BONOMI
moving energy since 1928

Electrodynamical analysis of a high voltage surge arrester

extracted from
Electromechanical simulations of high voltage equipment

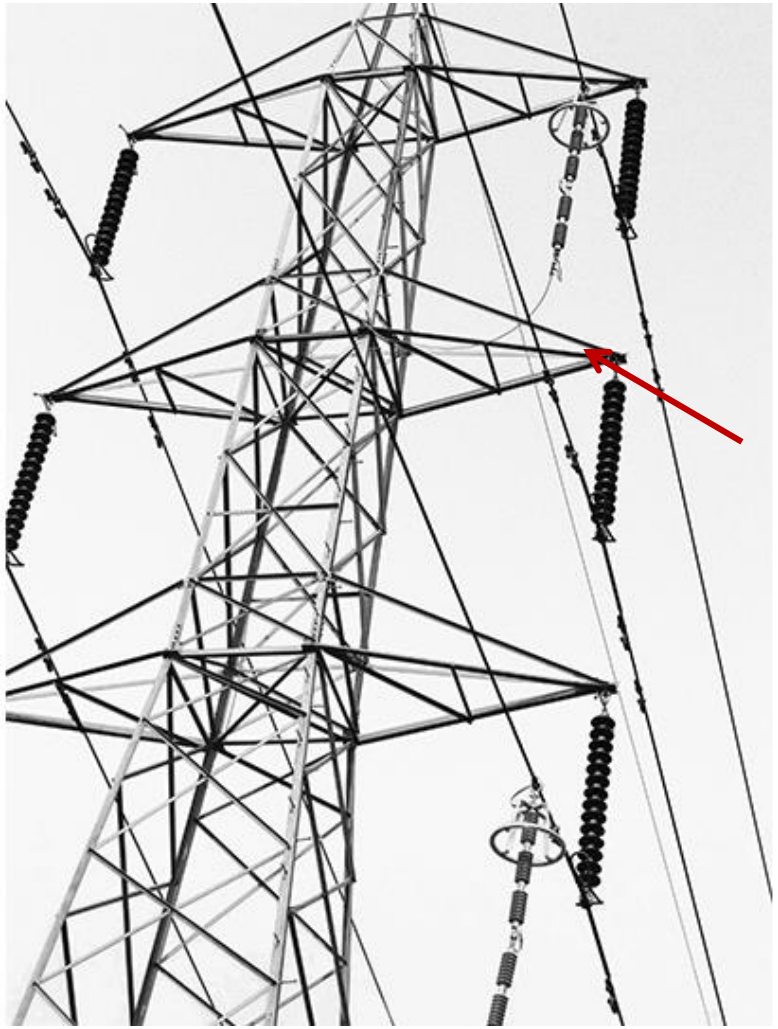
Dario Pellegrini, PhD

EB Rebosio – Gruppo Bonomi

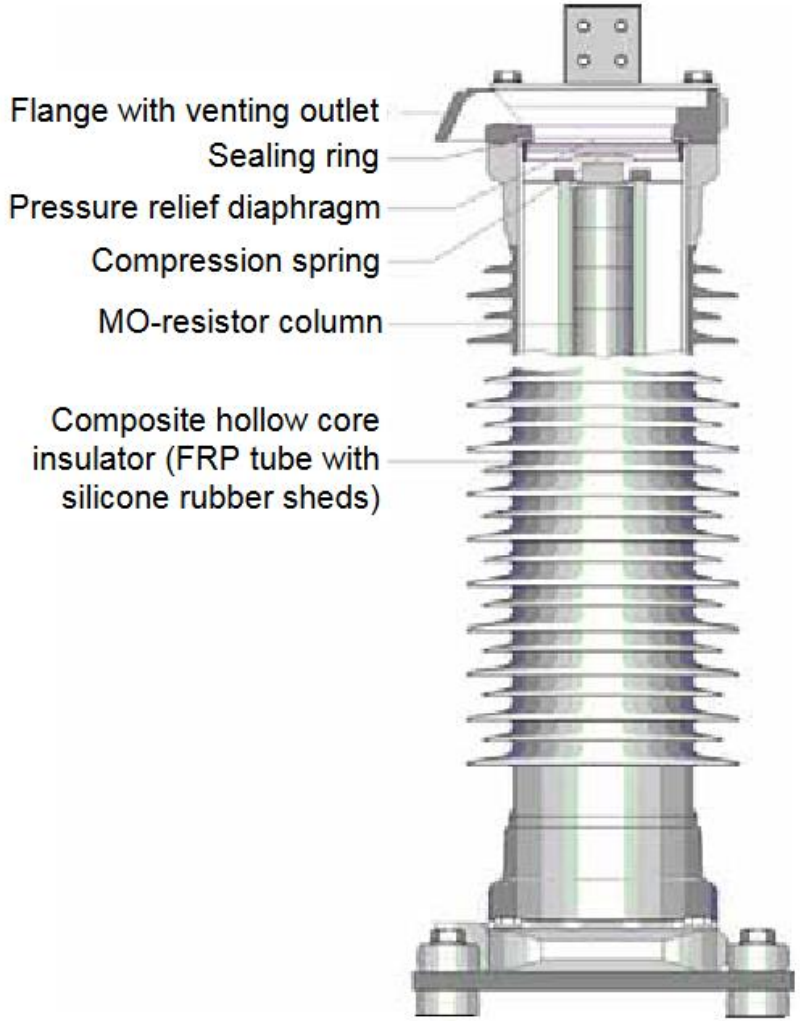
Introduction

The Problem

Surge Arresters

