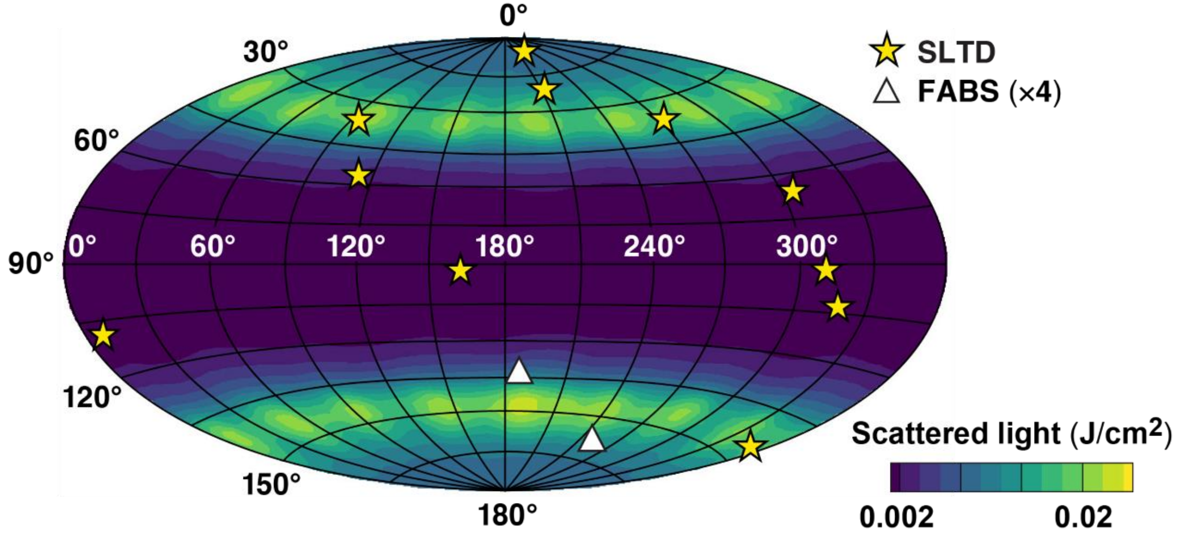
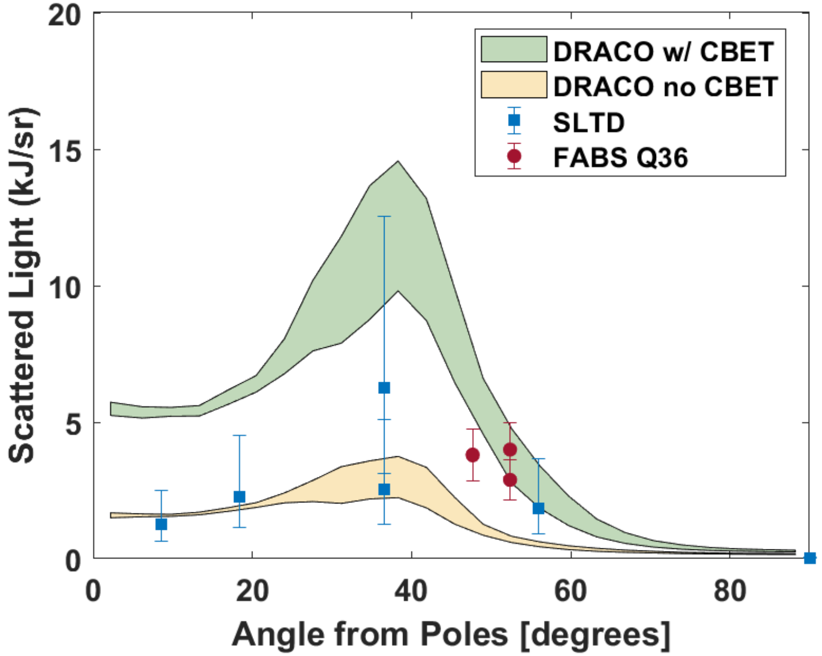
Using Scattered-Light Data to Validate 2-D Radiation-Hydrodynamic Energy-Coupling Models in Polar-Direct-Drive Experiments at the National Ignition Facility

2D DRACO simulated
351-nm scattered-light map



NIF solid sphere experiment time-integrated scattered light



Steven Kostick
University of Rochester
Laboratory for Laser Energetics

64^{th} Annual Meeting of the
APS Division of Plasma Physics
Spokane, WA
17-21 October 2022

Summary

Time- and angular-resolved scattered light data are used to evaluate energy-coupling models in NIF polar direct drive experiments

- **The Scattered Light Time-history Diagnostic* (SLTD) and Full aperture backscatter suite (FABS) collect time-resolved 351 nm scattered light measurements at up to 19 locations distributed around the NIF target chamber**

- **Scattered light data were collected on polar direct drive (PDD) solid sphere experiments at intensities between 4×10^{14} and 1.2×10^{15} W/cm^2**

- **Preliminary comparisons with 2D DRACO simulations with and without cross beam energy transfer (CBET) show:**
  - **Both models accurately predict polar angle of peak scattered light**
  - **DRACO with CBET overpredicts scattered light at the pole**
  - **Time-resolved data shows increasing deviation from CBET model with increasing intensity, especially towards the equator**

* M. Rosenberg *et al. Rev. Sci. Instrum. 92*, 033511 (2021)

Collaborators

M.J. Rosenberg, P. B. Radha, J.A. Marozas, R.S. Craxton, A. Sharma, J. Katz, T. Filkins, W. Theobald, T.J.B. Collins, and S.P. Regan

University of Rochester

Laboratory for Laser Energetics

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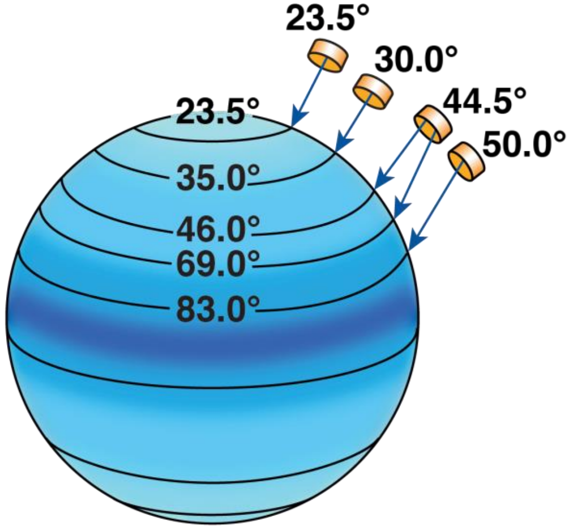
Lawrence Livermore National Laboratory

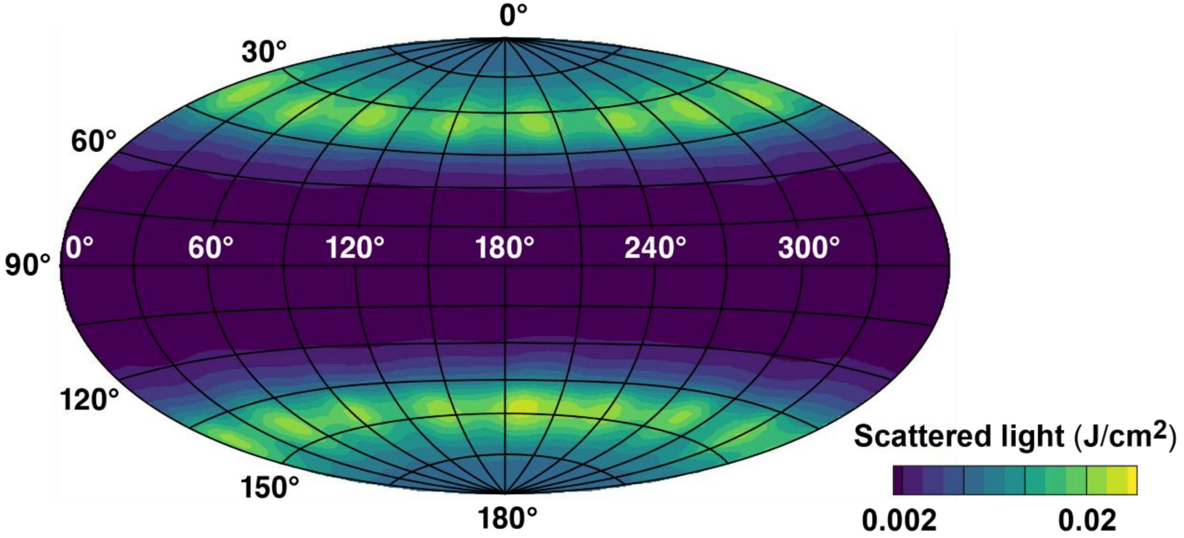
The angular distribution of scattered light is used to diagnose energy coupling models in NIF PDD experiments

2D DRACO calculation of PDD Solid Sphere N210301-002

PDD illumination geometry



351-nm scattered light map



DRACO is a 2D radiation-hydrodynamic code with 3D laser ray-trace including cross-beam energy transfer (CBET)

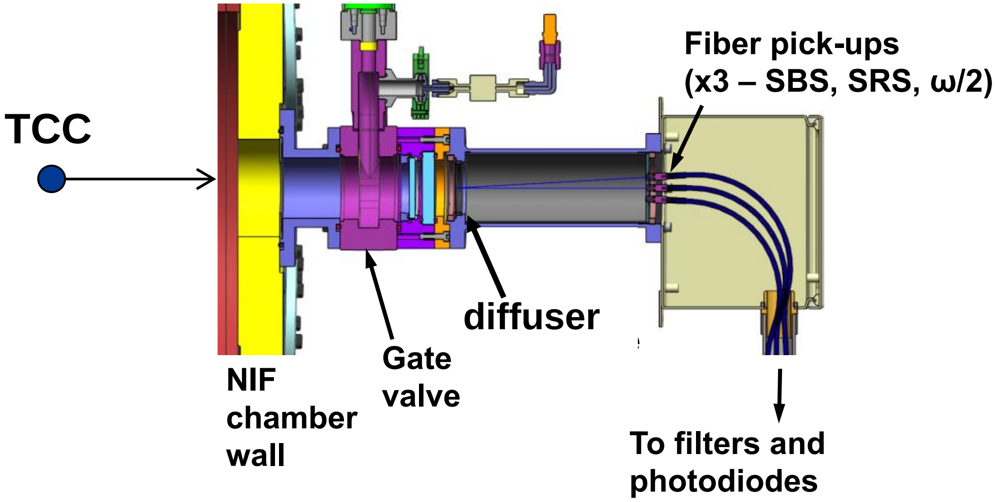
* Comparison of scattered light data to hydrocode SAGE is discussed in Craxton *et al.* [next talk]

