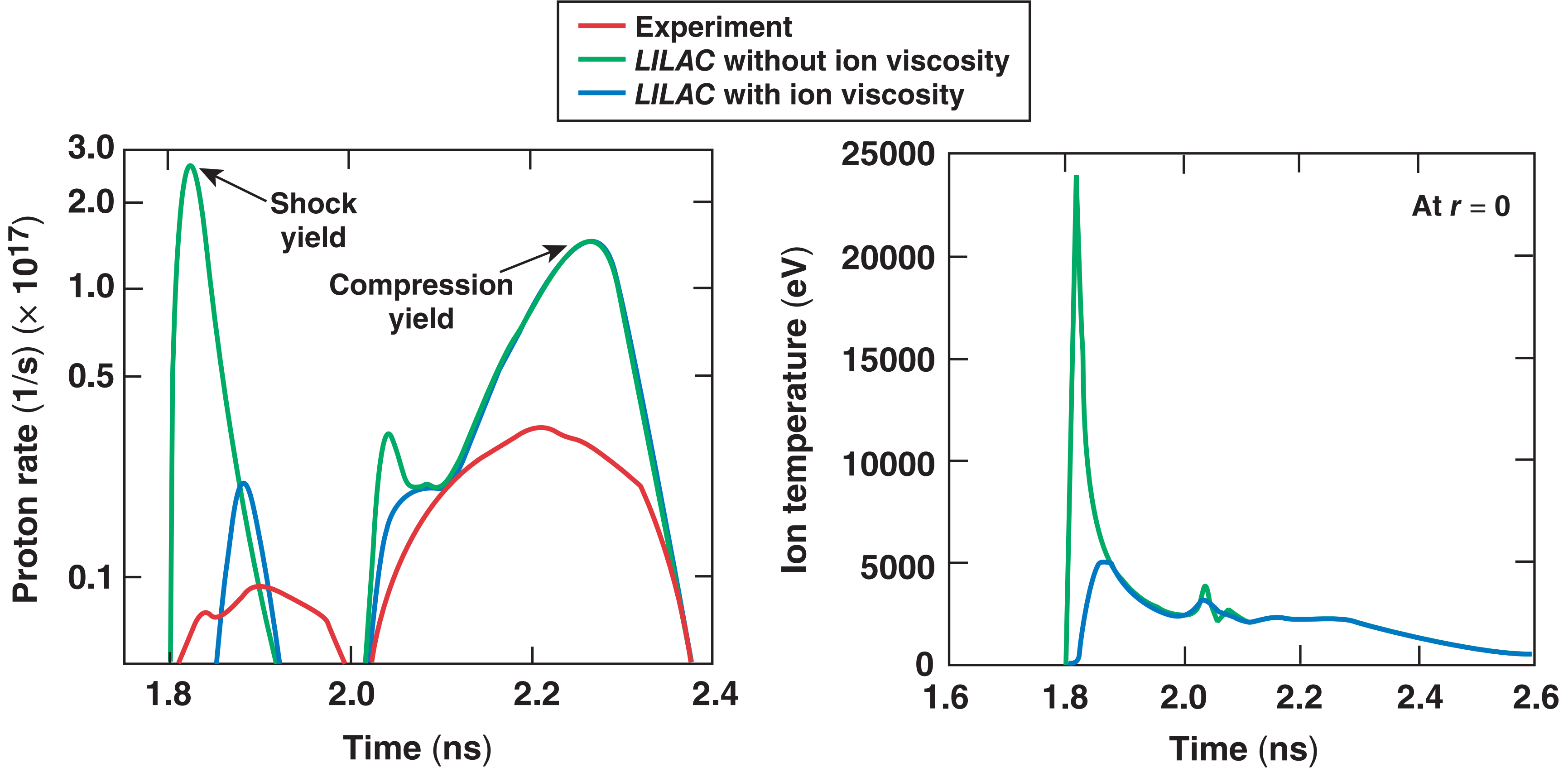
Effects of Ion Viscosity on the Shock Yield and Hot-Spot Formation in ICF Targets



