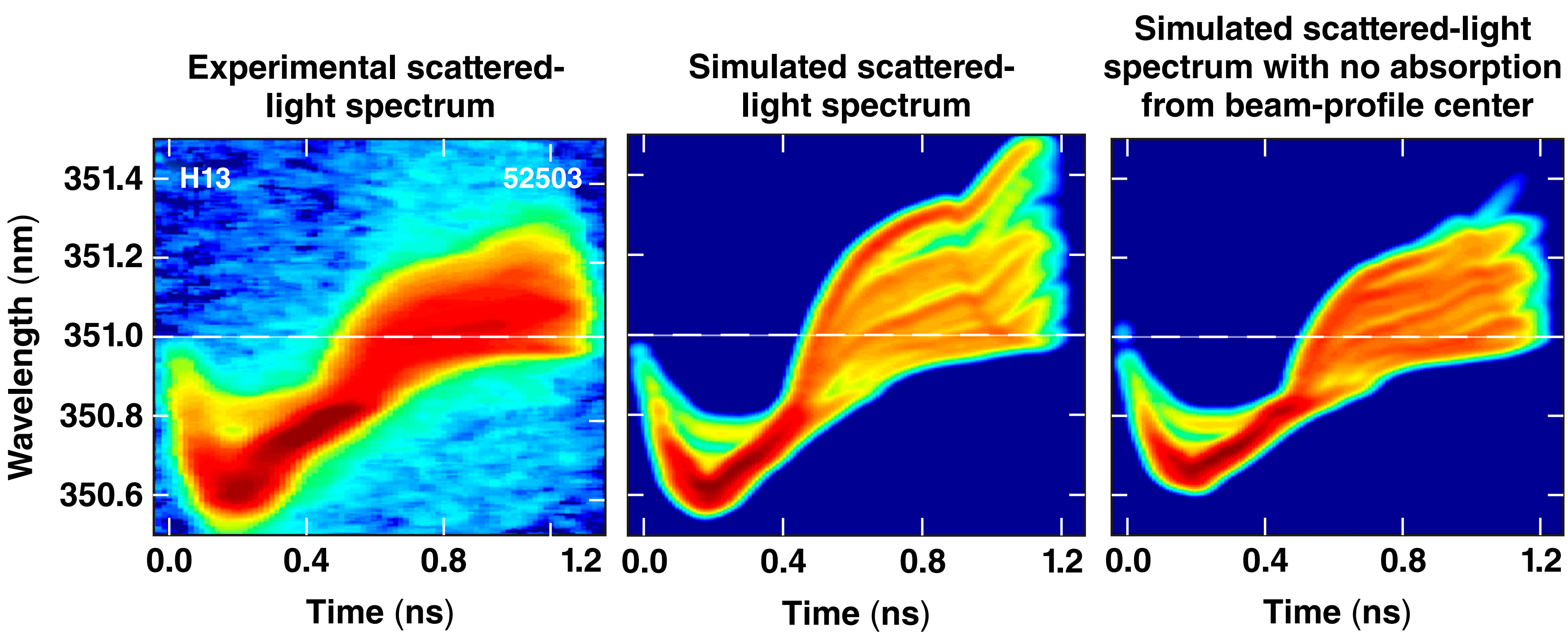
# Precision Scattered Laser Light Spectroscopy in Direct-Drive Implosions





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Summary

# Scattered-light simulations may be reconciled with experiments by cross-beam energy transfer out of the central portion of the beam profile

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- Time-dependent scattered-laser-light spectra are modeled by a combination of hydrodynamic and ray-tracing codes
- Analysis of the spectra indicates that the red shift of the scattered-light fan tail is poorly modeled
  - especially for scattered light originating from the central portion of the beam profile
- Modeled spectra with simulated cross-beam energy transfer out of the beam profile center produce a much better match to the experimental scattered-light spectra.

# Collaborators


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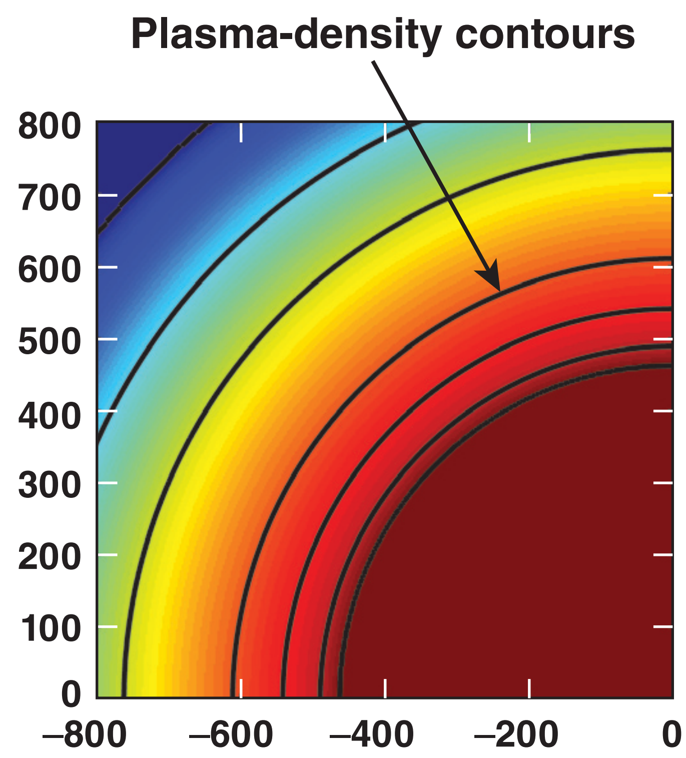
# Time-dependent scattered-light spectra are modeled for OMEGA implosions

- *LILAC*: 1-D hydrodynamic code predicts time-dependent plasma profiles using Goncharov nonlocal electron- heat transport model[1]






[1] V. N. Goncharov *et al.*, Phys. Plasmas 13, 012702 (2006).

