THE ADVANCED PHOTON SOURCE LINAC EXTENSION AREA BEAMLINE

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ABSTRACT

- The Linac Extension Area (LEA) is a flexible beamline area for testing accelerator components and techniques.
- The beamline is expected to be available soon for testing accelerator components and techniques using round and flat electron beams over an energy range 150–450 MeV.
- In the present work, we describe this beamline and summarise the main beam parameters.

MOTIVATION

- Driven by the Advanced Photon Source electron linac equipped with a photocathode RF electron gun, the Linac Extension Area houses a 12 m long beamline.
- Beamline is furnished with YAG screens, BPMs and a magnetic spectrometer to assist with characterization of beam emittance and energy spread.
- A 1.4 m long insertion in the middle of the beamline is provided for the installation of a device under test.

ELECTRON SOURCES

- APS linac provides electron beams to the injector complex, including LEA.
- Three electron sources can be configured to deliver electron beams to LEA, in different charge configurations.
- These include:
  - a photocathode (PC) radiofrequency (rf) gun,
  - two thermionic cathode (TC) rf guns, and
  - the Particle Accumulator Ring (PAR).
- Parameters of beams from different electron sources are summarised in Table 1.

Table 1: Parameters Of Beams From The Electron Guns And PAR.

Parameter	Units	PC	TC	PAR
Charge per cycle	nC	0.3	1.0	20
Bunch charge	nC	0.3	0.007	20
Bunch length	ps	1	1	1000
Bunches per cycle	…	1	29	1
Bunch spacing	ns	…	0.35	…
Repetition rate	s^{-1}	6	30	1

ELECTRON GUNS AND DAMPING RING

- Photocathode RF Gun
  - The PC gun is the principal electron source for LEA [1].
  - An Nd:Glass laser oscillator and amplifier provides ps laser pulses at 1053 nm wavelength [2].
  - The laser wavelength is frequency-doubled twice to 263 nm using SHG in beta barium borate crystals.
- Thermionic Cathode RF Gun
  - Two TC guns are the principal injectors for the APS injector complex [3].
  - The 2856 MHz rf frequency TC guns typically provide a train of electron bunches of ~1 nC total train charge, over a bunch train duration of ~10 ns.
- Particle Accumulator Ring
  - APS accelerator complex originally designed as a positron accelerator chain.
  - The PAR is operated as an electron beam damping and accumulator ring [4].
  - This represents an electron source for experiments at LEA with high electron bunch charge (≤20 nC), for applications or experiments where ~1 ps electron bunch durations are not required.

LEA BEAMLINE

- An elevation view of the beamline is illustrated in Fig. 1.

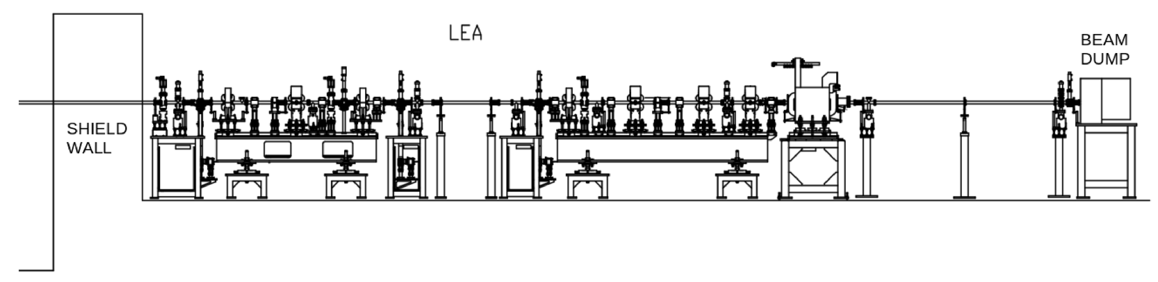

Figure 1: Schematic of the LEA beamline. Beam trajectory is from left to right.

- A photograph of the installed hardware of the LEA electron beamline [5] is illustrated in Fig. 2.

Figure 2: Photograph of the installed LEA beamline.

BEAMLINE LATTICE

- The longitudinal positions of the LEA beamline components are summarised in Table 2.
- Principal magnetic elements are quadrupoles, horizontal and vertical correctors, and vertical bending magnet spectrometer. A beam absorber and lead dump is at the end of the beamline.
- Lattice simulated using elegant to the beam dump in the orbit plane of the beamline is summarised in Fig. 3 [6].

Table 2: LEA Beamline Lattice.

