TARGET INJECTION INTO A GAS-FILLED CHAMBER

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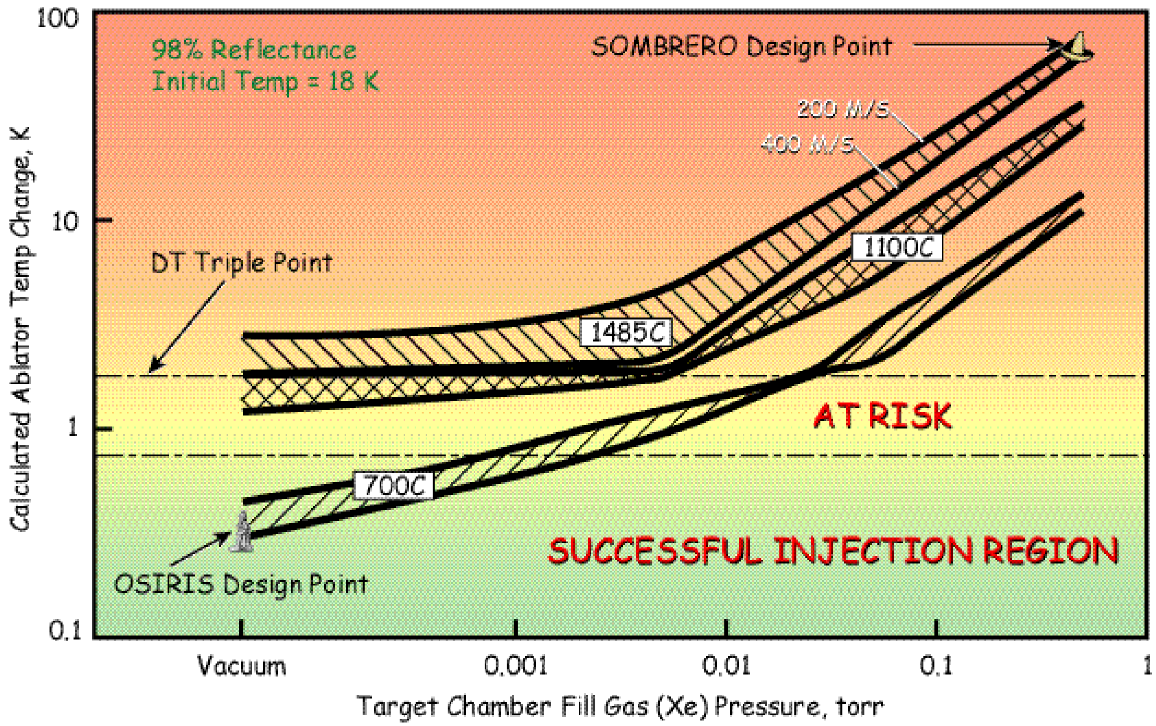
GENERAL ATOMICS

OUTLINE

- Purpose Of This Talk – ARIES Workscope:
  - "Expand the injection operating envelope; Goal: a self-consistent scenario"
- Target Heating During Injection
  - Finding a "Success Path"
  - Lower Temperature/Gas Pressure
  - Thicker Polymer Shell
- Target Reflectivity Measurements
  - Thin gold layers on polymer films
- Chamber Gas Effects on Target Trajectory and Tracking

PARAMETRIC ESTIMATES OF THE DT HEATUP UNDER VARYING REACTOR TEMPERATURE AND CHAMBER PRESSURE CONDITIONS HAVE BEEN PERFORMED

- **Bottom Line = DT Heatup is Far Outside the Survival Range for the Reference Chamber Conditions**
- **Chamber-Based Options:**
  - Reduce the fill gas pressure
  - Reduce the chamber temperature
  - Provide other wall protection methods
- **Target-Based Options:**
  - Provide additional target protection (e.g., change the target design)
  - Sacrificial frozen gas on the surface of the target
  - Co-injection of a "wake shield" to clear the area in the front of the target
  - Using a sacrificial sabot that protects the target until reaching the target chamber center
  - Fast-formed liquid target – an open-pore foam target filled with DT that is cooled until injection, then utilizes the chamber heating to generate an all-liquid DT fuel with a smooth inner surface



