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Title:	Fast Closure Development for the Confinement Subsystem of the LBPG System
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ABSTRACT

Fast Closure Development for the Confinement Subsystem of the LBPG System

The Large-Bore Powder Gun system has been under development at LANL for the past few years. The system will serve to conduct shock physics experiments on plutonium. One of the main technical challenges for the system is achieving a fast closure design that is reliable, and can operate over the entire operating profile of the gun system. The current status of the work to develop the fast closure design is given in this presentation.

Large-Bore Powder Gun Project

Fast Closure Development for the Confinement Subsystem of the LBPG System

November, 2011

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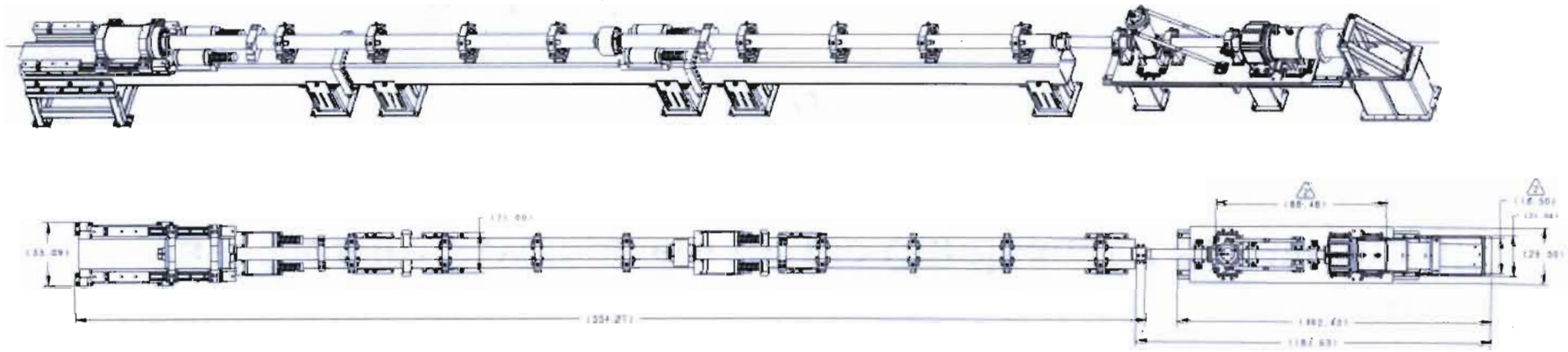
Los Alamos National Laboratory

