

# Sprucing and Analysis Productions: Offline data processing in LHCb without the pain

## CHEP 2024

N. Skidmore on behalf of the LHCb experiment

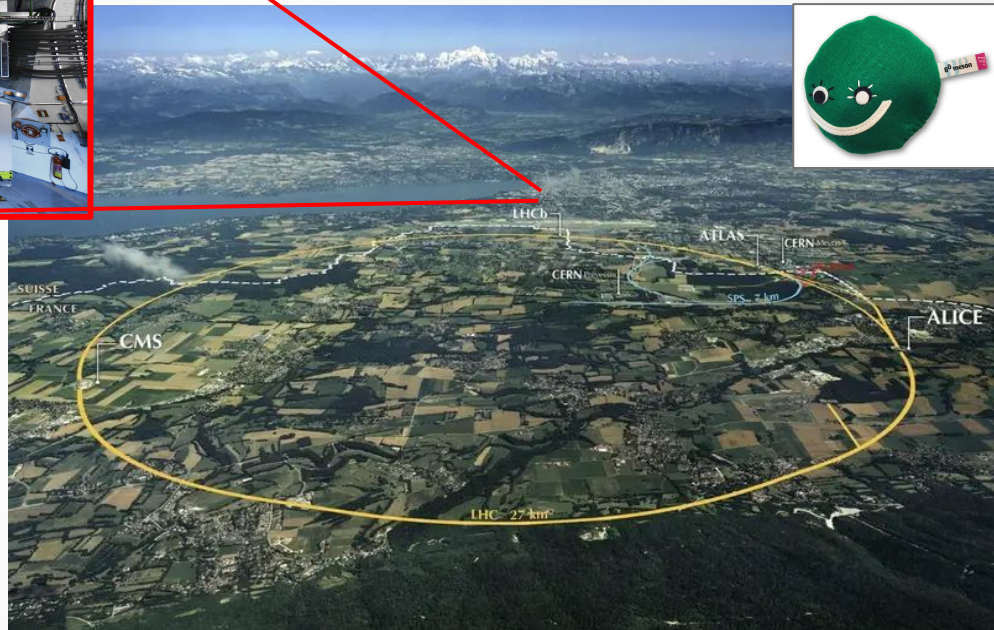
Oct 2024



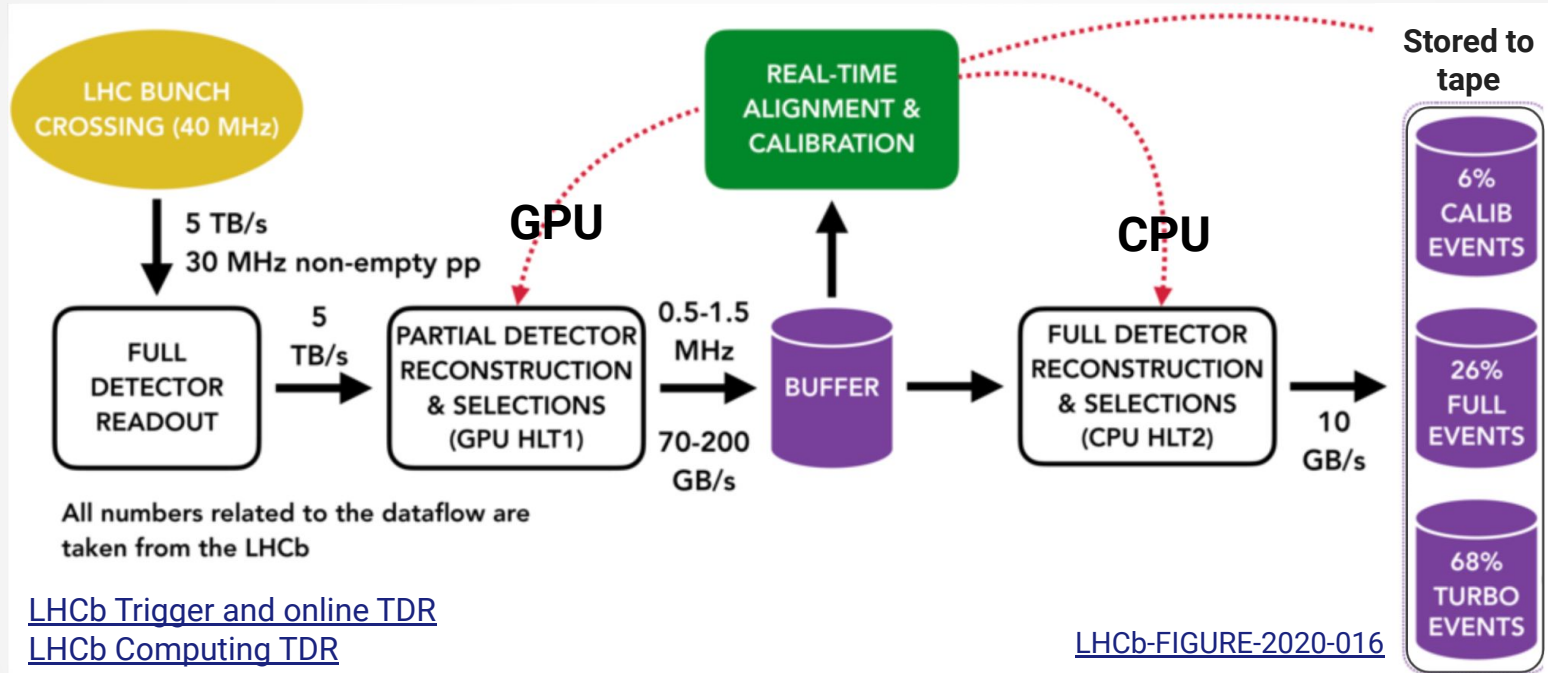
# The LHCb data challenge



- Dedicated b-physics experiment
- Single-arm forward spectrometer
- Upgrade to read out detector at 30MHz

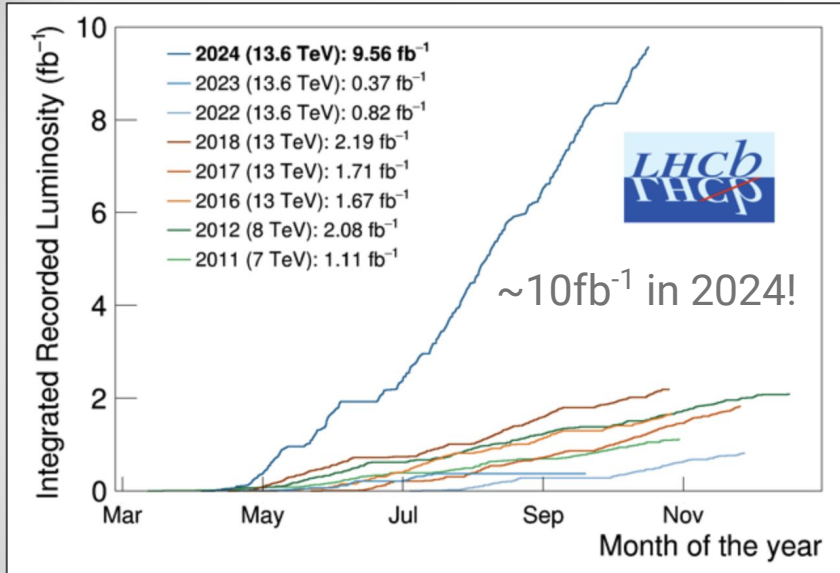


# The LHCb data challenge



# The LHCb data challenge

As of last week...



COLLABORATION DETECTOR LATEST POSTS OTHER PHYSICS RESULTS

## End of successful proton-proton collision data taking period

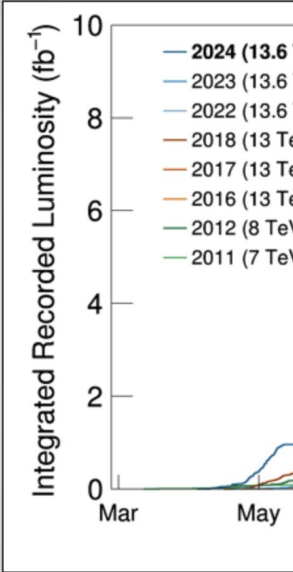
By [pietrzyk](#)

OCT 18, 2024 #data analysis, #data taking, #LHCb detector, #RTA

The 2024 proton-proton collision period at the LHC ended this week. This period was particularly successful for LHCb, also owing to the excellent performance of the LHC. The rate at which the experiment was able to acquire integrated luminosity was spectacularly higher than in previous years, as shown in the luminosity plots presented in this page. LHCb has largely exceeded its target of an integrated luminosity of  $9\text{fb}^{-1}$ , which is higher than the sum of luminosities from Run 1 and Run 2. LHCb operated at a record instantaneous luminosity of  $2 \times 10^{33}\text{cm}^{-2}\text{s}^{-1}$ , corresponding to  $\mu=5.3$ , the average number of visible pp collisions per bunch crossing. Not only did LHCb accumulate a record amount of data, but the efficiency of beauty and charm particle selection for hadronic channels has increased by a factor between 2 and 3 compared to previous years, due

[Public announcement](#)

# The LHCb data challenge



**collision**

particularly successful for LHCb, also  
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 $\mu=5.3$ , the average number of visible  
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# The offline LHCb data challenge

- LHCb has been saving 10GB of data to tape every LHC second
- Data necessarily has a complex journey before it reaches analysts
- For Run 3+ LHCb revolutionised this process for the benefit of the analyst

