UW First-Wall Threat Spectra Calculations

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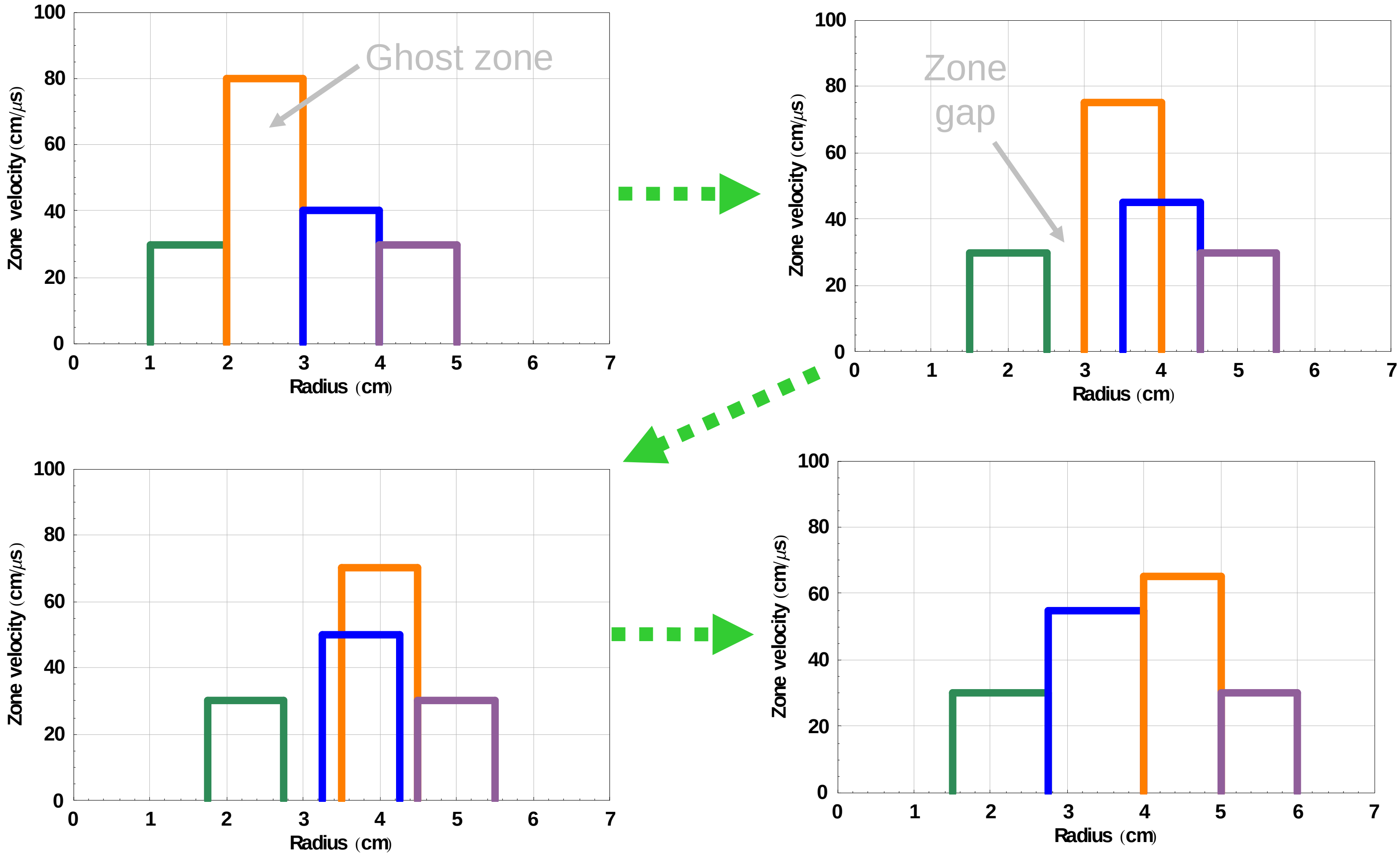
In the Present Approach, “Ghost” Zones Move through Hydro Zones

• Ghost zones interact with zone boundaries, but only as they pass through them.



