Top-level physics requirements and simulated performance of MRSt

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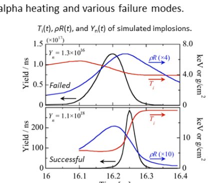
Overview

- The MRSt will measure time-resolved neutron spectra.
- This will be used to probe the impact of alpha heating and various failure modes.
- Hydro-simulations were used to define the top-level physics requirements.
- Monte-Carlo simulations were used to determine whether the system can meet those requirements.

$T_i(t)$, $\rho R(t)$, and $Y_n(t)$ of simulated implosions.



[4] J. Frenje, et al. *RSI*, 2016
[5] C. Parker, et al. *RSI*, 2018
[6] J. Kunimune, et al. RSI (accepted), 2021

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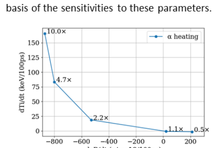
Numerous simulations were used to determine the top-level physics requirements

- Numerous simulations were performed to study the impact of mix, P2 asymmetry, and alpha heating on $T_i(t)$, $\rho R(t)$, and $Y_n(t)$.
- We determined the requirements in this table on the basis of the sensitivities to these parameters.



Parameter	Required accuracy
dT_i/dt at BT	± 1.9 keV/(100 ps)
$d\rho R/dt$ at BT	± 60 mg/cm²/(100 ps)
Burn width	± 7 ps
Burn skewness	± 0.3
Burn kurtosis	± 3
Absolute BT	± 10 ps

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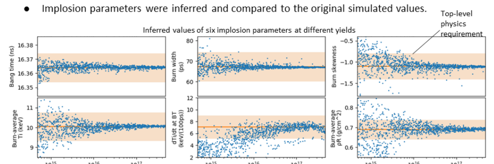
Monte-Carlo simulations were used to predict and evaluate the MRSt performance

- Synthetic MRSt data were created with Monte Carlo simulations at different yield levels.
- These were analyzed as actual MRSt data.
- Implosion parameters were inferred and compared to the original simulated values.

Inferred values of six implosion parameters at different yields



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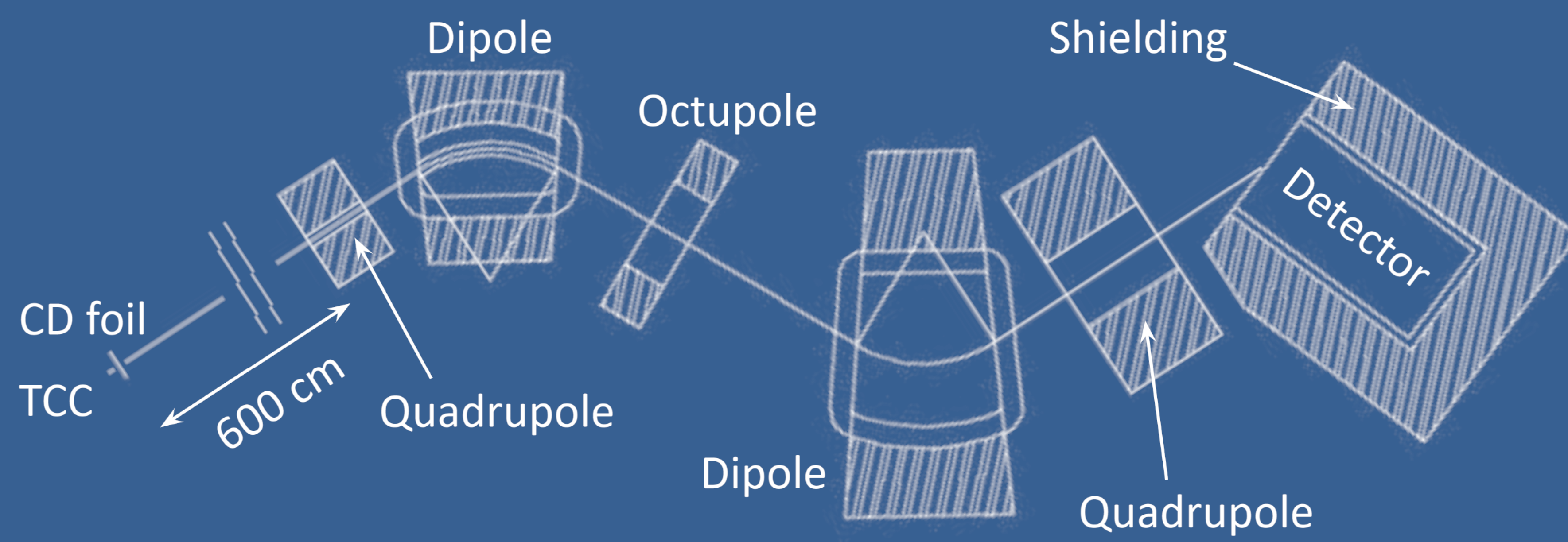

