M0 and M1 status and plans

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PD consortium meeting - 09/07/2024

Installation of PDS in ProtoDUNE-VD → May 24

- Installation performed during early 2023
- 8 cathode modules
  - SoF/PoF electronics from ‘22
    - Half Si PoF
  - 6 HPK, 2 FBK
  - 6 ZAOT, 2 PE filters
  - 5 WLS with dimples
- 8 membrane modules
  - 1 SoF, 4 HD, 3 VD electronics
  - 6 HPK, 2 FBK
  - 4 ZAOT, 4 PE filters
  - 6 WLS with dimples

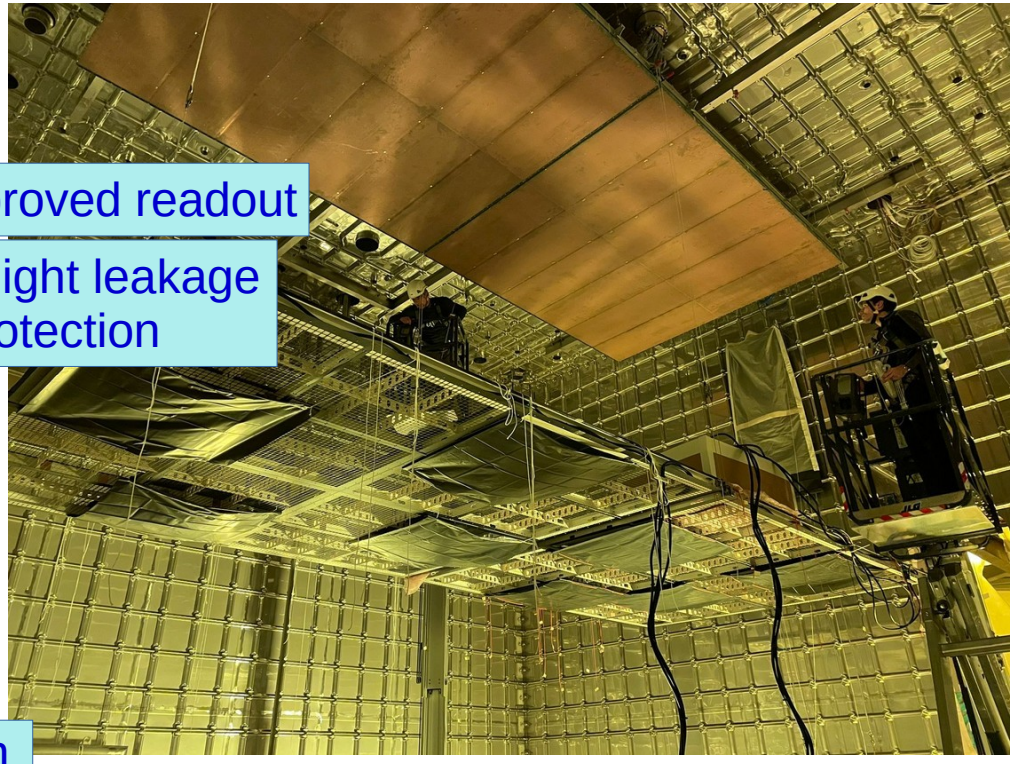
New improved readout

Improved GaAs

+ light leakage protection

New WLS format

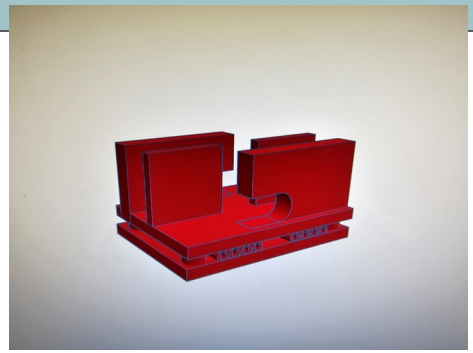
Replace with glass substrates



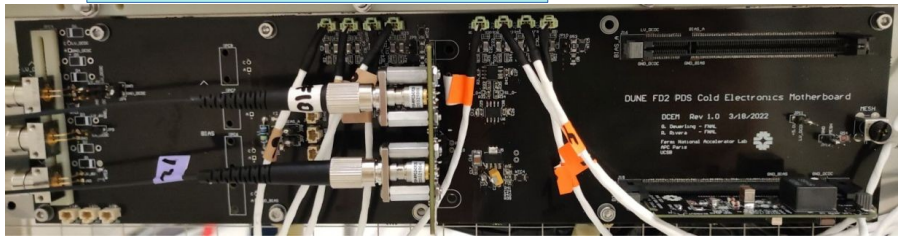
Risk of deteriorated performance due to light leakage
→ refurbishment of 8 cathode modules

