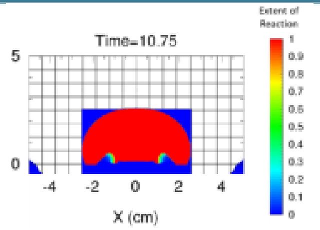
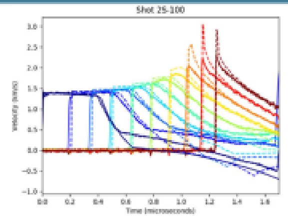
SAND2022-8956C

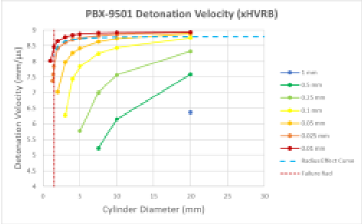
Sandia National Laboratories

Improvement in Explosive Performance Modeling with xHVRB





$$\phi = \frac{1}{\tau}\int_0^t \left(\frac{P-Pi}{P_r}\right)^{Z_r} dt$$



Leah Tuttle, Jeff LaJeunesse

APS SCCM 2022 – Anaheim, CA

Wednesday July 13, 2022

Session P02 11-12:30

U.S. DEPARTMENT OF ENERGY NNSA

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xHVRB Model Review

History Variable Reactive Burn (HVRB):

$$\phi = \frac{1}{\tau}\int_0^t \left(\frac{P - Pi}{P_r}\right)^{Z_r} dt$$

$$\varphi = \int_0^t \left[\frac{P_s - Pi}{P_r}\right]^{n_s} \left[\frac{P}{P_r}\right]^{n_b} \frac{dt}{\tau}$$

De-couple hot spot density from surface regression rate.

Replace hot spot density with pseudo-entropy

$$h(q_s) = \left(\frac{q_s}{c_{vo}} - \frac{p_i}{p_r}\right)^{n_s}$$

$$\frac{q_s}{c_{vo}} = \frac{q_{su}}{c_{vo}} + \frac{\Delta q_s}{c_{vo}}$$

Cumulative pseudo-entropy is defined here.

Change in pseudo-entropy is a function of the difference in shock pressures

$$\frac{\Delta q_s}{c_{vo}} = \frac{\Delta p_s / p_r}{\left(\frac{p_{su}}{p_0}\right)^{n_d}}$$

xHVRB uses captured shock pressure and detects multiple shocks for desensitization

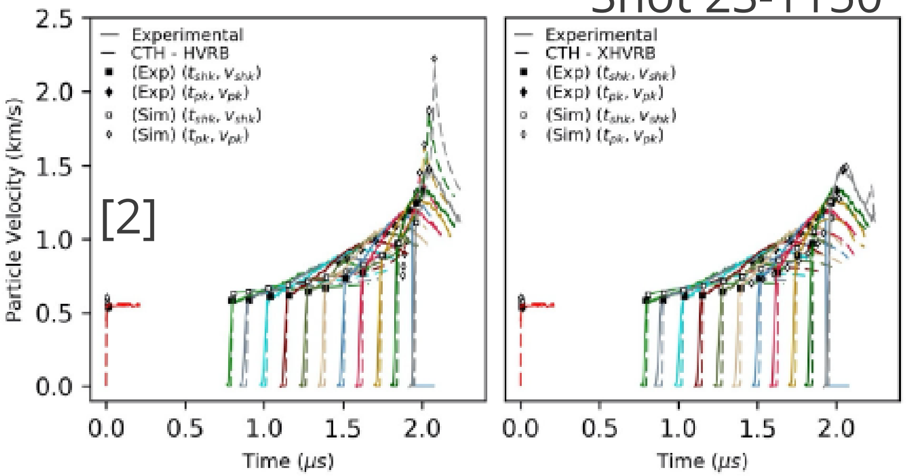
Parameters n_s and n_d can be used to fit model to material data for desensitization.

