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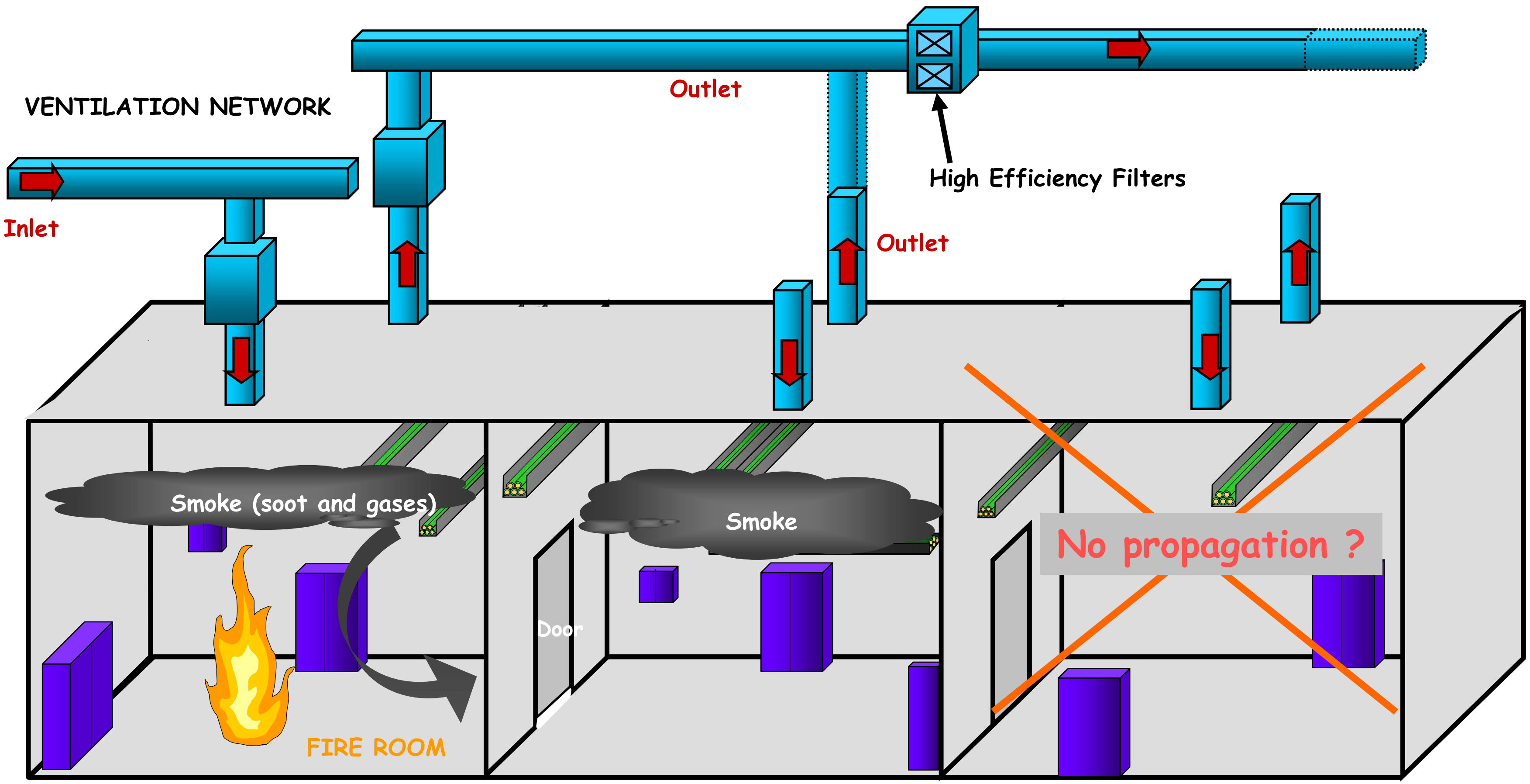
- Overview of the PRISME benchmarking Group

