

# Summary of 3x1x1 PMT System Studies

Operation Meeting 10/11/2017

On behalf of IFAE, CIEMAT and LAPP groups

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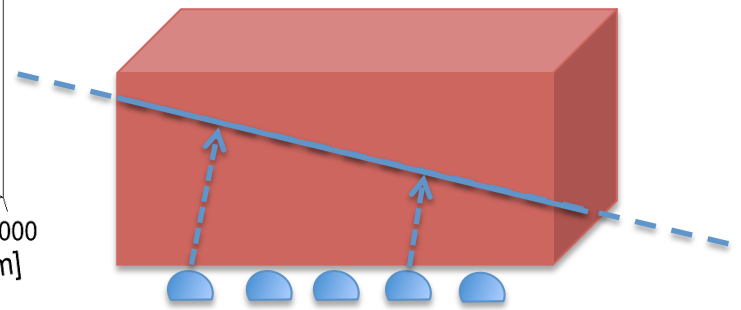
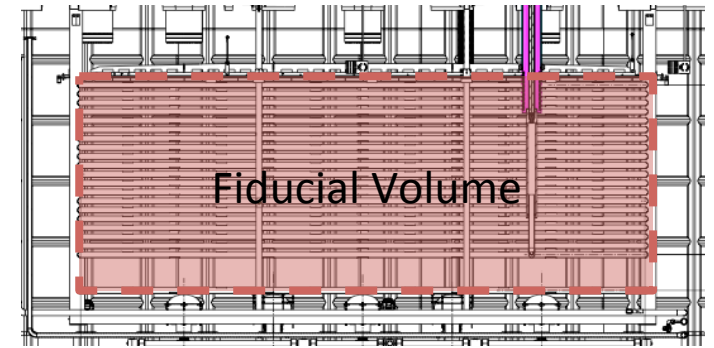
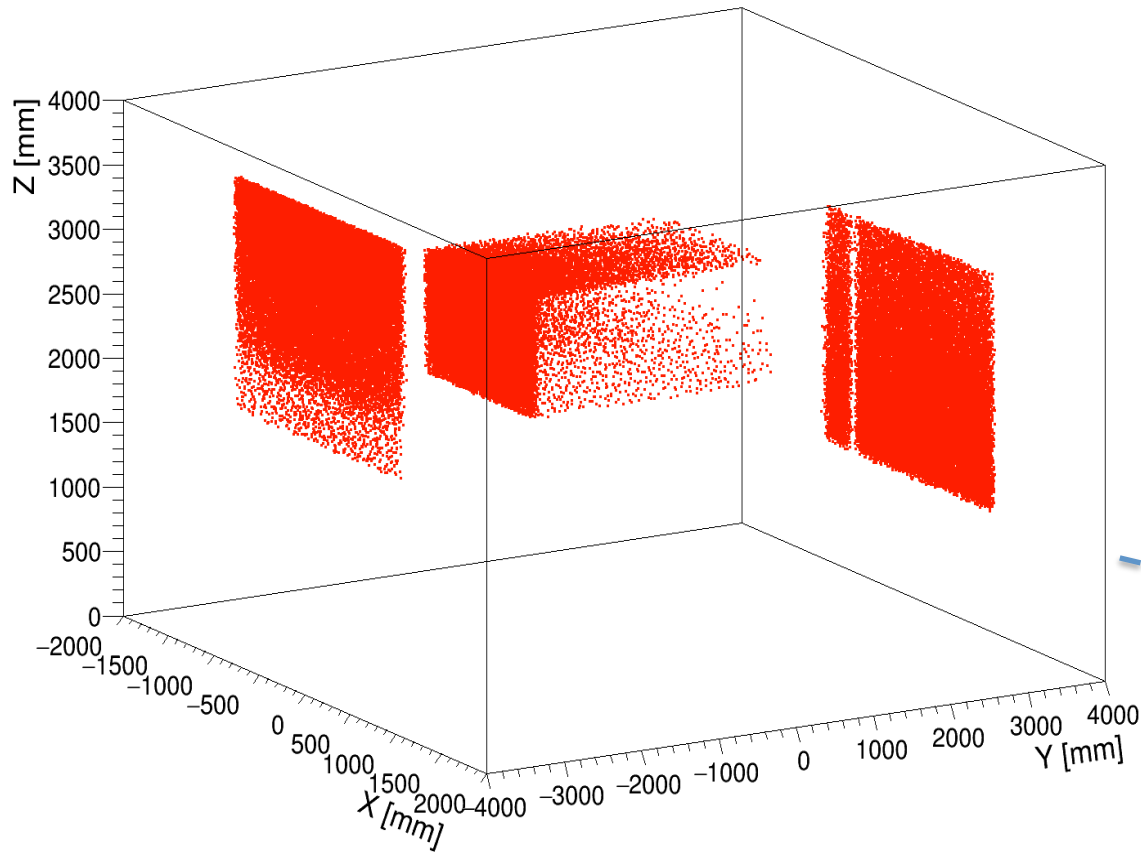
Anne Chappuis

# Ongoing Studies

- Characterization of combined PMT and CRT event reconstruction  
Chiara, Alberto, Silvestro
- Match of Light and Charge events  
Jose
- 3x1x1 Light Detection simulation with CRT triggered events  
Anne

