Activity Report on the Fifth Biennial African School of Fundamental Physics and Applications

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Abstract

We have established a biennial school in Africa, on fundamental physics and its applications (ASP). Fundamental physics is a good field to educate students in general science. The aim of the school is to build capacity to harvest, interpret, and exploit the results of current and future physics experiments and to increase proficiency in related applications. The school is based on a close interplay between theoretical, experimental, and applied physics. The participating students are selected from all over Africa. The school also offers a workshop to train high school teachers, an outreach to motivate high school pupils and a physics conference to support the broader participation of African research faculties. The duration of the school allows for networking–interactions among the participants. Support for the school comes from institutes in Africa, Europe, USA and Asia. The first school took place in Stellenbosch, South Africa on August 1–21 2010, the second edition in Kumasi, Ghana on July 15-August 8 2012, the third edition in Dakar Senegal on August 3–23 2014, the fourth biennial school at the University of Rwanda on August 1–19 2016, and the fifth edition in Namibia on June 24–July 11 2018. The activity report of the fifth edition of the school (ASP2018) is presented here.

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Contents

1 Introduction

The fifth edition of the biennial school of fundamental physics and applications, ASP2018, took place at the University of Namibia (UNAM) and the Namibia University of Science and Technology (NUST), in Windhoek Namibia, on June 24–July 14 2018 [1], with the support of the Namibia National Commission on Research, Science and Technology (NCRST). The school was based on a close interplay between theoretical, experimental, and applied physics. It covered a wide range of topics in nuclear & particle physics, astrophysics & cosmology, accelerators, radiation & medical physics, material physics, renewable energies & energy efficiency, high performance computing, physics education and physics communication. The participating students were selected from twenty-four African countries. A selection of lecture topics and conference talks 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, physics demonstrations and experimentation according to the proposed topics taking into account the diverse levels of the participants. The duration of the school allowed for networking—interactions among the participants. The school was funded by institutes in Africa, Europe, Asia and the USA.

The first edition of the school, ASP2010, took place in Stellenbosch, South Africa, on August 1–21 2010 [2], the second edition in Kumasi Ghana on July 15–August 8 2012 [3], the third edition in Dakar Senegal on August 3–23 2014 [4], and the fourth edition in Kigali Rwanda on August 1–19 2016 [5].

ASP2018 was a successful school as can be seen from the report presented herein. Such a success results from many factors, namely the dedication of the organizing committee (local and international), the careful preparation of the school, the logistical support offered by the host country, the motivation of the participants, 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 organizers of the school believe 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. Specialization 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 ASP2018, 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 ASP2018 would instill all these necessary skills to the students. Indeed, ASP2018 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 organizing this school every two years, with the next one in 2020, the basic objective of the school, i.e., increased and competitive higher education in fundamental physics in Africa, will be better realized.

The ASP2018 program was augmented by a one-week workshop for high school teachers, a one-week outreach to secondary schools in the Khomas region of Namibia, and a one-week physics conference. Regular training of high school teachers will equip them with the latest educational tools to prepare students for college education. The outreach to the secondary schools is expected to increase the curiosity, awareness and confidence of high school pupils towards fundamental physics and applications. The ASP conference was intended to attract ASP student alumni and African research faculties to present their research work and network with the international participants.

The motivation to carry out such a school in Africa is presented in Section 2. The organization 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 June 24–July 14, 2018 when the school took place in Windhoek: the logistical support offered by the host country and how this contributed to the success of the school, the lecture materials that were presented to the participants, and the discussion and practical sessions that were organized to reinforce the understanding of the lectures and to promote networking. respectively. In Section 5, 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 6, we discuss the prospects of organizing the school again in 2018. And finally, some concluding remarks are offered in Section 7.

2 Motivation

The basic objective is to help improve the quality of higher education in Africa and to help increase the number of African students acquiring higher education. This is achieved through an outreach effort, an increased awareness of the potential of high quality training offered by large scale experiments in context in various scientific disciplines, and a system of networking on the international scale. There is a strong alignment between the mission and the vision of African governments and policy makers on education and capacity building and their programs with the goals of the ASP. The ASP is committed to include African governments in the planning going forward, in order to take advantage of aspects such as consolidating bilateral agreements and their goals, building on synergy with other programs, improving the sustainability and impact of the capacity development and improving the measurement and visibility of the impact. By working with African governments and policy makers on education, ASP seeks to promote a culture of science that creates an attractive environment for African student alumni, thus encouraging their retention within Africa. ASP promotes sustainable scientific development in Africa by building a network between African and international researchers for increased collaborative research and shared expertise.

The aim is to establish a longer partnership with African governments and policy makers on capacity development for the component of funding, to improve the scientific program in order to better serve the education and research priorities of African countries, and to develop the project goals and the key performance indexes further. These developments are timely given the progress made by the ASP and the synergy that can be established with the African policy makers on education. Mechanisms to make ASP sustainable are considered, and in doing so, ASP truly contributes in a significant way to development in Africa. ASP2010-16 are positive steps towards the broader objective of ASP and encouraged the organization of the fifth edition of ASP, ASP2018. In doing so, we hope to help increase the global presence of African students and scientists.

3 Organization of the School

In this section, we discuss the organization of ASP2018, 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 realization. Late in 2008, there was a firm commitment from Center 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 [6] in February 2009. It was the beginning of concerted efforts on the first edition of the school, ASP2010.

The success of ASP2010 was encouraging and provided motivation to work harder towards the original objectives to organize the school every two years, and in doing so, truly contribute in a significant way to development in Africa. The international organizing 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, and Senegal for ASP2014. The fourth edition of the school, ASP2016, followed in Rwanda in August 2016. Then in June–July 2018, the fifth edition was held in Namibia. The activities of ASP2018 are discussed in this report.

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 ASP2018 was primarily targeted towards African countries, the host country was considered from that part of the world. A few options were explored in West Africa, Central Africa and Southern Africa. After several considerations, Namibia was finally selected as the host for ASP2018. 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 organizing committee dedicated to the objective and the success of ASP2018, 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 Namibia as the host for ASP2018, the venue of the school within Namibia 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 Namibia in June 2017 to meet the local organizing committee, to inspect the various options for the venue and to see the infrastructure that would be available for lectures, discussion 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.

Ultimately, UNAM and NUST were selected as the venues of ASP2018 after considering all the aforementioned requirements and in addition to the proximity of both universities to a major international airport for an easy commute of the international delegates.

3.2 Scientific Program

The scientific program contained four categories optimized for international university students, high school teachers, high school pupils, and a conference for professional physicists. All the four categories of the scientific program were based on research and education topics in nuclear & particle physics, astrophysics & cosmology, accelerator, radiation & medical physics, material physics, renewable energies & energy efficiency, physics education and physics communication. Lectures were delivered in theoretical fundamental physics, experimental physics, applied physics and/or high performance computing.

Each lecture 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, detector simulation with Geant-4 [7], data analysis with ROOT [8], and high-performance computing. The latter was structured partly into hands-on practical sessions. There were also discussion groups that provided opportunities for discussing questions arising from the lecture materials. These discussion sessions provided a framework for mentoring participants from different backgrounds.

During the conference, special lectures were organized to highlight the edge of current research and topics of special interest to the host region. Some of these lectures were more pedagogical in nature, and were open to a wider audience, e.g., from the host institutions and its surroundings. There were a few such talks for each of the main scientific themes.

The student program contained all the aforementioned activities condensed into three weeks, June 25–July 13. The workshop for high school teachers took place during the second week, in parallel to the student program, July 2–6. The outreach to secondary school took place with the third week, in parallel to the student activities, July 9–12. The physics conference took place on June 28–July 4, and offered plenary and poster sessions for all the participants on June 28, and in the mornings of July 2 and July 4.

All these additional activities were designed to complement and strengthen the ASP2018 program with the possibility of networking and informal discussions among the participants.

The details of the scientific program are shown in Ref. [1].

3.3 Financial Support

The school was sponsored by an unprecedented large number of international institutes and organizations in Africa, Europe, the USA and Asia, as shown in Figure 1, in addition to support from the private sector.

Figure 1: The institutes that financially supported ASP2018. Brookhaven National Laboratory provided a significant support to the school but declined the use of its logo.

We managed to collect a total budget of about €165467 as shown in Table 1. Travel and accommodation expenses of most lecturers were covered by their home institutes. The travel expenses for a few lecturers were covered from ASP2018 funds as shown in Table 2. The travel

Table 1: Summary of the ASP2018 budget. The contributions in this table were primarily used for student participation, and for travel and/or lodging accommodation coverage for a few lecturers. Travel and accommodation for most of the lecturers and organizers were covered by their own institutes: these are detailed in Table 2. The BNL contribution includes travel coverage for six of its staff and $10000 for student participation. The EPS contribution of €4000 was earmarked for the organizers and speakers of the renewable energy & energy efficiency track at the ASP conference.

Incomes (€)	
African Contributions	**60075**
South African NRF and DST R500,000	31148
Namibian Ministries of Education	20000
Inter-University Council of East African	7681
University of the Witwatersrand R20000	1246
European Contributions	**67355**
ICTP	30000
INFN	15000
CERN CHF 10000	9113
DESY	5000
EPS	4000
Paul Scherrer Institute (PSI) CHF 4000	3526
EU Delegation in Namibia $11500	716
USA Contribution	**36451**
Brookhaven National Laboratory (BNL) $10000	8817
BNL coverage for its staff $32158	
IUPAP	**7000**
Asian Contribution	**6000**
Shui-Chin Lee Foundation for Basic Science	6000
Private Sector	**15000**
Theorem Holdings Corporation	10000
Metatron Global SA	5000
ASP Conference Registration Fees	**1220**
Total Income 165467	

Table 2: Summary of the ASP2018 budget for lecturers, invited speakers and organizers. From the budget of ASP2018, we provided lodging accommodation for three lecturers, travels for one reporter and one speaker, and travel & lodging accommodation for one filming and recording expert. *During the site visit to Namibia in June 2017 and early 2018, BNL, ICTP, CNRS-IN2P3, CERN, and the University of Oklahoma provided travel coverage for their staff. One member of the site visit team paid for her own travel. This coverage is not reflected in this table.* The BNL travel coverage for its staff is not received as contribution into the ASP budget for students; it is simply shown to point out the significant contribution of BNL to the overall ASP2018 effort.

