The KATRIN Analysis Framework

2nd ASPERA Workshop on Computing and Astroparticle Physics
Barcelona 2011

Marco Haag - Institute of Experimental Nuclear Physics (IEKP)

Outline

1. The KATRIN Experiment
2. Data Taking and Experiment Control
3. The Analysis Software Framework
4. Implementation Details
5. Conclusion & Outlook

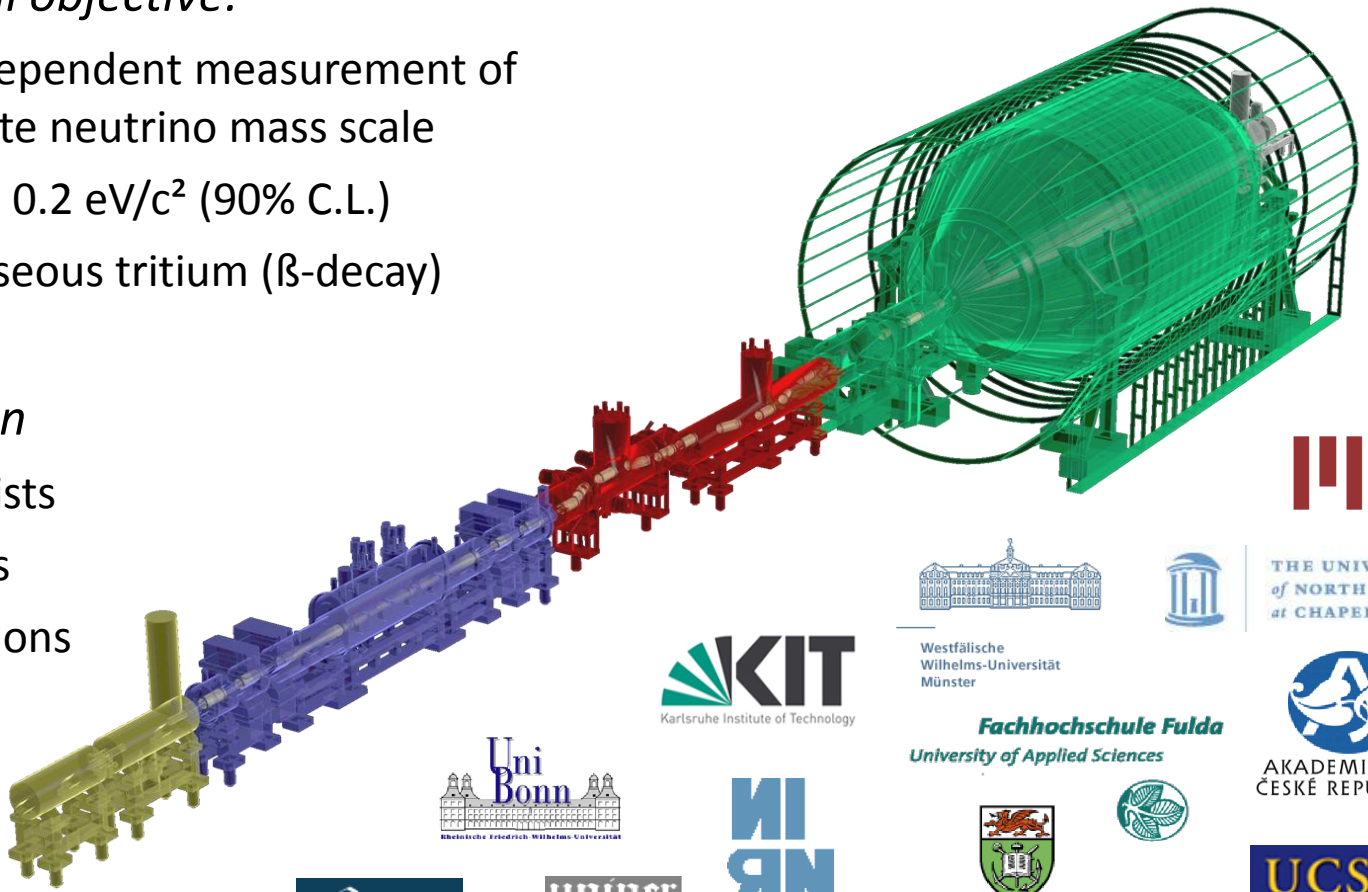
The Karlsruhe TRItium Neutrino (KATRIN) Experiment

Experimental objective:

- model-independent measurement of the absolute neutrino mass scale
- sensitivity: 0.2 eV/c² (90% C.L.)
- source: gaseous tritium (ß-decay)

Collaboration

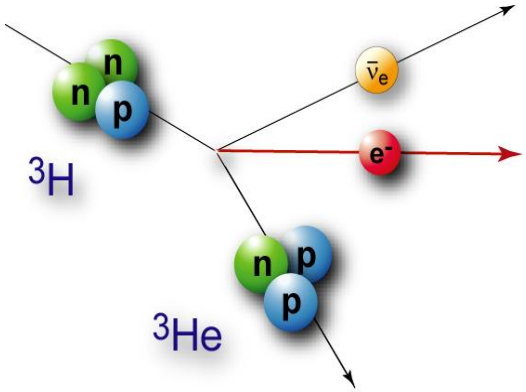
- 130 scientists
- 5 countries
- 13 institutions

