
CERN

DGS-SEE SEMINAR ON FIRE PROTECTION FOR PHYSICS RESEARCH FACILITIES

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CERN

CREATING A CABLE MATERIAL FOR FIRE SIMULATION – FIRST STEPS

TRISTAN HEHNEN

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Introduction

Introduction

Bundesministerium für Bildung und Forschung

CERN

BERGISCHE UNIVERSITÄT WUPPERTAL

- Member of the Doctoral Student Programme at CERN
- Work supported by the Wolfgang-Gentner-Programme of the German Federal Ministry of Education and Research (BMBF)

Supervisor:
Saverio La Mendola

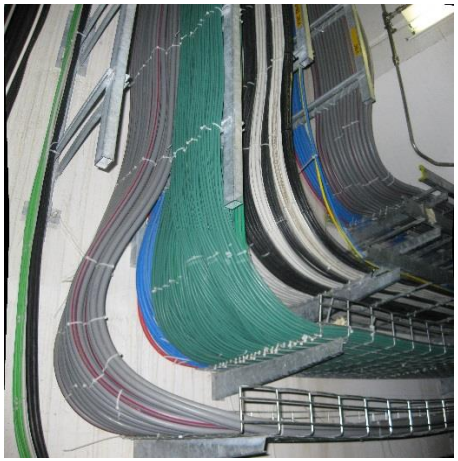
- Doctoral student at the Bergische Universität Wuppertal
- Department: Computer Simulation for Fire Safety and Pedestrian Traffic

Supervisor:
Armin Seyfried
Lukas Arnold

Duration of the doctoral programm: from Nov. 2014 to Nov. 2017

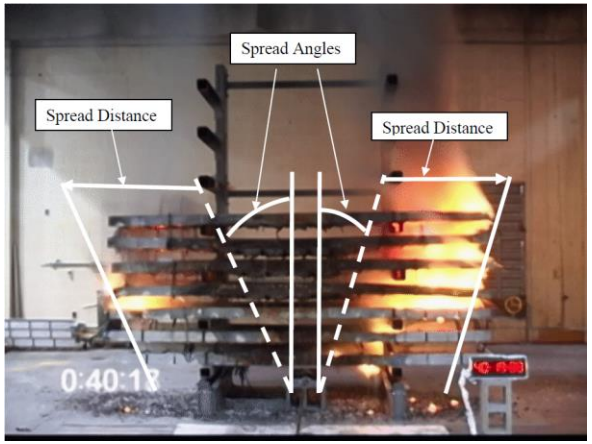
Aim

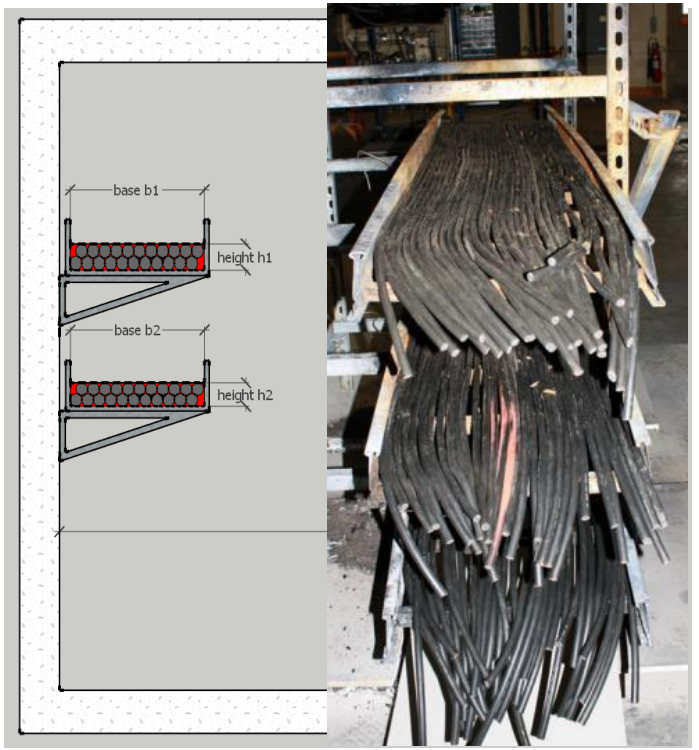
- Investigate fire behaviour of electrical equipment
- Cable trays first, maybe later cabinets and their interconnection
- Create simple model(s) to estimate fire propagation



Starting ideas
Cable fire models at CERN

- Work had been done by Fabio Corsanego DGS/SEE, based on the CHRISTIFIRE project conducted by U.S.NRC.
- Conservative and simple model for fire load estimation of cables inside a tunnel
- Guidelines for design fires, simplified the FLASH-CAT code into an Excel-sheet

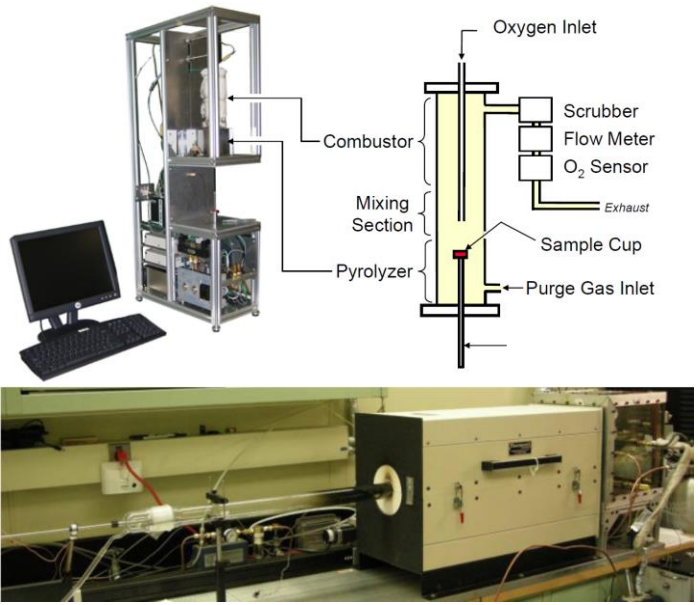


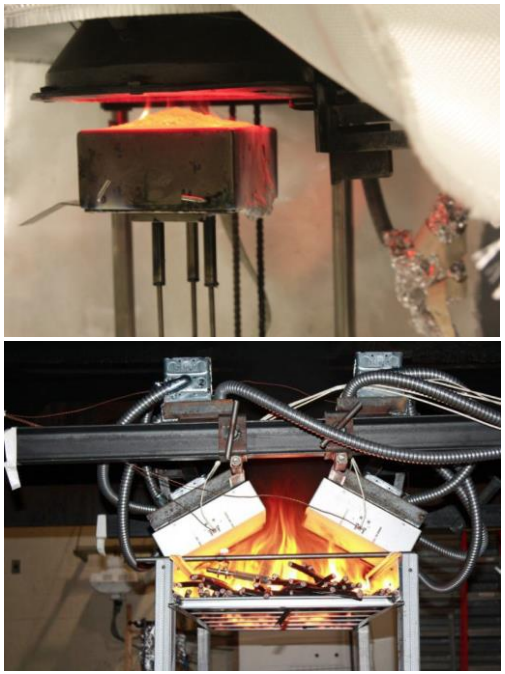


Picture: CHRISTIFIRE, phase 1

Starting ideas
CHRISTIFIRE programme

- Cable Heat Release, Ignition, and Spread in Tray Installations During Fire (CHRISTIFIRE)
- Plenty of data recorded, able to be utilised in simulations

