FireGrid

-Predicting fire development using computer simulations

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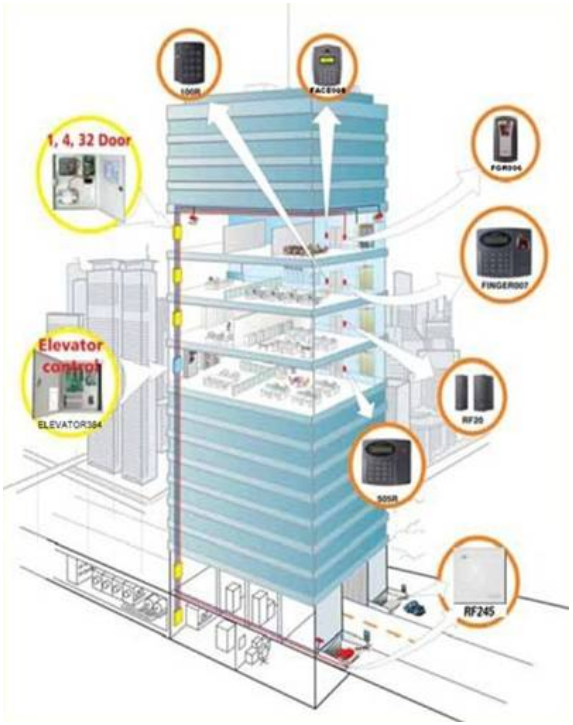
Context

- Lack of information for fire-fighters, occupants, for research
- Predicting fire development is extremely challenging due to complexity.
- Precise values of input parameters are difficult to define
- Computational cost of modelling real-world fires in detail is prohibitively expensive.

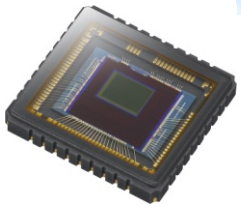
Context

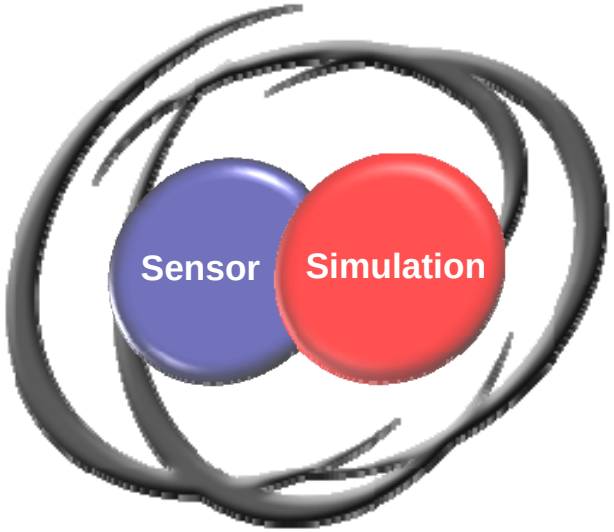
Abundant sensor resources

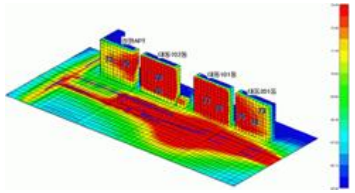
- Increase in intelligent buildings
- Increase in sensors
- Increase in information

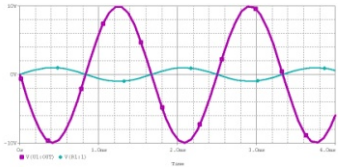


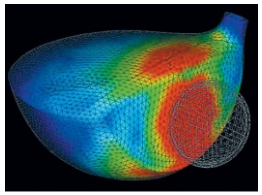
Linking sensor and computer simulation





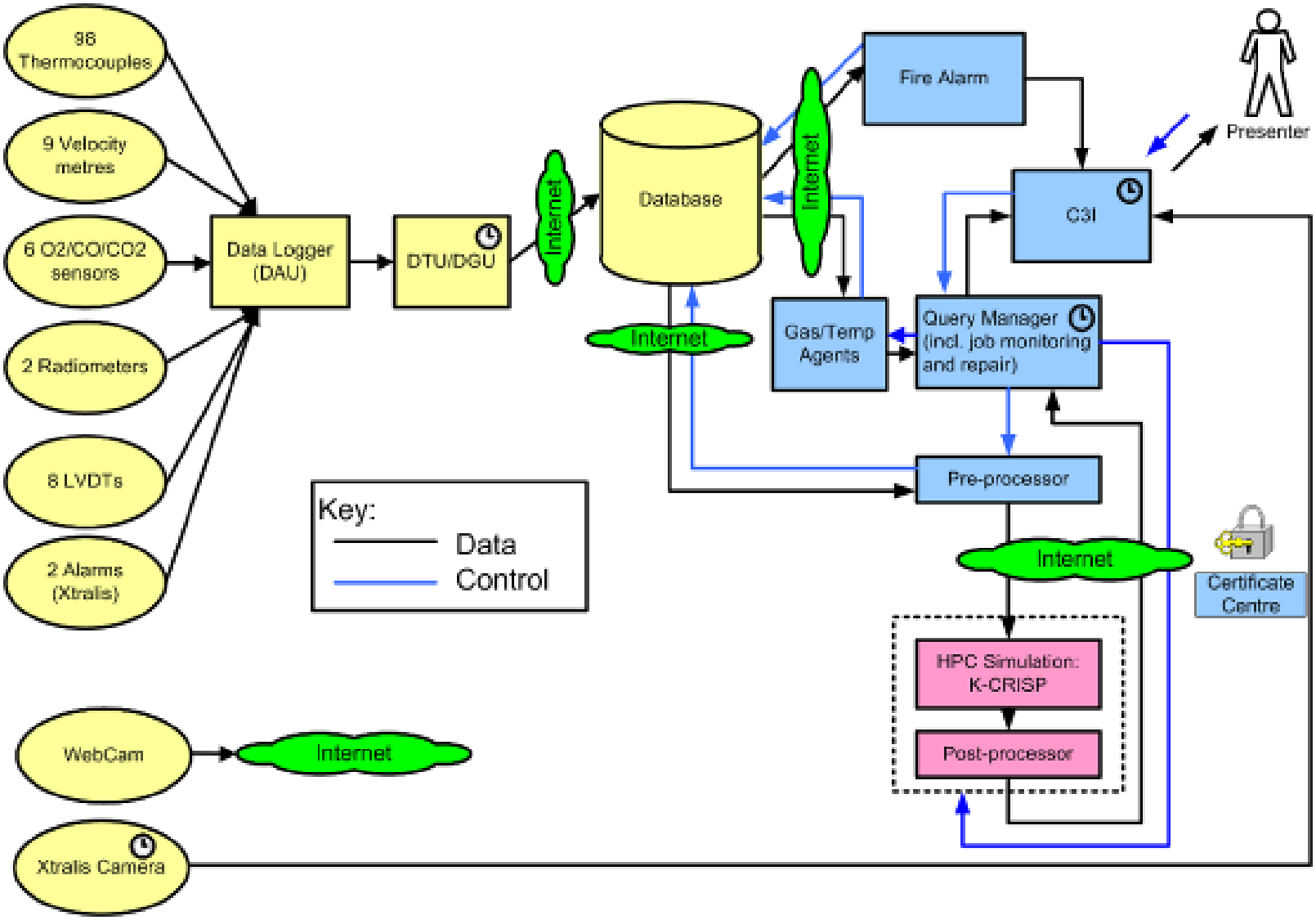






Context

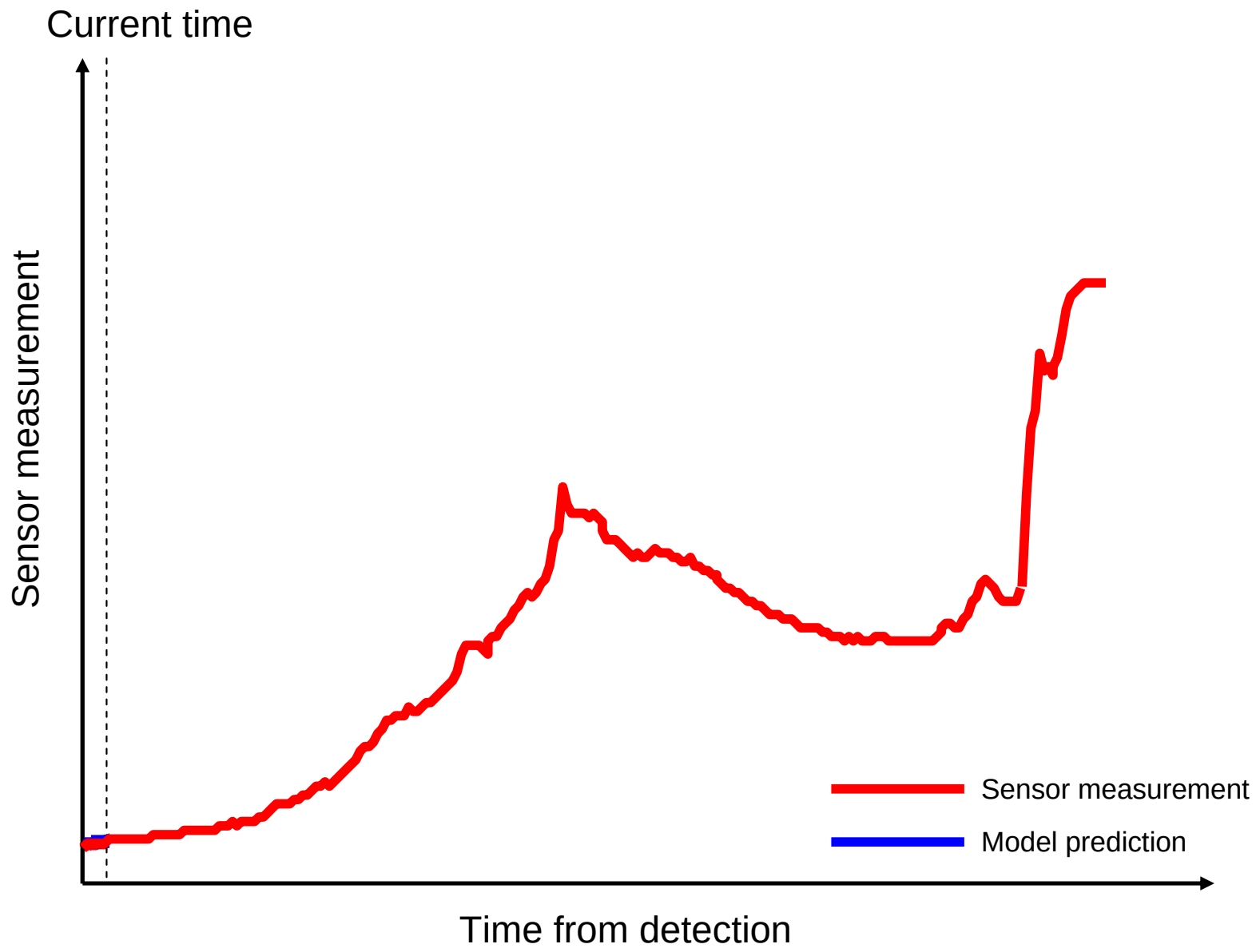
Architecture of FireGrid system



How it works

Approach so far . . .

