LEAPS INNOVATION

LEAPS-INNOV

WG2 Kick-off Meeting

WP6 „LIDs“ Status Report

23.10.2024

S. Di Mitri (Elettra) on behalf of WP6

This project has received funding from the European Union´s Horizon 2020 research and innovation programme under grant agreement No. 101004728

LEAPS League of European Accelerator-based Photon Sources

Overview

Scope

- **Push the limits of the present ID technology** for the benefit of SR and FELs.
- **Transfer the developed technology to interested companies at an early stage.**

Goals

- **involve industry** to prepare the technology transfer to European industry (WP6.1)
- **explore the possibilities of short period, high field, planar undulators for generating hard X-rays by building two prototype undulators**: a high temperature superconducting (HTS) undulator (SCU) with 10 mm period (WP6.2.1) and a cryogenic permanent magnet undulator (CPMU) with 12 mm period (WP6.2.2)
- **explore short period, high field elliptically polarised undulators for soft X-ray by building two prototypes**: a cryogenic APPLE III undulator (WP6.3.1) and a cost-effective compact APPLE X undulator (WP6.3.2)
- **build two prototypes of measurement benches to characterize the prototype undulators**: a small aperture, low temperature Hall probe measurement bench (WP6.4.1) and a pulsed wire measurement bench (WP6.4.2)

Tasks

- **Task 6.1 Industry involvement** (EuXFEL, ELETTRA, all) M1-M48
- **Task 6.2: Short period, high field, planar undulators for hard X-rays** (PSI, DIAMOND, ELETA, ESRF, ULUND, SOLEIL) M1-M48
- **Task 6.3: Advanced EPU undulators for soft X-ray** (HZB, DESY, DIAMOND, ELETTRA, SOLEIL, ULUND) M1-M42
- **Task 6.4: Measurement Benches** (ALBA-CELLS, DESY, ELETTRA, EuXFEL, PSI, SOLEIL, STFC, ULUND) M1-M24

Beneficiaries

Partners

WP No. **WP6**	Lead beneficiary **SOLEIL**													Start **1**		End **48**	
WP title	**LIDs LEAPS Insertion Devices**																
Participant No.	1	2	3	**4**	5	6	7	8	9	10	11	12	13	**14**	16	**17**	18	19
Participant short name	DESY	ALBA-CELLS	DIAMOND	**ELETTRA**	ENEA	ESRF	EuXFEL	FELIX	HZB	HZDR	INFN	ISA	KIT	**PSI**	SOLARIS	**SOLEIL**	STFC	ULUND
PMs	3	18	4	4	2	7	20	1	20	1	1	1	2	23	1	25	2	23

Young scientists

(over the last 4 years)

Johan Baader, EUXFEL

Xiaoyang Liang, PSI

Alexis Duthiel, SOLEIL

Alexandre Arsenault, PSI

Industry involvement – *ref. A. Bonucci (EU-XFEL) & M. Peloi (Elettra)*

WP6 IP training, Annual meeting, March 2023, Hamburg

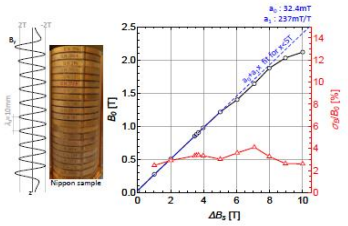
WP6 mets industry at IPAC2023, Venice, 2023 May 9

project presentations, bilateral meetings to discuss project updates.
The primary goal of the companies is to enter the market as technology providers. To support the growth of a specialized pool of suppliers for integrating innovative components of LEAPS-INNOV into the undulator sector, knowledge transfer actions or even technology transfer can be considered. The new characterization developed can play a vital role in facilitating collaborations for qualification purposes. The LEAPS institutions are currently evaluating the optimal timing for the knowledge transfer and technology transfer process.

44 participants
25 companies

Technology transfer proposal BSBF2024

Call for partnership



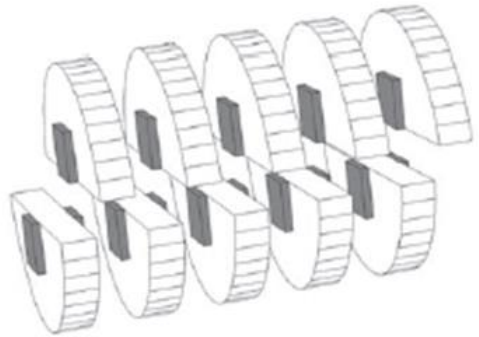
https://www.leaps-innov.eu
https://www.psi.ch/en
https://www.esrf.fr

BSBF 2024

WP6
Task 6.2

Short period high field planar undulator

HTSU – *ref. Marco Calvi (PSI)*



Concept Staggered array of GdBCO bulks with CoFe poles of 10 mm period, gap 4 mm, Magnetization with a solenoid

Assessments of various High Temperature Superconducting (HTS) materials - REBCO bulks (Y, Gd, Eu) from different manufacturers

=> bulk samples preferred to HTS tape stacks

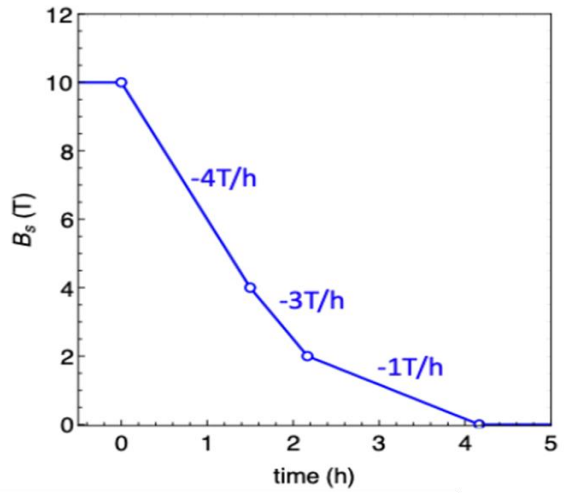
Kinjo, R., Calvi, M., Zhang, K., Hellmann, S., Liang, X., Schmidt, T., Ainslie, M. D., Dennis, A. R. & Durrell, J. H. Inverse analysis of critical current density in a bulk high-temperature superconducting undulator. Physical Review Accelerators and Beams 25. (Apr. 2022).

