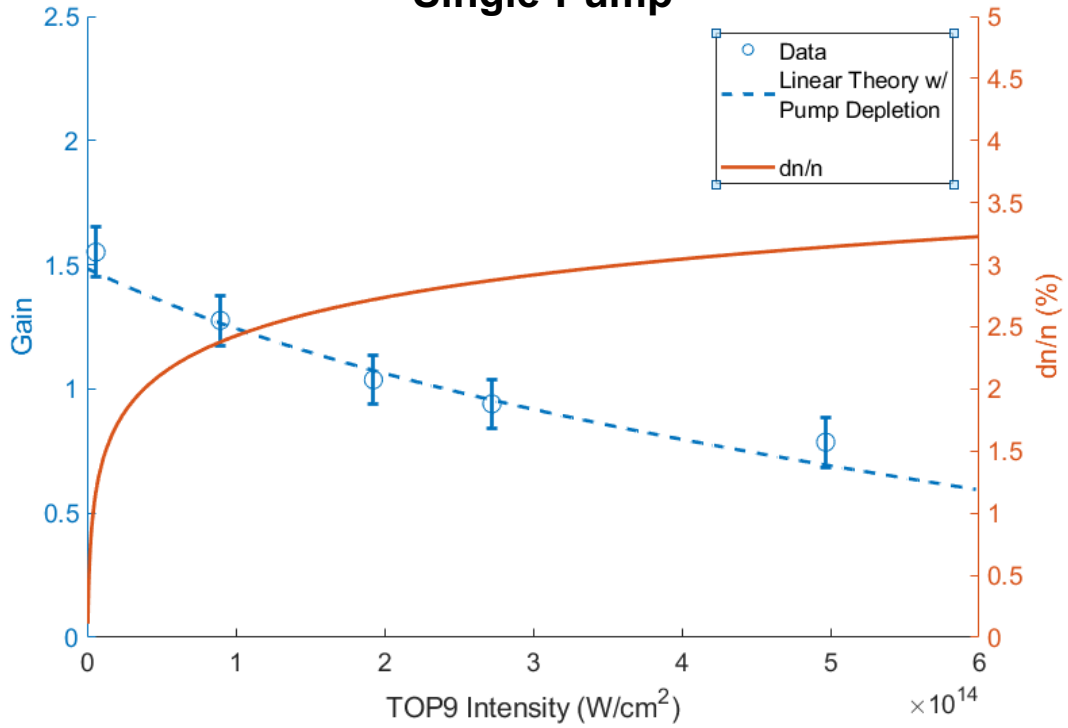
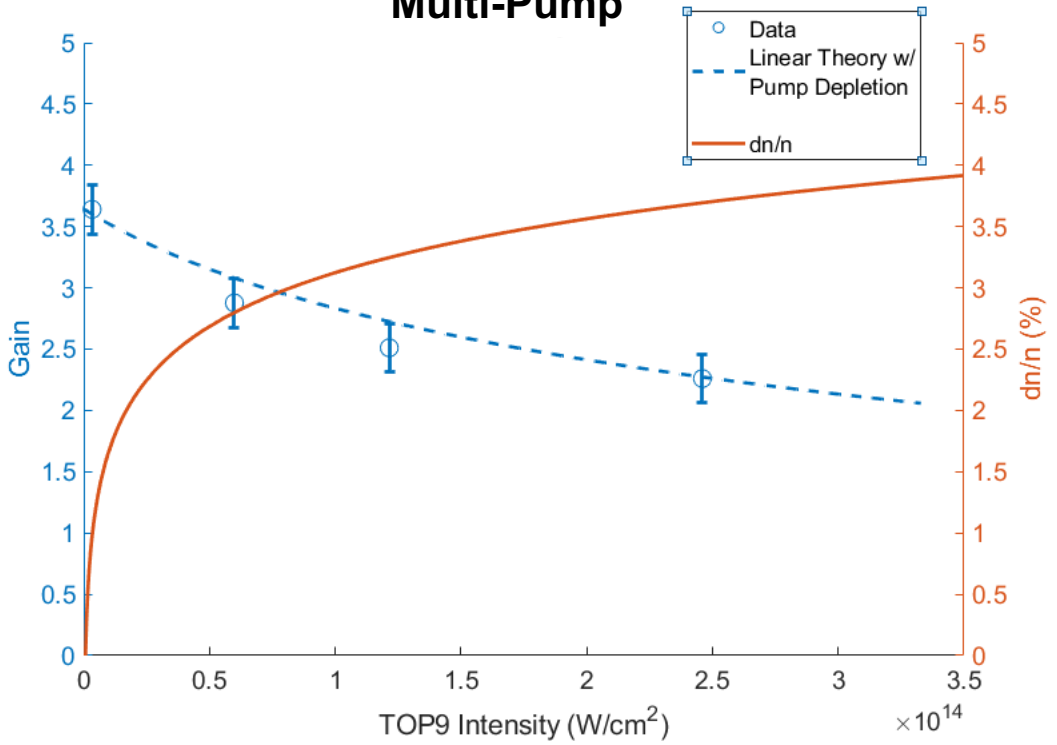
Cross-Beam Energy Transfer Experiments at High Ion-Acoustic Wave Amplitudes

Single-Pump



Multi-Pump



A. M. Hansen
Physics Department
University of Rochester
Laboratory for Laser Energetics

61st Annual Meeting of the APS DPP
Fort Lauderdale, FL
October 21-25, 2019

Summary

Crossed-beam energy transfer (CBET) was measured at high ion-acoustic wave amplitudes in single- and multi-beam configurations and was found to agree well with linear theory

- **The OMEGA LPI platform was utilized to study CBET using the Tunable OMEGA Port 9 (TOP9) laser**
- **Varied laser intensities scaled ion-wave amplitudes from dn/n < 1% up to dn/n ~ 3%**
- **Measurements of CBET gain were found to agree well with linear models and VPIC simulations**
- **Raytrace simulations were performed to predict ion wave amplitudes in a full scale 3D model**

Collaborators

**D. Turnbull, R. K. Follett, J. Katz, A. L. Milder,
J. P. Palastro, K. L. Nguyen, D. Mastrosimone, and D. H. Froula**

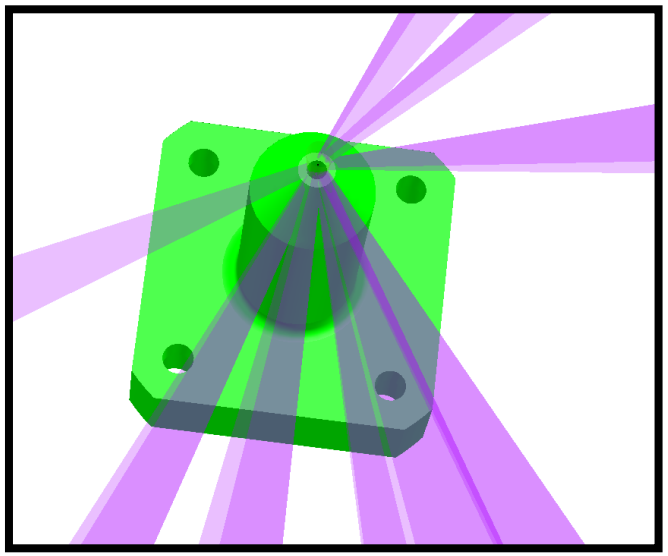
**University of Rochester
Laboratory for Laser Energetics**

L. Yin, B. Albright

Los Alamos National Laboratory

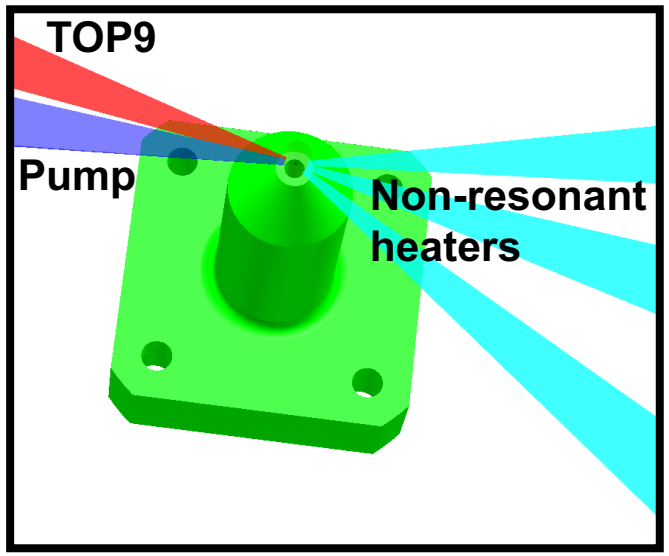
The OMEGA LPI Platform uses a gas jet along with 9 UV heater beams to form a large scale uniform plasma target