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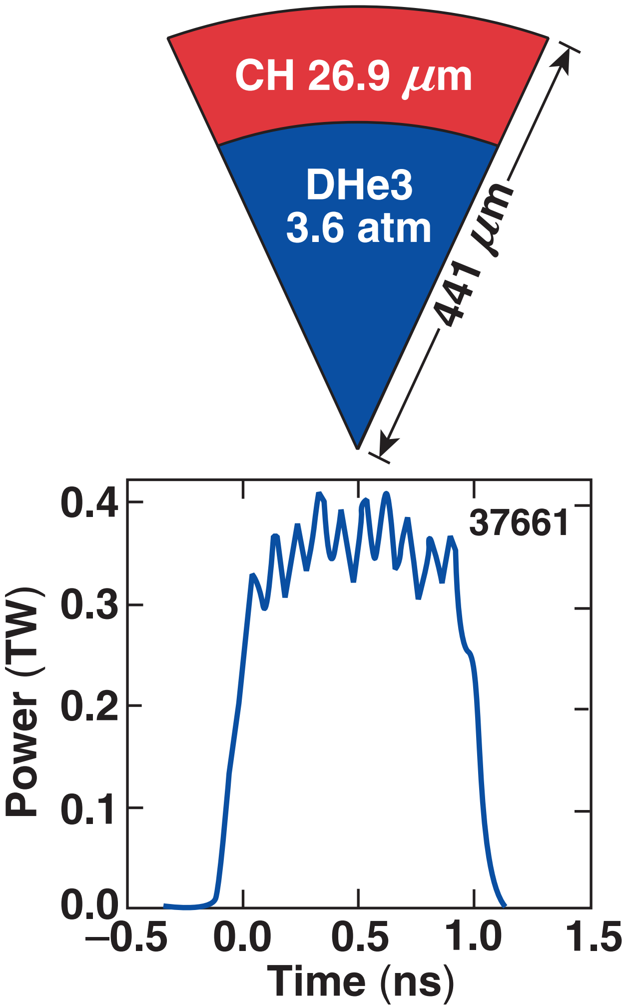
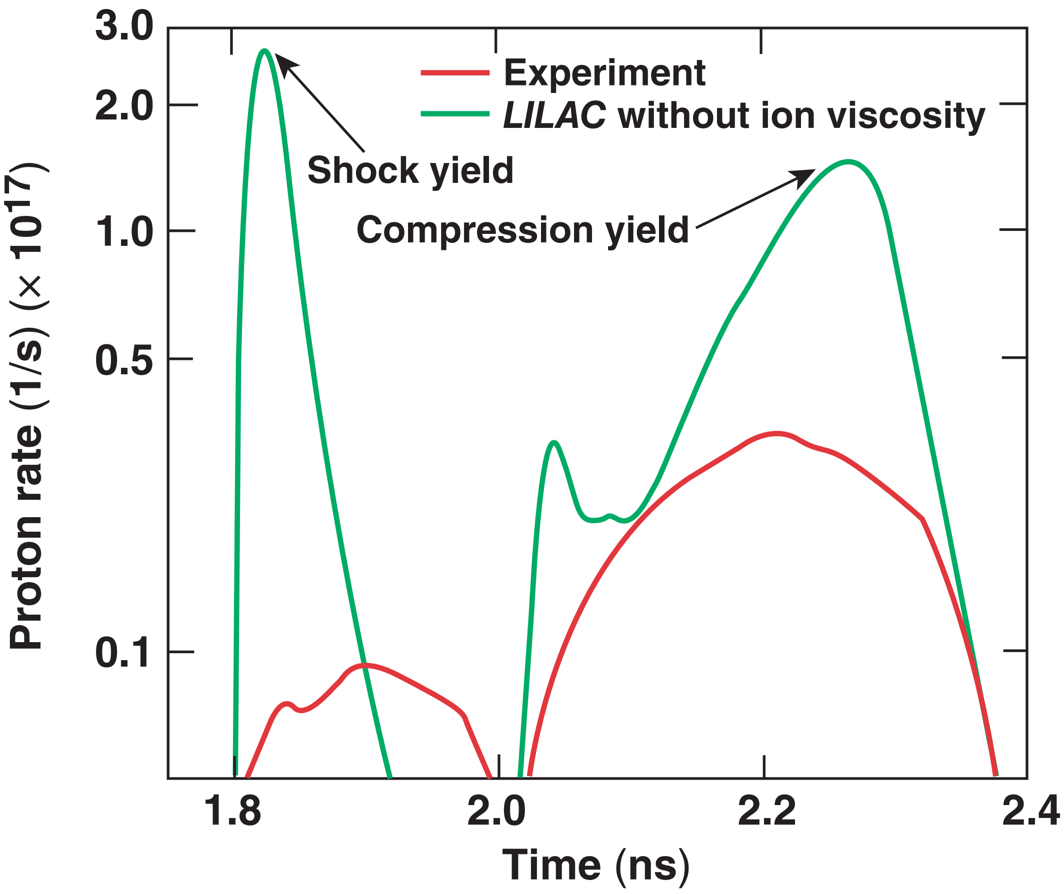
Summary

