Delivering e+ Beams from LERF Through Ce+BAF

Positron Working Group Workshop

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In collaboration with Alex Bogacz, Joe Grames, Yves Roblin, Amy Sy

Introduction

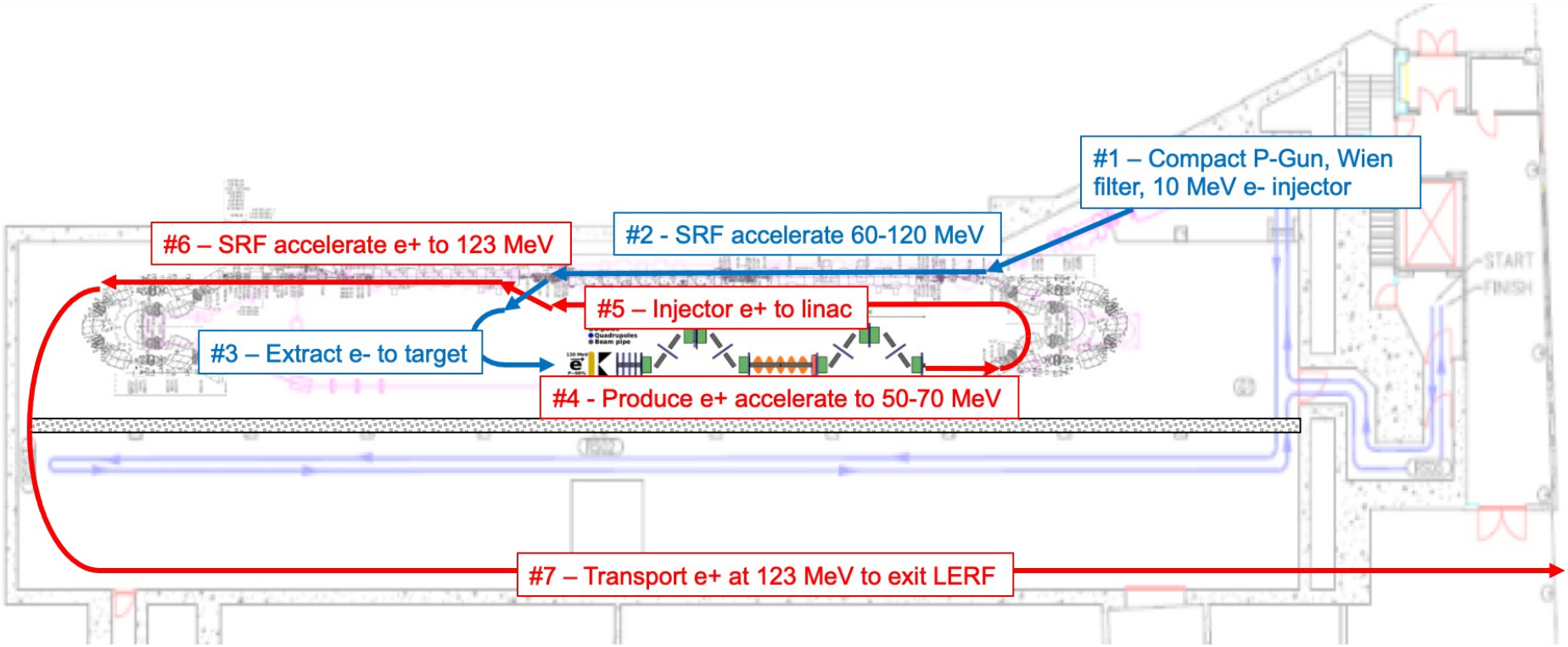
- We propose to inject up to 123MeV positrons into CEBAF and accelerate those positrons up to 12GeV with CEBAF.
- The positron source will be installed in the existing LERF vault.
- The present 12GeV electron accelerator functionality shall be maintained alongside the positron acceleration capability.
- The transport line for injecting positrons into CEBAF will be reused in the proposed 22GeV electron upgrade.

Introduction

Topics to Discuss

- Transport from positron source to CEBAF
  - Beamline layout from LERF vault to CEBAF
- Transport through 12 GeV CEBAF
  - Magnet polarity reversal
  - Acceptance studies

123MeV e+ Injector for 12GeV Positrons

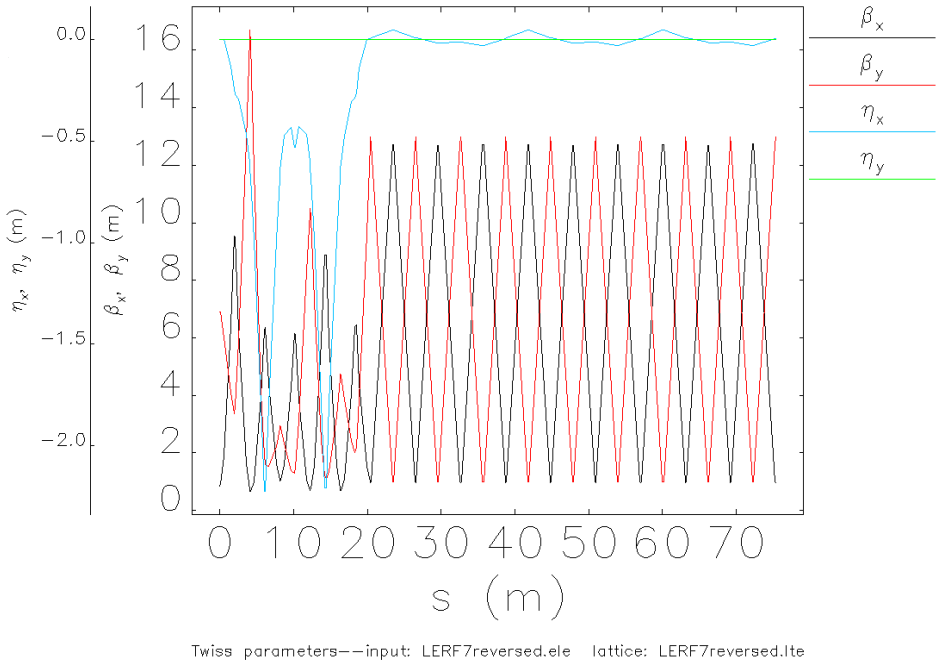


123MeV e+ Injector for 12GeV Positrons

Beam parameters exiting the positron source

Params	e^+ injection	CEBAF Acceptance
$\sigma_{dp/p}$ [%]	0.68	$\pm$ 1%
$\sigma_z[ps]$	4	$\leq$ 4
$\sigma_x[mm]$	6	$\leq$ 3
N $\epsilon_n[mm\ mrad]$	140	$\leq$ 40
Mean Momentum [MeV/c]	123	123
e^+ current	170 nA	100 nA

