Design for Insensitive Munitions Compliance of XM1069 120mm Multipurpose Tank Round

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

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NDIA IMEM Symposium, Tucson, AZ
11-14 May, 2009

Outline

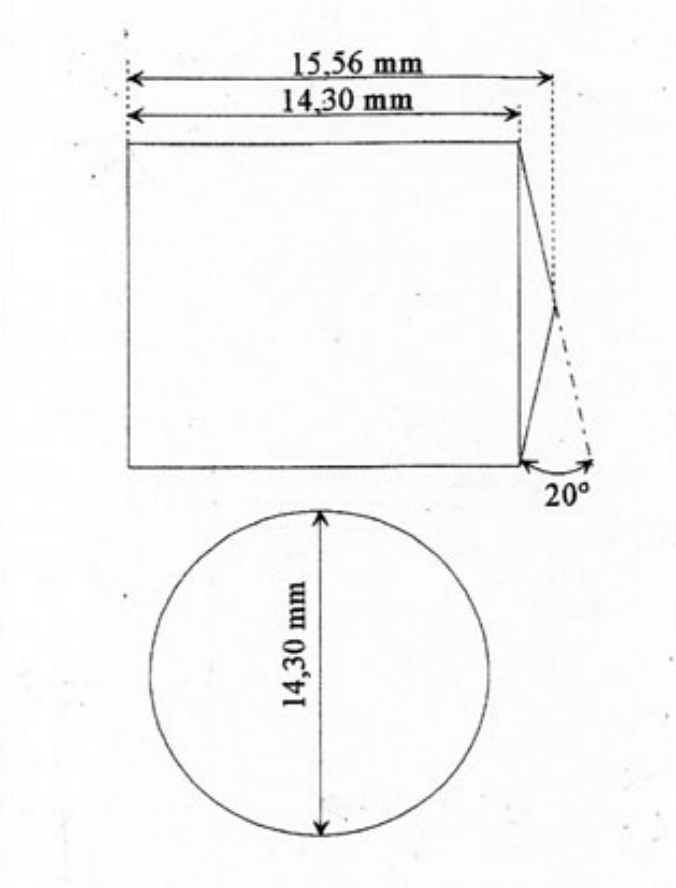
- XM1069 Intro
- Fragment Impact
  - Modeling
  - Test
- Cookoff venting
  - Penetration modeling
  - Cookoff testing

XM1069

- 120mm, Fin-Stabilized Multimode Tank Round
- Filled with ~5lbs PAX-3
  - HMX, Aluminum, Binder
- Computationally optimized
  - Outstanding performance against urban targets, light armor and personnel

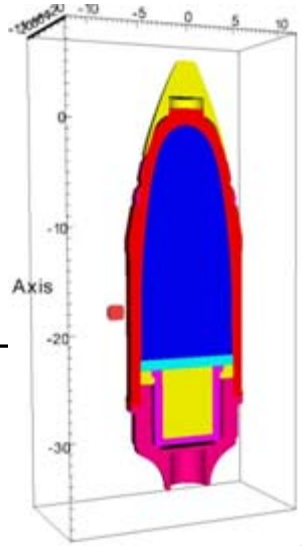
Fragment Impact

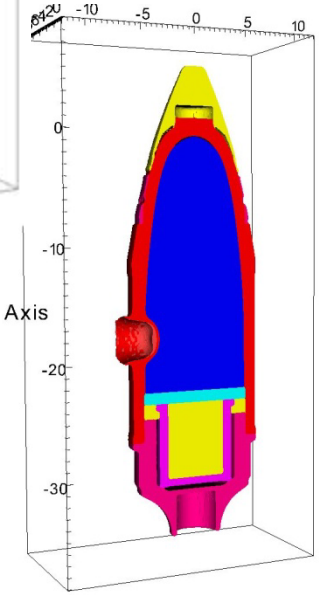
- Standardized IM test (STANAG 4496)
- 8300 ft/s (formerly 6000 ft/s) mild steel fragment
  - Shot in tactical configuration, shot in logistical configuration
- Possible shock initiation, shear or cookoff
- Required: Type V/Burn

