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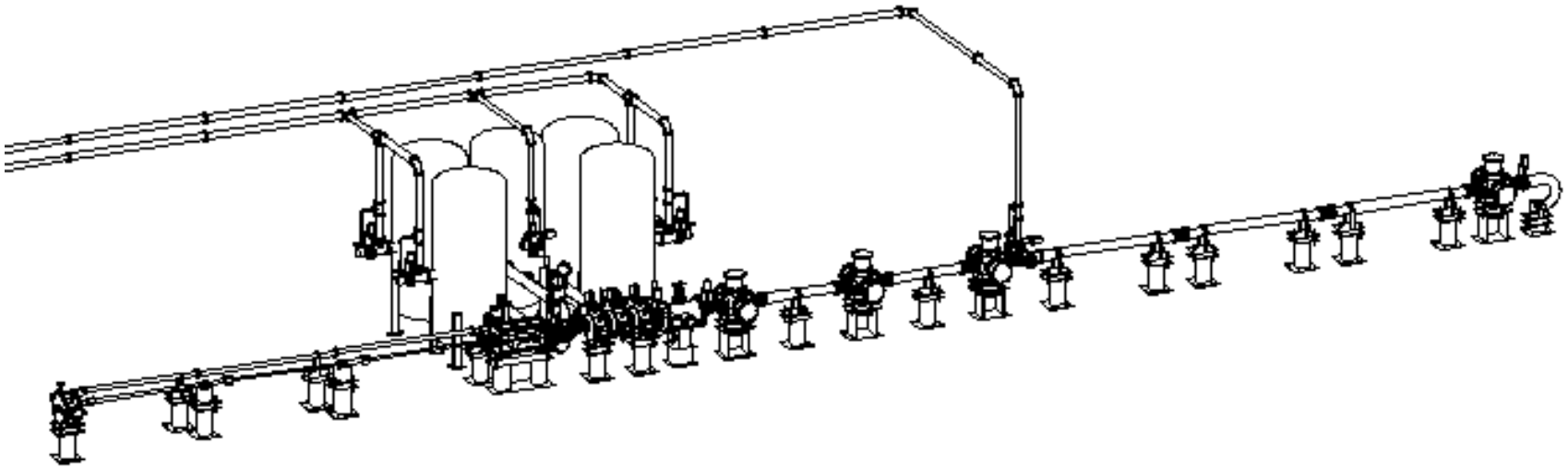
•Status of Experimental Target Injection and Tracking System



Ronald Petzoldt, Dan Goodin, Neil Alexander, Gottfried Besenbruch, Leslie Evans, John Follin, Tom Drake, Brian Vermillian, Bob Stemke and Kevin Jonestrask

US/Japan Workshop **General Atomics, February 4, 2003**

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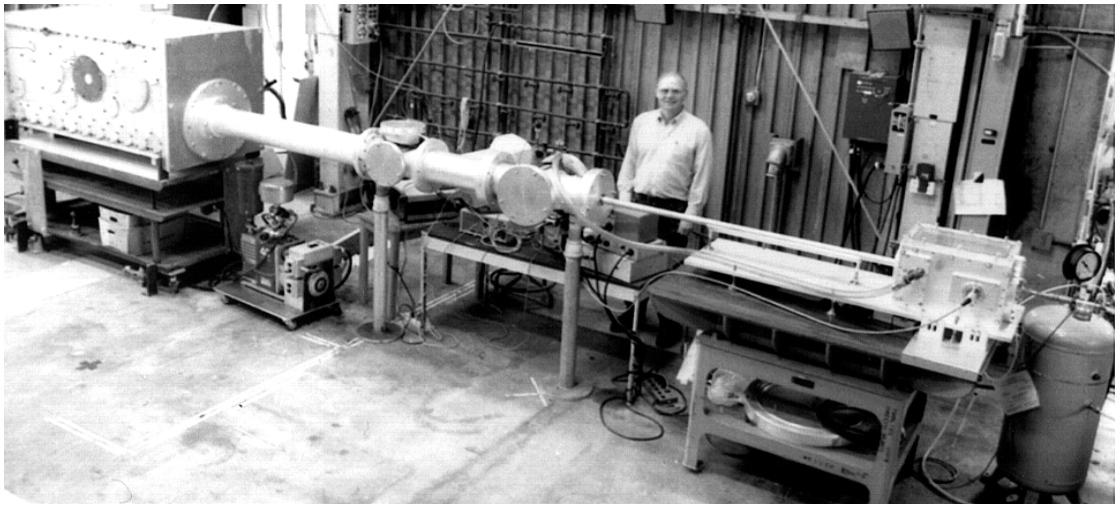
Overview/Summary