Beam transport from the positron source to exit of the LERF



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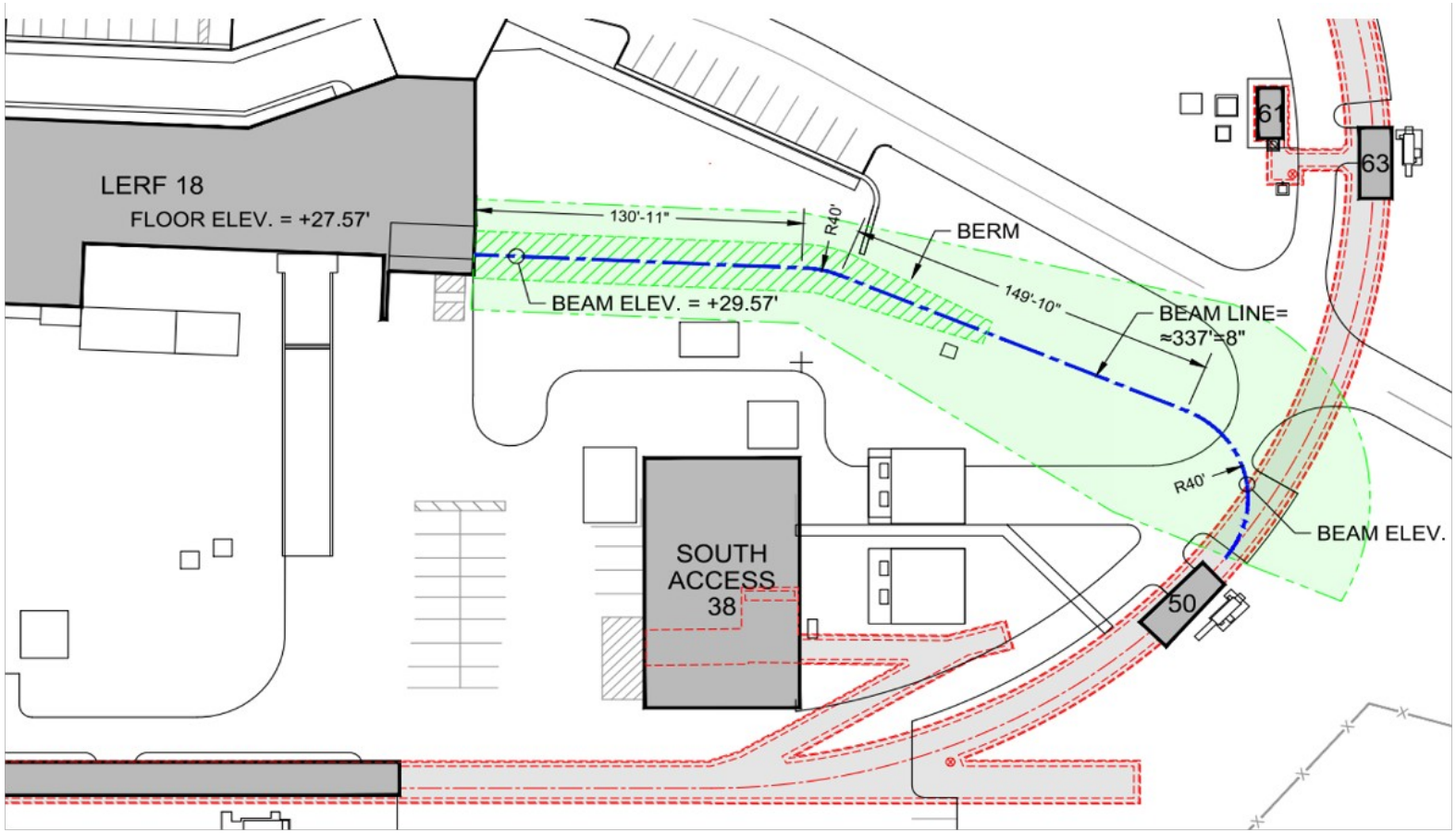
Tunnel from LERF to CEBAF East Arc

- ~3m elevation change
- Enters the CEBAF tunnel at ceiling height across the aisle from the east recirculating arc
- ~116 deg horizontal bend at the entrance to the CEBAF tunnel



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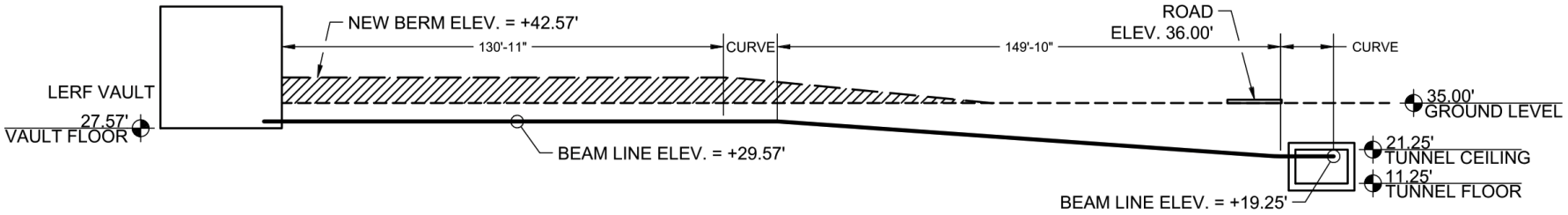
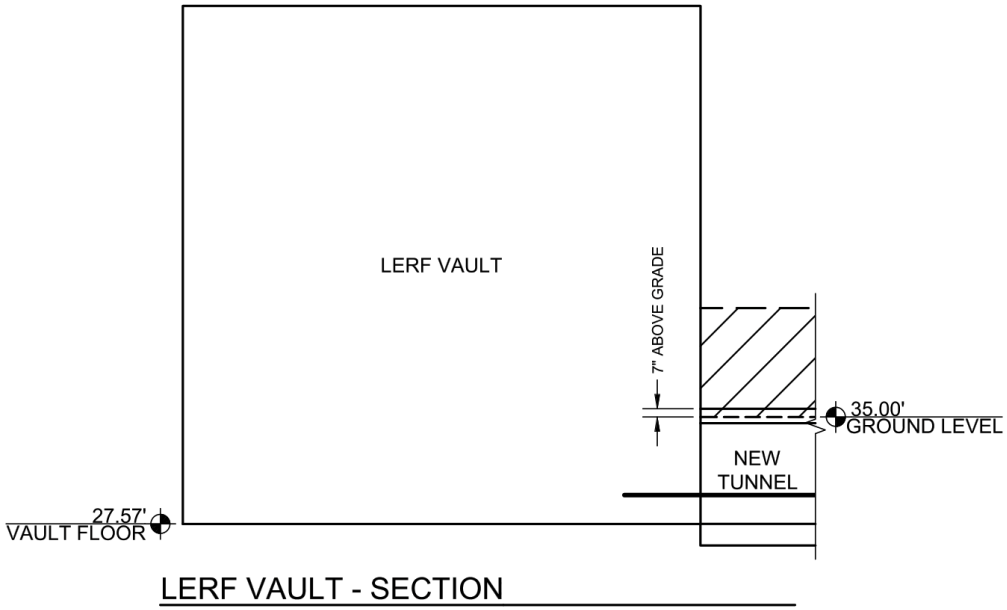
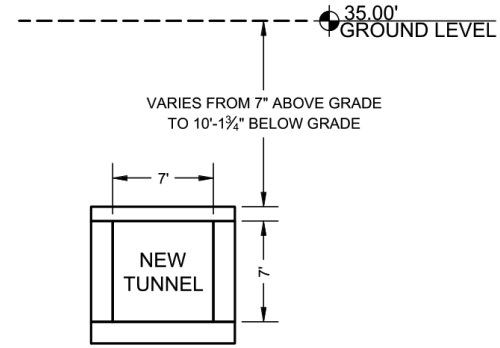


