Multi-scale modelling of electrical breakdown in vacuum: Influence of electromagnetic power

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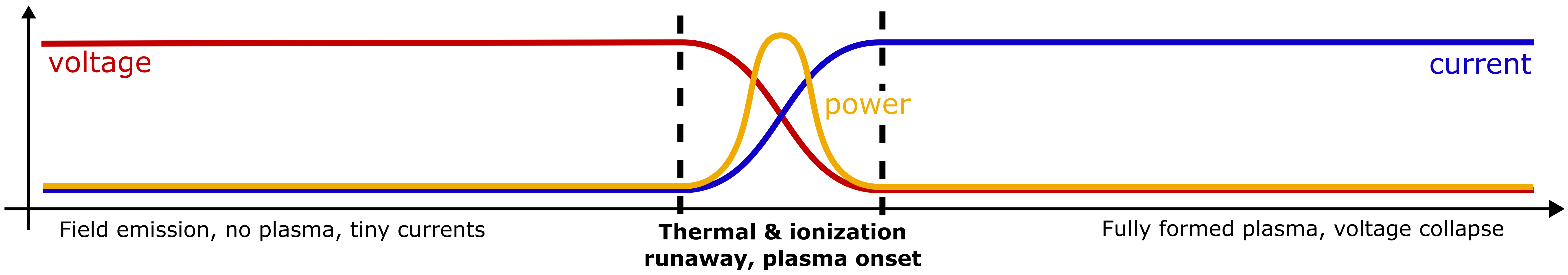
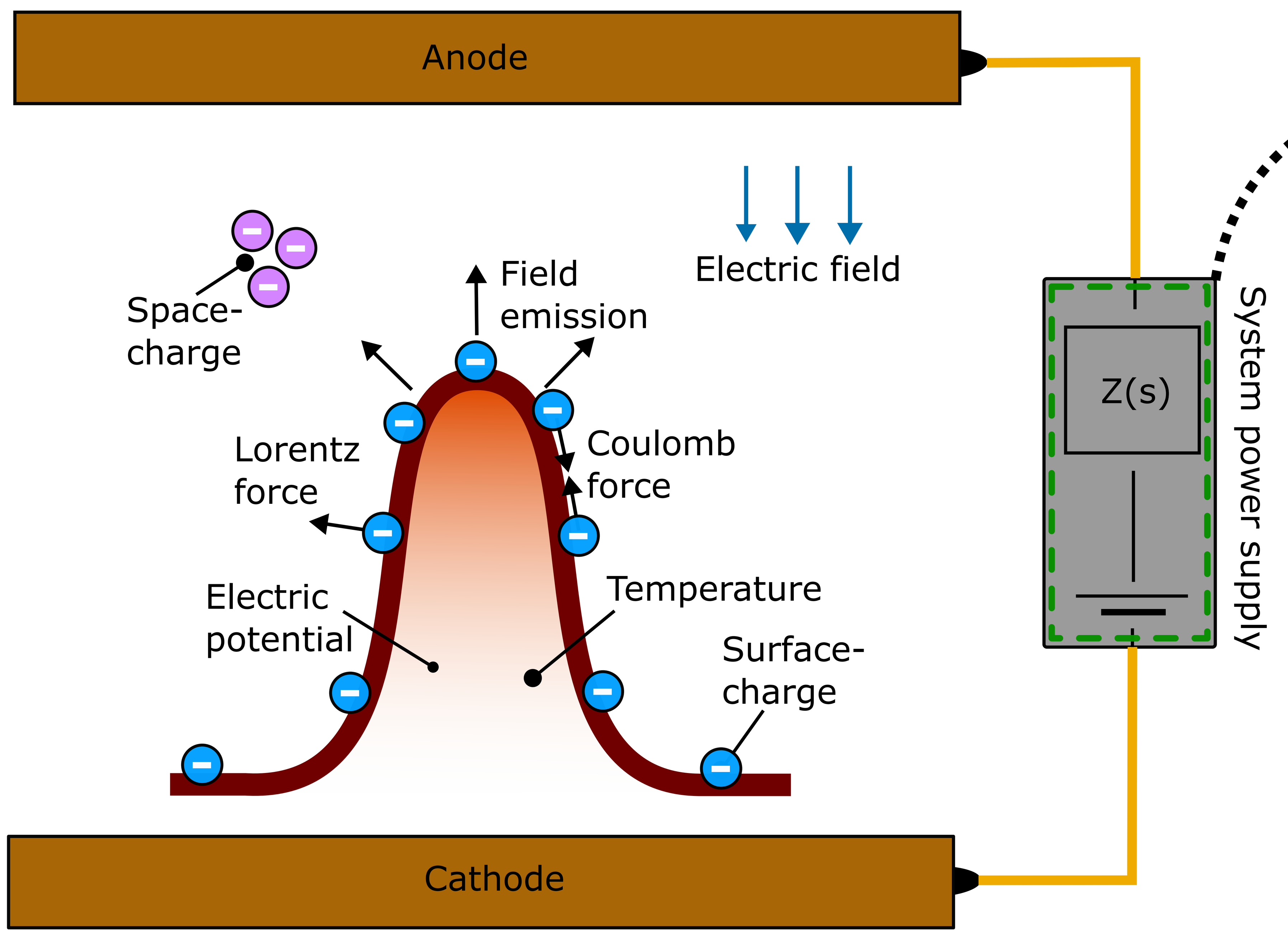
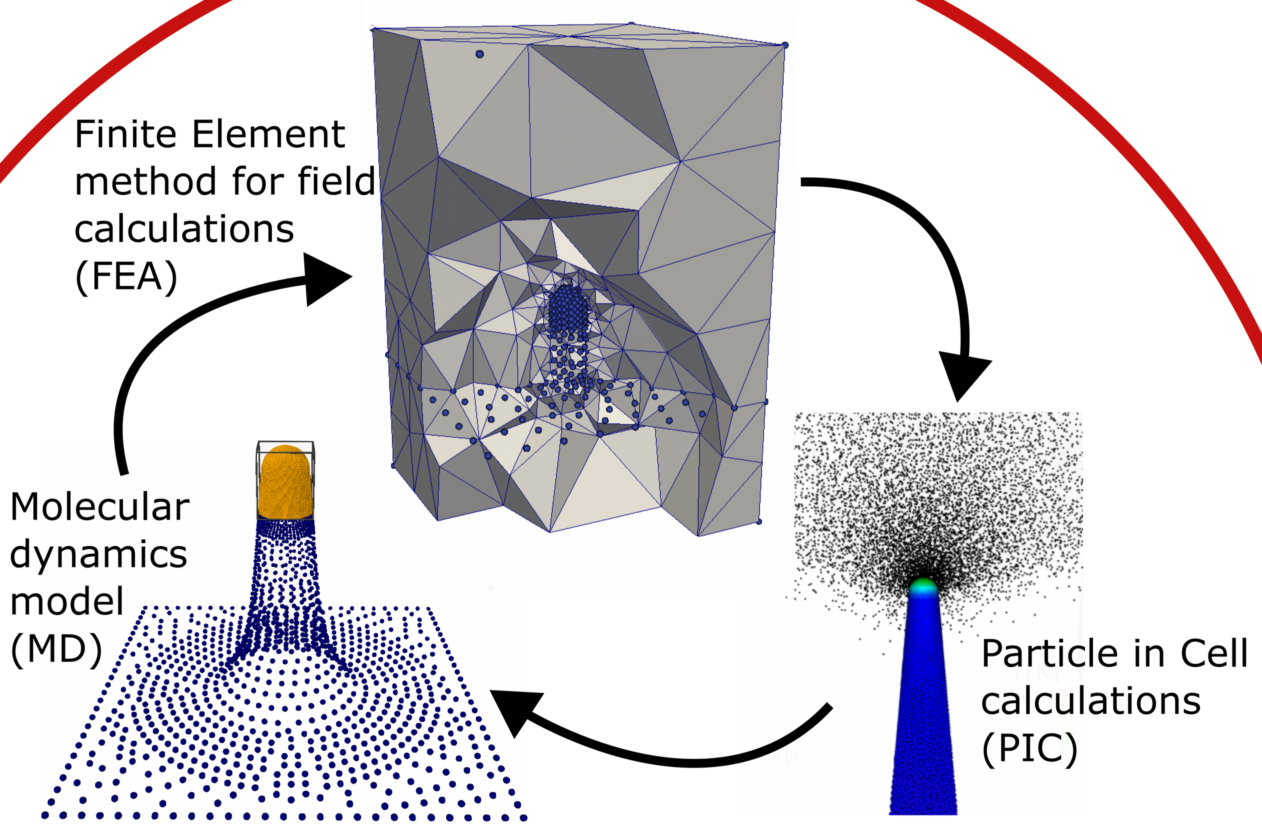


