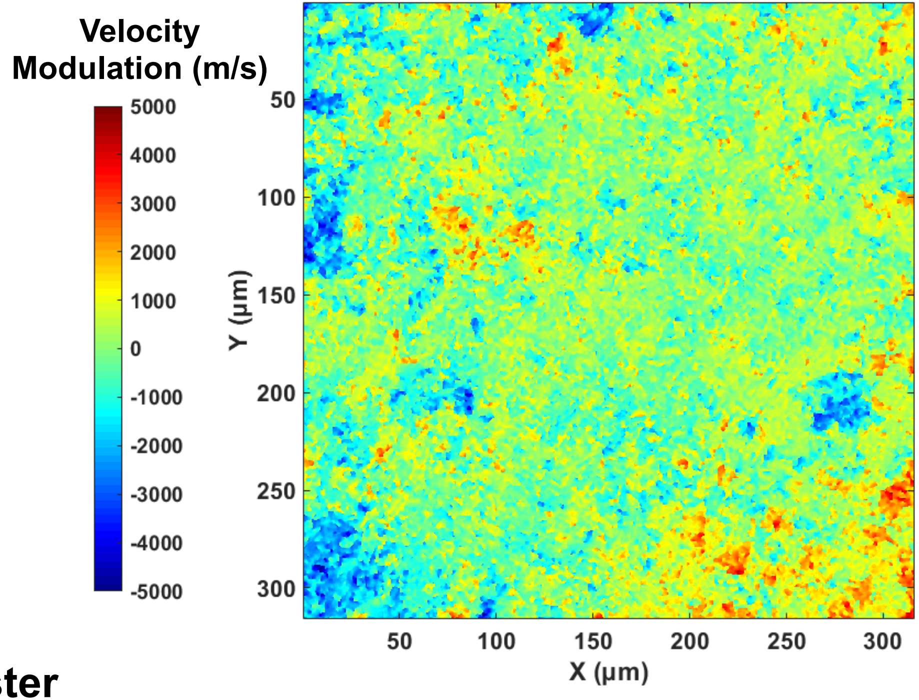
Measurements of Laser-Imprint-Induced Shock-Velocity Nonuniformities and Laser Imprint Mitigation



Imprinted shock front modulations from a single OMEGA beam

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APS-DPP

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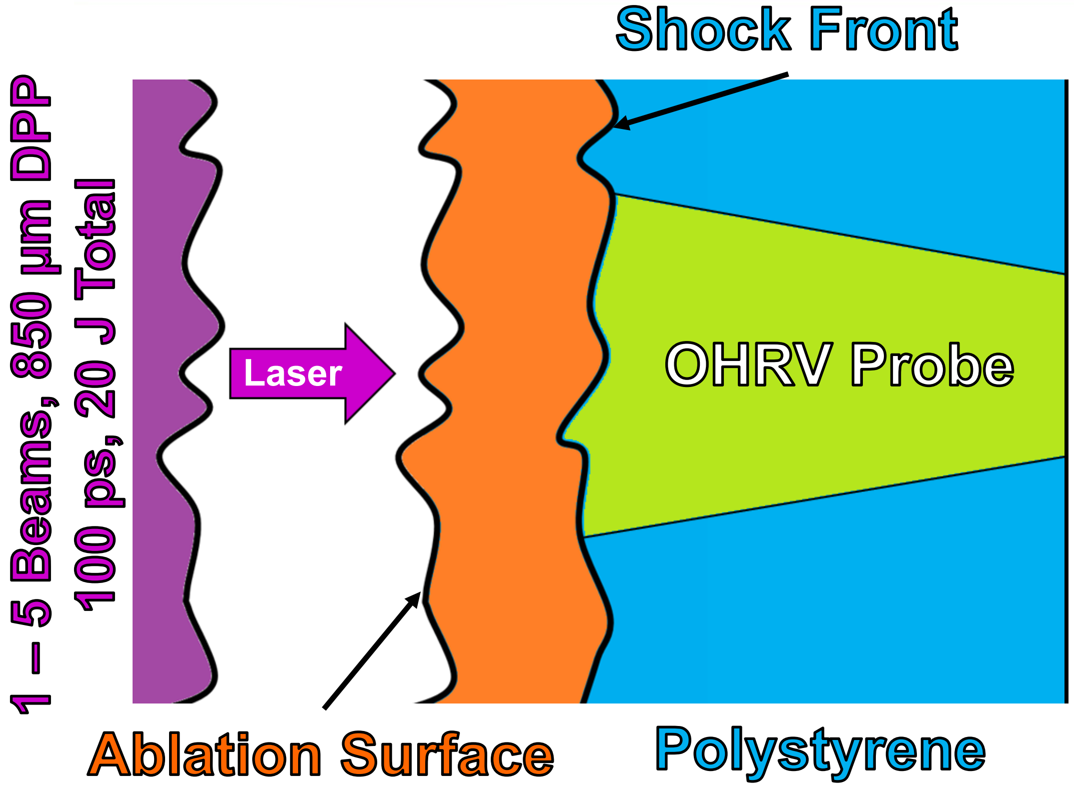
Experiments using 2D-VISAR show significant imprint reduction with overlapping beams

- Imprint appears to scale closely with $1/\sqrt{N_{Beams}}$ when there are more than 2 beams
- For single beam experiments more energy was present in large mode perturbations than expected
- 2D simulations including beam imprint underestimate modulations when compared to experiment

OHRV* probes the shock front, related to imposed modulation on ablation surface



OHRV measures distortions closer to the initial laser imprint seed than x-ray radiography

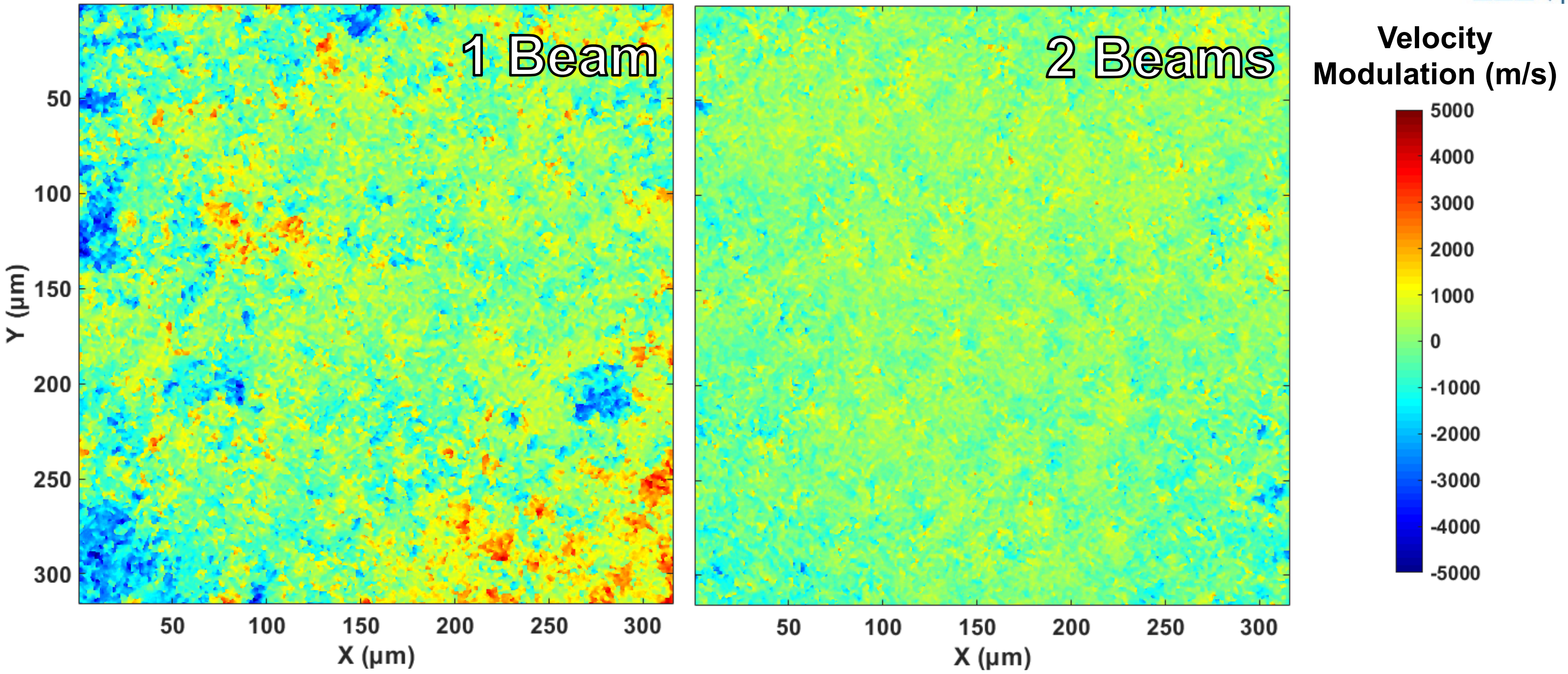
Optical blanking restricts probe timing (900 ps) and pulse shape (only 100 ps pickets)

