The Absolute Calibration of the Streaked Optical Pyrometer at the Omega Laser Facility

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System Response

The streaked optical pyrometer (SOP) was absolutely calibrated to infer temperatures of shocked targets

- The absolute calibration is performed using a NIST*-traceable tungsten-filament lamp
- The wavelength-dependent system response function is measured in seven narrow wavelength regions
- The overall response function is accurately predicted from this narrowband construct
- Brightness temperature is inferred from self-emission intensity using the absolute calibration
- Uncertainty in brightness temperature is less than 10%

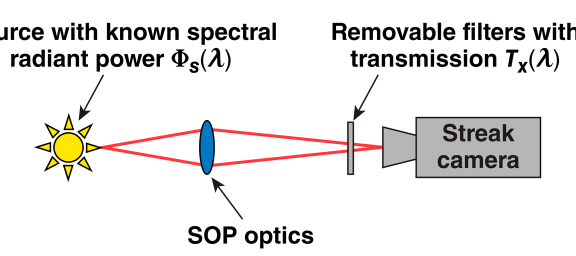
E22643

*National Institute of Standards and Technology

The wavelength-dependent system response was absolutely calibrated using a tungsten-filament lamp

- Camera output I is related to a NIST-traceable source of known spectral radiant power $\Phi_s(\lambda)$

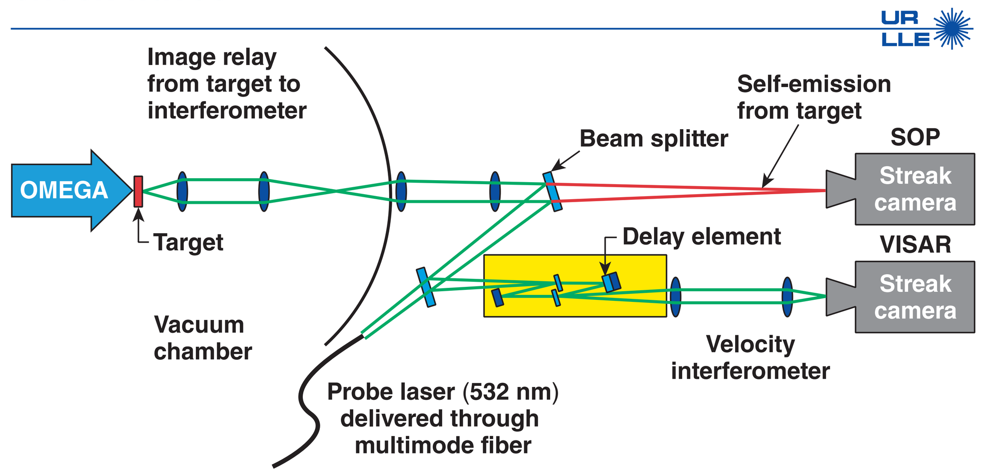
$$I = \Delta t \int_{\text{all } \lambda} d\lambda \, T_x(\lambda)\Phi_s(\lambda)\text{SR}(\lambda)$$



- System response SR (λ) includes S20 photocathode sensitivity and optical transmission of the system
- SR (λ) is measured in seven wavelength regions by the addition of 40-nm-wide bandpass filters with transmissions $T_x(\lambda)$

E22431

The SOP measures self-emission from laser-driven shock waves

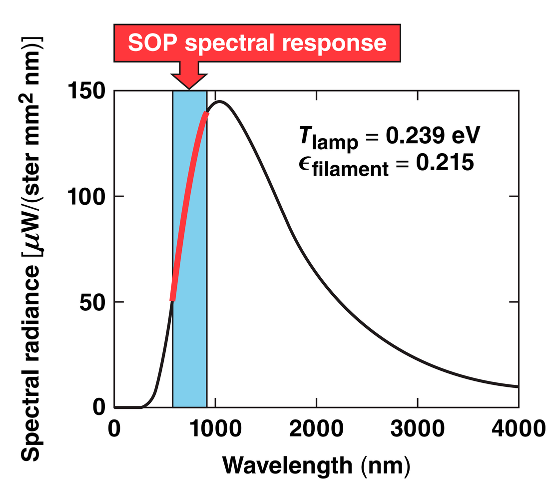


- 590- to 900-nm light from the shock front is imaged onto a streak camera
- Spatial and temporal data are collected simultaneously with a velocity interferometer system for any reflector (VISAR)
- Brightness temperature is inferred from self-emission intensity using the absolute calibration

E11212f

The calibration source is a NIST-traceable tungsten-filament lamp* with known spectral radiance

