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Fermilab's Advanced Superconducting Test Accelerator

ASTA Newsletter

Impressive Progress at ASTA

ASTA is cited as one of eight major Fermilab accomplishments of 2013:

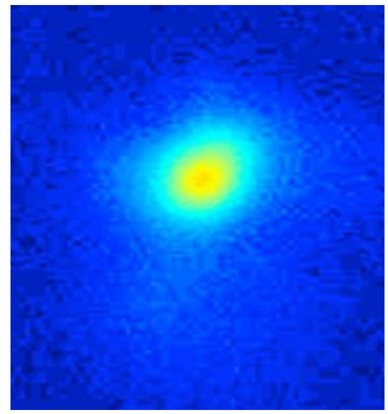
- From Fermilab's Director Nigel Lockyer article "Recognizing Accomplishments" (*Fermi-Today,* Dec.3, 2013): *"...Pushing ASTA forward through the first photo-electrons from the ASTA injector, holding the first ASTA user's meeting and developing a proposal for presentation to DOE."*

Inside this issue:

ASTA got off to rousing start in 2013, and 2014 promises to provide even more advances.

The **2013 most notable achievements** in bringing ASTA into operation include: a) completion of the first phases of Photoelectron Gun conditioning and first 3.5 MeV electrons produced and characterized; b) installation, cool down to 2K, and first operation of the 1.3 GHz SRF Cryomodule; c) cool down to 2K and commissioning of the SRF "Capture Cavity 2" (CC2) to 21 MV/m; d) rebuilding of the SRF CC1 with a higher gradient cavity, which was tested to 29 MV/m; e) installation and conditioning of a new 5 MW klystron for the Gun.

The first **ASTA Users meeting** took place at Fermilab on July 23-24, 2013 and brought together more than 80 people with the wide interest in the ASTA beams. Simultaneously held meeting of the ASTA Program Advisory Committee had greatly helped to formulate the science case for the Proposal for an **Accelerator R&D User Facility** at Fermilab's ASTA (see FERMILAB-TM-2568 at ***asta.fnal.gov***). The proposal has been co-authored by 97 people from 18 institutions, including 24 APS Fellows, 10 Accelerator Prize winners and over 25% young researchers representing large national and international laboratories, University groups, SBIR companies and detector R&D groups. It calls for modest support to complete the facility construction (more than 90% of the work is already done) and establishment of the nation-leading user facility for accelerator R&D towards future intensity and energy frontier machines and accelerator applications. It covers 31 individual beam study proposals and letters of intent—and that number is growing—which will take place at all three ASTA experimental areas: Exp.Area-1 with 50 MeV electrons (14 proposals), Exp.Area-2 with 300-800 MeV electrons (18) and Exp.Area-3 electron/proton IOTA storage ring (7). The proposal was reviewed by DOE OHEP in October 2013. The key elements of **the ASTA 2014 plan** include: a) gun commissioning with new klystron to get design energy high charge 4.9 MeV electron bunches from CsTe-coated cathode; b) beam commissioning of the CC2 and (later) CC1 and completion of the ASTA Injector to the 50 MeV beam absorber; c) the first round of beam experiments at 20 and then 50 MeV; d) full RF commissioning of the 1.3 GHz SRF cryomodule at the design gradient of 31.5 MV/m and pulse width/rate; e) construction of the cave extension for the high-energy portion of ASTA, f) the installation of the high-energy 300 MeV test beamline from the SRF CM to high power beam dump; g) continued design and construction of components of the IOTA ring.

