Second Project Review meeting

Thursday 20 June 2024
CERN

WP 9

Cryogenic Neutrino Detectors

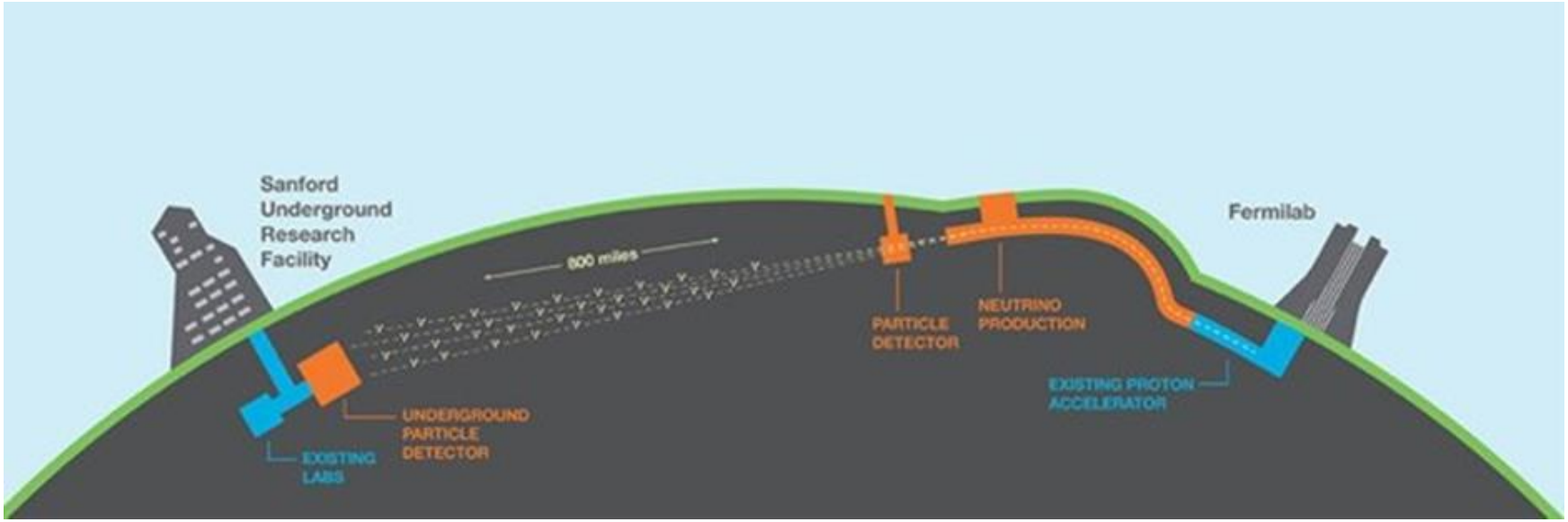
Dario Autiero and Andrzej M. Szelc

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101004761.

Objectives

WP9: Cryogenic neutrino detectors:

- Focus on innovative developments in large cryogenic detector readout:
  - Charge readout with pixels
  - Charge readout with vertical-drift detectors
  - Readout of scintillation light.
- Applications geared towards DUNE and large-scale DM detectors.



Objectives

- Task 9.1: Coordination and Communication (CNRS-IP2I, Edinburgh)

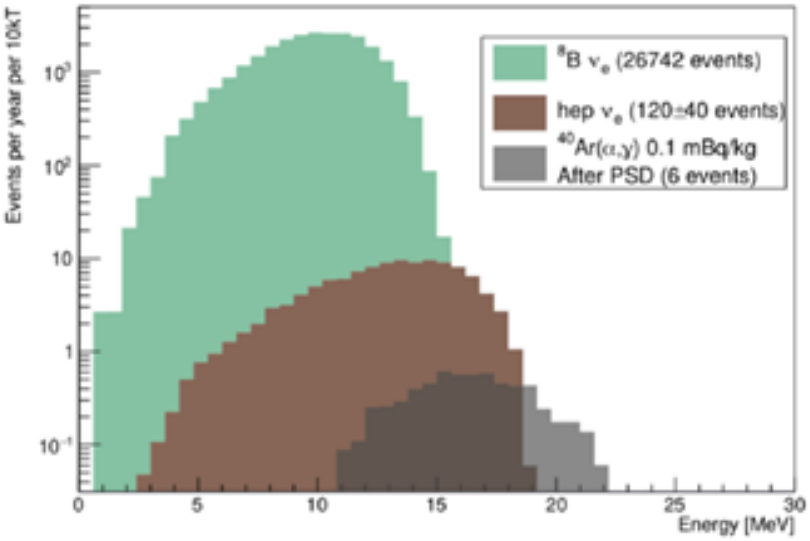
- Task 9.2: Pixel Charge Readout (Manchester, Bern)
  - Optimized pixel tile pattern for the DUNE LAr far detector
  - Design and prototype for large scale tile-based anode plane

