Ultra-High Energy Proton-Proton Collision in the Laboratory System as the Source of Proton, Neutrino and Gamma Spectra in Astrophysics

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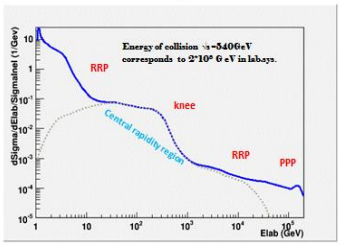
Outline

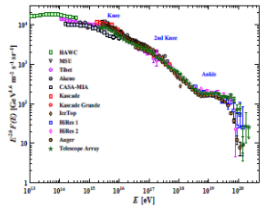
- The form of proton spectra within the Quark-Gluon Model : the components of proton spectrum in c.m.s. at √s = 540 GeV: central rapidity table, diquark contribution and triple-pomeron peak
- The procedure of spectrum transfer from c.m. system to laboratory system
- The specifics of proton spectrum in laboratory system: the "knee" and a bump at UHE
- The all-particle spectrum from CR measurements
- Expectations for the spectra of ν's and γ's – recent measurements at UHE
- Gamma spectrum from Cygnus-X3 (1990) as the result of $\pi^0 \rightarrow 2\gamma$ decay
- Entire-range gamma radiation and a bump at the end of gamma spectrum
- Conclusions

Specifics of proton spectrum in laboratory system: the "knee" and a bump at VHE



CR particle spectrum at UHE

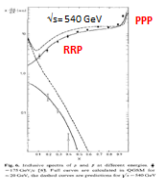
Particle Data 19: spectrum-cosmic-rays.pdf



The all-particle spectrum as a function of E (energy per nucleon)

The components of proton spectrum

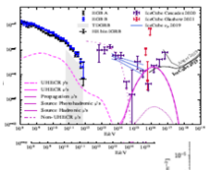
A.B. Kaidalov and O.Piskunova, Zeit. Phys. C**30** (1986), 145



1. Proton production density at x = 0 from vacuum diquark - antidiquark pairs is growing with energy
2. The contribution of walking diquark from beam proton (RRP term) should decrease with energy
3. Triple-Pomeron peak (PPP term) is the permanent contribution from diffraction dissociation of beam proton.
4. The triple-Pomeron peak doesn't measured yet at the up-to-date collider energies

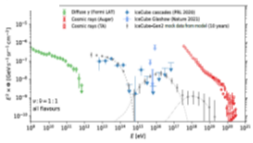
At ultra high energies (UHE) we will have only the fall down from central rapidity "table" and **the visible bump at the end of distribution**

Probing the environments surrounding ultrahigh energy cosmic ray accelerators and their implications for astrophysical neutrinos

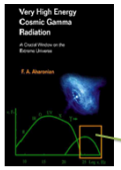


S. Musio, G.R. Farrar and M. Unger
arXiv.org: 2108.05512

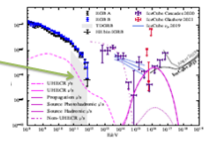
Ultra-High-Energy Cosmic Rays
The Intersection of the Cosmic and Energy Frontiers
arXive.org: 2205.05845



Entire-range photon radiation and a bump at the end of spectra

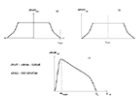


Aharonian F.A., Very High Energy Cosmic Gamma Radiation, Crucial Window on the Extreme Universe, World Scientific Publishing, 2004



Procedure for the transfer to lab. system

Formulas for spectrum transfer to lab. system



1) $d\sigma/dy = x d\sigma/dx$

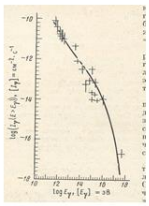
2) $d\sigma/dE_{lab} = d\sigma/dy_{lab}/E_{lab}$

For the proton-proton collision the produced proton spectrum has the complicated view due to triple-Pomeron peak (PPP).

Gamma spectrum from Cygnus-X3 as the result of $\pi^0 \rightarrow 2\gamma$ decay (1990)

O.I. Piskunova, Sov.Jou. of Nucl. Phys. **51** (1990) 1332

T.C. Weeks and M.F. Cawley, Astrophys. J. **296** (1984)185



Conclusions

The hadroproduction spectra **in laboratory system** have the power slope.

Each next interaction brings E^{-1}_{lab} to the spectrum.

Proton spectrum has the spesifics: the growing central rapidity density, the triple Pomeron peak at the highest energy and diquark contribution in between.

Proton energy distribution in space are bringing similar spesifics: knee as the central rapidity "table", the bump near the end from the triple Pomeron peak.

All this observed features tell us that **protons play important role in the particle production in space.**

Secondary particle spectra (neutrino, gamma etc.) reproduce the features of proton spectrum in proton-proton collision.

The main implications for astrophysics:
UHE protons appear from relativistic jet bursts as a result of deconstruction of baryonium DM. Such DM is to be situated around SMBH and has great potential energy. The released energy should be spent for giving to proton an energy of order $E_p = 6*10^8$ GeV

The details of suggested **baryonium DM** have been discussed in the preprint:
O. Piskounova, 1812.02691

VHECR Conference, 3-7 October, Gran Sasso, Italy