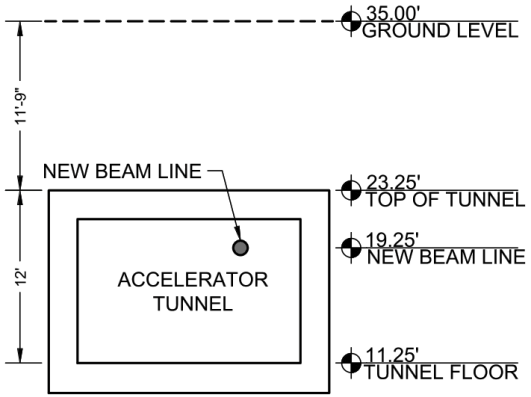
NEW BEAM LINE ELEVATION



LERF VAULT - SECTION



TYPICAL TUNNEL SECTION



BEAM CONNECTION SECTION

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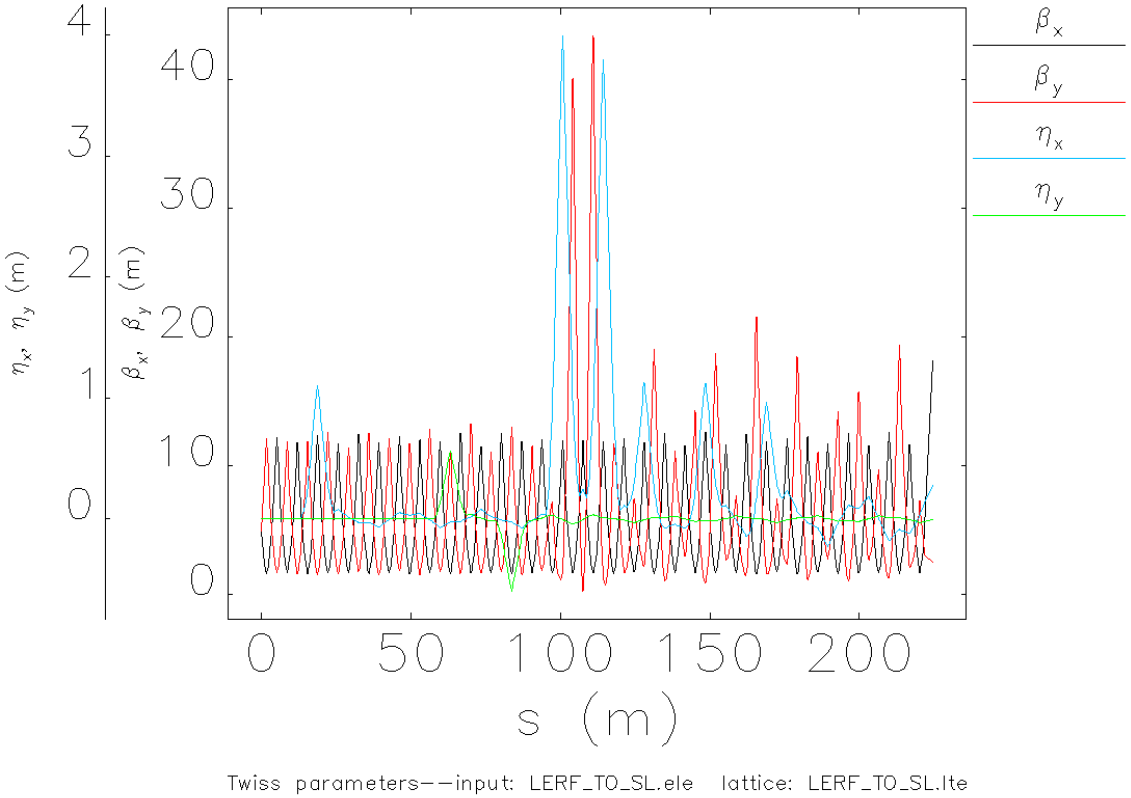
Tunnel from LERF to CEBAF East Arc

Beam transport from the exit of the LERF to the entrance of the South Linac



- Note the ~4m horizontal dispersion at the sharpest bend.
- This puts an upper limit on the energy spread from the positron source or a lower limit on beam pipe diameter.
- e.g. 0.5% energy spread at 4m dispersion leads to a 12cm beam pipe
- More work is needed here.

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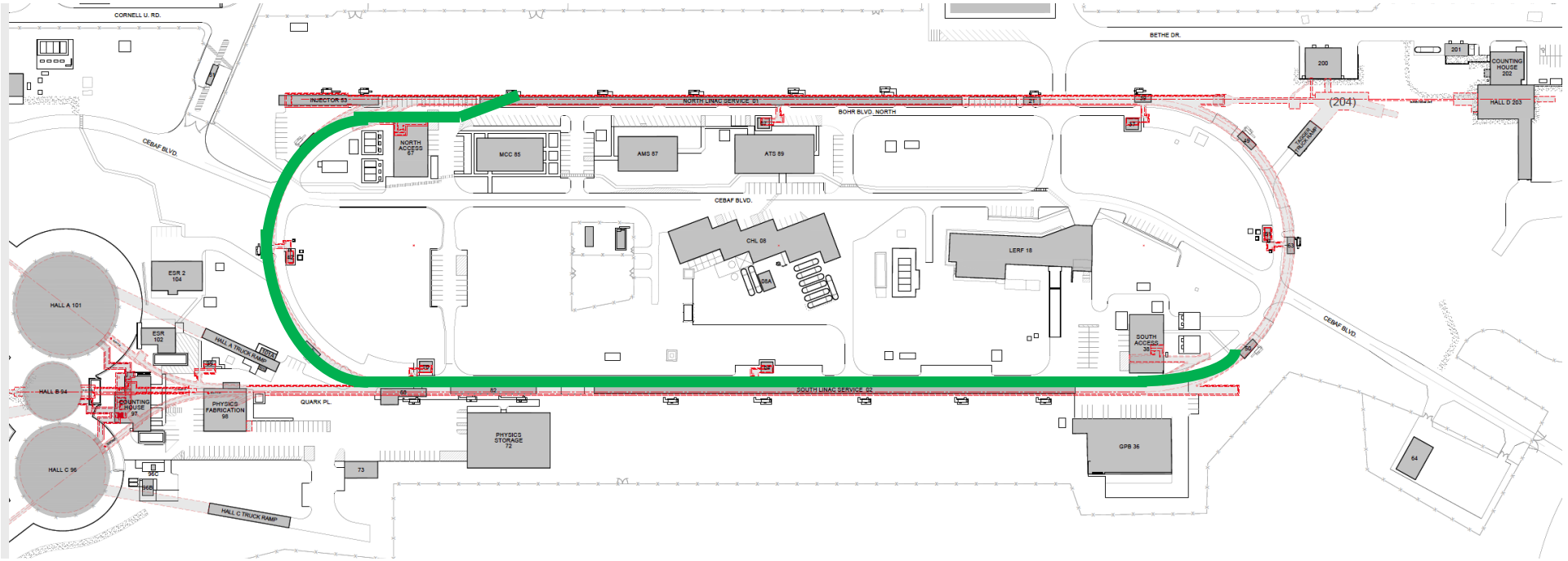
Along the South Linac and Around to the North Linac

