PMT geometry in Water Pool

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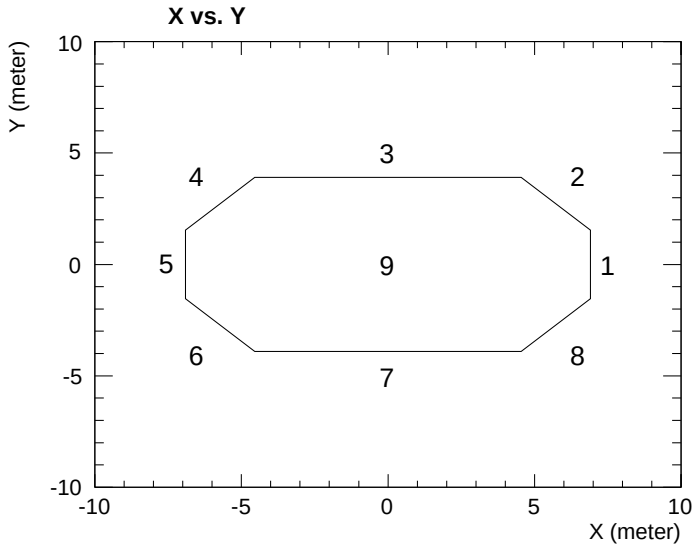
Dayabay Collaboration

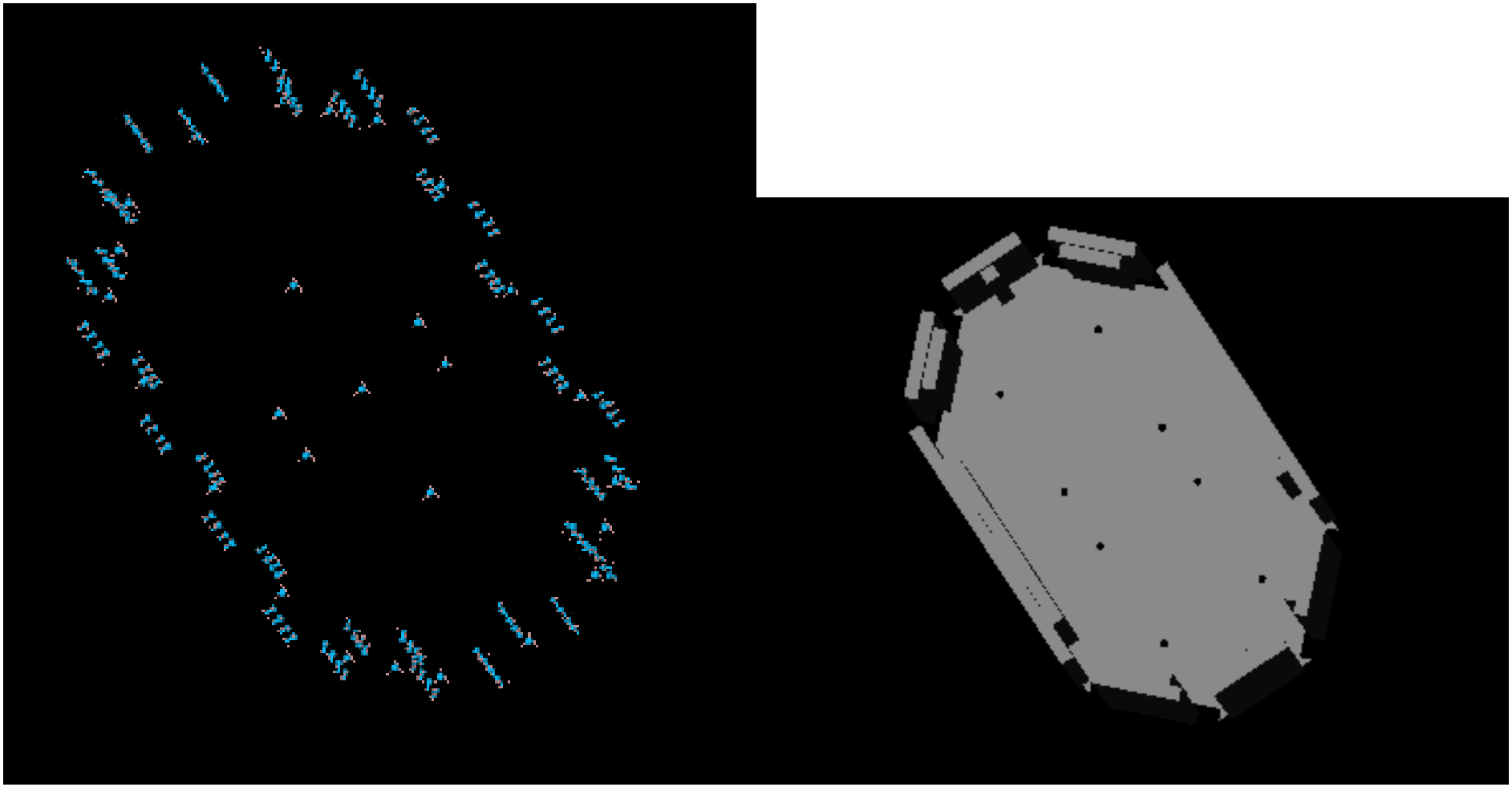
From engineer's numbers to NuWa

- Engineer provides two points for each PMT, the first point is the base, the second point is the top.
- The center of PMT implemented in NuWa is at the geometry center of PMT glass. I use the distance to the top (R=131 mm) to shift the second point to the center of PMT. The orientation angles θ, ϕ are calculated from the two points.
- PMTs are divided into three categories, Inner facing inward, Outer facing inward, Outer facing outward. In each category, PMTs are grouped wall by wall.
- 9 Walls, start from 3 o'clock and anti-clockwise.
- PMT id:

  `(site<<24)|pool<<16|inward<<12|wall<<8|spot`
- site: 0x01(dayabay), 0x02(la), 0x04(far)
- pool: 5(IWS), 6(OWS)
- inward: 1(face inward),0(face outward)