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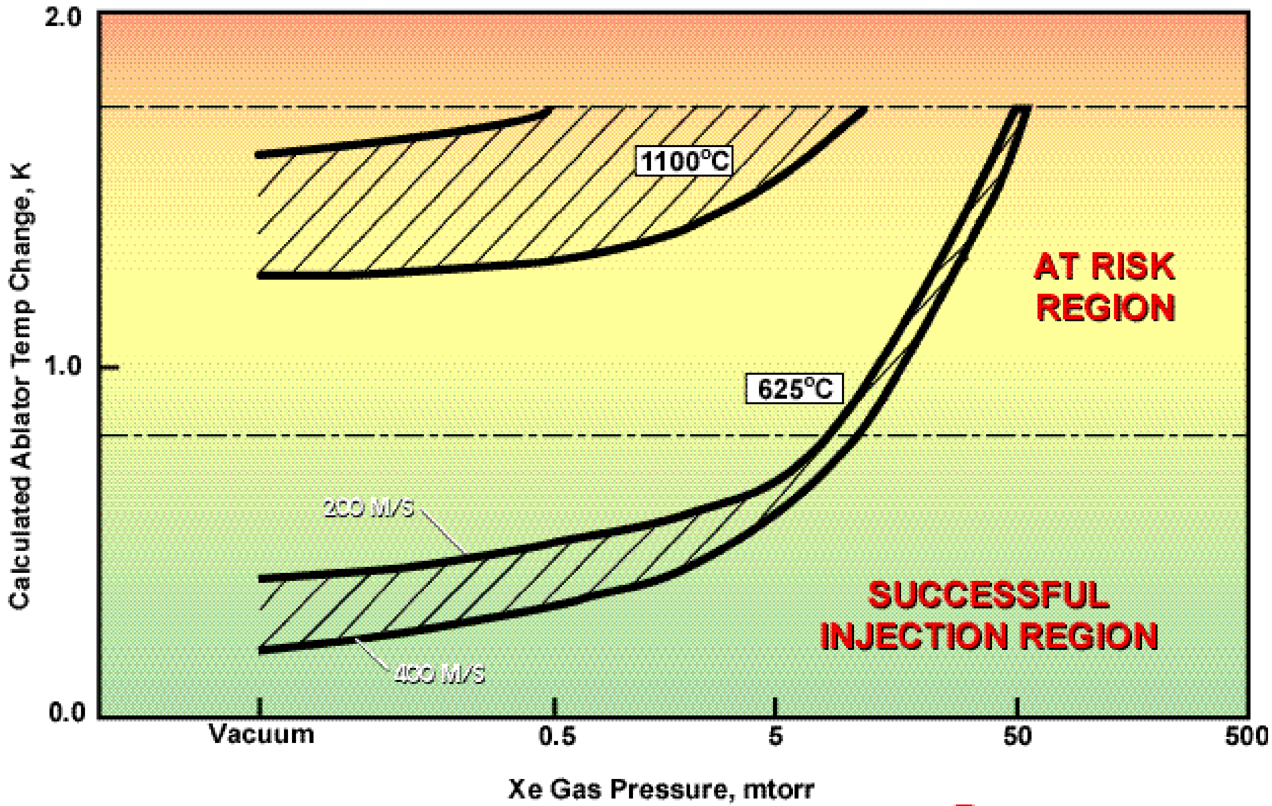
THERE ARE OPERATING REGIMES FOR SUCCESSFUL INJECTION OF DIRECT DRIVE TARGETS

- Assumes 98% Reflectivity of Target Surface (NRL Radiation Preheat Target)
- Calculations by DSMC Code; SOMBRERO Chamber Geometry
- Two-Level Failure Criteria Based on (1) Stress and (2) Reaching DT Triple Point
- It Has Been Suggested that Substantially Lower First Wall Temperatures May Be Feasible



