PDS Mechanical Design, Layout and Fabrication

David Warner for the Photon Detector Consortium

FD-2 (VD) Photon Detector Workshop

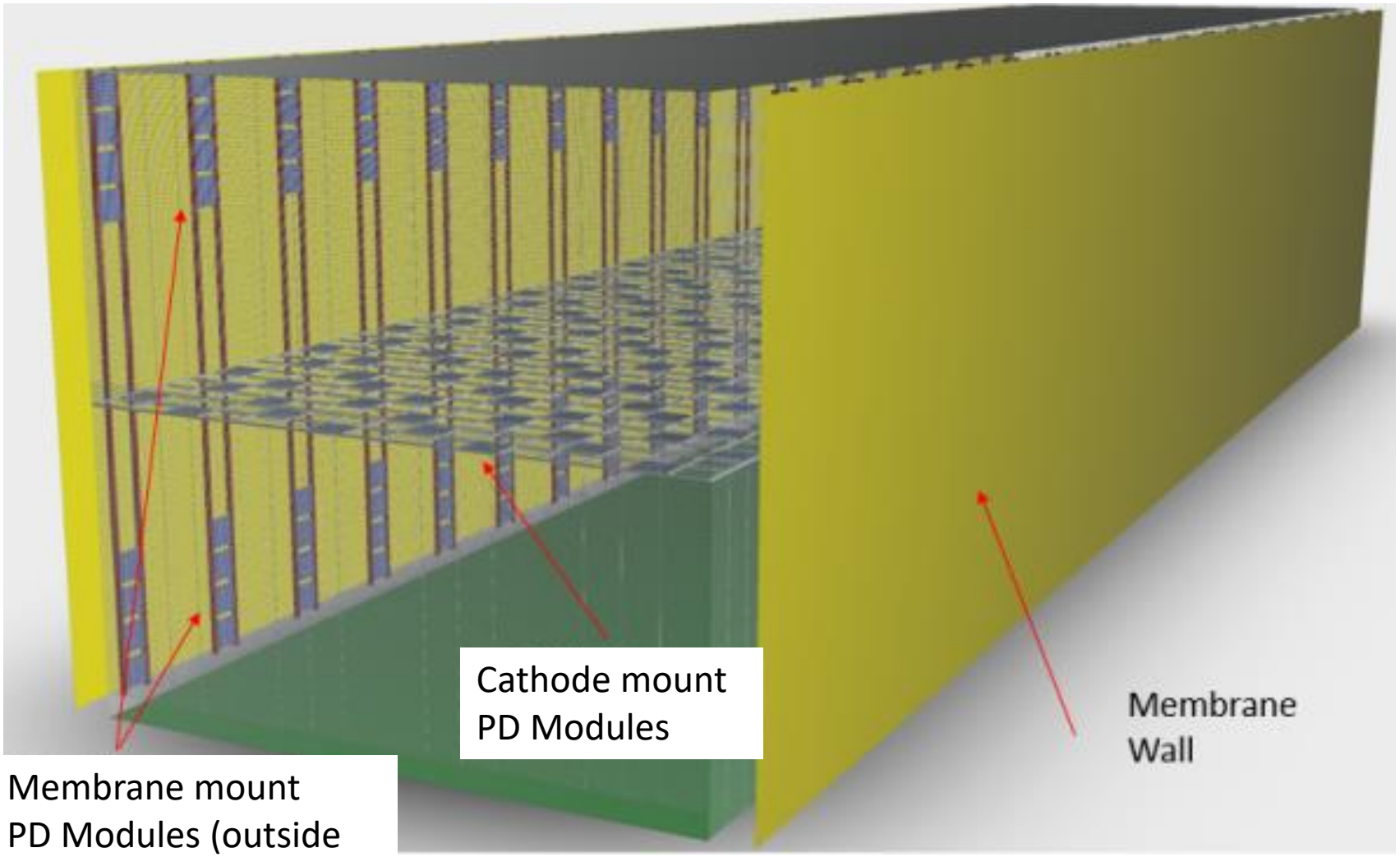
July 26, 2021

Outline

- Layout of FD2 PDS
  - Baseline layout
  - Alternate (fallback) layout
- PD module design
- Fabrication concept
- QC Testing
- Installation and integration
- Other opportunities for involvement

Baseline design (Cathode mounted PD modules with membrane mount auxiliary)

