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"Organization of the 16th Advanced Accelerator Concepts (AAC) Workshop by Stanford University"

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Executive Summary

Essentially all we know today and will learn in the future about the fundamental nature of matter is derived from probing it with directed beams of particles such as electrons, protons, neutrons, heavy ions, and photons. The resulting ability to "see" the building blocks of matter has had an immense impact on society and our standard of living. Over the last century, particle accelerators have changed the way we look at nature and the universe we live in and have become an integral part of the Nation's technical infrastructure. Today, particle accelerators are essential tools of modern science and technology.

The cost and capabilities of accelerators would be greatly enhanced by breakthroughs in acceleration methods and technology. For the last 32 years, the Advanced Accelerator Concepts (AAC) Workshop has acted as the focal point for discussion and development of the most promising acceleration physics and technology. It is a particularly effective forum where the discussion is leveraged and promoted by the unique and demanding feature of the AAC Workshop: the working group structure, in which participants are asked to consider their contributions in terms of even larger problems to be solved.

The 16th Advanced Accelerator Concepts (AAC2014) Workshop was organized by Stanford University from July 13 - 18, 2014 at the Dolce Hays Mansion in San Jose, California. The conference had a record 282 attendees including 62 students. Attendees came from 11 countries representing 66 different institutions. The workshop format consisted of plenary sessions in the morning with topical leaders from around the world presenting the latest breakthroughs to the entire workshop. In the late morning and afternoons attendees broke out into eight different working groups for more detailed presentations and discussions that were summarized on the final day of the workshop. In addition, there were student tutorial presentations on two afternoons to provide in depth education and training for the next generation of accelerator scientists. This is the final technical report on the organization and outcome of AAC2014.

Summary of Major Results

Advanced Accelerator R&D covers long term research and development in accelerator physics. It includes R&D of new concepts, devices and technologies in accelerator and beam physics. Since 1982, the community doing research in these long-term Accelerator and Beam Physics R&D topics has met biennially at Advanced Accelerator Concepts (AAC) Workshops to exchange ideas, promote research in this field and provide a forum for dissemination of new ideas.

The Advanced Accelerator Concepts (AAC) Workshop is the only acknowledged and fully sponsored forum that provides a platform for interdisciplinary discussions on advanced accelerator and beam physics/technology concepts covering a wide range of applications. The 16th Advanced Accelerator Concepts (AAC) Workshop was organized by Stanford University from July 13-18, 2014. The meeting was devoted to cross-disciplinary discussion of advanced accelerator concepts, including new methods of particle acceleration and high energy photon generation, techniques for production of ultra-high accelerating gradients, diagnostics and control of particle and photon beams and various associated energy, particle beam and RF sources.

1. Organization

The AAC Core Committee consists of several previous AAC Chairs, the current AAC chair (selected at the previous AAC) and a DOE representative. The Organizing Committee consisted of the core committee plus representatives chosen to ensure a wide spectrum of expertise in the fields that are the focus of the Workshop. The OC for AAC2014 included wide representation from U.S. Universities and National Laboratories, and one representative each from Europe and Asia. The membership of the OC was finalized in a series of conference calls in November and December 2013.

The local organizing committee consisted of Zhirong Huang and Michelle Young from Stanford University Pulse Institute, Mark Hogan and Vitaly Yakimenko from SLAC National Accelerator Laboratory, and Brigid Neff (Meeting Planner) and Dan Harris (Web Site Developer) from Stanford Conference Services. This committee determined all aspects of the workshop save the technical program. The workshop organizers utilized the Stanford Conference Services and Stanford Meeting Planning Services agencies to ensure a smooth and professionally executed conference. These agencies specialize in Financial Management, Logistics and Program Support.

