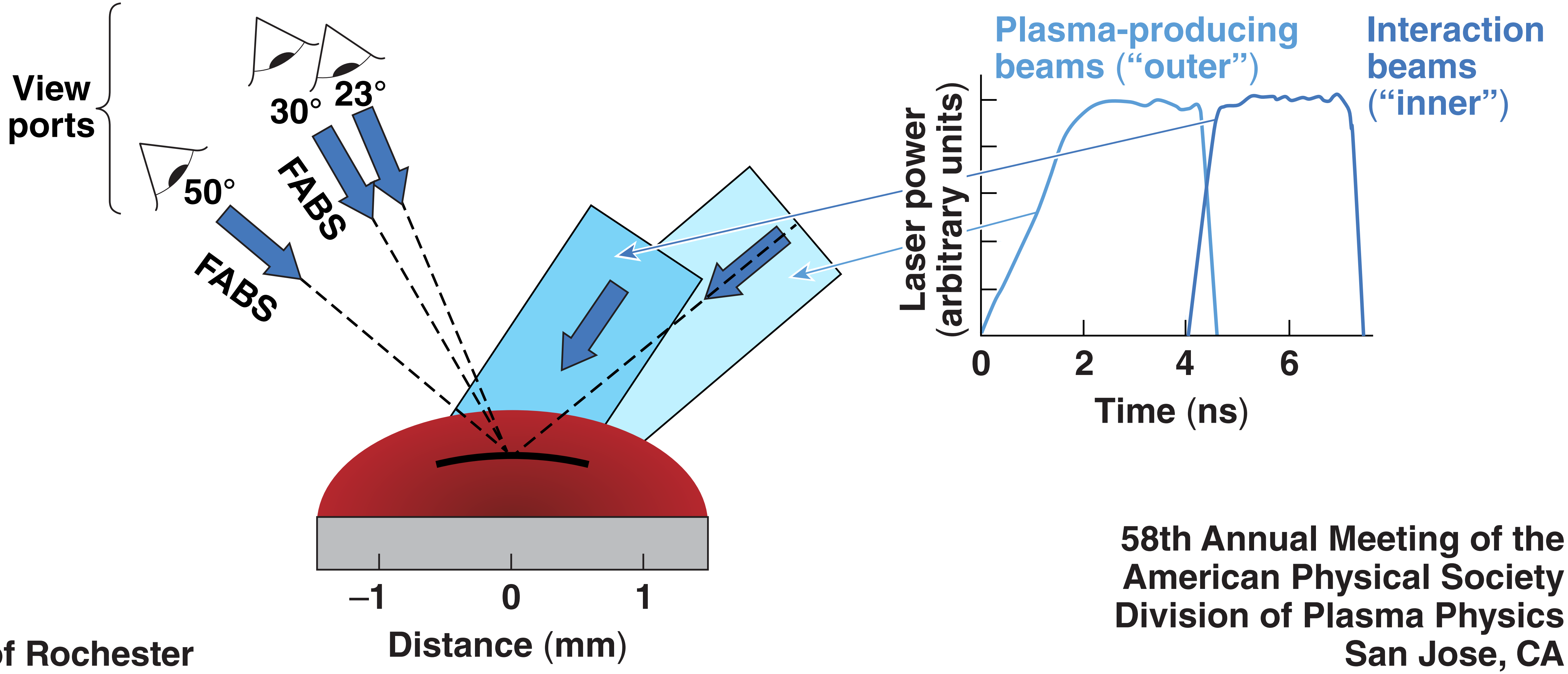
Stimulated Raman Scattering in Direct-Drive Inertial Confinement Fusion

Experiments carried out at the National Ignition Facility



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Summary

Absorption and refraction significantly affect stimulated Raman scattering (SRS) in National Ignition Facility (NIF) planar-target experiments

- Planar NIF experiments are SRS dominated
- SRS spectra are strongly affected by absorption and refraction
  - are predominantly caused by sidescattering
  - coronal T_e predictions match measurements using spectroscopy
- Estimates of total SRS levels ~5% of incident are based on simulations, ray-trace calculations, a few measurements, and large extrapolations

