

# UPGRADING OF LINEAR INDUCTION ACCELERATOR X-RAY FACILITY (LIAXF)

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## Abstract

Linear Induction Accelerator X-ray Facility(LIAXF) is a pulsed X-ray machine at Institute of Fluid Physics which produced X-ray by impacting an electron beam on target with beam parameters of 10MeV, 2kA with 90ns pulse width(FWHM). The machine was upgraded to LIAXFU by increasing energy and current and reducing its spot size in 1996 in order to increase the capability of penetration. Description of the LIAXF and upgrades to LIAXF are presented. Simulation on the redesigned drift and focusing section is also given. Experimental results of 12MeV, 2.6kA with 90ns pulse width, about 4mm spot size have been obtained.

## 1. INTRODUCTION

Linear Induction Accelerators are powered by causing a large, pulsed, time-varying current to once circle a ferrite annulus. This results in a large, time-varying, azimuthal magnetic field to be imbedded in the ferrite annulus. A particle beam threading the center of the annulus acts as the secondary of this 1:1 pulsed transformer and is accelerated by the induced electromotive force. Stacking many such transformers in series and having the particle beam be the secondary common to all modules enables high beam energy to be obtained.

Induction Linac has many application in the fields such as free electron laser[1], high power microwave, flash X-ray radiography[2], heavy ion fusion[3], and so on due to its distinct advantage of high peak power, capacity of producing high current, high energy beams with pulse durations ranging from tens of nanoseconds to microseconds. LIAXF is a linear induction accelerator designed to produce X-ray by impacting the electron beams onto a tantalum target with the nominal beam parameters of 10MeV, 2kA with 90ns pulse width, which was developed by scientists at Institute of Fluid Physics, CAEP, in the early 1990s'. LIAXF was assembled with a four-induction-cell injector and 28 accelerator cells. The first 12 induction modules were used as driver for SG-1 free electron laser[4].To improve the capability of the LIAXF, the upgrades to the LIAXF centered on improving beam quality and increasing beam energy and current.

## 2. DESCRIPTION OF THE LIAXF

### 2.1 Injector

The injector is composed of four induction cells and a field emission diode, each cell of the injector is applied to 250kV, for a 90ns(FWHM) high voltage pulse. The voltage contribution of the four cells is summed along the hollow stainless steel stem to drive the diode. The surface of the cathode is covered by the velvet cloth, the anode aperture is closed off with fine tungsten mesh. The emitting current is collimated and matched into the accelerating section by axial magnetic field.

### 2.2 Accelerating Section

There are total 28 accelerating cells that are arranged in four-cell blocks in the LIAXF. Each accelerating cell contributes about 320keV energy to the beam. The electron beam from the injector is guided by a near-continuous array of solenoids that are positioned both internal and external to the accelerating cell. The current view resistor(CVR) between the four-cell blocks give the beam current and position information for machine tuning. The capacitor probe at each cell measures the accelerating voltage of each cell.

### 2.3 The Ferrite Toroids Used in LIAXF

The characteristics of the ferrite are very important to the accelerating cells. In order to obtain a non-distorted high voltage pulse, Large saturated and residual fluxes are expected. The ferrite toroids used in the LIAXF were developed by ourselves. It worked very well. The characteristics of the ferrite toroids are as follows:

Bs:	3.9kG
Br:	3.0kG
$\mu$ :	350
$\rho$ :	10(6)Ohm-cm

#### Dimensions:

OD:	508mm
ID:	230mm
Ht:	25mm

### 2.3 Beam Drift and Focusing Section

The beam drift and focusing section of the LIAXF is composed of five solenoids and three thin magnetic

lenses, and a tantalum target. The total length of this section is about 4.5m.

## 2.4 The Pulsed Power System

The pulsed power system can be divided into charging system and triggering subsystem. There are five Marx Generators in charging subsystem. Each charges six or seven Blumlein pulse forming lines through inductors.

There are three stages of triggering switches. One first stage switch triggers five second stage switches that then trigger 32 Blumlein switch in turn. Therefore the output voltage of each Blumlein was synchronized with the beam and applied to the induction cell to accelerate the electron beam.

## 3. UPGRADES TO LIAXF

The first task was to add four induction cells to the end of LIAXF, then increase the working voltage of each accelerating module from original 320kV to 350kV. The total beam energy can be more than 12MeV.

The next tasks in improving LIAXF beam quality were to realign the mechanical axis of the whole machine for reducing the corkscrew motion and improve the synchronization of the accelerating voltage with the beam for reducing the beam energy sweep.

The injected beam current into accelerating section was also increased to about 3kA.

The drift and focusing section was redesigned to achieve smaller spot size. The length of this section was shortened to about 2cm. Only two solenoids and two thin magnetic lenses were employed. Simulation showed that 4mm spot size can be achieved.

## 4. CONCLUSION

With the completion of these upgrades, LIAXFU produced the electron beam with parameters of 12MeV, 2.6kA with 90ns pulse width. The spot size was reduced from 6mm of LIAXF to about 4mm. LIAXFU has stronger capability of penetration and smaller spot size.

## REFERENCES

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