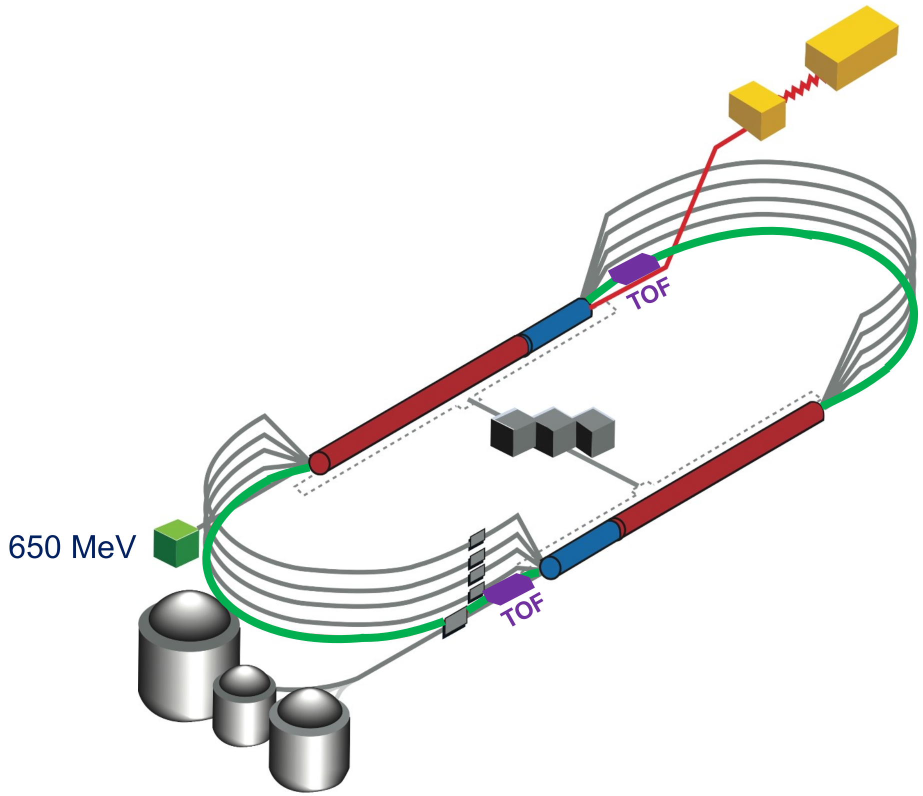
22 GeV CEBAF Energy Upgrade – State of the Concept

Feasibility study for additional FFA racetrack in the existing CEBAF tunnel to reach the top energy of about 22 GeV



Alex Bogacz (first nine slides) Jay Benesch (last four)