E25679

Collaborators

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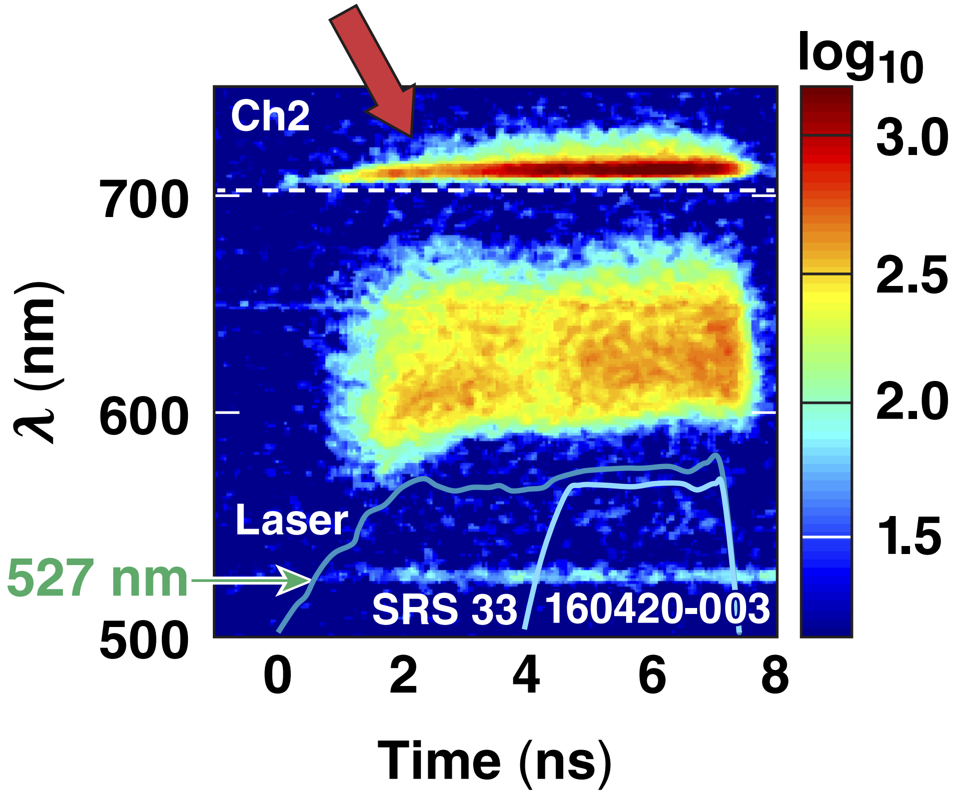
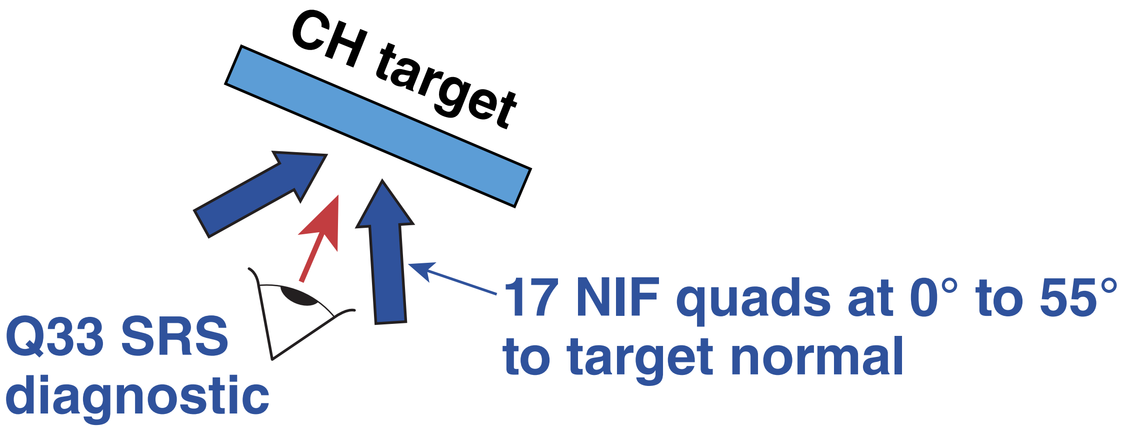
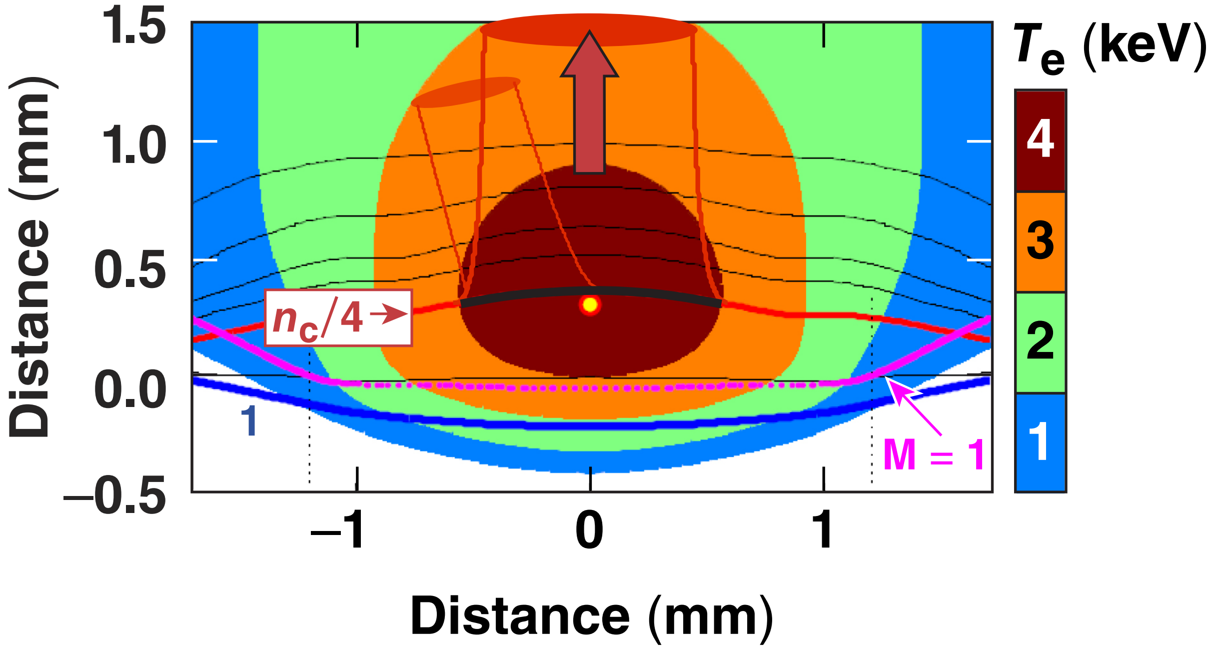
$\omega/2$ light (702 nm) from absolute SRS can escape at $\lesssim 18°$ from ∇n although with rapidly decreasing efficiency

