Modeling area over peak as a function of liner reflectivity (s) and water absorption (w)

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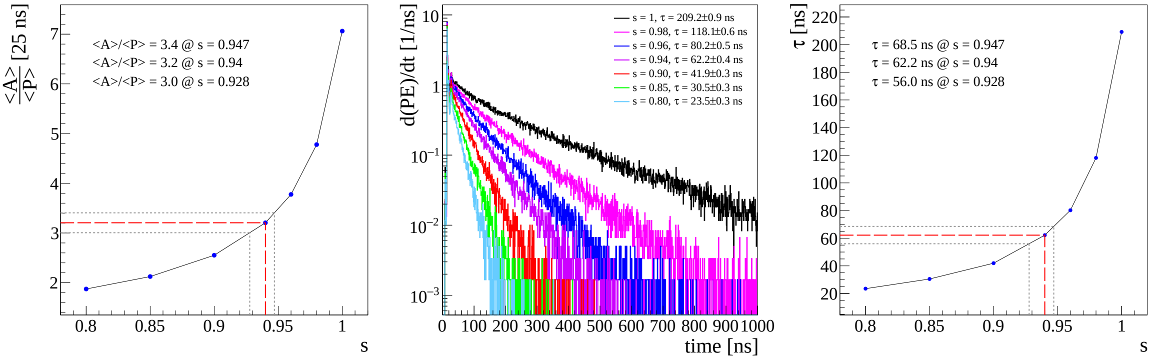
Area over peak and decay constant vs liner reflectivity

What we obtained in the previous work: (link OCM - Calibration Session)



Injected vertical muons @ $E = 1\,\mathrm{GeV}$ in the center of the tank.

Previous results and new outlook

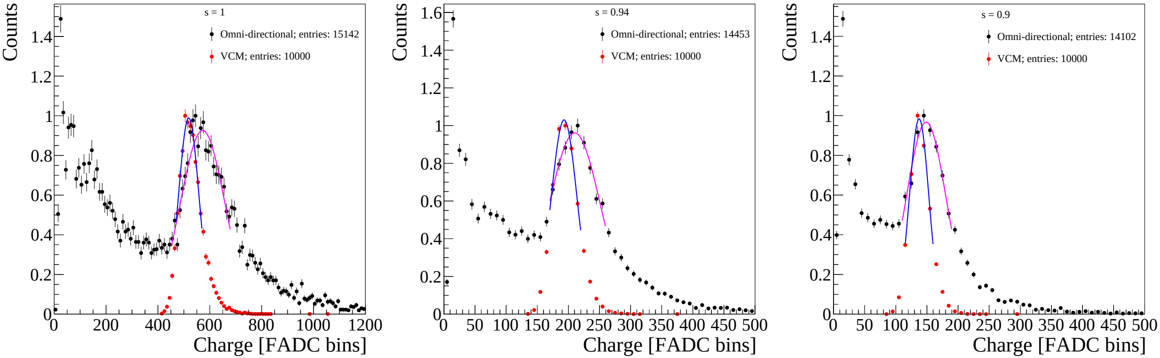
Modelling the A/P evolution by a change in the liner reflectivity

- A change of ± 0.2 in A/P for vertical muons corresponds to a change of ± 0.01 in the liner reflectivity (normalisation)
- A change of ± 0.01 in liner reflectivity (s) leads to a change of $\pm 6\,\mathrm{ns}$ in the decay constant

Additional steps in the analysis:

- Crosscheck the scaling factor f_Q evolution as a function of liner reflectivity in simulations
- Evaluate the contribution of the water absorption to the evolution of A/P in simulations
- Analyze data and compare results

Charge distributions for different s: Omnidirectional and vertical muons

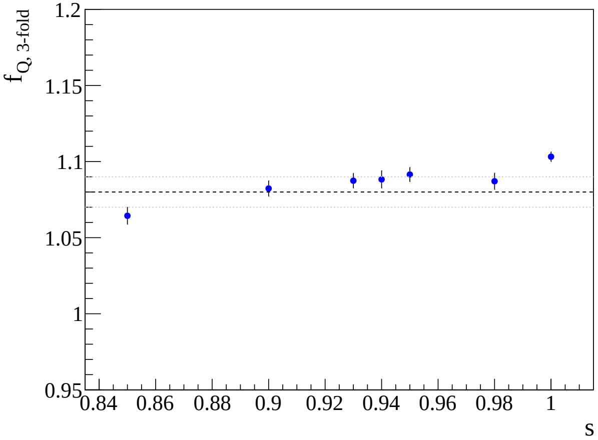


Each histogram shows the average charge over the PMTs.

