Shock-Augmented Ignition Using Indirect Drive

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Shock-Augmented Ignition

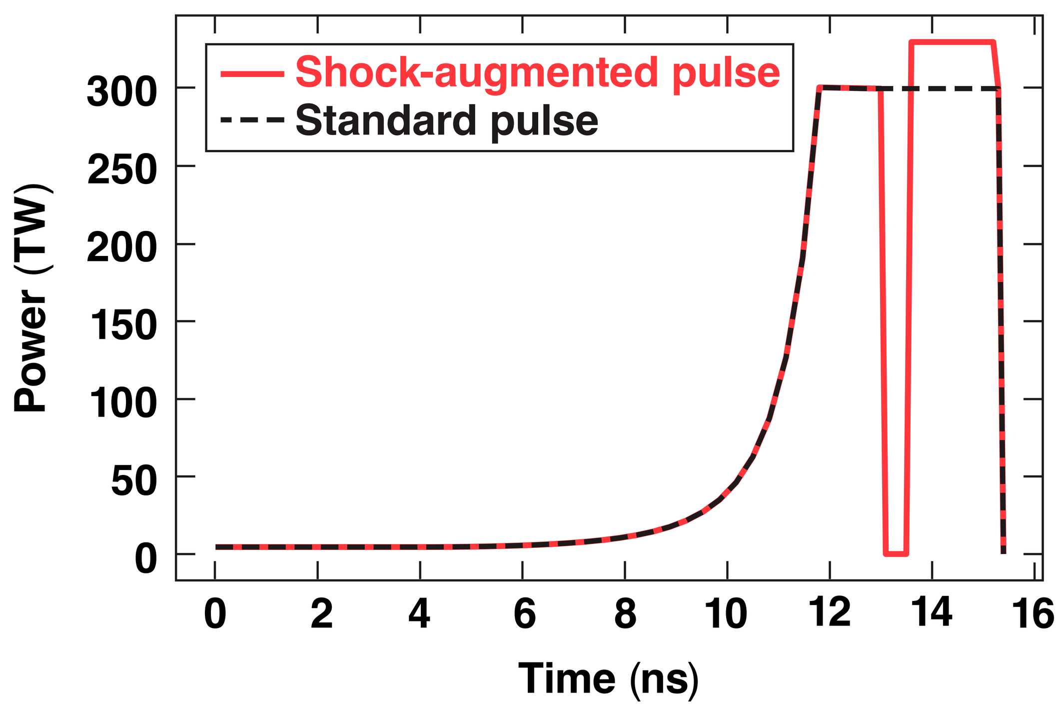

Figure 1. Comparison between a shock augmenting pulse and a standard central hot spot (CHS) ignition pulse

TC15919

- Proposed by R. Scott *et al.* [1]
- Drop in drive power reduces coronal pressure
- Allows for the launch of a late-stage strong shock with moderate power
- Lower peak intensities can mitigate laser–plasma instabilities

Shock Collision

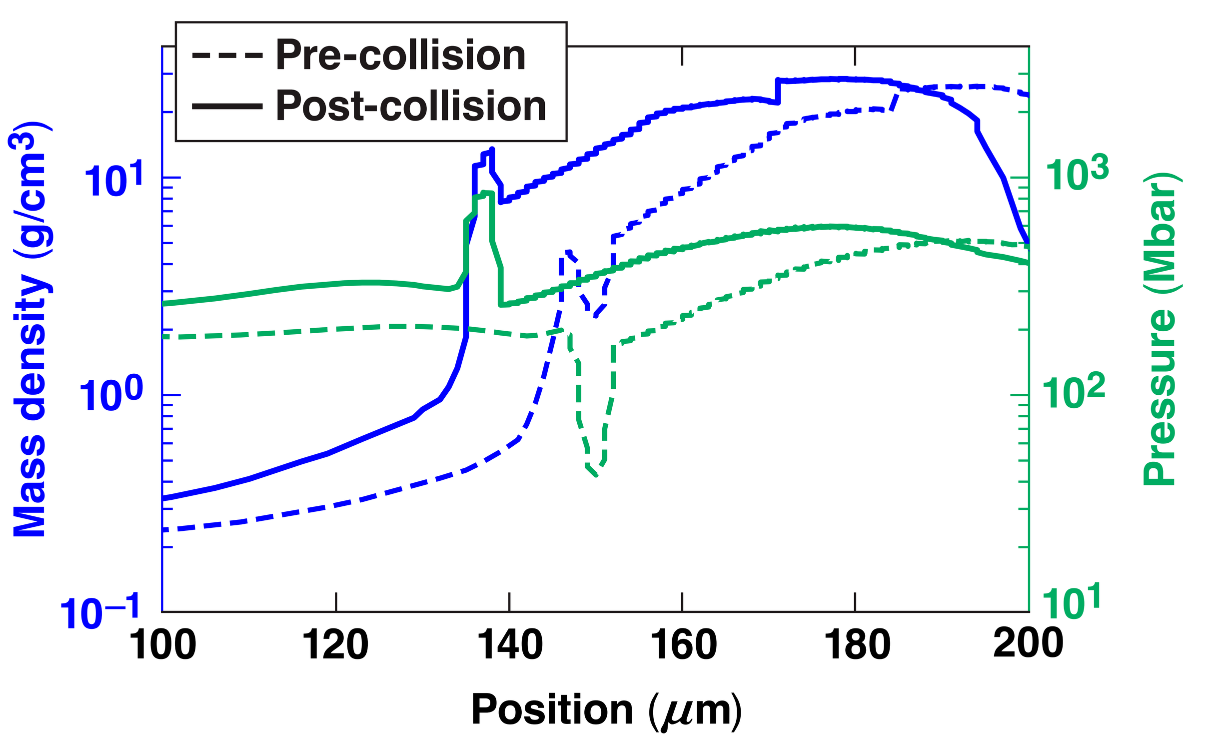

Figure 2. Plot of the pressure and density profiles in the shell before and after the shock collision