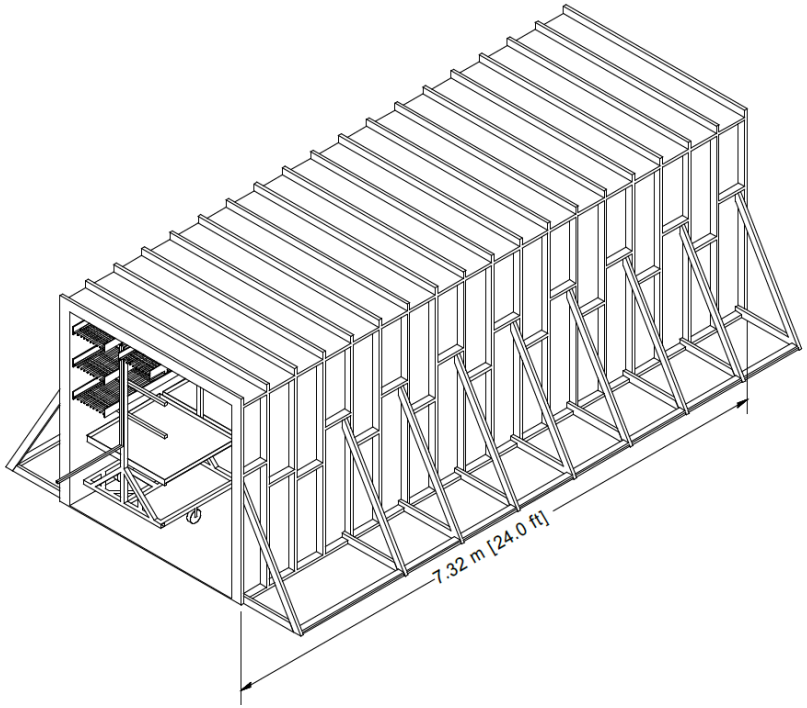


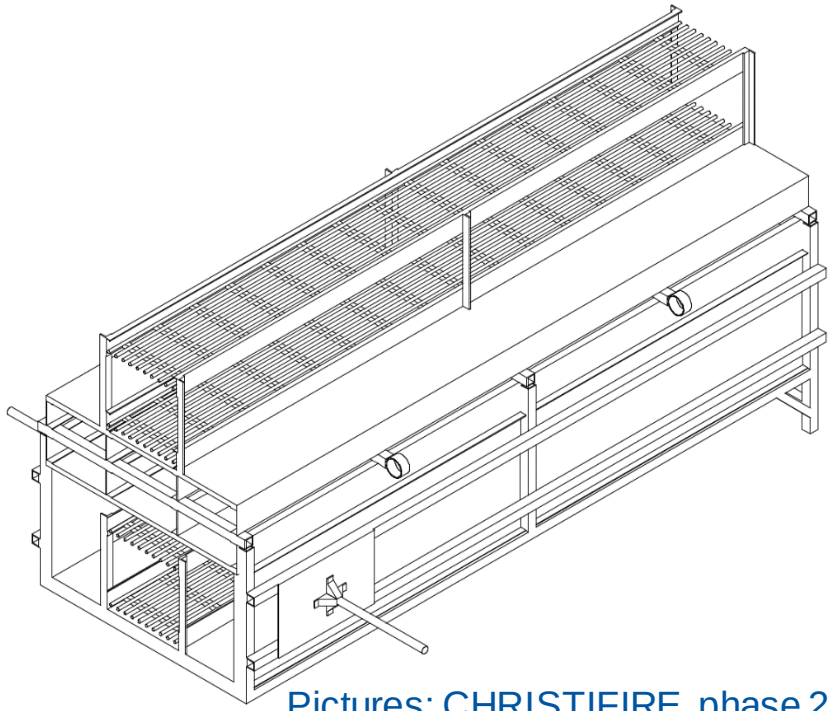


Pictures: CHRISTIFIRE, phase 1

Strating ideas
CHRISTIFIRE programme

- Phase 2:
  - Additional 23 cables
  - Small- and full-scale
  - Corridor (2.4 m * 2.4 m * 7.3 m), up to four trays
  - Shaft, two trays inside, two trays outside

