

# Water Pool Muon Veto Efficiency

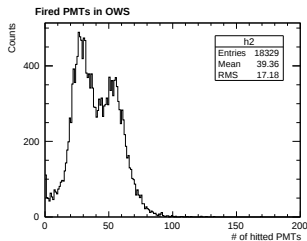
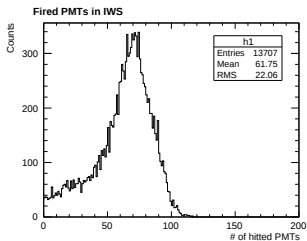
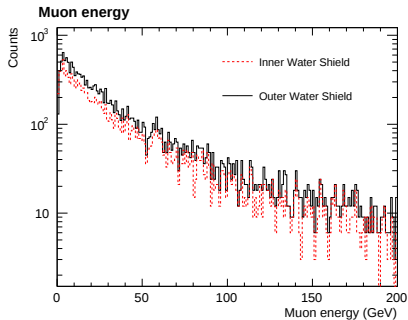
Qing He

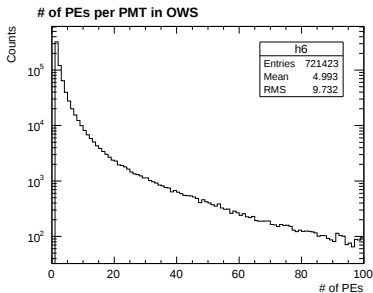
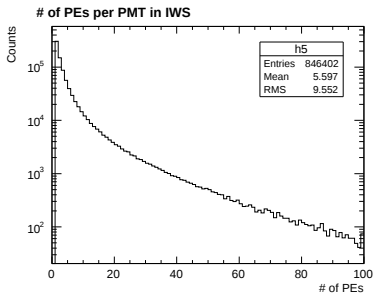
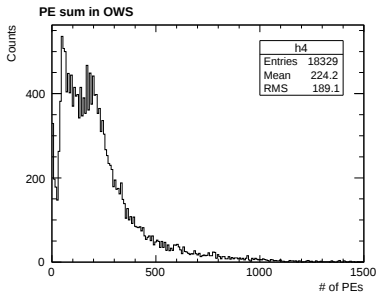
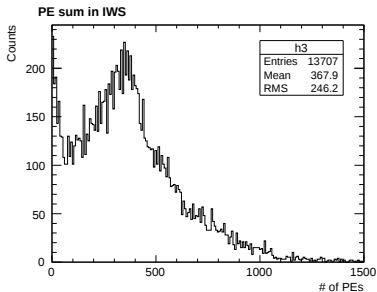
Princeton University

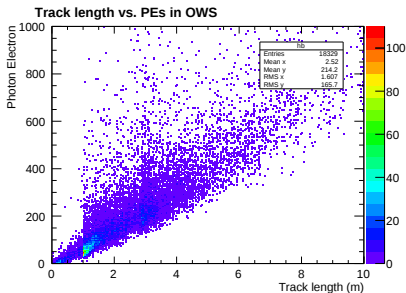
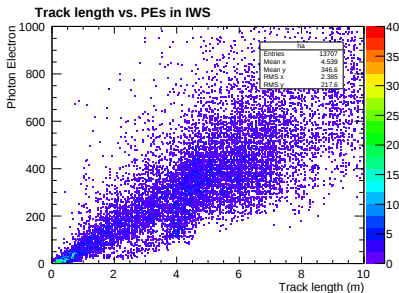
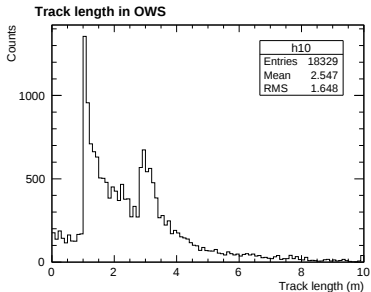
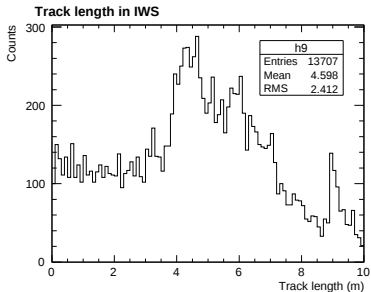
Dayabay Collaboration

