

FD-VD MegaCell PDE Measurement @CIEMAT

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Goal

Measure absolute LAr PDE for XA-VD (MegaCell)

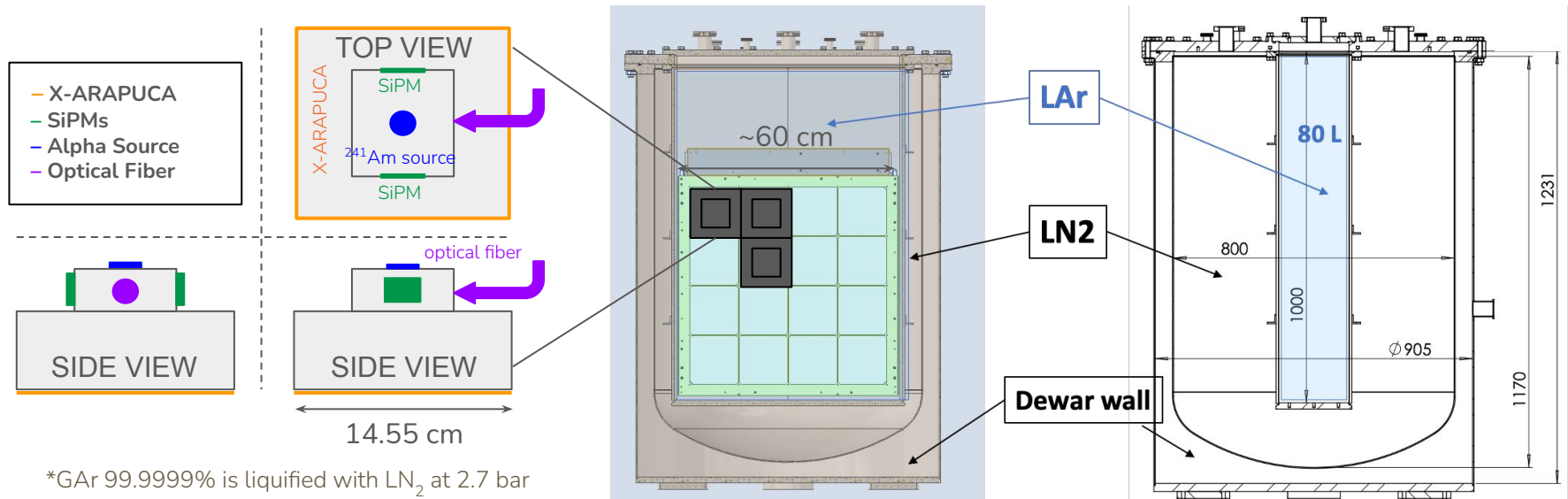
Compare measured MegaCell Configurations:

- Measured using Milano electronics (no undershoot):
- ZAOT-XA: G2P (no dimples) / FBK-TT / $80 \text{ mg}^* \text{kg}^{-1}$ / ZAOT
- W/O-XA: G2P (no dimples) / FBK-TT / $80 \text{ mg}^* \text{kg}^{-1}$ / *w/o Filter

*This new configuration uses pTP coated substrates.

Setup Description

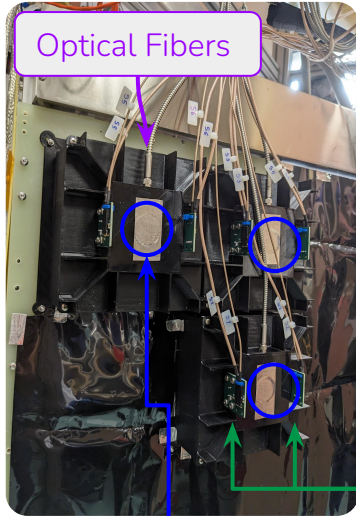
- **MegaCell PDE** measured wrt. the known efficiency of reference VUV SiPMs in *LAr with light from three ^{241}Am alpha sources at the **only 3 unidentical XA positions**.



Setup Description: Ref. Sensors

Calibration Boxes

Optical Fibers



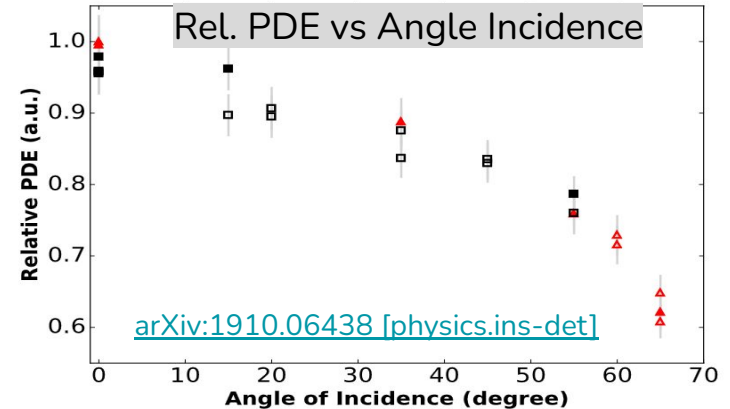
3 Alpha Sources

SiPM

- Ref. SiPMs: HPK VUV4 SiPMs S13370 – 6075CN.
- Characterised at CIEMAT ([L. Pérez DUNE CM](#)).
- Measured Xtalk: $(14.7 \pm 0.5)\%$ @ 4 OV & CT.
- Measured SiPM efficiency @ CT VUV 127 nm:

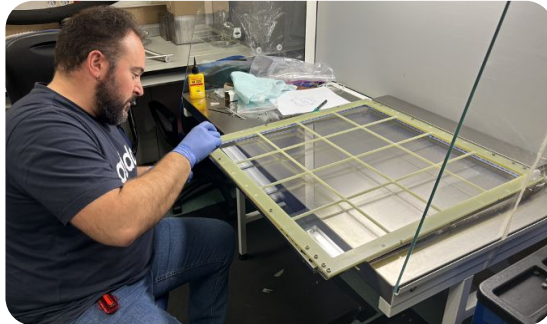
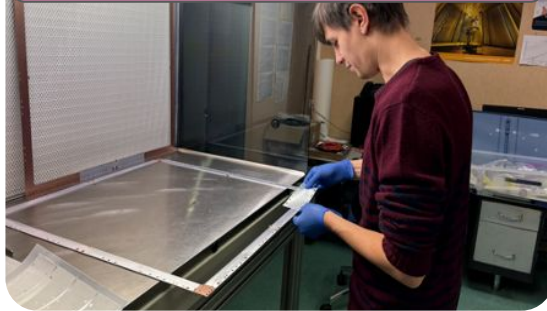
$$\epsilon_{\text{Ref.}}^{\perp} = (12.3 \pm 1.09)\%$$

*Absolute value is corrected for specific incidence angle

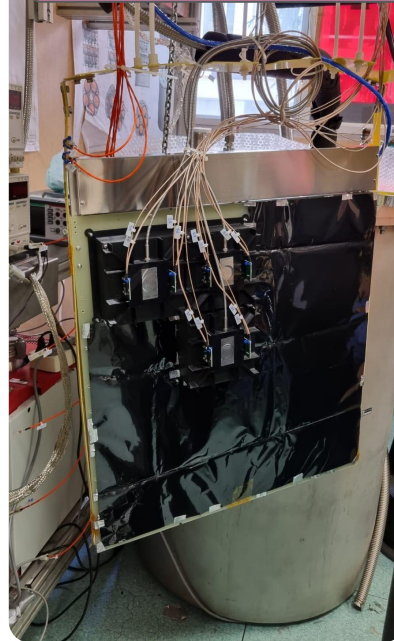


Setup at CIEMAT: X-ARAPUCA Assembly & Insertion

XA-Assembly

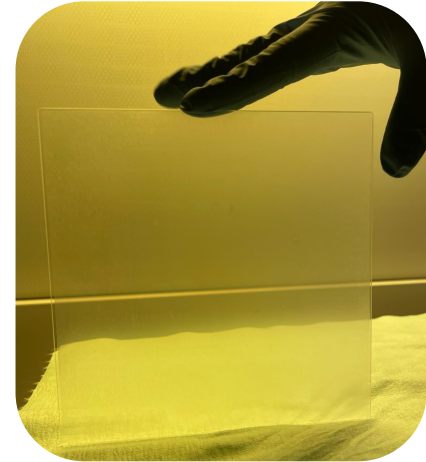
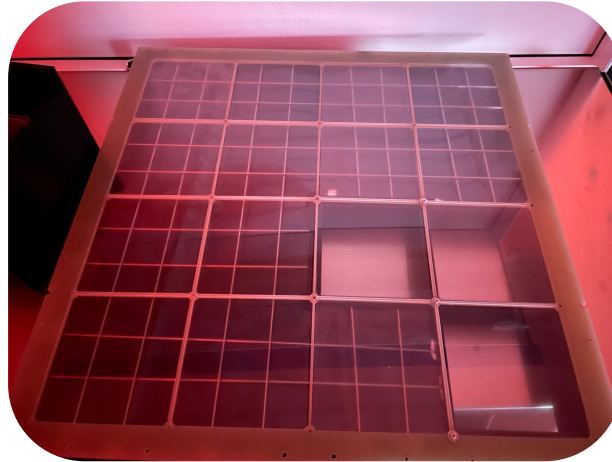
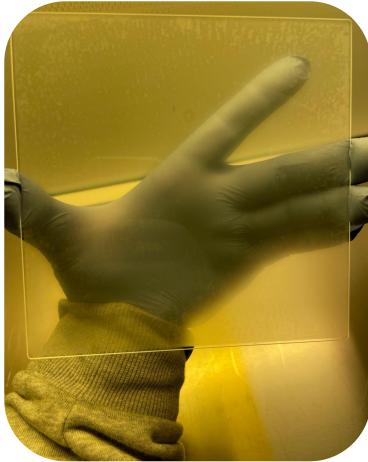


Inserting the VD-XA in the vessel



Setup at CIEMAT: X-ARAPUCA Substrate w/o filter.

- New configuration tested with pTP coated substrate windows w/o dichroic filter.