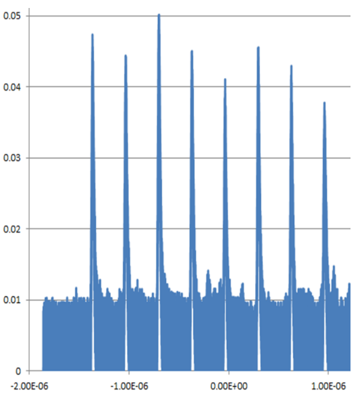


ASTA 3.5MeV electrons as seen at the "9-way cross" YAG screen

IOTA Parts Arriving from Collaborating Institutes

Many collaborating institutions are providing components for the construction of IOTA ring at ASTA. The transverse focusing in the machine will be done by some 40 conventional quadrupole lenses. JINR (Dubna, Russia) is sending 32 high-quality quadrupoles (in exchange for electron cooling components). BINP (Novosibirsk, Russia) is ready to deliver an RF cavity if we determine that it meets the project specifications. A very important component of the IOTA physics program – the nonlinear magnet, is under development at RadiaBeam Technologies, Inc. funded by a DOE SBIR Grant. The University of Maryland has expressed interest in developing a quadrupole pickup device for use at IOTA. Last, but not least, the entire ASTA high energy beam line and IOTA ring will be supported by 56 very nice stands (pictured) provided by MIT/Bates, which arrived at the facility in October.

First Beam at ASTA



First electrons as measured on a loss monitor at the "9-way cross" – 8 bunches (horizontal axis—time in seconds)

The afternoon of 20 June 2013 was significant for ASTA as for the first time electrons were produced by the photoelectron gun. This achievement capped off many months of work by the dedicated ASTA team. The electrons were produced using an 'uncoated' Molybdenum cathode, so the charge was much lower than design, as expected, yet gave the commissioners a chance to check out the "9-way cross" diagnostics and calibrate the low-energy instrumentation.

Subsequent study time allowed the nominal bunch charge to be calculated to be 0.5 picoCoulomb as measured independently by both the resistive wall monitor and Faraday cup. The output energy is of approximately 3 MeV at a gun gradient of 31.5 MV/m. This measurement also allowed verification of operation of corrector dipoles and the YAG screen and readout software at the "9-way cross". Improved measurements, of course, will result when the first CsTe-coated cathode is installed in the coming weeks.

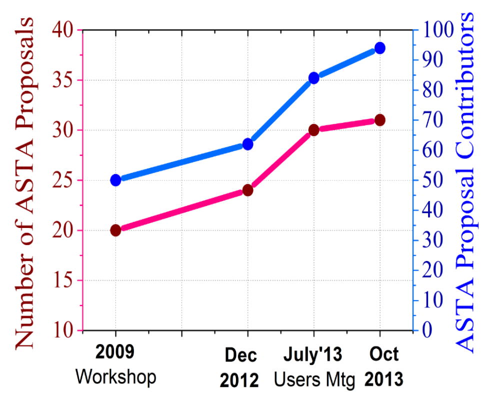
Since these initial steps were made, attention has turned to improve the quality of the laser light and increasing the gun performance. In the past week (early December 2013) a klystron capable of producing 5 MW at 1.3 GHz was installed to power the gun. By the end of 2013 it is expected that the gun RF output will reach its design power over a 1 millisecond pulse width at 5 Hz repetition rate. Work is also in progress to replace the existing multi-pass laser amplifier to achieve 'cleaner' pulses in time. CsTe-coated cathodes are in hand and will be installed once the 4.9 MeV gun conditioning is completed. Early 2014 is expected to be a busy time as ASTA's first electron *beam* will be characterized and accelerated to at least 20 MeV.

First ASTA User's and PAC Meeting

"ASTA can play a key role in some of the areas identified in the [Accelerator Stewardship] program, especially in discovery science"

Eric Colby (DOE/OHEP)

The first ASTA users meeting and meeting of the ASTA Program Advisory Committee took place at Fermilab on July 23-24, 2013. Eighty-four people attended the meeting, two-thirds of whom were from institutions outside of Fermilab. Thirty-six talks covered the status and plans of the facility and the total of 30 experimental proposals, including 6 new ones. Representatives of each proposal were given 15 to 30 minutes to present their ideas for experiments. Users also took a tour of the facility and attended an hour-long talk by Eric Colby (DOE). Valuable recommendations of the ASTA PAC (see page 4) helped to better formulate the case for the ASTA Users Facility proposal. See all the materials at ***asta.fnal.gov***



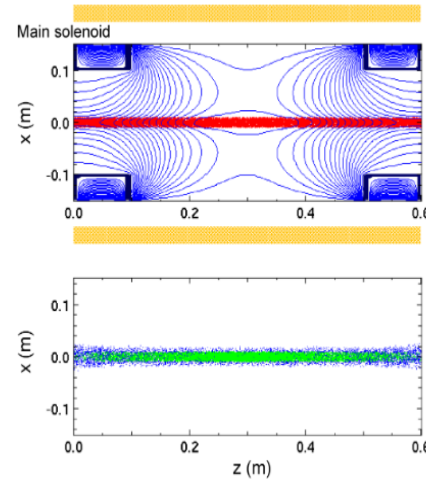
Auralee Morin of Colorado State University carries out her PhD thesis research at ASTA.