Institute	*Number of lecturers or organizers covered*
South African Institutes	12
BNL	6
ASP2018 Budget	6
CERN	4
INFN	3
EPS	3
CNRS-IN2P3	3
Private Sector	3
King's College London	2
Jefferson Lab	2
University of Oklahoma	2
DESY	2
Swedish Institutes (Uppsala & Lund)	2
University of Notre Dame	1
Academia Sinica Taiwan	1
IOP	1
IPHC CNRS	1
ICTP	1
ESS	1
ALBA Institute	1
University of Hamburg	1
University of California Berkeley	1
University College London	1
PSI	1
Senegalese Ministry of Education	1
Cadi Ayyad University	1
Weizmann Institute	1

and accommodation support from the home institutes of lecturers was crucial for ASP2018 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 5.1.

3.4 Student Selection

We received 523 applications as shown in Figure 2: the international organizing committee set up a selection committee consisting of 28 lecturers to evaluate the student applications and retain the ones best suited for the school. Each student application consisted of a Curriculum Vitae, a letter of recommendation, a letter of motivation and university transcripts. We selected 85 students in the male:female ratio of 50:35 from 26 countries, as shown in Figure 3. The total number of students selected was dictated by budget constraints and the logistical support of the host country. There were 14 Namibian students among the 85 selected.

There were 14 declinations from the original 85 selected students and in the end, a total of 71 students participated in ASP2018. Of the 71 students, one was the USA, 12 from Namibia and the rest from other African Countries.

Further details on the profiles (age, university level, and area of study) of the selected students are shown in Figures 4–6.

4 ASP2018

In this section, we report on the school itself, i.e., the running of the school during the period of June 24–July 14, 2018. A few of the photographs taken at the school are shown in Appendix A.

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 ASP2018.

The ASP2018 was hosted at UNAM and NUST in Windhoek, Namibia. The lecture halls could accommodate all the students (or high school teachers), lecturers and organizing committee members for plenary sessions, an atmosphere that encouraged questions from the participants 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, ROOT, Monte Carlo Generators and GEANT-4 [7] exercises) were carried out in the lecture halls equipped with PCs.

The student and high school teachers activities took place at UNAM whereas the ASP conference and Forum took place at NUST. Activities for the high school learners took place

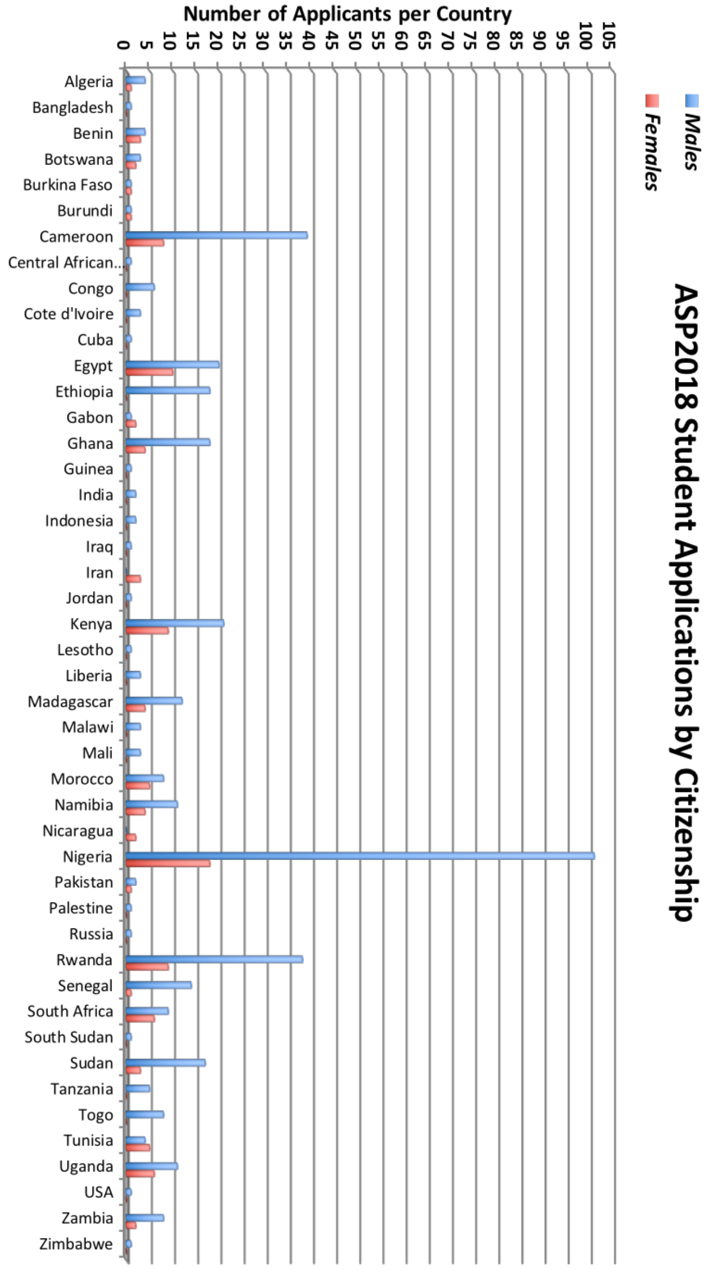


Figure 2: The distribution of the ASP2018 students. The numbers of applicants (total and female) per country are shown.

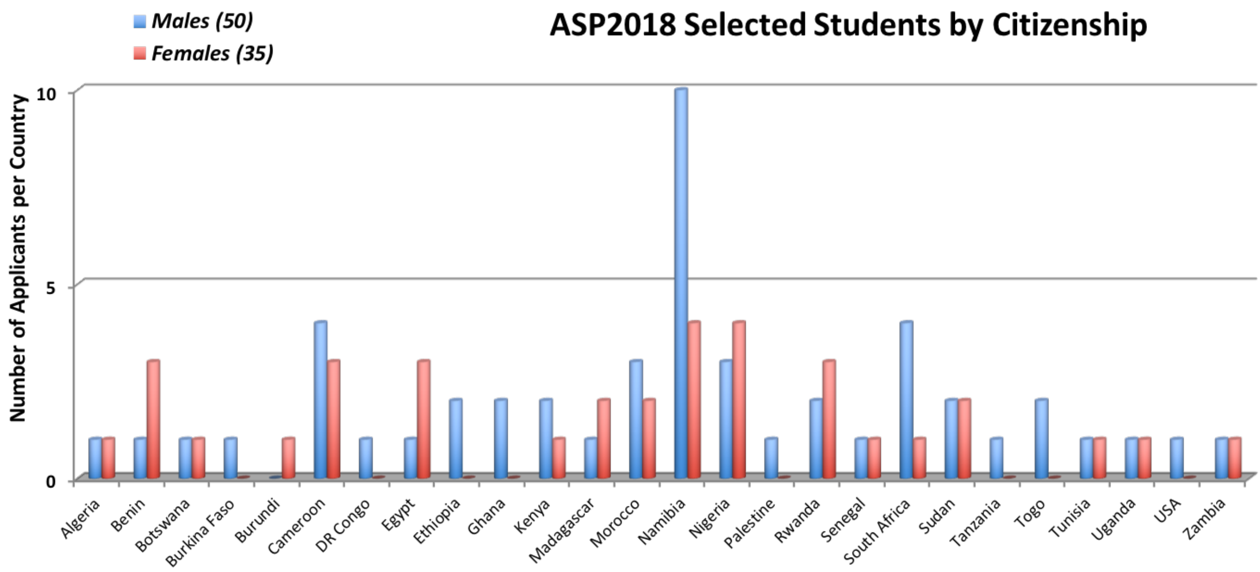


Figure 3: The distribution of the selected students that attended the school by country of citizenship.

