20th Anniversary

Thailand-CERN

A project in honor of
H.R.H. Princess Maha Chakri Sirindhorn, on Her Royal Highness' 65th birthday anniversary, 2 April 2020.

“Advances in science and technology are essential in bringing progress to the country in every way and a basis for the people’s good quality of life.”

An opening speech by H.R.H. Princess Maha Chakri Sirindhorn
at NSTDA Annual Conference 2018
9 March 2018

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A project in honor of
H.R.H. Princess Maha Chakri Sirindhorn, on Her Royal Highness' 65th birthday anniversary, 2 April 2020.

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iggs boson
iscovered;
hai educational
nstitutions got involved
CMS and ALICE

2012

2013

14 March Higgs boson discovery confirmed;

Peter Higgs and Francois Englert won the Nobel prize in physics;

Thailand joined WLCG

2015

5th royal visit;

LHC phase 2;

CERN-SLRI framework collaboration agreement

LHC phase 1 completion;

2018

Thailand-CERN International Collaboration Agreement (ICA)

6th royal visit;

Inspection of the Beam Test Facility

2019

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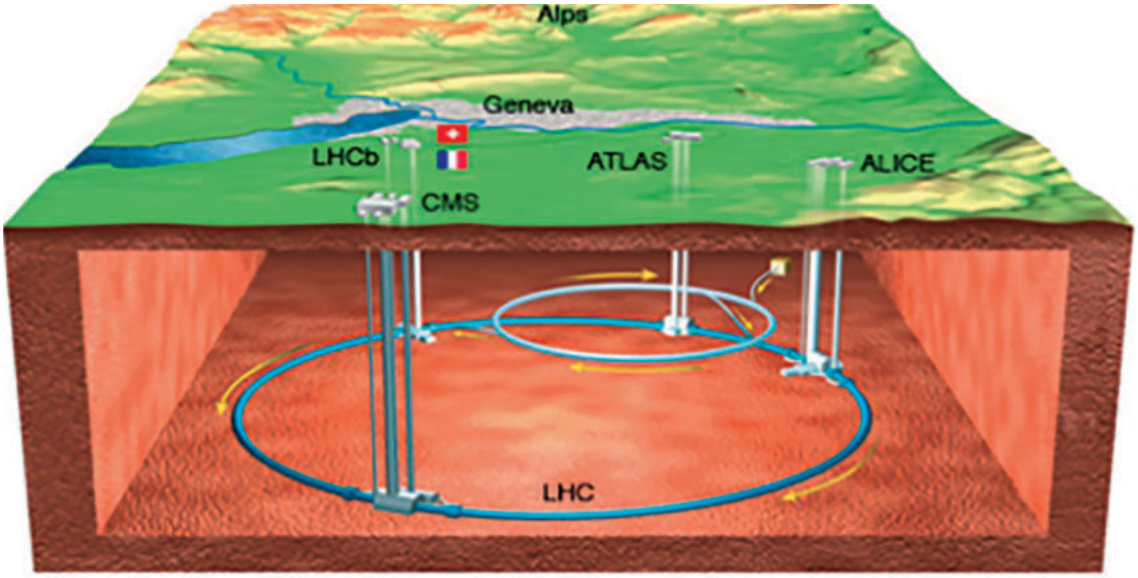

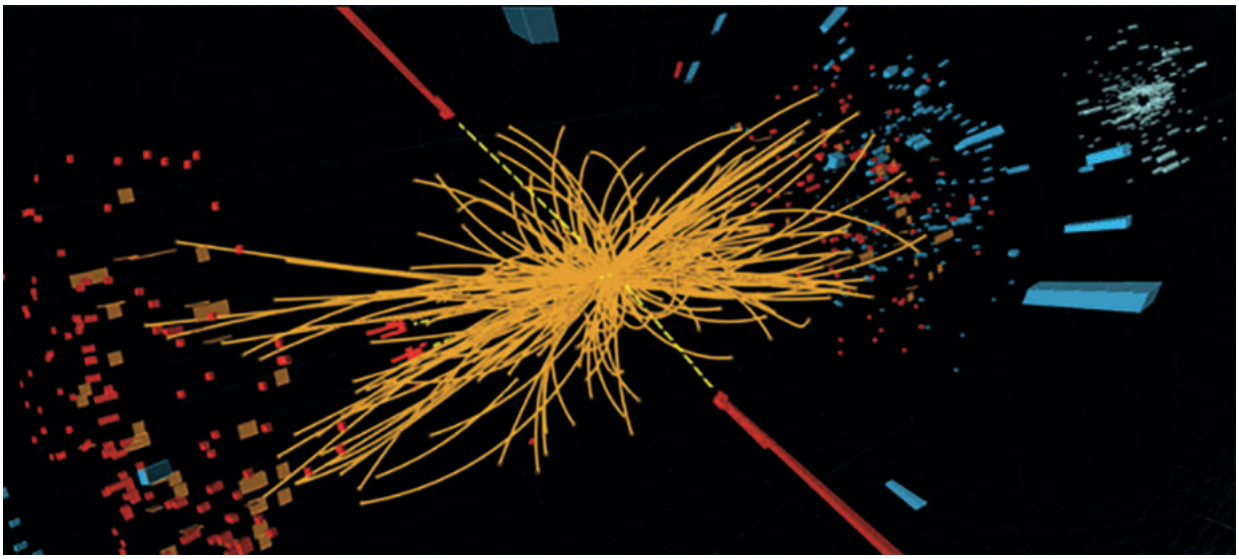

CERN and the discovery of Higgs boson
(top left) LHC, a 27-Km ring accelerator, sits 100 meters underground, with LHCb, ATLAS and ALICE detectors. (top right) The LHC tunnel. (bottom left) Proton colli-

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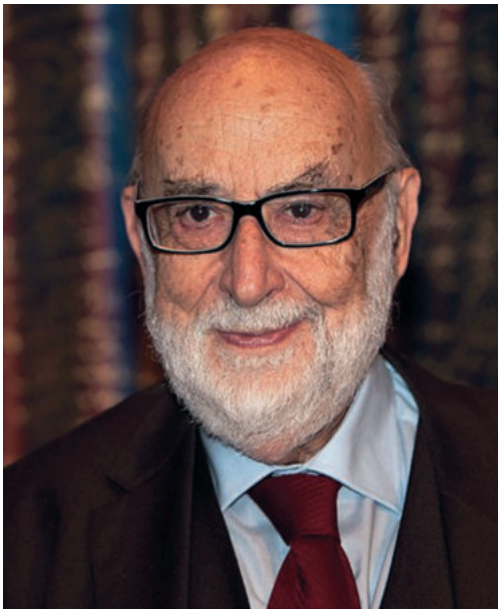

sion producing Higgs boson-like particles in 2012 and confirmed in 2013. (bottom center) François Englert and (bottom right) Peter W. Higgs jointly received the Nobel prize in physics in 2013.

