FEM analysis of Current Dissipation in Lightning Strike Protection Systems

UCM-ELEC

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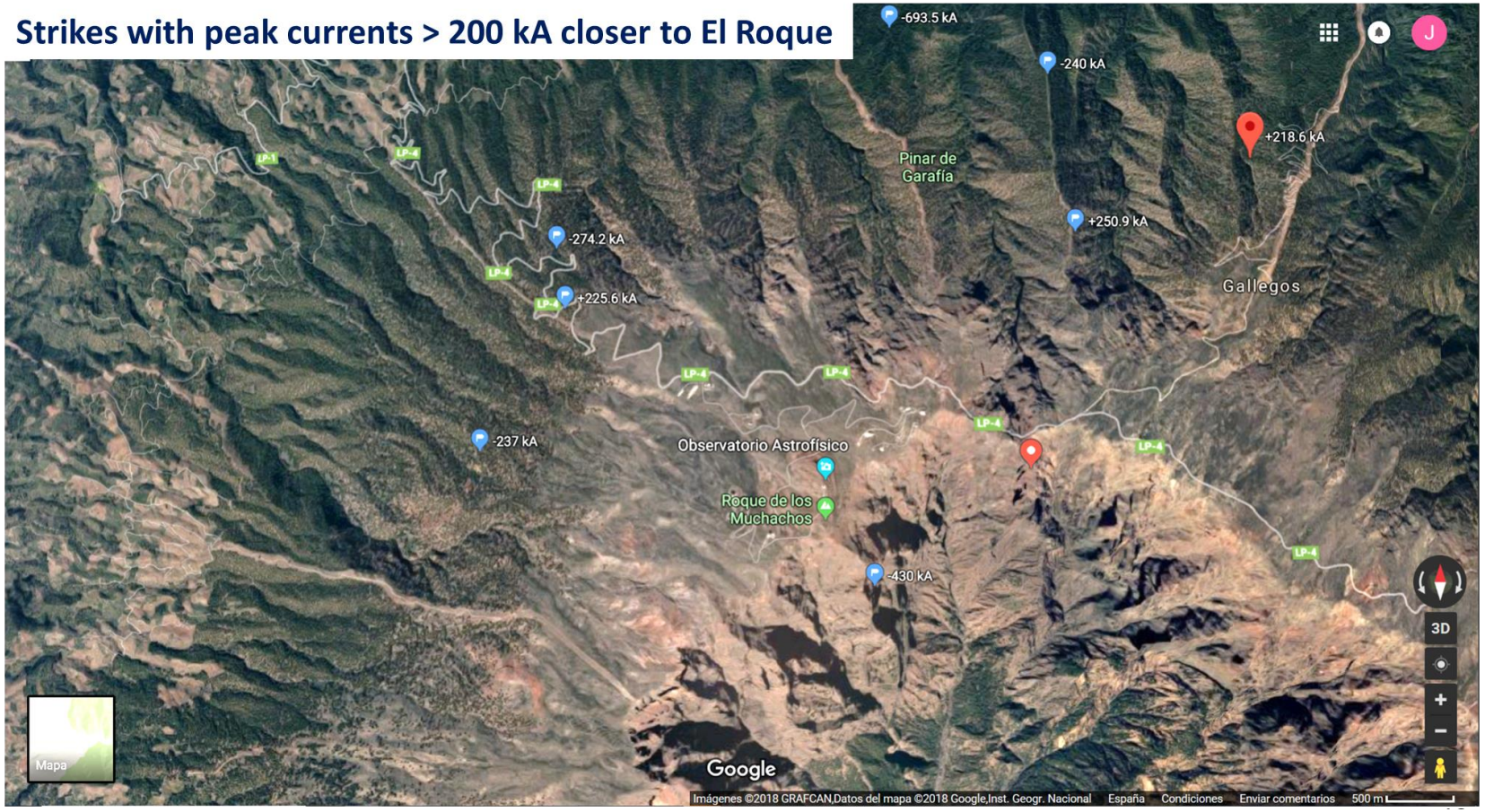
Main topics

- ❑ The importance of lightning protection an earthing
- ❑ Finite Element Simulation basics
- ❑ Simulation of a lightning strike in LST Earthing System actual design

Lightning

Lightning: “Natural phenomena that can discharge currents of **the order of hundreds of kiloamps** in a fraction of a second” This can have devastating effects.



