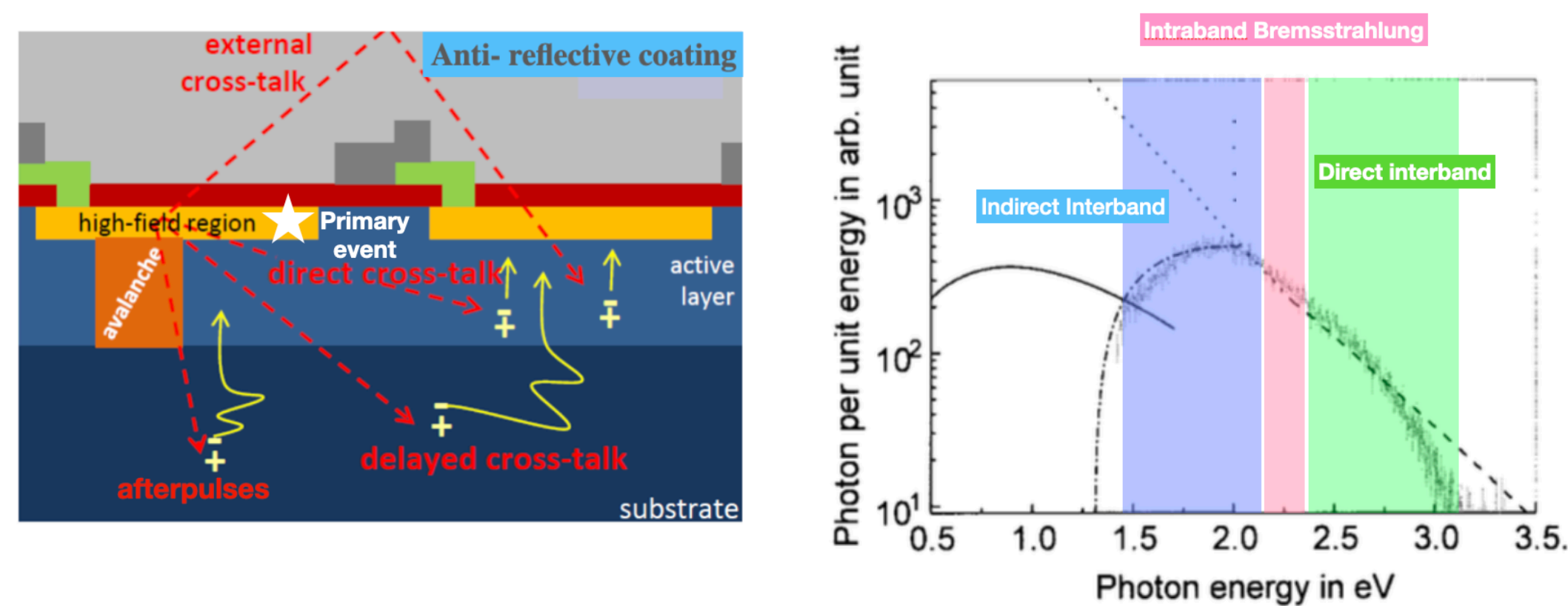


Abstract

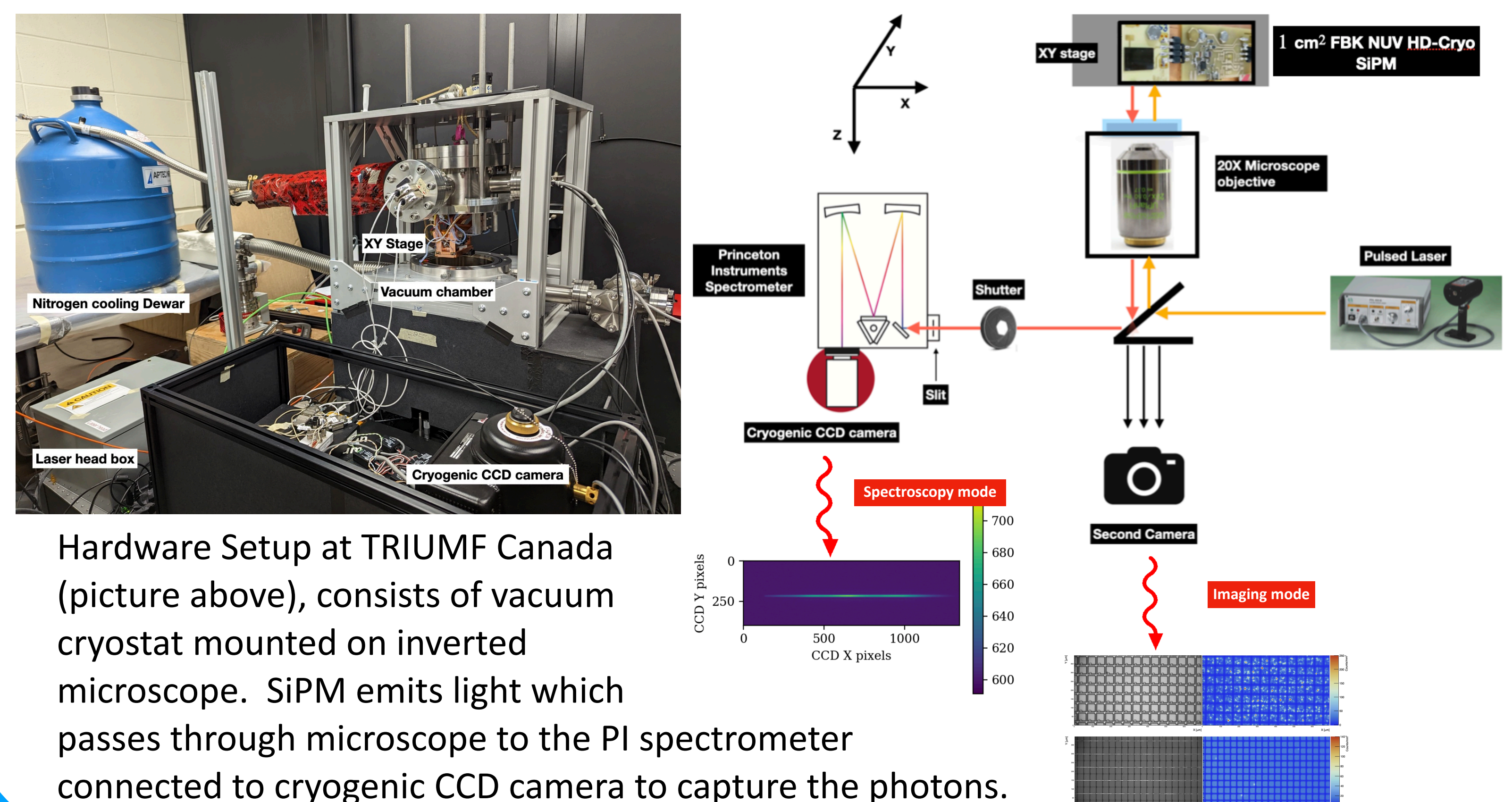
To quantify the photon yield from the SiPMs which can deteriorate the overall performance of detectors with large photosensitive area, a study on SiPM secondary photon emission was conducted. It determined the absolute secondary photon yield equal to the number of photons emitted per charge carrier (γ/e^-) using spectroscopy. The photon yields were calculated at 163 K and 87 K to mimic the SiPM performance at liquid Xenon and liquid Argon temperatures. A summary of the spectroscopy technique and data analysis used to quantify the secondary photon yield at these temperatures have been presented.