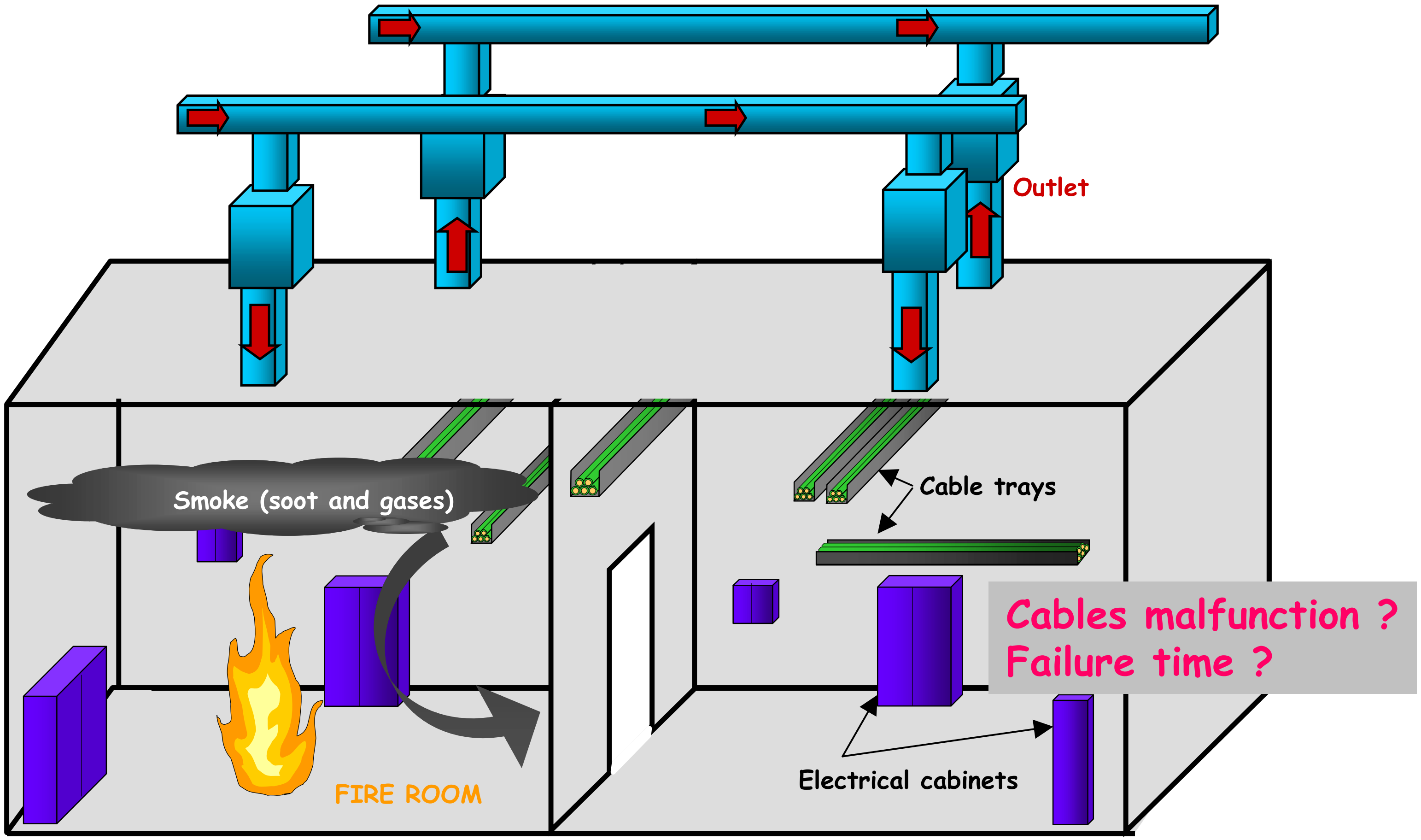
Fire Safety assumptions/questions

- Propagation of heat and smoke from the fire room towards others rooms



Fire Safety assumptions/questions

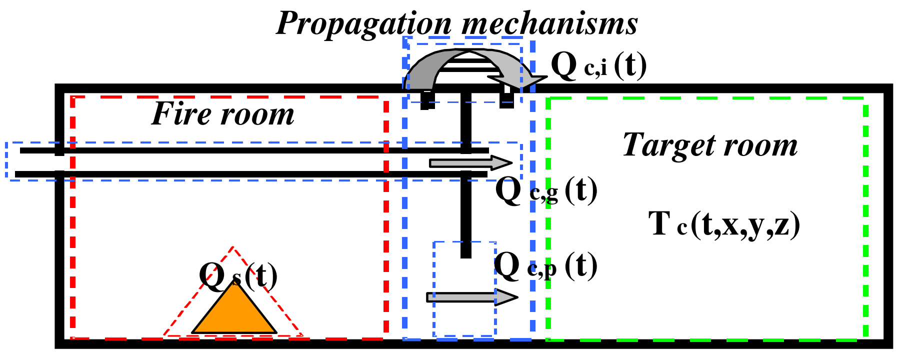
- Impact of heat and smoke on safety critical systems



OECD PRISME Program (2006-2010)

- **Partners:**
  - Belgium (AVN, Tractebel), Canada (AECL), Finland (VTT, STUK), **France (IRSN, EDF, DGA [IUSTI]),** Germany (GRS, iBMB), Japan (JNES), Netherlands (NRG), Spain (CSN), Sweden (Ringhals AB), Korean (KINS), UK (HSE), USA (NRC)

