Improvements to the VISAR and Streaked Optical Pyrometer at the Omega Laser Facility

M. K. GINNANE,[1] A. SORCE,[1] J. D. KENDRICK,[1] R. BONI,[1] B. SALTZMAN,[1] D. WEINER,[1] M. ZAGHOO,[1] D. N. POLSIN,[1] B. J. HENDERSON,[1] J. ZAO,[1] M. COUCH,[1] C. M. ROGOFF,[2] M. C. GREGOR,[3] T. R. BOEHLY,[1] J. R. RYGG,[1] and G. W. COLLINS[1]

[1] University of Rochester, Laboratory for Laser Energetics
[2]ASML, [3]Lawrence Livermore National Laboratory

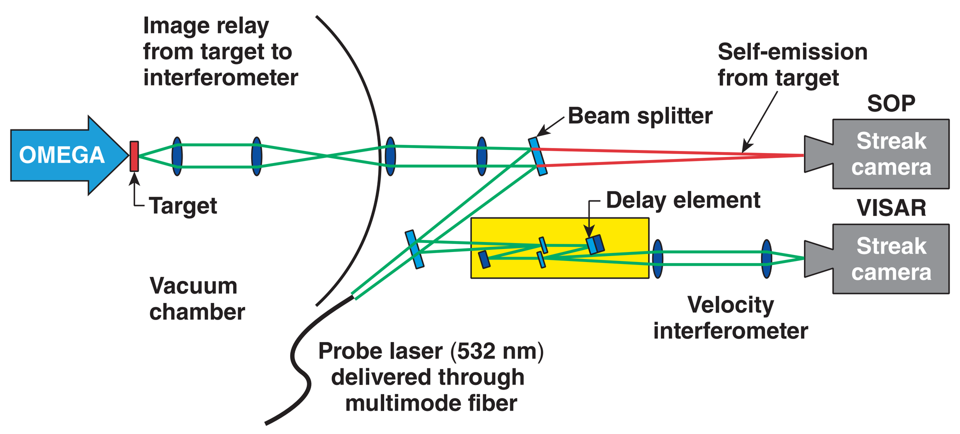
Update to VISAR and SOP diagnostics

- In response to users' requests, VISAR and SOP will have periodic timing and calibration tests
  - a T-0 test will be performed twice a year
  - SOP calibration will be performed twice a year
- Telescopes and optical relays on OMEGA and OMEGA EP will be redesigned
  - improve SOP optical performance in 590- to 850-nm ranges
  - install baffles to reduce throughput of light from outside FOV
  - mount SOP calibration on telescope
- OMEGA EP TIM-12 upgrade
  - install TIM periscope to improve alignment for off-axis campaigns

FOV: field of view
TIM: ten-inch manipulator
VISAR: velocity interferometer system for any reflector
SOP: streaked optical pyrometer

E26082a

VISAR and SOP use a common telescope to acquire data from laser-compressed samples



- 590- to 850-nm light from the shock front is imaged onto a streak camera
- Spatial and temporal data are collected simultaneously with a VISAR
- The brightness temperature is inferred from self-emission intensity using the absolute calibration

E11212i

An upgraded telescope will improve SOP imaging, calibration, and VISAR alignment

Imaging
- The current telescope is only optimized for 532-nm light, which causes the SOP to have imaging capabilities that are nearly 40× the diffraction limit

Calibration
- The current calibration source cannot be repeatedly installed and aligned
- The calibration source is only available on OMEGA

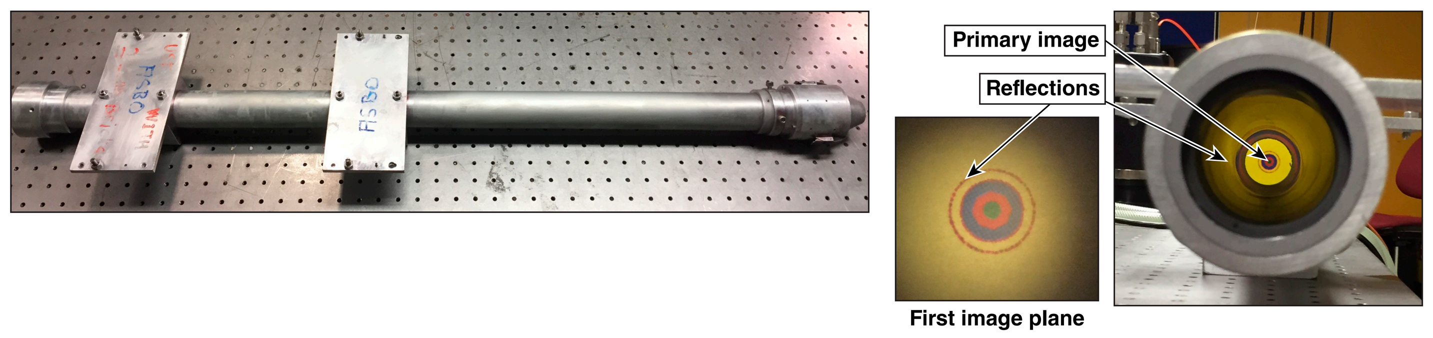
Alignment
- The design of the current telescope inhibits the ability to accurately point and center through the three primary optics
- Additional alignment aids will be developed to quantify and improve alignment

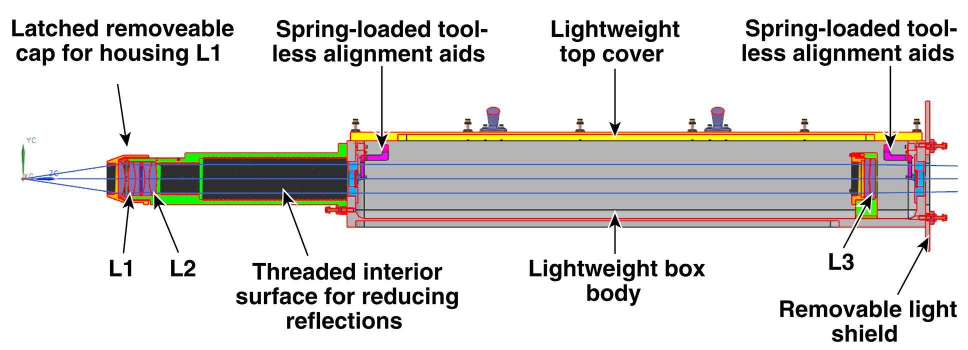
Upgrading the telescope gives an opportunity to make many improvements to the VISAR/SOP system as a whole.

