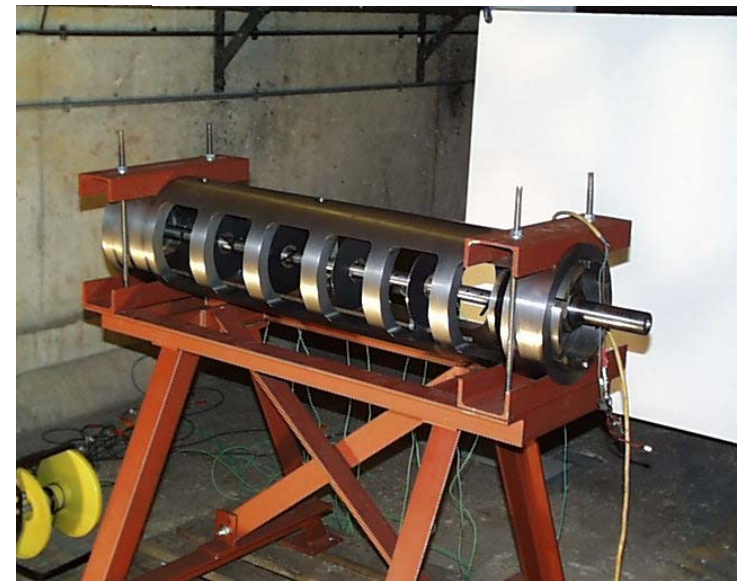
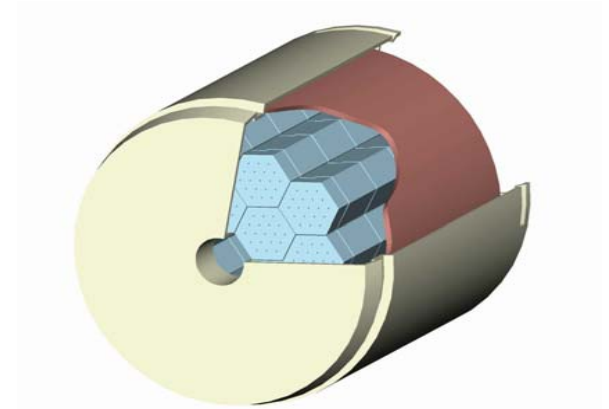


## Modelling the Ignition of Modular Charges

Clive Woodley & Steve Fuller

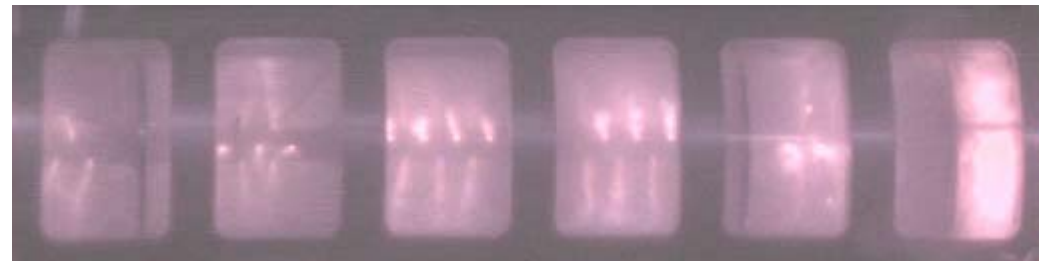
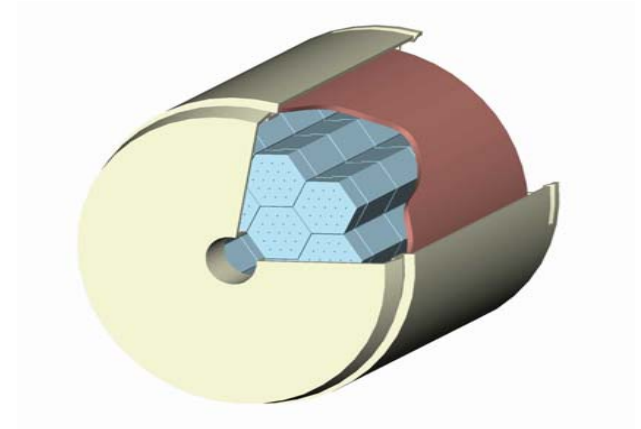
A presentation to: 42<sup>nd</sup> Guns & Missiles Conference

April 2007

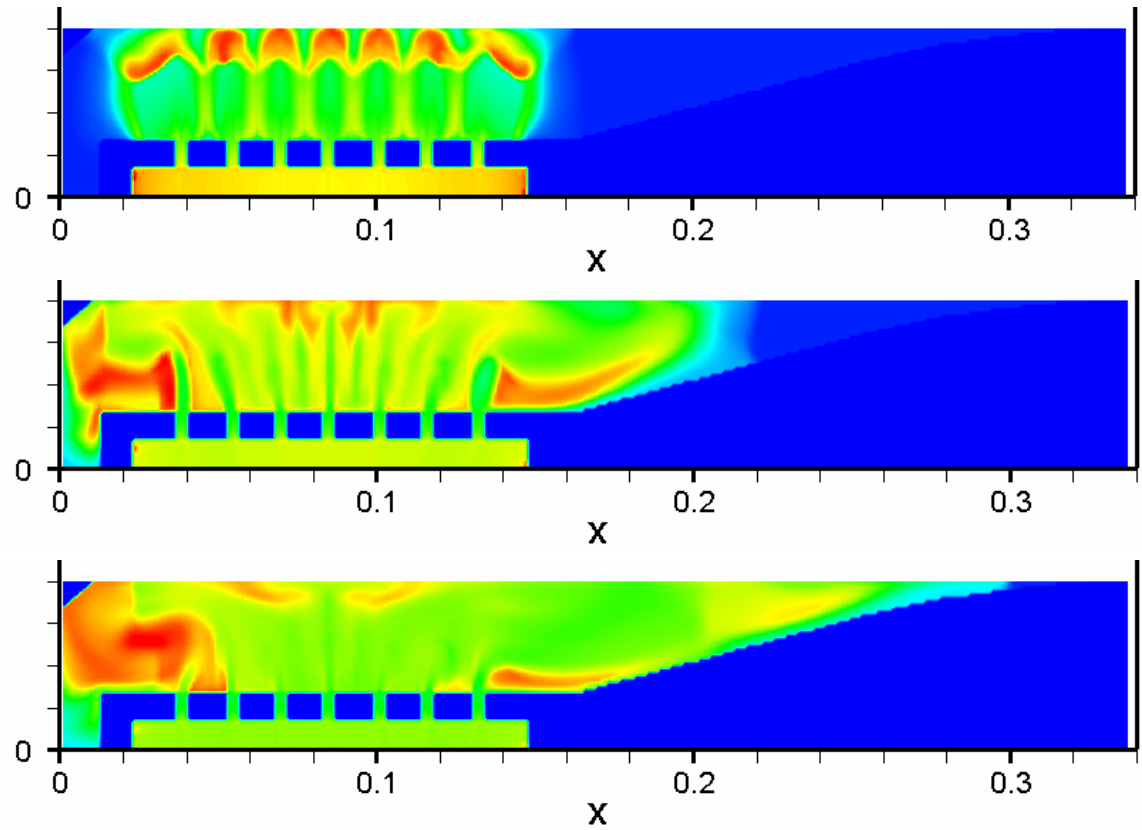


# Contents

- 01 Background
- 02 Validation
- 03 Simulations
- 04 Conclusions & future work

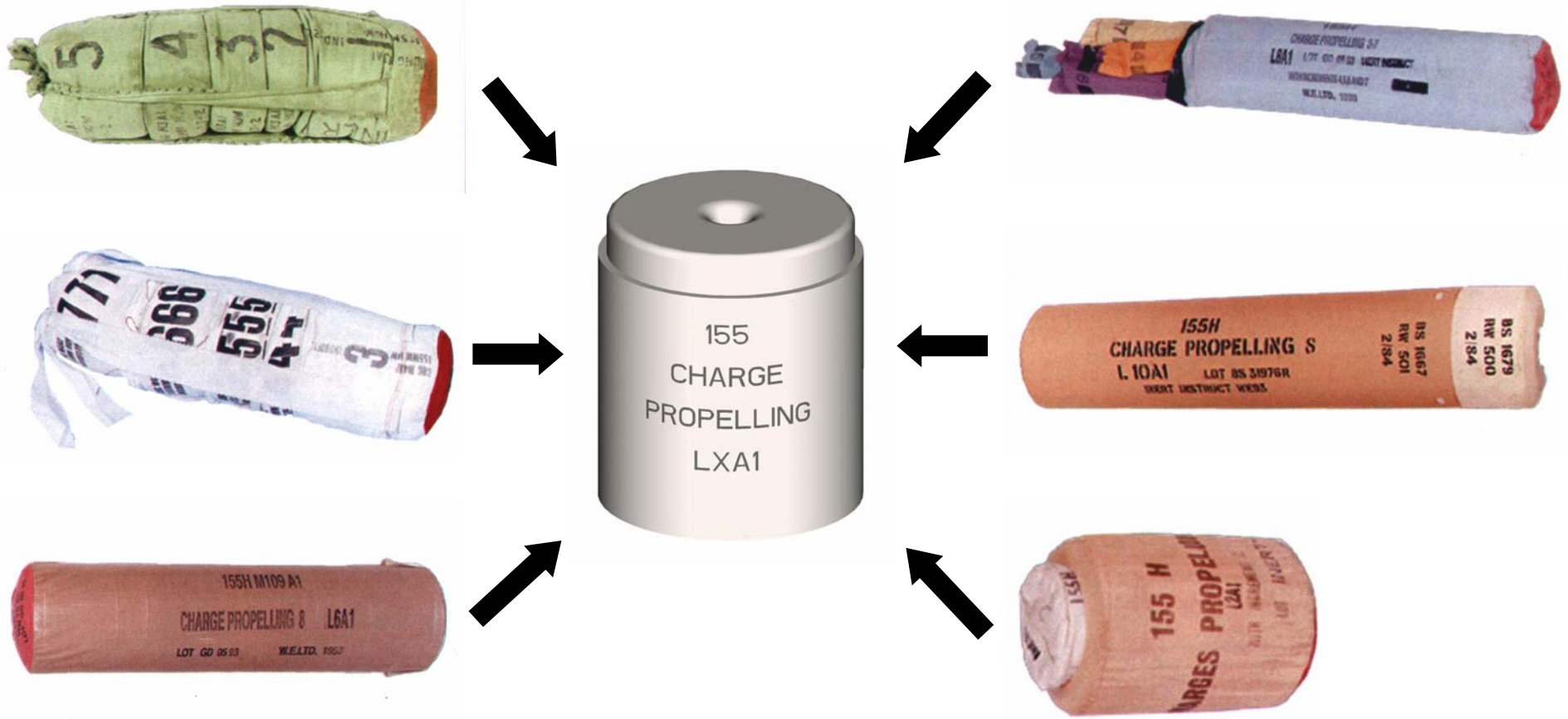


# 01 Background



# 01 Charge design – why UPCS?

Existing inventory replaced with 1 module



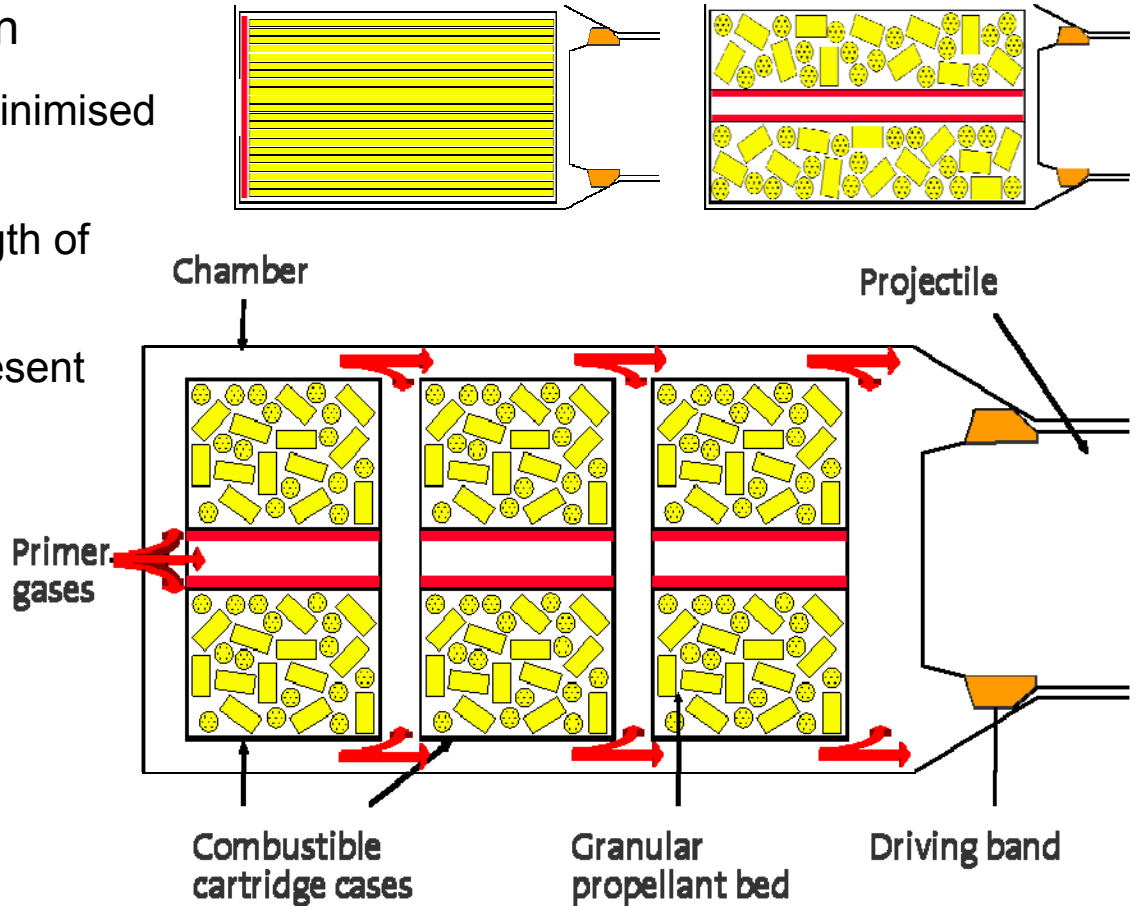
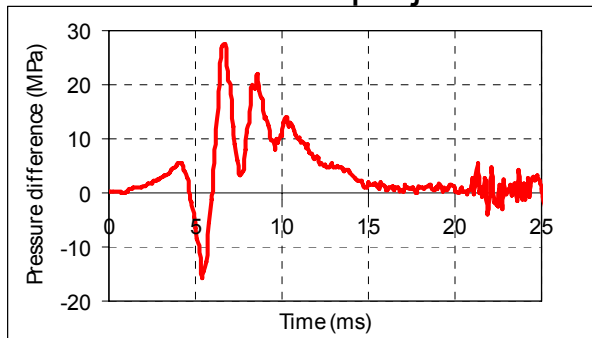
## 01 Charge design – advantages of UPCS

