# Internship proposition level M2

**Duration:** 6 months (starting February 2026) **Location:** Grenoble

**Desired Profile:** Electrical Engineering background, or Master's degree in Physics or in Materials Science

**Contact:** Rachelle.hanna@grenoble-inp.fr

**Key words:** High Voltage, Triple Point, Gas/Solid Insulation, Charge Density, Potential Decay, Pre-Breakdown.

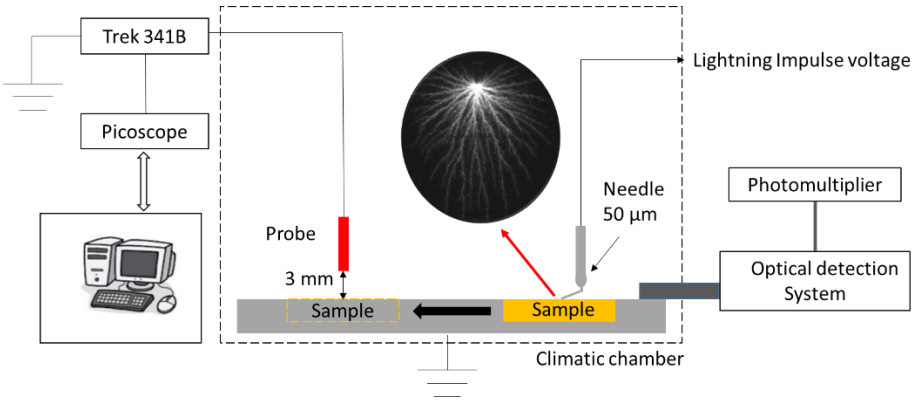
## Charge Accumulation in Dielectrics: Application to Medium Voltage Hybrid Gas/Solid Insulation Systems

### 1) Context:

Climate change is a global and urgent challenge that calls for innovative solutions across all sectors, including electrical engineering. A key challenge in this field is the replacement of sulfur hexafluoride ($SF_6$), widely used in medium and high-voltage insulation systems due to its exceptional properties, including low electrical losses, high thermal conductivity, and a breakdown voltage approximately 3 times higher than that of air. However, $SF_6$ is also known as the most potent greenhouse gas, with an environmental impact of 1 kg of $SF_6$ equivalent to 24 tons of $CO_2$. This high global warming potential has driven both researchers and industry developers to seek alternative gases for insulation.

Environmentally sustainable alternatives are now being actively investigated, particularly for medium-voltage applications. Among the potential substitutes, dry air and $CO_2$ have emerged as promising options. Yet, beyond identifying substitute gases, the transition to sustainable insulation systems requires a deeper understanding of the physical mechanisms governing discharge initiation, propagation and transition to breakdown in these new gases.

Hybrid gas/solid insulation, used in critical applications such as gas-insulated switchgear, presents unique challenges. One area with many unanswered questions concerns the physical mechanisms governing the initiation of electrical discharges, often occurring at the “triple point” where two insulators with different dielectric properties intersect with a conductor. This intersection is the weakest region in the insulation system, where discharges may start, potentially leading to equipment failure.



Ensuring the long-term reliability of gas–solid insulation systems using these alternatives gases requires a thorough understanding of both pre-breakdown and breakdown mechanisms especially at the gas–solid interface, where discharge phenomena are influenced by a complex interplay of factors. These factors can be classified into 3 essential categories: gas-related factors (such as gas type, pressure, and humidity), solid material properties (including permittivity, surface conductivity, and other intrinsic properties, and geometric factors (such as surface roughness, electrode configuration, and gap distance). Among these, charge accumulation on the dielectric solid plays a particularly critical role, as it can distort the local electric field and significantly impact the initiation and propagation of discharges.

## 2) Objective :

The main objective of this internship is to study the influence of charge density deposited (from previous discharges) on solid insulating surfaces on the initiation and propagation of electrical discharges in air and $CO_2$ under varying humidity conditions. This research is part of the ongoing work carried out at G2Elab and aligns with current scientific challenges and the strategic orientations of France and Europe in the field of energy transition. In the medium term, this study will contribute to the modelling of discharge initiation and propagation phenomena, aiming to overcome key scientific barriers related to the increase of operating voltages in next-generation electrical systems.

## 3) Tasks

You will be part of the MDE "Materials, Dielectrics and Electrostatics" team at G2Elab and will also benefit from the support of experts from the GEEPS laboratory as part of an academic collaboration.

Your main tasks will include:

- **Literature review:** Study of the current state of research on discharge mechanisms and surface charge effects under impulse voltage in gas/solid insulation systems.
- **Design and development:** Conception of a discharge detection system based on specific requirements related to the test bench configuration and experimental conditions.
- **Parametric experimental study:** Investigation of the influence of several key parameters on discharge initiation and propagation under positive fast rising impulse voltage, including:
  - ⇨ the nature of the solid insulating material (PTFE, PVC, and PVDF)
  - ⇨ gas nature (air and $CO_2$)
  - ⇨ gas humidity at 1 bar,
  - ⇨ gas pressure (ranging from $10^{-2}$ mbar to 1 bar),
  - ⇨ and the presence of pre-deposited surface charges on the dielectric (memory effect).
- **Data analysis and reporting:** Analysis and synthesis of the results, followed by the preparation of the final internship report.

This internship may lead to a continuation in a Ph.D. program.