2. Working Group Structure

The Working Groups (WGs) form the basic structure of the AAC Workshop. Each WG had a Leader and Co-Leader who managed WG sessions during the Workshop. The OC selected WG Leaders and Co-Leaders for AAC 2014 in a series of conference calls in February 2014. WG Leaders (and Co-Leaders) together with the OC comprised the AAC 2014 Workshop Program Committee. The Program Committee guided the scientific program of the workshop, including selection of Plenary Talks and the agendas of individual WGs. The WG leaders selected talks from submitted abstracts for oral presentations in their WGs and solicited invited oral presentations in their WGs that contribute to the mission of the WG. The WG leaders orally summarized the deliberations of their respective WG on the last day of the workshop, and submitted a written summary to the Workshop Proceedings.

The AAC2014 working groups, working group leaders and the opening charge of each working group is given below.

WG1: Laser-Plasma Wakefield Acceleration

Working Group Leaders: Eric Esarey, LBNL, Xiaoming Wang, U. Texas

Working Group 1 (WG1) will primarily focus on the acceleration of electrons and positrons using laser-plasma accelerators (LPAs). WG1 will also address basic laser-plasma physics, novel radiation sources as a tool to diagnose the LPA, and challenges that need to be overcome for application of LPAs to high-energy physics and compact light sources.

Electron beams accelerated in the few GeV energy range have been demonstrated in a single stage laser-plasma accelerator. Control over particle injection for improved beam quality and stability is progressing using a variety of methods. Further improvements in beam quality and stability are desirable for applications. Also, improved efficiency and a path to higher energy are required for HEP applications, whereas improved emittance and energy spread are required for compact light source applications. WG1 will be organized about the following sub-topics and questions:

1. How can particle injection into the laser-driven plasma wakefield be controlled for stable, reproducible, high-quality beams?

2. Staging laser-plasma accelerators is required to reach high beam energy for HEP applications. How can staging best be achieved while preserving beam properties?
3. How can the efficiency of energy transfer from the laser to the beam be improved and/or optimized? (Note: Keep these general – no need to mention power and/or density regimes.)
4. Laser guiding is required to extend the laser-plasma interaction length. What methods are available for creation of pre-formed plasma channels and plasma structures? What are the accuracy requirements in the profile and density uniformity? What challenges must be overcome when considering the high repetition rates and durability necessary for light source and HEP applications?
5. How to optimise laser-plasma interactions to generate brighter radiation for user applications? How can the properties of laser-plasma accelerated electron beams be best exploited for radiation generation? How to best exploit the properties of this radiation to deduced properties of the plasma accelerating structure and of the electron beam?
6. How to develop additional diagnostic techniques to better understand the electron beam properties and the laser-plasma interaction?

Contributors are encouraged to address these topics. We will arrange working group discussions around these topics, and joint sessions with other working groups will be arranged based on contributions.

WG2: Computations for Accelerator

Working Group Leaders: Jean-Luc Vay, LBNL, Alex Arefiev, U. Texas

The quest for advanced accelerator concepts is bounded by technology limitations, cost of experiments, and by the limits of the breadth and speed of computations. Numerical modeling complements and guides the design and analysis of advanced accelerators, and can reduce development costs significantly. In a time of intensifying funding constraints in particular, there is an increasing interest for modeling tools that are (or will be) capable of virtual prototyping and ultimately virtual experimentation. This calls for the development of a novel generation of efficient modeling tools that handle self-consistent modeling of comprehensive set of multi-physics phenomena in complicated geometries.

The computational working group will review recent progress and determine future needs in the science (algorithms and numerical analysis) and technology (codes and hardware) of computer modeling of advanced accelerators. The participants are strongly encouraged to use this as an opportunity to highlight open issues and technical challenges that are critical for computer modeling of advanced accelerators. One of the goals of this working group is to serve as a forum for discussing those topics and findings that are typically left out during conference presentations, but are crucial for obtaining correct physics results.

The presentations and discussions will focus on methods that push the state-of-the-art in accelerator computer modeling through increased accuracy, speed of execution, breadth of physical models, validation, versatility of application or usability of computer codes. Topics include: novel algorithms, reduced models, more efficient implementation (single core optimization, parallelization, etc), next generation hardware (CPU, GPU, manycore), extension and integration of physical models and numerical tools, evaluation and numerical analysis of algorithms performance and stability, validation and verification. Needs in additional physics and code development toward improved modeling of the various applications, and toward tools capable of virtual prototyping and experimentations when applicable, will also be discussed.