1. Motivation



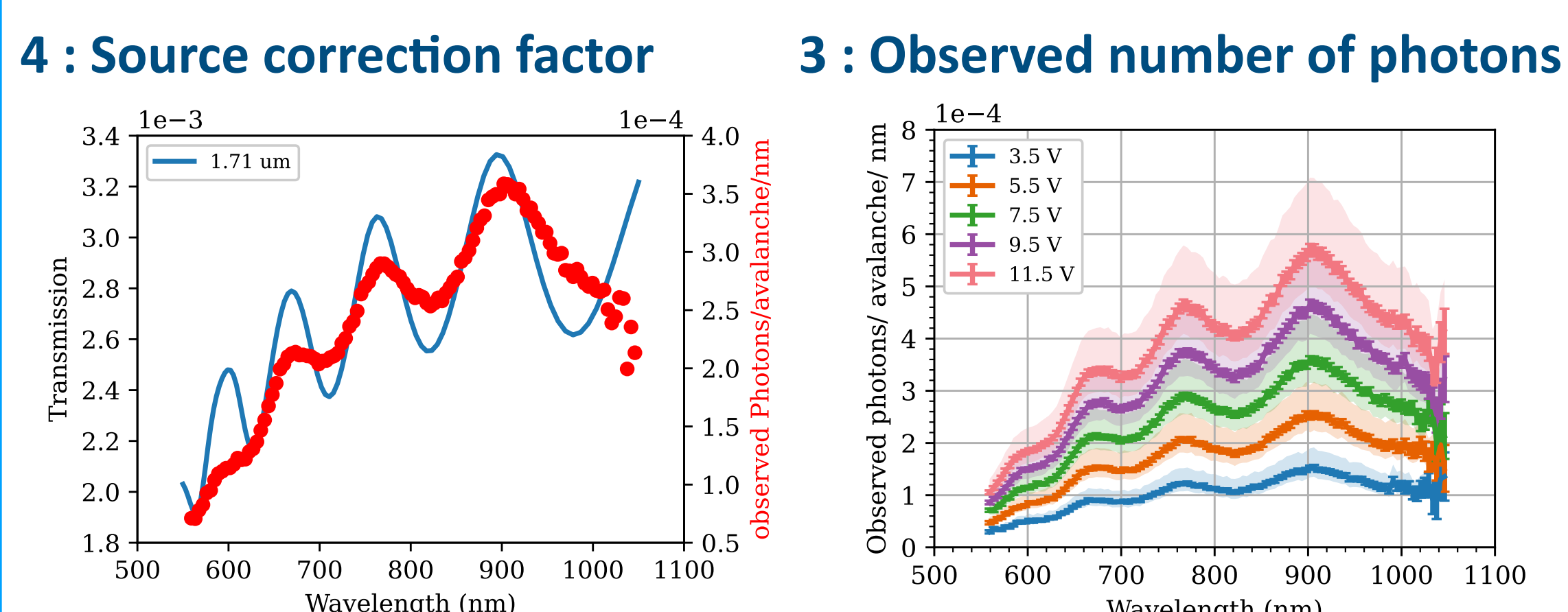
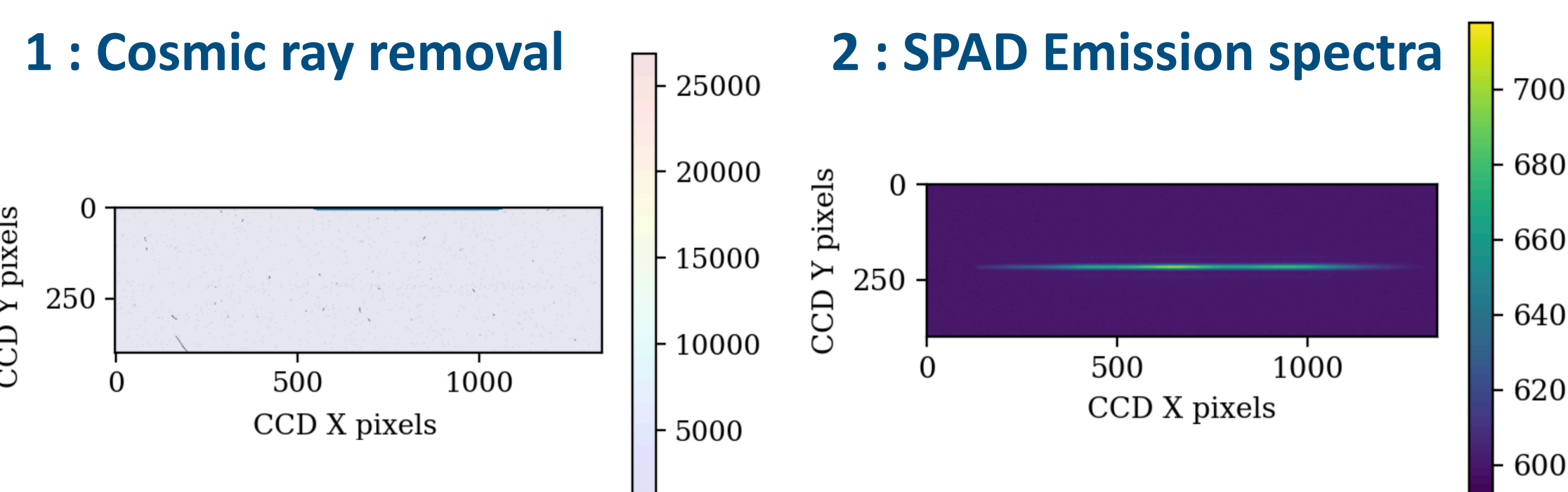
- Model the properties of source of the secondary photon emission
- Understand its temperature dependency
- Calculate photon per avalanche for the different photon wavelengths (energies)
- Calculated secondary photon emission for potential impact on large photosensitive detectors using SiPMs

