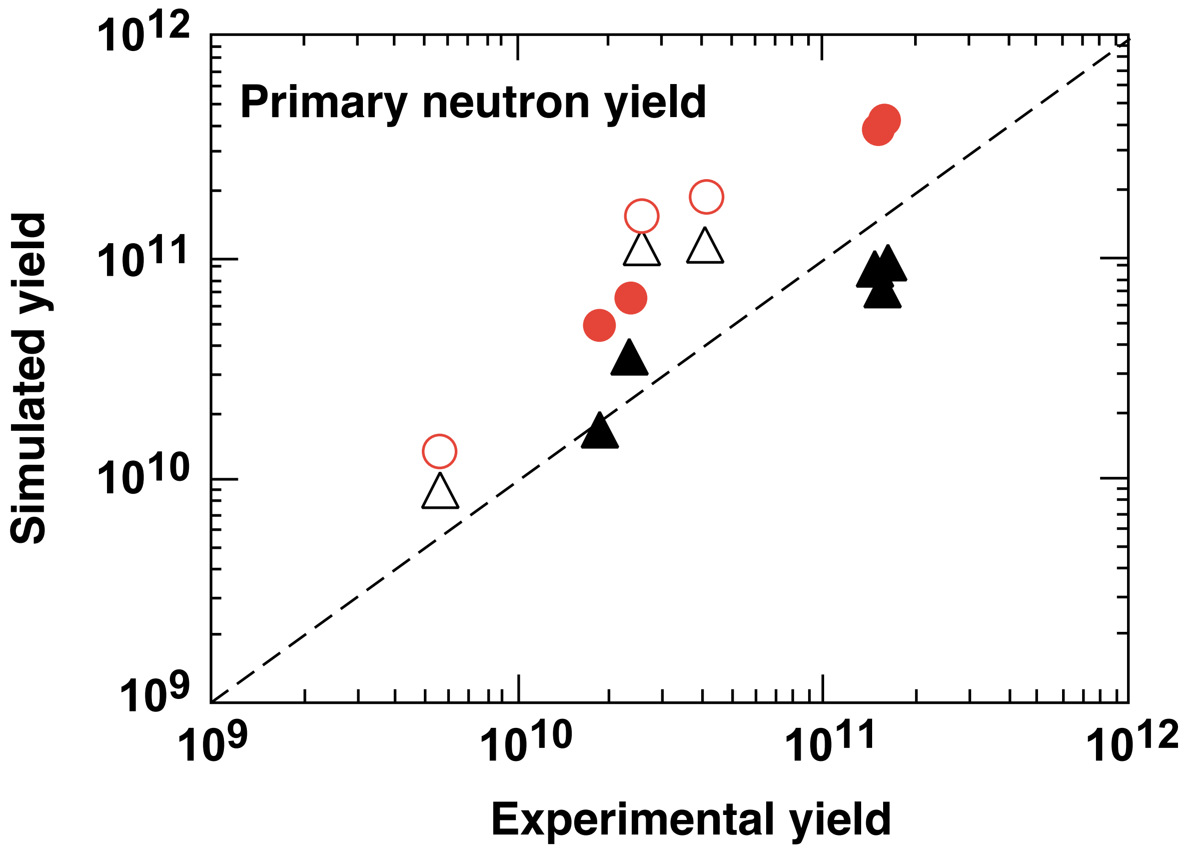
# One-Dimensional Simulation of the Effects of Unstable Mix on Neutron and Charged Particle Yield from Laser-Driven Implosions

