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Design Calculations for NIF Convergent Ablator Experiments

To be presented at Inertial Fusion Sciences and Applications
Bordeaux, France, September 14, 2011

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The NIC convergent ablation experimental tuning effort is underway, and we have found some unexplained aspects of the capsule implosions.

Radiographic data and simulations:

Baseline post-shot simulations do not match radiograph data for Ge and Si doped CH capsules. → The baseline simulations implode much too quickly.

Modified (85% laser peak power) simulations are consistent with radiograph data for Ge- doped CH capsules, but do not quite match radiograph data for Si-doped CH capsules.

→ For Si-doped capsules, the modified simulations implode a bit too slowly.

This implies that the implosion velocity advantage of Si-doped CH is confirmed.

Proton data and simulations:

The baseline and modified simulations over-predict the WRF shock flash total ρr by ~ 10%, but have shock flash times that bracket the pTOF measurements.

This implies that there might be some preheat or shock mis-timing.

X-ray flux data and simulations:

Baseline post-shot simulations under-predict x-ray flux measurements by ~8%.

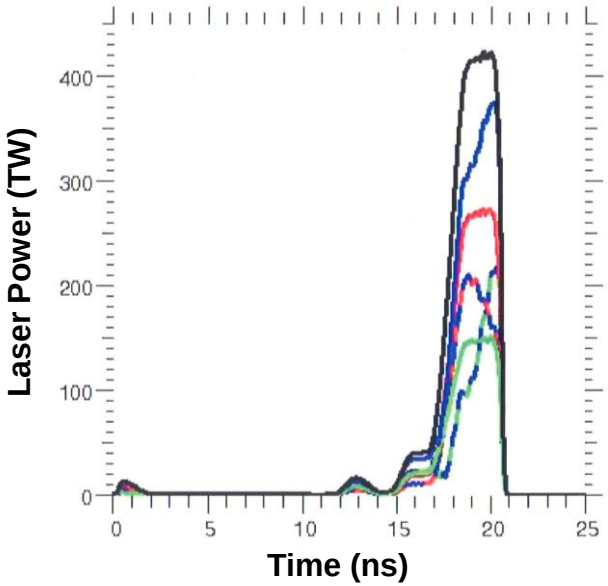
Modified (85%) simulations under-predict x-ray flux measurements by ~30%.

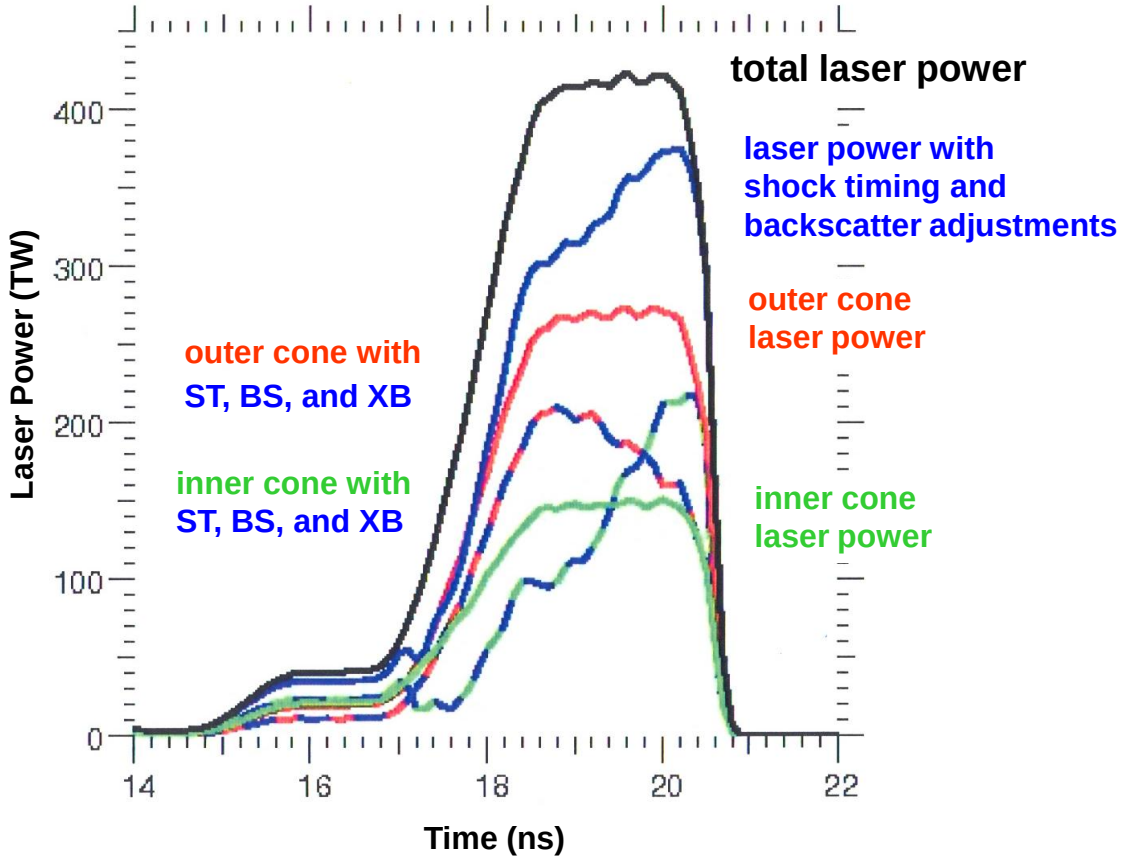
The inconsistency between the x-ray flux and radiography data implies that there are important unexplained aspects of the hohlraum and/or capsule behavior. Possible explanations might involve uncertainties involving LEH plasma, LEH closure, backscatter, cross-beam transfer, or opacities.

Integrated 2D Hydra simulations of the hohlraum and capsule include measured laser input with backscatter and cross beam transfer corrections.

Baseline post shot simulations include:

- measured target parameters
- measured laser power
  - shock timing adjusted (ST)
  - backlighter beams removed
- measured backscatter (BS)
- calculated cross beam (XB) transfer



