MOPV005

TOWARDS A NEW CONTROL SYSTEM FOR PETRA IV

R. Bacher, T. Delfs, D. Mathes, T. Tempel, T. Wilksen
Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany

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Control System Framework	**PETRA III:** • 2300-metre-long storage ring feeding 24 user beamlines • Operated either in brightness mode (480 equally distributed bunches, 120 mA stored beam) or in timing mode (40 equally distributed bunches, 100 mA stored beam) • Research groups from all over the world use the particularly brilliant, intense X-ray light for a variety of experiments - from medical to materials research	**PETRA IV:** • High-resolution 3D X-ray microscope for chemical and physical processes • Will extend the X-ray view to all length scales, from the atom to millimetres • Offers outstanding possibilities and optimal experimental conditions for industry • Will replace PETRA III, but keeping the existing experimental halls • An additional experimental hall will provide space for additional 18 user beamlines • New booster synchrotron DESY IV	Data Acquisition and Archiving
Graphical User Interfaces			High-Level Control Applications
Hardware Interfaces	**From PETRA III to PETRA IV:** • Preparatory phase: 2020 – mid 2023 → Technical Design Report • Construction: Expected to begin in early 2026 • Commissioning: In 2028		Quality Assurance

HELMHOLTZ RESEARCH FOR GRAND CHALLENGES

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Control System Framework

- *Distributed Object-Oriented Control System (DOOCS)*
  - Architecture: Distributed client-server, combined with a device-oriented view
  - Transportation layer: Standardized, industrial RPC protocol
  - Implementation:
    - Server: C++
    - Client: C++, Java, Python or MATLAB
  - Device interface: Variety of fieldbus and hardware interfaces via device classes
  - Development history:
    - Started in 1993
    - Is constantly updated to meet the needs of users and keep pace with developments in IT technologies
  - Interoperability: Client API provides access to e.g.
    - EPICS (facility control system at DESY)
    - TANGO (beamline control system at PETRA)

Graphical User Interfaces

- *Java DOOCS Data Display (JDDD):*
  - Tool of choice for the standard beam operation as well as operating technical accelerator devices and systems
  - Thin-client approach with a functional and rich set of widgets
  - Individual UI components can be easily created through a versatile editor IDE without the knowledge of any programming language
- *Python*:
  - Tool of choice for rapid prototyping and visualization of scientific procedures and data
- *Progressive Web Apps (PWA):*
  - Multi-platform, browser-based applications with a look-and-feel of versatile classical desktop applications
  - Based on React JavaScript framework
  - Under investigation

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Hardware Interfaces

- *Interfaces for Triggered, High-Performance Applications:*
  - Compliant with MTCA.4 technology
  - Linux
  - Remotely manageable
  - Specific modules, e.g.
    - Timing:
      - Beamline experiments can make use of the same timing system hardware
    - Digital I/O:
      - e.g. for beam diagnostics / control
- *Interfaces for Conventional Slow-Control Applications:*
  - Compliant with industrial process control standards
  - Generic bridge server available for, e.g.:
    - OPC UA servers
    - Beckhoff controller
    - Classical PLC

Data Acquisition and Archiving

- *Implemention:* Domain-specific interface standards and technologies.
- *Data:*
  - Time series data:
    - Fast data streams in synchronism with the beam revolution frequency (130 kHz), e.g. single-turn orbit data
    - Slow data stream updated asynchronously with less than 100 Hz, e.g. multi-turn orbit data or magnet currents
  - Snapshot data:
    - Measured and stored once
    - Triggered by e.g. value changes, specific events, operator requests, …
- *Versatile visualization and analysis tools*:
  - Particular emphasis will be placed on the capability to support data science applications (e.g. learning feedbacks, failure prediction)

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High-Level Control Applications

- *HLC Team:*
  - Controls experts and accelerator physicists
  - Interfaces specific needs of beam commissioning and operations and implements corresponding tools and applications
- *MATLAB Middle Layer Library Suite:*
  - Supplemented by procedures developed for PETRAIII operation
  - Will be adapted for further use at PETRA IV
- *Machine Learning:*
  - Novel control concepts for PETRA IV are being developed and tested at PETRA III
- *Virtual PETRA Accelerator:*
  - Similar to Virtual European XFEL Accelerator
  - Will be used to test new concepts, enhancements or just modified and improved applications before they will be put into the field

Quality Assurance

- *Quality Assurance Measures:*
  - Issue and bug tracking workflow:
    - Existing workflow has been revised
  - Requirements Management:
    - Template has been worked out to document the requirements
    - Requirements will be regularly reviewed and adapted if needed
  - Training courses for application developers, e.g.:
    - Application software development, graphical user interface design, software testing etc.
- *Configuration Management:*
  - Includes all software and hardware components
  - During all stages of the PETRA IV life cycle
  - Implementation, e.g.
    - Configuration management data base
    - Well-defined workflows and processes for change and release management

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Contact

DESY. Deutsches
Elektronen-Synchrotron

www.desy.de

Reinhard Bacher
reinhard.bacher@desy.de
+49 40 8998 3056