HPDC 2024

June 3-7, 2024

Pisa, Italy

International Workshop on High Performance and Quantum Computing Integration (HPQCI)

COMPONENT-BASED QUANTUM-INTEGRATED SUPERCOMPUTING

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ABOUT PARTEC AG

Foundation / History

The birth of today's ParTec AG was the spin-off from the University of Karlsruhe in **1999**. The change of legal form (GmbH to AG) took place in **2021**.

Business Units

- Development and production of innovative and world-leading modular **supercomputers** and **quantum computers**
- Development and production of associated **system software** including consulting and support services
- Worldwide **licensing** of the dynamic Modular System Architecture (dMSA)

Celebrating 25 Years ParTec in October 2024

>70

Number of employees plus freelancers and researchers (rapidly growing)

>150

patents granted and registered in the world's industrialised regions

Stock market listing

8.000.000

#shares

~1.029.000

Shares in free float (13%)

In the **Scale** segment of the Frankfurt Stock Exchange since July 2023, in **Xetra** since August 2023.

Located in Europe:

Headquarter and ParTec Quantum Factory located in Munich, **Germany**

Milestones

- 2005
  Start of cooperation with the Jülich Research Centre (FZJ)
- 2010
  Development of the "dynamic Modular System Architecture" (dMSA)
- 2017
  Operation of JURECA, the world's first modular supercomputer
- 2020
  Operation of JUWELS "Booster", the fastest supercomputer in Europe at the time and number 7 on the TOP500 list
- 2022
  Successful participation in the tender for the Israel National Quantum Initiative (delivery of a superconducting QC solution)

  Contract Award for ParTec and Atos EuroHPC JU BSC MareNostrum5
- 2023
  Announcement of QBridge, a software jointly developed with Quantum Machines for the integration of classical and quantum computers

  Listing on the Frankfurt Stock Exchange and Xetra

  Contract Award for ParTec and Eviden EuroHPC JU JUPITER

  Announcement of “ParTec Quantum Factory” in Munich
- 2024

  Announces of high-performance modular AI solution – collaboration with Supermicro