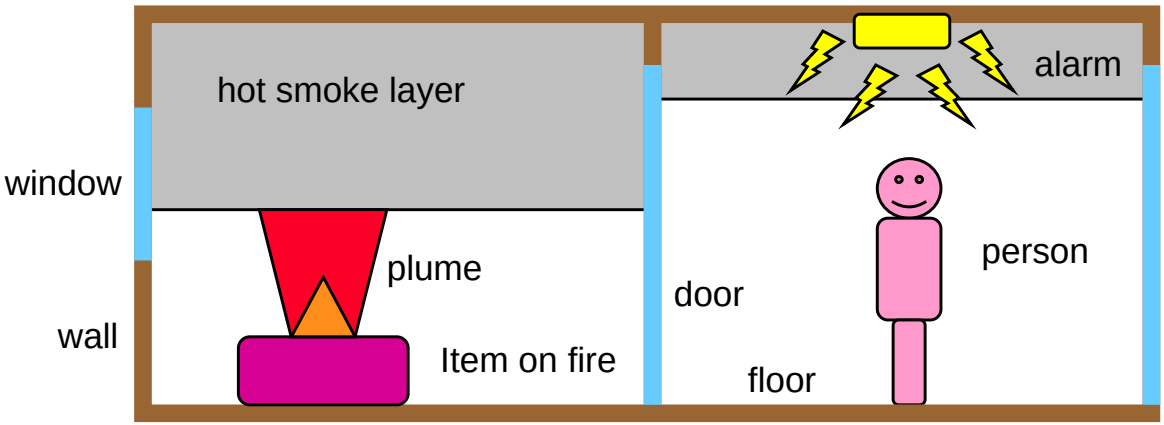
Demonstration



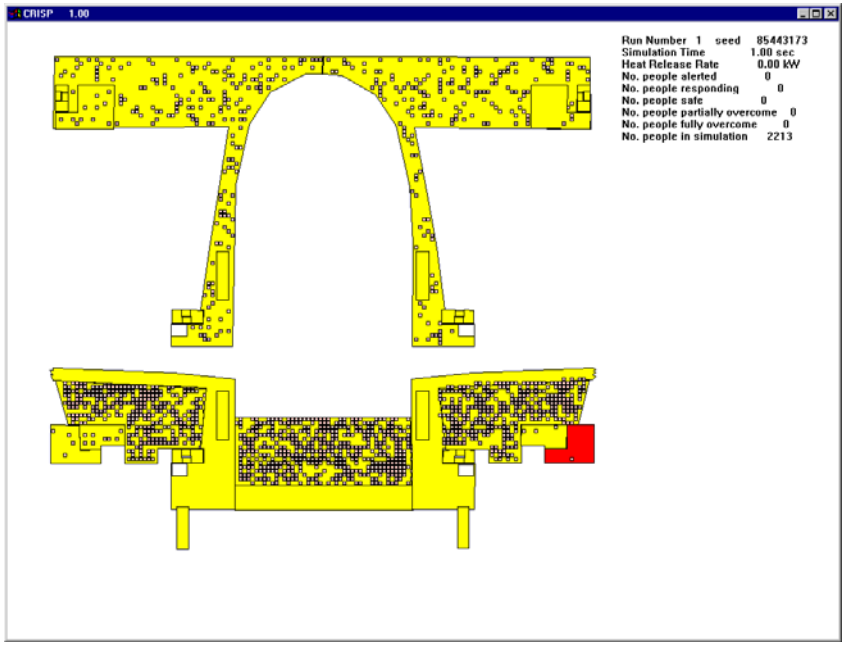
What we did

What is CRISP?

- Computation of Risk Indices by Simulation Procedures
- Simulation of the entire fire ‘system’
- Monte-Carlo method



Object Types in CRISP

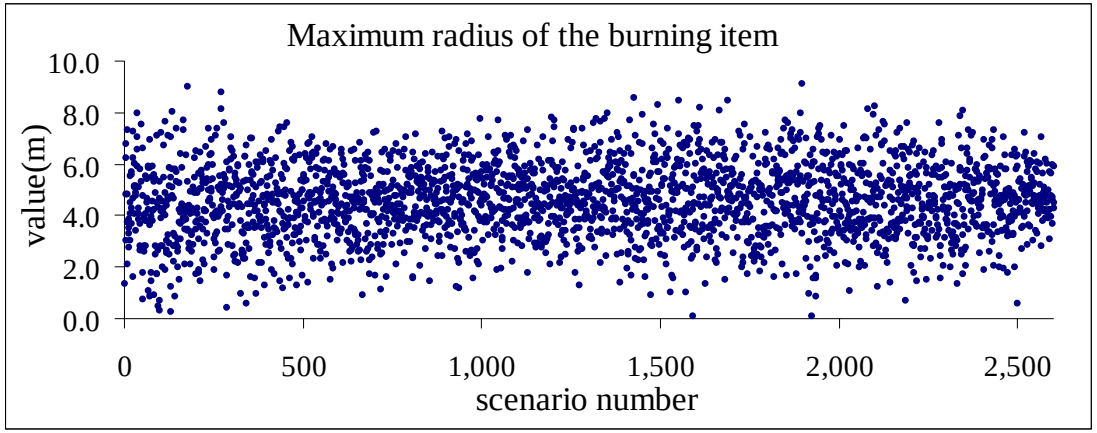


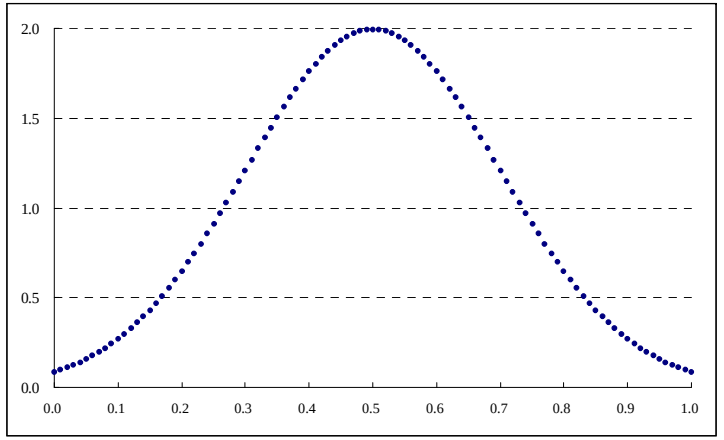
What we did

Randomization

- Changing format of input parameters

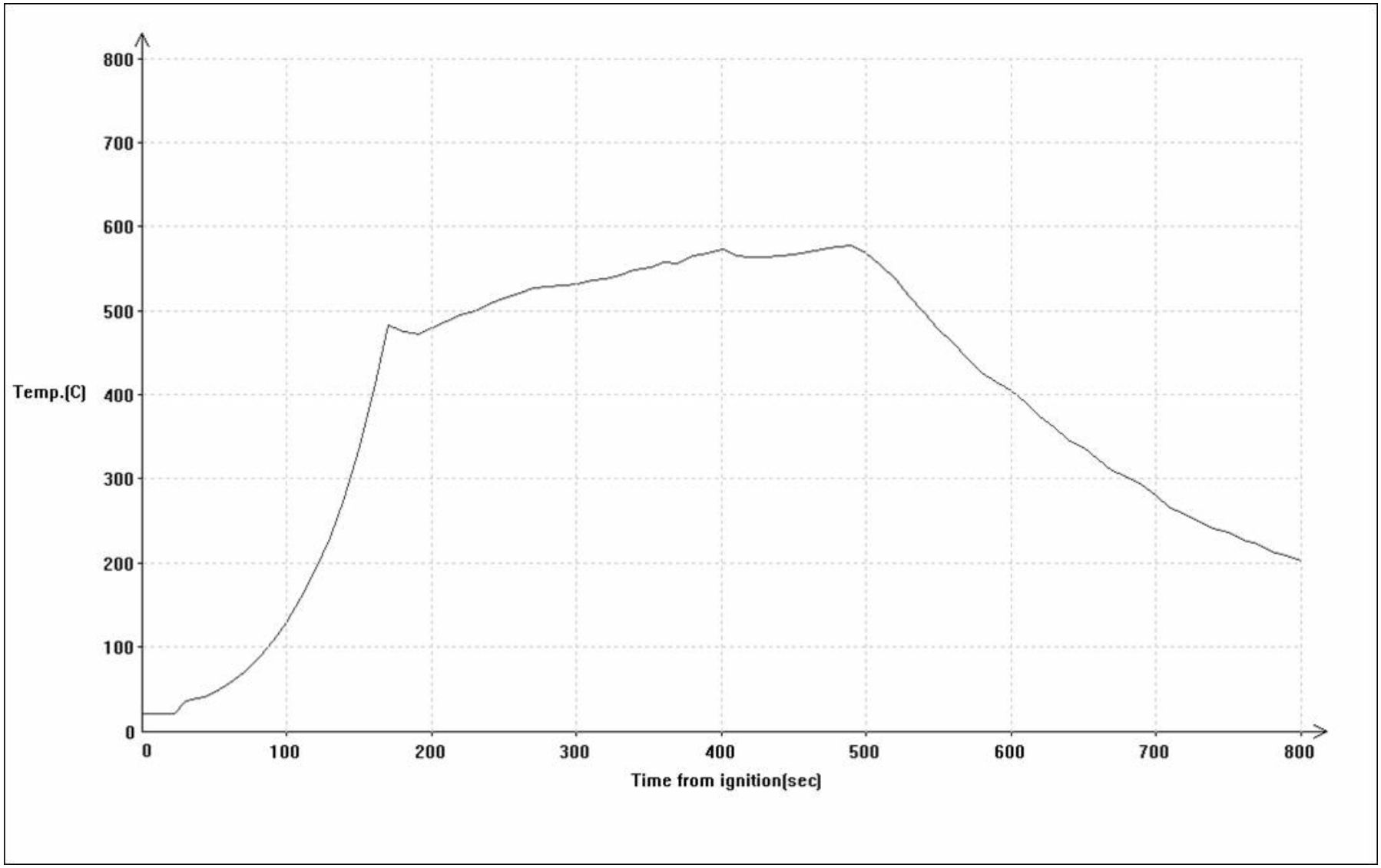
Parameter	Mean value	Standard deviation
Maximum radius of burning surface (m)	3.0	1.0
Height of burning surface (m)	0.5	0.2
Initial fuel load (kg)	200	100
Fuel at onset of burnout (kg)	50	10
Rate of flame spread (m/s)	0.003	0.002
Flashover threshold 1 (°C)	500	100





What we did

Randomization



What we did

Goodness-of-fit test

-Chi-squared equation

$$\chi^2 = \sum_{i=1}^{n} \frac{(O_i - E_i)^2}{\varepsilon^2_{TOT,i}}$$

-Error

$$\varepsilon^2_{TOT} = \varepsilon^2_{sensor} + \varepsilon^2_{model}$$

-Applying to fire model

$$\chi^2 = \sum_{t}^{m} \sum_{i=1}^{n} \frac{(O_{t,i} - E_{t,i})^2}{\varepsilon^2_{TOT,t,i}}$$

What we did

Goodness-of-fit test

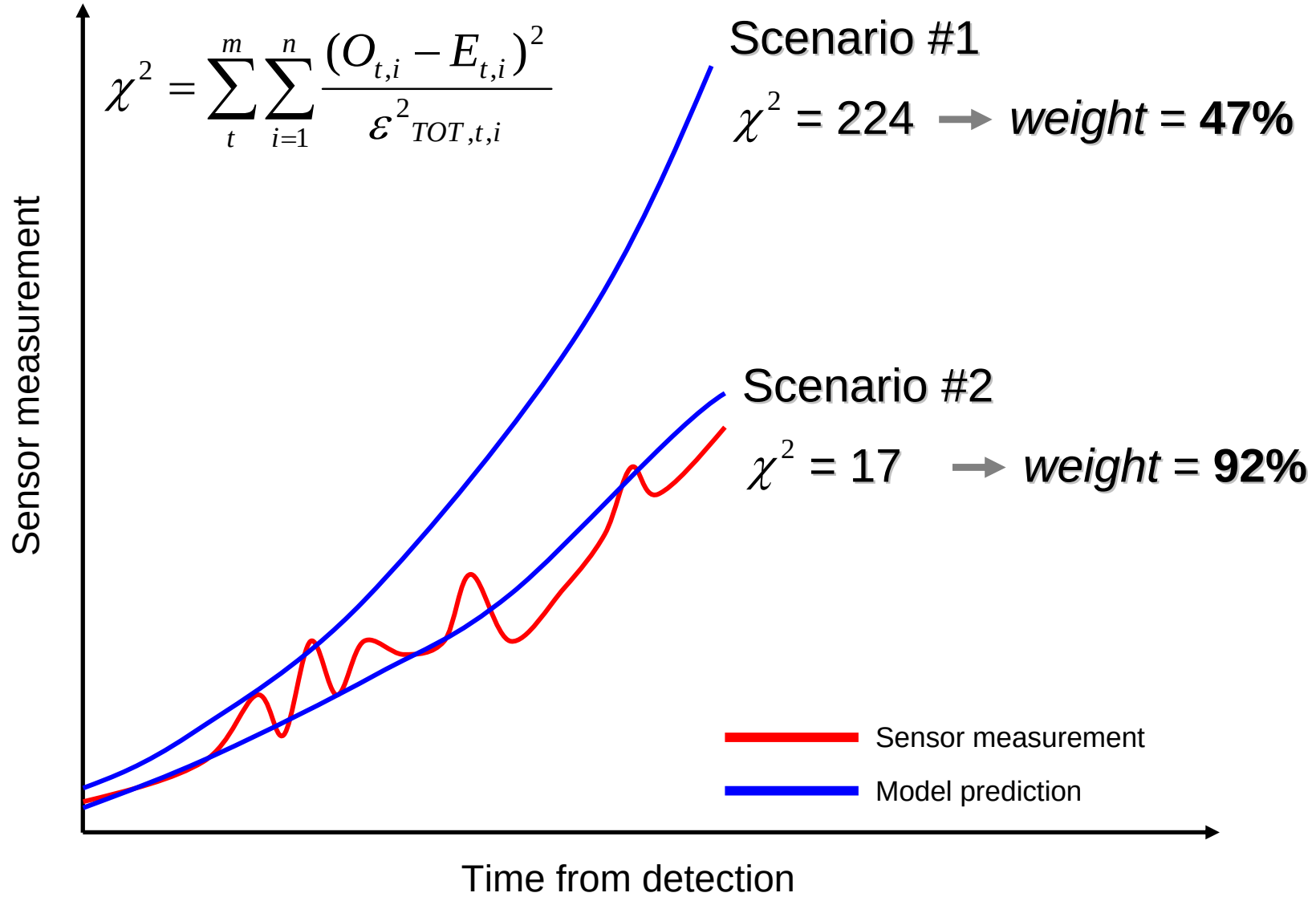
$$\chi^2 = \sum_{t}^{m} \sum_{i=1}^{n} \frac{(O_{t,i} - E_{t,i})^2}{\varepsilon^2_{TOT,t,i}}$$