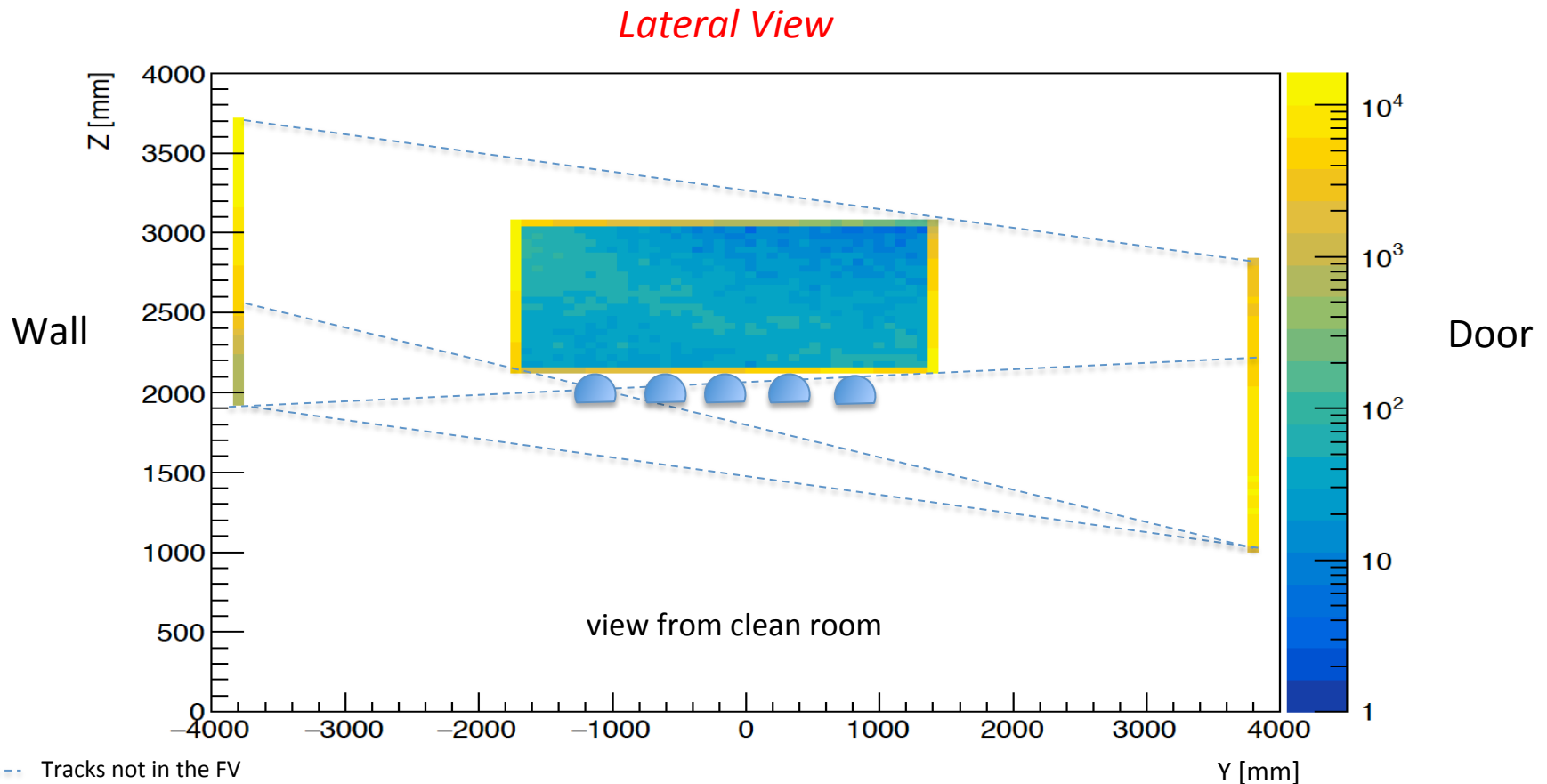
# CRT Track Reconstruction

- 3D CRT Track intersection with LAr Fiducial Volume:
  - Track Length inside active region
  - Distance between trajectory and PMT surface



# CRT Track Reconstruction

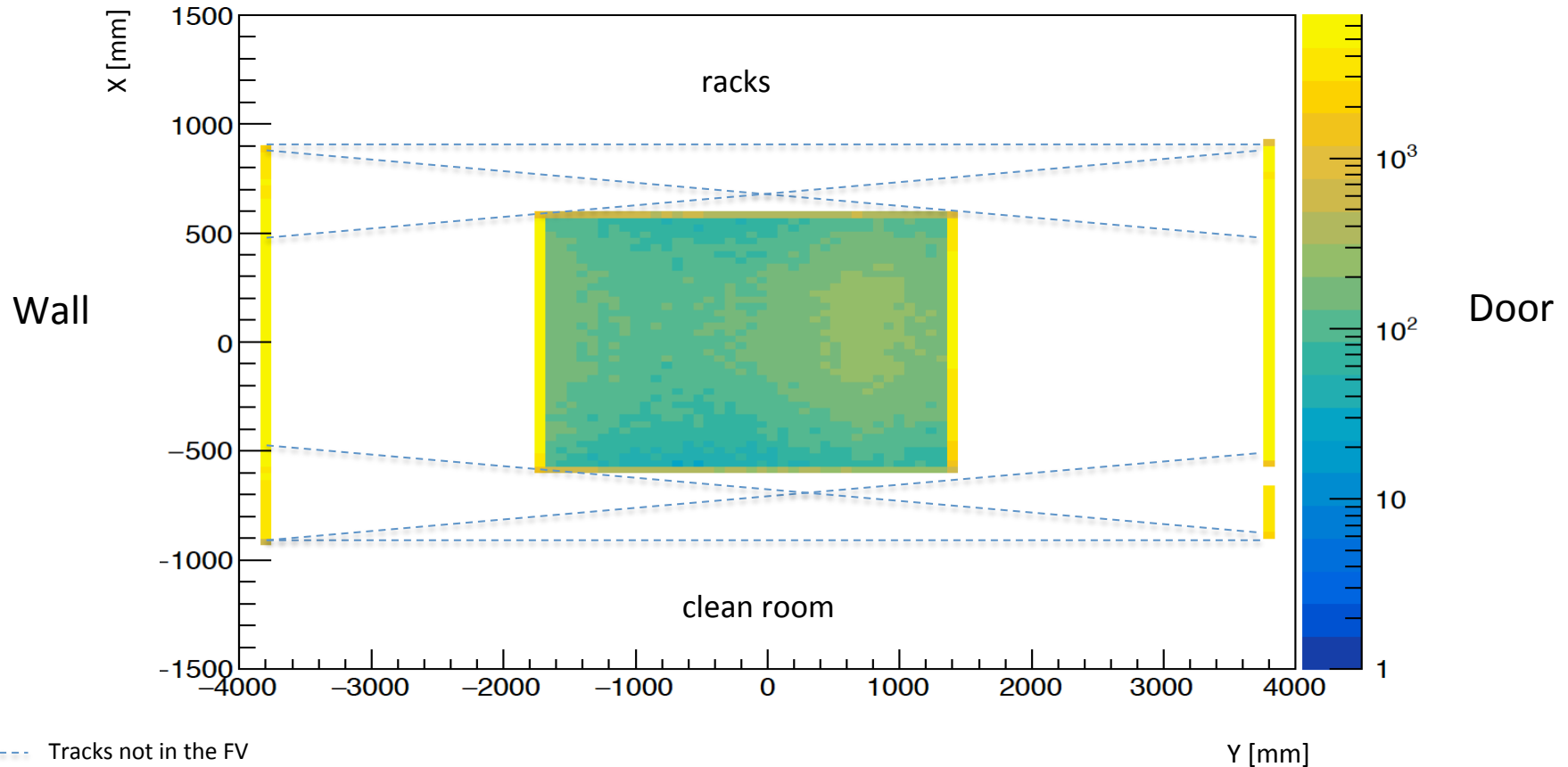
- Hit map in the vertical plane using
  - Entry end Exit point of trajectory on the CRT panels and on the LAr Fiducial Volume



