



A CORUÑA | 2016 | OCTOBER | 12<sup>th</sup> - 14<sup>th</sup>



# II CONGRESO INTERNACIONAL de SEGURIDAD INDUSTRIAL en PUERTOS

## II INTERNATIONAL CONGRESS of SAFETY in PORTS

Puertos del Estado





### PRESENTACIÓN - INTRODUCTION



Piotr Tofilo, PhD

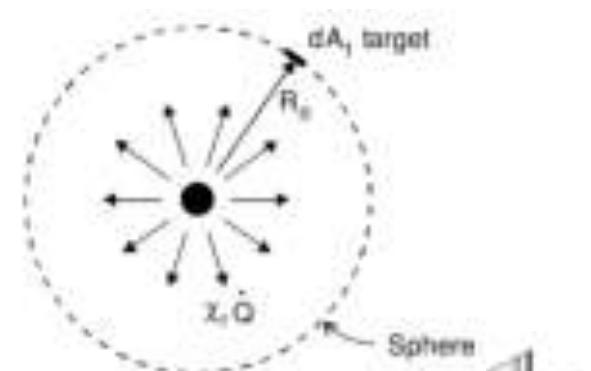
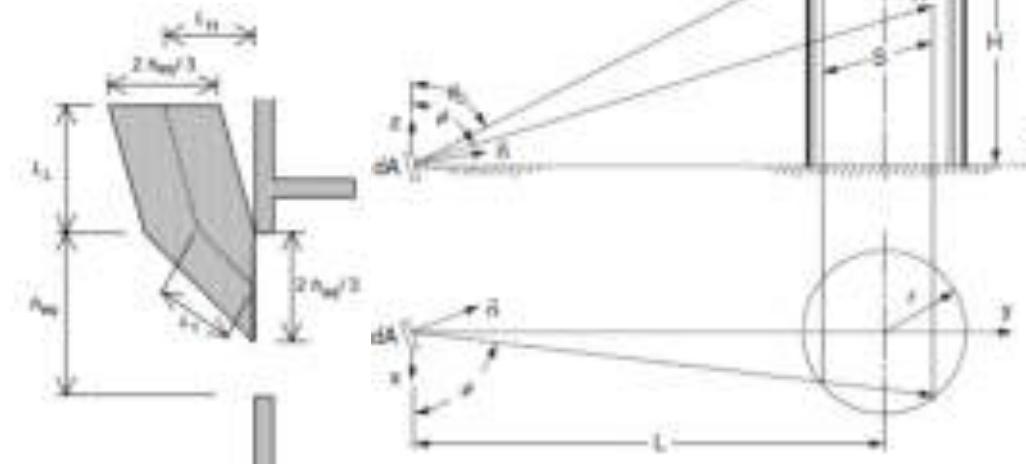
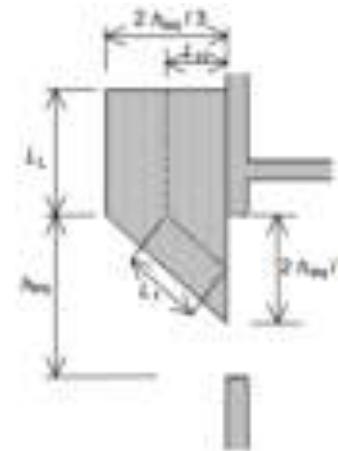
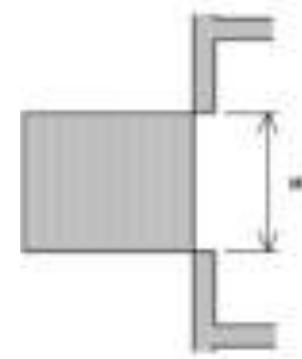
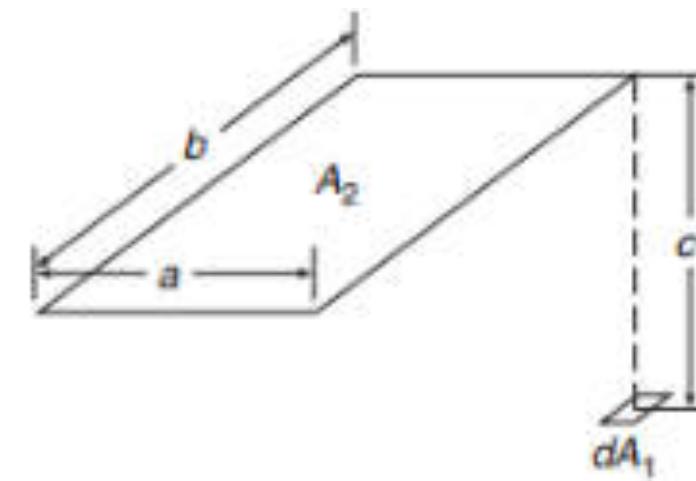
- *From 2009 – Researcher/Lecturer – The Main School of Fire Service, Warsaw (Building Fire Protection)*
- *From 2016 – President of ECCG (SFPE Europe)*
- *From 2012 – President of Polish SFPE Chapter*
- *2012 – Guest Researcher, NIST*
- *2006-2008 – Senior Fire Engineer, London (Ramboll)*
- *2003-2006 – Doctoral studies, University of Ulster (behaviour of glazing in fires)*

# Heat radiation for hazard analysis

- External fire spread between buildings (or its parts)
- Fire spread between fire load islands
- Structural fire protection
- Buildings under construction
- Facade fires in high rise
- Warehouse / external storage fires
- Oil & gas sector, pool fires, jet fires, fireballs, etc.
- Wildland - urban interface fires
- Modeling – flame/fire spread, pyrolysis, ignition

# Analytical Methods

- Point source (Modak)
- Simple radiating rectangle (View Factor)
- External radiating flame (Eurocode, NRCC)
- Cylindrical flame model (Dayan/Tien, Shokri/Beyler, Modan/Croce)



# CFD Methods for solving RTE

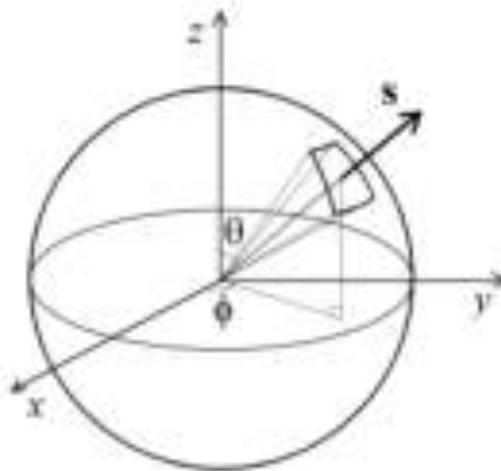
- Direct Transfer Radiation Method (DTRM)
- Finite Volume Method (FVM)
- Discrete Ordinate Method (DOM)
- Monte Carlo
- P1 (Spherical harmonics)
- Rosseland
- ViewFactor / Surface2Surface

## CFD - Finite Volume Method

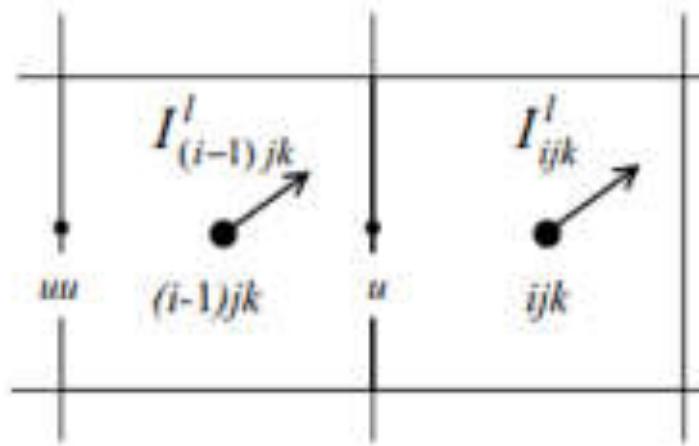
RTE

$$\int_{\partial\Omega} \int_{V_{ijk}} \mathbf{s} \cdot \nabla I(\mathbf{x}', \mathbf{s}') d\mathbf{x}' ds' = \int_{\partial\Omega^I} \int_{V_{ijk}} \kappa(\mathbf{x}') [I_b(\mathbf{x}') - I(\mathbf{x}', \mathbf{s}')] d\mathbf{x}' ds'$$

Angular discretization



Intensity calculations



Discretization schemes

Step

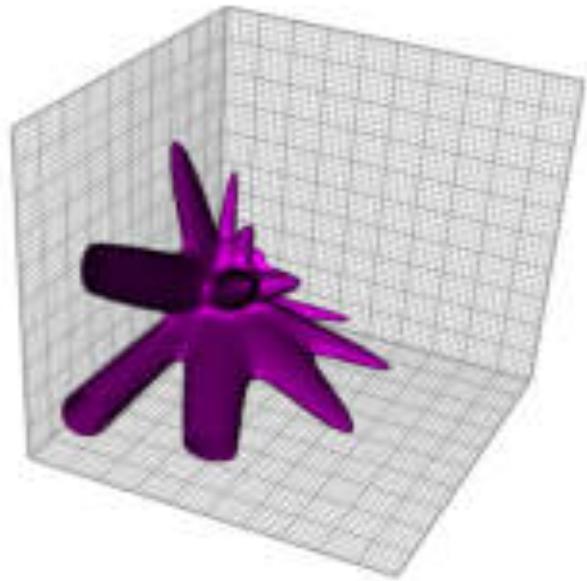
Diamond

$$I_u^I = 2I_{(i-1)jk}^I - I_{uu}^I$$

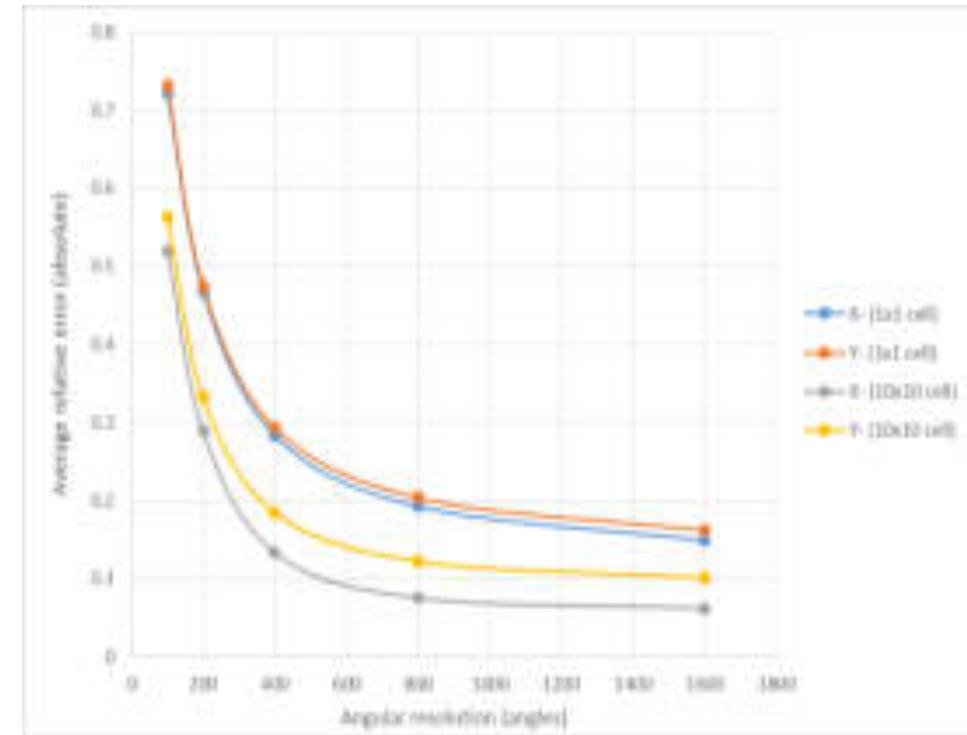
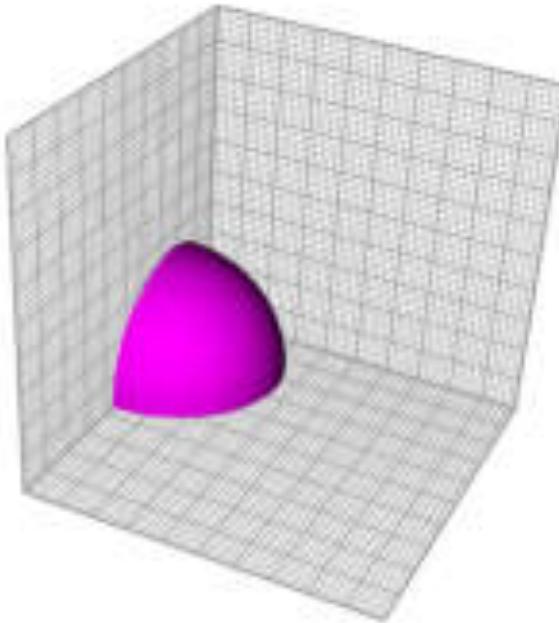


## CFD (VFM) – error studies

100 angles (FDS default)



Exact – view factor based



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## FireRad

- S2P model (Surface to Point)
- Radiation in 3D
- Based on Stokes theorem
- Triangulation of shapes
- Obstructions (shading)
- Very fast
- Interactive, easy to use