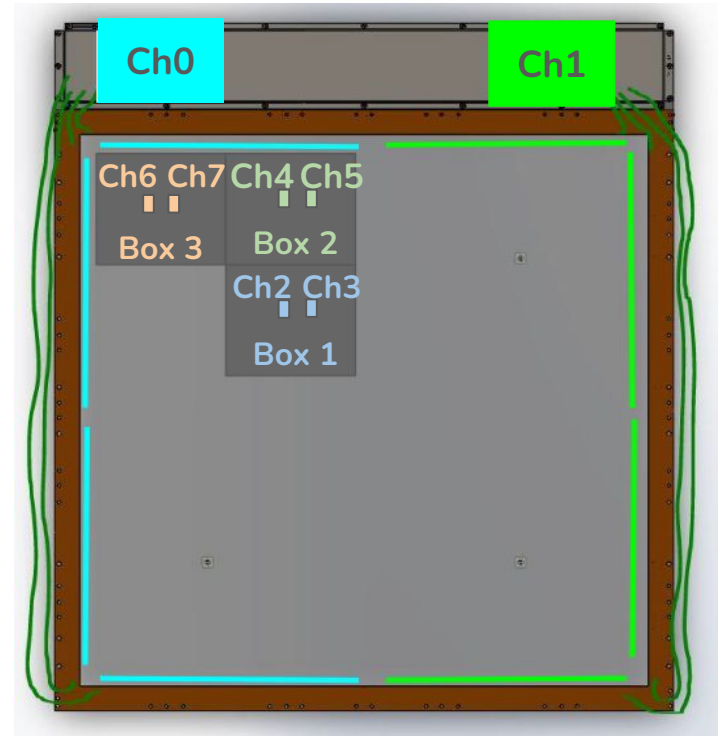


MegaCell Configurations

- ZAOT-XA Dichroic: ZAOT (Module-0); W/O-XA No Dichroic filter
- SiPMs: 160 FBK-TT
- WLS: G2P w/o dimples (80 mg/kg Chr.)
- Electronics: (from Milano) w/o undershoot

Config	Setup Timeline	
ZAOT-XA	Membrane XA assembly	Jul. 23
ZAOT-XA	LAr setup commissioning	Aug. 23
ZAOT-XA	Gain and noise characterization LN ₂	Sep. 23
ZAOT-XA	LAr PDE Data taking	(13 th - 15 th) Dec. 23
W/O-XA	Noise characterization LN ₂	Mar. 24
W/O-XA	LAr PDE Data taking	(13 th - 14 th) Mar. 24

Setup Channel Arrangement

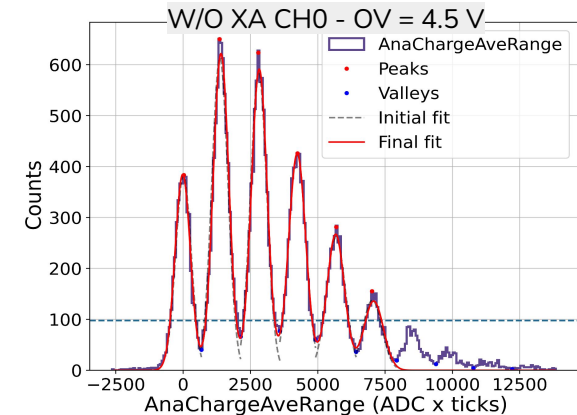
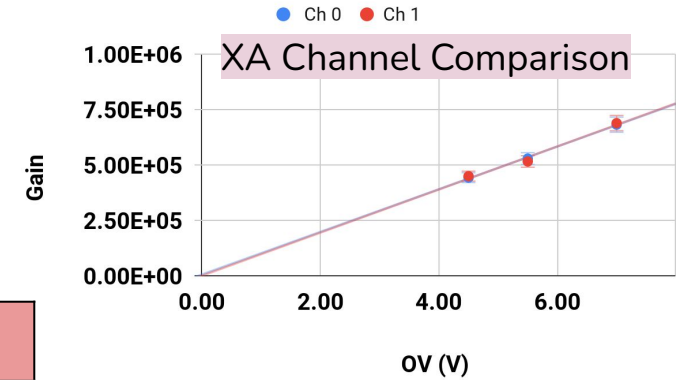


XA Gain and S/N

- Both XA-channels successfully calibrated.
- Compatible results between configs.

ZAOT XA	XA0			XA1		
OV	Gain e ⁻	DGain e ⁻	S/N	Gain e ⁻	DGain e ⁻	S/N
7.0	6.86E+05	1.5E+03	5.37	6.94E+05	2.1E+03	5.86
5.5	5.29E+05	9.3E+02	6.50	5.18E+05	1.5E+03	7.24
4.5	4.45E+05	1.3E+03	4.48	4.51E+05	2.0E+03	4.54

