RF2.0

RESEARCH FACILITY

TOWARDS A MORE ENERGY-EFFICIENT
AND SUSTAINABLE PATH

RESEARCH FACILITY 2.0

GIOVANNI DE CARNE

Funded by
the European Union

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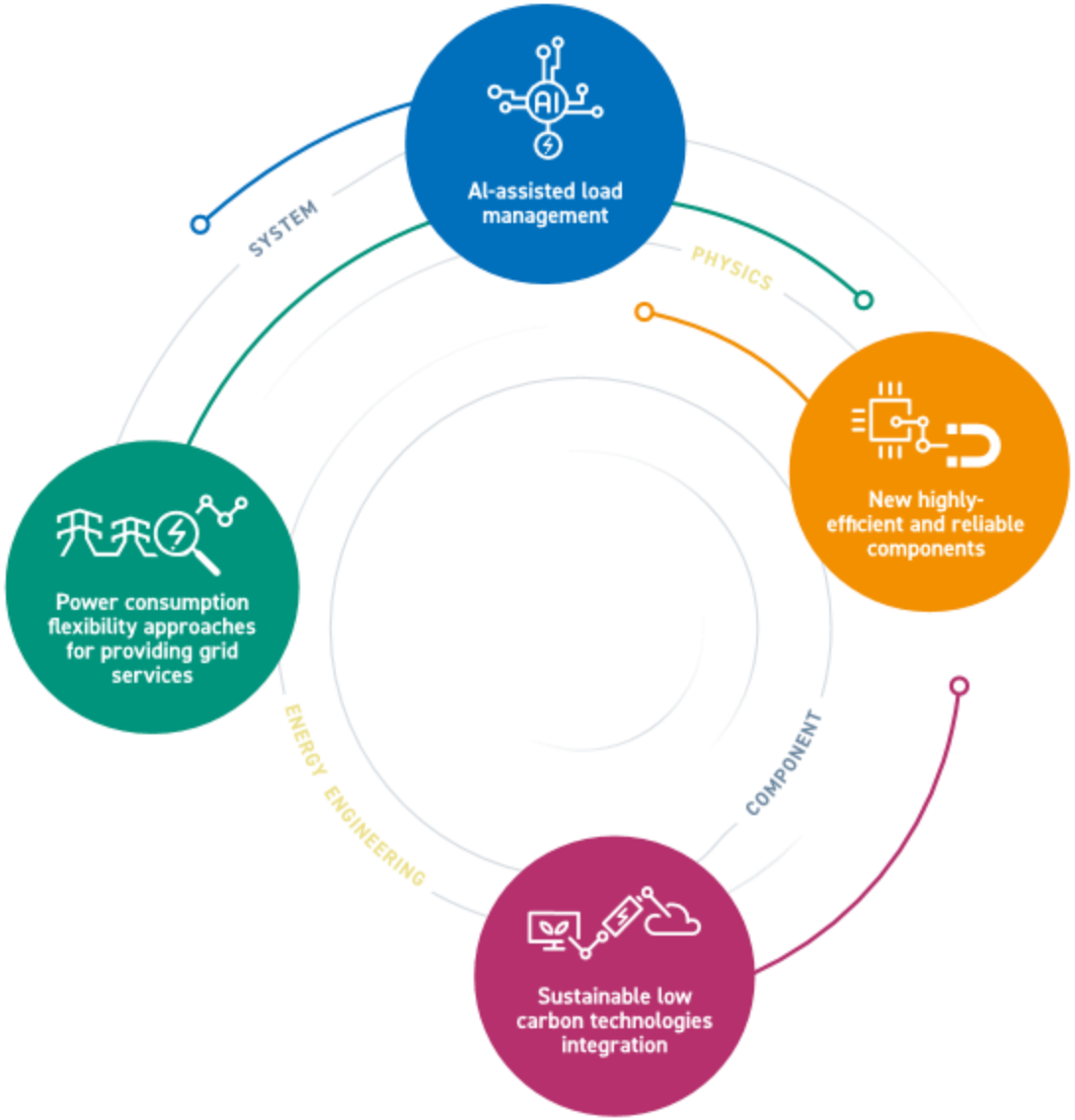
PROJECT OVERVIEW

CONSORTIUM & VISION

TOWARDS A MORE ENERGY-EFFICIENT AND SUSTAINABLE PATH

- **The RF2.0 partners envision a future where accelerators are designed, operated, and supplied with 100% renewable energy, ensuring secure and stable performance at any time.**
- **This approach aims to make operations nearly independent of the public power grid while significantly reducing environmental impact.**



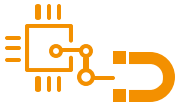
RF2.0 APPROACH

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.

