An Extraction Scheme for Future CEBAF FFA Based Energy Upgrade At JLAB

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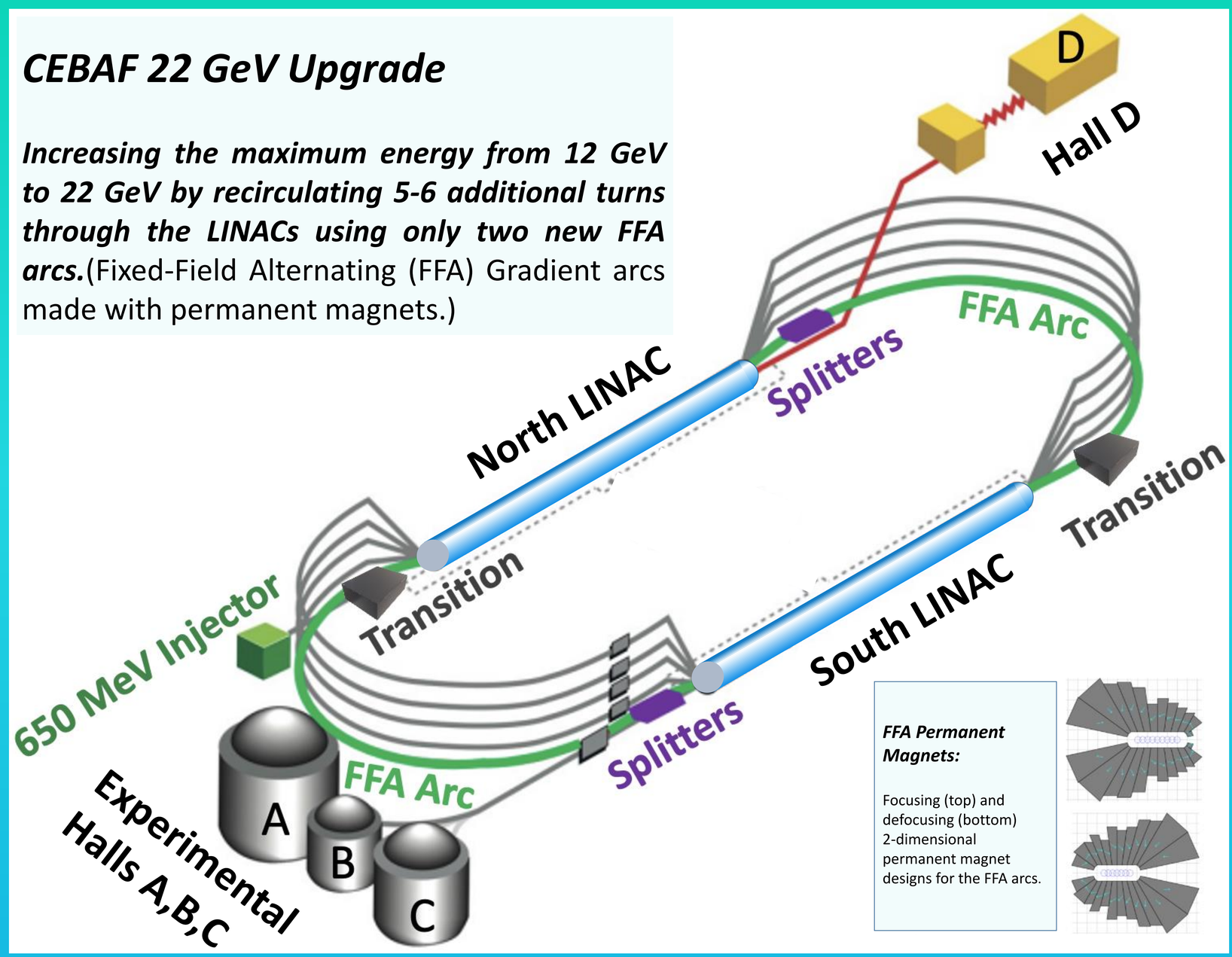
Abstract

Jefferson lab is considering an energy increase from current 12 GeV to 22 GeV for its CEBAF accelerator. This will be accomplished by recirculating 5-6 additional turns through two parallel CEBAF LINACs using an FFA arc at each end of the racetrack. The total recirculation turns would be 10 times, the first four turns use present conventional arcs to make the 180-degree bends from one LINAC to the other. However, the last 5-6 turns will all share a single beam line inside two FFA arcs. This reduces the footprint and the cost of the project significantly. On the other hand, having the trajectories of last 5-6 recirculating beams close to each other makes it challenging to extract beams from different passes with different energies. In this paper we will explain our present extraction system for 12 GeV, our challenges and limitations, and a possible extraction solution for the 22 GeV upgrade with the goal of extracting beam at different turns/energies to different experimental halls.