  Annoucement full-stack quantum computing solutions offering

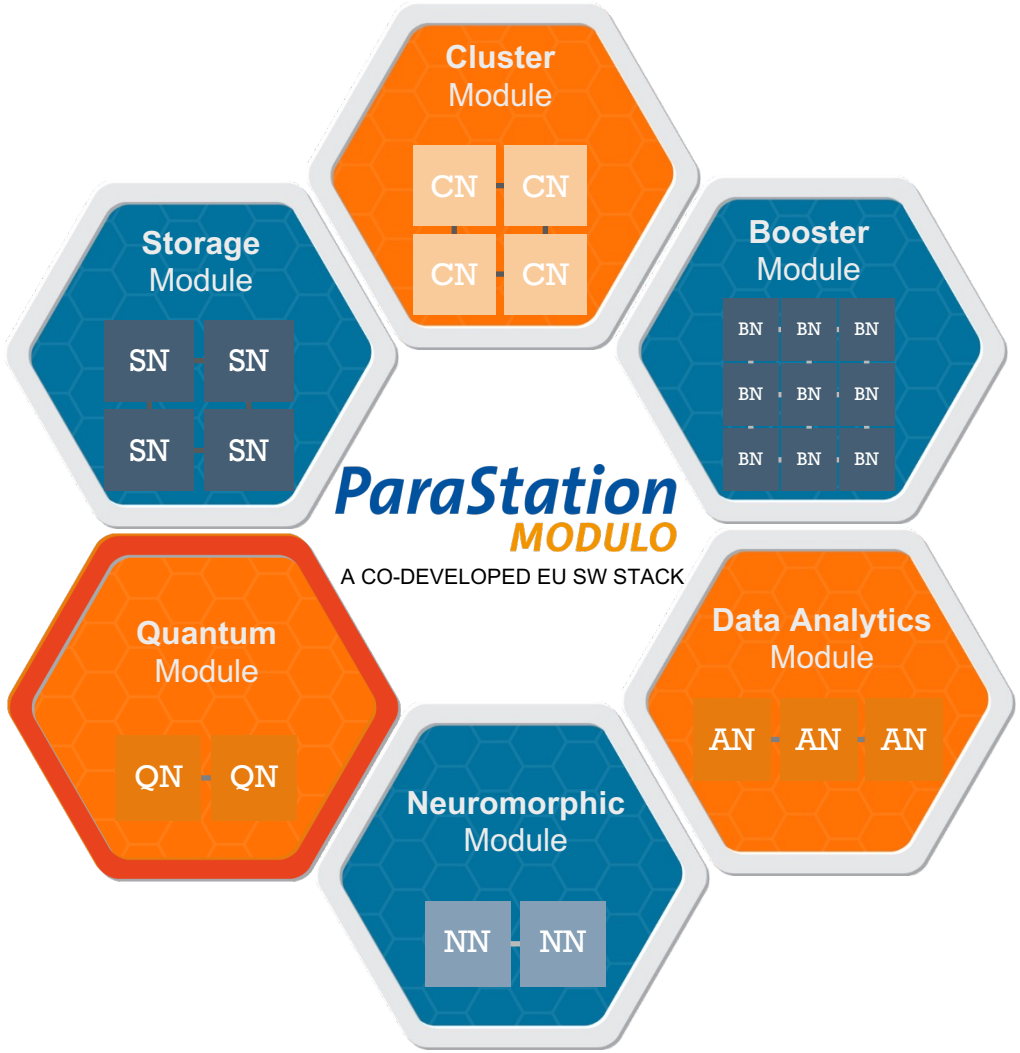
MODULAR SUPERCOMPUTING ARCHITECTURE

ParaStation CLUSTERTOOLS
Hardware-agnostic management CLI
Image management, Rolling updates,
Stateless & stateful booting, Slurm integration,
Distributed config DB

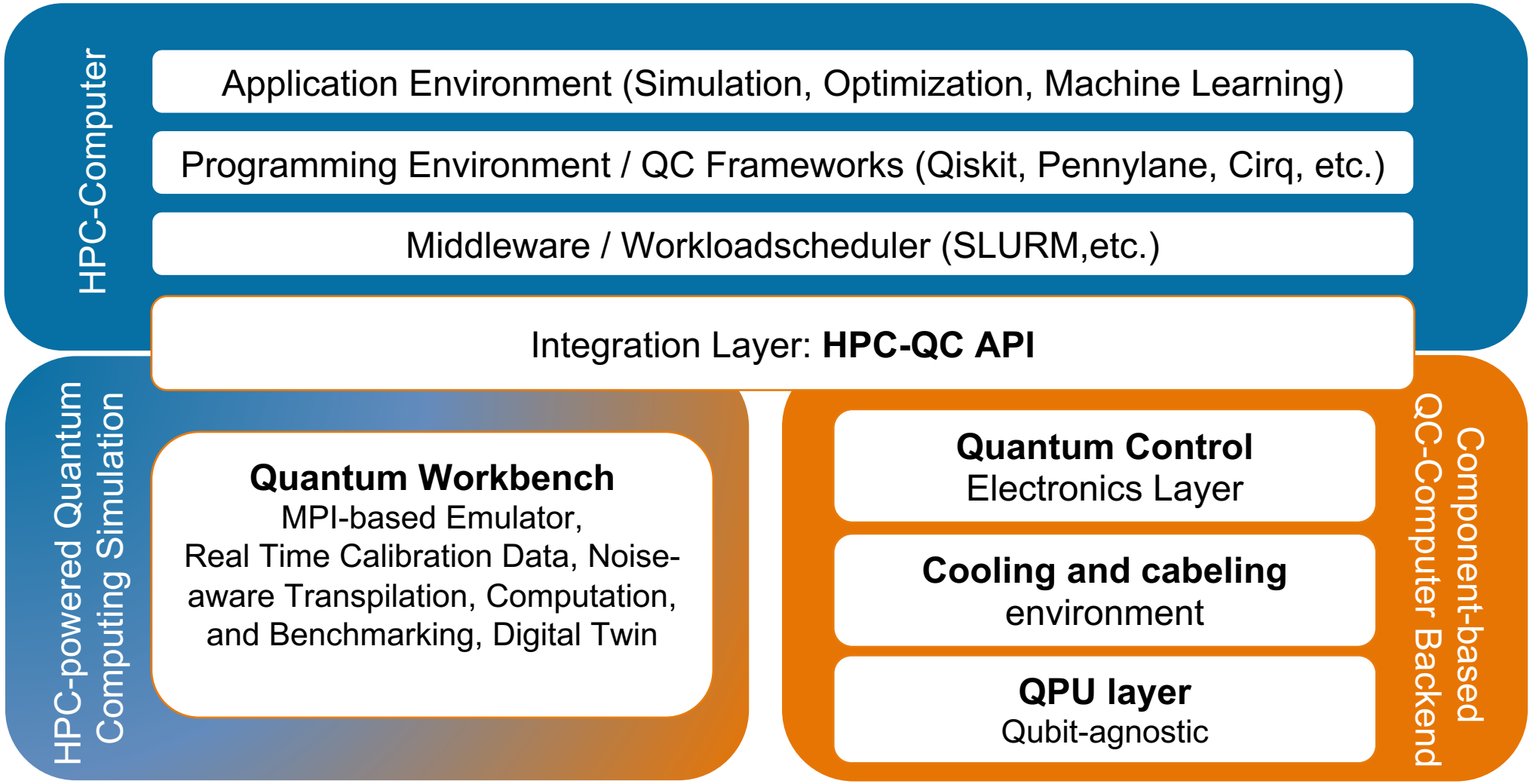
ParaStation HEALTHCHECKER
Automated error detection & handling, Various hook-in points, Highly configurable & customizable, 100+ tests (HW/SW), Node/System/Fabric