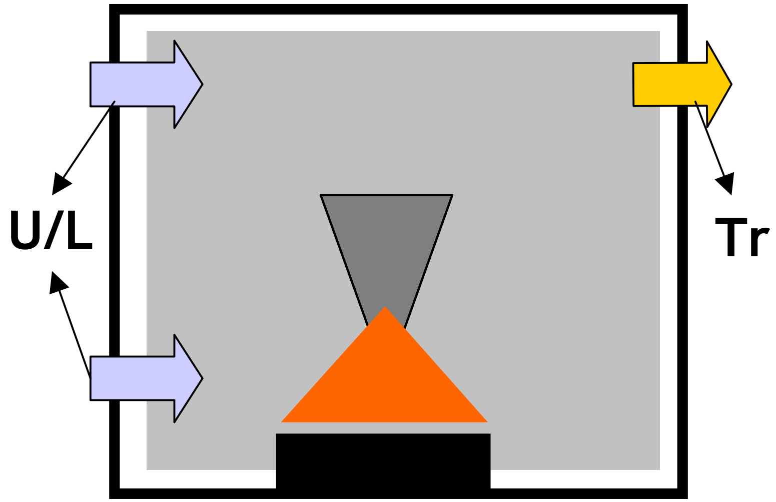
- **Objectives:**
  - Primary objectives of the project:
    - To study the mechanism of smoke and heat propagation from a fire within a room towards neighbouring rooms in a confined and mechanically ventilated facility
  - Secondary objectives of the project:
    - To study equipment behaviour when submitted to thermal stresses generated by a fire: for instance electrical cables failure and degradation