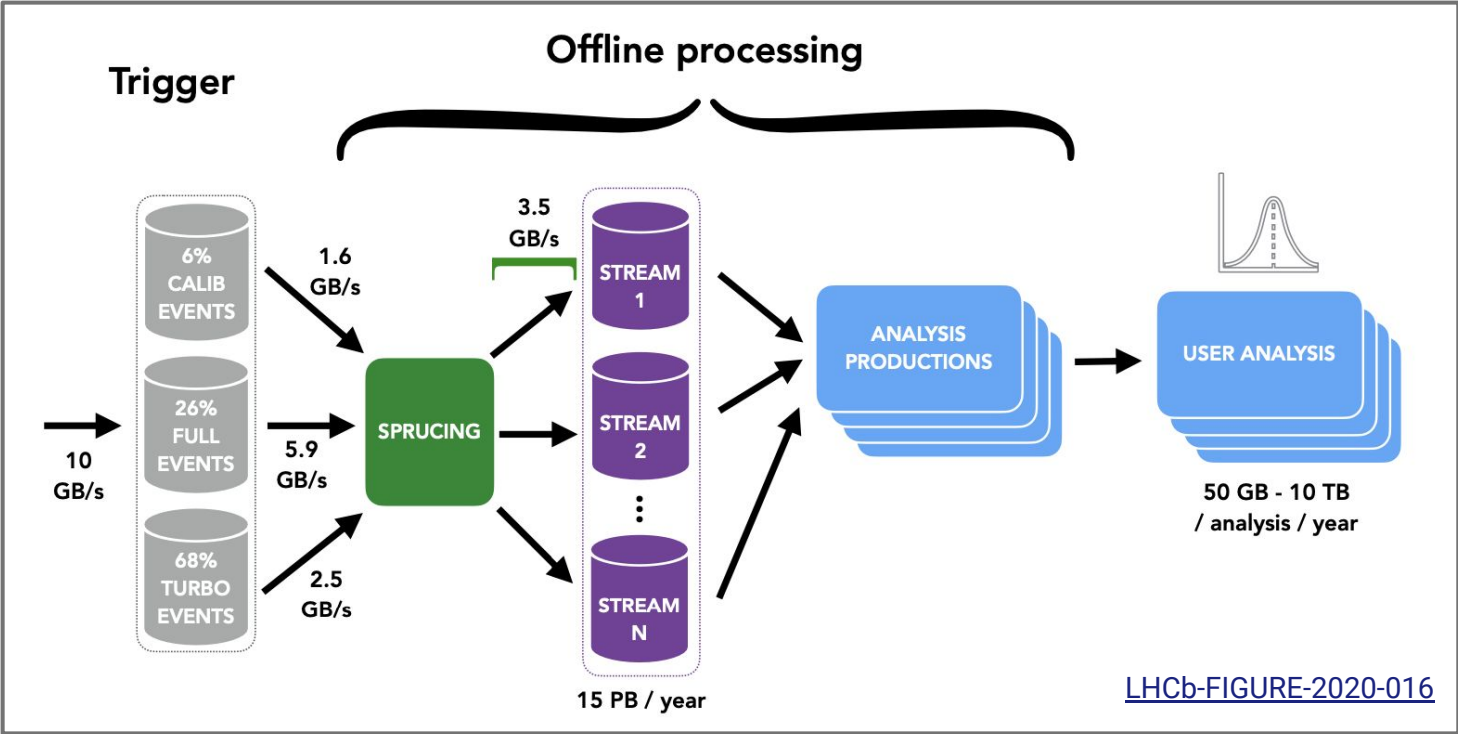


Typical LHCb analyst circa 2018

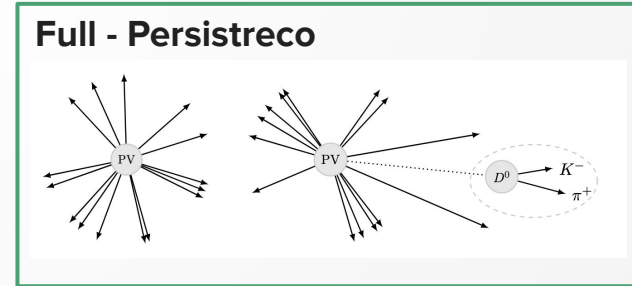
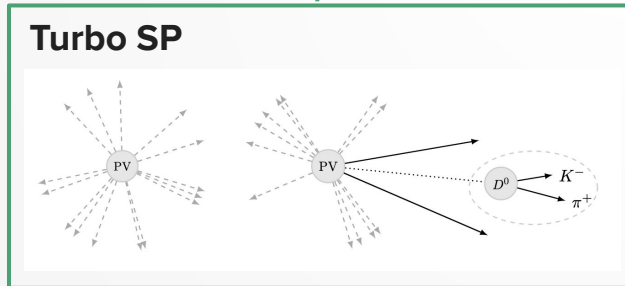
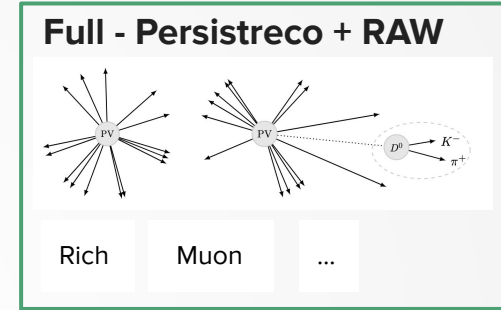
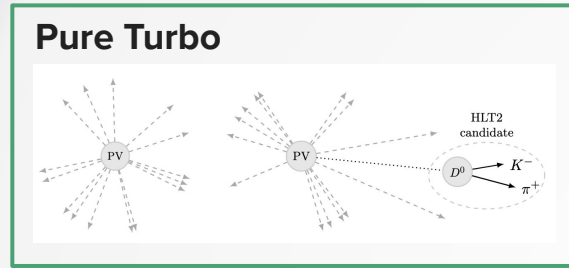