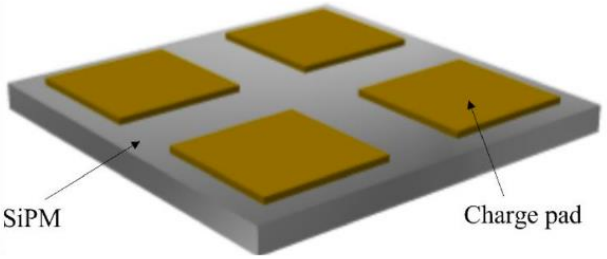
- Task 9.3: Vertical Drift Charge Readout (CNRS-IP2I, CNRS-IJCLab, CNRS-LAPP)
  - Novel Vertical Drift perforated anodes charge readout design evolving from the dual-phase charge readout stack
  - Development and tests of novel design of the Charge Readout Plane (CRP) integration surface of the Vertical Drift perforated anodes
  - Developments and tests of integrated cold electronics, new feedthrough chimneys design
  - Developments in associated digitization hardware and online data treatment

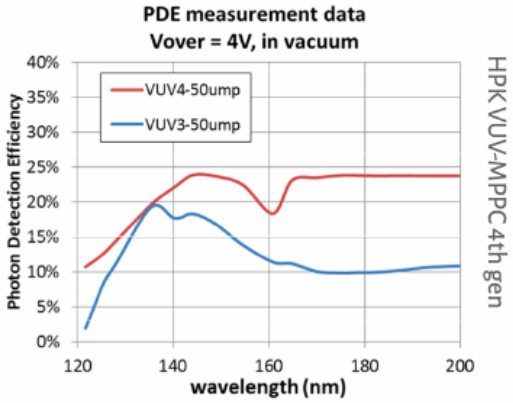
- Task 9.4: Light Readout (CIEMAT, INFN-MIB, Edinburgh)
  - Characterization of new photon detection methods, calibration devices and readout electronics
  - Implementation and characterization of a more efficient light collection system in NP02/ProtoDUNE phase II (Xe doping and Wave-Length Shifting (WLS) combined with reflective foils)
  - Dissemination of R&D results and NP02/ProtoDUNE II light-collection performance (web site)

Results/highlights
Pixels charge readout [T:9.2] (UNIMAN, UBERN)

- Pixels as an idea to replace wires
- Simultaneous charge and light readout with special Pixel-SiPM pads.
- Enables low-energy neutrino optimized LArTPC – the SoLAr concept
- New generation VUV-sensitive SiPMs.



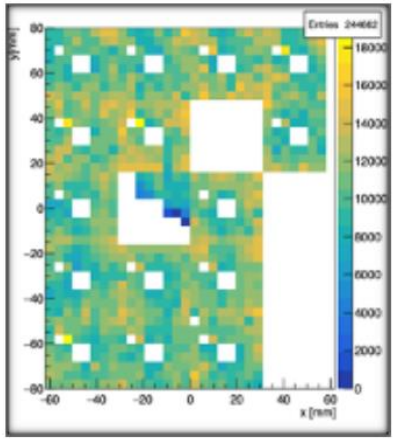




Results/highlights
Pixels charge readout [T:9.2] (UNIMAN, UBERN)

- V2 prototype (July 2023)
- 30x30x30 cm^3 volume
- 20 LArPix chips
- 64 Hamamatsu VUV SiPMS