Motivation

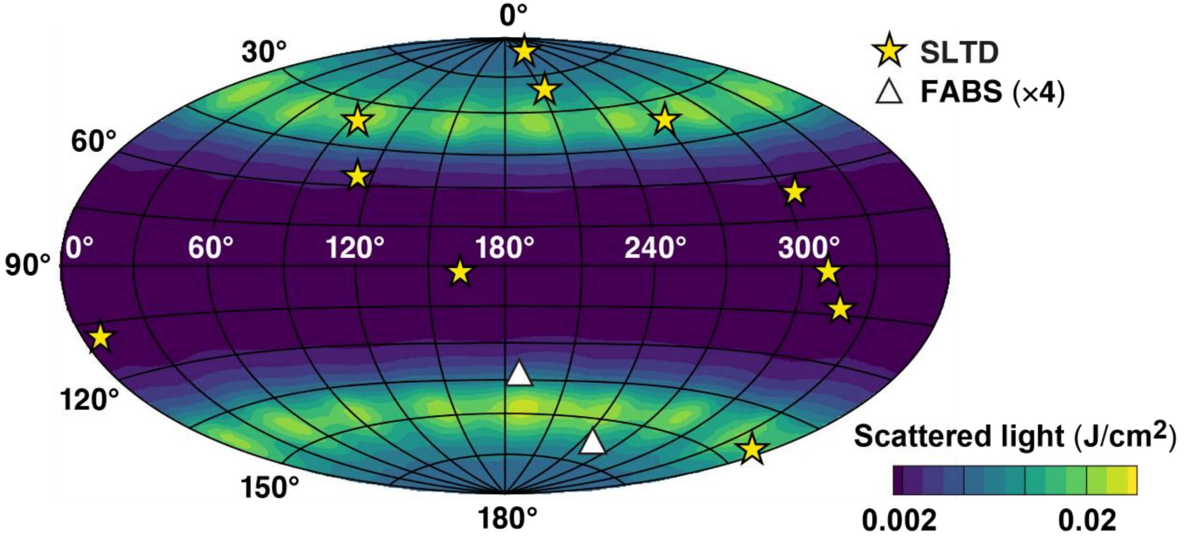
The angular distribution of scattered light is used to diagnose energy coupling models in NIF PDD experiments; it is diagnosed using FABS and SLTD

2D DRACO calculation of PDD Solid Sphere N210301-002

SLTD schematic

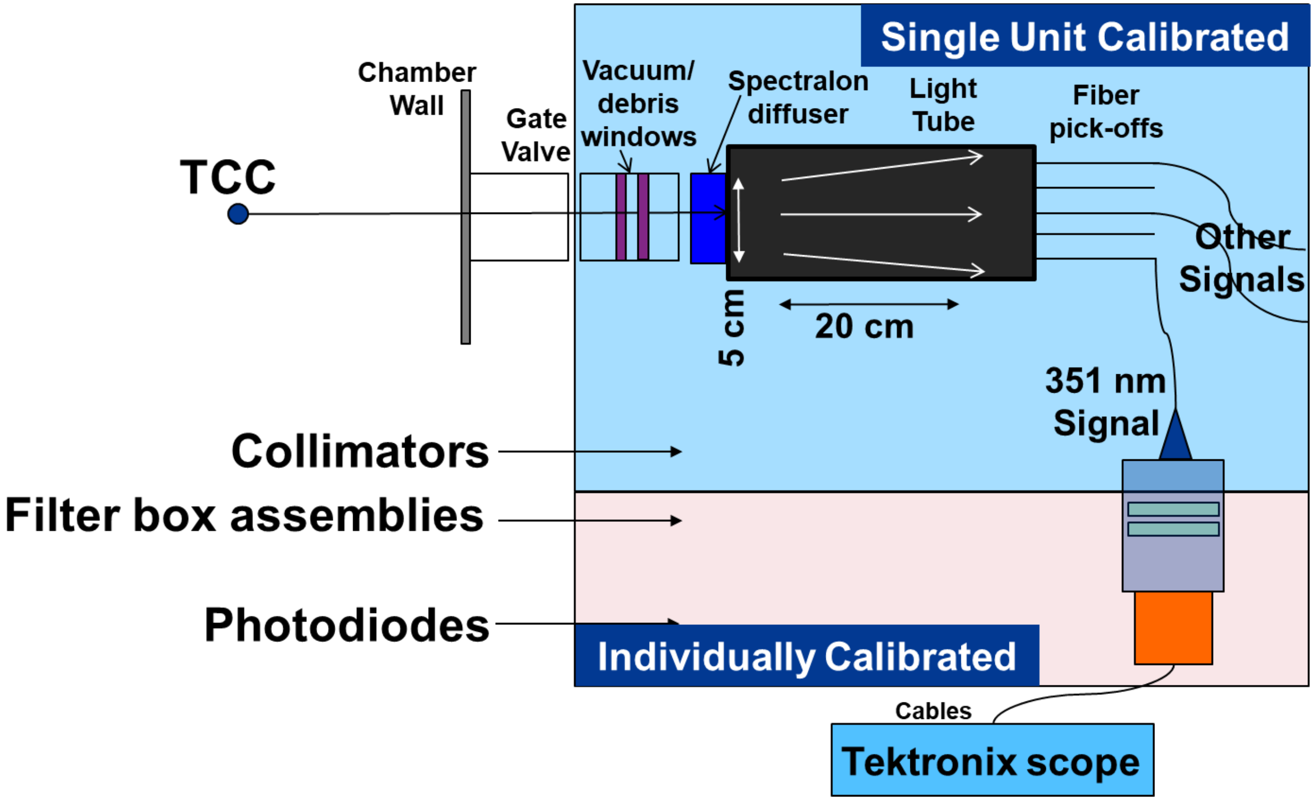


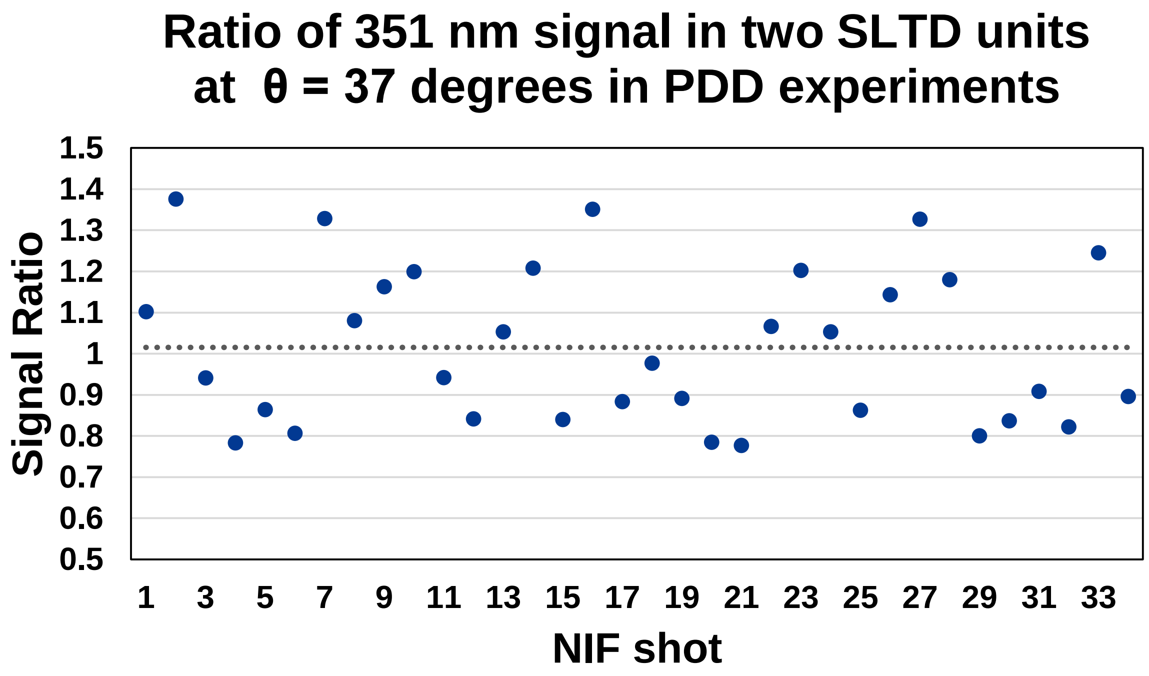
351-nm scattered light map



FABS and SLTD each measure time resolved scattered light at various wavelength including 351 nm

The absolute calibration of SLTD is in progress and currently has a factor of 2 uncertainty