CONTRIBUTION OF RF2.0

AI-assisted load management

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



New highly-efficient and reliable components

- Permanent magnets (TRL 2 → TRL4)
- Semiconductor technologies
- Solid-State Amplifier (TRL 2-3 →TRL 5-6)

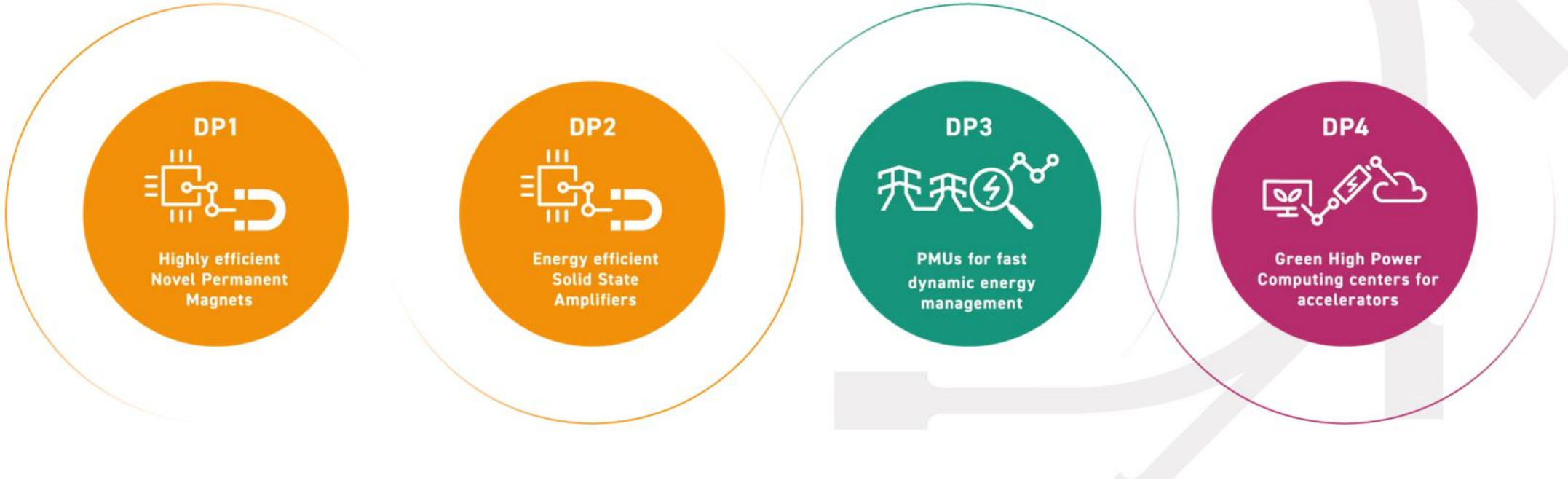
Power consumption flexibility approaches for providing grid services

- Power electronicsand DC grids
- Fast measurement systems (Phasor Measurement Units) TRL 5-6 → TRL 7-8
- Energy costs and resources analysis

Sustainable low carbon technologies integration

- Energy storage systems and technologies (batteries, supercaps, hydrogen)
- Flexible power consumption as for HPC centres / Renewable power-driven scientific computing

4 DEMONSTRATOR PROJECTS



TARGET GROUPS

4 TARGET GROUPS WITH SEVERAL ACTORS

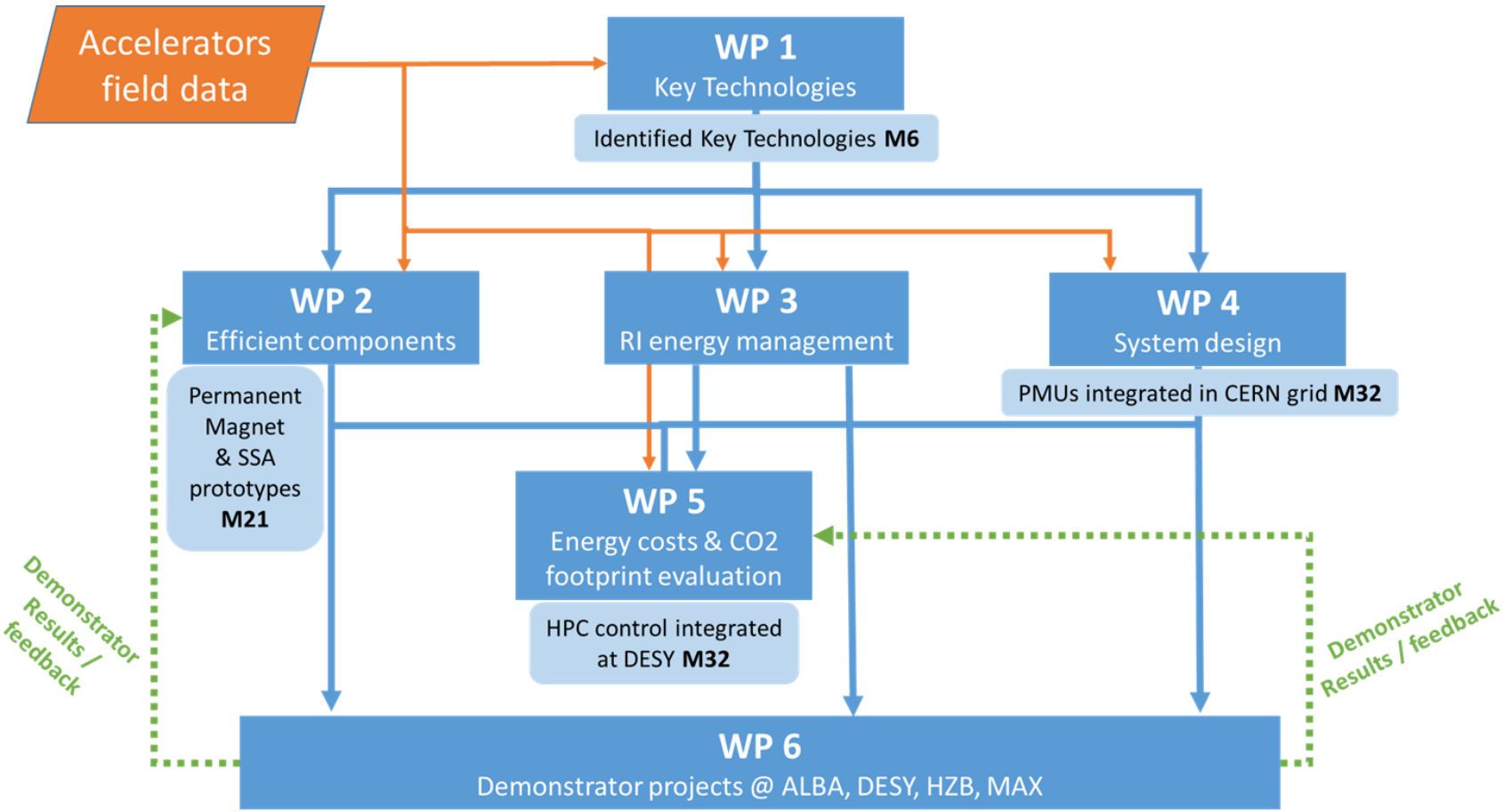
1) Research facilities
   - Particle accelerators, data centres, medical facilities, other ESFRI and ERIC operators

