Scintillation time profile in PD-VD using PMTs

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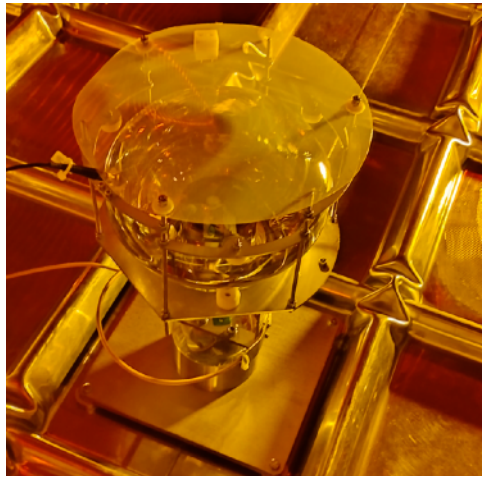
1. Introduction

Objectives

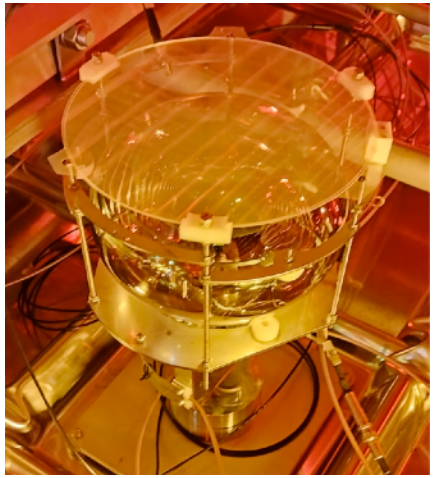
- Understand the time profile of the different time components using various combinations of WLS (PEN, TPB), Quartz windows and Xenon concentrations

Installation aspects

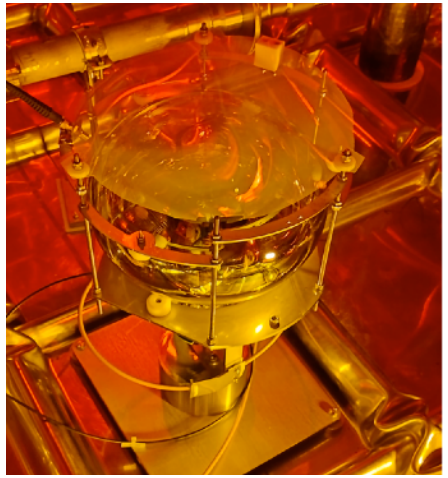
- IFIC (J. Soto) organized and installed Quartz windows on several PMTs and X-ARAPUCAS on ProtoDUNE-VD
- They are Photon Export UV Grade Fused Silica glasses, already characterized at IFIC



PMT with PEN

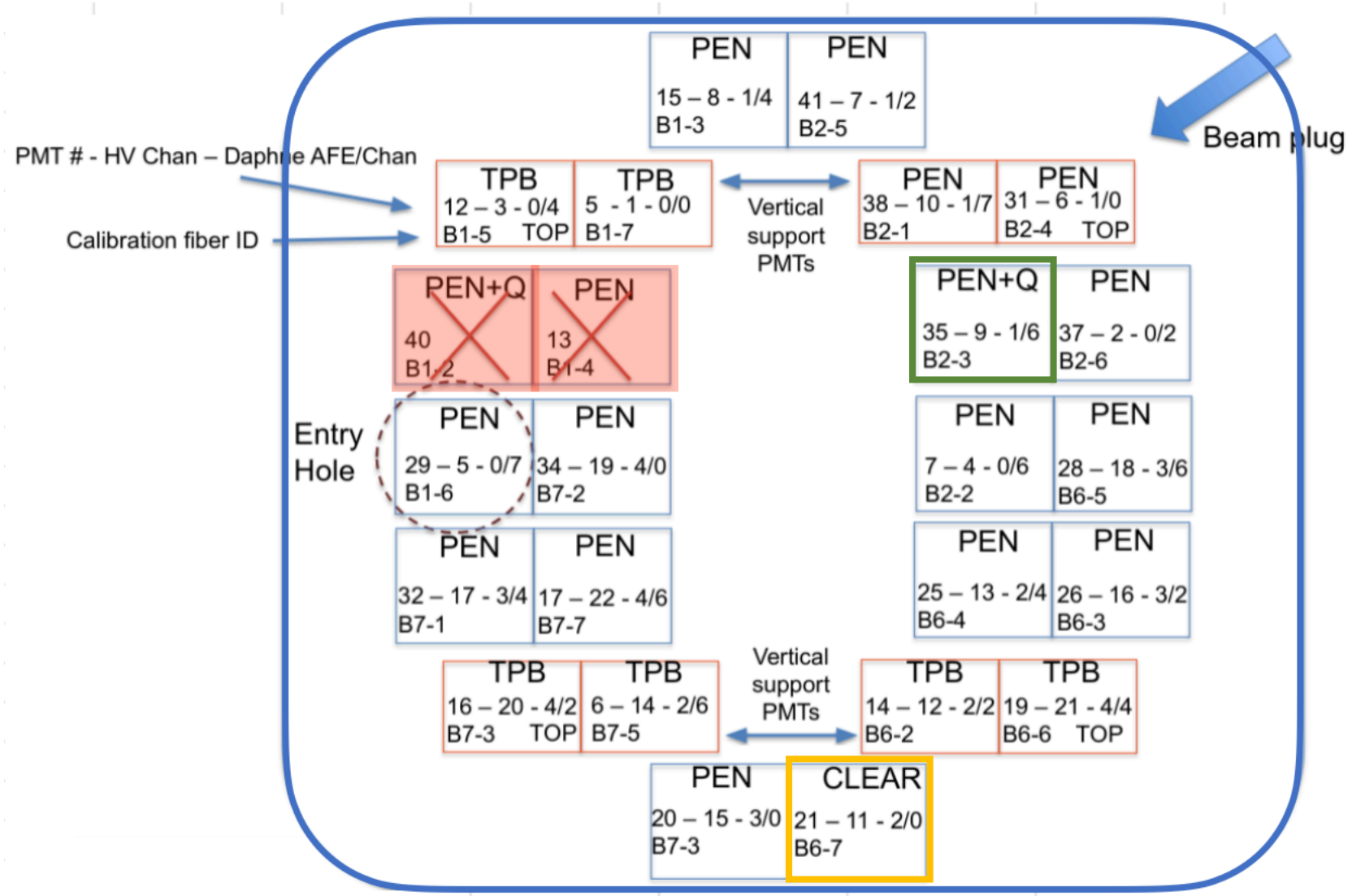


PMT with PEN and Quartz window



PMT with PEN next to the one with Quartz

1. Introduction - PMTs mapping



1. Introduction - Light contributions in LAr

PMTs with Q

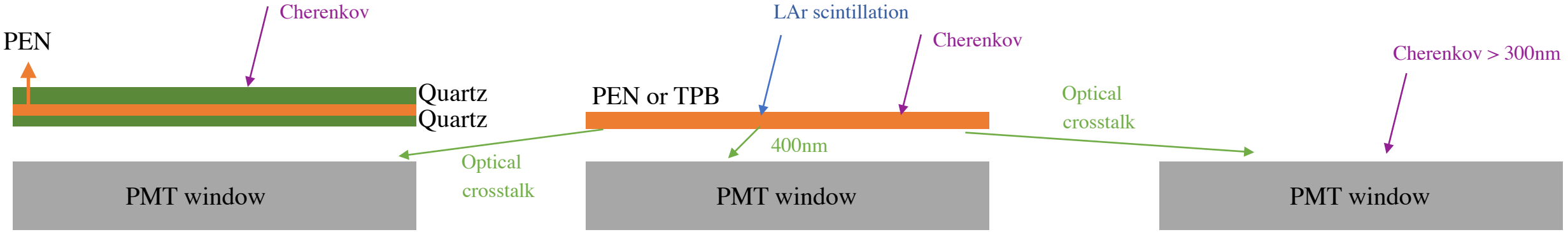
- Cherenkov from ~170nm
- Crosstalk from near PMTs

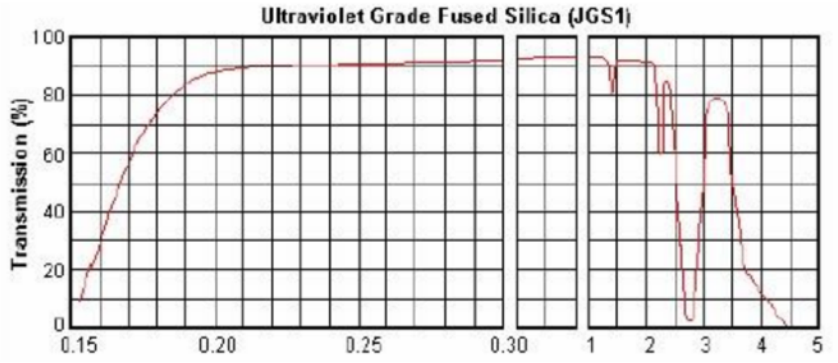
PMTs with PEN or TPB

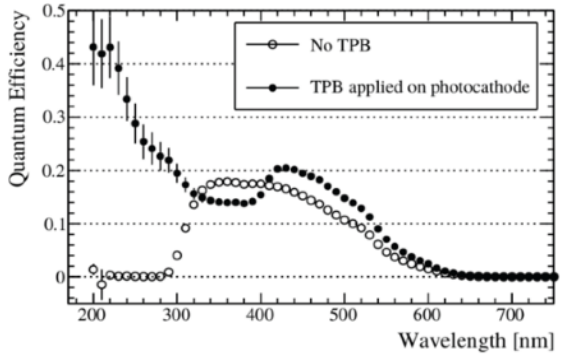
- Scintillation from LAr at 128nm
- Cherenkov from ~128nm
- Optical crosstalk from near PMTs