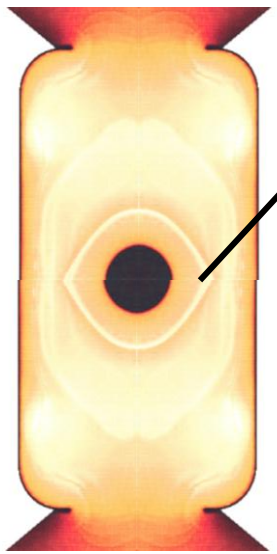


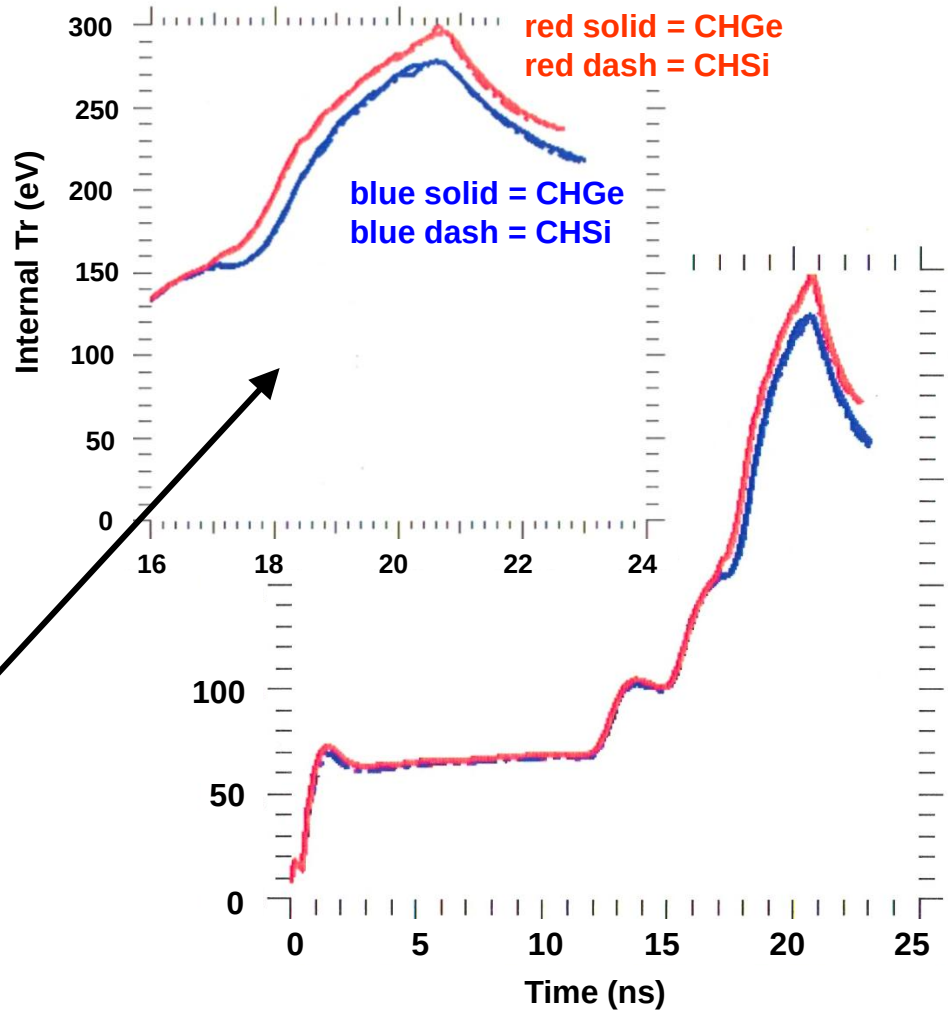
The laser pulse shapes and absorbed laser energies are nearly identical for the Ge and Si doped CH capsule experiments compared in this presentation.

In modified simulations, the peak laser power is reduced by 15% resulting in a reduction of the capsule drive. The differences in capsule radius and Ge vs. Si dopants have very little effect upon Tr.

Red = "baseline" post shot simulation
2D integrated Hydra including:
measured target parameters
measured laser power
(shock timing adjusted)
(backlighter beams removed)
measured backscatter
calculated cross beam transfer

Blue = "modified" post shot simulation
same as red, except 85% multiplier
on laser power for time > 17 ns.





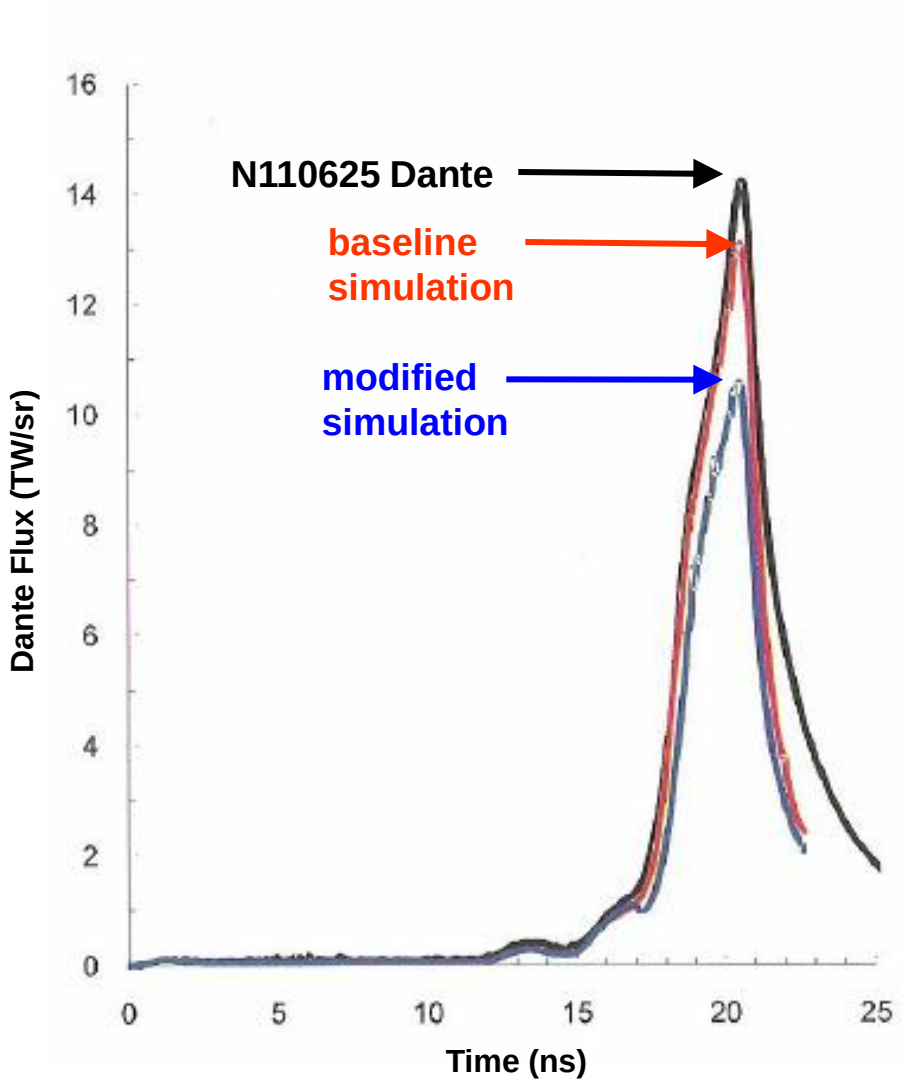
The Hydra simulations under-predict the Dante peak flux.

Black = Dante x-ray flux measurement

Red = "baseline" post shot simulation
2D integrated Hydra including:
measured target parameters
measured laser power
(shock timing adjusted)
(backlighter beams removed)
measured backscatter
calculated cross beam transfer
Dante flux under-predicted by ~8%

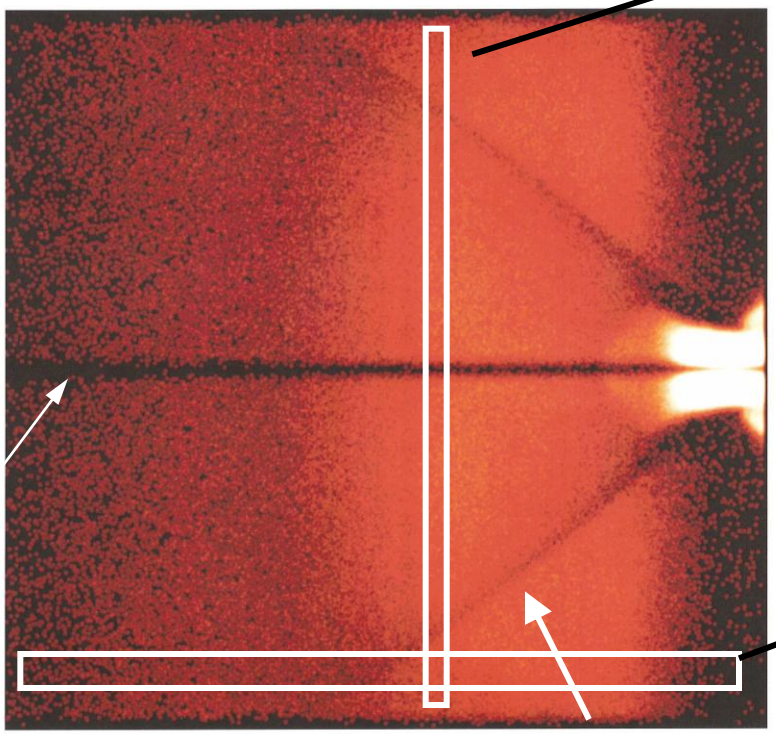
Blue = "modified" post shot simulation
same as red, except 85% multiplier
on laser power for time > 17 ns.
Dante flux under-predicted by ~30%

