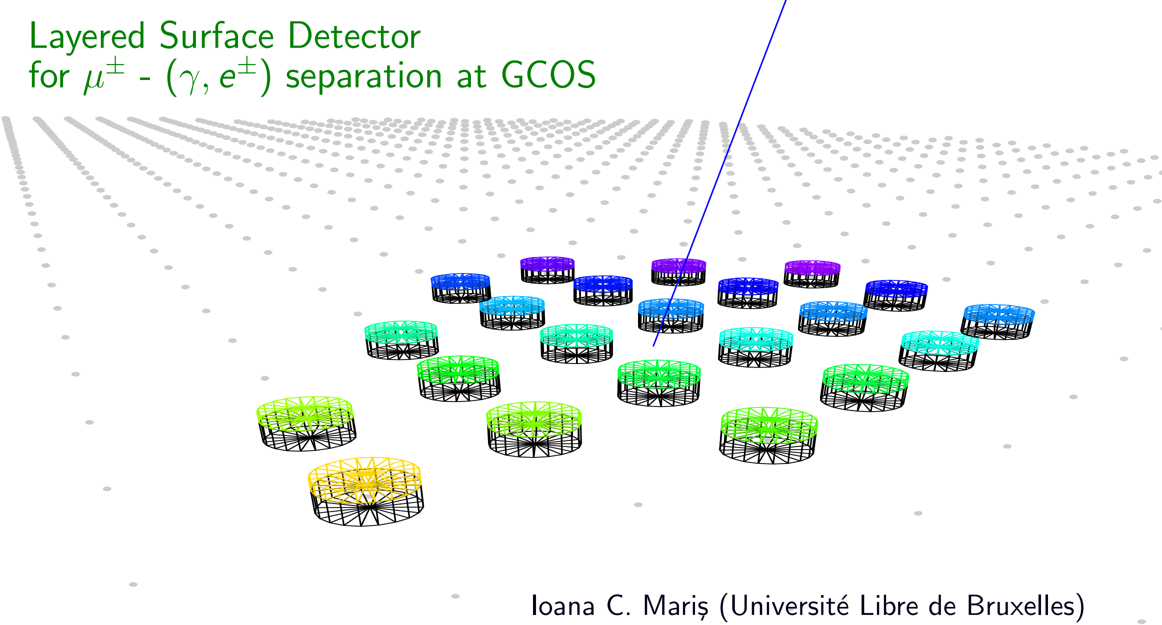
Layered Surface Detector for $\mu^{\pm}$ - $(\gamma, e^{\pm})$ separation at GCOS



Ioana C. Mariș (Université Libre de Bruxelles)

(A. Letessier-Selvon, P. Billoir, M. Blanco, I. C. Maris, M. Settimo, NIM A767 (2014), arxiv:1405.5699)

Global Cosmic Rays Observatory

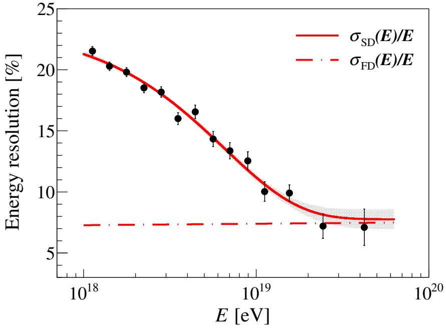
How to reach the physics case with a surface detector?

A. Energy resolution: 10% at 100 EeV
$\rightarrow$ Driven by spacing between detectors and number of particles measured in the detectors