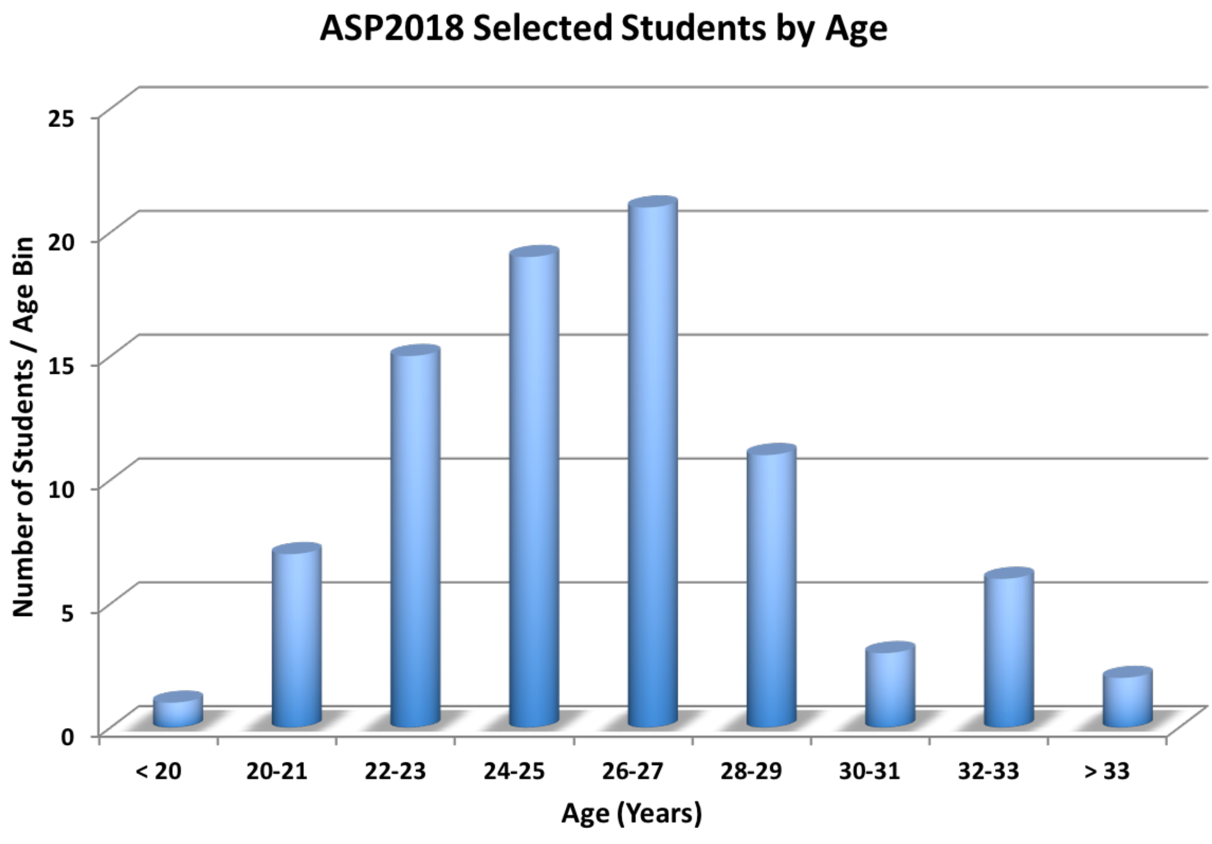


Figure 4: The selected student age distribution.

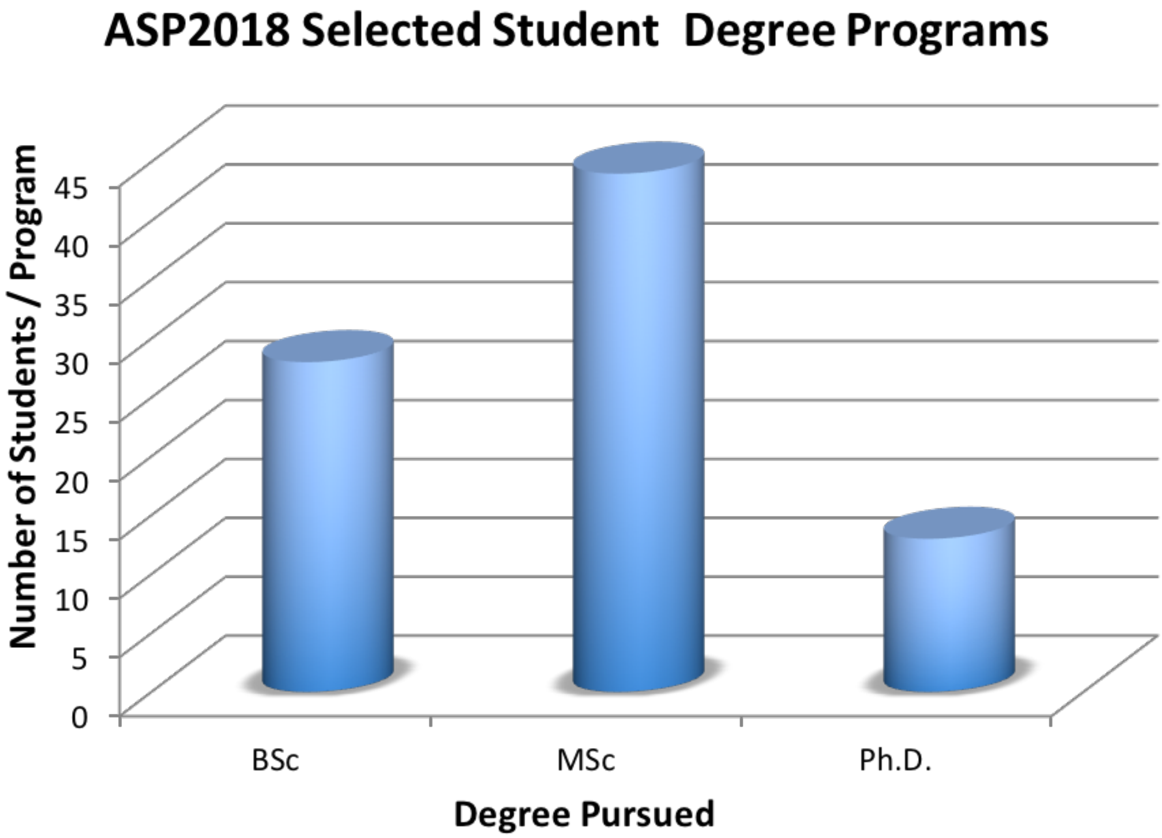


Figure 5: The university degrees pursued by the students at the time of their participation in the school.

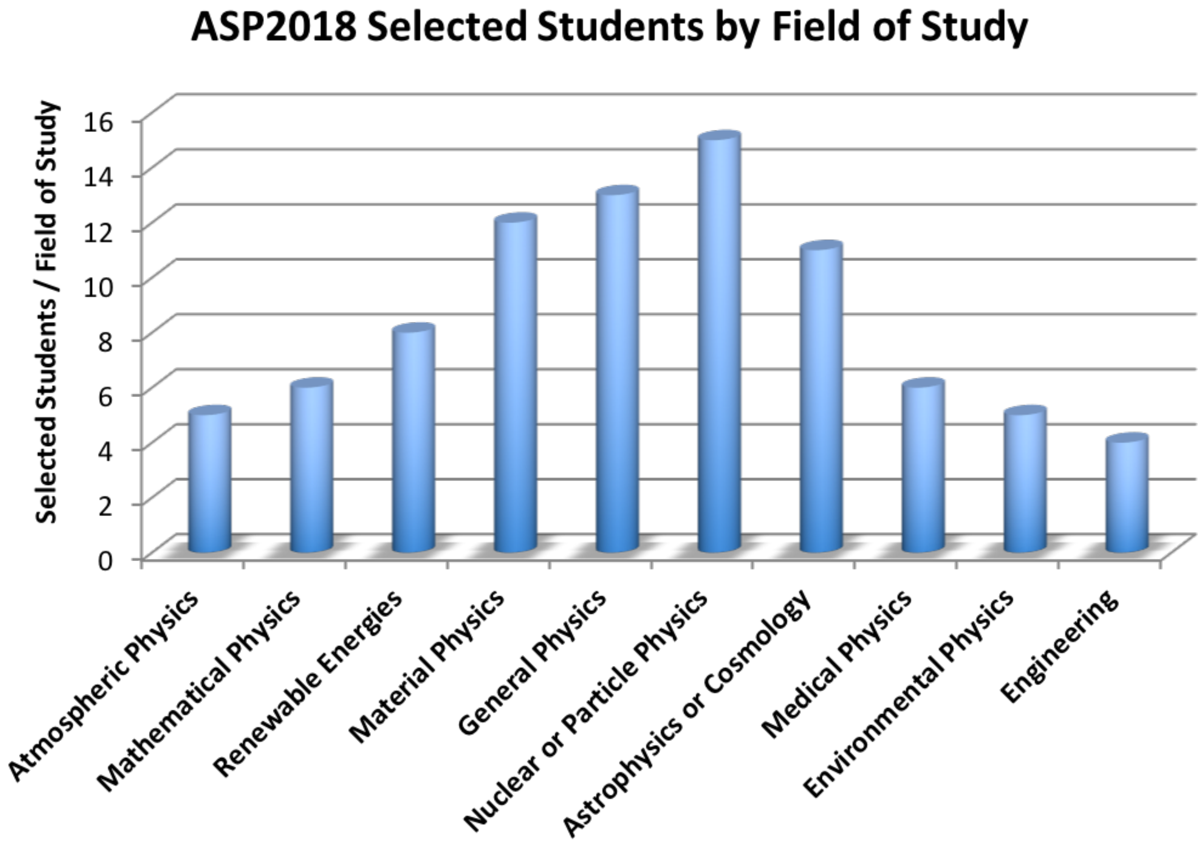


Figure 6: The major areas of concentrations in the selected students university education.

at selected high schools—see Section 4.2 for details.

The local and international students were hosted at the UNAM dormitories, to create an atmosphere of increased interactions and networking among the students.

Lecturers were hosted at various hotels in Windhoek. Interactions between lecturers were useful to fine-tune and adapt the materials presented to the students.

The logistical support offered to the ASP2018 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 well. The available Internet bandwidth did allow for video conferencing, live web-cast connections to the International Conference on High Energy Physics (ICHEP 2018) which was taking place in parallel in Seoul, South Korea. Through the video conference, a discussion session was organized on July 7 2018 between the participants at ASP2018 and ICHEP 2018 with the theme "life as physicist". This discussion session allowed the ASP2018 students to ask questions and hear about the experiences of professional physicists.

A professional filming team was available during the ASP2018. Video clips of the various activities of ASP2018 is available in Ref. [1], a few selected photos are shown in Appendix A and more photos are available in Ref. [1].

The logistical support contributed significantly to the success of ASP2018.

4.2 Lectures for Students

The details of the lectures, discussion and practical sessions for students are documented in Ref. [9] and followed the main topics as outlined in Section 3.2. The theoretical physics theme was concentrated in the first week of the school. The Experimental Physics theme dealt with what we know about fundamental 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 applications of fundamental physics.

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 Monte Carlo generators.

A Linux boot camp session was organized to introduce the students to the basics of Linux. This was essential for the subsequent hands-on tutorials and exercises in Monte Carlo generators, Geant-4, ROOT and Grid computing.

