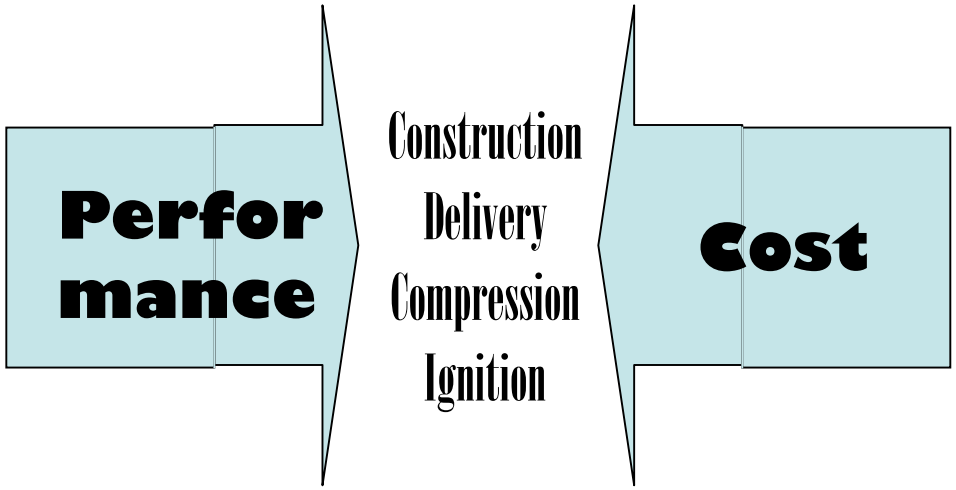
Reactor constraints FI targets

Rich Stephens
General Atomics

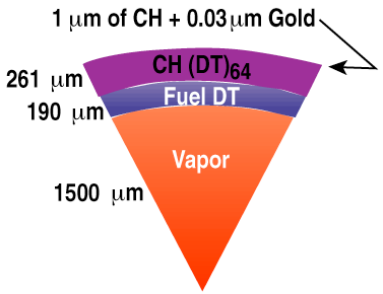


US/Japan Target Fab Workshop 2003
General Atomics, 3-4 Feb '03

FI target design strongly affects reactor design

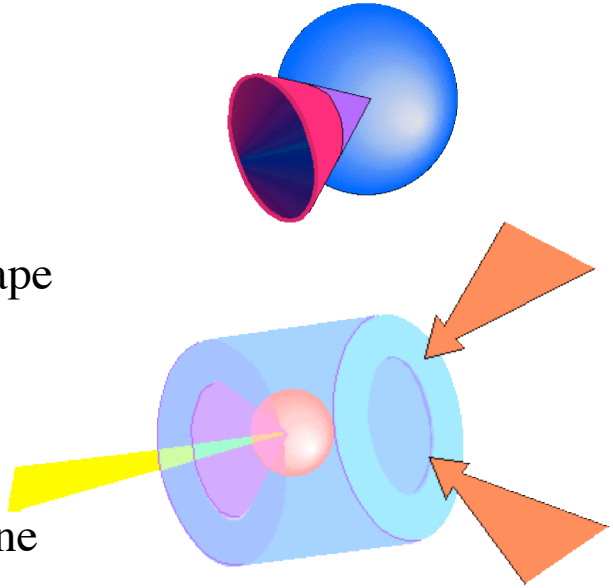
- Construction
  - Factory complexity
  - Inventory- especially of tritium
- Delivery to TCC
  - Temperature and pressure limitations on reactor chamber
- Compression
  - Flexibility in driver location, quality of drive beams
- Ignition
  - Short pulse limitations on chamber pressure