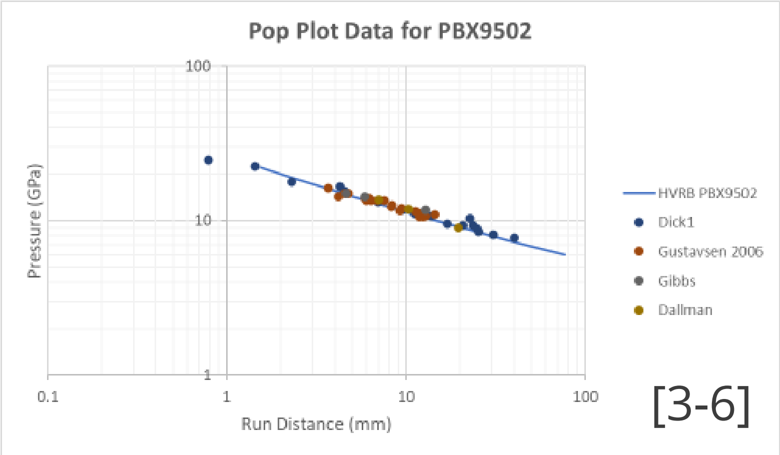
Model Constructions – PBX9501 and PBX9502 Improvements to Library Models

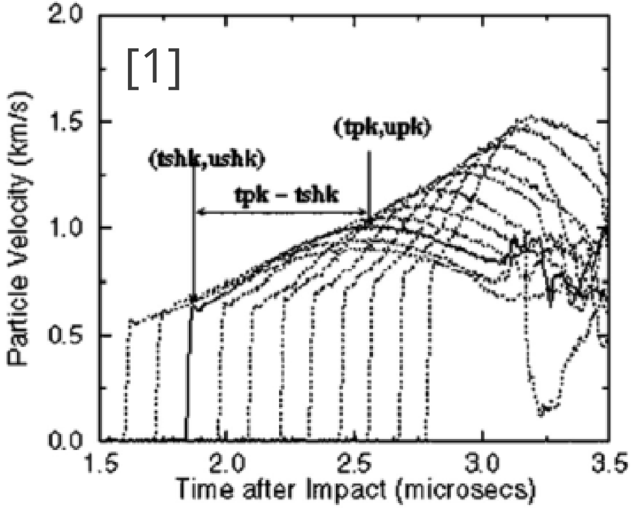
We used the basic training data (Hugoniot, Pop-plot, detonation velocity, and expansion) PLUS single shock long-pulse embedded gage data.

PBX-9501

Shot 2S-1150







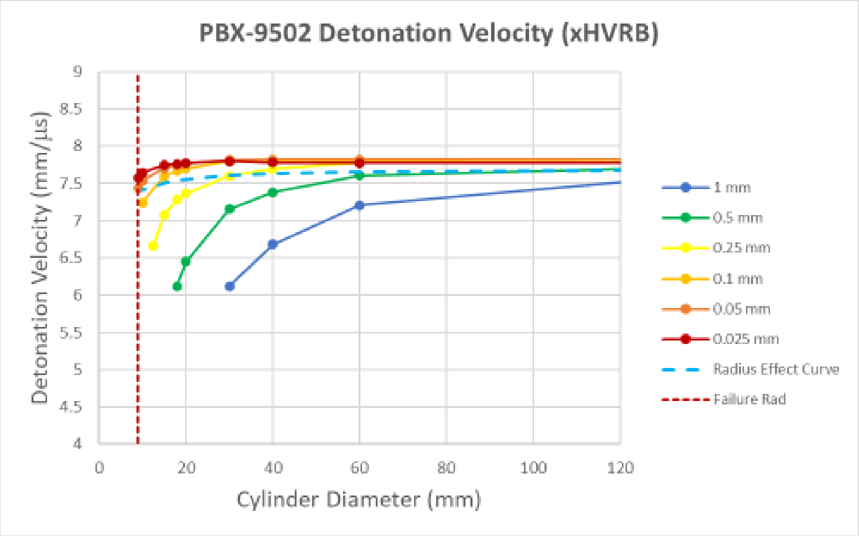
**See Jeff LaJeunesse's Presentation T03 Thursday 9:15 AM