Histograms are normalized to the number of entries of the bin with the maximum value of the muon peak.

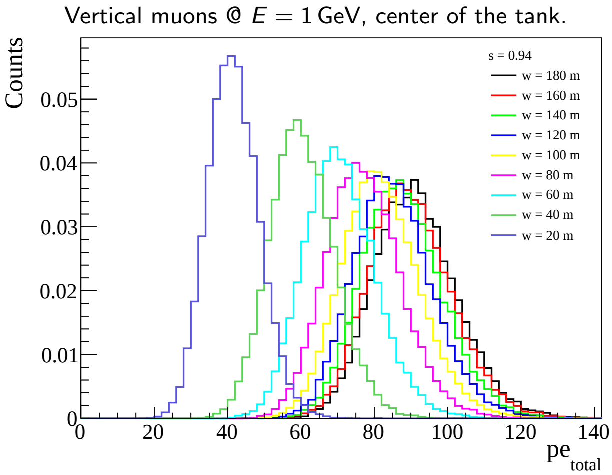
f_Q is computed as: $f_Q = Q_{OD}^{peak} / Q_{VEM}^{peak}$

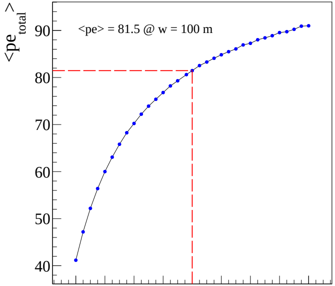
f_Q as a function of s

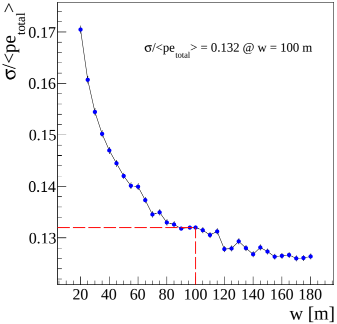


f_Q is stable.
The dashed line represents $f_Q = 1.08 \pm 0.01$
This value comes from the RPChodoscopePaper (link)

