When heavy ions meet cosmic rays : potential impact of QGP formation on the muon puzzle

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- **What is this contribution about ?**

  A possible explanation for the muon deficit in air shower simulations.

- **Why is it relevant / interesting ?**

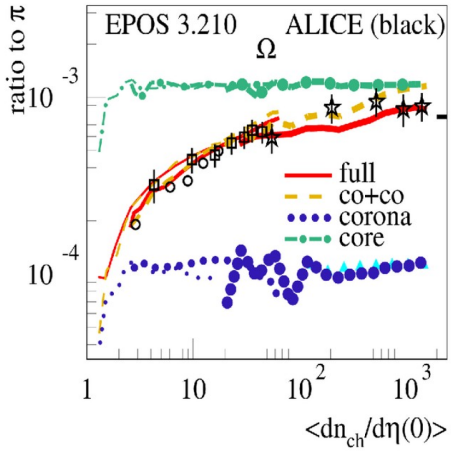
  The solution is NOT based on unknown physics at very high energy but on a growing impact of a different hadronization as observed in LHC data.

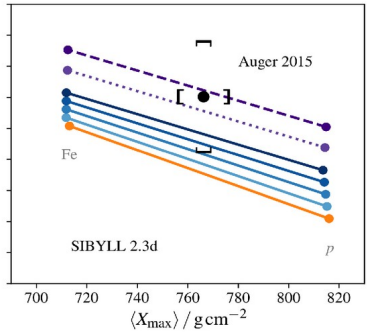
- **What have we done ?**

  A simplified core-corona approach has been implemented in CONEX to apply the model to any hadronic interaction model.

- **What is the result ?**

New input from LHC crucial to reproduce EAS data consistently: collective effects in light system may bring a solution for the muon puzzle.





Core-Corona appoach and EAS with CONEX

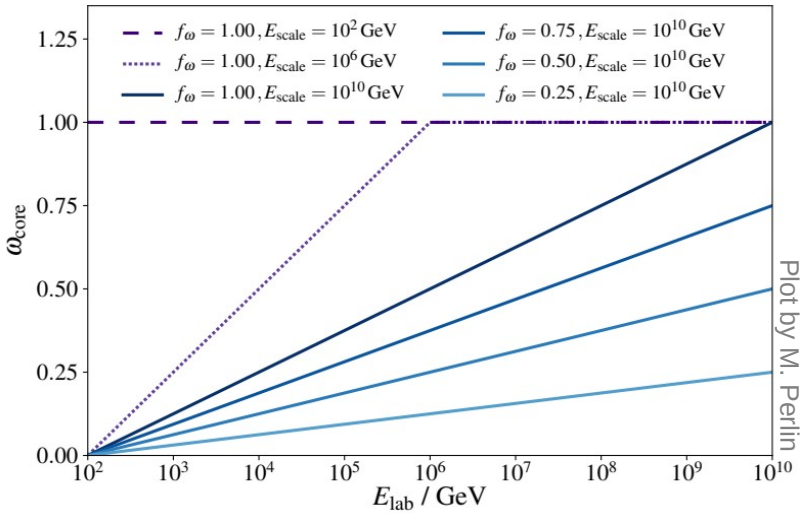
$$N_i = \omega_{\rm core}\, N_i^{\rm core} + (1-\omega_{\rm core})\, N_i^{\rm corona}$$

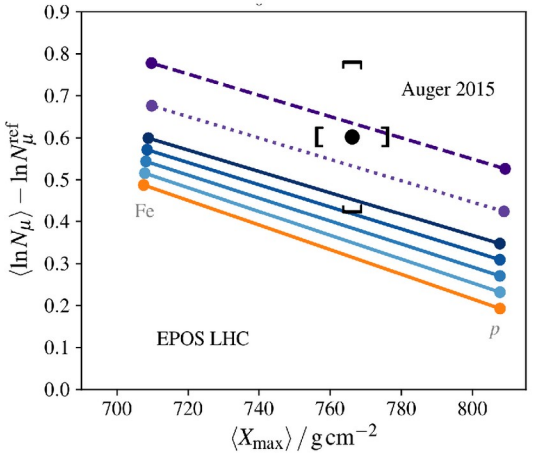
$$\omega_{\rm core}(E_{\rm lab}) = f_\omega \underbrace{F(E_{\rm lab}; E_{\rm th}, E_{\rm scale})}$$

