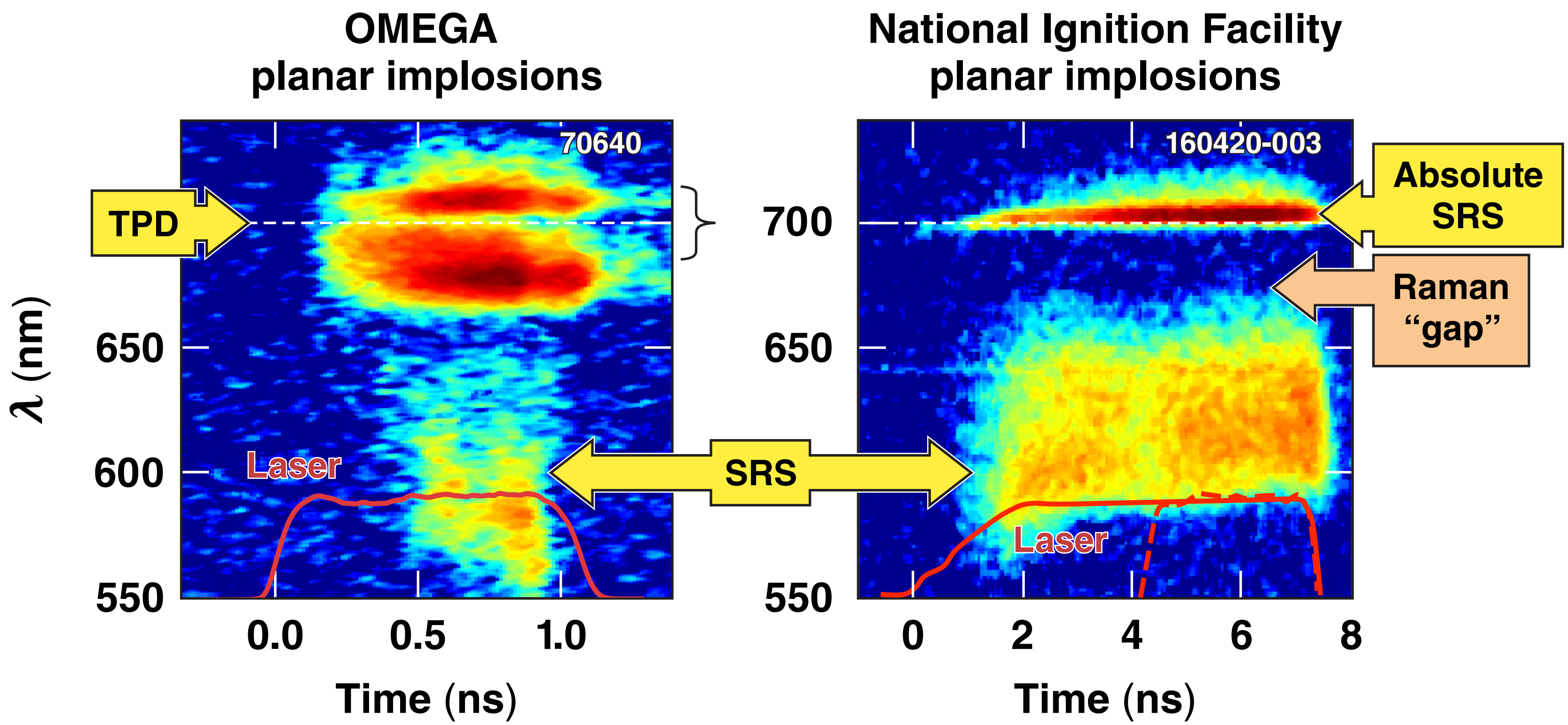
Two-Plasmon Decay and Stimulated Raman Scattering for Direct-Drive Inertial Confinement Experiments



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Summary

The two-plasmon–decay (TPD) instability dominates over stimulated Raman scattering (SRS) on OMEGA in contrast to the National Ignition Facility (NIF)

- OMEGA
  - TPD is observed in most planar and spherical experiments
    - near $n_c/4$: $L_n < 150\ \mu m$, $T_e < 3$ keV, $I_{overlapped} \geq 10^{14}$ W/cm^2
    - Thomson scattering helps interpretation of $\omega/2$ spectra
  - SRS is observed in extreme cases only
- NIF
  - only absolute and convective SRS is observed ($E_{SRS} \leq 5\%$)
    - near $n_c/4$: $L_n < 700\ \mu m$, $T_e \sim 3$ to 5 keV, $I_{single\ quad} \geq 5 \times 10^{13}$ W/cm^2
    - sub-$n_c/4$ SRS may be multibeam for a limited number of beams
    - TPD presence cannot presently be determined