- Transport beamline runs along the ceiling, inboard of the existing beamlines
- Starts at the East Arc
- Runs parallel to the South Linac
- Follows the West Arc
- Horizontal bend and ~2m elevation change into the entrance of the North Linac
- Then accelerate up to 12GeV for physics



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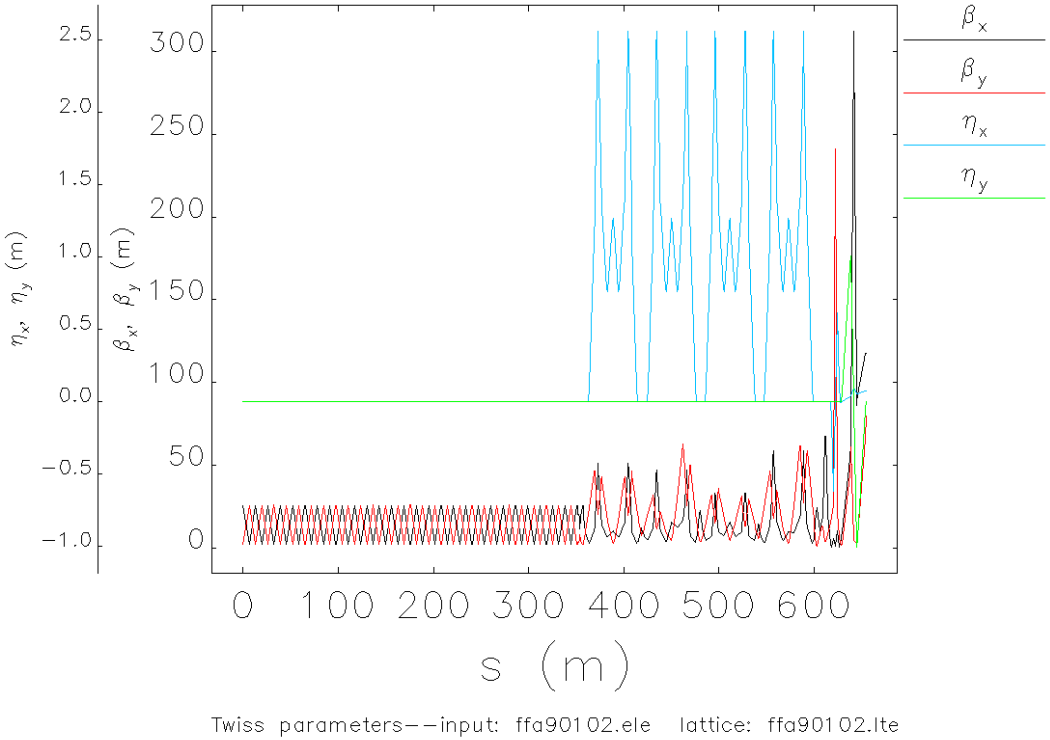
Along the South Linac and Around to the North Linac

Beam transport along the South Linac into the North Linac



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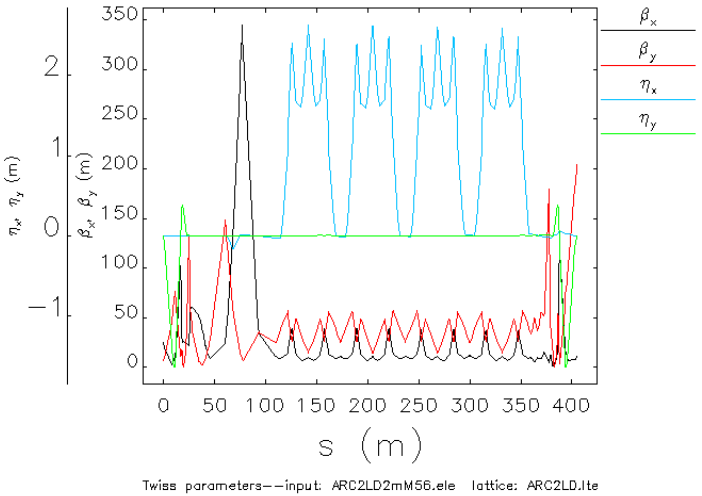
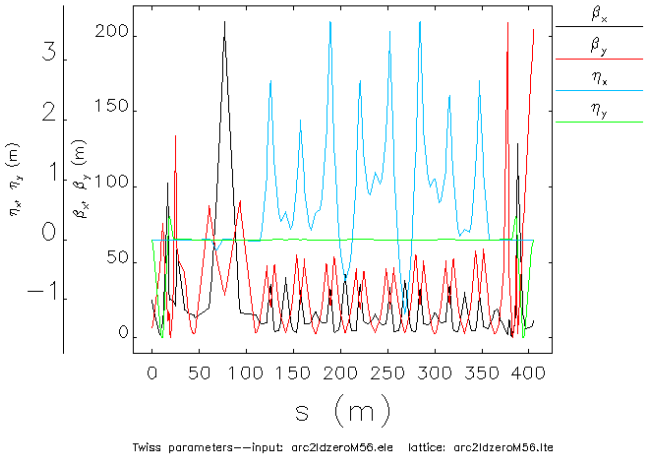
Modified Arc 2 Optics

Present Arc2 optics with M56=2m

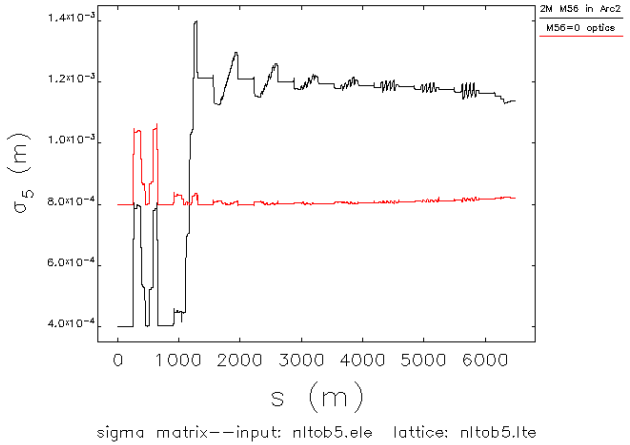


Modified optics with M56=0m



Arc 2 optics modified to allow up to 1% energy spread at injection into the North Linac while keeping the bunchlength <800um.

