Photosensor R&D Priorities and Proposals

R. Wilson (CSU), V. Zutshi (NIU)

Preamble

- The focus is on a defensible resource-loaded R&D plan, consistent with PDS priorities that gets us to a convincing TDR

- Necessarily constricts vision to a degree

- Not discouraging innovative ideas but will need to balance resources and priorities

- Similar considerations imply close two-way coordination of R&D plan with interface WGs (e.g. electronics, collectors)

- The plan also needs to be very cognizant of proto-DUNE and what can and cannot be learned from it

- Preliminary general interest received from Caltech, CSU, Fermilab, Iowa, LSU, NIU, Prague and UniCamp and some "proposals" subsequent to calls from PD leadership

R&D Goals

- Establish cryogenic reliability and performance of candidate SiPMs

- Establish cryogenic reliability and performance of candidate SiPM aggregates

- Operational considerations

Note that we are not asking for very custom performance characteristics. However, in detail SiPMs from vendors differ from each other which may result in different behavior under these extreme conditions.
Proto-DUNE did not and will not address this gap in our understanding to a sufficient degree.

Cryogenic Reliability and Performance

- Includes both mechanical and electrical characteristics

- Easy to state but how do we establish it?

- Need to specify a testing protocol/regime that is adhered to

- Easily identifiable characteristics to be studied:

  ➢ Breakdown and breakdown spread

  ➢ I-V (forward and reverse) characteristics and spread

  ➢ DCR

  ➢ Signal shape and time characteristics

  ➢ Gain and amplitude

  ➢ X-talk (delayed or otherwise)

  ➢ Afterpulsing

  ➢ PDE (??)

Monitored along with mechanical integrity as the devices are thermal cycled

Are there more?

Procurement

- Apart from procedure; an important parameter in these studies is the number of sensors tested

- Looking primarily towards FBK & Hamamatsu currently

- How many of what type and what packaging?

- Centrally procured and then distributed? Apart from cost benefits may naturally enforce coherence and coordination between interface groups.

- Would like to know if you have deep and influential contacts with vendors

SiPM Testing and Evaluation

- CSU

  ➢ functional warm and cold test stands in place

- Iowa

  ➢ past experience with SiPMs; warm test stand largely in place; will need resources for cold test stand setup

- NIU

  ➢ functional warm and cold test stands in place

- Prague

  ➢ setting up lab for SiPM testing with both warm and cold testing functionality

Do we need common readout if there are multiple testing sites?

Long-term Behavior

- An essential part of our "certification" process. Optimally done with sensors on the proposed readout board

- Caltech

  ➢ test stand with this in mind exists; dc current monitoring

  ➢ is that adequate? Pulse measurements?

- Iowa

  ➢ expression of interest in long term monitoring and aging (?) studies

Mechanical Integrity

- Not just related to the actual device

- Understanding differential CTE stresses for the SiPM-cold electronics board assembly

- Benchmark simulation with measurements on current cold board to help validate DUNE designs

- Supplements and broadens long-term behavior studies

- NIU:

  ➢ In collaboration with ME faculty with stress and thermal analysis experience

Ganging

- Design largely in Electronics group (any EE resources in the Photosensor group that could assist?)

- In detail things will depend on the exact device but quite likely that devices in the 1 nf range and current level electronics noise* 12 is the limit for ganging 12 in parallel passively

- Brings other ganging schemes (active & passive) into the picture if more ganging is needed (is it? ARRAPUCA?)

- Would like to coordinate closely with them (e.g. sensor choice and its impact) on the design and participate actively in the testing of the ganged sensors

- Would require prototyping of a certain number of boards (justifiable?)

Operational considerations

- Sensor calibration

- Sensor monitoring

- Needed for TDR but is most probably a FY19 item

- What can we learn from proto-DUNE? Do we need special run types?

- LSU:

  ➢ Expression of interest in thinking about calibration and monitoring