Data and processing resources for analysis

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EPA WP9

with input from
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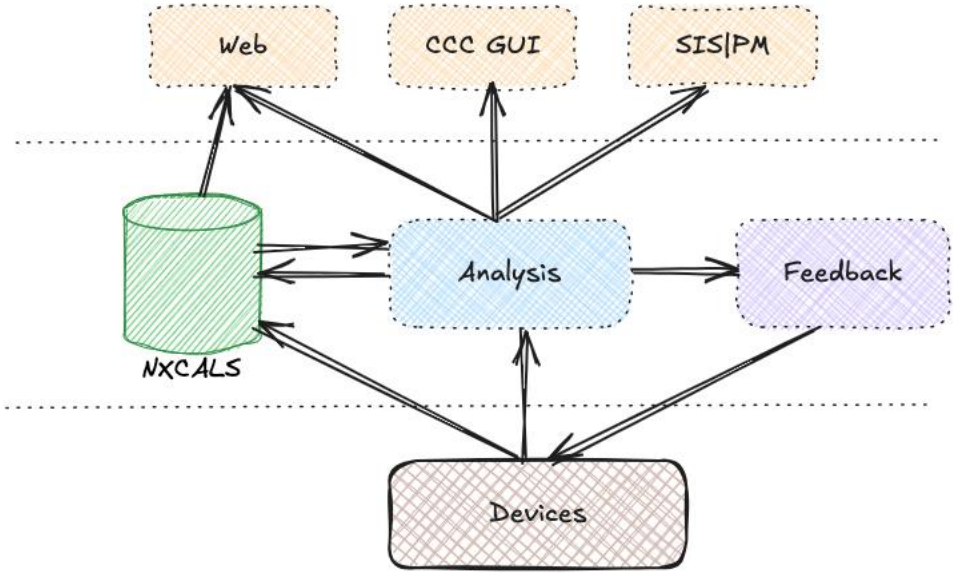
Overview



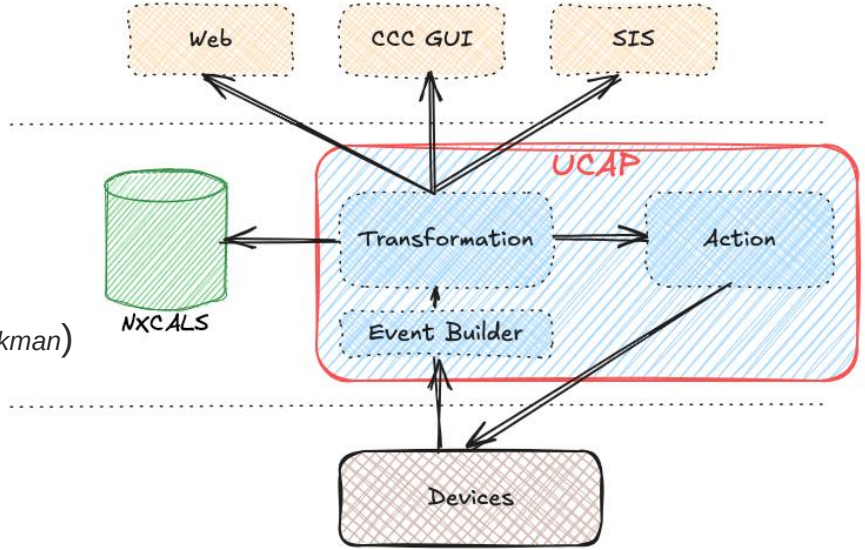
Online Data Processing

UCAP – the primary choice for online data processing

Common pattern: Data aggregation → Process → Publish + Store [Notify]

Many different use cases:

- Processing & concentration of operational signals
- Wire Scanner analysis
- Diamond BLMs
- Automatic Fault Recording (*see talk by A. Asko*)
- SISv2 complex logic
- Automated multi-bunch tomography (*see. talk by A. Beeckman*)
- etc...