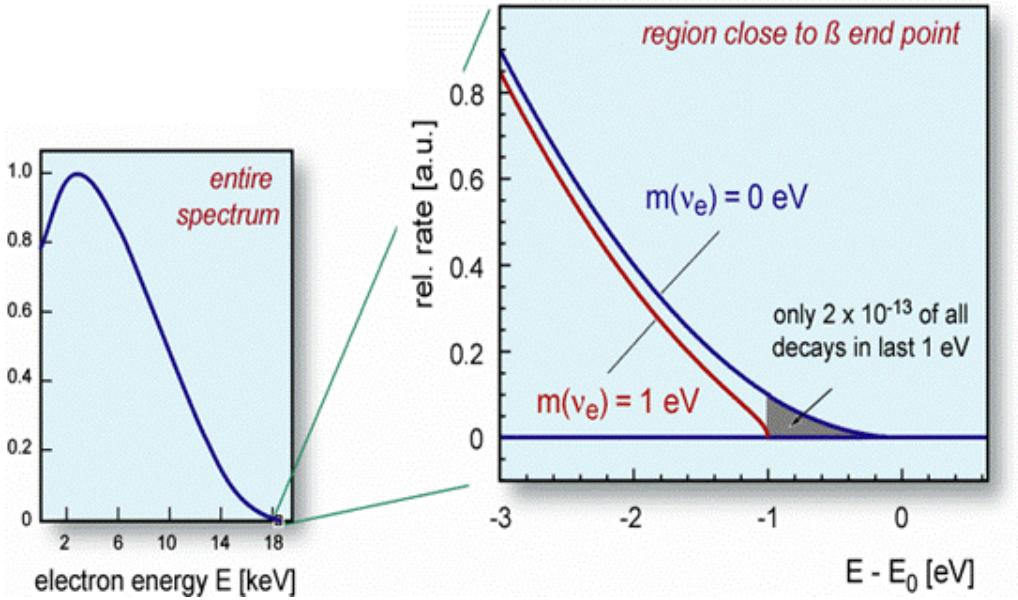


β-decay and neutrino mass

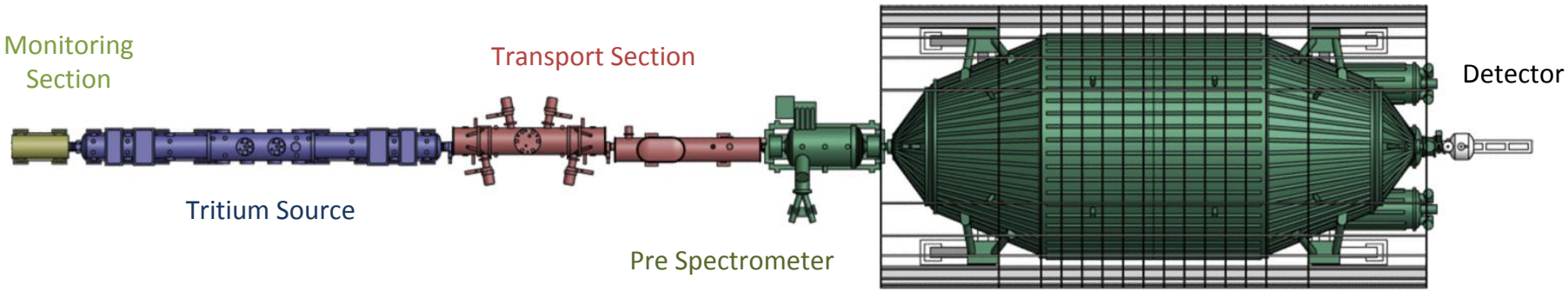
- Direct kinematic measurement of the effective neutrino mass
- Tritium as β-emitter
- MAC-E filter (electrostatic filter with magnetic adibatic collimation) as spectrometer
- Data rate: mHz - kHz

$$m_{\nu_e} = \sqrt{\sum_{i=1}^{3} |U_{ei}|^2 m_i^2}$$





Experiment Control & Data Taking



DAQ / ORCA*
Rear Monitordetector

PCS7 (Siemens)
Cryogenics
Tritium Loops
LARA

PCS7
Heating
Cooling
Vacuum
Magnets

LabView (NI)
Air Coils
Magnetometer
3D Temperatures
High Voltage

LabView
Detector SC

DAQ / ORCA
Detector
Veto

DAQ / ORCA
Monitorspektrometer

* Mark Howe, John Wilkerson et al., UNC

SQL Databases ... ...

File Storage

Calibration

Geometry Sensor Catalogue | Version Control Simulation Data | ...

