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Title:	Update on the Performance of the Helium Driven Two-Stage Gun at Los Alamos
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Form 836 (7/06)

Update on the Performance of the Helium Driven Two-Stage Gun at Los Alamos

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Abstract: The Shock and Detonation Physics Group at Los Alamos National Laboratory has operated a helium driven two-stage gun since 1994. The gun consists of a 100.8 mm diameter by 7.6 m long pump tube and a 50.8 mm diameter by 7.6 m long launch tube. The 1.5 cubic foot (42.5 liter) breech can be pressurized with up to 15,000 PSI (103 MPa) of helium. Pump pistons weigh about 5.3 kg and are made of polyethylene and aluminum. The pump tube is typically operated with 255 PSI (1760 KPa) of helium. Projectiles are made of Polycarbonate (Lexan) and weigh 90 – 235 grams: 150 grams is typical. To date, the maximum velocity achieved is 3.6 km/s and the minimum velocity achieved was 0.66 km/s. The minimum velocity shot used Argon as the working fluid in the breech and pump tube, and was the only time we have used a gas other than helium. The peak acceleration for a 180 g projectile reaching a muzzle velocity of 2.6 km/s was recently measured at 625 km/s^2, or about 64,000 G. The current launch tube has over 500 shots on it and has never been honed out to a larger size.

Update on the Helium driven two stage gun at Los Alamos National Laboratory

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The 62nd Aeroballistic Range Association Meeting
18-23 September 2011
Put-In-Bay (Cleveland), Ohio

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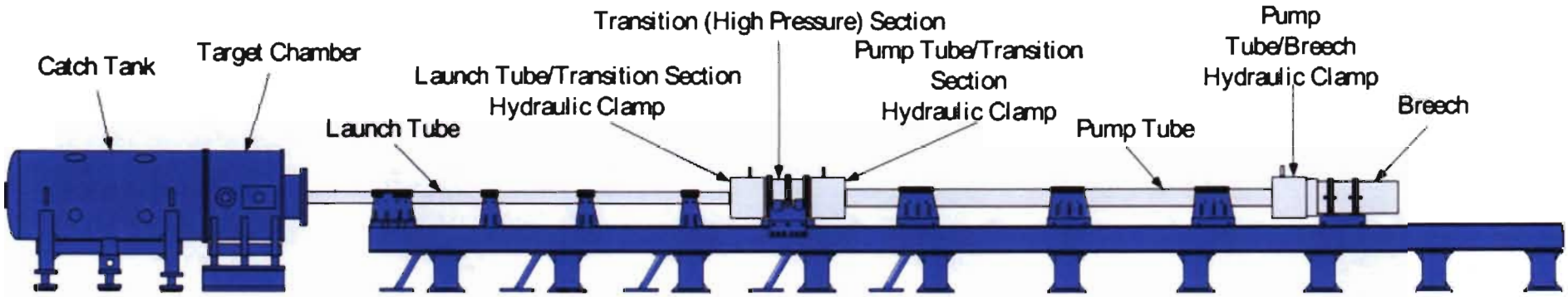
Overview



- Purpose: Equation of State (EOS) & shock induced reactivity (shock initiation) studies
- pump tube: 4" (101.6 mm) φ by 25' (7.6 m) long
- launch tube: 2" (50.8 mm) φ by 25' (7.6 m) long
- First shot 5/94
- 557+ shots to date

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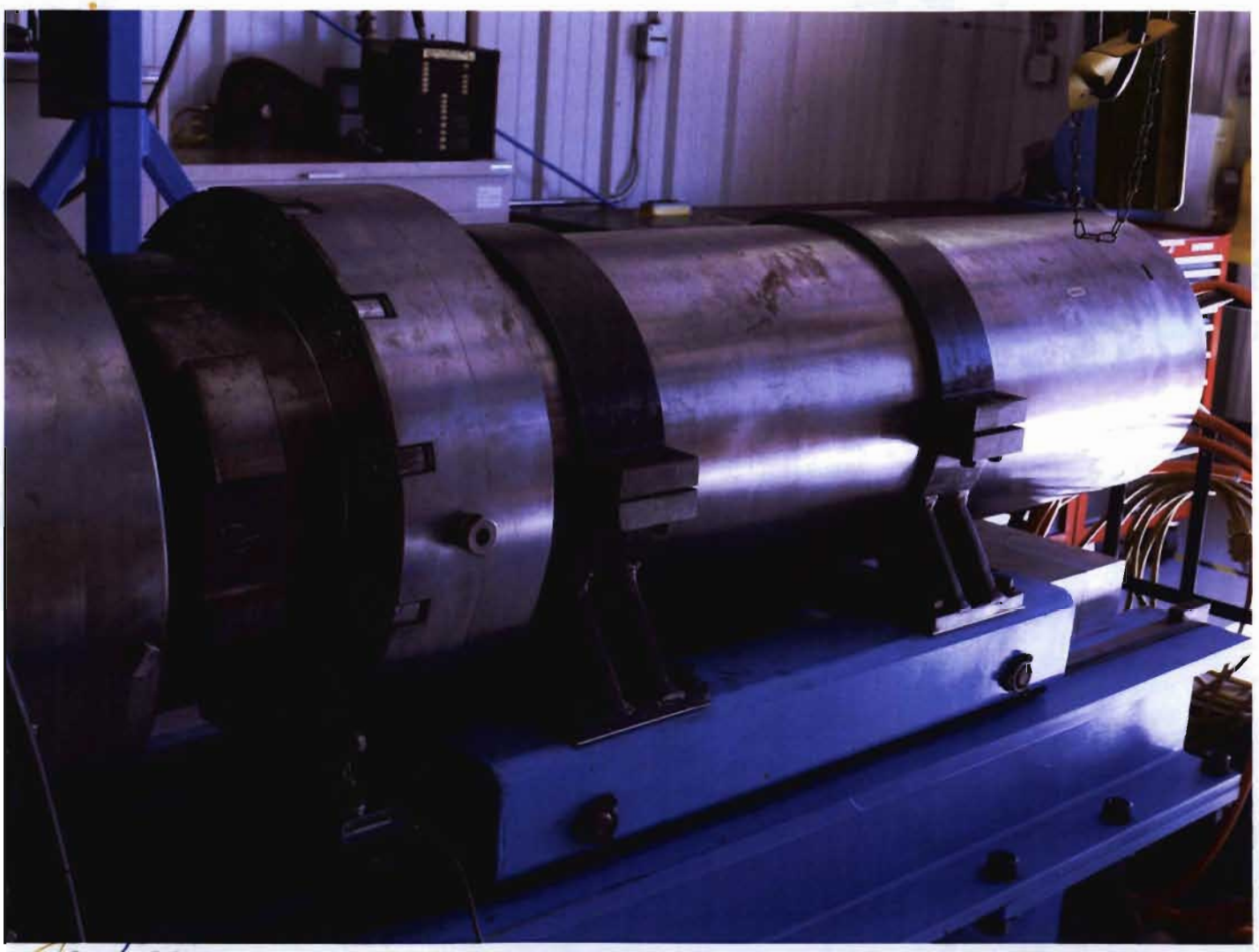
Breech



- 1 ½ cubic feet (40 liters)
- 15,000 PSI
- wrap-around design
- Back O-rings replaced ~ every 100 shots

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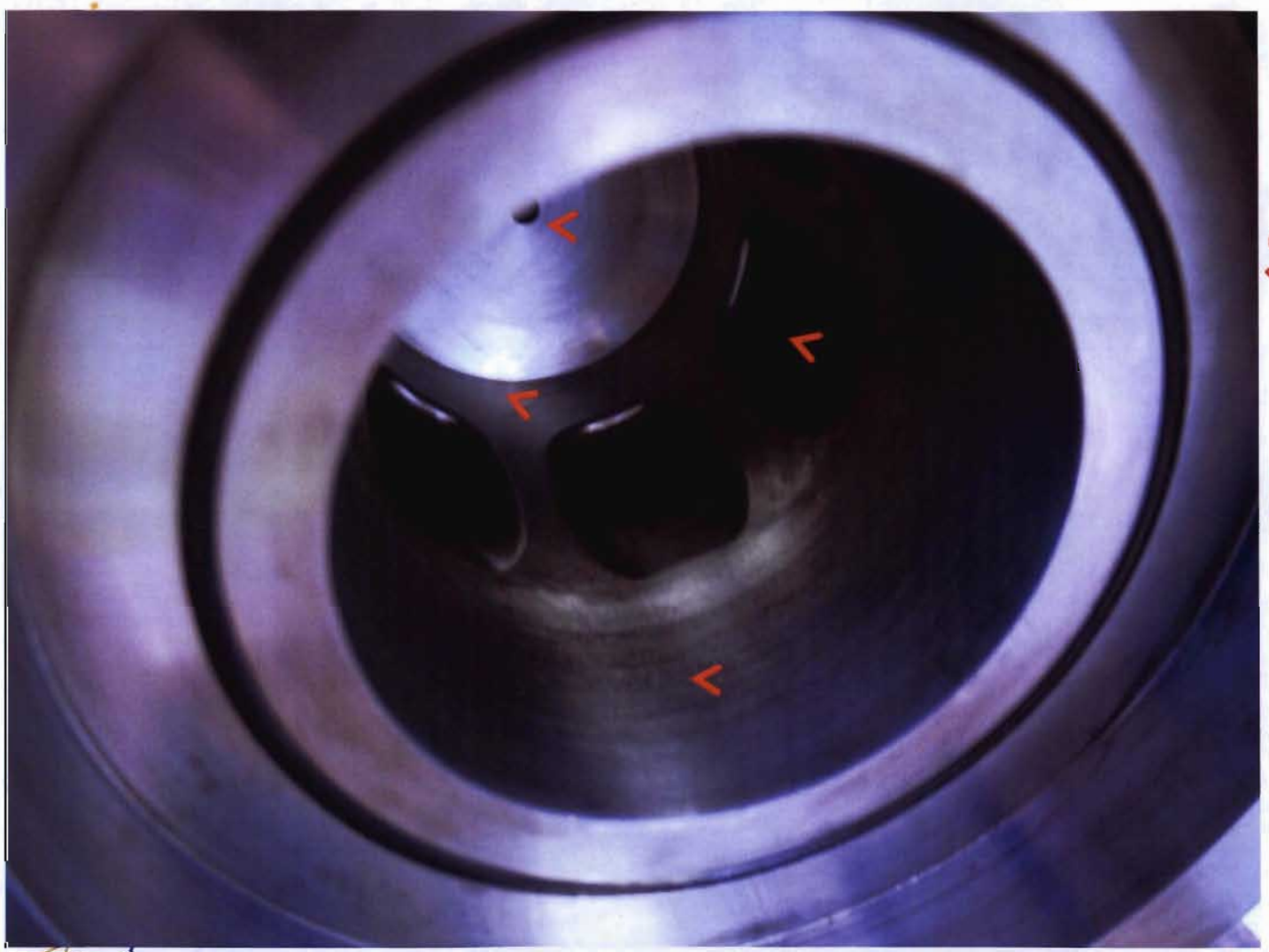
Wrap Around Breech Insert (interior)