CEBAF 22 GeV Upgrade

Increasing the maximum energy from 12 GeV to 22 GeV by recirculating 5-6 additional turns through the LINACs using only two new FFA arcs.(Fixed-Field Alternating (FFA) Gradient arcs made with permanent magnets.)

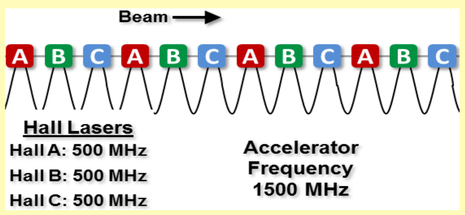


FFA Permanent Magnets:

Focusing (top) and defocusing (bottom) 2-dimensional permanent magnet designs for the FFA arcs.

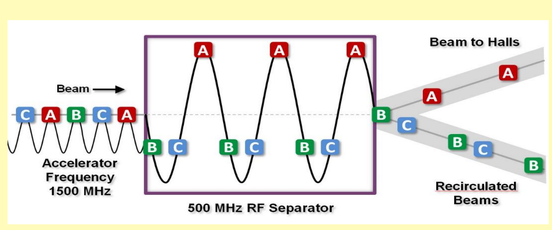
Existing Beam Extraction System Using RF Separators:

Three interleaving beams are created at the injector:

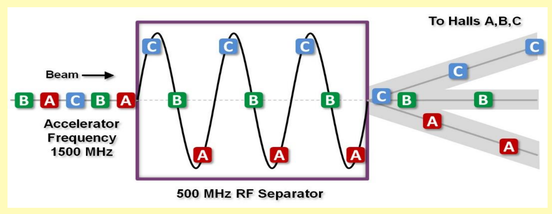


500 MHz Separators:

Two-way separation
One beam extracted
Two recirculated
(used in lower passes, 1, 2, 3, and 4)



Three-way separation
Beams split
in three directions
(used in separating the Last pass to three halls)



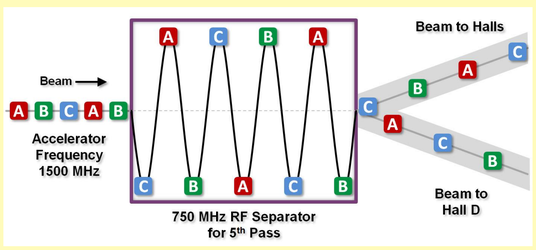
750 MHz Separators:

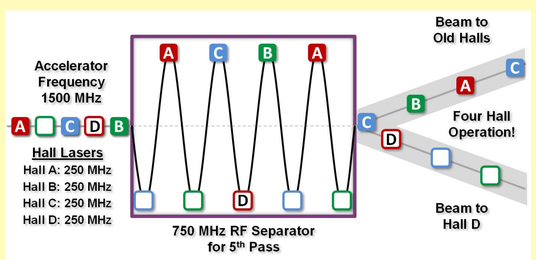
Hall D separation

The 750 MHz separator splits the beams in two directions

Then switch all beams to half repetition rate 250 MHz

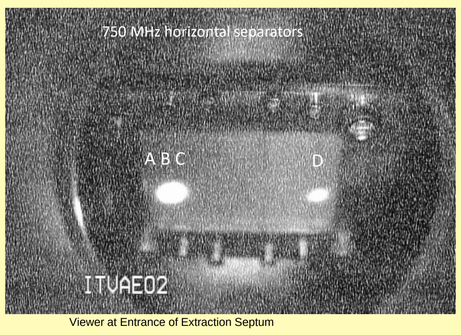
Now Hall D can fit in and will be separated from the A,B,C beams
(used in separating Hall D at present 5th pass)



