

The KATRIN Analysis Framework

2nd ASPERA Workshop on Computing and Astroparticle Physics
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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

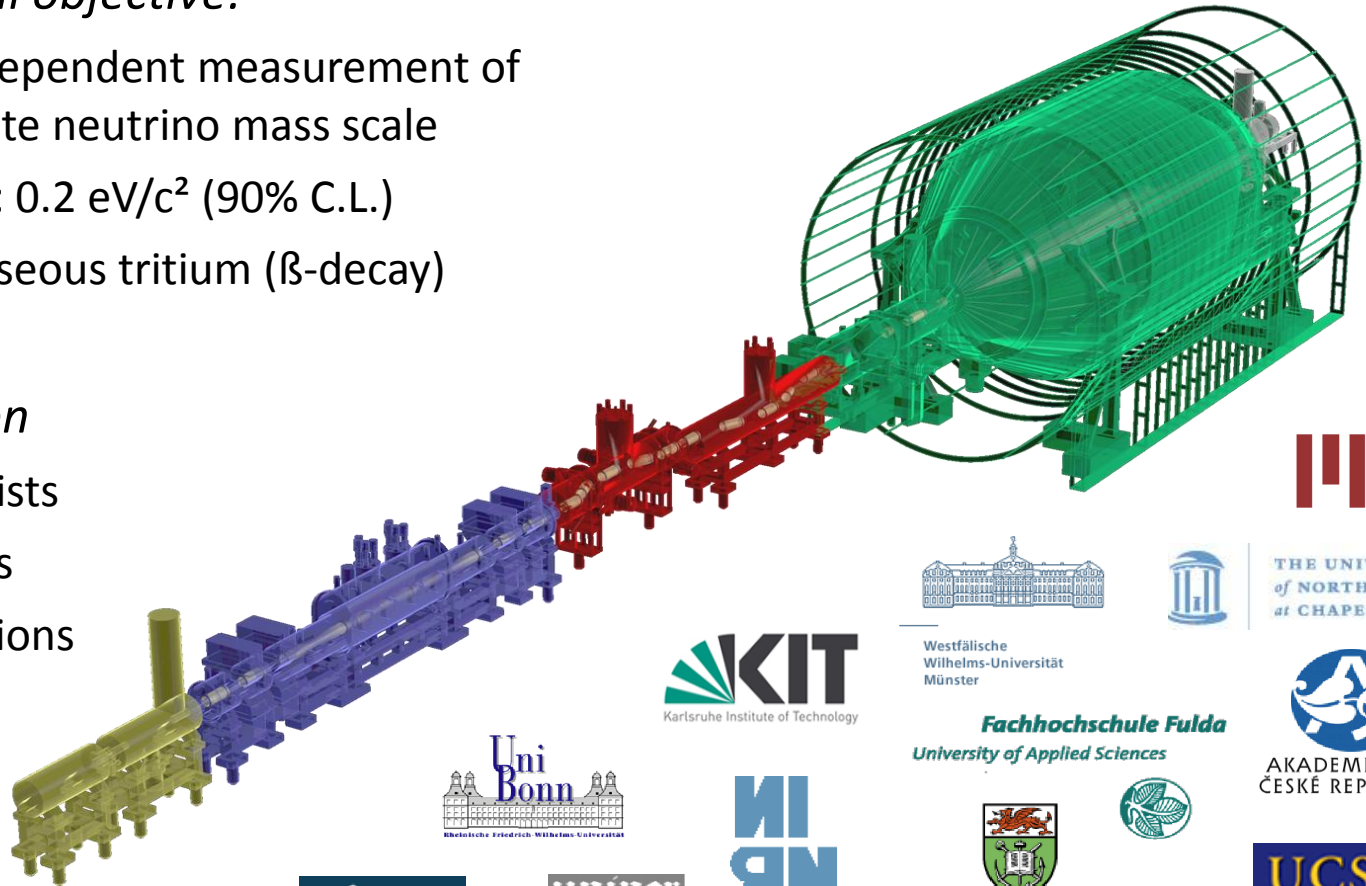


Experimental objective:

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

Collaboration

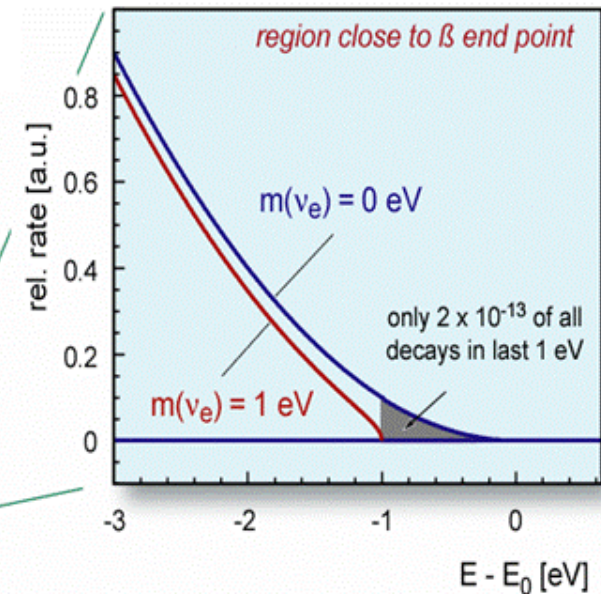
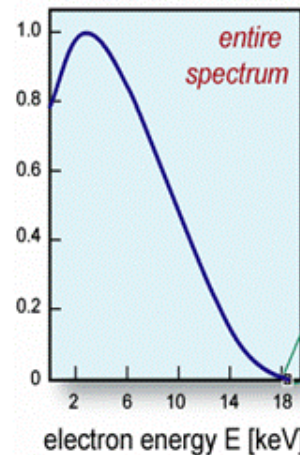
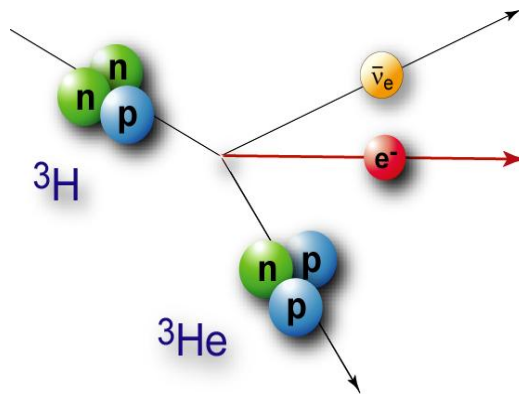
- 130 scientists
- 5 countries
- 13 institutions