UCAP overview

10 bare-metal machines (***cs-ccr-[1:10]***)

2 machines with GPU (***cs-513-ml002, cs-ccr-ml004***)

Node count: **203 nodes** : 95 PRO, 102 TEST, 6 TESTBED

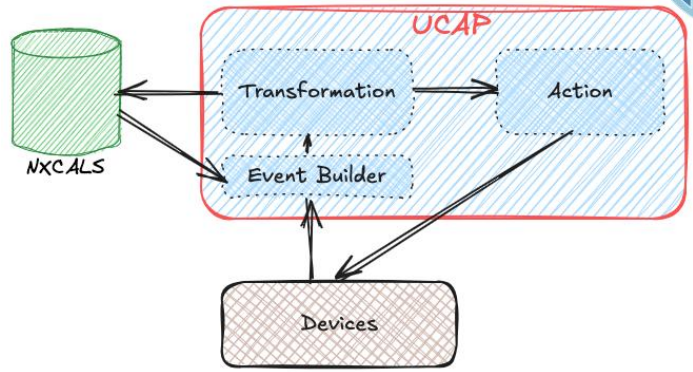
UCAP extensions and improvements

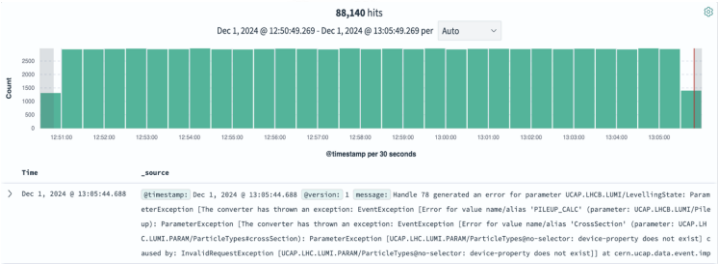
Recent developments driven by EPA & community

- Combine online and offline data → integration with NXCALS
- Simplifying debugging → logs are now stored in OpenSearch
  - Still room for improvement for Python (debugging from IDE)
- LSA Trim, AFT, Email Actors, SET support, and many more.

Planned improvements

- Automatic device declaration in CCS
  - No more manual declarations in the CCDE web interface
- *ucap-persistence* to keep Converters state when UCAP node is rebooted
- Support for event recording & replaying
- Streamline configuration with automated JSON generation





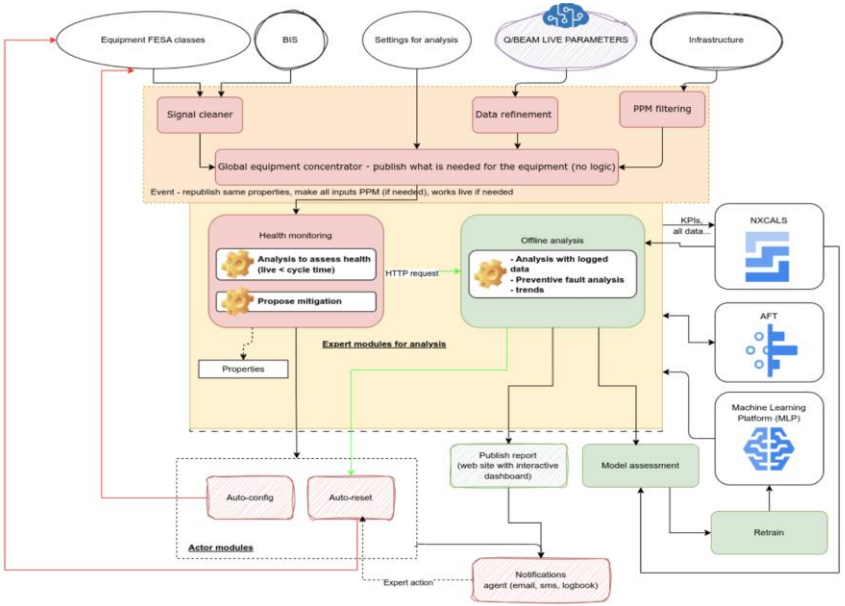
Limitations:

- UCAP is not a virtual device framework, i.e. unsuitable to implement e.g. Orchestration server → We need something else
- In UCAP all data is expressed in JAPC-style, however, operating on domain-specific types would be more convenient

