LEAPS League of European Accelerator-based Photon Sources

LEAPS - WG2 Photon Sources

Pilot project proposal LIDs (LEAPS Insertion Devices)

LIDs LEAPS R&D for Insertion Devices

New requirements **for future FELs and compact sources**

Short period, polarization control, small size, low cost , radiation hardness

New parameter space for synchrotrons

DLS with on-axis injection allow small and round vacuum chambers

New technology choices

advances in HTS and Nb_3Sn superconductors

improved PM materials

new geometries for polarizing undulators (Apple X, Delta…)

⇒ **R&D Goals are insertion devices with:**

Increased photon energy range

Improved polarization control

Lower cost

Improved radiation hardness

R&D goals and concepts are in parts driven by

and EuCompactLight

LEAPS League of European Accelerator-based Photon Sources

LIDs LEAPS R&D for Insertion Devices

LIDs proposal was put together by ID experts from LEAPS labs and associated labs coordinated by **Marie-Emmanuelle Couprie** /SOLEIL and **Thomas Schmidt** /PSI

Key event was LEAPS WG2 LIDs Mini Workshop hosted by HZB on 1 Oct. 2018

Participants

Pavel Evtushenko/HZDR
Marie-Emmanuelle Couprie/ SOLEIL
Markus Tischer / DESY
Hans-Heinrich Braun / PSI
Josep Campmany / ALBA
Sara Casalbuoni /KIT now DESY
Bruno Diviacco / ELETTRA
Johannes Bahrdt / HZB
Joachim Pflüger /Eu-XFEL
Andreas Jankowiak /HZB
Jim Clarke / UKRI STFC
Hamed Tarawneh / MAX IV
Thomas Schmidt /PSI
Atoosa Meseck /HZB
Ed Rial / Diamond
Simone Di Mitri /ELETTRA
Joël Chavanne / ESRF
Massimo Ferrario / LNF

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Tasks in LIDS

Task	Subtasks		Deliverables
Short Period, high field planar undulator	Staggered HTS	Advanced CPMU	Prototypes & Report
Advanced EPU devices	Cryogenic EPU	Low cost compact EPU	Prototypes & Report
Measurement and optimisation tools	Measurement benches for small aperture, cryogenic undulators	Advanced pulsed wire measurement bench	Bench prototype & Report
Undulator Machine Interface	Wakefield studies and measurements	Radiation damage	Test series & Report

Designs available for all LEAPS member labs

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H2020- Call: INFRAINNOV-04-2020 Innovation Pilots for Research Infrastructures

A Research and Innovation Action (RIA)

- https://ec.europa.eu/info/funding-tenders/opportunities/portal/screen/opportunities/topic-details/infrainnov-03-2020
- 3 communities will be funded: LEAPS, ARIES, AIDA
- Max requested EU contribution per project: 10M€
- Deadline for call: 17/03/2020, Postponed finally due to covid to 15/05/2020.

LEAPS pilot to foster open innovation for accelerator-based light sources in Europe

Project Coordinator: Dr. Elke Plönjes, DESY

Project time: 4 years, if successful starting in 2021

Budget: 10 million EUR, with own contribution of 8.3 million EUR without reporting to EC

LEAPS INNOVATION

LEAPS League of European Accelerator-based Photon Sources

INFRAINNOV-04-2020 LEAPS INNOVATION proposal
Overall objectives

- to pilot actions towards the implementation of the LEAPS Technology Roadmap

- to explore open innovation strategies for partnership with industry in development of cutting-edge technologies, including targeted actions to

o improve cooperation with industry as collaborators in high-technology development at an early stage

o better enable European industry to supply products and technologies to the LEAPS community, photon facilities worldwide and the general market

- to enhance industrial use of photon sources, in particular SMEs

- to pilot activities to engage users from academia and industry of large European research initiatives in the co-creation of innovative scientific instruments, particularly having relevance towards solving global challenges.