The FFA@CEBAF Collaboration

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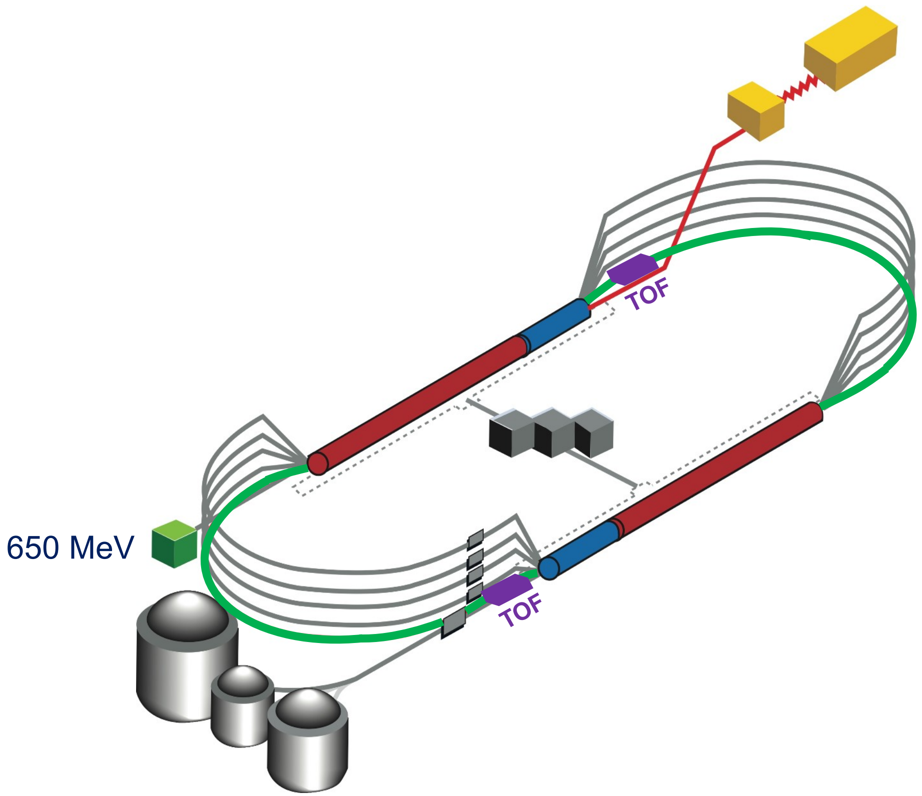
Jefferson Lab Thomas Jefferson National Accelerator Facility   BROOKHAVEN NATIONAL LABORATORY   OAK RIDGE National Laboratory   Cornell Laboratory for Accelerator-based Sciences and Education (CLASSE)

Overview

- Current baseline: 650 MeV inj + 4-pass CEBAF + 6.5-pass FFA
- FFA Arc Architecture – CBETA-style
  - Non-scaling FFA based on high-gradient permanent magnets
  - 650 MeV injector upgrade
- Modified CEBAF ‘switchyard’, Arcs 1-8 and TOF correction ‘splitters’
- Reality (Benesch)
- Question for Users

