



Permanent Magnets LEAPS Internal Collaboration



What it is?

PerMaLIC is a *LEAPS Internal Collaboration*,
i.e. a collaboration between the institutes of the LEAPS Consortium
(<https://leaps-initiative.eu>),
about **development of Permanent Magnets for the future, ultralow
emittance, light sources.**

Motivation

The **use of Permanent Magnets** in the new light sources has mainly two advantages: in the one hand, it allows a **more compact distribution of magnets**, since there is no need of coils and water cooling; in the other hand, it allows to **reduce the running costs and the carbon footprint** of the facility thanks to the removal of the power supplies associated to conventional electromagnets.

However, the use of Permanent Magnets also presents some **serious challenges**. These challenges include the **loss of flexibility** for the correction of errors, correction that it is needed to ensure the proper beam dynamics performance and stability, and the **long term stability** of the magnets themselves due to the risk of radiation-induced demagnetization.

Goals:

- Establish a regular Workshop
 - Once per year
 - 2 days
 - Presential, rotating between the partners
- Organize specific seminars
 - Each 2 to 3 months
 - Virtual – via Zoom
 - 45min + 15min questions
- Use the mailing list leaps-permalic@desy.de to generate open discussions
- Collaborate to solve the identified challenges:
 - Tunability
 - Radiation damage
 - Temperature stability
 - Measurement of small apertures

2021 Activities

- Started with an email interchange in March 2021
 - Accepted by the R&D Board in April
 - Call for interest at the beginning of May
 - Created list of contacts: leaps-permalic@desy.de
35 contacts / 13 institutions
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- May 31st 1st Meeting
 - September 22nd 1st Workshop
 - December 3rd 1st Seminar:
Permanent Magnets developments at STFC. Achievements and lessons learned, by Ben Shepherd - STFC – Daresbury
 - November 26th Presentation PerMaACC to GA

PerMaACC

Accelerator's Magnets using Permanent Magnets and Recycled Magnetic Material.

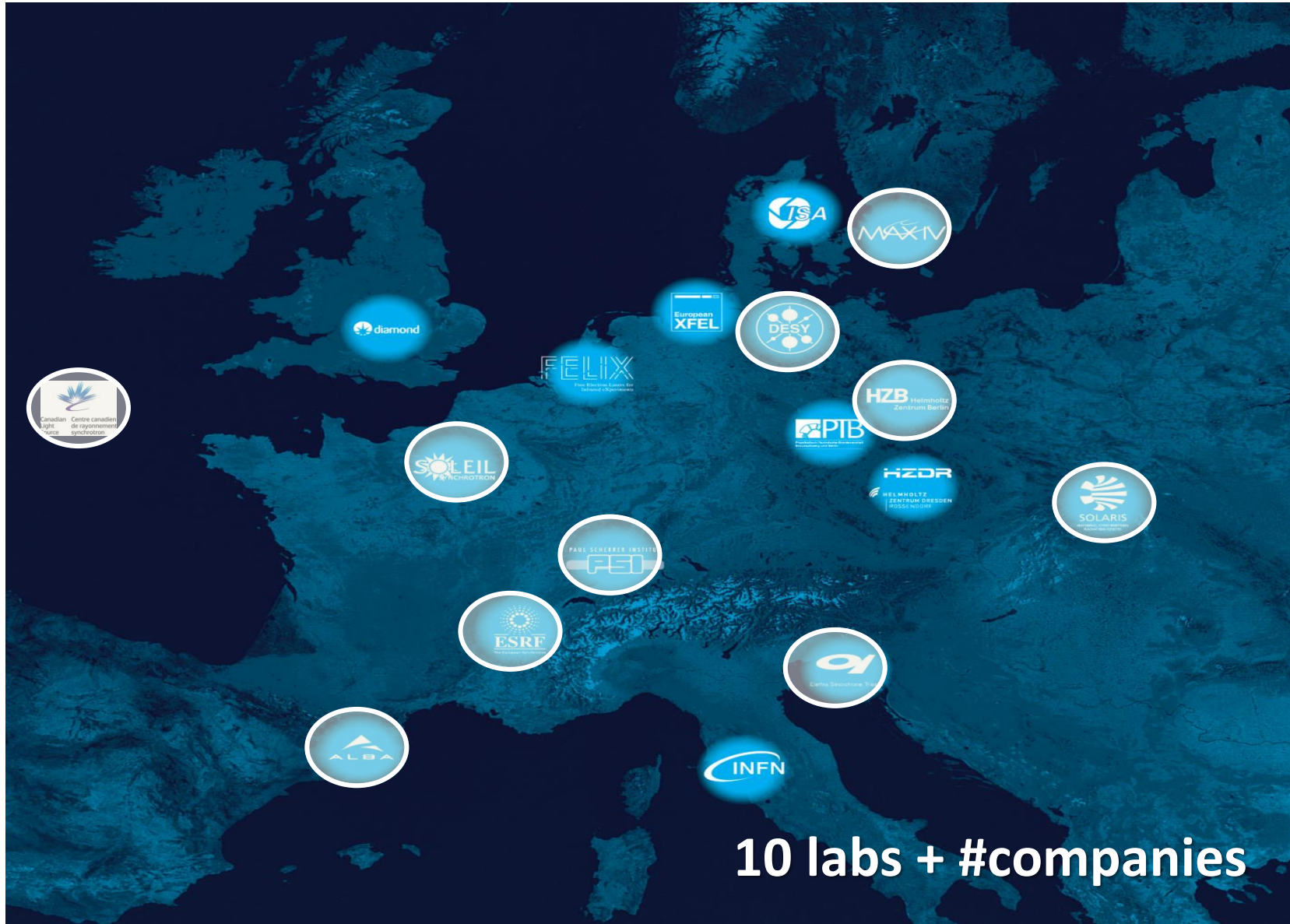
A proposal from the PerMaLIC collaboration