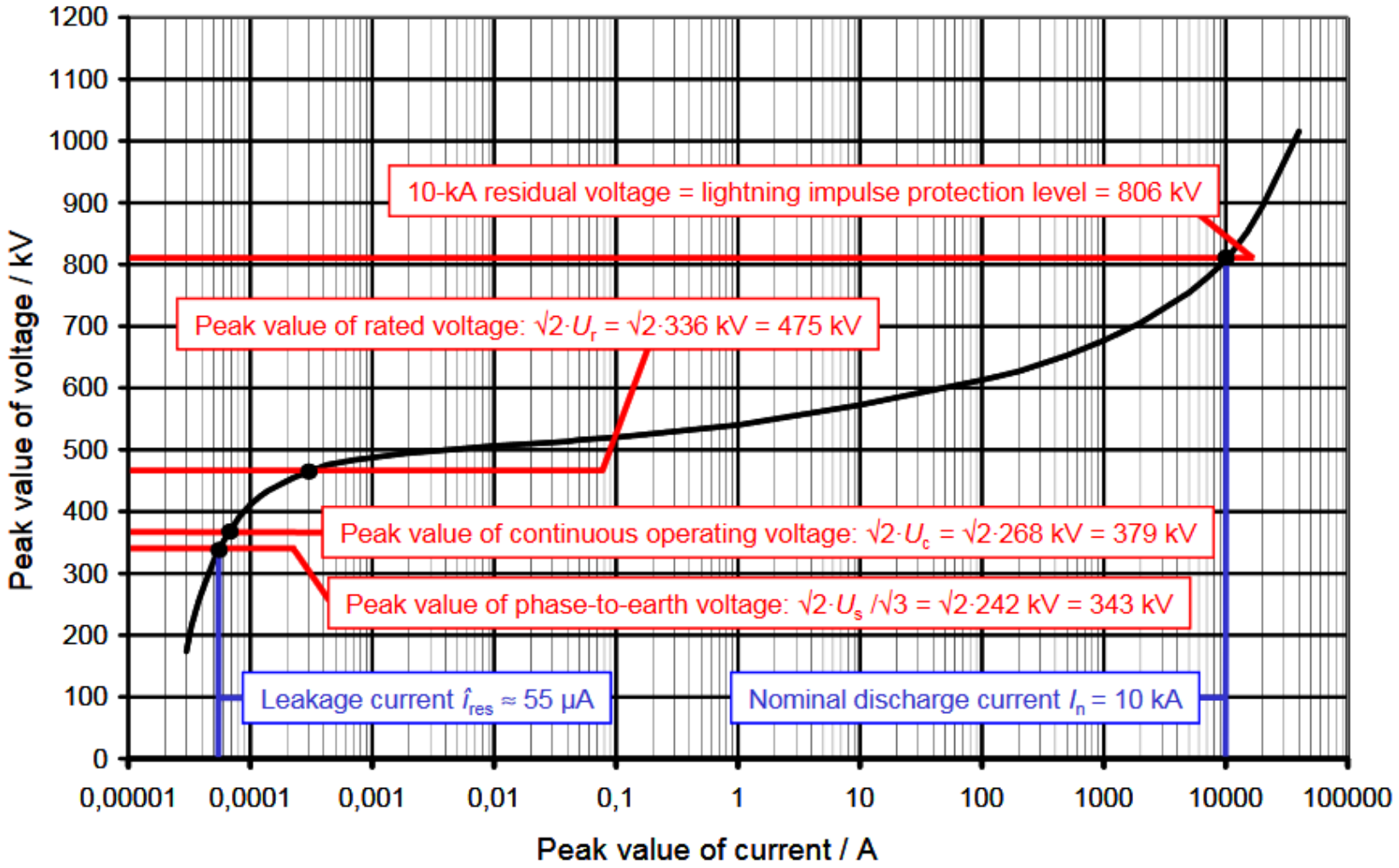


Structure



Doped Metal Oxide Tab Resistors

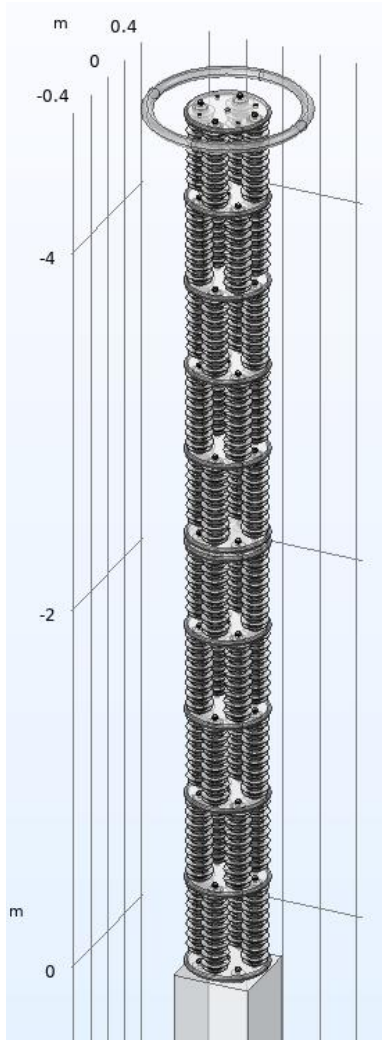
Zinc Oxide Properties



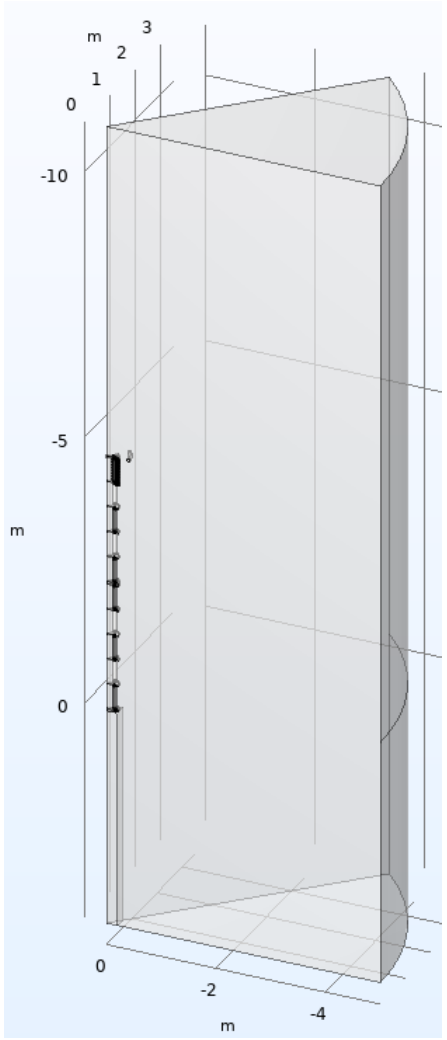
Highly non linear resistivity, acting almost as an open circuit for low voltages, switching to a high conductivity at higher voltages.