IRSN

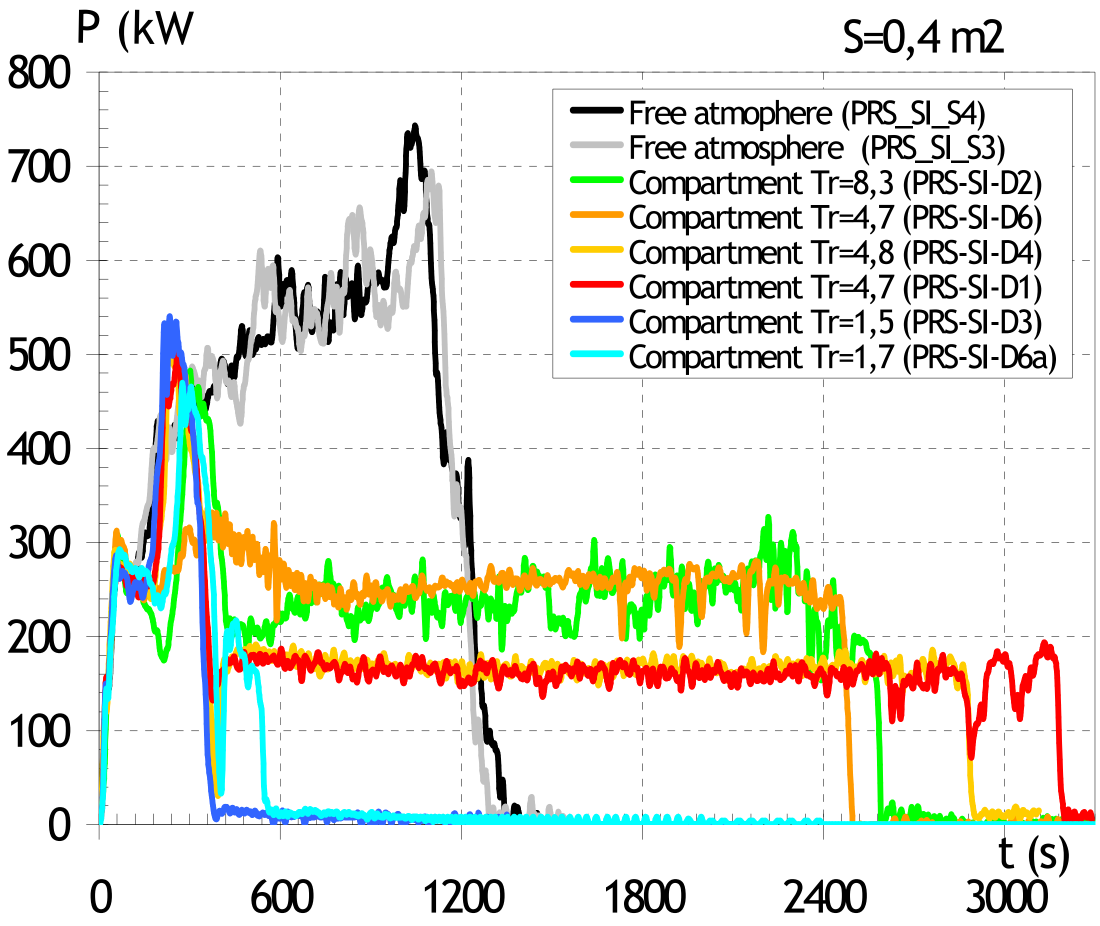
PRISME Program (2006-2010)

- **Fire source characterization**
  - PRISME Source (2005 & 2007)
    - ➢ around 20 tests in open atmosphere (SATURNE hood)
      - Various heat release rate
    - ➢ 8 tests in confined atmosphere (DIVA Facility)
      - Large range of ventilation conditions (one room)
    - ➢ Fuel: Dodecane (HTP)



Pretrel, H., Querre, P., "Experimental Study of Burning Rate Behaviour in Confined and Ventilated Fire Compartments", 8th IAFSS, 2005, pp. 1217-1229.

Heat Release rate



Name	S (m²)	Tr	Inlet Position
SI_D1	0.4	4.7	U
SI_D4			U
SI_D2		8.4	U
SI_D3		1.5	U
SI_D5	0.2	4.6	U
SI_D5a		1.6	U
SI_D6	0.4	4.7	L
SI_D6a		1.7	L