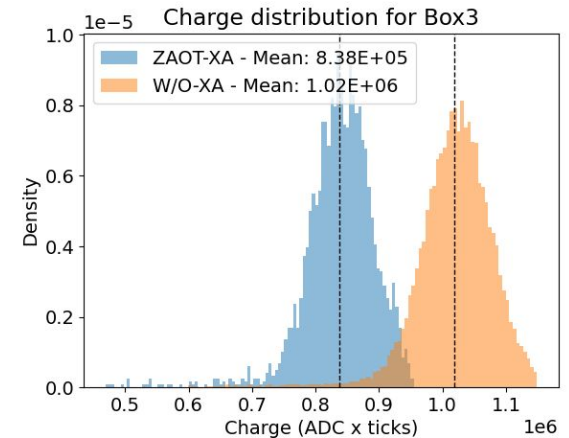
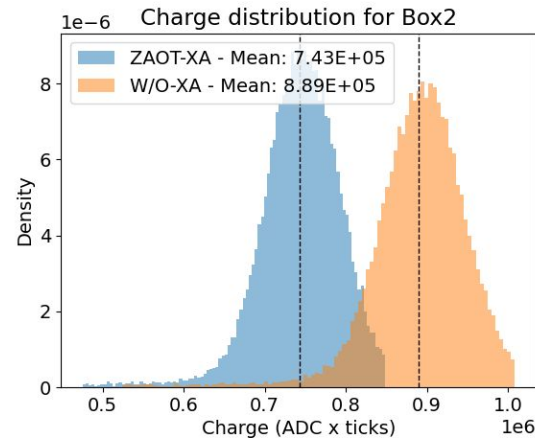
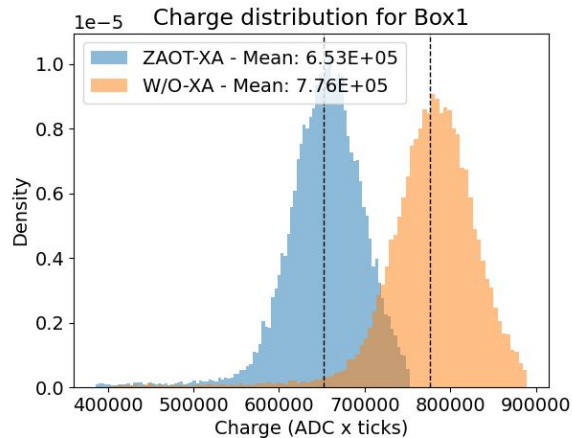
W/O XA	XA0			XA1		
OV	Gain e ⁻	DGain e ⁻	S/N	Gain e ⁻	DGain e ⁻	S/N
7.0	6.64E+05	1.2E+03	6.47	6.91E+05	1.7E+03	5.95
5.5	5.13E+05	7.6E+02	5.37	5.35E+05	1.2E+03	5.45
4.5	4.33E+05	7.2E+02	4.56	4.28E+05	6.8E+02	4.57



MegaCell Charge Difference

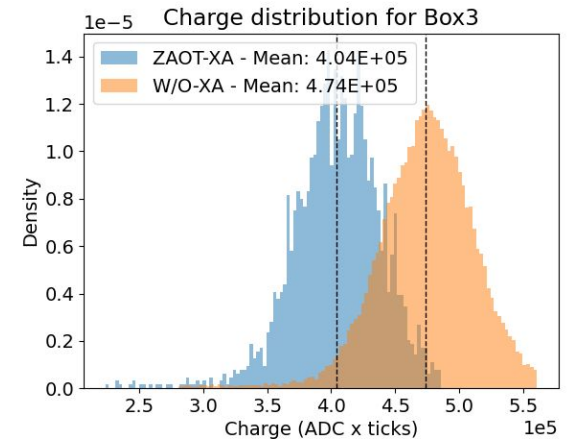
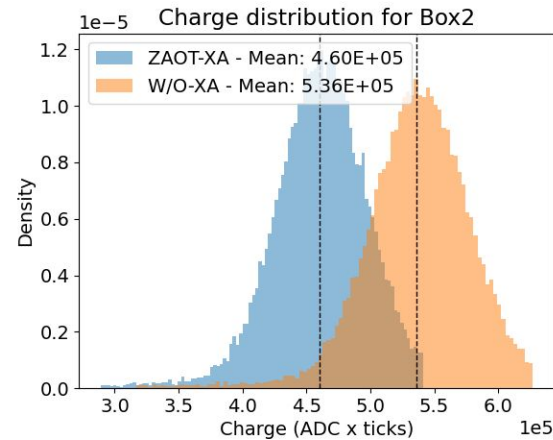
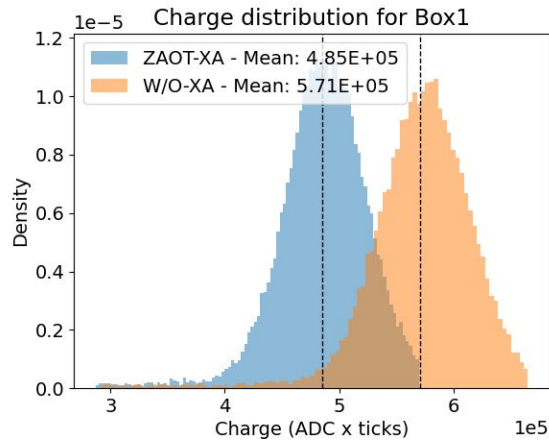
- From ref. SiPM we observe decrease in produced light of $\sim 3.5\%$ \rightarrow Similar purity!
- Observed increase in collected charge! XA w/o filter sees $\sim 24 - 21\%$ (for ch0 - ch1) **more charge** (after correcting for abs. light difference).

