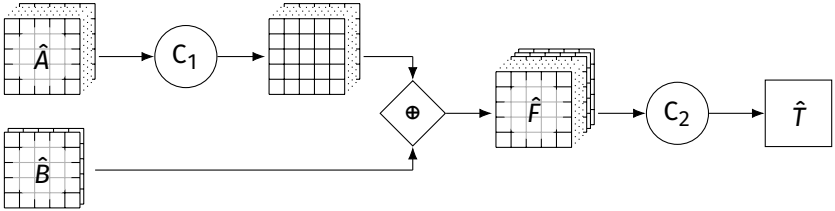
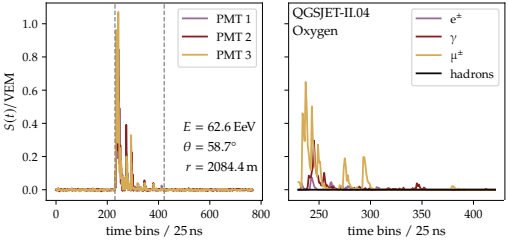
Methods for Estimating Mass-Sensitive Observables of Ultra-High Energy Cosmic Rays using Artificial Neural Networks (using SD)

S. Hahn, M. Roth, D. Schmidt, D. Veberič | Supvs.: R. Engel, B. Wundheiler | 11.11.2022

KIT - IAP

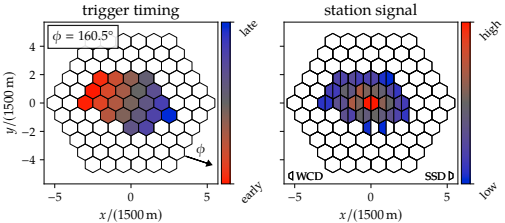


Why?



complex trace signals ⟺ “speech”

complex event structure ⟺ “images”



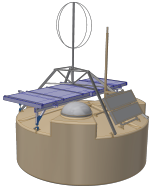
What? - I

Artifical Neural Networks

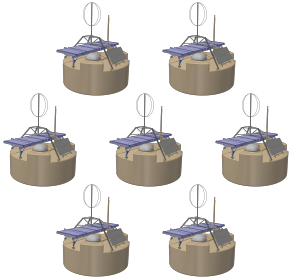
? → station-level: “bottom-up”

? → event-level: “top-down”

S_μ, f_μ



X_{max}, R_μ, $\ln A$

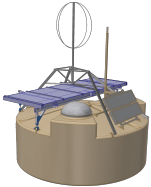


What? - II

Artifical Neural Networks

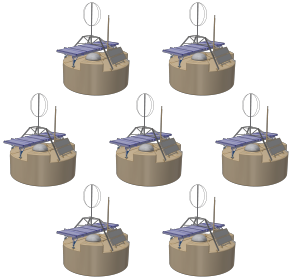
station-level: “bottom-up”

S_μ, f_μ

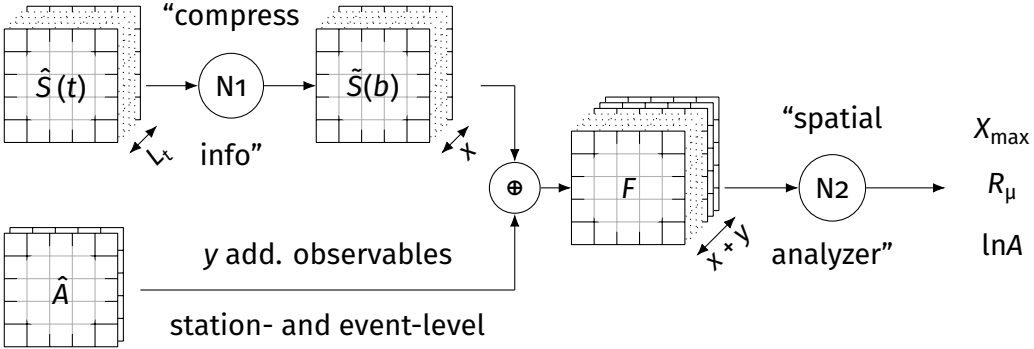


event-level: “top-down”

