Previous Photodetector Simulation

Simulation shows SiPM on edge doubles photon collection efficiency than glued at the center of acrylic

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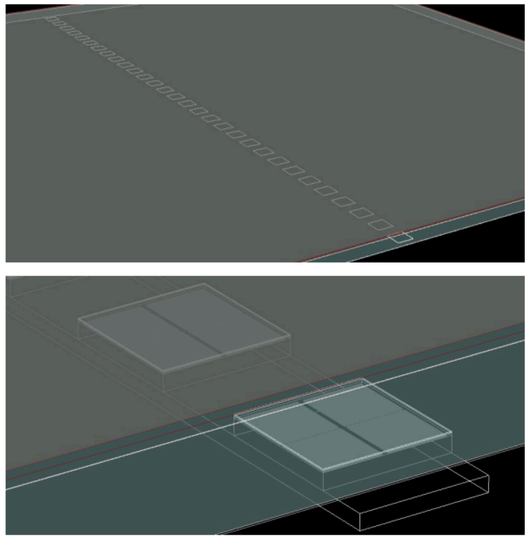
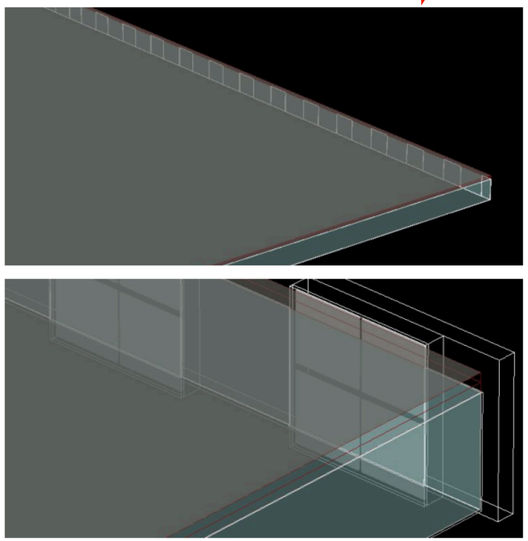
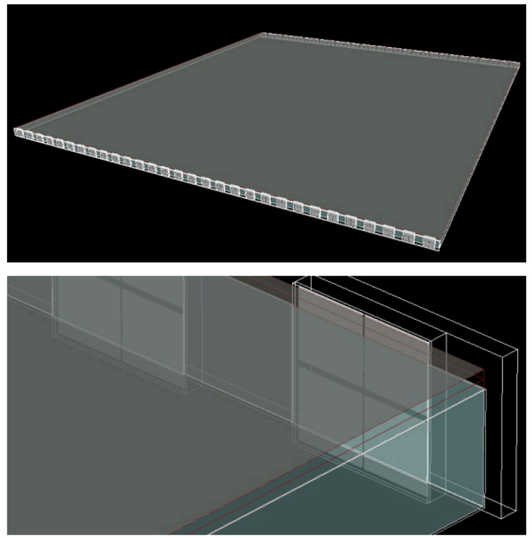
Results

Baseline	Side SiPMs	Side SiPMs (doubled)
		
