



# INTERNAL POST OPERATION CHECK SYSTEM FOR KICKER MAGNET CURRENT WAVEFORMS SURVEILLANCE

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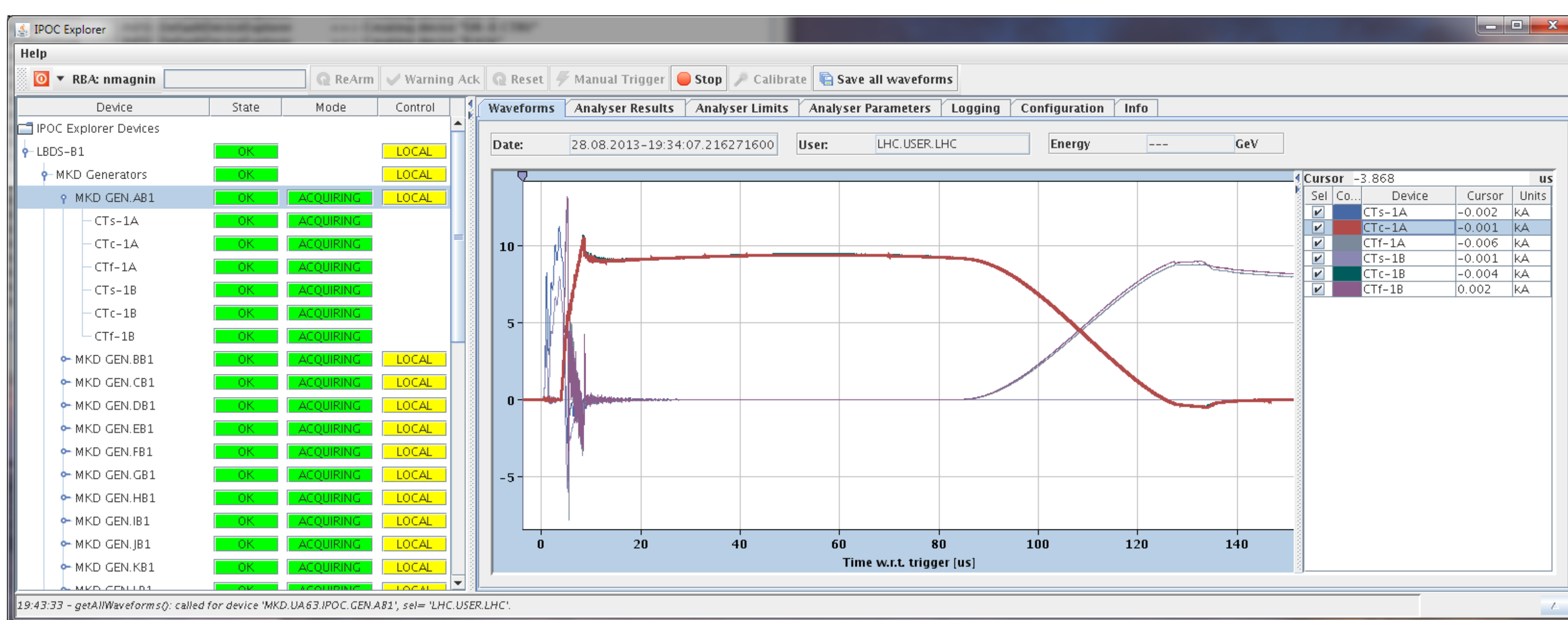
## LHC Beam Dumping System Post-Operation Checks

The LHC Beam Dumping System (LBDS) kicker magnets are powered by high-voltage generators which are composed of **internal redundant paths**, and are triggered by four **redundant Power Trigger Units (PTUs)**.

The LBDS also relies on a complex Trigger Synchronisation and Distribution System (TSDS), **partially fault-tolerant** thanks to the implementation of a high level of **system redundancy**.

To guarantee that the LBDS is **'as good as new'** for the next operational cycle, one has to make sure that **all the fault-tolerant redundant parts operated properly** for every beam dump.

The various IPOC systems deployed at the LBDS are used to acquire and analyse **more than 500 waveforms** after every beam dump.



IPOC-Explorer application displaying the internal currents of an MKD generator.