Modern day LHCb analyst

# The offline LHCb dataflow

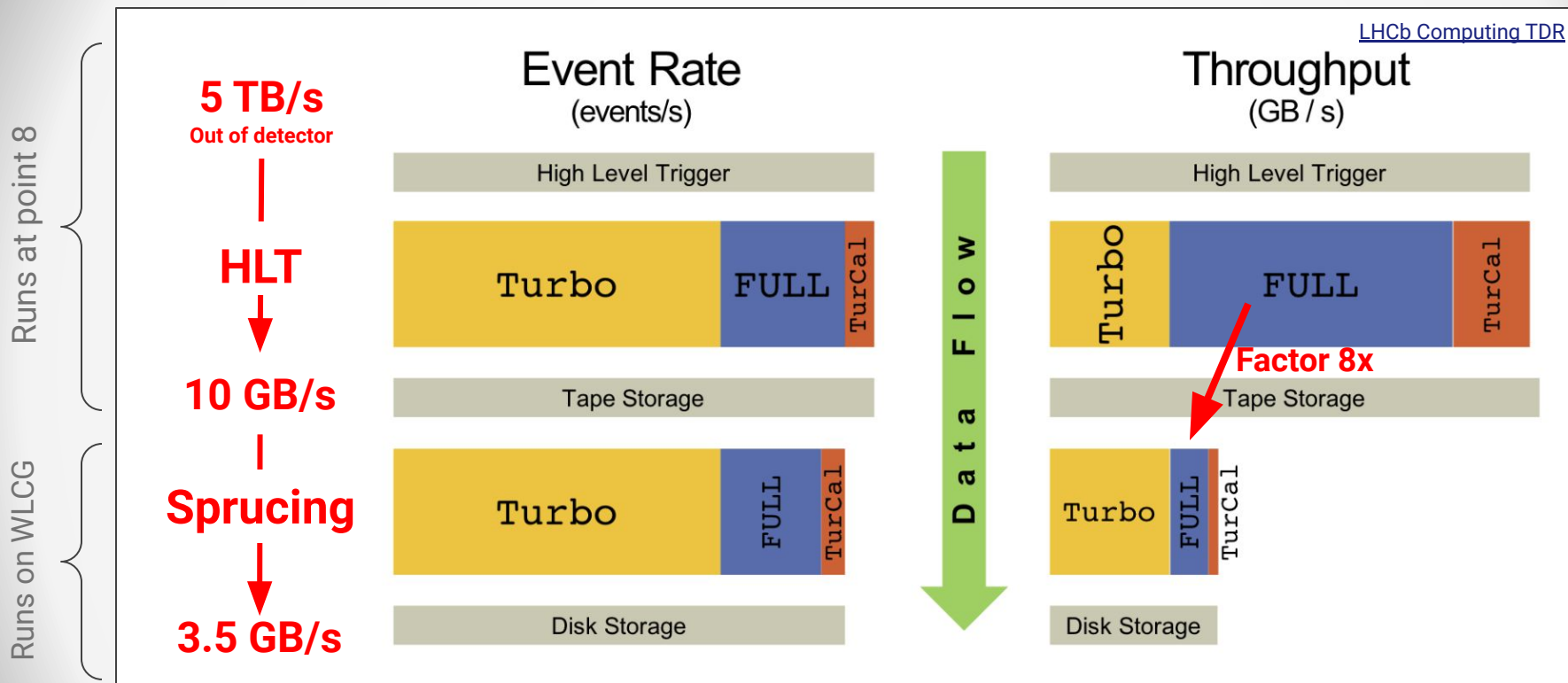


# Sprucing - managing tape/disk persistency





# Sprucing - how to manage tape/disk persistency

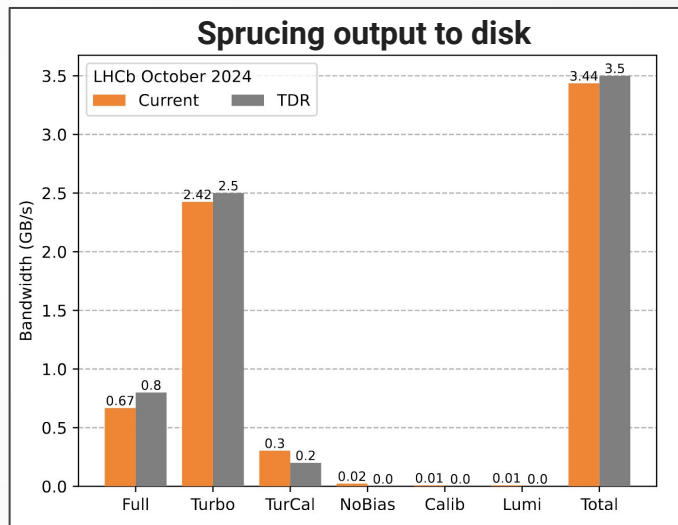
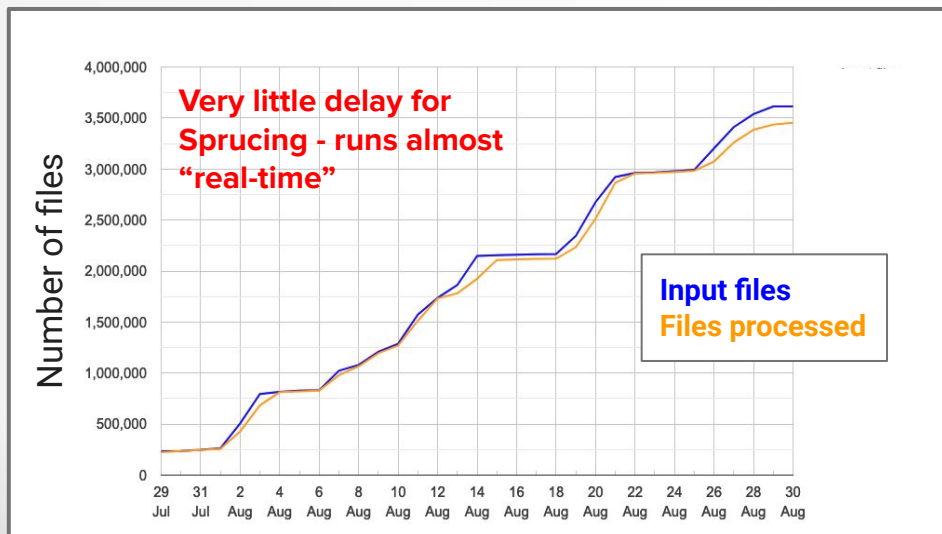


Can keep inclusively selected full events on tape for future exploitation in yearly re-sprucing campaigns

# Sprucing - managing tape/disk persistency

LHCb spruced **35PB** of data in 2024 over 3 physics streams and 2 technical streams

- Bandwidth reductions met
- Sprucing on FULL stream requires **5x less CPU per event** compared to the Run 2 analogue



# Analysis productions - declarative ntupling

Pre - run 3 analysts made their own ntuples

## THE PROBLEM

- Submitting, monitoring and error handling  $O(10,000)$  grid jobs
- No data provenance
- Thousands of failing grid jobs

⇒ BIG barrier between analysts and data



# Analysis productions - declarative ntupling

## THE SOLUTION ⇒ Analysis productions

- Centralise and automate ntuple creation  
⇒ Saves countless analyst-hours