- Current charges
  - Not fully IM compliant
  - Not cleared for A1/C2 climatic conditions
  - Wasteful – decremental system
  - Costly & L10 can't routinely be used for training
  - Often remain in WMR until they 'life out'
- With UPCS
  - Same charges are used in training as are deployed for war fighting
  - Training simplified/more realistic
  - Substantial cost savings can be achieved through incremental system
  - Logistic burden reduced
  - Autoloader compatible

# 01 Modular charges – the problem being addressed

Safety & performance are important requirements – linked to ignition

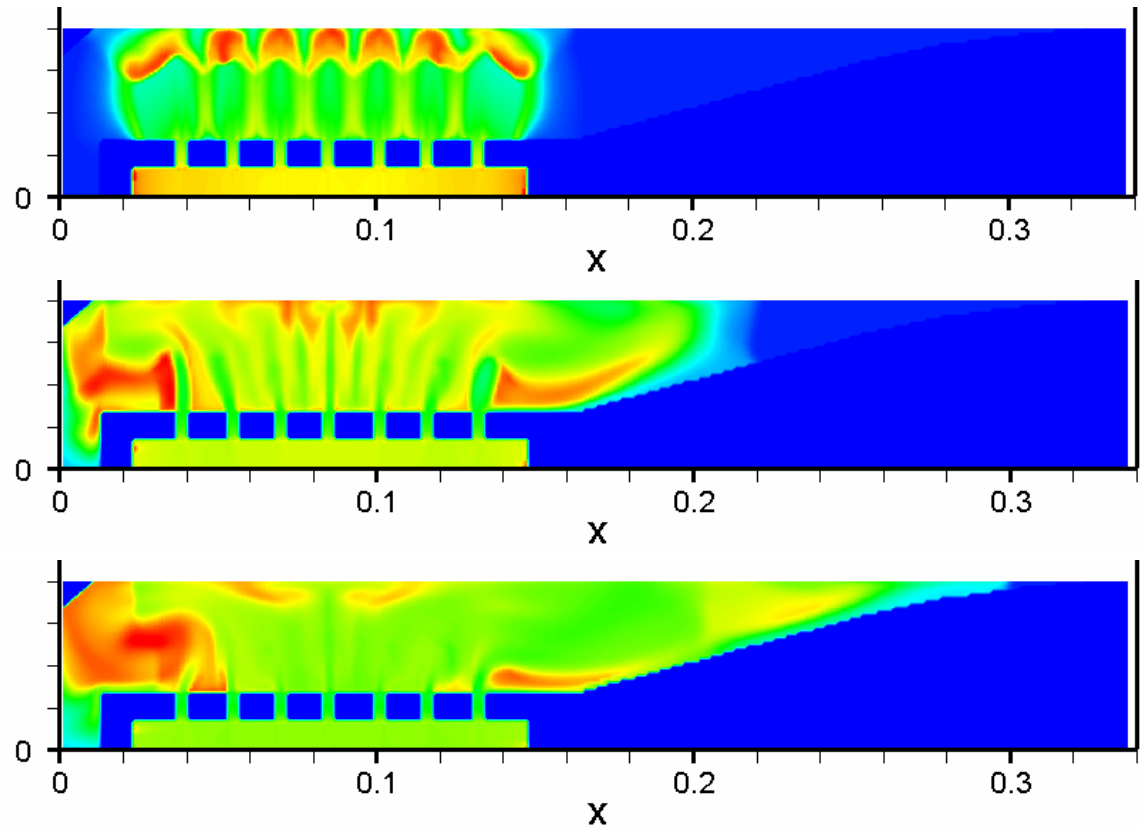
- Pressure waves eliminated or minimised and consistent
- Simultaneous ignition along length of charge
- Combustible cartridge cases present barrier to flamespread along the propellant bed
- Modules act as projectiles!



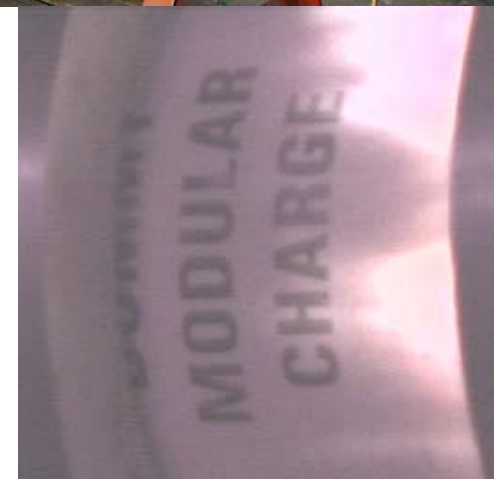
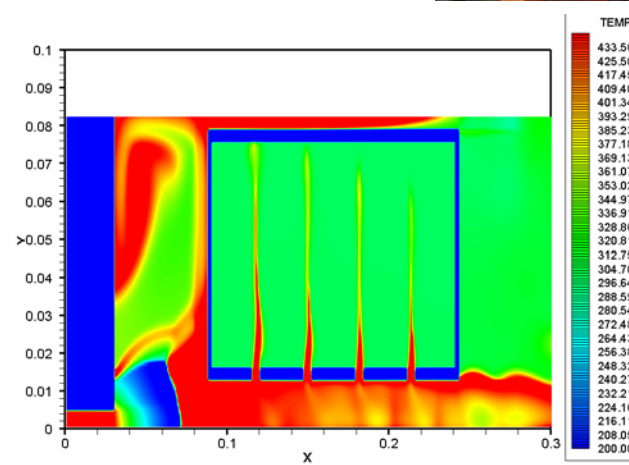
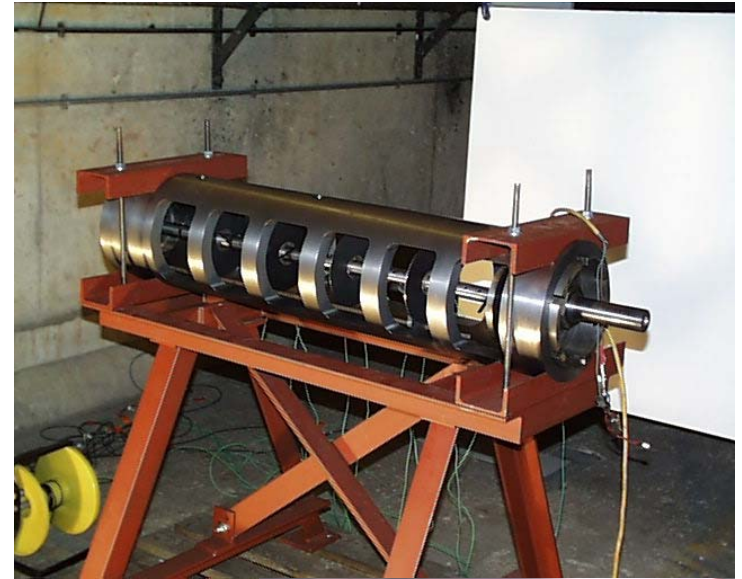
## 01 Modelling approach - QIMIBS

### 2D mortar code

- Developed initially with MOD funding
- Developed further using QinetiQ funding
- Details presented at 22<sup>nd</sup> International Symposium on Ballistics
- Ability to represent internal solid boundaries

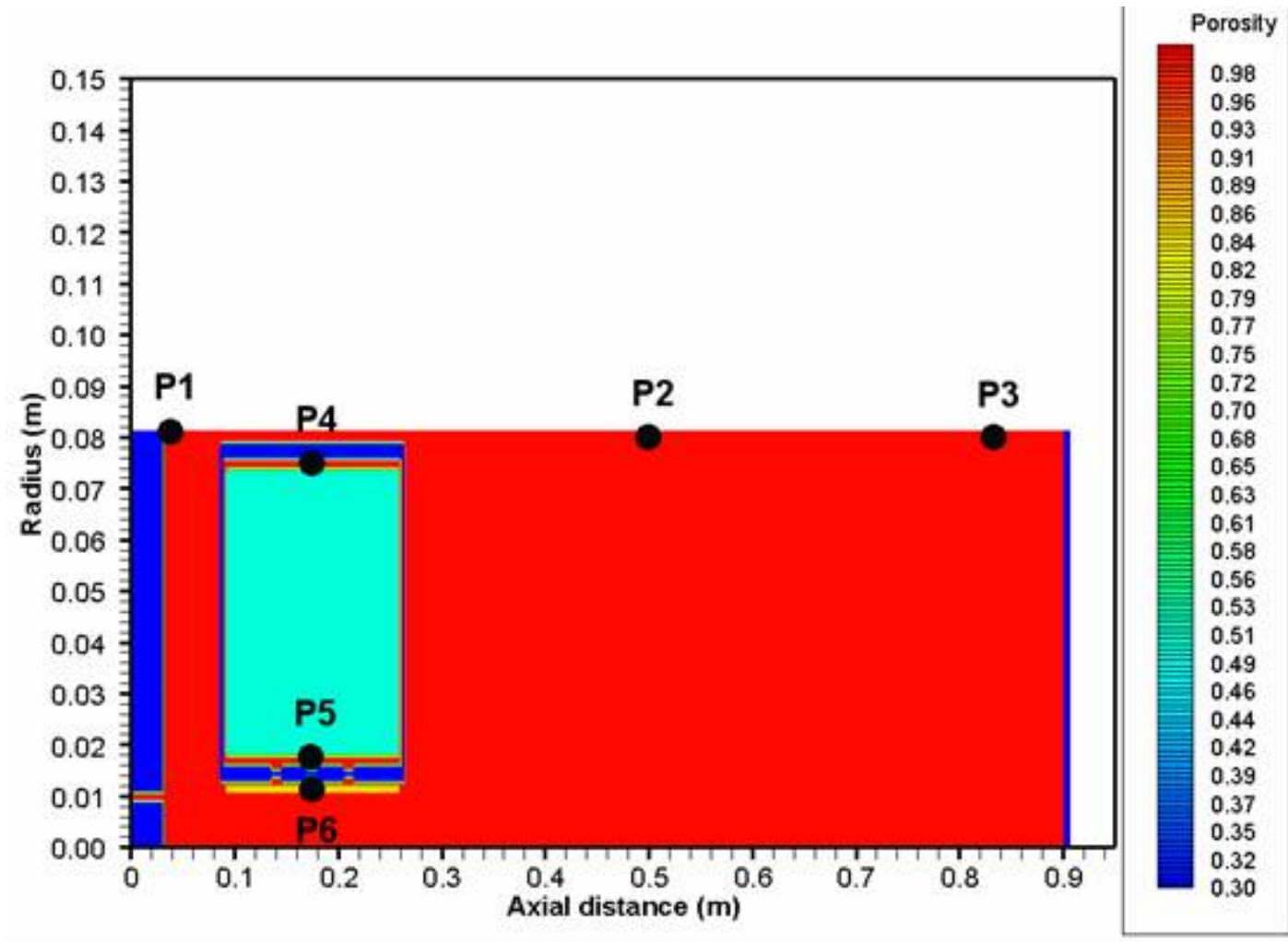


## 02 Validation

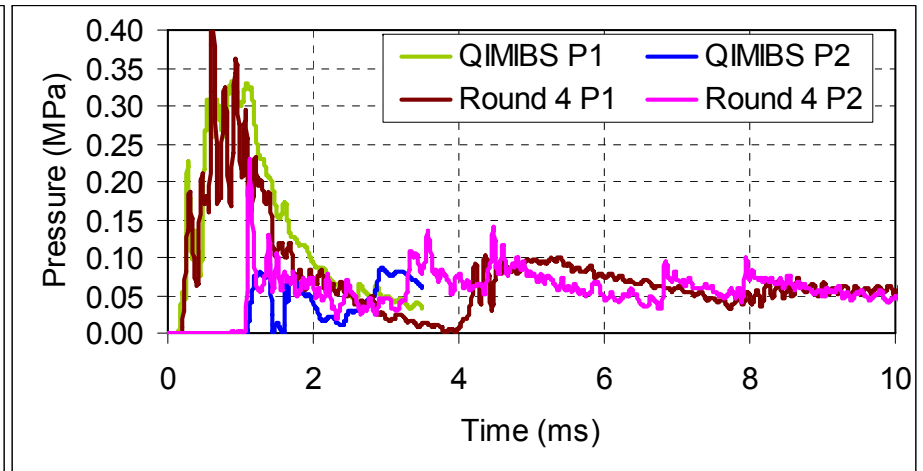
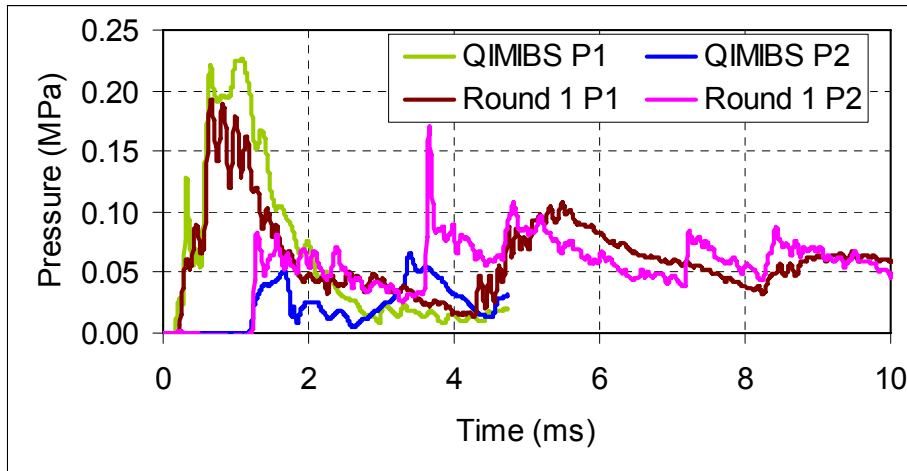