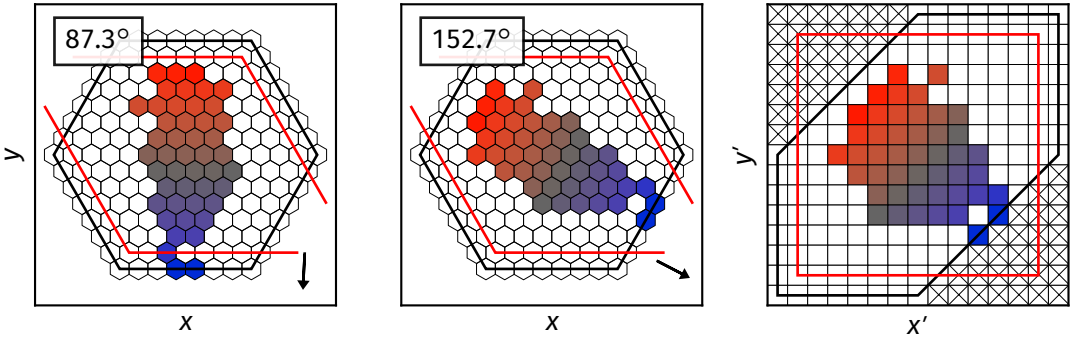
X_{max}, R_μ, $\ln A$



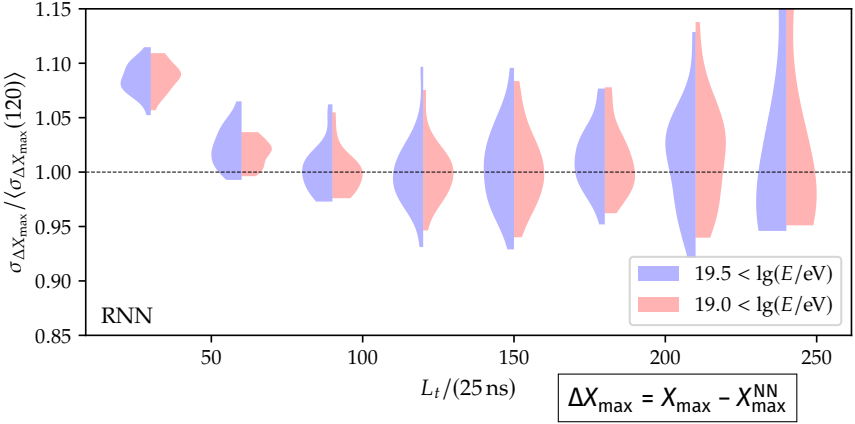
How? - architecture



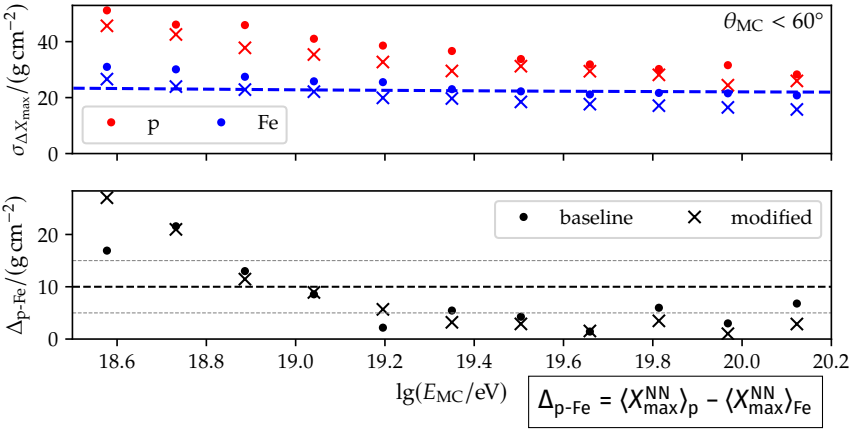
How? - standardization



Simulations - I

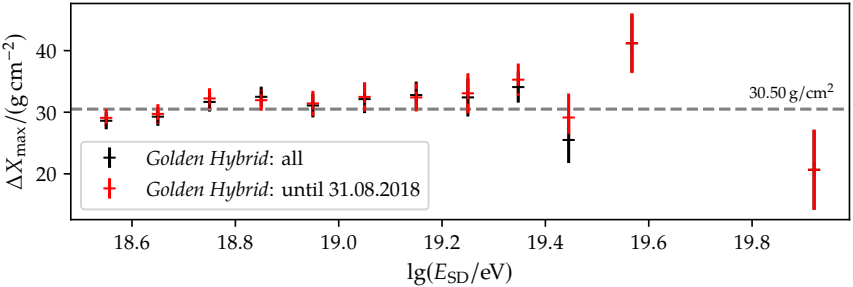


Simulations - II

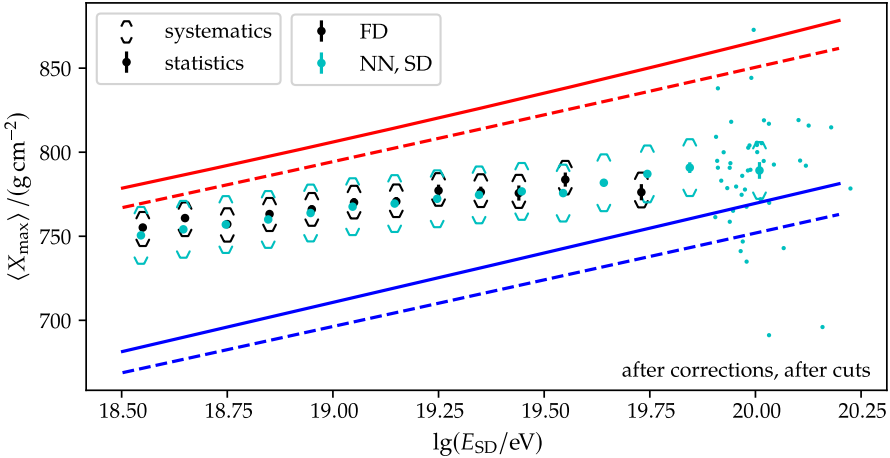


$$\Delta_{p\text{-}Fe} = \langle X^{NN}_{max}\rangle_p - \langle X^{NN}_{max}\rangle_{Fe}$$