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Manpower development

82 high school students accompanied by 13 teachers in 7 seasons (2013-2019) were selected to join the CERN High-School Student Internship

CER

LHCb

CMS

16

CMS Collabo
7 students
3 postdocs
7 lecturers/re
(1 researcher ha

46 graduate
at CERN (20

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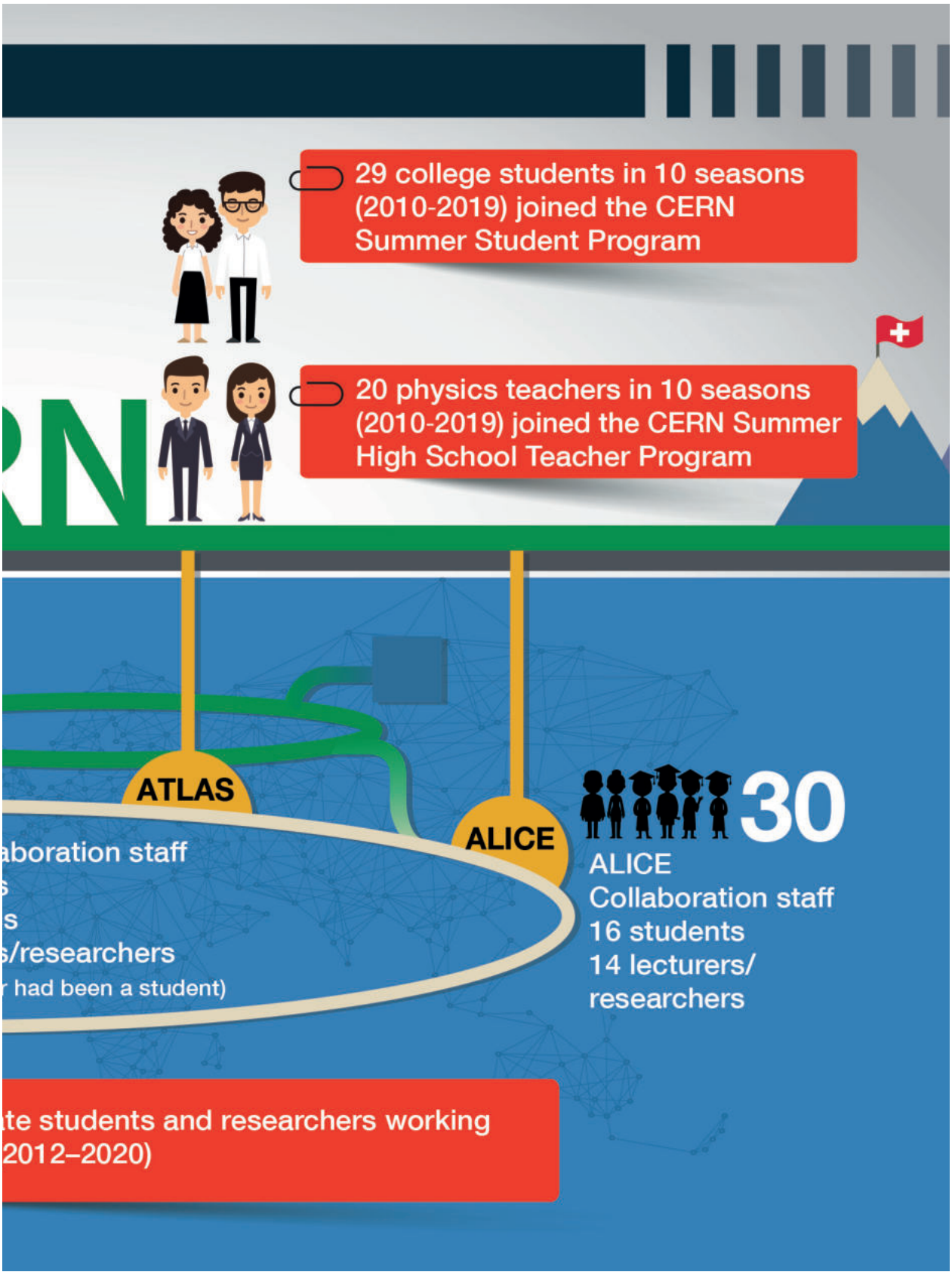

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By **Visanu Euarchukiati**

Thailand-CERN relationship under Royal Kindness

CERN's official name of European Organization for Nuclear Research, with 12 founding members being all European countries, clearly indicates a Eurocentric focus. CERN's particle physics work at the frontier of knowledge, however, benefits the world. It is natural that research projects at CERN now enjoy collaborations from all 22 member countries as well as other countries in the world, including Thailand.

The close relationship between Thailand and CERN is not a recent development, but a gradual accumulation, starting from H.R.H. Princess Maha Chakri Sirindhorn's first visit two decades ago. Her Royal Highness led Thailand into particle physics and has been supporting and keeping track of the relationship ever since.

Between 2000 and 2020 CERN has had the opportunities to welcome H.R.H. Princess Maha Chakri Sirindhorn six times. There were many occasions when CERN executives on visits, to follow up on CERN-related projects, were received in Thailand by Her Royal Highness. Thailand benefited from every one of Her Royal Highness' CERN visits, both directly and indirectly. The latter include projects inspired by or are consequences of Thailand's involvement with CERN, all of which add significant boosts to Thai science.

Royal interest in particle physics

H.R.H. Princess Maha Chakri Sirindhorn visited CERN for the first time in 2000. Because of Her Royal Highness' renowned interests in arts and sciences, CERN, which was becoming a major particle physics research center in the world, submitted an invitation to H.R.H. Princess Maha Chakri Sirindhorn to visit the Center in Switzerland.

On 18 May 2000, H.R.H. Princess Maha Chakri Sirindhorn visited CERN and toured the DELPHI experiment, one of the four main detectors in the Large Electron-Positron Collider. It was the first contact between Thailand and CERN, a beginning of a relationship that would bring about positive effects on science in Thailand in the years to come.

Royal presentation

Three years later, between 8-9 December 2003, CERN in association with UNESCO, International Council for Science and the Third World Academy of Sciences hosted the Role of Science in the Information Society (RSIS) conference. H.R.H. Princess Maha Chakri Sirindhorn was invited as a speaker.

H.R.H. Princess Maha Chakri Sirindhorn gave her keynote address on 9 December 2003 on the Needs for ICTs in Developing Countries. Her Royal Highness related her experience following His Majesty the King (Rama IX) to almost every corner of the country, seeing His Majesty's development work based on scientific research and first-hand knowledge of landscape and culture. Her Royal Highness adopted the same approach in her work, including those related to IT. Her focus was on promoting IT literacy among four underprivileged groups: rural school students, persons with disabilities, sick children in hospital, and prison inmates. A pilot program would be initiated, each setting closely managed in trial–error–improvement mode, before further scaling up. The challenge was that there was no

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On 18 May 2000 Dr. Tiziano Camporesi led the tour of the DELPHI experiment, one of the four main detectors in the Large Electron-Positron Collider (LEP), for H.R.H. Princess Maha Chakri Sirindhorn's first CERN visit. The construction of the Large Hadron Collider (LHC) to replace LEP was already ongoing.

On 16 March 2009 H.R.H. Princess Maha Chakri Sirindhorn toured the CMS experimental area and LHC tunnel with CMS Spokesperson Jim Virdee (fourth from the left) serving as a guide.

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ready-made and no single formula for development that would suit the needs of everyone, everywhere. The fundamentals must be achieved first. With enough to survive and basic needs met, people would have a healthy and creative mind to accept ICTs. Scientific approach and method as well as strong commitments were always needed.

World-class particle physics for Thai people

CERN Bulletin Issues 15/2009 & 16/2009 & 17/2009, Mon 06 April 2009 carried an article titled "A Princess at CERN".

> *On 16 March HRH Princess Maha Chakri Sirindhorn of Thailand visited CERN for the third time. After meeting the Director-General [Rolf-Dieter Heuer], she toured the CMS experimental area and LHC tunnel with Coordinator for external relations Felicitas Pauss and CMS Spokesperson Jim Virdee. During her visit she took a particular interest in CERN's education program.*

Although the LHC had started operation since September 2008, during H.R.H. Princess Maha Chakri Sirindhorn's visit there was an ongoing repair due to a magnet failure incident. It was an opportunity for Her Royal Highness to see the experiments down in the tunnel.