BONOMI
moving energy since 1928

The Project

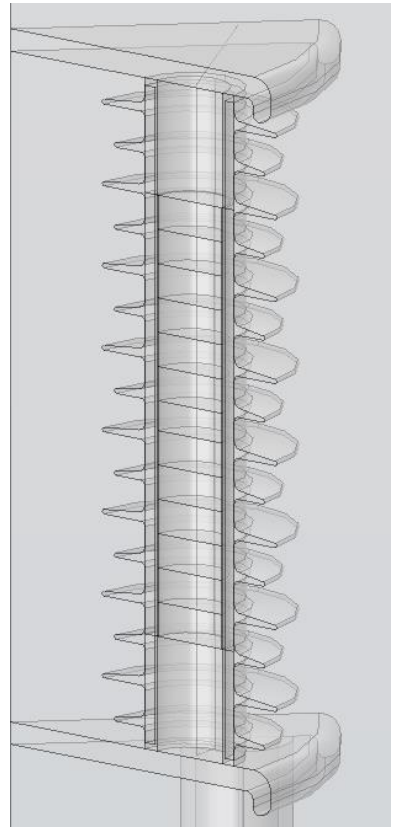


Multistage surge arrester tower for a nominal 420 kV line.
Composed by 40 modules (4 per floor, 10 floors)



