X-ARAPUCA efficiency for visible light

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on behalf of LabLeptons group

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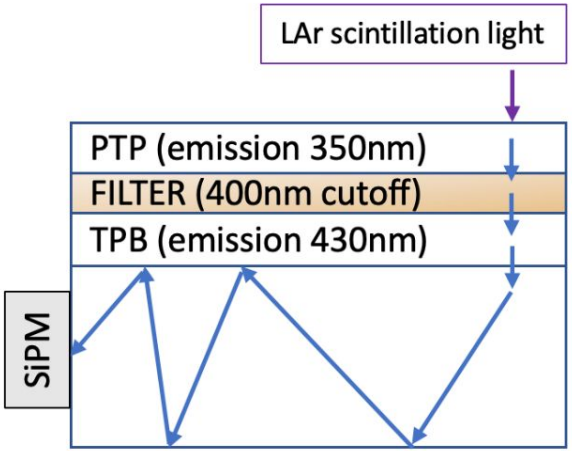
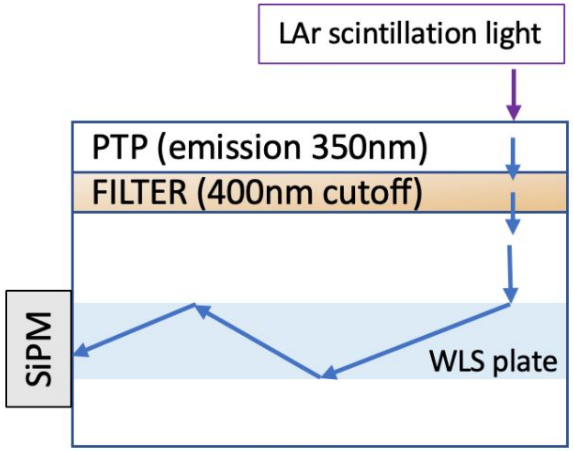
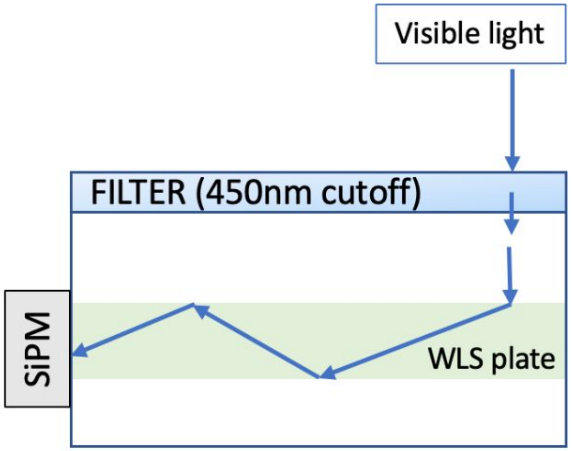
LAB. LEPTONS

