PAUL SCHERRER INSTITUT

PSI

WIR SCHAFFEN WISSEN – HEUTE FÜR MORGEN

Alexandre Mayor, Oxana Actis, Benno Rohrer, David Meer
Centre for Proton therapy :: PSI

Software Framework QAClient for Measurement / Automation in Proton Therapy

17th Conference on Accelerator and Large Experimental Physics Control Systems

October 5-11, 2019 | New York, NY, USA

17th Biennial International Conference on Accelerator
and Large Experimental Physics Control Systems

ICALEPCS 2019

PAUL SCHERRER INSTITUT
PSI

Gantry 3 (Varian)
In clinical operation
since 2018

Superconducting cyclotron (2006)

PSI + Varian, 250 MeV

OPTIS2 (Ocular Tumors)
In clinical operation
since 2010

Experiment

Gantry 2
Second generation
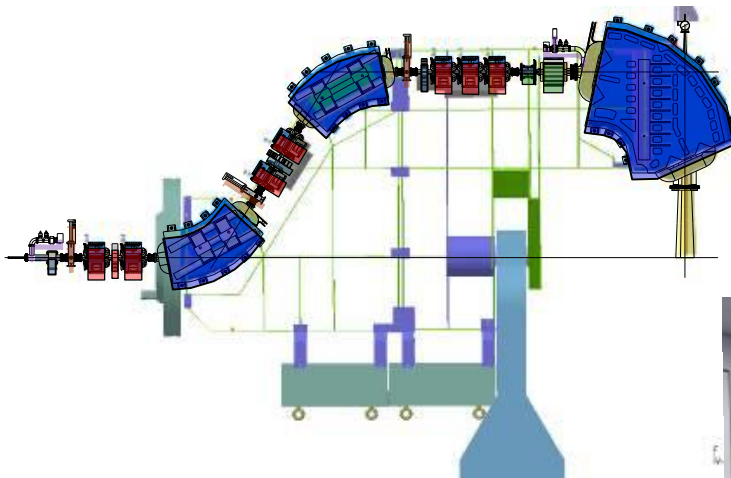PSI gantry
In clinical operation
since 2013

Gantry 1 (1996-2018)
First Pencil Beam
Scanning Gantry

Proton Therapy – Extensive Quality Assurance

Proton Therapy

Complexity of involved Systems used for medical patient treatment requires extensive Quality Assurance (QA)

Involved Actuators & Detectors

- Mechanical: Gantry, Nozzle, Patient Couch…
- Electromagnetic: Beam Delivery, Magnets
- Detectors: Ionization & Strip Chambers

Daily QA

Daily verification of most important proton beam, dose and position parameters has to be performed in a standardized and efficient way.

QAClient - Motivation

QAClient Development Started for Gantry2

- Development started in 2011

- Main Goals of QAClient:
    - Full automation of QA test procedures like daily QA
    - Integration of different control systems and measurement devices
    - Comprehensible reports and long-term QA data storage
    - Fully configurable for different projects (no programming necessary)
    - Easy to use, user interaction and visualization of data and results
    - Reduce errors and execution times of repetitive tasks
    - Less highly-specialized personnel necessary for QA

- QAClient Is now used for many other purposes:
    - Monthly QA
    - Patient Table Calibrations
    - Beam Tune Calibration
    - System Integration Tests (as test engine)
    - …

QAClient - Overview

QAClient - Technologies

QAClient Technologies

- Programming Language **Java**
- requires OpenJDK 8, runs on Windows XP, 7, 10, Linux etc.
- **Swing / AWT** User Interface (uniform look on all platforms)
- **JMS** (Java Message Service) using Apache ActiveMQ
- **RMI** (Remote Method Invocation) to Gateways
- **EPICS** (Experimental Physics and Industrial Control System) to Patient Safety and Accelerator Control Systems
- **HTTP** Service
- **HTML** and **PDF** Reports
- **SMTP** (Simple Mail Transfer Protocol) using JavaMail
- different proprietary **TPC-IP / UDP** protocols
- **OJDBC** database access
- **XML** configuration

QAClient - Features

QAClient Features

- **Graphical user interface** ("expert"/"simple" mode, textures for color-blind operators)
- **XML** based application **configuration** using **standard tasks**
- Generic mechanism of **data transfer** between different tasks
- Dynamic **flow control** (conditions based on data or user decision)
- Programming **loops** and input file driven measurement loops
- Data **checks** and **validations**
- Sending **Commands** to different Control Systems, LabVIEW, MatLab
- Processing **Notifications** from Control Systems, LabVIEW, MatLab
- **Logging** framework with adjustable severity level
- **LDAP** user identification and authorization
- **Persistent** states to continue aborted tasks
- Generic **dialogs** to show/visualize data and ask for user decisions
- **Archiving** of QA data and measurement results in external database
- **Generating** and **printing** of summary **reports** (HTML, PDF)
- **Visualization** of archived QA data