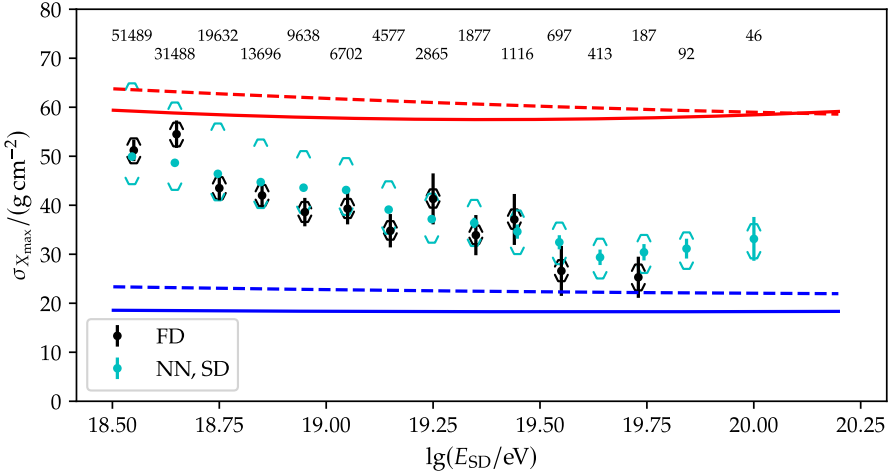
Measurements - $X_{\mathbf{max}}$ - I



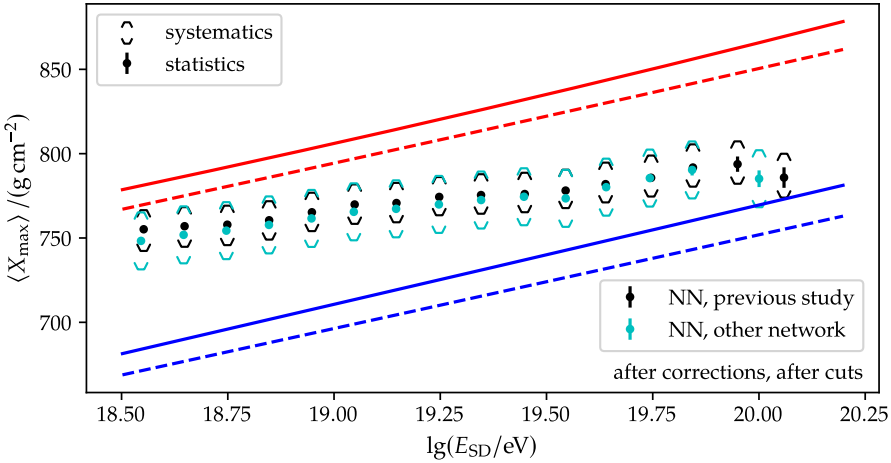
Measurements - X_{max} - II



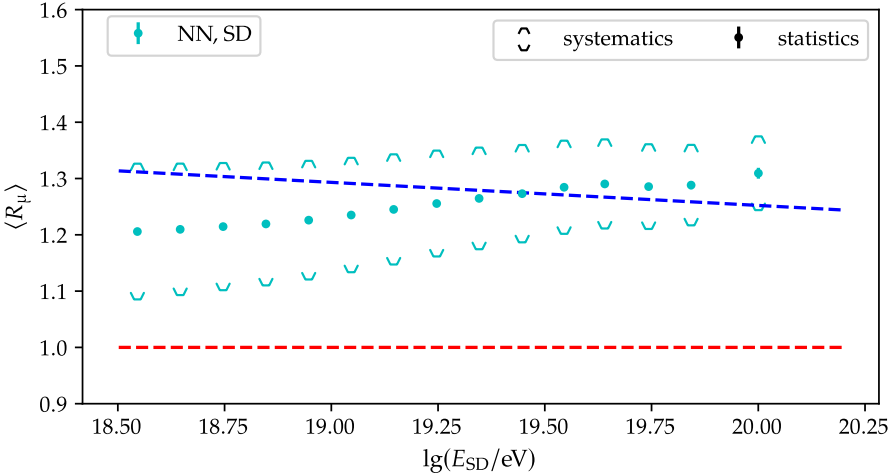
Measurements - X_{max} - III



