Interplay of Raman Scattering and Two-Stream Flux Inhibition in Hohlraum Dynamics (new)

Talk CO5.9

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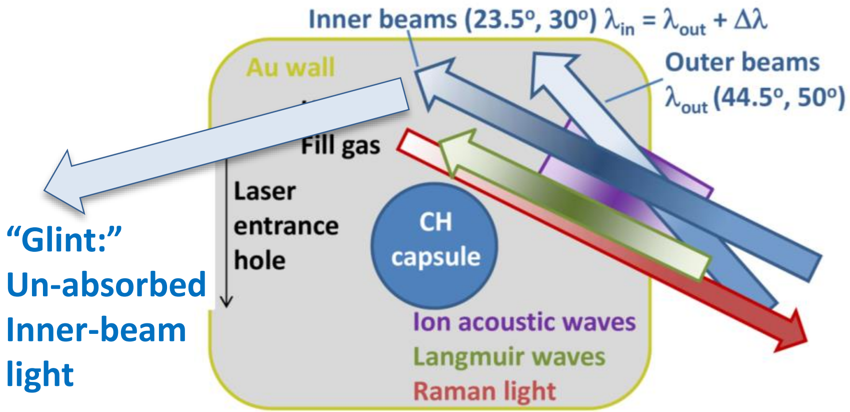
Inner-beam "glint[1]" recently appreciated as possible significant energy loss from NIF hohlraums



"Inline" LPI models[2] in hydro codes:

- **Cross-Beam Energy Transfer (CBET)**
  - Outer → Inner + ion acoustic wave
- **Stimulated Raman scattering (SRS)**
  - Langmuir wave heating
  - SRS light absorption (minor)

Hohlraum energetics:

- Laser coupled to hohlraum = Incident – Backscatter – Transmitted
- Transmitted = "Glint" = (1-absorption)*(inner power after LPI)
- Inner power after LPI = Incident + CBET from outers – BS – Langmuir and SRS heating

[1] D. Turnbull, P. Michel, J. E. Ralph, L. Divol, et al., *Phys. Rev. Lett.* (2015)
[2] D. J. Strozzi, D. S. Bailey, P. Michel, L. Divol, S. M. Sepke, G. D. Kerbel, et al., *Phys. Rev. Lett.* (submitted)

Summary: "two-stream" thermal flux limit reduces CBET to inner beams and enhances glint

- Glint = (1-absorption)*(inner power after LPI)
- Inner power after LPI = Incident + CBET from outers – (Langmuir and SRS heating)

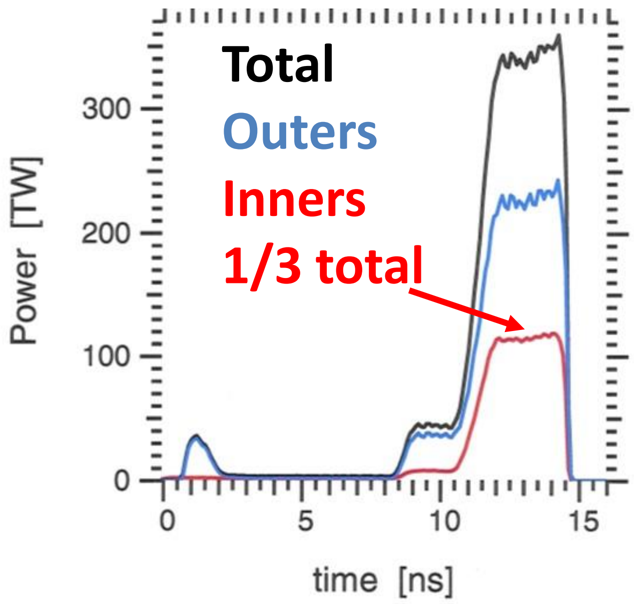
Langmuir heating or two-stream → Hotter electrons, but different places → less CBET → less glint; less absorption → more glint (compete)

Compared to Base case	Langmuir heating	Two-stream	Both – closest to drive, shape data
Electron Temp.	Up in LEH	Up throughout fill	Way up in LEH
CBET to inners	Down	Down	Way down
Glint	Down a bit	Way up	Up
X-ray bangtime	+140 ps	+1100 ps	+640 ps, ~ experiment

