High Energy Physics: A Solution to our Major Environmental, Foreign Medical Tourism and National Security Concerns as a Nation

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Abstract
The deplorable state of our environment, the huge amount of money spent on foreign medical tourisms and pace of killings by Boko Haram, alleged Herdsmen and Militants have been sources of major concerns and threat to the existences of our dear country Nigeria. Several efforts and strategies have been employed by successive government for years in finding solutions to address these menaces but none has yielded sustainable results. This research elucidates how High Energy Physics (HEP) can be of a sustainable solution to these problems. The fundamentals of the standard models were formerly considered and the basic constituents of matter with their interacting forces known. Afterward, the various achievements of High Energy Physics (HEP) detailed with respect to advances and benefits derived by developed countries in match with the problems. It was observed that the desire for knowledge is a profound human instinct and knowledge of the universe at the most basic level is one prerequisite of our existence; HEP and physicist are critical and central in providing solutions to our major environmental, national security and foreign medical tourism concern as a nation. HEP technologies are already contributing to making the world safer.

Key Words: *High Energy Physics (HEP), Environmental Monitoring, Foreign Medical Tourism, National security.*

Introduction

High Energy Physics (HEP) investigates the universe by understanding the basic constituents of matter and radiation, probing the interactions between them, and exploring the basic nature of space and time. Like other basic sciences, it relies on innovative tools, technologies, and techniques to accomplish its mission through experiments, theories, simulations, and computations. It seeks to understand the evolution of the Universe in the first fraction of a second after its birth in the Big Bang in terms of a small number of fundamental particles and forces. The processes involved ultimately resulted in the creation of atoms and the complex molecules that led to our existence. In context, these basic constituents of matter are referred to as the irreducible smallest detectable particles not composed of other particles and whose fundamental forces are necessary to explain their behaviours. Invariably, all theoretical and applied sciences are derived from the study of the fundamental particles and their investigations have found wide uses in society (Boyarkin, 2011; BNL, 2012; Demarteau *et al*, 2016).
Fundamental particles are either the building blocks of matter, called fermions (Leptons and quarks) or the mediators of interactions, called boson. These are mainly subatomic particles including atomic constituents such as electrons, protons and neutrons, baryons (protons and neutrons composites) made of quarks produced by radioactive and scattering processes including photons, neutrinos, and muons as well as wide range of exotic particles. These particles are mainly excitation of quantum fields that governs their interaction, thus, their name field quanta. They are dynamic in nature by exhibiting particle like behaviour under certain experimental conditions and wave like behaviour in others, which is wave-particle duality. In more technical terms, they are described as quantum state vectors in a Hilbert space (Donald, 2000; Kek, 2012).

Advanced particle accelerators, cutting-edge particle detectors, and sophisticated computing techniques are the hallmarks of High Energy Physics (HEP) research. Currently, these tools and technologies depend critically on advances from other fields, and their value extends to the society by integrating and probing deeply into matter and creating new particles. In the heart of HEP experiments short lived particles have to be identified with high demands on spatial resolution and timing where imaging detectors are the gigantic microscopes that allow their recognition (IAEA, 2010; Meng *et al*, 2015).

HEP has played a major role in the development of modern technology which includes the progresses in the microelectronics industry; photolithography and printed circuit technology that paved the road to the production of Micro Pattern Gaseous Detectors that now achieve unprecedented spatial resolution, high-rate capability, radiation hardness, high time resolutions and good counting rate; development of scintillating crystals. The intellectual curiosity embodied in HEP is also at the foundation of philosophy, art and other scientific disciplines which, together, have shaped the modern world. Without such innate curiosity, the modern world would not exist (Short, 2004; HNINP, 2016)

HEP challenges our preconceptions, inspires and seeks to move human knowledge forward at a basic level – wherever that may lead. These advances have been tapped by developed countries such as Japan, China, United State of America, and United Kingdom etc as means and tools for uncommon technology advancements through their various laboratories facilities and economic diversification to grow their gross domestic products (GDP) rapidly. Now that our dear country is in need of modern technological advances to surmount the threats from insecurity especially terrorist attacks from the Boko Haram and alleged Herdsmen in the northern parts and militants in the southern part; high level of poverty, diseases epidemics, very high rate of unemployment, corruptions, endless foreign medical tourisms and with all sorts of leadership and followership anomalies the benefits of application of High Energy Physics for the development of our nation cannot be overemphasized.

This paper begins with an overview of the standard model known as the basis of High Energy Physics followed by the presentation of the materials and methods employed in broad array of fields where high energy particle detector technologies are being developed and deployed before the discussions of the results from its application in environment, medicine; and national security.

The Standard Model

The standard model is an established and well-tested physics theory describing three of the four known in the universe as well as classifying all known fundamental particles (fermions, gauge bosons and the Higgs boson) which in turns can be distinguished by other characteristic such as colour charge (Figure 1 and 2). It was developed in stages throughout the latter half of the 20th century, through the work of many scientists around the world, with the current formulation being finalized in the mid-1970s upon experimental confirmation of the existence of quarks. Since then, confirmation of the top quarks (1995), the tau neutrino (2000), and the Higgs boson (2012) have added further credence to the Standard Model. In addition, the model has predicted various properties of weak neutral currents and the W and Z bosons with great accuracy (Oerter, 2006).

