

*UW First-Wall
Threat Spectra Calculations*

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University of Wisconsin

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THE UNIVERSITY

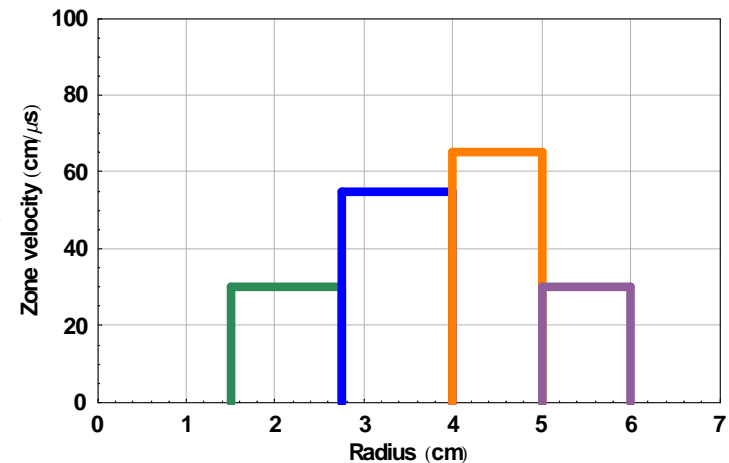
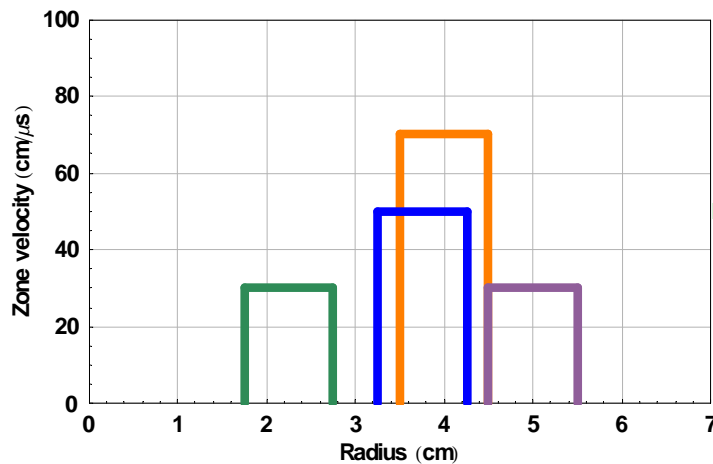
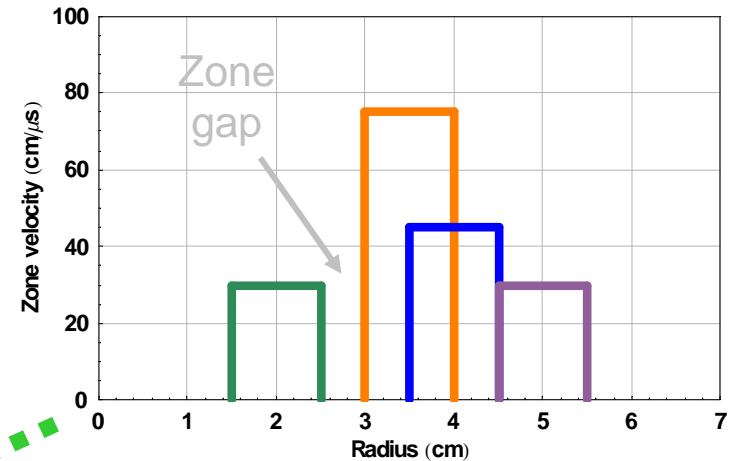
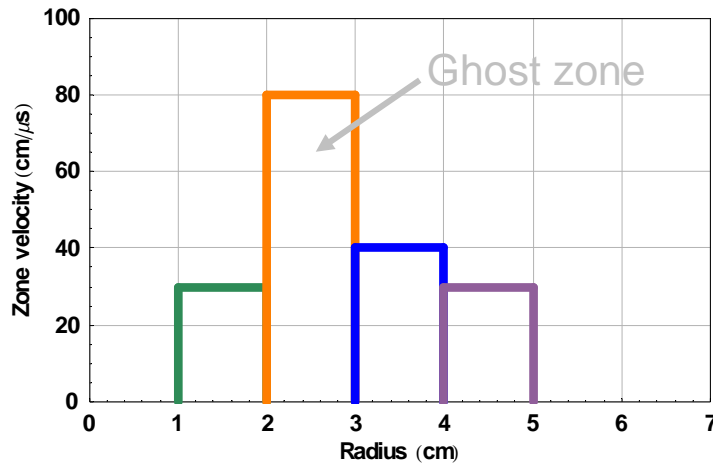
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In the Present Approach, “Ghost” Zones Move through Hydro Zones