2) Energy utilities and system operators
   - Grid operators, engineering companies, national network regulators

3) European Policymakers
   - Public and private facilities, policymakers, standardisation bodies, general public

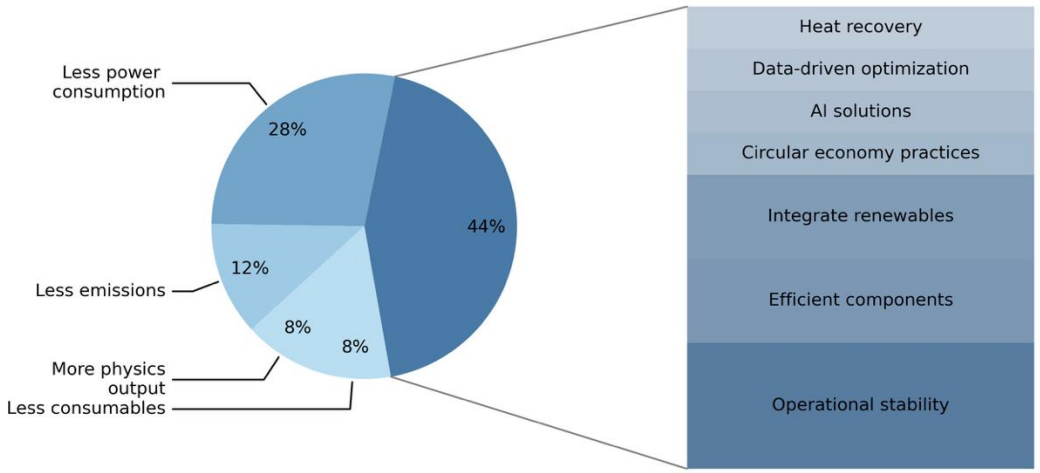
4) Manufacturers and technology providers
   - Manufacturers, software and AI companies, High-tech SMEs

