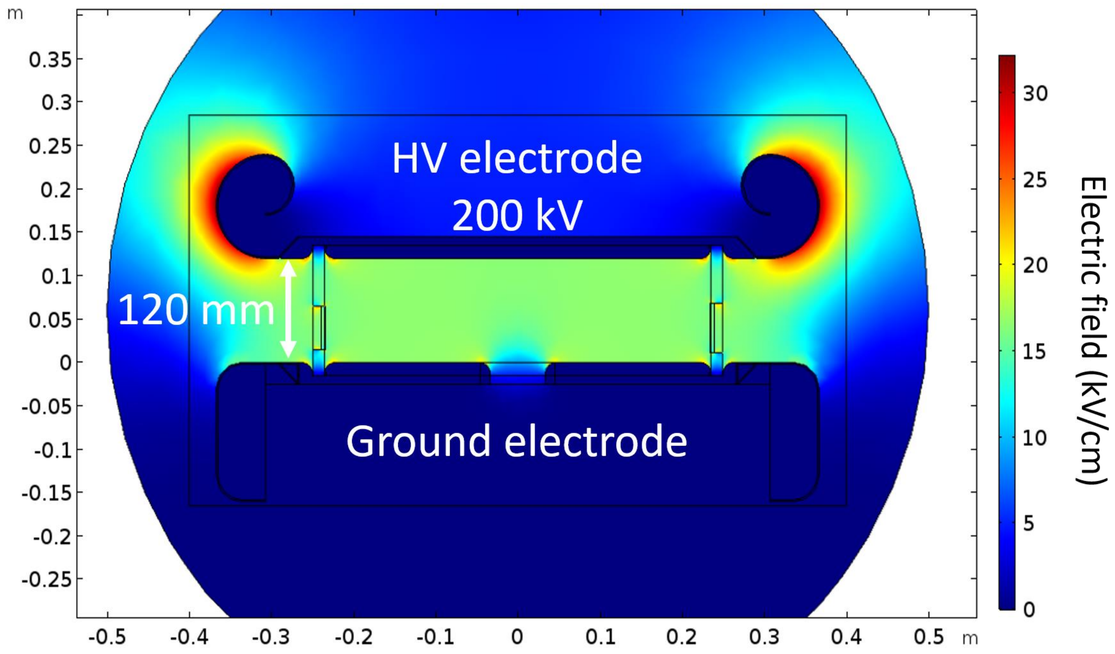

Figure 2: The electric field in the nEDM experiment, shown using COMSOL. The maximum electric field is on the corona of the HV electrode ~32 kV/cm.

The maximum electric field defines our limit on the HV electrode. The n2EDM precession chamber has the following geometric constraints:

- Electrode separation of 120 mm
- Insulator internal diameter of 800 mm
- Total electrode stack height < 400 mm

Optimisation

Starting from a baseline of simple thin plates for electrodes, we define regions to adjust the geometry to reduce the electric field at these locations.

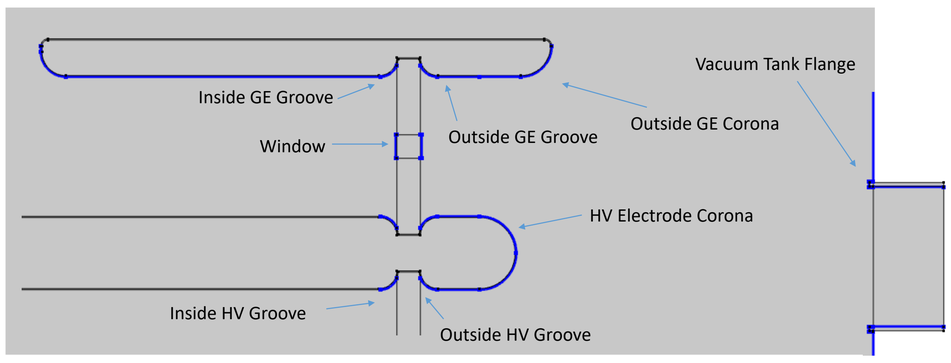

Figure 3: Diagram of regions optimised in the simulations.

Electric field [kV/cm]

	HV Electrode Corona	Inside HV Groove	Outside HV Groove	Outside GE Corona	Outside GE Groove	Inside GE Groove	Vacuum Tank Flange	Window
Baseline	44.4	27.6	33.3	25.3	26.0	24.7	4.4	15.6
Optimised	36.3	23.6	24.4	20.5	21.3	22.1	0.1	15.6

Table 1: Improvements in electric field from baseline to optimised design.

