Exercises for Experimental methods in Astroparticle Physics

Universität Heidelberg 30. October 2019 **Hand in:** 6. November 2019

Sheet 2

1. On the Nature of Cosmic-Ray Particles

Neddermeyer and Anderson used cloud chambers in a series of experiments with great success in the beginning of the 20th century.

(a) Read up on the details of cloud chambers and describe their underlying principle. Which type of particles can be detected? How are they detected? What properties of particles can be measured? Make a sketch of a cloud chamber to support your statements.

(b) Look at Fig. 1 and Fig. 2 and comment on the charge and energy of the particles shown. Why do more tracks appear in Fig. 2 below the lead plate?

(c) Read the paper from Neddermeyer and Anderson, Phys. Rev., Vol. 51, 884 (1937) with the title "Note on the Nature of Cosmic-Ray Particles" (clickable link in electronic version). In this paper they are presenting results from experiments in a cloud chamber in the presence of a platinum plate placed inside the volume.

(d) Answer the following questions:

i. What is the goal of the experiment? What is the role of penetrating and non-penetrating particles in the experiment?

ii. What is shown in Figure 1? What is the explanation of the authors for values with $\frac{\Delta E}{E} > 0$? What checks are they carrying out to understand their measurement? How confident are the authors about the quality of their data?

iii. What is the interpretation of their findings for penetrating particles? Based on what argument do they say that the particles do not have protonic mass? What consequences do they derive from their mesaurement?

iv. What is the particle they discovered?

2. Inverse Compton Scattering

Photons emitted near neutron stars via Synchrotron radiation may have typical energies around $100\,\mathrm{keV}$. What is the minimal energy of an electron in order to shift this energy via *inverse Compton scattering* up to $\sim 10\,\mathrm{GeV}$? Write the solution as a function of the angle (θ) between the incoming electron and the gamma.

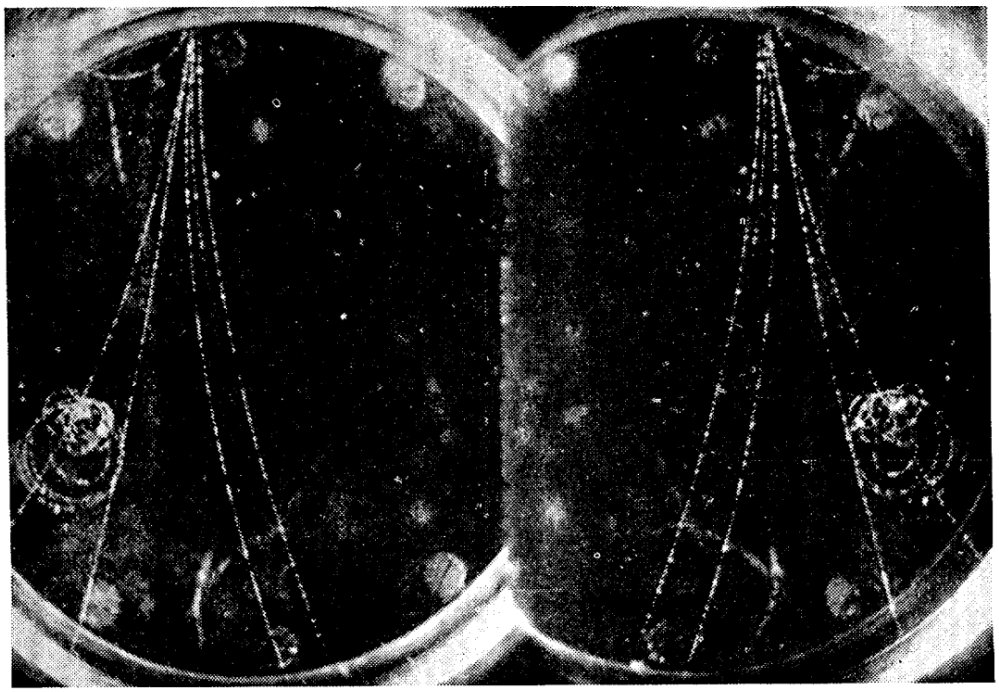

Figure 1: Example of an image taken with a cloud chamber. The magnetic field is directed into the paper. Figure taken from Anderson and Neddermeyer, Phys. Rev. Vol. 50, No. 4 (1936).

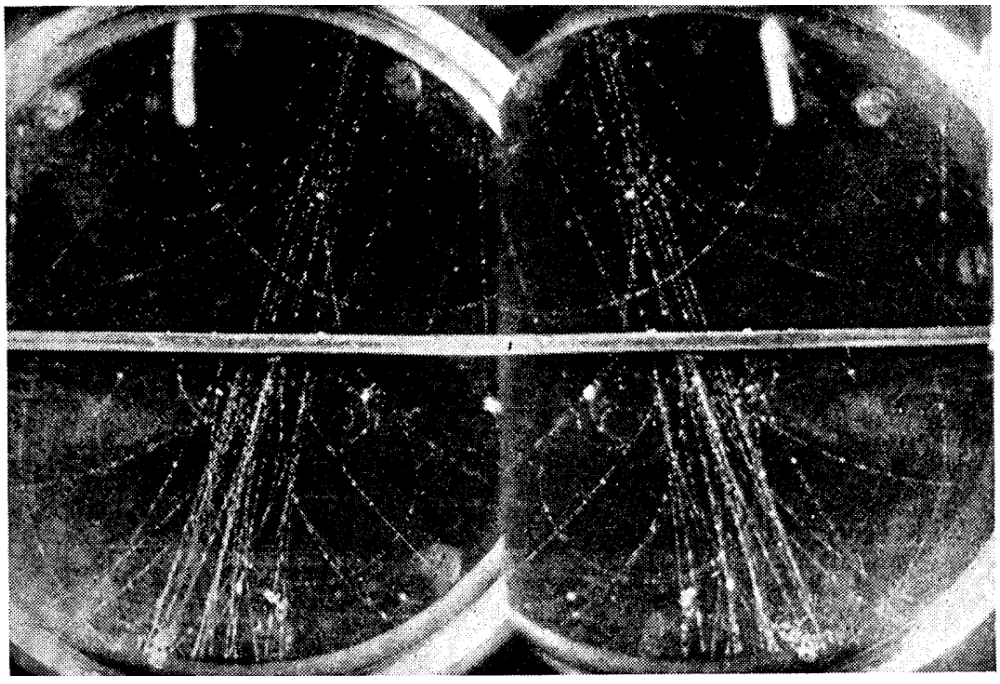

Figure 2: Example of an image taken with a cloud chamber in presence of a thin lead plate. The magnetic field is directed into the paper. Figure taken from Anderson and Neddermeyer, Phys. Rev. Vol. 50, No. 4 (1936).