KGW KOPERNIKUS GYMNASIUM WALSUM

Team Kopernicium

-Research proposal -

competition: a beamline for schools

Graphene FETs in Space

School: **Kopernikus Gymnasium Duisburg-Walsum, Germany**
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A short story at the beginning

The view out of the window was the same like every day: Millions of stars, every now and then a planet and, except from that, just infinite blackness. Especially odd was the fact that there was neither day nor night – just the constant shine of the sun.

Indeed they have been on the way for four months, exactly 126 days, but no one could really get used to the cramped circumstances. Still half of their way lied ahead of them. The communication to their homes was increasingly getting exhausting. Due to the increasing distance the signal delay was unbearable by now. How should someone have a conversation if the family would answer ten minutes later? The only alternative was to write mails.

To survive such a long time with only a couple of other people, living all together on such a narrow space you need a regular daily routine. One got up, ate something (you could get used to the food), checked the systems, took a gaze out of the window and spent the rest of the time doing sports or other group activities. There was one advantage: You learned very fast how to avoid conflicts. Because how should you avoid somebody after a conflict? You had to be careful with what you said, even if it was in your mother tongue. Learning foreign languages was a popular amusement. And there was really no lack of mother-tongue speakers in the international choice of team members.

All the stresses and strains, the missing privacy, that was bearable if you kept thinking of the purpose of your mission. All of them would go down in history – in fact they already have gone down in history, even if their mission failed. But nobody wanted to think about that, because in case of an emergency there was no hope for any help or rescue. Here everyone was on one's own. In addition to that the critical point had already been reached: It wasn't possible to return anymore. The fuel wouldn't last for the distance anymore. There was only one acceptable thought: We will do it – we will reach the Mars!

One problem worried everyone: In principle they were protected from cosmic radiation but in real life it was slightly different. Especially the electronic systems were much more fragile than expected. On the one hand it was promised to the astronauts that the technology was prepared for their mission but on the other hand years ago new gears should have been attached, which should shorten the journey to the Mars significantly. None of this had happened. The human race wanted this mission – no matter what risks they had to take.

For the fact that a dozen electric circuits had failed, the electronic systems worked quiet well. But the mission was nowhere near its end.

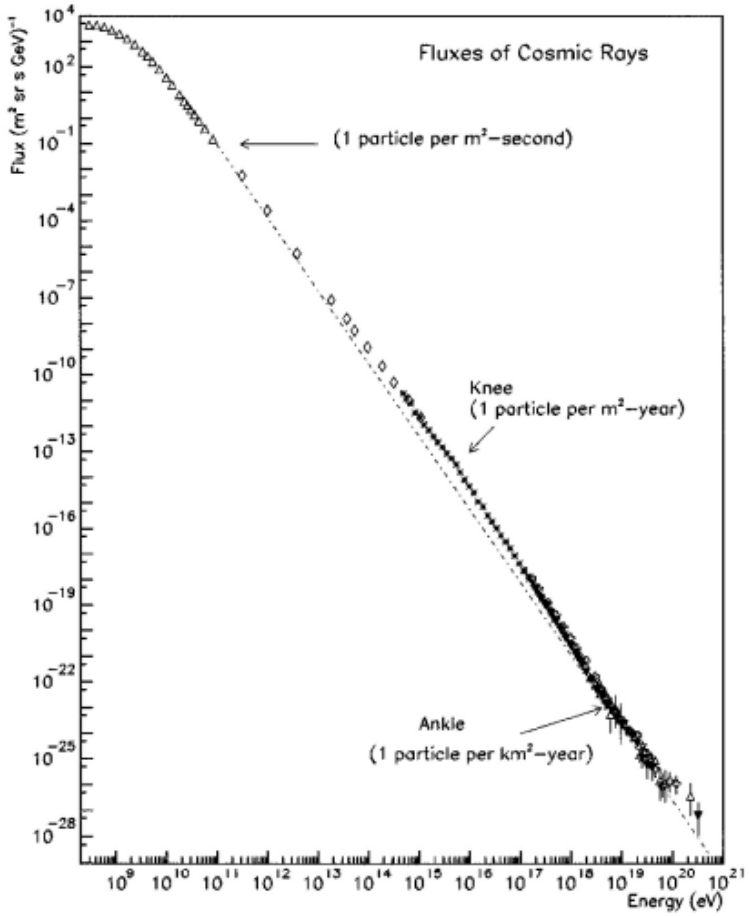
Of course there had been a lot of advanced ideas in the field of computer science but would they lead to a ground-breaking discovery? Two decades ago a group of students from a German school in Duisburg sought to find an answer to this question.

Graphene – Future material?

Within our project we would like to research how cosmic radiation affects graphene in electronic devices, e.g. transistors, and if graphene as material for electronic devices in space is a usefull and powerful alternative, e.g. during a flight to the Mars.

In cooperation with the University of Duisburg-Essen [1] we plan to build graphene field effect transistors (FETs) and measure their capabilities and efficiency over characteristic curves.
At CERN we would like to irradiate protons at the transistors, which represent the cosmic radiation as it is in outer space. We intend to do this study with varying incidence angle, fluence and flux.

We will compare the transport measurements of the graphene FETs before and after exposure to the proton beam, which allows us to make first conclusions, if the transistors were damaged and to what extent.
The particles which arise during the collision are going to be detected, to find out how the material interacts with the proton beam. During the process the type of particle as well as their energy is important to us. Therefor we would like to use the existing detectors at CERN.
Concluding we plan on analysing the damages of the transistors with an atomic force microscope at the University of Duisburg-Essen.



We would like to conduct this experiment at CERN, because the provided proton beam represents a very good simulation of the cosmic radiation. The cosmic radiation mainly consists of protons (up to 98 percent)[2], whose energy ranges from hundred to one thousand megaelectronvolts (10^8 to 10^{10} electronvolts, cf. fig.1), which is almost exactly in the range offered.

Figure 1: Frequency of the particles of the cosmic radiation (particle per surface) referring to the energy[3]

In a few words

Object of research	**:**	graphene FETs
Working schedule	**:**	Irradiation of the transistors with protons as simulation of the cosmic radiation, analysis of the transport measurements/ interdependency at CERN, analysis with atomic force microscope at the University Duisburg-Essen
Aim	**:**	Evaluation of the efficiency of grapheme FETs in spacetechnology; statements about life expectancy, interdependency etc.
Our motivation	**:**	Cosmonautics is a fascinating and current field of research with unsolved problems, like the protection of electronic devices from cosmic radiation. To conduct such a research project at CERN and to take part in the research in that field is very interesting for us.

Sources:

[1] O. Ochedowski et al., Radiation hardness of graphene and MoS 2 field effect devices against swift heavy ion irradiation, 2013, http://dx.doi.org/10.1063/1.4808460

[2] http://www.pit.physik.unituebingen.de/studium/Astroteilchenseminar/ws0203/SonjaFritz.pdf
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[3] http://www.pit.physik.uni-tuebingen.de/studium/Astroteilchenseminar/ws0203/SonjaFritz.pdf
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