## 02 Primer only – single module – initial geometry



## 02 Primer only – single module



1.43g black powder

Max velocity measured: 1.5m/s

Max velocity predicted: 3.2m/s

1.25g NC

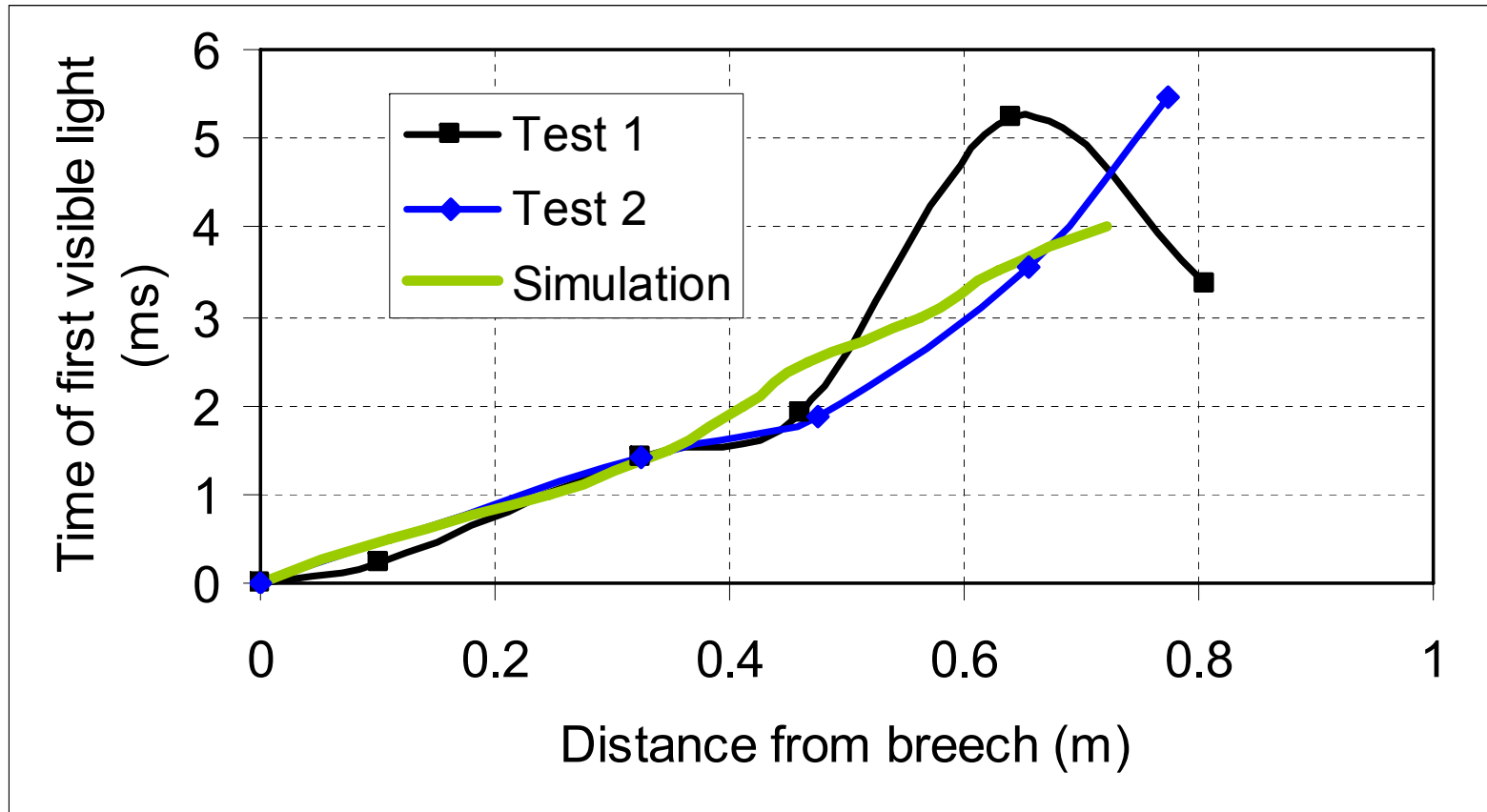
Max velocity measured: 2.0m/s

Max velocity predicted: 5.0m/s

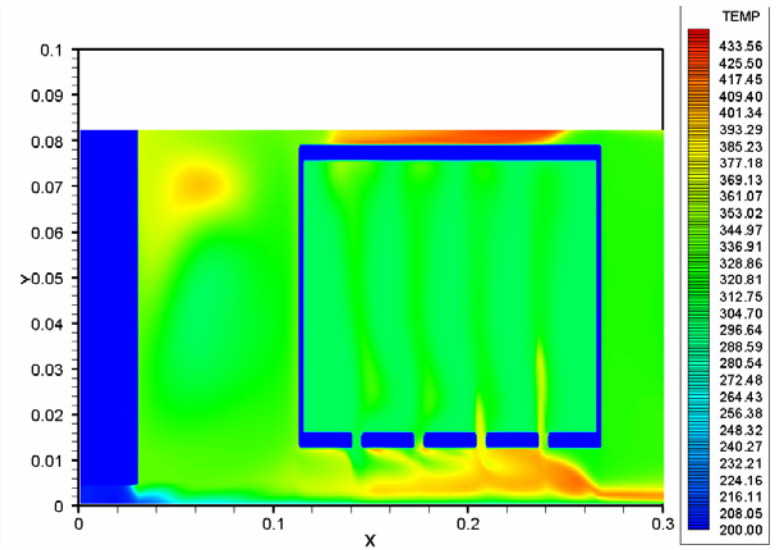
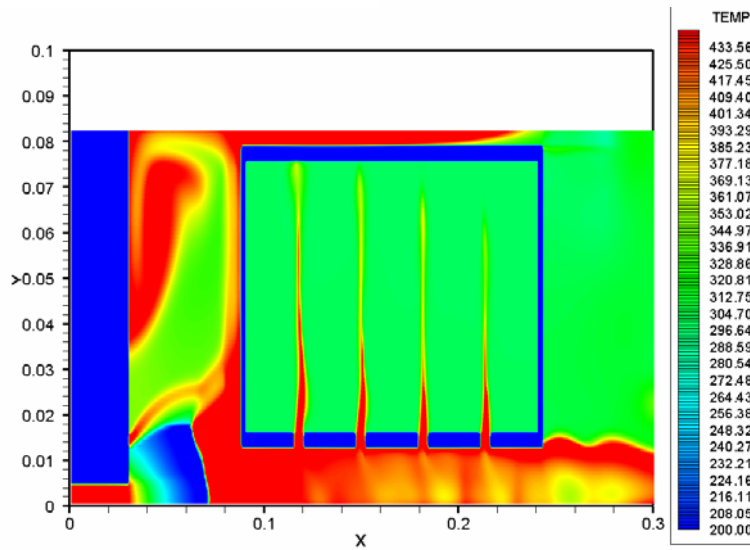
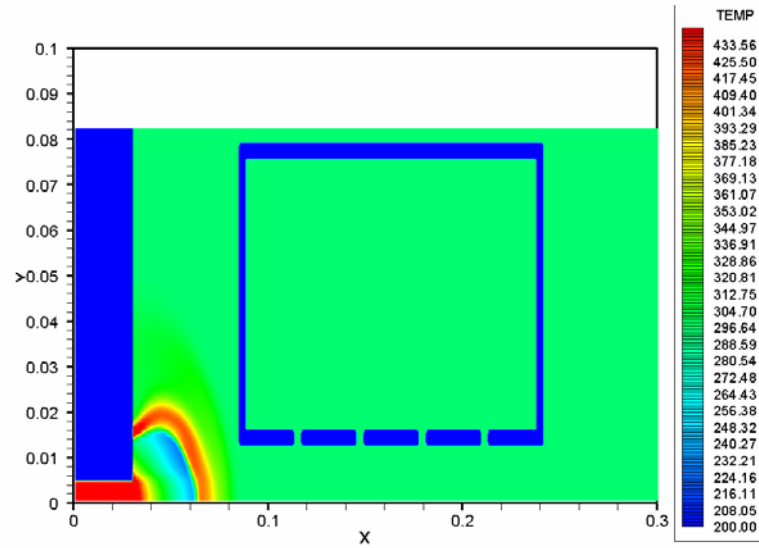
**Correct trend predicted for pressure and module velocity**

**Module velocities overpredicted but no account taken of sliding resistance**

## 02 5 modules - flamespread

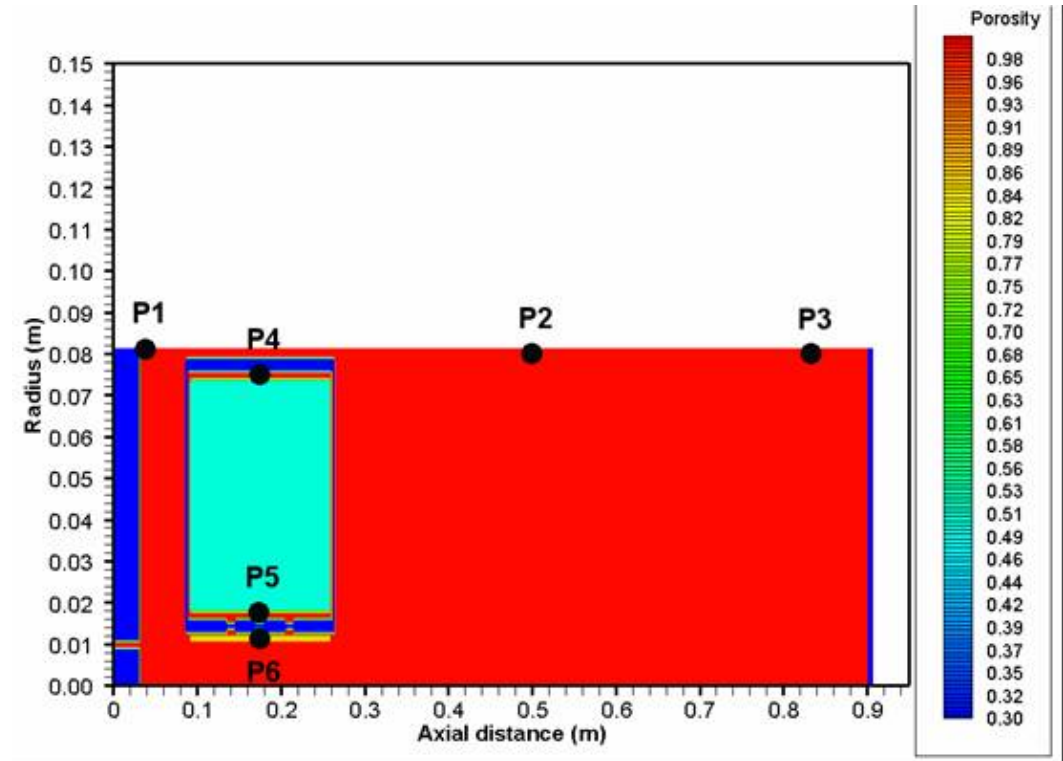


# 03 Simulations



## 03 Simulations

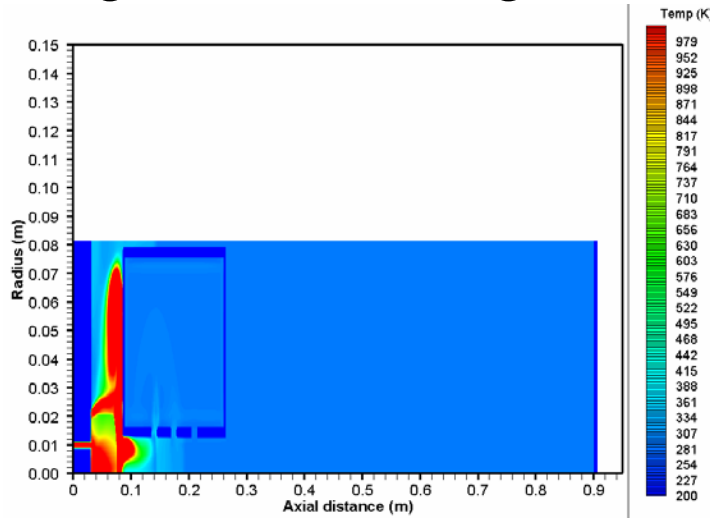
- Single module
  - Igniter mass & location
  - Flash tube diameter & vent hole size