- MRSt is a spectrometer for time resolved measurements of the neutron spectrum.[1,2,3]
- Top-level physics requirements for the MRSt were determined based on numerous simulations.
- It is predicted that the MRSt will adequately probe alpha heating and various failure modes at current NIF yields.

[1] D. Casey, et al. *RSI*, 2013
[2] T. Hilsabeck, et al. *RSI*, 2016
[3] C. Parker, et al. *RSI*, 2019

Conclusions

Burn parameters and their predicted accuracies

Quantity (units)	Req.	High-eff.	Med.-eff.	Low-eff.
Reference Y_n		1×10^{16}	1×10^{16}	5×10^{16}
dT_i/dt at BT (keV/100ps)	1.9	1.4	1.4	1.4
$d\rho R/dt$ at BT (g/cm²/100ps)	60	170	200	310
Bang time (ps)	10	3.8	1.9	2.7
Burn width (ps)	7	1.5	1.6	2.4
Burn skewness	0.3	0.26	0.18	0.23
Burn kurtosis	3	0.9	1.0	1.6

- Three configurations with different resolutions and efficiencies were identified.
- According to these simulations, the MRSt will meet most of the requirements at current NIF yields.
- At these yield levels, the MRSt will provide valuable information on mix, P2 asymmetry, and alpha heating.

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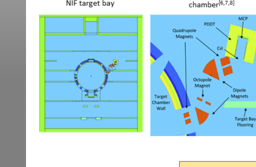
MRSt will be configured in three modes on the NIF target chamber depending on anticipated yield

NIF target bay

MRSt on the NIF target chamber[6,7,8]



	High-eff	Med.-eff	Low-eff
CD foil thickness (μm)	100	50	25
CD foil radius (μm)	400	300	100
Aperture width (mm)	5	4	2
Time res. (ns)	100	75	40
Energy res. (keV)	780	390	190
Efficiency	4.9×10^{-12}	1.1×10^{-12}	3.1×10^{-14}

A CH foil can also be used for 2× improved time resolution

[6] A. Sandberg. Master's thesis, MIT, 2019
[7] C. Wink. Master's thesis, MIT, 2017
[8] C. Wink, et al. *RSI*, 2016

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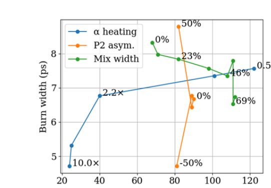
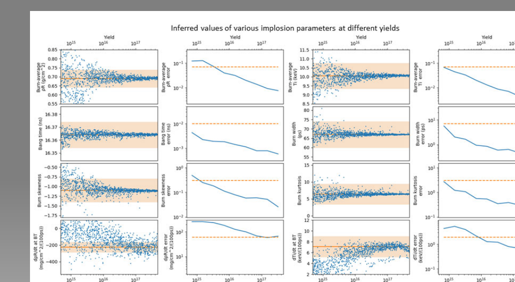
Alpha heating, P2 asymmetry, and mix can all be probed with the MRSt



The burn moment trajectories are determined a combination of alpha heating and both failure modes.

Inferred values of various implosion parameters at different yields



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