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Summary

# Mix effects on particle yields can be described effectively by mix modeling in the 1-D hydrocode LILAC

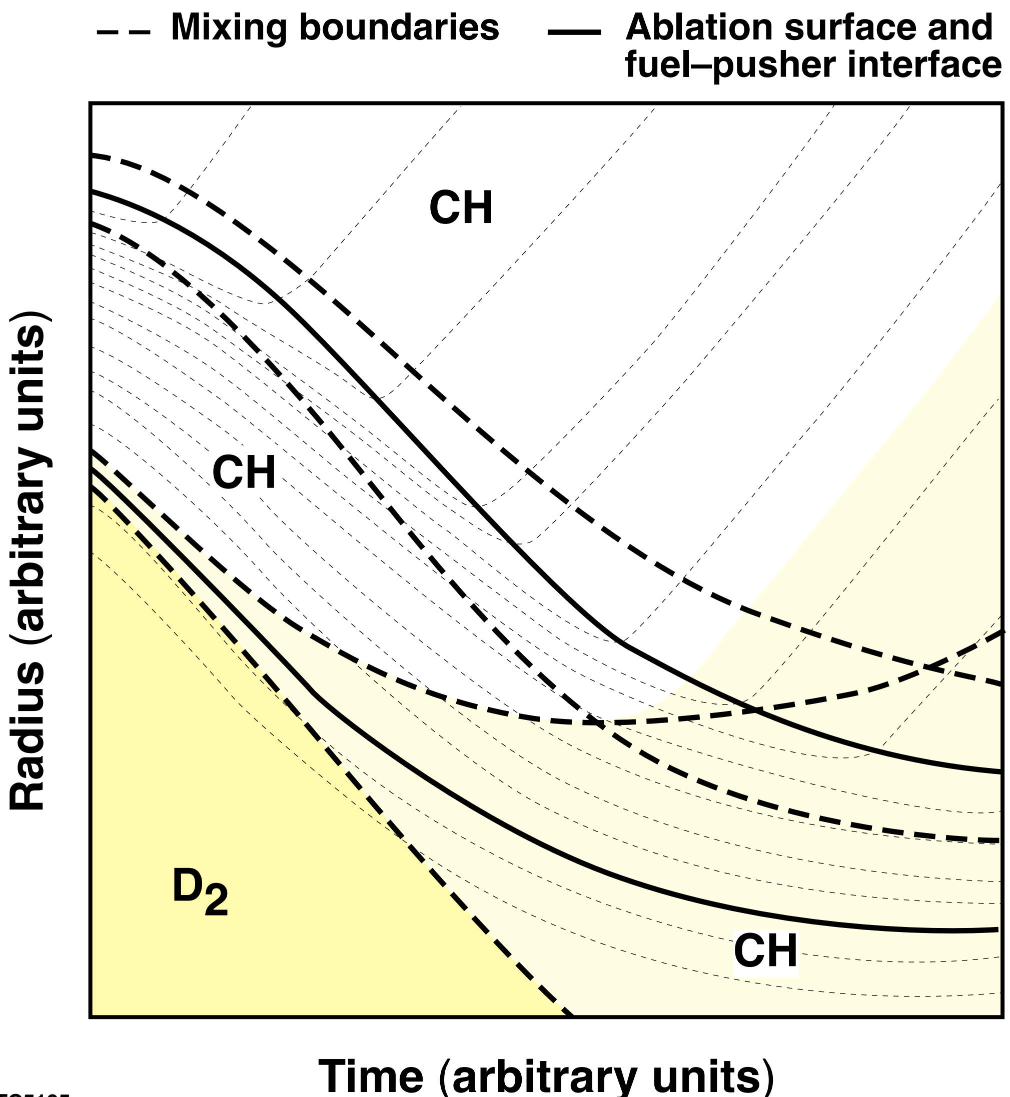
- **The mix model includes the transport of target constituents, thermal energy, and turbulent energy due to both the acceleration and deceleration instabilities.**

- **Including mix in 1-D simulations of experiments provides improved predictions of primary and secondary particle yields over a broad range of target performance.**

# Outline

- Modeling of mix in 1-D
- Comparison of simulated and experimental yields
- Secondary neutron and proton production
- Conclusions

# "Bubble and spike" mixing thickness is obtained from a multimode Rayleigh–Taylor perturbation model*

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- $\frac{d^2}{dt^2} A_\ell = \gamma^2(t) A_\ell$ including Bell-Plesset effects
- Takabe/Betti form for $\gamma^2(t)$
- Haan saturation procedure for