SlowControl Data

DAQ Data

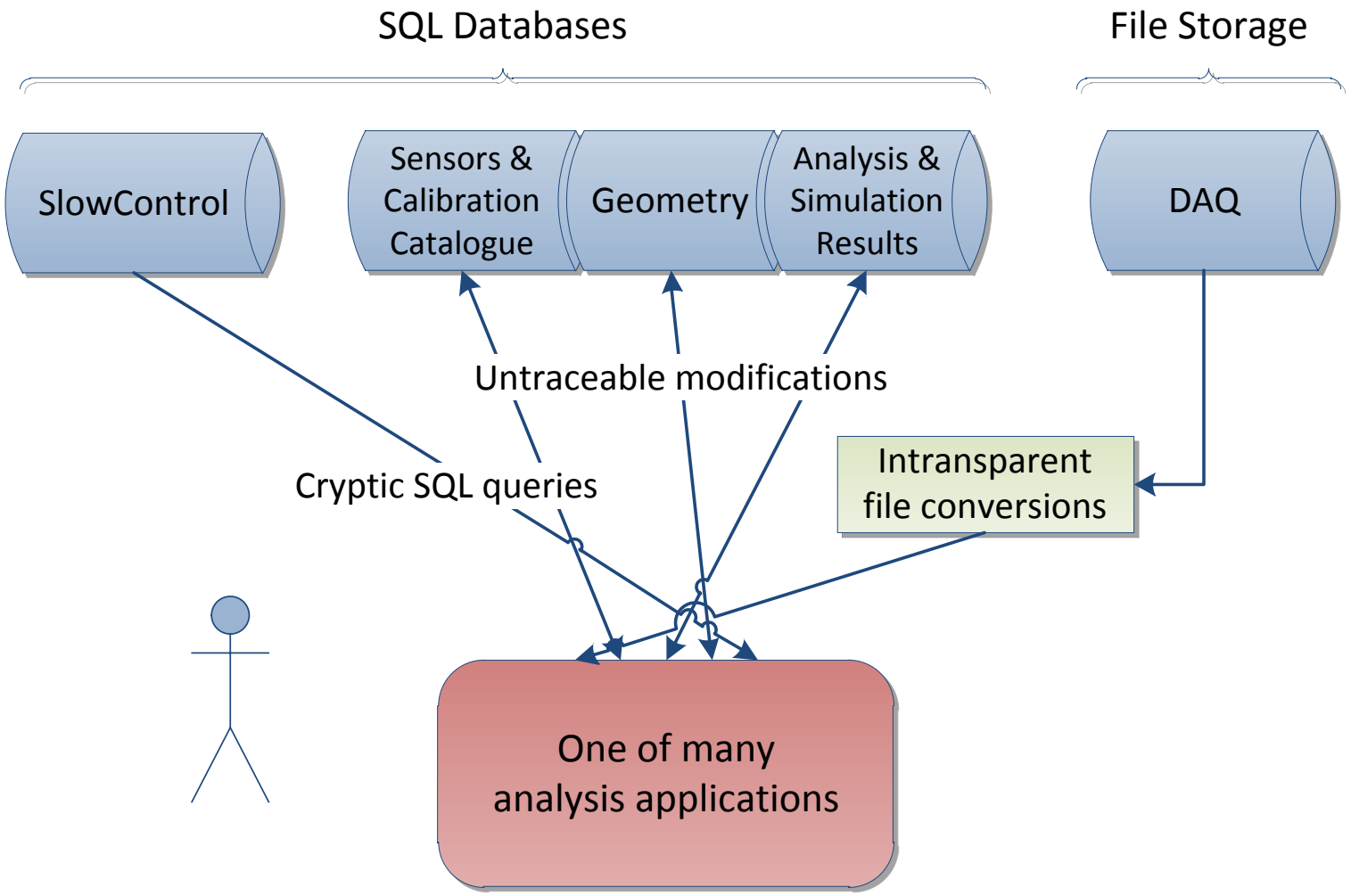
Requirements

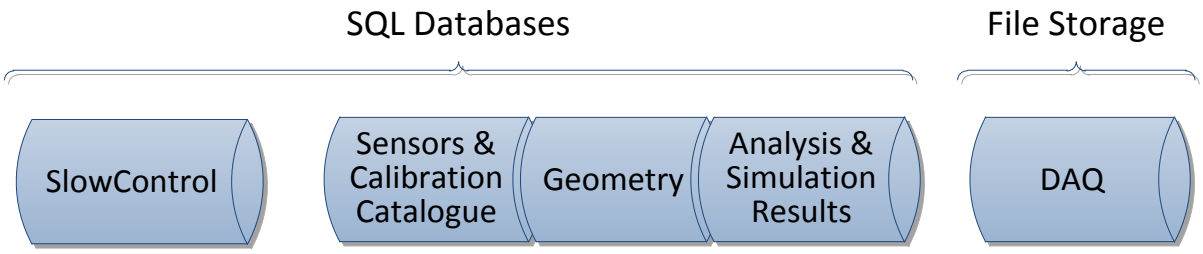
- DAQ: around 1 GB per day
- SlowControl: Large number of heterogenously distributed sensors, ca. 10.000 channels
- Calibration, geometry information, simulation results, …

- Constant monitoring is necessary to maintain highly stable operating conditions over years.
- The neutrino mass sensitivity goal of 0.2 eV/c^2 demands many parameters to be reliably known on the ppm (10^{-6}) level.

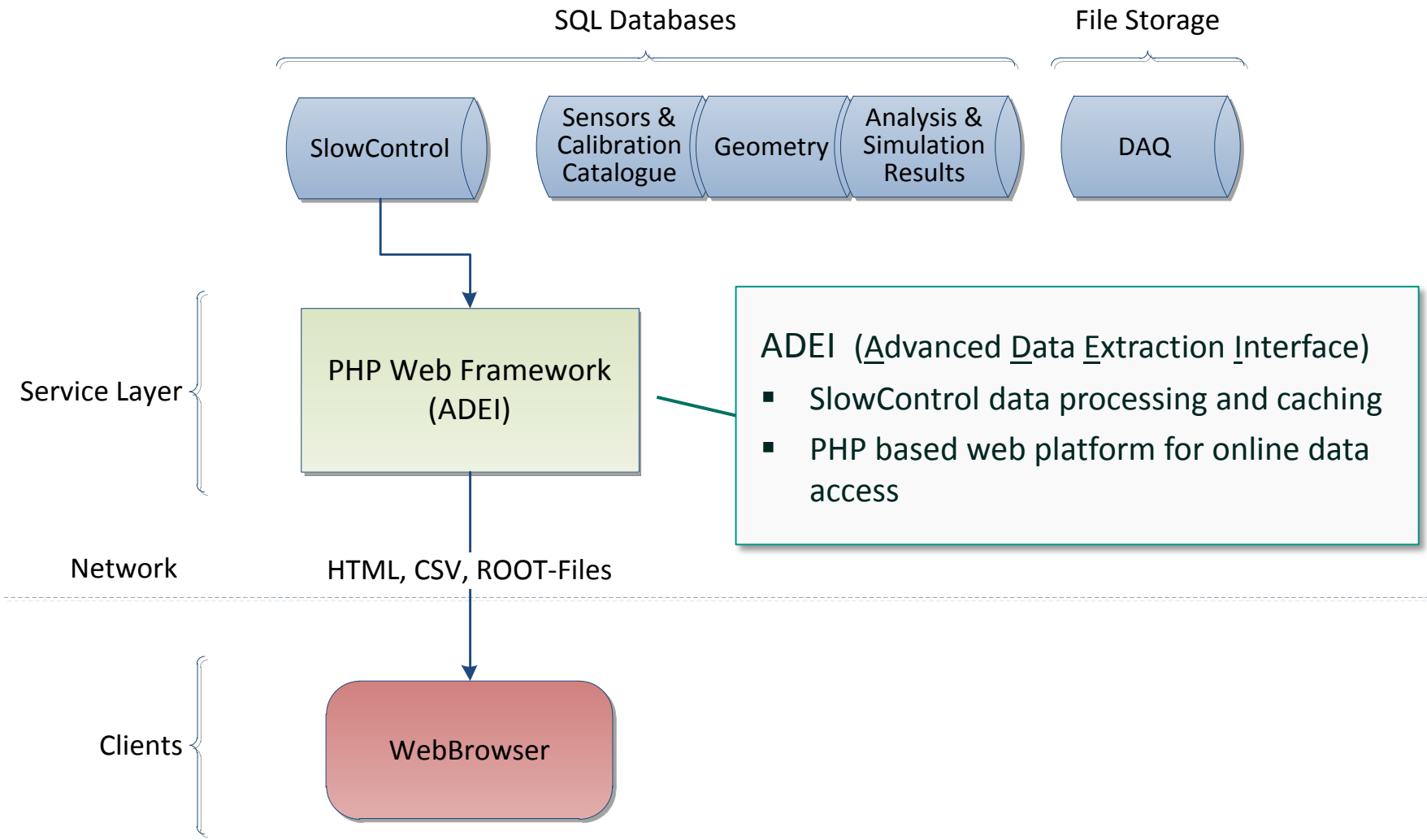
- Data has to be restructured, calibrated and merged from many different sources, even for simple analysis tasks.