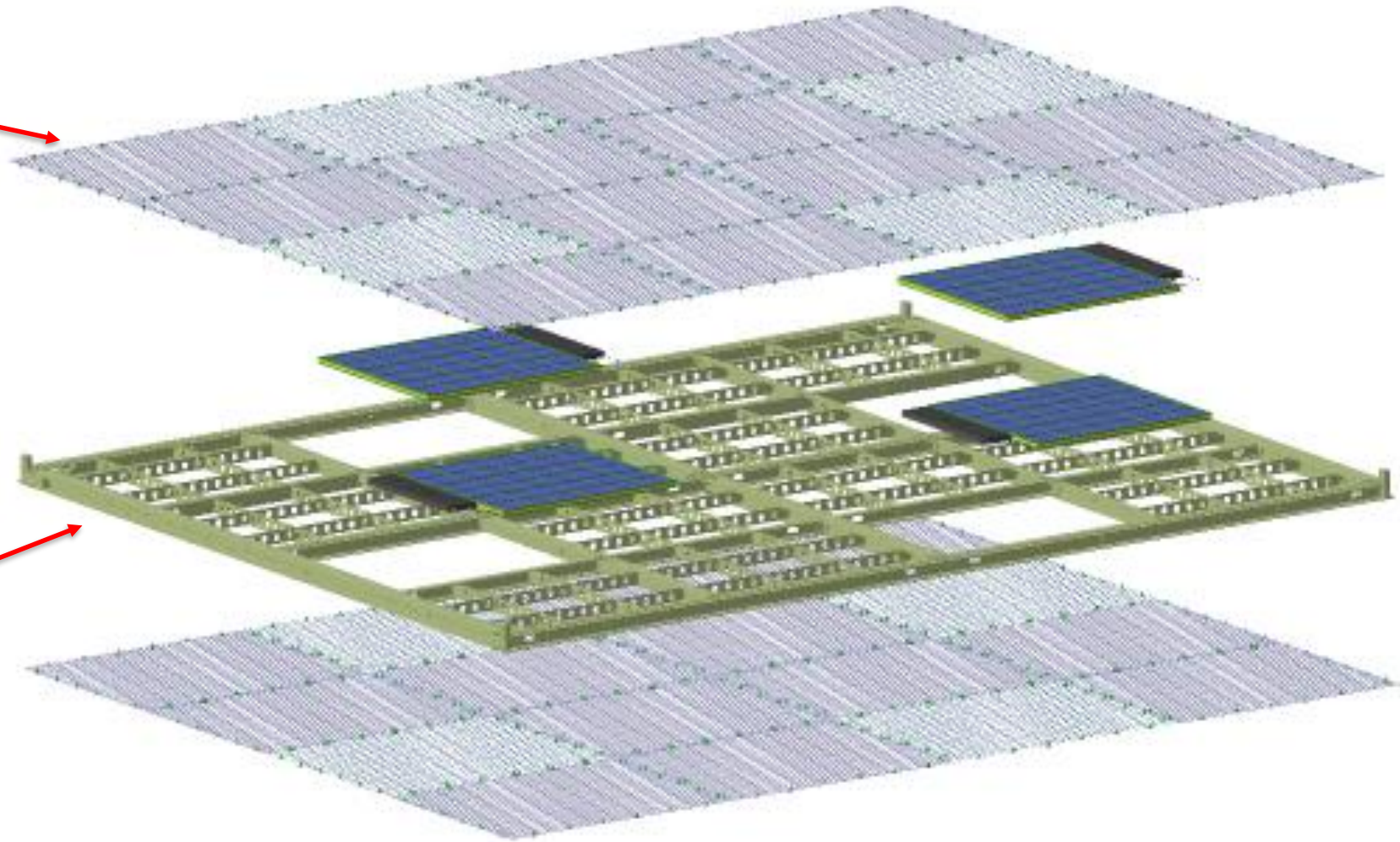
- 320 cathode-mount PD modules
  - 4 modules/cathode module
  - 80 cathode modules
- 320 membrane-mount modules
  - 20 columns
  - 8 modules/column
  - 2 sides of cryostat



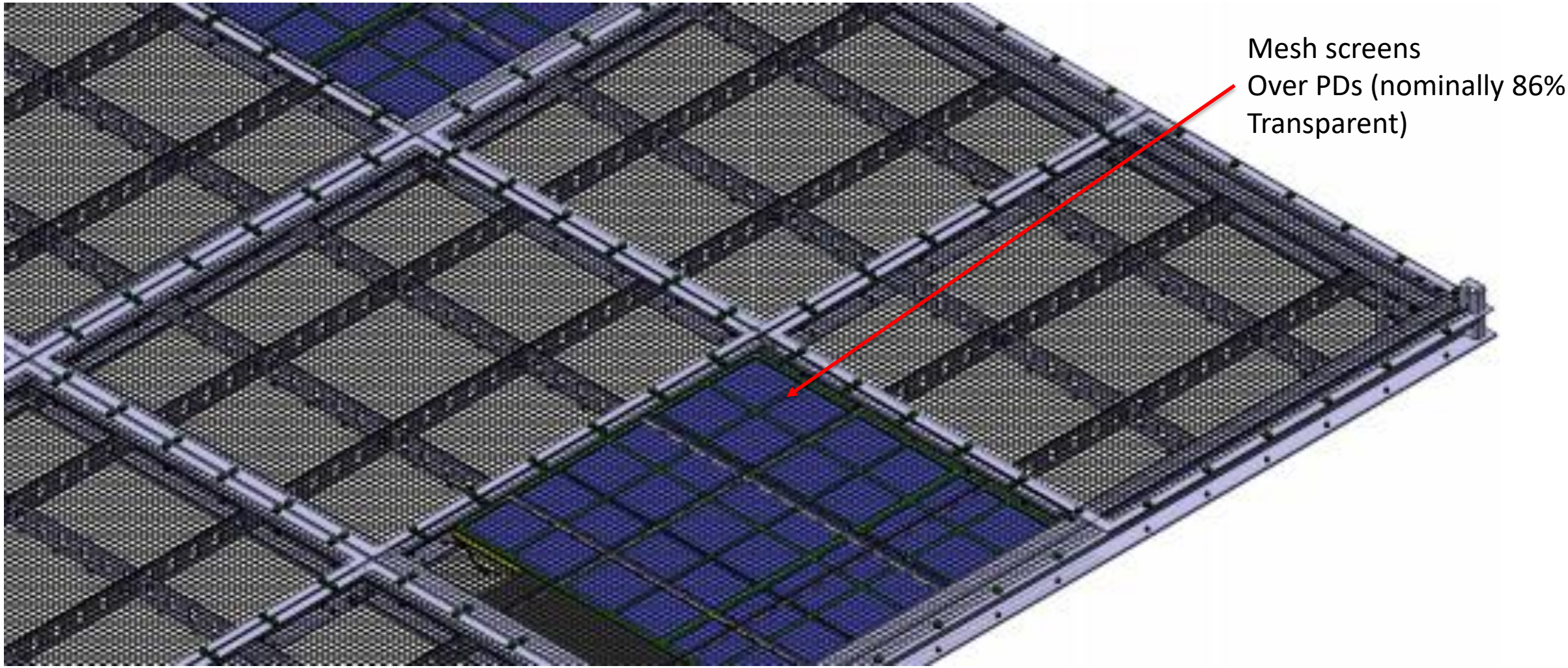
PD modules mounted in cathode module (4 tiles/module)

