

The Road Map for Discoveries for Africa

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Kwame Nkrumah University of Science and Technology**

Kumasi, Ghana



First to the Ghanaian people and leaders we extend out sincere condolences for the passing of your former President,

John Evans Atta Mills



Outline

Applied and Basic Research, Time, and Discovery

How the most simple became the most complex

A very few Pioneers

What is the value of pursuing truly new knowledge?

A Road Map for Africa

Investment, Future Value, and Impact

Some Applied Research is closer to solving a problem of a specific and well defined Issue.

What method is best for extracting oil from oil shale ?

Fundamental Research does not have so true a focus because the questions are sometimes broader.

An example would be:

What laws of nature determine the course of future history and constrain other research efforts or our understanding of the truth?

How large is the universe?

It often takes time to pursue the individual answers to research questions and often substantial resources.

So the problem could be defined as resources over time and gauging the impact of solving a particular problem, or even better, making a discovery.

Industry supports the applied research effort mostly, and the society often supports the academically motivated and more basic research effort.

Is the investment better because we have an expected outcome?

Long-term Benefits:

- * Knowledge is the foundation of future technology
- * Technology drives economic growth
- * Fundamental Research → Innovation → Prosperity
- * Particle physics research produces transformative discoveries and contributes positively to the health of a national scientific structure.
- * Examples:
 - * Faraday's experiments on electricity → electric light
 - * H E P communication needs → World Wide Web
 - * Superconducting wire → new machines

Cost and benefits of public investment have been shown to be a positive outcome.

Near-term (~ our lifetimes):

- * Employment
- * Procurement
- * Technology Transfer, Knowledge Transfer

Benefits of Fundamental Physics Research

- Increase our understanding of nature and how it works
- Technological spin-offs –
- much of today's economy is based on late 1800s – early 1900s research on the electron →
TV (accelerator) & communications

DISCOVERY

Extracting and understanding a phenomena for the first time!

Leading to answers and often more questions

Usually a piece of a puzzle that took some time to ascertain

Often connecting many separate fields of study.

The Road Map

Capacity development in human potential as well as institutional development is crucial to the continued and increase participation of Africa in Discovery Science.

High School participation using the QuarkNet Program focused on the LHC continues to be very successful. This led to the use of decommissioned research equipment for use in some High Schools in the USA and elsewhere.

This concept can also be implemented for student institutions represented in this African School for Fundamental Physics Research.



As an agricultural chemist, Dr. Carver discovered hundred of uses for Peanuts and hundred more for: Soybeans, Pecans, Sweet potatoes, and made them into: adhesives, bleach, buttermilk, sauces, axle grease, fuel briquettes, ink, metal polish, paper, plastics, synthetic rubber, and many more..

Dr. George Washington Carver
USA Library of Congress
LC J601-302

However, Dr. Carver only applied for three patents:

paints and stains from soybeans

#1,522,176, 1/06/1925, Cosmetics & Plant Products

#1,522,178, 1/06/1925, Paints & Stains

#1,632,365, 6/14/1927, Paints & Stains



U.S. DEPARTMENT OF
ENERGY

Lincoln University, 1946

Courtesy: Leo Baeck Institute, New York & The Albert Einstein Estate

 **Fermilab**

Research has provided long-term benefit through applied physics:

The quantum theory of solids leading to semiconductors and computer chips

Nuclear Magnetic Resonance leading to MRI imaging

Particle accelerators leading to particle beams for cancer treatment.

Could Dr. Einstein's theories of special and general relativity also be connected to current day benefits?

Relativity plays a key role in the multi-billion dollar industry
concentrated around the
Global Positioning System (GPS)



Military Navigation amounts to \$10 billion effort

24 atomic clock satellites in orbit at 14000 km/hr and
20,000 km above the Earth

Gravity is \sim four times weaker

The GPS clocks run faster than earth based clocks.

Relativity is needed to adjust the time
by **38** micro-seconds/day

For roughly every billion anti-particles there are one billion and 1 particles.