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Collaborators

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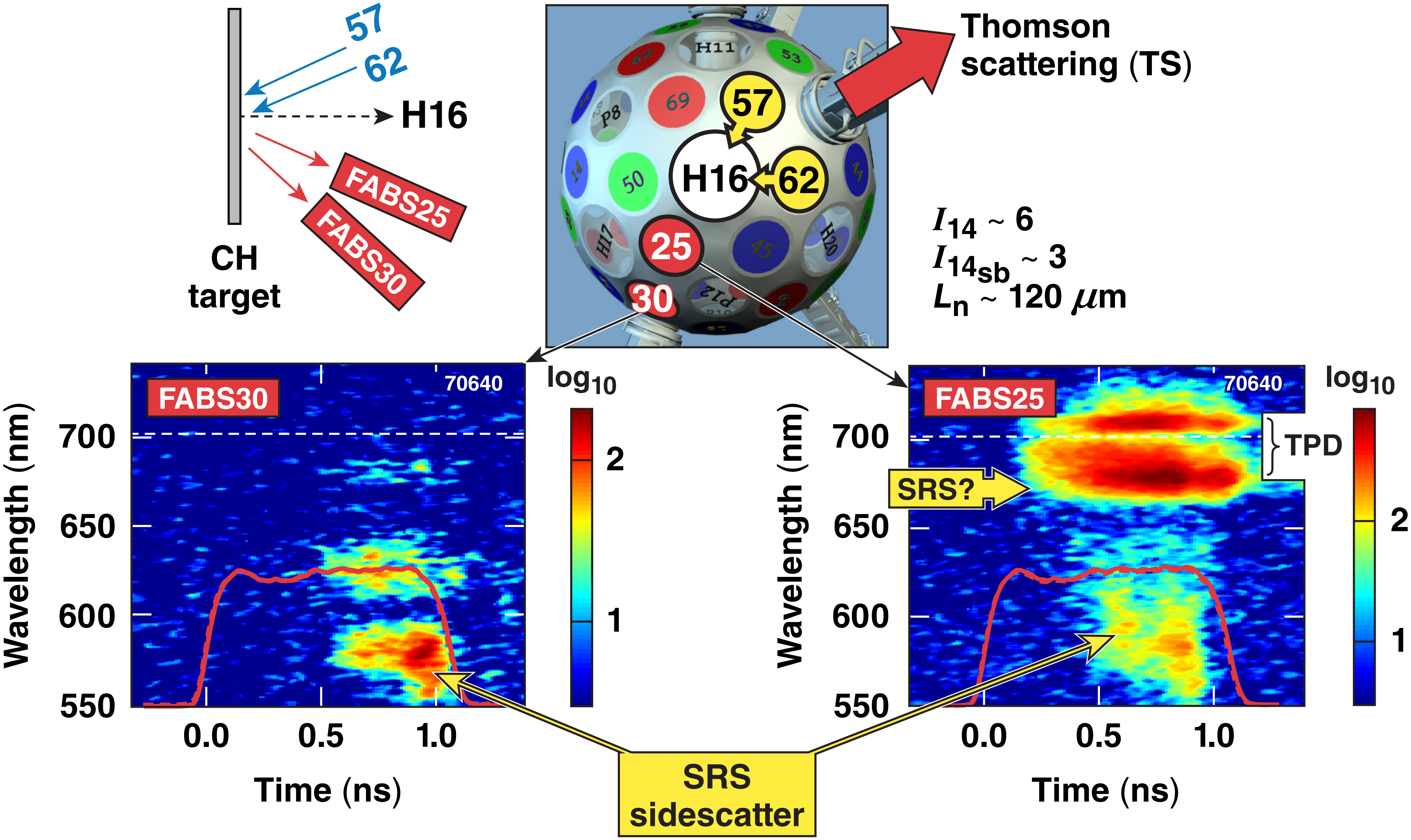
Evidence of TPD and SRS is observed on OMEGA in high-intensity planar-target shots