LEAPS League of European Accelerator-based Photon Sources

INFRAINNOV-04-2020 LEAPS INNOVATION proposal

LEAPS-INNOV strategy

Implement first projects of LEAPS roadmap

Foster and accelerate Co-Innovation & Co-Creation

Develop urgent technology with early involvement of industry WP2-WP7

Support and foster collaboration with industry WP8

Enhance use of LEAPS facilities by SMEs WP8

Pilot support of Co-Creation between LEAPS & HE clusters WP9

Draft strategy for sustainable Co-Innovation & Co-Creation of LEAPS

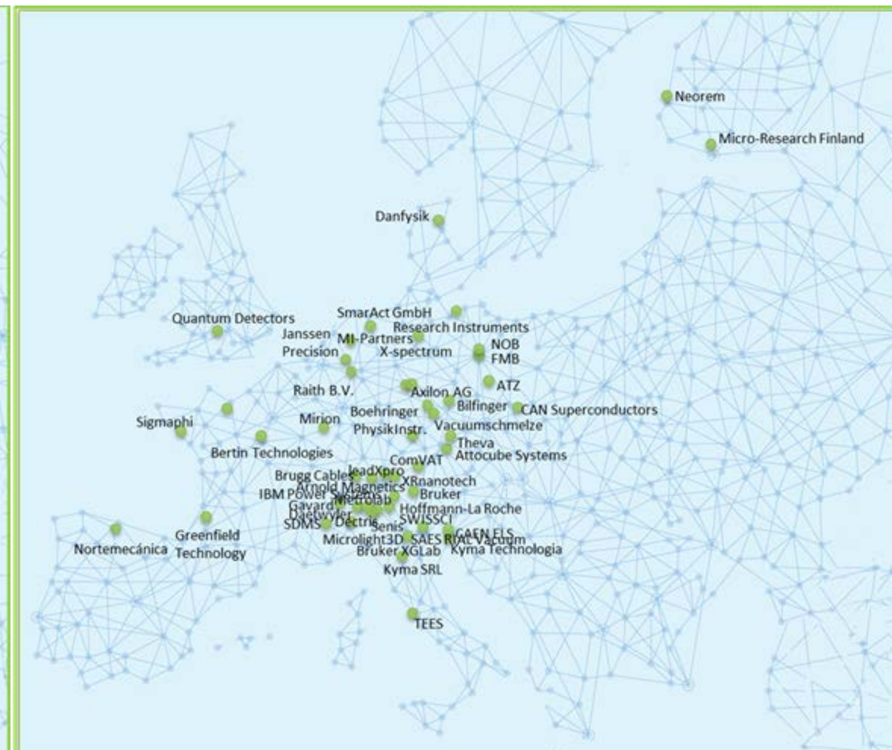
LEAPS League of European Accelerator-based Photon Sources

INFRAINNOV-04-2020 LEAPS INNOVATION proposal Consortium

22 beneficiaries: all LEAPS members (16), 3 SMEs, 3 technology partners (ENEA, KIT, STFC)

More than 50 European industrial partners of which > 77% are SMEs and 20 with support letter

Beneficiaries



Industry partners

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INFRAINNOV-04-2020 LEAPS INNOVATION proposal Tasks

WP	Title	Lead / Co-lead	WP leaders
WP1	MGT: Coordination, dissemination and exploitation	DESY	U. Krell
WP2	XAFS DET: Development of High Throughout X-ray Spectroscopy Detector System	DLS/SOLEIL	N. Tartoni F. Orsini
WP3	SuperFlat: The production of high-performance X-ray mirror and grating substrates	ESRF/SOLEIL	R. Barrett F. Polack
WP4	Nextgrating : Next generation of X-ray diffraction gratings	PSI/HZB	C. David F. Siewert
WP5	POSIT: New positioning and scanning systems for speed and accuracy	HZB/DLS	K. Kiefer R. Owin
WP6	LIDs : LEAPS Insertion Devices	SOLEIL/PSI/ ELETTRA	M.-E. Couprie T. Schmidt S. Di Mitri
WP7	DATA: Data Reduction and Compression	DLS/DESY	H Graafsma D. Bruce
WP8	INDUSTRY: Industrial Innovation through Light Source	DLS/ESRF/ ALBA	E. Shotton E. Mitchell A. Sanchez
WP9	CO-CREATION: Innovation by Co-creation towards Global Challenges	MAXIV	F. Heenies