PCE ~ 0.63%	PCE ~ 1.23%	PCE ~ 2.27%
30 SiPMs	***30 SiPMs***	***60 SiPMs***

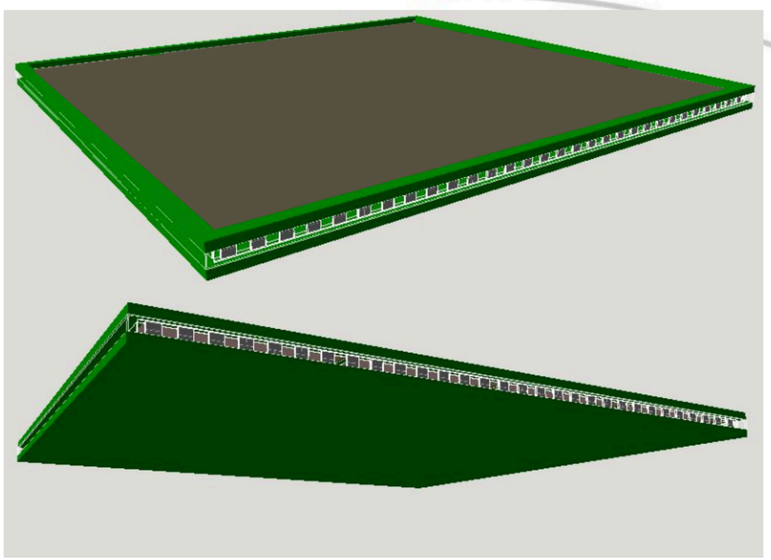
Simulated Detached Dichorics (Gaps Filled with LAr)

Same 30 SiPMs
Single-sided PDE: 1.23% —> detached dichroics PDE: 1.73% (40% higher)

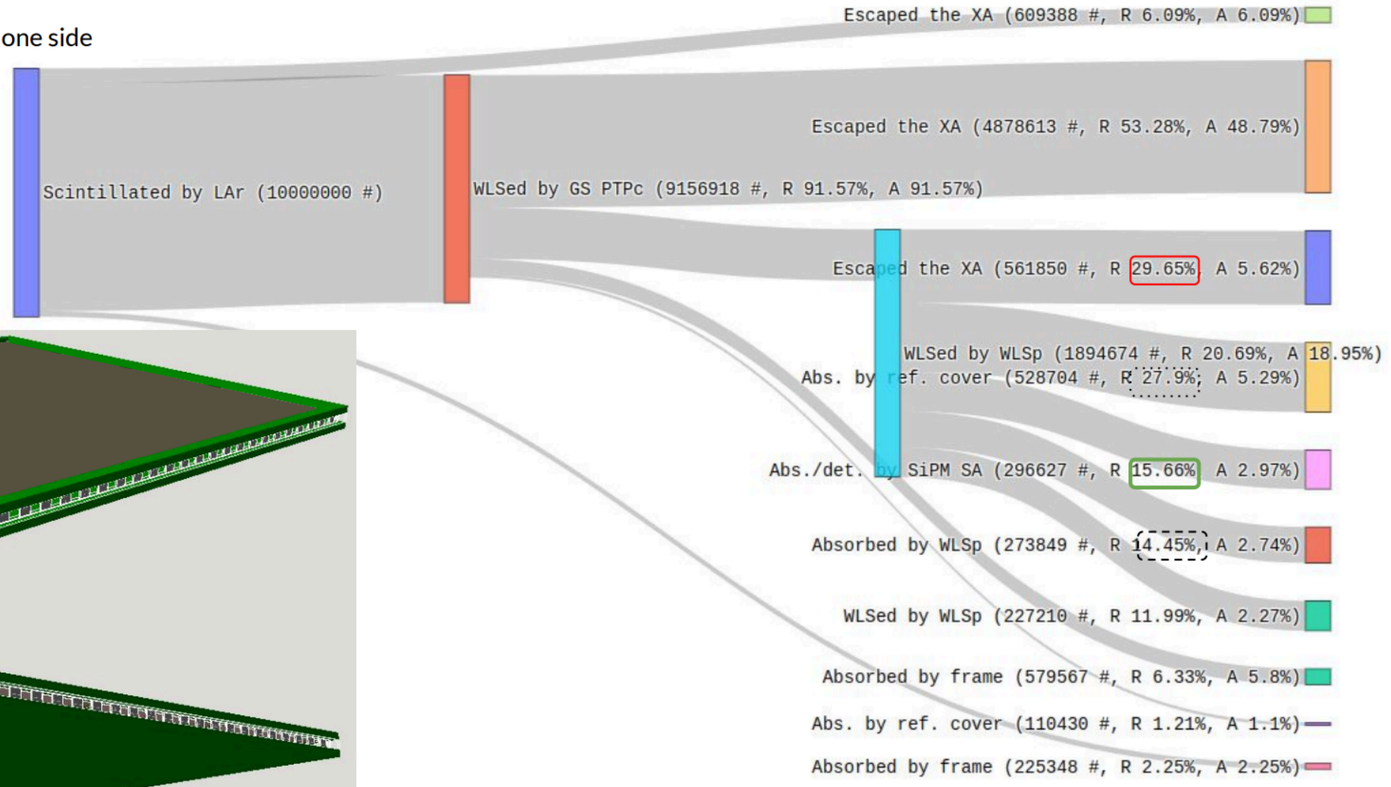
APEX with separated DF (XA approximation)