4.2.2 Experimental Physics

The Experimental Physics theme dealt with detectors, experimental methods and data analysis. 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, nuclear physics, and material 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 [10]. 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 Applied Physics

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 and material science were discussed. The first section of the third week was dedicated to understanding the beam physics behind the design of a particle accelerator, light sources and their applications and high performance computing. The second section of the third week was dedicated to accelerator based medical physics, nanotechnology and solar energy applications.

4.2.4 Information Technology and Grid Computing

The Grid Computing section of ASP consisted of lectures from members of the Distributed Organization for Scientific and Academic Research (DOSAR) and the Open Science Grid (OSGrid). The two-day sessions (in the third week of the school) covered a range of topics related to distributed computing theory and applications in traditional lectures and dedicated a large fraction of time for various hands-on practice opportunities.

The opening lectures of the school were designed to show and teach students the concepts of Grid Computing. Examples of different types of academic and research computing and their uses were shown. The results of actual analyses carried out on the OSGrid which uses high-throughput computing were presented and demonstrated the access to a massive amount of computing power that is distributed all over the world through the Grid Computing technology.

Students were led through a variety of hands-on exercises that demonstrated the fundamental concepts of Distributed High-Throughput Computing (DHTC), such as sustained computation, reliability, and workflow management. While many of these concepts were new to most students, they began to pick up on the concepts and to understand how these computing resources could be used to further their own research.

The final example the students worked through was to use a program called ROOT to perform an analysis of actual data from the LHC at CERN. This exercise depicted just a small part of the massive workflow that the LHC experiment uses to analyze their data. Students were able to see the results on their computers as their Grid computing jobs complete and return the outcome.

Good coordination with the local computing administrators and additional work by lecturers done remotely prior to the school led to a smooth roll out of the CentOS6 Linux system to all computers used by the students. The exercises ran without delay or issue during the school because of these efforts.

Theoretical and experimental topics were included in practical sessions on doing event generation and Monte Carlo simulation (using GEANT-4 [7]) on the Grid. Introduction to the data analysis framework ROOT [8] and practical sessions on data analysis on the Grid, using ROOT were covered.

4.3 Workshop for High School Teachers

A parallel scientific program was organized for high school teachers. The objective was to support teachers growth in the planning and delivery of instructions in physics and mathematics. Sixty-two high school teachers from Namibia attended a one-week workshop on July 2–6, 2018. The participating high school teachers were selected by the local organizing committee and the Namibia Ministry of Education, Arts and Culture. The teachers were hosted at the UNAM dormitories and the scientific activities took at UNAM in parallel to the student program. The teachers also attended the *Physics Education* and *Physics Communication* sessions of the ASP conference, and one of the teachers served on a panel for discussions on science education and capacity development in Africa. Other details about the scientific program for the teachers can be found in Ref. [11].

4.4 Outreach for Secondary Schools

We also organized outreach programs for the 39 high schools in the Khomas region of Namibia during the week of July 9–12, 2018 [12]. The objective was to motivate pupils to develop or maintain interest in physics and related disciplines. Each of the high schools identified 40–50 pupils of the tenth to the twelfth grade to participate in the programs. This amounted to upwards of one thousand-five-hundred pupils. In order to effectively cover that large number of pupils in one week, four of the high schools were selected as the venues, namely Windhoek, Shifidi, Chairman MDSS, and Concordia College High Schools. We visited one of these venues a day. The pupils from five or six high schools congregated at the venue that we visited on that day, in the morning and a different set of five or six high schools in the afternoon. This allowed for a coverage of about ten high schools in day for a fixed program of four hours in the mornings and in the afternoons. As a result, each session in the morning or afternoon contained on average 200–250 pupils. A group of five or six lecturers, supported by members of the local organizing committee, covered each of of the high school sessions. Details on the scientific program for pupils can be found in Ref. [12].

4.5 ASP Conference

An international conference was also organized on June 28–July 4, 2018 with the objective to attract ASP student alumni, African research faculties to present and discuss their research work, network and establish new collaborations with other participants. The conference attracted about sixty extra international participants—in addition to the lecturers, selected students, and high school teachers—that might not have attended ASP2018. Indeed, given the volume of student applications, former ASP participants have low priority to be selected for the current edition of the school. Also, African research faculties that are not invited lecturers have no opportunity to attend ASP. The conference addresses these concerns by providing a platform of an international gathering of experts with interactions and networking with ASP selected students and high school teachers. The scientific program at the conference included invited and contributed talks in nuclear & particle physics, astrophysics & cosmology, accelerator, radiation & medical physics, renewable energies & energy efficiency, material physics, high performance computing, physics education and physics communication. Since the students and teachers programs were designed along the same topics, the ASP conference provided additional plenary, discussion and poster sessions to support the pedagogical activities of the students and the high school teachers. The Namibia Deputy Minister of High Education, Training and Innovation (HETI) gave the guest of honor address during the opening session of the conference. The proceedings of the ASP conference are in preparation to be published as a special issue of the African Review of Physics [13]. Further details on the ASP conference can be found in Ref. [14].

4.6 Discussion Sessions

Some of the academic lectures were organized as discussion sessions. The students were divided into two small groups. 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 a few lecturers. The topics that were not sufficiently addressed during the lectures were assigned as homework to be researched further, and covered 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 participation in the discussions.

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

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

Similar discussion session sessions were also carried out during the workshop for the high school teachers and the outreach to the secondary schools.

4.7 Practical Sessions

To complement the lectures, practical exercises and tutorials were organized, on Monte Carlo event generators, GEANT-4 [7] and FLUKA [15, 16] simulations, on data acquisition and on data analysis in ROOT [8], 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 detector simulations not only in nuclear and particle physics but also in related applications such as medical physics, the use of ROOT as a data analysis took kit, and the use of the Grid for high performance computing.

Demonstrations of the usage of cloud chambers as a simple example of particle detectors were carried out for students, teachers and high school learners. The high school teachers were introduced to mathematical teaching tools based on the Raspberry Pi. Particle physics masterclasses were organized for students and high school teachers.

These sessions have been highly appreciated by the participants 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 participants 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 participants were very lively and enthusiast in participating in these practical sessions.

The hands-on experience has been invaluable in helping the participants 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 the participants to discuss and interact more among themselves.

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

4.8 Student Poster and Oral Presentations

The students were encouraged to prepare posters on their current research activities. Some of the students brought their posters with them to Windhoek. Other posters were printed during the school. Poster session was integrated with the ASP conference. The students were able to display their posters for several days to allow all the participants to learn more about their research projects. Lecturers were assigned to review the posters and select the three best ones. The criteria for selecting the three best posters consisted of: the clarity of the poster, the contribution of the student to the research presented in the poster, and the student's oral description and presentation of the poster.

The three students with the best posters were awarded a scholarship in the amount of €1000 each to be used for one or the combination of:

- academic travel costs, to a conference, workshop or school relevant to the student;
- or participation in the next school, ASP2020, to mentor the new students.

To be eligible to receive this award, the student must still be enrolled in an academic institution, working towards an academic degree or training. The €3000 reserved for the student poster awards are reflected in Table 3.

Some students also gave oral presentations of their research work as contributed talks during the ASP conference, and also during the third week of the school. This provided an opportunity to know more about the students in order to design an effective mentorship program. Three students with the best oral presentations were also allocated €1000 each as described above for the poster awards.

4.9 ASP Forum

The Outreach/ASP Forum [17] was held on July 4, 2018, 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 Namibia and Africa in general.

The Namibia Depute Minister of Education, Arts and Culture gave an inspiring speech highlighting the prime importance of education as vector of development in Africa. Education and outreach efforts by the ICTP were presented. Feedback from the participating students were also discussed. The ASP mentorship program was introduced. Some of the other topics discussed during the ASP Forum included the South Africa–CERN program, and beyond capacity development for the retention of trained African nationals with African institutes.

4.10 Excursions and School Dinner

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, Namibia.

There were organized excursions to the Okapuka Ranch [18] on June 30, 2018, and also to see the H.E.S.S. telescopes [19] on July 7, 2018.

The European Union (EU) Delegation in Namibia helped sponsor the school dinner during the evening following the ASP Forum [17], on July 4, 2018. It consisted of a buffet meal of a variety of dishes that catered also to the need of vegetarian participants. During the dinner, the head of the EU delegation in Namibia gave an inspiring talk to motivate the participants.

5 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 through the mentorship program.

5.1 Balancing the Budget

The main priority of the budget was to:

- organize and run ASP2018 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.

As shown in Table 1 and Table 3, the estimated budget covered very well all the expenses of the school. Most of the support received for ASP2018 were used towards student participation and expenses as can be seen in Table 3. There is a surplus of about €23000. This is due to the fact that our original budget was for 85 selected students but 14 students declined the invitation or could not attend ASP2018 because visa or personal problems, or opted to attend a different education program. We were able to replaced 2 declinations from the waiting list in time but it was too late to replace all the declinations. Of the 12 students that did not attend ASP2018, two were Namibians, one Palestinian and the rest from other African countries. The expected coverage for the twelve students that could not attend ASP2018 was about €21000. The actual expected surplus to cover contingencies was about €2000. We propose to use the surplus of funds to invite ASP student alumni to attend the ASP conference during ASP2020.

5.2 Feedback

The ASP2018 experience was extremely valuable for all the participants. The inspirational enthusiasm of the participants at ASP2018 exceeded our expectation and we have received much positive and constructive feedback. Some feedback from the participants is available in Refs. [20].

Table 3: Summary of the expenditures made from the base budget of ASP2018 as described in Table 1. The lecturers travel and accommodation costs covered by external sources as described in Table 2 are not reported here.

