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ALEGRO, THE ADVANCED LINEAR COLLIDER STUDY GROUP

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Abstract

We briefly describe activities of ALEGRO, the Advanced LinEar collider study GROup.

INTRODUCTION

The ICFA-ANA panel [1] has started the organization of a series of workshops in order to bring together the novel and advanced accelerator (ANA) community behind a common project with application to a future high-energy collider. Advanced and novel accelerators provide alternatives to the metallic radio-frequency cavities of conventional accelerators with dielectric or plasma media. Instead of the microwave power source, either an intense laser pulse or a relativistic particle bunch is used as power source. Combining these two advanced power sources with the two novel media leads to four accelerator schemes: the dielectric laser accelerator (laser pulse in dielectric structure, DLA), the structure wakefield accelerator (particle bunch in dielectric tube, SWFA), the laser wakefield accelerator (laser pulse in plasma, LWFA) and the plasma wakefield accelerator (particle bunch in plasma, PWFA).

The common prospect of the ANAs is to accelerate particles with an average gradient of 1 GeV/m. A higher accelerating gradient leads to shorter accelerators that could also potentially be cheaper than conventional ones. A higher accelerating gradient may open the way to energies not reachable with conventional machines.

ADVANCED AND NOVEL ACCELERATORS

All ANAs have demonstrated peak accelerating gradient of ~1 GeV/m or more. Large energy gains have been obtained with the LWFA (4.2 GeV/m in 9 cm [2] and the PWFA (42 GeV/m in 85 cm) [3]. However, producing particle beams with quality comparable to that produced by conventional accelerators remains a challenge. The four ANAs have their own advantages and challenges and may become relevant for a collider over different time scales. Straw-man designs for a e^-/e^+ colliders based on ANAs exist. However, these designs need to go through the same improvement and scrutiny processes that designs for conventional colliders such as the international collider (ILC) of the compact linear collider (CLIC) went through. In particular, R&D topics need to be identified and prioritized in order to determine the feasibility of an ANA-based collider and to make rapid progress towards a conceptual design report.

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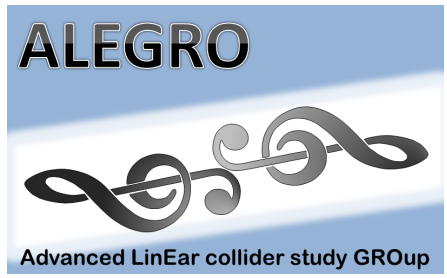

Figure 1: The ALEGRO logo.

ANAR WORKSHOP AND ALEGRO

The first workshop, the Advanced and Novel Accelerator for high energy physics Roadmap (ANAR) workshop was organized at CERN in March 2017 [4] and was focused around four ANA working groups. It gathered more than eighty scientists. It identified the main scientific challenges for ANAs and determined a very first list of priorities for R&D. It also took stock of the existing roadmaps, in particular those drawn for ANAs in the US, and drew a first worldwide roadmap. The work of the ANAR2017 workshop is summarized in a published report [5].

During this workshop, the 2018-2020 European Particle Physics Update was identified as a major step for ANAs to be considered as acceleration schemes worthy of further development towards application for high-energy physics. A new study group named ALEGRO for Advanced LinEar collider study GROup was proposed and formed.

ALEGRO's general charge is to coordinate the preparation of a proposal for an advanced linear collider in the multi-TeV energy range. ALEGRO consists of (30) scientists with expertise in advanced accelerators concepts, accelerator physics and technology, detectors and particle physics drawn from national institutions or universities in Europe, America and Asia.

FIRST ALEGRO WORKSHOP

The first ALEGRO workshop was organized in March 2018 at the John Adams Institute [6]. This time, work was distributed to eight working groups addressing global issues related to a collider project: the physics, the collider machine design, the theory and simulations of ANAs, the LWFA, the PWFA, the SWFA, the DLA and a joint sub-working group on positrons acceleration.

Goals of the workshop included determining the readiness of the community to propose a machine project and the drafting of a structure for an ALEGRO input document for the European Particle Physics Strategy Update. A first version of the document will be prepared and discussed in a one-day ALEGRO meeting organized on August 12th, the

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day before the start of the 2019 advanced accelerator concepts (ACC'18) workshop in August in Breckenridge, CO. This workshop is one of the two major ANA conferences, organized every other year, in alternance with the European version, the European advanced accelerator concepts (EAAC) workshop.

ALEGRO is considering long term and ambitious goals for the field, with discussions of an e^-/e^+ collider with 30 TeV CM collision energy and luminosity in the $10^{36}\,cm^{-2}s^{-1}$ for studying Higgs coupling to the top quark, Higgs self-coupling and for precision measurements. While these long term goals provide a general frame, shorter term goals have also been identified and several demonstrations will have to be achieved step by step, for example to validate the reliability of ANAs and demonstrate their capability to achieve higher average power in the accelerated beam.

There is an increasing interest for SWFA structures consisting of simple dielectric tubes to replace the RF structures in a CLIC-like design. This could lead to an increase in accelerating gradient by a factor of two and has the advantage of re-using the well-developed CLIC scheme. Dielectric structures could replace all RF structures from the start or be integrated in a later upgrade towards higher energies. However, systematic breakdown rate measurements, as well as thorough understanding of limitations from transverse wakefields are necessary for further consideration.

Acceleration of positrons was identified as one of the major challenges for plasma-based acceleration schemes (LWFA and PWFA). It was recognized that there are very few facilities (SLAC FACET II) where positron beams suitable for PWFA experiments will be available. There is therefore a need for positron sources producing high energy, high charge and low emittance positron beams, either for LWFA or PWFA studies. The option of a γ/γ collider, avoiding the need for acceleration of positrons was also mentioned. The relevance of a e^-/e^+ or of a γ/γ collider needs to be discussed in the context of the physics case.

A PWFA scheme could be used for producing electrons for an e^-/p collider [7] or even for what is referred to as beam dump experiments (collision of electrons with a solid target). This option, with application to QCD, is developed in the context of AWAKE at CERN [8].

The ongoing Horizon 2020 design study for a 5 GV plasma-based accelerator with industrial quality and dedicated user areas, including driving a free electron laser, named EuPRAXIA [9], will deliver its report in 2019. Beyond reaching the beam energy over a short distance, the study aims at designing a plasma accelerator (LWFA or PWFA) producing a beam quality comparable to or better than that conventional accelerators with the same stability and reliability. Reaching such goals would be a crucial milestone for plasma-based particle accelerators.

SECOND ALEGRO WORKSHOP

A second ALEGRO workshop will be organized in late March 2019 at CERN to continue the effort. Working groups will be organized according to colliders systems: the physics case, the acceleration (plasma,dielectrics), the power sources (drive beam, laser, etc), the luminosity delivery (beam sources, beam cooling, tolerances, stabilization, focusing) and the detector (machine detector interface). Other workshops will follow.

CONCLUSION

ALEGRO, the Advanced LinEar collider study GROup was recently formed to gather the advanced and novel accelerator community behind a common linear collider project. ALEGRO organizes workshops providing opportunities for the community to get organized and progress in the definition of the project. The first goal for ALEGRO is a document as an input for the European Particle Physics Strategy Update. However, ALEGRO will continue activities, including participants worldwide to develop ambitious new collider concepts.

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