

Photon Detectors

Snowmass Subgroup Conveners:
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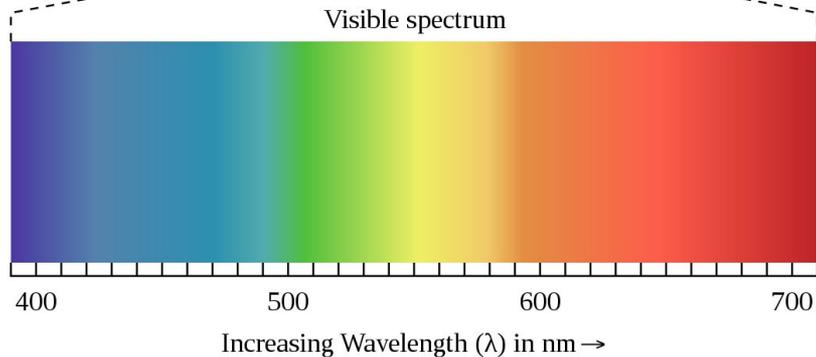
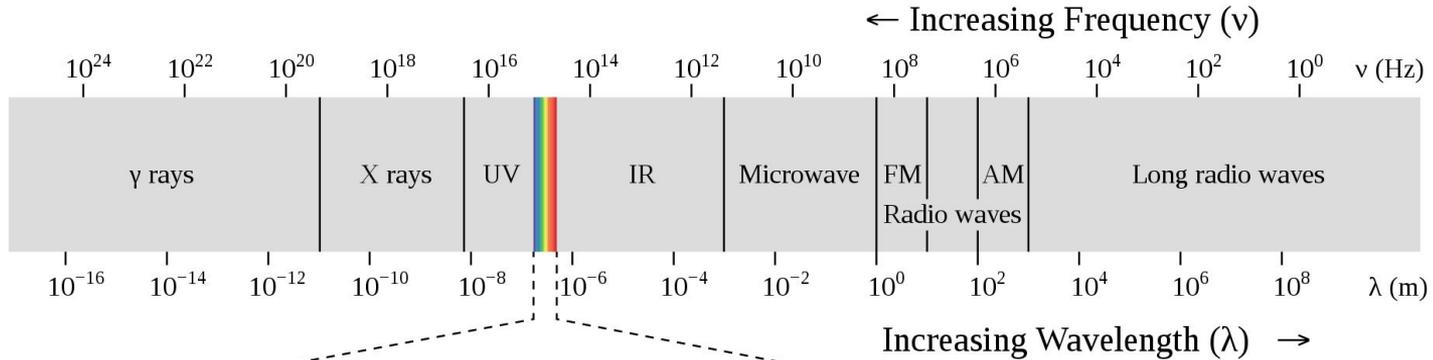


Goals of the Photon Detectors Group (IF02)

This subgroup covers the detection of photons at all wavelengths, from gamma ray, visible and ultimately radio. Included are technologies (sensors and light collection systems) that are incorporated into telescopes, calorimeters, spectrometers and trackers. Applications include, but are not limited to, detectors in collider experiments, neutrino detectors, and Dark Matter and Dark Energy searches.



Across All Wavelengths



Across All Frontiers

	Neutrino Frontier	Cosmic Frontier	Energy Frontier	Rare & Precision
Sensors hiE		●		
Sensors UV	●	●		●
Sensors VIS	●	●	●	●
Sensors IR		●		
Sensors μ wave/Radio		●		
Large Area	●			●
Low Background				●
Fast Timing	●	●	●	
Light collection	●	●		●

Neutrino Frontier (overlap with Rare Processes)

Large-Area/Volume instrumentation:

- ❖ Neutrino detectors need to be large and resistant to high pressure environment.
- ❖ Examples: IceCube DOMS, HyperK photosensors, LAPPDs.