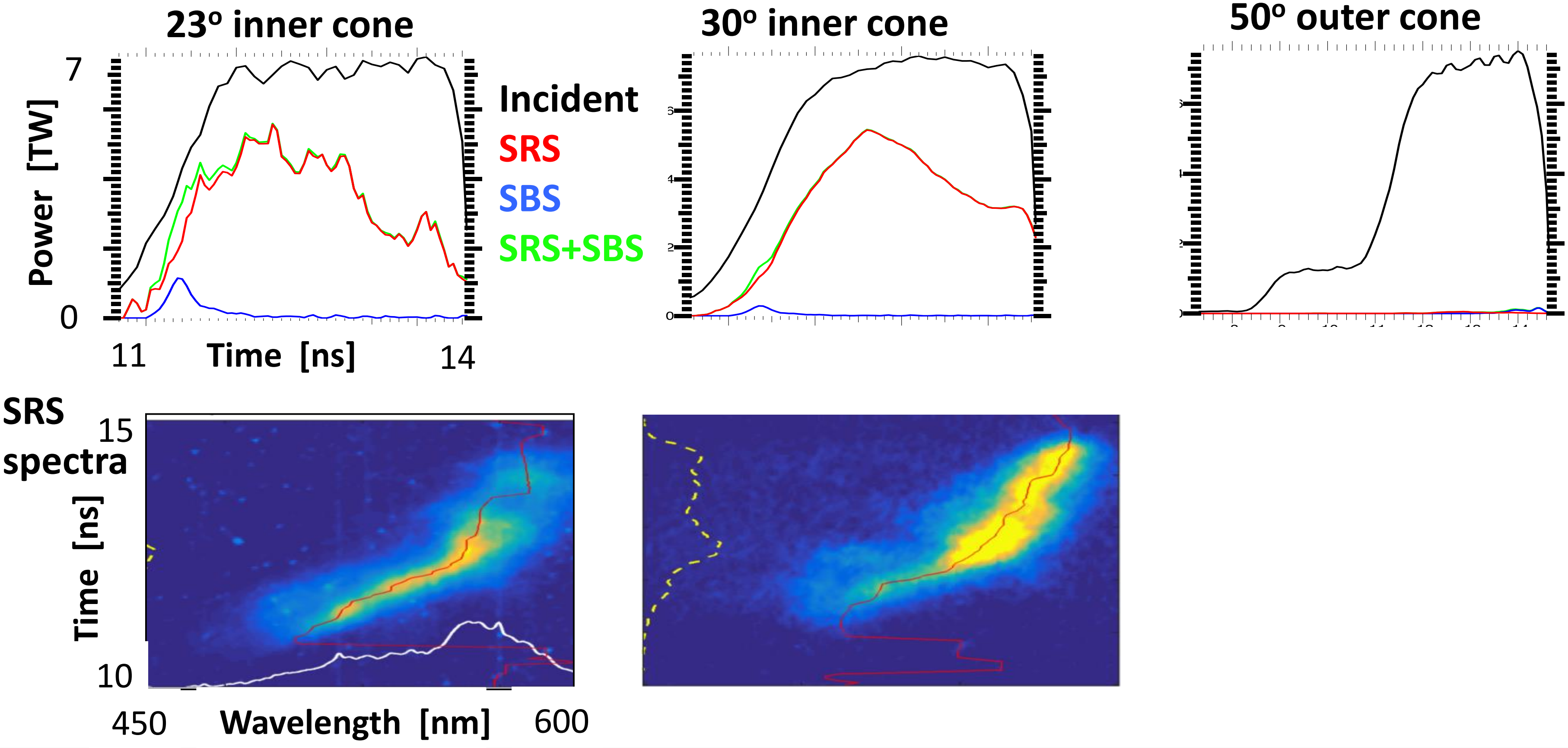
We model with Lasnex NIF shot N121130: early “high-foot” plastic symmetry capsule

- E_{laser} = 1270 kJ P_{laser} = 350 TW
- $(\lambda_{23}, \lambda_{30}) - \lambda_{out}$ = (8.5, 7.3) Ang.
- CBET to inners: tune polar P2 shape
- CBET to 23’s: tune azimuthal M4 shape
- Fill 1.45 mg/cc He
- Gold hohlraum: “575 scale”

