Perspective and opportunities

DUNE FD-2 (VD) Photon Detector Workshop

July 27 2021

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A bit of history

- Since its inception, DUNE has been conceived as a staged programme with a day-1 detector suite made of **two modules**
- The «**vertical drift**» (VD) option is based on
  - ✓ The achievements of the horizontal drift (HD) design (X-Arapuca, cold electronics, SiPMs, etc.)
  - ✓ The achivements of ProtoDUNE-DP (6 m drift length, charge readout without wires, light yield and attenuation in ProdoDUNE-DP)
- The Vertical Drift option, however, poses unique challenges to the Photon Detection System, which are being addressed by a dedicated (and very successful!) R&D

The VD is now FD-2

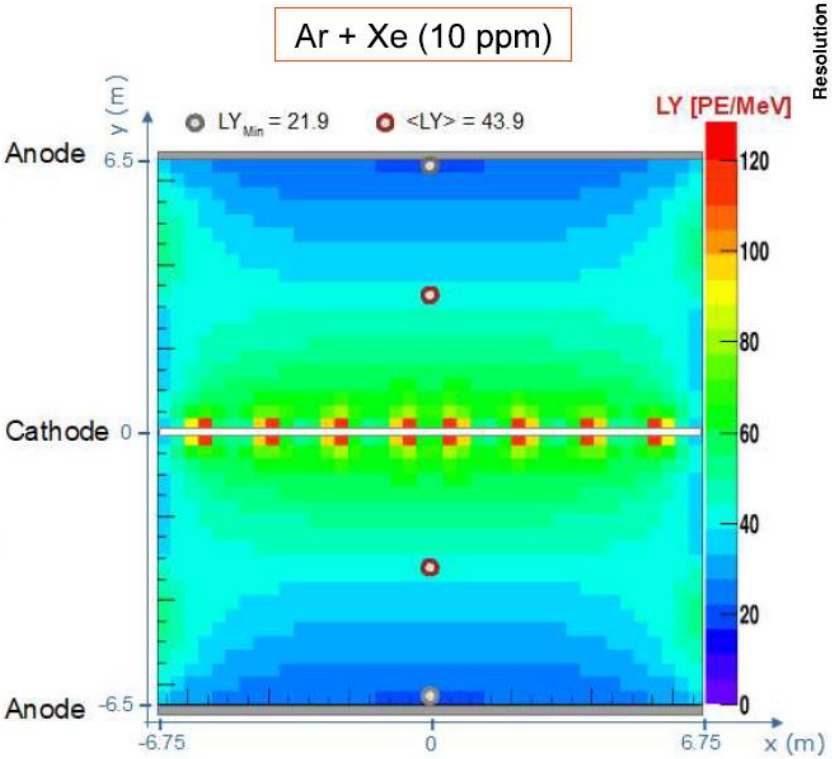
- This activity has been boosted by the decision of employing the VD design as the **reference design for FD-2**
- This workshop marks the start of a new phase in the PDS VD design:
  - ✓ Demonstrate readiness for construction in a timescale consistent with FD-2
  - ✓ Address the most important challenges not validated yet
  - ✓ Perform a test campaign comparable with the one of FD-1 HD.
- The **PDS Consortium** offers the ideal environment because many items have already been addressed for FD-1 and all groups have expertise in light detection in liquid argon.

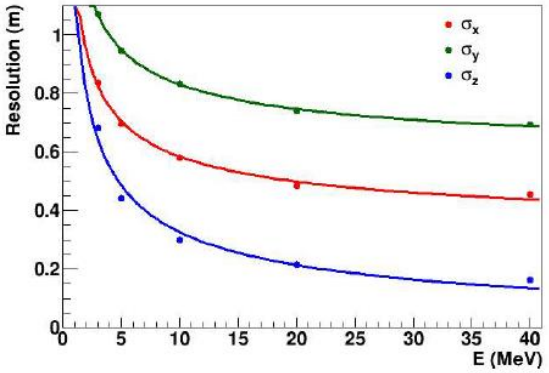
The impressive achievements of the VD R&D

