# Biennial African School of Fundamental Physics and its Applications 2012 Report

B. S. Acharya[1], K. A. Assamagan*[2], C. Darve[3], J. Ellis[4], S. Muanza[5], R. Tabrizi[6], J. Yu[7]

[1] *ICTP, Trieste, Italy and King's College, London, UK*
[2] *BNL, Upton, NY USA and the University of Johannesburg, SA*
[3] *ESS, Lund, Sweden*
[4] *King's College, London, UK*
[5] *CNRS-IN2P3, CPPM, Marseilles, France*
[6] *Simon Fraser University, Vancouver, Canada*
[7] *University of Texas Arlington, USA*

November 29, 2012

**Abstract**

The second African School of Fundamental Physics and its Applications was held in Kumasi, Ghana on July 15 – August 8, 2012. The organisation of the school and the feedback from the students are presented.

*Corresponding author: ketevi@bnl.gov

# Contents

# 1 Introduction

The second edition of the biennial school of fundamental physics and its applications, ASP2012, took place at the Kwame Nkrumah University of Science and Technology (KNUST) in Kumasi Ghana [1], from July 15 to August 8, 2012 [2]. The school was based on a close interplay between theoretical, experimental, and applied physics. It covered a wide range of topics: particle physics, particle detectors, astro-particle physics and cosmology, computing, accelerator technologies, medical physics, light sources and their applications. The participating students were selected from all over Africa and beyond. A selection of lecture topics in theory, experimental and applied physics was proposed for the school. Scientists from Africa, Europe and the USA were invited to prepare and deliver lectures according to the proposed topics taking into account the diverse levels of the students. The duration of the school allowed for networking — interactions among students and between students and lecturers. The school was funded by institutes in Africa, Europe and the USA.

The first edition of the school, ASP2010, took place in Stellenbosch, South Africa, on August 1-21, 2010 [3].

By all accounts, ASP2012 was a very successful school as can be seen from the report presented herein. Such a success results from many factors, namely the dedication of the organising committee (local and international), the careful preparation of the school, the logistical support offered by the host country, the motivation of the students and the lecturers, the atmosphere of networking which continues after the school, providing students with valuable contacts and advice for higher education. Arguably, it is the connection between theory, experiment and practical applications that the organisers of the school believed to be important for a solid education in Africa. Over-focusing on one of the three aspects — theory, experiment, applications — at the expense of the others cannot prepare the students to be flexible and adaptable in an increasingly global and highly competitive international level. Specialisation would still be necessary at some stage in the student's education, but only after a solid foundation in theory, experiment and applications, after which the students can better match their areas of expertise with personal aspirations, to a narrower future research career. Networking was important in the basic education proposed at the ASP2012, to allow the students to seek and acquire information before deciding on their higher education and career paths. It is pretentious to suggest that the ASP2012 would instill all these necessary skills to the students. Indeed, ASP2012 is complementary to the basic education of the students, it expands the networking base of the students, allowing for the creation of valuable contacts across Africa and beyond. Furthermore, it is hoped that by organising this school every two years, with the next one in 2014, the basic objective of the school, i.e., increased and competitive higher education in fundamental physics in Africa, will be better realised.

The motivation to carry out such a school in Africa is presented in Section 2. The organisation of the school is discussed in Section 3, this includes a careful selection of the venue, of the curriculum, the financial support for the school and the selection of the students. In Section 4, we discuss the school itself, i.e., the activities during the period July 15–August 8, 2012 when the school took place in Kumasi: The logistical support offered by the host country and how this contributed to the success of the school, the lecture material that was presented to the students, and finally the discussion and practical sessions that were organised to reinforce the understanding of the lectures and to promote networking. In Section 6, we present the activities after the school, which included balancing the budget, the obtaining of feedback from and maintaining contacts with the students. In Section 7, we discuss the prospects of organising the school again in 2014. And finally, some concluding remarks are offered in Section 8.

## 2 Motivation

The aim of the school is to contribute to capacity building in Africa by harvesting, interpreting, and exploiting the results of current and future physics experiments with particle accelerators, and increasing proficiency in related applications and technologies. As an example, we discuss the opportunities offered by the Large Hadron Collider (LHC) [4] and its experiments, although the basic objective is to help improve the quality of higher education in Africa, to help increase the number of African students acquiring higher education. We believe that the knowledge students gain will benefit them in whichever careers they may pursue. Many students trained in fundamental physics go into industry, become educators or go into basic research.

Large experiments at the LHC and the Tevatron [5] have drawn on the involvement of research institutes and universities from around the world. Some of the salient LHC experiments include ATLAS, CMS, ALICE and LHCb [6, 7, 8, 9]. ATLAS and CMS are general purpose experiments (for precision tests of the Standard Model of elementary particles and the search for new physics beyond the Standard Model) whereas ALICE and LHCb are dedicated experiments to study the early universe and the matter–antimatter asymmetry in the universe. These are very complex and intricate detectors whose design and operation necessitate the collaboration of many physicists and engineers from around the world. The ATLAS collaboration for example consists of upwards of 3000 physicists spread across different countries and time zones. The LHC itself is the highest energy accelerator ever built; it has a circumference of 27 km and accelerates and collides protons and heavy ions. These collisions are expected to re-create some of the conditions that existed in the early universe or to create elementary particles whose existence would enhance our understanding of the dynamics between matter and forces in the universe. Indeed some of the questions that could be answered at the LHC by ATLAS, CMS, ALICE and LHCb experiments include the nature of Dark Matter, the electroweak symmetry breaking and the generation of mass for elementary particles, the origin of matter–antimatter asymmetry in the universe, the state of the quark-gluon plasma. We therefore have a cutting edge accelerator equipped with very complex detectors built with a variety of detection techniques. The operation of these detectors requires efficient triggering system to sift through the very high rate of the LHC collisions and identify the interesting events whose detailed analysis could shed some light on the aforementioned fundamental questions of particle physics, astro-particle physics and cosmology. The complete system of the LHC and its detectors, together with efficient triggering mechanisms to select interesting events, is complemented by a network of data sharing based on the Grid. Indeed, within less than a few days of recording the data at CERN, these are distributed through the Grid to many centres around the world, allowing different research groups to partake in the analyses without explicit presence at CERN.

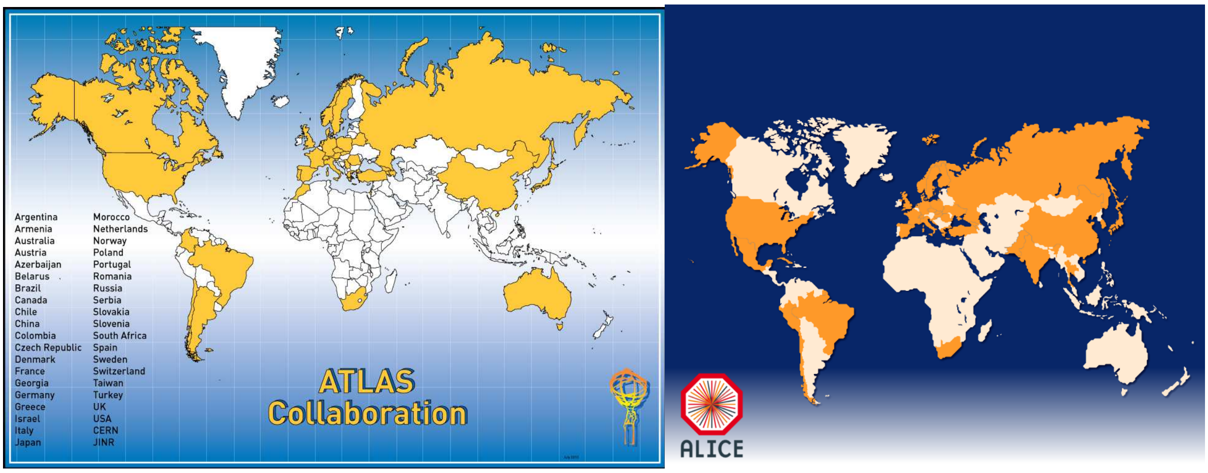


Figure 1: The distribution of participating countries in the ATLAS (left) and ALICE (right) projects. From Africa, only Morocco and South Africa are involved in ATLAS. South Africa and Egypt the only African countries in ALICE.