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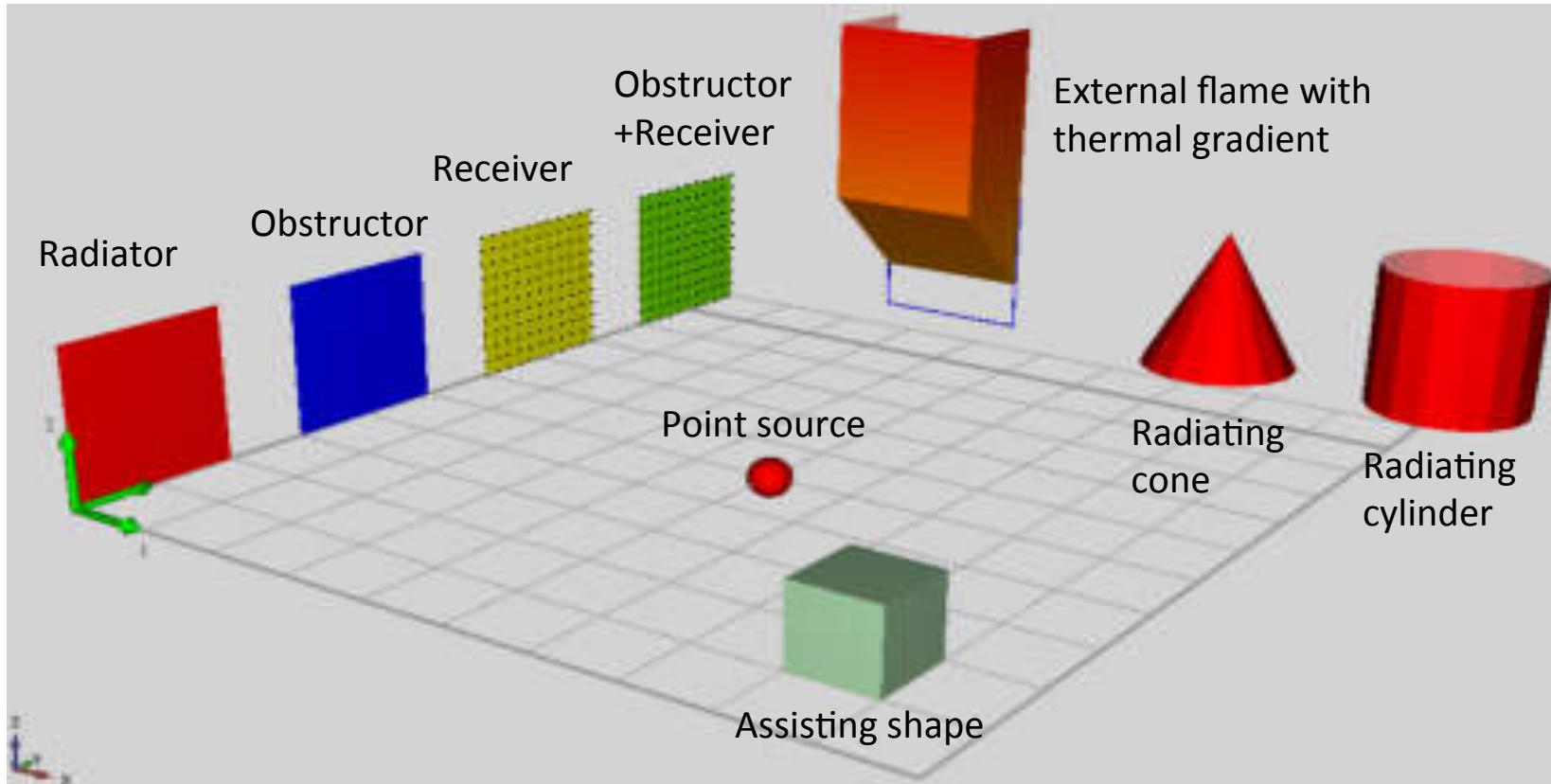


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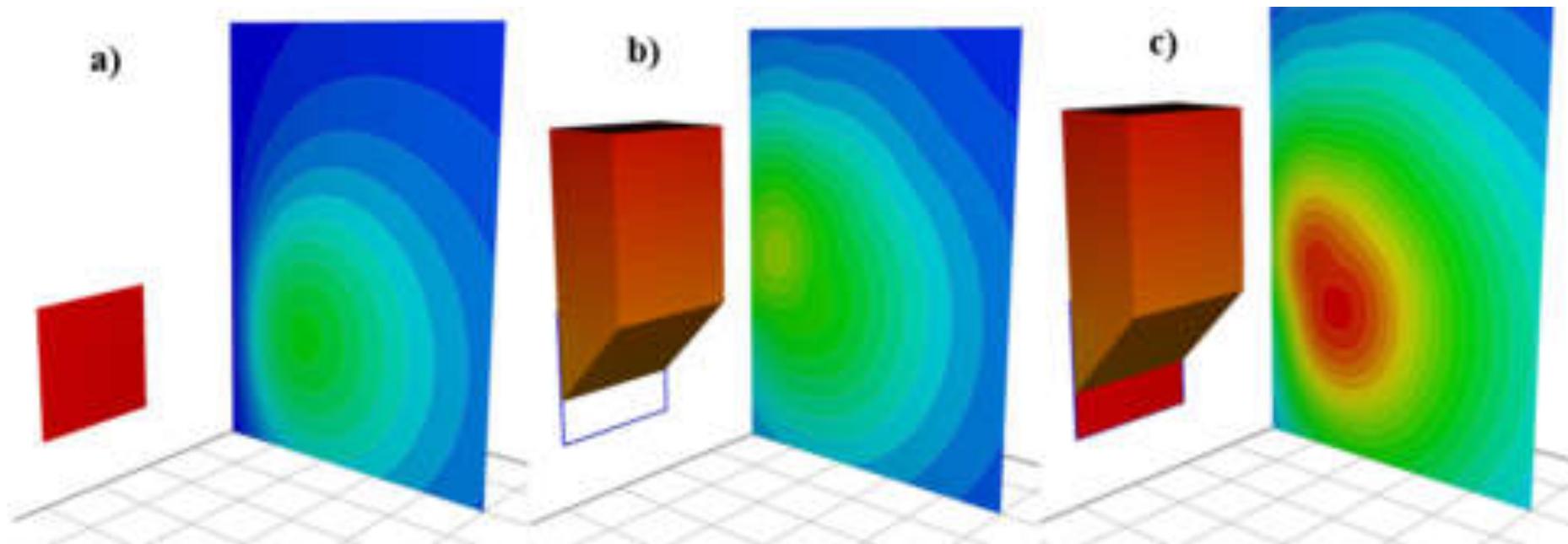


