Status of IFE Tritium Inventory and Target Mass Production

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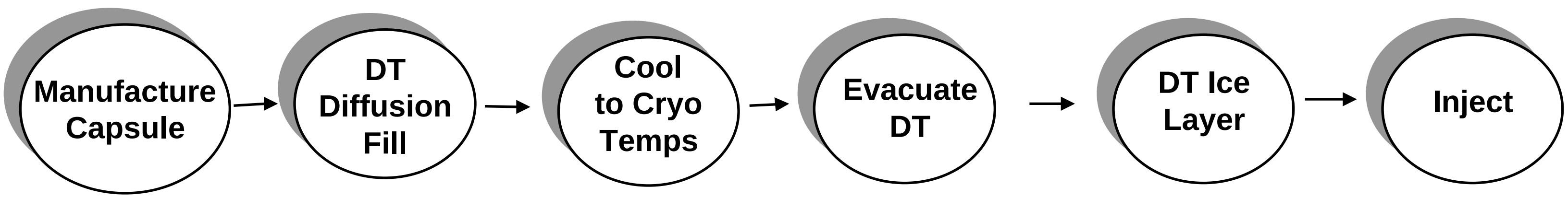
Fill facility tritium inventory evaluation is important for IFE power plants

- Develop model to evaluate the tritium inventory of the target fill facility as a function of target designs and target handling methods
- Current model evaluates influence of:
  - Target DT permeability during diffusion filling
  - Target strength parameters (foam density and shell wall thickness)
  - Fill system void fraction
  - Target cool down time
  - Target layering time
- Iteration with target design effort

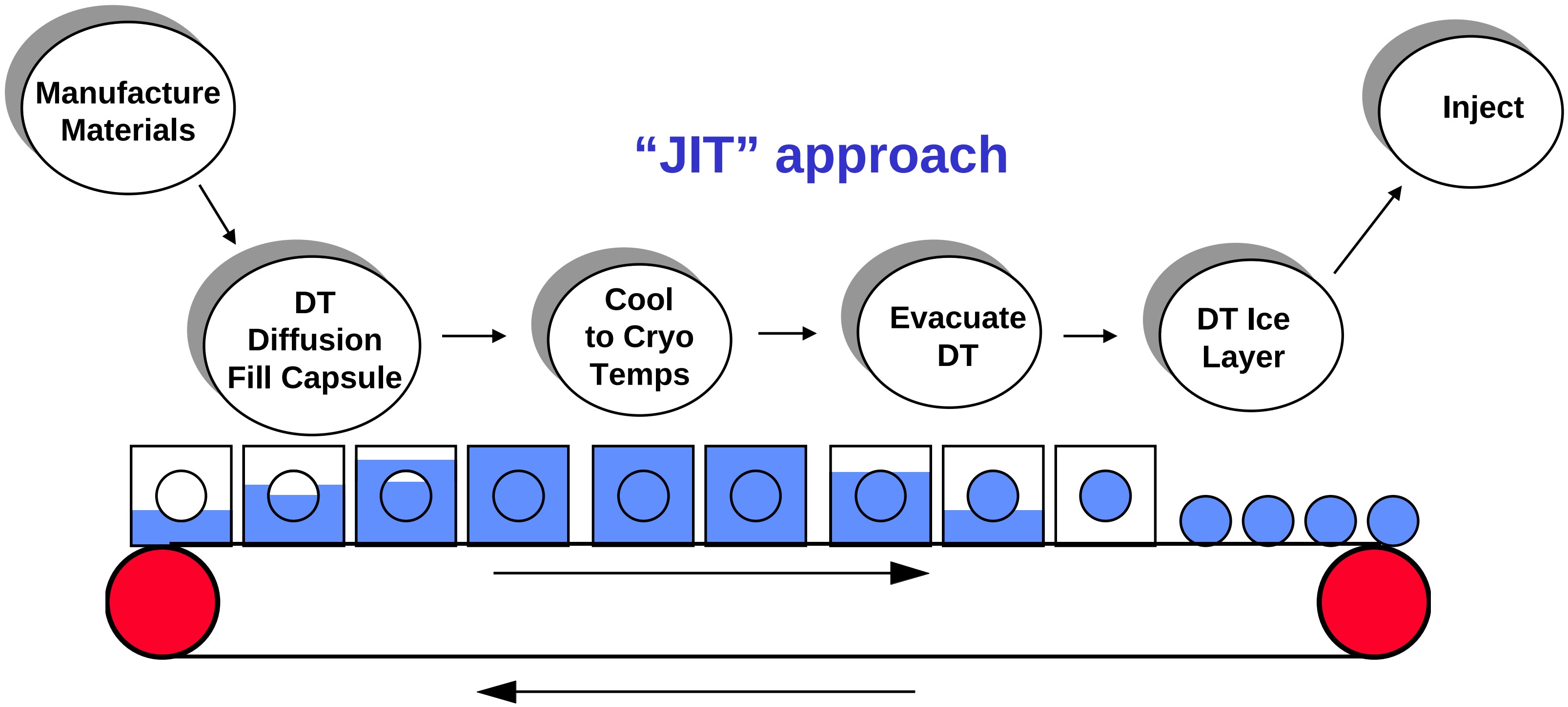
What's new with tritium inventory evaluation since the last meeeting?
⇒ evaluated influence of higher foam density
⇒ updated permeability data
⇒ evaluated target cool time