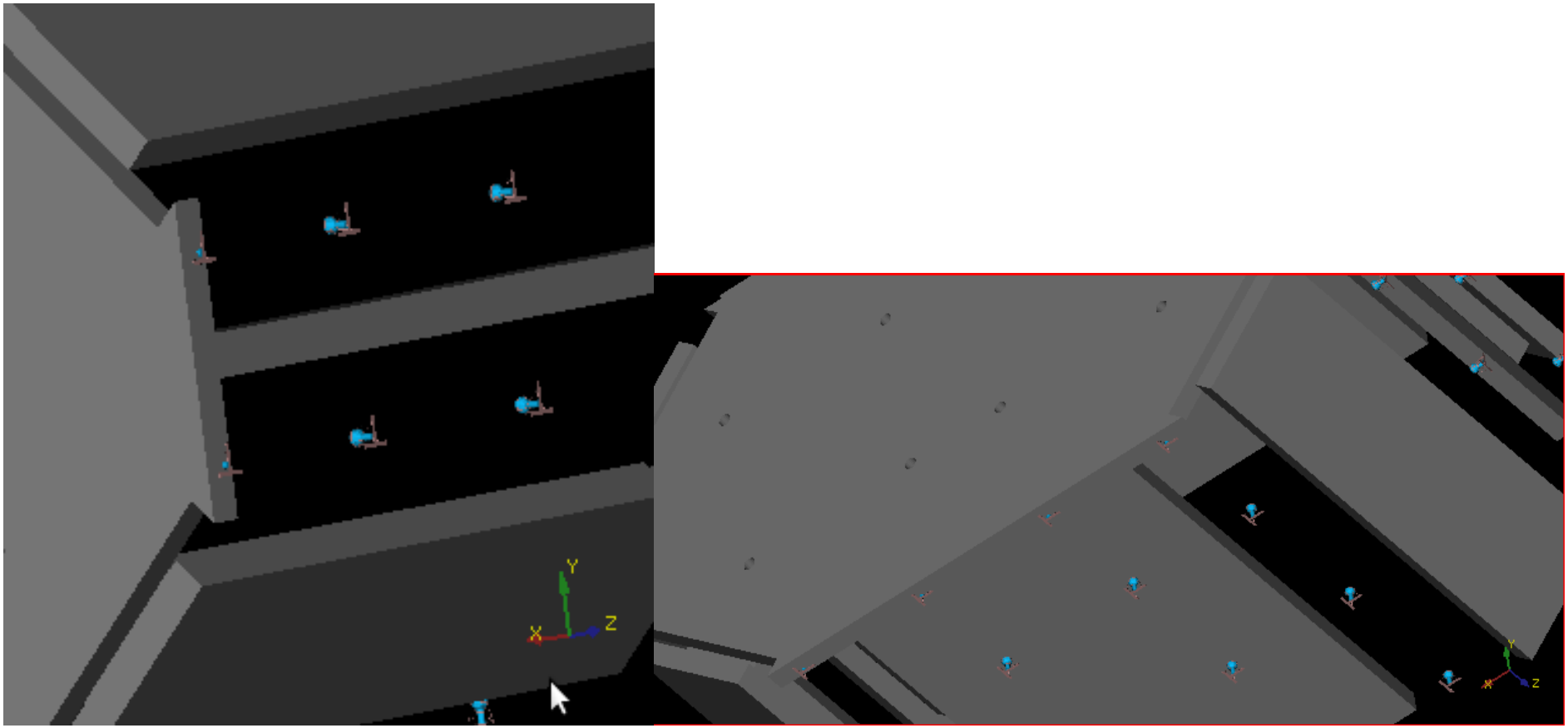


Using quanjing to check



- Left: My implementation of PMTs in Outer water pool.
- Right: Kevin use some PTE box to place the PMTs. Material of the box is water.

Using quanjing to check the overlap



Files modified

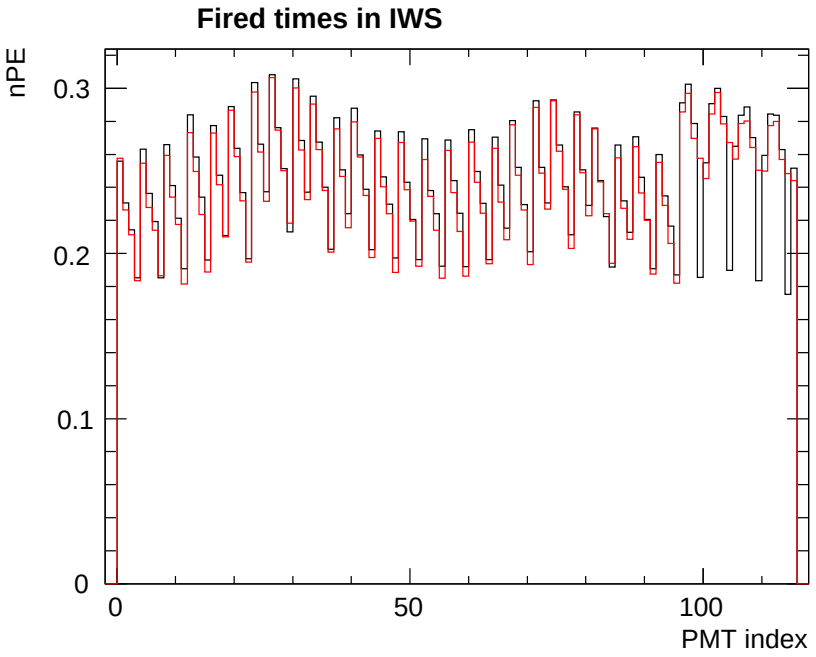
- The PMT positions are shown in WaterPoolPmtPosition.txt
- `~dybgaudi/Detector/XmlDetDesc/DDDB/PmtPanel:`
  `geometry.xml, parameters.xml, pmtpanels.xml, vetopmt.xml`
  `~dybgaudi/Detector/XmlDetDesc/DDDB/Pool: IWS.xml, OWS.xml`
  `~dybgaudi/Detector/XmlDetDesc/DDDB/PoolPmtStructure:`
  `dbInnFin.xml, dbOutFin.xml, dbOutFout.xml,`
  `laInnFin.xml, laOutFin.xml, laOutFout.xml`
- Note that files under dybgaudi/Detector/XmlDetDesc/DDDB/Pool and dybgaudi/Detector/XmlDetDesc/DDDB/PoolPmtStructure are automatically generated files, they only appear after you compile the package. (You can modify them by brute force and the change will take effect without recompile, but you will lose all the changes if you recompile.)

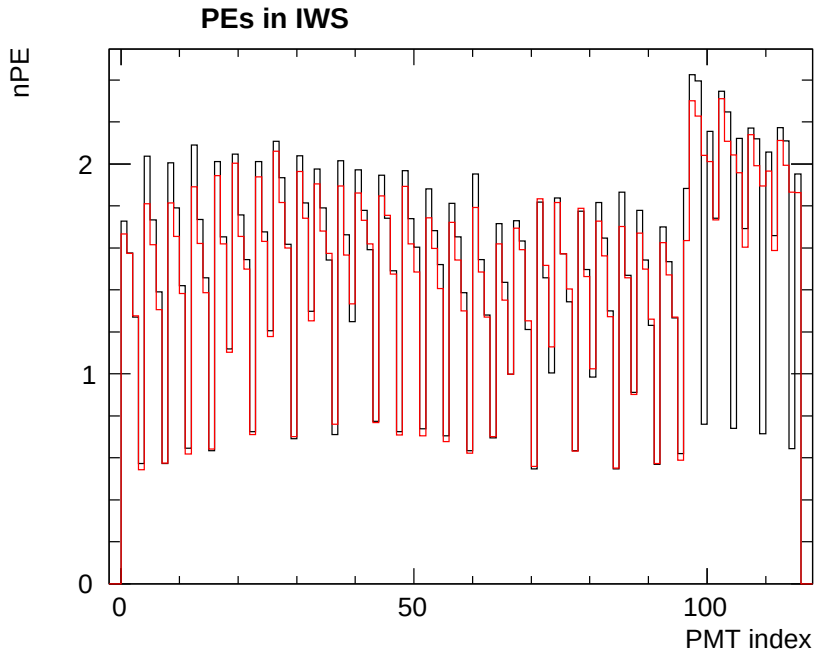
As a check for the changes, compare simulation results between the old and new method by implementing the old PMT positions using the new method.