Status of injector

- **Introduction**
- **Construction status**
- **Testing status**
- **Planning overview**

Recent injection and tracking work in US

1990-1995: Computational and analytical thesis prepared at LLNL
Target Injection, Tracking, and Beam Pointing for Inertial Fusion Energy
1996-1998: Experimental injection and tracking experiment carried out for room-temperature, indirect drive targets at LBNL
-Position prediction accuracy of ± 100 μm achieved at 3 m distance, 70 m/s, and low repetition rate
- Current requirements:
Direct drive- 400 m/s and ±14 μm at 16 m; Indirect drive 180 m/s and ±100 μm at 11 m and 6 Hz.



1999-Present: Updated analytical, design, fabrication and test work for more capable direct and indirect drive target injection in progress at General Atomics
- Equipment for single shot single axis operation fabricated in 2002
- Ultimate goal is injection of cryogenic targets into (simulated) high temperature chamber

The SDD lists the experimental injector requirements

Requirement name	Indirect drive	Direct Drive
Injection target type	Yes	Yes
Maximum target speed	At least 180 m/s	At least 400 m/s
Maximum target acceleration	At least 50,000 m/s^2	At least 50,000 m/s^2
Injector length	1.6 m	Up to 8 m
Free flight distance	Up to 11 m	Up to 16 m
Repetition Rate	Up to 6 Hz	Up to 6 Hz
Target mass	1 to 5 g	3 to 10 mg (1 to 5 g sabot)
Target diameter	Up to 15 m	3 to 8 mm
Maximum operating pressure	Up to 2.8 MPa	Up to 2.8 MPa
Gas reservoir size	≥1200 times barrel volume	≥1200 times barrel volume
Target spin	1 revolution each 60 cm	Not required
Target exit accuracy	± 0.3 mrad	± 0.3 mrad
Target position prediction accuracy	± 0.1 mm transverse ± 0.3 mm axial at least 5 m from sensors	± 0.014 mm at least 9 m from sensors
Upgradable to cryogenic ops	Yes	Yes
Position detector location	≥0.5 m from target path	≥0.5 m from target path

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We have moved into the newly refurbished building 22

April 2002

December 2002

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Fabrication of target injection and tracking system is nearly complete

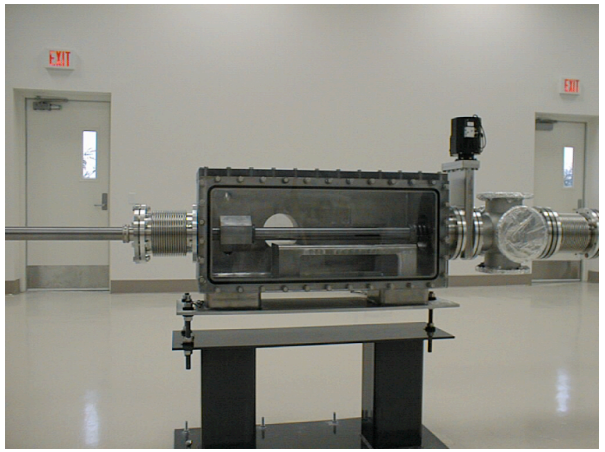
- High-speed gas valve completed and tested by ORNL in March 2002
- Revolver Chamber, gun barrel, muzzle gas diverter, sabot deflector, detector chambers, sabot catcher, stands and tubing are complete