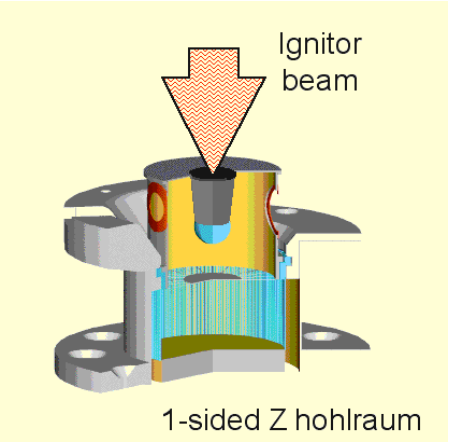
Target factory for central hot spot targets doesn't seem appropriate for asymmetric FI targets



NRL radiation preheat target

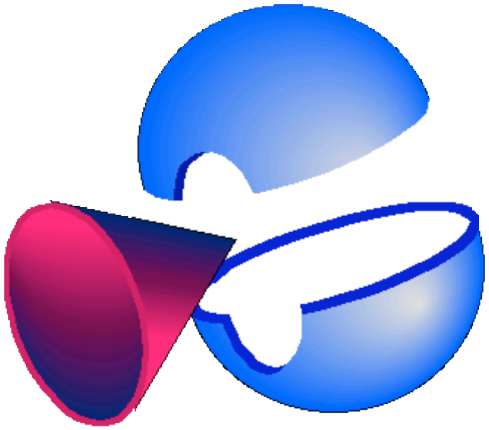
- **Construction complexity causes problems:**
  - ✕ Using surface tension for shell shape
  - ✕ Beta-layering for ice
  - ? Cool assembled target
- **FI targets have new concerns**
  - – Robust joint between reentrant cone and shell
  - – Uniform ice layers
  - – Contamination from cone
  - – Minimize hot spot

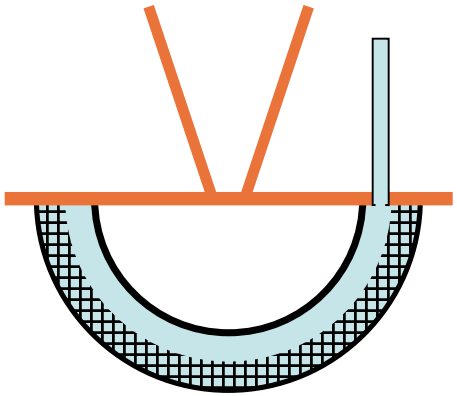




Molding ice layers might solve these problems

- **Molding allows more freedom**
  - Not dependent on isotherm geometry
  - Not restricted to high temperatures
- **Several approaches possible**
  - Stamp out and join hemishells
  - Injection mold and freeze in place (use foam for opacity adjustment)
  - Capillary fill of low density foam



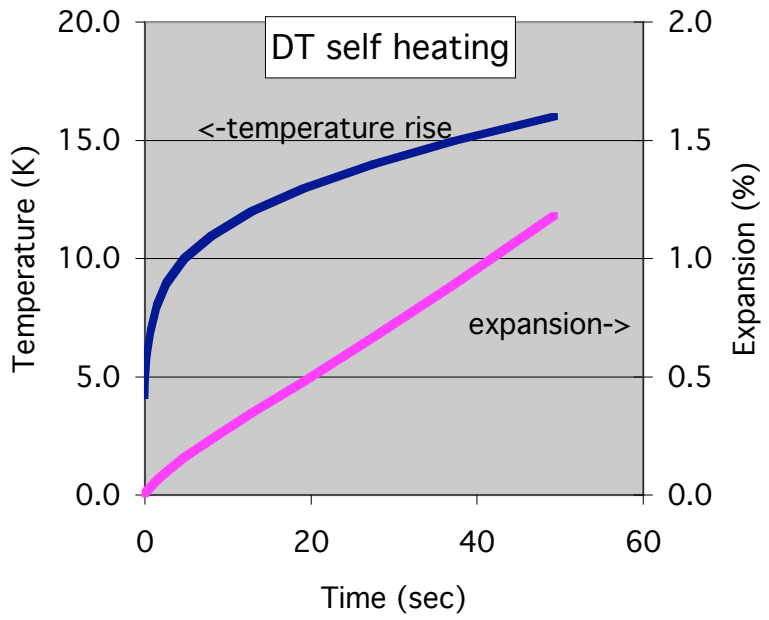


Ref S.A. Slutz "Fast Ignition capsules using liquid fuel"

Can molded surface meet surface smoothness specs?

