RESEARCH FACILITY

TOWARDS A MORE ENERGY-EFFICIENT
AND SUSTAINABLE PATH

THE KITTEN TEST FACILITY AND THE RESEARCH FACILITY 2.0 PROJECT FOR SUSTAINABLE RESEARCH INFRASTRUCTURES

DR. FALASTINE ABUSAIF (KIT)

On bahalf of the RF2.0 project

Funded by
the European Union

RF2.0

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THE KITTEN TEST FACILITY

KITTEN TEST FACILITY

- KIT Test Center for Energy Efficiency and Grid Stability.
- A joint venture between the accelerator KARA and the test field Energy Lab 2.0.

KIT TEN

KIT Testfeld für Energieeffizienz und Netzstabilität
in großen Forschungsinfrastrukturen

KITTEN TEST FACILITY

- Improving the energy use and power quality in large research infrastructures.
- Component ➡ System level: Incorporating ideas for energy efficiency and sustainability into both new and existing accelerators.

KIT TEN

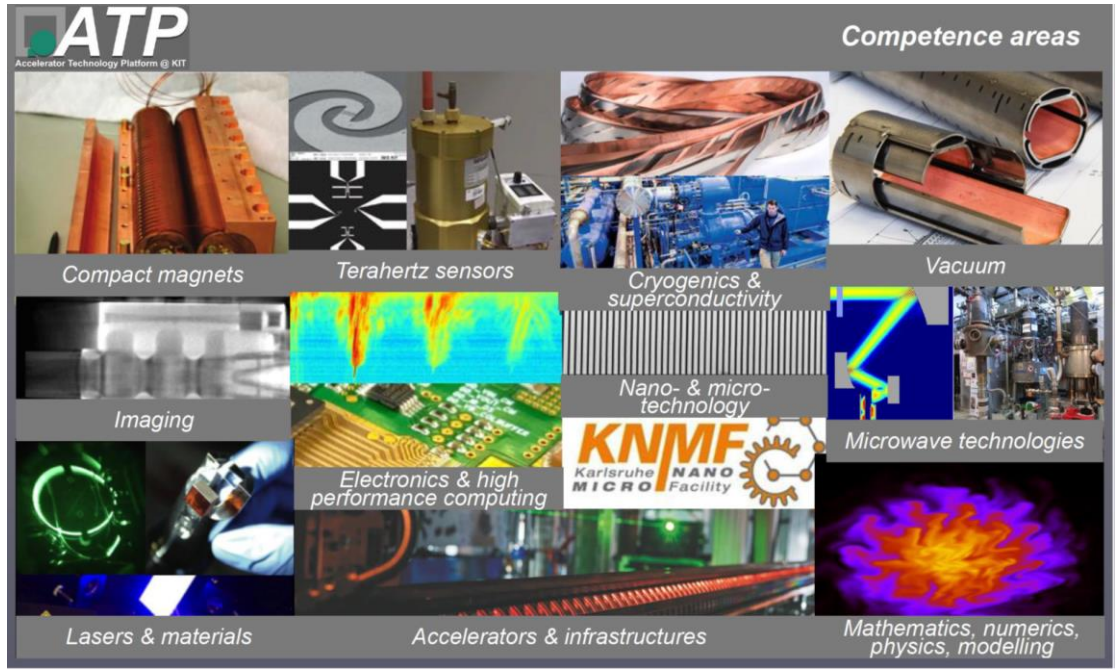
KIT Testfeld für Energieeffizienz und Netzstabilität in großen Forschungsinfrastrukturen

KITTEN TEST FACILITY

- KITEEN is embedded in the Accelerator Technology Platform (ATP) at KIT.
- ATP: Developing the accelerator technologies of the future, create new designs for the large-scale research infrastructures, and to operate them.

KIT TEN

KIT Testfeld für Energieeffizienz und Netzstabilität in großen Forschungsinfrastrukturen

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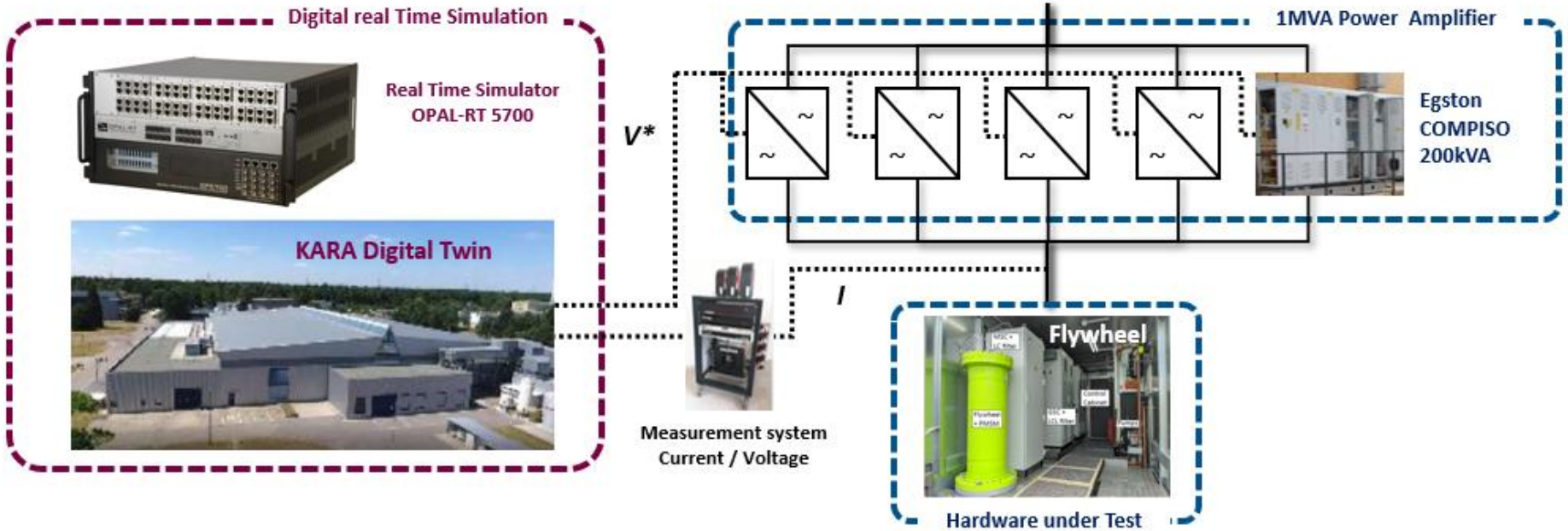
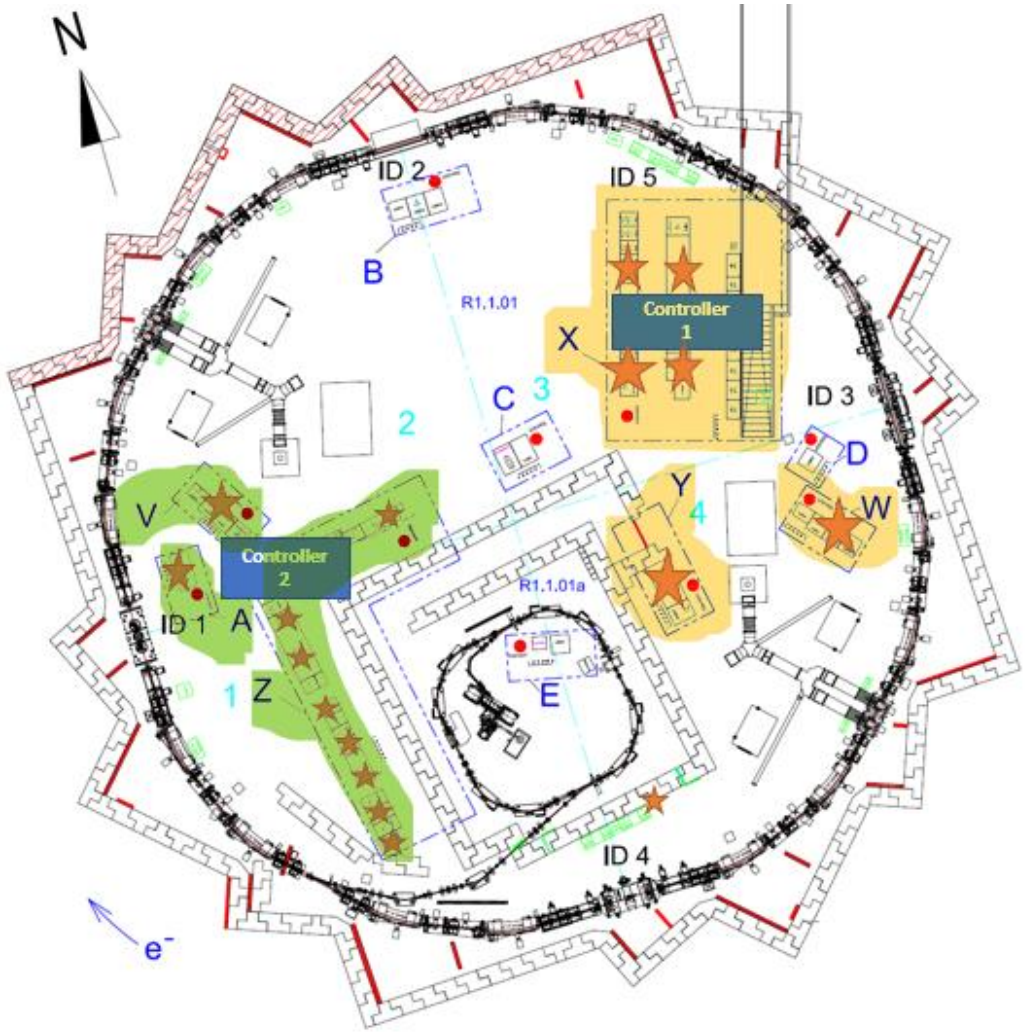
LATEST EFFORTS