Conventional file-based data access is not feasable:

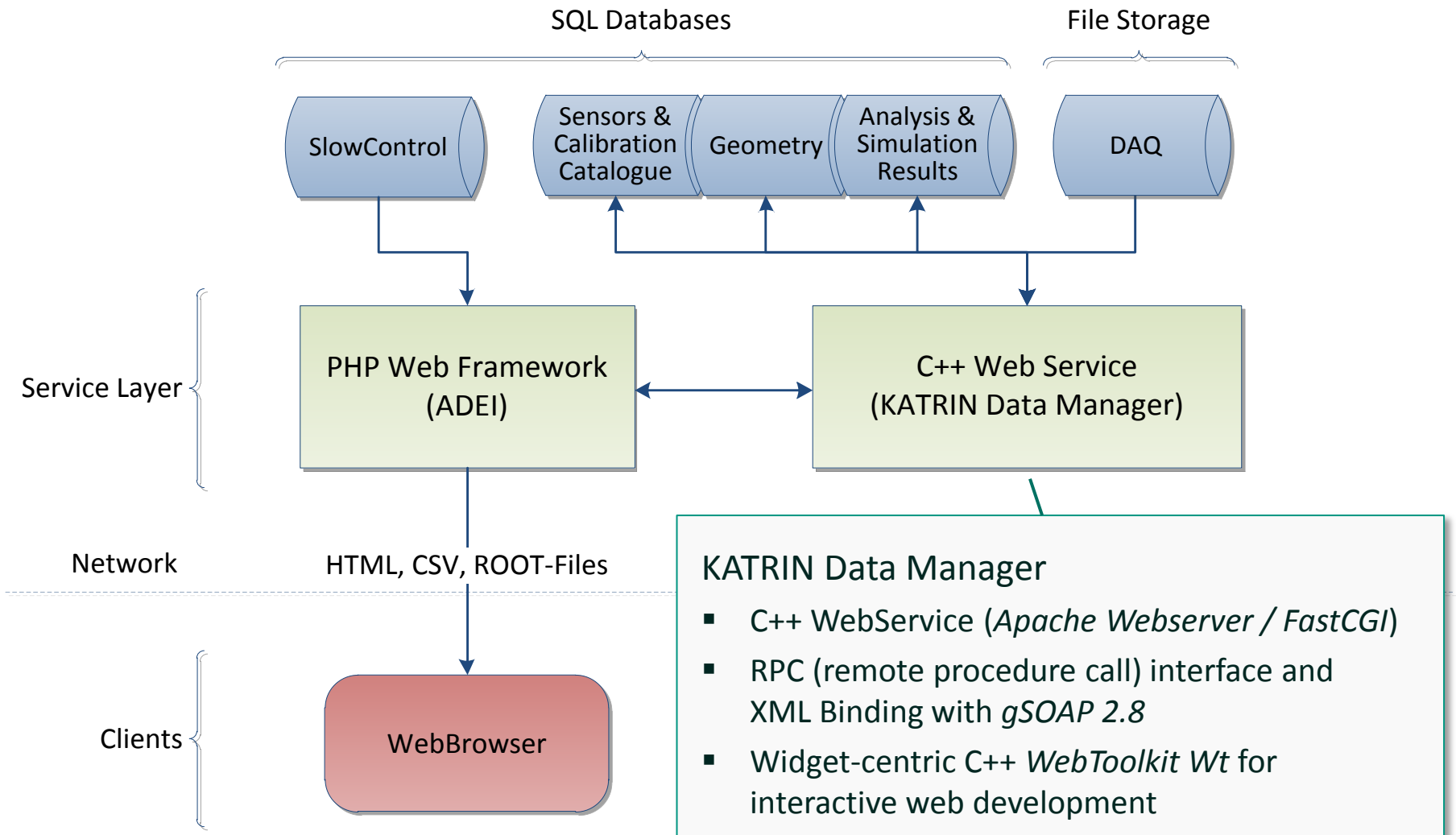



SQL Databases
File Storage
SlowControl
Sensors & Calibration Catalogue
Geometry
Analysis & Simulation Results
DAQ