[1] James and Lambourne, J. Appl. Phys. 100, 084906 (2006); https://doi.org/10.1063/1.2354416
[2] Gustavsen, Sheffield, and Alcon, 11th Detonation Symposium, p. 821
[3] Gibbs and Popolato, LASL Explosive Property Data, 1980
[4] Dick, Forest, Ramsay and Seitz, Journal of Applied Physics 63, 4881 (1988)
[5] Dallman and Wackerle, 10th Detonation Symposium, p. 130
[6] Gustavsen, Sheffield, and Alcon, J. Appl. Phys. 99, 114907 (2006)

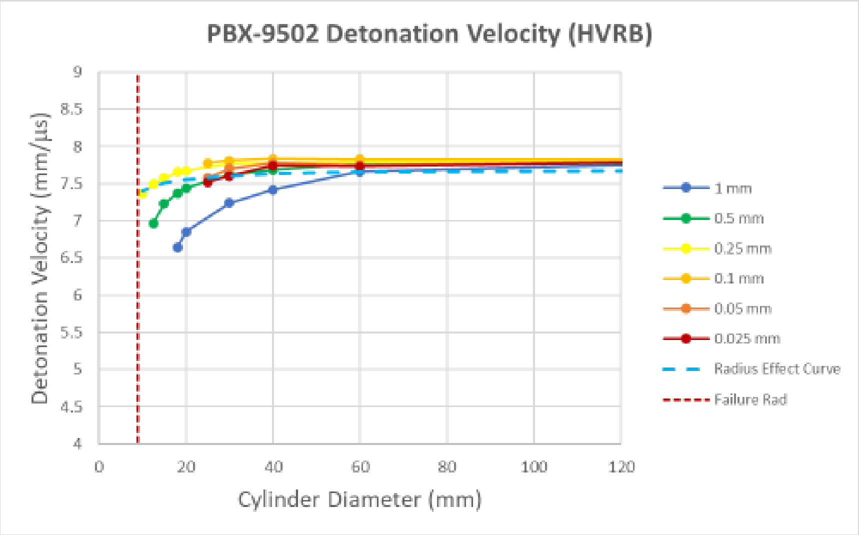
Diameter Effect

PBX-9502

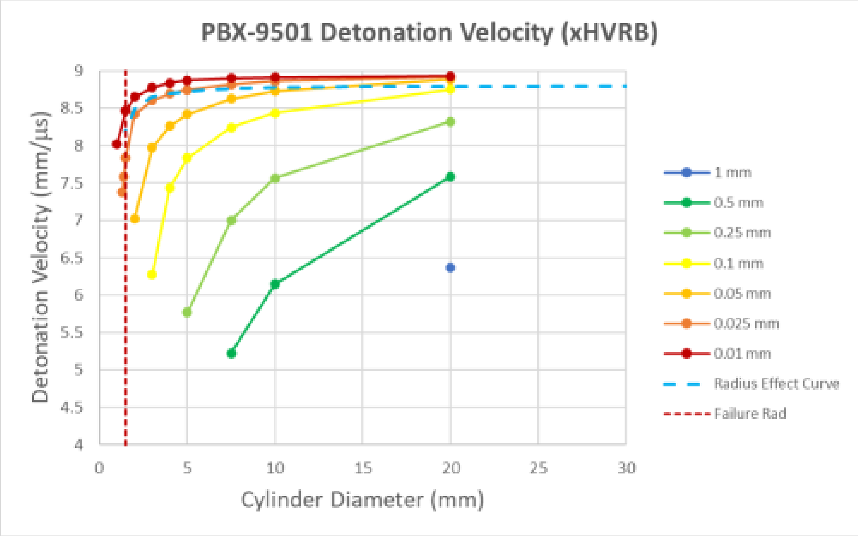
xHVRB