HV conducting Surfaces (both sides)

FR-4 cathode structure



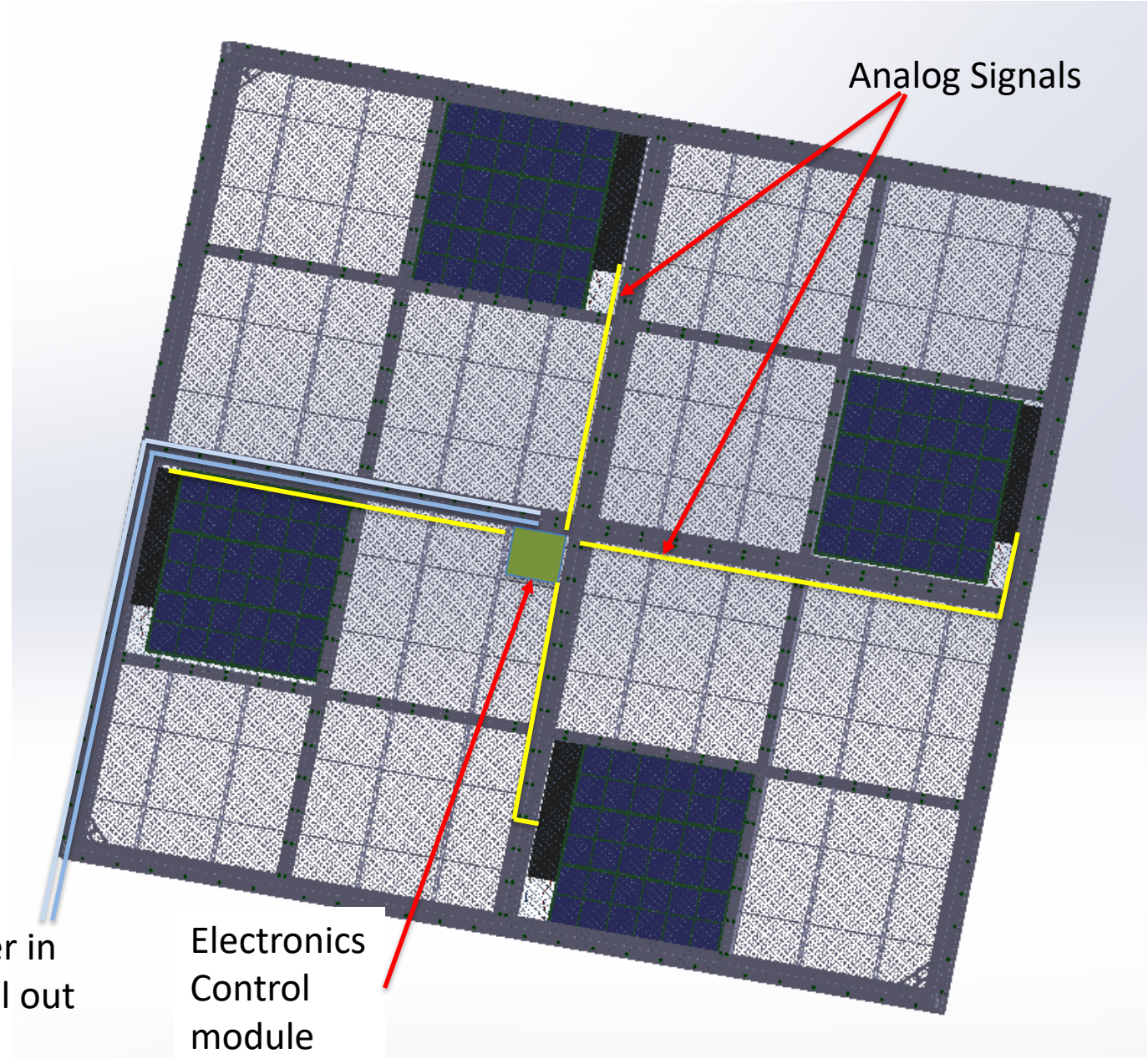
PD Modules mounted in cathode module



Frame mounting

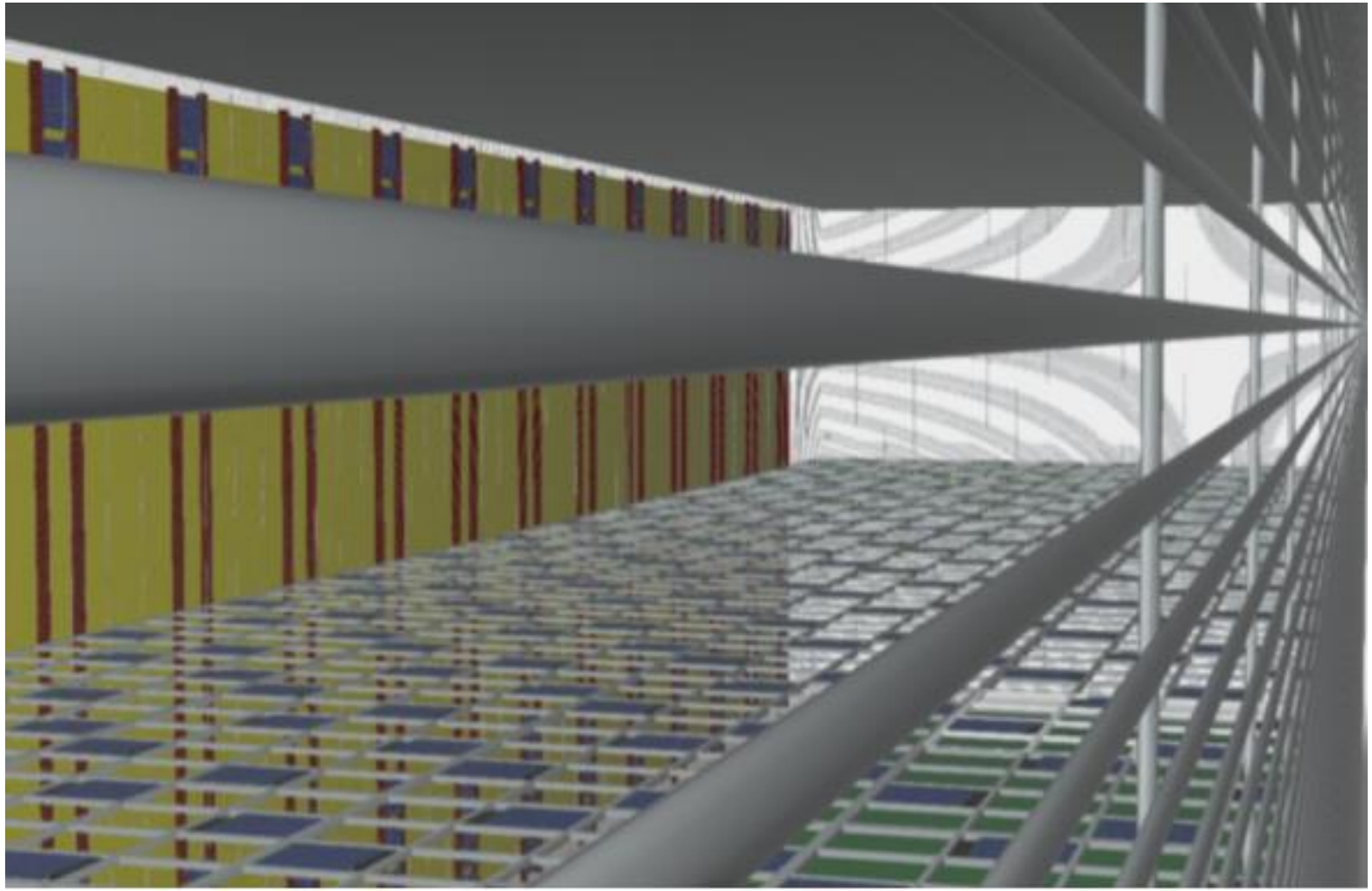
- 4 PD modules per cathode module
- Baseline electronics consolidation:
  One readout electronics assembly per cathode module
  - ~200mm^
