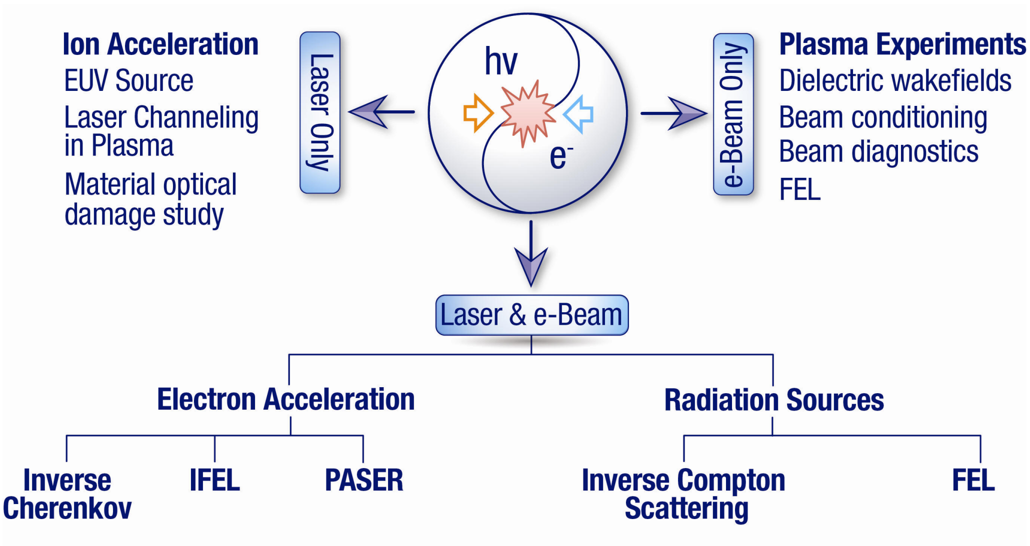

ATF Newsletter

Summer 2014

www.bnl.gov/atf

@ATFatBNL

IT'S TIME TO START THINKING ABOUT SUBMITTING YOUR PROPOSALS

ATF Status Update

Welcome to the ATF summer newsletter, the first thing to do is congratulate Ariel Nause who won the RHIC & AGS Users Thesis Award for his thesis titled *"Beating the Shot-Noise Limit: Collective Interaction Optical Noise Suppression in Charged Particle Beams"* – well done Ariel!

Now is time to start thinking about the future of the ATF's experimental program with new user proposals. New proposals will be considered at this year's User Meeting that will take place on 14-15th October 2014. Proposals are due by 15th September; visit **http://www.bnl.gov/atf/access.php** to begin the proposal submission process and email, **fedurin@bnl.gov**, for more information. The User Meeting will be followed by a two-day workshop, 16-17th October 2014, dedicated to the upgrade of the ATF. There follows a brief overview of this quarter's experimental work:

High-brightness picosecond ion beam source based on BNL TW CO_2 laser – A team from SUNY SB, Imperial College and ATF explored a method of hydrodynamic shaping of a helium gas jet for controlled shockwave acceleration of He+ ions. Obtained experimental results are matched with simulations. This research is being submitted for publication.

Plasma Wakefields in the Quasi-Nonlinear Regime – For the UCLA experiment, the ATF achieved a beam size of < 6μm at the entrance to the plasma capillary. Plasma focusing effects allowed the beam to be kept at a small size for the entire 25mm length of the tube. During the experiment the density of the plasma, through which the electron beam travels, was varied and at specific densities the beam was seen (via OTR) to experience transverse modulations about the beam axis. (see p5 for a full report)

Beam Manipulation by Self-Wakefield at the ATF – A group from Euclid Techlabs performed a measurement of narrow-band THz radiation generated by passing an electron bunch train through a dielectric loaded waveguide (see p3 for a full report).

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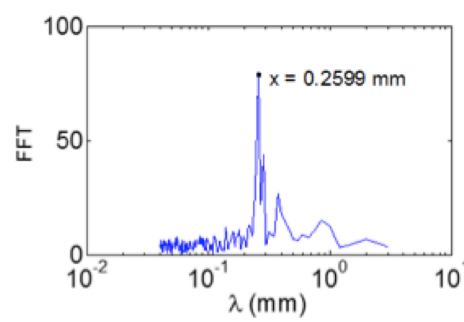

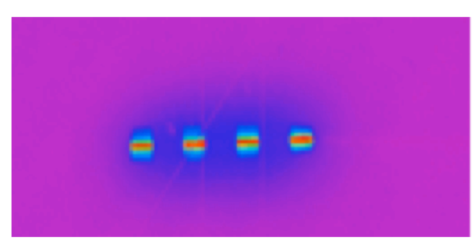

Nonlinear inverse Compton scattering – UCLA continued their pioneering studies of Compton harmonics and mass-shift effect using the high-power CO_2 laser. They recently made the first observation of a radiation pattern of 3rd harmonic Compton X-rays in a circular polarized beam. Also, the mass shift effect in the Compton fundamental spectrum has been observed to a higher clarity.

