



U.S. Army Research, Development and
Engineering Command

New Techniques in Producing and Controlling the Laboratory High-g Environment

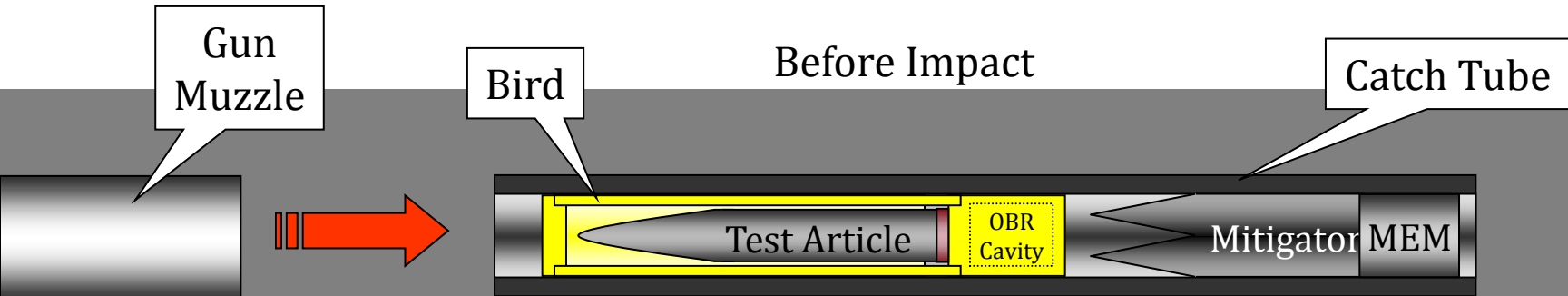
ARL

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

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- ARL's airgun facilities originated in the 1950's using a pressurized tube to propel a 40 lb projectile into a stack of lead blocks producing a high-g event that was useful in assessing the survivability of fuze hardware. The technology was motivated by
 - Low Cost
 - Rapid Turnaround
 - Immediate data availability
 - Soft launch, **NOT** soft catch
- Through several years and refinements the current configuration of ARL's airguns were developed
 - Driven by atmospheric pressure or light gas
 - Crushable Mitigator
 - Use of a Momentum Exchange Mass
- New Techniques for Generating/Using the Energy Available from an Airgun Have Been Developed
 - Solid Mitigator
 - Air Mitigator
 - External Payload
 - EM Braking

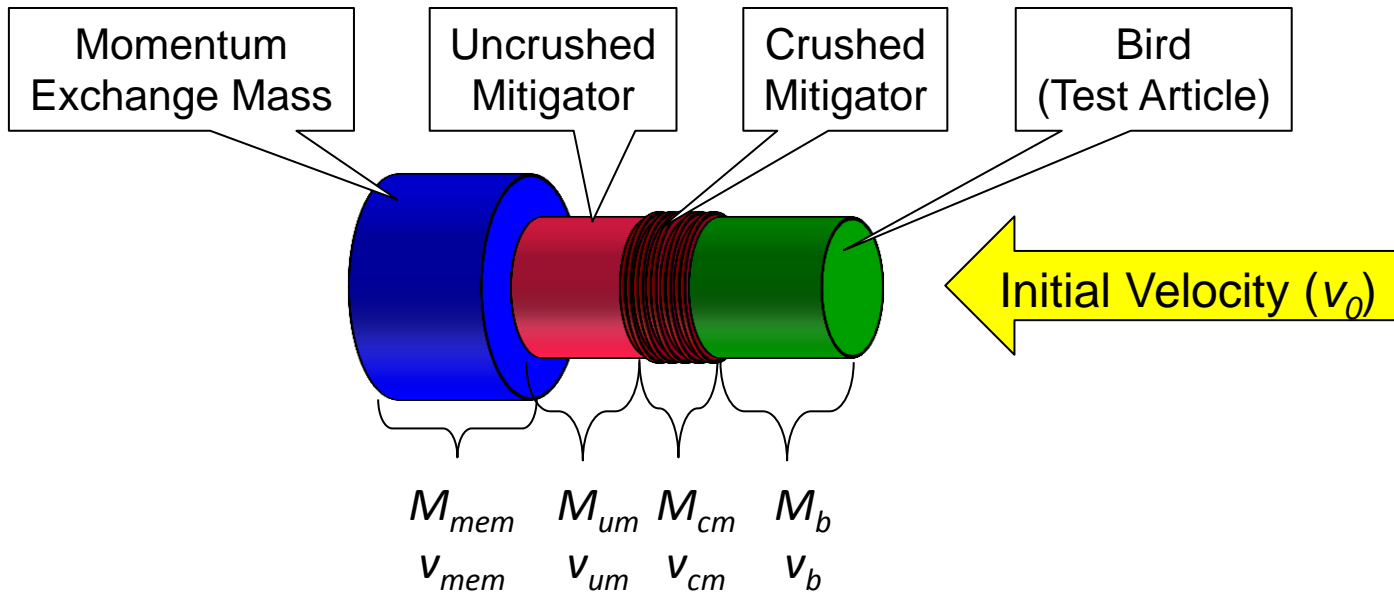
1. Bird is slowly accelerated in airgun by pressured gas or atmospheric pressure.
2. Bird exits muzzle and enters catchtube.