The third royal visit to CERN in 2009 by H.R.H. Princess Maha Chakri Sirindhorn was the most significant for Thai science because it was the first formation of a collaboration between CERN and Thailand as a non-member state. The Thai agency was the Synchrotron Light Research Institute (Public Organization) (SLRI), represented by Weerapong Pairsuwan, Director of SLRI, and the CERN agency was the CMS experiment, represented by Tejinder Virdee, CMS Spokesperson. Her Royal Highness presided over the Expression of Interest document signing ceremony at CERN.

The EOI resulted in Thailand being given the opportunity to select and nominate college students in physics to join CERN Summer Student Program and to select Thai high school physics teachers for participation in CERN's High School Teacher Program over the summer starting from 2010.

The activities were the beginning of a working relationship between CERN and Thailand. More collaboration projects involving more agencies would follow.

Working toward the National e-Science Infrastructure

LHC was back in operation in March 2010, and the royal visit to CERN in April 2010 would be H.R.H. Princess Maha Chakri Sirindhorn's fourth visit. The site visited was the SM18 test facility for cryomagnets used in the particle accelerator.

In this visit, one obligation arising from the EOI signed in the previous visit was initiated. The computation infrastructure, i.e., high efficiency computer systems, data storage suite and a communication network to link all nodes, was set up to become a part of CERN's distributed computing infrastructure (WLCG—Worldwide LHC Computing Grid). The National e-Science Infrastructure Consortium's 5 founding members were National Science and Technology Development Agency (NSTDA), Chulalongkorn University, Suranaree University of Technology (SUT), King Mongkut's University of Technology Thonburi (KMUTT) and National Hydroinformatics and Climate Data Center (NHC).

Memoranda of understanding signed under Royal kindness

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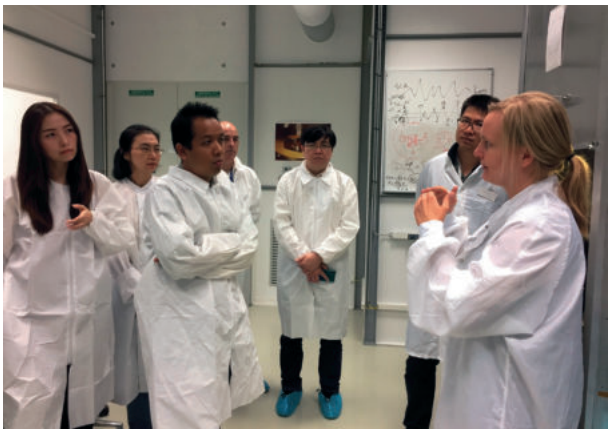

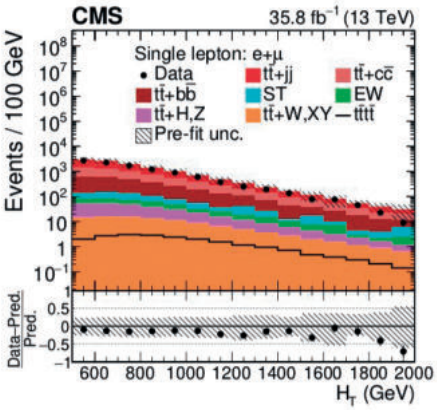

Chula-CMS Collaboration: Researchers and students using a remote desktop from CMS experiment at Chulalongkorn University (top left). Researchers from Chulalongkorn University and CERN discuss sensor fabrication to improve detection at the CMS experiment (top right). Published research paper in an international journal, in collaboration with researchers from many countries (bottom).

In 2012 two memoranda of understanding were signed between Thai agencies and CERN units. H.R.H. Princess Maha Chakri Sirindhorn presided over both events.

Chulalongkorn University became an official member of the CMS experiment upon the signing of a memorandum of understanding on 14 July 2012 at Sa Pathum Palace between the President of Chulalongkorn University, Pirom Kamolratanakul, M.D., and CMS Spokesperson, Joseph Incandela. The ceremony took place under the presidency of Her Royal Highness. Thai researchers from Chulalongkorn University were collaborators and shared the great success of the Higgs boson discovery, a particle long sought by physicists for more than half a century.

On another occasion, H.R.H. Princess Maha Chakri Sirindhorn once more presided over the signing of a memorandum of understanding, on 13 December 2012, at Sa Pathum Palace between Suranaree University of Technology (SUT), represented by the Rector, Prasat Suebkha, and CERN's ALICE experiment, represented by ALICE's Spokesperson, Paolo Giubellino. The agreement paved the way for SUT's involvement in the Inner Tracking System (ITS) upgrade project at the heart of the experiment.

In the following year, on 10 October 2013, H.R.H. Princess Maha Chakri Sirindhorn also presided over the signing of a new memorandum of understanding for the development of the National e-Science Infrastructure as a part of the Worldwide LHC Computing Grid (WLCG) took place at Sa Pathum Palace. The 4 signatory agencies were CERN, by Director-General Rolf-Dieter Heuer,

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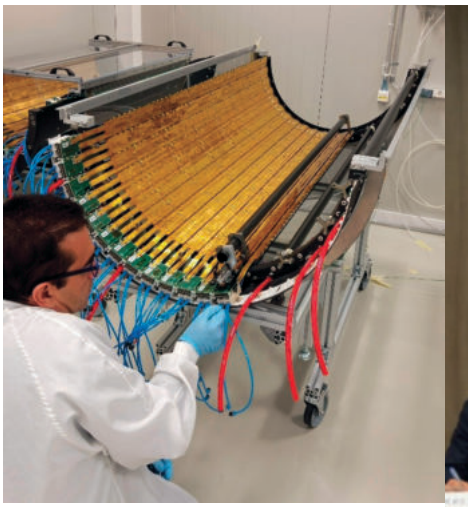

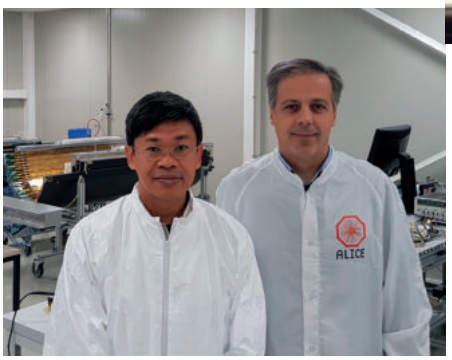

ALICE experiment and the Inner Tracking System (ITS): H.R.H. Princess Maha Chakri Sirindhorn visited ALICE on 4 September 2019 (left). Collaboration Spokesperson Frederico Antinori led the tour of the facility. ALICE technician assembles ITS' 5th of 7 cylindrical layers (top right). Thai coordinator Chinorat Kobdaj (SUT) and Spokesperson of the ALICE Collaboration Luciano Musa (bottom right).

Chulalongkorn University, by President Pirom Kamolratanakul, M.D., SUT, by Rector Prasat Suebkha, and the National Electronics and Computer Technology Center (NECTEC), by Executive Director Thaweesak Koanantakool.

Framework Collaboration Agreement led to technology transfer

H.R.H. Princess Maha Chakri Sirindhorn's 5th visit to CERN was reported on CERN Bulletin 49/2015 & 50/2015 on Monday 30 November 2015.

