Signal Monitoring Project

Status of Preparation for HWC Analysis

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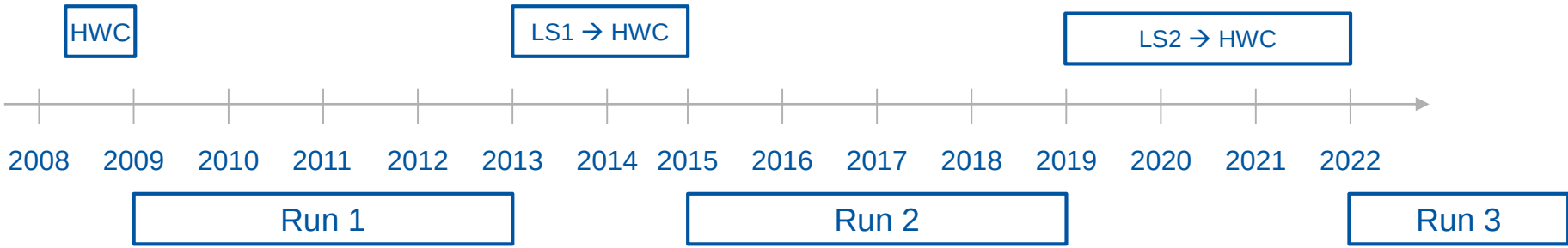
Find out more at: https://cern.ch/sigmon

HWC and Operation

During Hardware Commissioning (**HWC**) campaigns all LHC Super Conducting circuits are tested and analysed by the **MP3** team (http://cern.ch/mp3) in a very rigorous and detailed way.

The HWC campaigns take place after each long shutdown (**LS**) and after each **X-mas** stop.

The execution of tests and their analysis is orchestrated by **AccTesting**.

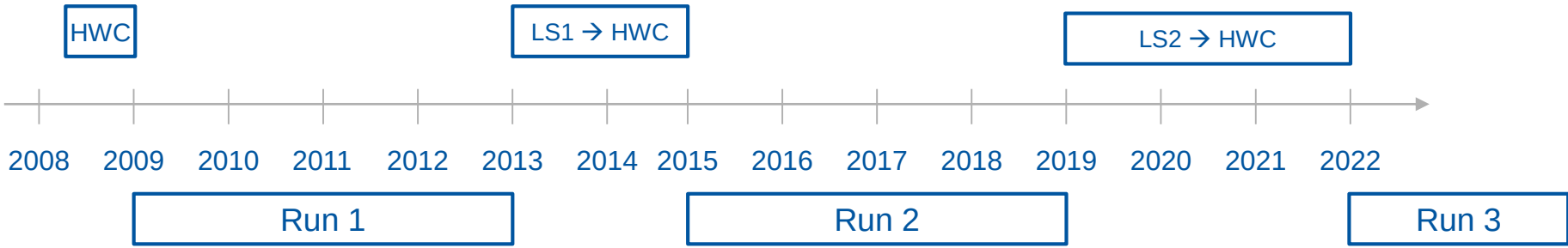


During operation each quench event (**FPA** analysis) is thoroughly analysed by the MP3 team.

Some Numbers

So far, 15204 HWC tests signed by the MP3 team:

- 2489 automatically by eDSL
- 4962 automatically by PM
- 7753 manually

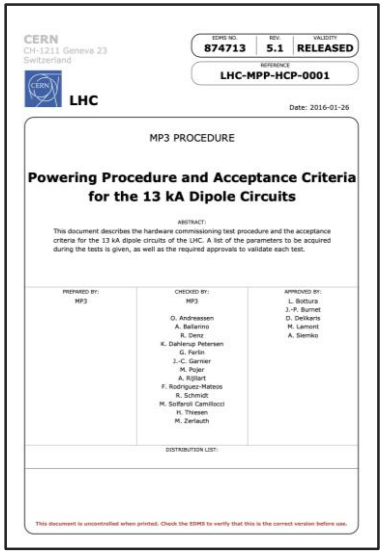


Over 2900 quench events manually analysed by the MP3 team.

RB	RQ	IT	IPD	IPQ	600A
1545+	100+	25+	55+	460+	720+

Need for automation of repetitive tasks. A lot of data for further analysis.

Current Workflow



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REFERENCE LHC-MPP-HCP-0001

LHC

Date: 2016-01-26

MP3 PROCEDURE

Powering Procedure and Acceptance Criteria for the 13 kA Dipole Circuits

ABSTRACT:

This document describes the hardware commissioning test procedure and the acceptance criteria for the 13 kA dipole circuits of the LHC. A list of the parameters to be acquired during the tests is given, as well as the required approvals to validate each test.

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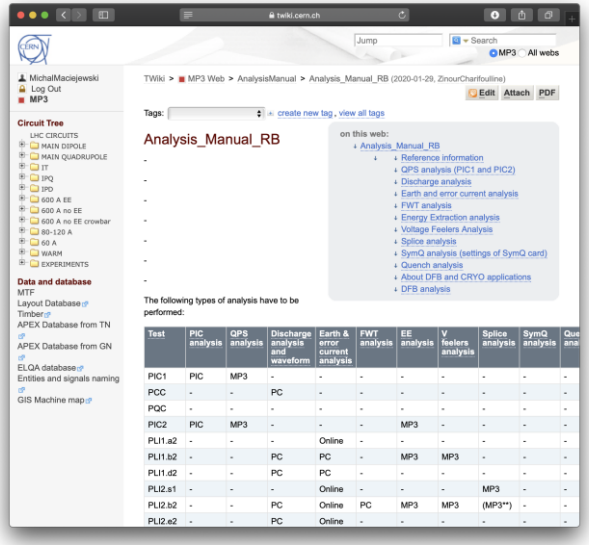

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MichalMaciejewski
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TWiki > MP3 Web > AnalysisManual > Analysis_Manual_RB (2020-01-29, ZinourCharifoulline)

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Tags: create new tag, view all tags

Circuit Tree
LHC CIRCUITS
MAIN DIPOLE
MAIN QUADRUPOLE
IT
IPQ
IPD
600 A EE
600 A no EE
600 A no EE crowbar
80-120 A
60 A
WARM
EXPERIMENTS