OHRV probe:

- Spatial resolution of 2-3 μm
- Velocity resolution of < 3.7 km/s per fringe shift, < 200 m/s per pixel
- Probe λ = 395 nm, 2 ps

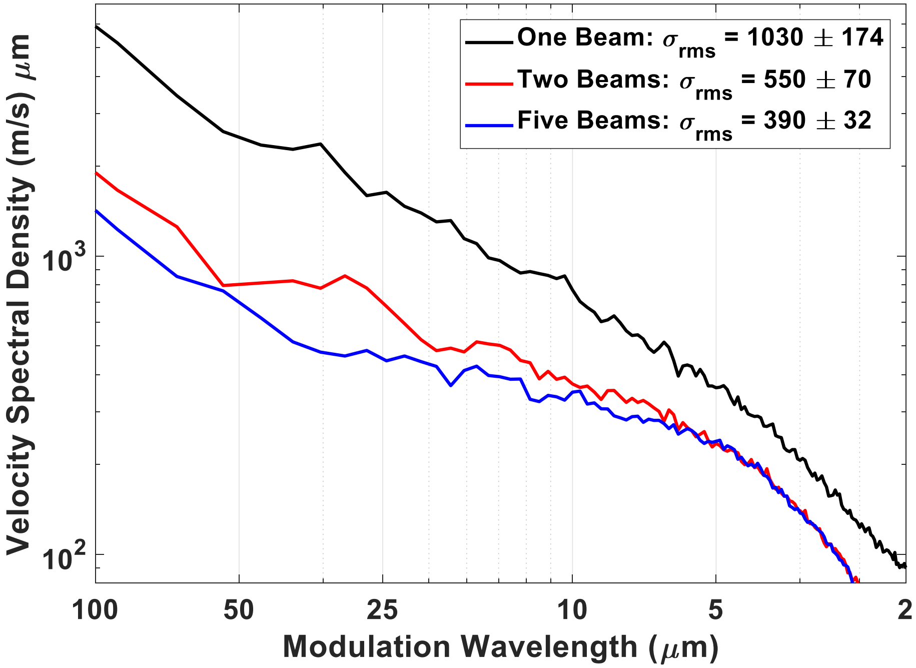
*P. M. Celliers, et. al., Rev. Sci. Instrum. **81**, 035101 (2010)

OHRV provides 2-D snapshots of shock-front velocity perturbations at a point in time



Addition of second beam shows clear reduction of imprinted modulations

Prior results predict σ_{rms} for the modulations should be reduced by the square root of the number of beams*