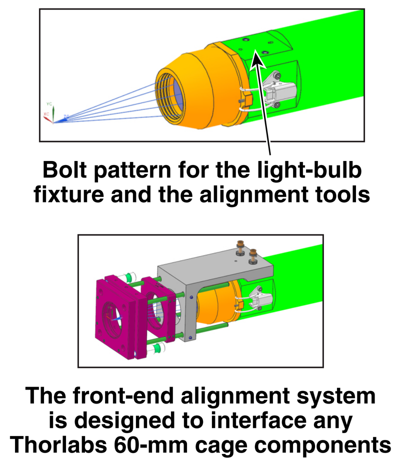
E26087b

VISAR/SOP telescope

The previous telescope design allowed light from outside the desired field of view to be relayed to the streak cameras

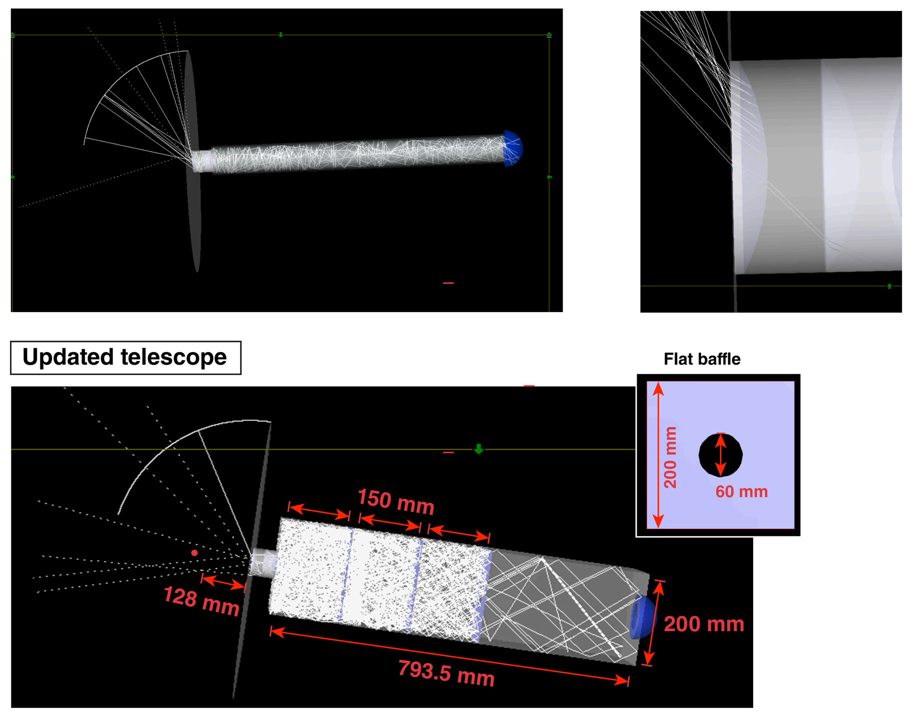






E26089b

The updated telescope reduces scattered-light collection by a factor of 200

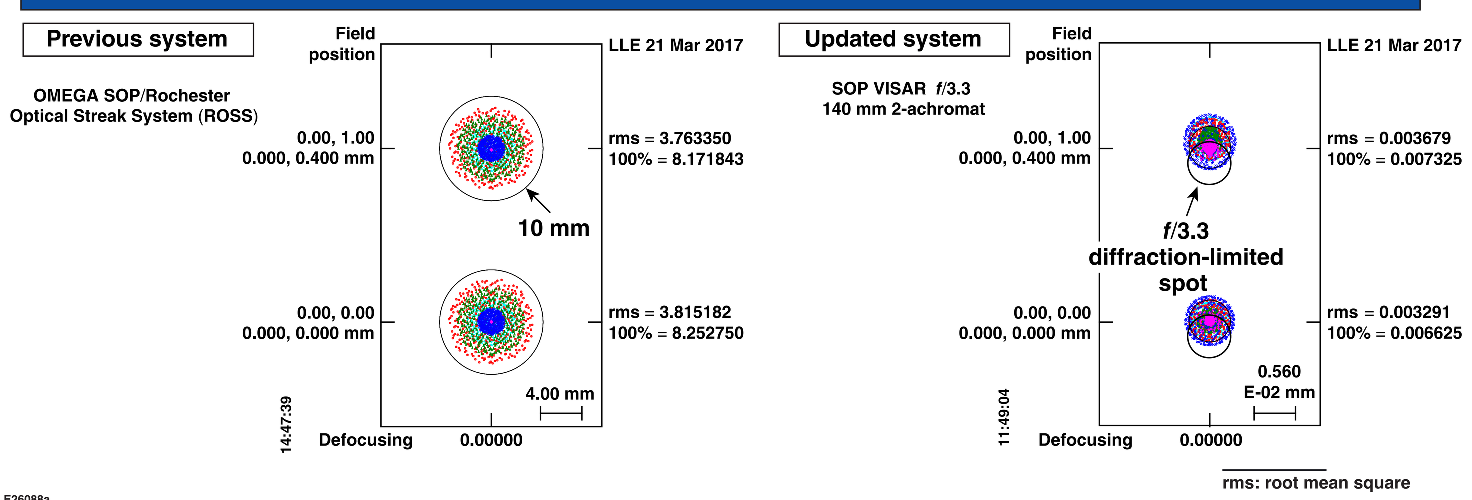


The previous telescope allowed 2.2% of target chamber (TC) scattered light incident on the f/3.3 collection lens to exit the telescope

- Energy loss mechanisms
  - absorption/total internal reflection (TIR) by lenses
  - absorption by metal
- The baffled telescope allows 0.011% of TC scattered-light energy incident on the collection lens to exit the telescope—an improvement of 200×

E26090c

Achromat design performance over the 590- to 850-nm SOP spectral band is near-diffraction limited

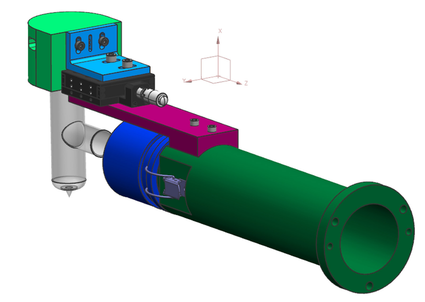


rms: root mean square

E26088a

Recent calibration of SOP on OMEGA EP

A NIST-traceable source is used to calibrate the spectral response of the SOP

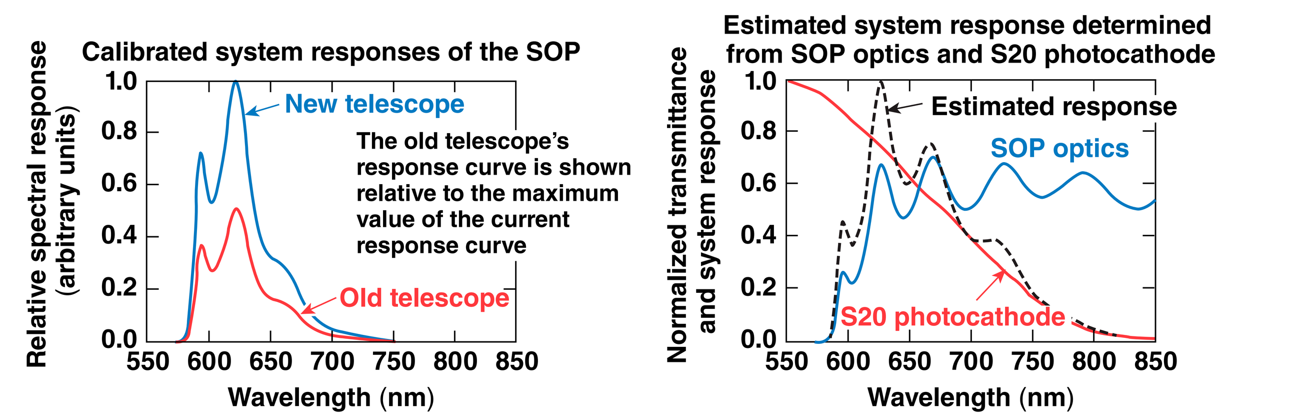


- New telescope mounts the source kinematically; SOP focus on the filament is fine-tuned with the TIM insertion depth
- Narrow bandpass filters isolate regions of the source's emission spectrum and the SOP response in each region is measured
- An estimated system response curve is fit to the measured SOP response within each wavelength range