CEBAF FFA Upgrade – Baseline under Study

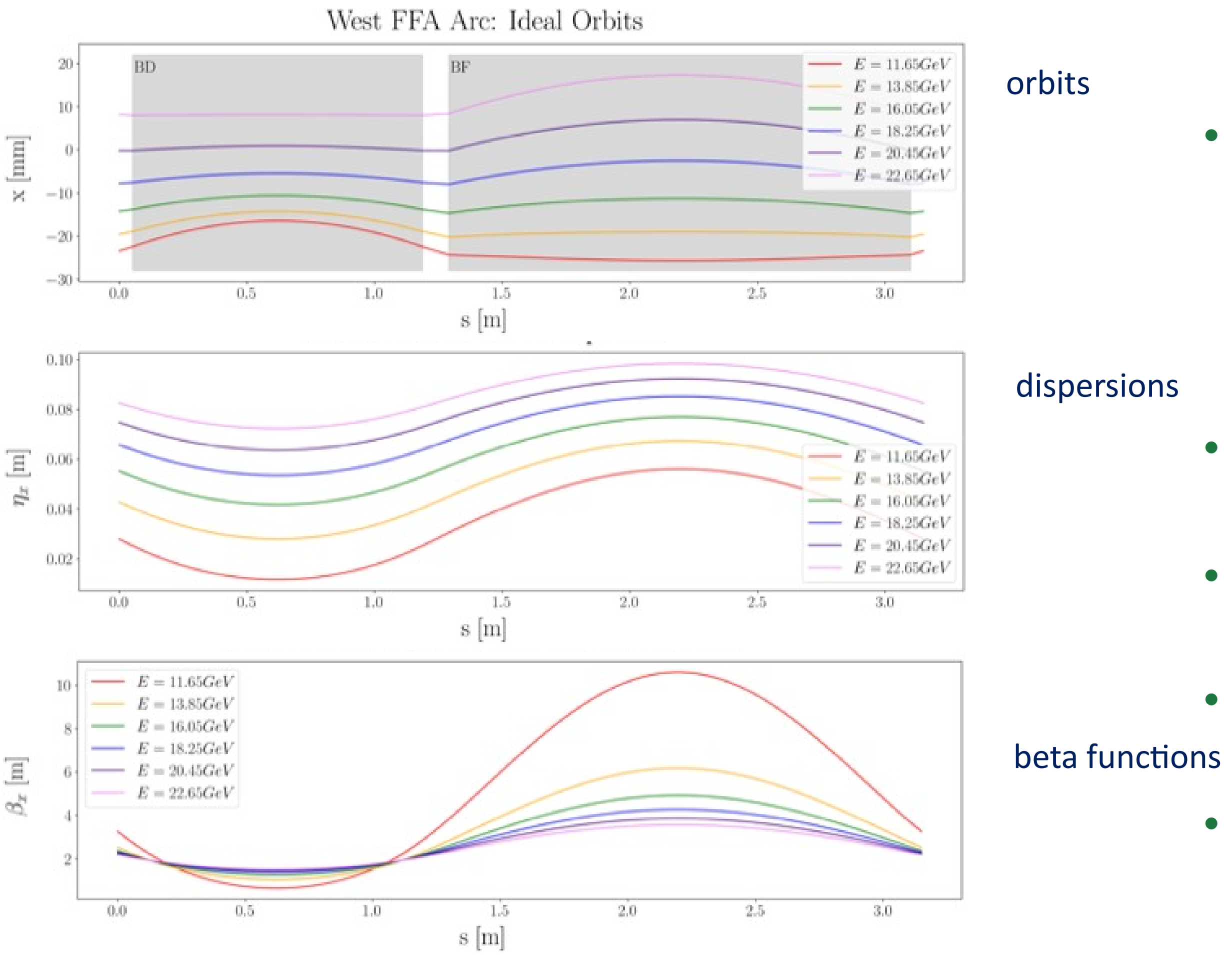
- Starting with 12 GeV CEBAF
- NO new SRF (1.1 GeV per linac)
- New 650 MeV recirculating injector
- Remove the highest recirculation pass (Arc 9 & A) and replace them with two FFA arcs including time-of-flight chicanes aka splitters
- Recirculate 4 + **6.5** times to get to **22 GeV**



Enabling Technology:

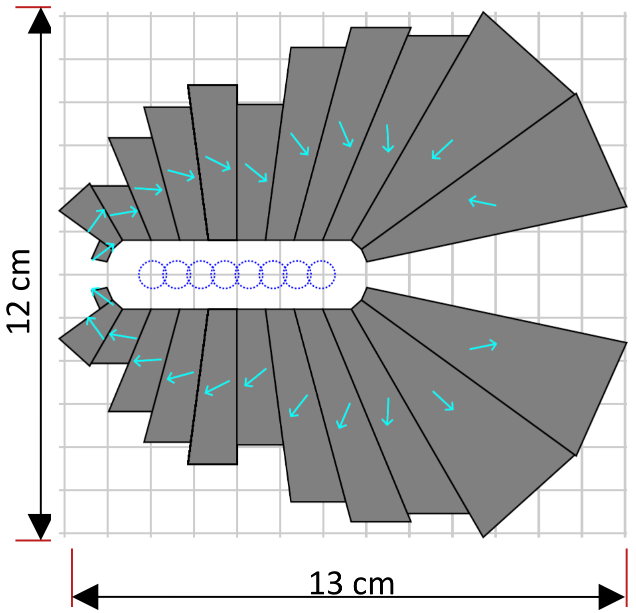
Novel permanent magnets, CBETA-like used for power and cost savings

FFA Arc – Compact FODO Cell



- Large momentum acceptance FFA cell, configured with combined function magnets capable of transporting six beams with energies spanning a factor of two
- Arc composed of 86 cells, L_{cell} = 2.8 m
- Closely spaced orbits for all six beams (~ 5 cm)
- Low betas (~ 5 m)
- Extremely low dispersions (a few cm) - Virtue of combined function FFA magnets