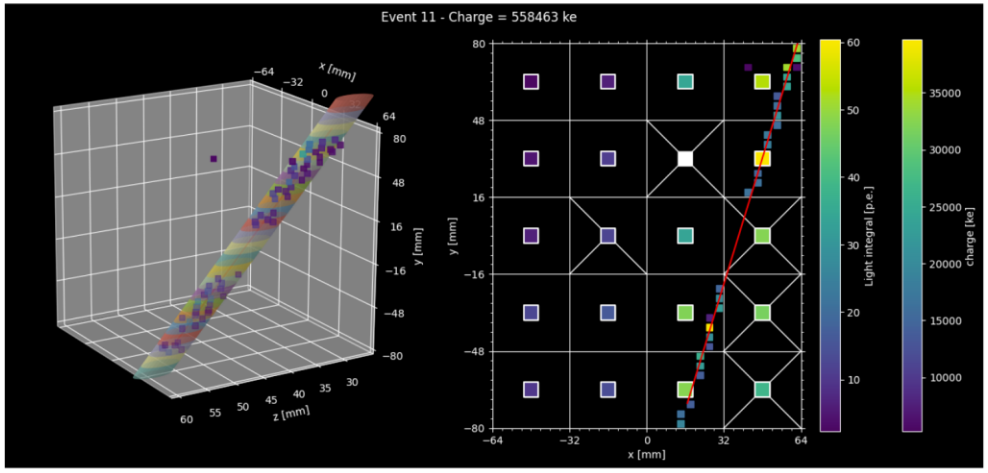
- 10 days of data taking
- Cosmic rays + ^{60}Co



Hit map shows location of disabled pixels

MS36, and D9.1 (M44)

Charge & light event display!



- 10-ton scale prototype proposed for Boulby (proposal submitted in May)

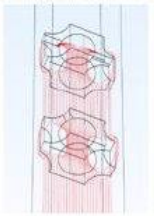
Results/highlights
Vertical Drift [T: 9.3] (CNRS-IP2I, CNRS-IJCLab, LAPP)

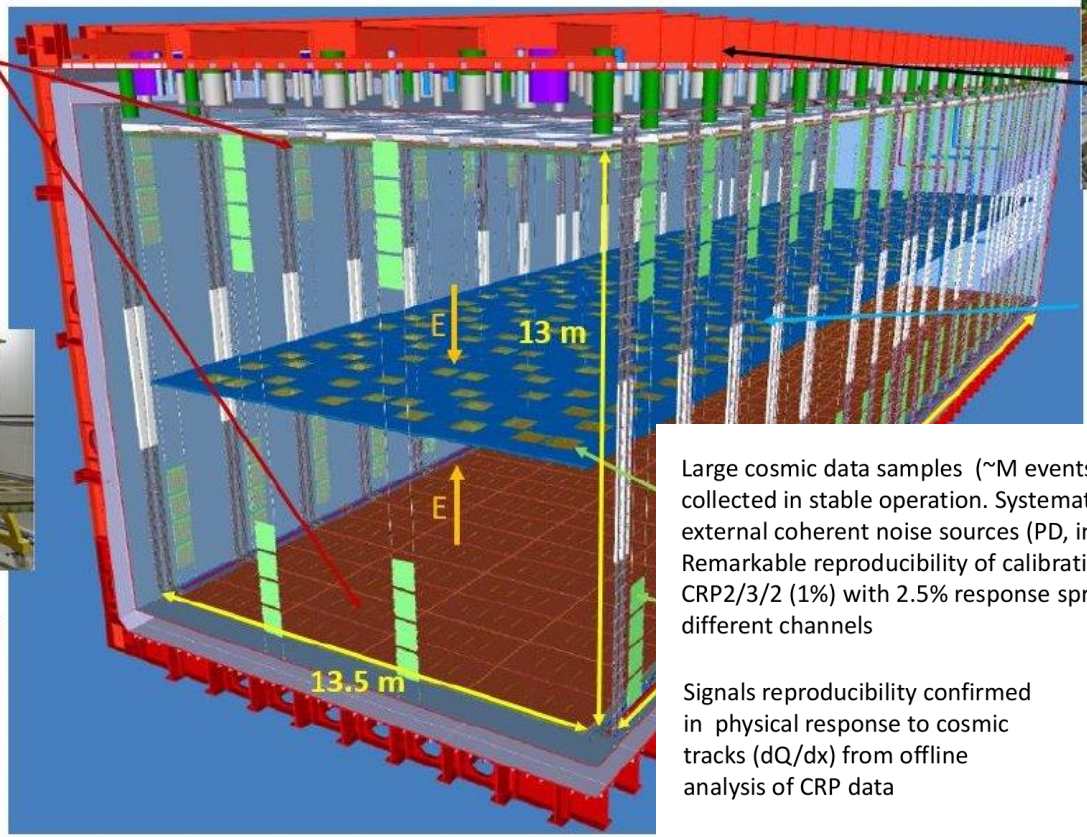
Vertical Drift: novel and optimized LAr TPC technology, anodes based on segmented perforated PCB