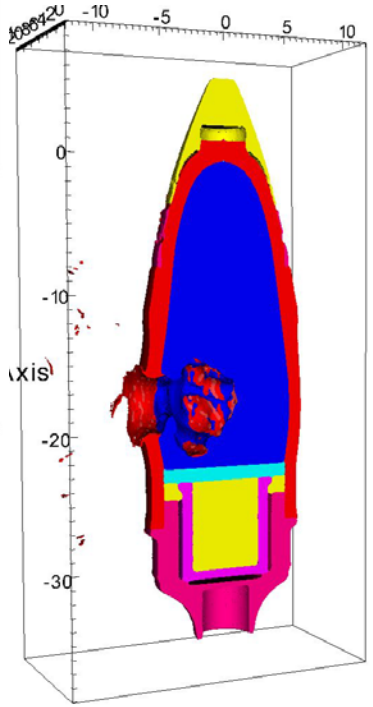


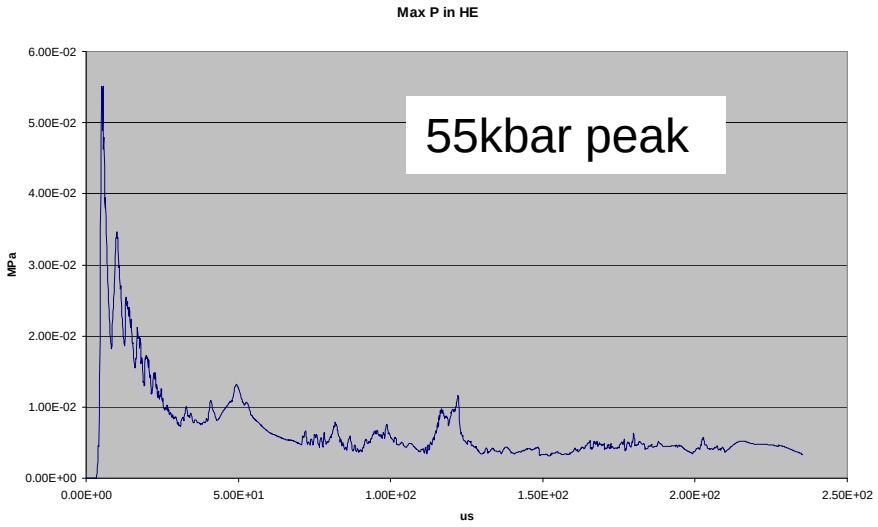
Non Explosive Main Fill

- First approach, tried-and-true
- 4M elements
- Approx 1200 cpu-hours on ARL HPCC
  - 3 calendar days on 32 cores – Ended by time limit
- HE main fill modeled as a Mie-Grüneisen EOS with no strength model