$$A_\ell(t) > \frac{2R(t)^*}{\ell^2}$$

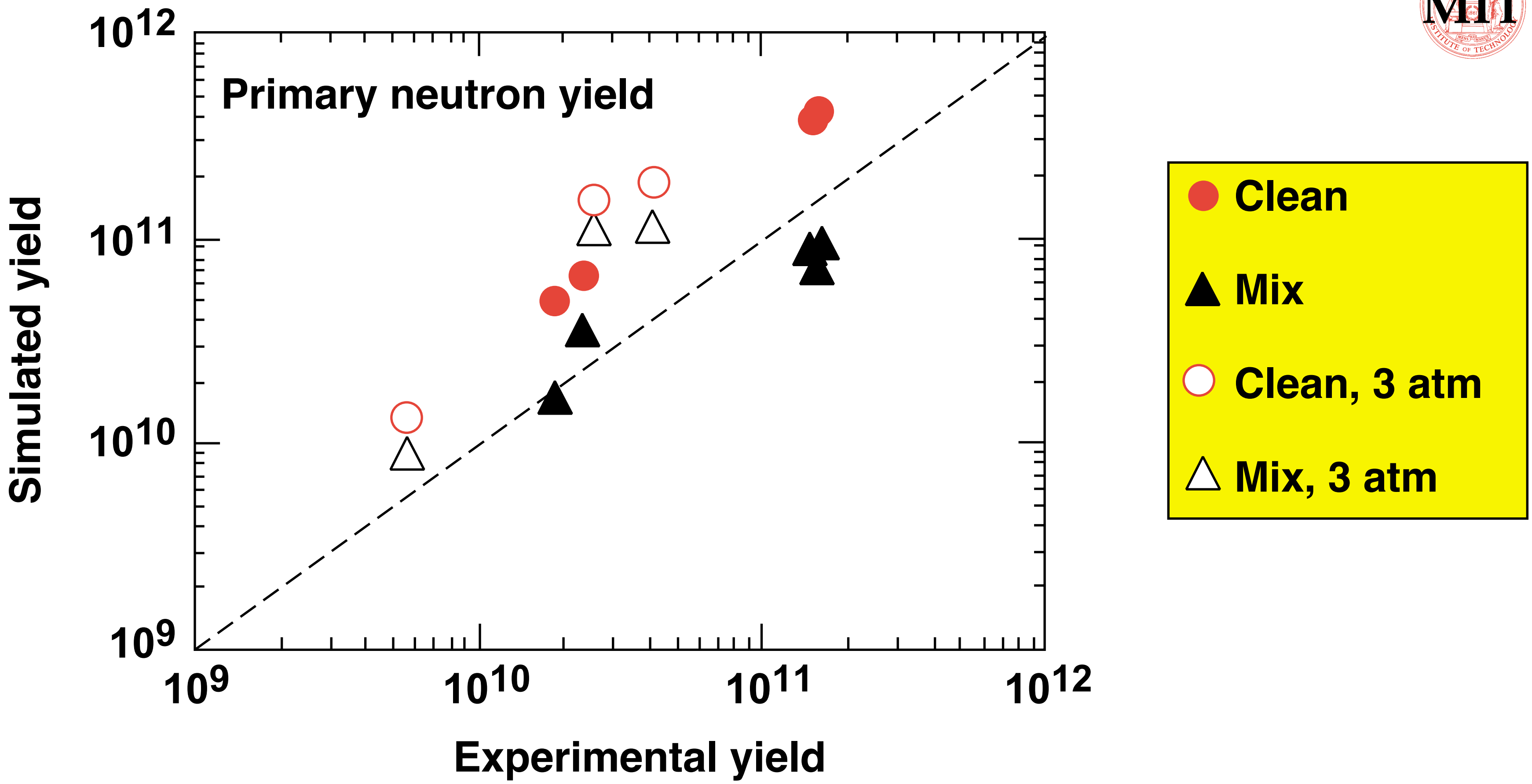
- Initial perturbation spectrum $A_\ell(t = t_0)$ specified at ablation surface and fed through to fuel–pusher interface over time.
- Mix is modeled as a diffusive transport process.

*S. W. Haan, Phys. Rev. A 39, 5812 (1989).

# The mix model is based on carefully formulated phenomenology

- Perturbations due to single-beam imprint were obtained from ORCHID calculations based on measured single-beam nonuniformity.
- Beam-imbalance effects are based on power-imbalance measurements from each shot and the geometrical superposition of the acceleration distributions of 60 beams.
- The formulation of the perturbation growth using fully time-dependent perturbation equations allows secular nonuniform irradiation effects and “feedthrough” from the outer to the inner instabilities to be treated as driving terms, rather than as instantaneous effects.
- Plausible flux limitation of the diffusive mix transport is obtained by allowing that the mixed constituent profiles can remain self-similar under expansion.