Incident laser power



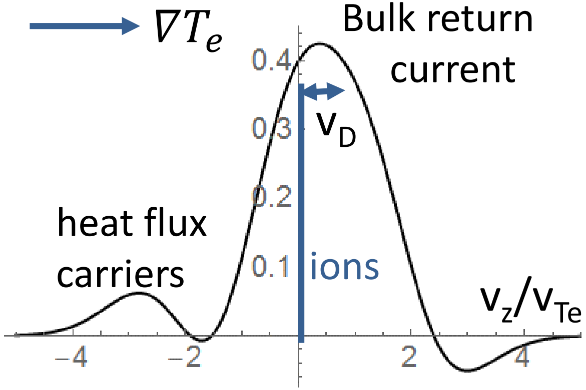
Inputs to runs: measured SRS power and maximum wavelength



Lasnex two-stream flux limit: crude return current instability model

- Spitzer-Harm heat flux carried by e- with (2-4)v_{Te}
- Zero net current → bulk electrons drift vs. ions

Electron distribution



Ion acoustic drift instability if:

- v_D > sound speed
- Growth rate exceeds ion Landau damping → $ZT_e/T_i \gg 1$

q = e- heat flux = min($f^* n_e T_e v_{Te}$, q_{SH})

f = flux limit

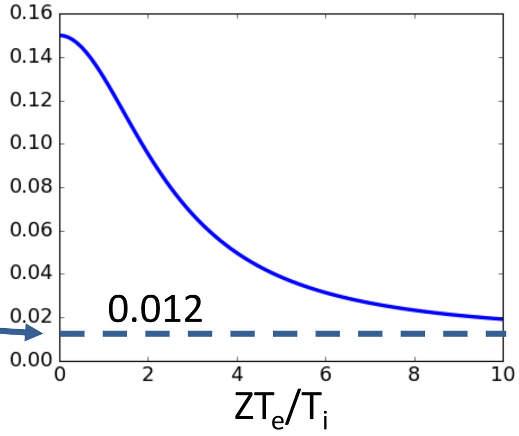
f_0 = user-specified = 0.15 here

$$f^{-1} = f_0^{-1} + \frac{a^2}{1 + a^2\left(\frac{Zm_e}{m_i}\right)^{1/2}}$$ TS