- Absorption of $\omega/2$ light is high (>97%)
- Refraction severely limits the angular emission of $\omega/2$ light
- <u>Only a tilt of the target allows for $\omega/2$ light to be observed at NIF ports</u>







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The total absolute SRS emission can be estimated from ray trace and simulated plasma conditions

- Absorption of $\omega/2$ light is high (>97%)
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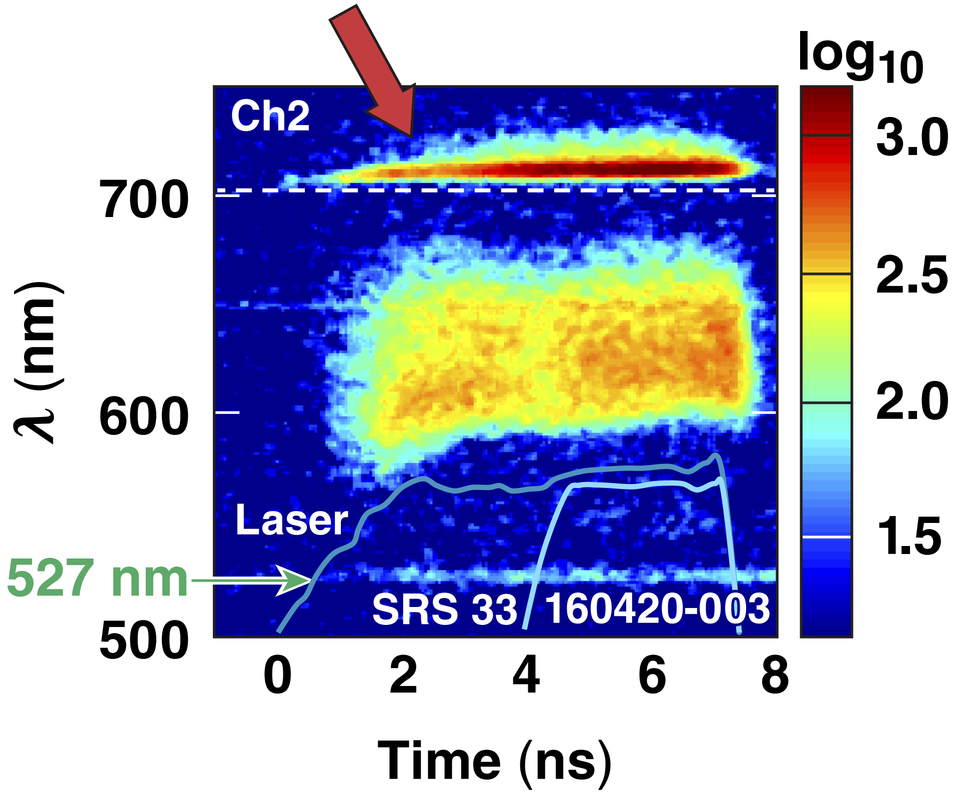