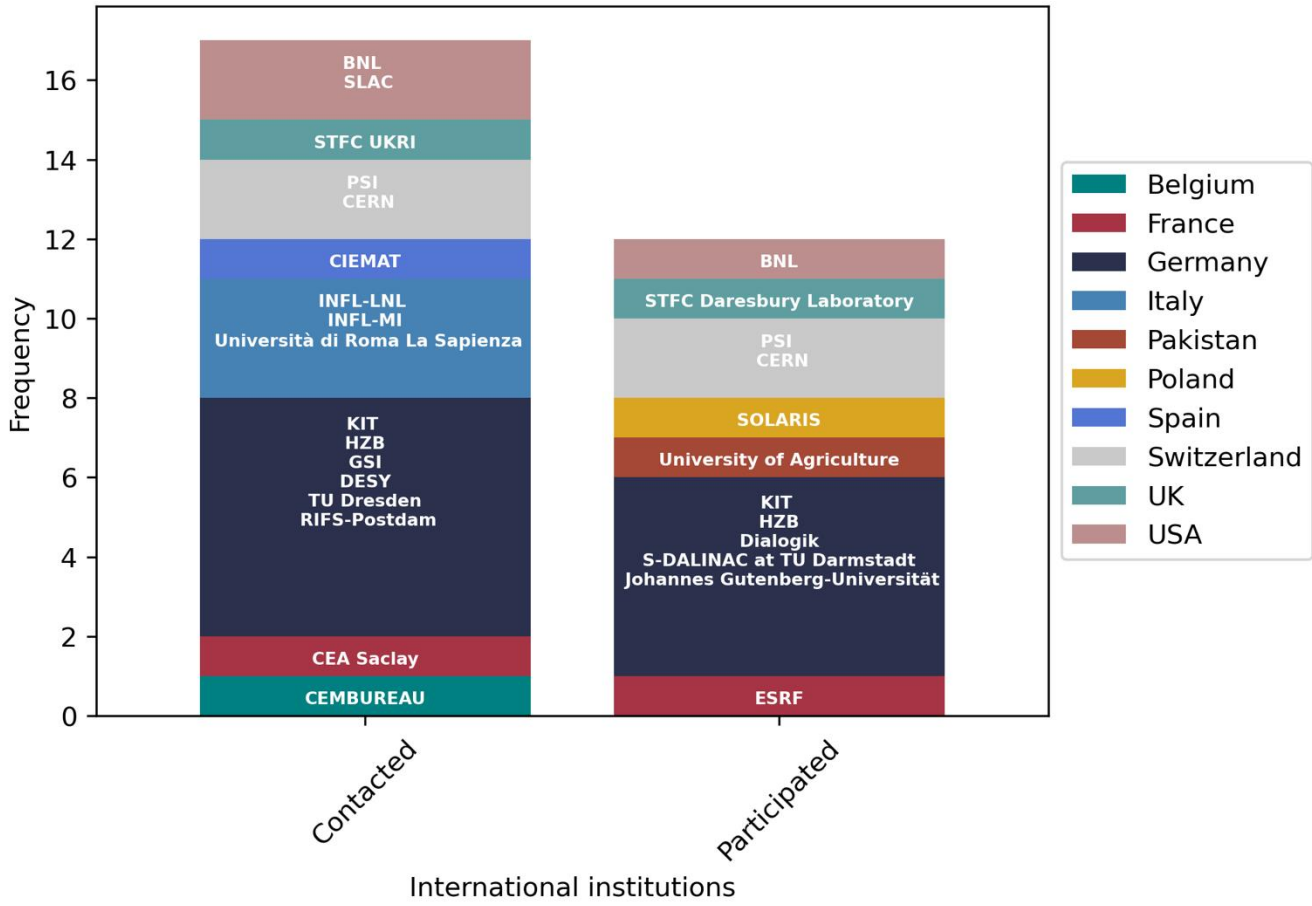
WORKFLOW


Accelerators field data
WP 1
Key Technologies
Identified Key Technologies M6
WP 2
Efficient components
Permanent Magnet & SSA prototypes M21
WP 3
RI energy management
WP 4
System design
PMUs integrated in CERN grid M32
WP 5
Energy costs & CO2 footprint evaluation
HPC control integrated at DESY M32
Demonstrator Results / feedback
Demonstrator Results / feedback
WP 6
Demonstrator projects @ ALBA, DESY, HZB, MAX

WP1: SUSTAINABILITY SURVEY AND METRICS

- WP 1: Identification of key technologies for improving energy efficiency in accelerators
- Survey responses:
  - In March 2025: 8 responses
  - Currently, 22 responses (sec. 1)
  - 17 responses (sec. 2)





WP1: SUSTAINABILITY SURVEY AND METRICS

- ❑ WP 1: Identification of key technologies for improving energy efficiency in accelerators
- ❑ Sustainability metrics

Main Metric	Quantifying unit
Energy/operation	kWh/operation-hour
GHG/operation	CO2e/operation-hour
Material/operation	kg/operation-hour
Energy/science	kWh/scientific output capacity
GHG/science	CO2e/scientific output capacity
Material/science	kg/scientific output capacity

Initially developed by RF2.0

- ❑ 43% Energy
- ❑ 25% GHG
- ❑ 7% Material
- ❑ 25% Other {land, water, acidification, recycability index, LCA, percentage of renewables, power usage effictiveness, total cost of ownership}

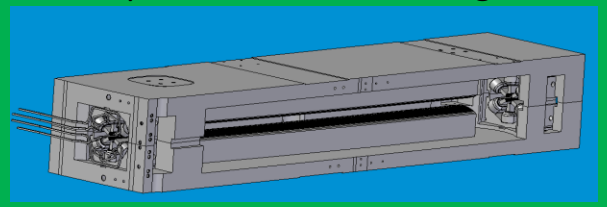
- ❑ 39% introduced the ‚per reference' = ‚per time' or ‚per physics'