Sabot Deflector Detector Chamber

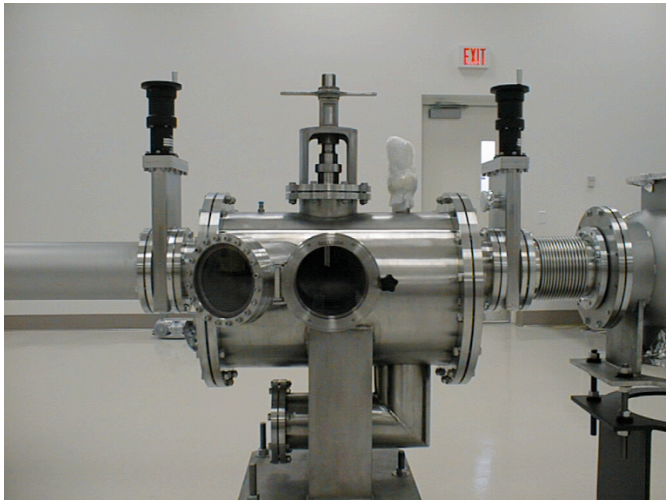
Revolver Chamber (Partial)

Injection system components in Bldg. 22

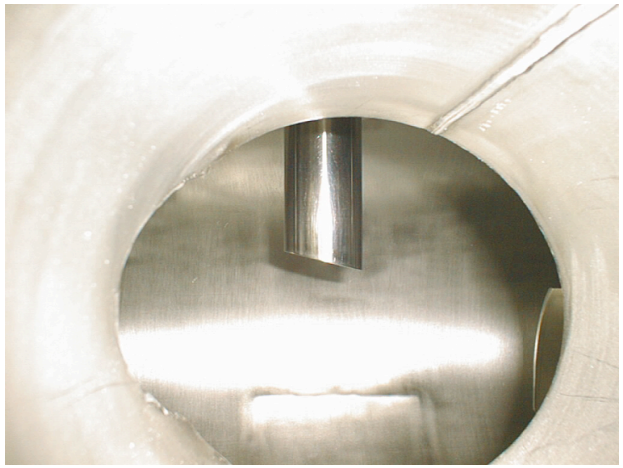
Gun Barrel



Muzzle gas diverter



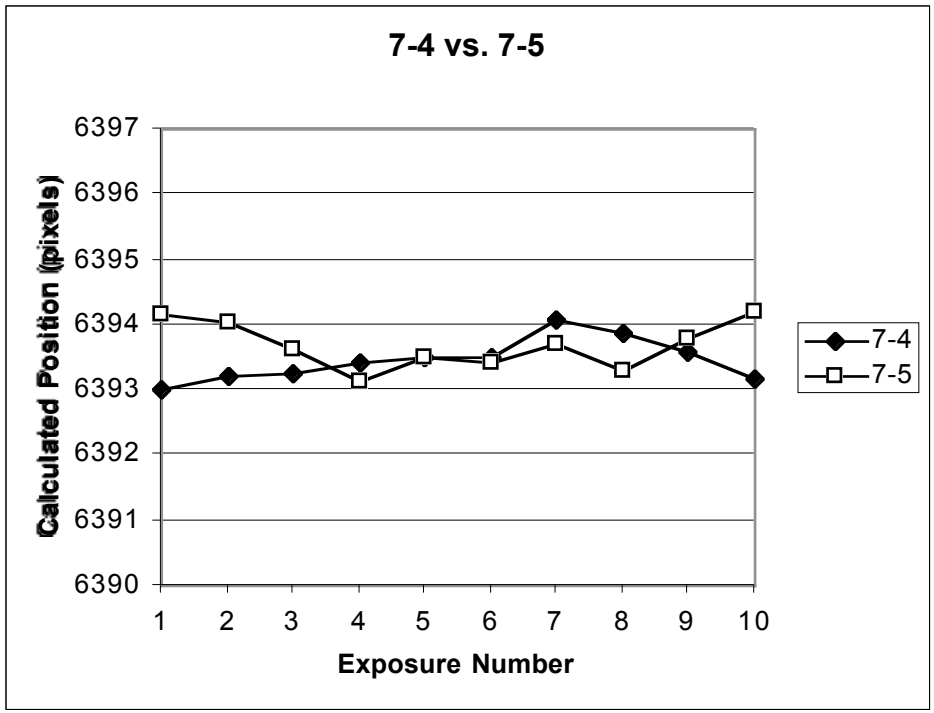
Sabot deflector



Sabot deflector close-up

Stationary target tracking testing showed good repeatability

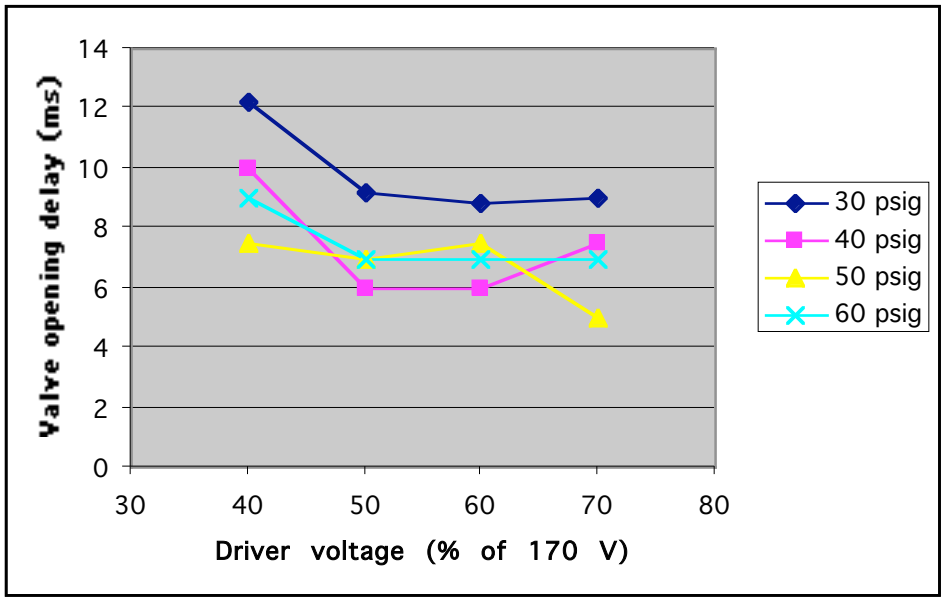
Targets were placed in known positions with translation stages