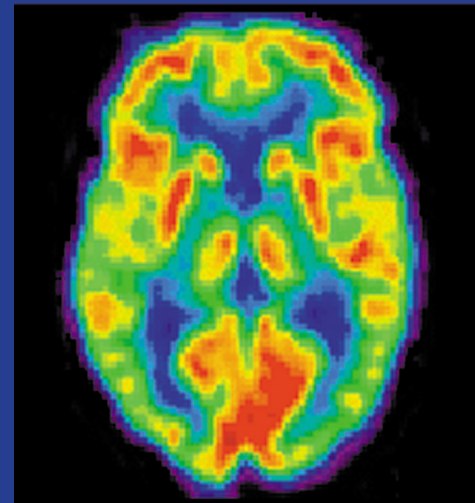
The cosmic microwave background radiation during the forming of the Universe is the leftover energy from the annihilations of matter and anti-matter.

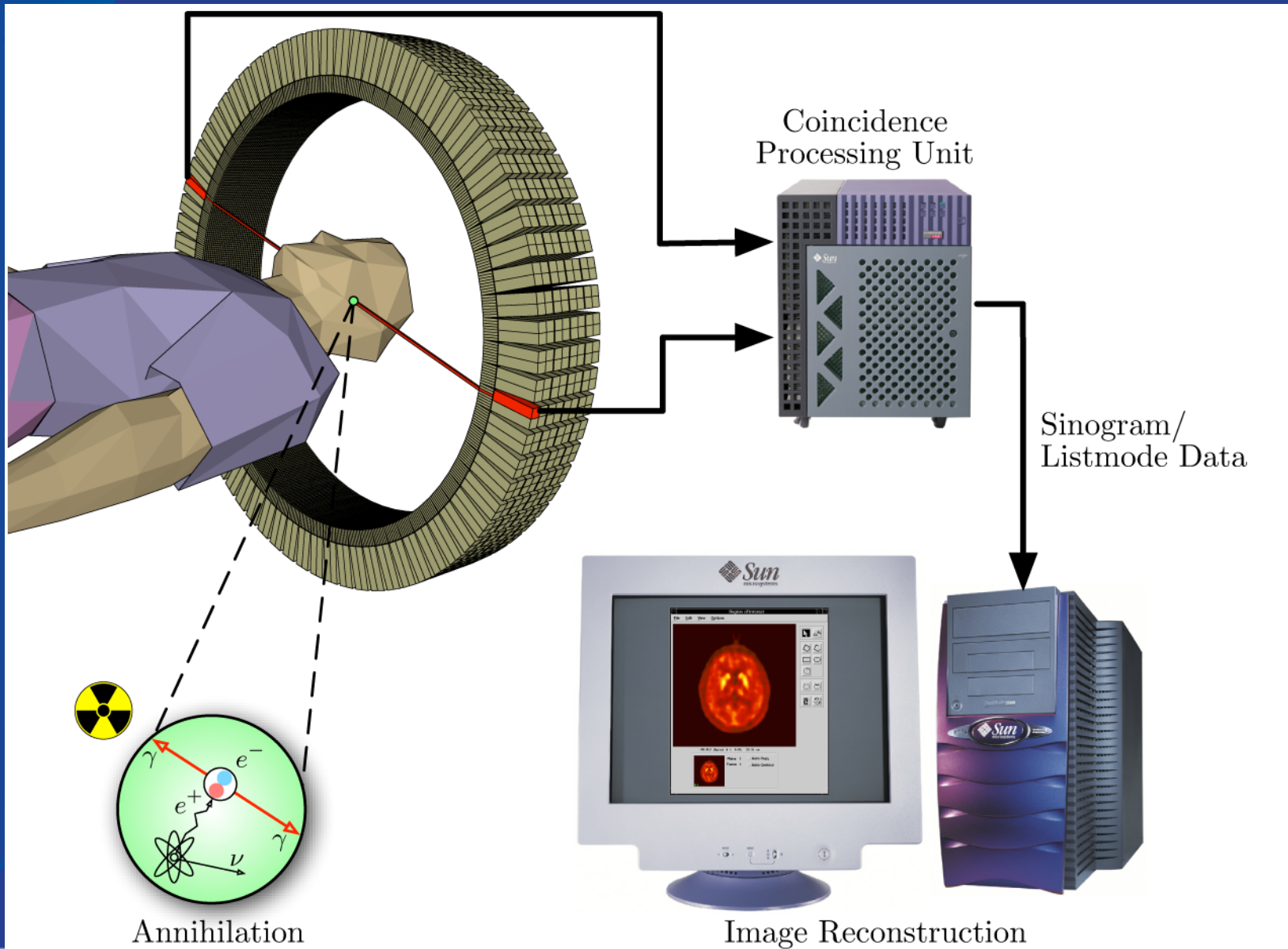
The matter left over from the billions of matter and anti-matter annihilations makes up the matter Universe (Stars, galaxies and Us as we know it now).

