Modelling the Internal Ballistics of Lightweight Plastic Driving Band Projectiles

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A presentation to: 26th International Symposium on Ballistics

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QinetiQ

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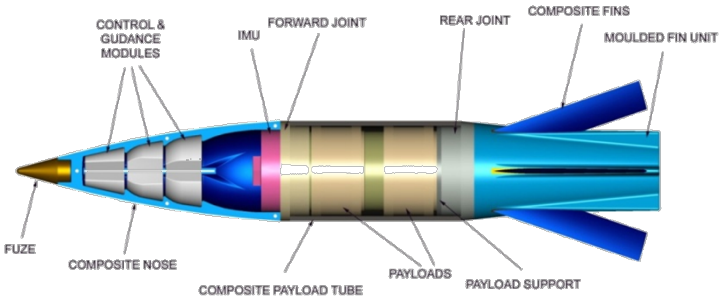
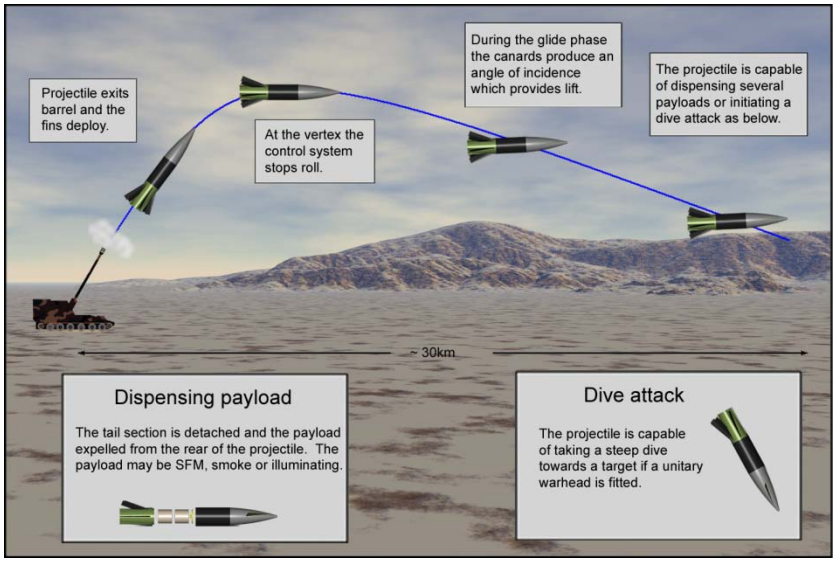
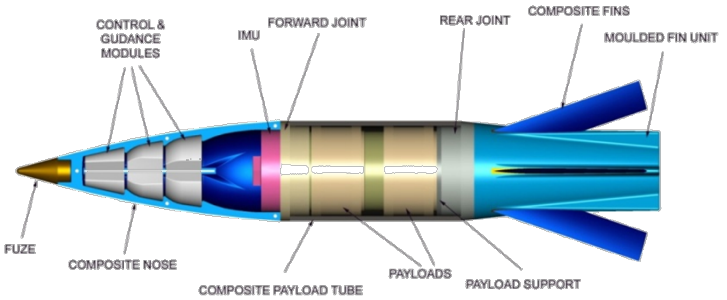
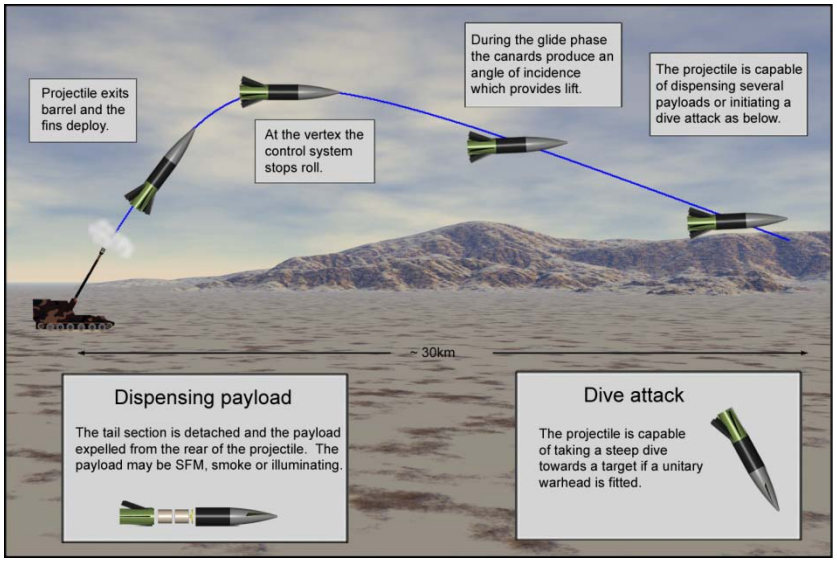




1
Background





1 Background

History

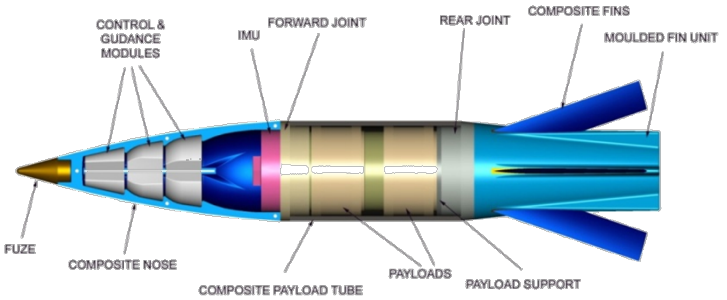
- Firings of mature charge systems with experimental guided munitions gave lower than predicted maximum pressures and muzzle velocities
- Ballistics were consistent so the phenomenon was not investigated further
- More recently, work commenced on a lightweight guided munition
  - 30 kg mass
  - Reduced recoil
- Firings with well understood charge system resulted in lower than predicted maximum pressure of 40MPa and muzzle velocity of 50m/s
- Ram brake and fin case protection based on previous project