Measured SOP intensity, I (ADU's):

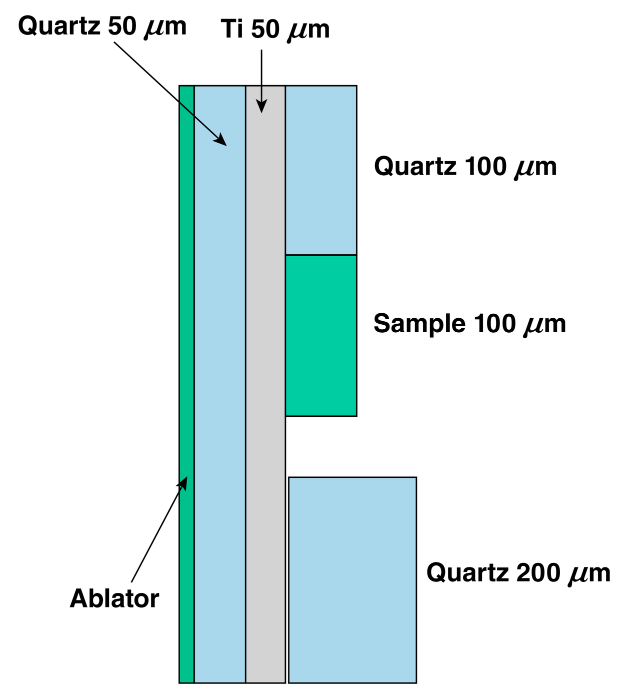
$$I = A_0 \frac{T(W_{S0})}{\eta} \int_{\text{all } \lambda} d\lambda\, L_s(\lambda) T_x(\lambda) \mathrm{SR}(\lambda)$$

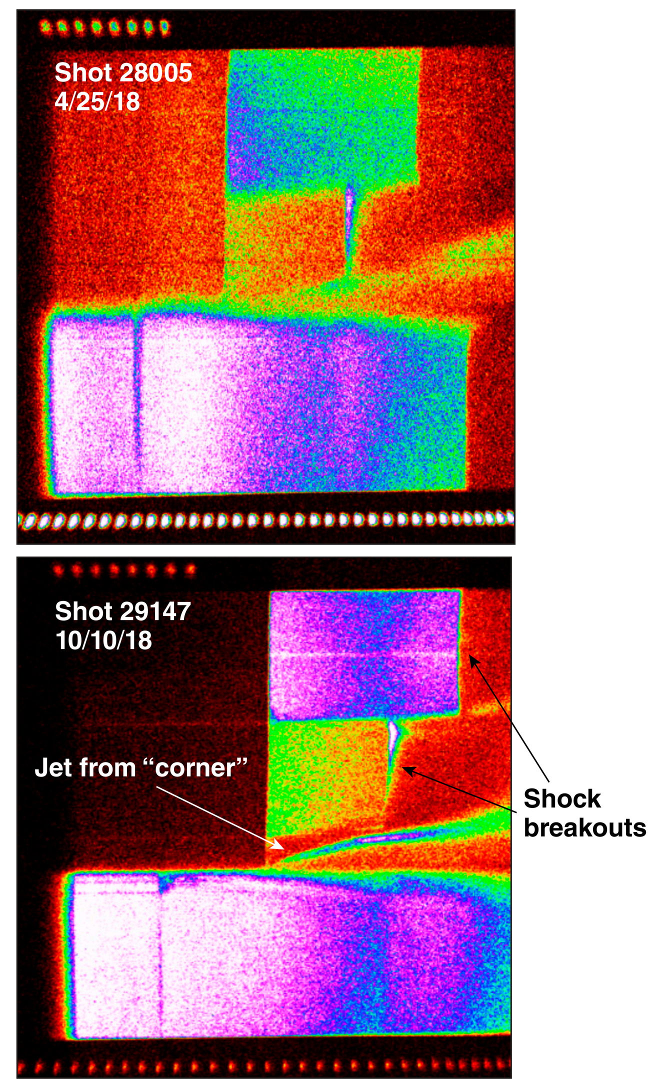
A_0 = calibration parameter
$X(W_{S0})$ = throughput depending on experimental slit width, W_{S0}
η = sweep rate in pixels/ns
L_s = source spectral radiance
T_x = transmission spectra of neutral density (ND) or bandpass filters
SR = system response



E26094a

The updated telescope improves temporal and spatial resolution in the SOP data





The effect of increased temporal and spatial resolution is apparent when comparing similar experiments.
Courtesy of C. A. McCoy (SNL)

E28092

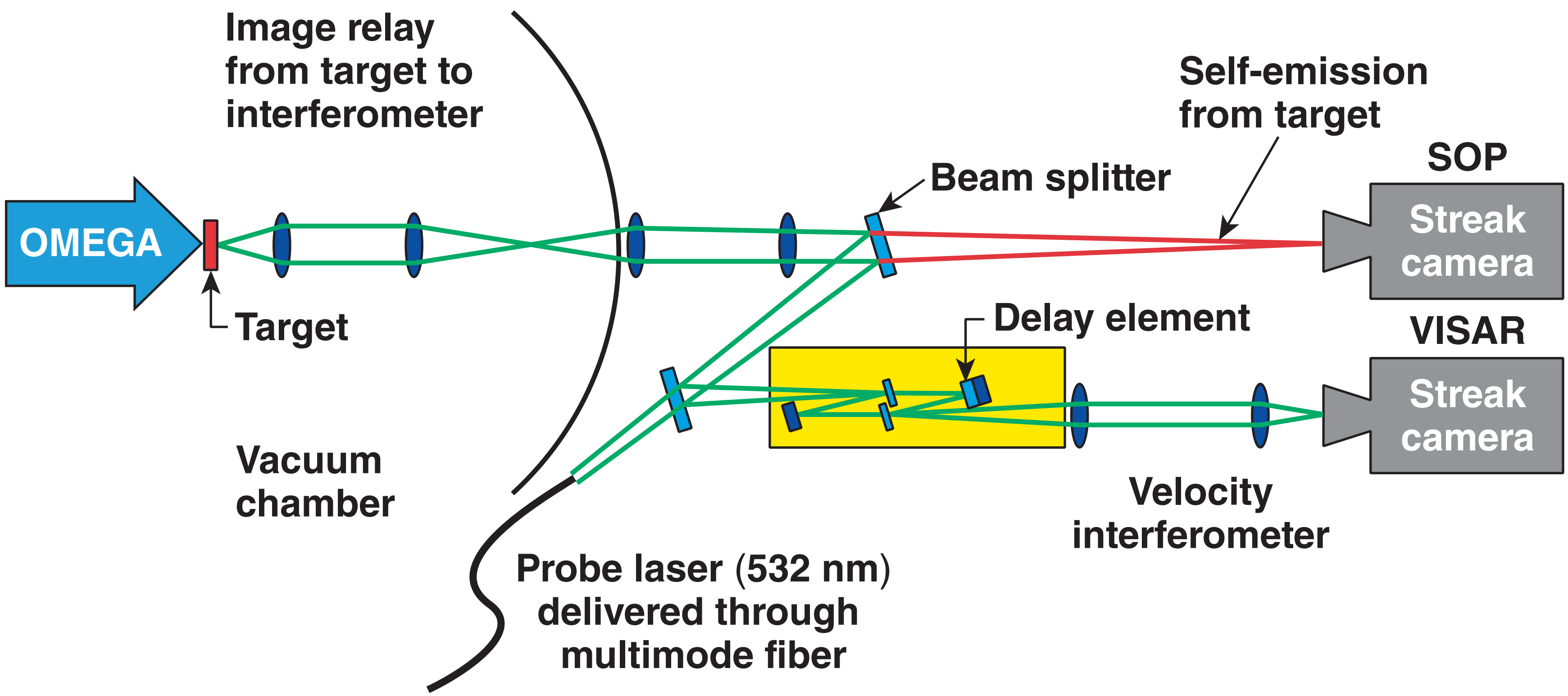
- In response to users' requests, VISAR and SOP will have periodic timing and calibration tests
  - a T-0 test will be performed twice a year
  - SOP calibration will be performed twice a year
- Telescopes and optical relays on OMEGA and OMEGA EP will be redesigned
  - improve SOP optical performance in 590- to 850-nm ranges
  - install baffles to reduce throughput of light from outside FOV
  - mount SOP calibration on telescope
- OMEGA EP TIM-12 upgrade
  - install TIM periscope to improve alignment for off-axis campaigns