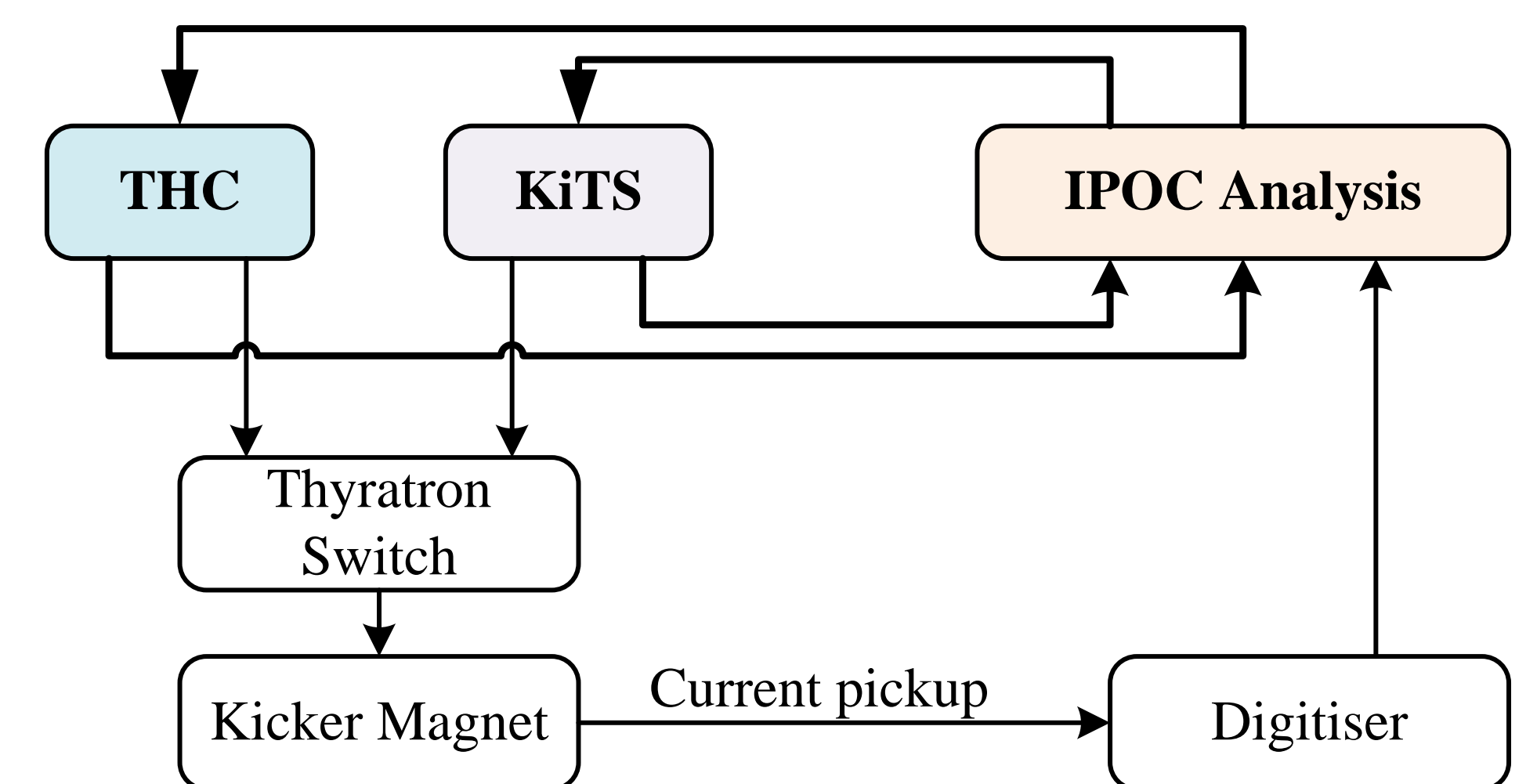
## Thyratron switches closed-loop control

The thyratron switches contain gas and use **heater modules** to maintain the **gas pressure** to a nominal value, to obtain the nominal **rise time** and **turn-on delay**.

The thyratron switch control elements are the following:

- The Thyratron Heater Controller (THC) is based on a **Siemens S7-400 industrial PLC** system, controlling the **heater power supplies**.
- The Kicker Timing System (KiTS) is a **VME crate**, fitted with various **off-the-shelf fine delay boards**, that generates the **precisely synchronised trigger**.

To automatically **compensate for ageing deviations** of the thyratron switch, an IPOC system will analyse the kicker current waveform and perform a **double feedback loop** to adjust the THC and the KiTS settings.