The Fermions are 12 elementary particles of spin½that is, each of the six having antiparticles; respect Pauli's exclusion principle and occur in two basic groups called quarks and leptons. Each group consists of six particles, which are related in pairs, or "generations". The lightest and most stable particles make up the first generation, whereas the heavier and less stable particles belong to the second and third generations. All stable matter in the universe is made from particles that belong to the first generation. Heavier particles quickly decay to the next most stable level. The six quarks are paired in the three generations – the "up quark" and the "down quark" form the first generation, followed by the "charm quark" and "strange quark", then the "top quark" and "bottom (or beauty) quark"(Oerter, 2006;Boyarkin,2011). The defining property of the quarks is that they carry colour charge and hence, interact via the strong interaction (Figure 2).

Quarks also come in three different "colours" and only mix in such ways as to form colourless objects .A phenomenon called colour confinement results in quarks being very strongly bound to one another, forming colour-neutral composite particles (hadrons) containing either a quark and an antiquark (mesons) or three quarks (baryons).

The familiar proton and neutron are the two baryons having the smallest mass. Quarks also carry electric charge and weak isospin. Hence, they interact with other fermions both electromagnetically and via the weak interactions (Donald, 2000; Close, 2004; Close*et al,* 2006).

The six leptons are similarly arranged in three generations – the "electron" and the "electron neutrino", the "muon" and the "muon neutrino", and the "tau" and the "tau neutrino". The electron, the muon and the tau all have an electric charge and a sizeable mass, whereas the neutrinos are electrically neutral and have very little mass (Figure1). The three neutrinos do not carry electric charge either, so their motion is directly influenced only by the weak nuclear forces, which makes them notoriously difficult to detect. However, by virtue of carrying an electric charge, the electron, muon, and tau all interact electromagnetically. Specifically, all atoms consist of electrons orbiting around atomic nuclei, ultimately constituted of up and down quarks. Second and third generation charged particles, on the other hand, decay with very short half-lives, and are observed only in very high-energy environments. Neutrinos of all generations also do not decay, and pervade the universe, but rarely interact with baryonic matter(Oerter, 2006, CERN, 2016).

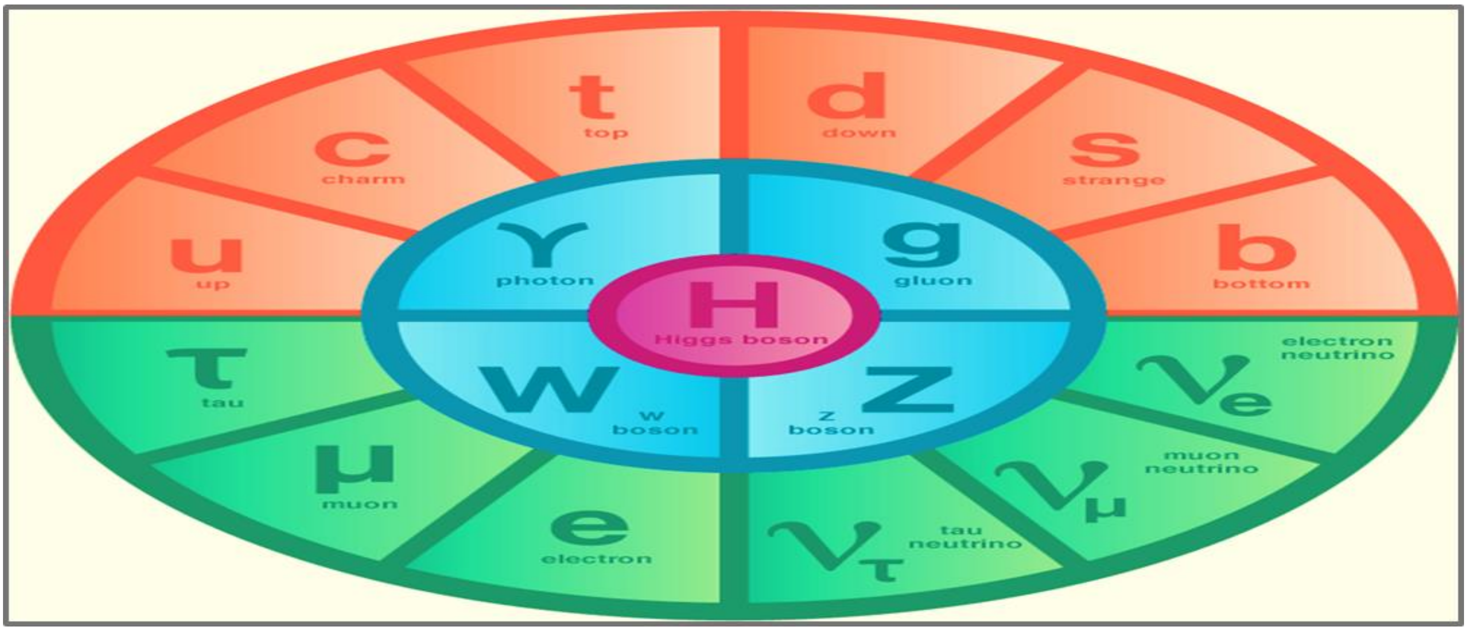


Figure 1: The Standard Model (Oerter, 2006)