- The tungsten *ribbon* filament was imaged onto the photocathode



Spectral radiant power:

$$\Phi_s(\lambda) = \int_{A_{px}} dA \int_{\Omega_{lens}} d\Omega L_s(\lambda)$$

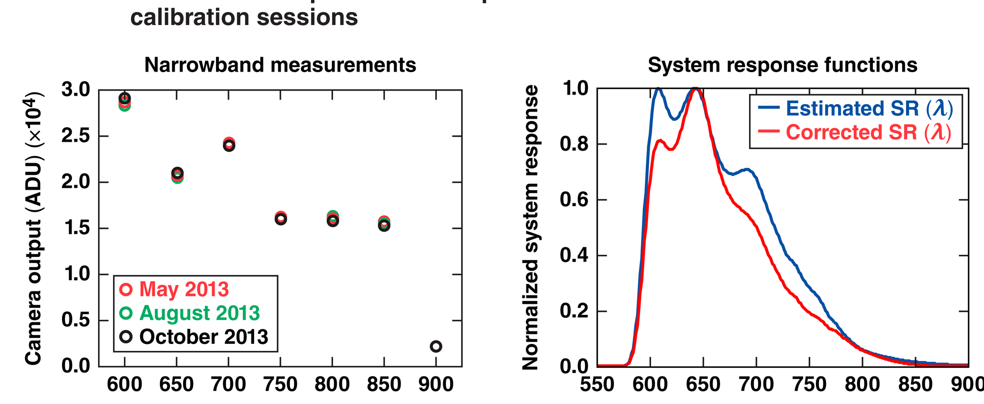
- $L_s(\lambda)$ = source radiance
- A_{px} = area of the filament that maps to a single pixel
- Ω_{lens} = solid angle of VISAR f/3.3 telescope

E22432

*OL Series 550 Standards of Spectral Radiance with Sapphire Windows Specification Manual, Optronic Laboratories, Inc., Orlando, FL 32811.

An estimated system response function was corrected using the narrowband measurements

- The estimated system response was formulated from optical transmission and S20 photocathode sensitivity
- Narrowband responses were reproduced within 3% over three calibration sessions



The corrected system response function predicts wideband (590- to 900-nm) camera output within 4%.

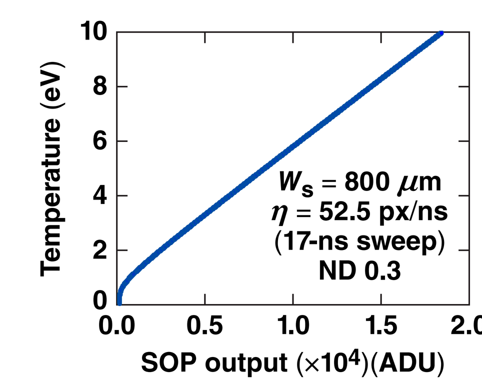
E22582

Temperature Dependence

The shock-wave brightness temperature is inferred by assuming a Planckian source

- The source radiance in the 590- to 900-nm region is related to that of a blackbody
- The camera output I is predicted for a range of temperatures T

$$I = \frac{X(W_s)A_0}{\eta} \int_{\text{all } \lambda} d\lambda \frac{T_x(\lambda)\text{SR}(\lambda)}{\lambda^5 (e^{hc/\lambda T} - 1)}$$



- A_0 is constant for all experimental configurations
- Adjustable parameters include
  - sweep speed η
  - slit width W_s
  - neutral density (ND) filter transmission $T_x(\lambda)$
- Magnification (TCC* → slit): 14.7× (1.84 μm/px for 2 × 2 binning)

E22438

*Target chamber center

The internal optics of the ROSS* camera are aligned and focused prior to calibrations and experiments

- Center image on photocathode using secondary mirror
- Decrease iris size to confirm centering
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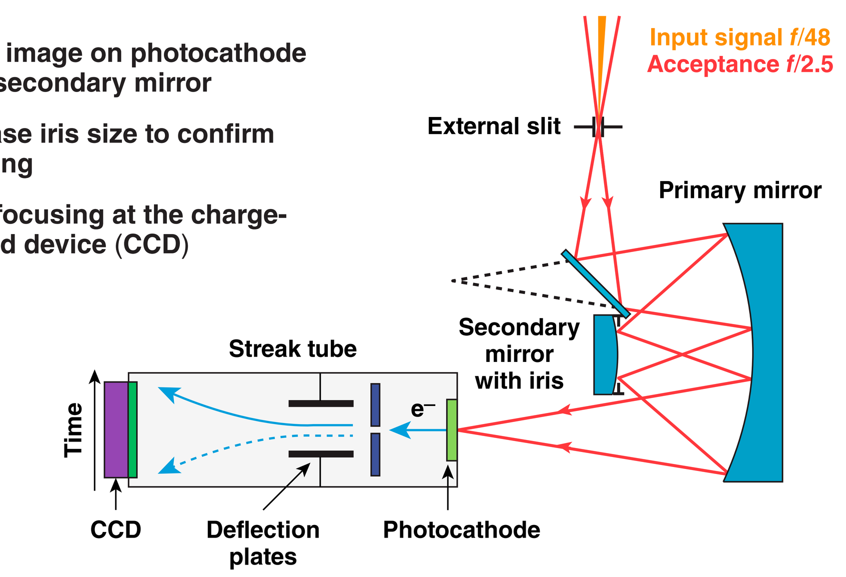