FABS: full-aperture backscatter station

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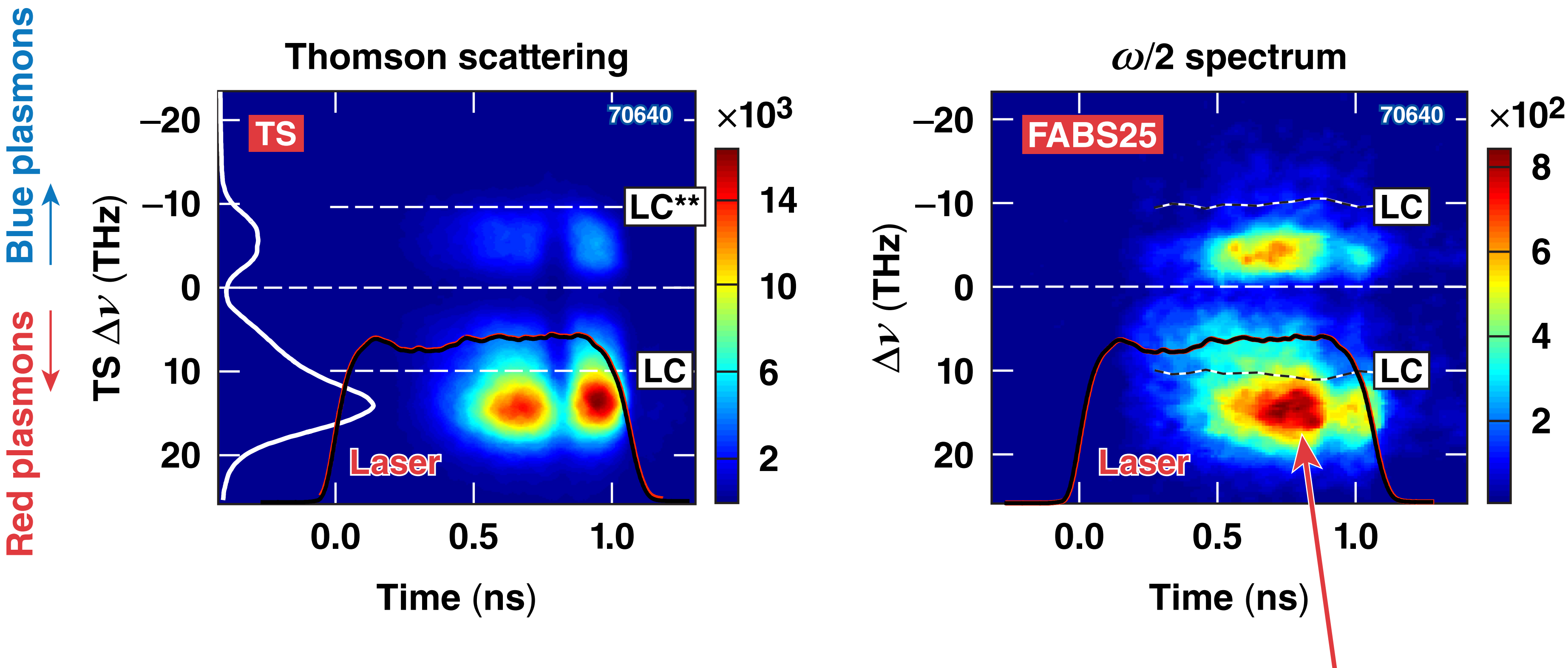
Thomson* and $\omega/2$ spectra taken at the same time are nearly identical and clarify some aspects of the $\omega/2$ spectra



Thomson probe: 263 nm
TS down-scattering off TPD plasmons to ~400 nm
Arranged to probe TPD plasmons

Thomson probe: 351 nm (drive beams) "self-scattering" off TPD plasmons

*R. K. Follett *et al.*, Phys. Rev. Lett. 116, 155002 (2016).
**LC: Landau cutoff