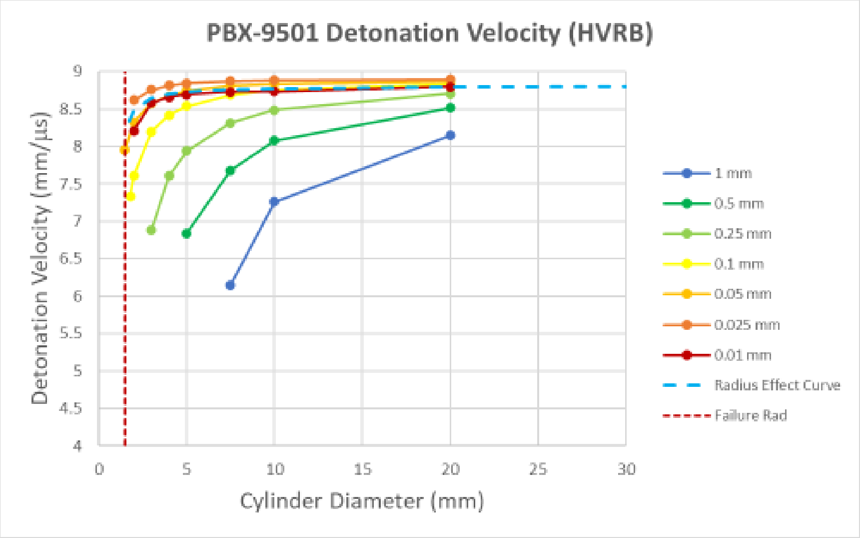


HVRB



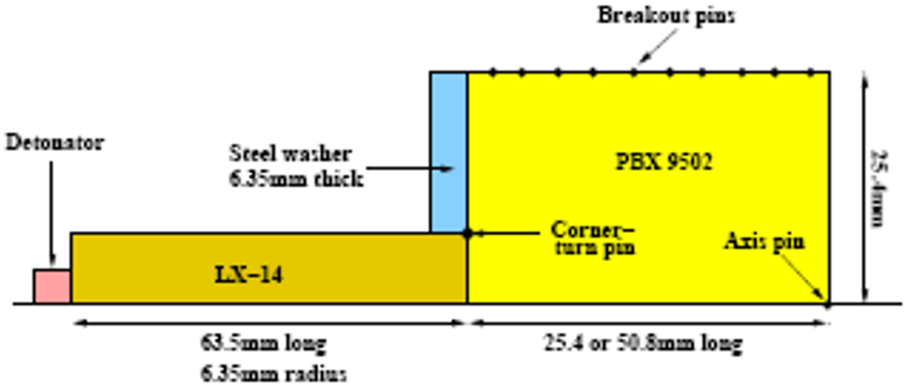
PBX-9501

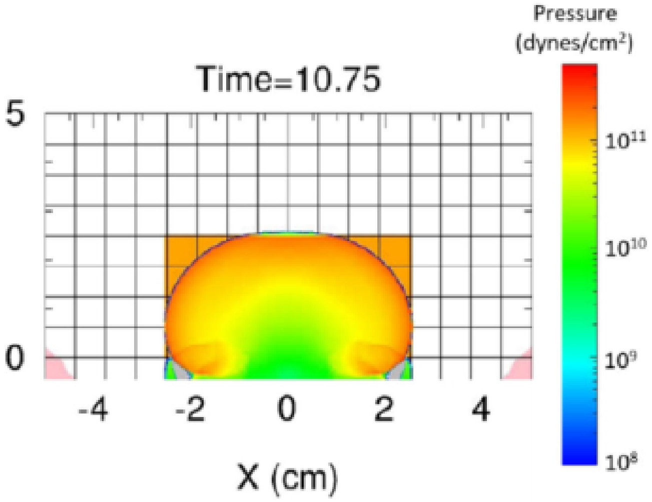


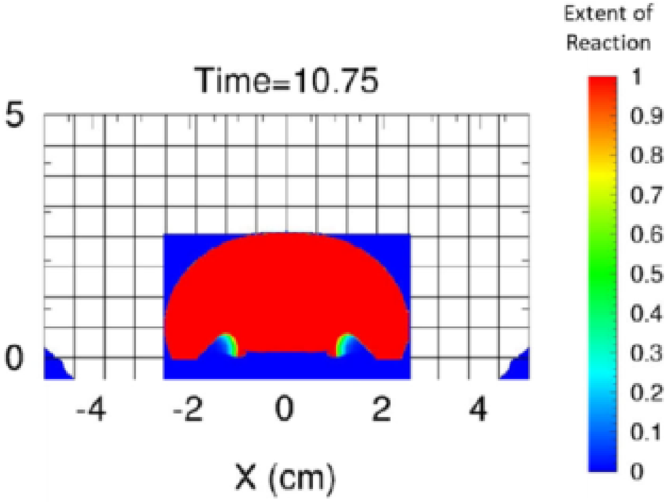


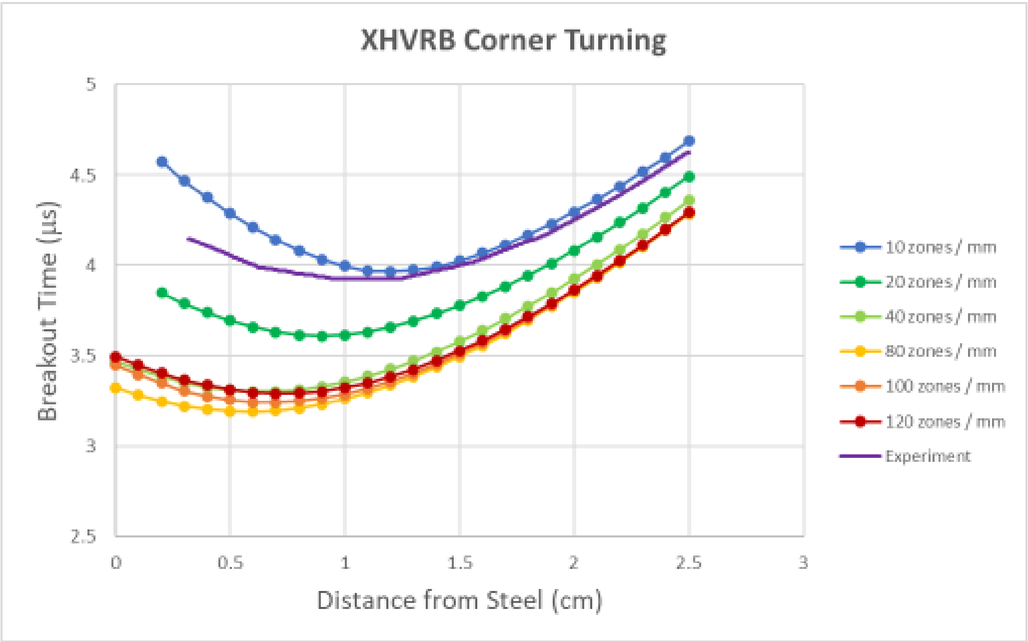
HVRB showed stability issues for low sensitivity explosives