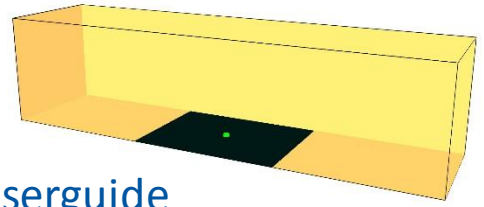




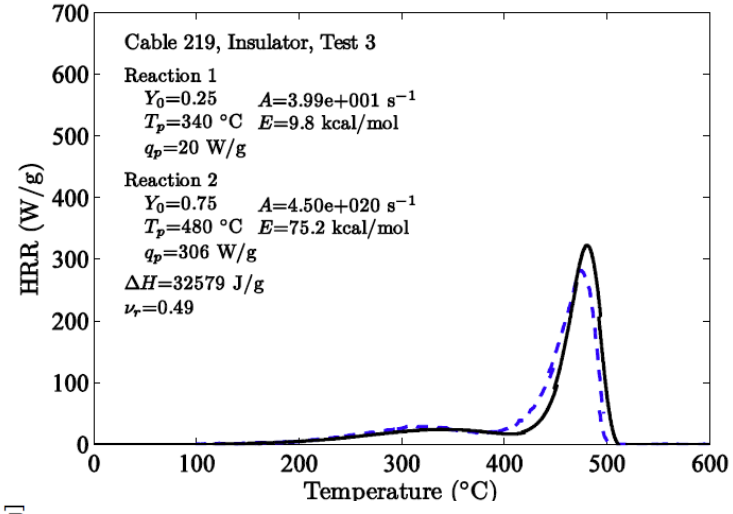
Pictures: CHRISTIFIRE, phase 2

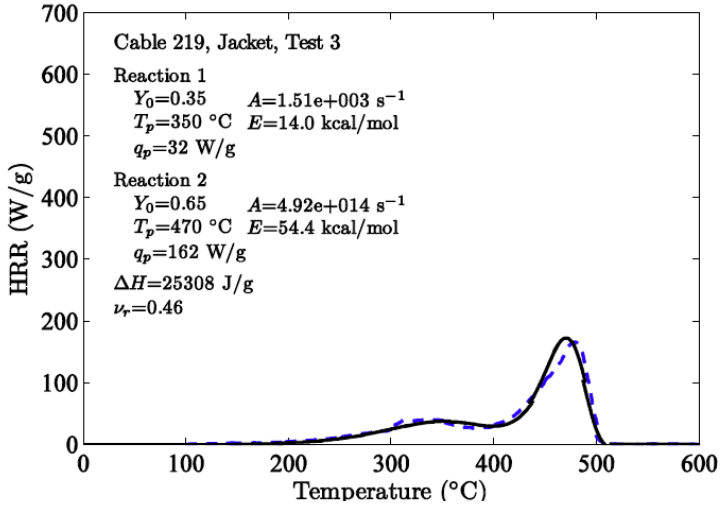
Cable material first steps

Cable material first steps
Micro-Combustion Calorimetry

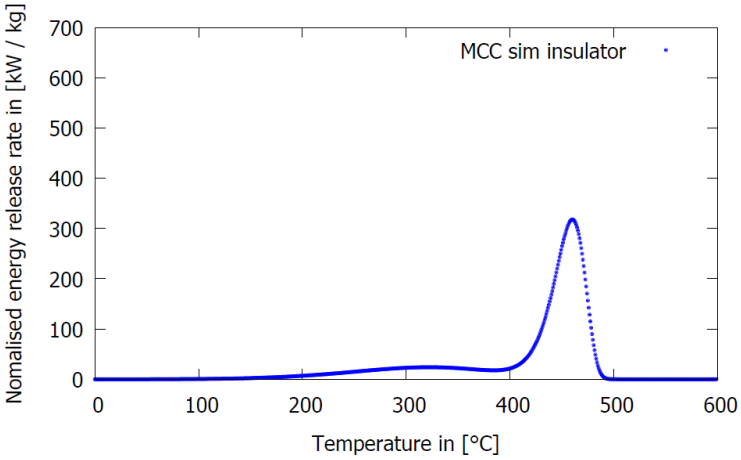


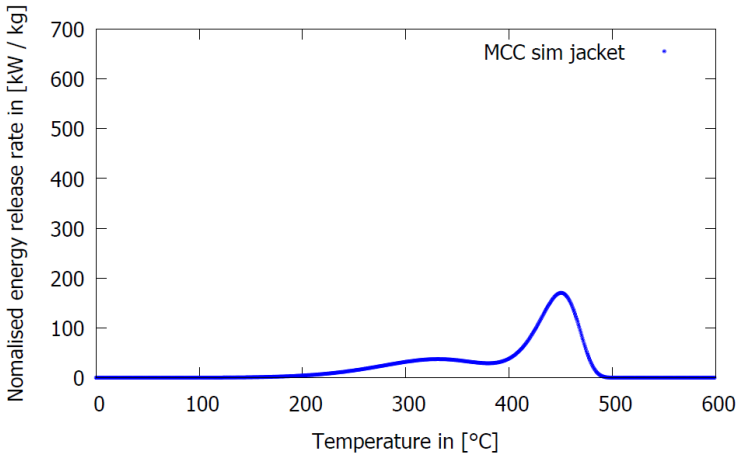
- MCC with CHRISTIFIRE data (cable #219); Simulation from FDS Userguide





Experiment





Simulation

Cable material first steps

Cable material

- Material #219 to FDS
- Projection of the circular cross section to a rectangle, width = cable diameter
  - Layer 1 and 5: ~3,1 mm
  - Layer 2 and 4: ~1,4 mm
  - Layer 3 : ~0.1 mm
  - BACKING=`INSULATED`

Structure of the SURF

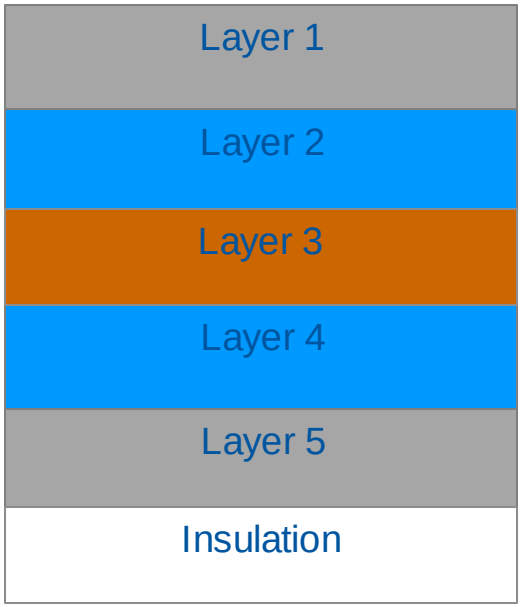
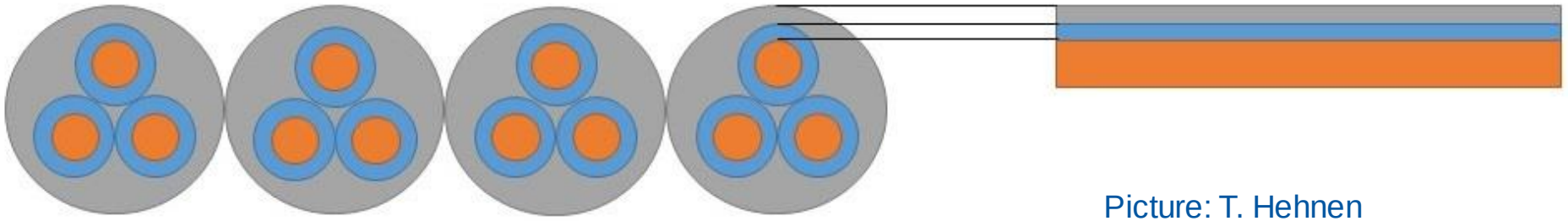


Illustration: How to represent the cables?