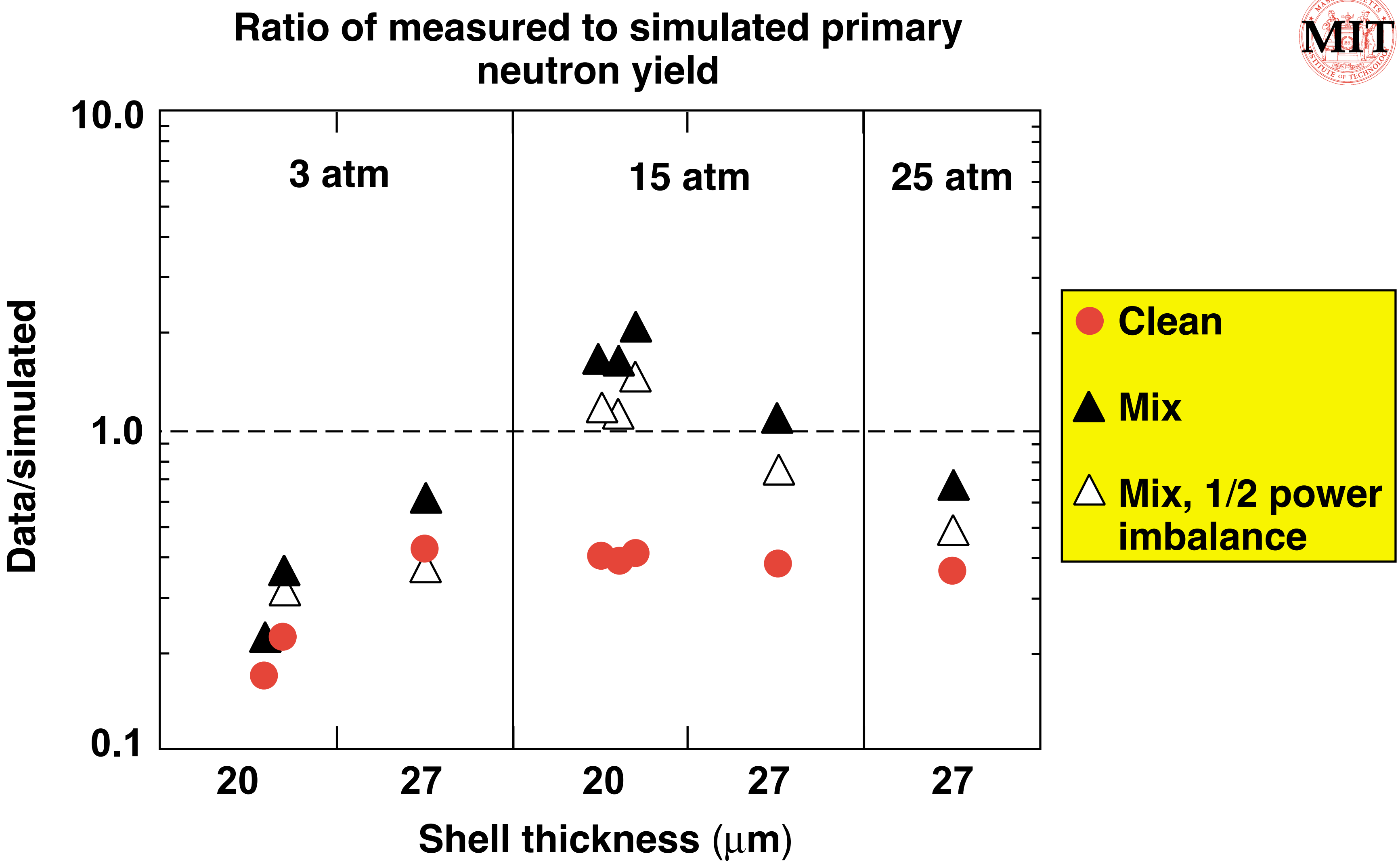
# Mix modeling improves the agreement of simulated primary neutron yield with implosion data




