Design and Status of the VISA II Experiment

G. Andonian, R. Agustsson, A.Murokh, C.Pellegrini,
S.Reiche, J.B.Rosenzweig, G.Travish, UCLA
I. Ben-Zvi, V. Yakimenko, BNL
L.Palumbo, C. Vicario, INFN

Abstract

VISA II is a follow-up venture to the succesful Visible to Infrared SASE Amplifier (VISA) experiment. This is a collaborative effort headed by UCLA and the ATF (Accelerator Test Facility) at BNL. There are two main experiments associated with the VISA II program. The first is the study of strong bunch compression, via a chicane compressor, and deep saturation investigations. The next undertaking is the study of the physics of a chirped-beam SASE-FEL, where a linear energy chirp is imparted on the beam and injected into the undulator. The VISA II program encompasses a number of hardware upgrades at the ATF, including the installation of the chicane compressor and addition of sextupole magnets to mitigate second order effects.

More information can be found at
http://pbpl.physics.ucla.edu/visa

Summary of VISA I Results

The successful VISA I experiment was designed to investigate physical properties of SASE-FEL.

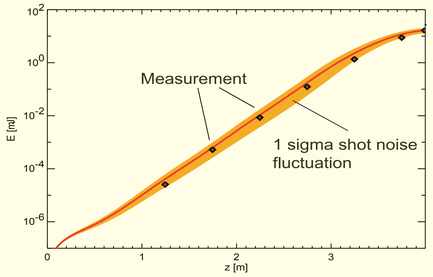
A novel bunch compression mechanism was developed during the VISA I experiment. This scheme utilized second order momentum error effects in the dispersive line.

VISA I also was successful in benchmarking the numerical codes used for start-to-end (cathode to undulator) beam simulation.

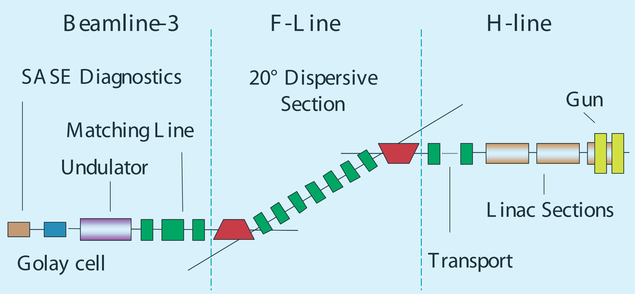
VISA I Performance Parameters

	Non-Comp. Beam	Comp. Beam	Undulator	
Energy	71.2 MeV	70.7 MeV	Period	18 mm
Energy Spread	0.10 %	0.17 %	Number of Periods	220
Emittance	2.1 μm	3.3 μm	Parameter (K)	1.26
Charge	250 pC	140 pC	Length	4 m
Peak Current	55 A	250 A		
Gain Length	29.7 cm	17.9 cm		
Wavelength	831 nm	842 nm		

Saturation Curve of VISA I. Measured data and simulation.



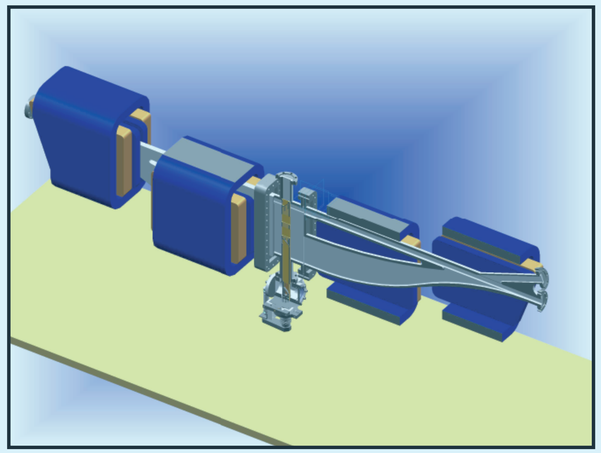
Beamline Description



Schematic of the VISA beamline at the ATF (not to scale).