There are advantages in direct molding of targets

- Avoids stresses from cooling
- Avoids diffusive fill and beta-layering
- Avoids vapor transport (unsuitable for asymmetric FI targets
- Avoids tight temp controls
- Allows longer heatup time on injection
  - ~5X more heat input allowed than for central hot spot target



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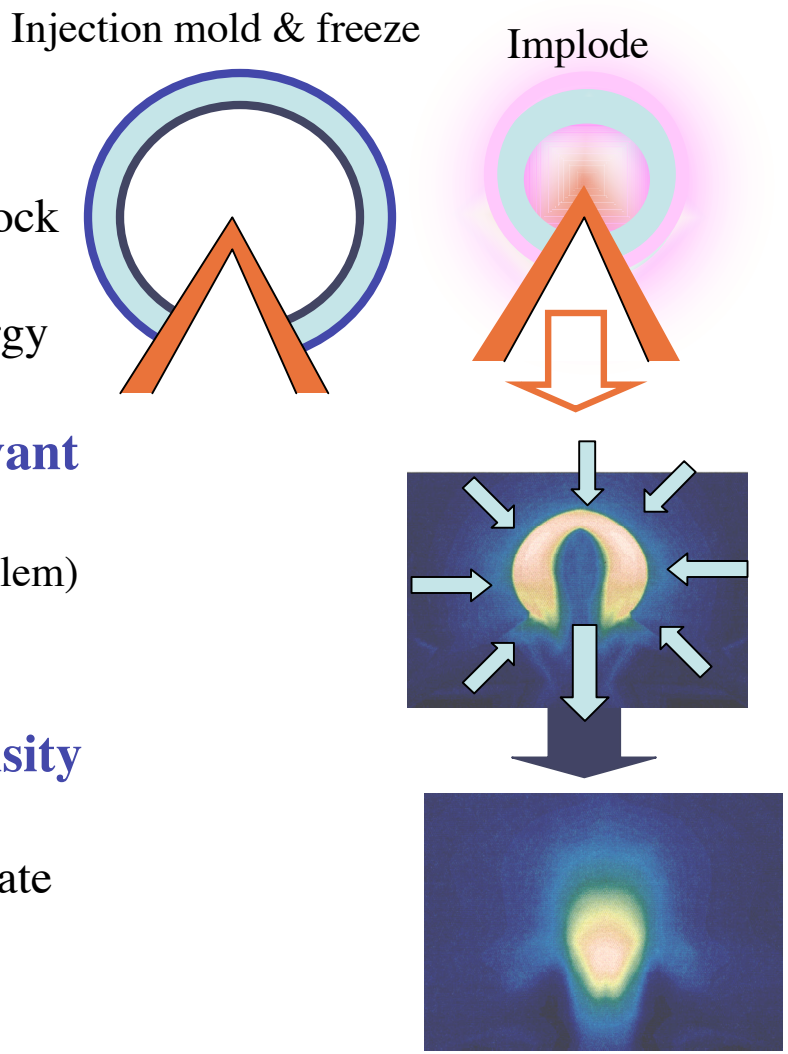
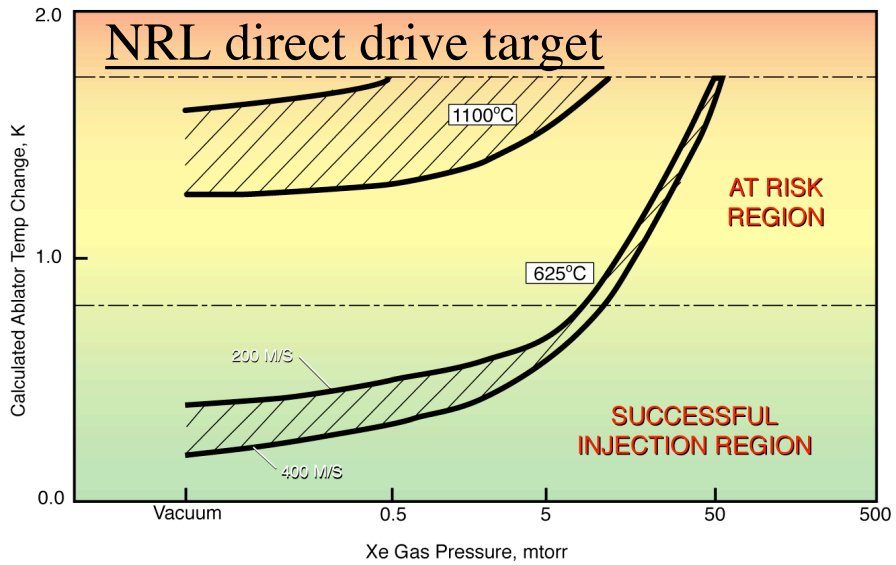
Mold contamination might be tolerable?