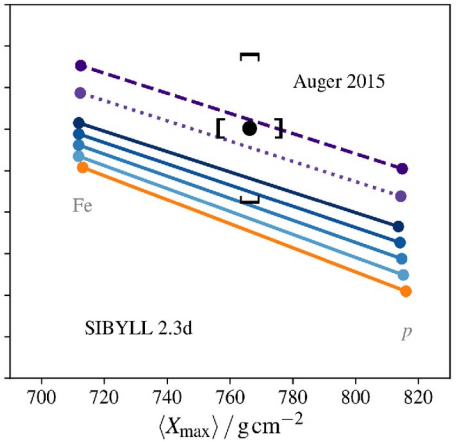
$$\frac{\log_{10}(E_{\rm lab}/E_{\rm th})}{\log_{10}(E_{\rm scale}/E_{\rm th})} \text{ for } E_{\rm lab} > E_{\rm th}$$

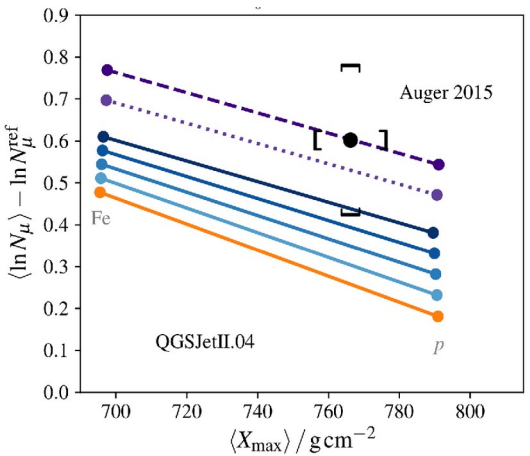
$$E_{\rm th} = 100\,{\rm GeV}$$

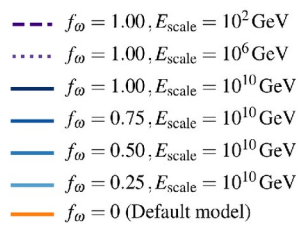
Note : the leading particle is NOT modified
(projectile remnant)