- APEX dimensions
- 30 Broadcom SiPMs on just one side
- Optical contact
- Same DFs

PCE ~ 1. 73 %

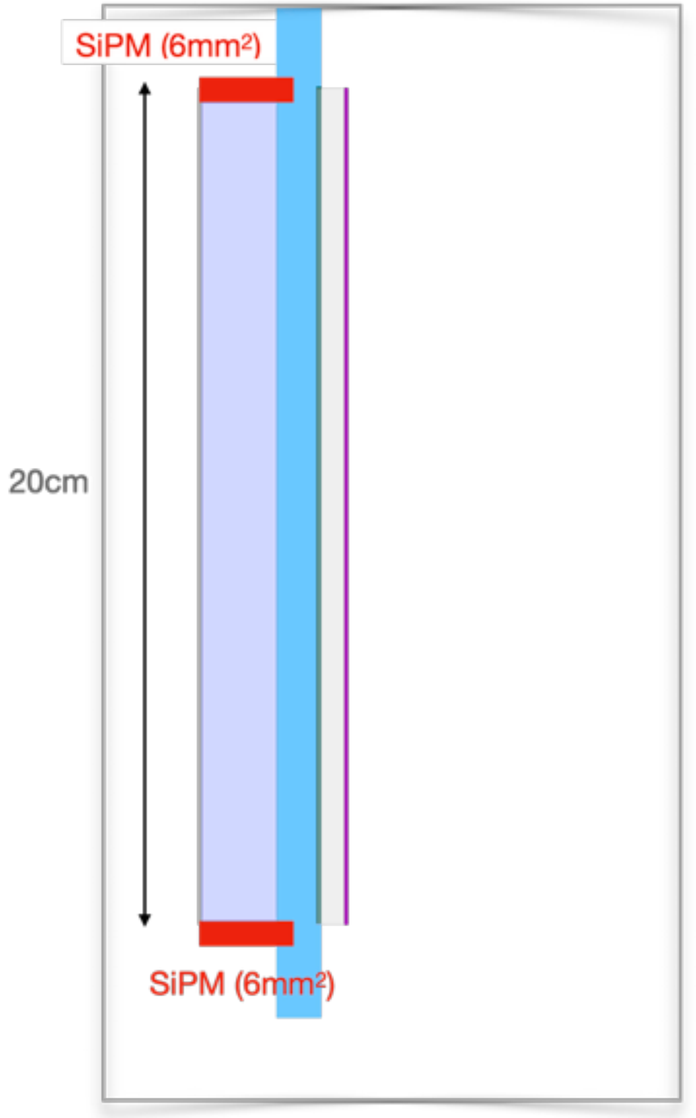


30 SiPMs



X-**ARAPUCA** concept implemented in FD1

[Reflector - WLS2 (4mm) - LAr. - Dichroic - Glass - WLS1]
VIKUITI foil - PMMA(Blue) - 2mm - Evap. - (1.5mm) - pTer film



Propose a Baseline Photodetector Design for FD3 APEX

Recently (1-2 yrs) on FD2 XA:
Sim and measurement of FD2 style XA show dichroics not helping

Sim

OV	1. DF-XA	2. DF-XA-DS	3. noDF-XA	4. noDF-XA-DS
3.5	2.7%	2.9%	3.1%	3.2%
4.5	**3.0%**	**3.2%**	**3.6%**	**3.6%**
7	3.9%	4.1%	4.7%	4.6%