Process for fabrication and filling of the direct drive target



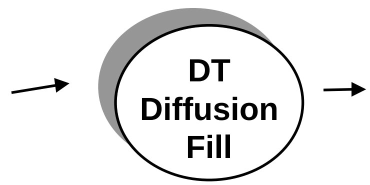
We are evaluating the minimum tritium inventory required for IFE plants

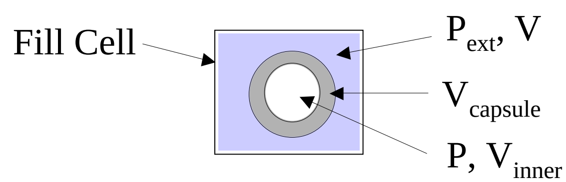
Fabrication of Direct Drive Targets



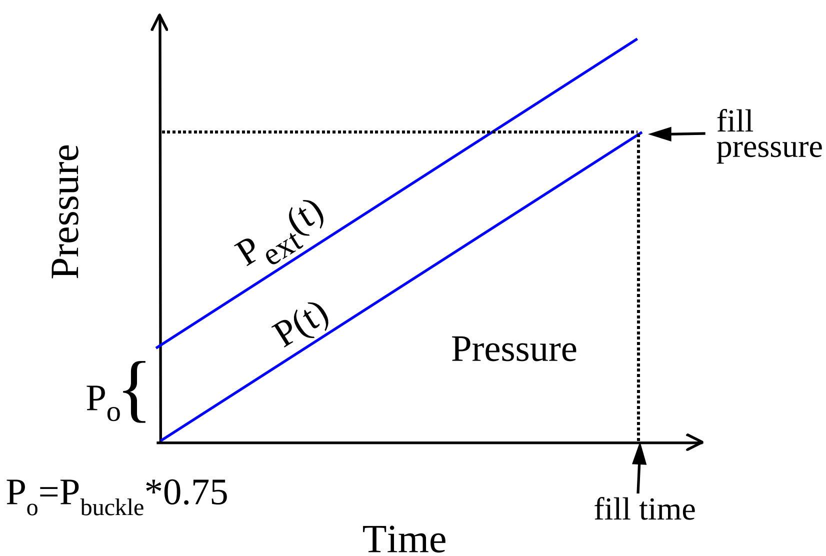
Targets are processed at the rate necessary for injection
Benefit of model: eliminates engineering assumptions