Case 1: geometry with old method

Case 2: geometry with new method

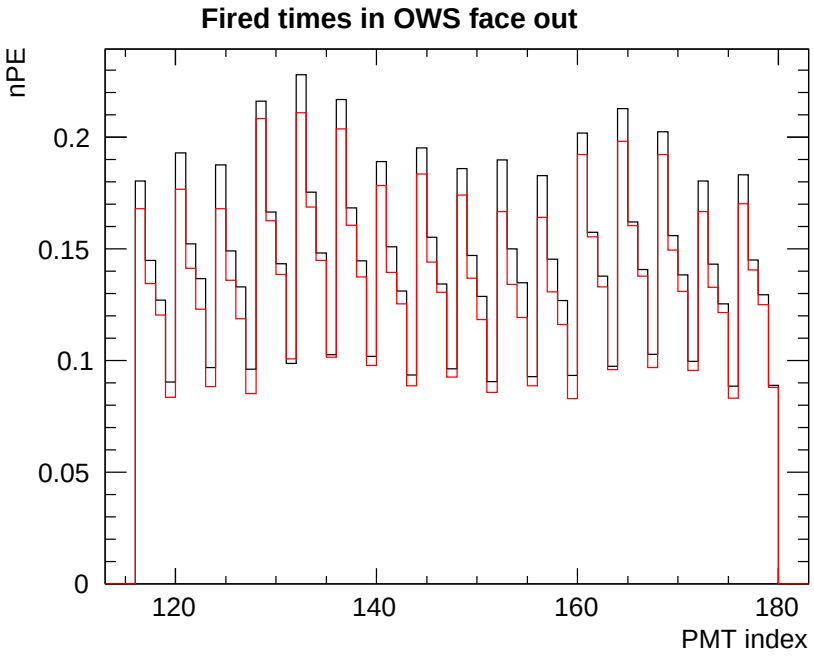
IWS

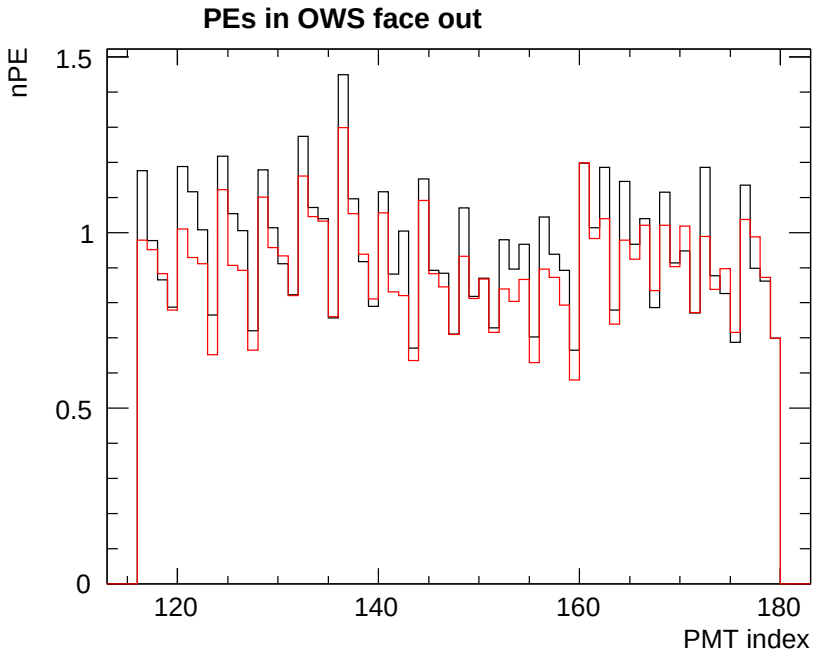




- Black: Case 1 (20000 events), Red: Case 2 (20000 events)
- Nomalized using number of events
- Some significant difference at the right hand side, which are located at the bottom.

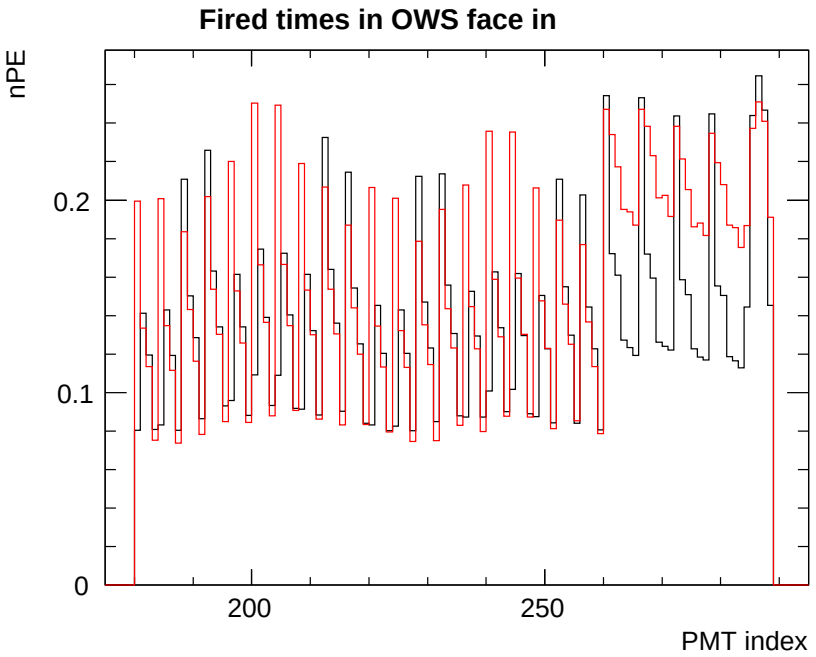
OWS face outward

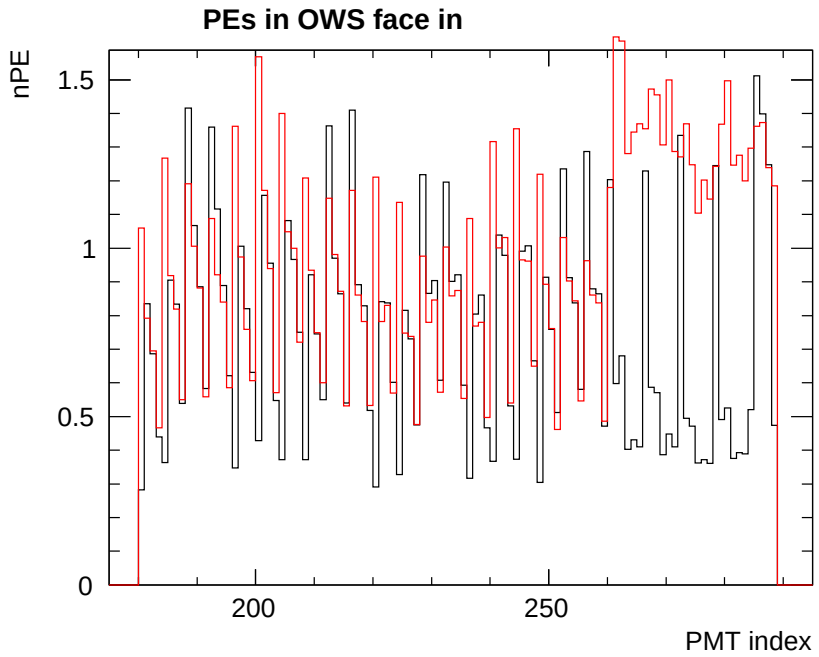




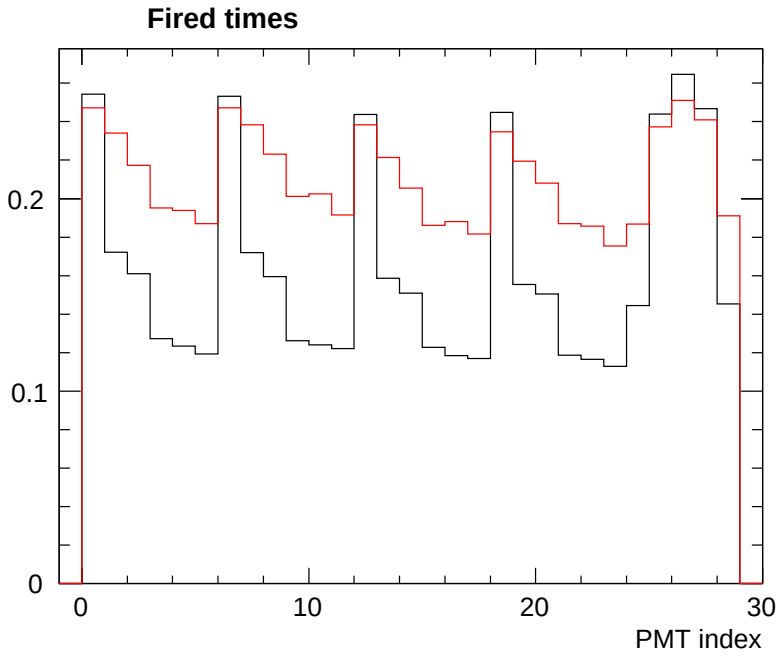
- Black: Case 1, Red: Case 2
- Nomalized using number of events
- Not much difference, but Case 2 all have slightly lower hits than Case 1.