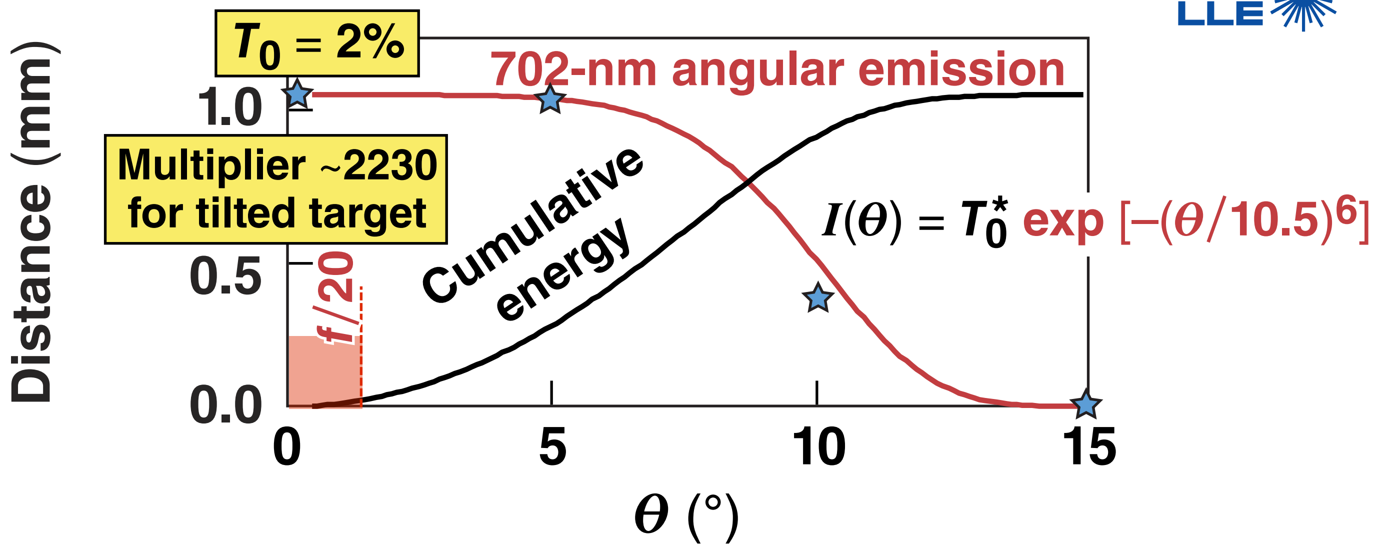

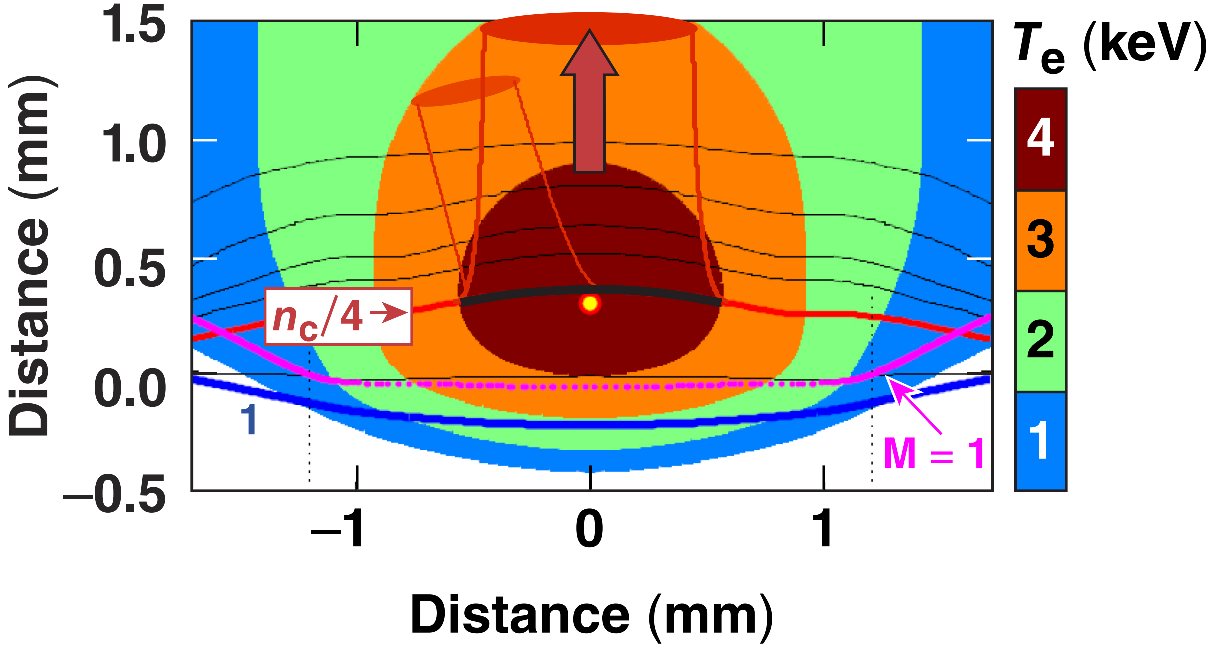

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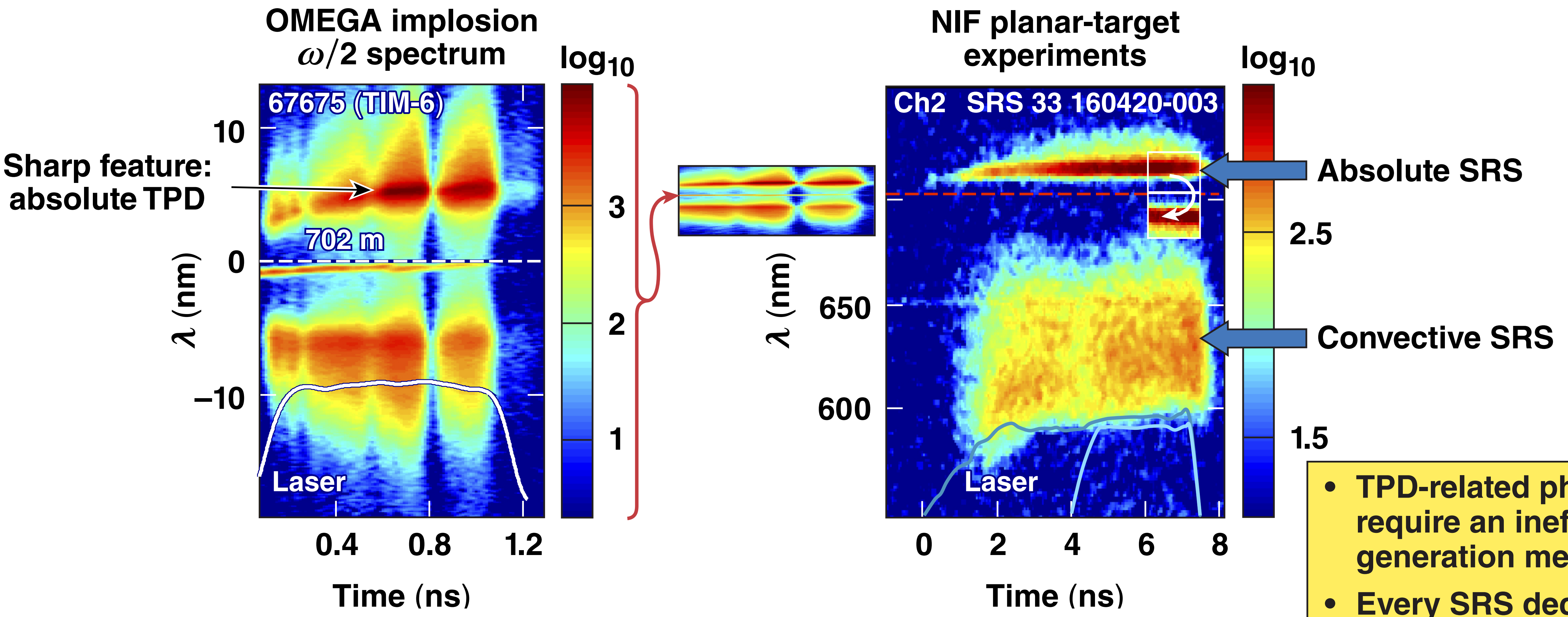