ARAPUCA & X-ARAPUCA





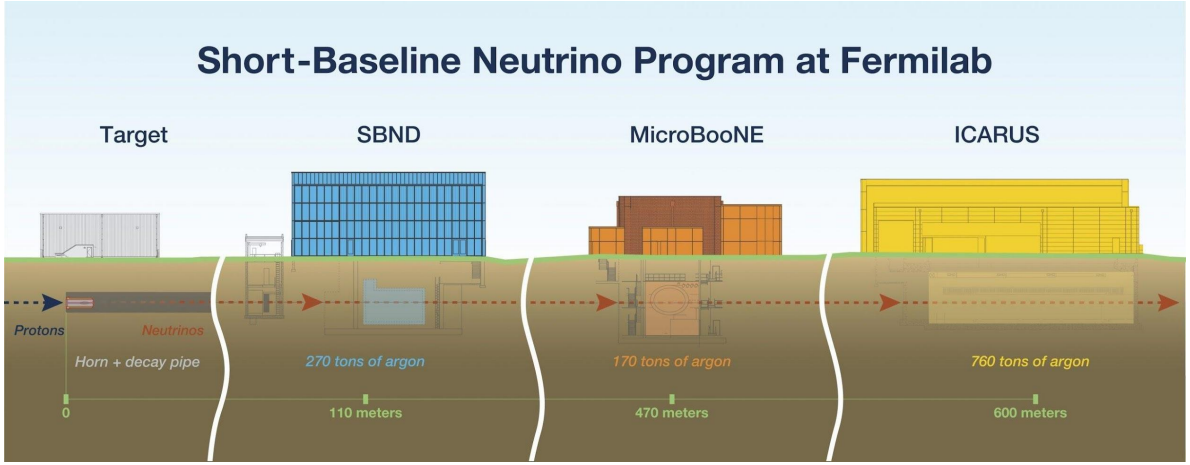


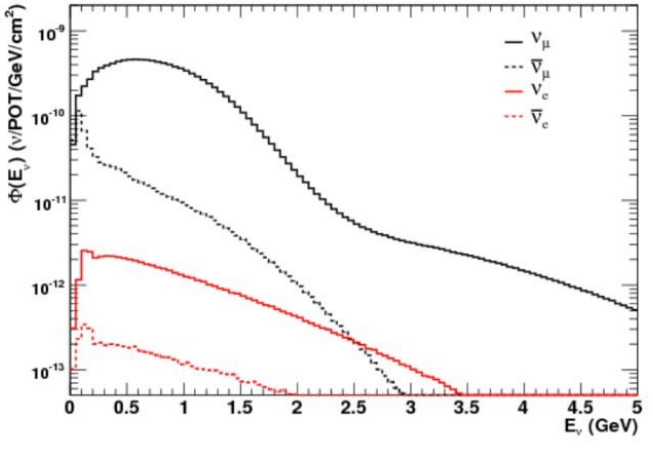
Dichroic filter cutoff **450nm**
NO wavelength shifter **coating** on the filter
Light guide with emission on the **green** wavelength

Motivation

SBN - **S**hort **B**aseline **N**eutrino Program at Fermilab.

Consisting of 3 experiments **(SBND - MicroBooNE - ICARUS)** that use the LArTPC technique and are located a short distance from the particle beam generated in the BNB (Booster Neutrino Beam) at Fermilab.

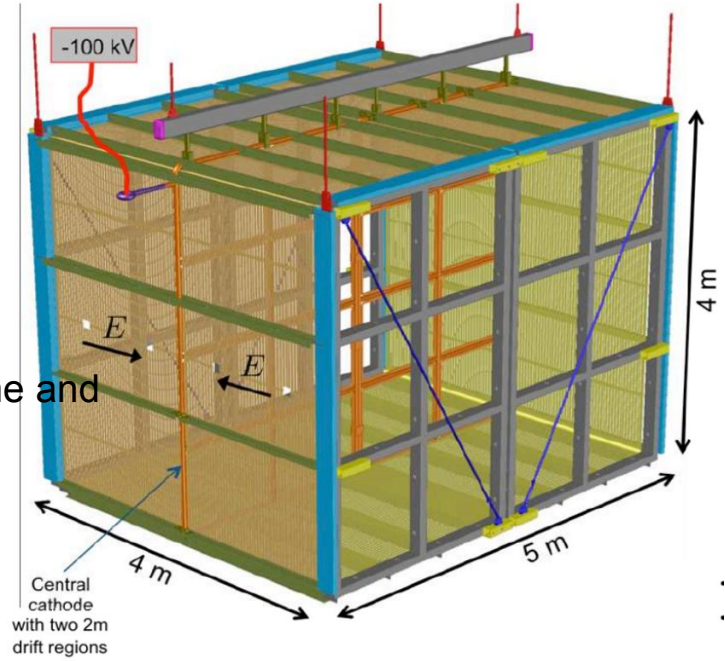




Short Baseline Neutrino Detector

LAr - Time Projection Chamber

- LAr at **87K**
- 112-ton - (4 x 4 x 5)m of active volume - (2 drift volumes)
- Cathode Plane Assembles **(CPA)** – central **(+TPB)**
- Anode Plane Assembles **(APA)** at the ends
- APA has 3 wire planes with 3mm distance between each plane and orientation: vertical (y) and ±60° (U&V)
- **The photon detection system is composed of: PMTs and X-ARAPUCAs**
- **E= 500V/cm**