Large-Bore Powder Gun Project

LBPG Integrated System

Launcher Subsystem

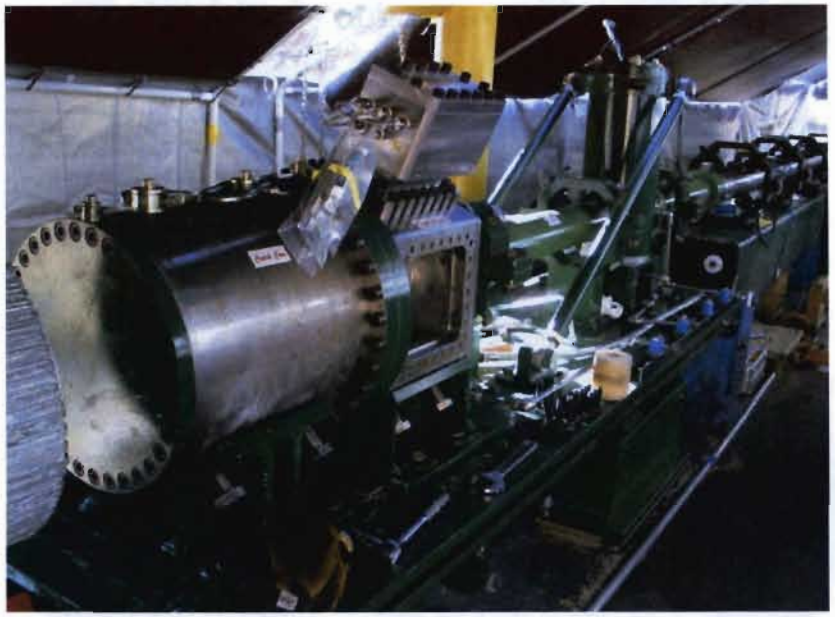
Confinement Subsystem



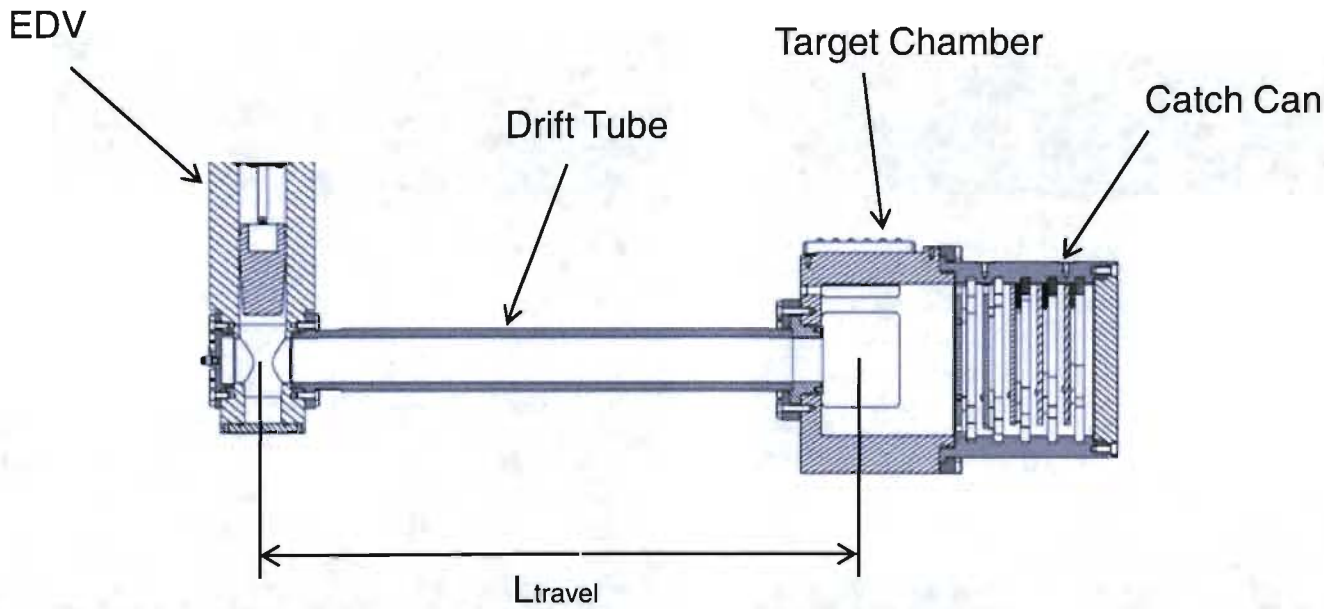
Large-Bore Powder Gun Project

Launcher

Confinement



Large-Bore Powder Gun Project



Ltravel is the approximate projectile travel distance from the EDV to the impact experiment sample.

Ltravel ~ 54 inch (1.37 meter)

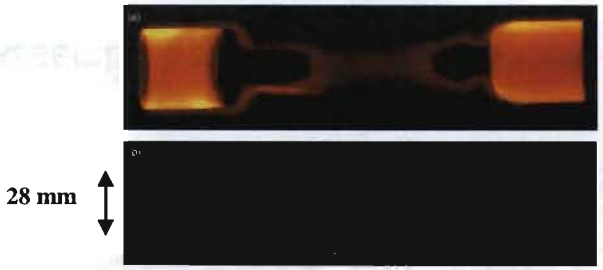
The T&F projectile travel distance from the existing barrel sensing location to the impact experiment sample is 145 inch, (3.68 meter). The system available time response window from the projectile passage sensing to sample impact at 2.0 km/sec is 1.8 milliseconds.

Large-Bore Powder Gun Project

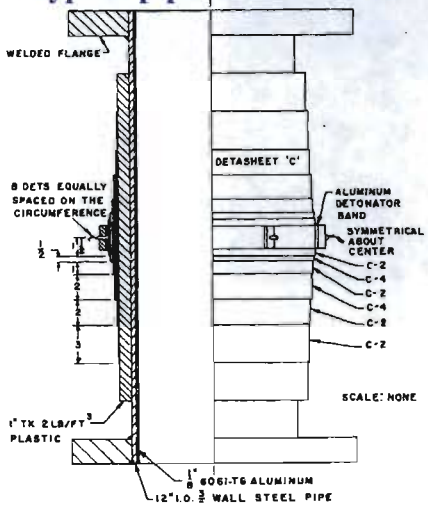
- Ancho gun system used a tandem valve configuration:
  - 95% closure valve using 2-flat pistons (debris block)
  - 100% closure valve using tapered piston (leak-tight)
  - 1100 Al pistons to improve seal and minimize system time
  - Allowed free-flight of piston prior to entering containment
- Pipe-closure technology available
  - Optimal for system with projectile free-flight

Containment system for 2-stage gun (EDV view)