- Data from eight shots (August 2000)
- Pure-CH shells, 20–27 μm, 900-μm diameter, $D_2$ fill, 3–25 atm

TC5667

# Primary yield ratios indicate that implosion degradation is comparable to the predictions of mix modeling

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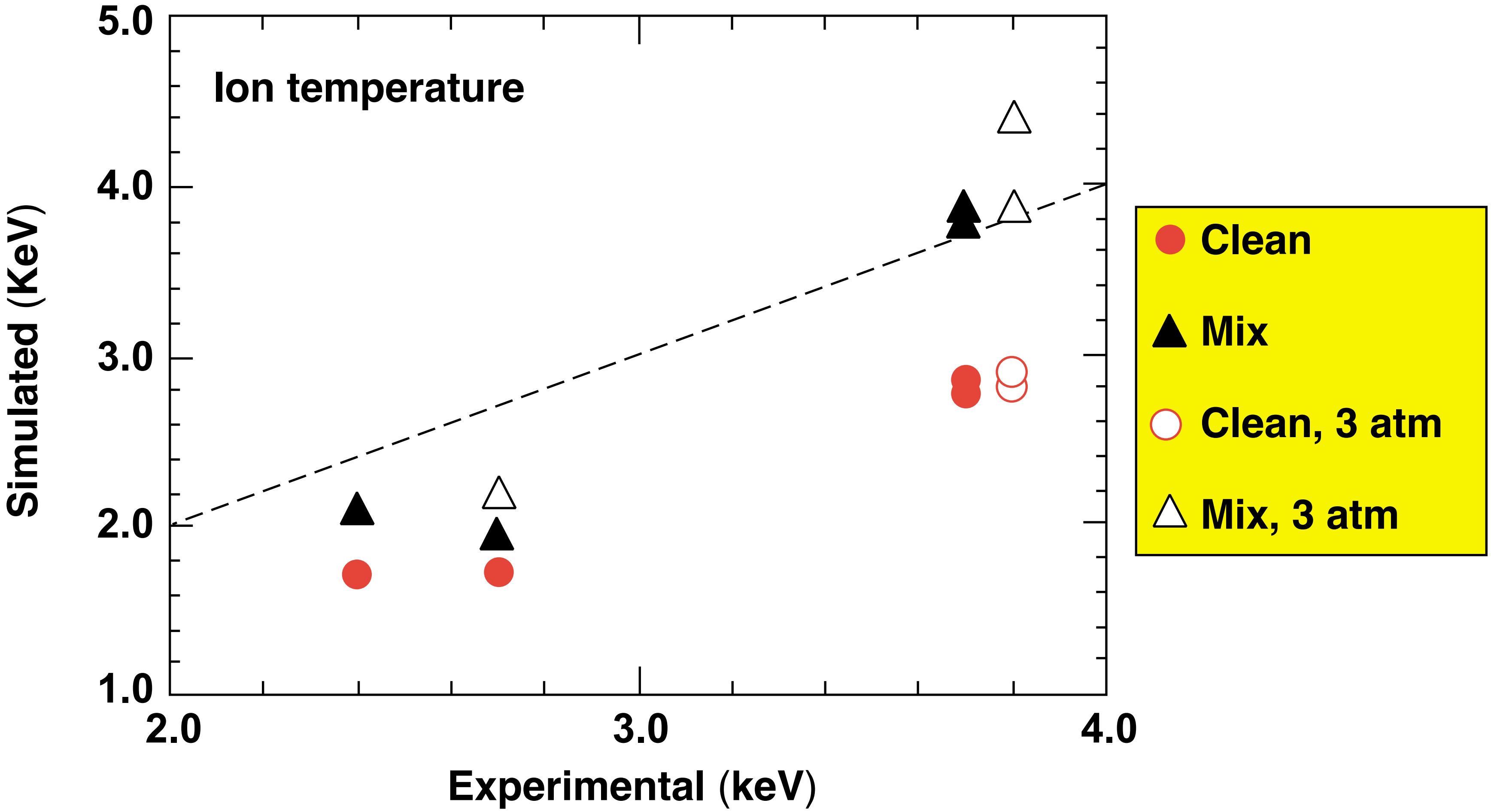
# Simulated and measured neutron-averaged temperatures show some improved agreement with mix modeling