Space modelled profiting from sector symmetry

Module geometry



BONOMI
moving energy since 1928

Methods and use of COMSOL Multiphysics

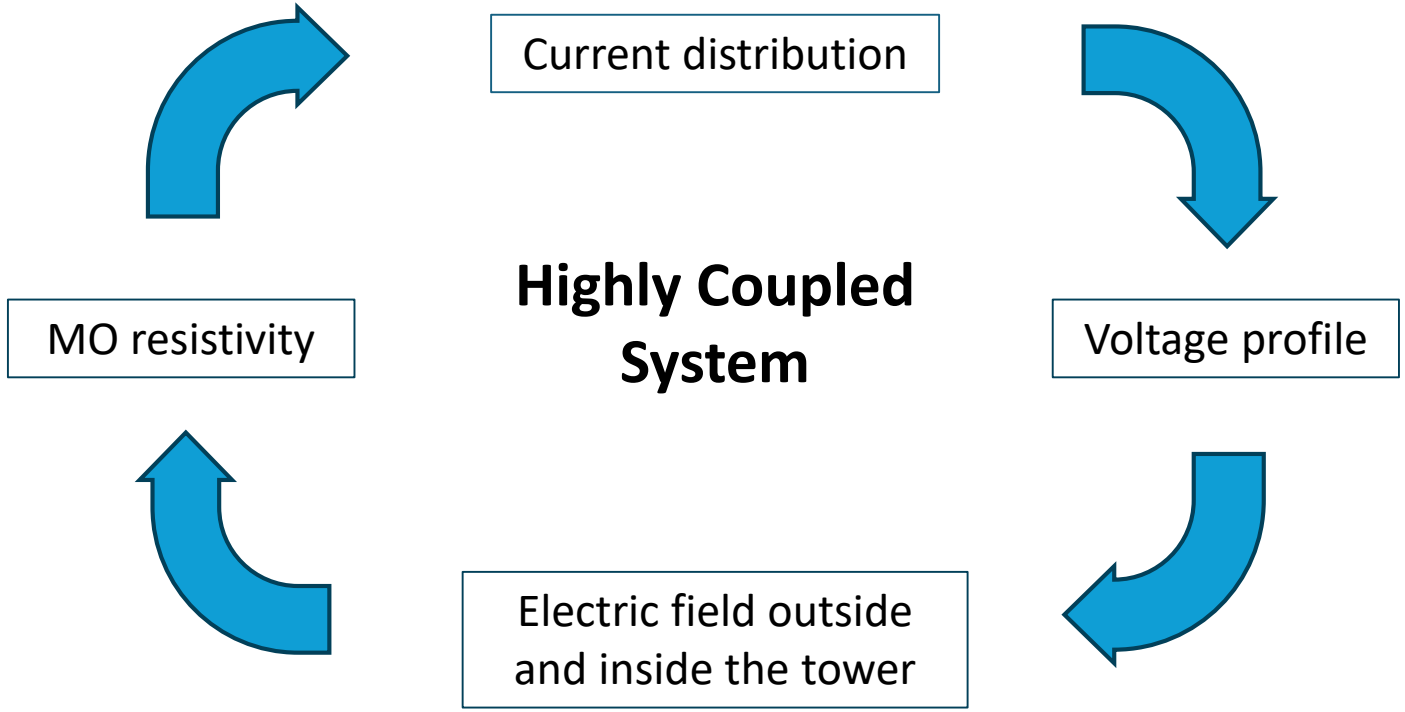
How COMSOL AC-DC Module can help

Evaluation of the electric field

1. Inside the Metal Oxide tabs:
   Prevent excessive stress and premature ageing

2. At the surface:
   Prevent corona activity, tracking, and erosion of the silicone housing

Complication

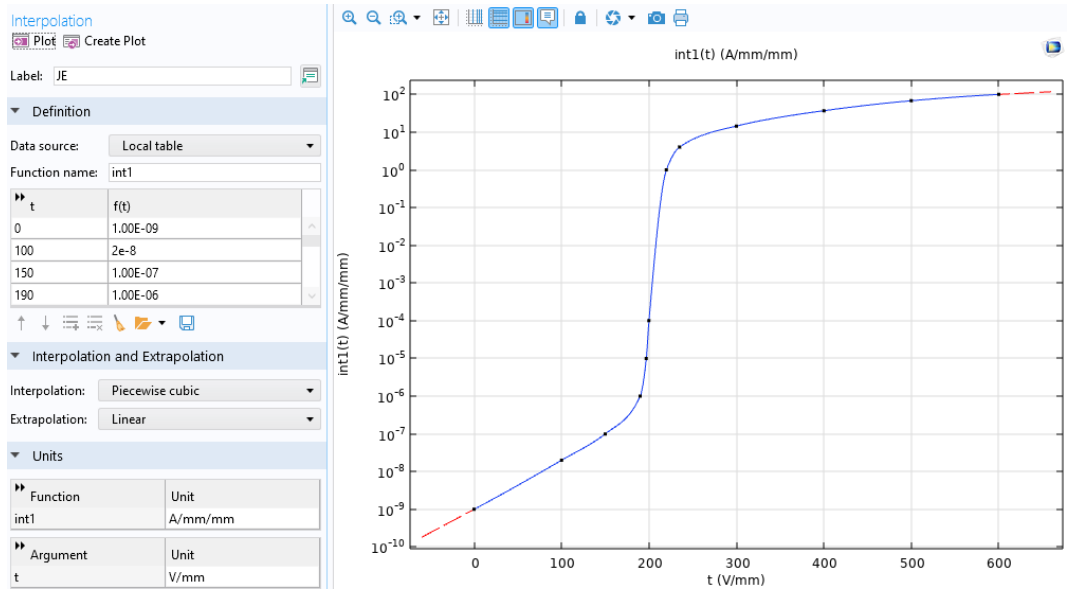


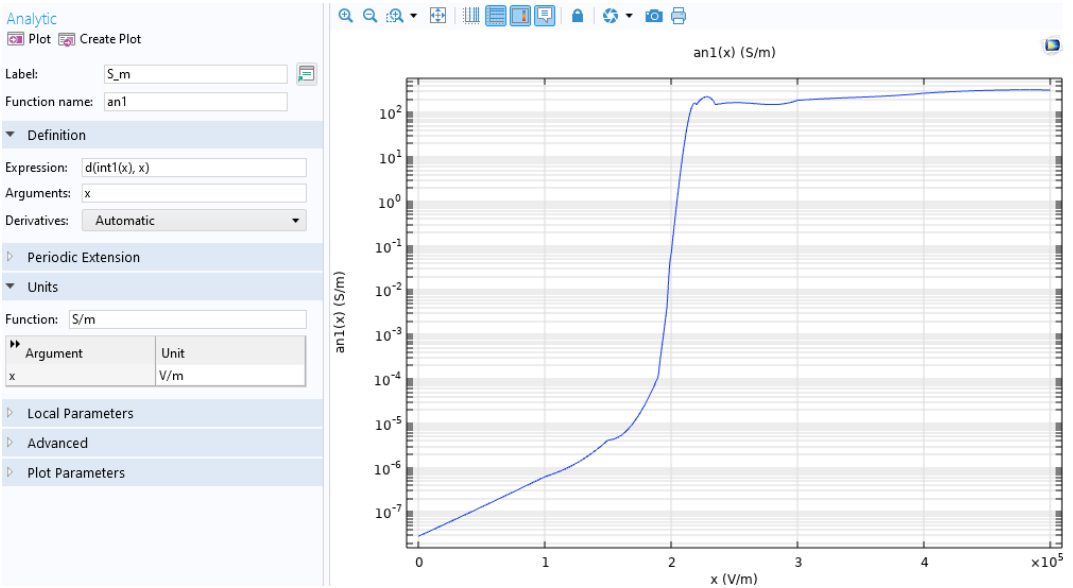
Setup

Voltage-current caracteristic of a tab with particular size from supplier.

Size independent electric field-current density input to COMSOL.

Electric field-Conductivity material property obtained taking a derivative.