## FireRad - available objects



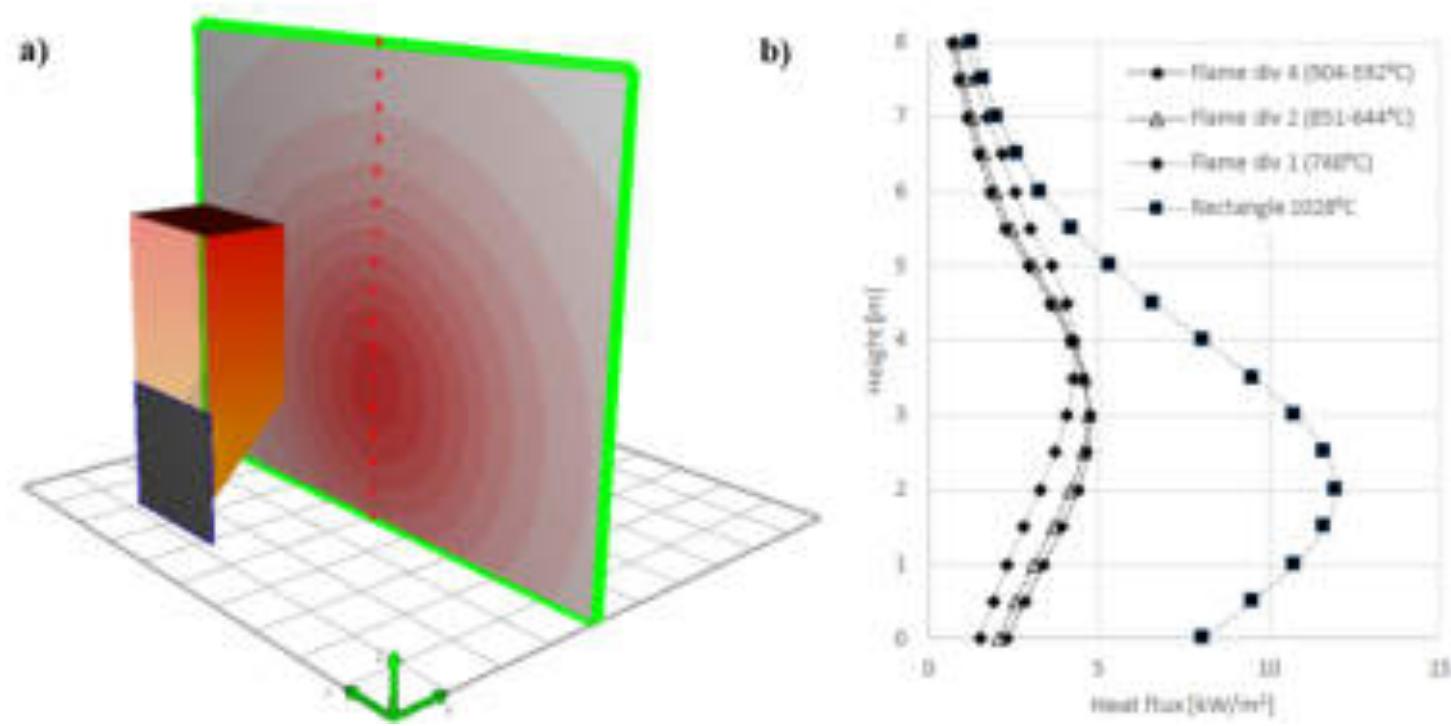


## External radiation modeling – different approaches



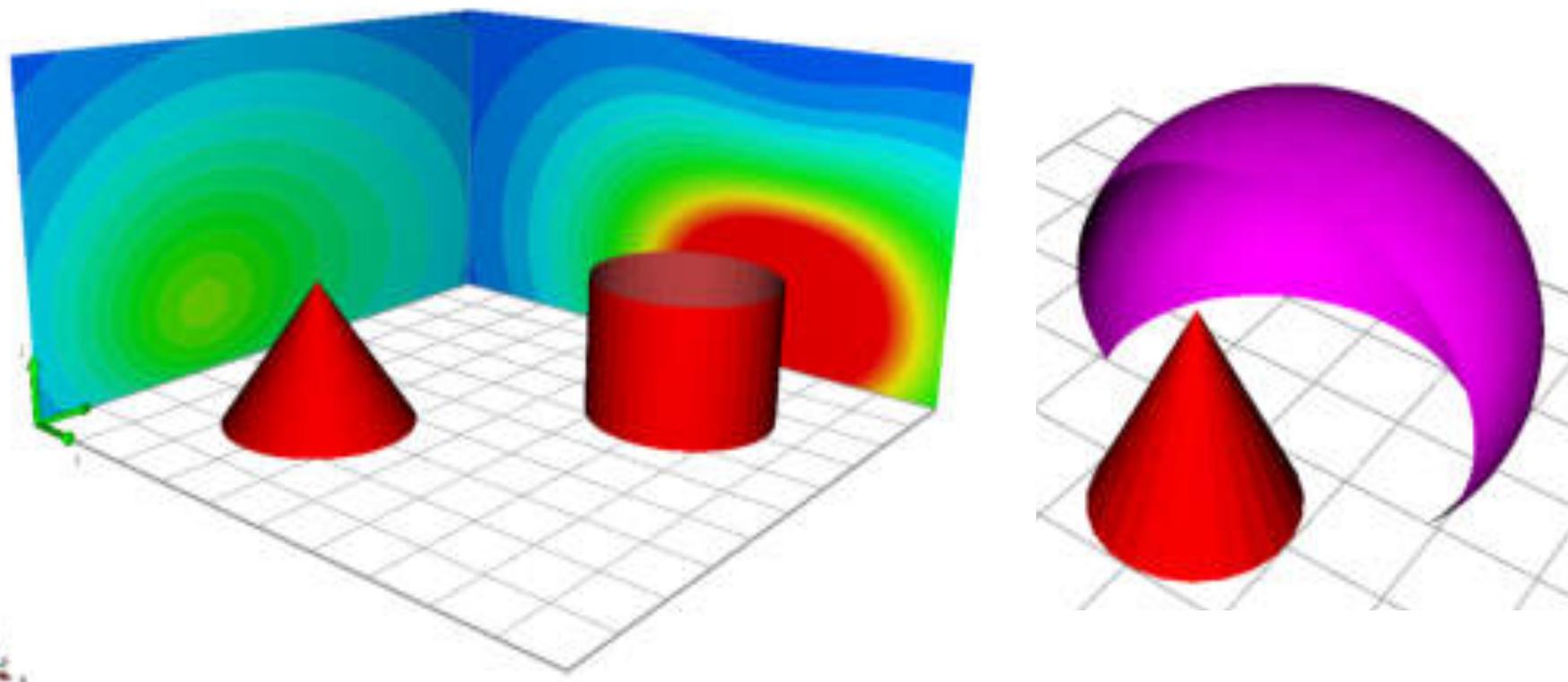


## External radiation modeling





## External radiation modeling



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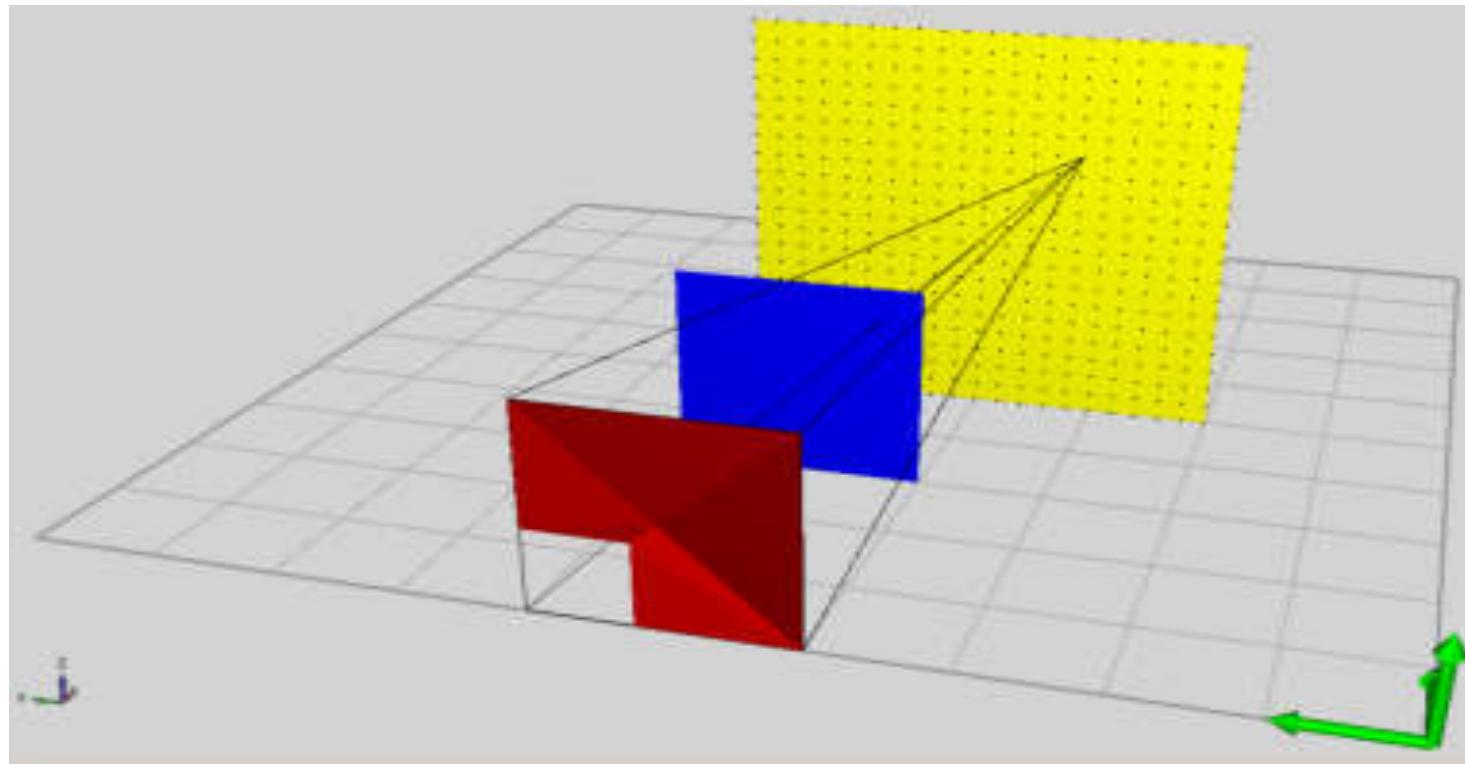


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## Obstructions and triangulation



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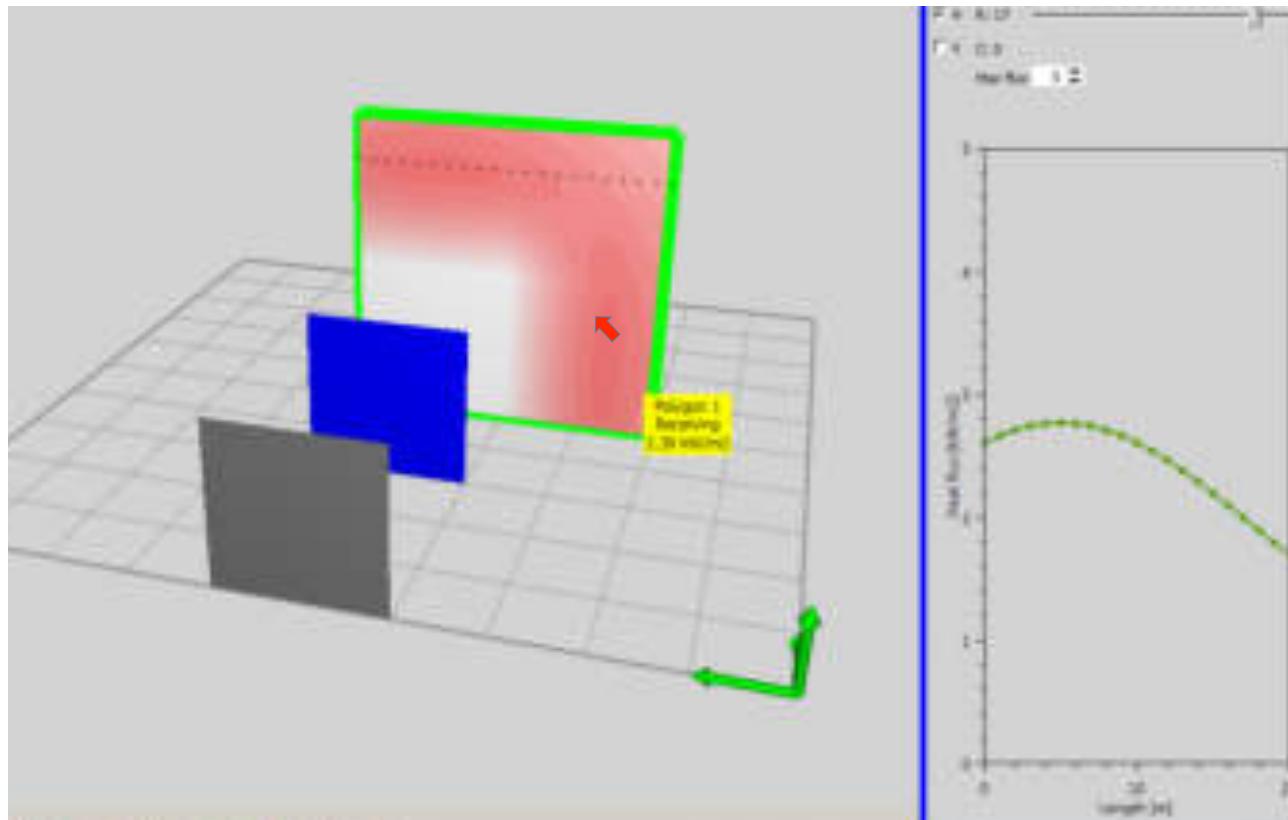


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## Results 2D



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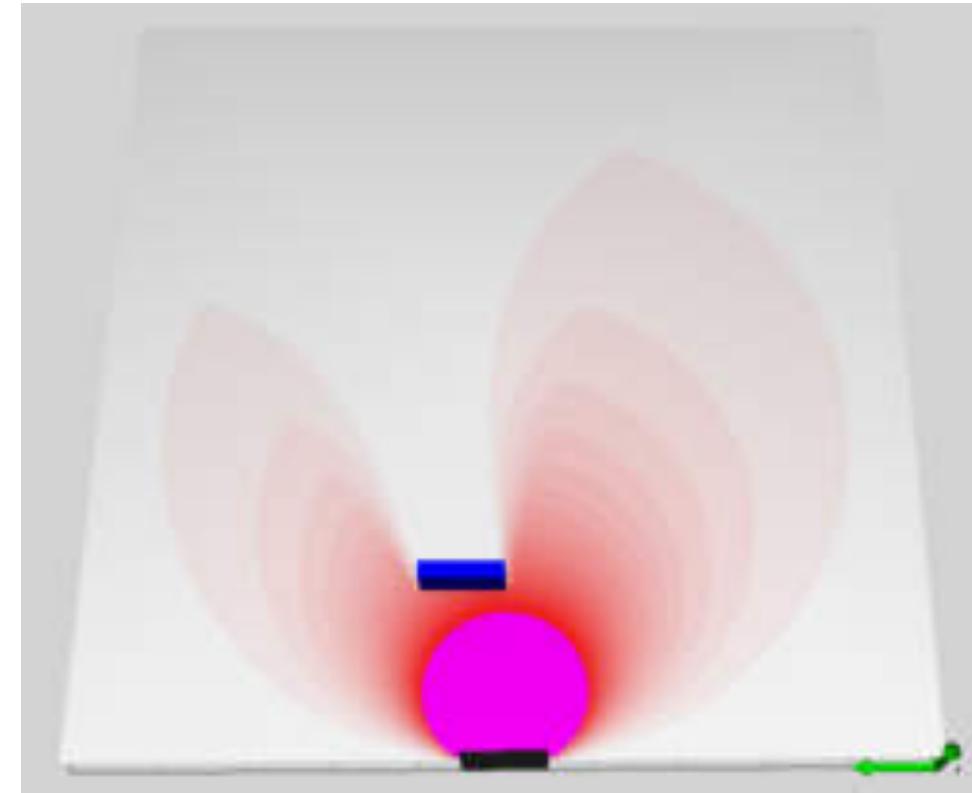
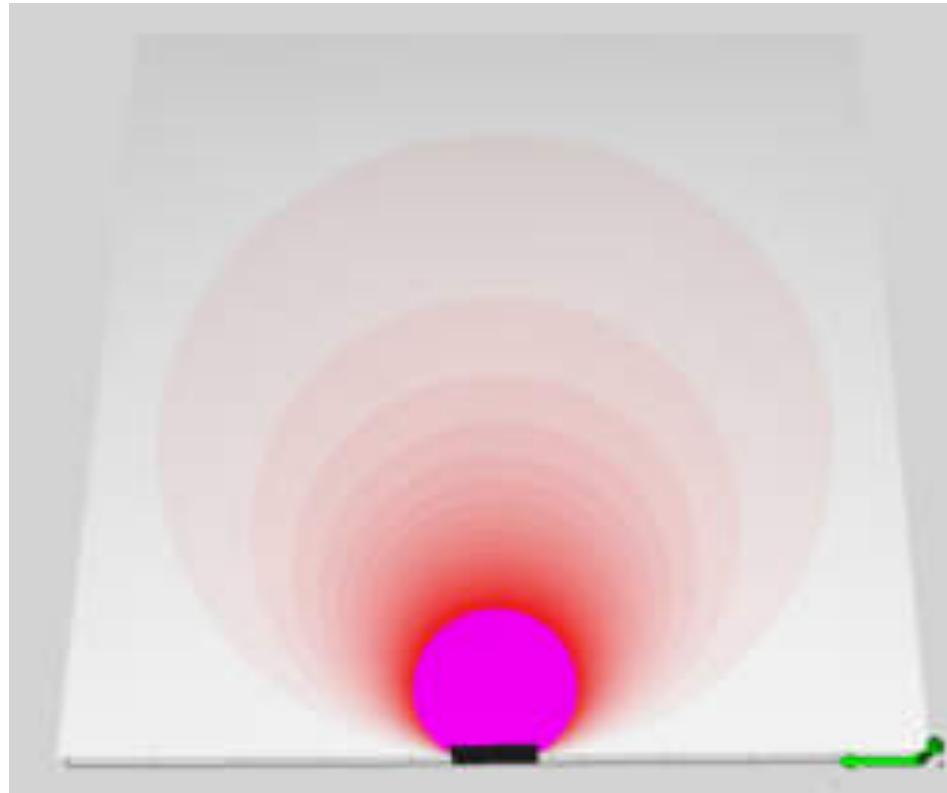