  - Two PCBs in vertical stack: One analog board with amplifiers, (4 ADCs?) one digital board with signal readout, power, slow control

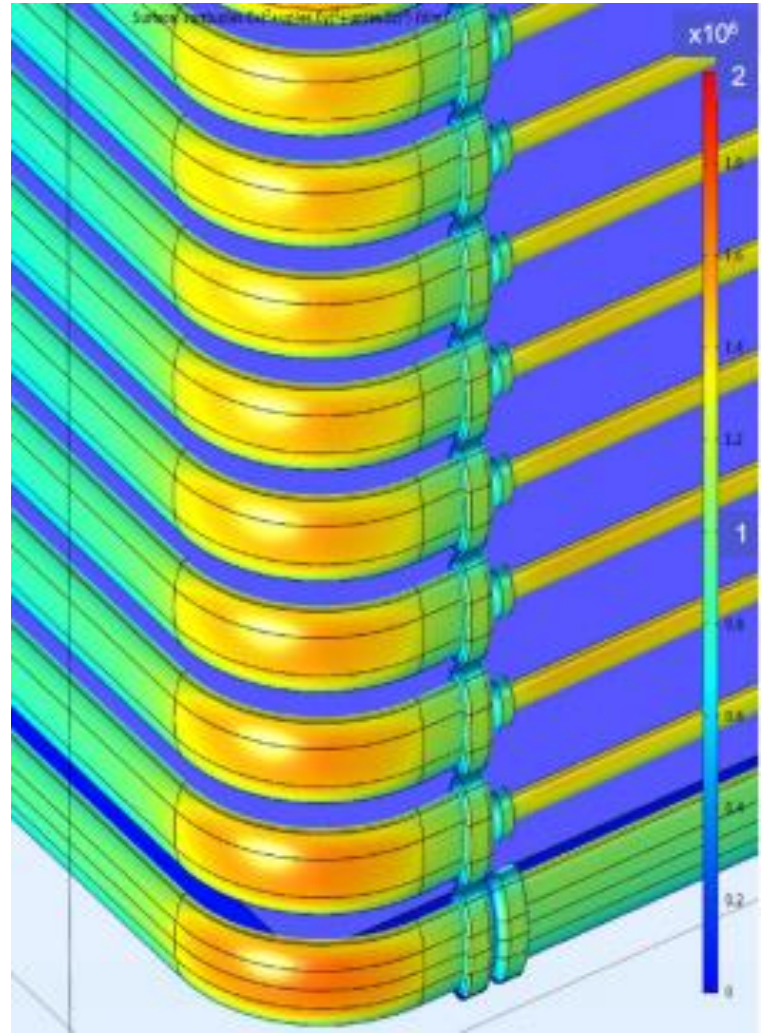
May not be possible/desirable due to concerns around possible impact on PD electronics due to pickup of large signals from cathode HV breakdown on copper PD wires routed inside cathode module