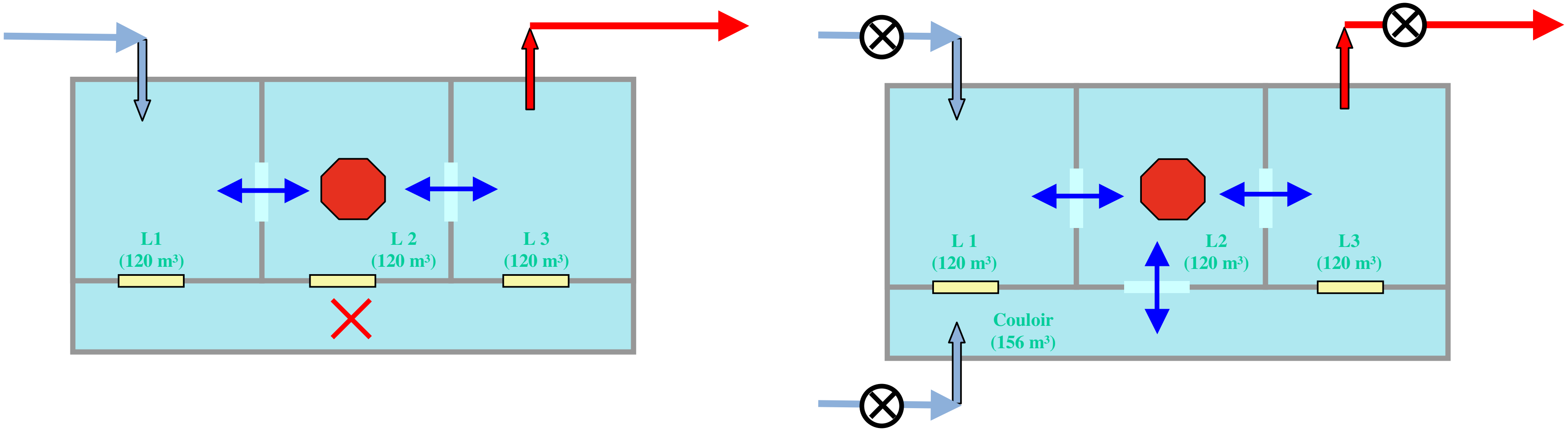
IRSN

PRISME Program (2006-2010)

- **Propagation modes**
  - PRISME Door (2007 – 6 tests)
    - Propagation through a door
    - 2 or 3 rooms
    - Under and over ventilated conditions
  - PRISME leak (2008 – 4 tests)
    - Propagation through leakages
    - Heat of a crossing ventilation duct
- **Real scenarios**
  - PRISME Integral (6 tests):
    - Specification: Discussions with partners underway
    - Realisation: 2010

PRISME Program (2006-2010)

- **PRISME Integral**
  - **Only one parameter will change in order to compare tests among themselves**
    - Test 1: 3 rooms, TPH
    - Test 2: 3 rooms, TPH, sprinkler
    - Test 3: 3 rooms, real fire source: vertical cables tray
    - Test 4: 4 rooms, TPH.
    - Test 5: 4 rooms, TPH, dampers
    - Test 6: 4 rooms, real fire source: electrical cabinet, dampers.



Specifications of the 1st exercise

- **BE #1**
  - **Post-calculations of the PRISME Source tests in the DIVA facility**
  - **Pre-calculations of the PRISME Door tests**
- **Objectives:**
  - **to evaluate the fire codes capabilities to model**
    - ➢ The effect of under-ventilation conditions on the burning rate
    - ➢ The interaction between fire and ventilation network
    - ➢ The smoke and soot propagation from the fire room to the adjacent room
    - ➢ The thermal stress on several targets located in the rooms

BE #1

- **Status of Numerical Results (Website / E-mail) (27th March 2009)**

Type	Computer code	Organisation	PRS-SI-D1
CFD	FDS (v4)	CSN	O
CFD	FDS (v4)	JNES	O
CFD	FDS (v4)	IBMB	O
CFD	FDS (v4)	NRG	O
CFD	FDS (v4)	Tractebel	O
CFD	FDS (V5)	Lund University / Vattenfall	PBG 7
CFD	FDS (v5, Dev)	VTT	O
CFD	FDS (v5)	KINS	O
CFD	SAFIR	Université de Provence / DGA	PBG 7
CFD	ISIS (v1.0, Dev)	IRSN	O
Lumped	COCOSYS (v2.4, Dev)	GRS	O
Zones	CFAST (v5.0)	JNES	O
Zones	CFAST	BEL V	O
Zones	CFAST (v6.0)	NRG	O
Zones	ŒIL (v1.5)	DGA	O
Zones	MAGIC (v4.1.2)	EDF	O
Zones	SYLVIA (v1.2.2, Dev)	IRSN	O