On Tuesday, 17 November 2015, HRH Princess Maha Chakri Sirindhorn of Thailand visited CERN. Princess Sirindhorn was visiting the Laboratory for the fifth time, following her last visit in 2010. At CERN, the Princess was given a brief update on the Laboratory's activities since her last visit, in April 2010. Later, she witnessed the signature of the framework collaboration agreement between CERN and the SLRI. Afterwards, the Princess and her delegation met a small group of young Thai scientists working at CERN before

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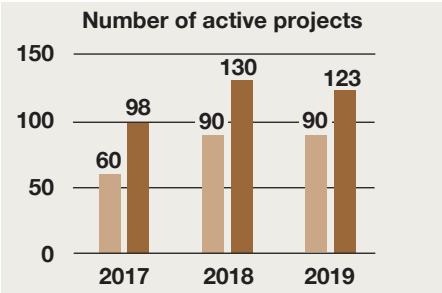

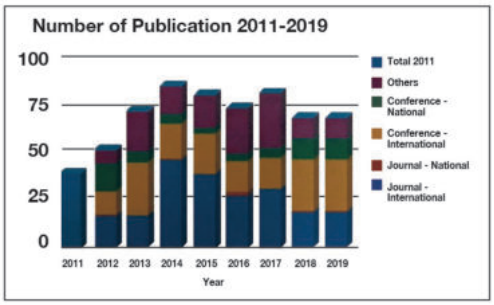

A press conference on 10 October 2013 announcing the Partnership Agreement on CERN's Worldwide LHC Computing Grid (WLCG) between Rolf Dieter Heuer, CERN's General Director (third from the left), and delegates of National e-Science Infrastructure Consortium at Chulalongkorn University (top). Number of projects making use of WLCG (bottom left). Number of publications from the Consortium (bottom right).

concluding their visit with a guided tour of the ISOLDE facility and the LEIR accelerator.

The main issue in the agreement concern the use of particle accelerators in medicine. Thai people would learn more about this area of application, but actual implementation was not yet a possibility. In the beginning, medical application of particle accelerators was unattainable due to the high degree of precision and skills involved. Technology transfer, therefore, came off in SLRI's development of a vacuum brazing furnace and the agricultural application of linear electron accelerator and Chiang Mai University's natural rubber vulcanization by linear electron accelerator.

KCMH Proton Center at King Chulalongkorn Memorial Hospital would become the first project to implement a medical application of a proton accelerator in Thailand.

International Co-Operation Agreement

During H.R.H. Princess Maha Chakri Sirindhorn's 5th visit to CERN in 2013, a CERN executive suggested that Thai-

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land should consider signing an International Co-operation Agreement (ICA) on the science and technology of high energy physics with CERN. It would raise the level of relationship that Thailand and CERN had had since 2000. At the time there were already 6 memoranda of understanding between Thai agencies and CERN units. The new agreement would be between CERN and the Royal Thai Government. On 20 February 2018 the Thai Cabinet resolved to approve the signing of the draft International Collaboration Agreement between the Kingdom of Thailand and CERN.

H.R.H. Princess Maha Chakri Sirindhorn graciously presided over the signing ceremony on 13 September 2018 at Sa Pathum Palace. CERN's Director for International Relations, Charlotte Warakaulle, signed the agreement with the permanent secretary of the Science and Technology Ministry, Soranit Siltharm.

Observing Thai work at CERN

In 2019 the project which SUT had acted as the main coordinator for other Thai agencies—including NSTDA, SLRI and KMUTT—at the ALICE experiment was complete. CERN invited H.R.H. Princess Maha Chakri Sirindhorn for a visit to observe the work on 4 September 2019. It was Her Royal Highness' 6th CERN visit. Her Royal Highness would observe the Beam Test Facility and tour the experiment's tunnel that was being prepared for an upgrade in which Thailand's contribution was also present.

What is CERN?

CERN is a common name for the European Organization for Nuclear Research. The acronym came from Conseil européen pour la Recherche Nucléaire, the French for European Council for Nuclear Research, founded in 1952 to set up the present organization. Although the name of the organization was changed in 1954, the old acronym was more convenient, hence the name CERN remains and has become more recognized than the full title itself.

For people with passing interest in science, CERN may be associated with the discovery of the Higgs boson, or the birthplace of the ubiquitous World Wide Web. CERN was cast as the scary organization when some sources stated that CERN's particle accelerator would cook up a black hole that would devour us. Yet the world goes on, and CERN is still hard at work at the frontier of scientific knowledge, especially particle physics, in a suburb of Geneva near France-Switzerland border.

The study of elementary particles that make up all matters began in the 19th Century with John Dalton's theory that each element of nature was composed of a single, unique type of particle, the atom. Then came the discoveries of the spectrum, radioactivity, the development of more accurate detectors, and with the rise of quantum mechanics scientists were able to probe deeper into the subatomic structure of matter.

To learn more about particle structure, the scientists smashed particles together and observe the debris resulting from the collision. It is comparable to someone who wants to know what a wristwatch is made of, and smashes it violently on a hard surface to see the cogs and springs that flew from the broken watch. If the smashing was not forceful enough, the watch may not break.

In terms of particles, shooting them against a fixed target is not as forceful as accelerating two particles into a

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collision. The result would yield even more information.

There is a cycle in nuclear physics and particle physics where an experiment yields an outcome, whose explanation needs a new theory, which requires a new experiment to verify. This cycle was repeated in Europe and the US several times throughout the pioneering period in the early 20th Century. At the end of the Second World War, European science was no longer world-class. A handful of visionary scientists imagined creating a European atomic physics laboratory. Such a laboratory would allow European scientists to share the increasing costs of nuclear physics facilities.

The first official proposal for the creation of a European laboratory at the European Cultural Conference, which opened in Lausanne on 9 December 1949. A further push came at the fifth UNESCO General Conference, in June 1950, and the European Council for Nuclear Research, CERN's eponymous organization, was founded on 5 May 1952.

The scientists divided their responsibilities. One group led by Niels Bohr, the Physics Nobel laureate, pushed on with research, the other group would draw up plans for the laboratory's first machine and another was tasked with organizing and setting up an international laboratory, from financial procedures to buildings and workshops. Geneva was selected as the site for the CERN Laboratory. The city's central location in Europe, Swiss neutrality during the war and that fact that it already hosted a number of international organizations, all factors gave it the edge over other competing sites.

Construction started in 1954 and in the same year the European Organization for Nuclear Research was born, the provisional council was dissolved. What

CERN Milestones

1952 European Council for Nuclear Research was founded on 5 May 1952

1954 European Organization for Nuclear Research was founded on 29 September 1954

1957 CERN's first accelerator, the Synchrocyclotron, started up, providing beams for experiments in particle and nuclear physics

1965 First observations of antinuclei in the Proton Synchrotron (PS)

1970 First proton-proton collisions in the Intersecting Storage Rings (ISR)

1981 First proton-antiproton collision seen in the Super Proton Synchrotron (SPS)

1983 Discovery of W boson and Z boson, mediators of the weak interaction in the Standard Model

1986 Began accelerating heavy ions in the SPS to study quark gluon-plasma

1989 Large Electron-Positron Collider (LEP)'s first injection—with 27-kilometre circumference, the LEP is the largest electron–positron accelerator ever built

1995 First antiatoms produced in the Low Energy Antiproton Ring (LEAR) which was later converted into the Low Energy Ion Ring (LEIR), used in the lead ion injection process for the LHC and in medical accelerator research

2008 Start up of the Large Hadron Collider (LHC) in 27-Km ring of thousands of superconducting magnets, where two high-energy particle beams traveling at close to the speed of light—in opposite directions and in separate beam pipes—are made to collide in 4 large detectors: ATLAS (A Toroidal LHC ApparatuS), Compact Muon Solenoid (CMS), ALICE (A Large Ion Collider Experiment), and LHCb (Large Hadron Collider beauty)

2012 Discovery of Higgs boson, a theoretical elementary particle in the Standard Model of particle physics proposed in 1964, another validation of the Standard Model

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remains of the council is its acronym which has been appropriated by the new organization.