Zone Flow Logic

- Check all zones for ratio of $\kappa\lambda$ to dr in both directions.
  - λ is mean free path.
  - κ is a chosen multiplier, typically 3.
- If $\kappa\lambda$<dr for a zone, use pure hydro.
- If $\kappa\lambda \geq$dr for a zone, move through next zone in **u** direction, depositing momentum and energy, for time step δt=time of next zone boundary contact.
- Adjust radii of zones.
- Repeat process until dt is reached or no zones satisfy $\kappa\lambda \geq$dr.
- Renumber zones, if necessary.

Vector *kz* Indicates Detachment Status of Zone

0 ≡ attached hydro
1 ≡ hydro detached on inner edge
2 ≡ hydro detached on outer edge
3 ≡ hydro detached on both edges
4 ≡ detached ghost zone
5 ≡ ghost zone detached on trailing (inner) edge only
6 ≡ ghost zone detached on leading (outer) edge only
7 ≡ zone ready to be renumbered

Hydro Subvector Components

Hydro subvector elements are $\{j, r_j, r_{j+1}, u_j, u_{j+1}\}$, where

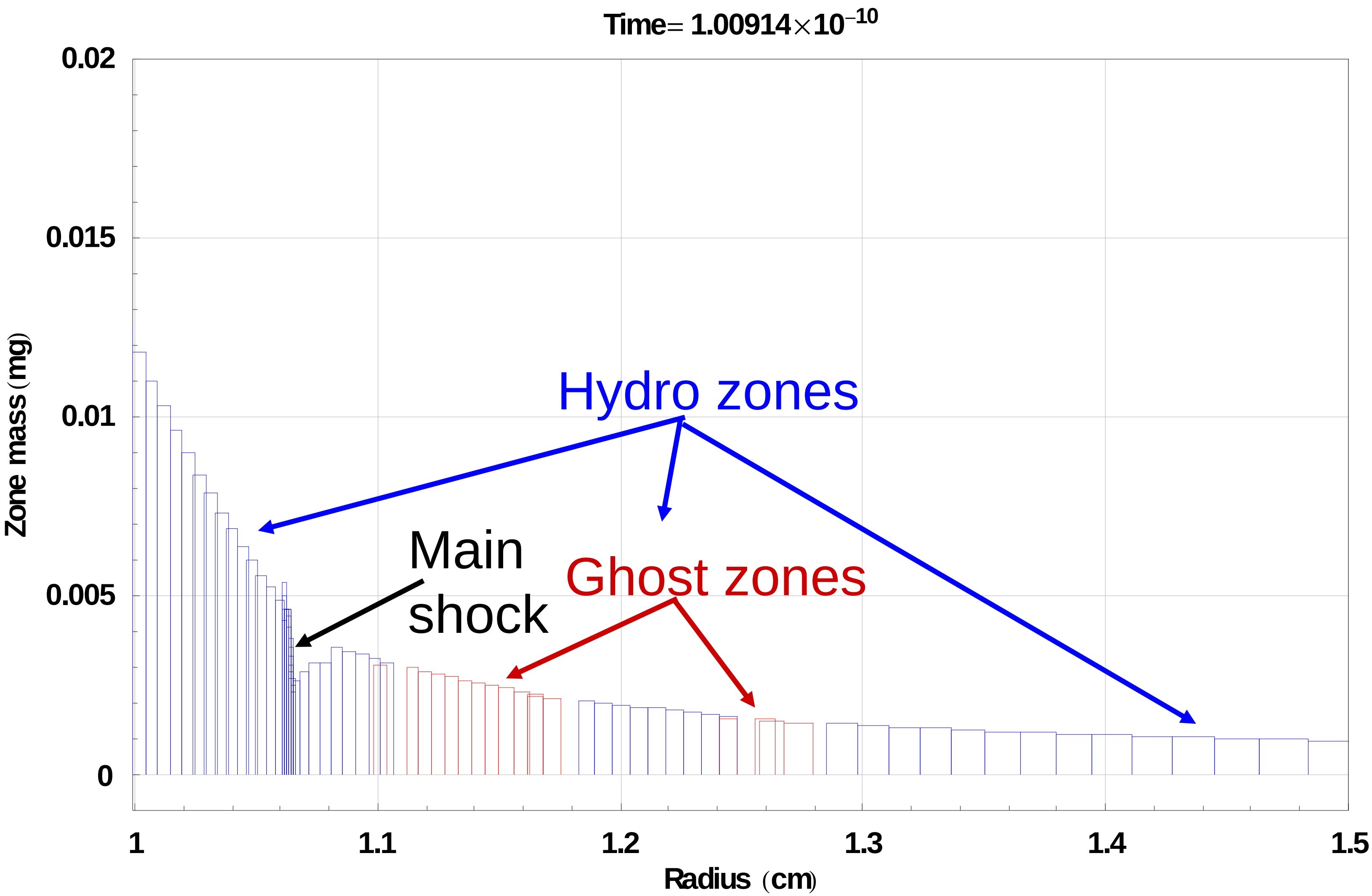
Place	Name	Definition
1	j	Lagrangian index of hydro zone
2	r_j	position of inner edge of hydro zone
3	r_{j+1}	position of outer edge of hydro zone
4	u_j	velocity of inner edge of hydro zone
5	u_{j+1}	velocity of outer edge of hydro zone

