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# Statistics on participation of emerging and developing countries in LHC and other experiments

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International by nature, the scientific collaborations working for the Large Hadron Collider (LHC) at CERN, as well as other experiments count a small presence of emerging and developing countries. After exposing the metrics of country classification, the cases of the ATLAS and CMS Experiments will be presented, along with a brief mention of the DUNE Collaboration. Several initiatives and programmes are key game changers to grow the starting efforts. The talk gives as conclusions several recommendations on how – at both institutional and individual levels – the current landscape can be changed. More diversity and inclusion are assets in scientific endeavours, and for people from the developing world, this means nothing more than life-changing opportunities.

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## 1. Introduction

Important scientific endeavours such as the main experiments of the Large Hadron Collider invariably rely on extensive collaboration, often described as international. Yet, most participating countries are developed ones, with governments dedicating significant budgets for fundamental research. What about emerging and developing countries? After presenting the metrics for "country tagging," the situations in the ATLAS and CMS Collaborations will be described. The case of the Deep Underground Neutrino Experiment (DUNE) will also be mentioned. The final section introduces several game changers: initiatives, schools and institutes that are transforming the landscape and giving opportunities to talented young scientists from the Global South eager to take part and contribute to subatomic science.

## 2. Country classification

There is no clear agreement on what exactly a developing country is. The World Bank assigns the world's economies to four income groups – low, lower-middle, upper-middle, and high income – based on the Gross National Income (GNI), an alternative economic statistic that supersedes the Gross National Product. The low-income countries fall below a GNI of $1,046 (USD in all the following) while the lower-middle countries are between $1,046 and $4,096. The upper-middle category follows up to a GNI of $12,696, above which we have then high-income – aka rich – countries (see Figure 1). It is to be noted that the term "Third World" is not an economical but rather a political term from the Cold War. The United Nations Conference on Trade and Development (UNCTAD) maintains a list of "Least Developed Countries," reviewed every three years by the United Nations' Economic and Social Council (ECOSOC). It is based on three groups of criteria: income via the GNI per capita, human assets (mortality rate, school enrolment ratio and literacy rate) and economic and environmental vulnerability index (share of agriculture in GDP, stability of exports, share of population living in disaster-prone zones). In 2023, 45 economies designated by the United Nations belong to the Least Developed Countries (33 in Africa) [2].

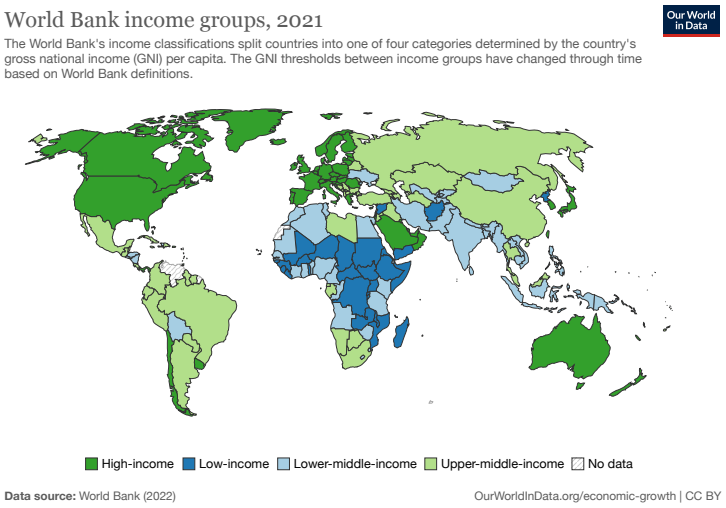


**Figure 1:** Classification of countries according to the World Bank. Low and lower-middle countries are considered developed countries. More information in text. Source: Our World In Data [1].

Nations facing economic challenges find it difficult to reach the scientific output of wealthy countries. This is notably discernible in the number of scientific papers published: in 2016, the number of articles published in the whole Africa and Central America continents represents 2% and 3% respectively of the total amount of publications worldwide (2.2 millions) [3].

