LEAPS Working Group 2 - Sources

Status and Activities

What´s going on?

Collaboration is the name of the game!

Digital LEAPS

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28th ESLS Workshop
16 – 17 December, 2020

LEAPS storage ring based light source facilities & partners

LEAPS laboratories:

ALBA

DESY. PETRA III

diamond

Elettra Sincrotrone Trieste

ESRF The European Synchrotron

HZB Helmholtz Zentrum Berlin BESSY II

INFN Istituto Nazionale di Fisica Nucleare DAFNE-Light

ISA ASTRID2

MAX IV

PTB MLS

PAUL SCHERRER INSTITUT PSI SLS

SOLARIS NATIONAL SYNCHROTRON RADIATION CENTRE

SOLEIL SYNCHROTRON

and LEAPS international partner labs:

SESAME since 2018

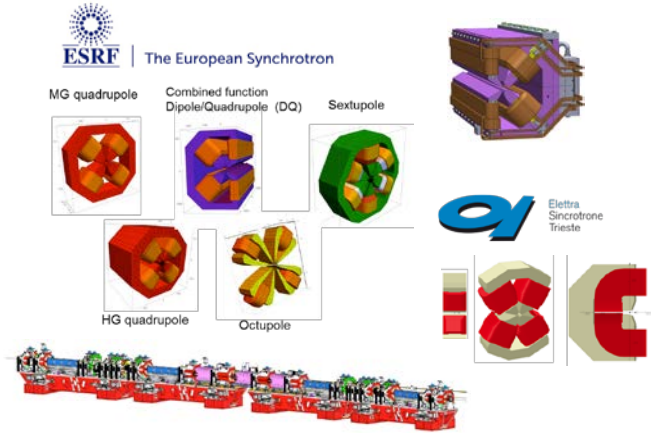
Canadian Centre canadien Light de rayonnement Source synchrotron since 2020

First ideas for a technology roadmap (SOLEIL Workshop 2017, …)

Goal: to define technology roadmap, valid for 7 years, starting 2021,
worth some 100 Mio€ of funding …

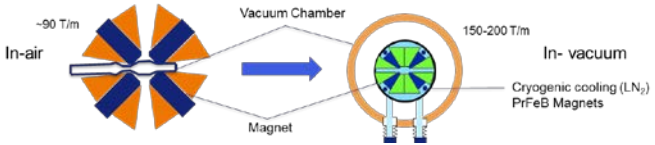
- extrapolate from the present activities (funded upgrades) to a more distant future
- take into account the needs of upgrades of existing facilities and new facilities presently under study / preparation / discussion (most likely some of them will start before outcome of Technology Roadmap is there → ESRF-EBS = done ☺)
- do that as a joint activity, demonstrating that we are able and willing to join forces (together with industry) to advance our field
- identify and define common requirements and standards
- concentration on some major “technological developments”
- joint effort of FEL, Storage Ring, new Compact Sources (aka PWA)

e.g. work package magnet development & industrialisation

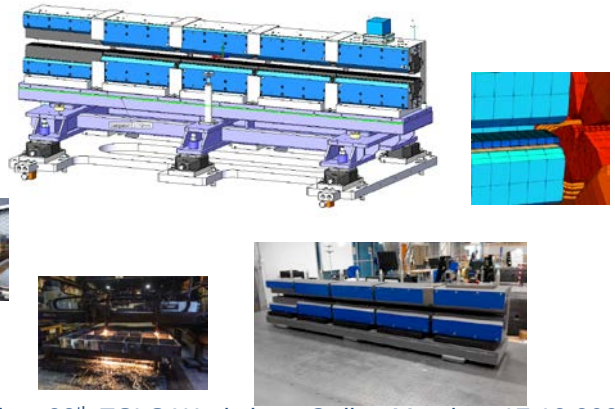


resistive magnets of many different kinds
- high gradient, “combined function”, …
- relying on highest manufacturing precision
- precise magnetic field measurement for development work and quality control