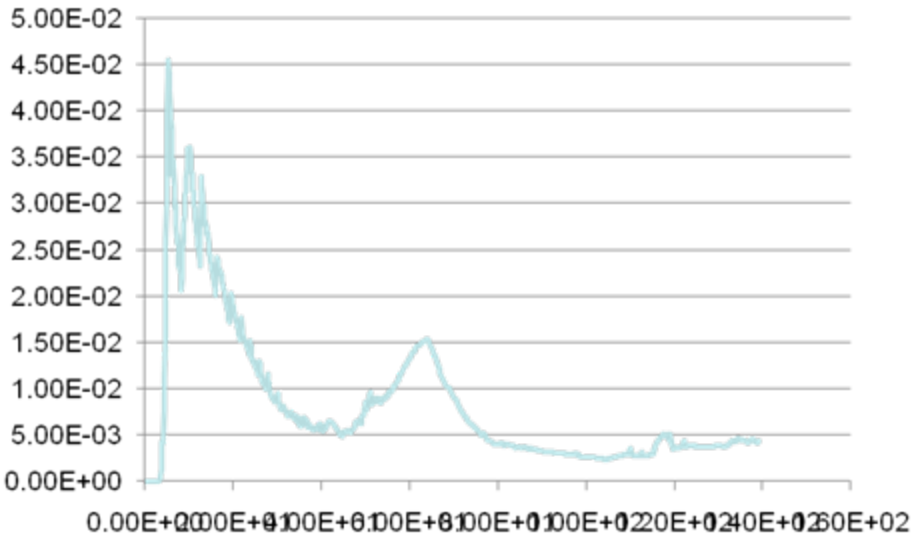


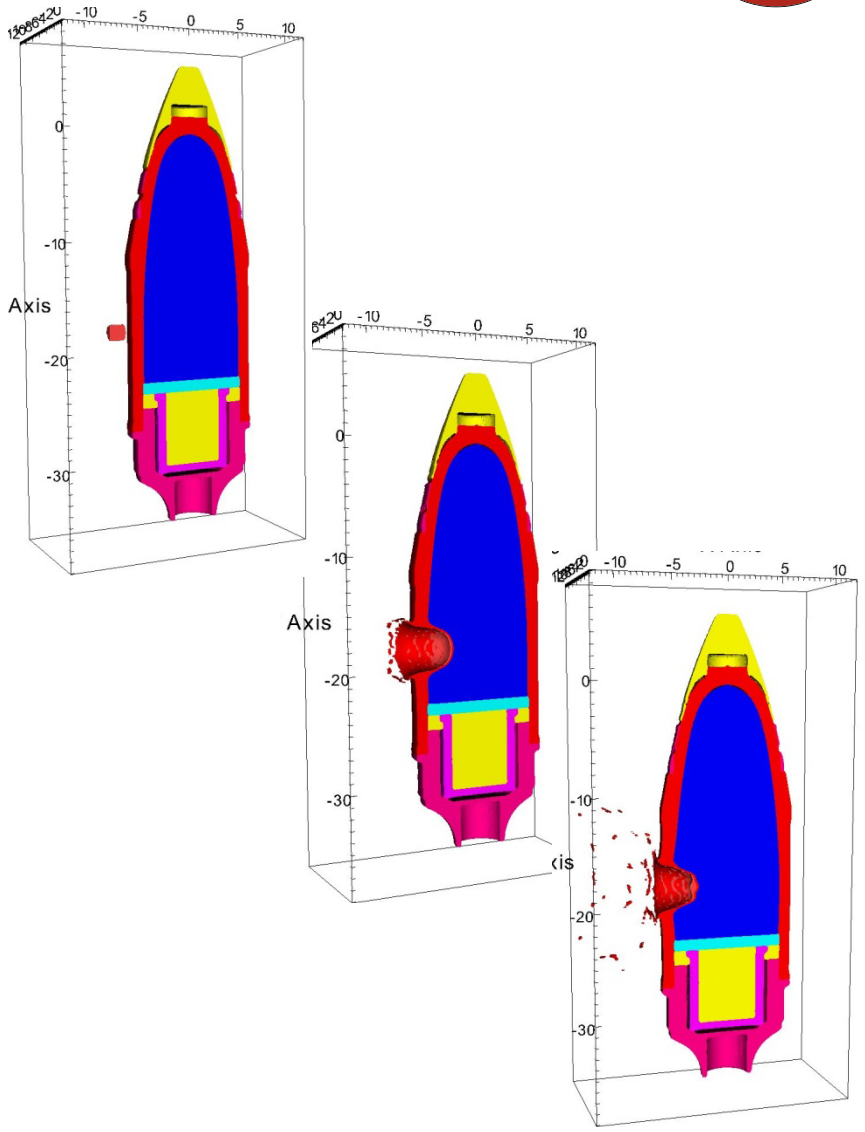






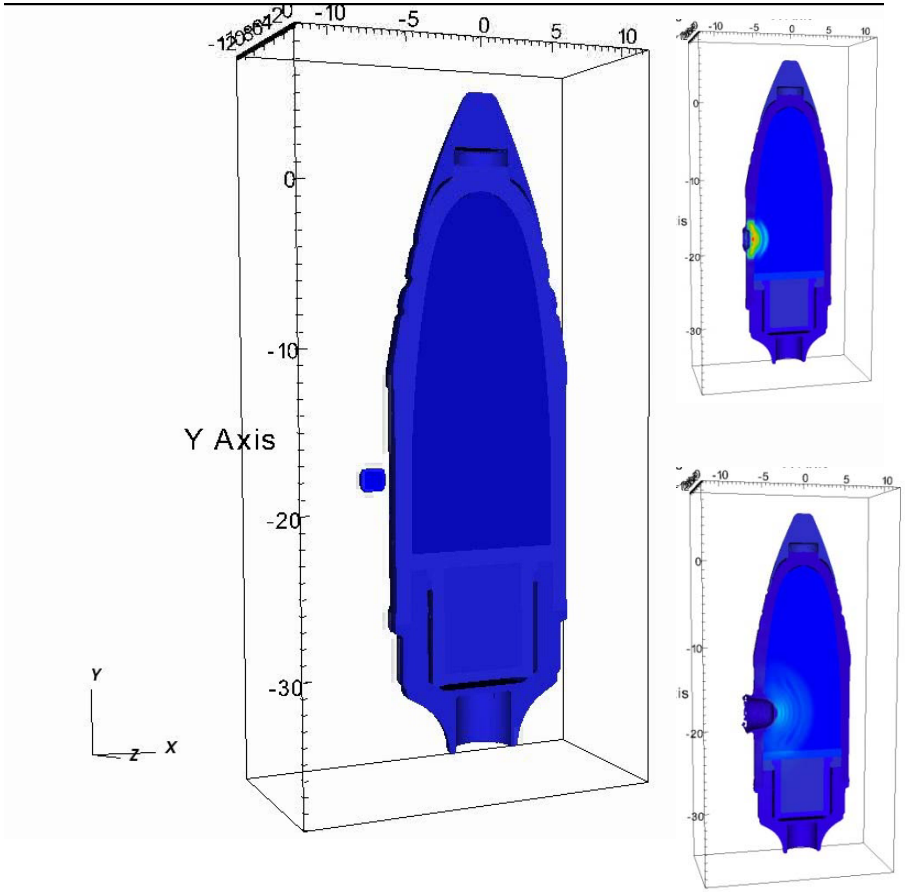
Plastic



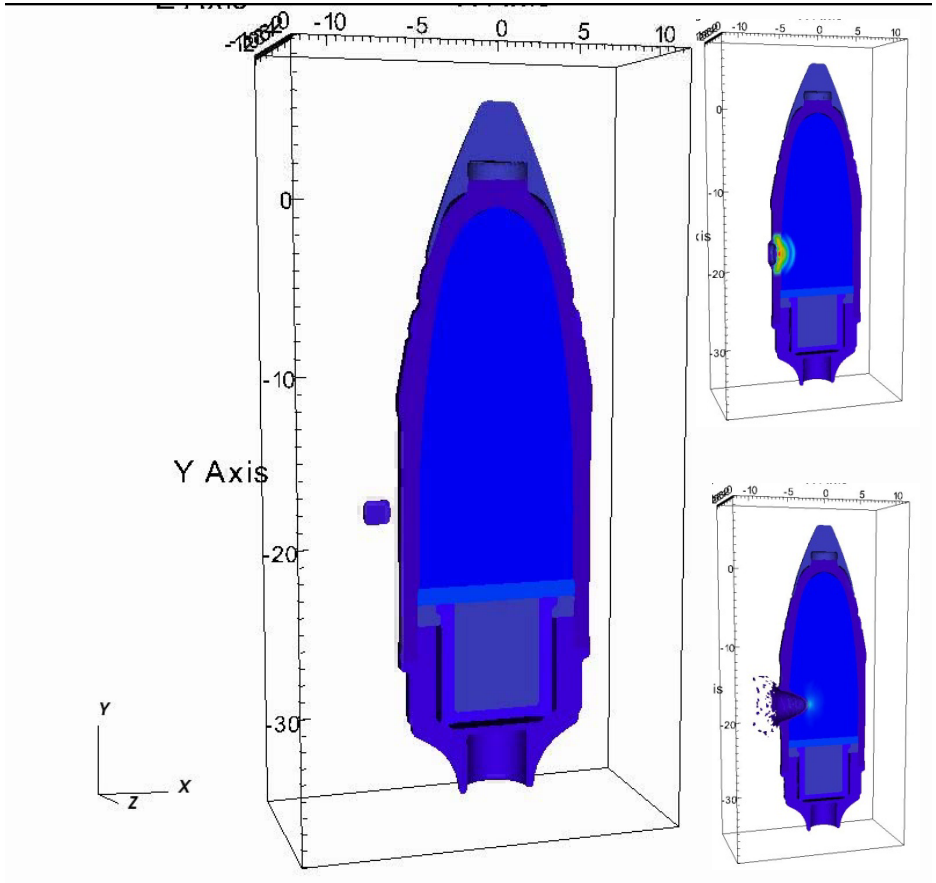


- Same computer cost as MG model
- Used PMMA or other plastic material with constitutive model
- Pressure peak at 45 kbar
- Added strength model makes penetration much more shallow

Animations



Inert Explosive Mie-Grüneisen
No constitutive model



Inert Explosive Mie-Grüneisen
Constant yield and shear modulus

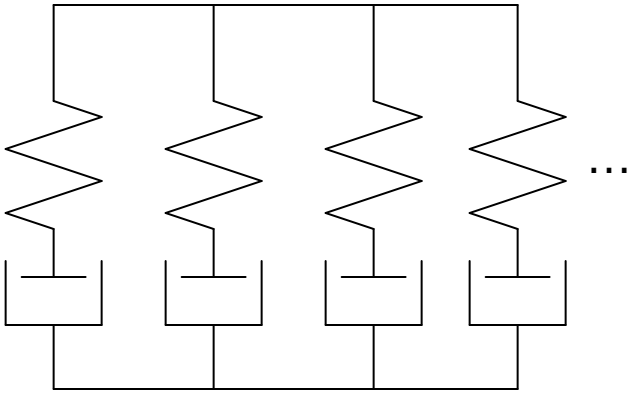