2. Experimental setup

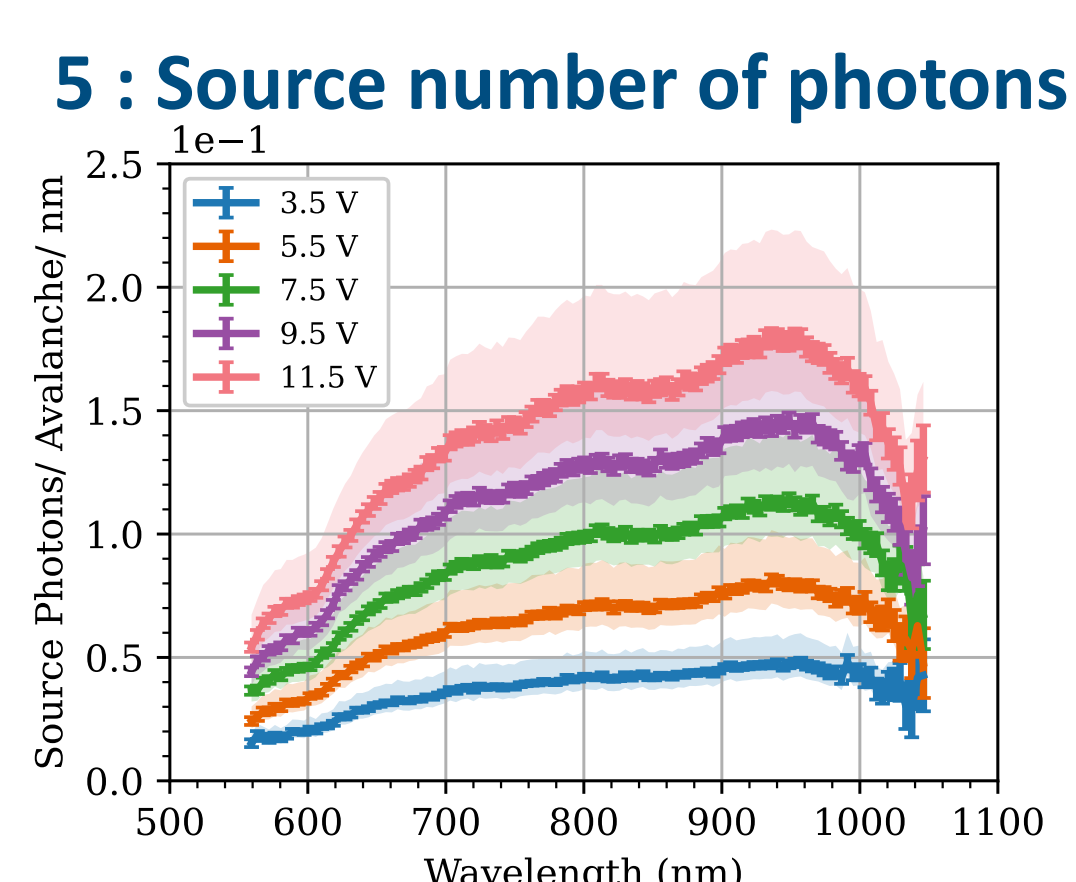


Hardware Setup at TRIUMF Canada (picture above), consists of vacuum cryostat mounted on inverted microscope. SiPM emits light which passes through microscope to the PI spectrometer connected to cryogenic CCD camera to capture the photons.

