ALEGRO LOI for Snowmass2021

Towards an Advanced Linear International Collider

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Endorsed by the Advanced and Novel Accelerator panel of ICFA https://icfa.fnal.gov/

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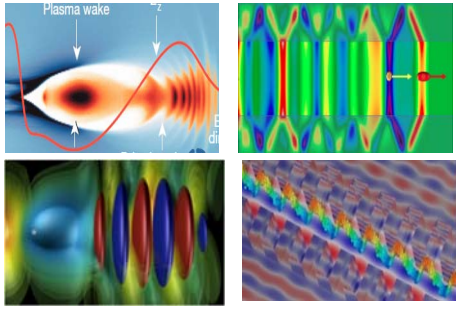
On **behalf of ALEGRO collaboration**
member list at http://www.lpgp.u-psud.fr/icfaana/alegro/alegro-members

Advanced LinEar collider study GROup missions

- To foster and trigger Advanced Linear Collider related activities based on Advanced and Novel Acceleration (ANA) concepts
- Provide a framework to amplify international coordination, broaden the community, involving accelerator labs/institutes
- Identify topics of ANAs requiring intensive R&D and facilities needed



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Towards an Advanced Linear International Collider (ALIC)

Long-term goal :the design of an e^+/e^-/gamma collider with center-of-mass energy in the multi-TeV range setting the baseline for a technology path supporting up to 30 TeV- **the Advanced Linear International Collider (ALIC)**.

Mid-term goal: 5-10 years construction and operation of dedicated ANA facilities that can reliably deliver high-quality, multi-GeV electron beams from a small number of staged accelerating modules.

On the path to this collider, a **number of milestones** have to be established. These will lead to **spin-offs at lower energy** that will benefit ultra-fast X-ray science, medicine, and industrial applications.

Key items to be addressed at running or upcoming facilities

Objective: demonstrate what could be the first stage of ALIC, injector + accelerator module for beams in the 5-25 GeV range

External injection of a high-quality electron bunch in an accelerator section.
Bunch quality, efficiency, stability and reproducibility equivalent to those produced by conventional accelerators.
Plasma sources with sufficient control and reproducibility of the density,
Driver development for operation at high repetition rate (LWFA) and the availability of independently shaped drive- and main-beams at PWFA and SWFA facilities

Facility	Readiness	ANA	Specific Goals
BELLA	Operating	LWFA	**e^-, 10 GeV, multi-GeV staging**
kBELLA	Design study	LWFA	**e^-, 1 GeV, kHz rep rate, 1 kW avg. power**
KALDERA	Start 2025	LWFA	**e^-, 1 GeV, kHz rep rate, 1 kW avg. power**
EuPRAXIA	Design study	LWFA, PWFA	**e^-, 5 GeV, reliability**
AWAKE	Operating	PWFA p-driven	**e^-, beam quality, multi-GeV, HEP fixed target exp.**
FACET II	Start 2020	PWFA	**e^-, 10 GeV boost, beam quality, e^+ acceleration**
FLASHForward	Operating	PWFA	**e^-, 1.5 GeV, beam quality, high rep rate, 10 kW avg. power**
AWA	**Operating**	**SWFA**	**e^-, sub-GeV, high charge, beam shaping, TBA and CWA**

Specific resources are needed to address collider design

- **Multi-stage challenges with high-energy beams** also need to be addressed. It is thus clear that **in the longer term, a facility to test staging with collider-like quality beams is necessary.**

- These ambitious projects require **strong scientific and financial support** to make suitable progress towards ALIC.

  - **Encouraging feedback from ESPP** update process: follow-up actions are under discussion

  - A ressource loaded **design study for a plasma collider** performed by an international collaboration would certainly drive the field significantly forward