---

FOV: field of view
TIM: ten-inch manipulator
VISAR: velocity interferometer system for any reflector
SOP: streaked optical pyrometer

E26082a

VISAR and SOP use a common telescope to acquire data from laser-compressed samples



- 590- to 850-nm light from the shock front is imaged onto a streak camera
- Spatial and temporal data are collected simultaneously with a VISAR
- The brightness temperature is inferred from self-emission intensity using the absolute calibration

E11212I

An upgraded telescope will improve SOP imaging, calibration, and VISAR alignment

Imaging

- The current telescope is only optimized for 532-nm light, which causes the SOP to have imaging capabilities that are nearly 40× the diffraction limit

Calibration

- The current calibration source cannot be repeatedly installed and aligned
- The calibration source is only available on OMEGA

Alignment

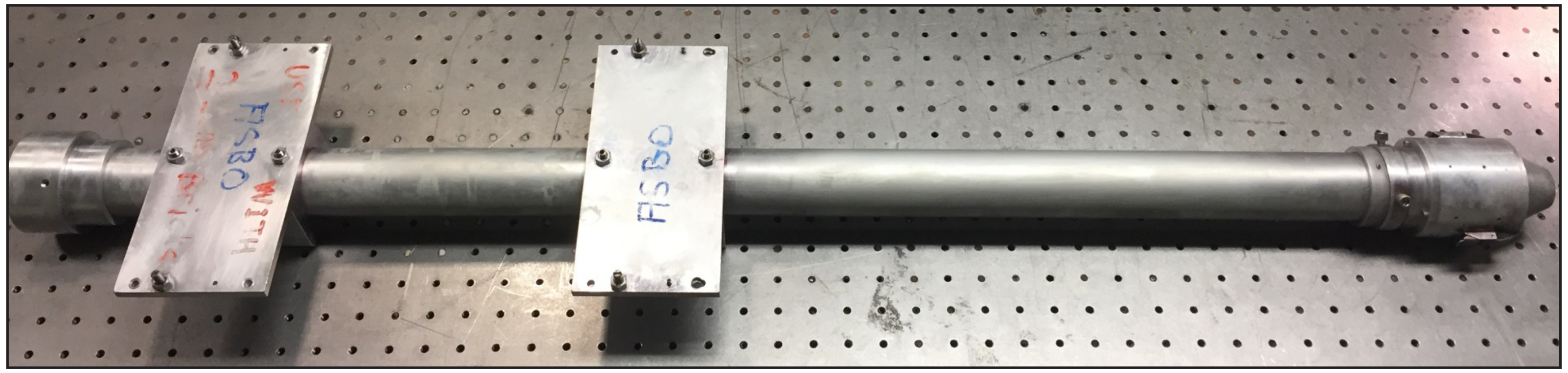
- The design of the current telescope inhibits the ability to accurately point and center through the three primary optics
- Additional alignment aids will be developed to quantify and improve alignment

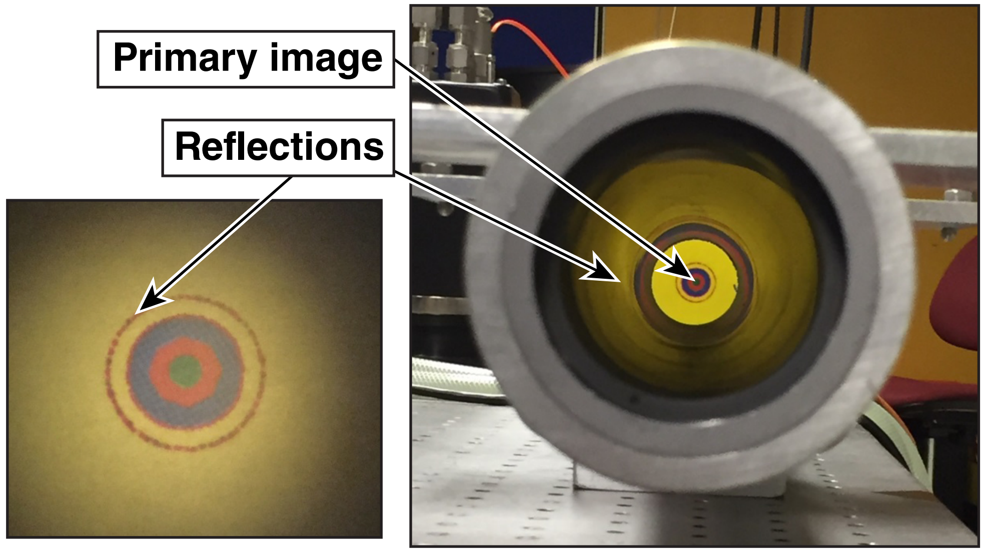
Upgrading the telescope gives an opportunity to make many improvements to the VISAR/SOP system as a whole.

