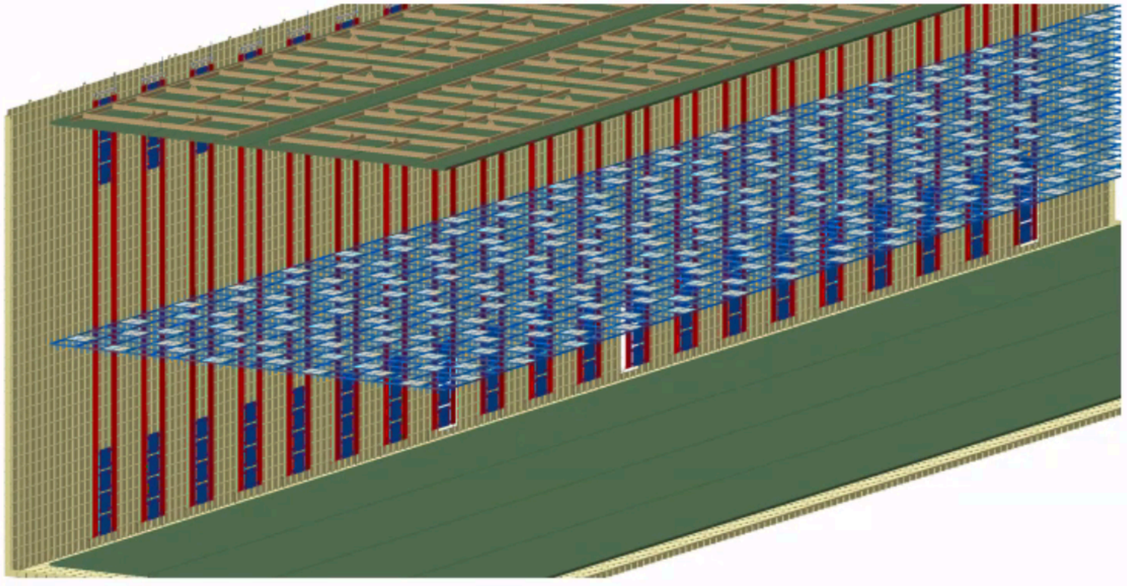
# Perspectives of the VD-SP PD R&D and Simulation