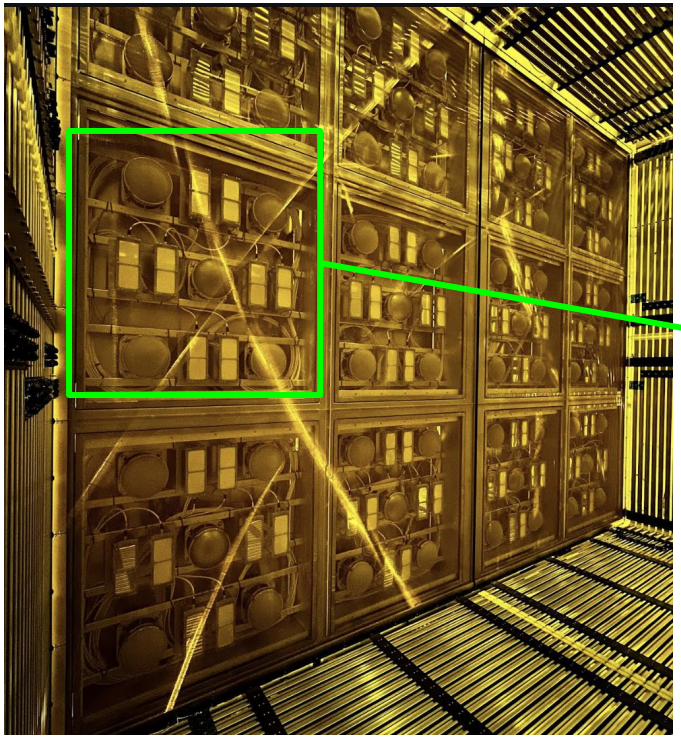


https://arxiv.org/abs/2103.06395

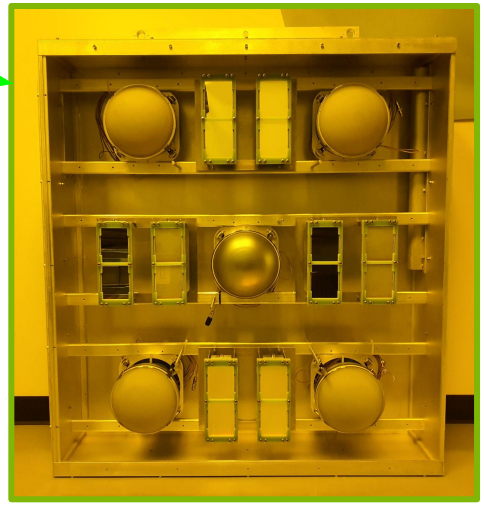
TPC

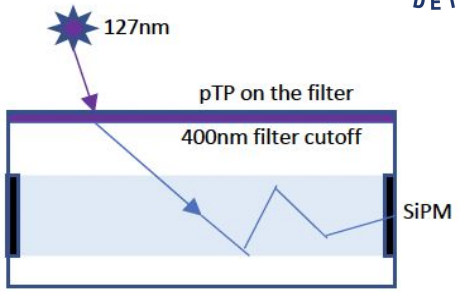
SBND - PDS

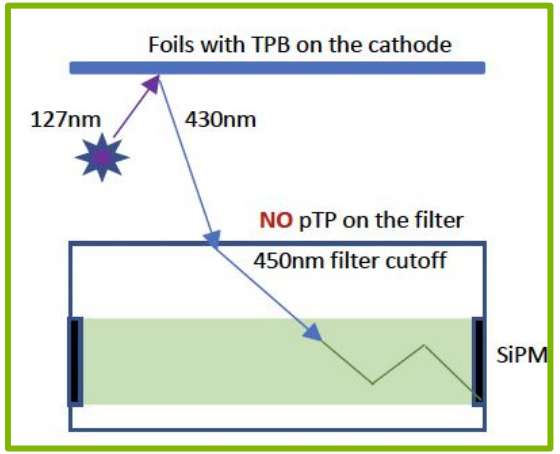
Presented by Rodrigo Alvarez Garrote



- 120 PMTs
- 192 X-ARAPUCAs
  - 96 VUV
  - **96 VIS**

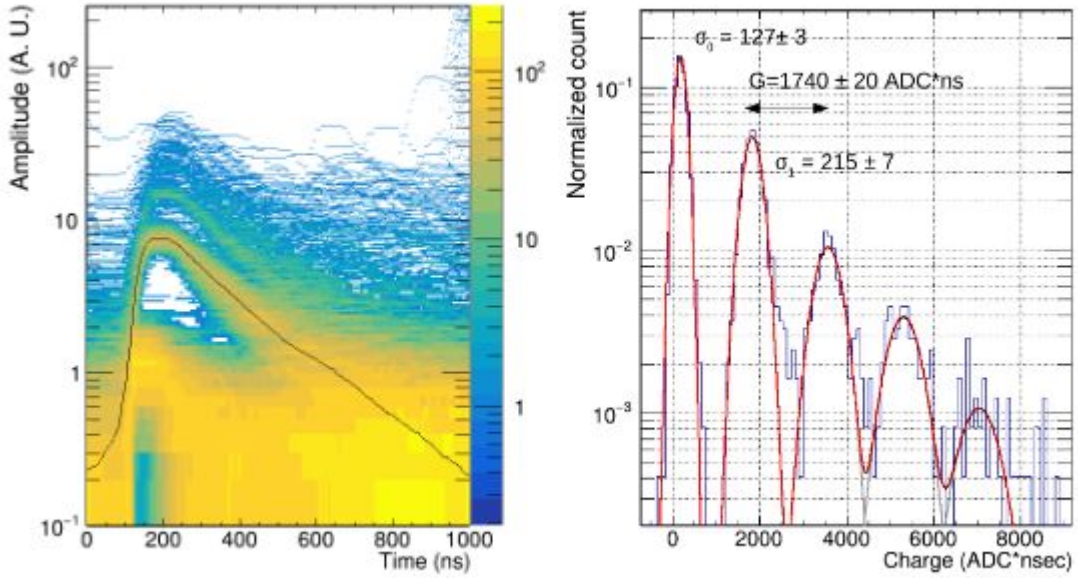






Efficiency for ARAPUCA VUV

From previous work :