0 - 500 ps



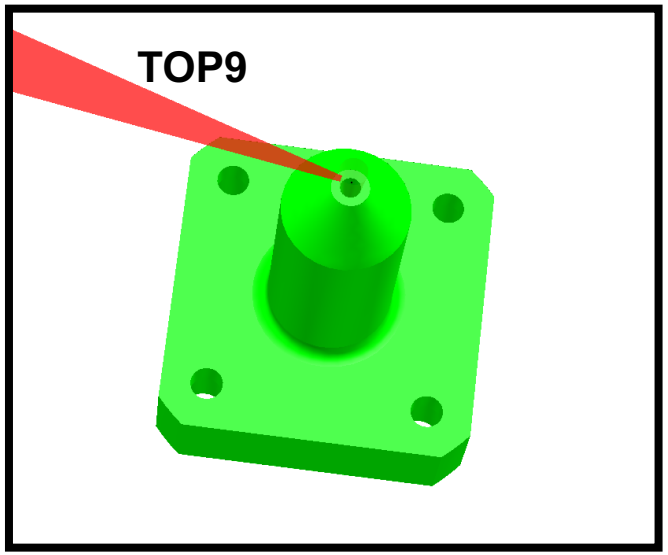
Plasma formation with heater beams in 55/45 H_2/N_2 gas mixture

600 - 1100 ps



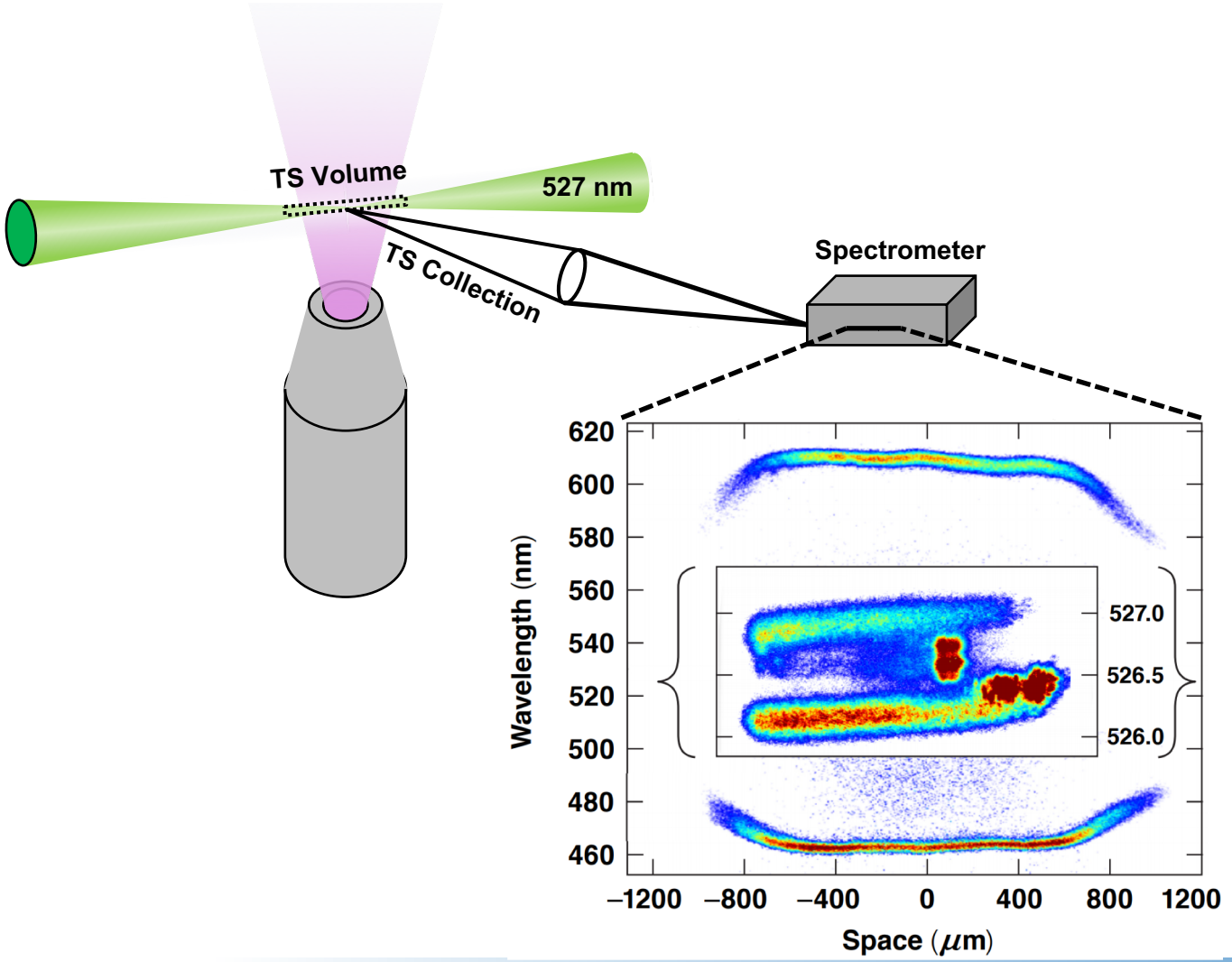
CBET interaction

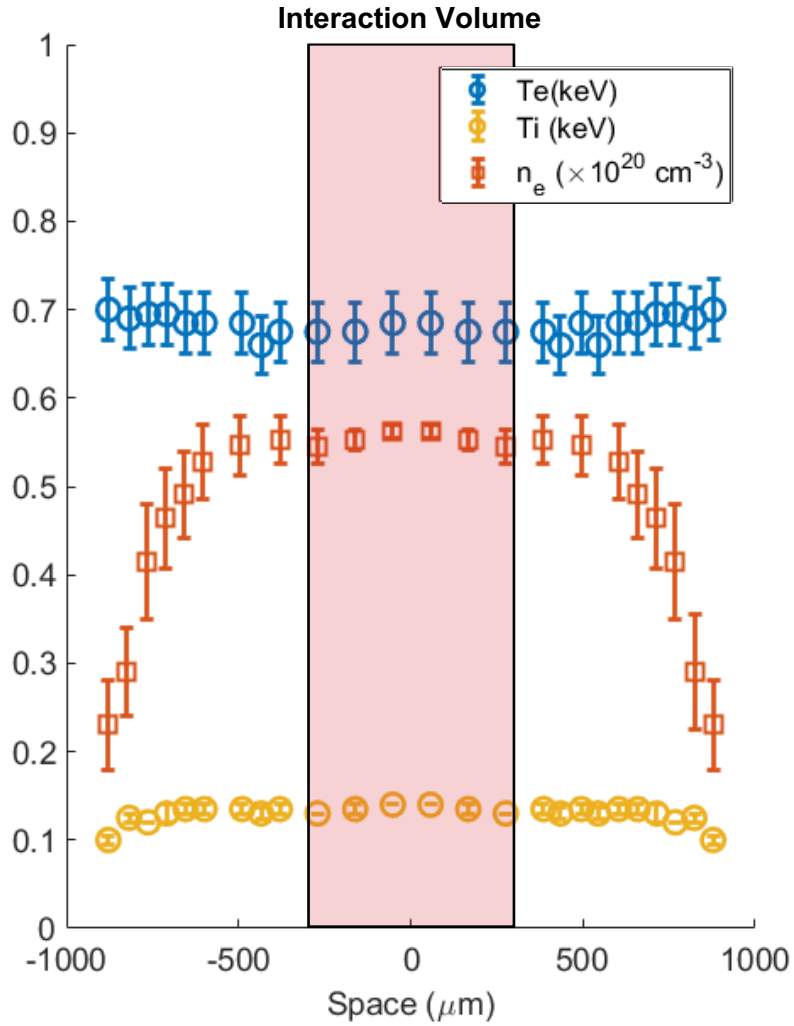
1100 - 3000 ps



TOP9 transmission measurement

The target plasma was characterized in space using imaging Thomson-scattering and found to be uniform over the interaction volume