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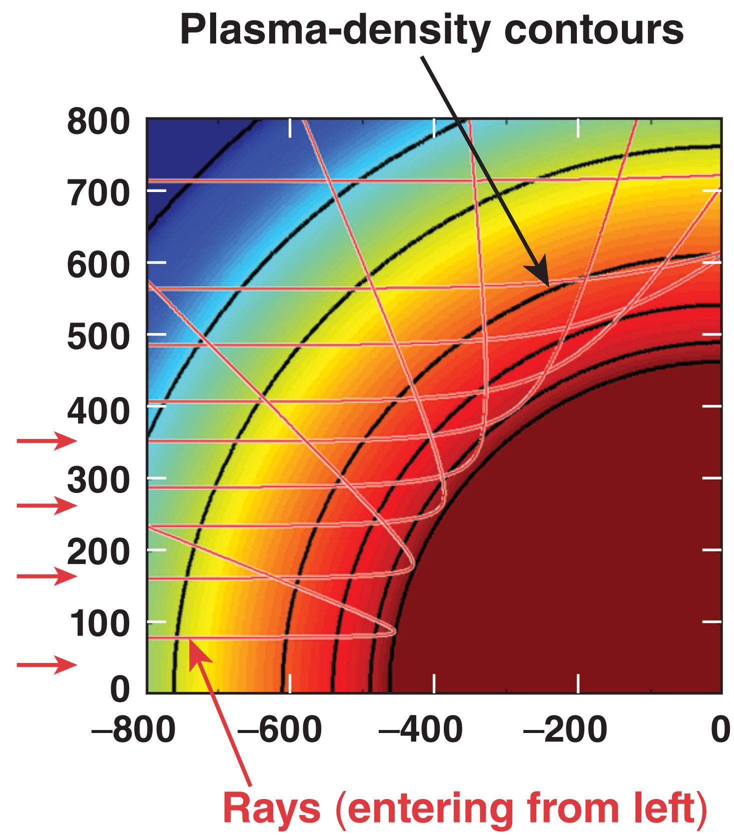
- *SAGERAYS*: Ray traces 351-nm-drive laser light through plasma and calculates spectral shift along each path[2]

$$\Delta\omega = -\omega_0 \frac{\partial \tau_f}{\partial t} = +\frac{\omega_0}{2c}\int \left(1-\frac{n_e}{n_c}\right)^{-1/2} \frac{\partial}{\partial t}\left(\frac{n_e}{n_c}\right) ds$$

$\tau_f$ = time of flight of light along ray
$n_e$ = plasma density
$n_c$ = plasma critical density
$\omega_0$ = laser-light angular frequency

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E15990c

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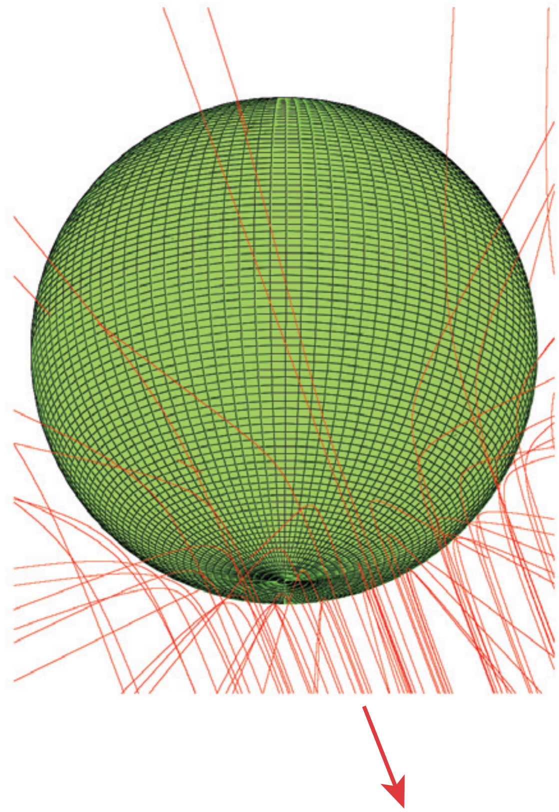
- **MATLAB 3-D code calculates total spectrum collected by FABS from all 60 beams**



Rays collected by FABS

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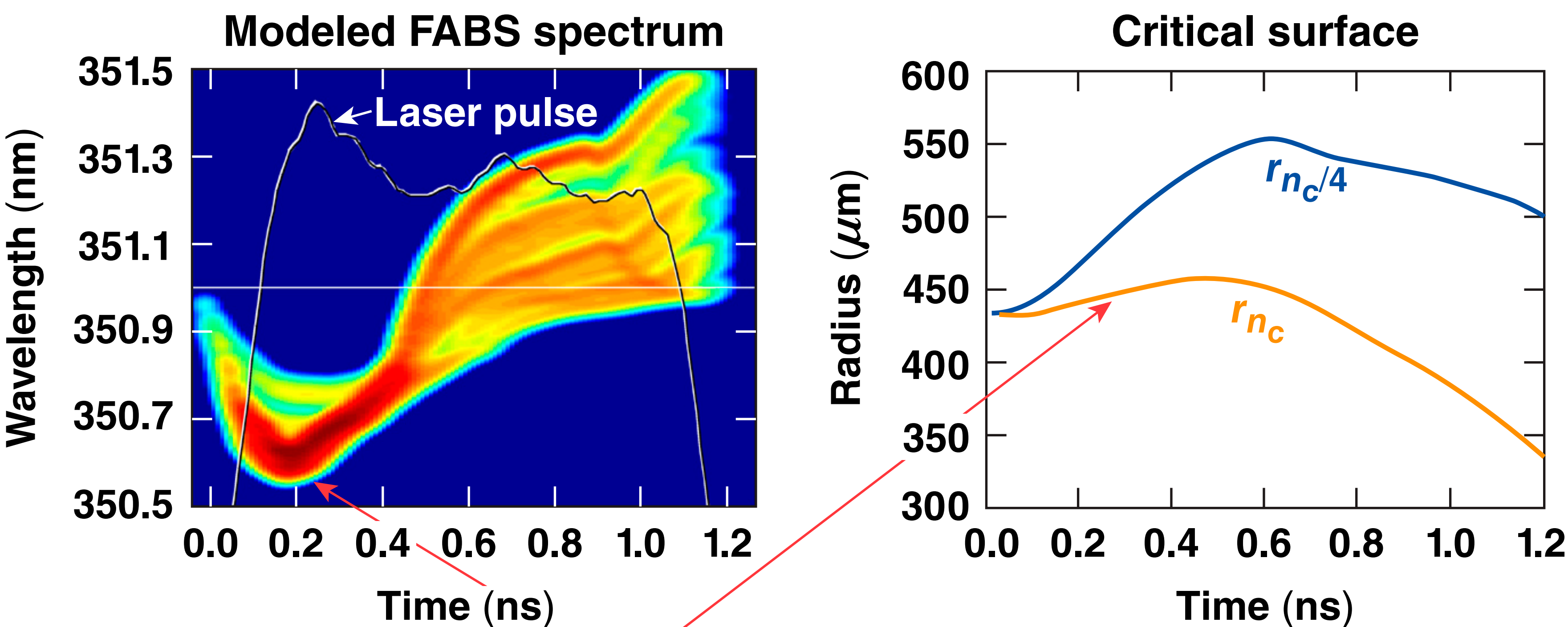
# Modeled scattered-light spectra show a detailed structure with both blue- and red-shifted components