Transient Noise of MCT Detector Array Due to 70 MeV Electrons – The JPL experiment group came to the ATF to test shielding intended to protect equipment that will be sent on a future mission to Jupiter's satellite, Europa. During that mission, the spacecraft will be aggressively bombarded by high-energy particles and the ATF was used to simulate this. The shielded MCT camera was exposed to a 70 MeV electron beam and data were recorded at varying bunch charges. This data will be compared to Monte-Carlo simulation and used to develop improved shielding. The ATF works hard to get users up and running as soon as possible. This experiment went from proposal to results in just nine weeks.

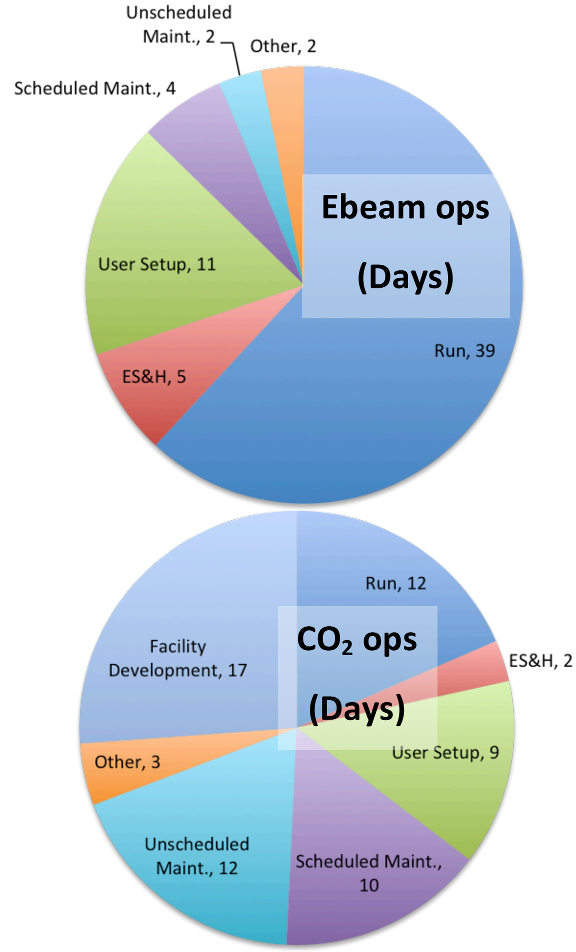

Figure 1: Operations for FY14 third quarter.

Operations etc.

by Christina Swinson

Sub-femtosecond beam line diagnostics – Preparation of experimental space has begun in anticipation of installation of new equipment. The long-term goal of this experiment is to develop a bunch length measurement method using an X-band deflector cavity.

Electron Beam and CO_2 Laser Status

During the second quarter of the year the ATF played host to six different experiments, most notably seeing the improved observation of a radiation pattern of 3rd harmonic Compton X-rays. Together with work on user experiments, time was devoted to progressing with the CO_2 power upgrade with initial testing of a stretched pulse amplification system and development of femtosecond diagnostics. Simultaneously, installation of equipment in preparation for experiment AF62 began. See right (fig. 1) for distribution of e-beam and CO_2 laser activities. The following user experiments were served with typical ebeam parameters ranging from 45 – 70 MeV in energy and 30 – 500 pC charge and CO2 laser of 1 TW peak power:

AE35 - High-brightness picosecond ion beam source based on BNL TW CO_2 laser (SUNY SB)

AE50 - Plasma Wakefields in the Quasi-Nonlinear Regime (UCLA)

AE52 - Beam Manipulation by Self-Wakefield at the ATF (Euclid Techlabs)

AF53 – Nonlinear inverse Compton scattering (UCLA) feasibility

AE61 - Transient Noise of MCT Detector Array Due to 70 MeV Electrons (JPL)

