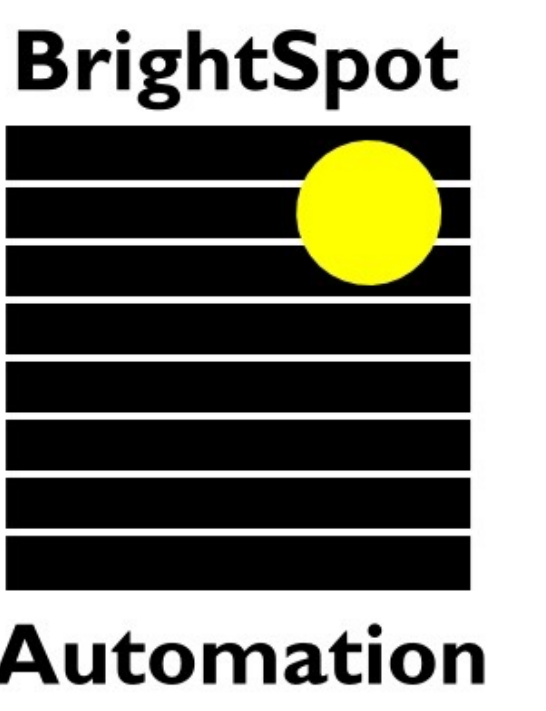


Low-Cost Daytime Electroluminescence Imaging

Jared D. Friedl, Rich Landy, and Andrew M. Gabor
BrightSpot Automation, Boulder, CO, USA



1. Background/Motivation

- Most outdoor electroluminescence (EL) imaging of solar panel defects is performed at night to avoid noise light from the sun overwhelming the signal from the panels