What Value?

Antimatter can be used for

- PET Scans





Ideas can be implemented in any country.
Collaborations and cooperation for mutual benefit is the true basis of executing pioneering research.

The models of CERN and collaborations around the world on complex research projects are primary examples.

We want to suggest this for the countries in Africa.

The World Wide Web

For decades, HEP physicists shared preprints through the mail.

The USA government created ARPANET, (Advanced Research Projects Agency Network)

linking academic institutions and research centers

1983 network splitGovernment
.....Civilian branch

1995 Civilian branch was renamed the **Internet**
an international network of computers connected by the
same communications protocol.

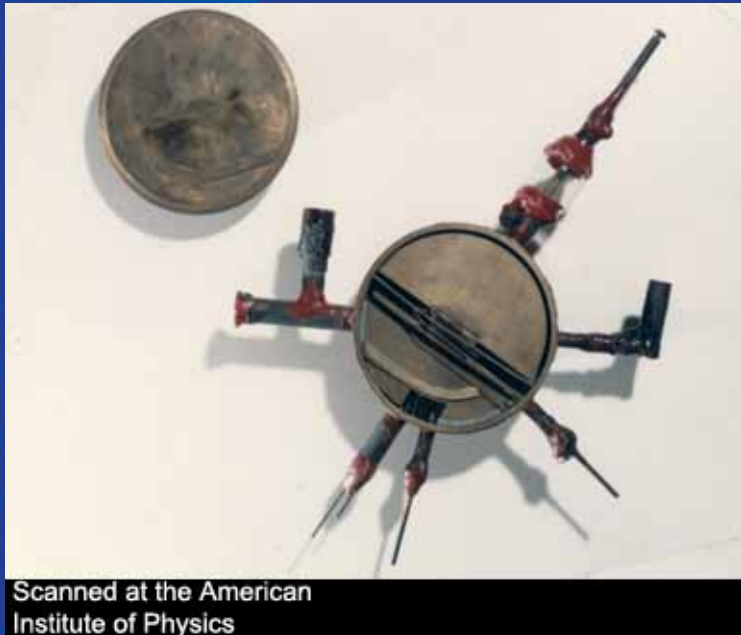


In 1990, physicist **Tim Berners-Lee**, at the CERN Lab created the Hyper Text Transfer Protocol (**HTTP**)

In very large science research, we often solve problems that we do not know we have. The **Web** was created to manage data using the internet and provided a solution to handling information that was not considered before. This led to a major impact on the quality of life in our present world, influencing the way we work, play, control commerce, and govern.

Clearly of great value to some, and unpredictable!

The First Accelerators



Scanned at the American Institute of Physics

Lawrence and Livingston began developing this 4.5-inch cyclotron in 1929-30.



Scan @American Institute of Physics

Livingston (left) and Lawrence with the magnet of the 27-inch cyclotron, operating in 1932 at 3.6 MeV.

If you have some protons to spare, one makes neutron beam for cancer therapy :



Fermilab also built a proton Therapy accelerator for Loma Linda, California. 350,000 treatments so far!



Particle accelerators: invented for pure research, then applications come.

I wish also to thank our hosts and organizers for an outstanding effort in making this conference and school such a success.

My best wishes to
Professor I. K. Dontwi of the Institute of Mathematics

And particularly to
Dr. Peter Amoako-Yirenkyi of the department of Mathematics and his staff who set up a very successful system for the students and lecturers alike at this institution.