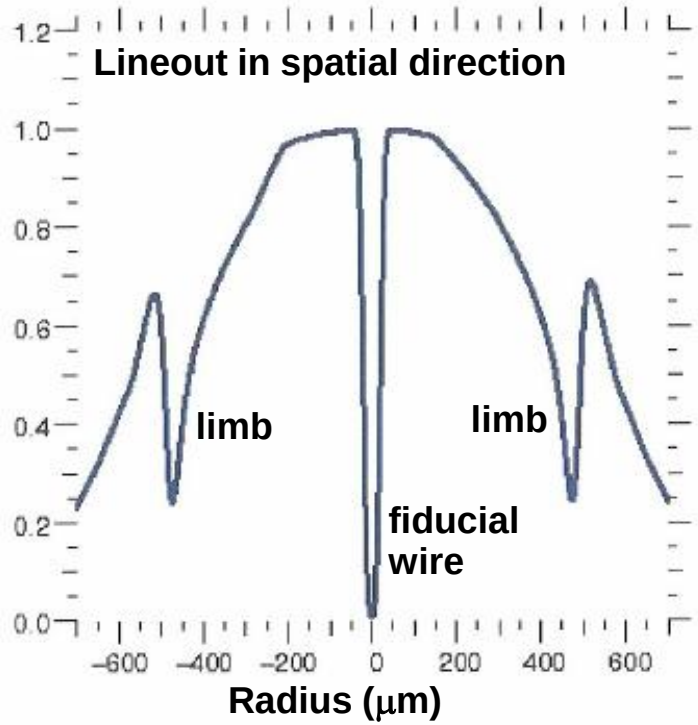
The laser pulse shapes and absorbed laser energies are nearly identical for the Ge and Si doped CH capsule experiments compared in this presentation.

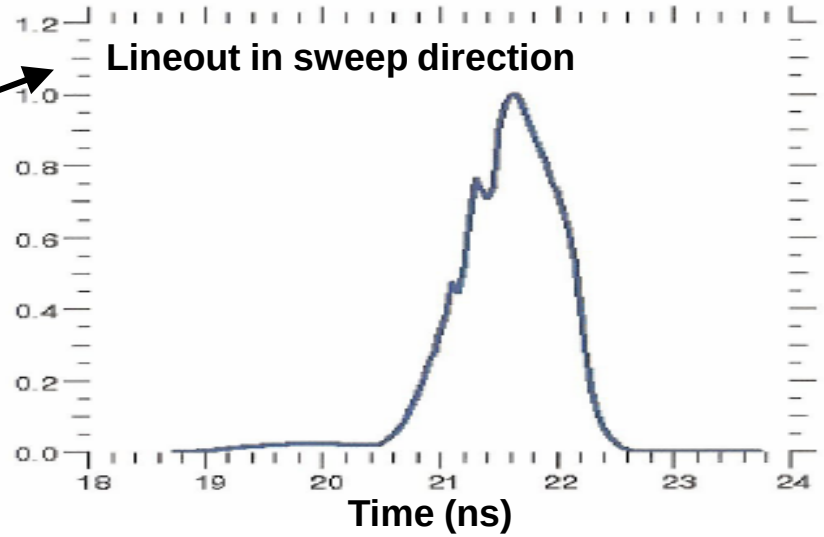


The integrated Hydra hohlraum+capsule calculations are combined with 2D Lasnex backlighter calculations to produce simulated streaked radiographs.