3. In catchtube, bird crushes shaped Al honeycomb mitigator to generated desired acceleration profile.
4. Test article remains stationary in catch tube and MEM exits back end of catch tube.

After Impact





Mitigator Mass:

$$M_{mit} = M_{cm} + M_{um}$$

Prior to impact :

$$p_{total} = M_b v_0$$

crushed mitigator joins bird $v_b = v_{cm}$

During Impact :

uncrushed mitigator joins MEM $v_{mem} = v_{um}$

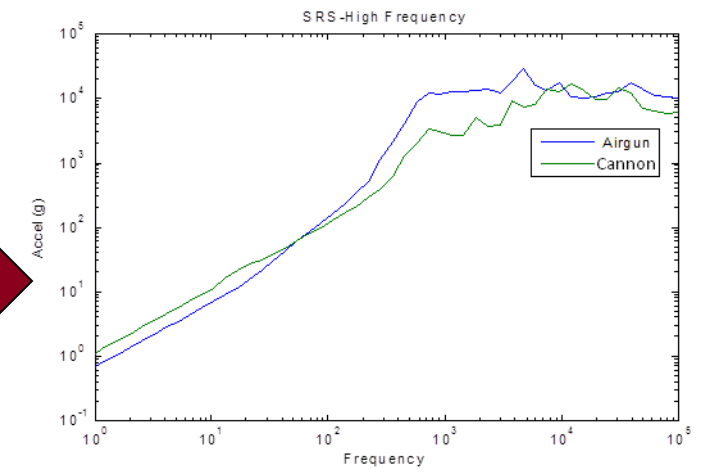
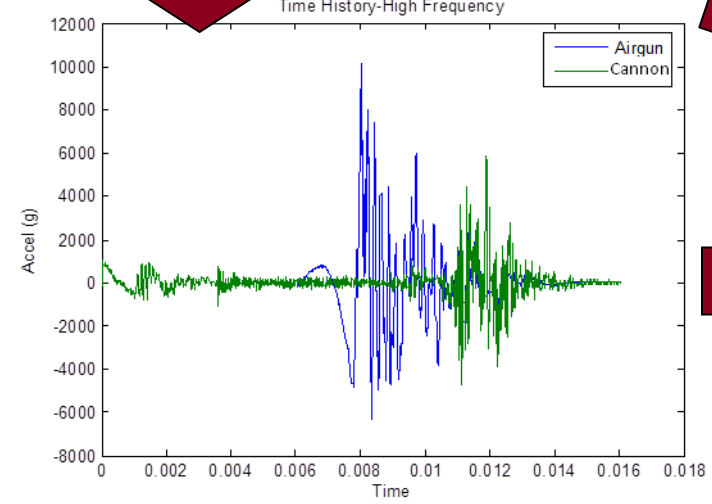
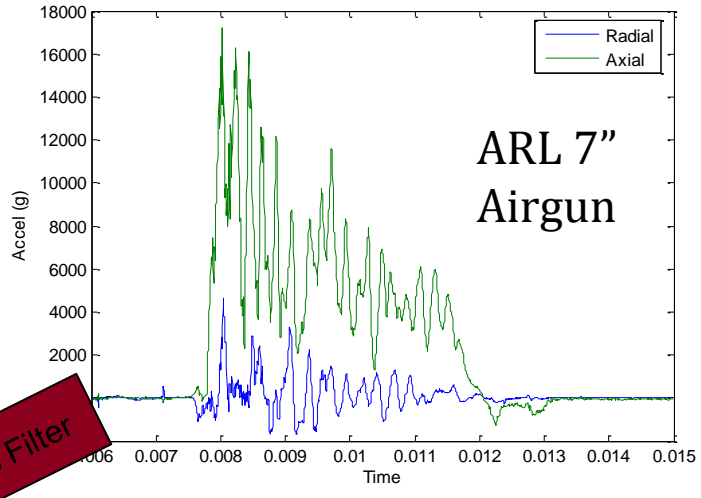
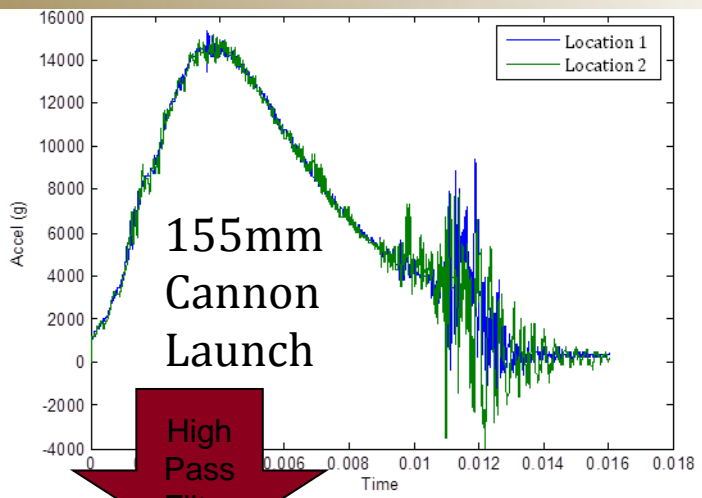
$$p_{total} = (M_{cm}(t) + M_b)v_b(t) + (M_{um}(t) + M_{mem})v_{mem}(t)$$