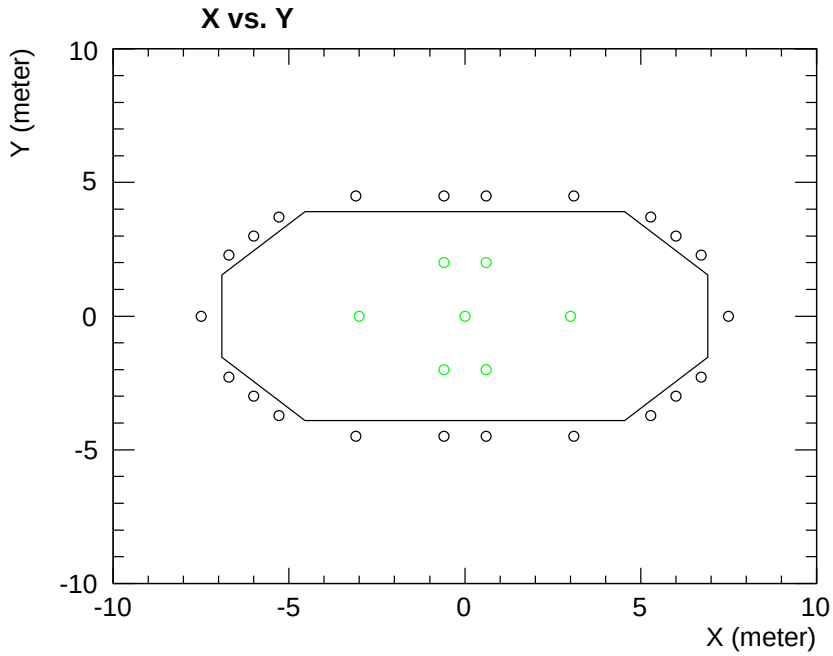
OWS face inward

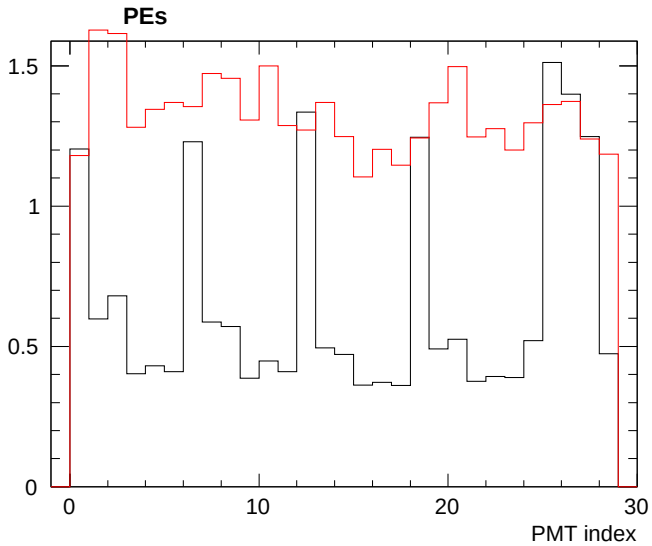




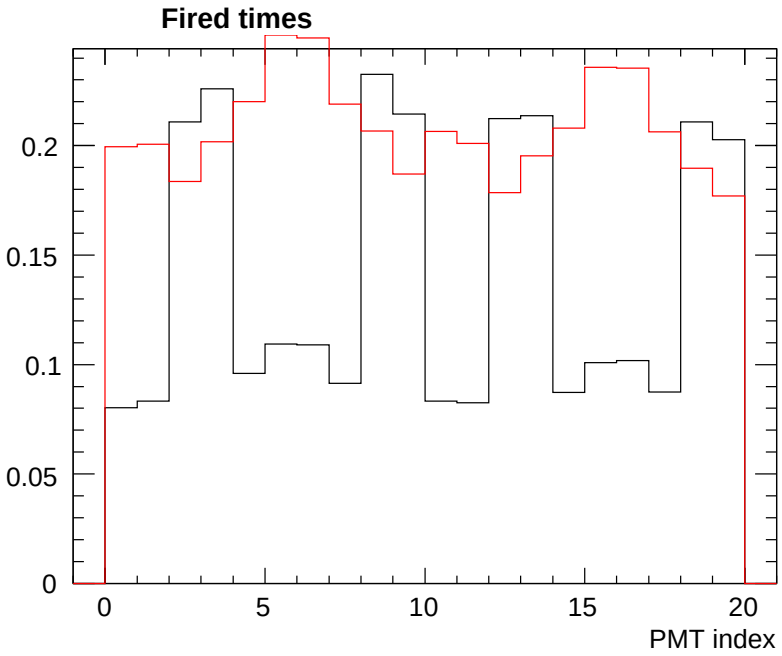
- Black: Case 1, Red: Case 2
- Nomalized using number of events
- Some significant difference at the bottom of pool.

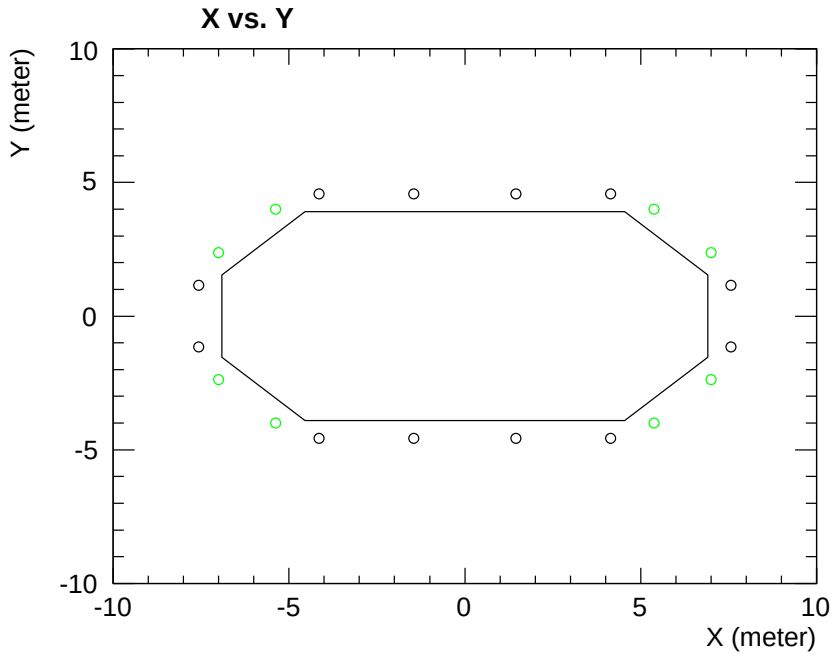


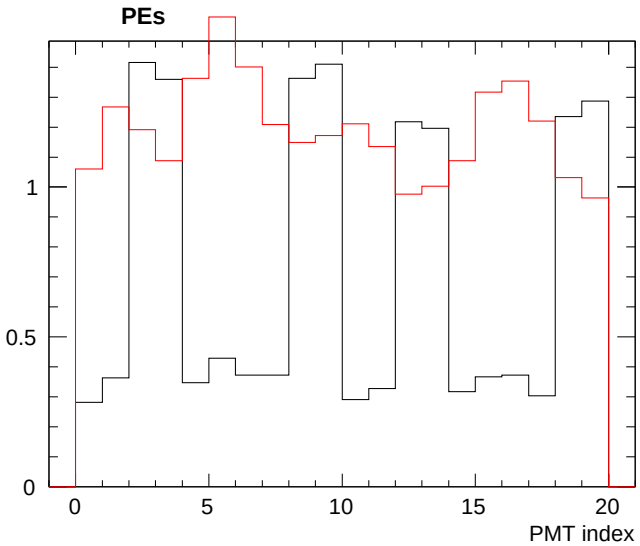




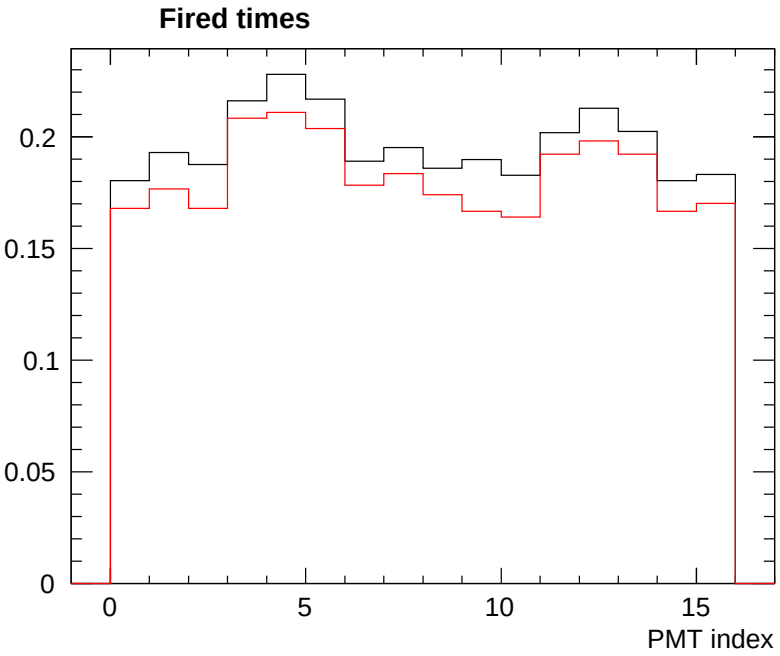
- Black: Case 1, Red: Case 2, Green: $n_{fired} > 0.2$
- Nomalized using number of events
- Z = -4612 mm, Outer pool floor