$$f = \left(\frac{Zm_e}{m_i}\right)^{1/2}, \quad a = \frac{ZT_e}{T_i} \gg 1$$

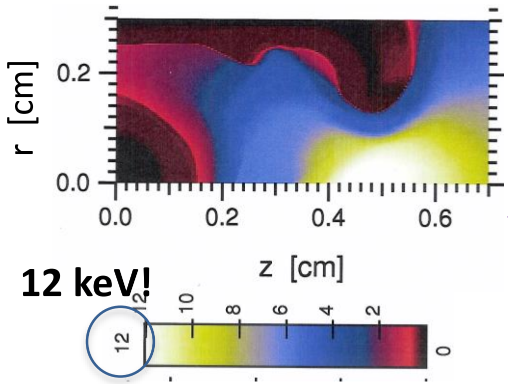
→ $q = n_e T_e c_{sound}$

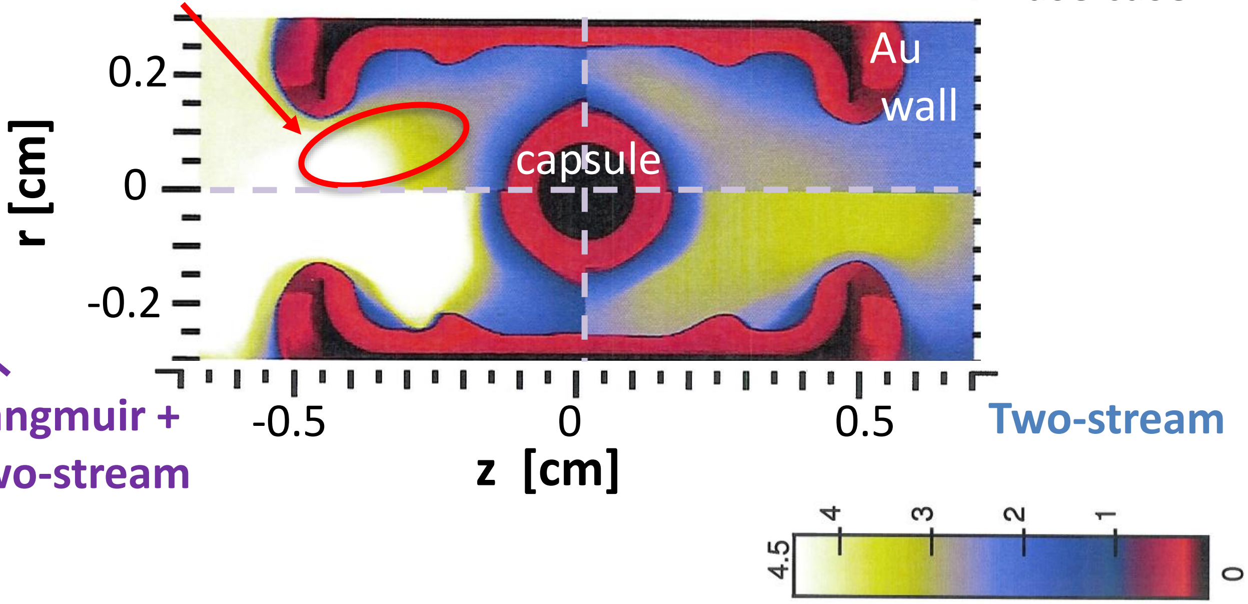
f for Z/A = 0.25, e.g. Z=50 Au



Two-stream flux limit increases fill temperature – especially with Langmuir heating

Electron temperature [keV] at 13 ns – mid peak power



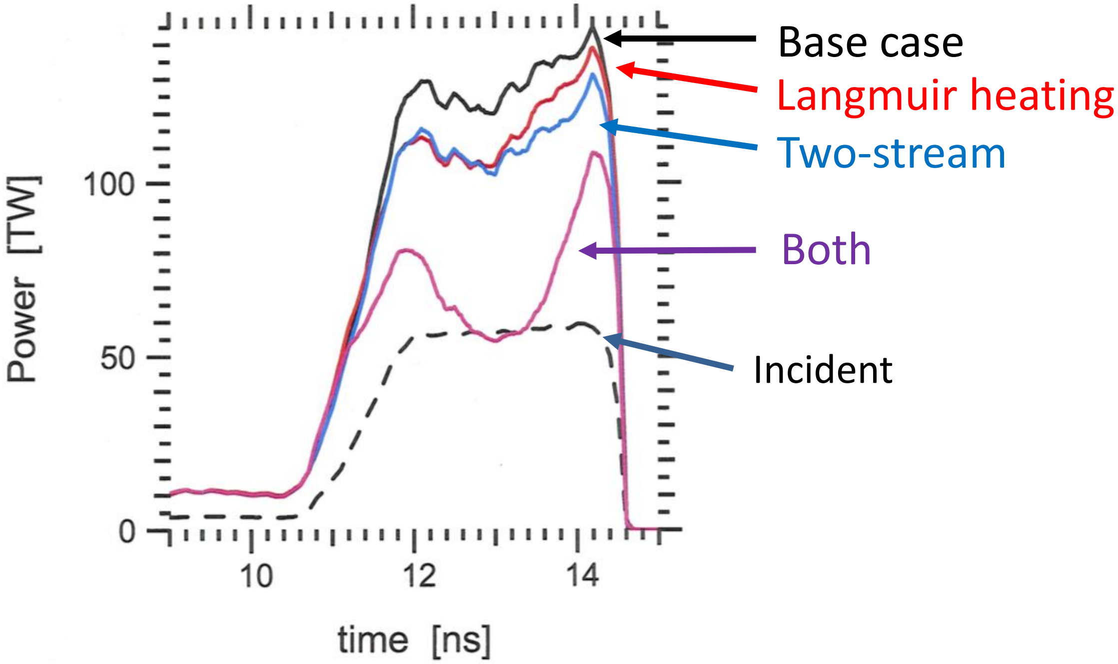


High T_e reduces CBET and laser absorption

[1]D. J. Strozzi et al., *Phys. Rev. Lett.* (submitted)