Lightning is an imperative for modern structures

Ligthning protection system design

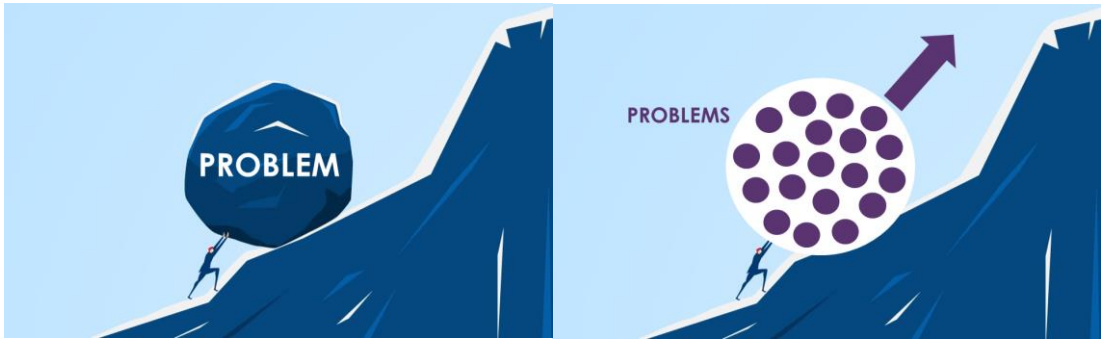
International Electrotechnical Commission

IEC 62305-1	General Principles
IEC 62305-1	Risk Management
IEC 62305-3	Physical Damage to Structures and Life Hazard
IEC 62305-4	Electrical and Electronic Systems

IEC 62305: International Lightning protection standard

- 62305-1: General Principles
- 62305-2: Risk
- 62305-3: Human damage
- 62305-4: Electronic

Finite Element Method basics



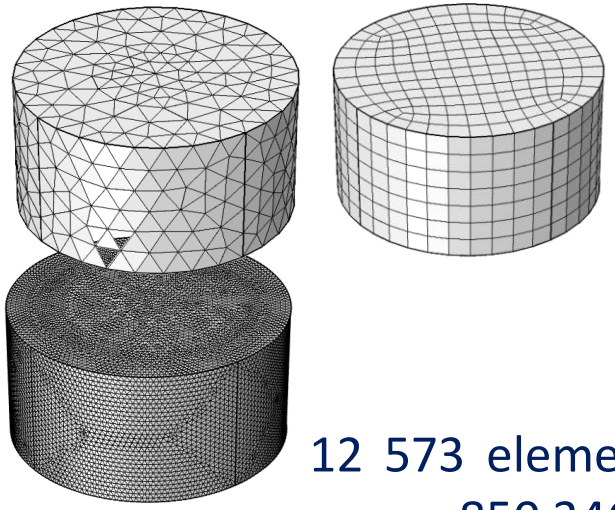
Software to simulate multiphysics processes