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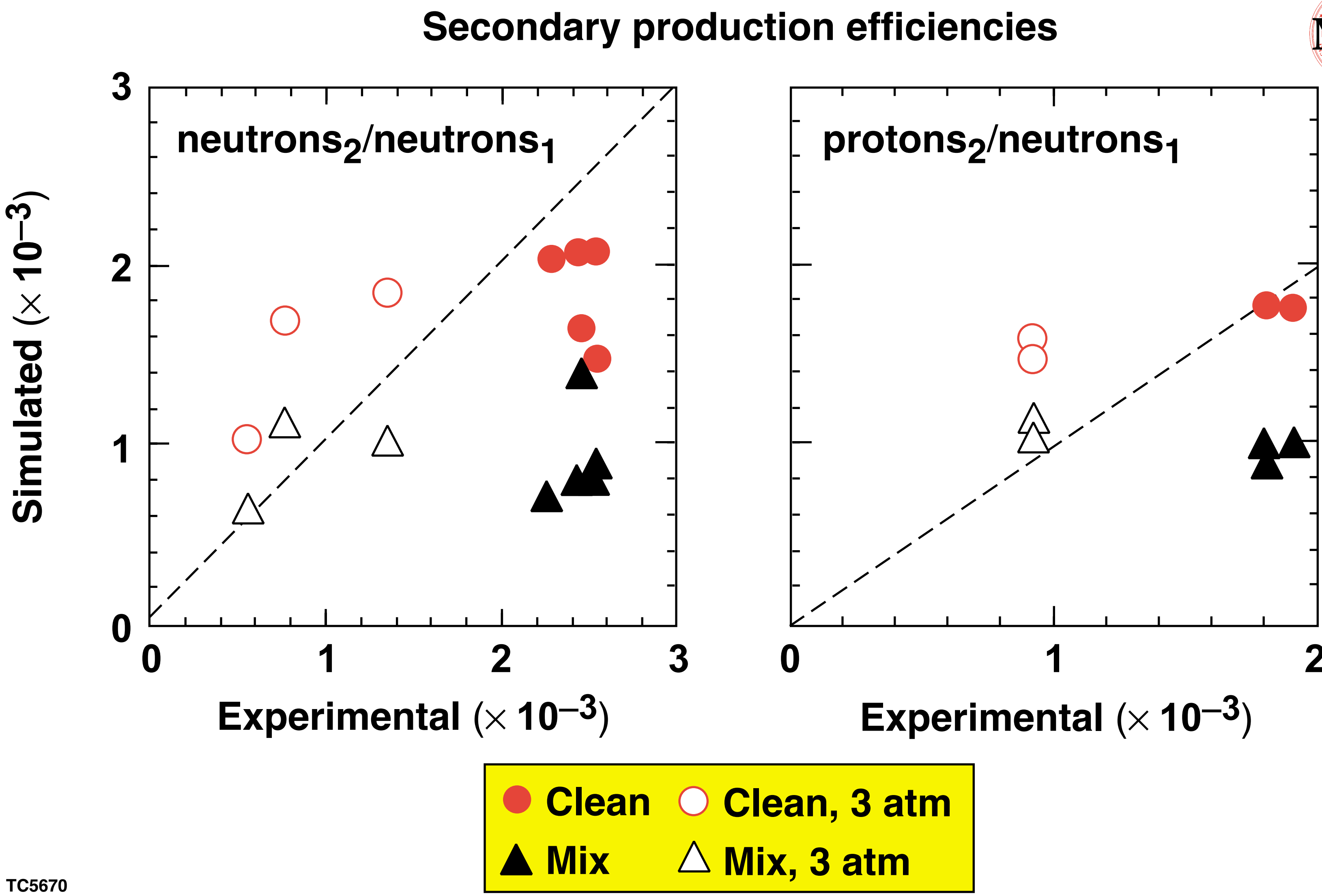
# Comparison of simulated with measured secondary particle yield ratios suggests sensitivity to dynamics