MegaCell Ch0 - OV 4.5 V - Config. Comparison



MegaCell Charge Difference

MegaCell Ch1 - OV 4.5 V - Config. Comparison



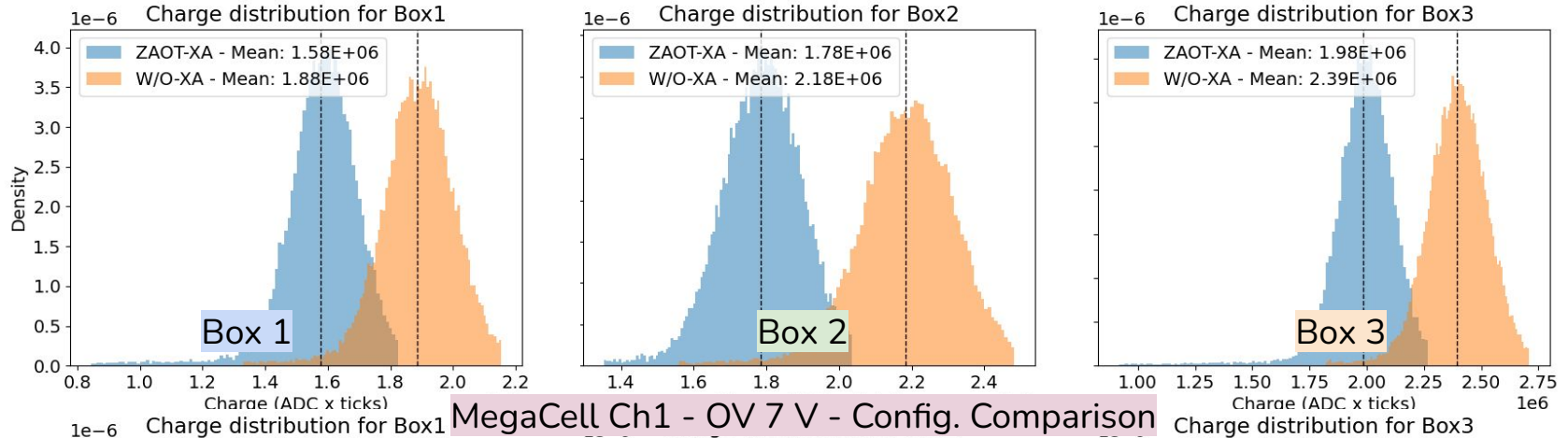
*See backup for all 7, 3.5 OV values

Conclusions

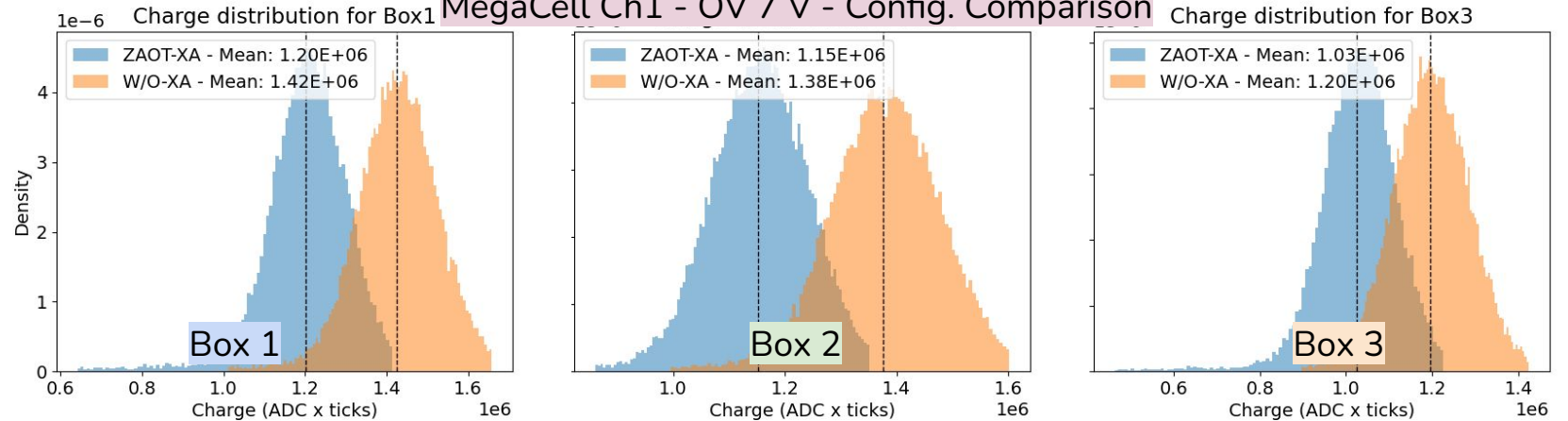
- Setup shows stable measurement conditions among different MegaCell configs.
- Showing **preliminary CIEMAT measurement** of the absolute MegaCell PDE @CT in LAr for the 3 different positions and for 2 different setups.
- XA w/o dichroic filter sees **~20% more light** wrt. previous config. Complete analysis ongoing!
- **Next measurement proposal:**
 - MegaCell with **24 mg/kg Chromophore** concentration and pTP coated substrates (no filters).