B. Angular resolution: 0.5 degrees at 100 EeV
$\rightarrow$ Driven by spacing between detectors and the time resolution

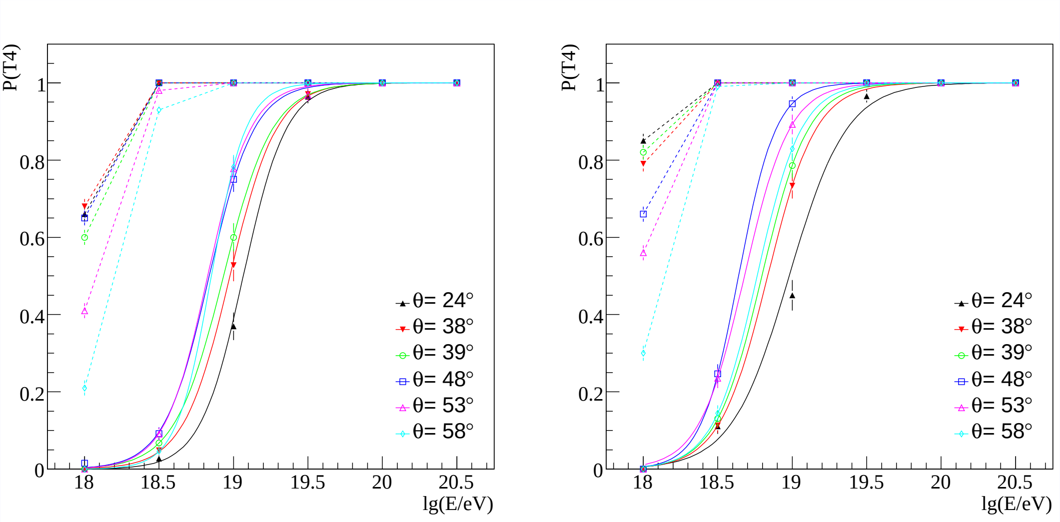
C. Excellent mass composition determination
$\rightarrow$ Determined by the quality of the separation between the em and muonic components of air-showers and hadronic interactions modeling

D. Huge exposure
$\rightarrow$ Driven by the effective cost of a detector (including deployment) and constrained by resolutions



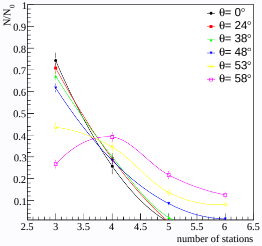
Can Water Cherenkov Detectors do it?

1.5 km spacing vs 2.25 km spacing

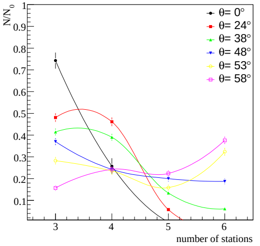


(a) proton (b) iron

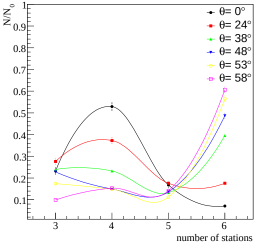
Number of stations at 2.25 km spacing



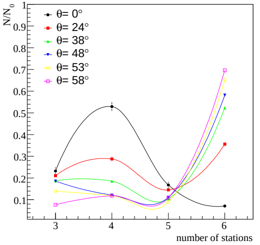
(a) lg(E/eV)= 19



(b) lg(E/eV)= 19.5



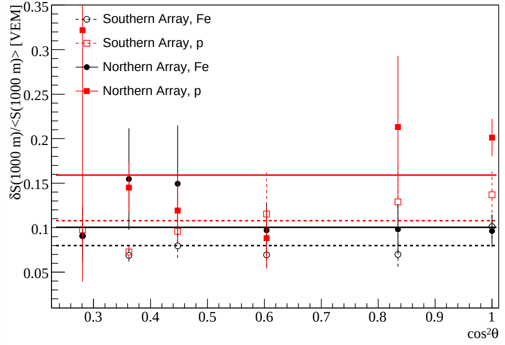
(c) lg(E/eV)= 20



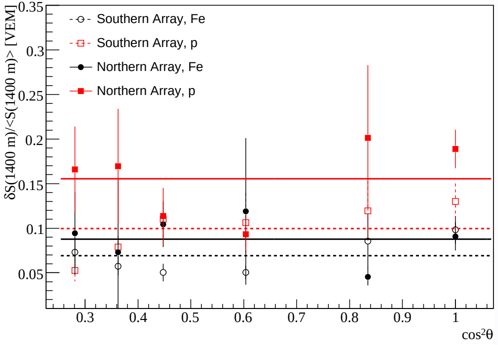
(d) lg(E/eV)= 20.5

Statistics dominated by the 3 fold and 4 fold events up to 30 EeV

S(r) (energy) resolution



(c) relative spread 1000 m

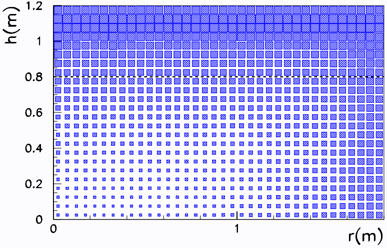


(d) relative spread 1400 m

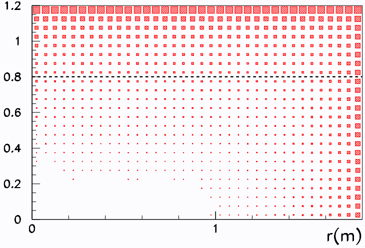
The idea: optical separation of a Water Cherenkov Tank