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- Augmenting shock collides with rebound shock near inner surface of shell
- Raises shell density and hot spot pressure, triggering ignition

Laser to X-Ray Hohlraum Model

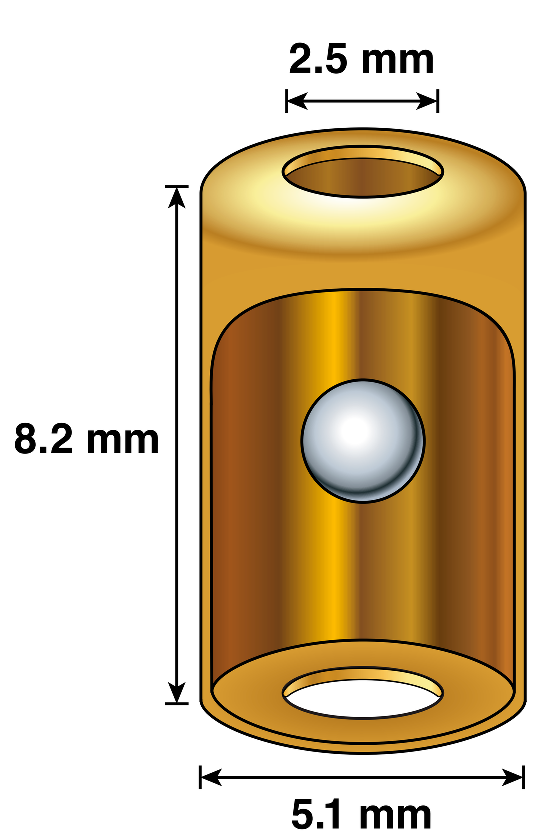

Figure 3. Schematic of hohlraum dimensions

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- Laser to x-ray conversion was handled with a time-dependent physics model [2]

$$S_r = 14.1 \times S_a^{0.748} \times E_a^{0.511}$$

S_r: flux reflected from wall
S_a: laser flux absorbed in wall
P_{las}: laser power
A: absorbing surface area

Funding Information

We gratefully acknowledge funding from the EPSRC through Grant EP/P026796/1 and EUROfusion project CFP-FSD-AWP21-ENR-01-CEA-02.

EUROfusion

Engineering and Physical Sciences Research Council

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Ignition Comparison

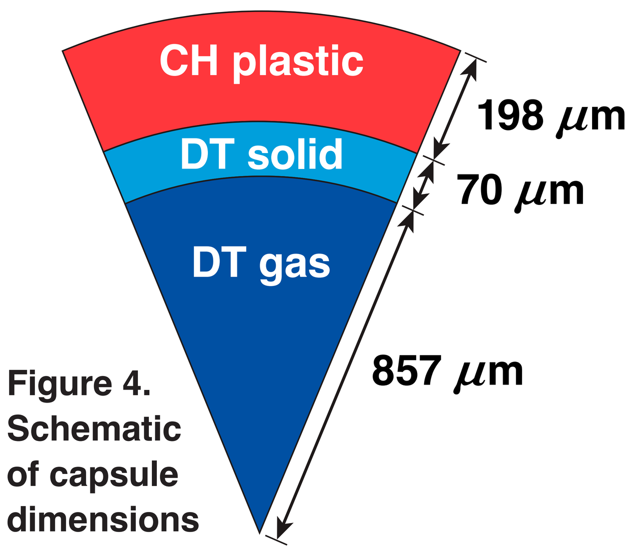

Figure 4. Schematic of capsule dimensions

- Hohlraum model converts laser pulse to x-rays
- One-dimensional implosion simulated using 1-D radiation-hydrodynamics code *HYADES*
- Shock-augmented pulse created from modified NIF-like pulse