JASPER Fast-closure



Typical pipe closure valves



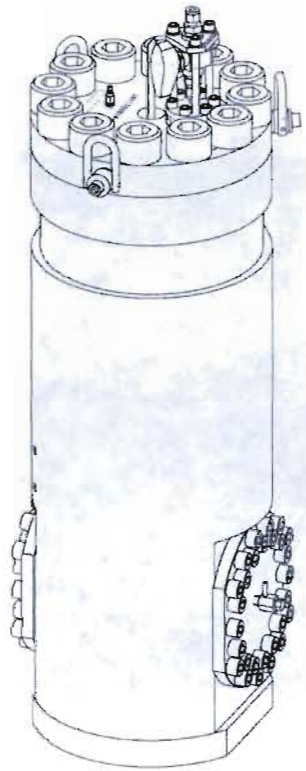
Large-Bore Powder Gun Project

Explosively Driven Valve

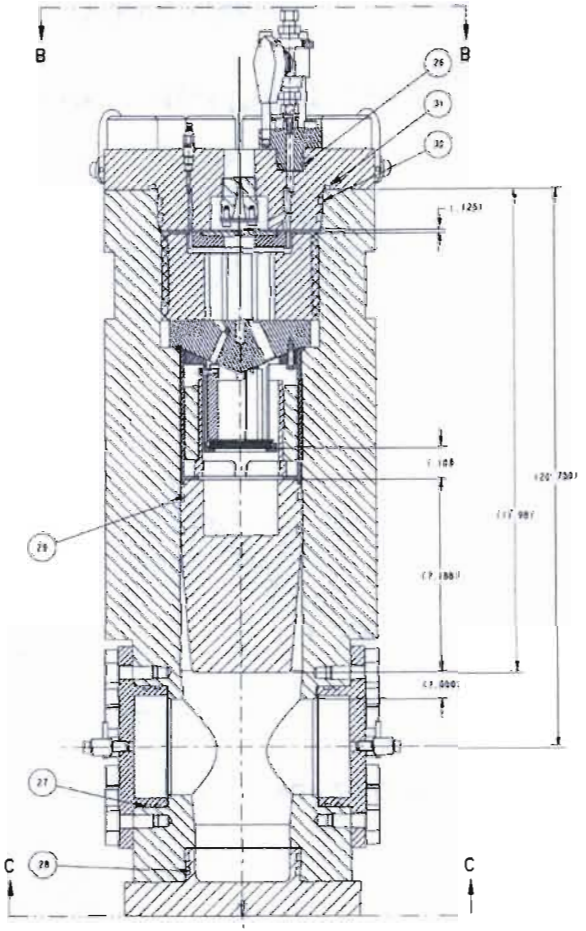
Main Attributes of the Current EDV Design

- Assembly weight: 560 pounds
- Piston weight: 8.3 pounds
- Piston material: aluminum 6061 alloy, fully annealed, S_y ~ 7,000 lb/in**2
- Body material: AISI 4140 steel, S_y ~ 110,000 lb/in**2
- Maximum high explosive charge in breech: 85 grams PBX9501
- Closure time: less than 1.6 milliseconds

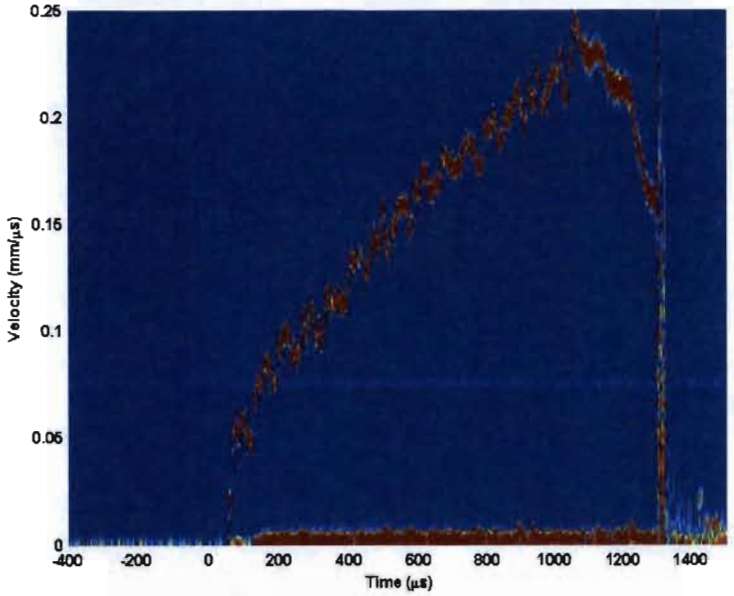
Large-Bore Powder Gun Project



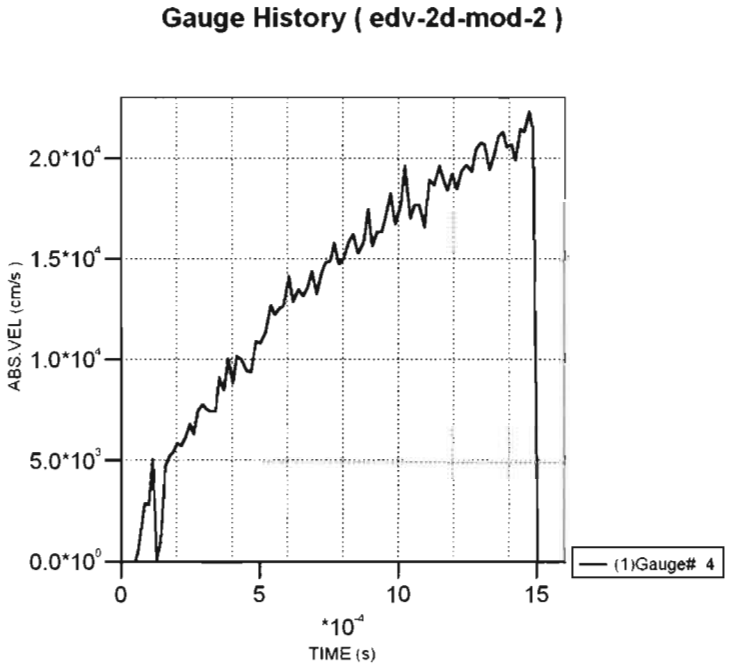
Most Current EDV Design



Large-Bore Powder Gun Project



- Test Measured Piston Velocity (no gas flow load)
- Peak = 0.25 km/sec
- Closing Time ~ 1.3 millisec



- Model Predicted Piston Velocity (no gas flow load)
- Peak ~ 0.23 km/sec
- Closing Time ~ 1.5 millisec