CERN's innovations

Touch screen: in 1972 Bent Stumpe, a CERN personnel, invented a capacitive touch screen with a fixed number of programmable buttons presented on a display to control the Super Proton Synchrotron (SPS). Commercial production soon followed. Nowadays touch-screen technology is ubiquitous in devices such as mobile phones, tablets and computers.

World Wide Web: in 1990 Sir Tim Berners-Lee defined the Web's basic concepts, the html, http and URL, and had written the first browser/editor and server software. The new framework would provide access to data from multiple sources through hypertext for scientists in universities and institutions.

CERN technology for the public

CERN-MEDICIS (Medical Isotopes Collected from ISOLDE): some radioisotopes that can be produced only at CERN are made available for medical research.

Medical accelerator for challenging environments: the program aims to treat patients in low- and middle-income countries by 2027.

Medipix: using X-ray imaging detectors to inspect paintings in order to assess their condition and identify painted-over or forged works.

CERN and education

CERN's engagement with science education focuses mainly on secondary school teachers and students. CERN's teacher programs help participants increase their insight into particle physics. CERN has introduced additional programs for school students to strengthen their understanding of science, develop their skills in a high-tech environment and ignite their passion for a career as a scientist or engineer.

CERN's work with countries of the world

There are 5 levels of participation that CERN can relate to countries of the world. As at the end of 2018 there are 22 Member States, 3 Associate Members in the pre-stage to membership, 5 Associate Members, 3 countries with observer status, and 43 Non-Member States currently involved in CERN programs.

Strengthening Thailand-CERN relationship

Thailand has been in contact with CERN for 20 years. In concret terms, the contact has meant many trips between Thailand and Switzerland; missions, joint studies, interactions with researchers, teachers and students at CERN, the signing of official documents, the transfers of obligatory payments, and, most importantly, the gracious support of H.R.H. Princess Maha Chakri Sirindhorn.

This contact has become a fruitful relationship for Thailand. There are tangible benefits that can be made indefinitely sustainable.

Fostering technology

One aspect of Thailand's relationship with CERN is the knowledge transfers that give rise to technological development. Yet, Thailand is not a mere receiver, research in the country have also been stimulated, creating internationally recognized progress in Thai science and engineering.

National e-Science Infrastructure

CERN's Worldwide LHC Computing Grid

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H.R.H. Princess Maha Chakri Sirindhorn presided over the International Collaboration Agreement (ICA) signing ceremony on 13 September 2018 at Sa Pathum Palace. The ICA turning Thailand's relationship with CERN from a non-member state with scientific contacts to a non-member state with collaboration agreement.

CERN's Historic images: Many of CERN's founders gathered for the Third Session of the provisional CERN Council in Amsterdam on 4 October 1952. At this session, Geneva was chosen as the site for the Laboratory and it was decided to build a 25-30 GeV Proton Synchrotron (left). On 10 June 1955, Felix Bloch, Swiss-American physicist and Nobel Laureate, laid the foundation stone on the Laboratory site, watched by Max Petitpierre (black suit), then the President of the Swiss Confederation (right).

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(WCLG) is a huge network infrastructure, a global collaboration by many countries, whose purpose is to store, distribute and analyze data from the LHC. WLCG is composed of 4 Tiers. Each Tier is made up of several computer centers and provides a specific set of services. Tier 0 is the CERN Data Centre. All data from the LHC pass through this central hub. Tier 0 distributes the raw data to 13 Tier 1 sites in 12 countries. Tier 1 passes data to more than 140 Tier 2 sites in 39 countries for local scientists' research work. Tier 3 resources are local clusters.

In Thailand, 5 agencies—Chulalongkorn University, SUT, KMUTT, NHC and NSTDA—have jointly created the National e-Science Infrastructure Consortium. At present there are 4 additional member agencies: National Astronomical Research Institute of Thailand (Public Organization) (NARIT), Bureau of Personnel Administration Development and Legal Affairs, Synchrotron Light Research Institute (Public Organization) (SLRI), and Thailand Institute of Nuclear Technology (Public Organization) (TINT); and 3 associate members: Kasetsart University, Mae Fah Luang University, and Walailak University. The pooled resources allow Thailand to establish two Tier 2 centers for CMS and ALICE data where Thai and international researchers can access. The two centers are T2-TH-SUT-NPP and T2-TH-CU-NSTDA.

Vacuum Brazing Furnace

The vacuum brazing furnace is the work of engineers at SLRI. Metals joined in a brazing furnace exhibit minimum distortion and join precision can be better controlled. The metals to be joined can be different metals.

Inside the newly designed vacuum brazing furnace is a front-loading 0.3×0.3×0.5 cubic meter high vacuum chamber. Maximum temperature is 1,200 degrees Celsius.

Vacuum brazing process is a metal-joining process in which two or more metal items are joined together in a vacuum environment. The metals can be different. The join is achieved with a filler metal—a wire made of silver or an alloy, e.g., brass or copper-phosphorus alloy—with a melting point of more than 450 degrees Celsius, but lower than the melting points of the adjoining metals. The filler metal is inserted into the gap between base metals. The assembly is then heated to a temperature that higher than the melting point of the filler metal, which will flow into the gap between close-fitting parts by capillary action.

Once the assembly is loaded, a high vacuum is created in the chamber, and the temperature is raised to greater than the filler metal to achieve the brazing. Once the process is completed, wait until the temperature in the chamber is lower than filler metal's melting point, further cooling is done with nitrogen, water, and ventilation. The assembly is unloaded when chamber temperature is below 100 degrees Celsius.

SLRI's vacuum brazing furnace represents a saving of 18 million baht on import and can be adapted for many different industries.

Linear particle accelerator for fruit irradiation

The application of particle accelerators in agriculture is to use a linear particle accelerator to drive electrons to collide with heavy metal target to produce x-ray. The x-ray is used to sterilize fresh produce, resulting considerably extending their shelf-lives. The energy level for fruit and vegetable irradiation is regulated according to WHO to avoid making

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the fruits radioactive.

SLRI initiated the development and construction of a 6 MeV particle accelerator to produce X-ray for fresh fruit sterilization. The amount of radiation is regulated to prevent the risk of fruit toxicity. The dose depends on the type of fruit and irradiation objective. The fruit's color, texture, taste, and nutritional properties remain unchanged.

A linear electron accelerator for material improvement and natural rubber vulcanization

Only 30%-40% of the rubber latex is actually rubber, the rest is water. A common method to extract rubber from latex is to add weak formic acid, but the resulting coagulated (raw) rubber becomes sticky and soft when hot, and hard and brittle when cold. At this stage the rubber is generally unusable and needs valcanization process by which the rubber is heated, and sulfur, peroxide or bisphenol are added to improve resistance and elasticity in a wider range of temperature.

The most popular vulcanization process is to heat raw rubber with sulfur which forms cross-linking bridges between sections of isoprene polymer chains (polyisoprene) in natural rubber. The rubber vulcanized or cooked with sulfur also needs more chemicals to improve the speed of vulcanization. Some accelerators are known to produce nitrosamine which is carcinogenic.

Another problem with using sulfur is free sulfur that seeps up to the product's surface. An uneven distribution of incompletely dissolved chemicals may make the latex lumpy which affects clarity and, consequently, consumer acceptance. Residual protein can cause allergy, especially when used in baby nipples or medical applications such as surgical gloves, which is why synthetic latex is becoming more popular.

Another way to vulcanize rubber without sulfur and its suite of chemicals is irradiation by gamma radiation or beta radiation. Gamma radiation, however, is sourced from highly radioactive substances and is too dangerous to use. Beta radiation is safer since it is a beam of electrons with kinetic energy and can be produced in a particle accelerator without any radioactive substance.