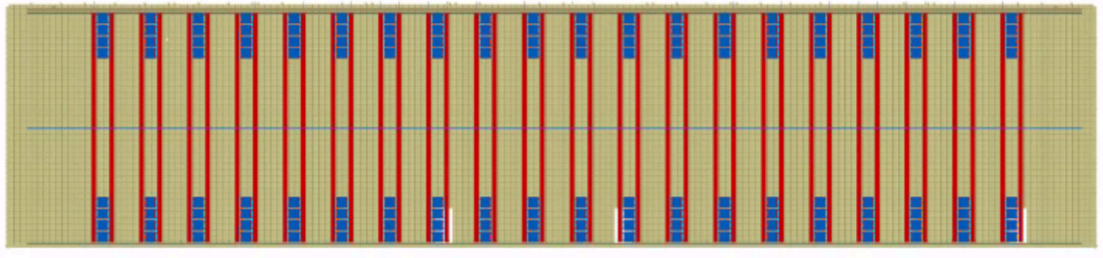
Flavio -

## Reference Design

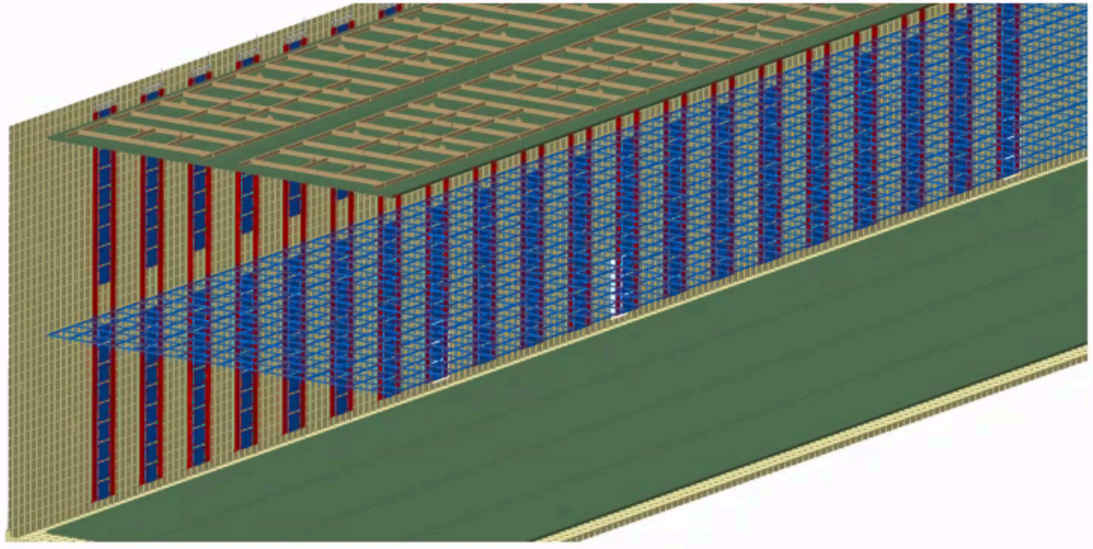


4 pi layout :

- Full trigger capabilities down to 10 MeV
- T0, E, Position
- xArapucas 60x60 on the cathode, 115 mq, analog readout
- xArapucas 60x60 on the cryo membrane, ~3m from anode

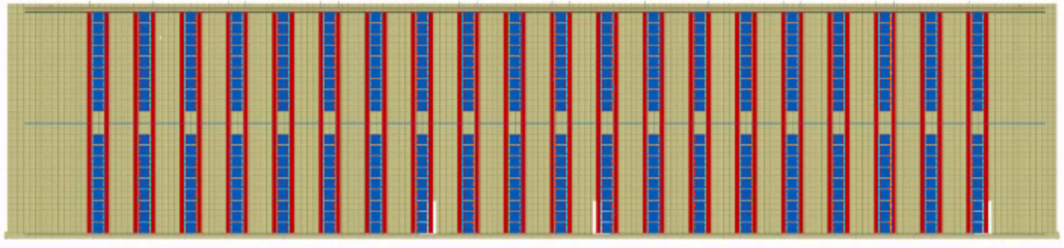


## FallBack Design



Minimal layout:

- Trigger via charge TPC readout down to 10 MeV
- T0, E, Position
- xArapucas 60x60 on the cryo membrane, 20 columns, each column 18 xArapucas, SPHD readout



# Reference design for a PD System for the VD LAr Volume

- With a solution for operating a PD on HV surfaces:

**PD Active Optical Coverage distributed onto 3 sides of the LAr Volume (Cathode side and 2 Long Field Cage sides)**

**+**

**PD Passive Optical Coverage (reflector) on the Anode side**

**+**

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

*The Reference design endorses the* ***~4π coverage concept****:*

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

- *Detailed study of PD impact on LowEn UG Physics (trigger and reconstruction, combined with TPC) is the main next step of the DUNE MC Simulation campaign*

# Progress of VD PD R&D

**HD-SP PD development** (including **protoDUNE-SP**) and **PoF R&D** at FNAL&CERN advanced in 2020 and the aggressive **R&D on Transmission + CE & Detector optimization** started in Feb. '21:

⇒ xARAPUCA detector design (tile geometry) established and optimized (large WLS plates + SiPM opt.contact)

⇒ Passive ganging scheme promising for S/N optimization and (in general) n. of SiPM can be tuned

⇒ on the Cathode:

- PoF for SiPM demonstrated (optimization in progress)
- PoF for CE in progress (easier for Analog CE option)
- SoF (Signal over Fiber): Analog Option very advanced in EU (nearly demonstrated by DS)
- SoF (Signal over Fiber): Digital Option very strongly pursued in US, new tests & progress every day *(very confident it will also be demonstrated soon)*

⇒ what if neither the Analog nor the Digital transmission will be fully demonstrated?