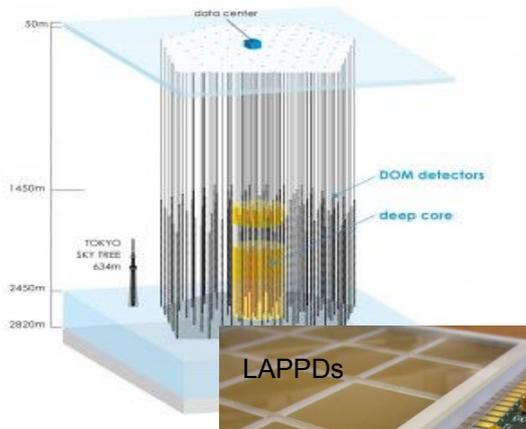
Fast-timing photodetection:

- ❖ Novel detectors using timing to enhance physics reach.
- ❖ Examples: LAPPDs, SiPMs

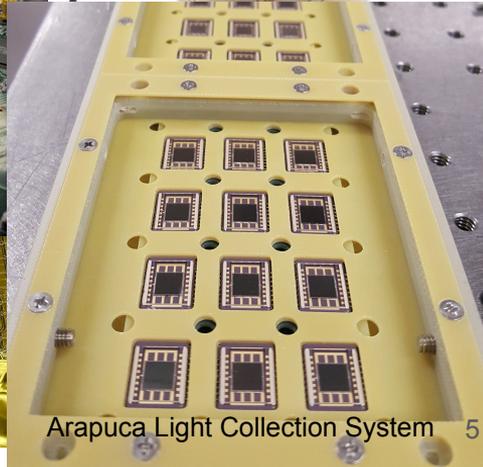
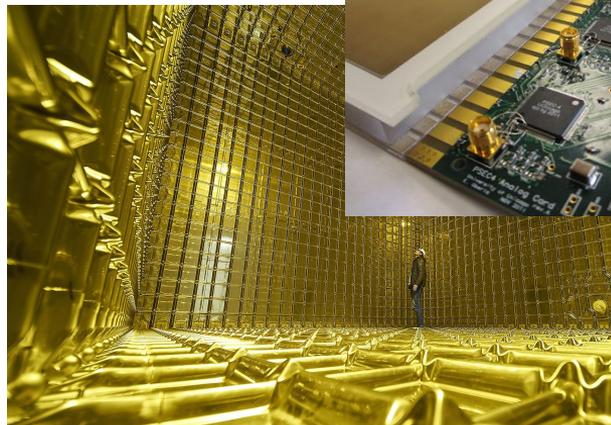
Light collection at cryo temperatures:

- ❖ Liquid Argon TPCs are key to the long-baseline neutrino program.
- ❖ Efforts on light collection systems such as ARAPUCA for DUNE.

... much more



IceCube DOM



Arapuca Light Collection System 5

Cosmic Frontier

Wide-ranging technologies are being developed for:

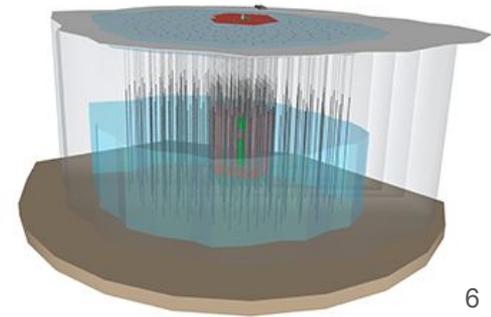
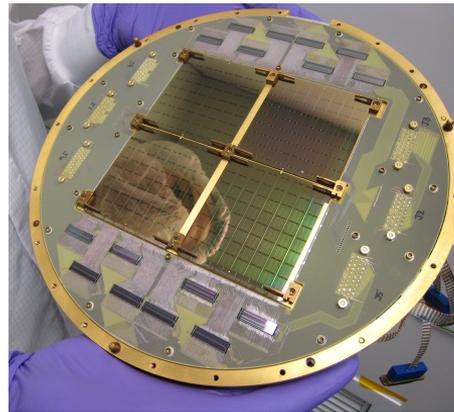
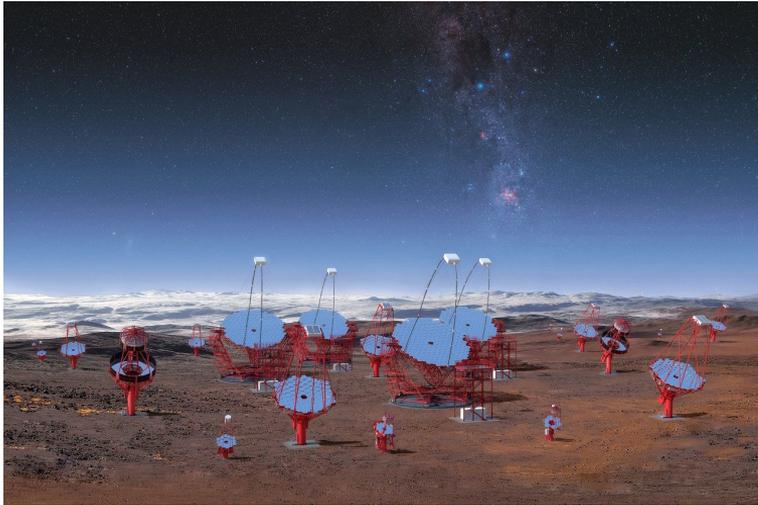
Cosmic Surveys