- Sharp initial blue shifts due to plasma production as laser pulse rises

**40-μm plastic shell**

E16793a

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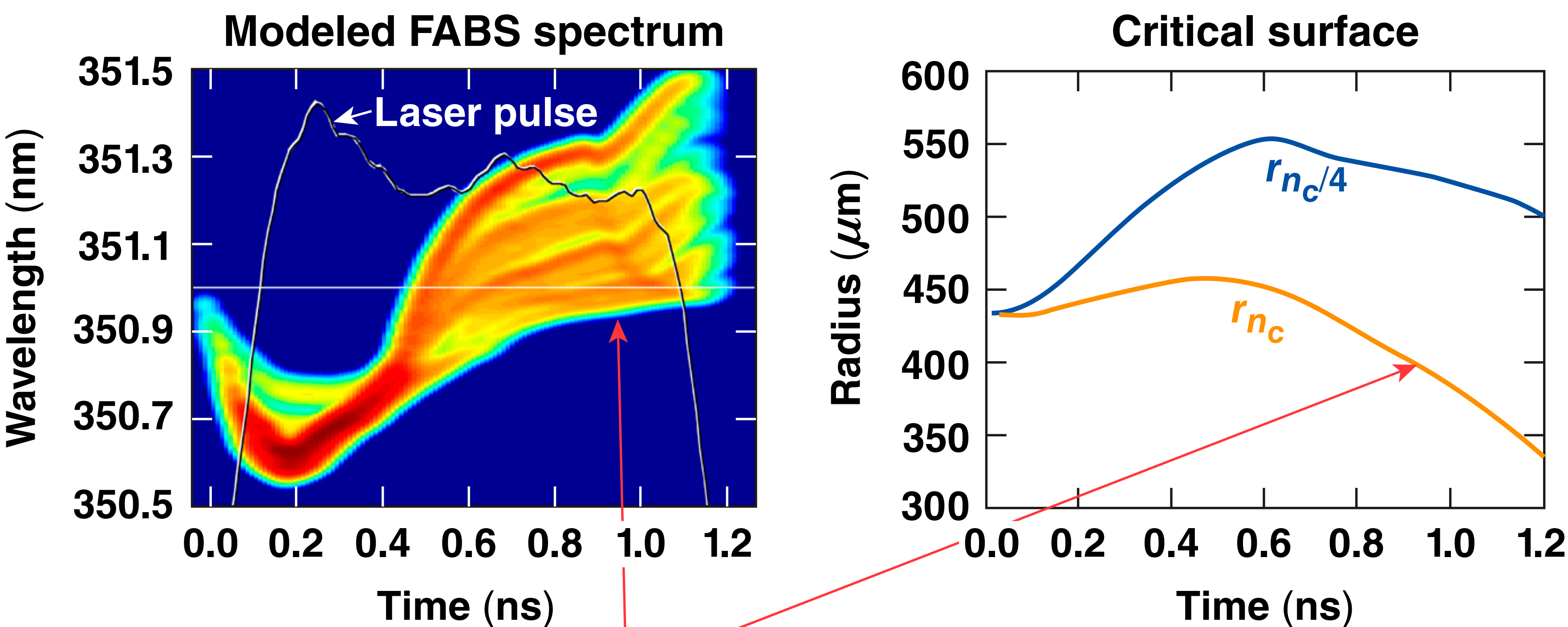
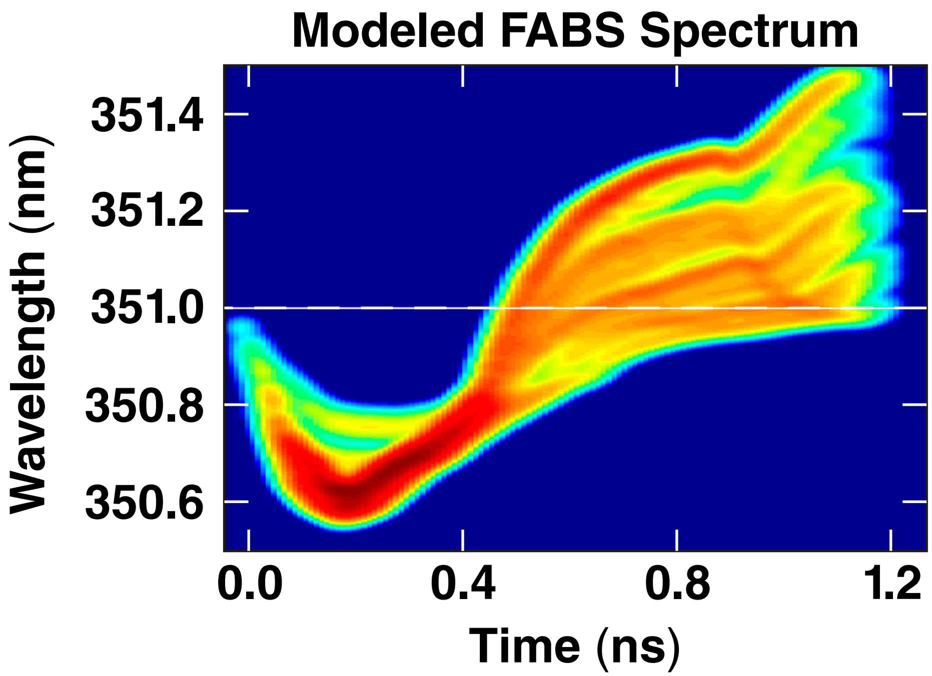