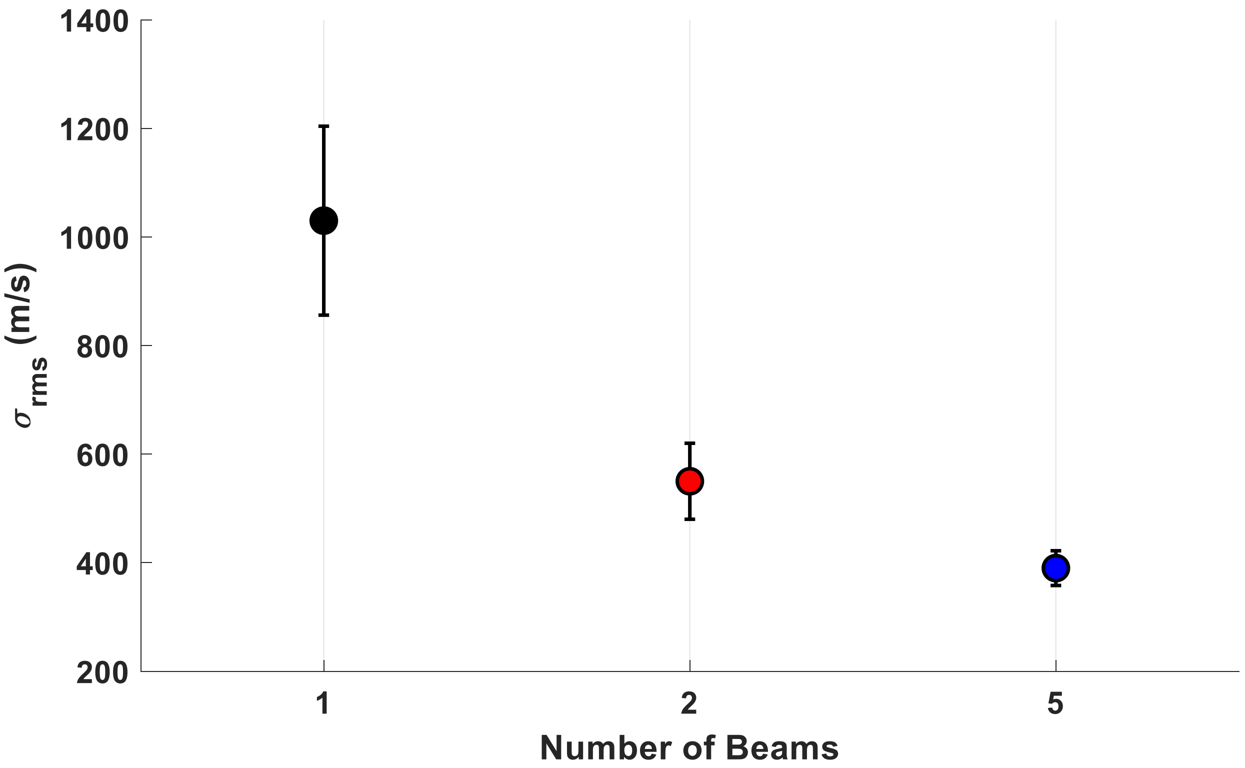


Applying the $\sqrt{N_{Beams}}$ factor requires choosing a reference

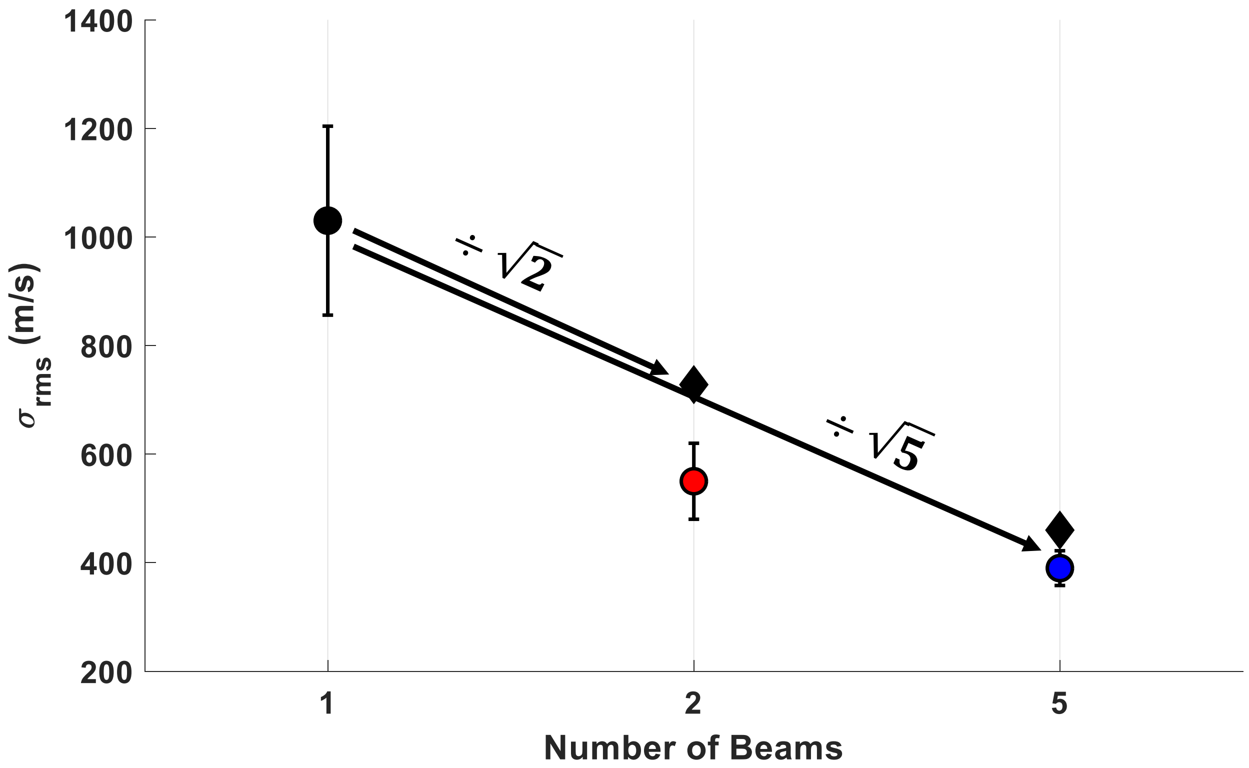
$$\sigma_{rms\ expected} = \sigma_{rms\ ref}\sqrt{\frac{N_{Ref}}{N}}$$

*V. A. Smalyuk, et. al., Phys. Plasmas **12**, 072703 (2005).

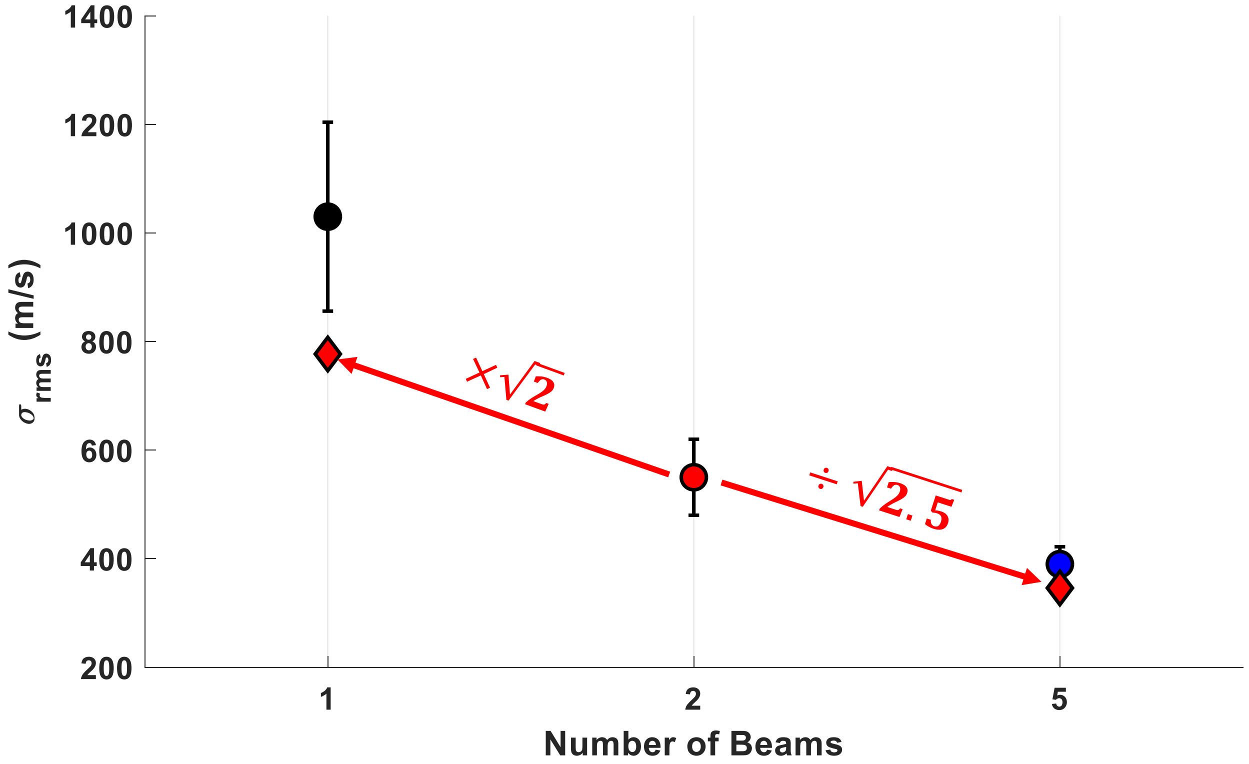
Does using $\sqrt{N_{Beams}}$ accurately predict experimental σ_{rms} ?



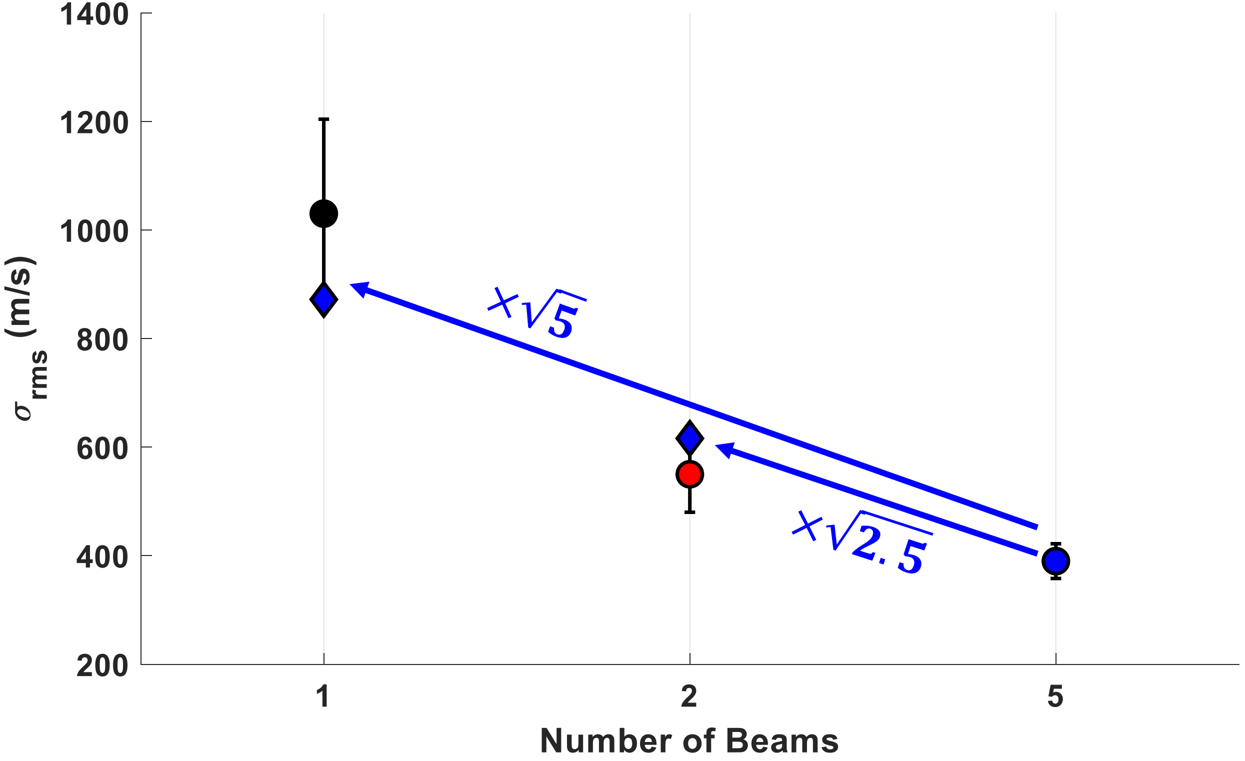
Using the 1 beam case as a reference predicts values higher than measured