The bosons are integer spin except Higgs, respect Bose-Einstein statistics and classified as gauge boson and scalar boson having non-zero spin and zero spin respectively. The gauge bosons are defined as force carriers or messenger particles that mediate the strong, weak, and electromagnetic interactions. In context, a force is described as an exchange of bosons between the objects affected, such as a photon for the electromagnetic force and a gluon for the strong interaction. The four fundamental forces are classified as the strong force, the weak force, the electromagnetic force and the force of gravity where the latest is hypothetical in the standard model due to its stochastic level of incompatibility in fitting into the framework of the model (Figure 2 and Table 1).The gauge bosons have spin (as do matter particles) of 1 and have no theoretical limit on their spatial density (CERN, 2016).

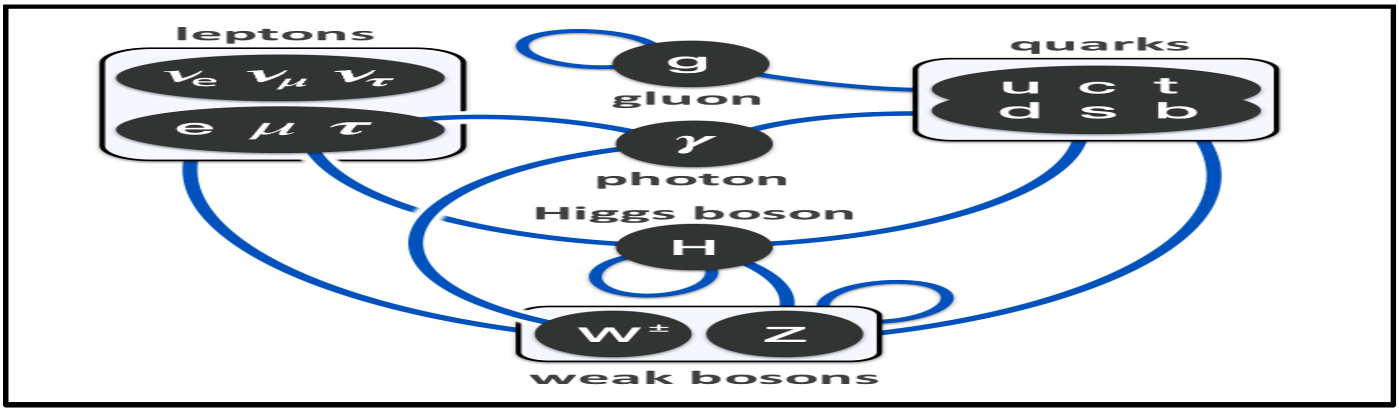


Figure 2: Summary of interactions between particles described by the Standard Model (Oerter, 2006**)**

The forces have variable strengths and ranges. Both the electromagnetic force and the force of gravity have infinite ranges but the latter is weakest among the four. The strong and weak forces are only effective at very short range precisely in the subatomic. The weak forces are stronger than gravity but the weakest among the other three while the strong force is the strongest of all the fundamental interactions. Three of these forces are derived from the exchange of force-carriers particles that are called bosons. Particles of matter transfer discrete amounts of energy by exchanging bosons with each other. Each fundamental force has its own corresponding boson – the strong force is carried by the "gluon" which is of eight types. The eight gluons mediate the strong interaction between colour charges (the quarks). Gluons are massless. The eightfold multiplicity of gluons is labelled by a combination of colour and anti colour charge (e.g. red–antigreen). Because the gluons have an effective colour charge, they can also interact among themselves. The gluons and their interactions are described by the theory of quantum chromo dynamics. The electromagnetic force is carried by the "photon", and the "W and Z bosons" in the form W+, W-, Z known as weak boson (Figure 2) are responsible for the weak force. Hypothetically, the graviton may be the force-carrying particle of the force of gravity (Oerter, 2006; CERN, 2016).

The Higgs boson is a massive elementary particle with no intrinsic spin. It plays a unique role in the Standard Model, by explaining why the other elementary particles, except the photon and gluon, are massive. In particular, the Higgs boson explains why the photon has no mass, while the W and Z bosons are very heavy. In electroweak theory, the Higgs boson generates the masses of the leptons (electron, muon, and tau) and quarks. As the Higgs boson is massive, it must interact with itself. Although the Standard Model is believed to be theoretically self-consistent and has demonstrated huge successes in providing experimental predication, it is an incomplete theory of fundamental interactions as it is unable to account for the accelerating expansion of the universe described as dark energy; does not fully explain baryon asymmetry and its incapacity to in cooperate neutrino oscillations with their non-zero masses and full theory of gravitation as described by general relativity. It does not contain any viable dark matter particle that possesses all of the required properties deduced from observational cosmology (Oerter, 2006; Mann, 2013; CERN, 2016).