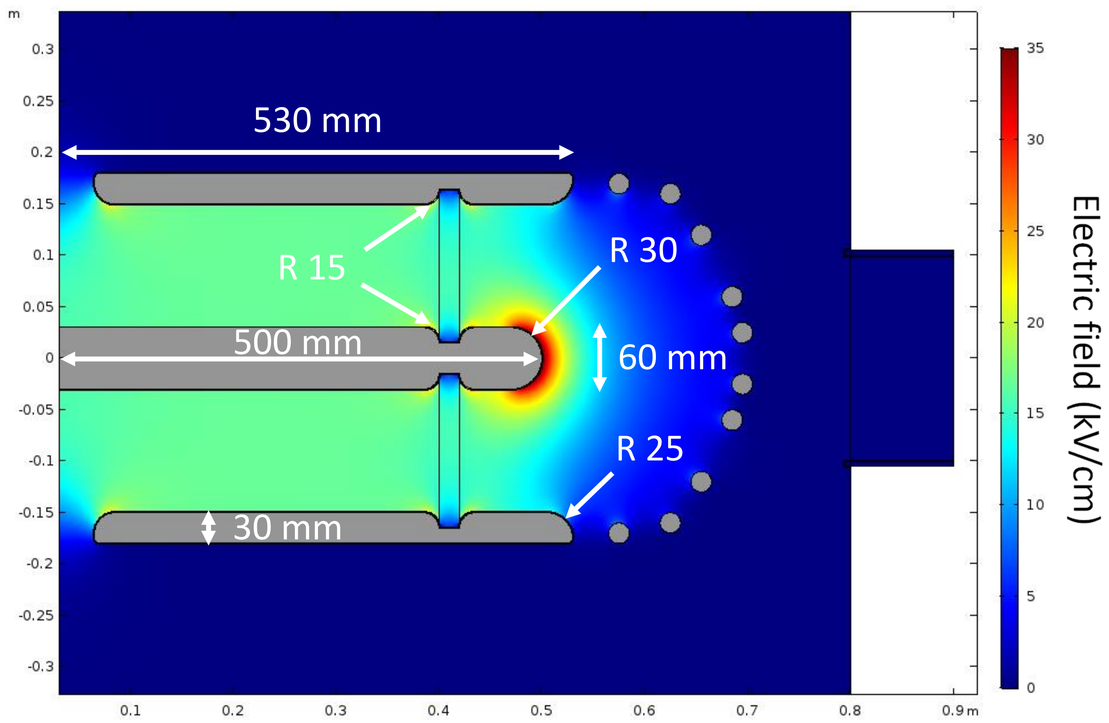

Figure 4: COMSOL simulation showing the electric field of the n2EDM precession chamber. The position and size of the rings are designed to reduce the field on the HV corona and the flange.

Initial High Voltage Testing

As an experimental check, smaller electrodes were constructed. The geometry is the same as the simulations but the surface area is ⅓ of the full scale design.

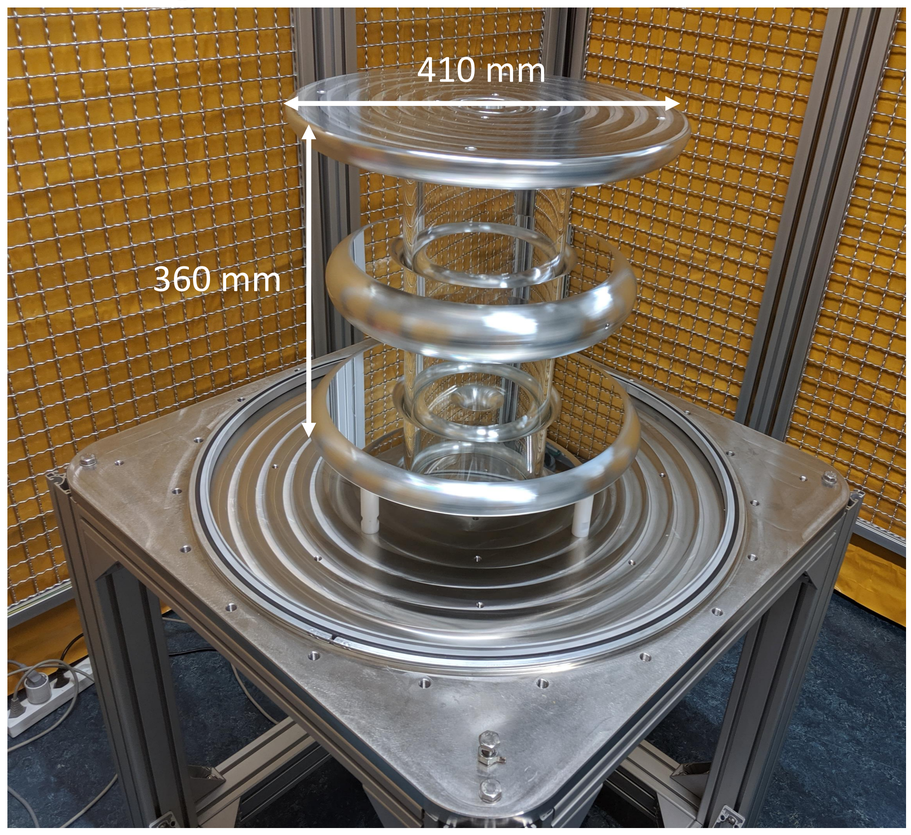

Figure 5: Double electrode stack placed on the base of a vacuum chamber for high voltage testing.

Figure 6: Custom ±200 kV non-magnetic feedthrough.

To deliver ±200 kV to the HV electrode, a custom non-magnetic feedthrough was developed. The conductor is made of aluminium and the insulator of POM-C.

Currently HV tests are being performed to achieve our target electric field.

FNSNF Fonds national suisse Schweizerischer Nationalfonds Fondo nazionale svizzero Swiss National Science Foundation

erc European Research Council Established by the European Commission