Tritium inventory during filling





DT pressures during filling



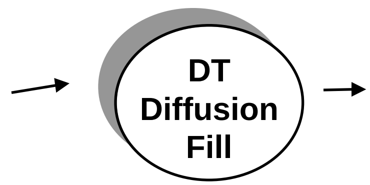
$$g_{fill\_outside} := \frac{MW \cdot (V - V_{capsule})}{R \cdot T_{fill}} \cdot \int_0^{N_{fill}} P_{ext}(n)\, dn$$

$$g_{fill\_inside} := \frac{MW \cdot V_{inner}}{R \cdot T_{fill}} \cdot \int_0^{N_{fill}} P(n)\, dn$$

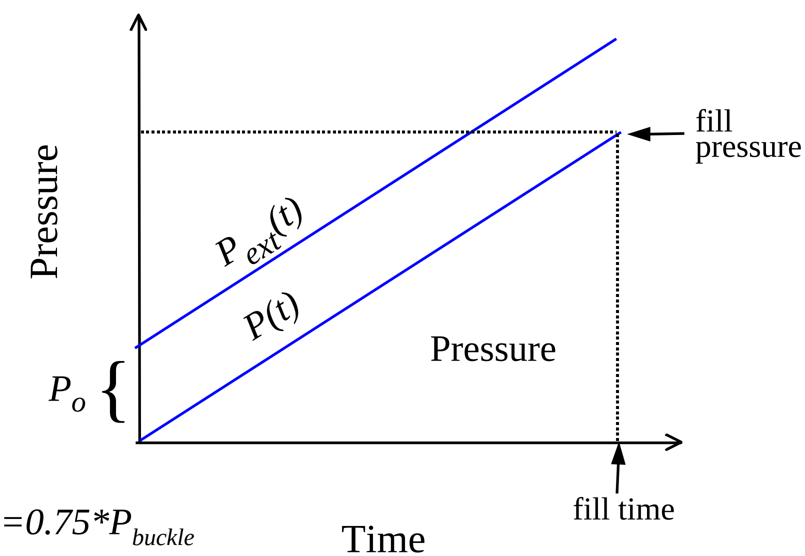
$$g_{fill\_TOTAL} := g_{fill\_outside} + g_{fill\_inside}$$

N_{fill} = (shot rate) x (fill time)

The capsule fill time is a function of the capsule wall thickness and internal foam properties

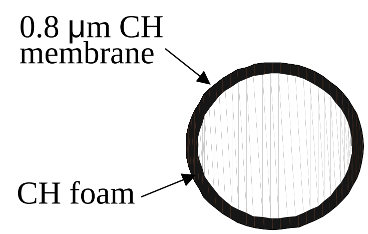


DT pressures during filling



$P_o = 0.75 * P_{buckle}$

Direct Drive Target



$$P_{buckle} = \frac{2E_{Foam}t^2}{r^2\sqrt{3(1-\nu_{Foam}^2)}}$$

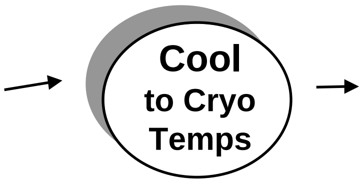
$$E_{foam} := E_{solid}\left(\frac{\rho_{foam}}{\rho_{solid}}\right)^2$$