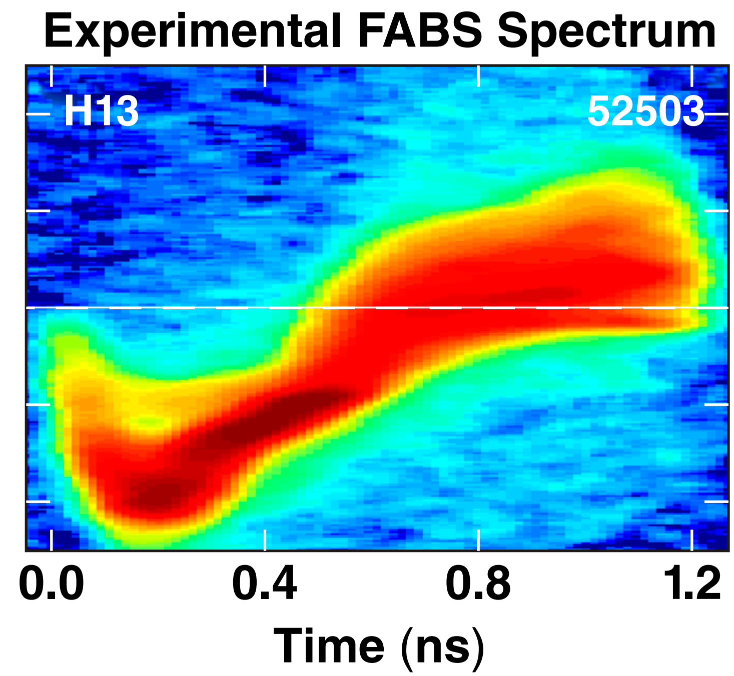

- Red-shifted "fan-tail" caused by compression of target
- Fan tail "fingers" are from beams at different angles with respect to spectrometer

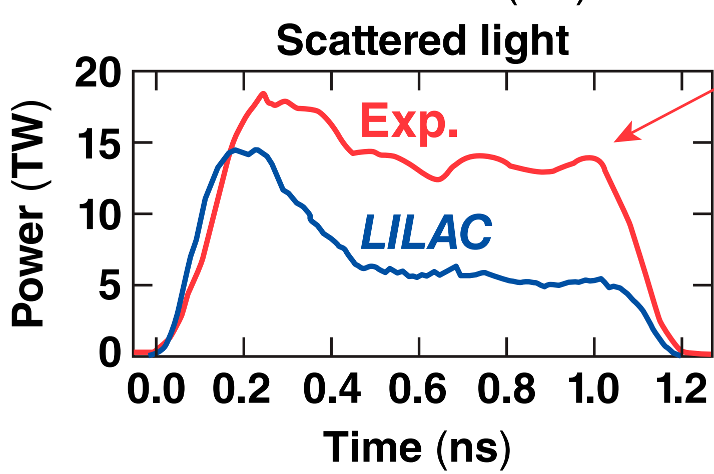
**40-$\mu$m plastic shell**

E16793b

# Modeled spectra show all the basic structures of the experimental spectra but differ in some details




Total scattered light underpredicted (only 12% difference in total absorption)

20-$\mu$m plastic shell
1-ns square pulse

E17329

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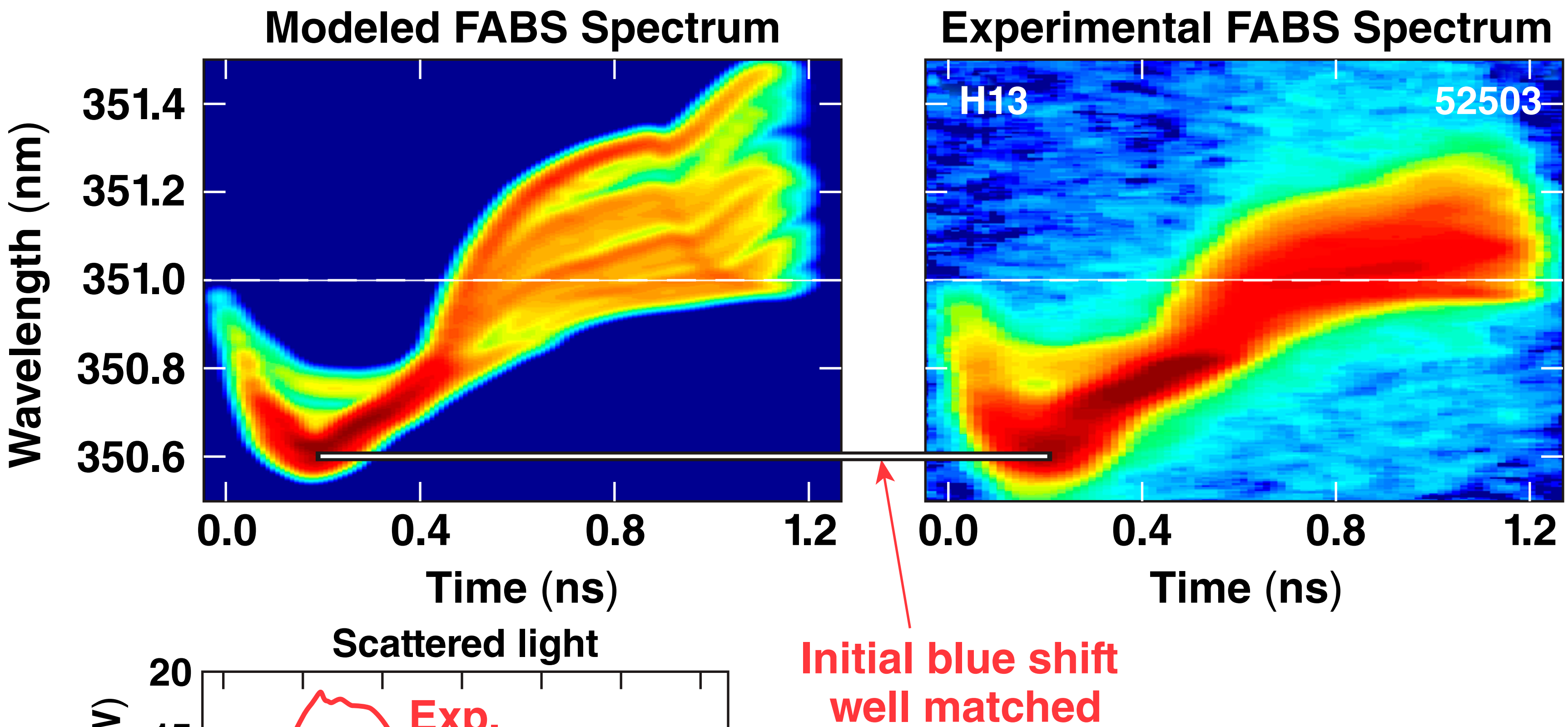