After Impact :

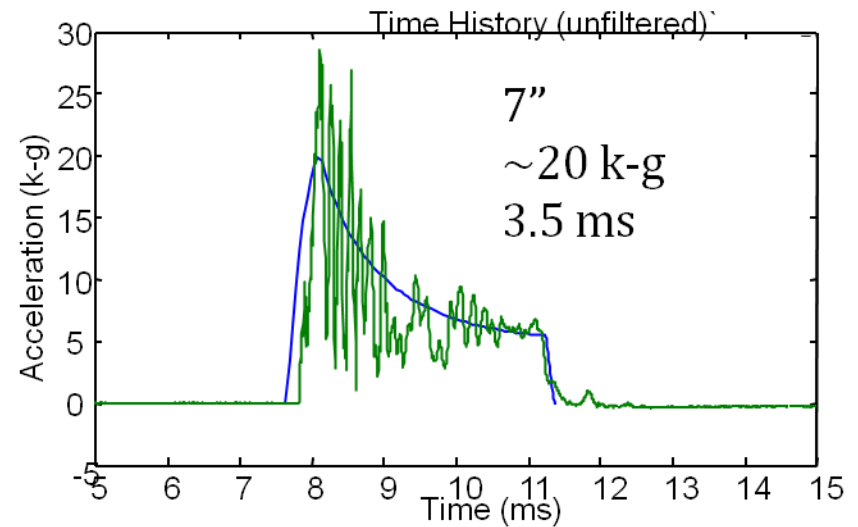
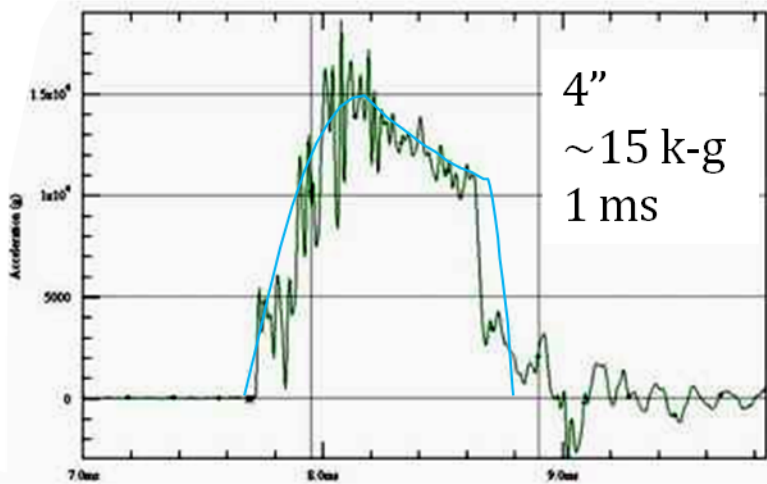
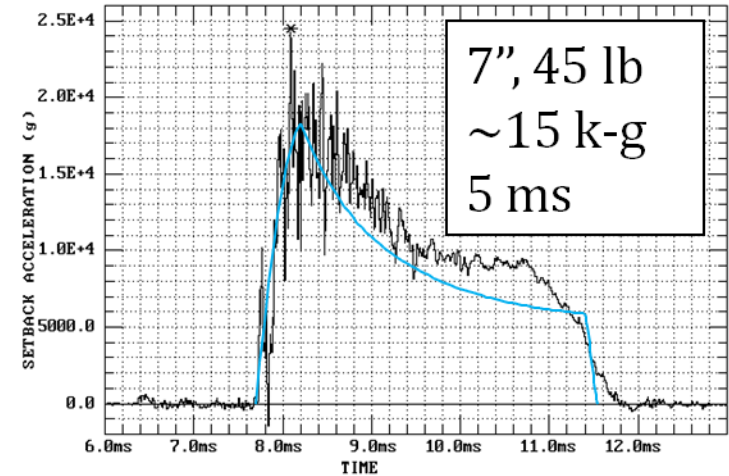
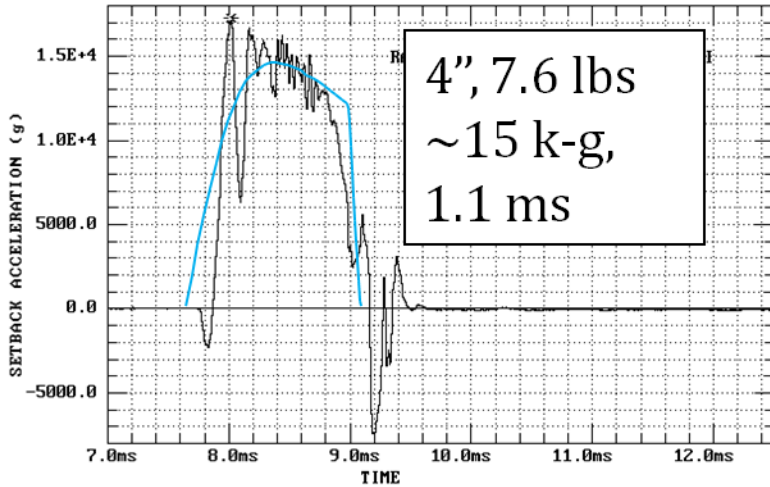
$$p_{total} = M_{mem} v_{mem}$$