Scenario #1

χ^2 = 224 → *weight* = **47%**

Scenario #2

χ^2 = 17 → *weight* = **92%**



What we did

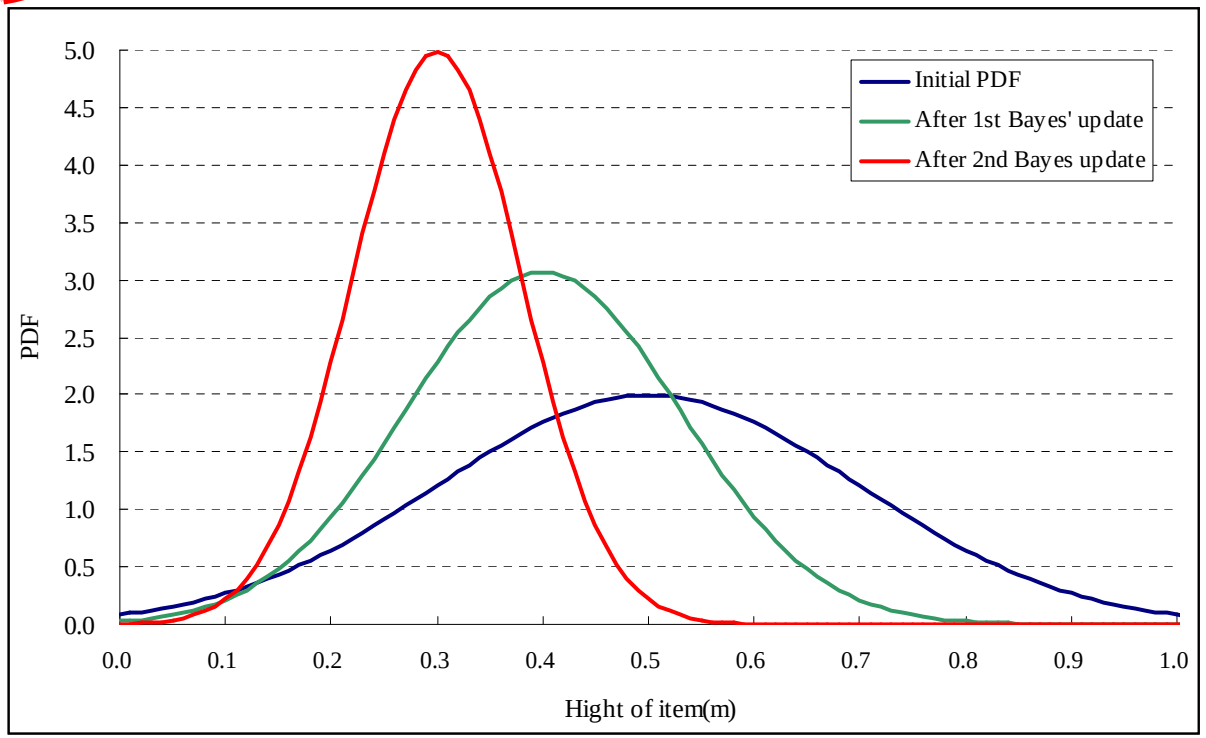
Bayesian inference

$$P(A \mid B) = \frac{P(B \mid A).P(A)}{P(B)}$$

$$P(A_j \mid B_i) = \frac{P(B_i \mid A_j).P(A_j)}{\sum_k P(B_i \mid A_k).P(A_k)}$$

$$L(B_i|A_j)$$

$$P(A_j \mid B_i) = L(B_i \mid A_j).P(A_j)$$

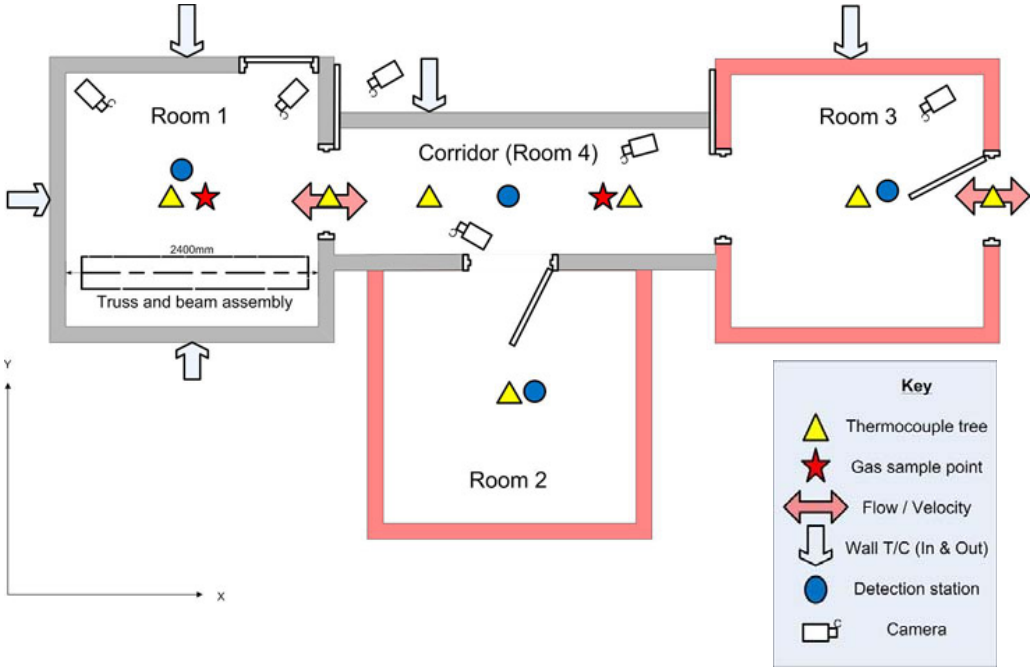


What we did

Real time feed back process

What we did

Full scale fire test



- HPC (ECDF – The Edinburgh Compute and Data Facility)
- High-performance cluster of servers (1456 processors)
- Processors:
  - 4 instances of CRISP
  - 1 Pre-processor