- vacuum & fire port
- Gas ports
- Pump piston o-rings seat here

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Wrap Around Breech Insert (exterior)

- Gas ports

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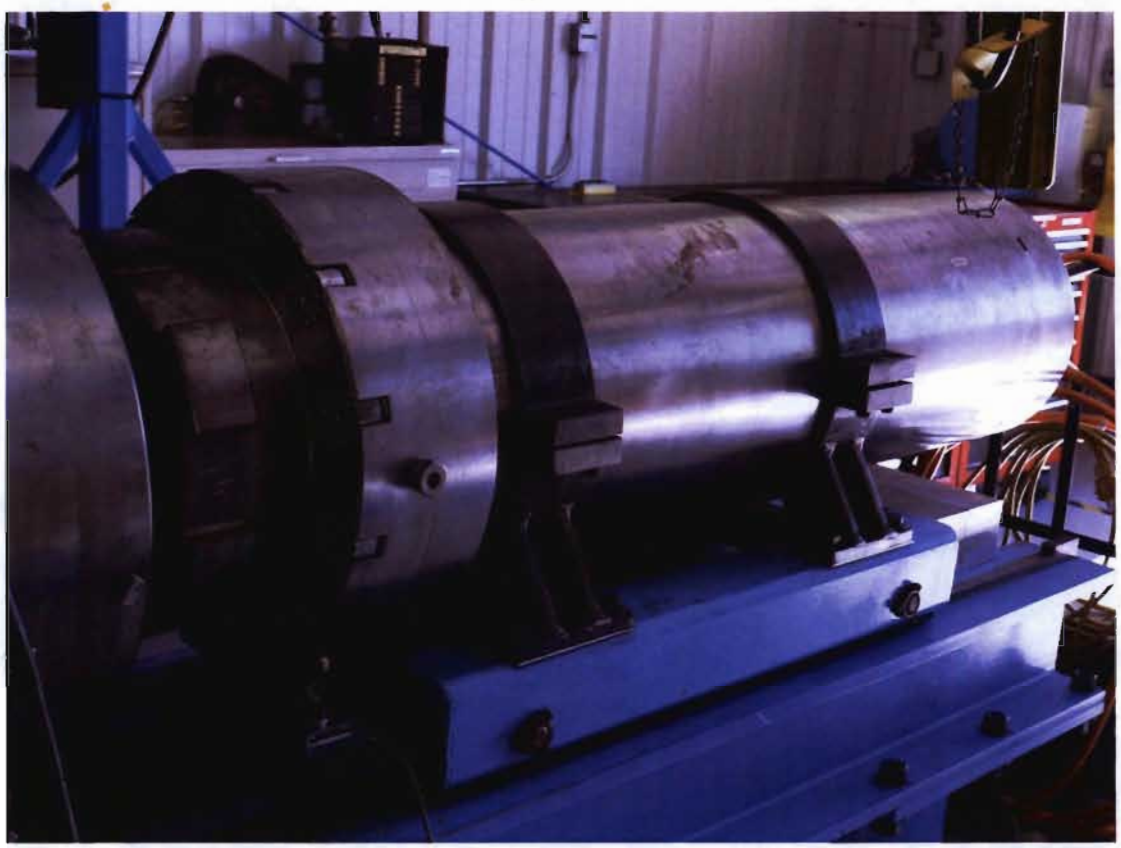
Breech – firing statistics



- Min: 1840 psi (diaphragm did not break)
- Max: 14,900 psi
- Median: 7,550 psi
- Standard Deviation: 3,426 psi

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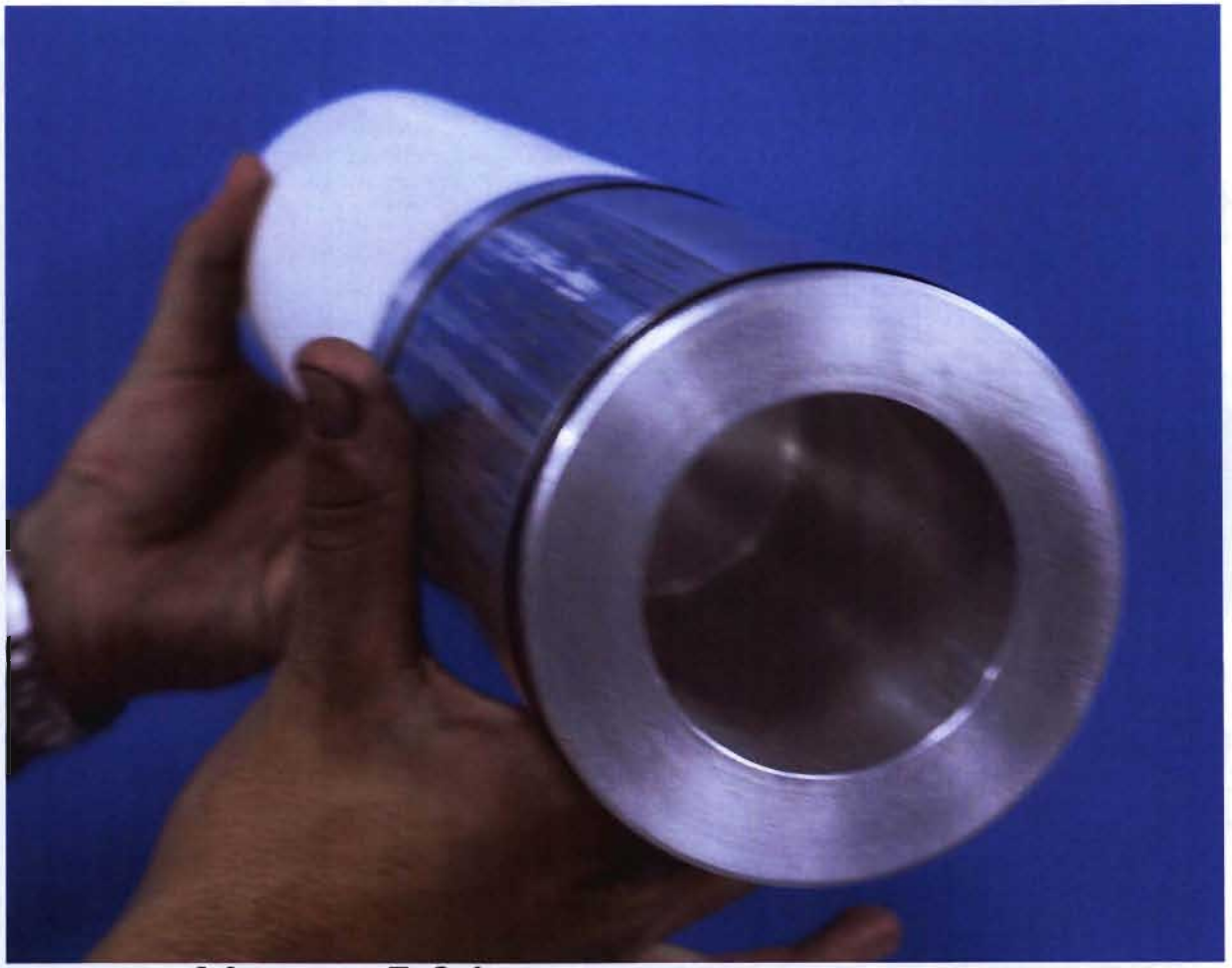
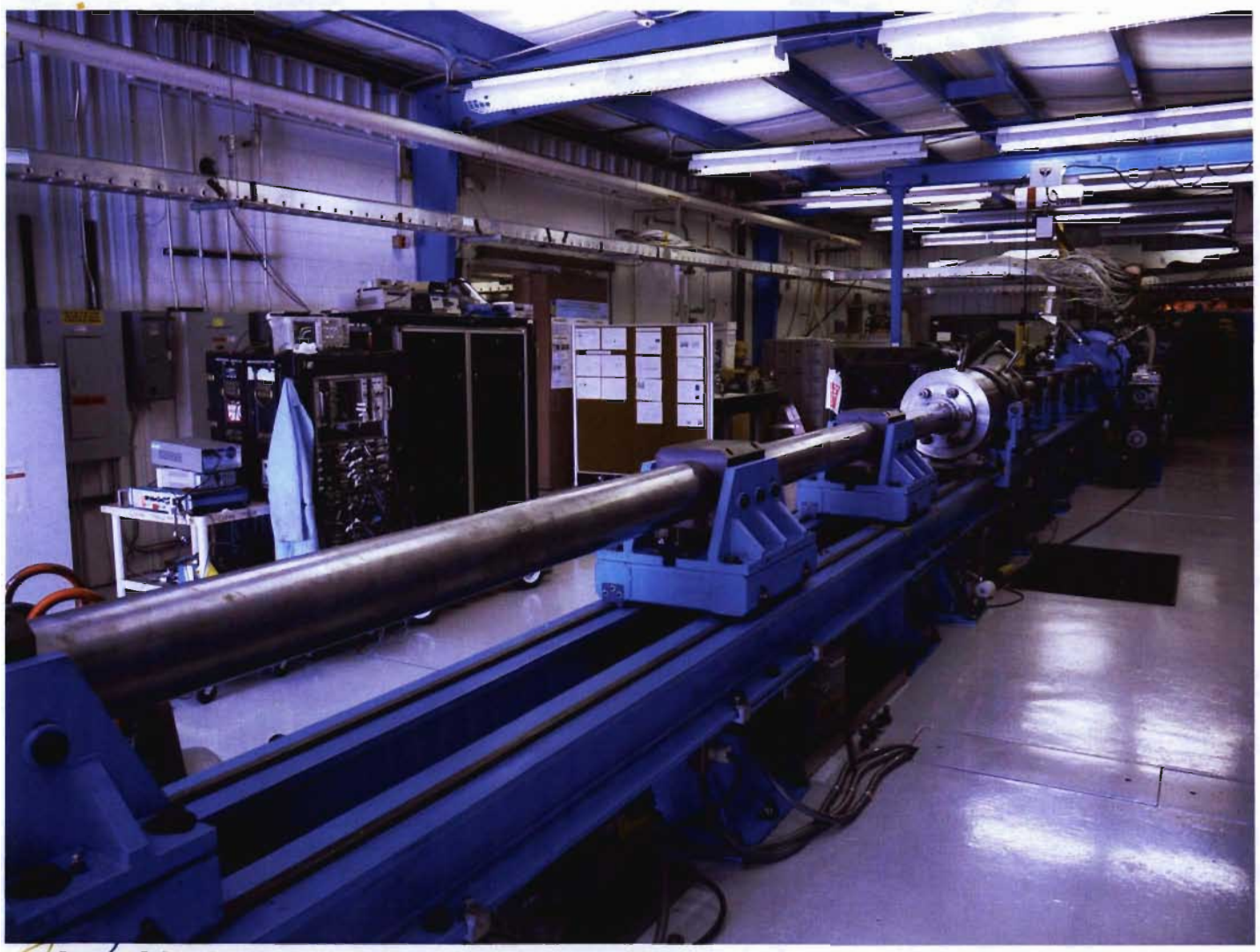
Pump Piston