PMTs with NONE

- Cherenkov from ~300nm
- Crosstalk from near PMTs



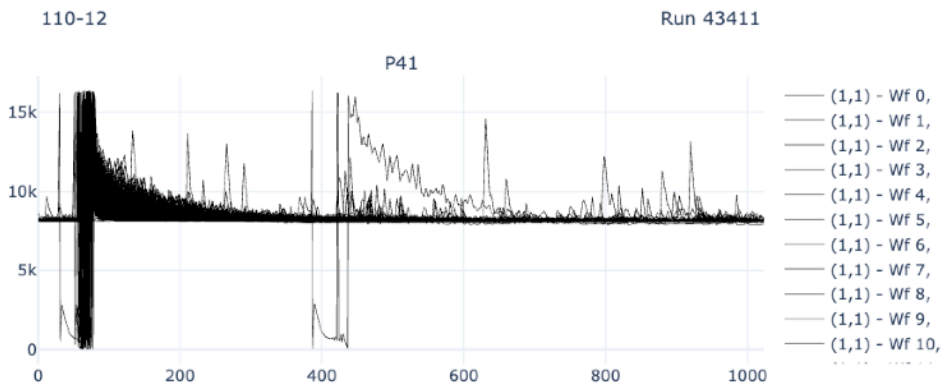


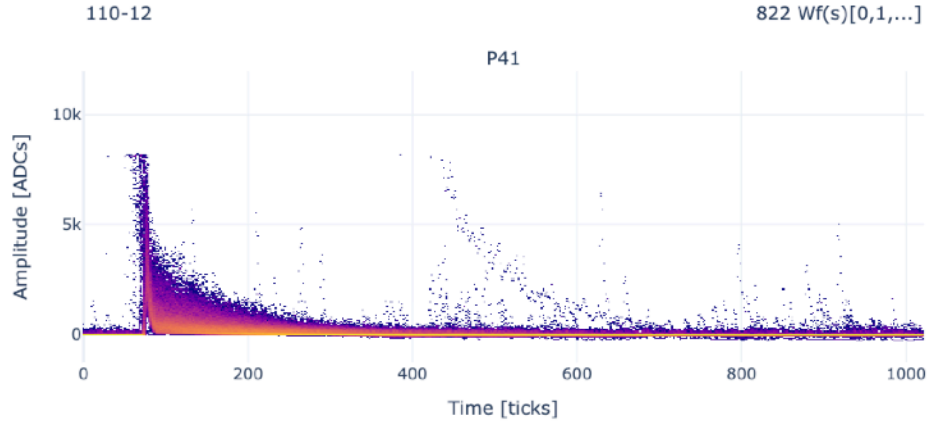


- An additional LAr fast component above 160nm has been shown in Ettore's presentation, that could be detected by the Quartz and PEN/ TPB PMTs