17 Participants

8 codes used

BE #1

Initial proposal

Name	Nber of Rooms	Pool Surface	Renewal rate	Inlet location
PRS_SI_D1	1	0.4 m^2	4.7 h^{-1} (560 $m^3 h^{-1}$)	High
PRS_SI_D3	1	0.4 m^2	1.5 h^{-1} (180 $m^3 h^{-1}$)	High
PRS_SI_D6	1	0.4 m^2	4.7 h^{-1} (560 $m^3 h^{-1}$)	Low
PRS_D1 (Door)	2	0.4 m^2	0 h^{-1} (0 $m^3 h^{-1}$)	High
PRS_D3 (Door)	2	0.4 m^2	4.7 h^{-1} (180 $m^3 h^{-1}$)	High

: Open calculations

: Blind calculations

Final proposal

- PRS SOURCE D1 with experimental HRR as input data
- Discussion on the metrics

BE #1

L2-Norm Index (Peacock):

$$\frac{\left\|\Delta\vec{Y}\right\|}{\left\|\vec{Y}_{exp}\right\|} = \frac{\left\|\vec{Y}_{exp} - \vec{Y}_{num}\right\|}{\left\|\vec{Y}_{exp}\right\|} = \frac{\sqrt{\sum_i \left(Y_{exp,i} - Y_{num,i}\right)^2}}{\sqrt{\sum_i \left(Y_{exp,i}\right)^2}}$$

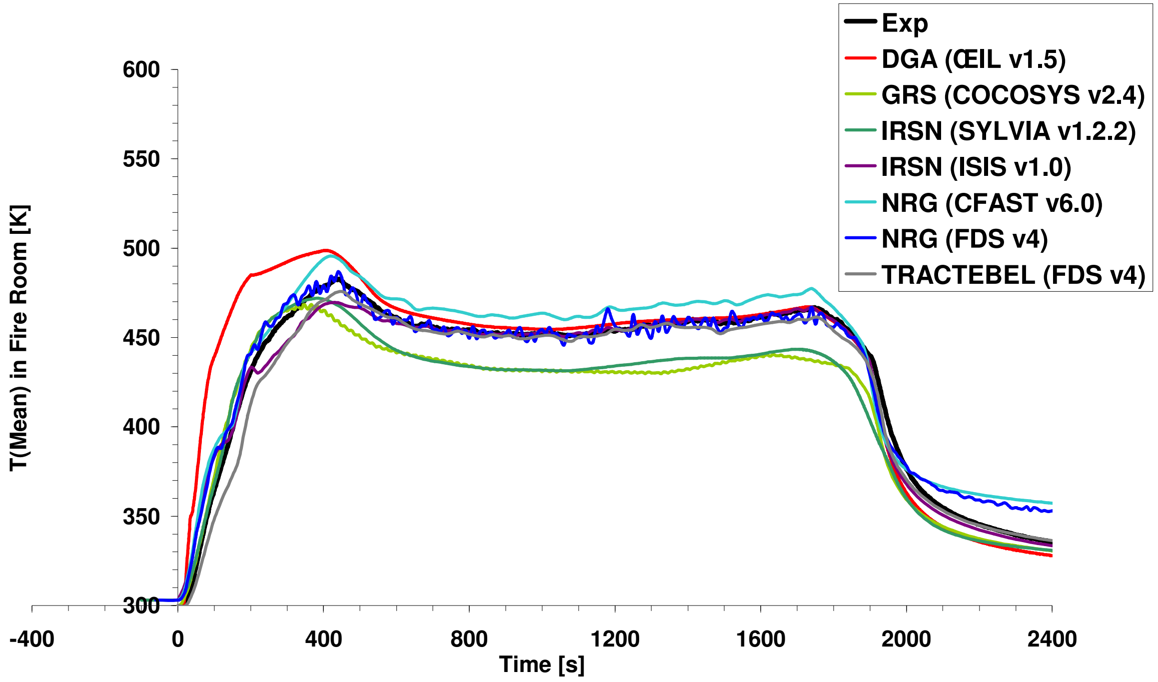
Type: Global ; Bounded: No ($[0;+\infty[$) ; Success: $|I| \approx 0$