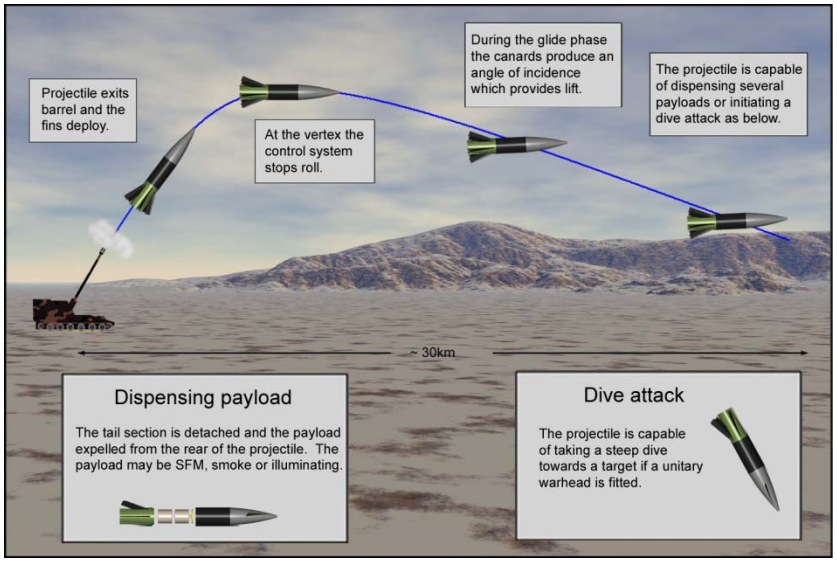
1 Background

Internal ballistics models used in investigation

- Proteus – 0D
- QIBS (**Q**inetiQ **I**nternal **B**allistics **S**oftware) – 1D
- QIMIBS (**Qi**netiQ **M**odular **I**nternal **B**allistics **S**oftware) – 2D