Beta radiation vulcanization works at room temperature and rubber durability is better than sulfur vulcanization at high temperature. Molecular bonding is stronger and does not degrade with oxidation, thus a longer lasting end-product. Moreover, this technique results in a shortened protein chain that can be washed off more thoroughly. Protein allergy is eliminated entirely or is almost negligible.

The team of researchers at the Electron Linac Laboratory of the Plasma and Beam Physics Research Facility, Chiang Mai University, have worked on the linear particle accelerator for natural rubber vulcanization research project, reengineering and assembling components from a medical linear accelerator donated from Maharaj Nakorn Chiang Mai Hospital. Many parts have been developed internally under the "Innovative Physics for Enhancing Value of Agriculture Products" research program, in collaboration NSTDA's National Metal and Materials Technology Center (MTEC) "Development of Electron-beam Vulcanized Natural Rubber Latex Technology" Research Group, and Rubber and Polymer Laboratory, Faculty of Engineering and Agro-Industry, Maejo University.

At the end of the research project, the electron beam generator will be the first electron beam crosslinking apparatus built in Thailand. It may be the starting point for other polymer crosslinking

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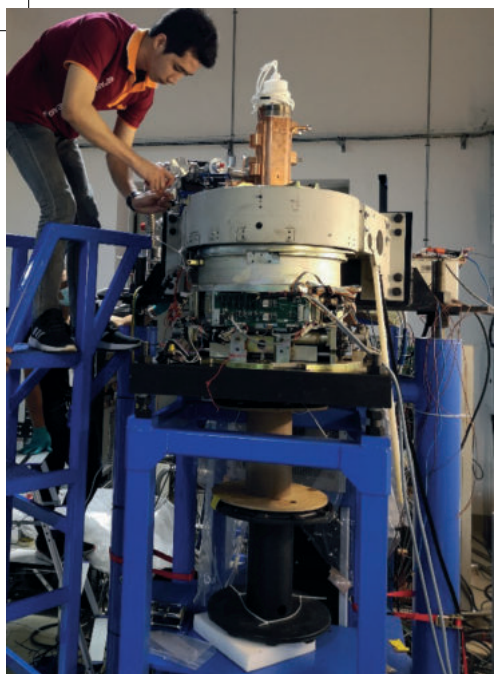

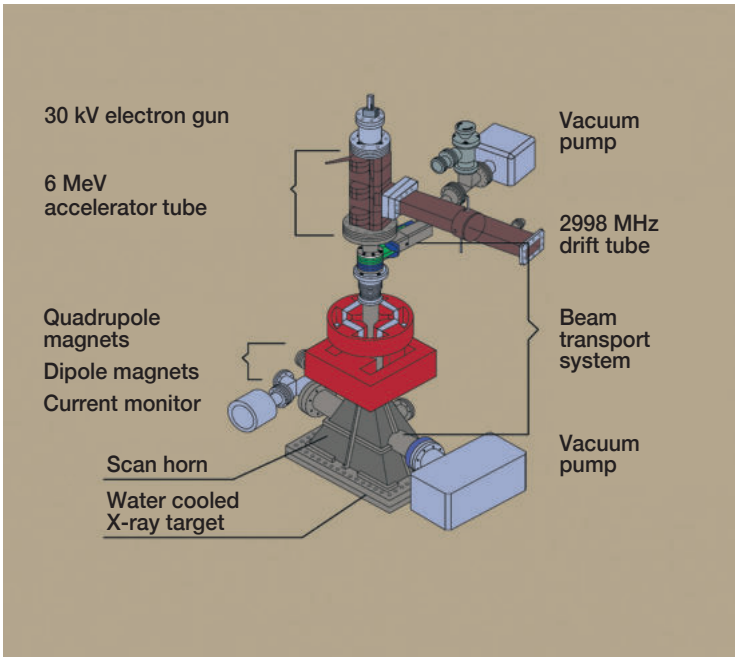

Particle accelerator for agriculture: SLRI technician installs the linear particle accelerator for fruit irradiation (left). Components of the SLRI particle accelerator, as of January 2020 (right).

applications, especially in the petrochemical industry.

KCMH Proton Center

Radiation therapy for cancer has been a continuous progress, starting with low energy X-ray to gamma radiation from cobalt-60 to high energy X-ray. The goal is to use high doses of radiation on the tumor while minimizing exposure on adjacent normal tissues. Proton therapy is the next step up. It has been recognized as one of the most effective therapies available.

For the auspicious occasion of H.R.H. Princess Maha Chakri Sirindhorn's 65th Birthday Anniversary in 2020 King Chulalongkorn Memorial Hospital has initiated the proton therapy center project to provide treatment for cancer patients with proton radiation, the first in Thailand and in Southeast Asia.

King Chulalongkorn Memorial Hospital, Thai Red Cross Society, initiated the plan for proton therapy in 2014 and carried out a feasibility study while making sure the hospital's staff are qualified to operate the new facility. KCMH Proton Center is housed 15 meters below ground level, equivalent to a 3-story building. The proton machine consists of a 90-ton particle accelerator or cyclotron and a 230-ton gantry with a nozzle that can move around the patient's body.

The protons are produced from the cyclotron which accelerates the particle to around 250 MeV. The advantages of proton over X-ray are the low radiation delivered to the healthy tissues in front of the tumor and almost no radiation on healthy tissues at the back, thus reducing side effects in adjacent vital organs.

Proton is a more effective type of radiation therapy than X-ray. Proton gives a more consistent dose on the target tumor, while non-tumor tissues receive minimal radiation. Doctors can increase the maximum dose to destroy all cancer cells and still keep side effects in check. Proton therapy is particularly suitable for young and old patients. Oncologists around the world are now converging on proton. Proton

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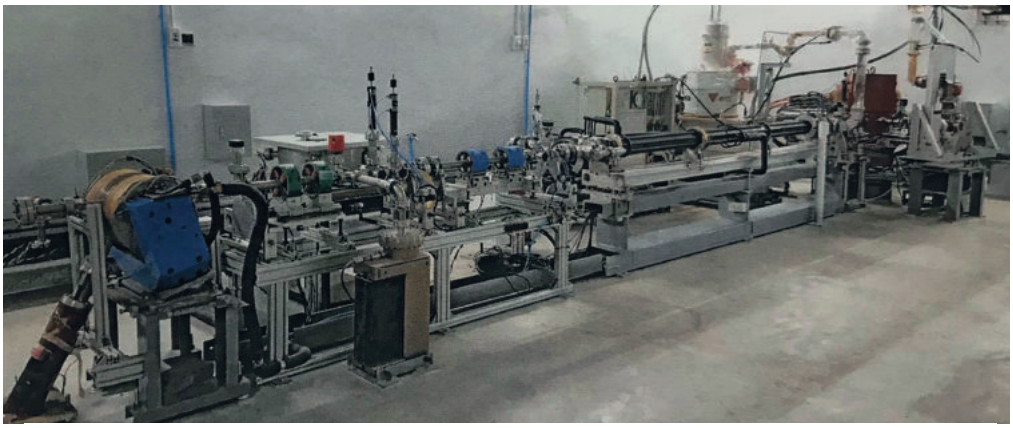