simulated streaked radiograph for a NIF 1.3 MJ convergent ablation experiment

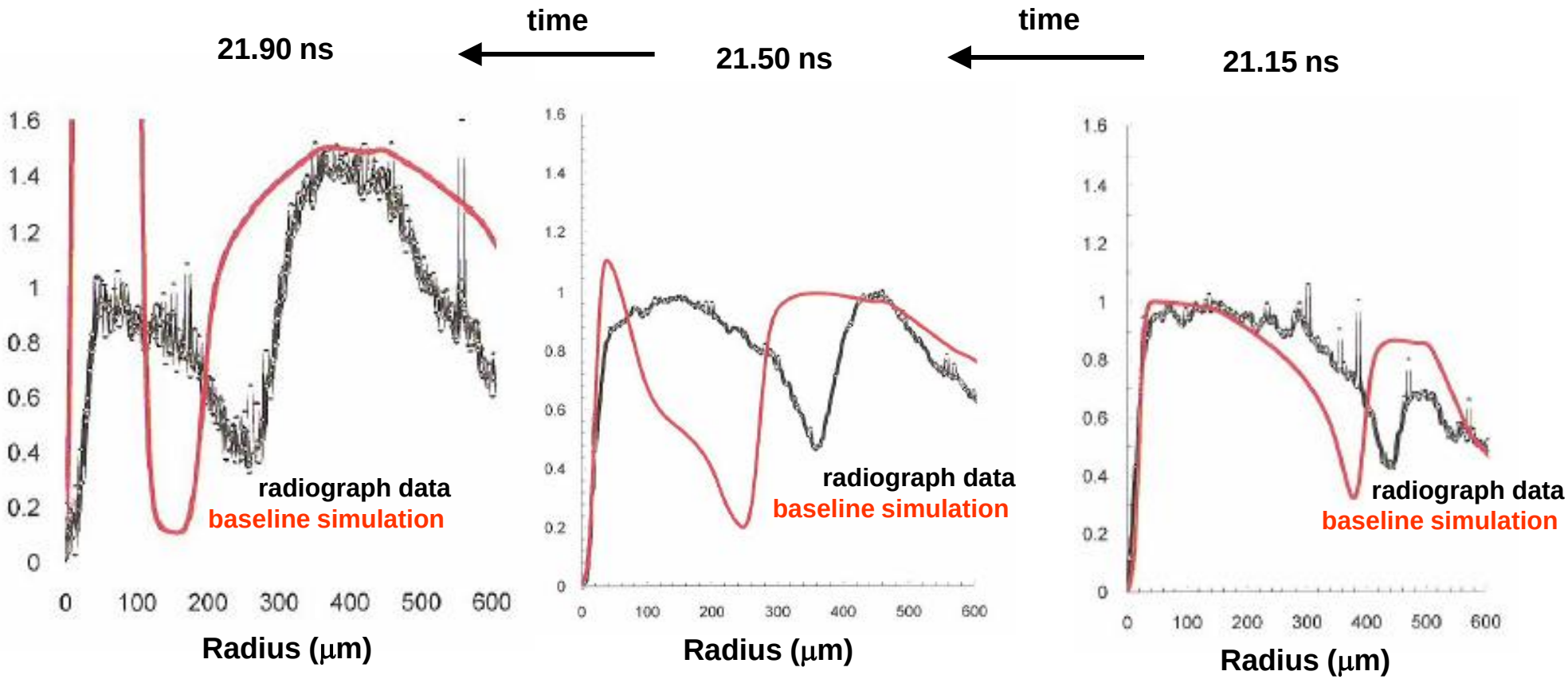




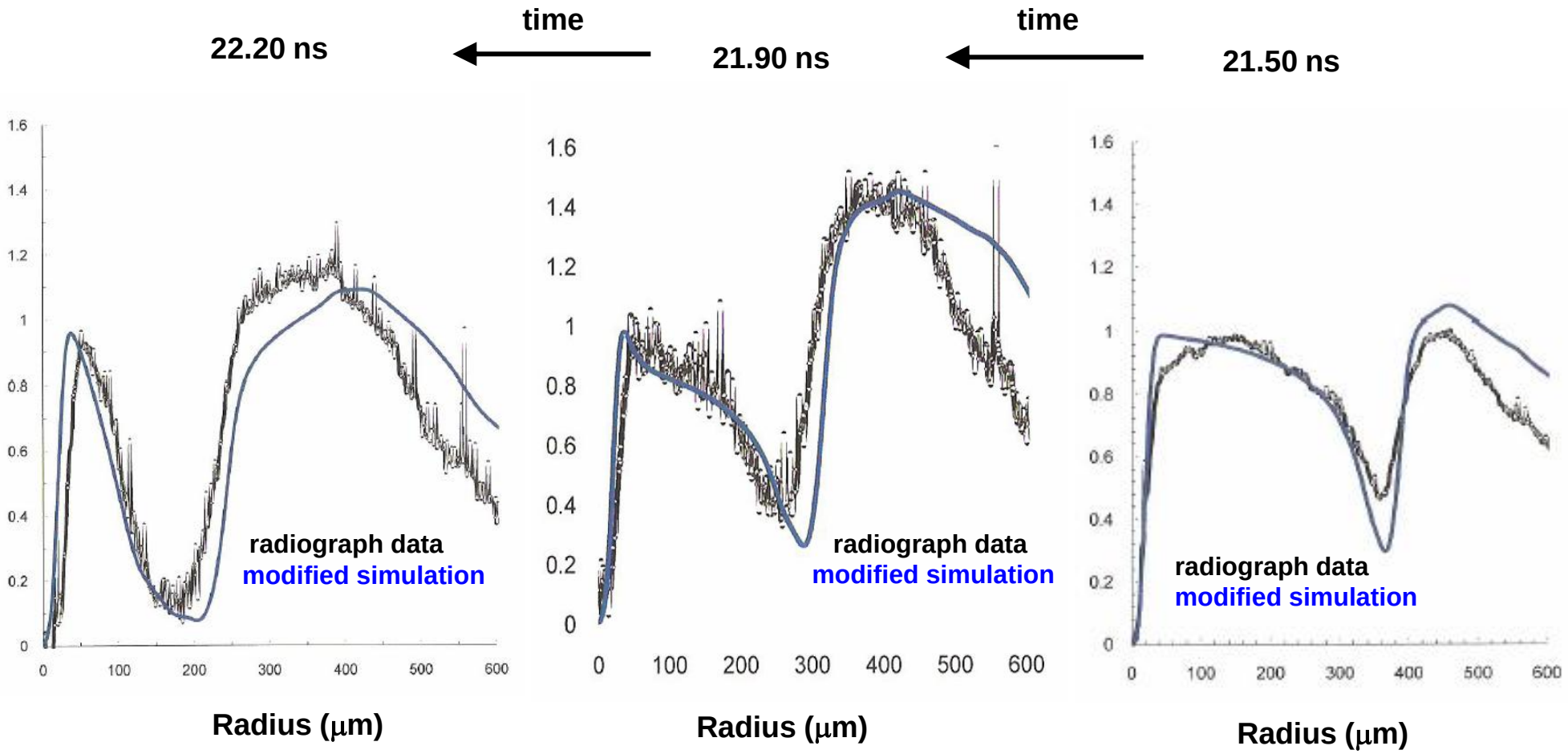


The simulated radiograph from the baseline post shot simulation clearly does not agree with the N110625 (Ge-doped CH capsule) experimental data.

The N110625 baseline post shot simulation implosion converges much too quickly.



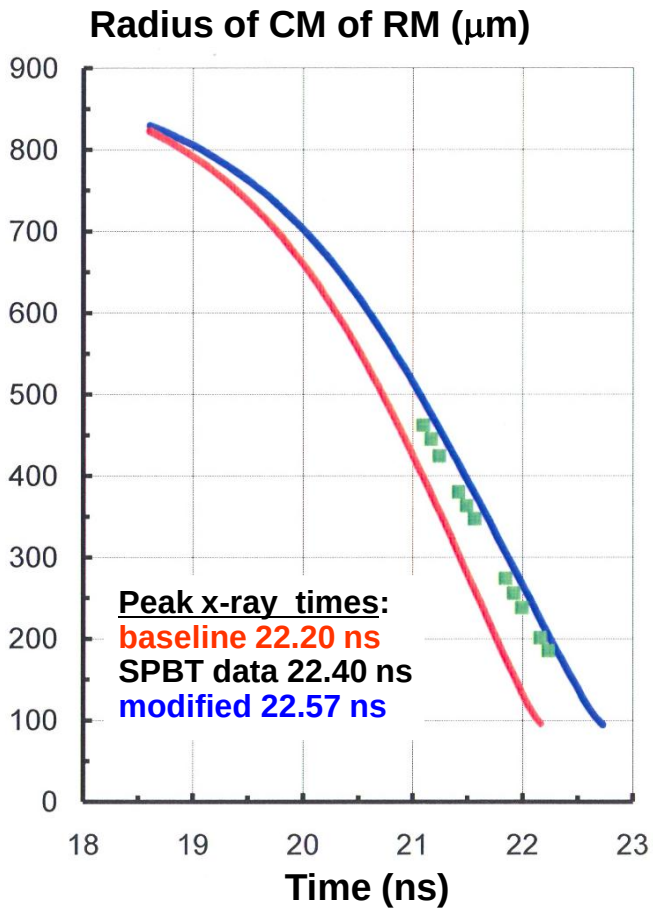
The modified (85% laser peak power) post shot simulation provides a reasonable match to the N110625 (Ge-doped CH capsule) radiographs.

