

Continuous Electron Beam Accelerator Facility (CEBAF) Overview

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Graduate Seminar
Fall 2022

Outline

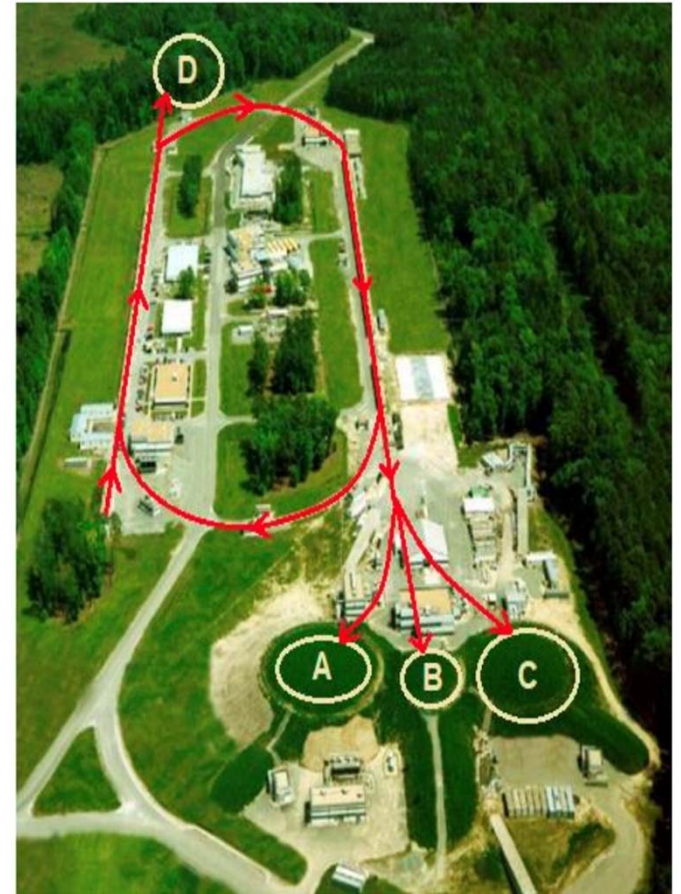
- The purpose of talk is to describe what the CEBAF is, the subsystems it consists of , how they work, their purpose
- Subsystems
 - Injector
 - LINACs-Linear Accelerators
 - CHL-Central Helium Liquefier
 - Recirculation Arcs
 - Spreaders and Recombiners
 - Beam Extraction Region

Jefferson Lab Overview

- The Thomas Jefferson National Accelerator Facility
- Location : Newport News, Virginia
- Primary Facility : CEBAF
- Created in 1984
- Started physics operations in 1995
- Mid-sized lab
- Core Competencies
 - Nuclear Physics Research
 - Superconducting Radio Frequency (SRF) Technology Leadership
 - Polarized Electron Sources
 - Cryogenics Research and Development

Quick Facts of CEBAF

- Particle accelerator at JLab
- Electron beam energy up to 6 GeV until 2012 and now up to 12 GeV
- High Polarization ~90%
- 4 experimental halls
- Use SRF techniques



CEBAF Tunnel

- CEBAF Tunnel ~30 feet underground, ~10 feet high and ~13.5 feet wide
- 7/8 miles around (1.4 km)
- Two superconducting LINACs (linear accelerator), each ~1/4 mile long
- Composed largely of over-consolidated sand, clay and seashells (Built on Yorktown formation-an ancient seabed)