LEAPS INNOVATION

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INFRAINNOV-04-2020 LEAPS INNOVATION proposal Budget

WP	Acronym	WP title	Lead / Co-Lead	PM	EC requested costs k€	Addittional Own contr. K€
1	MGT	Coordination, dissemination and exploitation	DESY	60	501	263
2	XAFS-DET	Development of high throughput X-ray spectroscopy detector system	DIAMOND/ SOLEIL	44	755	882
3	SuperFlat	The production of high-performance X-ray mirror and grating substrates	ESRF/ SOLEIL	122	2116	1283
4	NeXtgrating	Next generation of X-ray diffraction gratings	PSI/ HZB	102	1090	480
5	POSIT	New positioning and scanning systems for speed and accuracy	HZB/ DIAMOND	103	1080	2743
6	LIDs	LEAPS insertion devices	SOLEIL/ PSI/ ELETTRA	153	2003	1275
7	DATA	Data reduction and compression	ULUND/ DESY	121	994	775
8	INDUSTRY	Industrial innovation through light sources	DIAMOND/ ESRF/ALBA-CELLS	53	788	611
9	CO-CREATION	Innovation by co-creation towards global challenges	ULUND/ DESY	15	673	28

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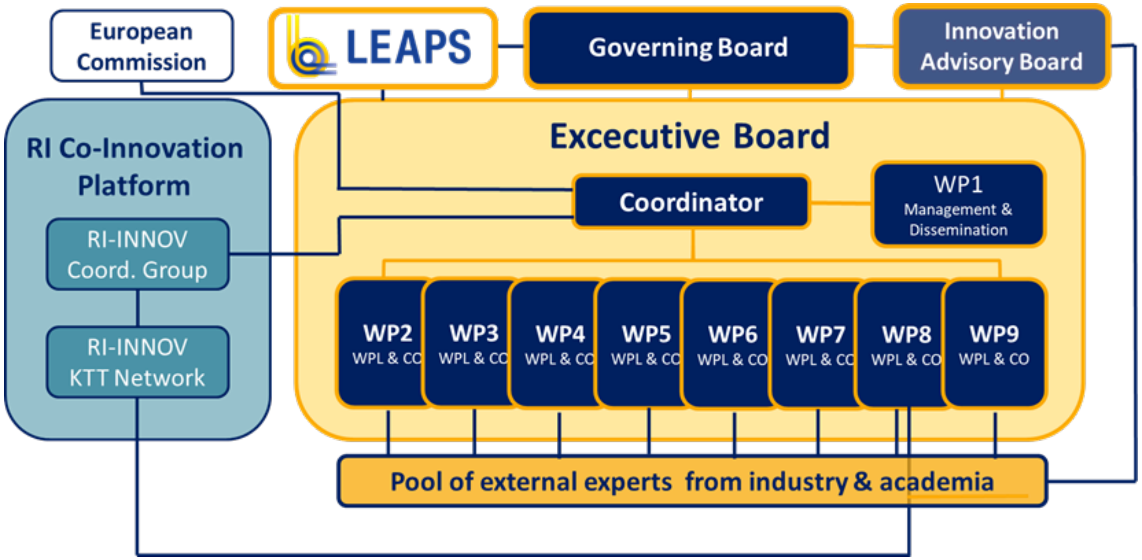
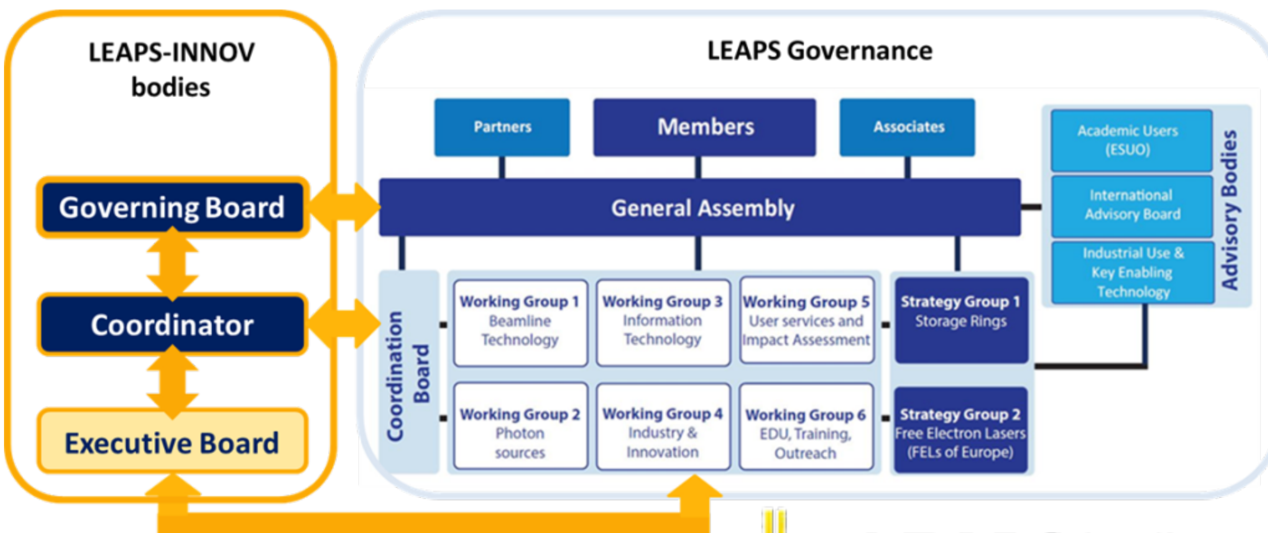
INFRAINNOV-04-2020 LEAPS INNOVATION proposal Governance