These LHC projects are world wide efforts and the African participation and contributions can still be increased. For example, the only African countries in the ATLAS project are Morocco and South Africa as shown in Fig. 1 (left). Only South Africa and Egypt are in the ALICE project with three institutes, namely the University of Cape Town, iThemba LABS, and the Academy of Scientific Research and Technology Cairo, see Fig. 1 (right). Egypt and Tunisia are the only African countries in the CMS experiment. Figure 2 shows the distribution of CERN users from various countries where it is evident that the participation of African scientists is not significant. These LHC projects offer significant capacity building for the countries involved. For example, on the ATLAS experiment alone, there are about 1000 Ph.D. students, similarly for the CMS experiment. Furthermore, undergraduate students participate in summer student programs at CERN where they are offered the opportunity to work with experimentalists and theorists on various projects. The fraction of Ph.D. students from Africa on these experiments or the fraction of undergraduate students from Africa participating in the

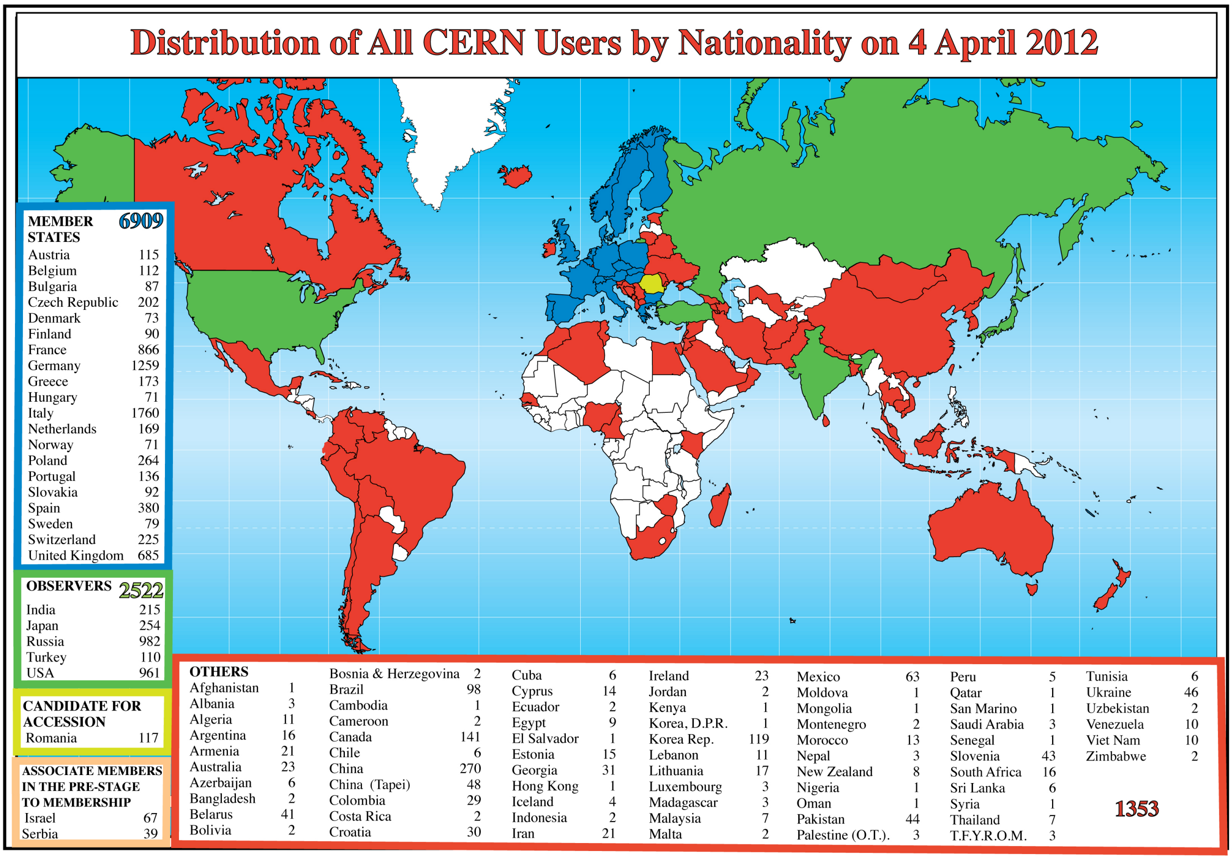


Figure 2: A distribution of CERN users per country. The fraction of CERN users from African countries is about 0.5%.

summer student programs at CERN is nearly negligible.

We have taken the example of projects at the LHC to motivate the needs to increase capacity building in basic science in Africa. The situation presented above is not limited to projects at CERN but reflects the general trend in major research facilities around the world.

The primary motivation for the school is to increase the knowledge and improve the capacity building of African students. We expect to achieve this through an outreach effort, an increased awareness of the potential of high quality training offered within the LHC context in various disciplines not just particle physics, and a system of networking. ASP2010 and ASP2012 are a positive step towards the broader objectives of the school. We hope to continue with another school in 2014, ASP2014, and in doing so, help increase the global presence of African students and scientists.

# 3 Organisation of the School

In this section, we discuss the organisation of ASP2012, i.e., all the preparatory activities necessary to ensure the success of the school. The preparation for the first biennial African school of fundamental physics and its applications, took some time, from its conception to realisation. Late in 2008, there was a firm commitment from Centre National de la Recherche Scientifique (CNRS)/IN2P3 in France to support and fund this project. This was the encouragement needed to seek the additional financial support required to cover the total budget for the school, as discussed in Section 3.3. The first milestone was achieved with a proposal for a school in Africa submitted to the ICTP [10] in February 2009. It was the beginning of concerted efforts on ASP2010.

The success of ASP2010 was encouraging and provided motivation to work harder towards the original objectives to organise the school every two years, and in doing so, truly contribute in a significant way to development in Africa. The international organising committee (IOC) proposed a similar school in 2012, ASP2012, but in a different African country. The committee had explored this option, and of the various host countries proposed, Ghana was selected to host ASP2012.

## 3.1 Selection of the Venue

The selection of the host country was very important because the support offered by the host country has a large impact on the success of the school. Since ASP2012 was primarily targeted towards African countries below the Sahara, the host country was considered from that region. A few options were explored in West Africa, Central Africa and Southern Africa. After several considerations, Ghana was finally selected as the host for ASP2012. Some of the considerations that went into this decision include: the logistical infrastructure that is required for the school, and the ability of the host country to provide such a support; the ability to put together a local organising committee dedicated to the objective and the success of ASP2012, and directly involved in the preparation of the school; the prior experience — that may have been accumulated in the host country — from previous schools held in the country in question; the existence of physics teaching capacity in local universities up to at least the Bachelor degree; the existence of some local research/teaching in fundamental physics.

After identifying Ghana as the host for ASP2012, the venue of the school within Ghana was then discussed. A few viable options were explored, taking into account the timing of the school and some of the considerations mentioned above. The IOC made a visit to Ghana in May–June 2011 to meet the local organising committee, to inspect the various options for the venue and to see the infrastructure that would be available for lectures, discussions and practical sessions during the running of the school. In Section 4.1, we discuss how the logistical support contributed to the success of the school.

In the process of studying the various options for the venue, the IOC learnt that CERN and KNUST had signed an expression of interest for facilitating the establishment of cooperation between CERN and Ghana. KNUST, the Information Technology Department of CERN (IT), the Collaboration conducting the ATLAS experiment at the CERN LHC accelerator and the CERN Scientific Information Service expressed their joint interest in enabling students from KNUST to participate in research in information technology and experimental particle physics, and to further the development and exchange of digital resources for scientific purposes. This ultimately will allow to provide the training of a qualified personnel to operate and maintain a Grid computing node in Ghana. This facilitated the choice of the KNUST as the host of ASP2012.

## 3.2 Courses

Four main topics formed the backbone of the school: Theoretical Fundamental Physics, Experimental Subatomic Physics, Information Technology and Grid computing, and Accelerators and Applied Technologies, for a total duration of three and a half weeks.

Each topic is further divided into an initial set of recaps of essential background knowledge, followed by the main lecture themes, and finally a dedicated theme on computing-related aspects of the topic, including Monte Carlo generators, Grid computing, and high-performance computing. The latter was structured partly into hands-on practical sessions and concentrated into the last three days of the school, the AfricaGrid School. There were also discussion groups that provided opportunities for discussing questions arising from the lecture materials. These discussion sessions provided a framework for mentoring students from different backgrounds. Finally, special[1] lectures were organised during the school, to highlight the edge of current research and topics of special interest to the host region. These were more pedagogical in nature,

[1]These were motivational speeches.

and were open to a wider audience, e.g., from the host institution and its surroundings. There was one such talk for each of the main scientific themes.

### 3.3 Financial Support

The school was sponsored by an unprecedented large number of international institutes and organisations in Africa, Europe and the USA as shown in Figure 3.

Figure 3: The institutes that financially supported ASP2012.

We managed to collect a total budget of €131,465 as shown in Table 1 in the school team account at CERN. This centralised the financial management of the expenses.

Travel and accommodation expenses of most lecturers were covered by their home institutes. Travel expenses for a few lecturers were covered from ASP2012 funds. The travel and accommodation support from the home institutes of lecturer was crucial for ASP2012 and represents significant fraction of the total travel budget for the lecturers.

Further details on the usage of the funds, in particular for the students, can be found in Section 6.1.

### 3.4 Student Selection

A total of 50 students participated in ASP2012. Among them, 49 students were selected from 14 different African countries and their transportation, accommodation and meals fully covered; one student was selected from Iran and also had his transportation, accommodation and meals fully funded. Of the 49 African students, 11 were already living in Ghana and most of them were studying at KNUST. Figure 4 shows the distribution of the students, where 22% of the students were female. The students were selected from more than 132 eligible applicants.

## 4 ASP 2012

In this section, we report on the school itself, i.e., the running of the school during the period of July 15 to August 8, 2012. A few photographs taken at the school are shown in the Appendix.