WG3: Laser and High-Gradient Structure-Based Acceleration

Working Group Leaders: Gil Travish, UCLA, John Power, ANL

WG3 is doubly challenged with understanding the state of, and pushing the limits in, both high-gradient RF and laser powered structures. While these two sub-disciplines are technologically distinct and demand different approaches, they share a number of challenges. During past AAC workshops, a number of experimental hurdles including breakdown, pulsed heating, materials & surface treatments, etc. were considered towards the general goal of increasing accelerating gradients, and indeed are still relevant. Both areas have made considerable progress since AAC2012 and still face new and old challenges. Our working group will serve to update the community on progress and challenges in these and new areas. In addition, the working group discussions will explore opportunities for novel collaborations that can allow for further progress in the field of structures. As part of this effort we will gather input from the community on tangible benefits these structures can offer, what we need to deliver, what breakthroughs are required, and what are the strengths of the various approaches. Come join us for lively working group discussions on the progress and challenges in the field of advanced accelerating structures, on gathering community wide milestones, and considering new joint programs!

WG 4: Beam-Driven Acceleration

Working Group Leaders: Sergey P. Antipov, Euclid/ANL, Sebastian Corde, SLAC

Short, high current electron beams are capable of driving high gradient wakes in plasmas and slow-wave structures. Accelerating gradient in beam-driven plasma accelerators of more than 50 GV/m have been demonstrated experimentally. In a recent experiment at FACET, a discrete trailing bunch, following a drive beam by about hundred microns, had been accelerated in a plasma with high energy transfer efficiency from the wake to the trailing bunch. Other experiments on beam-driven plasma accelerators are underway or in preparation at CERN, DESY, BNL, and elsewhere. Structure based wakefield acceleration is being experimentally studied at facilities like AWA (ANL), ATF (BNL), FACET (SLAC) and others over a wide range of frequencies from GHz to THz. We will examine the latest results in theory, simulations and experiments. The main discussion topics in this group will be around linear collider designs, with emphasis on emittance preservation and staging, efficiency, transformer ratio, luminosity and beam delivery system.

WG5: Beam Sources, Radiation Generation, Monitoring, and Control

Working Group Leader: John Byrd, LBNL, Co-leader Felicie Albert, LLNL

WG 5 will address the four subjects in its title:

1. Beam sources: Advanced accelerators (AA) and beam sources require and/or generate beams with unique characteristics including femtosecond bunch lengths, high peak currents, correlated and uncorrelated energy spreads, and position, pointing, and timing stability. This group will examine the pros and cons of these requirements and beam properties with respect to conventional accelerators and sources. What are the fundamental limits on the performance of the advanced sources in brightness and stability

(shot-to-shot reproducibility)? The requirements for synchronization of multiple AAs are severe. Do some AA techniques have advantages in synchronization?

2. Diagnostics: AAs carry a much larger burden in terms of diagnostics than conventional accelerators. The properties of AA beams must be measured plus the behavior of the accelerator structure plus the source driver. The ultimate goal is the single shot 6-d characterization of the particle beam phase space. How far are we from this? Are there challenges in measuring the beam position and pointing stability? How does the plasma vary from pulse-to-pulse? Is this correlated with electron and drive properties?

3. Beam control and manipulation: AAs are notorious for fluctuation in beam parameters such as energy, charge, pointing stability, etc. The capabilities of diagnostics to measure the beam properties have advanced tremendously over the past decade. Is it possible to feedback beam or accelerator structure measurements to improve beam quality and stability? Several accelerator concepts also produce large correlated energy spreads from effects such as beam loading. This presents a number of challenges for transporting the beam through magnetic optics but also several opportunities for manipulation of the bunch shape.