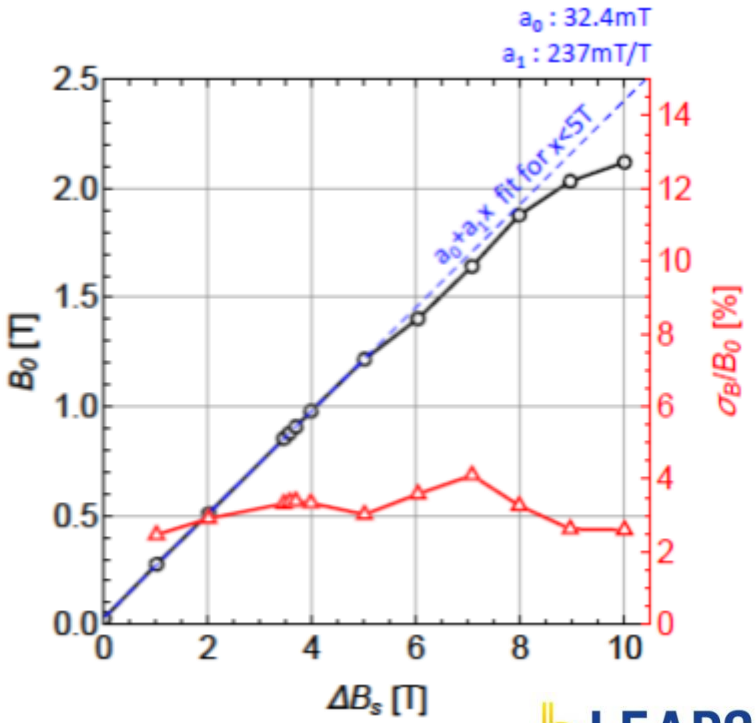
Exploration of different ferromagnetic pole/shim materials (FeCo, Ho)

short prototype made of GdBCO bulks (Nippon Steel).

B> 2 T for 10 mm period and 4 mm magnetic gap.

Magnetic field not reached with conventional SCU or CPMU !!





Procurements and plan to finalization

Procurements finalized for:
- Vacuum vessel
- HTS current leads,
- cryocoolers with compressors,
- power supply

The vacuum vessel at the Fermi National Laboratory

Nb3Sn 12T solenoid at Fermilab supplier:
challenges in manufacturing the have resulted in delays from March to September 2024), with issues in the impregnation procedure following winding and heat treatment necessitating tooling redesign

Next plans :
First cryogenic test of the prototype : first quarter of 2025 completing the LEAPS-INNOV project (TLR 6).
Installation in the new storage ring of the Swiss Light Source : 2026 (TLR8).

Short period high field planar undulator

CPMU – *ref. Mathieu Valleau (SOLEIL)*

Delivery of parts

- Magnets and poles delivered on July 2024 (2 month delayed due to magnets exceeding tolerances)
- Girders have been machined, drilled and LN2 connections have been soldered (1month delayed due to a leakage under pressure)
- All the mechanical pieces for the supermodules assembly have been received on time by mid-July
- The carriage is aligned on the measurement bench
- All the pieces have been cleaned for UHV compatibility

Prototype assembly

- Magnets have been measured on :
  - Helmholtz coil bench
  - Field mapper
  - Rotating coil bench

- 4 Supermodules have been assembled

(21 remaining)

- The bench for the robotic arm is operational

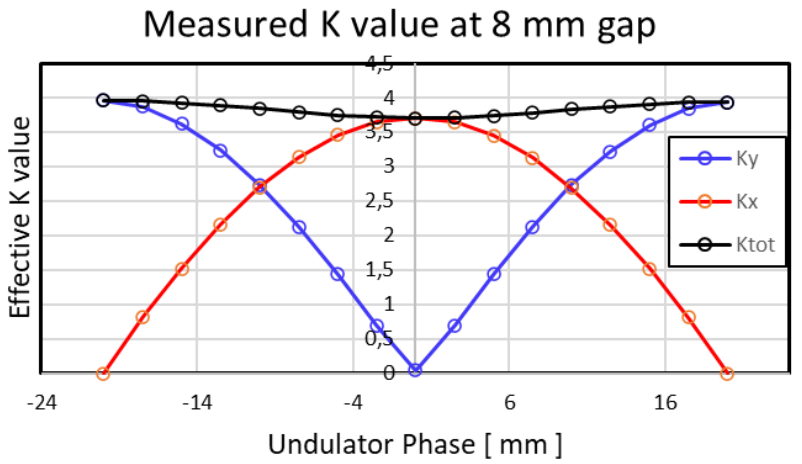
- Robotic application for the supermodule optimisation in automatic mode is nearly finalized