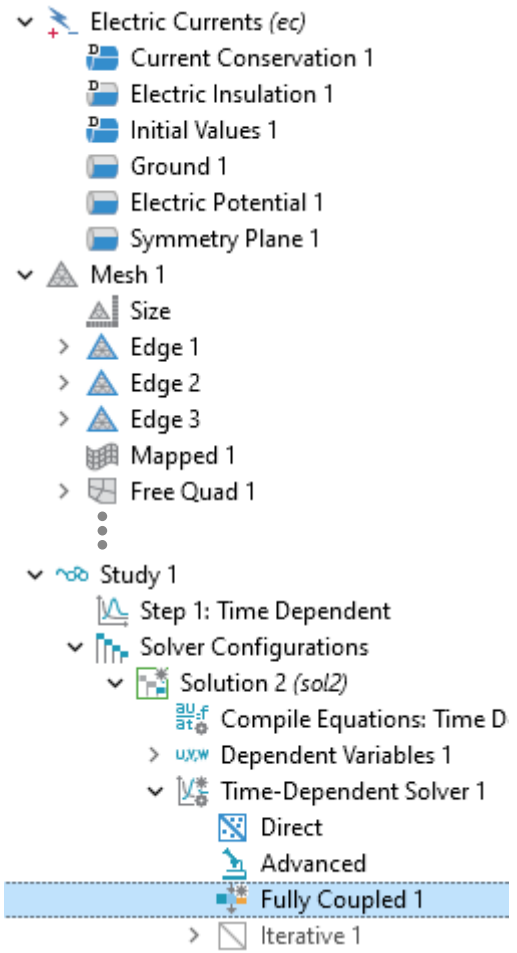


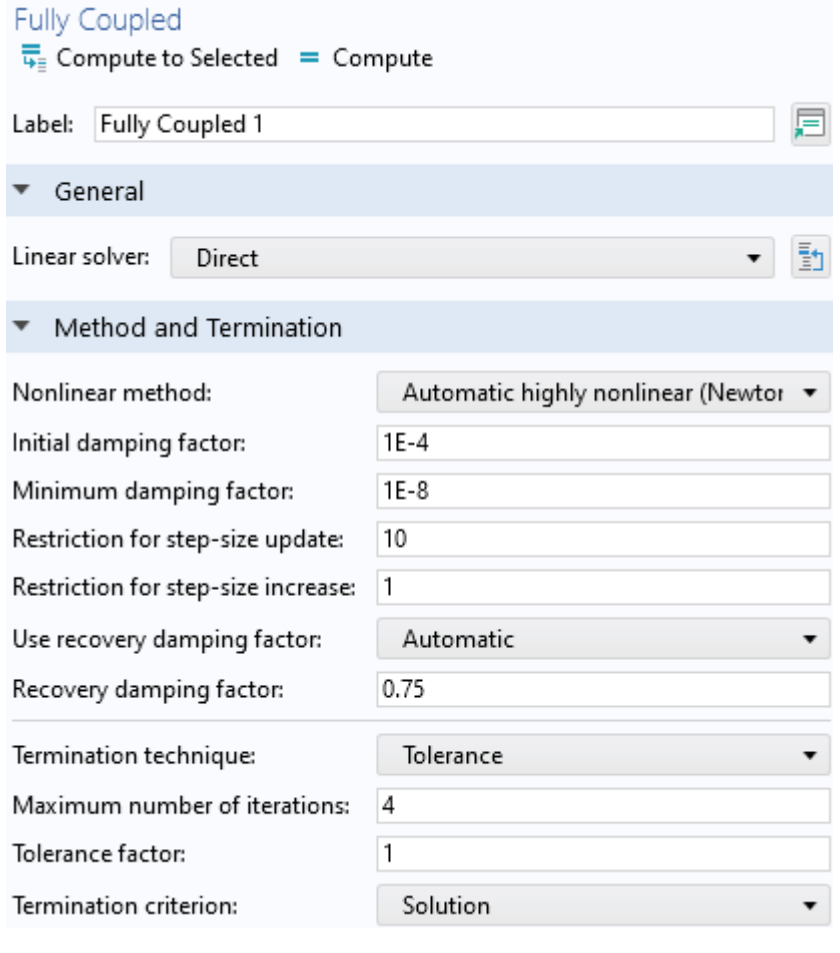
BONOMI
moving energy since 1928

Other Settings

Material	Permittivity [#]	Conductivity [S/m]
Air	1	10^{-18}
Alluminium	1	10^{6} *
Silicone Gum	3.5	10^{-12}
Epoxy Fiber Glass	4.5	10^{-15}
ZnO	830	an1(root.comp 1.ec.normE)

* Can be reduced by a couple of orders of magnitude to improve convergency without impacting on the result (unstable current loops are sometimes observed)





