HiSPARC

A Learning Journal

J.J. Velthuis

Introduction

HiSPARC is a very successful outreach project for high school students to participate in real research on cosmic rays. In Holland there are about 100 schools participating and many more on the waiting list. The programme has been rolled out in other countries as well. Our plan is to roll out HiSPARC initially in the wider Bristol area and make use of the existing infrastructure and know-how of our Dutch colleagues.

HiSPARC is a serious international scientific collaboration doing real cosmic ray research. For example, the collaboration investigates potential sources of high energy cosmic rays, the rate of the cosmic rays, the energy distribution, long and short range correlations between cosmic rays, weather effects, etc. The aim is to produce real scientific papers. A key aspect of HiSPARC is that the actual research is done by the students themselves. The scientists only facilitate the research and answer questions but do not do any of the data analysis. This makes HiSPARC a good example of 'citizen science'. This is important as the students learn about physics/maths/statistics etc and how exciting it can be by undertaking the research. If the scientists would take an active role, students would miss out on this fascinating experience.

When schools join HiSPARC they receive a detector system to measure cosmic rays. The detector system is delivered as a DIY package. The students build the detectors themselves. After installation they are made responsible to monitor the data and the performance of their system. As members of

the collaboration they get access to all data of the entire network and all the analysis tools that have been developed.

To do the physics research the students first need to understand the physics. There is no proper lesson plan available for HiSPARC. This is intentional. There are lots of lesson letters developed that the students can access through a web page. The level of the lesson letters spans from material understandable for fourteen year olds to A-level students. The idea is to stimulate the students to do the research, this will generate questions and then let them search for the answers themselves. This is a different learning method than the normal classical model where a teacher lectures a large group of students. It has been found that because of different learning method, the project appeals to different students. In particular girls; the fraction of girls participating in HiSPARC is significantly higher than the fraction in class.

The key aim of HiSPARC is to enthuse students for STEM subjects by letting them do real science. This will benefit the students themselves, the HE institutes and society in general.

HiSPARC has been very successful. Personally, I think that there are several factors that contribute. In no particular order:

- The novel learning method. The learning method is different than the students are used to. That means that the project also appeals to students who normally would not be so interested in STEM education. The students develop questions for which there is sometimes no answer. If there is an answer they need to find it out more or less for themselves. Obviously, there is support available but still.

- The chance to do real science. This appeals to the students involved at that moment. They have the chance to find out things that no other person every knew. They can publish the results and give talks on the HiSPARC conference. But also as progress is made, there will be new questions every year. This is a major difference with many other projects. Usually the project is the same every year. That also means that the answers are already available.

- The schools are contributing financially. HiSPARC is not free. This is a conscious decision and not only because the detectors are expensive. If schools are given equipment for free, they will not maintain the

equipment properly in the long run. Now the need to find some funding and are therefore also more motivated to maintain the systems. It also eliminates schools where there is not a lot of support for the project.

- Working in a large international collaboration. This also opens possibilities to make contact with students abroad which can enhance interest in language modules as well.
- The close contact with the university. Students find it exciting to speak to scientists and ask questions to which the scientists do not know the answer.
- The detector and data acquisition software structure are very well designed. In principle the only action required after installation is the odd computer reset every couple of months.
- Long term contracts. The schools and HiSPARC sign very long term contracts. This also forces the schools to have a long term plan.
- The topics involved and width of the project. HiSPARC contains particle physics, relativity, quantum mechanics & astrophysics. In addition, there are (electrical) engineering, computing, statistics and mathematical aspects to the project. These aspects are usually not offered in depth at A-level, but they are the topics that students will read about most besides their school material. So they are quite keen to learn about those topics.

Engaging schools

It turned out to be very easy to engage schools in HiSPARC. As HiSPARC is already running for 10 years, a lot of thought has gone into developing a good working model for the organisation. So we inherited the global structure. We needed to design the local structure based on the global one. To do this we made an inventory of what was different between the UK and the Netherlands by talking to some physics teachers, which was mainly the financial situation of the schools.

To launch the project properly, we first installed a detector system ourselves so that we could demonstrate what we wanted schools to do and to gain experience in building the detectors ourselves. In the end, school pupils will need to build their own detectors as they are delivered as DIY packages. There is support available for this but we needed to gain the experience first

ourselves.