Ion viscosity smoothes the shock front and significantly reduces shock yield in ICF implosions

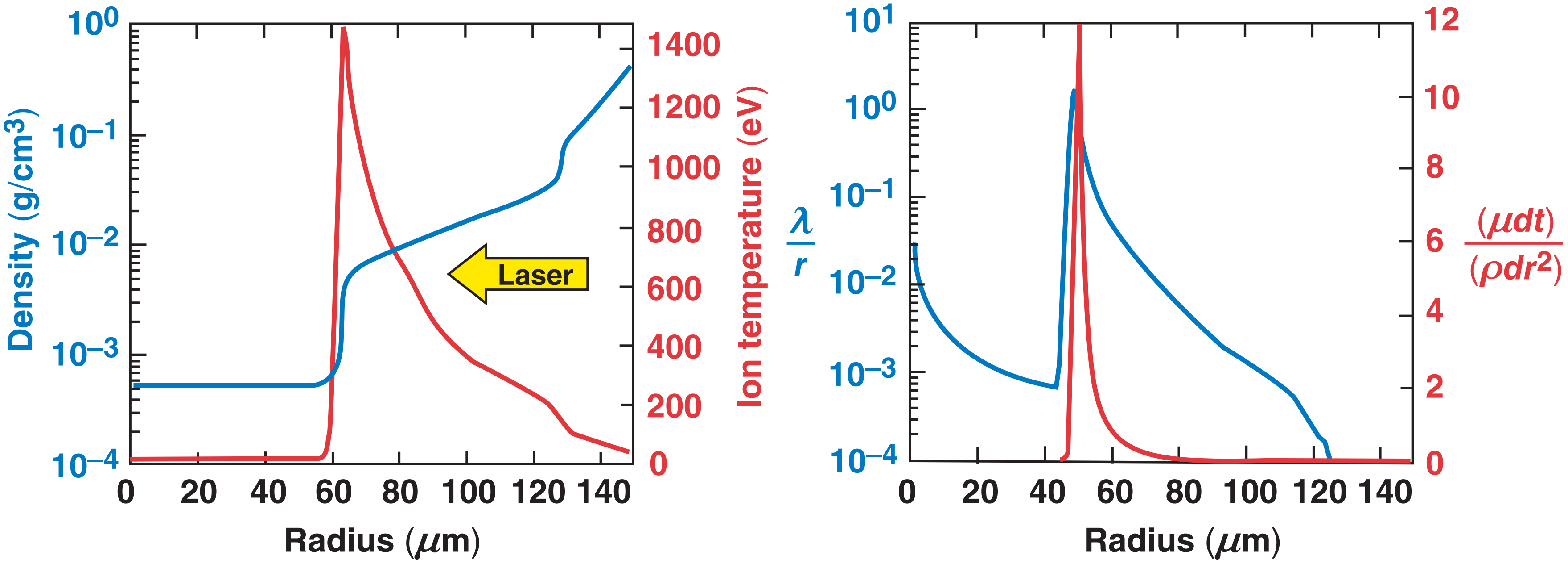
- The mean free path of the ion is comparable to the size of the hot spot at shock coalescence.
- Ion viscosity is very important at the shock front propagating in the vapor.
- Ion-viscosity terms are added into hydrodynamic equations and implemented into *LILAC*.
- Nonlocal effects will be studied in future work.