- Same as MDC09b muon generation
- 30000 events generated for DayaBay site
- 14000 events generated for Far site
- Most plots are from DayaBay site samples if not otherwise stated
- Detector level data, no electronic and trigger simulation for the moment.
- Basically repeat Kevin's work (Doc 2938, Doc 3147 etc.)

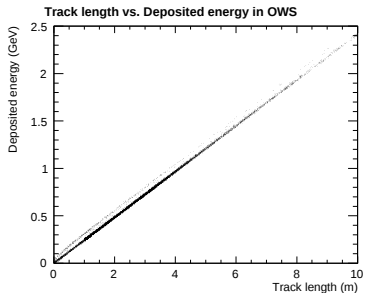
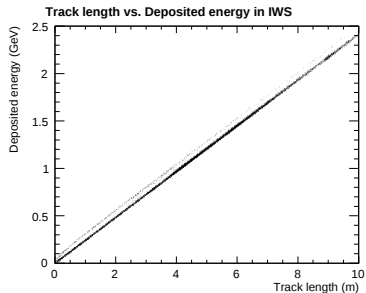
# Muon energy and number of fired PMTs





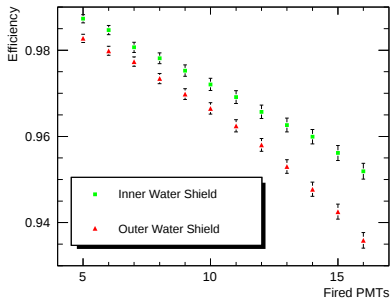


# Track length vs. Deposited energy

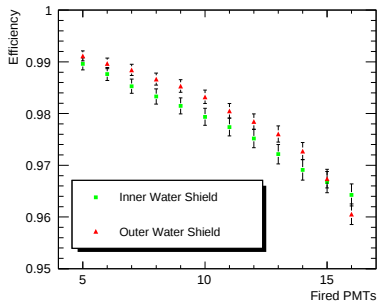


# Muon Efficiency vs. Threshold

## Near site efficiency

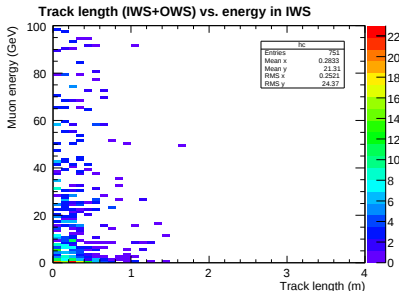
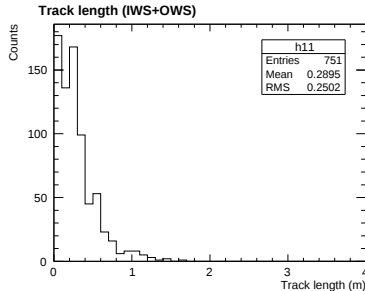
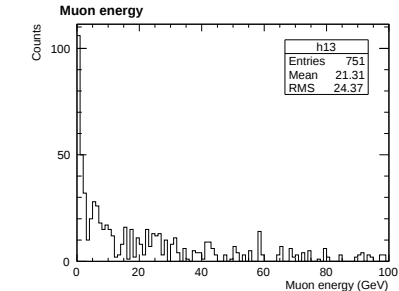