70% Transparent field cage concept

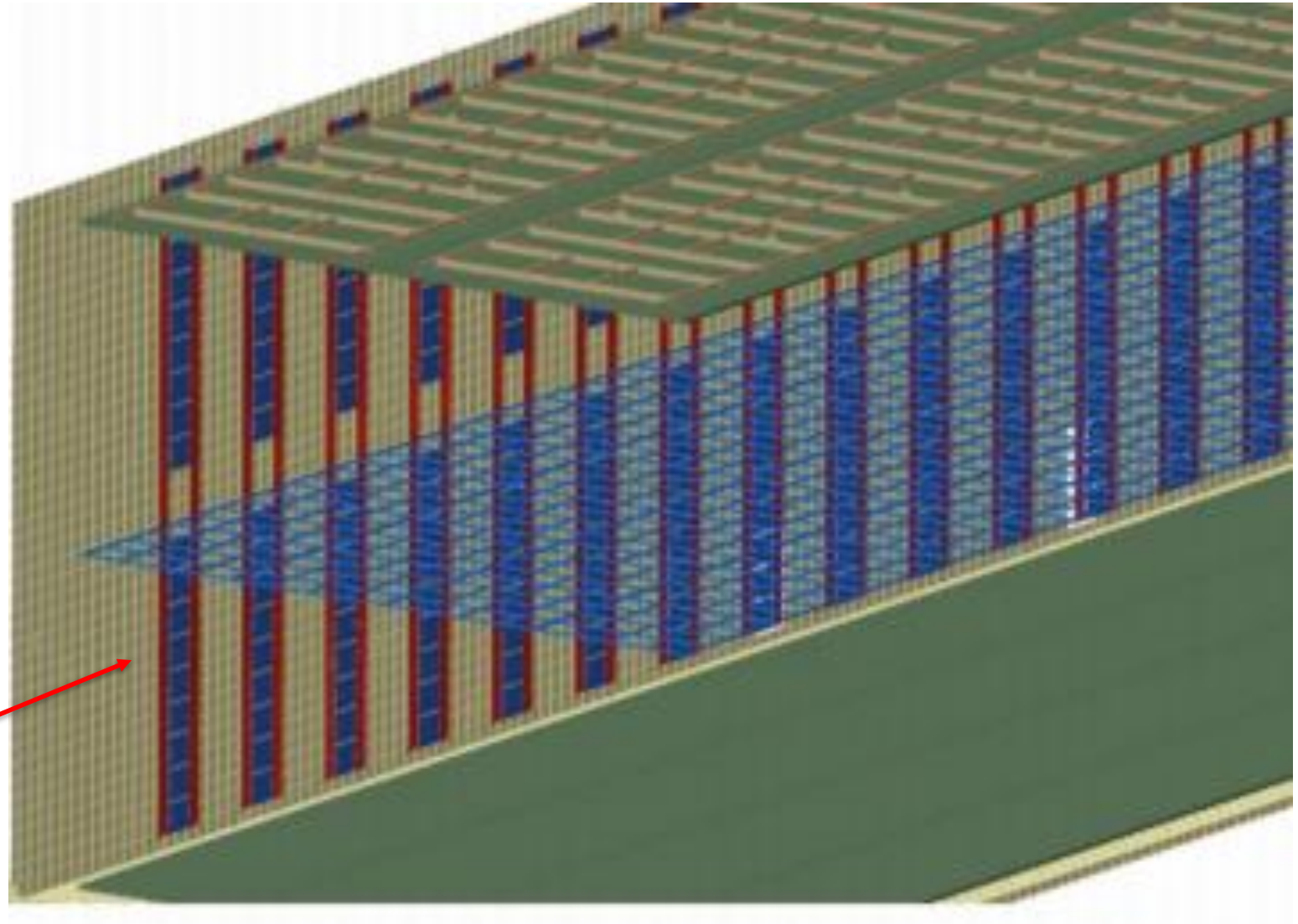
Narrow field cage profiles
For improved transparency





Alternate layout (all membrane mount)

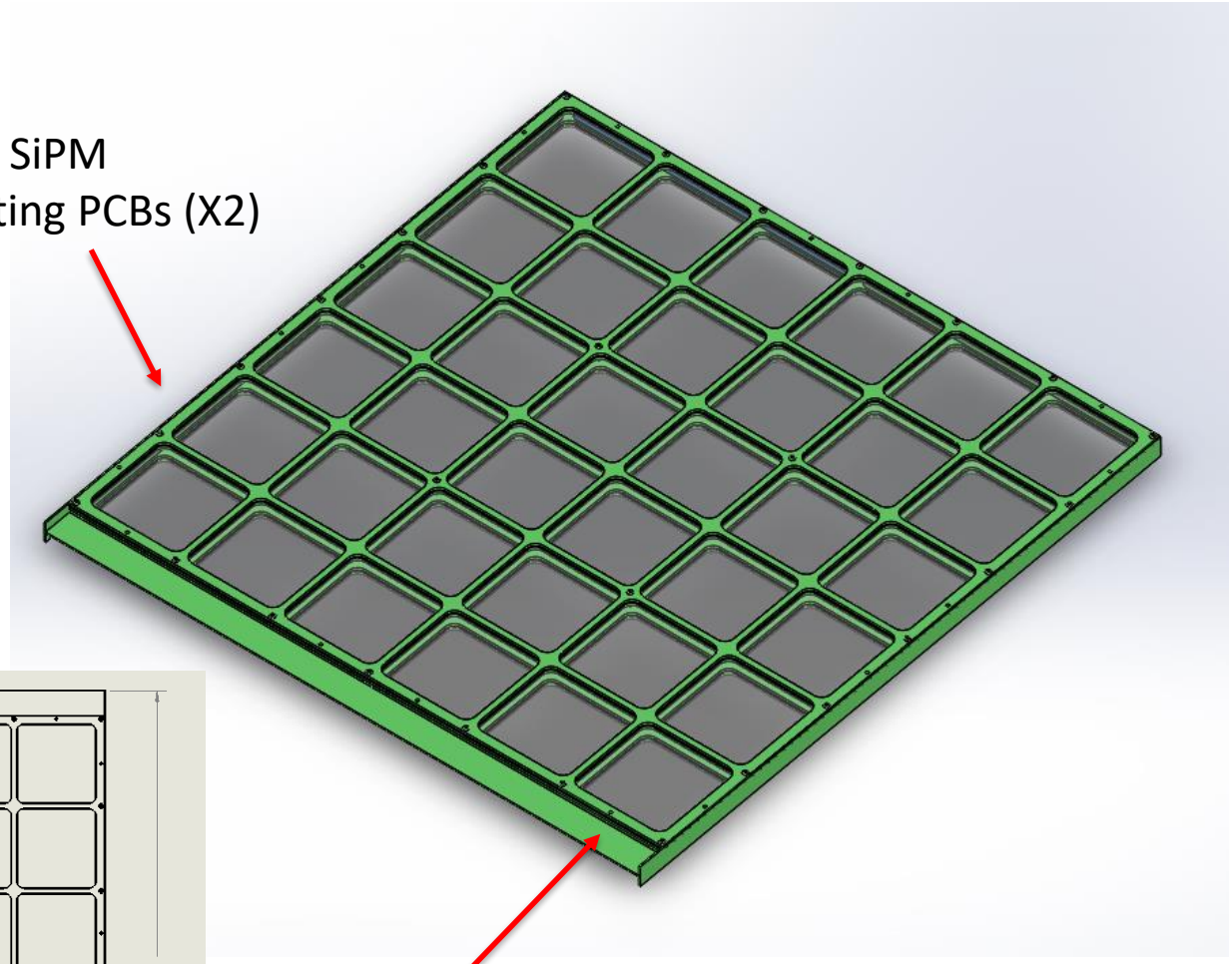
Does not require power over fiber or fiber readout (though could use them)