A water volume responds different to photons, $e^{\pm}$ and $\mu^{\pm}$

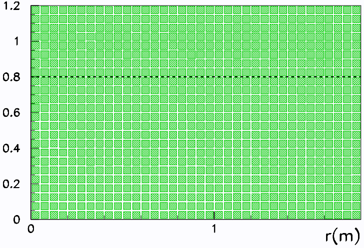
photons

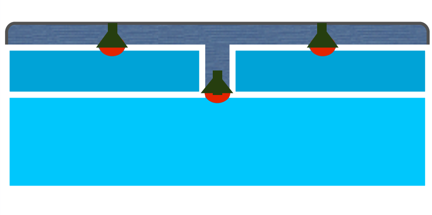


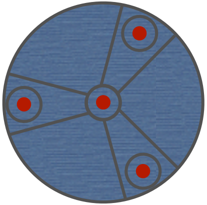
electrons

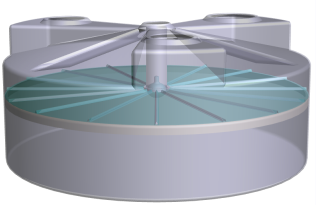


muons





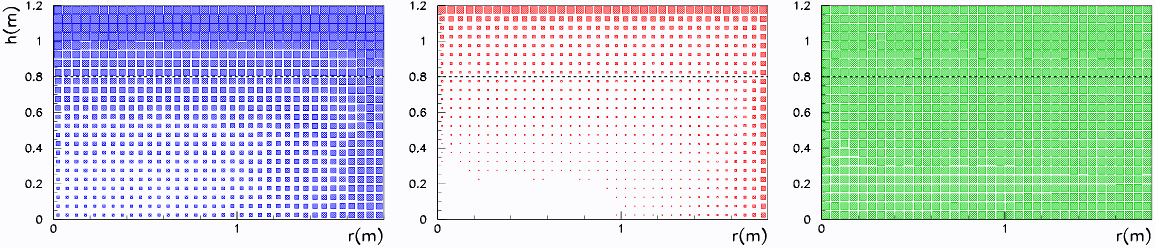


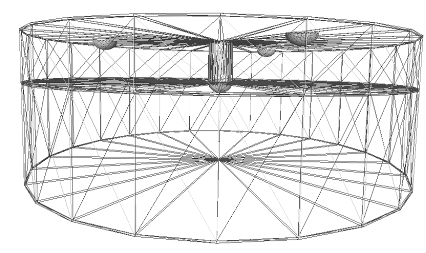


The idea: optical separation of a Water Cherenkov Tank

A water volume responds different to photons, $e^{\pm}$ and $\mu^{\pm}$

photons electrons muons



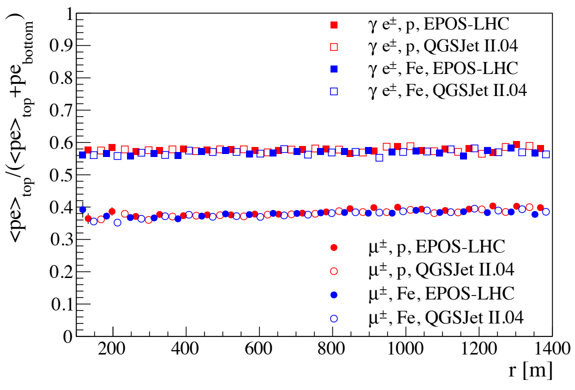


$$\begin{pmatrix} S_{top} \\ S_{bot} \end{pmatrix} = \mathcal{M} \begin{pmatrix} S_{EM} \\ S_{\mu} \end{pmatrix} = \begin{pmatrix} a & b \\ 1-a & 1-b \end{pmatrix} \begin{pmatrix} S_{EM} \\ S_{\mu} \end{pmatrix}$$