ParaStation TICKETSUITE
Prioritization, Routing/Triage, Documentation, Maintenance planning, Interfaces with external ticketing systems

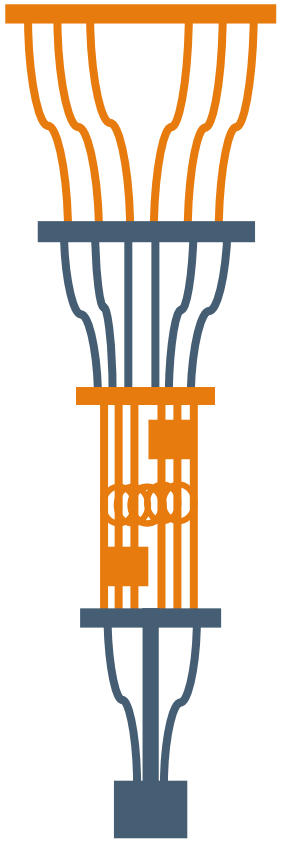
ParaStation MPI
MPI-4.0 compliant, MPICH ABI-compatible, Multiple Interconnects, Modularity Support, PMIx Support, Slurm Integration



PARTEC FULL-STACK COMPONENT BASED QUANTUM SOLUTION



PARTEC QUANTUM FACTORY STARTING IN H2 2024



- ParTec's manufacturing site for quantum products
  - Allows parallel integration of several systems
  - Spare-part storage for customer installations
  - Customer training and events location
- Pre-builing and testing of customer quantum solutions.
- Development and testing infrastructure for classical compute Software.

PARTEC'S DIRECT PARTNERSHIPS

QBridge

Co-developed with

QUANTUM MACHINES

QBridge = HPC-QC API:

- Provides a secure, efficient, and familiar environment to integrate QC into HPC or cloud datacenter.
- Integrating with ParTec's ParaStation Modulo facilitates modular computing capacity in terms of hybrid HPC-QC.
- Ready to use with Quantum Machine Control Electronics.