Table 1: Elementary Particles and their fundamental interaction of nature (Oerter, 2006)

The four fundamental interactions of nature					
Property/Interaction	**Gravitation**	**Weak**	**Electromagnetic**	**Strong**	
		(Electroweak)		**Fundamental**	**Residual**
Acts on:	Mass - Energy	Flavour	Electric charge	Colour Charges	Atomic nuclei

Particles experiencing:	All	Quarks, leptons	Electrically charged	Quarks, Gluons	Hadrons
Particles mediating:	Not yet observed (Graviton hypothesised)	W^+, W^- and Z^0	γ (photon)	Gluons	π, ρ and ωmesons
Strength at the scale of quarks:	10^{-41}	10^{-4}	1	60	Not applicable to quarks
Strength at the scale of protons/neutrons:	10^{-36}	10^{-7}	1	Not applicable to hadrons	20

Materials and Methods

The High Energy Physics research are mainly conducted at the world's highest-energy particle accelerator laboratories such as that seen at the beautiful and gleaming Diamond light house (Plate 1) and the Large Hadron Collider (LHC) which is the world's largest and most powerful particle accelerator etc. of which there are only a handful in the world due to cost and maintenance or smaller accelerators primarily used to examine materials and biological samples with beams of various kinds, using X-rays, neutrons and muons to examine matter on tiny scales, for example, the Laser-Plasma Accelerator in Berkeley Laboratory, USA(Plate 1) and 3mm long Nanofabricated Chips of fused Silica(Plate 2) in SLAC National Accelerator Laboratory, Stanford, USA..

Plate 1: The Diamond Light Source High Energy Physics Laboratory (image at Diamond Light source, 2015)

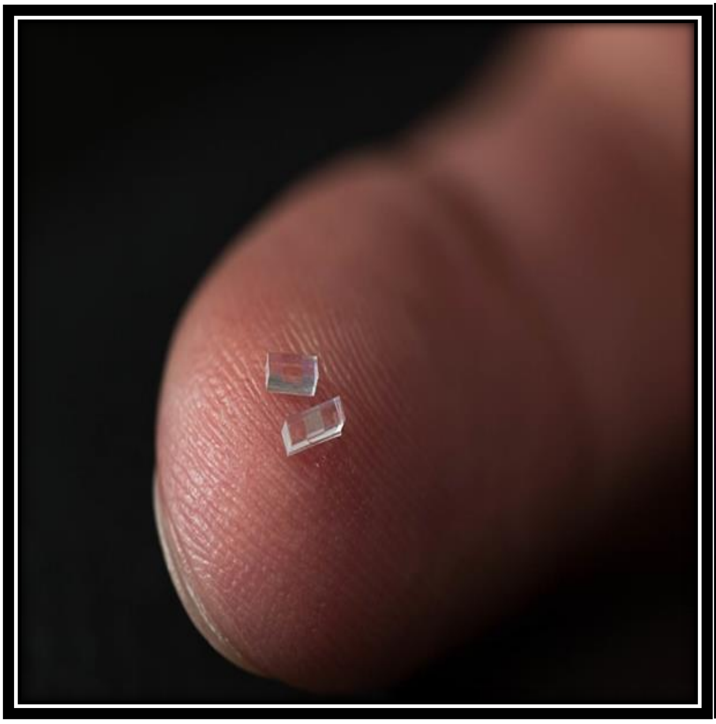
The light house facilities have become the work horse of several fields, allowing researchers to use X-rays, Ultraviolet rays and infra-red light to study materials, proteins, chemical reactions and other phenomena of incredible details. It develops out of the recognition of the values of synchrotron radiation for a wide range of fundamental studies(CERN,2015).

Plate 2: The Large Hadron Collider (LHC) is the world's largest and most powerful particle accelerator (Image: CERN, 2015)

The Large Hadron Collider (LHC) consists of a 27-kilometre ring of superconducting magnets with a number of accelerating structures to boost the energy of the particles along the way. Inside the accelerator, two high-energy particle beams travel at close to the speed of light before they are made to collide. The beams travel in opposite directions in separate beam pipes – two tubes kept at ultrahigh vacuum. They are guided around the accelerator ring by a strong magnetic field maintained by superconducting electromagnets. The electromagnets are built from coils of special electric cable that operates in a superconducting state, efficiently conducting electricity without resistance or loss of energy. This requires chilling the magnets to -271.3°C – a temperature colder than outer space. For this reason, much of the accelerator is connected to a distribution system of liquid helium, which cools the magnets, as well as to other supply services (CERN, 2015).

Thousands of magnets of different varieties and sizes are used to direct the beams around the accelerator. These include 1232 dipole magnets 15 metres in length which bend the beams, and 392 quadrupole magnets, each 5–7 metres long, which focus the beams. Just prior to collision, another type of magnet is used to "squeeze" the particles closer together to increase the chances of collisions. The particles are so tiny that the task of making them collide is akin to firing two needles 10 kilometres apart with such precision that they meet halfway. All the controls for the accelerator, its services and technical infrastructure are housed under one roof at the CERN Control Centre (CERN, 2015).