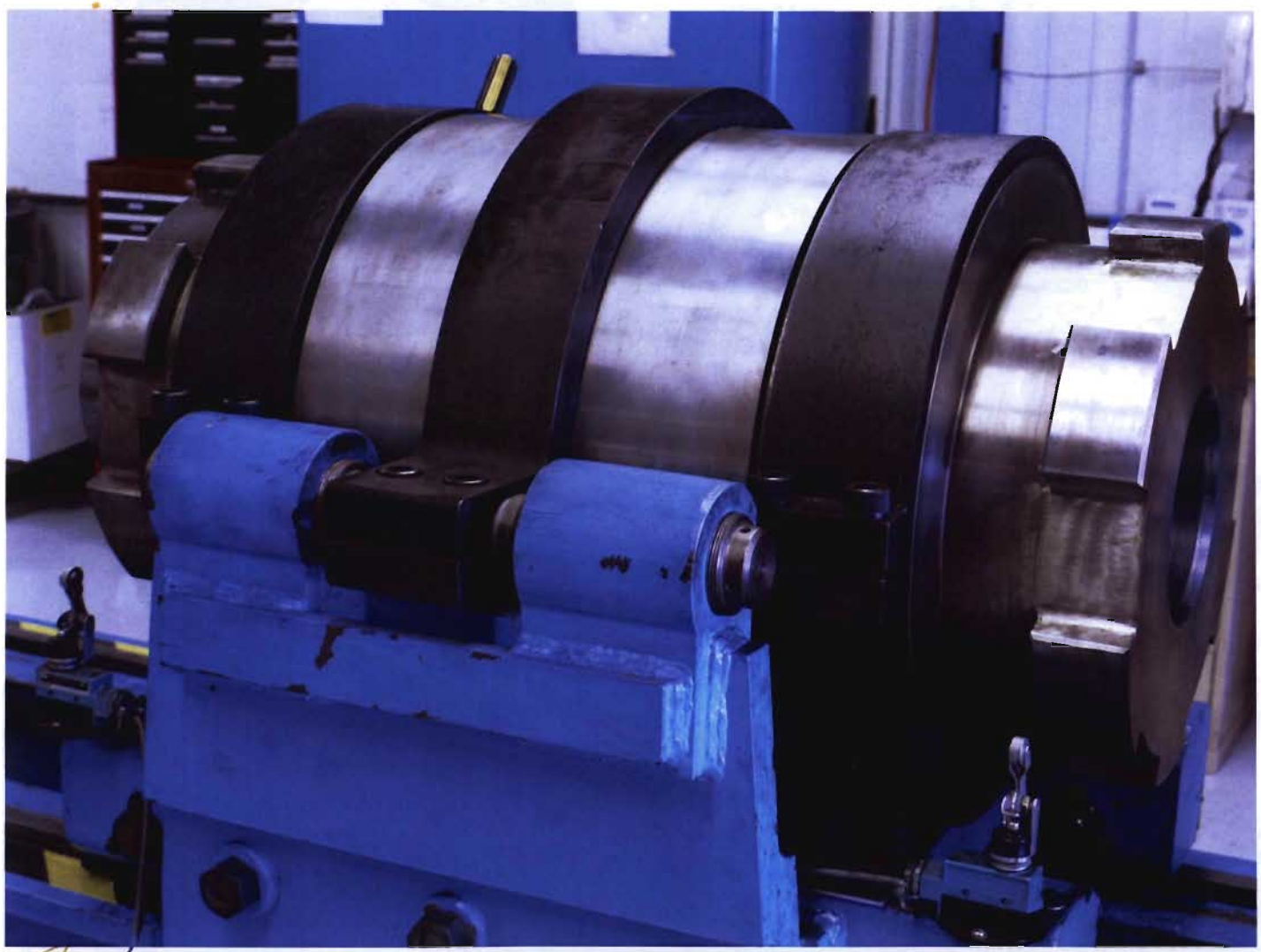
- Mass = 5.3 kg
- Aluminum = 7.25” (184 mm)
- Polyethylene = 12” (305 mm)

Pump tube – looking toward muzzle



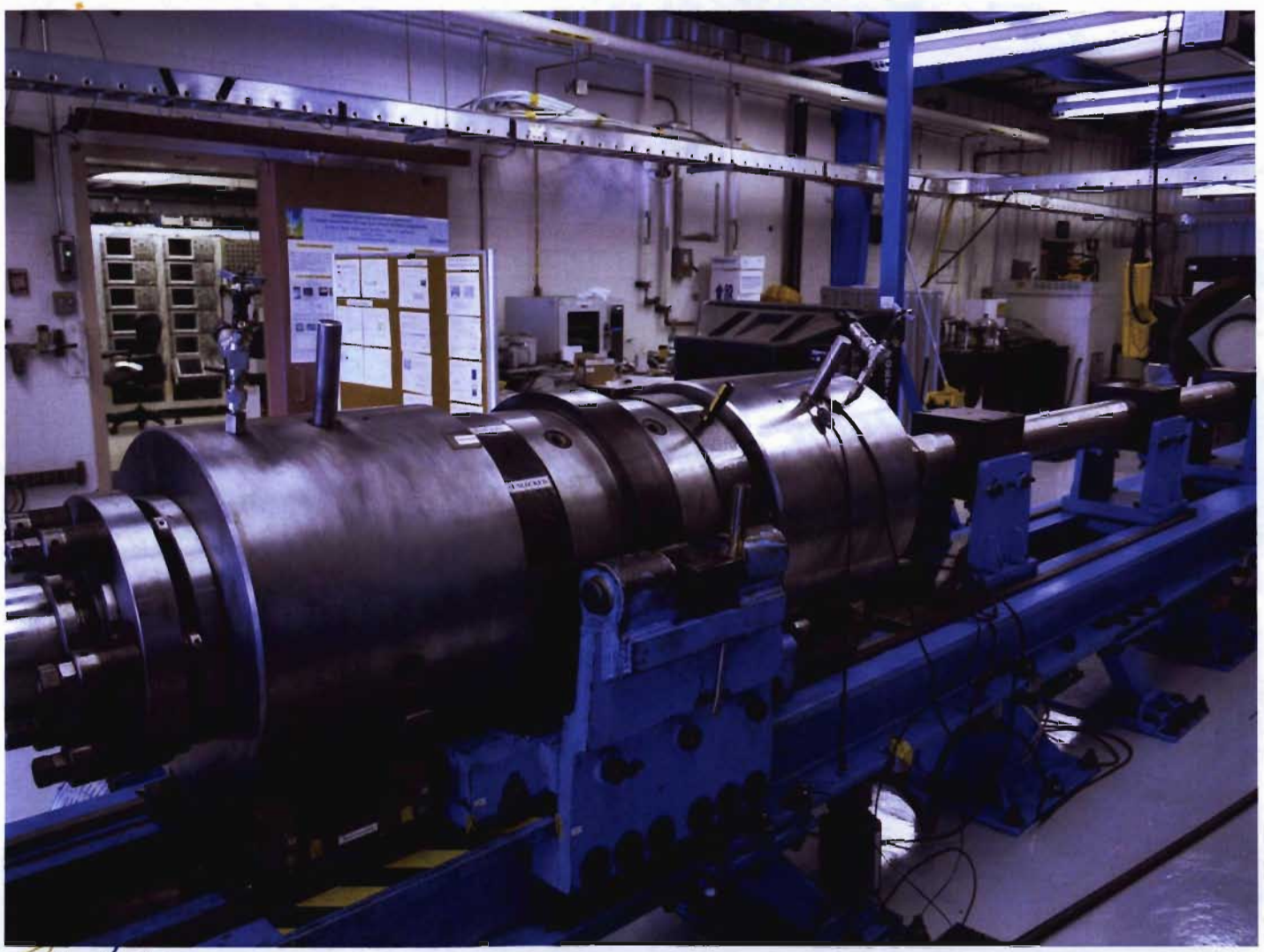
- pump tube always pressurized to 255 +/- 5 psi He
- pump tube purged w. He prior to final fill