Bunchlength with and without Arc2 M56



Why not inject directly into the South Linac?

- The common dipoles in the spreaders and recombiners are designed to bend multiple beams at fixed ratios of beam energy. Injecting into the South Linac would require redesign of the common dipoles and we would lose the present 12GeV electron capability
- We would miss one linac pass, limiting the maximum beam energy to ~10GeV to Halls A, B, and C, ~11GeV to Hall D.
- The East Arc dipole strings would need to be upgraded to handle twice the beam energy they can presently handle.
- We would lose the ability to use the present injector for electron beam

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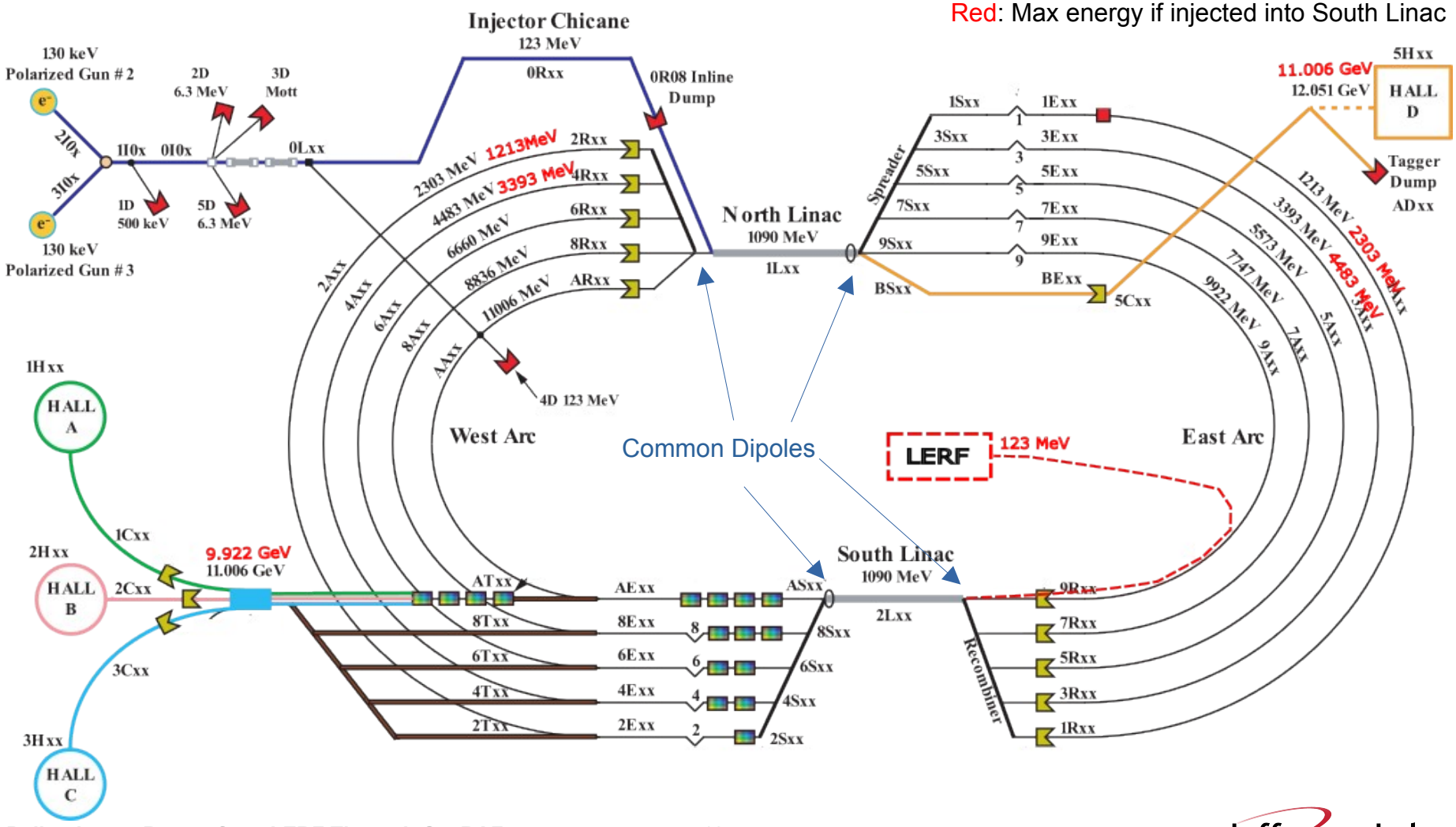

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CEBAF 12 GeV : Magnetic Transport System

Reversing polarity of 2100 CEBAF magnets

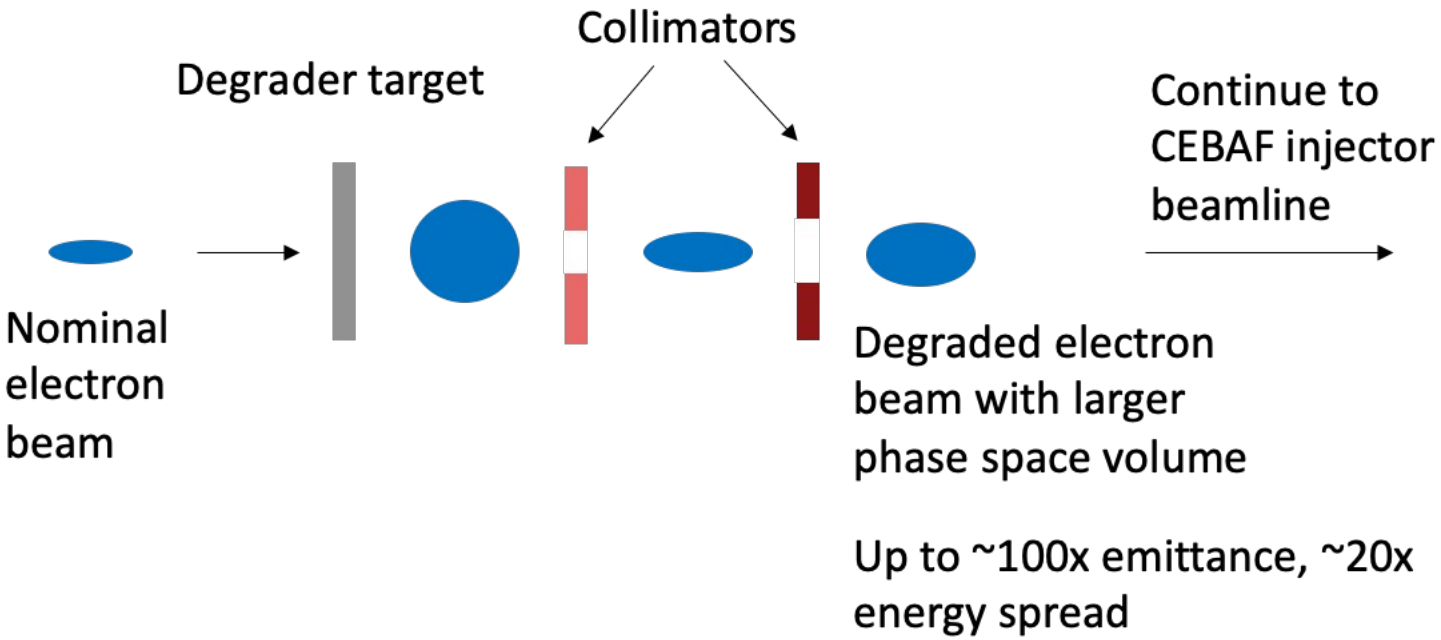
- 1900 quads and steering soils have bipolar power supplies
- **39 Unipolar power supplies need new engineered switch gear**
  - recirculation & dog-leg dipoles
  - extraction dipoles
  - end-station transport & dump dipoles
- **Hall D is only permanent magnet** – needs to be addressed