KARA DIGITAL TWIN

- Digital replica of KARA: develop and validate new energy solutions, real-time monitoring and responsive decision-making.
- Possibility of experimental validation by means of Power Hardware In the Loop (PHIL) and explore flexible grid services.



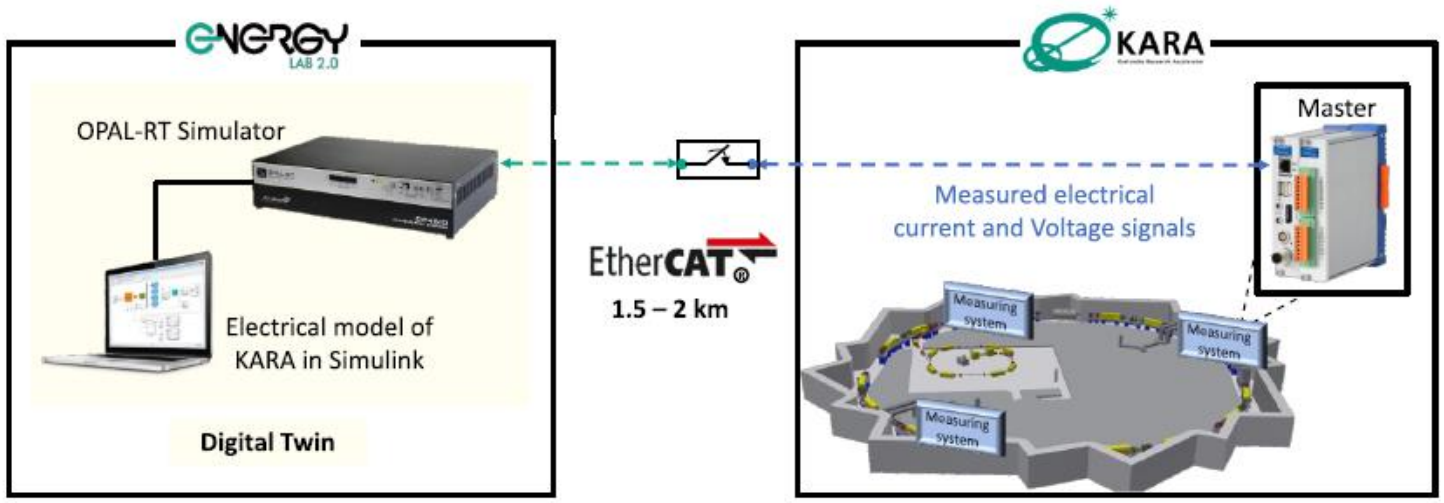


Installation of voltage and current sensors (>60) for fast data acquisition (Gantner A127).

Installation and tests of two fast data acquisition systems (Gantner Q.station and Q.sync).

KARA DIGITAL TWIN

- Data transfer from KARA to Energy Lab 2.0 via Ethernet at 1 kHz of first two connected sensors.
- Planning for data transfer via EtherCAT up to 10 kHz.



