

Integrating sphere superposition technique for quantifying the linearity of InGaAs detectors

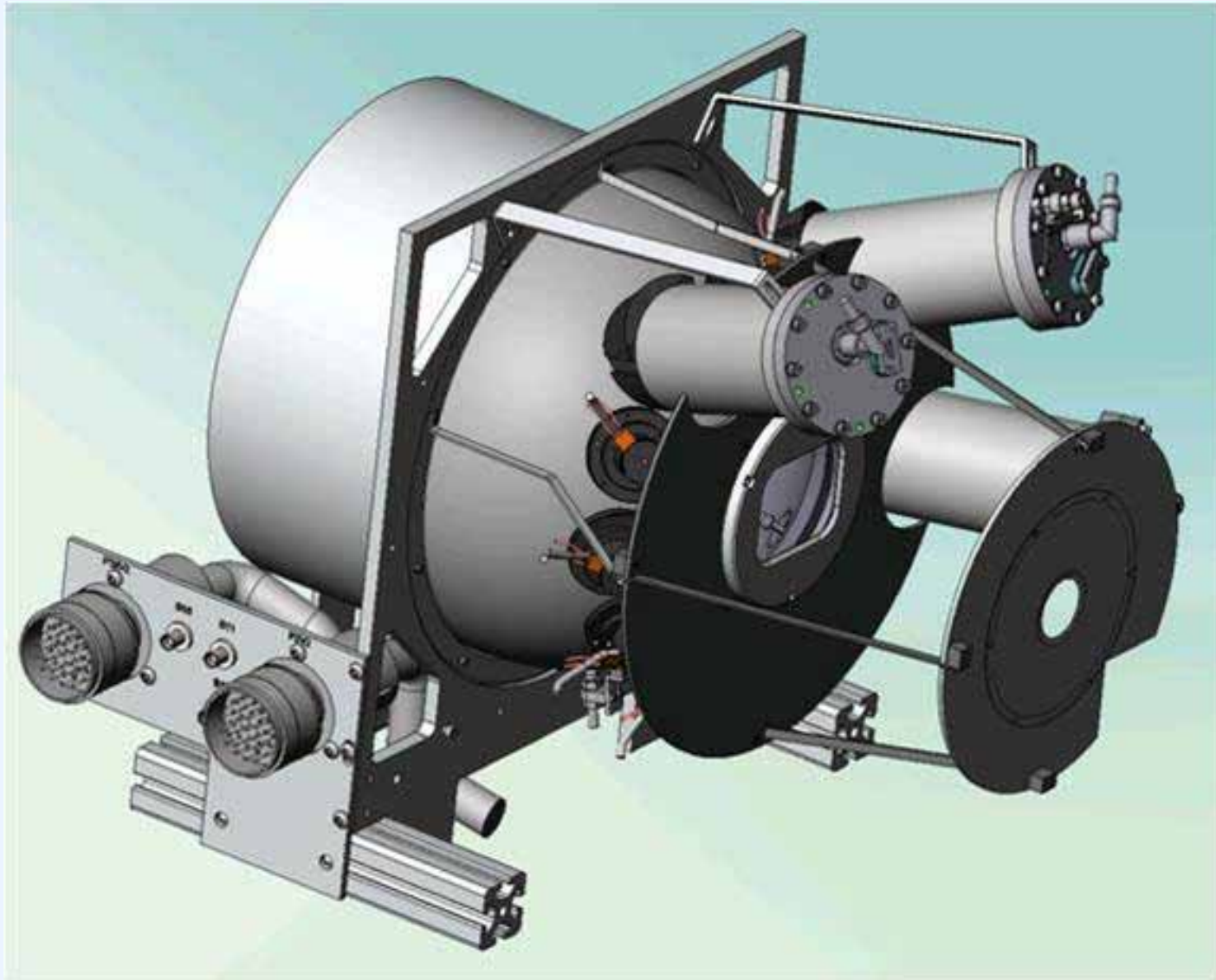
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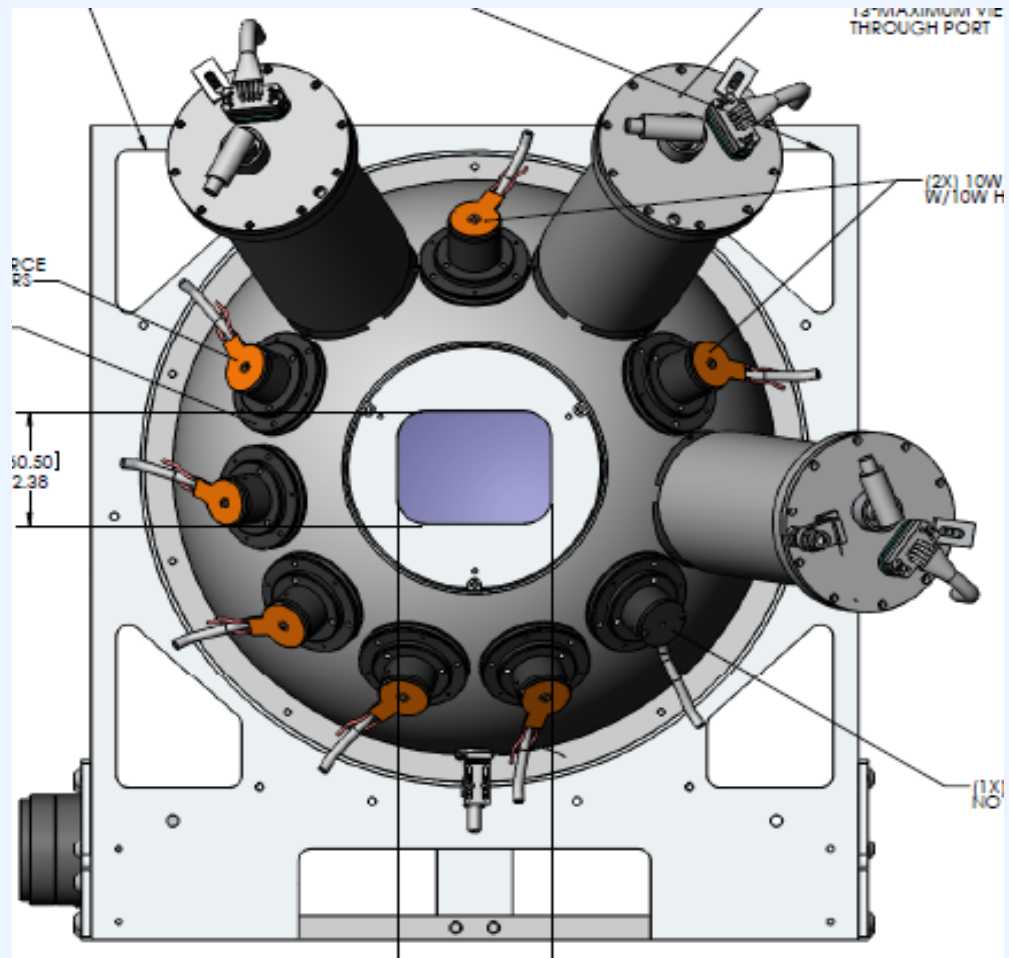
Background