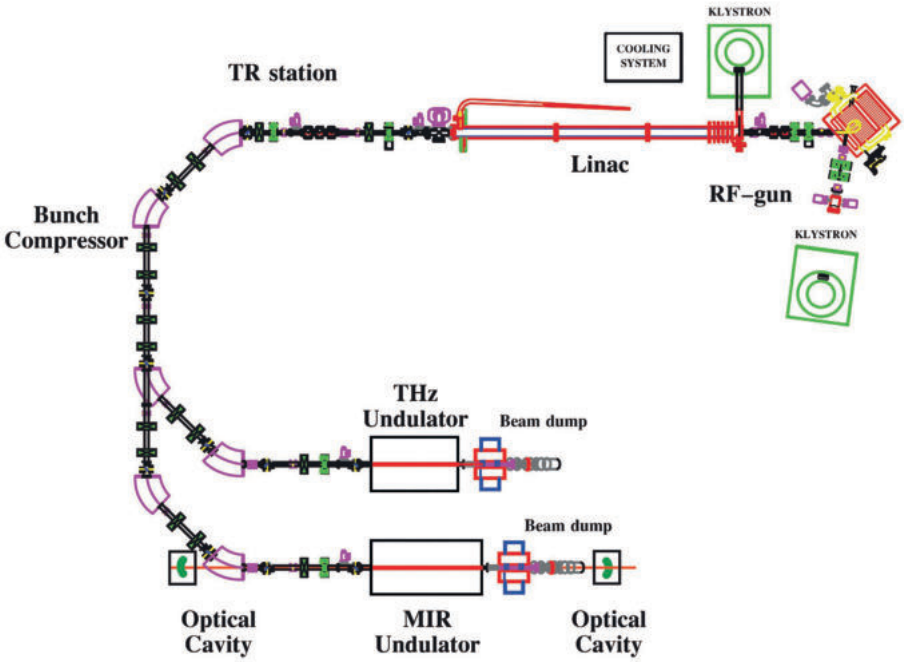

A part of Chiang Mai University's 25 MeV teraHertz/mid-infrared free electron laser (FEL) accelerator for agriculture, industry, and advanced research applications, e.g., molecular structure analyses of rice grains, rubber, medicine, narcotics, electrolytes in modern fuel cells, or state changes in graphene (top). A diagram of the FEL accelerator (bottom).

therapy is the future of standard cancer treatment.

When the KCMH Proton Center opens in 2020 it will be able to provide treatment for 400-500 patients per year. The patients will be comprehensively looked after. Systematic data collection and research will help make KCMH Proton Center a model radiation therapy center for the region and the world.

Fostering people

On the less abstract side, progress in science and engineering can never happen without people of the right quality. Contact with CERN has helped Thailand create a new generation of the specialists, provided an opportunity for

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science teachers and students to travel to CERN and exchange their experiences with teachers and students from all over the world.

Sending high school students to visit CERN

The High School Visit Program at CERN is a project that selects high school students for a week-long visit to CERN. Since 2013 the project has sent students on CERN visits and let the experience inspire them to take on further education in science and high technology.

In the first year 10 students from Mahidol Wittayanusorn School were sent. In subsequent years students from all over the country were also given the opportunity to join the project. Seven agencies lend their supports: Institute for the Promotion of Teaching Science and Technology (IPST), Office of the Basic Education Commission (OBEC), Science Classrooms in University-Affiliated School Project (SCiUS), Junior Science Talent Project (JSTP) under NSTDA, Mahidol Wittayanusorn School, Chitralada School, and Science Society of Thailand Under the Patronage of His Majesty the King. Until 2019 there have been 82 students and 13 accompanying teachers, in 7 parties, who joined the activities.

CERN Summer Student Program

The CERN Summer Student Program is one of the educational activities that CERN hosts for international students annually, especially for undergraduate and graduate students in physics, computing, engineering and mathematics. The students will learn about CERN's mission from past to present, research directions and development in particle physics, join in the day-to-day work of research teams participating in experiments, e.g., designing components of particle detectors, analyzing data from the particle detectors, simulating particle collisions in the particle detectors, fine-tuning database systems, analyzing data from the experiments and comparing them to theoretical predictions in particle physics.

Throughout the 8–12 weeks program, the students receive more than academic lectures and site visits. They also work with foremost scientists and in a multidisciplinary and multicultural environment toward a common goal, to fulfill a collective mission of study and research at CERN. Until 2019 there are 29 students in 10 seasons who have joined the program. The returning students are required to describe their experience to the public in a talk, or a written document, or a set of exhibition posters.

CERN Summer High School Teacher Program

The CERN Summer High School Teacher Program began in 1998. Its goal is to enrich physics teaching, especially particle physics, at high school level by lectures and workshops. The teachers will meet with teaching colleagues from around the world. Those who graduated from the program are expected to pass on what they have learned to their students.

Over the 1998–2018 period CERN has already educated and developed 12,320 teachers worldwide. By 2019, in 10 seasons, 19 Thai high school physics teachers have joined the program. These teachers are also expected to pass on their experience and knowledge to other teachers and the public.

Particle physics education activities

People in Thailand can get CERN knowledge too. There are Thailand-CERN

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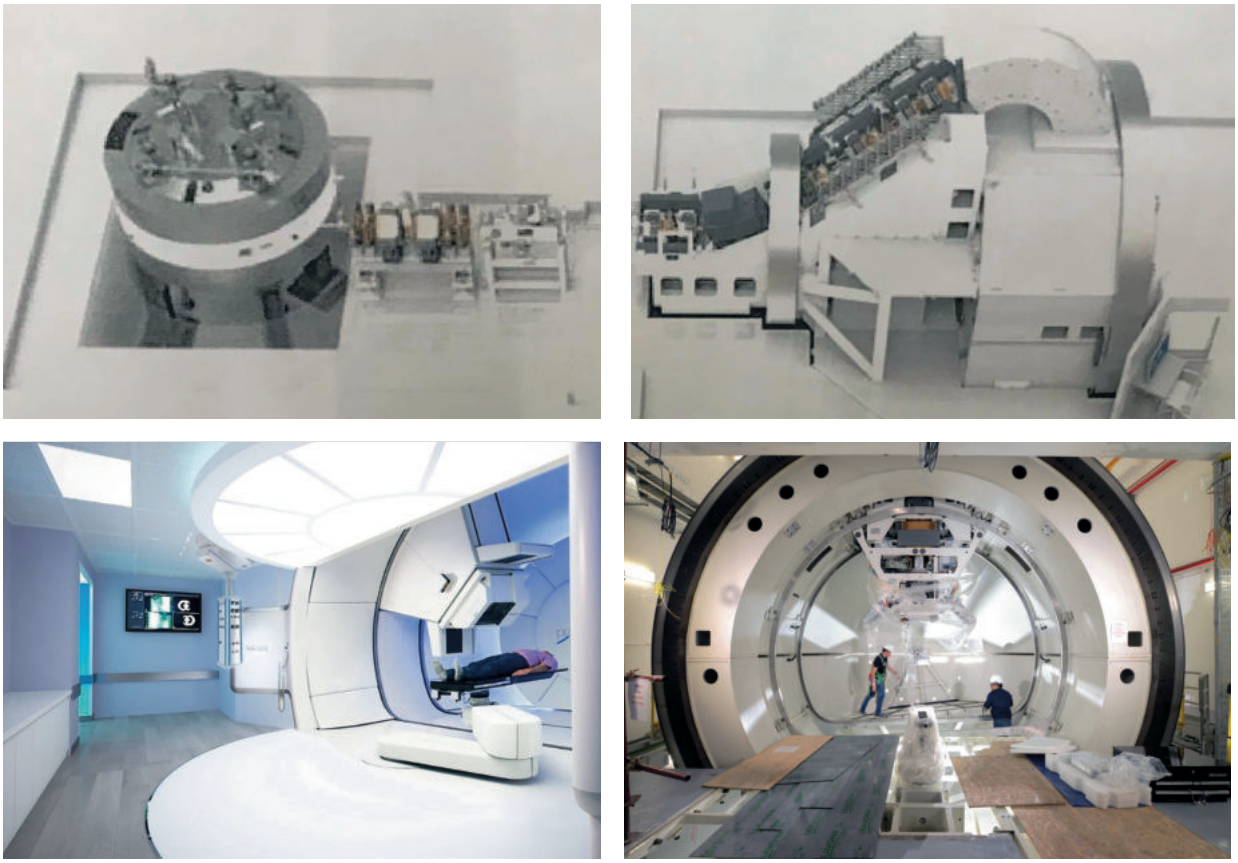

KCMH Proton Center: Cyclotron configuration (top left, top right). The gantry room was completed in late 2020 (bottom left). An ongoing construction in February 2020 (bottom right).

organized activities which provide particle physics education to school and university students and physics teachers. The 5 programs are as follows.