Foam strength is sensitive to foam density

↓

Strong effect on inventories

Tritium Inventory During Cooling

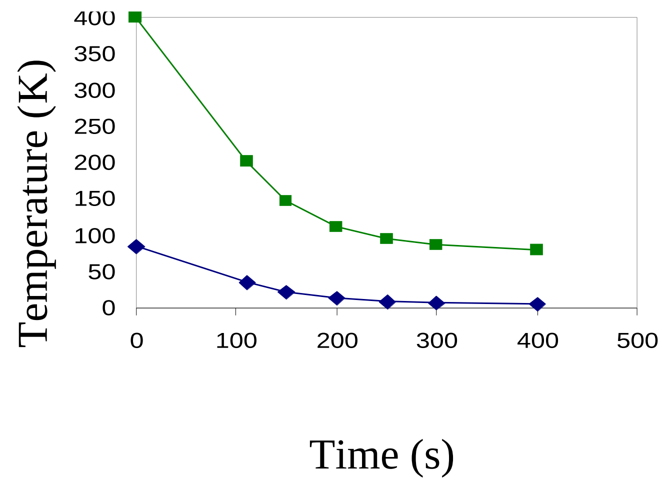


Pipes immersed in N_2, He

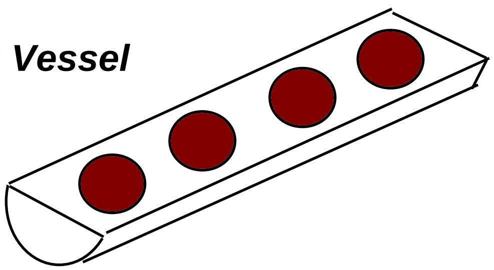
ρ, κ, **Cp** ⟶ α, **effective thermal diffusivity**

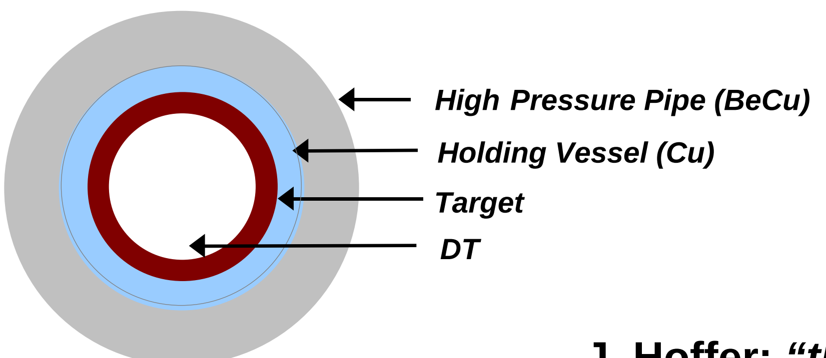
transient thermal conduction

15 min



Target Holding Vessel

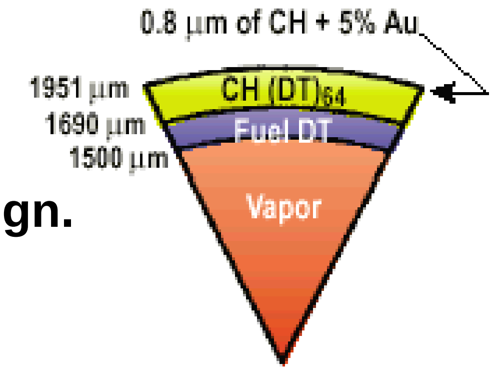




J. Hoffer: ***"this can be cooled within 30 minutes"***

Target fabrication feasibility and cost is being evaluated for proposed target designs

Assume target is based on the original NRL design.



Previous calculations	PARAMETER	Current calculations
6.5×10^{-15} mol/m Pa s	PERMEABILITY	19.5×10^{-15} mol/m Pa s
6.7 Hz	REP-RATE	17 Hz
10 mg/cc	FOAM DENSITY	100 mg/cc
9 days	FILL TIME	0.8 hr
14.8 kg	TRITIUM INVENTORY*	1.6 kg

* 33% void fraction, fill at 300K, 8 hr beta layer

Tritium inventories have been evaluated

Theoretical minimum tritium inventory ***(Actual inventories will be higher)***

	DD Target
Buckle Pressure	**4.65 atm**
Fill Time	**0.8 hours**
8 h Layering Time	**1.6 kg**
2 h Layering Time	**0.64 kg**

- **17 shots per second***
- **Void fraction – 10%**
- **Fill Temp – 27°C**
- **Cool time - 1/2 hr**
- **Evac time - 1 hr**
- **Layer time – 2 and 8 hr**
- **Fill overpressures are 75% of buckle pressure**