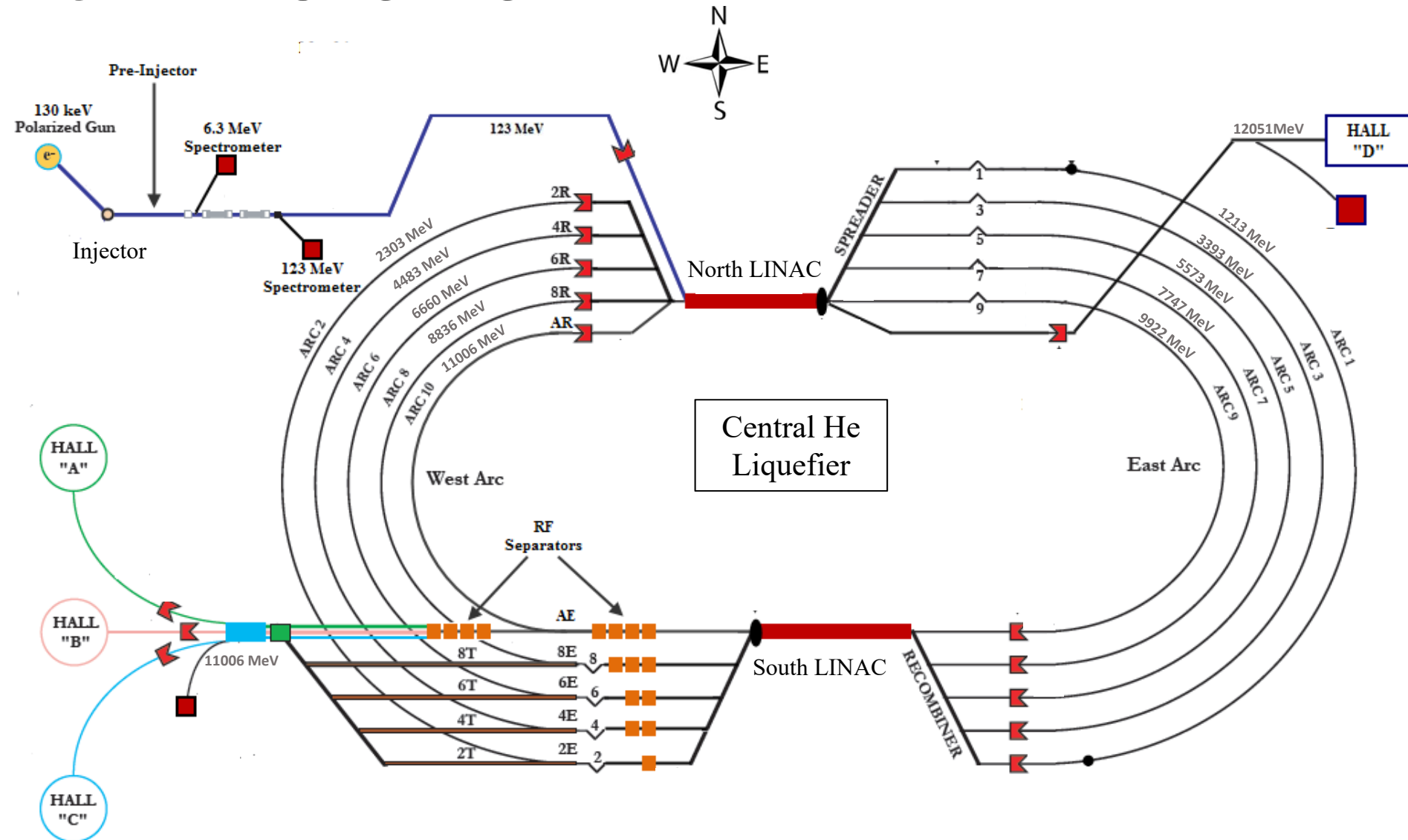


East Arc Tunnel

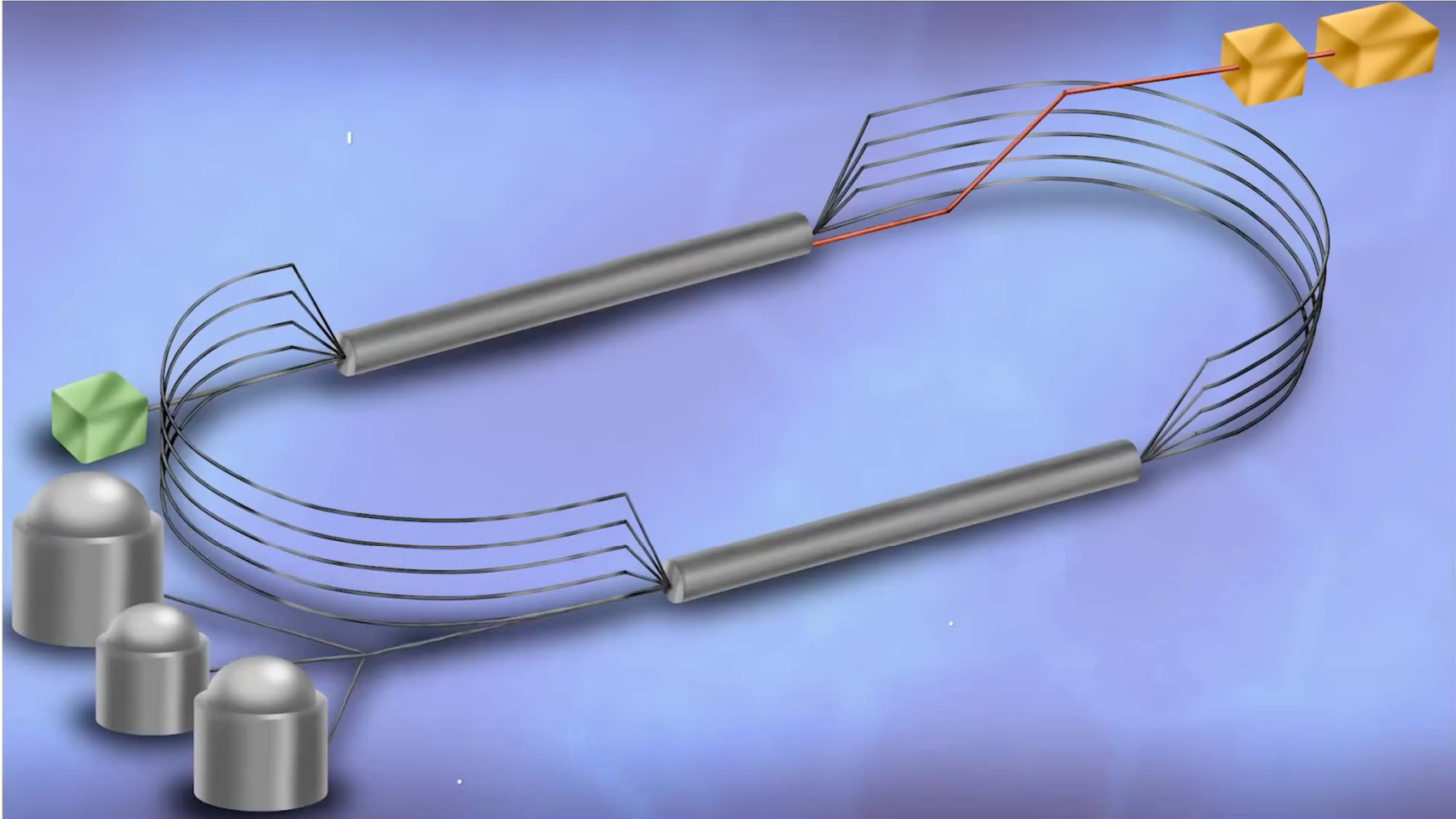


LINAC Tunnel

CEBAF Overview

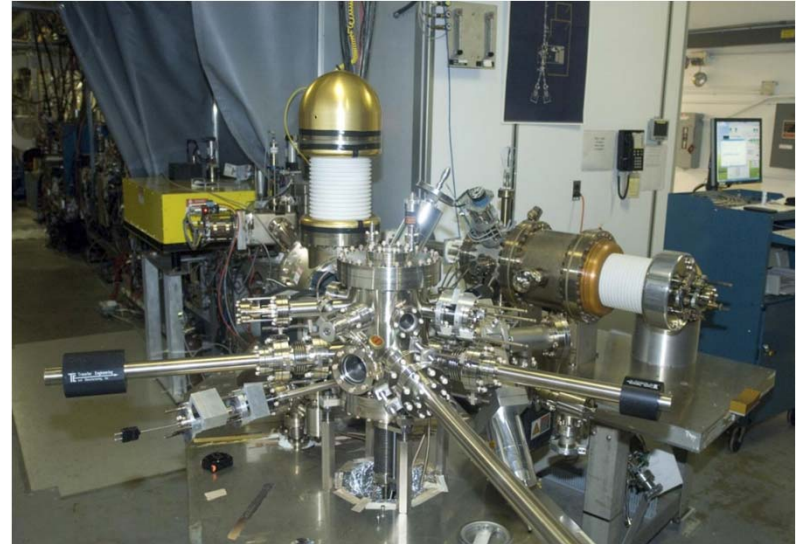


CEBAF Overview-Electron Beam

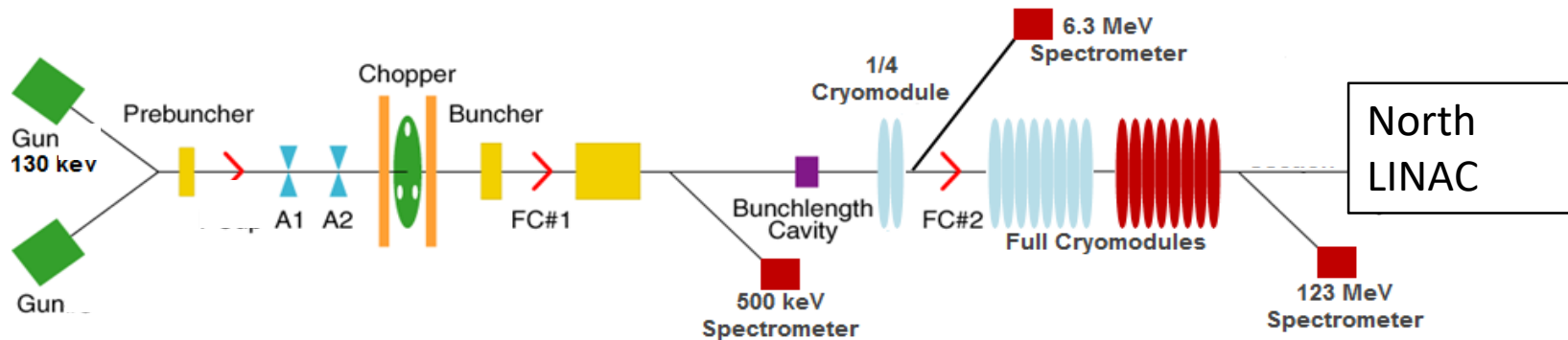


CEBAF Injector

- Laser light that shines on the Gallium Arsenide photocathode emits electrons
- During three-hall operations, three separate lasers—one for each hall—are used to generate three interlaced electron beams