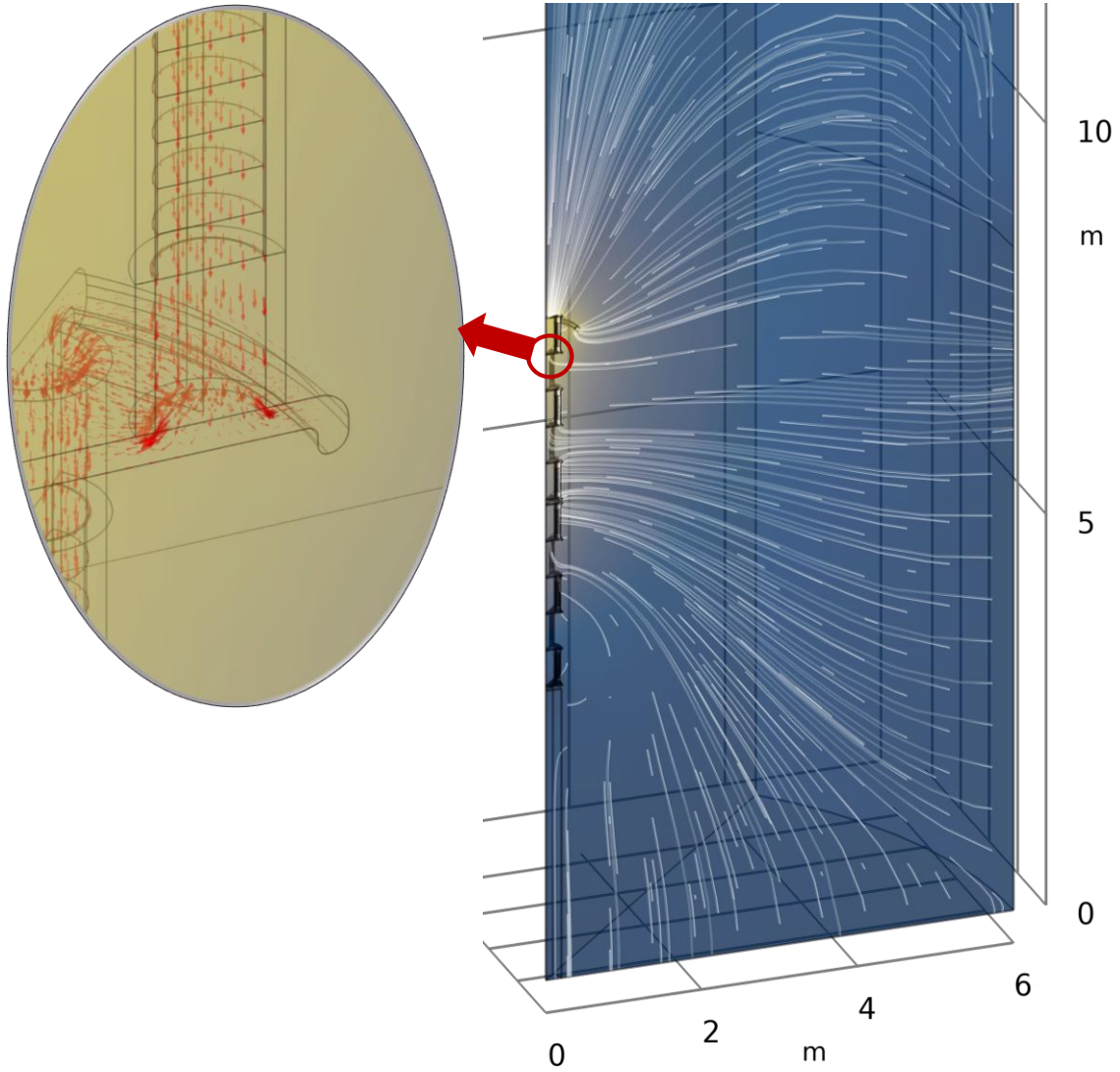
BONOMI
moving energy since 1928

Obtained Results

Overview

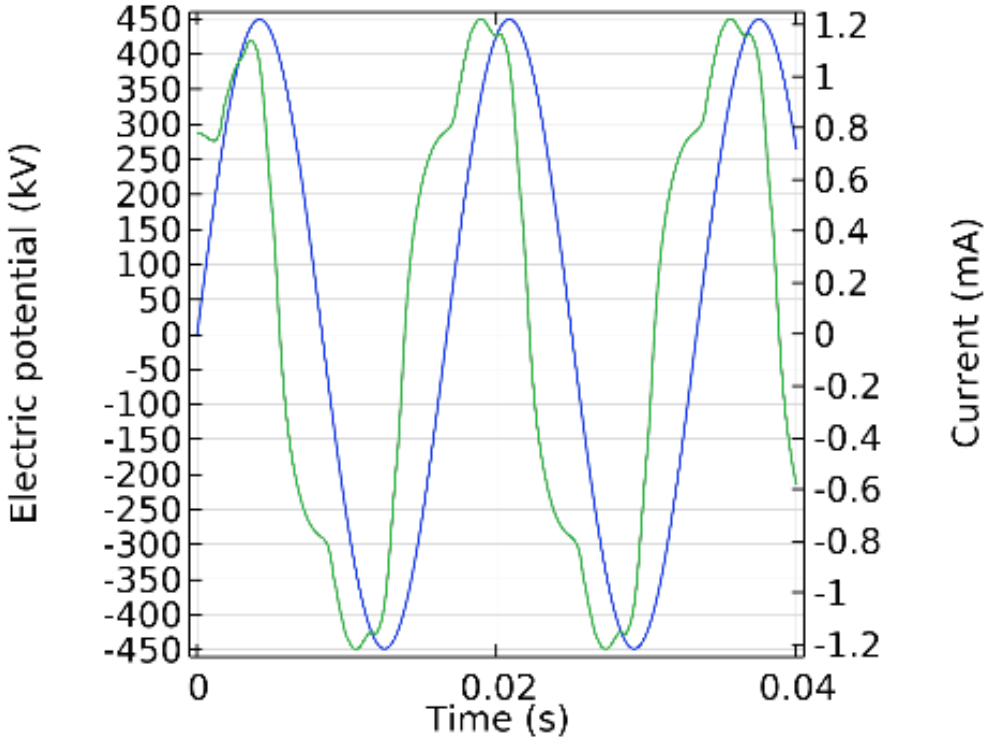
Check of:

- Voltage distribution (blue to yellow)
- Electric field lines (white lines)
- Current density along the tower (red arrows)

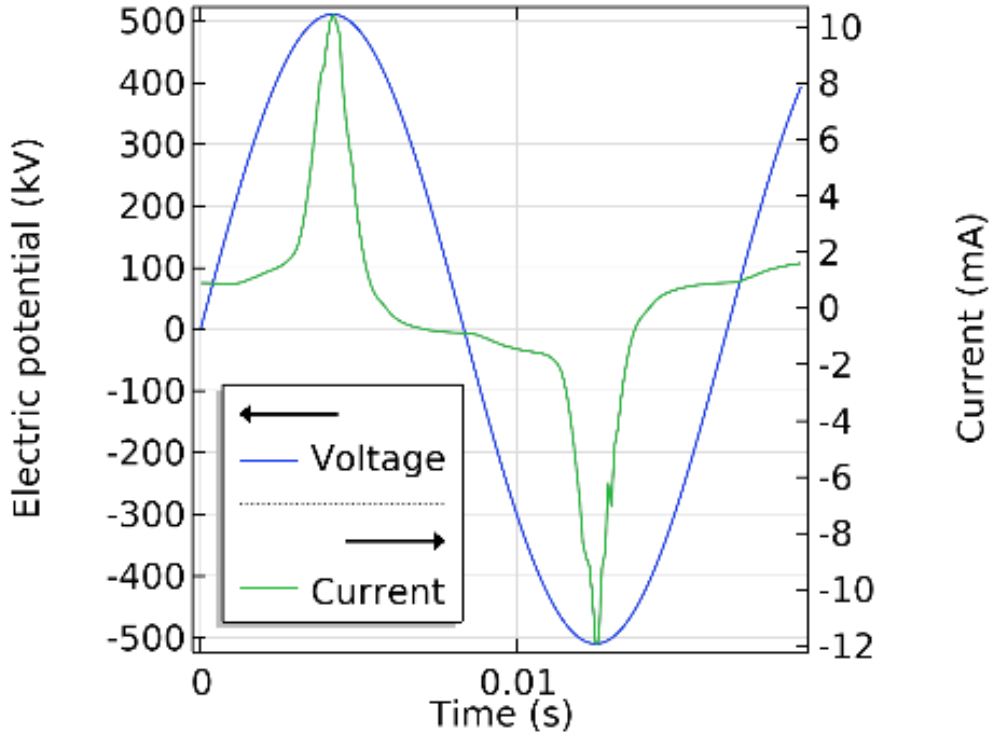


BONOMI
moving energy since 1928

Time dependent current and voltage



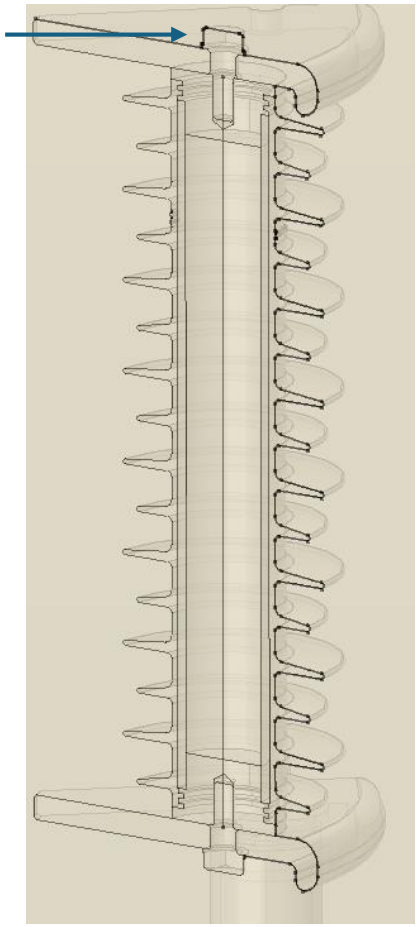
Slightly below activation voltage:
strong capacitive component.