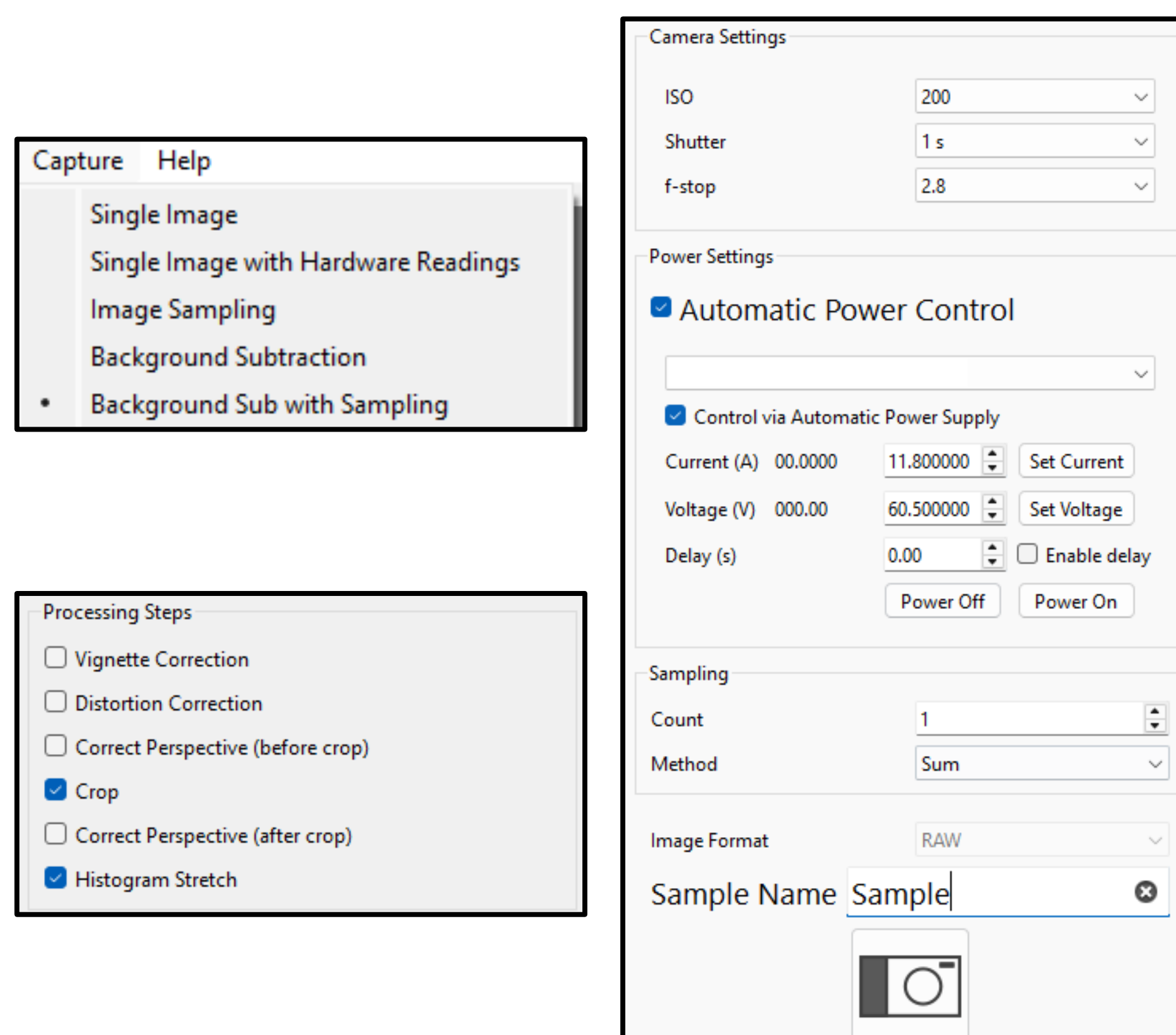
TravEL-Spot



- Daytime measurements are desired by some groups
- Daytime solutions exist, but are generally expensive and have low resolution
- Even for indoor testing, sunlight and fluorescent light can add noise
- We present a low-cost approach to taking low-noise EL images in high-noise conditions using IMPEL software which controls both the high-resolution camera and the power supply. An **image pair** is captured with the power supply on, then off, and a **Difference image** is generated by subtracting these images on a pixel-by-pixel basis to remove noise
 - If the signal-to-noise ratio (SNR) of a single **Difference image** remains inadequate, multiple **image pairs** are produced sequentially, and their **Difference images** are summed together to improve SNR