Data and database
MTF
Layout Database
Timber
APEX Database from TN
APEX Database from GN
ELQA database
Entities and signals naming
GIS Machine map

Analysis_Manual_RB

on this web:
- Analysis_Manual_RB
  - Reference information
  - QPS analysis (PIC1 and PIC2)
  - Discharge analysis
  - Earth and error current analysis
  - FWT analysis
  - Energy Extraction analysis
  - Voltage Feelers Analysis
  - Splice analysis
  - SymQ analysis (settings of SymQ card)
  - Quench analysis
  - About DFB and CRYO applications
  - DFB analysis

The following types of analysis have to be performed:

Test	PIC analysis	QPS analysis	Discharge analysis and waveform	Earth & error current analysis	FWT analysis	EE analysis	V feelers analysis	Splice analysis	SymQ analysis	Que ana
PIC1	PIC	MP3	-	-	-	-	-	-	-	-
PCC	-	-	PC	-	-	-	-	-	-	-
PQC	-	-	-	-	-	-	-	-	-	-
PIC2	PIC	MP3	-	-	-	MP3	-	-	-	-
PLI1.a2	-	-	-	Online	-	-	-	-	-	-
PLI1.b2	-	-	PC	PC	-	MP3	MP3	-	-	-
PLI1.d2	-	-	PC	PC	-	-	-	-	-	-
PLI2.s1	-	-	-	Online	-	-	-	MP3	-	-
PLI2.b2	-	-	PC	Online	PC	MP3	MP3	(MP3**)	-	-
PLI2.e2	-	-	PC	Online	-	-	-	-	-	-

- PM Browser
- (NX)CALS Browser
- LabVIEW tools
- Java tools

The output for an HWC analysis the output is a signature (passed/failed) test.
The output for an FPA with a quench is a row in the Excel database.

Multiple manual steps (e.g., event synchronization) with several tools.
New PM LabVIEW browser improves this process for RB quenches.

Existing Tools

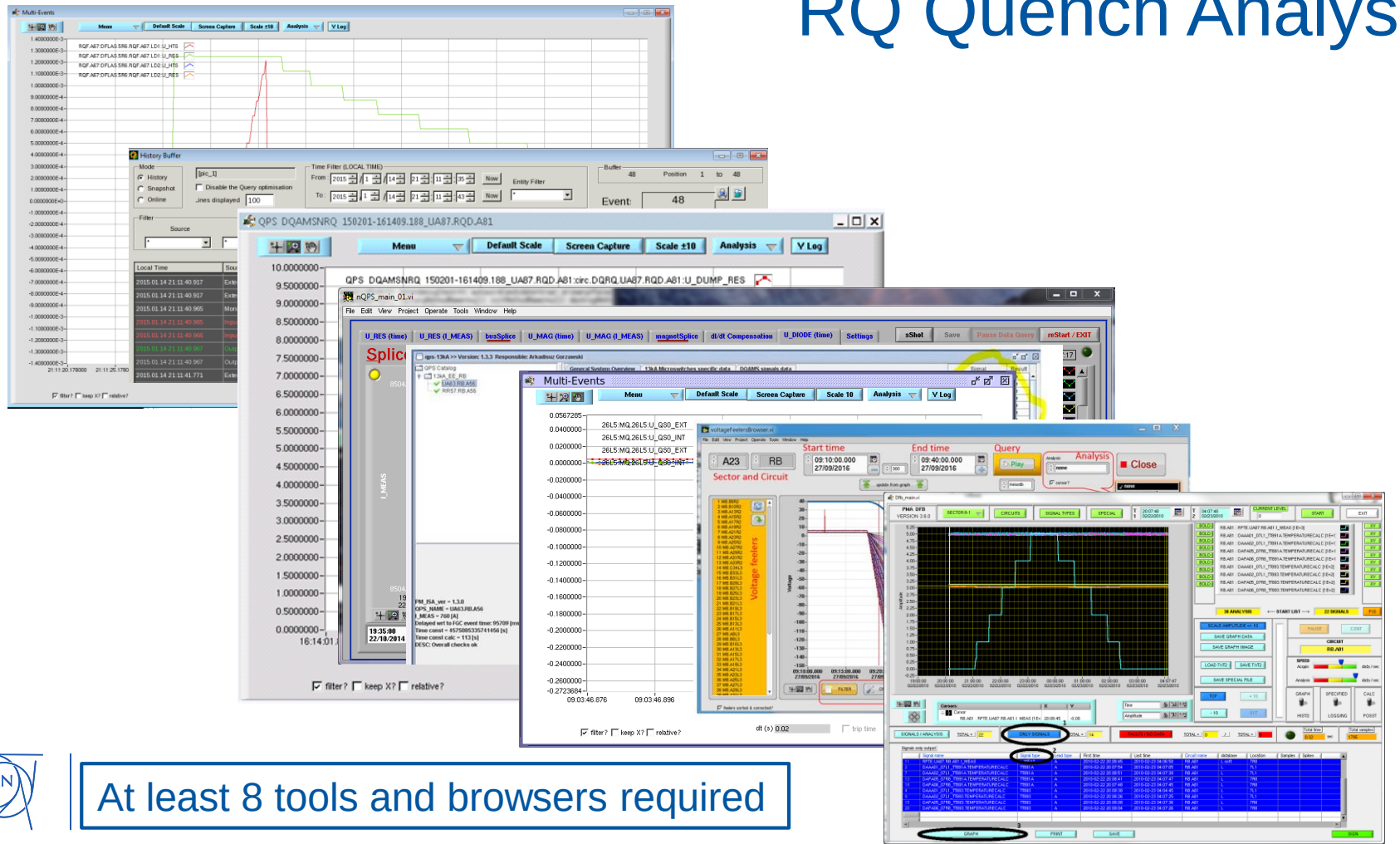
HWC Tests\Circuits	60A	80-120A	600A	IPD	IPQ	IT	RQD/RQF	RB
PCC	eDSL(EPC)	eDSL(EPC)	LV(EPC,MP3):Disch, eDSL(EPC,MP3)	LV(EPC):Disch	LV(EPC):Disch	LV(EPC):Disch	LV(EPC):Disch	LV(EPC):Disch
PIC2	-	eDSL(PIC)	eDSL(PIC)	eDSL(PIC), PMF(MP3):QHDA	eDSL(PIC), PMF(MP3):QHDA	eDSL(PIC), PMF(MP3):QHDA	LV(PIC):PIC, PMF(MP3):EE	LV(PIC):PIC, PMF(MP3):EE
PCS	-	-	LV(MP3):PNO2	-	-	-	-	-
PLI1/2/3	-	-	eDSL(MP3)	LV(EPC,MP3):DFB, PMF(MP3):QHDA	LV(EPC,MP3):DFB, PMF(MP3):QHDA	LV(EPC,MP3):Disch, PMF(MP3):QHDA	LV(EPC,MP3):Disch, DFB, PMF(MP3):EE,QHDA	LV(EPC,MP3):Disch,DFB, PMF(MP3):EE,QHDA
PLIM.b	-	-	-	-	-	-	PMF(MP3):EE	PMF(MP3):EE
PLIS.s	-	-	-	-	-	-	LV(MP3):SM	LV(MP3):SM
PNO.b	-	-	eDSL(MP3)	-	-	-	LV(EPC,MP3):Disch, PMF(MP3):EE	LV(EPC,MP3):Disch, PMF(MP3):EE
PNO.c	-	-	-	LV(EPC,MP3):DFB	LV(EPC,MP3):DFB	-	-	-
PNO.d	eDSL(EPC)	eDSL(EPC)	LV(EPC):Disch	-	-	LV(EPC):Disch	-	-
PNO.a	LV(MP3):PNO2	LV(MP3):PNO2	LV(MP3):PNO2	LV(EPC):Disch	LV(EPC):Disch	LV(EPC,MP3):DFB	LV(MP3):DFB	LV(MP3):DFB
Quench*	LV(MP3):PMB	LV(MP3):PMB	LV(EPC,MP3):Disch, PMB	LV(EPC,MP3):Disch,PMB, PMF(MP3):QHDA	LV(EPC,MP3):Disch,PMB, PMF(MP3):QHDA	LV(EPC,MP3):Disch,PMB, PMF(MP3):QHDA	LV(EPC,MP3):Disch,PMB, PMF(MP3):EE,QHDA	LV(EPC,MP3):Disch,RBA, PMB, PMF(MP3):EE,QHDA