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## Virtual plane



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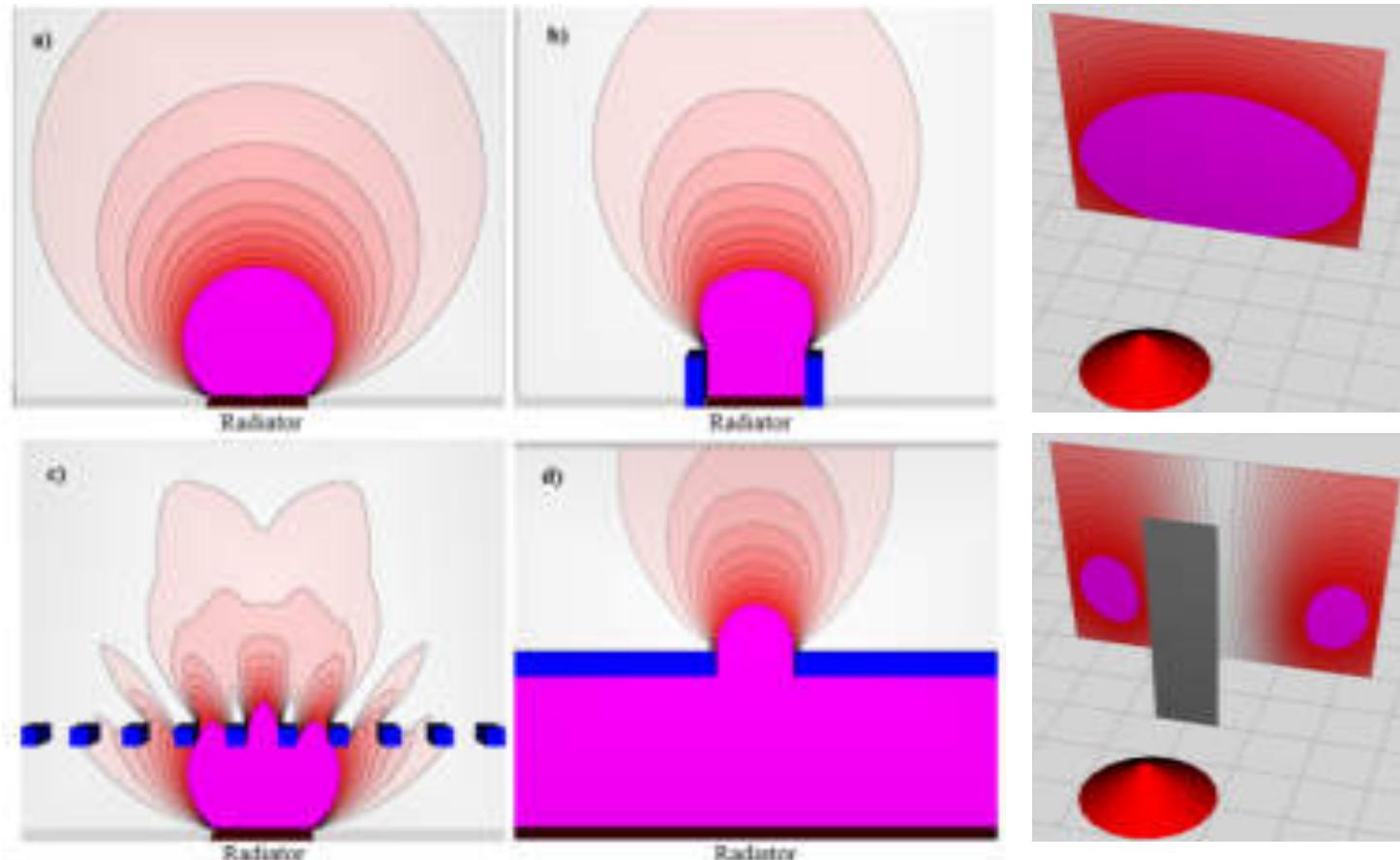


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## Effects of obstructions



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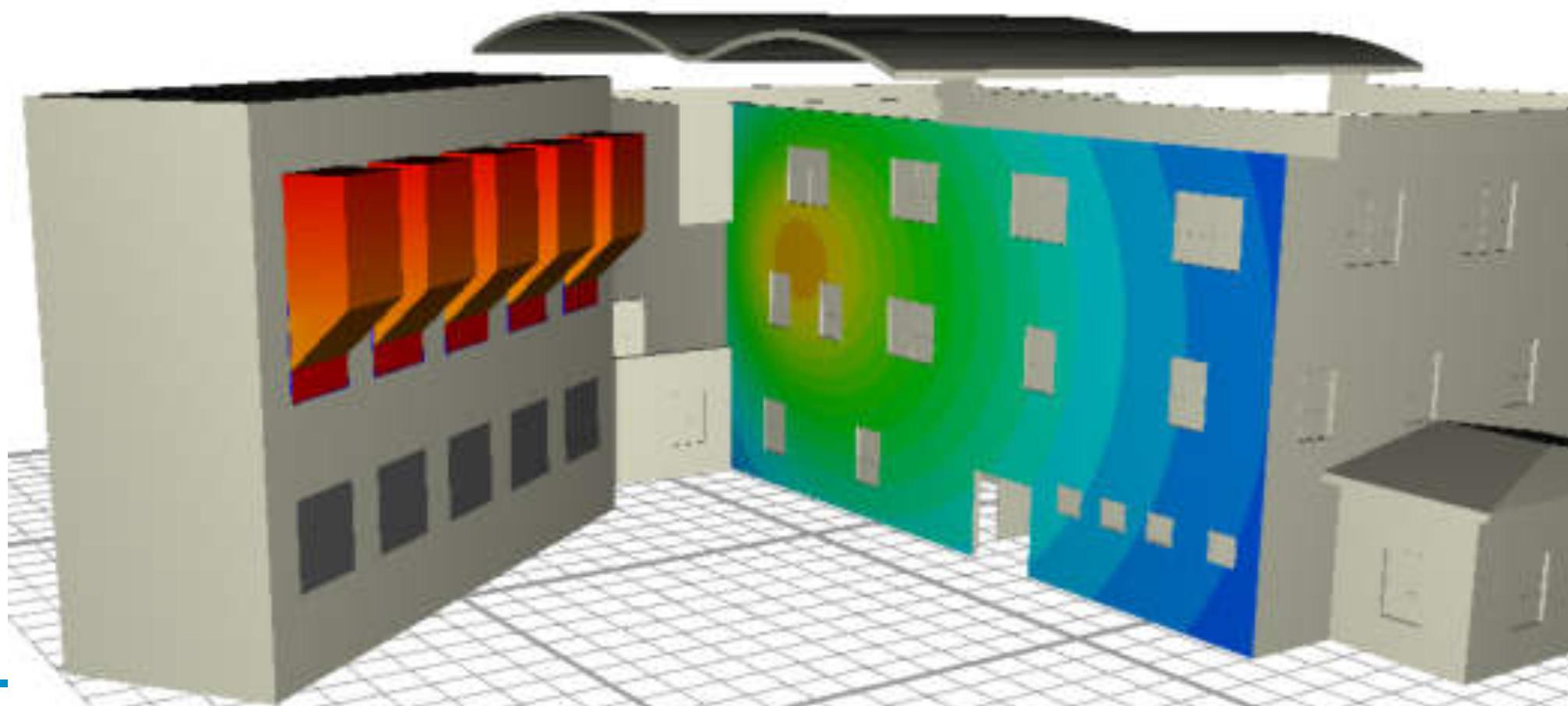


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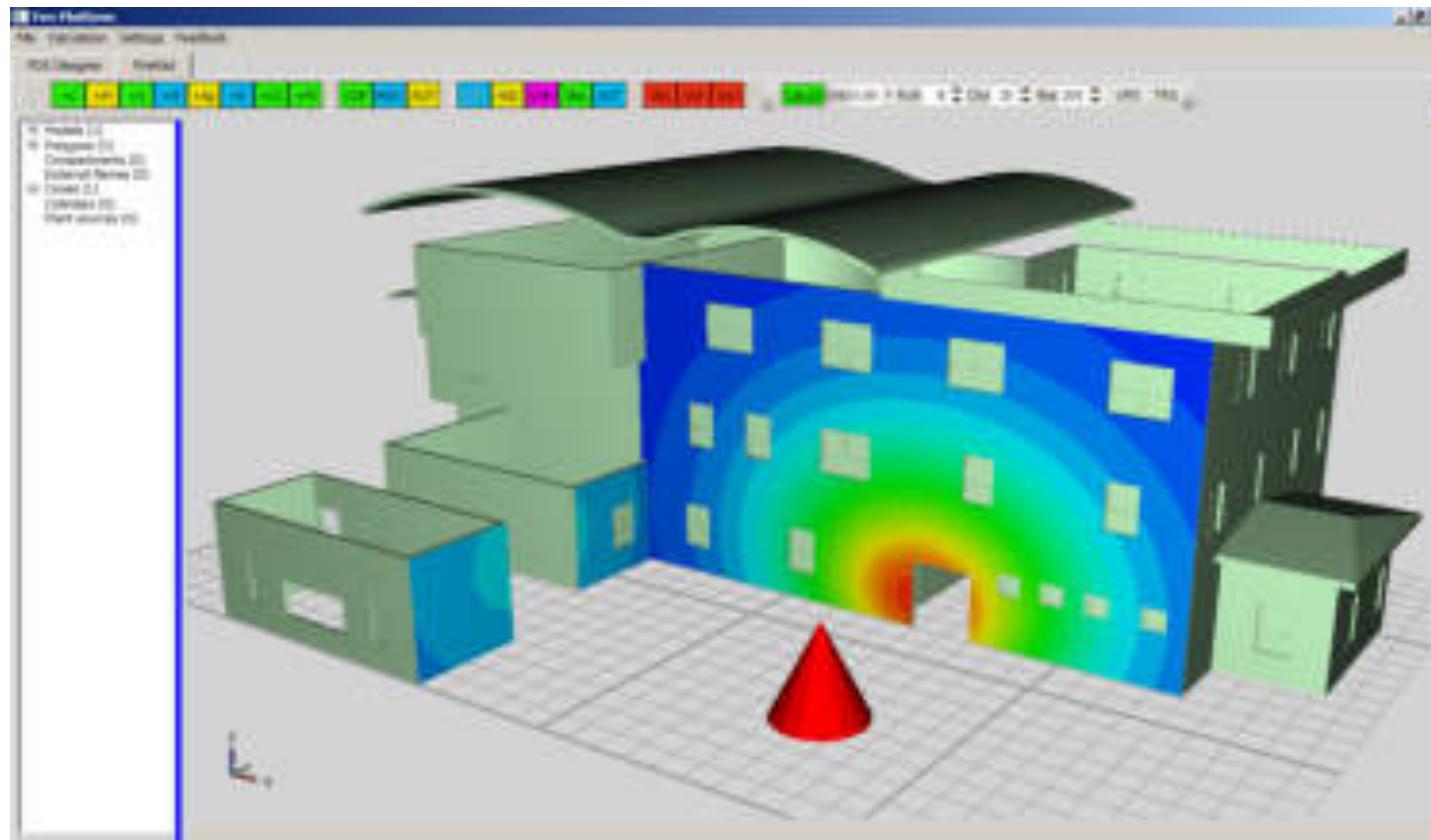


## CAD import (REVIT)





## 2D heat flux distribution



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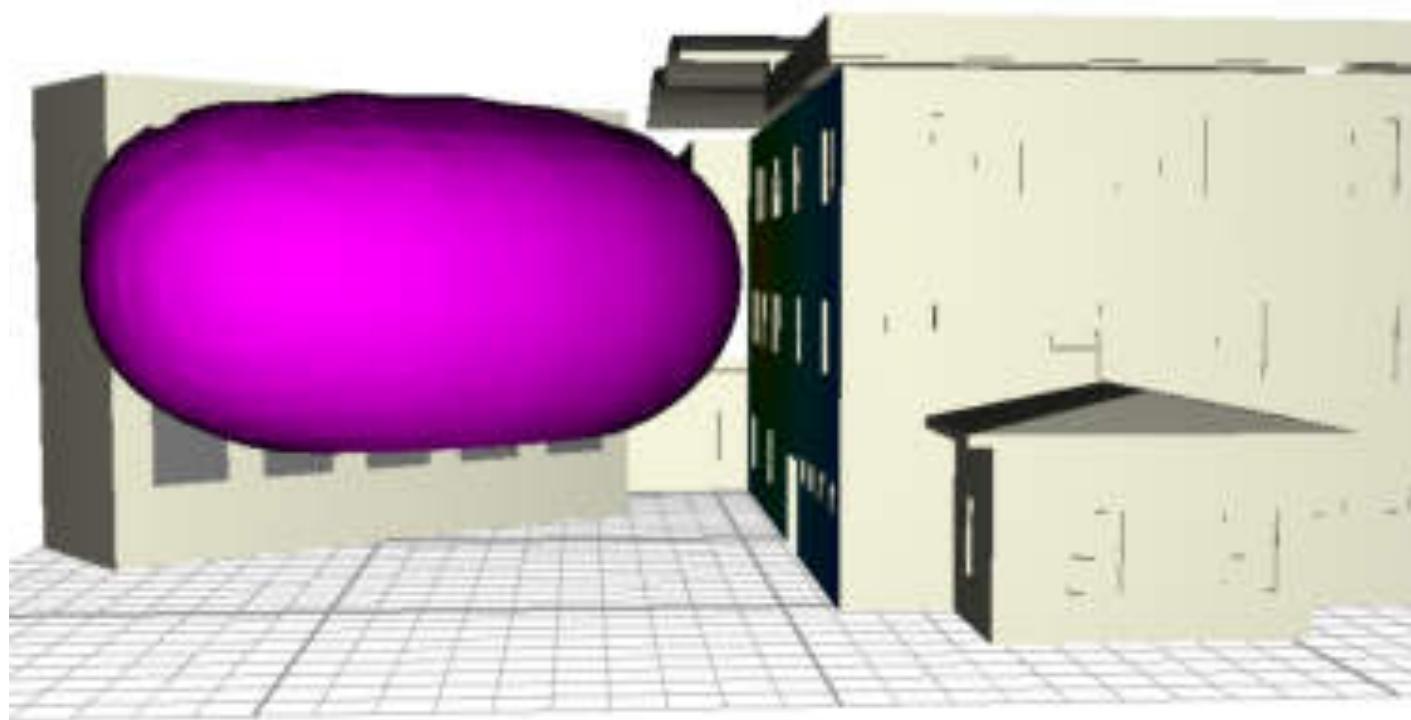


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## 3D results – critical heat flux