* target design 17 Hz reprate for HYLIFE_IIconceptual plant design for net power of 1 GWe

- **The above analysis has been performed to evaluate "minimum" tritium inventory - this allows comparison of inventories for different approaches without assuming an engineering approach.**
- **"Actual" tritium inventories based on real engineering scenarios will be evaluated in the future.**

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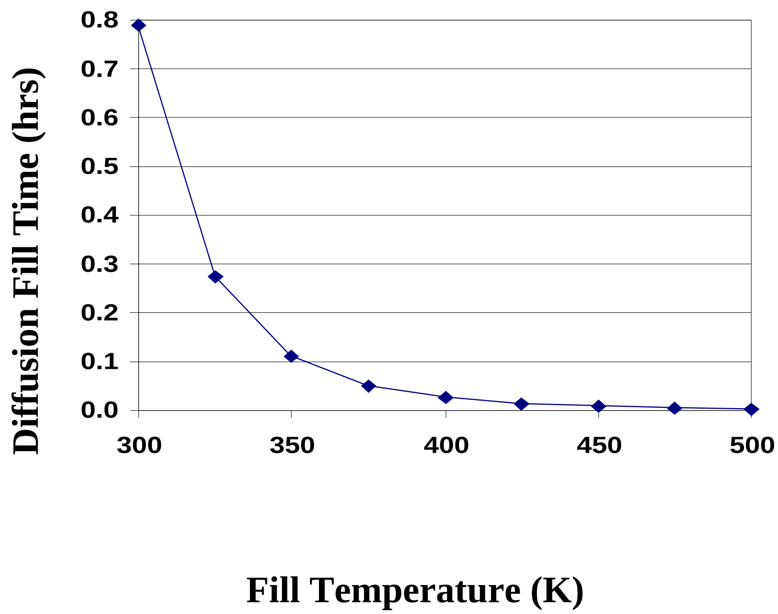
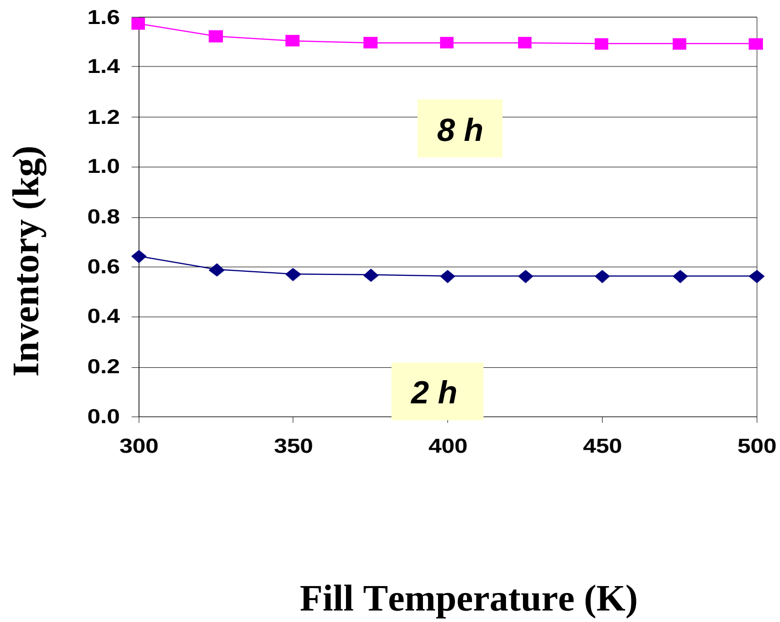
Increasing the capsule temperature during filling and decreasing layering time decreases tritium inventory