- Exploit DIRAC transformation system  
⇒ Full data provenance
- Full job testing on GitLab CI  
⇒ No buggy jobs on grid

## Simple yaml job configuration

```
defaults:  
  application: DaVinci/v64r10@x86_64_v2-e19-clang16-opt  
  output: DATA.ROOT  
  options:  
    entrypoint: bs2dspirun3.dv_simple:alg_config  
    extra_options:  
      input_raw_format: 0.5  
      input_type: ROOT  
      simulation: False  
      data_type: "Upgrade"  
      geometry_version: run3/trunk  
      conditions_version: master  
      input_process: "TurboPass"  
      input_stream: "b2oc"  
  inform:  
    -  
  wg: B20C  
  
{%- set datasets = [  
  ('2024Data', 'MagDown', '24c2'),  
  ('2024Data', 'MagUp', '24c2'),
```

What application  
to run

Job options

Data to run on

Use Jinja templating to “render” the YAML

# Analysis productions - declarative ntupling

## Comprehensive job testing through GitLab pipelines

Looks good!

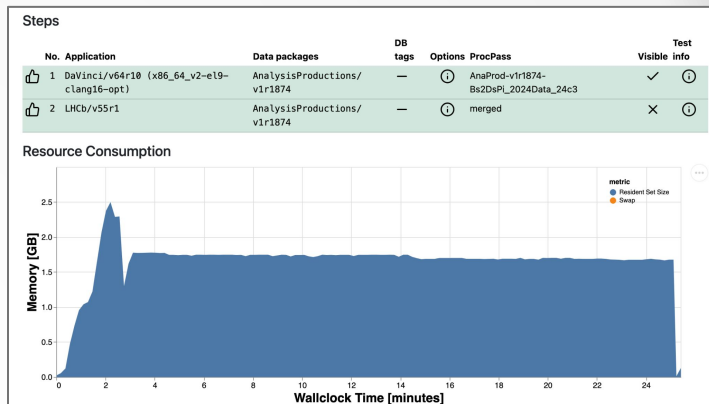
Ran for 213720 events in d1rac:951865446  
Production was submitted as 341617.

