Threat Spectra Calculations for HAPL Chamber First Wall

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HAPL Team Meeting

Princeton Plasma Physics Laboratory

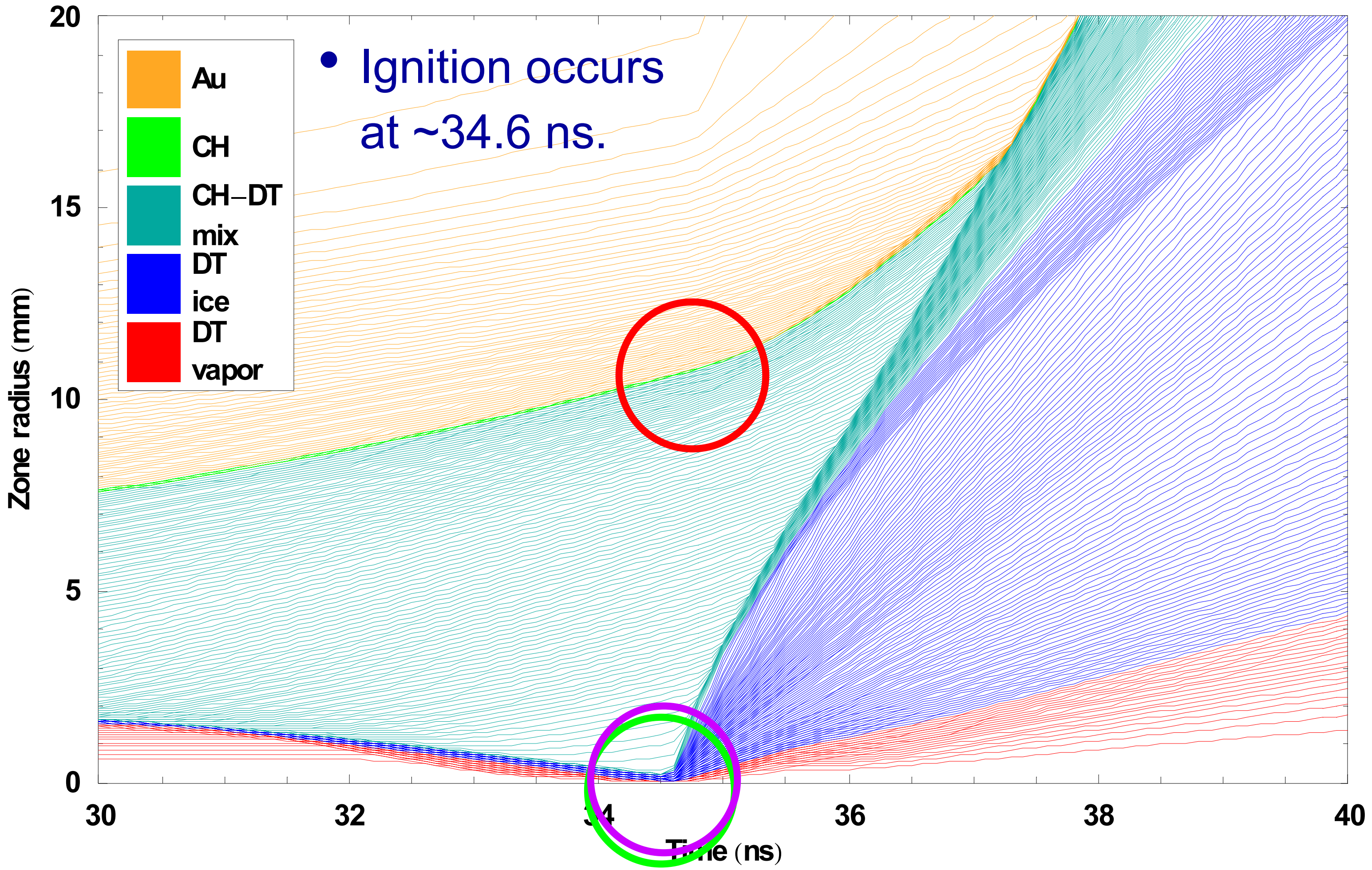
October 27-28, 2004

Progress on Three Modeling Issues

- Threat spectra target source computed by BUCKY.
  - **Fluid approximation not valid (*TOFE '04*).**
  - Hybrid fluid-kinetic approximation.
- Ion threat time of flight transport to first wall and deposition in wall computed by BUCKY.
  - Temporal prediction of ion threat at the first surface in BUCKY improved (piece-wise continuous model replaces discrete model.) **Model verified.**
- Chamber—first wall integrated calculation computed by BUCKY.
  - Replace two region model with integrated e.o.s. and conductivity models. **Modifications completed.**

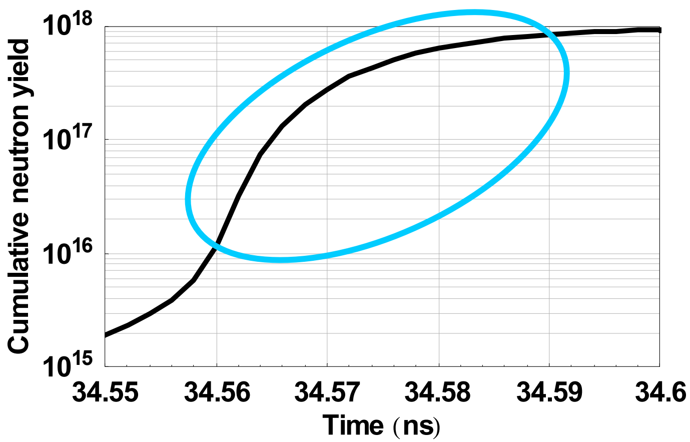
For the Examination of Long Mean Free Path Effects, the Time Near Ignition Will Be the Focus