Table 1: Summary of the ASP2012 budget. In addition to the contributions mentioned in this table, the following institutes covered travel and/or accommodation costs for their lecturers: BNL, INFN, ESS, PSI, Université Catholique de Louvain (Belgium) and University of Uppsala paid for travel and accommodation costs for six lecturers (one from each institute); CERN paid travel costs for six lecturers; CNRS-IN2P3 paid travel costs for two lecturers. The South Africa-CERN programme paid for travel costs for two lecturers. The University of Texas Arlington, the University of Oklahoma, the Louisiana Tech University and NSF provided travel support for seven lecturers of the AfricaGrid part of ASP2012.

| **Incomes (€)** | |
|---|---|
| *European Contribution* | *91,589* |
| Int. Center for Theoretical Physics (ICTP) - Italy | 28,500 |
| INFN, Italy | 15,000 |
| CERN (10,000 CHF) - Switzerland | 11,765 |
| DESY - Germany | 5,000 |
| French Embassy in Ghana | 5,000 |
| University of Uppsala, Sweden CHF 6000 | 4,959 |
| University of Uppsala International Science Program, Sweden 40 kSEK | 4,513 |
| ARDENT | 4,000 |
| DITANET | 4,000 |
| Paul Scherrer Institute (PSI), Switzerland CHF 4000 | 3,306 |
| EPFL - Switzerland CHF 4000 | 3,306 |
| Private Donation - Mats Lindroos (ESS) CHF 1,500 | 1,240 |
| CEA-IRFU | 1,000 |
| *American Contribution - USA* | *28,159* |
| Jefferson Lab and Jefferson Science Associate $10,000 | 7,692 |
| Fermi National Accelerator Laboratory $10,000 | 7,692 |
| National Science Foundation (NSF) $8,000 | 6,154 |
| Brookhaven Nat. Lab. (BNL) $5,000 | 3,846 |
| American Physics Society $3,500 | 2,775 |
| *South African Contribution* | *6,982* |
| Nat. Inst. for Theoretical Physics (NITheP), Stellenbosch R50,000 | 4,674 |
| AIMS-Next Einstein Initiative $3,000 | 2,308 |
| Total Income 126,730 | |
| **Expenses (€)** | |
| *School Running Costs* | *70,698* |
| Students Catering and Accommodation | 49,327 |
| Students Local Transportation | 6,140 |
| Students Visa on Arrival | 2,145 |
| Generator and Fuel | 6,087 |
| Lecturers Accommodation | 6,999 |
| *Travel Costs* | *52,683* |
| for Students | 42,590 |
| for Lecturers | 10,093 |
| *Social Events* | *4,596* |
| Excursion | 2,550 |
| School Banquet | 2,046 |
| *Other Expenditures and Overheads* | *1,200* |
| Total Expenses 129,177 | |
| *Deficit* | *-2447* |

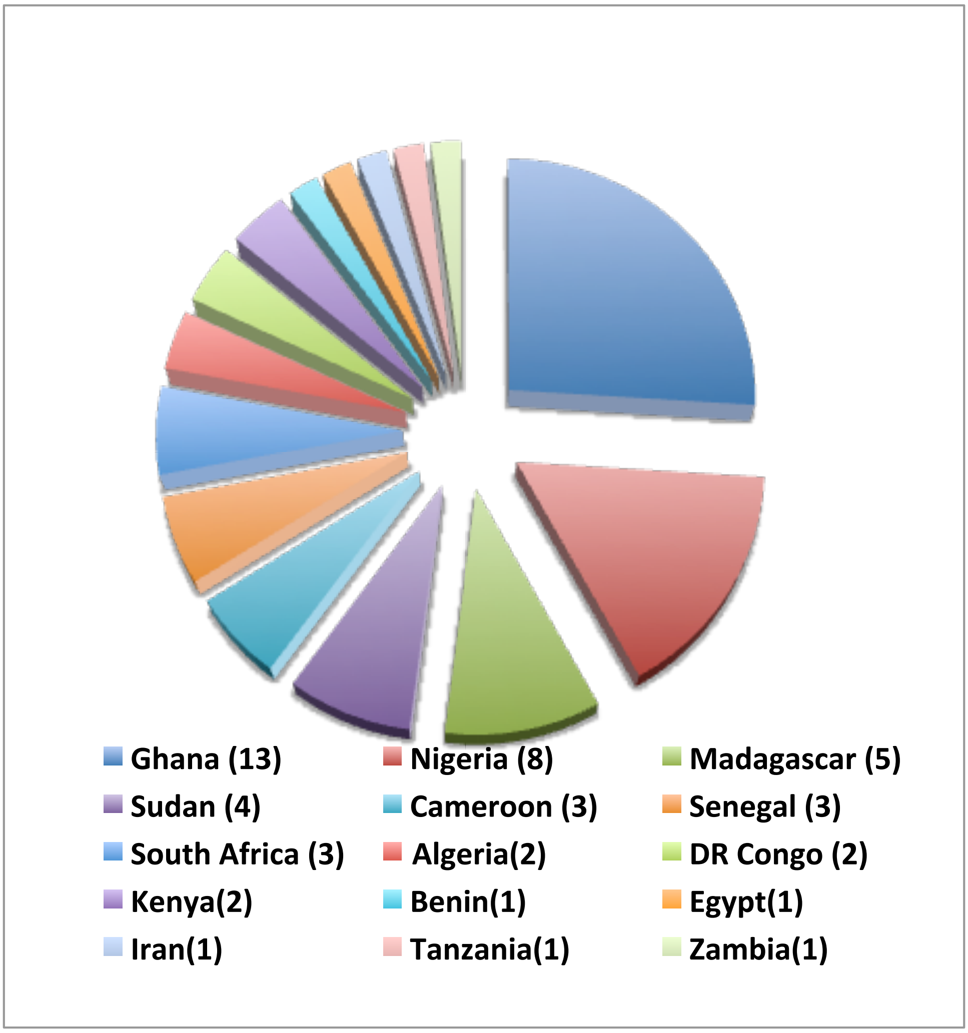


Figure 4: The distribution of the selected ASP2012 students by country of citizenship.

### 4.1 Logistical Support

The support provided by the host country in terms of infrastructure is essential to the success of the school. The logistical support offered by the host country is one of the criteria in the selection of the venue as explained in Section 3.1. In this section, we provide some feedback on the logistical support for ASP2012. The ASP2012 was hosted by the KNUST [1] in Kumasi, Ghana. The lecture hall could accommodate all the students, lecturers and organising committee members for plenary sessions, an atmosphere that encouraged questions from the students and invited discussions. The facility also offered different halls and rooms for coffee breaks, lunch and breakout sessions for small group topical discussions. The lectures that required hands-on computing (Grid computing and GEANT4 [11] exercises) were carried out in the same lecture hall equipped with PCs.

The students were hosted at a common student residence at KNUST within walking distance of the lecture hall. Hosting the students at the same guest house increased interactions and networking among the students themselves.

One of the university guest houses and a hotel outside the university were proposed for the lecturers. The guest house was within walking distance of the lecture hall but a shuttle service (covered from ASP2012 funds) was available between the lecture hall and the guest house or the hotel. Interactions between lecturers were useful to fine-tune and adapt the materials presented to the students. It also allowed valuable interaction between international and African lecturers.

The logistical support offered to the ASP2012 created a friendly atmosphere during the school. It allowed the students to interact with the lecturers and with the other students. It also made the presentation of the course material and the discussion sessions easy and hassle free. Furthermore, the necessary equipment for the practical sessions in computing were available and worked very well.

Broad bandwidth Internet connectivity made video conferencing and live web-cast connections to the outside research community possible, and this was exploited during interactive connections to the ATLAS Control Room [6].

A professional filming team was available during the ASP2012. A total of one week of filming was recorded [12].

The logistical support contributed significantly to the success of ASP2012.

### 4.2 Lectures

The details of the lectures, discussion and practical sessions are documented on the ASP2012 website [2, 13] and followed the main topics as outlined in Section 3.2. The theoretical physics (TH) theme was concentrated in the first week of the school. The Experimental Subatomic Physics (EP) theme dealt with what we know about subatomic physics including experimental results and methods. It formed the core of the lecturers in the second week. The scope of the third week's courses was for the students to learn the basics of particle accelerator technology and applied physics (AT). The scientific disciplines of medical physics, material and biochemical based research using synchrotron radiation were discussed.

### 4.2.1 Theoretical Physics

The theoretical physics theme was concentrated in the first week of the school. The focus was on theoretical nuclear and particle physics, with the emphasis on particle physics, and the main purpose was to describe the Standard Model of particle physics, including its foundations in quantum field theory. Additional main topics included physics beyond the Standard Model, the interplay with astro-particle physics and cosmology, particle physics phenomenology, and computer physics.

### 4.2.2 Experimental Physics

The Experimental Subatomic Physics theme dealt with what we know about subatomic physics including experiments results and methods. It formed the core of the lecturers in the second week. A significant part of it focused on reviews of the existing body of experimental knowledge, including particle physics, heavy-ion physics, and nuclear physics. The participants were also given a thorough review of the extremely versatile range of modern particle detectors, such as those employed by the LHC experiments. Further, a course on data analysis and statistical treatments gave participants an introduction to how raw data is transformed into final measurements, including calibrations, backgrounds and uncertainty estimations.

### 4.2.3 Accelerators, Technologies and Applications

The scope of the third week's courses was for the students to learn the basics of particle accelerator technology and applied physics. The scientific disciplines of medical physics, material and biochemical based research using synchrotron radiation were discussed. The first section of the third week was dedicated to understanding the beam physics behind the design of a particle accelerator. The second section of the third week was dedicated to accelerator based medical physics. Following this, a series of lectures on the applications of synchrotron light was presented.