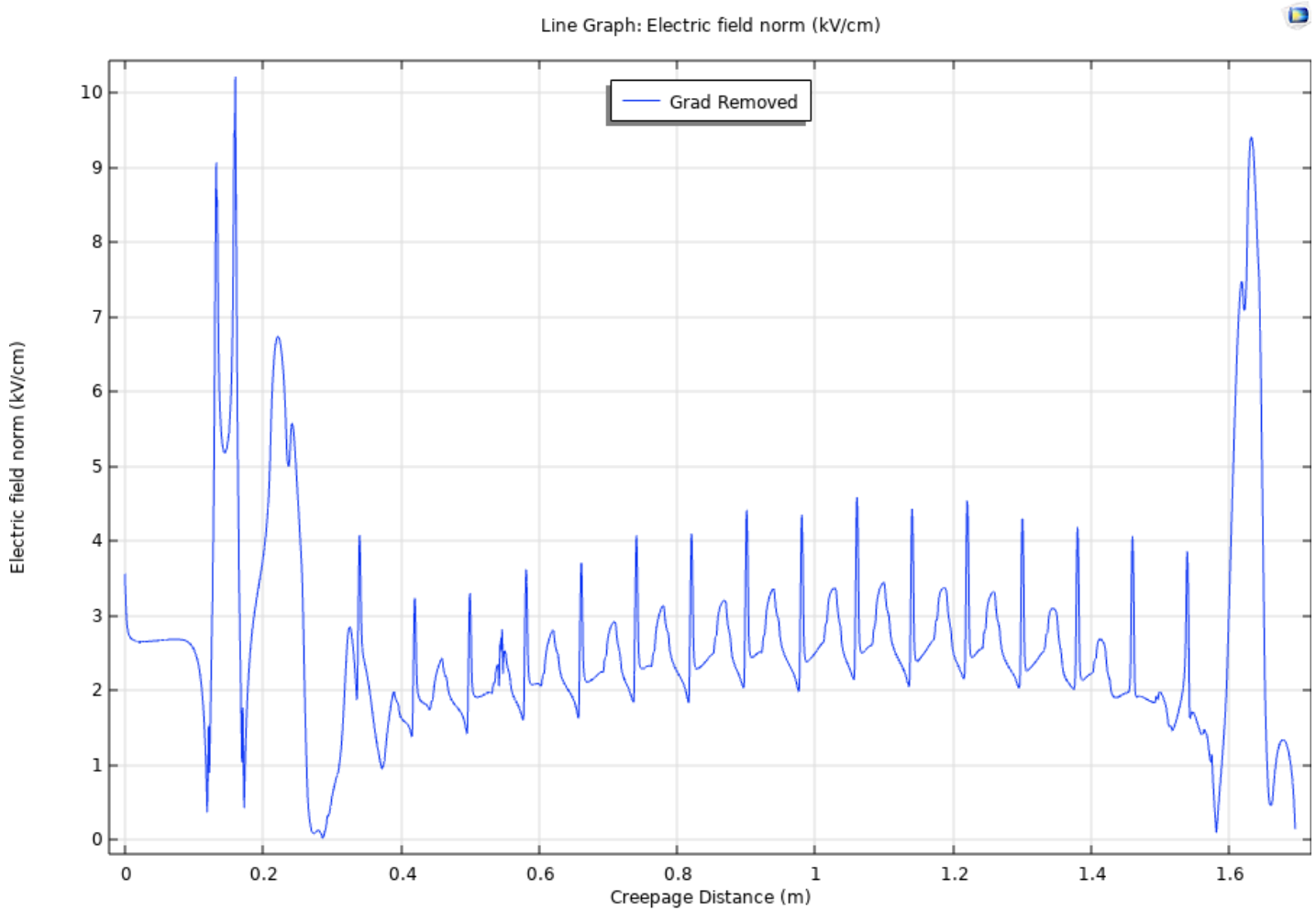


Slightly above activation voltage:
strong resistive component.