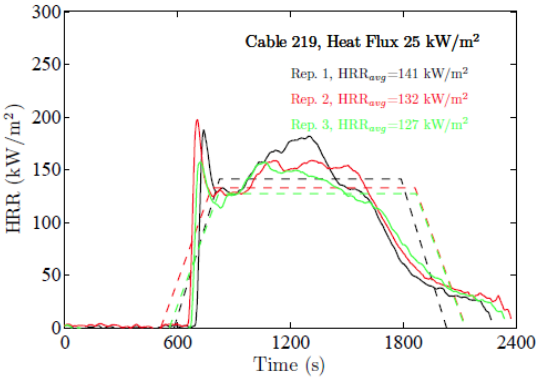
Picture: T. Hehnen

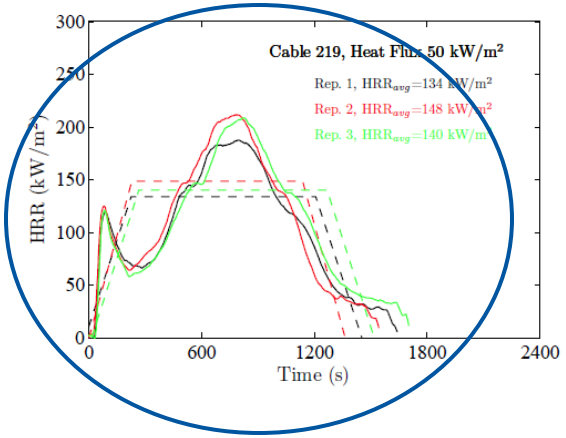
Cable material first steps

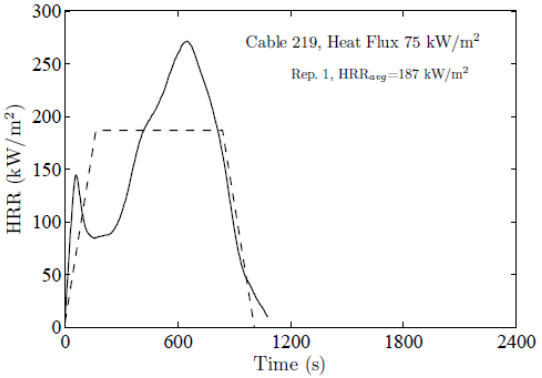
Cone Calorimetry

- cable #219 in Cone test
- Adjust material parameters to fit simulation to experimental results

Cone Calorimeter results



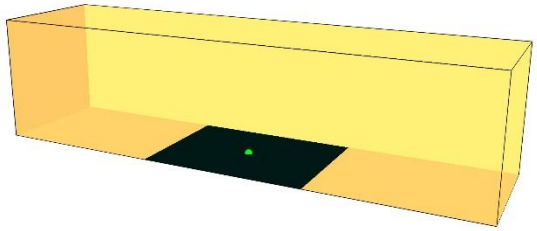




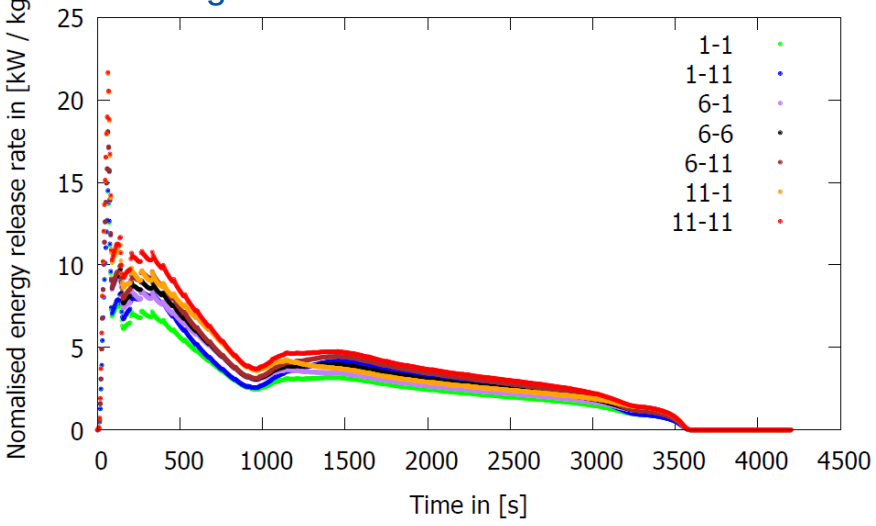
Picture: CHRISTIFIRE phase 1

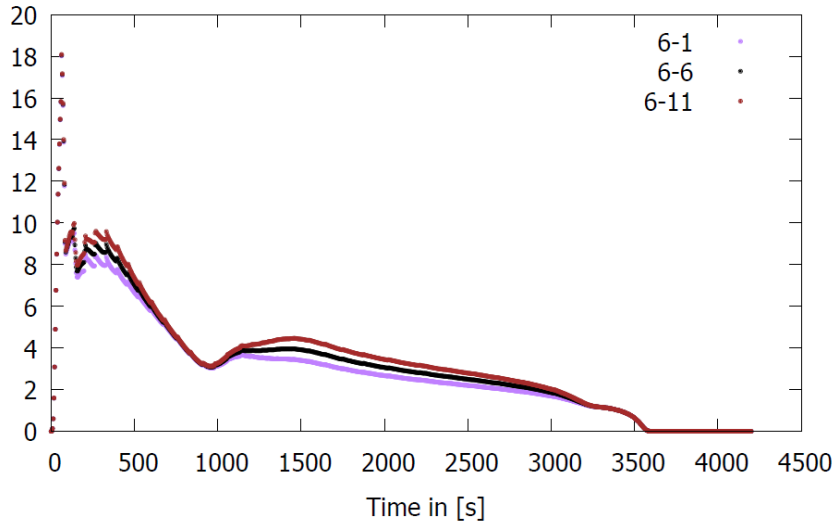
Cable material first steps
Cone Simulation

- Variation of the heat of combustion, ± 20 %
- Simulation in simplified Cone (from FDS Userguide)
- Parameter from CHRISTIFIRE in black



