U.S. DEPARTMENT OF ENERGY | Office of Science

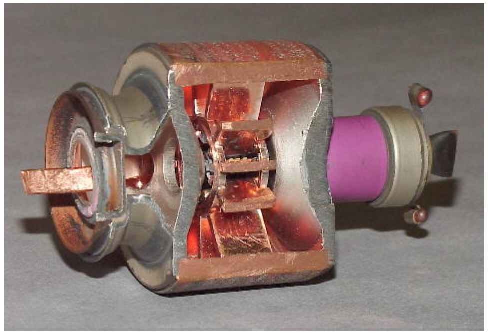
Office of Science Perspective

Symposium on Accelerators for America's Future

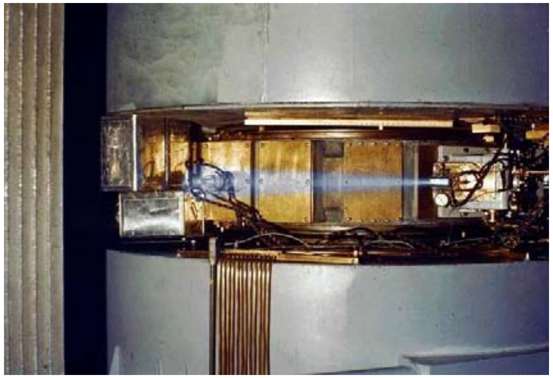
October 26, 2009

Dr. William F. Brinkman
Director, Office of Science
U.S. Department of Energy

A Rich Heritage of Advancement

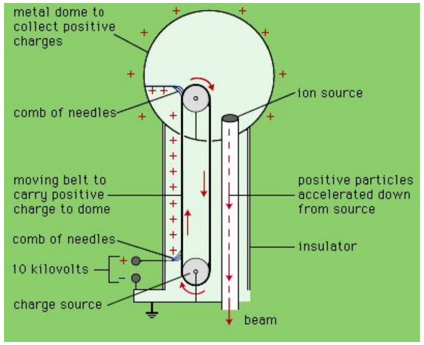


Magnetron



Cyclotron

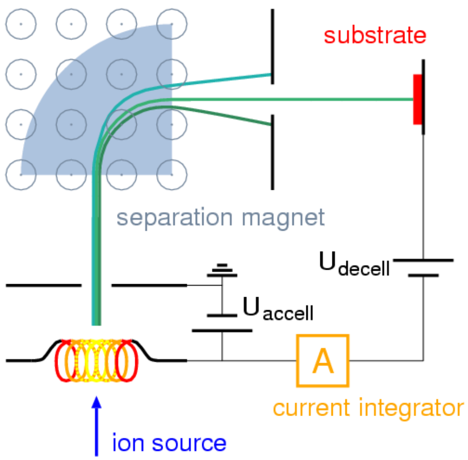
Synchrotron



Van de Graaff

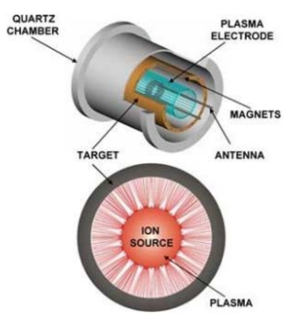
Linear Accelerator

Accelerators Touch Our Lives in Many Ways



Ion Implantation

Isotope Production



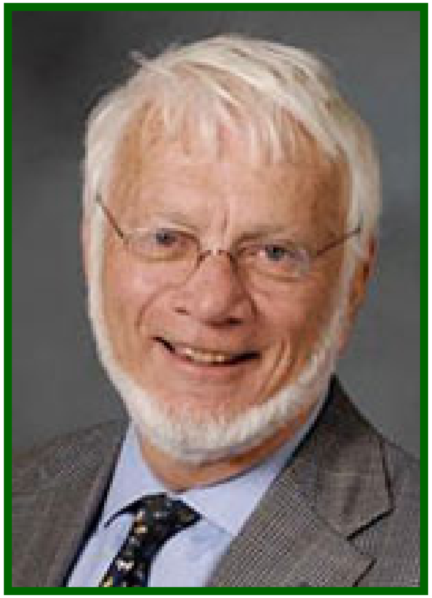
Neutron Generators

Medical Use

2009 Nobel Prize in Chemistry based on X-ray Crystallography

Venkatraman Ramakrishnan

Ada Yonath

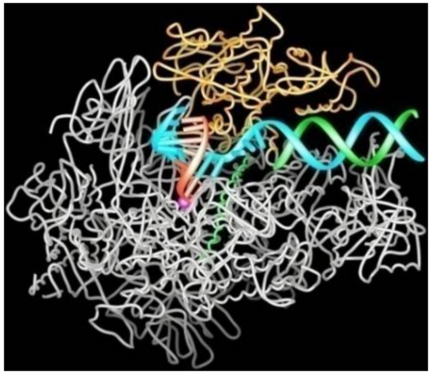


Thomas Steitz

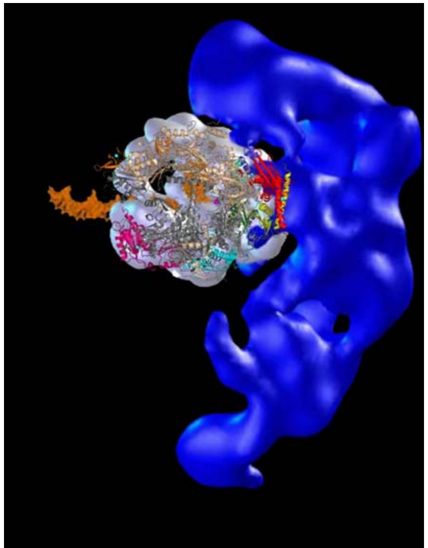
- Three molecular biologists who mapped the structure and inner workings of the ribosome — the cell's machinery for churning out proteins from the genetic code — have won the Nobel Prize in Chemistry in 2009.
- Venkatraman Ramakrishnan, who works at the Medical Research Council's Laboratory of Molecular Biology in Cambridge, UK; Ada Yonath of the Weizmann Institute of Science in Rehovot, Israel, and Thomas Steitz at Yale University in New Haven, Connecticut, share the prize equally.

Reading the Genetic Code – How Does DNA Transcription Occur - How Is It Regulated?

The SSRL Structural Molecular Program is funded by DOE-BER, NIH-NCRR and NIH-NIGMS

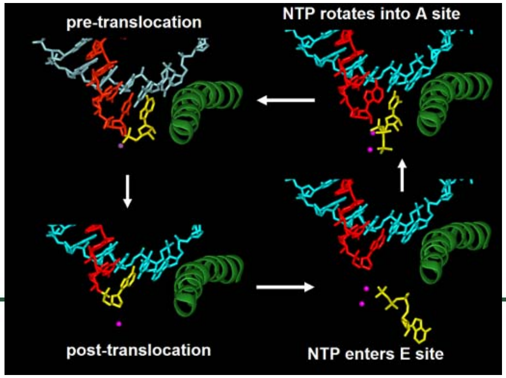