- are we at the limit? What next?



permanent magnets
- **large scale installation**
- **stability, field quality**
- **longterm rad. hard.**



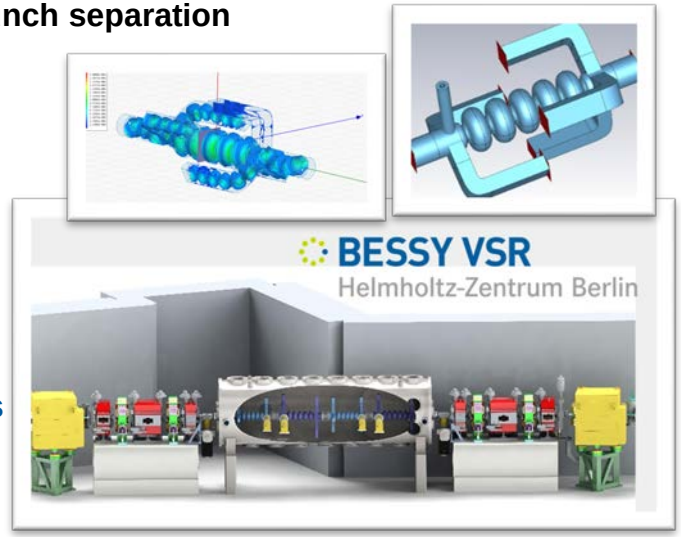
SR

FEL

Compact

e.g. work package nc/sc cavities

sc / nc. crab cavities
- **short photon pulses**
- **bunch separation**



sc cw multi cell, high gradient cavities
- **short electron pulses**
- **beating schemes for variable pulses**
- **usage in DLSR ?**

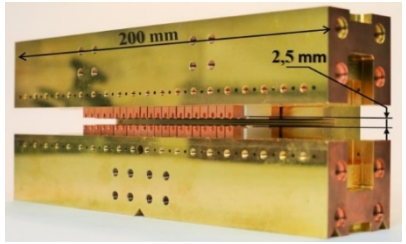
SR
FEL
Compact

- **nc/sc cavities with a variety of frequencies**
- **from some 10 MHz up to 2 GHz for ultimate control of the longitudinal phase space !**

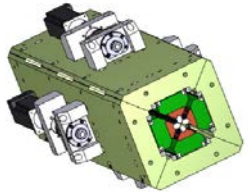
e.g. work package insertion devices

- advanced in-vacuum CPMU
  - polarized photons (APPLE II/III type)
  - shorter period length
- in-vacuum SC Undulators, polarized (?)
- special “dipole” / WLS like devices for “*hard* bending radiation” from DLSRs
  - with traceable field quality, e.g. for metrology applications

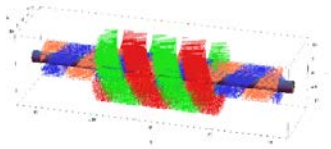
HZB 9mm-Prototyp 2 with hybrid poles (FeCo & PrFeB)



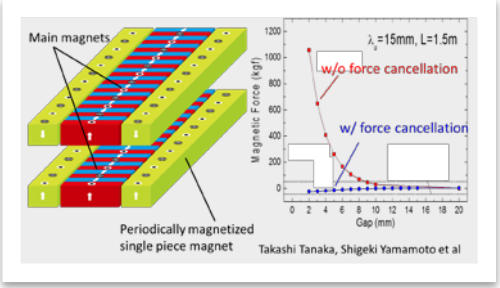
DELTA Undulator



sc Helical



force free P.M. IDs, fixed gap IDs



SR

FEL

Compact

Funding for ID development became (partly) reality
→ LIDS – LEAPS ID Pilot
(funded, lead by E.M. Couprie / SOLEIL & Th. Schmid / PSI)

The full view after collection of ideas for all different work packages (I)