Change of the heat of combustion

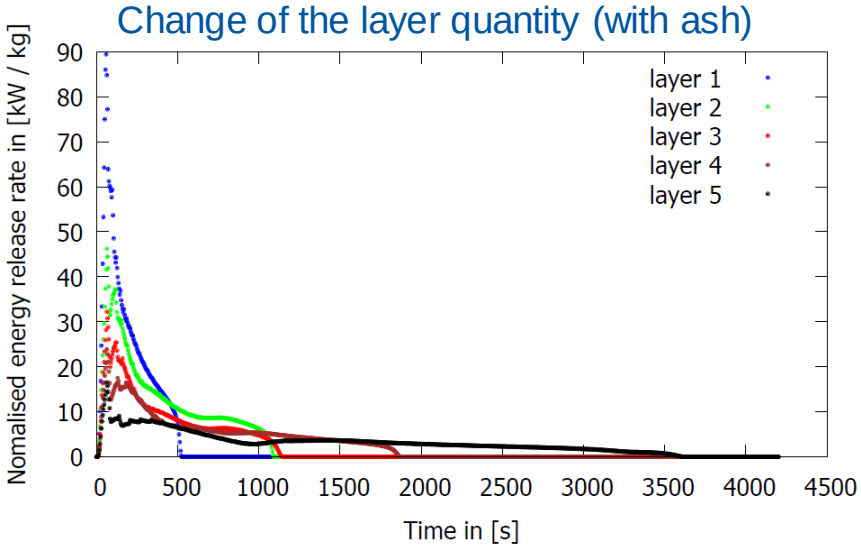


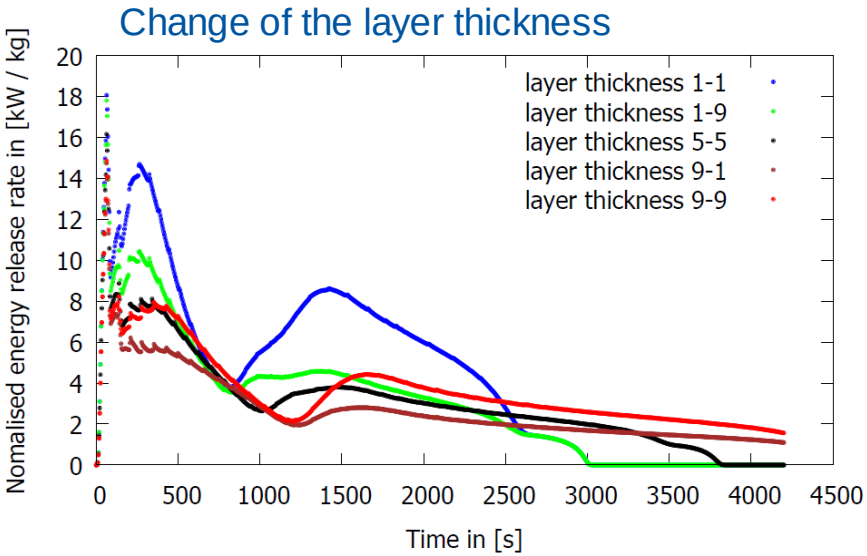


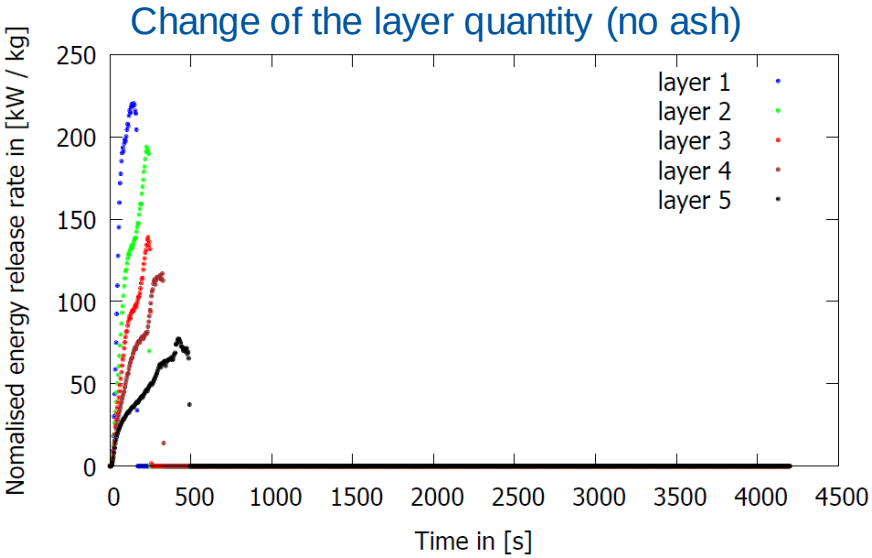
Cable material first steps

Cone Simulation

- Variation of the layer quantity, starting with top layer
- Variation of the layer thickness, ± 20 %;
- Parameter from CHRISTIFIRE in black





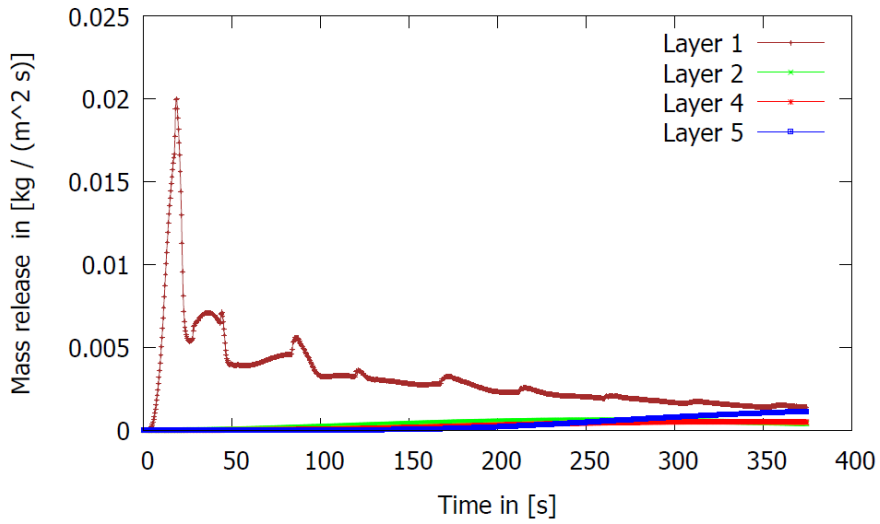


Cable material first steps

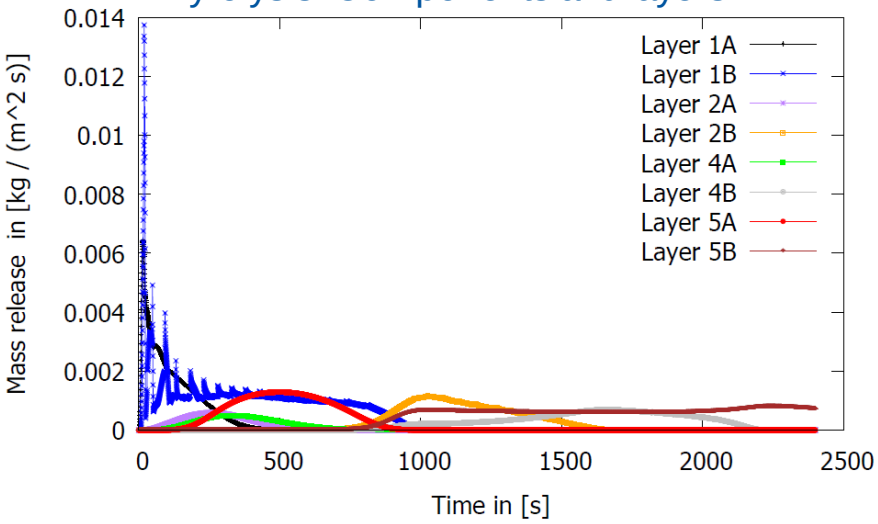
Cone Simulation

- Pyrolysis monitored per layer
- Layers 1-5, layer 3 is copper – no pyrolysis in the simulation
- Simulation in „Coarse Cone“ (7,5 mm cells)