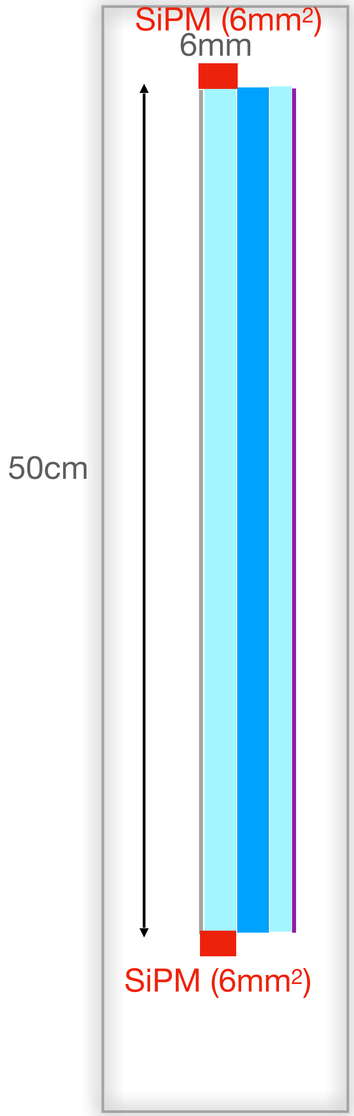
Measurement@CIEMAT

OV	1. DF-XA	2. DF-XA-DS	3. noDF-XA	4. noDF-XA-DS
3.5	(2.9 ± 0.3) %	(3.3 ± 0.3) %	(3.7 ± 0.3) %	(3.5 ± 0.3) %
4.5	**(3.3 ± 0.4) %**	**(3.7 ± 0.4) %**	**(4.2 ± 0.4) %**	**(4.1 ± 0.4) %**
7	(4.2 ± 0.4) %	(4.7 ± 0.5) %	(5.4 ± 0.5) %	(5.2 ± 0.5) %

Motivations for FD3 APEX light trap detectors:
- Remove dichroics
- Adopt two detached acrylic plates design