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INFRAINNOV-04-2020 LEAPS INNOVATION proposal

WP6: LIDs - LEAPS Insertion Devices

❖ Objectives:

- ✓ **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.**
- ✓ **The development will be made as follows:**
  - ✓ **early and continuous involvement of industry** to prepare the technology transfer to European industry
  - ✓ **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 and a cryogenic permanent magnet undulator (CPMU) with 10 mm period
  - ✓ **explore short period, high field elliptically polarising undulators with a cryogenic in-vacuum APPLE-III system by building two prototype undulators**: a cryogenic APPLE III undulator and a cost-effective compact APPLE X undulator
  - ✓ **build two prototypes of measurement benches to characterise the prototype undulators**: a small aperture, low temperature Hall probe measurement bench and a pulsed wire measurement bench

LEAPS League of European Accelerator-based Photon Sources

INFRAINNOV-04-2020 LEAPS INNOVATION proposal
WP6: LIDs - LEAPS Insertion Devices

❖ 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

DELIVERABLES
D6.1 Summary report on design of the short period high field prototypes (M12)
D6.2 Summary report on design of advanced EPU prototypes (M12)
D6.3 Summary documentation of the two measurement bench prototypes (M24)
D6.4 Summary report on performance of the short period high field prototypes (M42)
D6.5 Summary report on performance of the advanced EPU prototypes (M42)
D6.6 Midterm report on WP6 meets industry (M24)
D6.7 Report on WP6 KT and TT best practice (M46)

WP Tasks		Year 1												Year 2												Year 3												Year 4											
No.	Title	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
6.	LIDS																																																
6.1	Industry involvement																								D																						D		
6.2	Short period, high field, planar undulators for hard X-rays												D																								M						D						
6.3	Advanced EP undulators for soft X-ray												D																														D						
6.4	Measurement benches												MD												D																								

153 PM

LEAPS League of European Accelerator-based Photon Sources

INFRAINNOV-04-2020 LEAPS INNOVATION proposal
WP6: LIDs - LEAPS Insertion Devices

❖ Impact:

- **On storage rings, FELs and compact sources**
- **Bring companies to a strong position in the world market**
- **support structuring European industry for a market that1 will grow with the arrival of new facilities and large facility upgrades**

❖ Participants:

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

LEAPS League of European Accelerator-based Photon Sources

INFRAINNOV-04-2020 LEAPS INNOVATION proposal

WP6: LIDs - LEAPS Insertion Devices

Task 6.1 Industry involvement (EuXFEL, ELETTRA, all) M1-M48

possible patents or technology licences.

targeted by technology transfer of the prototypes to interested companies.