2. Results from PMTs in LAr

Visualization of raw waveforms





Apply generic cuts for all runs and PMTs

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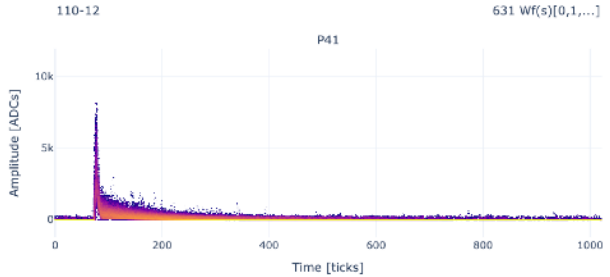
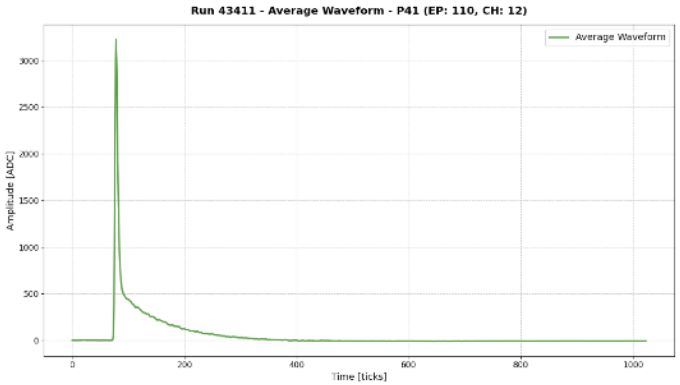
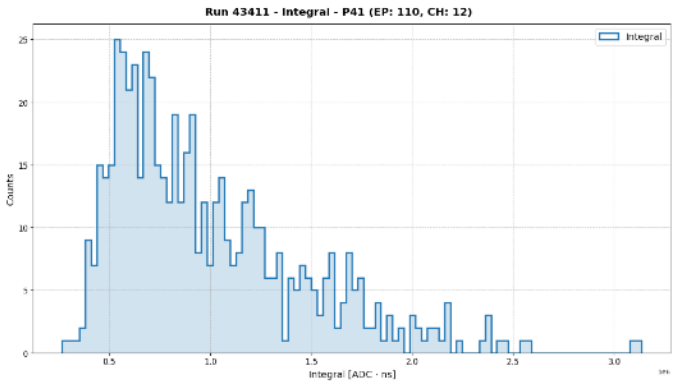
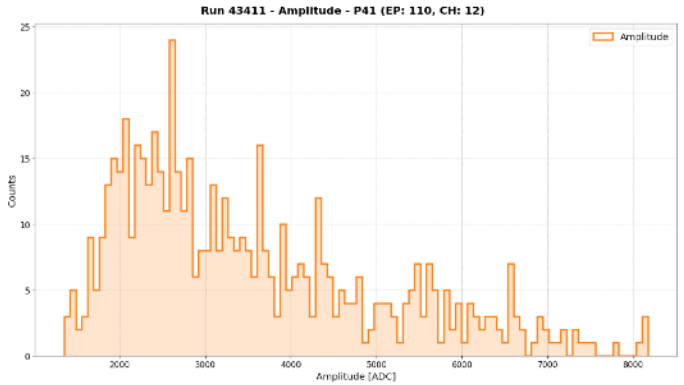
.defaultPcut: &defaultPcut
    1: { t0: 0,   tf:   67, threshold:  300, type:   lower, filter:  0, npop: max }
    2: { t0: 200, tf:  400, threshold:  1500, type:   lower, filter:  0, npop: max }
    3: { t0: 400, tf:  1024, threshold:  600, type:   lower, filter:  0, npop: max }
    4: { t0: 90,  tf:  1024, threshold:  5110, type:   lower, filter:  0, npop: max }
    5: { t0: 0,   tf:  1024, threshold:  -300, type:  higher, filter: 0, npop: min }
```



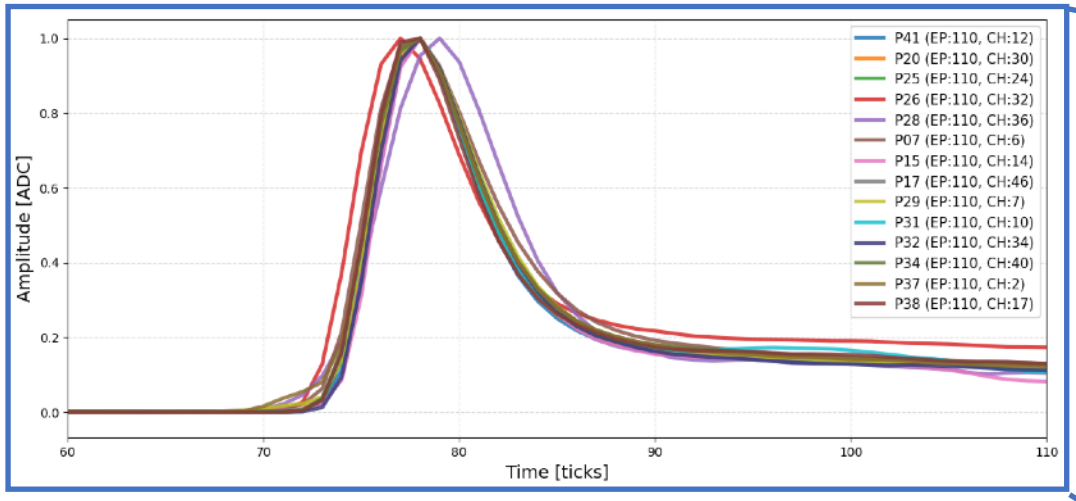
Average waveform, integral and amplitude histograms

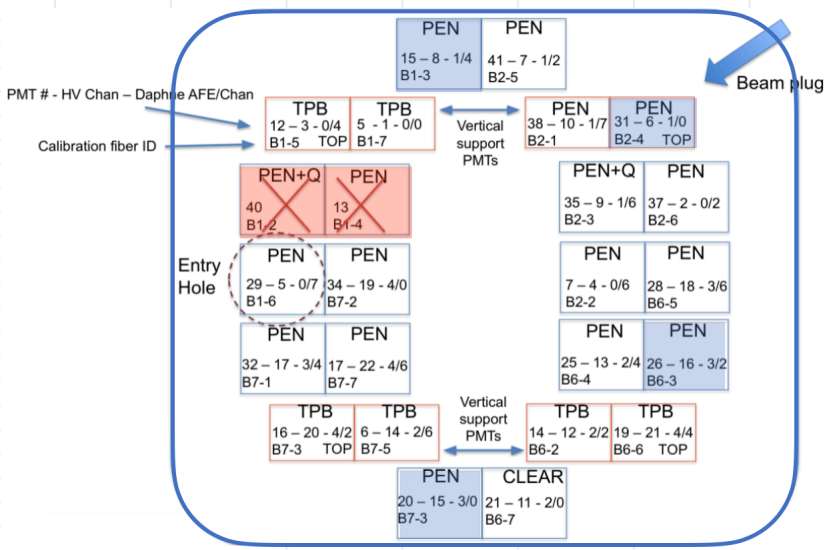


