AURORA:

leArning sUpeRcOnductivity thRough Apps

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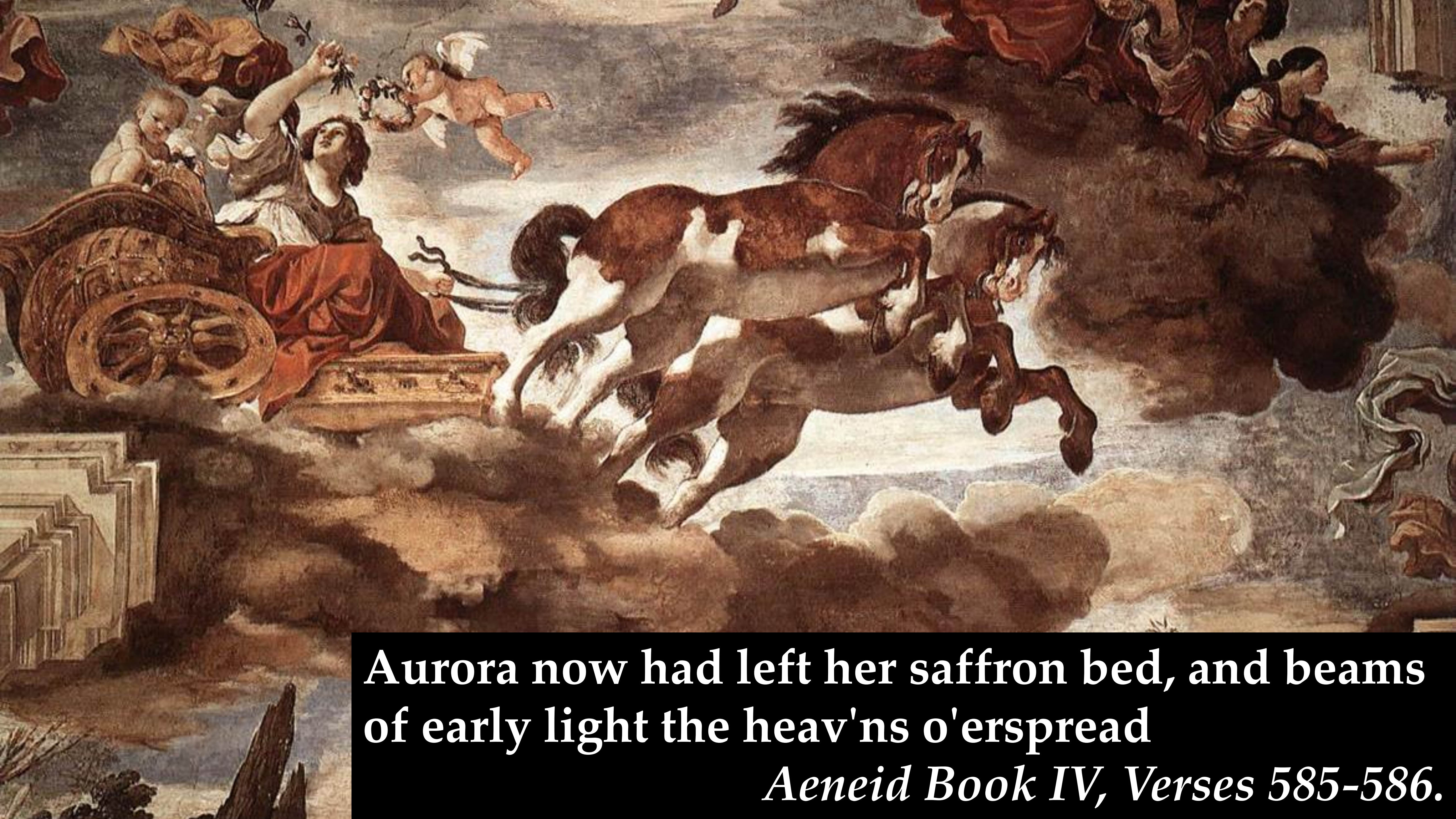

Aurora now had left her saffron bed, and beams of early light the heav'ns o'erspread
Aeneid Book IV, Verses 585-586.