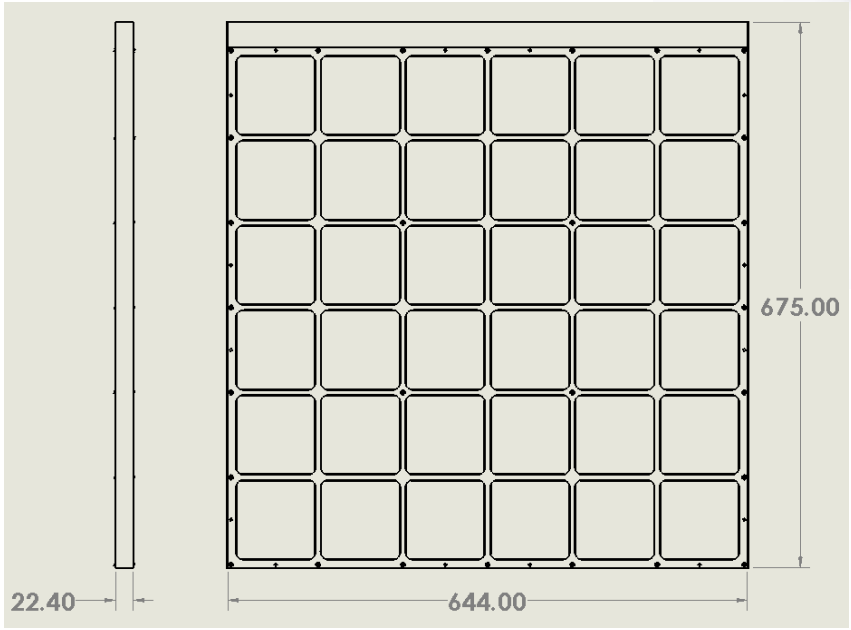


20 columns of
18 tiles (9 in top
Drift region, 9 in bottom
Drift region-- 720 total
PD Modules)

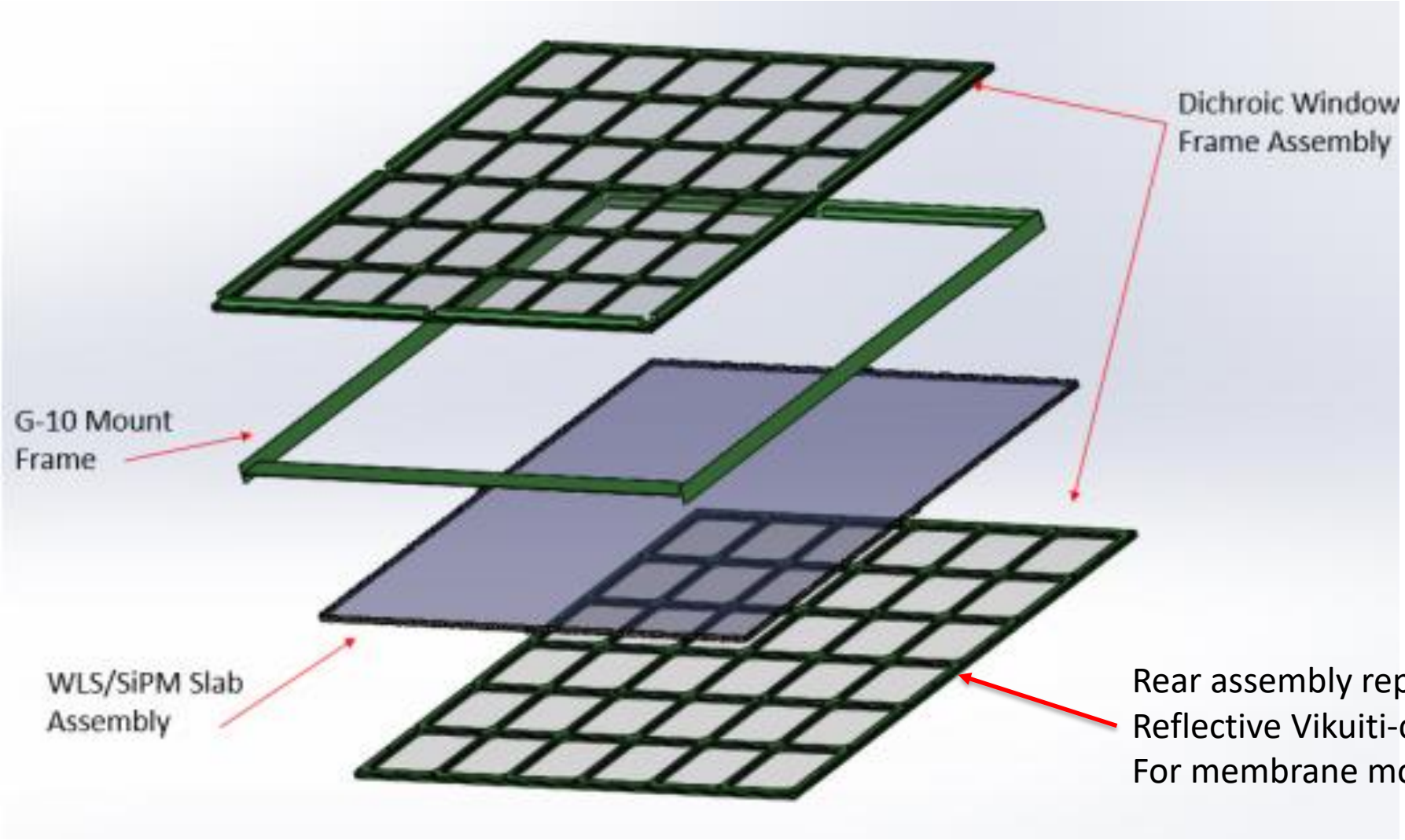
Mechanical frame (Concept)