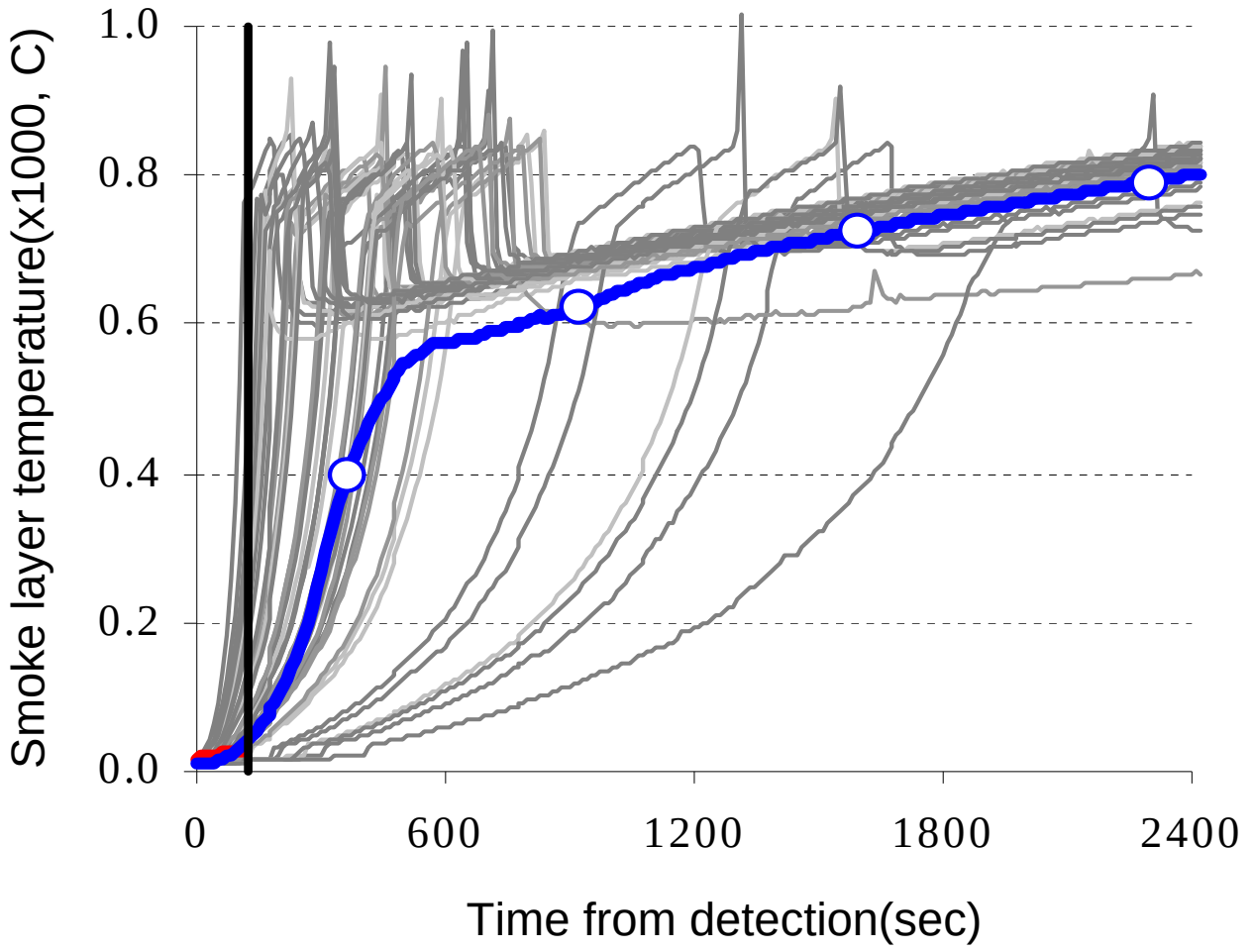
Results

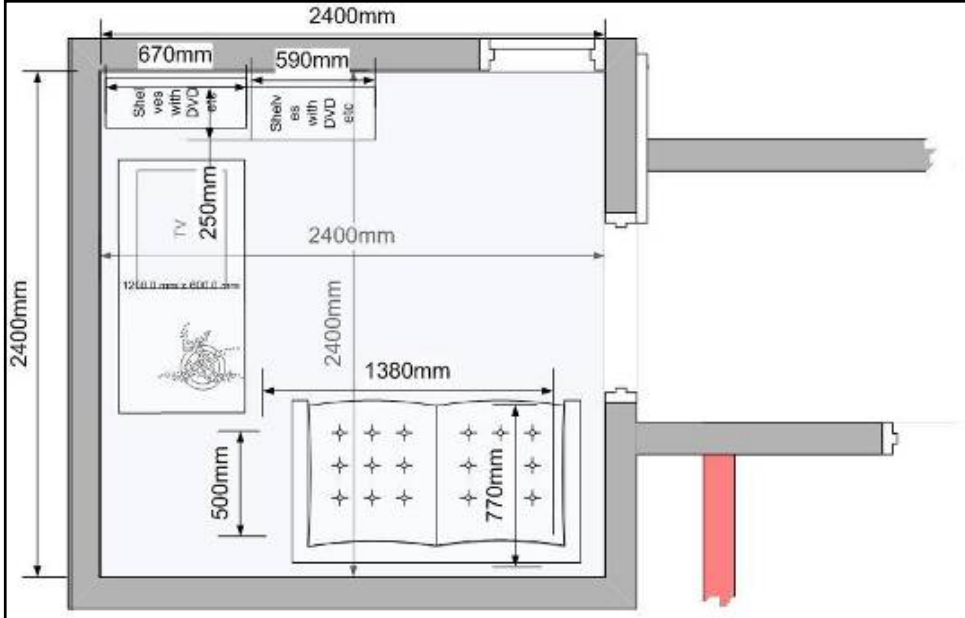
Predictions

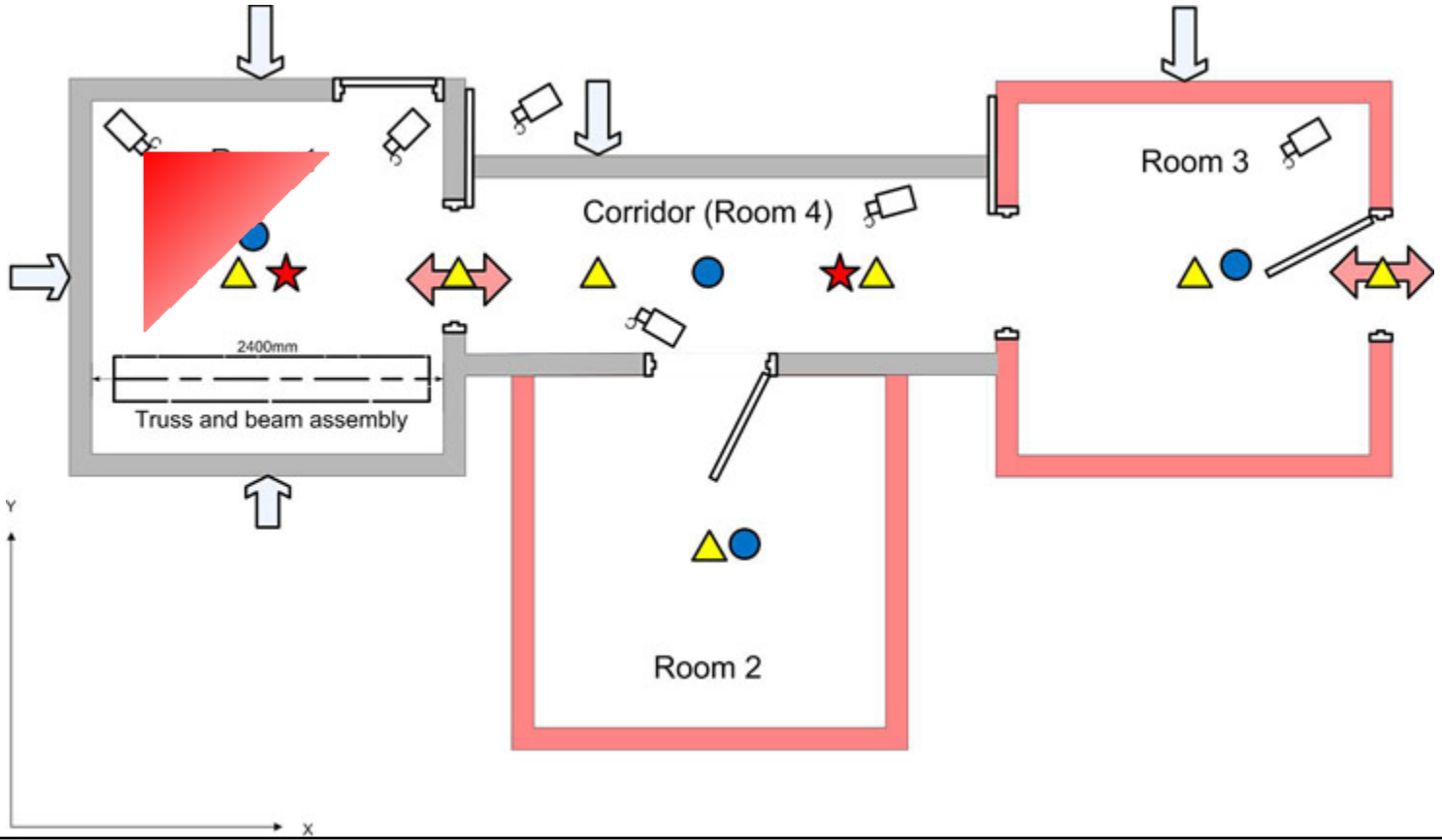
Sensor measurement

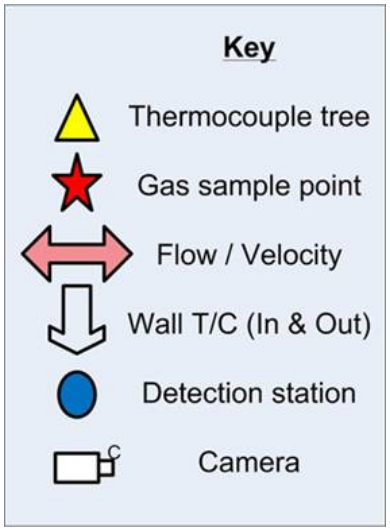
prediction

Current time

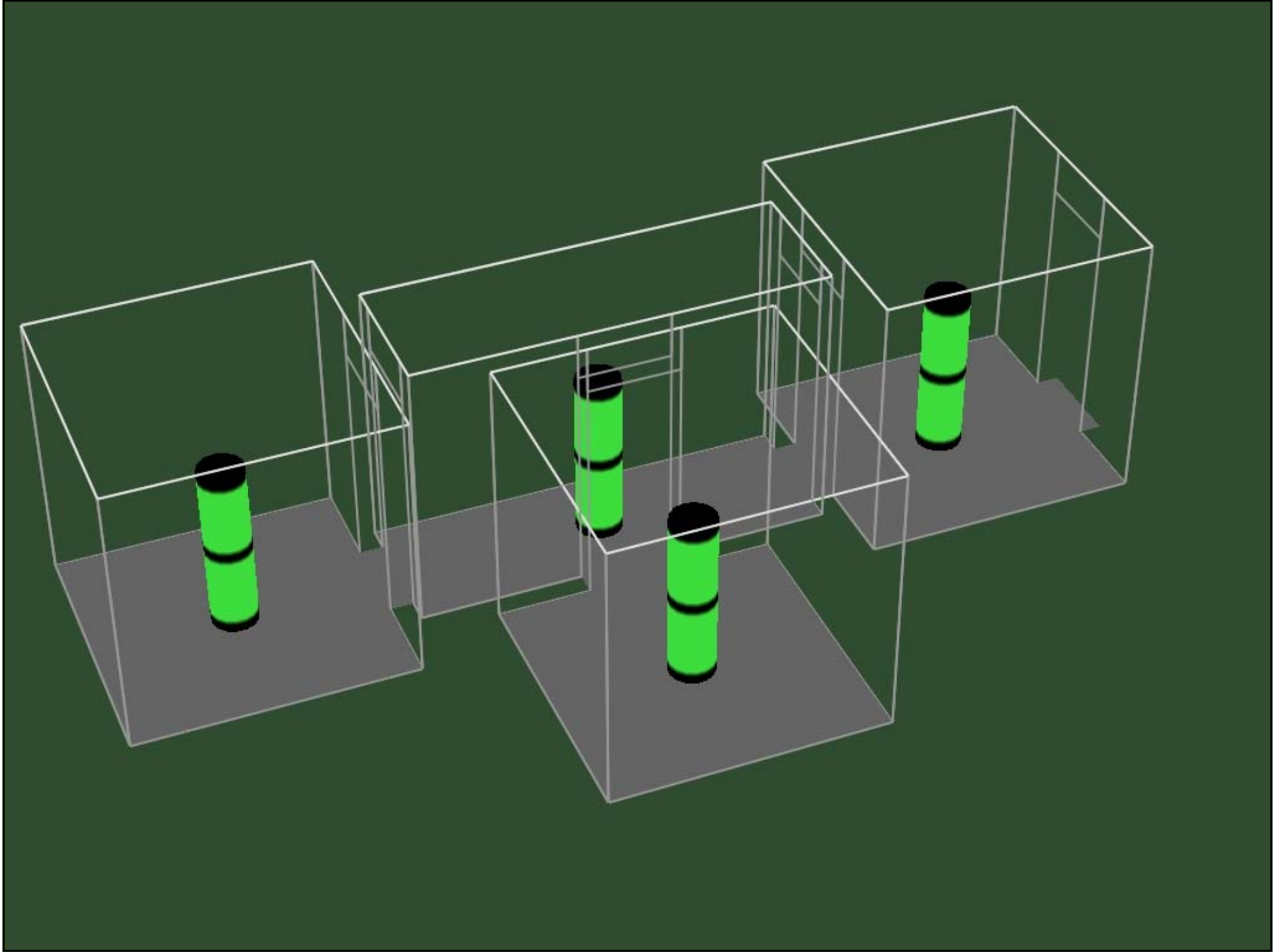


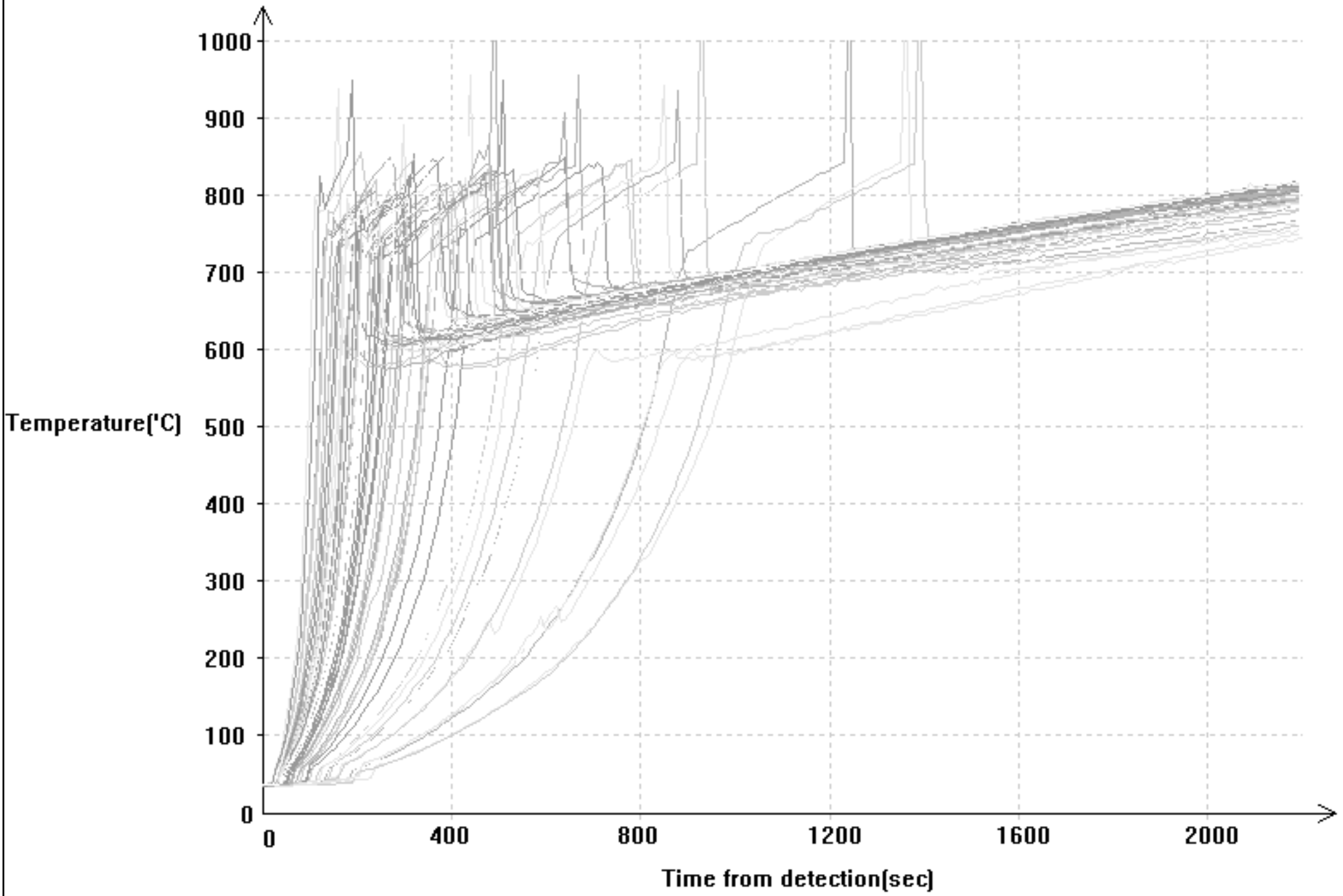

2400mm
670mm
590mm
Shelves with DVD etc
Shelves with DVD etc
TV
250mm
2400mm
2400mm
2400mm
1380mm
500mm
770mm