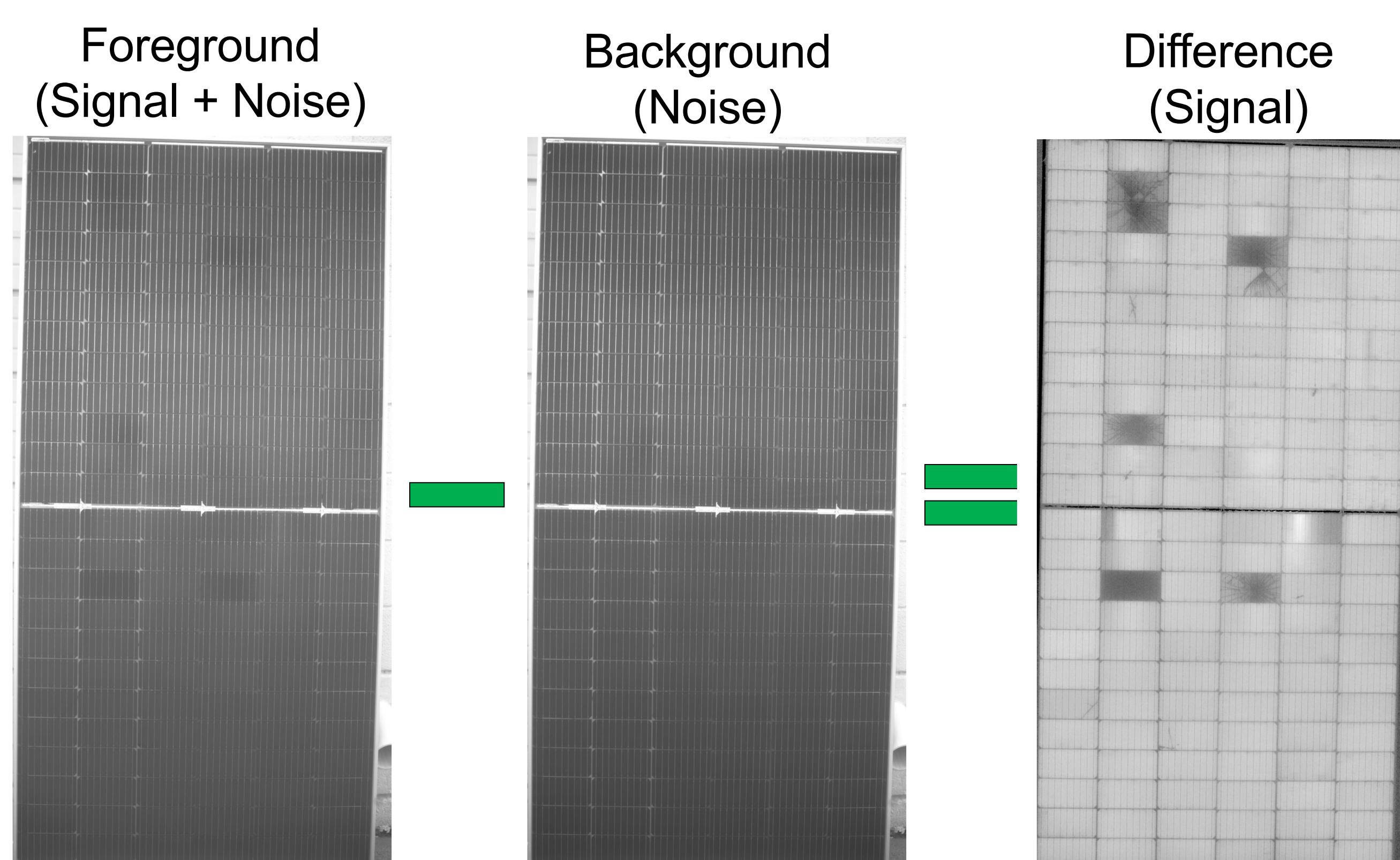
2. Implementation in IMPEL Software

- IMPEL software controls and coordinates camera and power supply with user-defined settings
- Multiple background subtractions can be sampled to generate final Difference image
- Image contrast is enhanced via a user defined histogram stretch

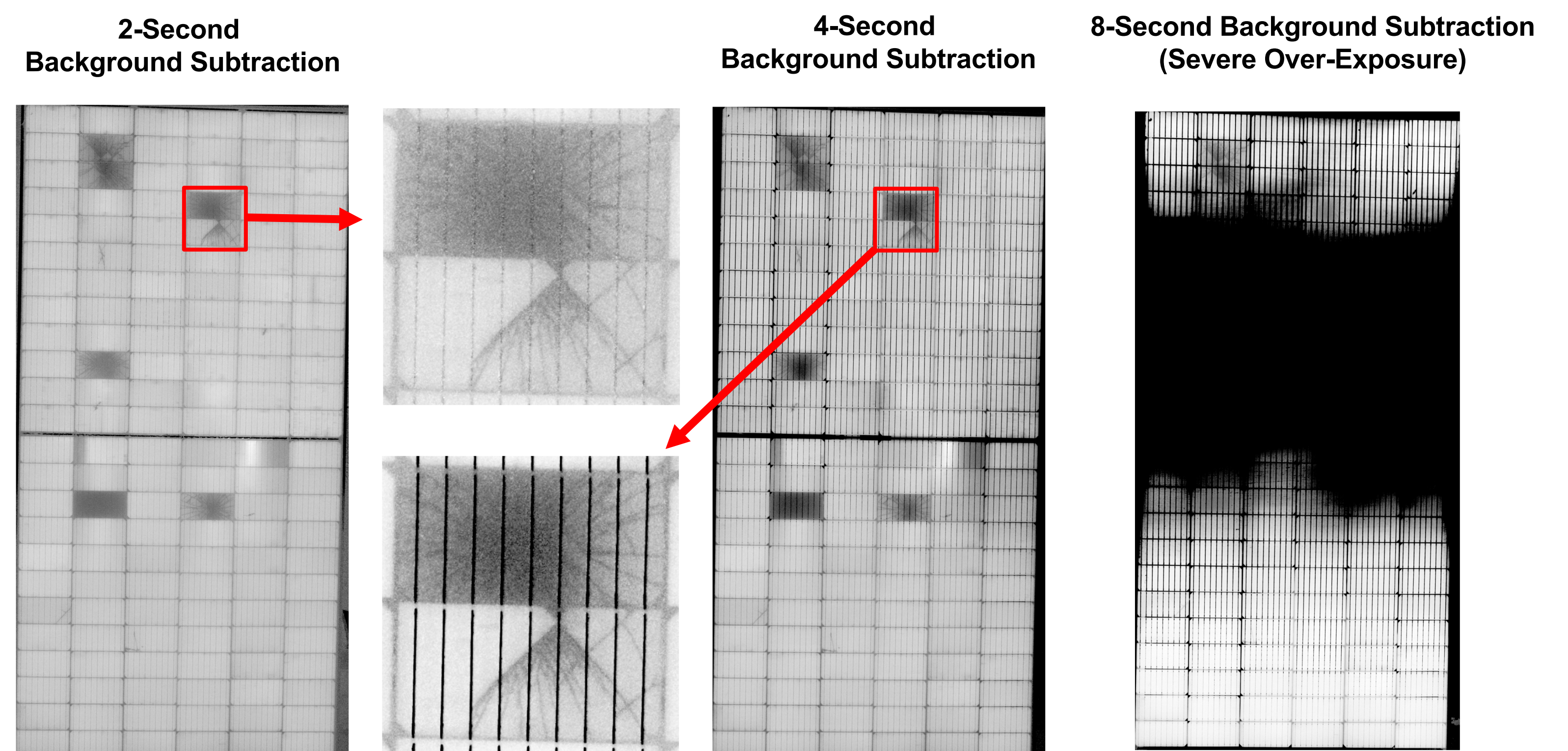


3. Background Subtraction

- Background subtraction effectively extracts EL signal even when noise light is far brighter
- Histogram stretch improves contrast of EL-only image and reveals damaged or degraded cells