Photoelectrons vs water absorption length

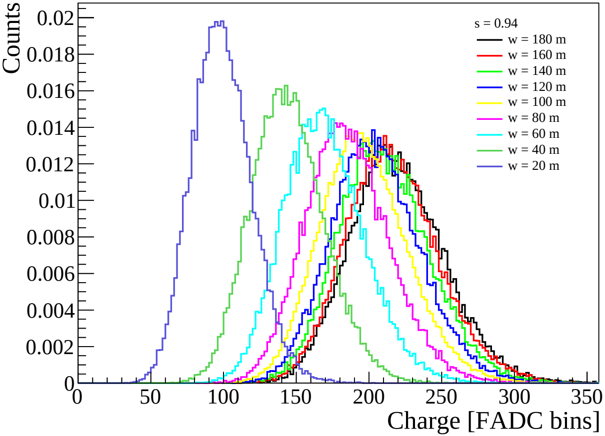


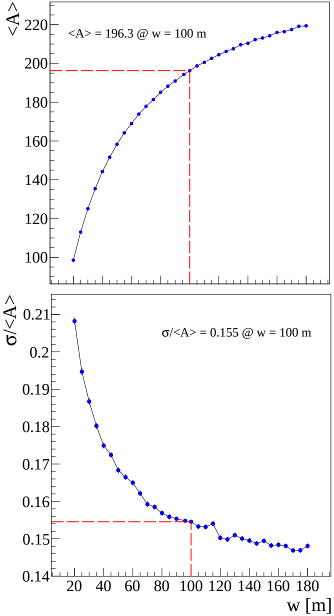




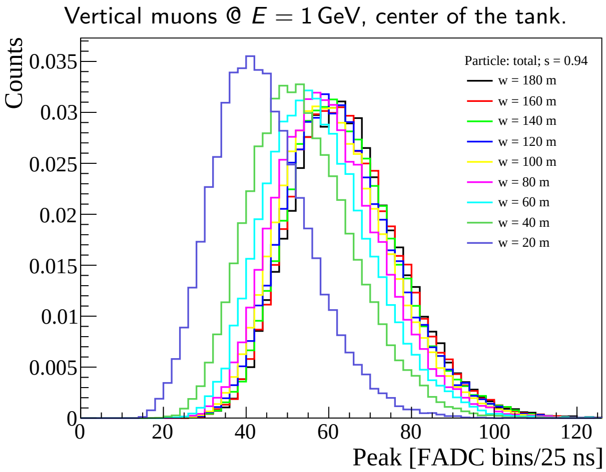
Charge vs water absorption length

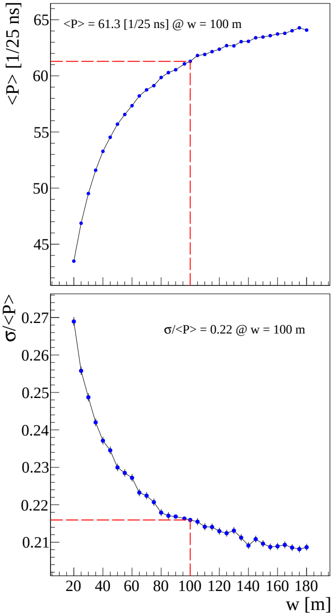
Vertical muons @ $E = 1\,\text{GeV}$, center of the tank.



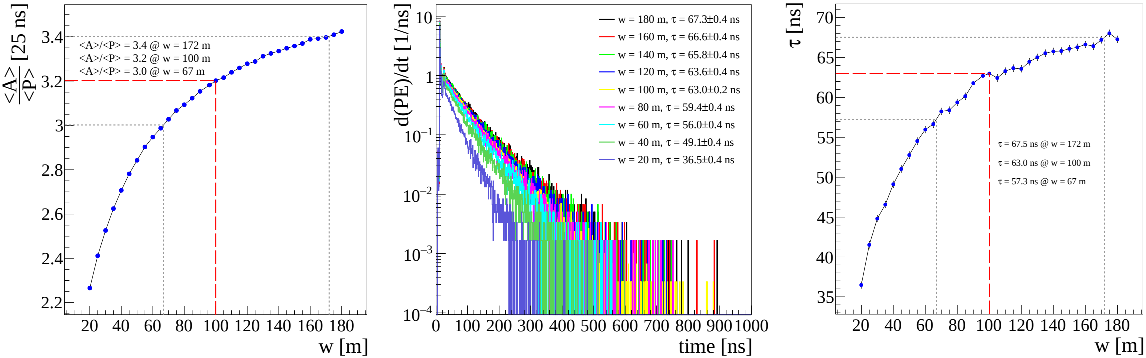


Peak vs water absorption length





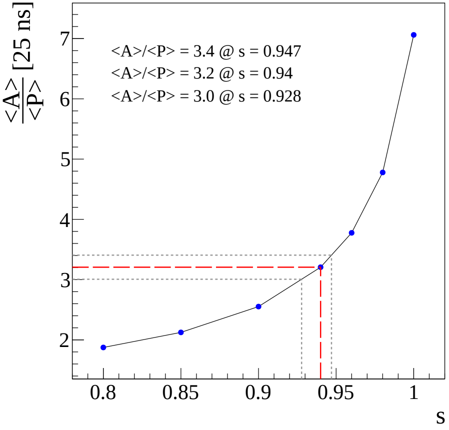
Area over peak and decay constant vs w

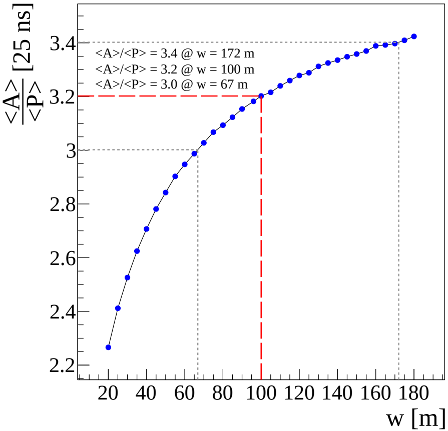


A change of $\pm 0.2\,[25\mathrm{ns}]$ in A/P for vertical muons corresponds to a change of respectively $+72$ m and -33 m in water absorption length