Service Oriented Architecture at KATRIN



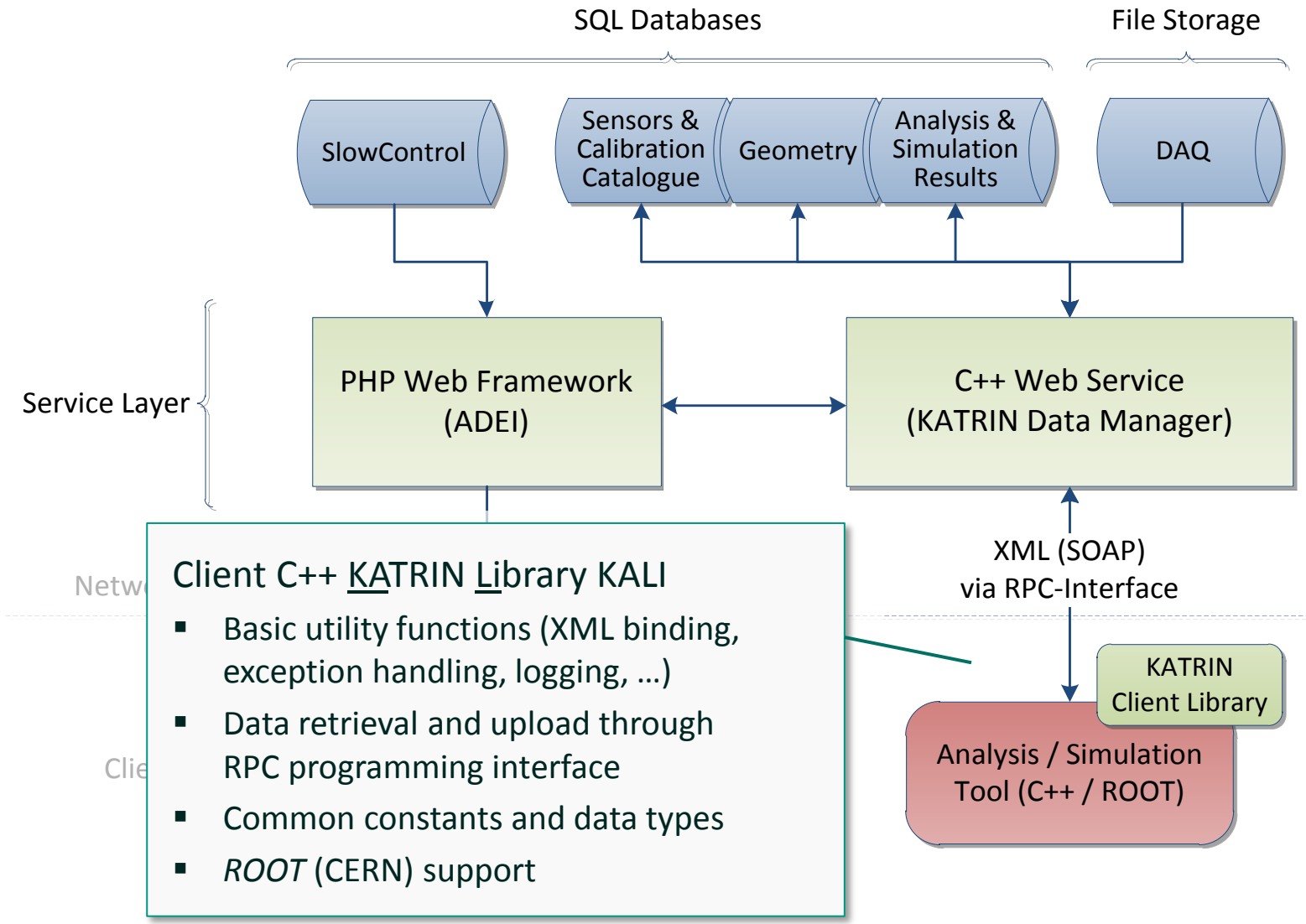
Service Oriented Architecture at KATRIN



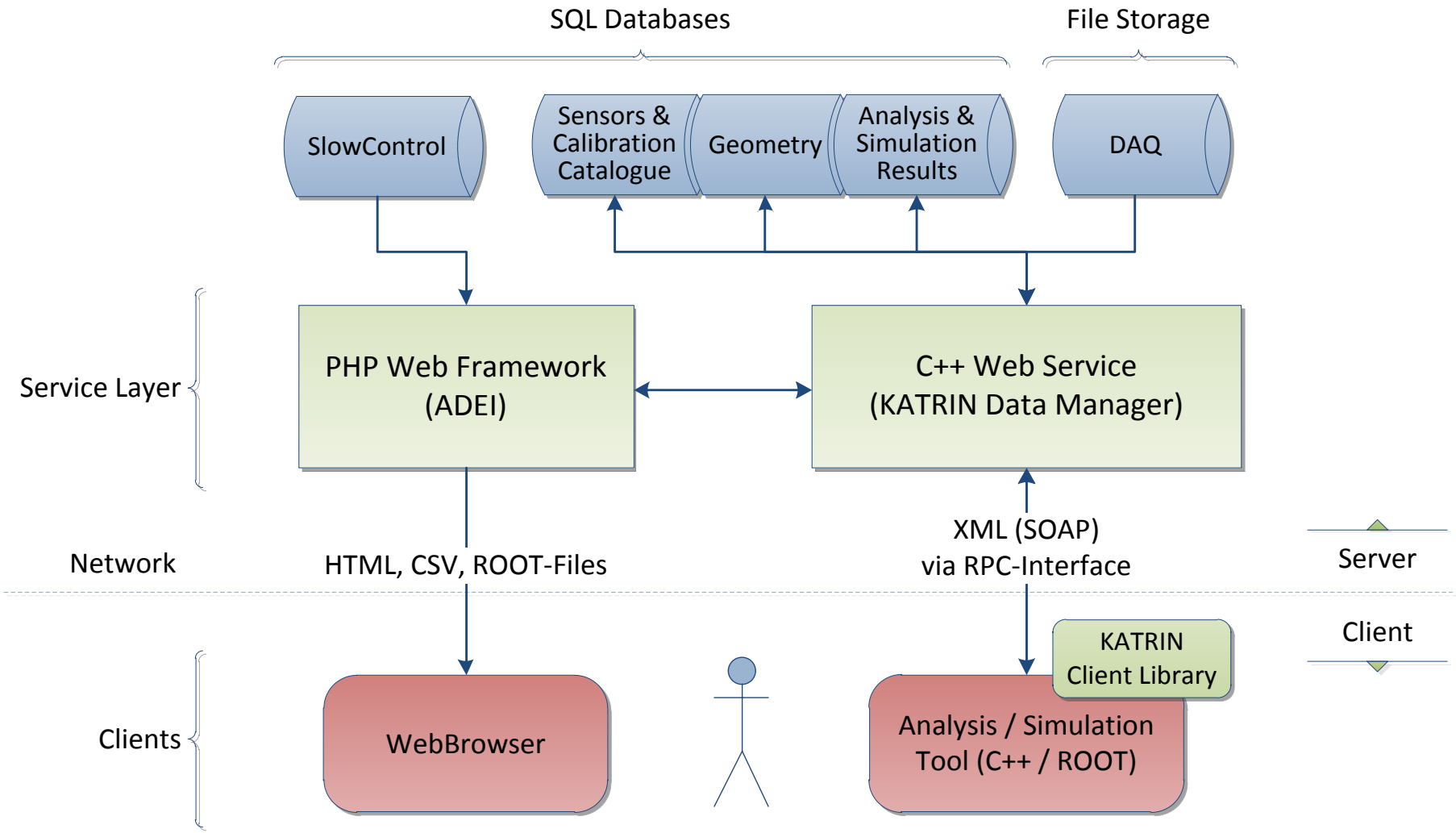
KATRIN Data Manager

- C++ WebService (*Apache Webserver / FastCGI*)
- RPC (remote procedure call) interface and XML Binding with *gSOAP 2.8*
- Widget-centric C++ *WebToolkit Wt* for interactive web development
- SQL database access through ORM (object relational mapping) abstraction layer *Wt::Dbo*