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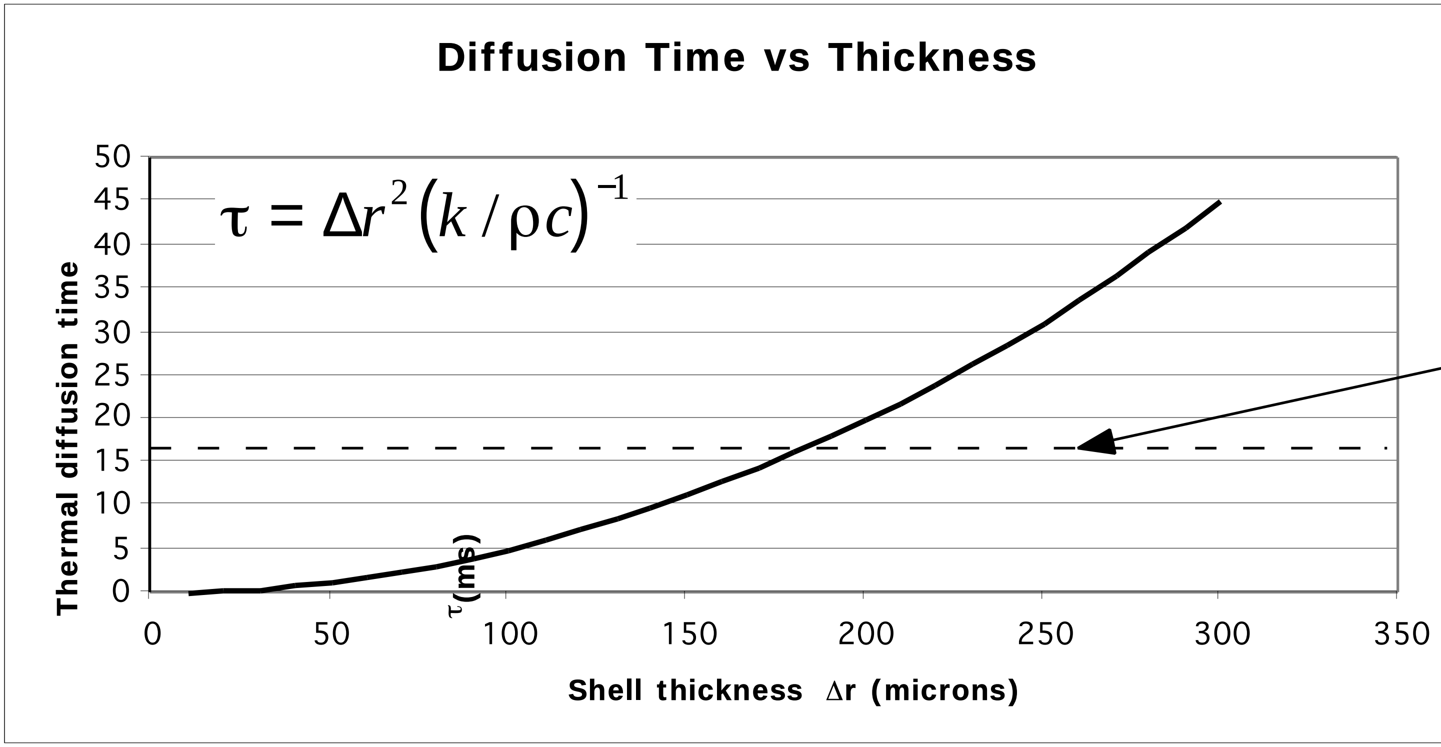
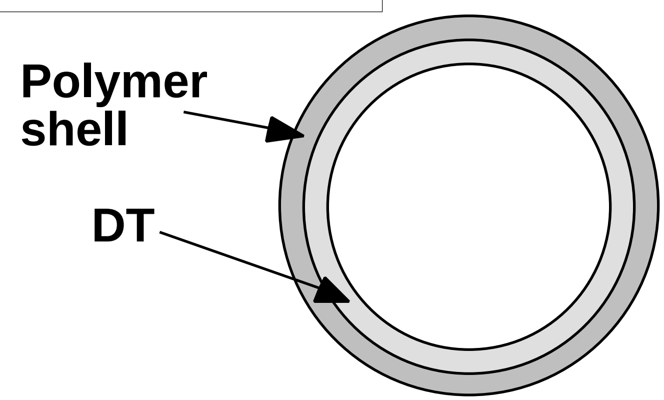
ABOUT 200 MICRONS OF POLYMER WOULD PROVIDE SIGNIFICANT INSULATION FOR THE DT