- Total PD module area ~675 X 644 X 22.4 mm^3
- Total active area ~3380cm^2 (X2 sides for cathode mounted PD modules)
- Estimated mass ~5.5kg per PD module
- 160 SiPMs (40 per side)
- FR-4 G-10 Frame components



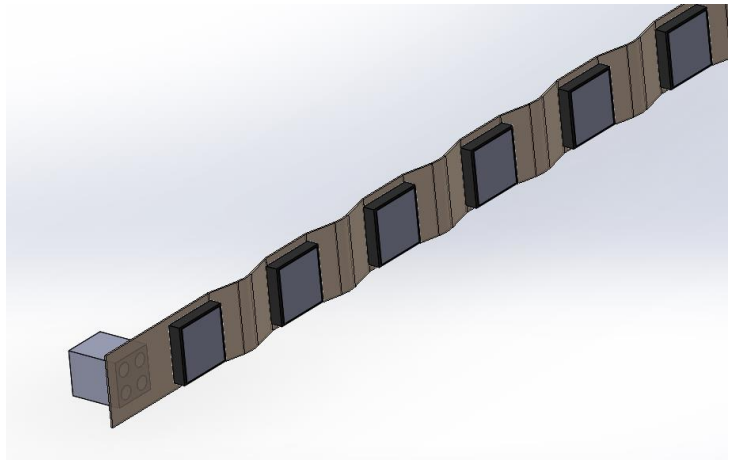


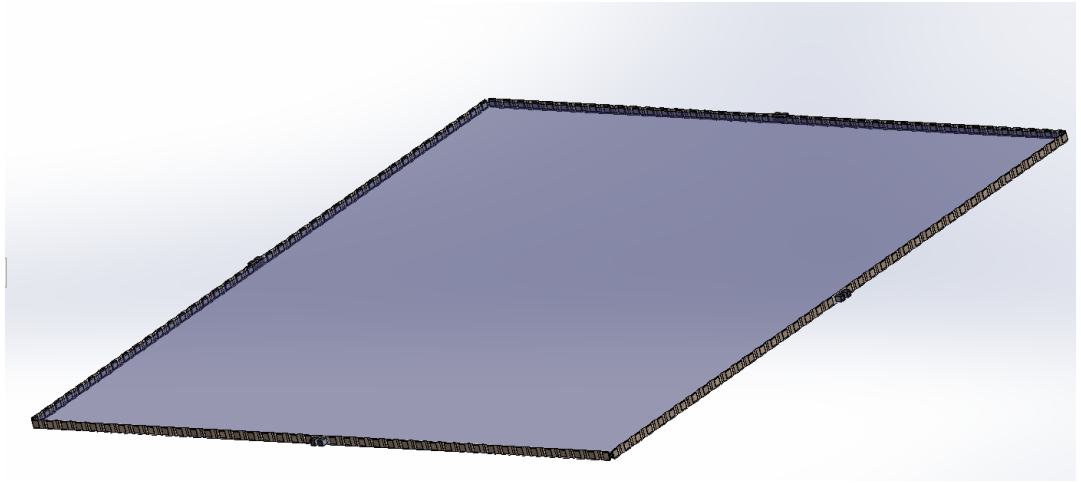
PD module- exploded view

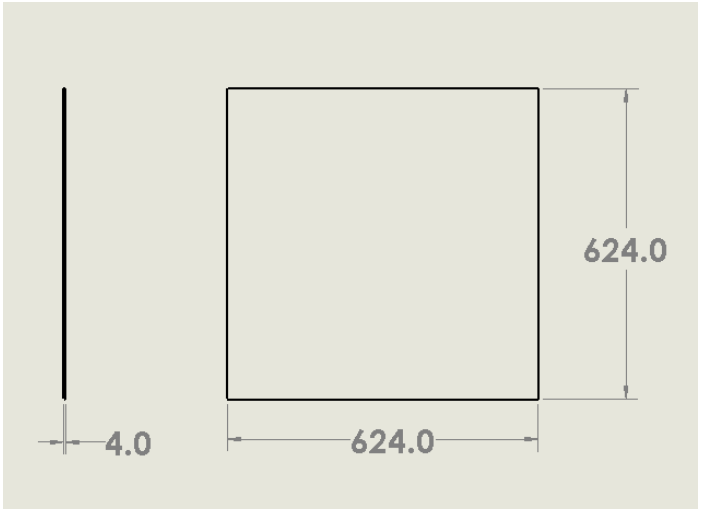


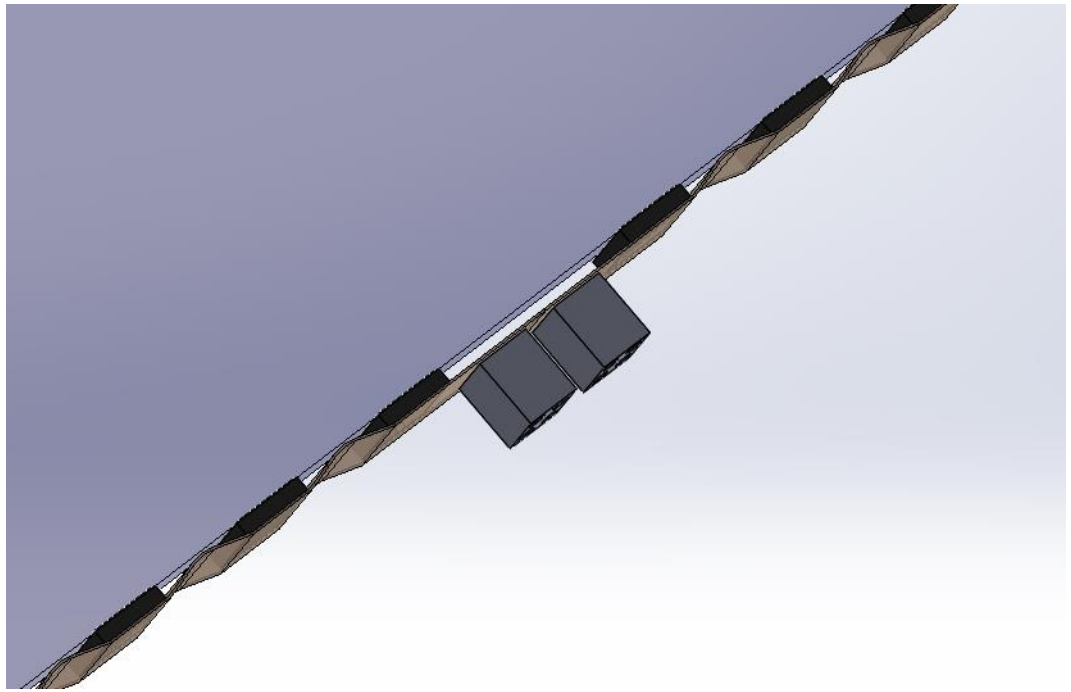
WLS plate assembly

- 160 SiPMs (40 per side)
  - Glued to WLS Bar for improved performance
- SiPMs mounted on Kapton flexi-PCB
  - Addresses relative thermal contraction of WLS plate/frame.
- Glass to Power FB-118 WLS plate (Milano) (Note: May use 600 X 600 X 3.8mm)
- Concept new to VD PD-- under development









PD module component summary

Item	Cathode tile	Membrane tile
Module frame	1	1
Dichroic filters	72	36
Filter frame assemblies	2	1
WLS plates	1	1
SiPMs	160	160
Flexi PCB assemblies	8	8
Ganging amp./Signal readout boards	1	1

Reference design: 320 cathode PD modules, 320 membrane PD modules
Alternate (fallback): 720 membrane PD modules

Fabrication elements & steps (PD Modules)

- SiPMs
  - Procurement
  - Assembly to flexi PCBs
  - Testing
- WLS plates
  - Procurement & testing
  - Assembly to WLS plates & testing
- Filter assemblies
  - Filter procurement & testing
  - Filter coating & testing
  - Assembly into filter assembly frames
- Ganging amplifier PCB
  - Procurement
  - Testing
- PD module assembly (multiple sites)
  - PD module frame fabrication
  - PD Module assembly
  - Testing
  - Possible variations between cathode mount and membrane mount PD modules

QC Testing

- Very conceptual at this point!