Service Oriented Architecture at KATRIN



Service Oriented Architecture at KATRIN



The Benefits of a Service Oriented Approach

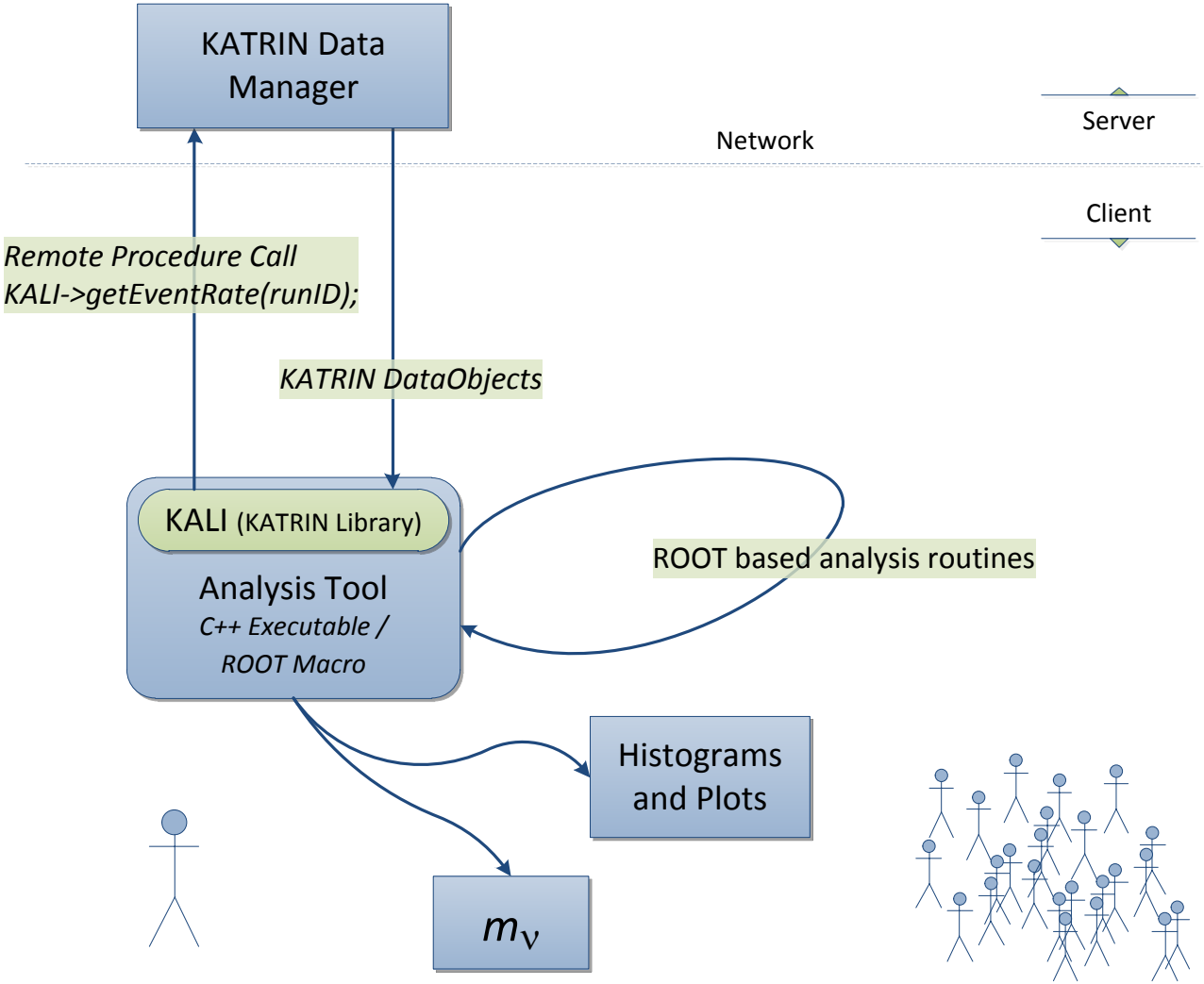
- Well defined data flow and server-side processing (unnecessary data transfer is minimized)
- Automated data quality and integrity checks

- Central version and user access control
- Reliable transaction handling

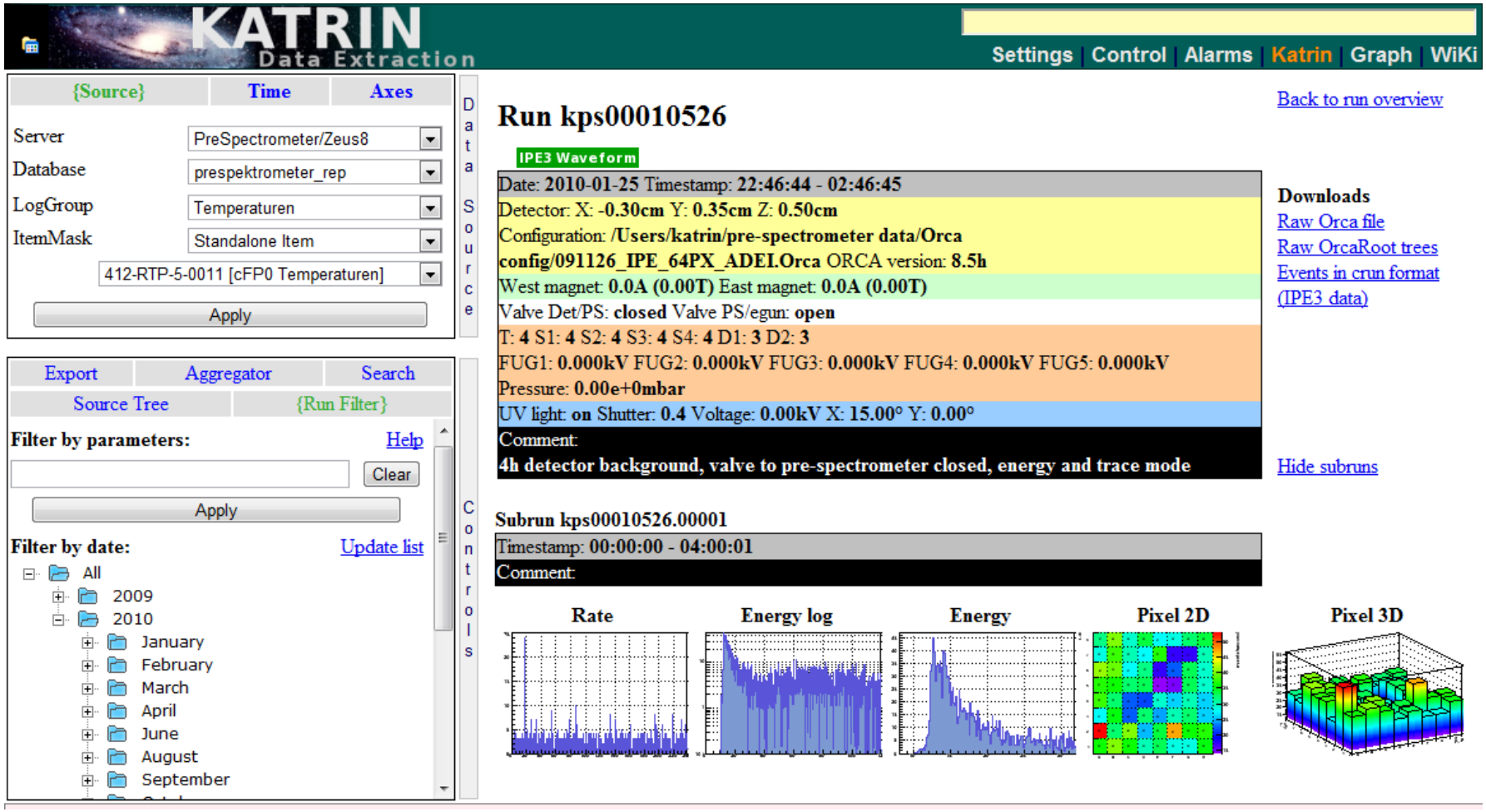
- Data access through intuitive and consistent programming interfaces
- Standardized code, common constants and data formats

- Server-side data processing is performed by only few maintainable services
- Consistent set of client applications (analysis and simulation) speaking a „similar language“