### 4.2.4 Information Technology and Grid Computing

The Information Technology (IT) theme mainly dealt with practical sessions on Grid computing. The lectures on Grid computing were concentrated in the last three days of the school, August 6–8, 2012 in the AfricaGrid part of the school. Given the LHC experiments efforts in harnessing computing powers into a world-wide computing grid, the school of computing grid we offered was a perfect match for the fundamental idea of ASP. The grid computing portion focused on hands-on exercises which were preceded by a lecture that provide fundamental ideas and the tools. In preparation of the school, about 50 Linux computers have been set up at KNUST. These computers were setup for grid computing environment ahead of the school. Some of the instructors arrived at KNUST a day early to confirm and verify the setup. Various TWiki pages were prepared beforehand to facilitate students learning process. The school had three focal areas of the computing grid technology: high throughput computing with Condor, workload management, glide-in and security system, distributed remote storage system and the use of computing grid technology in physics analysis. Students appreciated the in-depth grid computing lessons. Over 97% of the students wanted the computing grid school to be offered as a regular program in future ASP.

Theoretical and experimental topics were included in practical sessions on doing event generation (using PYTHIA [14]) and Monte Carlo simulation (using GEANT-4 [11]) on the Grid. Introduction to the data analysis framework ROOT [15] and practical sessions on data analysis on the Grid, using ROOT, were covered.

## 4.3 Discussion Sessions

Some of the academic lectures were organised as discussion sessions. The students were divided into two small groups of French and English speaking students. The topics of the discussions and relevant reading materials were distributed to the students well in advance. These discussion sessions were guided and moderated by one or two lecturers. The topics that were not sufficiently addressed during the discussion sessions were assigned to some of the students to be researched further, and the students reported their findings during subsequent discussion sessions. Some of the lecturers spoke both English and French and this was very useful to the French speaking group of students, and it increased their levels of participations in the discussions.

These sessions not only provided the necessary time to discuss and thus crystallise the content of the academic lectures, but it also allowed to create a spirit of dialogue between students and teachers that in turn made the lectures lively. Knowing better the needs of the students was of course a very important input for the teachers to understand how to best focus their lectures.

These sessions were extremely profitable for both students and teachers and have contributed to the success of the school.

## 4.4 Practical Sessions

To compliment the lectures, practical exercises and tutorials were organised, on event generation using PYTHIA [14], on detailed GEANT-4 [11] simulation, on data acquisition and on data analysis in ROOT [15], to give the students "hands-on" scientific training. During these practical sessions, the students became acquainted with the use of GEANT-4 as a package for

Monte Carlo simulations not only in nuclear and particle physics but also in related application such as medical physics, the use of ROOT as a data analysis took kit, and the use of the Grid for high performance computing.

These sessions have been highly appreciated by the students mostly because of the very high level of preparation of these classes. A tremendous effort was made by the lecturers to prepare well suited and captivating exercises. Many students have requested possible extensions of these practical examples and the methods to install all the necessary software on their personal computers. As was the case for the academic lectures, the students were very lively and enthusiast in participating in these practical sessions.

The hands-on experience has been invaluable in helping the students to relate the very large amounts of concepts they have been taught in the academic lectures to more tangible facts. It also gave an opportunity to students to discuss and interact more among themselves.

The practical sessions were therefore an essential ingredient to the success of the school.

# 5 Outreach and Innovation

The Outreach/Forum Day [16] was held on July 28, 2012, with the goal of sharing ideas oriented towards building international collaborations and developing innovative technology in partnership with universities, national laboratories, the government and industry. The forum day consisted of lively discussions and debate about education and capacity building in Ghana and Africa in General. There was a buffet lunch of different Ghanaian dishes during the Forum day. The live performance by Agya Koo Mimo [17] at the beginning and during the breaks created a relaxed ambiance to enrich the discussions.

## 5.1 Excursion and School Banquet

During the school, inter-cultural understanding and networking was encouraged and enhanced by providing non-academic settings where the students could interact with one another and with the lecturers and gain an enhanced understanding of the cultural and natural environment of the host country, Ghana.

The first such event was an organised excursion on the first weekend of the school which included a guided bus tour of the Kakum National Park [18] and to the Cape Coast Castle Museum [19] where students saw some of the beauty of the diverse fauna and flora in central Ghana and learnt about the history of slavery on the west African coast.

The school banquet was hosted at the KNUST on the second weekend of the school. The banquet was preceded by the Forum Day. It consisted of a buffet meal of a variety of Ghanaian dishes that catered also to the need of vegetarian students. The performance of Agya Koo Mimo continued well into the evening during the banquet. This created a relaxed and warm atmosphere. During the evening, students representing each of their countries, made heartfelt speeches, introducing themselves, their countries and expressed their experiences of the school. The ambiance of the evening was warm and joyous, and the students and lecturers enjoyed and participated in music and in dance.

# 6 Follow-up

In this section, we discuss activities after the school. These include balancing the budget, the feedback from the students and maintaining contact with the students.

## 6.1 Balancing the Budget

The main priority of the budget was to:

- organise and run ASP2012 with a full coverage of the travel, accommodation and living expenses for African students;
- also invite students from elsewhere to provide a multicultural setting, meant to initiate networking and to share experiences in learning physics and pursuing research in this field.

Figure 5 shows the breakdown of the origin of the funds. In total we supported 50 students for the full duration of ASP2012 while some local students attended occasionally some selected lectures. All the students relied on ASP2012 funds. The details of the expenditures are shown on Fig. 6.

As shown in Table 1, the estimated budget covered very well all the expenses of the school. There is a small deficit of about €2,447[2].

## 6.2 Student Feedback

By all accounts, the experience was extremely valuable for all the participants. The inspirational enthusiasm of the students at ASP2012 exceeded our expectation and we have received much positive and constructive feedback. Some student feedback has already been included in published press releases [20, 21, 22].

In order to understand the impact of ASP2012 from the students' perspectives two surveys were prepared. The first survey was designed to complete our database and provide us with easy and accessible basic information such as the home institute and degree of each student. The second survey was designed to provide us with feedback about the quality of the school in order to take this into consideration in future versions of the school. A few students also

[2] The actual deficit was €9,447. We requested supplemental funds from ICTP and CERN in the amount of €3,500 each to reduce the net deficit to €2,447.

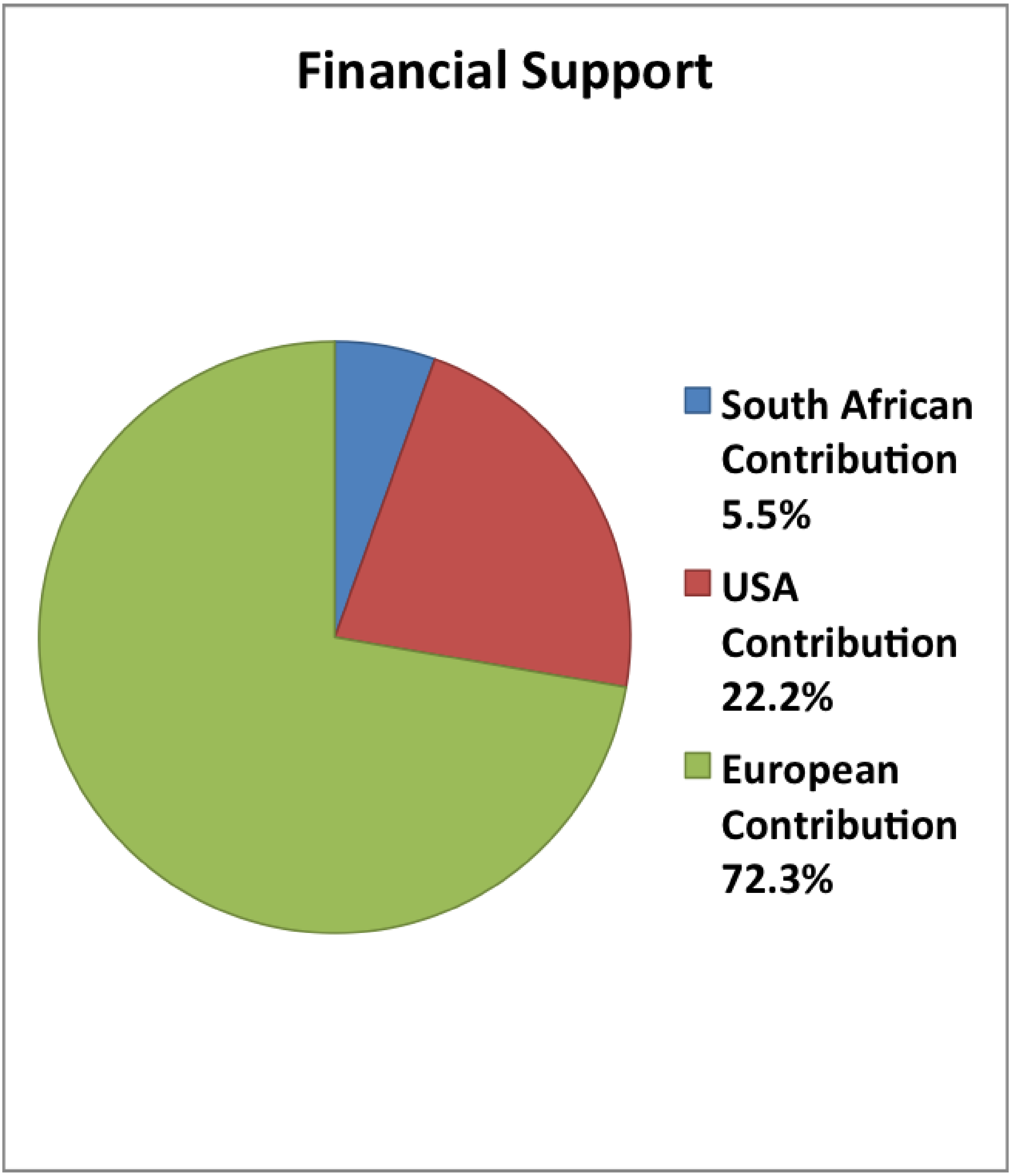


Figure 5: Origin of the funds used for ASP2012 and their percentage of the total budget. The lecturers travel costs paid from external sources are not included.