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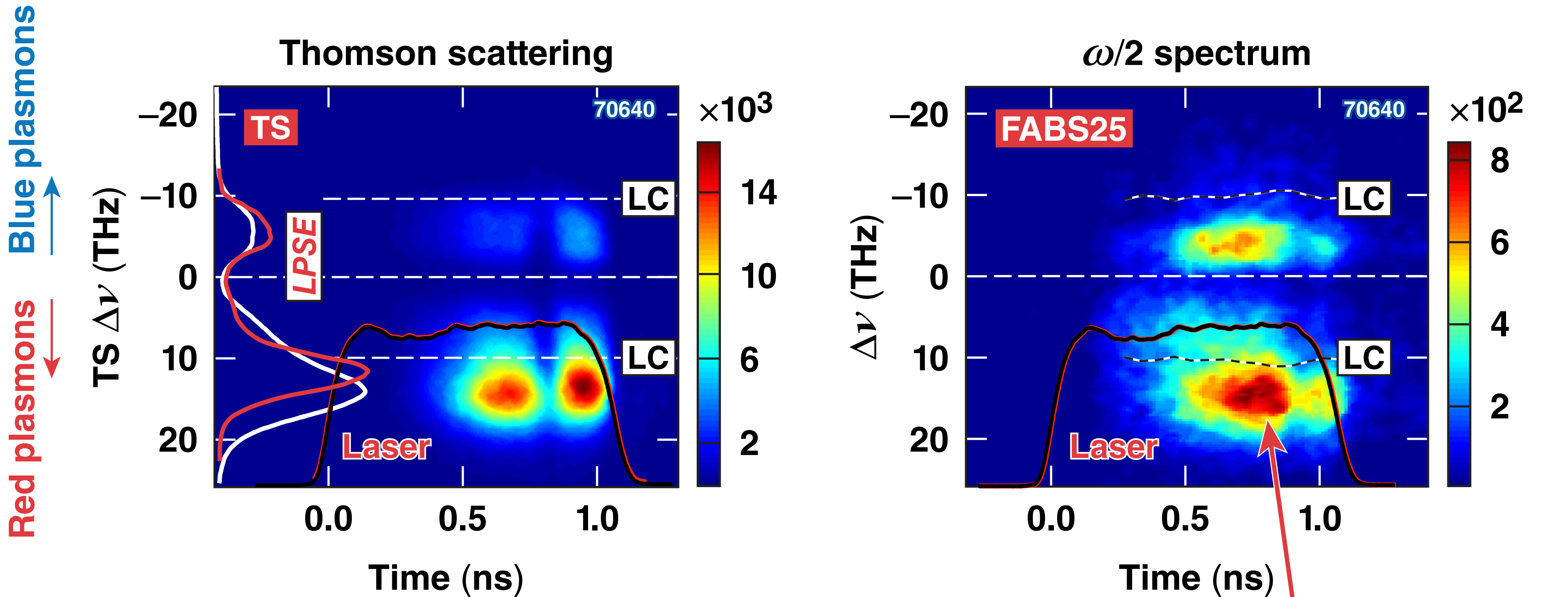
LPSE can predict Thomson-scattering spectra very well and therefore helps understand $\omega/2$ spectra