# CRT Track Reconstruction

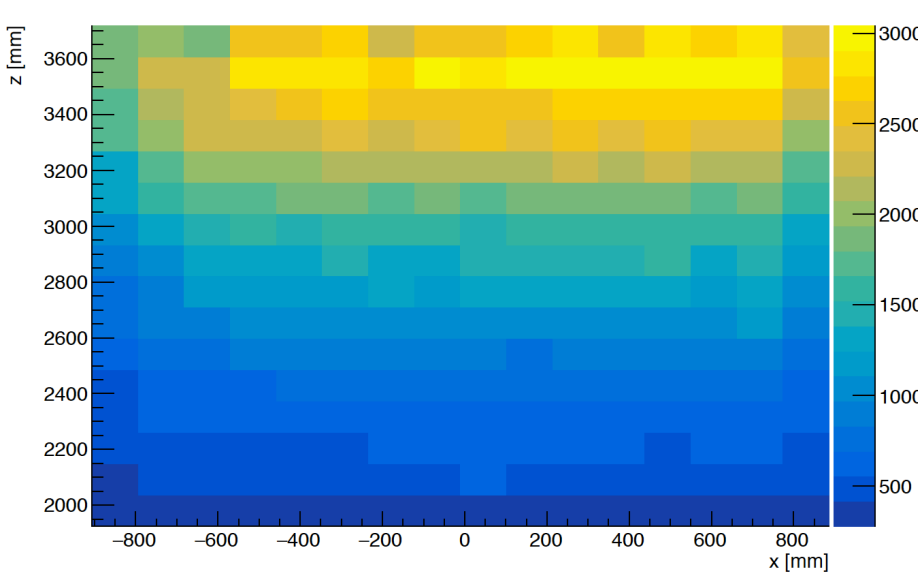
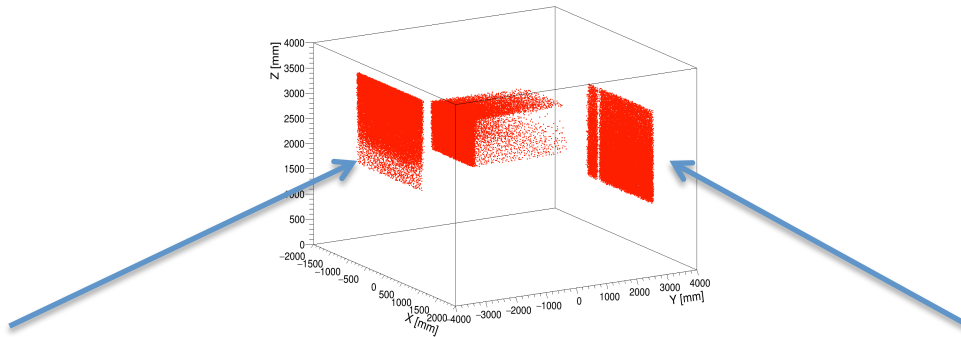
- Hit map in the horizontal plane using
  - Entry end Exit point of trajectory on the CRT panel and on the LAr Fiducial Volume

*Top View*

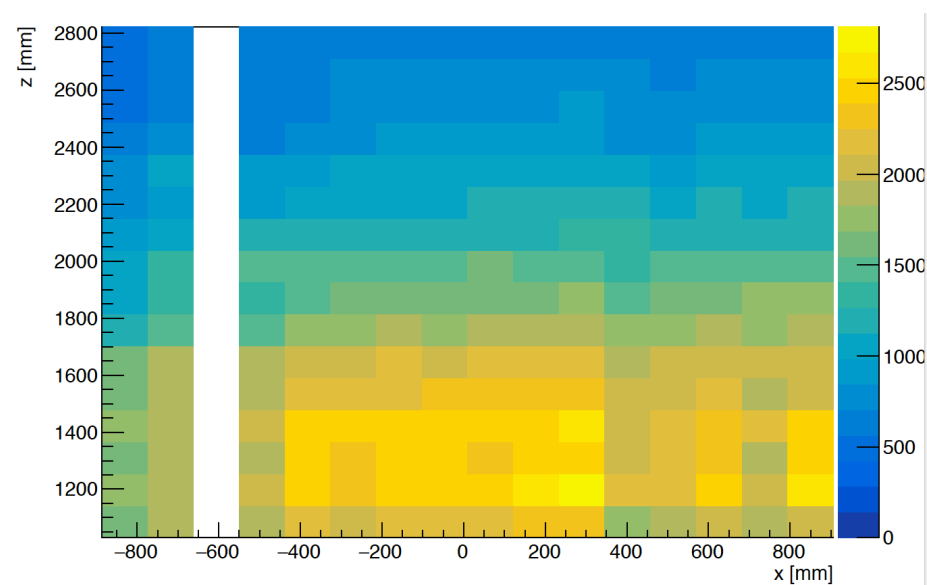


# CRT Track Reconstruction

- Hit map on the CRT stations for track candidates:
  - plane hit occupancy consistent with downward going tracks