Standard *LILAC* simulation overpredicts the shock yield





The mean free path of the ion is comparable to the size of the hot spot at shock coalescence



λ = ion mean free path

Shock width $\boxed{\Delta x \sim \frac{\mu}{\rho_0 v_t} \frac{P_0}{P_1 - P_0}}$

Standard *LILAC* $\mu = \mu_n$ **numerical viscosity**

$\mu_n < \mu_i$ **at shock front**

TC7522

The ion-viscosity term is added into hydrodynamic equations

Navier–Stokes equation

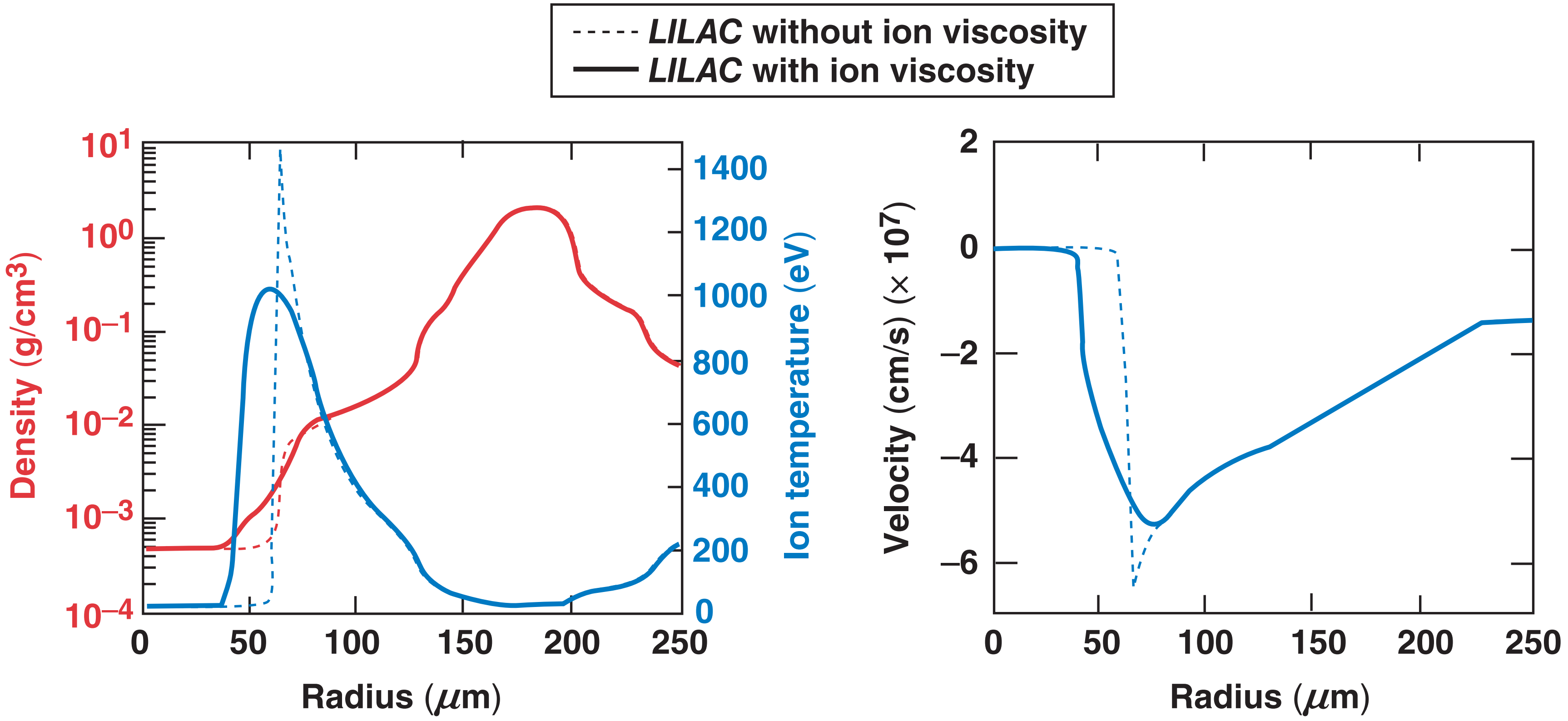
$$\rho\left(\frac{\partial u}{\partial t}+u\frac{\partial u}{\partial r}\right)=\frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2 p\right)+\boxed{\frac{4}{3r^3}\frac{\partial}{\partial r}\left[r^4\mu_i\frac{\partial}{\partial r}\left(\frac{u}{r}\right)\right]}$$

$$\mu_i = 0.96\ n_i T_i \tau_i \qquad \tau_i=\frac{3\sqrt{m_i}\,T_i^{3/2}}{4\sqrt{\pi}\,\Lambda e^4 Z^4 n_i}$$

- Ideal gas equation of state for ion is assumed.
- Implicit Crank–Nicholson scheme is used to solve diffusion equations with ion viscosity.

