1. Good afternoon, dear jury and students. My name is Kristína Tomanková and I'm currently in my 4th year at the bilingual section of the Gymnázium Ľ. Štúra in Trenčín. I'm going to present my „high school scientific work“ which is called „Elementary particles and quark-gluon plasma“.
2. We get to know elementary particles in high school already, they are the smallest pieces of matter of which we are all composed. They are often seen in the form of the Standard Model. The particles are divided into quarks, there are 6 of them, leptons, there are also 6 of them and bosons of which we know 5. Quarks are elementary particles that make up for example a proton or a neutron and bosons are particles that mediate interactions among other particles. Gluons relate to mentioned quarks as they mediate the strong interaction among them. Quarks always bind together with the strong interacion to make up particles. There is only one exception that we shall see in a moment.
3. You may ask why we even bother with the research of the smallest pieces of our world. I mean, we can't really profit out of it in real life, right? Well, the truth is different. A lot of devices could be created based only on our research of the elementary particles. We are talking about various machines used in medicine, such as the positron – emission tomografy or magnetic resonance. In today's world nanotechnologies are becoming popular as well as microchips used in phones or computers. So, without any fear we can say that our lives are getting more comfortable thanks to our knowledge of the elementary particles.
4. Now let's talk about the quark-gluon plasma that is probably a new term for a lot of high school students. This explanation is crucial for understanding the practical part of my work. It is the mentioned exeption, it is a mixture of free quarks and gluons, not binded in particles. So, to be able to create it we need an enormous amount of energy, stronger than the actual strong interaction. If we want to study its characteristics, we need to create similar conditions here on Earth, which was accomplished in the swiss laboratory CERN.
5. The practical part of my work consisted of an analysis of the CERN particle collision data from the detector ALICE. I was able to get this data thanks to my consultant, who used to study at the same high school as me and now works at ALICE. I analysed data of plumb – plumb collisions from 2010. CERN organises similar exercises for high school students all around Europe every year. They are called „Masterclasses“ and I've been able to participate twice already.
6. Here we can see a random collision, so that we can imagine the plumb – plumb collisions figuring in my analysis. In the centre we can see the point of the collision and also the particles created by the collision that are flying towards all directions.
7. However, not every collision is of the same centrality. In the picture we can see two nuclei, nucleons inside are divided into participants which participate in the collision and spectators which do not participate. Based on this we can divide the collisions into so called „centrality classes“. The lower the percentage, the higher centrality. Collisions of the highest centrality can then be thought of as almost perfectly elastic collisions.
8. My consultant proposed that I would analyse the data using the nuclear modification factor. It is a physical quantity that describes the difference between the particles that were created during nucleus – nucleus collisions and proton – proton collisions. Considering that the nucleus of plumb contains 208 nucleons and a proton is only 1 nucleon, we can't compare the yields straight away. First, we need to multiply the proton – proton yield by the $\langle N_{coll} \rangle$ factor, so that we actually can compare the yields. It is true that the nucleus of plumb contains also neutrons, not only protons, but their masses are almost the same, so we can compare simply with proton – proton collisions.

9. If the value of the nuclear modification factor is 1, we can say that nothing particularly interesting happened. On the contrary, if it is inferior to 1, a compression of the particle productivity has occured, meaning that the resulting number of particles created by the collision was smaller than expected. On the other hand, if it is superior to 1, an enhancement of the particle productivity has occured. We are going to concentrate on the compression.
10. The analysis needed to be done in the Linux operating system. Linux is more suitable for scientific research than Windows. Firstly, I had to gain access to Linux. At home I have the common Windows and at school too, so I decided to create a USB with Linux. Then I booted from it and was able to turn my computer on in Linux. My consultant then sent me the data for the analysis and he also recommended a program that would be the best for the analysis.
11. The programming part was the most difficult one for me. We have done some programming at school, in the Pascal language, but this was much more complicated. This program was in the C++ language. My consultant helped me with putting the nuclear modification factor formula to the program and I had to do some other adaptations. For example here (show in the picture) the programme took data about the particles from the TPC detector and I had to ensure that it would take information from all classes of centrality, not just these two that are written here. The result of the program was a diagram that I needed to explain.
12. And here we can see the resulting diagram. It is the nuclear modification factor in function of transverse momentum of the particles. Up here (show in the picture) we can see which colour represents which class of centrality. The program analysed about 100 000 collisions, but in the professional research, they use even billions of analysed collisions. We can see that in every class of centrality, there has occured a compression, because the nuclear modification factor is always inferior to 1. I had to find out why there has been this compression. I noticed that the more central the collision is, the more visible the compression is as well. So I asked myself what the main difference between central and less central collisions is. Well, during central collisions there are also more nucleons that collide with other nucleons, therefore the energy that is created must be much bigger than the one that is created during the less central collisions. Because of this energy, something must have been created that was responsible for the compression. So I asked myself again what it could be. What causes that the number of resulting particles is so compressed? The only solution that came to my mind was the quark-gluon plasma that literally diffuses the particles to quarks and gluons. My consultant agreed with this solution of mine which strongly motivated me to pursue the particle physics further on. I believe that if we continue the research of quark-gluon plasma, we can obtain a wide range of new information that might helps us in constructing new technologies in the future.
13. Thank you for your attention.