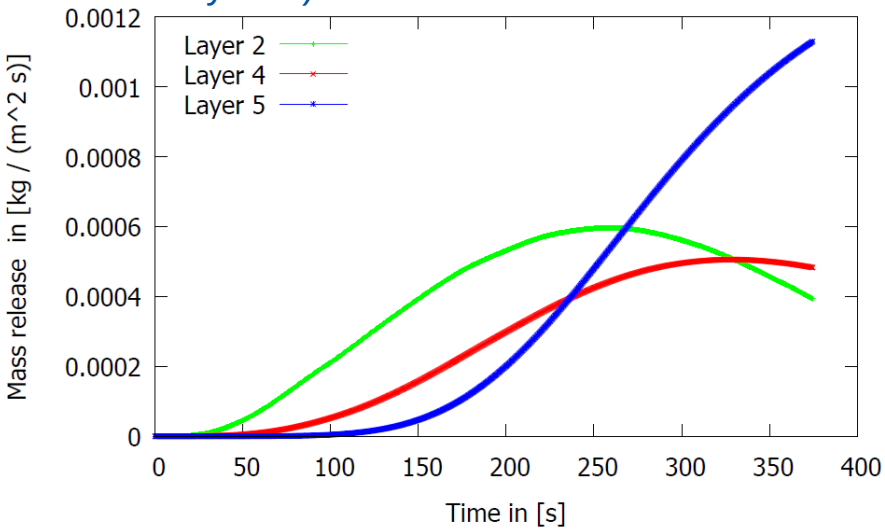
Pyrolysis: Layers



Pyrolysis: Components and layers



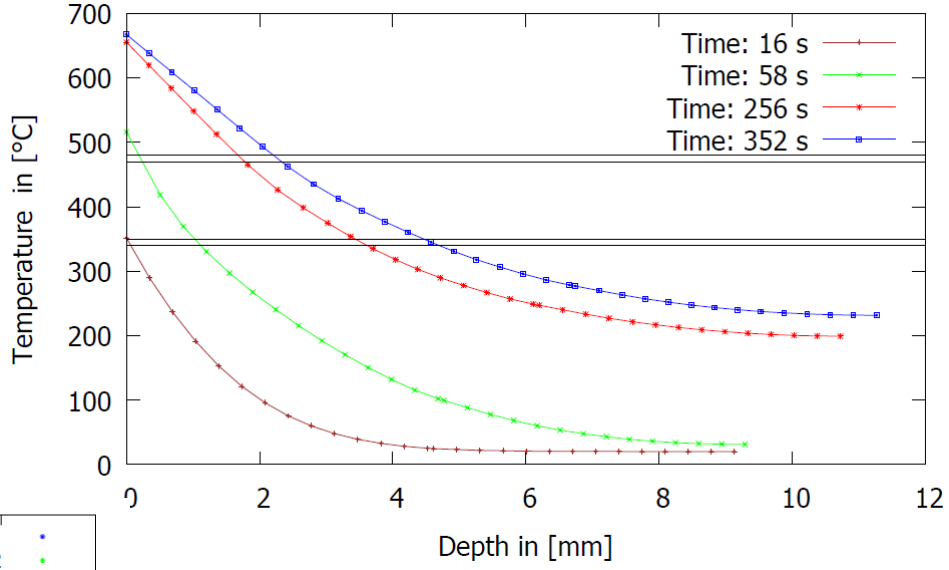
Pyrolysis: Layers (form above without layer 1)

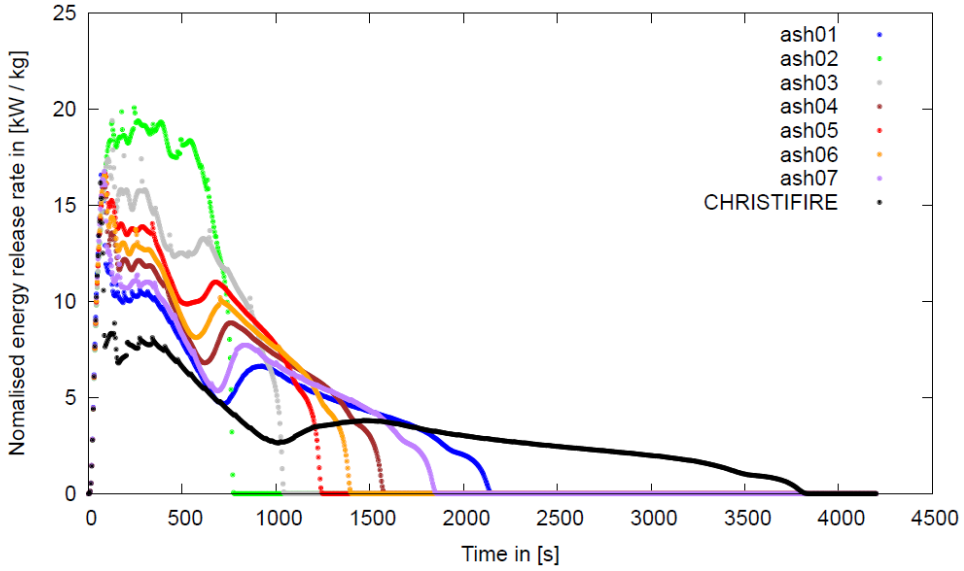


Cable material first steps

Cone Simulation

- Heating of the different layers at different times
- Changes in thermal properties of the ashes