2
Lurch phenomenon

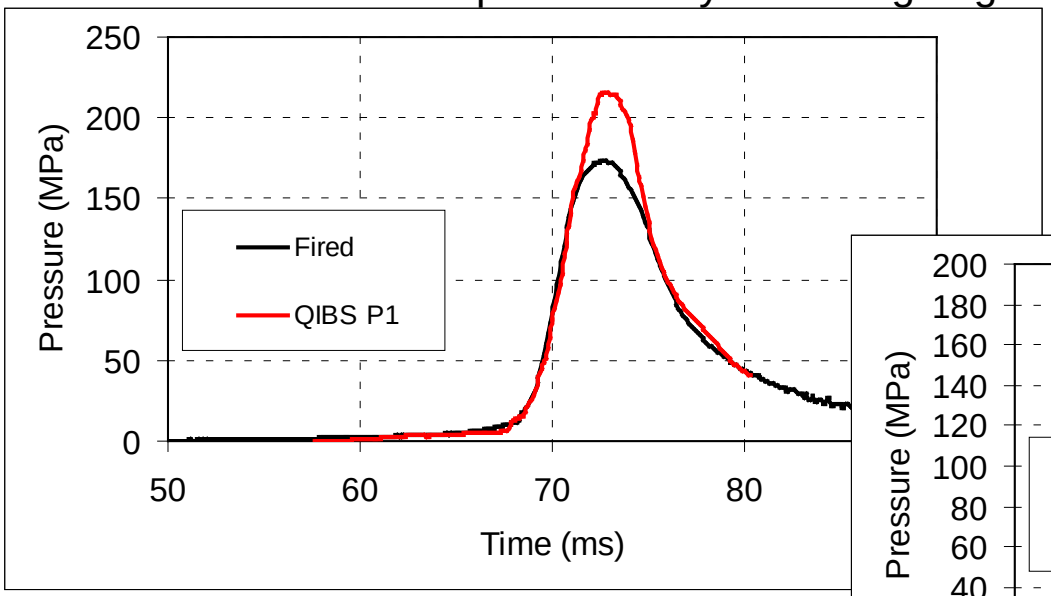




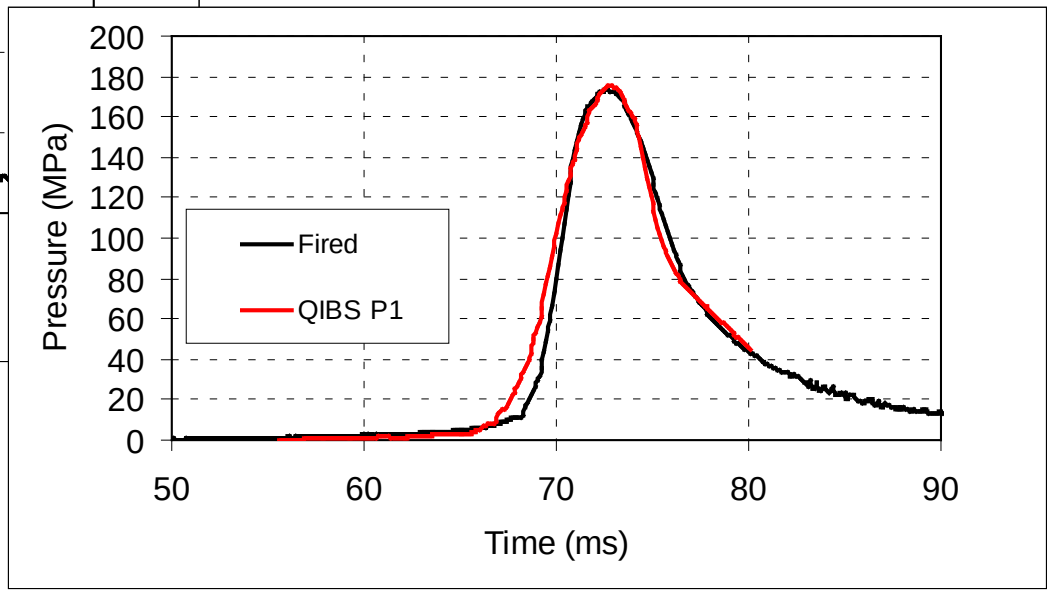
2 Lurch phenomenon

Initial and improved comparisons

- Possible to match pressures by assuming larger than expected chamber volume

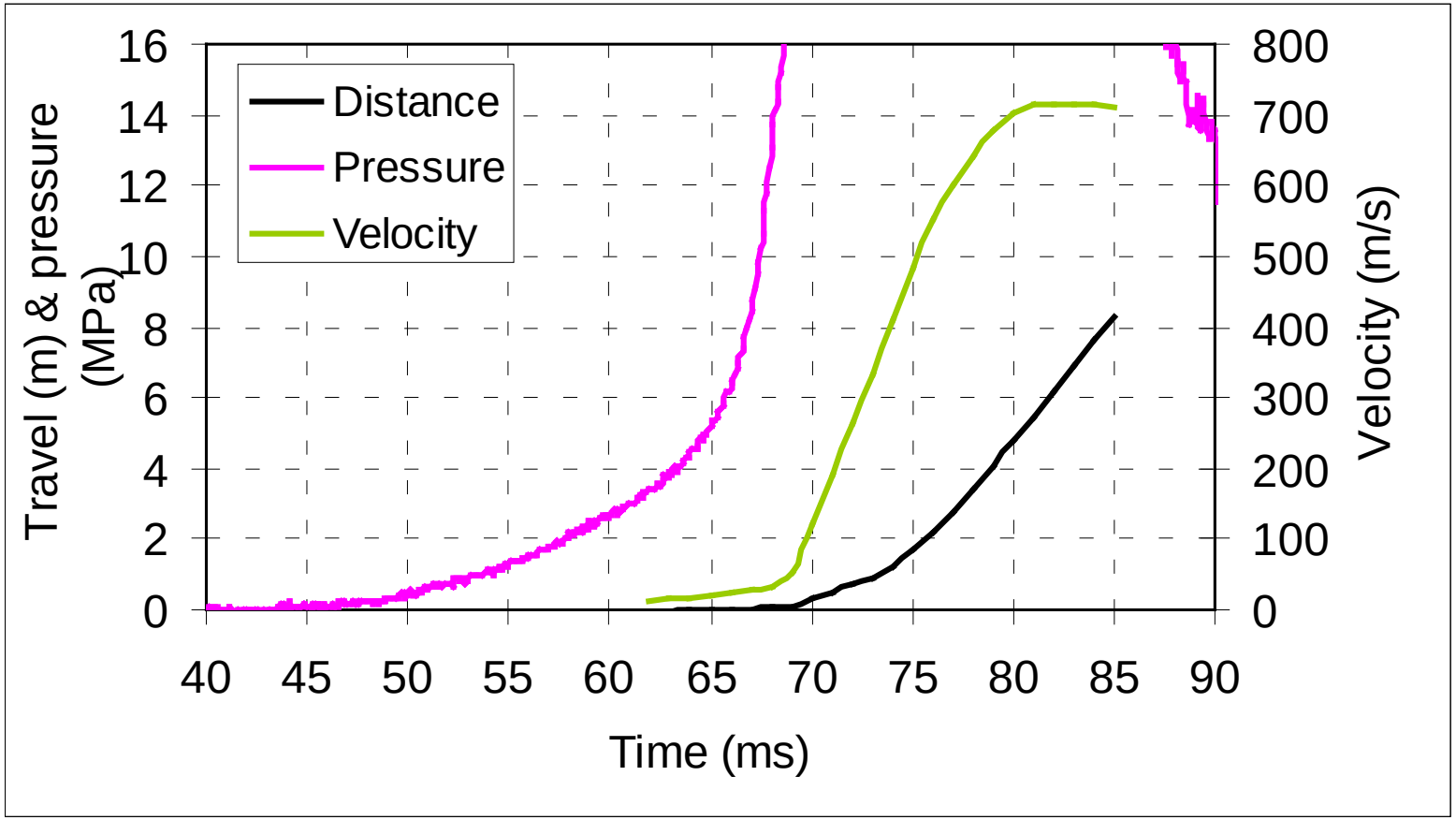


Lurch Phenomenon!