## Far site efficiency



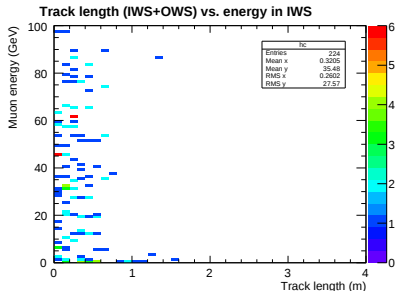
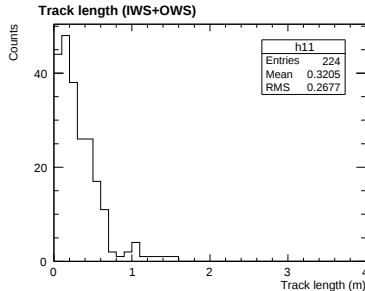
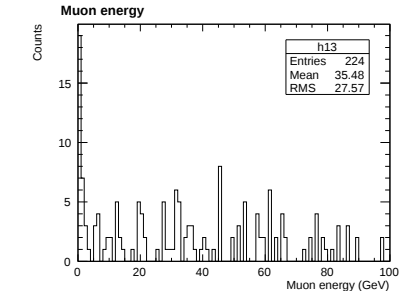
|                        | Near site          |                    | Far site           |                    |
|------------------------|--------------------|--------------------|--------------------|--------------------|
|                        | IWS                | OWS                | IWS                | OWS                |
| Multiplicity threshold | 10                 | 12                 | 11                 | 13                 |
| This Study             | $97.2q \pm 0.14\%$ | $95.80 \pm 0.15\%$ | $97.74 \pm 0.16\%$ | $97.61 \pm 0.15\%$ |
| Doc 3147 config. 12    | $96.45 \pm 0.16\%$ | $95.46 \pm 0.15\%$ | $96.87 \pm 0.27\%$ | $96.97 \pm 0.11\%$ |

# Near site Inefficient Muons



- Inefficient muons: not detected by IWS && not detected by OWS
- Track length is the total length in IWS and OWS

# Far site Inefficient Muons



- Inefficient muons: not detected by IWS && not detected by OWS
- Track length is the total length in IWS and OWS

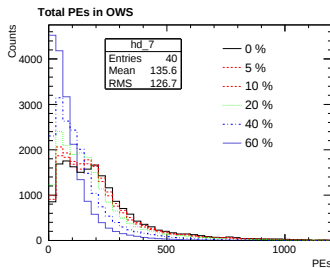
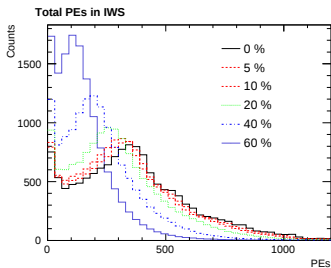
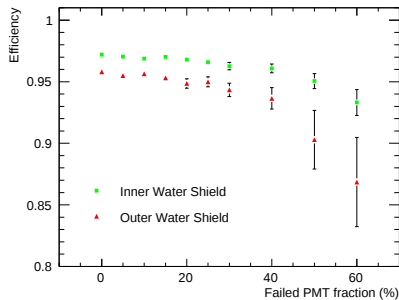
# Efficiency change due to PMT failure

- Randomly shut down some PMTs

| Failure fraction(%) | 0  | 5  | 10 | 15 | 20 | 25 | 30 | 40 | 50 | 60 |
|---------------------|----|----|----|----|----|----|----|----|----|----|
| Near IWS thresh.    | 10 | 10 | 10 | 9  | 9  | 9  | 9  | 8  | 8  | 8  |
| Near OWS thresh.    | 12 | 12 | 11 | 11 | 11 | 10 | 10 | 9  | 9  | 8  |

- Repeat 200 times for each fraction
- Get the mean value and RMS value of the distribution (all the following plots show the mean value with RMS value as error)