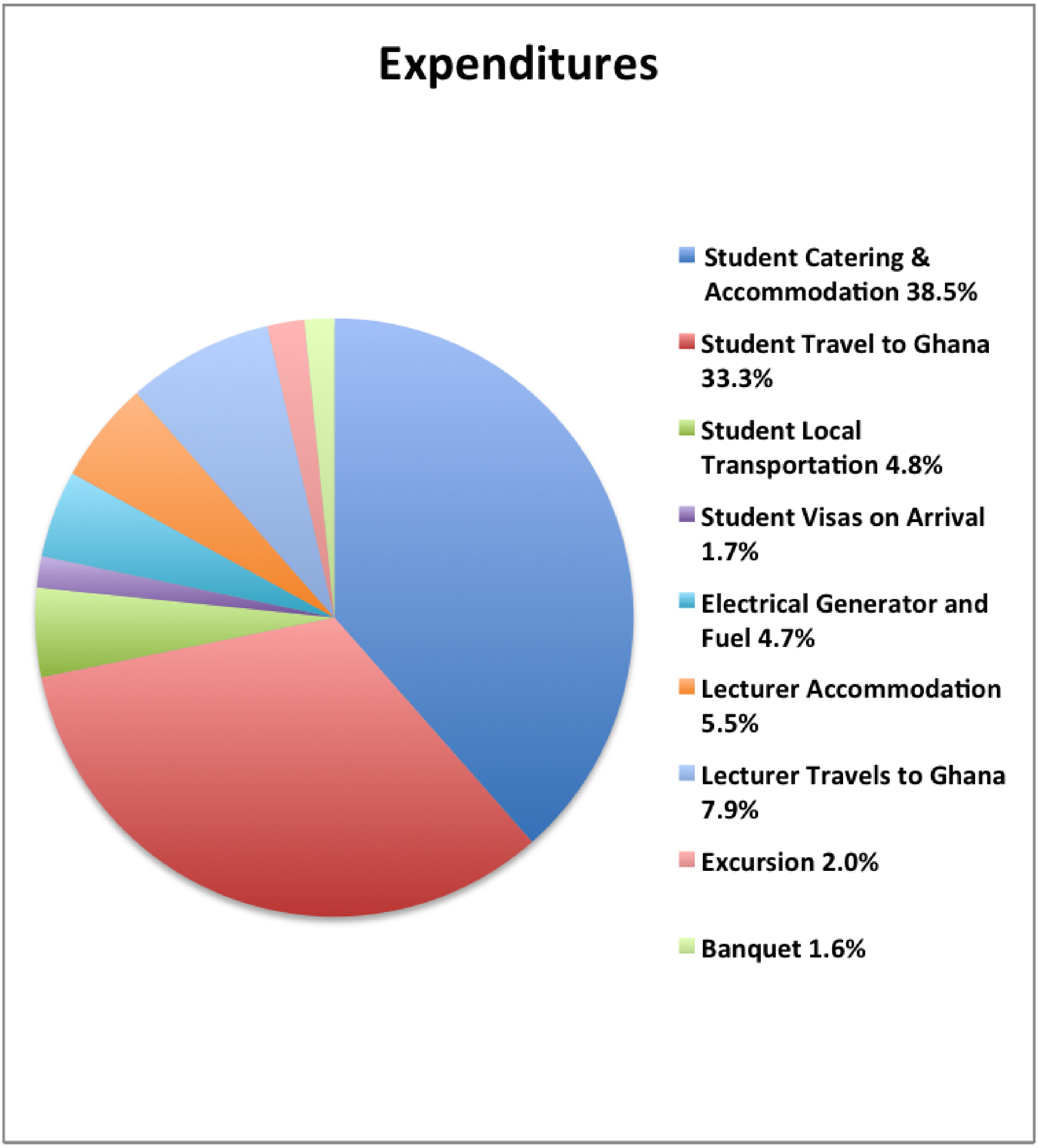


Figure 6: The details of the expenditures. Most of the support received was spent on the students.

shared their feedback through personal emails to the organisers. The following is a summary of these surveys and feedback.

It seems that most of the students heard about the school through word of mouth, advertisement in their departments or recommendation from their supervisors or colleagues.

By attending ASP2012, most of the students were expecting to learn more about the international high energy physics community, to make contacts through networking with lecturers and to get more information about scholarship and fellowship opportunities specially in North America and Europe. Some were also seeking to get ideas for their future research as well as connecting to other African physicists. Most of these expectations were met to a good extent. These results are summarised in Fig. 7.

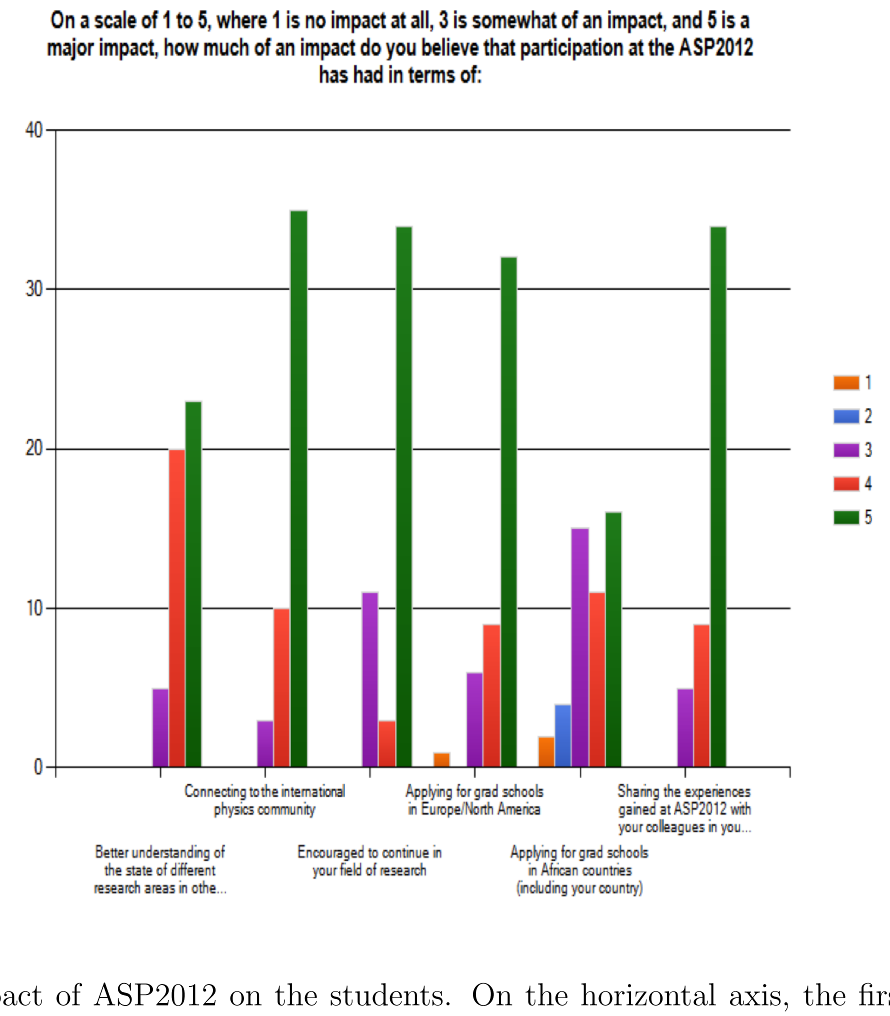


Figure 7: Impact of ASP2012 on the students. On the horizontal axis, the first and the last questions read respectively “Better understanding of the state of different research areas in other African countries, Europe and North America” and “Sharing the experiences gained at ASP2012 with your colleagues in your home institutes/universities”.

Some of the common suggestions to improve the school include increasing the computer lab sessions in order to get more hands-on experience as well as decreasing the variety of physics topics covered in the school. Many students believe that the school was long and there was little social time to interact with lecturers. It seems that there is also room for improvement in providing better accommodation for students. Overall, about 40% of the students are satisfied and 58% are very satisfied with their experience at ASP2012. 98% of the students will apply for the school again in future. The results are shown in Fig. 8.