BACKUP

MegaCell Ch0 - OV 7 V - Config. Comparison

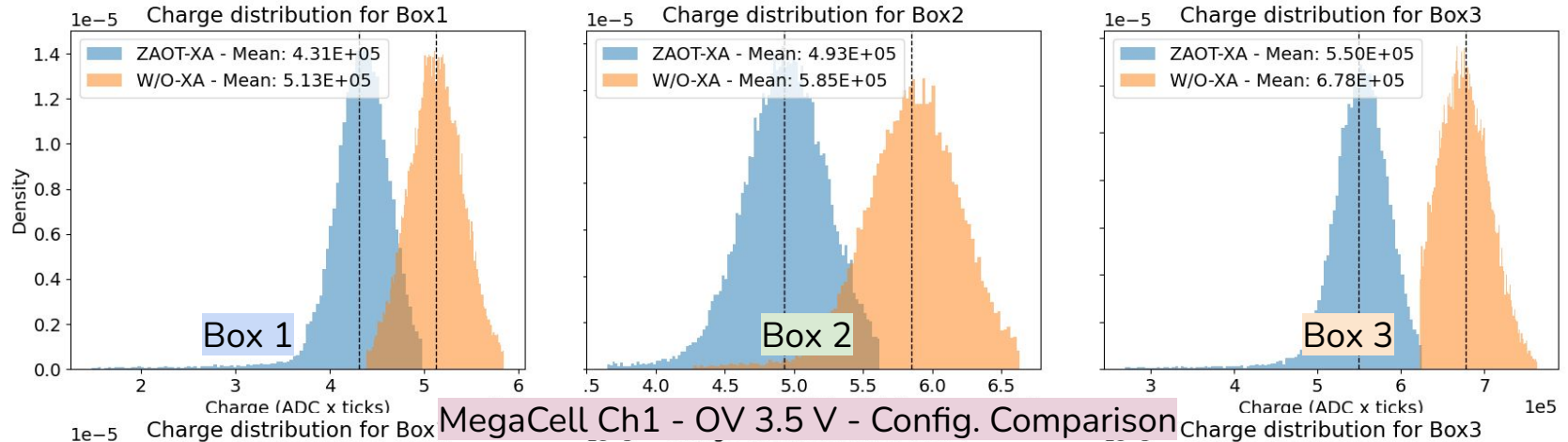


MegaCell Ch1 - OV 7 V - Config. Comparison

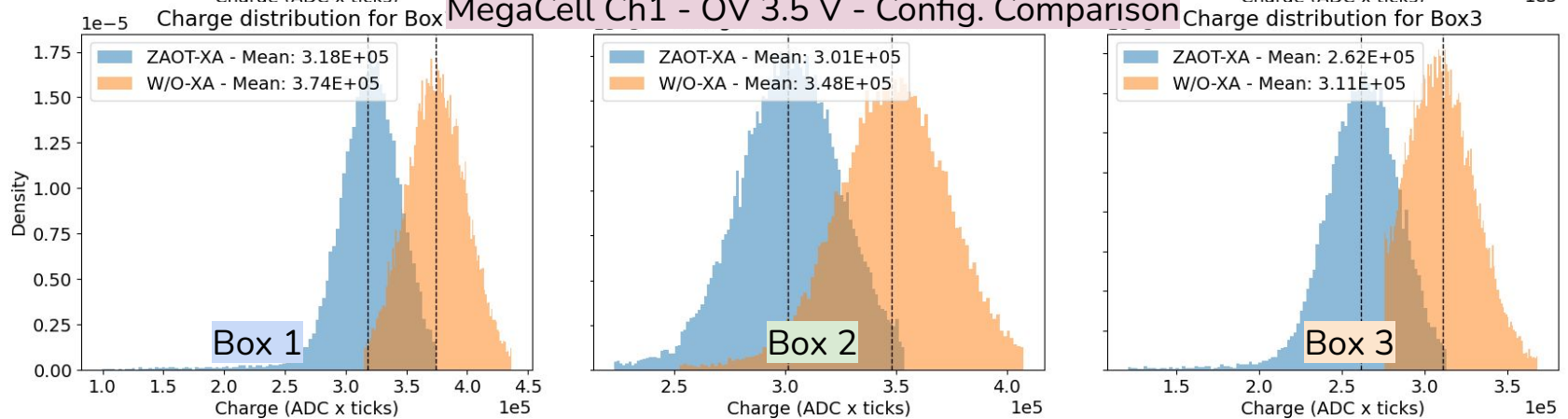


DUNE PH. COLLECTOR - 19 MAR 2024

MegaCell Ch0 - OV 3.5 V - Config. Comparison



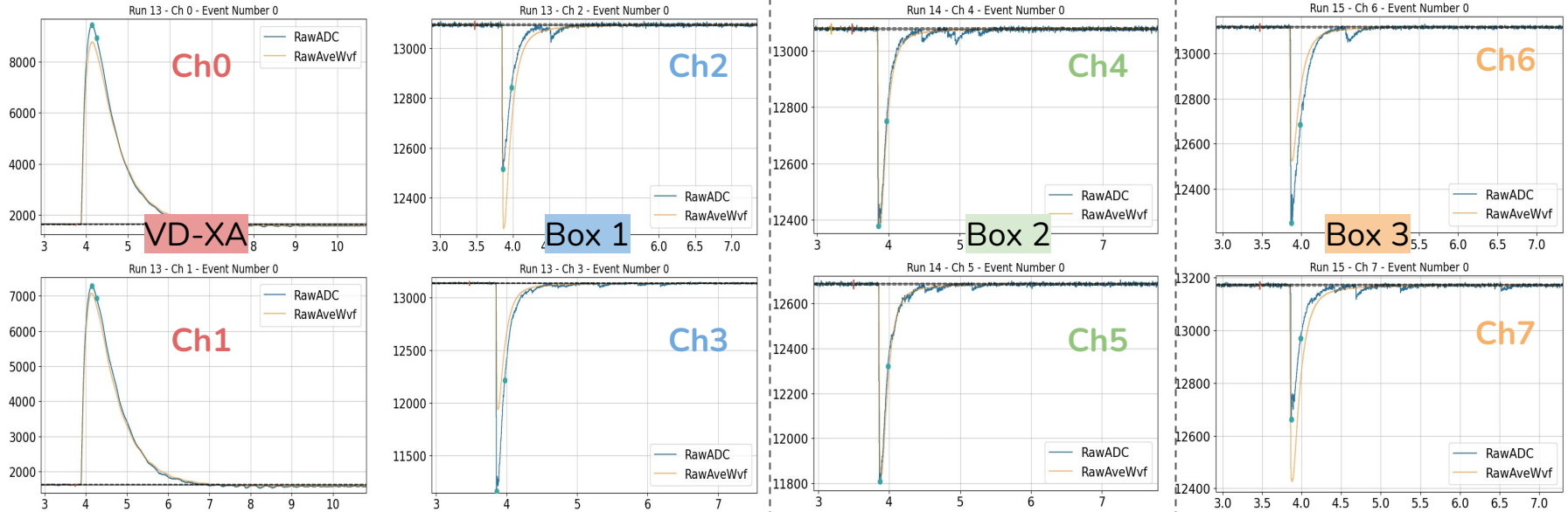
MegaCell Ch1 - OV 3.5 V - Config. Comparison