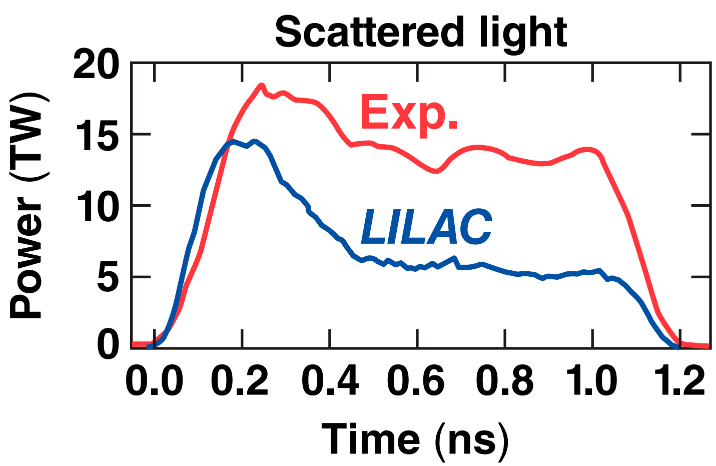


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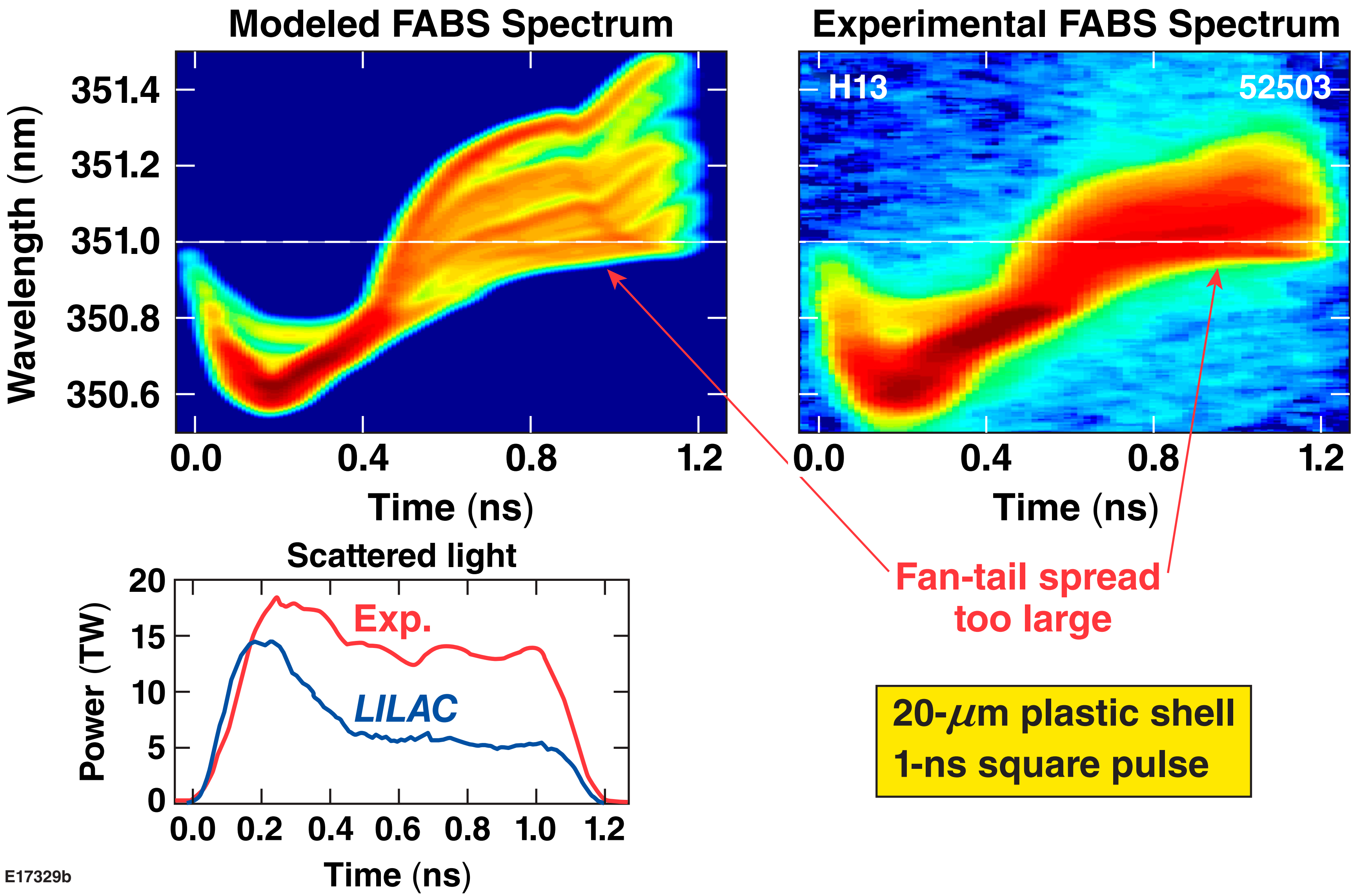