New Data Processing Requirements from EPA

EPA WP8 – towards equipment automation aka “smart and agile equipment”

A framework that allows equipment experts to design automation for their machinery



Courtesy to F. Velotti and K. Papastergiou (JAP23)

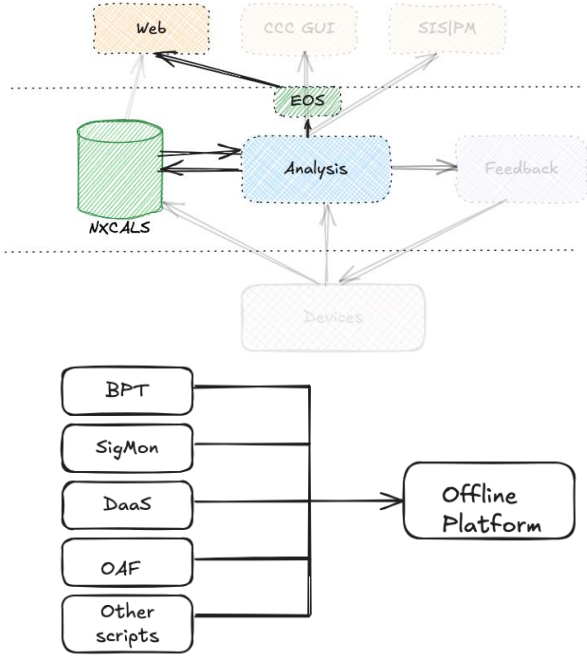
=> A more powerful and flexible analysis framework is needed

Offline Data Processing

Offline Data Processing Overview

Common pattern: Query data from NXCALS → process → publish + store + visualize

- Several different implementations exist with similar functionality
  - **O**ffline **A**nalysis **F**ramework – regular analysis of instrument data for tracking performance, aging, etc. (SY-BI)
  - **B**eam **P**erformance **T**racking - operation performance of the different accelerators (BE-OP, BE-ABP)
  - **Sig**nal **Mon**itoring – hardware commissioning, powering tests, circuit performance, quench analysis (TE-MPE)
  - **D**ata **A**nalysis **a**s a **S**ervice – water consumption, Cryo instrumentation and operation (BE-ICS, TE-CRG)
  - Several other systems from ABT, STI, TE-VSC
- Conceptually similar but with different implementation
  - mainly written in Python, different frameworks chosen
  - often operate on ad-hoc infrastructure that might not always be reliable enough
- Endorsed by the CTTB => Converge and provide a common solution



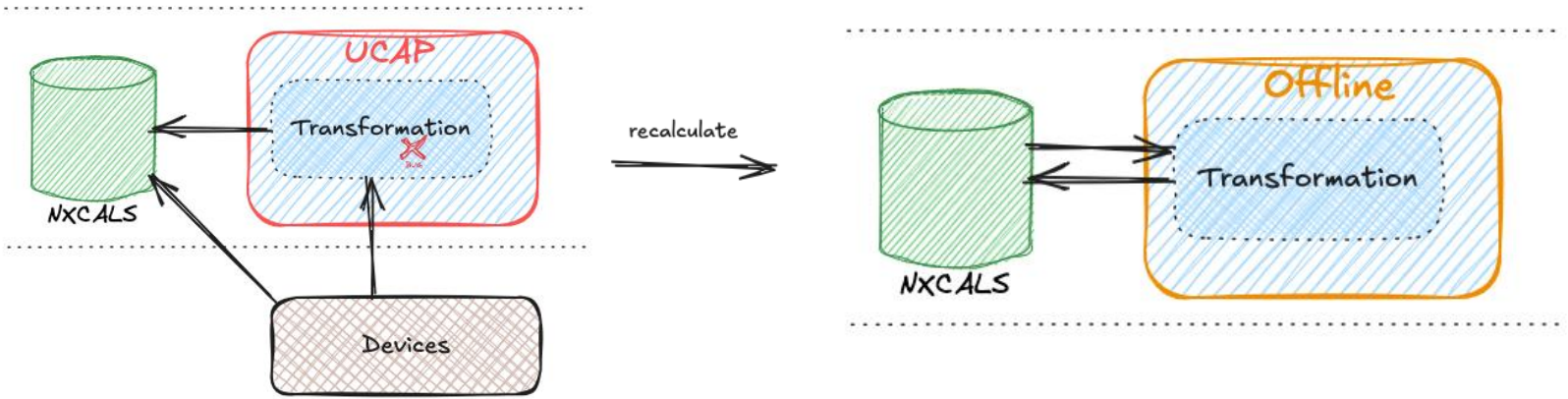
Vision/ideas for a unified offline solution