Proposal	Submitting Authors	Labs interested in R&D	Total cost estimate Mio€	Topic S=synchroton F=FEL C=compact
Short period insertion devices	M.E. Couprie (SOLEIL) T. Schmidt (PSI)	SOLEIL, PSI, DESY, ELETTRA, ESRF, HZB, Diamond, Maxlab, ALBA, ANKA	33.4	S,F,C
High Gradient/Field magnets with very small aperture	P. Tavares (MAXLAB)	ALBA, ASTRID, HZB, Elettra, DESY, ESRF, MAX IV, PSI, SOLEIL	10.6	S,C
Seed laser systems	M. Danailov (ELETTRA)	DESY, ELETTRA, EU-XFEL,HZDR, LNF, PSI	3.5	F
Electron bunch control (advanced bunch compressor, Laser heater, collimation)	S. Di Mitri (ELETTRA)	DESY, ELETTRA, EU-XFEL, MAXLAB, PSI	2.9	F,C
Advanced schemes for tailoring FEL pulses	S. Werin (MAXLAB) E. Allaria (ELETTRA)	ELETTRA, PSI, DESY, SOLEIL, MAXLAB, Eu-XFEL, DESY	14	F, C
Low emittance Photo-injectors (cw/sc and pulsed/nc)	T. Kamps (HZB)	HZB, DESY, HZDR, PSI, ELETTRA, LNF, MAXLAB	12	F,C
LEAPS accelerating techniques cwRF	H. Weise (DESY)	DESY, EUuXFEL, NCNR (Poland)	6.1	F
FEL tests stand (either stand-alone or attached to existing FEL)	M.E. Couprie (SOLEIL), B. Faatz (DESY)	SOLEIL, DESY, ELETTRA, PSI	24-41	F
Tunable high power THz source for Eu-XFEL	Frank Stephan (DESY Zeuthen)	DESY, EU-XFEL (+ large number of potentially collaborating universities)	5	F
Very small aperture vacuum chamber	T. Schmidt (PSI) C. Herbeoux (SOLEIL)	ALBA, DESY, PSI, ANKA, SOLEIL, DIAMOND, MAXLAB	10	S,F

The full view after collection of ideas for all different work packages (II)

Proposal	Submitting Authors	Labs interested in R&D	Cost estimate Mio€	Topic S=synchroton F=FEL C=compact source
Injection systems for low dynamic aperture rings (kicker and pulser)	R. Bartolini (DIAMOND)	ALBA, Elettra, DESY, HZB, ESRF, MAXLAB, PSI, SOLEIL	6.5	S
sc / nc cavities for bunch length control + RF systems	Jens Knobloch, Andreas Jankowiak (HZB)	ALBA, DESY, HZB, MAX IV, SOLEIL	15.9	S,F
Diagnostics and Feedback for advanced photon beam stability	G. Rehm (DIAMOND) R. De Monte (ELETTRA)	DIAMOND, Elettra, HZB, MAX IV, ESRF, PSI, SOLEIL	8.9	S,F
Sub femtosecond timing and synchronization	S. Hunziker (PSI)	PSI, DESY, ELETTRA	2.5	F,C
Joint R&D on compact plasma accelerator for photon science (context EU design study EuPRAXIA)	R. Assmann (DESY), M. Ferrario (INFN), U. Schramm (HZDR)	DESY, INFN, HZDR, ..., EuPRAXIA (EU) Consortium (38 institutes)	45	C

What happened since 2017?

- ESRF EBS commissioned, in user operation since 08/2020
- Elettra 2.0 funding decision in 2018, working on DDR, start implementation 2025
- SLS 2.0 CDR 2017, preparing for funding decision (Swiss parliament) 12/2020
- PETRA IV CDR 2019, TDR to be delivered 2022
- Diamond-II CDR 2019, working on TDR
- SOLEIL upgrade, working on CDR
- BESSY III / MLS II (combined “green field” facility), working on CDR
- SOLARIS working on new full energy injector for TopUp
- ALBA upgrade (low emittance) design started
- MAX IV first thoughts toward upgrade to 10 keV diffraction limited photons
- CLS start TopUp operation 06/2021, working on CLS2 CDR

Sorry for anything forgotten or not knowing everything!