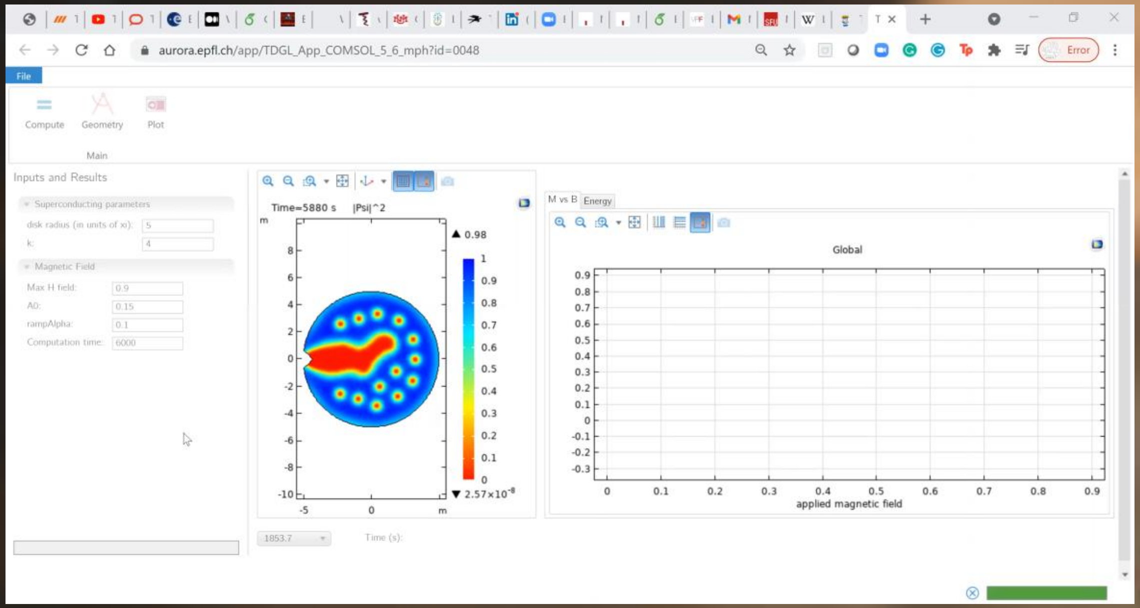
AURORA

LEARNING SUPERCONDUCTIVITY THROUGH APPS

KIT

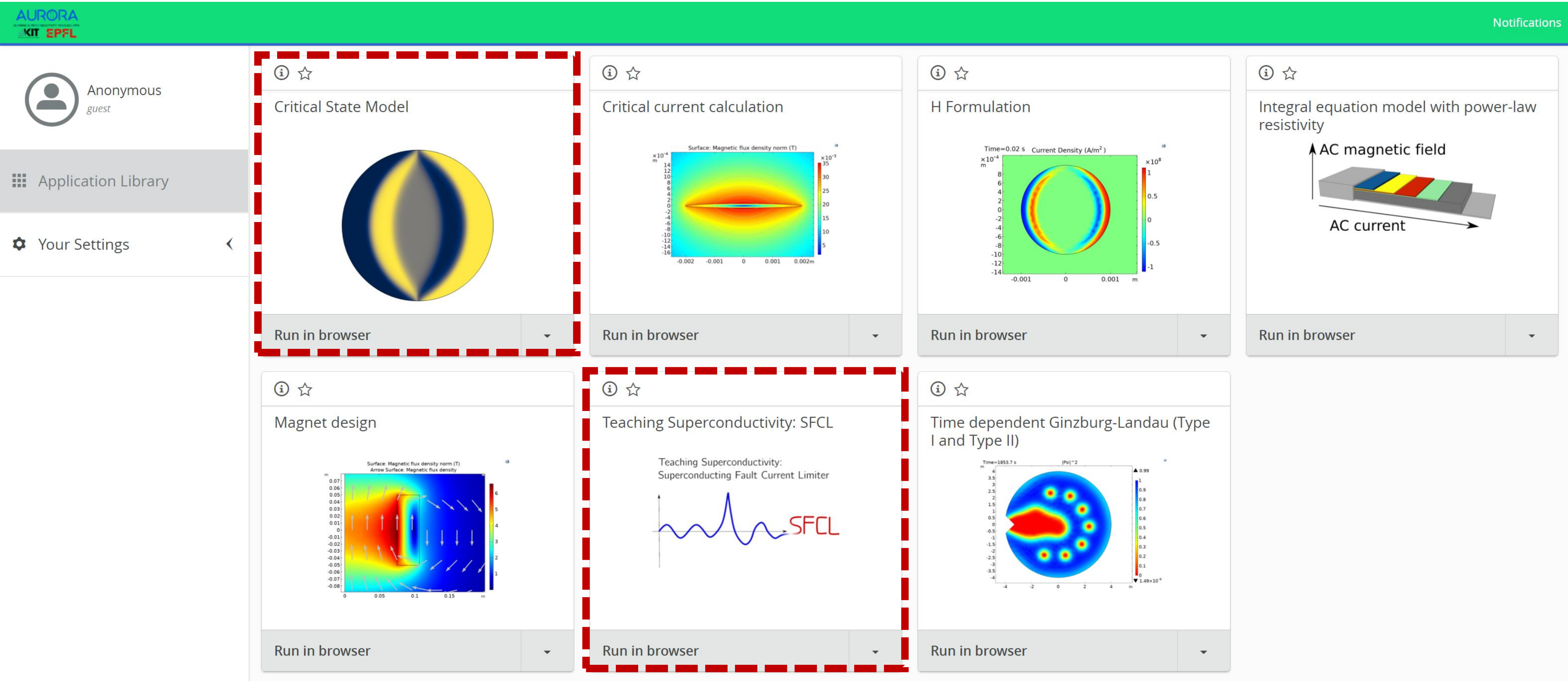
Karlsruher Institut für Technologie

EPFL



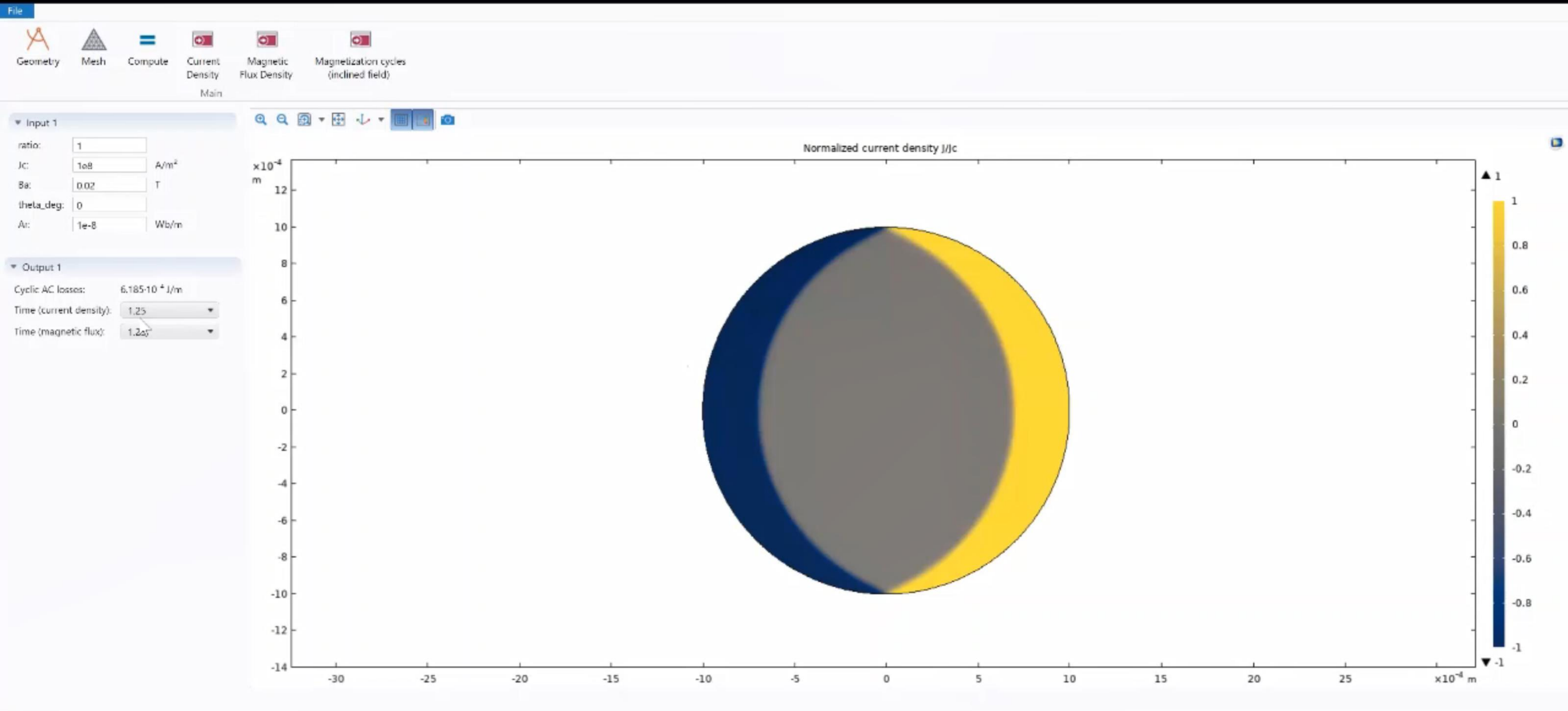
https://aurora.epfl.ch/app-lib

AURORA