Measured Acceleration



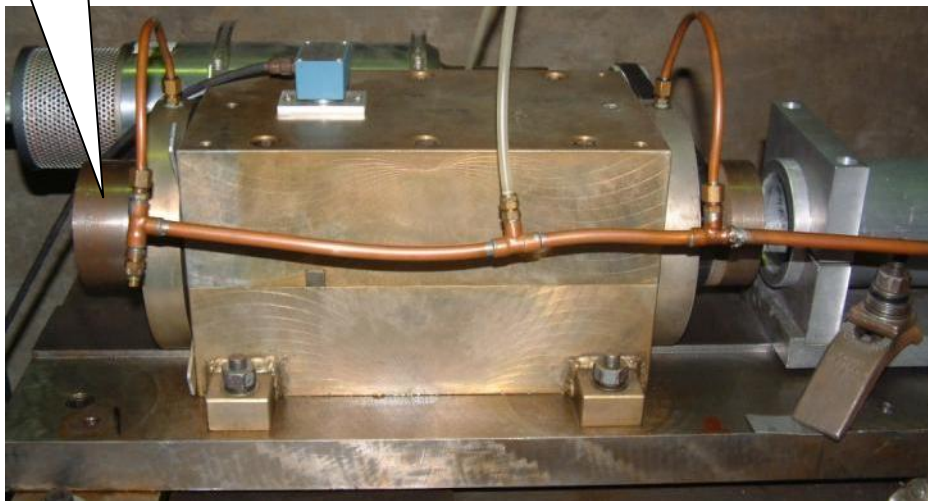
Dynamic Environment Comparable to 155mm Cannon Launch



1. Bird enters spinner and engages mitigator beginning the acceleration pulse
2. The bird is rapidly coupled to the spinner via frictional forces and the mitigator
3. Bird experiences simultaneous setback and spin environment comparable to launch from a rifled cannon