Ghost Subvector Components

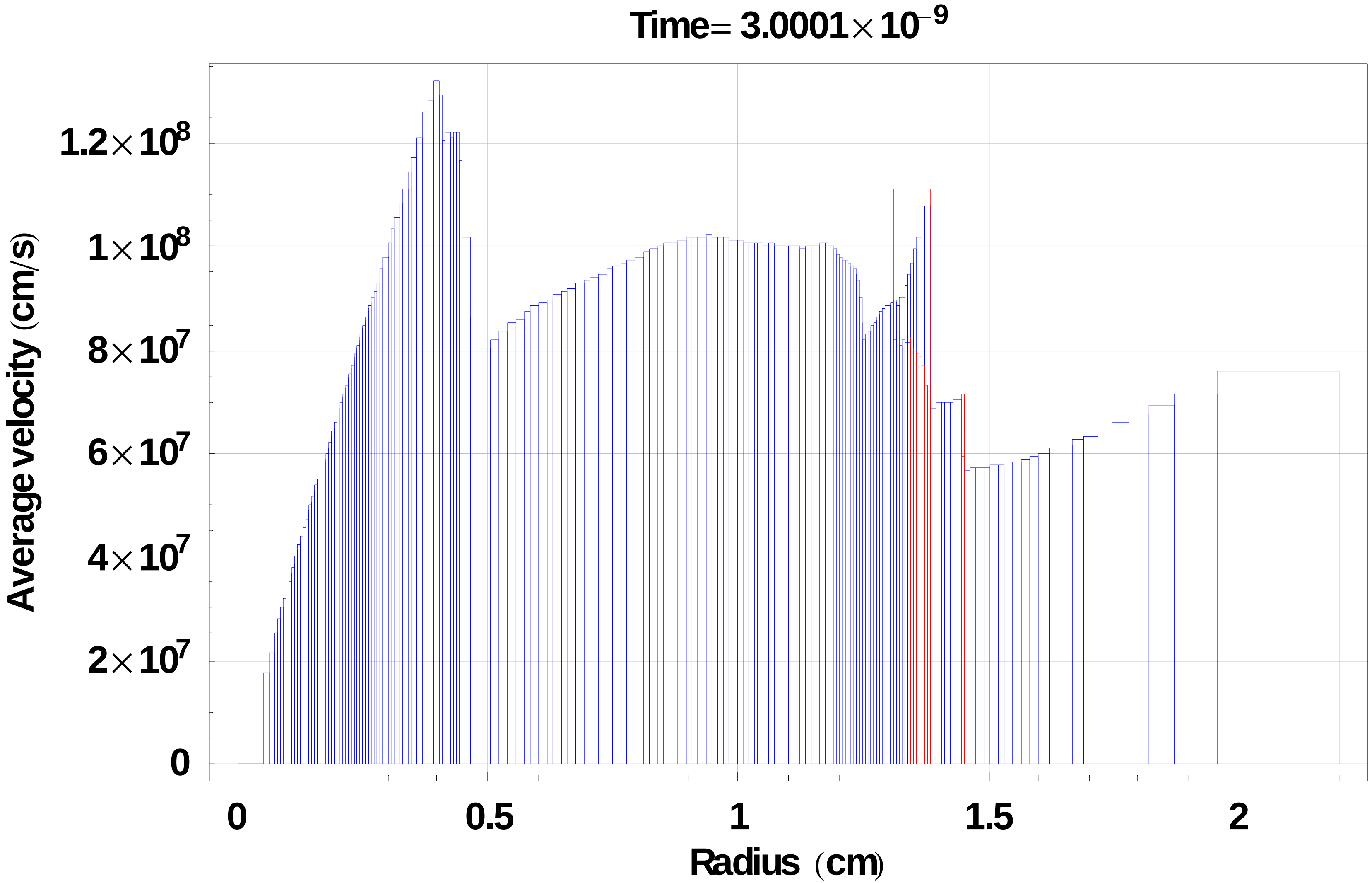
Ghost subvector elements are {j, k, l, q_j, s_j, v_j, w_j, $\hat{w}$, f_{dt}, δt, k_w}, where

