Studies of Gamma-Ray Shower Reconstruction Using Deep Learning

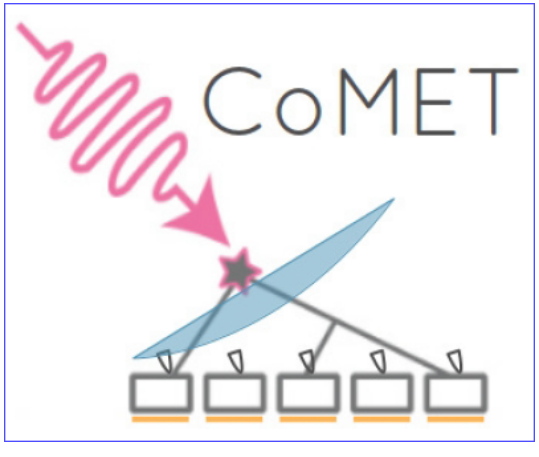
Tomas Bylund[1] Gašper Kukec Mezek [1] Mohanraj Senniappan [1] Yvonne Becherini [1] Michael Punch [1,2] Satyendra Thoudam [3] Jean-Pierre Ernenwein [4]

[1]Linnaeus University, Sweden

[2]Université de Paris, CNRS, Astroparticule et Cosmologie, France

[3]Aix Marseille Univ, CNRS/IN2P3, CPPM, France

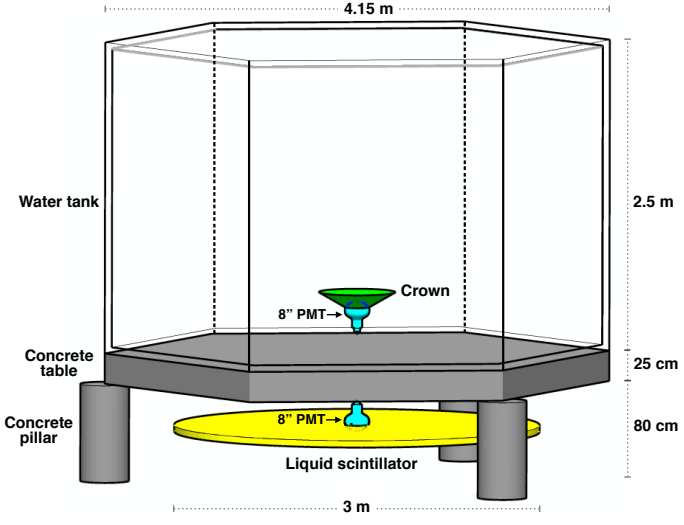
[4]Khalifa University, United Arab Emirates



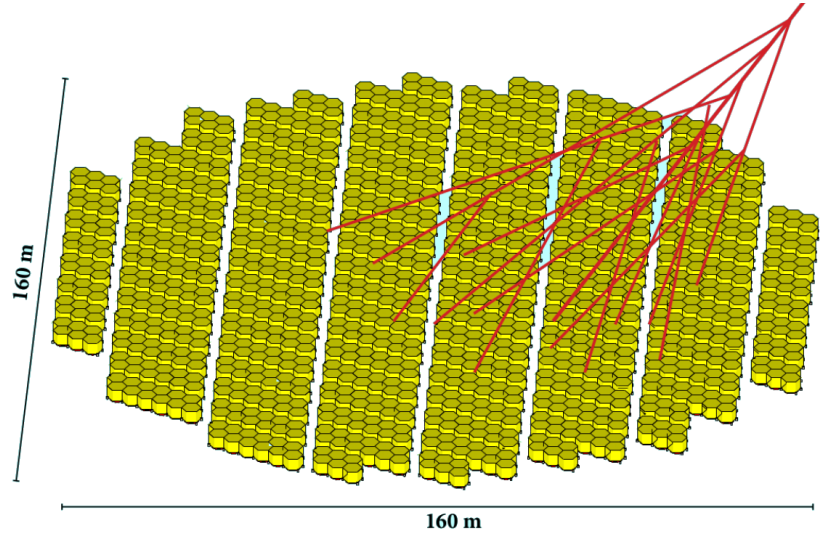
July 5, 2021

ALTO Gamma-Ray Shower Reconstruction

- CoMET R&D project is dedicated for observing very high energy gamma-rays (200 GeV – 50 TeV), optimising for extragalactic sources
- CoMET has two parts: atmospheric Cherenkov Light Collectors (CLiC) and a Particle detector array with 1242 detector units (water-Cherenkov and scintillator) called ALTO
- Here we only used the ALTO detectors