Labview + eDSL | **Labview + eDSL + jPMF** | **Labview (PMB)**

Red – manual, **Green – automatic**

Heterogeneous set of tools not covering all HWC and operational needs.

RQ Quench Analysis



At least 8 tools and browsers required

Limitations

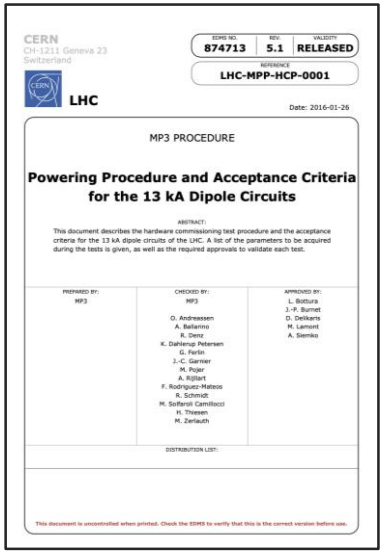
- Manual synchronization of timestamps across tools
- Some analyses performed manually
- Manual typing of results to respective databases
- Different naming and GUI conventions across tools
- Incomplete documentation
- Limited tracebility of results (an analysis needs to be redone)
- Upgrade to work with NXCALS

→ the analysis results might differ a bit depending on the person who does the analysis

\+ A lot of operational experience embedded in the tools. Demanding HWC ahead.

For more details, see:
https://twiki.cern.ch/twiki/pub/MP3/Meetings/2020-02-05_MP3_analysis_tools.pptx

New Approach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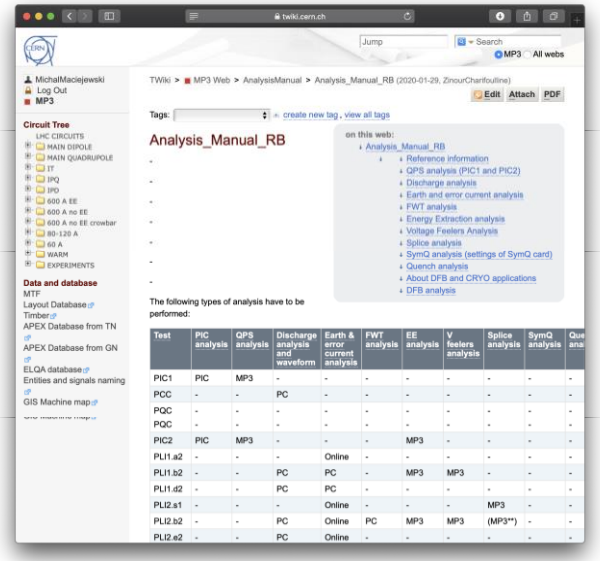


- PM Browser
- (NX)C… Browser
- LabV… ols
- Java tools

SWAN

Interactive notebook

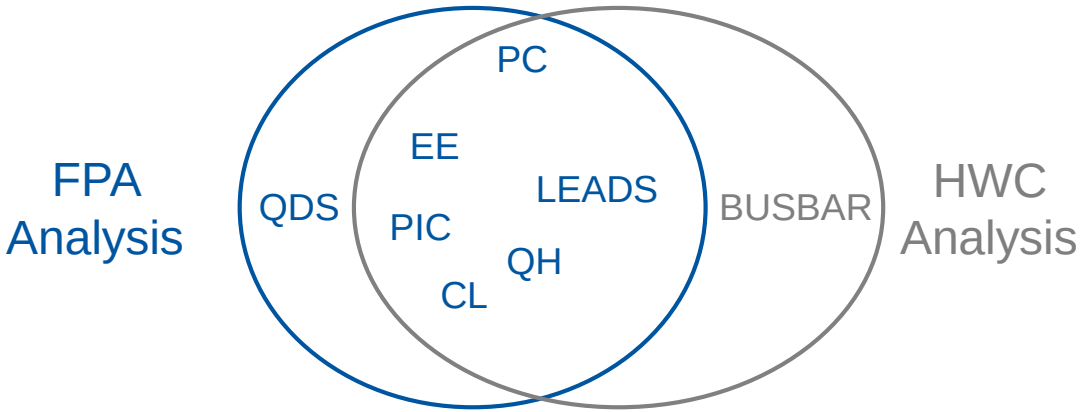
Automatic reports are a communication protocol in the industry.