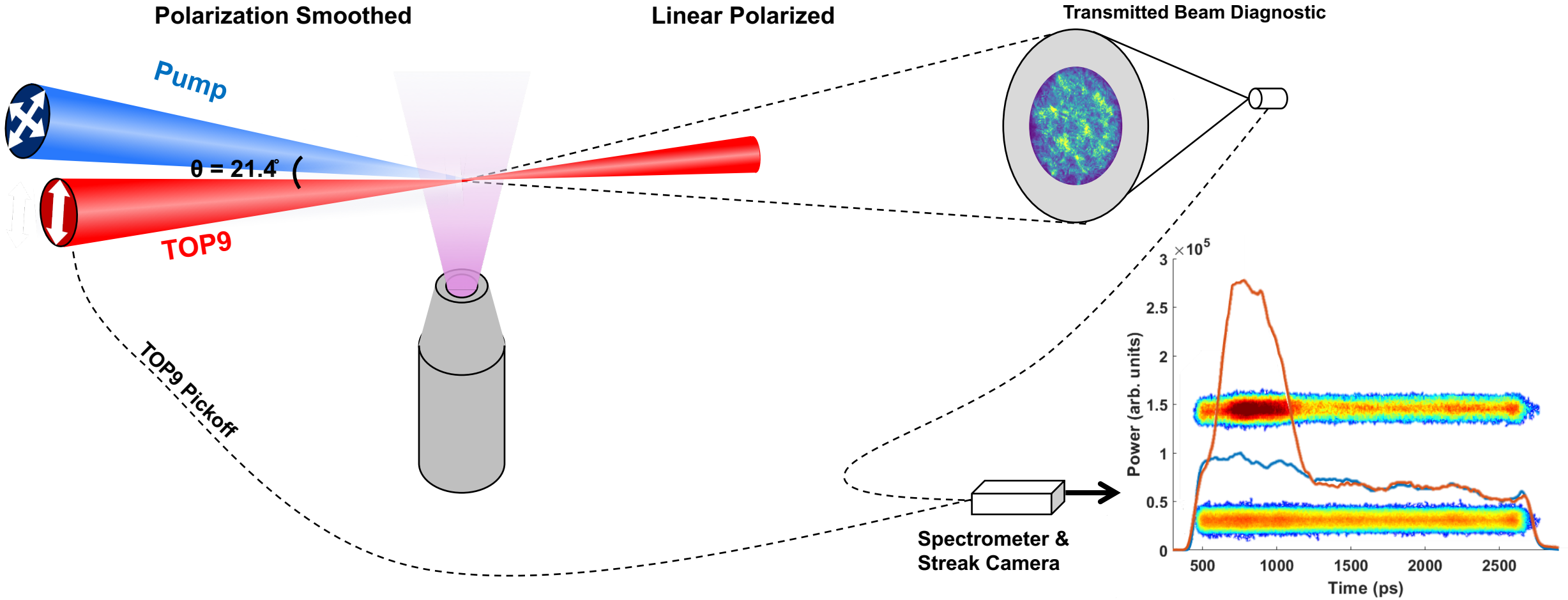




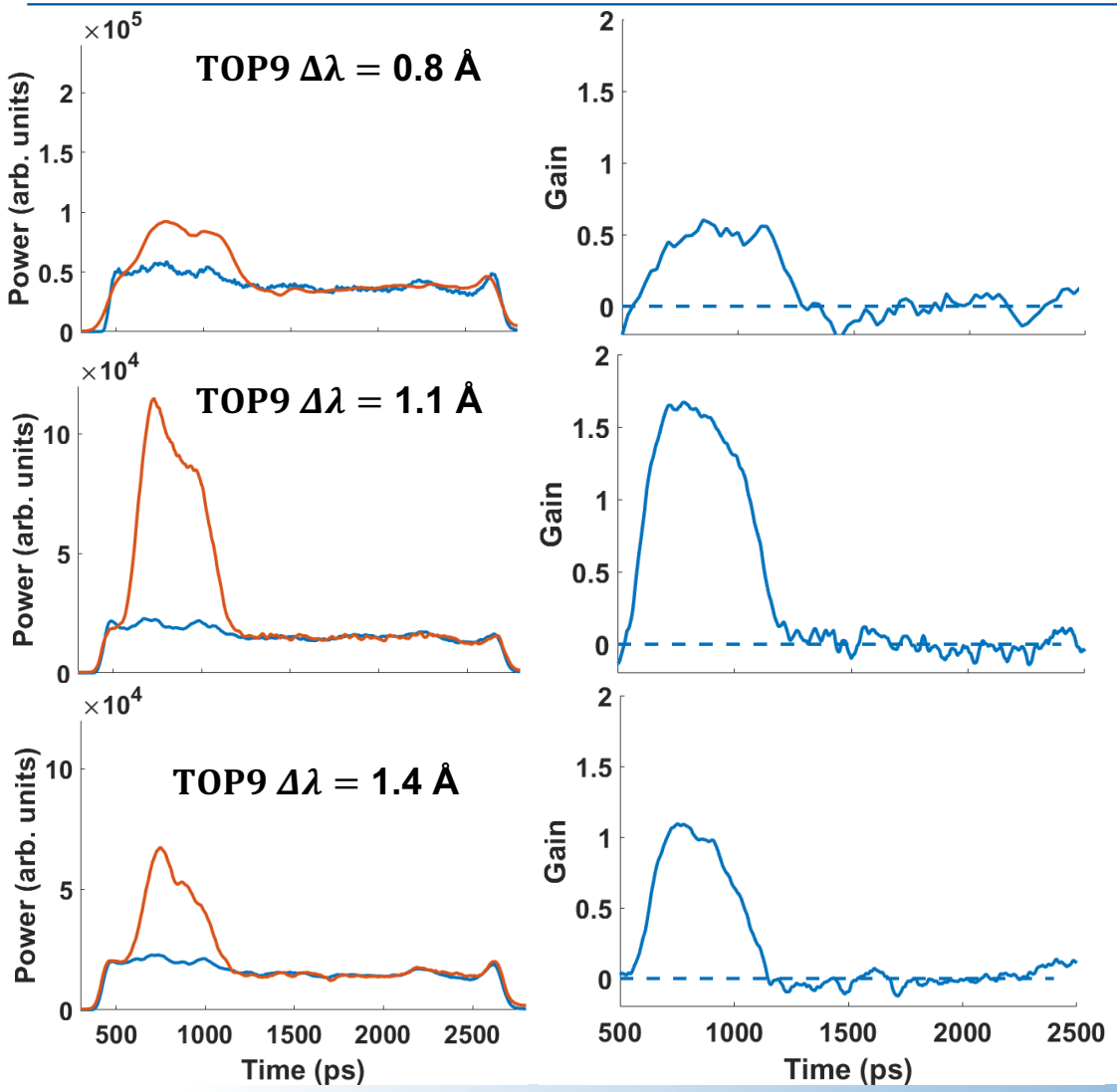
In the single-pump configuration, TOP9 interacts with a single polarization smoothed beam

Pump
1.9 x 10^{15} W/cm^2
f/6.7
Polarization Smoothed

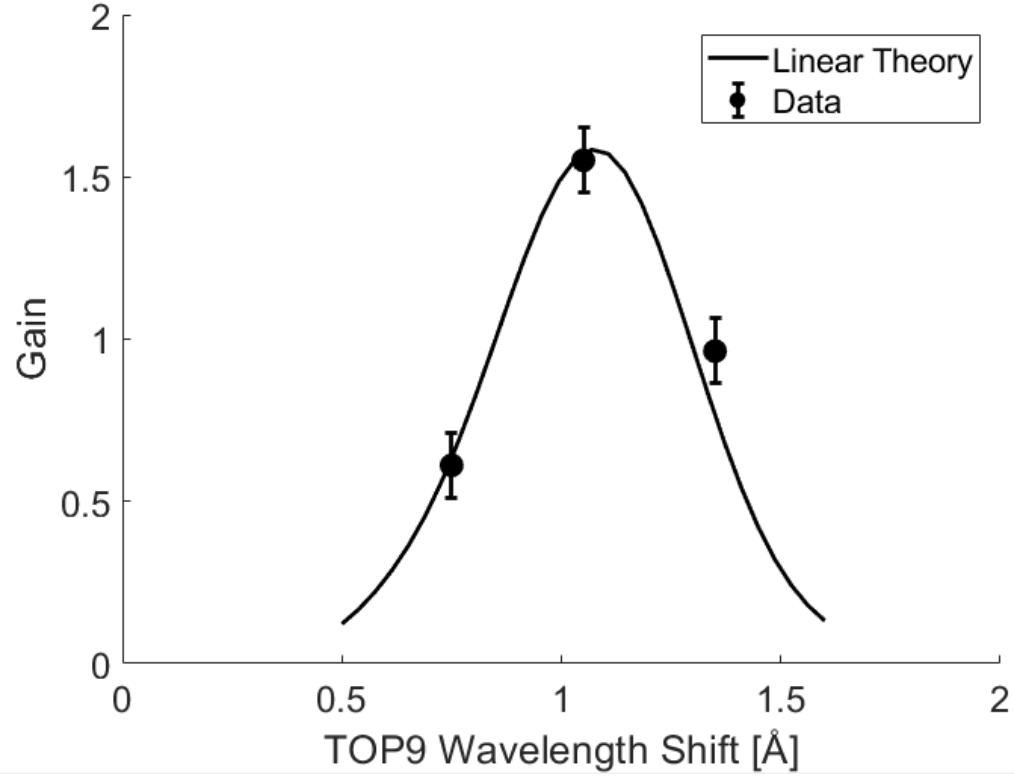
TOP9
0.04 -- 3.0 x 10^{14} W/cm^2
f/6.7
Linear Polarized