E22581

*Rochester optical streak system

The temperature calibration assumes a delta-function wavelength response to obtain a two-parameter fit

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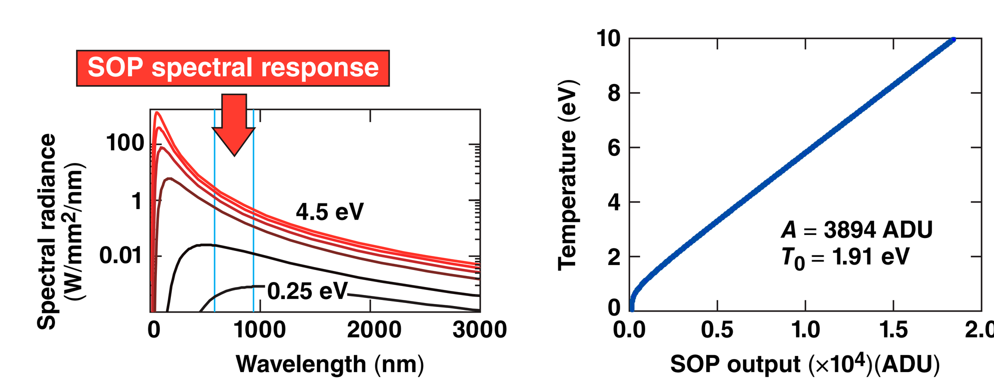
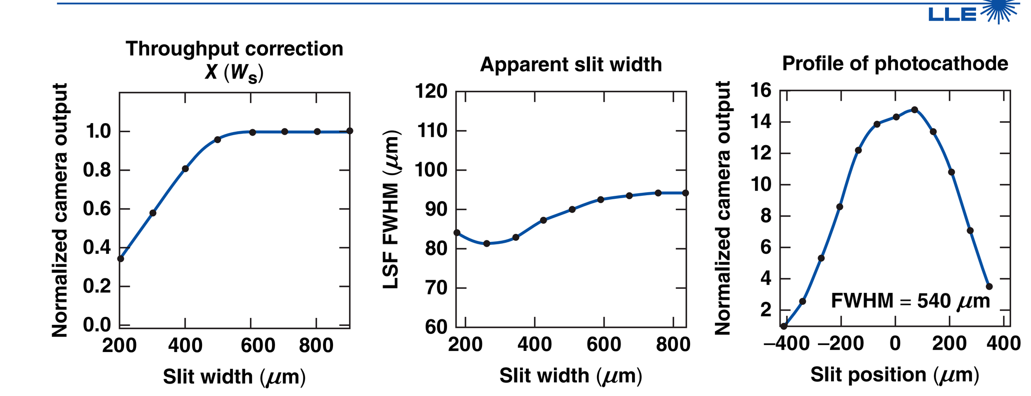


Parameters A and T_0 are a convenient means to infer temperature from measured SOP output for a given experimental configuration.

E22439

An 800-μm-wide slit provides optimal throughput, temporal resolution, and insensitivity to misalignment



- The camera output rises with the slit width until ~500 μm
- The line spread function (LSF) full width at half maximum (FWHM) is smaller than the actual slit width
- Wide slit widths are less sensitive to photocathode alignment

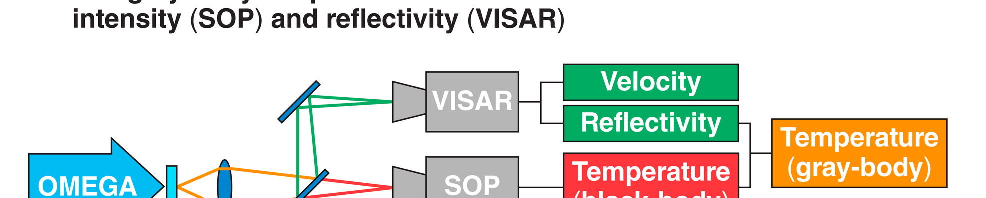
E22437

A "gray-body" approximation is used to determine shock temperatures

- The emissivity of the shock front is related to its reflectivity through Kirchoff's law $\epsilon = 1 - R$
- For measured camera output I and parameters A and T_0, gray-body temperature is calculated using

$$T = \frac{T_0}{\ln\left[1 + \frac{(1-R)A}{I}\right]}$$

- The gray-body temperature is calculated from the self-emission intensity (SOP) and reflectivity (VISAR)



