Cross calibration between WCD-SSD and UMD

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Main goal:

Development of a statistic estimator of the muonic component by means of the cross calibration between WCD-SSD and UMD.

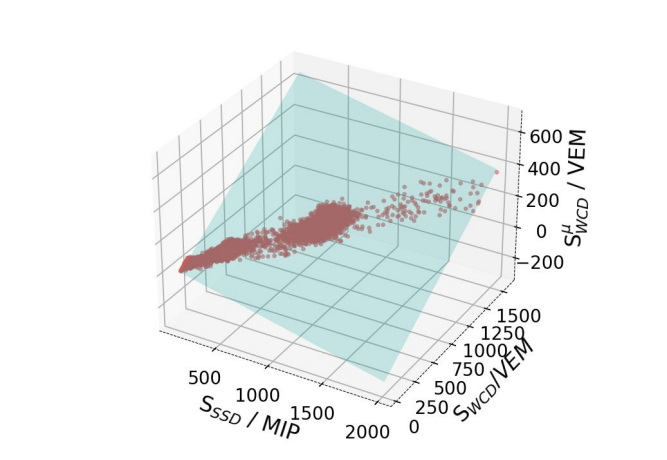
Current work:

Looking for a variable that approximates the muonic signal in WCD and that can be calibrated with the number of muons detected in UMD.

Reconstruction of muonic signal at ground in AugerPrime

From Matrix Formalism we can assume a linear relation between the muonic signal in the WCD (S^{μ}_{WCD}) and the total signal of WCD (S_{WCD}) and SSD (S_{SSD}).

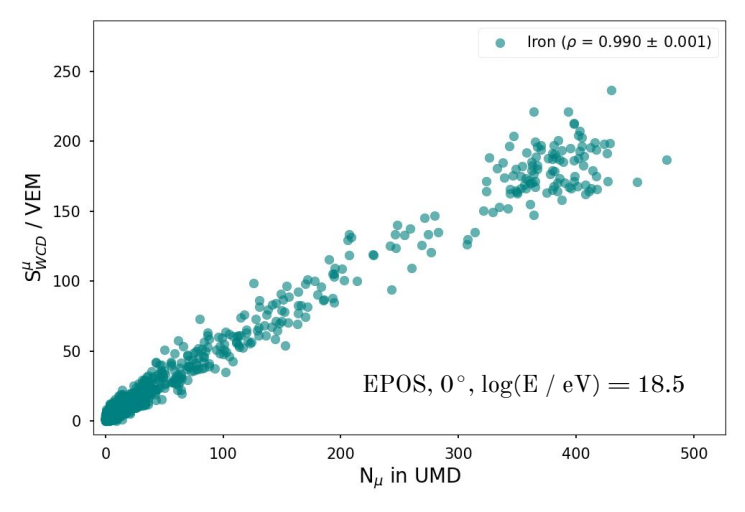
From this assumption we can estimate: $\hat{S}^{\mu}_{WCD} = m\, S_{SSD} + n\, S_{WCD}$

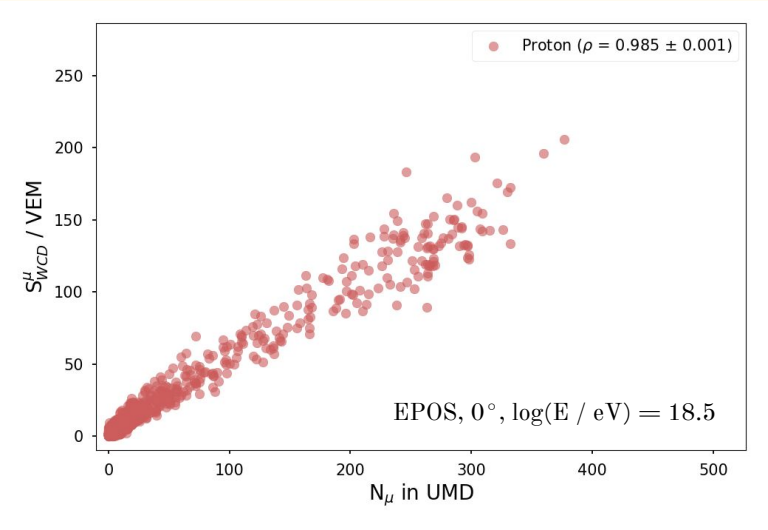


Proton and Iron EPOS, $\log(E / eV) = 19, 0°$

- We are looking for the plane with normal (m, n, -1) that best approximates the reconstructed signals

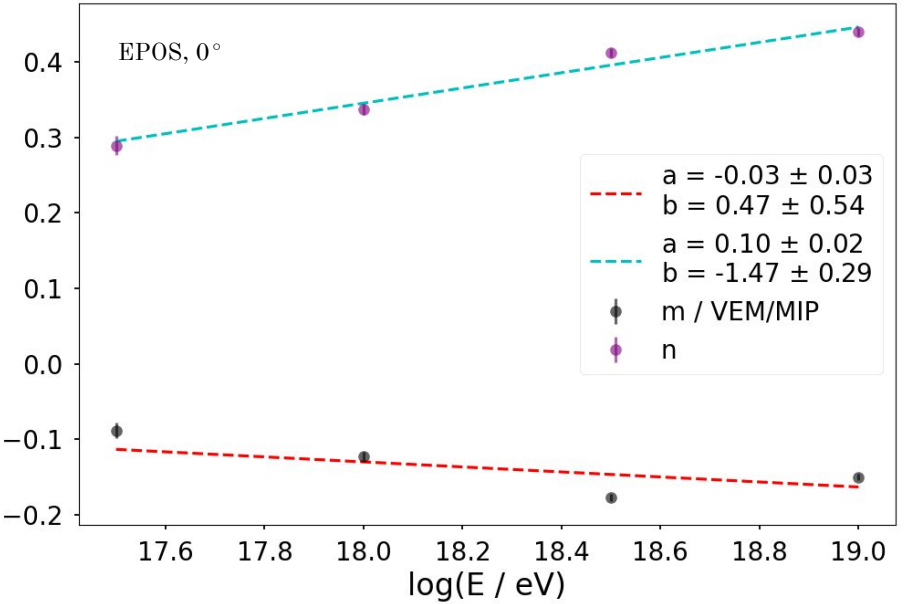
Correlation





- Taking the stations of the whole 750 m array, a very strong correlation can be observed between de muonic signal in the WCD and the number of muons in the UMD