- Once the electrons come out from the photocathode, the high voltage gun pushes them into the beam line
- There are two guns in the injector. One is a spare



CEBAF Injector



- Subsections:

- Pre-buncher/Buncher - control longitudinal size of beam (beam is conditioned and beam bunch is structured)
- Aperture A1 and A2 - collimate the beam
- Chopper system - independently control beam intensity for each experiment
- Faraday cups - measure beam current
- Cryomodules containing 8 SRF cavities in each - accelerate beam from 130 keV to 123 MeV and inject into the North LINAC
- Spectrometers - measure energy of the electron beam

North and South LINACS

- Straight part of CEBAF ~10 m in length
- Linear accelerator facility
- Electron circulate over the LINACs up to 5 times
- Purpose: accelerate the beam

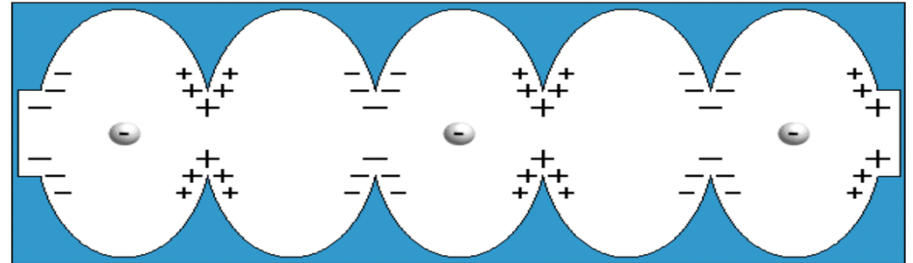
Subsections:

- Cryomodules
 - Insulated containers that shield cavities and liquid helium from the heat of the outside world
 - 8 SRF cavities in each cryomodule
 - Need very low operating temperature



North and South LINACS

- SRF Cavities
 - Consist of electromagnetic fields in the microwave region of the spectrum
 - Electrons gain energy by placing negative charges behind them and positive charges in front of them
 - Made up of Niobium
 - SRF cavities allows CEBAF to operate efficiently
 - SRF cavities sit in a bath of 400 gallons of liquid helium cooled to 2 Kelvin



Central Helium Liquefier

- Central Helium Liquefier keeps the cryomodules super cold
- CEBAF has one of the world largest 2K liquid helium refrigerator
- Consists of ~17000 gallons of liquid helium
- The CHL runs continuously 24×7



CEBAF Recirculation Arcs

- Recirculation arcs transport the beam between LINACs
- Low energy electron beam at the top
- High energy electron beam at the bottom
- 16 or 32 dipoles are used to complete the 180 degrees bend



- Subsystems

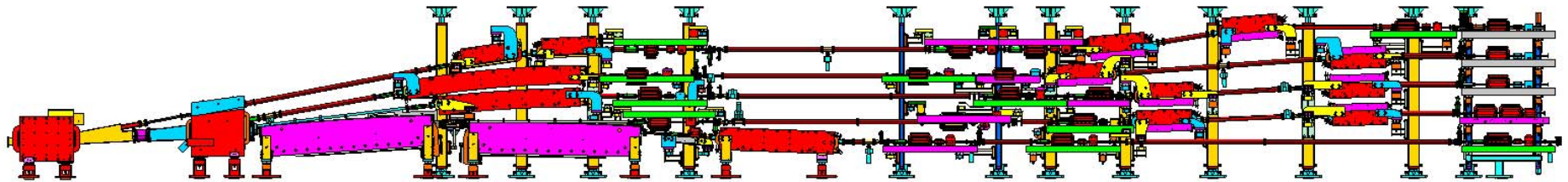
- Recirculation Magnets

- Purpose: Steer and focus the electron beam
 - 2200 magnets in CEBAF
 - Heaviest magnet is about 20,000 pounds
 - Magnets can be powered up to 300 Amps

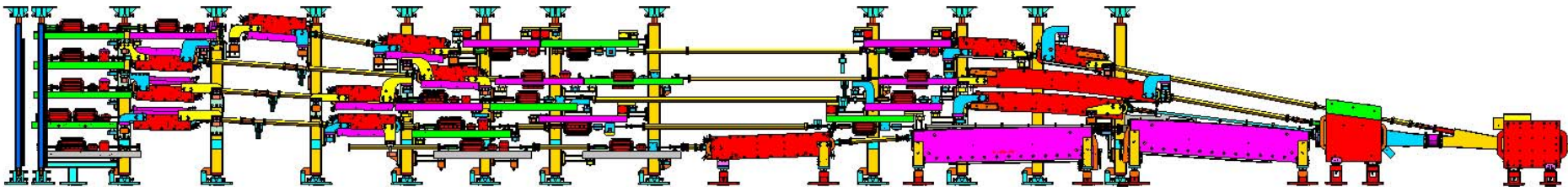
- Guarders
 - Correctors
 - Quadrupoles

Spreaders and Recombiners

- Spreader and Recombiner sections of the machine connect linear accelerators to recirculation arcs
- Recombiner is mirror-symmetric to the Spreader
- Spreader- distribute beam over 5 arcs
- Recombiner-recollect all the beams back