- 25000 photons per MeV of energy deposited
  - 75% for Xe
  - 25% for Ar
- 3% detection efficiency

LY_{min} = 21.9 PE/MeV

<LY> = 43.9 PE/MeV

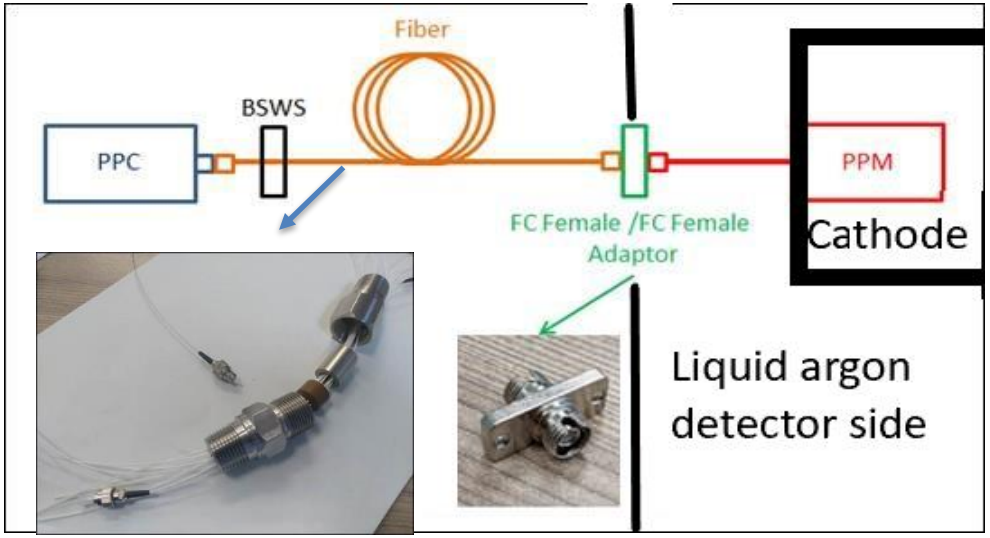




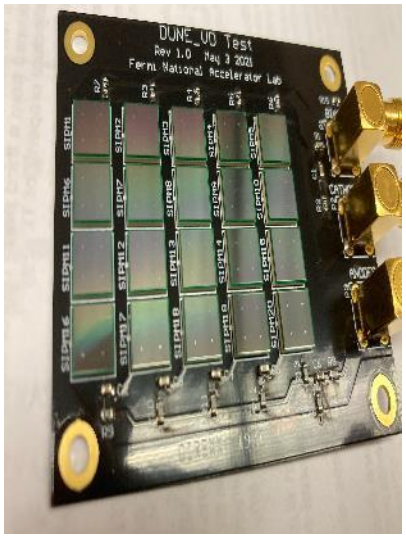
L.Paolucci @ this workshop

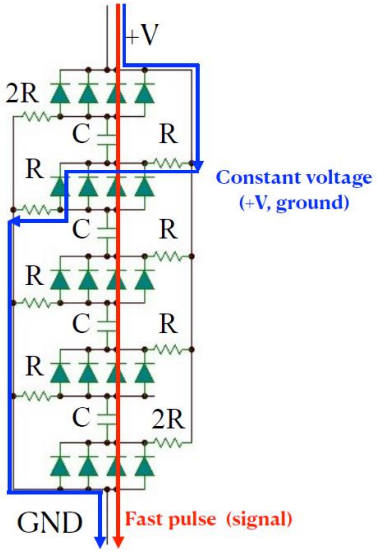
The impressive achievements of the VD R&D

First implementation of a PoF system for particle physics at cryogenic temperature!