m and n for mixed composition

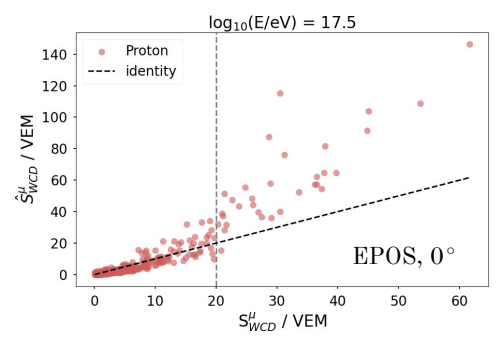


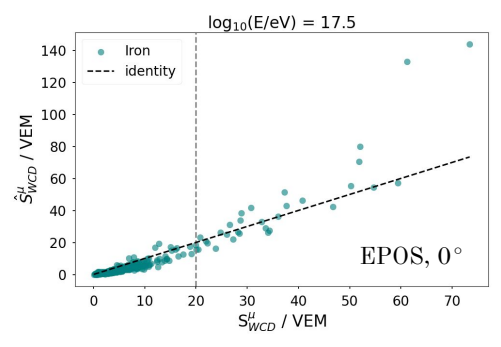
- Mixing the composition in a 50-50 basis to obtain the m and n values gives us a better idea of how to parameterize them vs. the energy:

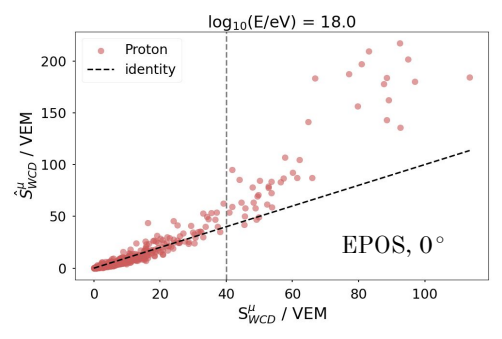
$$m, n = a\,log(E) + b$$

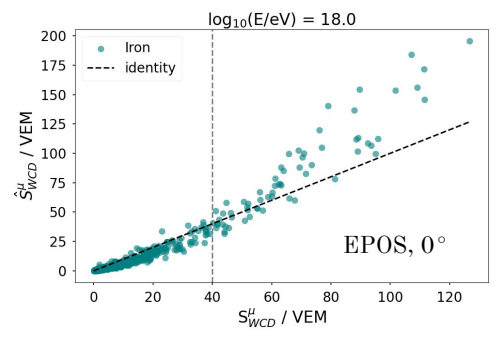
- For pure compositions a clear behaviour of m and n with the energy can not be observed

Signal reconstructed for calibration



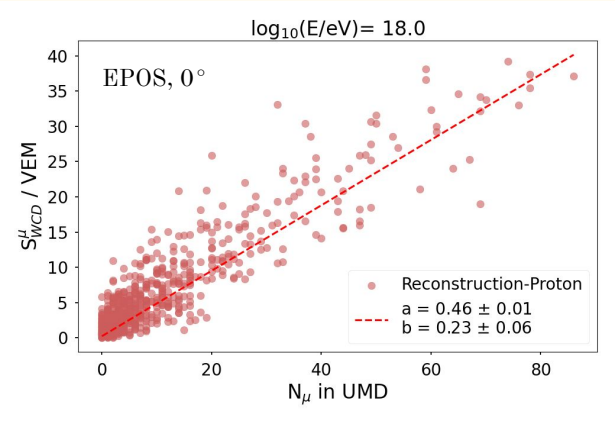


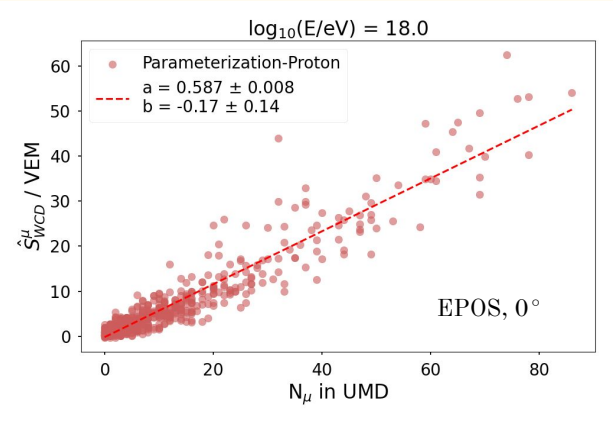


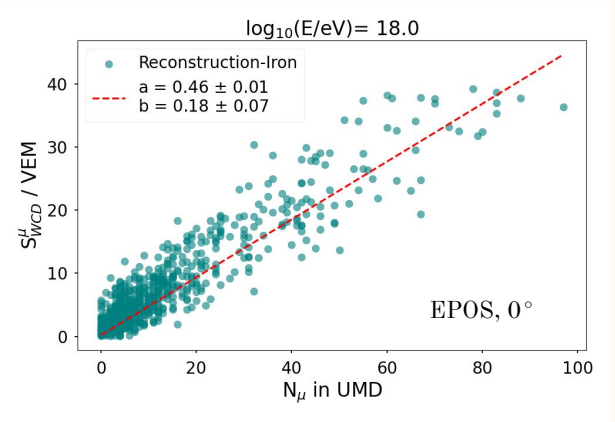


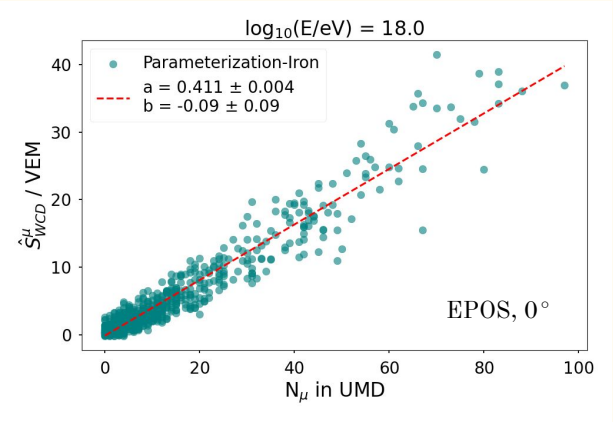
- The parameterization is closer to the reconstructed values below the vertical division.
- Events above the line are currently in study.
- For now, an upper quality cut must be applied in order to have a variable to calibrate with UMD