LEAPS

League of European
Accelerator-based
Photon Sources

PerMaACC



10 labs + #companies

Motivation

The **use of permanent magnets in the new light sources** has mainly two advantages: in the one hand, it allows a more compact distribution of magnets, since there is no need of coils and water cooling; in the other hand, it allows to reduce the running costs and the carbon footprint of the facility thanks to the removal of the power supplies associated to conventional electromagnets.

However, **the use of permanent magnets also presents some serious challenges**. These challenges include the loss of flexibility for some fine tuning of the beam optics and the correction of errors, needed to ensure proper beam dynamics and guarantee highest performance and stability, and the long term stability of the magnets themselves due to the risk of radiation-induced demagnetization. In order to deal with these issues the production of prototypes is mandatory.

In addition, the raw material required for the production of the permanent magnets comes from mining facilities in China, and requires a heavy process of chemical processing, solvent extraction, electrolysis and casting to produce the powder used for sintering the magnets, a process with very large environmental cost. In this sense, the possibility of **using recycled magnetic material from used magnets, to produce new ones**, shall be a goal in a Circular Economy.

Goals

The goal of the proposal is two-fold, from one side, **to produce prototypes** which would validate the techniques required for series production of the magnets needed for new accelerators, which need to comply with the required magnetic quality specifications, including long term stability, and which shall have built-in tunability to cope with the required flexibility for tuning and error correction.

On the other hand, **to establish the methodology to produce magnets from recycled material**, and validate the process with a “green magnet” prototype, by comparing it with an identical magnet from standard production processes.

In addition, **developments on the measurement system set-ups, and on tools for safely manipulate permanent magnets**, will be jointly pursued in order to ensure proper measurement of small bore combined function accelerator’s magnets, and safe assembly of series of permanent magnets.


Objective 1. Design of accelerator's magnets

This objective will be covered by the research labs, with **several designs** to be developed, covering different aspects and kinds of Accelerators Magnets.

Combined function


SLS 2.0 vs SLS : Energy savings (dipoles)

SLS2.0 Triplet = VB-BN-VB



Total number of triplets: 60
 BN: $B_y=1.35\text{ T}$; VB: $GdL=-40.64\text{ T/m}$
 Total Weight=900 kg
60 Triplets ~Total P=0 W

SLS BX Dipole




Total number of BXs:12
 $B_y=1.39\text{ T}$; $I=407\text{ A}$; $R=58\text{ m}\Omega$;
 Weight=2950 kg
 Cooling= 16 l/min
 $BX: P=58\text{ m}\Omega \times (407\text{ A})^2 \approx 9.6\text{ kW}$
12 BX ~Total P~116 kW

SLS dipoles : 116 kW x 6800 operating hours ; 789 MWh per year

Savings for 15 Years : 11.83 GWh

Hybrid, PM + tuning coils

GENERAL DESIGN OF VPHM

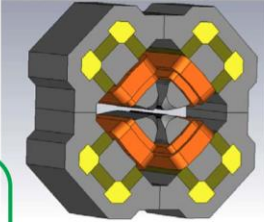


Variable Permanent Hybrid Magnets (VPHM)

- > soft iron for return yoke and pole shoes
- > a PM block (small μ_r) between yoke and pole

Advantages:

- > small external fields
- > iron yoke works as radiation protection and thermal stabilization for PMs
- > simply shaped PM blocks, perpendicularly magnetized
- > uncertainties of the easy axis and the residual fields are suppressed by yoke



Field variation: <20%
 Electric power: ~20W

- PM block as main magnetic source (NdFeB $B_r=1.3\text{ T}$, $H_c=10.8\text{ kOe}$)
- Aluminum Edges (Mag 1.0) (for stabilization and/or cooling)
- Soft iron yoke
- Corrector coils (air convection cooling -> 2 A/mm^2)

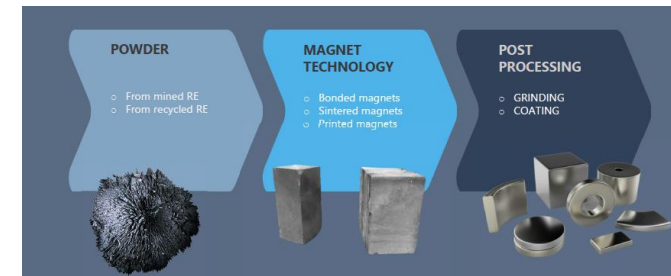
1. PerMaLIC Workshop – J. Völker 2021-09-22

Partners: ALBA, CLS, DESY, ESRF, HZB, MAXIV, SOLARIS, SOLEIL

Objective 2. Production of permanent magnets from recycled material and customization of fabrication procedures

This objective will be covered mainly by industrial partners, with the following two aspects:

- **Recycle material:** Collect permanent magnets from the partner labs and recover the rare earth through a hydrogen-based technology.
- **Produce permanent magnets** by sintering it **out of the recycled material**.