WG	# Events processed	Run time	Peak memory
b2oc	213,720	00:25:31	2.56 GB

### Inputs and outputs

Path	EOS path	Open in JSRoot	Size (this job)	Size (entire sample)
Input	LFN:/lhcb/LHCb/Collision24/B2OC_DST/00241744/0006/00241744_00007538_1_b2oc.dst		4.43 GB	101.87 TB
	LFN:/lhcb/LHCb/Collision24/B2OC_DST/00241585/0021/00241585_00210094_1_b2oc.dst		4.15 GB	
Intermediate	00012345_00006789_1.data.root	Copy	2.89 MB	
Output	00012345_00006789_2.data.root	Copy	2.76 MB	~ 32.82 GB

## Reporting on memory usage



## Reporting on estimated output size

LHCb Data Processing and Analysis @lhcbdpca · 1 week ago

Welcome to Analysis Productions!

This is a summary of the productions requested in this merge request:

Step	Production ID	Num Test LFNs	Run time	Estimated Output Size (MB)
Bs2DsPL2024Data_MagDown_24c2	123713	2	0:42:06.715033	3.1
Bs2DsPL2024Data_MagUp_24c2	123714	2	0:40:23.311033	3.0
Bs2DsPL2024Data_MagUp_24c3	123715	2	0:25:31.108833	2.6
Bs2DsPL2024Data_MagDown_24c3	123716	2	0:19:40.963231	2.5
Bs2DsPL2024Data_MagDown_24c4	123717	2	0:35:30.184766	3.2

## Interactive logs with warning/error highlighting

Logs

[DaVinci\\_1.log](#) [prmon\\_1.txt](#) [prodConf\\_DaVinci\\_1.json](#) [LHCb\\_2.log](#) [prmon\\_2.txt](#) [prodConf\\_LHCb\\_2.json](#) [DIRAC.log](#)

Copy Download

```
1 Overriding DIRACSYSCONFIG to /tmp/tmp1_mfqf08,/tmp/pilot.cfg
2 Restarting process with ['/cvmfs/lhcb.cern.ch/lhcbdirac/versions/v11.0.48-1727212764/Linux-x86_64/bin/dirac-production-request-run-local', '/t
3 Executing workflow locally
4 Executing from /tmp/951865446
5 Executing job at temp directory /tmp/951865446/Local_99hwhj07_JobDir
6 File not found Request_0_AnalysisProduction_AnaProd-v1r1874-Bs2DsPL2024Data_24c3_EventType_94000000_B2OC_1.xml
7 Job has input data requirement, will attempt to resolve data for DIRAC.LocalProdTest.local
8 Replica Lookup Time: 0.48 seconds
9 Metadata Lookup Time: 0.12 seconds
10 Job has a specific policy setting: DIRAC.WorkloadManagementSystem.Client.DownloadInputData
```

# Analysis productions - declarative ntupling

**Tree display**

This section displays the samples split by tags and is the recommended way of requesting datasets. Clicking on one of the boxes will filter the list of samples shown below. See TODD for more information.

Grouped tags  config  datatype  eventtype  polarity

Drag to sort config datatype eventtype polarity

as_fs_run2 60				hcb 16			
mc 44				2015 4			
2016 12				2016 4			
13264021 4		13264031 4		90000000 4		90000000 4	
magdown 2		magup 2		magdown 2		magdown 2	
13164042 4				magup 2			
magdown 2		magup 2		magup 2		magup 2	
2017 12				2017 4			
13264021 4		13264031 4		90000000 4		magup 2	
magdown 2		magdown 2		magdown 2		magup 2	
2015 8				2018 4			
13264021 4		13164042 4		90000000 4		magdown 2	
magdown 2		magdown 2		magdown 2		magup 2	
13164042 4				2018 4			
magdown 2		magup 2		90000000 4		magdown 2	
magup 2		magup 2		magdown 2		magup 2	

Full data  
provenance with  
datasets tagged  
by analysis



apd python packages allows  
for easy data file retrieval.  
Snakemake integrations!

```
1 from apd import AnalysisData
2
3 datasets = AnalysisData("b2oc", "bs2dsp_i_run3")
4 bs2dsp_i_2024data_magdown_24c2_pfn = datasets(polarity="magdown", eventtype="94000000", datatype="2024")
```