Top and bottom anode charge readout surfaces:

Made of 80+80 Charge Readout Plane units
3x3.375 m^2
Each unit: 2 stacked layers of segmented perforated PCBs

Strips 5 mm
Holes 2.4 mm





µTCA charge readout

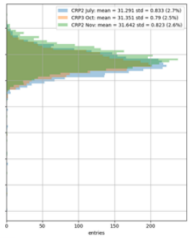
Cathode surface at -300 kV
→ E~500V/cm

1/40

ectors

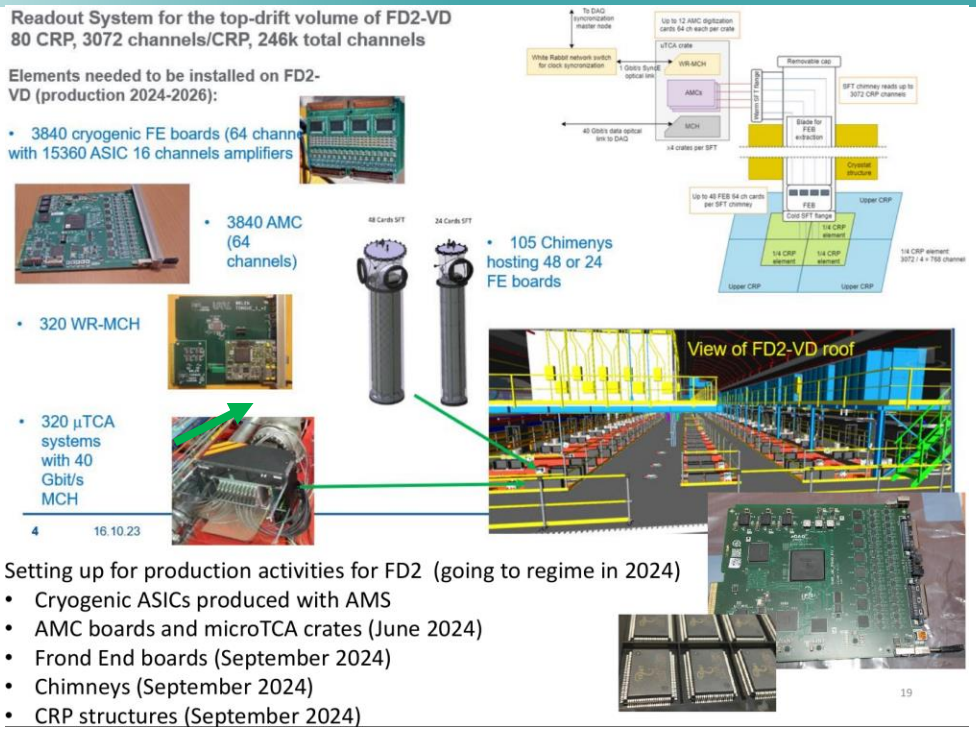
Large cosmic data samples (~M events per test) collected in stable operation. Systematic investigation of external coherent noise sources (PD, instrumentation)
Remarkable reproducibility of calibration data taken for CRP2/3/2 (1%) with 2.5% response spread among different channels

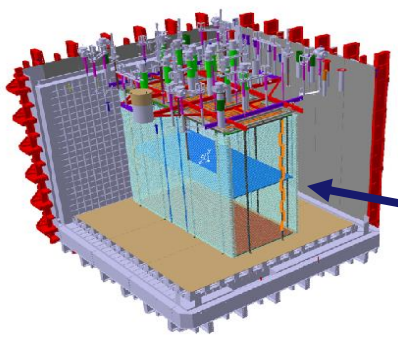
Signals reproducibility confirmed in physical response to cosmic tracks (dQ/dx) from offline analysis of CRP data



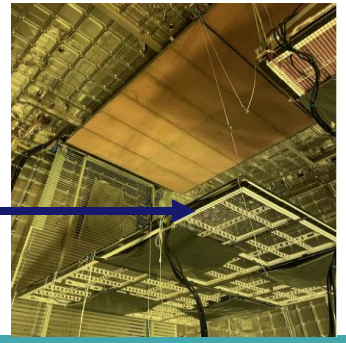
Results/highlights
Vertical Drift [T: 9.3]
(CNRS-IP2I, CNRS-IJCLab, LAPP)

- VD has transitioned into production phase for the DUNE FD
- Module-0/ProtoDUNE Vertical Drift: last Vertical Drift integration exercise before 2nd DUNE FD module construction -> completed in June 2023
- Detector will be filled (fall 2024, due lack of LAr) - main applications for reconstruction studies/development of cosmic and charged beam.