E26087b

The previous telescope design allowed light from outside the desired field of view to be relayed to the streak cameras

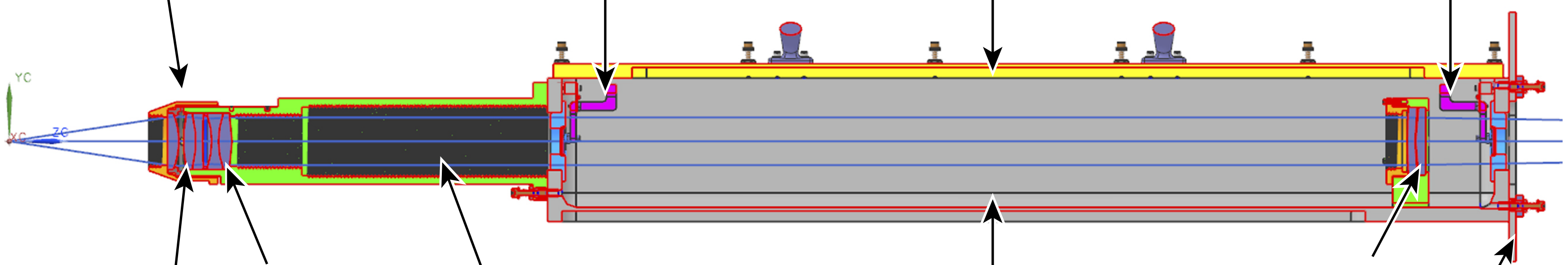
Previous telescope

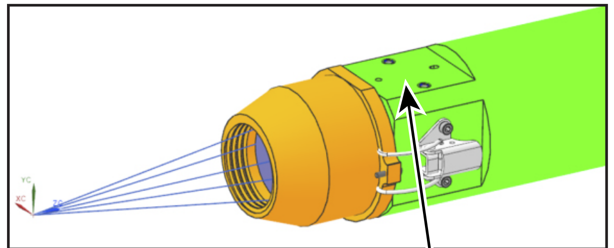




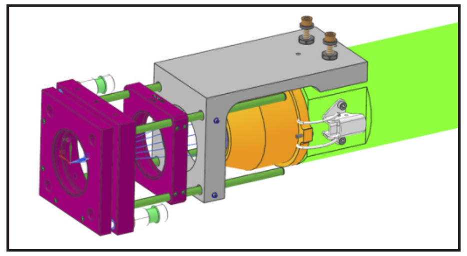
First image plane

Updated telescope





Bolt pattern for the light-bulb fixture and the alignment tools

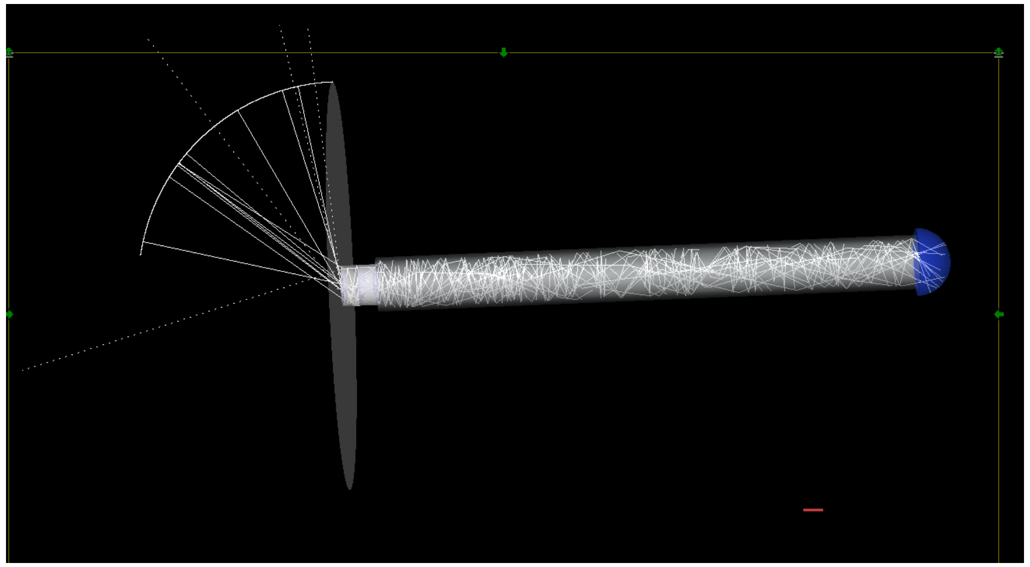


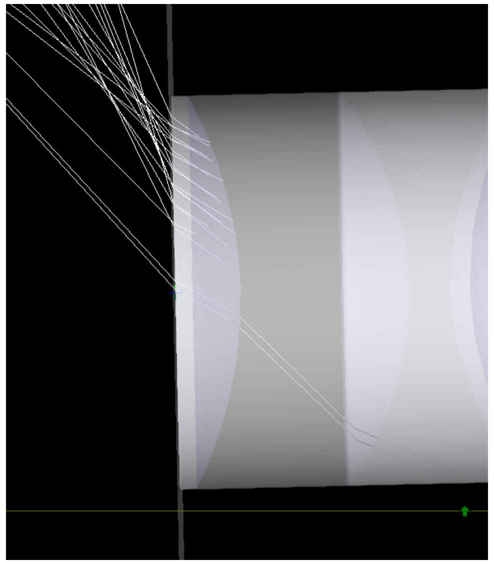
The front-end alignment system is designed to interface any Thorlabs 60-mm cage components

