Status report and outlook

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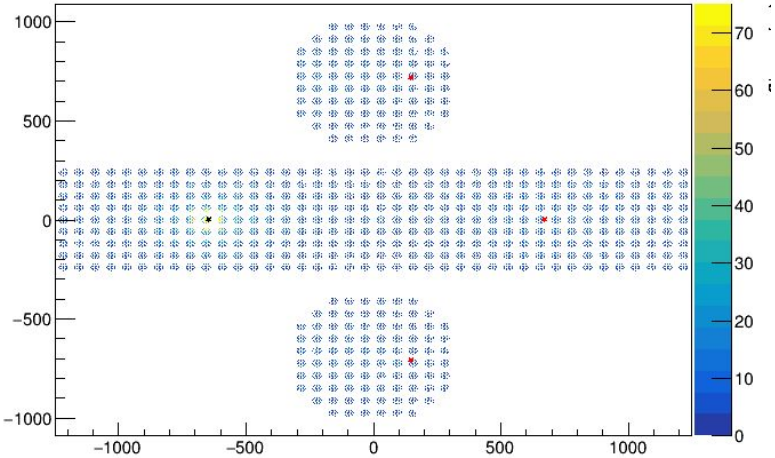
Reminder - on the two events

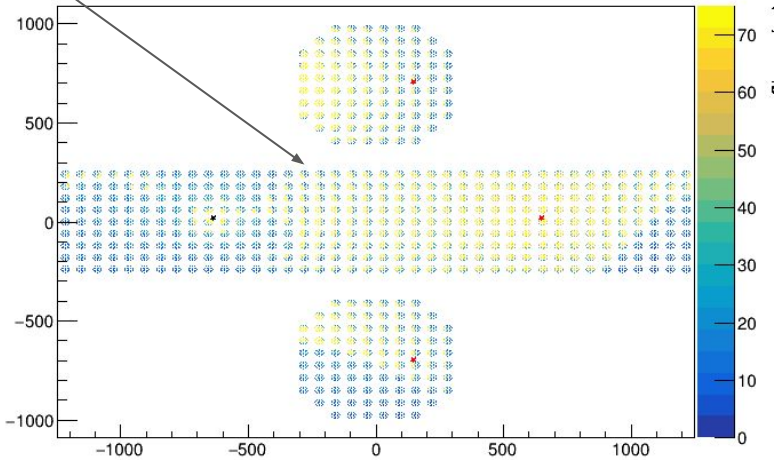
There seems to be two patterns in the photon-shotgun events:

- Below are both the sum of charges over 3M photons shot at (0, 0, 1)
- “B” has some strange “hit pattern”

A:



B:

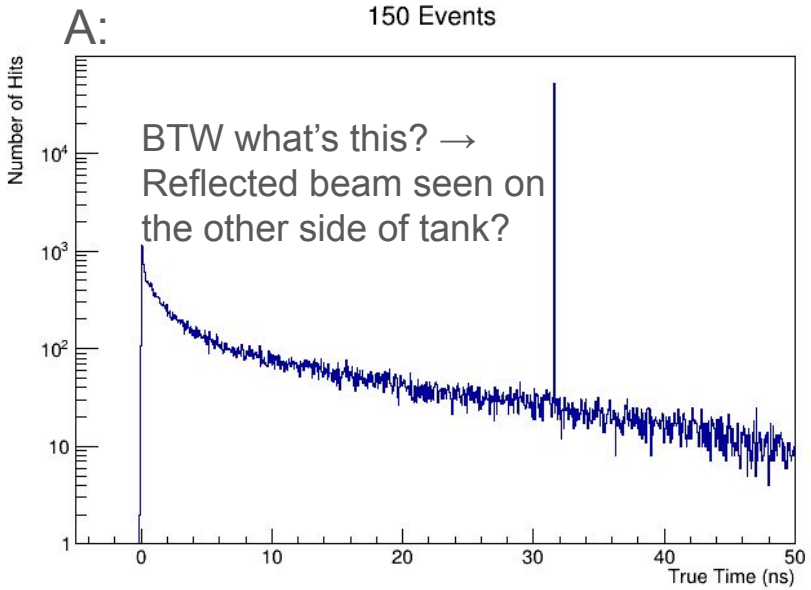


Understanding the differences and reasons for A&B events

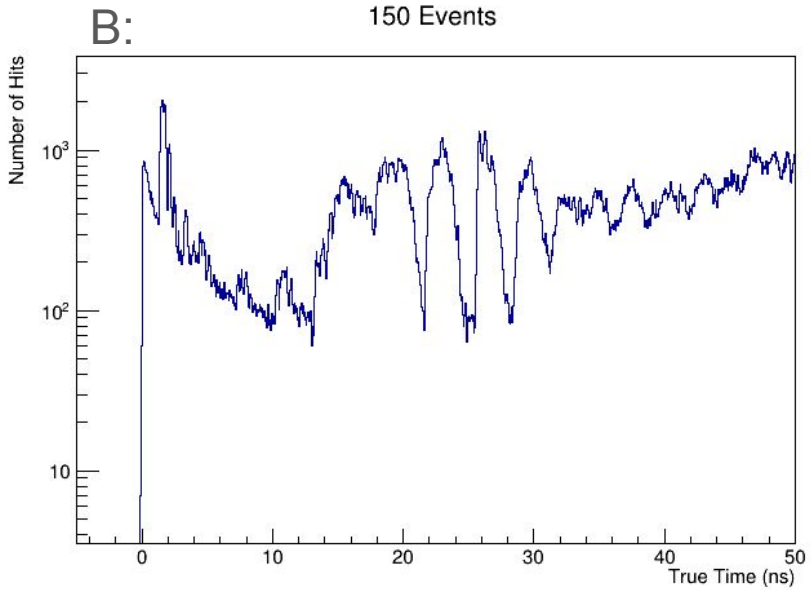
How can we check the hit patterns from many events? Need some quantity.
See very distinct true timing profile

- This “A” event has a long decay tail and most of the hits concentrate in the first few ns
- This “B” event has more peaks in the later timing

A:



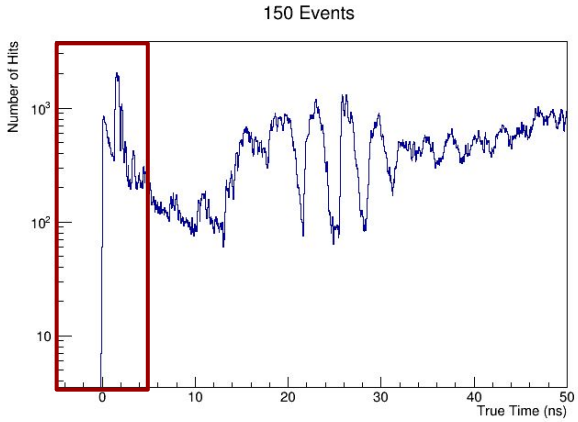
B:



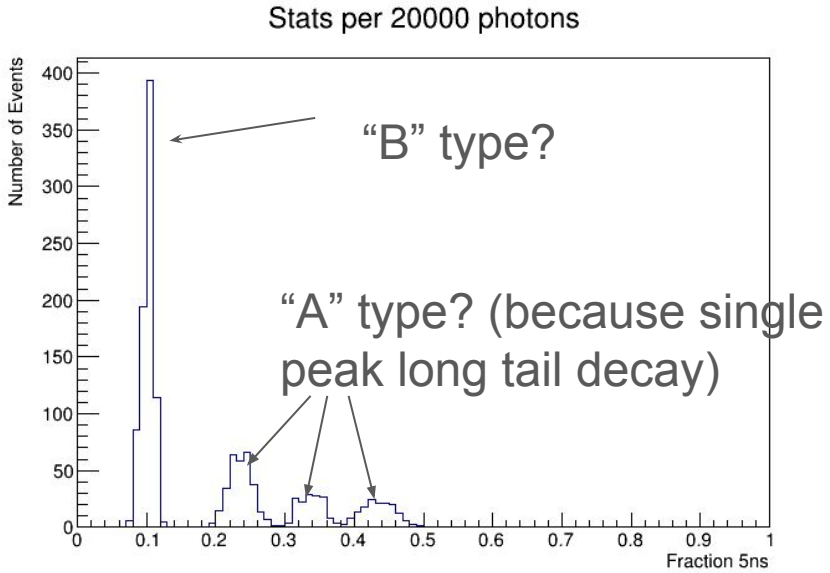
Understanding the differences and reasons for A&B events

Can the true timing be a parameter to distinguish between “A” and “B”?