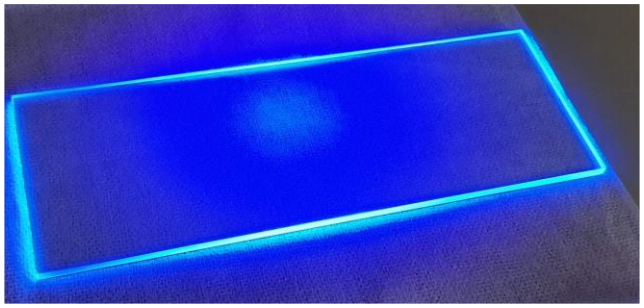
W.Pellico @ this workshop

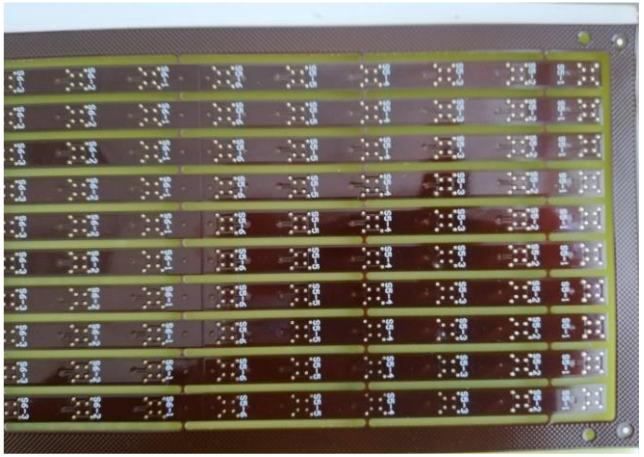




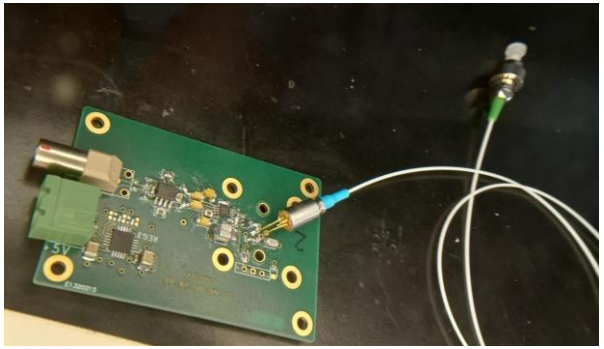
D.Totani @ this workshop

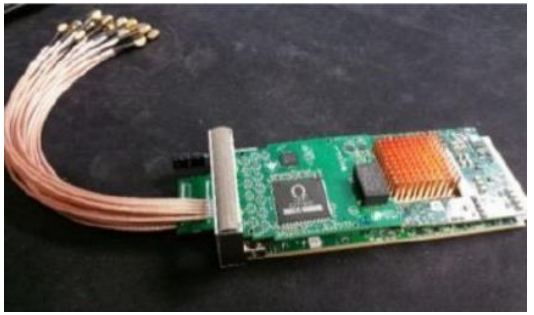
The impressive achievements of the VD R&D