Place	Name	Definition
1	j	*original* Lagrangian index of ghost zone
2	k	index of Lagrangian zone through which ghost zone's *inner* edge is attached or passing
3	l	index of Lagrangian zone through which ghost zone's *outer* edge is attached or passing
4	q_j	position of inner edge of ghost zone
5	s_j	position of outer edge of ghost zone
6	v_j	velocity of inner edge of ghost zone
7	w_j	velocity of outer edge of ghost zone
8	$\hat{w}$	direction of motion (positive is outward)
9	f_{dt}	accumulated fraction of dt used during this subcycle of moving the ghost zone
10	δt	partial time substep for calculation in progress
11	k_w	flag for zone motion: 0=no 1=yes 2=yes; reattach leading zone edge at end of δt 3=yes; reattach trailing zone edge at end of δt

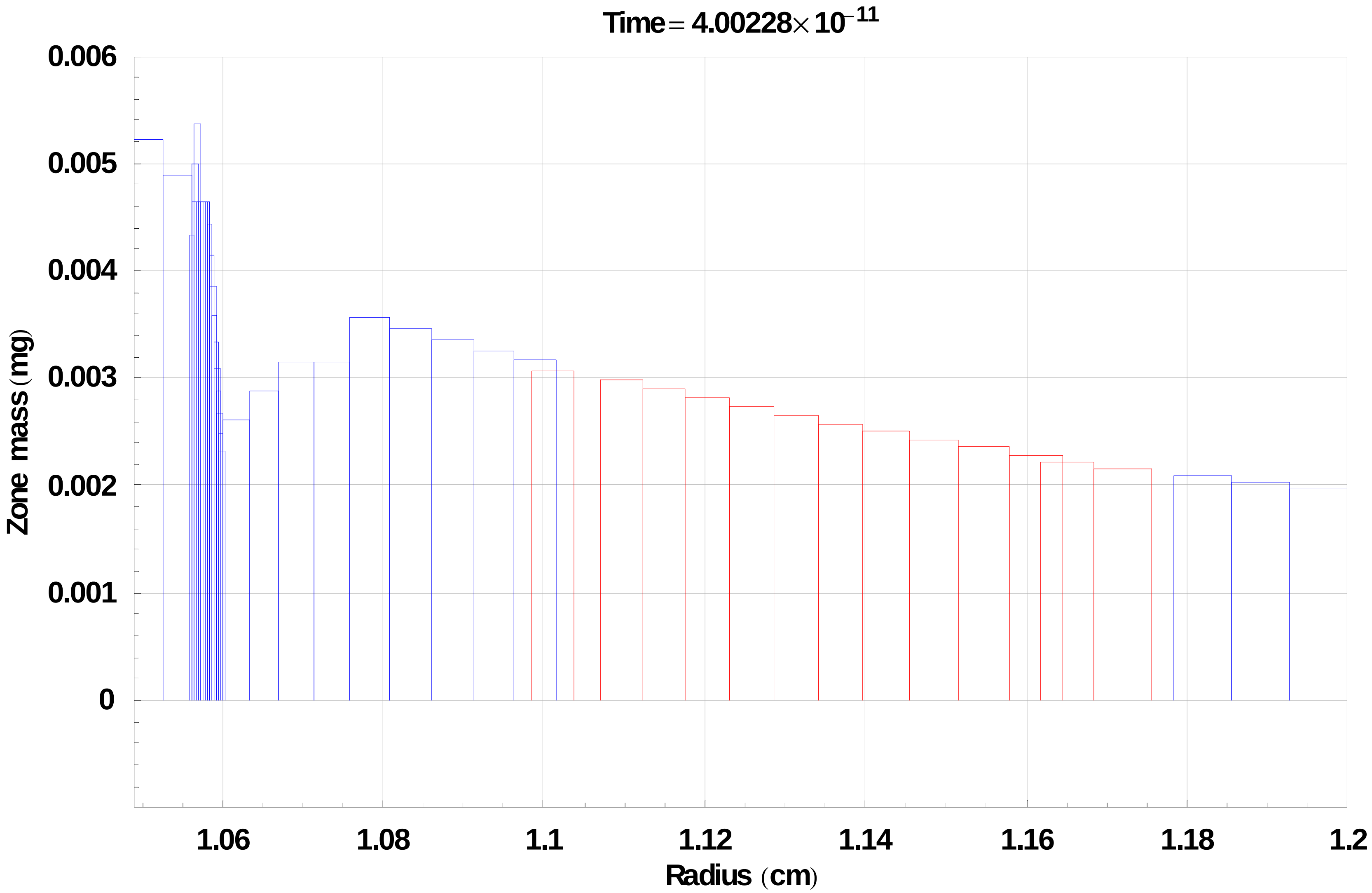
Lagrangian Zone Mass Density Falls Steeply



Lagrangian Zone Velocity Evolution for Mean Free Paths > Shock Thickness



Lagrangian Zone Mass Evolution for Mean Free Paths > Shock Thickness



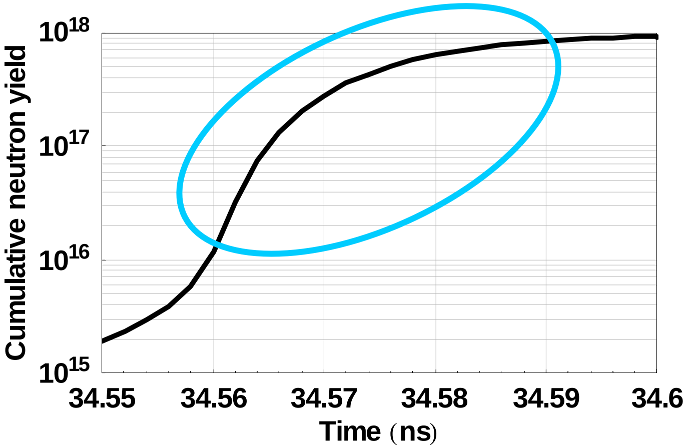
Status and Summary

- Have made progress with Mathematica® code for analysing velocity transfer between hydro and long mean-free path zones.
- Some debugging remains to be done.
- Should give a reasonable qualitative picture of the effect of long mean free paths on the ion threat spectra.

