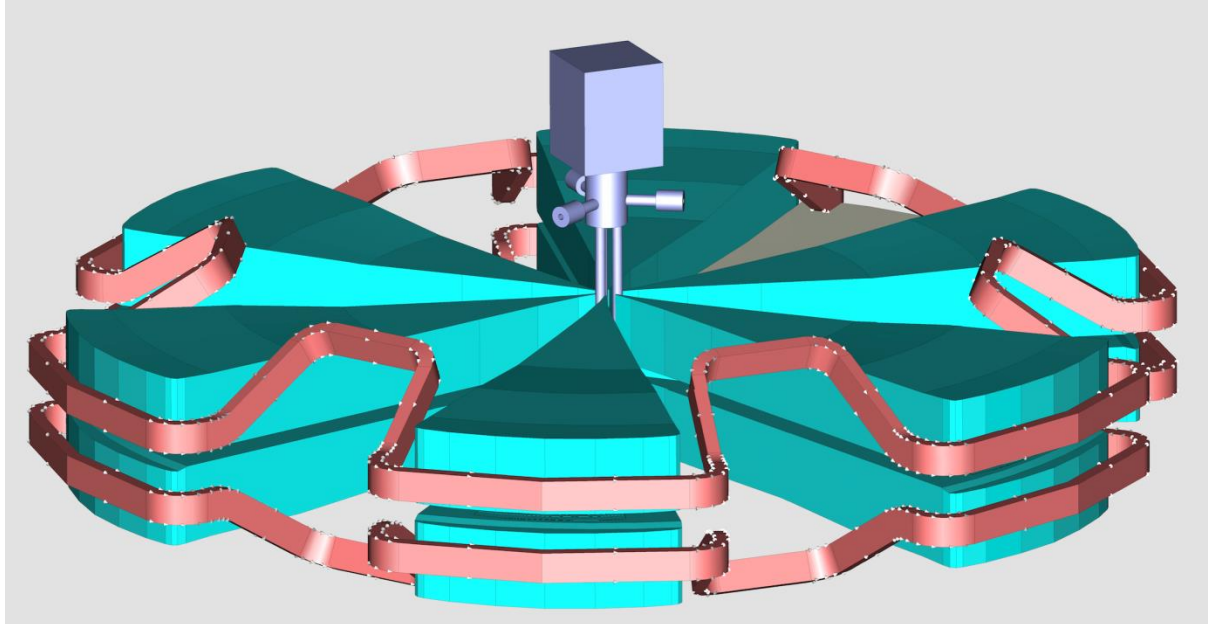


The CYCLADS Project

CYCLADS stands for “**CYCL**otrons for **Accelerator-Driven Systems**”.



The original layout of the CYCLADS cyclotron, compared to other cyclotron-based projects, allows to reduce the investment costs while increasing the overall efficiency and the reliability of the facility. It combines, in an innovative way, the advanced features of some of the other projects in the world, with the additional advantage of benefitting from the unique expertise of PSI and AIMA, leading world experts in cyclotron technology, which is a major asset for the project.

iTheC is a member of the consortium that submitted a proposal to the European Union, in the framework of the H2020-FETOPEN-2016-2017 programme, to develop an innovative single stage superconducting cyclotron as an alternative to linacs for Accelerator-Driven Systems

CYCLADS consortium partners:

- **iTheC**, an international, non-profit association, whose membership includes physicists, engineers, technicians, politicians, and concerned citizens. Several of the scientists in iTheC are former collaborators of Nobel Prize Laureate, Carlo Rubbia, on the Energy Amplifier project.
- **CERN**, the European Organization for Nuclear Research, one of the world’s largest centers for scientific research on fundamental physics.
- **AIMA DEVELOPPEMENT**, a private enterprise founded in 2005. Exploring new cyclotron designs for industrial and medical applications.
- **ASG Superconductors**, a private enterprise founded in 2001 following the privatization of the Magnet Unit of the Ansaldo Group in Genova (involved in superconducting magnets since the seventies). Today ASG is the world leader in

terms of superconducting magnetic systems design, construction and testing capabilities for high energy physics and thermonuclear fusion applications.