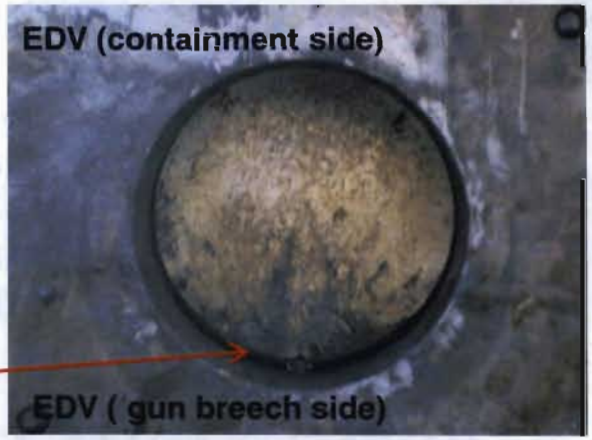
Large-Bore Powder Gun Project

- The first test using an EDV maintained containment, ~7 lbs M14 propellant used in the launcher.
- The aluminum deformation is visible on the containment side, but not on the breech side.
- A small gap is observed from the EDV bottom (on breech side).
- Piston depth is approx. 1.75-2" (less than prototype tests).
- The EDV closure at 7 lbs of M14 propellant in the launcher is reproducible.

EDV (containment side)

EDV (breech side)

EDV (bottom)



Gap

Piston depth measurement

Large-Bore Powder Gun Project

- With a launcher breech powder loading of nominally 11 pounds of M14 propellant the projectile velocity is approximately 1.8 km/sec, the EDV cannot close in this flow regime, the piston stops in the flow cavity.

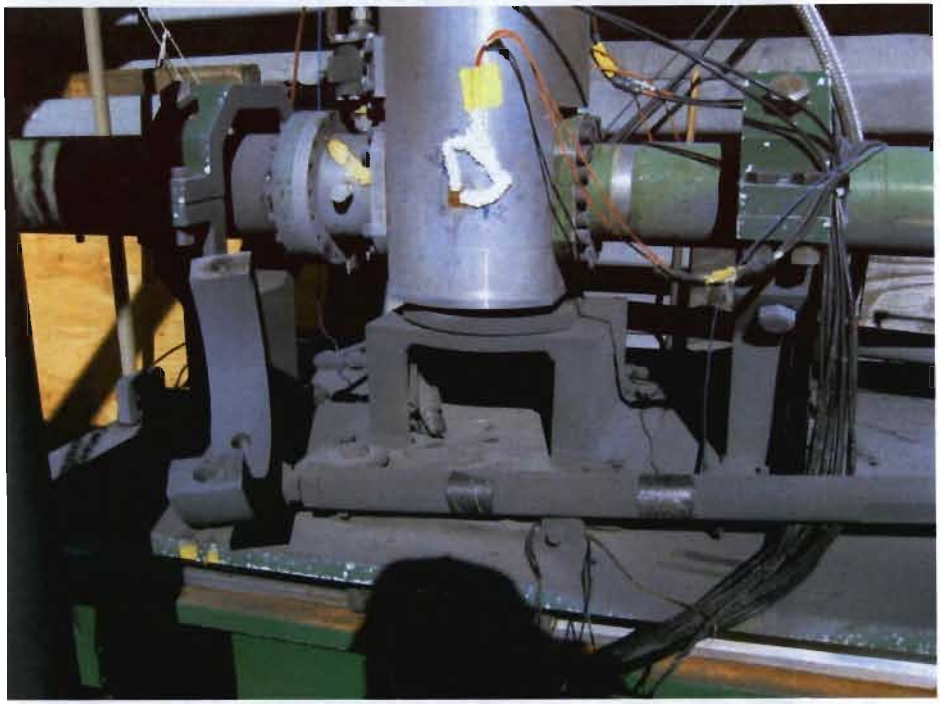
- The piston stopping in the flow cavity leaves it vulnerable to damage by high-temperature gas flow erosion.

Large-Bore Powder Gun Project

- The EDV failure in IST-7 (11 lbs M14 propellant in the launcher, vel~1.8 km/sec) was likely caused by the piston being over-driven into the seat.

- The EDV used a hybrid charge made of 55 grams of PBX9501 and 200 grams of IMR 4350 powder in the breech to drive the piston.

- The aluminum extruded into the lower volume below the seat, and caused a separation of the bottom sealing flange, and the entire inventory of high temperature gas escaped the system.