Lagrangian constant-mass zones from BUCKY run of HAPL case

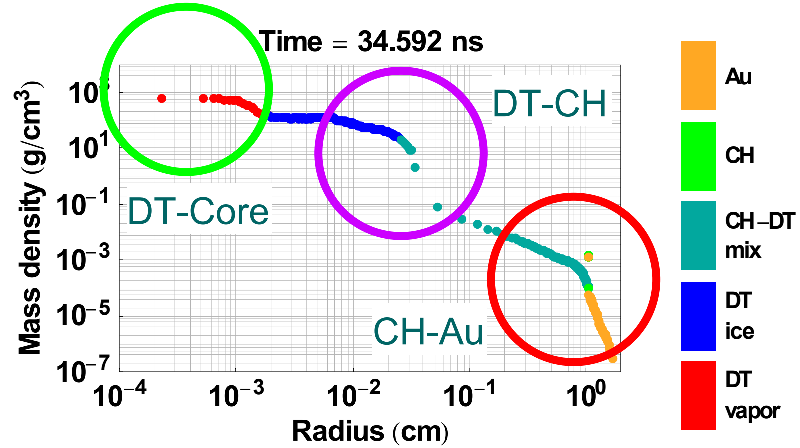


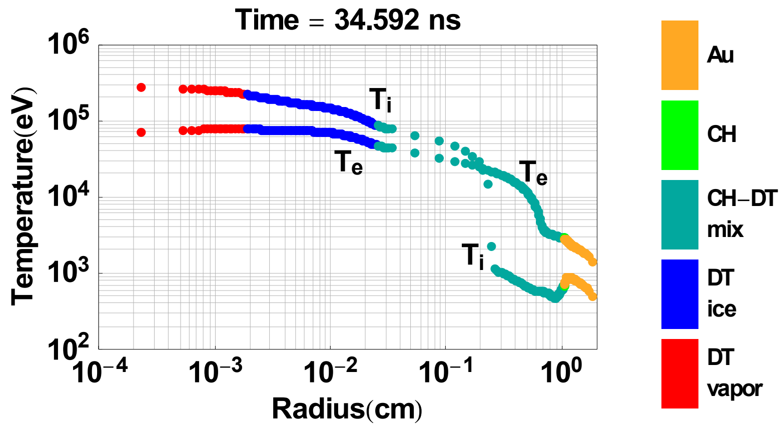
DT Core, DT-CH Shock, and CH-Au Shock Will Exemplify the Issues

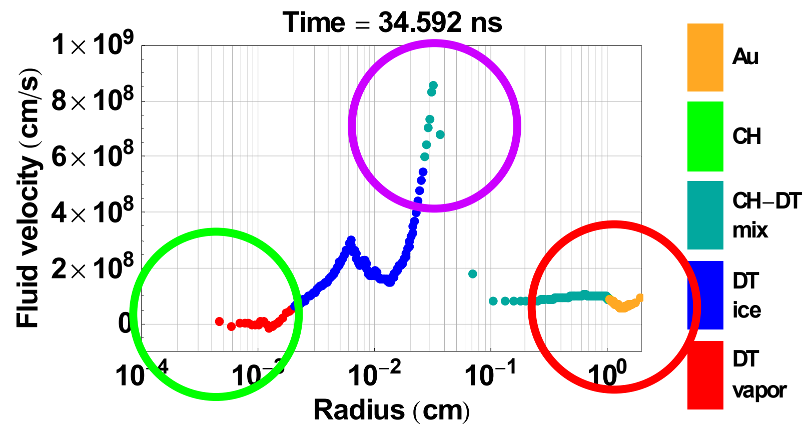
- Neutrons get produced within ~30 ps.



- Each point represents a Lagrangian zone of constant mass.





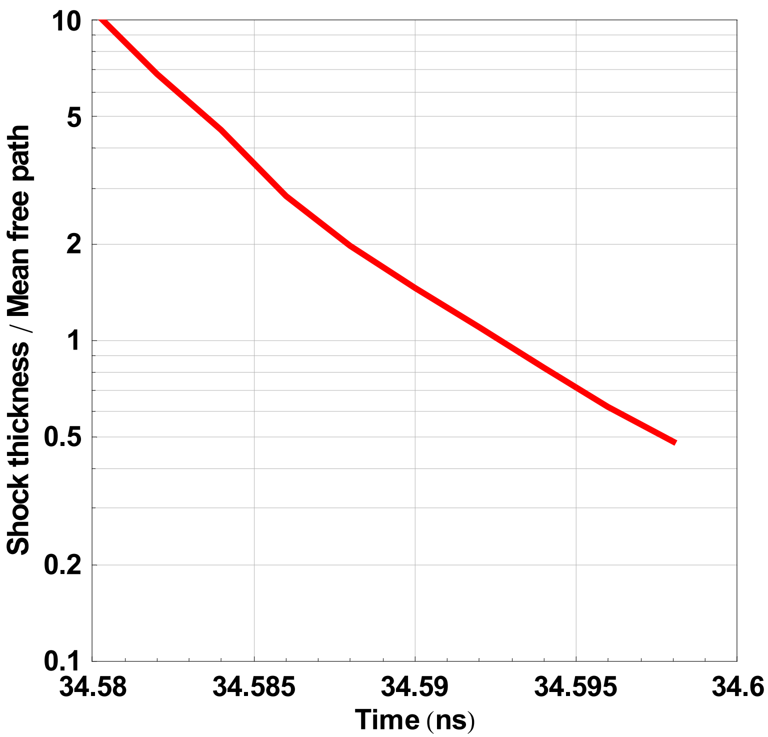


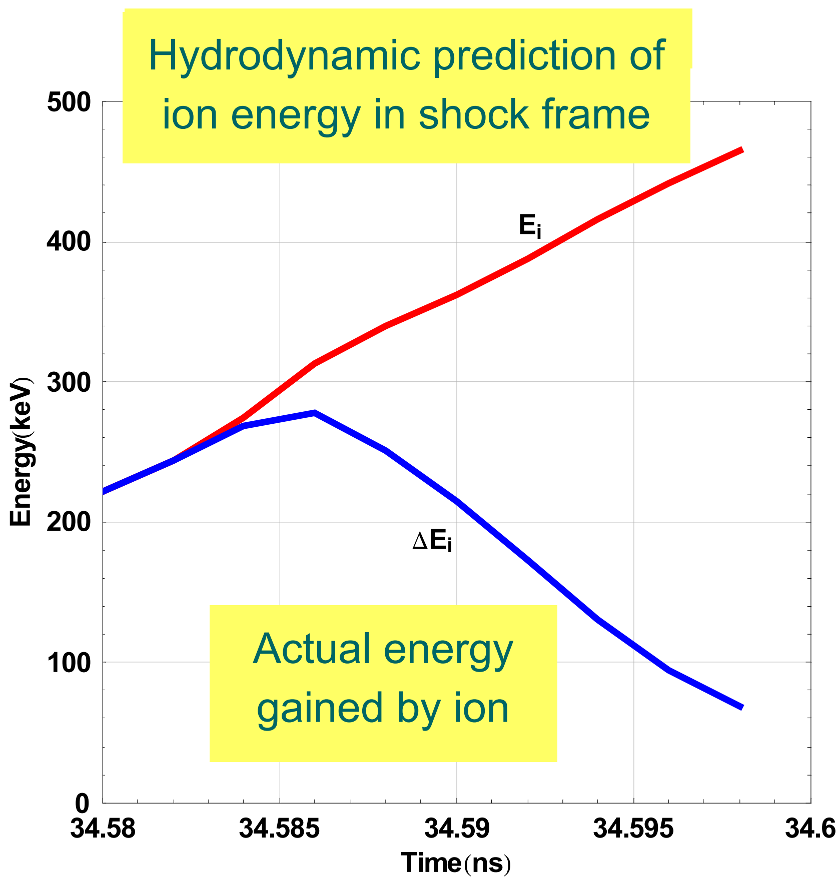
At 34.592 ns, the DT-CH Shock Thickness and Incoming Ion Mean Free Paths Become Comparable