E22440

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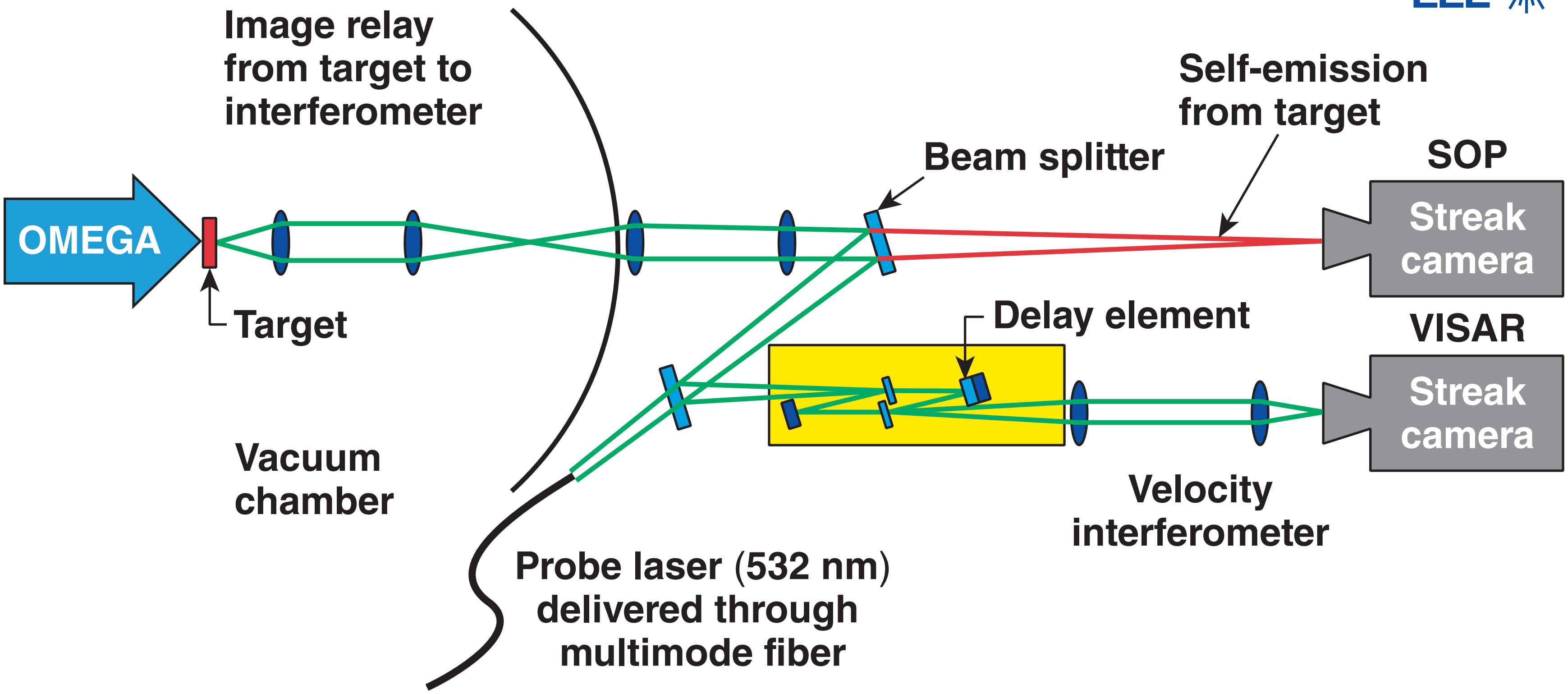

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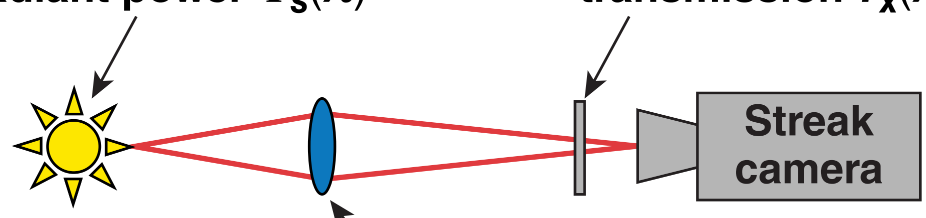