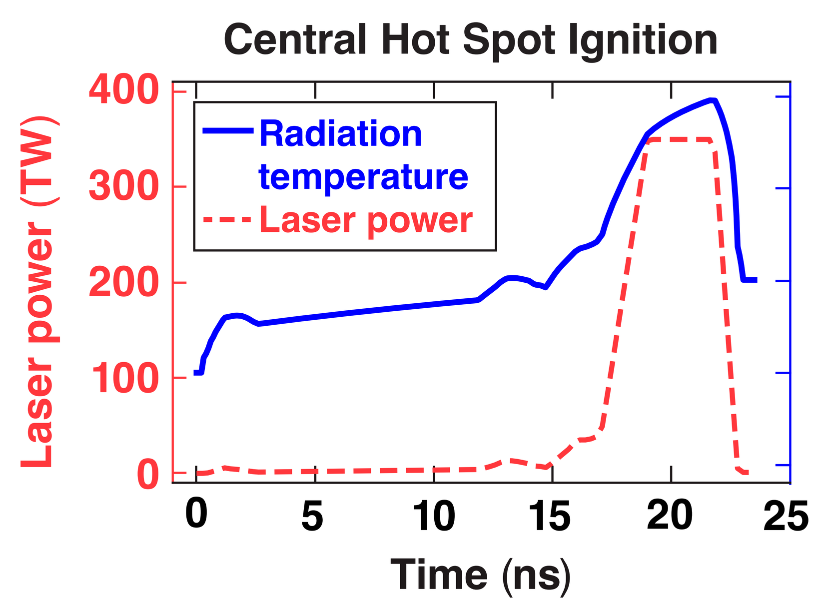

Figure 5. CHS laser pulse and x-ray drive

E_{laser} = 1.66 MJ
E_{yield} = 9.61 MJ
v_{imp} = 372 km/s

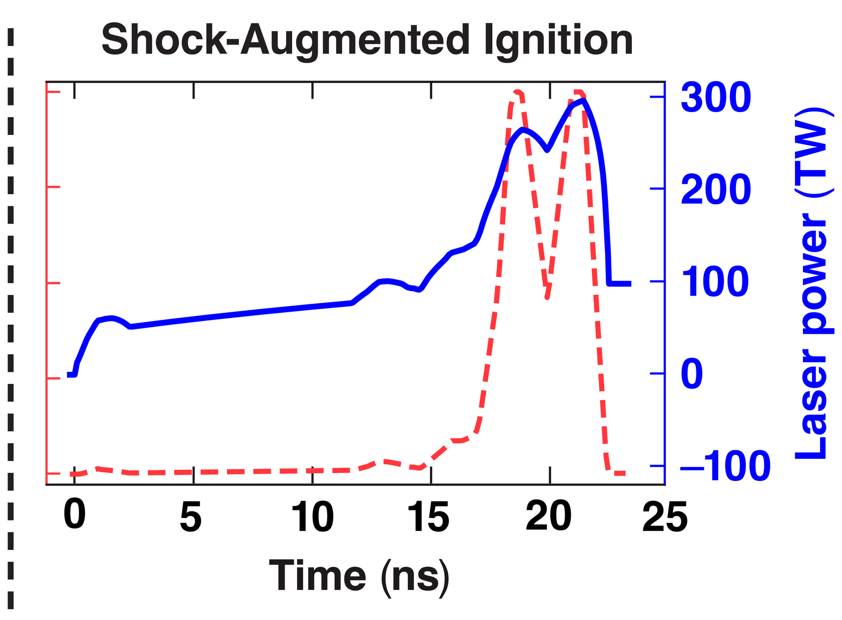

Figure 6. SAI laser pulse and x-ray drive

E_{laser} = 1.57 MJ
E_{yield} = 14.31 MJ
v_{imp} = 342 km/s

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Bayesian Optimization

- Bayesian optimization [3] is used to find the best pulse shape
- Choice of optimization parameter helps focus on low-velocity implosions
- Six parameters optimized over 1800 simulations

E_{laser} = 1.46 MJ
E_{yield} = 17.20 MJ
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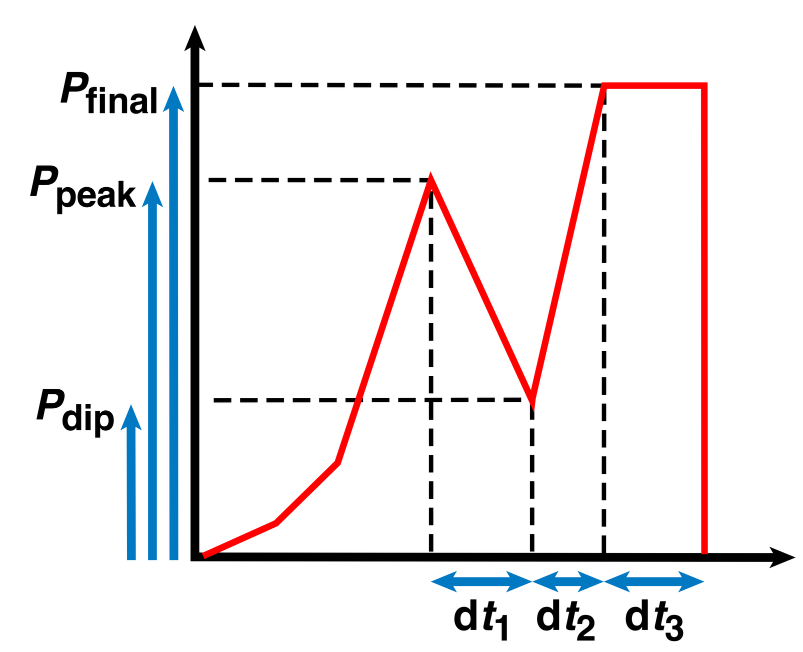

Figure 6. Plot showing the six pulse parameters that were used in the Bayesian optimization algorithm

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Conclusions

- A strong, late-stage shock can be launched in an implosion when coronal pressure is reduced via a drop in driver power
- Only a moderate rise (≈50 eV in 1 ns) in x-ray drive is required to launch the shock
- One-dimensional radiation-hydrodynamics simulations have shown that a shock-augmented pulse can increase yield compared to a CHS pulse while lowering implosion velocity