	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

By 30 ps after Ignition, DT-CH Shock Wave Is Ineffective at Transferring Energy

- Ignition begins at ~34.56 ns.
- Mean-free path calculations include ion-ion collisions and ion-electron drag.
- Δ_{shock} / mfp ratio quickly falls.



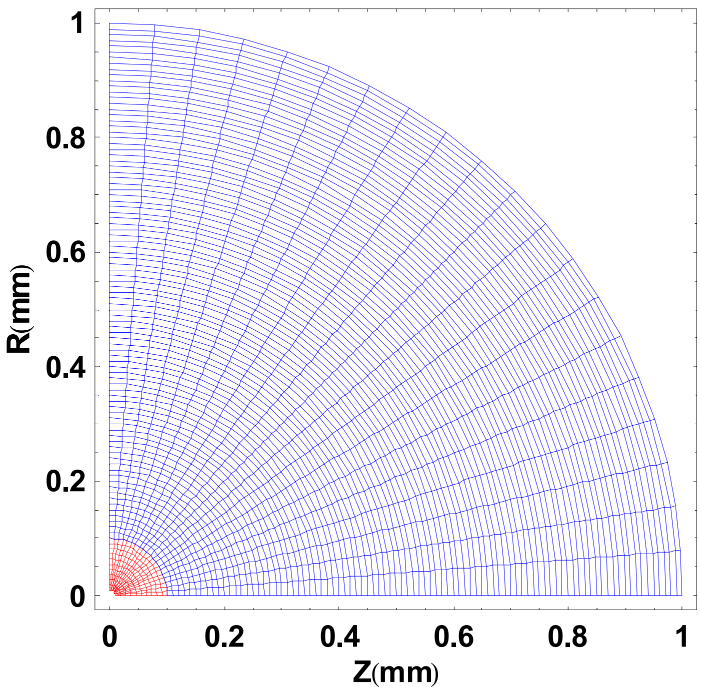


Implications for HAPL Ions

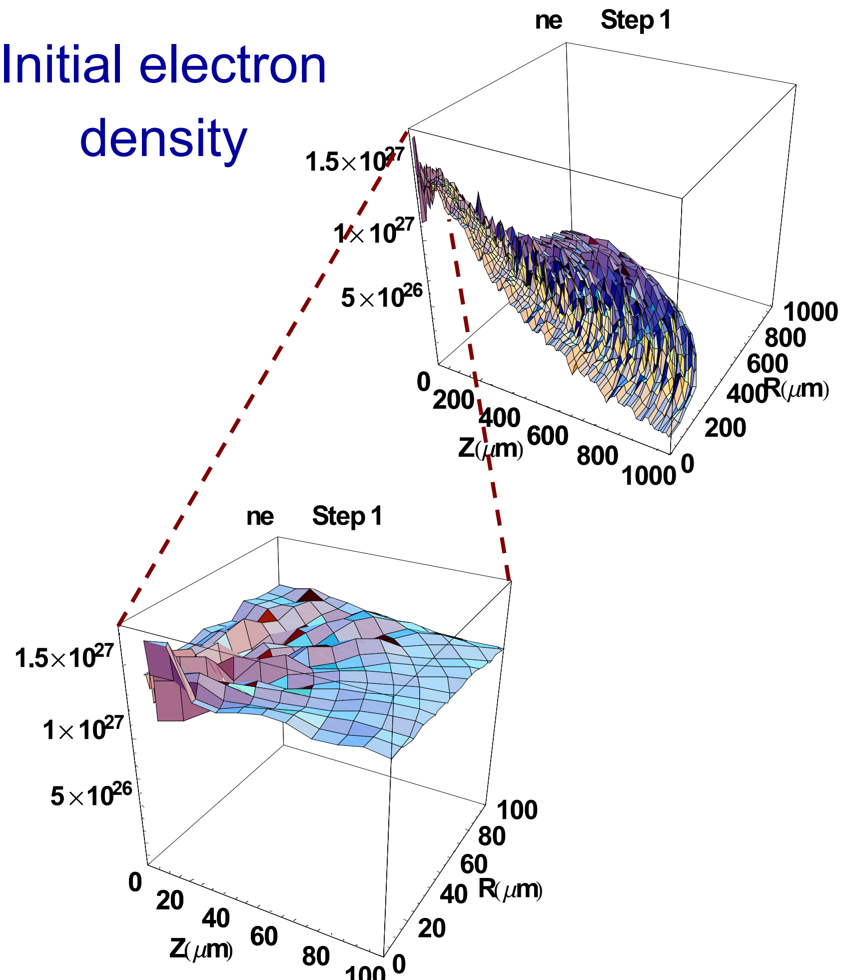
- Hydrodynamic assumption of perfect momentum transfer between Lagrangian zones fails after ~25 ps.
- By ~40 ps after ignition, ions in the shock wave are free streaming.
- Energy spectrum of ions hitting the first wall will be of lower energy than estimated by purely hydrodynamic codes.
  - Effect is being evaluated using the Icarus (SNL) Discrete Simulation Monte Carlo (DSMC) computer code.
  - UW 1-D radiation hydrodynamics code, BUCKY, will be modified to predict the HAPL ion energy spectrum.

UW is Simulating Target Explosions Using the *Icarus* Direct Simulation Monte Carlo (DSMC) Code

Icarus mesh for the HAPL problem.