For a full undulator:
KYMA (SI), Danfysik (DK), Sigmaphi (FR), Research Instruments (DE), Bilfinger Noell (DE), Axilon (DE), Bruker (CH), AVS (ES)

For the magnets:
Vacuumschmelze (DE), Neorem (FI), Arnold magnetics (CH)

For the magnetic measurement instrumentation: Senis (CH), Metrolab (CH)
For the superconducting components:
Bruker (CH), CAN superconductors (CZ), Theva (DE)
For the carriages and mechanical parts:
Nortemecanica (ES)
For the vacuum chamber:
SAES RIAL Vacuum (IT), SDMS (FR), FMB (DE), ComVAT (CH), TEES SRL (IT)

Regular meetings with industry

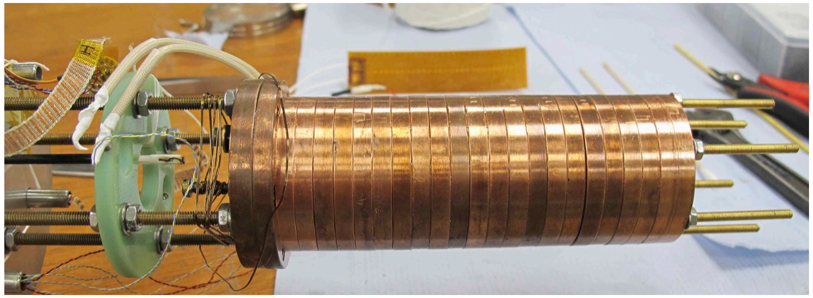
Aiming at technology transfers

INFRAINNOV-04-2020 LEAPS INNOVATION proposal
WP6: LIDs - LEAPS Insertion Devices

Task 6.2: Short period, high field, planar undulators for hard X-rays (PSI, SOLEIL, DIAMOND, ELETTRA, ESRF, HZB, ULUND,) M1-M48

Period ~ 1 cm, Length ~ 1 m

- a prototype based on cutting-edge HTS SCU technology lead of PSI / ESRF, will be built at PSI

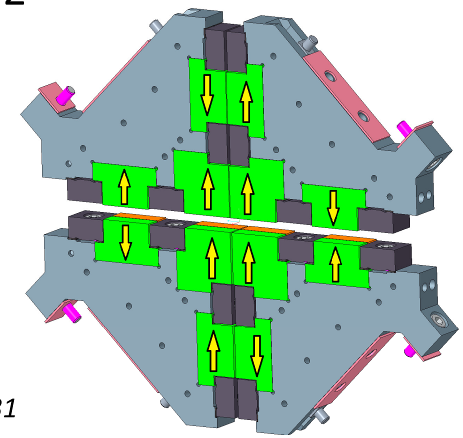


- a prototype such as a CPMU will be designed under the lead SOLEIL / DIAMOND, built at SOLEIL.

Ex of the 3 m CPMU under construction at SOLEIL

INFRAINNOV-04-2020 LEAPS INNOVATION proposal
WP6: LIDs - LEAPS Insertion Devices

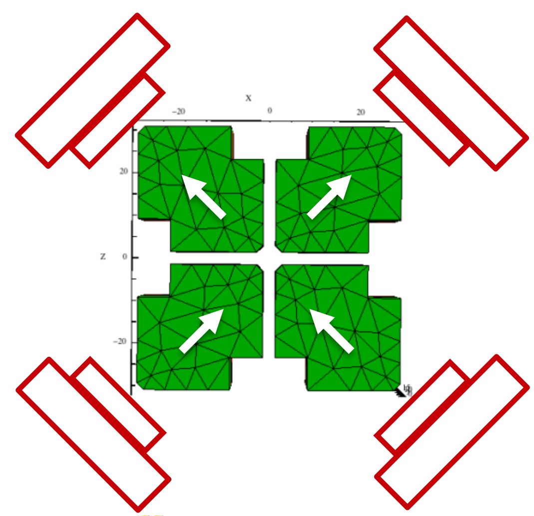
Task 6.3: Advanced elliptically polarising undulator (EPU) for soft X-ray (HZB, ULUND, DESY, DIAMOND, ELETTRA, SOLEIL) M1-M42