A founding member of the Novera QPU Partner Program:

rigetti NOVERA Partner Program

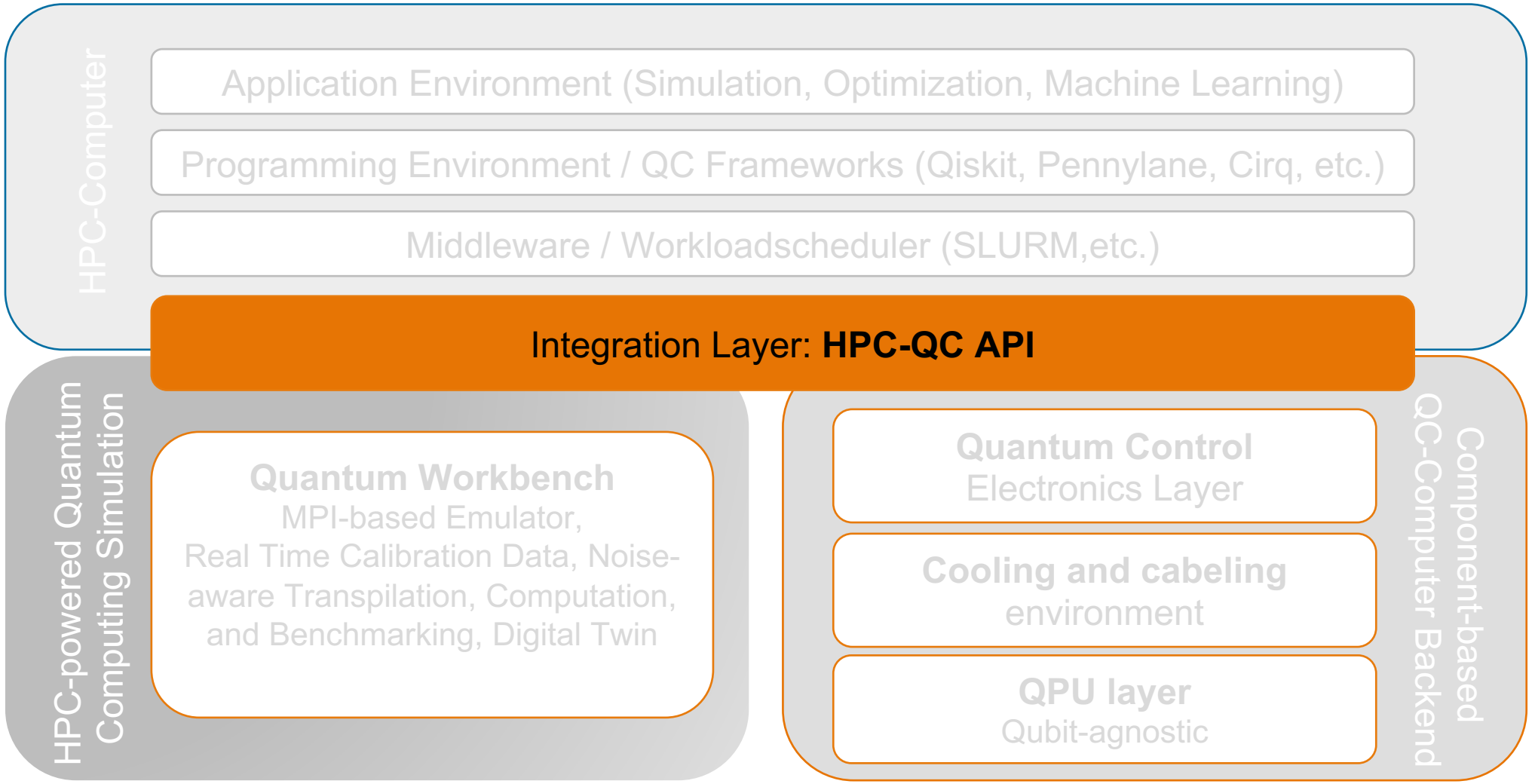
Cryogenics	Bluefors
Control Systems	Quantum Machines Zurich Instruments
Software	Q-CTRL Strangeworks Classiq Horizon Quantum Computing
Integration and Service Providers	TreQ ParTec AG
QEC-Solutions	Riverlane