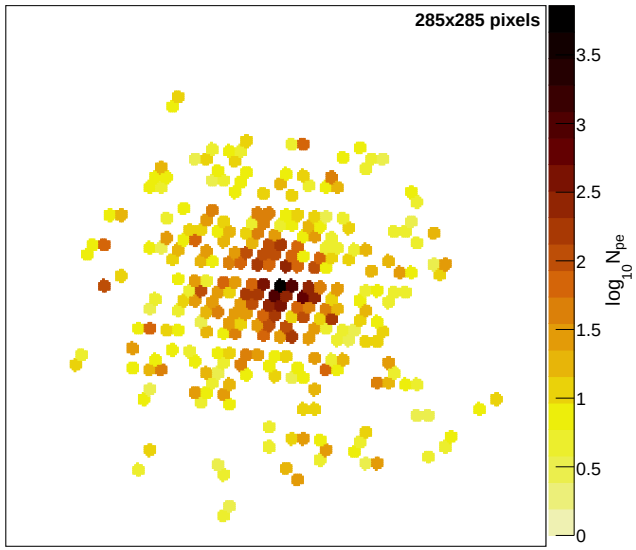
An ALTO tank



The ALTO array

Reconstruction with convolutional neural nets

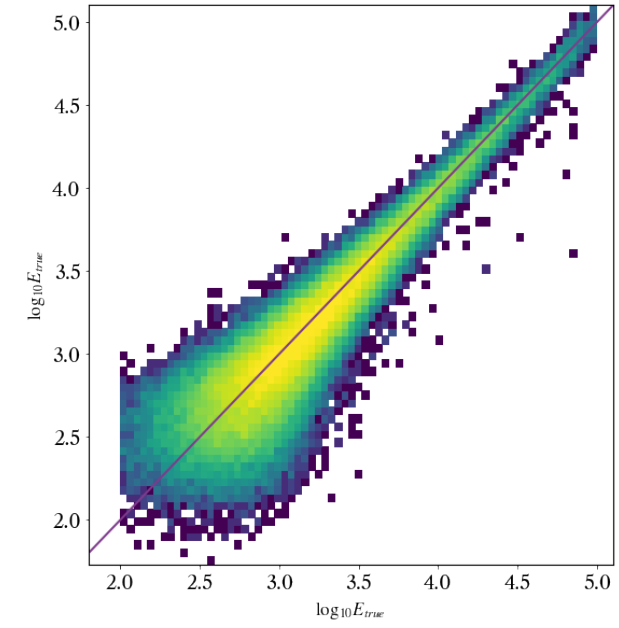
- Investigate power of Convolutional Neural Networks (CNN) to reconstruct Energy and depth of shower maximum X_{max}
- Use only log total number of physical photo-electrons seen per detector, $\log_{10} N_e$
- Convert from complicated detector geometry to square image for CNN to use with *oversampling*, events become 285x285 pixel images

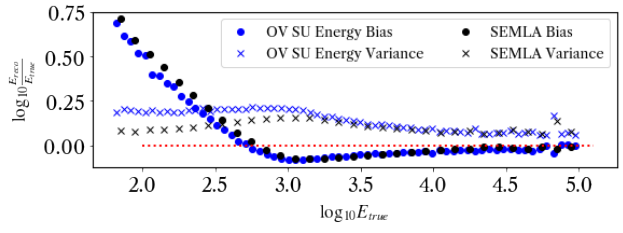


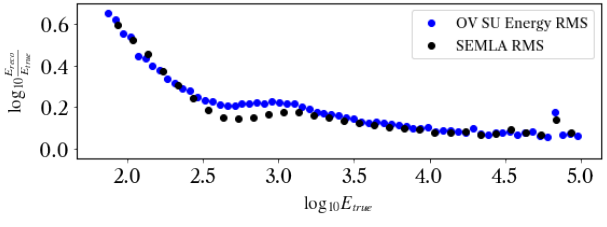
Oversampling converted event

Results: Energy

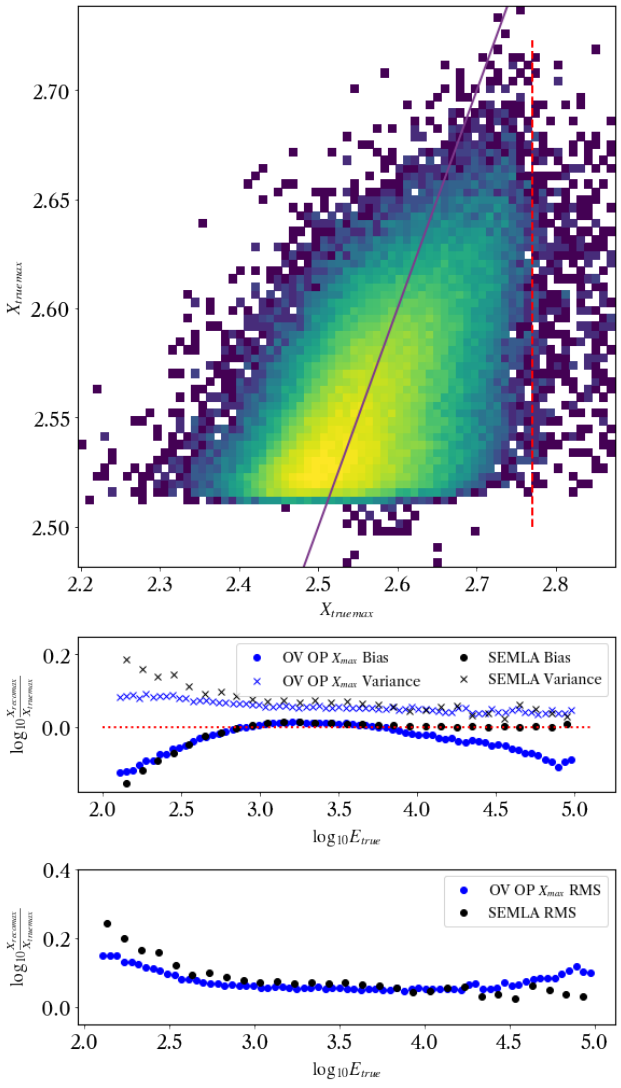
- Energy successfully reconstructed with straightforward CNN layout
- However, performance, as measured by the RMS of $\log_{10}(E_{\mathrm{reco}}/E_{\mathrm{truth}})$ only equivalent to traditional machine learning approach
- Tried data augmentation to address unbalance of samples at low energy, no importance for performance, but reconstruction quality slightly improved vs no augmentation







Results: shower maximum X_{max}



- The CNN achieves better RMS of $\log_{10}(X_{\mathrm{reco}}/X_{\mathrm{truth}})$ than traditional machine learning
- Balancing the training set with respect to Energy did not help with performance
- Absolute performance was modest, but potential to improve it further (see PoS ICRC2019, 270)
- At its current performance predicted X_{max} could help with improving energy performance

Thank you for your attention