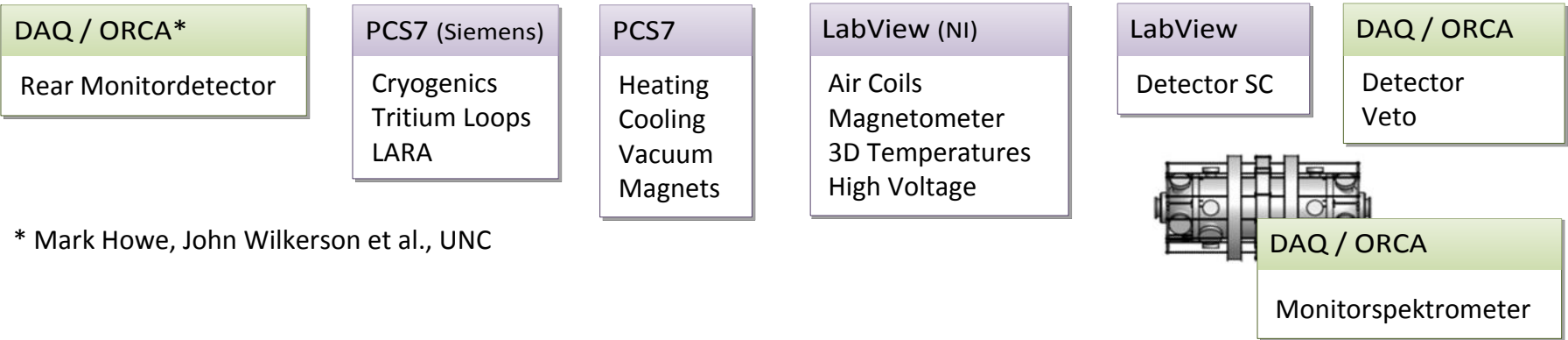
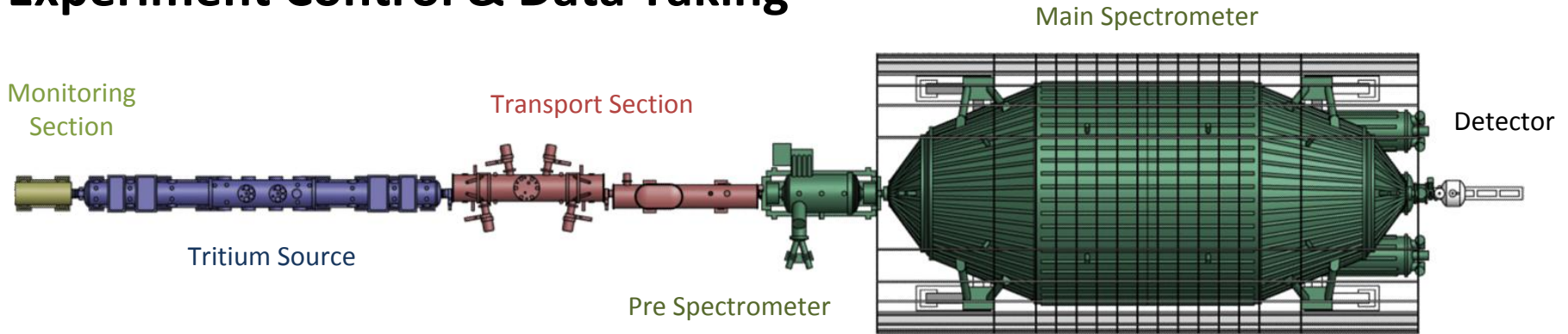
β -decay and neutrino mass

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

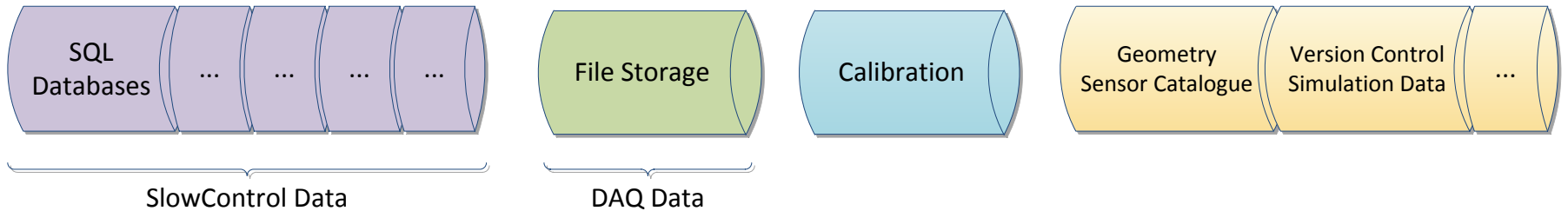
$$m_{\nu_e} = \sqrt{\sum_{i=1}^3 |U_{ei}|^2 m_i^2}$$



