On Sensitivity of Čerenkov Radiation to the Dynamics of High Energy Cosmic Ray Interactions

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What is the sensitivity of CR data to the interaction dynamics?
QGSJET, SIBYLL, DPMJET, ...
QGP model

Pion momenta generated according to Boltzmann distribution

\[ f(p) = \mu \exp(-\mu T) \quad \text{where} \quad T = \frac{p^2 + m^2}{\mu} - m^2 \]

- \( \mu = 170 \text{ MeV}, \) 4 or 8 nucleons melted
  if \( N_{\text{int}} = 19 \sim 21 \)

- \( \mu = 340 \text{ MeV}, \) 4 or 8 nucleons melted
  if \( N_{\text{int}} = 19 \sim 21 \)

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Detection

- underground energetic muons

- on the ground ėrenkov radiation
  our simulated experiment:
  string of 100 detectors
  3 x 3 m²
  10 meters spacing

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$kT = 170 \text{ MeV}$ in CMS

$\langle E_N \rangle \sim 1.25 \text{ GeV}$

$\langle E \rangle \sim 0.6 \text{ GeV}$

$kT = 340 \text{ MeV}$

$\langle E_N \rangle \sim 1.6 \text{ GeV}$

$\langle E \rangle \sim 1.1 \text{ GeV}$

$N_{\text{hot}} = 4$

QGP $\sim 5.7\%$ of $s$

$N_{\text{hot}} = 8$

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$\pi/N$ multiplicity, Fermi factor $F \approx s_{NN}^{1/4}$
Ratio of Čerenkov signal \( \gamma/p \) generated by QGSJET & CORSIKA.

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Ratio of Čerenkov signal $\frac{Fe}{p}$
generated by QGSJET & CORSIKA

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Ratio of Čerenkov signal QGP/Fe generated by QGSJET+ melted $N_{\text{hot}}$ & CORSIKA.

Lateral profiles of Čerenkov signal QGP and Fe generated by QGSJET+ melted $N_{\text{hot}}$ & CORSIKA

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dependence on plasma temperature

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dependence on number of melted nucleons
differences between Fe and QGP signal originate at high altitudes - integrals above given

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differences between Fe and QGP signal originate at high altitudes — differential dependence

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differences seen in whole array and their ratio
primary energy
and
lateral differences
and their ratio

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Cherenkov signal underground

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Conclusions

✓ increased pion production in primary cosmic ray interaction can be detected
✓ the difference in ėerenkov radiation is even bigger then in high energy muon distributions
✓ the difference in ėerenkov radiation increases with primary energy
× QGP does not explain muon bundles