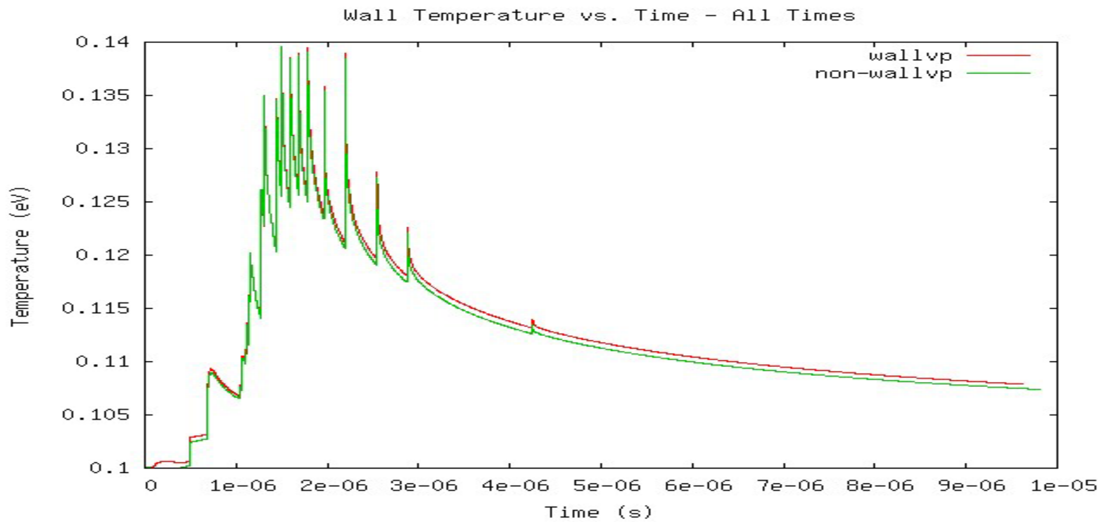
Initial electron density



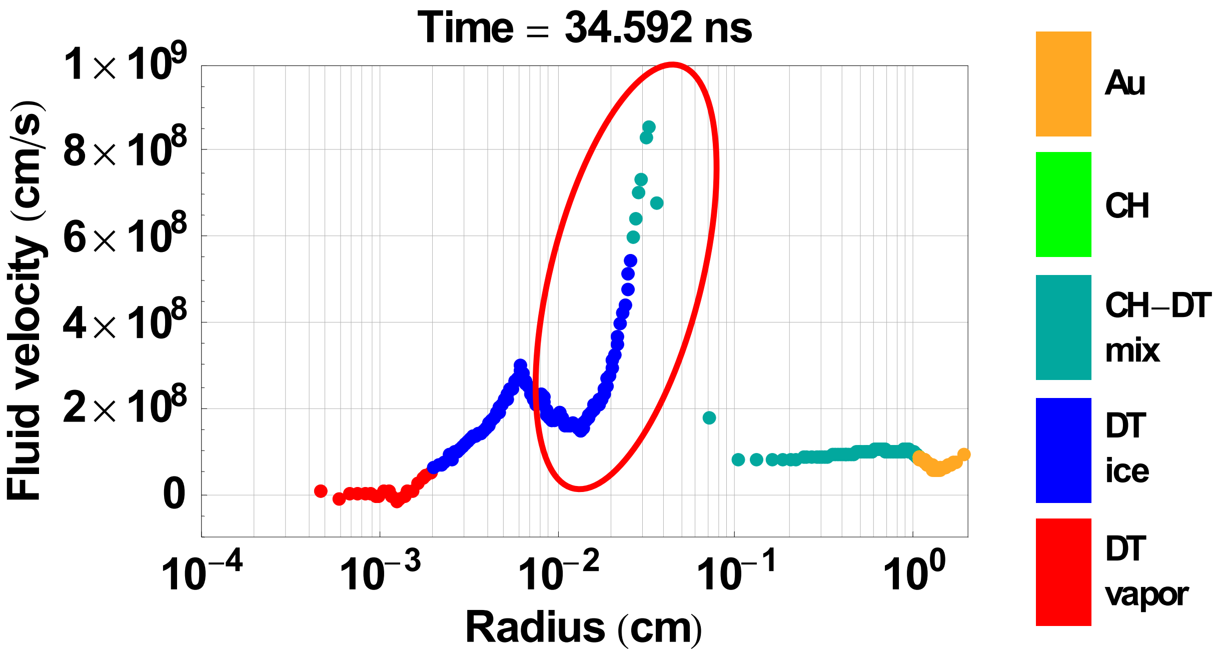
- Code written by Dr. Tim Bartel, SNL.

Ion threat time of flight transport to first wall and deposition in wall computed by BUCKY.

- Temporal prediction of ion threat at the first surface improved (piece-wise continuous model replaces discrete model.)
  - **BUCKY results reproduced in "stand-alone" simulation and compared to new model.**
  - **Further testing and comparisons.**
  - **Implementation in BUCKY with verification and validation.**