Corner Turning





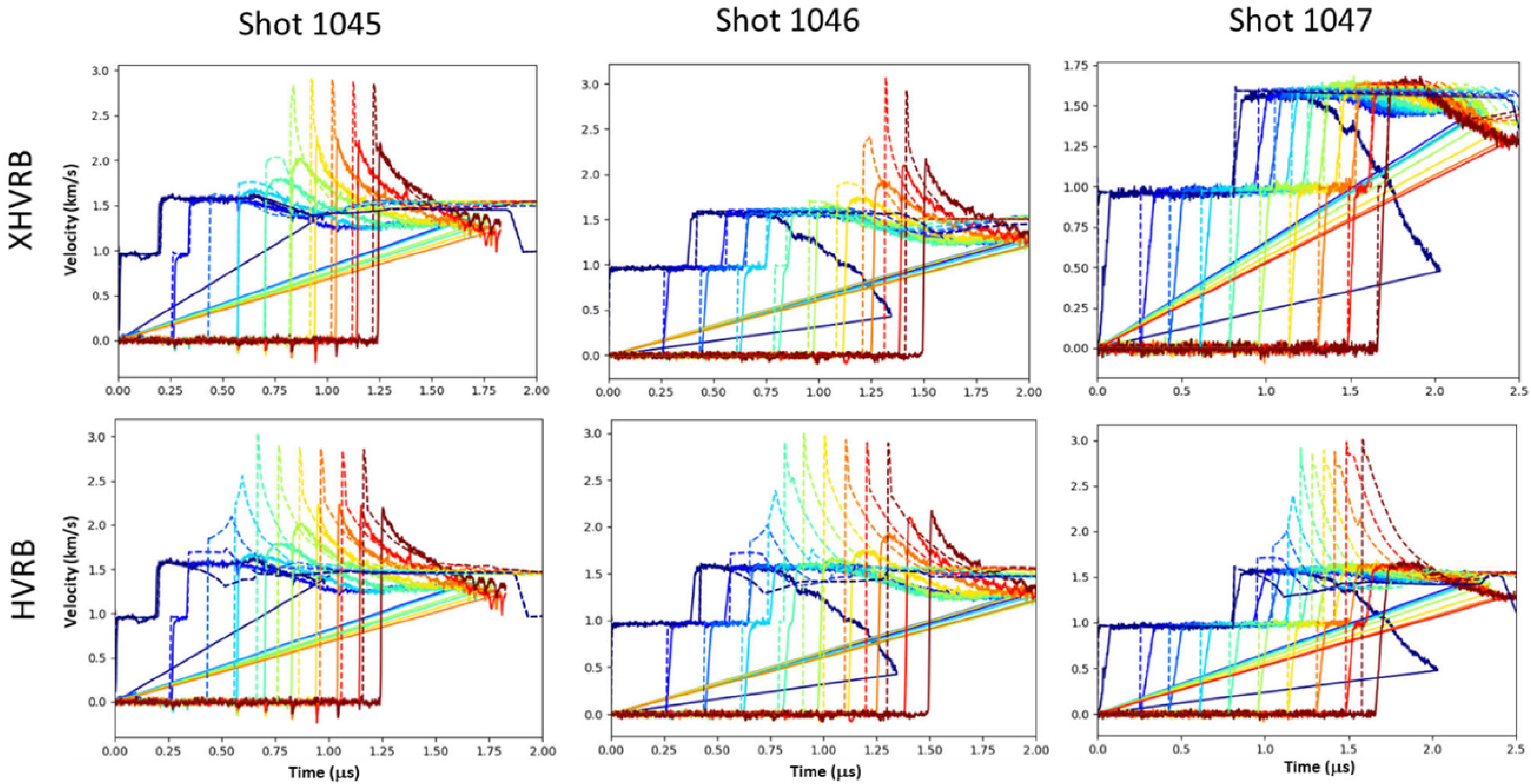




HVRB failed to detonate in the PBX9502, so no breakout results can be reported here.