- 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 \mathbf{u} direction, depositing momentum and energy, for time step $\delta t = \text{time of next zone boundary contact}$.
- 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 \equiv attached hydro

1 \equiv hydro detached on inner edge

2 \equiv hydro detached on outer edge

3 \equiv hydro detached on both edges

4 \equiv detached ghost zone

5 \equiv ghost zone detached on trailing (inner) edge only

6 \equiv ghost zone detached on leading (outer) edge only

7 \equiv zone ready to be renumbered

Hydro Subvector Components

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

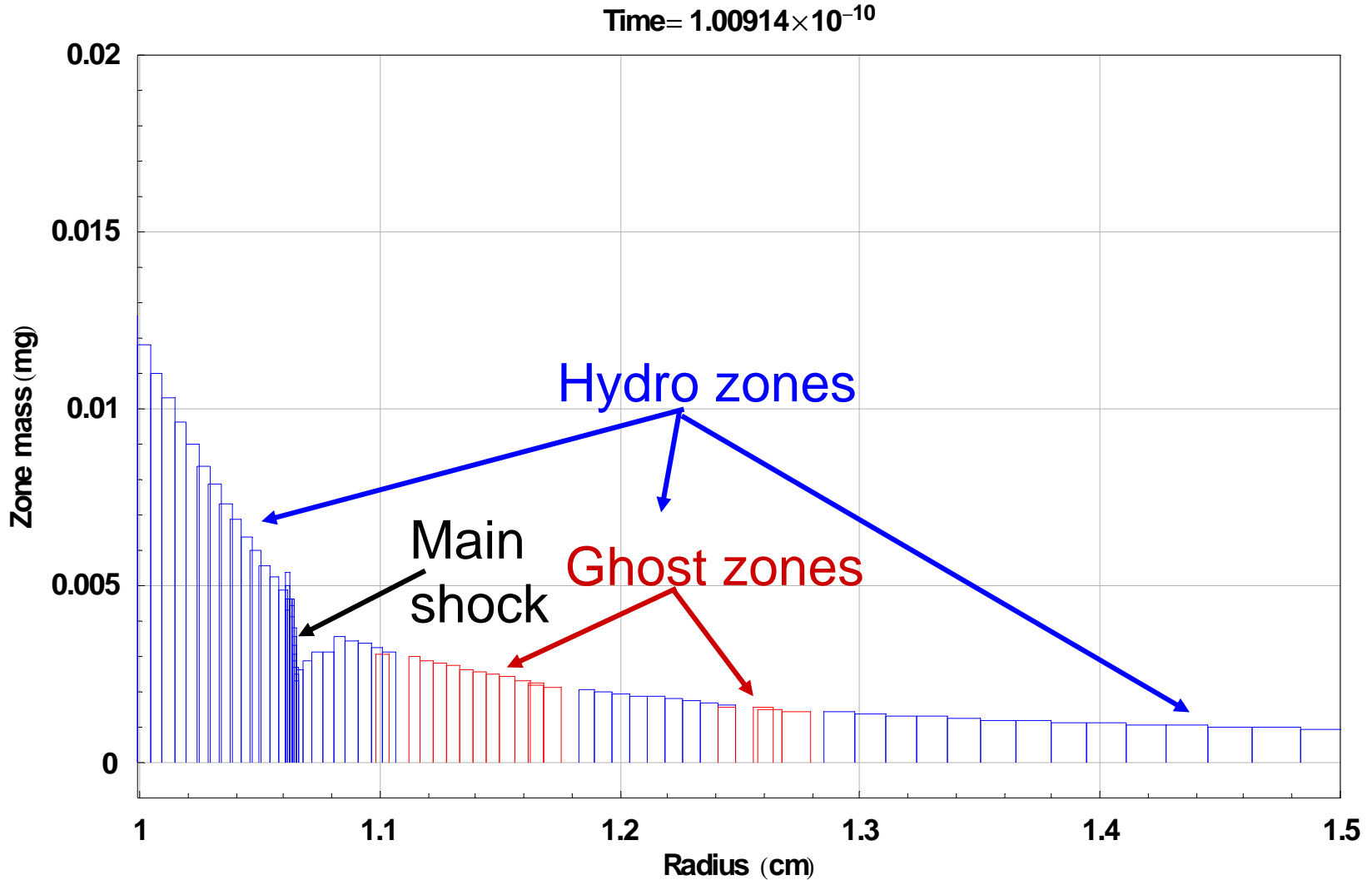
Place	Name	Definition
1	j	Lagrangian index of hydro zone
2	r_j	position of inner edge of hydro zone
3	r_{j+1}	position of outer edge of hydro zone
4	u_j	velocity of inner edge of hydro zone
5	u_{j+1}	velocity of outer edge of hydro zone