LEARNING SUPERCONDUCTIVITY THROUGH APPS



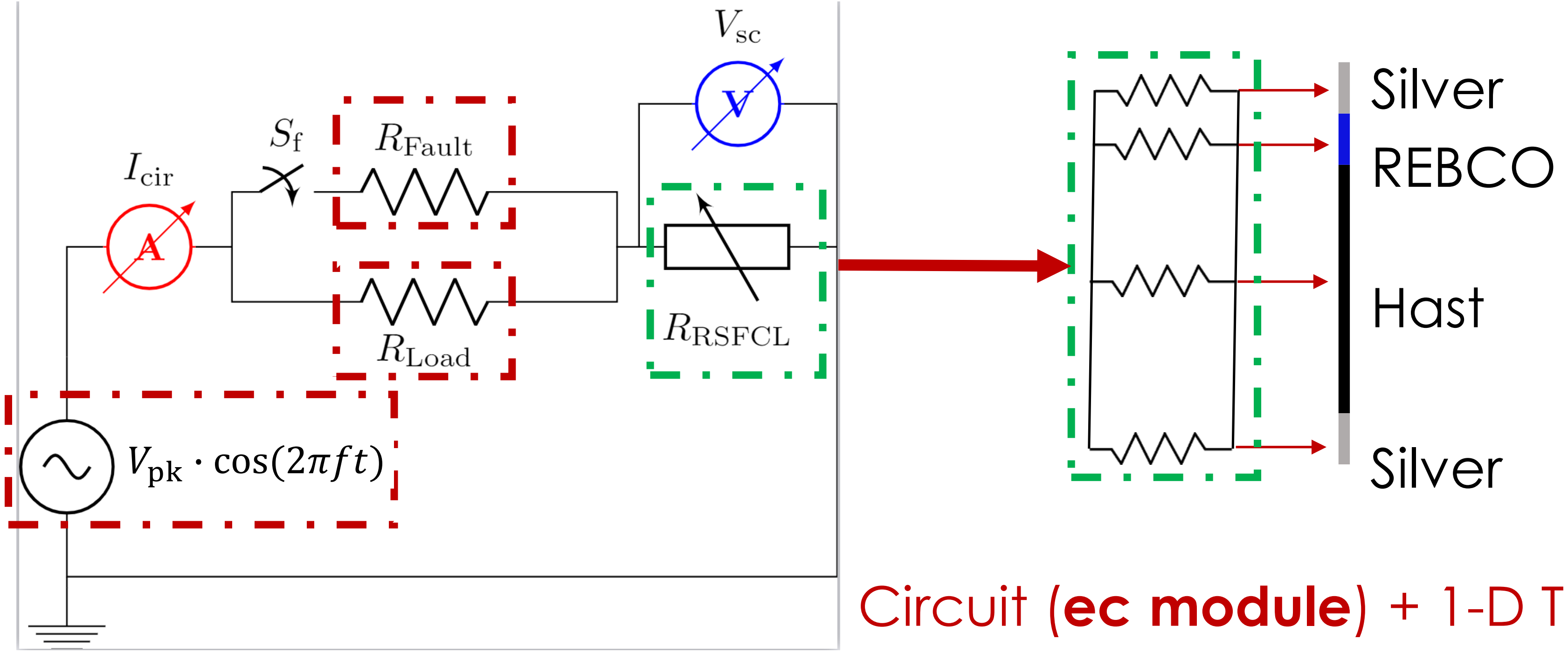
https://aurora.epfl.ch/app-lib

Critical State Model
Campbell’s Implementation


File
Geometry
Mesh
Compute
Current Density
Magnetic Flux Density
Magnetization cycles (inclined field)
Main
Input 1
ratio: 1
Jc: 1e8 A/m²
Ba: 0.02 T
theta_deg: 0
Ar: 1e-8 Wb/m
Output 1
Cyclic AC losses: 6.185·10^-4 J/m
Time (current density): 1.25
Time (magnetic flux): 1.25
Normalized current density J/Jc
×10^-4 m
m
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1