Permanent Magnet Design – Open Mid-plane Geometry

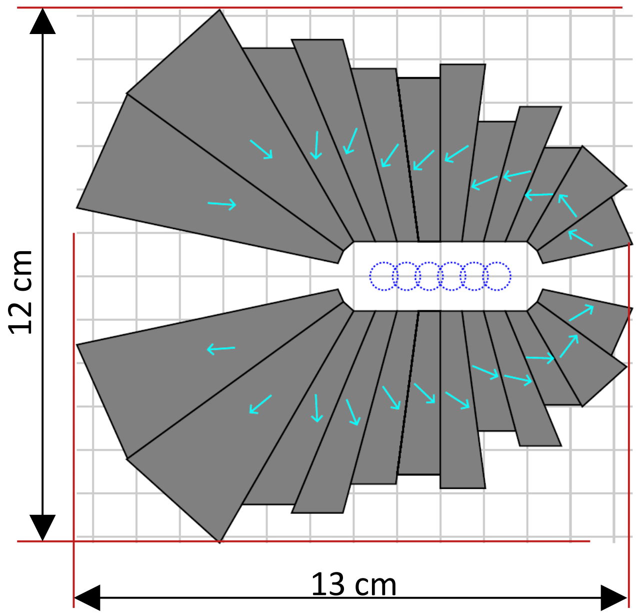


Focusing Magnet BF

G_F= -41.13 T/m

L_{QF}= 1.67 m

B_F= -0.812 T



Defocusing Magnet BD

G_D= 43.44 T/m

L_{BD}= 1.24 m

B_D= -0.593 T

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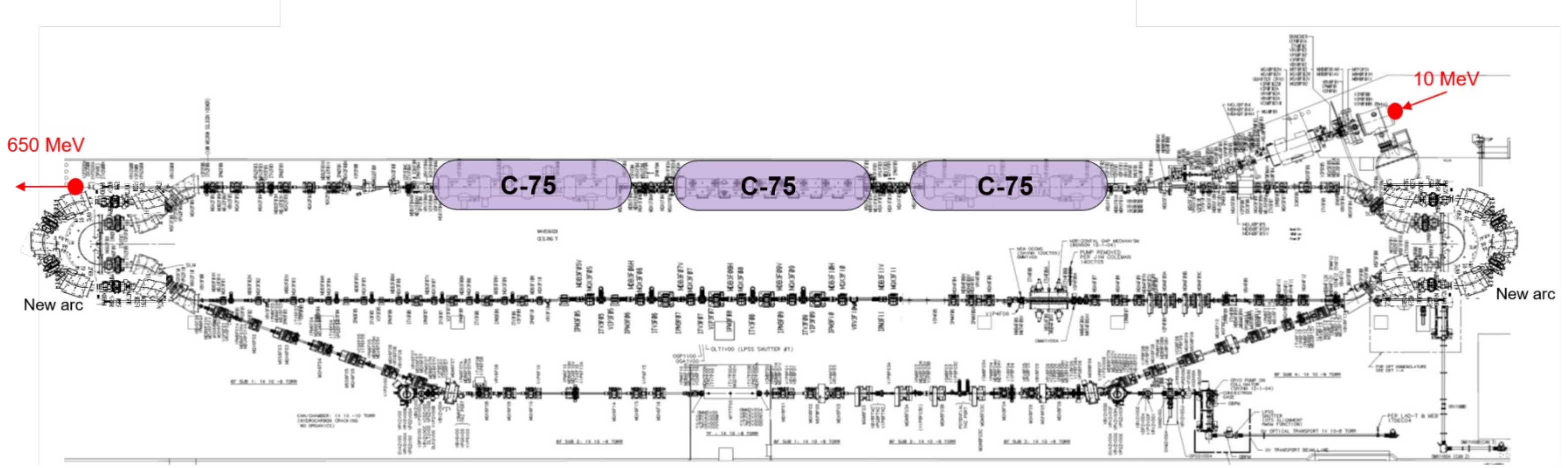