The 2 beam case as a reference predicts values lower, and closer to measured for the 5 beam case



The 5 beam case over predicts for 2 beams and under predicts for 1 beam



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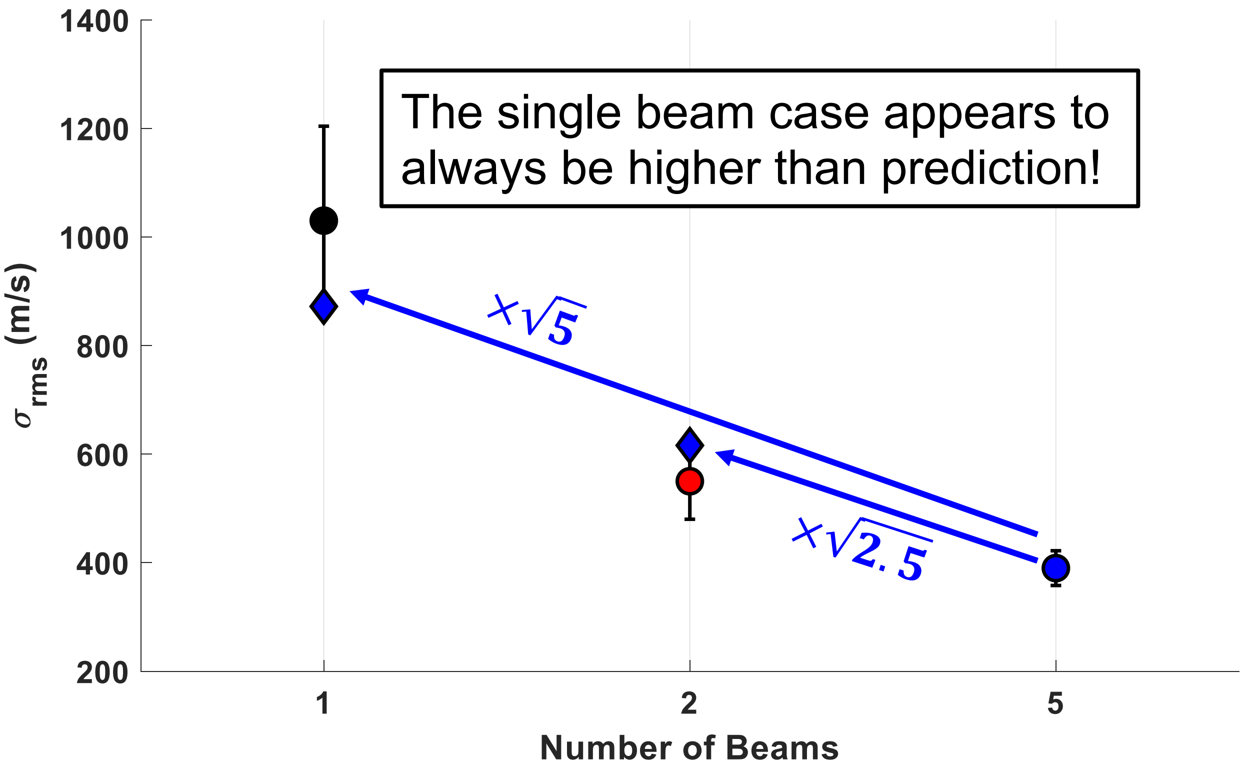
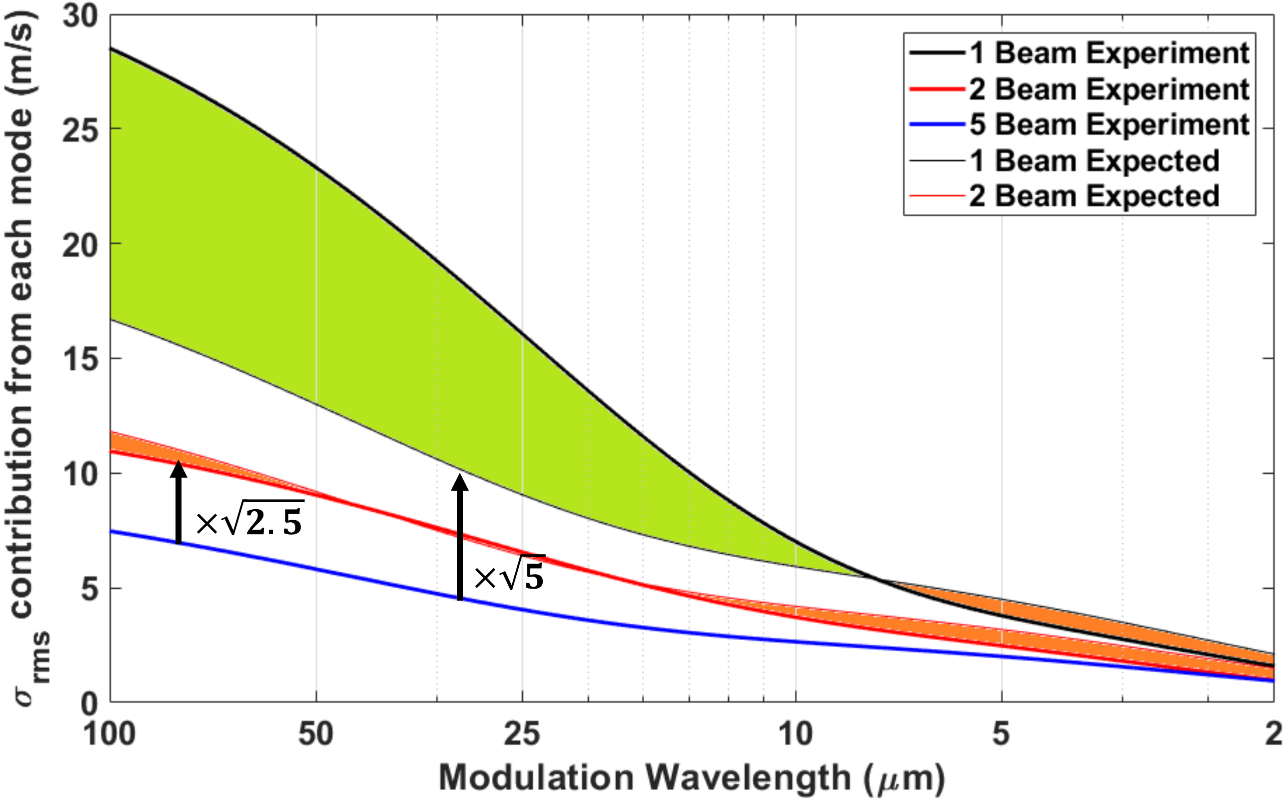


The larger modes of the single beam experiment are much more prevalent than expected and skew the σ_{rms} higher