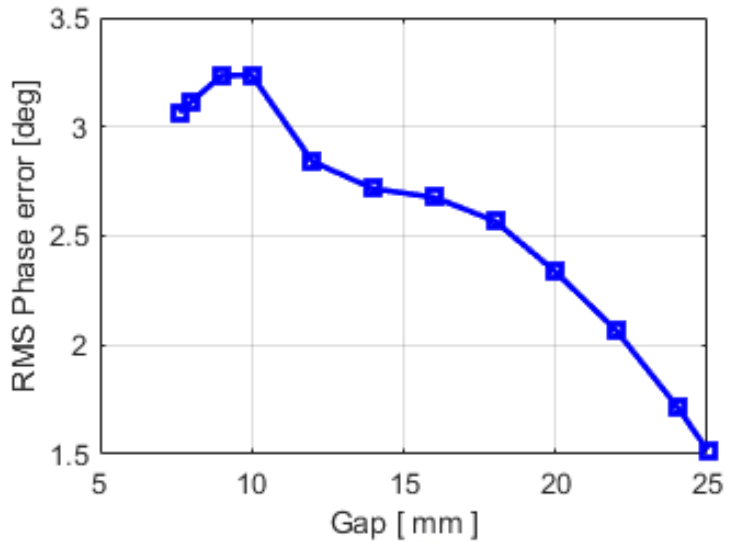
Advanced EPU

Compact APPLE X Undulator – *ref. Hamed Tarawneh (MAX IV)*

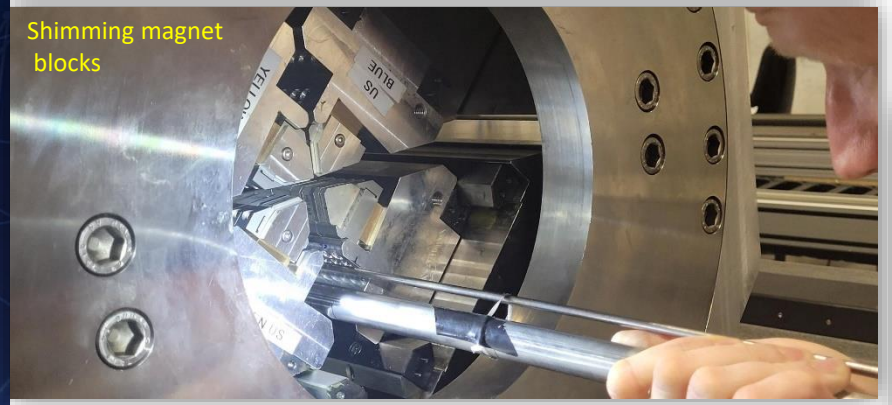
- Compact low cost undulator based on APPLE concept ensuring full polarization control.
- The project scope ranges from simulation and design (mechanical, electrical, control) via documentation, production & procurement to assembly and testing of a full-scale 2-meter-long undulator in MAX IV.
- Procurements of undulator parts started in Q1, 2022.
- Undulator assembly and tuning started in July 2023. ´Magnetic measurement and characterization finished in March 2024.
- Main findings;

1. Photon energy range has been fulfilled as specified for all polarization modes of operation.
2. Cost-effective solution for mass production. Up to 44% reduction in material cost in comparison to the APPLE II undulator built at MAX IV.
3. Magnetic-mechanical shimming and tuning in circular mode could be the best compromise, magnetic force direction, and distribution (lateral slit).

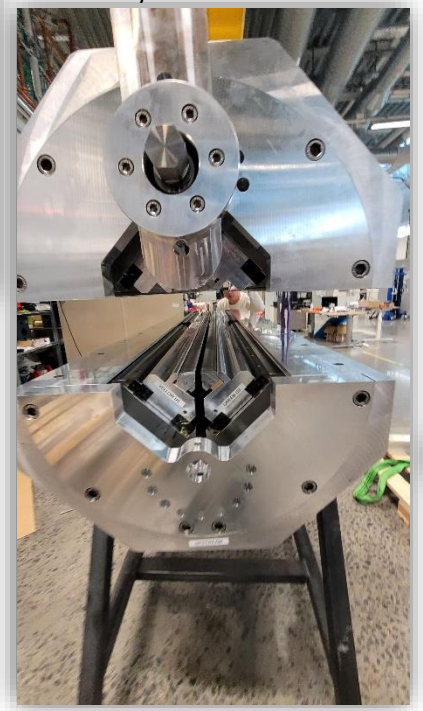




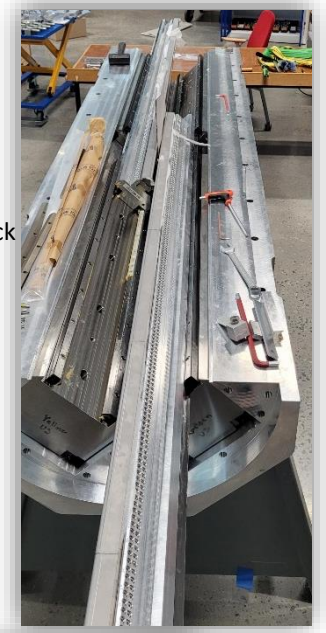
APPLE X Prototype Assembly & Characterisation