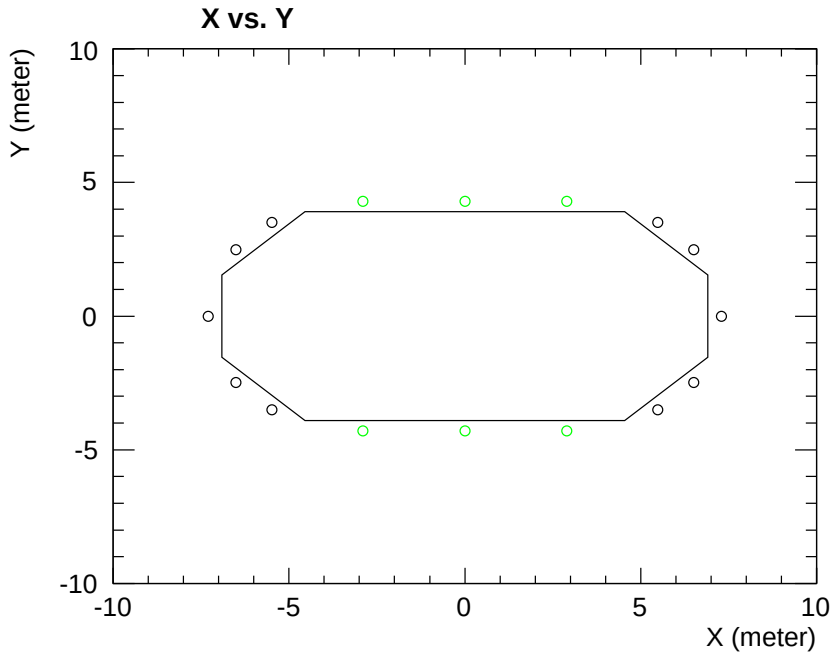


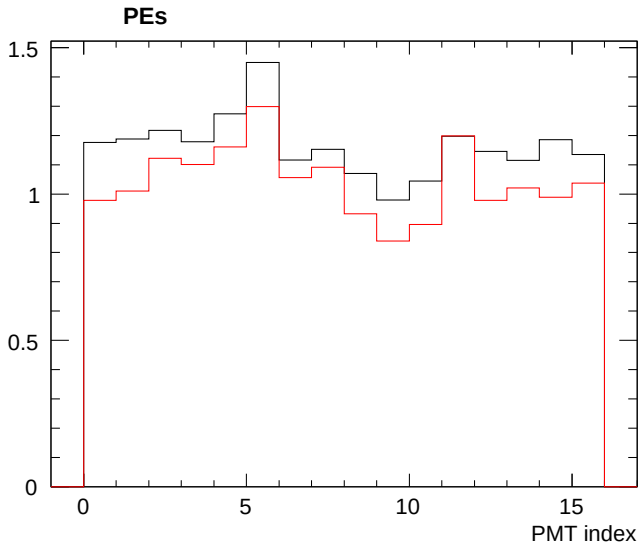




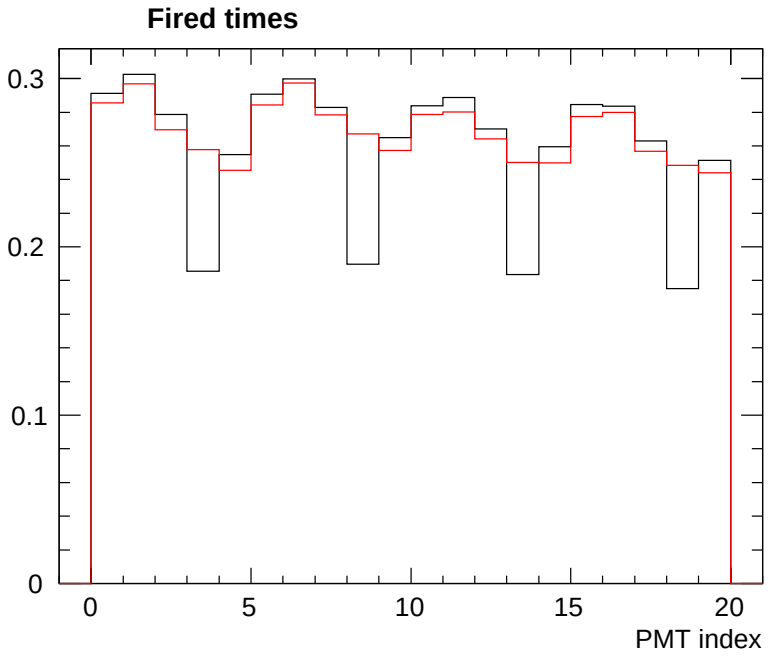
- Black: Case 1, Red: Case 2, Green: $n_{fired} > 0.2$
- Nomalized using number of events
- Z = -4581 mm, at the bottom of Outer pool wall

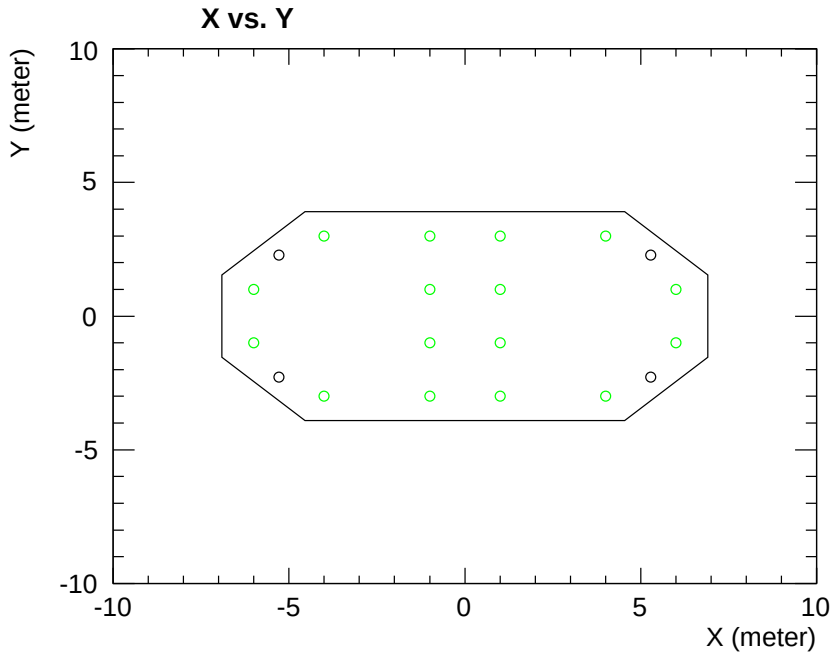


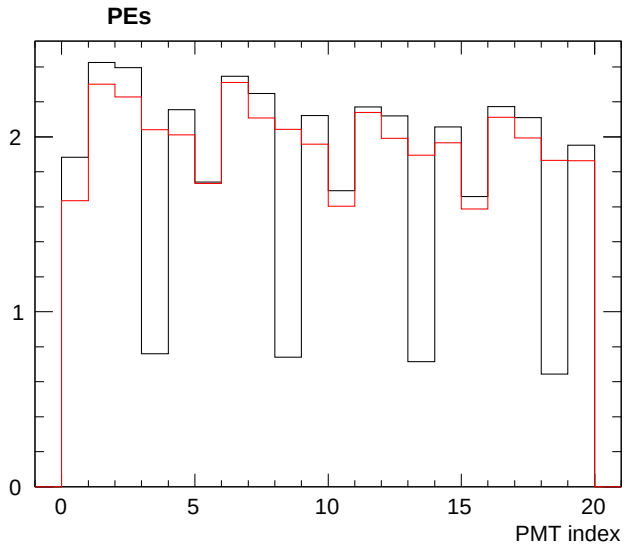




- Black: Case 1, Red: Case 2, Green: $n_{fired} > 0.2$
- Nomalized using number of events
- Z = -4081 mm, Outer pool facing ourward

