Slowing-Down in the Radiator and Cherenkov Radiation Angular Distributions from Relativistic Heavy Ions at FAIR, SPS and LHC energies*

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As shown earlier in Ref. [1-3], at relativistic heavy ion (RHI) energies of order of 1 GeV/u the slowing-down in a radiator leads to a significant broadening of the Cherenkov ring and forming a specific diffraction-like structure of the Cherenkov radiation (ChR) angular distribution, which is different compared with standard Tamm-Frank distribution (see, in Fig. 1, top). The ChR angular distribution width becomes dependent on: the energy, charge and mass of an ion; Cherenkov photon wave length and corresponding refractive index; stopping power of radiator and its thickness. The results of calculation show that only at higher RHI energies (> 30 GeV/u) (FAIR, SPS and LHC), the ChR angular distribution (at the reasonable radiator thickness) becomes very close to the Tamm-Frank distribution and practically does not depend on the RHI slowing-down in a radiator (Fig.1, bottom), if only ionization energy loss is taken into account [4].

Our calculations are based on the theory developed in [2-3] except that RHI mean ionization energy loss (stopping power) is calculated now using the computer code ATIMA [5] valid for RHI energies < 450 GeV/u. For higher RHI energies we used Lindhard and Sorensen theory of ionization energy loss [6], valid for ultra-relativistic case. Based on our calculations, we can distinguish three different RHI energy regions:

1. The first region (~ 1 GeV/u) - may be the most interesting, here the ionization energy loss is significant and ChR emission angle essentially decreases following the decrease of velocity during RHI penetration through a radiator. A complicated diffraction-like structure of the ChR angular distribution appears, and it probably can be used for Z- and A- identification of RHI.
2. The second region (> ~5 GeV/u < ~ 100 GeV/u): ChR emission angle depends on the RHI initial velocity, therefore the angular distribution of ChR is shifted towards greater ChR emission angles (compared to region 1), but ChR emission angle almost does not change during RHI penetration through a radiator of reasonable thickness and the structure of ChR angular distribution is similar to the Tamm-Frank distribution (calculated for RHI constant velocity).
3. The third region (> ~100 GeV/u): ChR radiation angle practically does not depend on the RHI initial energy and does not change during RHI penetration through a radiator of reasonable thickness and ChR angular distribution also remains similar to the Tamm-Frank distribution.

The RHI threshold energy for each of three regions is different for different ions species and radiators.

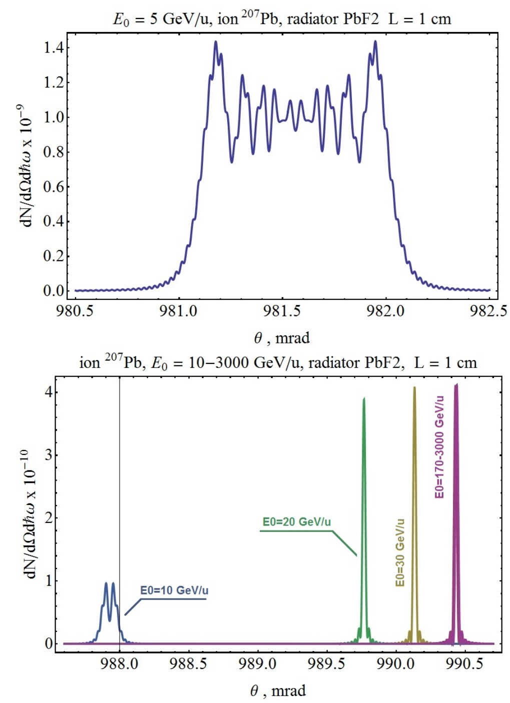

Figure 1: ChR angular distribution from 5 GeV/u (top) and 10-3000 GeV/u (bottom) ^{207}Pb beam in a PbF_2 radiator, thickness L = 1cm. The ChR photon wavelength is 0.39 nm, the corresponding refractive index = 1.82.

References

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