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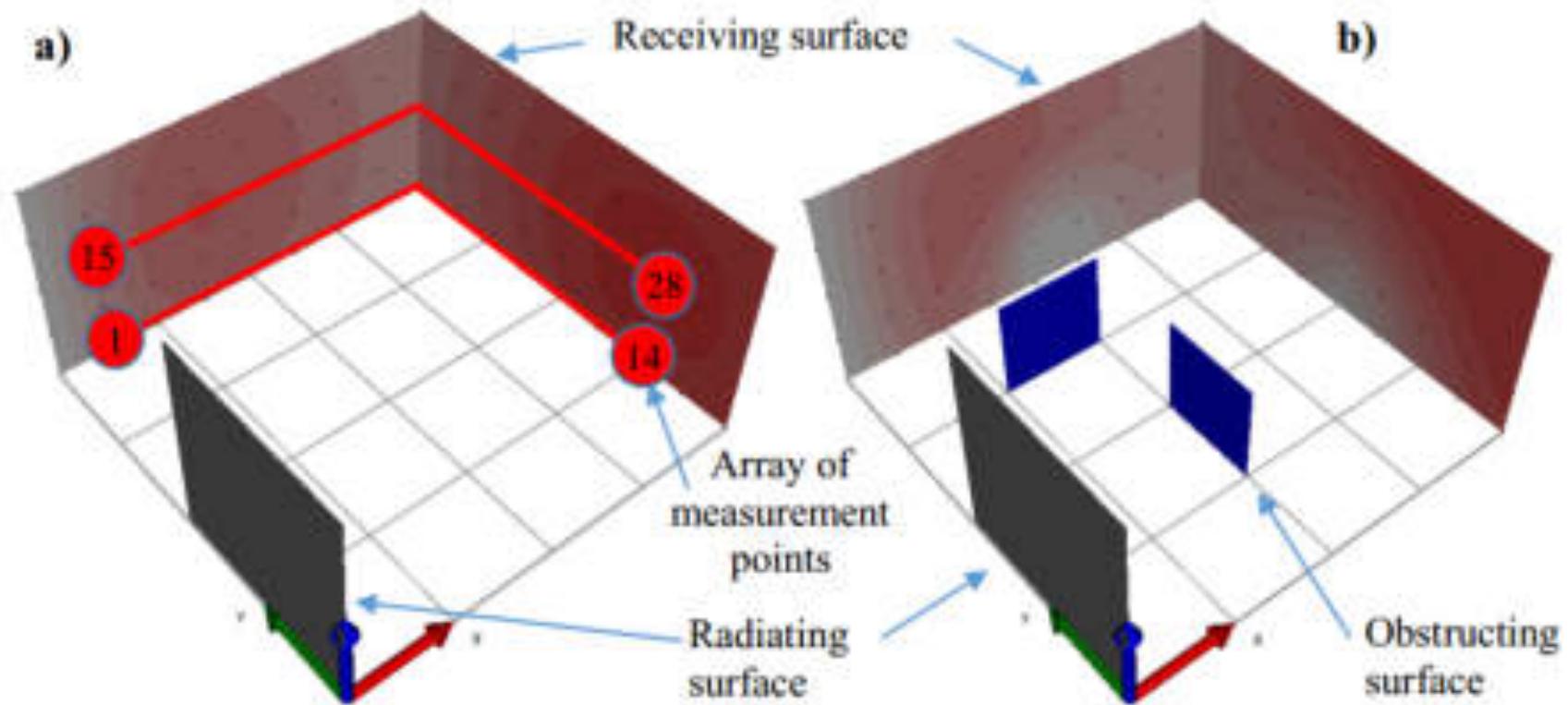
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# Verification



**Fig. A1.** Verification study. Configuration with a) radiating and receiving surfaces b) the same surfaces plus obstructions



# Verification

Table A1. View factors calculated with FireRad

Points	Position			View factor (unobstructed) Measurement point orientation			View factor (obstructed) Measurement point orientation		
	X	Y	Z	-X	-Y	+Z	-X	-Y	+Z
1	0.5	4	0	0.003935	0.020640	0.006665	0.003935	0.020640	0.006665
2	1	4	0	0.013020	0.034506	0.011219	0.013020	0.034506	0.011219
3	1.5	4	0	0.022306	0.039964	0.013092	0.016262	0.026163	0.009400
4	2	4	0	0.028843	0.039334	0.012963	0.000000	0.000000	0.000000
5	2.5	4	0	0.032156	0.035568	0.011771	0.000000	0.000000	0.000000
6	3	4	0	0.032938	0.030730	0.010198	0.011518	0.013239	0.003616
7	3.5	4	0	0.032085	0.025923	0.008617	0.024204	0.021054	0.006523
8	4	4	0	0.030320	0.021619	0.007194	0.030320	0.021619	0.007194
9	4	3.5	0	0.037481	0.022143	0.008843	0.030889	0.016802	0.007272
10	4	3	0	0.045300	0.021286	0.010630	0.026773	0.009869	0.006254
11	4	2.5	0	0.053092	0.018610	0.012399	0.016075	0.003000	0.003732
12	4	2	0	0.059864	0.013928	0.013928	0.000000	0.000000	0.000000
13	4	1.5	0	0.064519	0.008542	0.014974	0.014411	0.004484	0.003358
14	4	1	0	0.066183	0.004058	0.015347	0.033091	0.004058	0.007674

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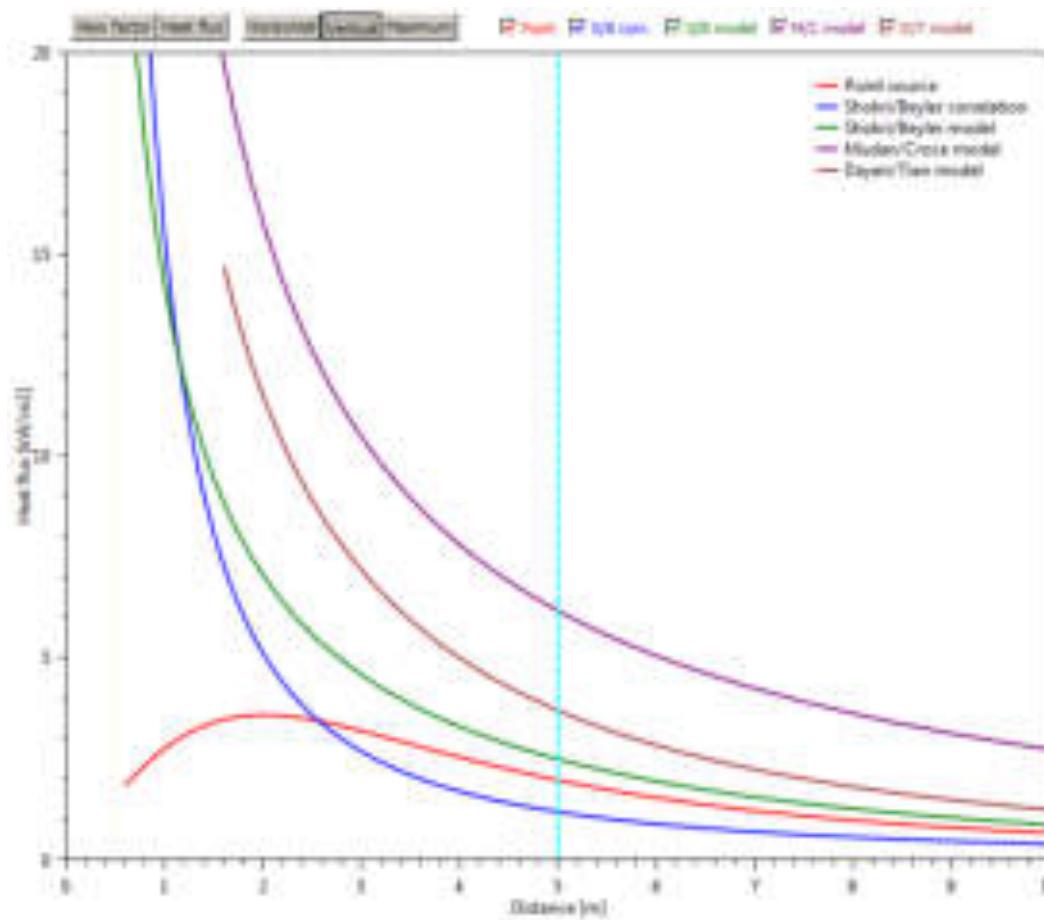


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## Radiation from pool fires

- Point source
- Shokri & Beyler correlation
- Cylinder fire model
  - Shokri & Beyler
  - Modan & Croce
  - Dayan & Tien



## Emissive Power to Equivalent Blackbody Temperature

- Shokri / Beyler
- Mudan / Croce
- Dayan / Tien

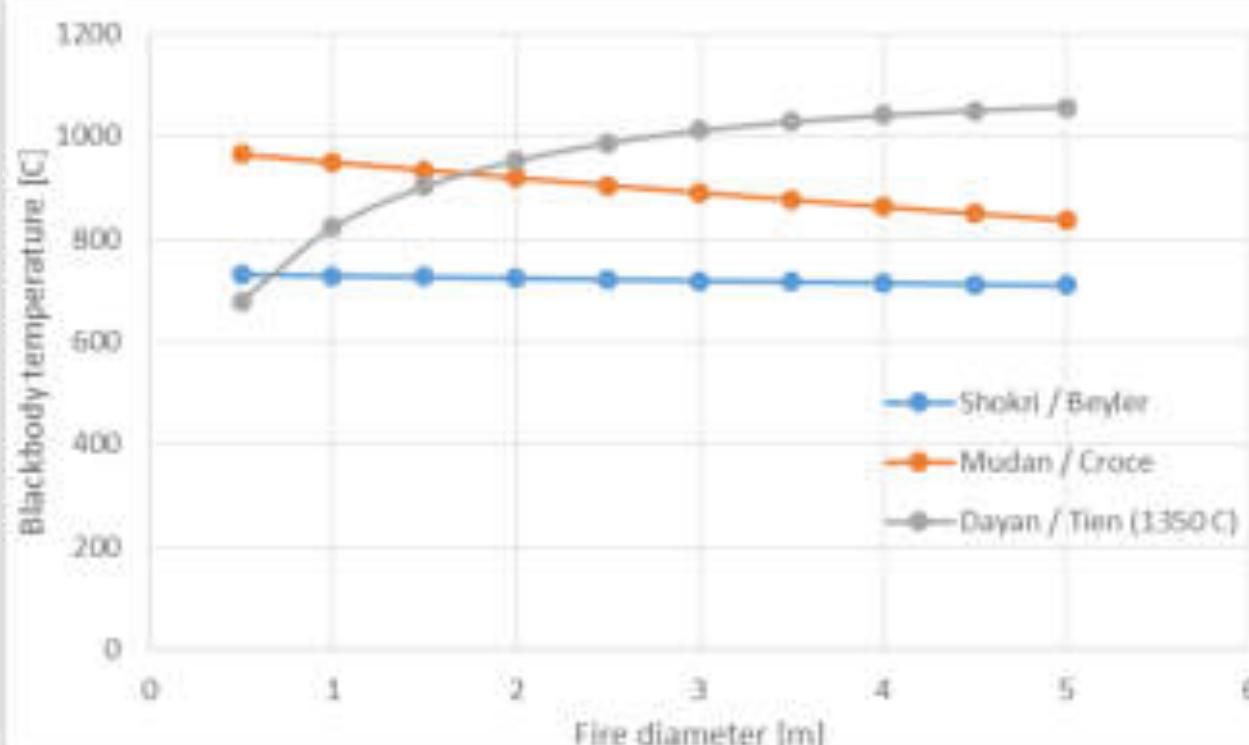
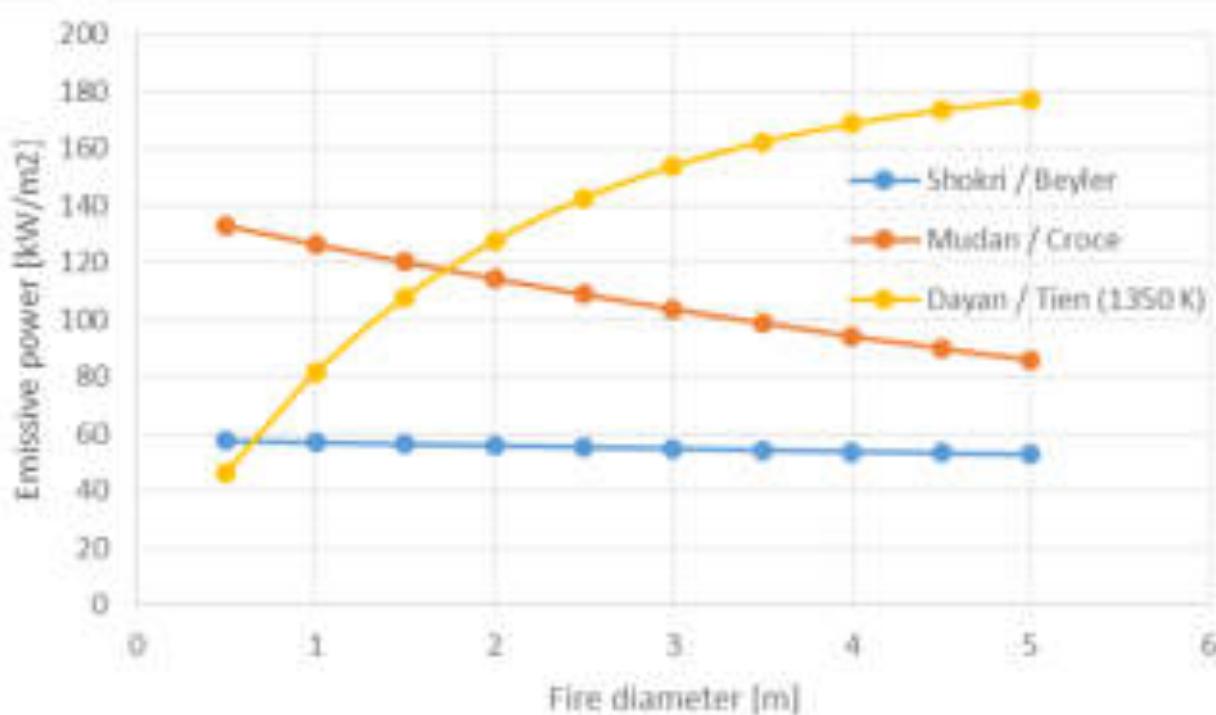
$$E = 58(10^{-0.00823D})$$

$$T_{BB} = (E/\sigma)10.25$$

$$E = E_{max} e^{(-\varepsilon D)} + E_s \left( 1 - e^{(-\varepsilon D)} \right)$$