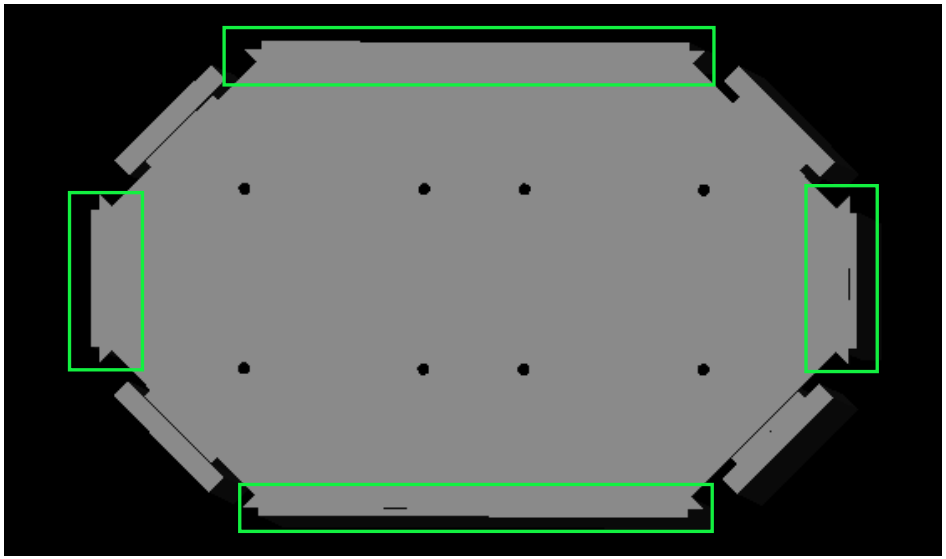






- Black: Case 1, Red: Case 2, Green: $n_{fired} > 0.2$
- Nomalized using number of events
- Z = -3608 mm, Inner pool floor

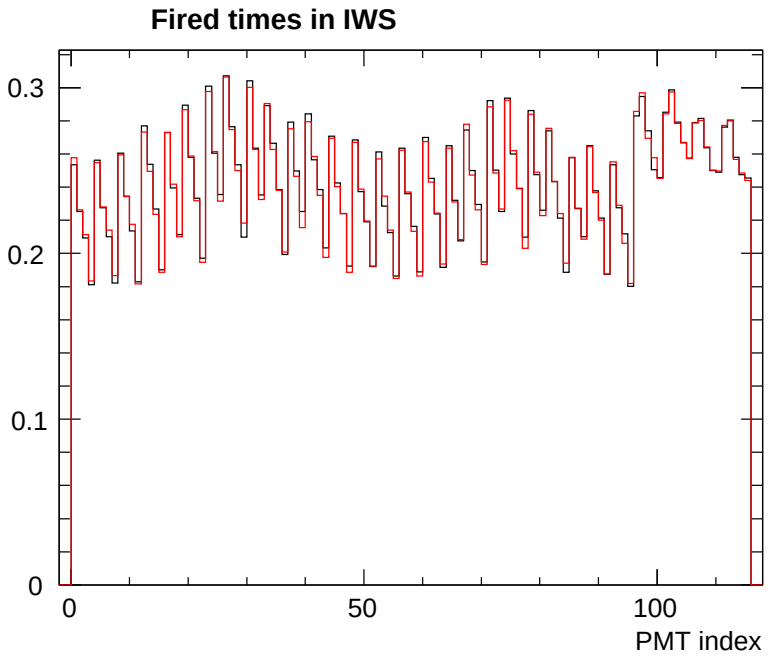
Investigate the old method

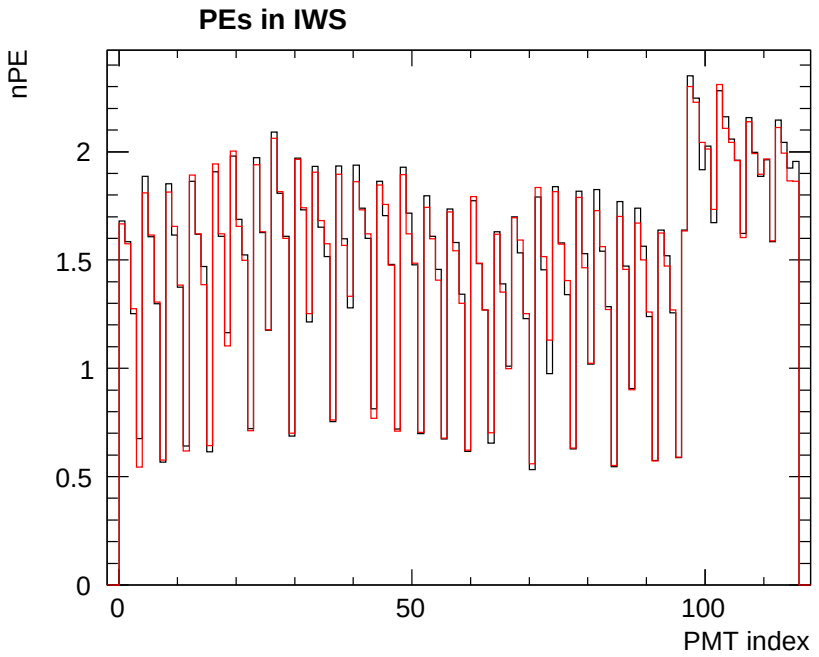


- There is some overlap between the PTE water boxes in the bottom of OWS. Overlap between lvolumes are not supposed to happen in Gaudi, the behavior at overlap region is not defined.
- Wall 1,3,5,7 have overlaps, page 10 show PMTs at the bottom of these walls have much lower rates of hit, it is possible the overlap has part of the PMT.

Case 3: Use the old method, but delete the water box.
Compare with Case 2.