Glas to Power	2.9 +- 0.1 %
ELJEN	1.8 +- 0.1%
	2.2 +- 0.5%

https://arxiv.org/abs/2104.07548

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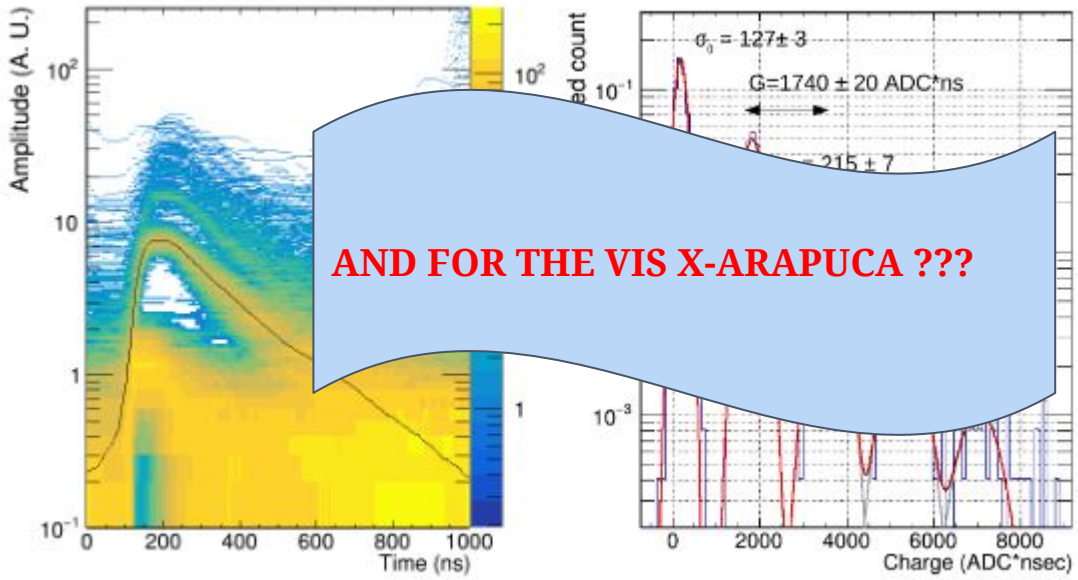
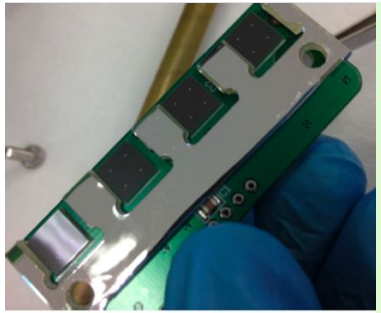


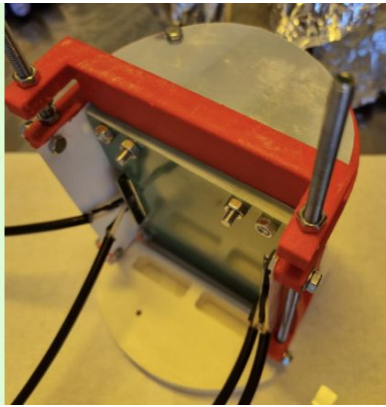
Glas to Power	2.9 +- 0.1 %
ELJEN	1.8 +- 0.1%
	2.2 +- 0.5%

https://arxiv.org/abs/2104.07548

Setup

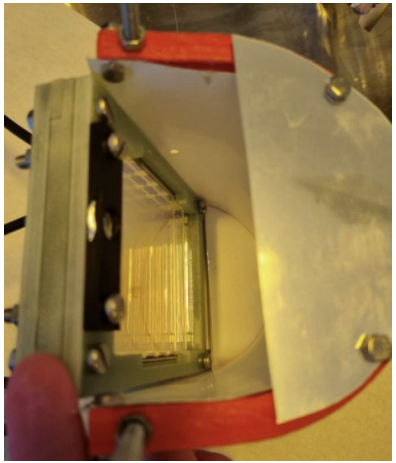
- Single cell X-ARAPUCA
- Cryostat with 6.0 LAr
- Vacuum < $1x10^{-6}$ mbar
- BLUE LED
- APSAIA amplifier (low gain)
- DT1730 digitizer
- SiPM HS (Hamamatsu 6X6mm^2)