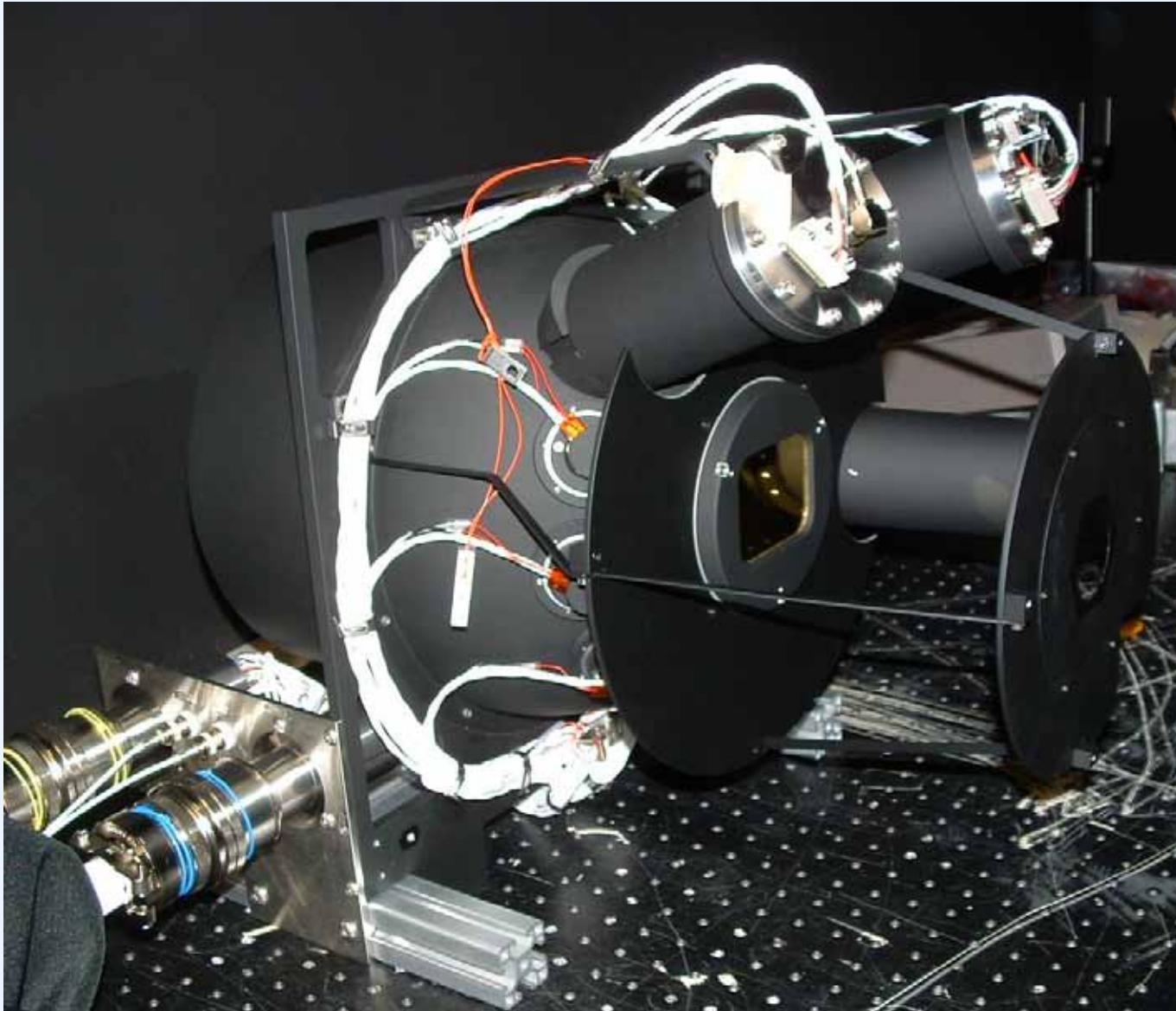
- Integrating sphere irradiance source
- Calibrating and verifying linearity of FPA
- Thermal vacuum chamber

Task

- Calibrate a laboratory detector with an FEL.
- Transfer that calibration to permanent monitor detectors.
- Confirm or characterize the linearity of the four detectors







Permanent monitor detectors

- 2 Hamamatsu G6122 InGaAs detectors with 1mm active area, integral TE-cooling and transimpedance amplifiers.
 - 1360 to 1390nm bandpass
 - 1565 to 1655nm bandpass
- 1 Hamamatsu G6122-03 Extended range InGaAs detector with 1mm active area, integral TE-cooling and transimpedance amplifier.
 - 2100 to 2280nm bandpass
- Each in its own atmospheric chamber

Calibration transfer detector

- Hamamatsu G5853-23 Extended range InGaAs detector with 3mm active area and two-stage TE-cooler. Operated with chopper and lock-in amplifier.
- Filter wheel with three filters identical to the filters on the monitor detectors.
 - 1360 to 1390nm bandpass
 - 1565 to 1655nm bandpass
 - 2100 to 2280nm bandpass

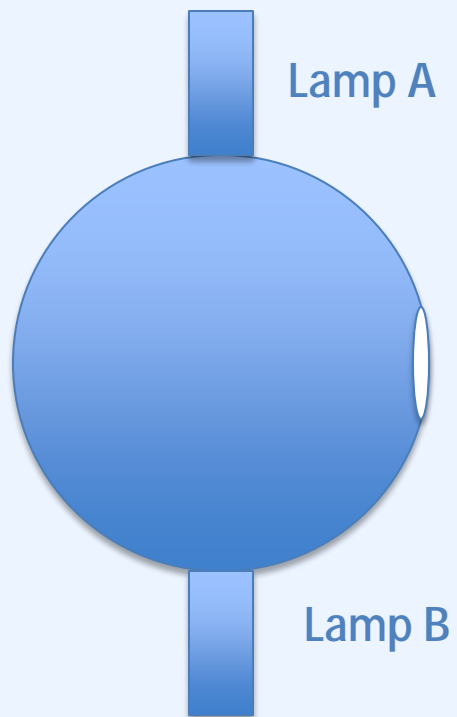
Dynamic ranges

- Calibration detector: 28dB
- Monitor detectors: low dynamic range, less than 10dB

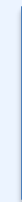
Superposition test

- Measure the detector output with input A: (V_A).
- Measure the detector output with input B: (V_B).
- Measure the detector output with inputs A and B together: (V_{A+B}).
- Compare (V_{A+B}) with (V_A) + (V_B).
- If they are equal, the detector is linear over that range.
- If not, the amount of inequality can be used to characterize the non-linearity.

Superposition test

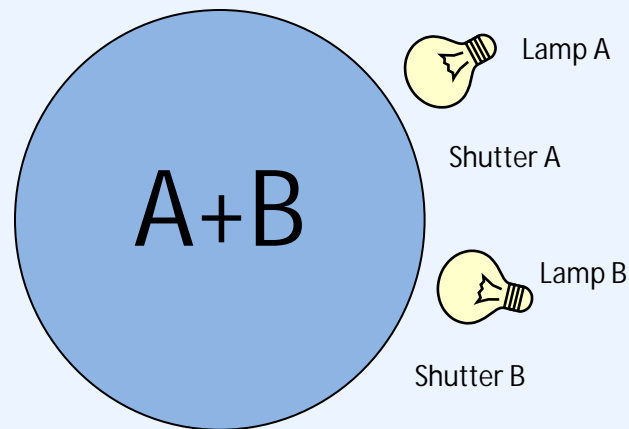
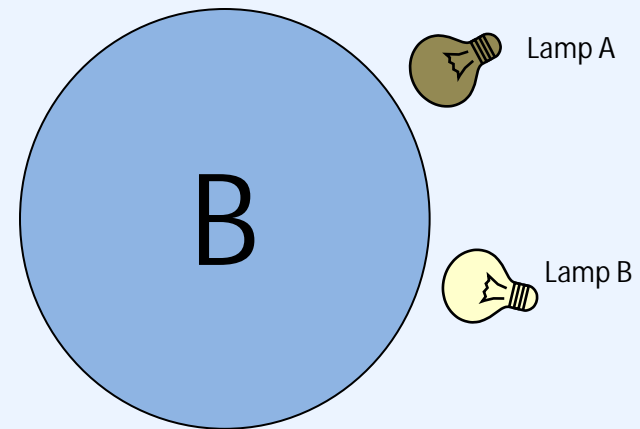
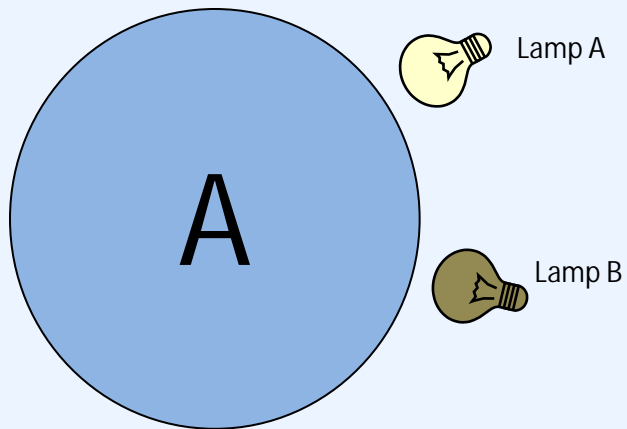