Some general trends (my personal view) are visible

- in general aiming for much lower emittances (200pm, 100pm, 10pm) (the name of the game)
- some trend to go for (somewhat) higher beam energies
  Diamond-II: 3.0 → 3.5 GeV, SLS 2.0: 2.4 → 2.7 GeV, BESSY III: 1.7 → 2.5 GeV, MLS II: 0.6 → 1.2 GeV, …
- on axis injection
- need for advanced longitudinal phase space manipulation to provide
  - long bunches under all conditions to maintain emittance goal and guarantee reasonable lifetime
  - ps bunch length (some need visible).

- vacuum apertures 10-20mm with resp. reduced magnet apertures, NEG coating, quadrupole gradients 100 T/m, permanent magnets for dipoles/multipoles, digital twins, ML, AI, …

The “LEAPS Technology Collaboration(s)” – What can we do?

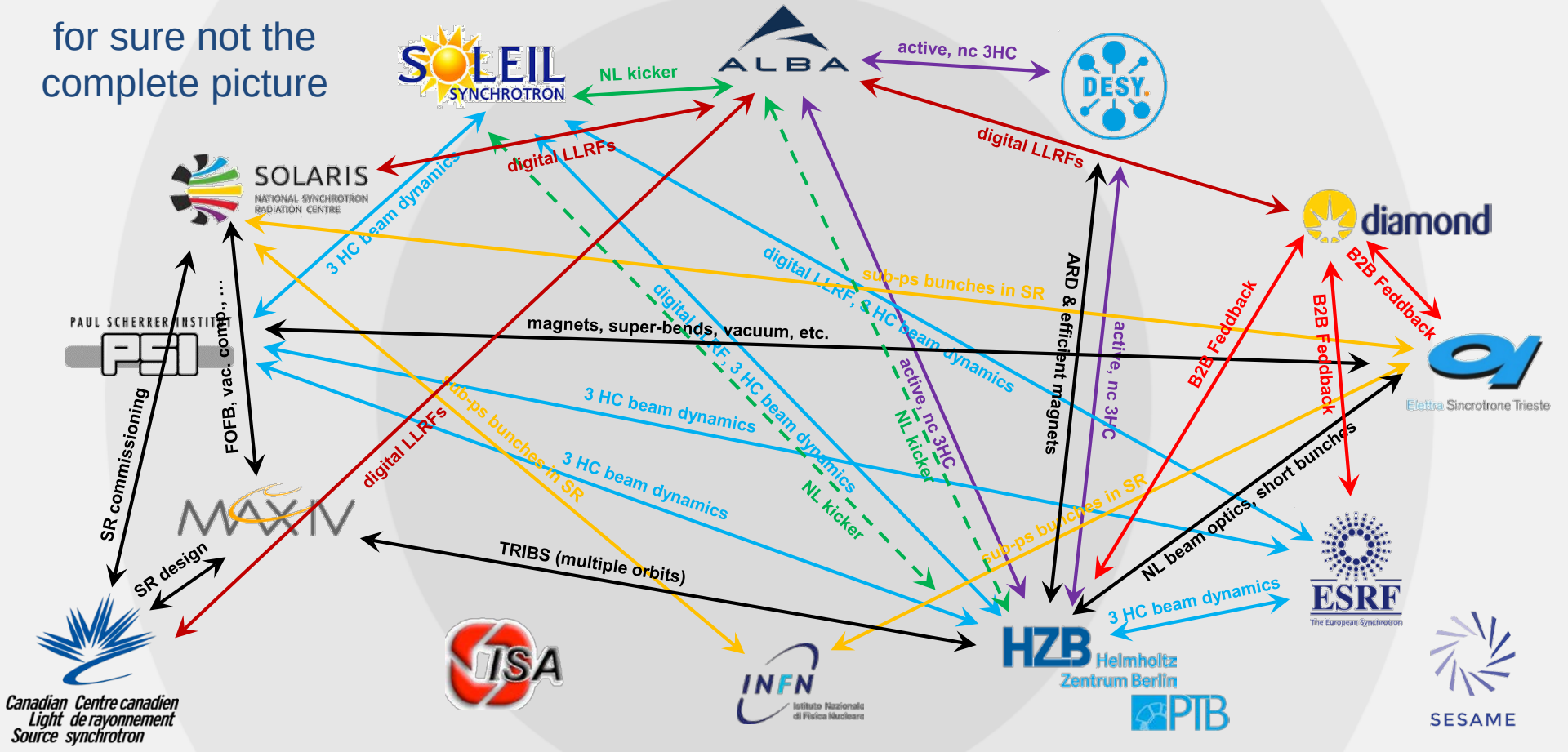
We all are involved in an continuous, ever lasting R&D process in accelerator science and technology to provide new capabilities and improved performance and stability to our international user communities.