E26089b

The updated telescope reduces scattered-light collection by a factor of 200

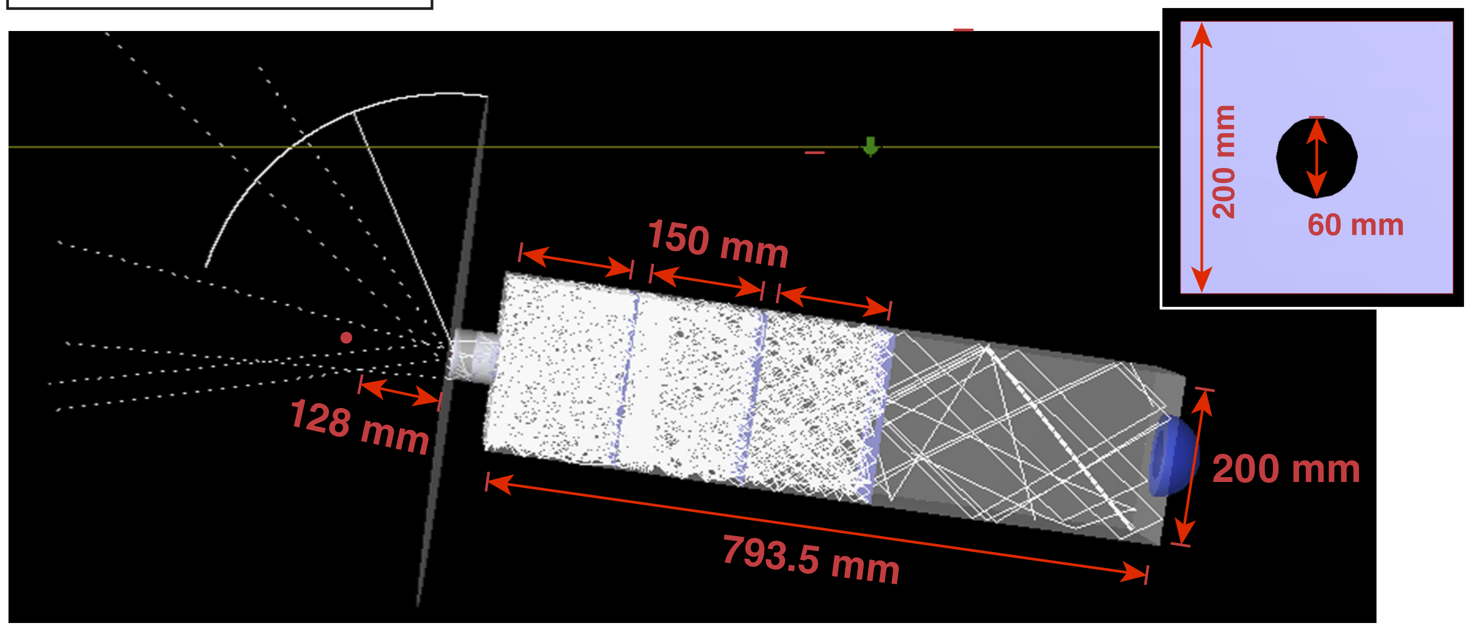
Previous telescope





Updated telescope

Flat baffle



The previous telescope allowed 2.2% or target chamber (TC) scattered light incident on the *f*/3.3 collection lens to exit the telescope

- **Energy loss mechanisms**
  - **absorption/total internal reflection (TIR) by lenses**
  - **absorption by metal**

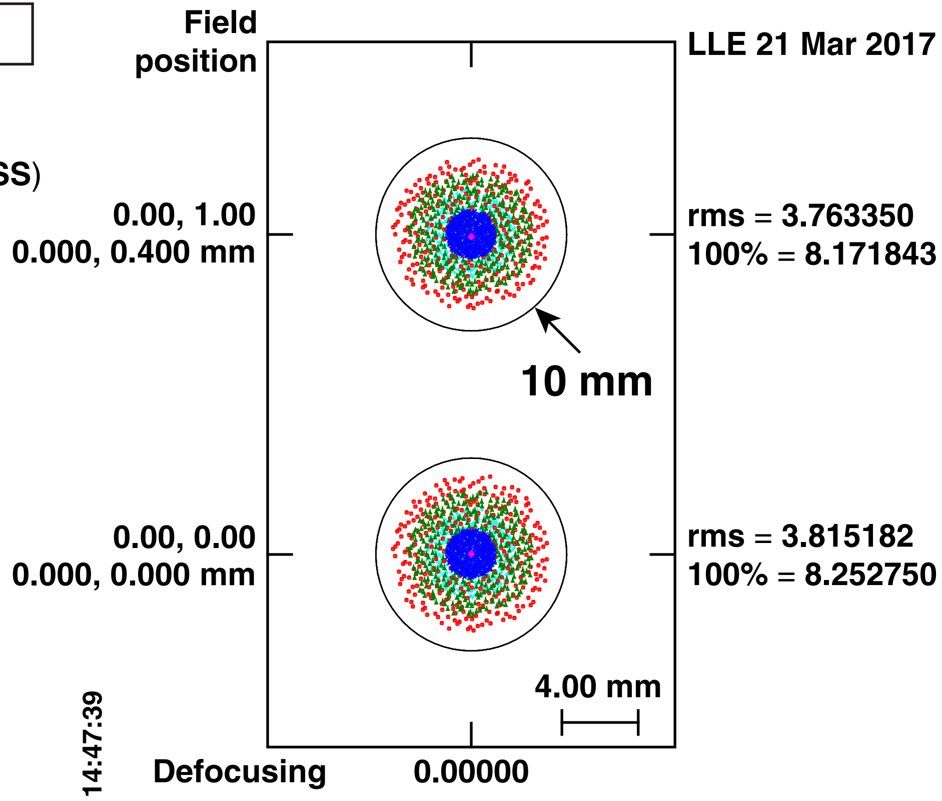
- **The baffled telescope allows 0.011% of TC scattered-light energy incident on the collection lens to exit the telescope—an improvement of 200×**

E26090c

Achromat design performance over the 590- to 850-nm SOP spectral band is near-diffraction limited

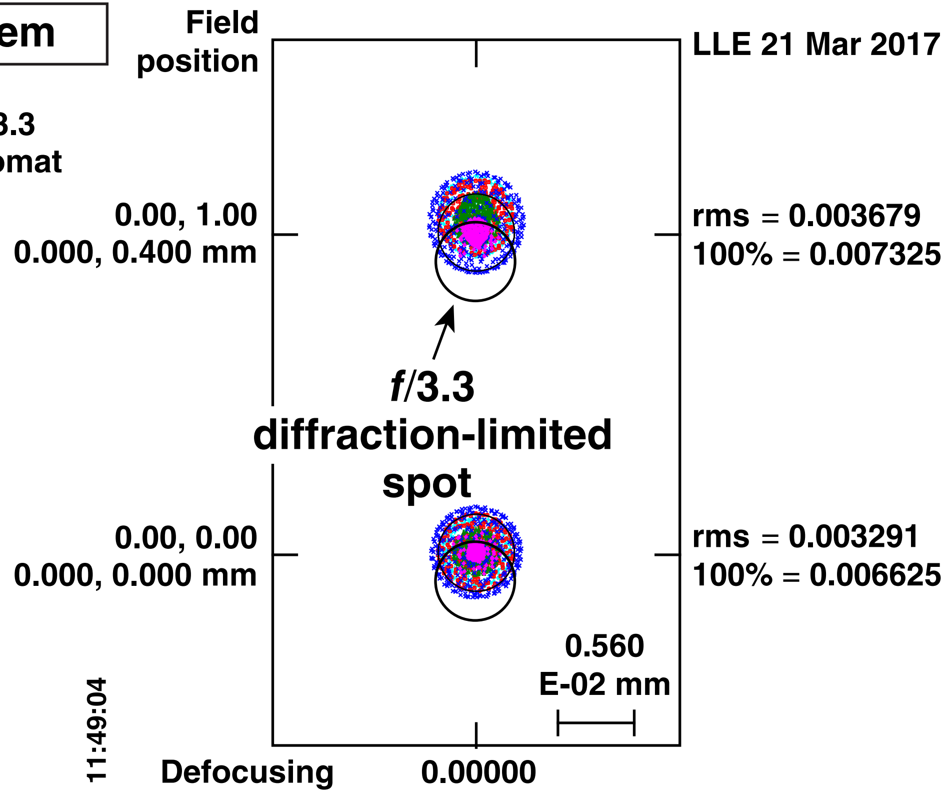
Previous system

OMEGA SOP/Rochester Optical Streak System (ROSS)