Experiment Control & Data Taking



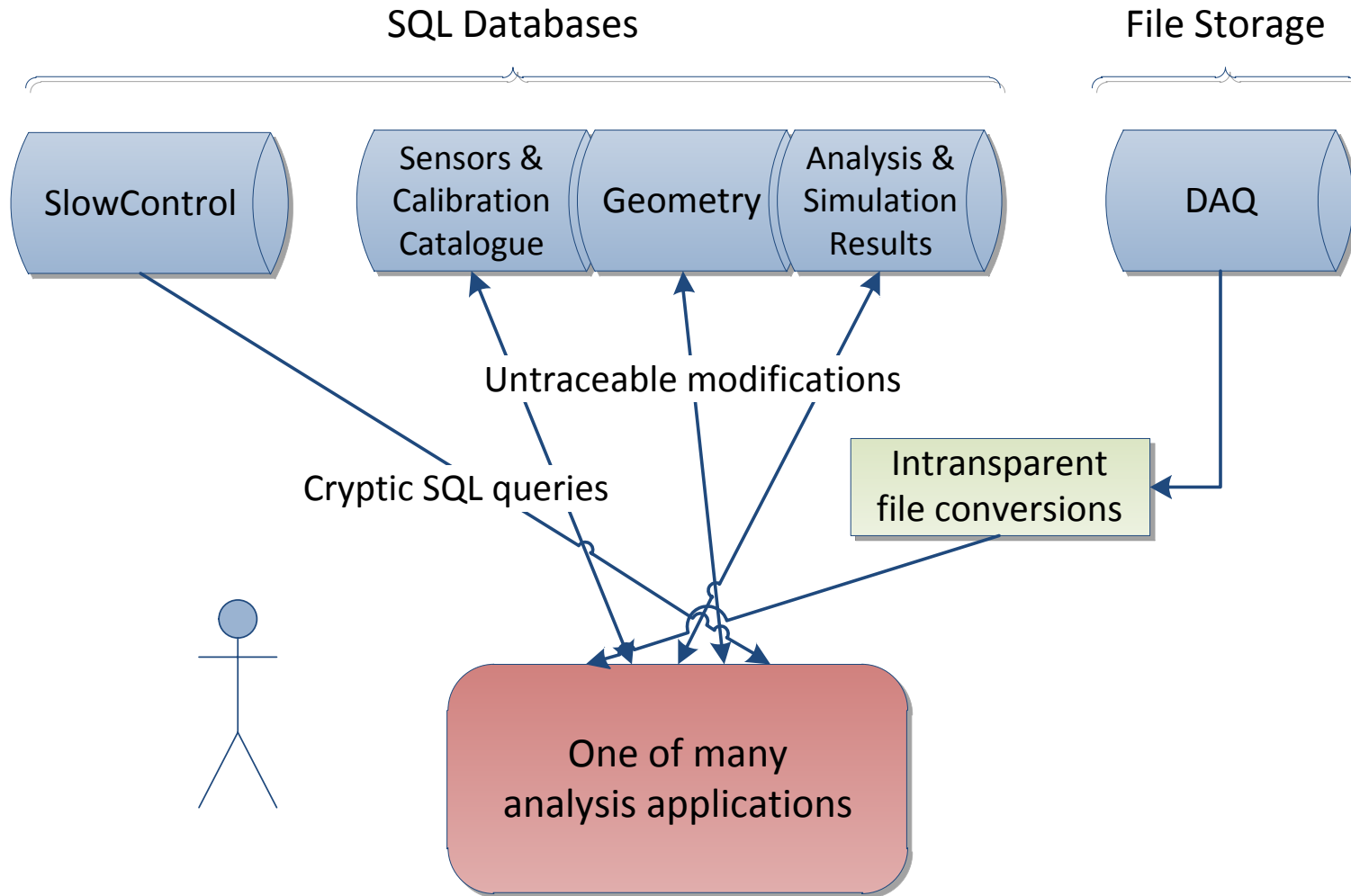
* Mark Howe, John Wilkerson et al., UNC

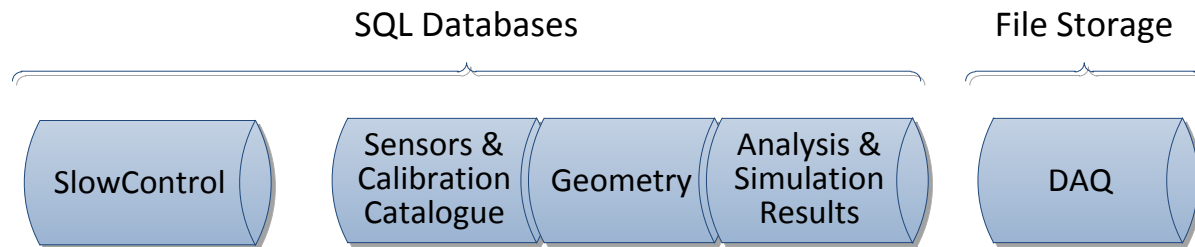


Requirements

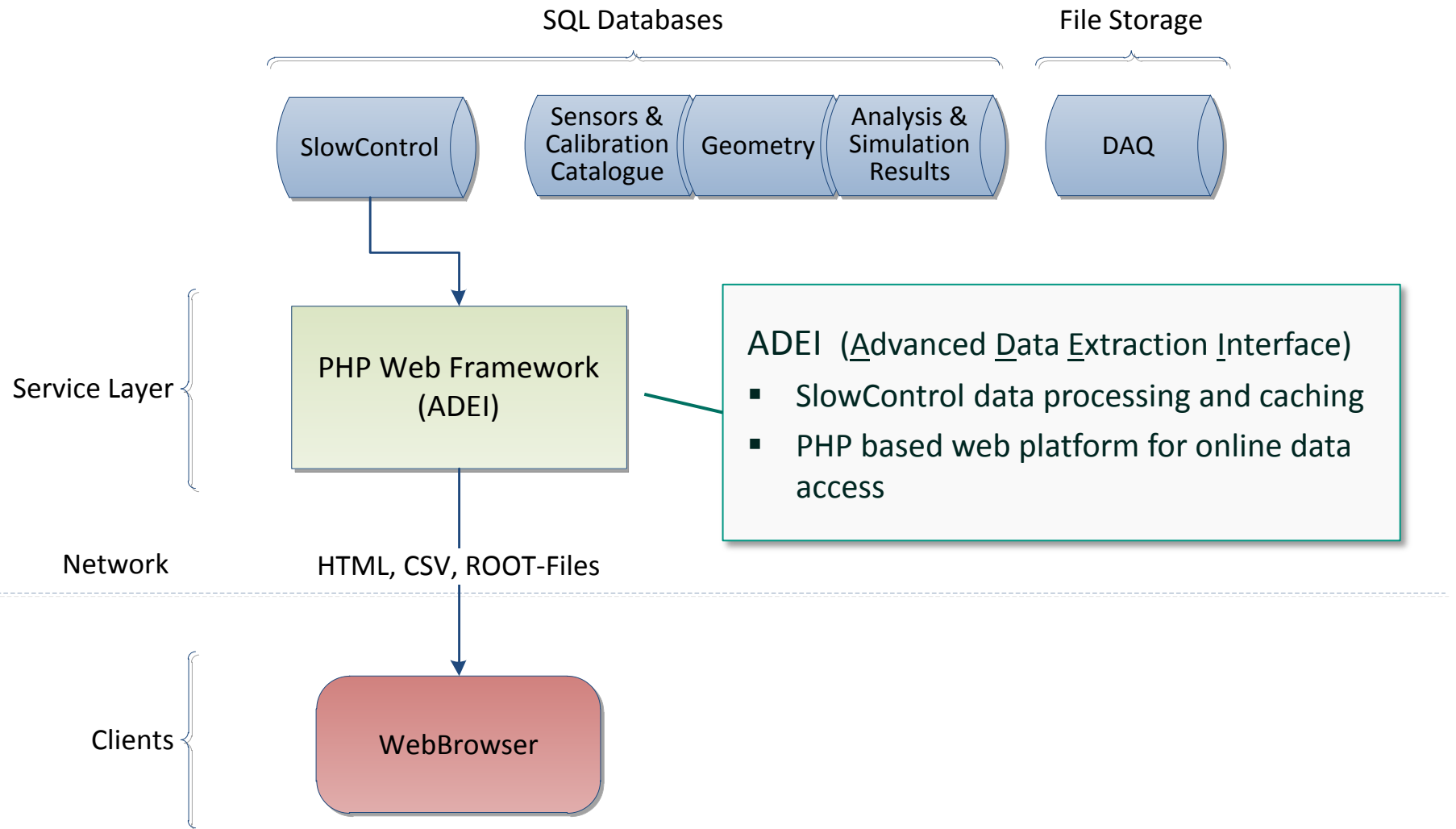
- DAQ: around 1 GB per day
- SlowControl: Large number of heterogenously distributed sensors, ca. 10.000 channels
- Calibration, geometry information, simulation results, ...
- Constant monitoring is necessary to maintain highly stable operating conditions over years.
- The neutrino mass sensitivity goal of $0.2 \text{ eV}/c^2$ 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 feasible:

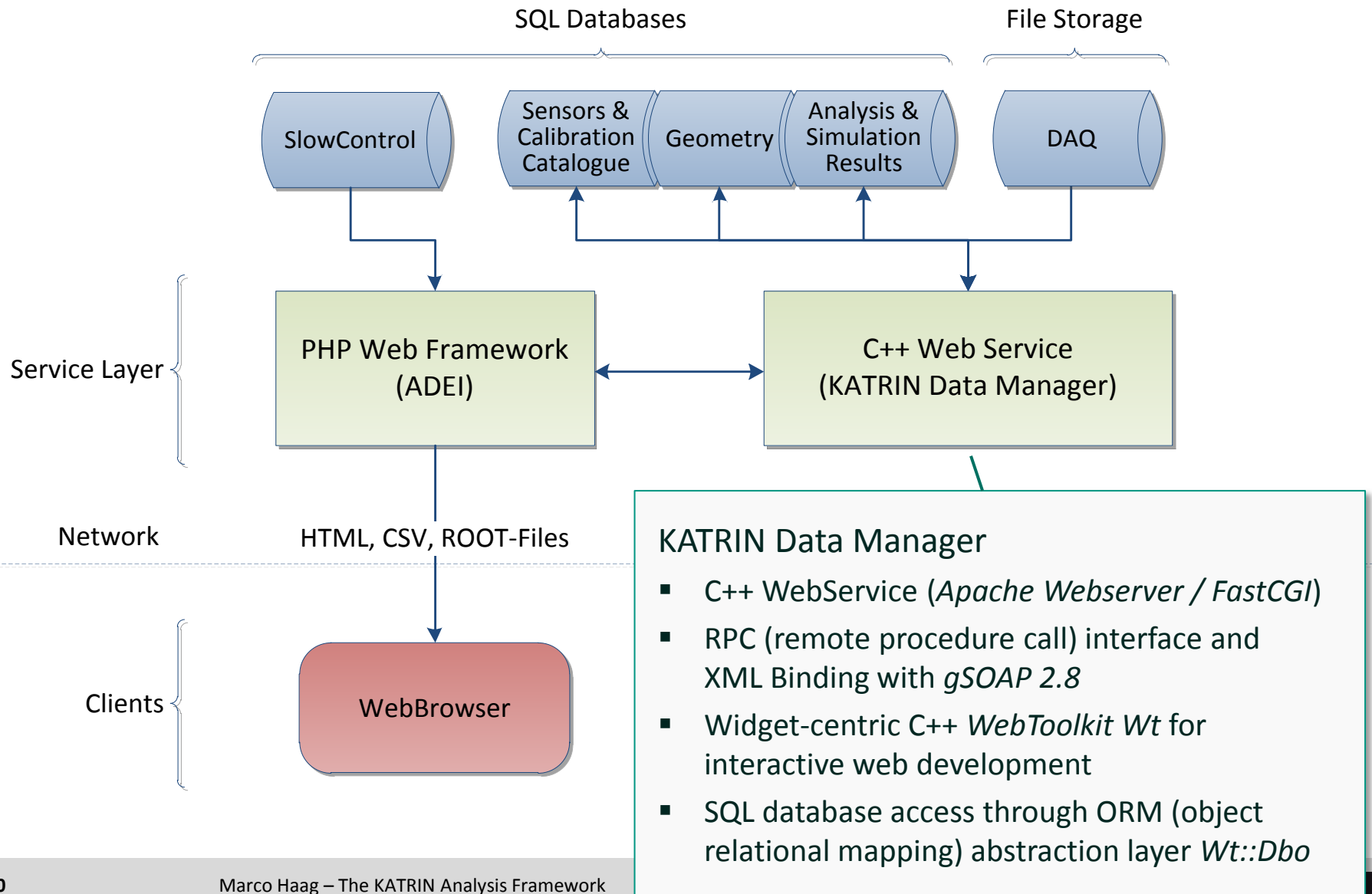




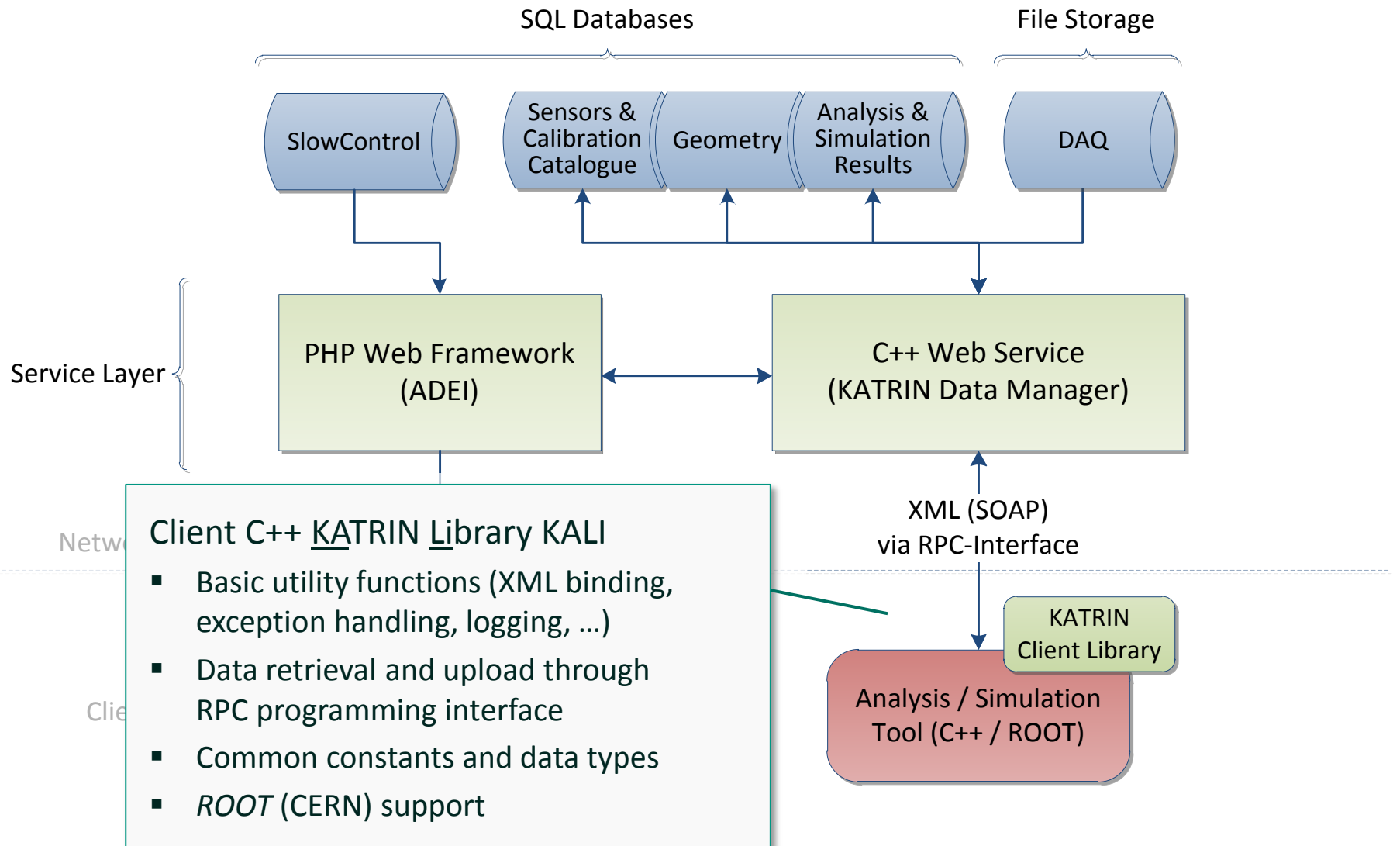
Service Oriented Architecture at KATRIN



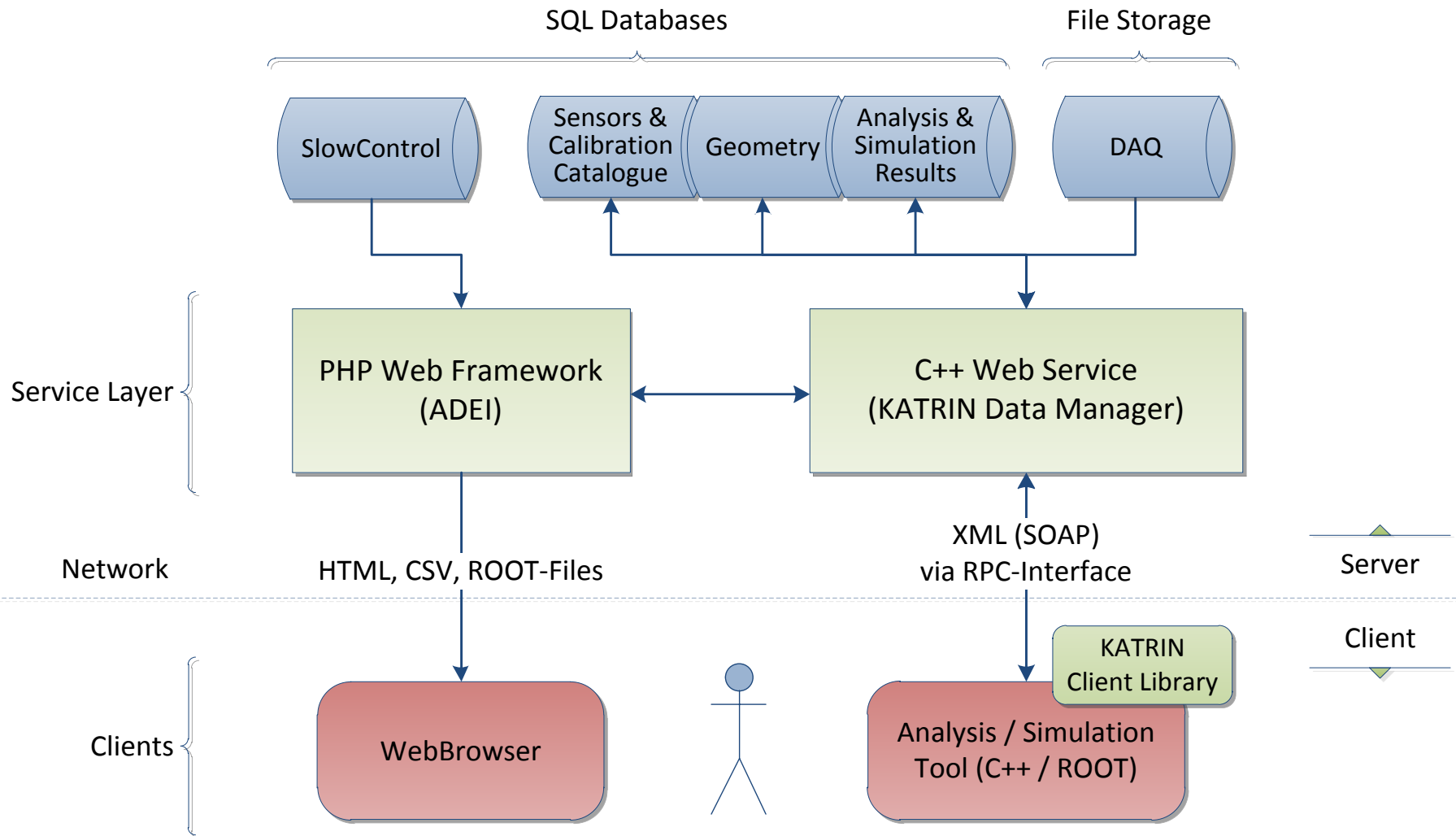
Service Oriented Architecture at KATRIN



Service Oriented Architecture at KATRIN



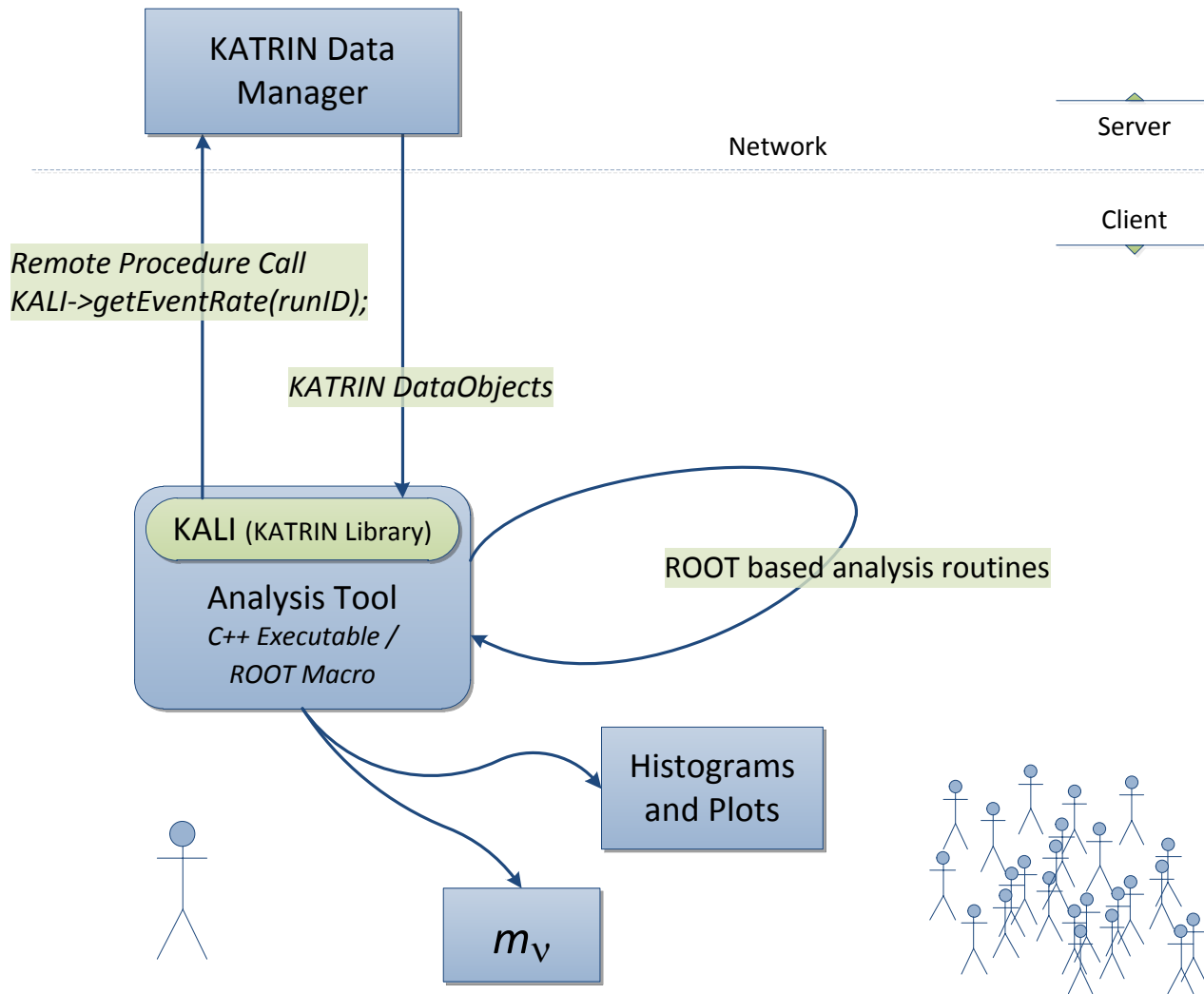
Service Oriented Architecture at KATRIN



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)

KATRIN Data Extraction Settings Control Alarms **Katrin** Graph Wiki

Source Configuration:

{Source}	Time	Axes
Server	PreSpectrometer/Zeus8	
Database	prespektrometer_rep	
LogGroup	Temperaturen	
ItemMask	Standalone Item	
	412-RTP-5-0011 [cFP0 Temperaturen]	

Apply

Run kps00010526 [Back to run overview](#)

IPE3 Waveform

Date: 2010-01-25 Timestamp: 22:46:44 - 02:46:45
Detector: X: -0.30cm Y: 0.35cm Z: 0.50cm
Configuration: /Users/katrin/pre-spectrometer data/Orca config/091126_IPE_64PX_ADEI.Orca ORCA version: 8.5h
West magnet: 0.0A (0.00T) East magnet: 0.0A (0.00T)