Building on the (world leading) accumulated expertise of all LEAPS partners, I am convinced that in an collaborative effort it is possible to harvest strong synergies, gain more efficiency, and be more labour and cost effective in the development of new concepts, technologies (and in purchasing the required hardware?).

On the mid- to long-term this effort may find support by funds of the European Union, but even without I believe in the strength of such collaborations.

Already existing collaborations between LEAPS labs on SR technology

for sure not the complete picture

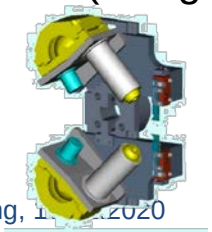


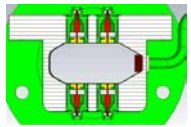
And for sure many more between LEAPS labs, partners, and others …

Possible R&D topics – personal summary

- Efficient and sustainable magnets with high gradients / fields (and PS)
  EM / PM / Hybrid, tuneable, dipole / multipole-magnets for our upgrade projects
  - data base of all existing magnets designs and performance parameters (from prototypes to series magnets)
  - definition of joint requirements and standards (where possible)
  - shared / distributed responsibilities for different “standard” devices (together with industry?)
  - …

- Cavities for efficient longitudinal phase space manipulation
  active/passive nc/sc cavities for bunch lengthening (and shortening)
  - theory and experimental studies for “complex” systems
  - cavity development (including auxiliaries and RF transmitters) and testing (low power, high power, beam tests)
  - …
- Advanced Diagnostics and Feedbacks for photon beam stability “on the probe”
  Integration eBPMS, xBPMs, “probe cameras” / advanced feedback (using ML, AI)
  - Concept development
  - Hardware development (Photon beam stability monitors ?)
  - System tests
  - …





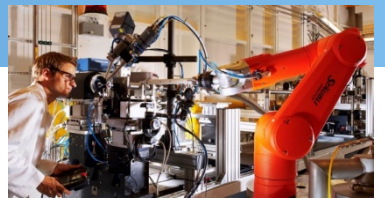
Possible R&D topics – personal summary

- On axis injection concepts and hardware
  (NL kicker, Ultra-Fast kicker/pulser, …)
- Beam loss management and control
  (collimators, shielding, beam loss & rad. measurement, …)
- Low aperture vacuum components
  (NEG coating, advanced handling procedures, …)
- Round beam generation / Multiple Orbits = TRIBs
  (emittance coupling with resonant skew excitation, advanced beam optics & dynamics, …)
- Advanced optimisation / automatization procedures
  (design / commissioning / operation – ML/AI, …)