Targets were then moved and returned to original positions minutes later
Detection system position measurements were reproducible to ± 2.5 microns
Maximum deviation from linear over 8 mm was 31 microns
Maximum deviation from linear over 1 mm was 10 microns
Non-linearity over 1 mm is probably due to beam roughness and interference

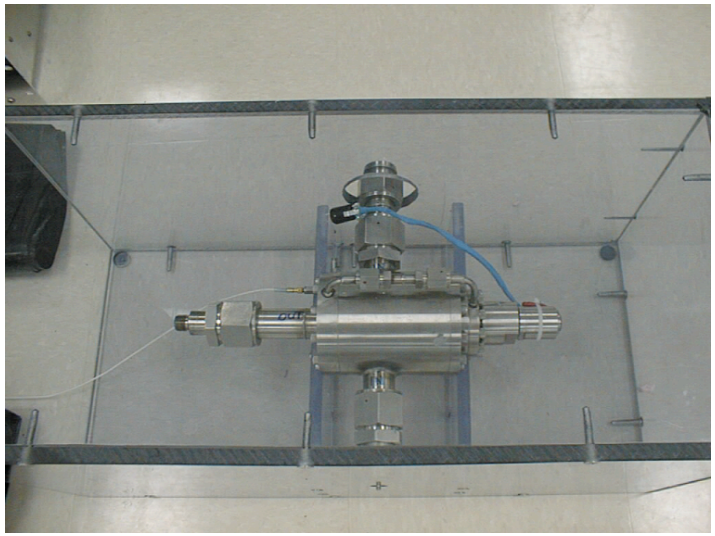


Example test data
(1 pixel = 1.6 microns)