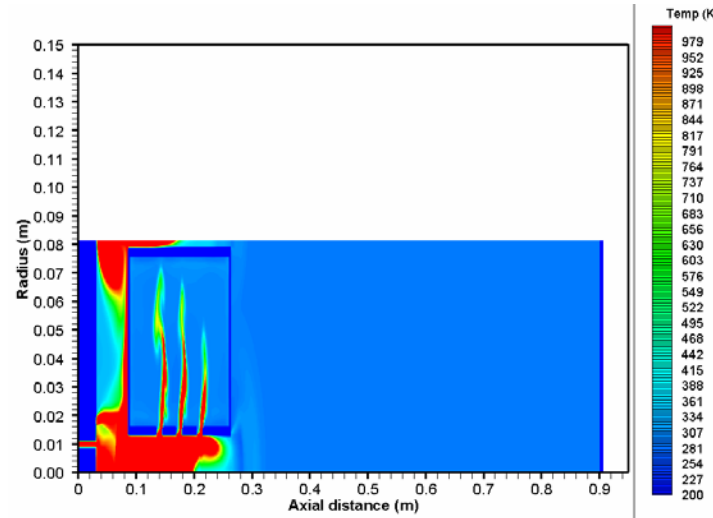
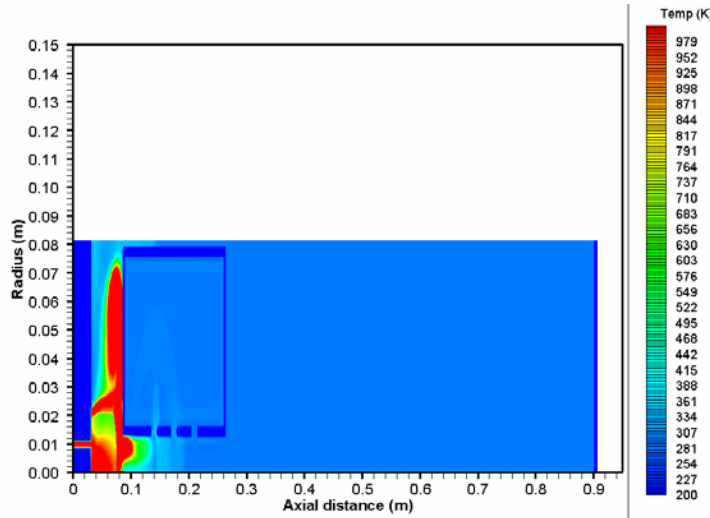
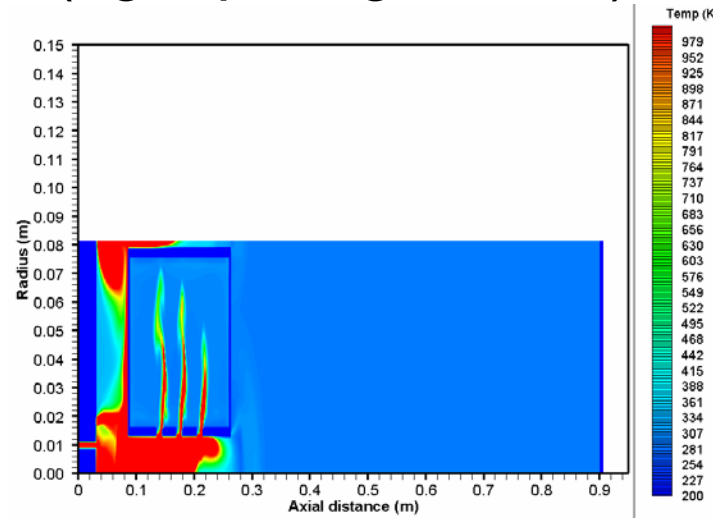
- Three modules
- Five modules

# 03 Single module – igniter mass (5g top, 15g bottom)

0.5ms

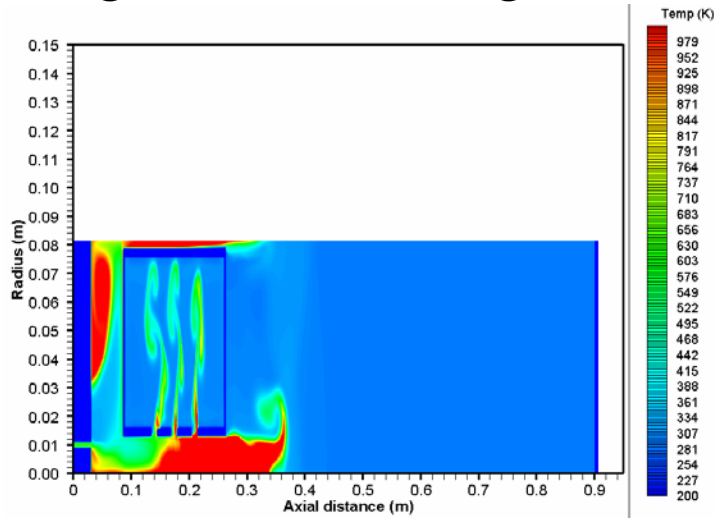


1.0ms

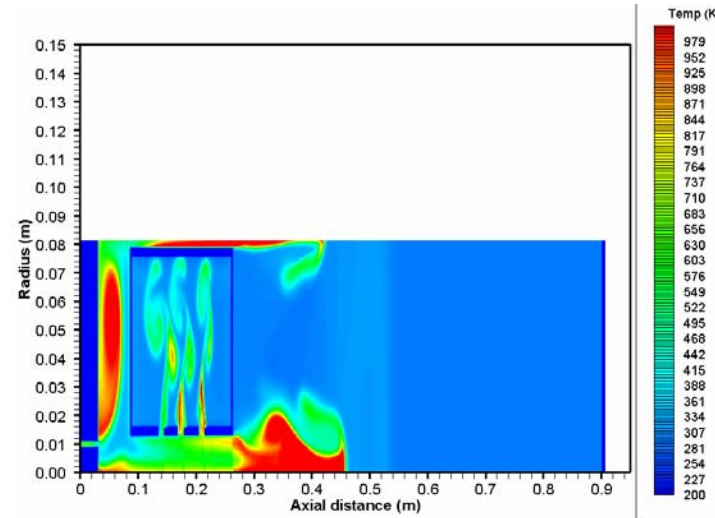
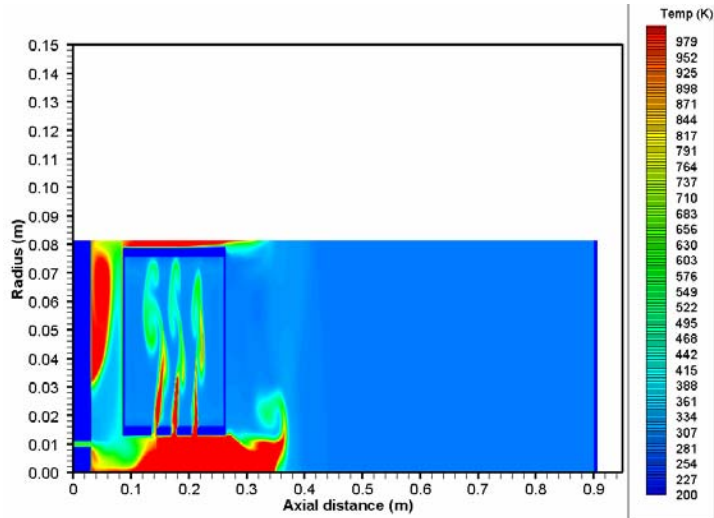
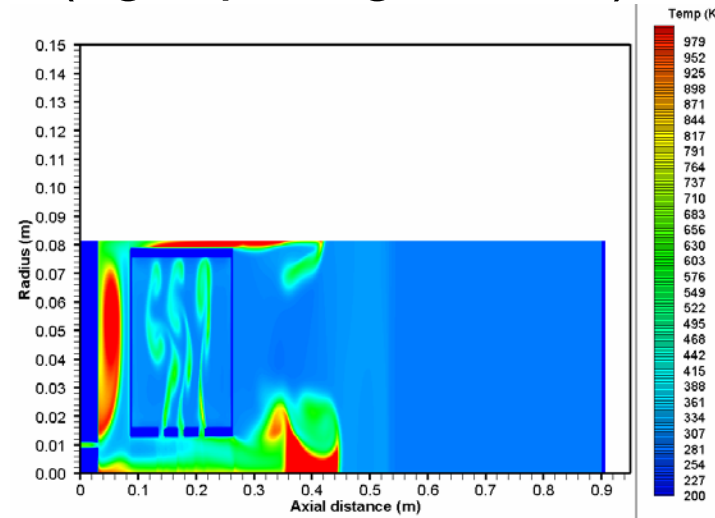


# 03 Single module – igniter mass (5g top, 15g bottom)

1.5ms

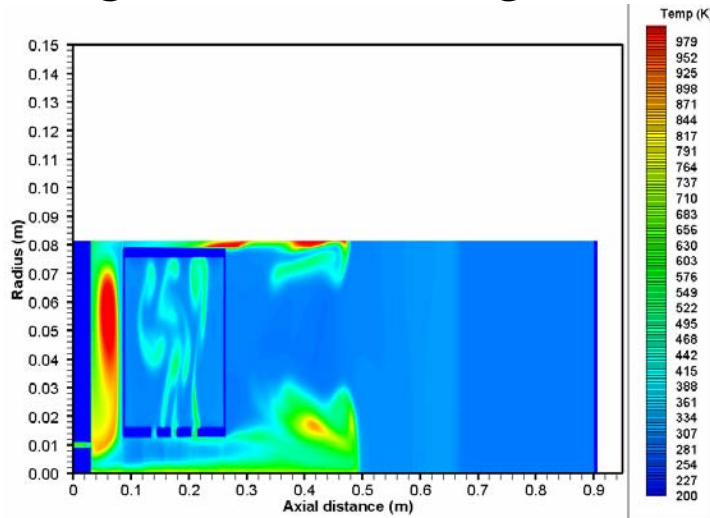


2.0ms

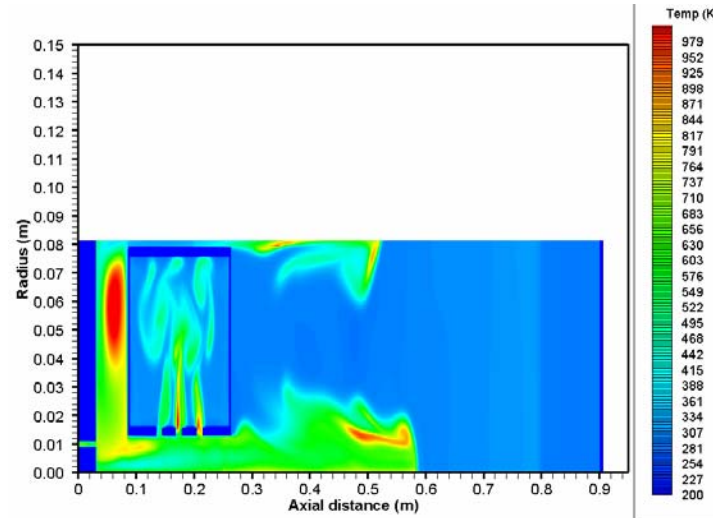
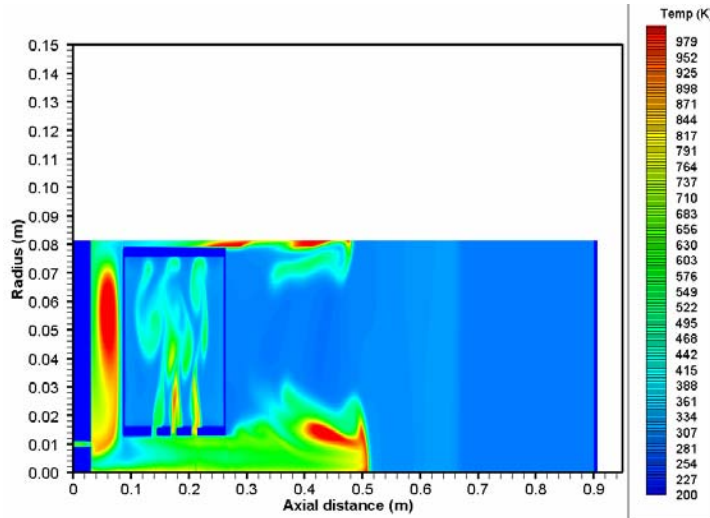
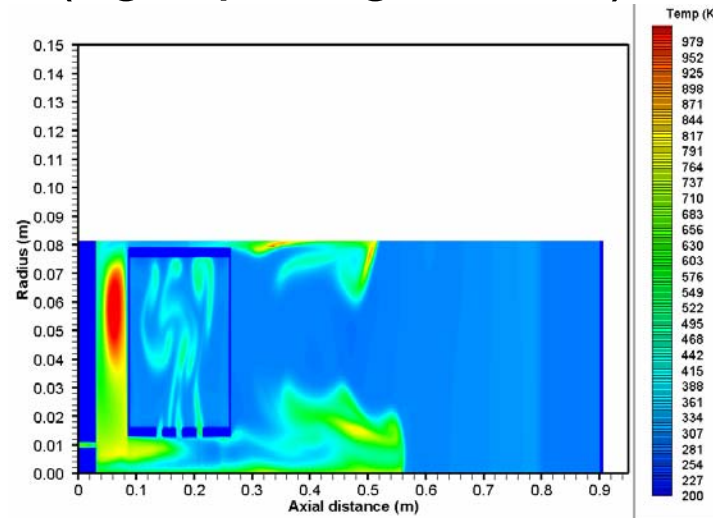