Cosmic Microwave Background (CMB)

Gamma Ray Observatories

Neutrino Observatories

Dark Matter Detection



Dark Matter Detection

Direct Dark Matter:

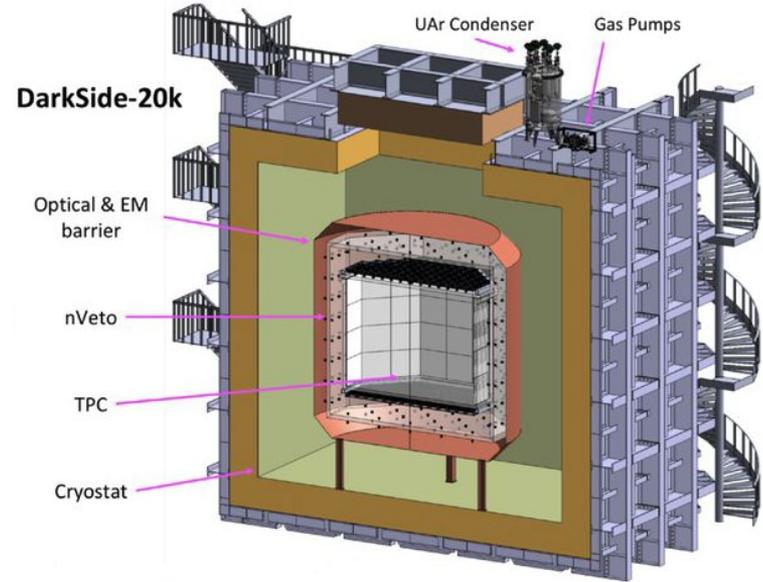
- ❖ Large area for next gen liquified noble element detectors (SiPM/PMT)
- ❖ Low background
- ❖ Cryogenic sensors (TES)
- ❖ Semiconductor single photon detectors
- ❖ Novel small gap materials, with long lived phonon modes (InSb, ZrTe5)

Axion Dark Matter:

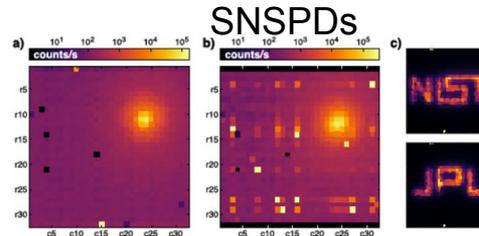
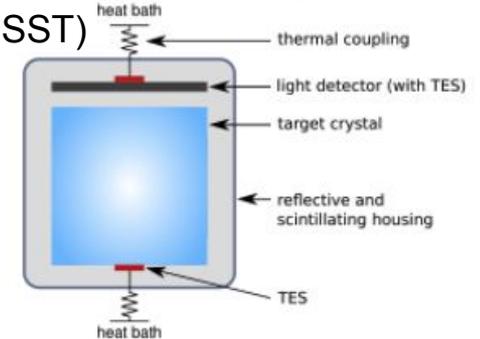
- ❖ Single photon detector in VIS-microwave for wide band antennas. MKIDs, SNSPDs
- ❖ Synthetic atom microwave single photon detector (overlap with quantum)

... much more

~ 11k SiPM channels (low background, large area)



Light detection with TES (CRESST)