A change of $+72$ m and -34 m in water absorption length (w) leads to a change of around ± 5 ns in the decay constant

A/P as a function of s and w

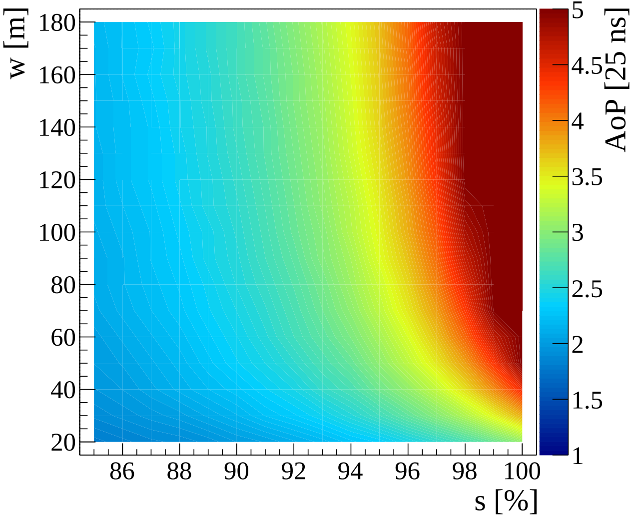




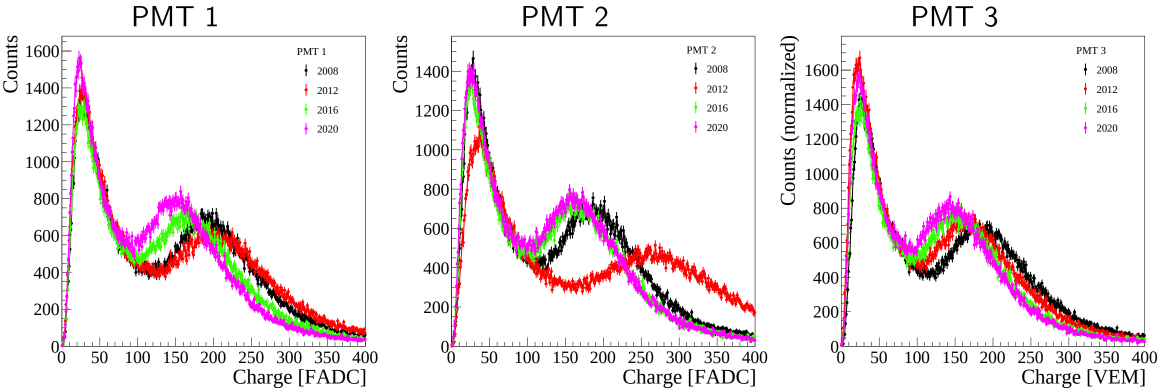
The dependency on the water attenuation is very mild and thus the time dependecy is most probably due to the liner reflections.

Ageing is mainly caused by a change in the reflectivity.