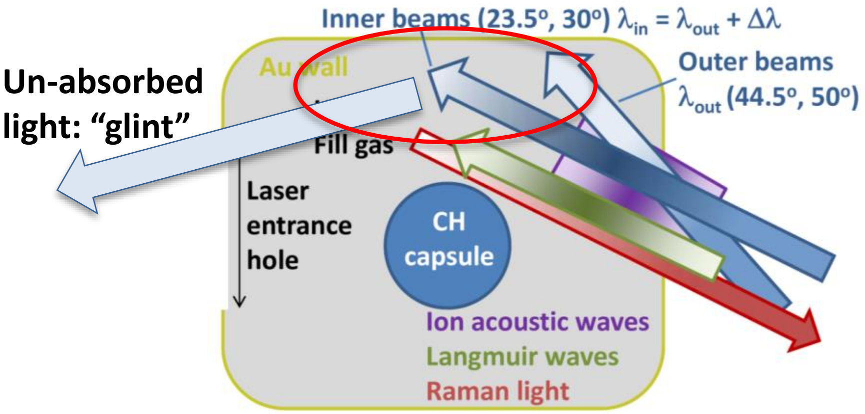
Langmuir heating and two-stream both reduce CBET to inners – strong synergy

Inner-cone power:
Incident + CBET – escaping backscatter

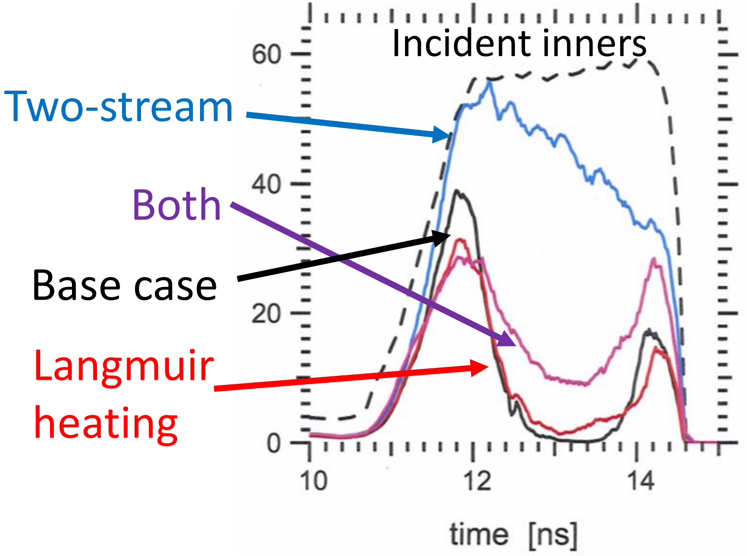


Two-stream flux limit reduces laser absorption: "enhanced glint"

Enhanced Glint



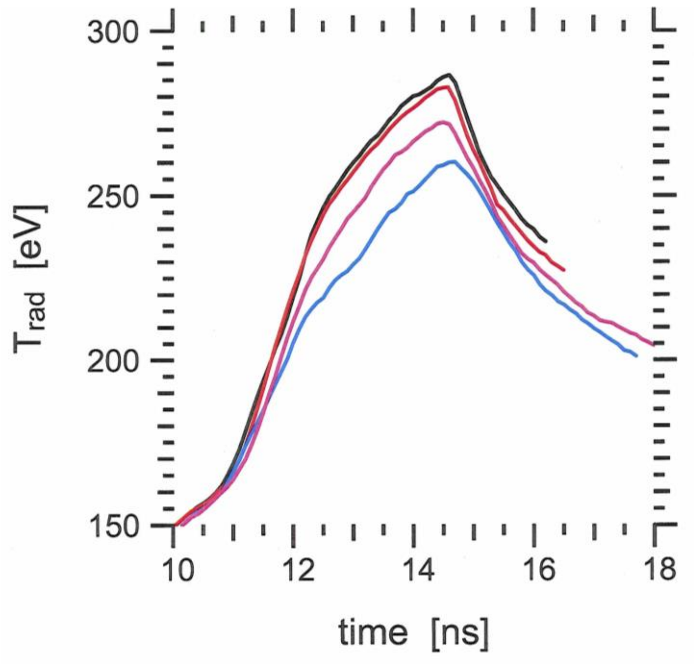
Glint: escaping laser power [TW]



L. J. Suter sees similar enhanced glint with low flux limit:
O. S. Jones: UI3.3 - Thursday 3:00 pm

Two-stream flux limit: enhanced glint reduces total drive

Radiation temperature on capsule



x-ray bangtime: experiment – simulated [ps]