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References

[1] R. Scott *et al.*, Bull. Am. Phys. Soc. 65, GO09.00010 (2020).
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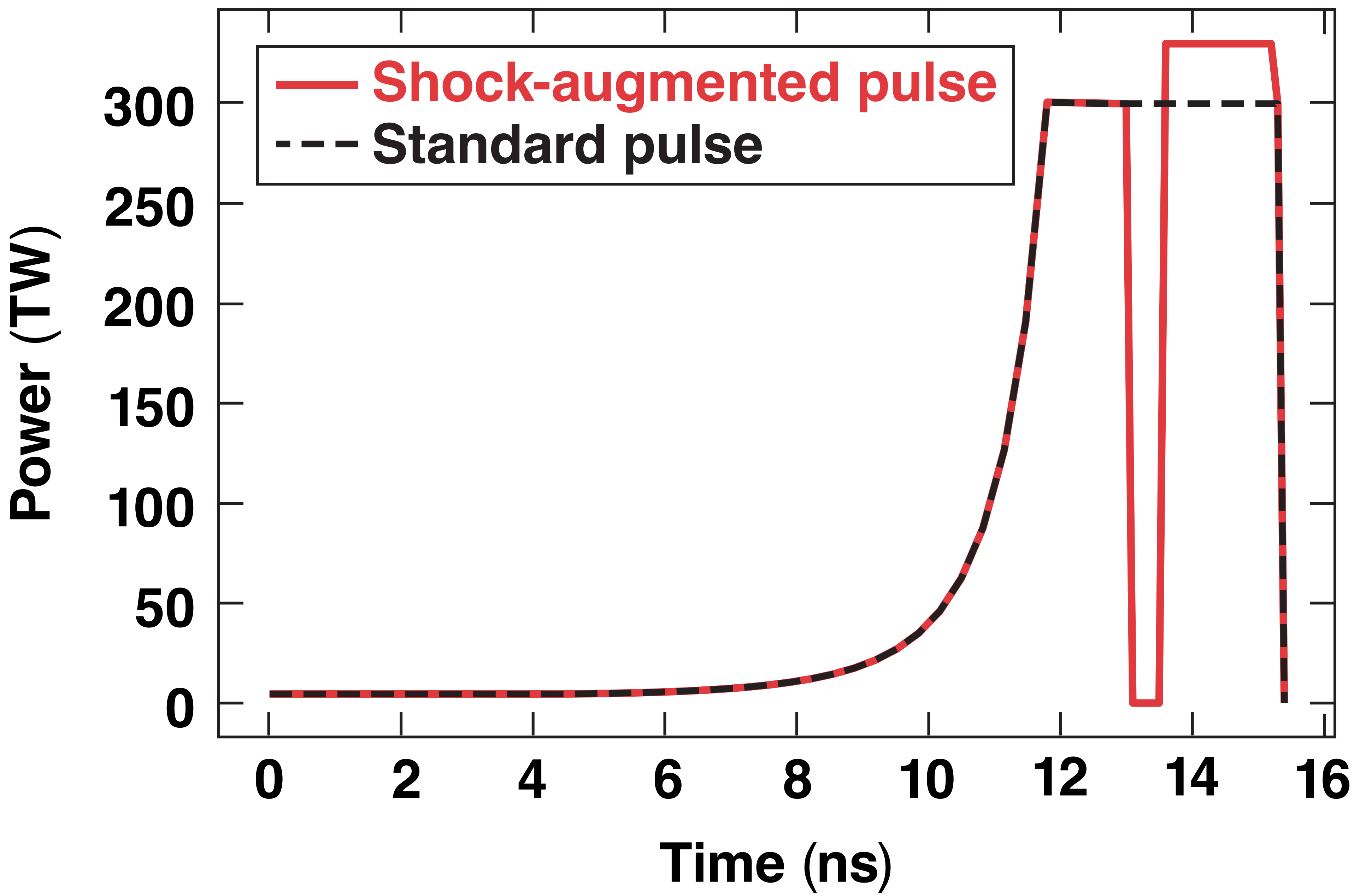