Ghost Subvector Components

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

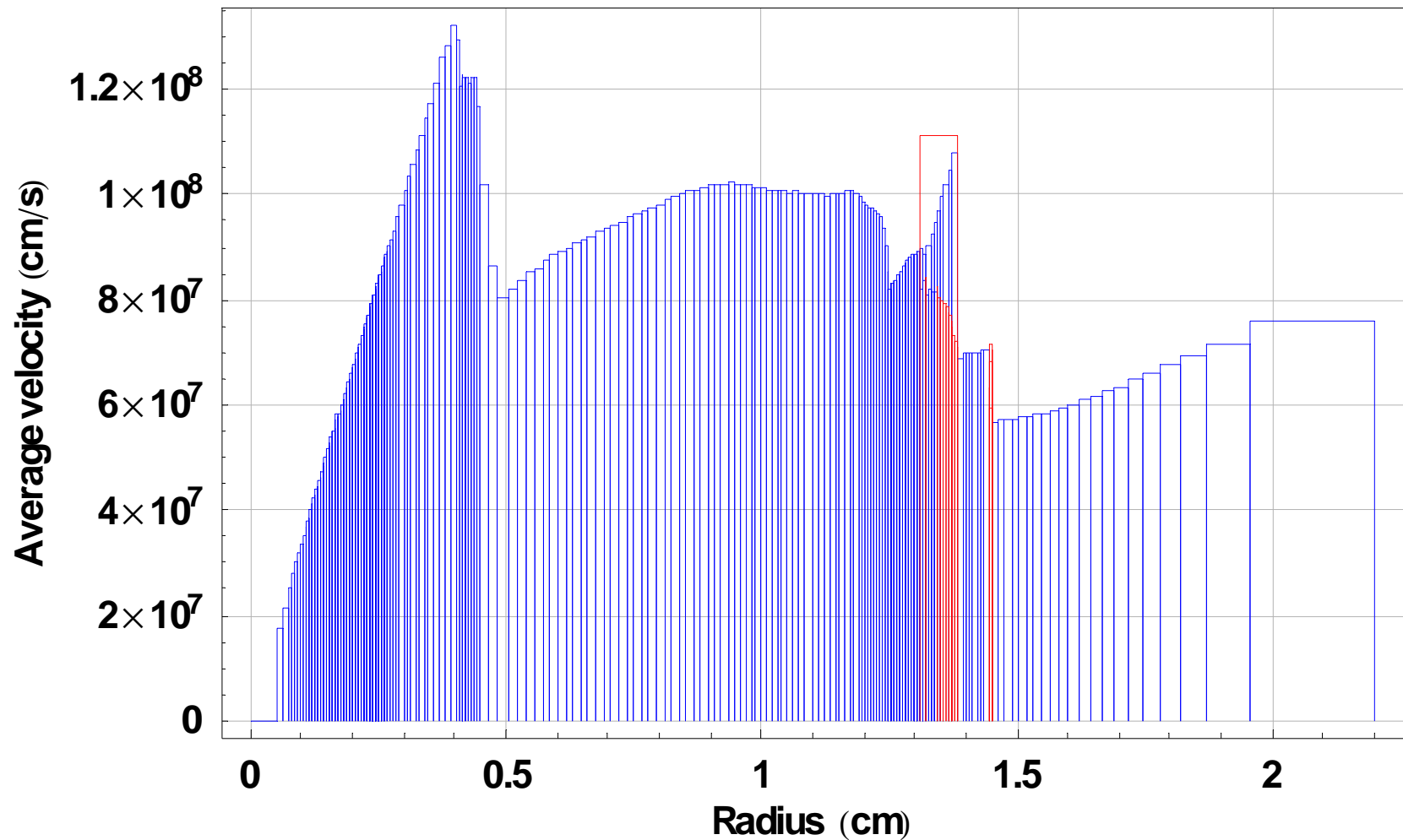
Place	Name	Definition
1	j	<i>original</i> Lagrangian index of ghost zone
2	k	index of Lagrangian zone through which ghost zone's <i>inner</i> edge is attached or passing
3	l	index of Lagrangian zone through which ghost zone's <i>outer</i> edge is attached or passing
4	q_j	position of inner edge of ghost 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