- Explore the ultimate possibilities of short period EPUs in developing a cryogenic in-vacuum short period EPU prototype which will be built at HZB, led HZB /SOLEIL,

J. J. Bahrdt, In-vacuum APPLE II undulator with force compensation, AIP Conference Proceedings 2054, 030031 (2019); https://doi.org/10.1063/1.5084594

- Optimise the recent trends for APPLE X type of compact performing elliptically polarising undulator



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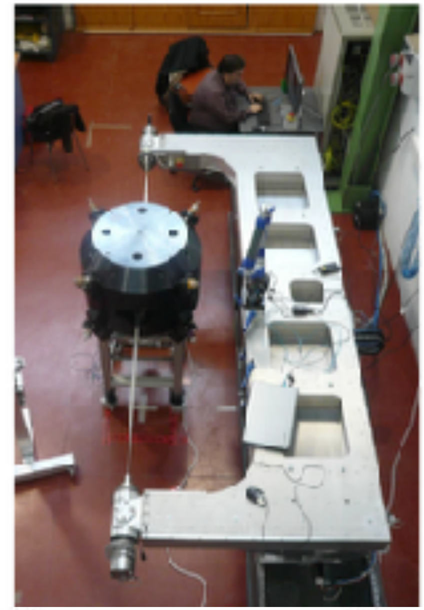
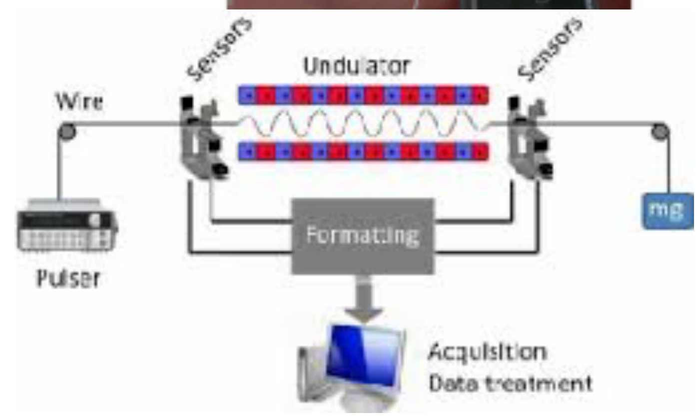
INFRAINNOV-04-2020 LEAPS INNOVATION proposal
WP6: LIDs - LEAPS Insertion Devices

Task 6.4: Measurement benches (ALBA-CELLS, DESY, ELETTRA, EuXFEL, HZB, PSI, SOLEIL, STFC, ULUND) M1-M24



- a Hall probe bench for small gaps and low temperatures under vacuum build at and lead ALBA-CELLS / DESY

- a bench prototype using the pulsed wire technology with the capability to obtain phase error information even for small period undulators, built at EuXFEL, lead EuXFEL / ULUND.



LEAPS League of European Accelerator-based Photon Sources

Additional slides

Objective 6	Photon Sources
Ambition	**Novel insertion devices for higher brilliance photon beams**
LEAPS Technology Roadmap	The LEAPS RIs are based on electron accelerator driven sources, storage rings and FELs. Whilst SR sources have been established for decades, recent development of so-called multi-bend achromat storage rings allows a dramatic increase of photon beam brilliance and coherence. FELs are complementary to storage rings with the capability to provide extremely intense, coherent photon pulses of femtosecond duration. Key challenges for FELs are better control of spectral and temporal properties to match future experimental requirements for improved energy and time resolution. In the longer term, many technologies and research activities at LEAPS facilities, including new compact sources (using plasma wakefield acceleration) will enhance specific capabilities of the current light sources and make them potentially available for specialised industrial, medical and smaller laboratory environments. A main goal of LEAPS is to maintain photon source technology in Europe at the leading edge worldwide and improve the competitiveness of the European accelerator industry though joint research in fields such as magnet systems (e.g. insertion devices), higher brilliance electron beams, laser systems or advanced diagnostics.
LEAPS-INNOV Action **WP6 LIDs**	To bring forward all photon sources and achieve a high technology transfer impact within the project time, WP6 will focus on one common SR and FEL research area with strong specificity for accelerator-based photon sources: insertion devices (ID - magnet systems for generating the photon beam) for the next generation of intense, high brilliance SR and FEL sources for users. WP6 aims to push the limits of present technology towards more compact, more sustainable and cheaper IDs which offer more flexibility and a presently unreachable performance. Four highly advanced undulator systems and two measurement benches for characterisation of the prototype undulators will be developed within the work package. The prototypes will go well beyond state-of-the-art and will combine two development goals: cutting-edge technologies and robust, reliable, cost effective systems. WP6 will aim at an early and continuous involvement of all specialised European suppliers capable of manufacturing these high-tech devices with the goal of preparing a technology transfer model which not only enables European suppliers to produce the new undulator types but also can be a role model for the LEAPS community.