Gas valve testing showed valve functionality and provided response times

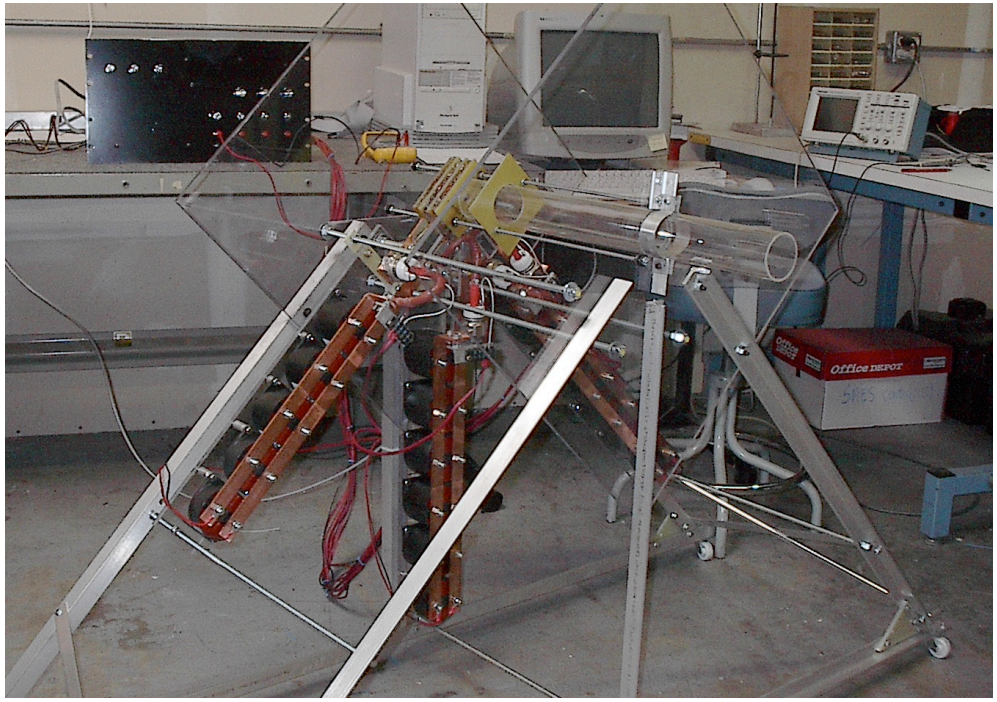
Using typical nitrogen pressure (30-60 psig), time delays from TTL input to valve driver to pressure change at valve inlet were measured





- **This type of component operation data is required to integrate system operation**
- **Initial timing circuit light source testing has been conducted**

EM injector (backup to gas gun) work is ahead of schedule



Injector concept review with NRL held on 18 October 2002

Injector support equipment is in place
High voltage, low voltage, and timing/driver control panels are in place
First stage is operating as expected
2nd and 3rd stage are being tested
Low level of effort project by subcontractor