Gain in the TOP9 beam was measured while varying the wavelength detuning and intensity of the beam



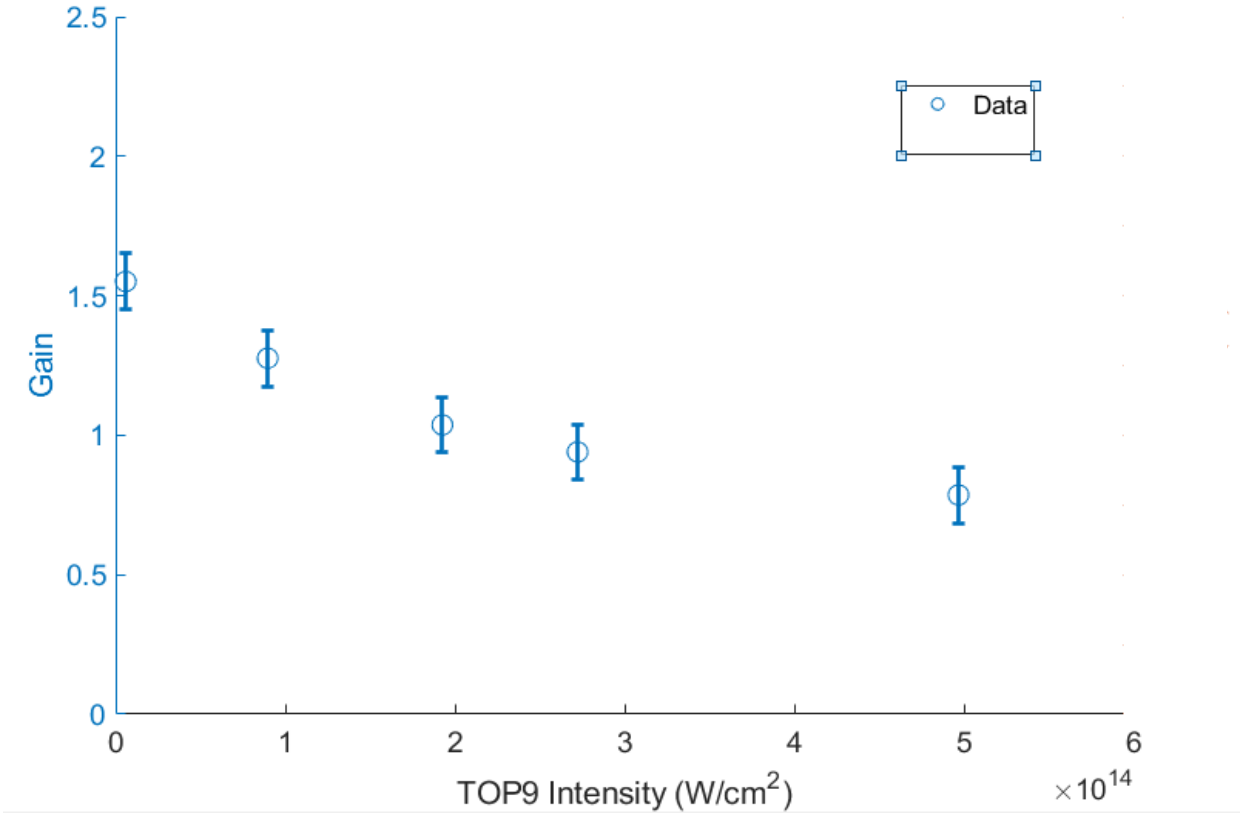
I_{probe} = 0.04 x 10^{14} W/cm^2



Linear theory agrees with measured gains

Gain in the TOP9 beam was measured while varying the wavelength detuning and intensity of the beam

$\Delta\lambda = 1.1$ Å
$I_{pump} = 1.9 \times 10^{15}$ W/cm^2

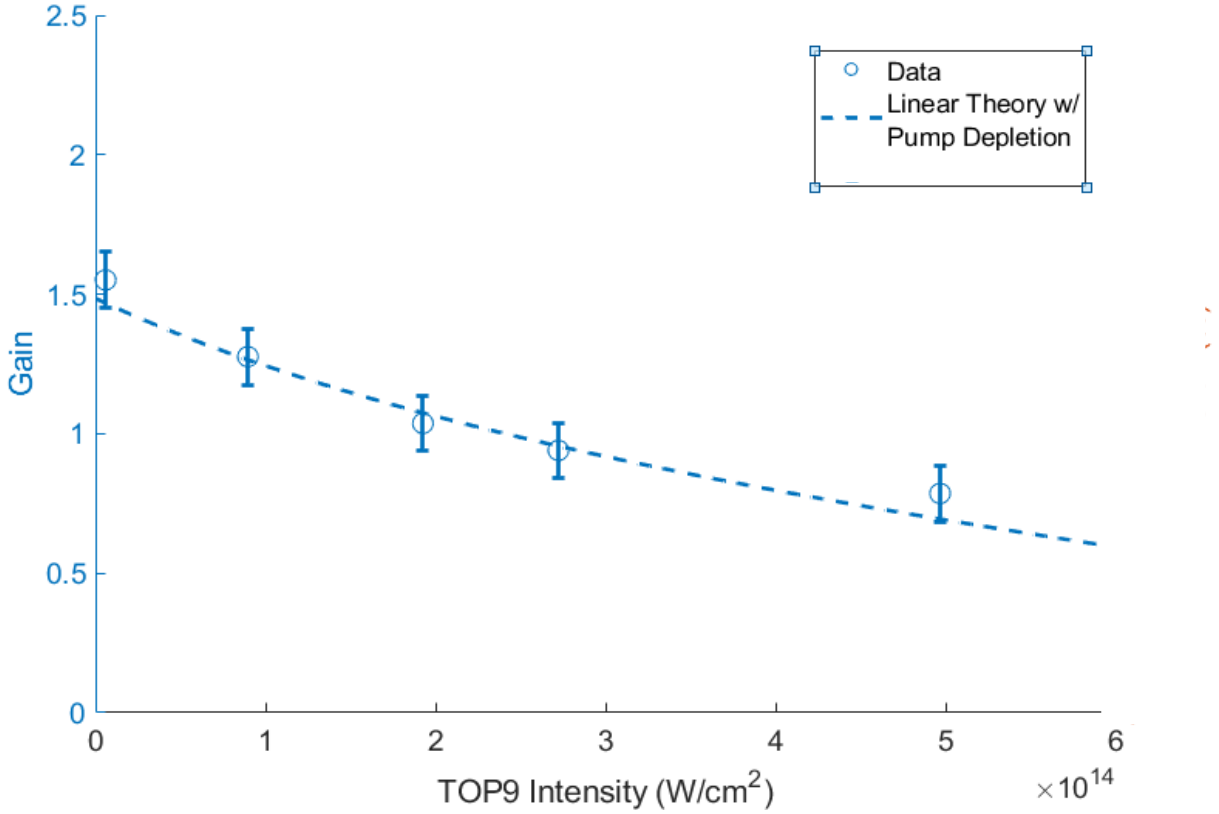


* C. L. Tang, J. Appl. Phys. 37, 2945 (1966)
** E. A. Williams Phys. Plasmas, 11 (231), 2004

Gain in the TOP9 beam was measured while varying the wavelength detuning and intensity of the beam