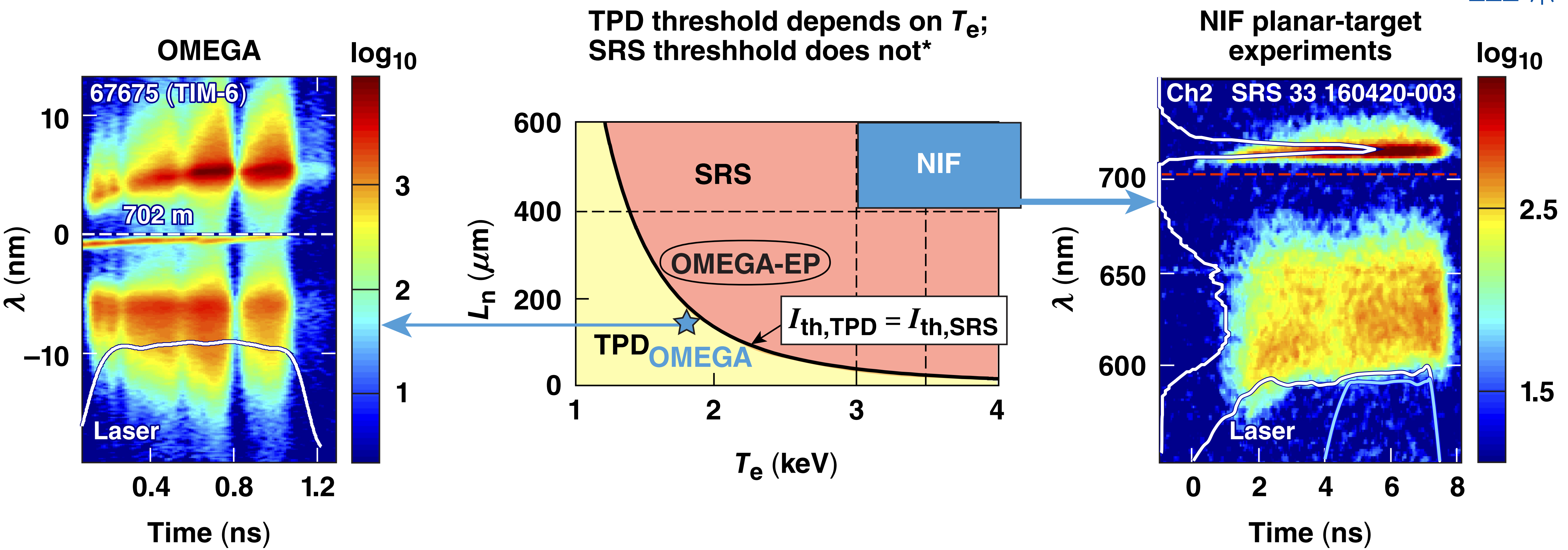
$\omega/2$ spectra in OMEGA implosions are a signature of two-plasmon decay (TPD), while on the NIF they represent the absolute SRS instability