Studies on SCRF Controls at ASTA

The high precision in beam energy and phase required by many of the experiments proposed at ASTA translates to state of the art control requirements for the RF systems. Auralee Morin, a doctoral student from Colorado State University, is stepping up to the plate to tackle some of ASTA's engineering challenges. Auralee's focus of study with advisor Sandra Biedron, is applying neural network based techniques to accelerator control systems. Auralee has the distinction of being the first ASTA user and is well along on her first project, that of adaptive resonant frequency control of the copper electron gun RF cavity. During her several visits to Fermilab, working with Brian Chase and Pierpaolo Stablile from the Accelerator Division, she has developed a learning based gray box model of the surprisingly complex behavior of the gun cavity temperature regulation system. Auralee will return in January to install to test her controller in the accelerator. There are several other control systems challenges that Auralee plans to tackle during the coming year with neural network techniques, such as resonance control of the SRF cavities, beam-based calibration and global system startup.

ASTA Presentations at NA-PAC'13

ASTA was extensively featured at the 2013 North-American Accelerator Conference (NA-PAC'13), held in Pasadena, September 30 - October 5, 2013. Approximately twenty presentations reported on work related to ASTA. The presentations included one invited talk (*The Fermilab Advanced Superconducting Test Accelerator (ASTA) Facility* by P. Piot, NIU/FNAL) and three contributed talks describing the science opportunities at ASTA (*Space-charge Compensation for High-intensity Linear and Circular Accelerators at Fermilab*, M. Chung, FNAL; *Model Ring With Exactly Solvable Nonlinear Motion*, T. Zolkin, U. of Chicago; *Test of Optical Stochastic Cooling in the IOTA Ring*, V. Lebedev, FNAL) and selected anticipated experiments (e.g. optical stochastic cooling, space-charge compensation, dechirper using deflecting cavities, integrable optics in IOTA) and a report on the progresses toward commissioning of the ASTA superconducting linac (currently installed and being conditioned). The majority of the presentations were in poster format and covered descriptions of possible advanced-acceleration experiments (e.g., dielectric and crystal beam-driven accelerations), reports on beam dynamics studies (phase space exchange, integrable optics, wakefield in 3.9-GHz cavities) of the ASTA accelerator along with training and education opportunities enabled at ASTA. The reports were produced by a wide range of authors affiliated with national laboratories (e.g., Los Alamos, Fermilab, Oak Ridge, Novosibirsk), or Universities, or small-business companies (e.g., Radiabeam SBIR company report on non-linear insert magnet).



WARP 3D modeling of the plasma formation and trapping in e-column (from M. Chung, TUOBB1 talk at NA-PAC'13)

Technical Plans for FY14

Fiscal Year 2014 promises to be an exciting year for ASTA. Significant progress will be made in the **low-energy 50 MeV portion of the accelerator**, including the commissioning of the electron gun to full RF power of 5 MW and electron beam energy of 4.9 MeV, as well as the completion of the installation of the magnets, instrumentation, and vacuum system. Commissioning of the first electron beam through the injector is planned to occur in early 2014, initially at about 20 MeV and then later at 50 MeV, following the installation of the refurbished "Capture Cavity 1" (CC1) SRF accelerating cryomodule. The **first round of beam experiments** will take place with 20 and then 50 MeV electrons.

The **1.3 GHz SRF cryomodule** will be brought up into full operation at 31.5 MV/m—equivalent to 250 MeV total acceleration. The warm coupler conditioning of all cavities has been carried out this past fall and individual power tests and characterization of the eight cavities comprising the cryomodule has began in December 2013.