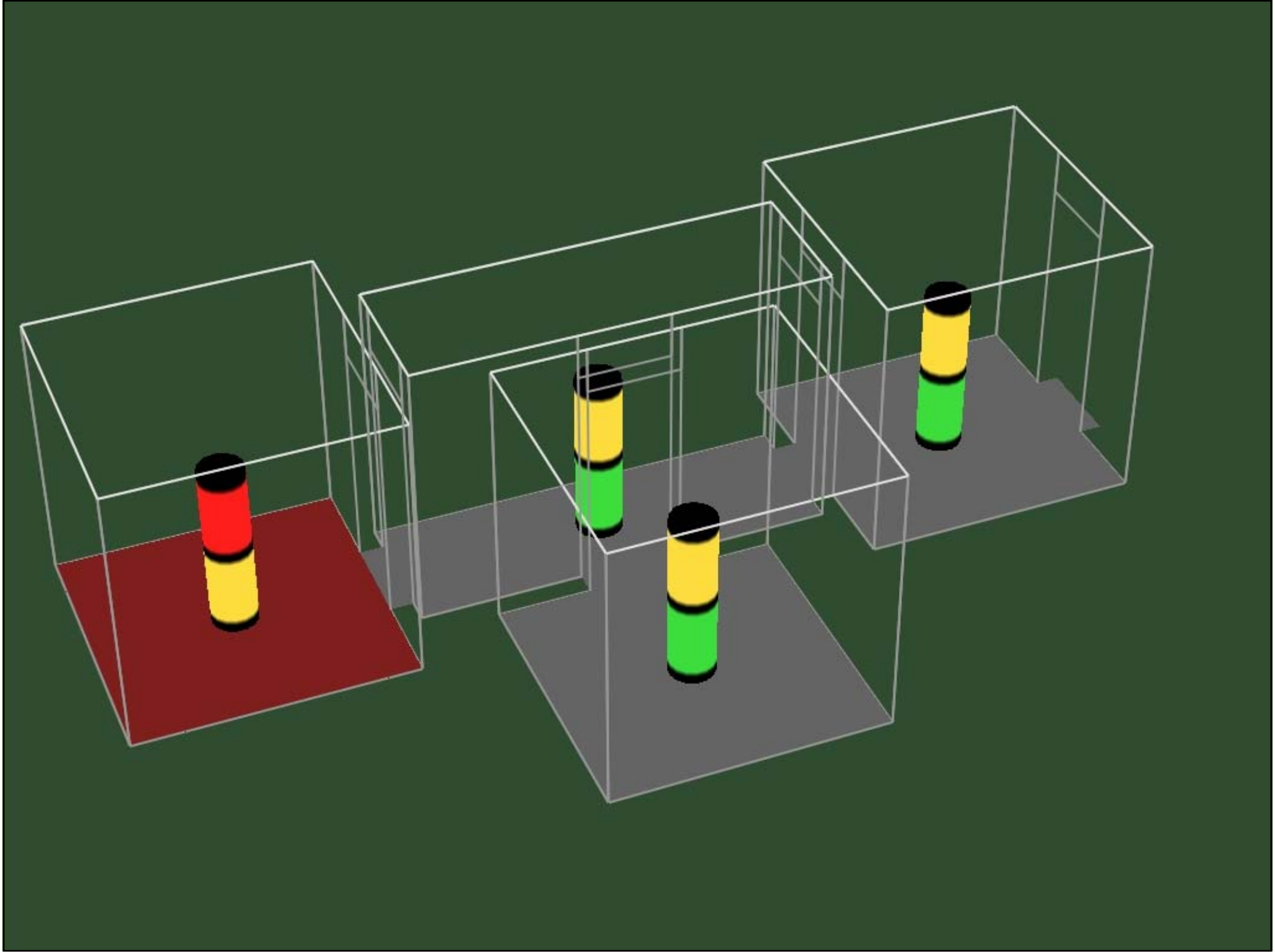

Corridor (Room 4)
Room 3
Room 2
2400mm
Truss and beam assembly
Y
X


Key
Thermocouple tree
Gas sample point
Flow / Velocity
Wall T/C (In & Out)
Detection station
Camera

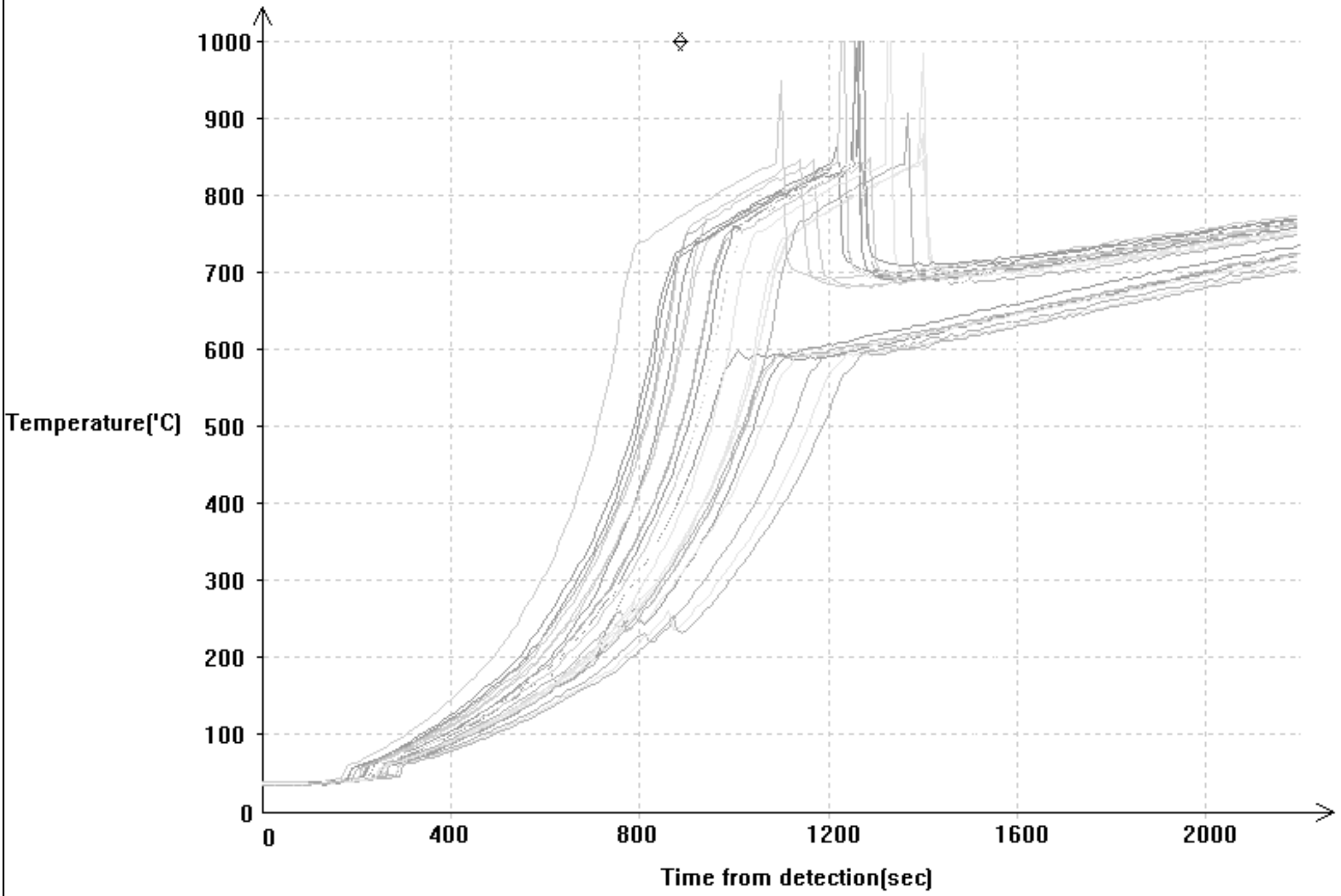

eral - 29/10/2008 12:01:27




Temperature('C)
1000
900
800
700
600
500
400
300
200
100
0
0
400
800
1200
1600
2000
Time from detection(sec)