QAClient – Standard Tasks

QAClient Provides 228 Standard Tasks

- **System Tasks**   like OpenFile, ExecuteSSHCommand etc.
- **Control System Tasks**   like StartupBeamline, MoveToPosition etc.
- **QAClient Tasks**   like ForEachFile, CreateData, ReceiveUDP etc.
- **LabVIEW Tasks**   like DataRequest, StartVITask etc.
- **MatLab Tasks**   like StatusRequest, ML_Command etc.
- **Database Tasks**   like SendData, ShowDBData etc.

QAClient Tasks Configuration

- Tasks are **defined in XML**
- Tasks can be **specialized with different parameters** to be reused
- Tasks can be **aggregated to TaskLists** to reduce complexity in project configurations

```
<Task id="TCS_PauseField" type="TCS" command="execute(TcsOpPauseField)"
      aSyncNotification="RpcNoteTcsState(sData=fieldPaused)"
      desc="Pause Field currently being applied.">
  <DefaultArg key="doNotWaitForRpcNoteRpcServer" value="true" desc="not waiting for RPC notification."/>
</Task>
```

QAClient – Application Configuration

Generic Architecture to Configure Applications

- **Scope**: QAClient application (automated measurement, daily QA etc.)
- **StepList**: Full measurement procedure
- **Step**: Smallest execution entity with all its parameters and input data
- **Task**: Standard Tasks with defined parameters, input and output data

QAClient - Configuration
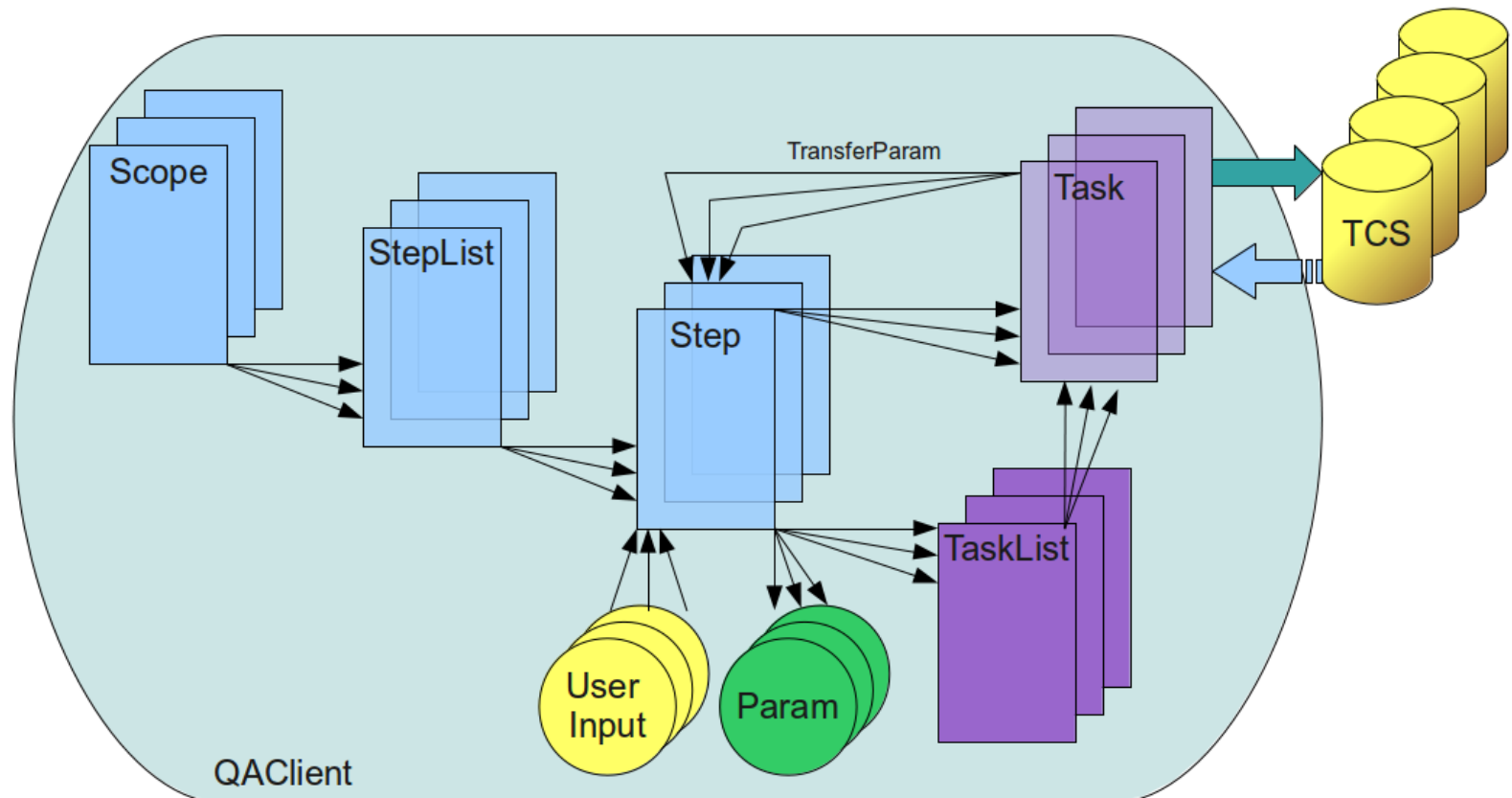
Generic XML / Graphical Configuration