- TPD-related photons require an inefficient generation mechanism
- Every SRS decay results in a scattered photon (100% efficiency)
- Absolute SRS may effectively suppress TPD

- The sharp, red-shifted spectral signature is a useful coronal T_e diagnostic
- Measured and *DRACO*-predicted electron temperature agree very well

Theory supports that NIF planar experiments are SRS-dominated, while the OMEGA experiments are TPD-dominated



702-nm photon escape: ~2%
630-nm photon escape: ~50%

*R.W. Short, based on single-beam theory (private communication).

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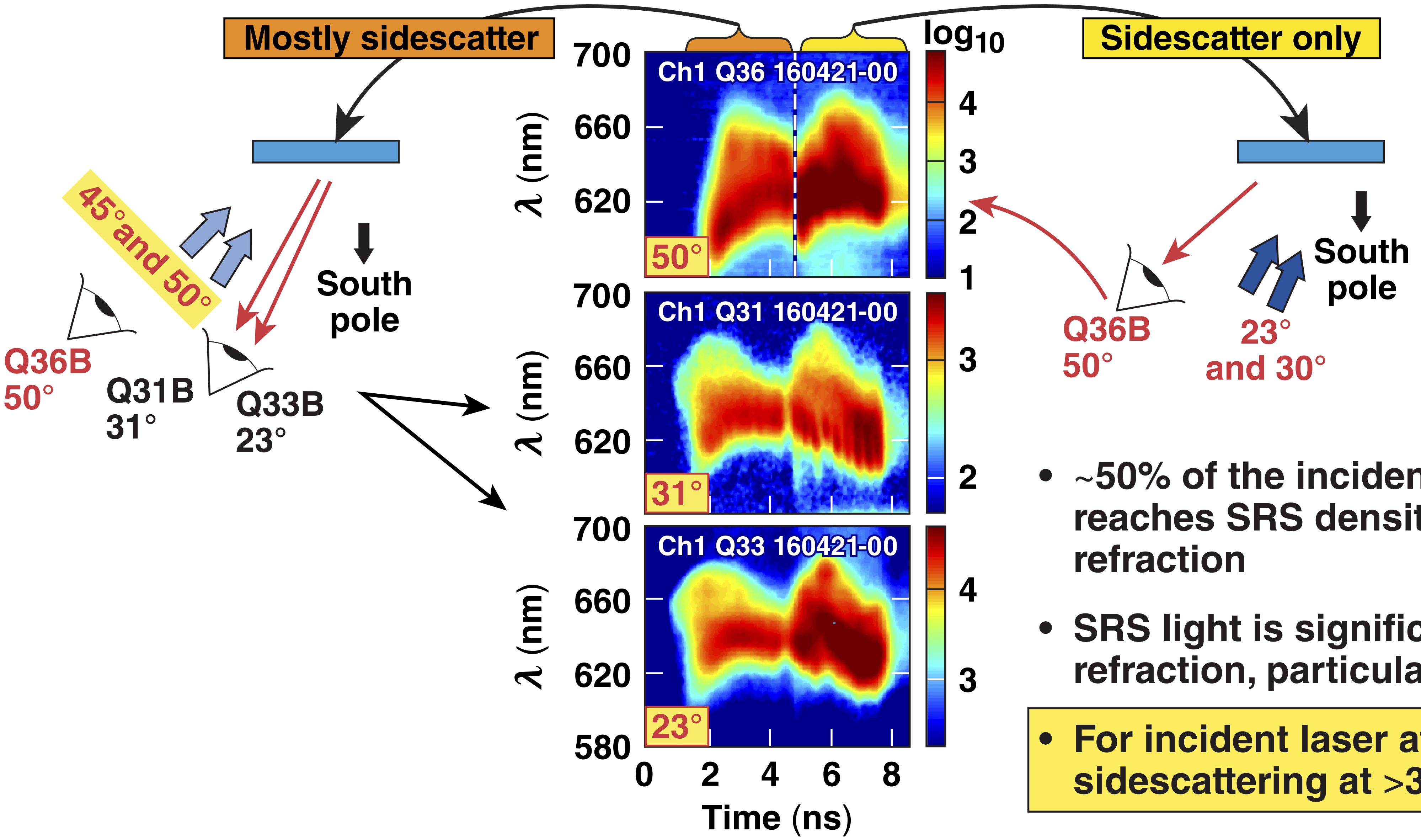
SRS spectra observed at 23°, 31°, and 50° indicate that SRS sidescattering dominates over backscattering