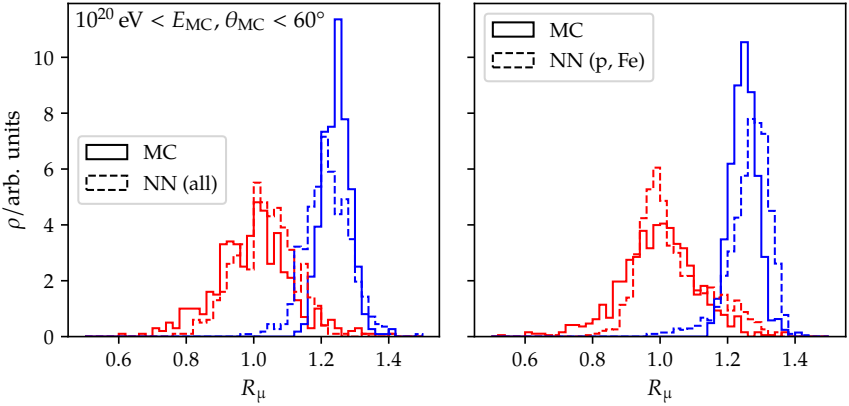
Measurements - X_{max} - IV



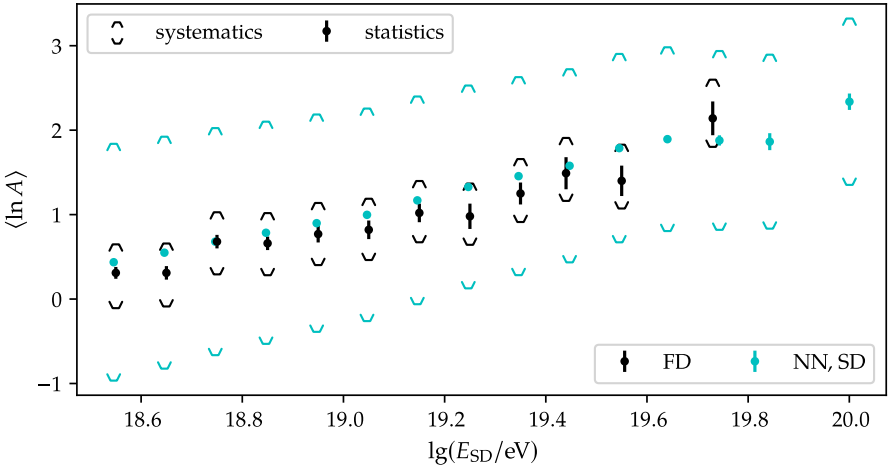
Measurements - R_μ - I



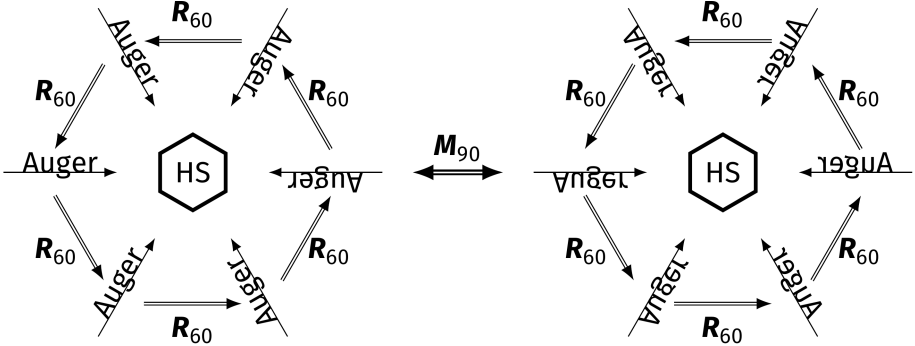
Measurements - R_μ - II



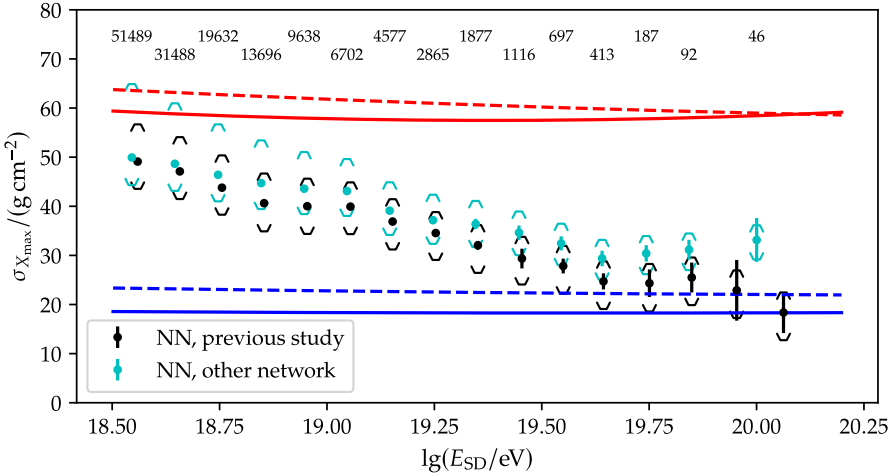