Magnetic Field Integrity

- **Soft iron steel expected to perform well under reversal**
- Deliberate magnet bench testing required
  - reproducibility upon polarity inversion
  - identify systematic effects
- Two decades of operation suggest remnant fields <20 G tolerable
  - Sudden power supply trips introduce uncontrolled flux
  - Modifications to power supplies or field maps

Degraded e- beam LDRD

- Goals: evaluate CEBAF acceptance and compare to simulation; evaluate machine limits on positron beam size and current; transport positrons through parts of the CEBAF injector
- How? Degrade electron beams in the CEBAF injector through multiple scattering in a thin target foil



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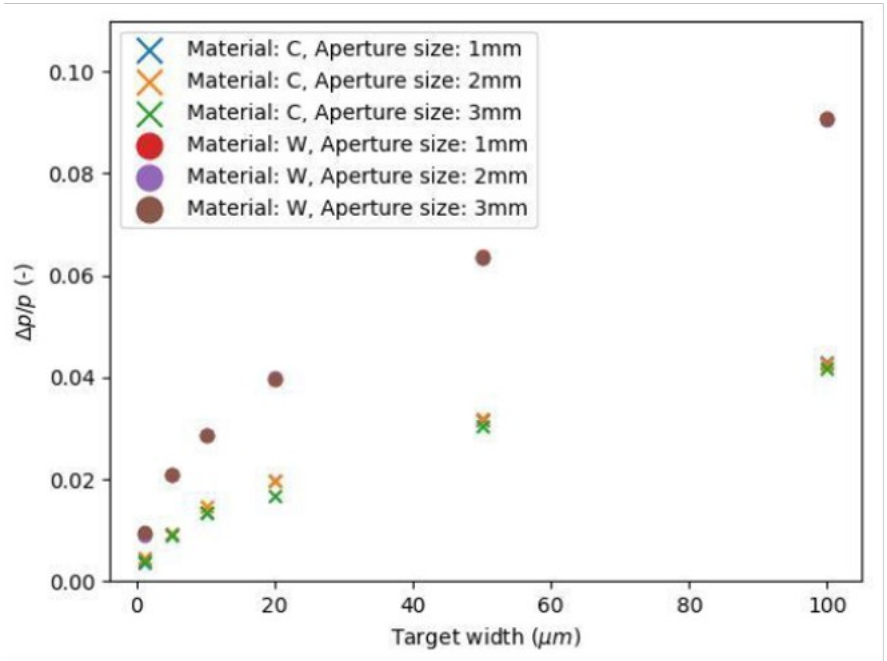
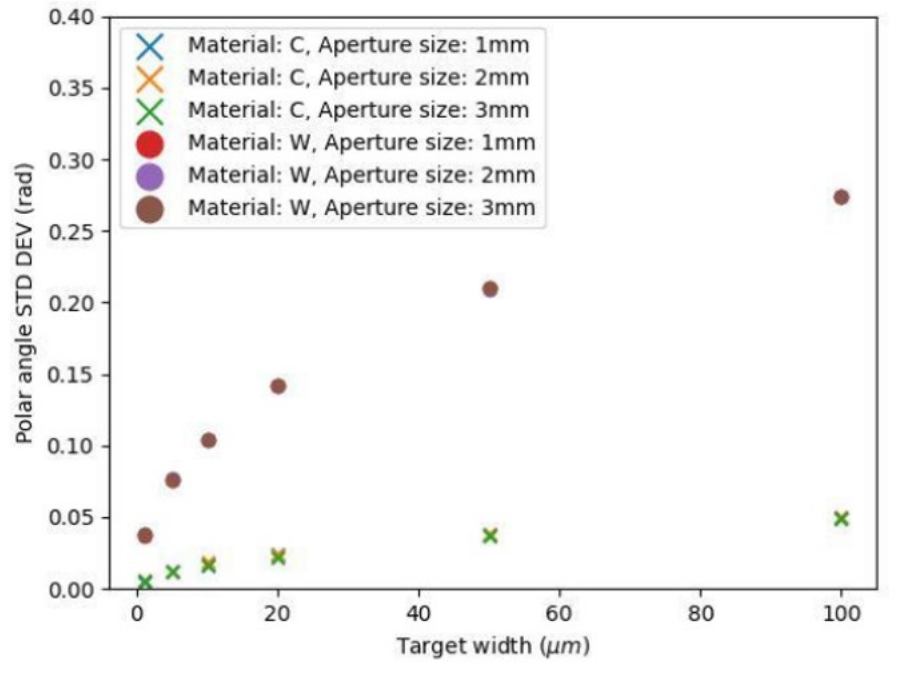
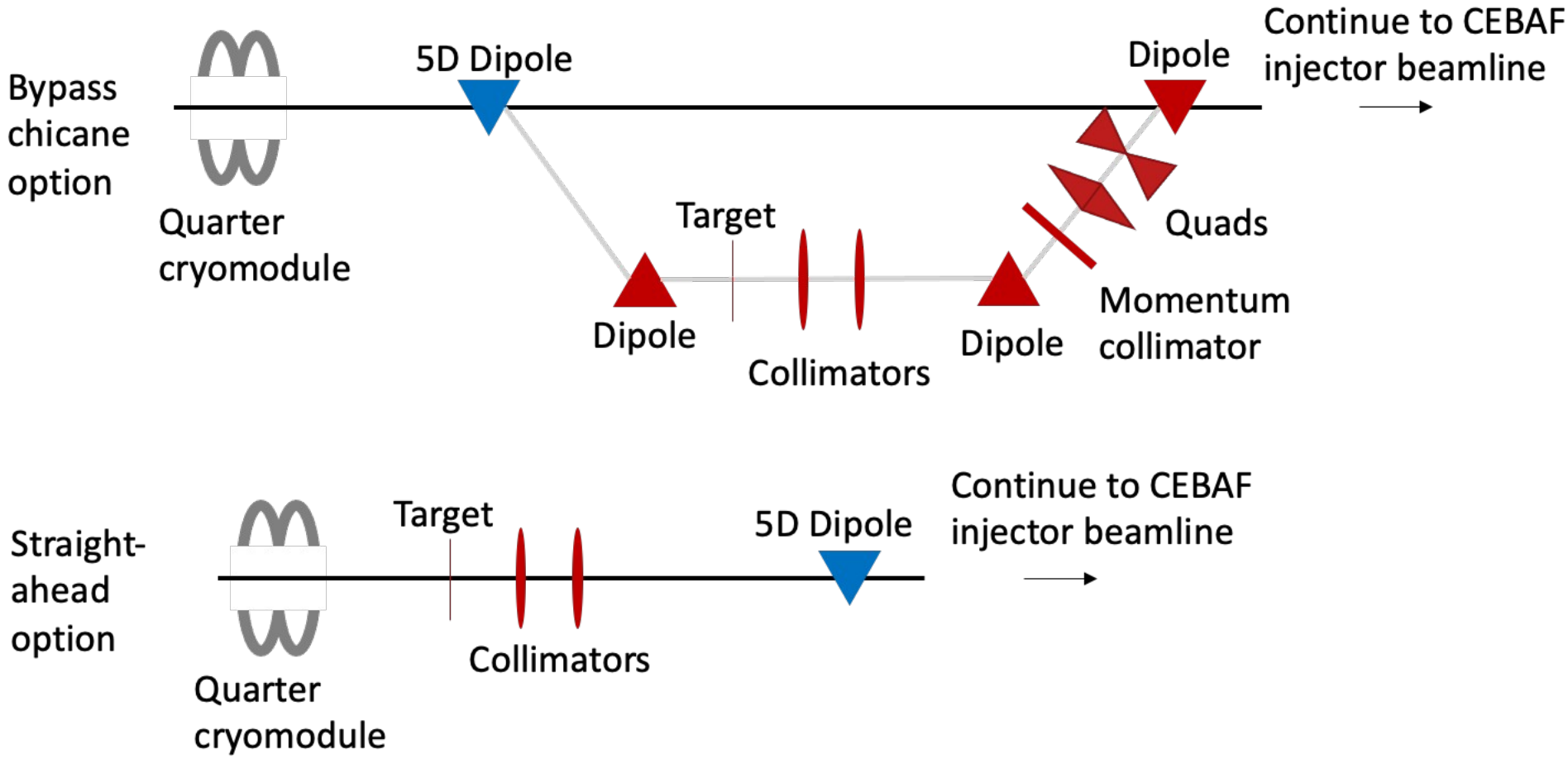