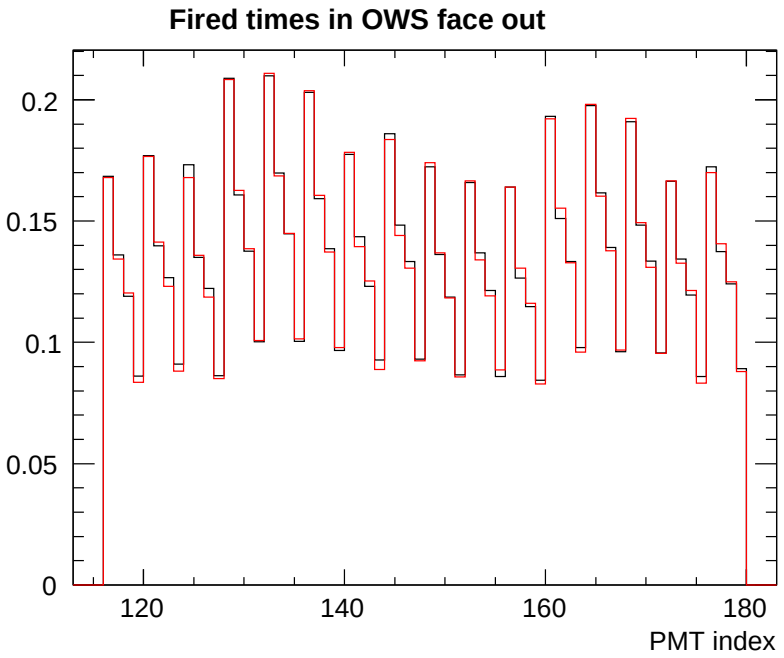
IWS

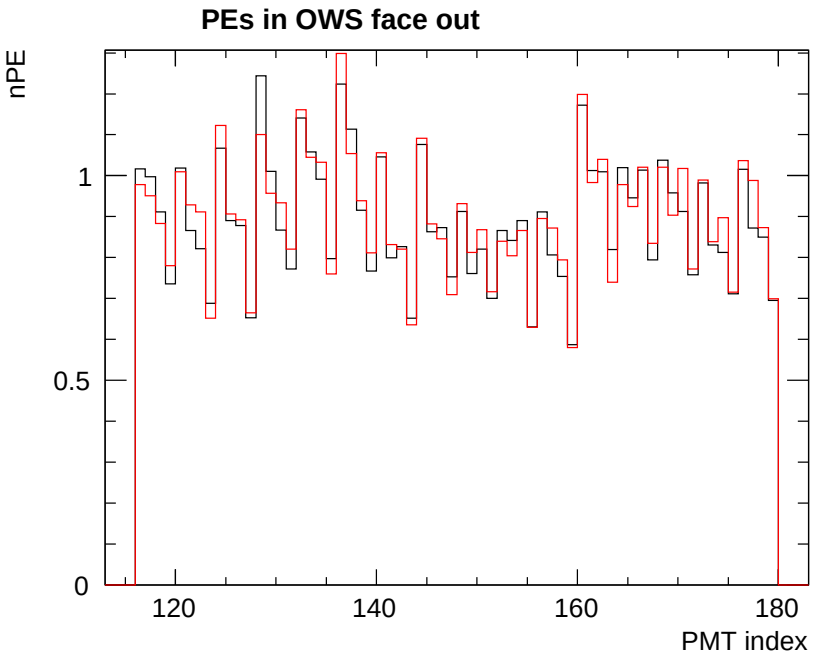




- Black: Case 3, Red: Case 2
- Nomalized using number of events
- Agree well.

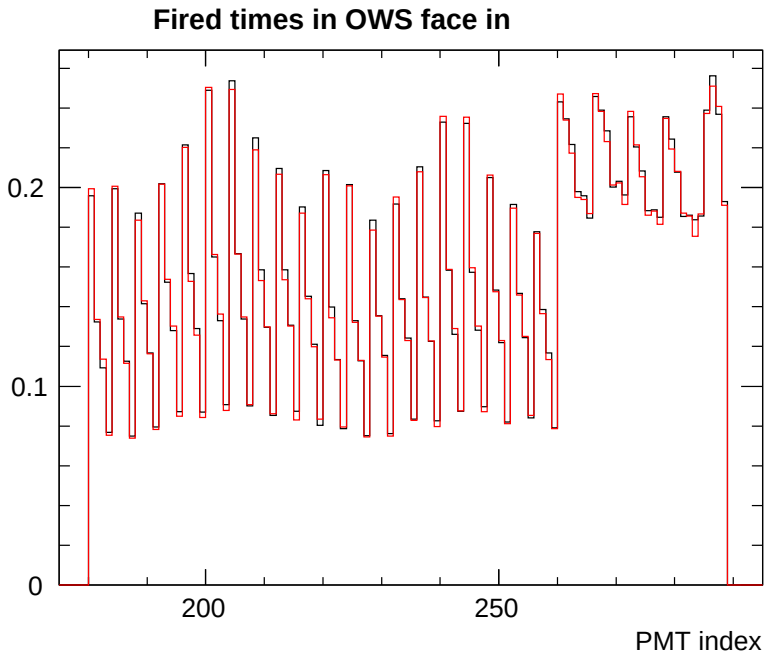
OWS face outward

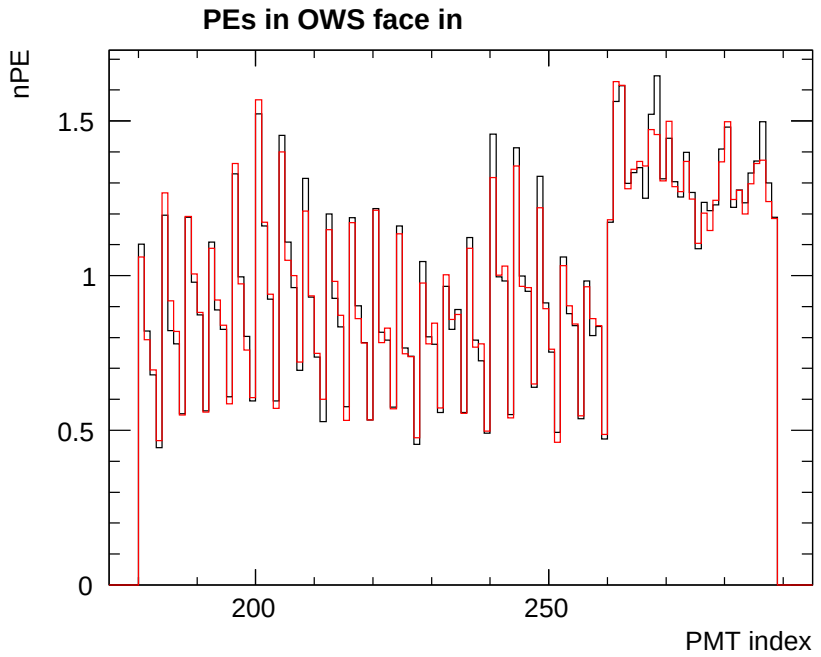




- Black: Case 3, Red: Case 2
- Nomalized using number of events
- Agree well.