COMSOL MULTIPHYSICS®

Subdomains: Meshing

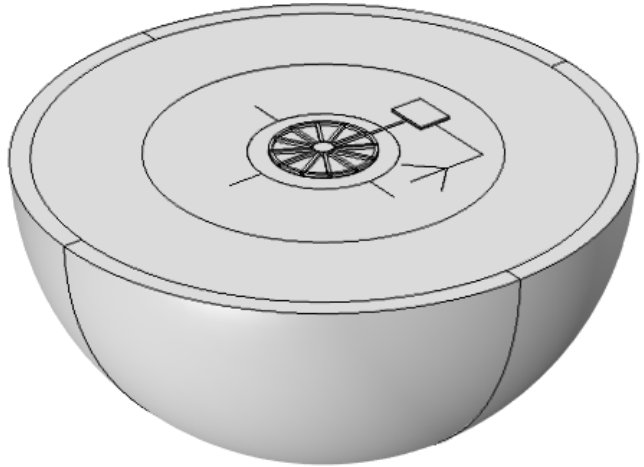
Tetrahedral

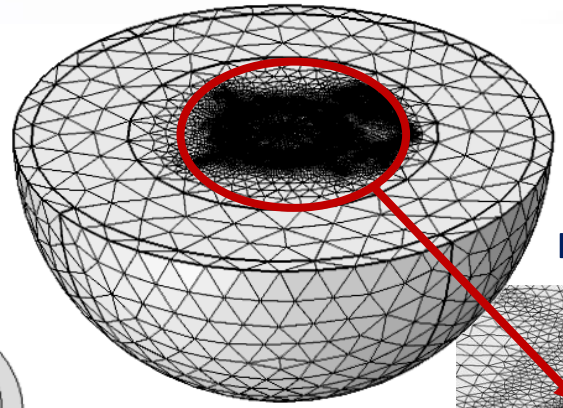
Cubic



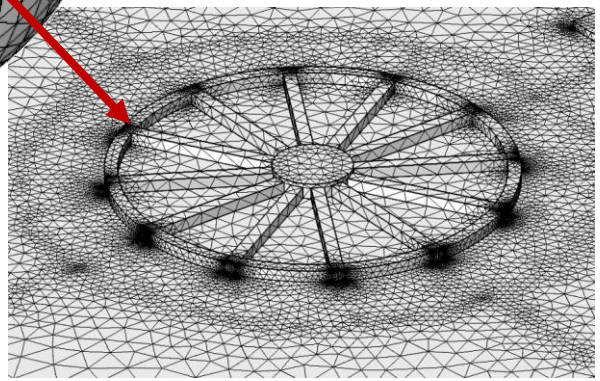
12 573 elements versus 850 346

Our design for LST Earthing System





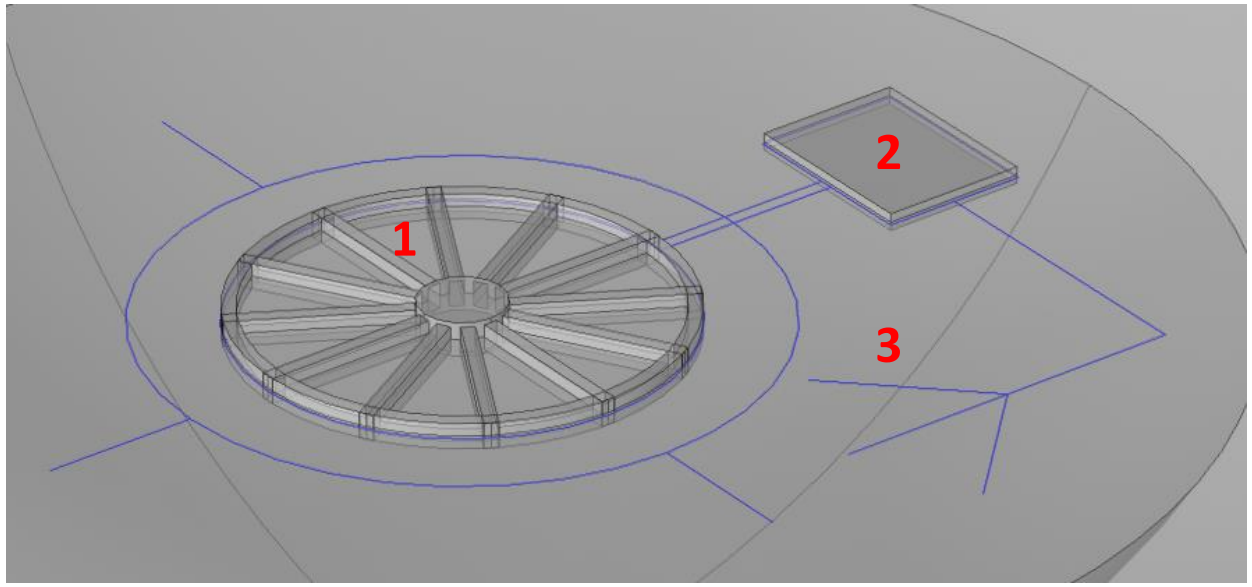
m and mm present



Specific mesh by parts

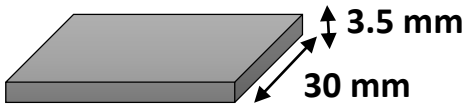
Finite Element Method basics

Reference design



(1) (2) Steel* solid blocks. They correspond to the metal grid of the reinforce concrete.