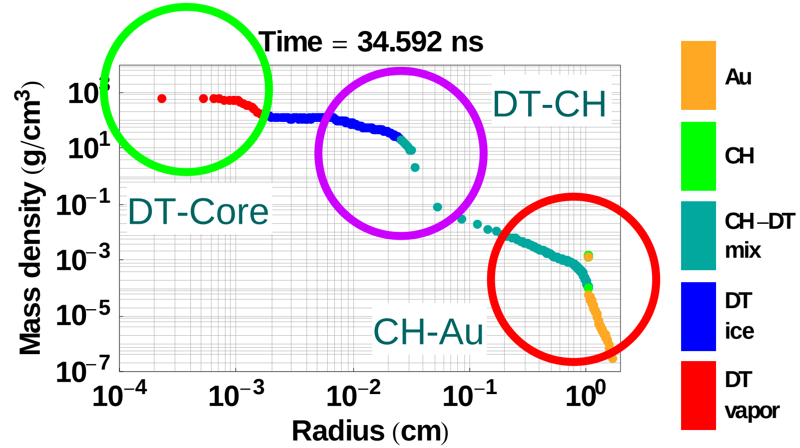
Back Pocket

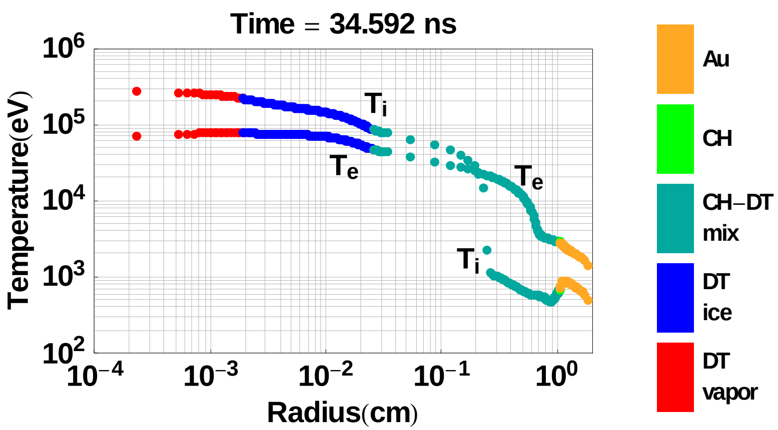
DT Core, DT-CH Shock, and CH-Au Shock Will Exemplify the Issues

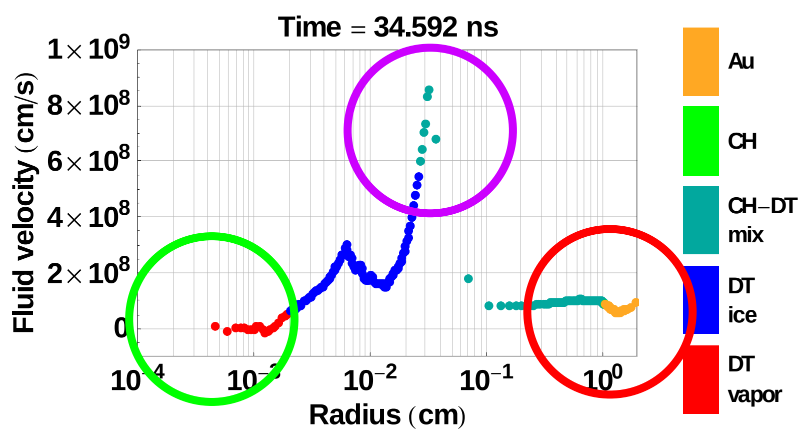
- Neutrons get produced within ~30 ps.



- Each point represents a Lagrangian zone of constant mass.







At 34.592 ns, the DT-CH Shock Thickness and Incoming Ion Mean Free Paths Become Comparable

	DT Core	DT-CH Shock	CH-Au Shock
r_{shock} (cm)	< 0.001	0.026	1.1
Δr_{shock} (cm)	< 0.001	0.02	0.004
v_{shock} (cm/s)	6.6×10^6	5.5×10^8	8.6×10^7
n_i (cm^{-3})	1.5×10^{26}	5.1×10^{24}	5.0×10^{18}
T_i (keV)	276	86	2.8
T_e (keV)	72	47	0.69
Ave. charge state	1	DT 1 CH 1	CH 1 Au 36
Δr_{shock} / mfp	> 1000	1.1	0.001