Transition Section

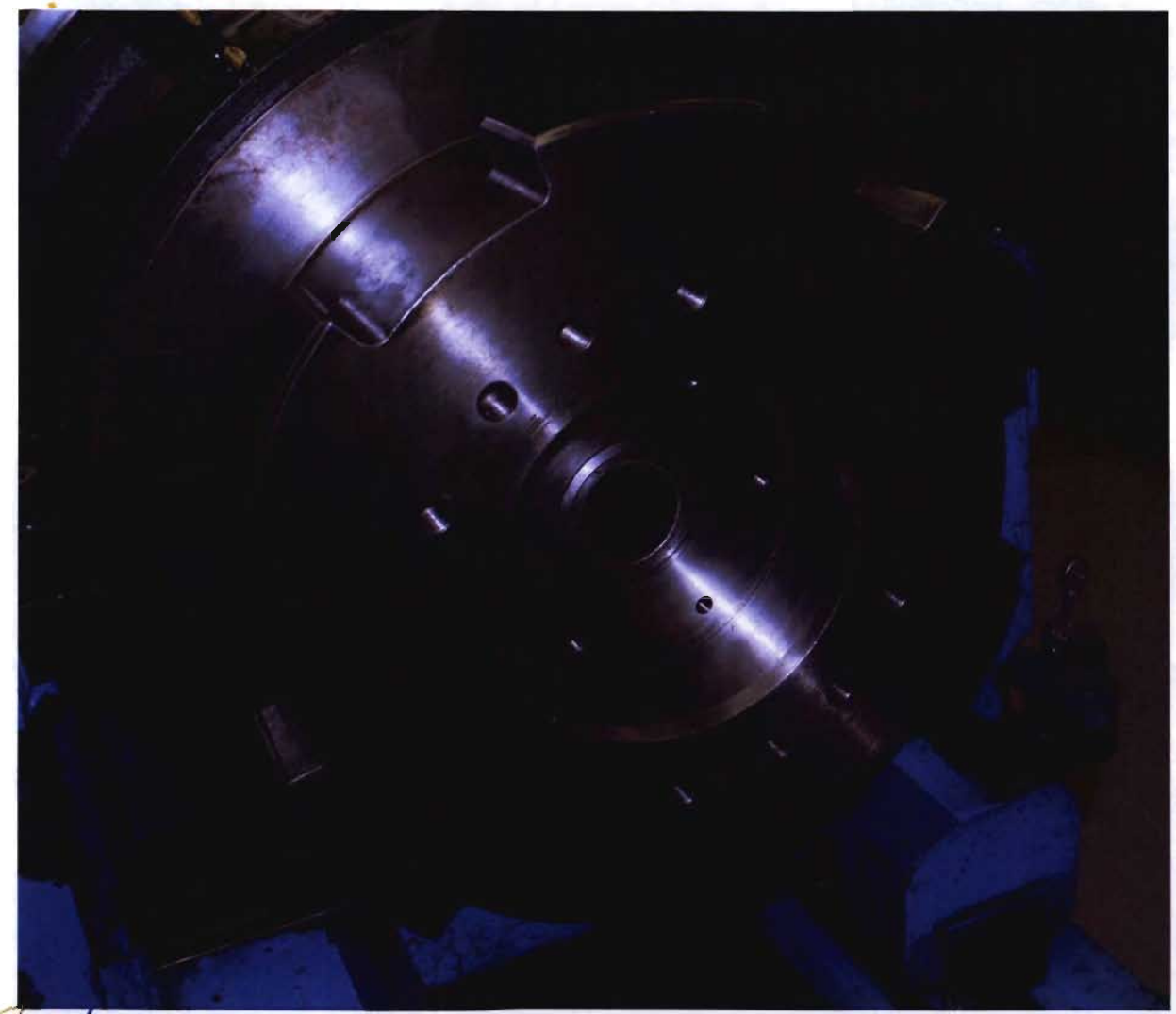


Taper 12” (300 mm)