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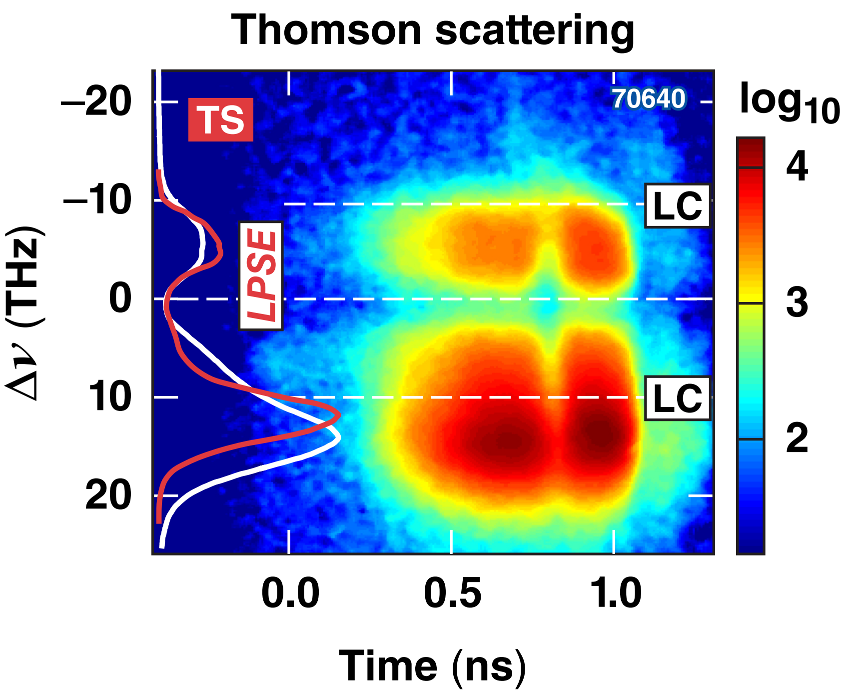
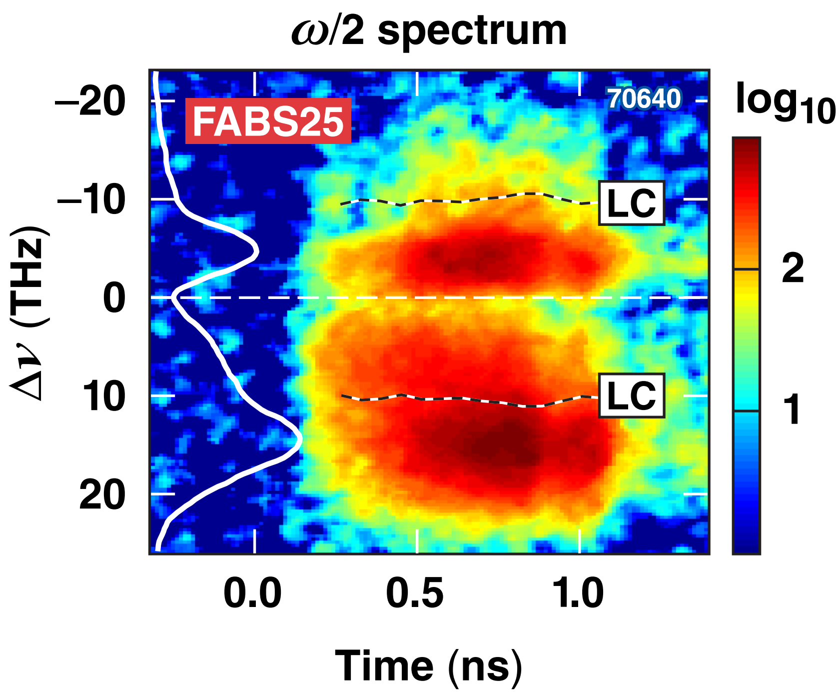
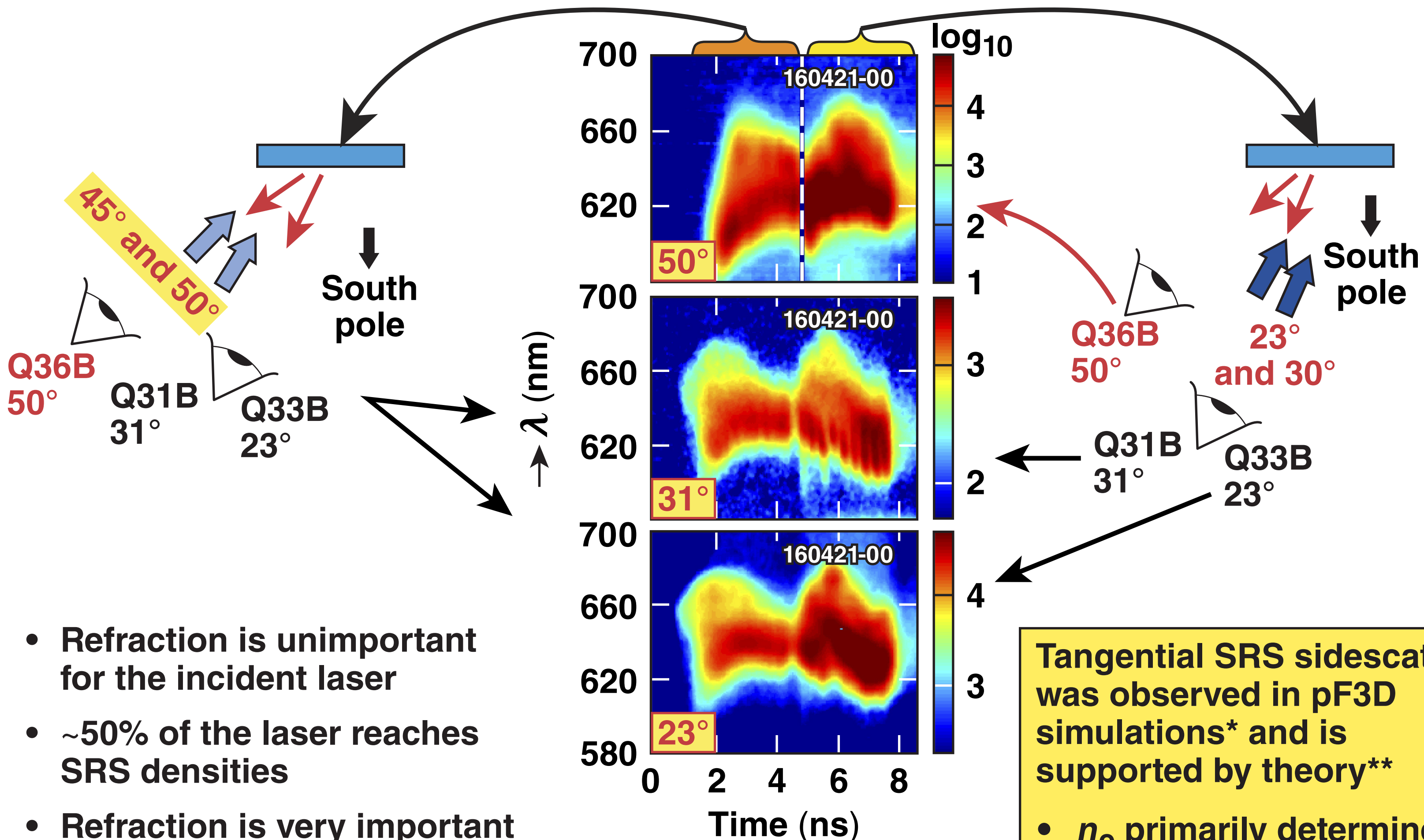
R. K. Follett *et al.*, Phys. Rev. Lett. 116, 155002 (2016).