- XML configuration in external editor
- Syntax and semantic check against XSD schema and standard tasks XML
- Graphical configuration tool

QAClient – Graphical User Interface

GUI Expert / Simple Mode

- Simple Mode: Reduced to what it is needed for daily usage
- Expert Mode: Offering full control and detailed information

Expert Mode

Simple Mode

QAClient – Graphical User Interface
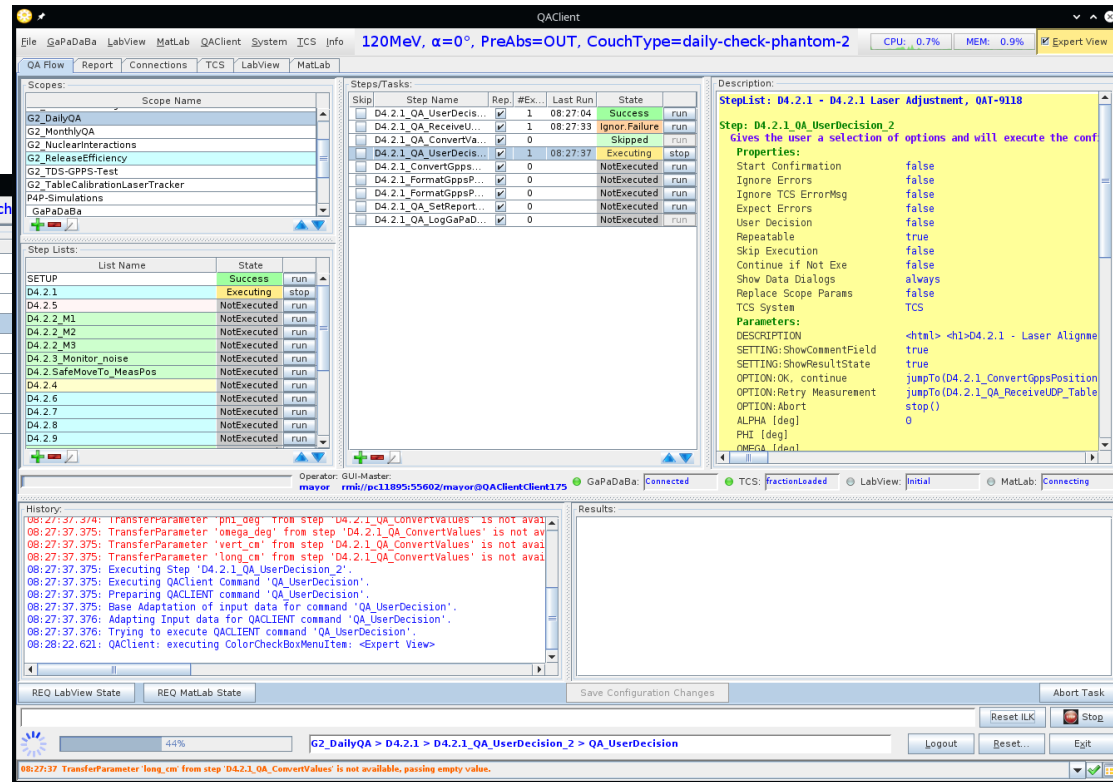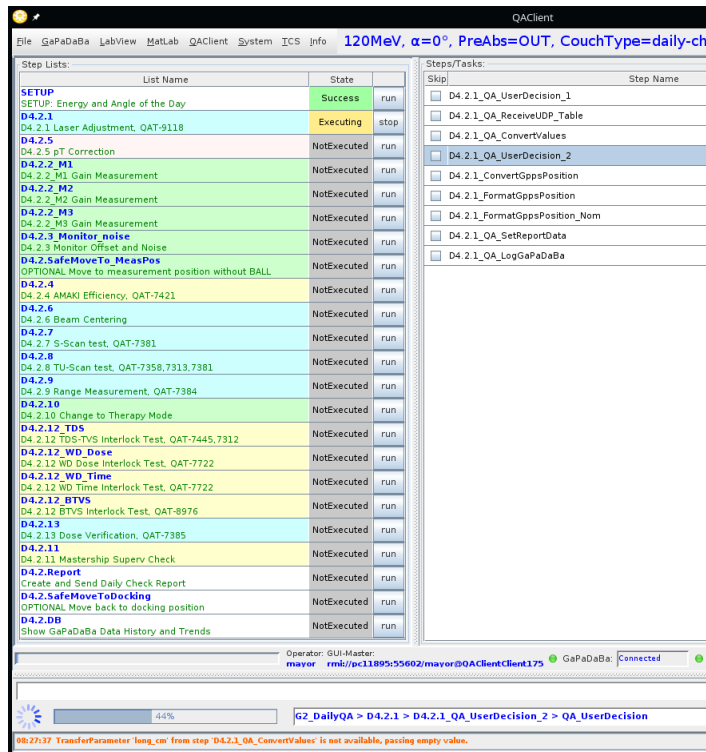
GUI Generic Dialogs