## 3. Cases of the ATLAS and CMS Experiments

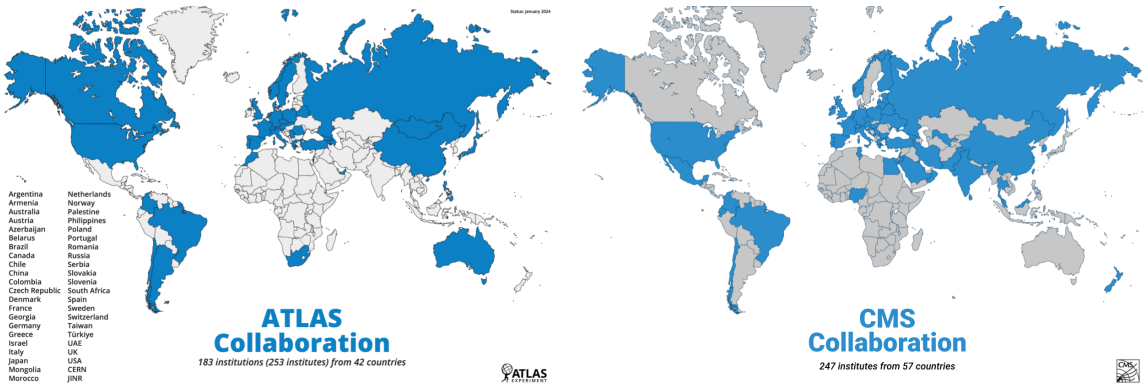


**Figure 2:** Maps showing the participating countries of the ATLAS (left) and CMS (right) Collaborations.

The ATLAS Collaboration counts 3000 authors from 253 institutes and 42 countries (see left map on Figure 2). The developed countries represent 55%, emerging countries 14% and developing countries 31% (none being LDCs). While the latter make almost a third of the participation in number, it is to be noted that the affiliated scientists are only 5% of the ATLAS members and 4% are authors. In Africa, the Moroccan cluster - born in 1996 with a working group between teams in Rabat, Casablanca and the Université de Grenoble in France - now counts seven institutes and 56 members, including 25 authors. The other cluster in the continent is South Africa, created in 2010 via an association with Brookhaven National Laboratory. It also counts seven institutes (one associate) and 97 members, including 26 authors. Both groups are actively contributing in ATLAS Phase-II Upgrade for the High-Luminosity LHC. South Africa has been a member of ALICE (since 2001) and ISOLDE Collaborations.

The CMS Collaboration lists 3394 physicists affiliated with 247 institutes from 57 countries and regions (see right map on Figure 2). 5.6% of CMS authors are from developing countries. In the database of talks and posters presented at major conferences (more than 2500 entries over 15 years), the average number of talks and posters per physicist or PhD student is 1.14 [6]. Half of the countries with the lowest average (below 0.25 for talks) are developing countries. Since 2021, newcomers such as Tunisia joined, as well as Nigeria, the first country in the South of Sub-Saharan Africa to partner with CMS and CERN [7].

## 4. Participation in neutrino science with DUNE

The Deep Underground Neutrino Experiment (DUNE) Collaboration comprises more than 1,400 collaborators from more than 200 institutions in over 35 countries. Madagascar, classified as Least Developed Country, is the only African country that joined in 2015. Physicists Rakotondravohitra and Martinez have been working hard to support students from Madagascar and Colombia, their respective countries [8].

## 5. The game changers: it is all about connections

Several actors have emerged to bring more members from developed countries in cutting-edge science. The African Strategy for Fundamental and Applied Physics (ASFAP), a recent initiative

proposed in 2020, aims at increasing African education and research capabilities, engaging African scientists. It will release a strategy report to define the most impactful physics priorities for Africa [9]. Topical schools organised and hosted by developing countries play an essential role in triggering interest and offering attendees the opportunities to learn and network (see Figure 3). The BCVSPIN – an acronym denoting Bangladesh, China, Vietnam, Sri Lanka, Pakistan, India and Nepal – summer schools were inaugurated in 1989 [10]. The CERN Latin American School of High Energy Physics (CLASHEP) started in 2001 [11]. The African School of Physics (ASP) in Africa had its first edition in 2010 [12]. The two latter schools are detailed in this Snowmass paper [13], that highlights engagements that can benefit US but most examples are non-US centric. Another game changer is the African Institute for Mathematical Sciences (AIMS), a "pan-African network of centres of excellence enabling Africa's talented students to become innovators driving the continent's scientific, educational and economic self-sufficiency" [14].


**Figure 3:** Posters of the 2022 and 2023 editions of summer schools ASP (left), CLASHEP (middle) and BCVSPIN (right) schools happening in Africa, Latin-America, and Asia respectively. More information in text.

## 6. Takeaways

Despite the small presence of developing countries in large scientific collaborations, more and more countries are joining. Takeaways are in the form of recommendations at two levels: institutional and individual. At the institute level, it is essential to have more partner universities or laboratories such as Université de Grenoble and BNL to kickstart efforts. We need special treatment to welcome countries with very low or zero budgets. The synergies between CERN and AIMS, ASFAP, ASP, BCVSPIN, CLASHEP, etc should be fortified. At the individual level, every scientist can play a role: it starts by advertising events, schools or special programmes to one's circles. A small gesture consisting of donating an old computer can make a difference, all the more if the charitable organisation is founded by CERN alumni [15]. Joining or initiating research supervision with students from developing countries as well as volunteering to teach in the developing world is welcome, as it has the potential to be life-changing for talented minds aspiring to become the scientists of tomorrow.

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