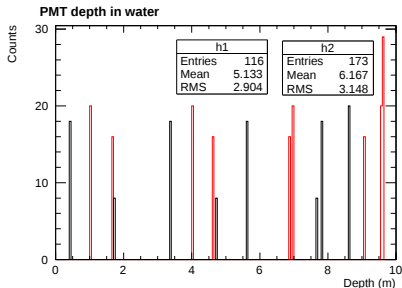
# Efficiency change due to PMT failure



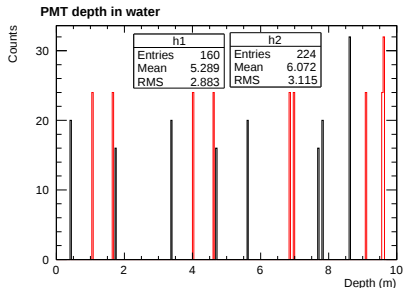
- Lots of discussions on Macro PMT failures recently
- Doc4586 has a recommendation on where to put recycled Macro PMTs
- Study the effect of Macro PMT failures here.

# PMT depth in water

## Near site



## Far site



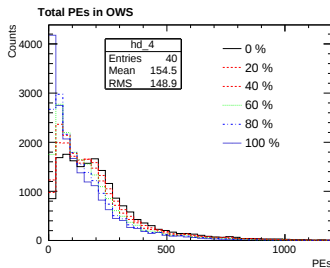
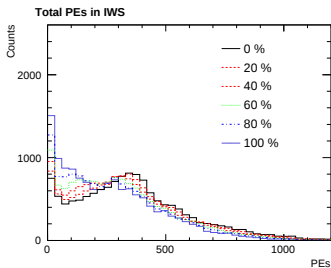
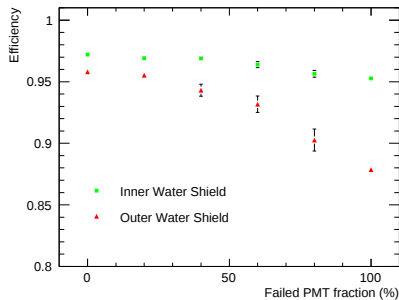
- Near site: 116 PMTs in IWS, 173 PMTs in OWS.
- Far site: 160 PMTs in IWS, 224 PMTs in OWS.
- Black histogram: IWS, Red Histogram: OWS
- The depth distribution is not consistent with Doc 4586.

## 2 configurations for Macro PMT failure

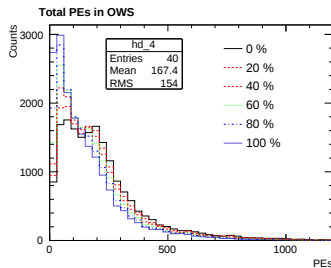
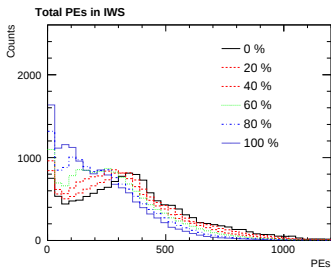
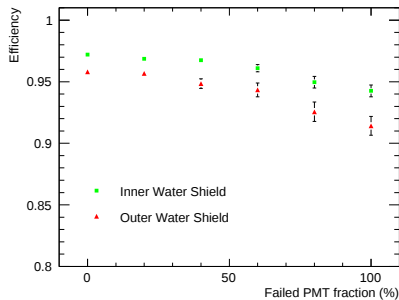
- First 7 rows (116 PMTs) are all Macro PMTs
- Among first 9 rows (142 PMTs), randomly pick 81.7% ( $142 \times 81.7\% = 116$ ) PMTs to set as Macro PMT.

| Failure fraction(%) | 0  | 20 | 40 | 60 | 80 | 100 |
|---------------------|----|----|----|----|----|-----|
| IWS threshold       | 10 | 10 | 9  | 9  | 9  | 8   |
| OWS threshold       | 12 | 11 | 11 | 10 | 10 | 9   |