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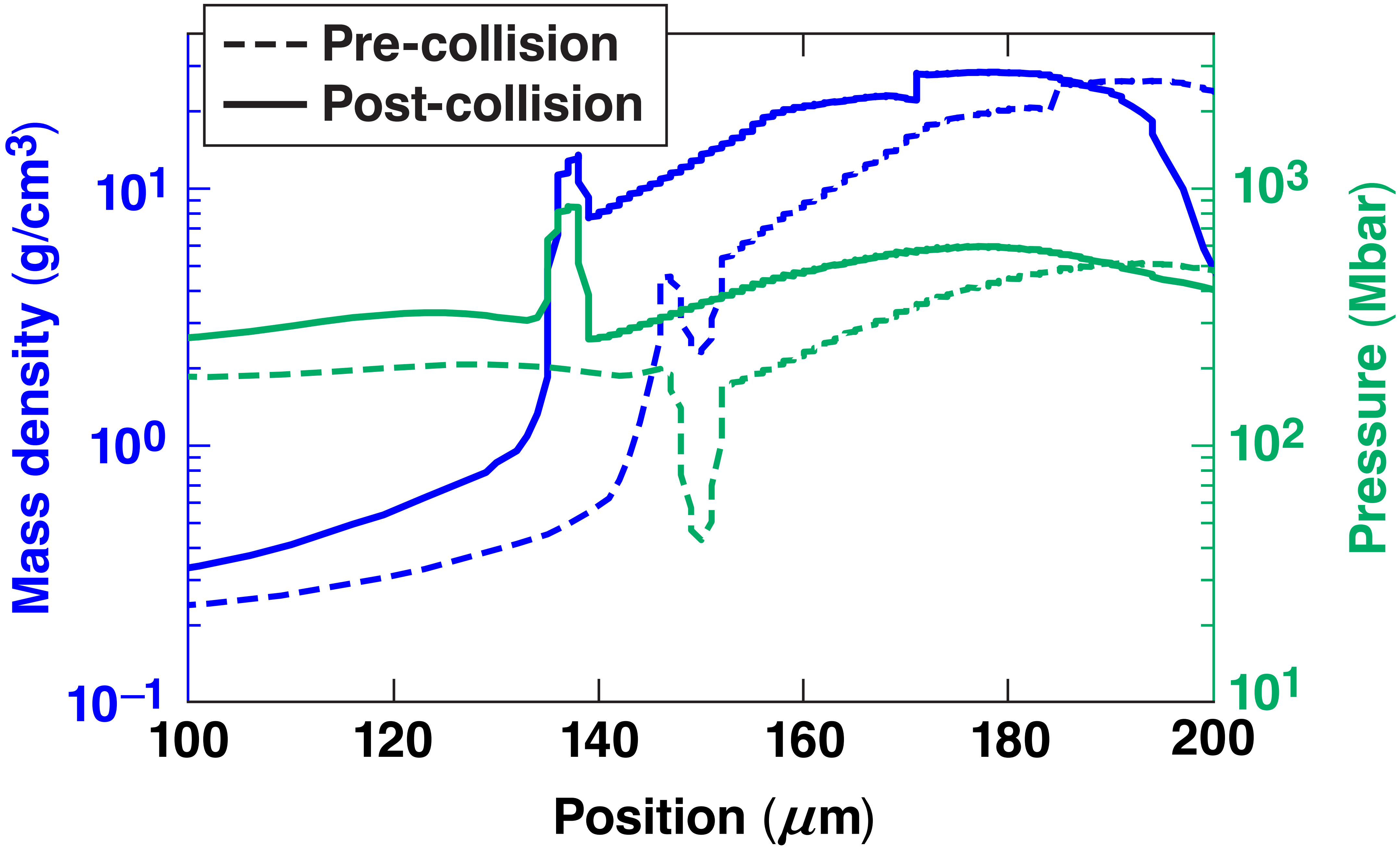

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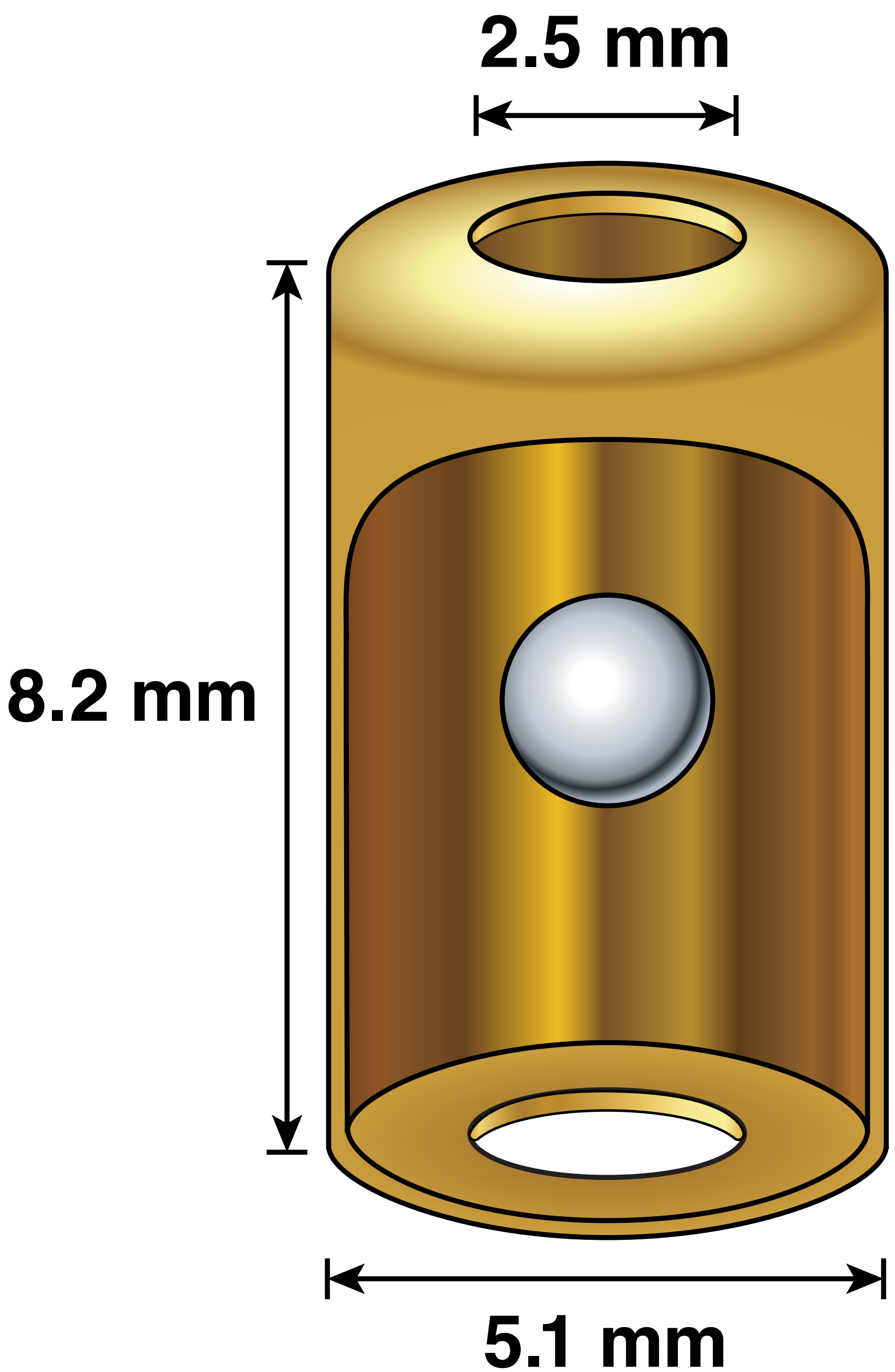