Outline

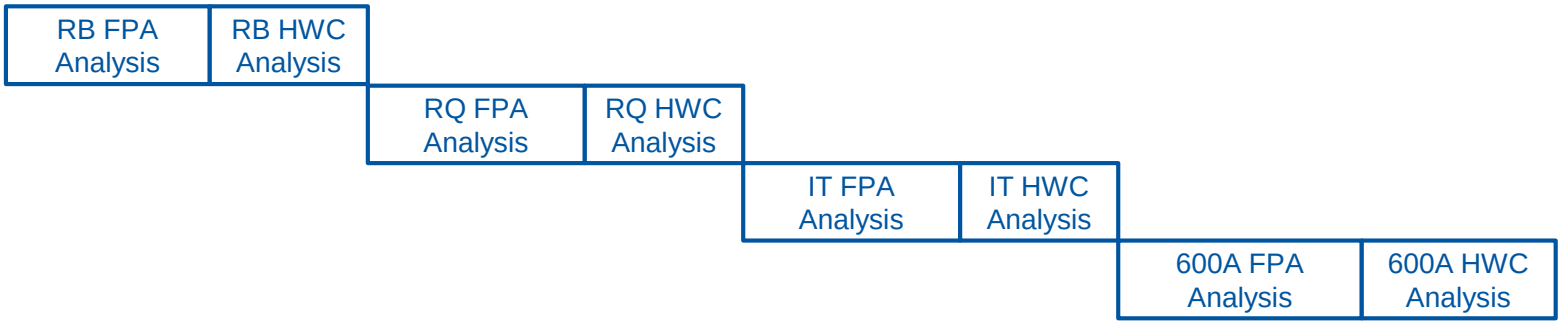
1. Methodology
2. Workflow
3. User Guide – Demo
4. Current Status
5. Integration with AccTesting and STEAM
6. Summary and Outlook

Methodology: Analysis

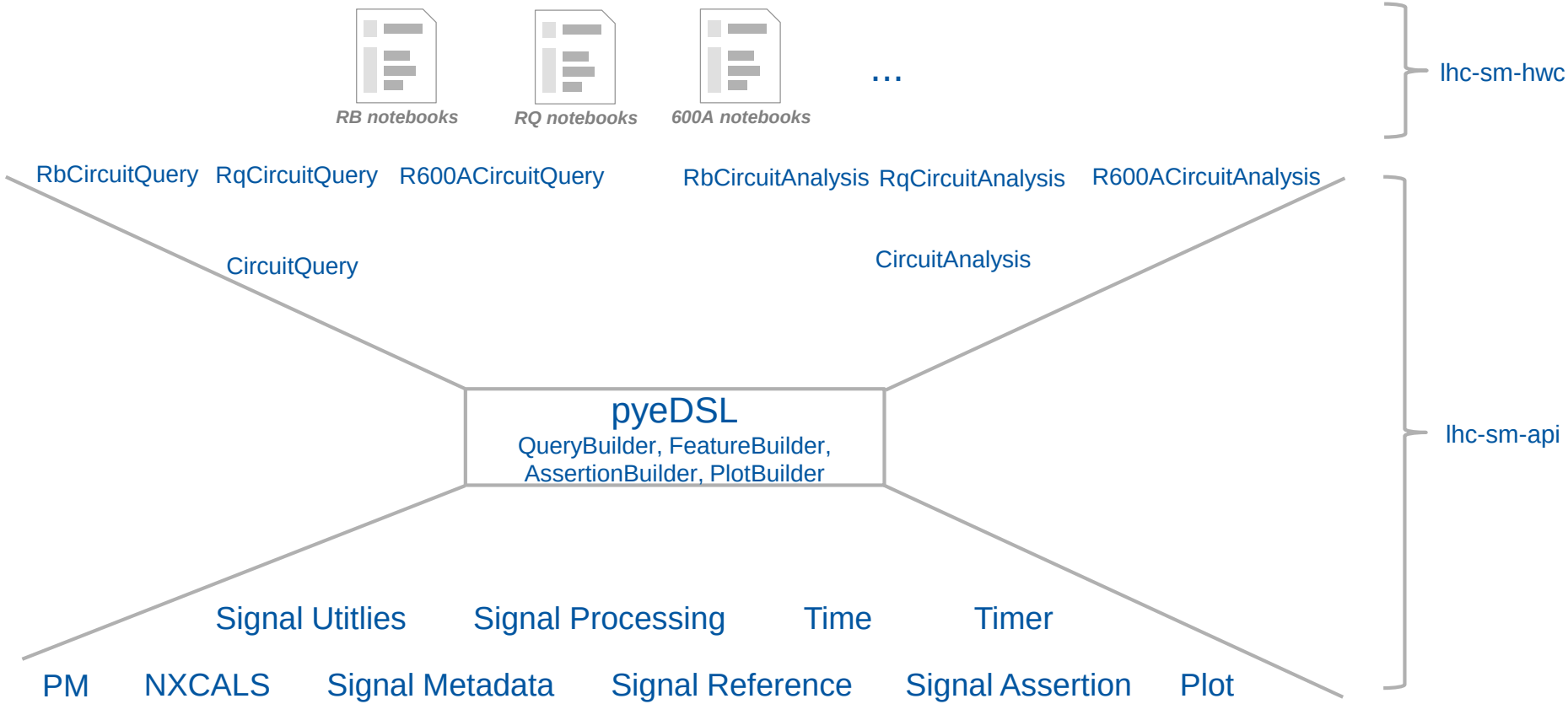
Firstly, we develop methods to analyze a quench event. Then we move to HWC.