Expenses (€)	
School Running Costs	**71694**
Students & teachers lodging accommodation	N$252327 (15210)
Catering	N$606217 (36513)
Lecturers accommodation	N$67060 (4143)
Entrance visa fees	N$58750 (3629)
Local transportation	N$52722 (3190)
Dry ice and Isopropyl alcohol	N$1645 (102)
Medications & medical bills	N$10054 (621)
Coverage for LOC support staff	N$73550 (3332)
Excursion	N$14700 (908)
Promotional items (Spice Corporate Namibia)	N$36327 (2242)
Custom and duty charges on equipment	N$28167 (1736)
LOC telephone calls	N$1080 (67)
Travel Costs	**56129**
Students	45238
Lecturers & invited speakers	10891
Experimental Physics Equipment	**$3992 (3519)**
Other Expenditures and Overheads	**1309**
USB memory sticks & protractors	$403 (355)
Shipping	$265 (234)
ASP2018 poster printing & distribution	R12048 (720)
School Dinner & Entertainment	**N$61828 (3725)**
Awards for the 3 Best Student Posters	**3000**
Awards for the 3 Best Student Oral Presentations	**3000**
Total Expenses 142376 **Twelve student declinations 20932** **Total Budget 165467**	
Expected Surplus	**2159**

5.2.1 Feedback From Students

In order to understand the impact of ASP2018 from the student 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 shared their feedback through personal emails to the organizers. The following is a summary of these surveys and feedback. Fifty-six of the seventy-one students responded to the surveys.

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 ASP2018, most of the students were expecting to learn more about the international physics community, to make contacts through networking with lecturers and to get more information about scholarship and fellowship opportunities. 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 summarized in Fig. 7.

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. The student's level of satisfaction is shown in Fig. 8.

In response to whether or not the students are interested in scholarship opportunities, most of them stated that they would be interested in fellowship opportunities in North America, Asia, Europe and Africa, see Fig. 9.

Figures 10 summarizes 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 ASP2018 is shown in Fig. 12.

A large number of the lecturers were fluent in English and French, and when necessary took questions ans answered in French. This improved greatly the understanding of French speaking students as shown in Fig. 13.

5.2.2 Feedback From High School Teachers

In a survey at the end of the workshop, similar to the students survey described in Section 5.2.1, high school teachers were asked to rate aspects of the workshop from 1 to 5, with 5 being the highest rating. Almost all of the responses were 4's and 5's with only 10% of responses less than these; the most common response was 4. The teachers overall rating for the workshop is shown in Figure 14.

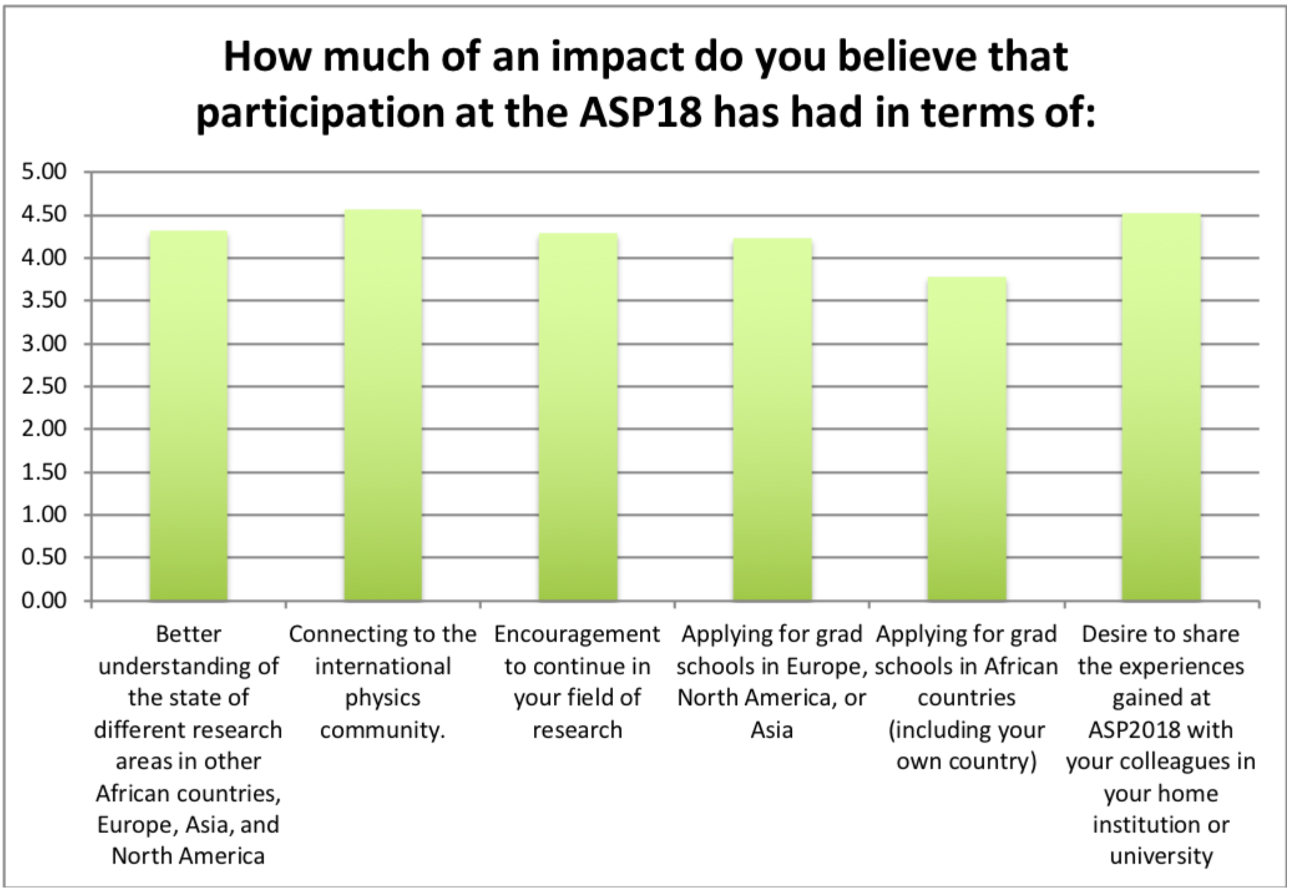


Figure 7: Impact of ASP2018 on the students. The students asked: "On a scale of 1 to 5; where 1 is not impact at all, 3 is somewhat of an impact, and 5 is a major impact; how much of an impact do you believe that participation at the ASP2018 as had in term of..."

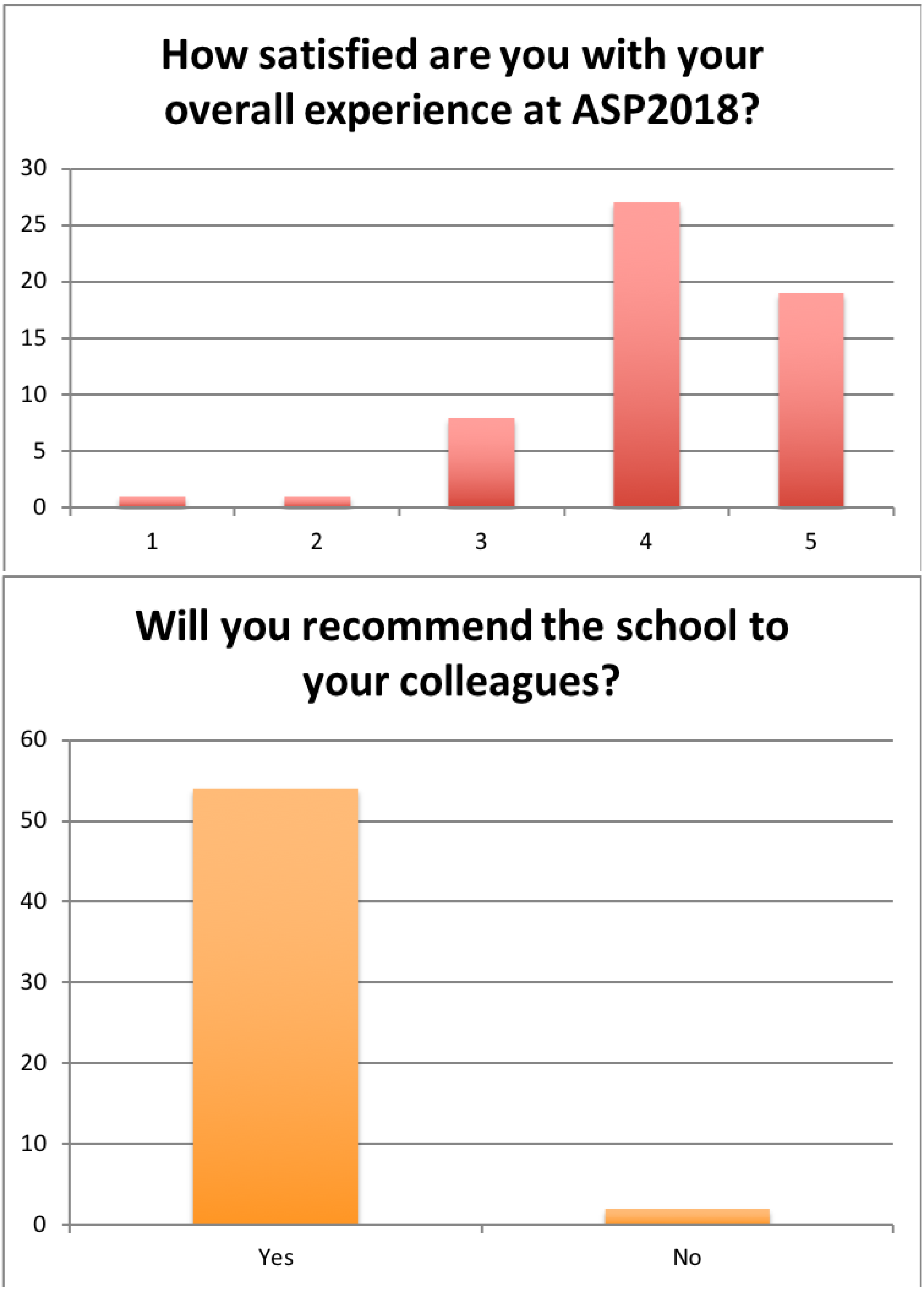
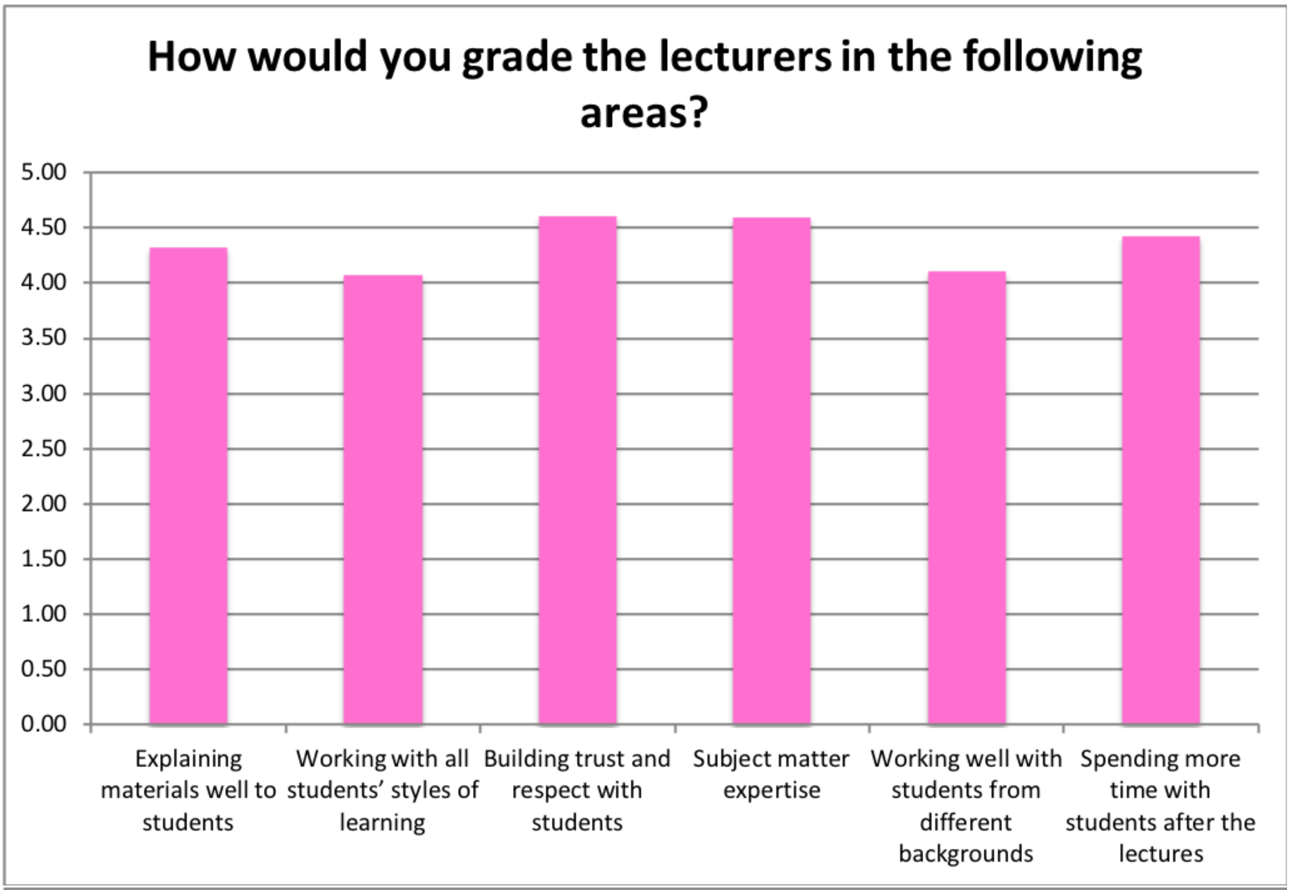