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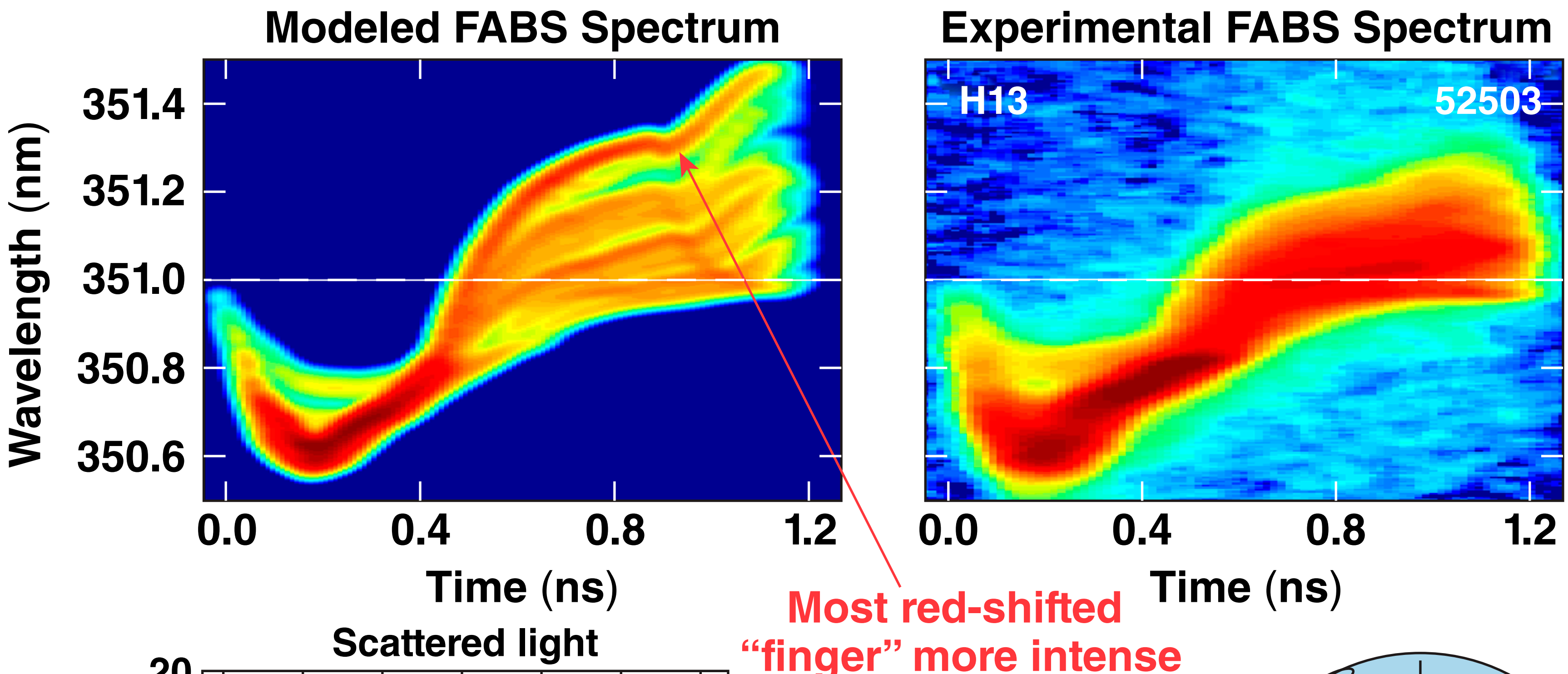