- ~50% of the incident laser radiation reaches SRS densities with minimal refraction
- SRS light is significantly affected by refraction, particularly at λ > 650 nm
- **For incident laser at 30°, local SRS sidescattering at >30° is required**

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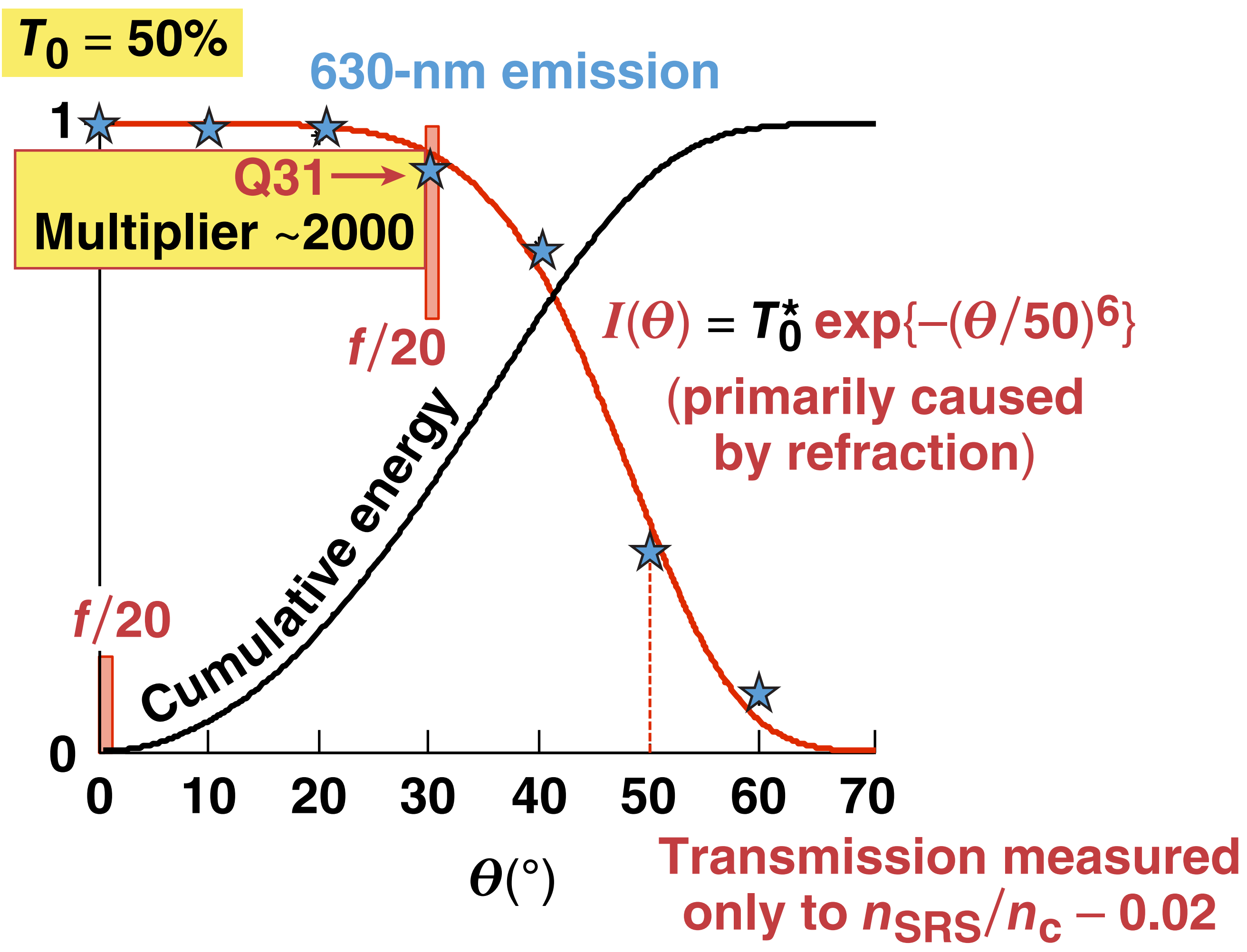
The total SRS emission can be estimated from measurements and simulations

- Estimates of total SRS energy of ~5% of incident (CH target shot 160406) and
  - measured SRS energies (fast diodes)
  - measured spectra
  - assuming sidescattering as deduced from ray trace using *DRACO* plasma parameters

Because SRS energy measurements are restricted on the NIF to two (non-optimal) locations, the extrapolations are problematic but still useful.