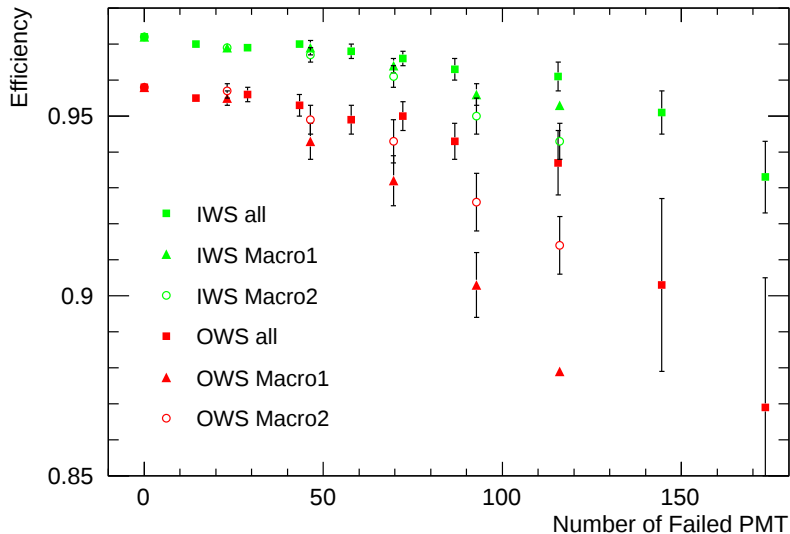
# First configuration



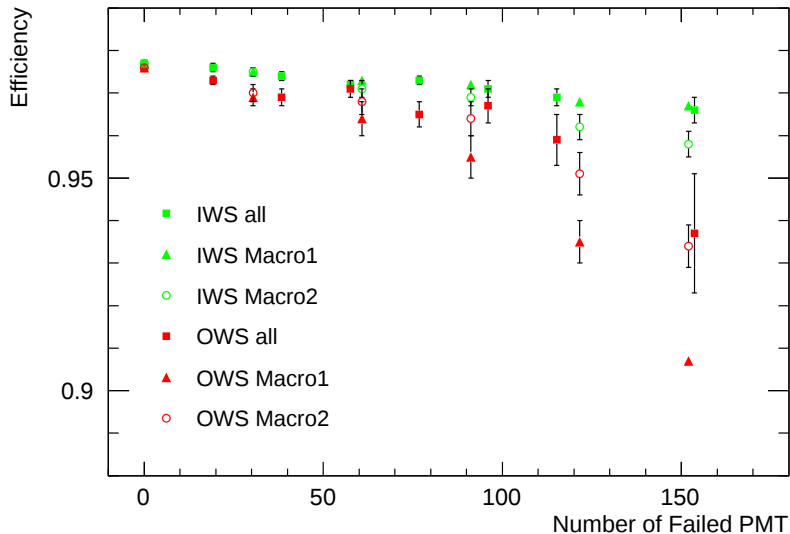
# Second configuration

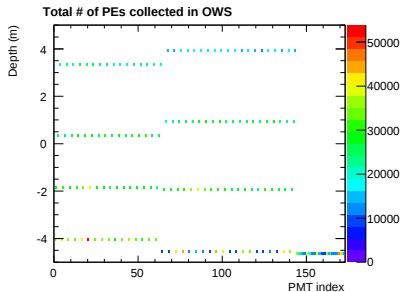
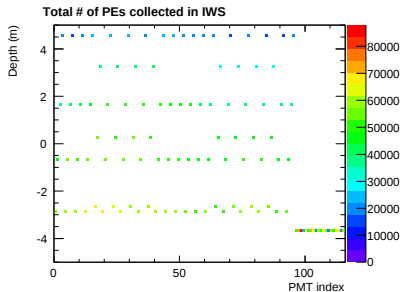
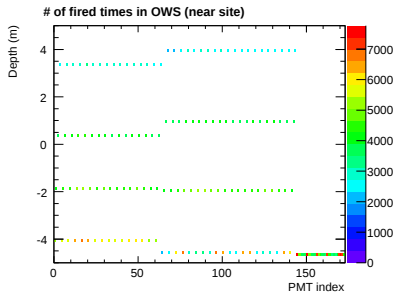
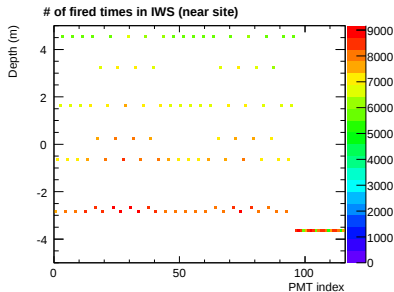


