CEBAF, the Continuous Electron Beam Accelerator Facility

CNU Lifelong Learning at Jlab
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Nuclear Model

- Need tiny probe to “see” inside the nucleus
- Need lots of energy to penetrate the atom
What to do?

Build a 5 mile long electron microscope!

Make it powerful enough to see inside a proton or neutron.
How to make the electrons “powerful”? Use radio(frequency) waves!!!

Electrons gain energy on each crest!
Cavity frequency is 1497 MHz.

Each cavity imparts millions of volts (MV) of energy gain to each passing electron.
How to reach Billion Volts (GeV) energy?
Recirculated Linac Concept
The S in SRF (very cold stuff!)
Magnets Make the Beam Turn
Typical Magnet Assembly
• Beam has its own radio signal.
• We use 4 antenna to find the beam.
Now that we have a beam, we need an experiment...
But wait, 1 accelerator & 3 experiments !?!

We need to take a big step back!
Where do the electrons originate?

Photoemission of spin-polarized electrons from GaAs

Daniel T. Pierce* and Felix Meier

Laboratorium für Festkörperphysik, Eidgenössische Technische Hochschule, CH 8049, Zürich, Switzerland

(Received 10 February 1976)
Electron Gun Cut-Away

Laser shines on GaAs & frees the electrons...

...the -100kV “battery” accelerates and forms the electron beam.
More modern version of an electron gun!
Continuous Electron Beam Accelerator Facility

- 0.6 GeV linac (20 cryomodules) 1497 MHz
- 67 MeV injector (2 1/4 cryomodules) 1497 MHz
- RF-pulsed drive lasers 499 MHz, Δφ = 120°
- Pockels cell
- Chopper
- RF separators 499 MHz
- Double sided septum
- Gun
- RF-pulsed drive lasers 499 MHz, Δφ = 120°
Photo Finish, but at 2 billionths of a second !!!

3 lasers pulsing

DC beam, not so useful

1497 MHz

60 degrees
The “C” in CEBAF

- Pulsed beams used prior to 1980 (100 mA)
  - Duty factor = 1%

  ![Diagram of pulsed beam]

  
  10 Coulombs
  0.01 second
  0 Coulombs
  1 second

- Advantages of a continuous beam with the same average current
  - Duty factor = 99%

  ![Diagram of continuous beam]

  
  0.01 second
  0.1 Coulombs
  1 second

- too many electrons in the target over the time interval $\Delta t$
- lots of random coincidences

- few electrons in the target -- few random coincidences

Office of Nuclear Physics

Thomas Jefferson National Accelerator Facility

U.S. Department of Energy
Continuous Electron Beam Accelerator Facility

Gun

Pockels cell

RF-pulsed drive lasers

499 MHz, \( \Delta \phi = 120^\circ \)

Chopper

RF separators

499 MHz

0.6 GeV linac (20 cryomodules) 1497 MHz

67 MeV injector (2 1/4 cryomodules) 1497 MHz

Double sided septum
“Pulse Pickers every 2 billionths of a second...”
• Stick something in the beam that glows
Remotely “driven” from the Machine Control Center
12 GeV CEBAF

Upgrade magnets and power supplies

Add 5 cryomodules

20 cryomodules

CHL-2

Add arc

Two 1.1 GV linacs

Add 5 cryomodules

20 cryomodules

New cryomodules get new rf zones

Two 0.6 GV linacs