wall side



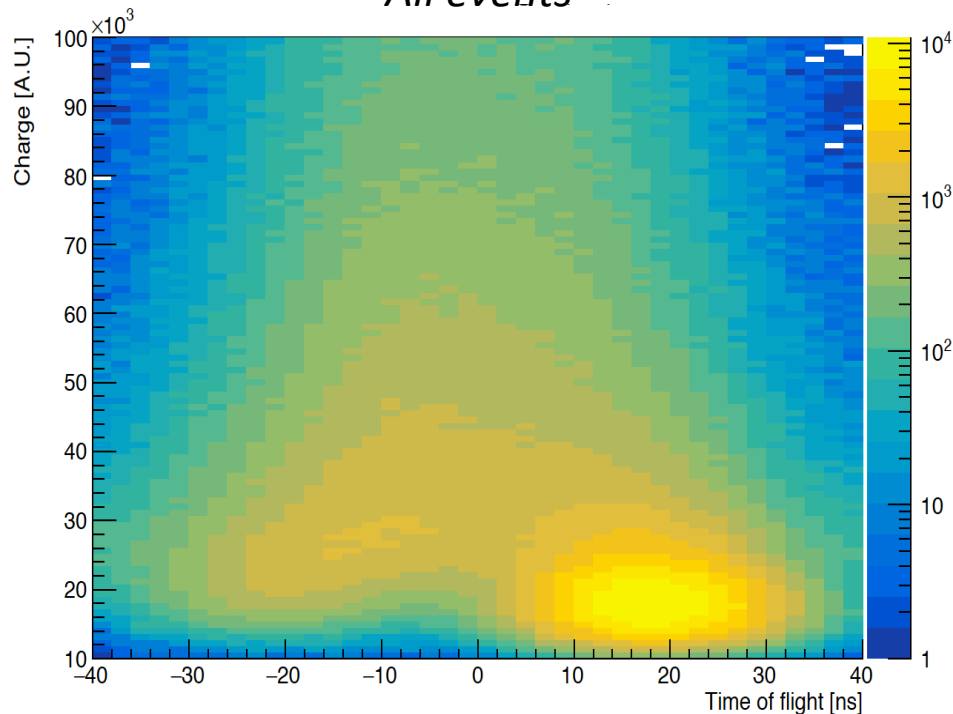
door side

# CRT Events Characterization

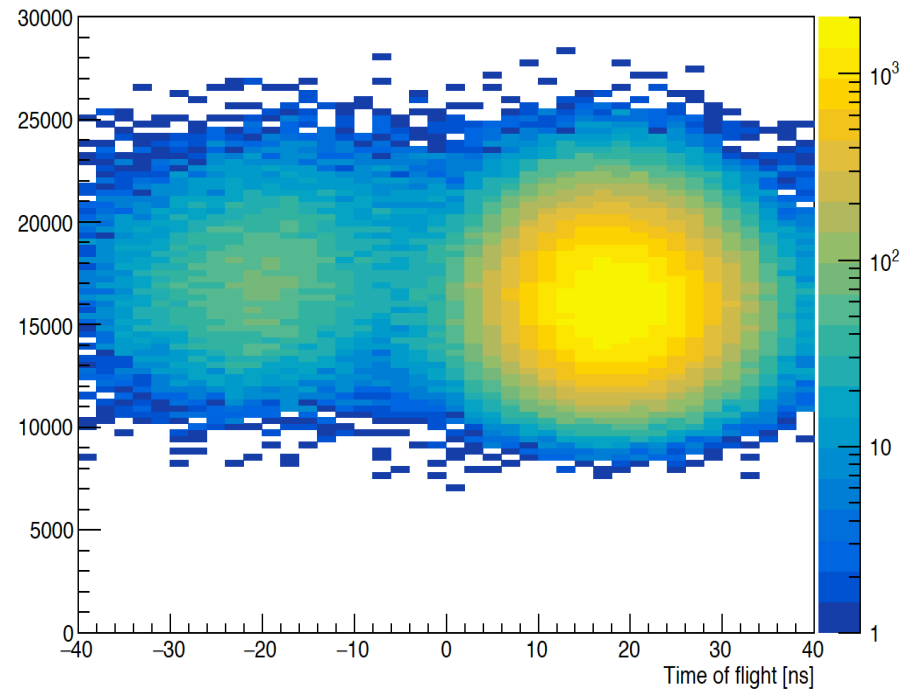
- Charge deposited in the CRT strips related to event topology
  - Events with ToF compatible with single downward traversing track deposit less energy