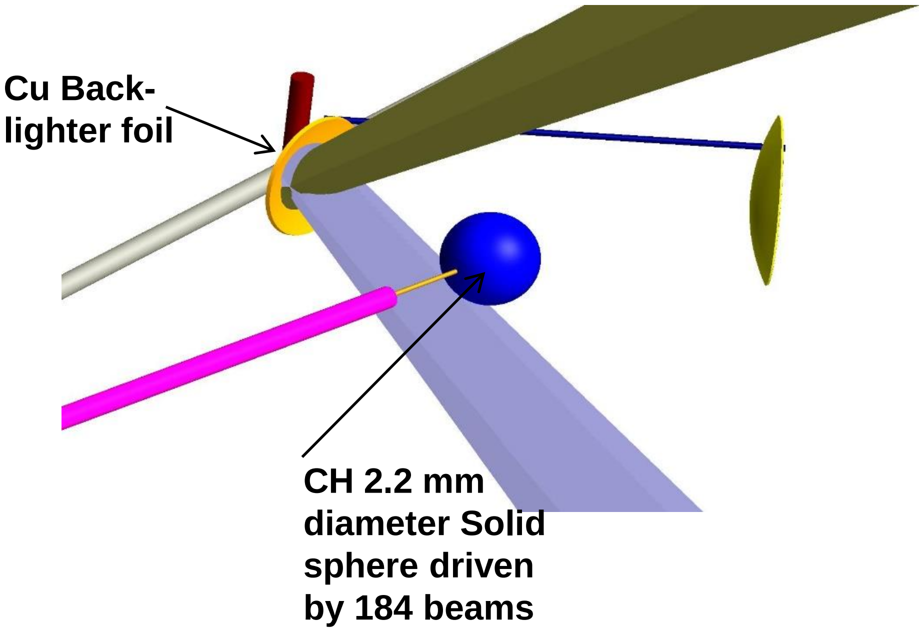




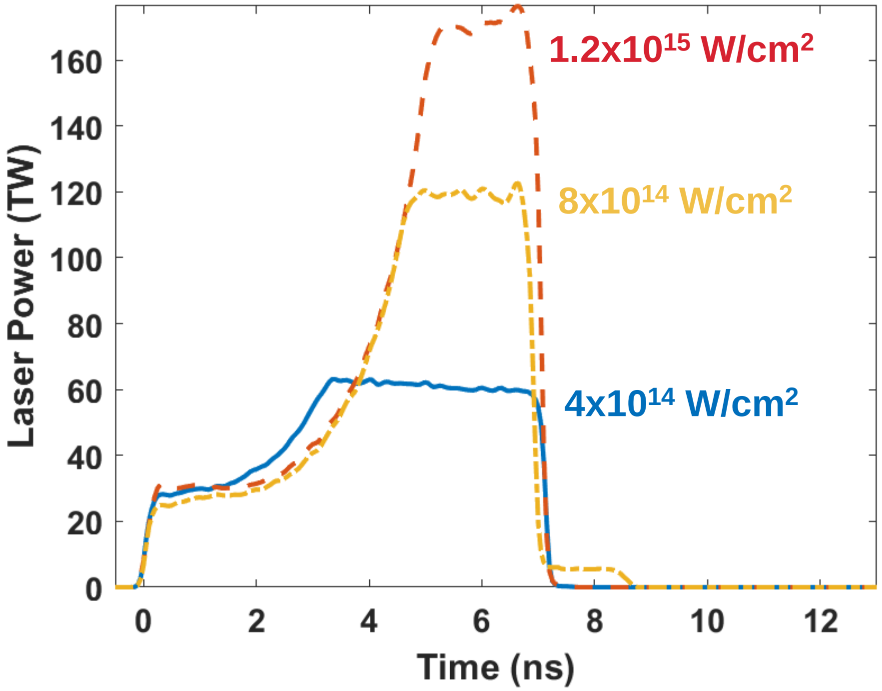
Preliminary SLTD calibration: Accuracy is a factor of 2; Precision is +/-18%

To evaluate models of energy coupling in 2D DRACO simulations, PDD solid sphere experiments at multiple intensities were performed on the NIF

NIF PDD solid sphere configuration*



Total Laser power



Scattered light measurements complement shock trajectory in evaluating energy coupling models; intensity scan used to assess CBET, which is calculated to increase with intensity

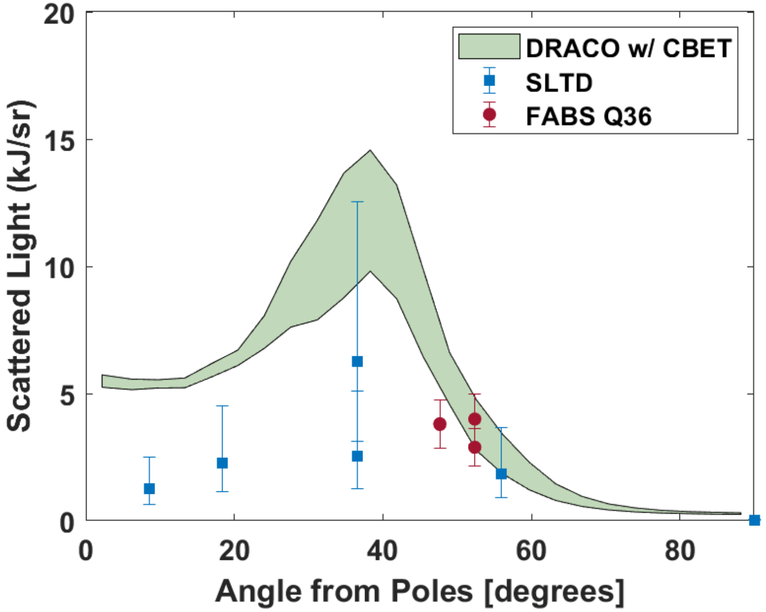
* Solid Sphere shock trajectory is discussed in Ceurvorst *et al.* [BO04.00003]

With the preliminary SLTD calibration, measured angular distribution of scattered light shows qualitative agreement with DRACO, with a peak at 30-40 degrees

Time-integrated scattered light data and simulations vs. polar angle

4×10^{14} W/cm^2

N210301-002 Draco, and Data



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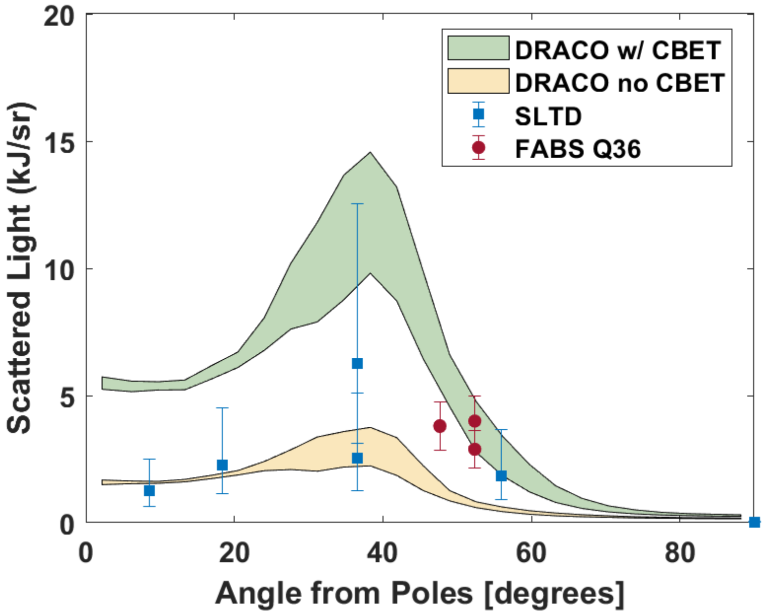
N210301-002 Draco, and Data



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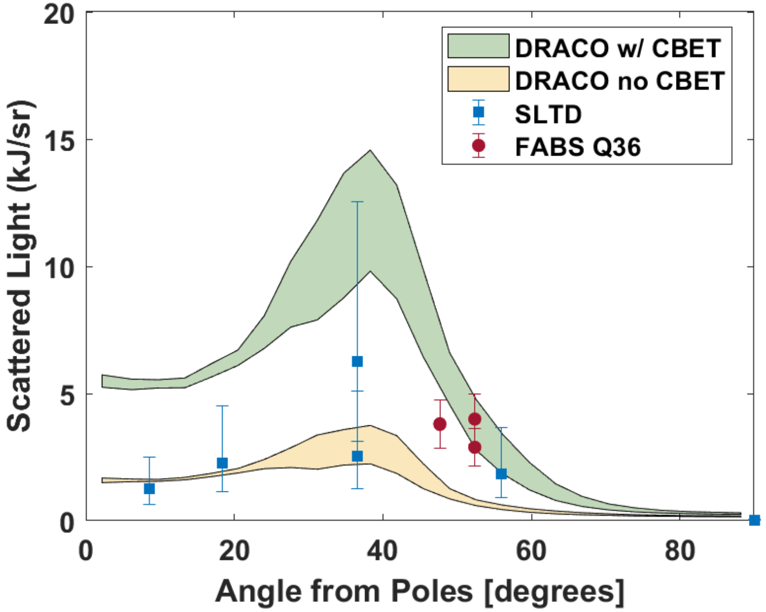
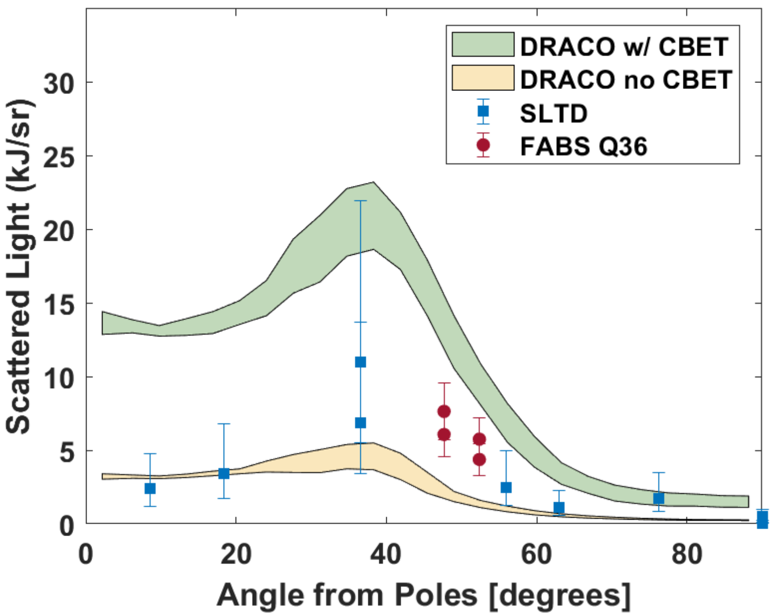
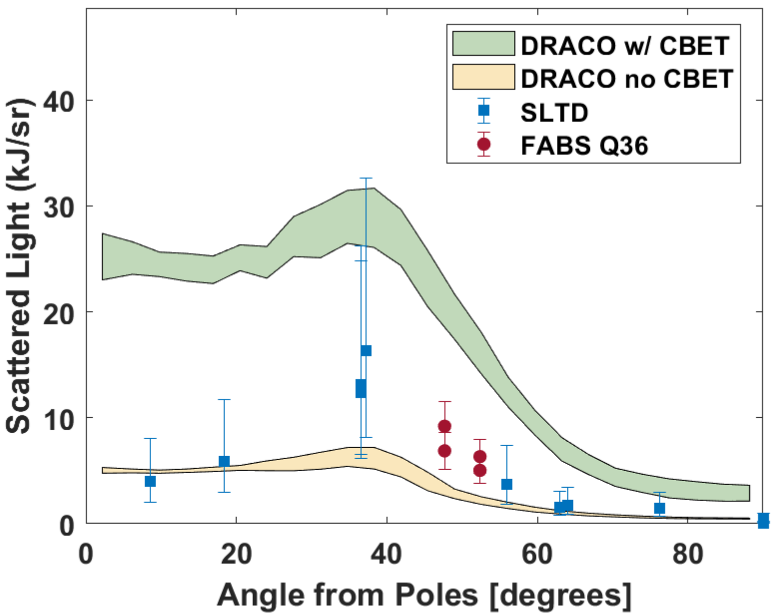