- Let’s check the fraction of hits in the first 5 ns time window as compared to the total hits



Below: fraction of the hits in the red box to all the hits from 10 files = 150*10*20k photons

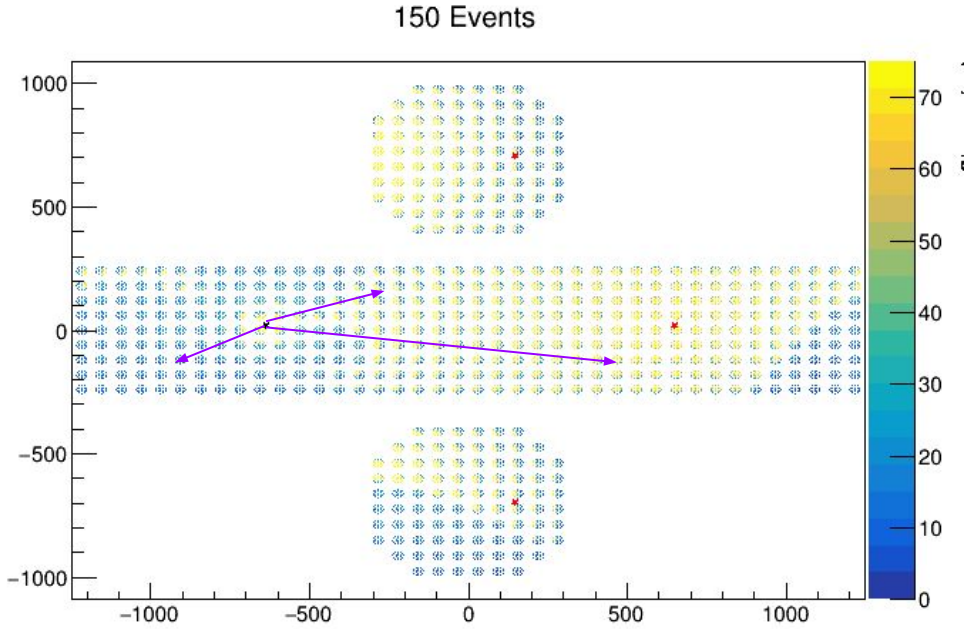


The spread of each peak comes from the statistical fluctuations in the 150 events at the same vertex.

Understanding the differences and reasons for A&B events

Seems like true timing is a good probe, but can we be sure?

- Need a second handle to represent the hit pattern and to verify it.



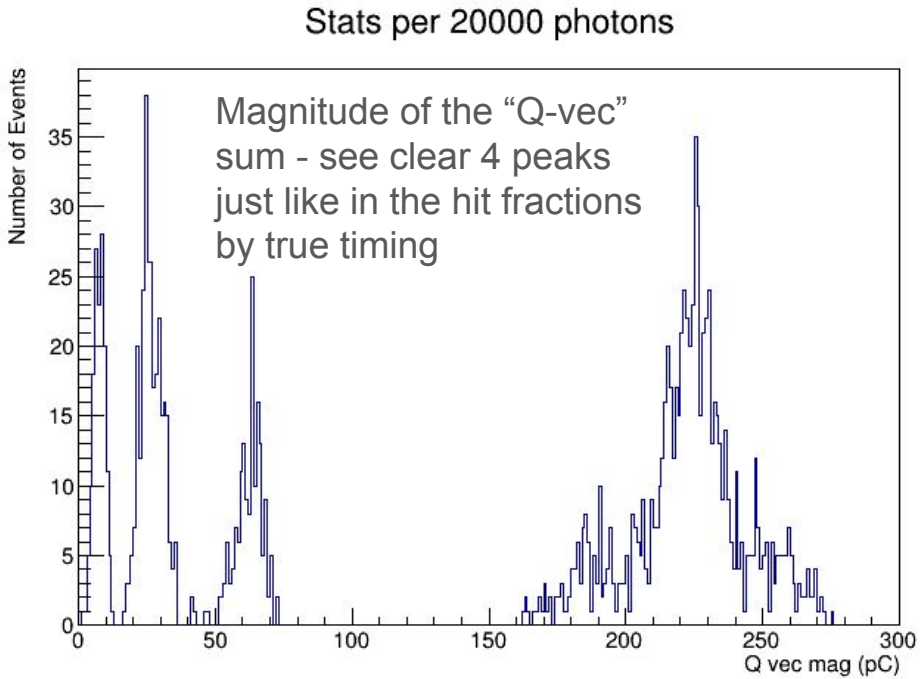
1. Draw a vector from the PMT that registered the most hits to any other **barrel** PMTs on this 2D eventdisplay
2. The module of each vector is the charge registered in each PMT
3. Sum all these “Q vectors” and normalize by `nPMT_barrel`

-> If it’s a perfectly symmetric “A” event, the summed “**Q-vec**” would have 0 magnitude. And the larger the magnitude, the more asymmetry in the hit pattern.