CQC – CRYO QUANTUM COMPUTING LAB

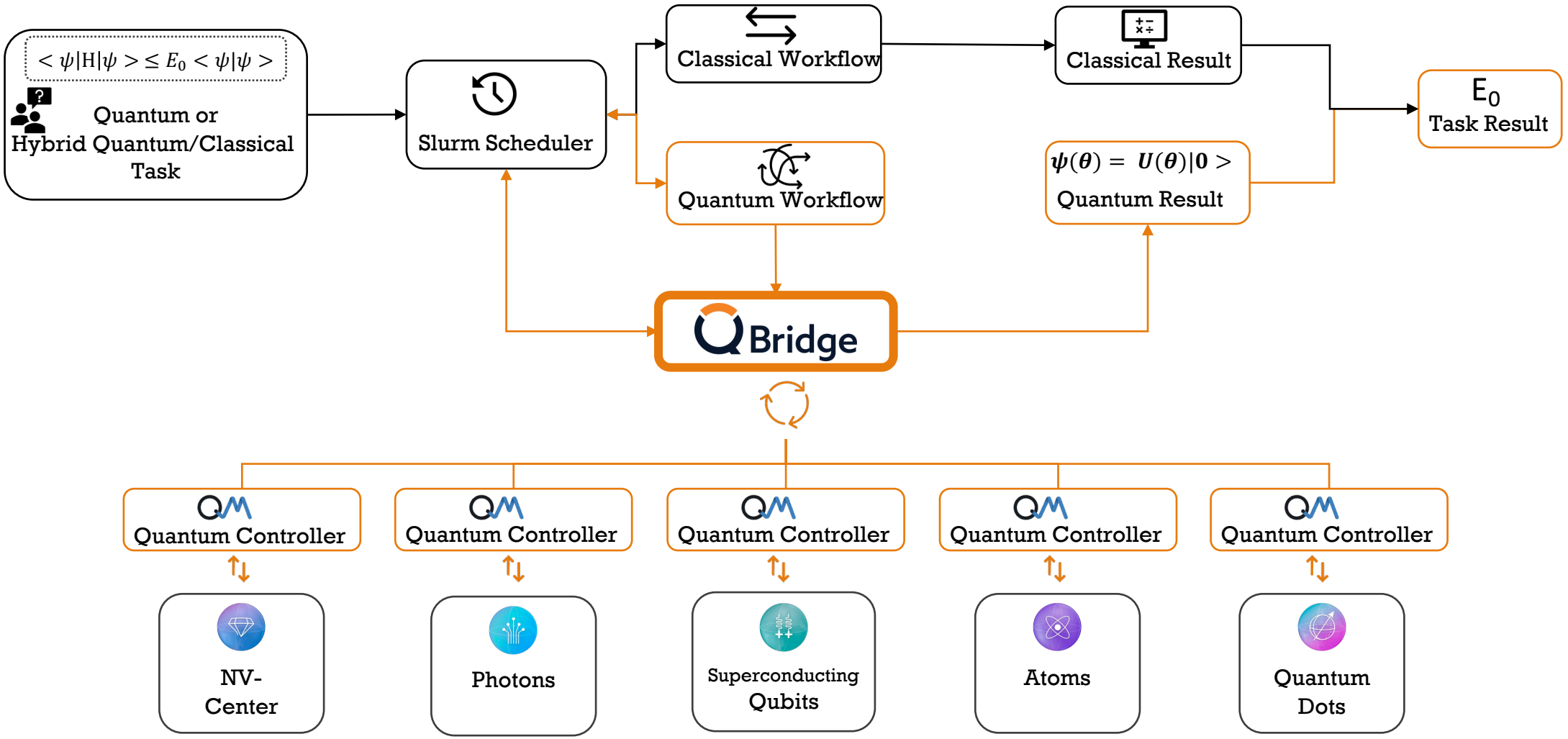
- Joining forces for pushing the realisation of QC and their integration in HPC systems forward:
  - Developing a 10+ superconducting qubit system and integrating it into the supercomputing infrastructure of the JSC.

- Collaboration passed first milestone after start in summer 2023:
  - Operating QC at JSC with a QuantWare 21+4 qubit Contralto Chip, a Bluefors cryostat and OPX quantum control environment from QM.
  - Successful calibration and seamless integration into JSC's JURECA using the Qbridge from ParTec and QM.