8×10^{14} W/cm^2
N210519-001 Draco, and Data



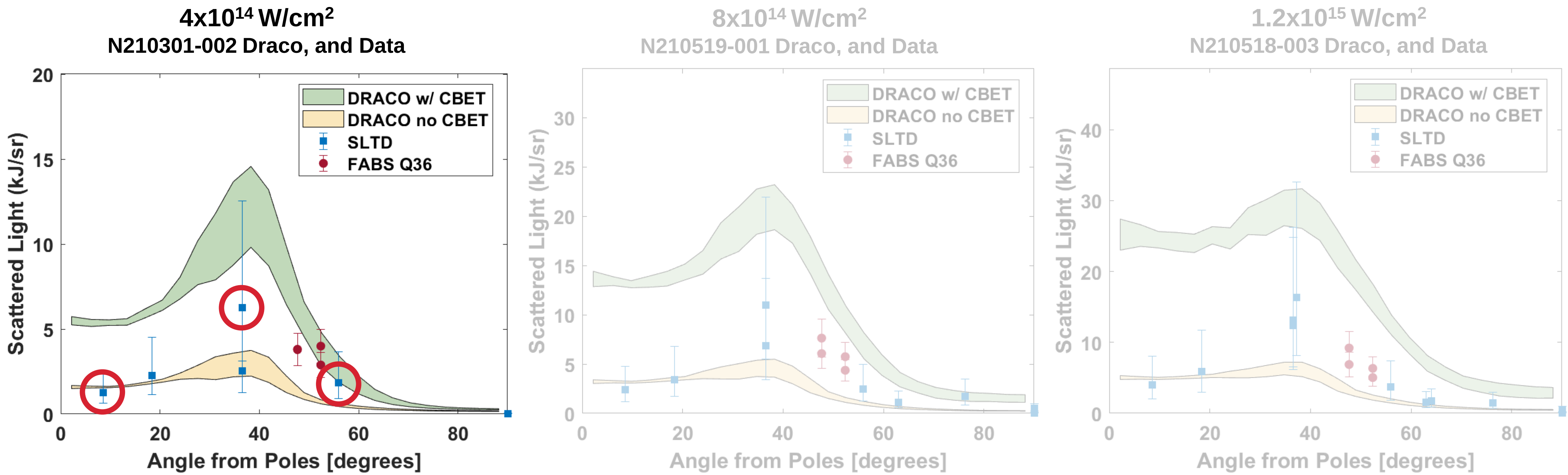
1.2×10^{15} W/cm^2
N210518-003 Draco, and Data



Scattered light is in closer agreement with the no CBET model at the poles but then falls between the models elsewhere

With the preliminary SLTD calibration, measured angular distribution of scattered light shows qualitative agreement with DRACO, with a peak at 30-40 degrees

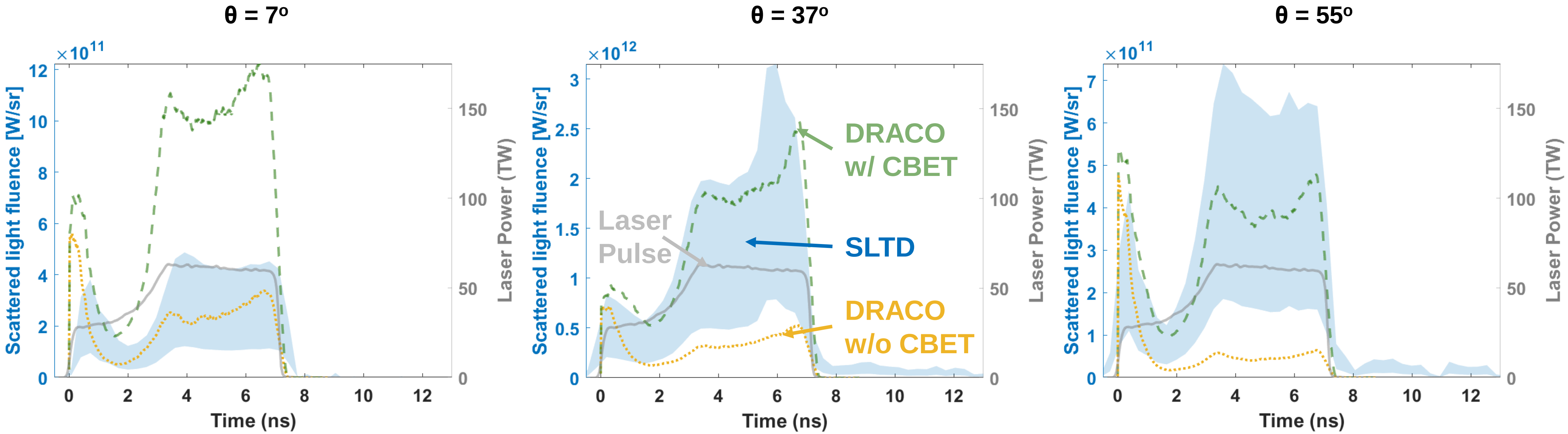
Time-integrated scattered light data and simulations vs. polar angle



Scattered light is in closer agreement with the no CBET model at the poles but then falls between the models elsewhere

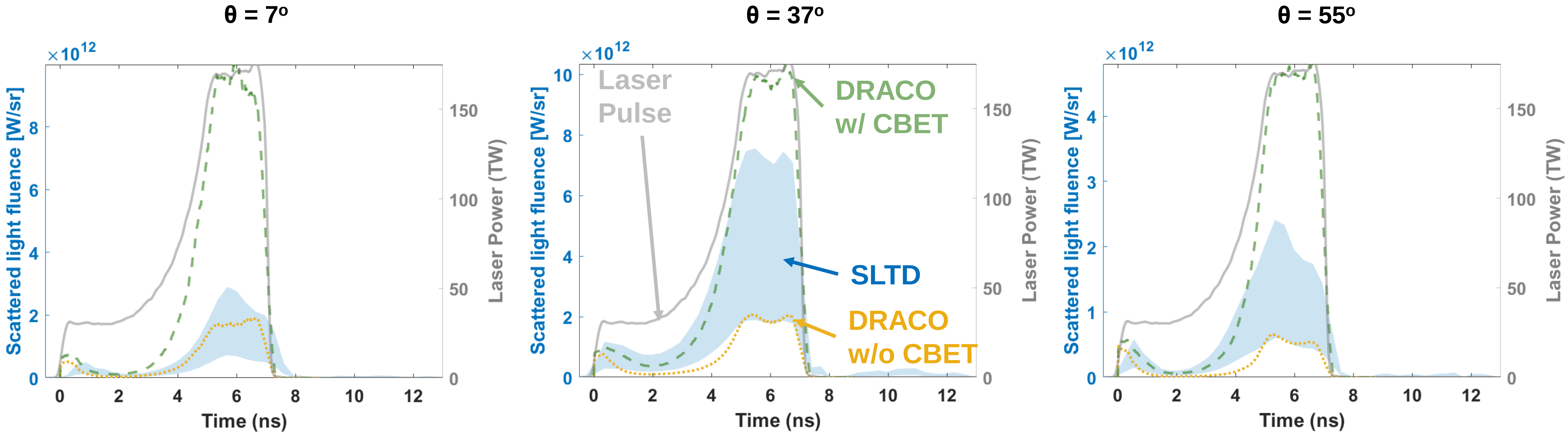
At the $4x10^{14}$ W/cm^2, the time resolved data shows better agreement with the no CBET model at the poles, but better matches the CBET model elsewhere

SLTD time-resolved scattered light



At 1.2x10[15] W/cm[2], the scattered light data continues to be in agreement with the no CBET model at the poles, but the CBET model overpredicts the scattered light everywhere

SLTD time-resolved scattered light



DRACO may overpredict the effect of increasing intensity on CBET

Time- and angular-resolved scattered light data are used to evaluate energy-coupling models in NIF polar direct drive experiments

- The Scattered Light Time-history Diagnostic* (SLTD) and Full aperture backscatter suite (FABS) collect time-resolved 351 nm scattered light measurements at up to 19 locations distributed around the NIF target chamber

- Scattered light data were collected on polar direct drive (PDD) solid sphere experiments at intensities between 4×10^{14} and 1.2×10^{15} W/cm^2

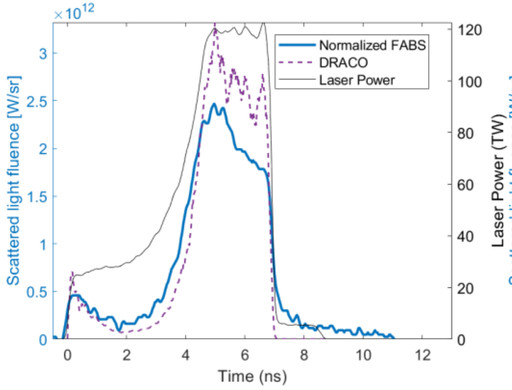
- Preliminary comparisons with 2D DRACO simulations with and without cross beam energy transfer (CBET) show:
  - Both models accurately predict polar angle of peak scattered light
  - DRACO with CBET overpredicts scattered light at the pole
  - Time-resolved data shows increasing deviation from CBET model with increasing intensity, especially towards the equator

The calibration is being refined for more stringent comparison of scattered light measurements to simulations

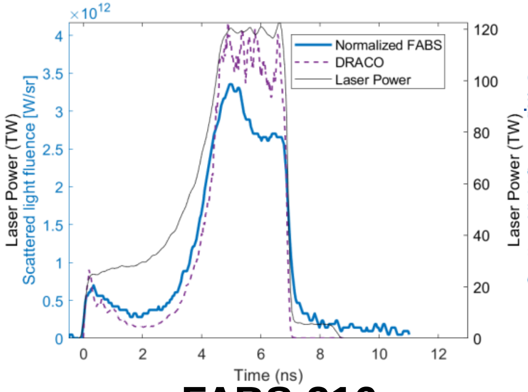
APPENDIX

N210519-001 8e14 W/cm^2

FABS 368



FABS 367



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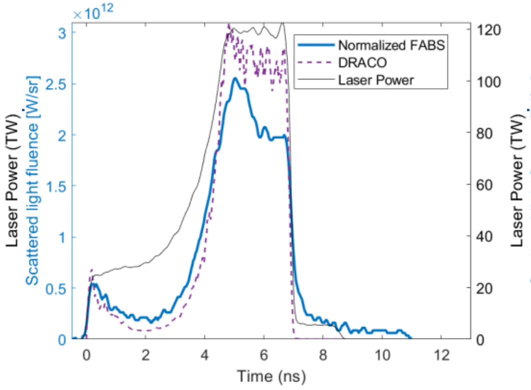