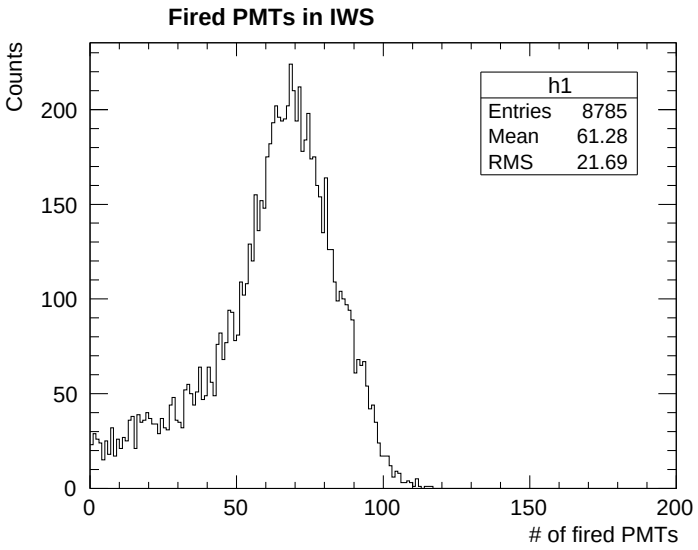
OWS face inward

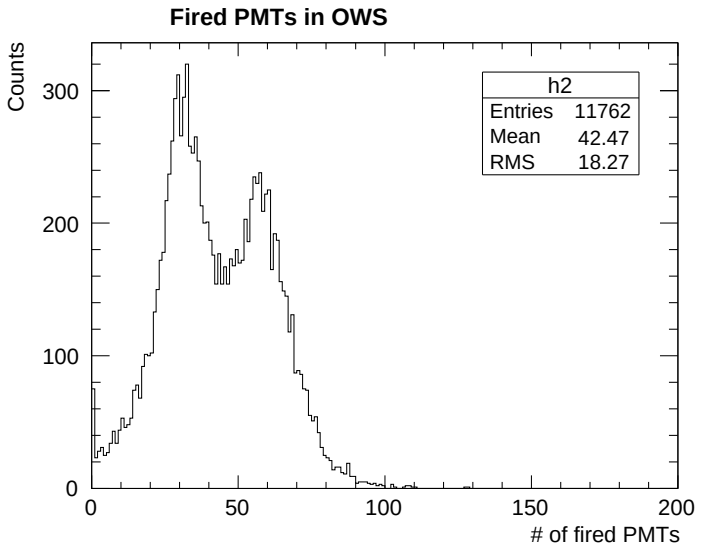


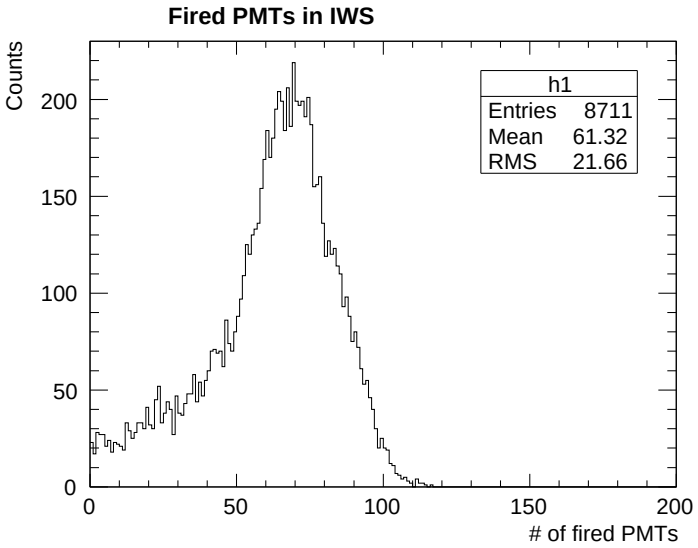


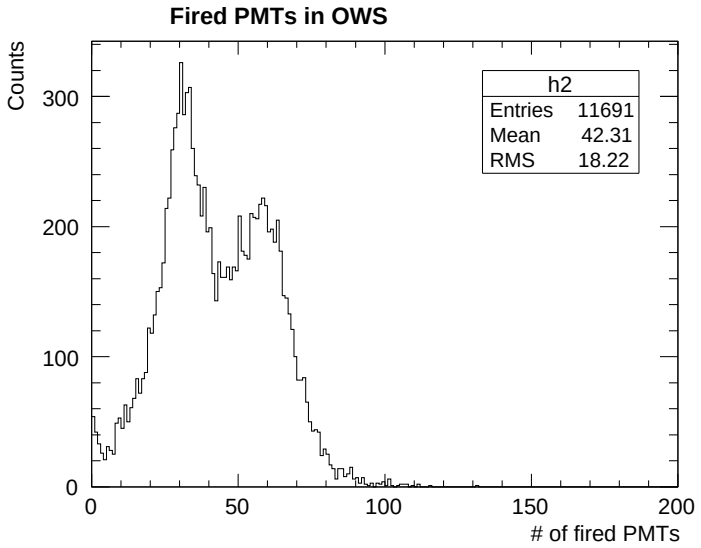
- Black: Case 3, Red: Case 2
- Nomalized using number of events
- Agree well.

Number of hit PMTs



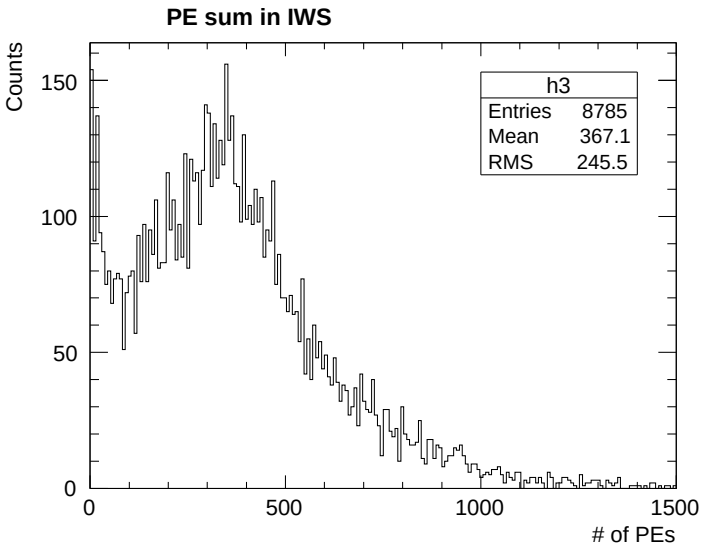


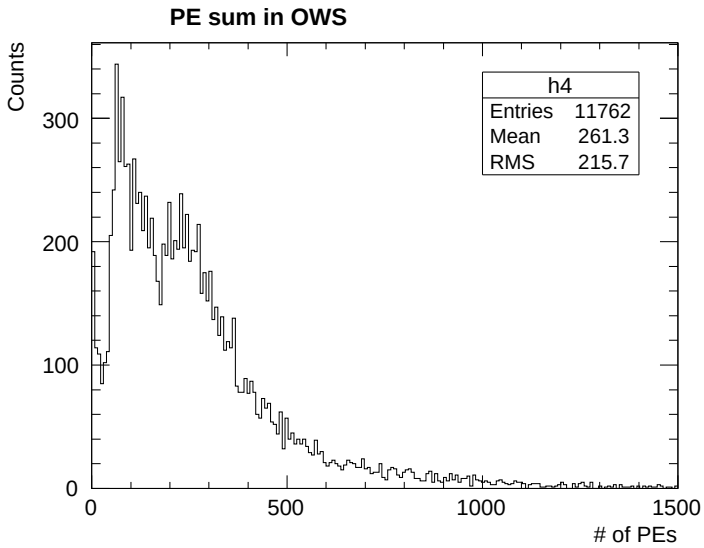


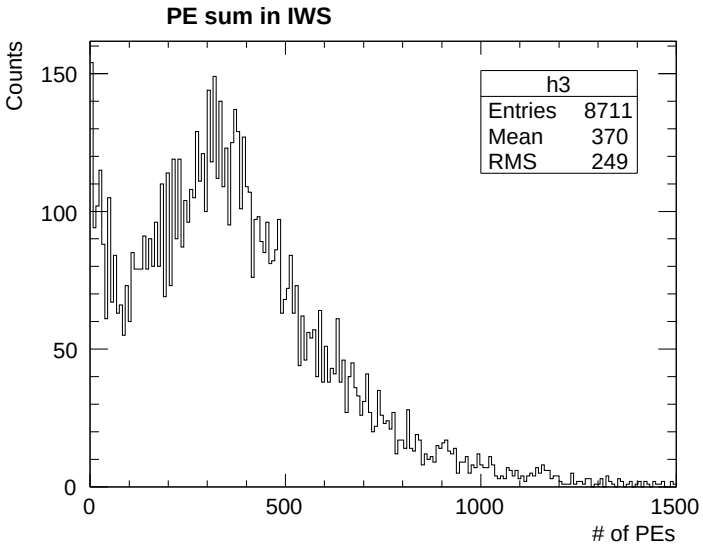


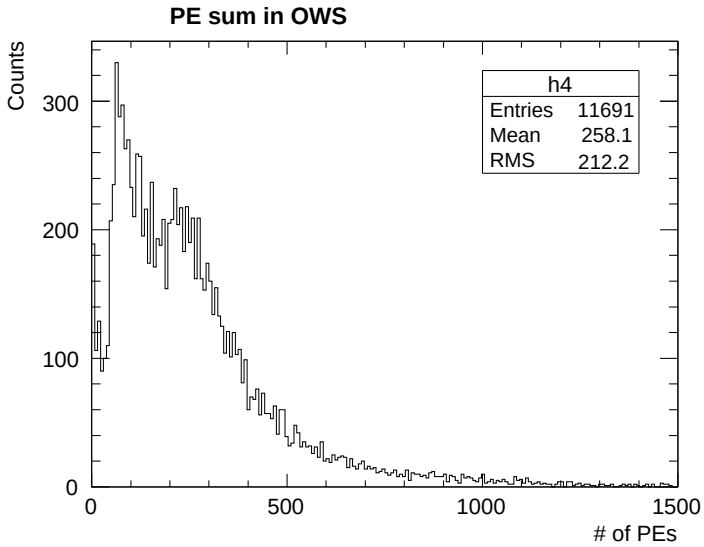
- Top: Case 3, Bottom: Case 2

Number of collected PEs









- Top: Case 3, Bottom: Case 2

Summary

- The original implementation of PMT positions in NuWa use some PhotoTube envelop boxes which are made of water. The water boxes are not necessary, just assembly will do the job.
- Overlap of daughter logical volumes can cause problems. Should be very careful to make sure it not happen.
- One of the most essential postulates of the Gaudi geometry structure: All boolean operations on volumes are strictly forbidden. Boolean operations should be performed at the level of Solids.
- After the correction, muon efficiency in OWS is a little bit higher than before.
- It will be helpful if someone can double check the changes.