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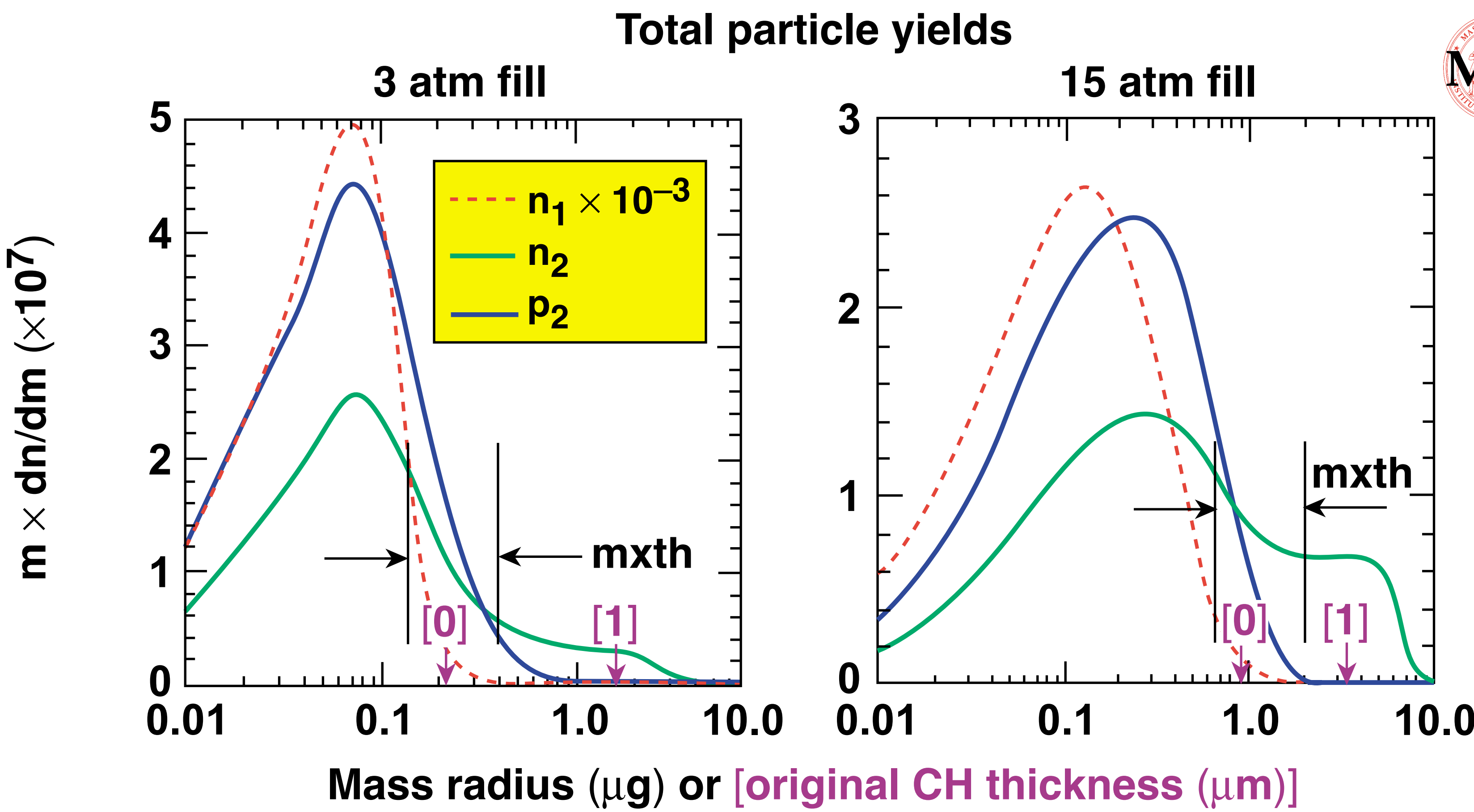
# The spatial distribution of secondary particle production depends on the extent of mix




- Mix thickness (mxth) is from the 1:3 to 3:1 mix points at the time of peak $n_1$ production rate.
- With the mass-spatial distribution as plotted here, the area under the curve is preserved.