Partners: *MagREEsources* (<https://www.magreesource.org>), *Vacuumschmelze*, *CLS*, *ELETTRA*, *ESRF*

Other possible partners, not yet contacted: *Urbanmining* (<http://www.urbanminingco.com>), *RockLink* (<https://www.rocklink.de/en/>), <https://passenger-project.eu>

Objective 3. Production of accelerator's magnets prototypes

This objective will be covered mainly by industrial partners, with the **production of several prototypes**, with and without recycled material, **including twin magnets with each kind of material to compare performances.**



V-Quadrupole prototype



PM quadrupole prototype for the upgrade

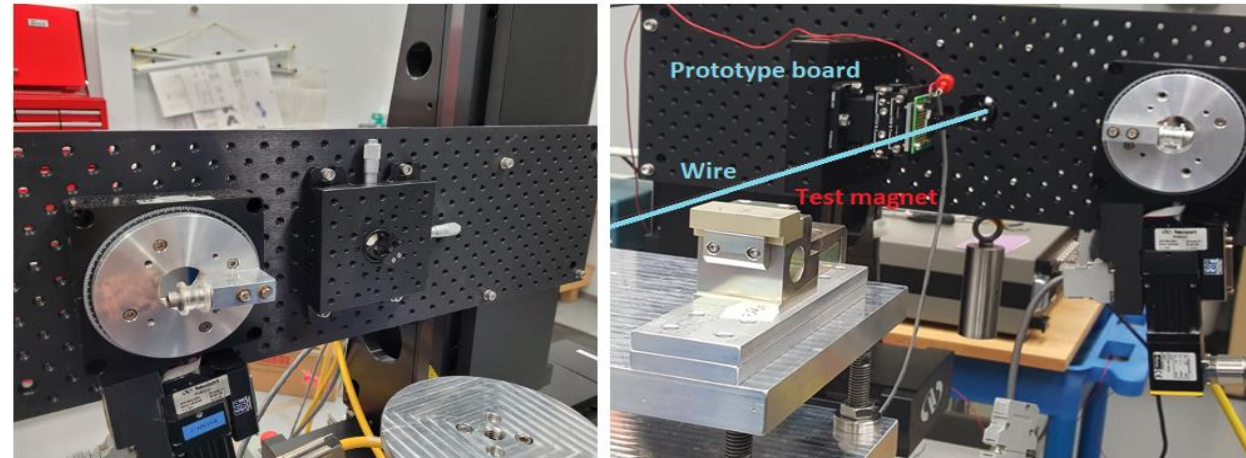
Typical size of the quadrupole in the present storage ring

*Partners: Usual magnet companies, to be contacted.
ALBA, CLS, HZB, MAXIV, SOLEIL*

Objective 4. Magnetic testing

This objective will be covered mainly by research labs, with the magnetic characterization of the prototypes. This will also require **developments in the actual magnetic labs** in order to deal with **small aperture combined function magnets**, and with the **safe manipulation and assembly of series of permanent magnets**.

Vibrating Wire (VW) Prototype



Partners: ALBA, CLS, ELETTRA, ESRF, HZB, MAXIV, SOLARIS, SOLEIL

Duration and budget

The duration shall be of **four (4) years**.

Budget still to be determined:

- *Several M€, depending on the final number of prototypes and companies involvement.*
- *Shall include a number of extra personnel.*

LEAPS GA Answer:

The scope of the PerMaAcc proposal fits the interests of a considerable amount of LEAPS facilities so there is interest on supporting it.

However, there were other proposals which are thought to address better the call criteria and you are kindly asked to consider looking into the PATHFINDER calls where the proposal can nicely fit. The overall budget of these calls is of 3-4 MEUR for a consortium of 6-8 partners, which must include industry.

You may count on the support of the LEAPS Coordination Board and support team to explore this possibility and identify if it may actually fit well with the project.



What can you expect as part of EIC Pathfinder?

With its Pathfinder programme the EIC supports the exploration of **bold ideas for radically new technologies.**

It welcomes the high-risk / high gain and interdisciplinary cutting-edge science collaborations that underpin **technological breakthroughs.**

Pathfinder goes beyond what is already known. Visionary thinking can open up promising avenues towards powerful new technologies.

At 1st glance it seems beyond the PerMaACC proposal



PerMaLIC

Thanks!



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