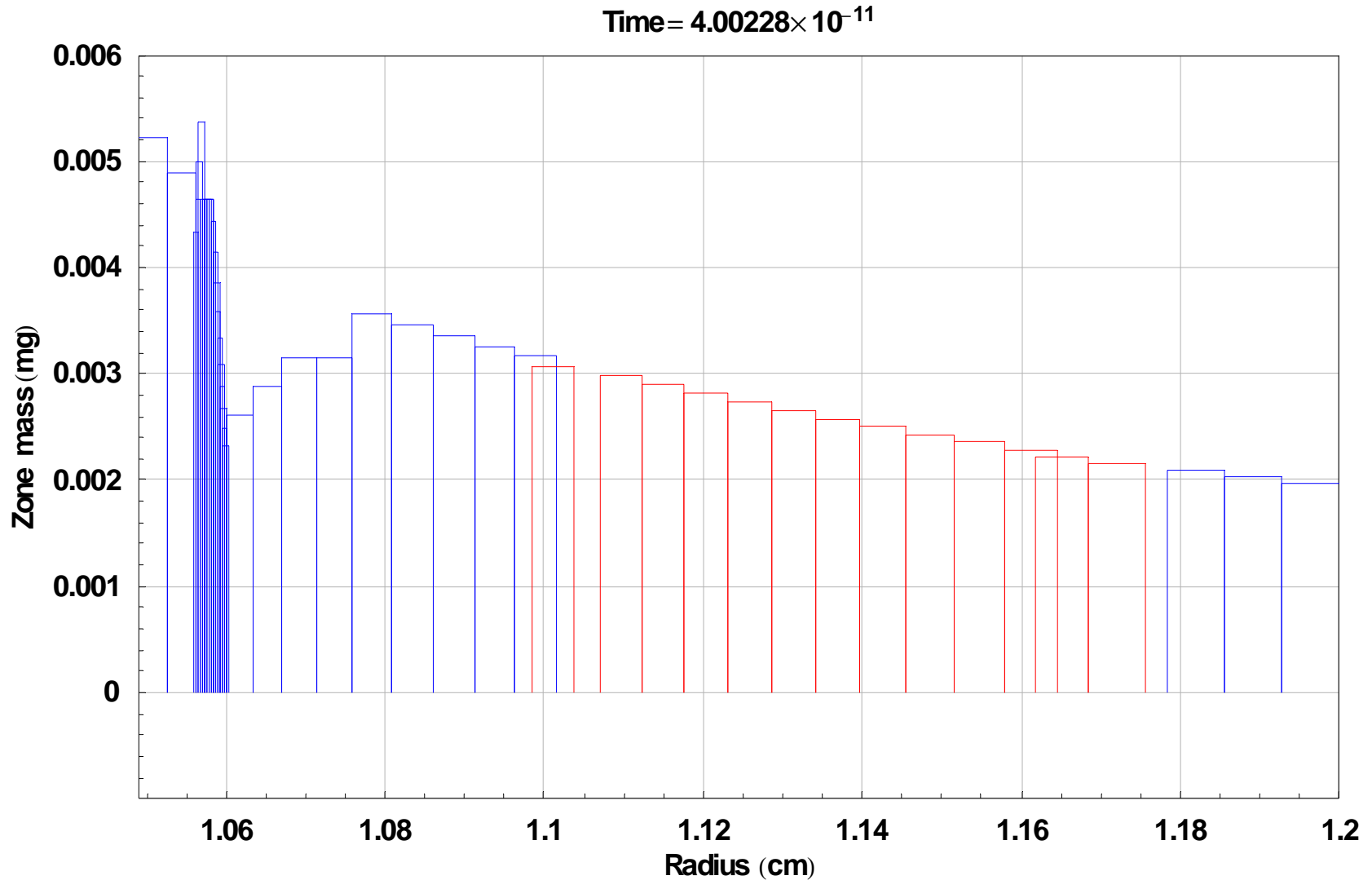


Lagrangian Zone Velocity Evolution for Mean Free Paths $>$ Shock Thickness

Time = 3.0001×10^{-9}



Lagrangian Zone Mass Evolution for Mean Free Paths $>$ Shock Thickness



Status and Summary

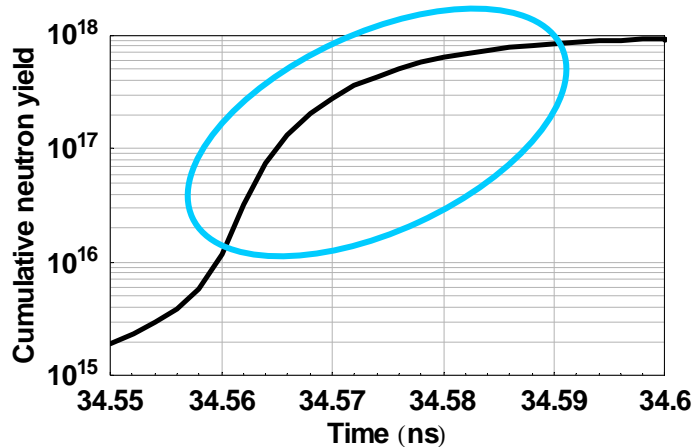
- Have made progress with Mathematica[®] code for analysing velocity transfer between hydro and long mean-free path zones.