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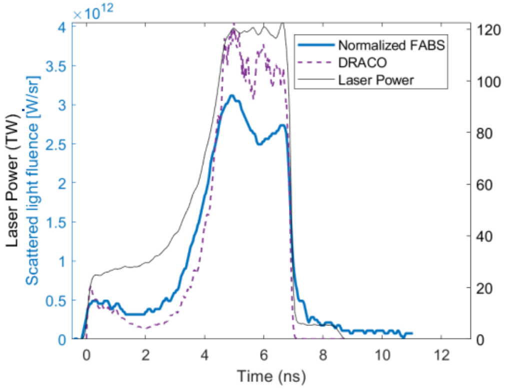

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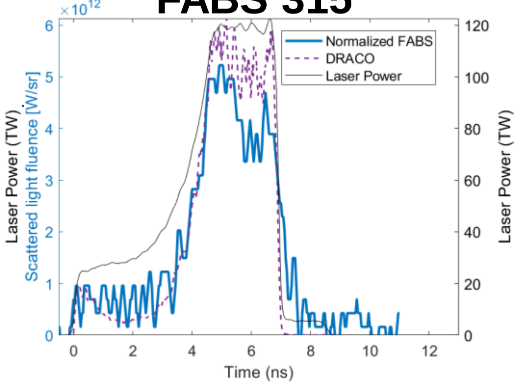
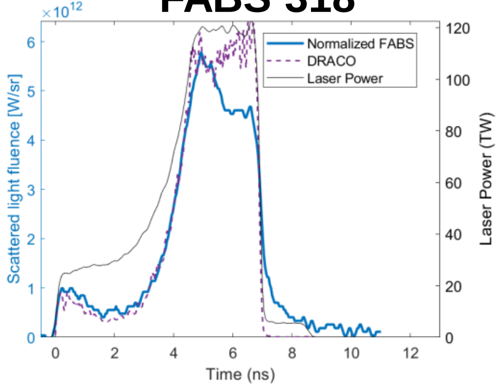
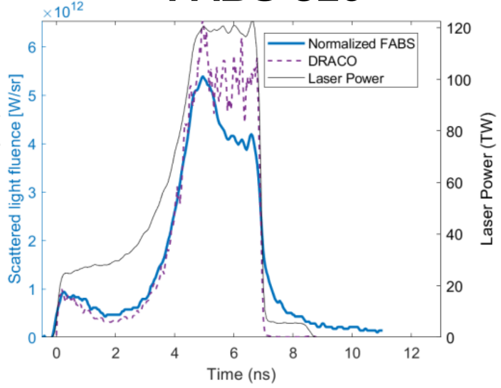


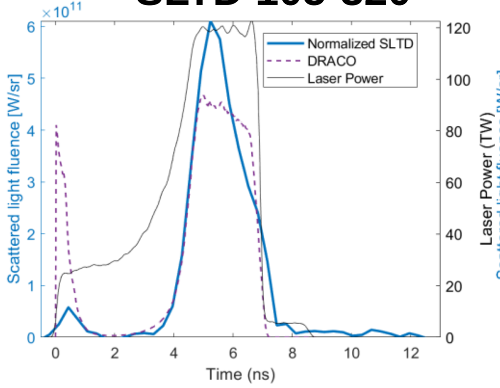
FABS 318



FABS 316



SLTD 105-320



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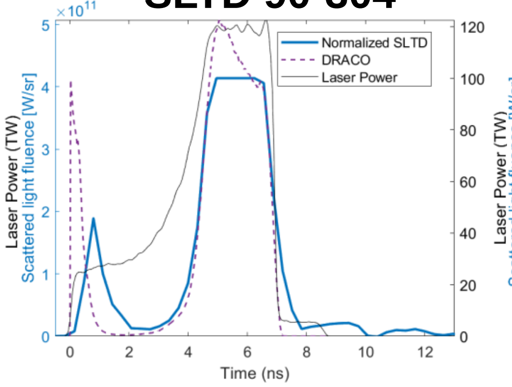
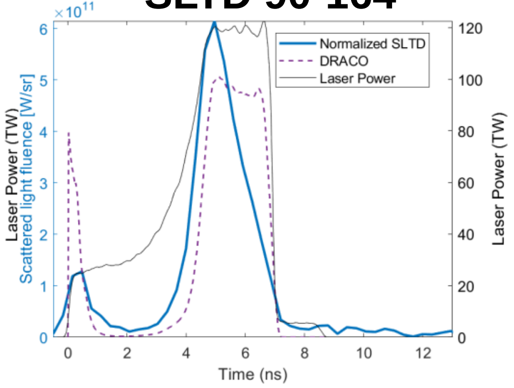
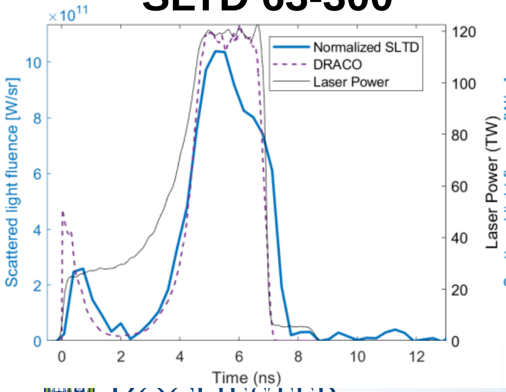


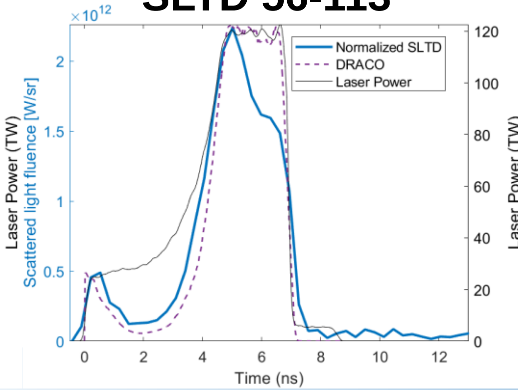
SLTD 90-164



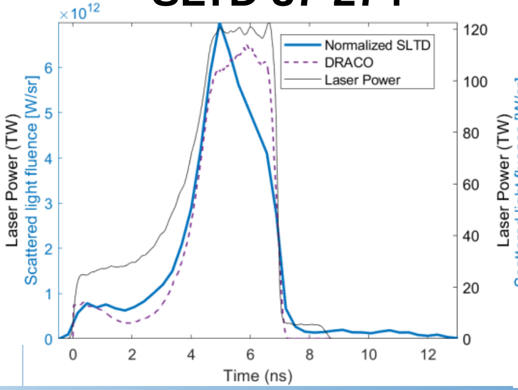
SLTD 63-300



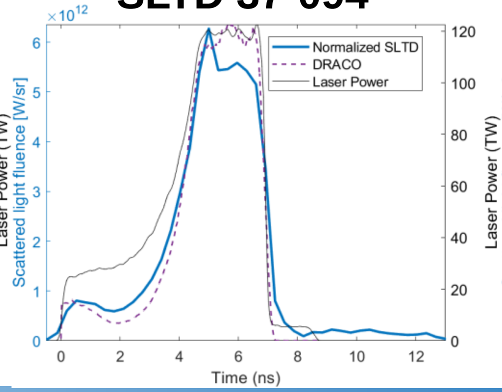
SLTD 56-113



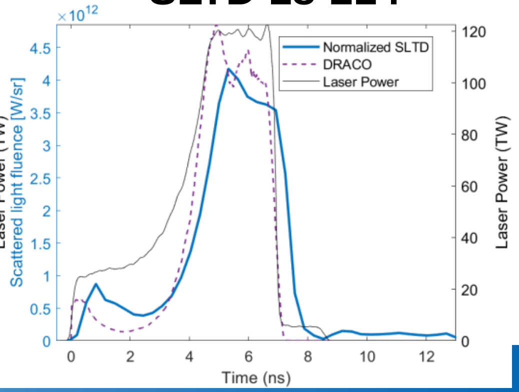
SLTD 37-274



SLTD 37-094

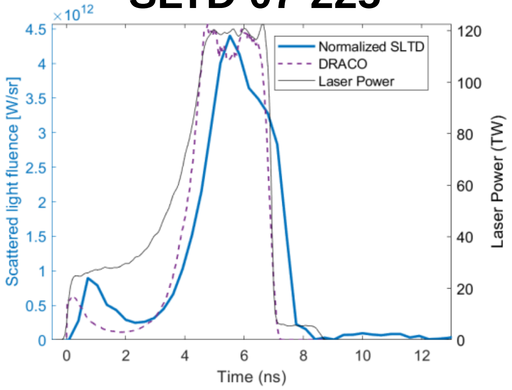


SLTD 18-214



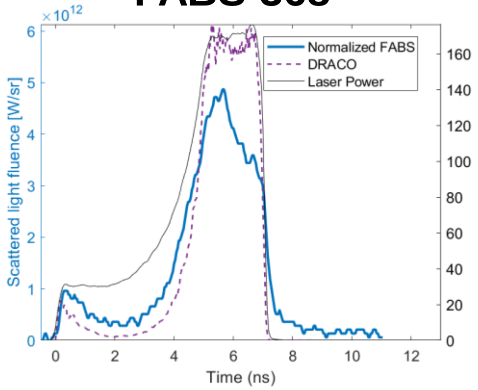
N210519-001 8e14 W/cm^2

SLTD 07-225



N210518-003 1.2e15 W/cm^2

FABS 368



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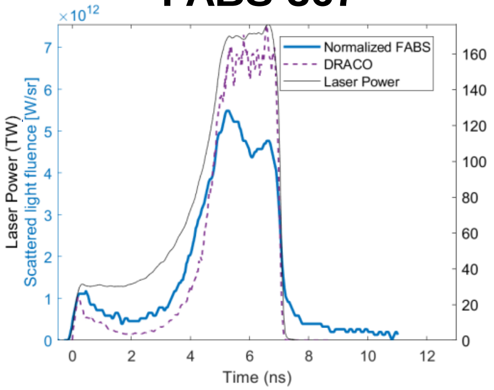