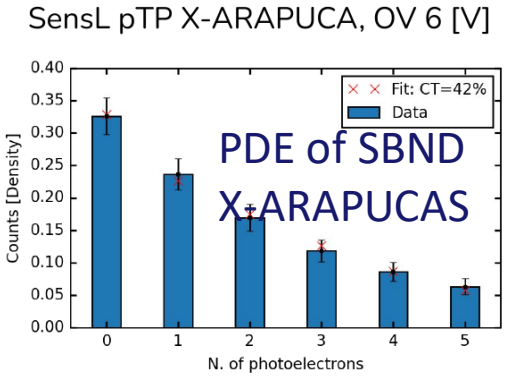


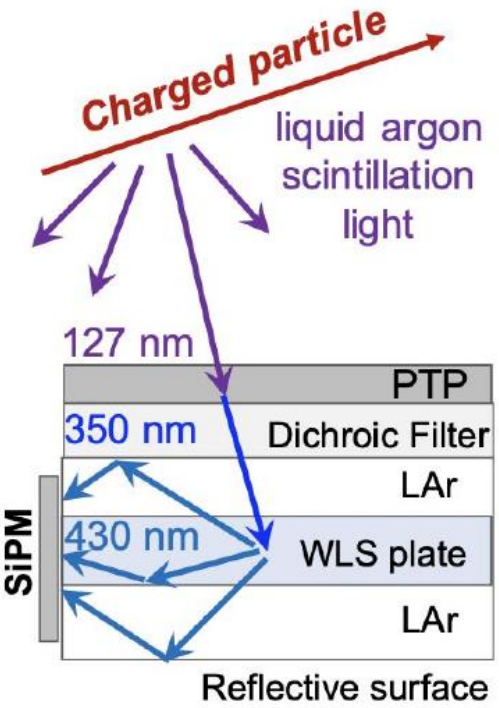
Cathode



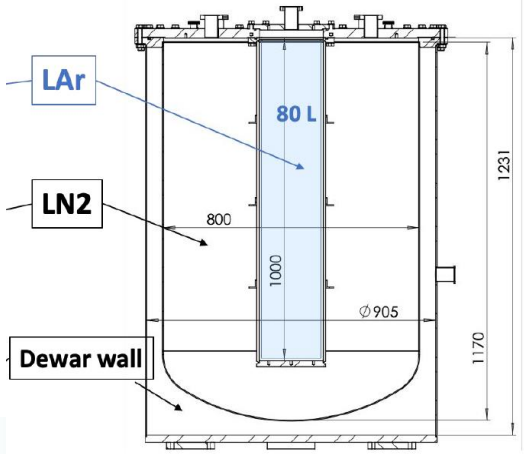
MS37,38 and 39, and D9.2 (M46)

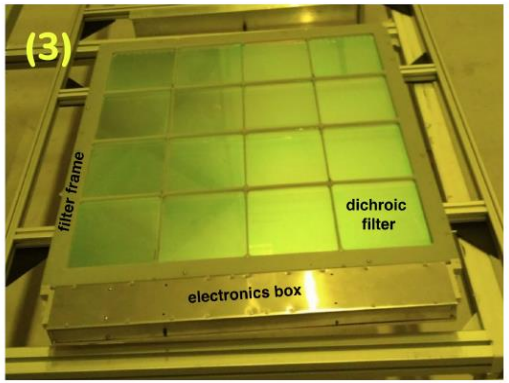
- Extensive tests of X-ARAPUCA devices for several experiments:
  SBND, DUNE-HD, DUNE-VD, ProtoDUNE-VD