Transition Section – assembled to pump tube and launch tube

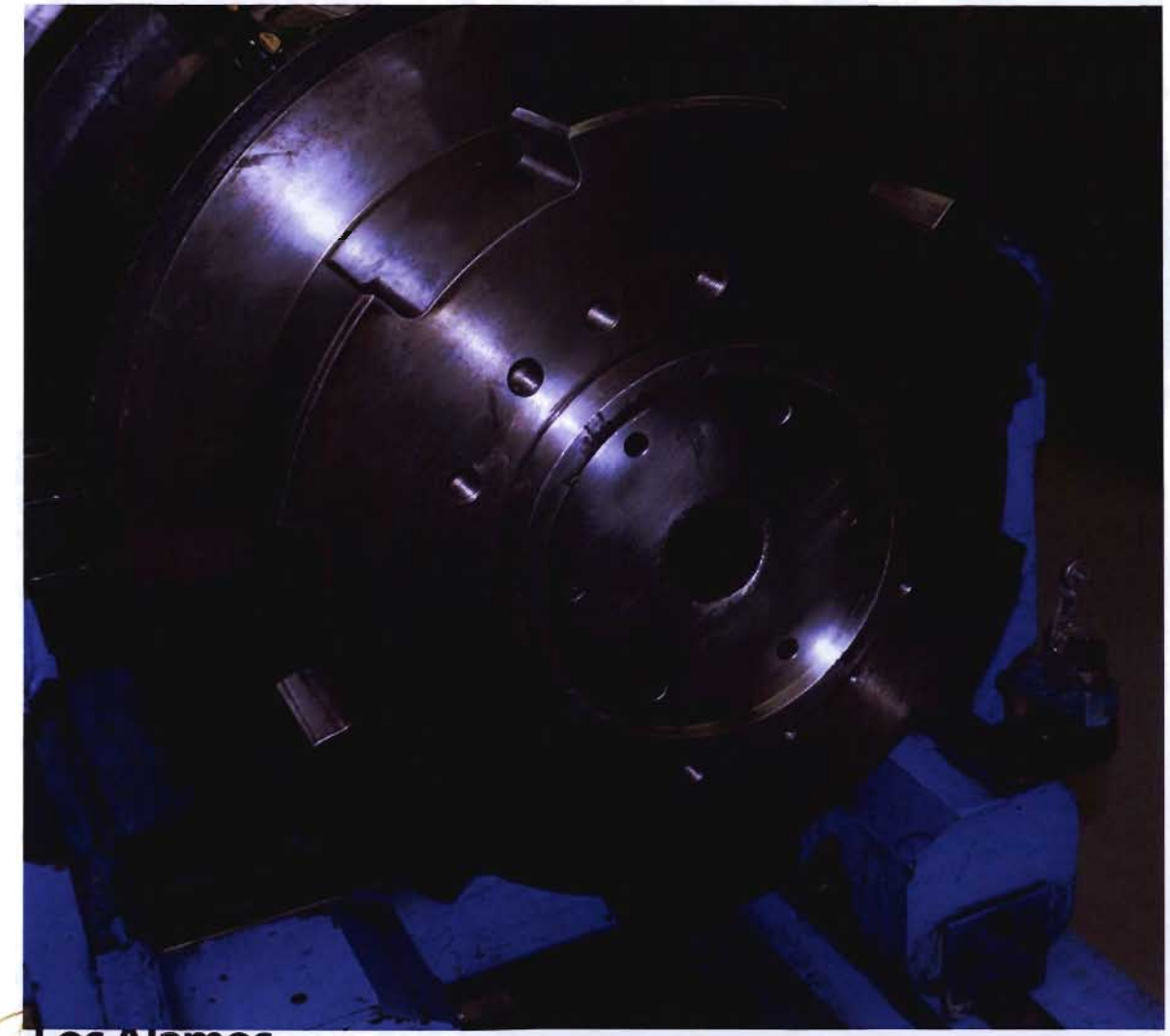


Diaphragm – 1/6



- Launch tube end of transition section

Diaphragm – 2/6



- diaphragm holding fixture

Diaphragm – 3/6

- Pure nickel
- 0.125” (3.1 mm)thick
- 0.04” (1.0 mm) groove depth

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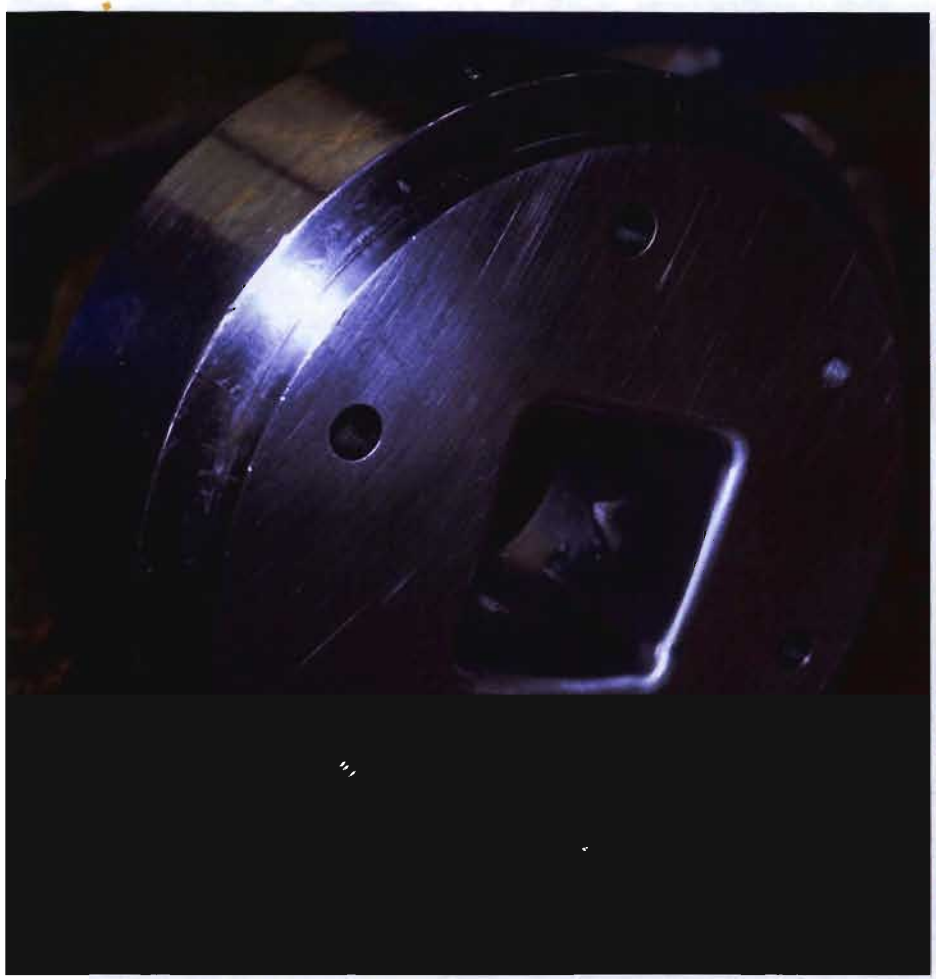
Diaphragm – 3/6



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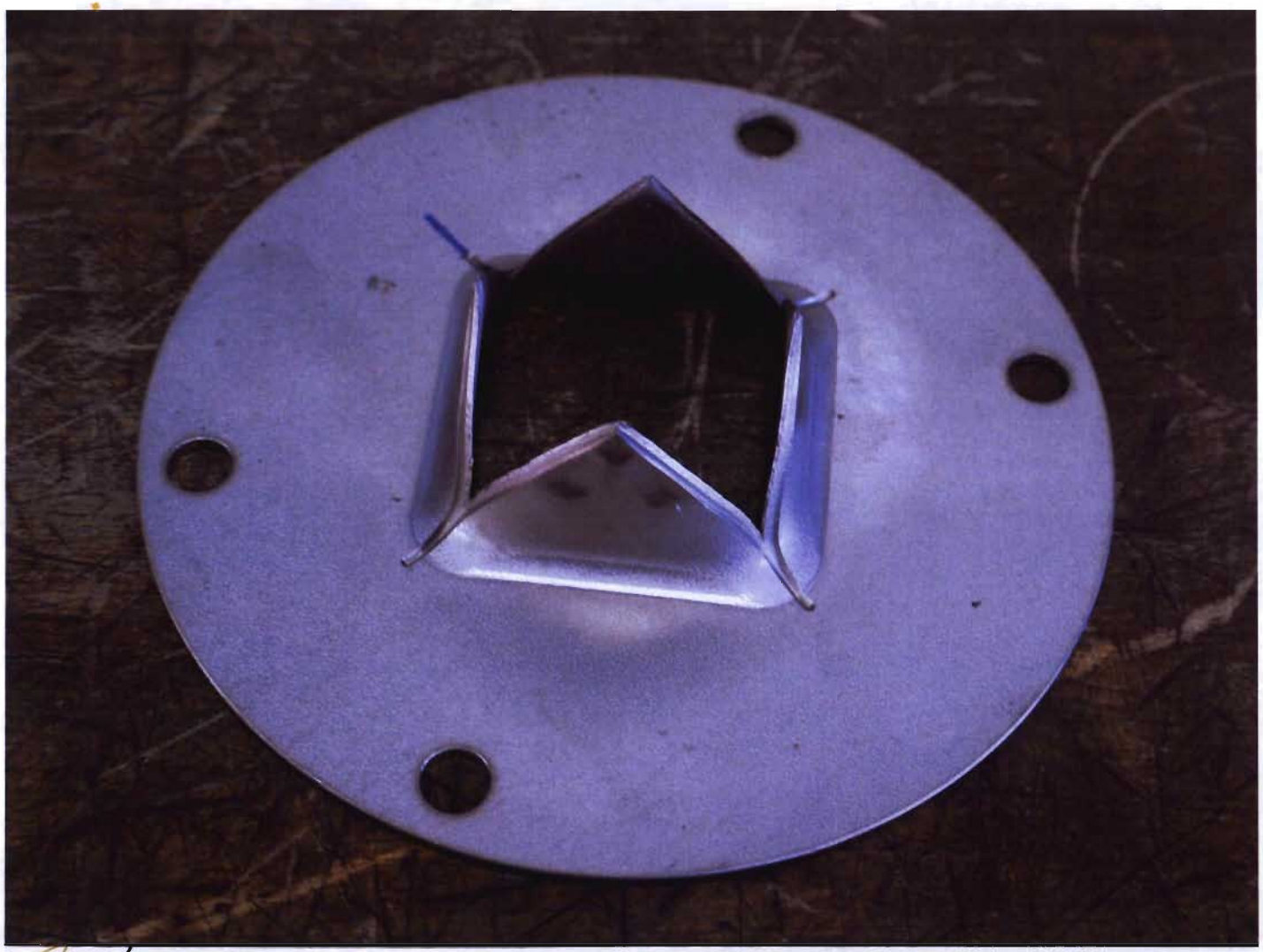
- diaphragm package front (front & back views)

Diaphragm – 4/6

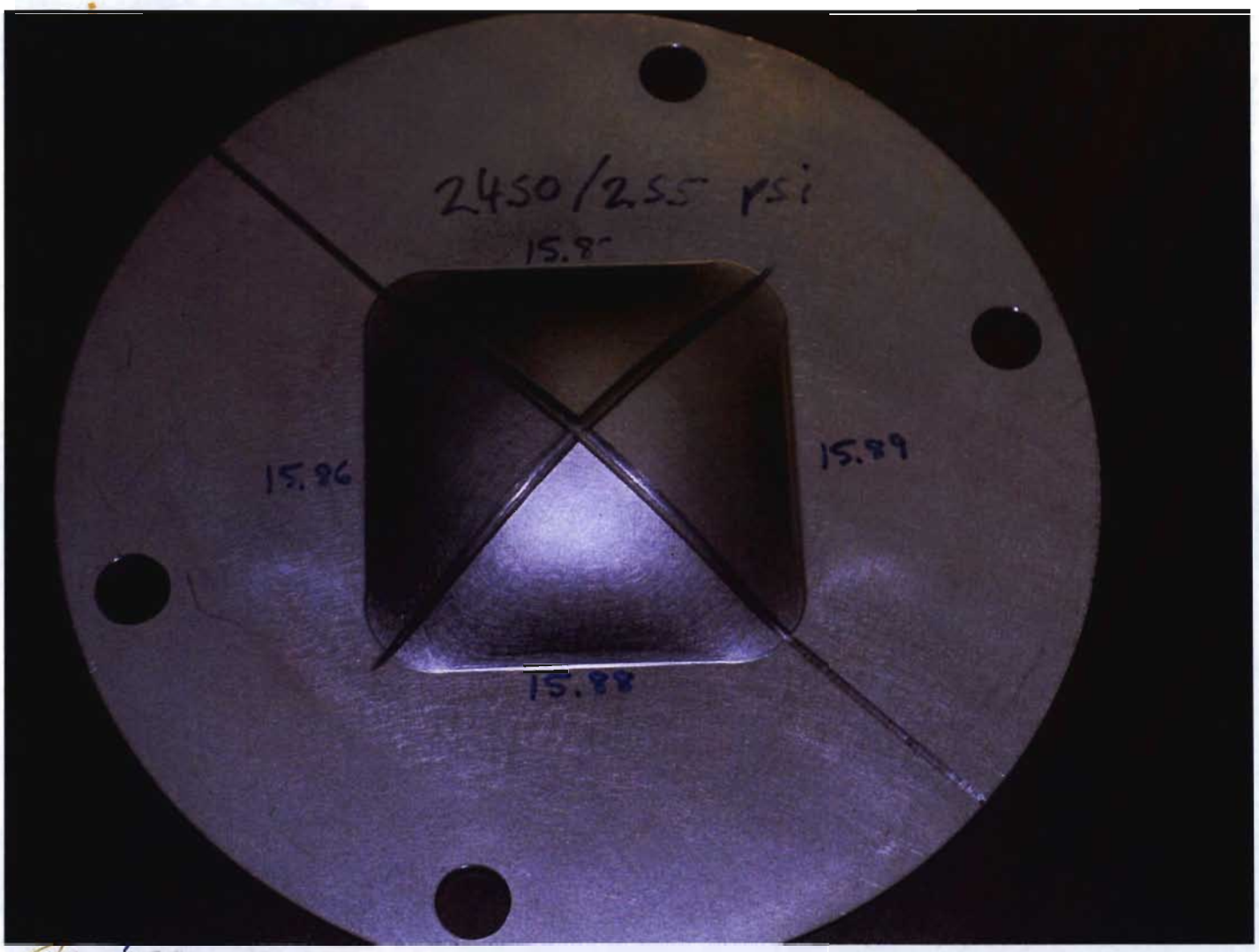
diaphragm package assembled to transition section