4. Radiation Generation: Electromagnetic radiation from beams can be used for diagnostics and as a source, especially when the radiation is in an energy range which is either not accessible with conventional sources or because it is inherently synchronized with an external laser. In addition, the unique properties of the beam such a femtosecond pulse length can have an advantage over conventional sources. Furthermore, there are opportunities to use the beam itself as a radiation source. We will also discus radiation generation from plasma-based accelerators during joint sessions with WG1 and WG2 (laser and beam driven wakefield acceleration). We will have opportunities to discuss radiation from electron beams wiggled by external magnetic structures, radiation from electron beams wiggled by the plasma (betatron radiation) and also radiation from electron beams wiggled by the laser (Compton and Thomson scattering). Future applications of these sources as well as their use as a diagnostic tool for plasma-based accelerators will be considered.

We will accept contributed papers, both theoretical and experimental, in the above areas as well as other related topics. We invite the speakers to take advantage of the new poster section to leave more space for discussion in the working group and make an effort to try to answer the questions posed in these general themes and identify the challenges that need to be addressed to further advance the field. Results of this assessment will be presented during the close out session of the workshop and in the written working group summary. Joint sections with other WGs on the topic of beam generation, diagnostics and radiation generation will be scheduled.

WG 6: Laser-Plasma Acceleration of Ions (Morgan Hill Room)

Working Group Leaders: Juan Fernandez, LANL, Zulfikar Najmudin, Imperial College U.K., Frederico Fiuza, LLNL

The study of the generation of high charge bunches of energetic ions of megavolt energies from intense laser-matter interactions continues to be an area of intense activity. The initial discovery of multi-MeV per nucleon ions produced when high intensity chirped-pulse amplified lasers are incident on solid targets has now lead to research in several new directions. In particular the use of novel shaped, ultra thin and low density targets have multiplied. These target manipulations allow access to enhanced efficiency into the ion beam through access to novel acceleration mechanisms such as radiation pressure, shock and hole-boring, and relativistic-transparency acceleration. Meanwhile, beamlines based on the tried-and-tested sheath acceleration approach are now being set-up and applications, particularly those in biomedicine, are being actively pursued.

In this working group, we highlight current advances in high intensity laser generation of energetic ions, focusing on reduced energy spread and higher efficiency at high energy, as well as prototype applications based on these beams. The group will also highlight high-performance computing that needs to be applied to the non-trivial simulation of high plasma densities at relativistic laser intensities. Based on presentations and working group discussions, we aim to identify promising paths for further progress in these areas.

WG7: Muon Colliders and Advanced Concepts

Working Group Leaders: Jean-PIerre Delahaye, SLAC, Sasha Valishev, FNAL

The subject matter of this WG has evolved over the years. With Muon Collider, a very attractive option to extend lepton colliders in the multi-TeV energy range, WG7 will address the major challenges facing the muon collider community, such as muon production, emittance reduction via cooling, high-gradient acceleration and will explore novel alternative methods. Another focus area of WG7 will be on advanced beam dynamics aspects in Intensity Frontier machines, with particular emphasis on the space charge effect, beam halo control and mitigation. Among other advanced concepts, new particle production, storage and acceleration techniques that lie outside the purview of the other WGs, will be explored.

WG 8: Laser Technology for Laser-Plasma Accelerators

Working Group Leaders: Bill White, SLAC, Marcus Babzien, BNL

This WG will bring together researchers from academia and national laboratories and representatives of commercial vendors of high average- and peak-power laser systems to explore needs and possibilities for the next generation of laser-plasma acceleration research. The goal of the WG is to address the following questions:

1) Which applications are approaching a feasibility demonstration that satisfies the desired parameters? How do these applications drive the laser technology? Beyond pure accelerating gradient, which key parameters remain to be demonstrated to achieve a successful demonstration?

2) Are there conclusions to be reached on the optimal media (gas jet, foil, discharge, ablation) for plasma sources in particular applications that would help to focus ongoing research?

3) Where shall the emphasis on laser development go from here to solve some of the key issues for implementation of a LWA-based accelerator/source - peak power, average power/repetition rate, beam quality, contrast, stability.