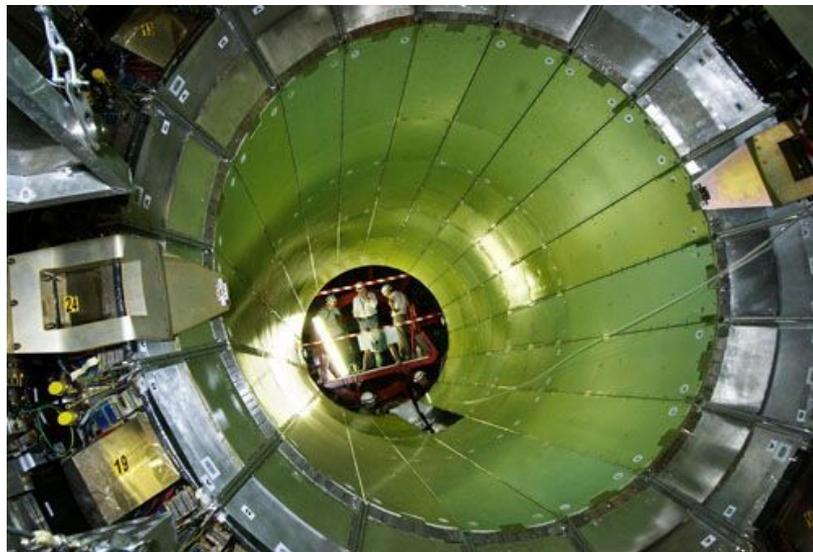


Energy Frontier

New technologies for:
LHC Upgrade, Next Generation Colliders

Solid state detectors (SiPM / SSPM):

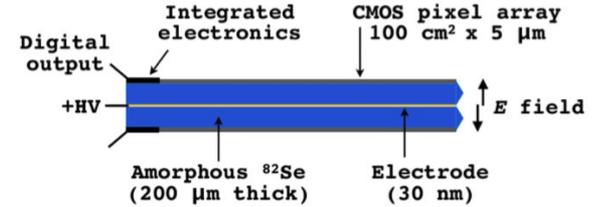
- Improvements on SiPM performance (crosstalk, afterpulsing, PDE, dark noise)
- Fast timing in SiPM
- Radiation hardness in SiPM
- Development of ultra high density SiMP
- SSPM with other semiconductors (SiC, GaAs)



Rare & Precision Frontier

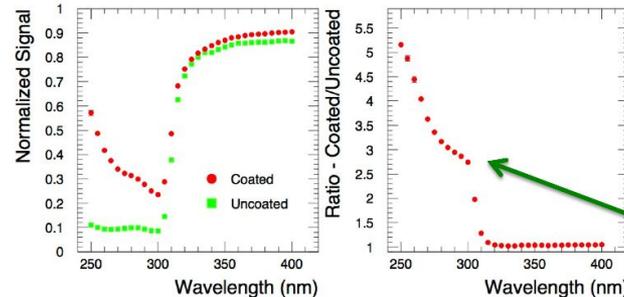
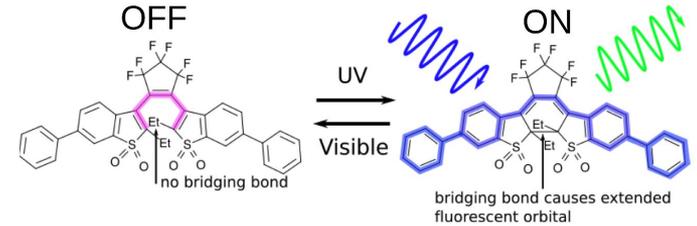
Neutrinoless double beta decay efforts

- ❖ CMOS imaging detectors for neutrinoless double beta in ^{82}Se , using technology developed for X-ray plate detectors
- ❖ Switchable fluorescent molecules to image tracks and measure energy in liquid double beta decay detectors.



Mu2e/G-2:

- ❖ UV sensitive solid state photon detectors for calorimeter.
- ❖ Nano-particle enhanced UV detectors



Si nanoparticle coating on plastic film (U of I partner)

Published result:
JINST 10 05008 (2015)

Enhanced response:
250 nm < λ < 300 nm

Interface to other subgroups/frontiers

Interfaces with the Science Frontiers
(Neutrinos, Cosmic, Energy, Rare & Precision)

Interfaces within Instrumentation:

- Quantum Sensors subgroup
- Electronics/ASICs subgroup

Want to make sure there are no gaps or repeats among instrumentation subgroups

Photodetector Group Logistics

- Conveners: Juan Estrada, Mayly Sanchez, Abigail Vieregg
- Plan for 1-2 half-day online workshops end of July/early August.
Proposed date for first one: Wednesday, July 29
- Wiki https://snowmass21.org/instrumentation/photon_detectors
- Communication channels:
Email list: SNOWMASS-IF-02-PHOTON-DETECTORS@FNAL.GOV
Slack: [#if02-photon_detectors](#)

Submit Your LOIs!

- This is a very wide-ranging subgroup
- LOIs may cross over with other instrumentation subgroups or other frontiers
- LOIs can (and should!) be on technologies that are more well-established as well as those that are more blue sky
- It is useful to include a discussion of the technology readiness, the state of R&D, if and how it is currently being used, and what the hopes and dreams for the future are