3. Spectral work flow



Source correction factor depends on the depth of the SiO₂ coating on SiPM (~1.71μm). Correction factor eliminates the interference pattern in observed photons to produce source photons

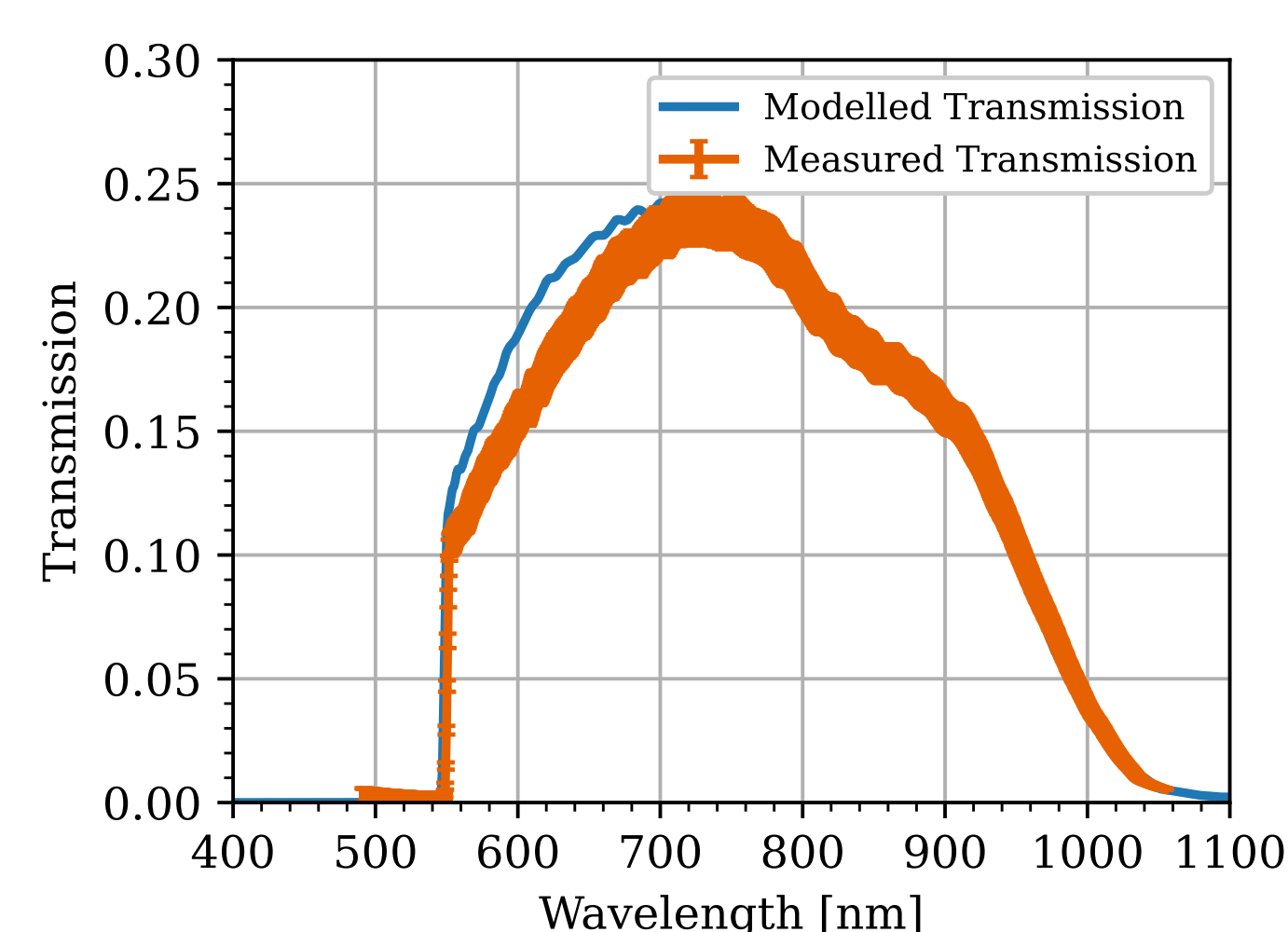


6. References

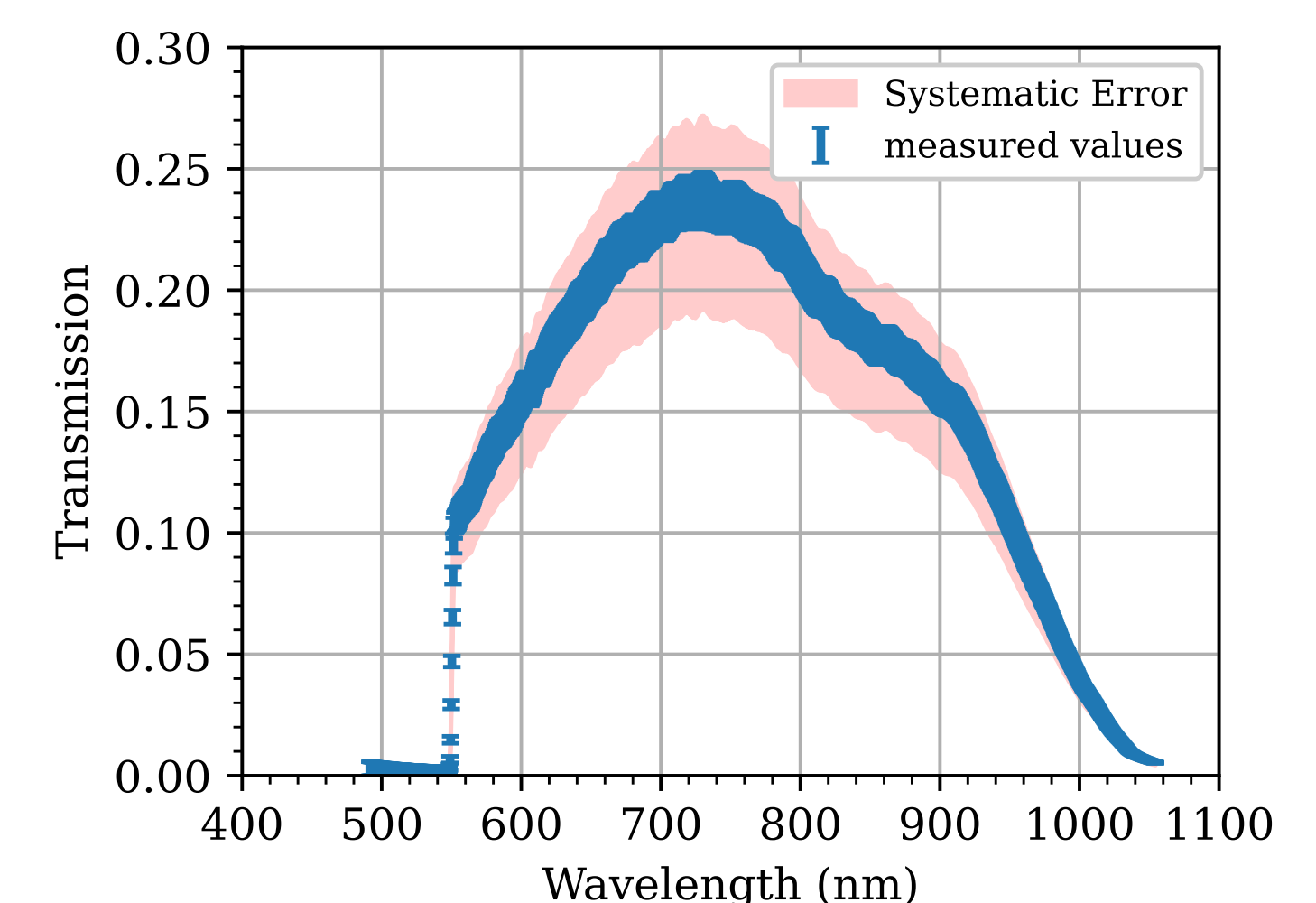
- [1] R. Newman. Visible light from a silicon p-n junction. Physical Review, 100:700–703, 10 1955.
- [2] N. Akil and et al. A multimechanism model for photon generation by silicon junctions in avalanche breakdown. 06 1999.
- [3] DK. Gautam and et al. Photon emission from reverse-biased silicon pn junctions. Solid-state electronics, 31(2):219–222, 1988.
- [4] J. B. McLaughlin and et al. Characterisation of SiPM Photon Emission in the Dark. Sensors, 21(17):5947, 2021