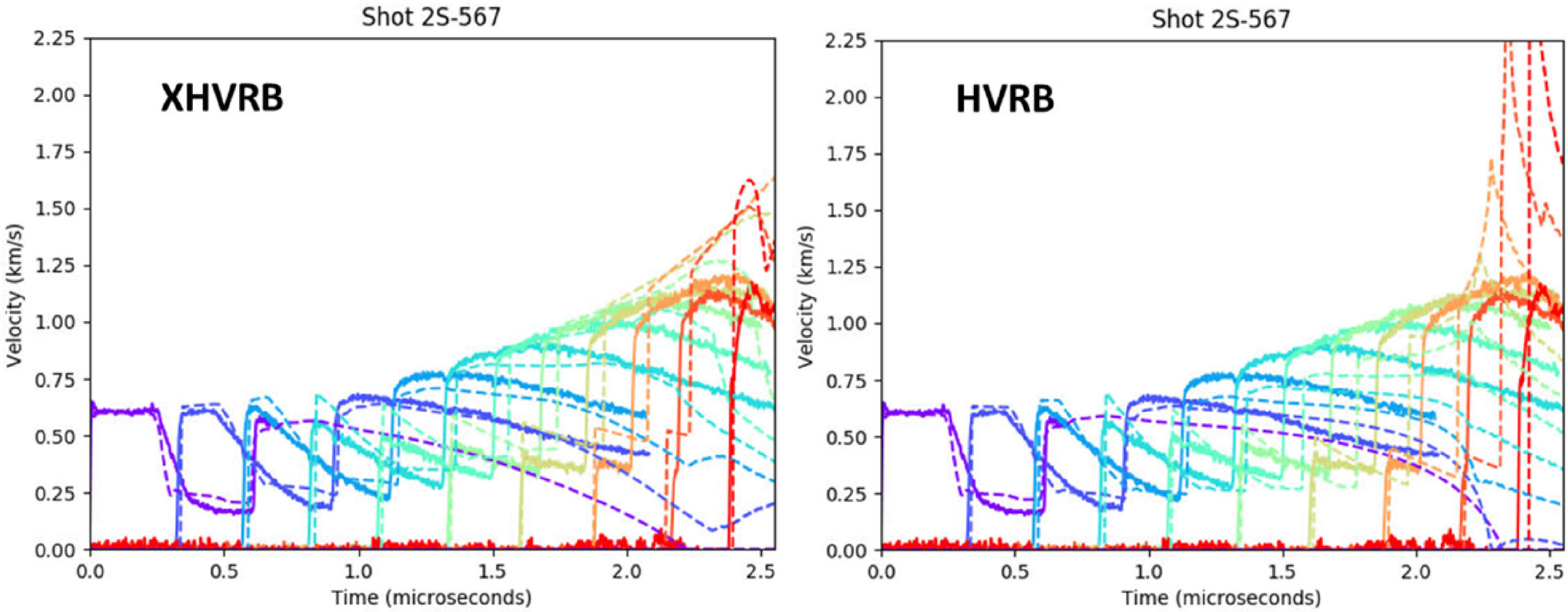
Souers P C, Lauderbach L, Garza R, Vitello P and Hare D E, 14th Detonation Symposium, p. 1237
Whitworth, J. Phys: Conf. ser. 500 052050, 2014