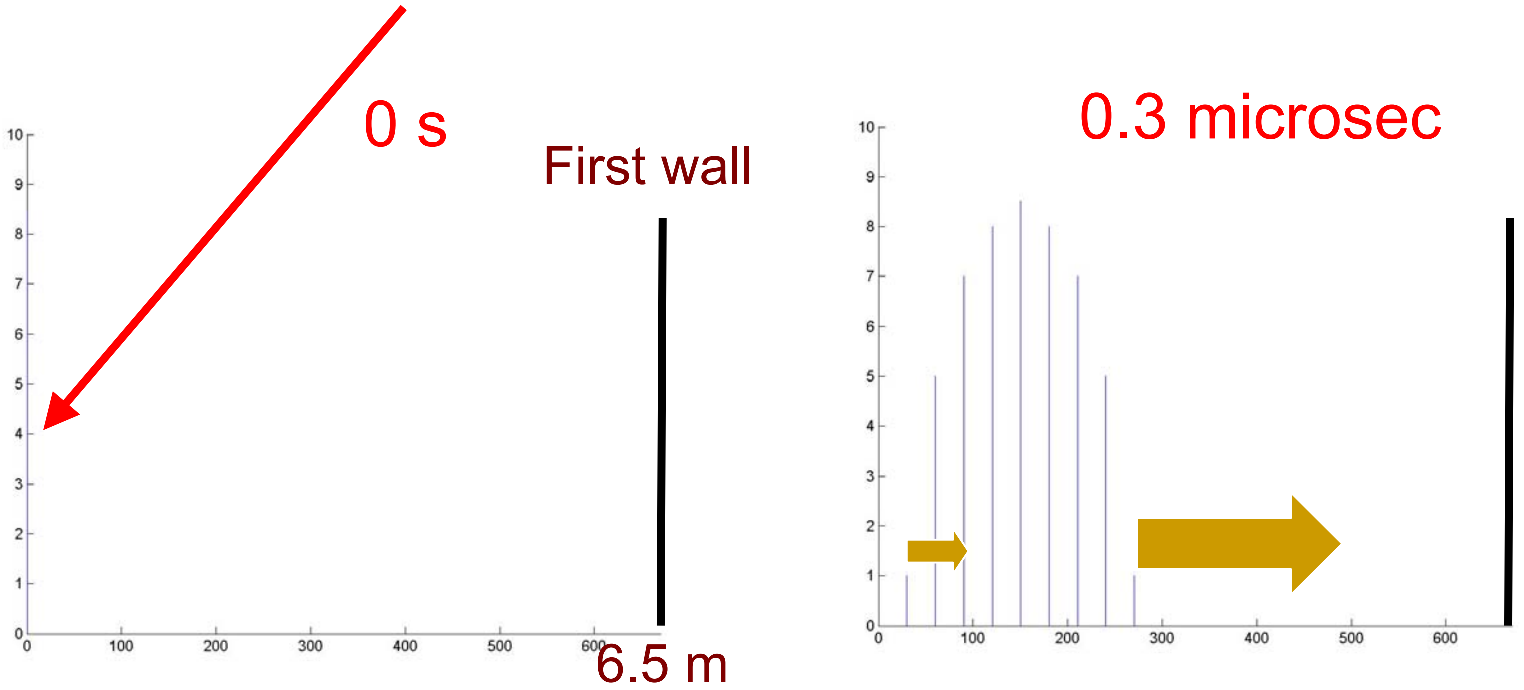
Select a portion of the HAPL ion spectrum to simulate using new model



