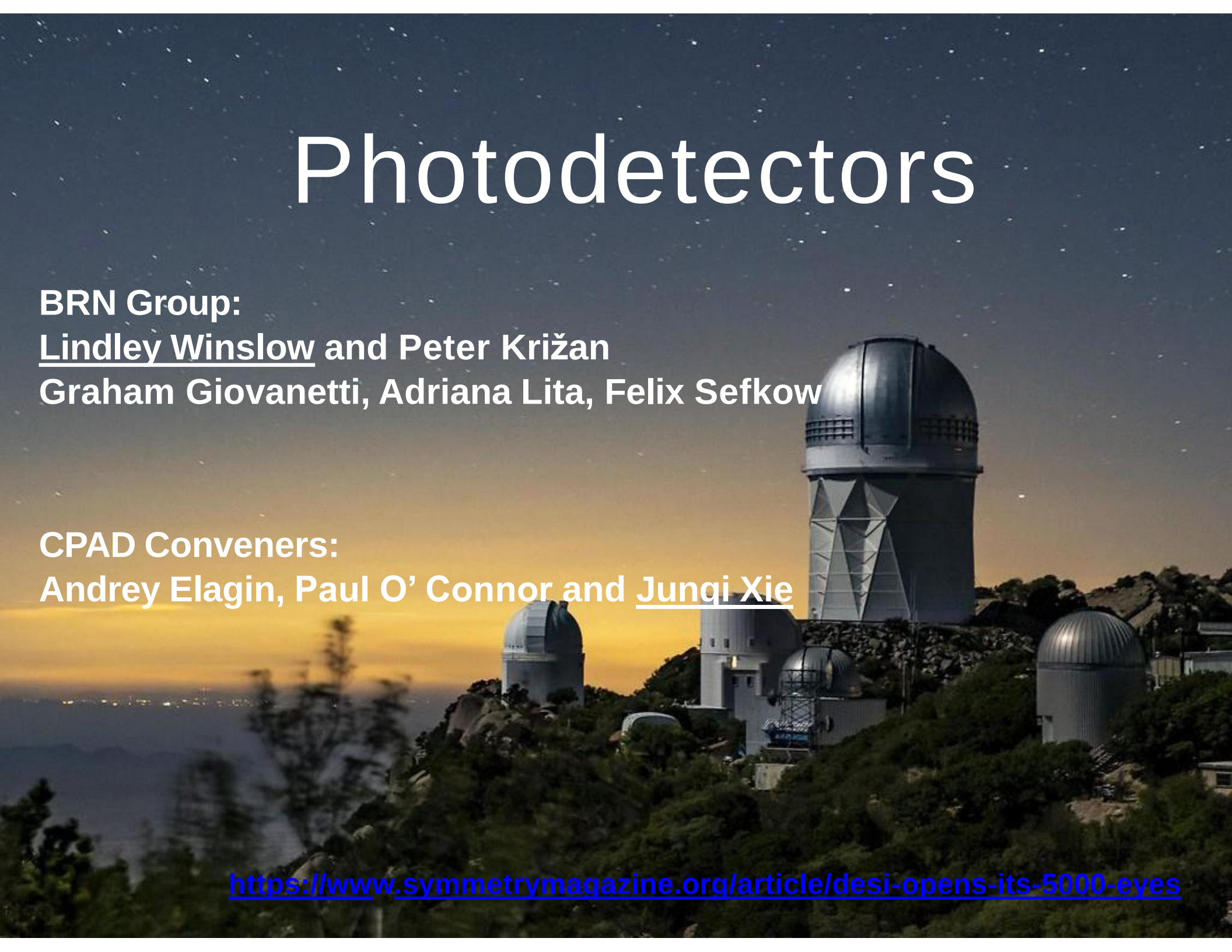
Photodetectors

BRN Group:
Lindley Winslow and Peter Križan
Graham Giovanetti, Adriana Lita, Felix Sefkow