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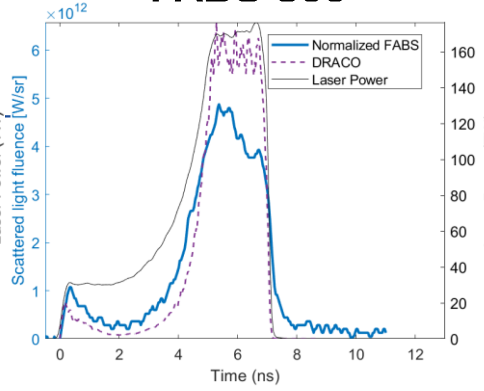
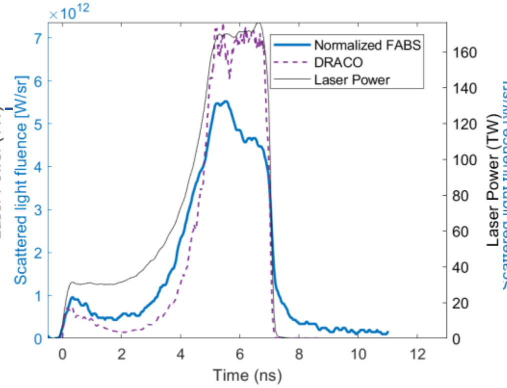


FABS 365



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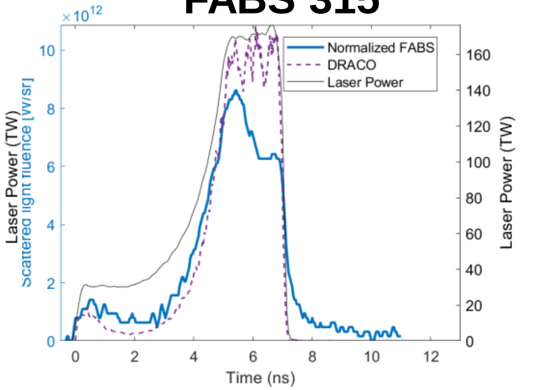

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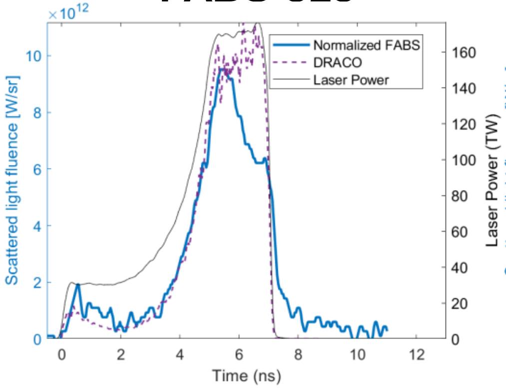

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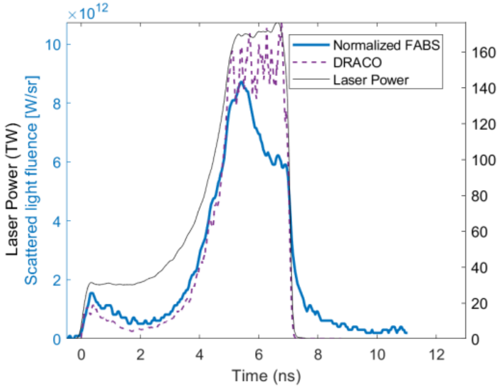

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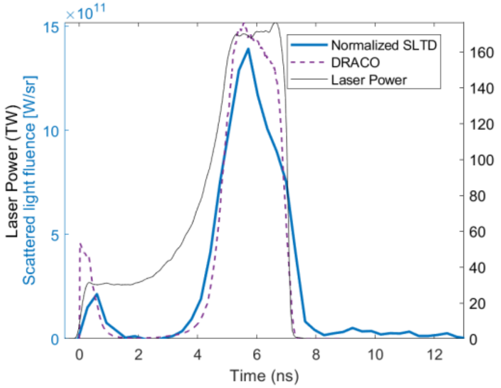

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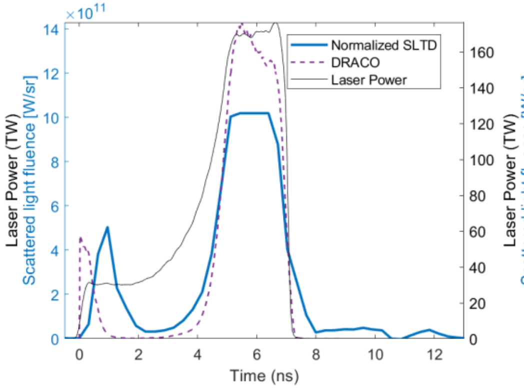

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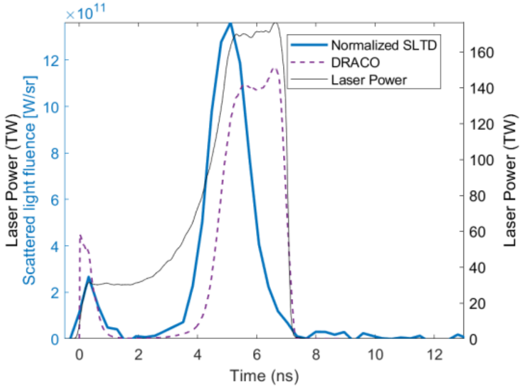

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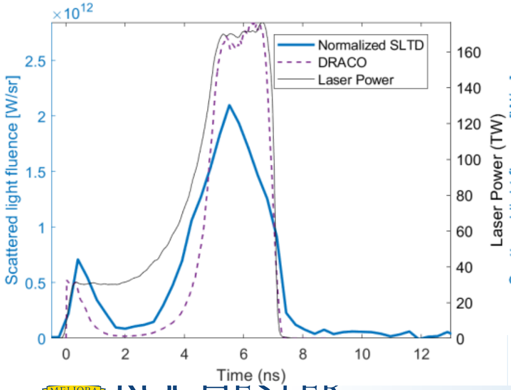

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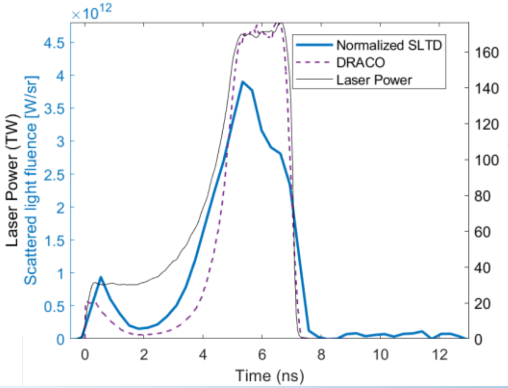

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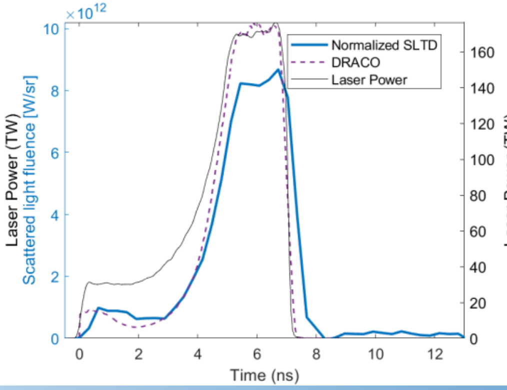

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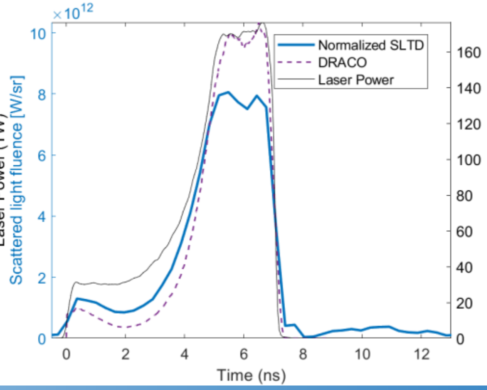

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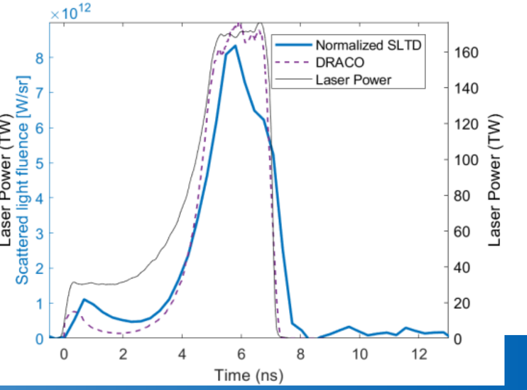
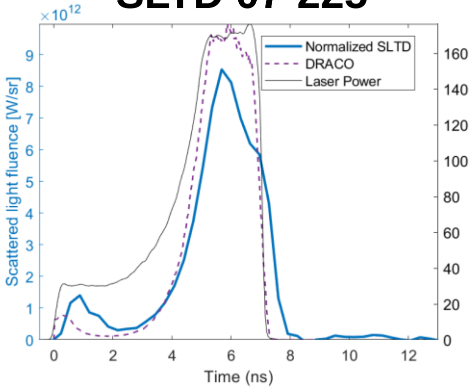


N210518-003 1.2e15 W/cm^2

SLTD 07-225



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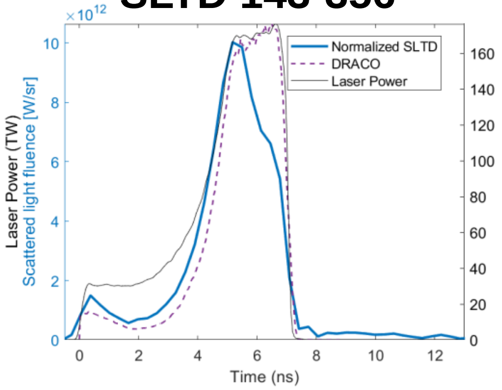

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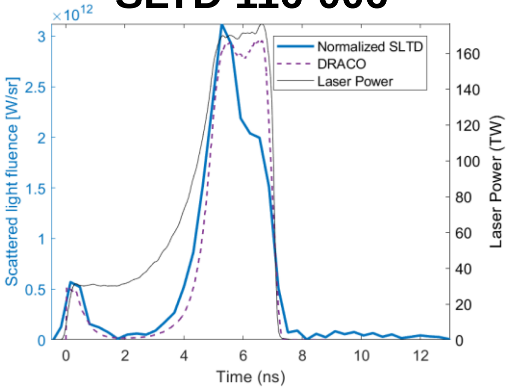
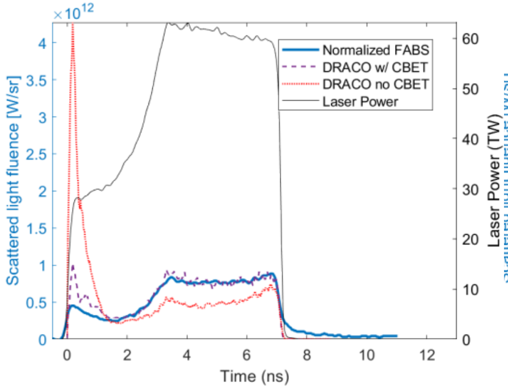