A/P as a function of s and w: 2D

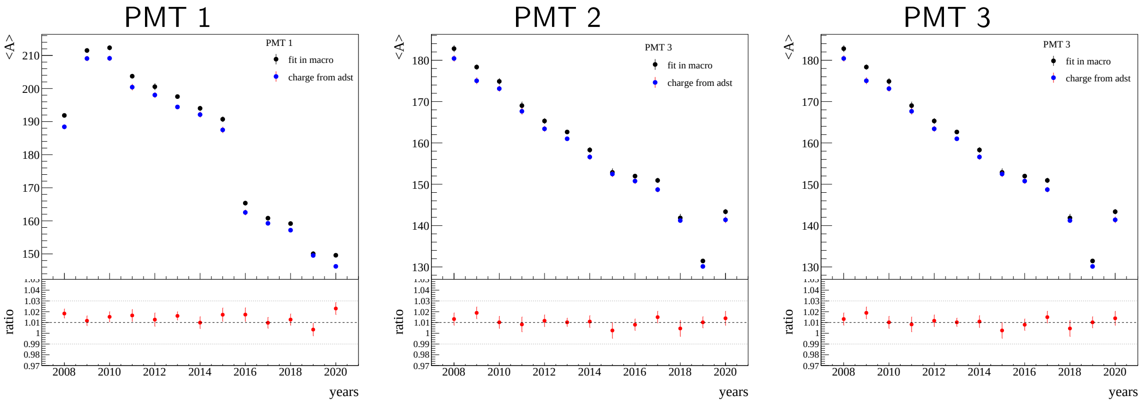


Station Denisa Maria. Charge histograms over time



Station Id = 1698.
Events are selected in the same period (October) for each year.

Station Denisa Maria. Charge scaling factor over time

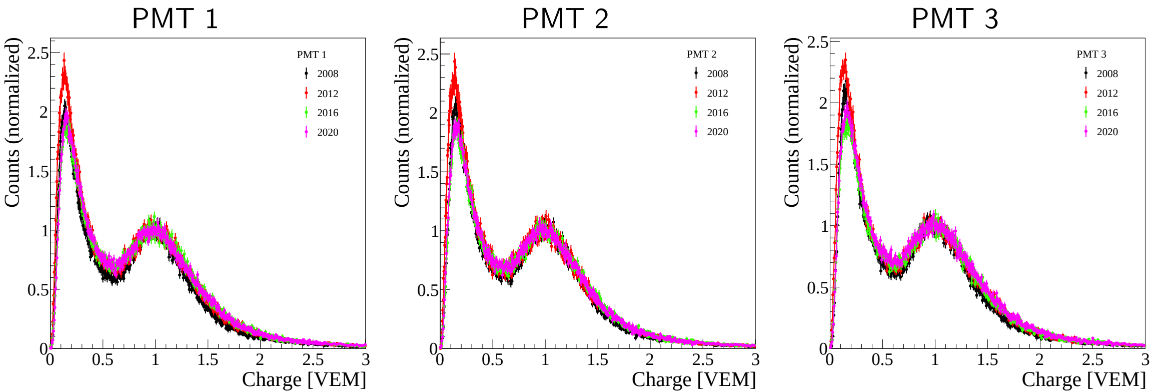


Station Id = 1698.

Events are selected in the same period (October) for each year.

The black dashed line shows the fixed value used in the Module *SdCalibrator*

Station Denisa Maria. Charge in VEM over time

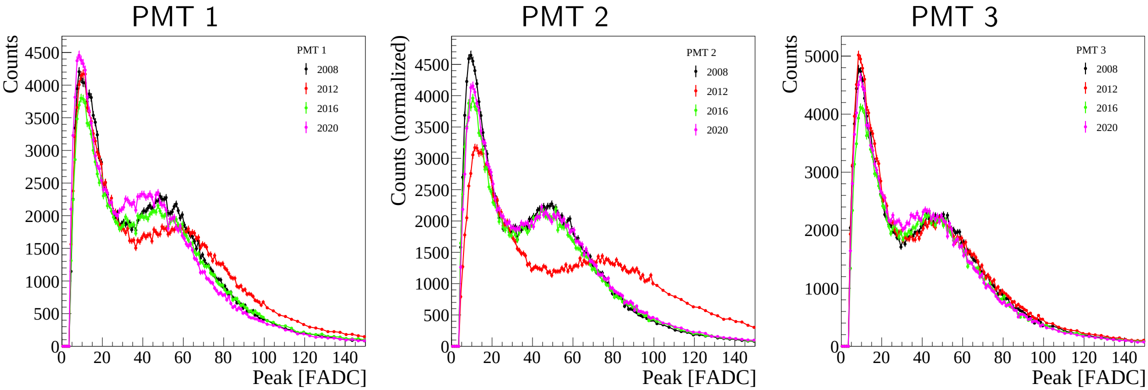


Station Id = 1698.

Events are selected in the same period (October) for each year.