LPSE simulations predict that "red" TPD plasmons are up-scattered to their Landau cutoff





NIF SRS spectra are observed at 23°, 31°, and 50° and identify SRS sidescattering is the dominant process



- Refraction is unimportant for the incident laser
- ~50% of the laser reaches SRS densities
- Refraction is very important for scattered light

Tangential SRS sidescattering was observed in pF3D simulations* and is supported by theory**

- n_e primarily determines λ_{SRS}

*P. A. Michel *et al.*, WeO-4, this conference.
**R. W. Short, A. V. Maximov, and W. Seka, WeO-6, this conference.

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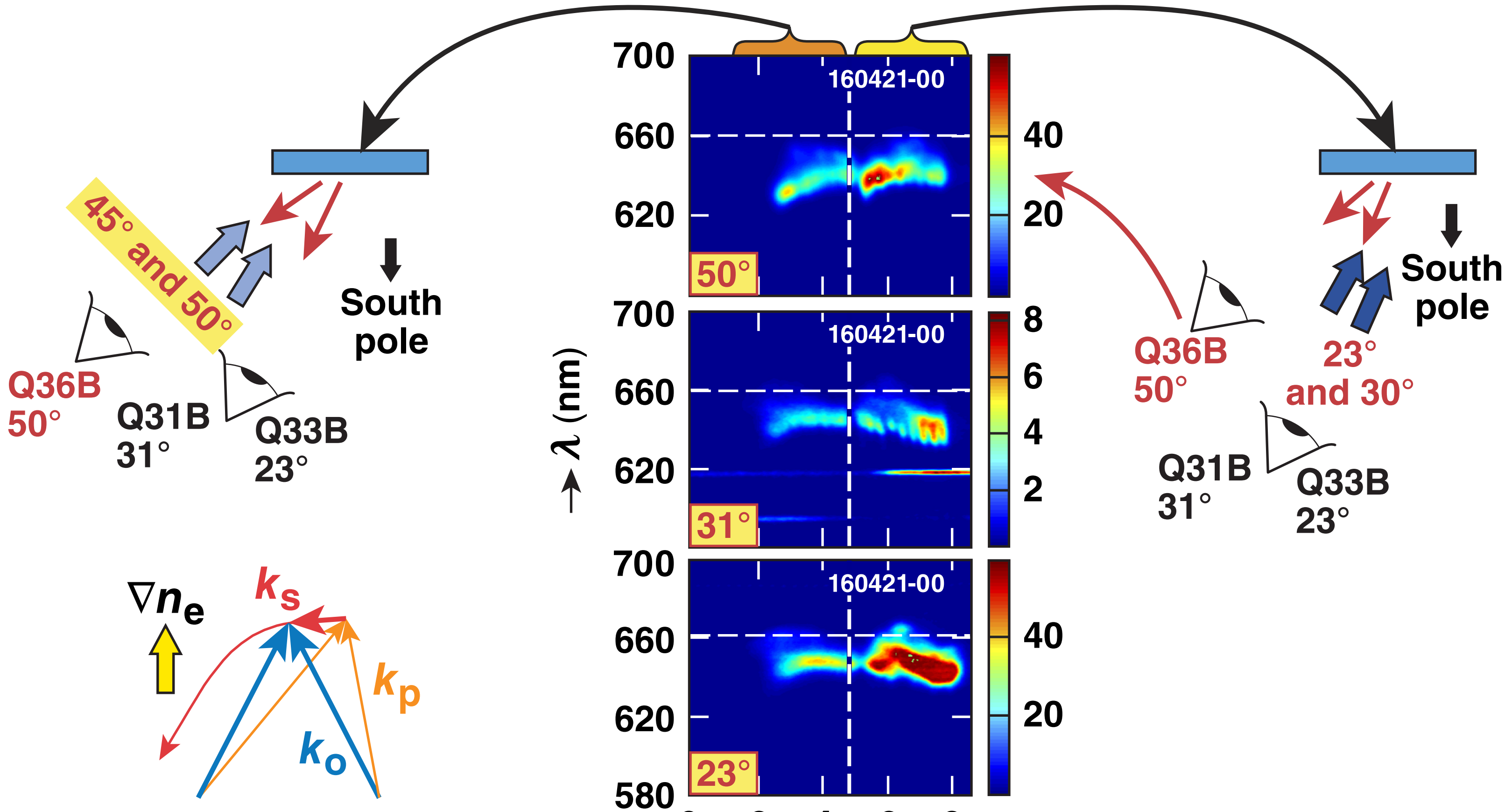
SRS spectra displayed on a linear scale indicate narrow and nearly constant density ranges for SRS