Preliminary: Linear relation with N_μ



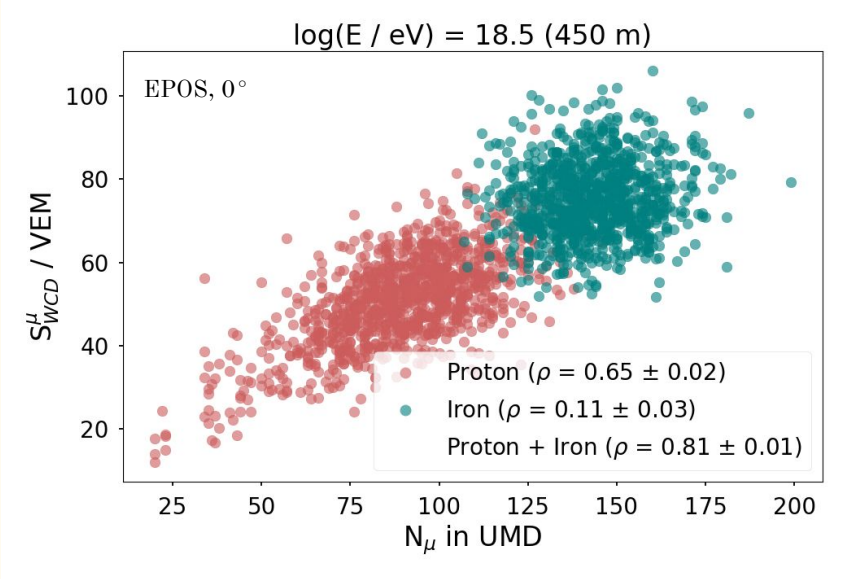






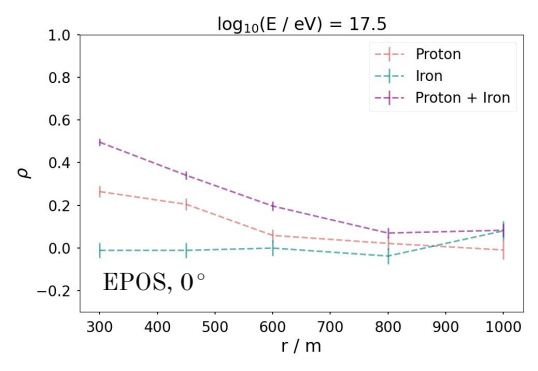
- A linear relation can be observed with the number of muons in the UMD applying the quality cuts for the estimated muonic signal.

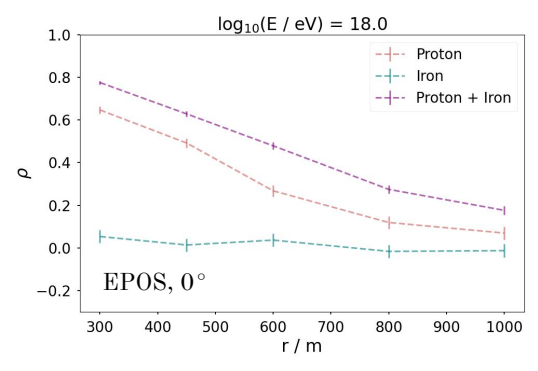
Correlation at fixed distances

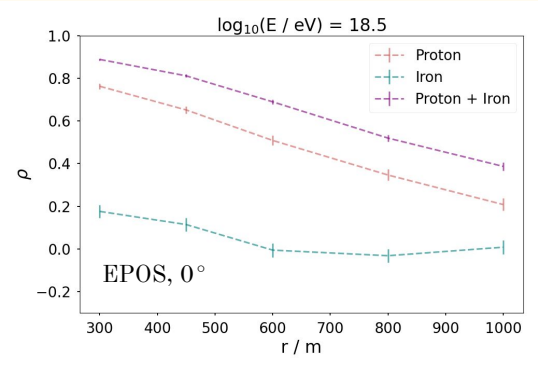


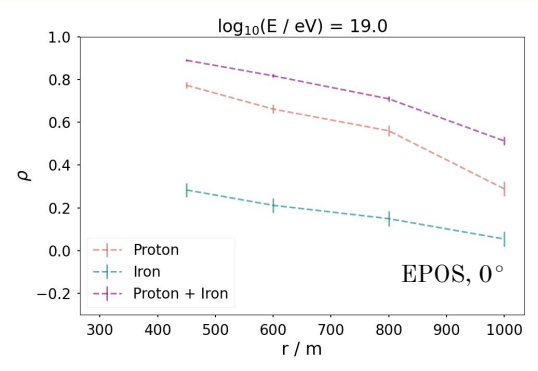
- For a fixed distance to the core, the muonic signal of the WCD shows a better correlation for a light composition.
- If we take the signals of both compositions, a higher correlation can be observed.

Better signal correlation at higher energies



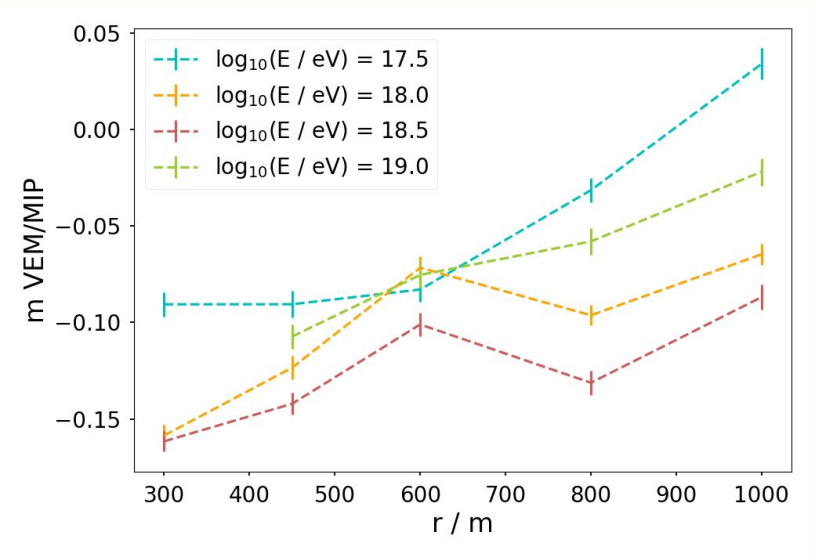


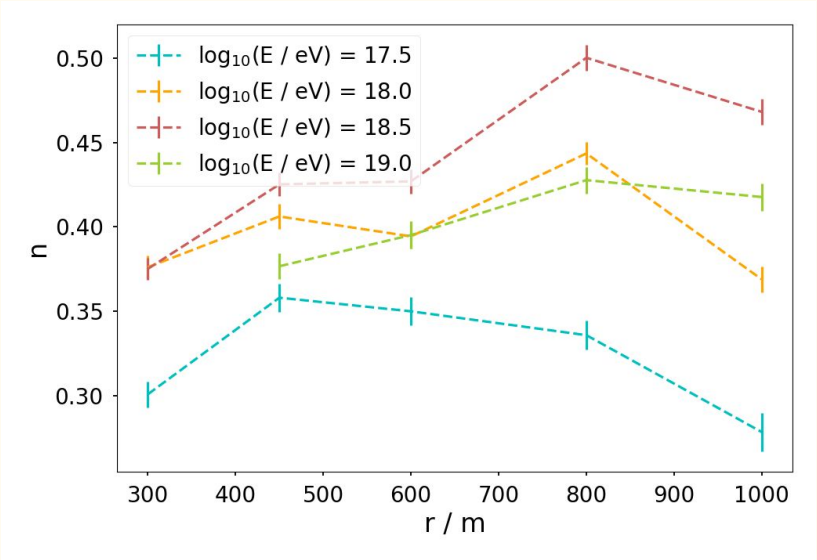




- The correlation between the muonic signal in WCD and the injected muons in UMD decreases with the distance to the core and increases with energy