Updated system

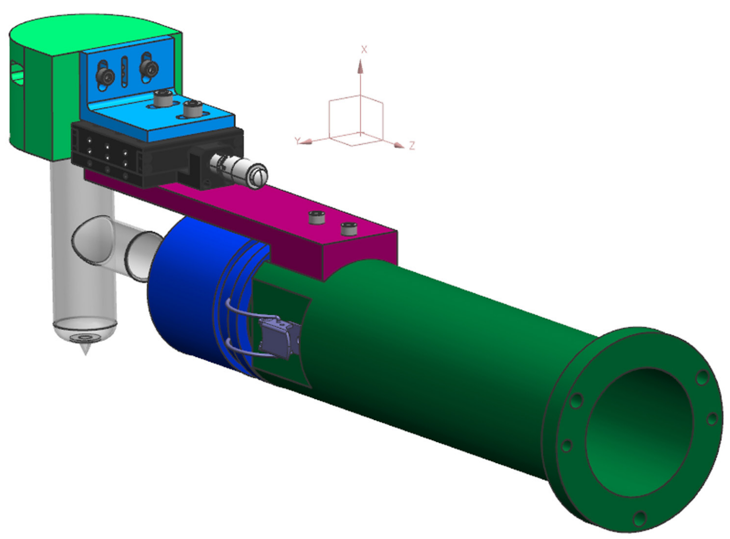
SOP VISAR *f*/3.3
140 mm 2-achromat



rms: root mean square

E26088a

A NIST-traceable source is used to calibrate the spectral response of the SOP

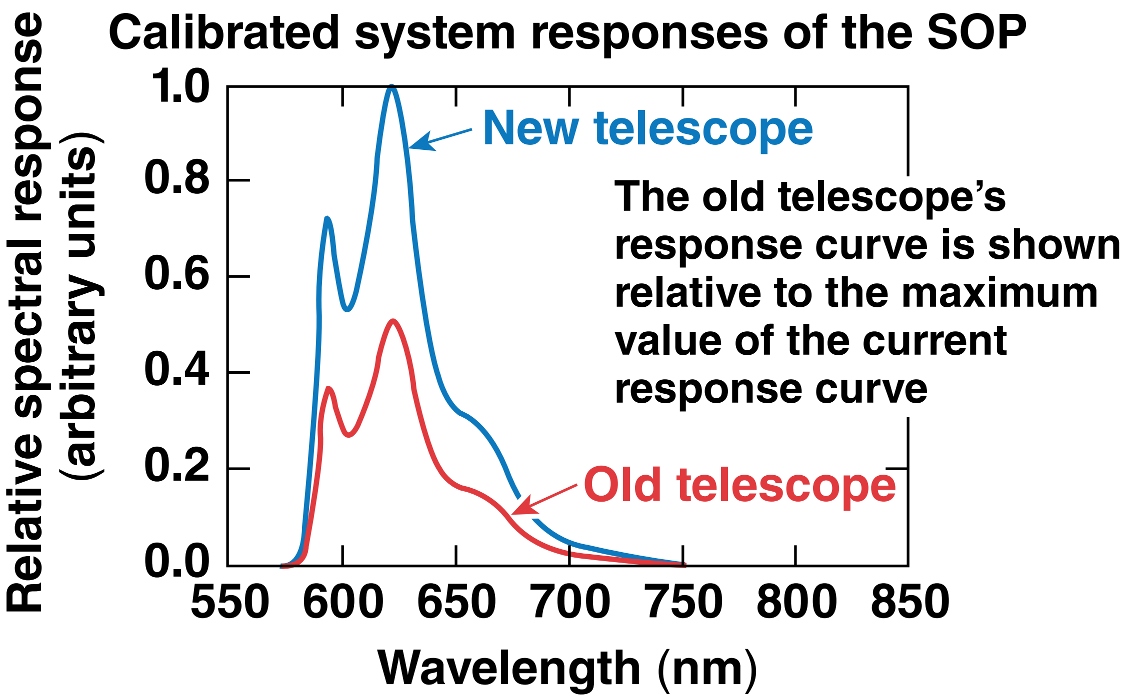


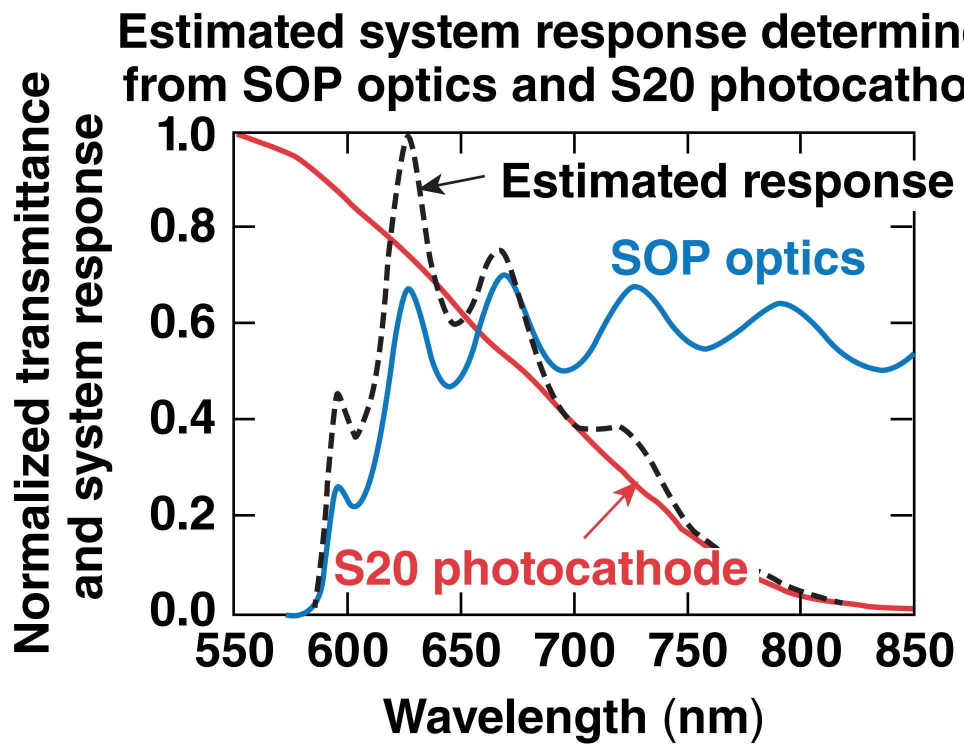
- New telescope mounts the source kinematically; SOP focus on the filament is fine-tuned with the TIM insertion depth
- Narrow bandpass filters isolate regions of the source's emission spectrum and the SOP response in each region is measured
- An estimated system response curve is fit to the measured SOP response within each wavelength range

Measured SOP intensity, I (ADU's):

$$I = A_0 \frac{T(W_{S0})}{\eta} \int_{\text{all } \lambda} d\lambda\, L_s(\lambda) T_x(\lambda) SR(\lambda)$$