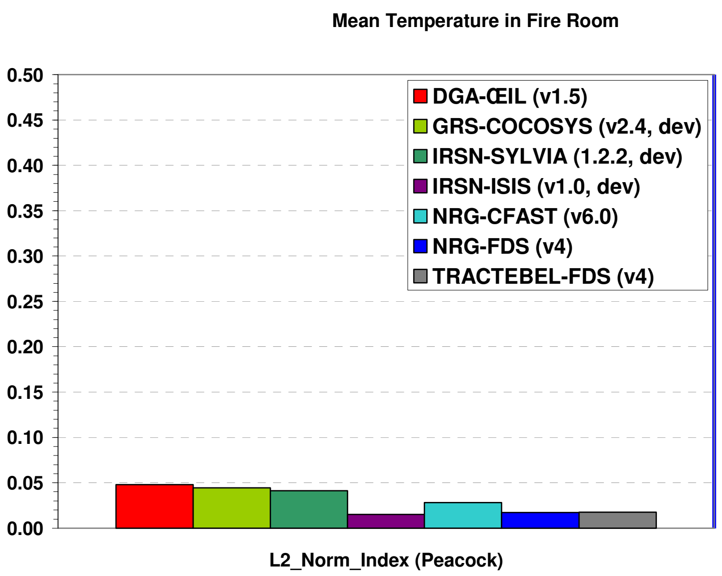
Meaning (Peacock-99):

“This norm based upon relative difference provides a measure of the difference in overall magnitude for the two curves (exp/num) normalized to the experimental data.”

BE #1

Mean temperature in fire room





Comments:

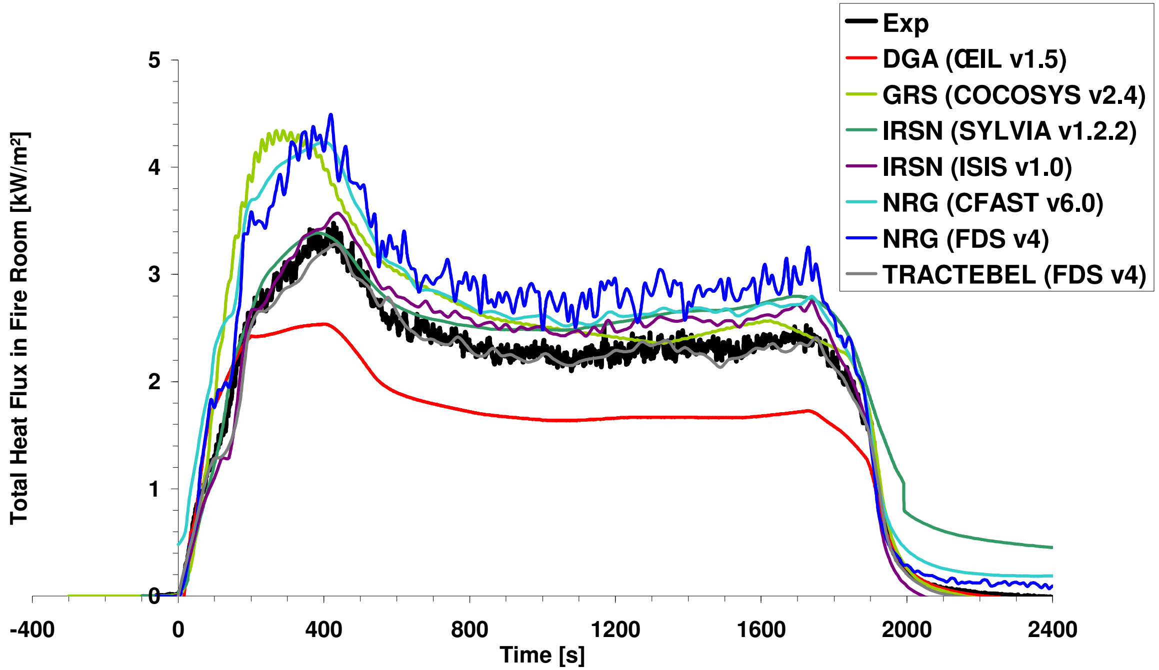
- All results are in good agreement.
- COCOSYS and SYLVIA are very close and slightly lower than the others codes and exp. data.
- The L2-norms give low values (<0.05) => good results.