In response to whether or not the students are interested in scholarship opportunities, all of them stated that they would be interested in fellowship opportunities in North America and Europe and about 88% are also considering opportunities in other African countries. These results are summarised in Fig. 9.

Figures 10 summarises the rating of the lecturers in terms of content of the lectures, clarity and easiness to follow, the speed of the lectures, etc. Overall, the students were very satisfied with the quality of lecturers.

Figure 11 shows the student feedback on each of the lectures and discussion sessions during the school.

The student feedback on the various aspects of the organization of ASP2012 is shown in Fig. 12.

## 6.3 Maintaining Contacts with Students

It was emphasised throughout the school that the students are main actors in their research careers. However, with a focus on empowering the students to make their own career choices, and in the spirit of increased networking, some career guidance and mentoring was given during ASP2012, by sharing with the students the websites where typically Ph.D. and post doctoral research positions are publicly advertised.

In order to retain contact with the students, a email group list was set-up through CERN [23] and a social networking facebook page [24] was created to share news and information. This has proved to be extremely helpful in communicating interesting physics news to the students and in getting updates on their evolving career paths. The email group list now contains the students of ASP2010 and ASP2012.

In order to identify a suitable host country and institution for the next ASP school, the contact with the existing students has already proved invaluable, in connecting through them to their universities and institutes to build potential future collaborating partnerships.

Since ASP2012, a strategic plan has being drawn between INFN and KNUST for the development of a "Ghana Multi-disciplinary Compact Laser Synchrotron at KNUST". It is a research infra-structure that will cost less than 15 M€, that can be installed inside the KNUST campus in a dedicated building ($25 \times 40$ m$^2$) and can feed several fields of scientific and technological research and serve a wealth of multi-disciplinary applications, based on a Compact Laser Synchrotron. It may constitute a national infrastructure to provide Ghana with an advanced resource to develop science and technology at the national and international level.

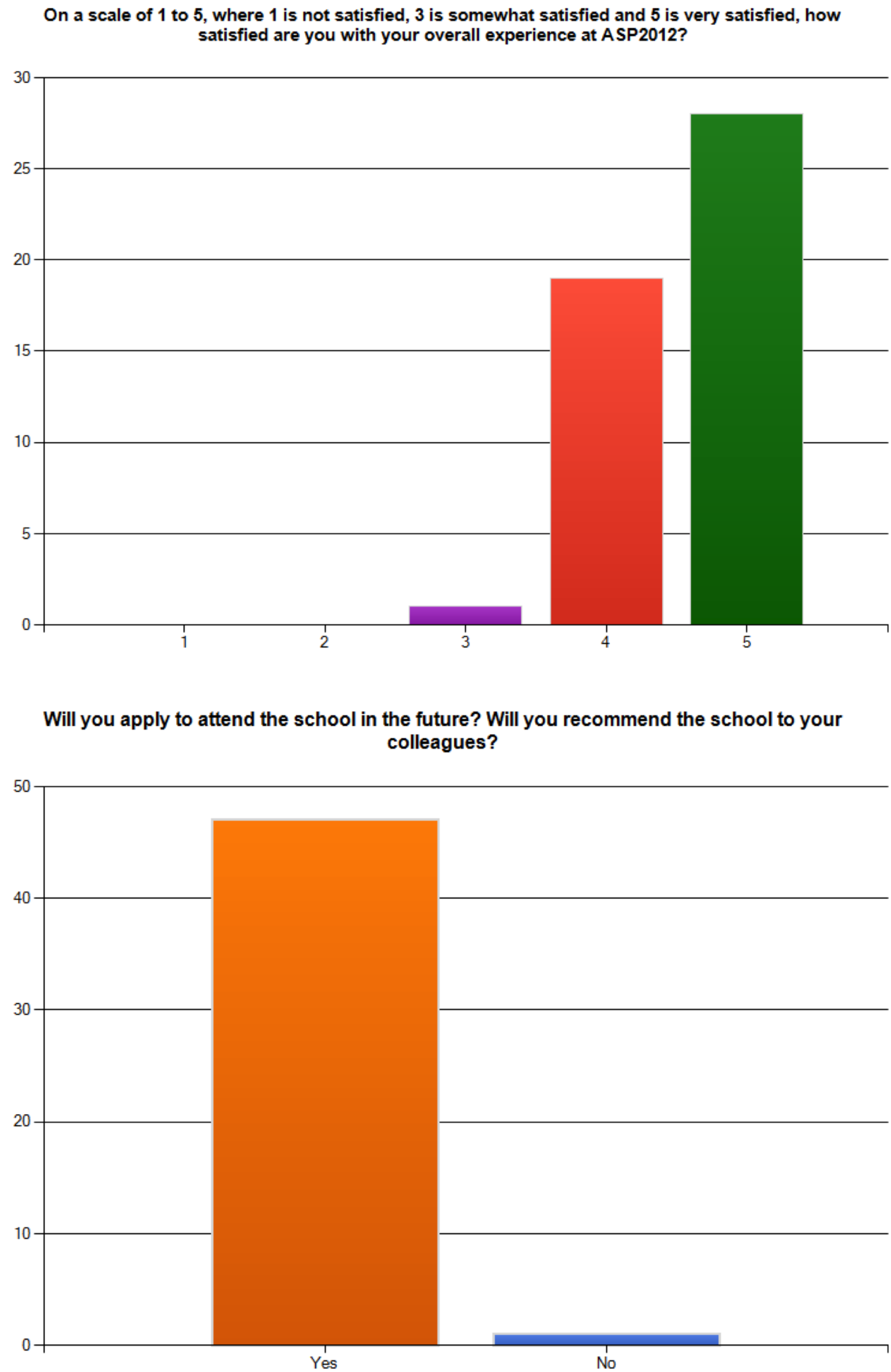




Figure 8: Satisfaction of the students and their willingness to attend the school again.

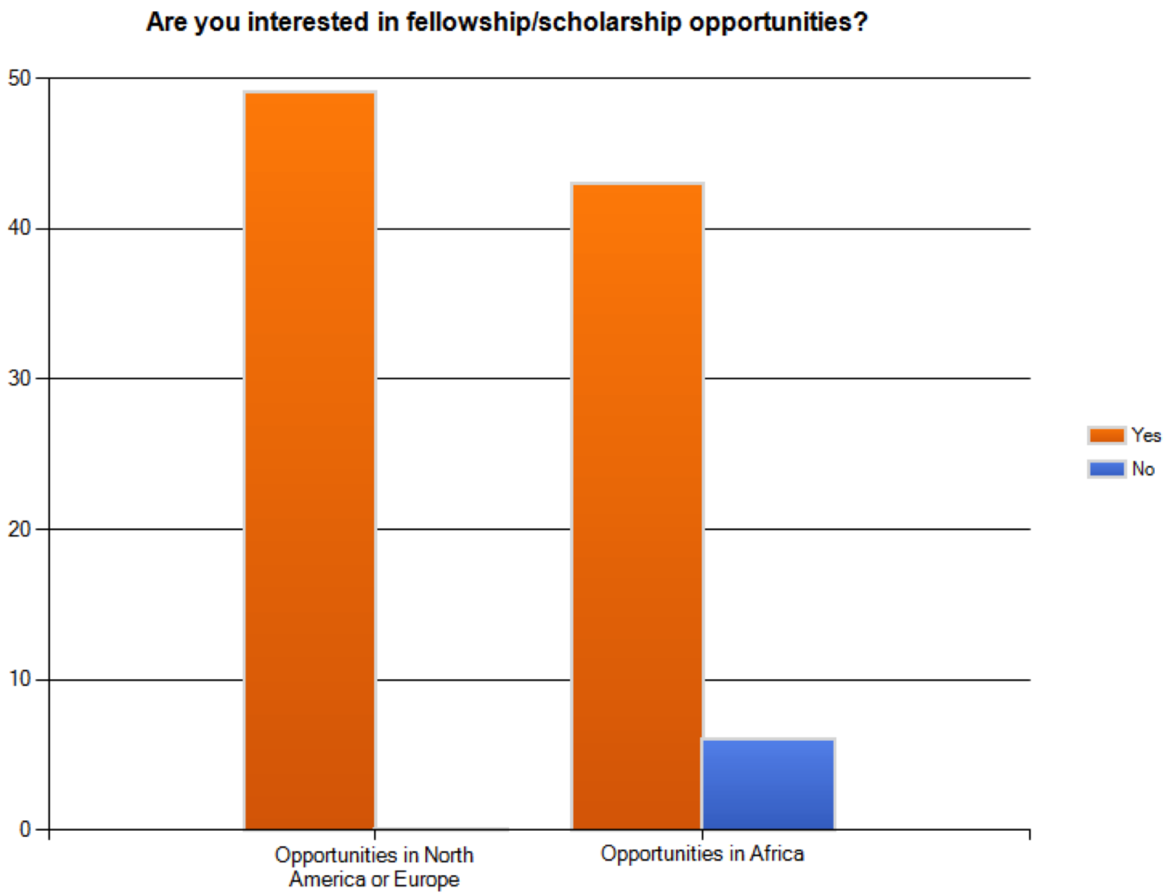


Figure 9: Student interest in fellowships and scholarships.