- Some debugging remains to be done.
- Should give a reasonable qualitative picture of the effect of long mean free paths on the ion threat spectra.



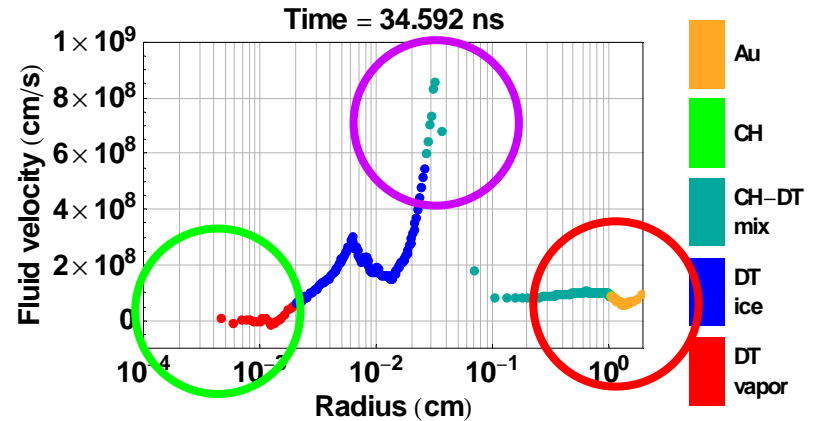
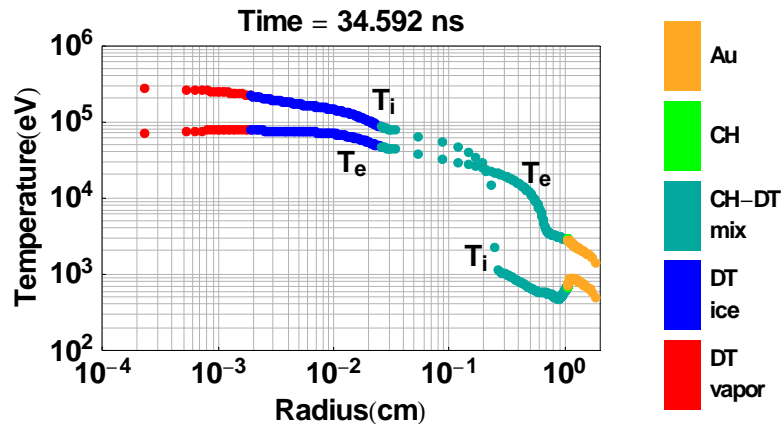
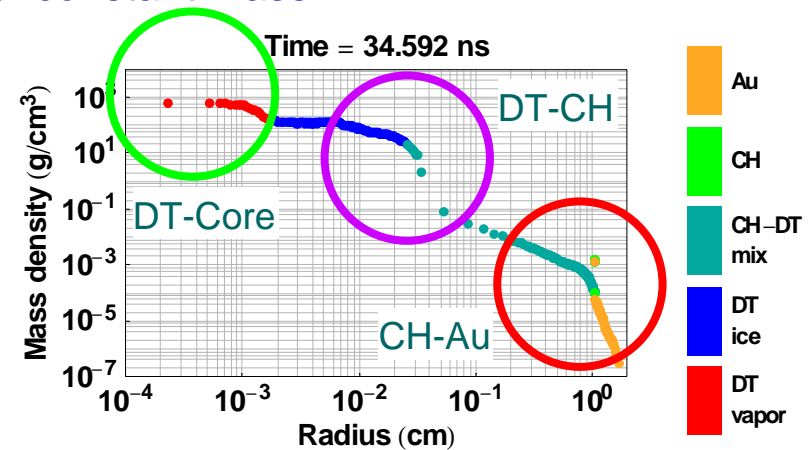
Back Pocket

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
$\Delta r_{\text{shock}} / \text{mfp}$	> 1000	1.1	0.001