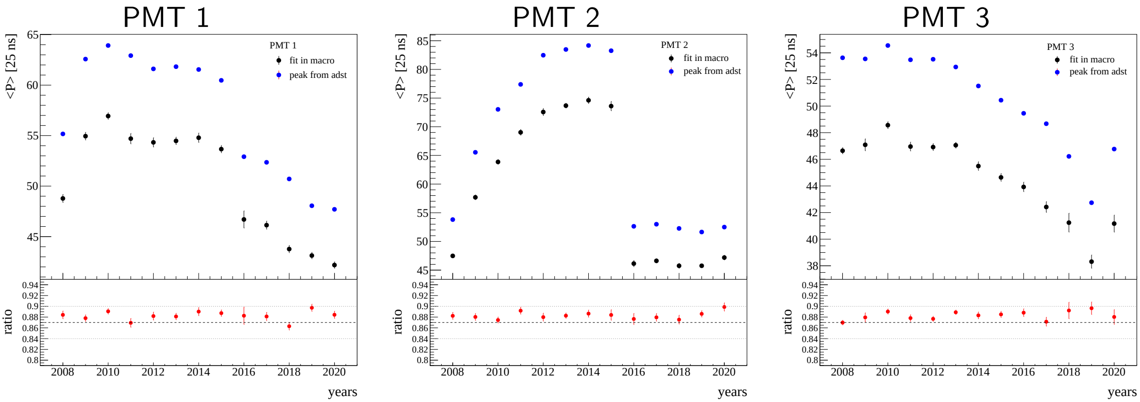
Events are scaled in VEM using the scaling factor computed in the previous slide.

Station Denisa Maria. Peak histograms over time



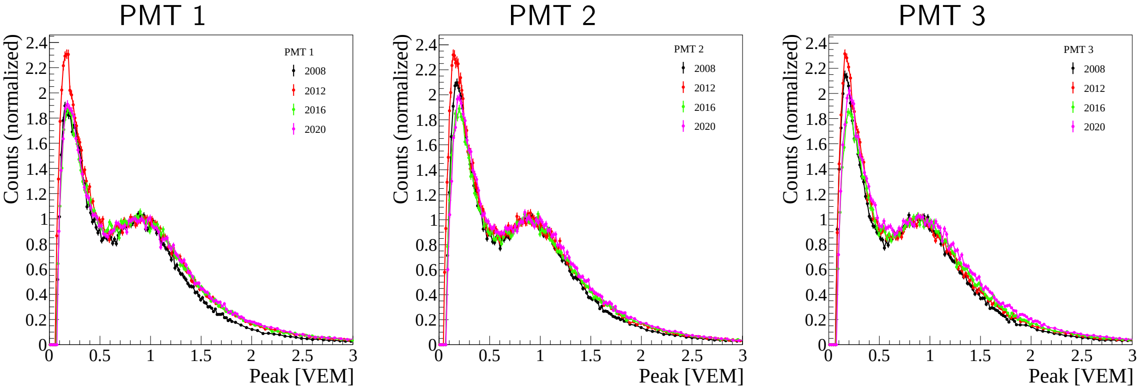
Station Id = 1698.
Events are selected in the same period (October) for each year.

Station Denisa Maria. Peak scaling factor over time



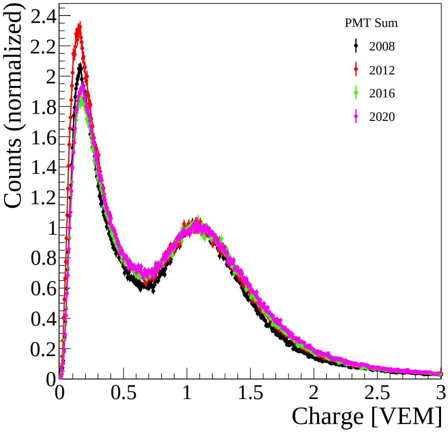
Station Id = 1698.
Events are selected in the same period (October) for each year.
The black dashed line shows the fixed value used in the Module *SdCalibrator*

