THPOY060

FOUR BEAM GENERATION FOR SIMULTANEOUS FOUR-HALL OPERATION AT CEBAF*

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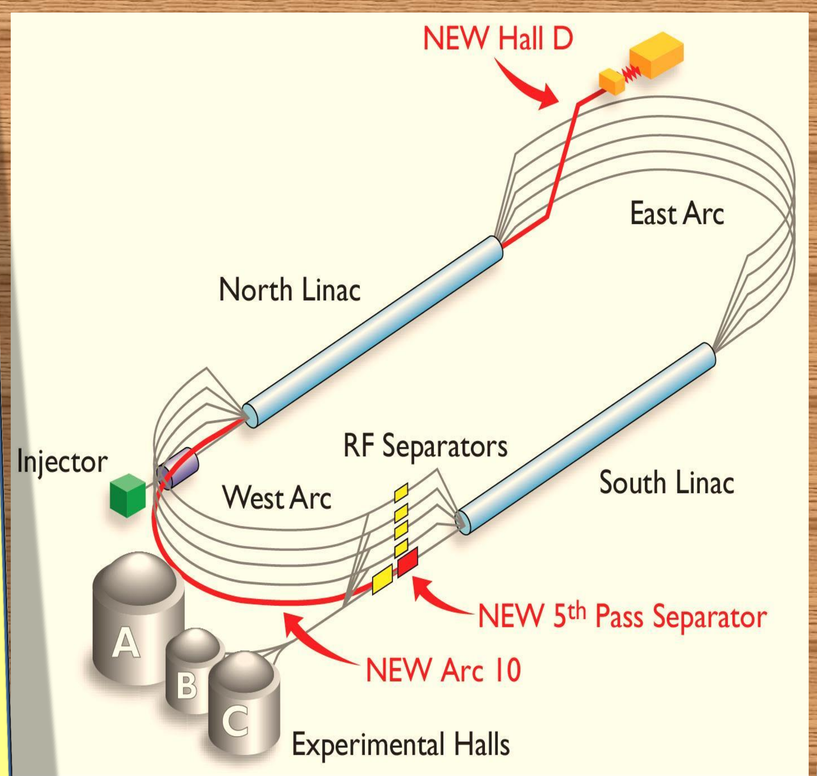
Abstract

As part of the CEBAF 12 GeV upgrade at Jefferson Lab, a new experimental hall was added to the existing three halls. To deliver beam to all four halls simultaneous-ly, a new timing pattern for electron bunches is needed at the injector. This pattern change has consequences for the frequency of the lasers at the photogun, beam behavior in the chopping system, beam optics due to space charge, and setup procedures. We have successfully demonstrated this new pattern using the three existing drive lasers. The implementation of the full system will occur when the fourth laser is added and upgrades to the Low Level RF (LLRF) are complete. In this paper we explain the new bunch pattern, the challenges for setting and measuring the pattern such as 180° RF phase ambiguity, addition of the fourth laser to the laser table and LLRF upgrade.

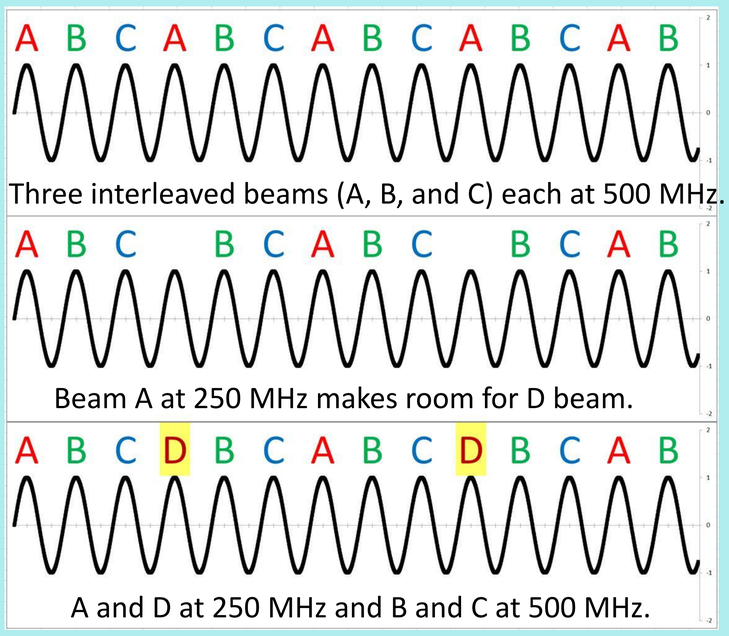


CEBAF 12 GeV Upgrade:
Increases maximum energy from 6 GeV to 12 GeV and adds a new experimental Hall D