Additional slides

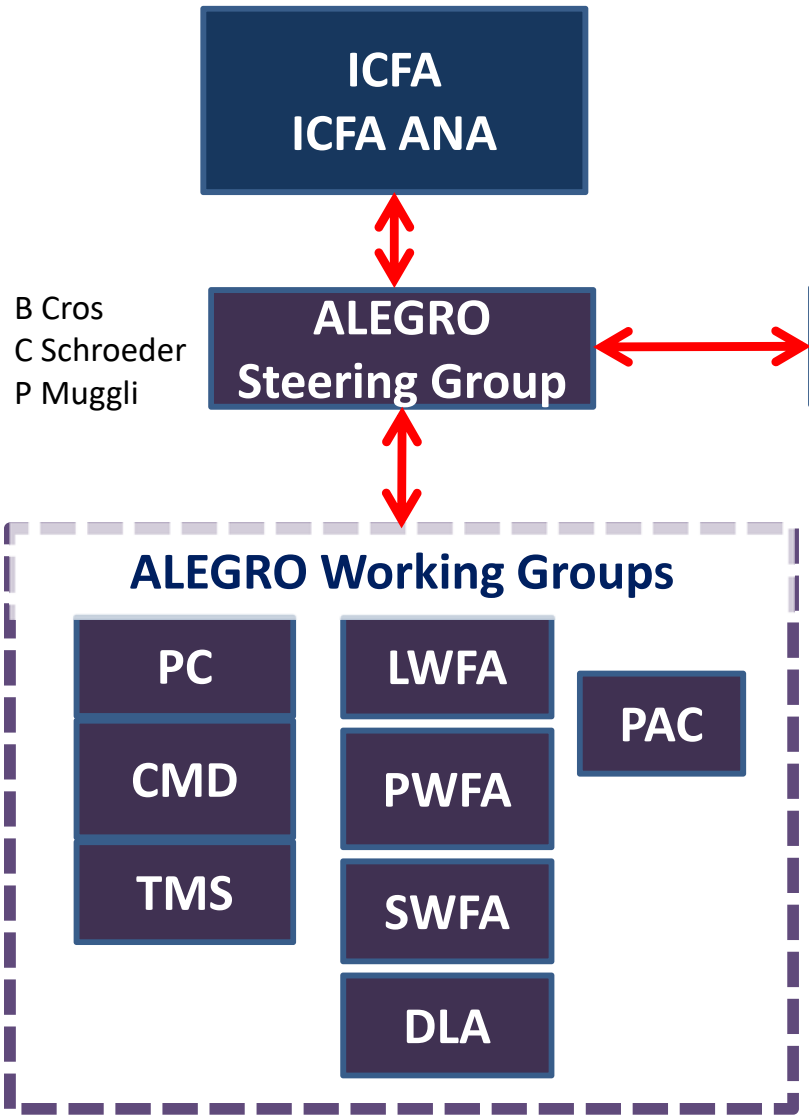
From the **Update of the European Strategy for Particle Physics,** June 2020

3. High-priority future initiatives

b) Innovative accelerator technology underpins the physics reach of high-energy and high-intensity colliders. It is also a powerful driver for many accelerator-based fields of science and industry. The technologies under consideration include high-field magnets, high-temperature superconductors, plasma wakefield acceleration and other high-gradient accelerating structures, bright muon beams, energy recovery linacs. *The European particle physics community must intensify accelerator R&D and sustain it with adequate resources. A roadmap should prioritise the technology, taking into account synergies with international partners and other communities such as photon and neutron sources, fusion energy and industry. Deliverables for this decade should be defined in a timely fashion and coordinated among CERN and national laboratories and institutes.*

https://europeanstrategyupdate.web.cern.ch/

Advanced LinEar collider study GROup: organisation



Opened to contributions from interested scientists worldwide

ALEGRO WG titles and leaders:

PC: Physics Case (M Peskin, J Tian)

CMD: Collider Machine Design (A Seryi, D Schulte, H Yamamoto)

TMS:Theory, Modelling, Simulations (JL Vay, J. Vieira)

LWFA: Laser wakefield Accelerators (C. Schroeder, S. Hooker, B. Cros)

PWFA: Plasma wakefield Accelerators (J Osterhoff, E Gschwendter, P Muggli)

PAC: Positron acceleration (S. Gessner, S. Corde)

SWFA: Structure wakefield accelerator (P Piot, J Power)

DLA: Dielectric laser accelerator (J England, B Cowan)

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Summary of ALEGRO intput for European Strategy Update

ALEGRO input for the 2020 update of the European Strategy for Particle Physics: comprehensive overview