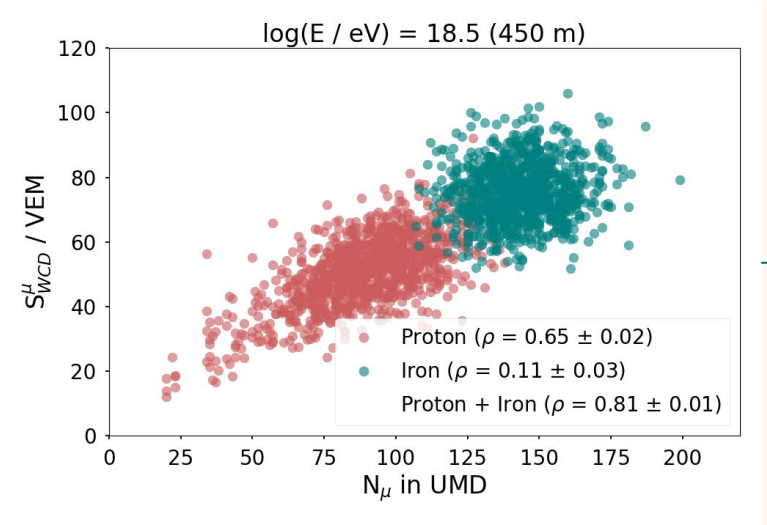
Work in progress: parameterization in r

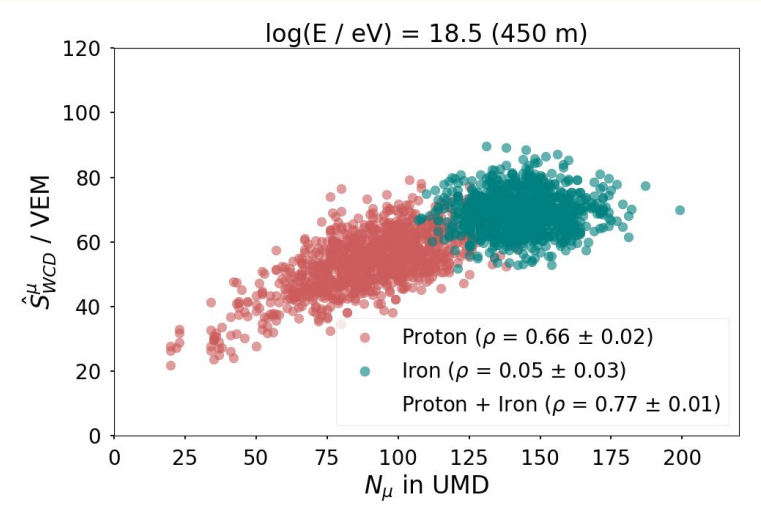




- At fix distances, m and n show a behaviour with $\log_{10}(E)$ for the three lower values.

Correlation of the estimation with N_μ





- For a fix distance, zenith and energy, the correlation between the estimated muonic signal in WCD and the number of muons in the UMD it's lower than the one with the Monte Carlo muonic signal in the WCD
- Still, a positive correlation can be observed for the estimation

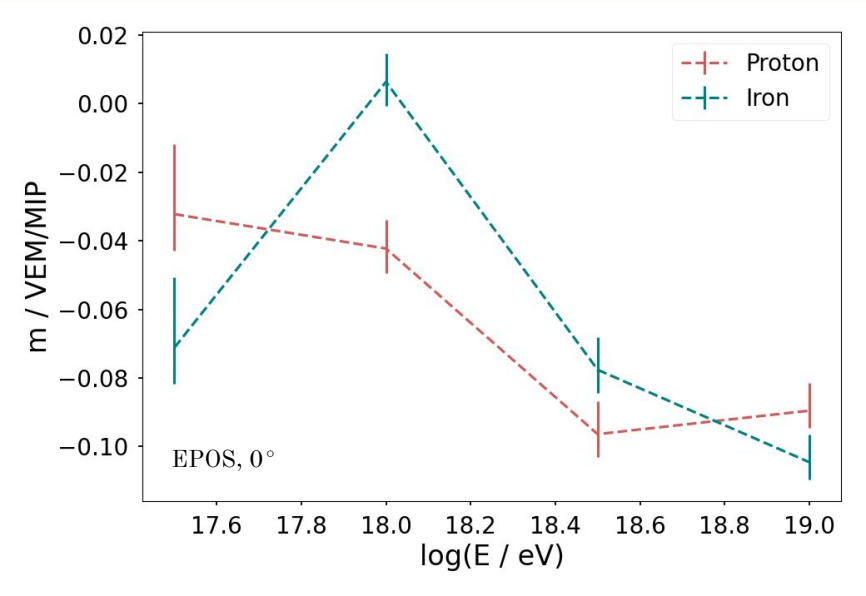
Summary and outlook

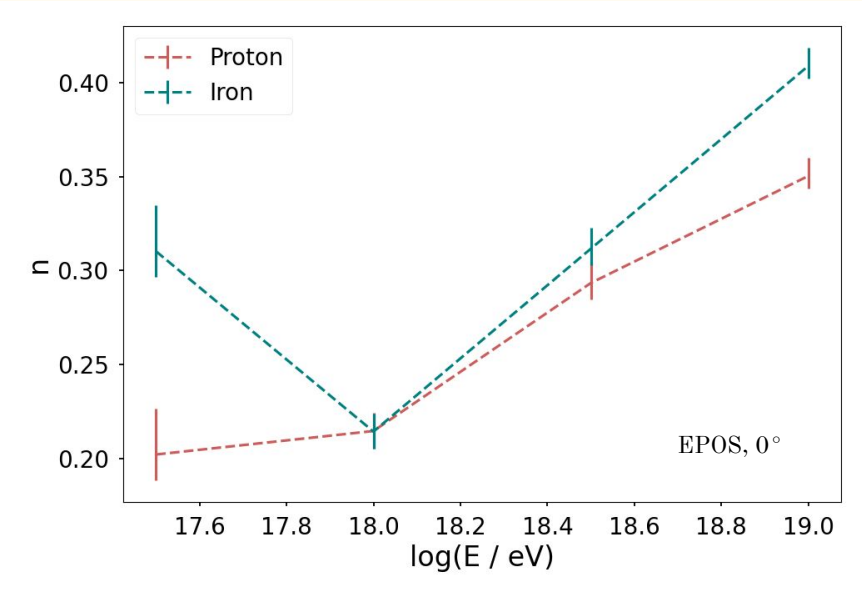
- A parameterization of the muonic signal in the WCD as a function of the total signal in the SSD and WCD is under study.
- Preliminary analysis indicate a level of agreement between estimated and reconstructed S^{μ}_{WCD} upto limiting values of WCD signal.
- Better quality and selection cuts are being developed to improve this agreement.
- For fix distances to the core, a positive correlation can be observed for the estimated S^{μ}_{WCD} with N_{μ}.
- Next step: global parameterization of m and n.