$\Delta\lambda = 1.1$ Å

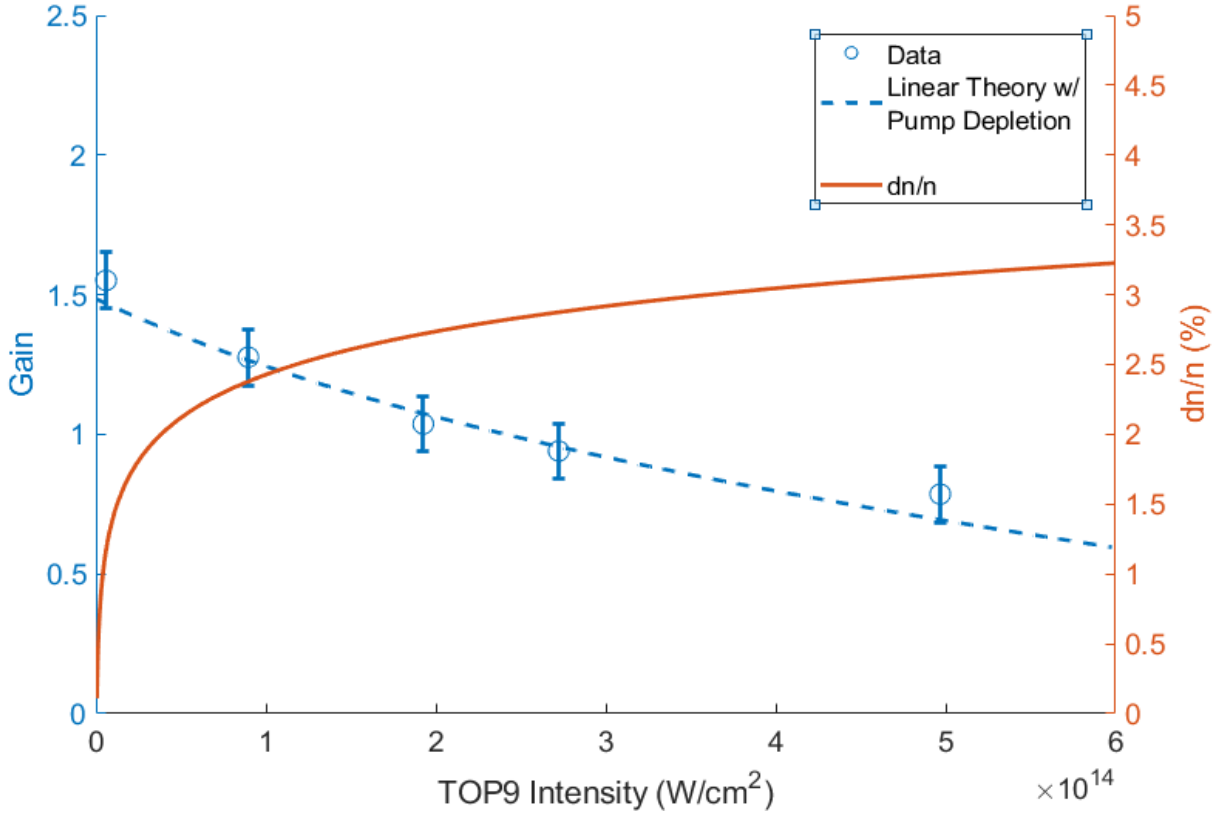
$I_{pump} = 1.9 \times 10^{15}$ W/cm^2



* C. L. Tang, J. Appl. Phys. 37, 2945 (1966)
** E. A. Williams Phys. Plasmas, 11 (231), 2004

Gain in the TOP9 beam was measured while varying the wavelength detuning and intensity of the beam

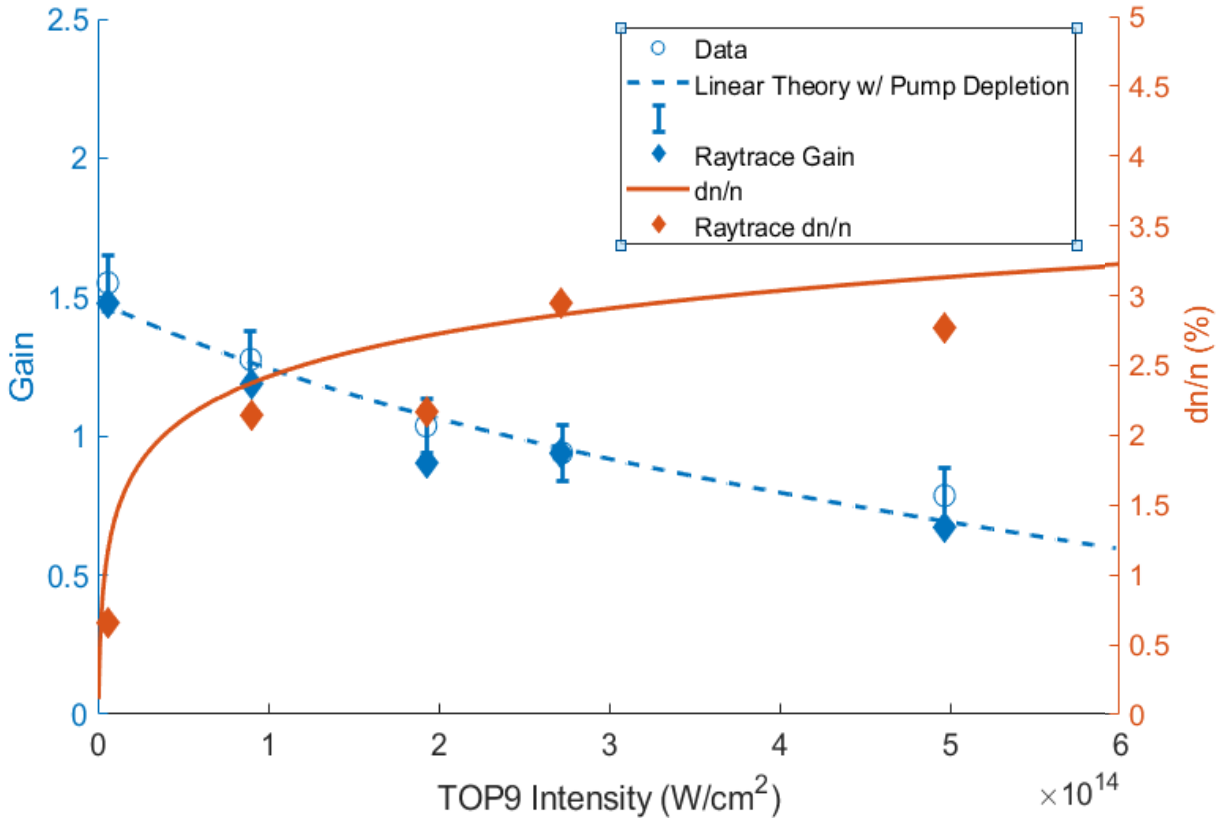
$\Delta\lambda = 1.1$ Å
$I_{pump} = 1.9 \times 10^{15}$ W/cm^2



* C. L. Tang, J. Appl. Phys. 37, 2945 (1966)
** E. A. Williams Phys. Plasmas, 11 (231), 2004

The 3D ray trace simulated gain measurements agree very well with predicted and measured linear gains and wave amplitudes

$\Delta\lambda = 1.1$ Å
$I_{pump} = 1.9 \times 10^{15}$ W/cm^2

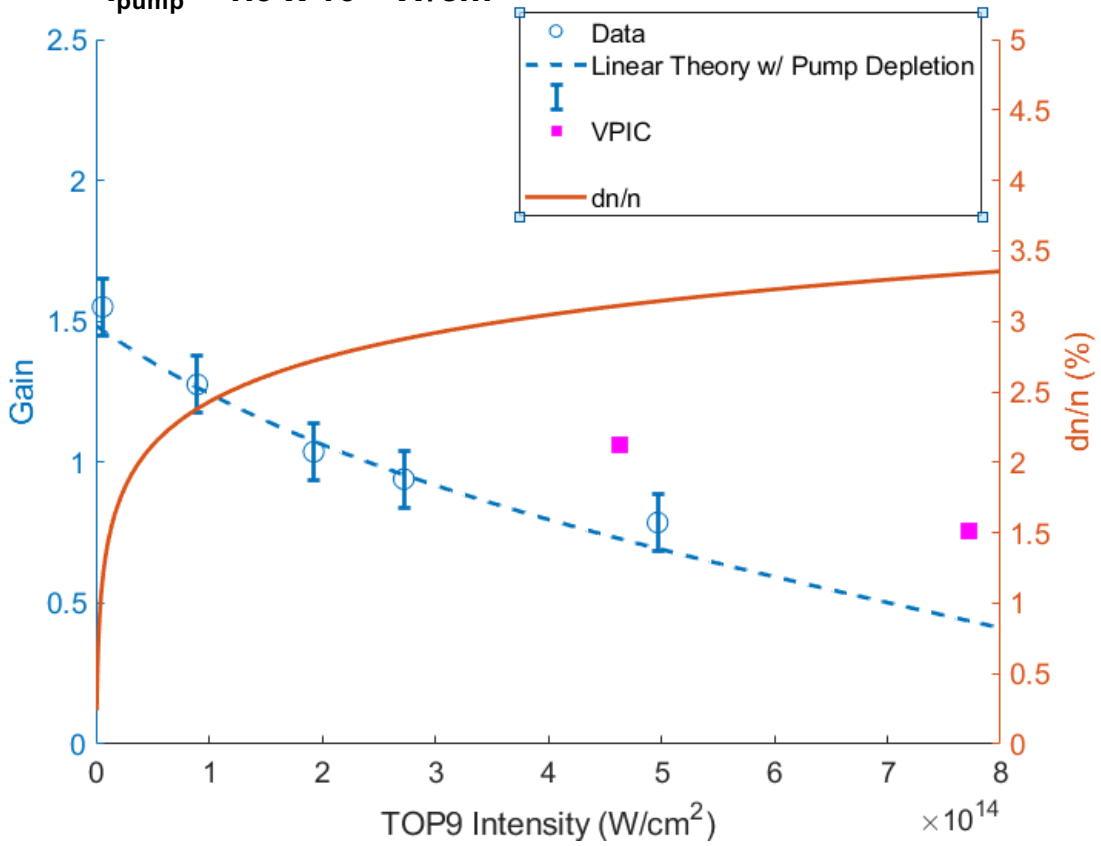


* C. L. Tang, J. Appl. Phys. 37, 2945 (1966)
** E. A. Williams Phys. Plasmas, 11 (231), 2004