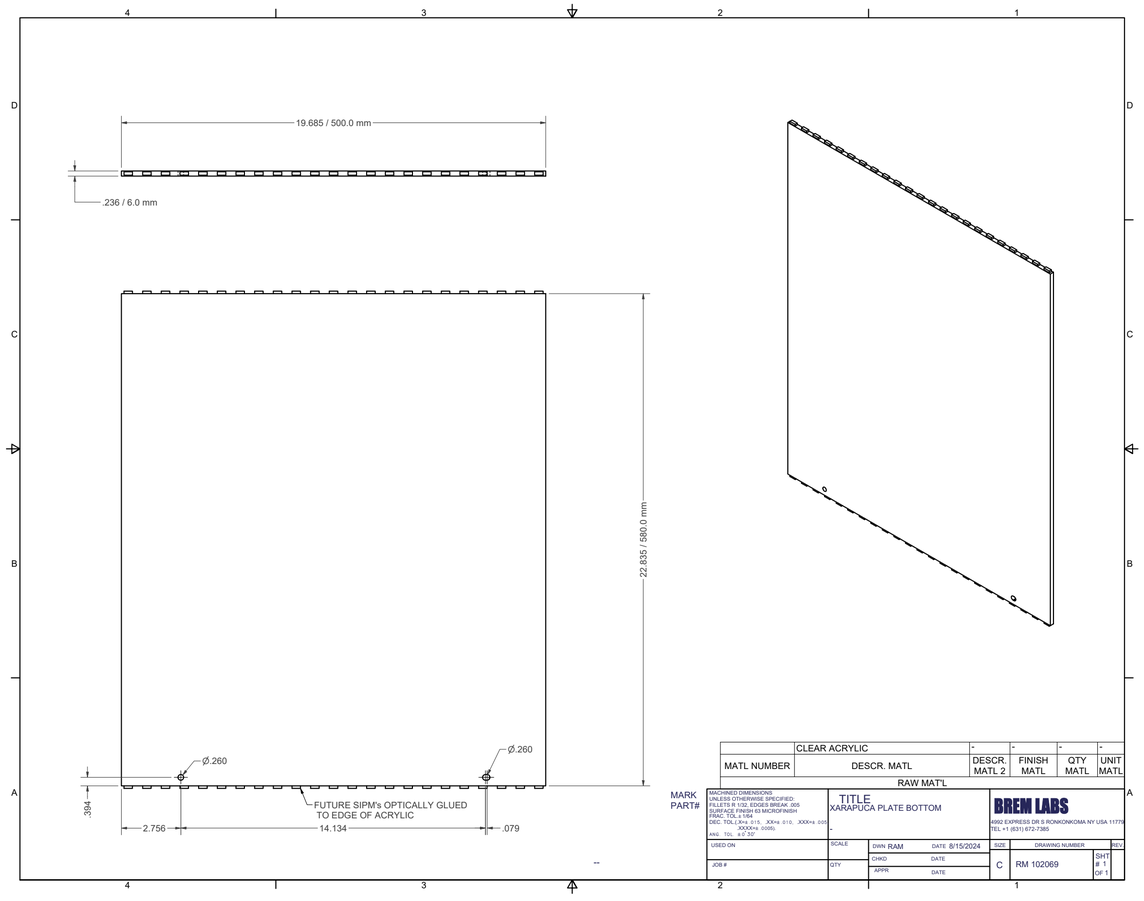
Proposed light trap in 2ton

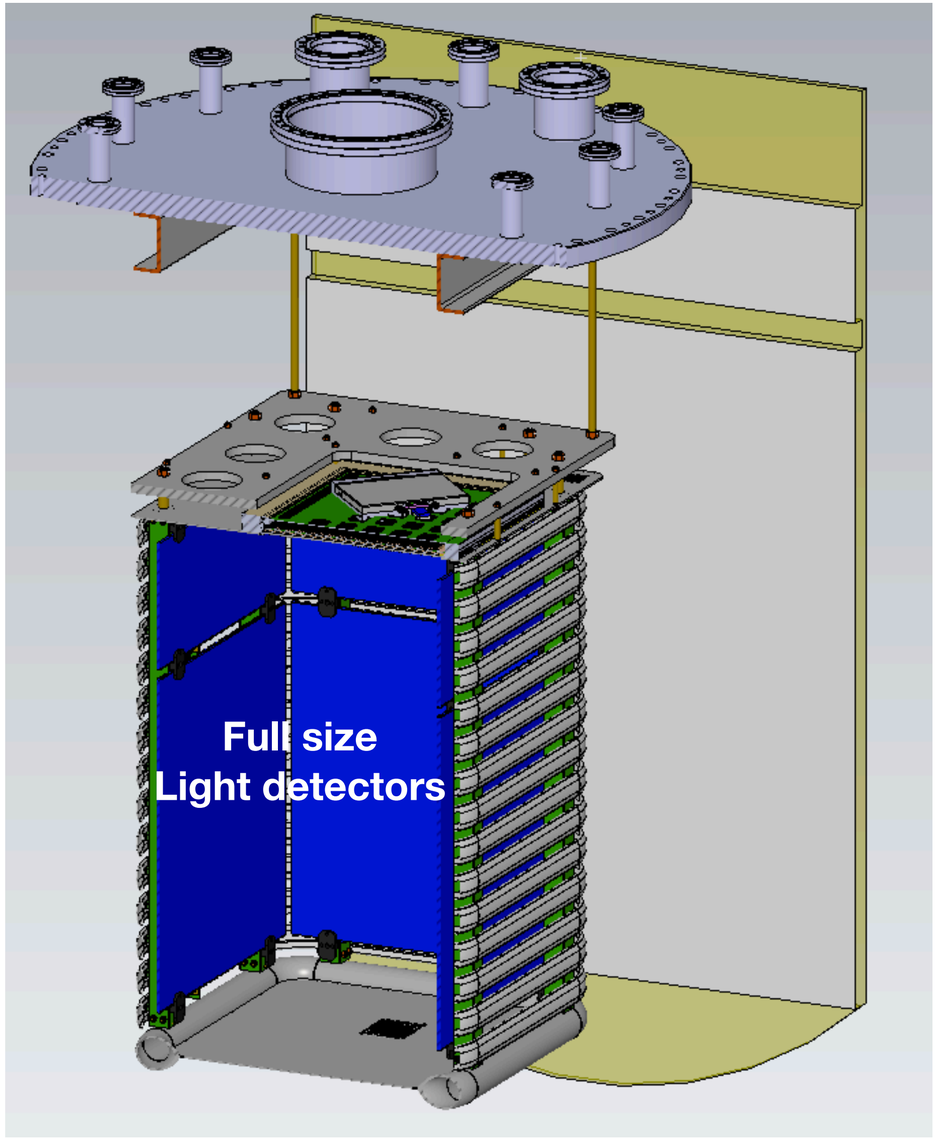
[Reflector - WLS2 - LAr - PMMA - WLS1]
VIKUITI foil - PMMA (doped) - LAr - PMMA - pTP film