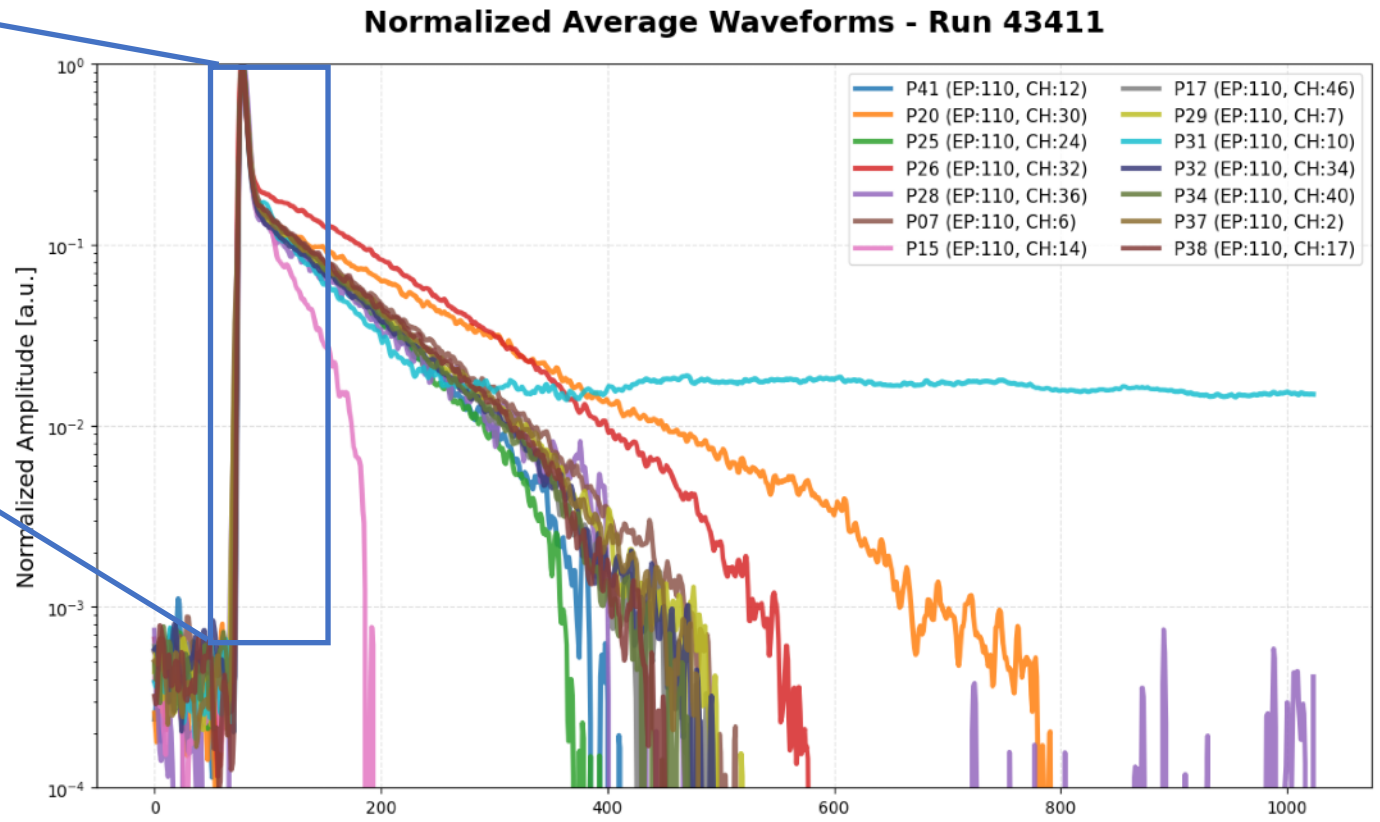




2. Results from PMTs with PEN in LAr



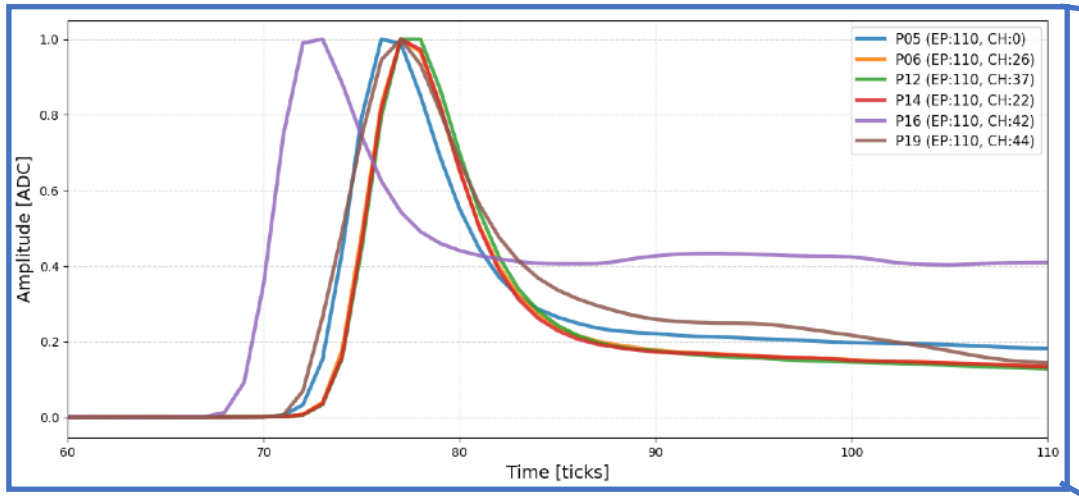


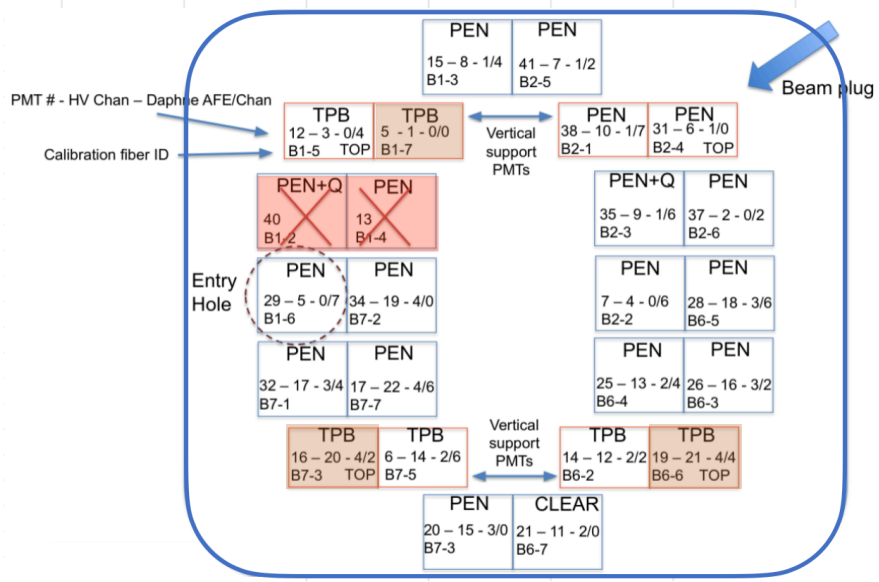


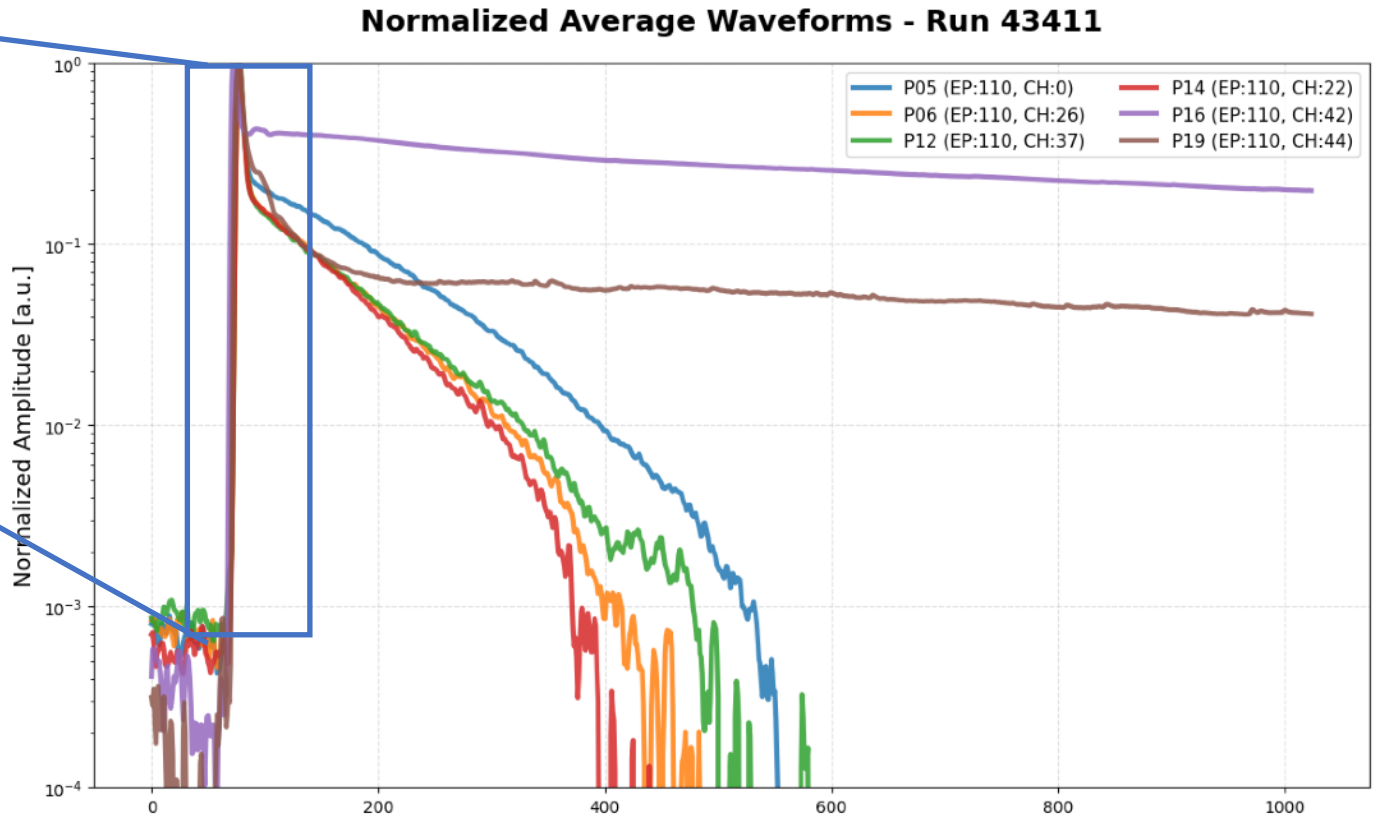
Conclusions

- P15, P31, P26 and P20 show a different and unusual tendency
- Exclude from this timing analysis from now on

2. Results from PMTs with TPB in LAr



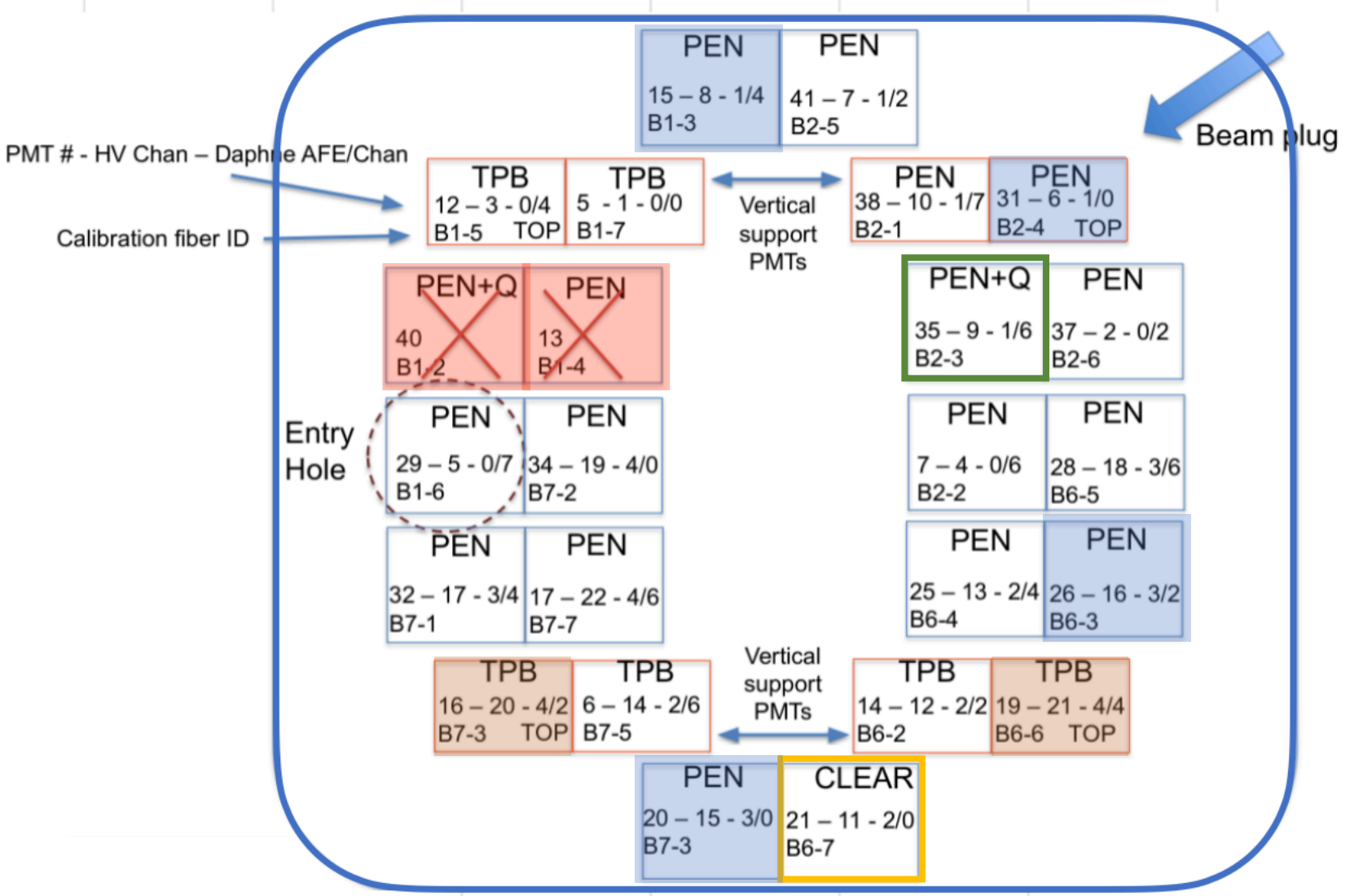




Conclusions

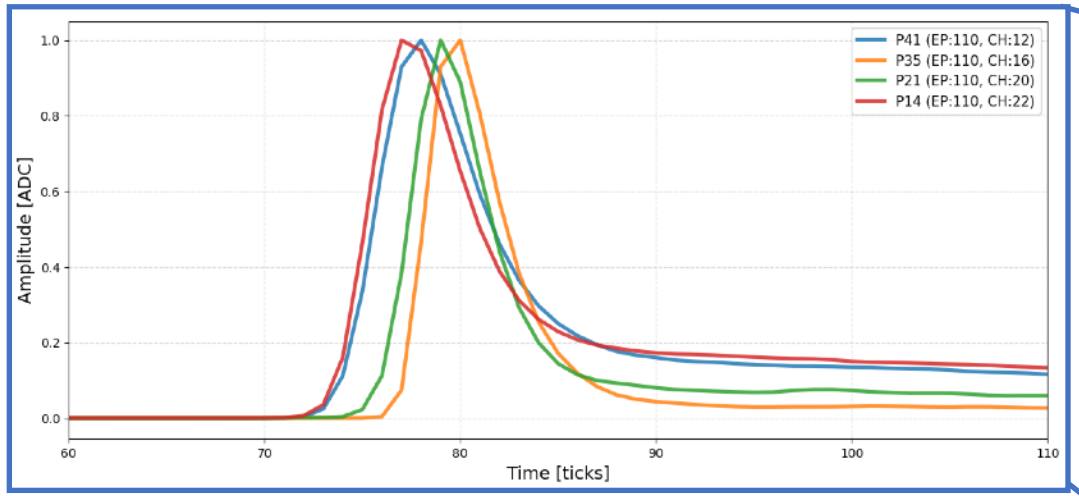
- P16, P05 and P19 show a different and unusual tendency
- Exclude from this timing analysis from now on

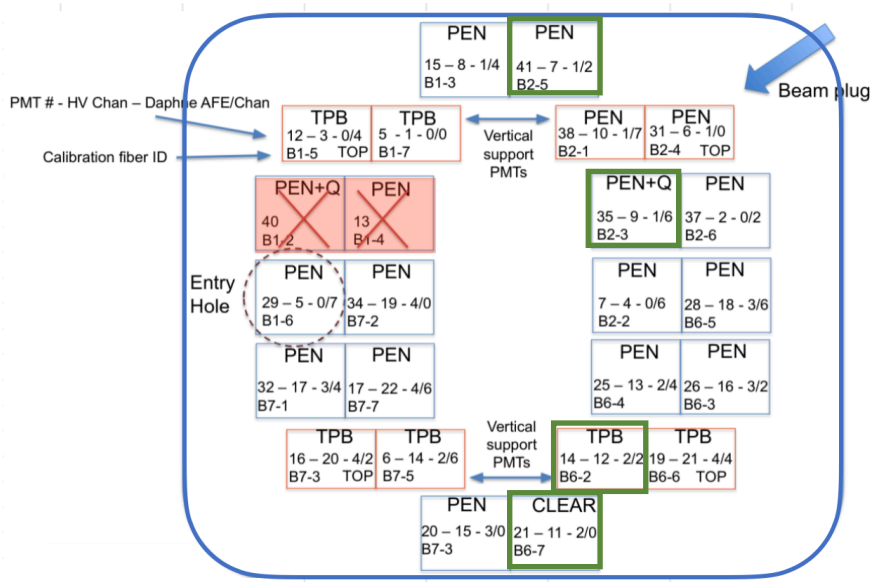
2. Results from PMTs in LAr - Mapping

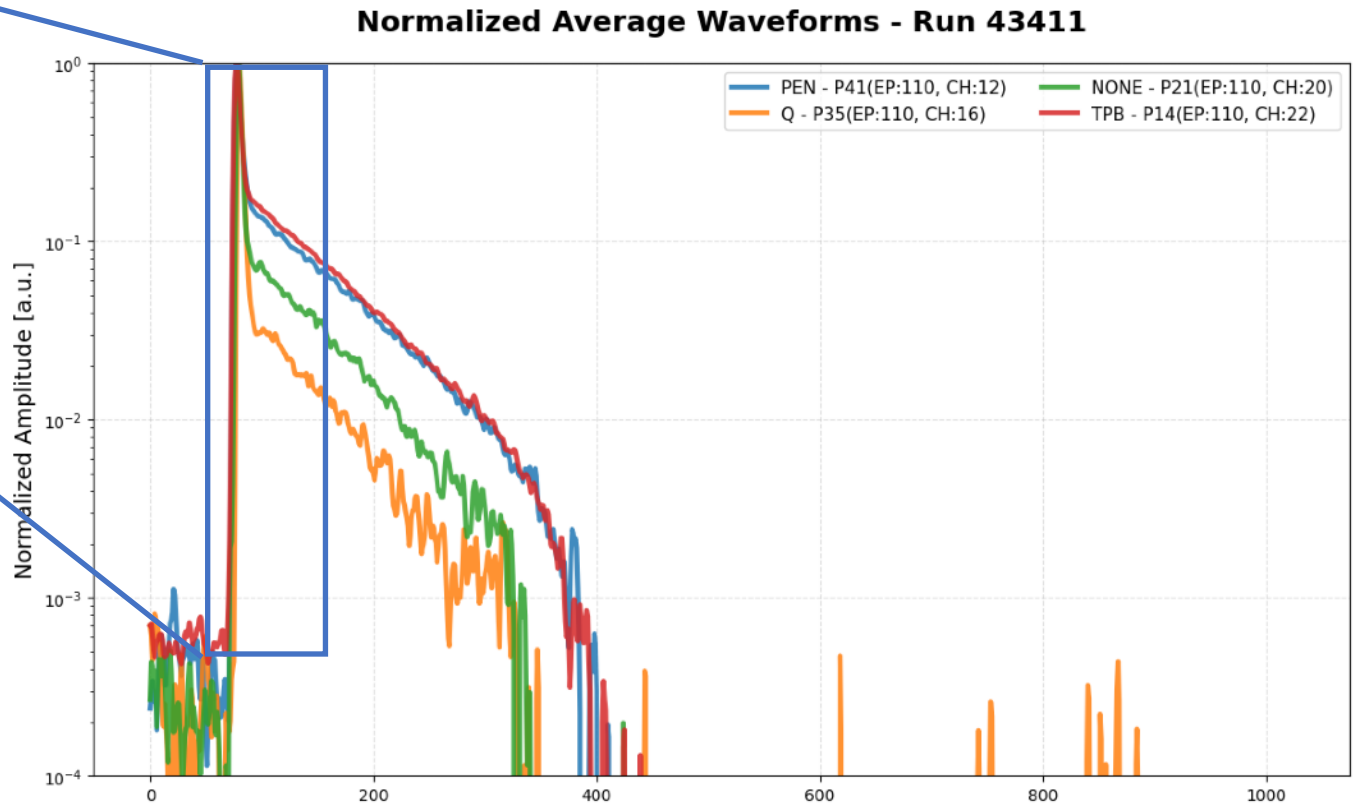


- Not connected
- PEN PMTs with a different tendency
- TPB PMTs with a different tendency
- PMT with a Quartz window
- Clear PMT

2. Results from PMTs in LAr



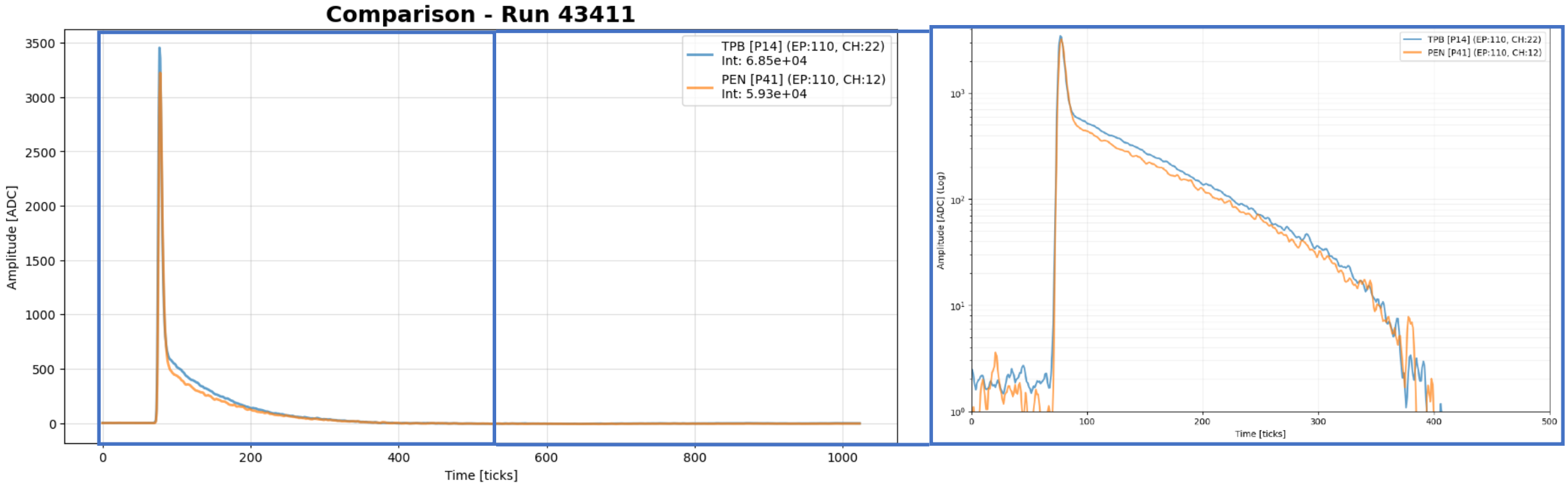