KARA DIGITAL TWIN

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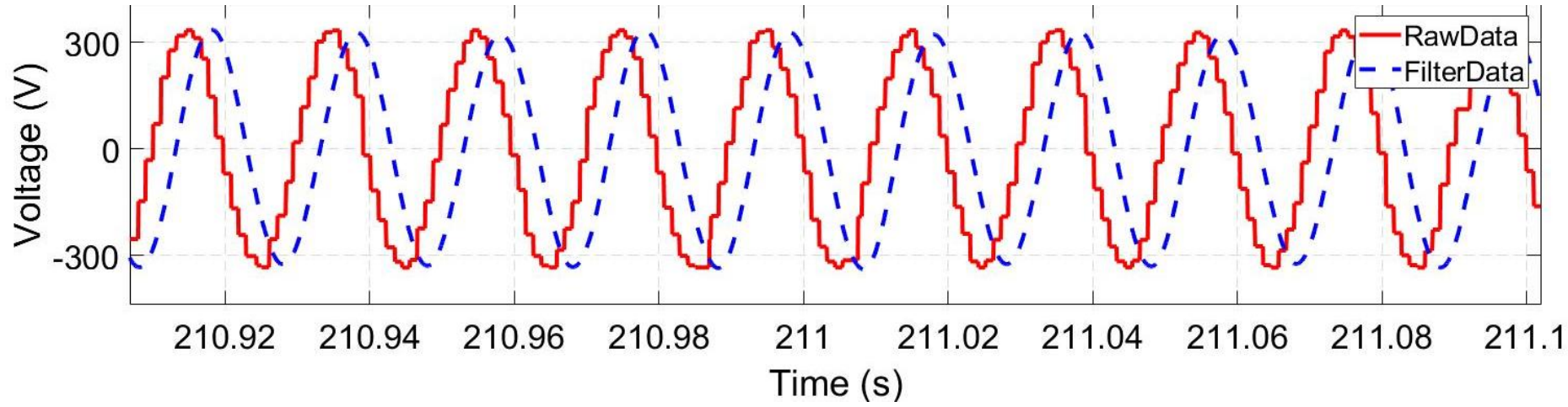
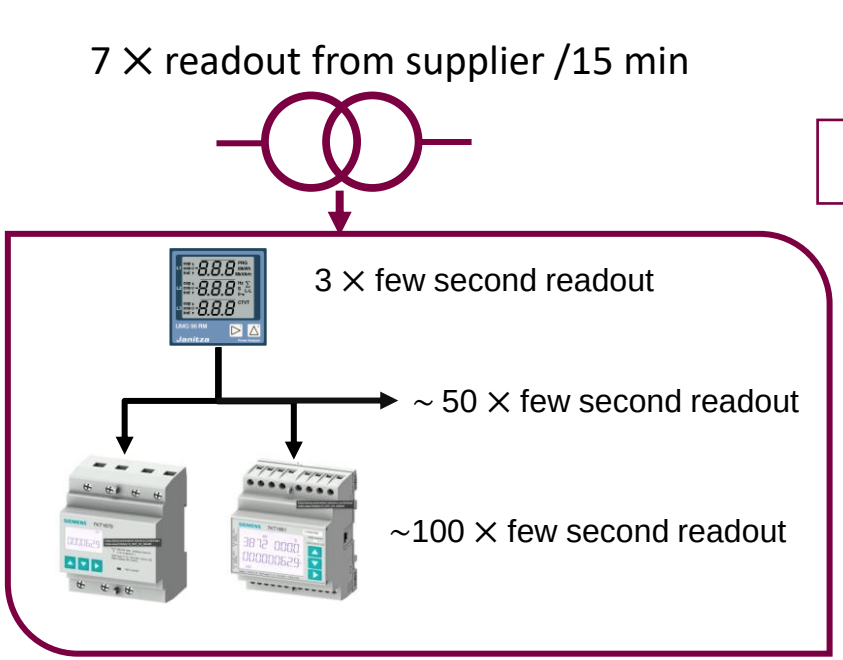
Voltage transmission in real time between KARA and EL2.0

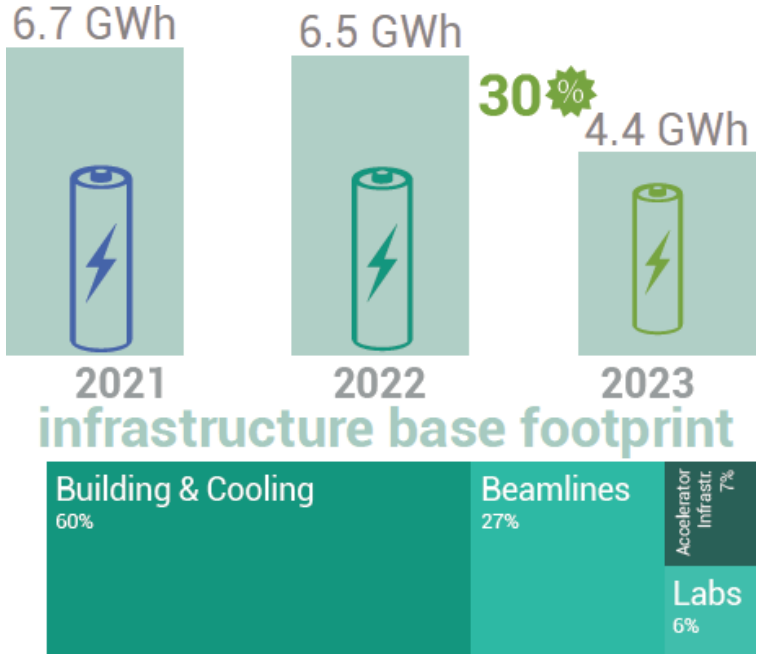


ENERGY-EFFICIENT ACCELERATORS

- Analysis of the main power consumers at KARA.
  - As a reference: analysis of the effect of super conducting insertion devices [J. Gethmann , et al., 2024].
- Decrease of the stand-by power consumption by 30 % of before KITTEN.



Informed actions

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RESEARCH FACILITY 2.0
(RF2.0)

CALL: HORIZON-INFRA-2023-TECH-01

NEW TECHNOLOGIES AND SOLUTIONS FOR REDUCING THE ENVIRONMENTAL AND CLIMATE FOOTPRINT OF RIS

Scope

- Delivering innovative technologies and solutions which reduce the environmental and climate footprint of RIs.
- Identifying common methodologies to assess environmental impact and strategies to reduce it.

Expected outcomes

- Reduction of environmental impacts.
- Optimization of resource and energy consumption through the full life cycle of RIs.
- Increased long-term sustainability of European RIs.

RF2.0: TOWARDS A MORE ENERGY-EFFICIENT AND SUSTAINABLE PATH

Project information:

Start date
1 January 2024

End date
31 December 2026

Funded under
Research infrastructures

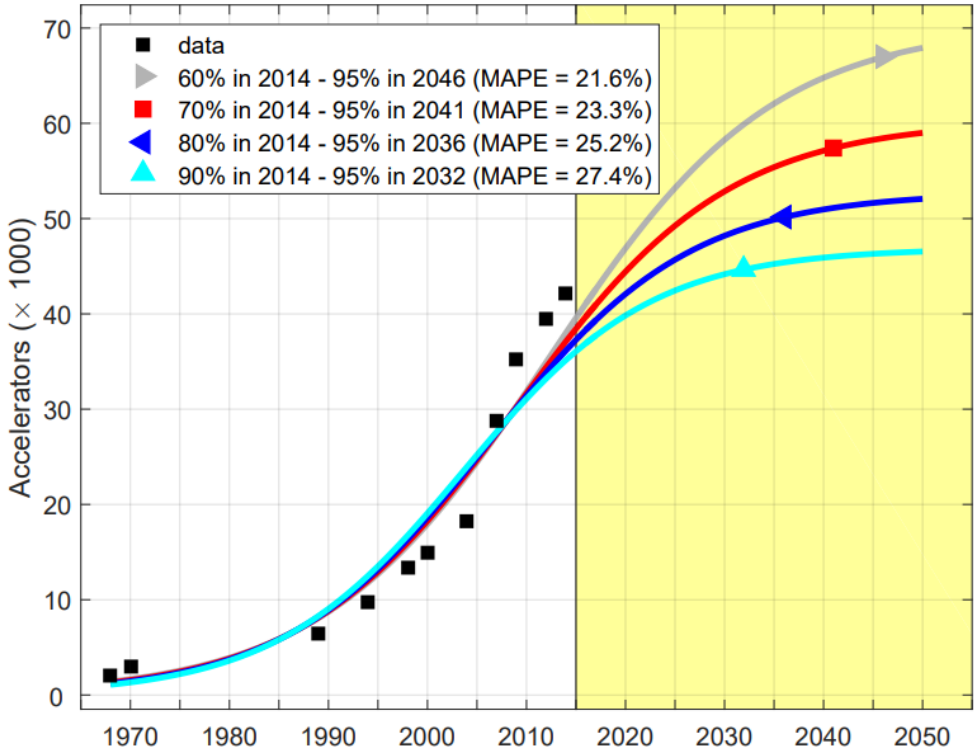
Total cost
€ 0,00

EU contribution
€ 4 999 625,25

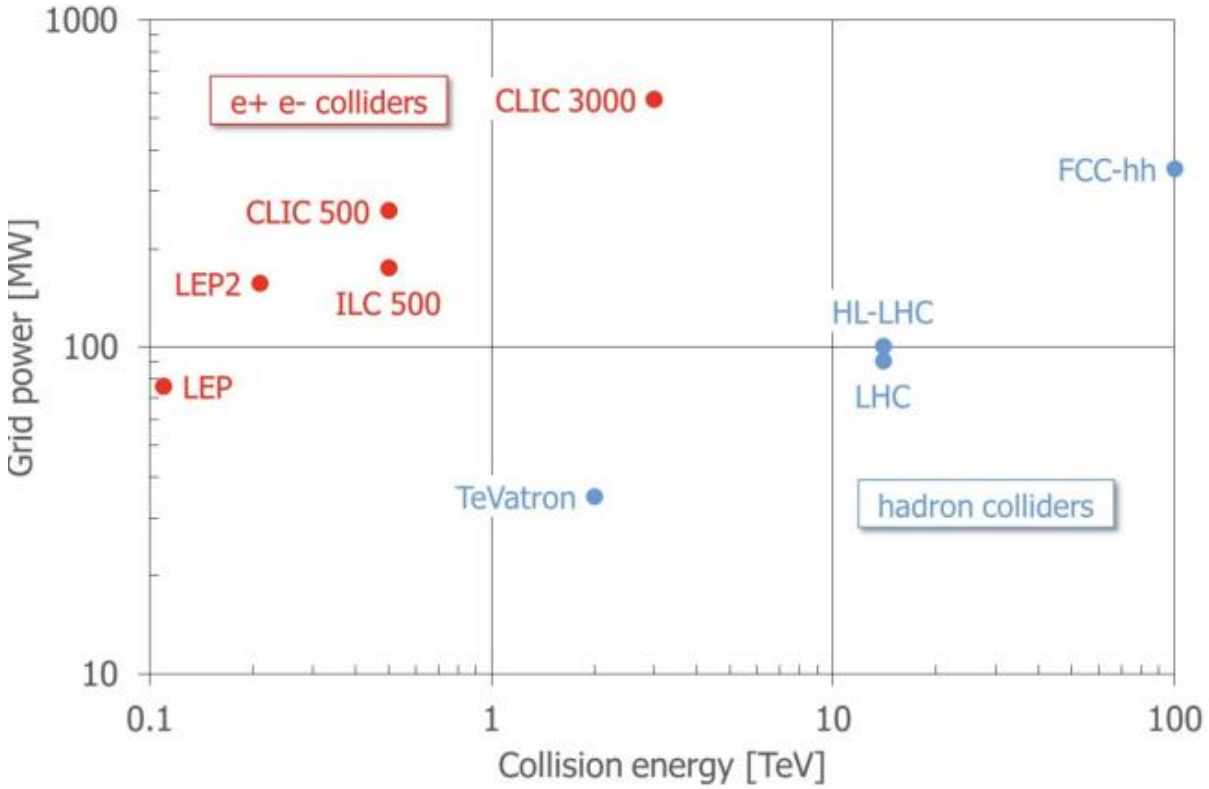
Coordinated by
KARLSRUHER INSTITUT FUER TECHNOLOGIE
Germany

CHALLENGES

Growing number of accelerators

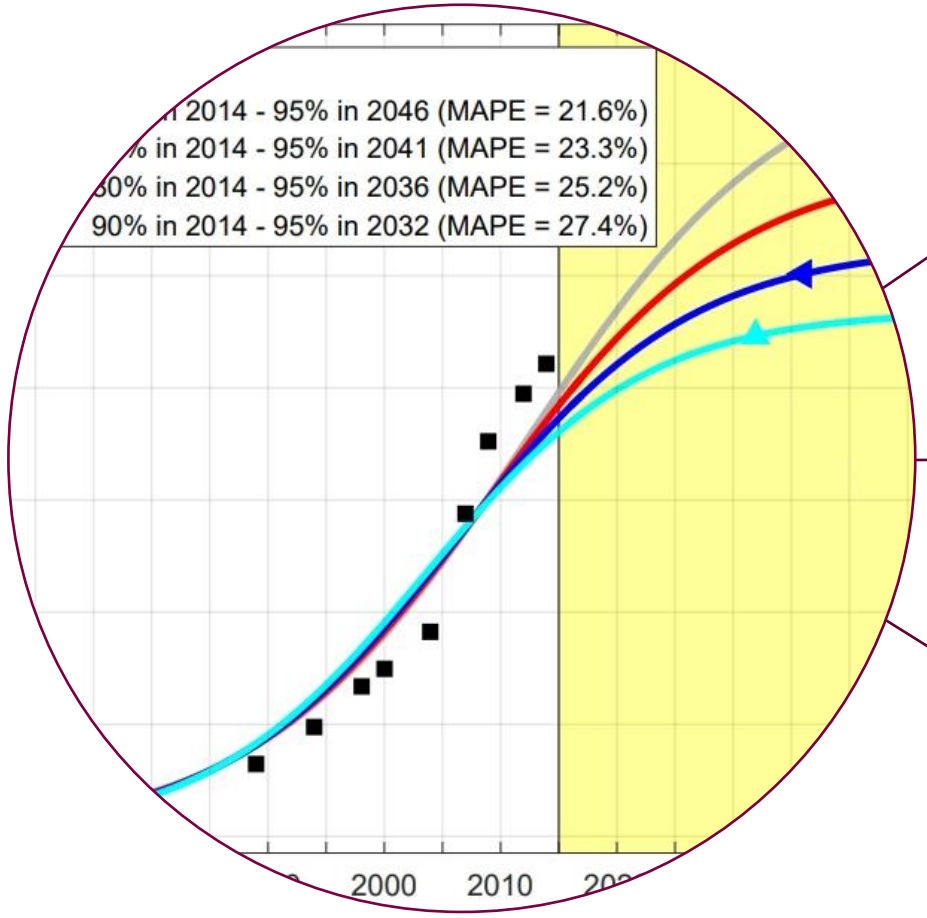


High power demands



[Paolo Castelnovo, 2018], [M. Bai, et al., 2022]

CHALLENGES: NOT ONLY POWER DEMANDS



High power demands

- Up to ~ GWh annually.
- Higher energy costs.
- Grid stability.
- Renewables have limited coverage.