Direct Drive Target

Higher temperatures decrease fill time

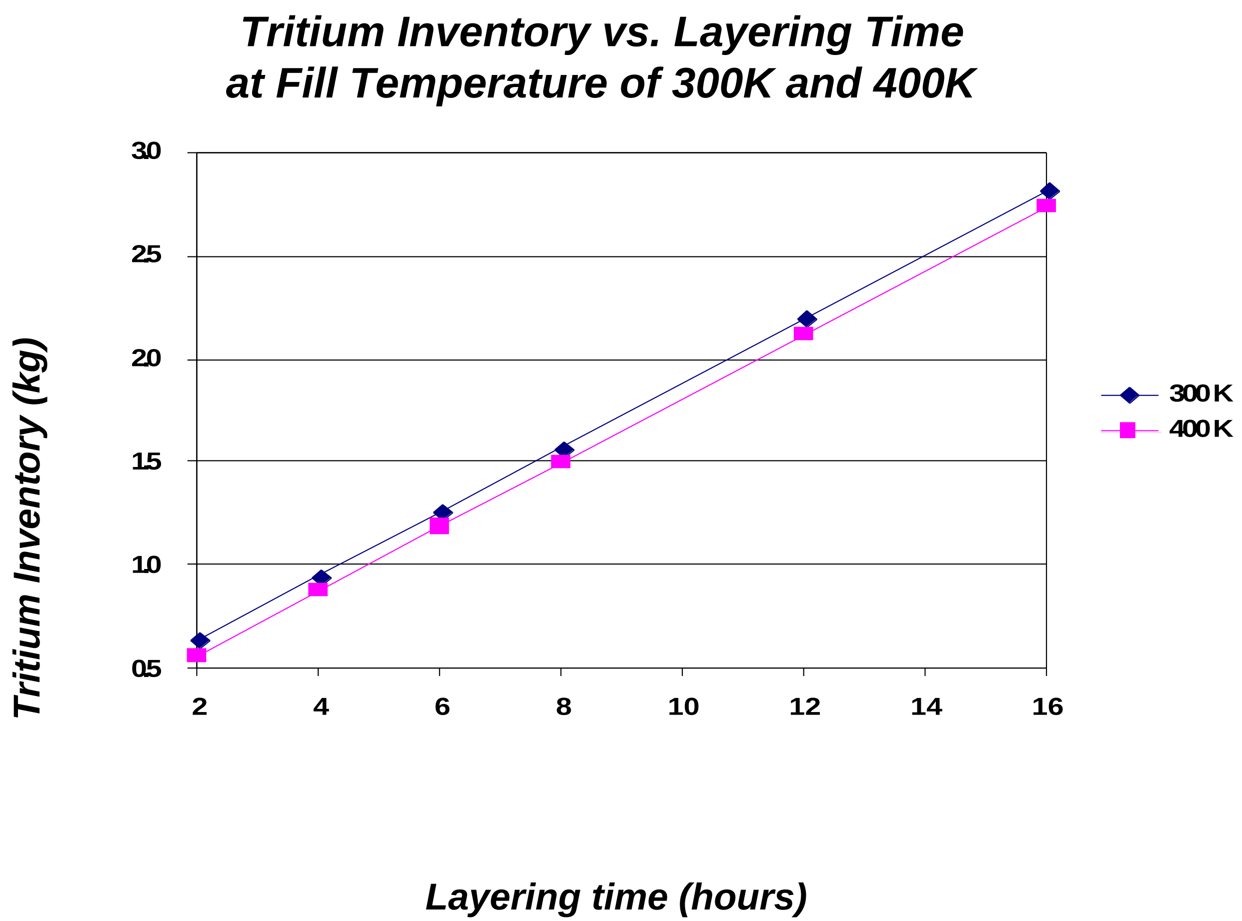


Shorter layering time decreases inventory



Assumes:
10% void fraction
100 mg/cc foam
rep-rate = 17 Hz

Decreasing the layering time in the fill system greatly decreases tritium inventory



Progress has been made in reducing IFE plant tritium inventories, but more work is required