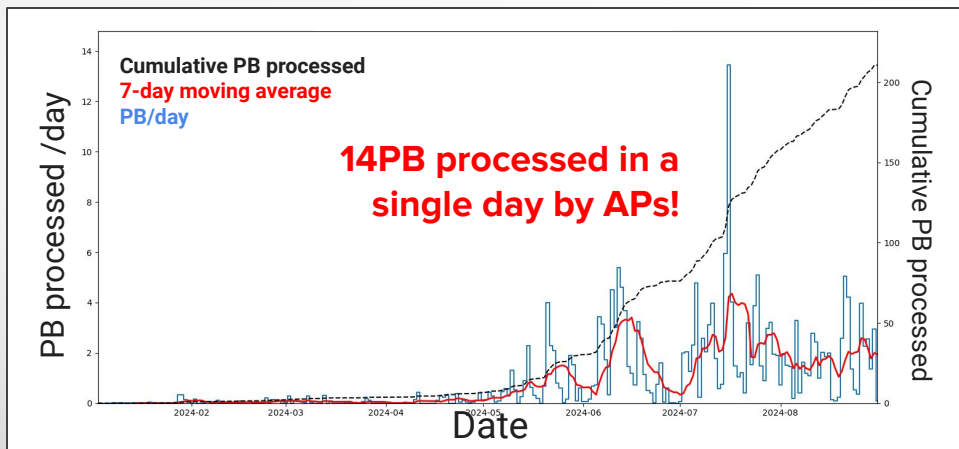
# Analysis productions - declarative ntupling

Full adoption of analysis productions at LHCb

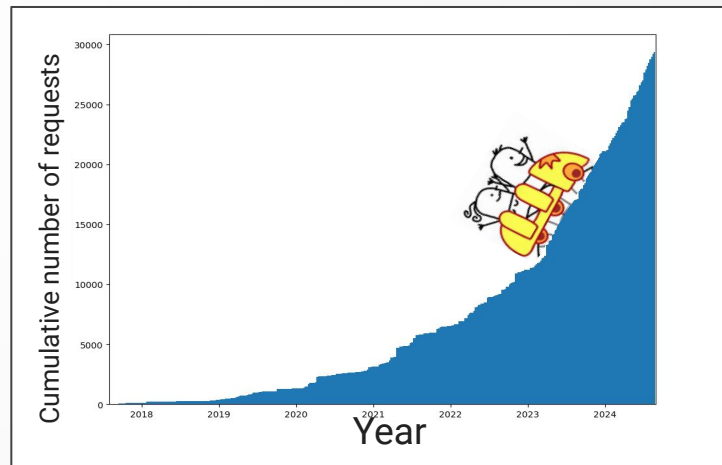
- Over 1200 Run 3 APs have been submitted so far
- 700+ “live” APs picking up data as it was Spruced
  - Analysts have been looking at data tuples days after it was recorded by detector
- We are making amazing use of the WLCG!

Analysis productions also facilitate MC productions

See [Emir's talk](#)



PB processed per day by APs with moving average



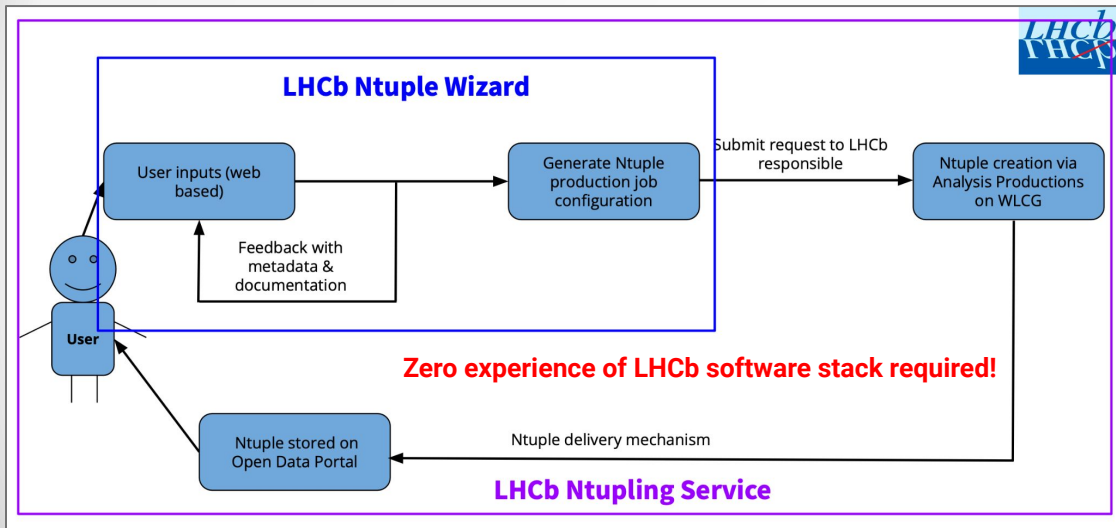
Cumulative APs submitted since invention

# Analysis productions and open data



LHCb released its full Run 1 dataset ~ 800TB

- Need scalable solution going forward - **NTuple Wizard!**



Typical non-LHCb analyst



# Helping LHCb members new and old

lhc-starterkit@cern.ch.' A 'Prerequisites' section is highlighted in light blue, containing the text: 'Before starting, you should be familiar with using a shell, like `bash`, and with programming in Python. The [analysis essentials course](#) has an introduction to these topics, as does the [Software Carpentry workshop](#), which includes many other useful computing tools.' At the bottom left of the page is a 'STARTERKIT LHCb' logo with 'Est. 2015' below it."/>

LHCb Run 3 Starterkit

Welcome to the Run 3 LHCb Starterkit!