- **Ideally all data that needs to be analysed is stored in NXCALS**
  - Data from devices ✓ (Data can be logged on-demand, e.g. only during an MD)
  - LSA settings ✓ (no need to use pjLSA)
  - Optics and other information ➔ to be addressed
- **Analysis scripts**
  - Are written in any supported language (e.g., Python, Java)
  - Triggered by a fixed schedule (cron) or an external event (e.g. End-of-Fill)
  - Results can be stored in NXCALS, published (CMW, email etc)
- **You (users) take care of:**
  - Developing the analysis scripts and defining its configuration (e.g., trigger, result publication etc.)
- **We take care of all the rest**
  - Infrastructure, monitoring, upgrades
  - APIs, integration between services, deployments, triggers ...

Bringing offline & online together

Online and offline – why and how to merge?

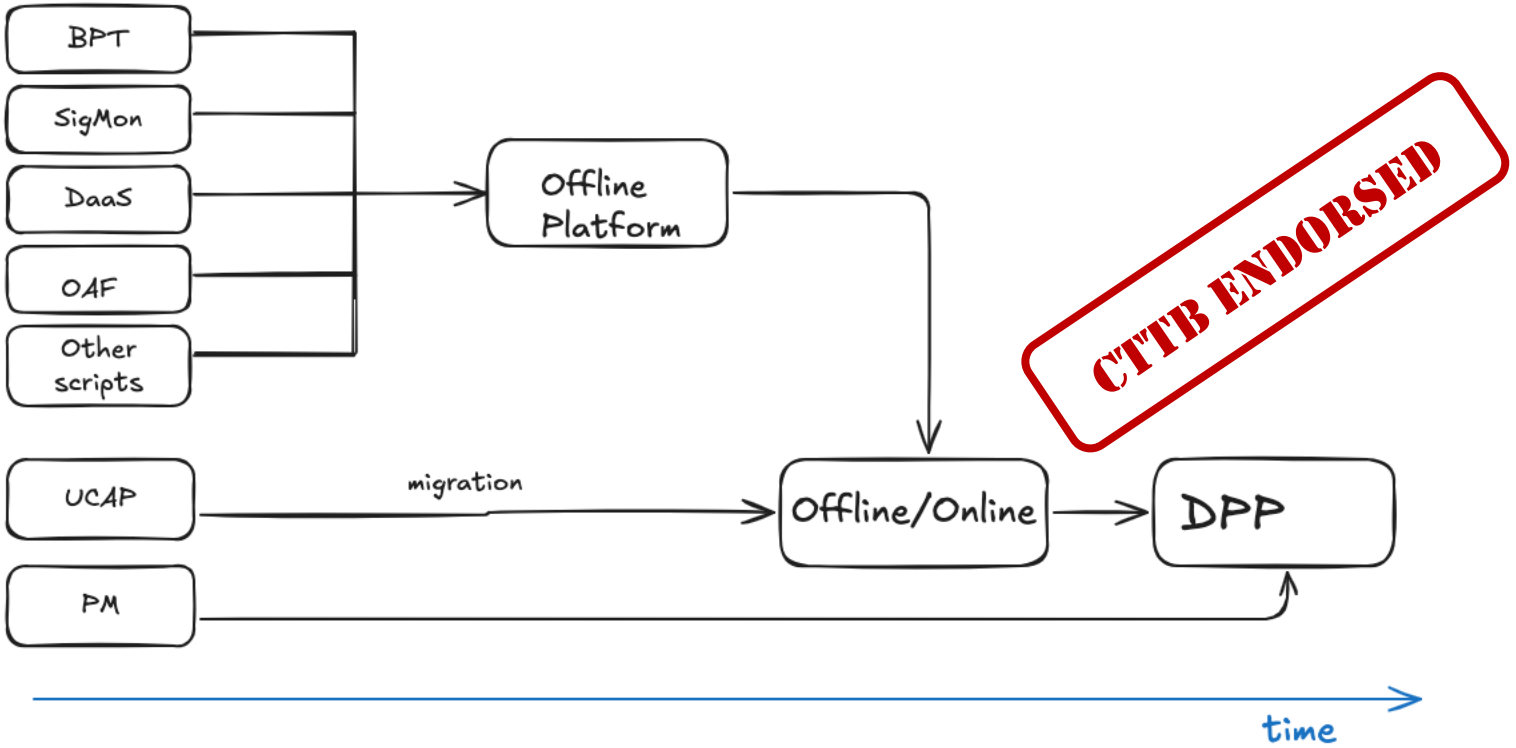
- Having distinct solutions for online and offline is inefficient
- Having the same (e.g., SWAN?) algorithm used for online and offline could be very useful