Plasma initiation requires a large influx of power, making the vacuum breakdown (VBD) occurrence directly dependent on the available electromagnetic (EM) power. Moreover, recent experimental evidence indicates that the distribution of **EM power is actually the main limiting factor** in arc initiation [1,2]. Thus, limiting the availability of the local EM power is a **promising VBD occurrence mitigation technique**. However, the physical mechanism underlying the very initiation of the phenomenon still remains unclear, leaving the VBD power flow dependence still an open question. This project aims to understand the physics underlying the power supply limitations on the VBD initiation and to **describe it quantitatively** for design optimization of future high electric field (HEF) applications.



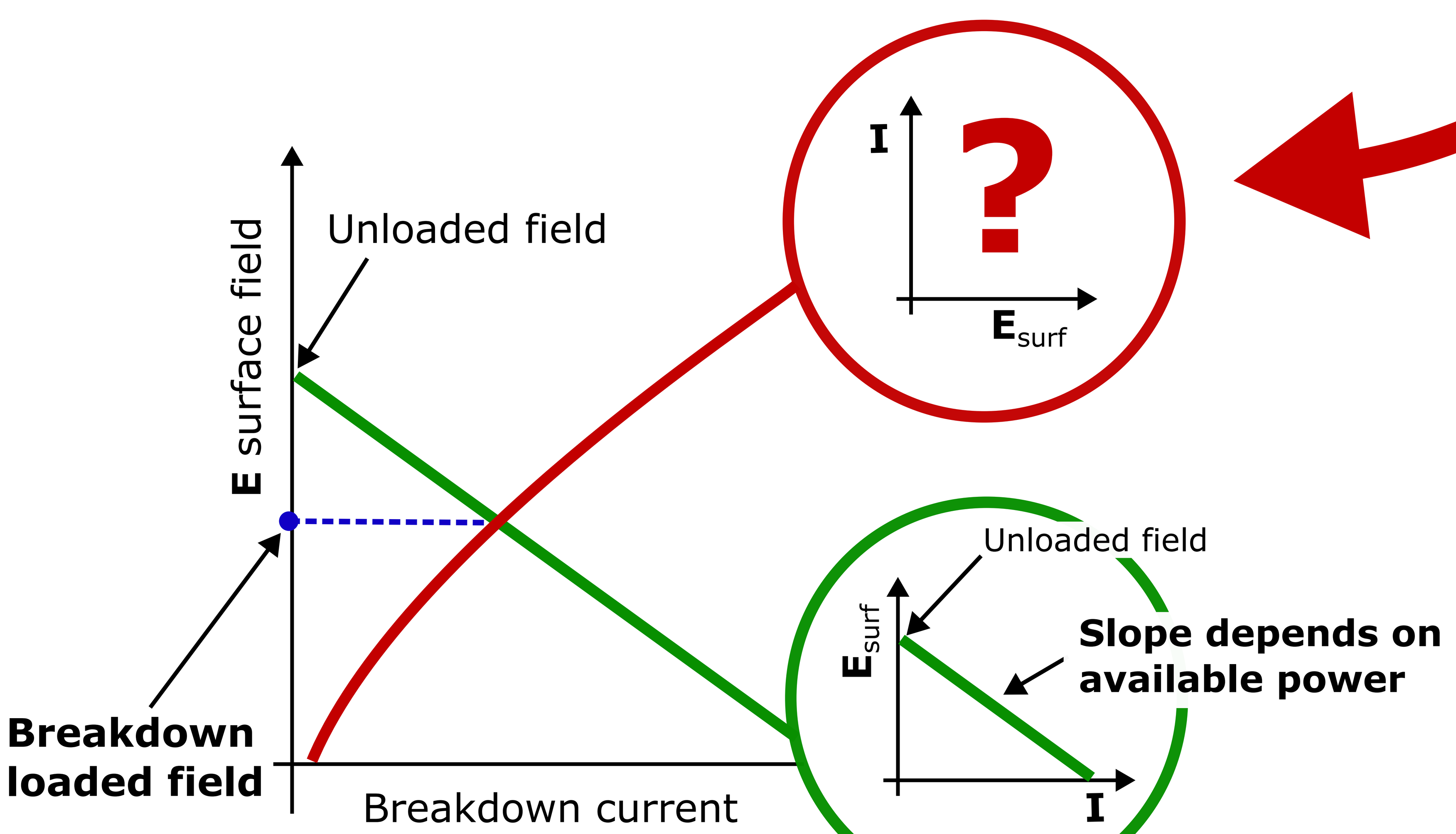
The accelerator structure, in terms of circuit analysis, can be described by a **single impedance value** Z(s) (*Thevenin theorem*). This allows to couple the local VBD phenomenon to the global accelerator system as $V_{sim}(s) = V(s) - I(s)Z(s)$. Thus, making the impedance, that corresponds at each point on the surface to an unique impulse response, **a design parameter**.



FEMOCS

Finite **E**lements **o**n **C**rystal **S**urfaces is an opensource library for coupling the effects of high electric field into molecular dynamics [4]. FEMOCS is based on the DEALII FEA library and incorporates the PIC implementation. Code is coupled with LAMMPS molecular dynamics simulator.

For any point in the domain one can evaluate the **dependence of local field on test current** and the **assumed function for VBD site emitted current**. Whereas, the quasi-equilibrium point gives the loaded field value. The VBD dynamics is often approximated by a "simple" non-linear circuit element (ex. *Child-Langmuir law*) [3]. However, the VBD phenomenon is anything but "simple". It is **highly complicated** multi-physical problem, requiring advanced mathematical tools to be solved accurately. Therefore, we introduce a VBD specific computational software **FEMOCS** to provide an **accurate estimation** of the breakdown phenomena.



Project outcome:

Quantification of the VBD power flow dependence!
This will lead to the mitigation of VBD occurrence through the **improved design** of HEF applications and provide a "full system" multi-physics **simulation tool** for VBD related research.

References:
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MATTER

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