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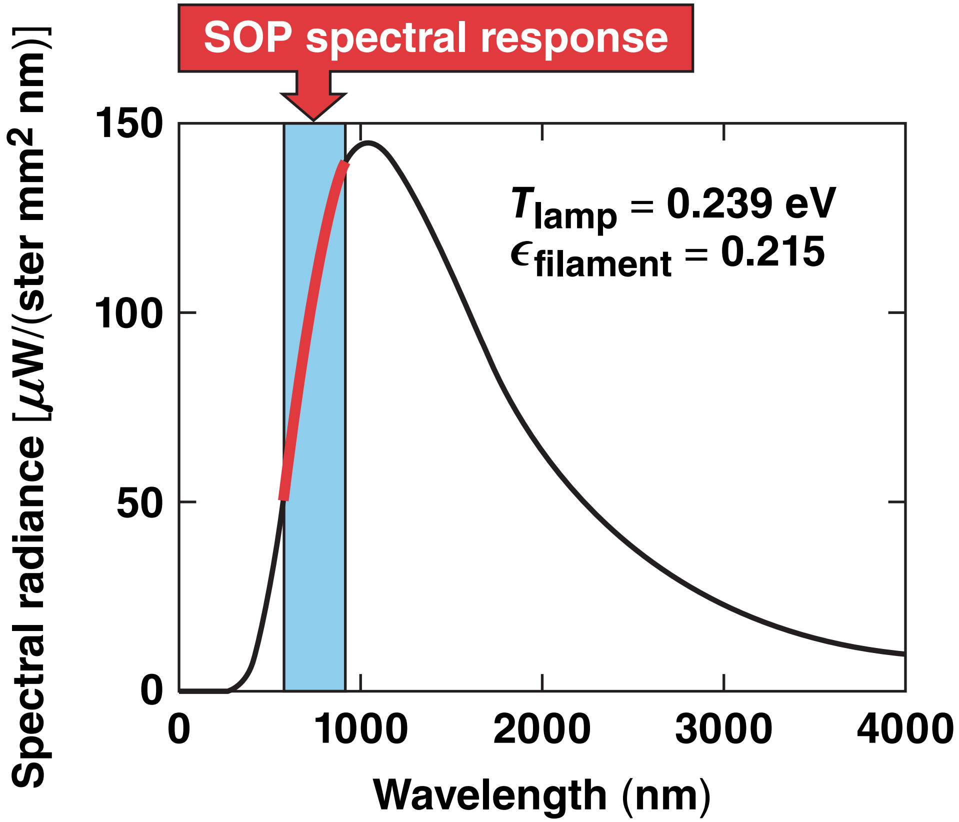

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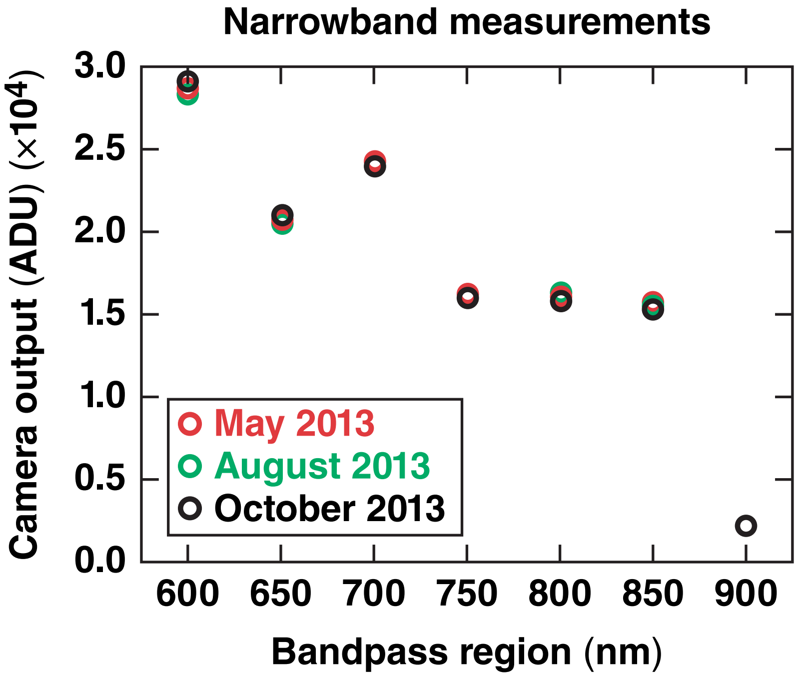