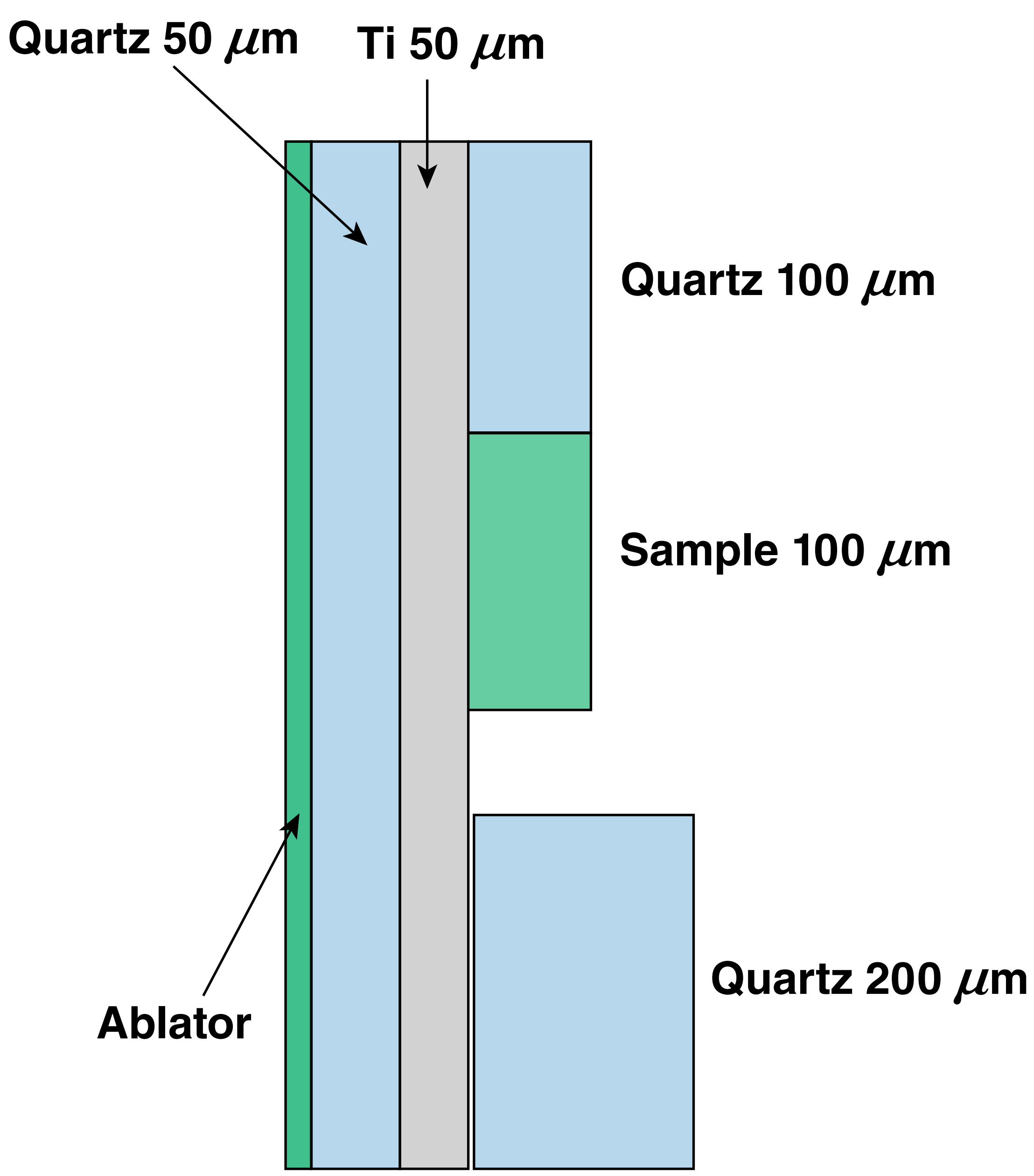
A_0 = calibration parameter
$X(W_{S0})$ = throughput depending on experimental slit width, W_{S0}
η = sweep rate in pixels/ns
L_s = source spectral radiance
T_x = transmission spectra of neutral density (ND) or bandpass filters
SR = system response

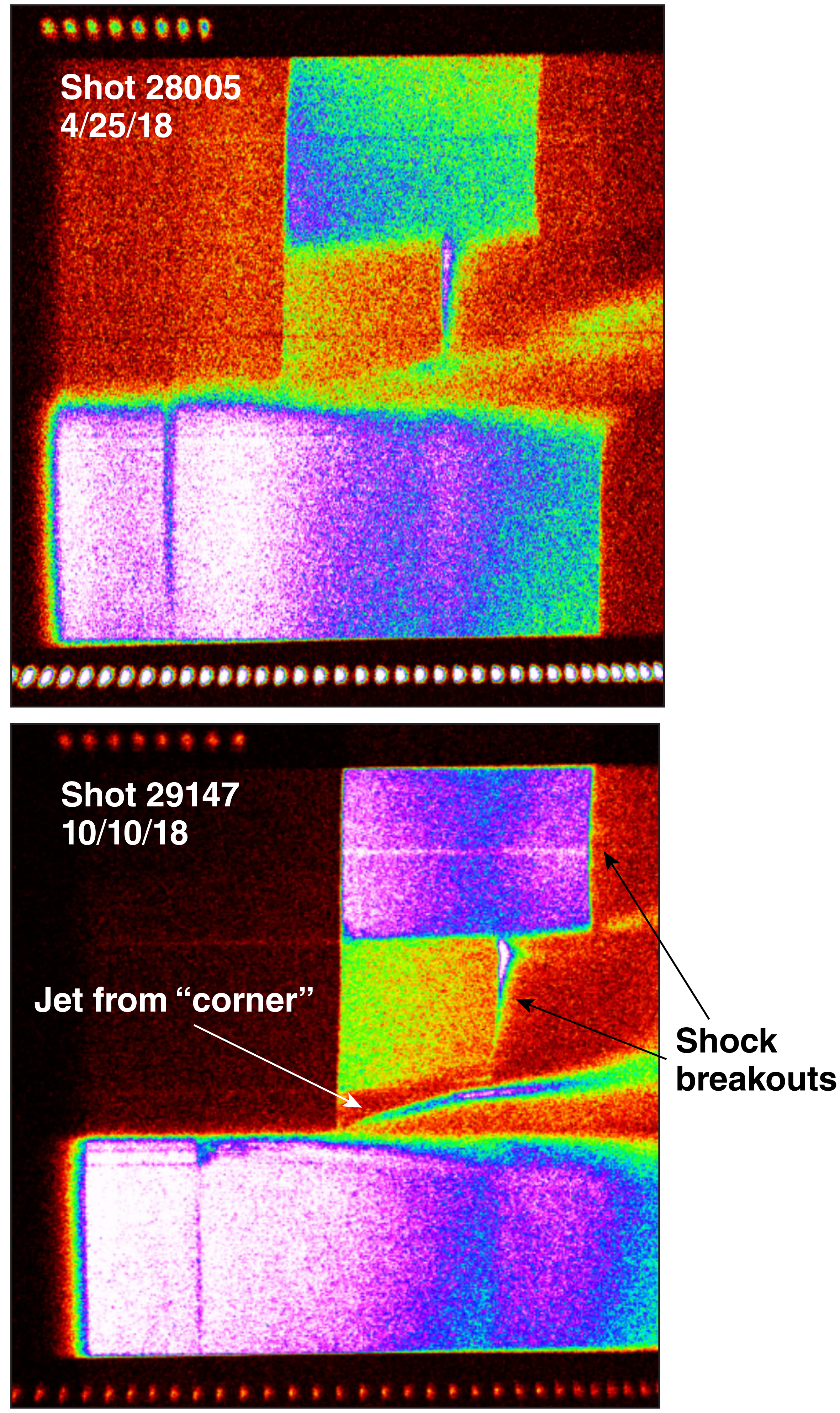




E26094a

The updated telescope improves temporal and spatial resolution in the SOP data





The effect of increased temporal and spatial resolution is apparent when comparing similar experiments.
Courtesy of C. A. McCoy (SNL)

E28092