THE UNITED NATIONS COMMISSION ON SCIENCE AND TECHNOLOGY FOR DEVELOPMENT

18th SESSION

4–8 May 2015
Geneva

Opening Session
4 May 2015

Contribution by

Department of Physics, MIT

Fundamental Science and Society

Prof. Samuel Ting

The views presented here are the contributor’s and do not necessarily reflect the views and the position of the United Nations or the United Nations Conference on Trade and Development
Presented to the Commission on Science and Technology for Development, 18th, Geneva
United Nations Conference on Trade and Development

Fundamental Science and Society

基礎科学与社会发展

Samuel C.C. Ting
丁肇中

Massachusetts Institute of Technology (MIT), Cambridge, MA, USA
and
European Organization for Nuclear Research (CERN), Geneva

May 04, 2015
Today, the problems which challenge us are immense. How can these challenges be met with the tools we have developed?

I would like to read a short passage:

“Humanity is being ravaged by disease; doctors are powerless against it; pollution is everywhere; men and women die daily in senseless ethnic conflicts; homelessness is rampant; people can’t read; children are being killed in the streets”

This was Europe in the year 1350
Yet from this period of despair, destruction and disillusionment sprung the greatest period of hope, new ideas and creative expression.

The Renaissance was born in Italy and spread throughout Europe transforming how people looked at the world and their place in it.

Scientists re-examined old ideas about the nature of the universe inherited from the ancient Greeks and Romans.

Modern science, or the understanding of natural phenomena using experimental techniques, was established during this time.
In 21st Century,

We enjoy unprecedented advancements in technological development such as in the fields of communication, computers, transportation, health care, etc ... which have had dramatic effects on the quality of life.
What is often forgotten is that the foundation of these achievements was laid down some time ago by scientists who were driven by intellectual curiosity and not by economic concerns.
The pyramid has grown with new applications increasing its height while fundamental research continuously widens its base.

The role of basic research implies that it finds itself in the outmost corners of the pyramid and hence is sometimes disregarded as being remote from daily life.

Only after time, when applications develop and the public becomes familiar with the new phenomena, does the value of basic research become more understood.
Physics at extremely small distances
Development of Accelerators

1612
Galileo’s work on Gravity
Energy: 0.0001 eV

2015
CERN
Invention of www
Study fundamental building blocks of nature
Energy: 14,000,000,000,000 eV = 14 TeV
CERN LHC Detectors

Discovery of Higgs Particle

ATLAS, CMS, LHCb, ALICE
Physics at extremely large distances

The Alpha Magnetic Spectrometer on the International Space Station
AMS: a U.S. DOE led International Collaboration
15 Countries, 46 Institutes and 600 Physicists

Strong support from NASA, CERN, MIT, DLR, ASI, AS, MOST, CDTI, CNES, INFN
300,000 electronic channels
650 processors
5m x 4m x 3m
7.5 tons
AMS: A trillion eV precision, multipurpose detector in space

Particles and nuclei are defined by their charge ($Z$) and energy ($E$). $Z$ and $E$ are measured independently by many detectors.
Cherenkov Detector
Major International Collaboration

...WE JUST DECIDED LAUNCHING MONEY DIRECTLY INTO SPACE WAS CHEAPER ...

Top currencies in the diagram: Yen (¥), DM, CHF, £, FFR, Lira, CHF.
The legislation unanimously approved by the U.S. House and Senate in 2008:

Section 611 (H.R. 6063)

(c) ADDITIONAL FLIGHT TO DELIVER THE ALPHA MAGNETIC SPECTROMETER AND OTHER SCIENTIFIC EQUIPMENT AND PAYLOADS TO THE INTERNATIONAL SPACE STATION.—

(1) IN GENERAL.—In addition to the flying of the baseline manifest as described in subsection (b), the Administrator shall take all necessary steps to fly one additional Space Shuttle flight to deliver the Alpha Magnetic Spectrometer and other scientific equipment and payloads to the International Space Station prior to the retirement of the Space Shuttle. The purpose of the mission required to be planned under this subsection shall be to ensure the active use of the United States portion of the International Space Station as a National Laboratory by the delivery of the Alpha Magnetic Spectrometer, and to the extent practicable, the delivery of flight-ready research experiments prepared under the Memoranda of Understanding between NASA and other entities to facilitate the utilization of the International Space Station National Laboratory, as well as other fundamental and applied life sciences and other microgravity research experiments to the International Space Station as soon as the assembly of the International Space Station is completed.
The USAF support for the C5 flight enabled us to transport of AMS from Geneva to Kennedy Space Center, Florida
In 4 years on the Space Station, AMS has collected over 60 billion cosmic rays.
AMS in Space

Science at extremely large distances
Search for the existence of Antimatter in the Universe

The Big Bang origin of the Universe requires matter and antimatter to be equally abundant at the very hot beginning

AMS is searching for the existence of antimatter to the edge of the observable universe
AMS Measurement of Periodic Table
1. The energy at which it begins to increase.
2. The rate of increase with energy.
3. The turn over energy.
4. The rate at which it falls beyond the turning point.

Collision of “ordinary” Cosmic Rays produce \( e^+ \), ...

Collisions of Dark Matter (\( \chi \)) will produce additional \( e^+ \), ...

The Science of AMS includes:

Understanding the Origin of Dark Matter

\(~ 90\% \) of Matter in the Universe is not visible and is called Dark Matter

\( m_{\chi} = 800 \text{ GeV} \)

\( m_{\chi} = 400 \text{ GeV} \)

\( e^+ , e^- \) from Collision of Cosmic Rays
1. The energy at which it begins to increase.
2. rate of increase.

11 million $e^+$, $e^-$ events

3. The turn over energy.
4. The expected rate at which it falls beyond the turning point.

To be determined in the next few years:

- Other astrophysical sources
- Dark Matter $m_\chi \sim 1$ TeV
- Collision of cosmic rays
- Turn over energy

Positron fraction vs. $e^\pm$ energy [Billion ev]
In Conclusion

The prime motivation of basic research is human curiosity - the innate passion to learn something new or obtain a deeper understanding of a natural phenomena. Today, basic research requires high standards of education at every level and thrives on political and popular support. Basic research also serves as a catalyst to industries in the development of new technologies. Spin offs from basic scientific research, although difficult to predict in advance, have had a profound effect on the quality of life. Basic scientific research is the foundation from which knowledge is advanced and technological development is propelled and should be supported.