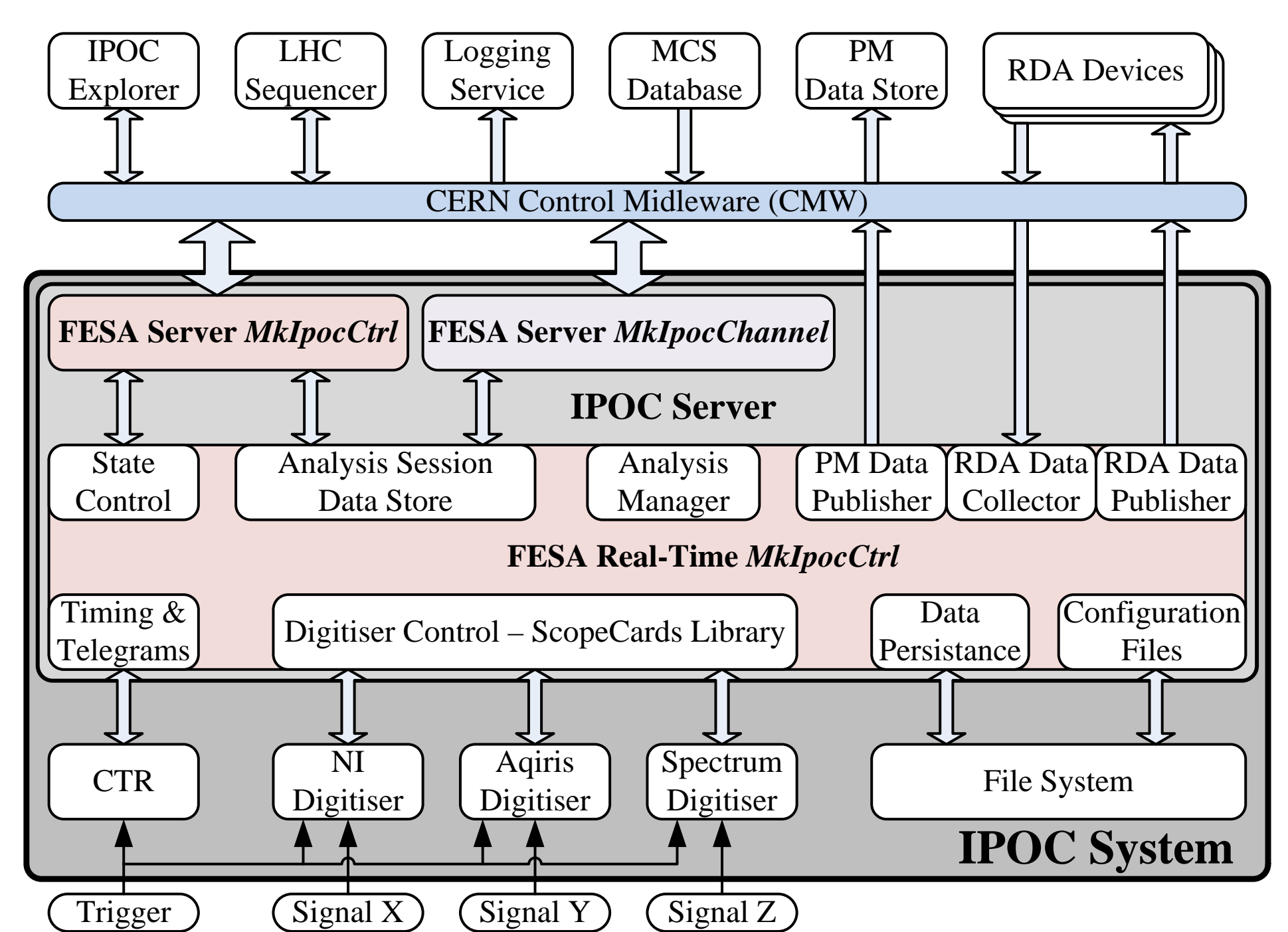


IPOC system for the closed-loop control of thyratron switches.

## Architecture & Implementation

An IPOC system is composed of a computer running the **IPOC server** application, fitted with one or more **digitiser card(s)**.

The IPOC server application **Real-Time part** handles the scheduling of the core functions of the IPOC system, and the **Server part** provides the communication interfaces needed to control remotely the IPOC system.



Block diagram of the IPOC system.