Next, we used the Particle Physics master class[1] to talk to teachers and students (there were 10 schools and 200 students attending the master class) about what they thought of the project and what a realistic time frame for implementation would be. We also discussed what a reasonable contribution from a school might be. We felt it important to charge schools as we thought that if they got the material for free, nobody would care. Even a modest contribution forces the school to actively participate as they need to defend their spending. It was really helpful to engage first with a large group of teachers before launching the project. This way we could get feedback before setting out the rules of the project. Things we adapted from our original plans after speaking to the teachers were for example: the time and date of our launch event, the contribution we asked from schools and the different type of memberships. The teachers also gave great feedback about the strengths of the project; this is not only about the physics but also about working in an international collaboration and thus opening the possibility of student exchange etc. It also gave us an idea how enthusiastic the teachers were about the project. As more than 90% said that they would join if they had the opportunity, we realized that HiSPARC could be a success. We also invited the IOP to come to the launch event as we found out that many schools are unaware of funding possibilities.

Meanwhile we engaged a Dutch trainee teacher with a lot of experience in the project to translate and adapt the already available material for the UK school system. The Dutch material can be found here: http://www.hisparc.nl/docent-student/lesmateriaal/routenet-lesbrieven/. It contains lesson letters and some short booklets on the physics. Especially worthwhile is the routenet. This is a large collection of lesion letters that students can study completely independently. On the web page it is clear which topics are linked, so that a student who does not understand for example the relativity module, automatically finds the Lorentz transform section. The trainee teacher has also tested his translated materials during classes at local schools.

Then we organized a launch event where we invited a lot of schools from the area and explained our plans. We wrote to approximately 50 schools in and around Bristol explaining briefly the project and inviting them to come

[1]The Particle Physics master class is a yearly event run by the UoB where we invite pupils to come to the university for a day to learn about particle physics. We organise a series of lectures and activities including some hands on event analysis.

for the evening. This was followed up by an email invitation and reminder. The launch event was well attended. There were about 15 schools represented and another 7 could not make that evening but made appointments for later visits.

During the evening we explained the project, the contracts, the funding, the teaching materials and the availability of the trainee teacher. We invited the IoP representative to talk about associated funding opportunities and somebody of the university legal team to discuss the contracts.

We have set up three memberships options:

- Gold. Buy your own detector system (£ 5,000)
- Silver. Rent your system for £ 300 p.a.
- Bronze. No detector for £ 200 p.a.

Everyone who signs up for a Silver or Bronze membership is obliged by the contract to try to generate funding and upgrade to Gold. This means that we need to find funding to buy the systems we will rent out, but those systems do generate some funding. This will pay for additional systems and our running costs for our annual conference and to send students to the big HiSPARC meeting in the Netherlands. The schools sign up for a long term commitment. This is achieved by charging a delivery and a pick up fee. That makes it undesirable to leave the project.

There are about 10 schools that are currently in an advanced stage of joining. We are also in discussions with At-Bristol to place a detector system and an online event display in their exhibit. This would raise the profile of the project and yield more data. Before launching the project, we held many internal discussions to ensure that we would have enough support for the project from the particle and astrophysics groups.

Top tips

As HiSPARC Bristol is still in its set up phase, it is a bit premature to give top tips. But here is a list of tips/decisions that we think helped making it a success.

- We used a proven, successful project/collaboration structure.

- HiSPARC is real science and therefore the material is new every year. This is important to keep students involved.
- We spoke at length to physics teachers to discuss our ideas. Then we used the master class to speak to a large group of teachers.
- We organised the information/launch evening in a quite professional manner, *i.e.* we had a university contracts expert to explain the contracts and the local IoP representative to explain funding possibilities.
- We translated a lot of the teaching materials before approaching the schools.
- We stay in touch with all teachers that have expressed an interest.
- We charge schools to participate. The cost-level is really important to get right. The cost need to be so high that schools who do not have the appropriate support do not join. It also needs to be so high that schools will feel obliged to maintain the systems. On the other hand it needs to be low enough so that every school could join if they wanted to.
- We introduced different levels of membership, but with the obligation to upgrade when possible. This was done as it is unrealistic to charge the actual detector cost (£ 5,000) in one go.
- We had a large system operating for a couple of months before the schools came to visit.

Obviously, in addition HiSPARC is a well-established, long running, successful project. That also made it an easy "sale".

Conclusion

HiSPARC is a very successful outreach project where students really do interesting research in an international scientific collaboration. As such it is a nice example of successful 'citizen science'. I feel that we as Bristol physics have the obligation to participate in such an interesting outreach project. Since the project involves real science, it remains interesting; not only for the students but also for the involved academics. We are trying to roll it out in the larger Bristol area and so far that has been a success. We have 10 schools that are in a very advanced stage of signing up (either contracts have been signed or requested). We are currently focussing on attracting funding to finance the systems for the schools that want to join.