Results

» Comparison between these PMTs (PEN, NONE, Q and TPB) will be shown in the next slides

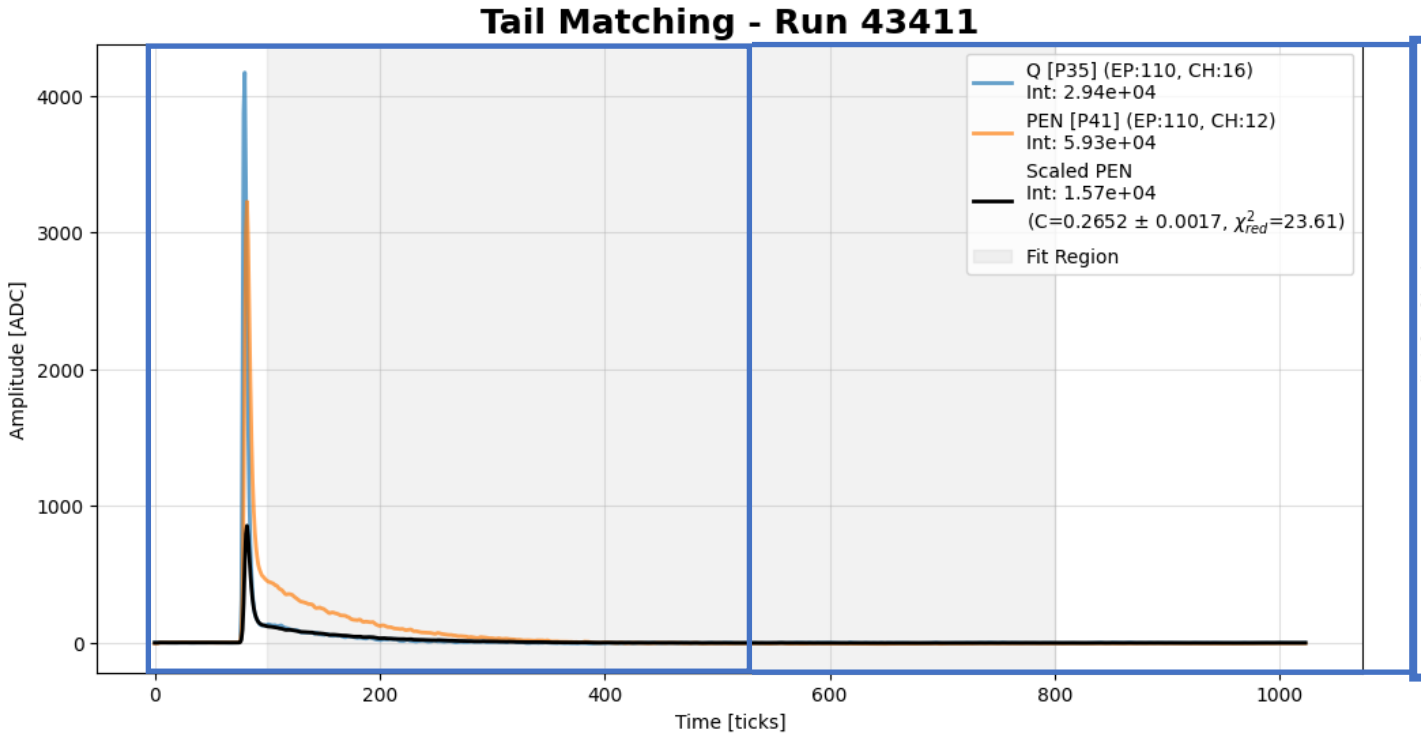
3. Comparison - Comparison btw PEN/TPB

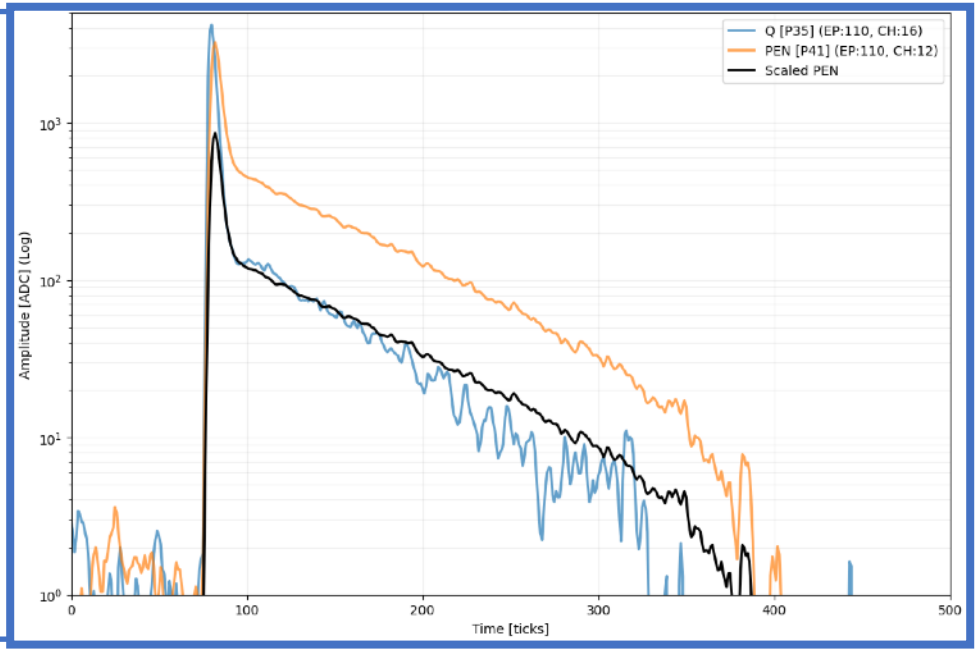


Light contributions

- PMT with PEN: LAr scintillation light, Cherenkov from 128nm and crosstalk from near PMTs
- PMT with TPB: LAr scintillation light, Cherenkov from 128nm and crosstalk from near PMTs
- Similar fast and slow components, since they have the same contributions

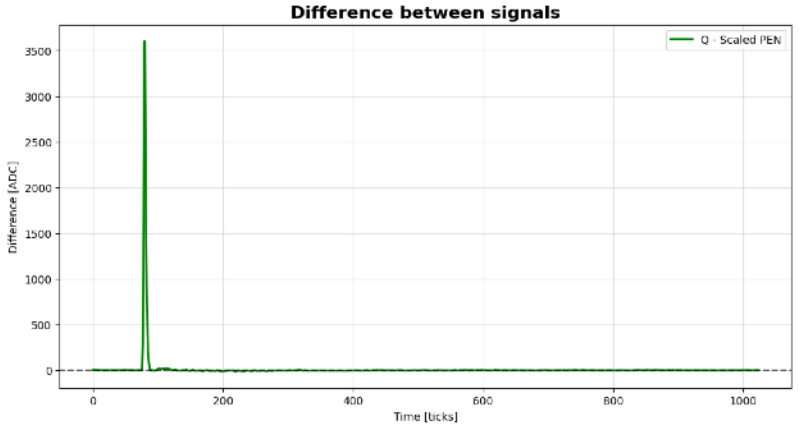
3. Comparison - Tail matching btw PEN/Q



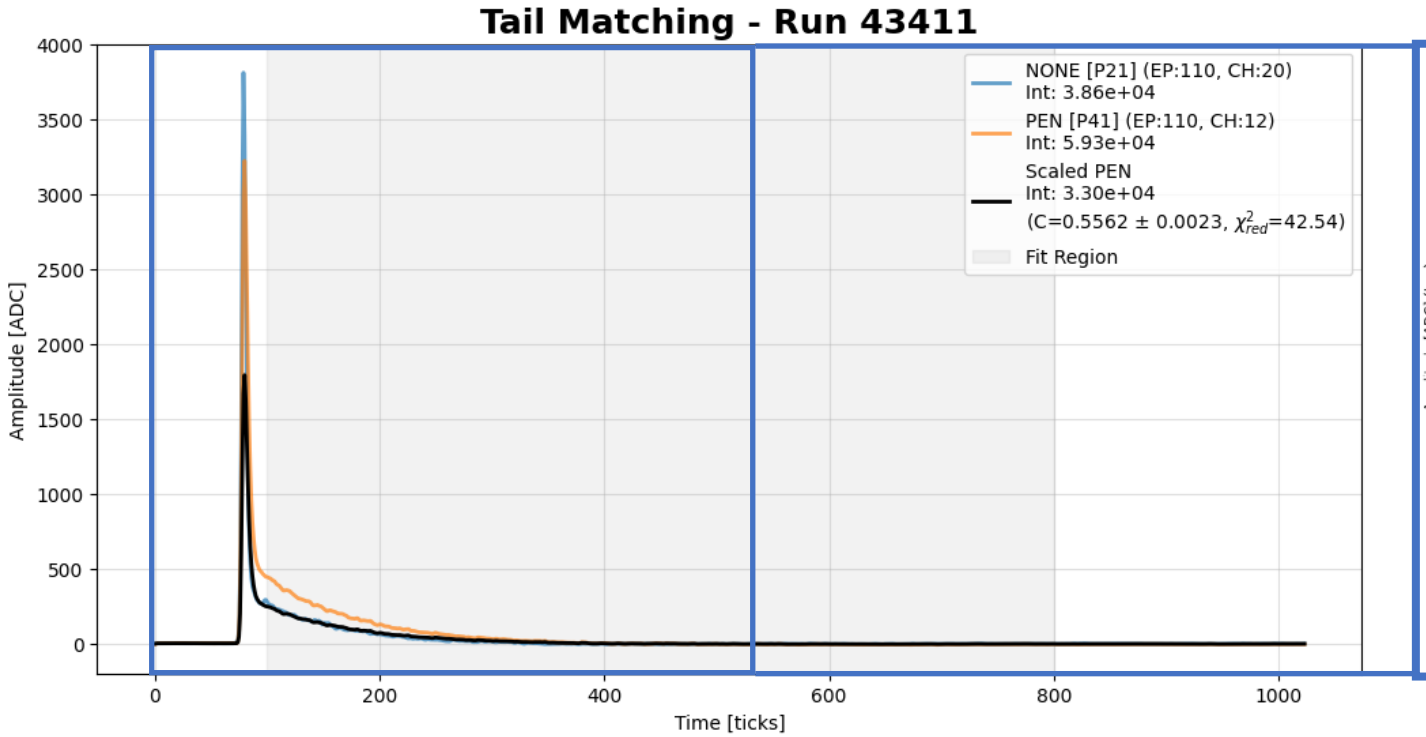


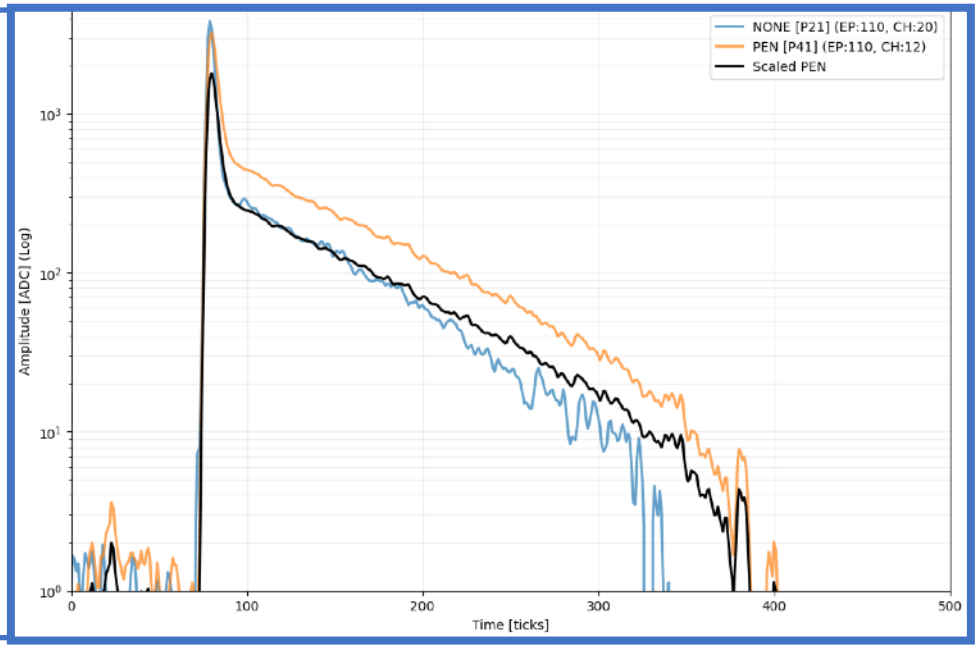
Light contributions

- PMT with PEN: LAr scintillation light, Cherenkov from 128nm and crosstalk from near PMTs
- PMT with Quartz: Cherenkov from 170nm and crosstalk from near PMTs