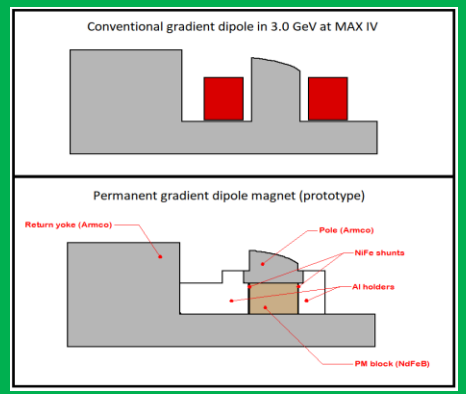
WP2: EFFICIENT COMPONENTS

- redesign of a MAX-IV electro-magnet to PM driven magnet
- investigation thermal shim parameter as function of thermal and mechanical stress (HZB)

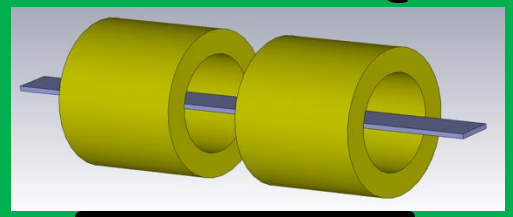
Dipole DC-to-PM @ MAX IV

-> PM blocks instead of coils in dipole
-> energy reduction of 45%
-> more space for further NL-magnets



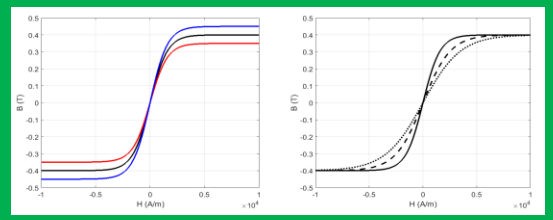


NIFe Test bench @ HZB



µr measurment driver

-> test bench for thermal shims
-> temperature effects
-> mechanical history

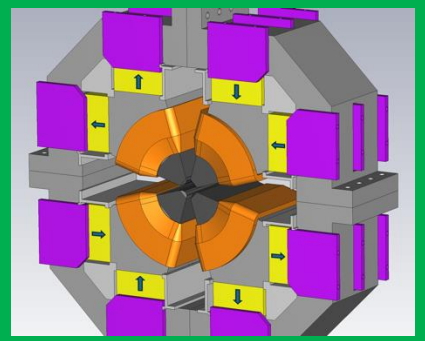


WP2: EFFICIENT COMPONENTS

- ❑ redesign of a MAX-IV electro-magnet to PM driven magnet
- ❑ prototyping variable high gradient PM-QP magnet concept (ALBA, Elytt, HZB)
- ❑ investigation thermal shim parameter as function of thermal and mechanical stress (HZB)
- ❑ prototyping High Efficient SSA for 500MHz and 1.5GHz (ALBA, Commtia, Cryoelectra, HZB)

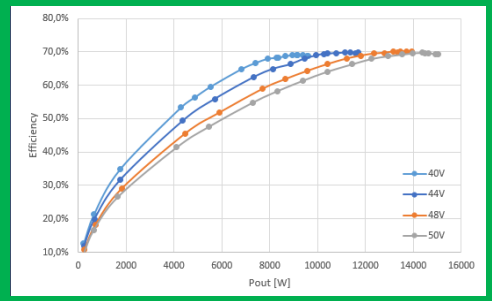
S-VPHM QP demonstrator @ ALBA+HZB

-> motorized PM QP magnet
-> gradients tuning between 70 and 105 T/m
-> slow mechanical, fast electrical tuner



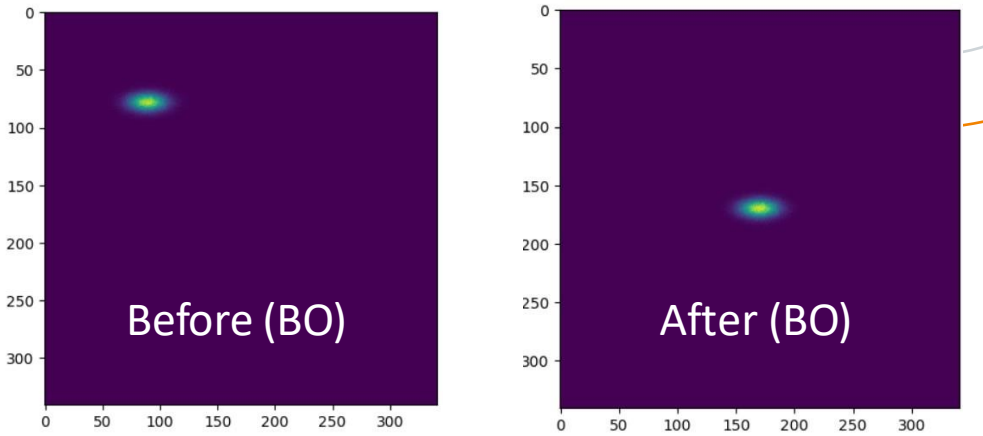
Solid State Amplifier (SSA) 500MHz demonstrator @ HZB
1.5GHz demonstrator @ ALBA