[V. Lizarraga-Rubio]

Degraded e- beam LDRD

- We are evaluating two options for the degrader addition
- In FY23 we will procure components for the selected option

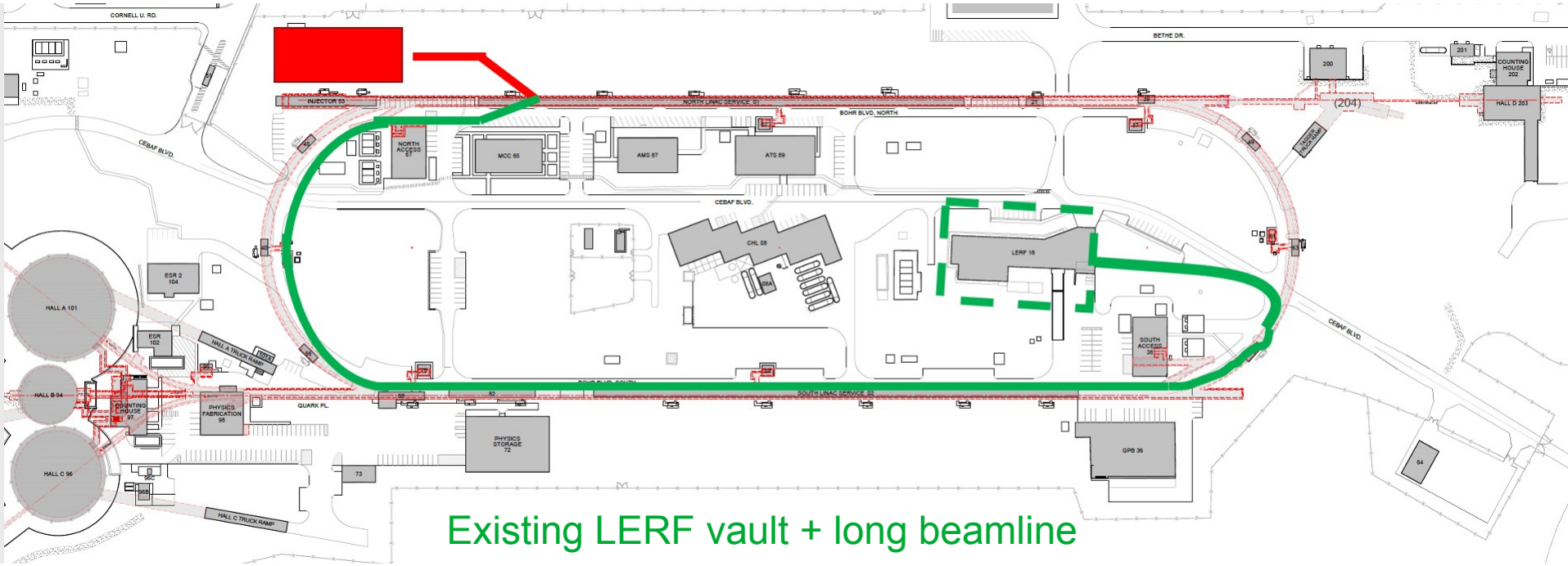


End

Questions?