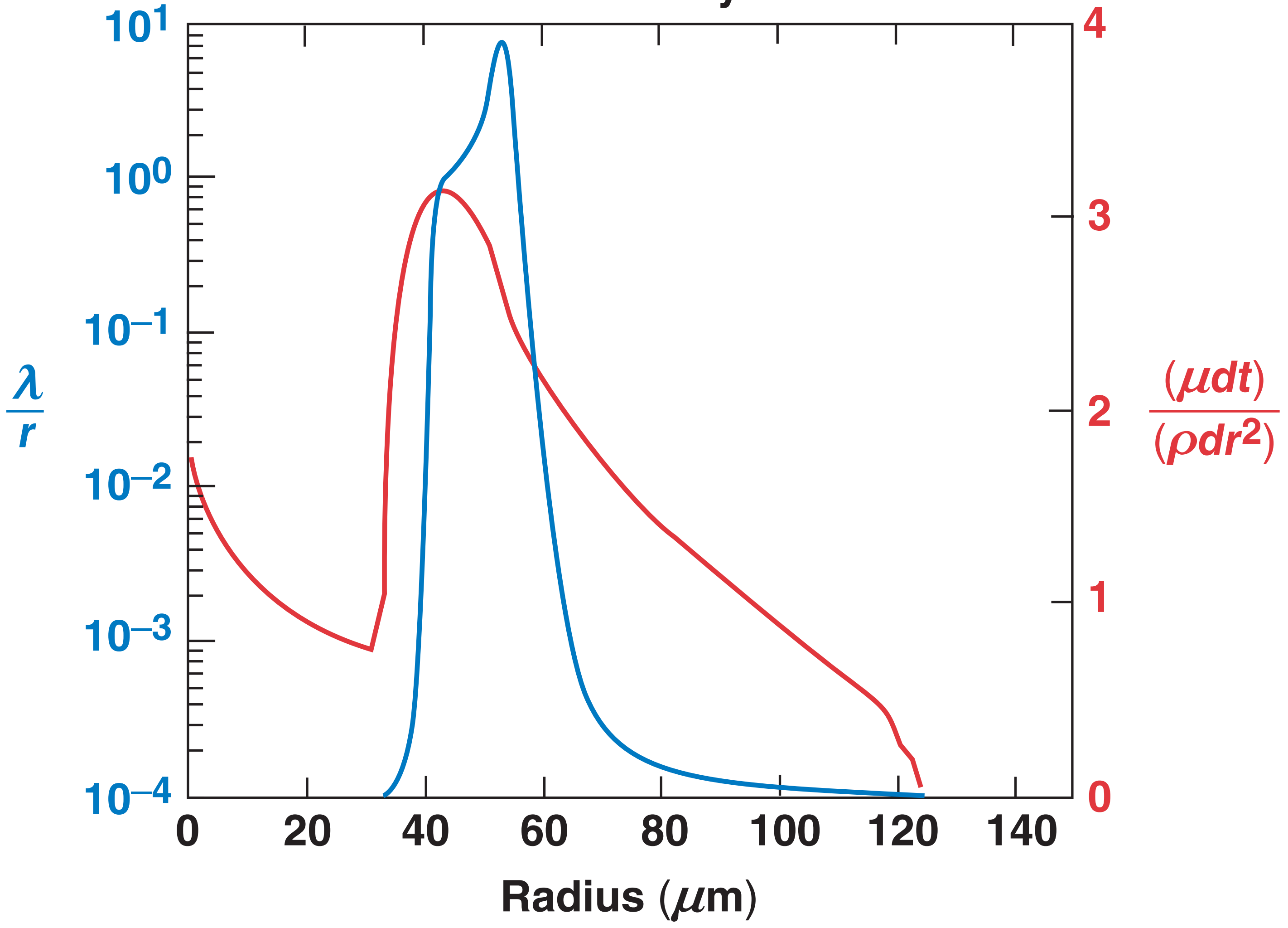
Braginskii, P202

The shock front is smoothed by ion viscosity



Ion viscous terms are important at shock front

Without ion viscosity: $\lambda/r \sim 1.5$



Nonlocal effects will further smear the shock front.