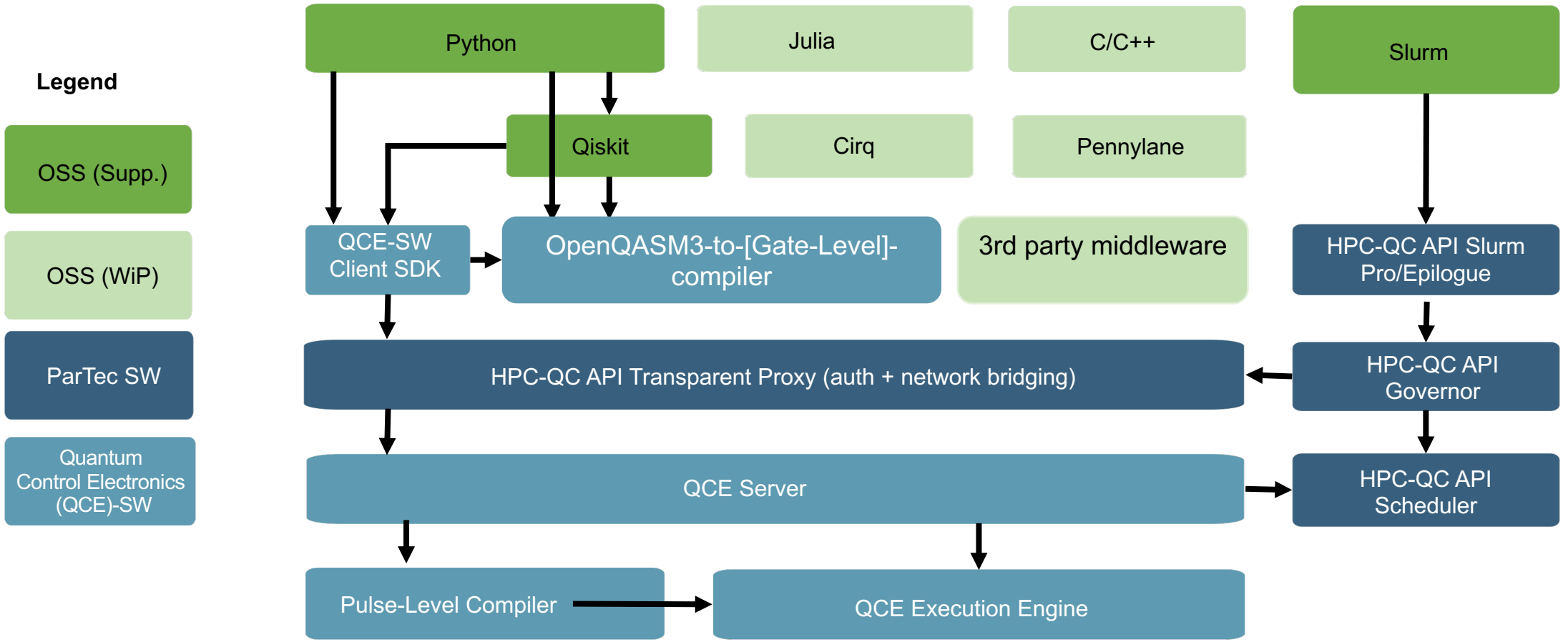
PARTEC FULL-STACK COMPONENT BASED QUANTUM SOLUTION