Multi-shock Embedded Gage – PBX9502



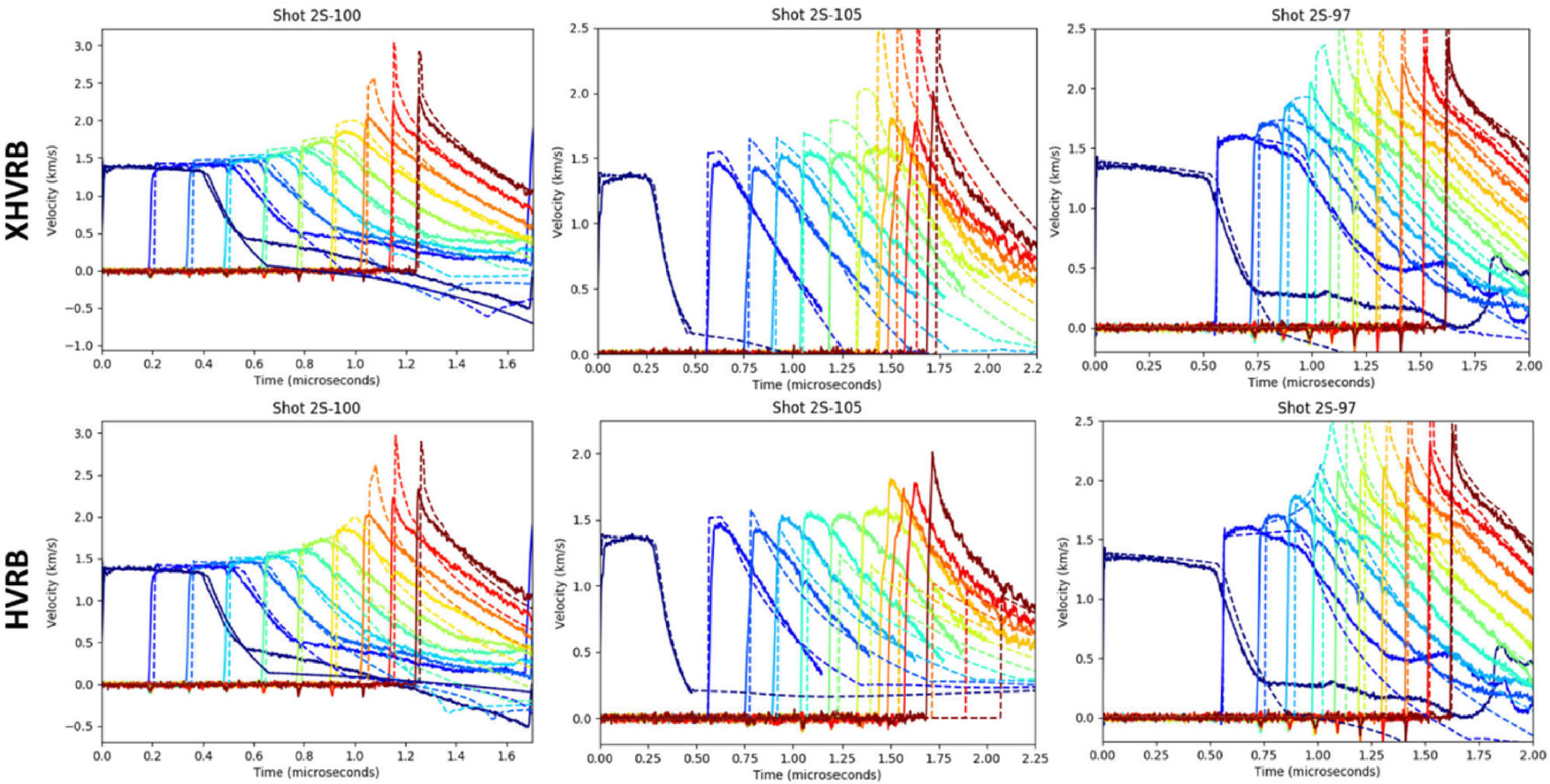
Gustavsen, Aslam and Bartram, 16th Detonation Symposium, p. 740

Shock-Release-Reshock with PBX9501



Aslam, Gustavsen, Whitworth, Menikoff, Tarver, Handley, and Bartram, SIP Conference Proceedings 1979, 100001 (2018)

Thin Pulse Initiation – PBX-9502



Gustavsen, Sheffield, and Alcon, J. Appl. Phys. 99, 114907 (2006)

Conclusions and Future Work

Both models did reasonably well with the diameter effect without including this behavior in the training data. *HVRB showed some instability

xHVRB showed improved behavior over HVRB compared to experimental data on thin pulse initiation, multi-shock initiation, and corner turning

xHVRB is being extended to include the effects of initial density and temperature (I hope you saw David Damm’s talk on Monday! ☺)

Next steps include examining model performance in multi-point detonation