M0 refurbishment

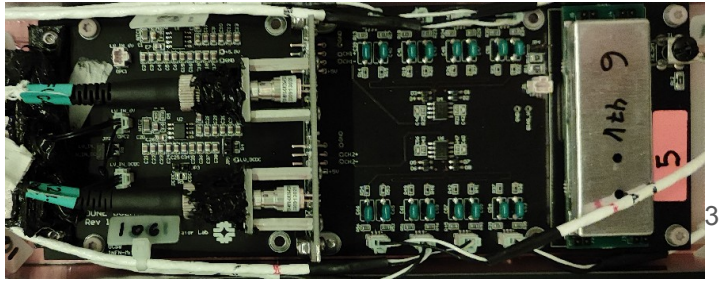
- Power:
  - Optimized GaAs PoF receivers with increased efficiency
  - Optimized DCDC design:
    - Lower noise
    - Better integration into readout electronics board (detachable board without connector)
  - Overall better optimization for warm operation (allows a better test modules at room temperature)
  - **New mechanical structure to contain IR light leakage**
- Signal-over-Fiber:
  - Optimized defocused laser increased light transmission efficiency
  - New PCB with optimized layout and component selection (avoid failure of capacitors)
  - Circuit version with only SiGe amplifiers tested in Module-1
    - 4 CMOS and 4 bipolar boards installed



DCEM 1.0 (Dec 22)

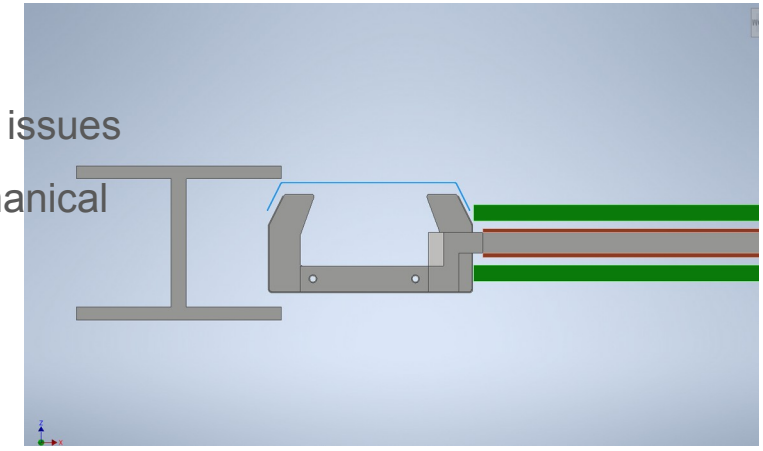


DCEM 1.31 (April 23)



Module 0 refurbishment

- Electronic boxes:
  - Modified during installation in ‘23, causing potential light leakage issues
  - New design for better light leakage containment and better mechanical integration (tapered edges, captive screws..)
  - All cathode boxes exchanged
- Dichroic Filters:
  - pTp detachment observed in PE filters in the coldbox (same prod. As M0)
  - All PE filters exchanged with pTp-coated glass substrates
- Wavelength-shifter:
  - With dimples → No dimples
  - New dimensions (5.5 mm thick) and optimized chromophore concentration
  - Mechanical adjustments done in all frames to avoid bending