- showing measured/calculated data
- offering access to data files
- showing plots and messages of previous tasks
- asking for user decisions (like "continue", "retry" or "abort") and comments or input
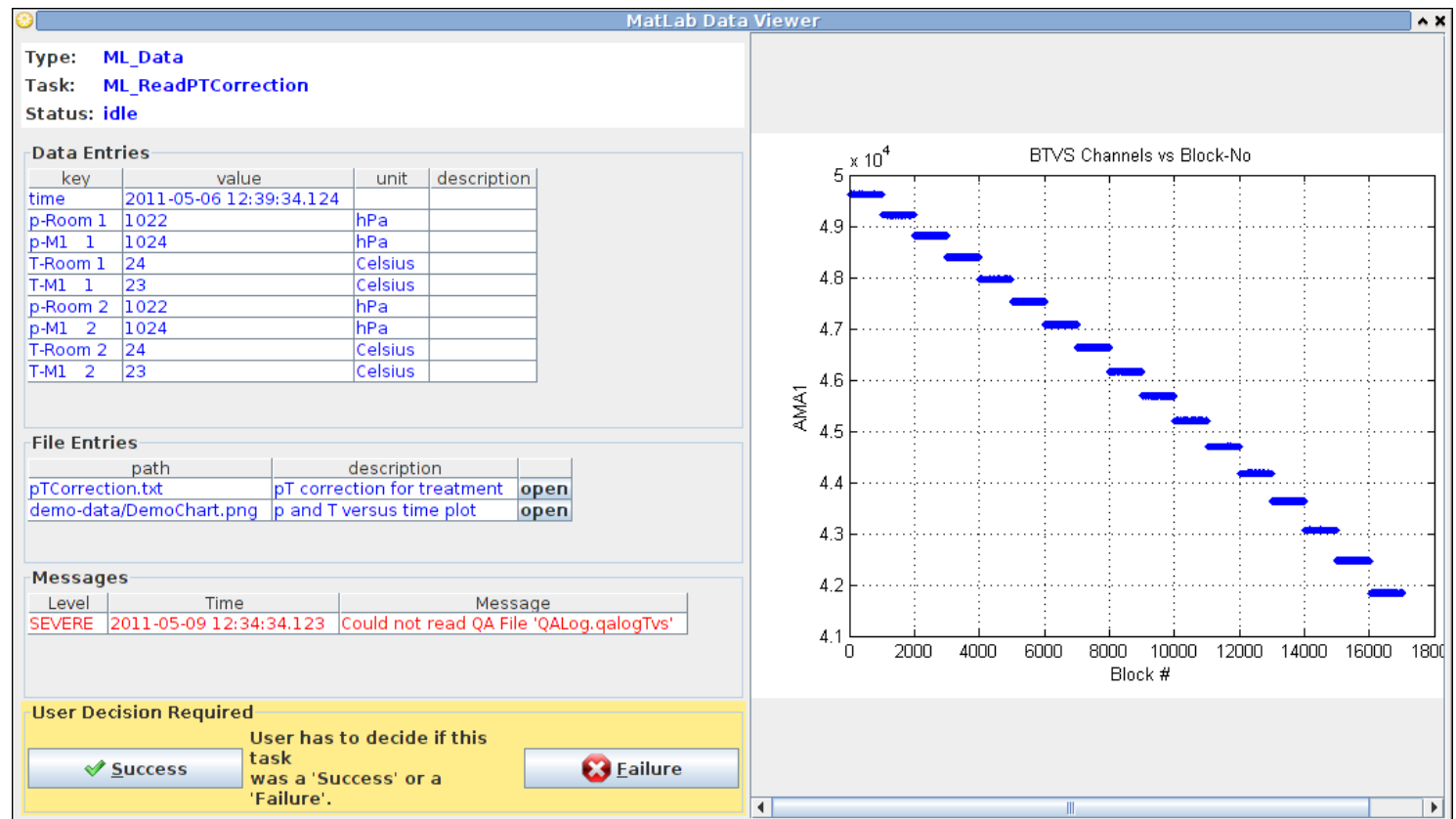
Reports & Data Archiving