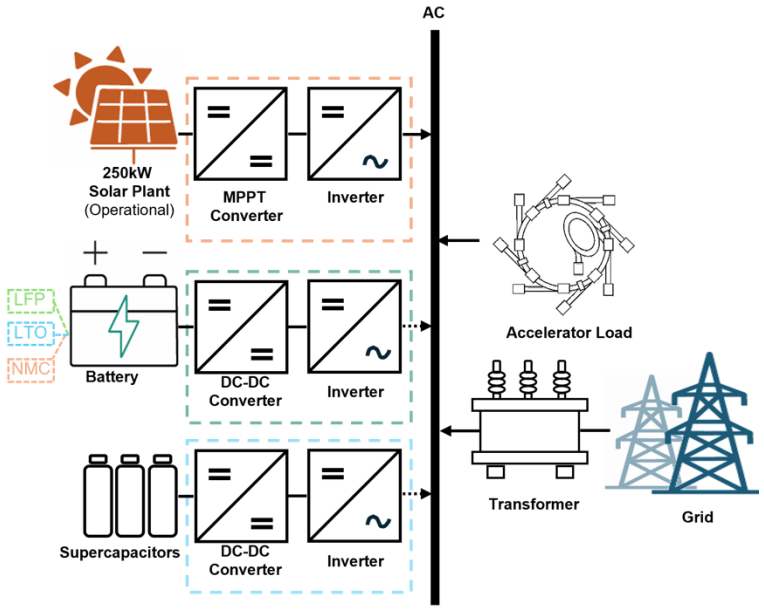
-> prototyping of SSA systems with optimized parameters of RF-transistors for 1.5 GHz (ALBA) and 500MHz (HZB)
-> for highest efficiency under varying load conditions

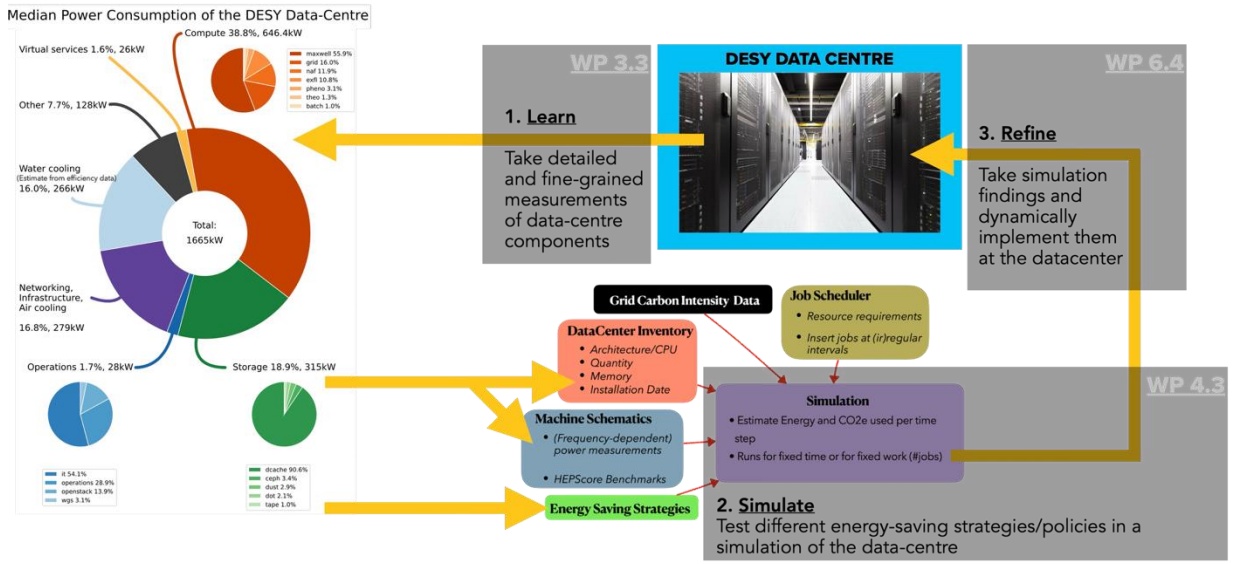


WP3: DATA-DRIVEN RI ENERGY MANAGEMENT

- ❑ On-line beam re-alignment → lower energy dissipation
- ❑ RES and ESS integration in Accelerators
- ❑ Optimal & Dynamic Energy Management in Data Centers and HPC