Multibeam SRS with shared electromagnetic waves normal to plane of two or more drive beams (*absolute instability)**

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*R. W. Short, A. V. Maximov, and W. Seka, WeO-6, this conference.

The total SRS emission can be estimated from measurements and simulations

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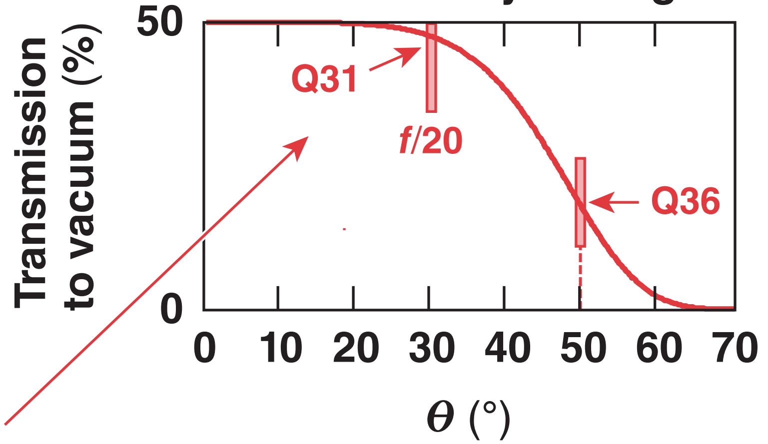
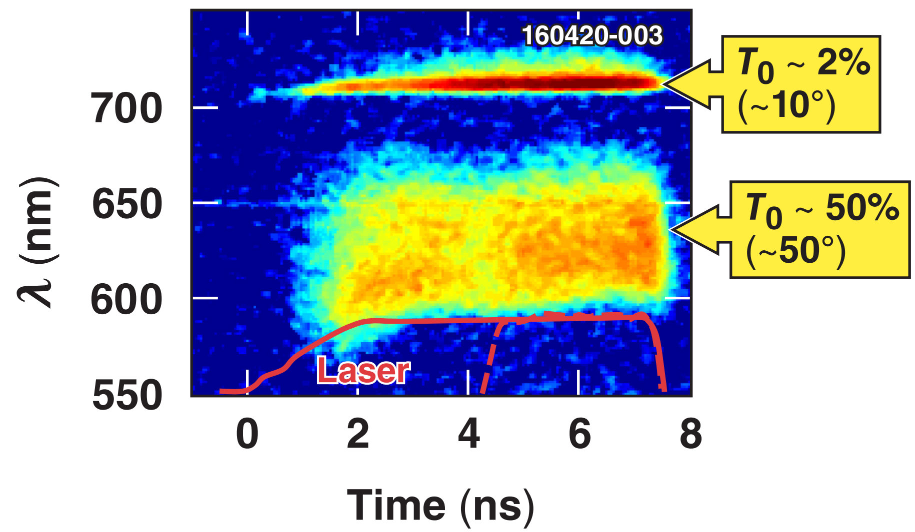
Estimates of total SRS energy of ~5% of incident for CH targets based on:

- Measured SRS energies (fast diodes)
- Measured spectra
- Polar angular distribution assumes SRS sidescattering and refraction as modeled with ray tracing using *DRACO* plasma parameters
- Assumed azimuthal symmetry based on sidescattering and large number of beam (quads)

