Indirect Drive Target Injection

Summary:
- Target Structure for Acceleration
- Target Heating
- Flibe Diffusion
- Tracking/Positioning

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The target’s structure must support acceleration

Target acceleration \( \sim 2500 \text{ m/s}^2 \)
Barrel length \( = \frac{v^2}{2a} \sim \frac{(100 \text{ m/s})^2}{[2(2,500 \text{ m/s}^2)]} = 2 \text{ m} \)

Flibe mechanical properties are unknown but may be similar to other salts
Low density foam properties are unknown
DT strength will be measured at LANL
  (extrapolated DD properties indicate 10,000 m/s\(^2\) acceptable)
Gas support membrane thickness for 2,500 m/s\(^2\) is \( \sim 4 \) microns.
  (4 microns absorbs about 1% of beam energy)
Capsule support membrane thickness \( \sim 0.2 \) micron\(^*\) for 2,500 m/s\(^2\)
Capsule displacement \( \sim 100 \) microns can be reduced by pre-stressing membranes

\(^*\)R. W. Petzoldt & R. W. Moir,
Membrane Support of Accelerated Fuel Capsules for Inertial Fusion Energy.
Heating of indirect drive targets during injection is small

Heating Profile:
- 300 K gas for 32 ms
- No heat load for 30 ms
- 900 K chamber for 40 ms
Counter flowing helium and shutters can minimize Flibe vapor reaching tracking system*

2 cm opening requires ~4 Torr He with shutter open 5 ms.
Average flow rate ~0.4 mg/s.
Unabated Flibe diffusion = ~3 kg/year.

\[ c = c_0 \exp \left[ - \left( \frac{v}{D} \right) x \right] \]

\[ D \sim 0.5 \text{ cm}^2/\text{s} \ (T/T_0)^{1.75}(P_0/P) \]

Need to demonstrate improved target tracking accuracy

1996-1998: Experimental injection and tracking experiment carried out at LBNL
- Total transverse position prediction accuracy of $\sigma = 160 \ \mu$m achieved at 3 m distance, 70 m/s, and low repetition rate. Extrapolates to $\sim 280 \ \mu$m at 9 m.
- Current requirements:
  Up to 180 m/s and nearly all targets $\pm 100 \ \mu$m at 9 m and 6 Hz
  Vibration isolation and multi-segment arrays are expected to improve accuracy
- We’re building experimental system to achieve improved accuracy
If Flibe droplet density and size are not excessive, in-chamber tracking should not be necessary.

\[ \Delta R = \frac{\Delta v}{v_0} R_c = \frac{m_d}{m_t} R_c \]

\[ m_d = \frac{\Delta R}{R_c} m_t = \frac{0.3 \text{ mm}}{3 \text{ m}} 2 \text{ g} = 0.2 \text{ mg} \]

Droplet radius is 0.29 mm. Smaller droplet density is limited to about 1 g/m³.

Occasional verification of beam on target position may still be required.
Summary and Conclusions

• Targets must be strong enough for acceleration
• DT mechanical properties are being measured, others need to be
• Indirect drive target heating is calculated to be small during injection
• Gas counter flow can keep Flibe out of tracking system
• Target transverse position is measured with linear photodiode arrays. (Requires high speed arithmetic on pixel outputs.)
Norimatsu studied for KOYO reactor (650 C LiPb) conservatively assumed all vapor molecules that hit target stick. Average 800 Å thick for 5 m at 200 m/s in 0.1 Torr LiPb vapor not uniform even if target spinning. DT surface heating <0.4 K is reduced to <0.2 K by deposited metal layer.