Electron and Photon Diagnostics	
Laser Diagnostics	Spectrometer, Joulemeters, CCDs
RF Diagnostics	Couplers, Phase Detectors
e-Beam Diagnostics	YAG and phospor Screens, BPMs
Temporal Struc.	CTR Measurements
Charge	Faraday Cup
Emittance	Quad Scanning
Energy Diagnostics	Dipole Spectrometers
Advanced Diagnostics	
Temporal Struc.	FROG
Bunch length (compression)	Interferometer, E-O Technique

Chicane Compressor



3-D Rendered Image of chicane compressor

The chicane compressor will be installed along the H-Line (initial transport). The dipole magnets were designed and fabricated at UCLA. The bend radius is 1.2 m, and the nominal field is .1964T. The effective magnetic length is 44.7 cm.

Once installed and operational, the chicane is expected to compress the beam down to a bunch length of 30 μm. Such a short bunch yields a current on the order of 1 kA.

The design of the vacuum port allows for studies of CSR. There are two locations for diagnostics at the midpoint of the chicane, due to a novel diagnostic assembly.

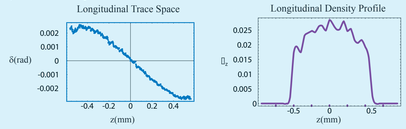
Linearization of Transport

The addition of sextupoles to the dispersive line (F-line) will yield control over second order momentum effects. This allows for a better understanding when running VISA II in the chirped mode.

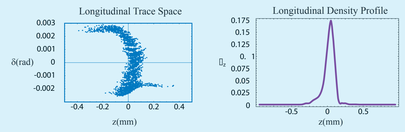
It was discovered from the VISA I runs, that the natural compression in the dipsersive line was dominated by second order effects. These effects will be minimized and yield control of beam properties at the undulator entrance.

The following plots were generated using ELEGANT.

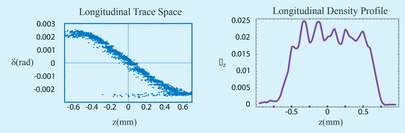
a) Initial Trace Space after linac.



b) Final Trace Space after dispersive section (without sextupoles).



c) Final Trace Space after dispersive section (with sextupoles).



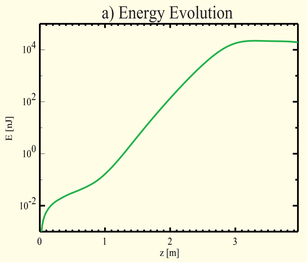
SASE-FEL Experimental Program

Compressed Bunch Overview

Summary of Simulations

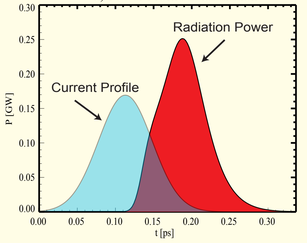
The follwoing plots were generated by GENESIS 1.3, a 3-D FEL Code

a) Energy Evolution

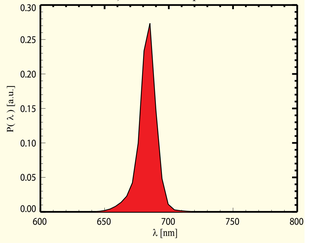


a) Saturation is evident at about 3m, well before the end of the undulator, allowing for deep saturation studies.
b)Slippage plays an important role in the compressed bunch case. Current is represented by the dashed curve.
c)The FEL Spectrum is peaked at about 685 nm.

b) Power Profile at Saturation

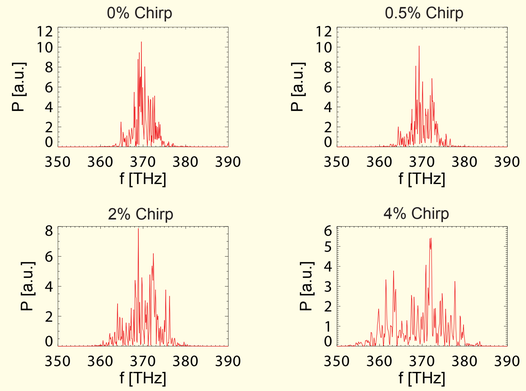


c) Saturation Spectrum



Chirped Beam Overview

Summary of Simulations



Theoretical Studies on the spectral response of an initially chirped electron beam. Simulations show that total energy at saturation is not affected by chirping up to 4% (no gain degradation). It is necessary to go to 2% chirp to overcome the intrinsic frequency width of the FEL amplification in order to achieve a correlation between frequency and time. An ideal case for FROG measurement.