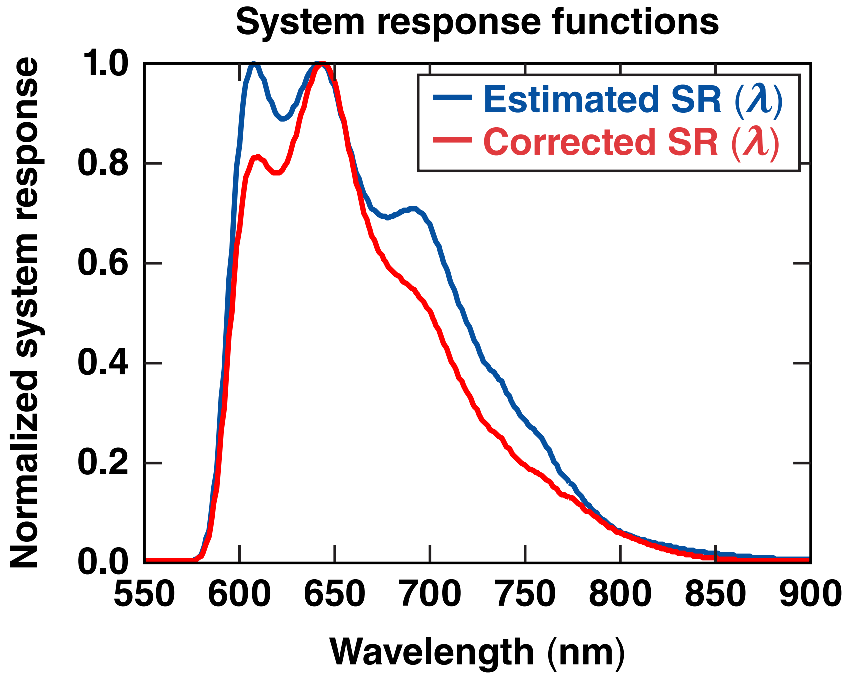

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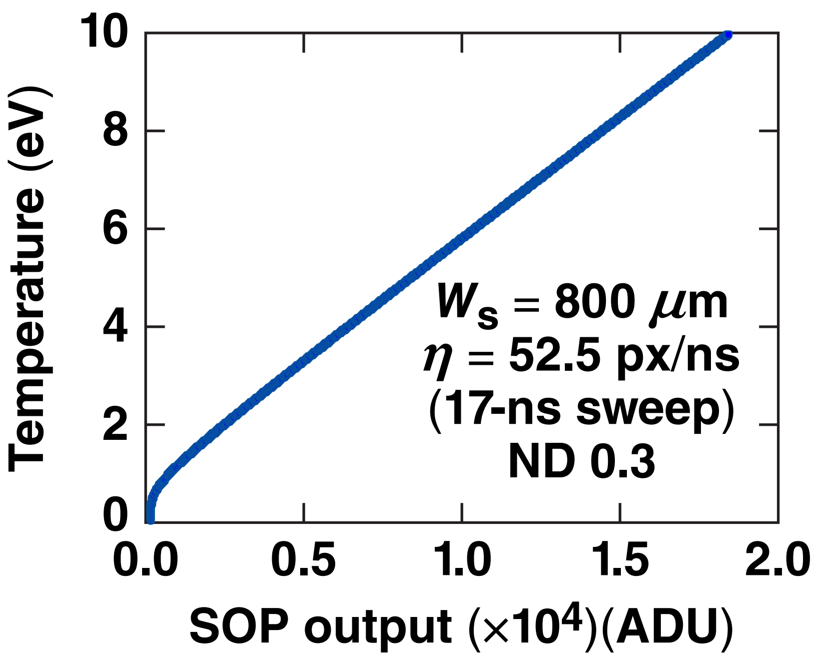

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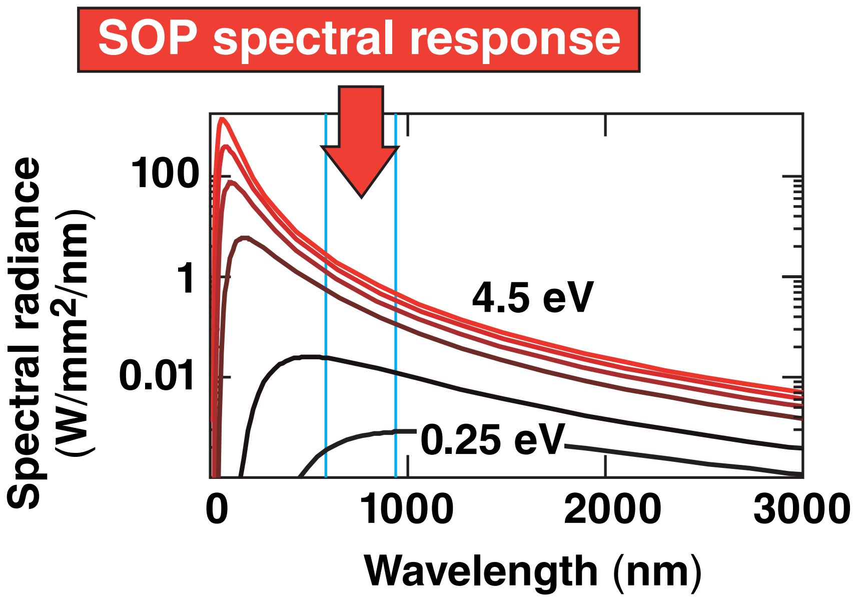