Raw materials concerns

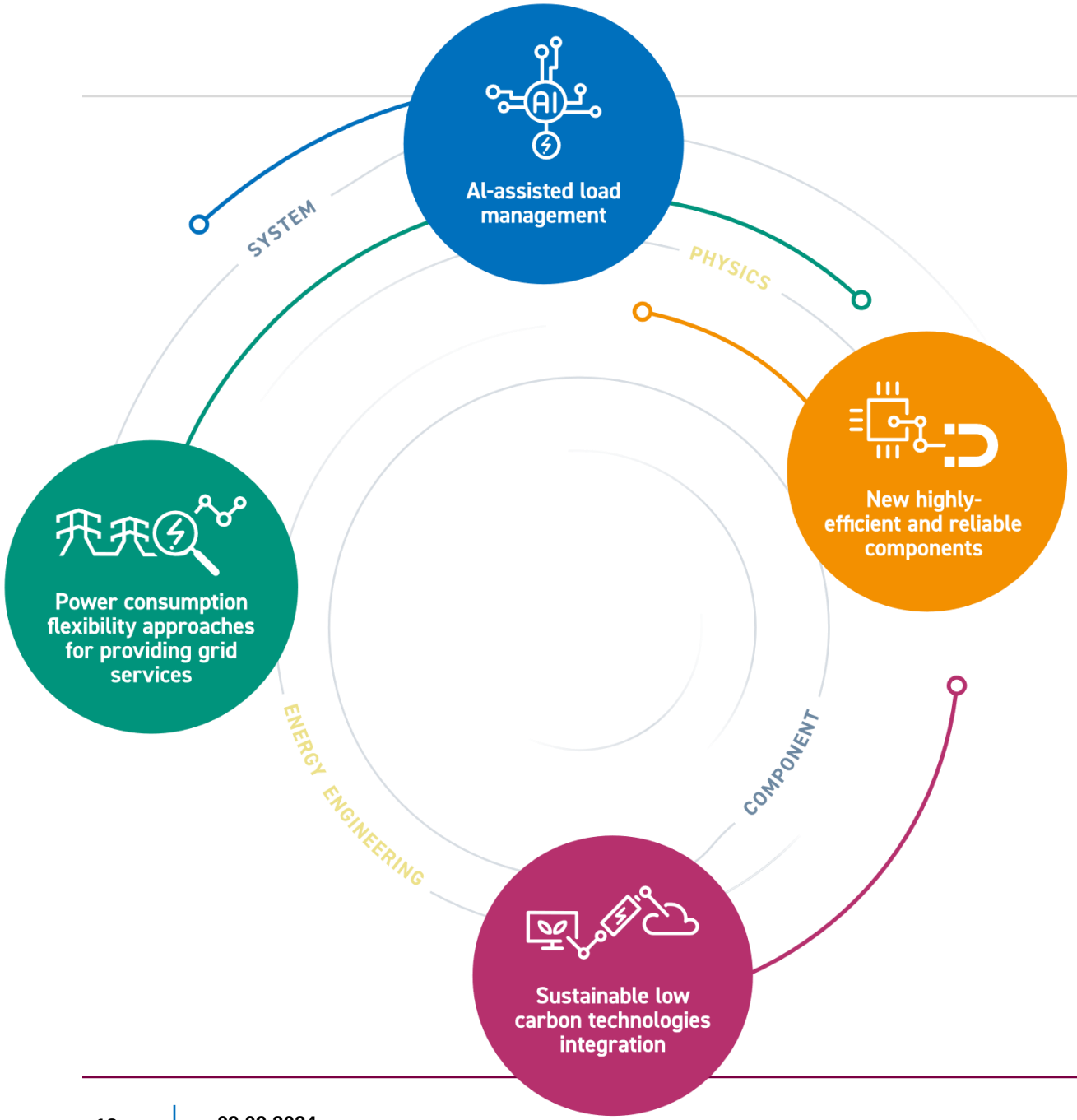
- Machine complexity.
- Higher raw material demands.
- Rare-earths challenges.

Carbon footprint

- Higher CO2 emissions.
- Increasing societal concerns.
- Compliance with EU aims of net zero carbon.

VISION

The RF2.0 partners vision is to design, operate and supply accelerators anytime in a secure and stable way on 100% renewable energy, i.e., almost independently from the public power grid, while reducing their environmental impact.



RF2.0 APPROACH

The RF2.0 partners have identified several bottlenecks towards this goal: at component and system level, involving both the physics and the energy technology topics in an interdisciplinary and unique approach.

IMPACT

Large research facilities

- Electricity costs reduction (≥10-25%).
- 100% renewable energy supply.
- Fully digitalized infrastructure.

System operators

- Power flexibility strategies for accelerators and computing centers (≥10-25%) for reduced consumption.

Technology manufacturers

- Improved magnets, power electronics, (TRL 1-3 → 4-6, -20% consumption).

Society

- Higher awareness of sustainable energy solutions.
- Training of public managers by means of demonstrators, schools, and workshops.
- Reduction of operation costs for public (hospitals, schools) and private (industry) facilities.
- Open-access data & Benchmark results.