Offline Analysis

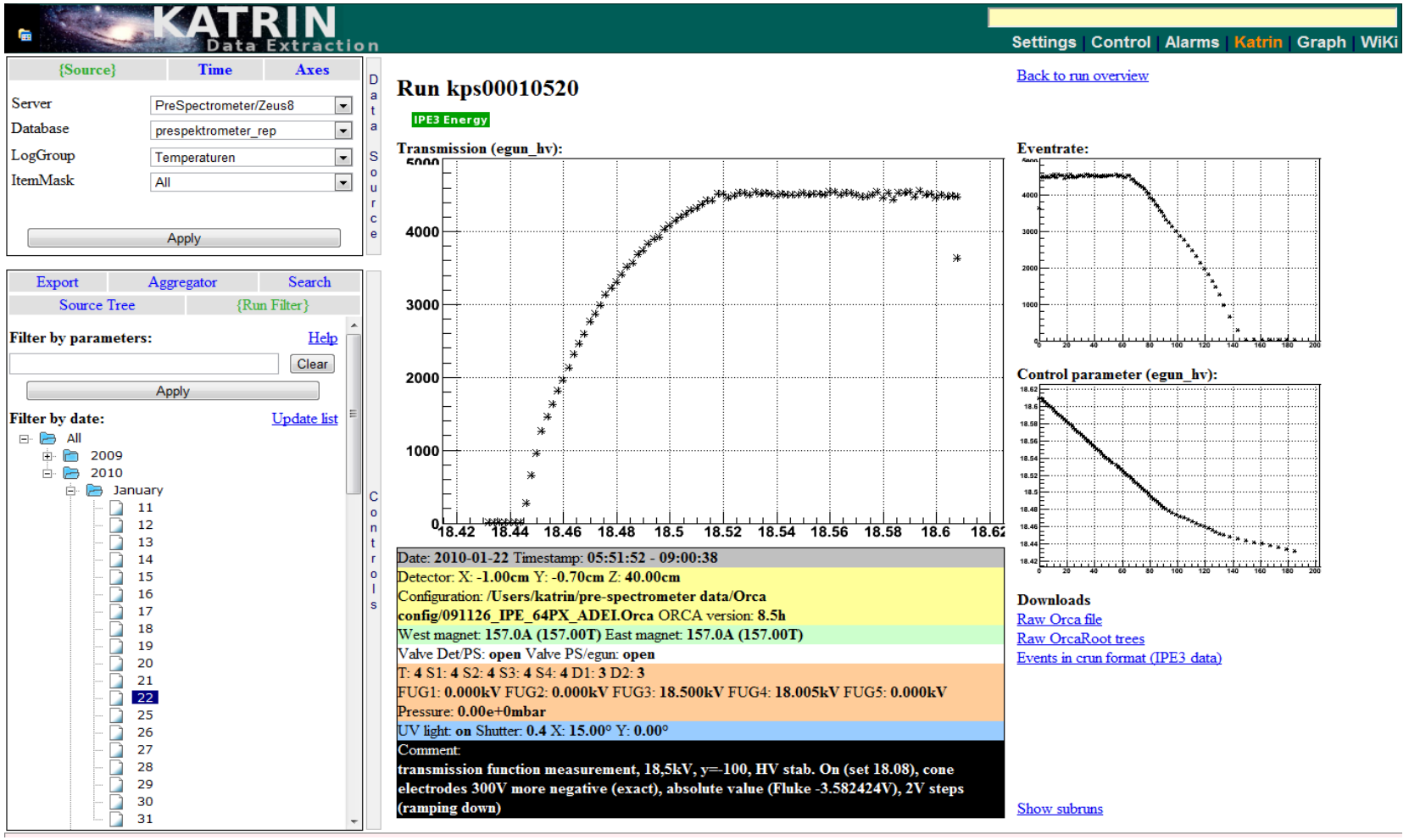


Online Analysis (Browser Screenshot)



External PHP application (ADEI) accessing KATRIN DAQ data through PHP-SOAP.
(Plugin developed by Sebastian Vöcking, University of Münster)

Online Analysis (Browser Screenshot)



Combined SlowControl and DAQ data:
Pixel detector hit rate over electron gun voltage.

Summary & Conclusion

- C++ web service with SOAP interfaces for client applications implemented and tested
- Standardized RPC interfaces (remote function calls) now allow intuitive access to heterogeneously distributed and structured data
- Automated data processing and caching established
- First stability and performance test look very promising

- Preliminary online analysis tools available
- Deployable C++ client library for offline analyses of main spectrometer commissioning measurements by the end of 2011

Thank you for your attention.

References and URLs

- The KATRIN Experiment:
  http://www-ik.fzk.de/tritium
- ADEI:
  http://dside.dyndns.org/adei
- Orca:
  http://orca.physics.unc.edu/~markhowe/Orca_Help
- gSoap:
  http://www.cs.fsu.edu/~engelen/soap.html
- Wt:
  http://www.webtoolkit.eu