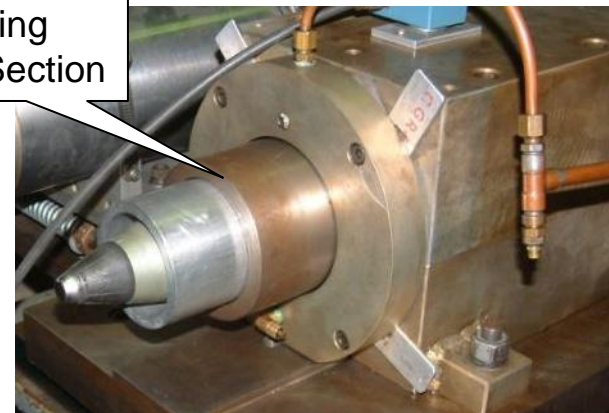
Spinning
Test Section

3" Spinner

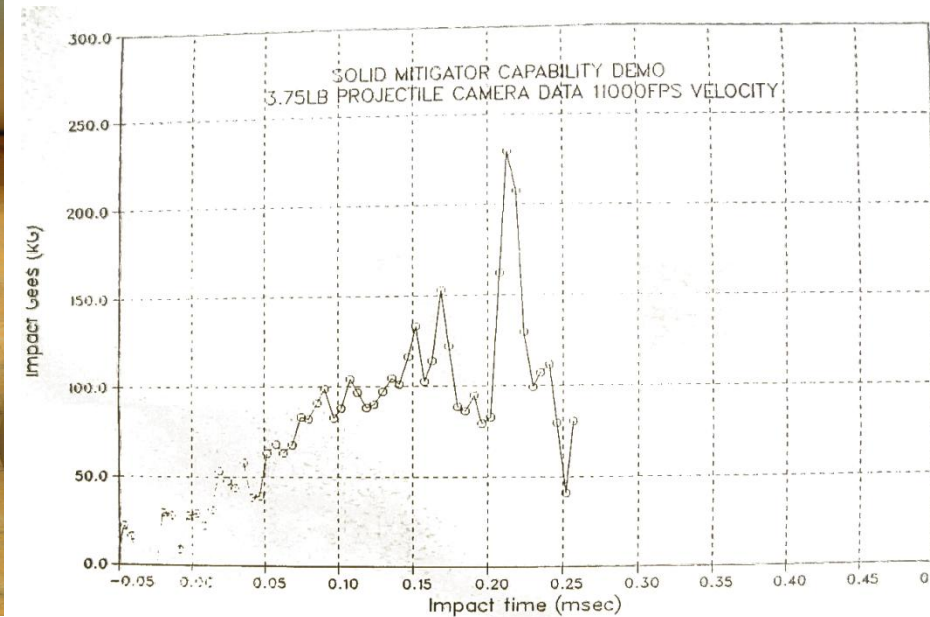


Test Article in Spinner

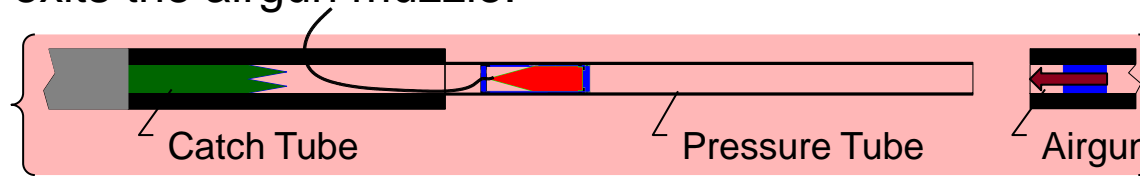
Spinning
Test Section



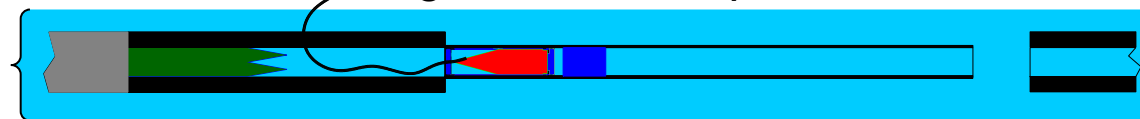
- Solid Mitigator Permits much High Acceleration Environments (100+ k-g)
- Pulse Length is much Shorter
- Understanding Crush Process of Solid Mitigator is Critical to Its Design



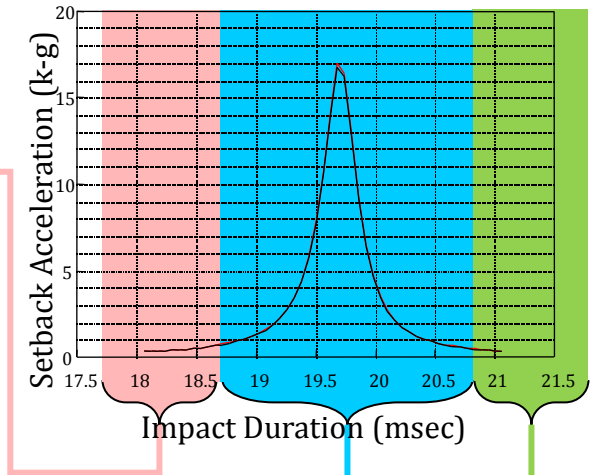
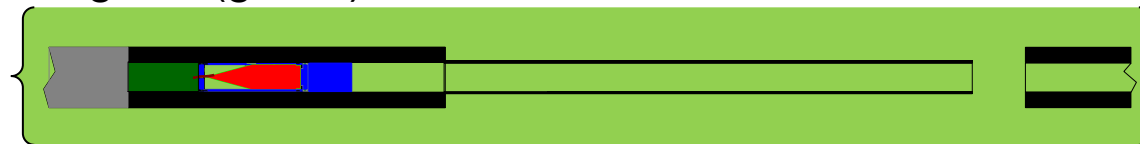
Test article (red) is prepositioned in the pressure tube with ground instrumentation. Energy Projectile (blue) exits the airgun muzzle.