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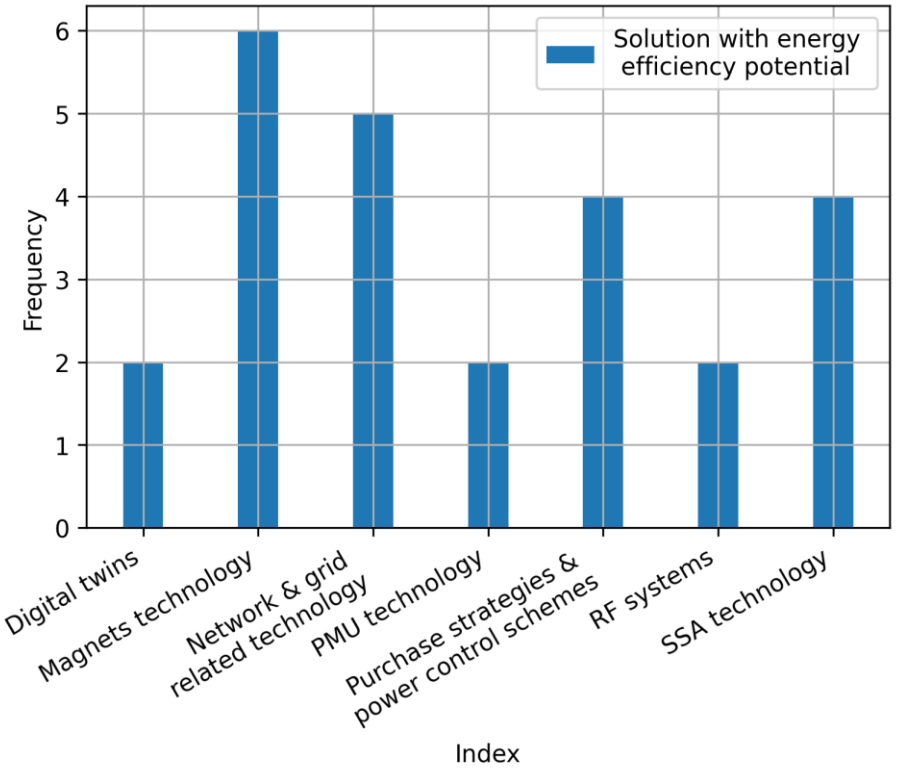
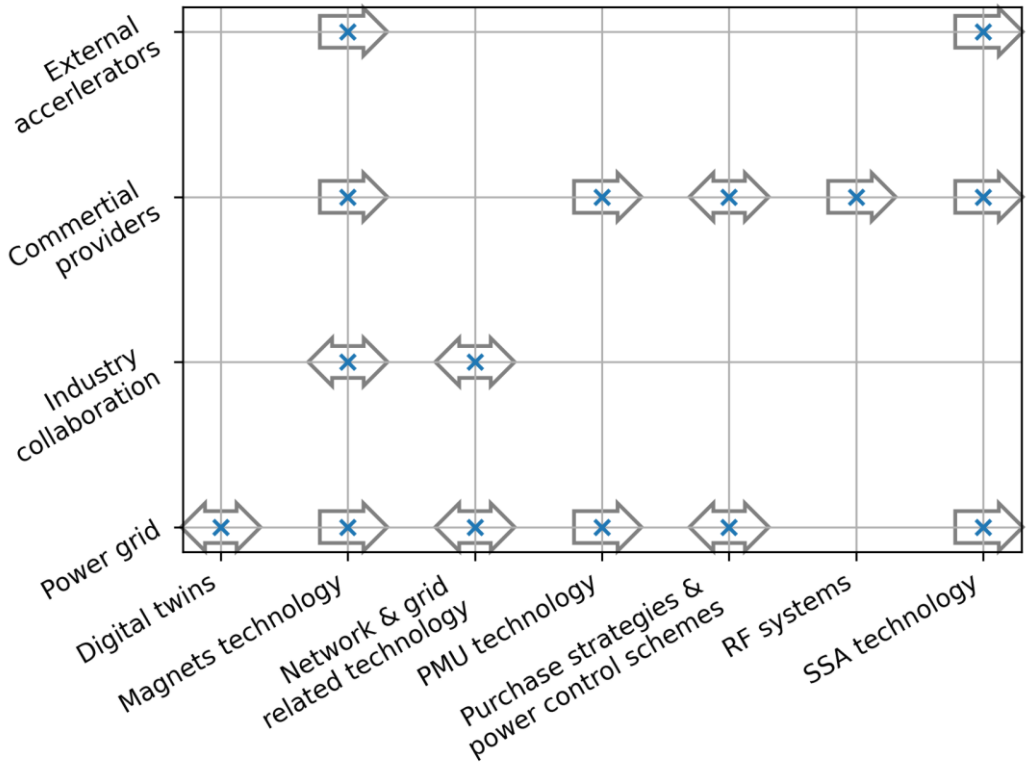
INITIAL RESULTS

KEY TECHNOLOGIES FOR IMPROVING ENERGY EFFICIENCY IN ACCELERATORS

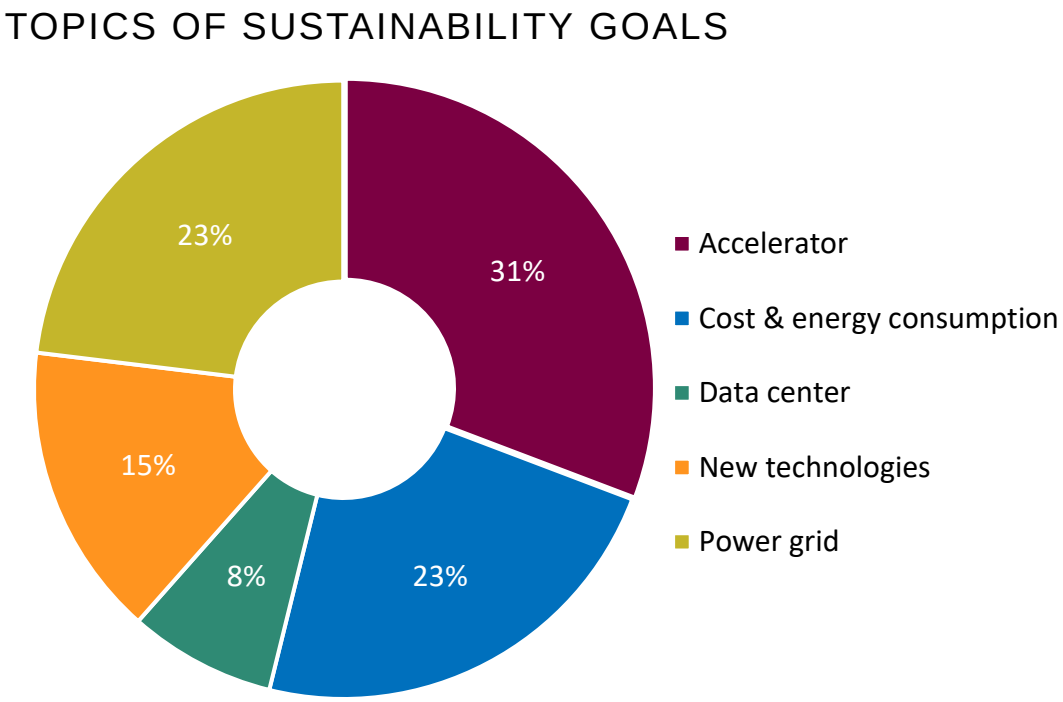
- Assessing existing technologies with energy saving potential (survey, all partners + external).





KEY TECHNOLOGIES FOR IMPROVING ENERGY EFFICIENCY IN ACCELERATORS

- Assessing existing technologies with energy saving potential (survey, all partners + external).
- Developing sustainability metrics.