Large-Bore Powder Gun Project

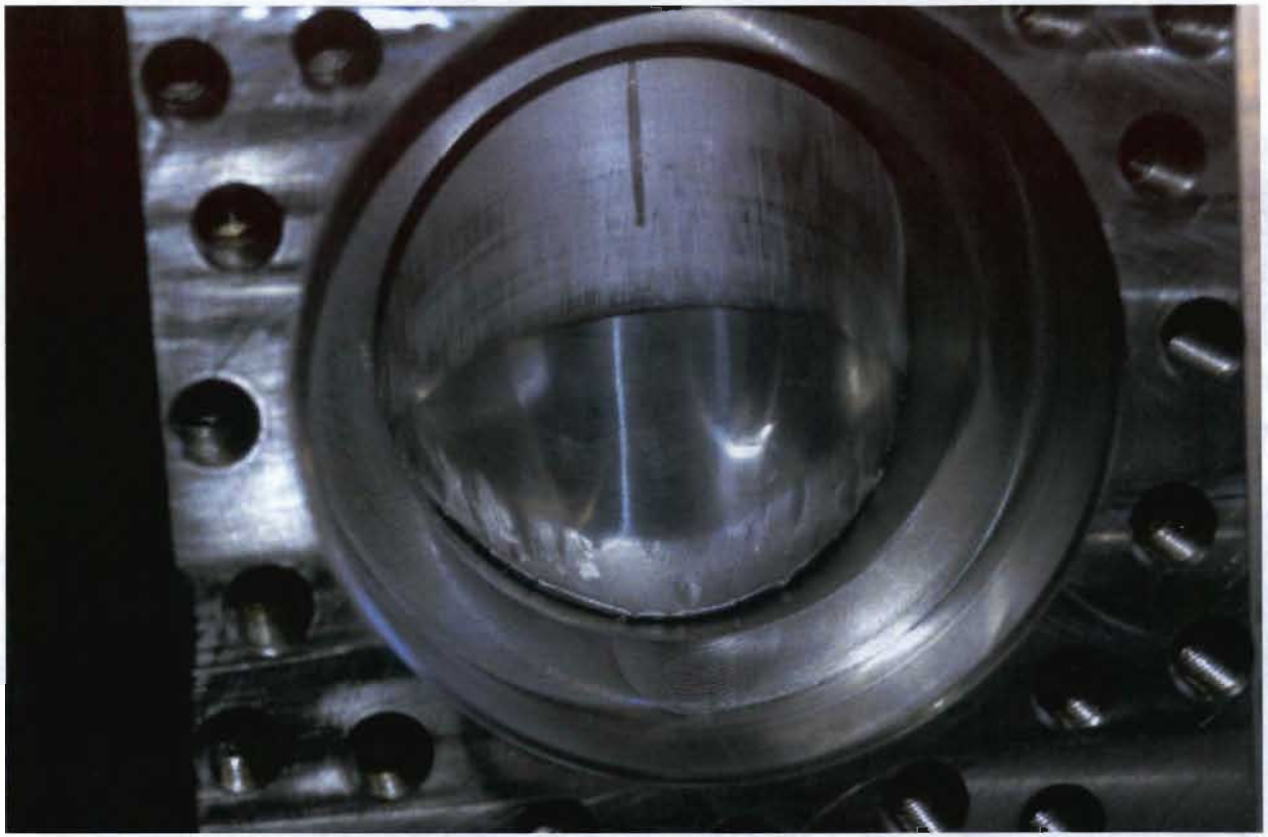
- The breech section of the EDV was redesigned to address some moderate problems in the design.

- An EDV stand-alone test with the new breech design was conducted in order to check the functioning with no propellant gas flow load present.

- The piston was driven into place, and a proper seal established.

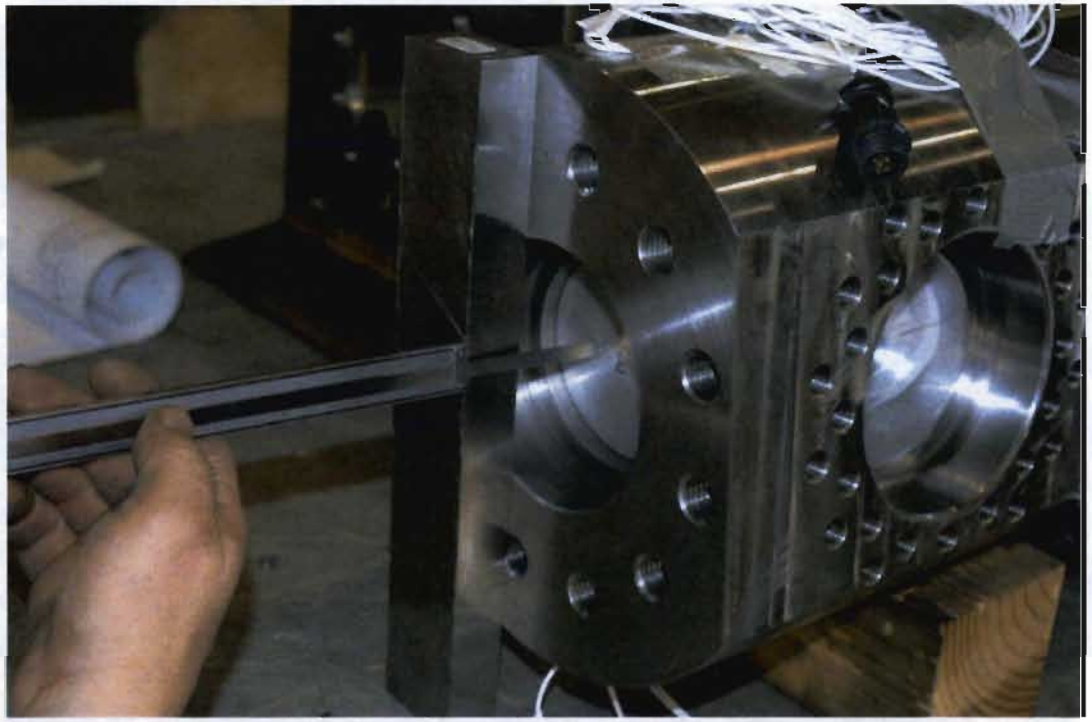
Large-Bore Powder Gun Project

EDV stand alone test – Piston closure with metal peel established indicating a good seating and deformation into a gas tight seal.



Large-Bore Powder Gun Project

Piston seat depth is within the allowable range, no threat to contact the lower sealing flange.



Large-Bore Powder Gun Project

- The current EDV design uses a relatively weak material (fully annealed 6061 aluminum) for the piston in order to undergo the proper deformation, and achieve a gas tight seal. It was not predicted to be possible to impart much more impulse to the piston without damaging it upon launch or seating.

