

ALEGRO input for the European Strategy for Particle Physics

ALEGRO



Advanced LinEar collider study GROUp

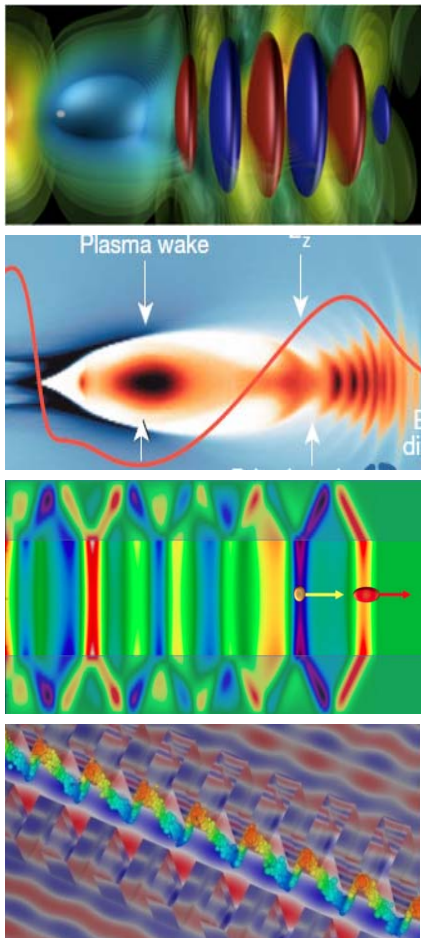
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Advanced and Novel Accelerator concepts (ANAs): definition

Acceleration gradients larger than 1GV/m



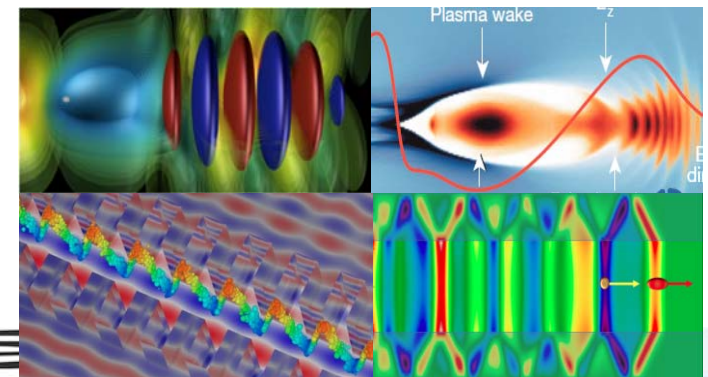
- ❖ Wakefields driven in **plasma** by **intense** laser beams : **LWFA**
- ❖ Wakefields driven in **plasma** by **particle** beams: **PWFA**
- ❖ Wakefields driven in **structures** (e.g. dielectric tubes) by **particle** beams: **SWFA**
- ❖ Wakefields driven in **dielectric structures** by **short-pulse** lasers: **DLA**

Challenging question for the community of ANAs



- ❖ Can we envisage the delivery of an **Advanced Linear Collider design** at $>1\text{TeV}$ (30 TeV) in 2035?
- ❖ Electron- positron Collider at the energy frontier
- ❖ Parameters defined for/by HEP (Luminosity)

Subject addressed in the frame of ICFA



Advanced LinEar collider study GROup: missions



- ❖ To foster and trigger Advanced Linear Collider related activities
- ❖ Provide a framework to amplify international coordination, broaden the community, involving accelerator labs/institutes
- ❖ Identify topics requiring intensive R&D and facilities needed

- 1st action : **Report** on ANA priorities as input for the European Research Strategy Group for HEP: published on arXiv ([link](#))
- a series of **workshops** to discuss and finalize the roadmap and monitor the work (WG8 EAAC sep 2017, 26-29 March 2018 Oxford, AAC 2018, **26-29 March 2019 CERN**)

Advanced LinEar collider study GROup: organisation



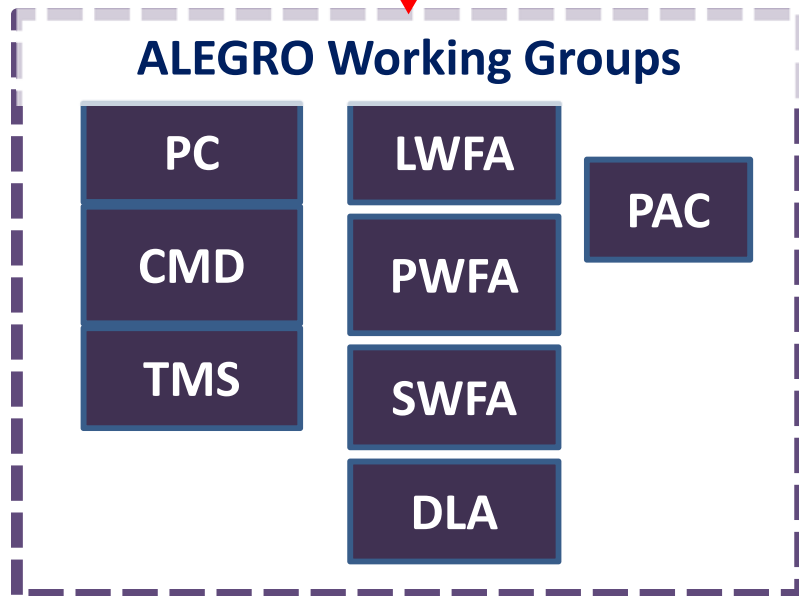
ICFA
ICFA ANA

Opened to contributions from
interested scientists worldwide

B Cros
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P Muggli

ALEGRO
Steering Group

Euronnac



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)

Summary of ALEGRO input 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^-/γ 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.lpggp.u-psud.fr/icfaana/alegro/documents>

ALEGRO proposal



ALEGRO proposes as **a long-term goal** the design of a $e^+/e^-/\text{gamma}$ 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 towards an ALIC



- ❖ Design of appropriate particle sources;
- ❖ Development of high-power lasers needed for LWFA's and DLAs;
- ❖ Achievement of required tolerances;
- ❖ Development of novel diagnostics for the ultra-fast bunches generated by ANAs
- ❖ Development of fast simulation methods.

From ALEGRO ESPP submission



8 What is needed? What do we support? 1/3

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.

From ALEGRO ESPP submission



8 What is needed? What do we support? 2/3

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

From ALEGRO ESPP submission



8 What is needed? What do we support? 3/3

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.

ALEGRO expectation from ESPP



2020 European Strategy Update
broadly supports further
development of ANAs (towards ALIC)



Summary



- ✧ **Long term and ambitious goals** for HEP give a new impulse to ANAs development: coordinated efforts to be undertaken for faster progress and increased funding
- ✧ **Mid term milestones identified** associated to the construction of specific facilities (e.g. EuPRAXIA, kBella, FACET II, ...)
 - ✧ to validate the **reliability** of ANAs
 - ✧ to demonstrate their capability to achieve **higher average power**
 - ✧ to develop compact **positron sources**
- ✧ **ALEGRO proposal submitted to ESPP**: support and commitment from HEP and accelerator communities would be a great help to speed up progress towards ALIC



26-29 March 2019 CERN