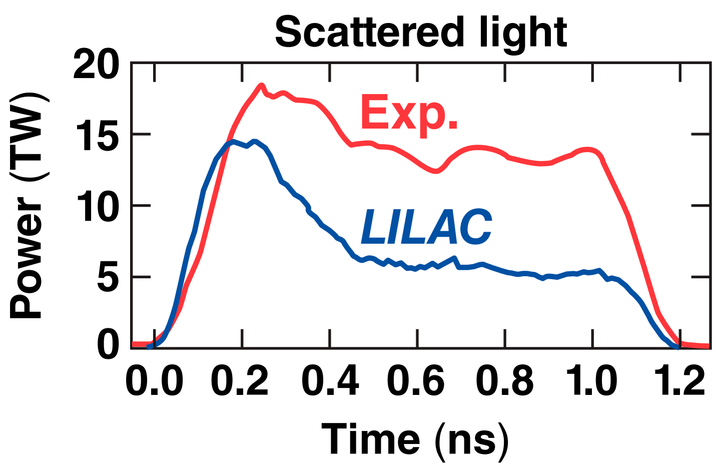


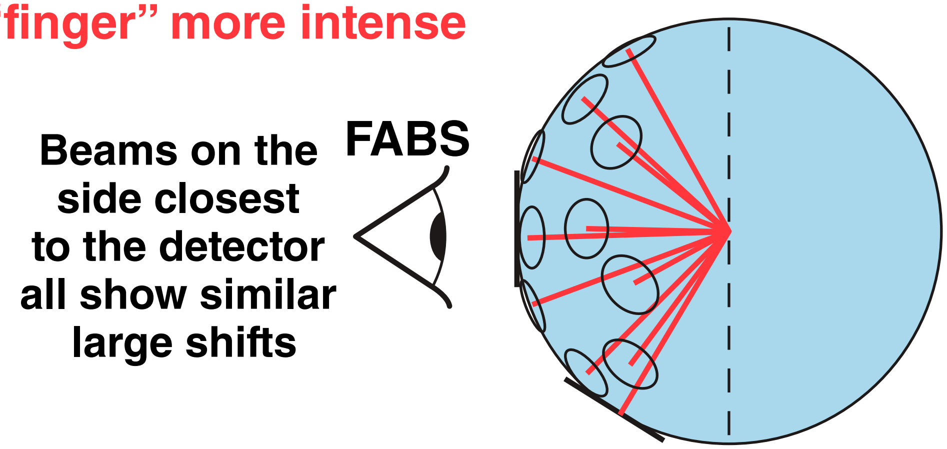


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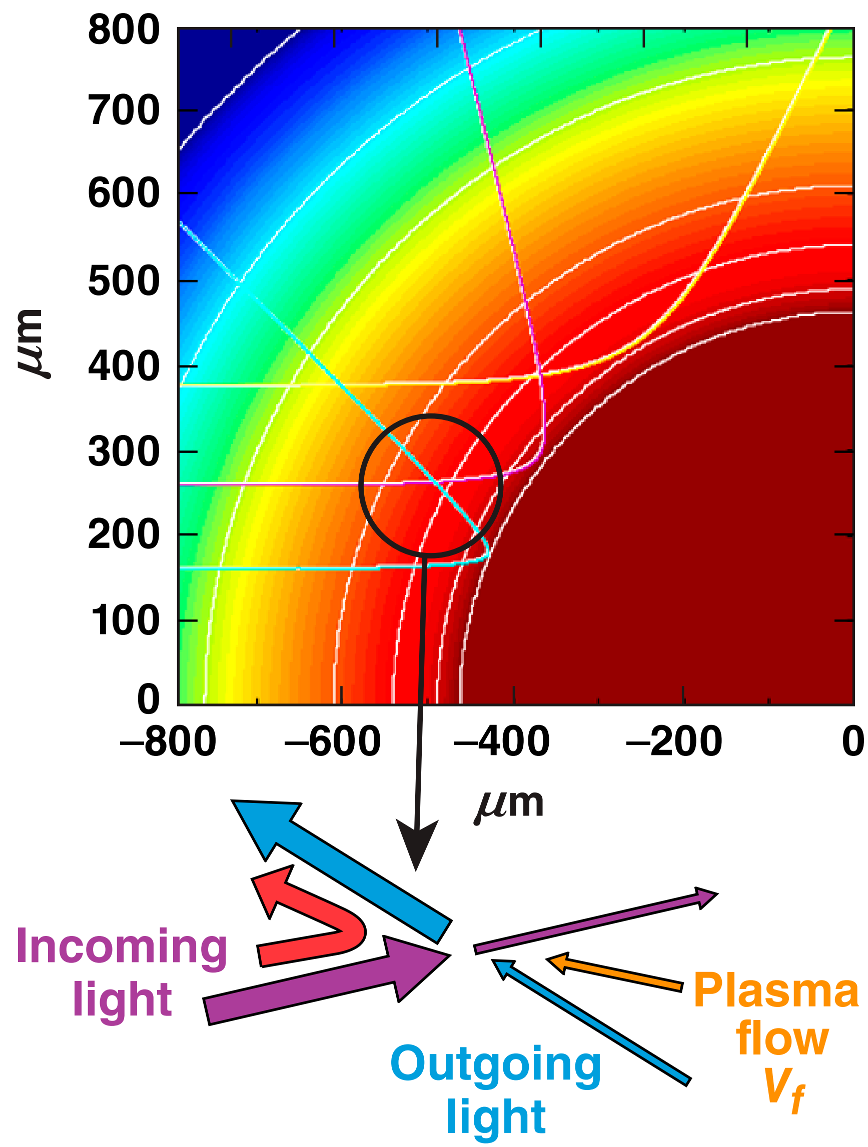
# The discrepancy between modeling and experiment is not simply an overprediction of absorption

- Global scaling of the pulse energy to match observed total absorption does not significantly improve the spectral-shift predictions
- The predicted bang times are typically within 50 ps of the experimental value, suggesting the overall drive is fairly well modeled
- The experimental lack of an intense red-most beam finger suggests that absorption may be underpredicted for this finger
- Altering the *profile* of the beam to shift energy out of the beam center may provide reconciliation with experiments.

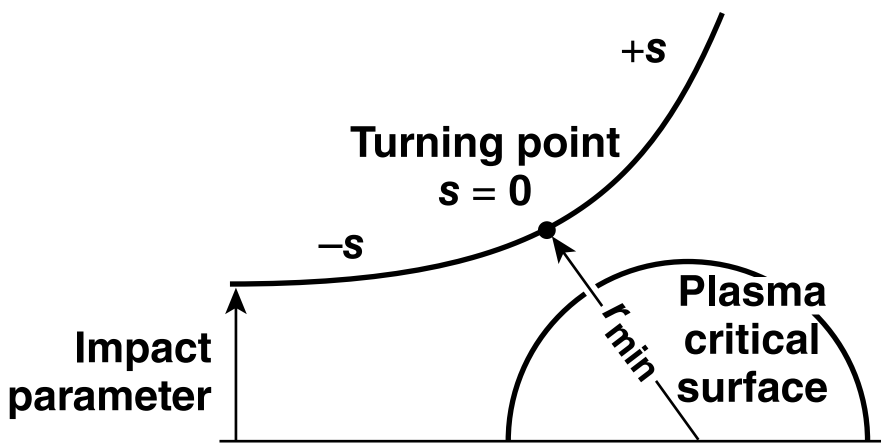
# EM-seeded SBS cross-beam power transfer might significantly alter the absorption profile