Gain in the TOP9 beam was measured while varying the wavelength detuning and intensity of the beam

$\Delta\lambda = 1.1$ Å

$I_{pump} = 1.9 \times 10^{15}$ W/cm^2



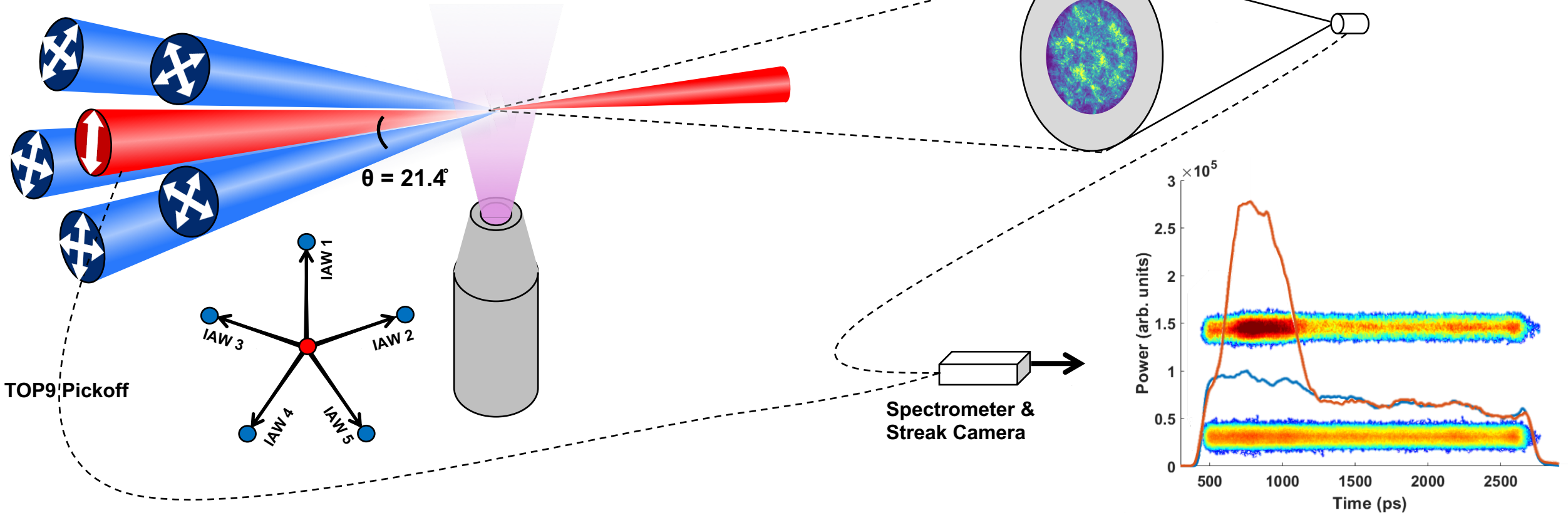
VPIC simulations find no saturation at high wave amplitudes

* C. L. Tang, J. Appl. Phys. 37, 2945 (1966)
** E. A. Williams Phys. Plasmas, 11 (231), 2004
† K. L. Nguyen APS 2019

In the multi-pump configuration, TOP9 interacts with five identical polarization-smoothed beams

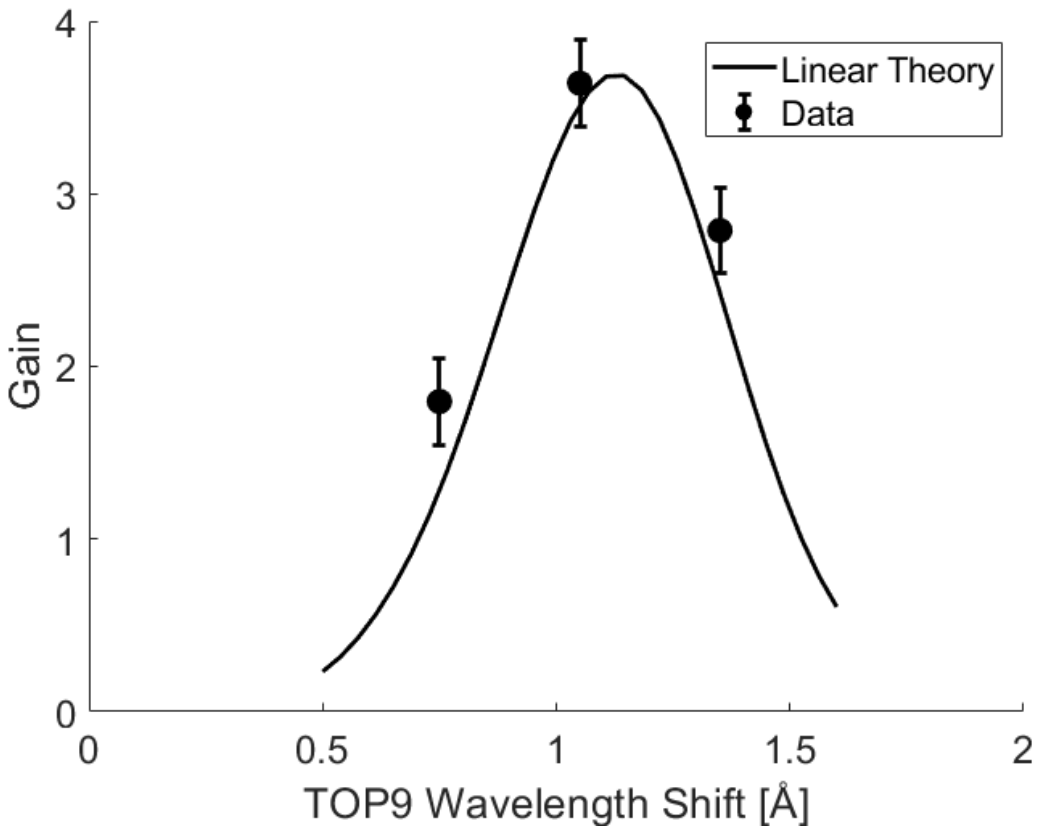
Pump
0.9 x 10^{15} W/cm^2
Total: 4.3 x 10^{15} W/cm^2
f/6.7
Polarization Smoothed