We started with high-current circuits. Then we move to the lower-current ones.



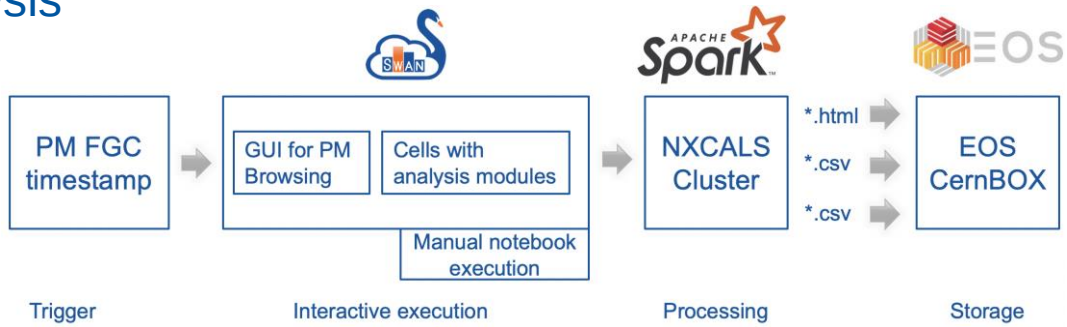
Methodology: Code



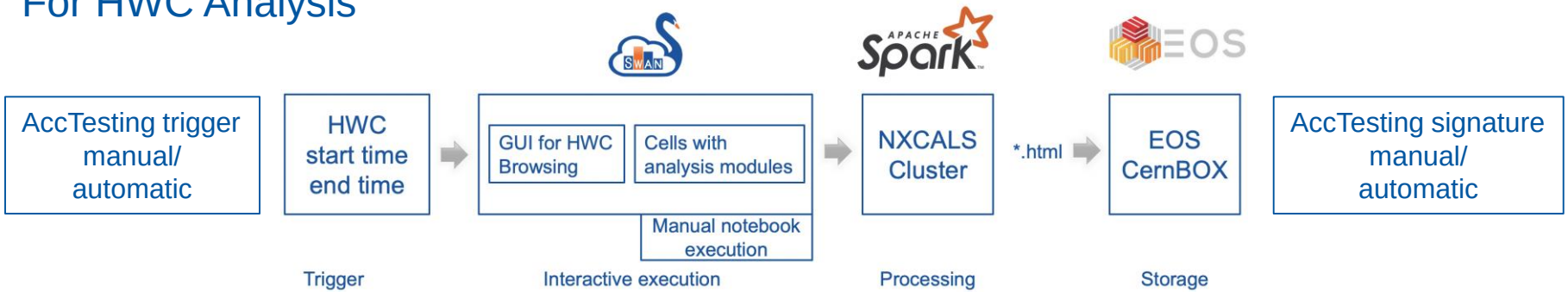
A handful of classes needed to perform an analysis. Meta-language for self-documented code.

Workflow

For FPA Analysis



For HWC Analysis



Current Status: RB

Type	Test	Current	Description	Notebook	Example report
HWC	PIC2	*IMIN*OP	Interlock tests with PC connected to the leads	AN_RB_PIC2	AN_RB_PIC2
HWC	PLI1.a2	I_INJECTION	Current cycle to I_INJECTION	AN_RB_PLI1.a2	AN_RB_PLI1.a2
HWC	PLI1.b2	I_INJECTION	Energy Extraction from QPS	AN_RB_PLI1.b2	AN_RB_PLI1.b2
HWC	PLI1.d2	I_INJECTION	Unipolar Powering Failure	AN_RB_PLI1.d2	AN_RB_PLI1.d2
HWC	PLI2.s1	I_INTERM_1	Splice Mapping	AN_RB_PLI2.s1	AN_RB_PLI2.s1
HWC	PLI2.b2	I_INTERM_1	Energy Extraction from PIC during the ramp	AN_RB_PLI2.b2	AN_RB_PLI2.b2
HWC	PLIM.b2	I_SM_INT_4	Energy Extraction from QPS	AN_RB_PLIM.b2	AN_RB_PLIM.b2
HWC	PLIS.s2	I_SM	Splice Mapping	AN_RB_PLIS.s2	AN_RB_PLIS.s2
HWC	PLI3.a5	I_INTERM_2	Current cycle to I_INTERM_2	AN_RB_PLI3.a5	AN_RB_PLI3.a5
HWC	PLI3.d2	I_INTERM_2	Unipolar Powering Failure	AN_RB_PLI3.d2	AN_RB_PLI3.d2
HWC	PNO.b2	I_PNO+I_DELTA	Energy Extraction from QPS	AN_RB_PNO.b2	AN_RB_PNO.b2
HWC	PNO.a6	I_PNO	Energy Extraction from QPS	AN_RB_PNO.a6	AN_RB_PNO.a6
Operation	FPA	I_PNO	FPA during operation with magnets quenching	AN_RB_FPA	AN_RB_FPA

For active links please refer to: https://sigmon.web.cern.ch/node/34#rb-circuit

Current Status: RB

- Table of timestamps
- Interactive schematic
- PIC (time synchronization)
- PC (time constant, earth current, maximum value w.r.t. the reference, earth current)
- EE (voltage, temperature, time synchronization)
- QDS (voltage rise, quench type, trigger source)
- QH (discharge analysis and comparison to the reference)
- Diode lead resistance
- Current leads analysis (voltage, temperature, valve opening)
- Voltage feelers (card status)
- Busbar and magnet resistance