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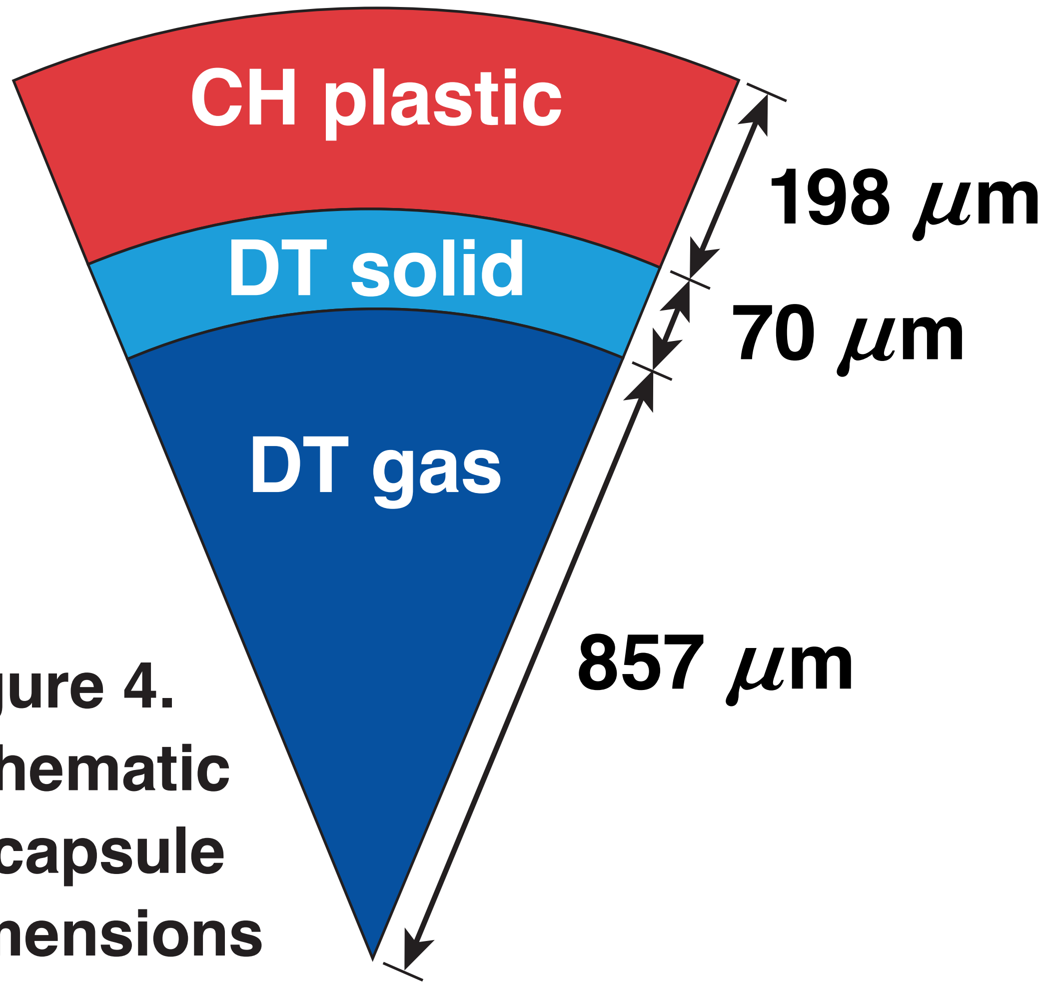