Cameral - 29/10/2008 12:15:27


Temperature('C)
1000
900
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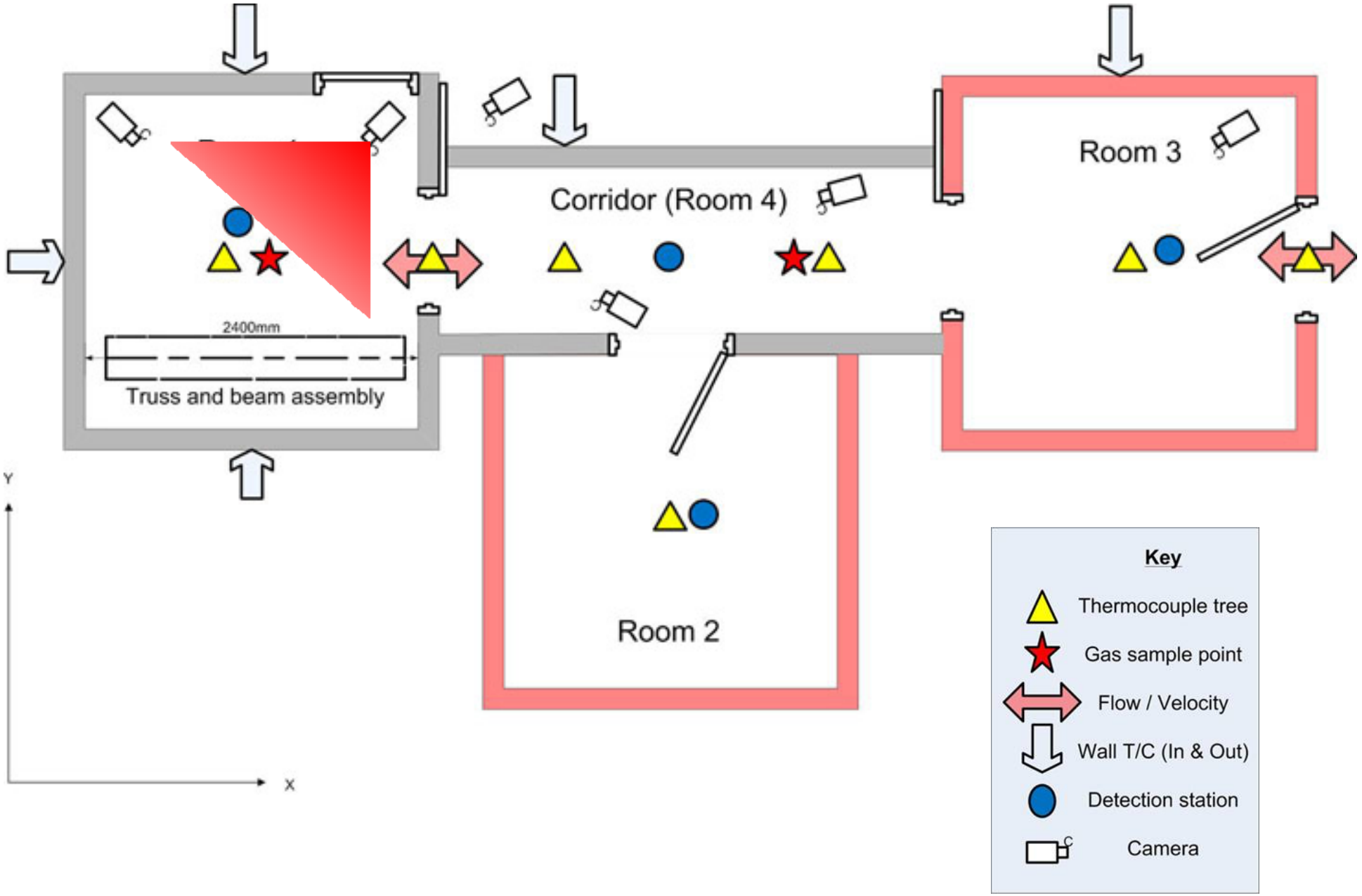
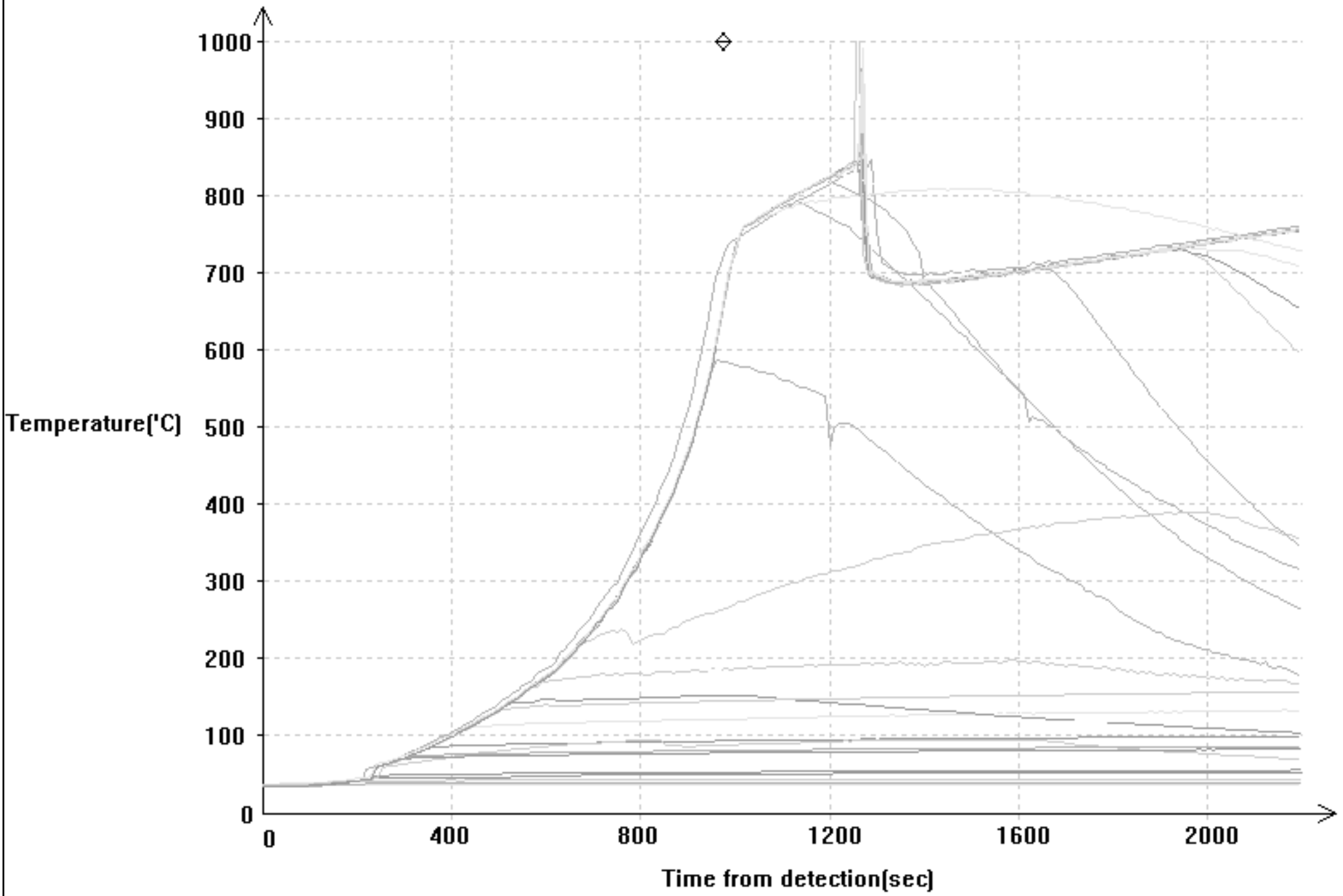
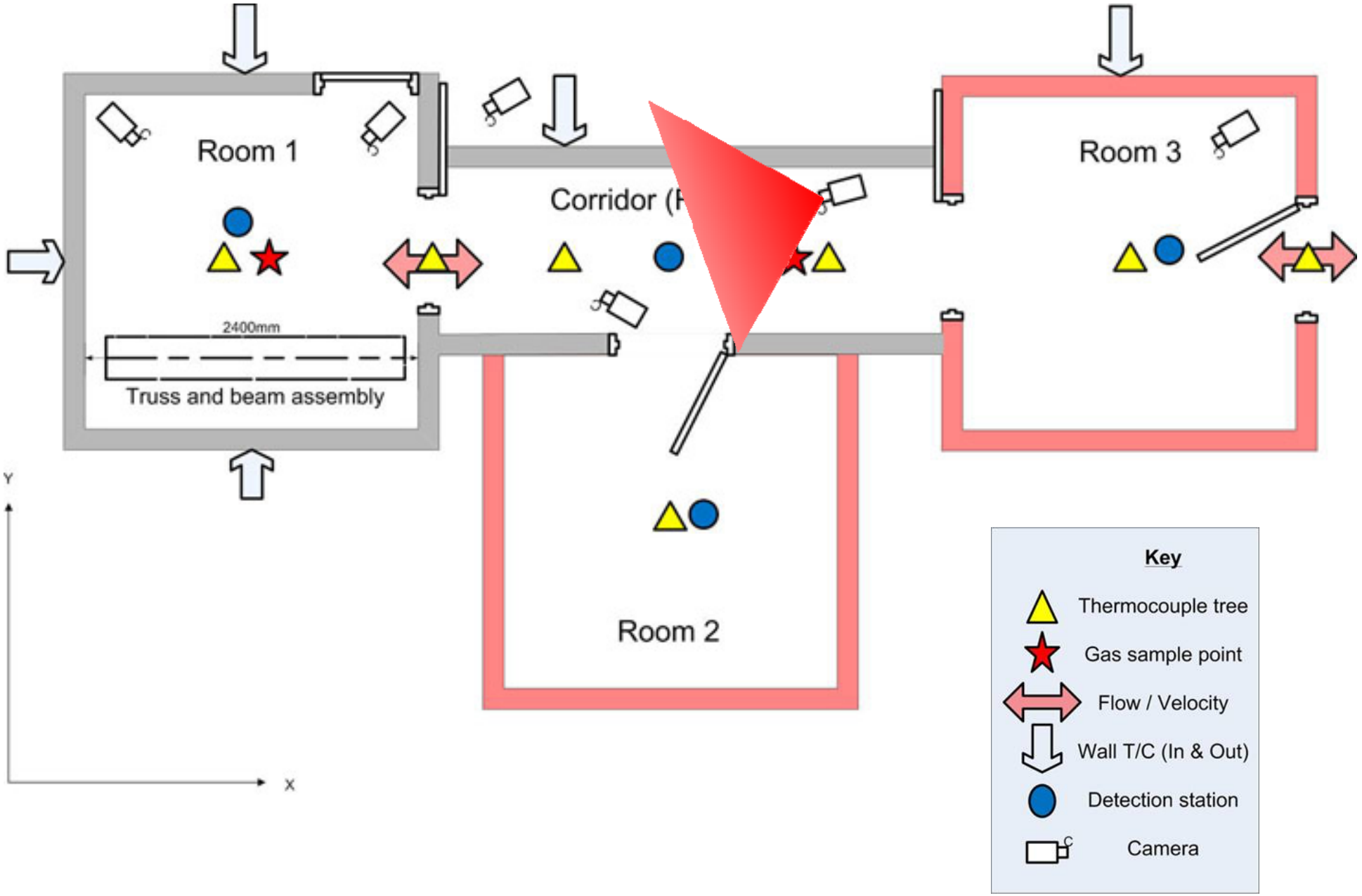
700
600
500
400
300
200
100
0
0
400
800
1200
1600
2000
Time from detection(sec)


Room 3
Corridor (Room 4)
2400mm
Truss and beam assembly
Room 2
Y
X
Key
Thermocouple tree
Gas sample point
Flow / Velocity
Wall T/C (In & Out)
Detection station
Camera