- **Reducing layering time is important for fill facility tritium inventory reduction**
- **Evaluate what can be done by filling at higher temperatures and shorter layering times.**
- **Evaluate inventories associated with higher foam densities, but tradeoff between reduced inventory with higher density foam vs. reduced yield needs to be evaluated.**
- **Implementation and optimization of batch target filling processes.**
- **Evaluate effects of gold layer permeabilities on inventory.**

Foam injection molding offers the possibility to form high precision shells, but some important issues need to be resolved

Injection Molding Advantages

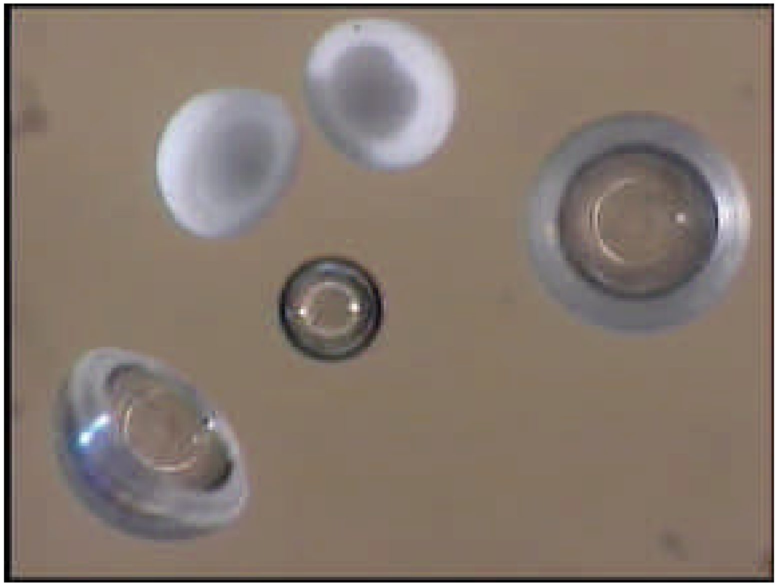
- Close control of target specifications
  - out of round
  - wall variation
  - outside diameter
- Process simplifications possible
- Mature industrial technology available

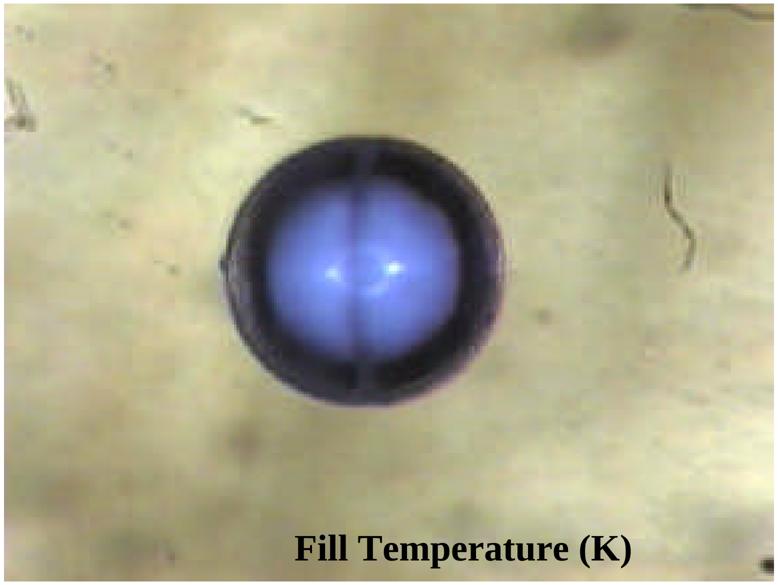
Issues

- Bonding of hemishells with acceptable defects
- Removal/elimination of "nub" from injection mold process
- Mold design
- Precision fabrication of molds
- Process for overcoat and surface finish