## Analysis Library

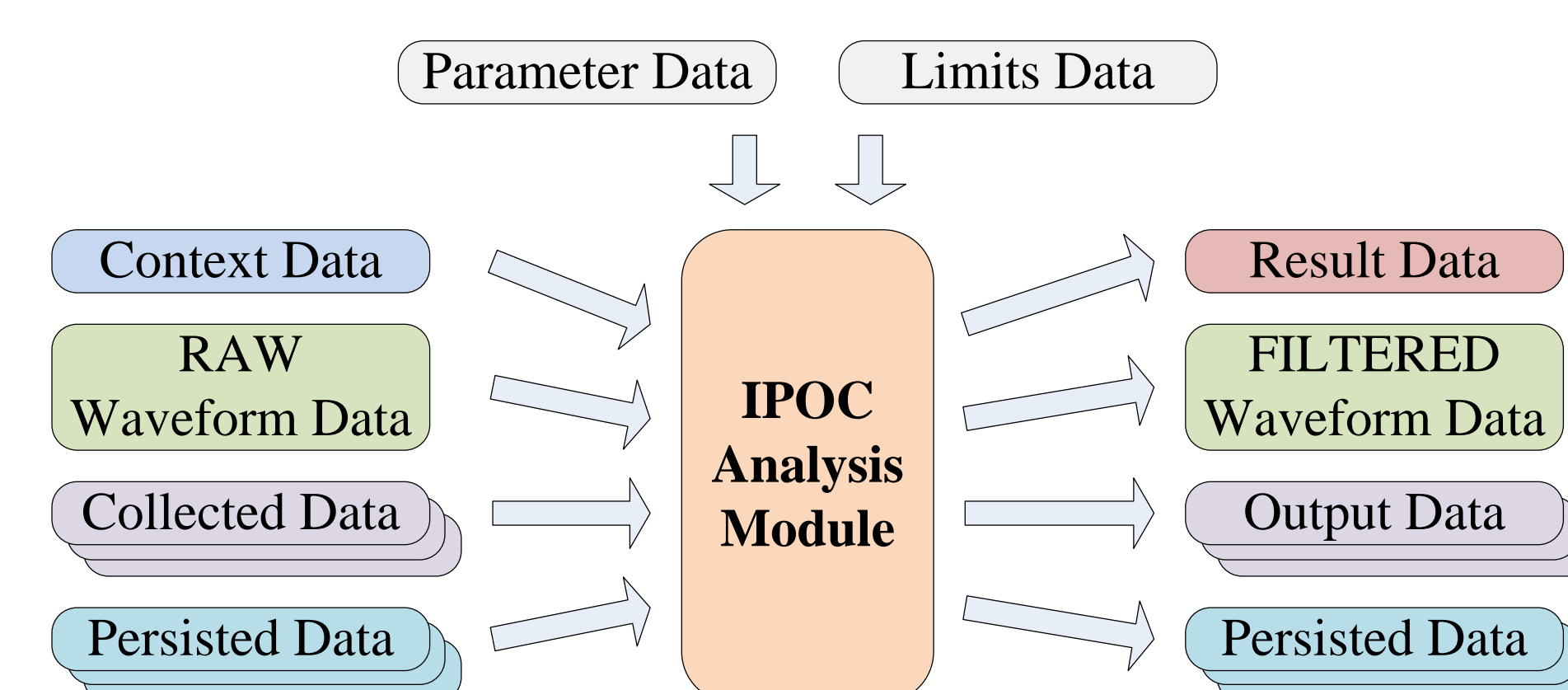
The **IpoAnalysis** library provides the Application Programming Interfaces (API) for developing an **analysis module** and the tools to create a new reusable **analysis plugin library**.

An analysis module implements a method that:

- Takes a **collection of IpoData** as input;
- Returns a **collection of IpoData** as output.

The analysis modules are initialised with:

- A **ParameterData** to configure the module;
- A **LimitData** to configure the analysis checks.