Implications:

- A new laser system is needed for the photo-cathode gun to run the new fourth hall.
- To run all four halls simultaneously, two or more halls have to run at half repetition rate (but not necessarily lower average current).
- The new beam pattern creates the possibility for having up to six beams at the highest energy that can be used for future applications or to feed future accelerators.
- The changes are only to the 5th pass separator and the electron gun laser system; all other systems are expected to function as before.

Making Room for the New Experimental Hall D

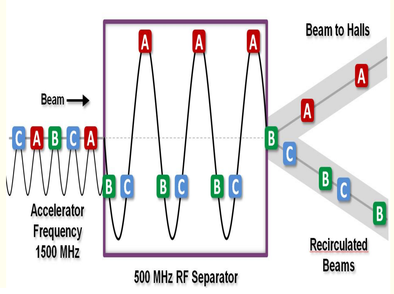


Each sine represents the 1500 MHz accelerating frequency.

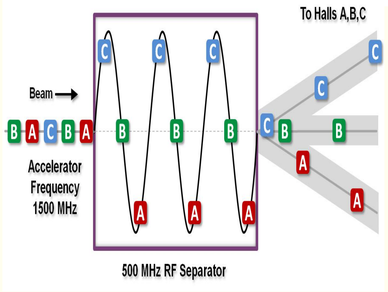
The Separator System:

500 MHz Separators:

Two-way separation:
used in lower passes
One beam extracted
Two recirculated

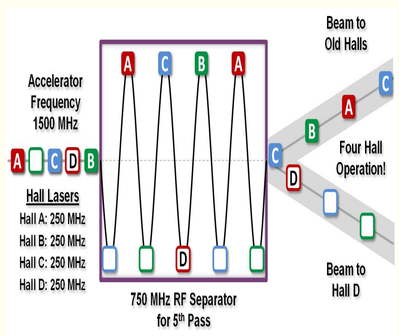


Three-way separation:
Used for splitting the 5th pass beams to three halls ABC.

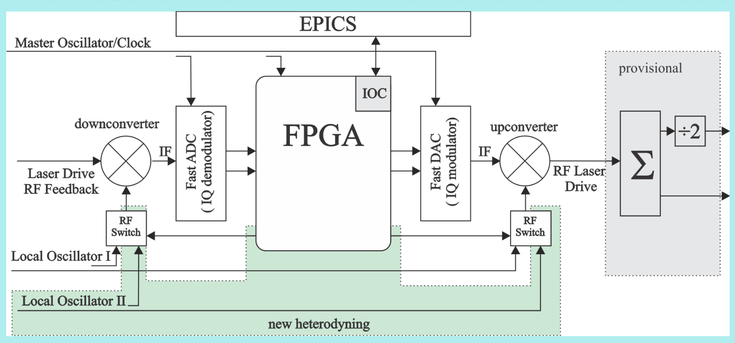


750 MHz Separator:

Splits each 500 MHz beam at highest pass to two 250 MHz beams, one going towards Halls ABC and other to Hall D