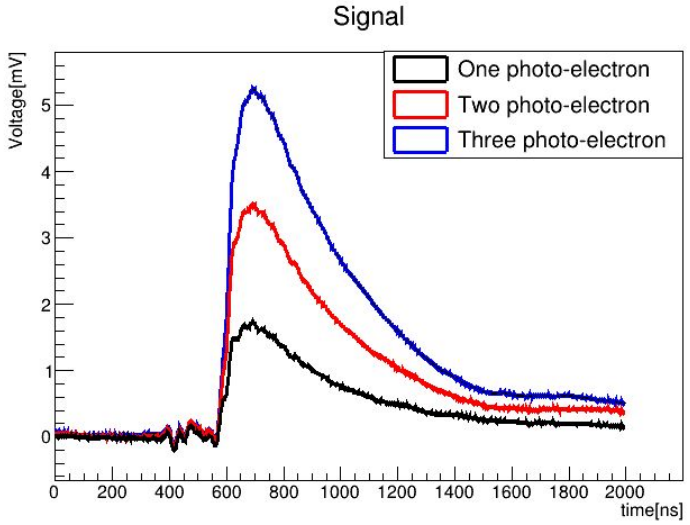


TPB + VIKUITI

Alpha source



Single Photon Electron



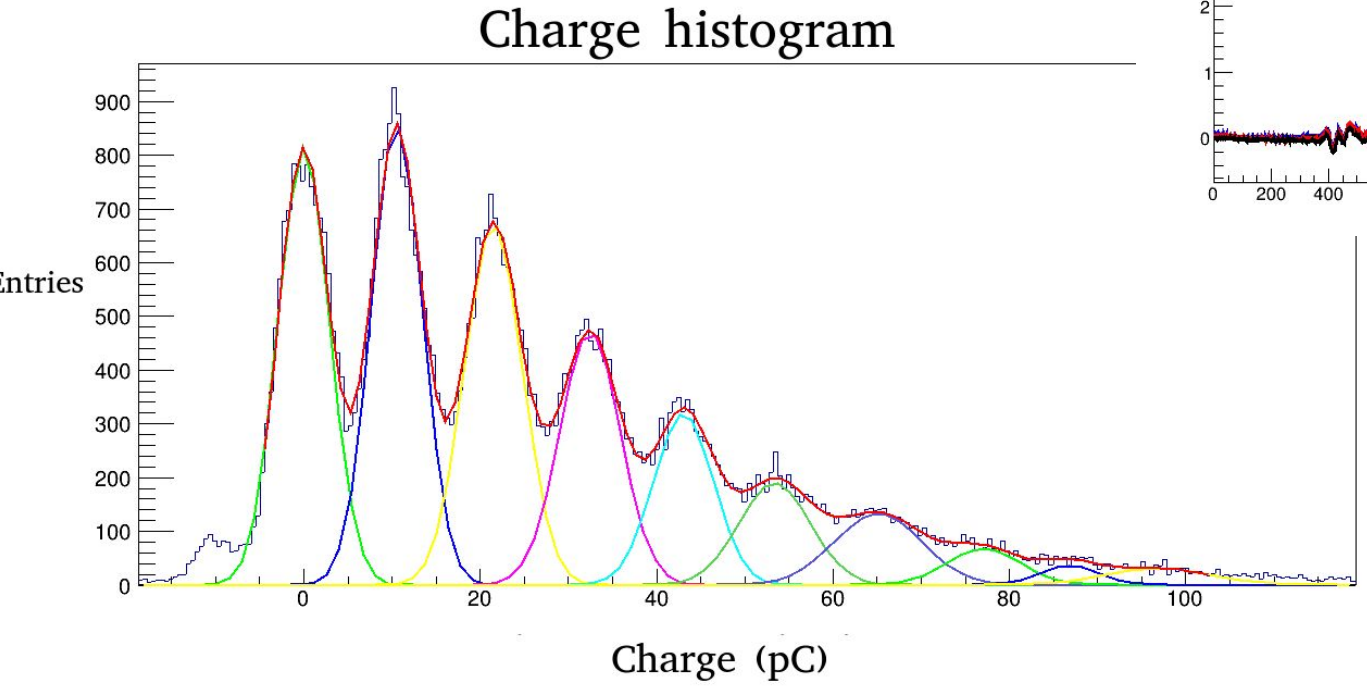
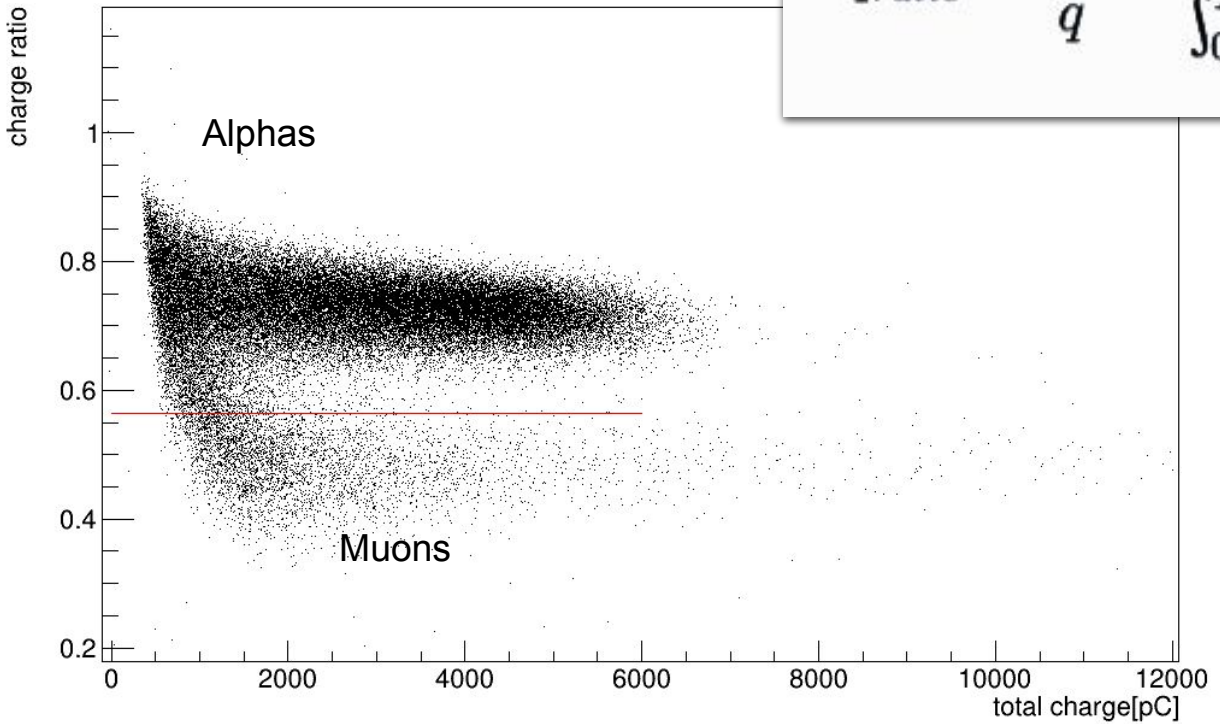


