Report from the Photodetectors Group:

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Science Drivers

- Everything…
- Collider Physics
  - Calorimeters (CMS, sPHENIX)
- Neutrino Physics
  - JUNO, Hyper-K
  - 0nubb (NEXO, SNO+, Kamland-ZEN+, nuDOT)
  - Nuprism, Theia, Watchman-II,
  - ANNIE, TARDIS
- Dark Matter
  - LZ
- Significant Cross-talk with Industry
  - Medical Imaging (PET), Non-proliferation/Homeland Security, etc.

Structure of Parallel Session

- Water-Based Liquid Scintillator (Minfang Yeh)
- Isotope Loading of LS (Szymon Manecki)
- Directional Liquid Scintillator Detector (Andrey Elagin)
- Photosensors at Hamamatsu (Ardavan Ghassemi)
- PMT Development for JUNO (Sen Qian)
- PMT Development for Hyper-K (Tom Feusels/Y. Nishimura)
- LAPPD (Jonathan Eisch)
- MCP photodetectors at Argonne (Ranjan Dharmapalan)
- 2D-doped Si APDs with Integrated UV filters for the Detection of the Fast Scintillation Component of BaF2 (John Hennessy)

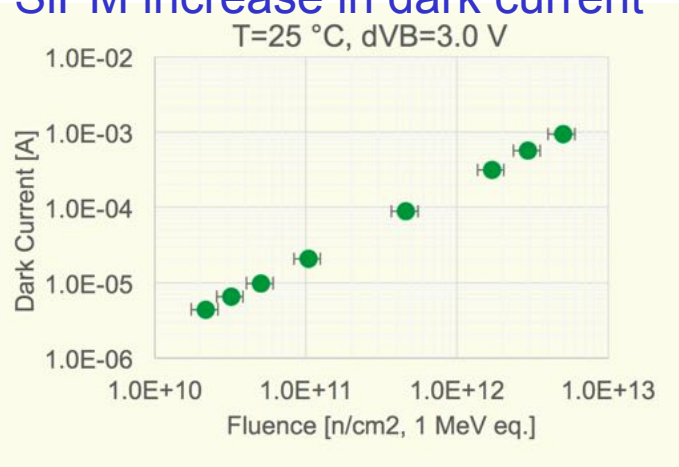
Structure of Parallel Session

- Low background photosensors for NEXO (Ako Jamil)
- Ultra High Density SiPM for Radiation Environments (Randy Ruchti)
- Radiation Damage and Recovery in SiPMs (C. Woody)
- Studies of GaInP based Geigor-mode APD arrays (B. Hirosky)
- Photosensors at HZC (Hongwei Li, Jidong Lyu)

