

# Photon Detector Project Status and Plans

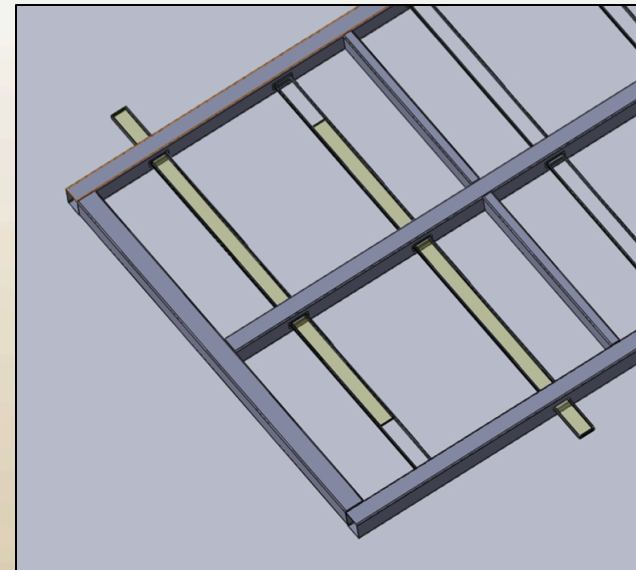
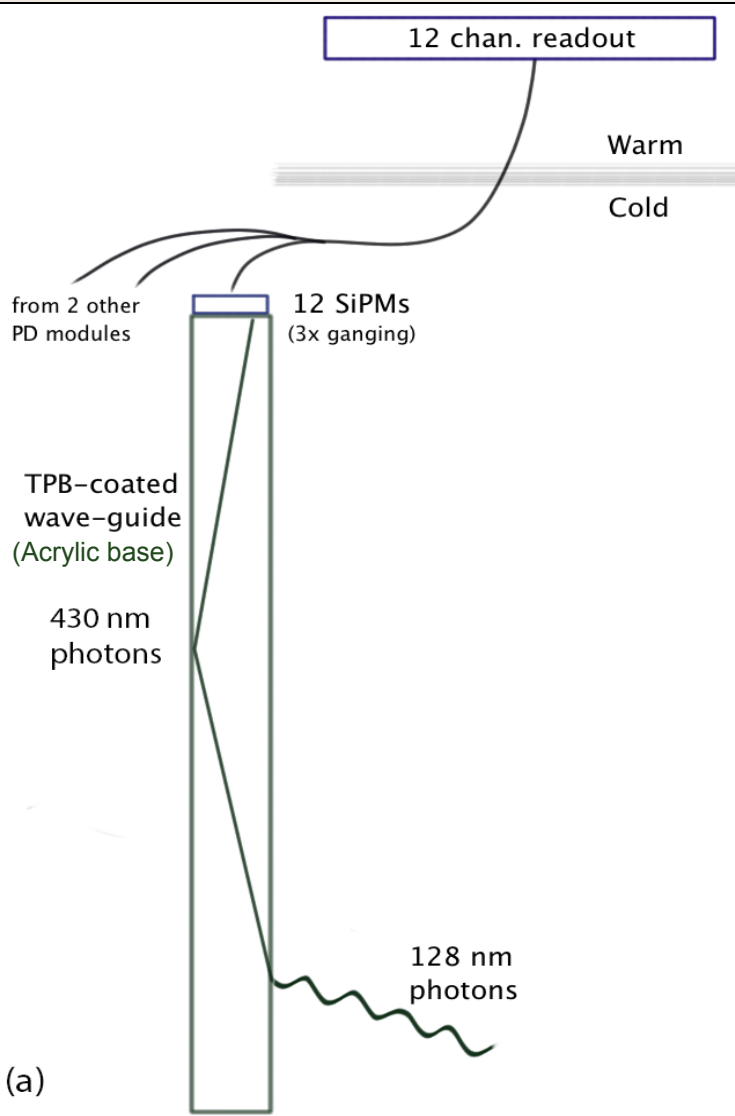
Norm Buchanan