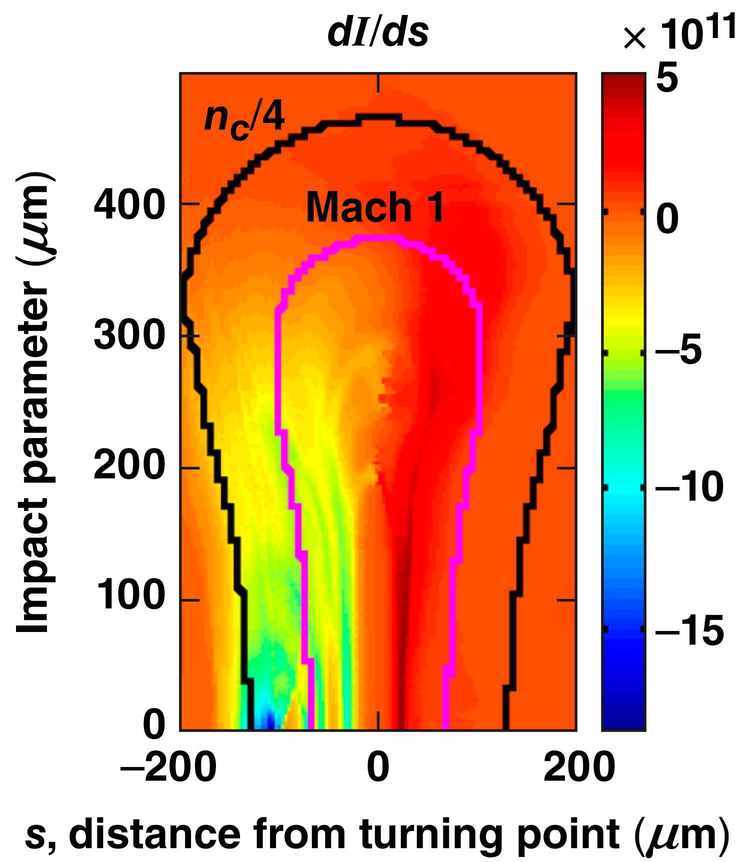


- Light entering the plasma can transfer energy to crossing light that is leaving the plasma via an ion acoustic wave.
- Laser-pulse energy from one part of the beam profile may be transferred to another, "bypassing" the highest absorption region (near the turning point).

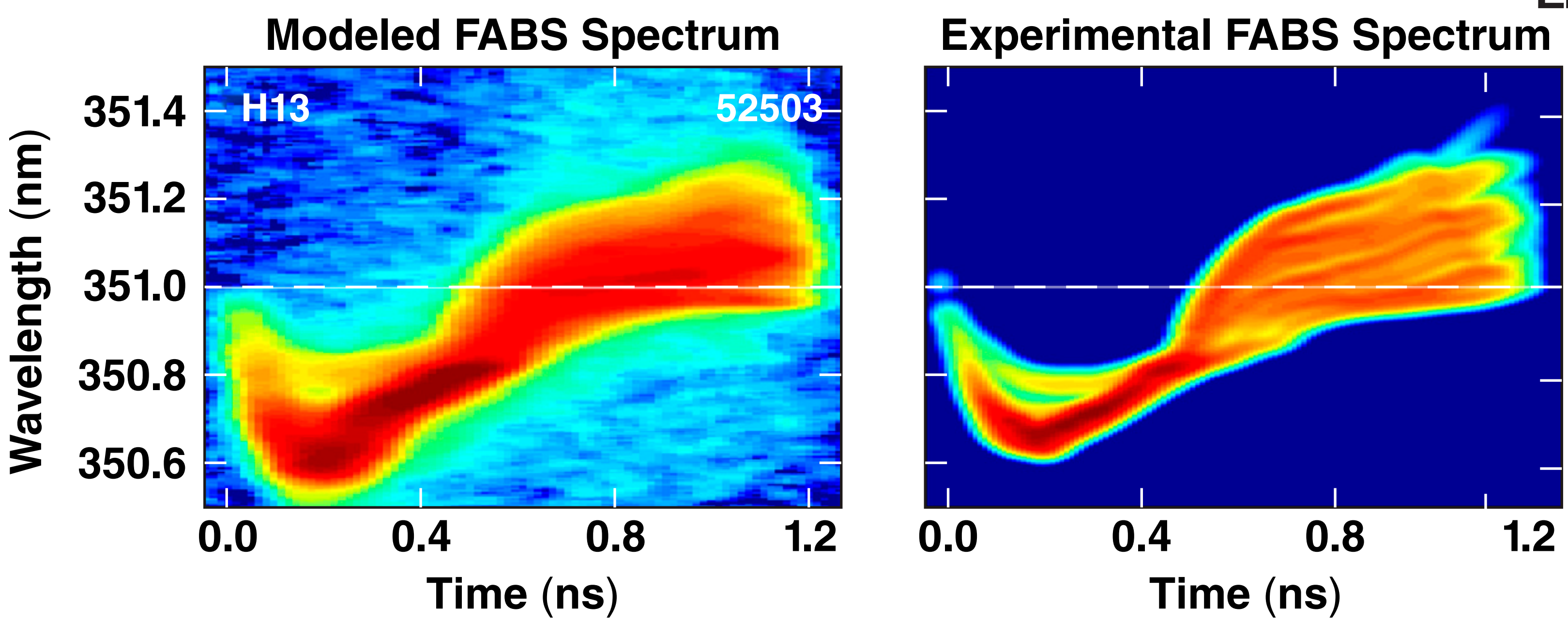


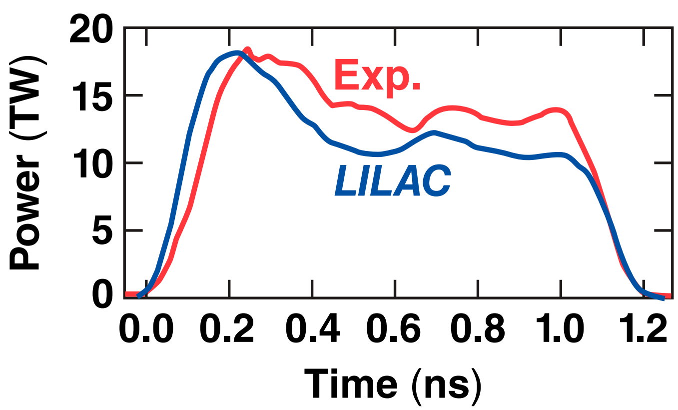
# Initial calculations support cross-beam energy transfer out of the beam profile center



# "Mock-up" simulation of energy transfer out of the beam center greatly reduces the discrepancy




- Energy turned off in LILAC for central 150 $\mu$m of beam profile
- Energy resdistributed to rest of spectrum in scattered light simulation

**Incorporating a self-consistent cross-beam power-transfer model into *LILAC* is necessary for complete simulations.**

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Summary/Conclusions

# Scattered-light simulations may be reconciled with experiments by reduced absorption in the central portion of the beam profile

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