3. Workshop Venue & Schedule

Meeting Space and Housing arrangements for up to 250 participants were contracted with the award-winning Dolce Hayes Mansion, located just 15 minutes from San Jose International Airport in the heart of the Silicon Valley. Recognized for excellent service, ambiance, amenities and technology features, the mansion has received many industry awards from leading magazines and organizations. A block of rooms at a special conference rate equivalent to the Federal Per Diem lodging rate ($144/night) was reserved for this purpose.

The plenary sessions were held in the Hayes Ballroom and breakout rooms for individual working groups rooms with varying capacities were reserved for the entire week. Additional rooms were allocated for the workshop office and computer room. The schedule for AAC2014 is shown below.

The 16th Advanced Accelerator Concepts Workshop (AAC 2014)
Dolce Hayes Mansion, San Jose, California

Time	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday
7:00 AM		Breakfast and Registration				
7:30 AM						
8:00 AM		Opening Remarks				
8:15 AM			Announcements	Announcements	Announcements	Plenary 7
8:30 AM		Plenary 1	Plenary 4	Plenary 5	Plenary 6	
9:00 AM						
9:30 AM						
10:00 AM		Refreshment Break	Refreshment Break	Refreshment Break	Refreshment Break	Refreshment Break
10:30 AM		Plenary 2	Working Groups 2	Working Groups 5	Working Groups 8	WG Summaries
11:00 AM						
11:30 AM						
12:00 PM		Lunch	Lunch	Lunch	Lunch	Lunch
12:30 PM					SLAC Tour Shuttle Pick Up (Main Entrance)	
1:00 PM						
1:30 PM		Plenary 3	Working Groups 3	Working Groups 6	Free Afternoon / SLAC Tour	WG Summaries
2:00 PM						
2:30 PM						
3:00 PM		Refreshment Break	Refreshment Break	Refreshment Break		Refreshment Break
3:30 PM		Working Groups 1 and Student Tutorials	Working Groups 4 and Student Tutorials	Working Groups 7		WG Summaries and Closing
4:00 PM						
4:30 PM						
5:00 PM		Reception (5:00 - 6:30pm)			SLAC Tour Shuttle Drop Off	
5:30 PM	Registration and Welcome Reception		Poster Session Reception			
6:00 PM		Program Committee Dinner		Banquet Shuttle Pick Up (Main Entrance)		
6:30 PM				AAC Banquet Dinner at the Computer History Museum		
7:00 PM						
7:30 PM						
8:00 PM						
8:30 PM						
9:00 PM						
9:30 PM				Shuttle Departures from Banquet		

Detailed content of plenary and working group presentations is given on the AAC2014 workshop web site.

4. Website

The AAC2014 workshop website is: https://aac2014.stanford.edu

The website was launched in 2014 and contains extensive information about the workshop. It will remain online indefinitely as a resource to the advanced accelerator community, future workshop organizers and the general public. It contains detailed information about the agendas for both plenary sessions and working groups, links to plenary presentations, participant list, and links to the previous AAC workshop websites.

5. AAC Prize

Since 2008, each AAC has awarded 'The AAC Prize' to individuals for outstanding contributions to the science and technology of advanced accelerator concepts. The AAC Prize Committee announced that prize nominations were open, collected the nomination packages, and determined the 2014 awardee: Phil Sprangle. The AAC Prize Committee was composed of the following members: I. Ben-Zvi, BNL (chair), C. Joshi (UCLA), J. Cary (Tech-X), D. Sutter (UMd), Bob Palmer (BNL), and W. Leemans (LBNL).

6. Proceedings

Submissions to the conference proceedings have been collected and edited. The proceedings will be published online in 2016 through the American Institute of Physics and will be made available in perpetuity to all interested users at no additional charge and with no credentials required. There will be no printed proceedings to due to insufficient demand. A link to the proceedings will be added to the AAC2014 website when the proceedings come online and the link is available.