# 03 Single module – igniter mass (5g top, 15g bottom)

2.5ms



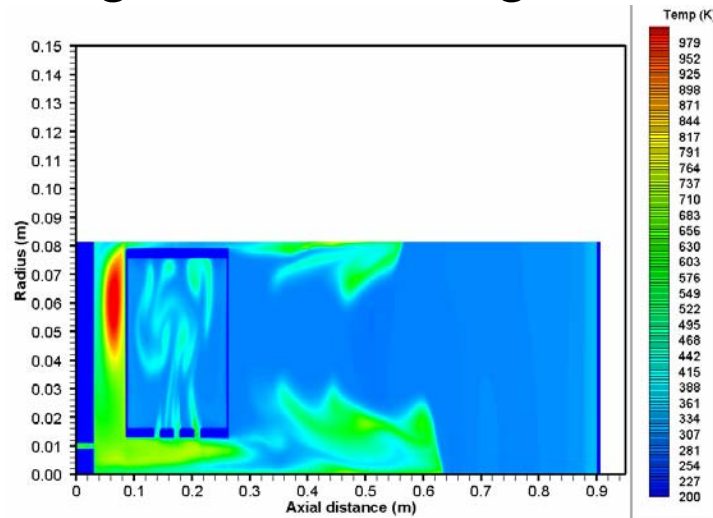
3.0ms



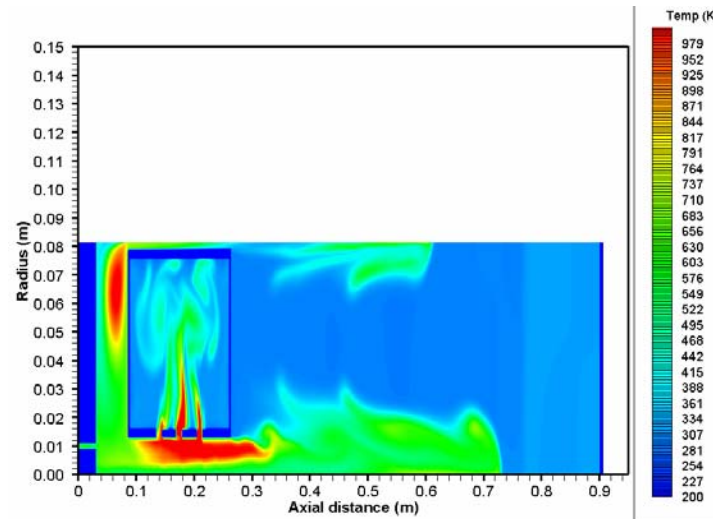
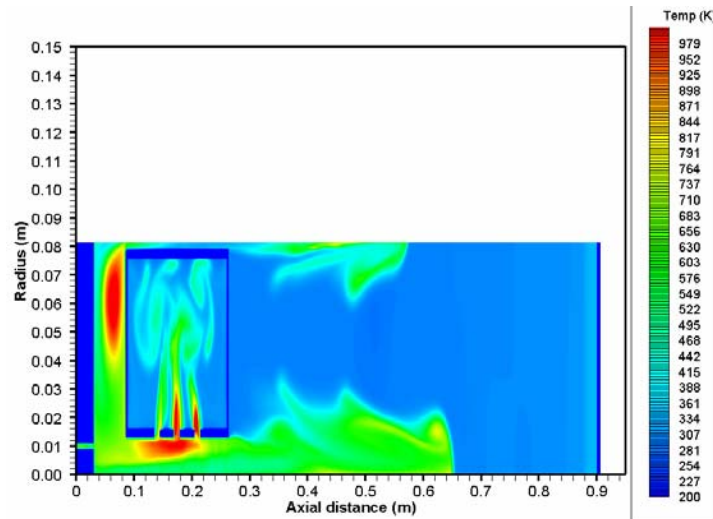
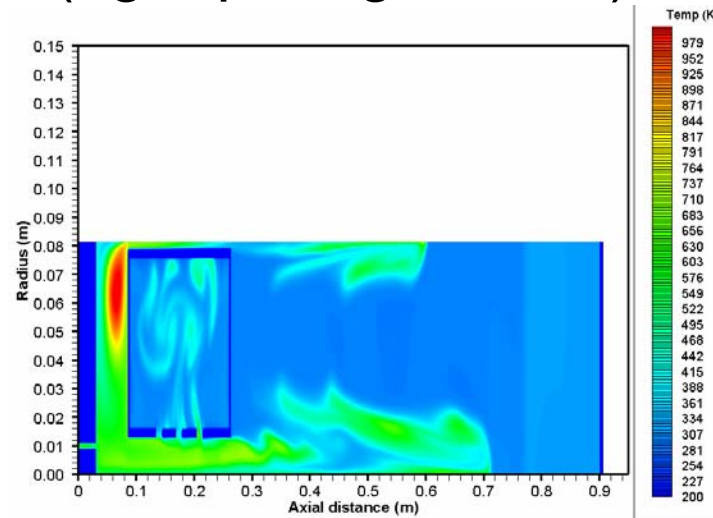


# 03 Single module – igniter mass (5g top, 15g bottom)

3.5ms

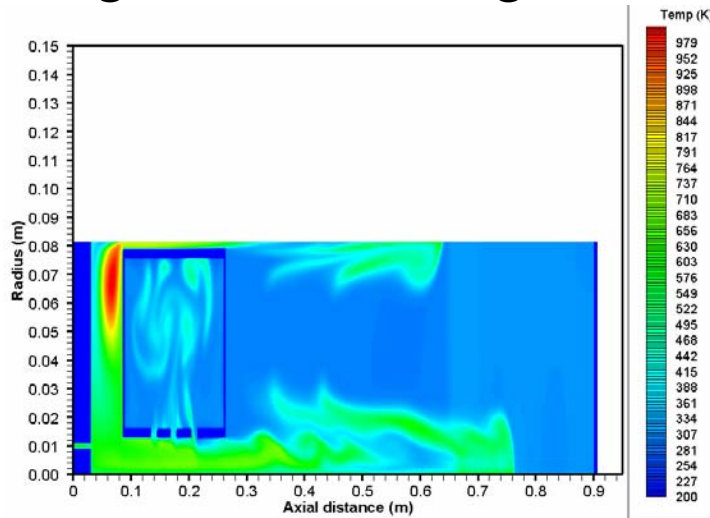


4.0ms

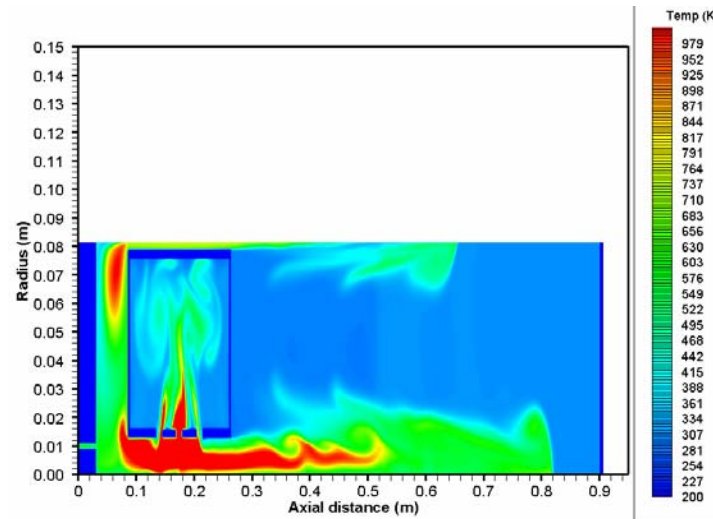
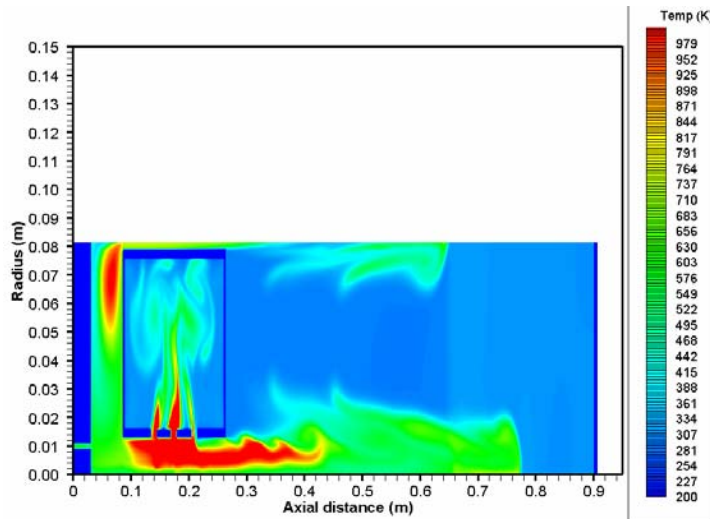
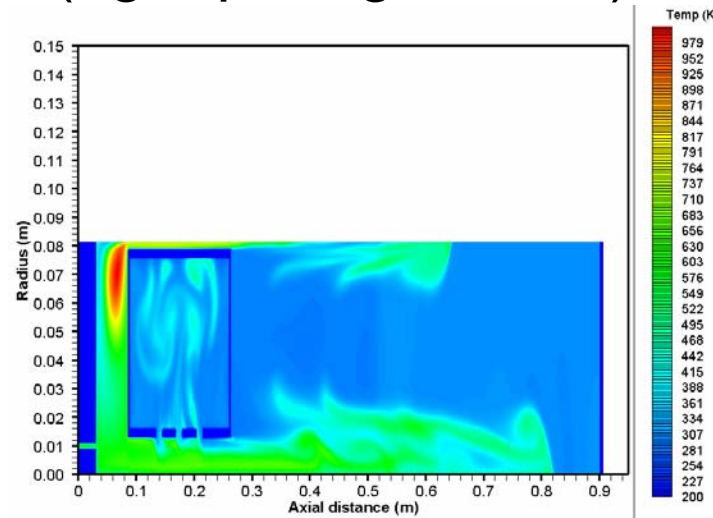


# 03 Single module – igniter mass (5g top, 15g bottom)

4.5ms

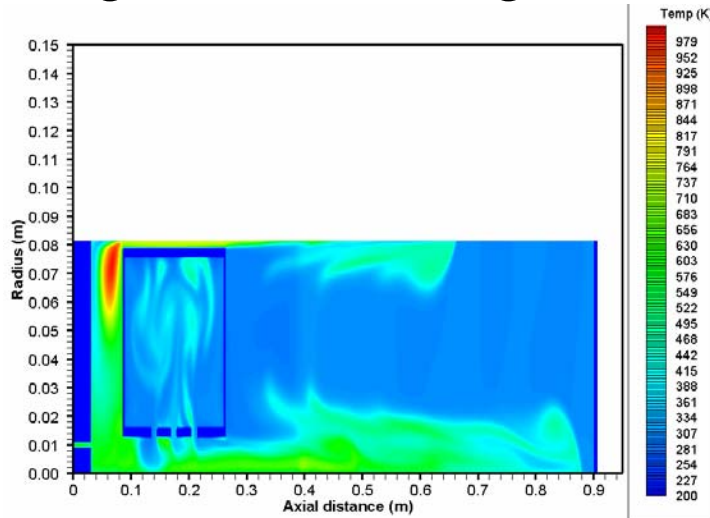


5.0ms

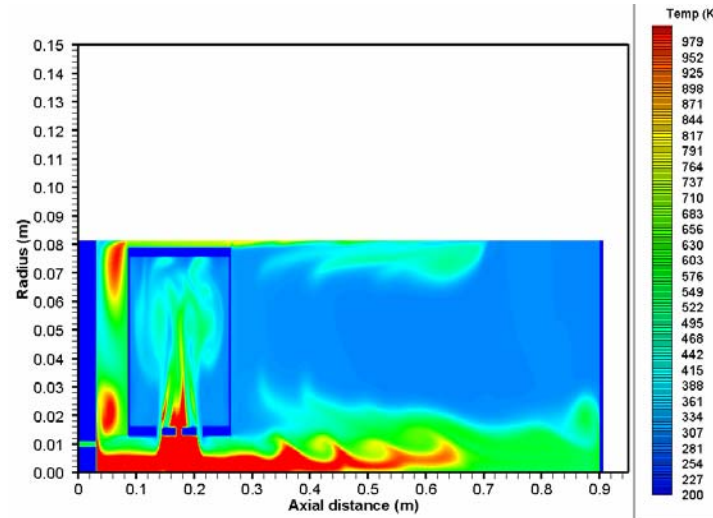
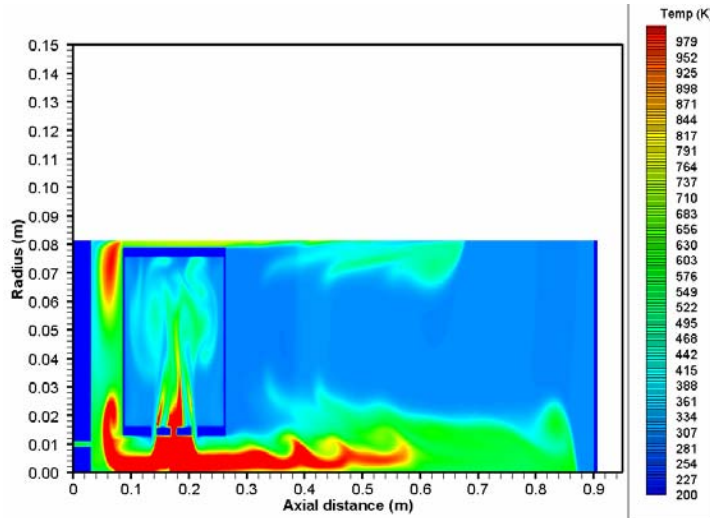
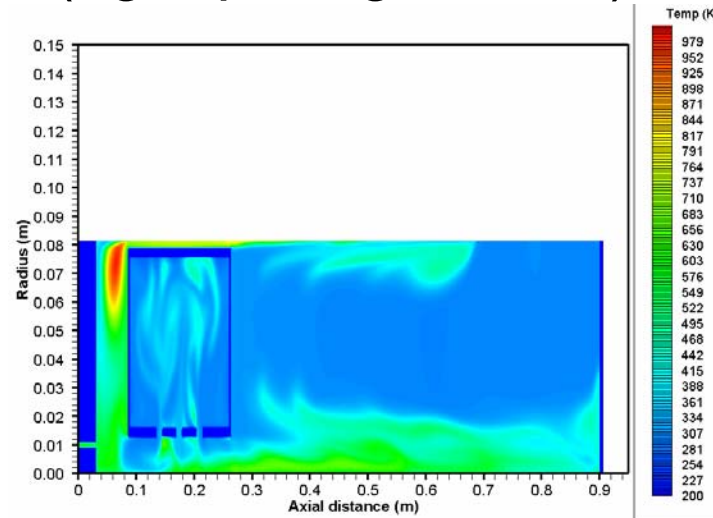