CPAD Conveners:
Andrey Elagin, Paul O' Connor and Junqi Xie



https://www.symmetrymagazine.org/article/desi-opens-its-5000-eyes

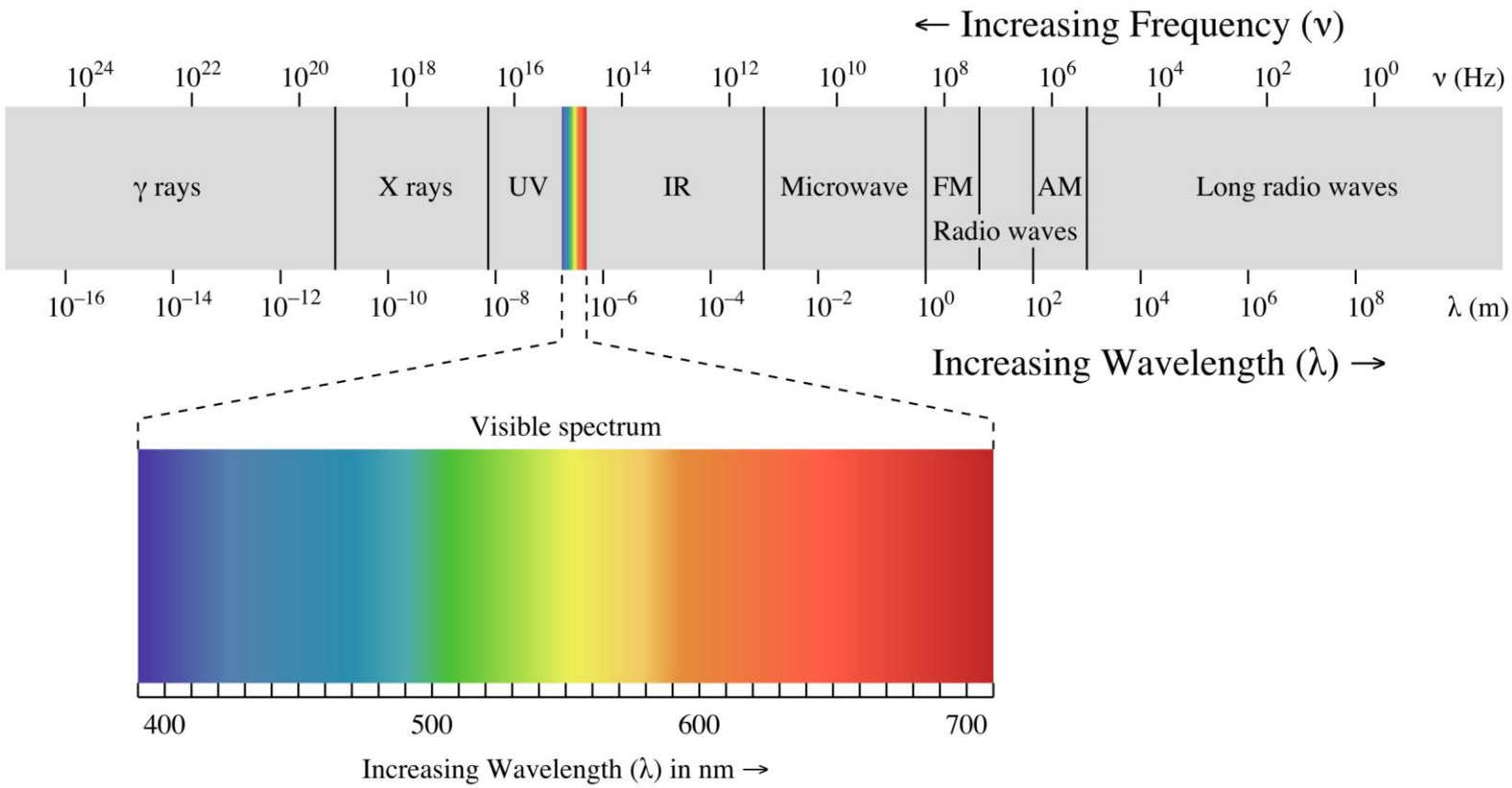
This is a big job.

THE DETECTOR R&D BRN STUDY

The Detector R&D BRN Study will:

- Survey the present state of the HEP technology landscape.
- Identify key capabilities and associated performance requirements to enable HEP science drivers.
- Identify technologies to provide or enhance such capabilities.
- Articulate long-term Priority Research Directions to push well beyond the current state of the art, potentially leading to transformative technological advances with broad-ranging applicability; flesh out the required R&D efforts with deliverables with notional timelines and key technical milestones along the way; and elucidate the technical infrastructure required to support these efforts.
- Formulate a small set of instrumentation Key Challenges that could, if addressed successfully, result in game-changing experimental capabilities.

All Wavelengths!



https://en.wikipedia.org/wiki/Light

Full range wavelength coverage: from gamma ray to UV-VIS-IR to microwave

All Frontiers!