- Transcription is the process by which DNA is "read" and converted into a message that directs protein synthesis with extremely high fidelity. Protein synthesis is carried out by the ribosome (the focus of the 2009 Chemistry Nobel Prize)
- Three main stages are initiation, elongation and termination, which are carried by an exceedingly complex molecular machine and associated proteins (RNA Polymerase-II)
- Synchrotron-enabled studies have provided molecular-level insight into the function of this molecular machine
- Most of the synchrotron work was performed at SSRL and strongly enabled by beam line automation and robotics



Structure of Pol II (white) and full mediator complex (blue) determined from EM. The high resolution crystallographic structure of Pol II has been fitted into the lower resolution structure from EM.

This structural information now serves to guide the development of new antibiotics



Roger Kornberg receiving the 2006 Nobel Prize in Chemistry for his research on RNA Polymerase II

Accelerator Support in the Office of Science Programs

Basic Energy Sciences (~$500+M, overwhelmingly operations of facilities)

National Synchrotron Light Source
Stanford Synchrotron Radiation Laboratory
Advanced Light Source
Advanced Photon Source
Linac Coherent Light Source
SLAC Linear Accelerator
National Synchrotron Light Source-II
Spallation Neutron Source
Manuel Lujan Jr. Neutron Scattering Center

Nuclear Physics (~$250M, overwhelmingly operations of facilities)

Continuous Electron Beam Accelerator Facility
Relativistic Heavy Ion Collider
Holifield Radioactive Ion Beam Facility
Argonne Tandem Linear Accelerator System

High Energy Physics (~$500M, with very substantial advanced R&D)