# 03 Single module – igniter mass (5g top, 15g bottom)

5.5ms

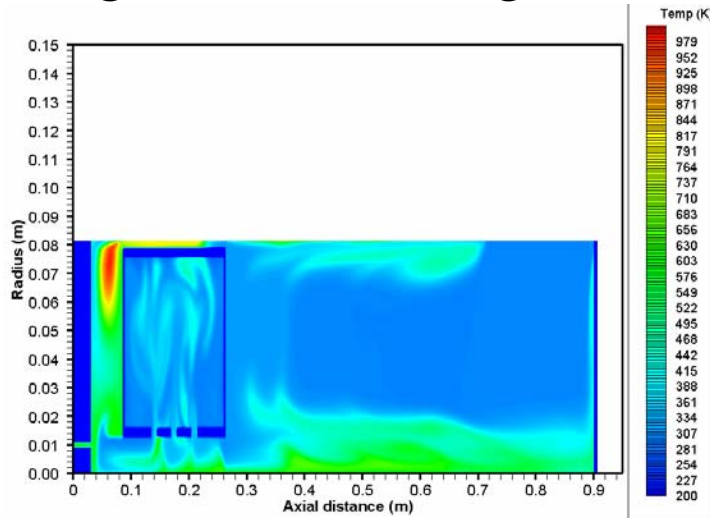


6.0ms

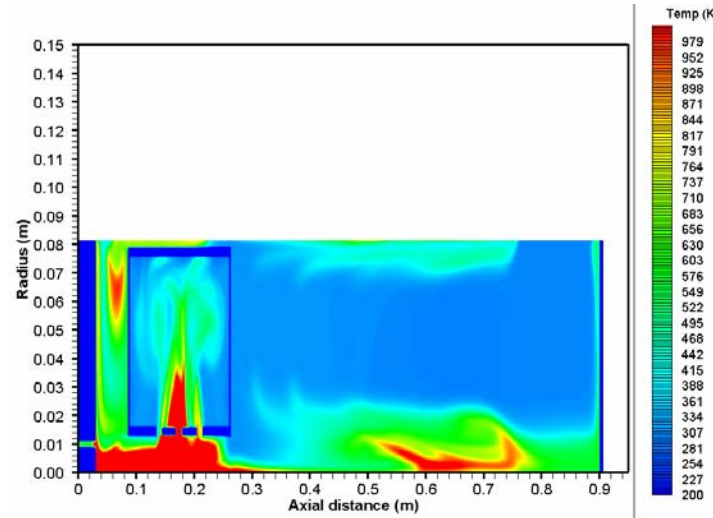
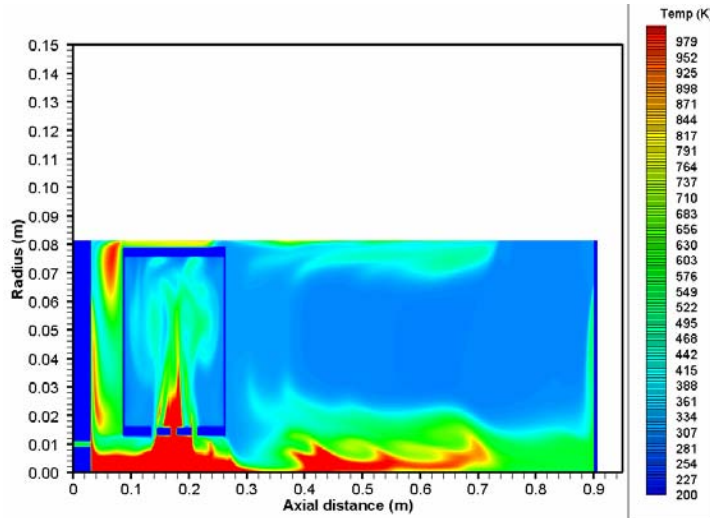
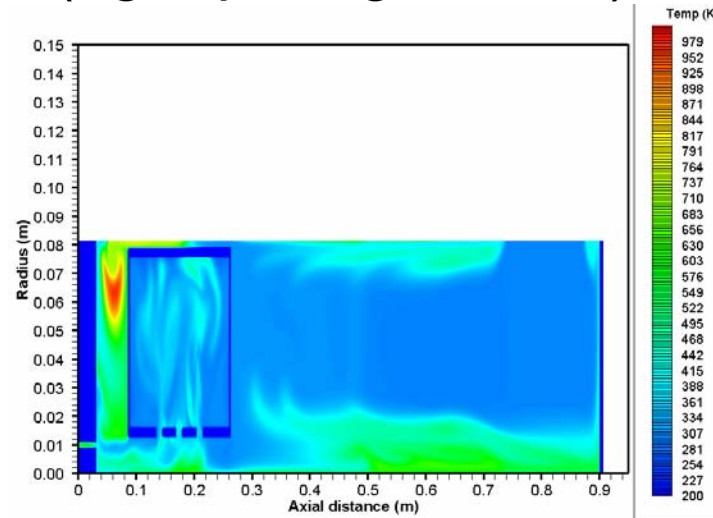


# 03 Single module – igniter mass (5g top, 15g bottom)

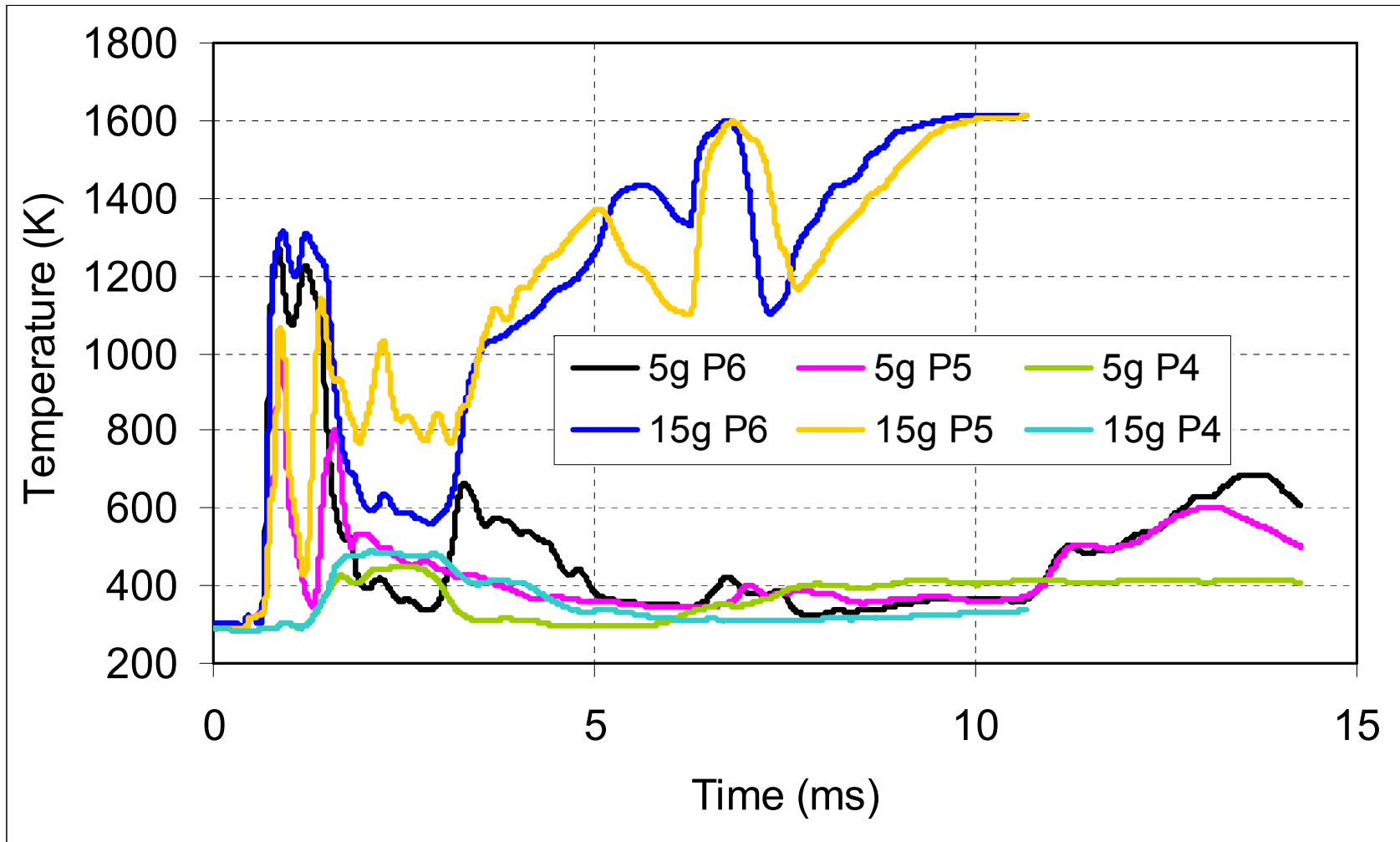
6.5ms



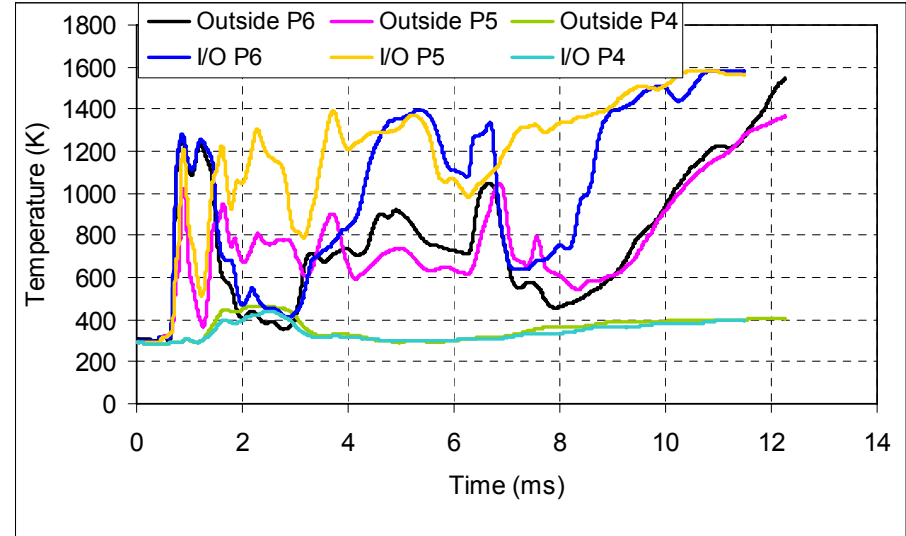
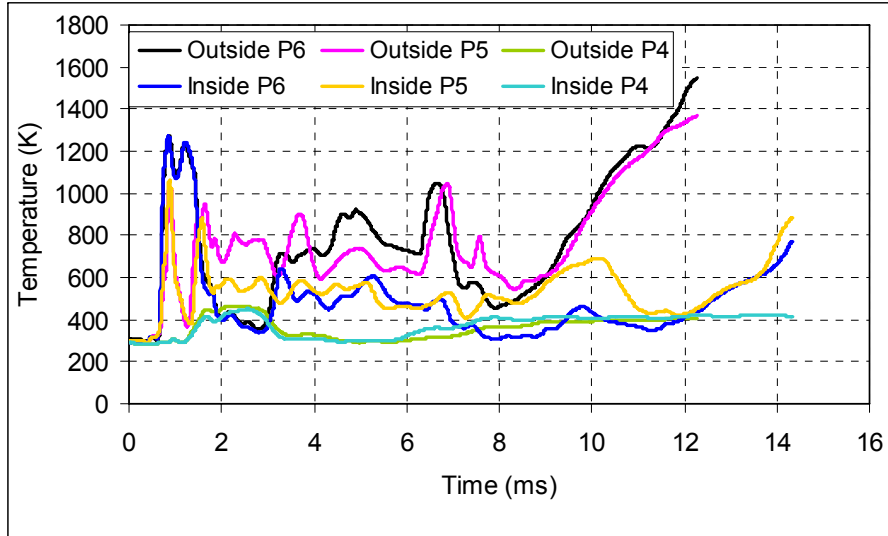
7.0ms