Using one of the most powerful lasers in the world, researchers have accelerated subatomic particles to the highest energies ever recorded from a compact accelerator. The setup is known as a laser-plasma accelerator, an emerging class of particle accelerators that physicists believe can shrink traditional, miles-long accelerators to machines that can fit on a table. The researchers sped up the particles—electrons in this case—inside a nine-centimetre long tube of plasma. The speed corresponded to energy of 4.25 giga-electron volts. The acceleration over such a short distance corresponds to an energy gradient 1000 times greater than traditional particle accelerators and marks a world record energy for laser-plasma accelerators. Traditional particle accelerators, like the Large Hadron Collider at CERN, which is 17 miles in circumference, speed up particles by modulating electric fields inside a metal cavity. It's a technique that has a limit of about 100 mega-electron volts per meter before the metal breaks down. Laser-plasma accelerators take a completely different approach. In the case of this experiment, a pulse of laser light is injected into a short and thin straw-like tube that contains plasma. The laser creates a channel through the plasma as well as waves that trap free electrons and accelerate them to high energies. It's similar to the way that a surfer gains speed when skimming down the face of a wave. Today's accelerators use microwaves to boost the energy of electrons (SLAC, 2015).



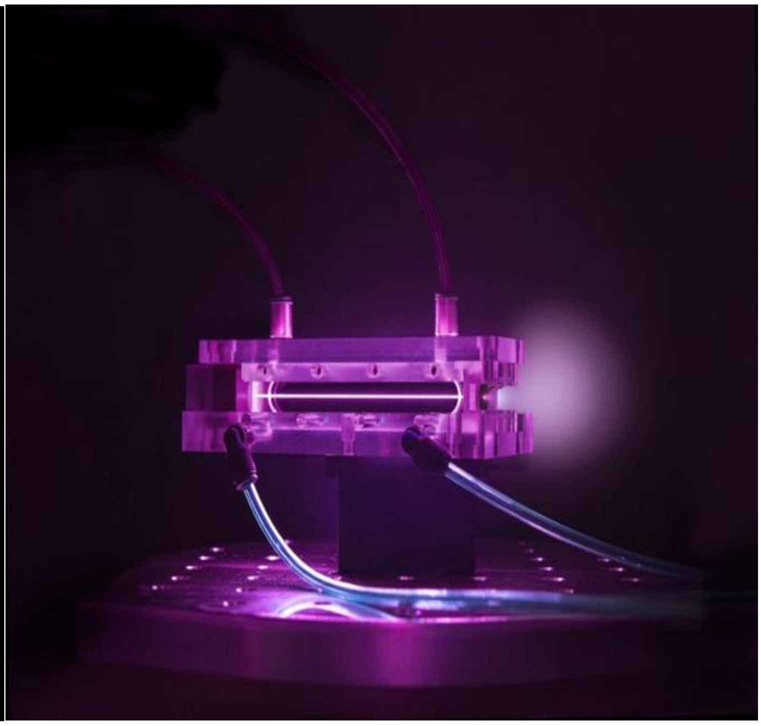


Plate 3a: Nanofabricated Chips of fused Silica SLAC National Accelerator Laboratory, Stanford, USA (SLAC, 2015)

Plate 3b: A Laser-Plasma Accelerator (SLAC, 2015)

The 3mm long nanofabricated chips of fused silica can accelerate electrons at a rate 10 times higher than conventional particle accelerator technology .At its full potential, the new "accelerator on a chip" could match the accelerating power of SLAC's 2-mile-long linear accelerator in just 100 feet, and deliver a million more electron pulses per second. In an advance that could dramatically shrink particle accelerators for science and medicine, researchers used a laser to accelerate electrons at a rate 10 times higher than conventional technology in a nanostructured glass chip smaller than a grain of rice. In the accelerator-on-a-chip experiments, electrons are first accelerated to near light-speed in a conventional accelerator. Then they are focused into a tiny, half-micron-high channel within a fused silica glass chip just half a millimetre long. The channel had been patterned with precisely spaced Nano scale ridges. Infrared laser light shining on the pattern generates electrical fields that interact with the electrons in the channel to boost their energy (Nakamura, 2010, SLAC, 2015).

Results and Discussions

The desire for knowledge is a profound human instinct, and knowledge of the Universe at the most basic level is one prerequisite for our survival in it .Over the years, great thinkers and experimenters have built up an elegant and profound description of Nature in terms of matter as discrete particles interacting via fundamental forces. We now know that the matter around us (including ourselves) consists of atoms, which in turn are made of more fundamental particles. HEP technologies are already contributing to making the world safer, by providing sensitive radiation-detection systems and scanners used to improve health and medicine; monitor and modelling of environmental tasks such as oil-prospecting, weather prediction, reducing emissions through traffic management and even monitoring the movement of wildlife; electricity generation; information technology and electronics; finance and commerce; analysis in materials science, geosciences, forensic science, art and archaeology; new materials development; engineering; energy production; and national security.