If you have any problems or questions, you can [send an email to lhc-starterkit@cern.ch](mailto:lhc-starterkit@cern.ch).

**Prerequisites**

Before starting, you should be familiar with using a shell, like `bash`, and with programming in Python.

The [analysis essentials course](#) has an introduction to these topics, as does the [Software Carpentry workshop](#), which includes many other useful computing tools.



Not code documentation but a teaching resource following best pedagogical practices

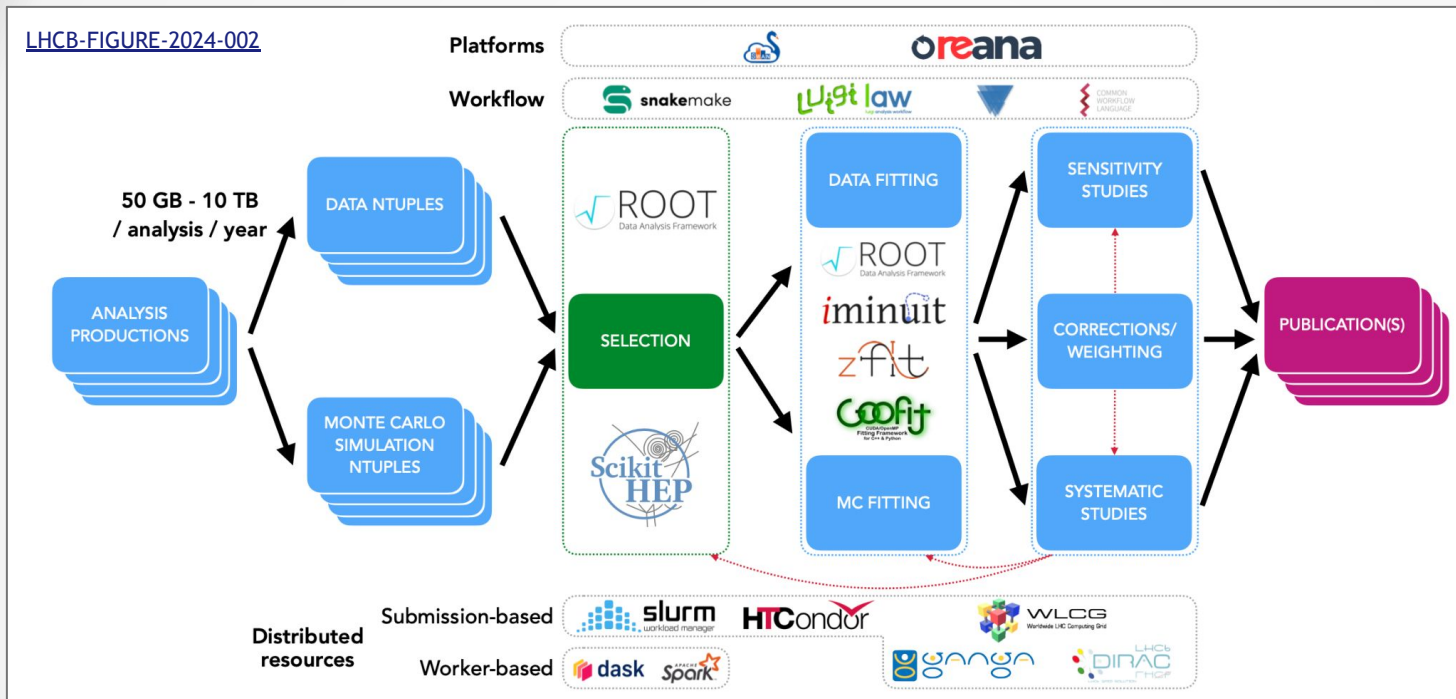
[Cross experiment paper on training initiatives in HEP](#)  
(submitted to Frontiers)

# Summary

- LHCb Run 3 necessitated an overhaul of the offline dataflow
  - Sprucing provides a method for keeping high event persistency on tape for future exploitation but also manageable disk requirements
  - Analysis productions for ntuple creation are one of the single-most transformative changes at LHCb saving countless person-hours
- Analysis productions also allow LHCb data to be “open” via the NTuple Wizard
- With such a change in the dataflow LHCb is creating the Run 3 StarterKit for onboarding and continuous reference material



# What then?



and tool  
has  
snakemake  
integrations