For active links please refer to: https://sigmon.web.cern.ch/node/34#rb-circuit

Current Status: RQ

Type	Test	Current	Description	Notebook	Example report
HWC	PIC2	I*MIN*OP	Powering Interlock Controller	AN_RQ_PIC2	AN_RQ_PIC2
HWC	PLI1.b3	I_INJECTION	Energy Extraction from QPS	AN_RQ_PLI1.b3	AN_RQ_PLI1.b3
HWC	PLI1.d2	I_INJECTION	Unipolar Powering Failure	AN_RQ_PLI1.d2	AN_RQ_PLI1.d2
HWC	PLI2.s1	I_INTERM_1	Splice Mapping	AN_RQ_PLI2.s1	AN_RQ_PLI2.s1
HWC	PLI2.b3	I_INTERM_1	Energy Extraction from QPS	AN_RQ_PLI2.b3	AN_RQ_PLI2.b3
HWC	PLIM.b3	I_SM_INT_4	Energy Extraction from QPS	AN_RQ_PLIM.b3	AN_RQ_PLIM.b3
HWC	PLIS.s2	I_SM	Splice Mapping at I_SM	AN_RQ_PLIS.s2	AN_RQ_PLIS.s2
HWC	PLI3.a5	I_SM, I_INTERM_2	Current cycle to I_INTERM_2	AN_RQ_PLI3.a5	AN_RQ_PLI3.a5
HWC	PLI3.b3	I_INTERM_2	Energy Extraction from QPS	AN_RQ_PLI3.b3	AN_RQ_PLI3.b3
HWC	PNO.b3	I_PNO+I_DELTA	Energy Extraction from QPS	AN_RQ_PNO.b3	AN_RQ_PNO.b3
HWC	PNO.a6	I_PNO	Current cycle to I_PNO	AN_RQ_PNO.a6	AN_RQ_PNO.a6
Operation	FPA	I_PNO	FPA during operation with magnets quenching	AN_RQ_FPA	AN_RQ_FPA

For active links please refer to: https://sigmon.web.cern.ch/node/34#rq-circuit

Current Status: RQ

- Table of timestamps
- PIC (time synchronization)
- PC (time constant, earth current, maximum value w.r.t. the reference, earth current)
- EE (voltage, temperature, time synchronization)
- QDS (voltage rise, quench type, trigger source)
- QH (discharge analysis and comparison to the reference)
- Diode lead resistance
- Current leads analysis (voltage, temperature, valve opening)
- Voltage feelers (card status)
- Busbar and magnet resistance

For active links please refer to: https://sigmon.web.cern.ch/node/34#rq-circuit

Current Status: 600A

Type	Test	Current	Description	Notebook	Example report
Operation	FPA	I_PNO	FPA during operation with magnets quenching	AN_600A_with_without_EE_FPA	-
Operation	FPA	I_PNO	FPA during operation with magnets quenching	AN_600A_RCDO_FPA	-
Operation	FPA	I_PNO	FPA during operation with magnets quenching	AN_600A_RCBXHV_FPA	-

Current Status: 600A

- Table of timestamps
- PIC (time synchronization)
- PC (time constant, earth current, maximum value w.r.t. the reference, earth current, MIITs)
- EE (voltage)
- QDS (voltage rise)
- Current leads analysis (voltage, temperature, valve opening)

For active links please refer to: https://sigmon.web.cern.ch/node/34#rq-circuit

User Guide

To run a notebook, a user needs to follow these steps

1. Request NXCALS Access (once only)
   → http://nxcals-docs.web.cern.ch/current/user-guide/data-access/nxcals-access-request/

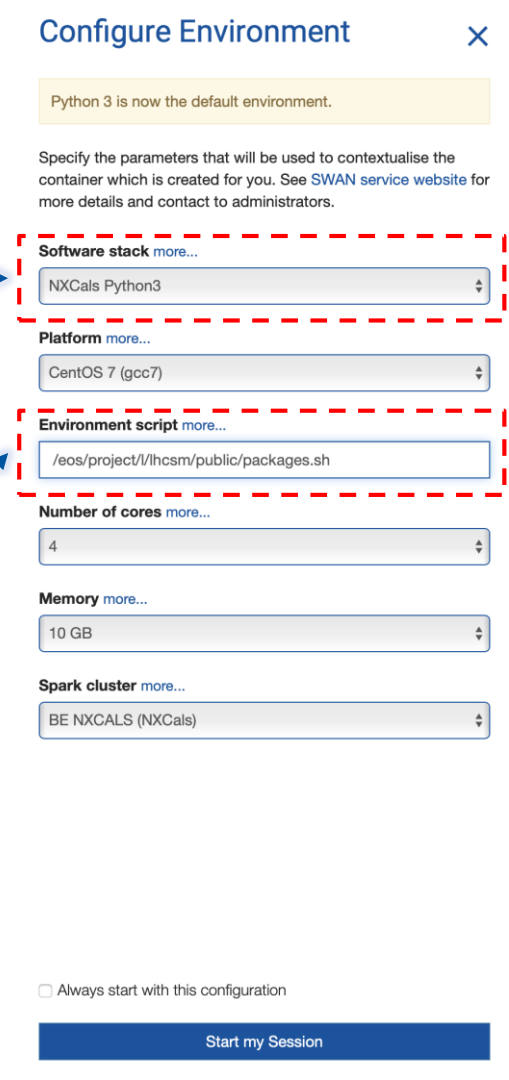
2. Request LHCSM Access (once only)
   → Send an e-mail to lhc-signal-monitoring@cern.ch

3. Log to SWAN
   → https://swan.cern.ch

2. Set environment script (at each login)
   → `/eos/project/l/lhcsm/public/packages_notebooks.sh`

NB: To ensure synchronization of version between notebooks and API, this operation deletes /hwc/ folder with notebooks and all your changes.