INFRAINNOV-04-2020 LEAPS INNOVATION proposal

WP1: MGT - Coordination, dissemination and exploitation

- ✓ **Coordinate the overall project** to ensure the objectives are delivered on time.
- ✓ **Organise regular follow-up meetings** of the projects boards and annual meetings to ensure progress and results are communicated efficiently within the consortium
- ✓ **Follow-up contractually and financially** the project and use of resources
- ✓ **Coordinate the dissemination and exploitation activities**
- ✓ **Cooperation with the other projects of INFRAINNOV towards open innovation**

WP2: XAFS-DET - Development of High Throughput X-ray Spectroscopy Detector System

- ✓ **Design a new generation of Germanium detectors for X-ray spectroscopy applications**
- ✓ **Deliver prototype detectors with performance well beyond the state-of-the-art.**

LEAPS League of European Accelerator-based Photon Sources

INFRAINNOV-04-2020 LEAPS INNOVATION proposal

WP3: SuperFlat - The production of high-performance X-ray mirror and grating substrates

- ✓ **Improve European capabilities for the production of high-performance X-ray mirror and grating substrates by developing improved optical surface processing and metrology technologies** essential for the industrial production of reflective optics capable of fully exploiting the performance of current and future X-ray light sources.

- ✓ **3 development activities:**
  - ✓ **A PCP action** to develop pilot processes for industrial production of moderate length flat X-ray mirrors with sub-1 nm figure errors and sub-50 nrad slope errors with surface roughness at the 1 Ångström level
  - ✓ **Exploration of basic limits of figure correction technologies for X-ray mirrors** in view of more complex optical figures
  - ✓ **Development of new metrology methods suitable for implementation in industrial environments applicable to complex optical figures**, including developing a universal data format for describing the measured surface topography of X-ray reflective optics.

LEAPS League of European Accelerator-based Photon Sources

INFRAINNOV-04-2020 LEAPS INNOVATION proposal

WP4: Nextgrating – Next generation of X-ray diffraction gratings

- ✓ **Development of designs for next-generation x-ray gratings** with advanced optical performance and functionality, including simulation of grating structures. Definition of prototype parameters. **Procurement of suitable substrates**.

- ✓ **Ex-situ metrology** on initial substrates, test grating structures, and finalized grating prototypes to safeguard the stringent requirements regarding shape errors, slope errors and surface roughness.

- ✓ **Development of the EBL processes** based on grey tone exposures in resists and pattern transfer into suitable substrates. Coating of the grating surfaces. Optimization of the exposure tools regarding hardware and software, development of writing strategies for efficient large area exposures. Exposure and pattern transfer of final prototypes gratings.

- ✓ **Characterization of prototype gratings**, first with optical and AFM metrology for profile shape and regularity, then with synchrotron and FEL radiation regarding their efficiency, and spectral resolution. Novel optical functionalities enabled by the EBL approach will be verified.

LEAPS League of European Accelerator-based Photon Sources

INFRAINNOV-04-2020 LEAPS INNOVATION proposal

WP5: POSIT - New positioning and scanning systems for speed and accuracy

- **Developing demonstrators for translation and rotation on the nanometre scale** which allow for faster and more accurate sample scanning. This implies not just positional accuracy but also, critically, measurement and feedback on sample location.
- **Developing a protocol to standardise the use of generic hardware** to solve nano-second synchronisation challenges of a multitude of beamline components for future streamlined implementation of in-situ timing experiments
- **Developing a common, pan-European, standardised set of tools and sample holders** for samples in solution and new modes of contactless sample delivery for room temperature experiments.