Valve Det/PS: closed Valve PS/egun: open
T: 4 S1: 4 S2: 4 S3: 4 S4: 4 D1: 3 D2: 3
FUG1: 0.000kV FUG2: 0.000kV FUG3: 0.000kV FUG4: 0.000kV FUG5: 0.000kV
Pressure: 0.00e+0mbar
UV light: on Shutter: 0.4 Voltage: 0.00kV X: 15.00° Y: 0.00°
Comment:
4h detector background, valve to pre-spectrometer closed, energy and trace mode

[Downloads](#)
[Raw Orca file](#)
[Raw OrcaRoot trees](#)
[Events in crun format \(IPE3 data\)](#)

[Hide subruns](#)

Subrun kps00010526.00001

Timestamp: 00:00:00 - 04:00:01
Comment:

Filtering and Search:

Export Aggregator Search
Source Tree {Run Filter}

Filter by parameters: [Help](#)

Filter by date: [Update list](#)


- All
- 2009
- 2010
 - January
 - February
 - March
 - April
 - June
 - August
 - September

Data Source Controls:

Rate Energy log Energy Pixel 2D Pixel 3D

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

Online Analysis (Browser Screenshot)



[Settings](#) [Control](#) [Alarms](#) [Katrin](#) [Graph](#) [Wiki](#)