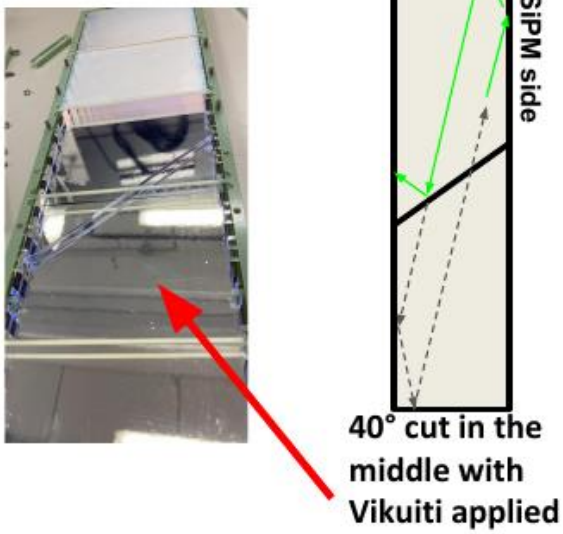
cathode X-ARAPUCA

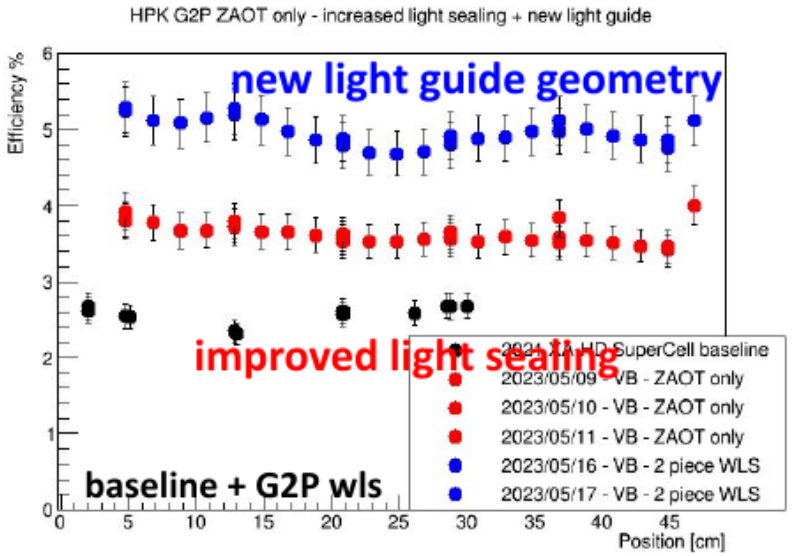




MS40, and D9.3 (M45)

Results/highlights
Light Readout [T:9.4] (CIEMAT, INFN-MIB, UEDIN)q

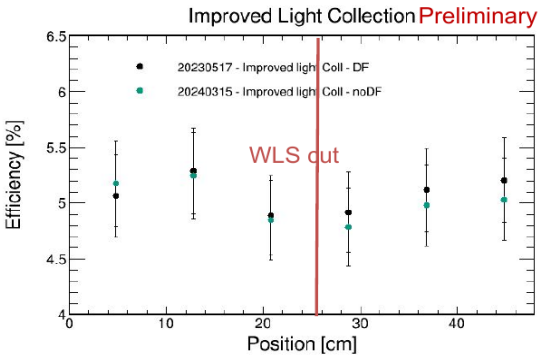




- SBND @ FNAL, getting ready to run. Equipped with 38^2 m of TPB-coated foils.

Detection efficiency doubled!
- > Improved resolution

In New Geometry, removal of dichroic filters does affect efficiency
-> Big reduction in cost and productio complexity.



Deliverables/Milestones

Milestones

MS #	Milestone Name	Lead beneficiary	Due Date (in months)	Means of verification
MS36	Pixel optimisation	40 - UNIMAN	23	Report (Task 9.2)
MS37	Status report on chimneys	8 - CNRS	22	Report (Task 9.3)
MS38	Status report on CRPs	8 - CNRS	23	Report (Task 9.3)
MS39	Status report on digitisation	8 - CNRS	33	Report (Task 9.3)
MS40	Large-scale WLS surfaces and SiPMs Tested	21 - INFN	22	Report (Task 9.4)

Deliverables

D #	Deliverable Name	Lead beneficiary	Type	Due Date (in months)
D9.1	Large-scale Pixel Anode	40 - UNIMAN	Report	44
D9.2	Vertical Drift chimneys, digitisation, CRPs	8 - CNRS	Report	46
D9.3	R&D in LAr optical readout	29 - CIEMAT	Report	45

Good progress on the prototypes – excellent resutls from varios tests. Some switching to production mode.

New collaborations enabled by AIDAInnova

All WP 9 milestones completed.

Deliverables schedule is on track.