Outer shell temperature can also rise too high for low conductivity-low specific heat shells



Assumes thermal diffusivity $k/\rho c = 2\times10^{-6}\ m^2/s$, target velocity = 400 m/s, and chamber radius = 6.5 m

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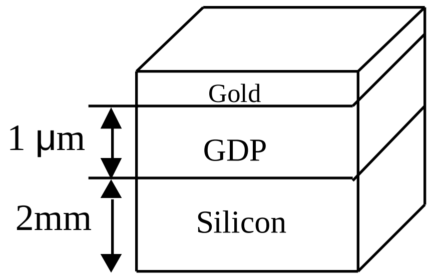
TARGET REFLECTIVITY MEASUREMENTS - STATUS

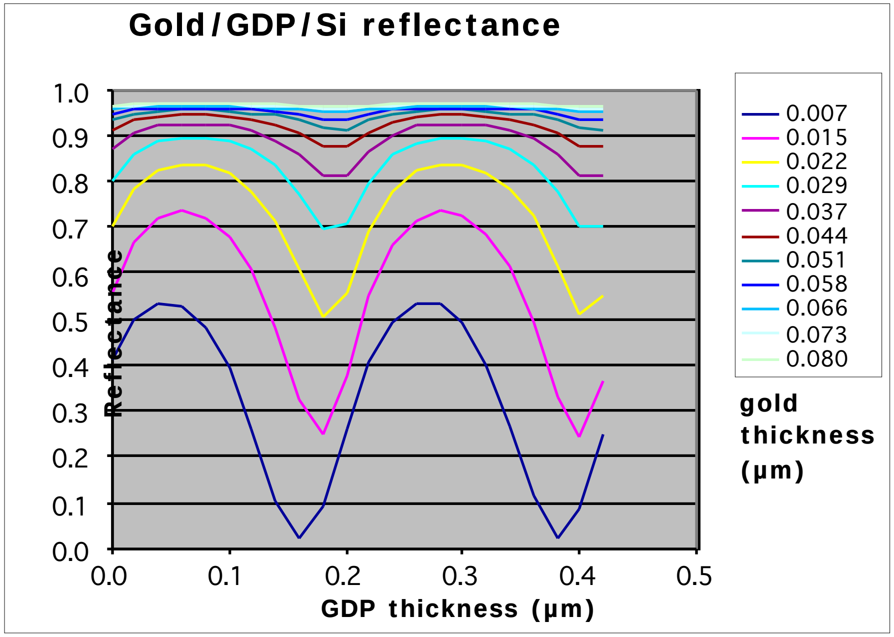
- Task Was "Fabricate Thin Gold Layers and Measure Reflectivity"
- Significance: Critical Factor in Estimating Target Heating During Injection
- Objective: Measure How Close We Are to Theoretical Values with "Prototypical" Processes, Equipment, and Materials
- Approach:
  - Deposit gold layers of 400 to 1250 A on ~1 μm GDP
  - Measure reflectance as function of wavelength and angle of incidence
  - Calculate overall hemispherical reflectance for given blackbody spectrum
- Procedure:
  - Deposit GDP on 1 cm square pieces of silicon using a plasma polymer coater
  - Sputter coat gold at 10 torr
  - Verify thickness using a profilometer and x-ray fluorescence