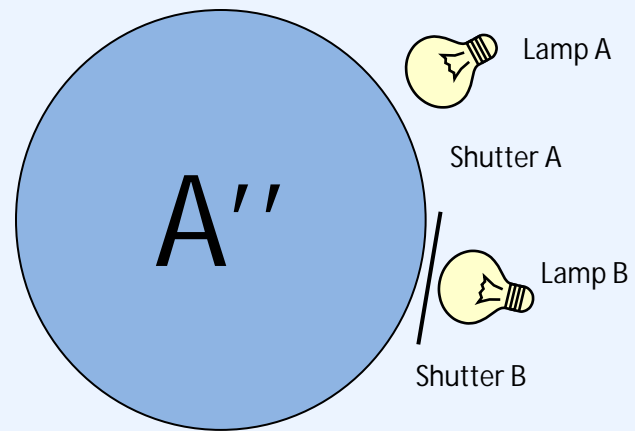
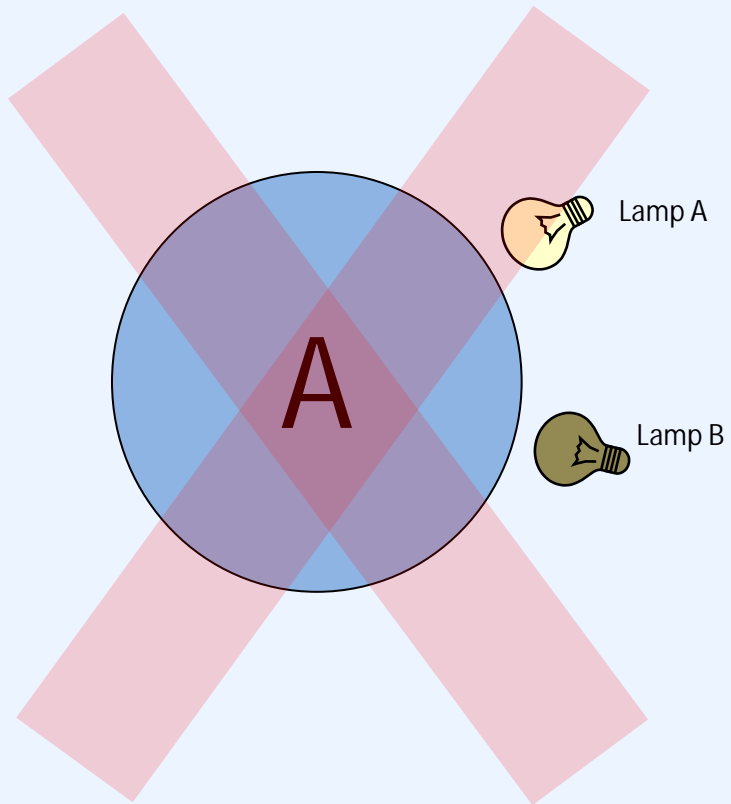
Filter