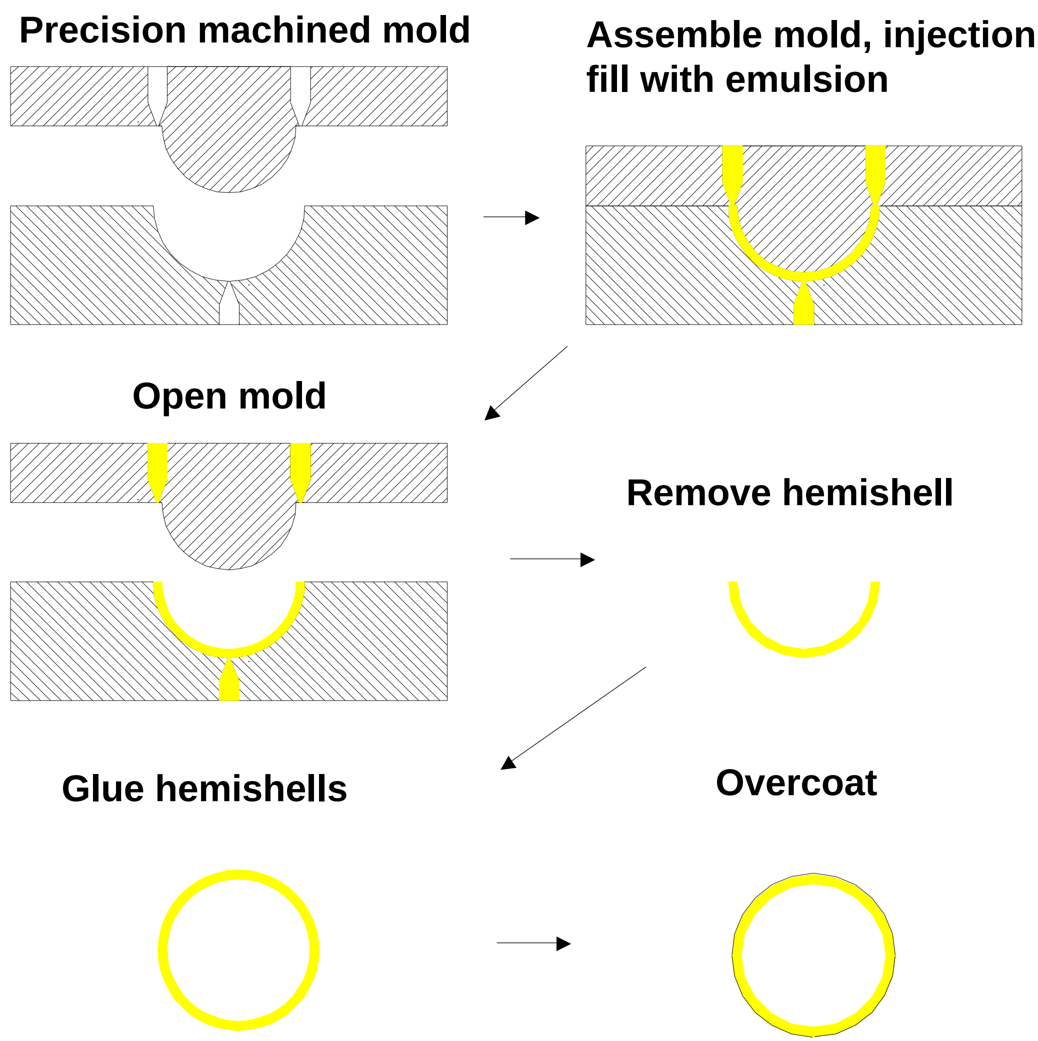
Machined and assembled foam hemishells are currently fabricated and used in ICF experiments

- **Evaluate what can be done by filling at higher temperatures and shorter layering times.**





Potential process for fabrication of overcoated foam hemishells



Summary

- Progress has been made on reducing tritium inventories, but further calculations will be ongoing.
- Injection molding of hemishells, hemishell bonding, and overcoating of resulting foam shells is being pursued as a means of fabricating targets.