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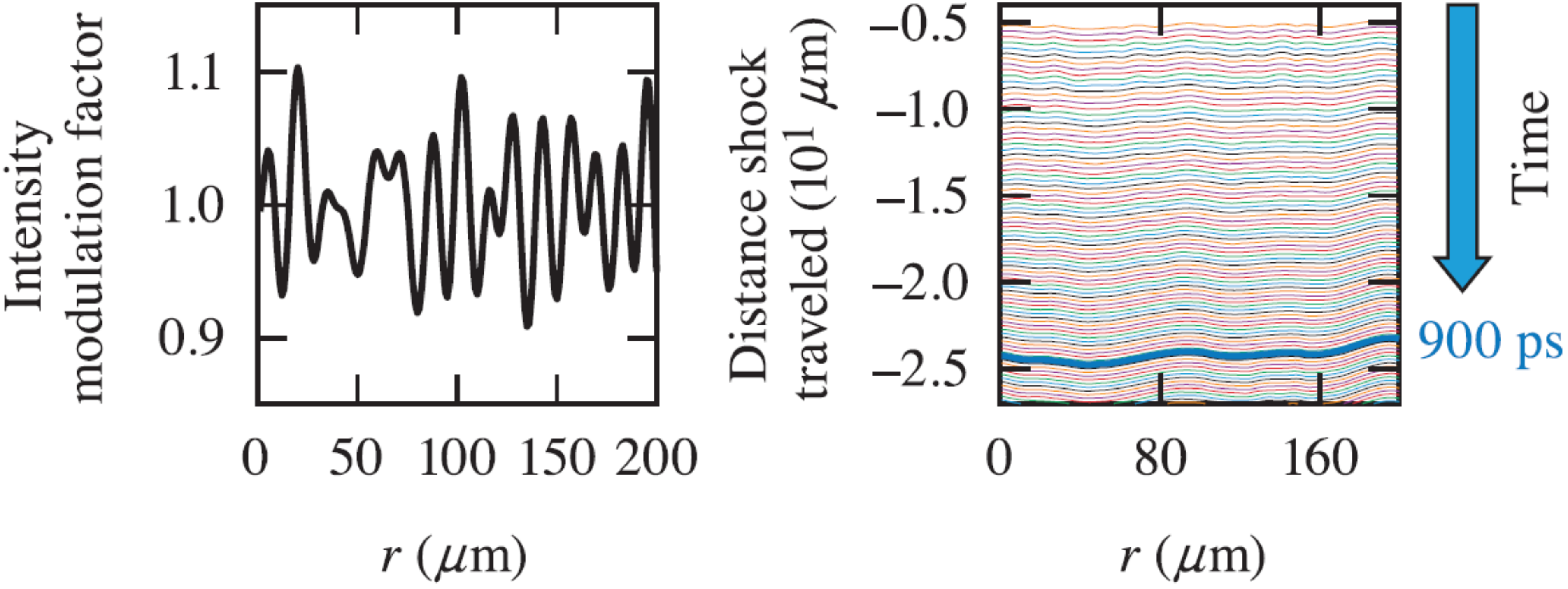
Initial 2D DRACO simulations created velocity spectra to be compared to experiments



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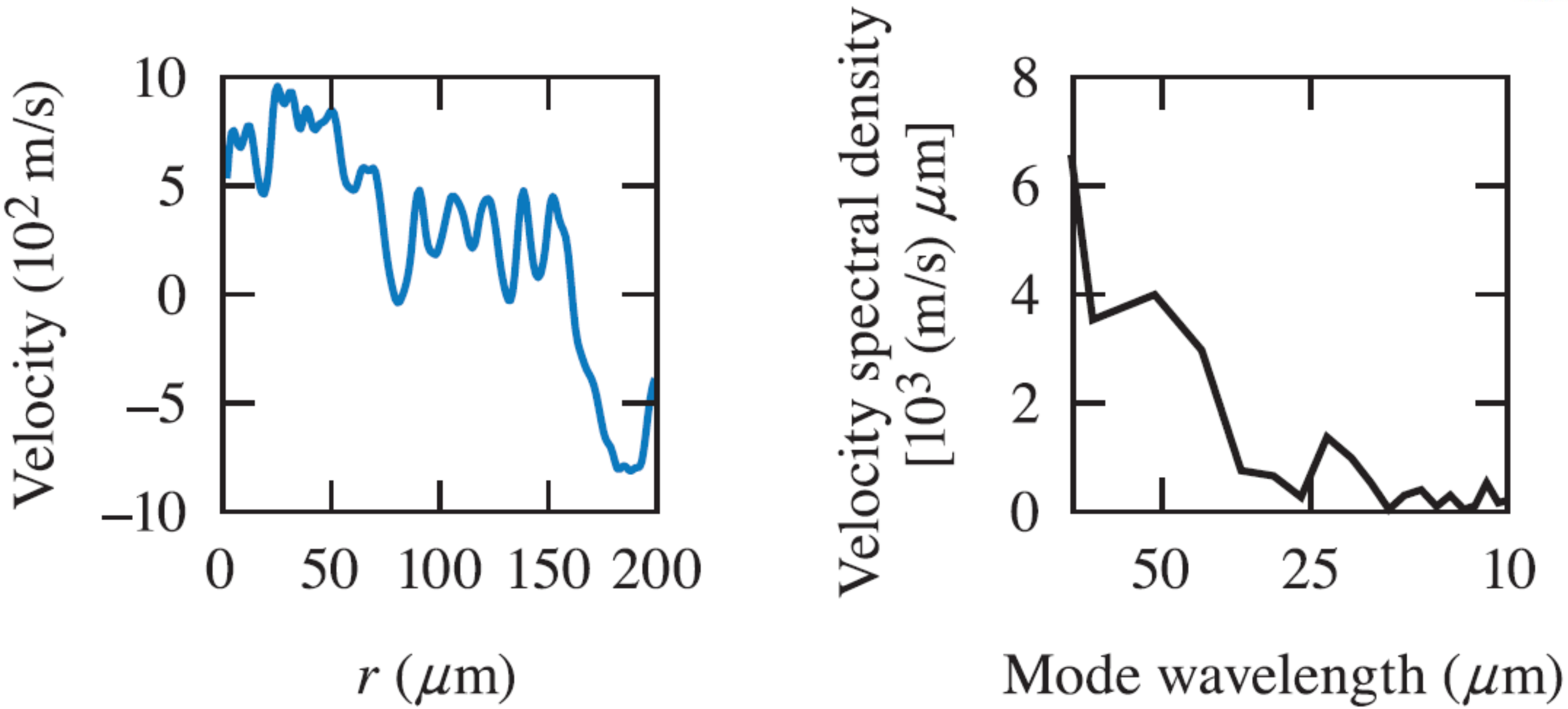
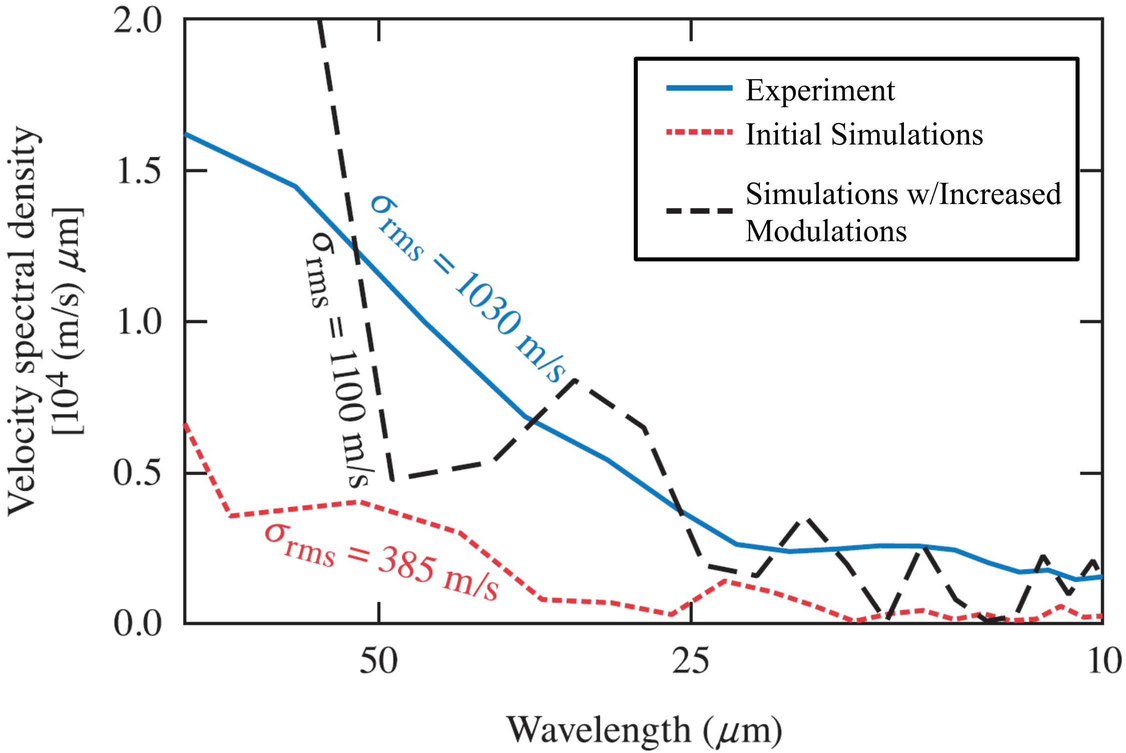


