

The SPVD PhDet Design and R&D

Options and Perspectives

Flavio -

Conceptual design for a **PD System** for the **VD LAr Volume**

- *PDS cannot be located at the Anode Plane (as in the DUNE SP Module#1)*
- With a solution for operating a PD on HV surfaces:

PD Active Optical Coverage can be distributed onto **5 sides of the LAr Volume** (Cathode side and 4 Field Cage sides)

+

PD Passive Optical Coverage (reflector) on the Anode side (laminated on perforated PCB)

+

Xe doping (minimize Rayleigh scatter for light at far distance)

*This would allow **$\sim 4\pi$ coverage**:*

*⇒ good uniformity of response, low detection&trigger threshold, energy resolution
and position resolution capability*

- *It would be a second detector - for Ar Scintillation Light Signals - complementary to LArTPC for LowEn UG Physics*
- *Guarantee **highest Live Time** → 100 % (PD active also when LArTPC may be OFF for purity drop/maintenance, HV issues/maintenance,..) particularly relevant for UG Physics*

Operating PD on HV surface requires

electrically floating Photo-sensors and r/o Electronics

⇒ **Power (IN) and Signal (OUT) transmitted via non-conductive cables**

none of the commercially available technologies is rated to operate in

Cold (at LAr Temperature)

⇒ **A highly specialized R&D has been launched (Feb.'21) and is currently**

ongoing

to validate existing technology in Cold

or develop Cold custom technology for this application

Other boundary conditions for VD PD on HV surface

⇒ **Power budget and limitation for power dissipation in LAr**

⇒ **Cost envelop for VD PD and plan for the US that puts a substantial part of the “cathode” mounting scheme in DUNE-US as the baseline plan**

⇒ **Creation of a new PD community from US, EU and International, within the existing DUNE PD Consortium, w/out subtracting resources to the realization of the HD PhDet (but retaining competence and expertise on xARAPUCA detector and r/o electronics)**

Status & progress of VD PD R&D

⇒ Aggressive R&D funded (mainly by DoE DUNE project + contributions from Eu/Intl.) in Jan. and started in Feb.

'21 - PoF R&D at FNAL&CERN already advanced since summer '20.

⇒ **Main R&D Goals (FY 2021) and Progress from ~2 months Activity :**

- Demonstration of **PoF technology** in Cold for Opt Pwr. Transport via Fibre and Opto-Electrical Conversion Efficiency ⇒ NEARLY ACHIEVED [22-30% effic., fiber glow, regulators]
- Demonstration of **Analog OR Digital Signal Transmission** (OptoLink) in Cold. ⇒ ANALOG OptoLink: solution ~available/very encouraging indications, DIGITAL OptoLink: positive progress (big effort on the way)
- Demonstration of **Cold Electronics** (specially for Digital Signal Transmission) in Cold ⇒ ADC & FPGA candidates ~available/very encouraging indications
- **Power Budget** for Analog OR Digital Signal CE+Transmission ⇒ well within Budget for ANALOG CE/Transmission, within but closer to Pwr.Budget limit for DIGITAL CE/Transmission
- **Realization of 2 Prototypes** (Detector+CE/Transmission) for “Cathode” mounting for ColdBox test at CERN (Fall 2021) ⇒ Large Size xARAPUCA Tiles (with optimized SiPM optical coupling and enhanced WLS plate)

Perspectives for VD PhDet (#1)

- ⇒ **Reliable Simulations fully developed** (stand-alone G4 and LArSOFT official) - LY Maps (and also Trigger efficiency, Energy and Position resolutions). Cross checks with other simulations in progress.
- ⇒ **xARAPUCA tile** (improved effic. for Ar+Xe light detection, > 3%) and **ANALOG CE/Transmission prototype#1 look achievable** in time for ColdBox test (Fall 2021)
- ⇒ **xARAPUCA tile and DIGITAL CE/Transmission prototype#2** may require few (eg. 3) more months.
- ⇒ **Level-2 Project Management:** detailed plan (Milestones, Schedule and Cost) in place
- ⇒ **\$Budget and Pwr.Budget Calculator** ready for immediate estimates of different options (from R&D inputs)
- ⇒ A very strong **new group** with highly specialized competence in CE and Signal Transmission is formed and complemented with existing highly specialized resources from PD Consortium. New groups are showing interest to join the VD PD effort.

Perspectives for VD PhDet (#2)

⇒ Ordered Options for VD PDS:

- **Cathode Mounted PDS** (320 xARAPUCA Tiles + ANALOG CE/Transmission) within Cost and Power Budget Limits, matching LY & Timing “Minimal” Requirements (t0 information for TPC) from SP-HD demonstrated by Simulations. Lowest Risk from R&D uncertainty. [option with DIGITAL CE/Transmission still fully open]
- **Cathode + FieldCage Mounted ($\sim 4\pi$ Option) [w/ reduced Opt Coverage, near Anode Planes]:** matching much more ambitious Physics Requirements (dedicated detector for DUNE Low Energy extended Physics). Power Budget within Limits, Cost affordable if/with additional Resources become available from International
- **Cryostat membrane Mounted:** No/very Low risks from PD R&D, within Power Budget, Higher cost (near or exceeding current availability), from current simulation it seems not matching LY “Minimal” Requirements (t0 information for TPC) from SP-HD. Risks from FC modification (70% Transparency) on EF Distortion in TPC active Volume and for HV instabilities to be determined.

Perspectives for VD PhDet (#3)

⇒ Material presented at this Discussion/Review:

- PD Requirements (and goals) for HD PD. Extension to VD PD. Ettore S.
- The VD PD Design (and options) and R&D. Flavio C.
- Simulations for VD PD. Laura P./Franciole M.
- Electronics, Transmission and Power
 - VD PD with Analog Transmission. Sabrina S./ Jaime D.*
 - PoF for Analog CE+Transmission Board. Bill P.*
 - VD PD with Digital Transmission + ADC and FPGA. Alan P. + Dave C. + Gustavo C*
 - PoF for Digital CE+Transmission Board. Bill P.*
- xARAPUCA Detector and Prototype for R&D. Dave W.
 - (if time allows for) SiPM ganging board. Dante T.*
- VD PD and R&D: Organization, Milestones and Costs estimates and R&D Schedule. Ryan R

⇒ **All this has been generated by an incredible effort made over the w.e.**, after the layout of the Discussion/Review has been agreed (Fri morning). (Apologies if you find not fully polished slides)