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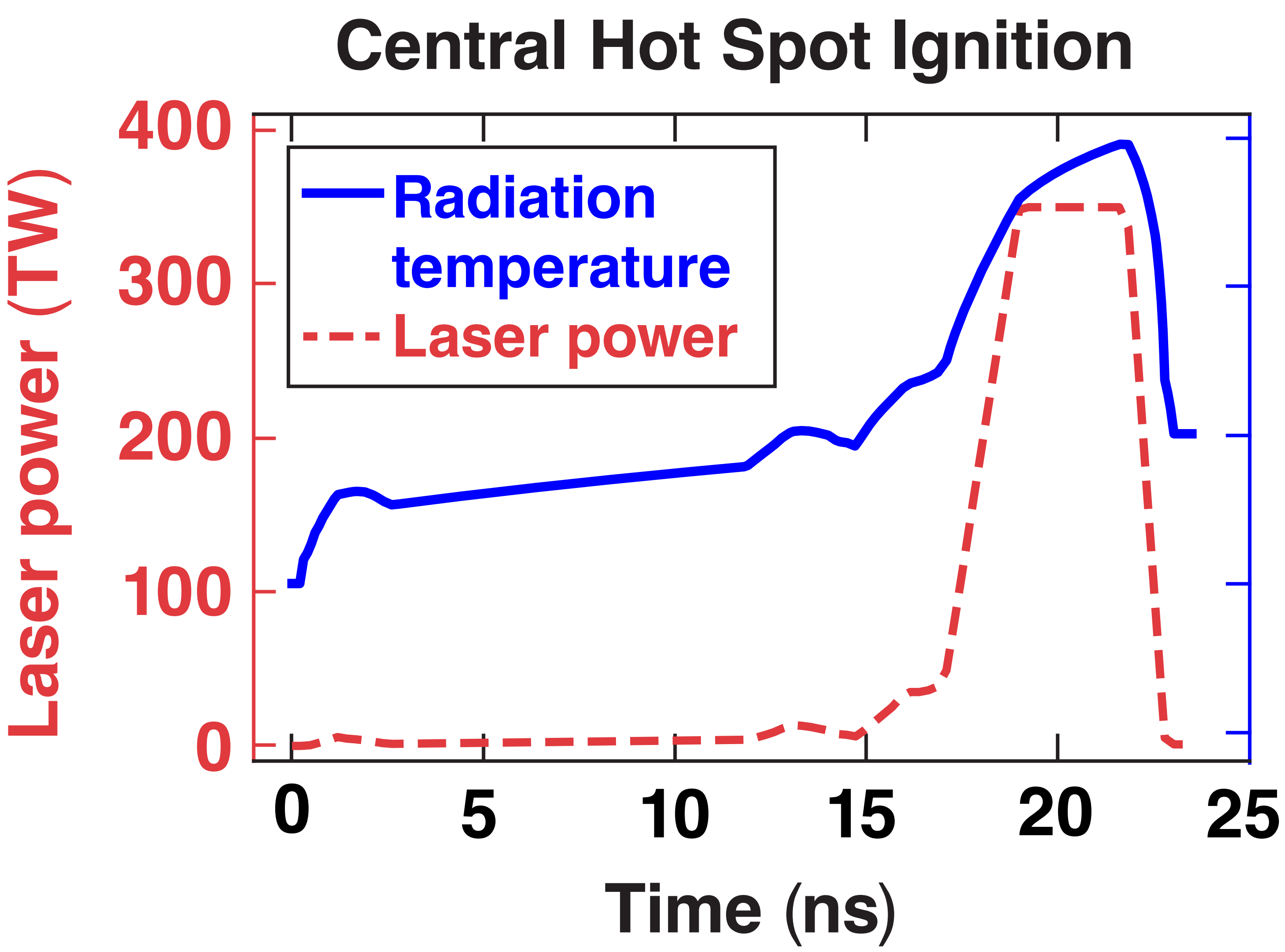

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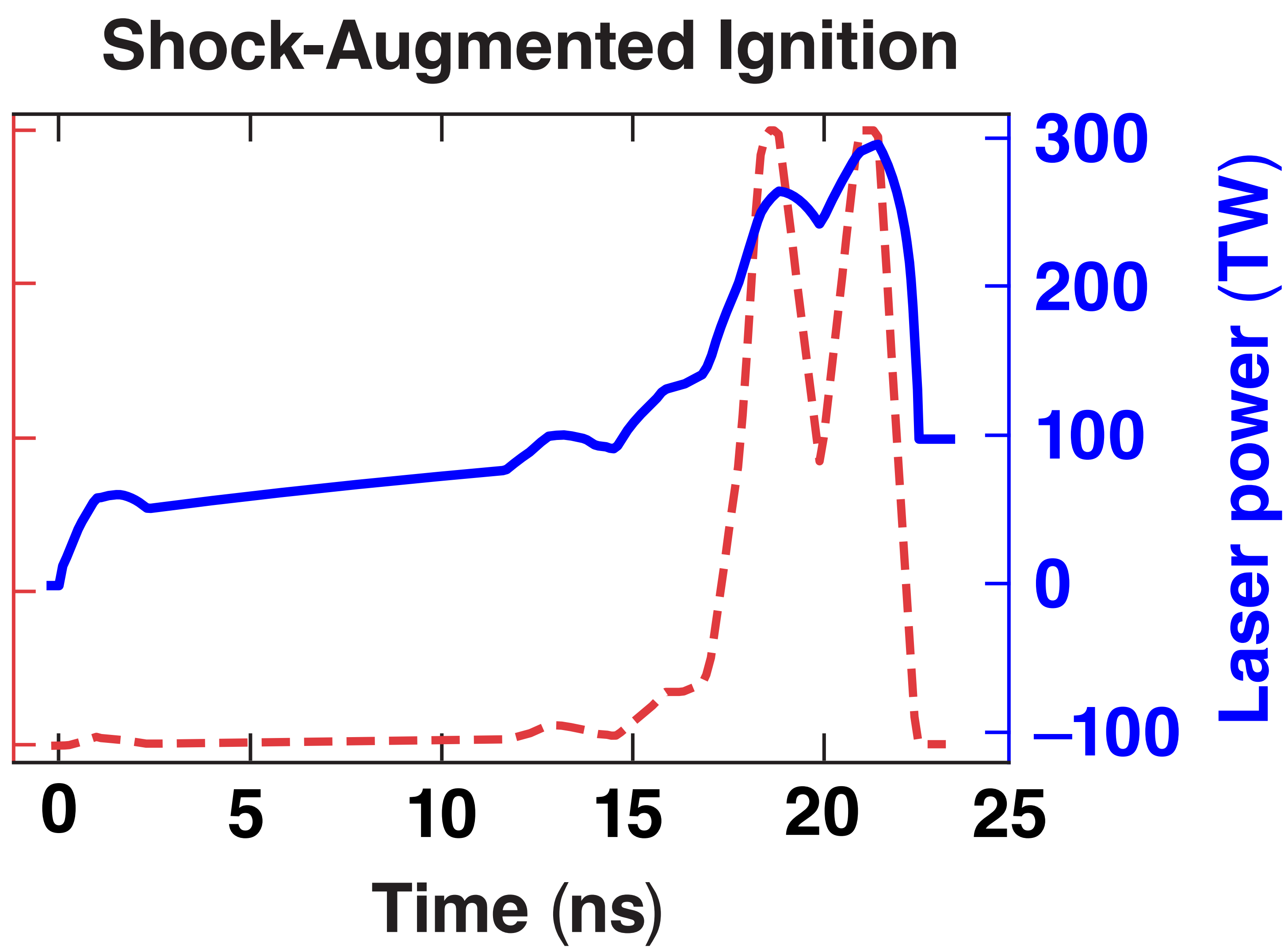