Environmental Monitoring and Modelling for Sustainability

Monitoring is best practice for addressing environmental concerns and adapting to new conditions. Evaluation allows for the analysis of monitoring and other data in order to understand the extend of environmental and social impacts (IAEA, 2010; EPA, 2017; Williams *et al*, 2014). Environmental modelling involves the application of multidisciplinary knowledge to explain, explore and predict the Earth responses to environmental change, both

natural and humanly induced. At present global climate changes on the Earth made a rational land use, environmental monitoring, forecasting of natural and technological disaster, and tasks of great importance. The need arises for an appropriate infrastructure that will enable the integrated and operational use of multisource data for different application domain. Grid-based approaches are ideal for environmental modelling and monitoring, which often involve several groups of people sometimes working in remote locations or on complex problems.
Grid approach can provide high performance computations and facilitate interactions between different actors by providing a standard infrastructure and a collaborative framework to share data, algorithms, storage resources and processing capabilities (Pienner *et al*, 2015; Rada, 2016).
Within the meteorological applications, the use of grid systems resources made it possible to considerably reduce time required for a model run. It is especially important for the cases when one needs to tune the model and adapt it to the specific region and thus run the model multiple times to find the best configuration and parametization. For flood application, grid allowed us to reduce the overall computing time required for satellite image processing, and made possible the fast response within international programs and initiatives concerned with emergencies. As for diversity application, the benefit of the grids comes from the ability to manage large volume of data, and provide high performance computations, since the analysis of historical data is required (Righini *et al*, 2013; USEPA, 2016; Forbes et al, 2015)
The operation of HEP accelerators in environment has also been a major environmental concern. Because high energy particle beams are a source of ionizing radiation and radioactive substances and there are radiological aspects to be taken into account. Penetrating particles, mostly of photons, muons and neutrons, can go through shielding structures and reach the environment. However, in modern practice several precautionary and safety measures are put in place to ensure that regulatory limits fixed for radiation level in the environment are not exceeded. In addition, computer simulation are carried out before commissioning new or modifying existing facilities and a network of dose rate monitors with on-line readouts is installed on the site and at some reference points. Regular surveillance, corrective actions and environmental awareness of the laboratories are major concern to the accelerators management by equipping the laboratories with the state of art environmental monitoring systems that will integrate radiation and radioactivity with other physiochemical parameters of discharge waters, level of non-ionizing radiation and ultra-sonic anemometers. The ultra-sonic anemometers are to provide an on-line site specific wind and atmospheric turbulence data for calculations of pollutant dispersion.

Based on inadequate supply of electricity energy in Nigeria, the Federal Government of Nigeria proposed to locate a Nuclear Station in some states including Akwa –Ibom state but the citizens residing in those state objected to the proposal. Their reason may not be different from the unavailability of adequate technology to monitor and avert the effects of radioactive fallouts, for proper disposal of nuclear wastes and prevention of ionizing radiation into the immediate environment. However, HEP technologies have the potential to dispose of nuclear waste and avert all the anticipated environmental problems. One of the most exciting developments is a reactor design developed at CERN, using thorium fuel that relies on a proton accelerator, and produces little long- lived radioactive material. This concept can also be deployed to transmute waste from conventional nuclear reactors into less harmful material and the destruction of plutonium and other high-level radioactive waste from nuclear weapons production and nuclear power plants.

Health and Medicine

Accelerators and detectors play important roles in diagnosing disease, shrinking tumours and sterilizing medical equipment. Large-scale computing makes it possible to determine which potential new drugs are most likely to work before starting large-scale human trials. Doctors and medical physicists are designing treatment plans using modelling tools developed for HEP to predetermine the electromagnetic and nuclear interactions of particles with tissue. In radiation therapy, this software can help doctors understand what will happen when a beam of particles passes through a patient's body.

Magnetic resonance imaging, the basic principles of which emerged from early research in physics, is more discerning than traditional screening, which sometimes can't make out tumours hidden within dense tissue. Magnetic resonance imaging, a fundamental technology of medical diagnosis, uses superconducting magnet technology that originated as a tool for physicists to accelerate protons to the highest energy in the world. MRI produces high-quality images of the inside of the human body, based on the principles of nuclear magnetic resonance. At the heart of MRI technology are powerful magnets made of superconducting wire and cable. When a patient is subjected to the powerful magnetic field inside an MRI machine, atoms inside his body line up in the direction of the field. A radio frequency current is temporarily switched on, causing the protons inside those atoms to flip around until the radio frequency is removed. At that point, the protons pivot back into place—each at a different rate. The varying rates are measured, allowing scientists to determine what's happening inside the living tissue.

In Cancer therapy, HEP has yielded dramatic advances in cancer treatment. Particle accelerators play an integral role in the advancement of cancer therapy. One of the most effective techniques to fight cancer uses the same technology particle physicists employ to accelerate particle beams to nearly the speed of light. There are more than 17,000 particle accelerators worldwide used for the diagnosis and treatment of disease (Kek, 2012; Meng *et al*, 2015; Femilab, 2012). Doctors exchange a scalpel for a beam of charged particles, which they aim at cancerous tissue, killing malignant cells by destroying DNA strands in the nuclei while sparing the surrounding healthy tissue. Medical linacs for cancer therapy were pioneered simultaneously at Stanford and in the UK in the 1950s using techniques that had been developed for high-energy physics research. Currently, every major medical center in the advanced nation where our leaders travels for medical tourism uses accelerators producing X-rays, protons, neutrons or heavy ions for the diagnosis and treatment of disease.