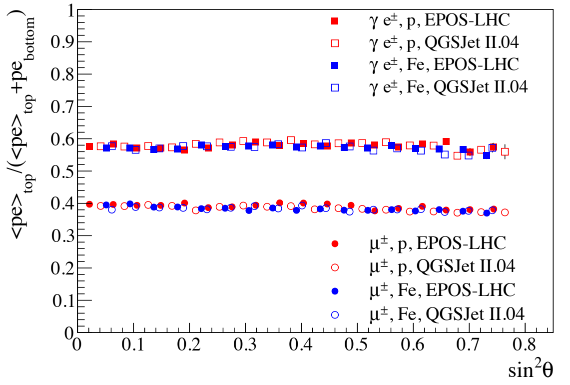
$$\begin{pmatrix} S_{EM} \\ S_{\mu} \end{pmatrix} = \mathcal{M}^{-1} \begin{pmatrix} S_{top} \\ S_{bot} \end{pmatrix}$$

Universality of a and b

independent of distance to axis

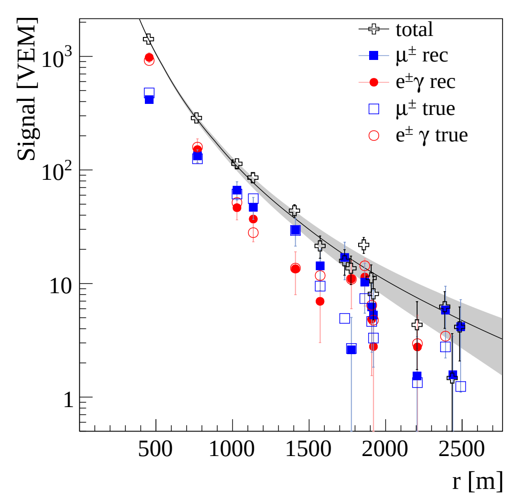


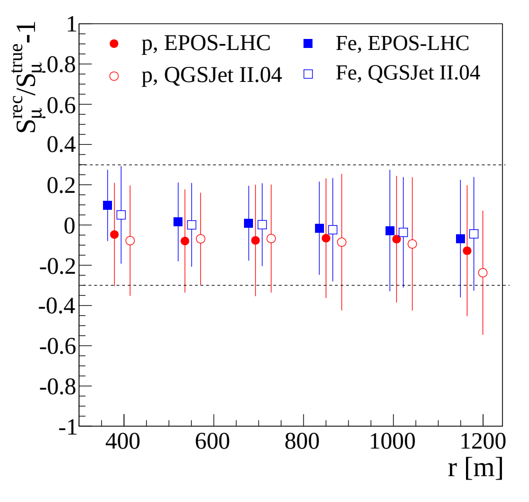
indepedendent of zenith angle



independent of hadronic models/primary

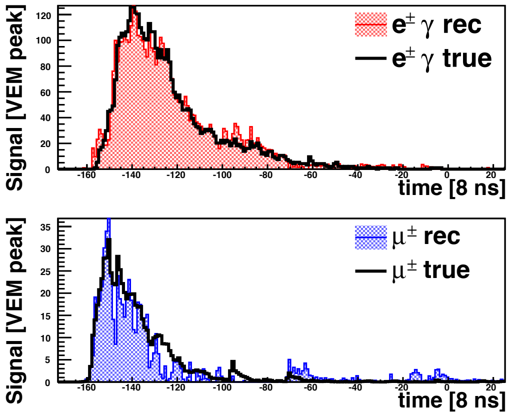
Good resolution for muonic and electromagnetic signals at station level



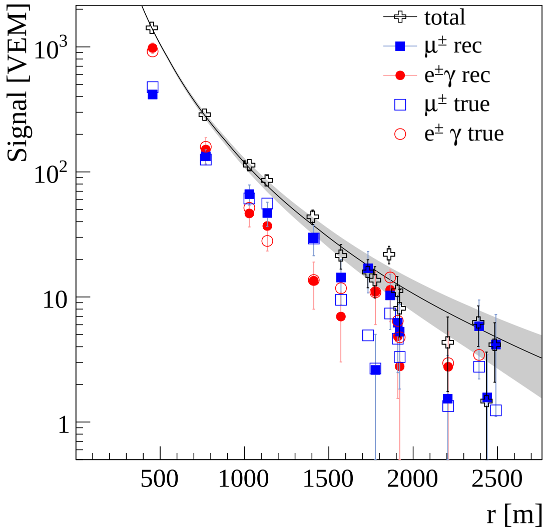


bias smaller than 5% and resolution of about 20-25% on station signal
leads to a event muonic signal resolution of better than 18%