- **ENEA**, Agenzia Nazionale per le Nuove Tecnologie, l’Energia e lo Sviluppo Economico Sostenibile, ENEA is the second major Italian research organization, with around 2700 staff employees distributed in its 9 research centers all over the national territory. The Agency’s activities are mainly focused on Energy Efficiency, Renewable Energy Sources, Nuclear Energy, Climate and the Environment, Safety and Health, New Technologies, Electric System Research.
- **HNE**, Hydromine Nuclear Energy S.a.r.l., a subsidiary of Hydromine, Inc., located at 230 Park Avenue, Suite 950, New York, NY 10169-0950. Hydromine is a project development company principally involved in a variety of natural resources, power generation and infrastructure development projects throughout the world, including mining, infrastructure and traditional and renewable power generation technology projects.
- **N-21**, Nuclear-21, an international operating expert firm specialised in nuclear science & technology decisioneering services to governments, investors, utilities, industry, R&D-laboratories and waste management agencies worldwide.
- **PSI**, Paul Scherrer Institut, the largest research institute for natural and engineering sciences within Switzerland. The institute performs world-class research in three main subject areas: Matter and Material; Energy and the Environment; and Human Health, and is operating the highest power (1.4 MW) cyclotron in the world.
- **INFN**, a world-class institution in nuclear and particle physics research, where there is long-standing expertise in cyclotron design studies, construction and operation at the Southern National Laboratory of Catania and where a group of researchers based at the Genova unit is working on ADS-related topics since a few years. The Genova group also cooperates with the local Engineering Department on CFD calculations and recently a HPC farm based on 12 Intel KNL 64-core processors has been installed at INFN Genova to test the coupling between neutronics and CFD codes. Such farm may be also available for specific tasks in CYCLADS.

Short description of the project

The CYCLADS project aims at designing an innovative High-Power Cyclotron as part of Accelerator-Driven Systems (ADS) breaking new ground in nuclear waste transmutation and other accelerator-based applications. This is achieved by combining experience and innovative ideas in accelerator, nuclear Science & Technology, and developments of High-Temperature Superconductors (HTS), thus generating a transformative impact to EU society. ADS are a new option for incinerating the long-lived actinide component of the increasing inventory of spent nuclear fuel that poses long-term radiological risks. By reducing volume and lifetime of most dangerous waste ADS would contribute to the feasibility of geological repositories. The Feb. 2017 CERN international workshop “Status of ADS Research and Technology Development”¹ showed that the current accelerator layout (linear accelerator) requiring installation of modules in cascade makes present ADS expensive, complicated and unreliable for industrial use. There is a consensus in the international expert community

¹<https://indico.cern.ch/event/564485/overview> and https://edms.cern.ch/ui/file/1325146/2/EuCARD2-Del-D4-4_Final.pdf

that cyclotron technology would represent a worthwhile route of investigation. Until now², no compact, single-stage cyclotron has been proposed for ADS. CYCLADS, building upon updated technological insights, will design a highly innovative Single-Stage High-Power Cyclotron (HPCy) in the MW power class. The project's ambition is to change the technical-economic equation for ADS by bringing new solutions able to alleviate most of the cost-drivers identified in ADS designs, making it adoptable by the market. In view of aggressive ADS developments in India and China, it is strategically important for Europe to retain its leadership in a field it has pioneered. To meet its objective the project will gather a multidisciplinary group of European leading experts in key technological areas: accelerator, target and subcritical system, ensuring that the full value chain is enclosed in a multifaceted analysis. The aim is to propose technological solutions and answers to questions such as: what is the final economic benefit of this technical development, what are the key drivers influencing the market potential? The results of CYCLADS will be translated to other high power accelerator applications: elementary particle physics, radioisotopes production, nuclear industry, multiplying the socio-economic values.

² OECD 2005 NEA No. 5421 NUCLEAR ENERGY AGENCY; M. SALVATORES et al., "Long-Lived Radioactive Waste Transmutation and the Role of Accelerator Driven (Hybrid) Systems", Nucl. Instrum. Methods in Physics Research A 414 (1998) 5-20; P. Mandrillon, N Fietier, C. Rubbia, "A cyclotron-based accelerator for driving the Energy Amplifier", Proc of 14th International Conference on cyclotrons and their applications, Cape Town, 1995;