Cosmic Frontier

- Surveys like DESI (shown on first slide)
- CMB
- WIMP Dark Matter
- Axion Dark Matter
- Other New techniques

Intensity Frontier

- DUNE
- mu2e
- Other muon and neutrino efforts
- Flavor factories

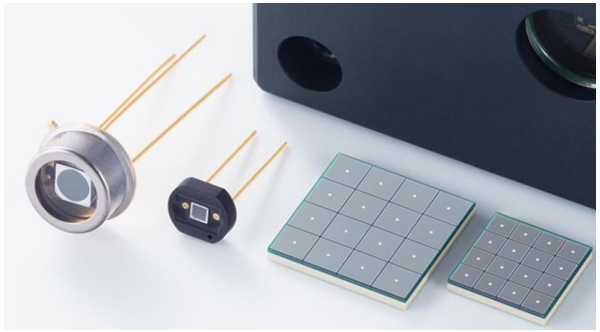
Energy Frontier

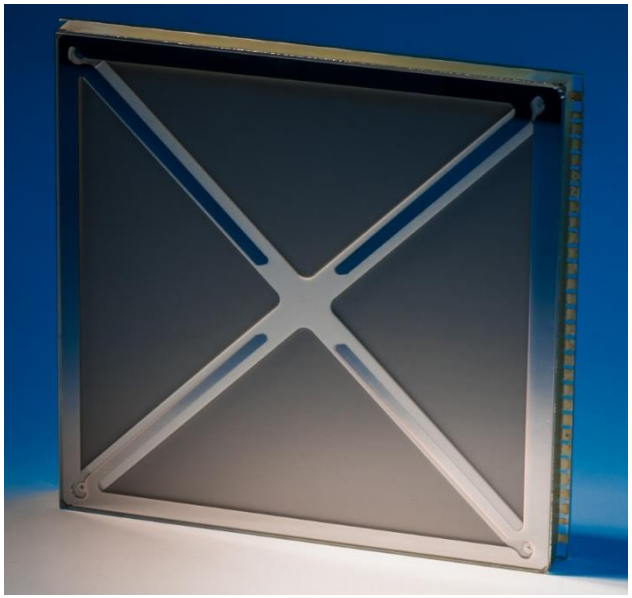
- LHC Upgrade
- Next generation colliders

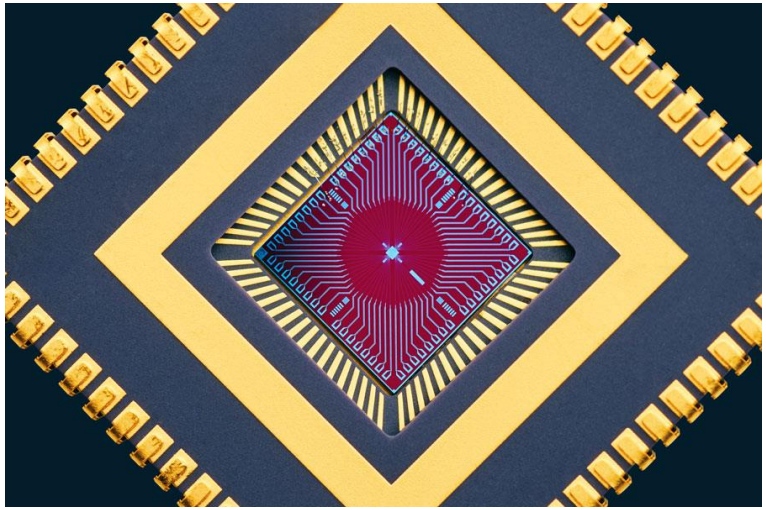
Application and impact in all HEP frontiers.

The team:

We tried to cover the full range of technologies from PMT alternatives like SiPMs and LAPPDs to noble liquids, superconducting devices and CCDs.







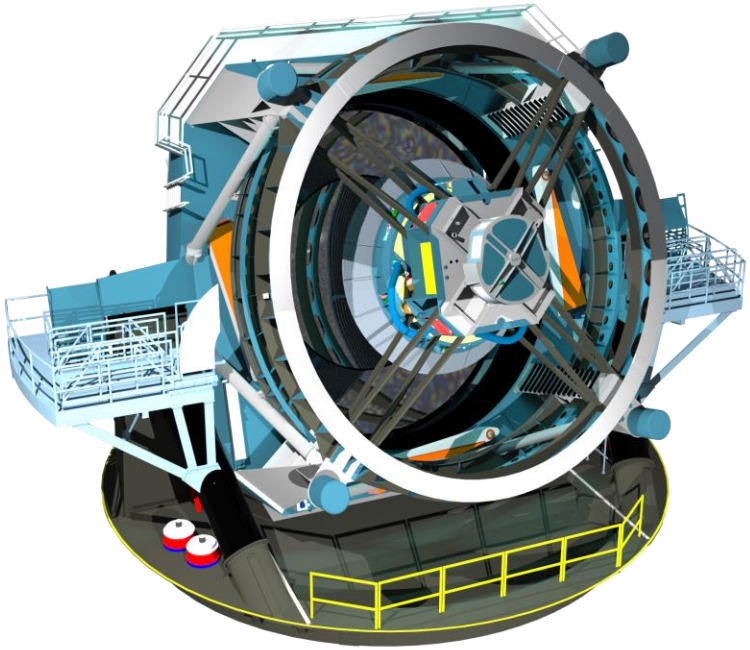
https://www.hamamatsu.com
https://incomusa.com
https://microdevices.jpl.nasa.gov/