Visco-SCRAM, Visco-DCA

SCRAM

- Material is characterized by a number of springs and dashpots with statistical cracks
- Older version has thermal effects in cracks, new version does not
- Initially we only have PBX9501

DCA

- Also visco-elastic form of material
- Used for brittle HEs
- Behavior determined by “dominant crack,” not an average
- No thermal term, yet
- Initially we only have PBX9501



n Maxwell elements (Visco)

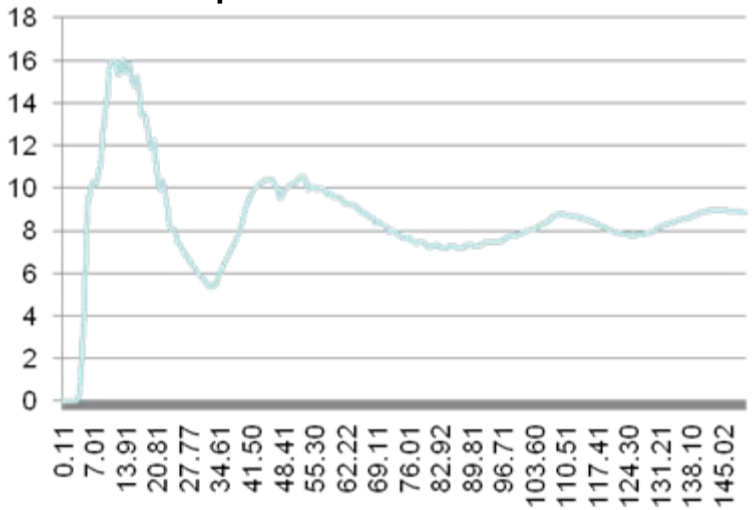
plus Statistical CRAck Mechanics (SCRAM)