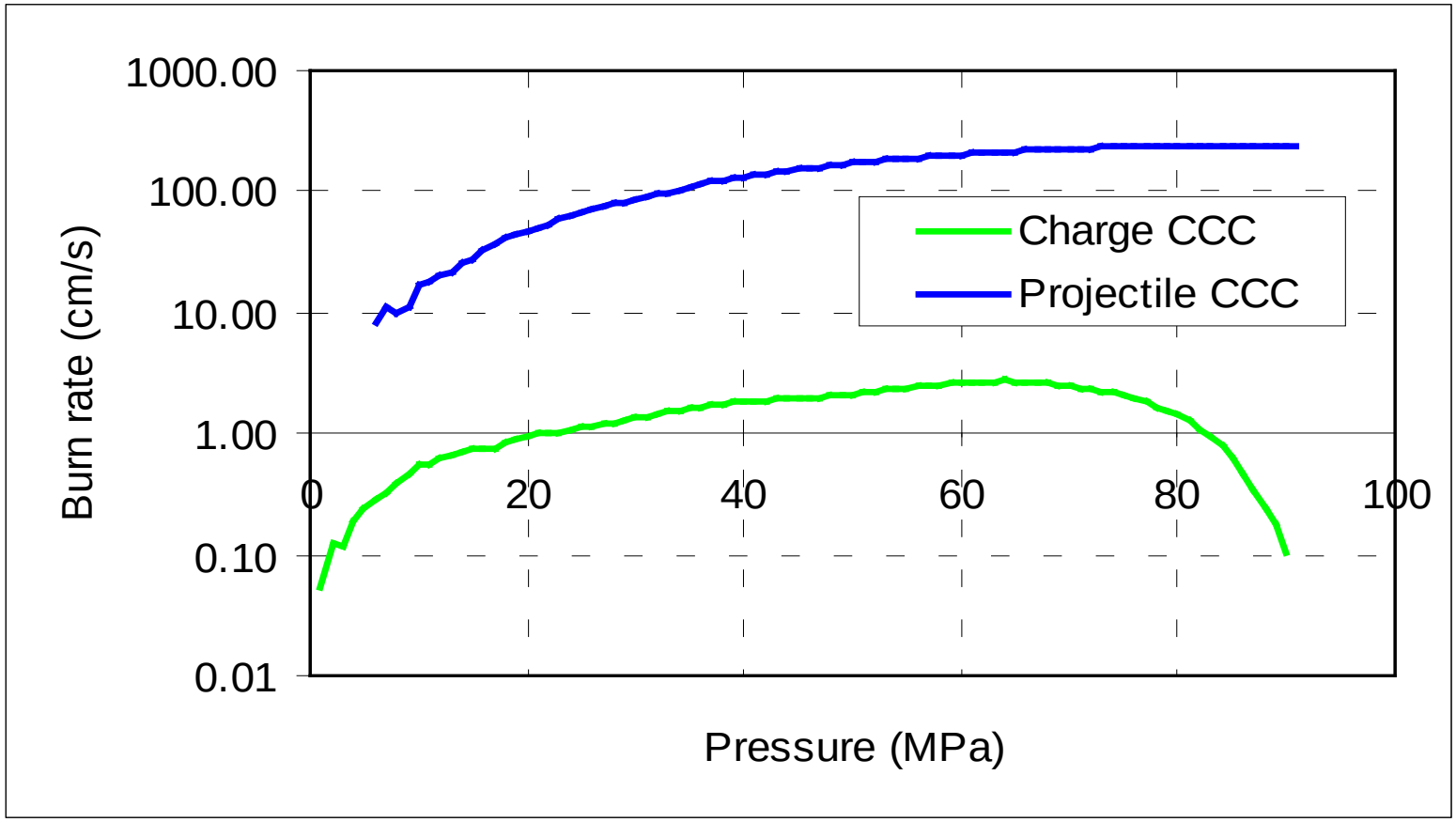
2 Lurch phenomenon

Detailed investigation undertaken to determine cause(s)