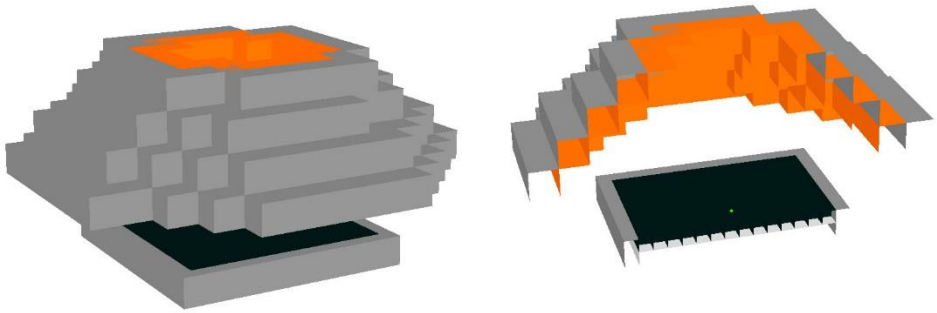


Cable material first steps

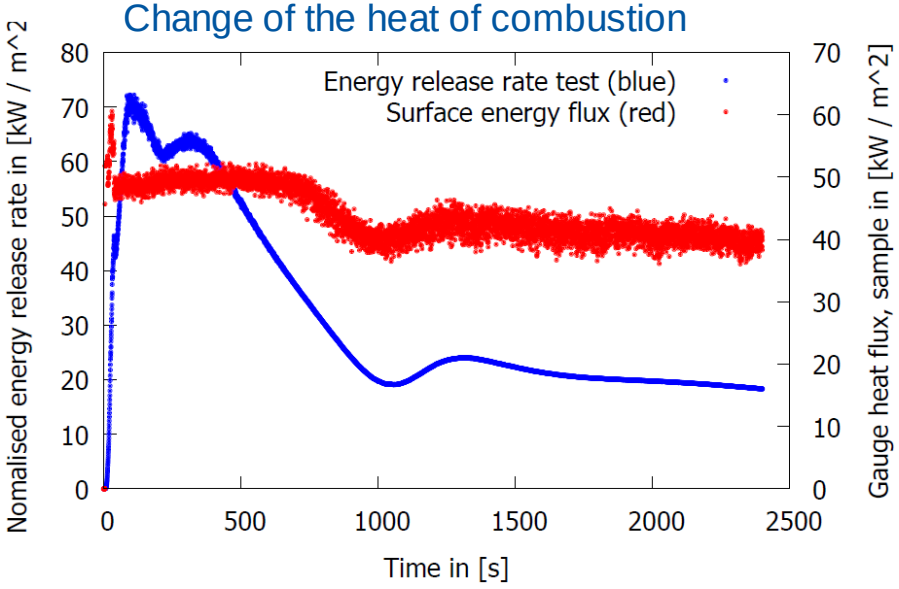
Cone Simulation

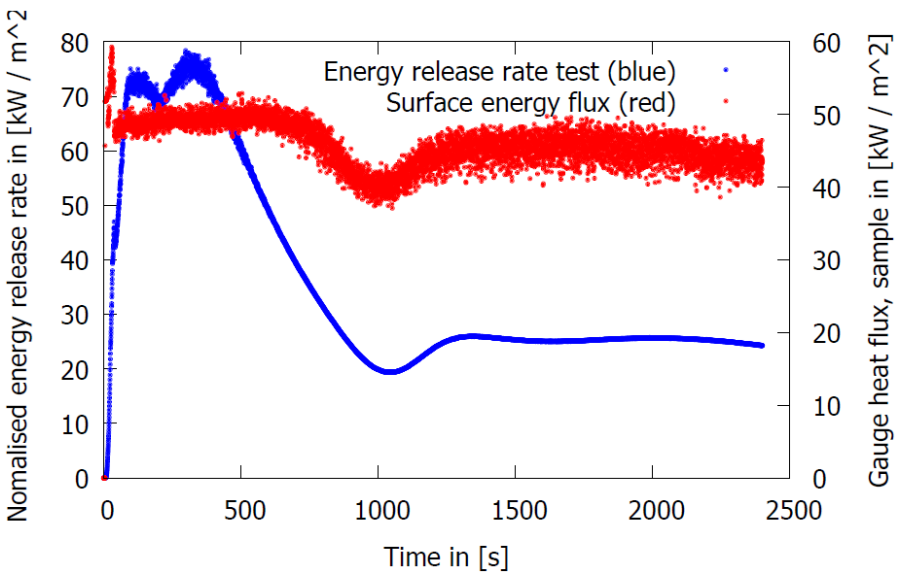
- Variation of the heat of combustion
- Simulation in „Coarse Cone“ (7,5 mm cells)

Cone with 7,5 mm cells



Change of the heat of combustion



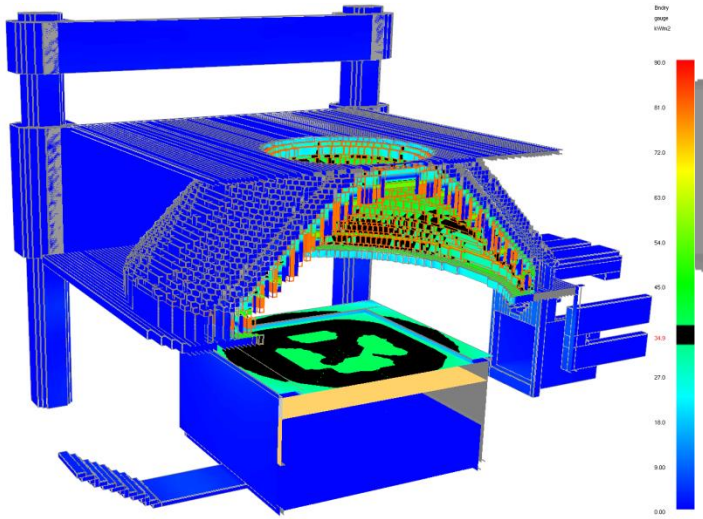


Future steps

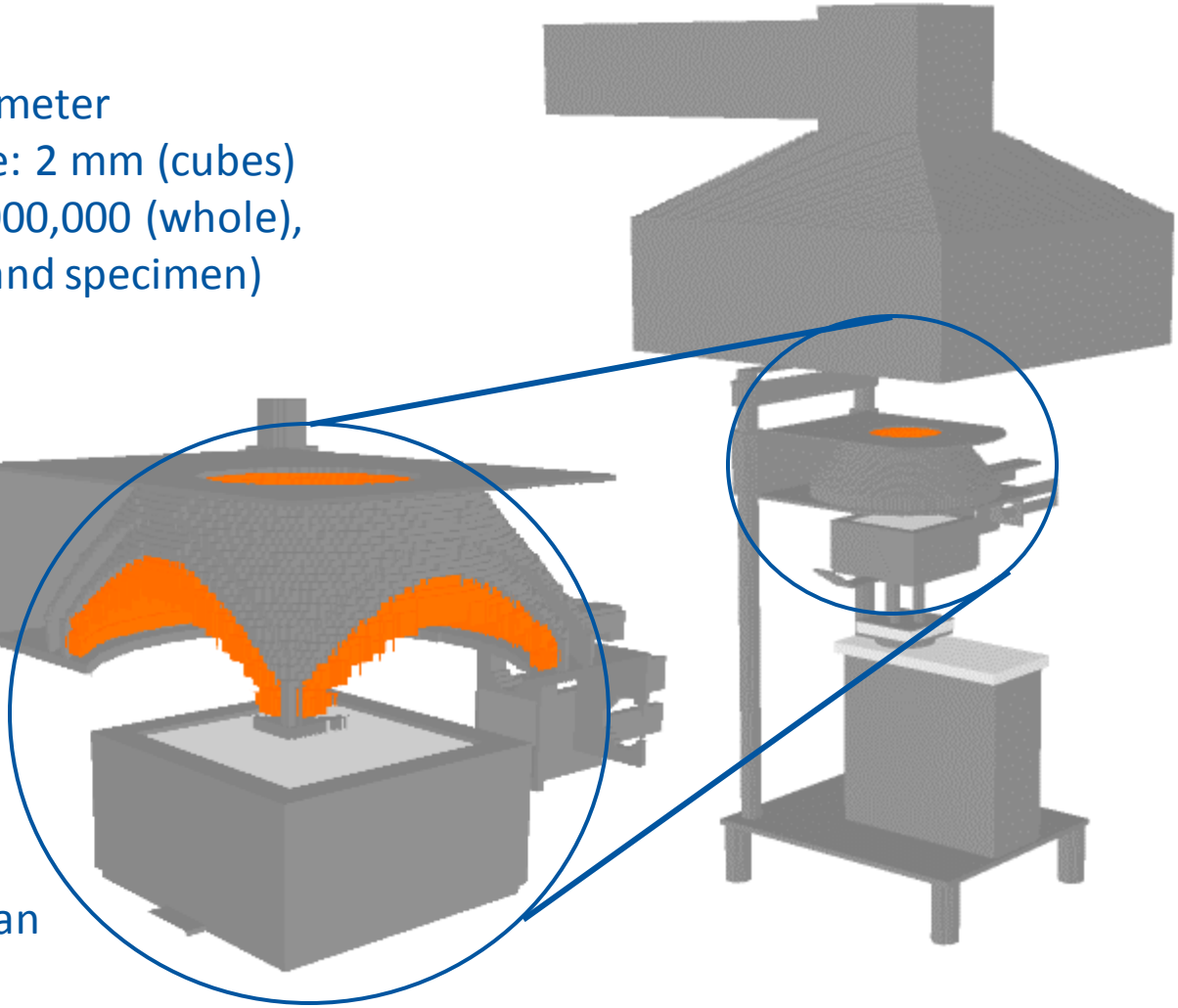
Future steps

Prepared models

- High-resolution cone calorimeter
  - Uniform mesh, cell size: 2 mm (cubes)
  - Number of cells: 125,000,000 (whole), 1,969,920 (only cone and specimen)



heater temperature: 598.69 °C, mean gauge heat flux at sample surface: 35.21 kW/m2