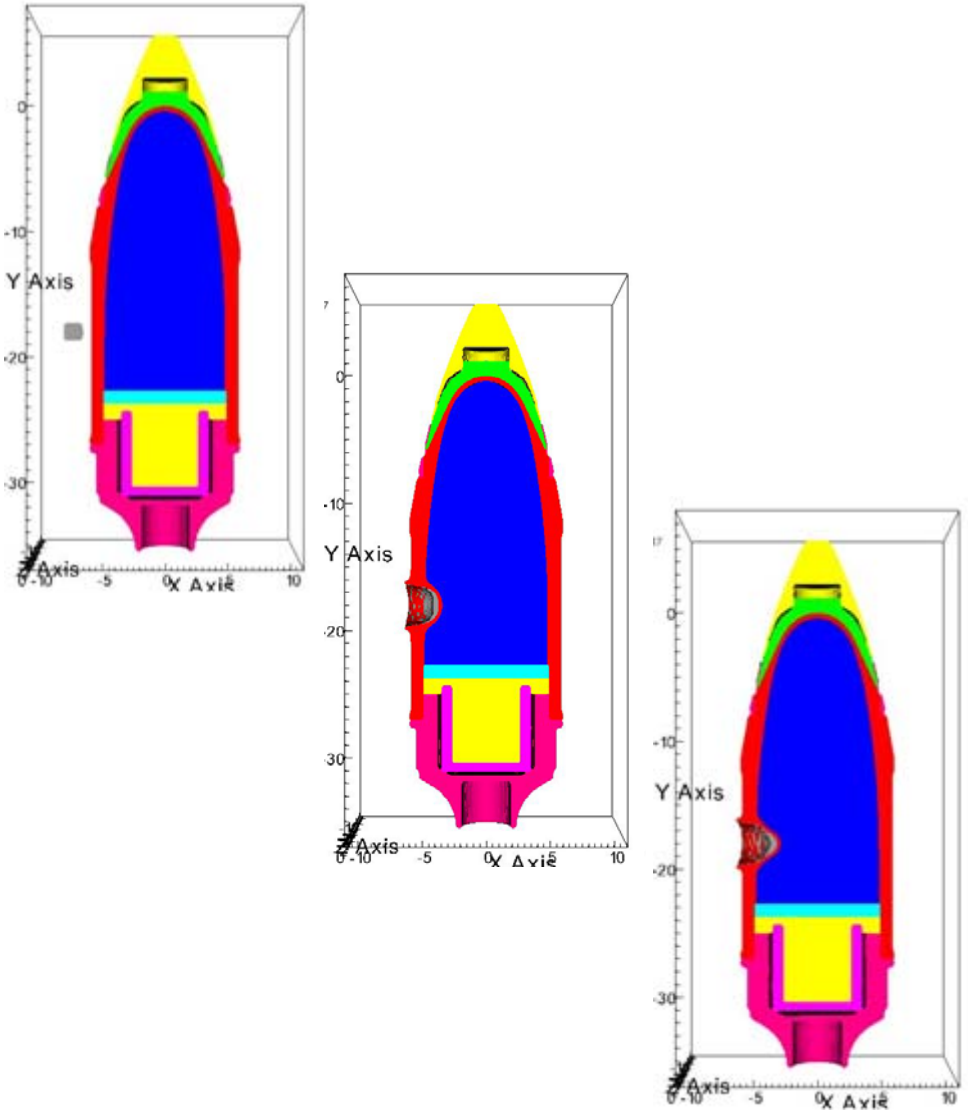
-or-

Dominant Crack Analysis (DCA)

Visco-SCRAM v1

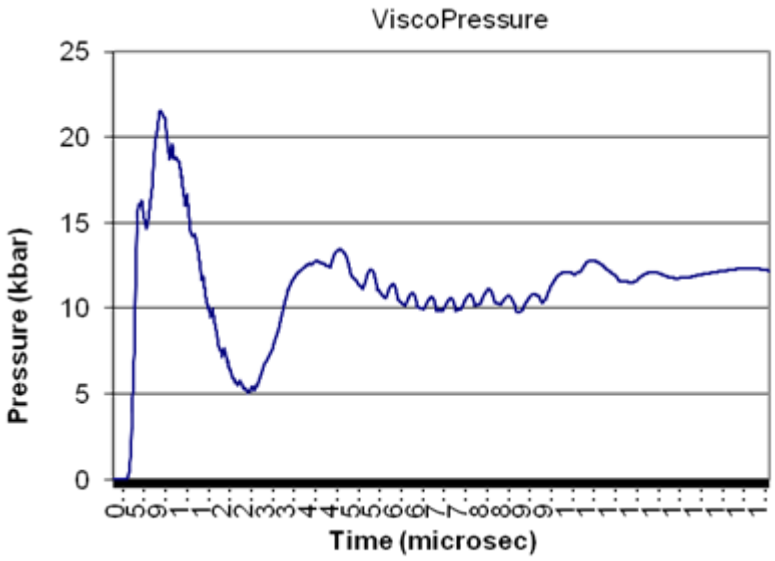
- Pressure peak is very low ~16kbar
- Fragment doesn't penetrate and even rebounds at the end
- Pressure trace shows damped oscillation
- Takes a very long time to run compared to MG