Backup

m and n vs. E

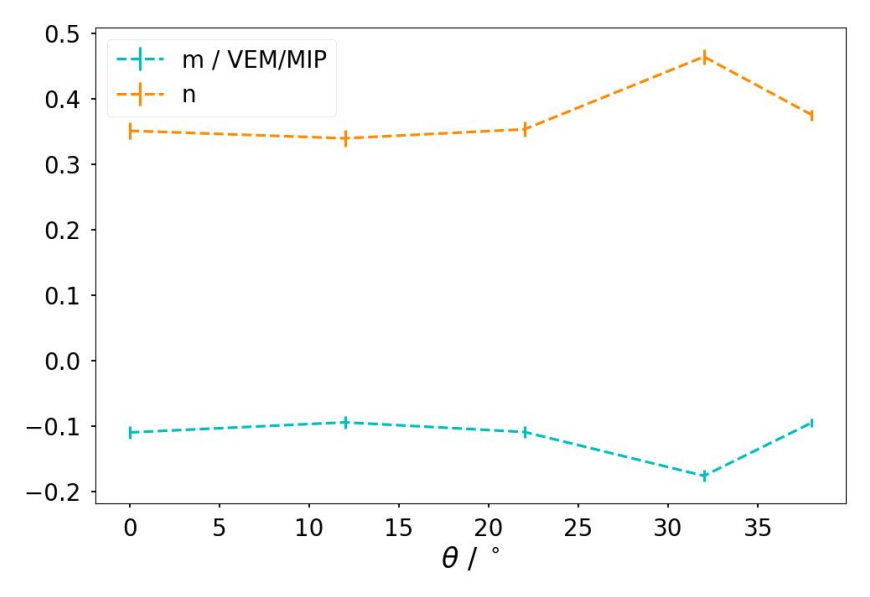
$$\hat{S}^{\mu}_{WCD} = m\, S_{SSD} + n\, S_{WCD}$$





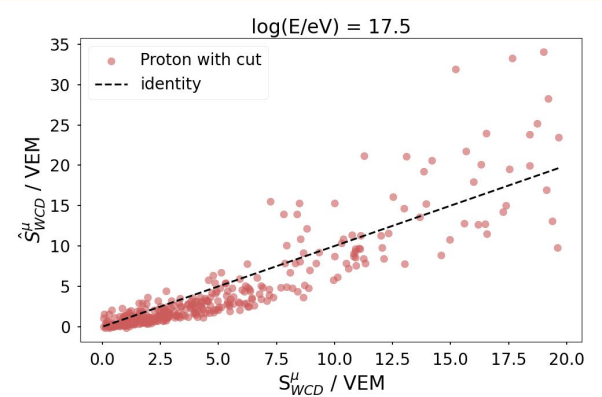
m and n parameter show discrepancies for the fix values of energy and a clear parameterization vs. the energy can not be observed.