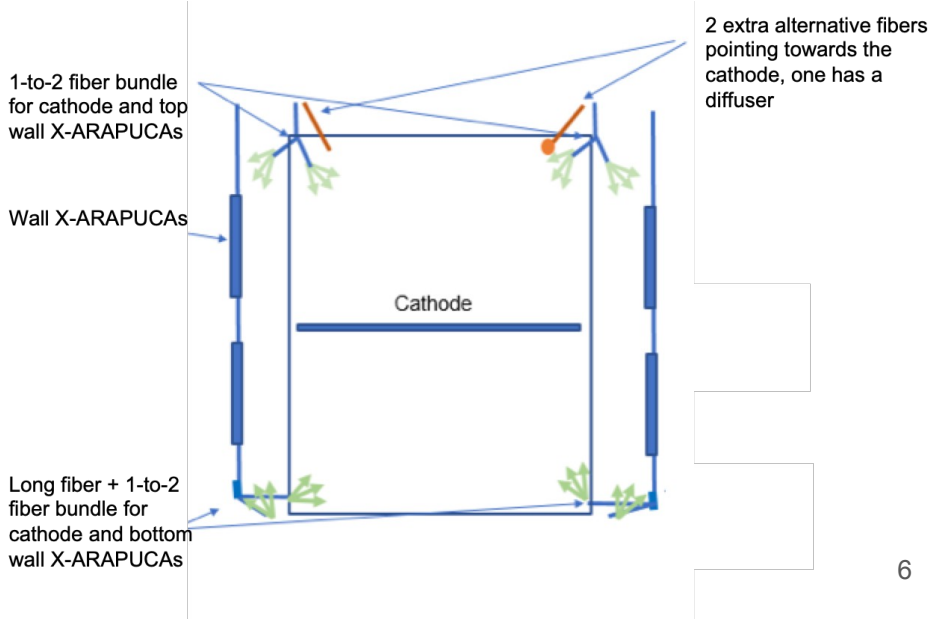
Refurbishment procedure is finished (~2 months)

- Extraction of modules from the cathode (May 24):
  - More complicated than expected (attachment to top mesh caused difficulties)
- All 8 cathode modules underwent refurbishment and testing
  - Mechanical adjustments
  - New SoF/PoF electronics → cryo testing in test stand
  - Finished on June 30th
- Re-installation (after cryo tests were finished):
  - Verification and cleaning of SoF fibers
  - Placement of modules in the cathode
  - Connection of fibers
  - Warm tests performed (4 and 4)
  - Potting and closure of electronic boxes
  - Mesh re-installation

Warm testing

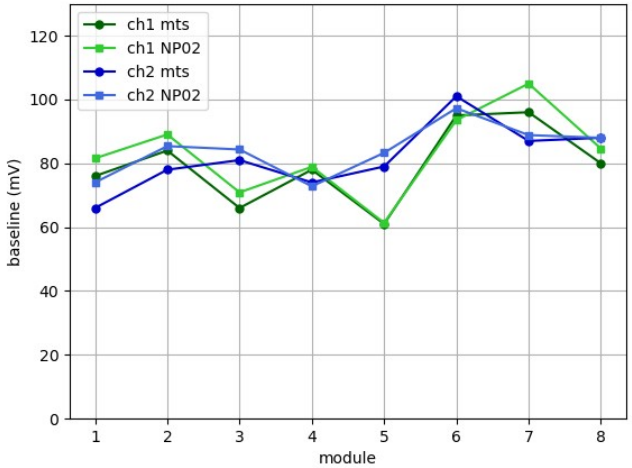
- Need to verify that modules are working correctly before finalizing the installation
- NP02 rack installation (at the expense of other setups :) :
  - New fully closed rack (for laser security)
  - All fibers closed within metallic tube (taken from test stand)
  - PoF box (from CB) with 8 lasers (one w/ burnt pigtail)
  - LED calibration:
    - Using installed calibration fibers
    - And CB 275 nm LED calibrator
  - Koherons(warm receiver) + oscilloscope
- To avoid over-heating, test can only last

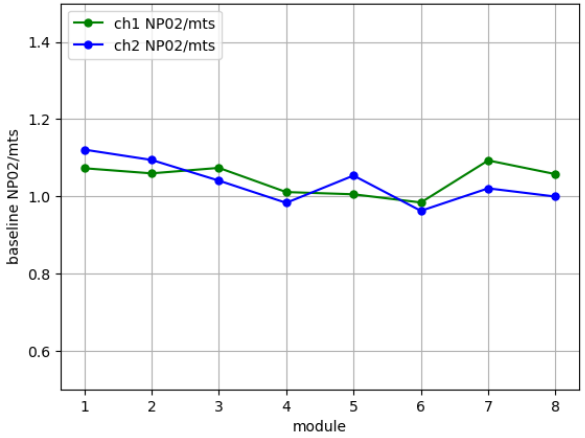
  ~1 min per module



Warm testing and installation

1. PoF OPC installation and voltage check
2. Module installation → SoF fiber check (just light) and cleaning before connection
3. First “alive” check: each module turned on one-by-one and the light output level was verified and compared to measurements at the test stand.
4. LED system used to see signals on each module
5. PoF OPCs were potted with black silicon and the light-tight enclosure closed. Electronics box closed
6. LED check performed in (4) repeated to verify good health of modules after final manipulations
7. Mesh is re-installed