*ToF vs Deposited Charge in the CRT*

*All events*

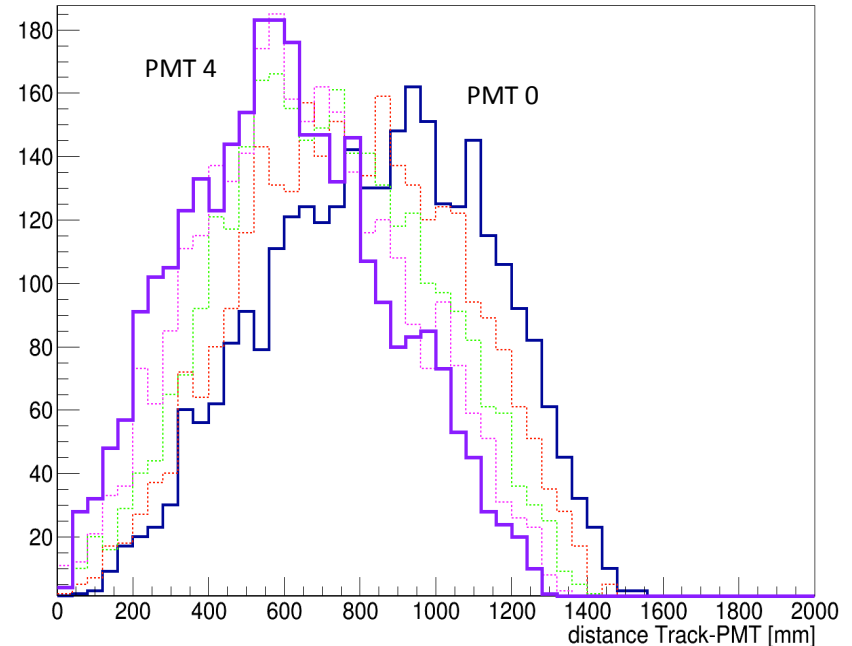
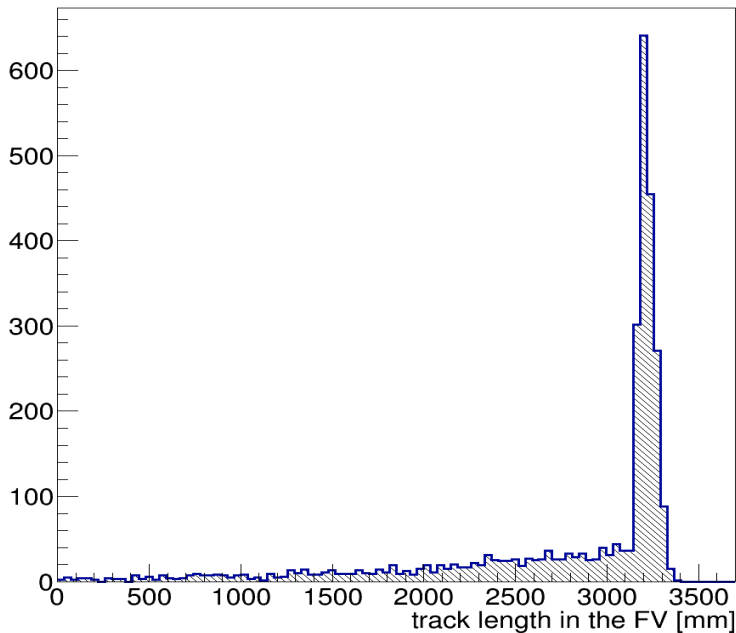
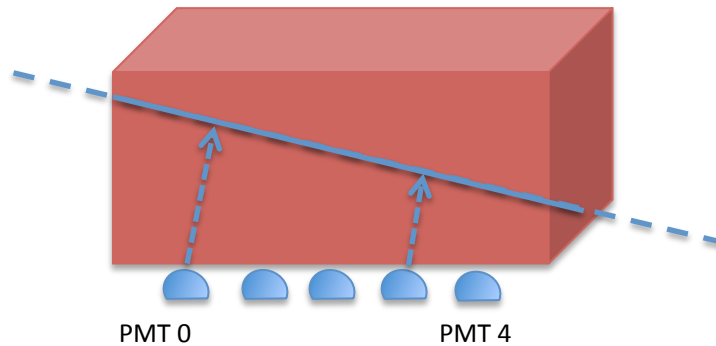


*Only track like events*



# CRT Track Reconstruction

- Length of tracks entering the Fiducial Volume peaked at  $L > 3\text{m}$  (traverse entire volume)
- Distance of closest approach between track and PMT smaller for PMTs close to the lower panel

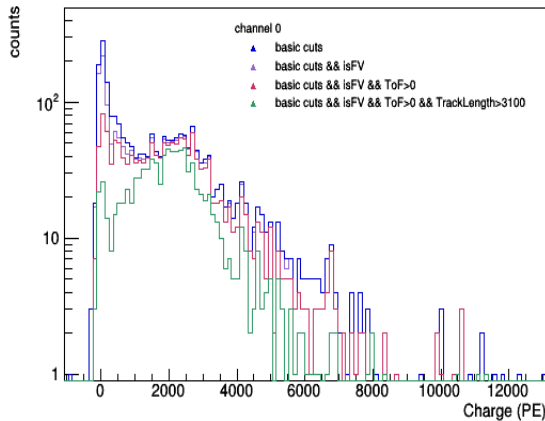




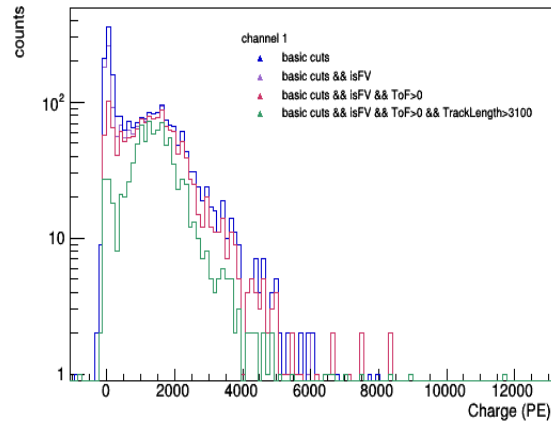
# PMT charge vs Track Topology

- Selections reducing fraction of event with  $\approx$  zero charge
  - Track cross entire FV volume : maximum scintillation production
  - ToF>0 : reduce triggers due to “muon bundles”