- Reports are saved in QA Management Tool, sent by email and printed
- Data is archived in QA Database and can be analyzed offline

G2 Daily QA Report

Example Application: Gantry 2 Daily Quality Assurance

G2 Daily Check is used every morning before patient treatment to check:

- Dose delivery accuracy using ionization chambers
- Proton beam position accuracy
- Proton beam parallelism and position
- Proton beam energy / range in water
- Beam kicker magnet closing efficiency
- Base check on patient safety system
  (beam on/off, beam interruptions, beam tune)

QAClient – Example: G2 Daily Check

Gantry 2 Daily Quality Assurance Equipment

- Mini-strip detector
- Multi-layer ionization chamber
- Ionization chambers at different depths

Integrated Systems

- Control Systems (TDS, TVS, GPPS)
- Patient Safety System (LPaSS)
- LabVIEW: measurements
- MatLab: data analysis
- QA database (GaPaDaBa)

Output Produced

- Measurement/Analysis reports
- Paperwork: QA document
- Long-term storage of QA data
- Archives & mails report

QAClient - Summary

- Flexible Software Framework
- Fully Configurable
- Reliable and standardized procedures
- Reduced operator errors
- Reduced QA execution times
  (Daily Check time reduction by 70%)
- Used for different applications / tasks
- Used in daily operation
- No programmer or software engineer
  needed to build an application
- Easy to use
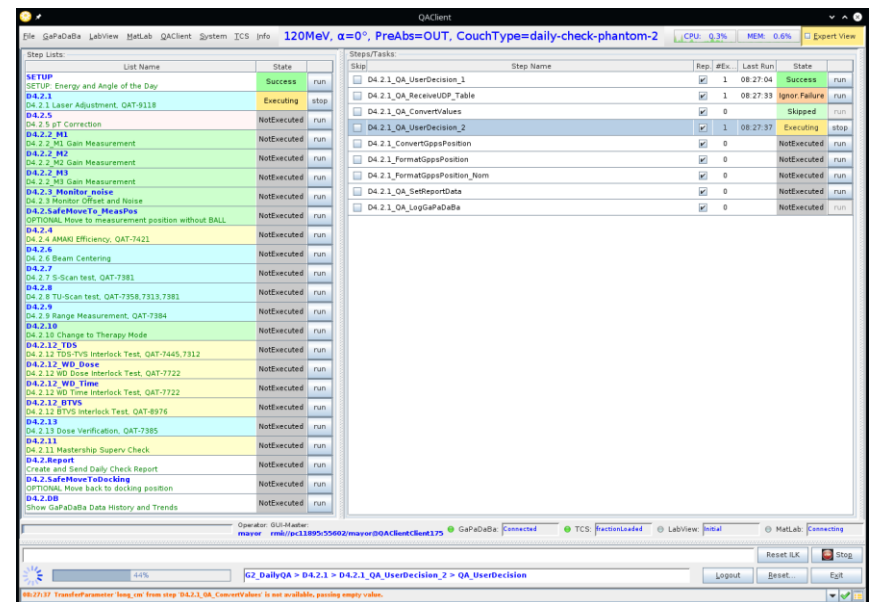
Thank you for your attention

Paul Scherrer Institut

Alexandre Mayor
Forschungsstrasse 111
CH-5232 Villigen PSI
Switzerland
alexandre.mayor@psi.ch

https://www.psi.ch/en
https://www.psi.ch/en/protontherapy/center-for-proton-therapy-cpt