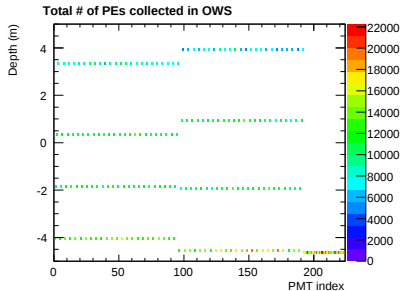
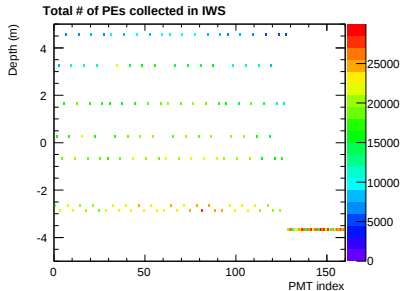
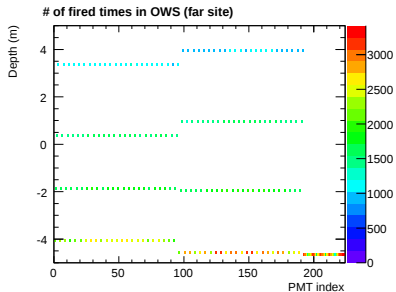
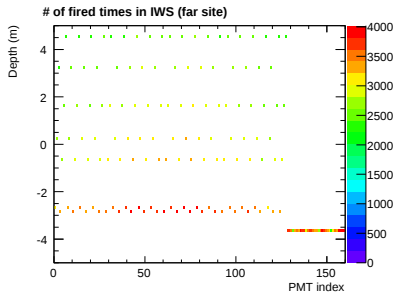
# Near site PMT failure



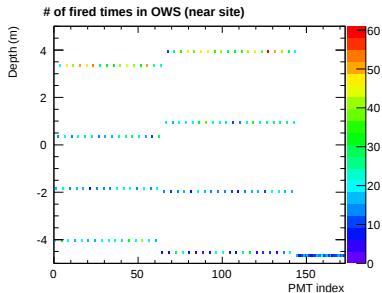
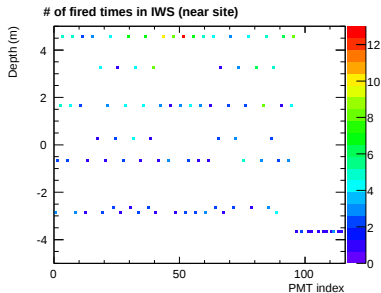
# Far site PMT failure







# Inefficient Muons (near site)



- Inefficient muons: not detected by IWS && not detected by OWS

# Which ones are more important, top or bottom?

## PMT failures in IWS

| # of failed PMT | 0     | 5     | 10    | 15    | 20    | 30    | 40    |
|-----------------|-------|-------|-------|-------|-------|-------|-------|
| IWS threshold   | 10    | 10    | 10    | 9     | 9     | 9     | 9     |
| Eff(A)          | 0.972 | 0.971 | 0.969 | 0.971 | 0.969 | 0.963 | 0.951 |
| Eff(B)          | 0.972 | 0.971 | 0.969 | 0.971 | 0.969 | 0.965 | 0.959 |
| Eff(C)          | 0.972 | 0.971 | 0.969 | 0.971 | 0.969 | 0.965 | 0.960 |