630-nm polar distribution based on ray tracing





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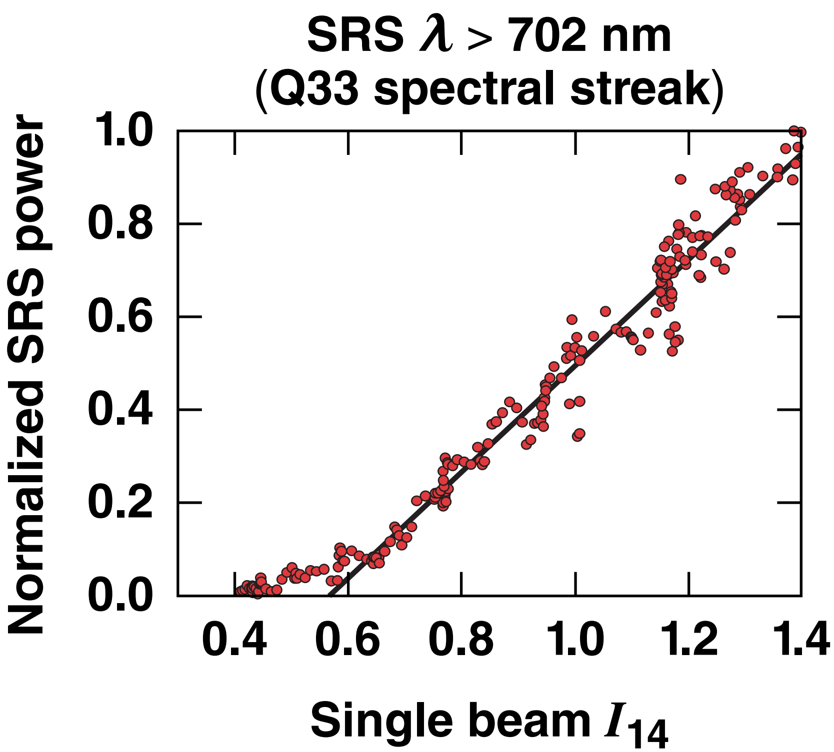
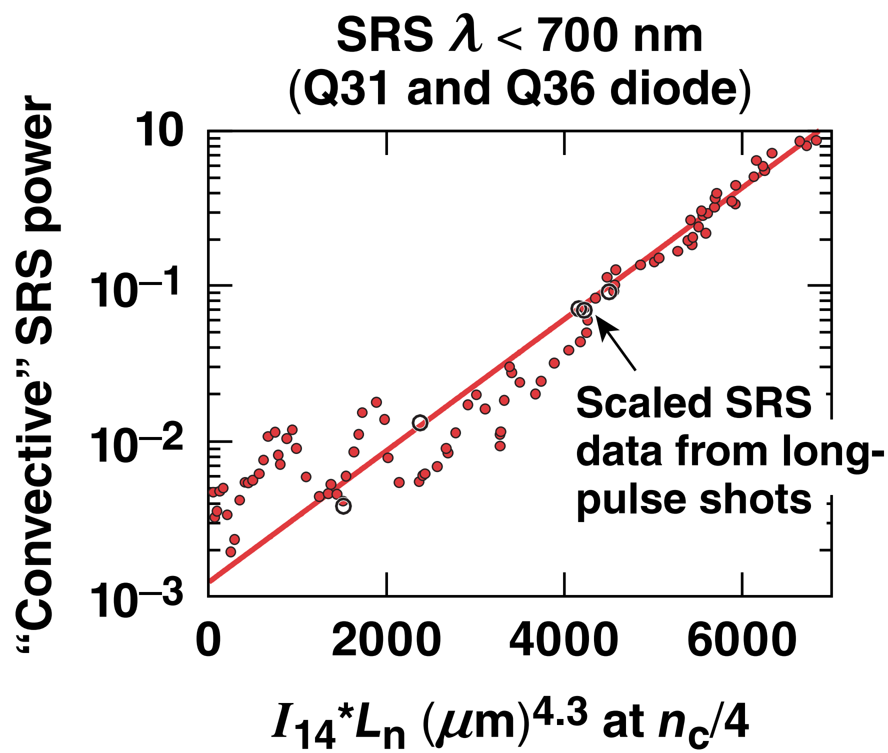
Conclusions from overall SRS observations

- **Absolute SRS accounts for ~30% of total SRS light**
- **Total SRS appears to reach ~5% of incident (~10% of light reaching interaction region)**
- **Below $n_c/4$, SRS appears to be dominated by tangential sidescattering (along isodensity surface → absolute instability)**
- **Absorption increases rapidly toward $n_c/4$ (down to ~2%)**
- **Refraction near $n_c/4$ is very strong**
- **“Raman gap” of the 1980s (*and now*) may really be an artifact of refraction and absorption**

Absolute SRS (>702 nm) scales linearly with incident laser power while sub-n_c/4 SRS scales exponentially

Data taken with linear ramp laser pulse, shot 161010-004





Saturated absolute instability

Unsaturated convective instability

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