The proton therapy offers important therapeutic benefits, especially for pediatric patients than the X-ray therapy. In proton therapy, pencil-like beams are obtained through collimation. The protons hitting the collimator will occasionally produce a neutron, which could pose a significant hazard to the patient. GEANT4 is used to determine the dose a patient receives from these undesirable, but unavoidable, background neutrons. A sophisticated toolkit, GEANT4 was developed by the particle physics community for the simulation and tracking of particle interactions in complex devices using Monte Carlo methods. GEANT4 is an "all particle" code that supports complex geometries, can handle motion in magnetic and electric fields (including time-varying fields), uses a modern programming language (C++), and, very important to its wider success, is open and free for use. Users have the capability in GEANT4 to describe intricate geometries, define the unique material properties of every element (Close, 2006; Kot-wask and Namiesnik, 2007; Demarteau et al, 2016)

The Neutron therapy has the highest energy and the deepest penetration of any fast neutron beam as neutrons are effective against large tumors. An exciting – and expanding – application is to employ particle beams (protons, neutrons and heavy ions) to kill tumours that are otherwise difficult to treat. The beams can be tailored so that their destructive energy is deposited only in the cancerous tissue, and are ideal for treating head and neck cancers. It has been estimated that there are more than 7,000 operating medical linacs around the world that have treated over 30 million patients(Femilab,2012;Boyarkin,2015;Memg et al,2015).

Diagnostic instrumentation uses an array of experimental techniques for detecting particles; they find a wide array of practical applications. Particle detectors first developed for high-energy physics are now ubiquitous in medical imaging. Positron emission tomography, the technology of PET scans, came directly from detectors initially designed for HEP experiments sensing individual photons of light. Silicon tracking detectors, composed of minute sensing elements sensitive to the passage of single particles, are now used in neuroscience experiments to investigate the workings of the retina for development of retinal prosthetics for artificial vision. Novel 'bionic' implants a new type of active pixel sensor developed for the LHC has many applications but the most exciting are retinal implants which have the potential to restore partial sight to the blind. Radiography and computer tomography (CT) use X-ray photons to study the human body (Nakamura, 2010; Demarteau *et al*, 2016).

The Medipix chip with its single proton counting technique is an excellent technology to be used in these fields. It has been applied in X-ray CT, in prototype systems for digital mammography, in CT imagers for mammography and for beta and gamma autoradiography of biological samples (Meng *et al*, 2015). Moreover, with the Medipix chip, these images will not be black and white anymore – they will have colours to indicate different energy levels of the photons. This colour X-ray imaging technique will produce clearer and more accurate pictures which will help doctors give their patients better diagnoses. The Medipix chip is also being exploited for commercial X-ray materials analysis. Together with an industrial partner, the Medipix collaboration has developed a revolutionary detector which can be used for a myriad of purposes such as the characterization of pharmaceuticals, evaluation and synthesis of new materials, and the detection of counterfeit drugs.

PET scanners are common tools that let medical professionals examine organs and tissues inside the body. Accelerators are used to produce radioactive isotopes for imaging (positron emission tomography, PET), radiotherapy and medical research. They use antimatter produced inside the body. When a special tracer is injected into a patient, a type of radioactive decay occurs, emitting positrons—the antimatter counterparts to electrons. These positrons annihilate with nearby electrons, releasing bursts of photons. The photons are detected and compiled into three-dimensional images (Demarteau *et al*, 2016).HEP experiments at colliders share the need for cost-effective, large-area particle detectors with the developers of next-generation PET scanners. Given the high sensitivity, good resolution, and complete field of view of this technology, small tumors can be detected with a much lower injected activity dose per patient. Measuring time is also reduced, which allows more patients to be scanned at lower cost per examination. CERN has recently designed a system using proton beams to make neutrons, which in turn can more efficiently generate new short-lived radioisotopes suitable for a range of diagnostic applications – in an environmentally clean way.

In Biomedical research, HEP technologies have an immediate application in the design of large-scale facilities (synchrotrons, free electron lasers, and neutron spallation sources) which generate high-intensity light and other radiation for analysing materials, in particular biological molecules and tissues in course to understand the origins of disease and how to combat them.

National Security

Our Nation security can be strengthened by HEP research into accelerator sources for explosives and contraband detection, neutron and proton radiography, and weapons effects simulations. High Energy Physics and physicists are central to the nation's security. This partnership between government and HEP in the advanced countries includes important areas such as the design of optics for reconnaissance satellites, new forms of cryptography, the aging of the nuclear stockpile, communications electronics, counter-terrorism, and ballistic missile defense. Rapidly evolving fields, such as the physics of new materials, and various applications of physics, ranging from physical oceanography to remote sensing, now are crucial for national security.