AF62 - Sub-femtosecond beam line diagnostics (UCLA) feasibility

KEY CONTACTS

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IF YOU LIKE THIS NEWSLETTER

Please pass this newsletter on to interested parties and email **cswinson@bnl.gov** if you wish to be added to the email distribution list

Publications

Advanced Concepts and Challenges in Compton Radiation Sources (IPAC'14, in proceedings and invited talk) – Igor Pogorelsky

THz Radiation Generation in Multimode Wakefield Structures (IPAC'14) - Sergey P. Antipov, Sergey Baryshev, Chunguang Jing, Alexei Kanareykin, Paul Schoessow, Alexander Zholents, Wei Gai, Mikhail Fedurin and DanWang

Progress and prospects of a Compton x-ray source driven by a high-power CO2 laser (contributed talk ICXRL 2014) – Igor Pogorelsky

High-brightness intra-cavity source of Compton radiation (submitted to Journal of Physics B) – I. Pogorelsky, R. Agustsson, T. Campese, A. Murokh, A. Ovodenko, M. Polyanskiy, and T. Shaftan

Manipulation of laser-generated energetic proton spectra in near critical density plasma (submitted to the Journal of Plasma Physics) – Charlotte A. J. Palmer, Nicholas P. Dover, Igor Pogorelsky, Matthew J. V. Streeter, and Zulfikar Najmudin

Stony Brook Accelerator Laboratory Course, CASE@ATF

V. Litvinenko, M.Fedurin and D. Kayran

The Center for Accelerator Science and Education (CASE) is as a joint venture between Stony Brook University (SBU) and Brookhaven National Laboratory (BNL). CASE established a classroom at the ATF with the purpose of teaching a gradate-level advanced accelerator laboratory course using the unique facilities available at the ATF. The goal of this class is to expose graduate students to modern accelerator technology and methods of generating, accelerating and controlling high brightness electron beams.

The course will include one training class, two classes for learning accelerator codes and ATF controls, and eleven experimental sessions using the ATF control room and equipment. Two CASE accelerator scientists will give this course: Dr. M. Fedurin and Dr. D. Kayran.

Graduate education in accelerator science and technology is historically an important part of the ATF mission. We look forward to this opportunity to further our support whilst strengthening ties with the Stony Brook science community.

FOR MORE INFORMATION

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Selective excitation of high order modes in a dielectric loaded waveguide by a sub-picosecond electron bunch train

S. Antipov (Euclid Techlabs), D. Wang (ANL), M. Fedurin, C. Swinson (ATF, BNL)

In the past decade, many approaches have been investigated to generate THz micro bunches that include: bunch generation from a photoinjector with micro laser pulses produced by birefringent crystals; bunch train with a picosecond separation using an emittance exchanger combined with transverse beam masking and other similar techniques; some bunch compression techniques and a two-step approach based on beam self-wake energy modulation followed by a compression in chicane. Once the THz content is introduced the beam is sent through the power extractor unit where it radiates a THz signal. In this experiment we consider a multimode wakefield structure, a dielectric loaded waveguide with thick dielectric wall (alumina, ID=0.51mm, OD=1.27mm, 2" long). Such a structure has a spectrum of closely spaced modes. If excited by a short electron bunch, all of these modes are generated (figure 1, left). This happens in part because a short electron bunch has a wide spectrum (figure 1, right, dashed line). A bunch train favors frequencies that correspond to the bunching periodicity (figure 1, right, solid).

Therefore, it is possible in principle to use a bunch train to select a certain mode from a multimode spectrum of this wakefield tube. High order modes typically have a low group velocity and allow generation of narrow band THz signals over short distances.