{Source} **Time** **Axes**

Server:

Database:

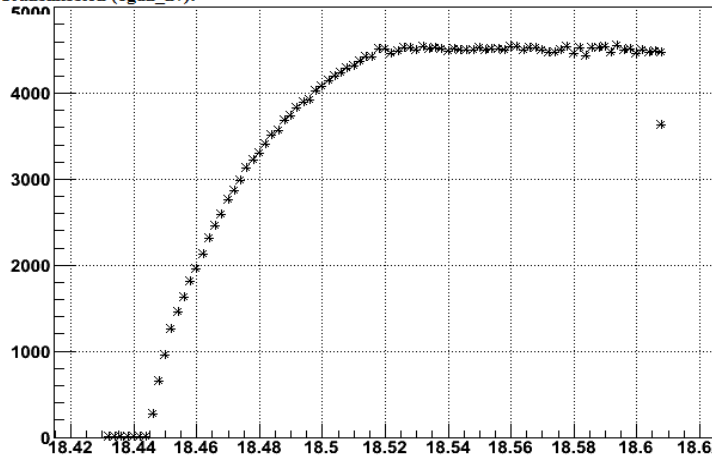
LogGroup:

ItemMask:

Run kps00010520

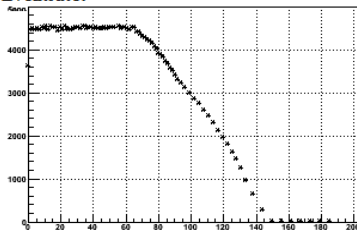
IPE3 Energy

Transmission (egun_hv):



[Back to run overview](#)

Eventrate:



Export **Aggregator** **Search**

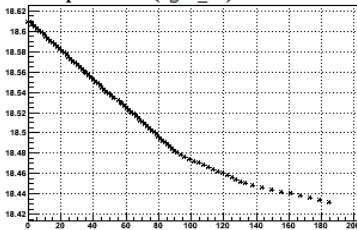
Source Tree **{Run Filter}**

Filter by parameters: [Help](#)

Filter by date: [Update list](#)

- [-] All
- [+] 2009
- [+] 2010
 - [+] January
 - [+] 11
 - [+] 12
 - [+] 13
 - [+] 14
 - [+] 15
 - [+] 16
 - [+] 17
 - [+] 18
 - [+] 19
 - [+] 20
 - [+] 21
 - [+] 22
 - [+] 25
 - [+] 26
 - [+] 27
 - [+] 28
 - [+] 29
 - [+] 30
 - [+] 31

Control parameter (egun_hv):



Date: 2010-01-22 Timestamp: 05:51:52 - 09:00:38

Detector: X: -1.00cm Y: -0.70cm Z: 40.00cm

Configuration: /Users/katrin/pre-spectrometer data/Orca config/091126_IPE_64PX_ADEL.Orca ORCA version: 8.5h

West magnet: 157.0A (157.00T) East magnet: 157.0A (157.00T)