4. Results (FBK NUV HD-Cryo SiPMs)

4.1 Intensity calibration

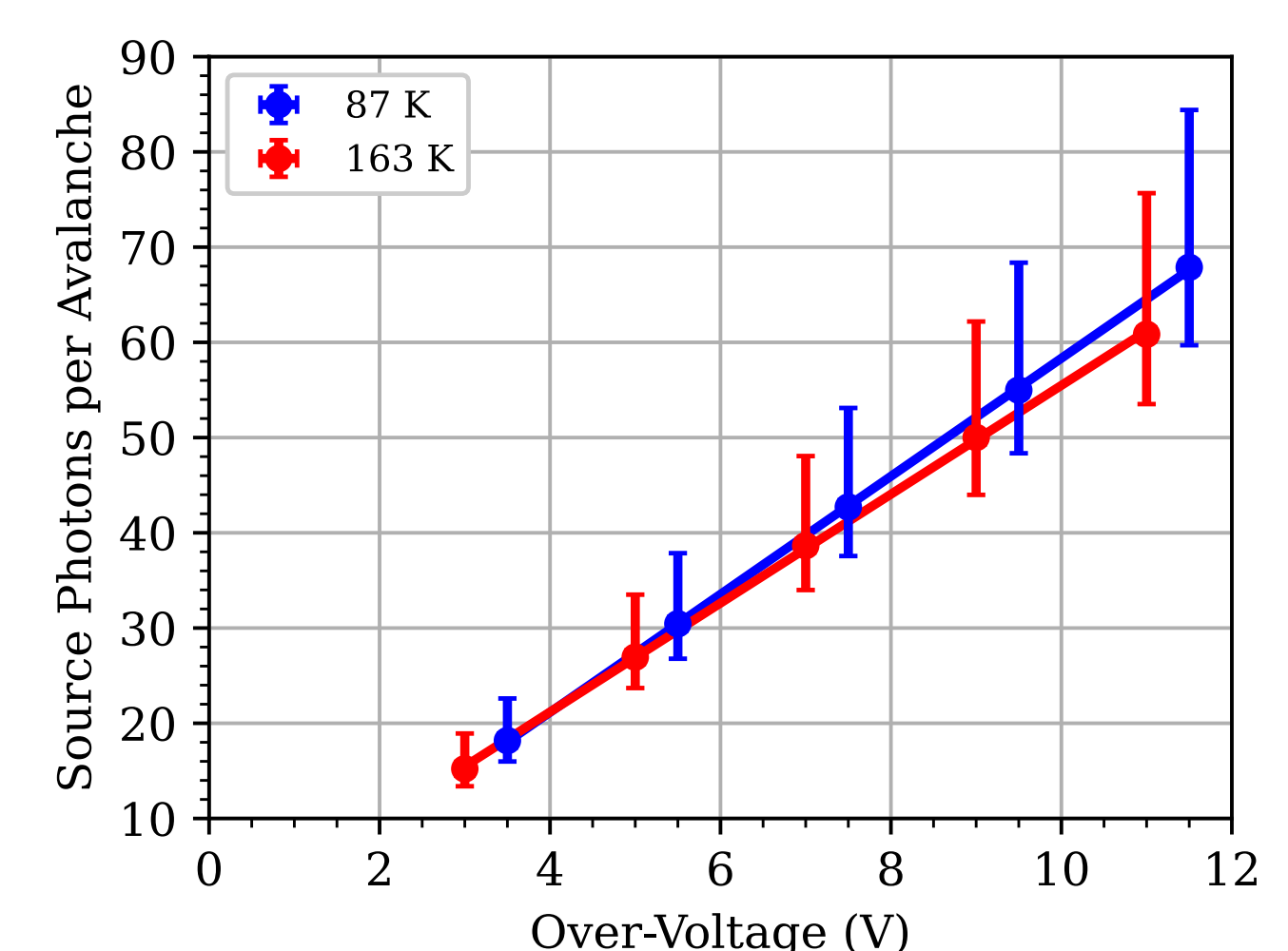
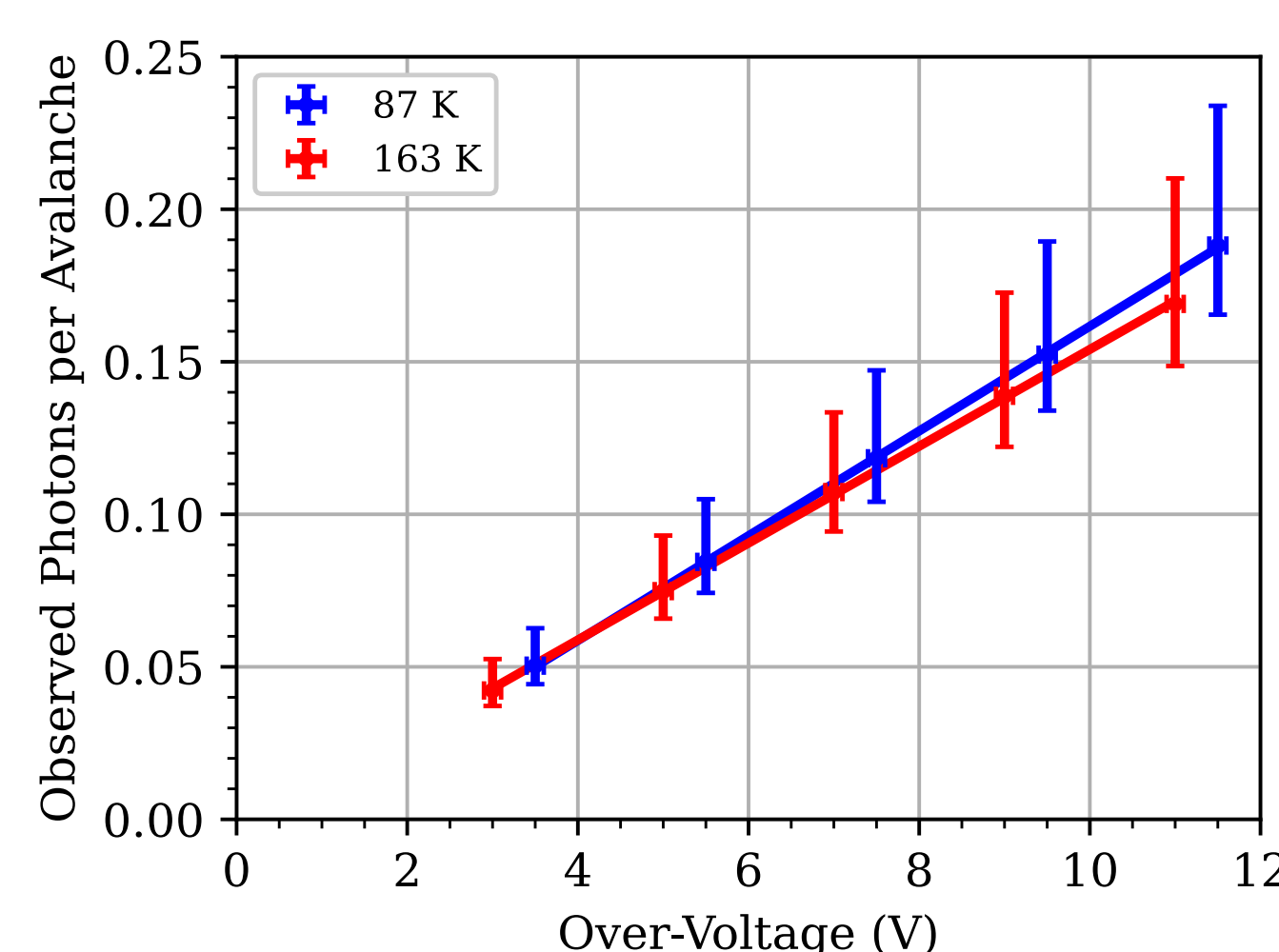


The measured curve is combined transmission curve of different optical components. The modelled curve is from a calibrated Tungsten halogen light source.



The relative error between measured and modelled curves gives the systematic uncertainty on the results.

4.2 Photon spectra (Integrated over wavelengths)



Out of the source photons generated isotropically, **only 0.4 % are detected** through the microscope acceptance whereas **99.6% are lost**. The photon emission remains consistent over temperatures within the error bars.

5. Conclusions and Outlook

This study on secondary photon emission was quantified to extrapolate the systematic effect that it can produce on detector performance due to SiPM noise phenomena. The results presented need to be modelled for larger photon acceptance for tonne scale detectors.