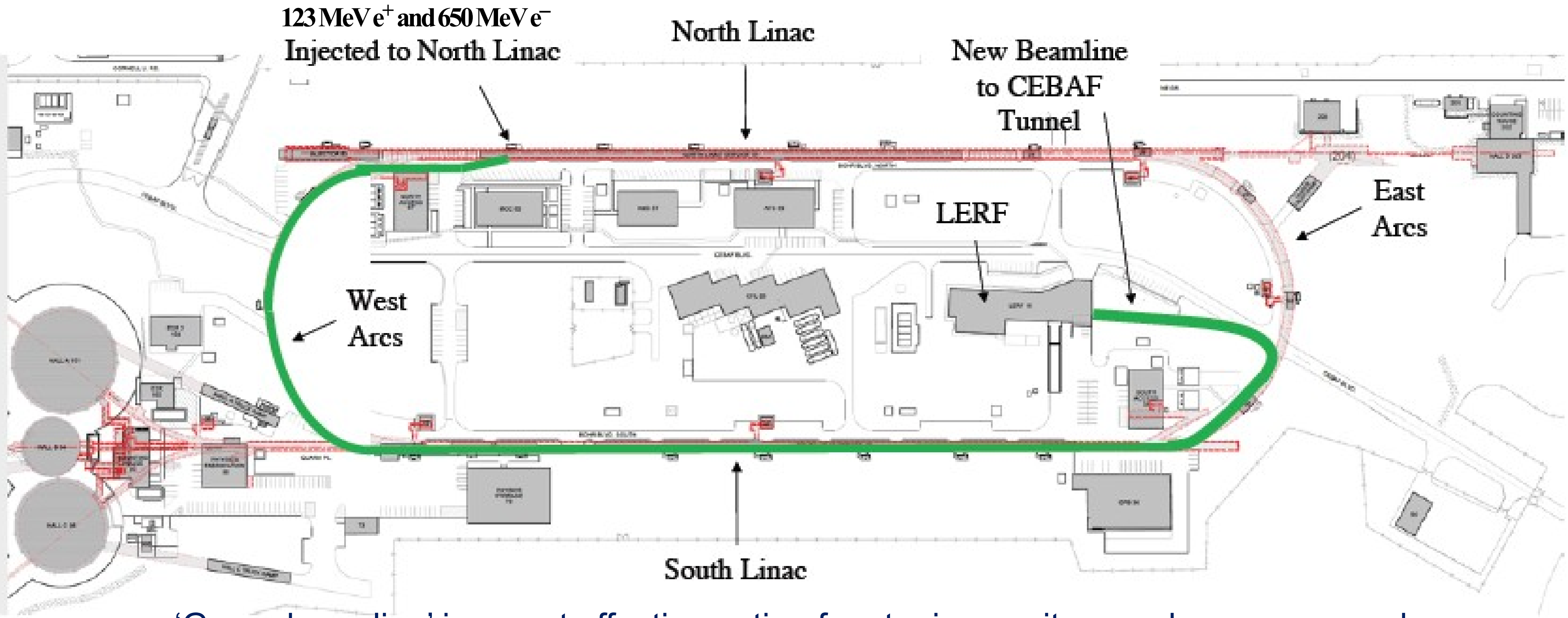
Injector Upgrade – 650 MeV Recirculating Injector

With the present 123 MeV injector, the difference in the first and final pass energies in the North Linac is too large (1:175) to effectively control the beam.