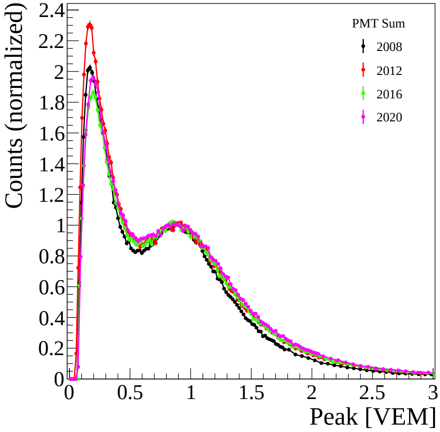
Station Denisa Maria. Peak in VEM over time



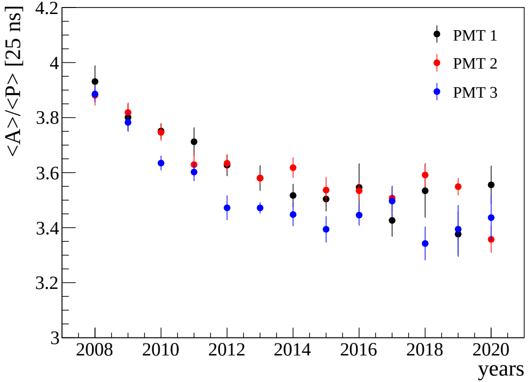
Station Id = 1698.
Events are selected in the same period (October) for each year.
Events are scaled in VEM using the scaling factor computed in the previous slide.

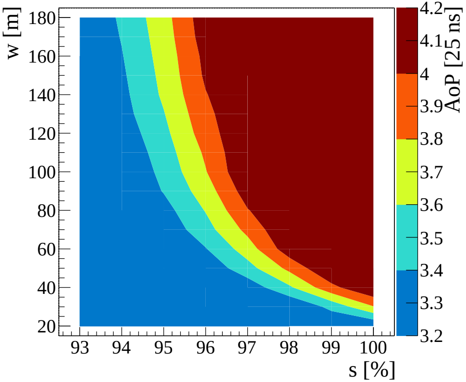
Charge and peak histogram - averaged sum over PMTs





A/P from data

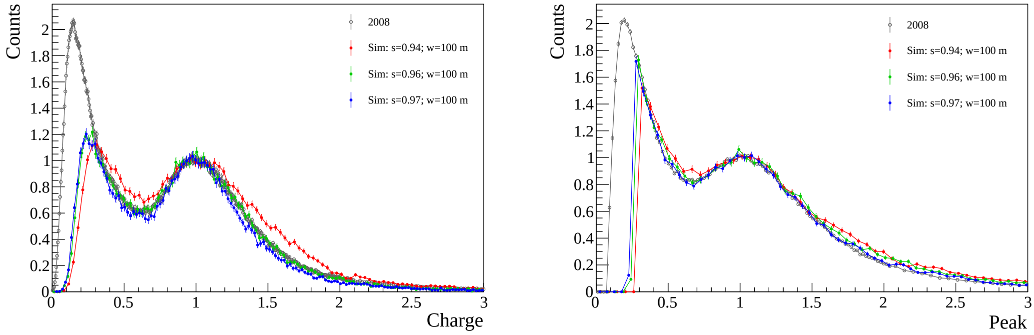




Area over peak for different PMTs for station Denisa Maria is between around $3.4 - 4$ ns
To account for such a change in A/P, it's possible to change either s (w) for fixed w (s).
In particular:

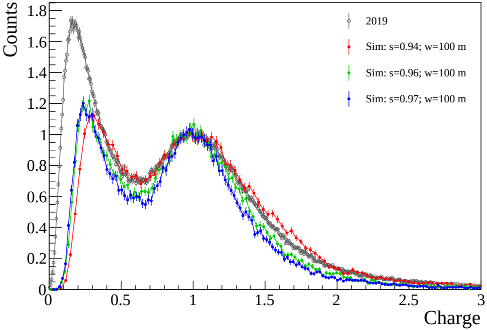
- At fixed w = 100 m: s ranging from 0.94 and 0.97
- At fixed s = 0.99 (extreme case): w ranging from 30 m and 50 m