Scintillation Charge Comparison

OV	Box	Dic_23	Mar_24	Diff.	Dic_23	Mar_24	Diff.
Config		Cannel 0			Channel 1		
7,0	1	1,54E+06	1,89E+06	23,32%	1,17E+06	1,43E+06	22,25%
7,0	2	1,73E+06	2,19E+06	26,96%	1,12E+06	1,38E+06	23,92%
7,0	3	1,93E+06	2,40E+06	24,38%	9,97E+05	1,20E+06	20,18%
4,5	1	6,34E+05	7,83E+05	23,51%	4,71E+05	5,76E+05	22,10%
4,5	2	7,21E+05	8,96E+05	24,29%	4,46E+05	5,40E+05	20,87%
4,5	3	8,13E+05	1,02E+06	25,94%	3,91E+05	4,76E+05	21,69%
3,5	1	4,21E+05	5,13E+05	21,82%	3,10E+05	3,74E+05	20,67%
3,5	2	4,77E+05	5,87E+05	23,00%	2,92E+05	3,49E+05	19,66%
3,5	3	5,34E+05	6,73E+05	25,89%	2,54E+05	3,08E+05	21,13%
				24,34%			21,38%

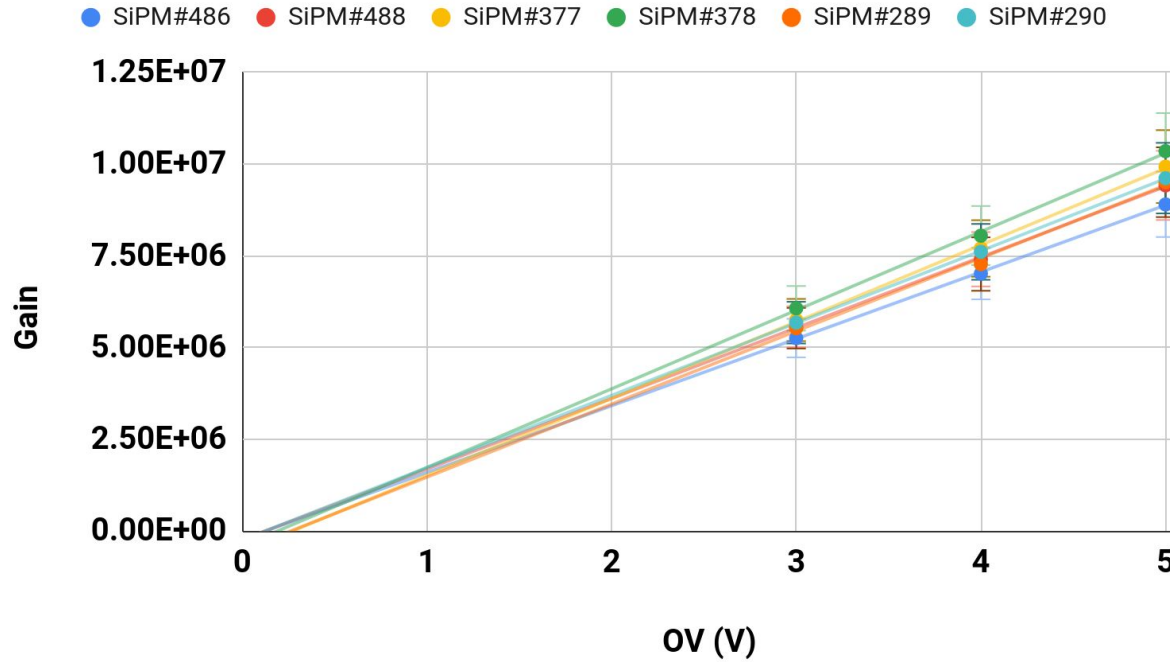
Event examples



- Ref. sensors in each Box provide trigger conditions based on **threshold + coincidence**.
- → Clean sample of alpha scintillation signals.

XA Gain and S/N

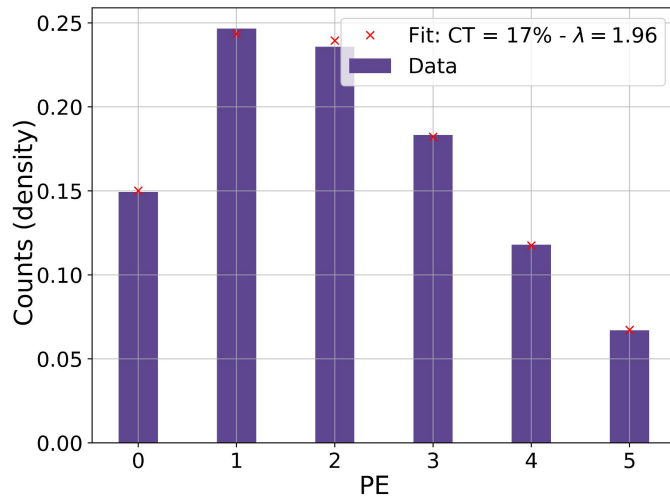
MegaCell Setup: SiPM Gain



Updated XTalk Computation!