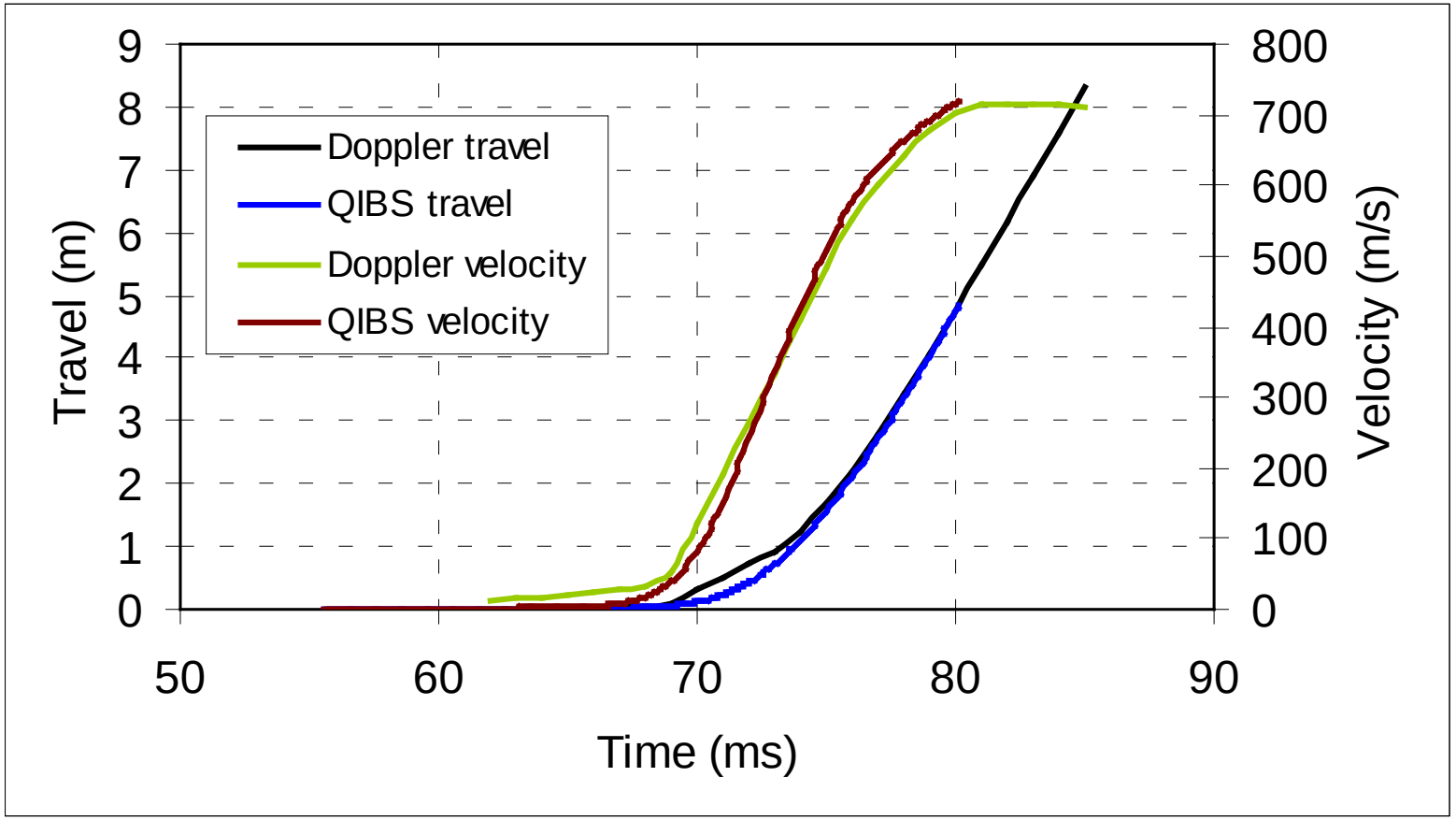
2 Lurch phenomenon

Combustion behaviour of combustible cartridge case significantly different



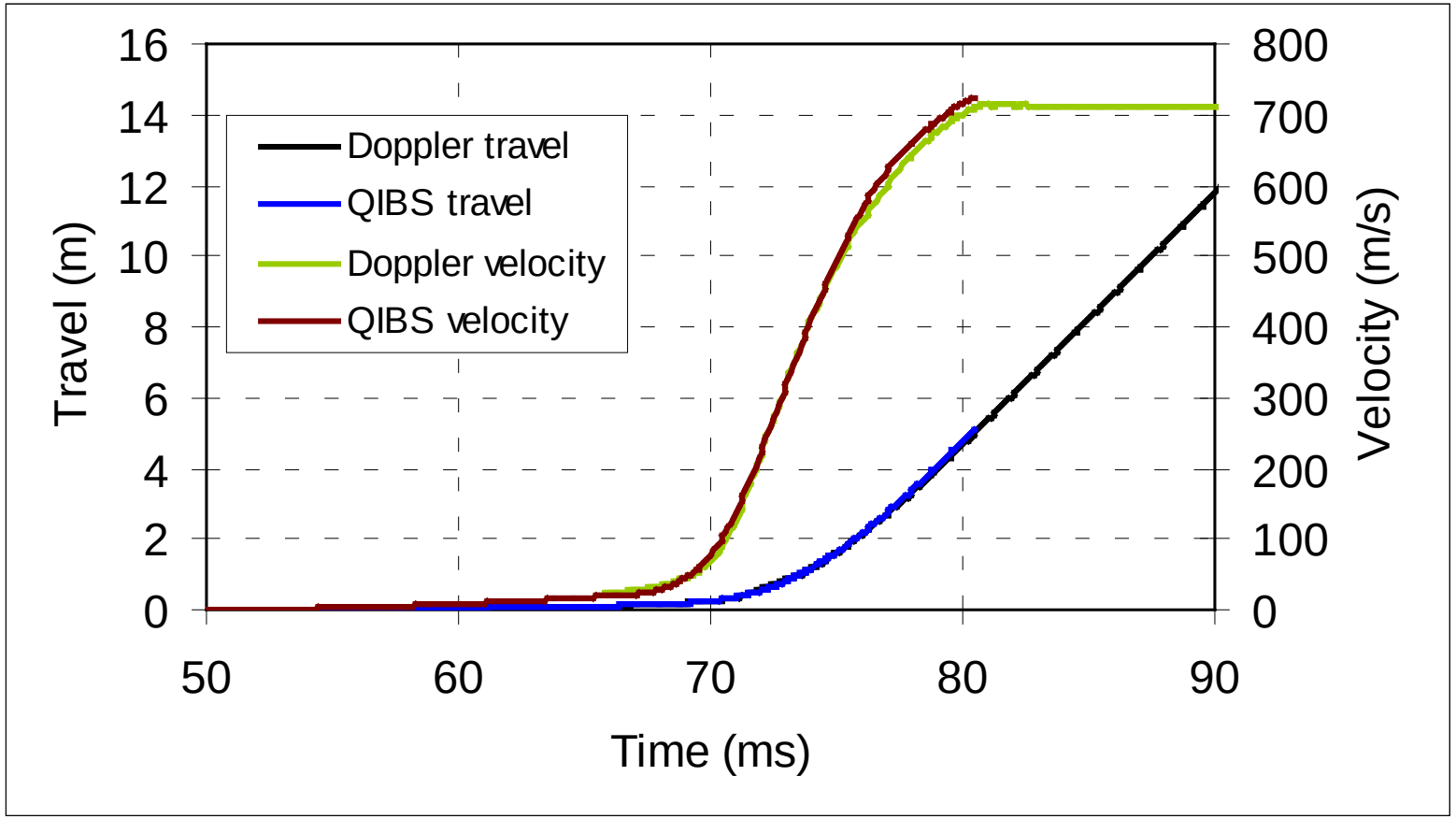
2 Lurch phenomenon

Effect of projectile initially 10cm further forward



2 Lurch phenomenon

Effect of ignition delay of 19ms (equivalent to stand-off of 12cm)