- Ion energies between 150 keV and 5 MeV

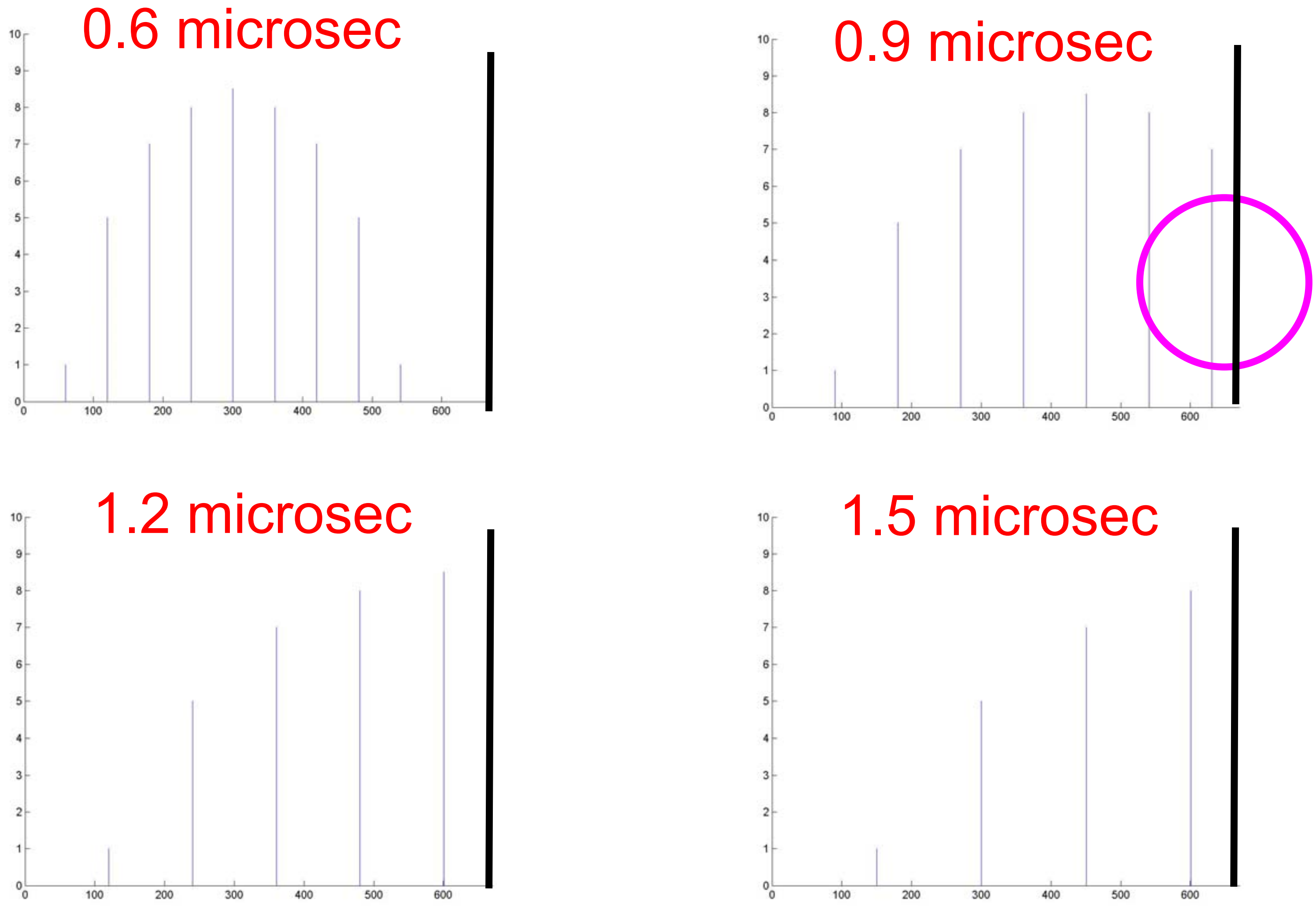
Discrete ion spectrum

Initial ion distribution < 0.5 cm

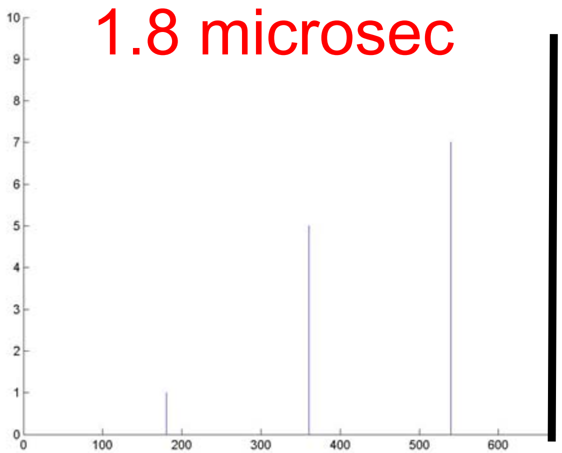


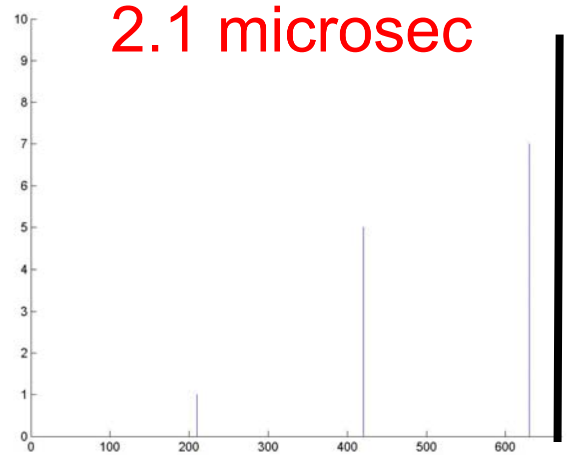
Outermost ions have highest velocities. Time-of-flight spreading widens pulse length at first wall.

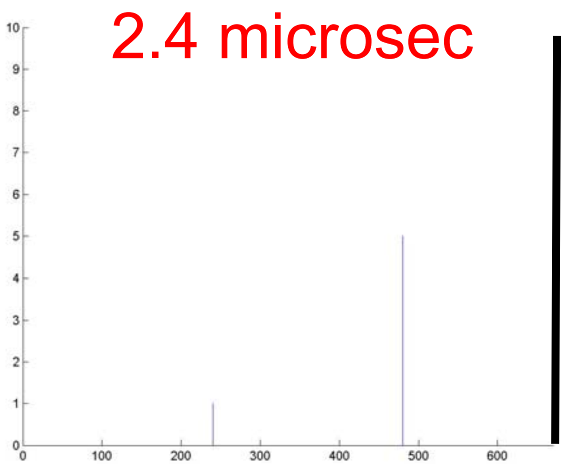
Discrete ion spectrum(2)

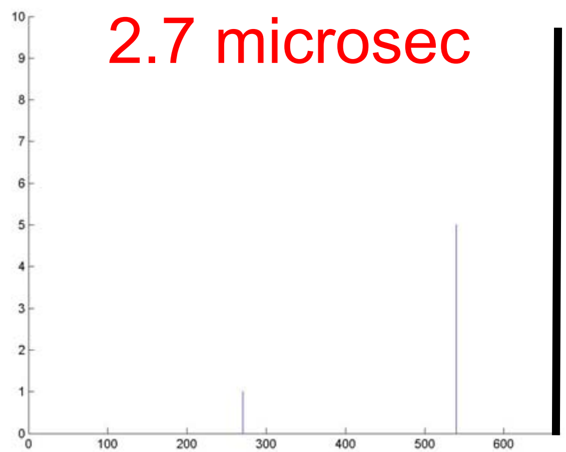


Discrete ion spectrum(3)