Assembly of two halves

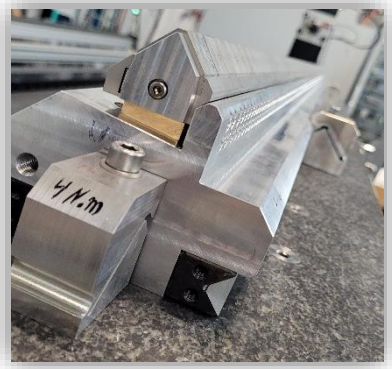


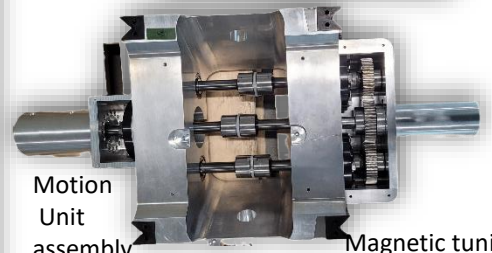
Two Girders Into Half strongback



Spring to hold magnet keeper

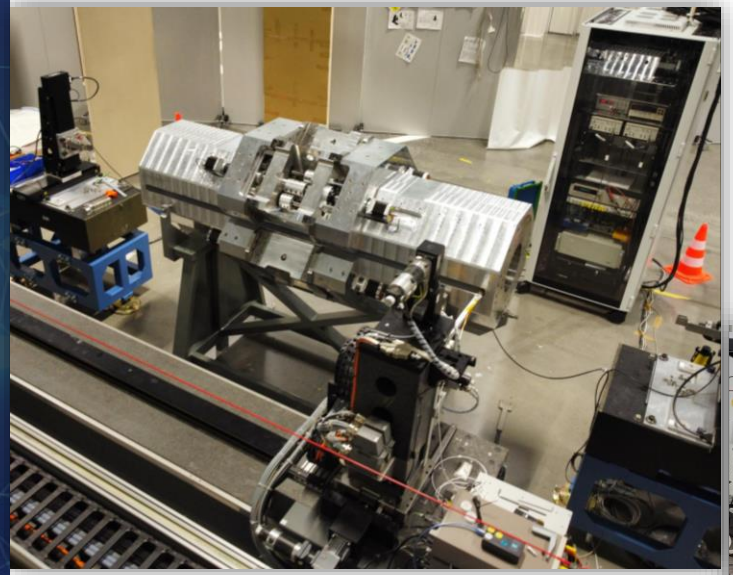
One girder aligned at stone





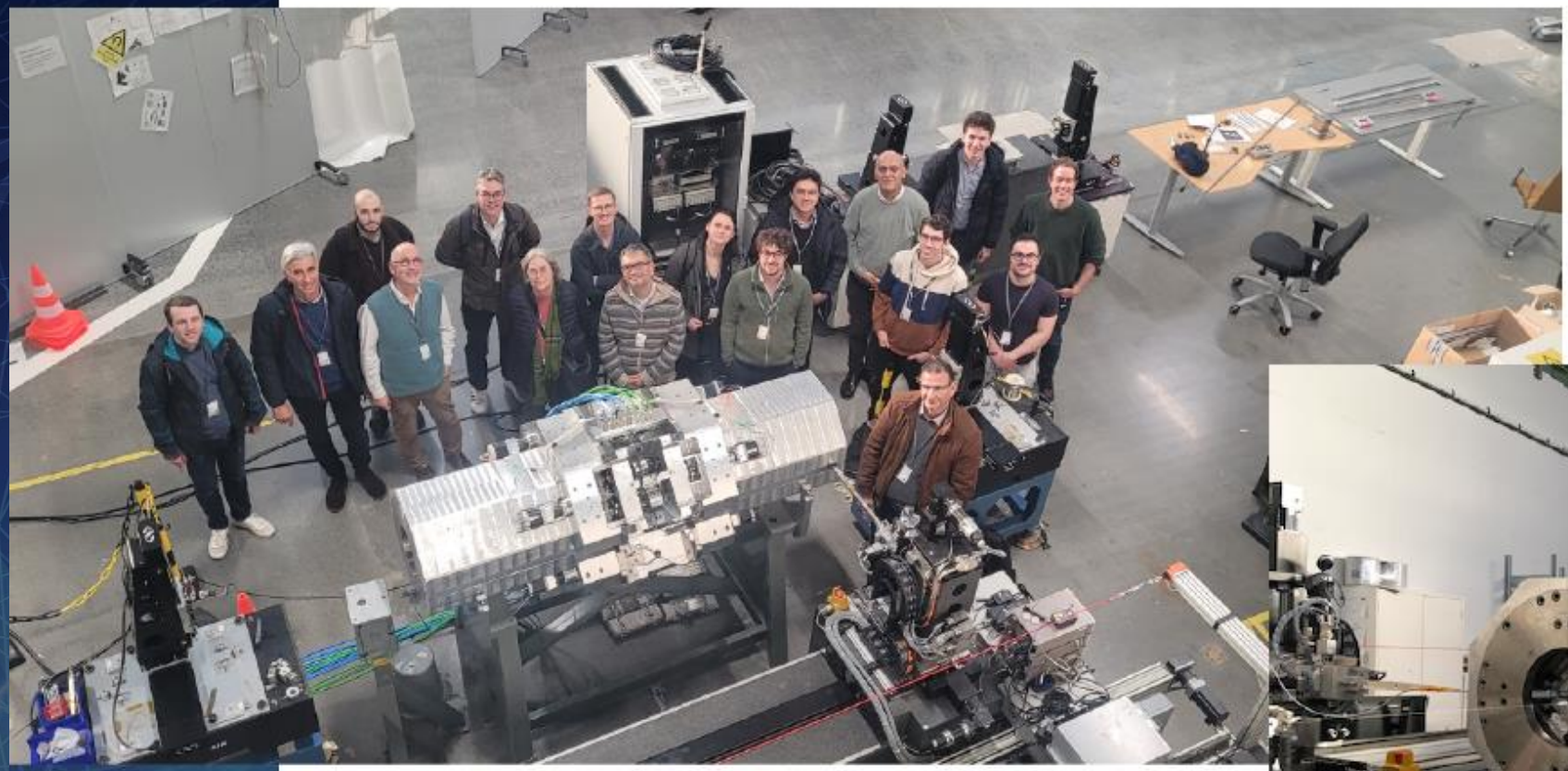
Motion Unit assembly

Prototype during magnetic measurement in magnet lab



Alignment of single girder

Magnetic tuning of single girder with Hall probe

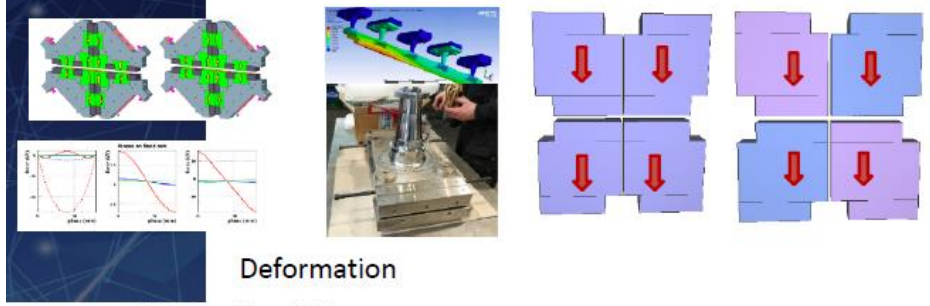


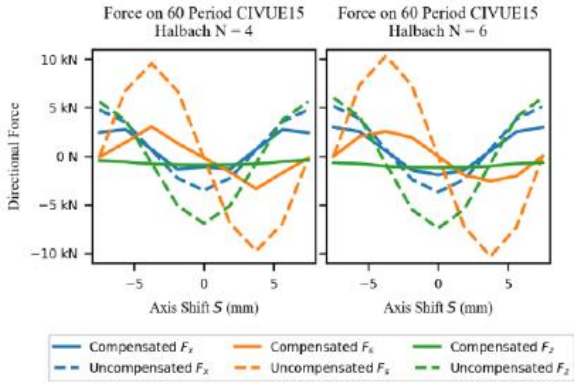
WP6 meeting- Lund, MAX IV, March 7-8
(23 participants from 12 institutions)