- Status: Spectral Analysis Pending

MODELING OF REFLECTANCE OF THIN GOLD FILMS

- **Model of Reflectance to Compare to Measurements**
  - Calculated “thick” bulk gold reflectivity of 97.6% for Sombrero spectrum
  - But for multiple thin layers, must consider reflectance at interfaces
  - Find reflectivity can vary dramatically for slightly different GDP thickness – at certain wavelengths and thickness
- **Modeled Normal Incidence Reflectivity as Function of Wavelength and Gold and GDP Thickness**
- **Periodic Constructive/Destructive Interference Effect**
- **Conclusions:**
  - Effect diminishes with increasing wavelength
  - Less for DT than for silicon substrate
  - Expected to “wash out” for real targets



Calculated normal reflectance from the surface of a gold/GDP/silicon surface at a wavelength of 0.73 microns

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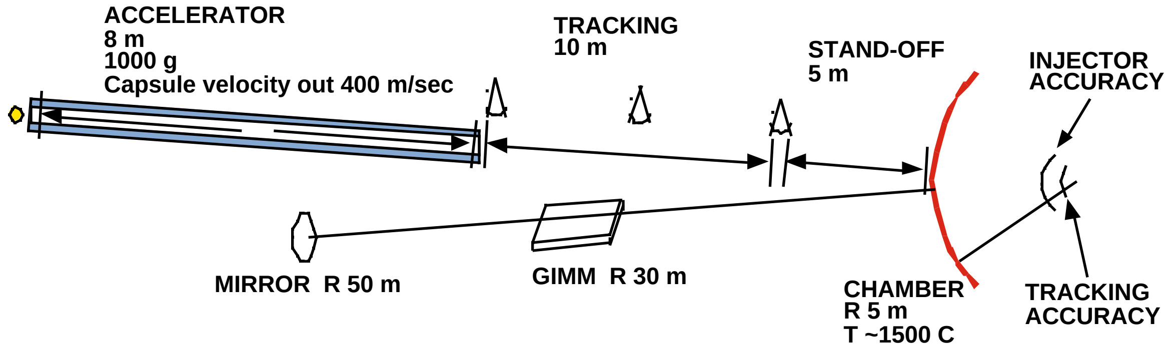
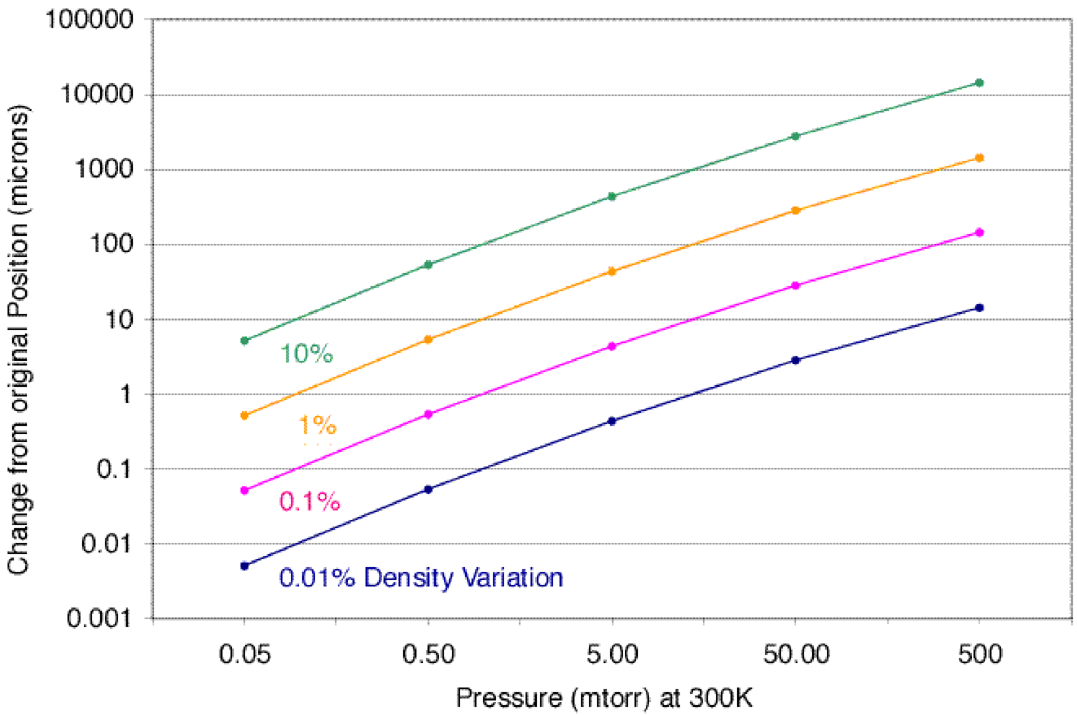
CHAMBER GAS EFFECTS ON TARGET TRAJECTORY