Initial 2D DRACO simulations underestimate imprinted modulations measured in experiment

- In order to approximate experimental data initial intensity modulations were increased by a factor of 2
- This indicates that current simulations do not adequately translate intensity modulations to pressure modulations



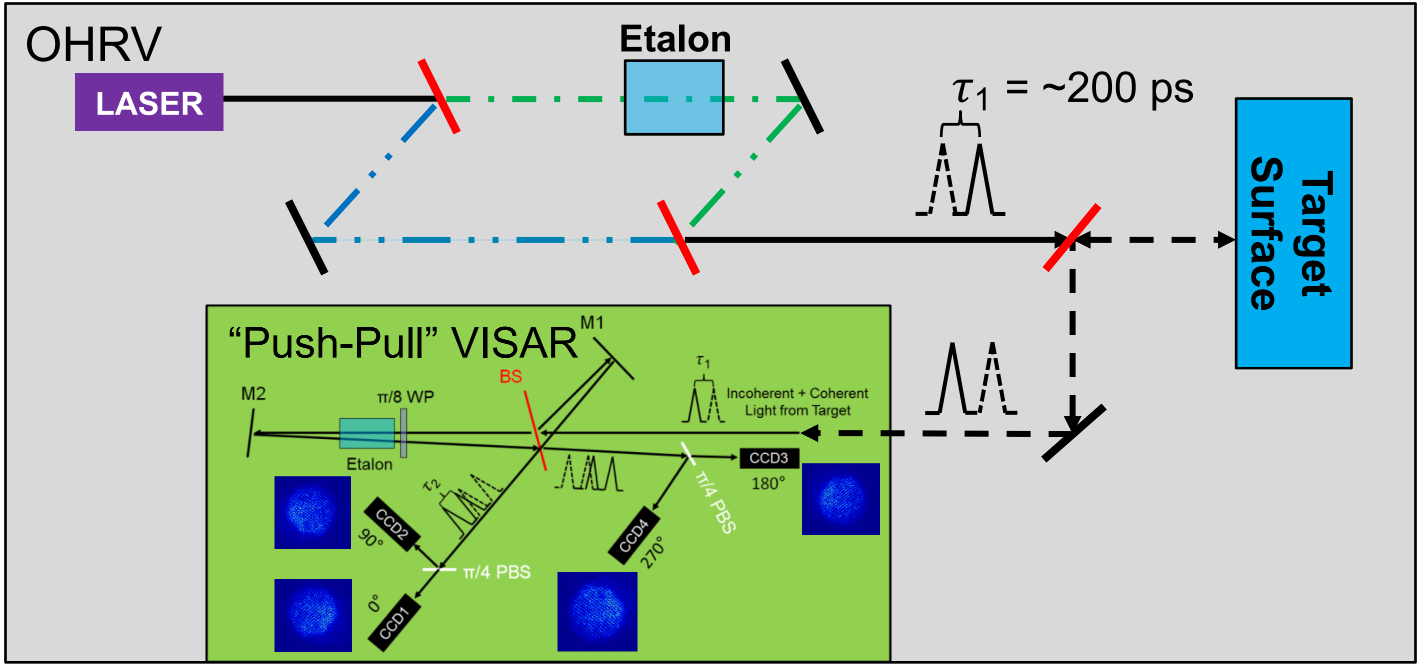
Experiments using 2D-VISAR show significant imprint reduction with overlapping beams

- Imprint appears to scale closely with $1/\sqrt{N_{Beams}}$ when there are more than 2 beams
- For single beam experiments more energy was present in long-wavelength mode perturbations than expected
- 2D simulations, which included beam imprint, underestimated modulations when compared to experiment

Backup

For 2D VISAR, a short probe pulse is split prior to interacting with the target

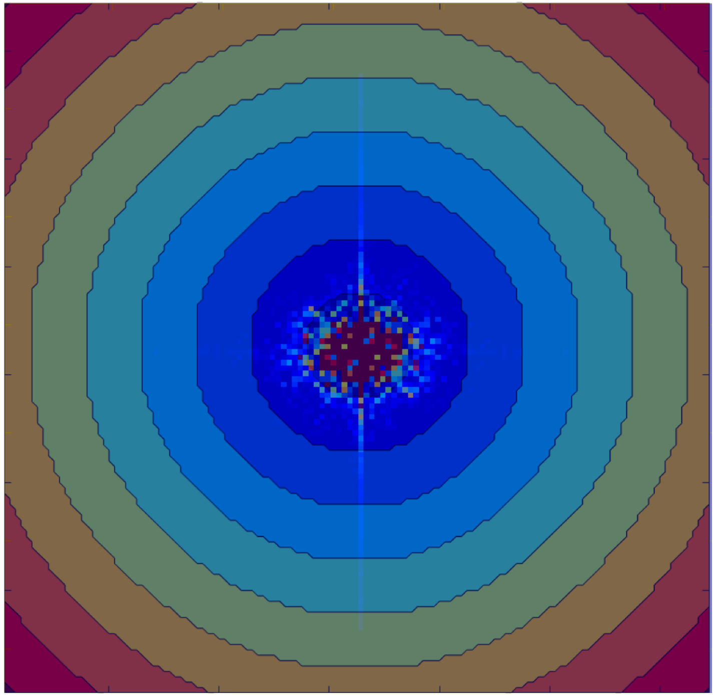
To retrieve the 2D velocity information from VISAR, create 2 short pulses, split them prior to hitting the target, then recombine them afterwards to create fringes.



P. M. Celliers, et. al., Rev. Sci. Instrum. **81**, 035101 (2010)

Analysis – Azimuthally averaged spectrum of perturbations

- Modes are characterized by the same routine for both OHRV and X-Ray Radiography
  - FFT the square of the normalized perturbation image to create a 2D power spectrum
  - Radially average for each frequency mode
  - Confidence intervals are provided by the variance of the unaveraged spectra