(3) Metal plates (Steel*)

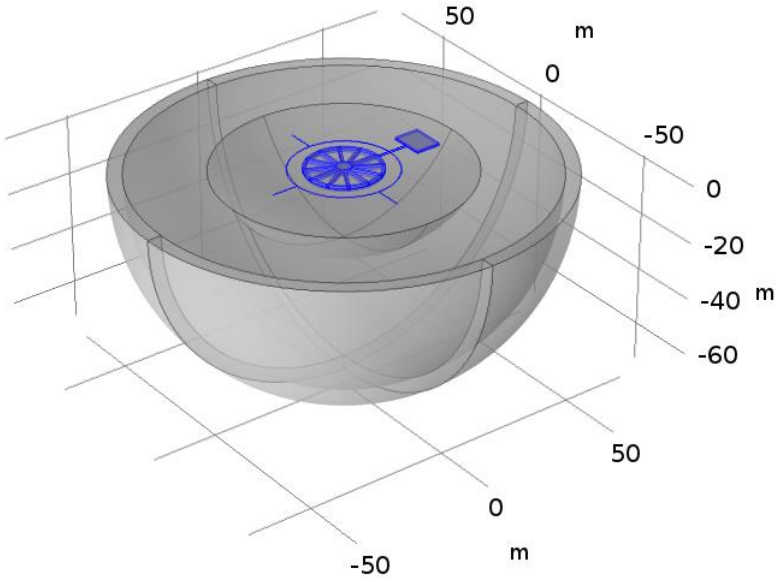


*Material properties of Steel: **conductivity of** $\mathbf{1.12\ 10^7\ S/m}$

Soil resistivity: $\mathbf{1.5\ k\Omega \cdot m}$ (LST1 reference)

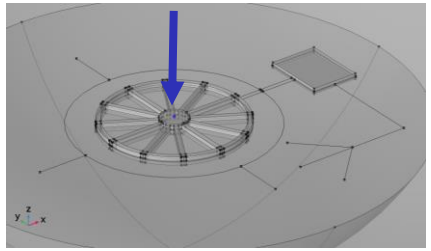
Finite Element Method basics

Design

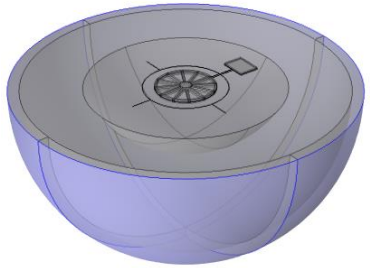


Soil **and** ER structure

Conditions

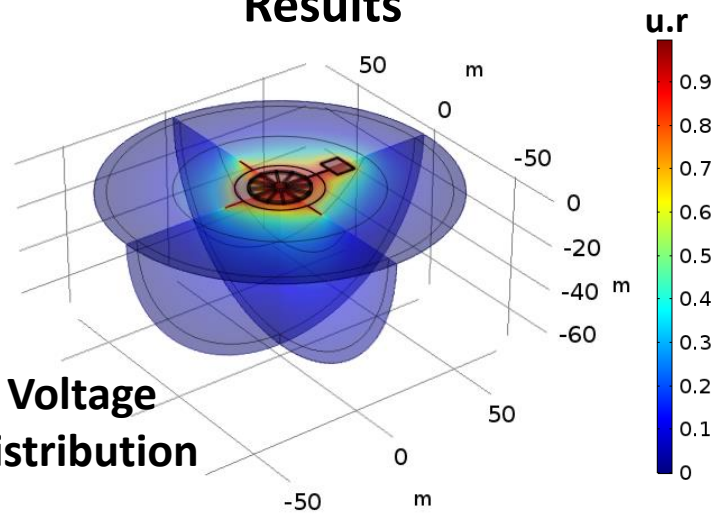


Point source of current



Ground Surface (at the infinite)