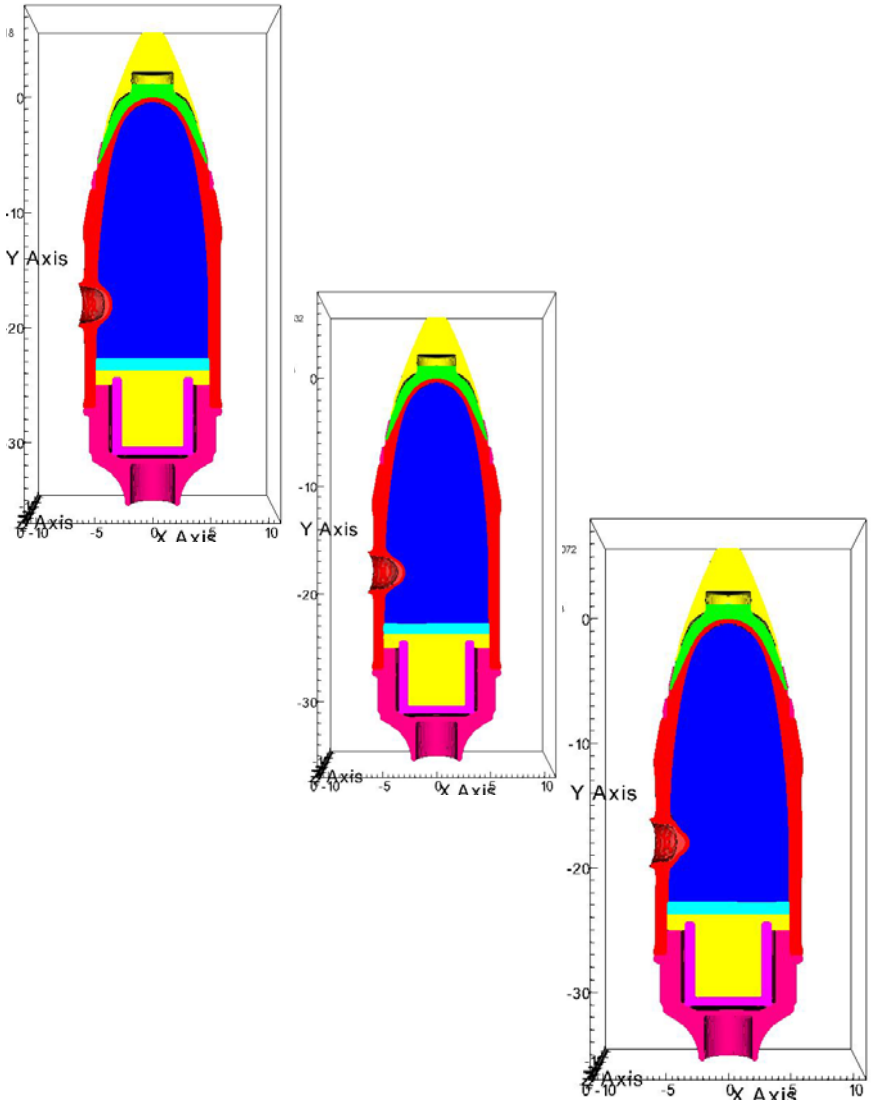




Visco-SCRAM v2

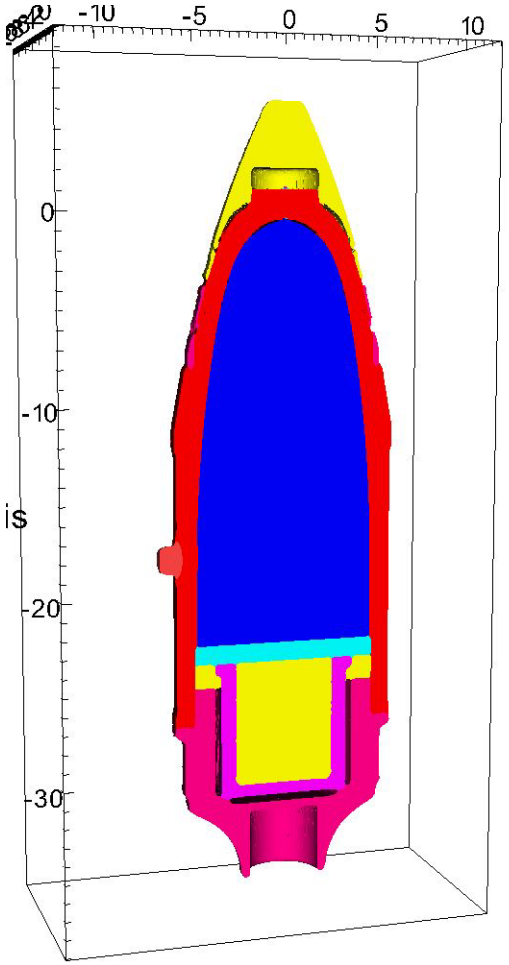
- Very similar to v1
  - Only crack mechanics updated
  - Hotspot model not included
- Pressure peak is higher than v1, lower than plastic





Visco-DCA

- Similar to Visco-SCRAM
- Differences would likely be in the damage morphology in the billet
- Much higher cost than SCRAM
  - Several days on 100+ processors



Experimental Results

- 5728 ft/s FI test conducted by General Dynamics
  - Type IV due to pressure and dent in witness plate
  - M&S Predicted 24kbar
- 2759 ft/s BI test
  - Type IV due to pressure and flight of closure disc