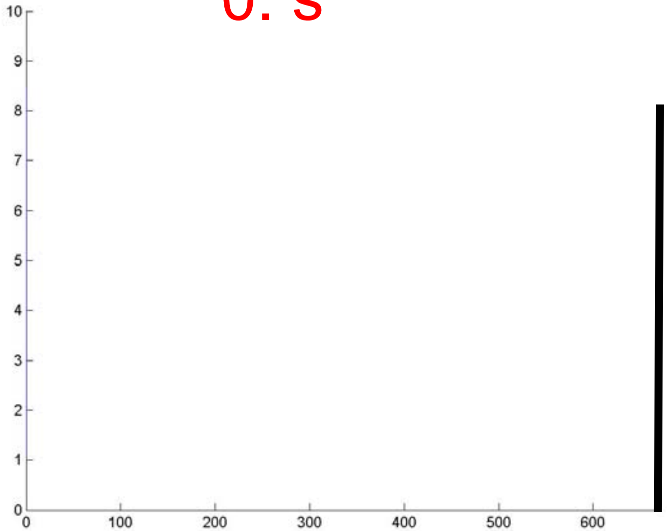




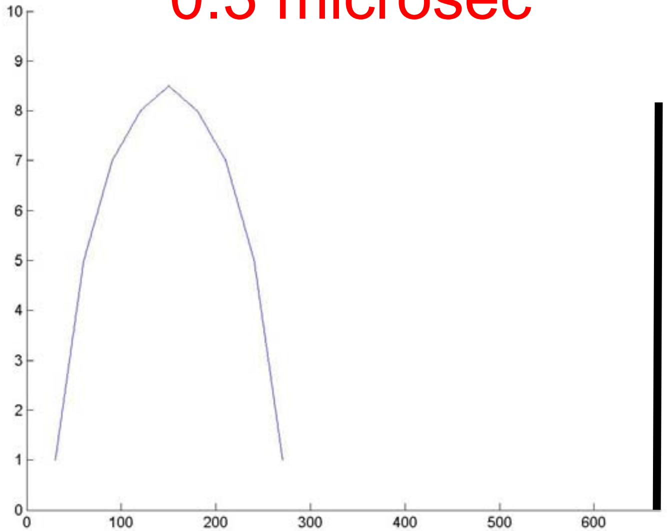


Continuous ion spectrum

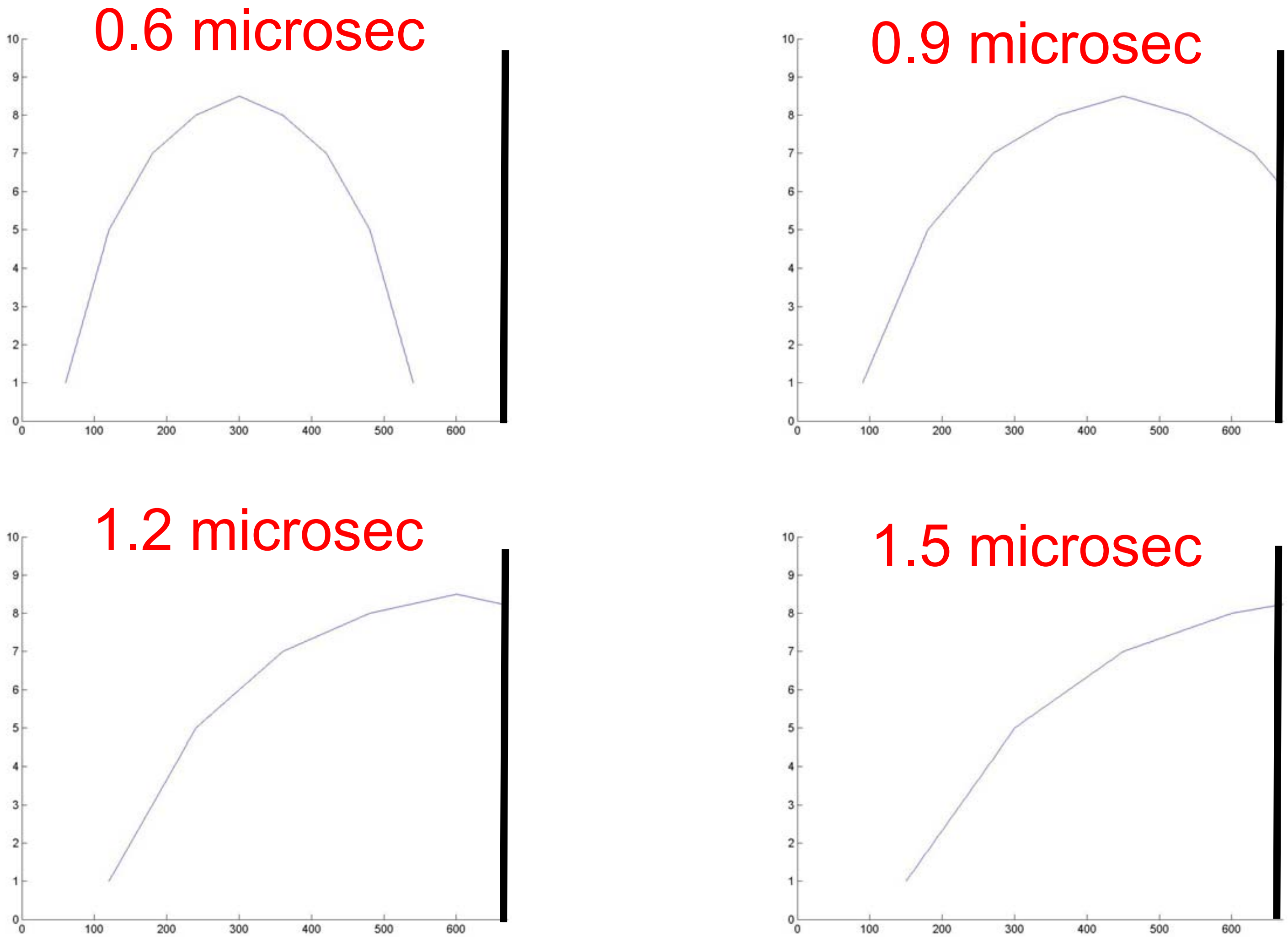
0. s



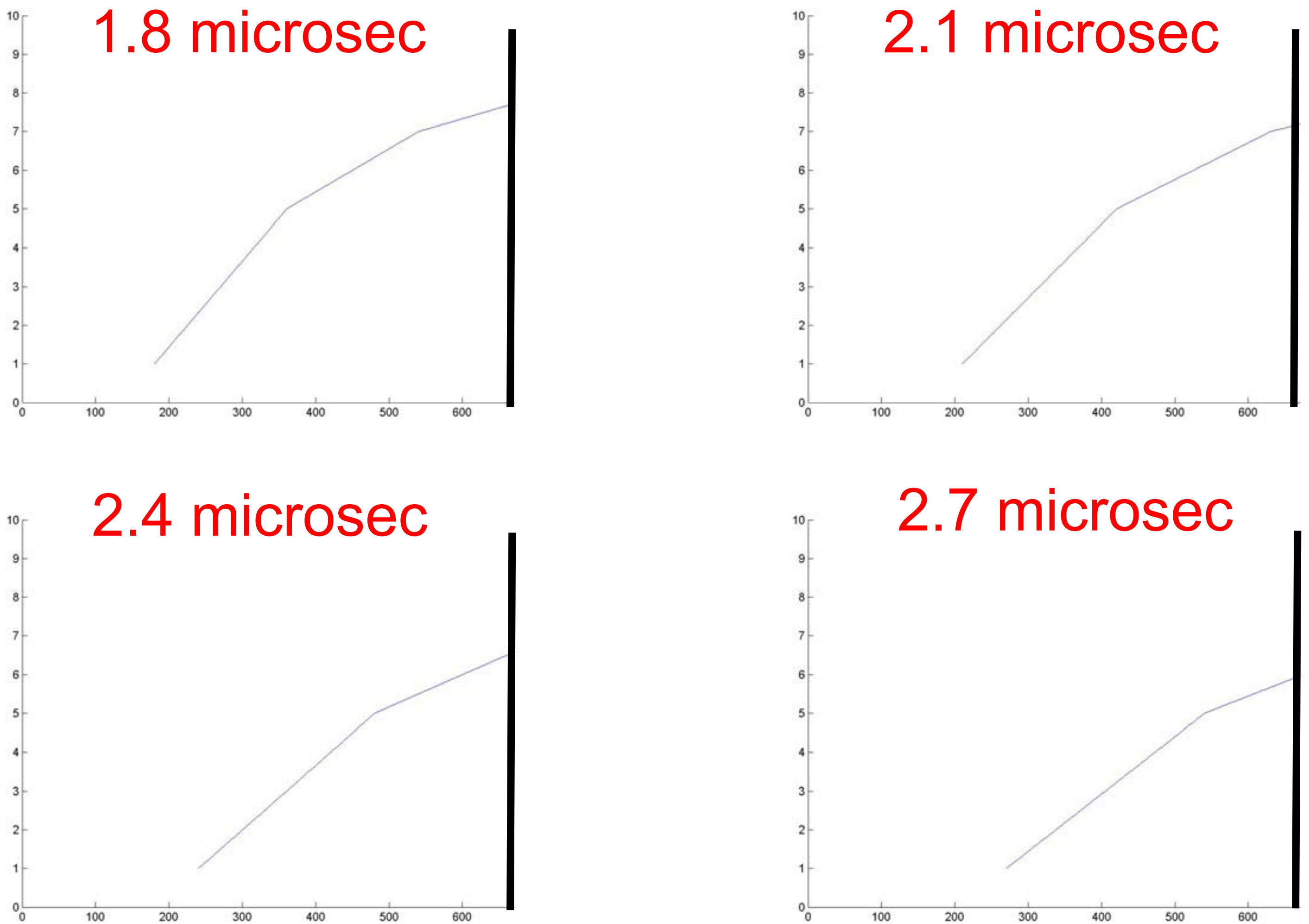
0.3 microsec



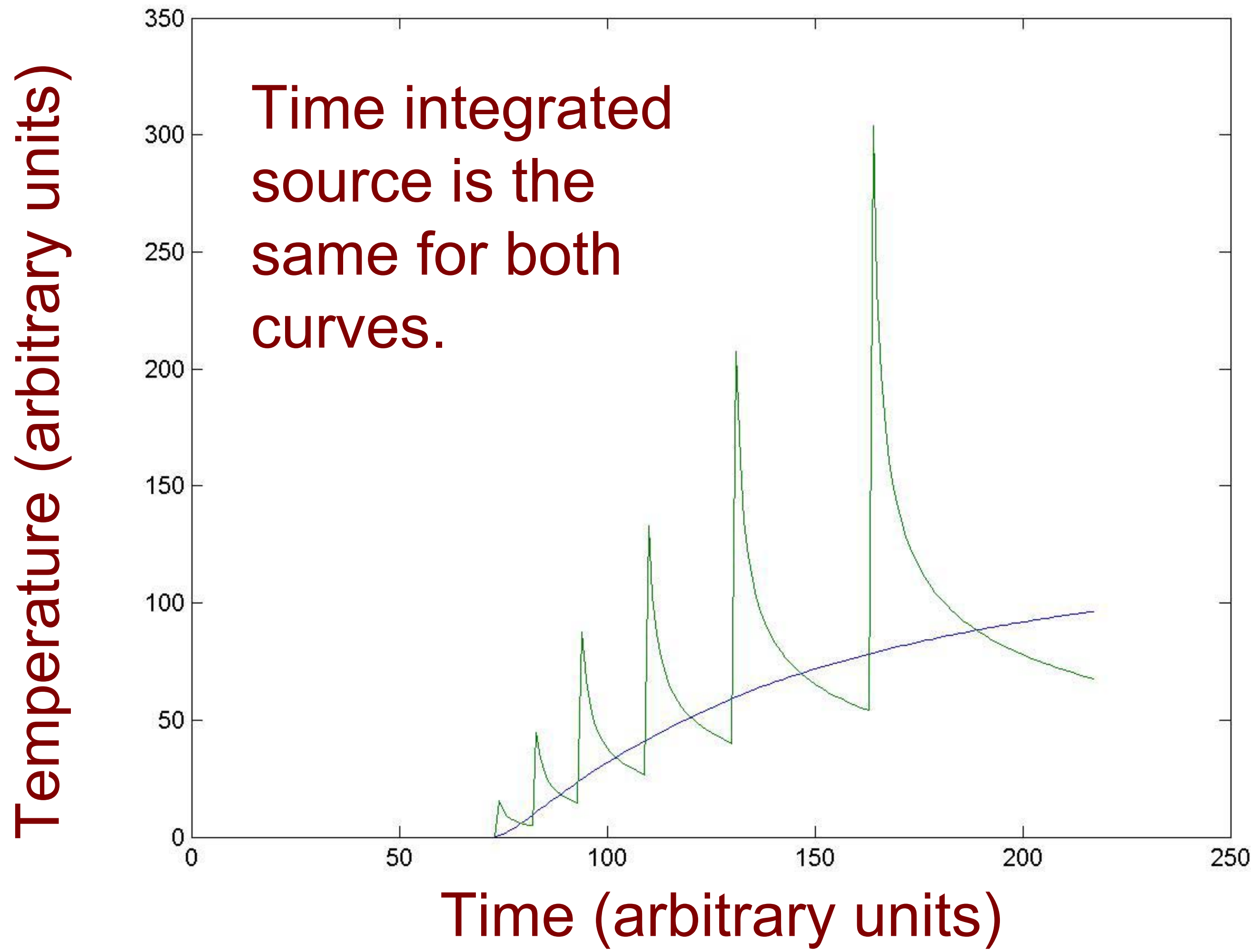
Continuous ion spectrum(2)



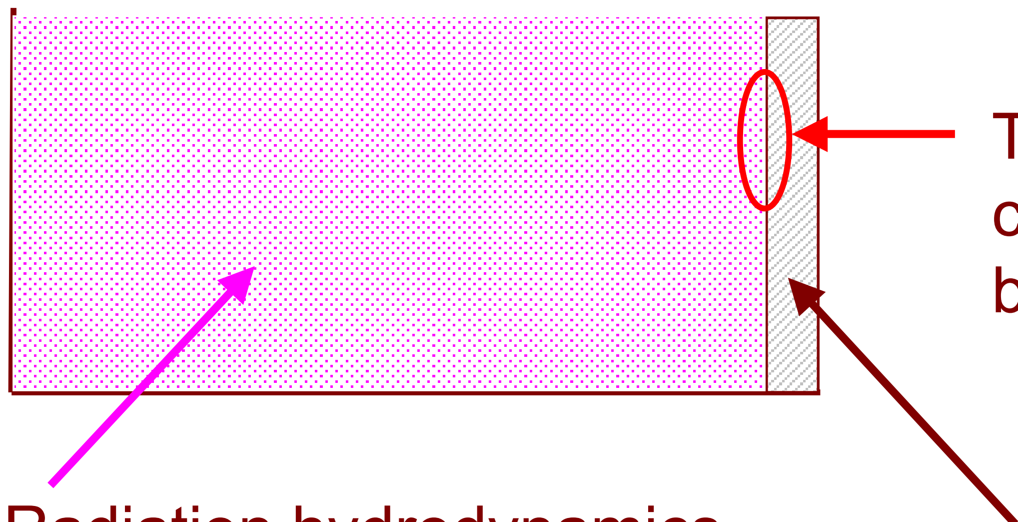
Continuous ion spectrum(3)



Surface temperature vs. time for discrete and piece-wise continuous ion spectrums



Chamber and first wall integrated calculation computed by BUCKY.



Two different models communicate across boundary.

Radiation hydrodynamics, plasma properties

Heat conduction, solid state properties.

Replace two region model with single region model with integrated equation of state and conductivity for plasma and solid state materials.

Future work in threat spectra task

- Perform DSMC analysis of long mean-free path ions and modify hydrodynamic model.
- Verify and validate BUCKY for new models.
- Continue with improved simulations for HAPL reactor design.
- Continue to interface with wall response simulations and cavity clearing simulations.