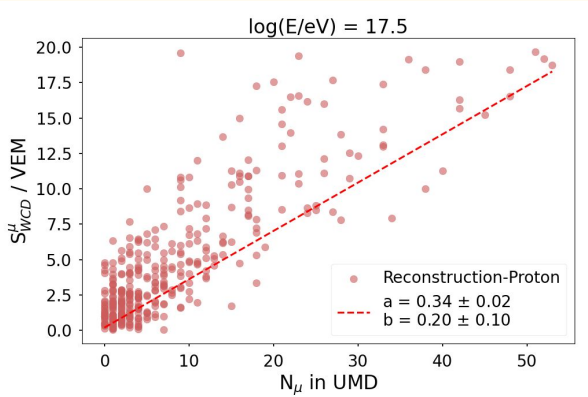
m and n parameterization in Θ: Proton

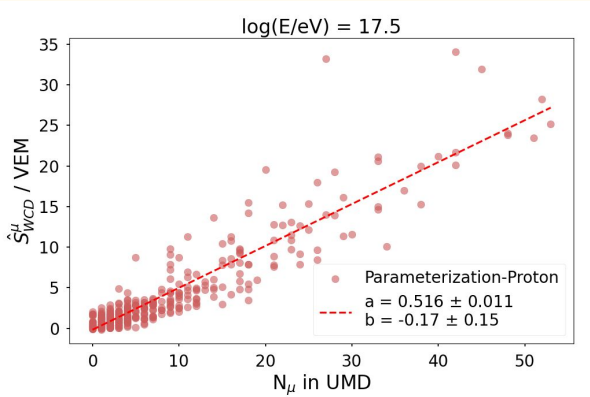


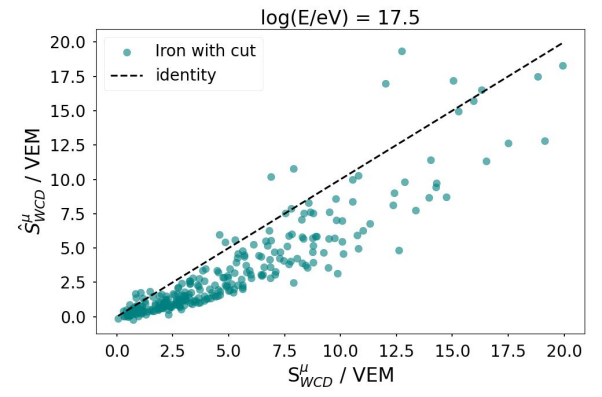
EPOS, log(E / eV) = 18.5

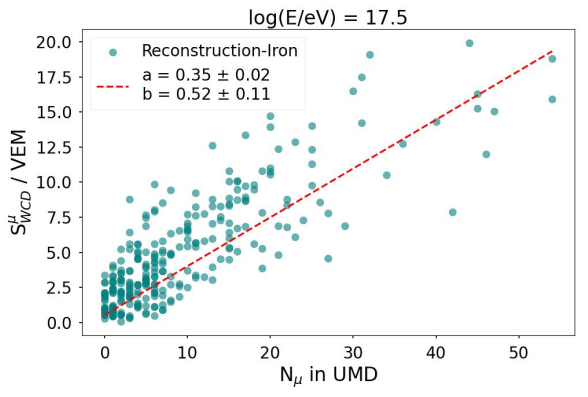
Relation with N_μ

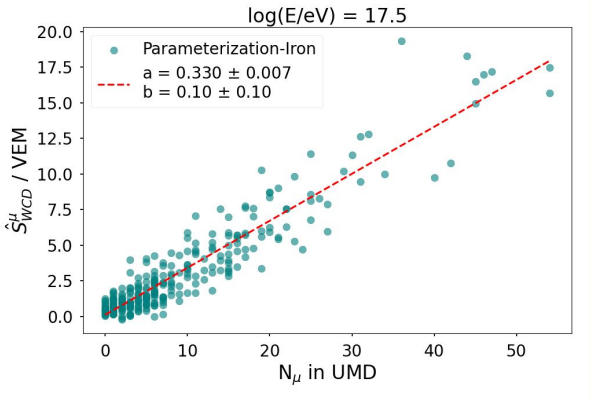




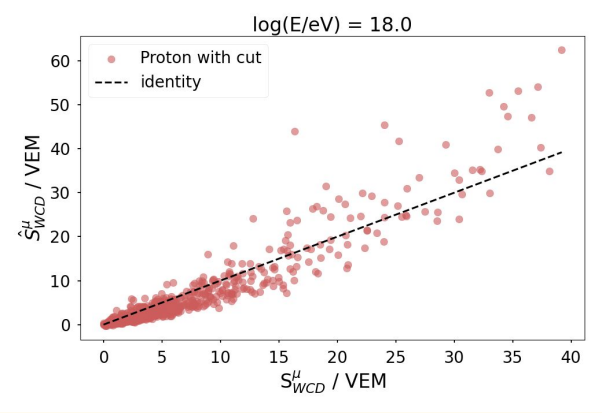


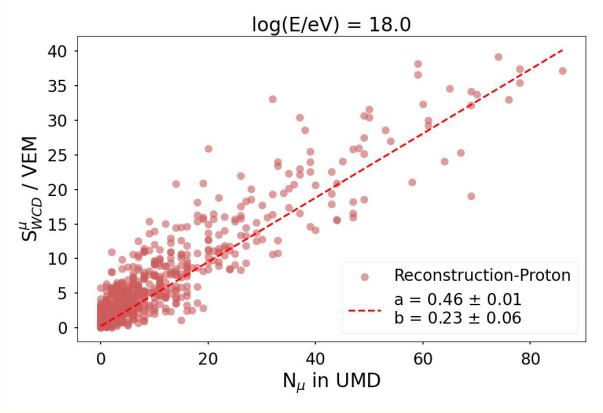


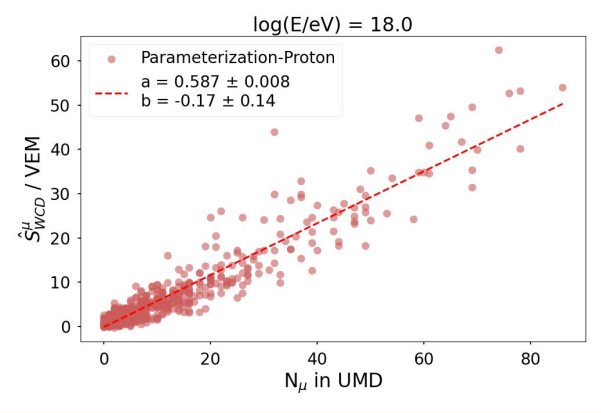