Photo-eletron Charge:
(10.53 ±0.05)pC

Gain = Q/(20.e^-)
= 3.2x10^6

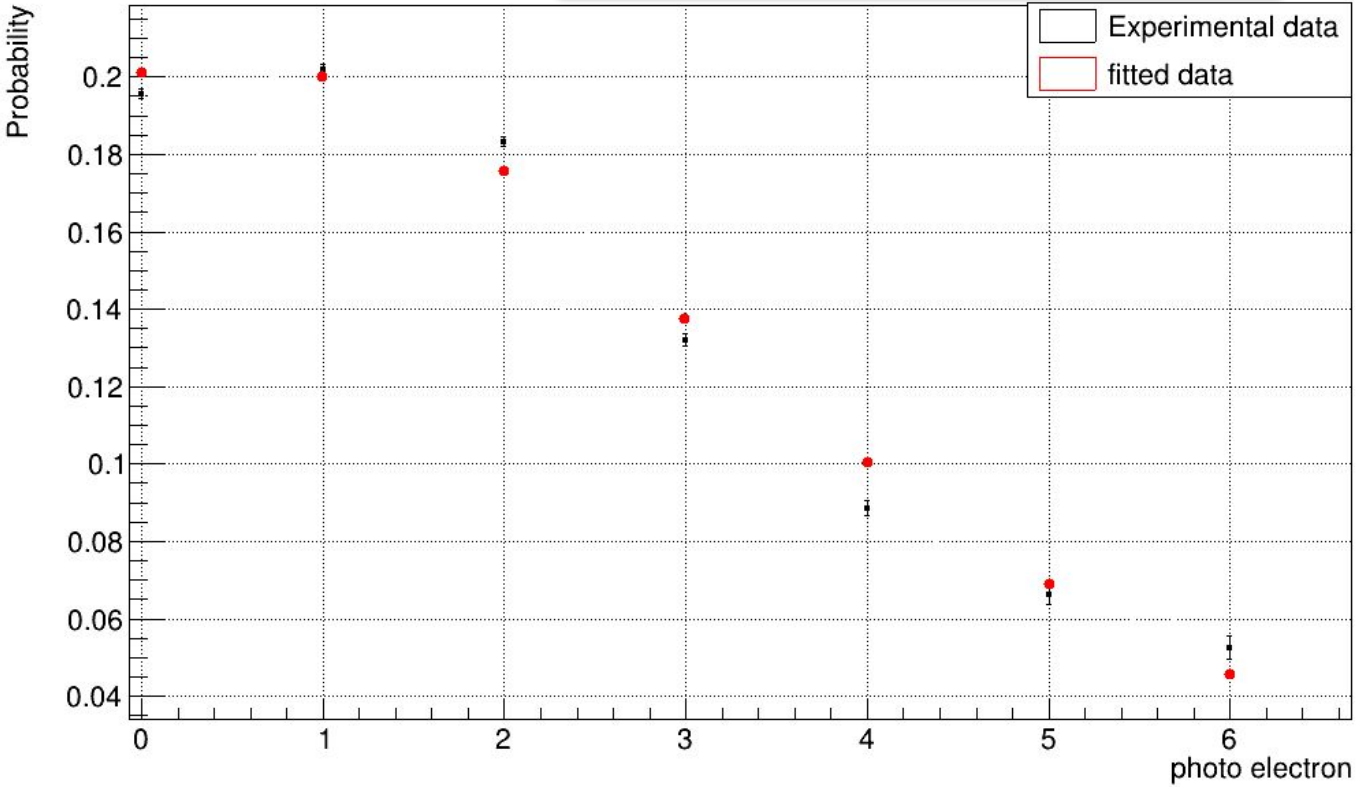
Muons vs Alphas

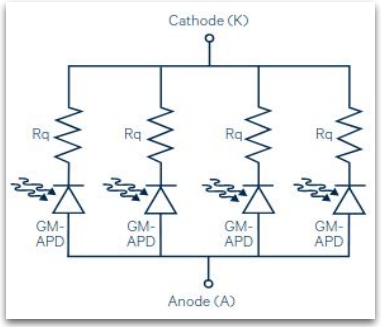
$$q_{ratio} = \frac{q_f}{q} = \frac{\int_0^{t_f} v(t)dt}{\int_0^{T} v(t)dt}$$



Crosstalk

$$P[k] = \frac{1}{k!}\left(\frac{d^k}{ds^k}\left(e^{\frac{\lambda(s-1)}{1-ps}}\right)\right)|_{s=0}$$