2 Lurch phenomenon

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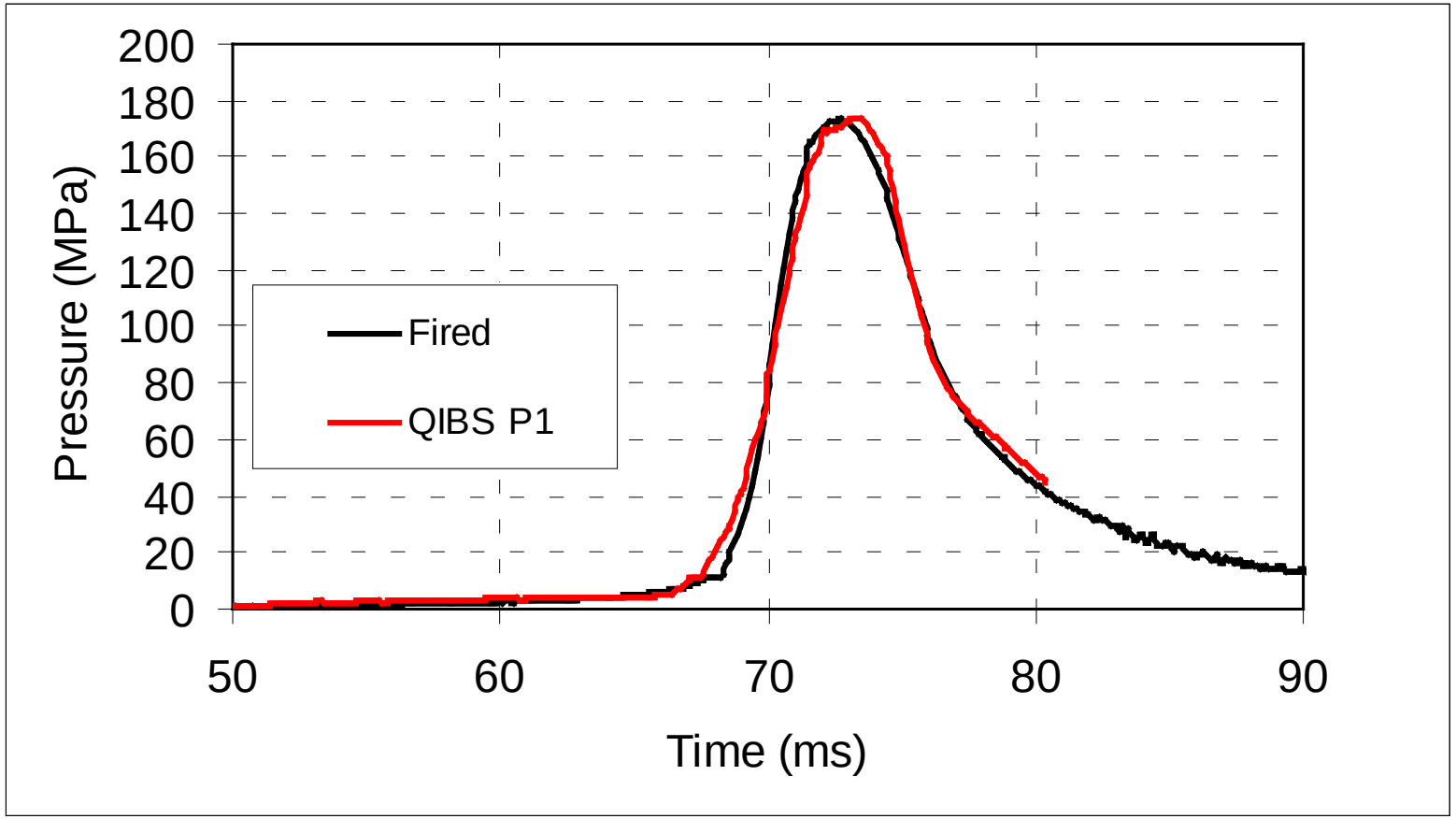
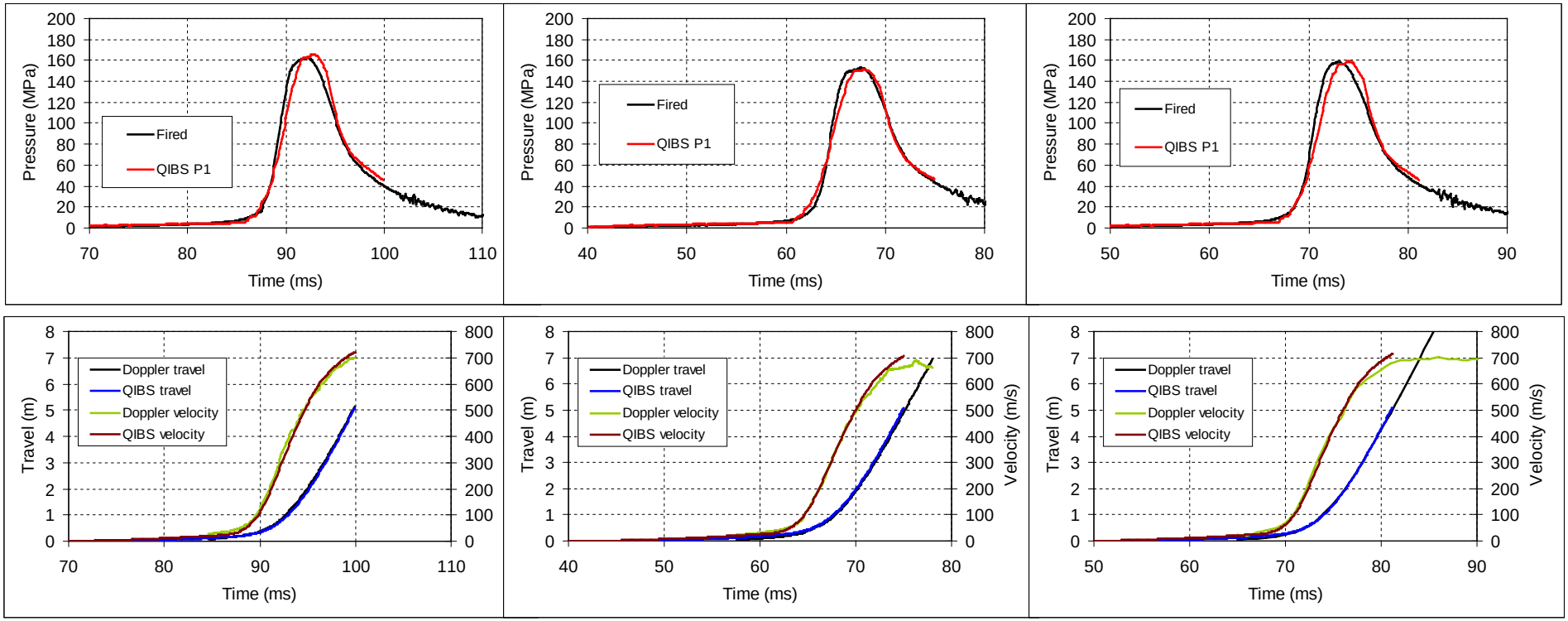