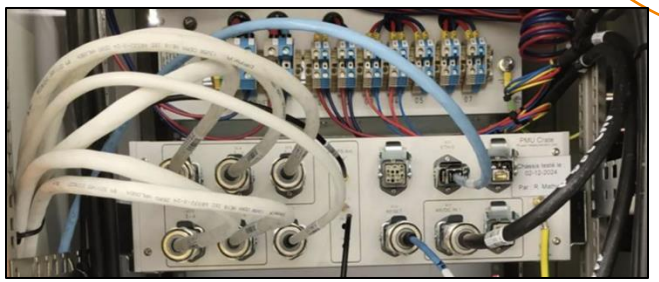


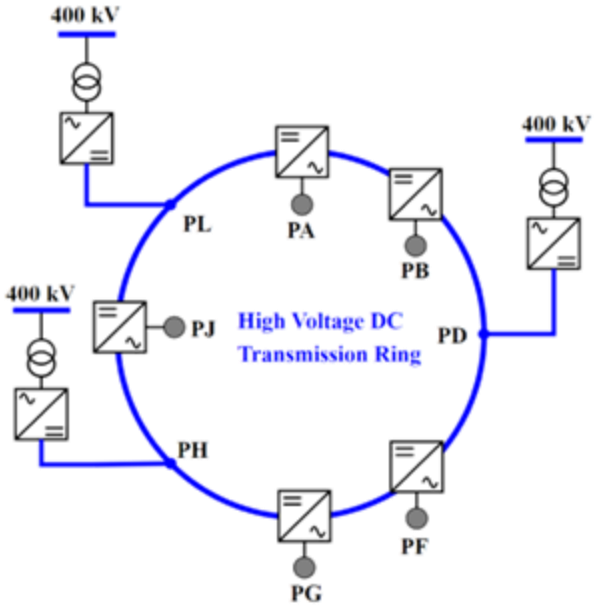


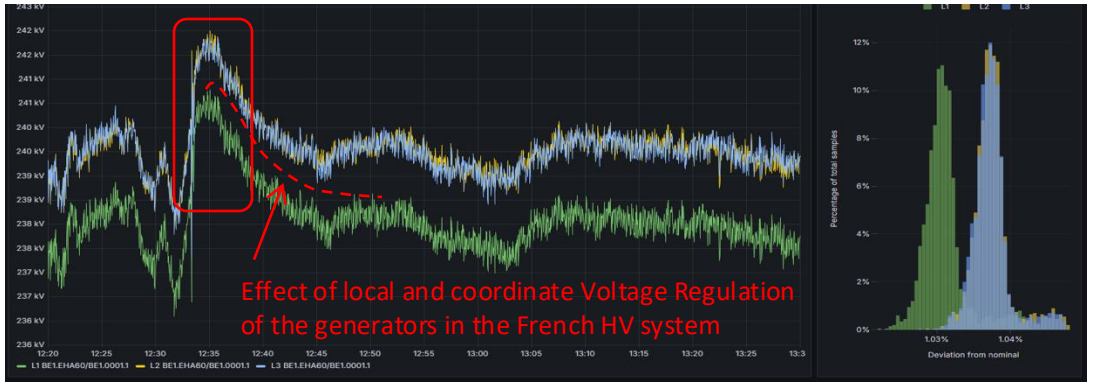


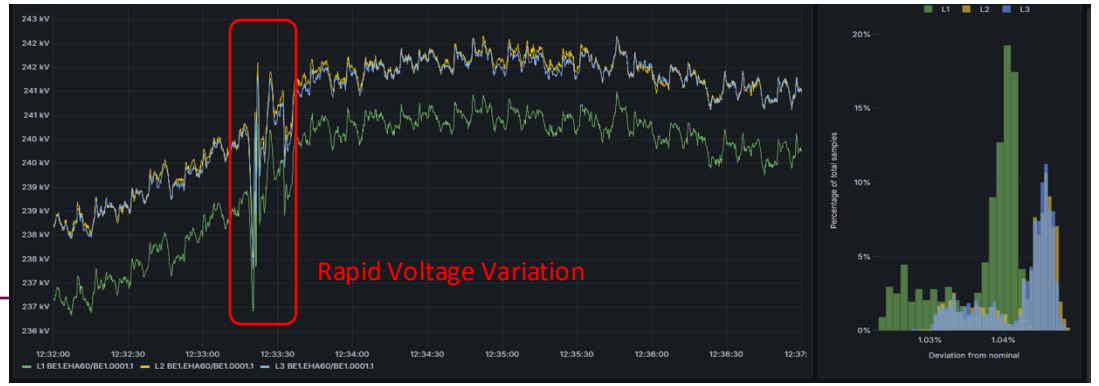
WP4: SYSTEM-LEVEL DESIGN OF FUTURE ACCELERATORS

- ❑ Modelling and Design of future accelerator networks
- ❑ PMU installation → advanced capability in detecting and reacting to grid disturbances