Measurements - ln A



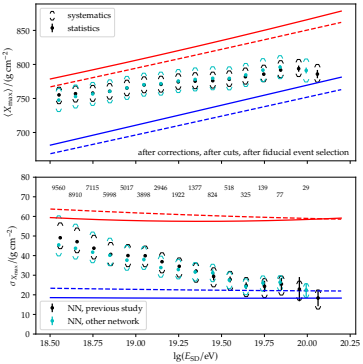
Standardization

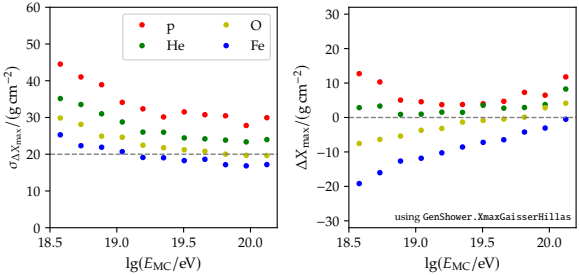


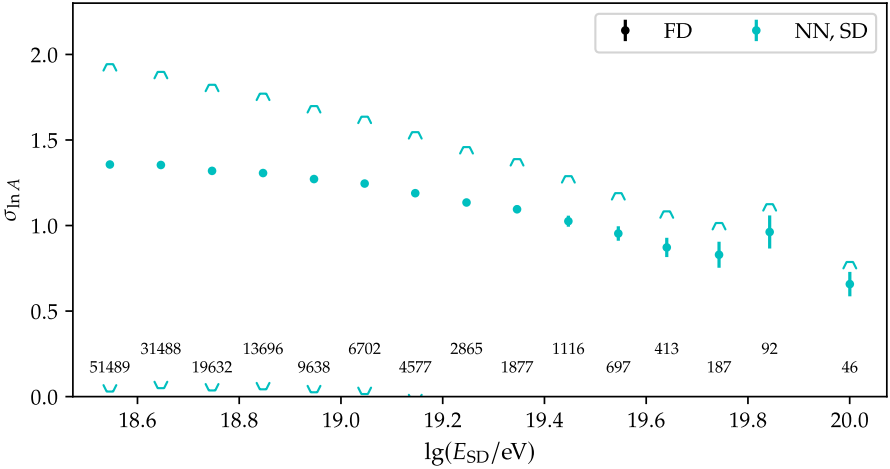
Second Moment - ?



Second Moment - ?





other network!

Measurements - ln A