2 Lurch phenomenon

Good agreement for three further rounds fired at similar conditions

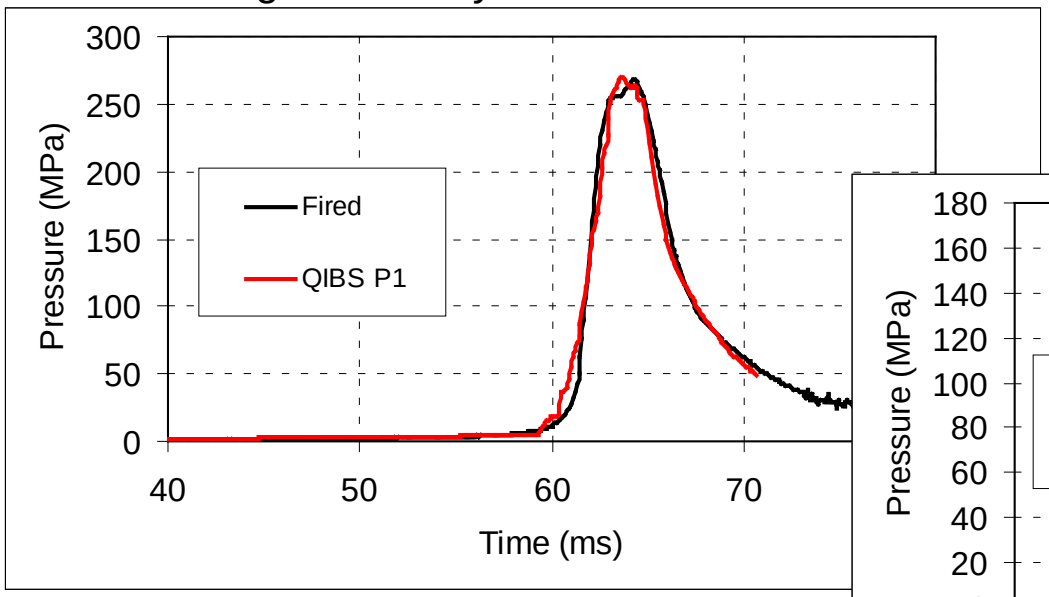
- Fitted ignition delays of 20ms, 22ms and 21ms



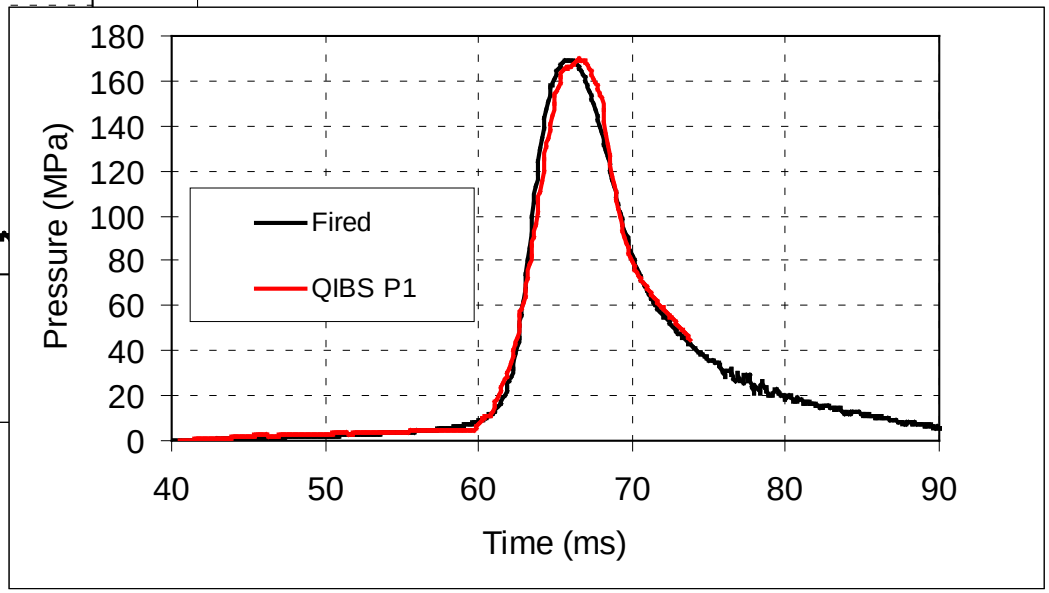
2 Lurch phenomenon

Good agreement for two further rounds with increased charge mass or heavier projectile