FI Judged to be a Type IV reaction

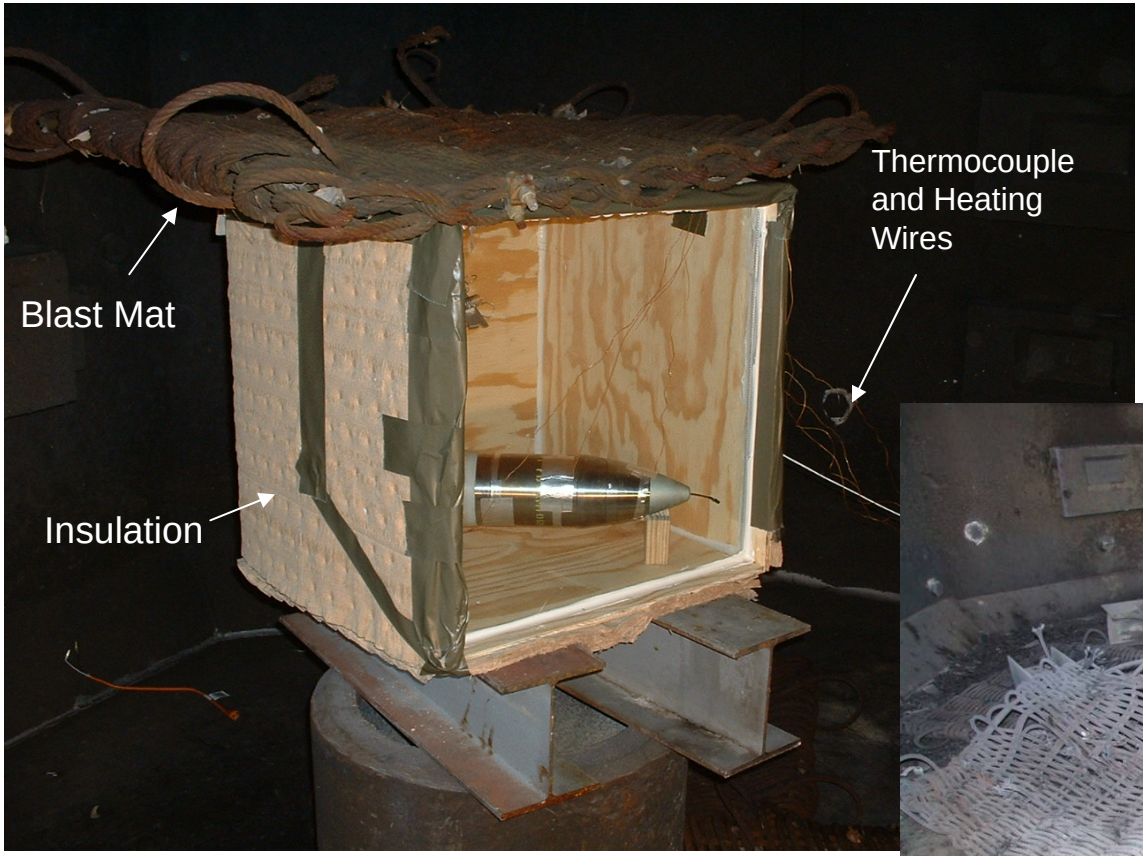
Unreacted PAX-3

BI Judged to be a Type IV reaction

Future Work

- Fragment Impact will be modeled and tested with a RM PIMS liner
- Liner creates a hugioniot mismatch which reduces transmitted pressure

Baseline Cookoff

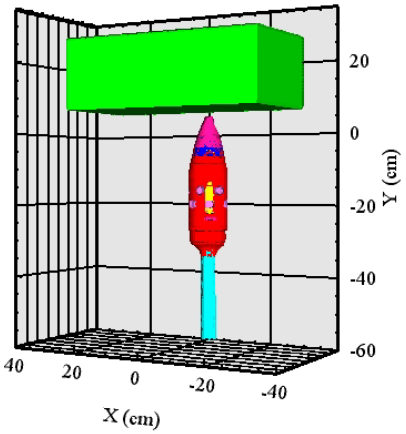


Baseline testing
50F/hr

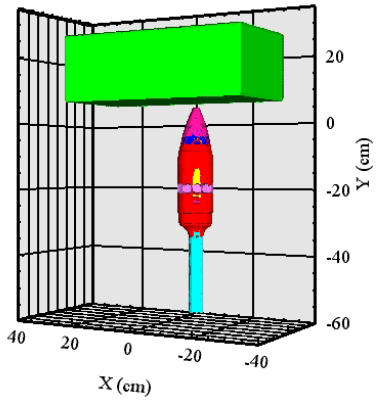
Type III (unofficial)

Cookoff Features

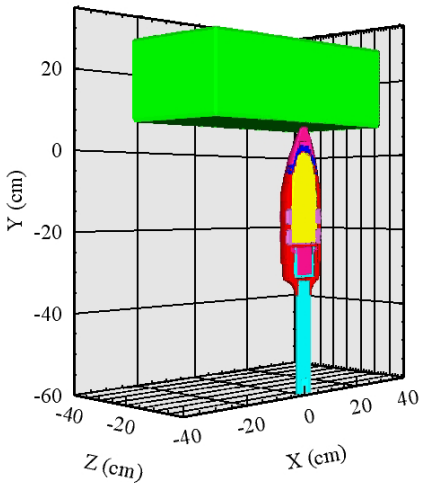
- Vent holes are needed to exhaust gasses during cook-off
- Vent hole size needed according to STEX testing: 12 holes x ø0.58”
- Modeling performed to see the effect of vent holes on performance