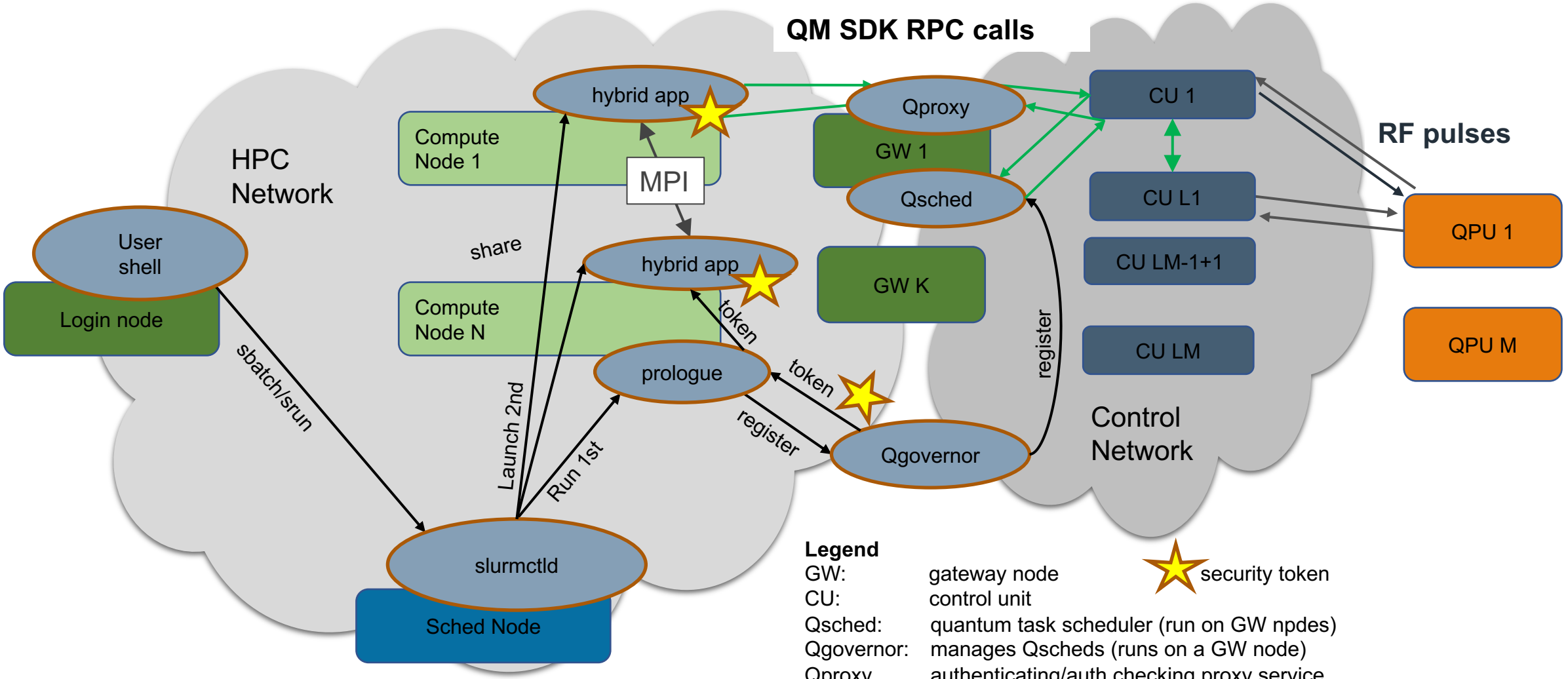
HPC-QC API: QBRIDGE SOLUTION HIGH-LEVEL ARCHITECTURE



HPC-QC API: USER LEVEL SOFTWARE STACK



HPC-QC API: HIGH-LEVEL COMMUNICATION FLOWS



HPC-QC API: INTEGRATION SOFTWARE DESIGN CONSIDERATIONS

QPUs are very expensive → Optimize for highest QPU Utilization

Typical QC tasks execute for O(1-100ms)
(at least on super-conducting QPUs)

HPC is expensive, too → Co-scheduling of HPC & QC resources

User needs variabilty → Batch access, Interactive access, Gate-level control, Pulse-level control