WP6.3 Advanced EPU : Cryogenic APPLE III – *ref. Ed Rial (HZB)*

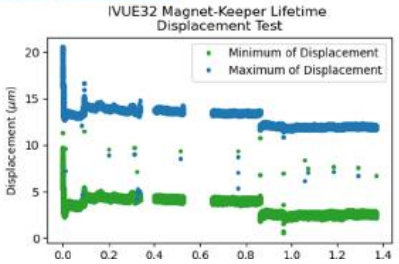
Magnetic and mechanical design

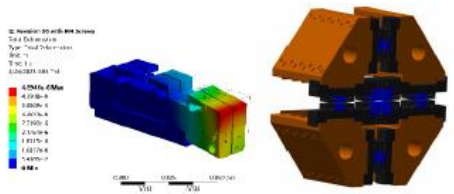
Magnetic force compensation



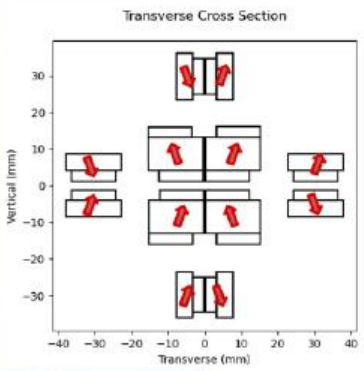


Deformation

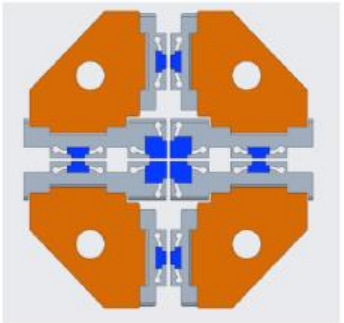


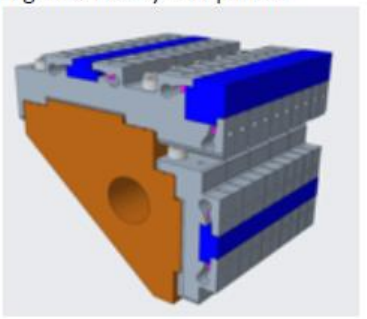


Internal components design under progress : Keeper and in vacuum girder design



Design for the in-vacuum girder nearly completed

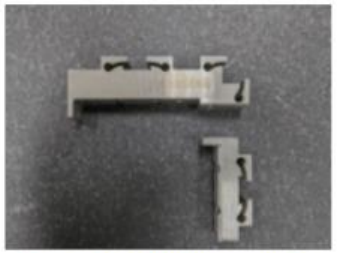




Cryo-APPLE in-vacuum girder design

Procurement of the in vacuum girder underwy

Prototypes of the keeper : manufactured



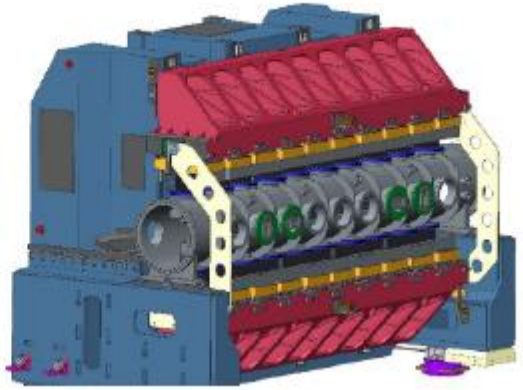
Cryo-APPLE keeper prototypes

The test structure of the room temperature in-vacuum APPLE IVUE 32 is assembled

Magnets under procurement for tests of the force compensations arrangement

Compensation magnet test structure

Structure of the final IVUE32 delivered



Cryogenic APPLE		2022				2023				2024				2025				2026				2027			
	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Set Requirements								HACK DELAYS																	
Magnet Structure																									
Mechanical Design																									
Thermal Design																									
Vacuum Design																									
Procurement																									
Assembly																									
Component Magnetic Measurements																									
In Vacuum Measurements																									
Documentation																									

Full scale system

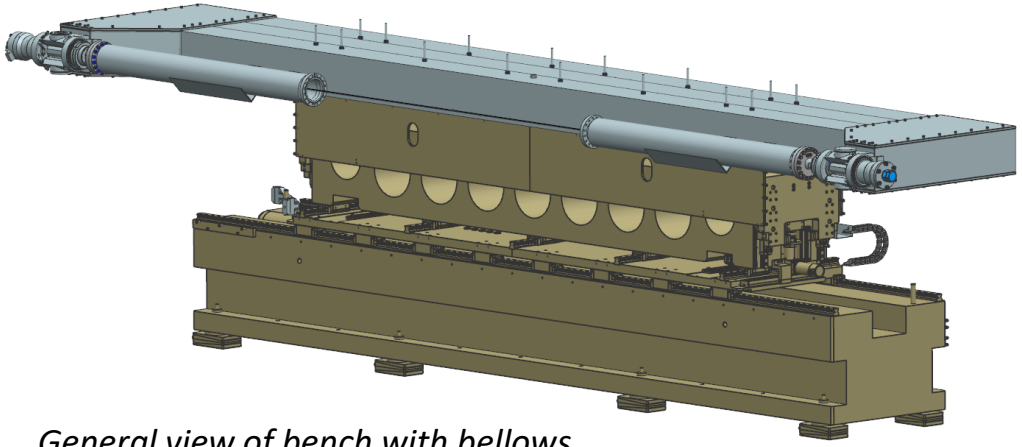
Although the complete undulator will not be completed before 2027, the EU LEAPS funding of 50k€ was targeted by HZB at magnetic design/shimming strategies, and undulator central components (keeper, in vacuum girder) that will be tested.

Small aperture Hall probe – *ref. Jordi Marcos Ruzafa (ALBA)*

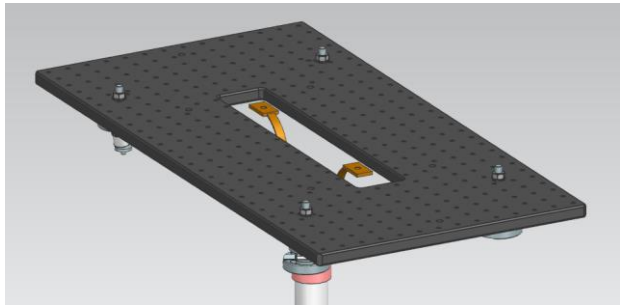
Project status:

- All the material for the adaptation was received by Feb'24.
- However, it was decided to put its **implementation** **on-hold** until a **suitable test structure is available**.
- The **design** of the test structure is **almost finished**, but it has not been possible to proceed with the procurement of parts due to the **lack of engineering resources** to prepare the manufacturing drawings. We hope to do so before **the end of 2024**.
- The **assembly of the final system** will be determined by those items of the test structure with the **longest lead-time** (most likely, the **cryo-coolers**), but we expect to be able to complete it **during the first half of 2025**.