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# The relative timing of peak neutron production and peak compression does not affect the coincidence of primary and secondary production times

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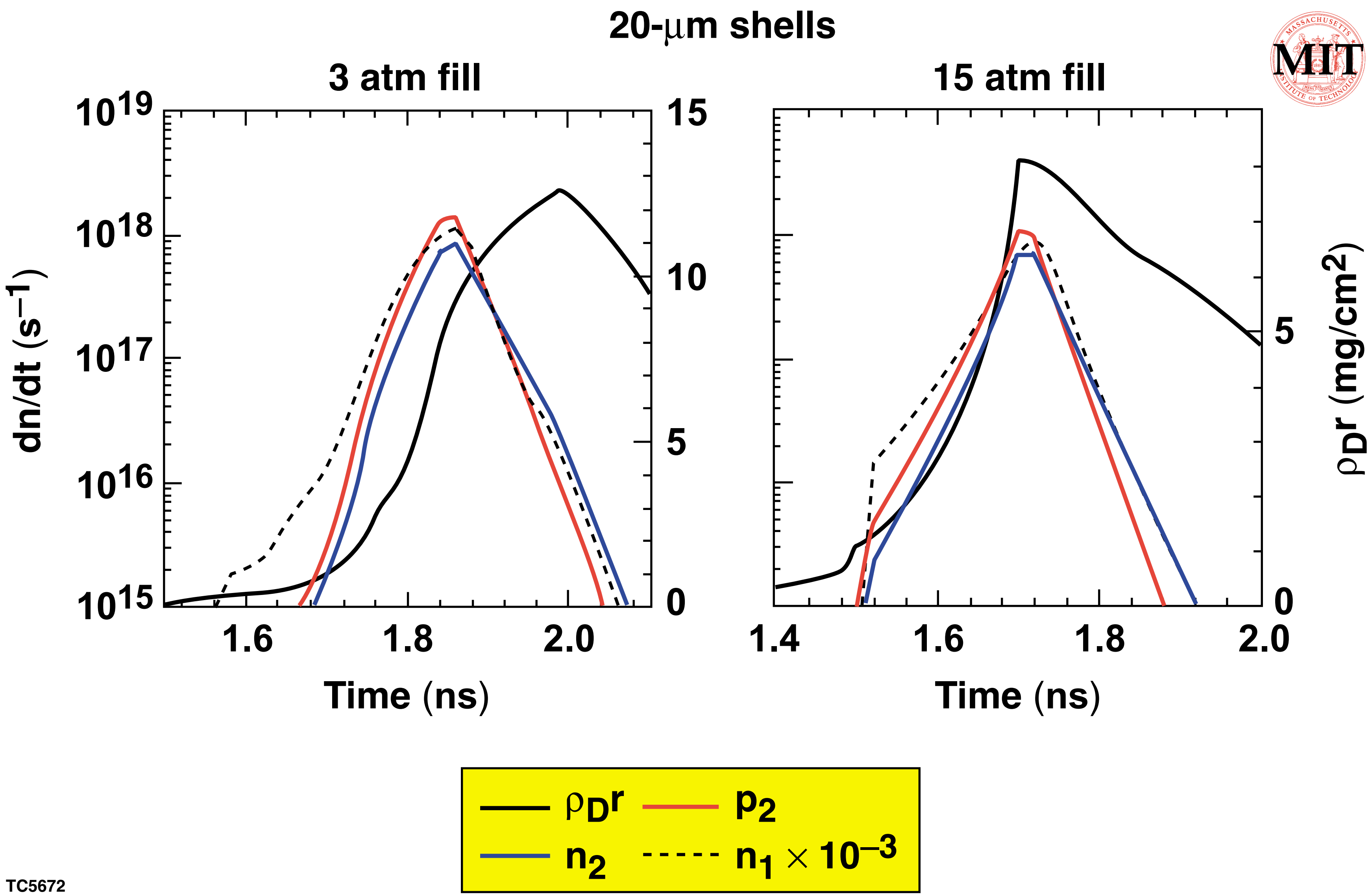


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Summary/Conclusion

# Mix effects on particle yields can be described effectively by mix modeling in the 1-D hydrocode LILAC

- The mix model includes the transport of target constituents, thermal energy, and turbulent energy due to both the acceleration and deceleration instabilities.
- Including mix in 1-D simulations of experiments provides improved predictions of primary and secondary particle yields over a broad range of target performance.
- The validity of approximating multidimensional hydrodynamics with a spherically symmetric model remains an issue.