Element	Position s (m)	Length l (m)	Gradient (T m^{-1})
LE:GV1	0		
LE:BPM1	0.464		
LE:YAG1	0.578		
LE:Q1	0.938	0.1	7.17
LE:SC1	1.318		
LE:CM1	1.623		
LE:Q2	1.941	0.153	-7.67
LE:SC2	2.295		
LE:GV2	2.396		
LE:Q3	2.863	0.1	7.78
LE:SC3	3.065		
LE:BPM2	3.275		
LE:YAG2	3.358		
LE:BPM3	5.253		
LE:YAG3	5.330		
LE:SC4	5.605		
LE:Q4	5.804	0.1	7.78
LE:GV3	6.011		
LE:SC5	6.405		
LE:Q5	6.779	0.153	-7.62
LE:CM2	7.024		
LE:SC6	7.382		
LE:Q6	7.755	0.153	7.17
LE:Q7	8.417	0.153	-4.26
LE:SC7	8.691		
LE:BPM4	8.871		
LE:SPECT	9.025		
LE:YAG4	13.538		

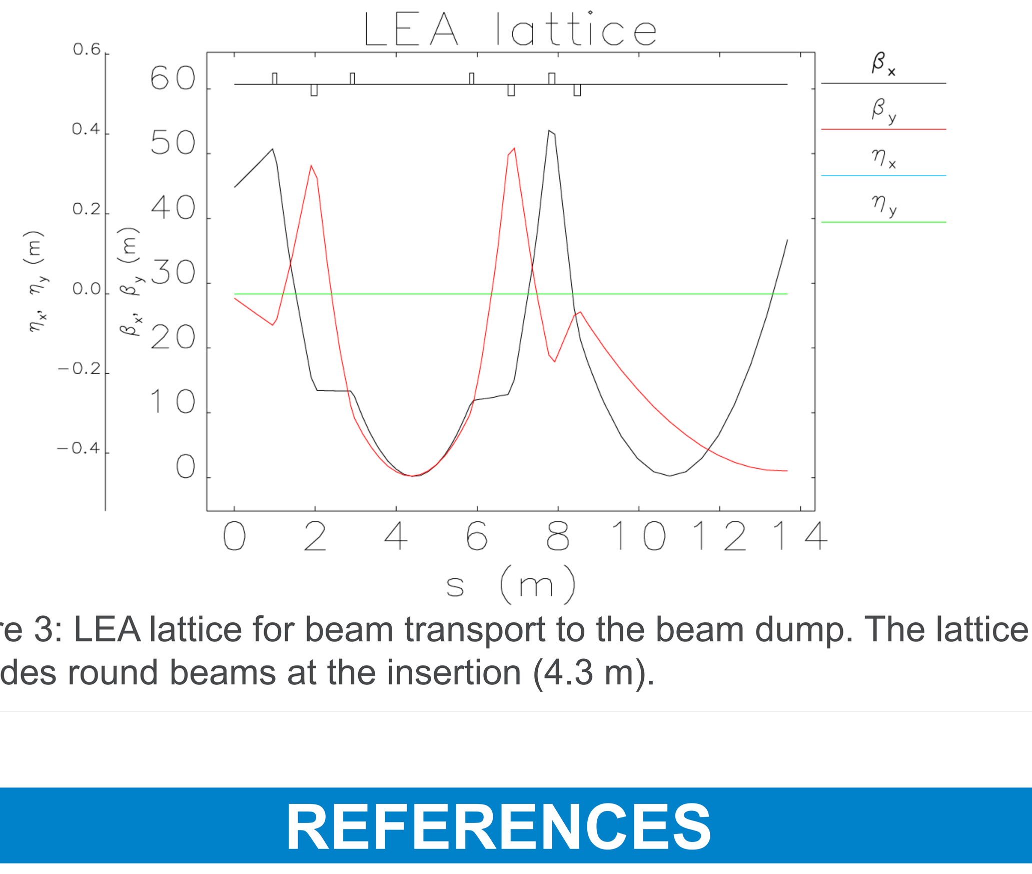

Figure 3: LEA lattice for beam transport to the beam dump. The lattice provides round beams at the insertion (4.3 m).

SUMMARY

- The LEA electron beamline at the APS is for the demonstration of accelerator technologies, instrumentation and techniques.
- The beamline was designed to transport round and flat electron beams over an energy range 150–450 MeV.
- With TC and PC electron guns and an electron damping ring as sources, a range of different potential experiments could be performed using the presently-installed LEA beamline hardware.

NEXT STEPS

- Opportunities for potential experiments using installed hardware:
  - Techniques for lattice optimisation and beam transport. Could include nonlinear or machine learning techniques.
  - Performance of materials for shielding gamma rays/neutrons could be evaluated.
  - Performance of distributed beam loss monitors as diagnostics in transport lines.
  - Imaging performance of different scintillator materials in beam profile monitors.

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