M0 upcoming activity: membrane modules

- Four bottom modules are not yet installed
  - M7 and M8: TCO side, need to be installed after closure, filters taken for M1 (PE)
  - M5 and M6: non TCO side, PE filters needed to be replaced
- M7 and M8: VD-style electronics
  - M8 has FBK SiPMs → electronics re-tuned
  - Both modules tested in LAr
- M5 (FBK) and M6 (HPK):
  - Electronics re-tuned
  - Still need to be tested
- Dedicated team at CERN on 24/07 to perform tests
- pTp coated glass-substrates in fabrication
- Modules to be placed inside NP02 to be installed after TCO closure
- A warm test should be conducted after installation

Final cathode configurations

- More comprehensive info in the 2024 installation documentation
  - (see links tab for 2023 documentation)

Module	WLS	Filters	SiPM	SPE (mV)	SNR ch1-ch2	comments
C1	No dimples, 5mm	ZAOT	HPK	1 – 0.8	7 - 5	Just mechanical adjustments
C2	No dimples, 5mm	ZAOT	HPK	0.8 – 0.9	5 - 6	Just mechanical adjustments
C3	No dimples, new 5.5mm	glass	HPK	1.1 -1	8 - 7	**Used C4 from coldbox/M1**
C4	No dimples, new 5.5mm	glass	HPK	1 – 0.8	8 - 6	Flex B1 has first SiPM partially lifted

Final cathode configurations

	WLS	Filters	SiPM	SPE (mV)	SNR	comments
C5	No dimples, new 5.5mm	ZAOT	HPK	0.6 - 1	5 - 7.5	
C6	No dimples, new 5.5mm	ZAOT	HPK	1.5 - 1	8 - 8	Oscillations seen, gone in second test. Suspect cable tension?
C7	No dimples, new 5.5mm	ZAOT	HPK	0.8 – 0.5	6 - 4	**replaced with C2 from CB**
C8	No dimples, new 5.5mm	ZAOT	HPK	1.2 – 0.9	8 - 5	Flex B3 has first SiPM partially lifted

Membrane Modules

Module	Position	Location	SiPM	CE	Filters	WLS
M1	No-TCO top	NP02	HPK	HD-style	ZAOT	5 mm no dimples
M2	No-TCO top	NP02	HPK	HD-style	ZAOT	5 mm no dimples
M3	TCO top	NP02	HPK	HD-style	ZAOT	5 mm dimples
M4	TCO top	NP02	HPK	HD-style	ZAOT	5 mm dimples
M5*	No-TCO bot	PDS room	FBK	VD-styles	glass*	5 mm dimples
M6*	No-TCO bot	PDS room	HPK	SoF(cop)	glass*	5 mm dimples
M7	TCO bottom	PDS room	HPK	VD-style	glass*	5 mm dimples
M8	TCO bottom	PDS room	FBK	VD-style2	quartz*	5 mm dimples

*not tested yet
**not yet at CERN

Coldbox (Module 1) status and plans

- Activity in 2024 - recap
  - Long run in January 2024 → 4 cathode modules + 2 membrane modules
  - Long run in April 2024 → test of full SiGe SoF eelctronics and DAPHNE readout
  - Short run June 2024 → cathode modules removed (pTp issue), only membrane
- Module 1 setup in need of important work → next run October 2024
  - Main goal: DAPHNE+DAQ data taking: improved tuning + DAPHNE V3 + 8-channel SoF receiver
  - All cathode modules need refurbishment:
    - C1 is FBK metal in trench → replace for FD SiPMs
    - C2 and C4 were installed in ProtoDUNE. The replacement M0 modules need new WLS (in hand) and glass substrates (in fabrication) + mechanical adjustments.
    - C3 WLS is potentially damaged (scratched? pTp stuck on it), PE filters
    - Need to clean – remove pTp- off 3 sets (38) of PE filters
  - Rack needs material: PoF, LED calibration, DAPHNE
  - Fibers need checking (hopefully no replacement needed)

Conclusion

- M0 PDS refurbishment campaign concluded (is concluding) with success
  - All key elements that required upgrade were replaced
  - Work finished well in time before TCO closure
  - Thanks to the very big effort from our PDS team at CERN
  - Update of documentation underway
- TCO closure expected to start mid-August and last 3 weeks
  - And I understand LAr transfer takes ~2 months
- We have (at least?) one more M1 run left
  - And ~2 weeks? Worth of work to get the setup ready and installed again.