Figure 8: Satisfaction of the students and their willingness to attend the school again. In the top plot, the students were asked: "On a scale of 1 to 5; where 1 is not satisfied, 3 is somewhat satisfied, and 5 is very satisfied; how satisfied are you with your overall experience at ASP2018?" In the bottom plot, the students were asked: "Will you recommend the school to your colleagues?"

Figure 9: Student interest in fellowships and scholarships. Here the students were asked: “Are you interested in fellowships/scholarship opportunities?”



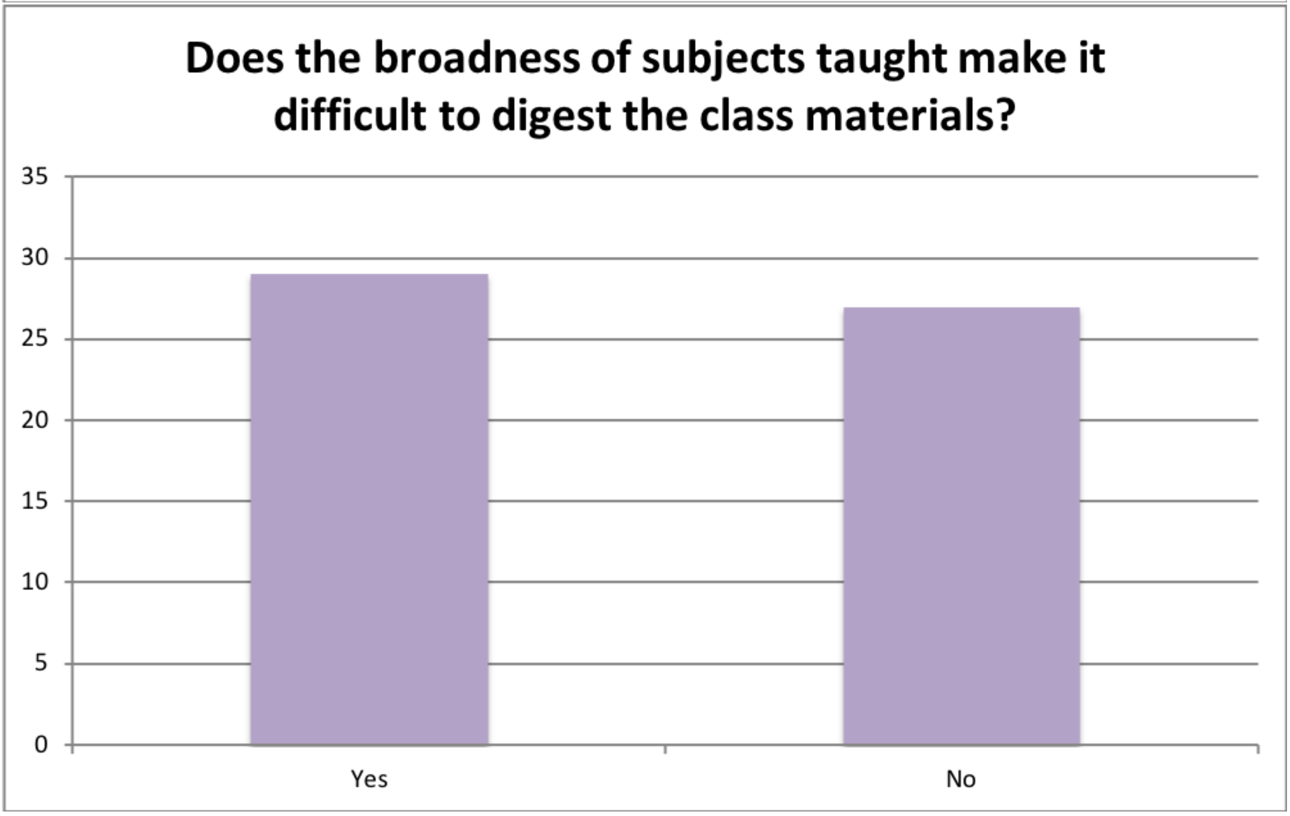


Figure 10: Student feedback on lecturers. In the top plot, the students were asked: "On a scale of 1 to 5; where 1 is terrible, 3 is good, and 5 is great; how would you grade the lecturers in the following areas?". In the bottom plot: "Does the broadness of subjects taught make it difficult to digest the class materials?"