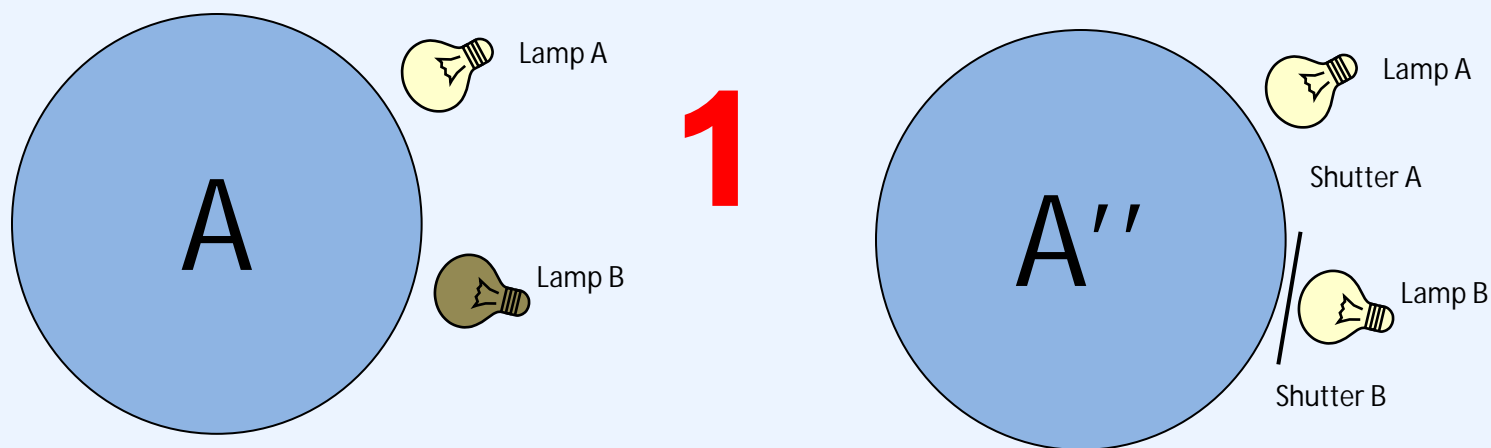


Detector

Superposition test

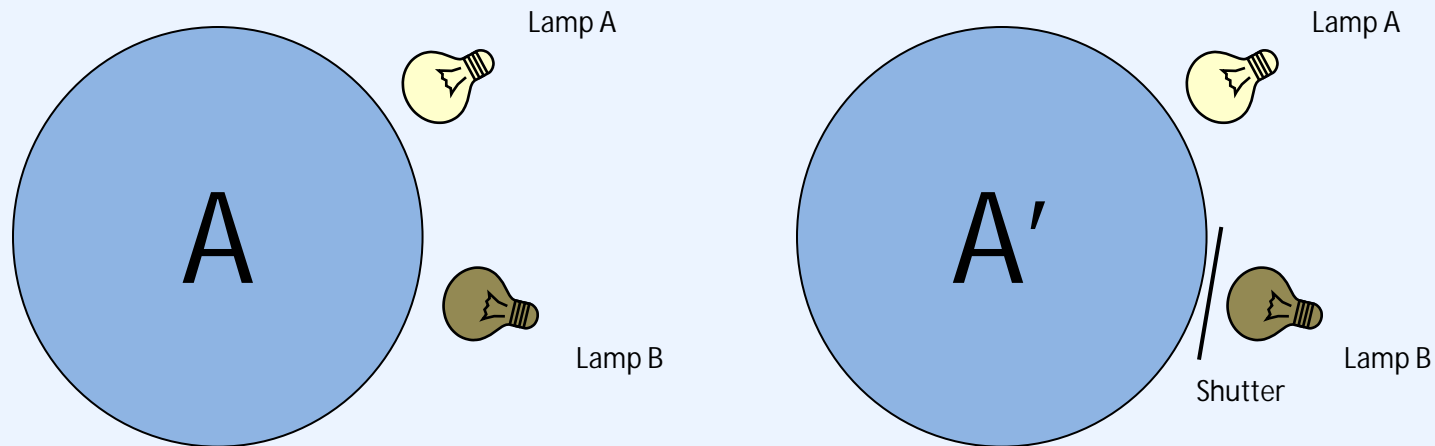






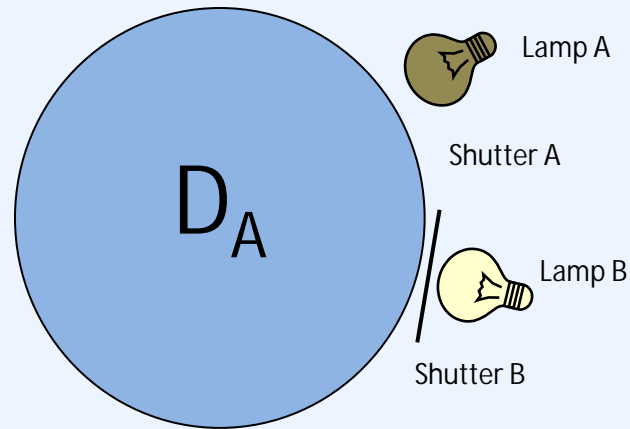
Substitution error
Stray light

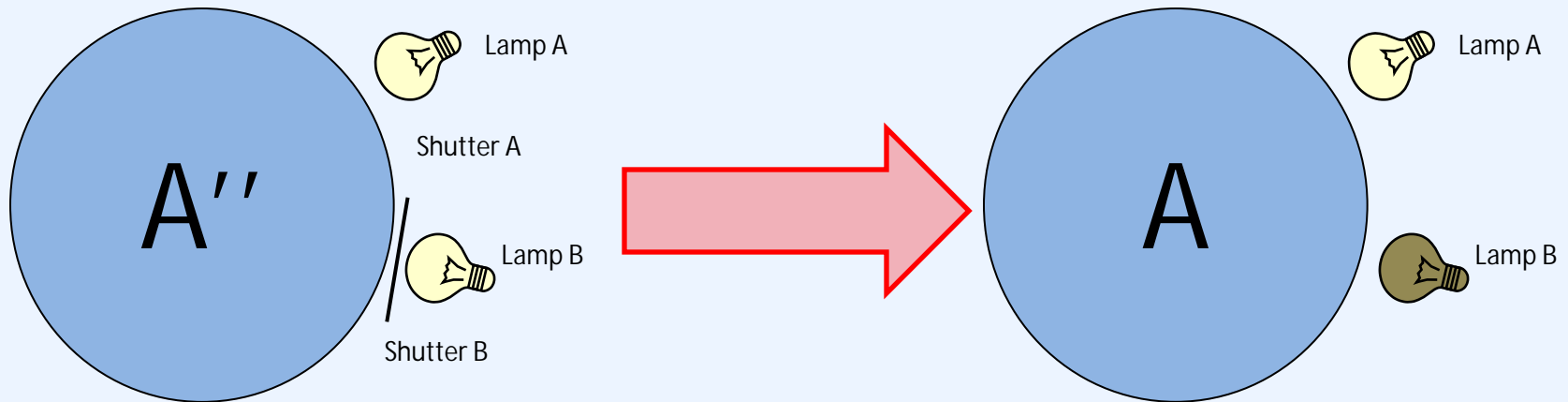