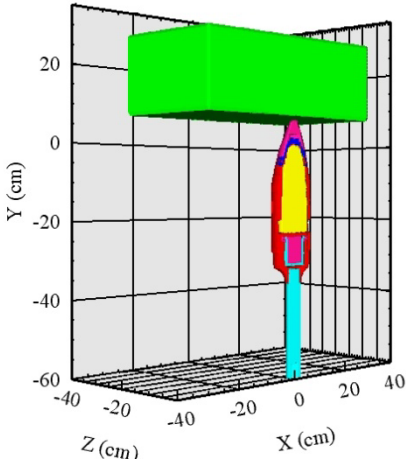
Offset holes



Aligned holes



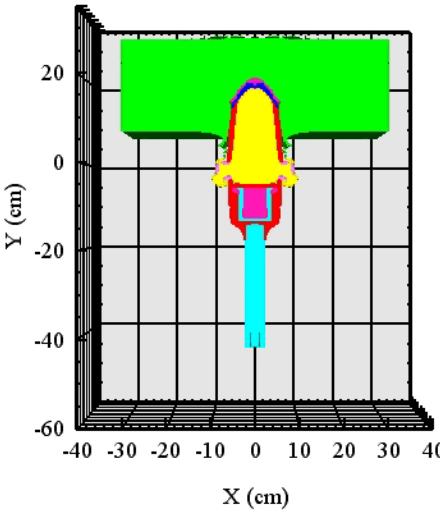
Aligned slots



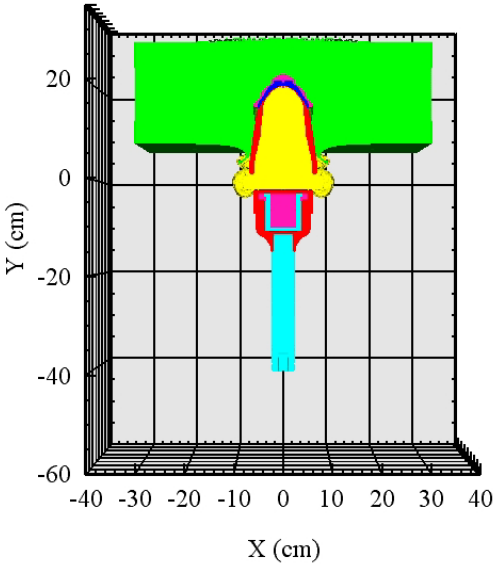
Staggered slots

Concrete Penetration

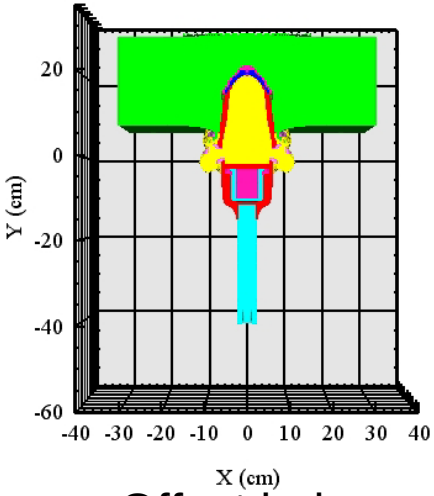
- All of the designs meeting the required vent area failed to penetrate
  - IM vents weakened the wall enough that the body collapsed



Aligned holes



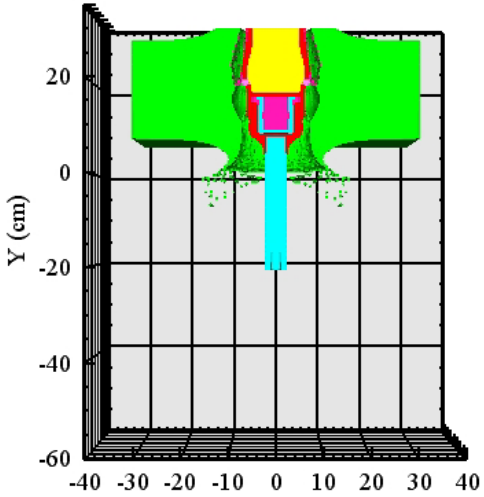
Staggered slots



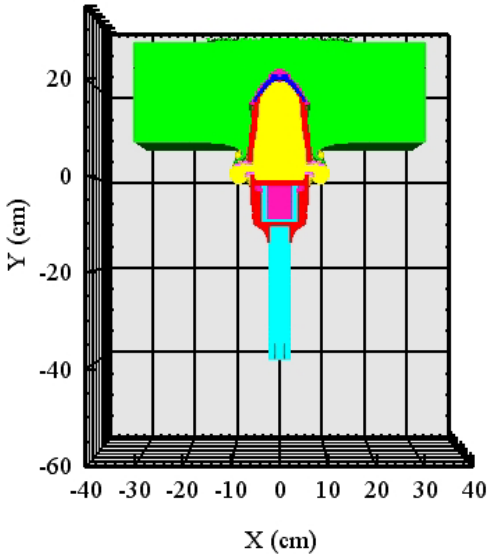
Offset holes

Concrete Penetration

- Design chosen: compromise vent hole size
  - ø0.30 holes found to penetrate
  - ø0.45 holes did not penetrate but made it ~2/3 through the wall
  - ø0.58 did not penetrate



ø0.30: Clears the target wall intact



ø0.45

Upcoming Work

- Vented design to be tested at ARDEC
- PIMS-lined warhead to be tested