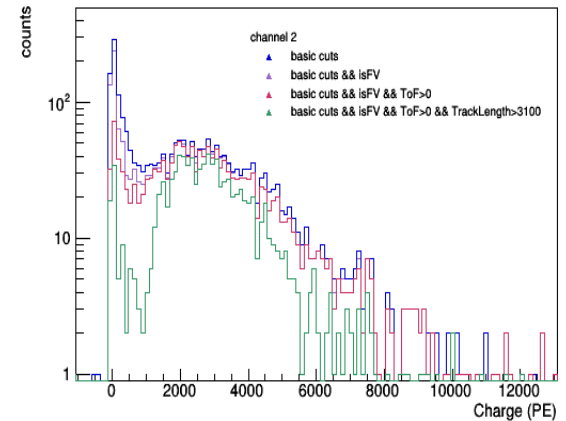
Charge [PE]- channel 0



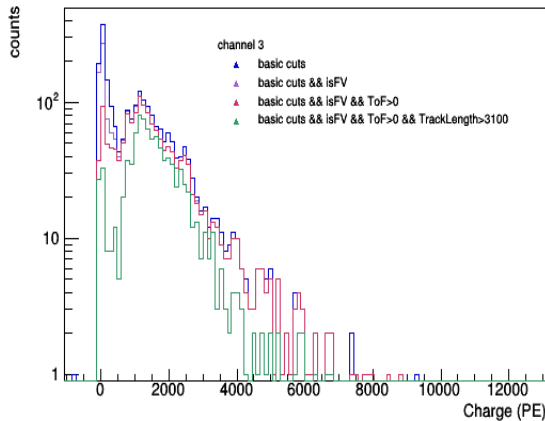
Charge [PE]- channel 1



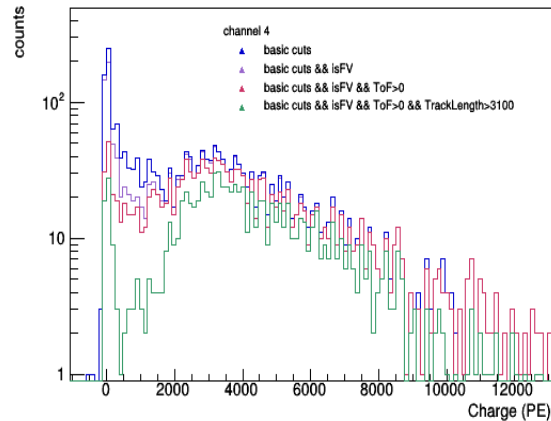
Charge [PE]- channel 2



Charge [PE]- channel 3



Charge [PE]- channel 4

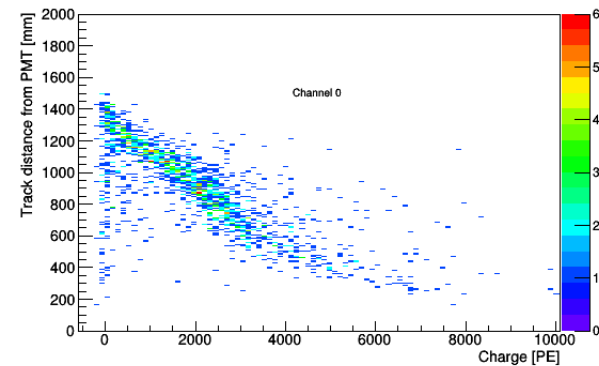


basic cuts: PMT event matched with a CRT event

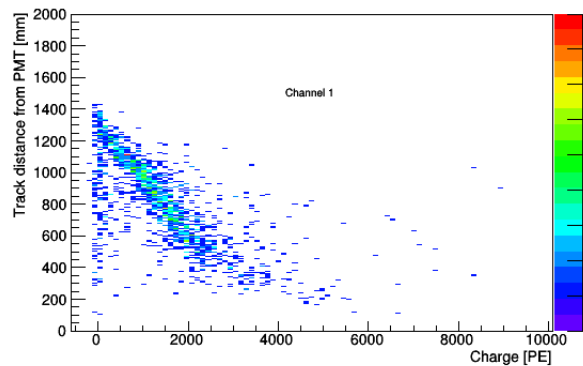
# PMT charge vs Distance to Track

- Two type of events:
  - Closest track implies higher light collection: a traversing muon
  - Small integrated charge not related to distance: not a traversing muon

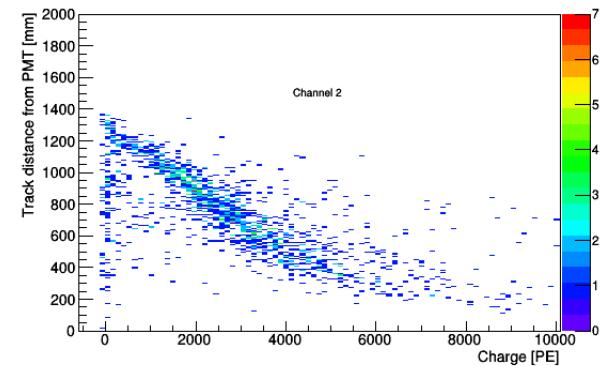
Track distance from PMT 1 vs Charge [PE] - in FV if ToF>0



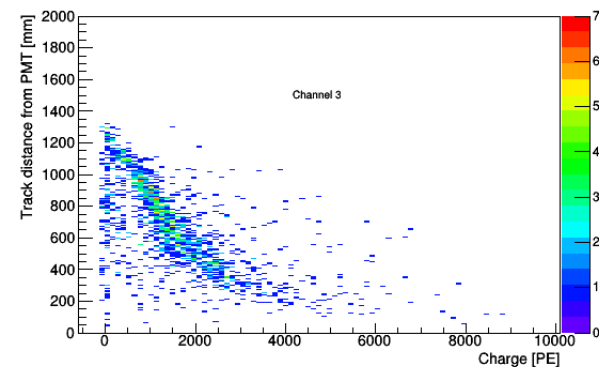
Track distance from PMT 2 vs Charge [PE] - in FV if ToF>0



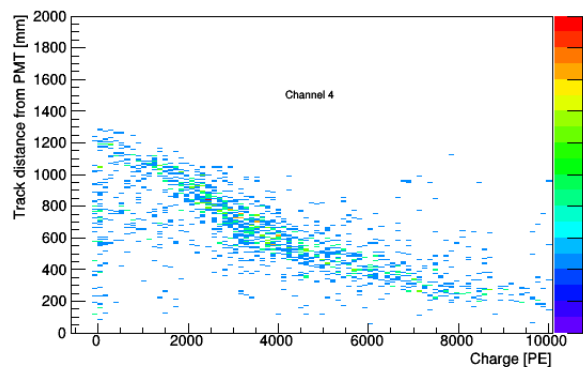
Track distance from PMT 3 vs Charge [PE] - in FV if ToF>0