Substitution error



$$S_A = \frac{A}{A\phi}$$

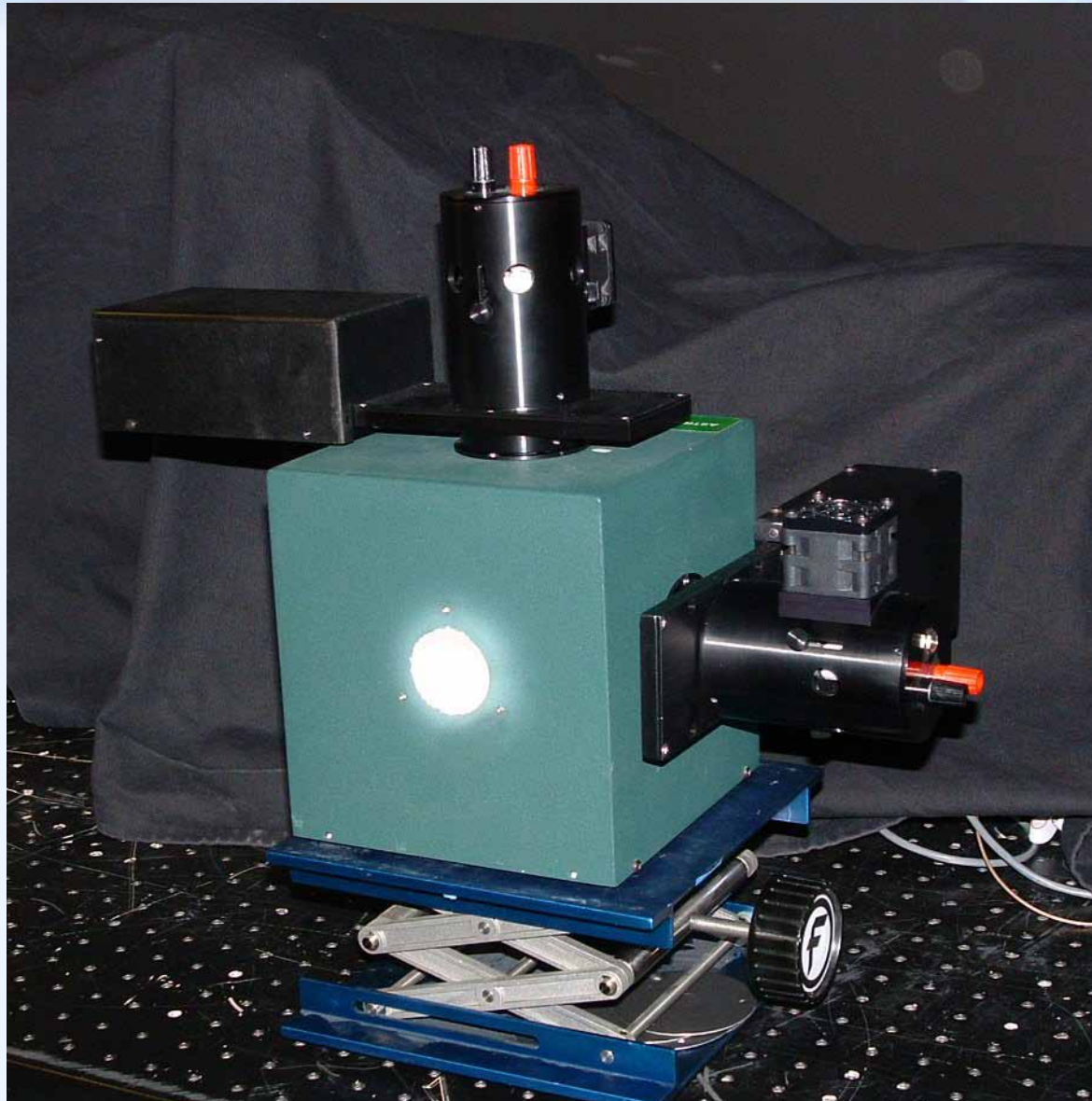
Stray light

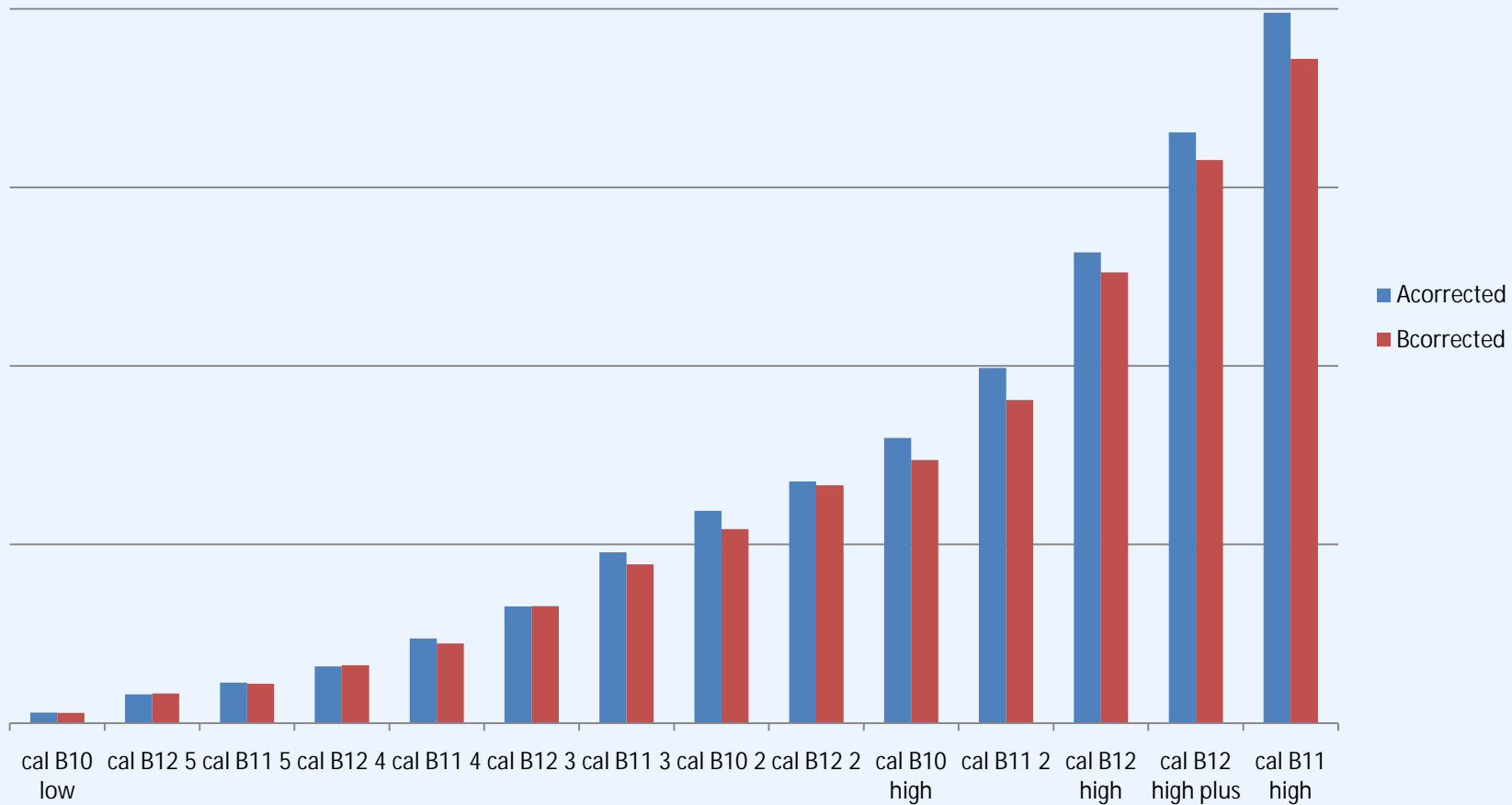




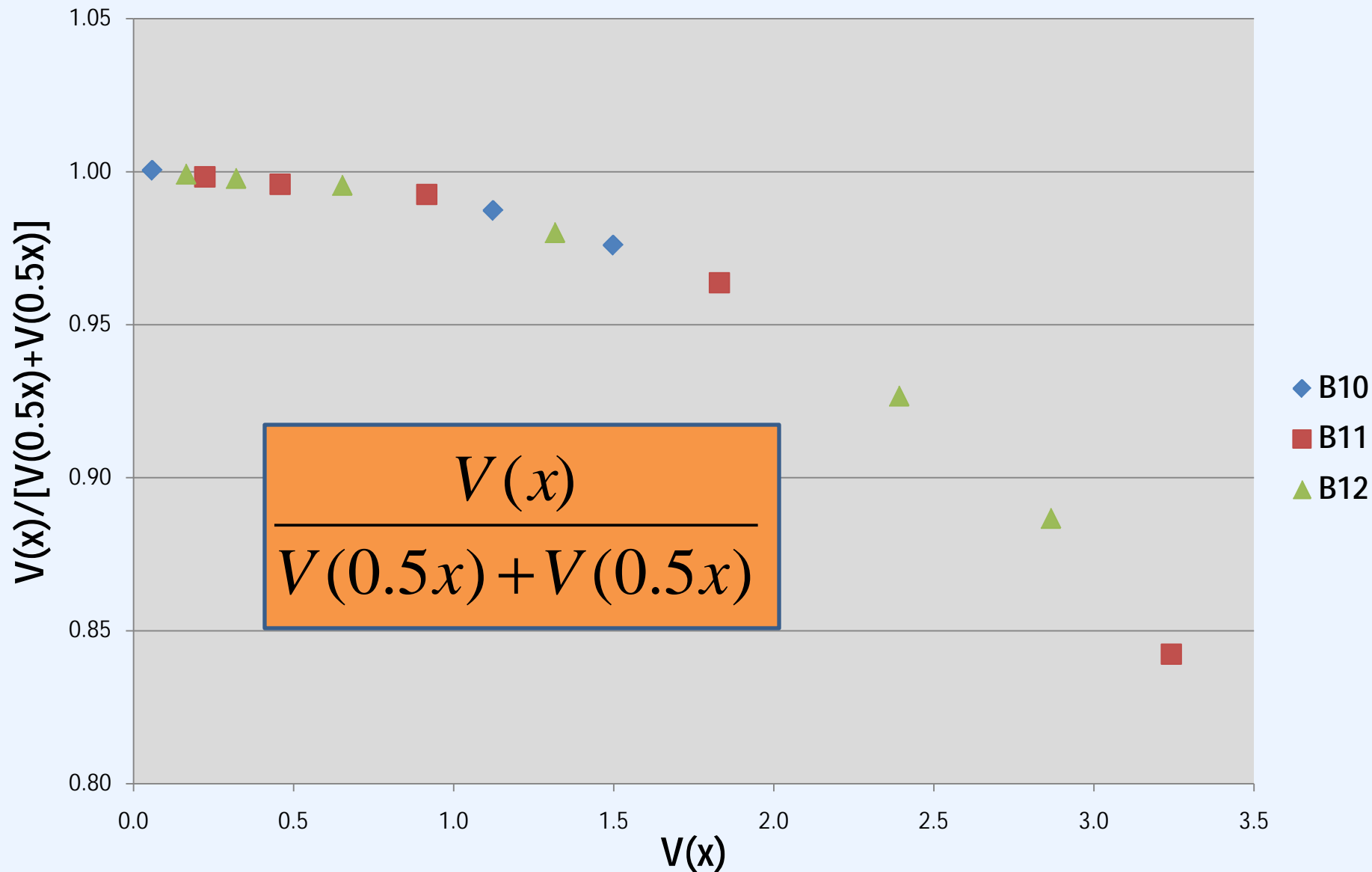