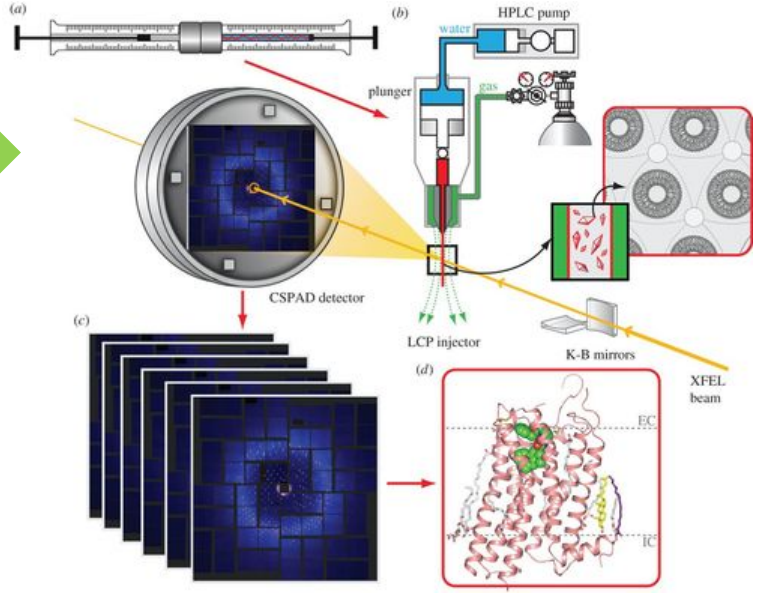
and of course as follow-up to LIDS

- Advanced Insertion Devices / Radiators
  (in-vacuum APPLE, variable period systems, APLLE-Knot, SCUs, SuperBends, …)

Digital LEAPS



- **AI-assisted resilient and energy-saving operation of LEAPS Research Infrastructures**
  Autonomous operation of complex accelerators
  Remote operation
- **Digital user operation modes**
  Remote user experiments
  Real-time analysis of data and real-time (exascale) simulations
- **Advanced Digital Communication**
  Lessons Learnt: new digital forms of communication between labs and between labs and users
- **Digital training concepts**
  New forms of training exploiting Virtual Reality (from schools to universities)
- **AI-assisted molecular infection fight**
  LEAPS facilities prepare for future infection fight *(virus, bacteria, parasites)*
- **Advanced materials for the digital transformation and circular economy**



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Digital LEAPS

DIGITAL LEAPS (DL):
a new Pathway of LEAPS Facilities into the Post-Corona Era

The DIGITAL LEAPS proposal is made up by four projects:

- **STAndardisation for Remote Sample Handling (STARS)**
- **LEAPS Integrated Platform (LIP)**
- **Reference Design for a Fully Automated User Beamline**
- **Collaboration Platform for LEAPS Members: From Technology News to "Innovation Mall"**

*Further LEAPS internal projects related to **Developments of Facilities** and to **Platforms and Networks** are proposed and they may be included in a different time scale.*

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Digital LEAPS – LEAPS Integrated Platform (LIP)

- The development of **an integrated platform**, *facility independent* interface system to access and operate our facilities, will be the back bone of this **DIGITAL LEAPS** project.
- The implementation of this new platform requires to involve competences within LEAPS on information technologies, industrial applications and innovation. A survey of available industrial standards shall be carried out prior to any concrete action in this direction.