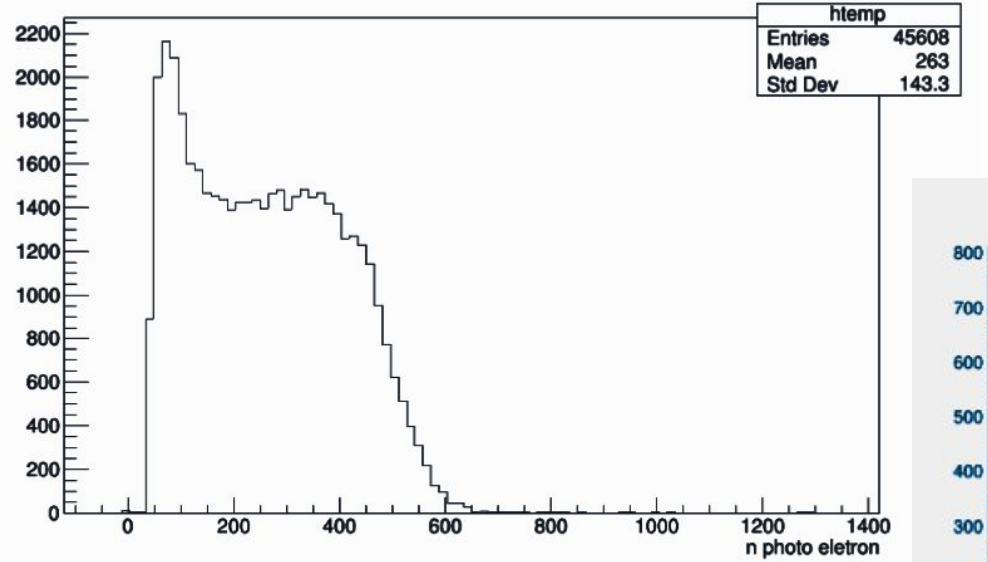


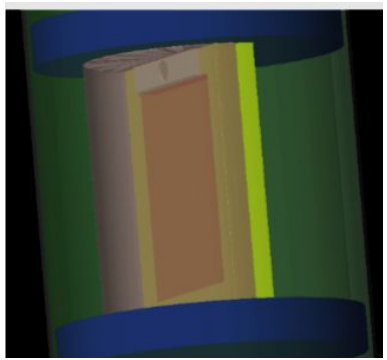


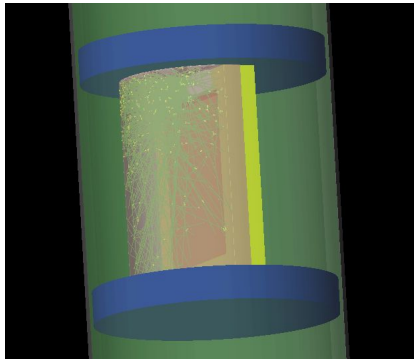
(38.1 ± 2.6)%

Detection Efficiency

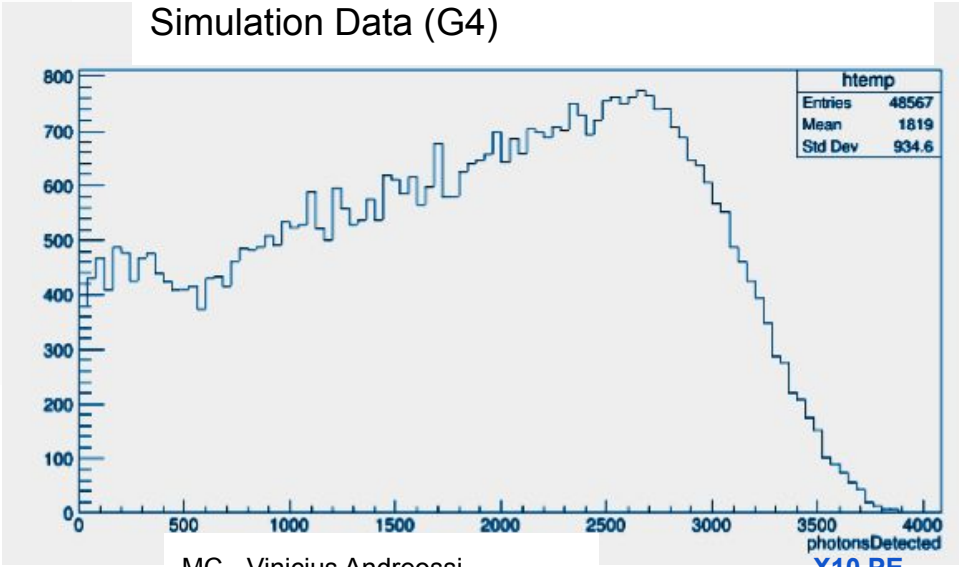
Experimental data







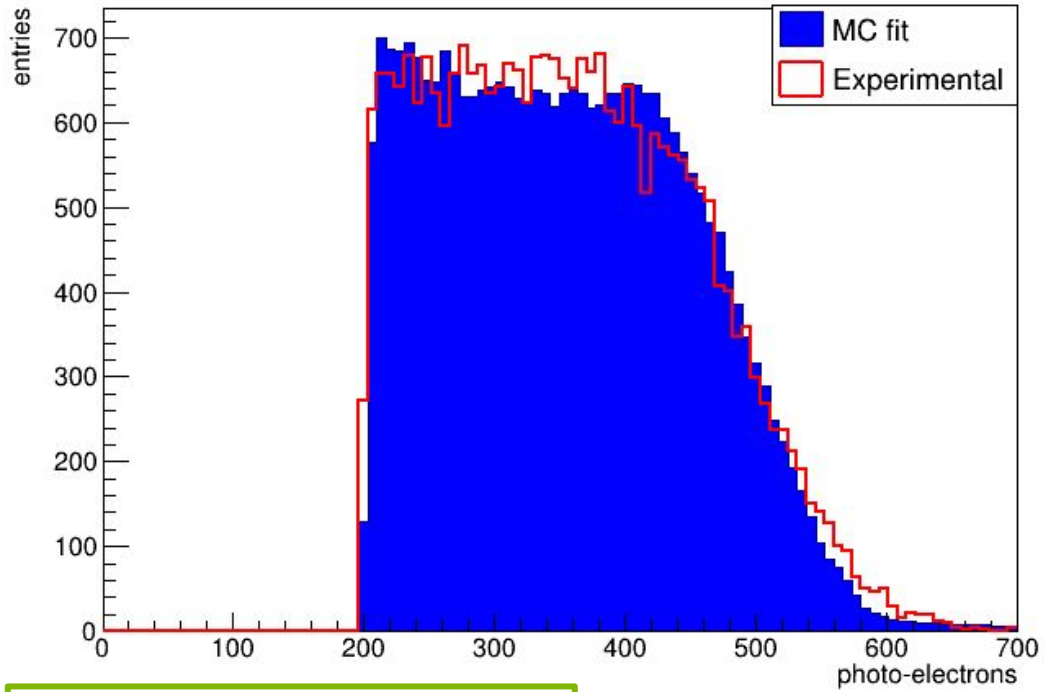
Simulation Data (G4)



MC - Vinicius Andreossi

X10 PE

Detection Efficiency



TPB efficiency: 0.7
https://www.sciencedirect.com/science/article/pii/S0168900211013271

$$\epsilon = \frac{0.0155 \times 2}{1.38 \times 0.7} = 0.032$$

$$(3.20 \pm 0.03)\%.$$

Conclusion

- In SBND we will detect direct LAr scintillation VUV photons and TPB shifted ones coming from the cathode

- The collection efficiency of VUV SBND X-ARAPUCA module was already measured by different groups, in different laboratories. (https://arxiv.org/abs/2106.04505 and https://arxiv.org/abs/2104.07548)
- It ranges from 1.8 to 2.9 %, depending of the sipms and light guide used

- The collection efficiency of a **single cell X-ARAPUCA** for **visible light** was measured for the first time at LabLeptons Laboratory in a small cryostat.
- The collection efficiency measured was: **3.2 ± 0.03%**

- The measure of VIS-X-ARAPUCA, SBND module (double cell) is ongoing

Thank you !!!!!

Acknowledgment :