- **Traditional Concept of Tracking is Out-of-Chamber**
- **Chamber Gas Variations Can Affect the Target Trajectory in a Non-Predictable Way**





- **Calculated Forces on Target from DSMC Code**
- **"Correction Factor" for Full Xe Pressure is Large (~20 cm)**
- **Repeatability of this Correction Factor Requires Constant Conditions or Precise Measurements**
- **A 1% Density Variation Causes a Change in Predicted Position of 1400 μm**
- **For A Manageable Effect at 50 mtorr, the Density Variability Must Be <.01%.**
- **Leads to In-Chamber Tracking**

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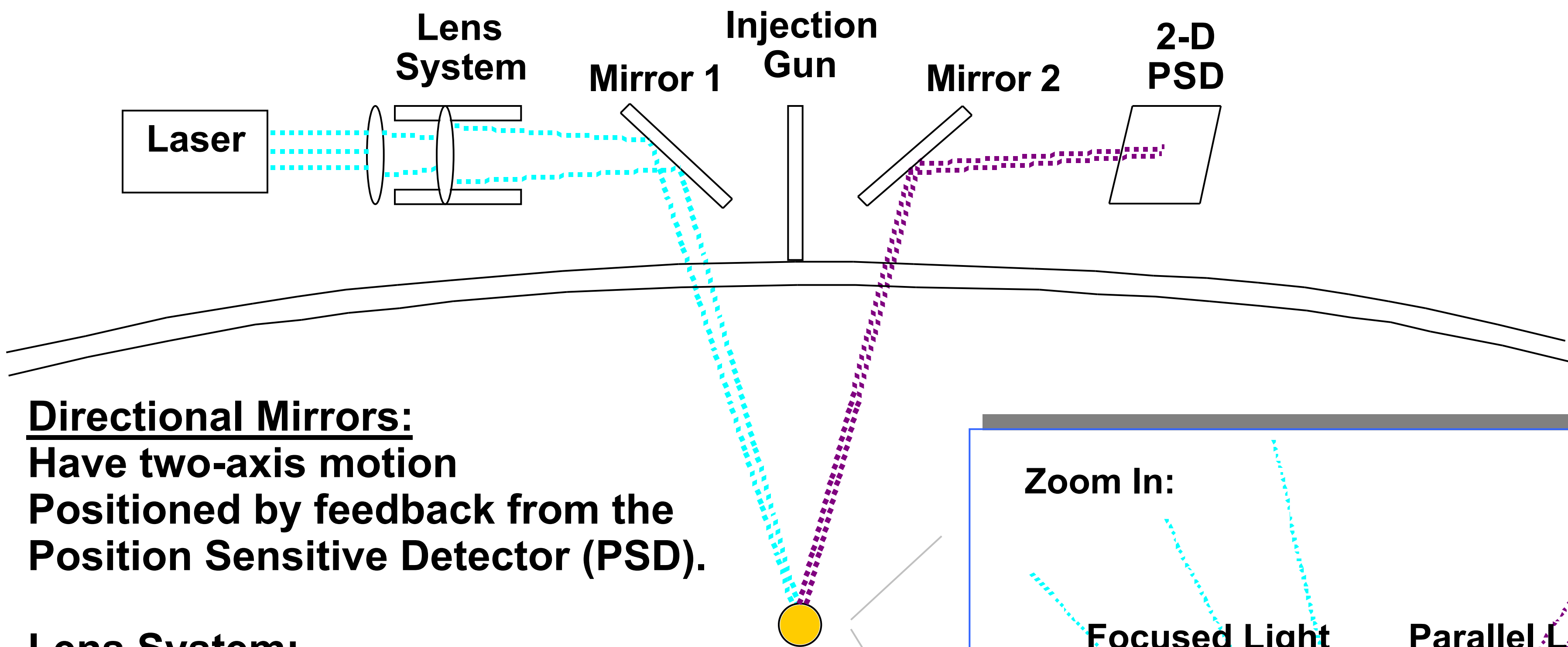
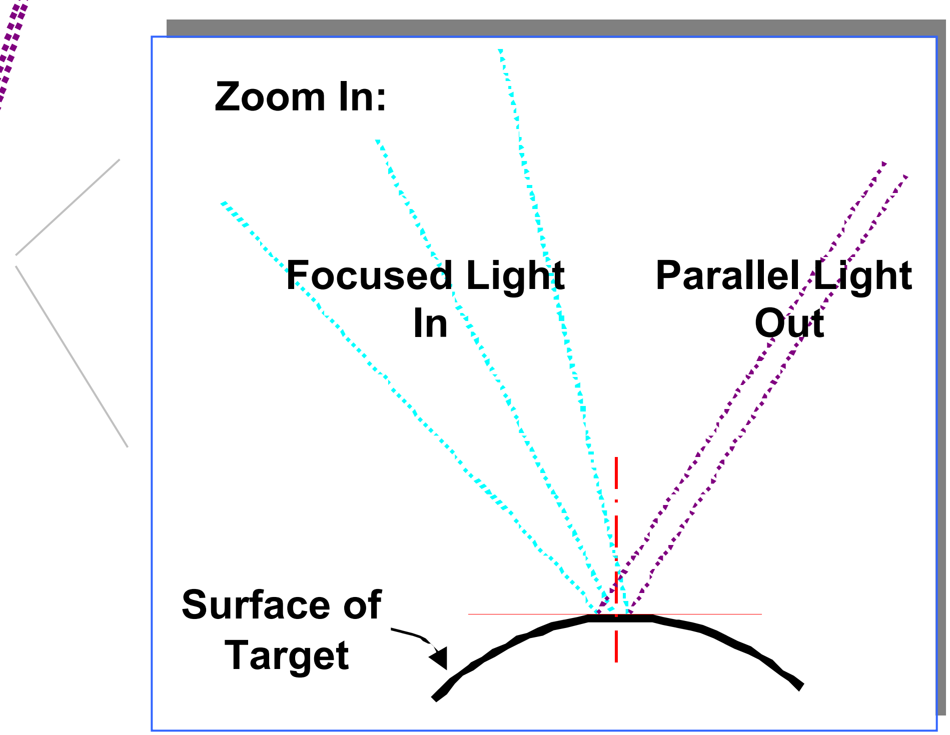
POTENTIAL METHOD FOR TRACKING TARGET IN-CHAMBER



<u>Directional Mirrors:</u>
Have two-axis motion
Positioned by feedback from the Position Sensitive Detector (PSD).

<u>Lens System:</u>
One fixed position & one with parallel adjustable axis (changes depth of focus to track target)

<u>Two Dimensional PSD:</u>
Dual axis motion to keep detector perpendicular to beam axis.



CONCLUSIONS

1. There Are Operating Regimes (Substantially Reduced Chamber Temperature and Gas Pressure) That Allow Successful Target Injection in A Dry-Wall Chamber

2. Roughly 200 Microns of Polymer Needed to Provide Significant Insulation

3. Measurements of Gold Layer Reflectivities Are Proceeding

4. Modeling of Reflectance Coupled with Measurements Should Give Us a Better Understanding of this Pathway for Target Protection from Thermal Radiation

5. Even millitorr Levels of Gases in the Chamber Can Have a Major Effect on the Target Trajectory and May Lead to In-Chamber Tracking