5. Run selected notebook



Demo

RB FPA Analysis – AN_RB_FPA

RQ HWC Analysis – AN_RQ_PLI2.s1

Documentation

- MP3 HWC Procedures:
  https://twiki.cern.ch/twiki/bin/view/MP3/HWCProceduresInfo
- MP3 Analysis Manuals:
  https://twiki.cern.ch/twiki/bin/view/MP3/AnalysisManual
- API Documentation:
  https://cern.ch/lhc-sm-api
- HWC Notebooks Documentation:
  https://gitlab.cern.ch/LHCData/lhc-sm-hwc/-/blob/master/README.md
- Youtube video (installation part needs to be updated, cf. slide #16):
  https://youtu.be/bDUT0_b4mnc?t=830

Verification and Validation

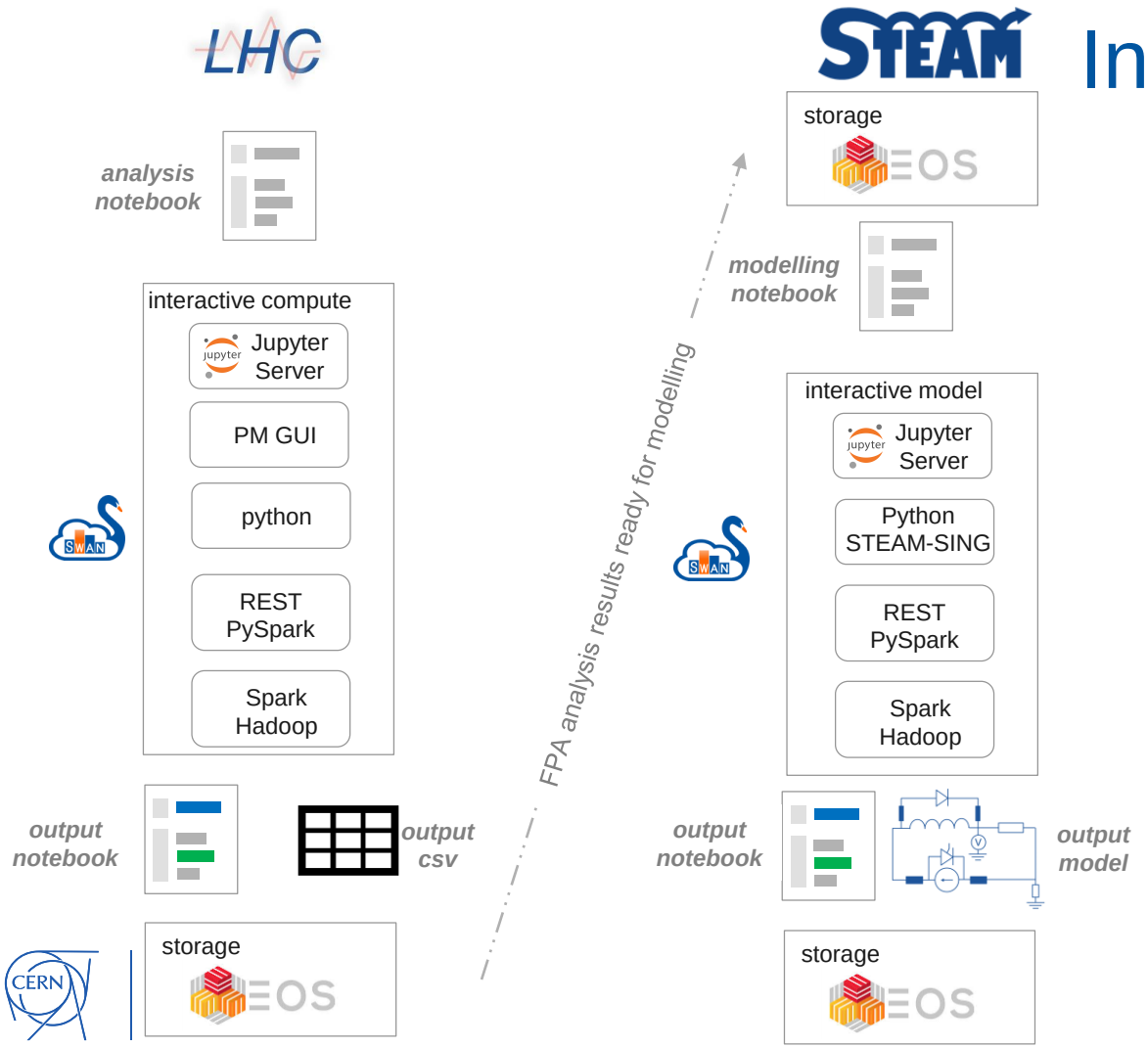
- The API is covered with **588** unit and integration test.

  Each function called from notebooks has at least one test.
- The notebooks are regularly cross-checked for each minor release of API
- The FPA analysis notebooks are tested for events from Run2 (**500+**)