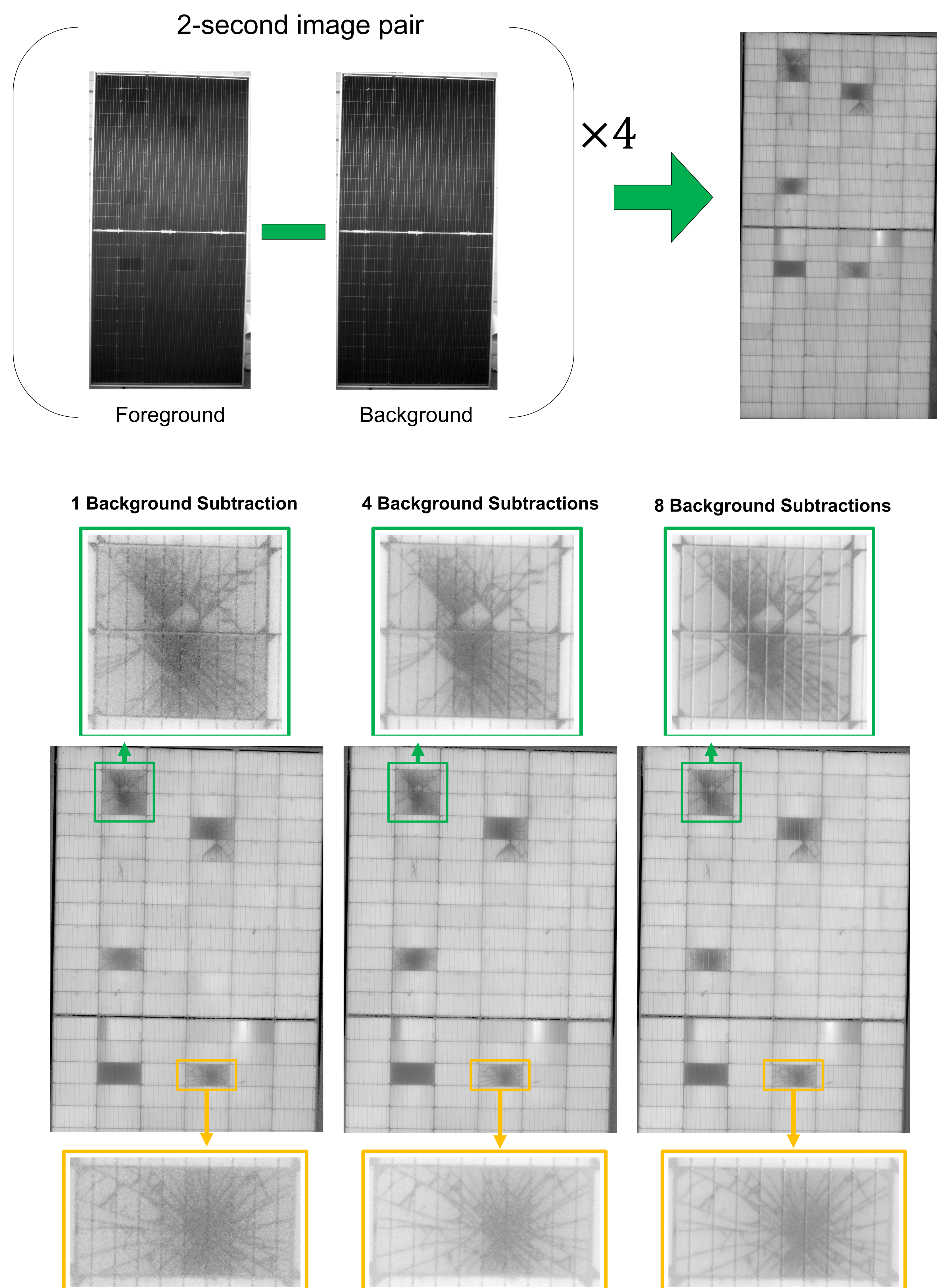


- Longer exposure times improve quality of background-subtracted Difference image, but:
 - Pixel saturation on inactive areas of the module – wires and backsheets – produces visual artifacts in the Difference image without invalidating active area signal
 - It is important to avoid pixel saturation in the active area of the module



4. Background Subtraction With Sampling

- Multiple Difference images from shorter-exposure image pairs are easily summed to improve EL image quality



- Background subtraction with sampling isolates EL signal in especially noisy conditions, such as outdoors in the sun, while a short duty cycle suppresses the effects of variable noise