Photon Detector Working group Meeting  
September 24, 2015



Colorado  
State  
University

# Reference Design

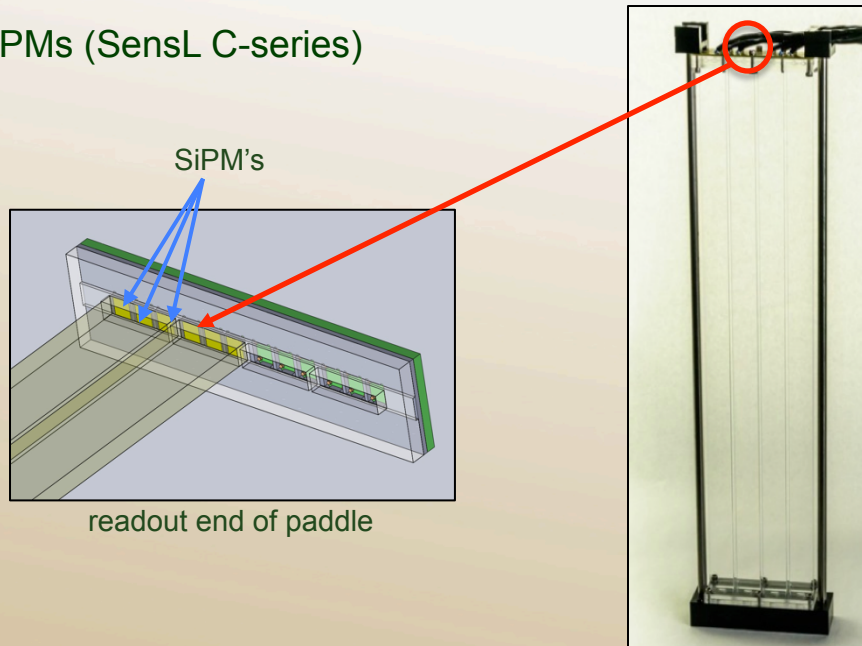


## Reference Design

- 10 PDs (2 m × 6 mm × 83 mm) per APA frame
- 12 SiPMs per PD
- 3 SiPMs per readout channel

# Reference Design

All designs use SiPMs (SensL C-series)



Prototype shown is 20" version mounted in frame for 35t phase 2 test.

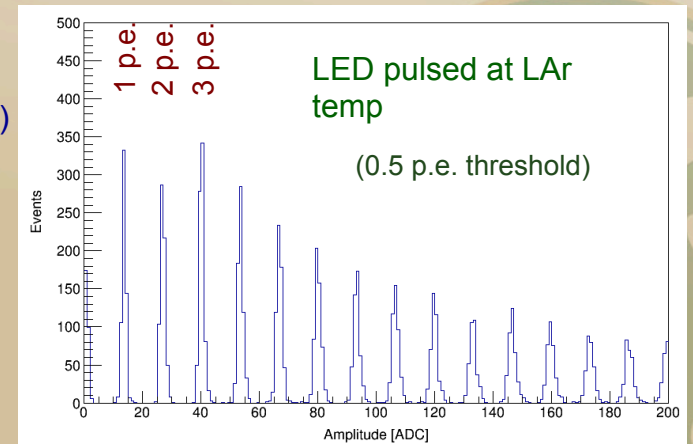
SiPM's

readout end of paddle

## SensL MicroFC-60035-SMT SiPM

- 6 mm x 6 mm active sensor (~19000 microcells)
- 24.5 V breakdown voltage ( $V_{br}$ )
- peak wavelength 420 nm
- Det. Eff. 41% @  $V_{br} + 2.5$  V
- Gain  $3E6$  @  $V_{br} + 2.5$  V

(data at room temp)



# Alternate Designs

## Fiber Bundle with TPB-coated radiator (CSU)

- 2 rows of Y11 fibers coupled to 6 SiPMs
- Thin plastic radiator coated with TPB mounted above fibers

## TPB-coated plate embedded with Y11 fibers(LSU)

- 2 rows of Y11 fibers coupled to 6 SiPMs
- Thin plastic radiator coated with TPB mounted above fibers

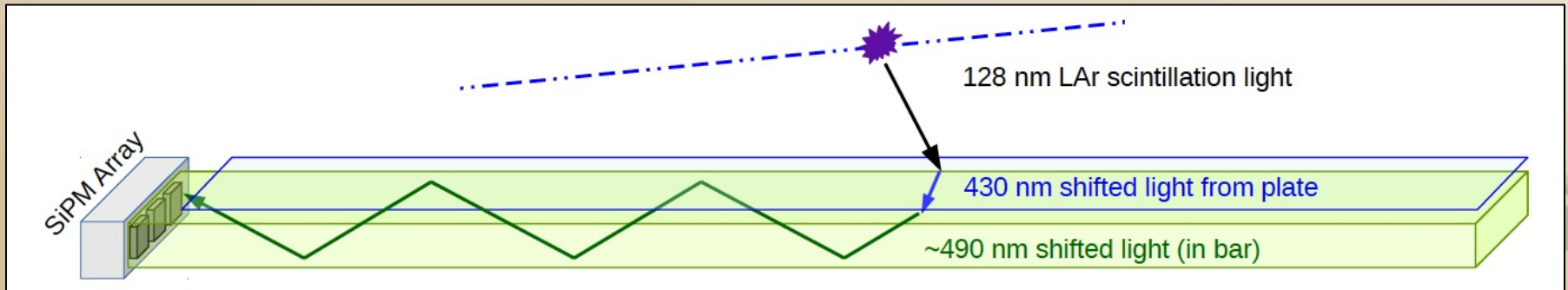


Reference Design

# Radiator + WLS Bar (IU)

Alternate design that meets DUNE PD requirements – WLS polystyrene bar utilizing a thin TPB-treated radiator (developed by Indiana University)