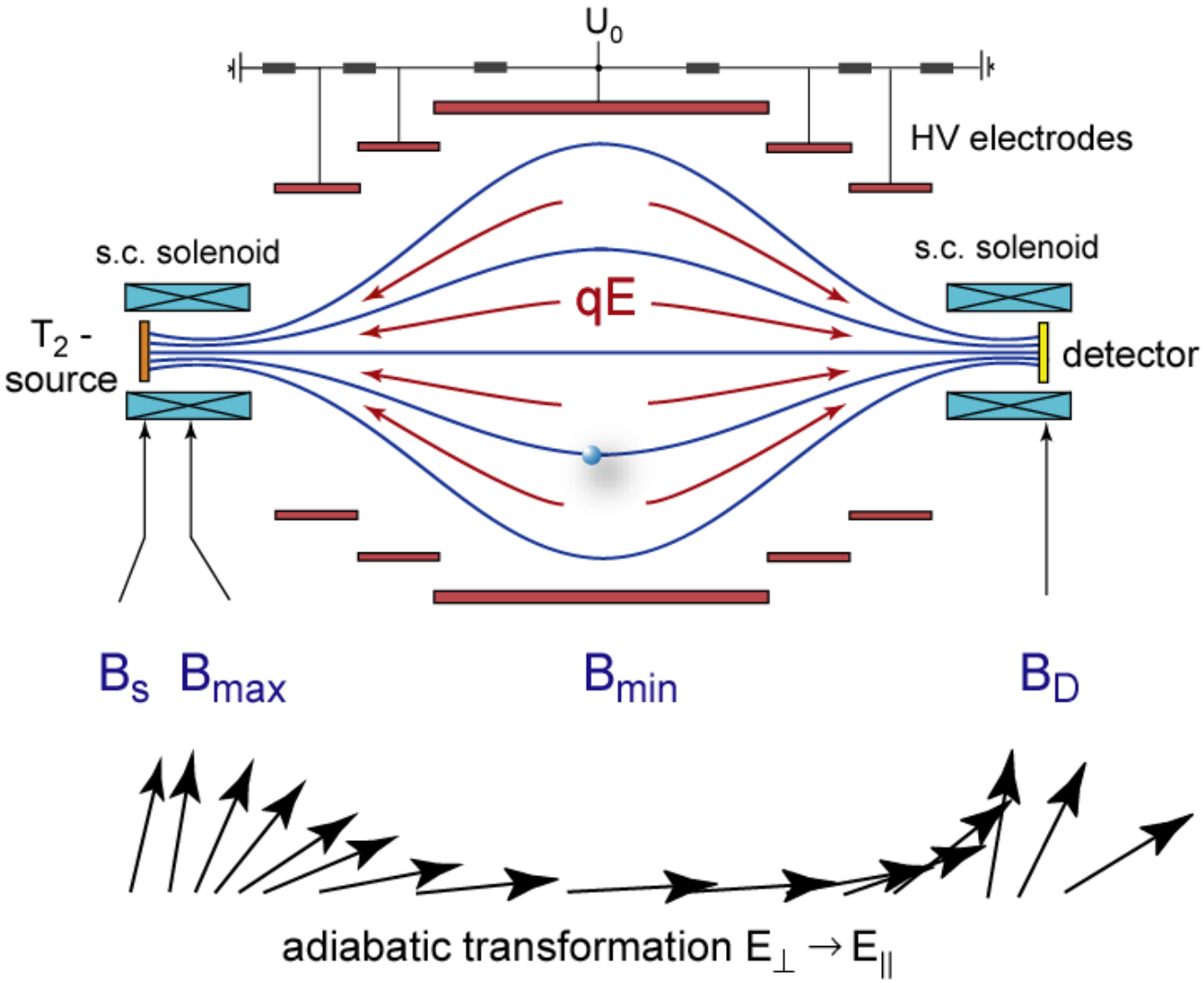
Implementation

- KATRIN Data Manager
  - C++ WebService (*Apache Webserver / FastCGI*)
  - RPC (remote procedure call) interface and XML Binding with *gSOAP 2.8*
  - Widget-centric C++ *WebToolkit Wt* for interactive web development
  - SQL database access through ORM (object relational mapping) abstraction layer *Wt::Dbo*

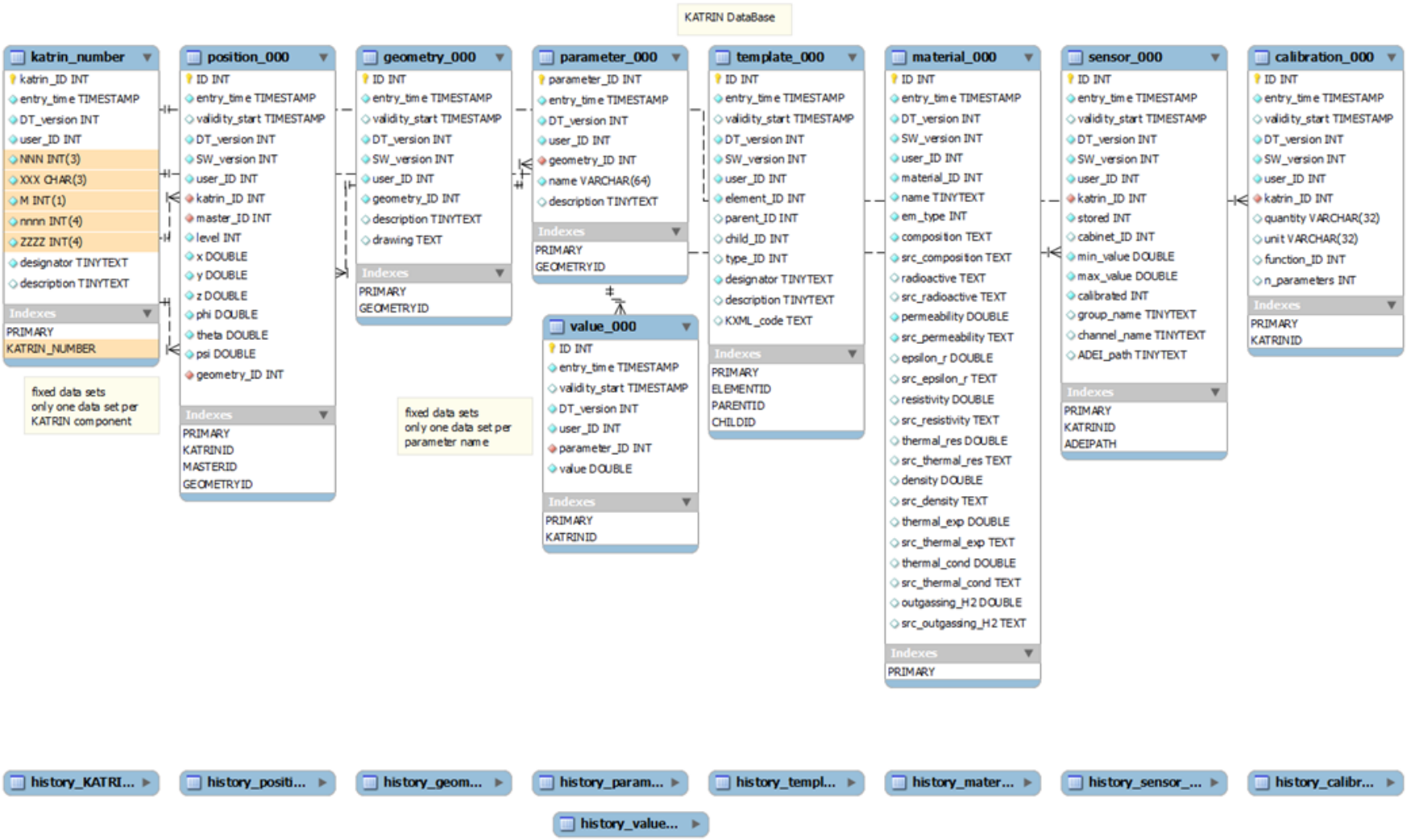
- Client C++ KATRIN Library KALI
  - Basic utility functions (XML binding, exception handling, logging, …)
  - Data retrieval and upload through RPC programming interface
  - Common constants and data types
  - *ROOT* (CERN) support

- ADEI (Advanced Data Extraction Interface)
  - SlowControl data processing and caching
  - PHP based web platform for online data access

Magnetic Adiabatic Collimation with Electrostatic Filter (MAC-E)



KATRIN number / sensor / geometry catalogue



KATRIN DataBase Administrator