N210301-002 4e1.4 W/cm^2

FABS 368



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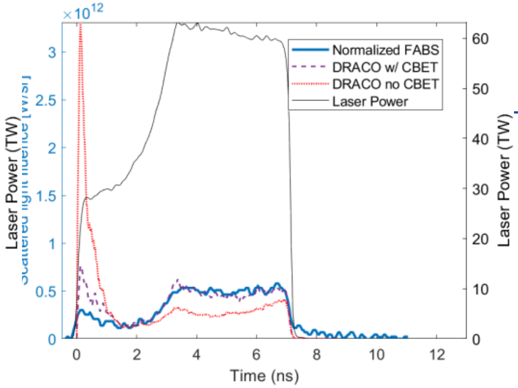

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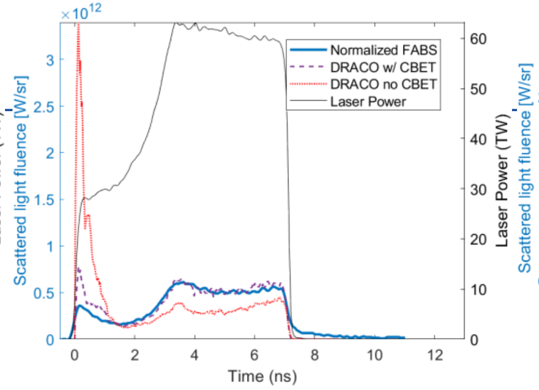

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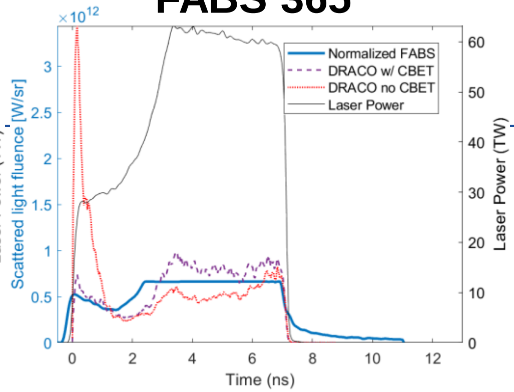

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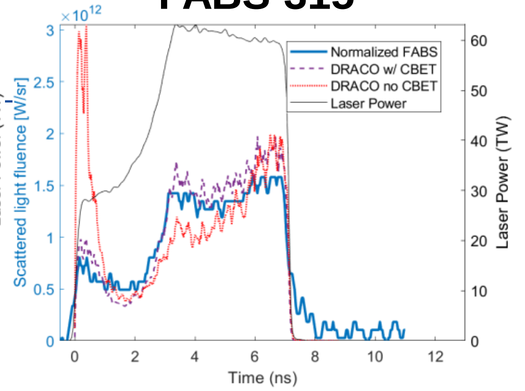
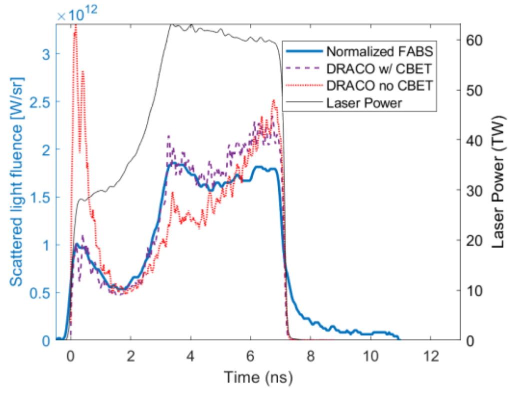


FABS 318



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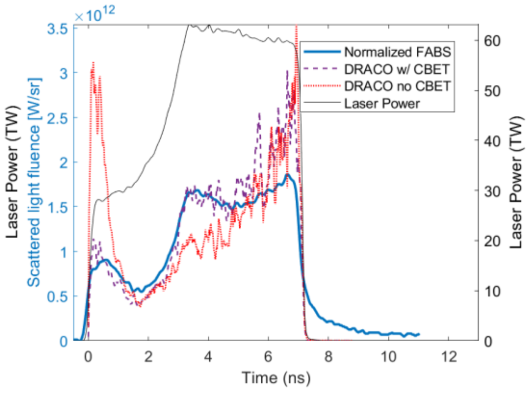

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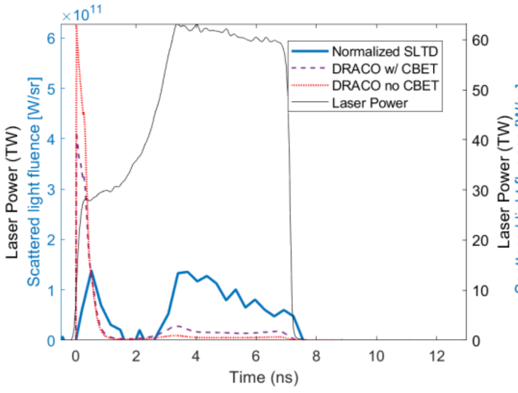
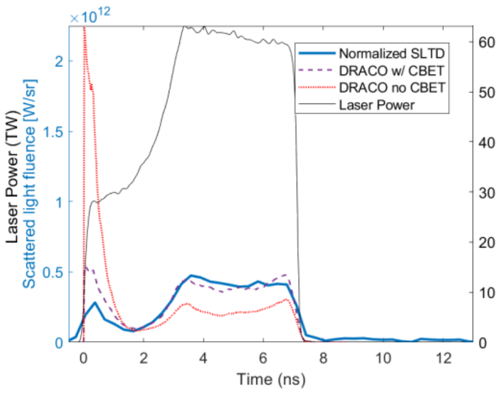
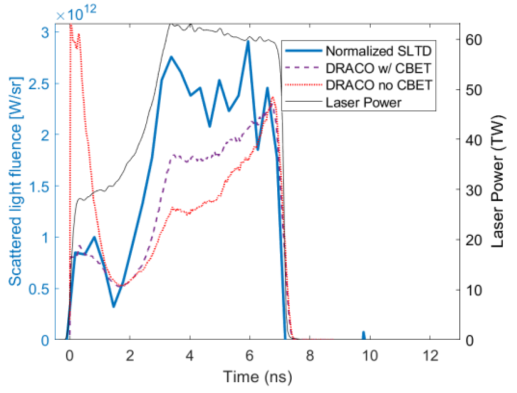