- Selected method for computation **Vinogradov model**: Fit composite poissonian to describes the effect of cross-talk.

OV 4.5 - Ch0 - XTalk Estimation Fit



XTalk Summary

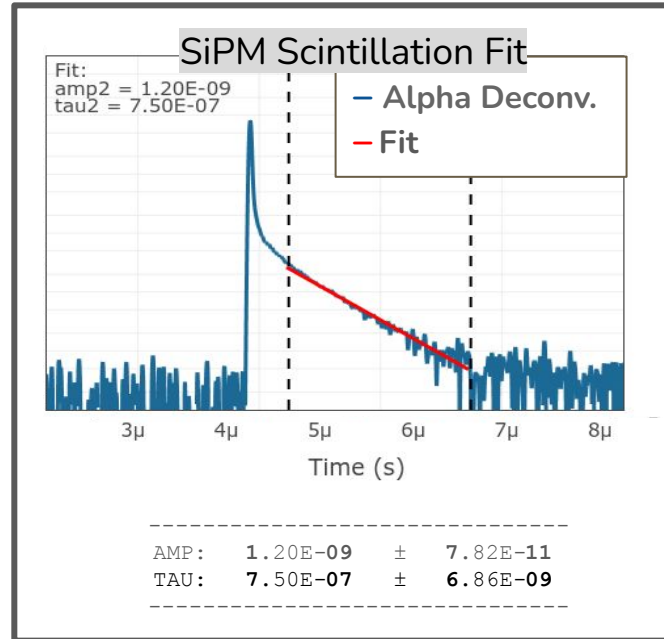
XA	Ch 0	Ch 1
OV	XT %	XT %
7	32±8	35±2
4.5	17±2	19±1
3.5	13±2	12±1

Duplication Factor

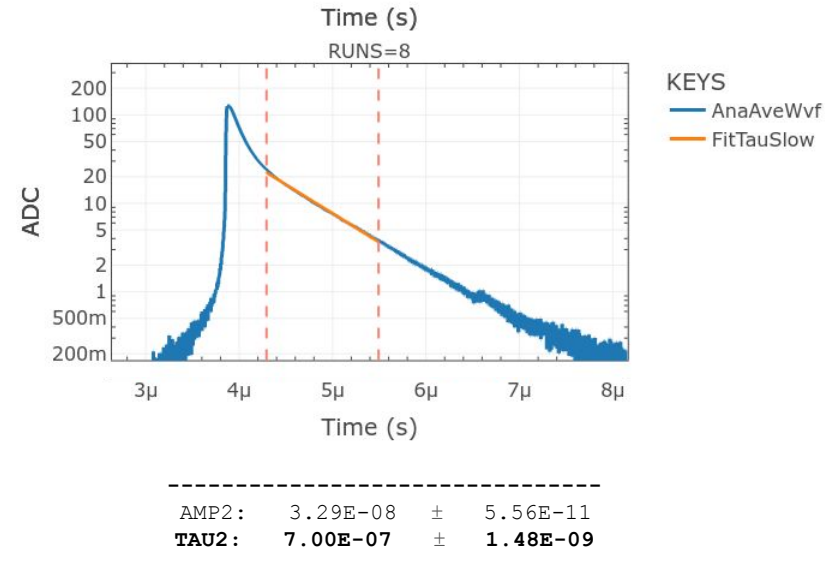
XA	Ch 0	Ch 1
OV	XT %	XT %
7	0.68±0.05	0.65±0.01
4.5	0.82±0.03	0.81±0.01
3.5	0.87±0.03	0.88±0.01

Setup Purity

- Purity change corresponds to measured light decrease of $\sim 3.5\%$.



Presented @ CM



W/O FILTER XA

FD2-VD X-ARAPUCA calibration in LN₂

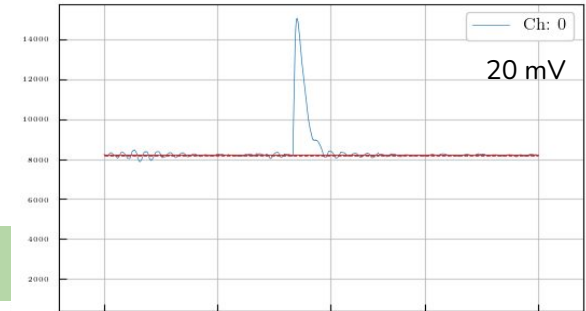
Calculation of the amplification factor (gain) of the new electronics with a controlled input from a pulse generator:

$$\frac{Q_{\text{out}} [(ADC \cdot \text{tick}) \cdot 2(V) / 2^{14} (ADC) \cdot 4(\text{ns})]}{Q_{\text{in}} [V_{\text{in}}(\text{mV}) \cdot 1(\text{nF})]} = 10813$$

Input V (mV)	Area (ADC/ticks)	Gain
10	221 000	10 780
15	331 000	10 770
20	446 000	10 890

Electronics amplification factor = 10813
[ADC x ticks] → [pC] factor = 22145.024

Input



XA output area