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Main Metric	Quantifying unit	Example
Energy/operation	kWh/operation-hour	Total energy consumption of an accelerator in a year
GHG/operation	CO2e/operation-hour	Reduce frequency of servers according to provisioning with renewable energy
Material/operation	kg/operation-hour	LCA to analyse costs of all demonstrator magnets' inputs
Energy/science	kWh/scientific output capacity	Minimize TAT: $TAT \approx TAT_{min,\ theory}$
GHG/science	CO2e/scientific output capacity	Shift computing jobs to times when renewables are abundant
Material/science	kg/scientific output capacity	Minimize component's volume per unit nominal field: $\frac{V}{Field_{max}} \leq \frac{V_{ref}}{Field_{max,\ ref}}$

KEY TECHNOLOGIES FOR IMPROVING ENERGY EFFICIENCY IN ACCELERATORS

- Assessing existing technologies with energy saving potential.
- Developing sustainability metrics.
- Define a comprehensive road-map for the four demonstrators' projects:

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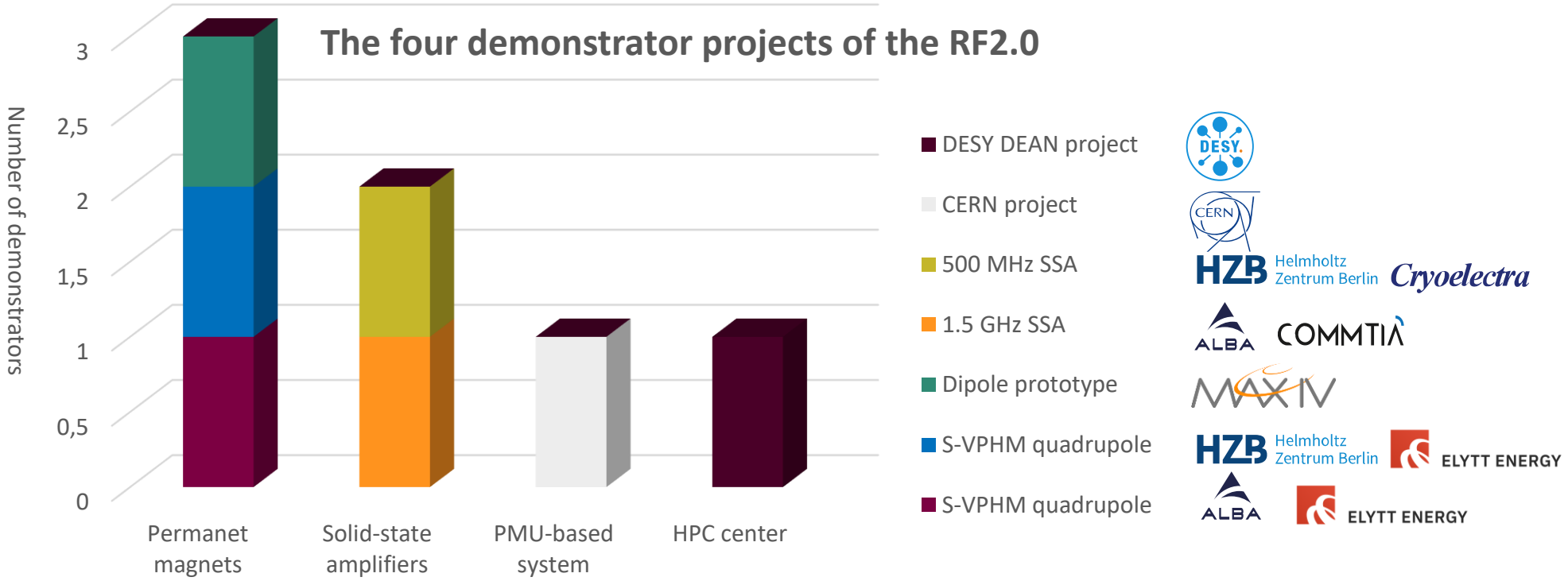

RF2.0

KIT Karlsruhe Institute of Technology

ALBA

CERN

DESY.

HZB Helmholtz Zentrum Berlin

MAX IV

COMMTIA

Zaphiro

Cryoelectra

ELYTT ENERGY

For further information and to follow our project progress visit www.rf20.eu

and our Social Media accounts: RF2.0 Project @rf20_project

Funded by the European Union

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Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Federal Department of Economic Affairs, Education and Research EAER
State Secretariat for Education, Research and Innovation SERI