Track distance from PMT 4 vs Charge [PE] - in FV if ToF>0



Track distance from PMT 5 vs Charge [PE] - in FV if ToF>0

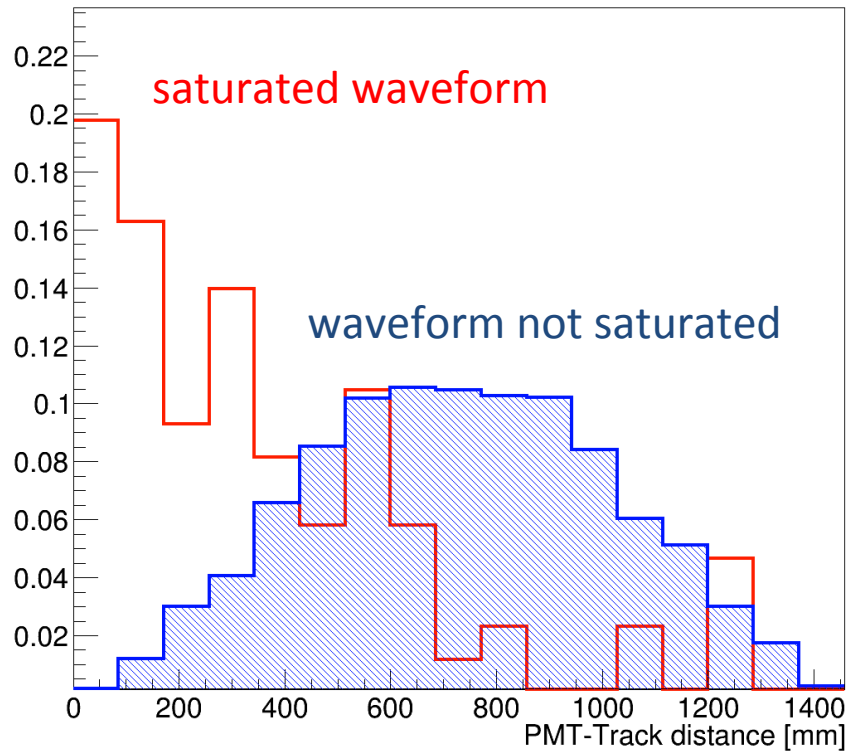


Track selection:

- ToF>0
- Inside FV

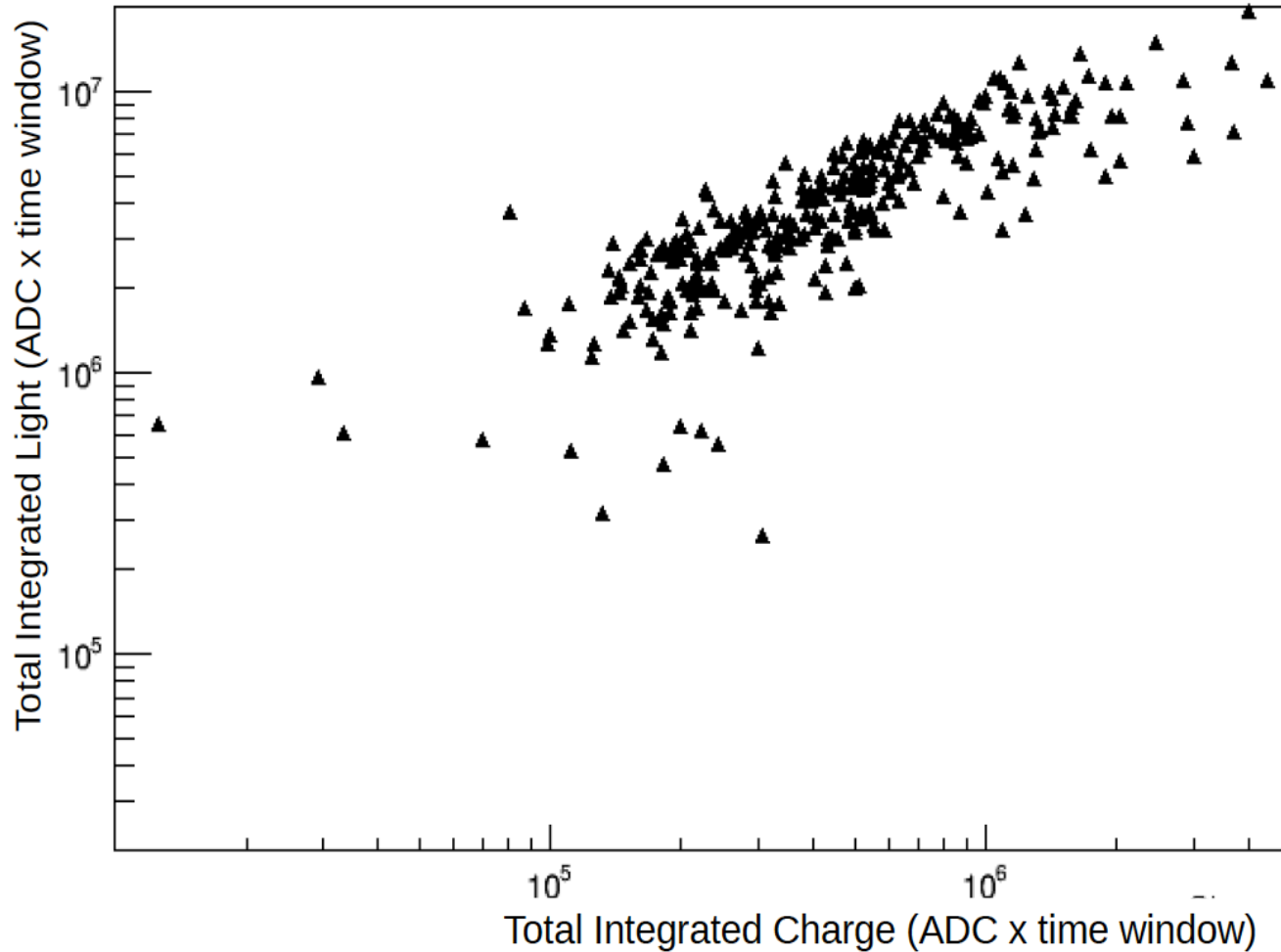
# PMT charge vs Track Topology

- Check that for PMTs with *saturated waveform* (-> highest integrated charge) reconstructed track is closer to the PMT