650 MeV recirculating injector (3-pass) based on LERF will allow a manageable difference in energies (1:33)



Electron/positron injector vault is required for 12 GeV e^+ and 22 GeV e^-

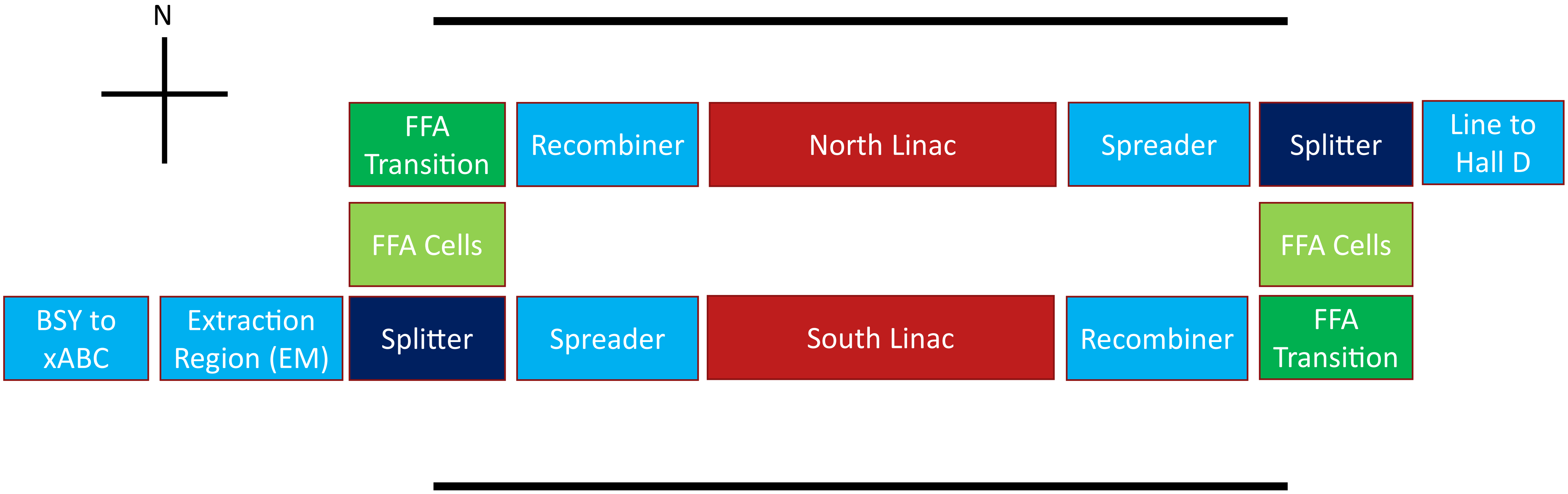


‘Green beamline’ is a cost effective option for staging positron and energy upgrades:

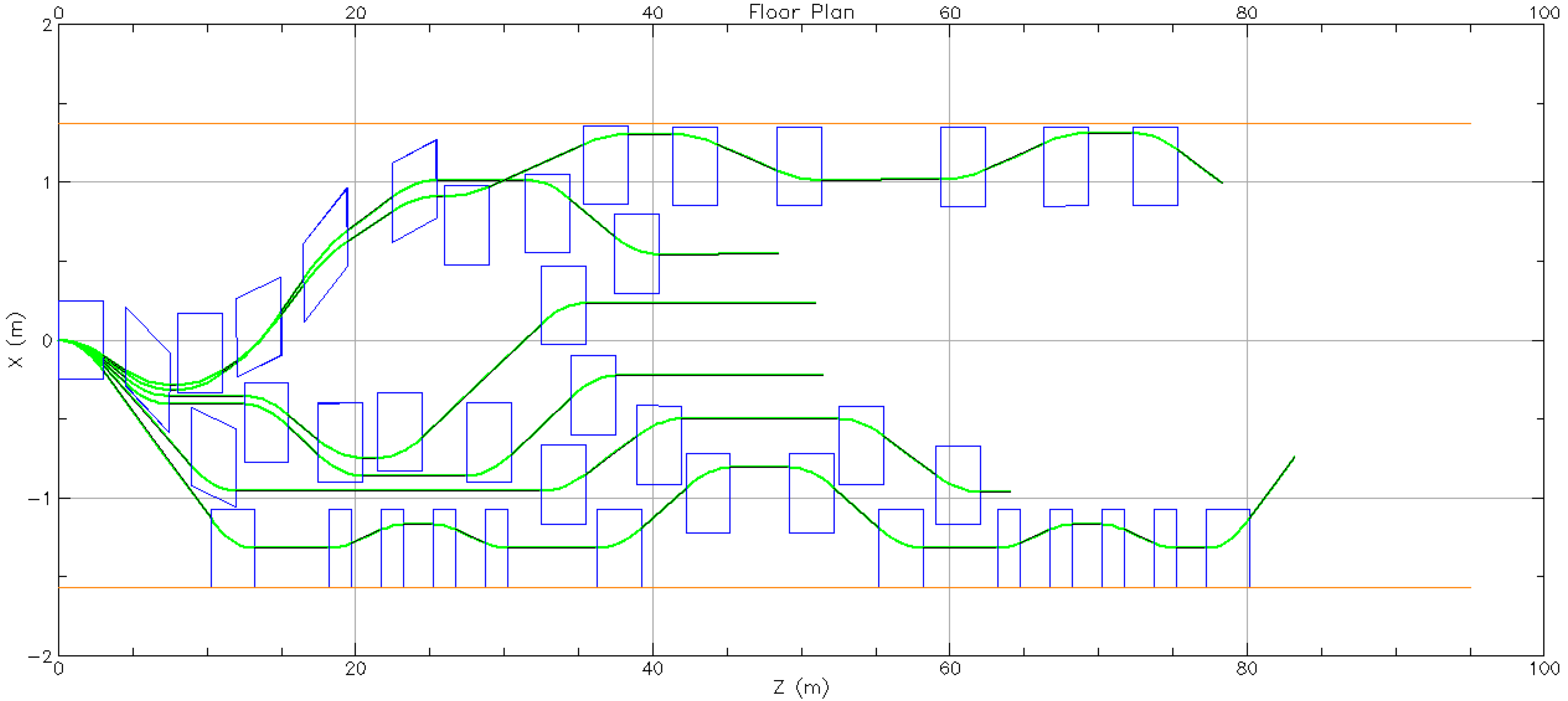
123 MeV e^+ for 12 GeV CEBAF

650 MeV e^- for 22 GeV CEBAF Energy Upgrade

Current Baseline Design: Layout (K. Deitrick schematic)



Splitter status (Ryan Bodenstein plot)



Partial dipole layout for a splitter. Tunnel is 3.96 m wide. Orbit closure, optics and pathlength compensation not yet completed. Raised floor and ramps will be required for cryomodule transport.

Reality

- The working group does not yet have an end-to-end layout.
- The emittance values previously provided are not valid and will not be until there is a layout. Beam size will then be recalculated.
- The magnets cannot be enlarged because the field is already at the limit for NdFeB. Radiation damage may be amplified by choosing higher fields.
- Permanent magnets have good field region sufficient for only six passes at exactly 1100 MeV/linac and not lower.
- Reduced linac energy is not compatible with this design.
- C100 in SL23 suffered a major helium leak, 94 MeV lost. More than 100 MeV headroom needed in each linac.

Reality II

- Extraction will take place from NE splitter to D at a half-pass below the other halls. *If it can be managed at all.*
- Extraction to A/B/C will occur in SW splitter and may require physically moving magnets, aka all halls get same energy.
- The permanent magnet layout can only accommodate six passes at exactly 1100 MeV/linac, giving discrete output energies of ~12, 14, 16, 18, 20 or 22GeV.
- If the number of passes were reduced to five, 1000-1100 MeV/linac possible. One might be able to stretch this range so a continuous range of energies 10-20 GeV are available (TBD)
- Electromagnet and optics designs for 22 GeV to A/B/C exist. D will copy B. 20 GeV would reduce saturation. See Jay's TNs.

Question for Users

- What is more important,
  - 22 GeV maximum with discrete energies (~12, 14, 16, 18, 20 or 22GeV)
  - or 20 GeV maximum with substantial continuous flexibility?
- FFA working group does not expect an answer today. We would appreciate an answer by the end of the fiscal year.