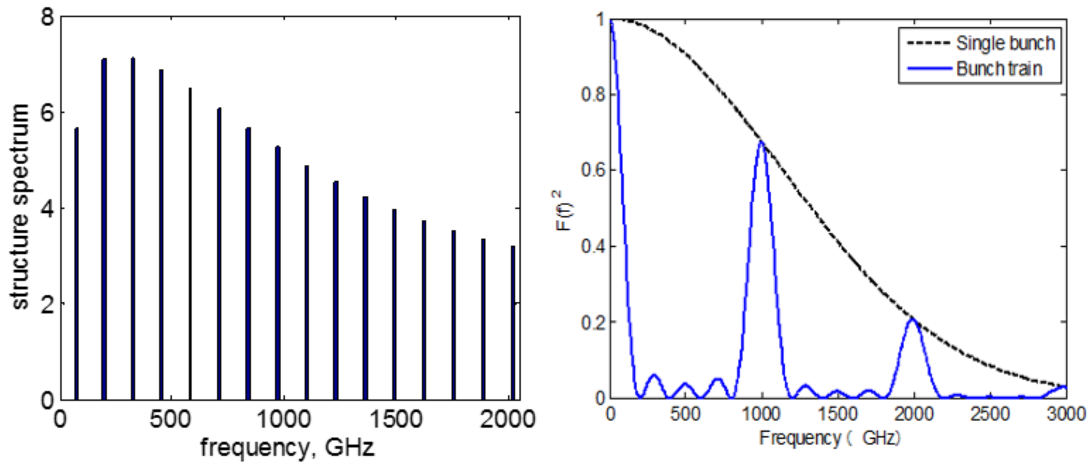

Figure 1: Left: structure spectrum. Right: single bunch vs bunch train spectrum..

In the experiment a train of 5 electron bunches with variable spacing (0.7 – 1.15 THz) was generated using the ATF mask method. This bunch train passes through a dielectric loaded waveguide and generates Cherenkov radiation. The signal is transported to an interferometer and measured (figure 2). Fourier transform shows a strong excitation of ~ 260µm wavelength (1.15 THz), a high harmonic selection by a bunch train in a multimode wakefield structure. This experiment (at the moment) is limited by the number of bunches in a bunch train, mode spacing in the structure and beam stability needed for long interferometer scans required to resolve spectrums in frequency space.

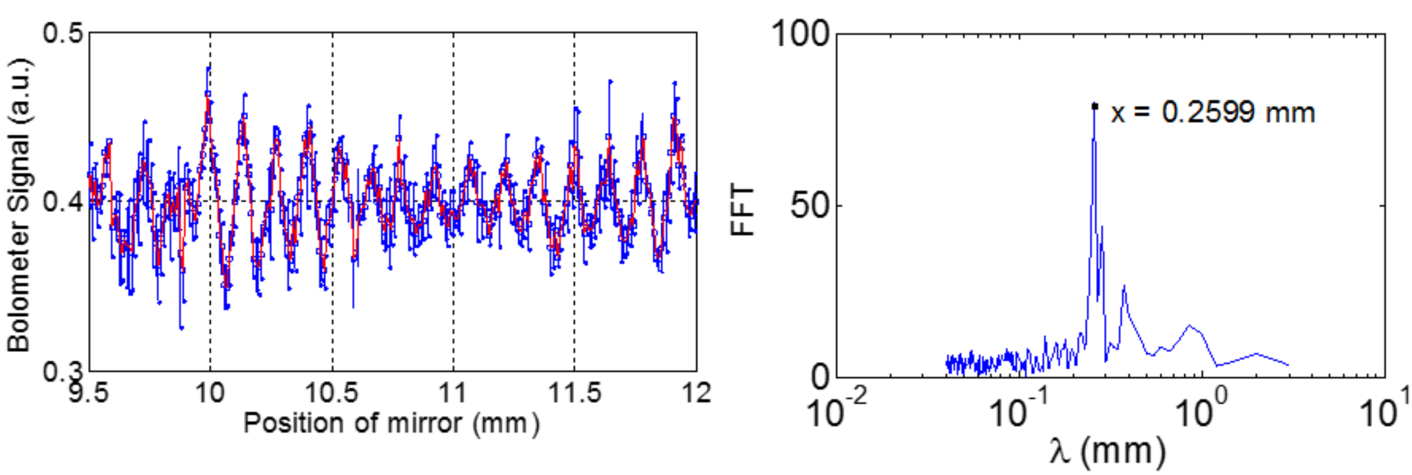

Figure 2: Autocorrelation function of the THz signal and its Fourier transform showing a narrowband signal at 1.15THz.

This work is supported by EuclidTechlabs SBIR award # DE-SC0009571

FOR MORE INFORMATION

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Quasi-nonlinear plasma wakefield experiments

by S. Barber

Further progress was made on plasma wakefield experiments in the quasi nonlinear regime during May. The primary focus of this project is to investigate the interaction of electron bunch trains with plasma given the following criteria: electron beam density greater than plasma density (~10^{16} cm^{-3}) and a bunch spacing equal to the plasma wavelength (~300 microns).