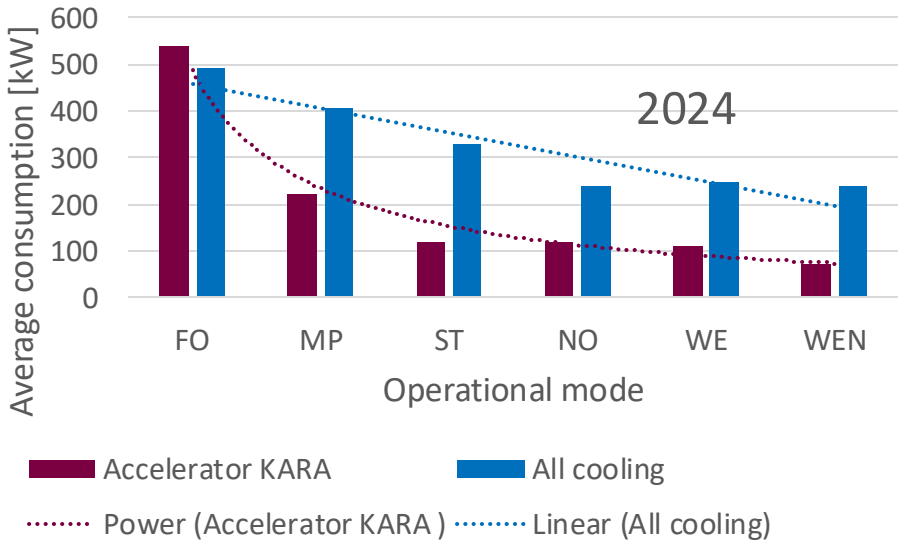


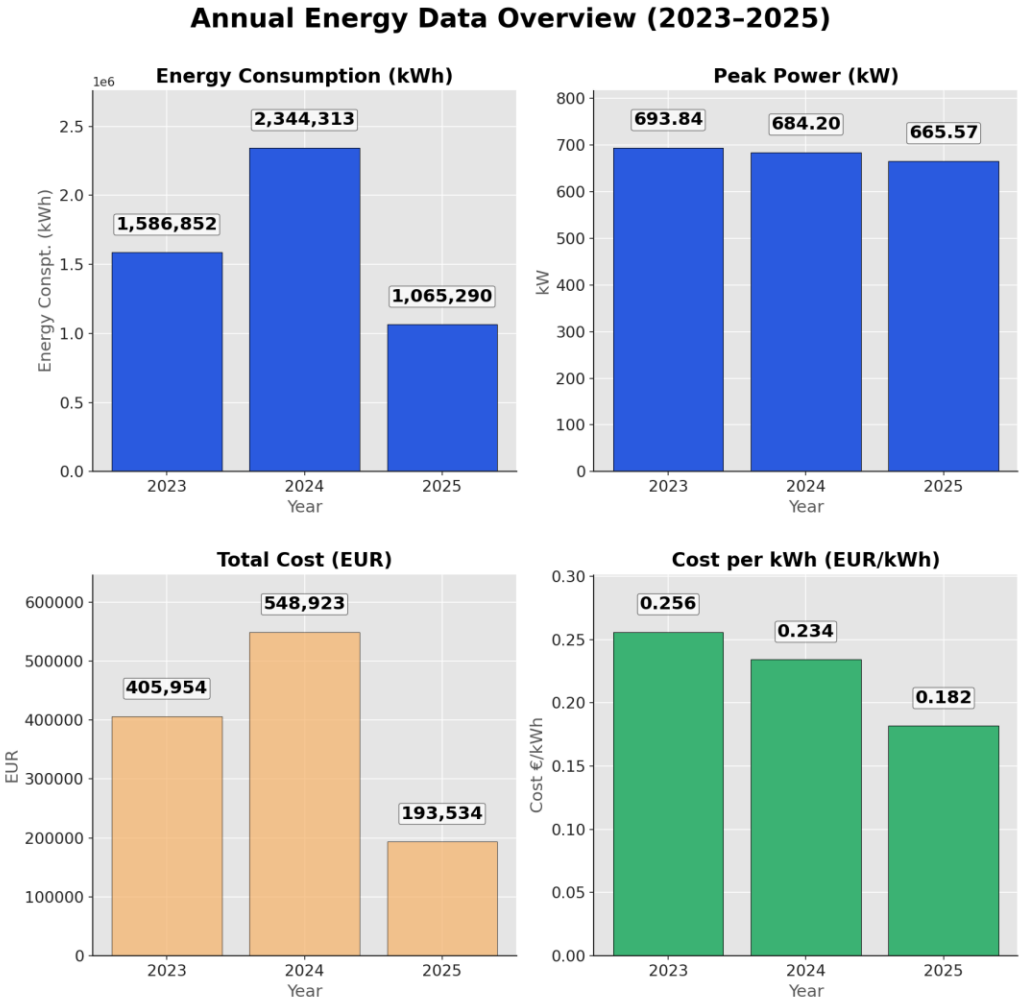




WP5: ENERGY COSTS AND CARBON FOOTPRINT OF ACCELERATORS

- Energy consumption analysis under different modes
- Costs and CO2-footpring analysis during accelerator lifetime





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ORGANIZATIONAL TOPICS

FOLLOW-UP PROJECT PLANNING

- HORIZON-INFRA-2026-TECH-01-01: R&D for the next generation of scientific instrumentation, tools, methods, digitalisation and solutions for research infrastructure upgrades
- Focus on exploitation for the next phase → RF2.0 and iSAS have complementary goals
  - RF2.0 → working at higher levels (components & systems)
  - iSAS → working on superconductive undulators (components)
- The goal is to develop a series of toolboxes for research infrastructures to achieve sustainable and efficient operations
  - Undulators and RF, energy management, grid stability, recyclability, etc.
- Initial discussions started few weeks ago → decision on consortium for January/February and start working on the project
- Forecasted 10M€ Budget, 15+ partners, enlarged accelerator pool (ESS, ESRF, SOLEIL, etc.)

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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