- Move ALL xARAPUCA Tiles from Cathode, outside the TPC, near the Membrane Cryostat (Long) walls -
  - ✳ No risks from PD R&D
  - ✳ FC need to be modified (increase Transparency) - no risks expected on HV

# Boundary Conditions are met

⇒ PD CE and PoF efficiency Power budget are within limitation for power dissipation in LAr

⇒ Cost envelop for VD PD for both Reference and FallBack solutions well within current limits for the US project. Resources from International  Expected  - under negotiations

⇒ PD core-community from US, EU and International created within the existing DUNE PD Consortium. Existing Groups are growing with new highly qualified resources, and new Groups show interest to join

**Requirements:**
- Comparison w/ Horiz. Drift (Light Yield, E resolution for HD and direct comparison for VD-Reference option and fall-back option)
-Additional timing resolution requirement based on vertexing?
- Digitizer requirements (dynamic range, sampling freq., bandwidth)

**Detector parameters open to optimization:**
- Detection of Ar (only), Ar+Xe, Xe-only Light
- 1-sided vs. 3- sided vs 5-sided
- w/ or w/o reflections from the Anode
- Transparent Cathode vs Opaque or Reflective Cathode

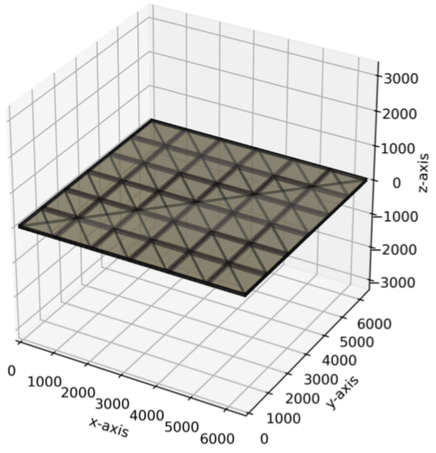
**Simulation Development (LArSoft)**: ***PARTIALLY DONE***
- VD geometry --> DONE
- Fast simulation --> ON THE WAY
- Xe timing parameterization --> DONE (adjustable parameters, including N2 in progress )

**Plan for this year**

- LArSoft simulation available
- PD Trigger (and prompt Bckgd Rejection) Strategy combined with existing TPC Trigger Strategies
- Goals for SNe and p-decay detection w/ PD:
    - minimum (t0)
    - enhanced physics (supernova neutrino background, NS cooling, ...)
- Backgrounds
- Other Low En UG Physics (eg Solar neutrinos)

Based on Simulation by UTFTR Grp. (Br)

36 Filters with 144 SiPMs. $\delta = 0.6\ \frac{SiPM}{cm}$, 36 SiPM/side.



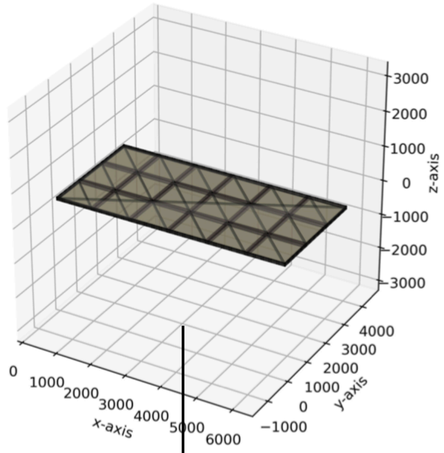

Efficiency: 36,51%

Dichroic Filters 10cm × 10cm
60cm x 60cm x 0.4cm thick light-guide
SiPMs around Perimeter

Efficiency = %percentage of detected photons by number of SiPM

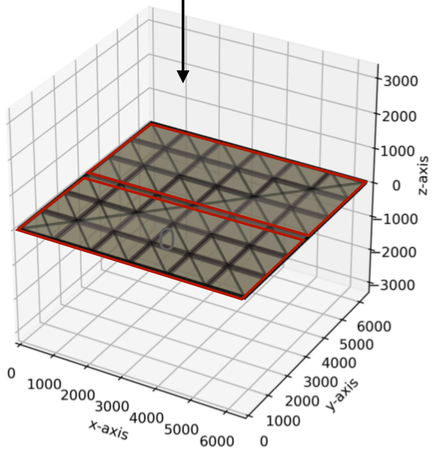
(reflection, refraction and
light guide total internal reflection and absorption above threshold)

18 Filters with 108 SiPMs. $\delta = 0.6\ \frac{SiPM}{cm}$ , 36 SiPM/L-side, 18 SiPM/S-side.




Efficiency: 40,5 %

x 2




108 SiPM x 2 = 216 SiPMs (per 60x60 cm tile)

Relative Increase N. SiPMs $(\frac{N_2 - N_1}{N_1})$: +50%

Relative Efficiency $\frac{(\epsilon_2 - \epsilon_1)}{\epsilon_1}$: + 10%

Note: If keep same N. of SiPM (144), effic. drops by 11%