TOP9
0.02 -- 1.5 x 10^{14} W/cm^2
f/6.7
Linear Polarized



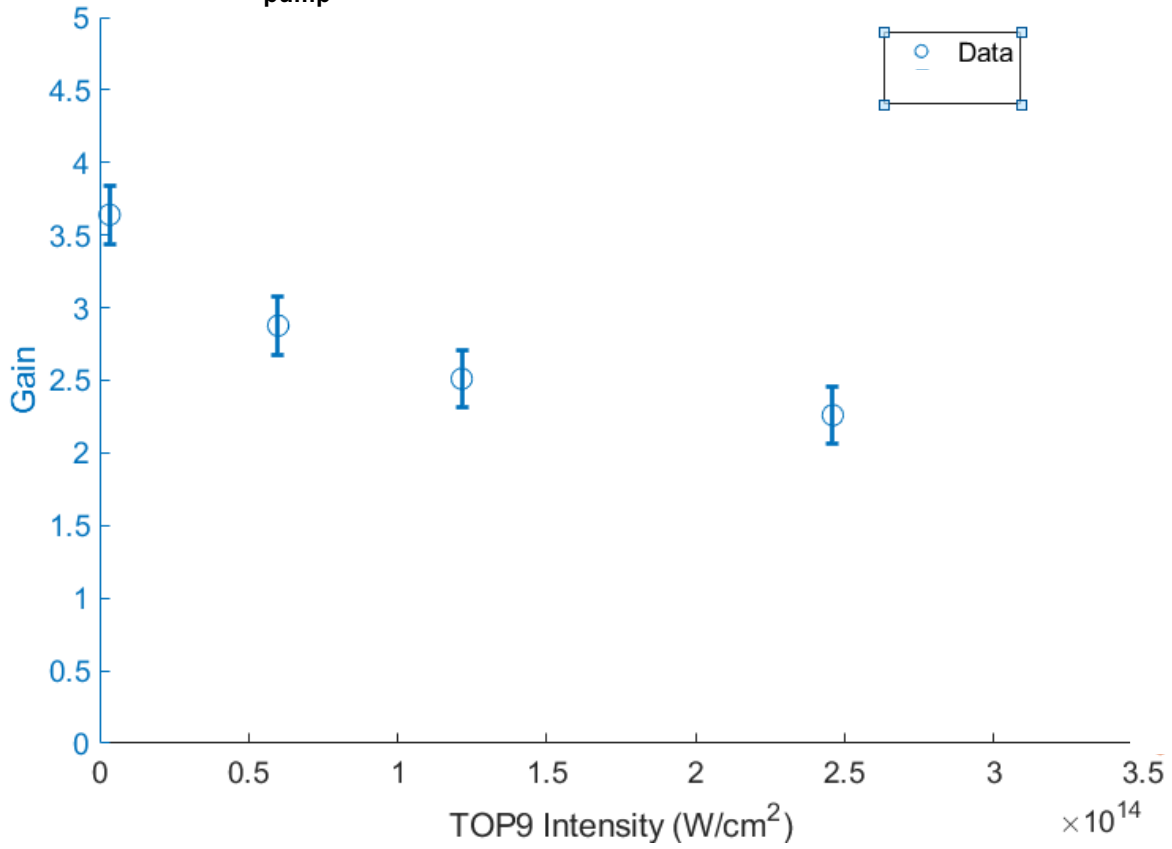
Gain in the TOP9 beam was measured while varying the wavelength detuning and intensity of the beam

I_{probe} = 0.02 x 10^{14} W/cm^2



$\Delta\lambda$ = 1.2 Å

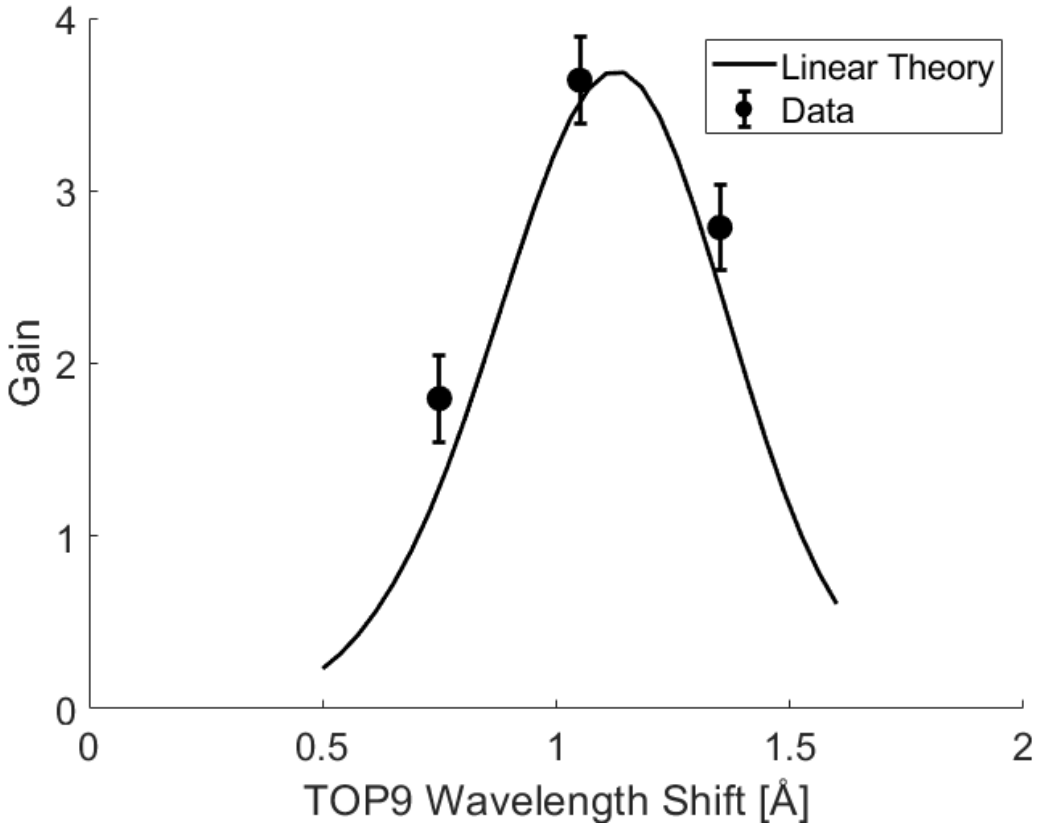
I_{pump} = 4.3 x 10^{15} W/cm^2



* C. L. Tang, J. Appl. Phys. 37, 2945 (1966)
** E. A. Williams Phys. Plasmas, 11 (231), 2004

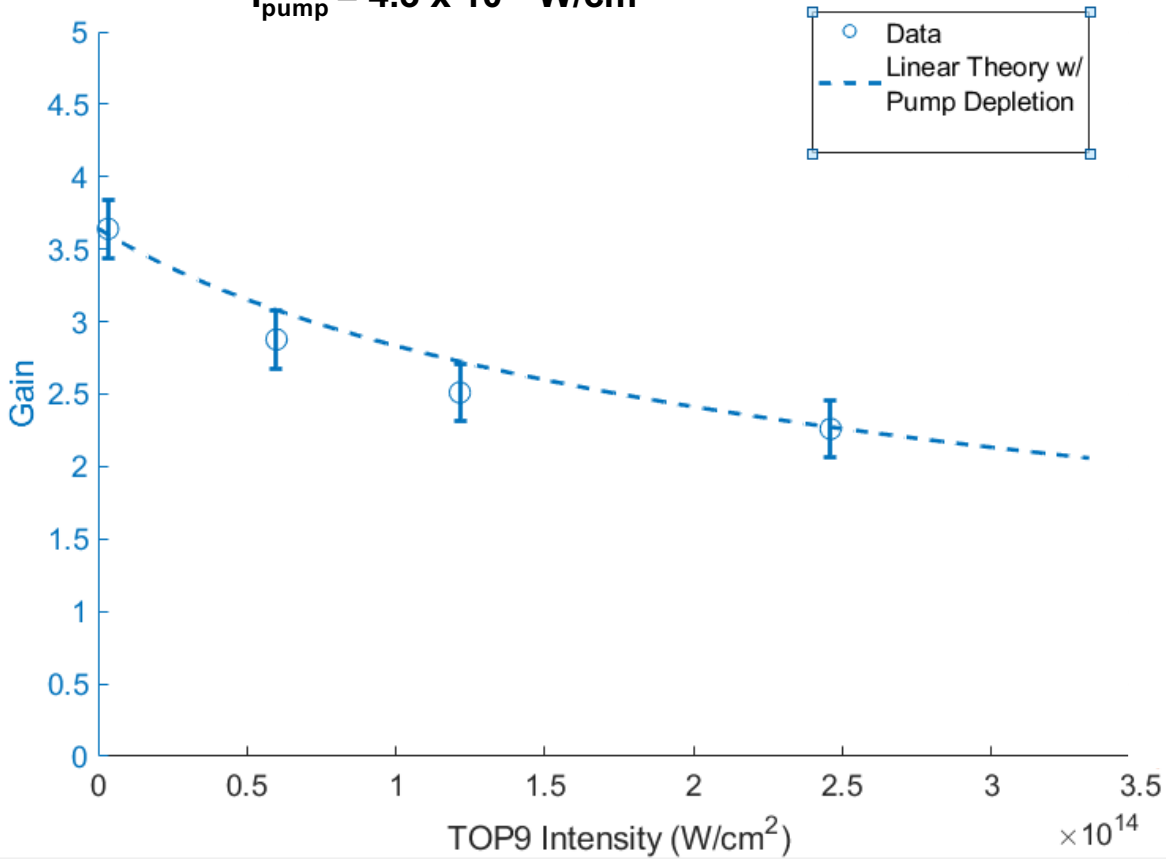
Gain in the TOP9 beam was measured while varying the wavelength detuning and intensity of the beam