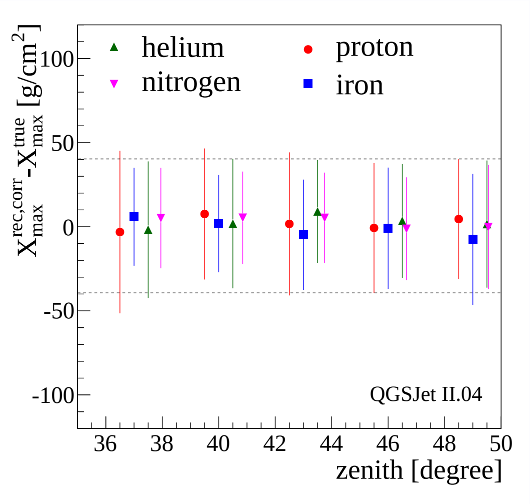
Not only total signal, but also time distributions

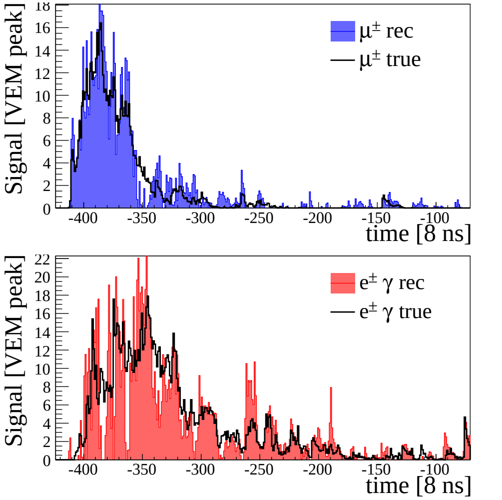


Based on Universality or DNN we can get X_{max}



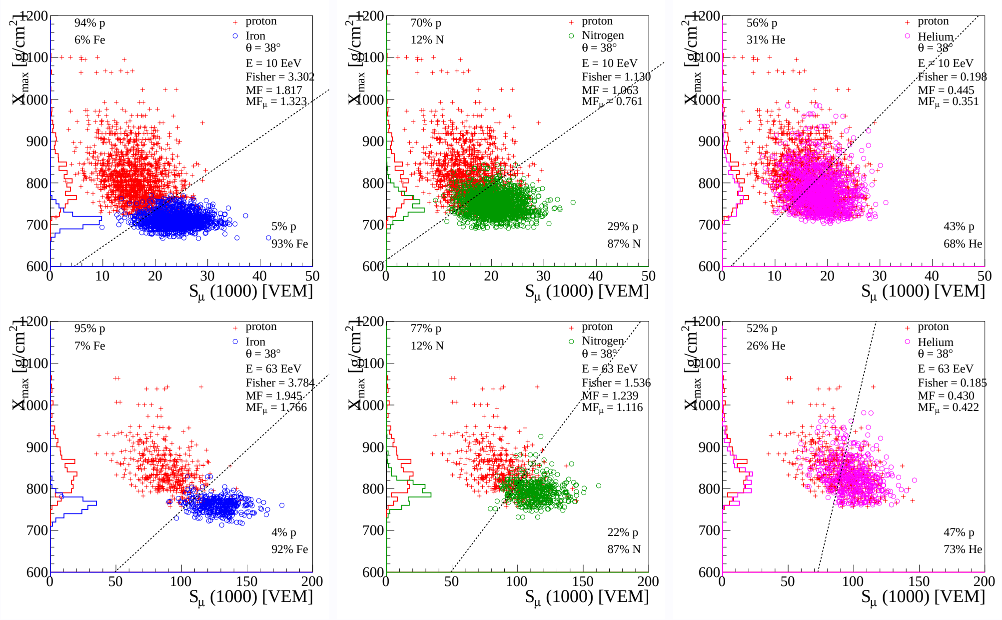
Example of X_{max} reconstruction from Universality