Run 2 @ CERN-2ton

- **Run 2 (early 2025)**: **IF** 1st prototype is successful, then maximally reuse the same structure
  - Active photodetector (with WLS functions, SiPM) + PoF/SoF digital readout + fiber routing





Detector Plan for Run 2 (early 2025)

- **Can instrument up to 4 “full size” light trap detectors**
  - **Detached acrylics with LAr in between** (baseline design: 3 options)
    - **1**. PEN plate/foil (INFN-Milano) (VUV→420 nm) + **green** WLS-LG (420 nm→480 nm) → run 2
      - PEN 1/4 (1/2) LE eff. of pTP@RT (LN2)
    - **2.** pTP deposited on PMMA (SBU-CERN - **chemical** brush/spray/spincoat) (VUV→350 nm) + FD2 style **blue** WLS-LG (350 nm→440 nm) → run 2
    - **3.** pTP deposited on PMMA (Milan/SBU-BNL - doctor blade/**evaporation**) (VUV→350 nm) + FD2 style **blue** WLS-LG (350 nm→440 nm) (**uncertain timeline**)
  - **Modified PEN (1 R&D design)**
    - **4.** Modified PEN/PEN embedded & green WLS-LG (**uncertain timeline**)
- **For light trap design 2, and 3**
  - **1st PMMA (for pTP deposit) thickness (design 1 - PEN foil (plate): ~0.25mm (~0.125mm) thick)**
    - For run 2: use **5.5 mm** thick UV(350nm)-transparent PMMA
    - Future aim to 1-2 mm thick? Cryogenic robustness to be tested
    - pTP thickness: FD2 deposit 100-200 μg/cm^2 - several 100 nm thick, efficiency saturates at ~ 500 μ g/cm^2, 127nm light attenuation length ~10 nm.
  - **2nd PMMA (Blue WLS) thickness - 5.5 mm**
    - SiPM is 6 mm x 6 mm / 8 mm x 8 mm
  - **~2 mm** thick LAr layer, any concerns?
  - **To be discussed with design team:** mechanical/HV feasibility of 5.5 mm + 2 mm + 5.5 mm thickness
- **Tentatively for run 2 we will need acrylic plates from INFN-Milano B. (Carla)**
  - 50 cm (wide) x 58 cm (height) x 5.5 mm (thick)
  - 4 WLS-LG (2 blue + 2 green)
  - 2 UV-transparent PMMA for pTP deposit - send to SBU/CERN for chemical coating
  - Contingency x2

[Reflector - WLS2 - LAr - PMMA - WLS1]
VIKUITI foil - PMMA (doped) - LAr - PMMA - pTP film