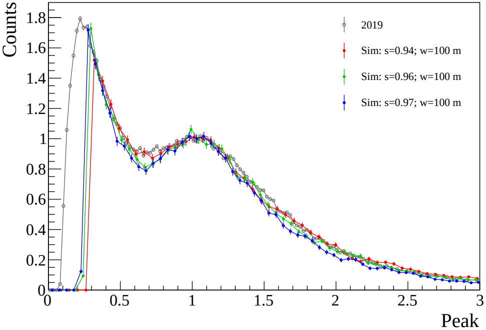
Comparing data and simulations: 2008



Comparing data in 2008 with possible values of s at fixed w = 100 m

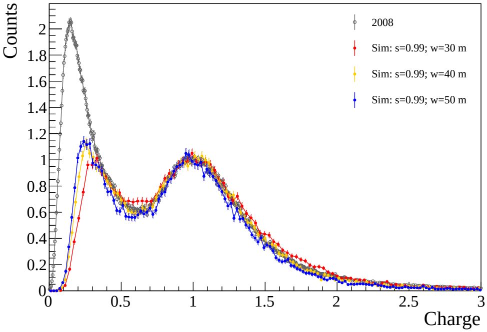
Comparing data and simulations: 2019

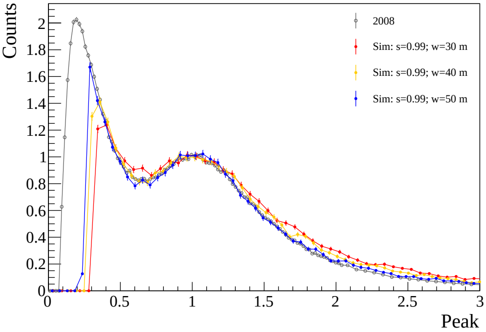




Comparing data in 2019 with possible values of s at fixed w = 100 m
A decrease in s leads to a widening of the muon peak and a smaller hump to valley ratio.

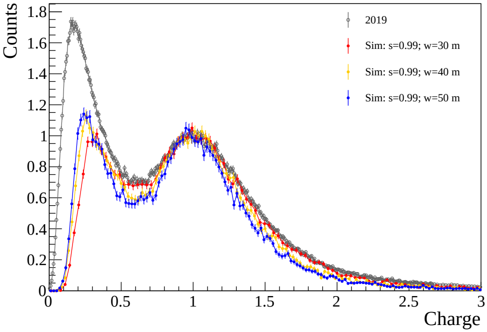
Comparing data and simulations: 2008

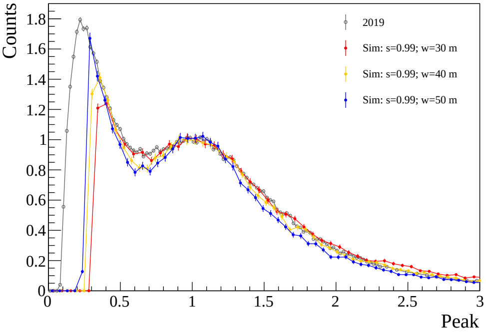




Comparing data in 2008 with possible values of w at fixed s = 99%

Comparing data and simulations: 2019





Comparing data in 2019 with possible values of w at fixed s = 99%

Conclusions

Modelling the A/P evolution by a change in the water absorption length

- A change of $\pm 0.2\,[25\mathrm{ns}]$ in A/P for vertical muons corresponds to a change of respectively $+72$ m and -34 m in water absorption length
- A change of $+72$ m and -34 m in water absorption length (w) leads to a change of around ± 5 ns in the decay constant

The ageing is mostly due to Tyvek reflectivity change, not water absorption

Comparing data and simulations: To account for a change of A/P of $\sim 0.6\,[25\mathrm{ns}]$ in data, we need

- At fixed w $=$ 100 m: s ranging from 0.94 and 0.97
- At fixed s $=$ 0.97: w ranging from 40 m and 80 m

Outlook

From detector evolution to air-showers simulations

- Compare data and simulation of full charge/peak distributions for station Denisa Maria with a test statistics to find the best match couple of values of s and w
- Which is the effect on the reconstruction of air-showers and can the known evolutions of risetime/number of station/etc... be reproduced?
- Use these information to produce SD real MC to assess the impact of the signal shape change on training of the neural networks