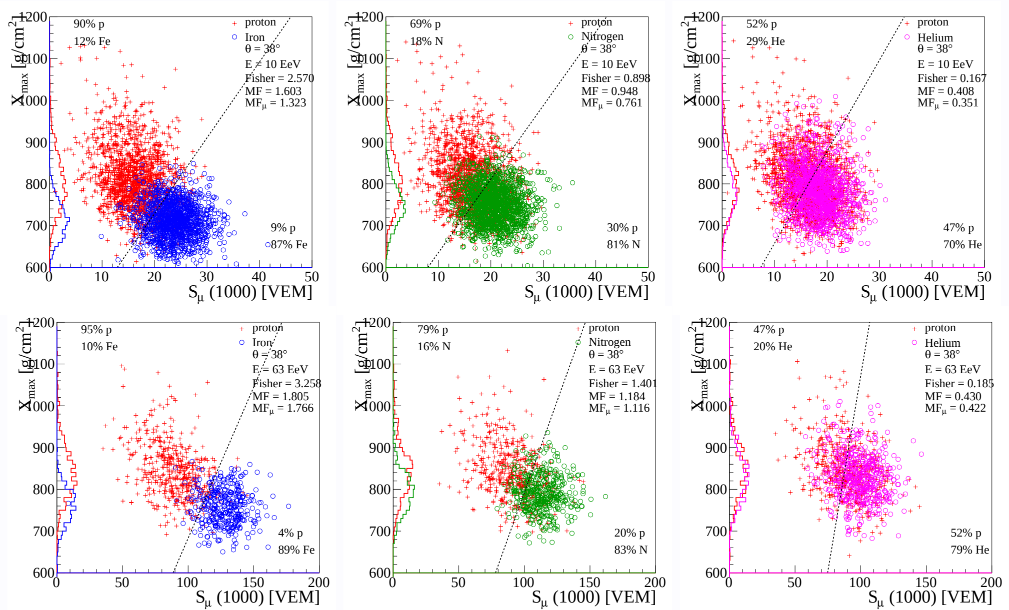


10 EeV primaries

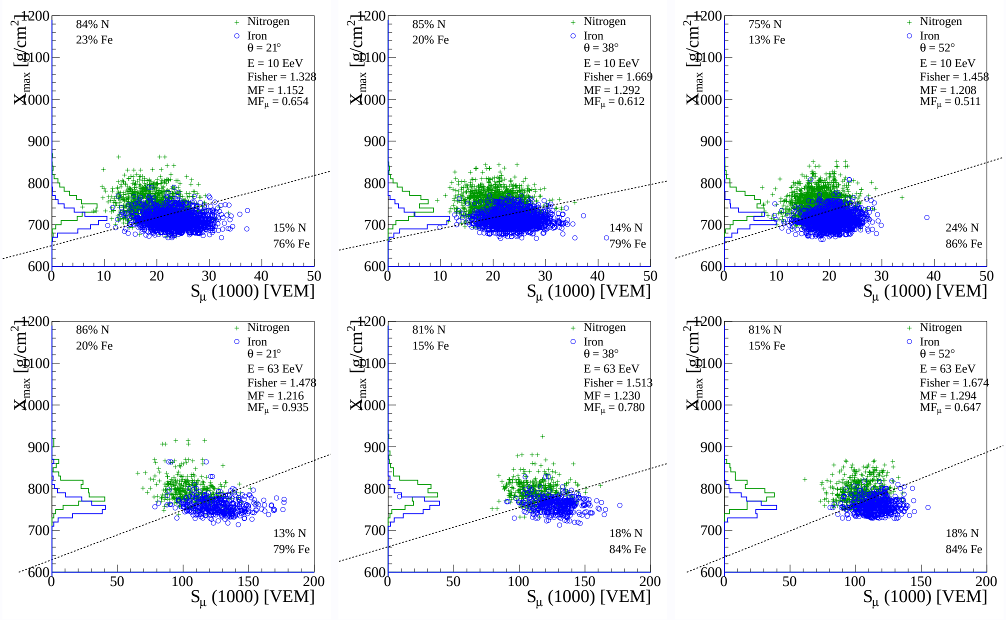
Example of merit factors at 10 EeV and 63 EeV



Example of merit factors at 10 EeV and 63 EeV(extra randomisation)



Example of merit factors at 10 EeV and 63 EeV



Example of merit factors at 10 EeV and 63 EeV(extra randomisation)