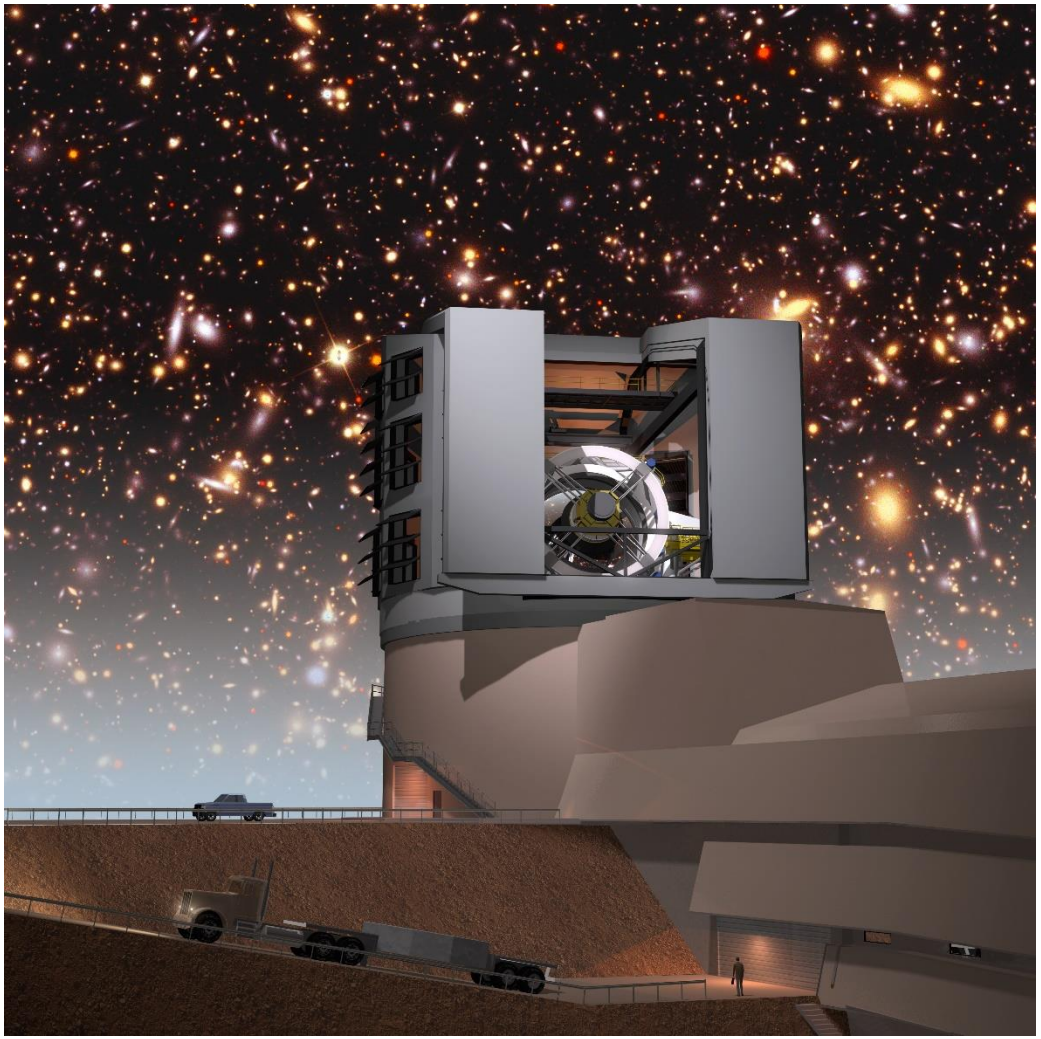
Our task:
From the bottom up, what are the technological breakthroughs that could enable more science?