- Assuming the slow light detected by PMT with Quartz is scintillation, this (scintillation) would be 26% of the total detected light



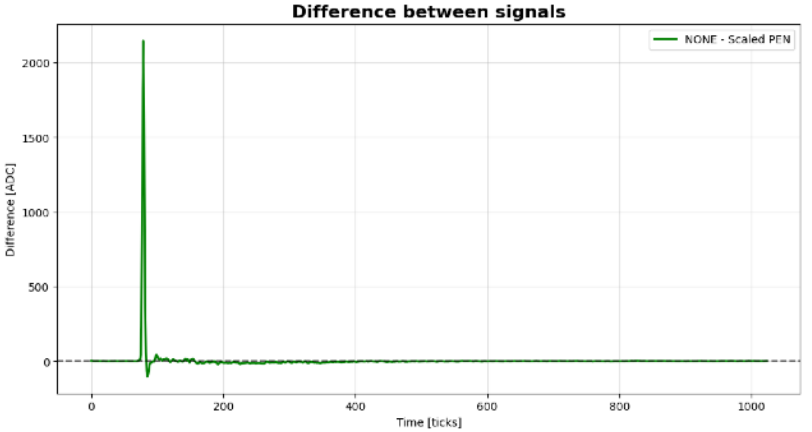
3. Comparison - Tail matching btw PEN/NONE



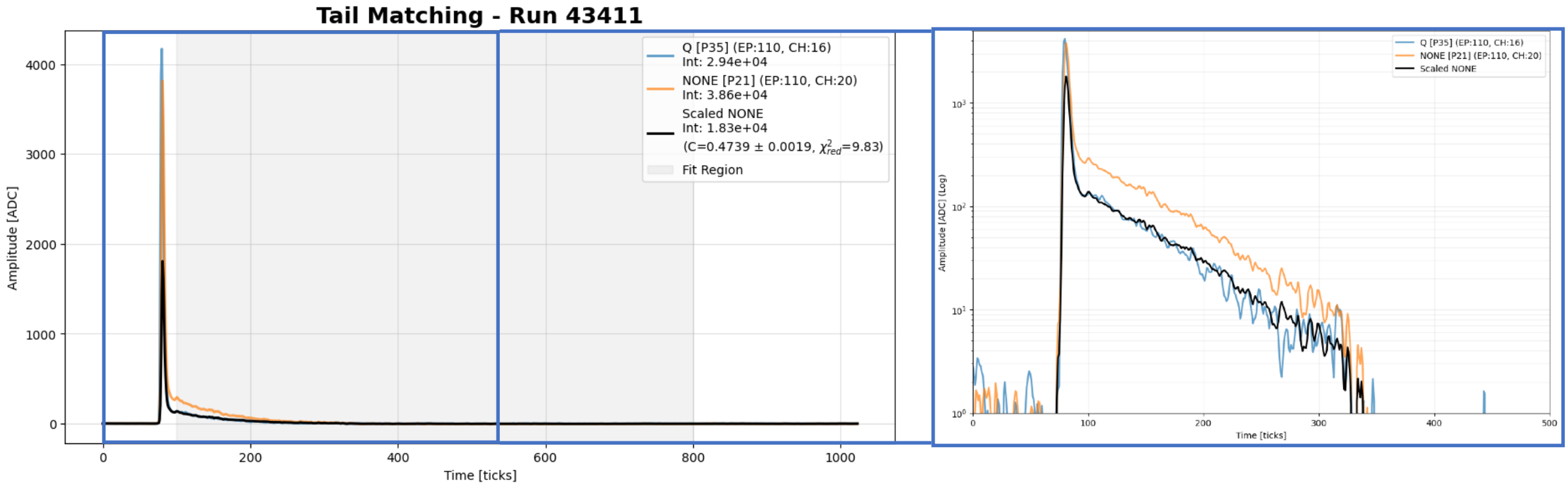


Light contributions

- PMT with PEN: LAr scintillation light, Cherenkov from 128nm and crosstalk from near PMTs
- PMT with NONE: Cherenkov from 400nm and crosstalk from near PMTs
- Assuming the slow light detected by PMT with NONE is scintillation, this (scintillation) would be 56% of the total detected light



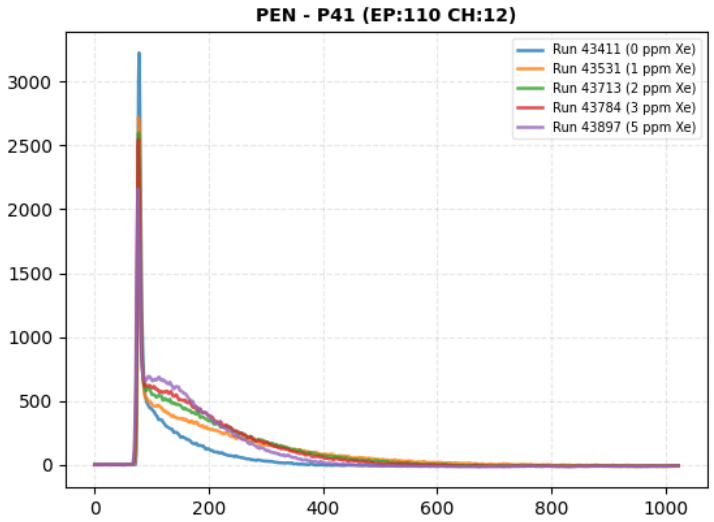
3. Comparison - Tail matching btw NONE/Q

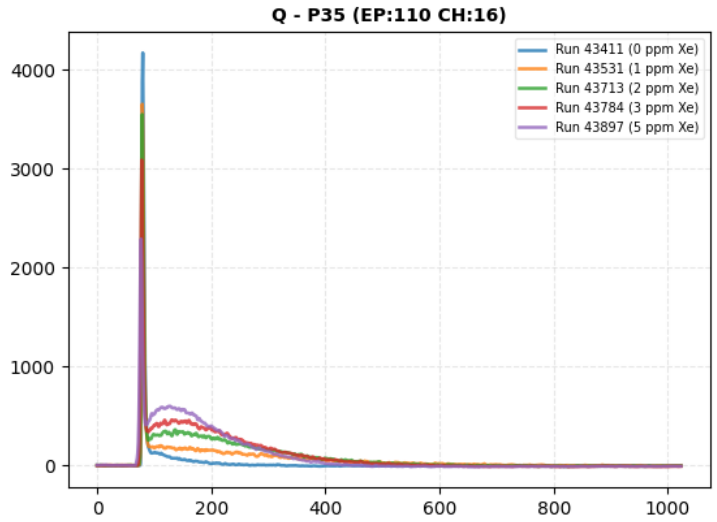


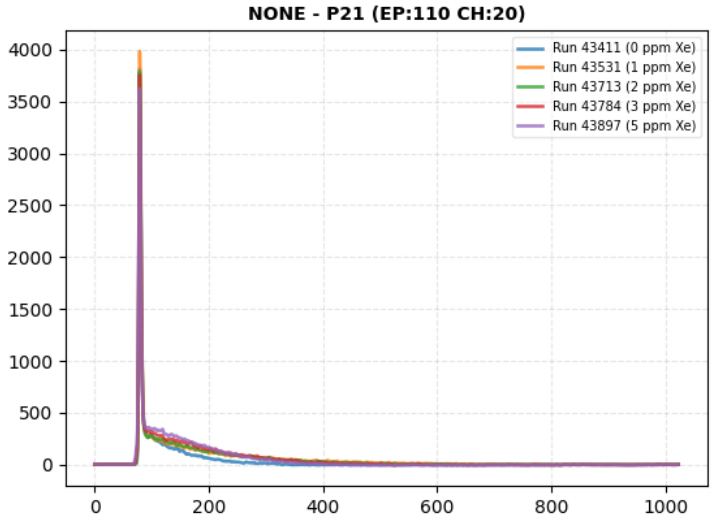
Light contributions

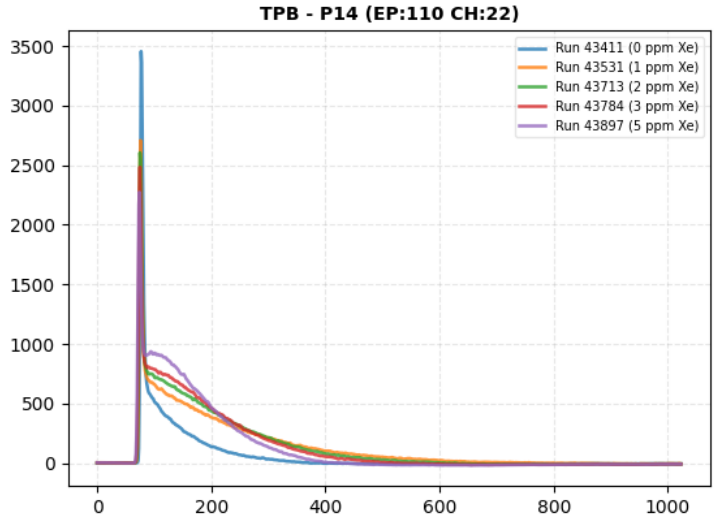
- PMT with NONE: Cherenkov from 400nm and crosstalk from near PMTs
- PMT with Quartz: Cherenkov from 170nm and crosstalk from near PMTs