- **Low density core will contain debris from initial structure**
  - Inner wall partially vaporizes when shock wave crosses
  - Cone surface vaporizes from high energy hohlraum spectrum
- **That contamination is largely irrelevant**
  - Reentrant cone geometry ejects such debris (inner mold surface might be a problem)
  - Fast Ignition doesn't burn low density volume
- **Must worry about mixing of low density core with dense shell**
  - Thin RT unstable shells used to eliminate low density core would be sensitive to these impurities



Targets requirements limit reactor conditions

- NRL direct drive target has gold coating to reject radiation heat
  - Assumes 98% reflectivity
  - Requires limits on reactor wall (and gas) temperature
- Chamber gas pressure limited to reduce heating and drag



Cold FI target relaxes reactor constraints

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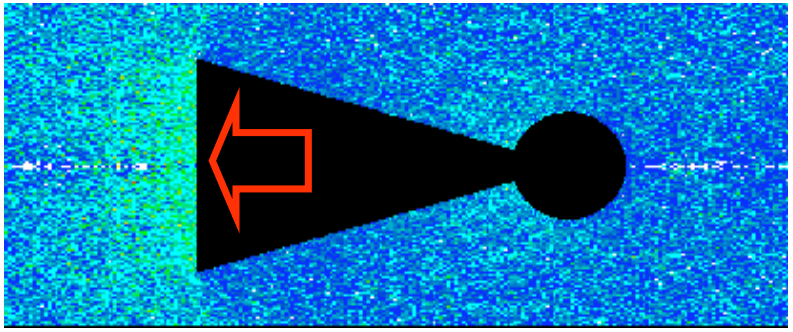
A FI cone is an advantage in delivery

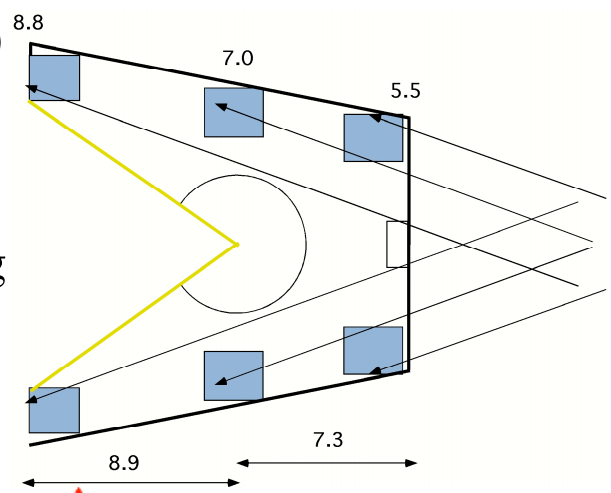
- The cone decreases total and asymmetric frictional heating