National security challenges are best addressed by laboratories with excellent basic science core competencies and with strong connections to outside university and industrial researchers. The dominant force behind the changes is a pattern of funding that de-emphasizes the long-term basic research that previously maintained laboratory excellence in core competencies. In addition, unfortunate security lapses and the response to them are contributing to morale and recruiting problems, endangering the historical partnership between government and laboratory scientists.

Many of the technical breakthroughs that have contributed to national security have their roots in advances in basic HEP research. Recent military actions in the Gulf War and in the Balkans showed the extent to which warfare has been transformed by technology. Technical superiority shortened the duration of these actions and helped to minimize the loss of life. Advanced optical systems are employed in space-based satellite surveillance systems, in manned and unmanned aircraft, in missiles, and even on rifles. In the Gulf War, night vision systems proved to be a crucial technology. Forward-looking infrared detectors (FLIRs) were acquired in the hundreds of thousands. There have been rapid developments in areas such as directed-energy weapons, surveillance, stealth, electronic countermeasures, guidance and control, information and signal processing, communications, and command and control. The pace at which a weapons system proceeds from the conceptual, to the commonplace, to the obsolete continues to accelerate (NRC, 2001, Robinson*et al,* 2009; Meng*et al*, 2015)

High Energy Physics was involved directly, as in laser guidance and satellite technology, and indirectly, by virtue of the many areas of basic research that underpin modern electronics, optics, and sensing systems. Scientists engaged in basic research also play a crucial role in evaluating new threats and opportunities arising from technical advances. Scientific risk/opportunity assessment increases the chances the nation will invest its defense resources wisely and avoid reactions to misperceived threats. Scientists in the developed countries are developing a portable technology that will safely and quickly detect nuclear material hidden within large objects such as shipping cargo containers or sealed waste drums. Particle detectors are used to monitor nuclear reactor cores and can check whether weapons-grade enriched uranium or plutonium are present. They can similarly be adapted to detect radioactive materials at airports and other points of entry into the country.

The core of the detection system is a next-generation source of high-energy photons, often referred to as X-rays or gamma rays. The technology will combine the capabilities of conventional building-size research instruments, such as Duke University's High Intensity Gamma-Ray Source (HIGS), which precisely control the energy (or colour) of the photons generated to improve sensitivity, with the compact size needed for use in most national security applications(Nakamura,2010;HNINP,2016). The problem with current techniques, such as those used by HIGS, is that there are only a few ways to produce mega electron-volt (MeV) photons—high-energy photons at energies a million times higher than visible light—within a narrow spread or range of energy, and those usually require an electron accelerator the size of a large building which is unavailable in Nigeria.

Fissile material used for the production of nuclear weapons, once a great barrier to entering the nuclear community, now exists in great quantities in the Nigeria. This is evident from the identified bomb factories destroyed by the military in the fight against Boko Haram Terrorism. Estimates of this stockpile range from 100,000 to 1,000,000 kg, while the amount needed for a bomb is about 10 kg (IAEA, 2014). There is great concern that not all of this fissile material is confined to politically stable parts of the Nigeria.

In a nutshell, there is need for collaborative efforts in all spheres of our endeavours to set up programs, interventions and HEP laboratories, if we actually want to stop the current trends of killings in our country as it was done Las Alamos, Livermore, and Sandia. These laboratories today have a central mission—reducing the global nuclear danger—that involves extraordinary challenges in stockpile stewardship, in non-proliferation and arms control, in nuclear materials management, and in the clean-up of the environmental legacy of nuclear weapons activities. Through these responsibilities, the government can also recognize new issues that affect the nation's physical and economic security and that require technological solutions. Examples include global climate dynamics, new energy sources, counterterrorism (including chemical and biological weapons of mass destruction), environmental protection and remediation, and biomedical technologies.

The motivation was the expectation that technical advances would further the nation's capabilities in areas such as surveillance, intelligence gathering, missile defense, communications, stealth technology, and nuclear physics. The Navy has interests in oceanographic physics, in the propagation of sound through water, in deep-ocean currents, and in meteorology. Air Force concerns include turbulent fluid flows, navigation, long-range observation, and pattern recognition, while Army interests include night and all-weather vision and techniques for avoiding detection. The Air Force, Navy, and Army share many common goals: Each service depends on surveillance and reconnaissance to assess threats before battle and to follow the evolution of a conflict once battle is joined; all need to defend their positions and to locate targets and destroy them before they themselves are attacked. The modern battlefield has changed remarkably as a result of technological advances. Lasers guide smart munitions and help in high-resolution surveillance.

Conclusion

i. The desire for knowledge is a profound human instinct and knowledge of the universe at the most basic level is one prerequisite of our existence.
ii. The discovery of a particle, the electron, and radiation (X-rays) at the turn of the 20th century was driven by human curiosity and it transformed the modern world
iii. High Energy Physics (HEP) and physicist are critical and central in providing solutions to our major environmental, national security and foreign medical tourism concern as a nation.
iv. HEP technologies are already contributing to making the world safer, by providing sensitive radiation-detection systems and scanners used not only to improve health and medicine; monitor and modelling of environmental, national security but also improve electricity generation; information technology and electronics; finance and commerce; analysis in materials science, geosciences, forensic science, art and archaeology; new materials development; engineering; energy production; and national security

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