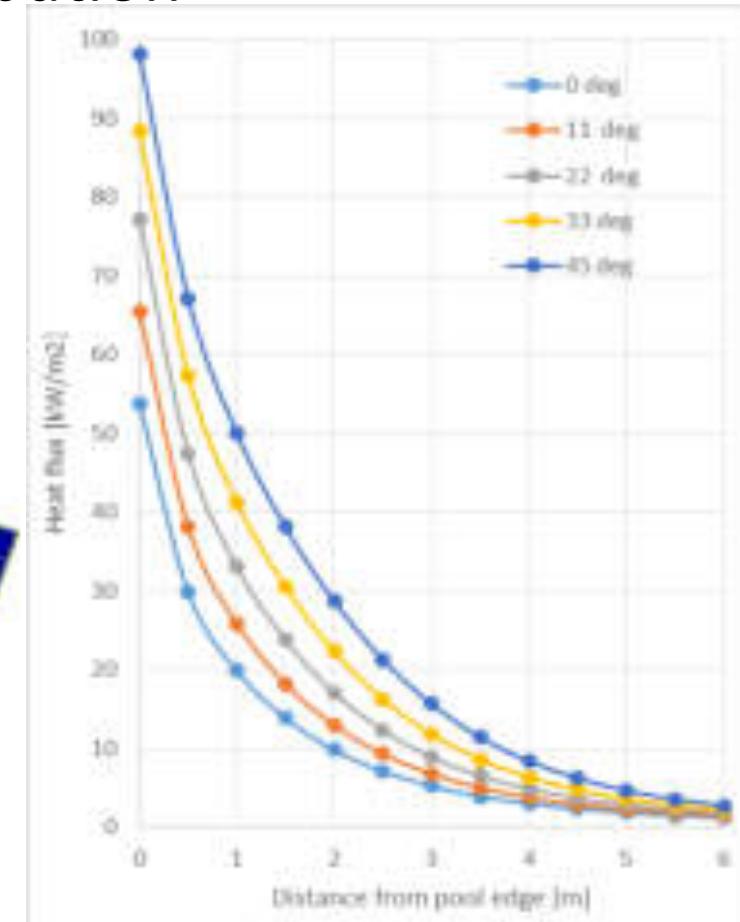
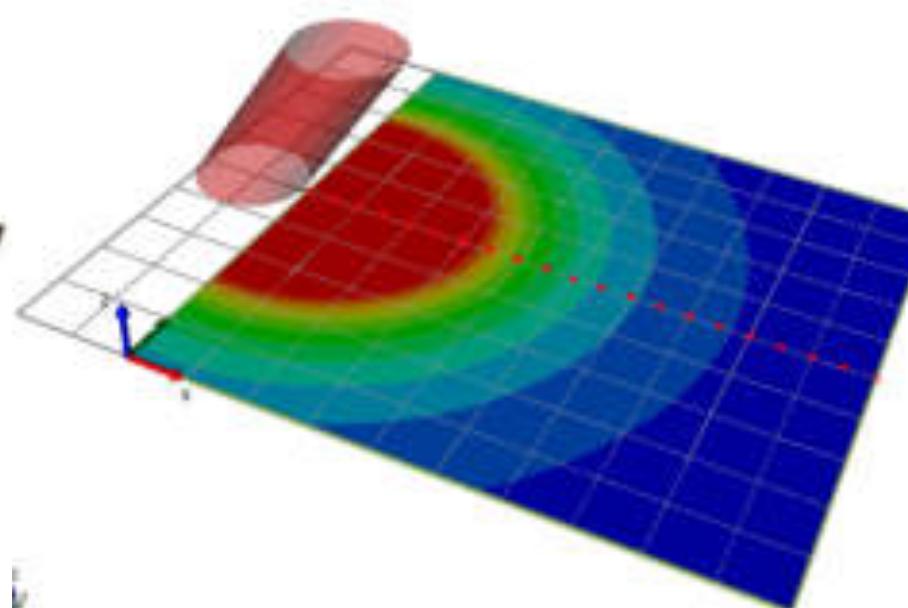
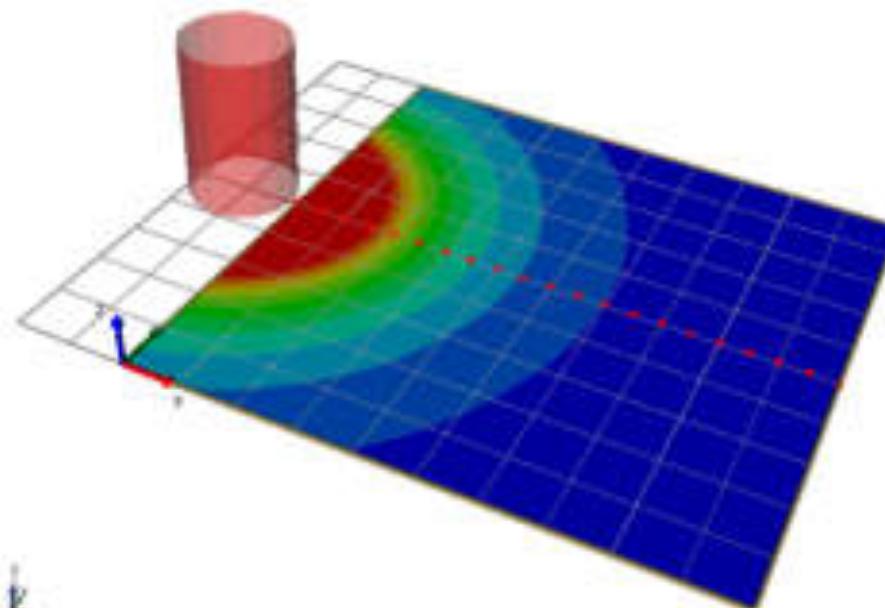
$$\varepsilon_k = 1 - \exp(-0.7\mu_k) \quad \theta_0 = \tan^{-1}(L/H)$$

$$\mu_k = 2r \frac{\kappa_k}{\sin(\frac{\theta_0}{2} + \frac{\pi}{4})}$$



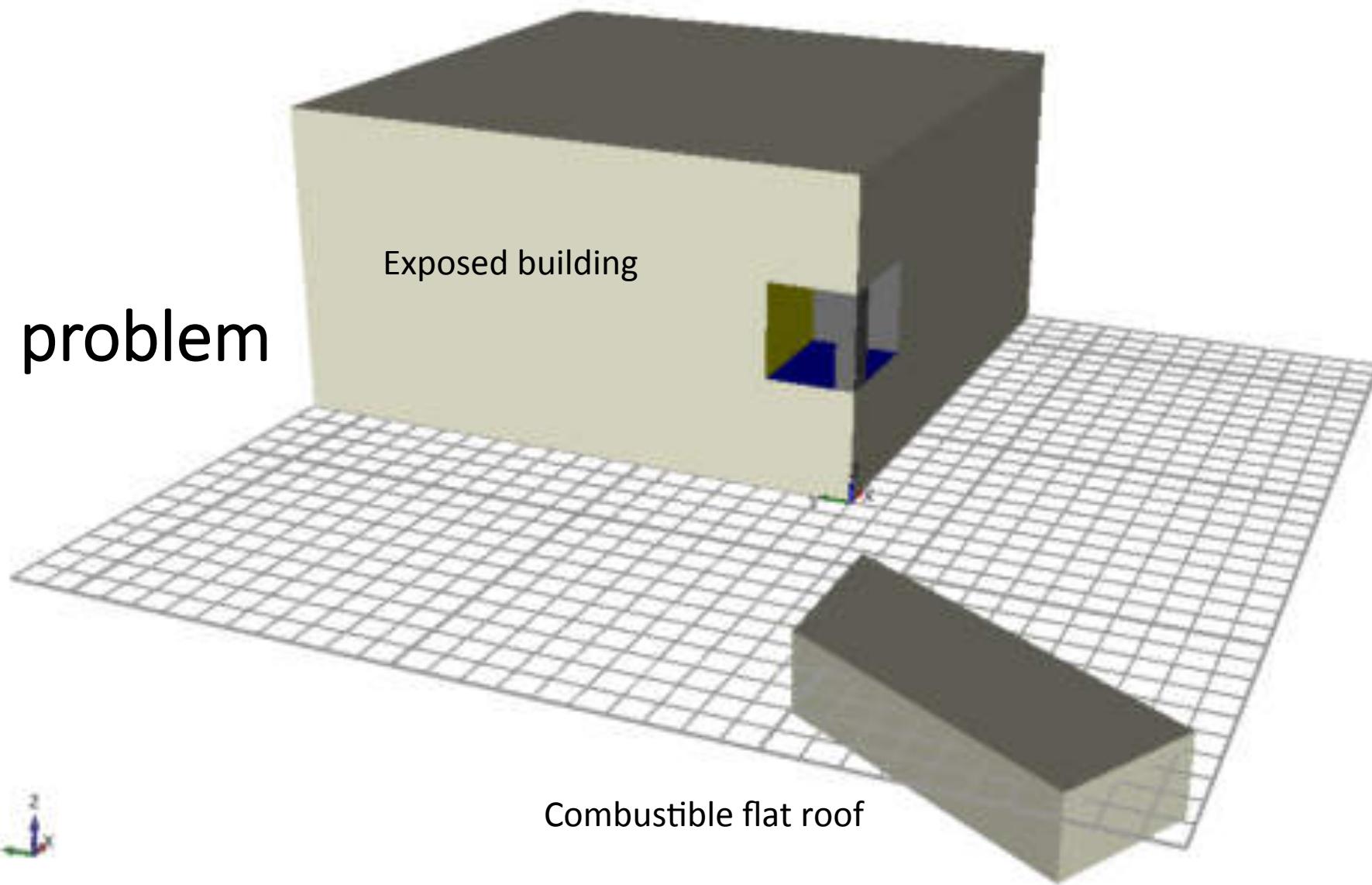
## FireRad vs. cylinder flame model

- With equivalent blackbody temperature heat flux distribution from FireRad is equivalent to cylinder fire model
- Solid bodies with conservative temperatures can represent flames