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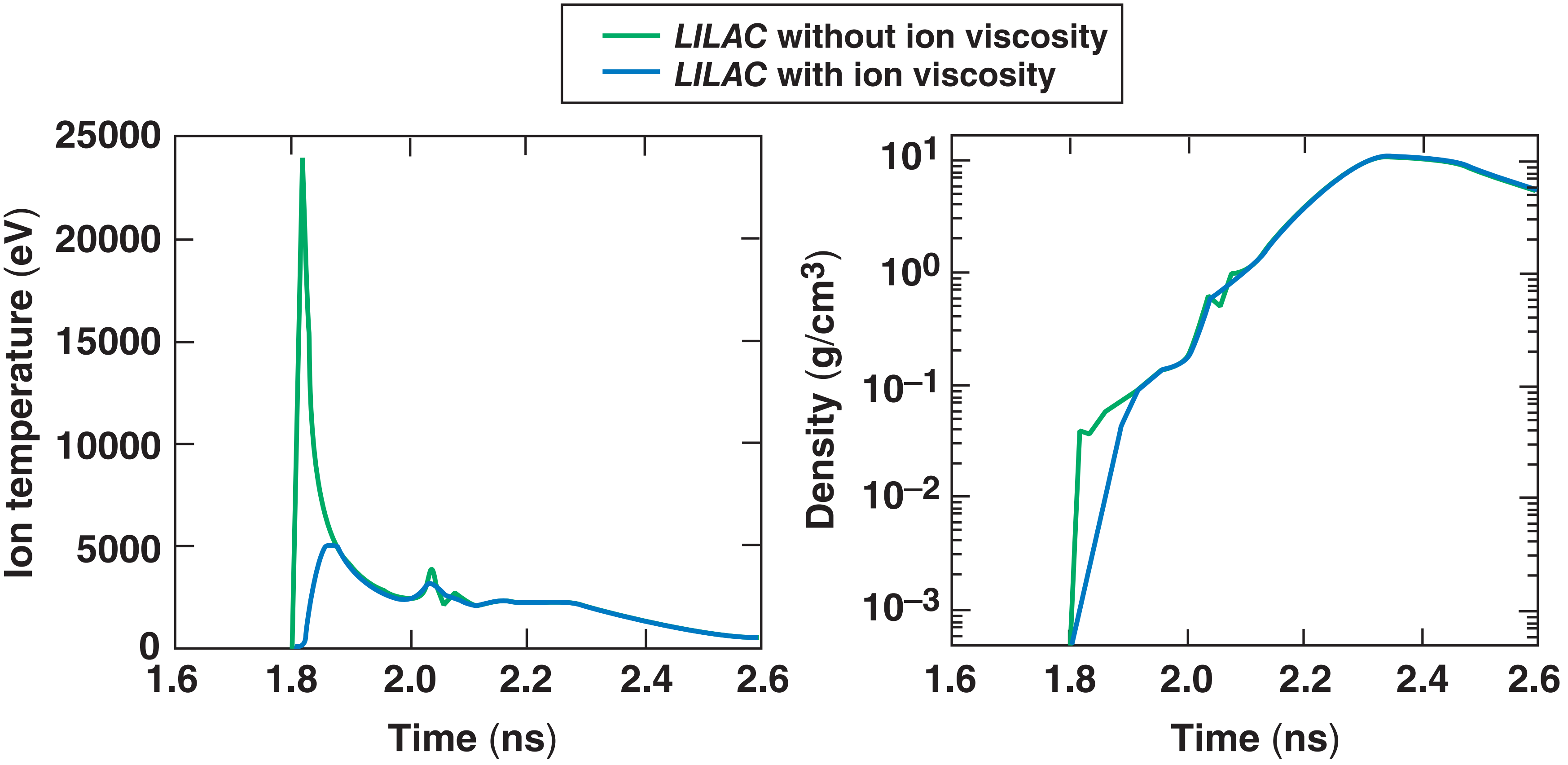
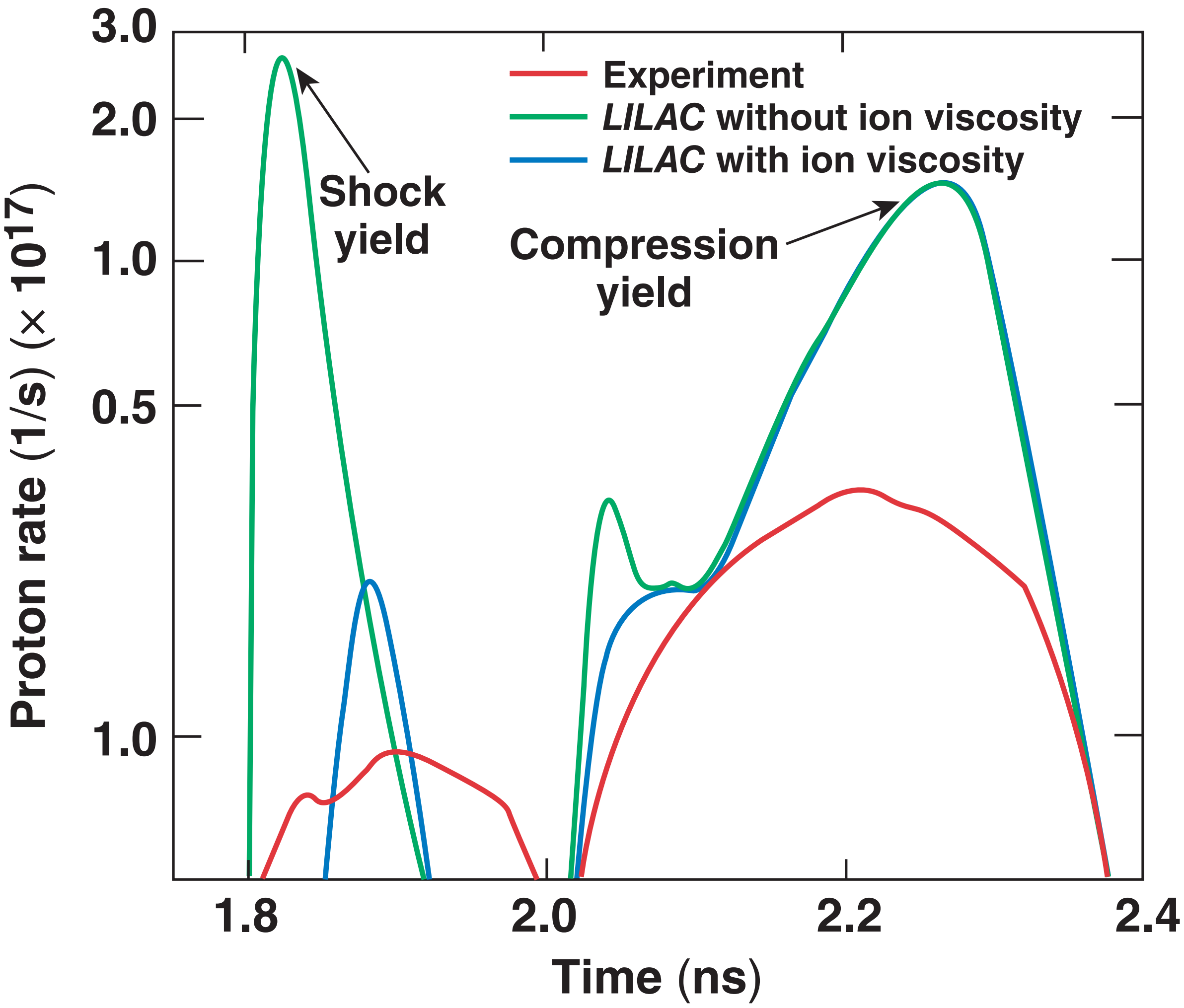
Ion viscosity reduces hot-spot temperature at shock coalescence

At $r = 0$



Shock yield is reduced by ion-viscosity effects, which is in better agreement with experiments



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Summary/Conclusions

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