Fast & robust QPU **calibration** and tight QPU **monitoring**

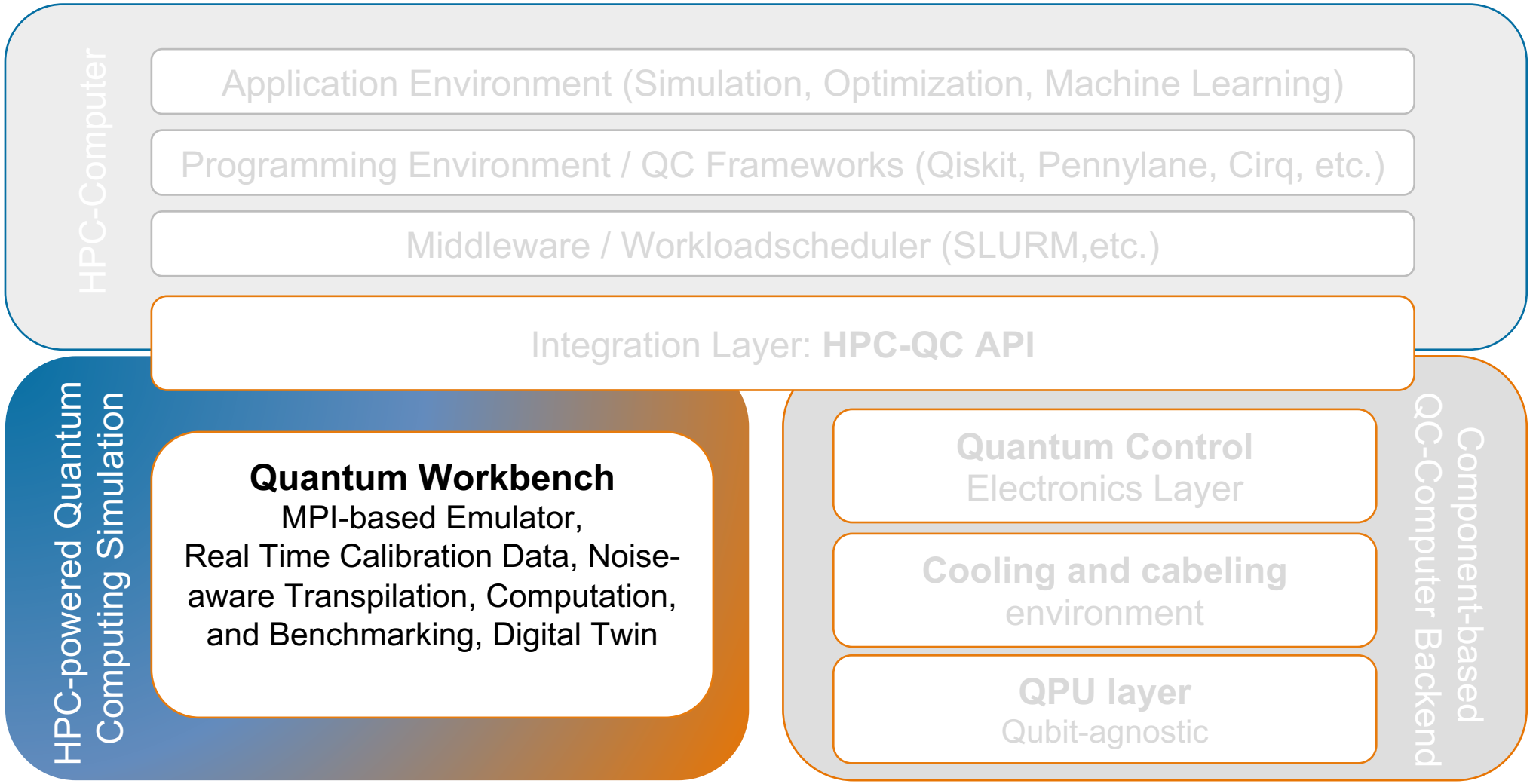
QPU Virtualization via interleaving of QC tasks from different jobs

Coordinated resource manager with flexible scheduling policies

Common API for different devices

Transparancy to low-level details

PARTEC FULL-STACK COMPONENT BASED QUANTUM SOLUTION



QUANTUM WORKBENCH PREVIEW: QUANTUM EMULATION FRAMEWORK

ParTec
MODULAR SUPERCOMPUTING

Target Class:
- *DB API*
- *Target Library*
- *Target Generator*

Real Time Calibration Data

Noise Model Class:
- *Custom or Pre-defined Noise Model Generator*
- *Noise Model Instance*

SDK:
- *Run / Config.yaml*
- *Quantum Circuit Object*
- *Noise Aware or Ideal Transpilation*
- *Noise Aware or Ideal Emulation*

Benchmark Library:
- *Circuit Generators*

Emulator/Simulator:
- *Aer*
- *Pennylane Lightning*
- *etc.*

Workflow Repository / Digital Twin:
- *Run Instance Snapshots*
- *Model Instance Snapshots*

THANK YOU!