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Advanced and Novel Accelerators (ANAs) can provide acceleration gradients orders of magnitude greater than conventional accelerator technologies, and hence they have the potential to provide a new generation of more compact, high-energy machines. Four technologies are of particular interest, all of which rely on the generation of a wakefield which contains intense electric fields suitable for particle acceleration. In the laser wakefield accelerator (LWFA) and plasma wakefield accelerator (PWFA) the wakefields are driven in a plasma by intense laser or particle beams, respectively; in the structure wakefield accelerator (SWFA), the wake is excited by a particle bunch propagating through a structured tube; and in the dielectric laser accelerator (DLA), a laser pulse directly drives an accelerating mode in a dielectric structure.

In view of the great promise of ANAs, and the substantial effort worldwide to develop them, the Advanced LinEar collider study GROup, ALEGRO, was formed at the initiative of the ICFA ANA panel. ALEGRO aims to foster studies on accelerators based on ANAs for applications to high-energy physics, with the ambition of proposing a machine that would address the future goals of particle physics. This document summarizes the current view of the international community on this topic. It proposes a list of priorities that the community would like to invest effort in over the next five to ten years.

We propose as a long-term goal the design of an e^+/e^-/gamma collider with up to 30 TeV in the center of mass - the Advanced Linear International Collider (ALIC). On the path to this collider, a number of stepping stones have to be established. These will lead to spin-offs at lower energy that will benefit ultrafast X-ray science, medicine, and industrial applications. **The major goal for our community over the next five to ten years is the construction of dedicated ANA facilities that can reliably deliver high-quality, multi-GeV electron beams from a small number of stages.** The successful demonstration of robust stages of this type would provide a platform for ANAs with large number of stages generating high-quality beams in the TeV range.

The document also discusses other challenges that must be met for the complete ALIC concept. These include the design of appropriate particle sources, the development of high-power lasers needed for LWFAs and DLAs, the achievement of required tolerances, and the need for additional tools such as the development of novel diagnostics for the ultra-fast bunches generated by ANAs, and fast simulation methods.

❖ 10 pages overview

❖ Large community, international effort

ALEGRO input for the 2020 update of the European Strategy for Particle Physics: ADDENDUM

ALEGRO collaboration

Abstract
This document provides additional information to support the ALEGRO proposal for R&D relevant to an Advanced Linear International Collider, ALIC, based on high gradient acceleration concepts.

Keywords
Advanced and Novel Accelerators, multi-TeV electron- positron linear collider

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❖ 80 pages addendum

http://www.lpgp.u-psud.fr/icfaana/alegro/documents

ALEGRO proposal

Advanced and Novel Accelerators (ANAs) can provide acceleration gradients orders of magnitude greater than conventional accelerator technologies…
Four technologies (DLA, SWFA, LWFA, PWFA) are of particular interest, all of which rely on the generation of a wakefield …

ALEGRO proposes as a long-term goal the design of an e^+/e^-/gamma collider with up to 30 TeV in the center of mass - **the Advanced Linear International Collider (ALIC).**

The major goal for our community over the next five to ten years is the construction of dedicated ANA facilities that can reliably deliver high-quality, multi-GeV electron beams from a small number of stages.

Challenges: design of appropriate particle sources; development of high-power lasers needed for LWFAs and DLAs; achievement of required tolerances; development of novel diagnostics for the ultra-fast bunches generated by ANAs; and fast simulation
methods.

From ALEGRO ESPP submission

8 What is needed? What do we support?

The results of ANAs R&D depend on the **availability of suitable laser and particle beams.** Large investment in feedback and control systems are necessary.

A number of key topics related to what could be the first stage of ALIC, consisting of an injector plus accelerator module, and producing beams in the 5-25 GeV range, are planned to be addressed:

- ✧External injection
- ✧Bunch quality, efficiency, stability and reproducibility
- ✧Plasma sources
- ✧Operation at high repetition rate
- ✧High-quality electron (e^-) and positron (e^+) bunches
- ✧Independently shaped drive- and main-beam
- ✧Multi-stage challenges with high-energy beams

In the longer term, **a facility to test staging with collider-like quality beams is necessary.**

The sharing of modules/codes, interoperability …, as well as the definition of standards for simulation input/output and for data structures, should be encouraged.