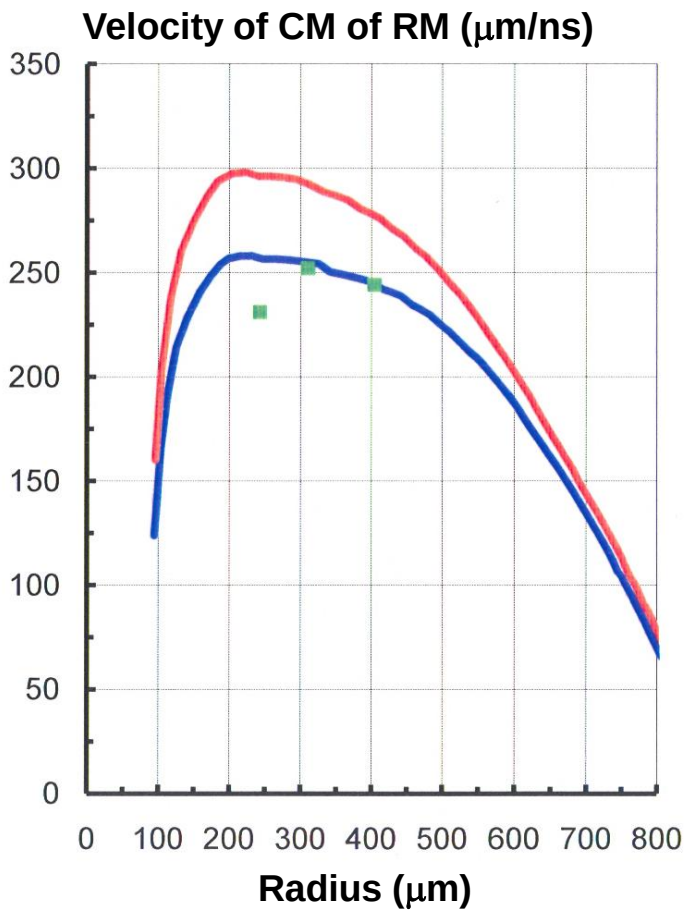


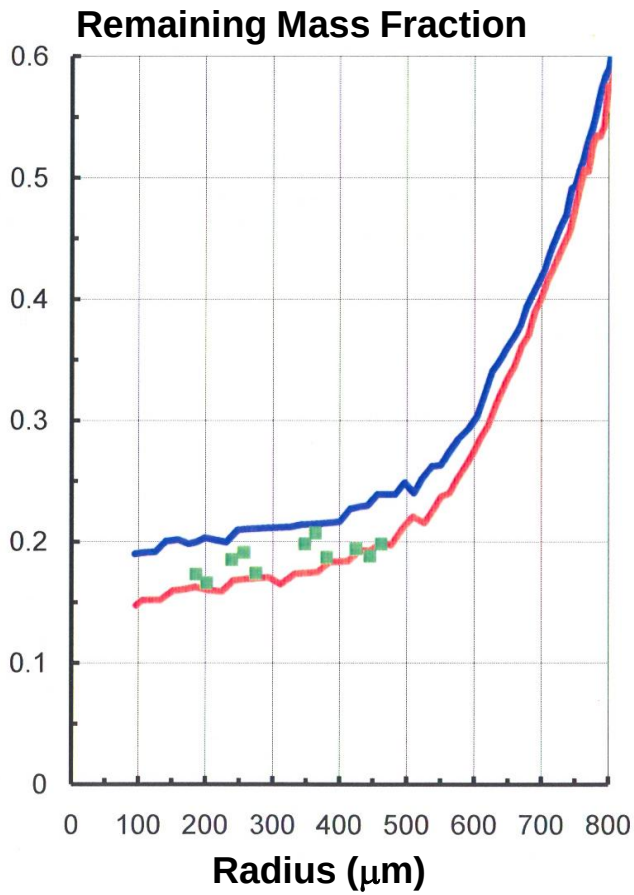
Ge-doped CH capsule

The radius, velocity, and remaining mass can be inferred from comparisons of the simulations with the radiograph data.

Red = baseline post-shot simulation – implodes too quickly compared to radiograph data.
Blue = modified post-shot simulation – approximately matches the radiograph data.
Green = radius, velocity, and remaining mass inferred via *xstreak** analysis of the radiograph data.







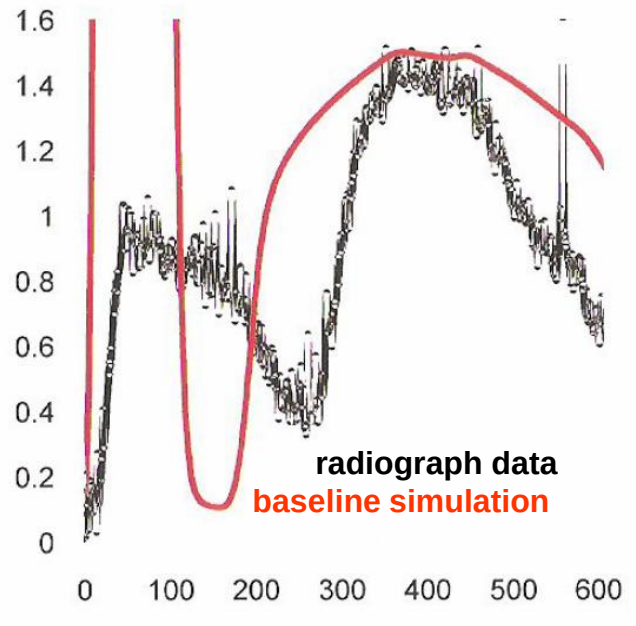
xstreak* IDL analysis code, see D. Hicks *et al.*, Phys. Plasmas 17 102703 (2010).

The simulated radiograph from the baseline post shot simulation does not agree with the N110627 (Si-doped CH capsule) experimental data.

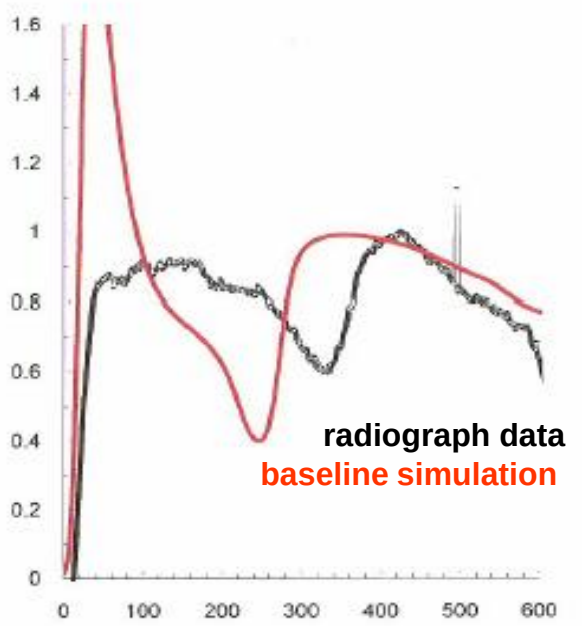
The N110627 baseline post shot simulation implosion converges much too quickly.

time ← time ←

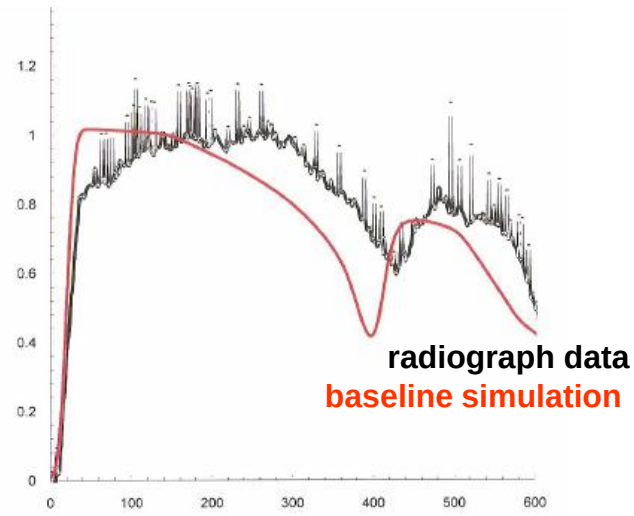
21.90 ns 21.50 ns 21.15 ns



Radius (μm)