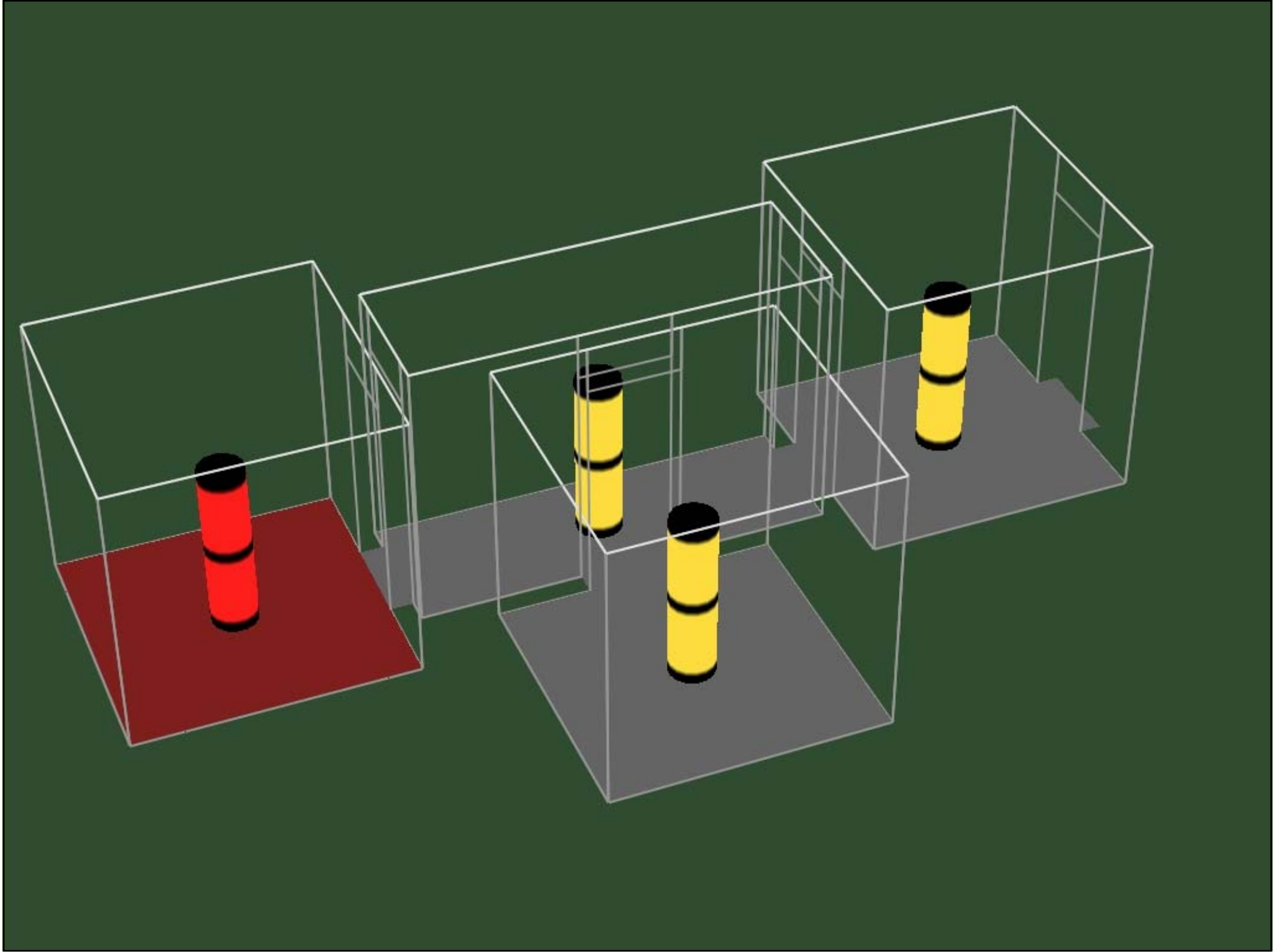

Camera2 - 29/10/2008 12:25:12

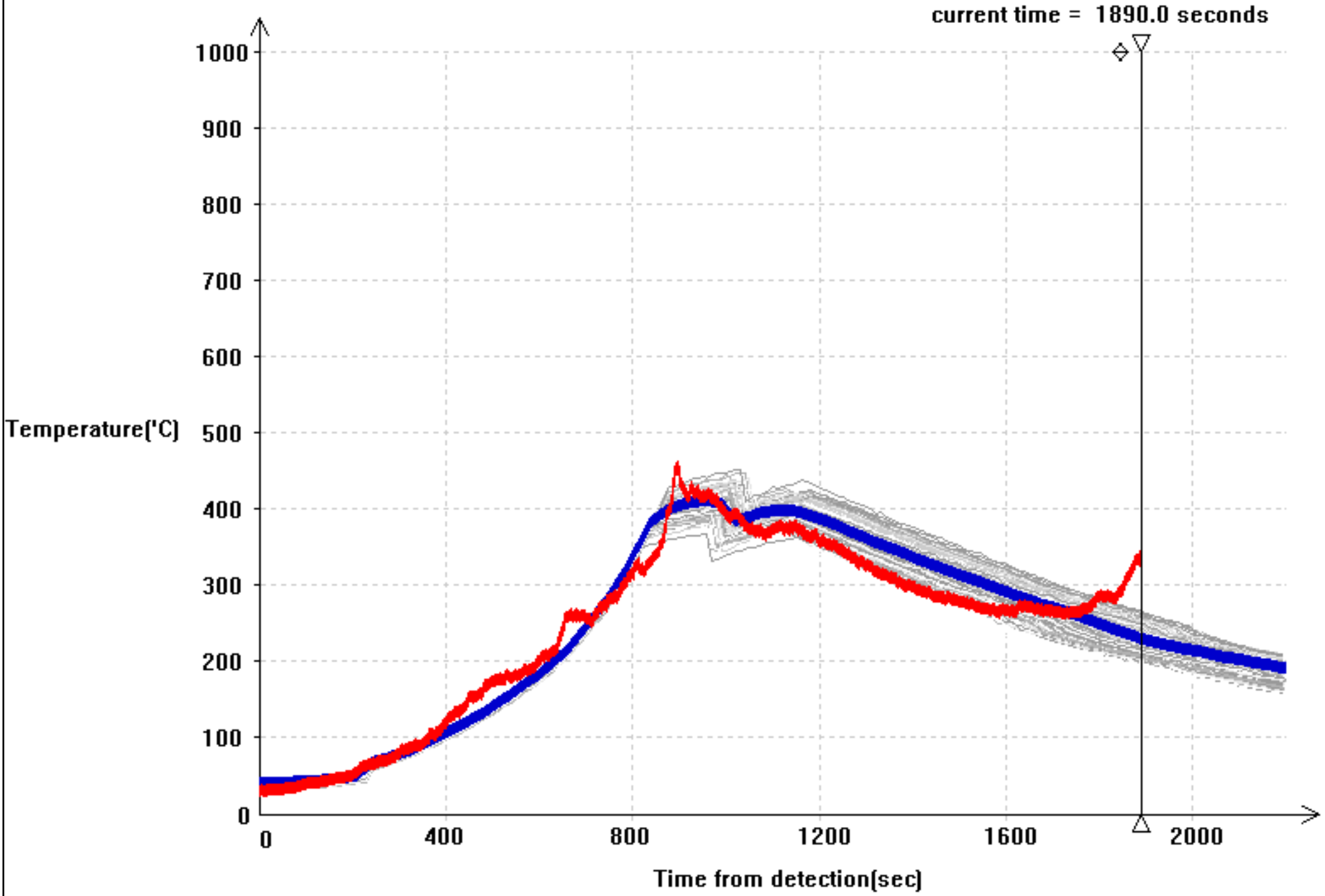

1000
900
800
700
600
500
400
300
200
100
0
Temperature('C)
0
400
800
1200
1600
2000
Time from detection(sec)

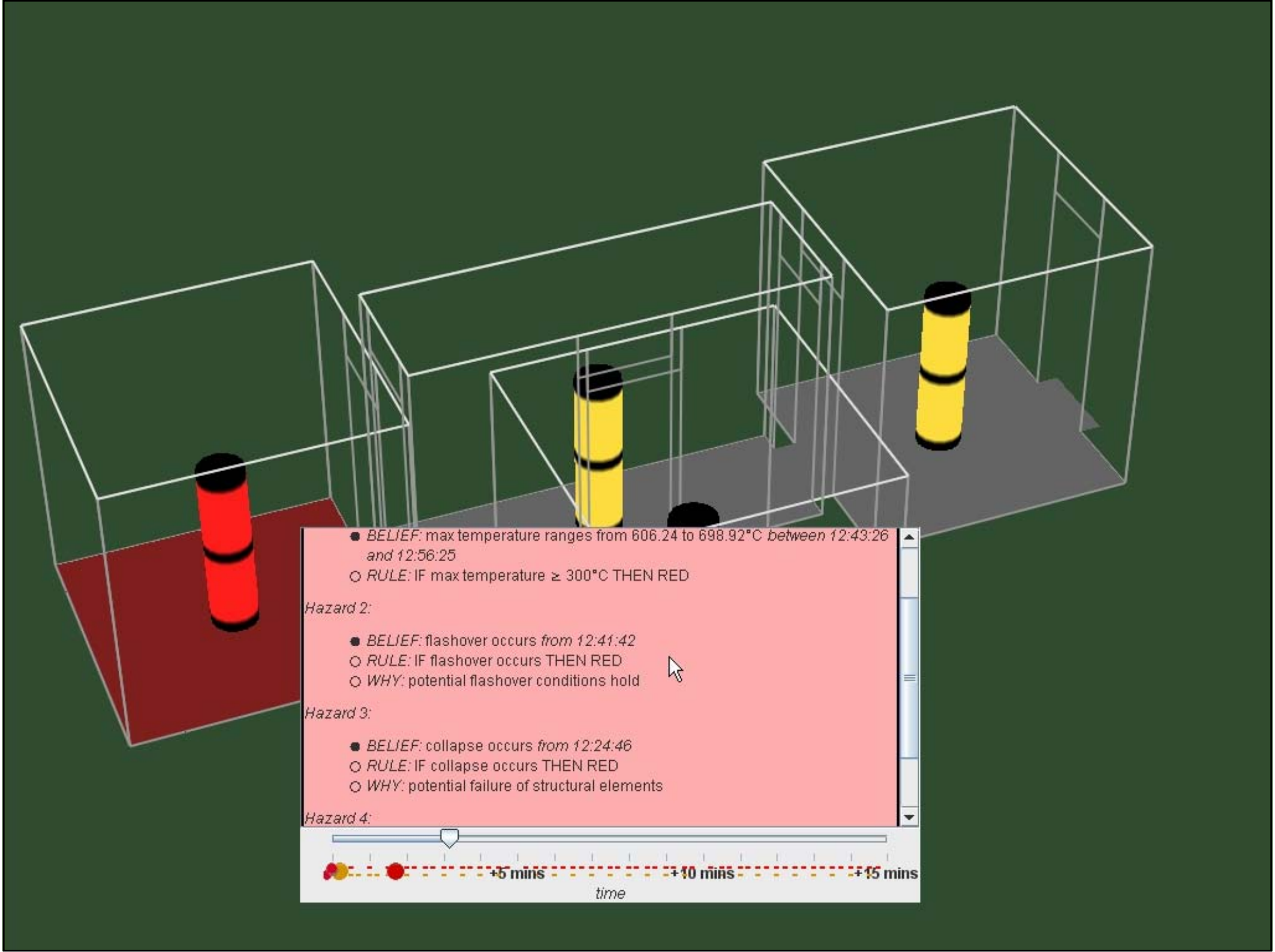

Camera2 - 29/10/2008 12:33:21


Room 1
Corridor (F
Room 3
2400mm
Truss and beam assembly
Room 2
Y
X
Key
Thermocouple tree
Gas sample point
Flow / Velocity
Wall T/C (In & Out)
Detection station
Camera