Achieving the desired bunch spacing is accomplished by way of the standard ATF mask technique and confirmed via measurements of the bunch train's coherent transition radiation spectrum (Fig 1a and 1b). Extreme focusing of the electron beam through the use of a short focal length permanent magnet triplet, a cornerstone of this project for reaching high beam densities, was improved upon compared to previous attempts. At present, we have demonstrated the ability to focus to 4.5 by 5 microns (Fig 1c) with greater than 90% transmission of charge to the end of the beamline, which satisfies the requirement for beam density.

A primary area of interest lies in the ability to drive a wakefield with a bunch train such that each bunch falls into the focusing portion of the oscillating wakefield. In this way the bunch train can be guided over many beta functions with little increase in beam size, which consequently sustains the large magnitude wakefields over long distances. By imaging the OTR radiation of the electron beam several millimeters downstream of the plasma we were able to observe such an effect. With the plasma off, the transverse beam size at the OTR screen is roughly 100 by 60 microns (or equivalently, ~20 by 12 beta functions from the waist). With the plasma turned on and tuned to a density corresponding to a suitable plasma wavelength, the size at the OTR screen is reduced to 20 by 15 microns (or 5 by 3 beta functions). Thus, strong guiding of a bunch train with the aid of plasma focusing force has been demonstrated.

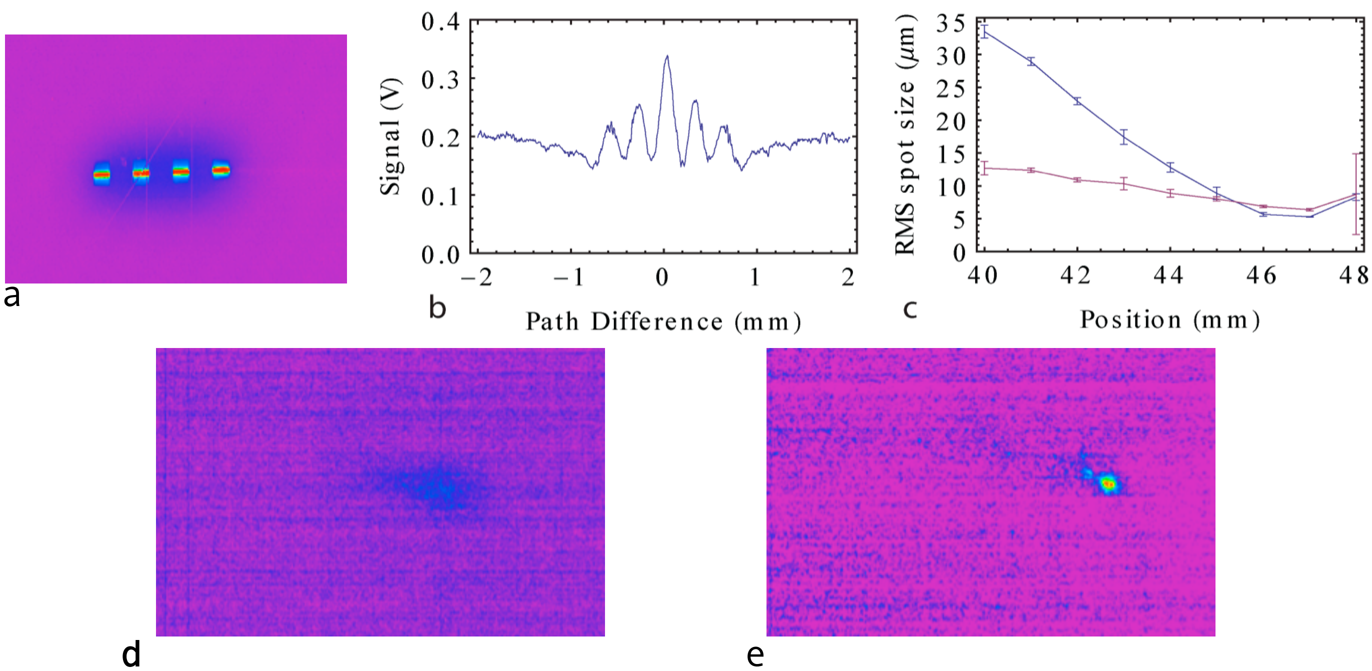

Figure 1: Image of the masked beam in the dispersive section (a) and raw interferogram of the CTR pulse from the masked beam showing separation of beams of 300 microns. Measurements of transverse beam size in horizontal (blue line) and vertical (red line) versus longitudinal position showing minimum beam size ~5 microns (c). Transverse image of bunch train 30 mm downstream of interaction point with no plasma (d) and with plasma tuned to a density with a plasma wavelength of 150 microns (e).

FOR MORE INFORMATION

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