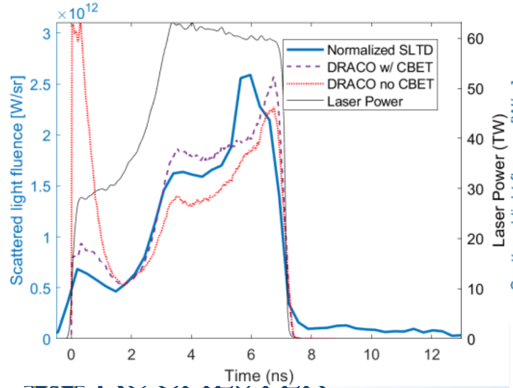
SLTD 56-113



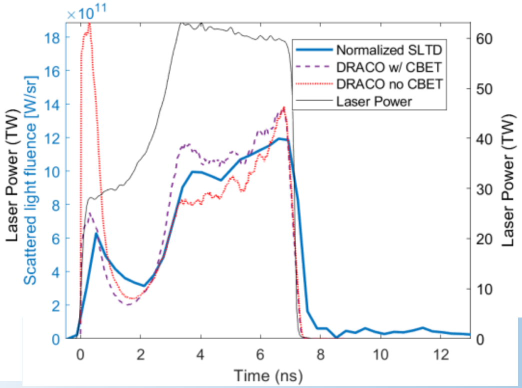
SLTD 37-274



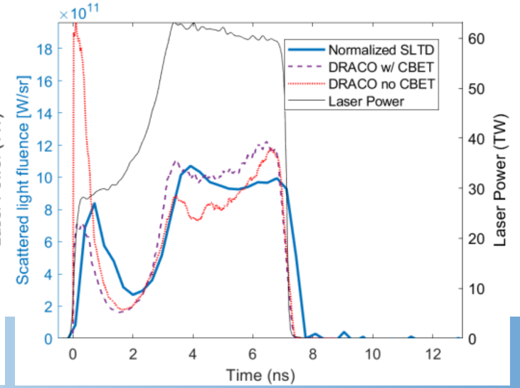
SLTD 37-094



SLTD 18-214

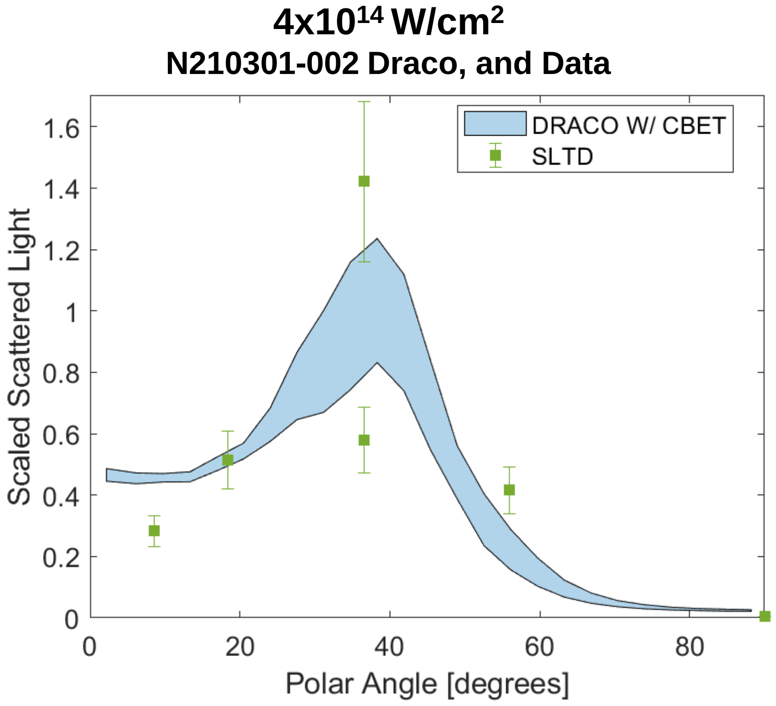


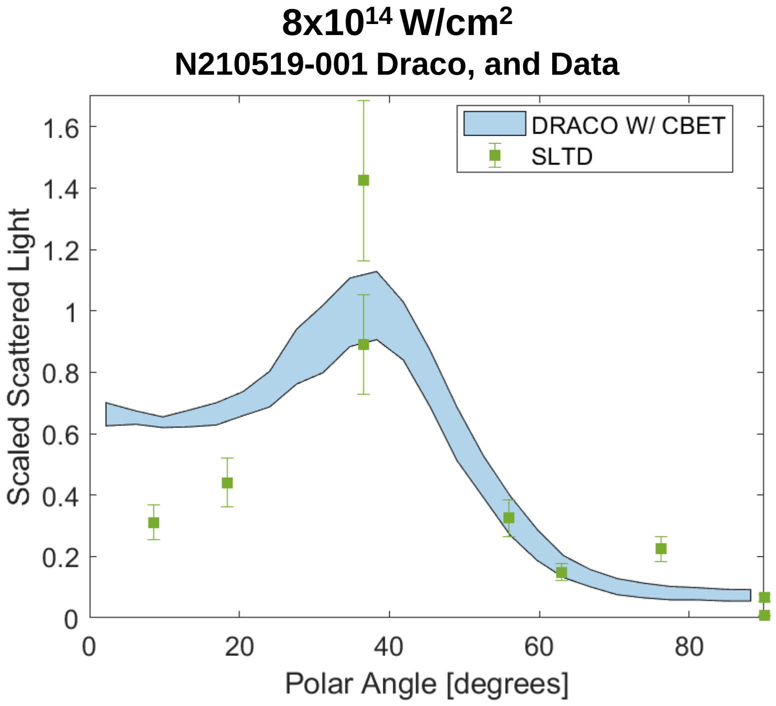
SLTD 07-225

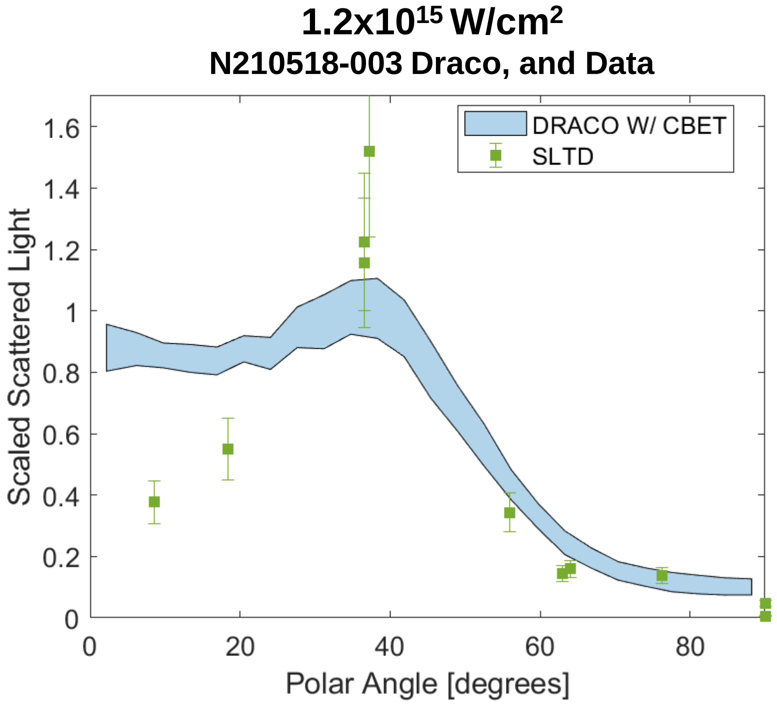


Angular distribution of scattered light as a function of intensity shows qualitative agreement with DRACO, with a peak around 30-40 degrees and falling off at the poles and equator

Time-integrated scaled scattered light data and simulations vs. polar angle



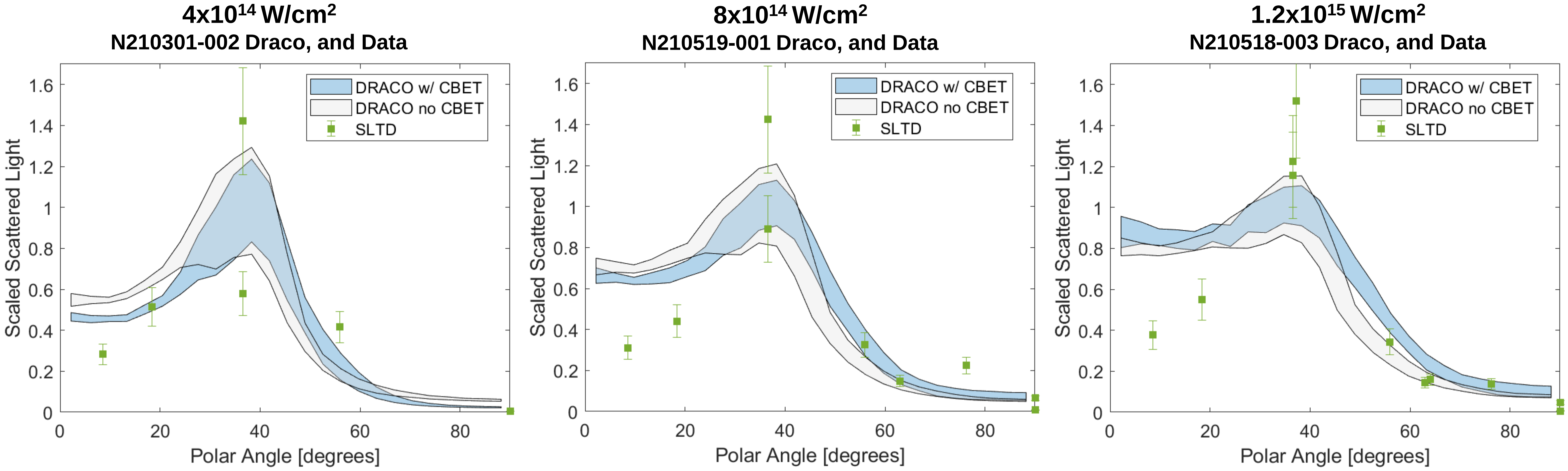




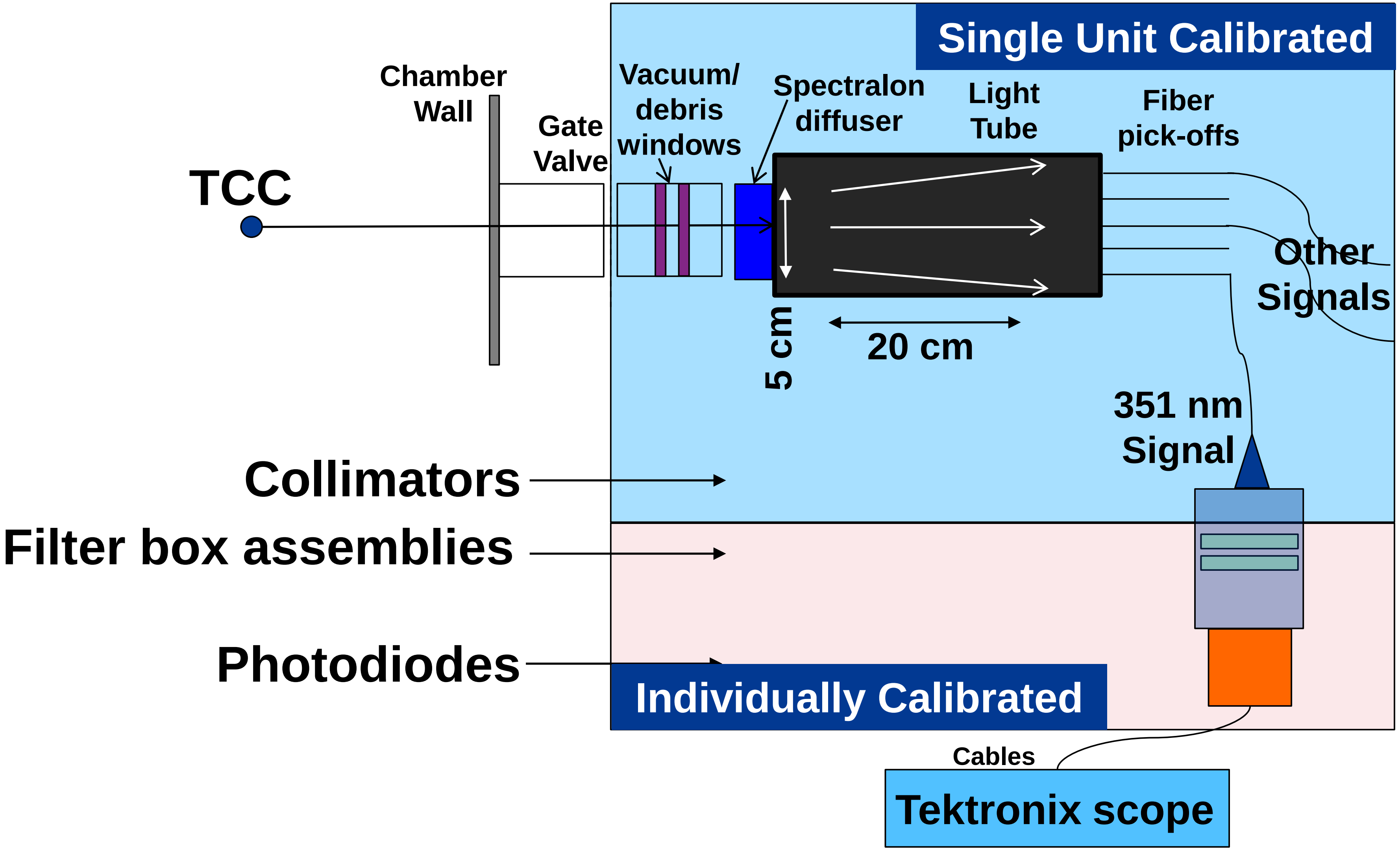
Flattening of scattered light distribution towards the poles with increasing intensity predicted by DRACO is not evident in the data, suggesting that CBET effect is not as strong as modeled

Angular distribution of scattered light as a function of intensity shows qualitative agreement with DRACO, with a peak around 30-40 degrees and falling off at the poles and equator

Time-integrated scaled scattered light data and simulations vs. polar angle



Flattening of scattered light distribution towards the poles with increasing intensity predicted by DRACO is not evident in the data, suggesting that CBET effect is not as strong as modeled


Single Unit Calibrated
Chamber Wall
Gate Valve
Vacuum/ debris windows
Spectralon diffuser
Light Tube
Fiber pick-offs
TCC
Other Signals
5 cm
20 cm
351 nm Signal
Collimators
Filter box assemblies
Photodiodes
Individually Calibrated
Cables
Tektronix scope