$$A = (A \ominus D_A) \times S_A$$

$$B = (B \ominus D_B) \times S_B$$

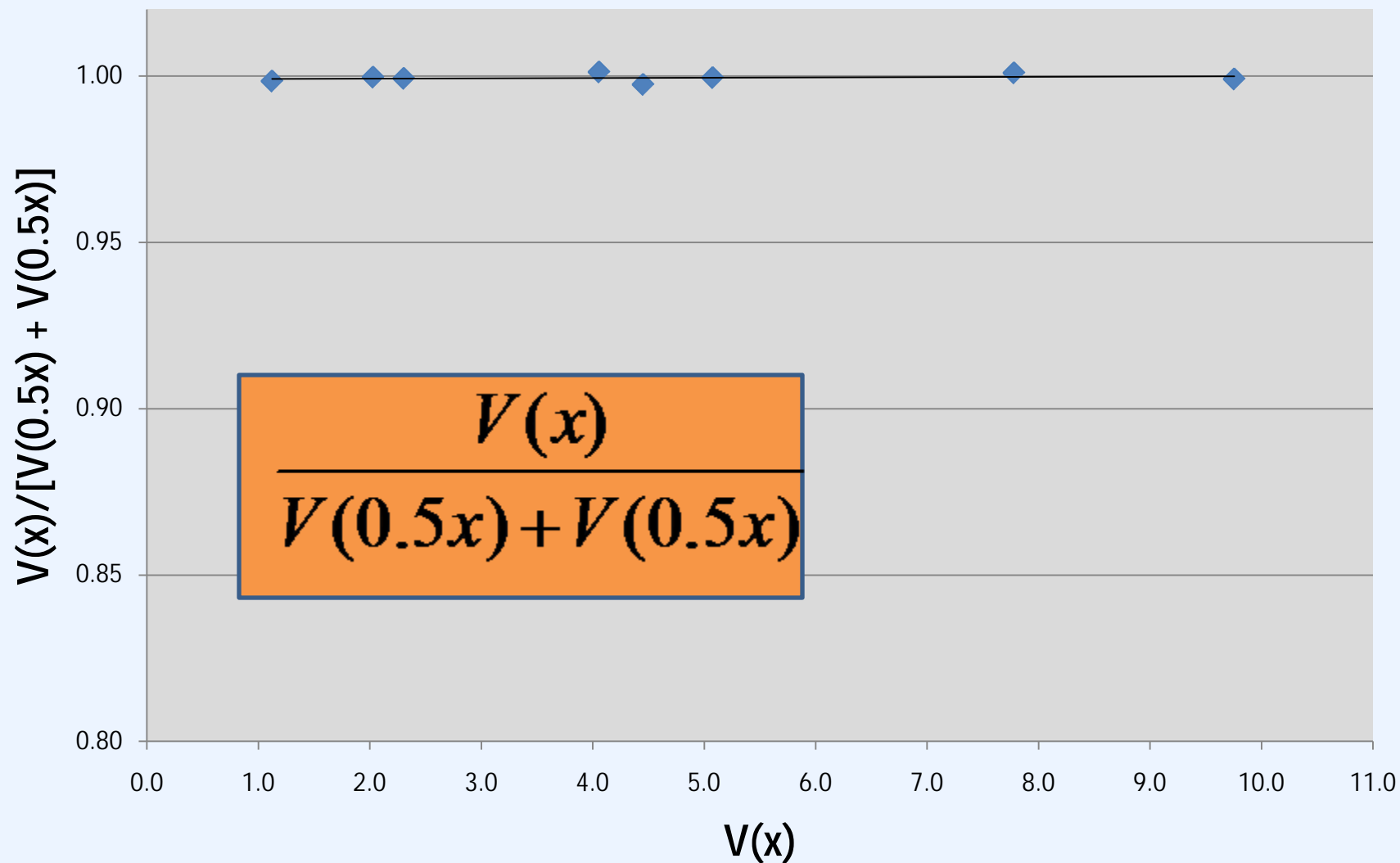




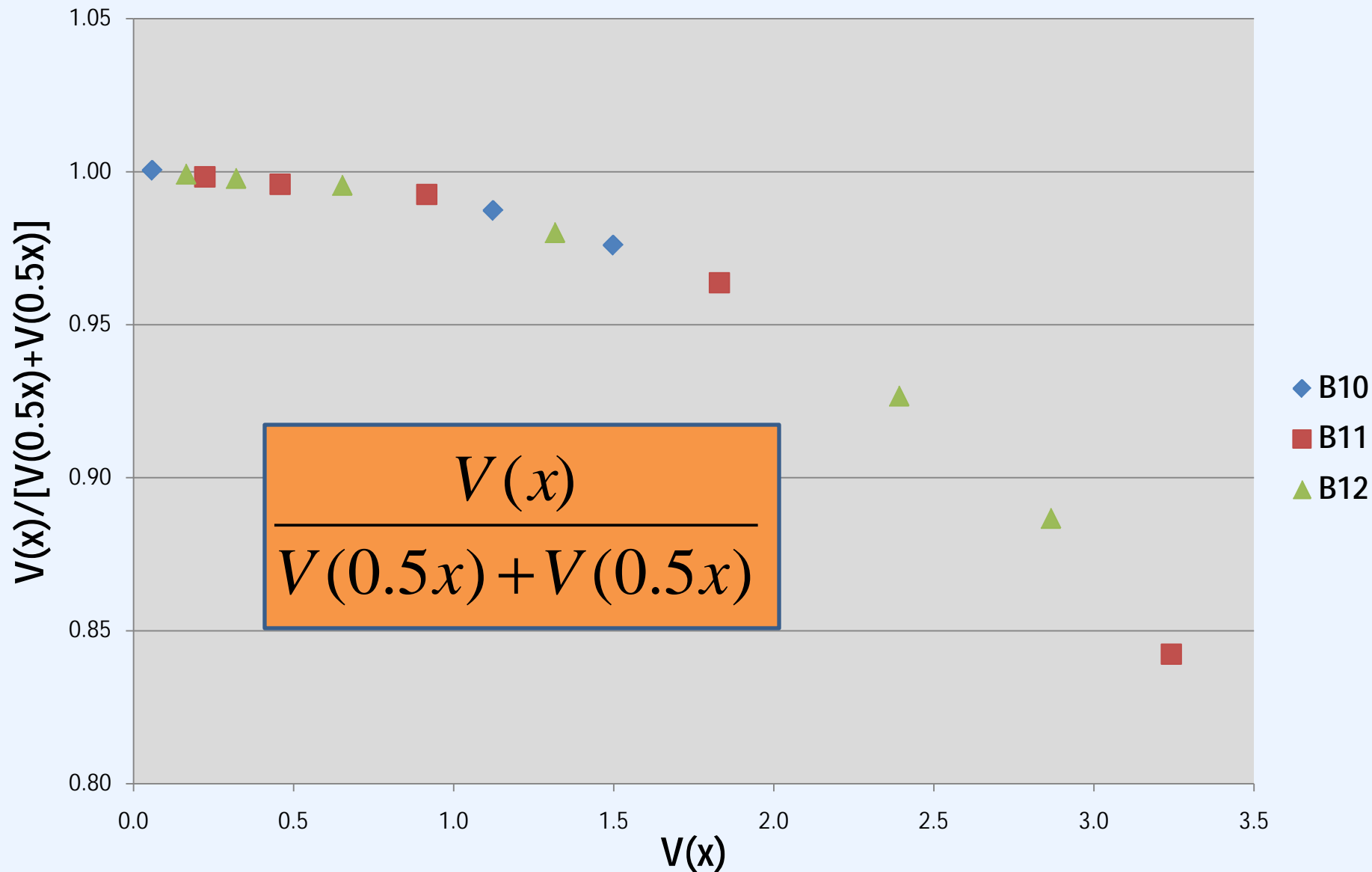
Calibration detector superposition



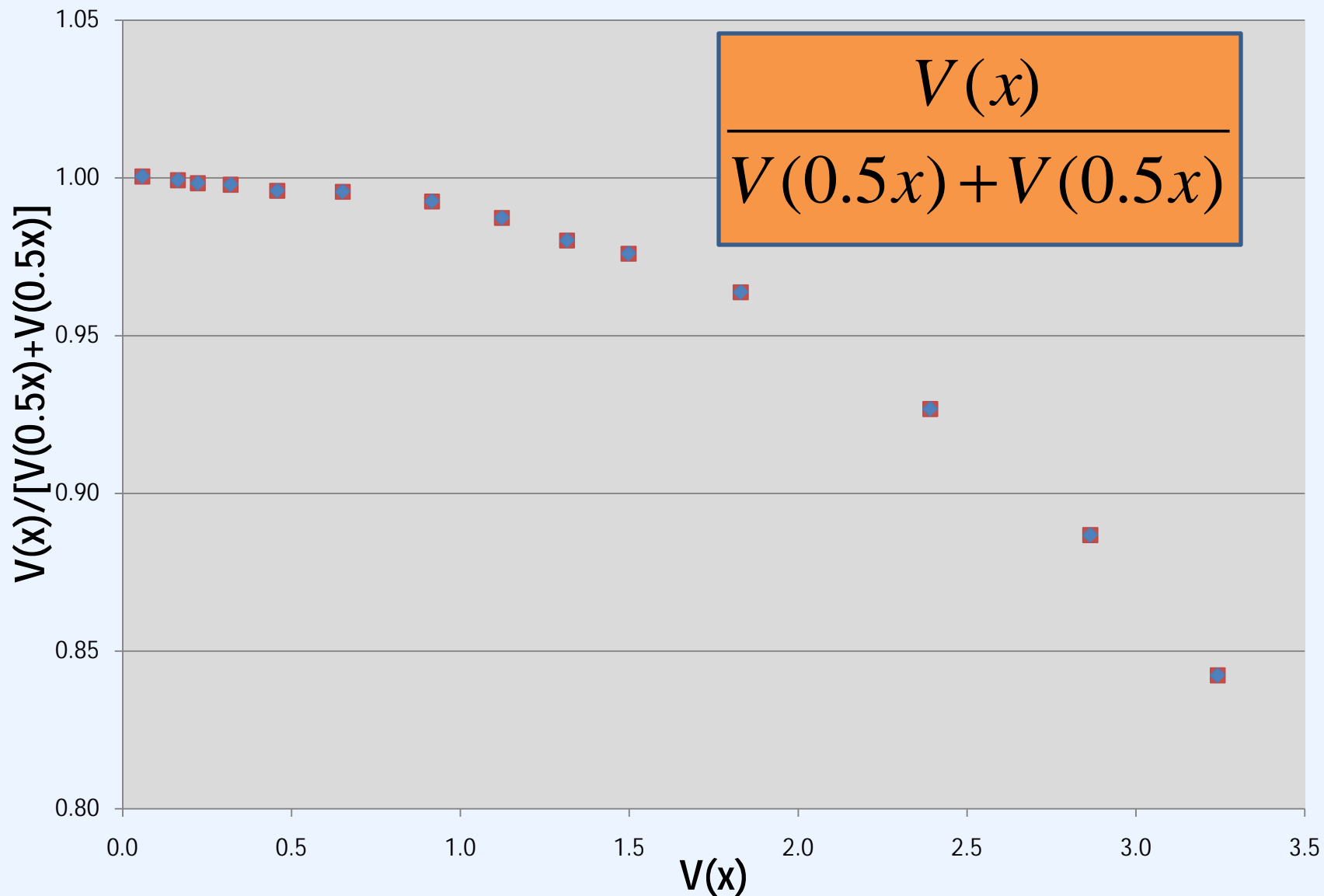