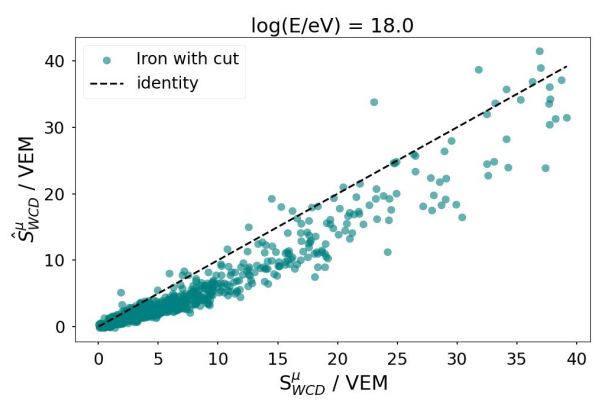


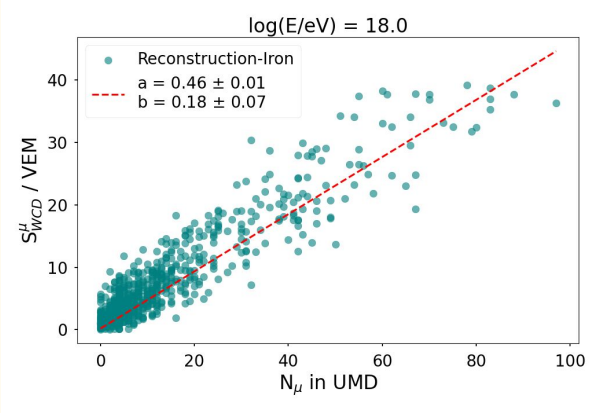
Relation with N_μ

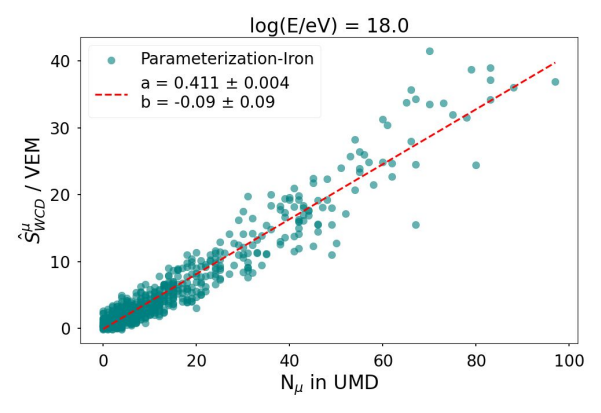












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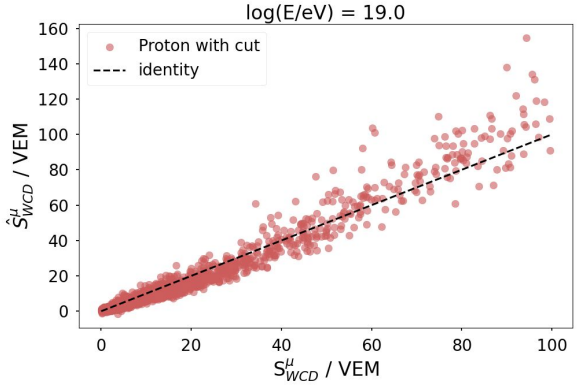
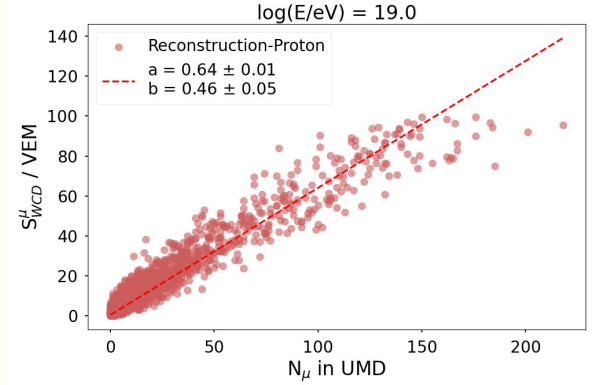
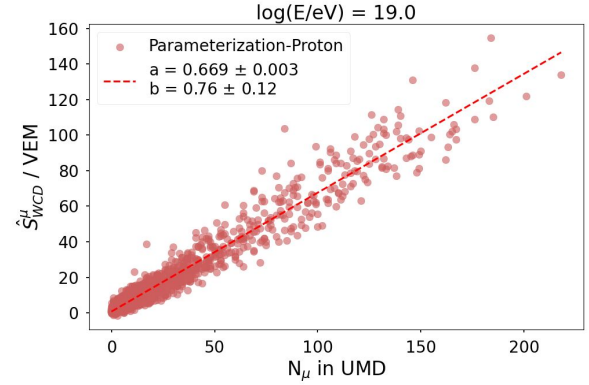
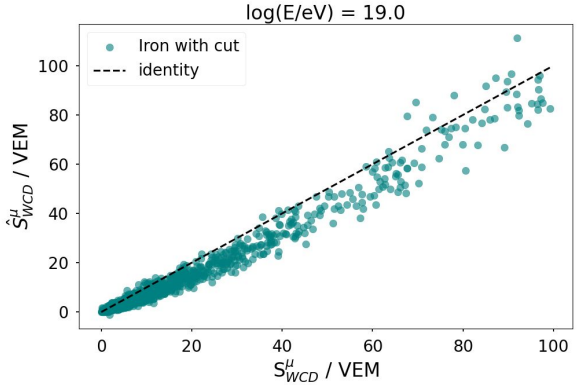
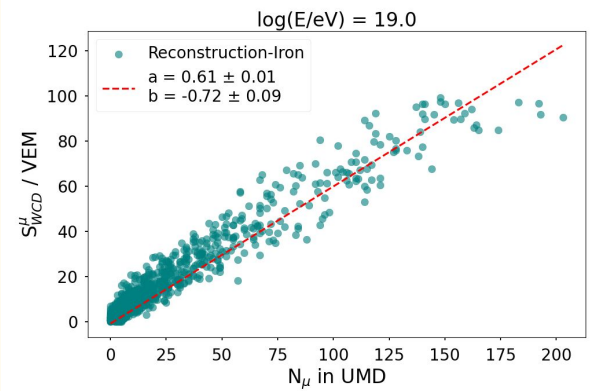
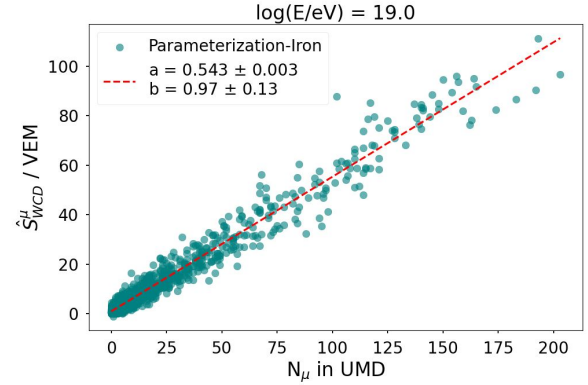