- The added mass reduces target deceleration
  - Direct & Indirect drive targets about the same mass

Direct or Indirect Drive? - Preference not clear

- Direct Drive puts more constraints on reactor
  - Drive symmetry more stringent
    - Laser drivers must be distributed over more of reactor wall? (using flat-topped beams, can get modest uniformity on NIF 26% p-v - is that sufficient for FI?)
  - Target not so robust
    - Reactor wall must be cooler, gas pressure lower
    - Target surface must be highly reflective or highly transmissive
  - Debris problems worse
    - Cone must be long and heavy (Hogan J/US FI WS)
- But Indirect drive is not great improvement
  - Can already tolerate drive asymmetry
  - Cold shell can already tolerate much more heating
  - Hohlraum losses reduce potential gain

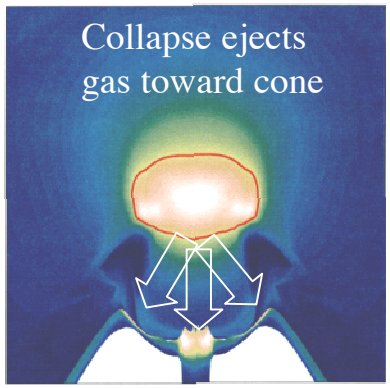


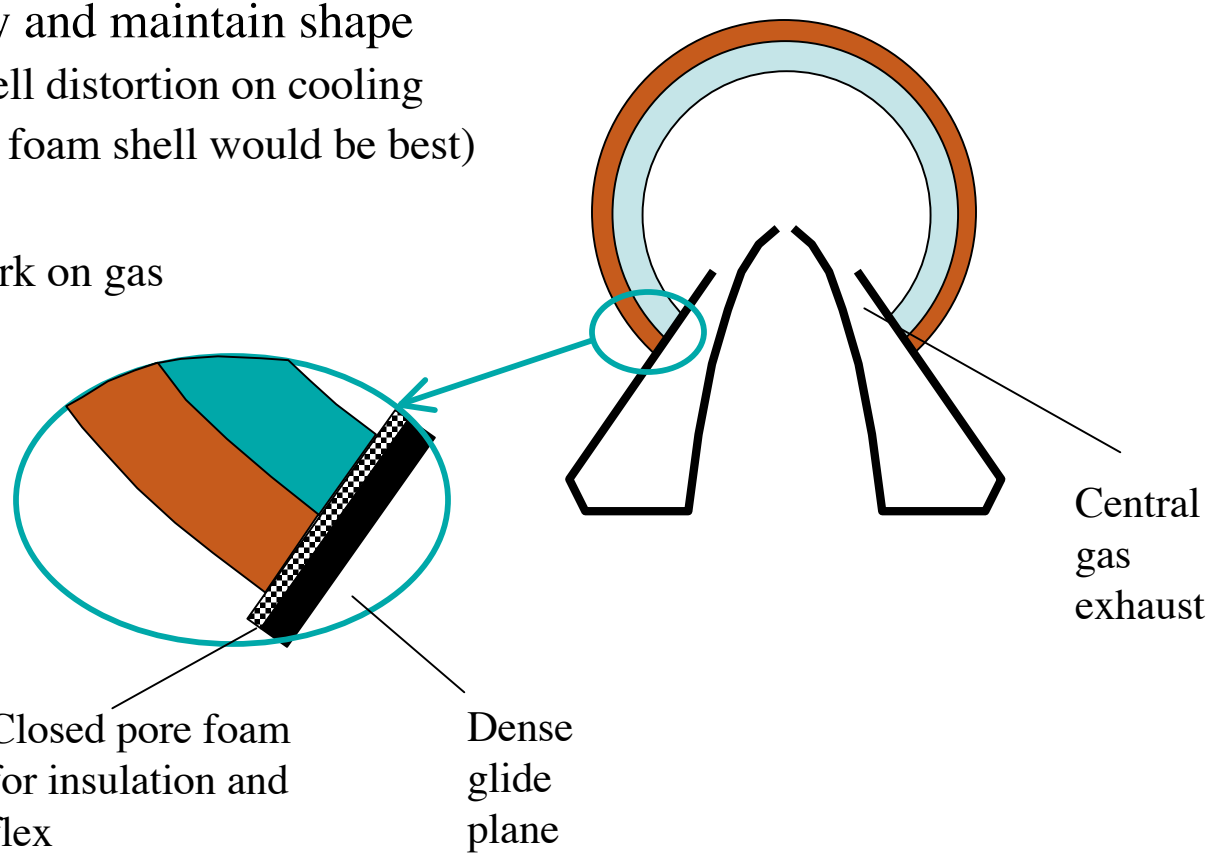
Reentrant cone is critical for Compression & Ignition dynamics