Valve Det/PS: open Valve PS/egun: open

T: 4 S1: 4 S2: 4 S3: 4 S4: 4 D1: 3 D2: 3

FUG1: 0.000kV FUG2: 0.000kV FUG3: 18.500kV FUG4: 18.005kV FUG5: 0.000kV

Pressure: 0.00e+0mbar

UV light: on Shutter: 0.4 X: 15.00° Y: 0.00°

Comment:
transmission function measurement, 18,5kV, y=-100, HV stab. On (set 18.08), cone electrodes 300V more negative (exact), absolute value (Fluke -3.582424V), 2V steps (ramping down)

[Show subruns](#)

Downloads

[Raw Orca file](#)

[Raw OrcaRoot trees](#)

[Events in crun format \(IPE3 data\)](#)

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>

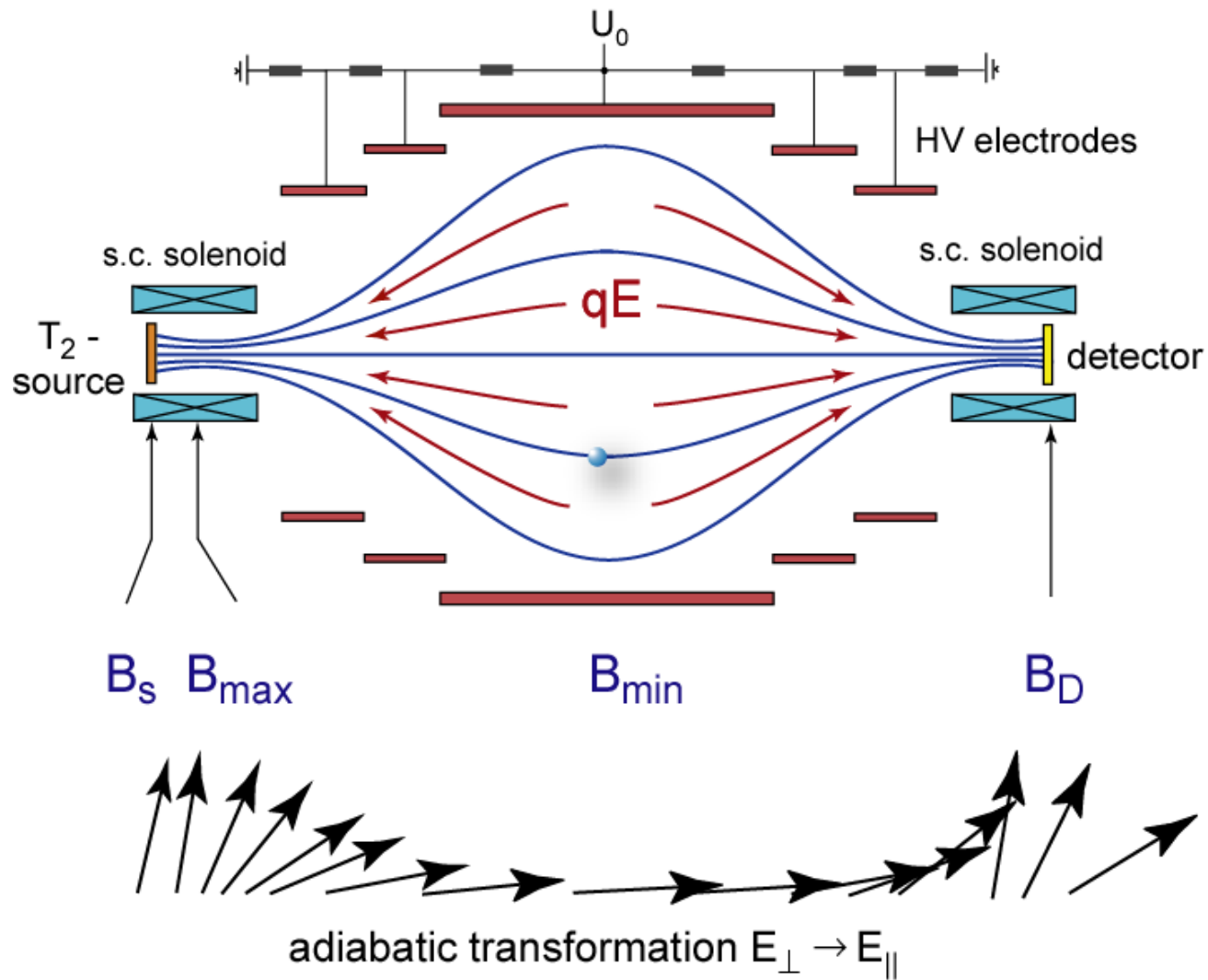
Implementation

- 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*

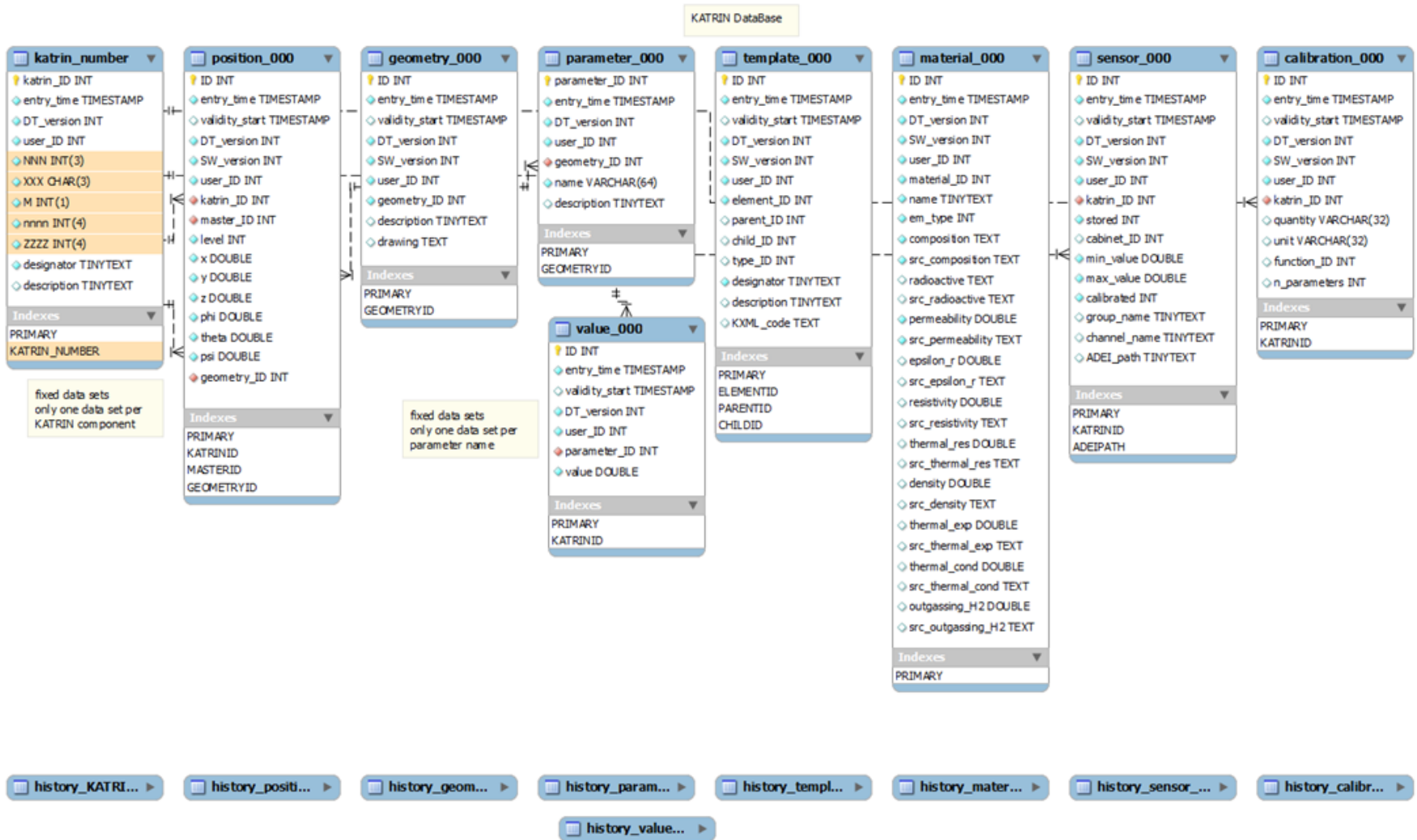
- Client C++ KATRIN Library KALI
 - Basic utility functions (XML binding, exception handling, logging, ...)
 - Data retrieval and upload through RPC programming interface
 - Common constants and data types
 - *ROOT* (CERN) support