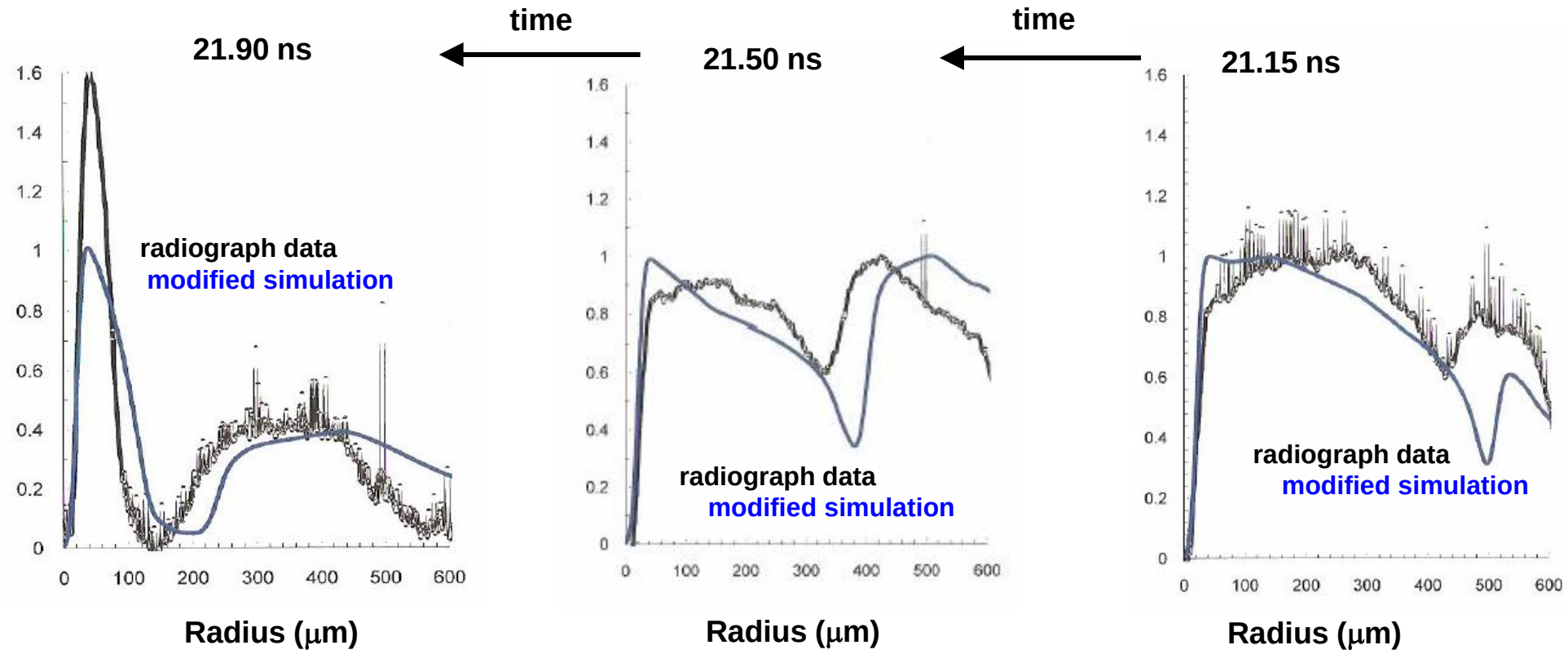
Radius (μm)



Radius (μm)

The modified (85% laser peak power) post shot simulation provides an improved match to the N110627 (Si-doped CH capsule) radiographs.

The modified post shot simulation implosion is closer to the data (compared to the baseline simulation), but converges a bit too slowly .



Si-doped CH capsule

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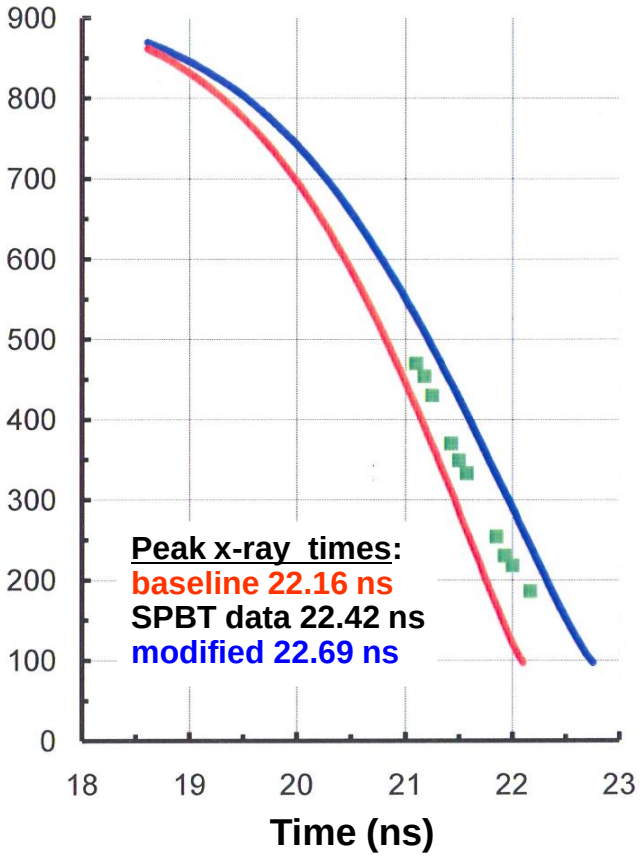
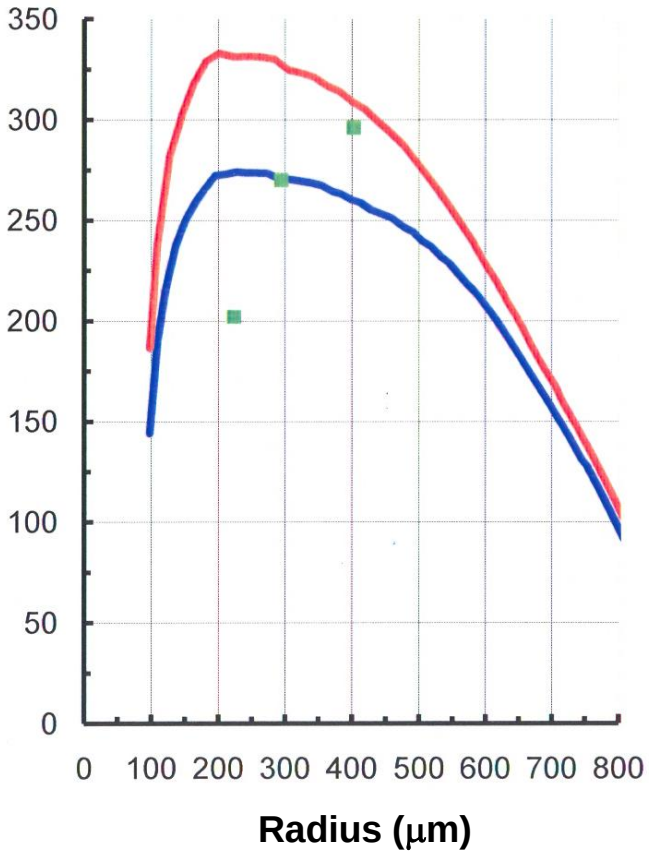
Green = radius, velocity, and remaining mass inferred via *xstreak** analysis of the radiograph data.

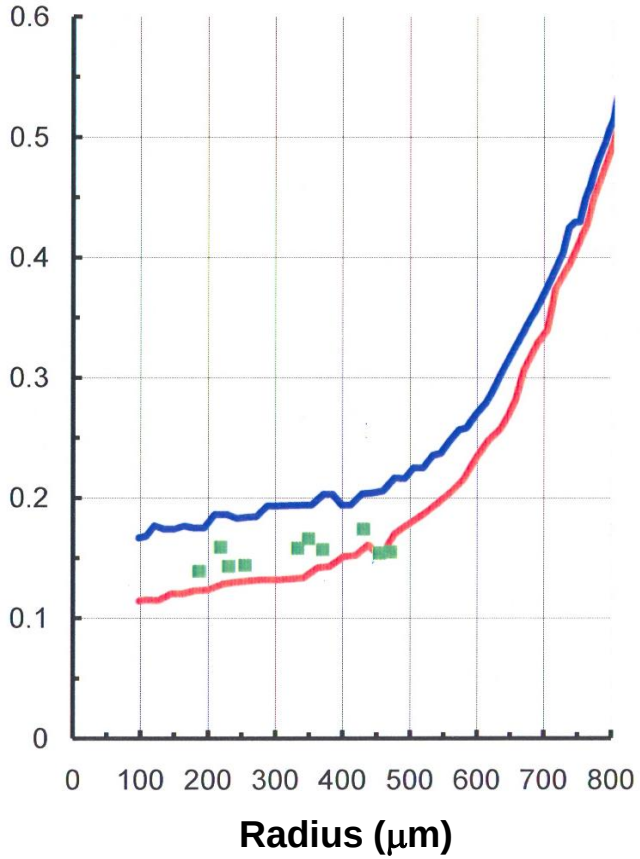
Radius of CM of RM (μm)