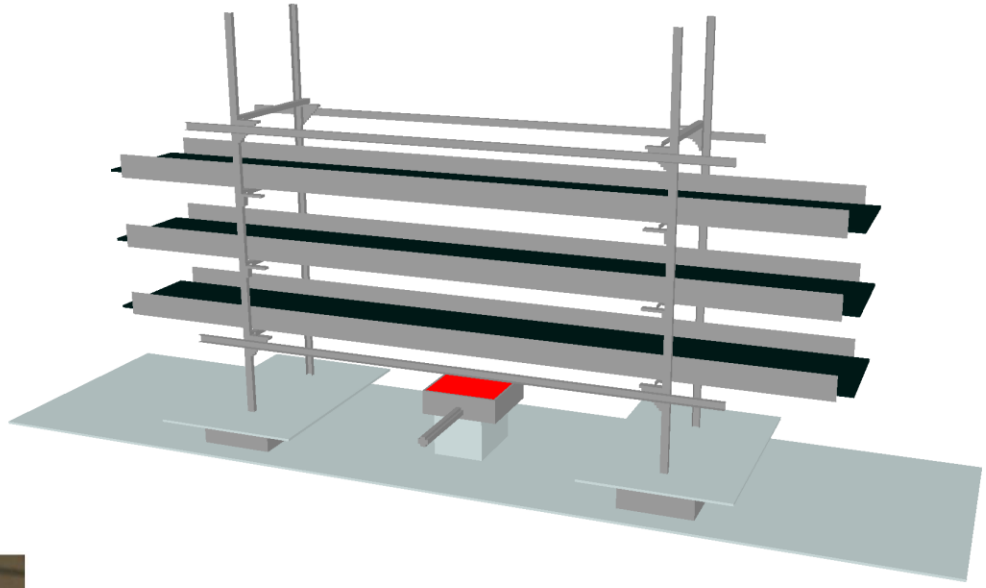


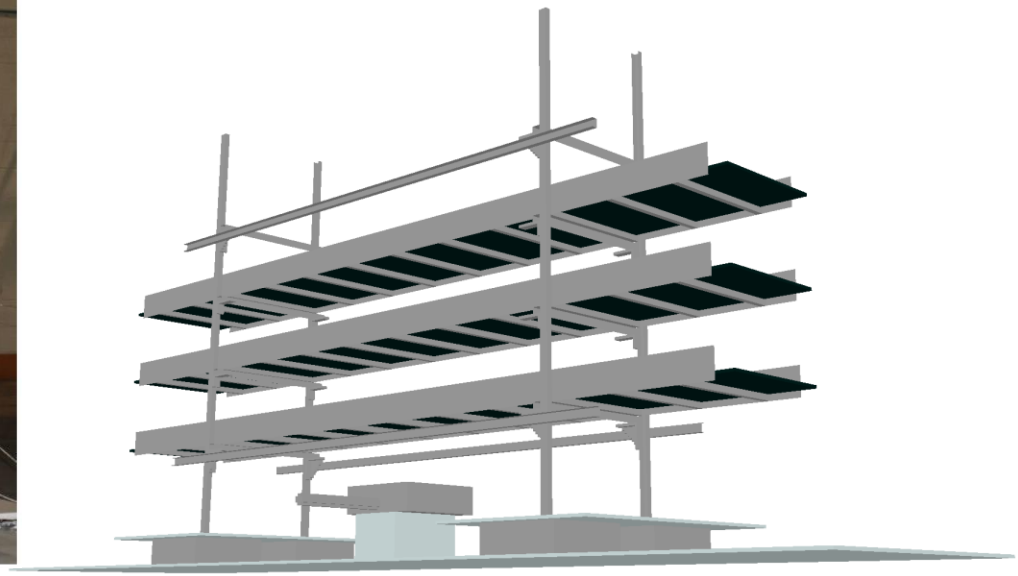
Pictures: T. Hehnen

Future steps

Prepared models

- Multiple cable tray experiment
  - Uniform mesh, cell size: 1 cm
  - Based on CHRISTIFIRE Phase 1 (MT Test 1)





Pictures: T. Hehnen, CHRISTIFIRE

Thank you for your kind attention!

Do you have any questions?

Literature
Excerpt

- ***Influence of input parameters on the fire simulation***, Trettin, C., Hagemann, P., Werrel, M., Wittbecker, F.-W., PROCEEDINGS Fire and Evacuating Modelling Technical Conference (FEMTC) 2014, Gaithersburg, Maryland, September 8-10
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- Drysdale D. ***An Introduction to Fire Dynamics***. John Wiley & Sons, Southern Gate, Chichester, West Sussex PO19 8 Q, England, second edition, 1998.
- ***Safety request form: "Request to characterize the burning behaviour of a vertical stack of horizontal cable trays."***, Answered by: F.Corsanego DGS/SEE, EDMS No.: 1357073 v1.0
- *Technical Note:* ***"Fire modelling tools: Parameters for vertical and horizontal cable tray fire modelling. Results from real-scale tests."***, F.Corsanego, DGS-SEE, EDMS No.: 1097020 ver. 1
- *Guideline:* ***"Fire modelling tools: Quick method to calculate the fire load of cable trays and cable ladders ."***, F.Corsanego, DGS-SEE, EDMS No.: 1405658 ver. 1

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- *Cable Heat Release,* ***Ignition and Spread in Tray Installations During Fire (CHRISTIFIRE) Phase 1: Horizontal Trays***, NUREG/CR-7010, Vol. 1, U.S.NRC, July 2012, McGrattan K., Lock L., Marsh N., Nyden M., Bareham S., Price M.,
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- **McGrattan K., McDermott R.,Weinschenk C., Overholt K.** Fire Dynamics Simulator (Version 6) User's Guide. Technical report, NIST, Gaithersburg, Maryland, USA, September 2014.

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- ***Staggs J. E. J***. Convection heat transfer in the cone calorimeter. *Fire Safety Journal*, 44(4):469 – 474, 2009.
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- ***Stein A. B., Sparrow E. M., Gorman J. M***. Numerical simulation of cables in widespread use in the nuclear power industry subjected to fire. Fire Safety Journal, 53(0):28 – 34, 2012.