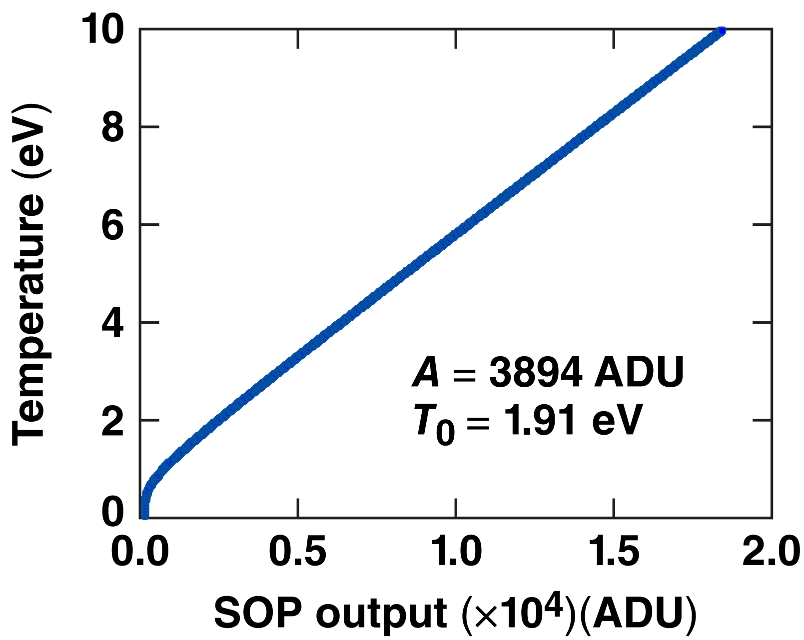

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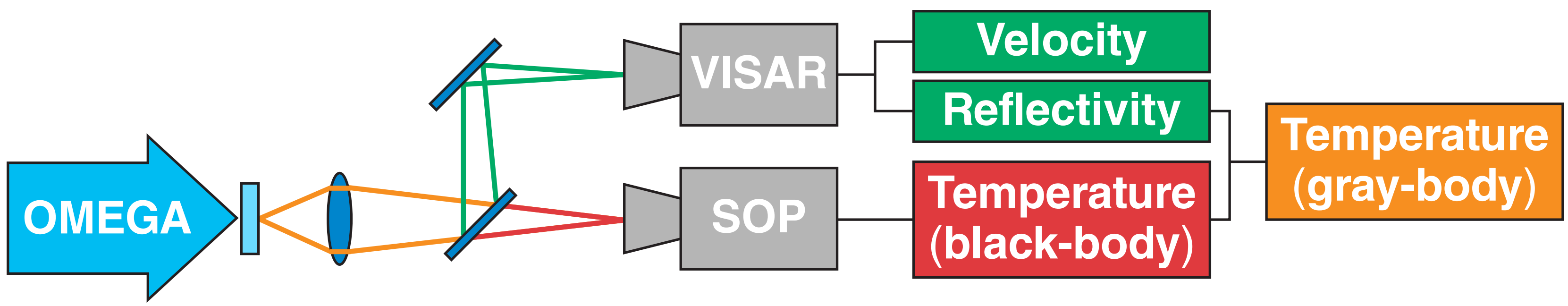

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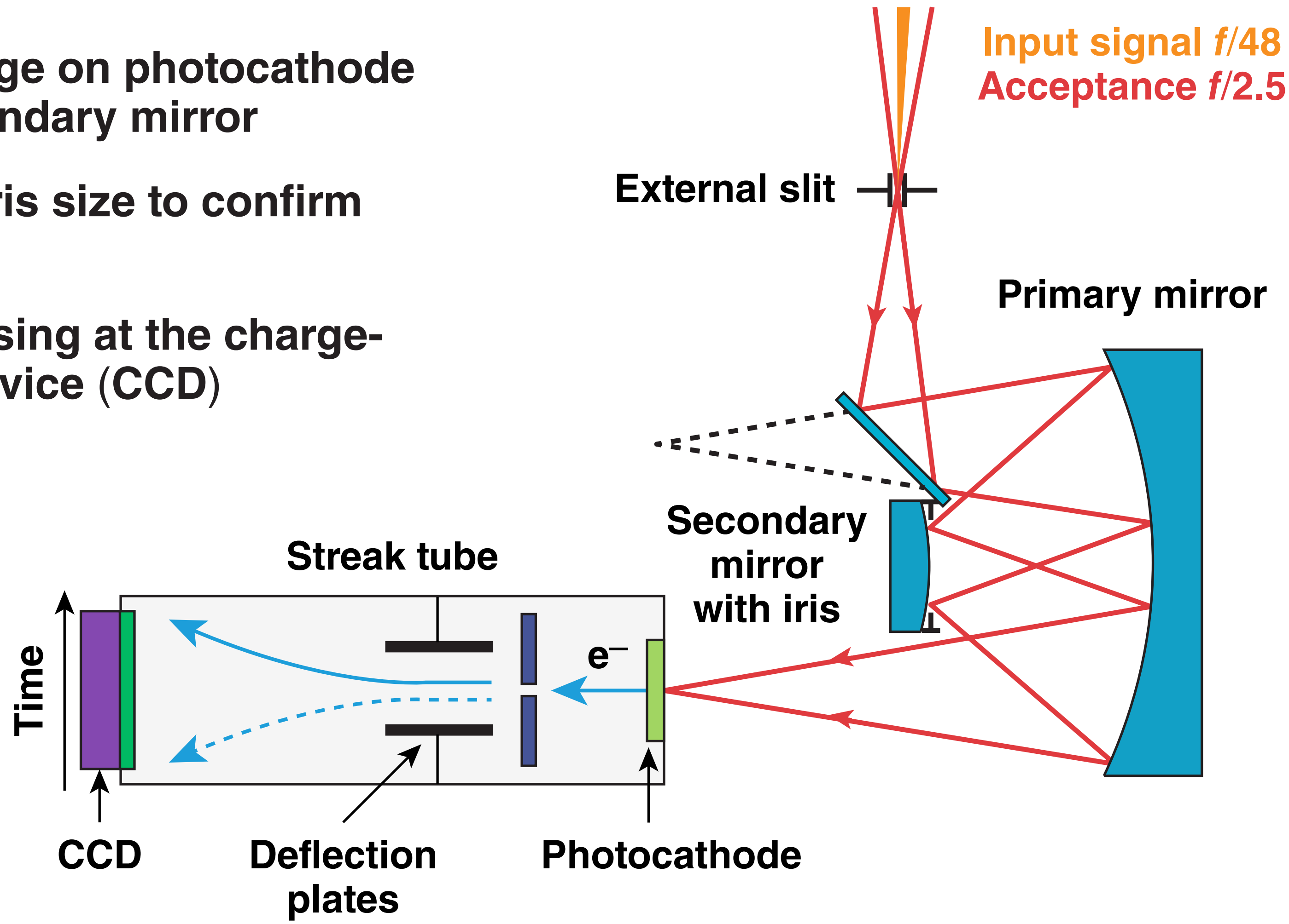