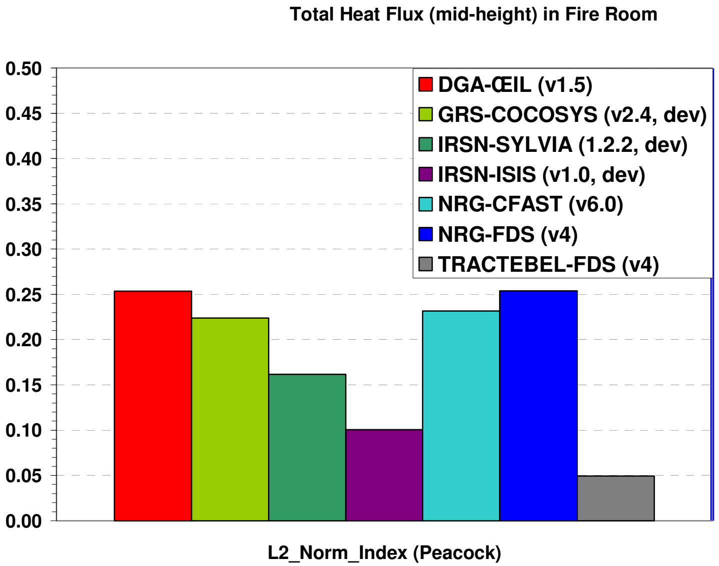
BE #1

Total heat flux

to the north wall

in fire room





Comments:

- Three codes (COCOSYS, CFAST, FDS-NRG) are above the exp. data.
- One code (OEIL) is below the exp. data.
- Three codes (SYLVIA, ISIS, FDS-TRACTEBEL) are in good agreement with the exp. Data.
- The L2-norms confirms this conclusion.

BE #1

- **Application of the metrics**
  - Comparisons with experimental data
    - Mean Gas temperature
    - Gas pressure
    - Vent flow (ISIS, MAGIC, COCOSYS, OEIL, SAFIR)
    - Heat Fluxes at 2.6 m
    - Oxygen concentration
    - Wall temperature at 2.6 m
  - Relevant metrics according the fire phase
    - Ignition
    - Stationary phase
    - Extinction
- **Publication in progress**

BE #2

- **Sensitive Analysis**
  - Fire test: Same test proposed in BE #1
    - PRS-SI-D1 ($S=0.4\ m^2$; TPH ; 4.7 RR)
  - Input parameters

Heat of combustion

	Input parameters	Init. Value	Lower value	Upper value	Reference
Fuel	~~HRR [kW]~~ (1)	Q(t)	-10%	+10%	PRISME-27
Fuel	X_r [-]	0.35	0.3	0.4	PRISME-23
Wall (concrete)	k [W/m/K] (2)	1.5	1.07	1.93	PRISME-09
Wall (concrete)	Cp [J/kg/K] (3)	~~740~~	~~280~~	1200	PRISME-09
Wall (concrete)	□ [-]	0.7	0.5	0.9	BE
Ventilation	Q_v [m3/h]	560	500 (-10%)	620 (+10%)	PRISME-27

1000 J/kg/K

800 J/kg/K

BE #2

- **Partners Simulations (March 2009)**
  - Monte-Carlo Simulations
    - FDS (VTT)
    - COCOSYS (GRS)
  - Fractional Factorial Design
    - FDS (KINS)
    - MAGIC (EDF)
    - SYLVIA (IRSN)

- **Comparison of the two approaches**
  - FDS (VTT)
  - COCOSYS (GRS)
  - SYLVIA (IRSN)

BE #2

- **Outputs analysis**
  - Mean temperature
    - Maximum value
    - At a given time during the steady phase: at t = 2000 s
  - Minimum oxygen mass fraction
    - Upper layer for zones codes
    - At z = 3 m for CFD codes
  - maximum wall temperature at 2.6 m
  - maximum radiative heat flux at 2.6 m
  - Total heat fluxes at 2.6 m
  - (Pressure)
    - At a given time during the steady phase: at t = 2000 s
    - maximum value (overpressure)
    - minimum value (under pressure)