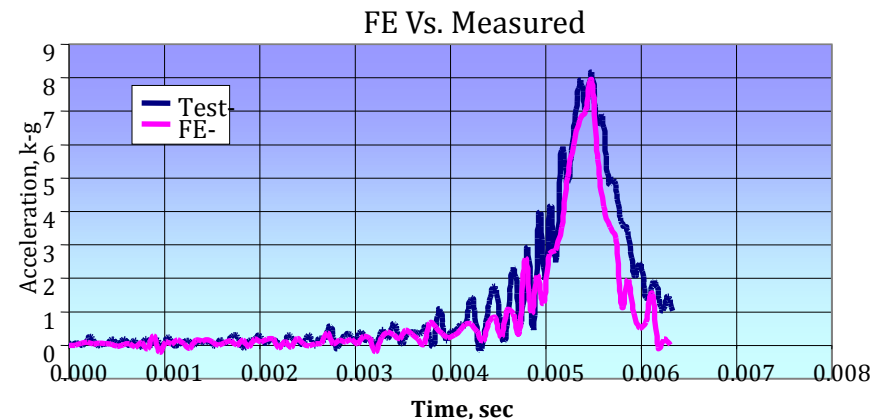
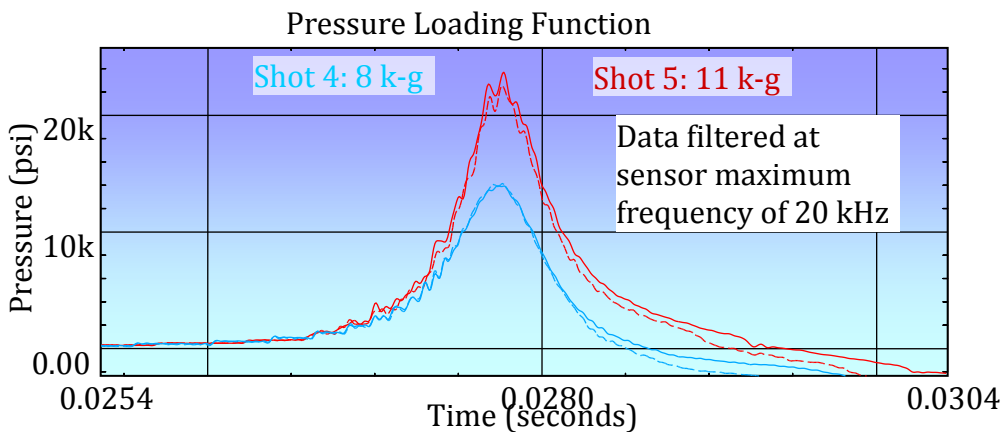
Energy projectile enters pressure tube and builds up pressure against test article (red). Test article (red) accelerates creating acceleration pulse.



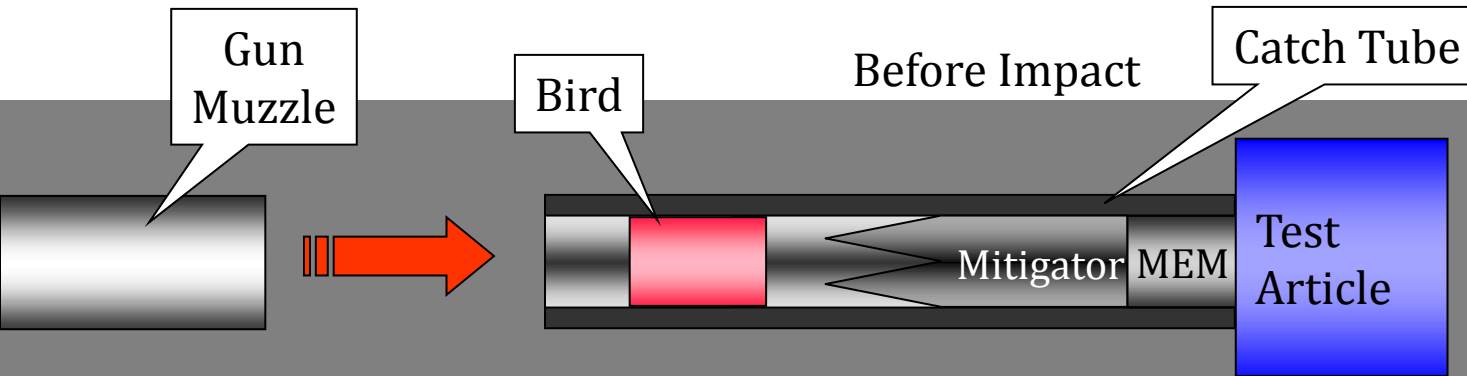
At conclusion test article (red) is stopped by crushing mitigator (green).



- Test article can be measured with unlimited channels by ground instrumentation
- No contact during test pulse
- Direct measurement of forcing function
- Test article must be soft-stopped
- Smooth loading pulse