- An upstream flow interrupting device was understood to be needed in order to lower the propellant gas load on the traveling EDV piston.

- The flow interrupter design using two colliding pistons is seen as having two distinct advantages over the existing EDV design alone, i) the high dynamic seating load is balanced with two pistons in motion at the time of collision, and ii) each piston could be made of high strength aluminum because the piston deformation for a gas tight seal was not needed. Only enough piston material deformation is needed for locking the pistons into place.

- The FI is not required to bring the propellant gas flow to complete rest, only to reduce the down stream flow load to where the EDV can close and seal reliably across the whole launcher projectile velocity operating range.

Large-Bore Powder Gun Project

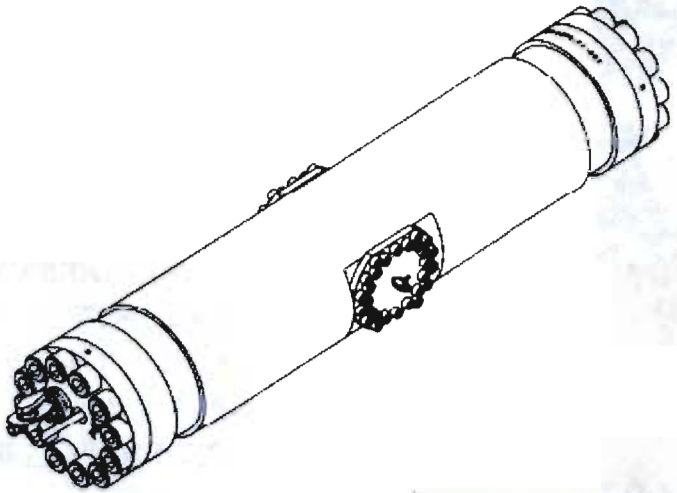
Flow Interrupter

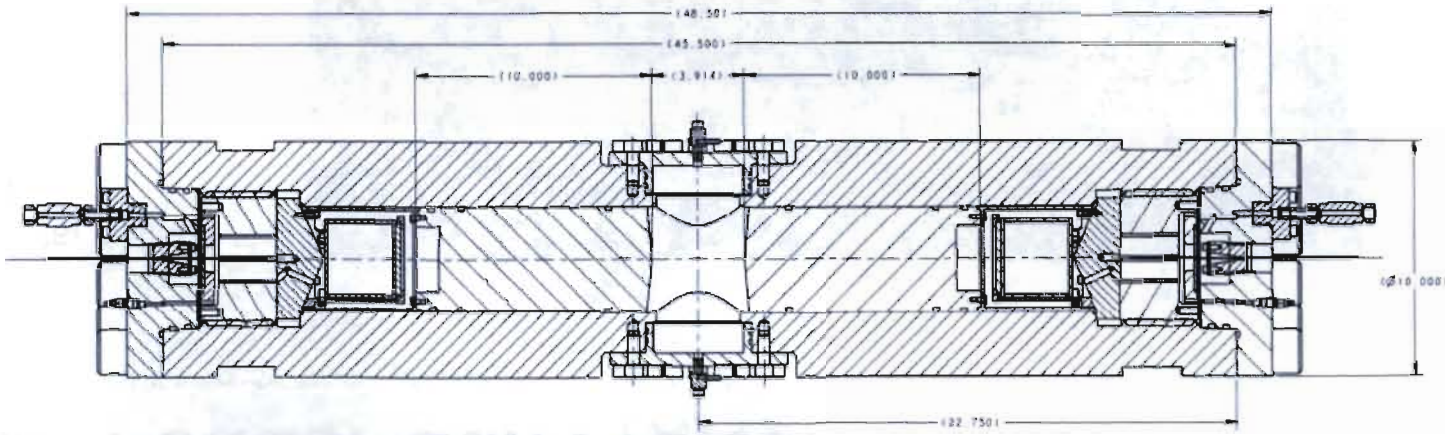
Main Attributes of the Current FI Design

- Assembly weight: 970 pounds
- Piston weight, each: 14.5 pounds
- Piston material: aluminum alloy 2024 with a T351 temper, S_y ~ 47,000 lb/in**2
- Body material: AISI 4340 steel, S_y ~145,000 lb/in**2
- Maximum high explosive charge in each breech: ~240 grams PBX9501 (with flow load), 60 grams PBX9501 (no flow load)
- Closure time: less than 1 millisecond

Large-Bore Powder Gun Project

Flow Interrupter Design





SECTION A-A

Large-Bore Powder Gun Project

- The FI test set-up for stand-alone testing is shown at right.