- Similar tail tendency, they seem to have the same slow component contribution
- Light difference between them in the fast component could be Cherenkov light

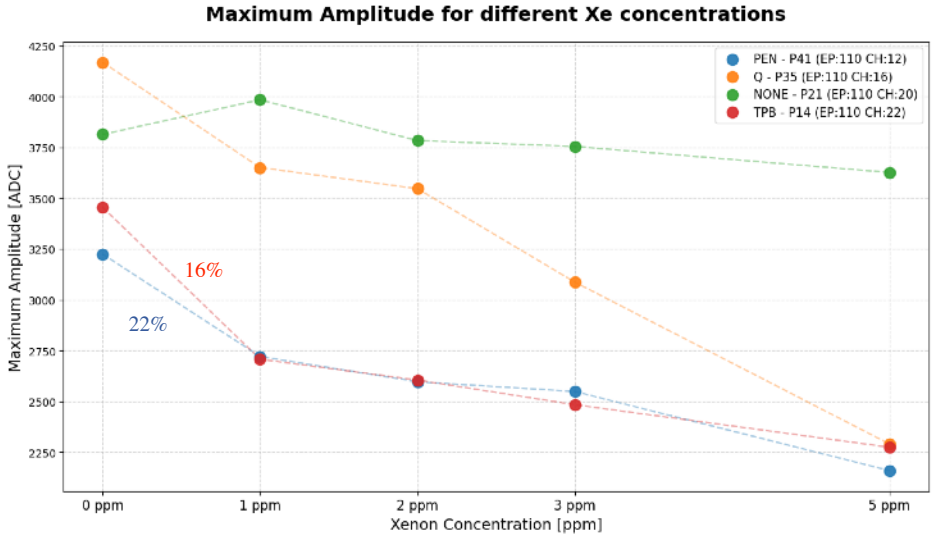
4. Results from PMTs in LAr with Xe doping







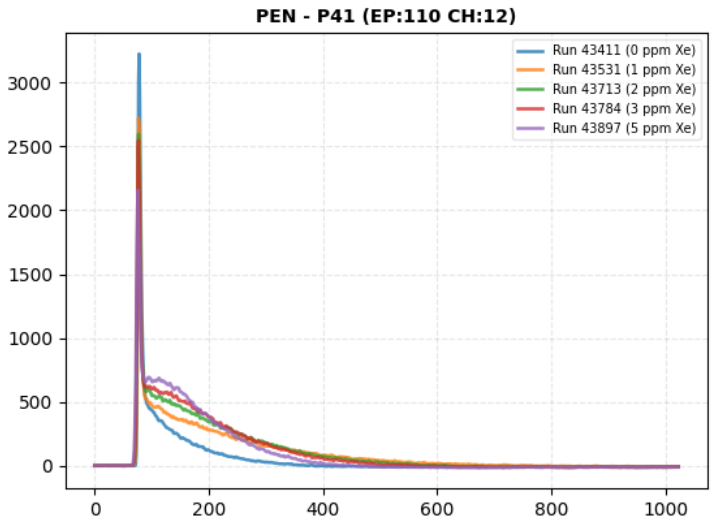


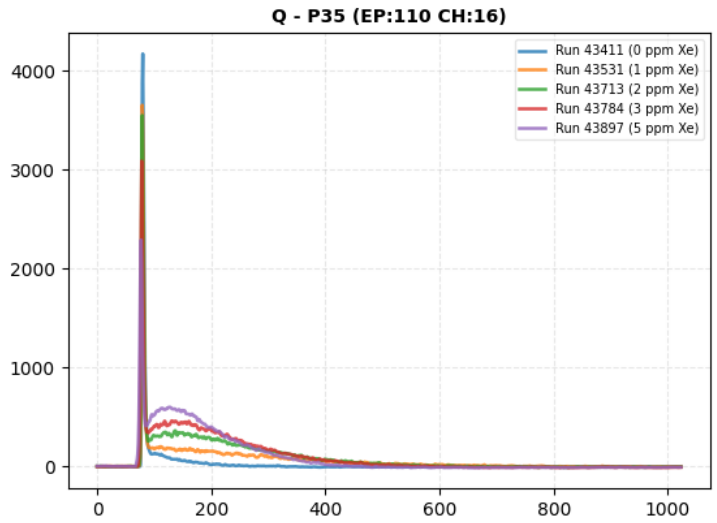


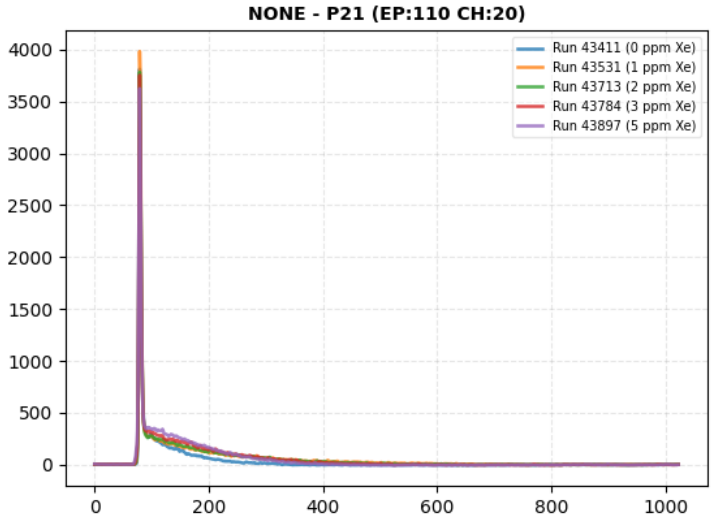
Conclusions

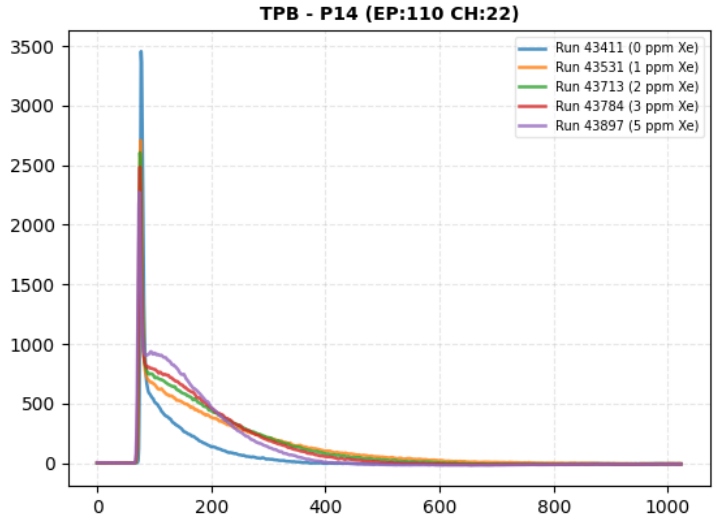
- The average waveforms change their tendencies, as the Xe concentration increases
- The amplitude of the fast component decreases, as the Xe concentration increases, in the Xe-sensitive PMTs

4. Results from PMTs in LAr with Xe doping



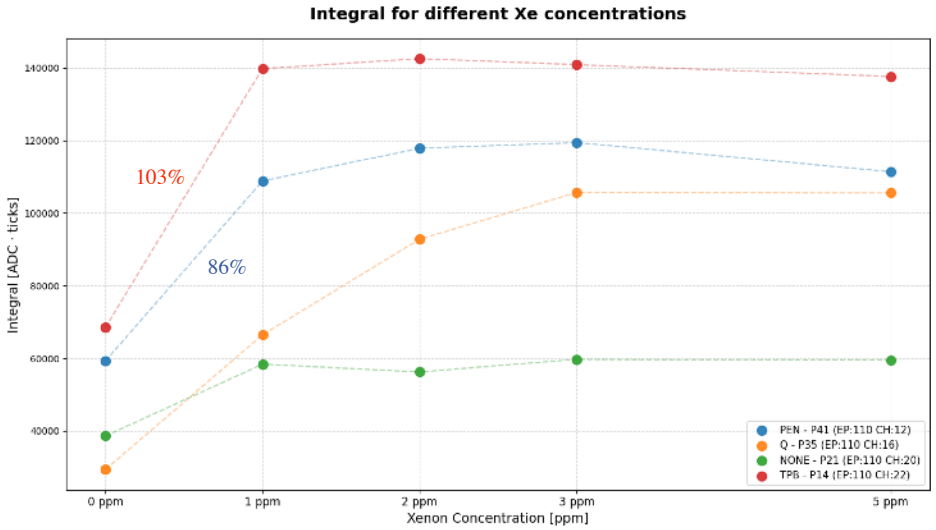




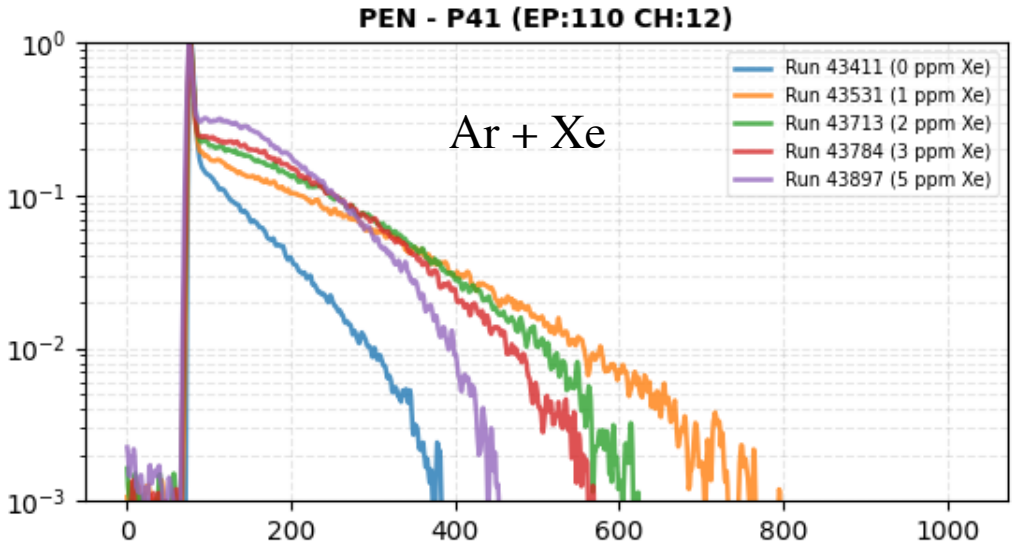


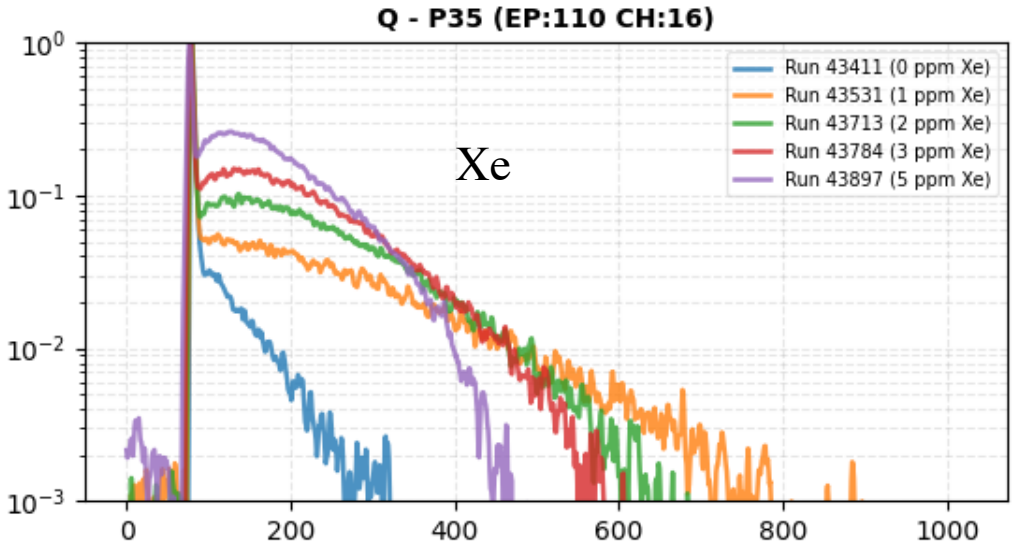
Conclusions

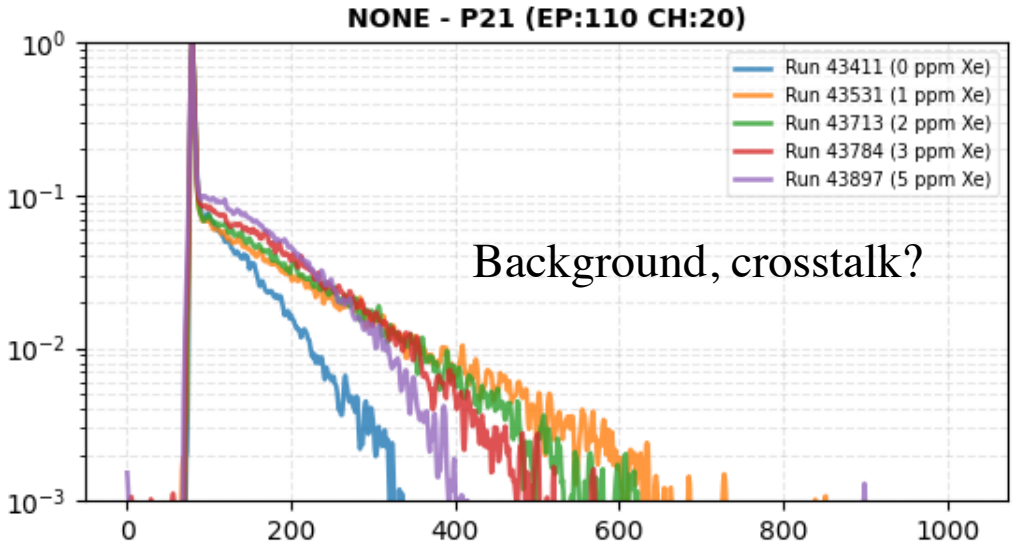