Velocity of CM of RM (μm/ns)

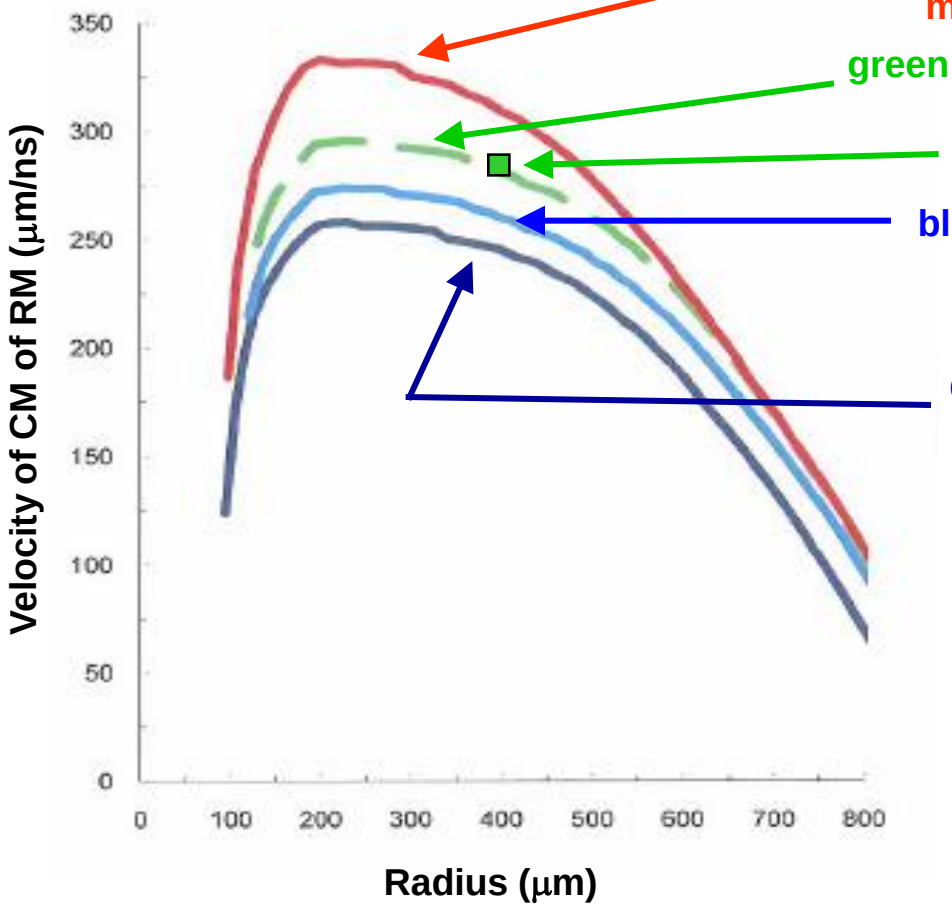


Remaining Mass Fraction



**xstreak* IDL analysis code, see D. Hicks *et al.*, Phys. Plasmas 17 102703 (2010).*

With the same laser pulse shape energy input*, the Si-doped capsule has a higher peak implosion velocity compared to the Ge-doped capsule.



red = CHSi N110627 baseline simulation
much faster than radiography data

green = CHSi likely agreement
with N110627 radiography data
(peak velocity inferred by *xstreak*)

blue = CHSi N110627 modified simulation
a bit slower than radiography data

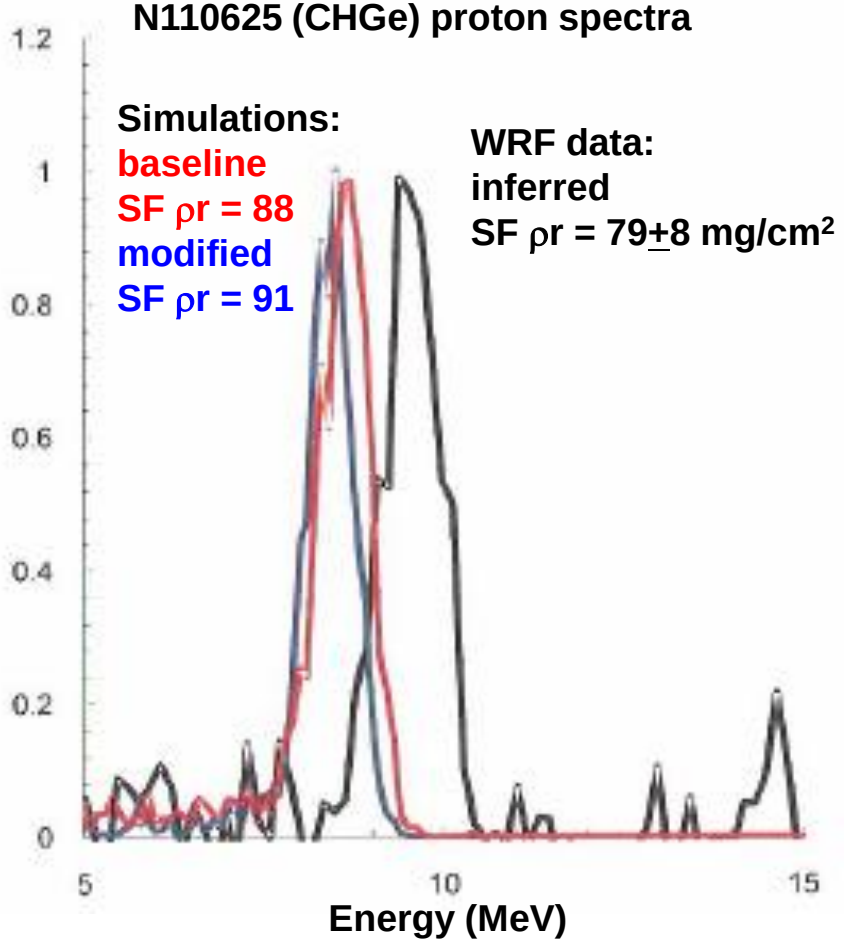
dark blue = CHGe N110625 modified simulation
agrees with radiography data

Conclusion: with the same laser input, the Si-doped CH capsule peak implosion velocity is improved by ~15% compared to the Ge-doped CH capsule.

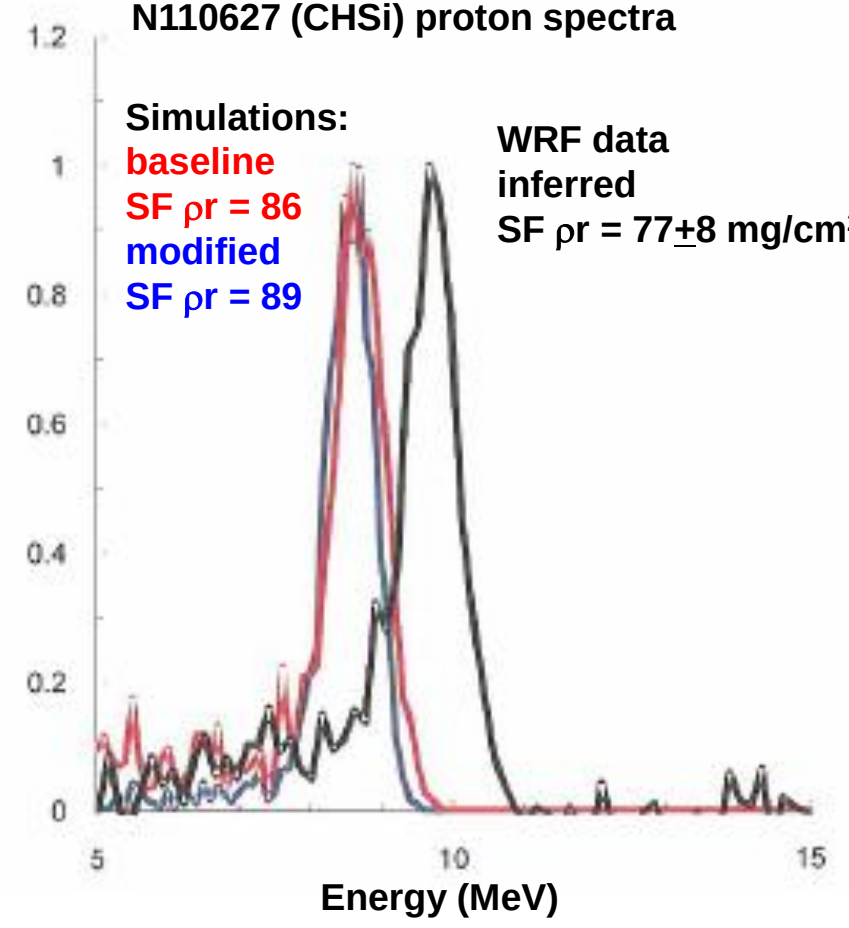
*Modified simulation absorbed laser energies within 0.2%