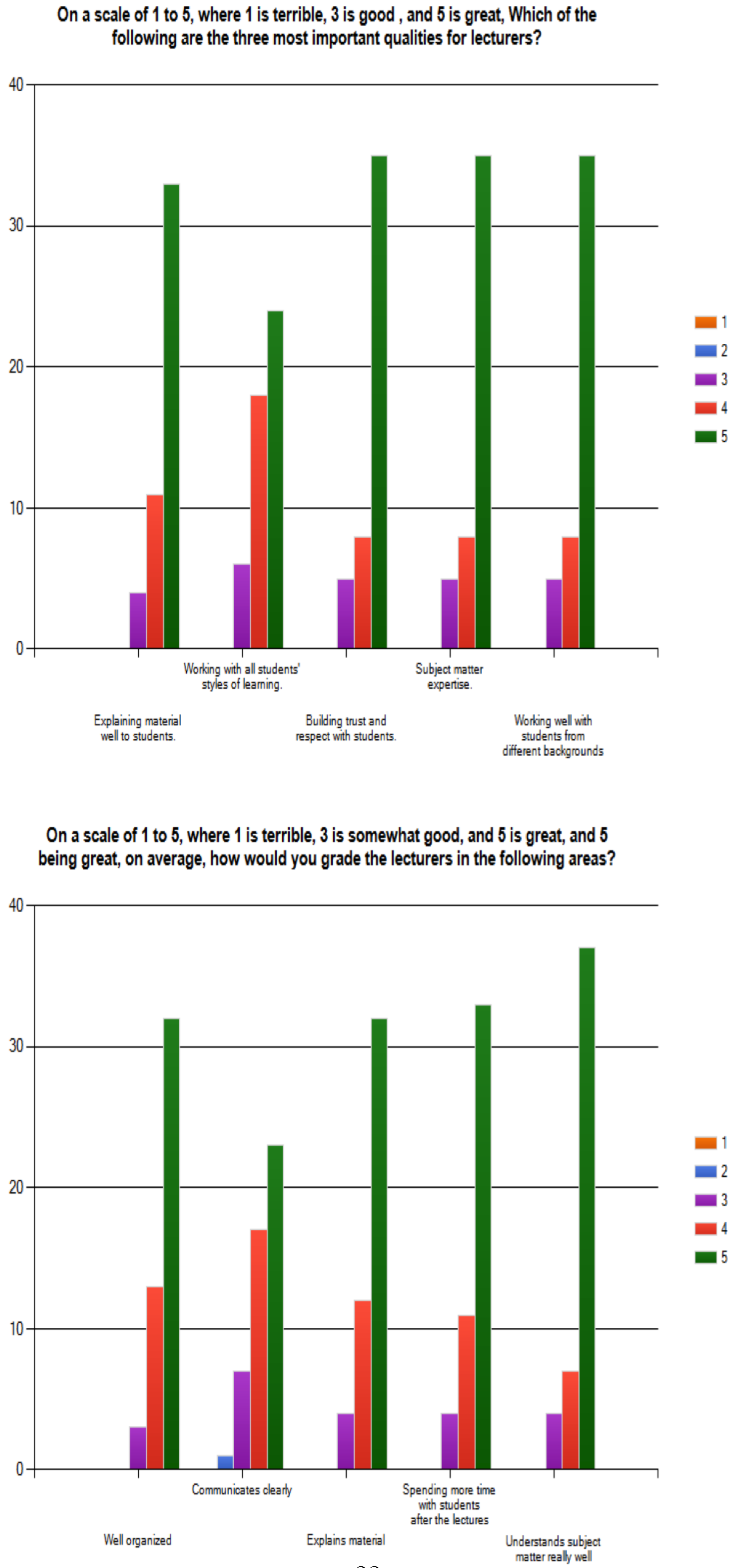




Figure 10: Student feedback on lecturers.

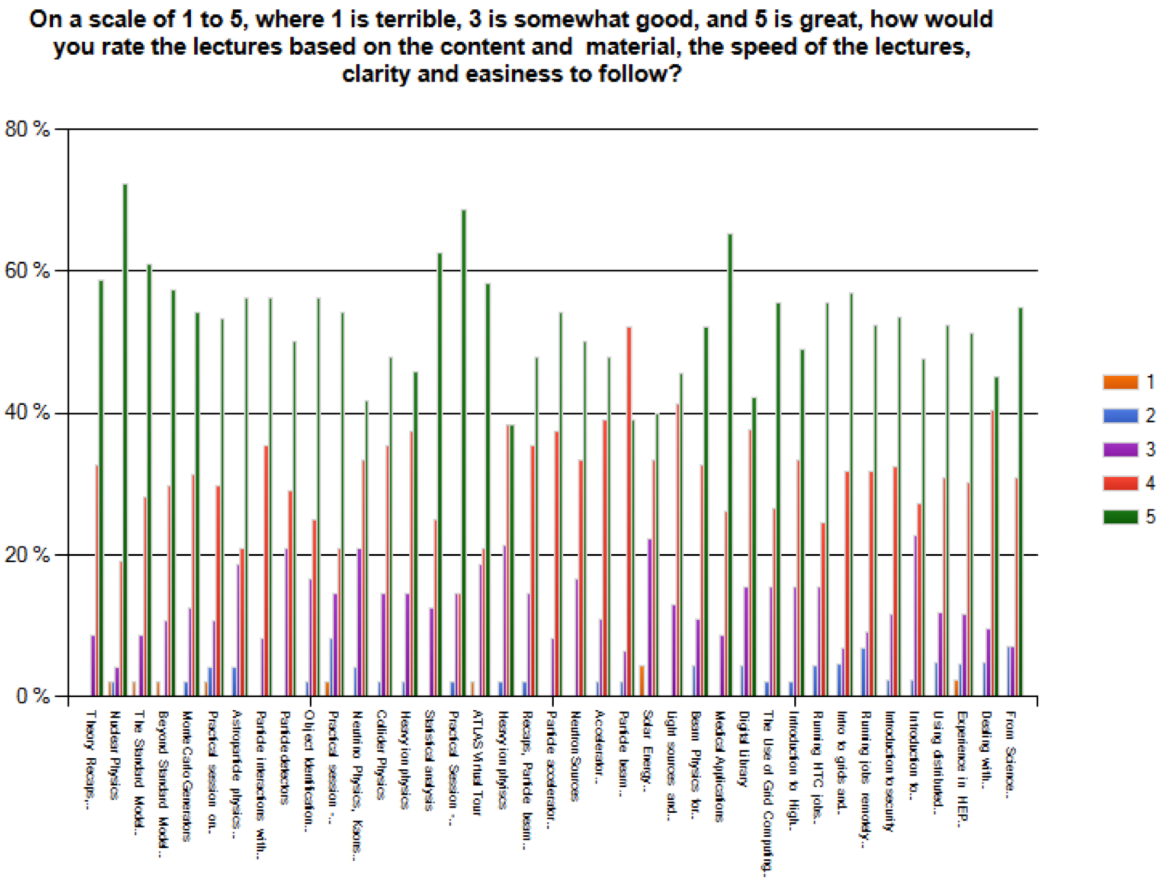


Figure 11: Student feedback on each of the lectures and discussion sessions.

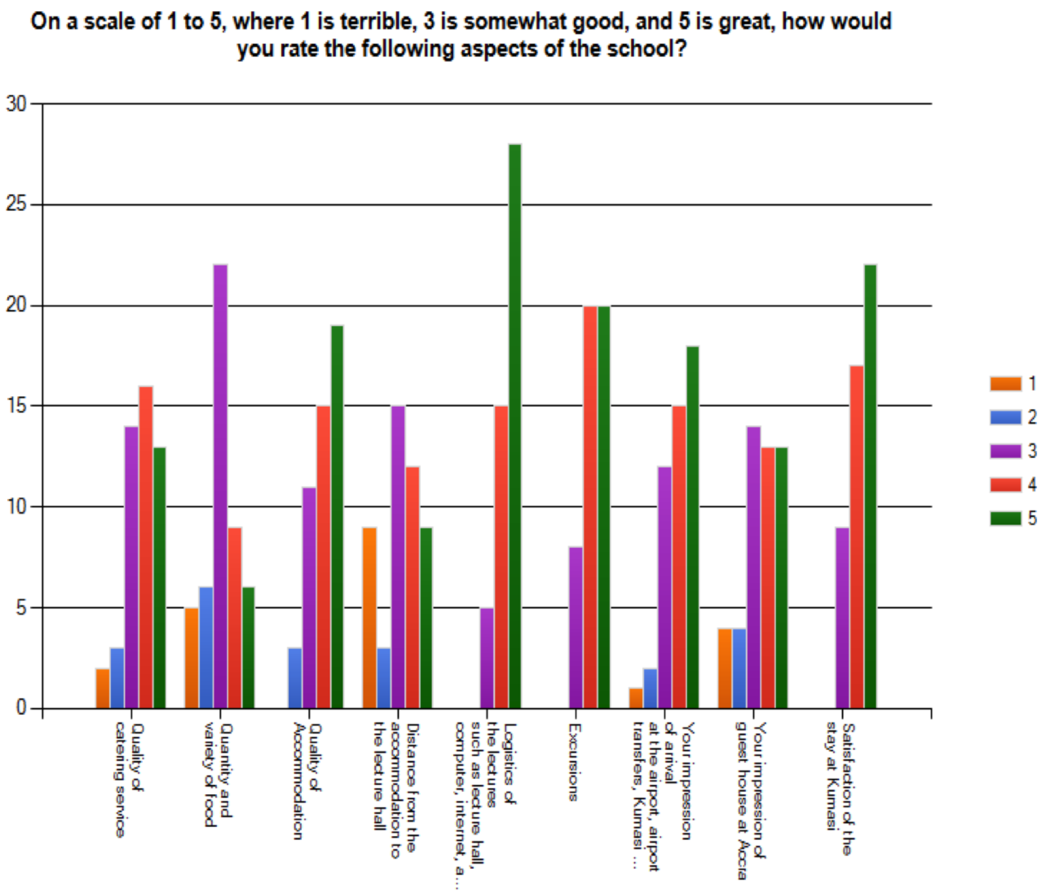


Figure 12: Student feedback on the various aspects of the school.