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Absorption and refraction significantly affect stimulated Raman scattering (SRS) in National Ignition Facility (NIF) planar-target experiments

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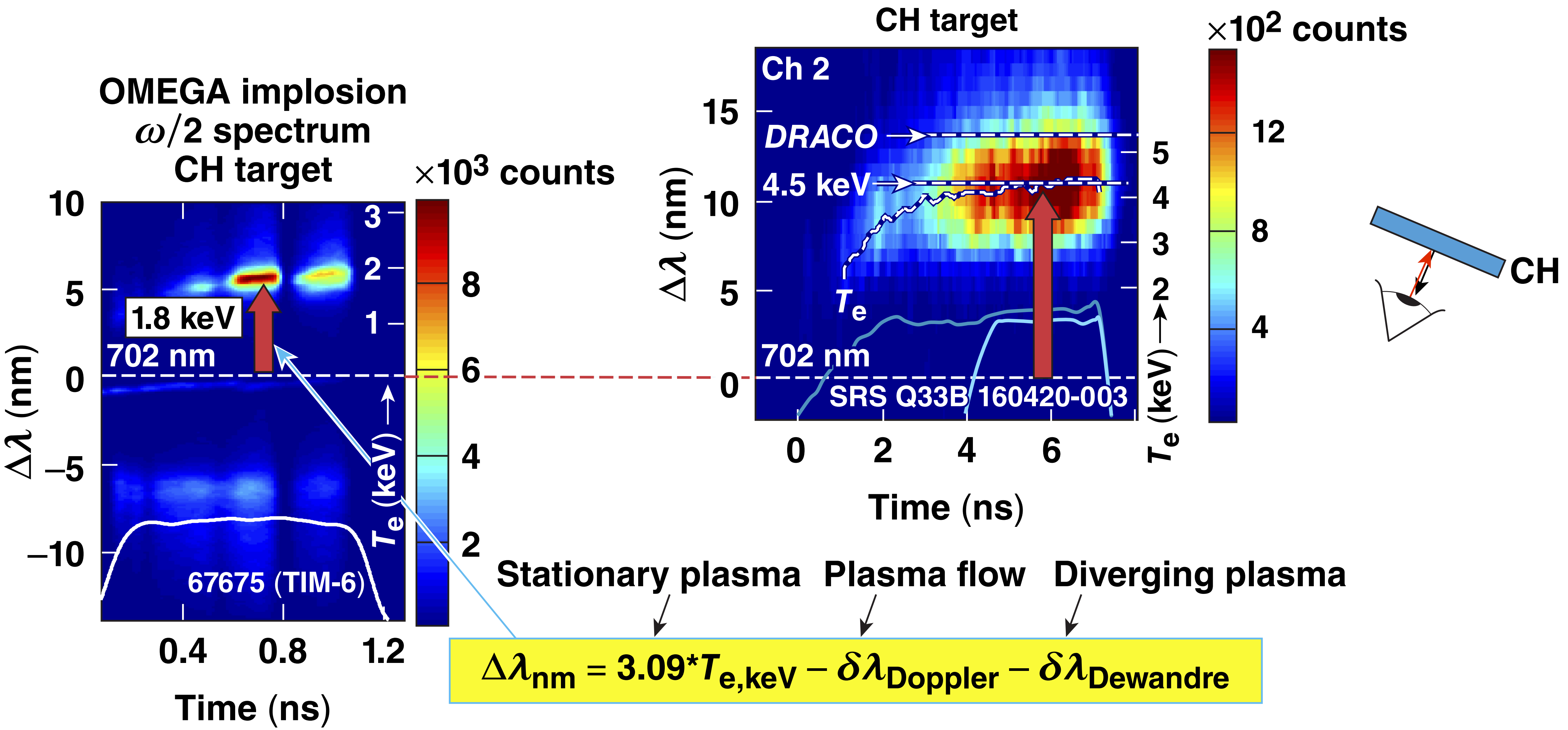
$\omega/2$ spectral shifts can be used for coronal T_e measurements

NIF planar-target experiments ($\omega/2$ spectra)



Stationary plasma Plasma flow Diverging plasma

$$\Delta\lambda_{\mathrm{nm}} = 3.09^{*}T_{\mathrm{e,keV}} - \delta\lambda_{\mathrm{Doppler}} - \delta\lambda_{\mathrm{Dewandre}}$$