Results



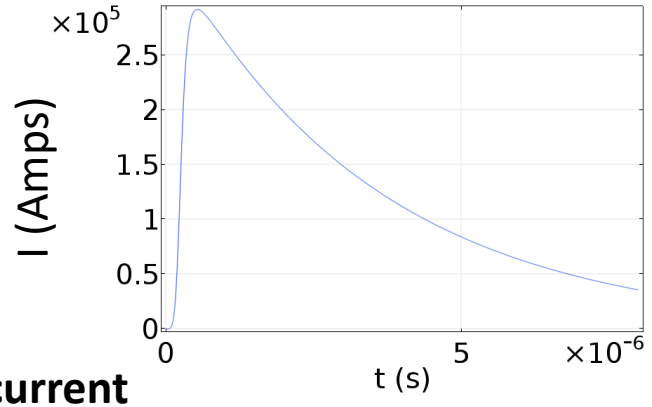
Voltage distribution

Simulation of a lightning strike in a Earthing system

Real

Heidler equation

$$I(t) = \frac{I_{peak}}{\eta} \frac{(\frac{t}{t_1})^n}{1+(\frac{t}{t_1})^n} \exp(\frac{t}{t2})$$



t1: current rise time~0.27 µs

t2: current decay time~3.5 µs

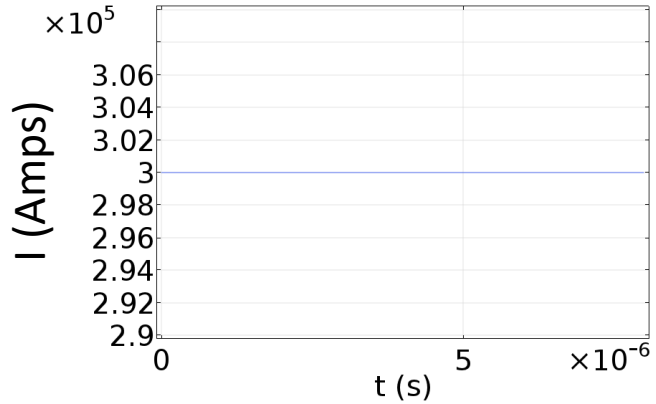
I_{peak}: current peak~300 kA

η: correction factor

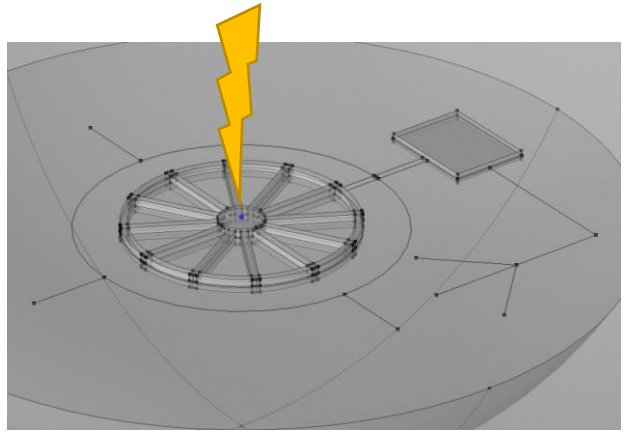
n: exponent~5

Continuous current

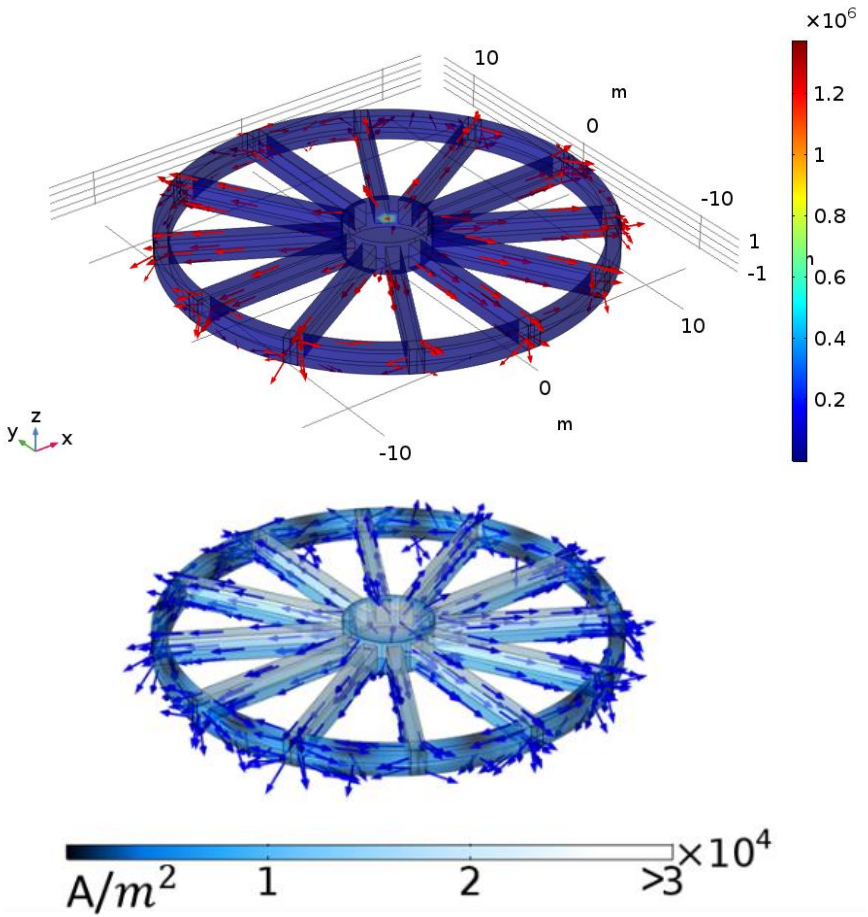
Simple recreation of the injection of a continuous point source in the center of the strucuture