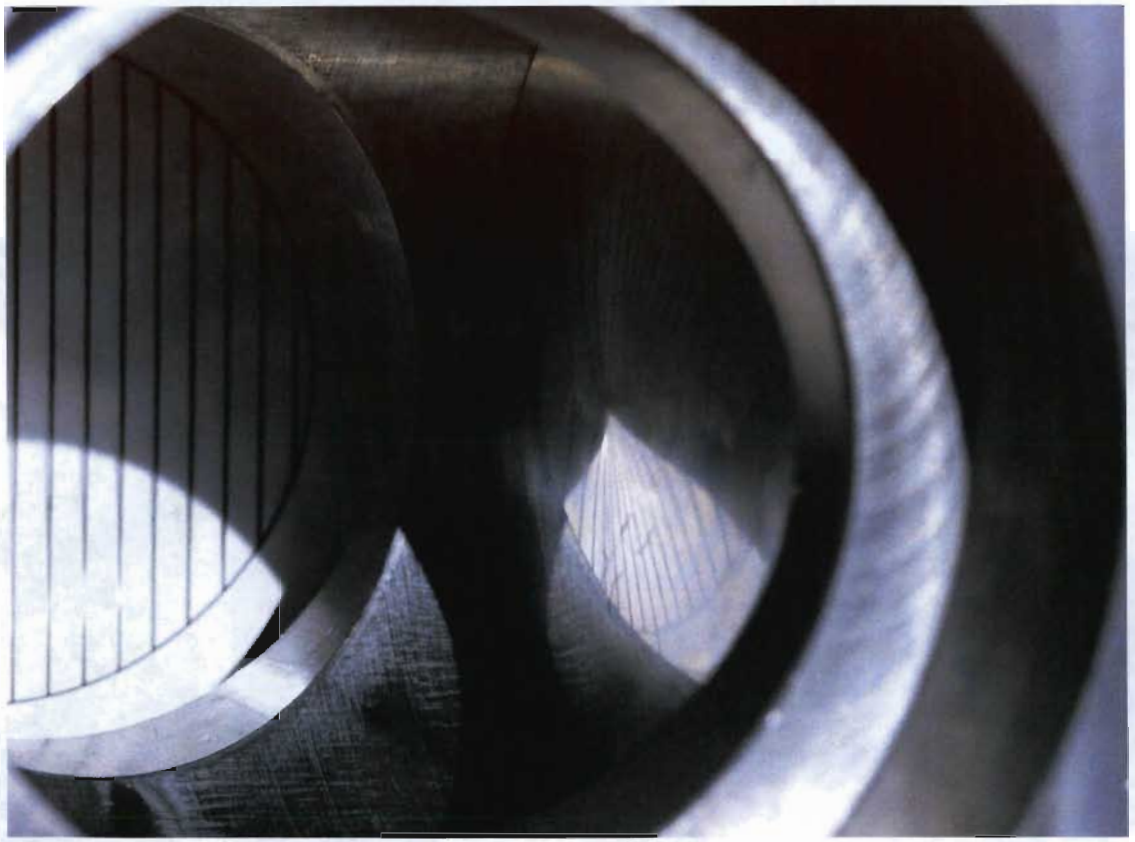
- Four stand-alone tests have been conducted by LANL.

- The FI stand-alone testing was completed, and an IST was planned having the FI incorporated into the confinement subsystem.

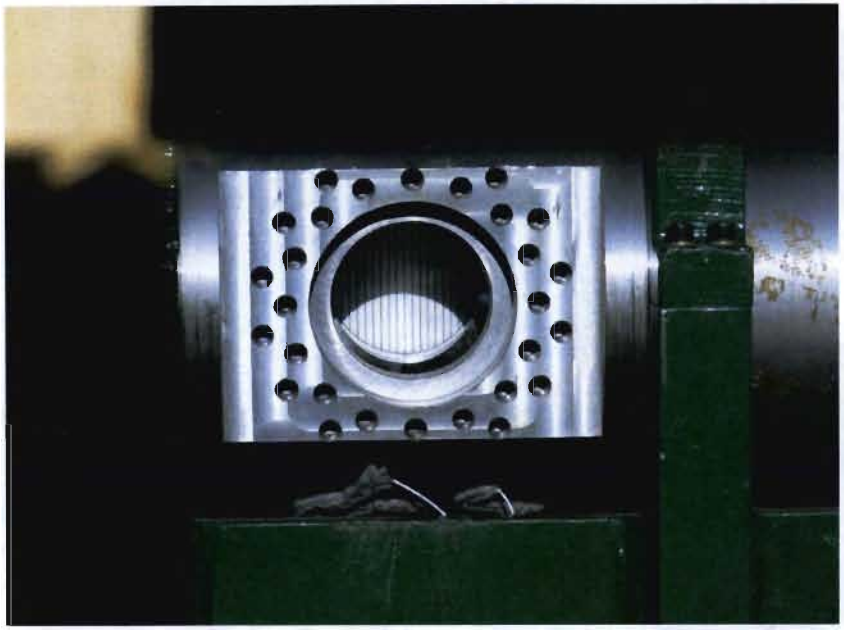
- This IST has not been conducted.