Monitor detector superposition



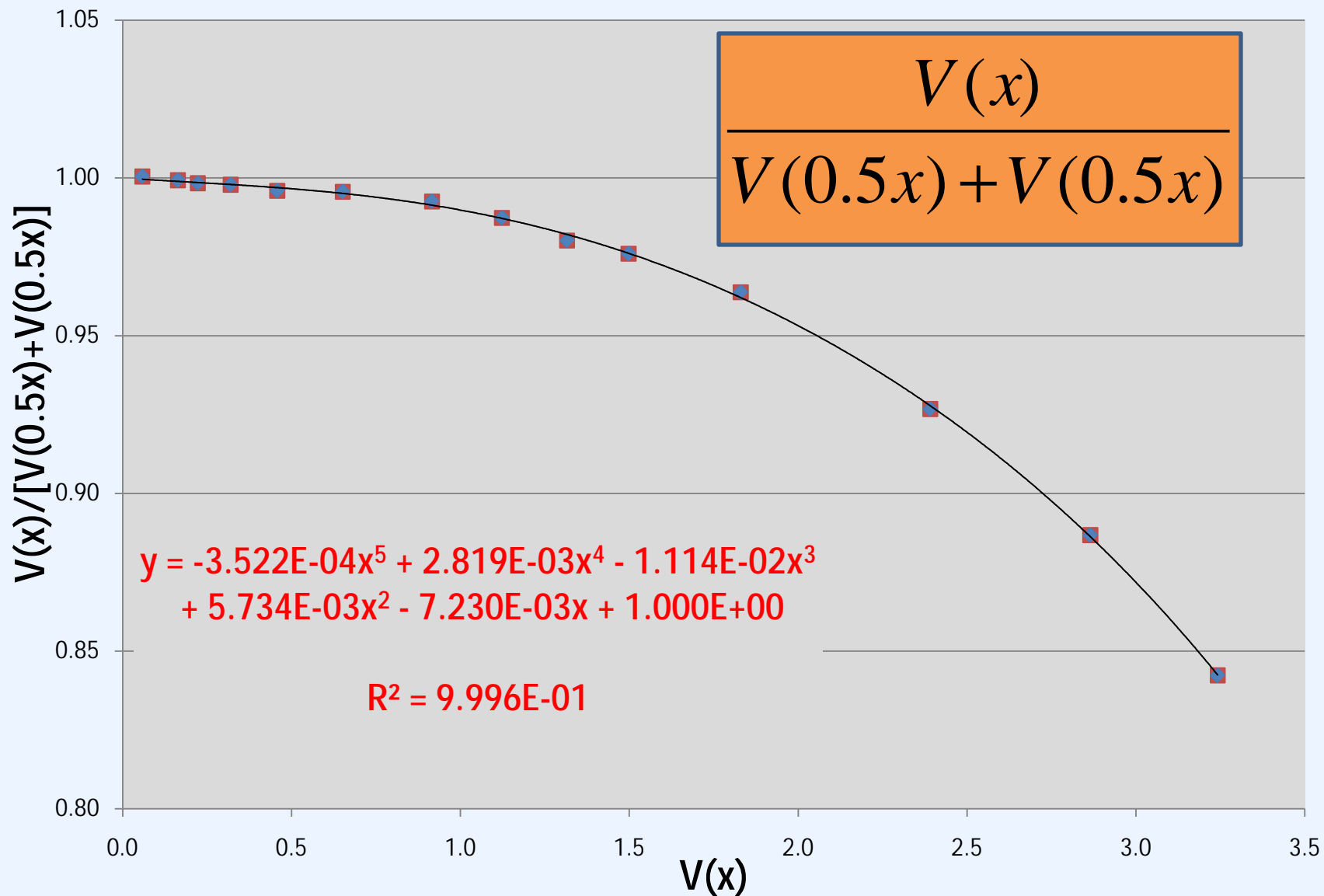
Calibration detector superposition



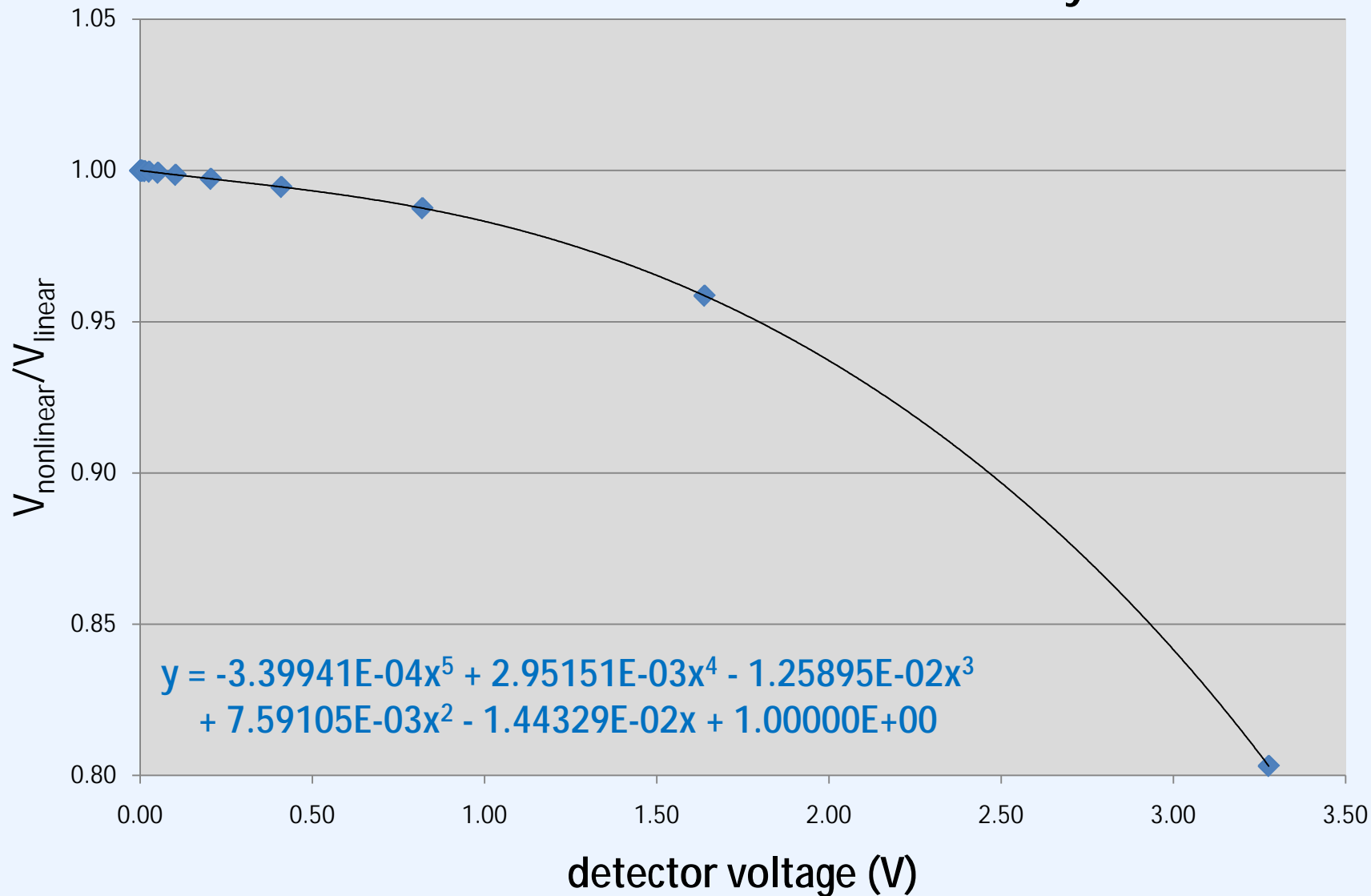
Calibration detector superposition