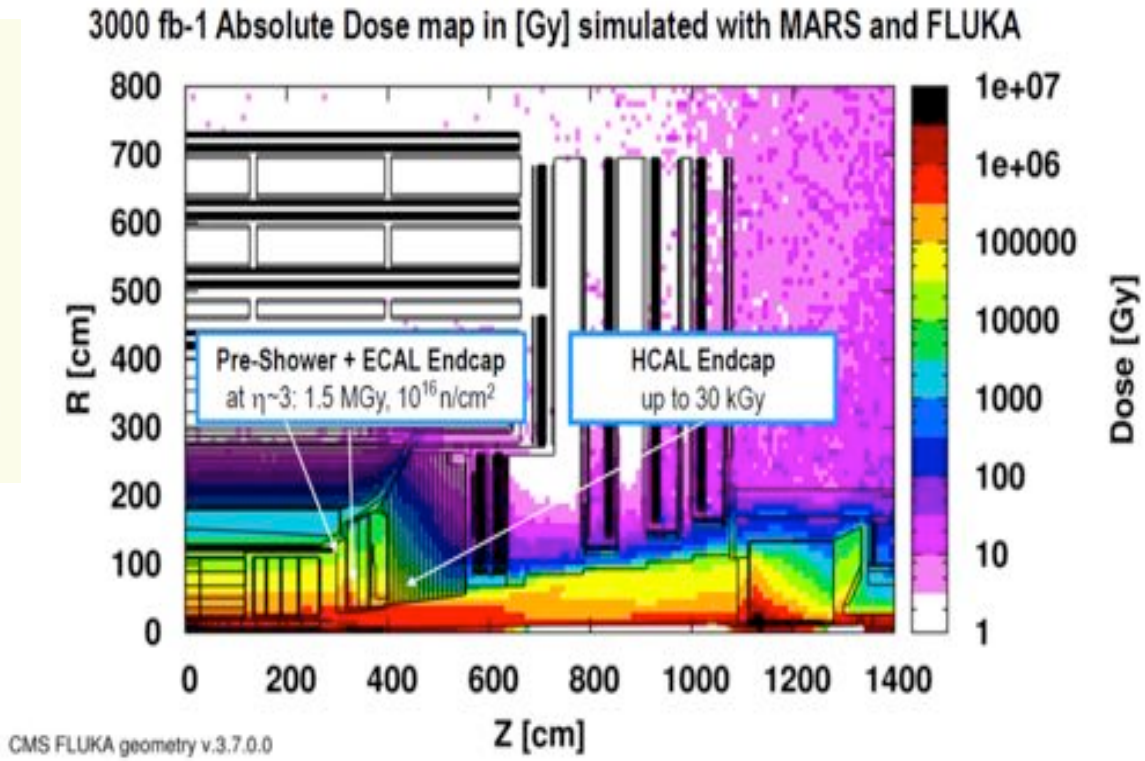
Findings

- Increase in luminosities are a major challenge to the field

SiPM increase in dark current



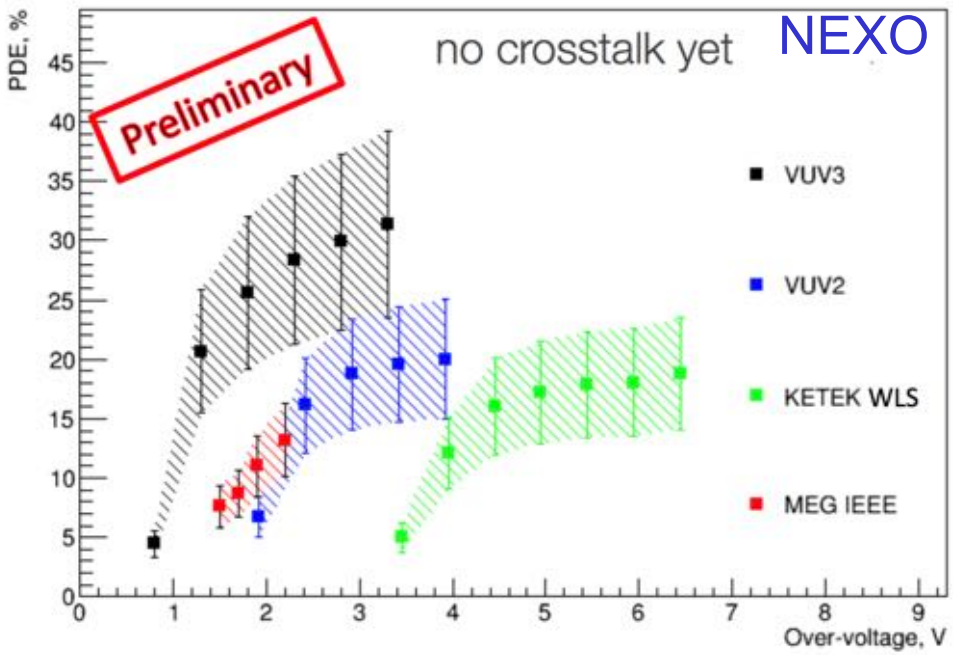
GaInP PM

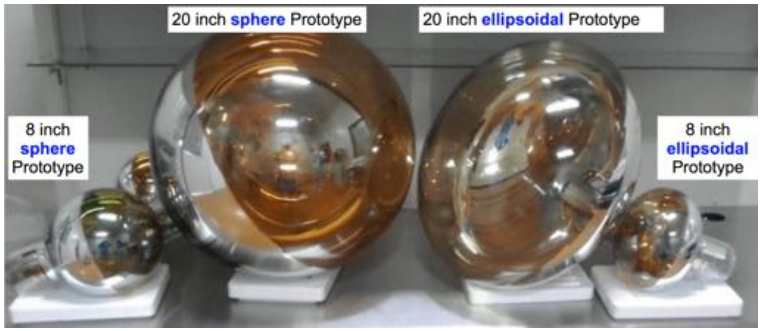


Mitigating factors by making smaller pixels, cooling, exotic semiconductos (GaInP), thermal annealing

Findings

- The community is optimizing photosensors in every direction, depending on need
  - Cost, Size, Spectral Coverage, Speed, Radiopurity, Efficiency