Diaphragm – 5/6



Diaphragm that opened normally > 2500 psi

Diaphragm – 6/6



diaphragm that didn't break 2450 psi breech

Projectile mass statistics

- Min: 92 g
- Max: 272 g*
- Median: 147 g
- Mean: 149 g
- Standard Deviation: 21 grams

*398 g Aluminum projectile was fired – damaged barrel

- After shot 18
- All projectiles made of Lexan (Polycarbonate)
- Majority of impactors Kel-F81, a high density plastic (2.14 g/cm^3)

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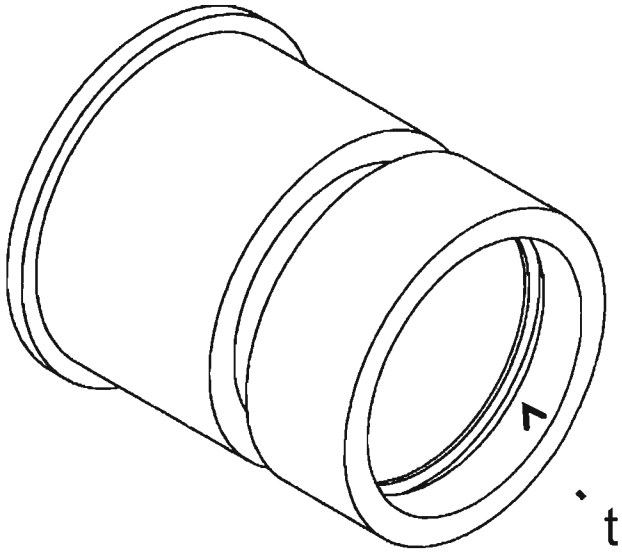
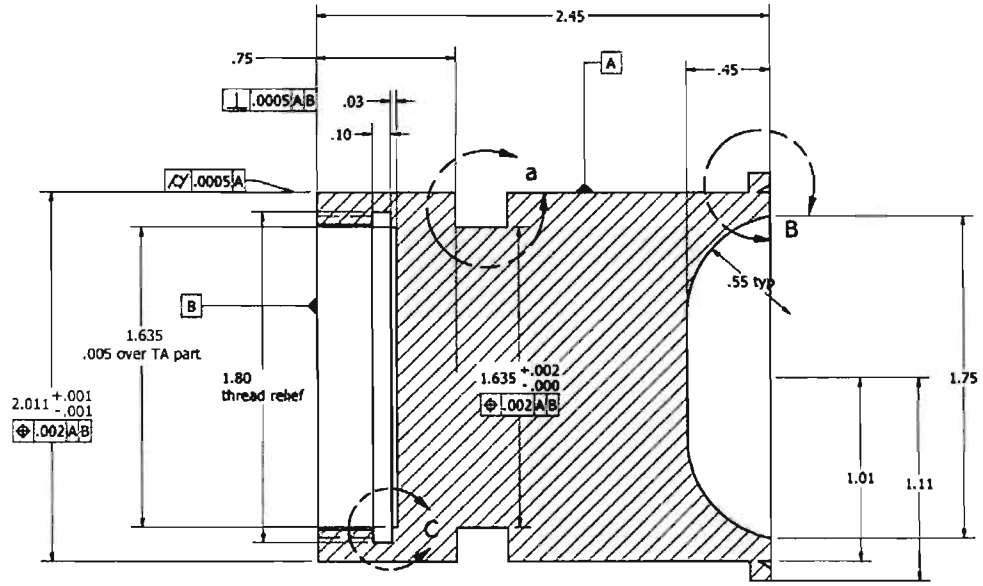
Projectile velocity statistics

- Min: 1.130 km/s*
- Max: 3.605 km/s
- Median: 2.532 km/s
- Mean: 2.505 km/s
- Standard Deviation: 0.520 km/s

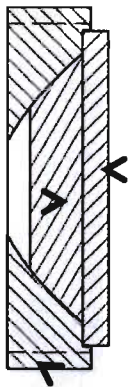
*0.660 km/s shot fired with Ar in breech and pump tube

Projectile example: Double shock projectile





- threads



- Ta

- Low Impedance matl.

- Low impedance material and retaining ring are machined to final thickness

- retaining ring

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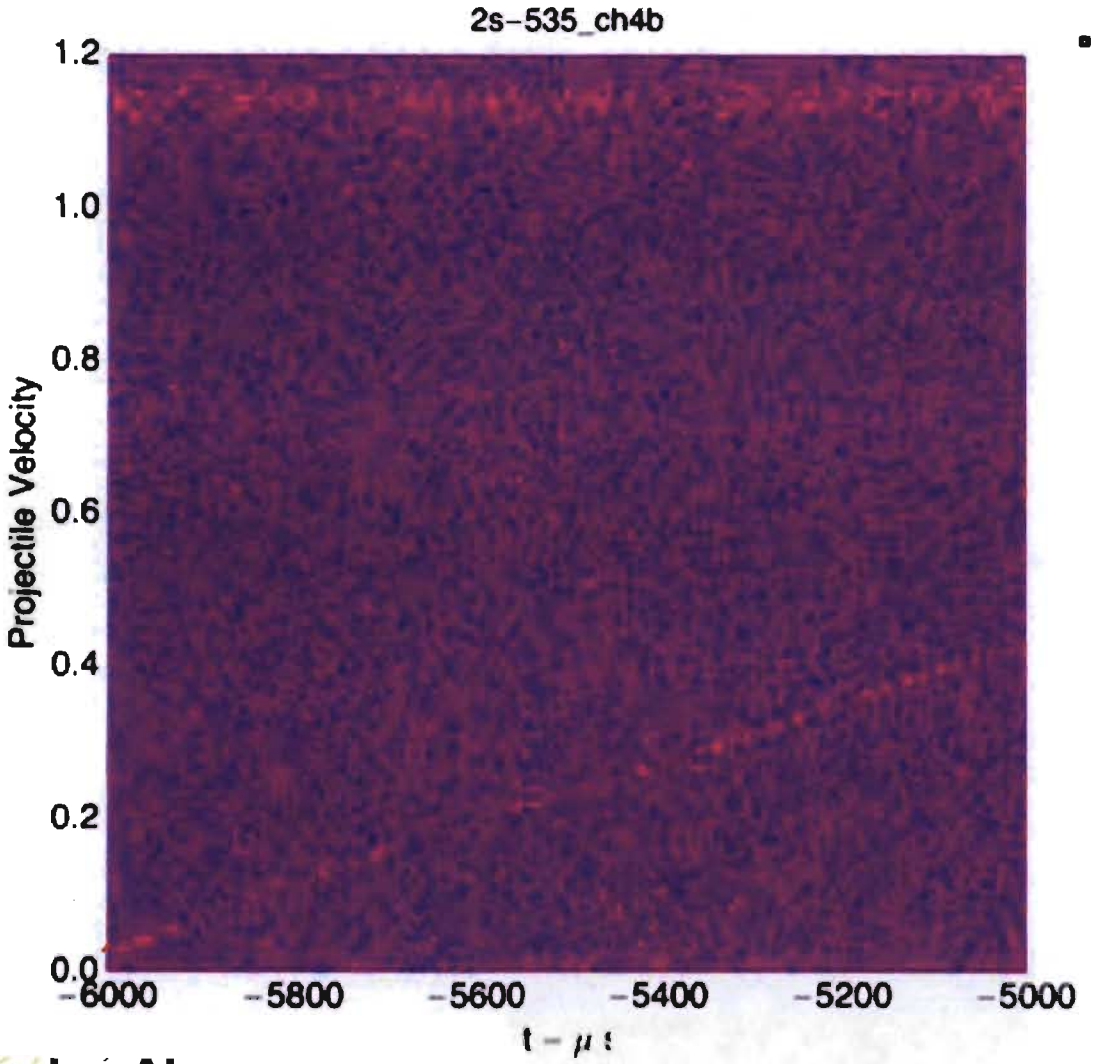
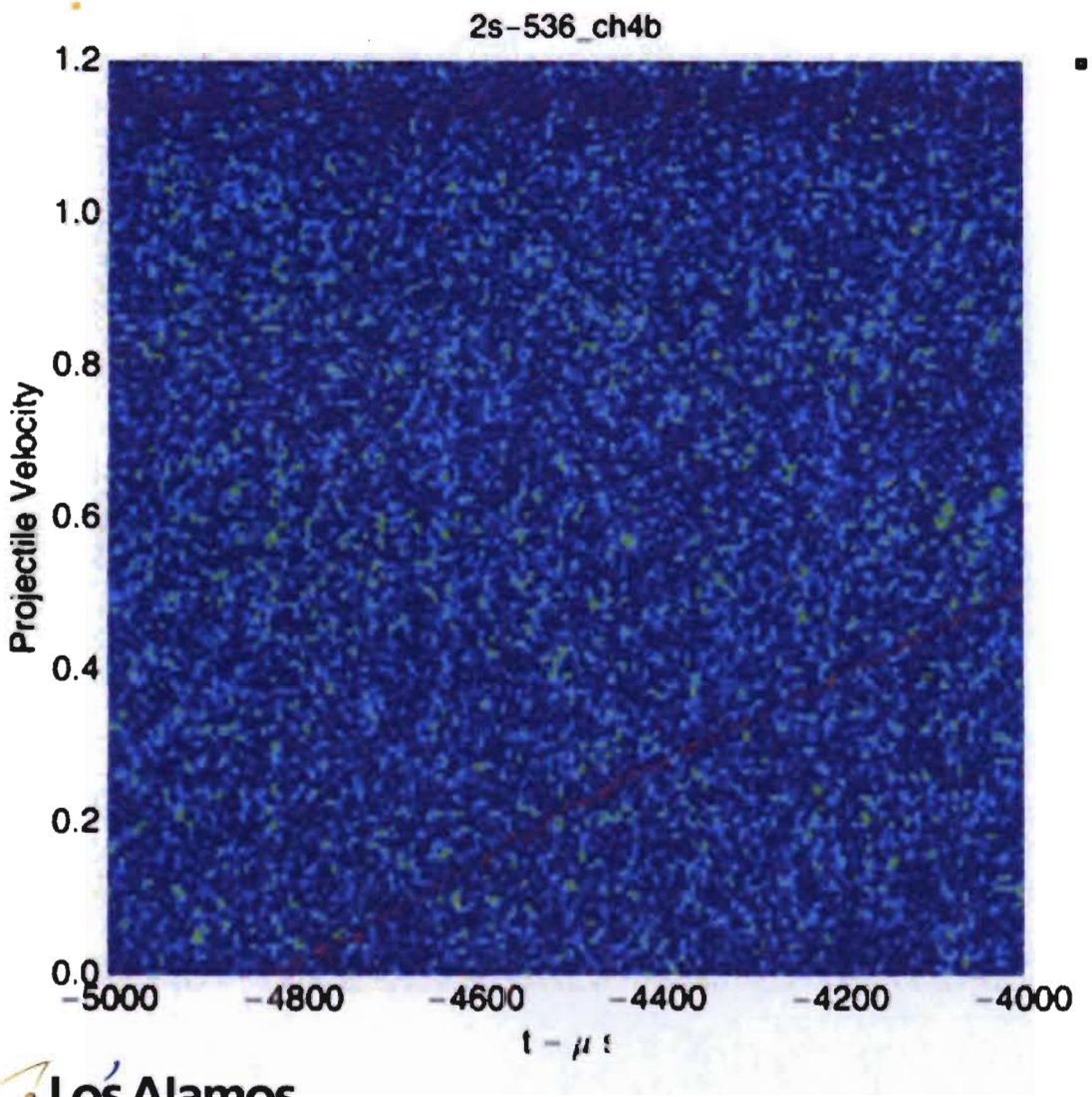
Projectile launch example