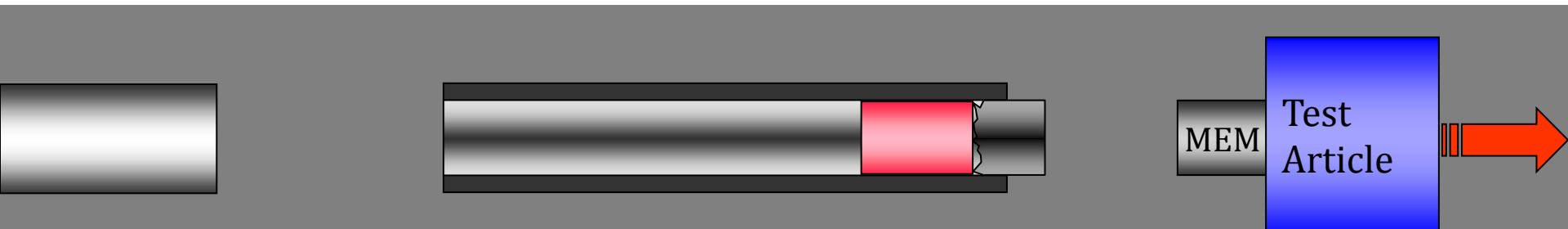


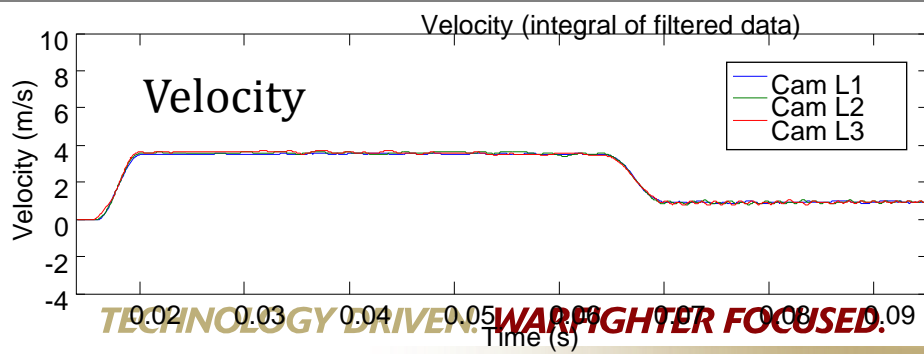
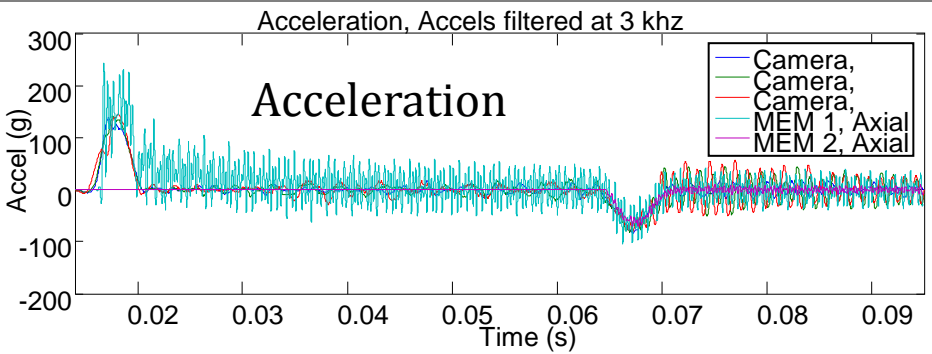
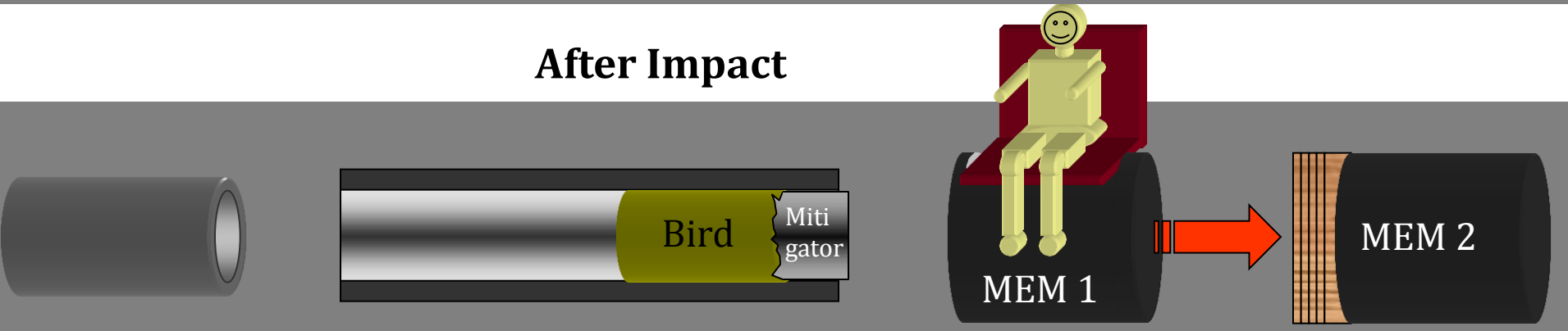
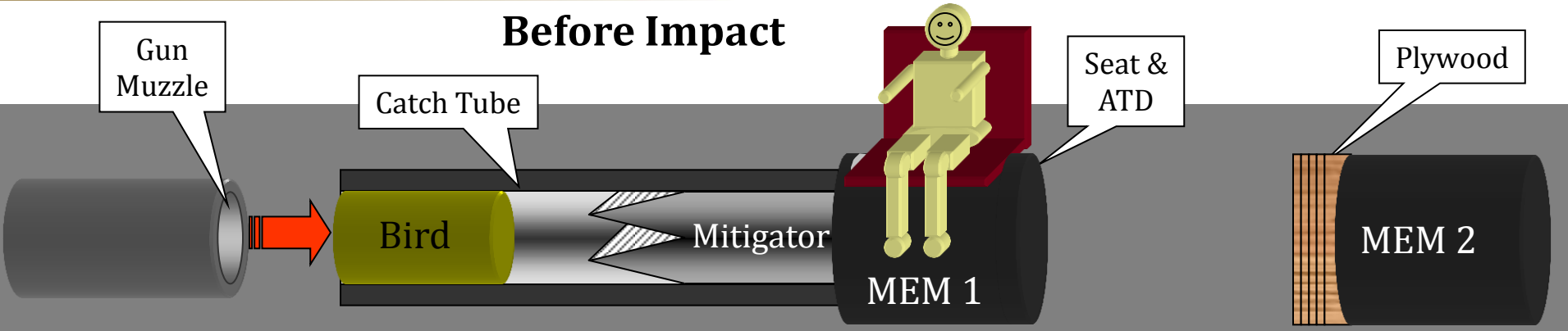
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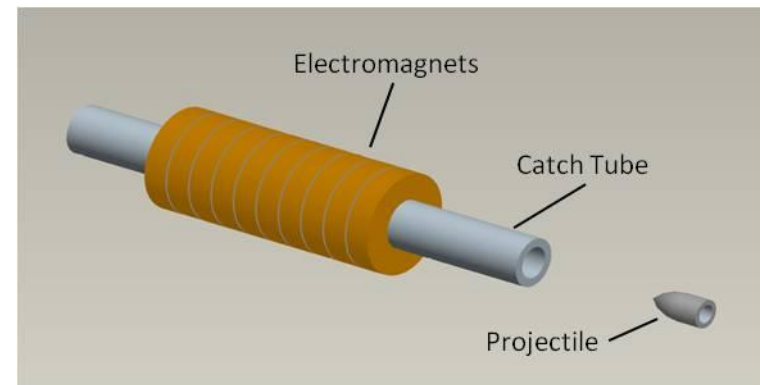
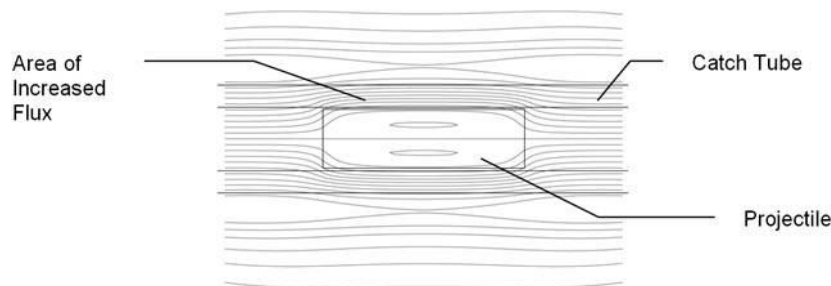