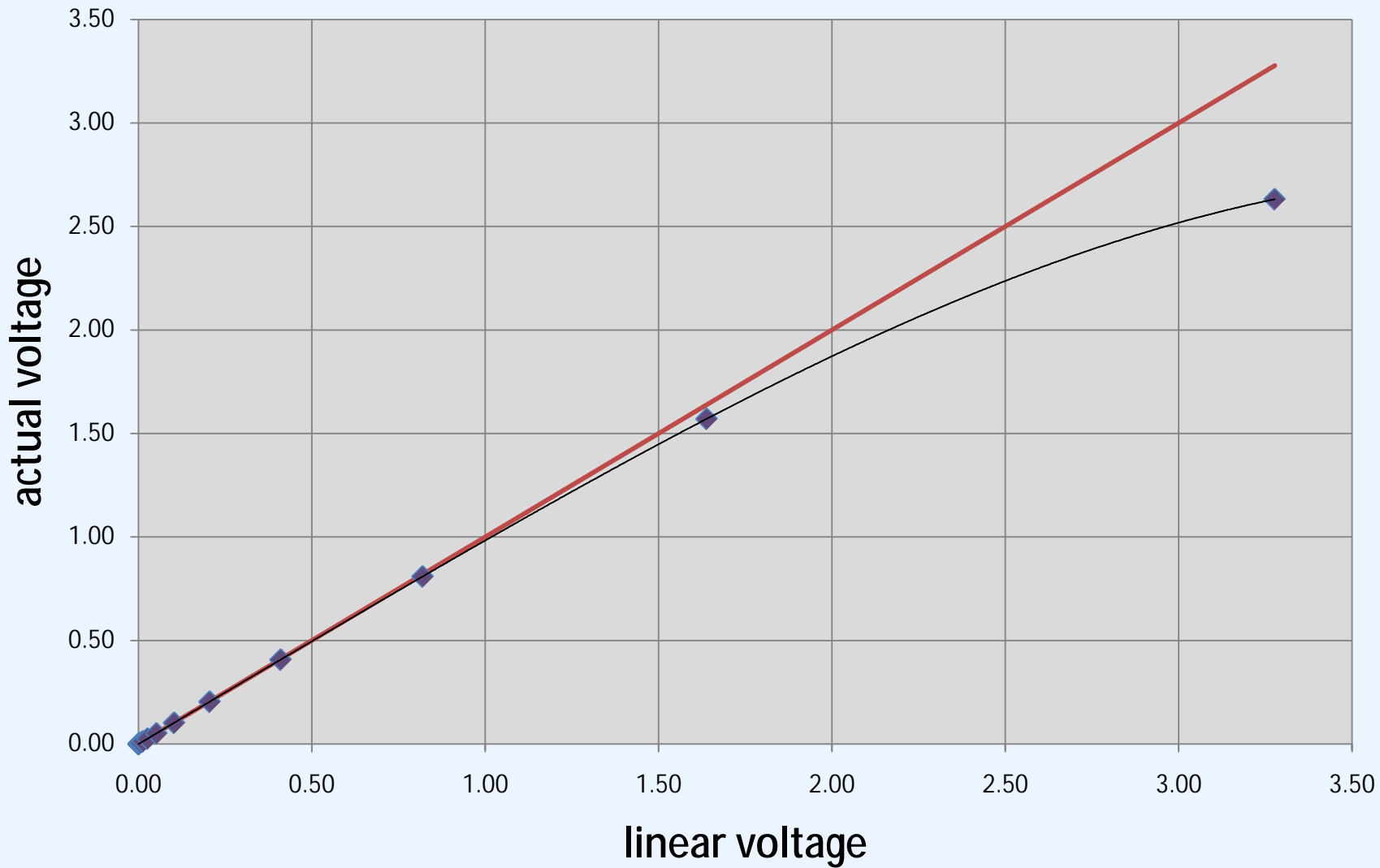
Calibration detector superposition



Calibration detector non-linearity



Calibration detector non-linearity



Acknowledgement

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