- PD Module assembly facility
  - Scan in LED scanner (similar to FD1 plan)
  - Cryogenic immersion in LN2?

- PD Module reception facility (Final stop before storage prior to use in DUNE)
  - Repeat Scan in LED scanner (similar to FD1 plan)
  - Cryogenic immersion in LN2?

- LED scan prior to integration into cathode modules/cryostat

- Cold box test prior to installation in cryostat (?)

Installation and Integration

- PD modules are integrated into the cathode modules underground at SURF
- Membrane mount PD modules are assembled into strings underground at SURF
- Cathode modules and membrane PD module strings will be tested prior to insertion (cold box?)
- Following integration in the cryostat, operation in situ and periodic monitoring until the cryostat is closed

Additional opportunities

- Mechanical supports
  - Cathode PD module integration
  - Membrane mount PD module support structure
- Fiber and copper cable design, routing, fabrication
- Monitoring system design, fabrication, installation
- Detector optimization for Xenon
- Test equipment, QC plan

Conclusions

- An X-ARAPUCA based photon detector design is in development for FD2
- The baseline design presents two options--
  - Hybrid Cathode mount/cryostat membrane mount PD modules(preferred option, requires power over fiber)
  - Membrane mount PD modules only (disfavored option, only requires copper readout)
- There are significant synergies between the two designs, and with the FD1 PD system.
- PD module design allows for multiple fabrication and assembly sites. Many opportunities exist for involvement in the production!
- Please contact us to get involved!