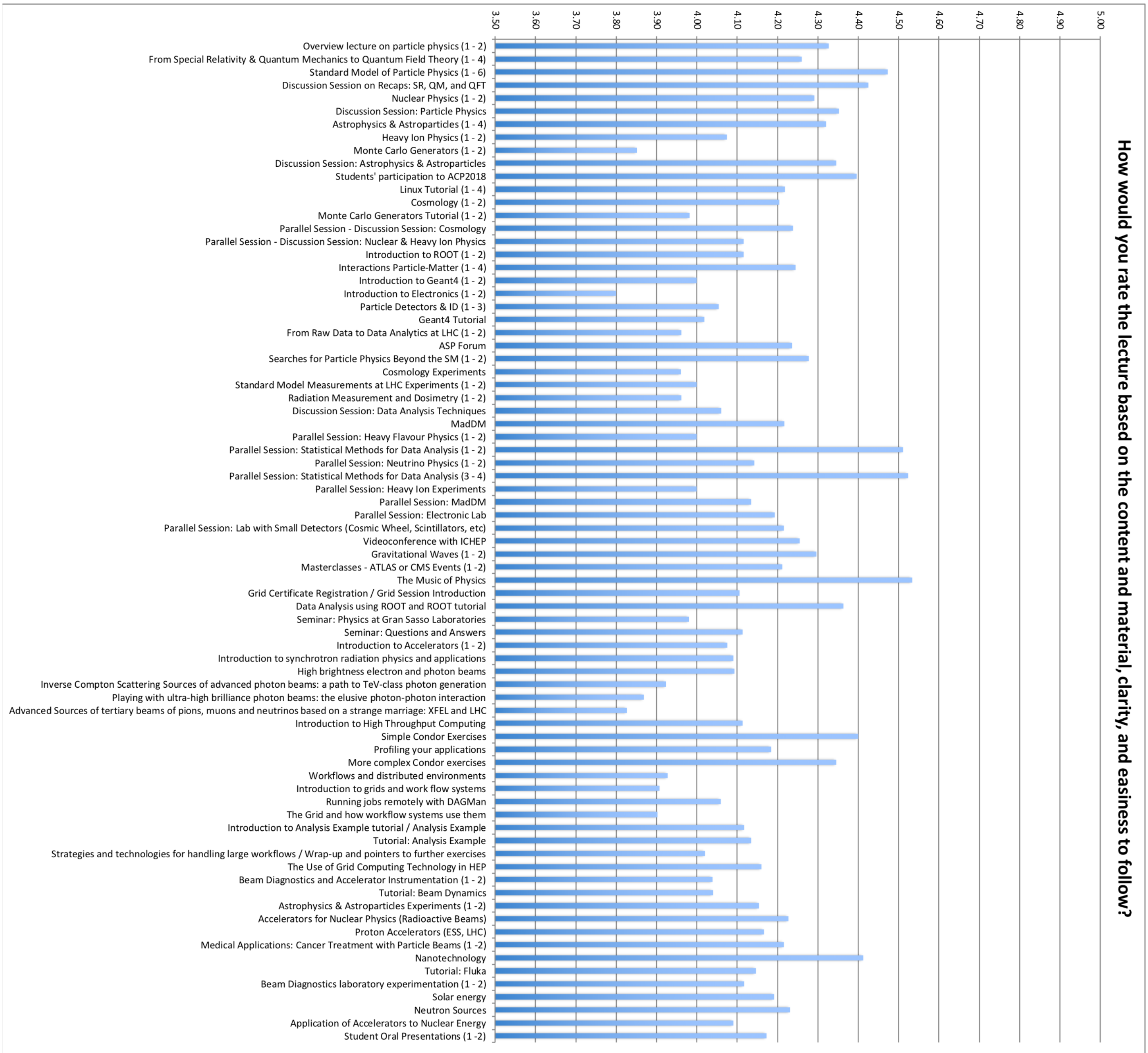


Figure 11: Student feedback on each of the lectures and discussion sessions. The students were asked: "On a scale of 1 to 5, where 1 is terrible, 3 is good, and 5 is great, how would you rate the lecture based on the content and material, clarity and easiness to follow?"

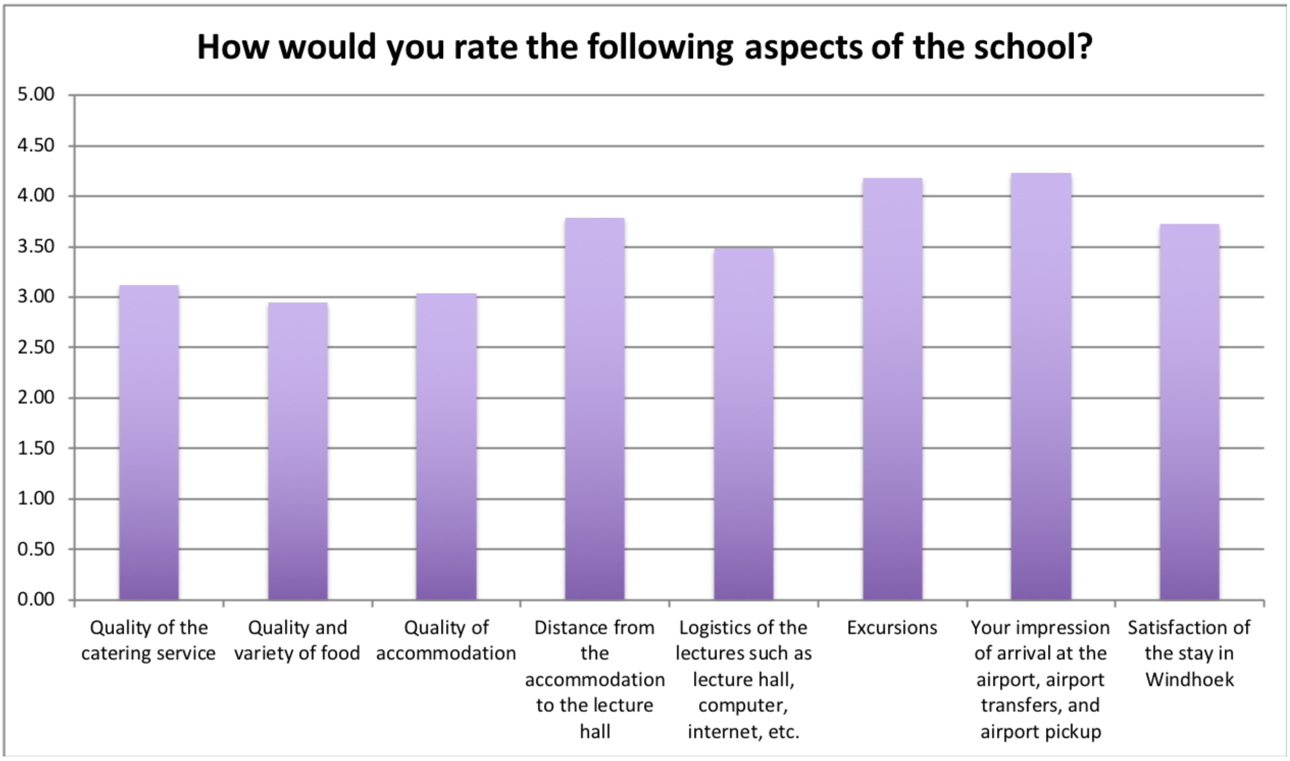


Figure 12: Student feedback on the various aspects of the school. The students were asked: "On a scale of 1 to 5; where 1 is terrible, 3 is good, and 5 is great; how would you rate the following aspects of the school?"

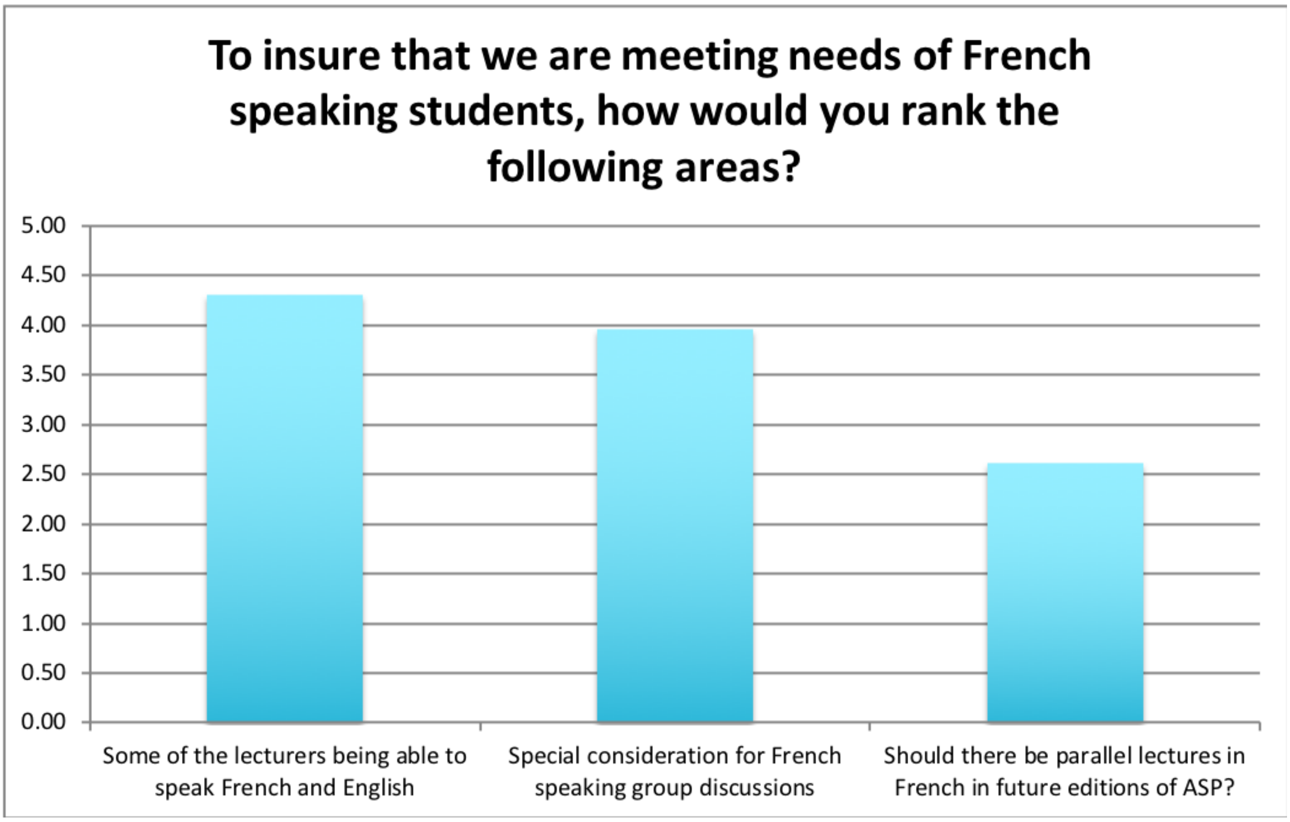


Figure 13: Lecturer's fluency in both English and French greatly improved the participation of the students.