## PMT failures in OWS

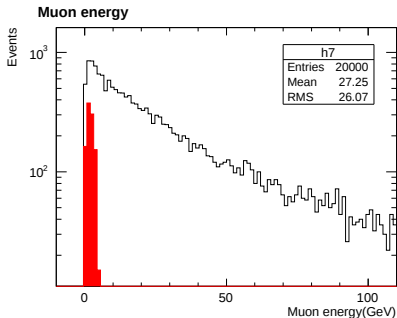
| # of failed PMT | 0     | 10    | 20    | 30    | 40    | 50    | 60    |
|-----------------|-------|-------|-------|-------|-------|-------|-------|
| OWS threshold   | 12    | 12    | 11    | 11    | 10    | 10    | 9     |
| Eff(A)          | 0.958 | 0.953 | 0.952 | 0.942 | 0.938 | 0.920 | 0.912 |
| Eff(B)          | 0.958 | 0.955 | 0.957 | 0.953 | 0.953 | 0.942 | 0.935 |
| Eff(C)          | 0.958 | 0.954 | 0.956 | 0.951 | 0.952 | 0.945 | 0.947 |

- A: PMTs fail in top region
- B: PMTs fail in bottom region
- C: PMTs fail randomly in any position

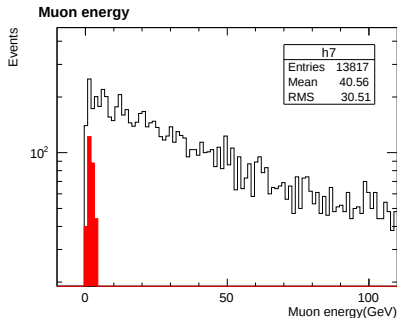
- Bottom PMTs receive more hits than top ones, this is more significant in OWS, less significant in IWS.
- Top PMTs have slightly larger effect on muon efficiency than bottom ones, this is more significant in OWS, less significant in IWS.
- Randomly pick positions for Macro PMTs is better than concentrate them in a small region, but Macro PMTs have a higher chance of failure at deeper places

# Stopped Muons

## Near site



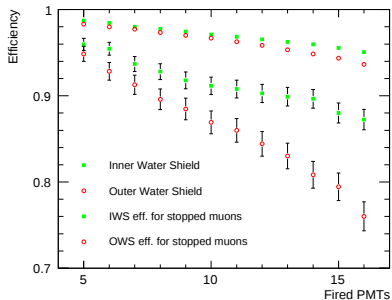
## Far site



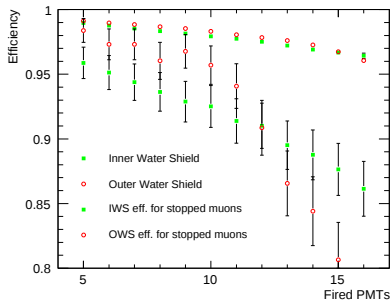
- Muons stopped inside OWS logical volume.
- Near site stopped muons:  $1015/12590 = 7.22\%$
- Far site stopped muons:  $312/9732 = 3.21\%$

# Efficiency for stopped muons

## Near site

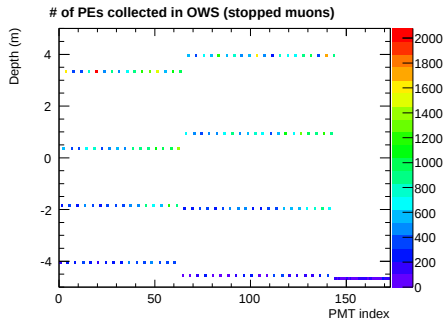
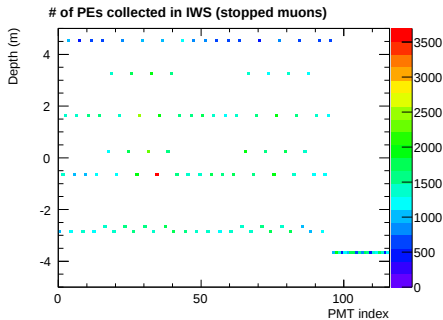


## Far site



- Efficiency for muons stopped inside OWS logical volume.

# Collected PEs for stopped muons (near site)



- Total number of PEs collected for all stopped muons.