The simulated proton spectra have peaks that are ~ 1 MeV lower than the proton peaks observed in the WRF* data

N110625 (CHGe) proton spectra



N110627 (CHSi) proton spectra

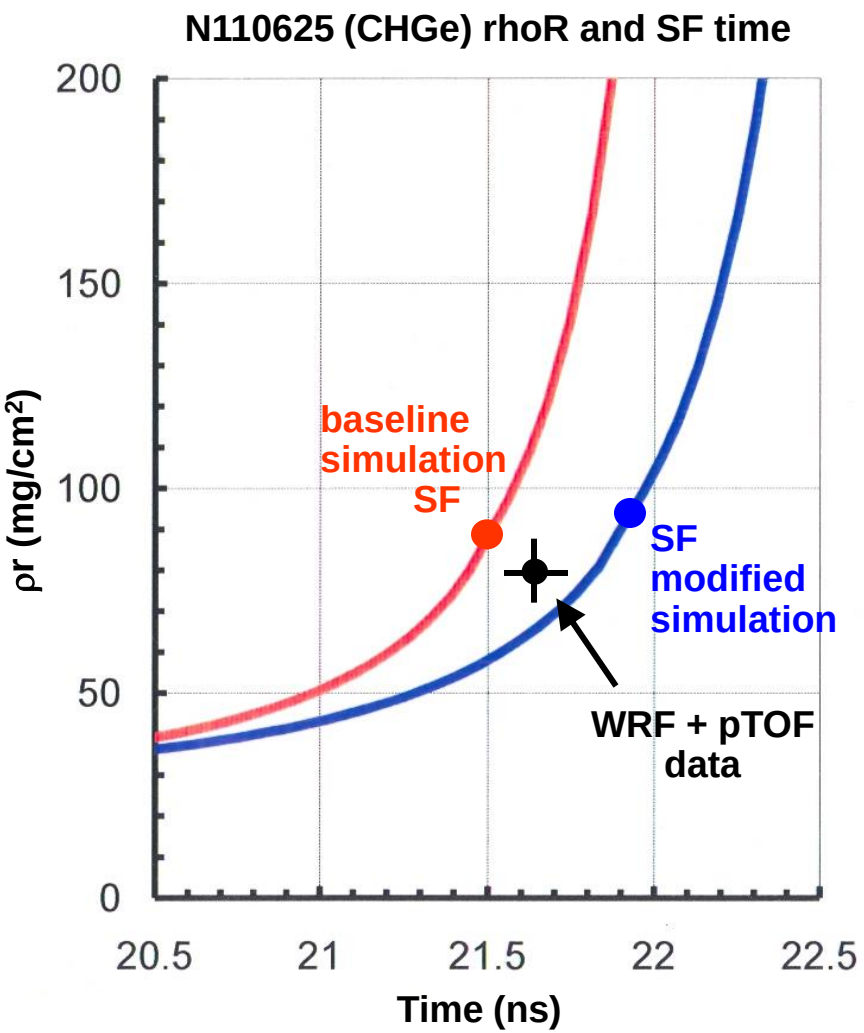


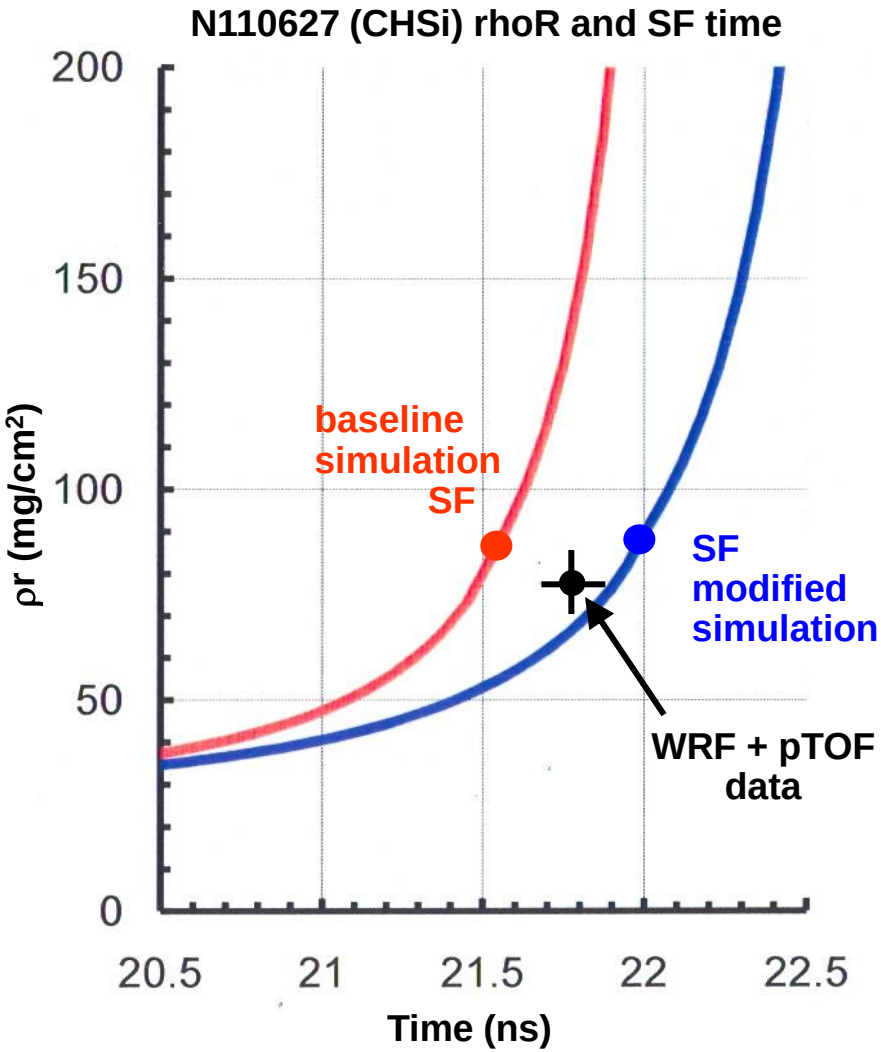
The simulations appear to over-predict the shock flash total rhoR by ~ 10%.
This conclusion is the same for both non-degraded and degraded simulations.

Note that the red plot is shifted to a bit higher energy than the blue plot.
This is consistent with a reduced mass remaining at shock flash time.

***R. Petrasso et al, paper # P.Tu_85**

The pTOF* measurement of shock flash time is combined with the WRF* measurement of shock flash rhoR and compared with simulations.





*R. Petrasso et al, paper # P.Tu_85

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