- 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

KATRIN DataBase Administrator

Navigation: KATRIN Numbers, Sensors, Units & Axis

KATRIN DataTables: Reload, Add, Delete

KATRIN Number	ADEI Path	ADEI Axis	Description	#C
435-RTP-5-0044-0000	katrin / hauptspektrometer / 2 / 3	Temperature [K]	PT 100 4 wire for monitoring - 200mm from vessel wall	0
435-RTP-5-0063-0000	tc / testcylinder / 2 / 4	Temperature [K]	PT 100 4 wire for monitoring - 100mm from vessel wall	0
435-RTP-5-0063-0000	mydetector / detector / 2 / 4	Temperature [K]	PT 100 4 wire for monitoring - 100mm from vessel wall	0
435-RTP-5-0063-0000	detector / katrin_rep / 2 / 4	Temperature [K]	PT 100 4 wire for monitoring - 100mm from vessel wall	0
435-RTP-5-0063-0000	opcreader / KatrinOPCTest / 2 / 4	Temperature [K]	PT 100 4 wire for monitoring - 100mm from vessel wall	0
435-RTP-5-0063-0000	opcreader / dbMagnet-archive_rep / 2 / 4	Temperature [K]	PT 100 4 wire for monitoring - 100mm from vessel wall	0
435-RTP-5-0063-0000	opcreader / dbMagnet-archive / 2 / 4	Temperature [K]	PT 100 4 wire for monitoring - 100mm from vessel wall	0
435-RTP-5-0063-0000	msz / aircoils_rep / 2 / 4	Temperature [K]	PT 100 4 wire for monitoring - 100mm from vessel wall	0
435-RTP-5-0063-0000	toskanadb / prespektrometer_rep / 2 / 4	Temperature [K]	PT 100 4 wire for monitoring - 100mm from vessel wall	0
435-RTP-5-0063-0000	katrin / hauptspektrometer / 2 / 4	Temperature [K]	PT 100 4 wire for monitoring - 100mm from vessel wall	0
435-RTP-5-0064-0000	tc / testcylinder / 2 / 5	Temperature [K]	PT 100 4 wire for monitoring - 200mm from vessel wall	0
435-RTP-5-0064-0000	mydetector / detector / 2 / 5	Temperature [K]	PT 100 4 wire for monitoring - 200mm from vessel wall	0
435-RTP-5-0064-0000	detector / katrin_rep / 2 / 5	Temperature [K]	PT 100 4 wire for monitoring - 200mm from vessel wall	0
435-RTP-5-0064-0000	opcreader / KatrinOPCTest / 2 / 5	Temperature [K]	PT 100 4 wire for monitoring - 200mm from vessel wall	0
435-RTP-5-0064-0000	opcreader / dbMagnet-archive_rep / 2 / 5	Temperature [K]	PT 100 4 wire for monitoring - 200mm from vessel wall	0
435-RTP-5-0064-0000	opcreader / dbMagnet-archive / 2 / 5	Temperature [K]	PT 100 4 wire for monitoring - 200mm from vessel wall	0
435-RTP-5-0064-0000	msz / aircoils_rep / 2 / 5	Temperature [K]	PT 100 4 wire for monitoring - 200mm from vessel wall	0
435-RTP-5-0064-0000	toskanadb / prespektrometer_rep / 2 / 5	Temperature [K]	PT 100 4 wire for monitoring - 200mm from vessel wall	0
435-RTP-5-0064-0000	katrin / hauptspektrometer / 2 / 5	Temperature [K]	PT 100 4 wire for monitoring - 200mm from vessel wall	0
435-RTP-5-0083-0000	tc / testcylinder / 2 / 6	Temperature [K]	PT 100 4 wire for monitoring - 100mm from vessel wall	0
435-RTP-5-0083-0000	mydetector / detector / 2 / 6	Temperature [K]	PT 100 4 wire for monitoring - 100mm from vessel wall	0
435-RTP-5-0083-0000	detector / katrin_rep / 2 / 6	Temperature [K]	PT 100 4 wire for monitoring - 100mm from vessel wall	0
435-RTP-5-0083-0000	opcreader / KatrinOPCTest / 2 / 6	Temperature [K]	PT 100 4 wire for monitoring - 100mm from vessel wall	0
435-RTP-5-0083-0000	opcreader / dbMagnet-archive_rep / 2 / 6	Temperature [K]	PT 100 4 wire for monitoring - 100mm from vessel wall	0
435-RTP-5-0083-0000	opcreader / dbMagnet-archive / 2 / 6	Temperature [K]	PT 100 4 wire for monitoring - 100mm from vessel wall	0
435-RTP-5-0083-0000	msz / aircoils_rep / 2 / 6	Temperature [K]	PT 100 4 wire for monitoring - 100mm from vessel wall	0
435-RTP-5-0083-0000	toskanadb / prespektrometer_rep / 2 / 6	Temperature [K]	PT 100 4 wire for monitoring - 100mm from vessel wall	0
435-RTP-5-0083-0000	katrin / hauptspektrometer / 2 / 6	Temperature [K]	PT 100 4 wire for monitoring - 100mm from vessel wall	0

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