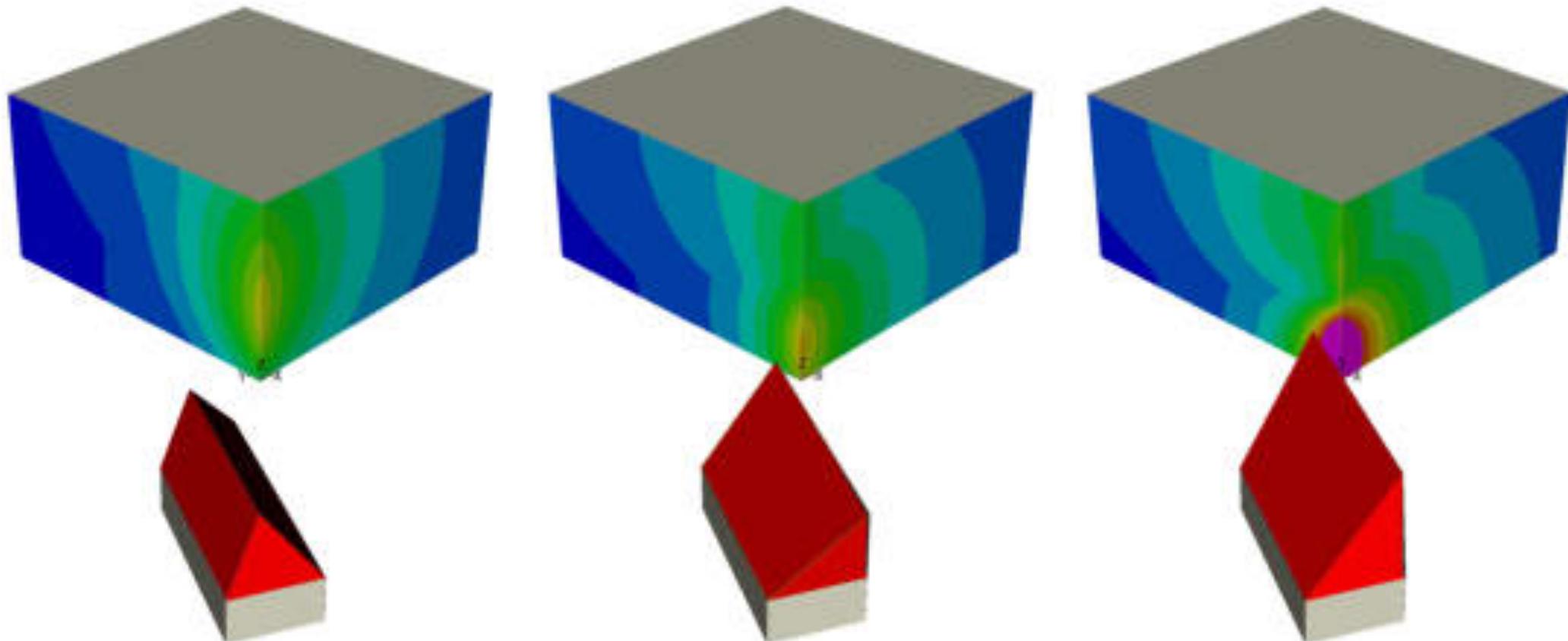


## Practical problem



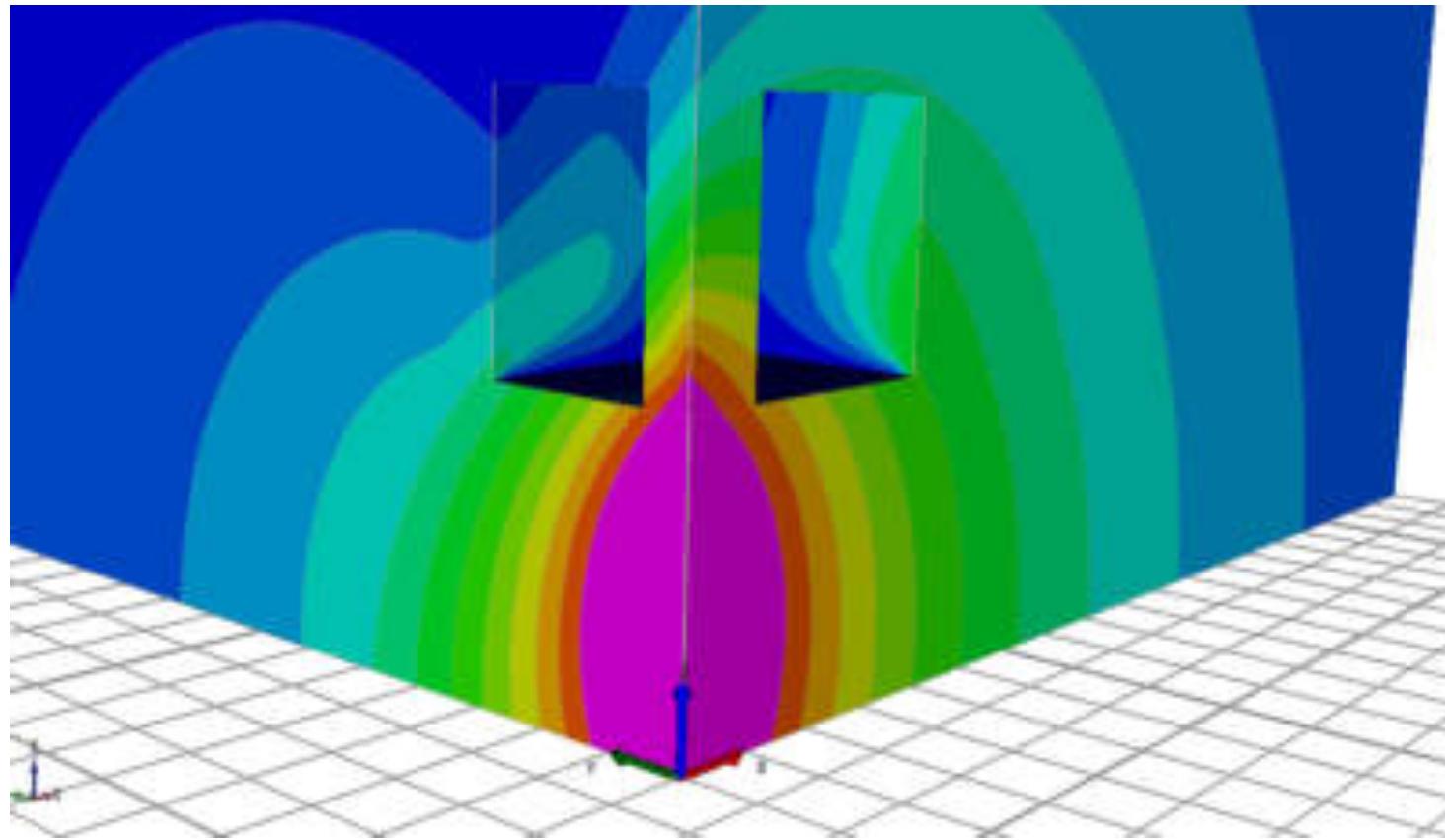
## Flux distribution for three wind options

Flame = solid surface, Temperature 900 C, Emissivity = 1, Flame height = 1 floor (NFPA 80A)





## Detailed flux distribution assessment



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## FirePlatform

- Tools for fire engineers
- From simple to complex
- All in one program
- Interactive, easy to use
- Modules:
  - SimpleModels (Fire plumes, Detection, Radiation)
  - FireStandards (NFPA 92, NFPA 204, Fire EC)
  - QuickZone
  - FireRad
  - FDS Designer
  - FDS Cloud
  - In progress: Structure, Egress etc.

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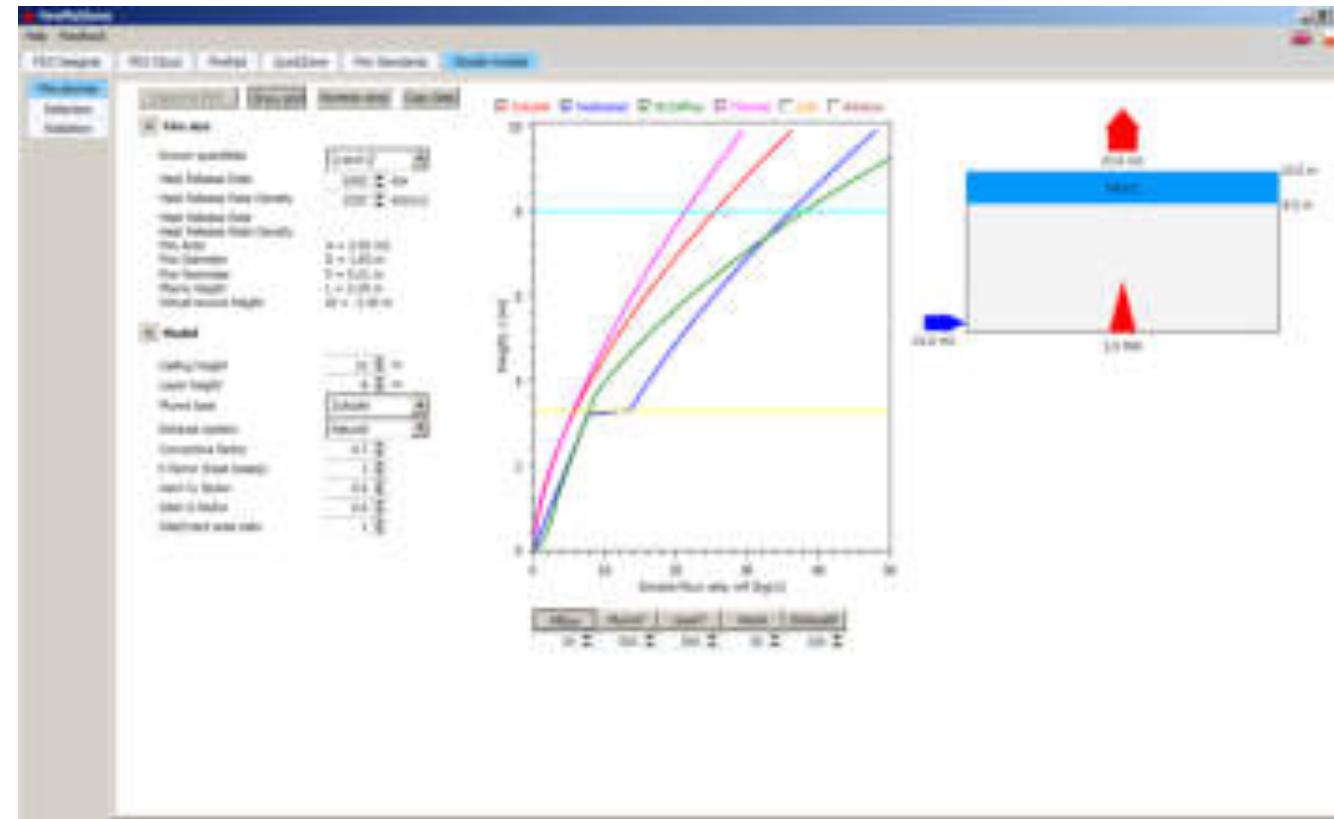


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# SimpleModels (Fire plumes)



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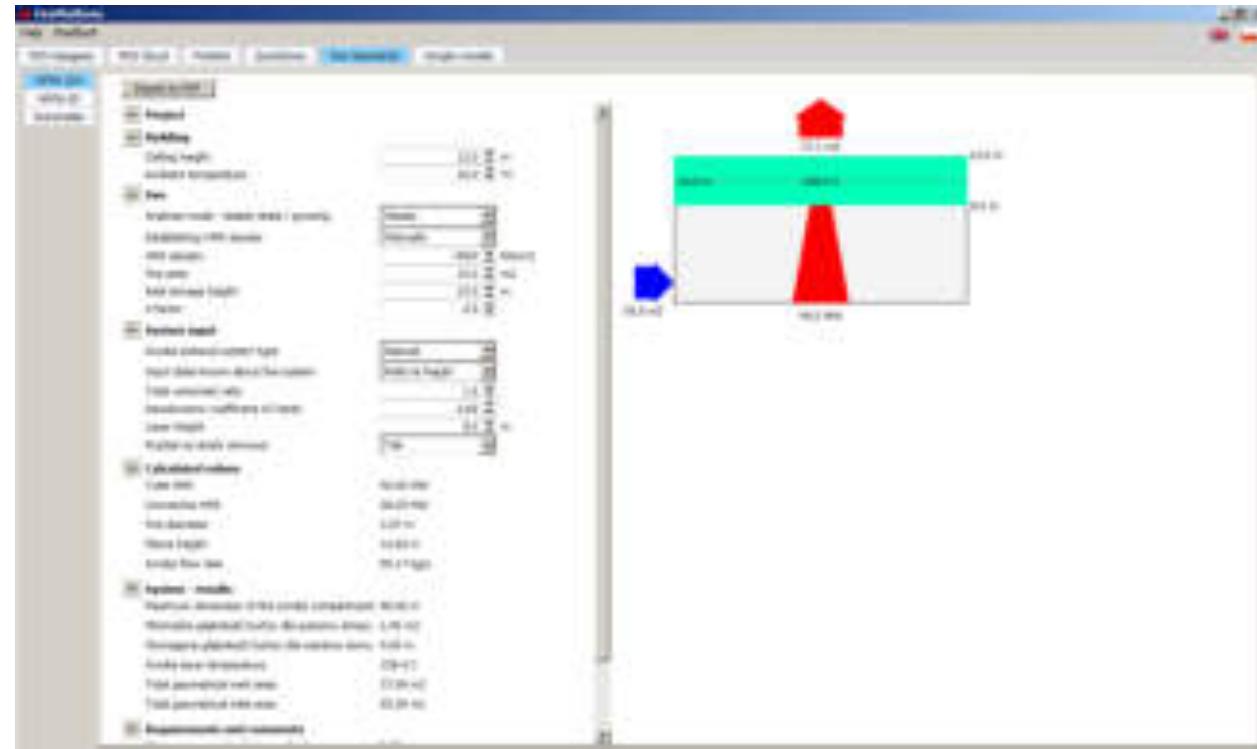


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## FireStandards (NFPA 204, NFPA 92)



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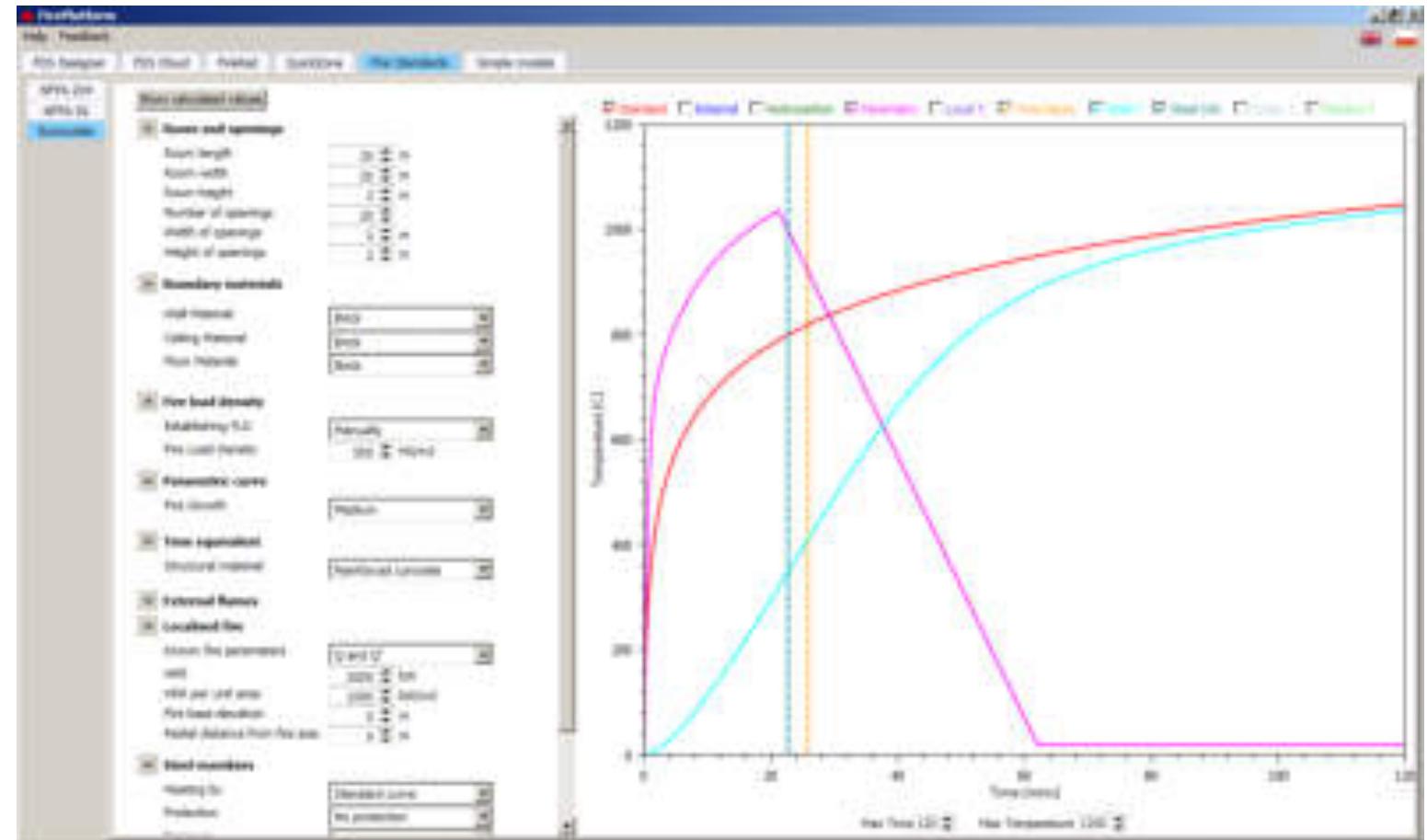
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# FireStandards (Fire EC)