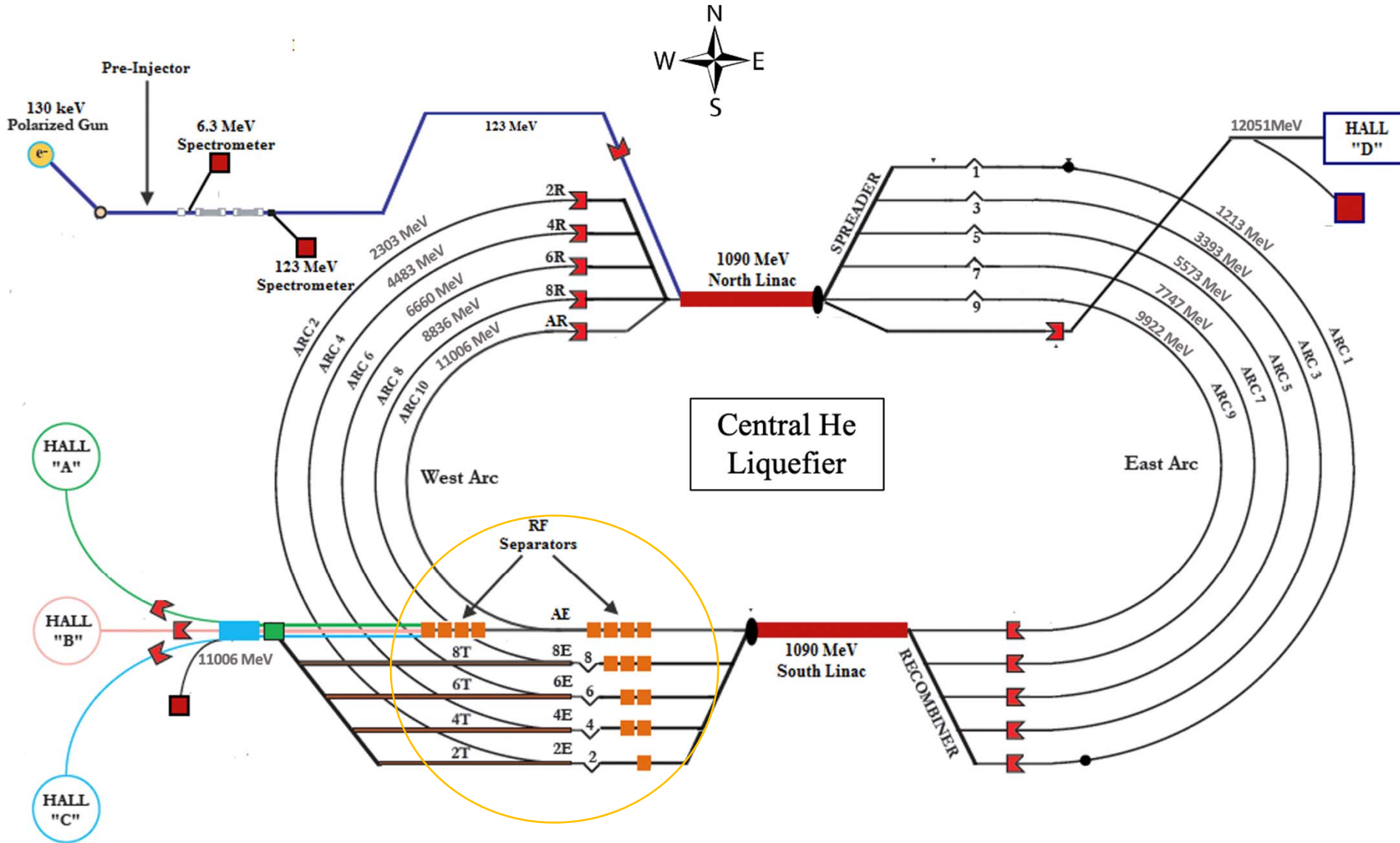


West Spreader



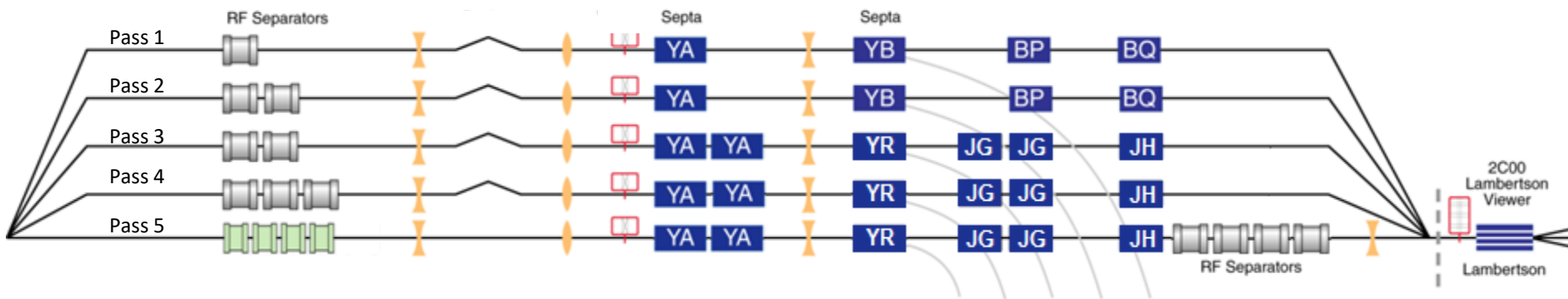
West Recombiner

Extraction Region



Beam Extraction System

- Any single user can receive beam from the first four passes
- All 3 users may receive beam from the fifth pass
- Time-dependent transverse kicks are applied to the micro bunch structure to selectively direct beams along the correct path
- Extraction system consists of RF Separators, Septa and Dipole magnets
- 1-4 pass uses horizontal separation to deflect one beam to halls A, B or C
- 5th pass uses vertical separation, and all 3 halls can have the maximum energy at the same time



Experimental Halls

❑ Hall A

- Electro- and Photo- induced reactions at very high luminosity with momentum and angular resolution

❑ Hall B

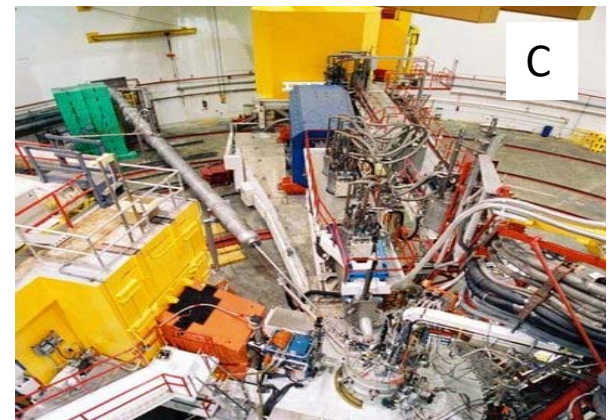
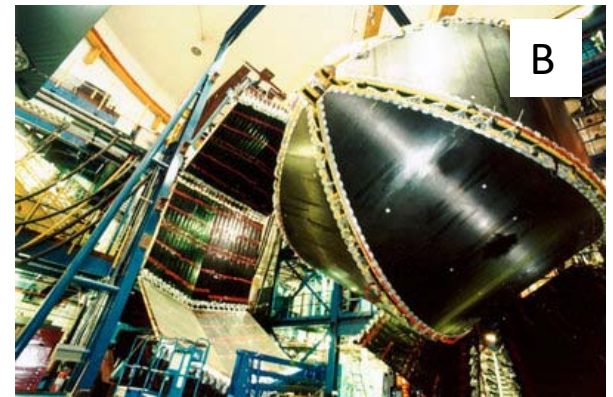
- CEBAF Large Acceptance Spectrometer (CLAS) is used to study electron-production reactions with radiator and tagging system, photo-production reactions

❑ Hall C

- High Momentum Spectrometer (HMS) is used to detect electrons, pions, kaons with high momentum up to 7 GeV/c and find the structure of baryons and mesons

❑ Hall D

- Experiments on Gluons - GlueX collaboration



Summary

- CEBAF is the particle accelerator at the Thomas Jefferson Accelerator Facility
- Injector produces the polarized electron beam by shining laser beams on GaAs photocathode
- LINACs accelerate the electron beams using SRF Cavities
- Recirculation arcs bend the beam in 180 degrees using dipoles and recirculation magnets
- Central Helium Liquefier produces the liquid helium required for cooling the system
- Spreaders and Recombiners help to connect the LINACs and Recirculation arcs
- Extraction region peels off the beam and kicks off the corresponding beam to corresponding experimental hall ; Hall A, B, C and D

Thank you!