Studying the Emission of Light from Single Photon Avalanche Diodes using LASERs

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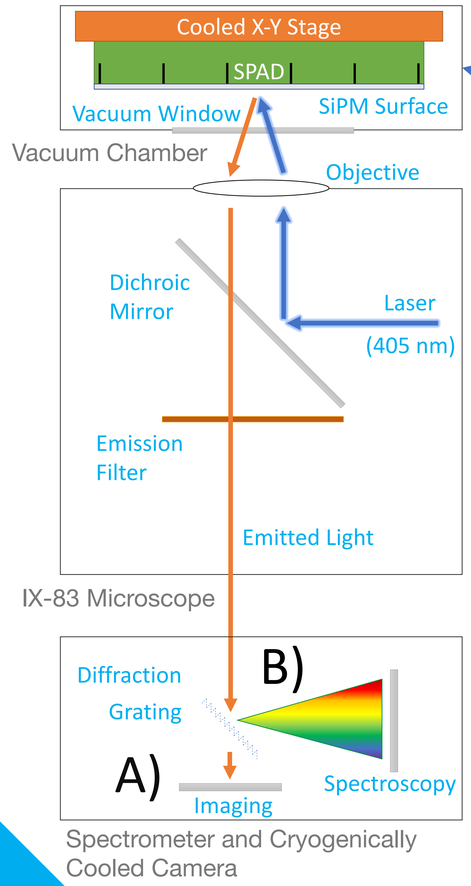
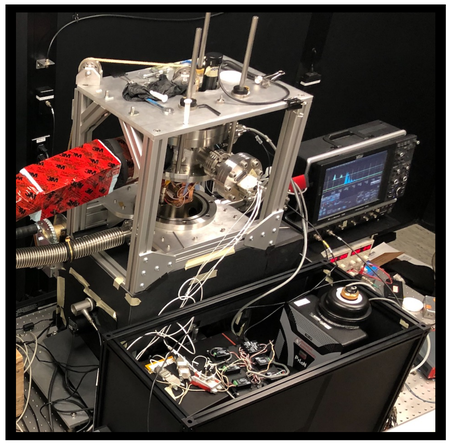
Detecting Single Photons

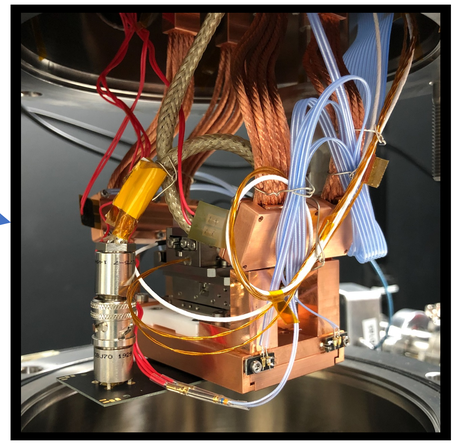
Single Photon Avalanche Didoes (SPADs) are operated at a voltage sufficient to form an avalanche yielding a signal large enough to detect single photons. An array of SPADs is called a Silicon Photomultiplier (SiPM). The nEXO experiment will use ~100,000 SiPMs and light emission during the avalanche is a serious concern.



Spectrometer and Cryogenically Cooled Camera



The MIEL Experiment



Cryogenically Cooled X-Y Stage with SiPM Mounted

Microscope for the injection and emission of light (MIEL)

- **LN2 Cooled X-Y Stage to mimic LXe (161 K) and LAr (86 K) conditions**
- **Sub-μm precision-controlled X-Y stage**
- **From 4x to 50x magnification to study Multi-SPAD and Sub-SPAD effects**
- **Long exposure spectroscopy and Imaging**

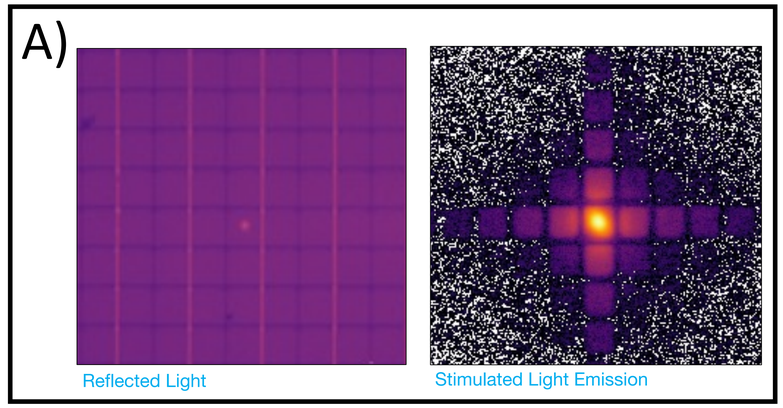
Controlled Emission of Light

Characterize devices at nominal voltages

SiPMs are normally operated around the nominal 4V over-voltage and stimulated using a pulsed laser to relate the rate of avalanches to the light produced.

Inspecting the emission from a single SPAD

Nearby SPADs can fire as a result of an avalanche in a SPAD. By locally firing one SPAD, light can be measured in nearby SPADs.



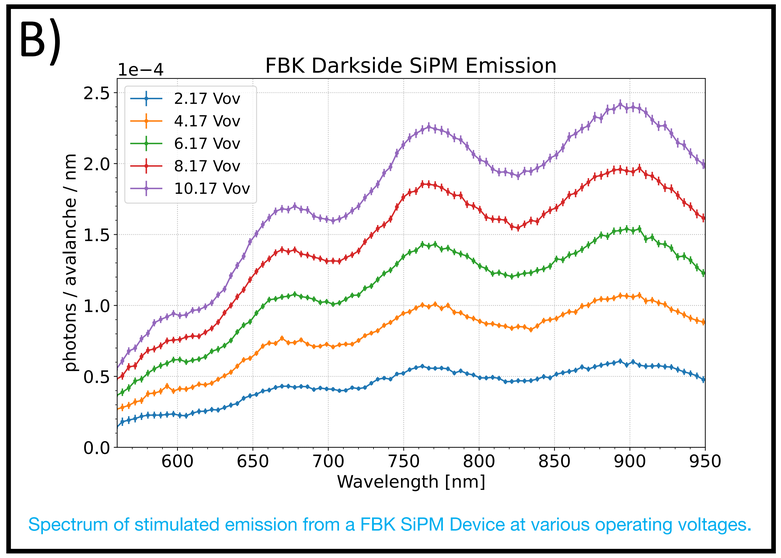
Characterizing SiPMs to inform the design of the next generation of SiPMs

Assessing the performance of current generation SPADs for large area particle physics experiments (nEXO, Darkside20k, etc)

- Identify SiPM emission at controlled temperatures and voltages matching the conditions in a physics experiment

Aid in the development of future devices (Direct dark matter detection, LiDAR, etc)

- Serve as a testbed for devices current generation of devices, and devices currently in development
- Can be used to constrain models used to design SPAD



Spectrum of stimulated emission from a FBK SiPM Device at various operating voltages.

Summary

The MIEL setup is used to characterize SiPMs for the next generation large area particle physics experiments. The emission of light can be used to estimate potential correlated events between different SPADs facing each other. MIEL can also be used to inform design decisions to develop future SiPMs.

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