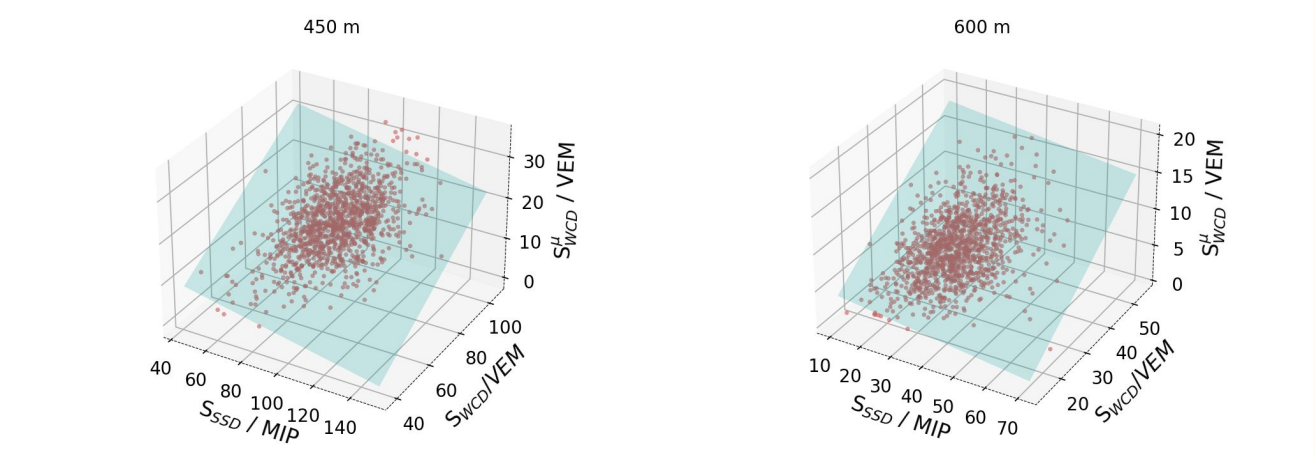






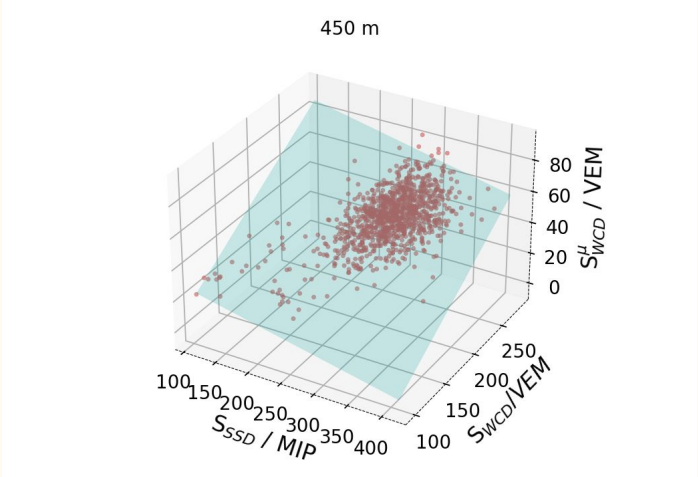


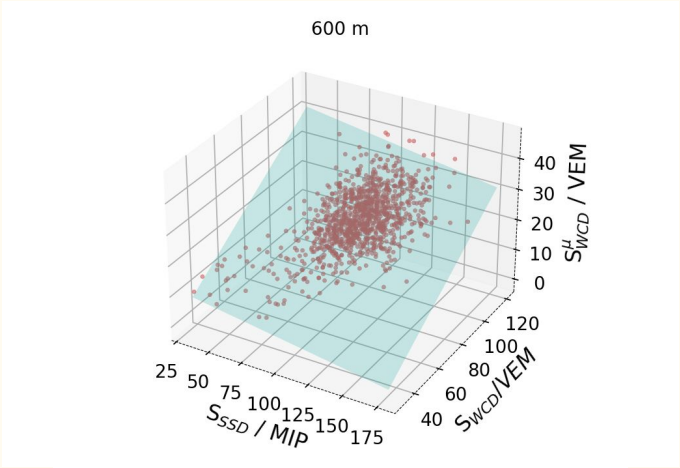
Plane plots

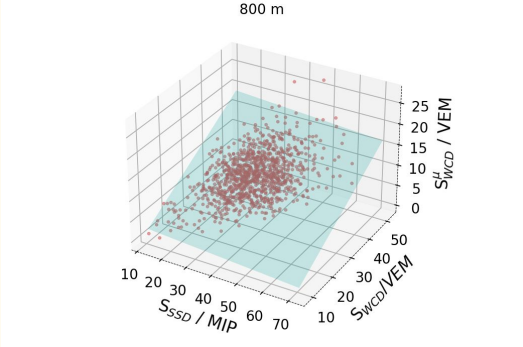


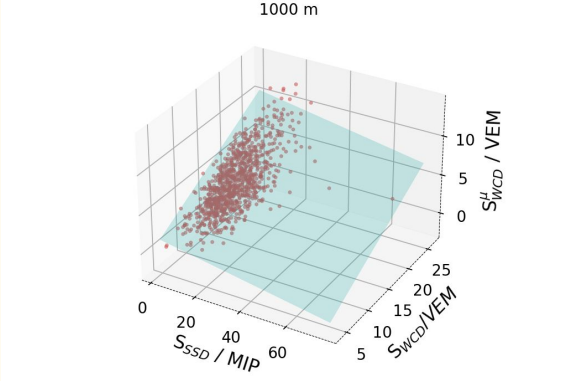
EPOS, log(E / eV) = 18.0, 0 °

Plane plots



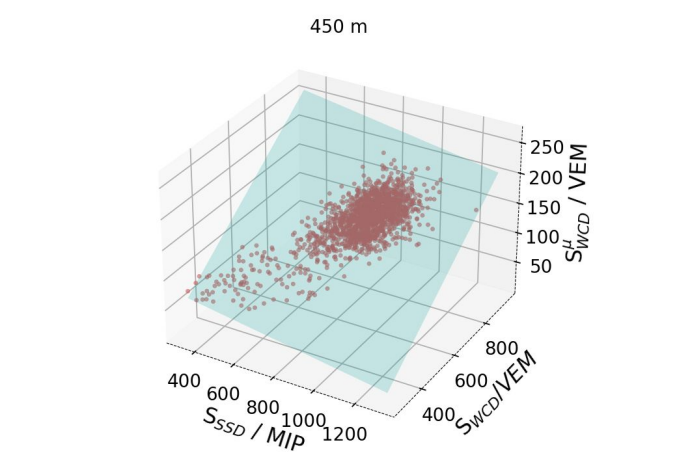


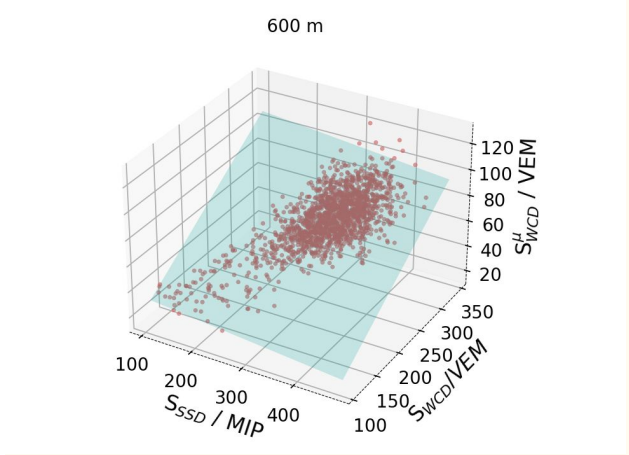


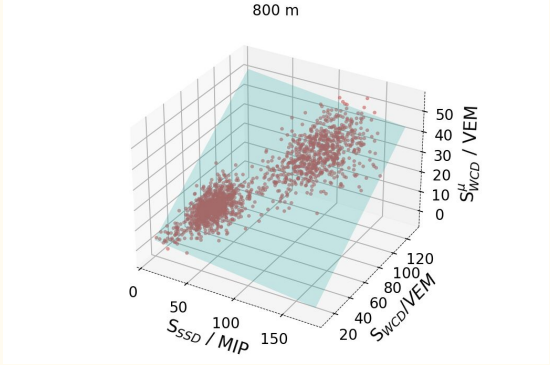


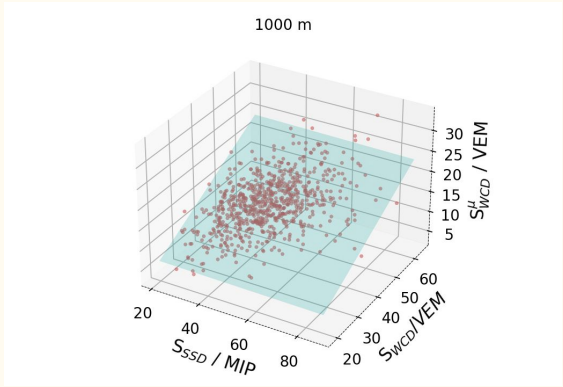
EPOS, $\log(E / eV) = 18.5$, $0\ ^{\circ}$

Plane plots









EPOS, $\log(E / eV) = 19.0$, 0°