RB	RQ	600A
10/1200	61/61	415/415

- The HWC analysis are tested against the last test from previous campaign

Integration with STEAM



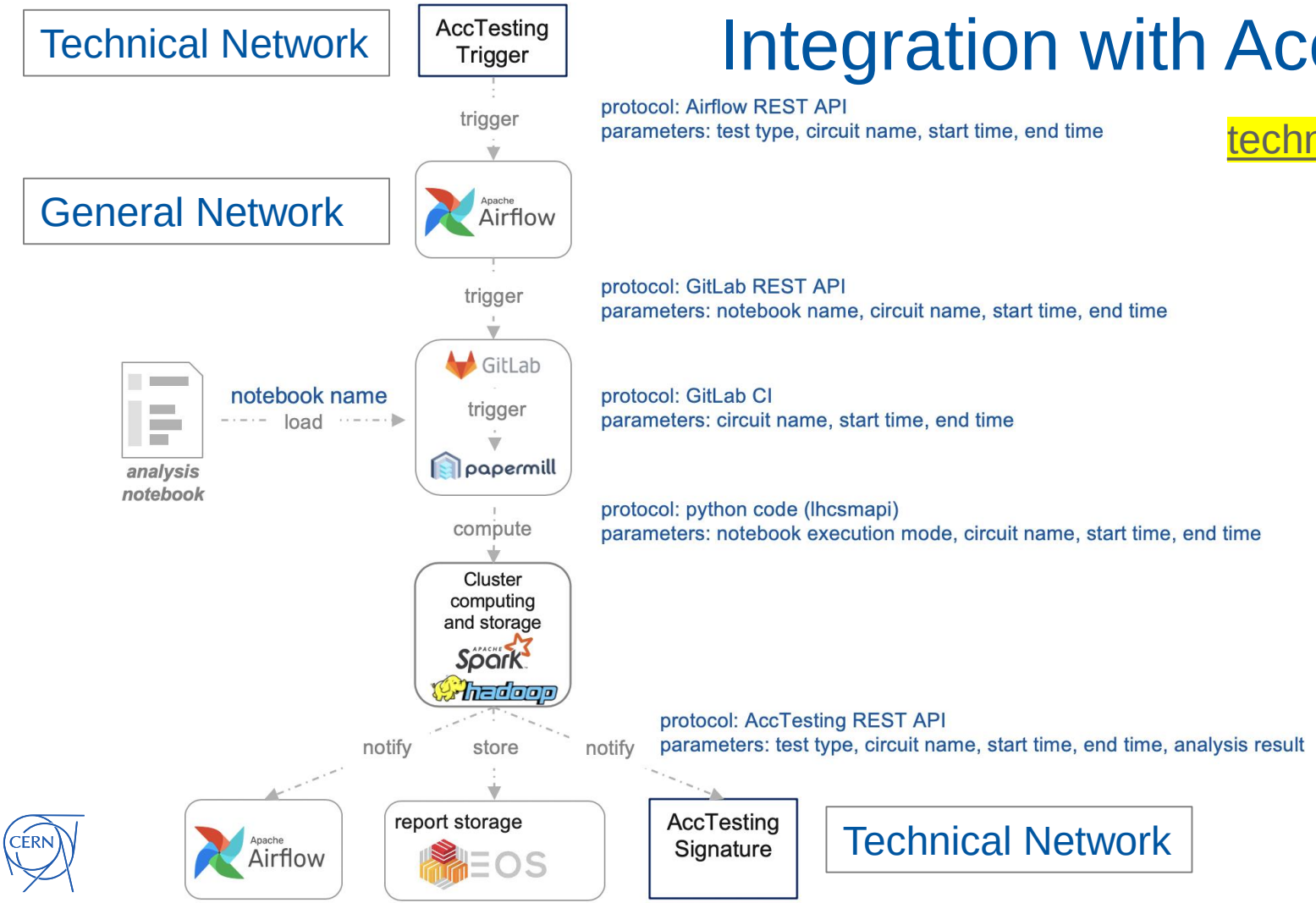
Some powering events are followed up by numerical simulations of electrical circuits.

Automatic generation of a circuit model of an FPA event with proper stimulus, timing of EE, quenching magnets

- Natural connection of both workflows
- Versioning of analysis as html reports
- Immediate reproducibility of results
- No extra code needed (API reuse)

technical blog entry

Integration with AccTesting

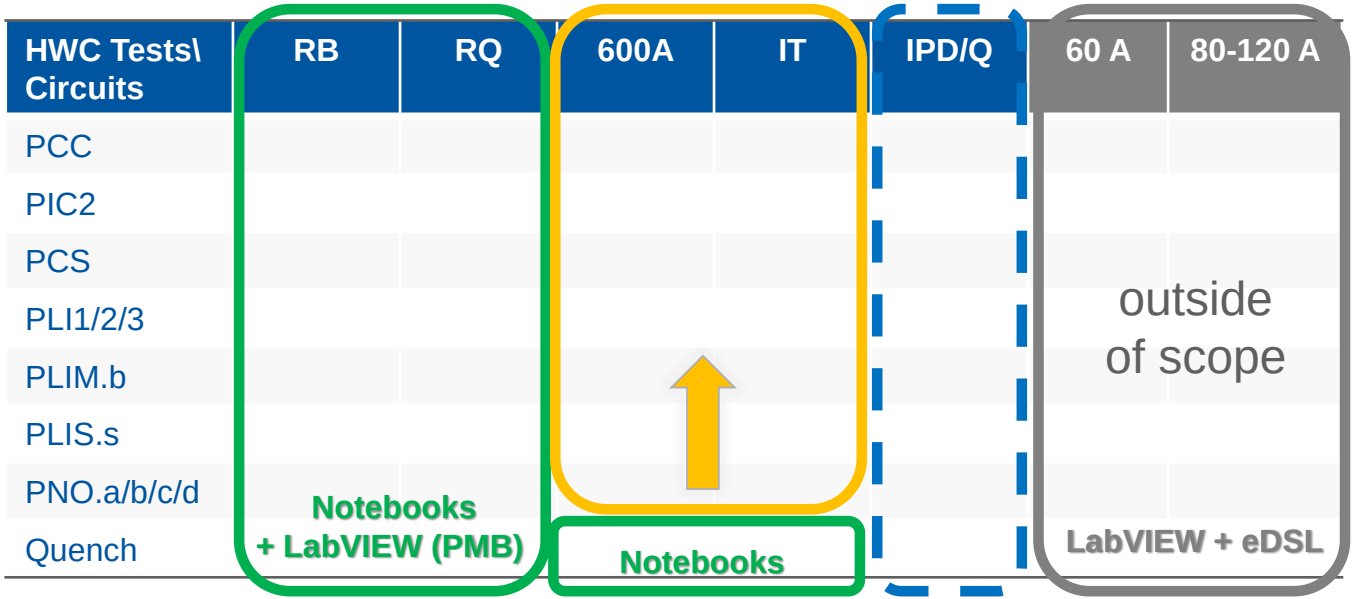


technical blog entry

Summary

- Integration of analysis manual and analysis itself
- Coherent naming, analysis, and documentation
- Integration with NXCALS
- Reproducibility and traceability of results
- Semi-automatic analysis leading to time reduction
- Maintenance of all services provided by IT department
- The same environment for signal analysis and model generation

Notebooks for HWC and Operation



- Each notebook has **similar** structure and is **open** for modification
- Analysis of a quench (with NXCALS) in RB&RQ **reduced** to ~15 minutes

Next Steps

1. Complete the HWC notebooks for 600A and IT.
2. Develop FPA and HWC notebooks for IPQ and IPD.
3. Test the notebooks against historical events
4. Integrate our notebooks with AccTesting for automatic analysis
5. Incorporate user feedback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