1. CERN School Thailand is a program to provide particle physics knowledge. Two sessions have been organized at Chulalongkorn University in 2010 and at Suranaree University of Technology in 2012

2. Thailand Experimental Particle Physics Novice Workshop is a workshop on particle physics, participants are given real experimental data from CERN to analyze, learn about particle accelerators and particle detectors. Four workshops have been organized.

3. Basic Particle Physics Program is an annual program to prepare selected students and teachers for summer activities at CERN.

4. Basic Particle Physics Program (Regional) is a program for target groups in other regions of Thailand.

5. Thailand School on High Energy and Astro-physics Program is a set of lectures for undergraduate and graduate students by Thai professors and domain experts.

Graduate students and researchers

Apart from the above programs, there are many Thai master's degree and Ph.D. students as well as Thai researchers who are studying or working at

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CERN or in other associated leading research institutions. They may be there because it is a part of their education or research, or apprenticeship. These people will become the future force of progress for Thai science and engineering.

Epilogue

Thailand-CERN collaboration project under the initiative of H.R.H. Princess Maha Chakri Sirindhorn has been successful for the past 20 years mainly because of Her Royal Highness' clear long-term vision that recognizes the significance and merits of basic scientific knowledge and engineering applications of nuclear physics and particle physics, and of creating opportunities for school students and teachers and university students at all levels as well as researchers to work in a world-class organization.

Another success factor is due to Her Royal Highness' attention on the operation, and the assignment of the Secretary of the Information Technology Foundation under the Initiative of Her Royal Highness Princess Maha Chakri Sirindhorn, Dr. Pairash Thajchayapong, to liaise with CERN. The Thai agency has continuously followed Her Royal Highness' initiatives, and always reports every activity in the annual committee meetings of Information Technology Foundation under the Initiative of Her Royal Highness Princess Maha Chakri Sirindhorn. NSTDA and SLRI have also received gracious royal kindness to be allowed to collaborate with the Information Technology Foundation under the Initiative of Her Royal Highness Princess Maha Chakri Sirindhorn.

Lastly, all agencies local and international are enthusiastic about Her Royal Highness' virtues and genius, seeing that Her Royal Highness' works are never for self-interest, but are truly for the benefits of Thai people and for mankind in general. These agencies have always given their best to serve Her Royal Highness' initiatives.

Writer and Photographer section
Visanu Euarchukiati is an author, a freelance academic and an astronomer with many published works. This story is the first he has written for the magazine. Ekaratana Panyathara is the photo editor and editorial photographer. This is his first scientific assignment.

A CERN program preparation session at
King Mongkut's University of Technology Thonburi in 2018.

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High school students from Thailand and other countries take part in a cloud chamber experiment in 2019 (top). Thai university students visited the venerable Proton Synchrotron in 2018 (middle). Physics teachers from Thailand attend a lecture by Professor Rolf-Dieter Heuer, CERN's Director-General, in 2014 (bottom).

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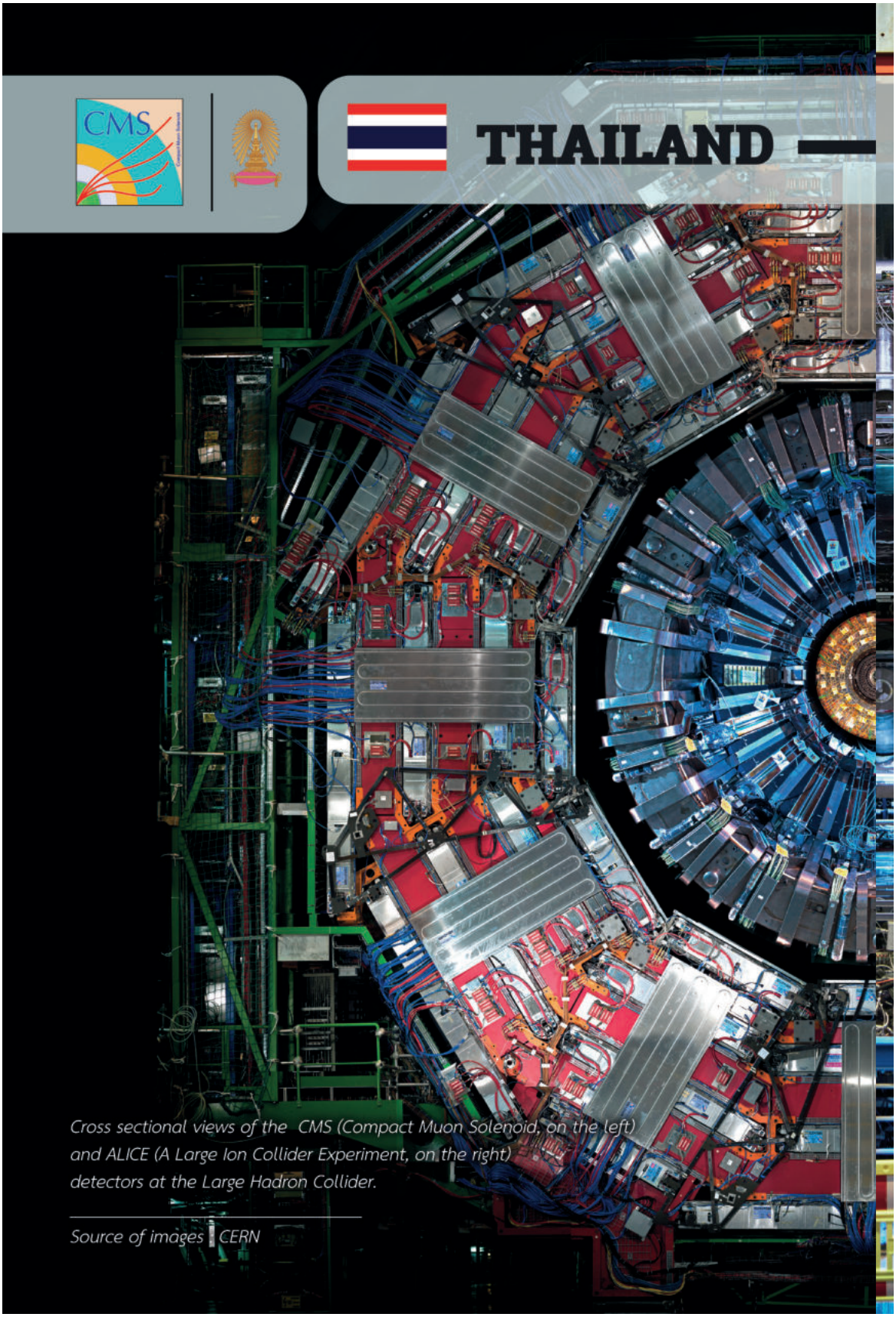

Cross sectional views of the CMS (Compact Muon Solenoid, on the left) and ALICE (A Large Ion Collider Experiment, on the right) detectors at the Large Hadron Collider.

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