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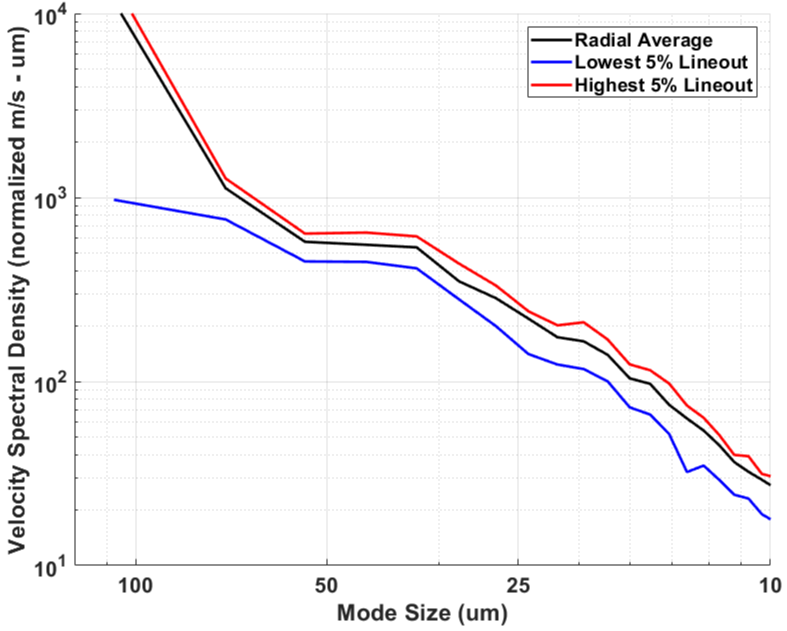
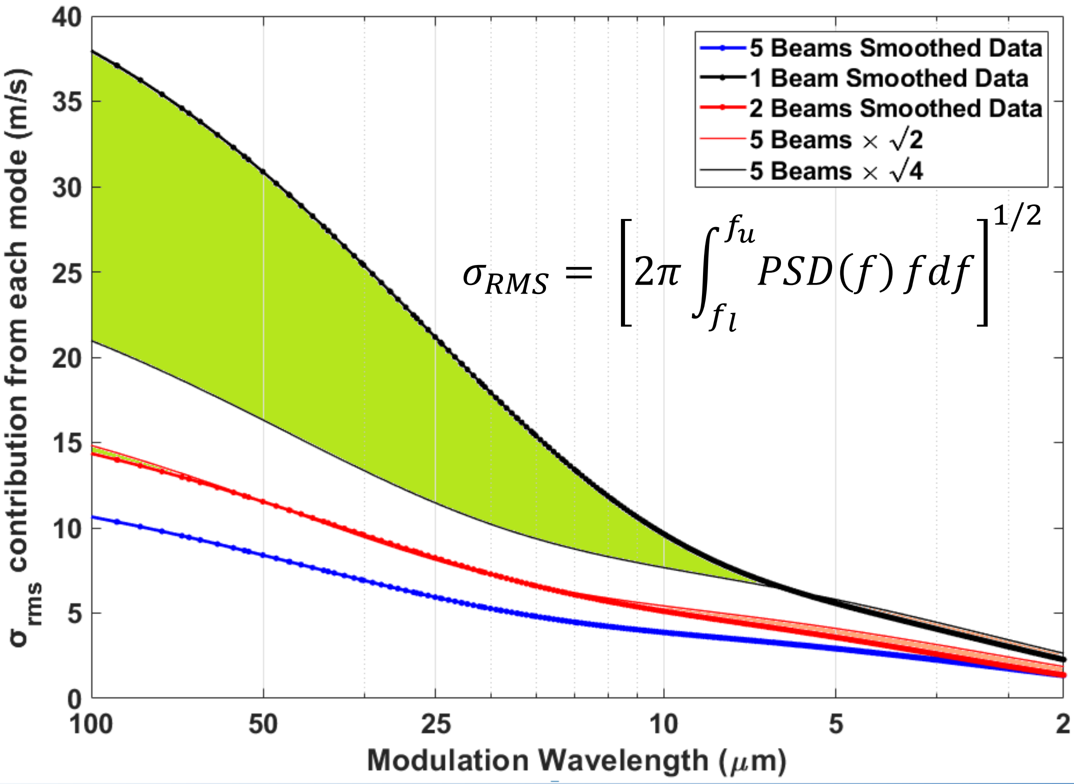
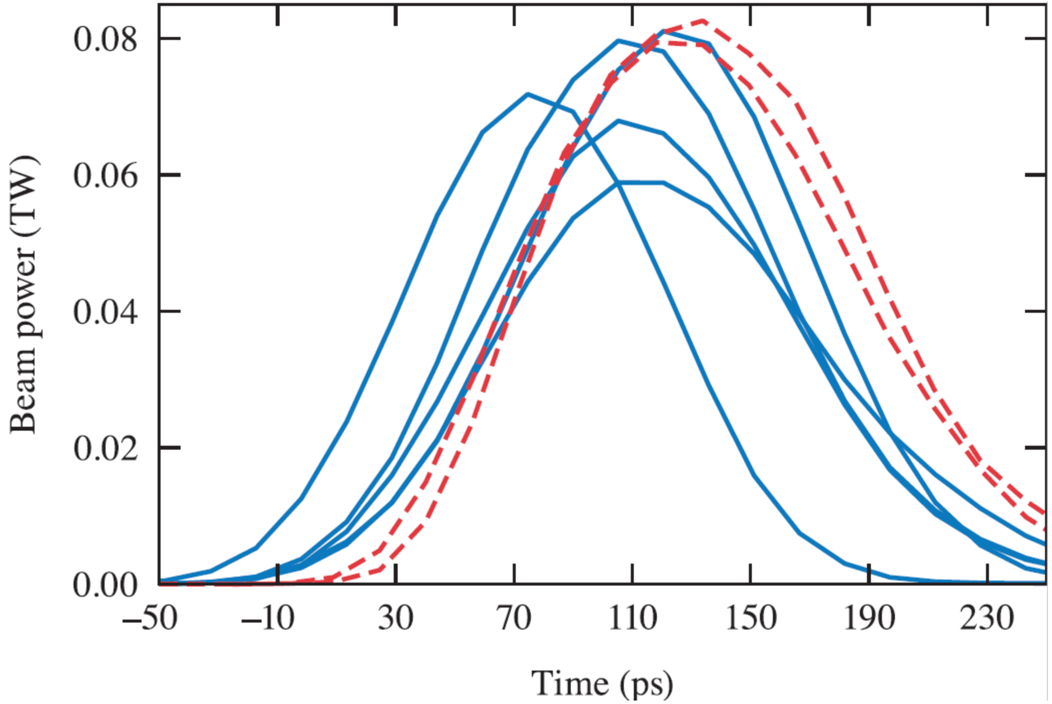


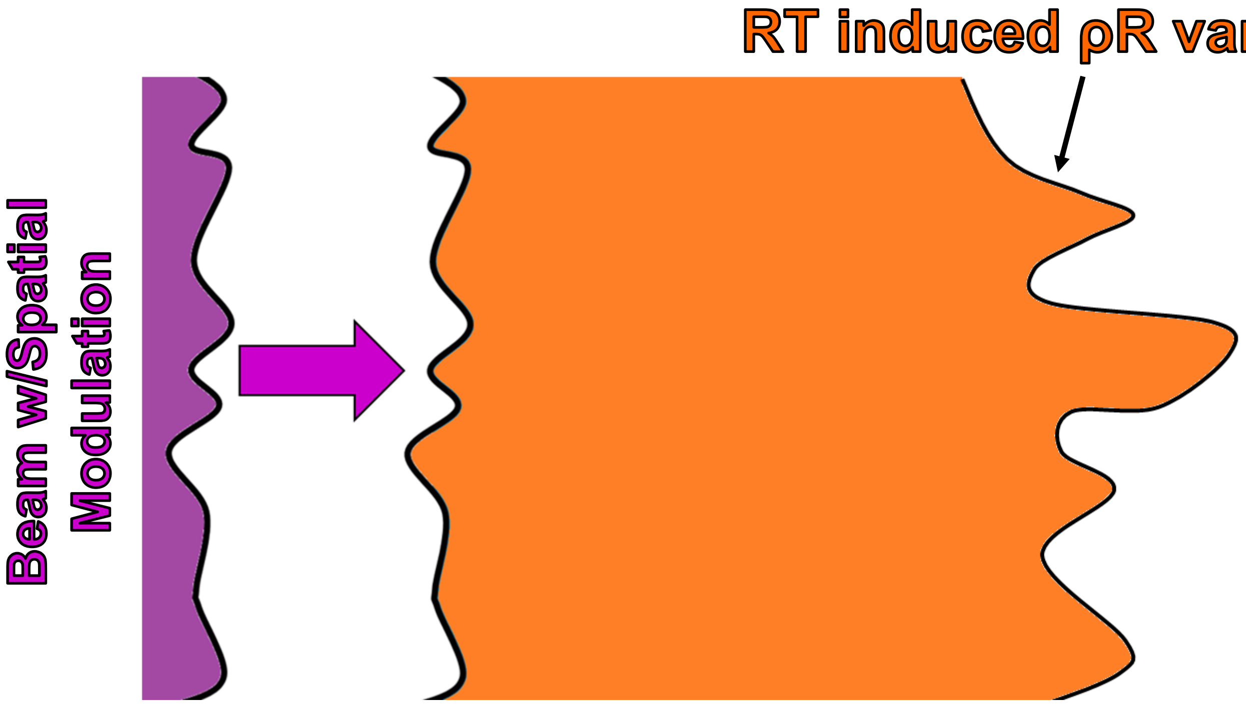
Expected greater imprint reduction from 5 beams, results are more in line with 4 beams



Beam timings for 2 and 5 beam experiments



Face on radiography measures ρR variation seeded by imprinted modulations



Rayleigh-Taylor requires nearly 2 ns to grow to levels detectable above background

Targets in these experiments were driven with a square pulse $I \sim 5\times10^{13}$ W/cm^2