WP7: DATA - Data Reduction and Compression

- Establishing a collaboration platform for data reduction and compression
- Assessment of future needs and development of metrics on possible technics
- Adopting algorithms and techniques for lossless and lossy data compression
- Early knowledge exchange with industry

LEAPS League of European Accelerator-based Photon Sources

INFRAINNOV-04-2020 LEAPS INNOVATION proposal

WP8: INDUSTRY - Industrial Innovation through Light Source

Coordination, support and networking activities with the objective to support the transfer of LEAPS skills, technology and know-how towards industry and the economy.

- **Boosting trans-LEAPS links** to exploit the critical mass of LEAPS towards industry
- **Supporting the LEAPS-INNOV technology work packages** and working with the WP9 co-creation pilot studies in intellectual property, industrial collaboration and exploitation of results
- **Supporting the Co-innovation Platform on RI technology developments** towards industry beyond the LEAPS light sources
- **Providing a dedicated SME access system** to exploit the LEAPS facilities, labs, skills and expertise
- **Building bridges towards industry** in its role as user, collaborator and supplier.

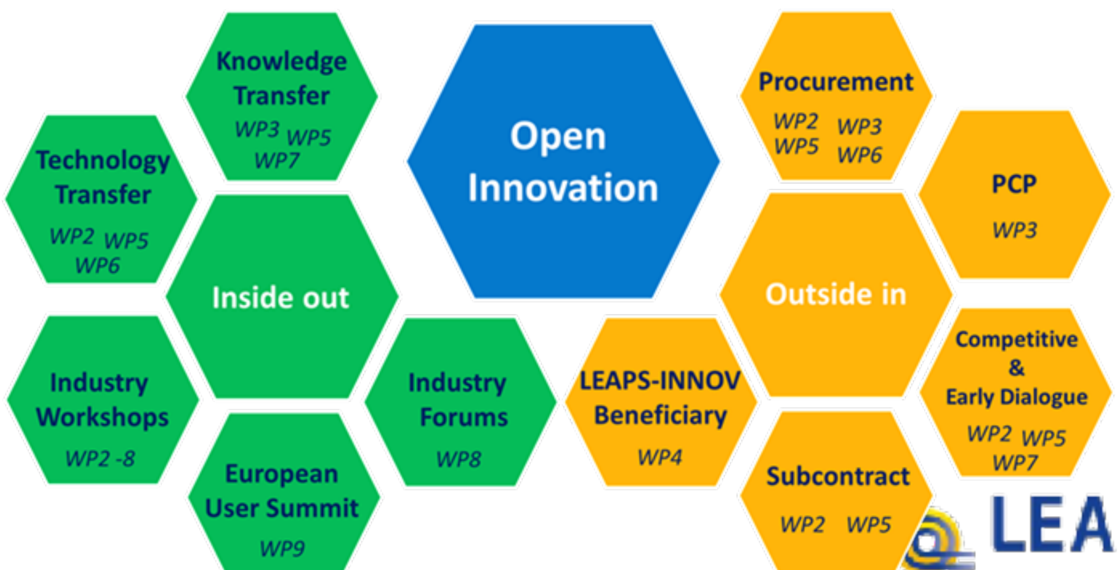
LEAPS League of European Accelerator-based Photon Sources

INFRAINNOV-04-2020 LEAPS INNOVATION proposal

WP9: CO-CREATION - Innovation by Co-creation towards Global Challenges

- **Establish a network of high-impact science consortia in Europe** to identify new-areas for co-creation, develop a co-creation advisory forum and create a whitepaper "co-creation strategy" for LEAPS
- **Launch a small number of co-creation pilots** addressing technology challenges collaboratively
- **Organise events** addressing emergent science fields and addressing co-creation opportunities in these fields

LEAPS-INNOV will foster technological development through different approaches of Open Innovation



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