- Projectile mass = 177 g
- Breech charge = 6,050 psi
- Pump tube = 255 psi
- Muzzle velocity = 2.132 km/s
- Acceleration = 400 km/s^2 or 41,000 G
- Calculated maximum transition section pressure = 11,900 psi

Projectile launch example



- Projectile mass = 178 g
- Breech charge = 8,600 psi
- Pump tube = 255 psi
- Muzzle velocity = 2.597 km/s
- Acceleration = 625 km/s^2 or 64,000 G
- Calculated maximum transition section pressure = 24,000 psi

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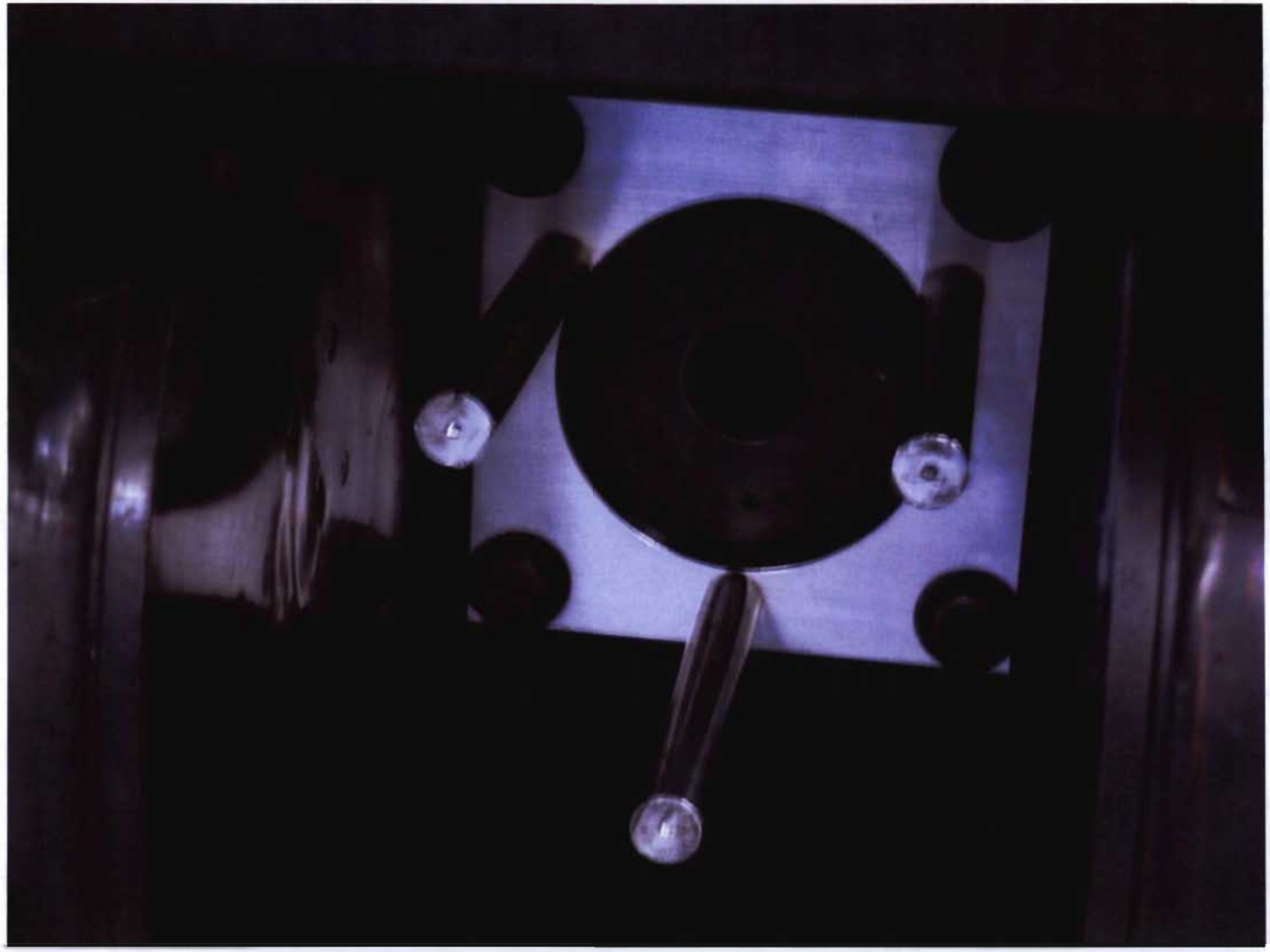
Target holding fixture (aka, the three legger)



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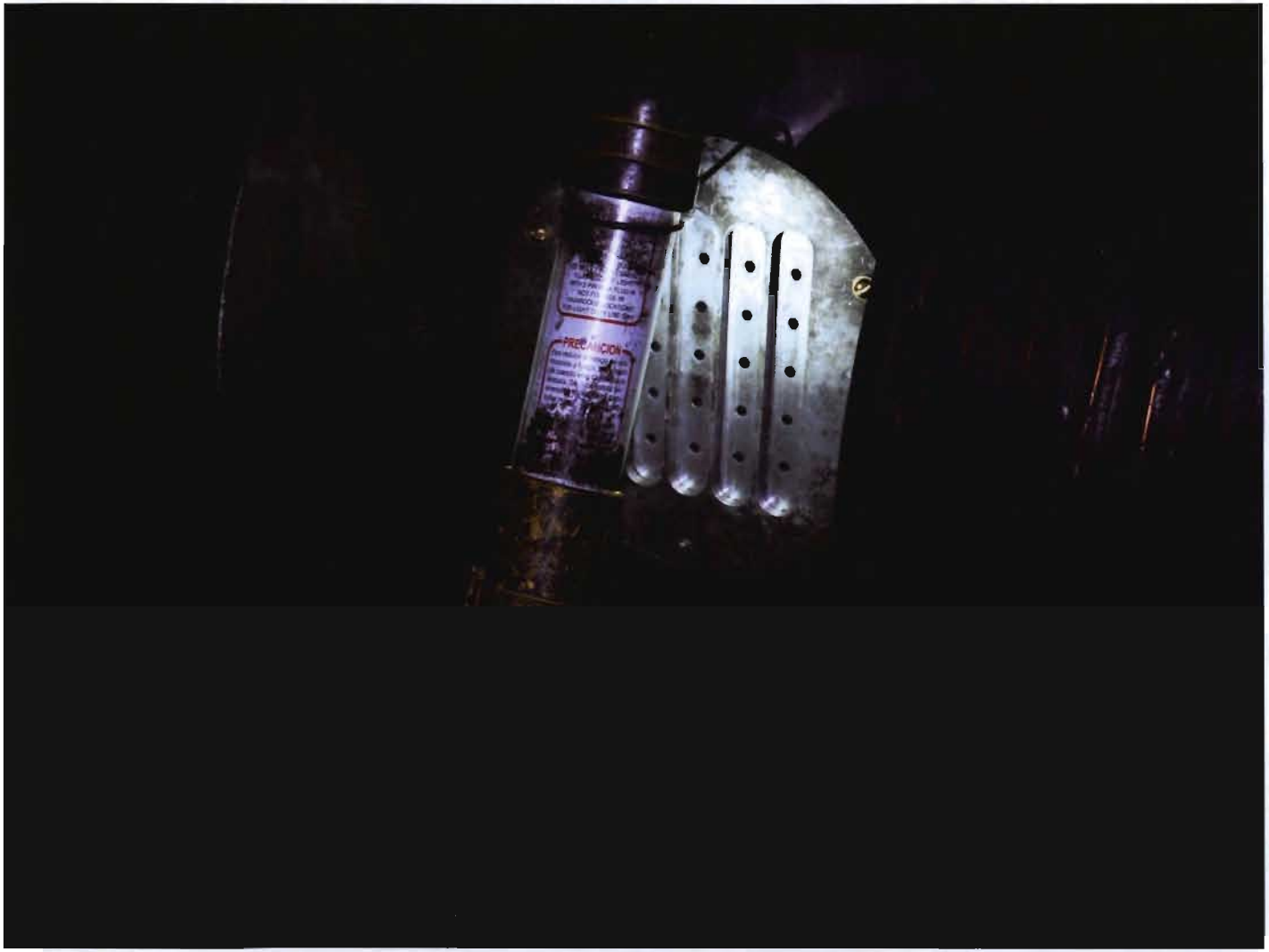
Fixture for centering target (and calibrating magnetic field)