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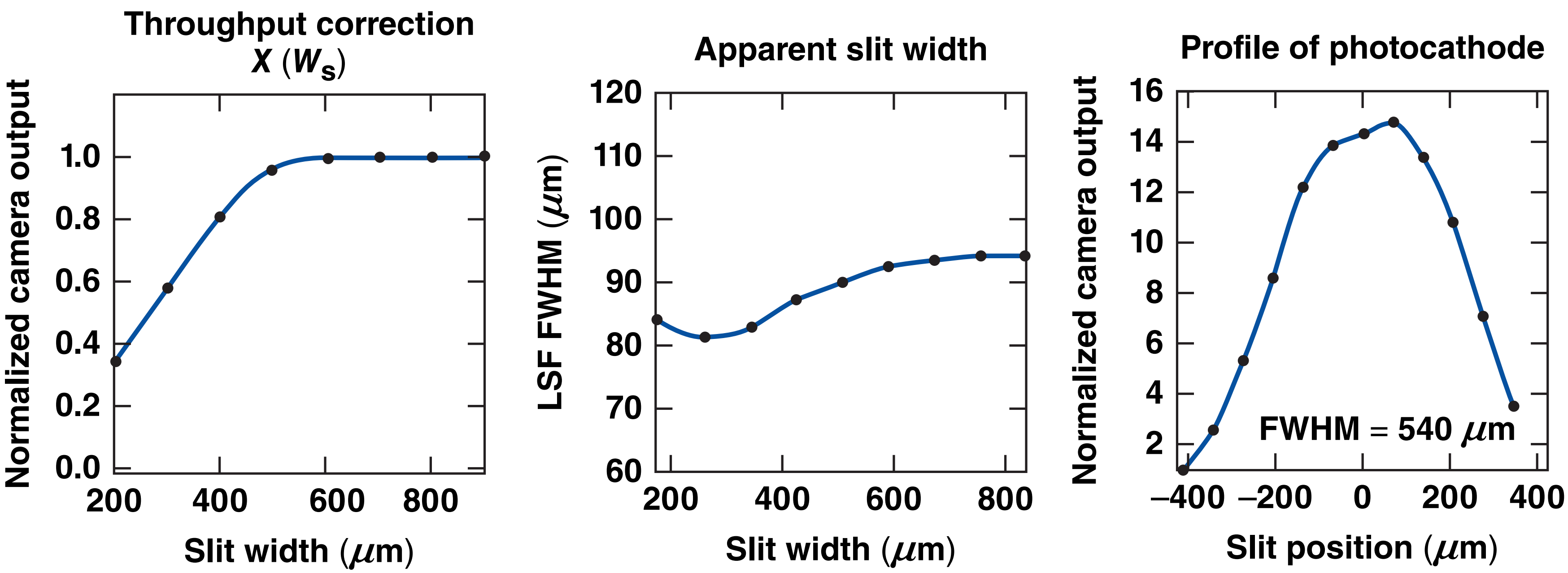

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