- Compact compressed fuel
- Guide laser
- Create electrons near compressed fuel
- Minimize work done on compressed gas
- Minimize contamination from cone

Should design cone to meet multiple concerns

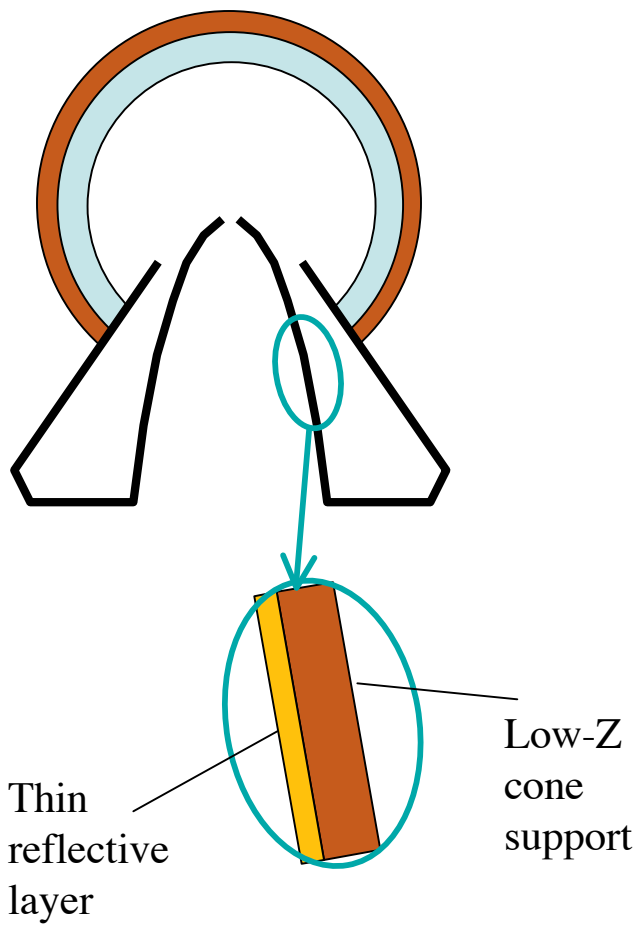
- Thermal layering?
  - Set up proper isotherms
- Mechanical integrity and maintain shape
  - Must not allow shell distortion on cooling (perhaps compliant foam shell would be best)
- Efficient collapse
  - Minimize PdV work on gas





Cone purposes (cont.)