- **=> These two approaches are complementary and should be combined.**

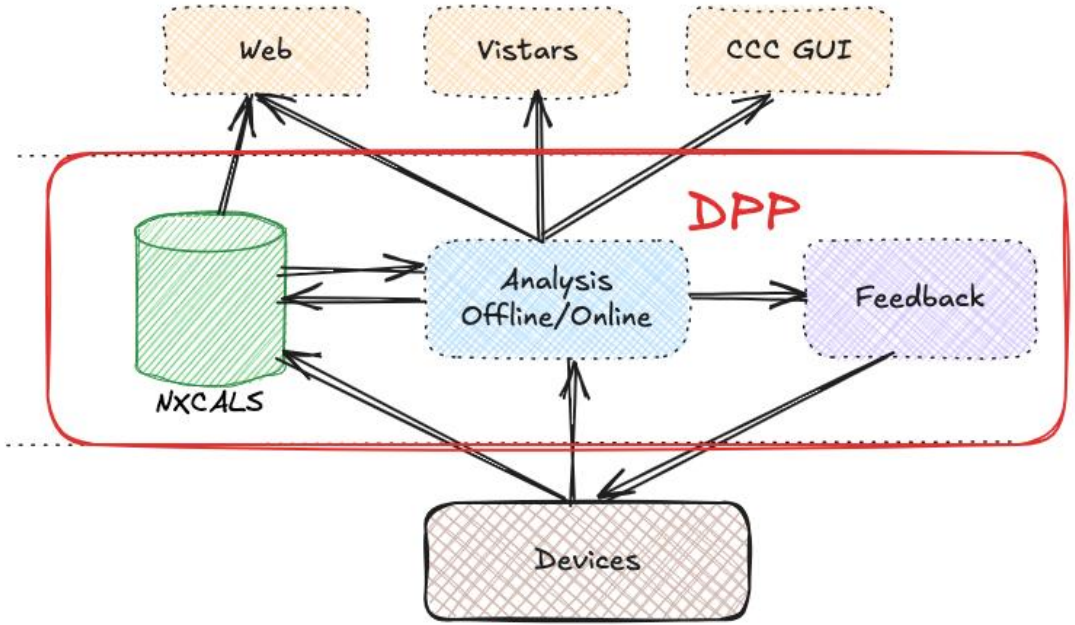
Challenges to achieve this: Finding a common way of expressing an algorithm for online and offline == common tools, data structures and APIs

Bringing online & offline together



Data Processing Platform

One tool for Online and Offline Analysis adopting the UCAP philosophy: focus on solving your problems and performing your analysis – we'll take care of the rest