Ref: <https://arxiv.org/abs/1902.09265>

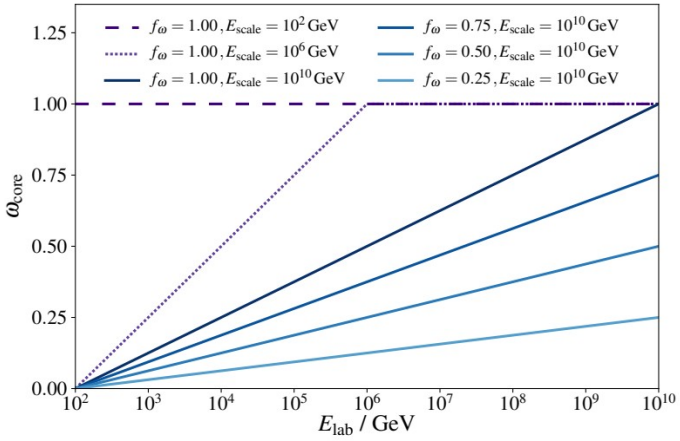
Results for z-scale

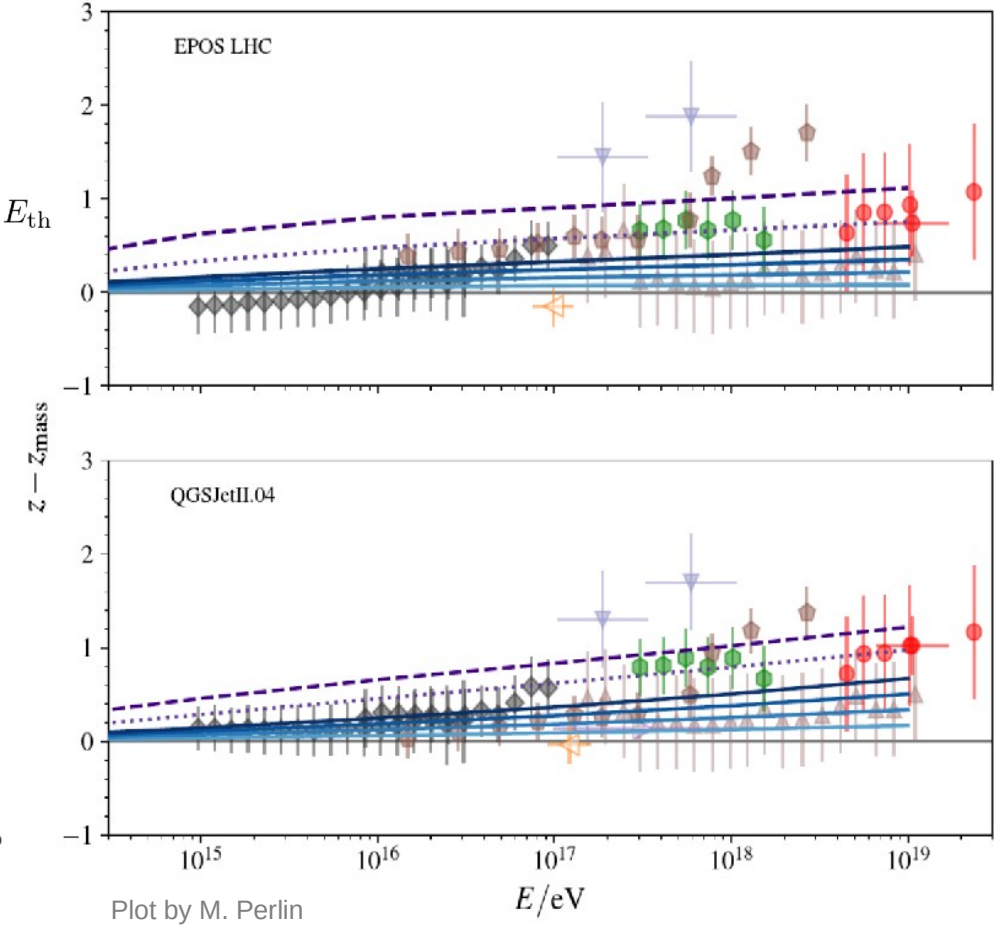
$$N_i = \omega_{\rm core}\, N_i^{\rm core} + (1-\omega_{\rm core})\, N_i^{\rm corona}$$

$$\omega_{\rm core}(E_{\rm lab}) = f_\omega \underbrace{F(E_{\rm lab}; E_{\rm th}, E_{\rm scale})}_{\frac{\log_{10}(E_{\rm lab}/E_{\rm th})}{\log_{10}(E_{\rm scale}/E_{\rm th})} \text{ for } E_{\rm lab} > E_{\rm th}}$$

$$E_{\rm th} = 100\,{\rm GeV}$$

Note : the leading particle is NOT modified (projectile remnant)





Plot by M. Perlin

$$z = \frac{\ln N_\mu^{\rm det} - \ln N_{\mu,p}^{\rm det}}{\ln N_{\mu,{\rm Fe}}^{\rm det} - \ln N_{\mu,p}^{\rm det}}$$

- $f_\omega = 1.00, E_{scale} = 10^2$ GeV
- $f_\omega = 1.00, E_{scale} = 10^6$ GeV
- $f_\omega = 1.00, E_{scale} = 10^{10}$ GeV
- $f_\omega = 0.75, E_{scale} = 10^{10}$ GeV
- $f_\omega = 0.50, E_{scale} = 10^{10}$ GeV
- $f_\omega = 0.25, E_{scale} = 10^{10}$ GeV
- $f_\omega = 0$ (Default model)

- Pierre Auger MD+SD [Preliminary]
- IceCube [Preliminary]
- NEVOD-DECOR
- Pierre Auger FD+SD
- SUGAR
- Yakutsk [Preliminary]
- EAS-MSU
- KASCADE-Grande

$$z_{\rm mass} = \frac{\langle \ln A \rangle}{\ln 56}$$

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