I_{probe} = 0.02 x 10^{14} W/cm^2



$\Delta\lambda$ = 1.2 Å

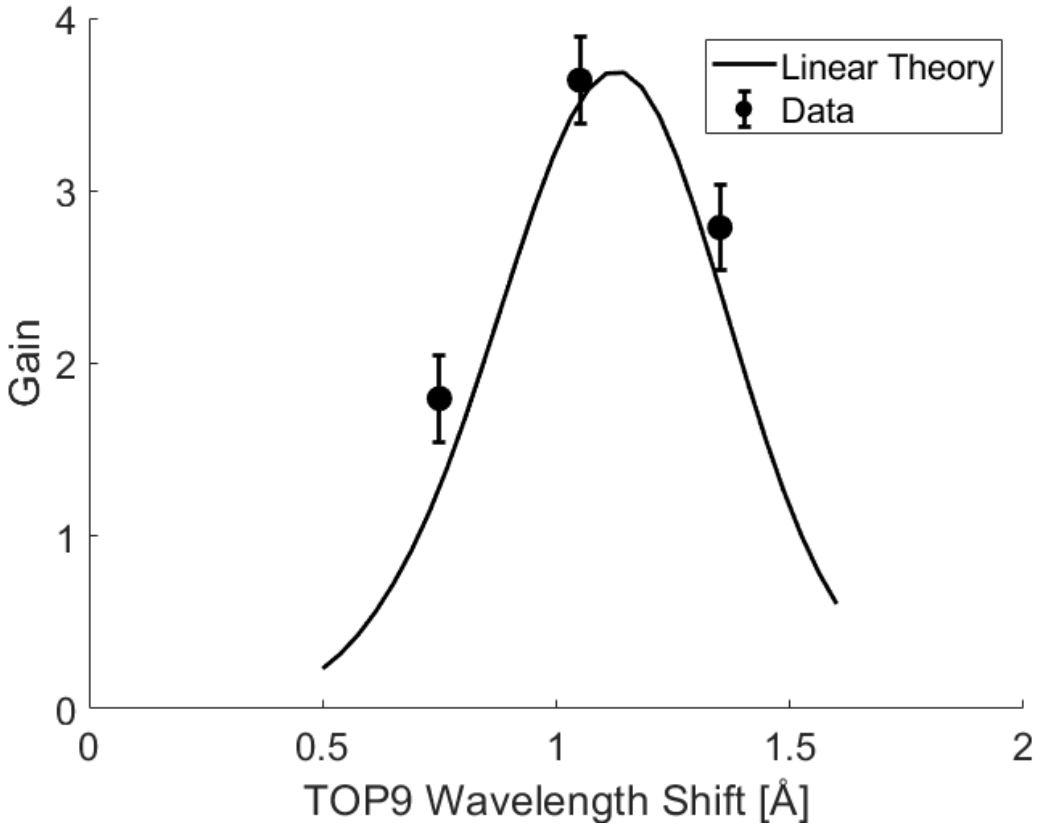
I_{pump} = 4.3 x 10^{15} W/cm^2



* C. L. Tang, J. Appl. Phys. 37, 2945 (1966)
** E. A. Williams Phys. Plasmas, 11 (231), 2004

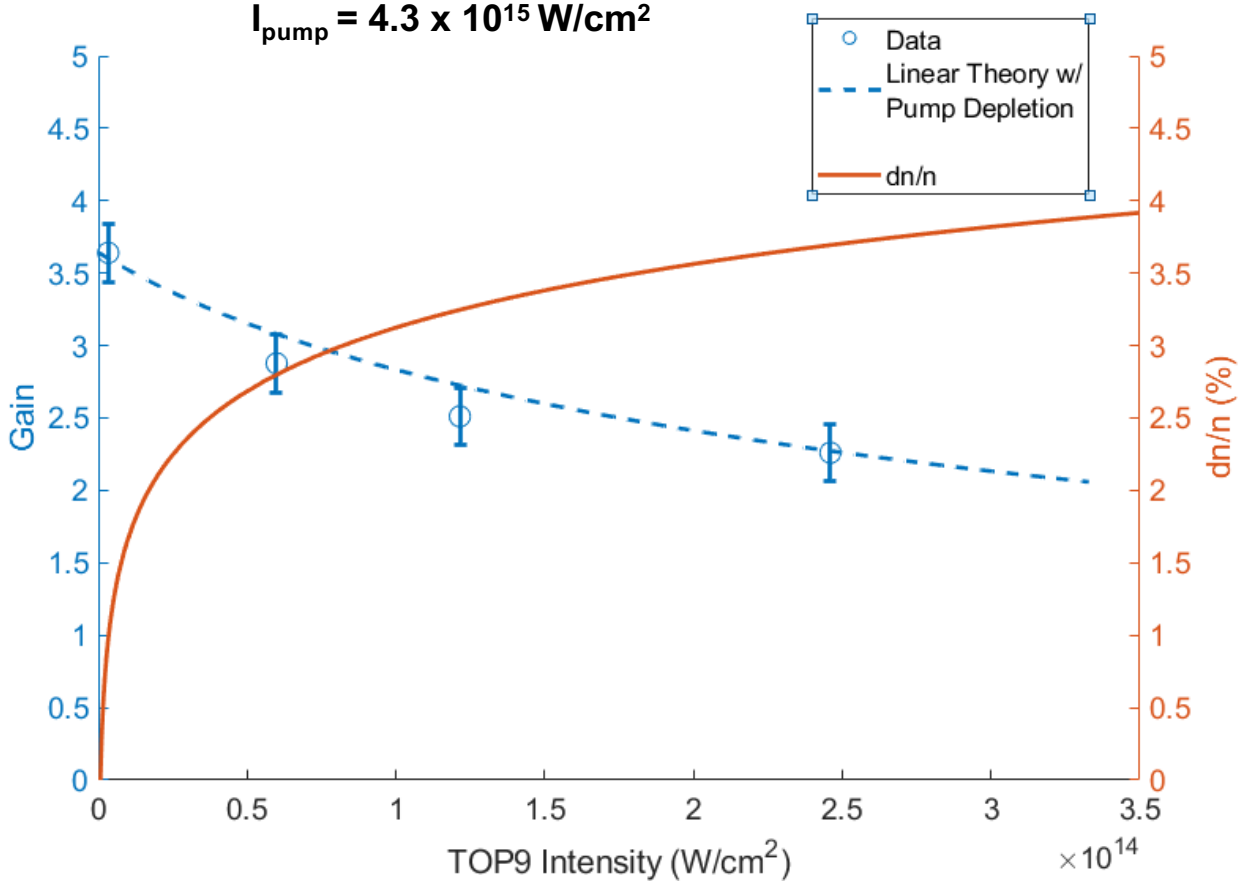
Gain in the TOP9 beam was measured while varying the wavelength detuning and intensity of the beam

I_{probe} = 0.02 x 10^{14} W/cm^2



$\Delta\lambda$ = 1.2 Å

I_{pump} = 4.3 x 10^{15} W/cm^2



* C. L. Tang, J. Appl. Phys. 37, 2945 (1966)
** E. A. Williams Phys. Plasmas, 11 (231), 2004

Summary/Conclusions

Crossed-beam energy transfer (CBET) was measured at high ion-acoustic wave amplitudes in single- and multi-beam configurations and was found to agree well with linear theory

- **The OMEGA LPI platform was utilized to study CBET using the Tunable OMEGA Port 9 (TOP9) laser**
- **Varied laser intensities scaled ion-wave amplitudes from dn/n < 1% up to dn/n ~ 3%**
- **Measurements of CBET gain were found to agree well with linear models and VPIC simulations**
- **Raytrace simulations were performed to predict ion wave amplitudes in a full scale 3D model**

VPIC Simulation Parameters

- Simulation box (in x-z plane)
  - Box size x = 500 micron
  - Box size z = 175 micron
- Plasma parameters
  - Te = 840 eV
  - Ti = 130 eV
  - ne = 1.10e20 cc-1 (uniform plasma)
  - Z = [1 7] (H and N)
  - Species Fraction = [0.55 0.45]
  - Non-Maxwellian order m = 3 (electrons)
- Laser Parameters
  - Vacuum wavelength ƛ0 = 351 nm
  - Detuning wavelength Δƛ= 1.027 A (Δω = 0.00265 ωpe)
  - Pump beam: Ipump = 9.0e14 W/cm2, linear polarized along y-direction, beam width = 80 micron, f# = 6.7, θpump= 10.705 degree
    - Polarization smoothing is under development
  - Seed beam: Iseed = 3.0e14 W/cm2, linear polarized along y-direction, beam width = 80 micron, f# = 6.7, θseed= -10.705 degree

The target plasma is characterized on each shot in time using the streaked Thomson-scattering system