Options for Positron Source Vault

New underground vault + short beamline

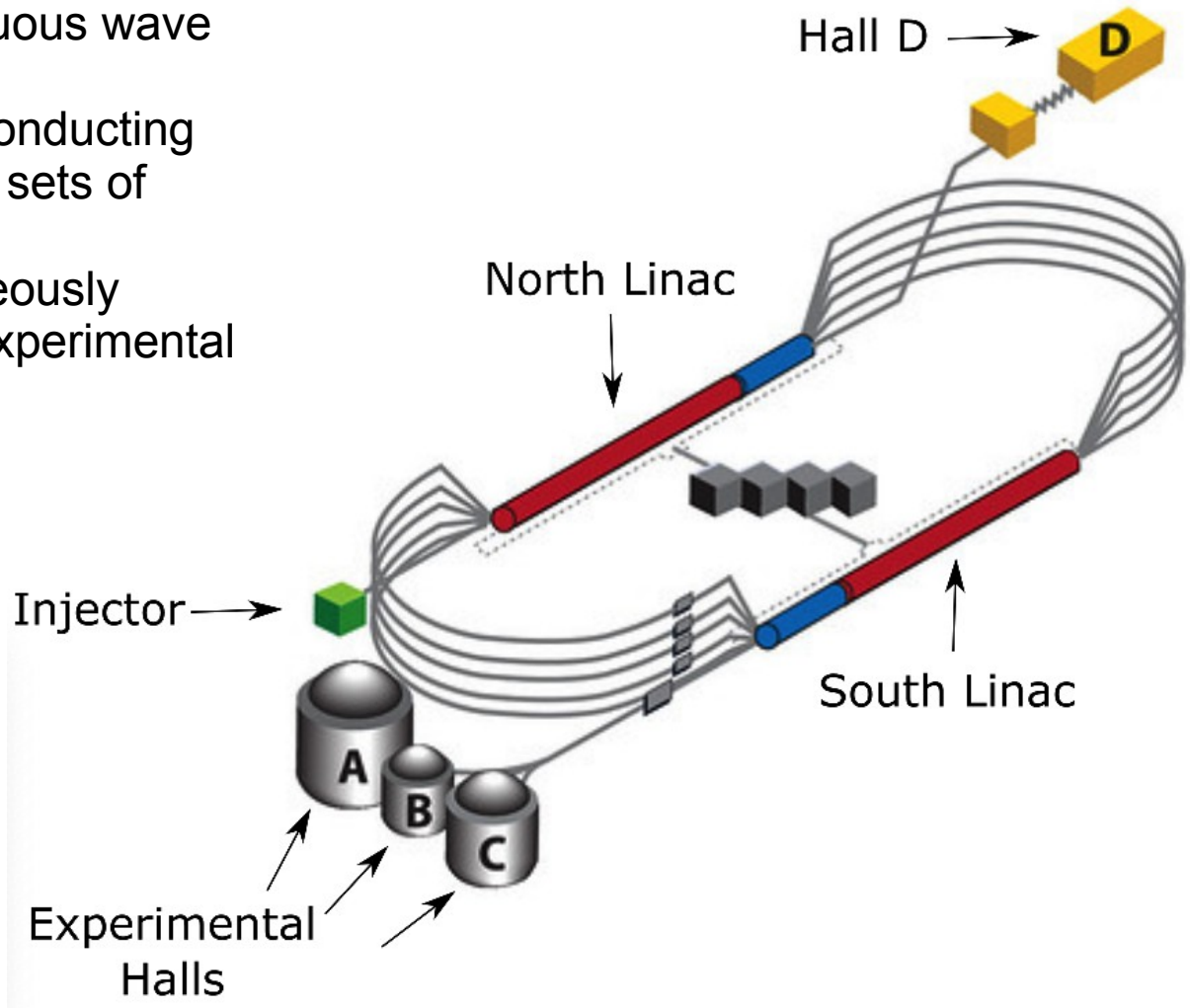


Existing LERF vault + long beamline

Green option is presently more cost effective and provide options for staging positron source

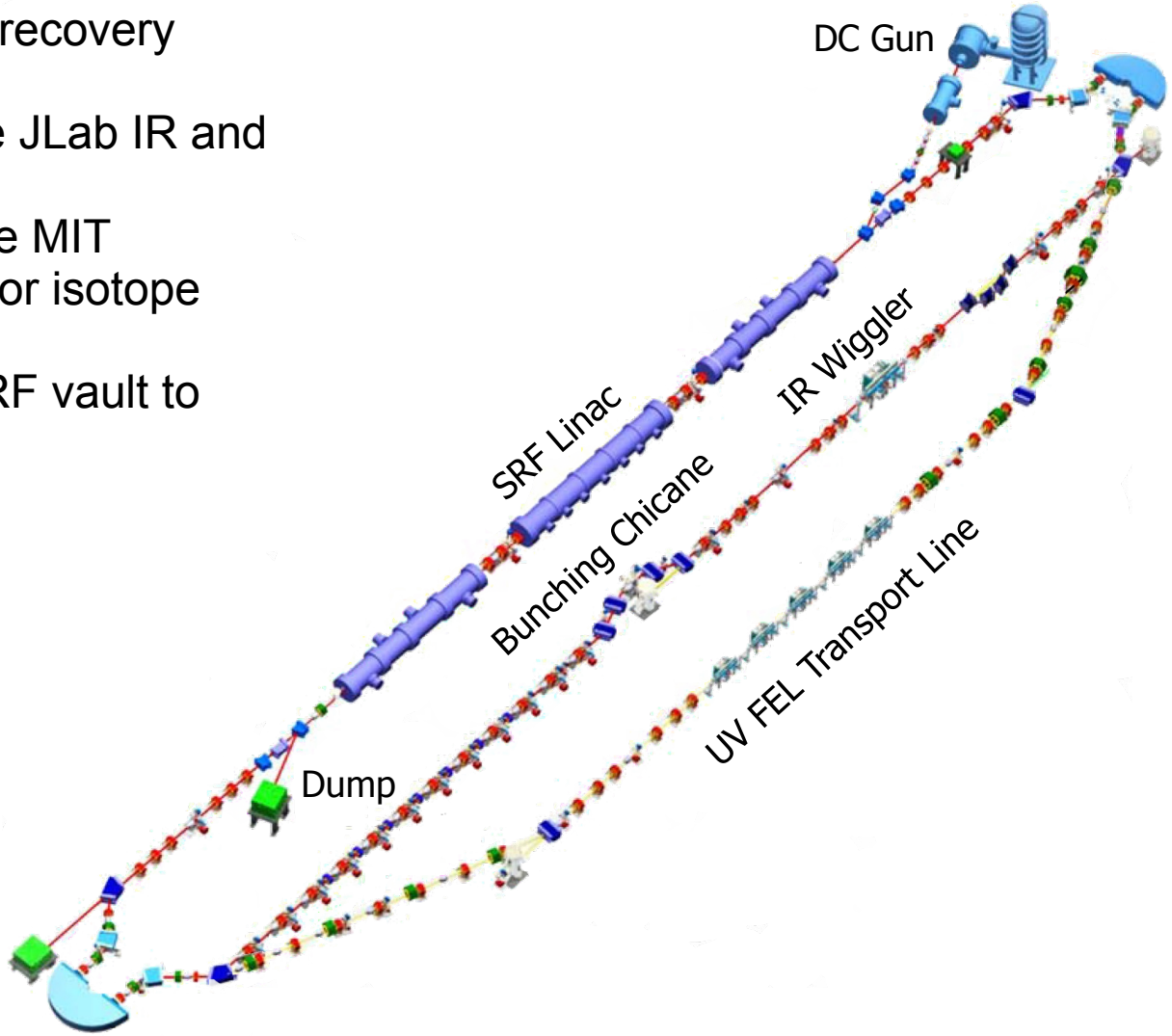
Continuous Electron Beam Accelerator Facility (CEBAF) Introduction

- 5.5-pass, 12GeV continuous wave electron accelerator.
- Two anti-parallel superconducting linacs connected by two sets of recirculating arcs.
- Beams can be simultaneously extracted to up to four experimental halls.



Low Energy Recirculator Facility (LERF) Introduction

- Up to 165MeV CW energy-recovery linac.
- Previously the driver for the JLab IR and UV free electron lasers.
- Since has been used for the MIT DarkLight experiment and for isotope production experiments.
- We propose to use the LERF vault to house a positron source.



Existing LERF Vault Layout

- Vault dimensions ~ 65x14 m
- Electrical, cryogenics, and other services already available
- Many of the existing LERF components can be reused