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Auto-collimating telescope to align target to barrel

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Diode Block for measuring projectile velocity

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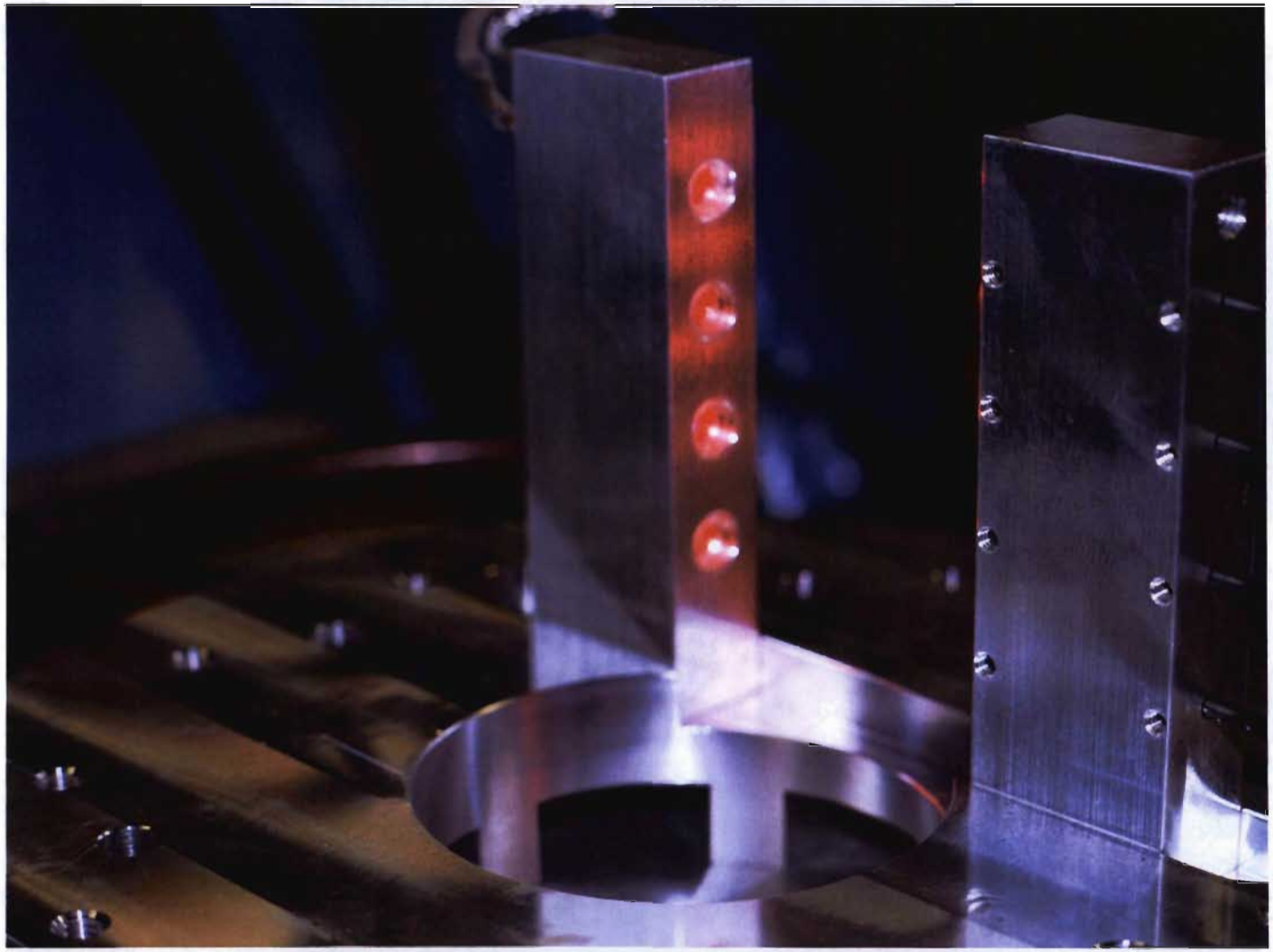
Diode Block for measuring projectile velocity



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Catch Tank

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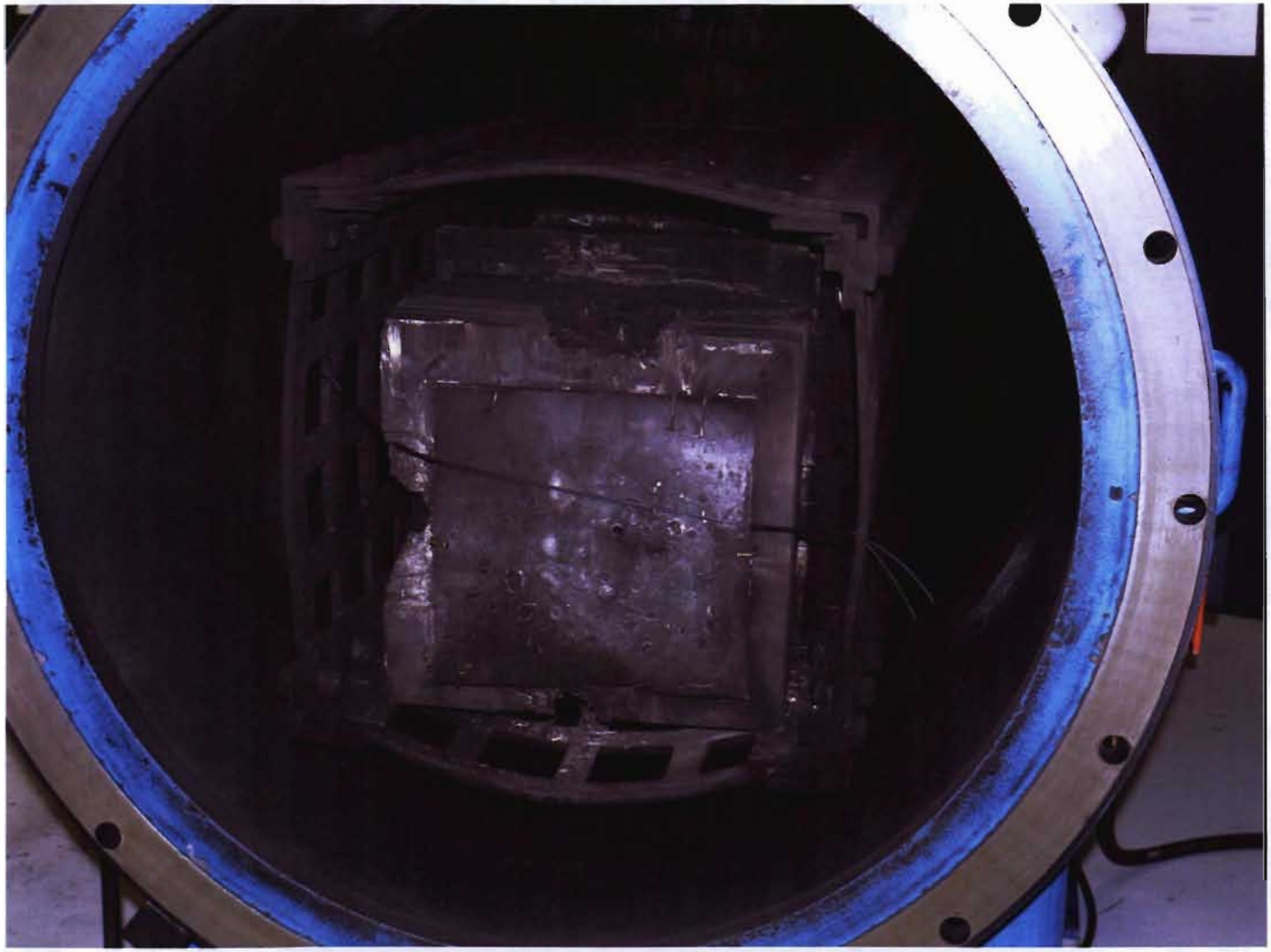
Projectile/shrapnel stop system: Cage with plywood pallets and steel plates



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Plywood pallet and steel plate

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Summary/Conclusions

- **The Helium driven two stage gun at Los Alamos has been in operation since 1994 and completed more than 560 shots to date.**
- **4" Bore Pump Tube, 2" Bore Launch Tube**
- **up to 15,000 PSI breech pressure**
- **Pump tube always pressurized to 255 +/-5 psi**
  - Low accelerations at launch = projectile integrity
  - Max transition section pressure is low
  - No barrel erosion?
- **Minimal down time**
- **~ 70 shots/year in recent years**
- **Capability in proof testing – precise triggering ~ 250 microsec prior to impact.**

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