Superconducting Fault Current Limiter

Method: 1-D FEM Model for Resistive SFCL



R_{Fault} → Fault currents

$$R_i(I_i, T_i) = \frac{\rho_{el,i}(I_i, T_i) \cdot L}{S_i}$$

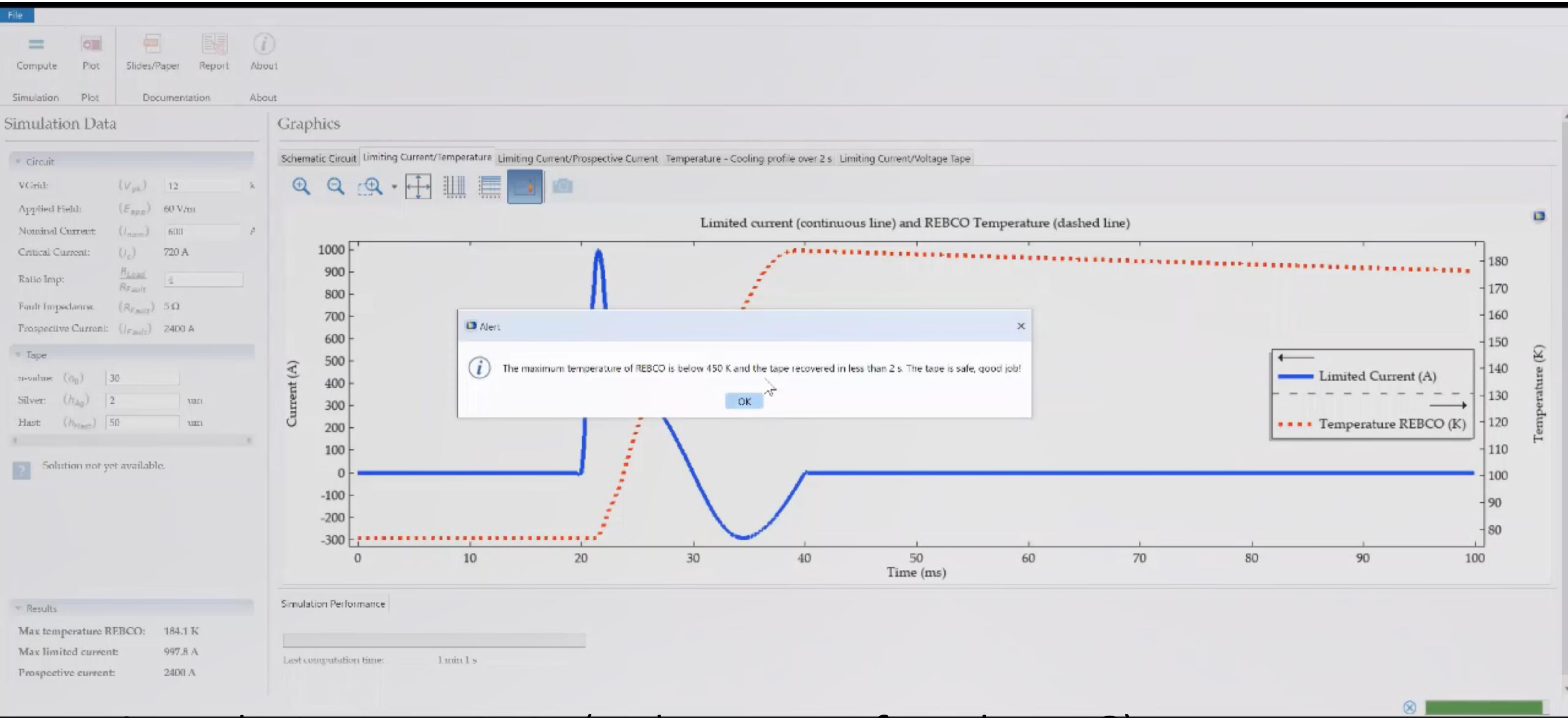
With i indicating Ag, REBCO(PWL), Hast

Circuit (**ec module**) + 1-D Thermal Model (**ht module**)

$$\rho_{m,i}(T_i) C_{p,i}(T_i) \frac{\partial T_i}{\partial t} + \vec{\nabla} \cdot \left(-k(T_i) \vec{\nabla} T_i\right) = \frac{R_i(I_i, T_i) \cdot I_i^2(t)}{L \cdot S_i} - h_{LN2} \cdot (T_i - T_0)\Big|_{\partial\Omega}$$

Heat Source (Joule Heating)

Convection Cooling (Boundary Condition)


File
Compute
Plot
Slides/Paper
Report
About
Simulation
Plot
Documentation
About
Simulation Data
Circuit
Applied Field:
60 V/m
Critical Current:
720 A
Ratio Imp:
Fault Impedance:
5 Ω
Prospective Current:
2400 A
Tape
n-value:
30
Silver:
2
Hast:
50
Solution not yet available.
Results
Max temperature REBCO:
184.1 K
Max limited current:
997.8 A
Prospective current:
2400 A
Graphics
Schematic Circuit
Limiting Current/Temperature
Limiting Current/Prospective Current
Temperature - Cooling profile over 2 s
Limiting Current/Voltage Tape
Limited current (continuous line) and REBCO Temperature (dashed line)
Current (A)
Time (ms)
Temperature (K)
Limited Current (A)
Temperature REBCO (K)
Alert
The maximum temperature of REBCO is below 450 K and the tape recovered in less than 2 s. The tape is safe, good job!
OK
Simulation Performance
Last computation time:
1 min 1 s

CONCLUSIONS:

- Various apps simulating multi-scale aspects of superconductivity

Advantages

- The AURORA server is public (license on our side) and can be used from PC/tablet/phone by everyone
- The students are engaged and they can learn several physical and practical aspects of superconductivity

Disadvantages

- AURORA currently runs on limited computing resources

—> Simple models, limited number of simultaneous users

AURORA

Curious about ***AURORA*** *and* ***you want*** *to test it right away?*

https://aurora.epfl.ch/app-lib

HTS Modeling Website

Curious ***many other*** *models for* ***superconducting applications****?*

Special thanks:

- EPFL and the IT team for providing the physical server where AURORA lives
- Sven Friedel, Hinrich Arnoldt (COMSOL) and Ivar Kjelberg (CSEM SA) for having provided feedback and useful tips to developing the apps