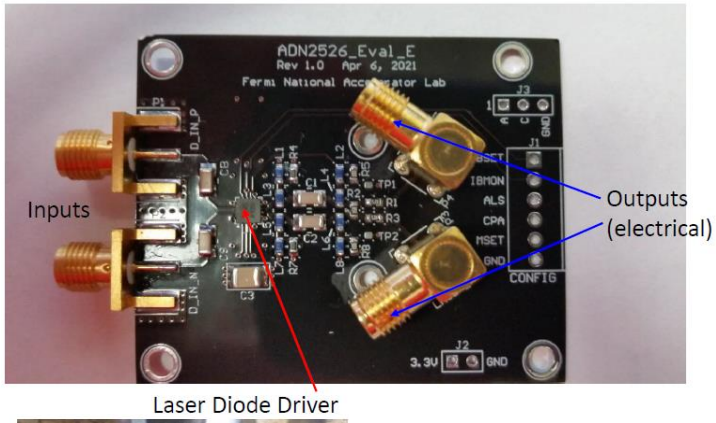
C. Cattadori @ this workshop



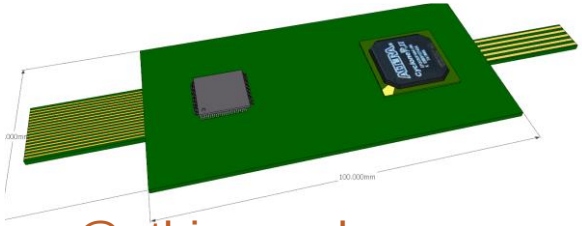


S. Sacerdoti @ this workshop

The impressive achievements of the VD R&D



A. Prosser @ this worskop



P. Rubinov @ this worskop

D. Cussans @ this worskop

Perspectives

Having the VD «ready to go» is still ahead of us and the forthcoming years offer many opportunities to groups inside and outside DUNE

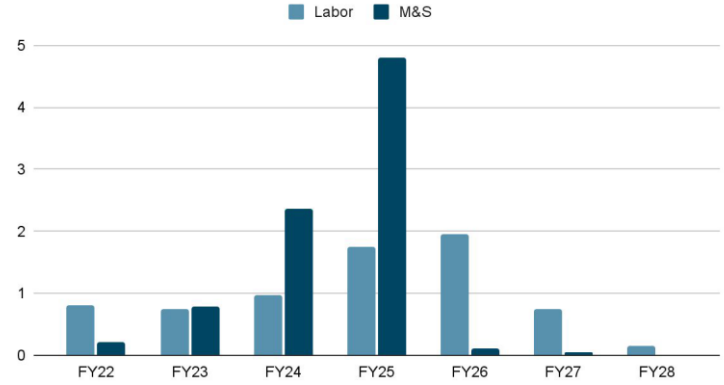
Item	Status	Challenges
WLS and dichroic filters	Search for new solutions and optimization ongoing	Optimziation for the Xe-doping!
SiPM and ganging/cold electronis	Search for new solutions (e.g. MEG-2 like) and optimization ongoing	Power consumption, cryo-reliability, optimal granularity, SiPM-fiber connection are still open issues
Mechanics	Mostly focused on cathode tiles	Membrane tiles. Field-cage tiles?

Perspectives

Item	Status	Challenges
PoF	Major results obtained on cryoreliability and SiPM powering	A lot of work ahead of us to pin down the optimal solution for VD (conversion efficiency, choice of the laser diode, aging and uniformity, light leaks…)
Optolink	Analog and digital solutions under development	Power consumption, cryo-reliability, uniformity among channels still to be assessed
Digitizer	Warm electronics inspired by DAPHNE, cold digital electronics under development	Analog (warm) versus digital (cold) solution. Impact on optolink. Re-consideration of the DAPHNE parameters

Have we the know-how and resources to address these challenges?

Judging from what has been presented during this workshop, I would say «yes, we have»:



R. Riveira @ this worskop

- The VD R&D groups are strong and already well ingrained into the Consortium
- The PDS Consortium offers the resource and environment to address R&D, validation and mass production issues
- Strong involvement of European groups (see I. Gil-Botella's talk)
- Strong involvement of US and LA groups with several new DUNE institutions interested in VD
- The physics and technology challenges of VD are interesting even outside the DUNE collaboration and can be pursued in synergy with them

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The next steps

- The **cold box and Module-0** tests are the most straightforward way to give major contributions to FD-2 VD and their outcome will be fundamental to reach and validate the final design
- Very few parts of the detector are already fixed: the **R&D phase** is not over at all and will impact the outcome of the cold-box tests
- The **PDS Consortium** must be enhanced (new working groups, additional institutions, external collaborations) to coordinate the PDS VD efforts
- The completion, publication and review (LBNC, DOE, RRB) of the **VD CDR** marks the start of this new phase and your comments, suggestions and contributions are very welcome!