- The average waveforms change their tendencies, as the Xe concentration increases
- The amount of light increases from 0ppm to 1ppm, and then stabilizes

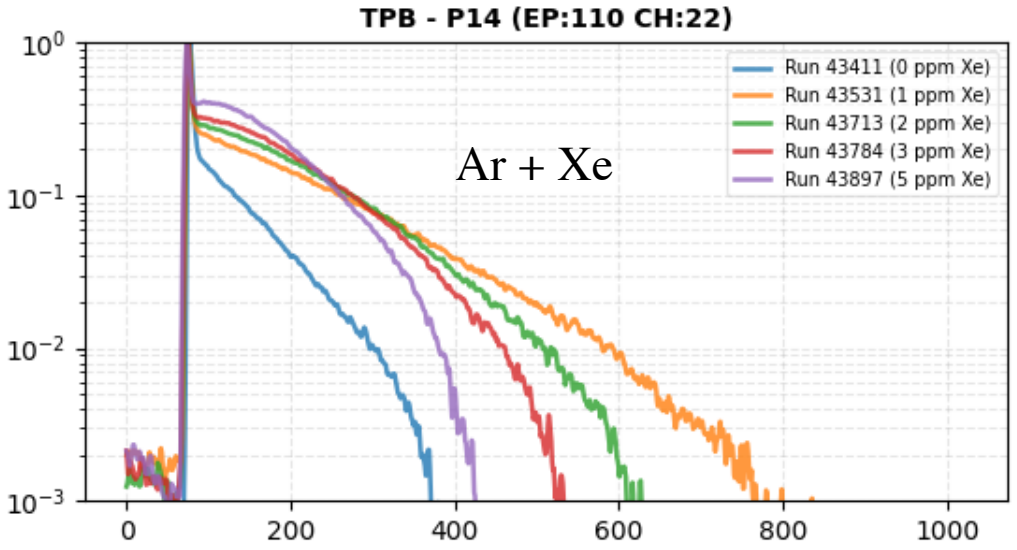


4. Results from PMTs in LAr with Xe doping









5. Conclusions and next steps

Conclusions

- Most PMTs are detecting light and working properly
- Employing different WLS and configurations help understanding the light insights
- This is a first approximation of a deeper Ar+Xe study

Next steps

- Perform an event per event study using CRTs data to acquire quantified results in LAr with Xe doping, related to scintillation, possible Cherenkov light and the additional fast component shown in Ettore's presentation
- Fit the average waveforms in different Xe concentrations to obtain the τ parameters
- Extend this study to all the different Xe concentrations in ProtoDUNE-VD
- Compare these results with the membranes and cathodes as well