Analysis Facilities for/in LHCb

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The really short version

❑ *As of today* LHCb has no Analysis Facilities set up, per se

❑ But then:
  - The concept of an AF is vague and/or can mean several things
  - Different experiments take / have taken different routes and solutions to their challenges/problems
  - Discussions have slowly started within LHCb DPA (WP4) on where we could go

❑ Our Upgrade 2 document stipulates the following in WP3.1 on Real Time Analysis:

> ● **Analysis facility with heterogeneous online compute resources:** Already in Run II, LHCb was able to exploit its HLT farm for simulation during periods without collisions. Many of LHCb's analyses rely on increasingly complex machine learning algorithms, where the training may become prohibitively expensive and the physics exploitation of the data may be compromised. Within this work package the framework for a so-called analysis facility will be designed and a prototype will be developed and tested.

❑ Liverpool:

| WP3.1.1-D3 | Prototype of analysis facility. | 2026 Q3 |

❑ There is a lot to say on this, and on what we could mean by a prototype AF

❑ Let's first "set the scene" a bit …

Analysis Facilities for/in LHCb – what's an AF, anyway?

❏ **Taken from the HSF Analysis Facilities Forum kick-off meeting, 15/03/2022**

What is an Analysis Facility?

"infrastructure and services that provide integrated <u>data</u>, <u>software</u> and <u>computational resources</u> to execute one or more elements of an analysis workflow. These resources are <u>shared</u> among members of a virtual organization and <u>supported</u> by that organization."

People
Dedicated support staff

Maintenance and development

Services
Access to experimental data

Storage space for per-group or per-user data

Access to significant computing resources

Hardware
CPUs and disks

Growing need for GPUs

Software
ROOT

Python-based ecosystem

Interactivity

Why is this important now?

New analysis techniques

- Development of new analysis workflows for more efficient analysis
  - Columnar analysis instead of traditional event loop approach
  - Workflow management tools
  - Increased use of alternative hardware
- Increased interoperability between ROOT and Python data-science tools
- Integration and adoption of industry tools in HEP analysis frameworks
  - Including machine/deep learning algorithms and sophisticated analytics engines like Apache Spark, DASK
- New user interfaces for interactive analysis (e.g. Jupyter notebooks)
- Analysis preservation - REANA platform

APACHE Spark™

DASK

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Analysis Facilities for/in LHCb – looking across HEP

❑ **Fast-forward to 2024:**

- Several meetings held by the HSF Analysis Facilities Forum
- Several workshops held with AFs as a key topic,
  notably the WLCG/HSF pre-CHEP workshop in 2023 and the WLCG/HSF workshop @ DESY in May 2024

- A White Paper got published (LHCb involved via DPA people)

- LHCC held a Focus Session on AFs in June 2023
  and has requested that experiments produce
  "a document which defines the use cases
  in order to establish realistic benchmarks."
- LHCC charged WLCG to oversee this continuous process
  and to report regularly on the progress and steps taken
- 1st step (June 2024): experiments dressed a list of questions
  that seek to define their expectations for AFs

# Analysis Facilities for/in LHCb – towards a prototype

❑ **It is clear that LHCb does not have much resources (people), even less for technical work on AFs**
- General issue, not at all UK specific (this would deserve a separate discussion within LHCb …)

❑ **It is clear that several other collaborations/institutes are way ahead**
- e.g. activities of CMS and IRIS-HEP (ServiceX, Coffea-casa, Analysis Grand Challenges, …), the DESY NAF

❑ **We hence should (can only afford to) be pragmatic:**
- Follow community activities to see what we can leverage/adapt for LHCb
- In the first instance focus on putting in place *some* AF to exploit our GPU and CPU farms
  - Connects very well with DPA WP4 activities, including the usage of modern analysis tools (e.g. on GPUs)
- Interest is the usage of the farms for analysis jobs (we did simulation jobs with our old pre-run-3 HLT2 CPU farm)
  - ML training studies and inference, fit studies, etc. (towards some ML/AI insfrastructure?)
  - More towards common solutions

❑ **I had first discussions with the Online team and then Computing back in Summer 2023**
- It is clear that the whole endeavour needs to involve all C&SW projects

Analysis Facilities for/in LHCb – towards a prototype

❑ Broadly speaking an AF builds on, and facilitates access to, 4 "components":

1. **Computing resources** – limit ourselves to our farms (ignore the cloud, for example)
2. **Storage** – we have EOS and CERNBox (not immediately obvious that this plays well in the HLT1 farm)
3. **Software** – via CVMFS and also user-specific
4. **A user interface** – requires discussion to go towards an interactive notebook session
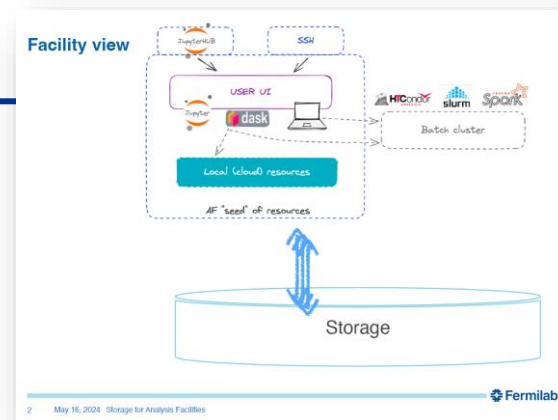
WP3.1.1-D3	Prototype of analysis facility.	2026 Q3

❑ **Getting to work:**

1. **Understand with Online and RTA what constraints there are, what setup is required to avoid clashes with data taking.**
   Discuss with Computing how to access those resources as special(=LHCb-internal) "Grid" resources, most probably via Dirac.

2. **Analysis jobs need access to storage whereas simulation jobs only produce files.**
3. **How to access/run/ship all software needed by analysts**
4. **AFs really shine as "elastic resources" for interactive analysis with the ability to scale-out on big datasets.**
   User interface is typically a Jupyter notebook. We need to investigate how to adapt Dirac/…

In short, there is A LOT to do, and people is close to nil !