### 03 Single module – igniter mass



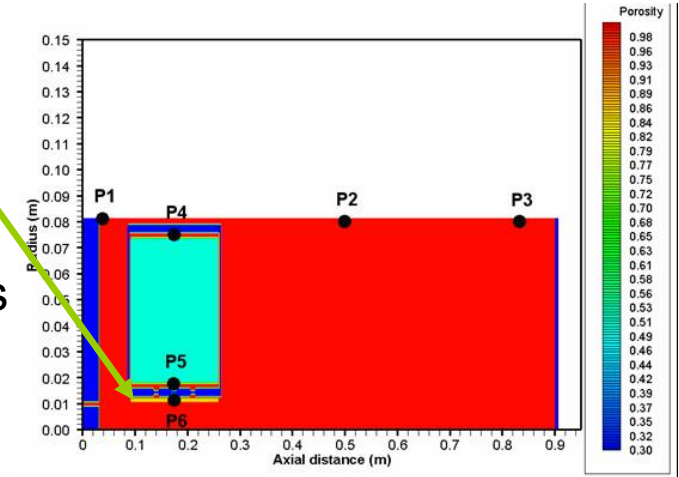
# 03 Single module – effect of igniter position



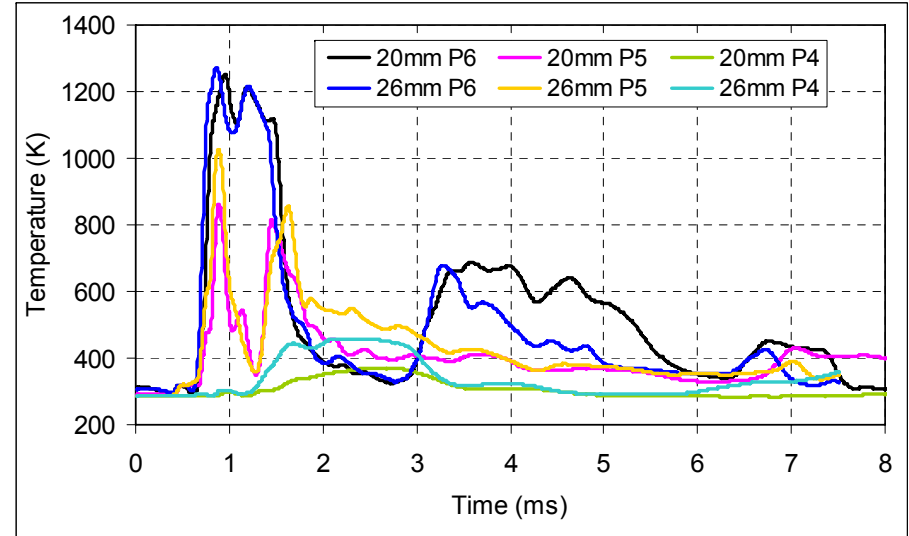
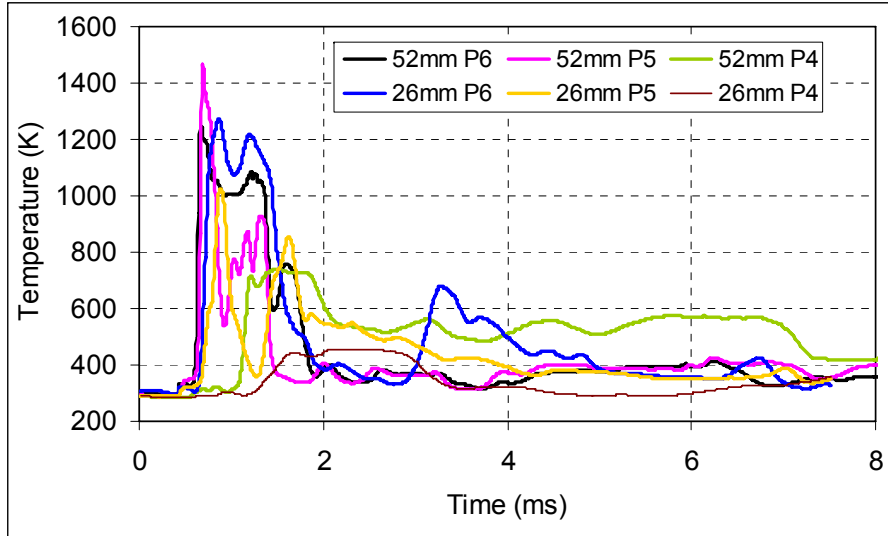
Outside = outside module but inside flash tube

Inside = inside module but outside flash tube

Modelling indicates better ignition if igniter material is both sides of the flash tube

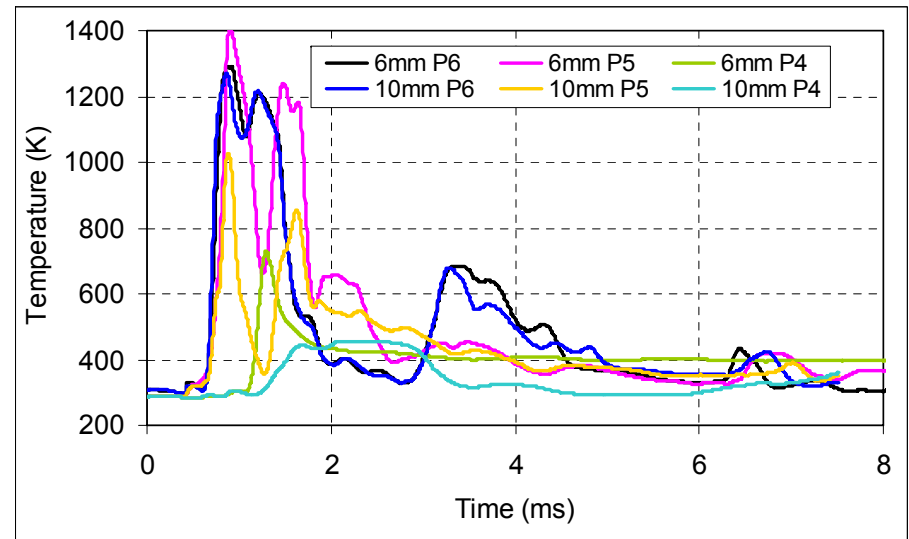
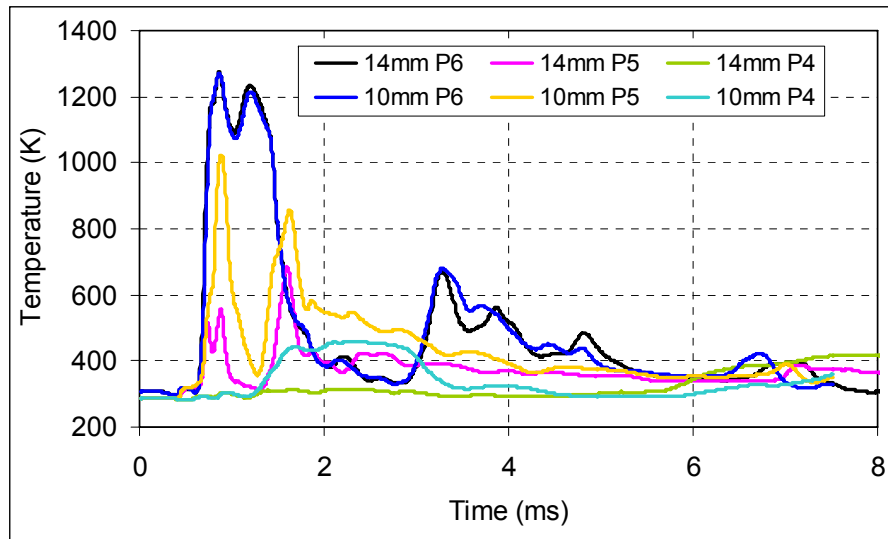


### 03 Single module – effect of flash tube diameter



Modelling indicates better ignition for 26mm flash tube diameter

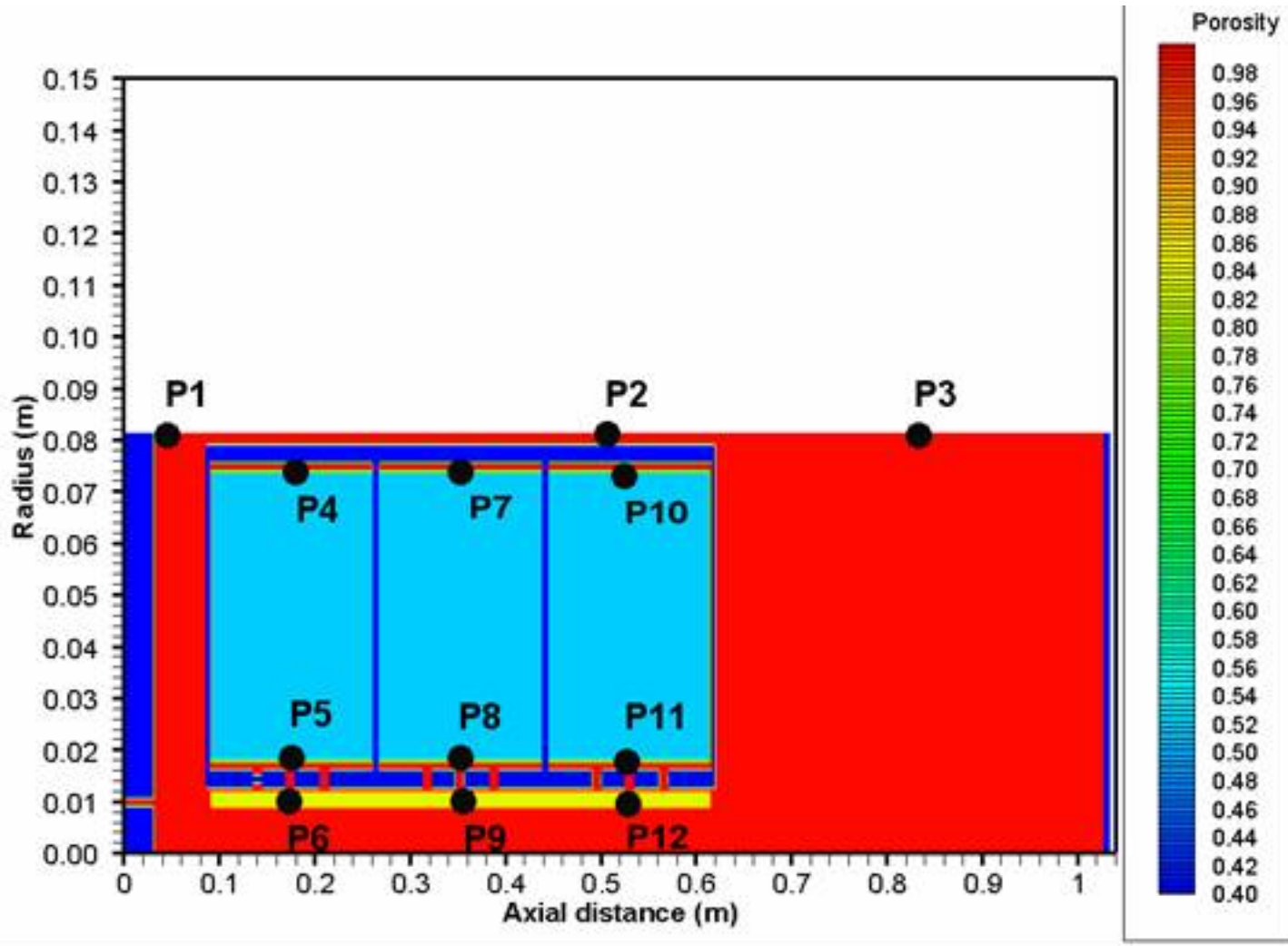
## 03 Single module – effect of flash tube hole size



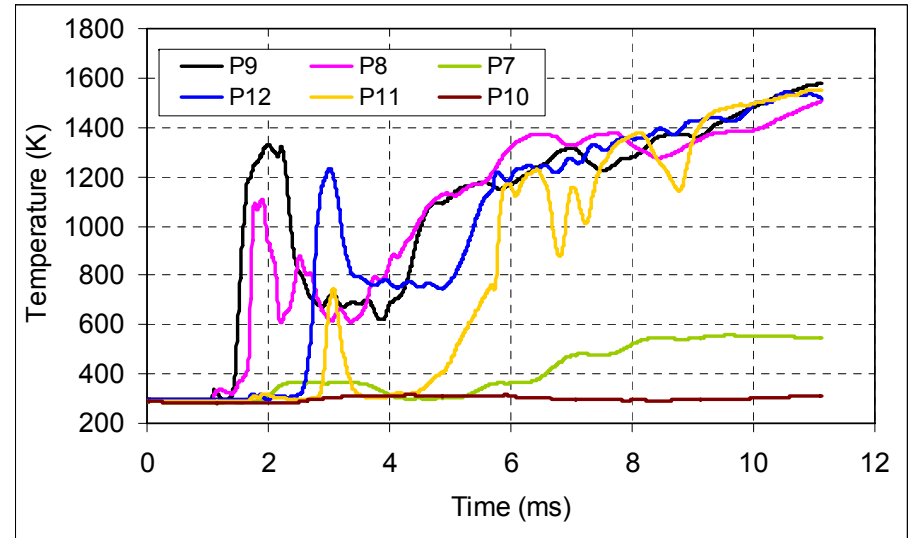
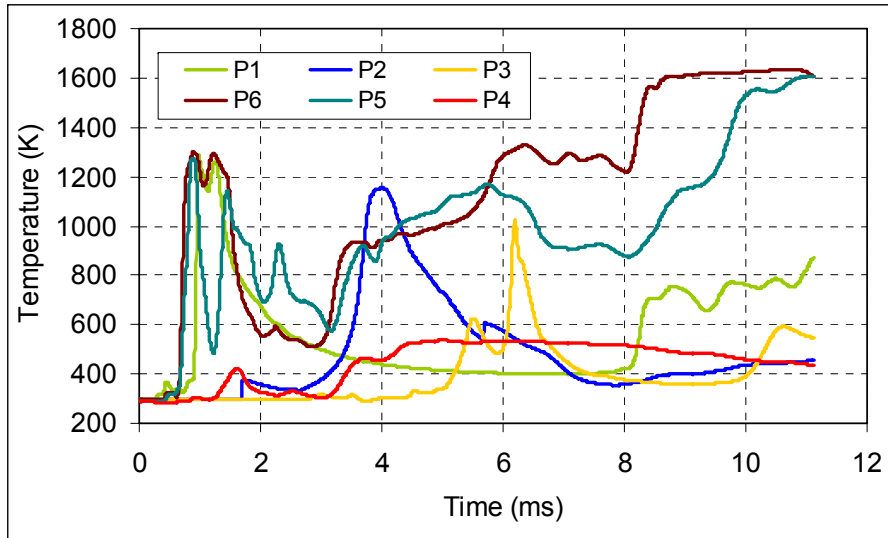
Modelling indicates better ignition for 6mm flash tube holes