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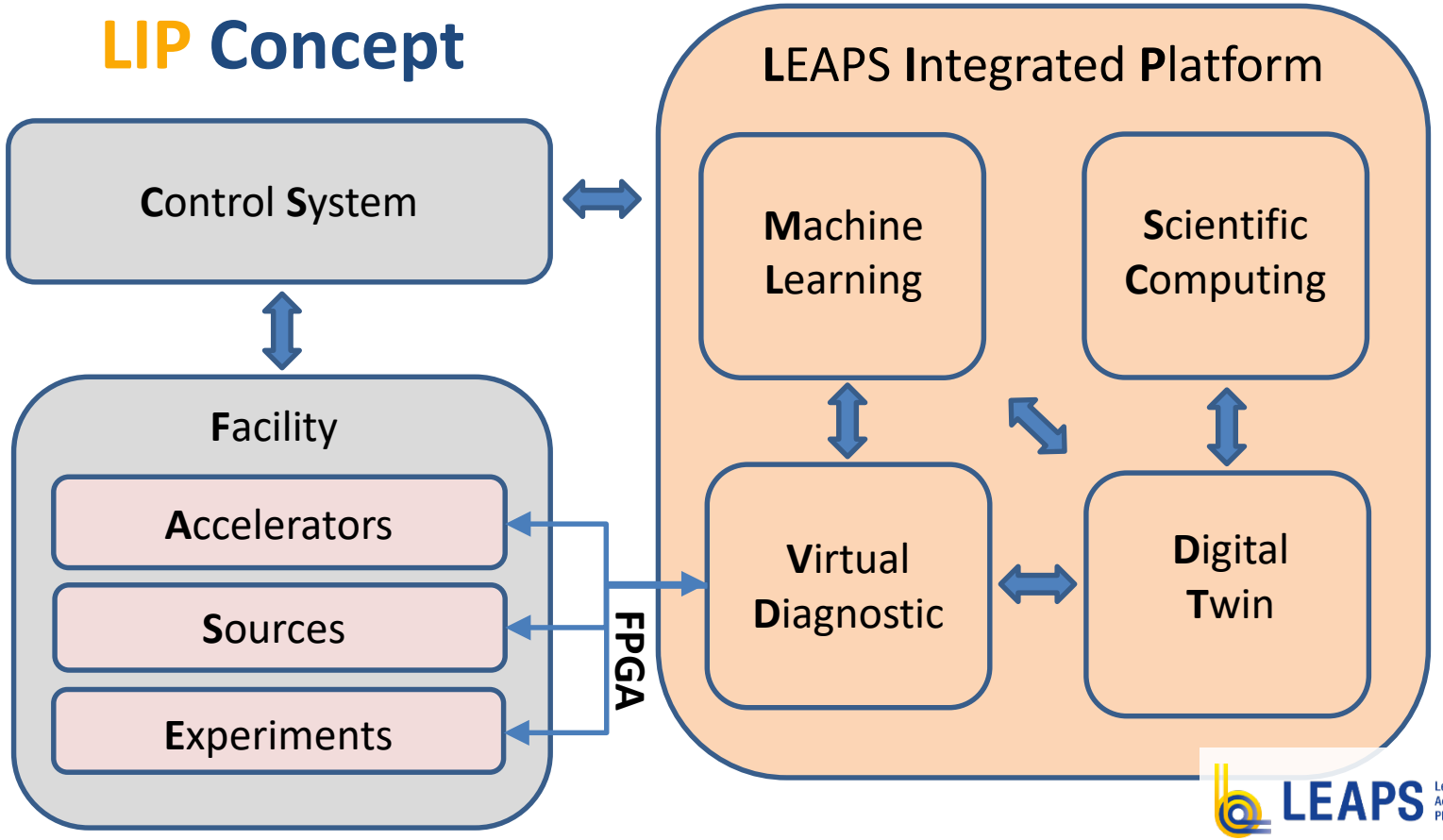
LEAPS Integrated Platform – The concept



LIP will enable faster and synchronized progress for intelligent & resilient operation of facilities

Work packages

- WP 1: LEAPS Integrated Platform (LIP)
- WP 2: Scientific Computing (SC)
- WP 3: Machine Learning (ML)
- WP 4: Virtual Diagnostic (VD)
- WP 5: Androids for Remote Access (ARA)
- WP 6: Remote Training (RT)

At present (till end 2020): LEAPS asks all labs where and how they will / want to contribute!

Role of LIP

Coordination between centres (we are stronger together), facilitate information exchange and fellowship programme, define interfaces, be inclusive, integration with existing work that is already being done at facilities.

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Light Matters

Thank you for your attention !