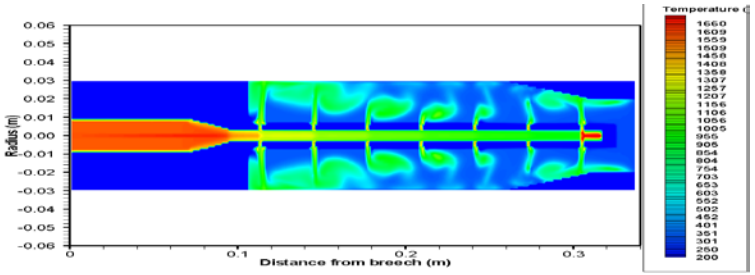
- Fitted ignition delays of 23ms and 19ms



OK but not predictive!



3
Application of QIMIBS



3 Application of QIMIBS

2D internal ballistics code developed to investigate ignition phenomenon

- Predicted the ignition delay for the charge used for the lightweight projectile

3 Application of QIMIBS

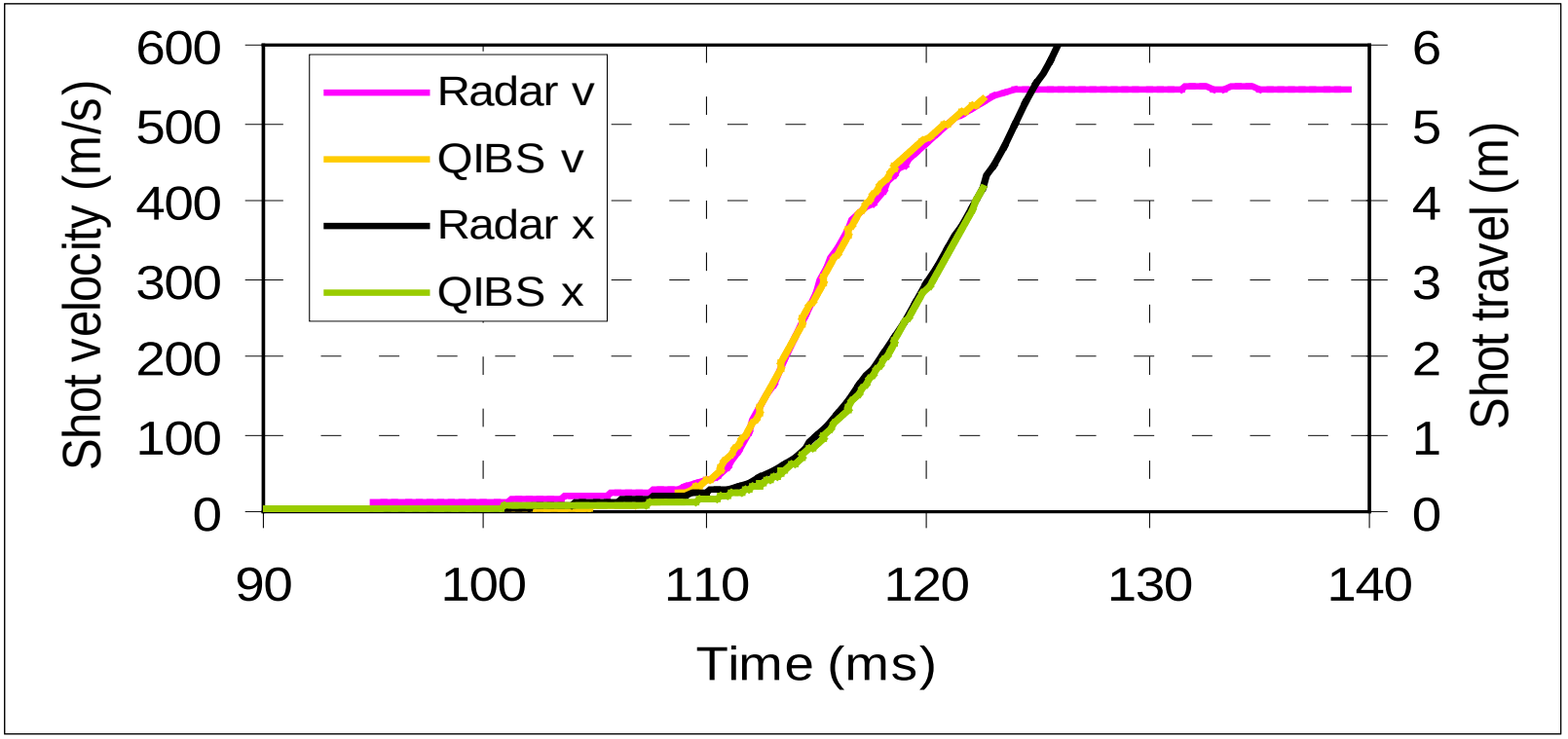
First simulation: ignition model not used

- Time base adjusted to align predicted and measured shot motion

3 Application of QIMIBS

Second simulation: ignition model used

- **No adjustment of time base required!!**



4 Conclusions

- Lurch effect likely to have been caused by a low shot start pressure (i.e. engraving resistance) together with a fast burning CCC material having a low ignition threshold
- Possible to simulate by using an ignition delay in 0D and 1D internal ballistics models
- QIMIBS was able to predict the ignition delay very well and also the maximum pressures for the lightweight projectile
- The advanced ignition models embodied in QIMIBS are able to provide the predictive capability needed for modelling the internal ballistics of the lightweight projectiles

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