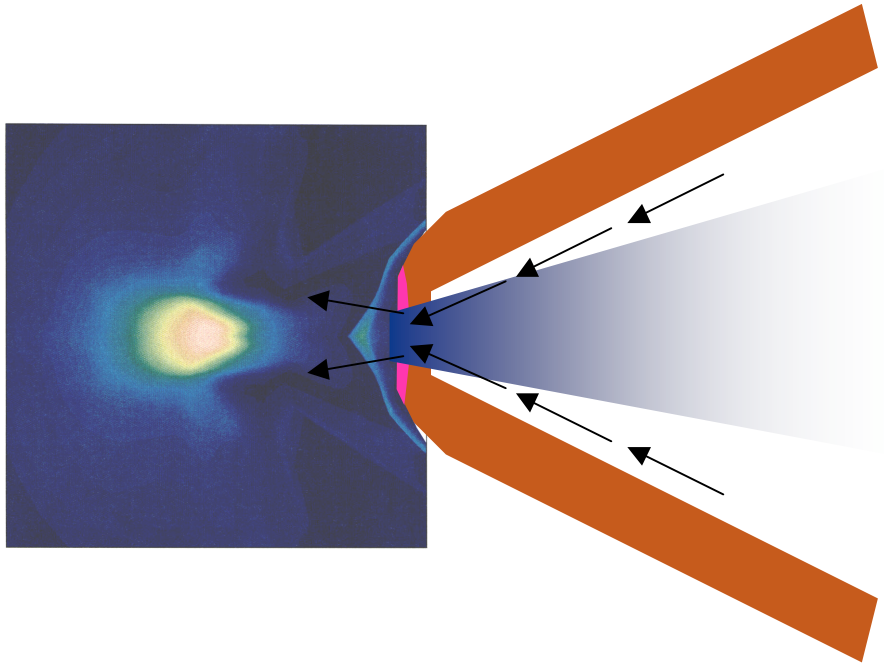
- Exclude plasma
  - Need high cone density only near outside
  - Longer than blow-off distance
- Focus laser? (outer region of cone)
  - Winston concentrator is most efficient optics
  - Must remain effective for ~30 ps
- Produce electrons (inner region of cone)
  - Gold is efficient
  - What thickness? (survive ~30 ps)



Cone purposes (cont.)

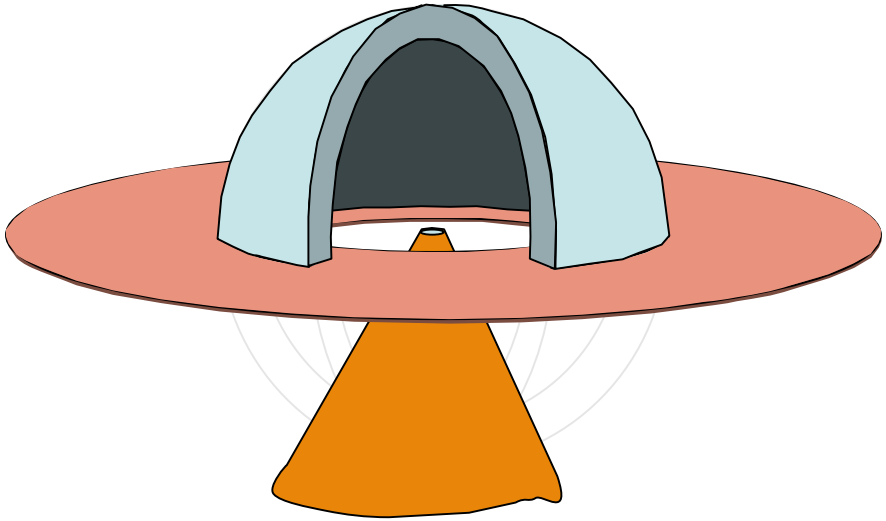
- Guide electrons to shell
  - Is side wall shape important?”
  - Hollow tip cone eliminates interfacial problems?

    (but that puts a jet of gas down the center of the cone)



Using flat outer “cone” makes construction simpler

- Hemishells easy to make:
  - Stamped in one piece - no seams
  - Molded as in SNL concept
- Minimize
- Flat sheet outer cone is simple
- Inner cone can be molded of plastic, inner metal reflective coating



Fast Ignition targets present opportunities

- Complex to make but construction shortcuts
- Thermal layering is difficult but low temperatures feasible
- Minimize mixing but relax symmetries
- Cone massive but protects during injection

But we can't yet evaluate the tradeoffs