Or:

Formulate a small set of instrumentation Key Challenges that could, if addressed successfully, result in game-changing experimental capabilities.

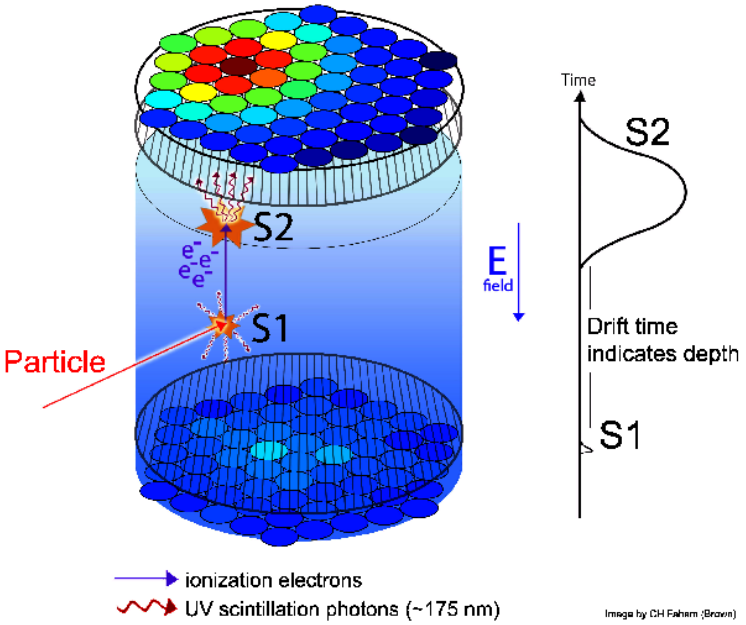
From Surveys and the need to move to longer wavelengths:

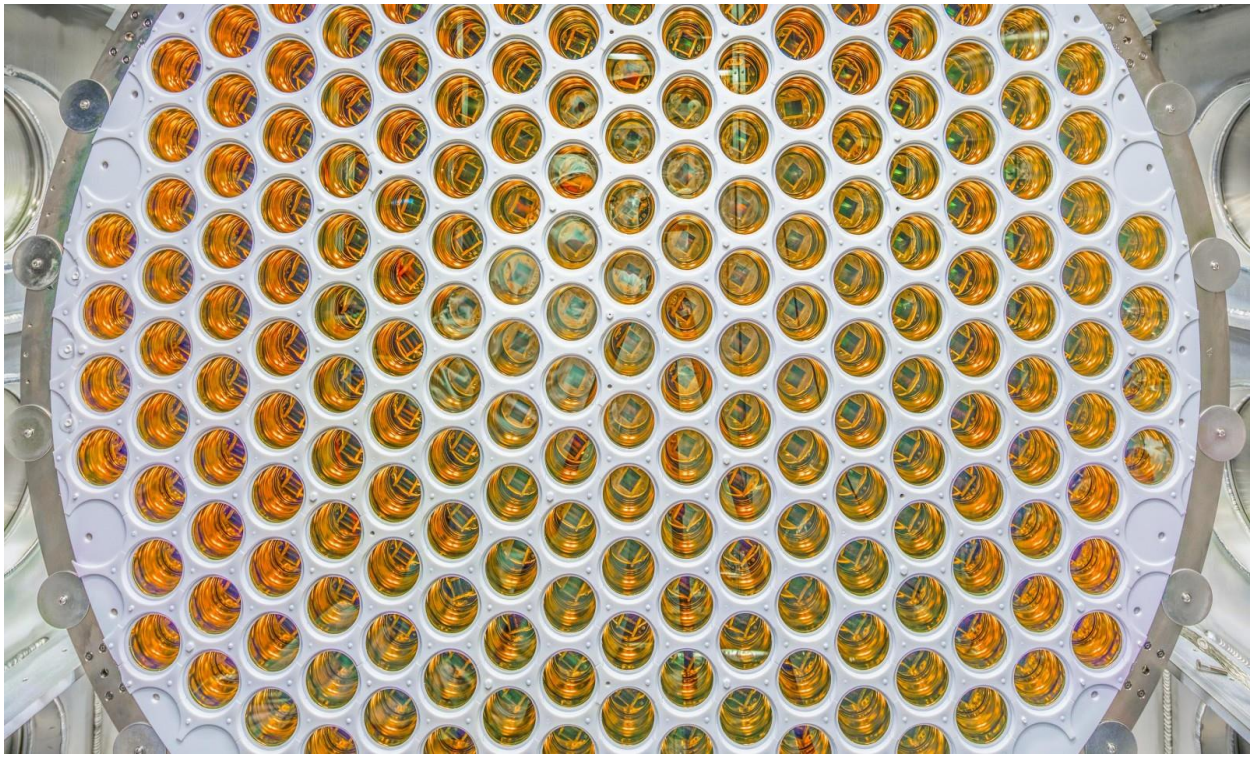




https://www.lsst.org/science

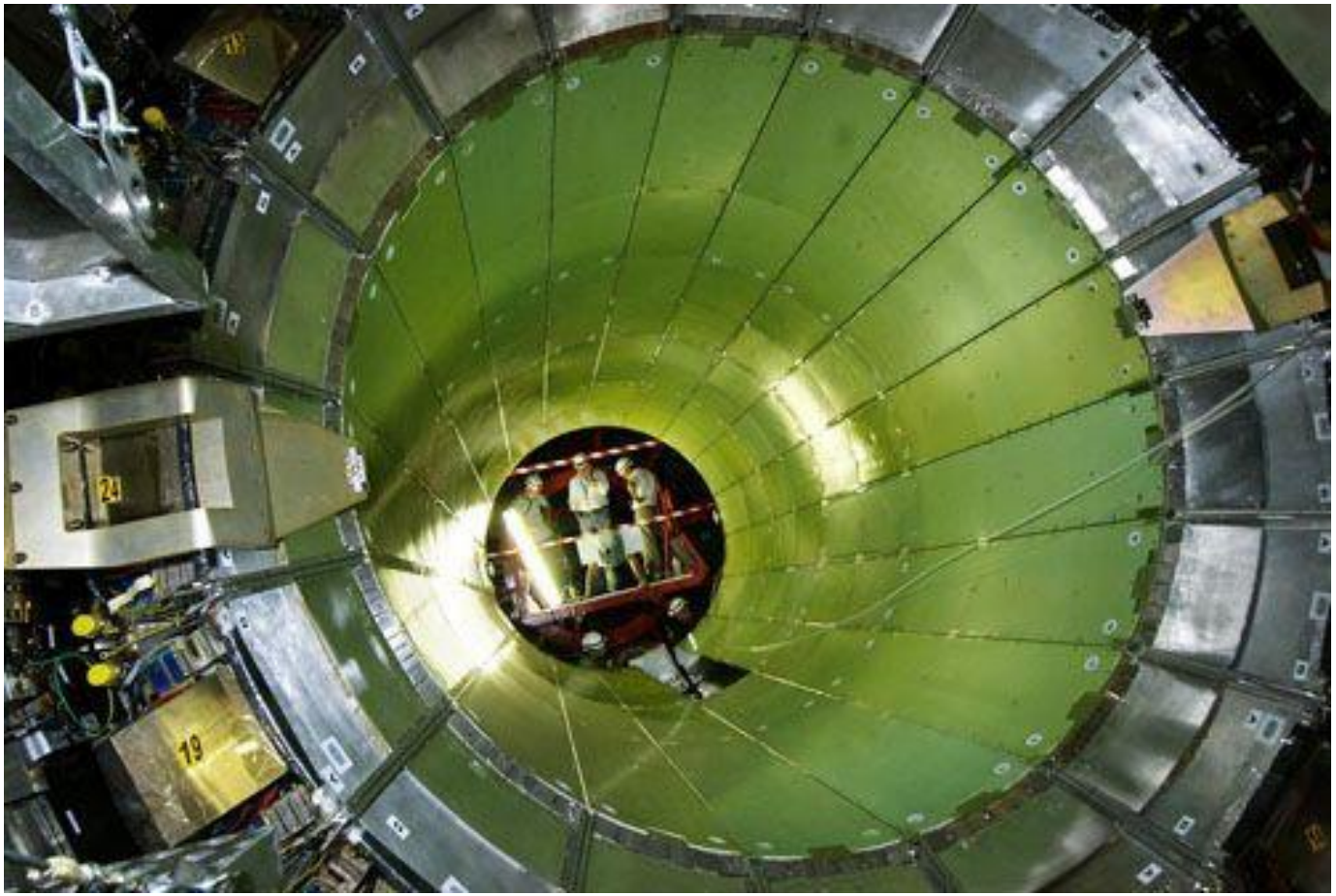
From Dark Matter and direct detection of UV Photons:





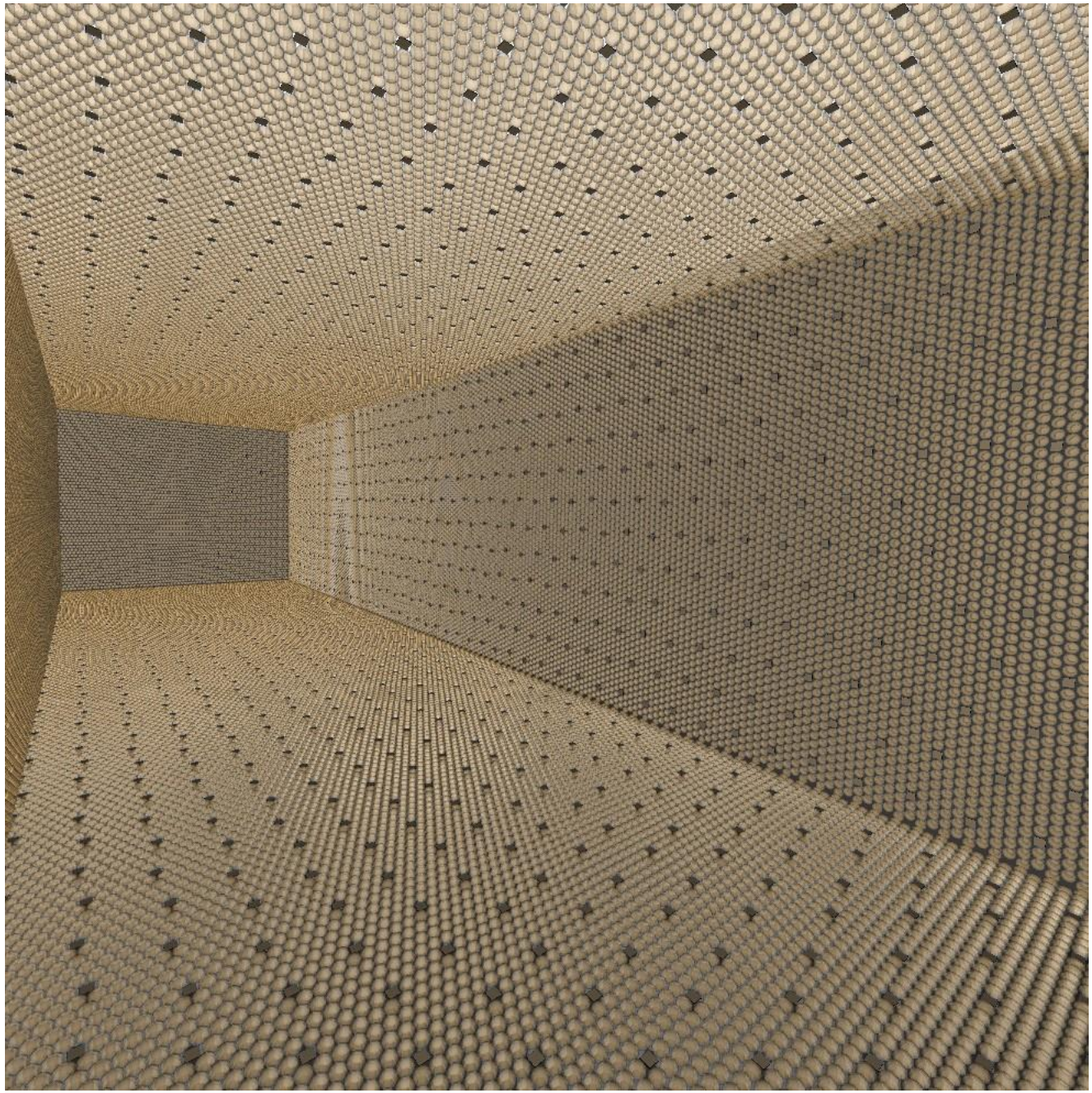
https://www.sanfordlab.org/feature/enhancing-search
http://luxdarkmatter.org/

To the LHC and timing and radiation hardness:



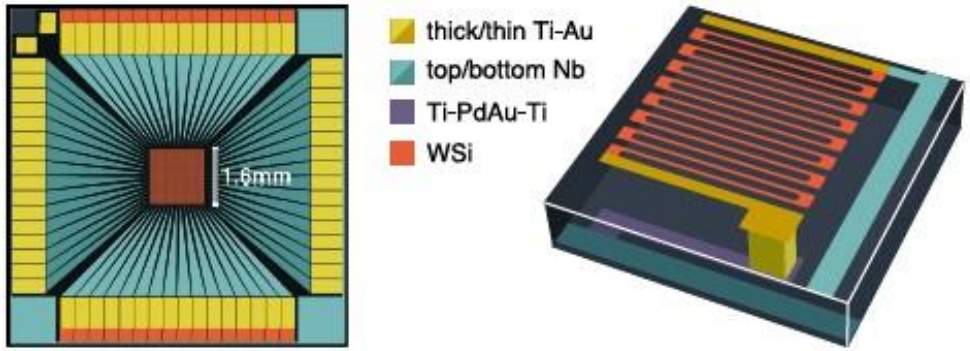
http://cms.web.cern.ch/news/electromagnetic-calorimeter

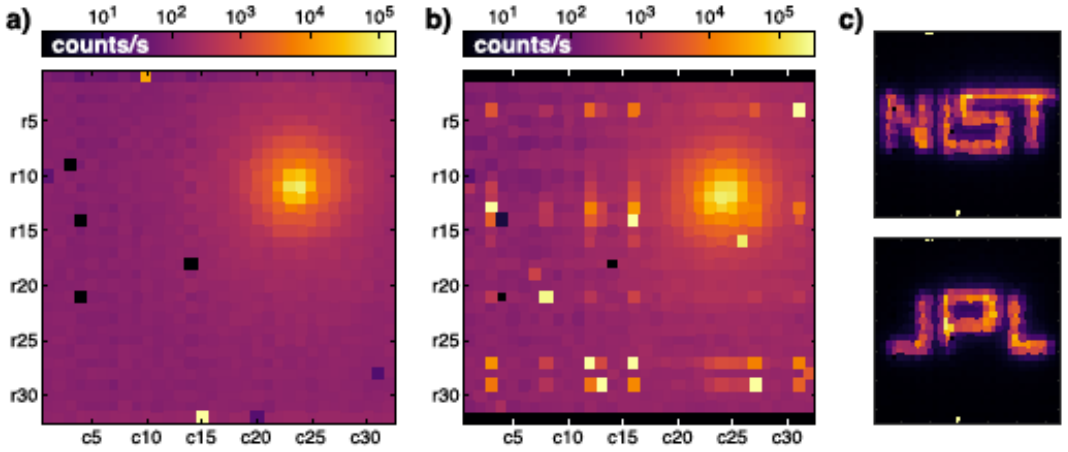
And New Technologies and concepts…. Fast timing with LAPPDs



Theia: An advanced optical neutrino detector, arXiv:1911.03501

And New Technologies….Superconducting Nanowire Single Photon Detectors





A kilopixel array of superconducting nanowire single-photon detectors, arXiv:1908.10520

This is our first draft of broad recommendations:

IR Sensitivity: The redshift range of surveys is limited by the wavelength range. There may be synergies with particle detectors that could move to longer wavelengths or the making of the devices into particle detectors themselves.

UV Sensitivity: Scintillators included liquid noble gases scintillate primarily in the UV, removing the need for wavelength shifting would improve the sensitivity of these detectors.

Radiation Hardness: This is a requirement that naturally comes from the next generation of colliders.

Timing: The study of ~50ps timing has lead to interesting new detector concepts. As both SiPMs and LAPPDs achieve this timing what would be possible with <20ps timing, or even 5ps timing, and in many fine pixels.

Improved low light level detection performance: particularlly important in single photon detection for particle ID detectors.

This is our first draft of technology recommendations:

SiPMs: Develop radiation hard devices, reduce the optical cross-talk, improve the UV/VUV sensitivity. Further reduce the impact of dark counts on single photon detection by light collection features.

LAPPD: Continue to pursue the development of the LAPPD for both its possible advanced timing characteristics and its ability to outperform PMTs in certain environments.

Germanium CCDs: This seems to be the most feasible technology to meet the needs of the next generation of surveys. An organized effort to build this expertise and facilities is needed.

Accessories: Filters, Waveguides, and Fiber Positioners are critical for extracting the most information from the detectors and their development should continue in parallel to the sensor development.

These are our general recommendations:

Cost Reduction: Whether it is CCDs in a telescope or LAPPDs in a neutrino detector, our ability to dream is limited by the cost of the new technology.

Explore New Technologies: New technologies are constantly emerging especially on the border with quantum sensors. These should be pursued and may lead us to interesting new science.

Your input is critical to the BRN study process
Bring your ideas to the BRN and CPAD conveners, CPAD 2019 is set to provide the most up-to-date photodetector needs to the BRN process.

Feel free to email directly with your comments.

lwinslow@mit.edu
peter.krizan@ijs.si