Miscellaneous

- NXCALS: More sophisticated *logging-on-demand* needed for MD
  - Support for predefined time windows (e.g., for the next 8 hours)
  - Nice to have: conditional logging triggered by external events (e.g., when there's a beam)
- NXCALS: Data post-processing, down sampling, repartitioning
- NXCALS: Simplified API, UTC → local time, pandas for seamless Analysis
  - Help people use Spark efficiently
- NXCALS: Even more data into NXCALS (Optics + Settings + Meas) for even more seamless Analysis
- UCAP, NXCALS: Even more support for Python
  - "*if Python was not supported we wouldn't use UCAP at all*"
  - *"Do we actually need Java in Client Facing API?"*
- MISC: Controls orchestration service strategy - clarify needs and roles between DPP and Sequencer 2.0 (WP5)
- MISC/DPP: *EventBuilder* as a specialized Python library or a service
- MISC: API for cross-accelerator correlation (e.g. to follow an LHC bunch back to the PS cycle that produced it)

Plans for 2025

UCAP

- Implementation of *ucap-persistence*
- Integration with Controls Configuration (CCS)
- Simplify configuration, hide JSON

DPP (offline)

- Technology research
  - Leveraging a rich Cloud-native (Kubernetes) landscape
  - Data Streaming solutions
- PoC Delivery: targeted for Q3 2025 including:
  - Two offline use cases from SigMon and OAF
  - EPA dashboards

MISC

- NXCALS/CCDB: Extend *logging-on-demand*
- More and better Python APIs (pyJapc → pyDA, …)

Summary

- There is a clear and growing need to provide a **D**ata **P**rocessing **P**latform as a Service
  - UCAP is successful and widely adopted for online use case
  - Multiple group in ATS have also implemented offline solutions their own way
- DPP is aimed to address both
  - It is endorsed by CTTB
  - Recruitment is ongoing
  - It factors in additional, emerging requirements, e.g., from EPA Work Packages
  - It brings more data in NXCALS, better Python support, better APIs
- **A Proof-of-Concept will be done in 2025 and we're looking forward to reporting back here in 1 year ☺**

Extra Slides

DPP - Ideas for the implementation

- User-Friendly Service Submission
  - Users can submit their code without worrying about the infra
  - Resources are scaled as needed
- Declarative usage: simplified interaction with existing systems (e.g., UCAP)
- Beginner friendly: prepare a simple analysis in less than 1 hour
  - Create a skeleton from a template → develop & test & run locally → deploy

```
→  knative dpp create -l python plotly-tmp-2
Created python function in /Users/msobiesz/dev/local/knative/plotly-tmp-2
→  knative cd plotly-tmp-2/
```

```
→  plotly-tmp-2 dpp deploy
   Function image built: gitlab-registry.cern.ch/msobiesz/knative-poc/plotly-tmp-2:latest
   Deploying function to the cluster
   Function deployed in namespace "default" and exposed at URL:
http://plotly-tmp-2.default.127.0.0.1.sslip.io
```

- Powered by a Kubernetes/Knative service, aka Function as a Service (FaaS)
  - Knative's Serving, Eventing, Func, Akka
- Plus: more powerful and convenient Python libraries to work with NXCALS
  - Pandas-on-Spark to run analysis in the NXCALS cluster;
  - API for cross-accelerator correlation (e.g. to follow an LHC bunch back to the PS cycle that produced it)
  - Local time by default (not UTC)

Online and offline – why and how to merge?

- **Having distinct solutions for online and offline is inefficient**
- **Online use case:**
  - **Scenario**: A UCAP transformation processes raw data from devices and publishes the results to NXCALS
  - **Advantage**: real-time availability of data e.g. for GUIs
  - **Downside**: the UCAP device must run continuously, else there are data losses
- **Corresponding offline use case as an alternative:**
  - **Scenario**: All raw data from devices is stored in NXCALS, and the same algorithm as above is executed in offline mode
  - **Advantage**: transformation can be run at anytime. If the algorithm changes, the whole year can be re-calculated
  - **Downside**: data cannot be displayed in real-time.
- **=> The two are complementary and should be combined.**

Challenges to achieve this: Finding a common way of expressing an algorithm for online and offline == common tools, data structures and APIs