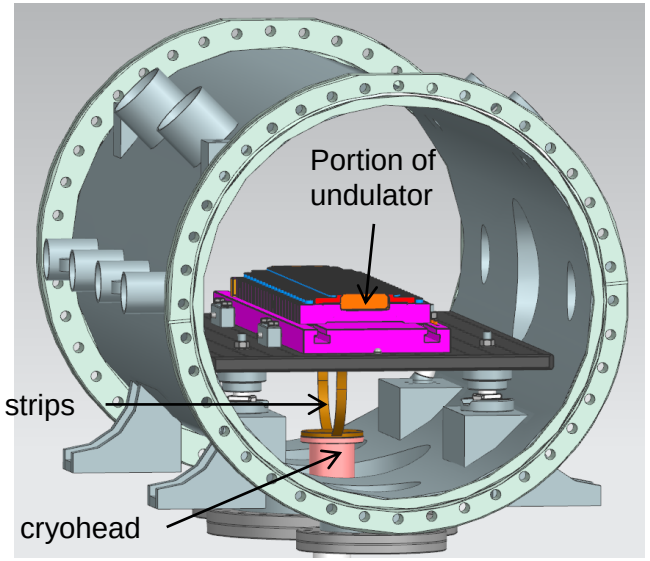
Drawings

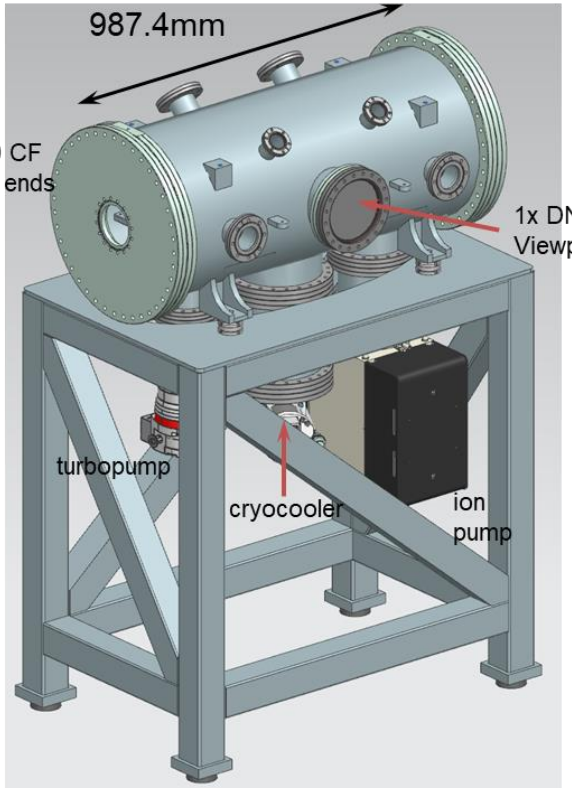


General view of bench with bellows



Base for the undulator array





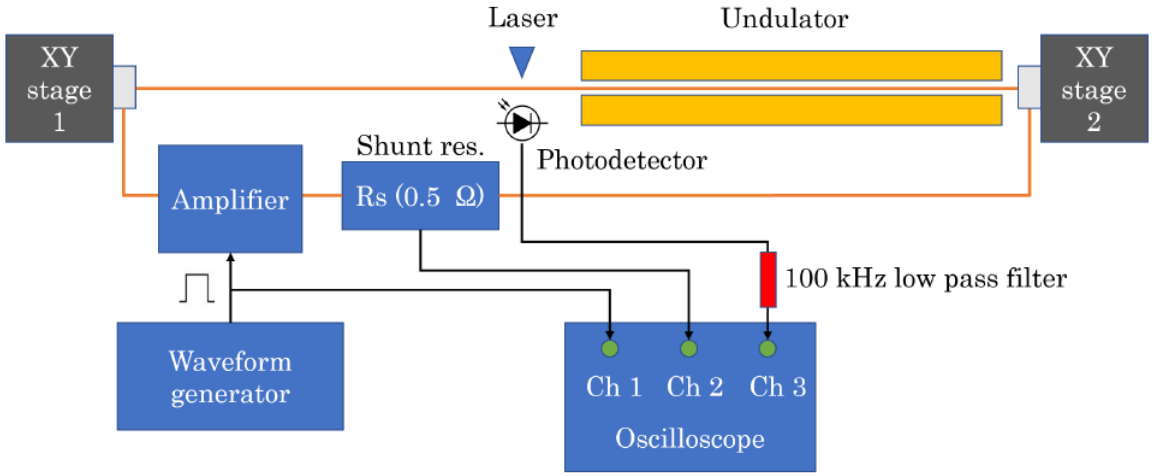
Details of the test structure

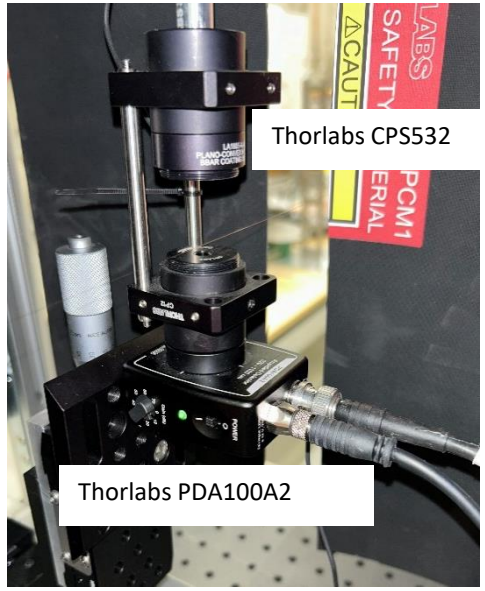
WP6
Task 6.4

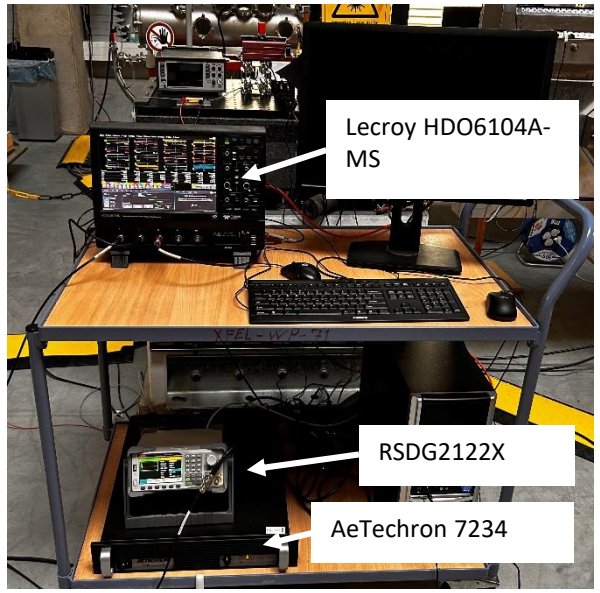
Magnetic measurement benches

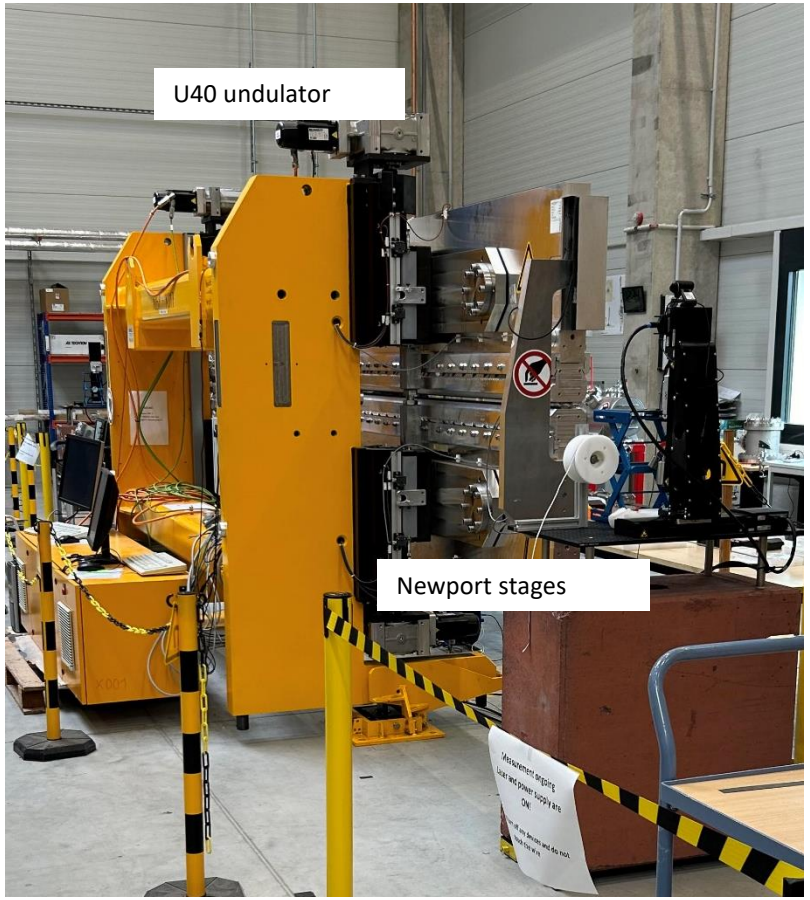
Pulsed wire – *ref. Sara Casalbuoni and Johan Baader (EU-XFEL)*

Set-up









J. Baader et al., IMMW23

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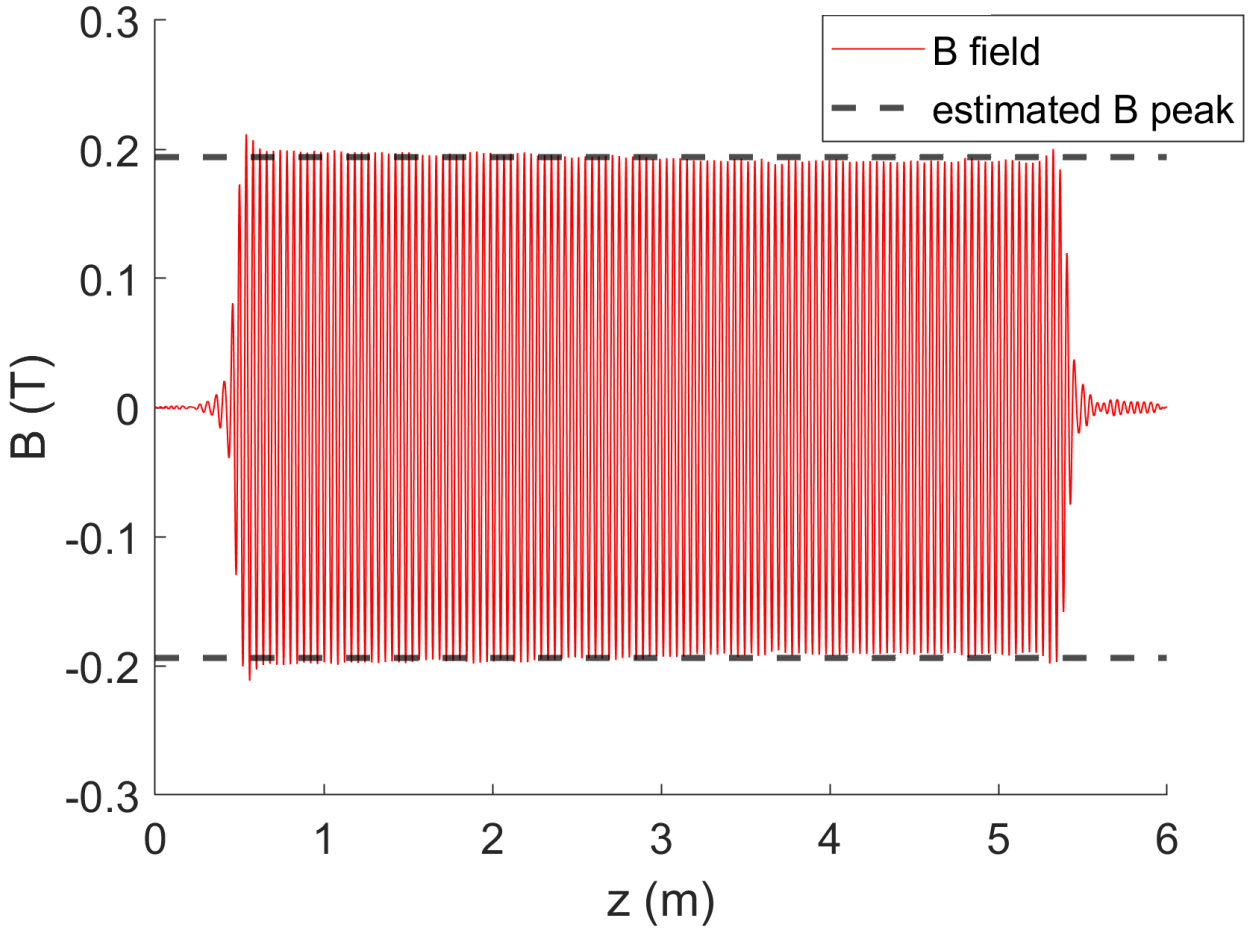
Preliminary results



- Wire parameters: 125 µm BeCu wire, 10.8 m long, stretched at 9.1 N
- 4x Newport M-ILS200LM-S stages used to place the wire
- Pulse parameters: pulse width of 20 µs; pulse amplitude of 520 mA; rise/fall time of 1 µs; overshoot <3%; pulse period of 30 s
- Magnetic field profile calculated by deriving I1 with respect to the longitudinal axis position

J. Baader et al., IMMW23

LEAPS INNOVATION

LEAPS-INNOV project extension proposal

+ 6 months, deliverables, milestones and budget shifts → project ends on 1st October 2025.