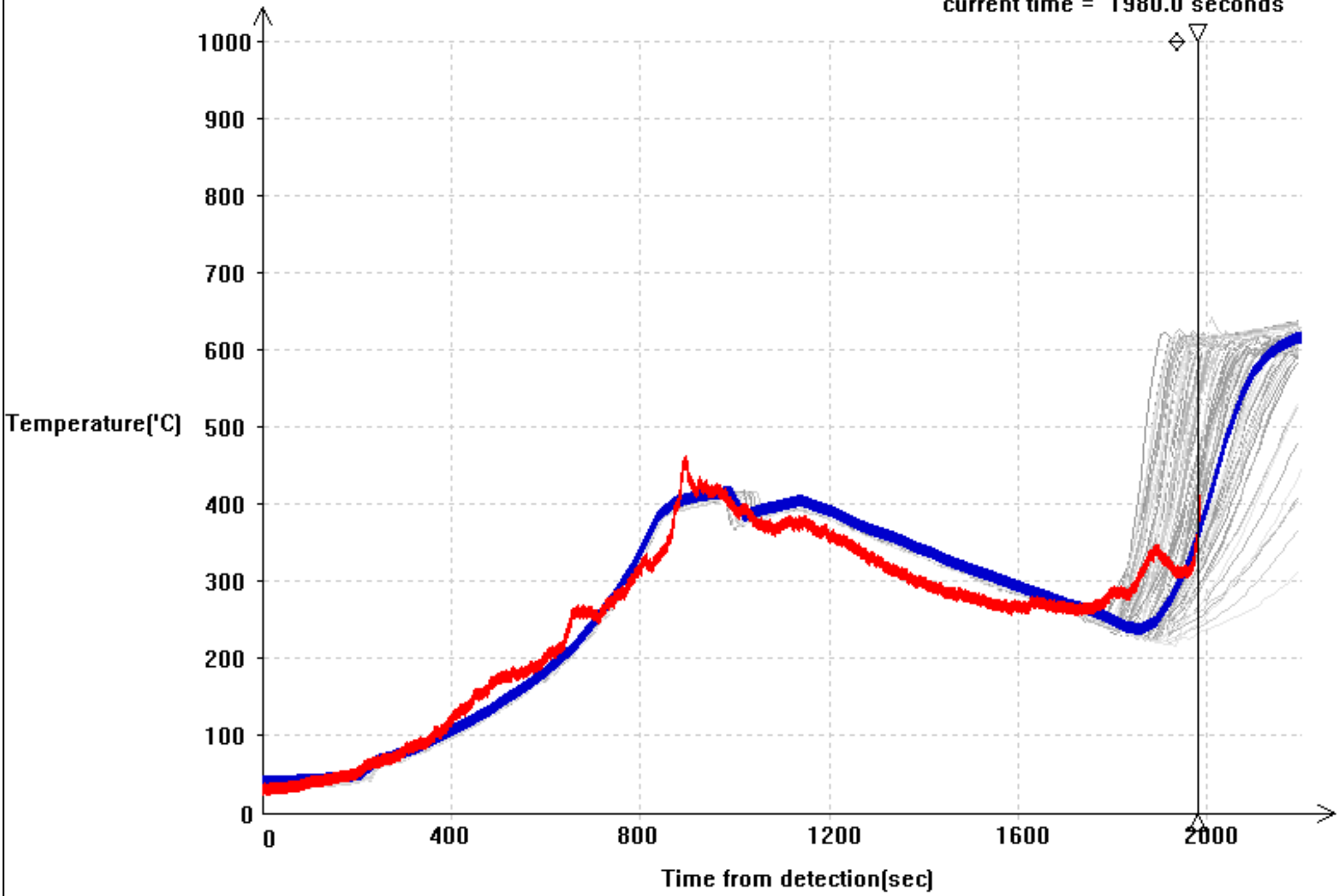

Camera4 - 29/10/2008 12:33:36

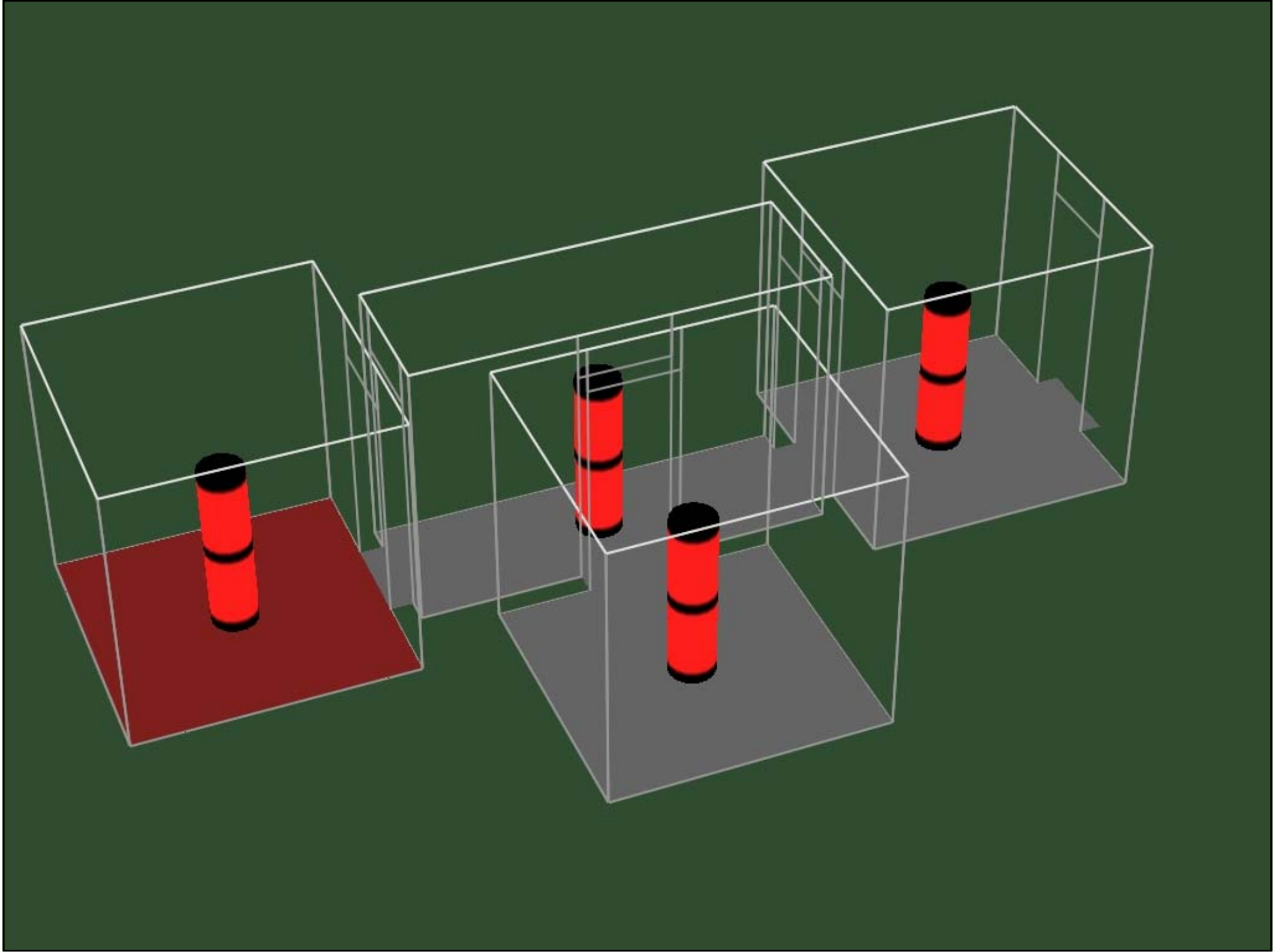



current time = 1890.0 seconds
1000
900
800
700
600
500
400
300
200
100
0
Temperature('C)
0
400
800
1200
1600
2000
Time from detection(sec)


● BELIEF: max temperature ranges from 606.24 to 698.92°C between 12:43:26 and 12:56:25
○ RULE: IF max temperature ≥ 300°C THEN RED
Hazard 2:
● BELIEF: flashover occurs from 12:41:42
○ RULE: IF flashover occurs THEN RED
○ WHY: potential flashover conditions hold
Hazard 3:
● BELIEF: collapse occurs from 12:24:46
○ RULE: IF collapse occurs THEN RED
○ WHY: potential failure of structural elements
Hazard 4:
+5 mins
+10 mins
+15 mins
time

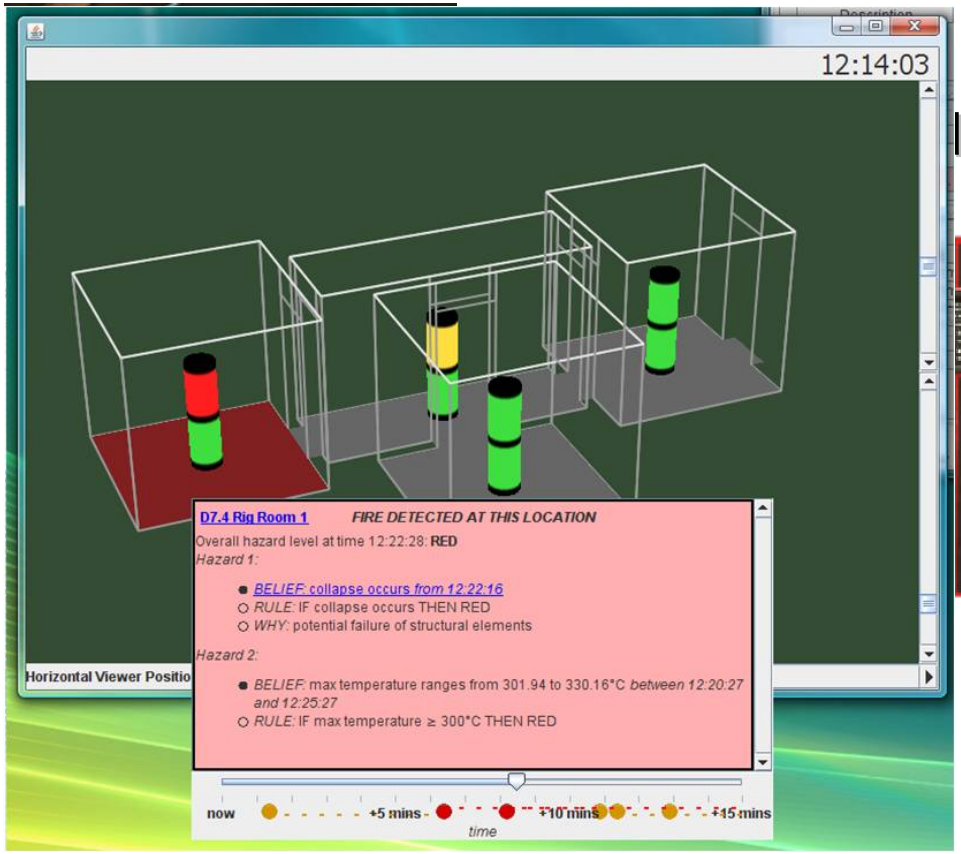

Camera4 - 29/10/2008 12:42:00


current time = 1980.0 seconds
1000
900
800
700
600
500
400
300
200
100
0
Temperature('C)
0
400
800
1200
1600
2000
Time from detection(sec)



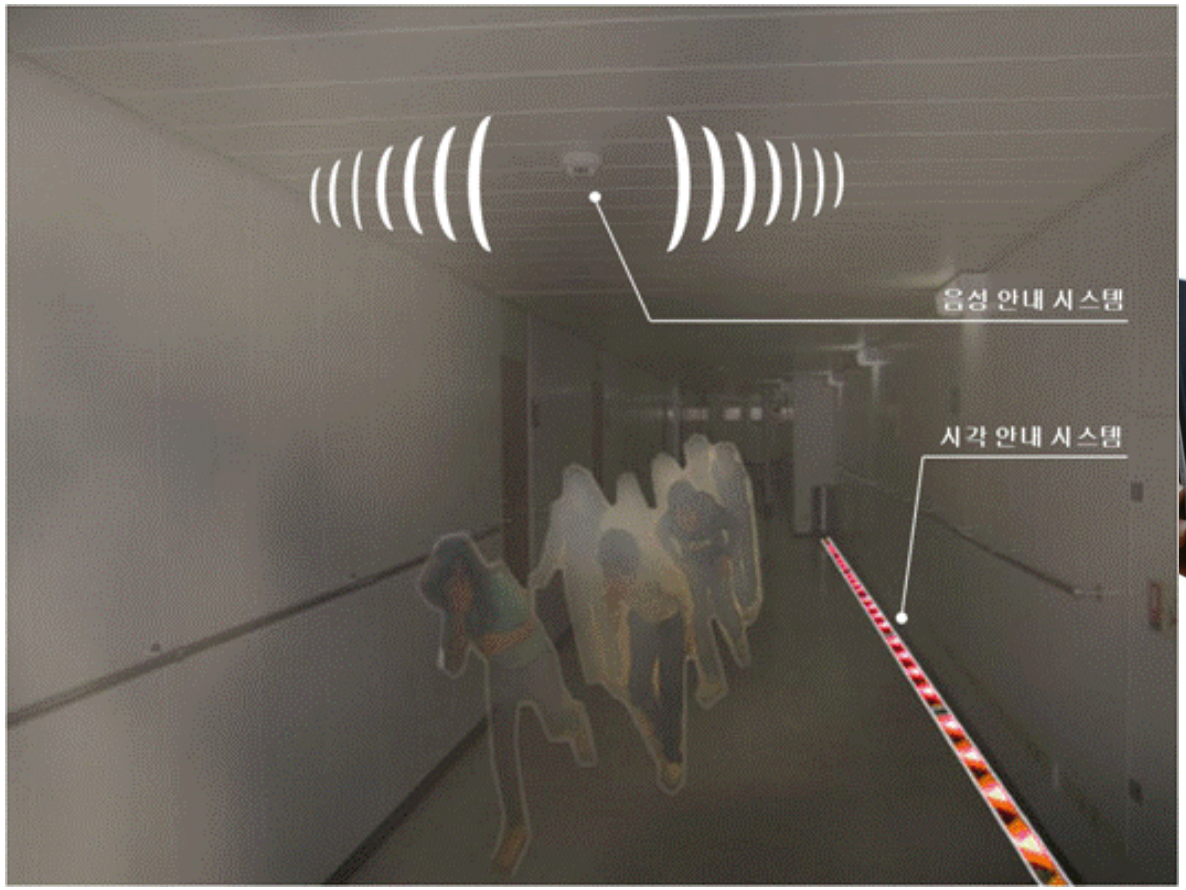
Applications

Emergency information device



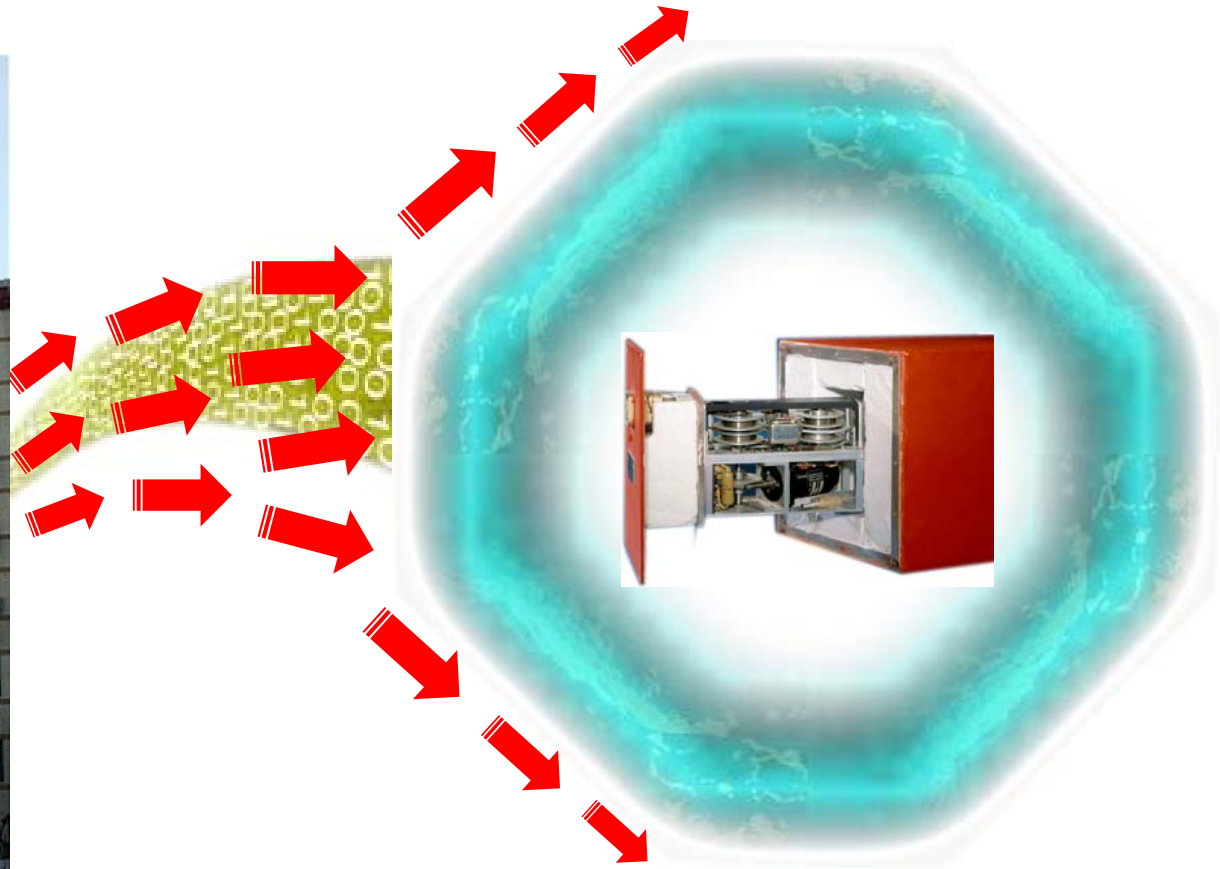
Applications

Egress guide system



Applications

Red box




Thank you!
S.Koo@ed.ac.uk