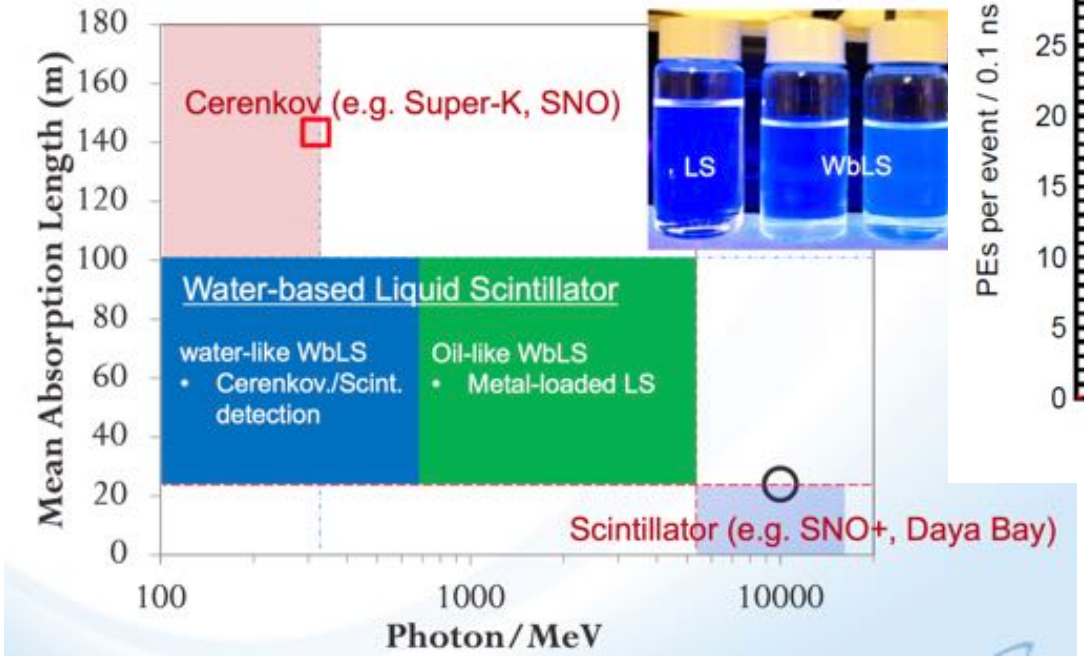


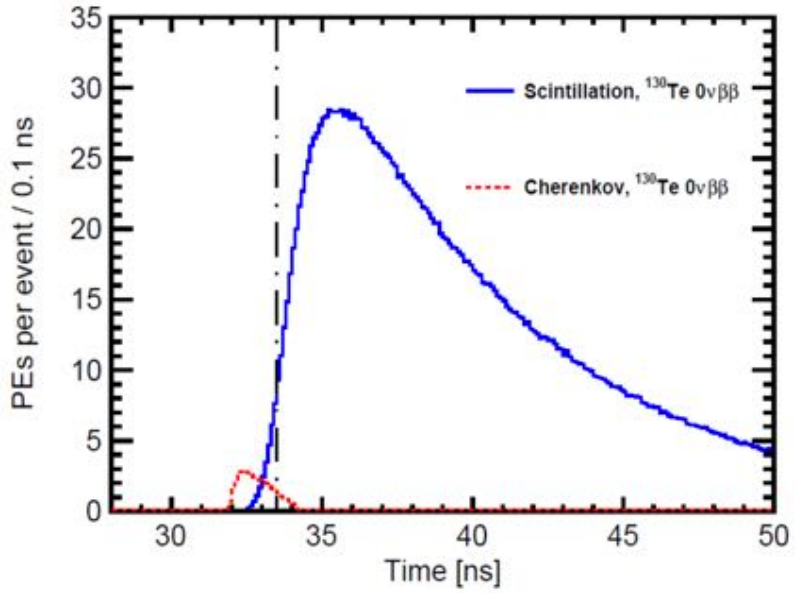


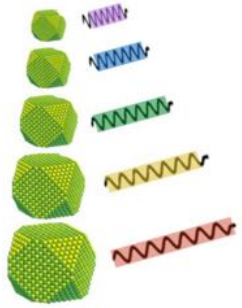
PMT development from IHEP China for JUNO

Findings

- Particular attention to separation of Cerenkov from Scintillation
  - PID of neutrinos