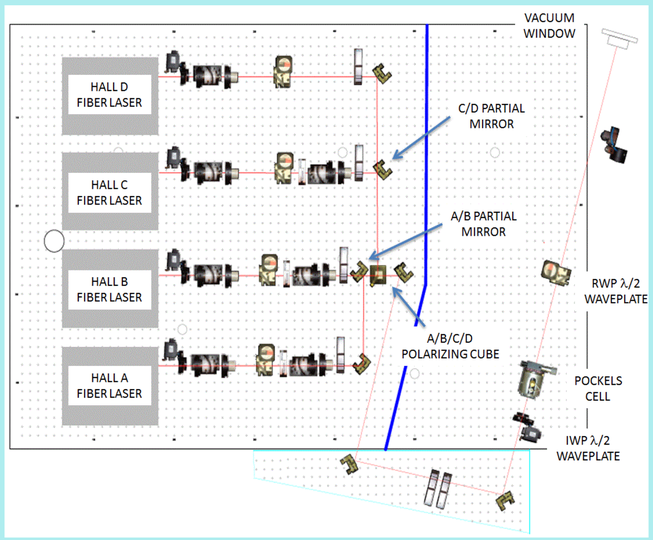


Architecture of LLRF Hardware for Each Laser



Signal processing involves mixing with the Local Oscillator to down and up convert RF signals, digital demodulation, Proportional-Integral control, and gen-erating the Intermediate Frequency (IF) signal using a single Digital to Analogue Converter (DAC) [8]. The green area shows the proposed addition to the LLRF to allow system operation at two frequencies while the grey is the present configuration.

The 4-laser configuration

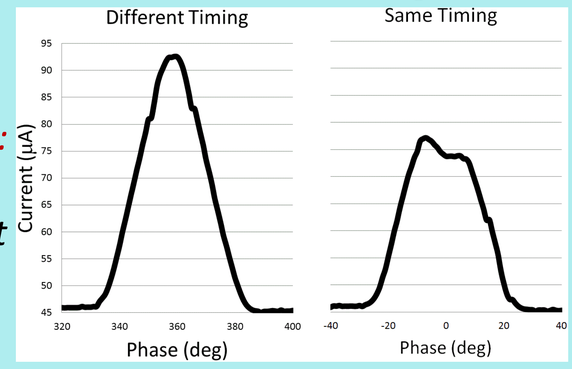


The two stages of combination onto a single axis. Once the four laser beams are combined, all four experience the same Pockels cell and waveplates which are used to convert the linearly polarized lasers into circularly polarized lasers prior to reaching the entrance window to the electron gun.

Two pairs of laser beams are combined using a partially a partially reflective mirror, passing a large portion of one beam and small portion of the other. Fortuitously, two end-stations require high-current and two require low-current, thus the pairing is decided this way. Next, the two pairs of laser beams are combined using a polarizing cube. One pair of lasers has linear polarization defined in one plane and vice-versa. Specifically, the A (high-current) and B (low-current) have the same linear polarization and are combined by one mirror; similarly the C (high-current) and D (low-current) have the same linear polarization (but orthogonal to previous pair) and are combined using another mirror. Finally the A/B and C/D beam are com-bined by a polarizing cube.

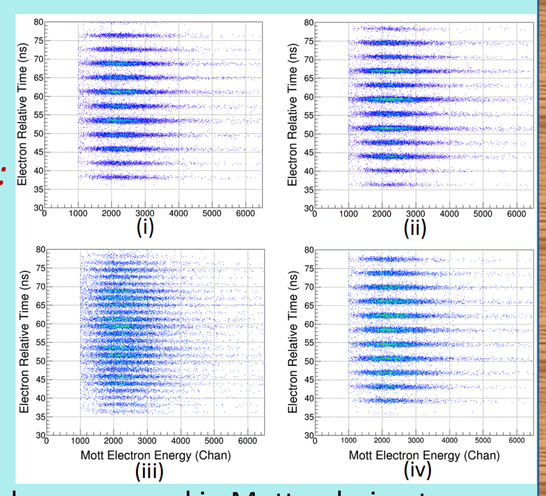
Measurement of Beam Timing

First Method: Using Space Charge Effect



Total current from two 250 MHz beams each at 45 μA peak.
Left: the beams are 2 nanoseconds apart in time.
Right: the two beams have simultaneous pulses showing signs of higher space charge.

Second Method: Using Mott Polarimeter System



250 MHz beam bunches measured in Mott polarimeter
(i) Beam A only,
(ii) Beam D only note bunches shifted in time by 2ns,
(iii) A+D 2ns apart,
(iv) A+D 0 ns apart after D timing changed to match A.

Conclusion:

- Significant progress has been made during the last year in production of 250 and 500 MHz beams essential to Four-Hall operation.
- 250 MHz physics quality beams have been directed to the appropriate experimental hall under the new separation system.
- An addition of fourth laser is needed.

Note: For simplicity the RF frequencies have been rounded to the nearest 10 MHz; CEBAF fundamental frequency is 1497 MHz and all references to 500 MHz and 250 MHz should be 499 MHz and 249.5 MHz to be precise.

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