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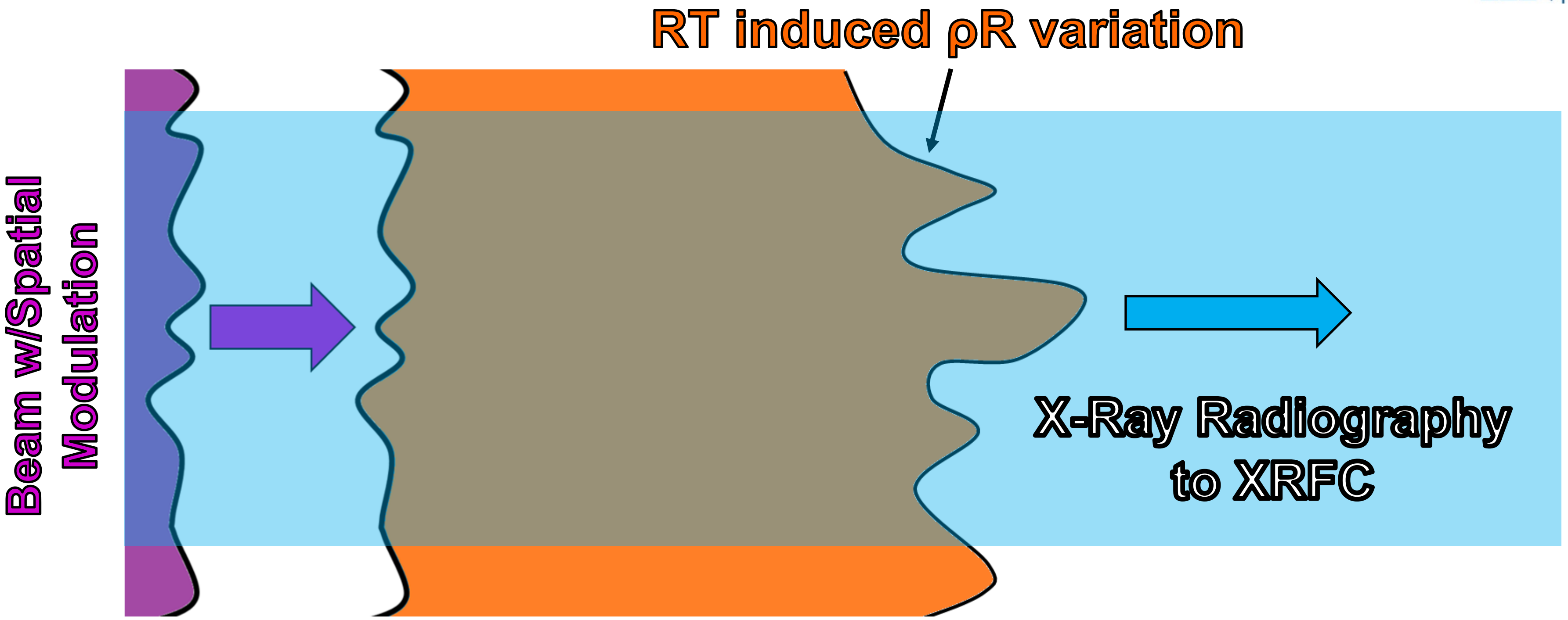
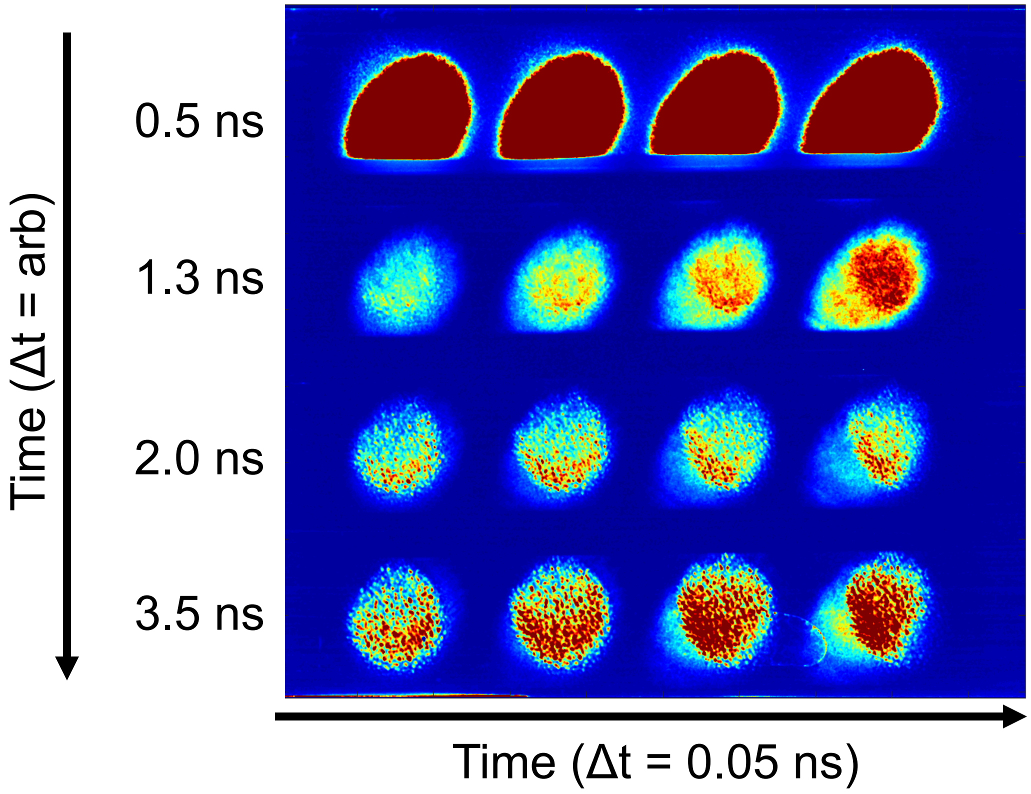
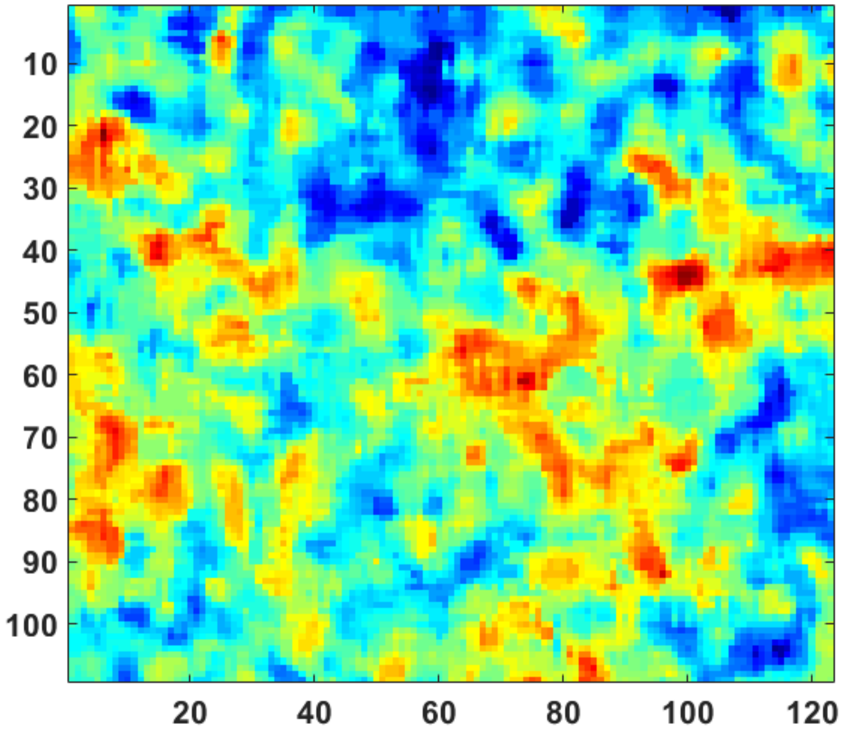


Raw data – x-ray radiography



Example: Single time snapshot of RT grown modulation



Example: Time history of RT growth of imprint