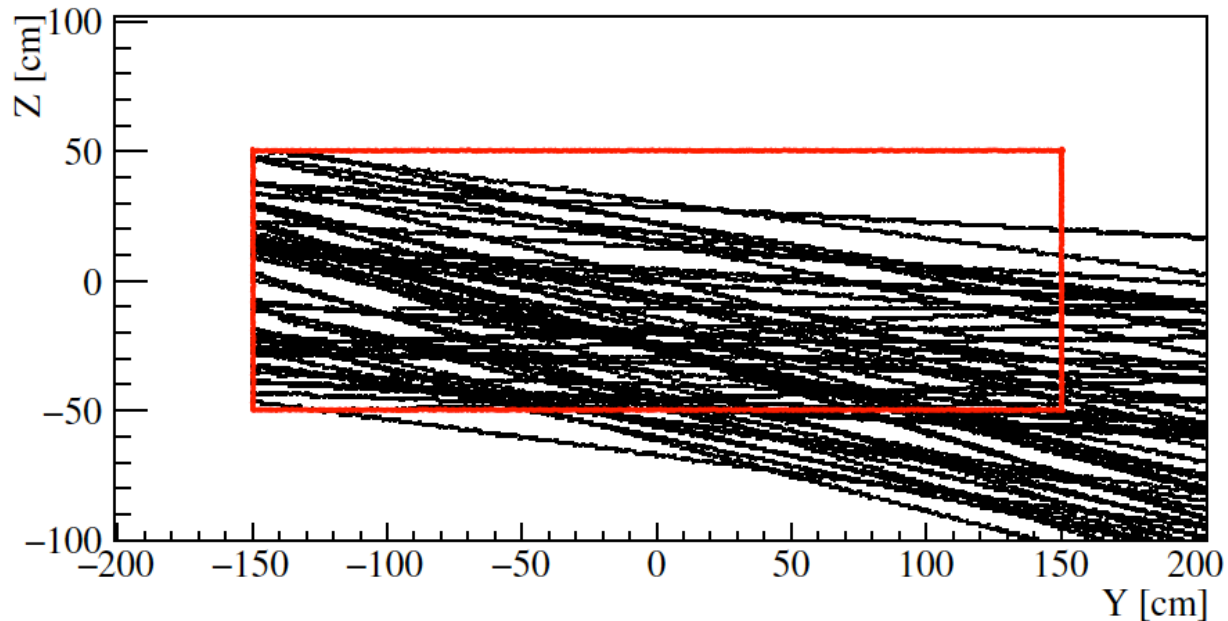
# Charge-Light Event Correlation

- First check of correct event matching (based on timestamp at *ms* level)
- Correlation between the quantity of light and charge detected for matched events



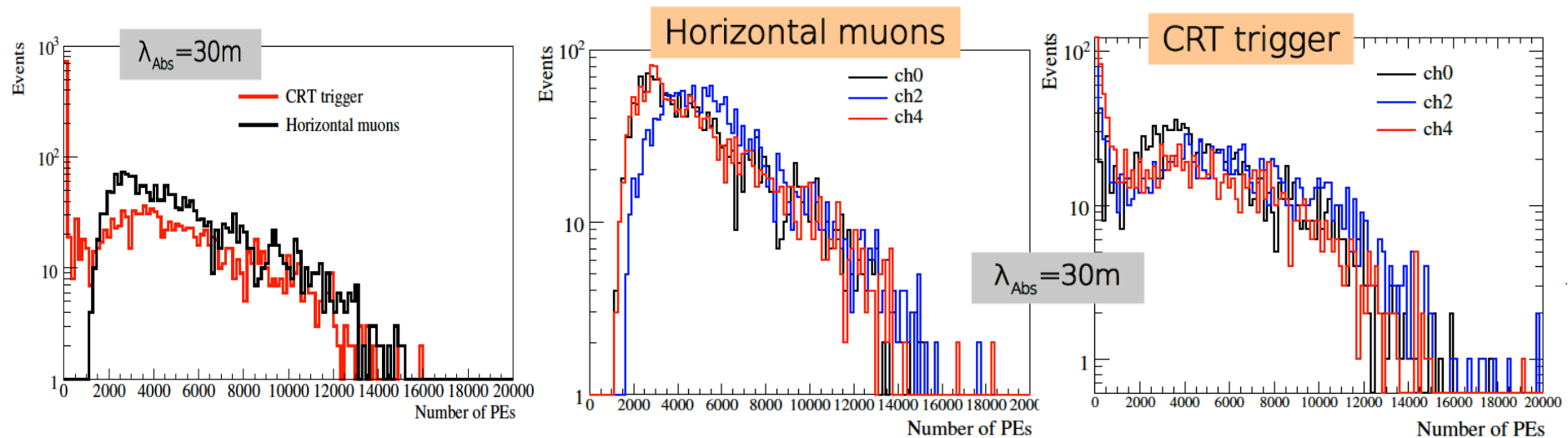
# 3x1x1 Light Detection System Simulation

- Implementation of the CRT trigger system
- Primary event:
  - Muons generated between the two CRT planes
  - Energy: 2-4 GeV



# Simulation: PMT charge vs Track Topology

- PEs distributions reproduce features seen in data
- Comparison between:
  - CRT trigger
  - Muons close to horizontal
- ✓ Peak close to 0 due to short tracks in the FV



# Conclusions

- Combined ongoing efforts towards:

- Characterization of PMT data
- Light Charge matching
- Data/MC comparison

# PMTs calibration

PMT	Voltage (V)	Gain ( $10^6$ )	Q (1PE) [pC]
0	1200	$1.10 \pm 0.14$	$0.18 \pm 0.02$
1	1200	$1.54 \pm 0.2$	$0.25 \pm 0.03$
2	1150	$2.3 \pm 1.7$	$0.4 \pm 0.3$
3	1150	$3 \pm 2$	$0.5 \pm 0.3$
4	1200	$1.6 \pm 0.3$	$0.25 \pm 0.04$