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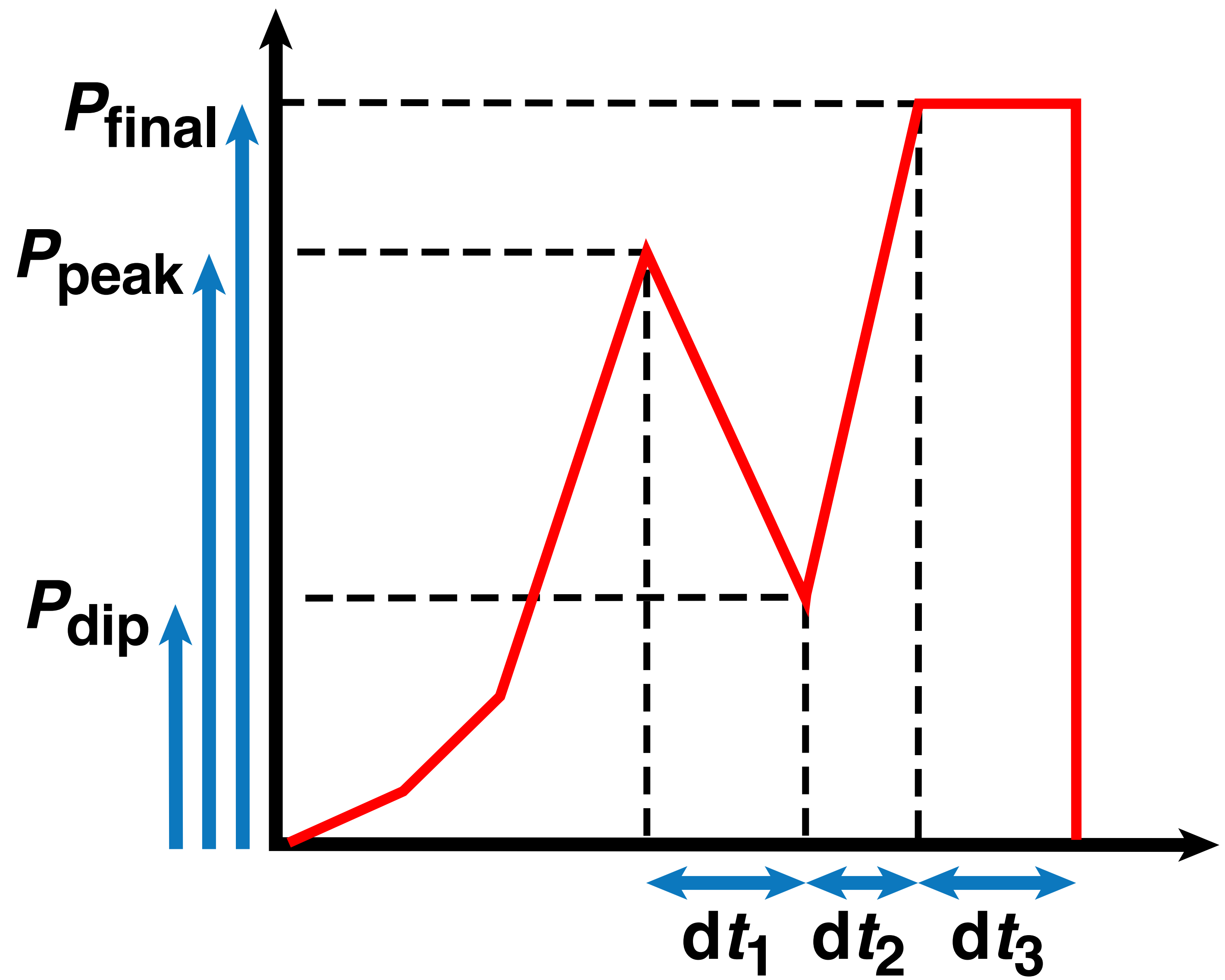

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