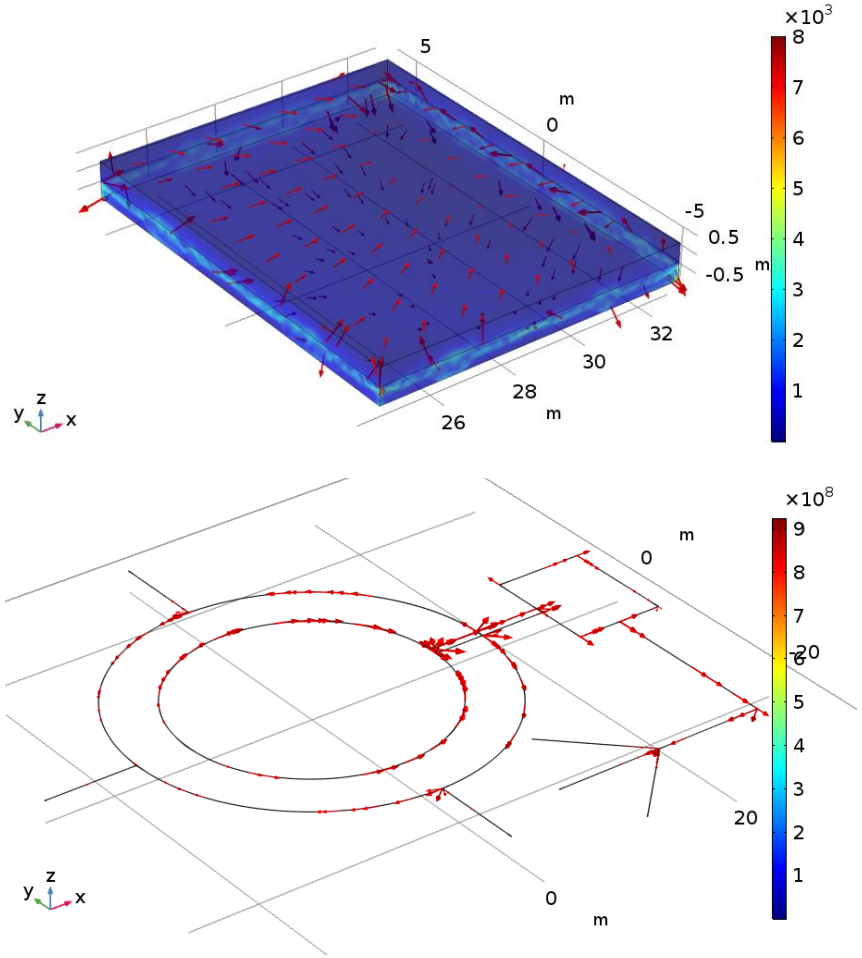
$I(t) = 300\ kA$



Simulation of a lightning strike in a Earthing system



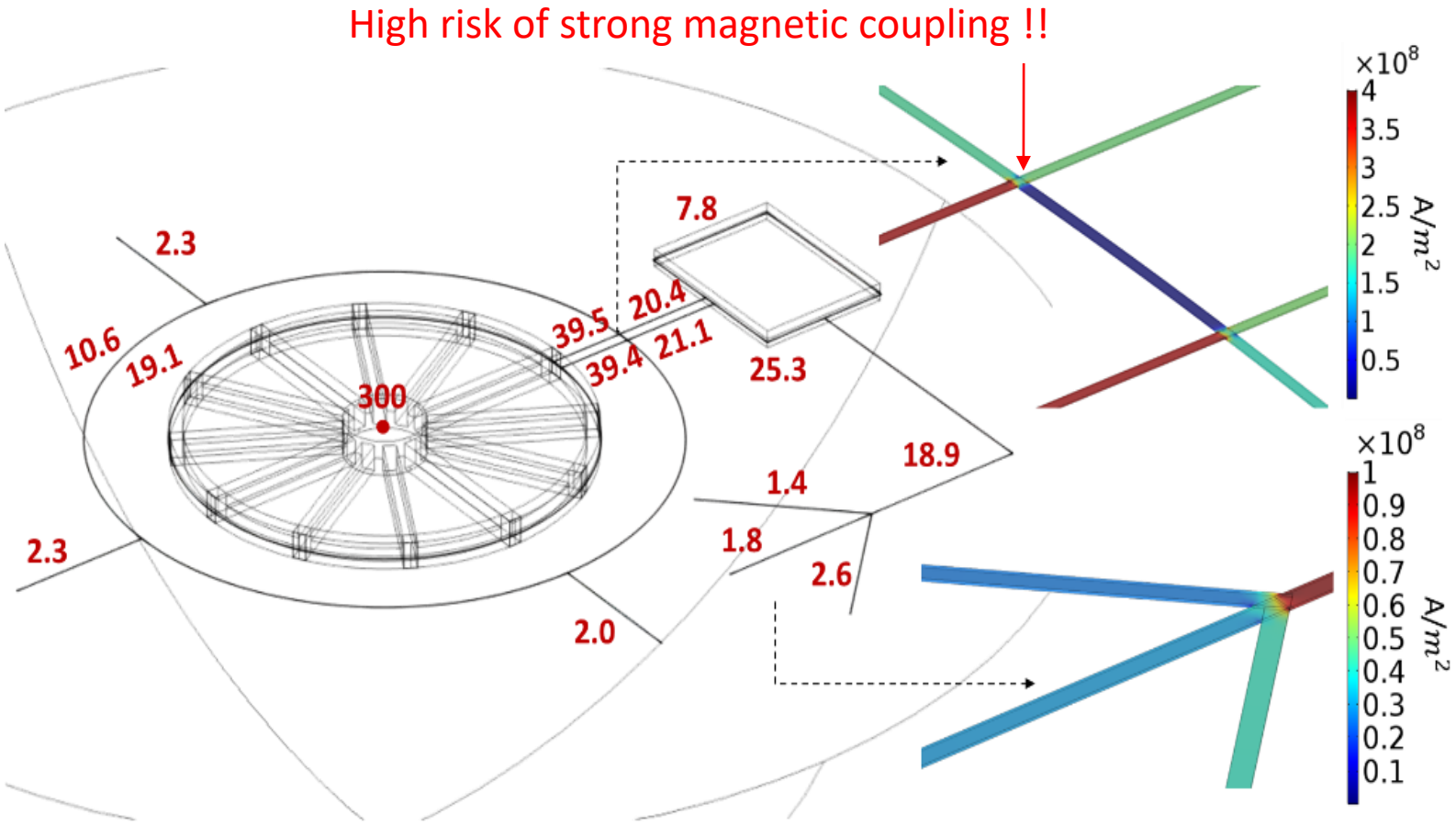
Surface current density and its direction



Simulation of a lightning strike in a Earthing system

Averaged current in kA within the plates

Reduction of one order of magnitude between the current injected and the one that flows through the plates



cherenkov telescope array