- **Which tasks will benefit from an extension and why?**

  Task 6.2: HTSU, CPMU

  Task 6.3: Cryogenic APPLE-III → adaptation of the task

- **What led to the delay?**

  Subtask 6.2.1 – HTSU. Challenges in manufacturing the Nb3Sn 12T solenoid at Fermilab have resulted in delays, with issues in the impregnation procedure following winding and heat treatment necessitating tooling redesign (+ 6 months, from March to September 2024).

  Subtask 6.2.2 – CPMU. The challenge of holding and adjusting the half-poles at the extremity of the undulator (0.9mm thickness). The mechanical solution found and proven.

  Subtask 6.3.2 – Cryogenic APPLE-III. The project has been delayed by a cyberattack to HZB.

- **Which work will be done in the additional 6 months?**

  - ***Subtask 6.2.1 – HTSU.*** Procurement of the solenoid components and assembly. Cryogenic test of the fully assembled prototype.
  - ***Subtask 6.2.2 – CPMU.*** The CPMU will be assembled and characterized at room and cryogenic temperature before the end of the contract. However, an extension of at least 6 months would provide more margin for the project, in the sense of minimizing the risks associated to the procurement of all the components.
  - ***Subtask 6.3.2 – Cryogenic APPLE-III.*** All the components needed to the construction of the prototype will be procured. The mechanical supports will be made in-house.

Milestones and Deliverables

MS No.	Milestones WP6	Period	Due Date (in months)	Delivery (in months)	Status
MS26	Design of the two measurement benches	P1	M12	M12	achieved
MS27	The four ID prototypes are assembled	P2	M36	M36=>M42 (September'24)	Partially achieved

Del.	Deliverable WP6	Period	Due	Delivery	Status
D6.1	Summary report on design of the short period high field prototypes	P1	M6	M6	Submitted
D6.2	Summary report on design of advanced EPU prototypes	P1	M6	M6	Submitted
D6.3	Summary documentation of the two measurement bench prototypes	P1	M12	M12	Submitted
D6.4	Summary report on performance of the short period high field prototypes	P3	M42	M48	
D6.5	Summary report on performance of the advanced EPU prototypes	P3	M42	M48	(March'25)
D6.6	Midterm report on WP6 meets industry	P2	M24	M25	Submitted
D6.7	Report on WP6 KT and TT best practise	P3	M46	M46	(Genuary'25)

Change of M27:

ORIGINAL: "The four ID prototypes are assembled"

NEW: "the ID prototypes APPLE-X, CPMU and HTS, Cryo-APPLE III, and the two Test Benches are assembled"

Change of D6.5:

ORIGINAL: "Summary report on performance of the advanced EPU prototypes"

NEW: "Summary report on the performance of the ID prototypes APPLE-X, CPMU and HTS, and validation of the components of the Cryo-APPLE III"

Next WP6 meetings:

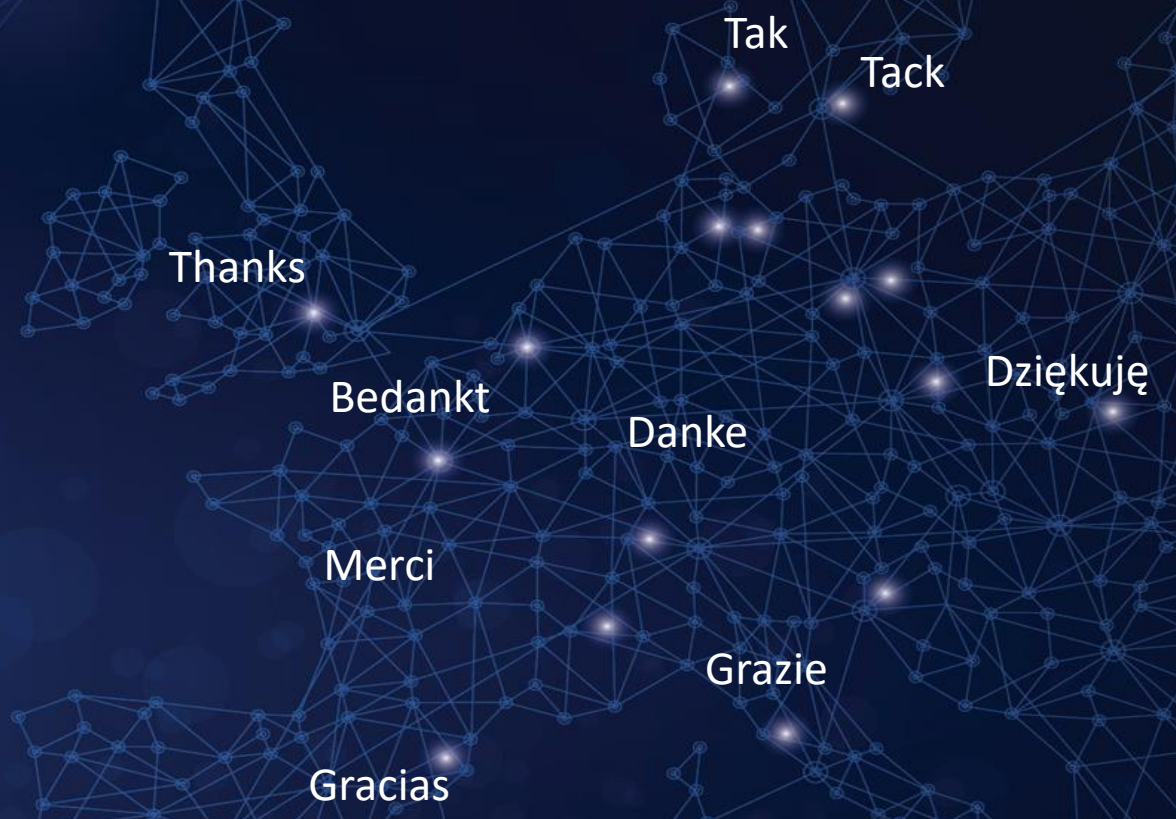
- Trieste, October 1-4, Big Science Business Forum, with poster from WP6 (WP6 meets industry)
- Nov-Dec 2024, WP6 technical meeting at SOLEIL to see the CPMU prototype
- March 2025, WP6 technical meeting at PSI to see the HTS SCU prototype
- Annual meeting

LEAPS INNOVATION

“ Foster open innovation for accelerator-based lightsources in Europe”

https://leaps-initiative.eu

This project has received funding from the European Union´s Horizon 2020 research and innovation programme under grant agreement No. 101004728



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