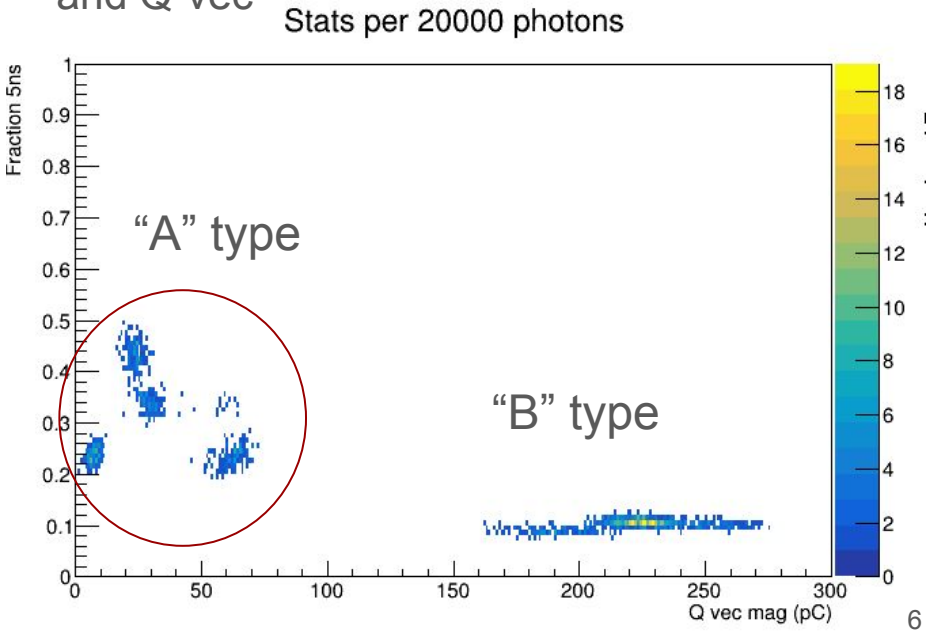
Caveat: the hit position is not always “centered” so this assumption is not always true

Understanding the differences and reasons for A&B events

For these 10 files the assumption seems to work fine (probably because the low hits PMTs don't contribute much to the Q-vec sum anyway)



Clear correlation between the hit fraction and Q-vec



Understanding the differences and reasons for A&B events

Now we have the parameters to say whether an event is “A” or “B”

Hypothesis for the different hit patterns:

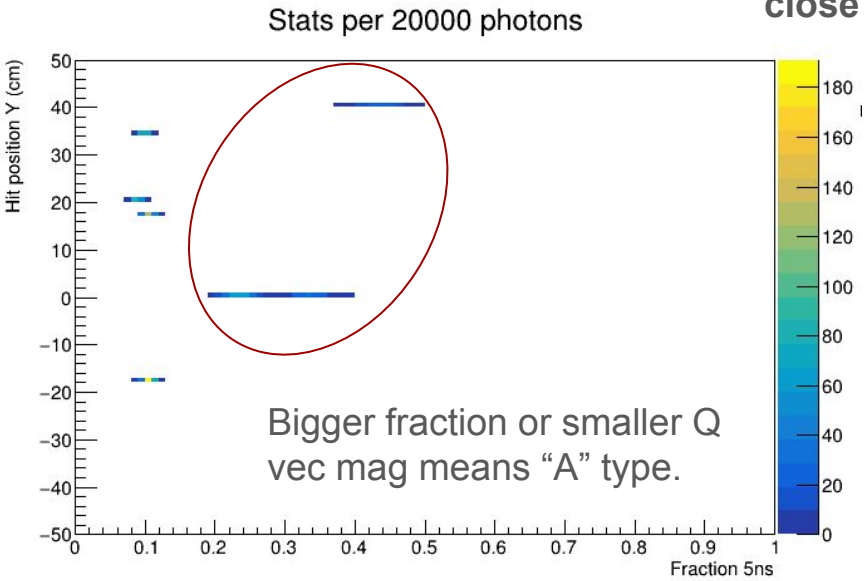
A. If a photon beam hits the PMT cover’s zenith point (90 degree), it will be reflected normally backward and the surrounding PMTs see equal amount of scattered light
B. If a photon beam hits the PMT cover at an angle, there will be an asymmetry in the reflected and scattered light