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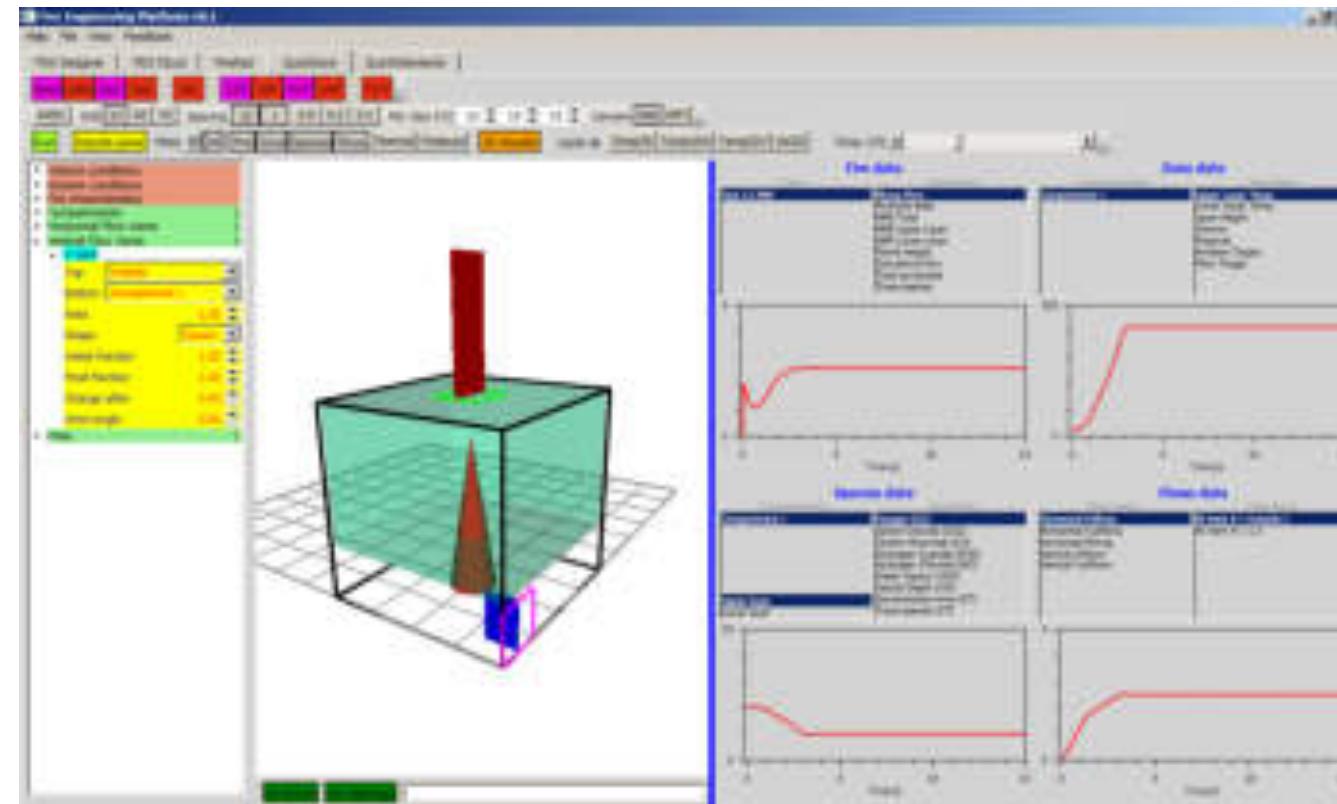
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## Quick Zone (Interactive CFAST)



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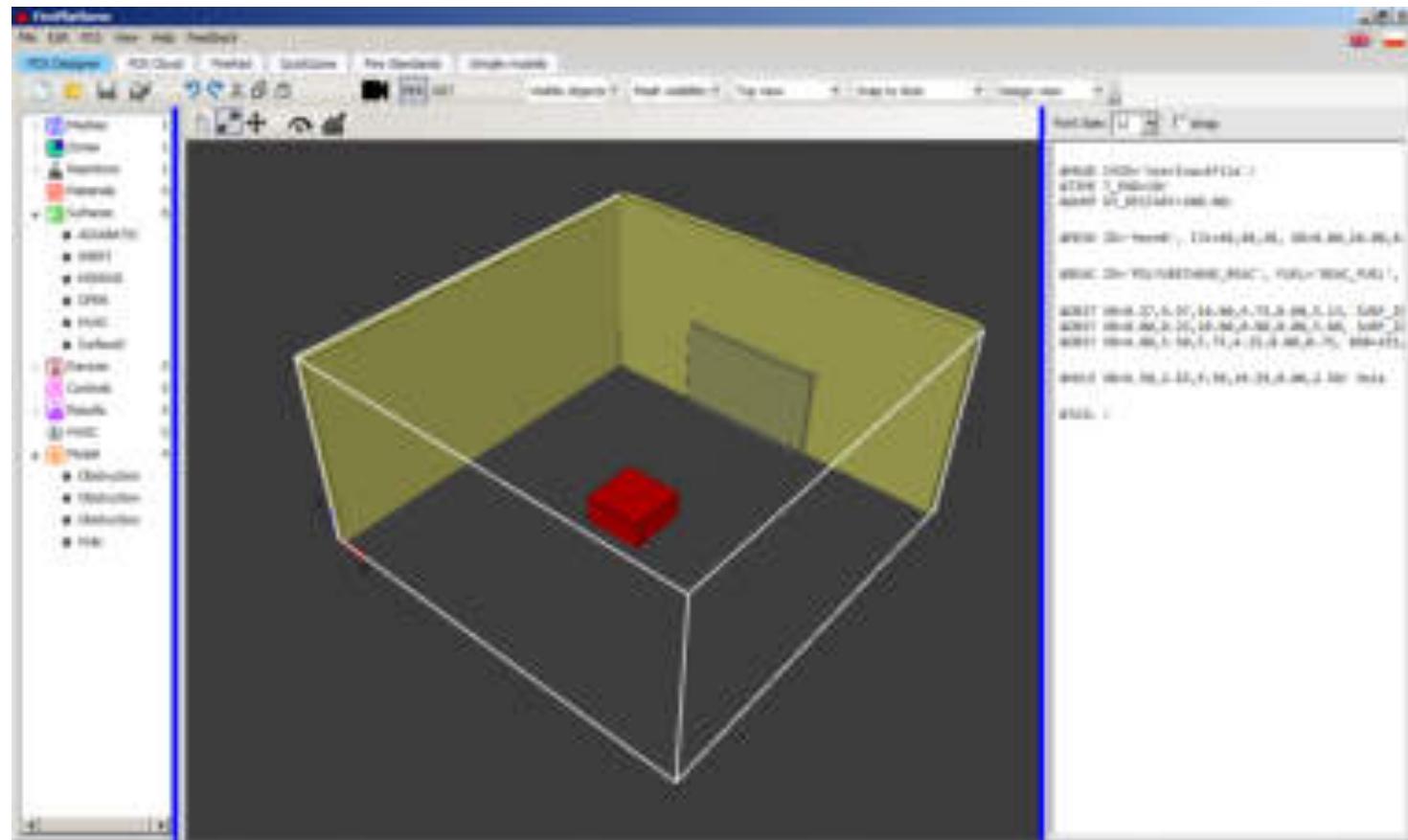


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## FDS Designer (preprocessor)



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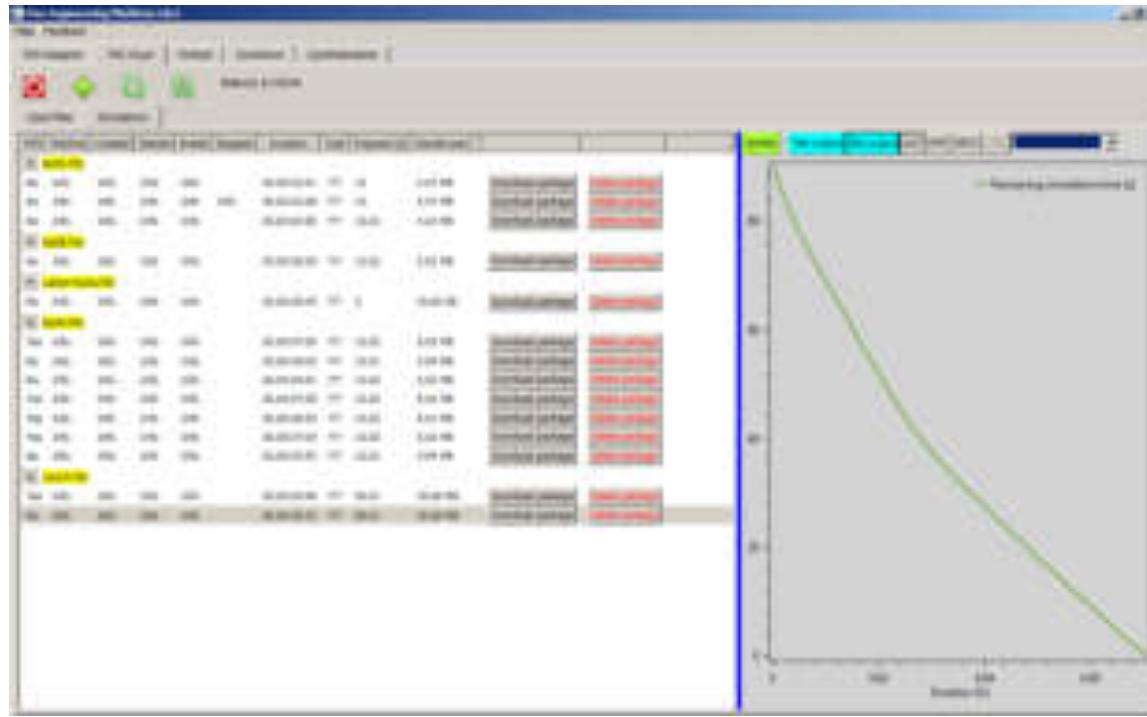


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## FDS Cloud (desktop)



## FDS Cloud (web)



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# Project website

FIREPLATFORM.EU

HOME | INTRODUCTION | COMPONENTS | PROJECT STATUS | DOWNLOADS | LANGUAGE

ABOUT FIRE

**GENERAL**

FirePlatform is a cross-disciplinary project which allows quick and effective model building with the possibility of benchmarking models, comparing them and easily sharing them. The models resulting from the project will be available for the industry and will allow directly the validation and the validation of the models by the end users.

[Read more](#)

**FEEDBACK**

FirePlatform is a complete fire detection solution - combination of sensing, communication and control system for port infrastructure. It is based on automated sensor fusion (multisensor, multi-sensor fusion) and fire detection models that are automatically learnt. The user can build the sensor network to protect his assets from C-class to D-class (gasoline). A unique fire detector platform.

[Read more](#)

**FGS-CLOUD-CLIENT**

FGS Cloud Client is a module for managing and monitoring FGS automation running in a cloud (either in a dedicated pilot site FGSCloud or in a public cloud). It provides a graphical interface to monitor and control the system using direct connection with external equipment. It translates and send environmental events messages via application to the user interface.

[Read more](#)

SCREENSHOTS



# Cloud

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## Request trial

FIREPLATFORM.EU

HOME INTRODUCTION COMMITMENTS PROJECT STATUS NEWS DOWNLOADS CONTACT

Contact information and details about the Fire Platform project (EU) can be found in the following sections. Information on how to contact us can be found below.

Name: \_\_\_\_\_

Organization: \_\_\_\_\_

Role: \_\_\_\_\_

Address: \_\_\_\_\_

City: \_\_\_\_\_

Country: \_\_\_\_\_

I would like to receive more information about the Fire Engineering Platform.

I would like to be the first user and receive updates and comments.

I would like to be the Fire Engineering Platform software and receive its license after review.

[SEND REQUEST](#)

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Thank you.  
Questions ?

[www.fireplatform.eu](http://www.fireplatform.eu)

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