# 03 Three modules – initial geometry



### 03 Three modules – 10g black powder per module

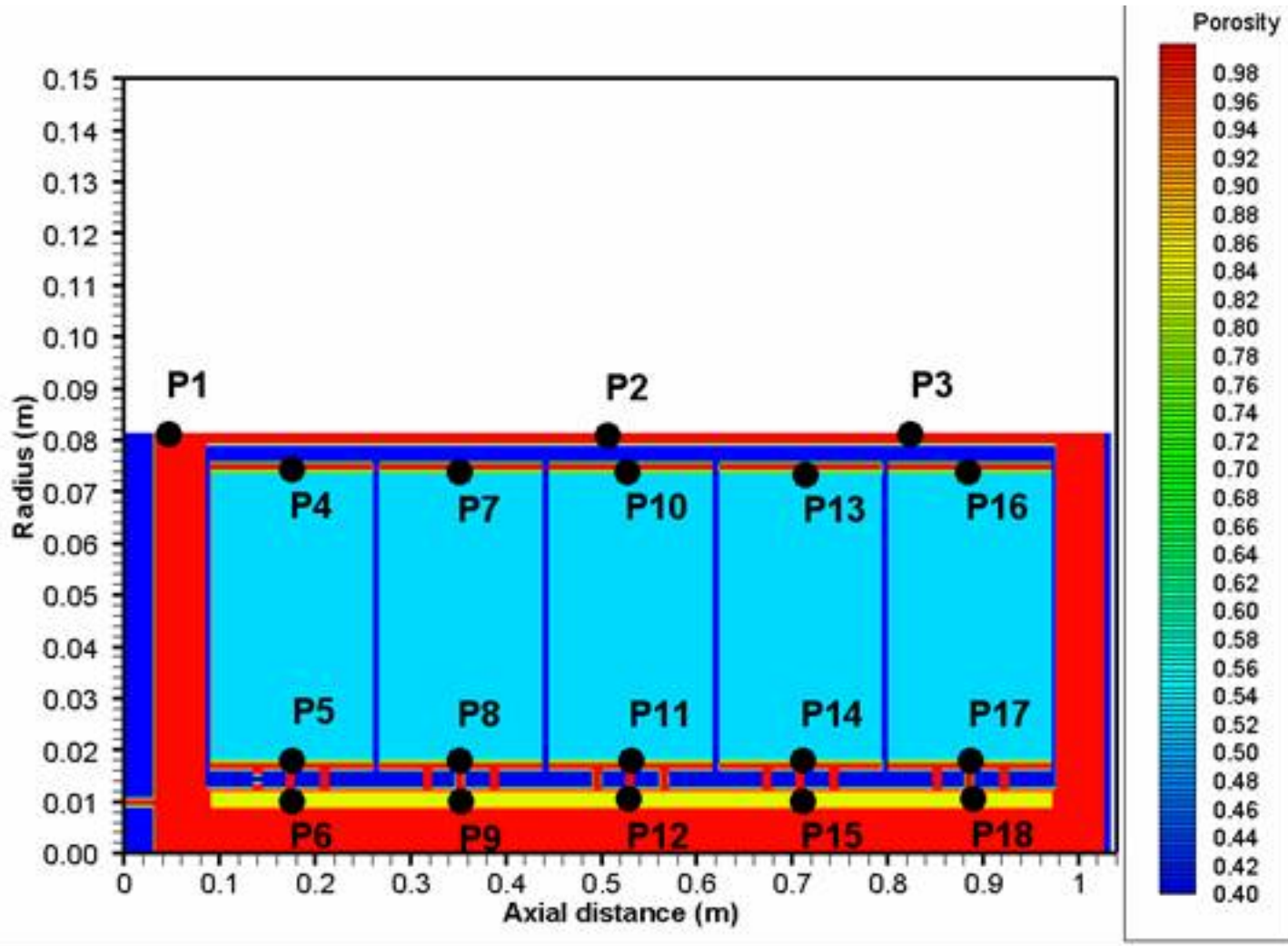


Taking 600K as the propellant ignition temperature, propellant in 2<sup>nd</sup> & 3<sup>rd</sup> modules ignited 0.8ms & 1.7ms after the 1<sup>st</sup> module

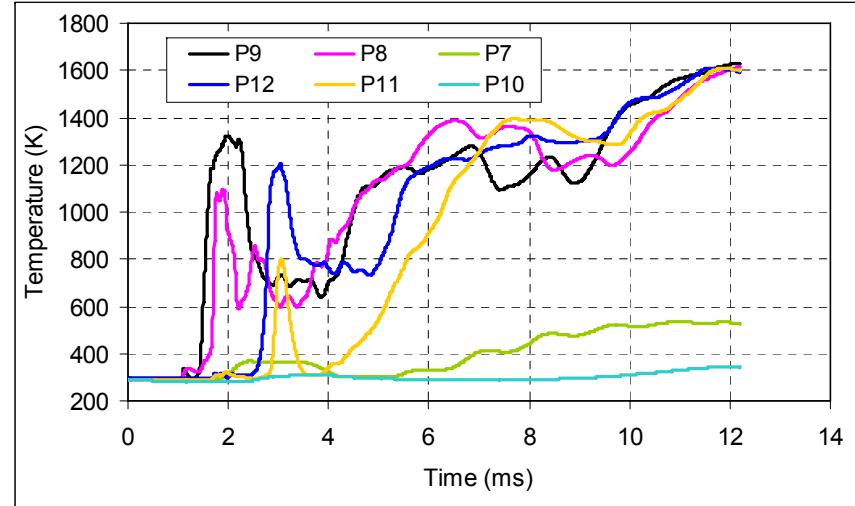
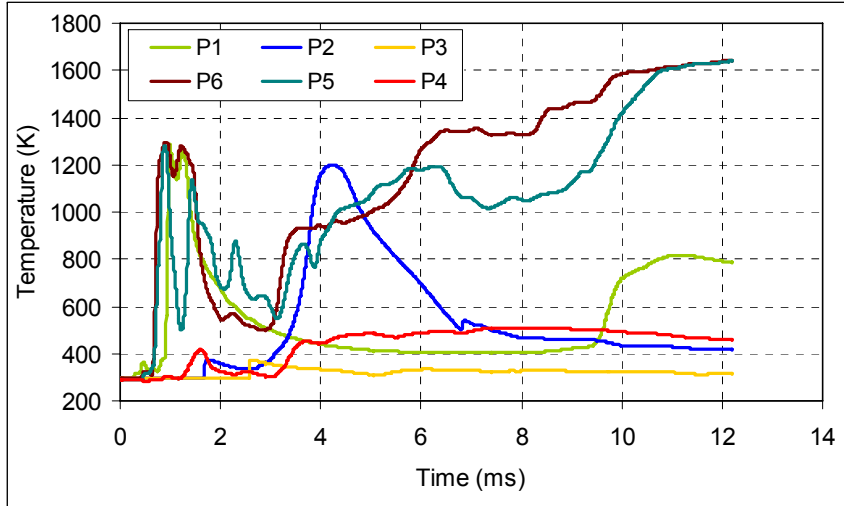


Use another internal ballistics code to predict pressure waves

# 03 Five modules – initial geometry



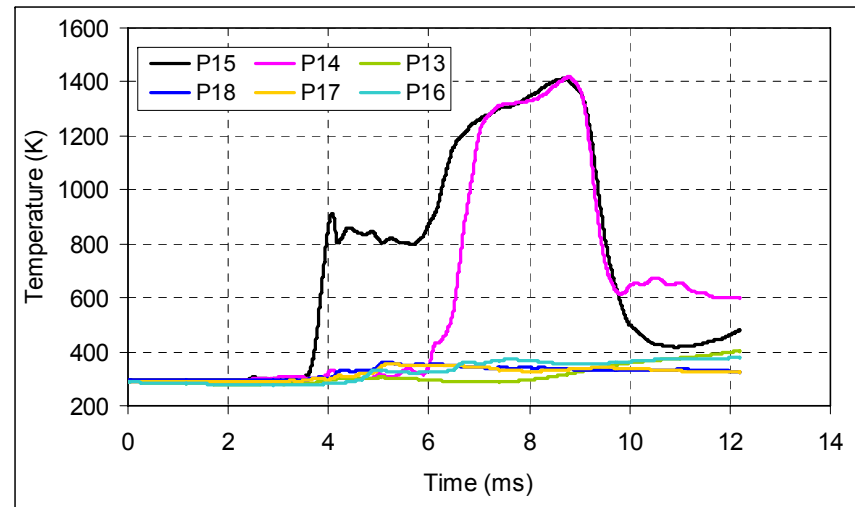
# 03 Five – 10g black powder per module



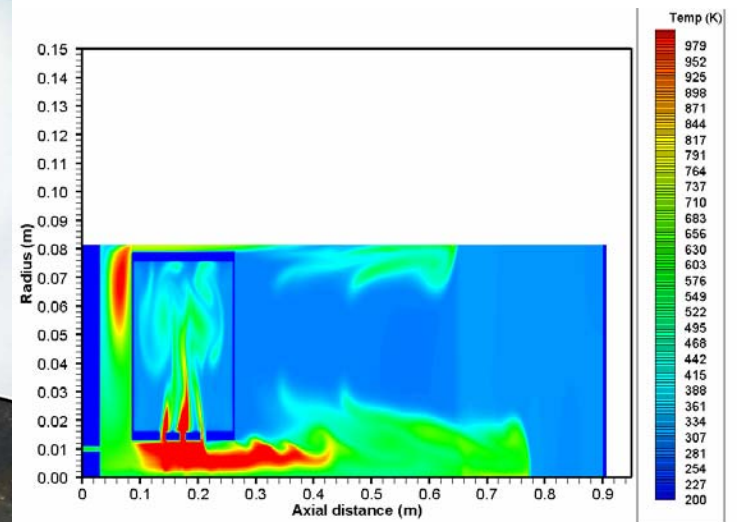
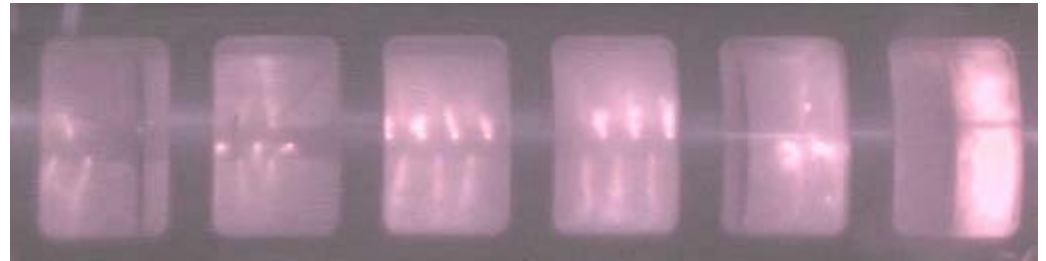
Igniter in last module not ignited

Module 2 might ignite first

Taking 600K as the propellant ignition temperature, propellant in 2<sup>nd</sup>, 3<sup>rd</sup> & 4<sup>th</sup> modules ignited 1ms, 2ms & 5ms after the 1<sup>st</sup> module – use another internal ballistics code for  $\Delta P$



# 04 Conclusions & future work



## 04 Conclusions & further work

- QIMIBS has much of the functionality required to model MCS
- Validated for two primers for 1 & 5 modules
- Parameter studies showed
  - 5g black powder per module not likely to ignite
  - Best position of igniter is both sides of flash tube
  - 26mm diameter flash tube better than 52mm and 20mm
  - Reducing flash tube vent area predicted to produce better ignition
- Predictions for 5 modules show
  - Primer and igniter insufficient to ignite (5<sup>th</sup>) module adjacent to the projectile
  - Module 2 might ignite before module 1
  - Possibility of significant ignition delay for 4<sup>th</sup> module
- 155mm gun firings planned & further modelling
- **Conclusions likely to be very dependent on primers and geometries used in this study**

# ***QinetiQ***

The Global Defence and Security Experts

[www.QinetiQ.com](http://www.QinetiQ.com)

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