Design separates the UVU → UV conversion from light-guide transmission to SiPM processes.



Design is not significant mechanical change from reference design but results in significant performance gain.

## Narrowing of design scope (project)

- A Talbo test was carried out at FNAL this summer to compare the performance (relative light collection – yield)
- The IU alternate design outperformed the CSU and LSU designs by about a factor of 4. (Details can be found in DUNE DocDB 138)
- In order to move forward with design optimization and component qualification the project will focus on the IU alternative design.
- Other designs can be explored off-project (MIT has a very promising design based on a unique dipping/annealing approach for example).
- Another constraint on the overall design is the interface with the APA. The APA design will be locked down at the end of CY 2015.

12 work packages to cover work required to get through design, qualification, and optimization for proto-DUNE test

## 1. PD Module Design and Integration

This work package covers design and mechanical testing of Photon Detector (PD) module assemblies, including mechanical design, integration into frame, prototype development and testing, and planning for quality assurance testing.

Needed to ensure PD design progresses and all integration issues are addressed.

CSU

## 2. Light Guide Optimization

This work package covers design, testing, and investigation of light guides for PD modules

Needed to ensure PD design is optimized to reach requirements defined by physics.

IU

## 3. Wavelength Shifting (WLS) Radiator Plates Optimization

This work package covers design, testing, and investigation of radiators for PD modules

Needed to ensure PD design is optimized to reach requirements defined by physics – assumes selected design for PD technology utilizes WLS radiators .

IU

## 4. SiPM Readout Circuit Board Qualification

This work package covers electro-mechanical testing of SiPMs and SiPM mount PCBs to demonstrate reliability.

Needed to as part of SiPM qualification. Must demonstrate devices can be mounted to readout boards and thermally cycled.

CSU

## 5. Readout Electronics (SSP) Operational Support

This work package covers support of existing SSP modules in use for PD development.

Needed to ensure SSP hardware supported through development and 35t test.

ANL

## 6. Cable/Connectors Qualification

This work package covers the selection and qualification of readout cable for the photon detection system. The current PD reference design calls for shielded twisted pair w/ 4 twisted conductor pairs per jacketed cable, but the performance of this cable has yet to be shown to meet PD performance requirements.

Needed as currently utilized cables aren't optimal in terms of cost and mechanical handling needs

ANL



## 7. Light Guide and Wavelength Shifting Radiator Cryogenic Qualification

This work package covers planning and preparation for long-term reliability testing for wavelength shifting (WLS) radiators and light guides for PDs in LAr environments.

Needed to as part of light guide/radiator materials qualification.

Not yet covered

## 8. Long-Term SiPM Cryogenic Qualification

This work package covers testing of candidate SiPMs to determine the expected long-term performance of the devices in a LAr environment.

Needed to as part of SiPM qualification.

Not yet covered

## 9. Passive SiPM Ganging Verification

This work package covers testing sensL SiPMs read out by a single electronics channel in groups of 3 and 6 SiPMs to demonstrate acceptable performance .

Needed to as part of system value engineering. Assumed as part of costed design.

Not yet covered



## 10. Active SiPM Ganging Verification

This work package covers testing sensL SiPMs ganged in groups of 3 and 6 SiPMs with active cryogenic electronic circuitry to demonstrate acceptable performance

Needed to as part of system value engineering. May allow further reduction in needed readout electronics.

Not yet covered

## 11. Readout Electronics design optimization

This work package covers optimization of SiPM readout electronics for performance and cost effectiveness. This includes refining of performance requirements and evaluation of modifications to existing custom electronics as well as examination of possible commercially available options.

Needed to as part of system value engineering.

Not yet covered

## 12. CERN Test PD Design, Engineering and Integration

Scheduling constraints will require completing a design and mechanical prototype of PD modules for the CERN test before we have completed the far detector design development. This work package covers the extra design, engineering, and integration with TPC and CERN test installation groups required to meet this schedule.

Needed to as part of preparation for prototDUNE test.

Not yet covered