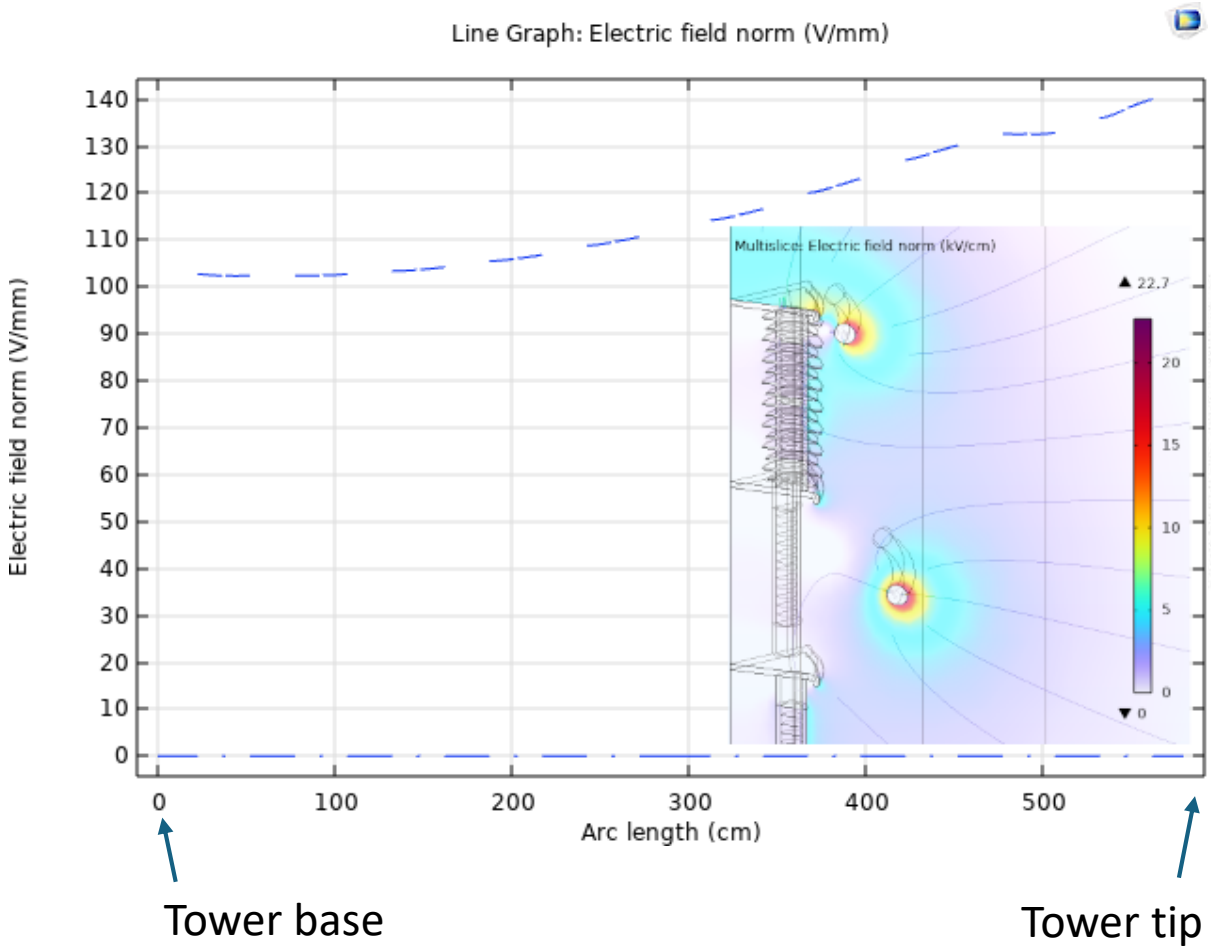
Field at the surface

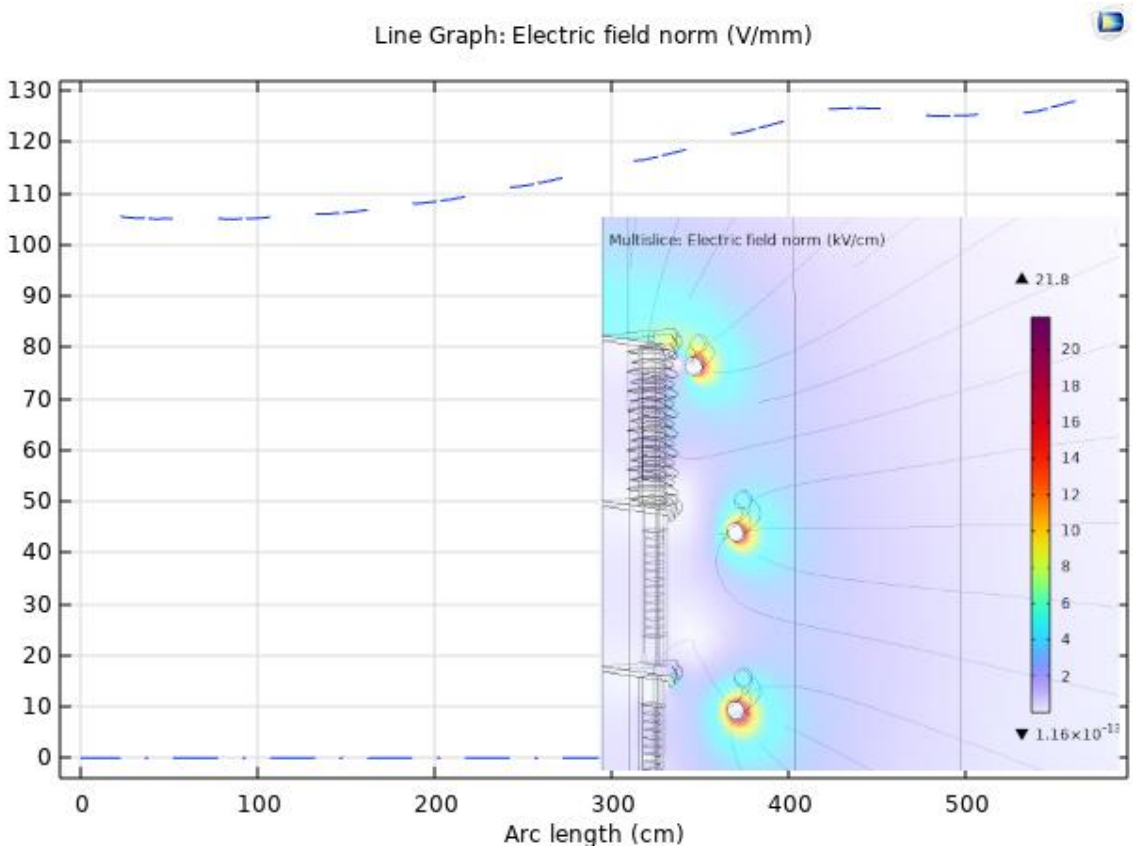
Field magnitude plotted along a line running 0.5mm from the external surface





Electric field in the tabs along the tower





Design of shielding devices (grading rings) to keep the field within 130 V/mm

BONOMI
moving energy since 1928

Conclusions

The study performed with COMSOL AC-DC Module allowed to characterize the **electrical behavior** of a surge arrester tower, establishing a design for **protective devices** (grading rings).

The completion of the study required a time transient analysis considering the **field dependent conductivity** of the metal oxide core.

In addition to the inspection of the field distribution, it was possible to investigate the **current density distribution** along the tower and to reproduce the **transition** from capacitive to resistive mode above the threshold voltage.


BONOMI
moving energy since 1928
Thank you
for your attention