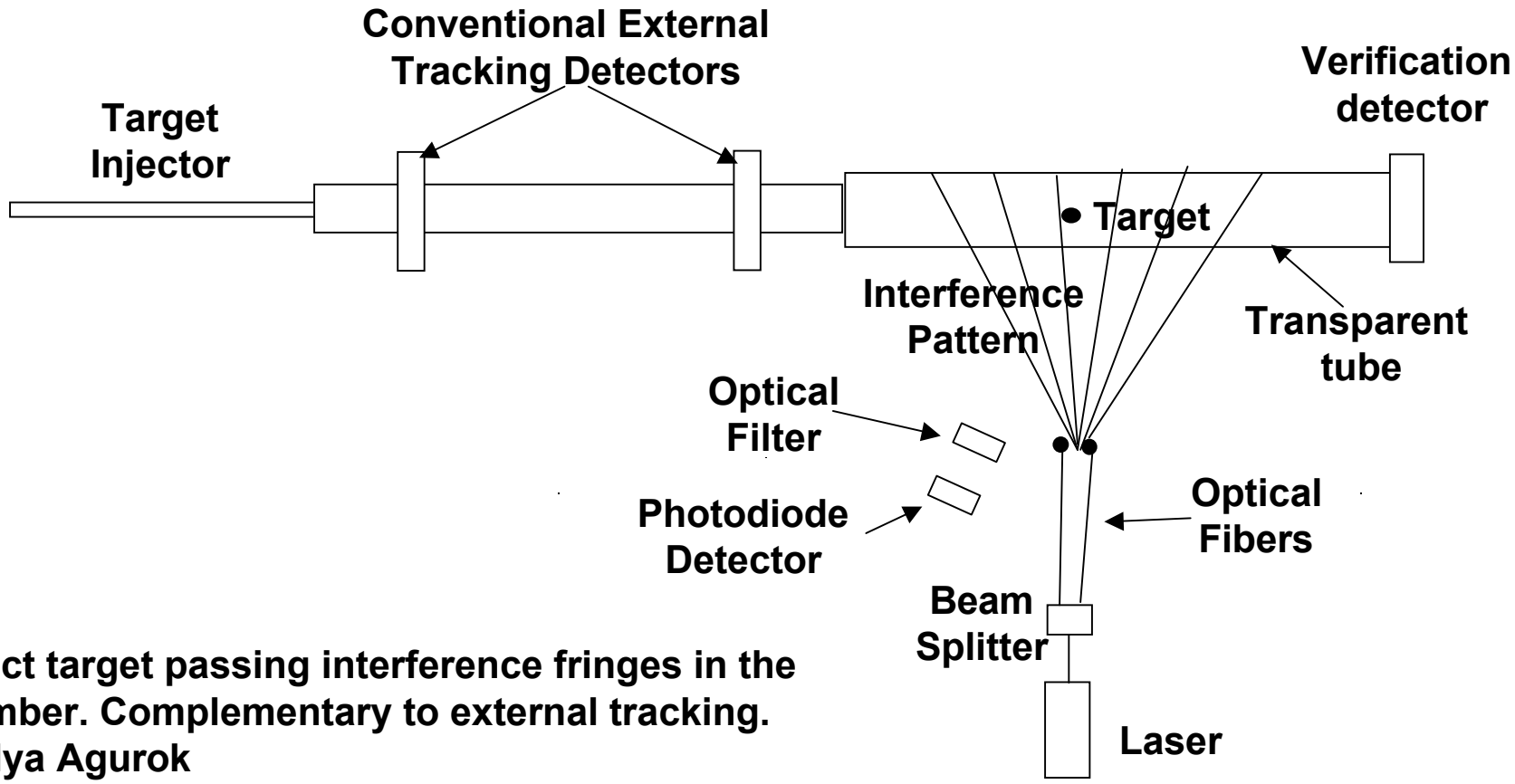
A three part approach is planned for Phase I testing

Phase I A
- Detector testing with externally launched solid plastic spheres (complete).
- Obtain remaining equipment (major equipment is now all here)

Phase I B
- Test all equipment through first detector chamber
  (gas valve, revolver, gun barrel, sabot deflector, position detector)
- Assemble system through first detector (including sabot separation detectors)
- Test interlocks, vacuum, vacuum sensors, revolver (for single shot), etc.…
- Shoot solid cylinders to check accuracy and verify equipment operation
- Shoot targets with sabots to achieve reliable sabot separation
- Achieve sufficient placement target accuracy at first detector

Phase I C
- Single shot, single axis position prediction with timing prediction
  (remaining position detectors and
  position prediction hardware/software testing)

Interferometric tracking to be tested on GA facility by POC



Detect target passing interference fringes in the chamber. Complementary to external tracking.
Dr. Ilya Agurok
Phase II SBIR-Physcical Optics Corporation, Torrance, CA

Summary and Conclusions

- Major component fabrication for single shot single axis tracking is complete
- A three phase approach is planned leading to single axis position prediction and timing prediction experiments as soon as possible
- Electromagnetic injector work is proceeding quite well
- Interferometric target tracking is being investigated