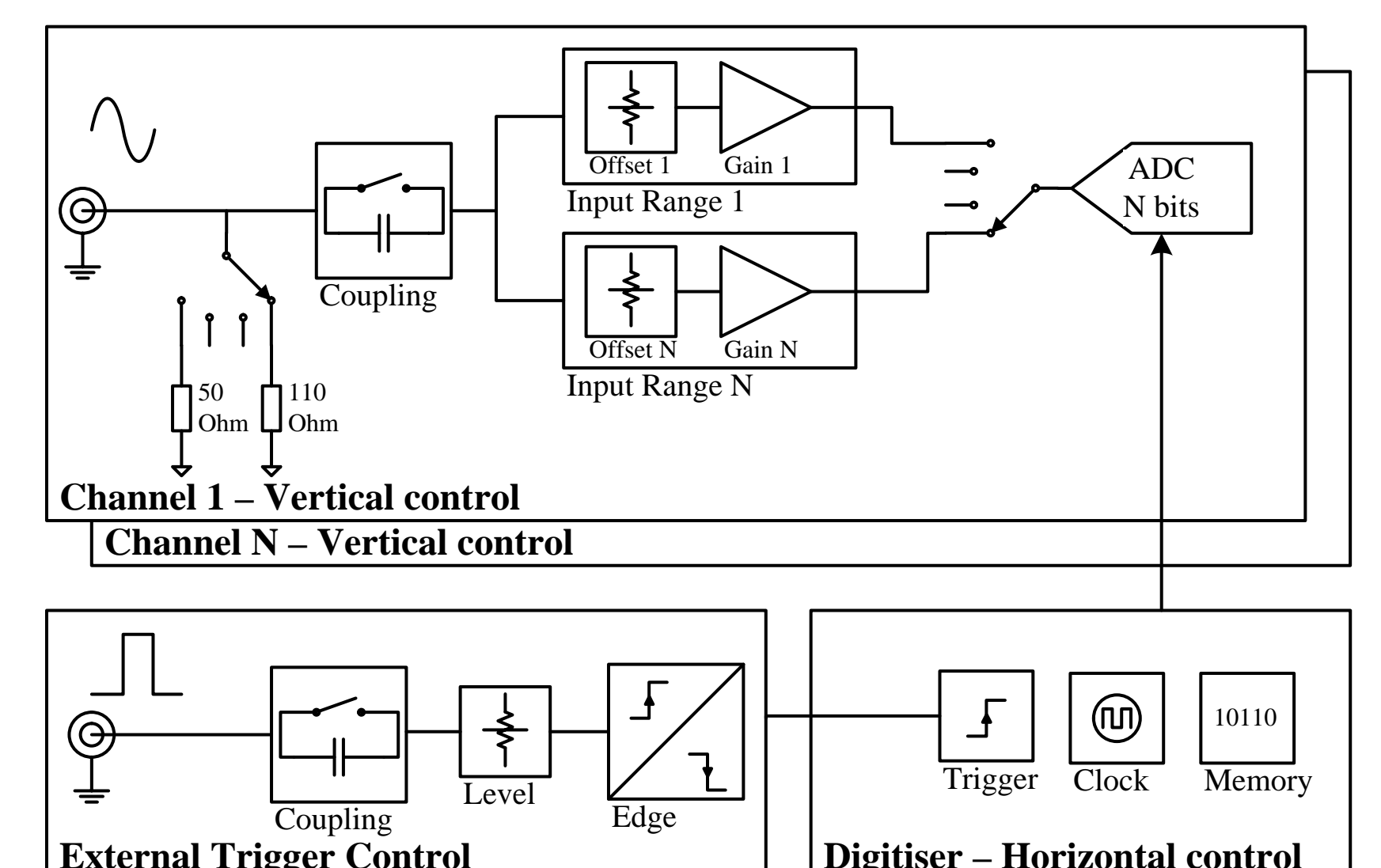
Data flow of an analysis module.

## Digitiser Library

The various applications of the IPOC system use different types of **off-the-shelf digitisers** from various manufacturers.

The user libraries provided by the different manufacturers are **proprietary** and their (APIs) are **not compatible with each other**.

The **ScopeCards** library defines an **abstraction layer**, based on a **simple model** of the digitiser functionalities.



Simple digitiser model of ScopeCards library

## SUMMARY

The IPOC system is a **fully-configurable pulse-to-pulse waveform acquisition and analysis system**.

It allows **macro-system configurations** involving the control of any **industrial system** interfacing with the CERN Middleware.

It provides a **plugin interface for analysis algorithms** and supports a wide range of **off-the-shelf digitisers**.

It is integrated into the LBDS post-operation checks and is therefore a **part of the LHC Machine Protection System**. In this context, it has **proven its reliability** over the past 3 years of LHC operation.

The IPOC system is also being **deployed on many other kicker systems at CERN**, for instance in a complex configuration to realise a **double feed-back closed-loop system** for the automatic regulation of thyratron switching characteristics.