Base case: +650

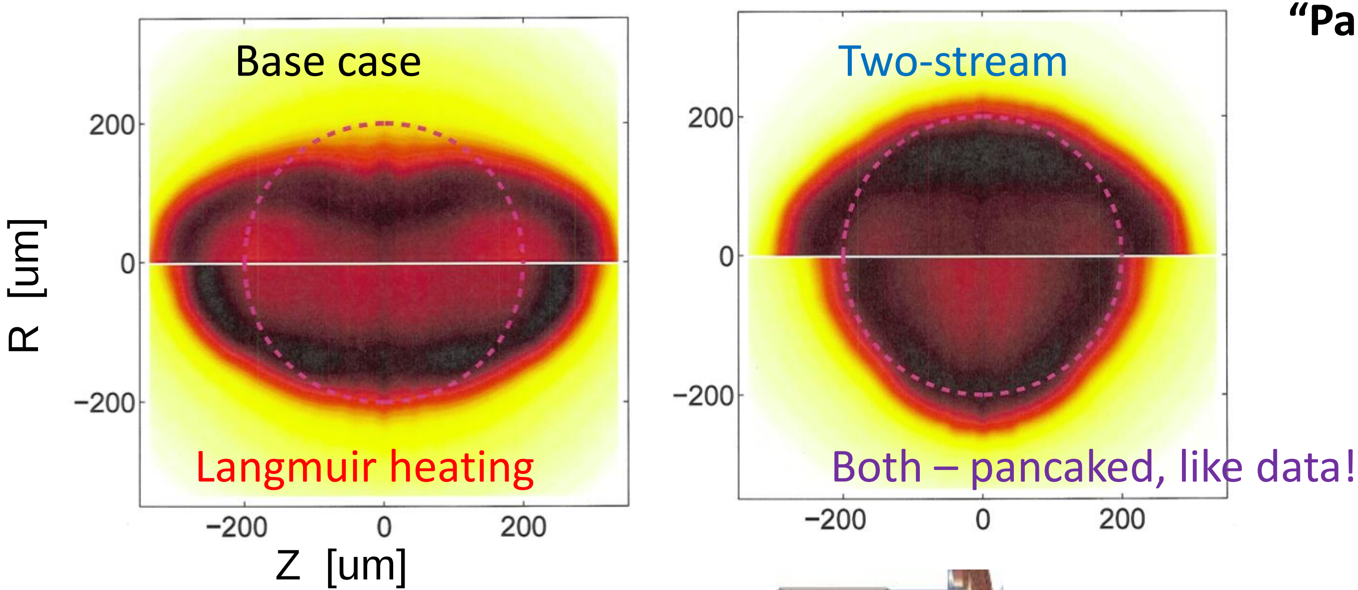
Langmuir heating: +510

Both: +10 matches experiment!

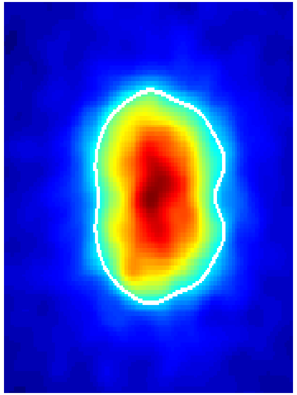
Two-stream: -450

Capsule shape combines CBET, Langmuir heating, and glint

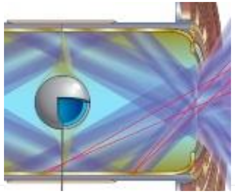
Simulated x-ray radiograph: "2D Convergent Ablator"



Measured x-ray self emission: "Pancaked", P_2/P_0 = -0.12



Hohlraum axis



Conclusion: two-stream flux limit increase fill temperature, reduces CBET to inners, enhances glint, reduces x-ray drive

Future work

- Glint in SBS data – blueshifted light: reflect off inward-moving wall
- T_e data: “micro-dot” (M. Barrios, CO5.1 this session), optical Thomson Scattering (~FY17)

- Improved model for return current instability
- Other flux inhibiters:
  - Nonlocal electron transport (J. Brodrick, CO5.11 this session)
  - MHD (W. Farmer, CO5.7 this session)
  - And their interplay

- SRS Langmuir waves → suprathermal or “hot” electrons:
  - Instead of fluid heating
  - SRS-driven currents and B fields