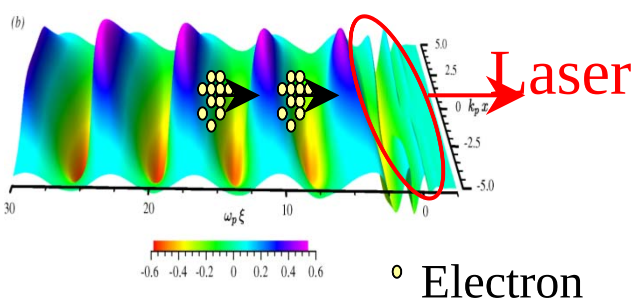
Tevatron Collider + improvements/upgrades
Large Hadron Collider
Advanced technology R&D

- **There are a number of promising emerging accelerator technologies now under investigation with HEP support:**
  - High-Gradient RF Structures
  - Muon Accelerators & Colliders
  - Photonic Band-Gap Structures
  - Superconducting Radio Frequency
  - Wake Fields in Plasmas or Dielectrics

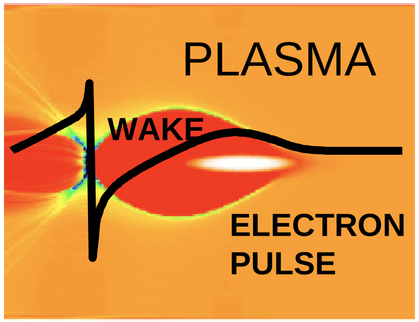
Example: Wakefield Technology

Wakefield technology proposes to miniaturize accelerators with ultra-high gradient acceleration of charged particles.

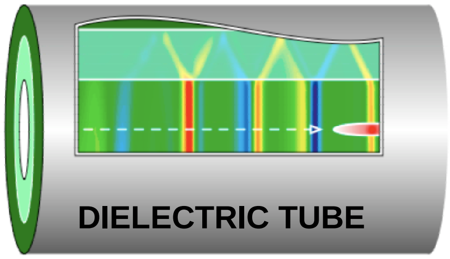
- A laser or electron beam pulse propagating through charged plasma or a dielectric tube excites a wake behind the pulse.
- The wake field is O(GeV/m), propagates at the speed of light, and accelerates a following beam bunch or plasma particles.
- A useful analogy has the particles “surfing” the wakefield.



Laser-Driven Plasma Wake



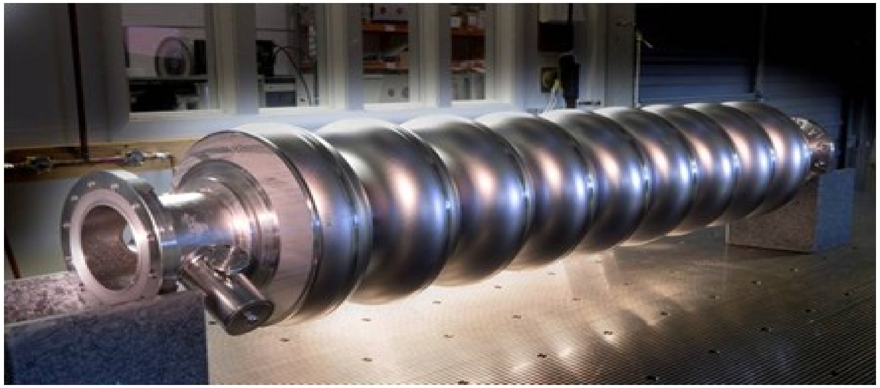
Beam-Driven Plasma wake



Dielectric wake field

Anticipated Improvements from Wakefield Technology

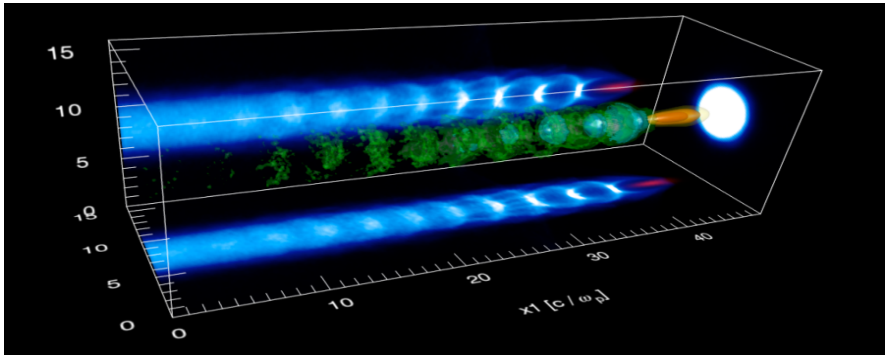
Conventional cavity: meter scale



Accelerating Gradient

10 - 40 MV/m

Plasma Technology: 100 micron scale



10 - 100 GV/m