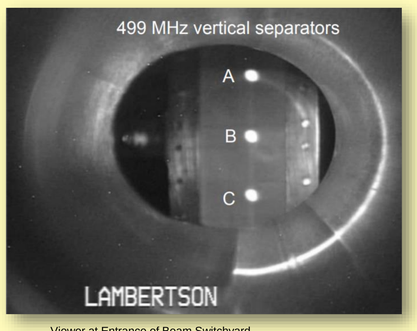


Horizontal Extraction at 750 MHz with three beams left and one beam right

5th Pass Vertical Extraction at 500 MHz showing A, B, C beams



Viewer at Entrance of Extraction Septum



Viewer at Entrance of Beam Switchyard

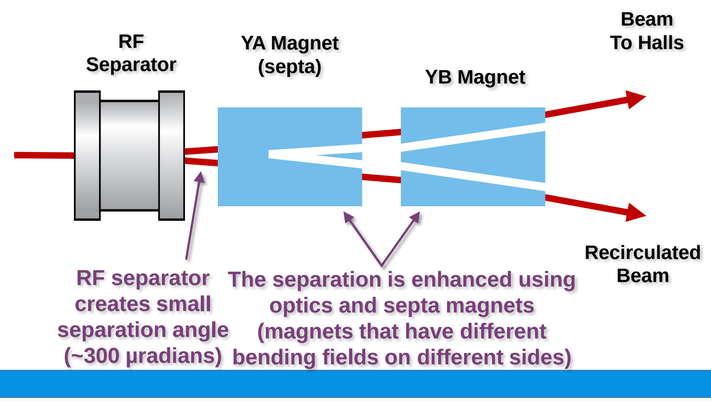
FFA Extraction Challenge:

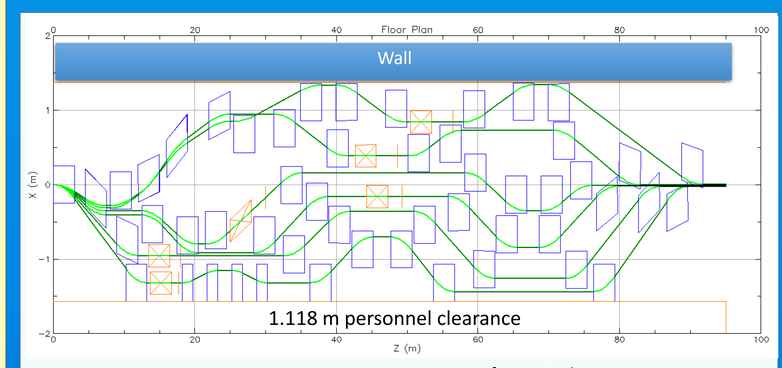
* Extract beams at different energies/passes when different passes have the same beamline.
* There is not enough space to have RF separators for each pass.

Proposed Solution:

Use RF separators that act on all FFA passes at the same time, reducing the total number of separators needed.
How? See below

RF Separator System:

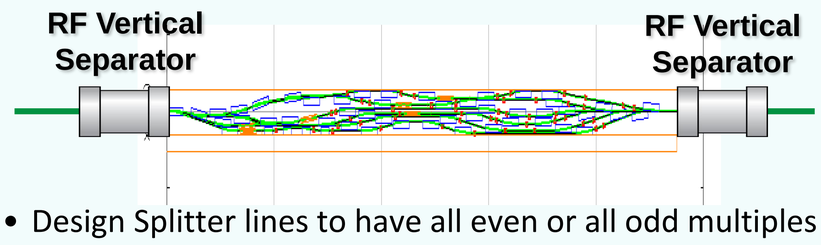




Courtesy of Ryan Bodenstein

Splitters are used in front of each FFA arc. They are used to split different energy beams (green lines) so that the timing and optics of each pass could be adjusted independently before beams are put back together and enter the FFA arcs.
(Note: the X and Z coordinates not drawn to the same scale. X width is exaggerated to show different lines. The blue boxes are bending dipole magnets and the orange boxes are extraction)

Imagine a Separator at each ends of a Splitter!



- Design Splitter lines to have all even or all odd multiples of π phase advance. [2nπ or (2nπ+1)]
- Now the kicks of the two RF separators can cancel out.
- Set the optics for **only** one line of the splitter to magnify the RF kick and turn on **only that line's** septa magnets.
- This way we can select which line/energy to extract just by turning on the proper septa and optics for that selected line.

Summary:

1. A design for the CEBAF energy upgrade using FFA arcs is being developed.
2. Since beams from different passes (different energies) transport close to each other, one of the challenges is how to extract beam at different energies to different experimental halls.
3. A solution is proposed using a single set of RF separators that acts on all beam passes.
4. Different variations of this solution can be used at each end of the accelerator.
5. Physics user input is needed to determine which options are worth pursuing.
6. The basic principles of the existing RF extraction and the proposed future extraction scheme is described in this presentation.

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