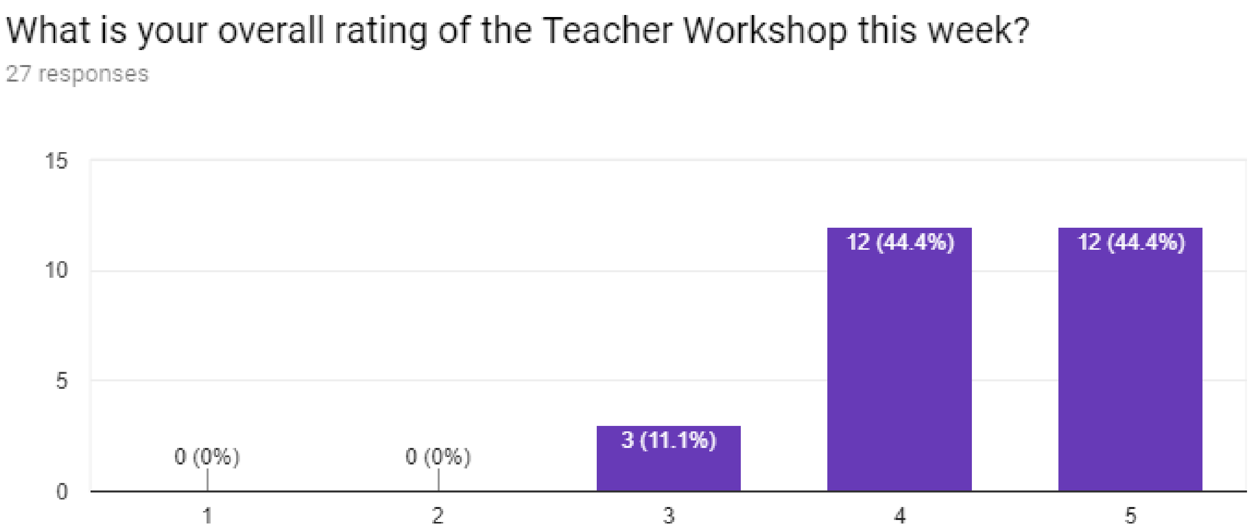


Figure 14: The overall impression of the high school teachers regarding the teachers workshop.

Teachers were also able to leave comments. The most relevant and useful were:

- the content of the workshop was extremely beyond our curriculum and level of understanding. It could have been interesting if one had a theoretical background of what was being discussed;
- the workshop was well organised and we learned a lot on the fundamental physics which can be used to introduce physics topics to the pupils;
- we think that there is a need for further workshops of this kind to equip teachers with advanced knowledge and skills;
- such types of workshops are more needed to update us on new developments (discoveries) in physics;
- some were initially overwhelmed with all the new terms and topics but as the workshop continued, it started to grow on them, and they really enjoyed learning new things throughout the week.

5.3 Maintaining Contacts with Students

5.3.1 Networking

It was emphasized 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 ASP2018, by sharing with the students the websites where typically doctoral and post-doctoral research positions are publicly advertised, and by organizing a dedicated session on how to apply for high education opportunities and alternative career choices.

In order to retain contact with the students, a email group list was set-up through CERN [21] and a social networking Facebook page [22] 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 ASP2010–18.

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, and to solicit institutional feedback on the impact of ASP.

5.3.2 ASP Mentorship Program

After each edition of ASP, and between consecutive editions, hence continually, the IOC manages a mentoring and coaching program for ASP student alumni. This is done in collaboration with the academic advisers of the students. The student alumni are paired up different ASP lecturers whose roles are to follow the academic progress of the students and help as much as possible in the academic development of the students. This program allows the ASP organizers to maintain contacts with the students after their participation in the school. Many ASP alumni are currently benefiting from this organized support structure that also allows the IOC to better answer the question: *"What happens to the students after their participation in an edition of ASP?"*

It is often the case that passing on knowledge is one of the greatest challenges facing human kind today. While it is hard to pass on, when well directed, passing on Knowledge can be very successful tool of achieving greatest goals. While experience is the best teacher, attentiveness can take us to greater and advanced degree of knowledge. Learning is a cognitive process that involves management of ones abilities through effective processes.

The objective of the mentorship program is to aid mainly PhD students after their participation in ASP to reach their goal of completing their PhD with assigned ASP lecturers as mentors. The ASP mentors are not replacements or substitutes of the students academics advisers. Rather, ASP mentors work together with students academic advisers for greater impact. The ASP mentors are volunteers physicists that have lectured at one of the previous editions of ASP.

The student are selected after satisfying a comprehensive application process. Through the mentorship program, it is possible to:

- gauge the impact of ASP;
- support ASP student alumni;
- identify obstacles;
- study problem solving trends;
- help manage, direct and differentiate between the different types of supports;
- identify more physics research and education related challenges in Africa.

The ASP mentorship program was formalized soon after ASP2016. Currently, 22 ASP alumni studentsgoing back all the way to ASP2010, and 19 ASP lecturers are involved in the program as mentors. A new cycle of the mentorship program is being initiated after ASP2018.

6 Outlook

The success of the school is due to the financial support from various institutes in the USA, Europe, Asia and Africa, to the dedication of the organizing 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 organizing 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 ASP2018 organizing committee to 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. 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 organization of ASP2010–18, the current success, although encouraging, is rather limited in scope. Firstly, the school resources only allowed for 85 students to be accommodated in ASP2018. 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. About thirty other good students could not attend the school due to logistical constraints and late declinations that could not be replaced promptly. 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. All these are not a failure of ASP2018 but rather a motivation to work harder towards the original objectives by organizing the school again in the future, and in doing so, truly contribute in a significant way to development in Africa.

To improve the organization of future ASP, it is desirable to:

- have a unique venue for all the ASP events, some of which may be occurring in parallel;
- achieve a better integration of the ASP scientific program so the ASP conference, the students, the high school teachers and the learners programs support each other for increased networking and sharing of knowledge and expertise;
- establish a procedure where late student declinations can still be replaced from the student waiting list.

To build up on the successes of ASP2010–18, the organizing committee proposes the firth edition of the school in 2020, ASP2020, but in a different African country. The committee had already explored this option and Morocco was selected to host ASP2020.

7 Conclusions

For the past few years, a group of local and international organizing committee members have worked hard to prepare for the fifth biennial school of fundamental physics and its application in Africa. Finally, the efforts of the organizing committee and all the supporting institutes and concerned individuals paid off and the school took place in Windhoek Namibia on June 24–July 14 2018. A total of seventy-one students from all over Africa (one from the USA) attended the school. Sixty-two high school teachers from all over Namibia attended a one-week workshop designed to improved their physics teaching skills. A one-week outreach was also organized with the participation of over one thousand-twelve-hundred pupils from the thirty-nine high schools of the Khomas region of Namibia. The scientific program was complemented with a one-week physics conference to draw the participation of ASP alumni and African research faculties that could not have otherwise attended ASP2018. A forum was also organized to discuss capacity development in Africa and how ASP can better support the education and research priorities of African countries. There was also the participation of high profile international and local lecturers, and speakers who prepared and presented the materials taught during the school.

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

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Thanks also to the lecturers and speakers for helping with the scientific program, the selection of students, and for the courses prepared and taught at the ASP2018, for the clarity of the materials presented to the participants and for their availability during discussion and practical sessions to interact further with the participants.

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Finally, we thank each member of the organizing 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] K. A. Assamagan et al., *African School of Fundamental Physics and Applications*, Available from http://www.africanschoolofphysics.org, 2018.

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

[3] K. A. Assamagan et al., *African School of Fundamental Physics and Applications*, Available from http://www.africanschoolofphysics.org, 2012.

[4] K. A. Assamagan et al., *African School of Fundamental Physics and Applications*, Available from http://www.africanschoolofphysics.org, 2014.

[5] K. A. Assamagan et al., *African School of Fundamental Physics and Applications*, Available from http://www.africanschoolofphysics.org, 2016.

[6] *The Abdus Salam International Centre for Theoretical Physics*, Available from http://www.ictp.it/.

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

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

[9] S. G. Muanza et al., *Agenda of the ASP Conference*, Available from https://indico.cern.ch/event/656460/, 2018.

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

[11] K. A. Assamagan et al., *ASP2018 Agenda of the Teachers Workshop*, Available from https://indico.cern.ch/event/667954/, 2018.

[12] K. A. Assamagan et al., *ASP2018 Agenda of the Outreach to Secondary Schools*, Available from https://indico.cern.ch/event/667966/, 2018.

[13] ICTP, *The African Review of Physics*, Available from https://www.ictp.it/programmes/outreach-activities/african-review-of-physics.aspx.

[14] K. A. Assamagan et al., *Agenda of the ASP Conference*, Available from https://indico.cern.ch/event/667667/, 2018.

[15] T. Bohlen, F. Cerutti, M. Chin, A. Fassò, A. Ferrari, P. Ortega, A. Mairani, P. Sala, G. Smirnov, and V. Vlachoudis, *The FLUKA Code: Developments and Challenges for High Energy and Medical Applications*, Nuclear Data Sheets **120** (2014) 211–214.

[16] A. Ferrari, P. R. Sala, A. Fasso, and J. Ranft, *FLUKA: a multi-particle transport code*, CERN 2005-10 (2005), INFN/TC 05/11, SLAC-R-773 .

[17] *ASP2018 Forum*, Available from https://indico.cern.ch/event/667816/.

[18] Namibia Tourism, *Okapuka Ranch, Windhoek Namibia*, Available from http://www.okapuka-ranch.com/.

[19] H.E.S.S. Collaboration, *High Energy Stereoscopic System*, Available from https://www.mpi-hd.mpg.de/hfm/hess//.

[20] *African School of Physics, feedback from participants*, Available from http://africanschoolofphysics.blogspot.com/.

[21] *Email List maintained by the International Organizing Committee of ASP through CERN*, ASP-Students-Network@cern.ch.

[22] *African-School-of-Physics: Facebook Page*, Available from https://www.facebook.com/groups/africanschoolofphysics.

685 # A Selected Photographs of ASP2018

Figure 15: Group photograph of students and lecturers in the first week of ASP2018. Courtesy of Gilbert Tékouté.

Figure 16: Photograph of high school teachers and lecturers during the second week of ASP2018. Courtesy of Gilbert Tékouté.

Figure 17: Photograph of high school learners and lecturers during the third week of ASP2018. Courtesy of Gilbert Tékouté.

Figure 18: Photograph of participants at the ASP2018 conference. Courtesy of Gilbert Tékouté.