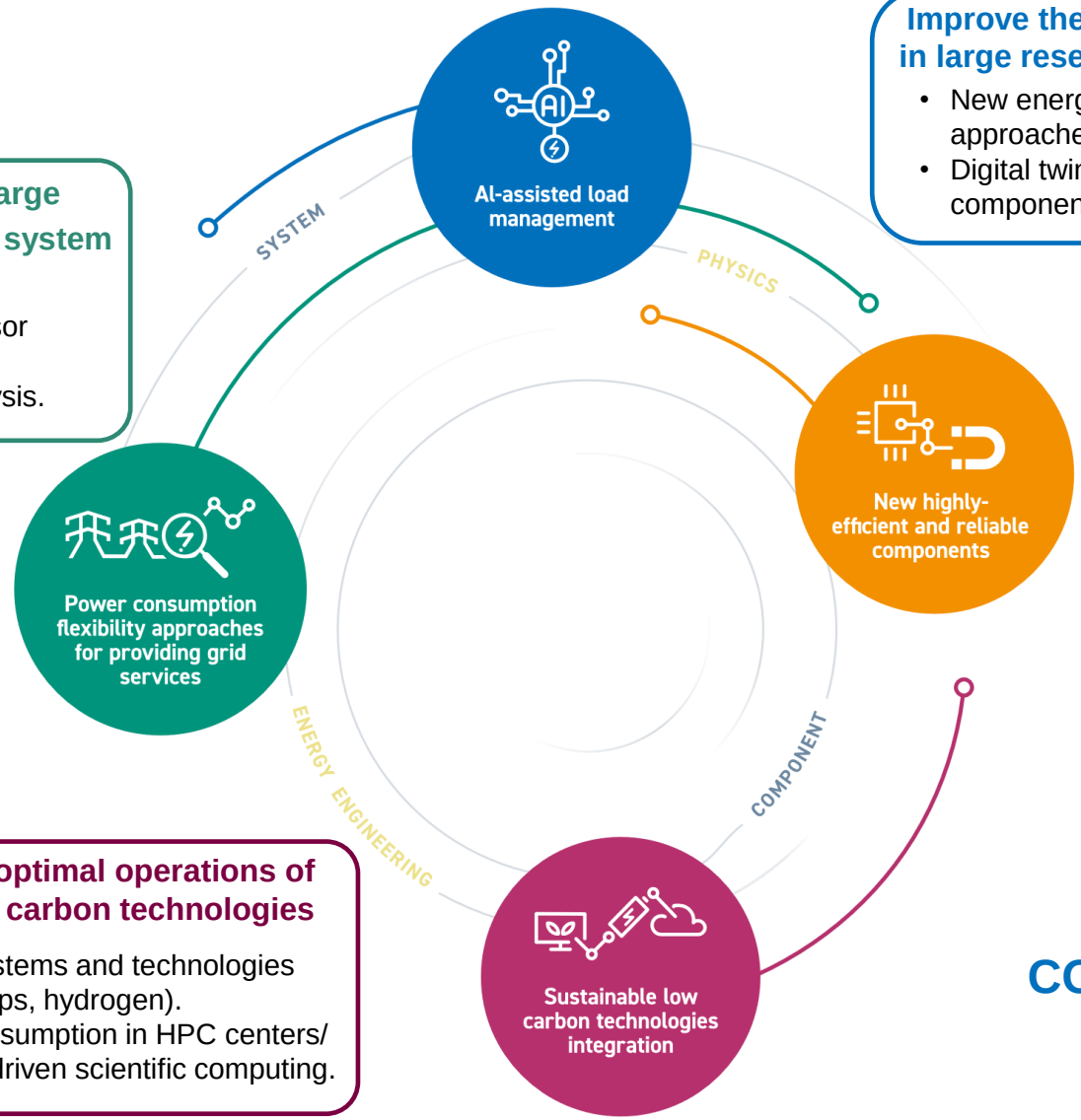
APPROACH

Increase the sustainability of large research facilities in the electrical system

- Power electronics and DC grids.
- Fast measurement systems (phasor measurement units).
- Energy costs and resources analysis.

Improve the efficiency operations in large research facilities using AI

- New energy management. approaches using AI.
- Digital twins of accelerators components and systems.



New materials and components targeting an efficiency increase

- Permanent magnets.
- Semiconductor technologies.
- Solid-state amplifiers.

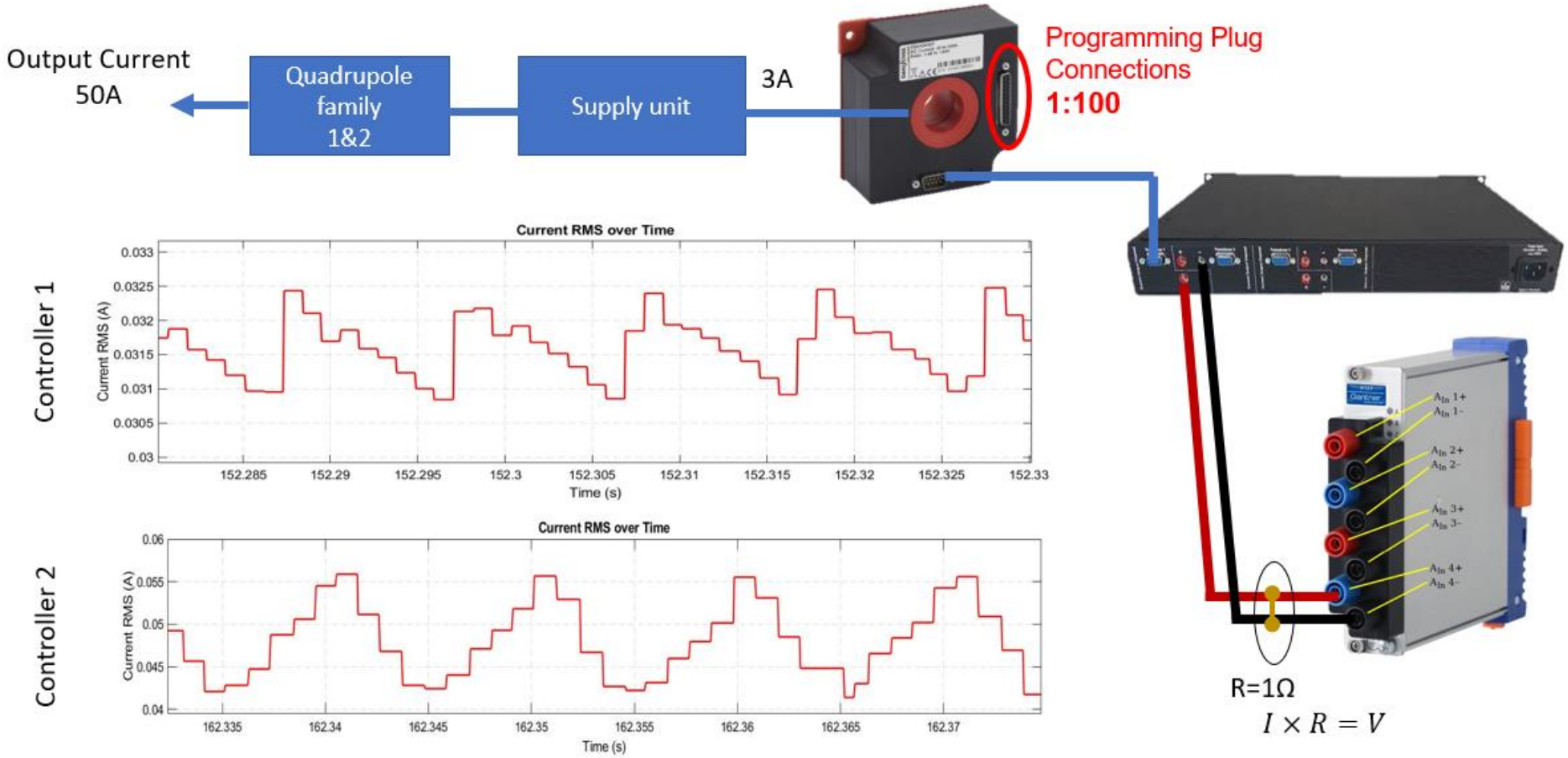
Integration and optimal operations of sustainable low carbon technologies

- Energy storage systems and technologies (batteries, supercaps, hydrogen).
- Flexible power consumption in HPC centers/ renewable power-driven scientific computing.

COMPONENT TO SYSTEM LEVEL

First comprehensive and systematic analysis of the energy use in large research facilities

KARA DIGITAL TWIN

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ONGOING EFFORTS

MORE EFFICIENT AND SUSTAINABLE COMPONENTS AND SYSTEMS

- Design and construction of magnets technologies based on permanent magnets.
- Design of solid-state amplifiers technologies.

DATA-DRIVEN RESEARCH INFRASTRUCTURE ENERGY MANAGEMENT

- Development of Artificial Intelligence-based accelerator tuning strategies for energy saving.
- Identification of energy storage technologies for accelerators energy need.
- Development of energy management strategies based on green-data centers.

SYSTEM-LEVEL DESIGN OF FUTURE ACCELERATORS

- Installation of 2 PMUs.
- Location: BE1 and BE2 (main CERN 400 kV substations).
- A pilot phase of project RF2.0 (Proof Of Concept).
- BE1 Technical Stop 1 (June – only voltage sensing).
- BE2 Technical Stop 2 (October).