- In FY09 (phase I) proposals were solicited for an SBIR topic “High-G Simulator for In-Flight Test Article.”
 - Develop a technology that can simulate the interior ballistic environment of a cannon launch as well as other high acceleration events.
 - Deliver a concept capable of stopping a 60 lb projectile traveling at 900 ft/s with a deceleration pulse that varies from 5 k-g to 50 k-g and a duration that varies from 1 ms to 5 ms.
- In FY12 a two year phase II award was made to deliver a prototype device for use with the 3” airgun capable of the following:

Projectile Mass (lb)	Projectile Velocity (feet/sec)	Peak Acceleration (kilo-g)	Minimum Duration (ms)
5	280	15	1.0
5	750	50	1.5
1	600	15	2.5
1	1000	50	1



- Magnetic braking technology will be used to stop the projectile
- Acceleration pulse profile programmable
 - Test article subjected to more consistent environment
 - Wide variety of high-g environments can be simulated
- Smooth deceleration curve
- Expendable materials eliminated
- Anticipated phase II completion of Sep 2013



graphics downloaded from <http://www.sierralobo.com/pages/highmagneticcapture.aspx>

- Low Cost High-g Simulation Environment
- Immediate Test Article Availability Post-Test,
- Soft Launch **NOT** Soft Catch
- Highly Flexible Configuration

– ARL's Conventional Airgun

- Up to 7" diameter test articles
- Up to 100 lb projectile
- Up to 200 k-g
- Up to 2000 ft/s

– Electromagnetic Method

- Digitally programmable pulse profile
- Highly repeatable environment

– Air Mitigator Technology

- Smooth loading curves
- Direct forcing function measurement
- Ground based instrumentation

– External Payload

- Unlimited test article volume & mass (acceleration dependent)
- Ground based instrumentation