# 7 Outlook

The success of the school is due to the financial support from twenty-three institutes in the USA, in Europe and in Africa, to the dedication of the organising committee, to the devotion of the lecturers, and to the interests of the students themselves. Many students in Africa face challenges in terms of the logistical support, the quality of education and the opportunity for higher education abroad. Some of us in the organising committee had faced these challenges ourselves. It is often the case in Africa that even the best students do not have the needed support to succeed or to acquire the necessary skills to be competitive at an international level. It was particularly important for the ASP2012 organising committee to do something, to be part of something where one could help resolve some of the challenges that students from Africa face. It is not to suggest that this particular school has solved all the issues, not at all. However, it is hoped that this school was useful in terms of networking, which in turn will help prepare the students to find practical answers to many issues that they may need to resolve.

Looking at the long term objectives (to help improve high training and education in Africa) that motivated the organisation of ASP2010 and ASP2012, the current success, although encouraging, is rather limited in scope. Firstly, the school resources only allowed for 50 students to be accommodated. That was sufficient for the efficient management of the school but it is only a small step in the right direction to making a significant impact. Secondly, the duration the school, although appropriate given the constraints from the budget, students and lecturers, could not allow for a more extended coverage of the topics that were presented. Thirdly, the budget available for the school could not allow a longer duration with more time spent on the details of each topic. Finally, as can be seen in Fig. 4, the participation of students from French speaking African countries could be improved. All these are not a failure of ASP2012 but rather a motivation to work harder towards the original objectives by organising the school again in the future, and in doing so, truly contribute in a significant way to development in Africa.

To build up on the successes of ASP2010 and ASP2012, the organising committee proposes a similar school in 2014, ASP2014, but in a different African country. The committee is already exploring this option and a number of host countries has been suggested. In time, the committee will select the host country and approach the funding institutes of ASP2010 and ASP2012 for support for the ASP2014, and the process of identifying students and lecturers will be carried out. Early involvement of the local host in the organisation process is essential to the success of the school.

# 8 Conclusions

For the past few years, a group of local and international organising committee members have worked very hard to prepare for the second biennial school of fundamental physics and its application in Africa. Finally, the efforts of the organising committee and all the supporting institutes and concerned individuals paid off and the school took place in Kumasi, Ghana on July 15 – August 8, 2012. A total of about 50 students from all over Africa (including one from Iran) attended the school. There was also the participation of high profile international and local lecturers who prepared and presented the materials taught during the school. They included theoretical and experimental particle physics, particle accelerators, practical applications and Grid computing.

Friendly atmosphere throughout the school encouraged direct contacts between the students and the lecturers and to hear the student's concerns about the possibility of pursuing higher education. The students established contacts and network with the lecturers and with other students; we expect these connections to be useful to the students and to be maintained far the beyond the school itself. Social events and a banquet were organised, and these encouraged further interactions among the participants. Feedback from students and lecturers suggests that it was a very successful and well received school, and that there is a demand for the school to be organised again within the next two years.

# Acknowledgements

We would like to thank the universities, research institutes and government agencies that provided the funding for ASP2012, namely, ICTP (Italy), INFN (Italy), CERN, University of Uppsala (Sweden), ISP (University of Uppsala, Sweden), The French Embassy in Ghana, ARDENT, DITANET, CEA (France), EPFL (Switzerland), PSI (Switzerland), NITheP (South Africa), AIMS-NEI (South Africa), Fermilab (USA), BNL (USA), Jefferson Lab (USA), JSA (USA), NSF (USA), APS (USA), KNUST (Ghana), NIMS (Ghana).

We also thank the institutes and universities that provided travel funds for their lecturers at the ASP2012 namely, SA-CERN, CERN, BNL, Louisiana-Tech University, University of Texas Arlington, University of Oklahoma, CNRS-IN2P3, Université Catholique de Louvain, INFN, ESS and NSF.

Special thanks to Dr. Mats Lindroos for donating personal funds to ASP2012.

Thanks also to the lecturers for the courses prepared and taught at the ASP2012, for the clarity of the materials presented to the students and for their availability during discussion and practical sessions to interact further with the students.

Thanks to Svetlana Palagina and Kate Shaw for the ATLAS virtual visit. Thanks also to Josiane Uwantege for preparing a sample video of the activities during ASP2012.

Thanks also to KNUST for hosting ASP2012 and for providing the logistical support, which was essential to the success of the school. Special mention and thanks to Peter Amoako-Yirenkyi, Edem Donkor and Akyana Britwum for their efficient logistical support in Kumasi.

Finally, we thank each member of the organising committee (local and international) for responding to the challenge to prepare this school, for their concerted efforts to contribute to

education in Africa. These were extra efforts beyond their professional obligations.

# References


[1] NIMS-Ghana, *Kwame Nkrumah University of Science and Technology*, Available from http://www.knust.edu.gh/pages/.

[2] K. A. Assamagan et al., *African School of Fundamental Physics and its Applications*, Available from http://africanschoolofphysics.web.cern.ch, 2012.

[3] S. Muanza et al., *ASP2010*, Available from http://africanschoolofphysics.web.cern.ch/africanschoolofphysics/2010/default.html, 2010.

[4] The LHC Project Collaboration, *The Large Hadron Collider*, Available from http://lhc.web.cern.ch/lhc/.

[5] CDF and D0 Collaboration, T. Aaltonen et al., *Combination of Tevatron searches for the standard model Higgs boson in the W+W- decay mode*, Phys. Rev. Lett. **104** (2010) 061802, `arXiv:1001.4162 [hep-ex]`.

[6] The ATLAS Collaboration, *Expected Performance of the ATLAS Experiment - Detector, Trigger and Physics*, Http://public.web.cern.ch/public/en/lhc/atlas-en.html, 2008. arXiv:0901.0512 [hep-ex] (2008) .

[7] The CMS Collaboration, *CMS Physics Technical Design Report, Volume II: Physics Performance*, Http://public.web.cern.ch/public/en/lhc/cms-en.html, 2007. J. Phys. G: Nucl. Part. Phys. **36** (2007) .

[8] The ALICE Collaboration, *A Large Ion Collider Experiment*, Available from http://public.web.cern.ch/public/en/lhc/alice-en.html.

[9] The LHCb Collaboration, *Large Hadron Collider Beauty*, Available from http://public.web.cern.ch/public/en/lhc/lhcb-en.html.

[10] *The Abdus Salam International Centre for Theoretical Physics*, Http://www.ictp.it/.

[11] S. Agostinelli et al., *GEANT 4 a simulation toolkit*, NIM A **506** (2003) 250–303.

[12] J. Uwantege, *Snapshots of Activities During the Second Week of ASP2012*, Http://cdsweb.cern.ch/record/1472184.

[13] K. A. Assamagan et al., *ASP2012 Agenda*, Available from http://indico.cern.ch/conferencetimetable.py?confid=145296#20120715, 2012.

[14] T. Sjostrand et al., *PYTHIA 6.4 physics and manual*, JHEP **05** (2006) 026.

[15] R. Brun et al., *ROOT Reference Guide*, Available from http://root.cern.ch.

[16] *Saturday July 28, 2012 - Forum and Outreach Day*, Https://indico.cern.ch/conferencetimetable.py?confid=145296#20120728.

[17] K. M. Agya et al., *African Drum and Dance*, Http://www.youtube.com/watch?v=rzf3pjtt6z0.

[18] Ghana Tourism, *Kakum National Park*, Http://www.touringghana.com/ecotourism/kakum.asp.

[19] Ghana Tourism, *Cape Coast Museum*, Http://capecoastcastle.ghana-net.net/.

[20] *High Energy Physics Lessons in Africa*, Http://www.bnl.gov/today/story.asp?item_no=3292.

[21] *Summer school gives African students glimpse into lives in physics*, Http://www.fnal.gov/pub/today/archive_2012/today12-08-31.html.

[22] *Into Africa - a school in fundamental physics*, Http://cerncourier.com/cws/article/cern/44114.

[23] *Email List maintained by the International Organising Committee of ASP through CERN*, Asp-students-network@cern.ch.

[24] *African-School-of-Physics: Facebook Page*, Http://www.facebook.com/groups/496292803718757/.

# A Selected Photographs of ASP2012

Figure 13: Group photograph of students and lecturers in the first week of ASP2012.

Figure 14: Group photograph of students and lecturers in the second week of ASP2012.

Figure 15: Group photograph of students and lecturers on the last day of ASP2012.