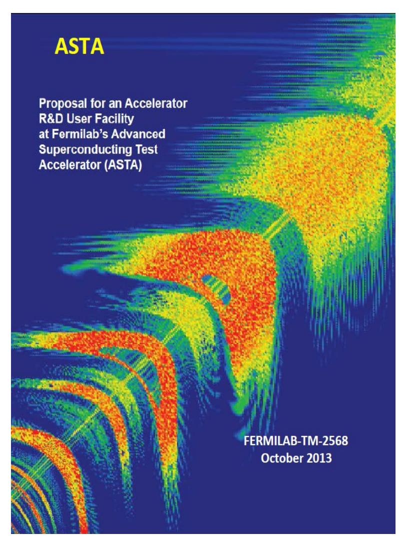
Construction of the shielding ("cave") extension for the high-energy portion of ASTA, as well as the installation of the necessary utilities will occur. The installation of the various magnets and vacuum systems for the high-energy **300-800 MeV test beamlines** of ASTA—from the SRF CM to the high power beam dump—as well as **the IOTA ring** are also planned to begin in the later part of FY14.

Fermilab Director Nigel Lockyer emphasized the important role of ASTA in the Laboratory's Strategic Plan at the DOE Review (October 23, 2013).

DOE Review of the ASTA Facility Proposal

A DOE comparative review of ASTA, ATF-II and FACET-II facility proposals took place in Germantown, MD on Oct 22-24, 2013. As part of the ASTA team presentation, Fermilab Director Nigel Lockyer emphasized the important role of ASTA in the Laboratory's Strategic Plan. Gerry Dugan shared with the review panel the ASTA PAC recommendations, impressions and overall enthusiastic support of the ASTA proposal. In the first day, 9 talks were given in 3 hours. At the end of the day the review panel came out with a list of 16 questions covering a broad range from relative priority of the proposal component to contingency estimate methodology. The answers were prepared overnight and delivered during a two-hour long Q&A session the next day by the team of Elvin Harms, Stuart Henderson, Jerry Leibfritz, Sergei Nagaitsev, Philippe Piot and Vladimir Shiltsev. Overall, the review went quite well. The panel recommendations and the outcome of the review are expected to be known in early 2014.

The ASTA Proposal document is available at ***asta.fnal.gov*** and as FERMILAB-TM-2568



Advanced Superconducting Test Accelerator

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The Advanced Superconducting Test Accelerator (ASTA) currently under construction and commissioning at Fermilab is proposed to enable a broad range of beam-based experiments to study fundamental limitations to beam intensity and to develop transformative approaches to particle-beam generation, acceleration and manipulation. ASTA incorporates a superconducting radiofrequency (SRF) linac coupled to a photoinjector and small-circumference storage ring capable of storing electrons or protons. ASTA will establish a unique resource for R&D towards Intensity and Energy Frontier facilities and a test-bed for SRF accelerators and high-brightness beam applications.

The unique features of ASTA include:

- *A high repetition-rate—up to 3 MHz in a macropulse, 5 times a second*
- *One of the highest peak and average brightness beams within the U.S.*
- *GeV-scale electron beam energy*
- *An extremely stable beam*
- *The availability of SRF and high-quality beams together*
- *Storage ring IOTA capable of supporting a broad range of ring-based advanced beam dynamics experiments*

ASTA is proposed to operate as a users facility and its three experimental areas will be available for research 9 months per year. The research program will be annually reviewed by the ASTA Program Advisory Committee, which provides recommendations to the ASTA Program Director.

Questions, inquiries? Please visit our Web site http://asta.fnal.gov or contact Dr. Vladimir D. Shiltsev—ASTA Director (Interim) at shiltsev@fnal.gov

ASTA Program Advisory Committee

The ASTA Program Advisory Committee comprises Michael Blaskiewicz (BNL), John Byrd (LBNL), Gerald Dugan (Chair, Cornell University), Georg Hoffstaetter (Cornell University) and Alexander Zholents (ANL). In addition, Richard York (MSU) and Marco Ventuirini (LBNL) took part in the 2013 ASTA PAC meeting.


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