Quantum Dots: wavelength shift Cerenkov above scintillator cutoff

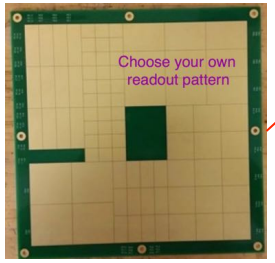
Findings

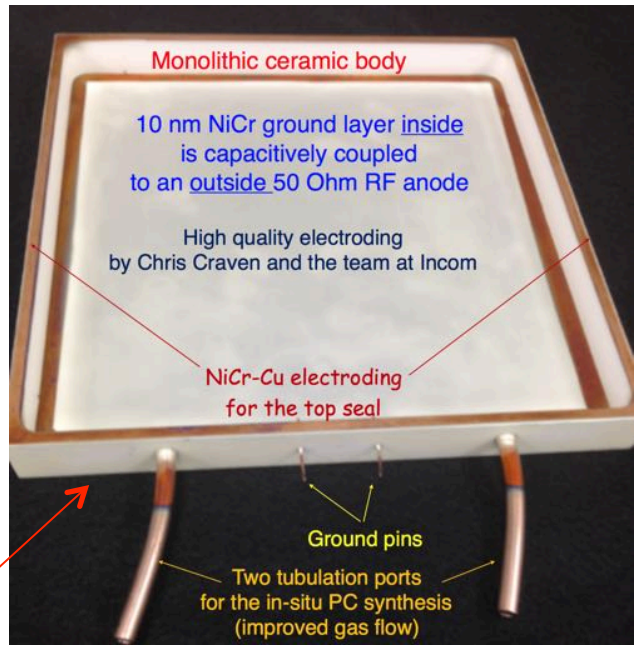
- LAPPD on the cusp of real world usage

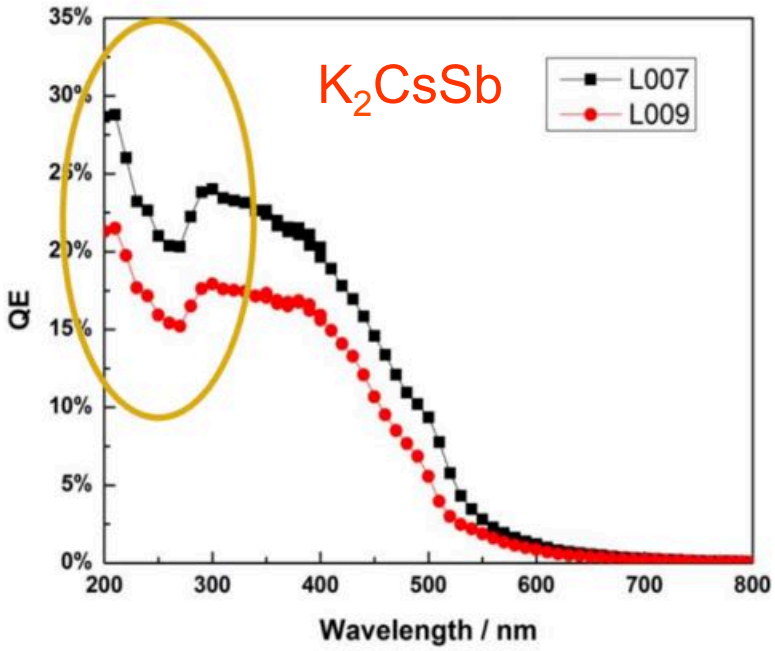
ANNIE, a LAPPD Early Adopter
Will use ANL 6 cm for early 2017 and LAPPD thereafter, with PSEC4 readout
Primary science goal: Measure the abundance of final state neutrons from neutrino interactions in water as a function of energy.
Tag charge-current quasi-elastic like events by the presence of neutrons and additional charged particles.

Findings

- Even the successful Grand Challenges can be improved







U. Chicago LAPPD Gen-II Design
Signals are capacitively coupled to PC signal board on outside

ANL 6cm MCP-PMT
Push to VUV and cryogenic applications

Identification of Risks and Opportunities

- What risks is the field exposed to if certain R&D does not get done
  - Fast timing is not achieved, you lose a lot of capabilities
  - Radiation damage mechanism still not well understood
    - Radiation hardness will prove some limiting factor at the LHC

- What opportunities exist?
  - VUV and DUV photosensors (in cryo)
  - WbLS seems stable, can be purified
  - Fast timing of BaF2 possible
  - 3D digital SiPM

Recommendations

- Wide diversity of applications, with very specific requirements
  - *If you always do what you always did, you will always get what you always got.* -Albert Einstein
  - Continue funding distinct groups, each working on their improvements – balance between grand challenges and project driven improvements
- Better communication and cooperation between different groups working on same projects, between physicists and industry, and between high energy and nuclear

Possible Grand Challenge Ideas

- We probably should keep pushing on the last Grand Challenge (LAPPD)
- Imaging optical Calorimeters
  - PID of neutrinos (neutrino and anti-neutrino) and background suppression (8B) via separation of CKOV and scintillation signals (fast timing and improved scintillators)