Large-Bore Powder Gun Project

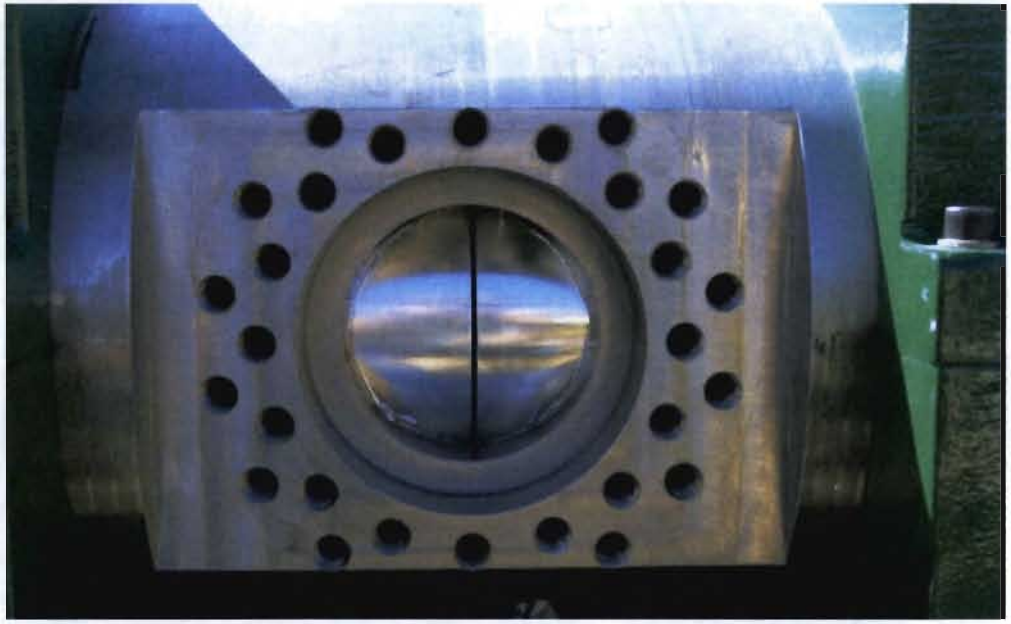
Image of the piston starting position relative to the flow channel. Reference grid for the high-speed imaging is mounted outside of the flow channel.



Large-Bore Powder Gun Project



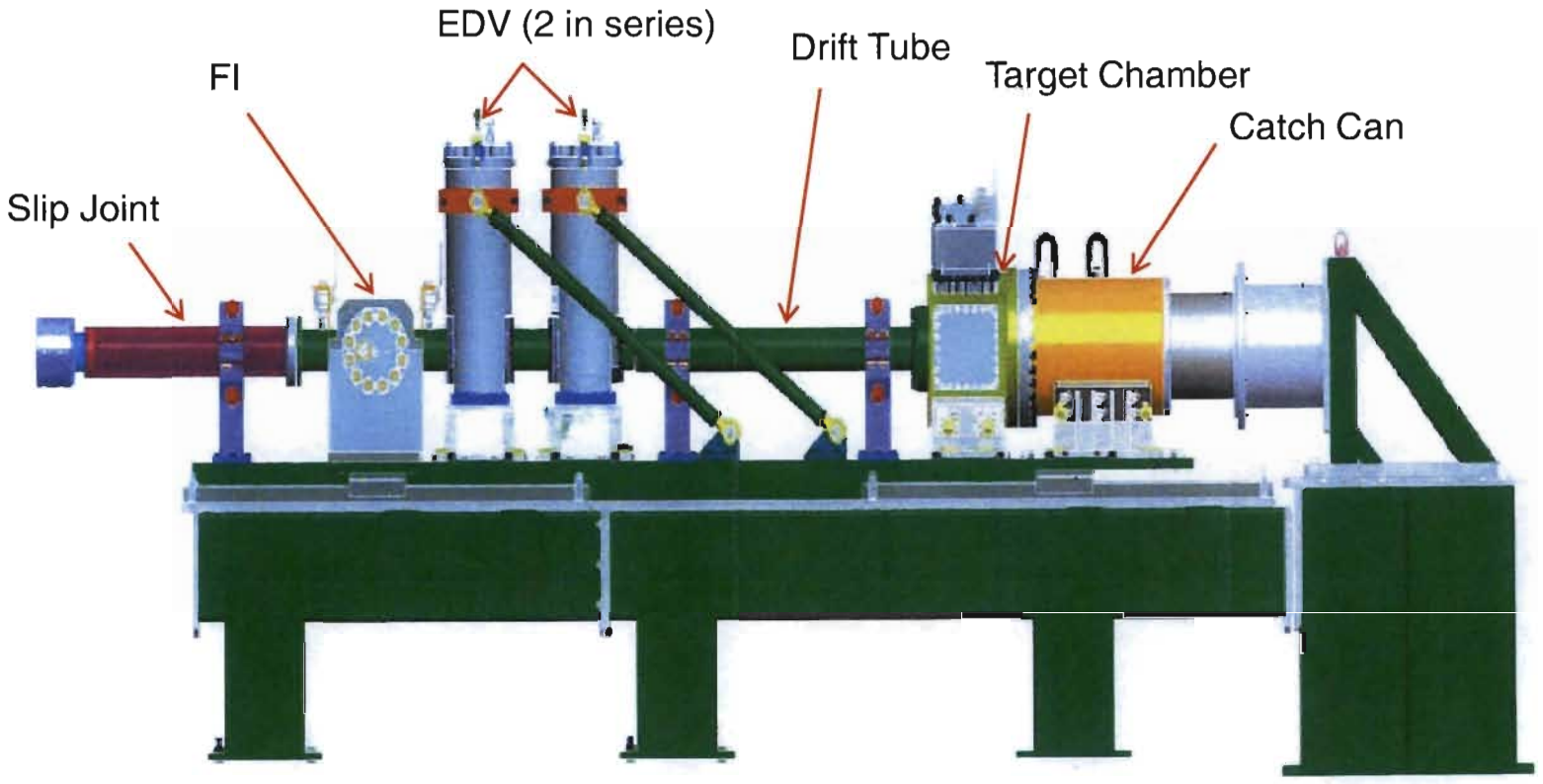
Pre-Shot Flow Channel View



Post-Shot Flow Channel View

(Pistons locked into place, note metal deformation and peeling)

Large-Bore Powder Gun Project



Past Conceptual Layout of the Confinement Subsystem