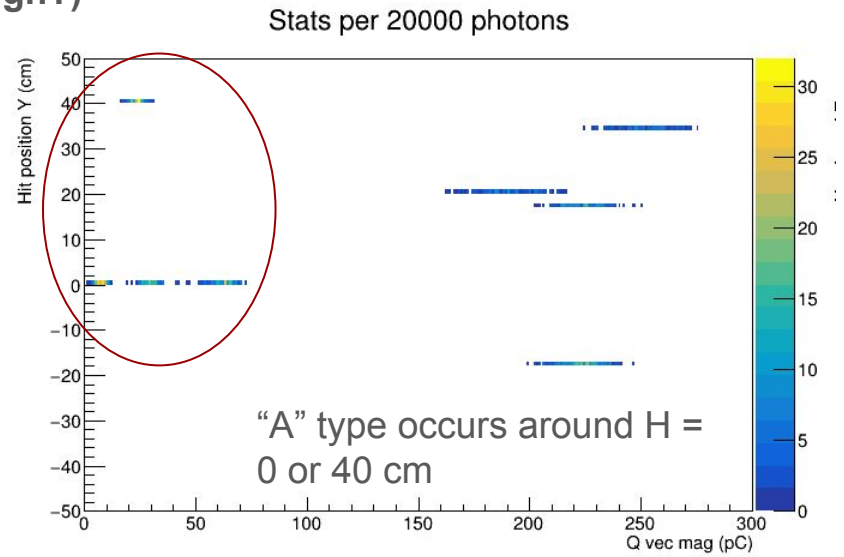
Understanding the differences and reasons for A&B events

In these 10 files, all photons are shot horizontally. So need to check if the hit fraction by true timing or the Q-vec magnitude has some dependence on the hit position height.

Y axis: the nearest hit PMT height to the beam direction

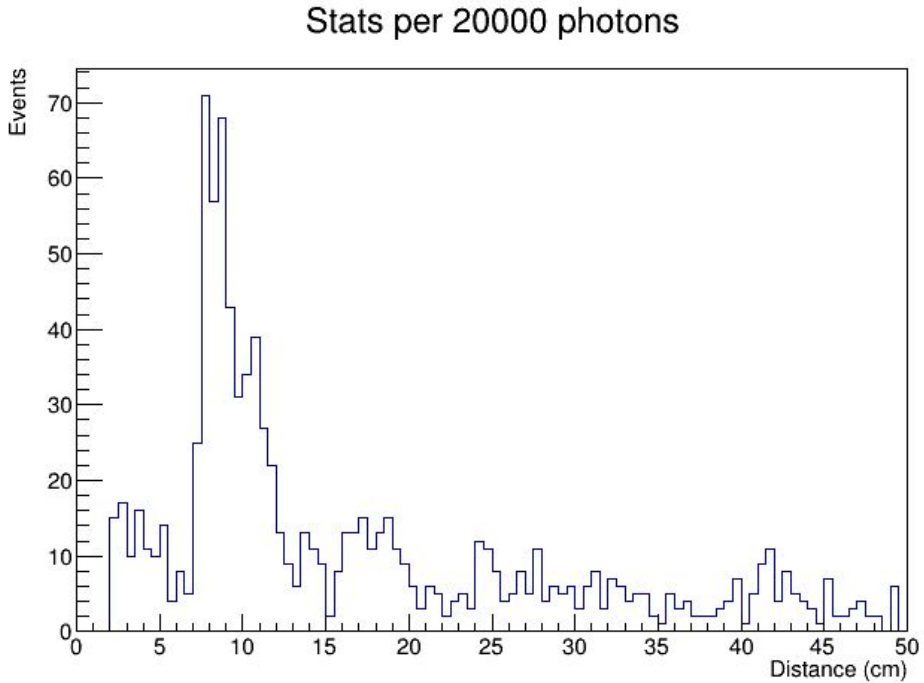
Diameter of mPMT module is ~ 40 cm? (actually 50cm, but close enough?)





Some bonus

Checked the photon scattering in water by checking the distance between **the position of the first hit photon** and **the point of beam direction intersecting on the tank wall**:



Most of the beams got scattered and smeared by ~10 cm.

Many low grasses though

Summary and outlook

Two promising quantities to represent different hit patterns:

1. The fraction of hits in the first 5 ns of the true timing
2. The “Q-vec”

Difference in the reflected photon directions caused by the different hit angle w.r.t the mPMT cover is a possible reason for the difference in the hit pattern

To further improve this check:

1. Need to migrate the most-hit PMT to the center of the 2D event display plane for Q-vec
2. Can check other quantities like the angle between the beam direction and the Q-vec
3. Can try to include end cap PMTs?
4. How to migrate these to digi-hits/reconstructed quantities?

For the training of SIREN I think the current MC files mostly look reasonable.