

# Analysis Productions: A declarative approach to ntupling

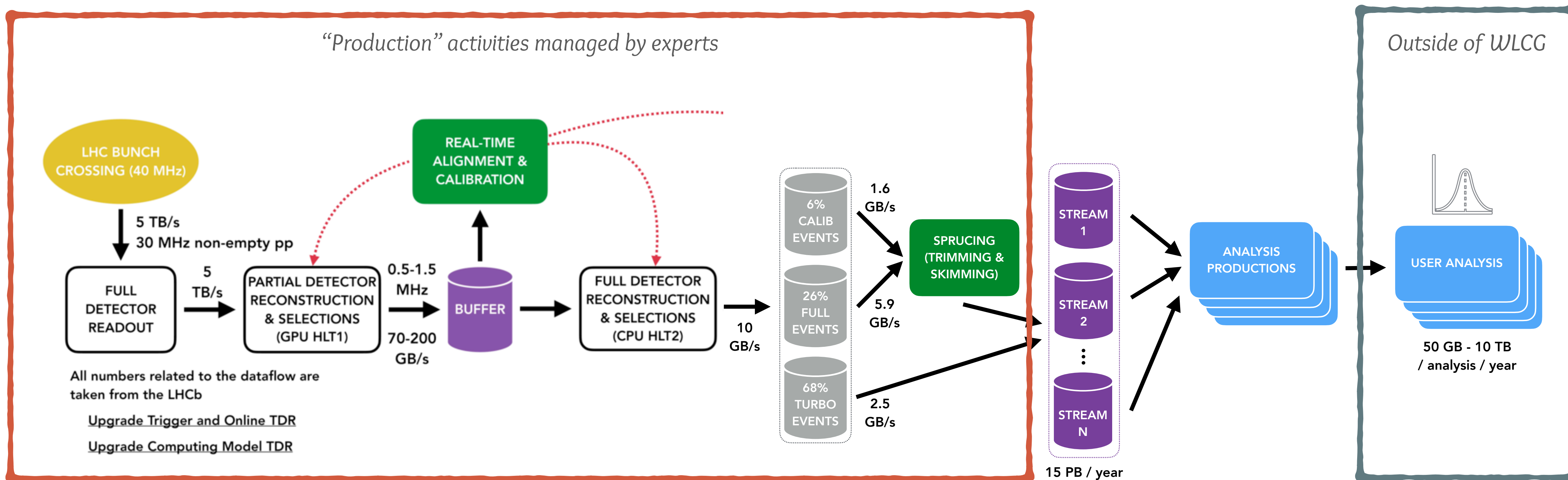


Chris Burr on behalf of the LHCb collaboration

9th May 2023



- Everything before “user analysis” is **embarrassingly parallel**
- Almost all LHCb analyses start by making ROOT TTrees using the LHCb physics applications
  - Filter large datasets down to something manageable with local resources
  - Later analysis is done outside of the LHCb software (ROOT/pandas/numpy/...)
- Historically analysts were responsible for running  $O(10,000)$  grid jobs to produce ROOT files





- It's really time consuming
  - Everyone doing analysis needs to learn how the grid works and how to handle transient errors
- There is a provenance gap between “production” and “user analysis”
  - Documenting how data is produced is left to analysts
  - Lack of visibility and data reuse
    - Emails and copying data to public locations to avoid reprocessing
- Instability
  - Did you test that before submitting?

**Fundamentally\* the activity is the same as “production” activities**



# What does it mean to produce files?

1. Pass some configuration to an application that converts input file -> output file
2. Run that application on all the files that contain physically-similar data (or simulation)
3. Repeat for all the different types of input you're interested (ranges from  $O(1)$  →  $O(1000)^*$ )

```
1  MySample:
2    wg: WG
3    inform:
4      - someone@cern.ch
5
6    application: DaVinci/v45r4
7    options:
8      - make_ntuple.py
9    output: DVNtuple.root
10
11   input:
12     bk_query: /some/bookkeeping/path/
```

1. What to do

## 2. What input data

Also support chaining productions, e.g.

Run HLT1 then  
use as input for HLT2 then  
as input for ntupling

\* 2 magnet polarities × 6 years × (data + simulation) = 24 productions for a simple† analysis

† Common to have many final states and many simulation samples per final state



```

1 defaults:
2   application: DaVinci/v45r4
3   wg: WG
4   automatically_configure: yes
5   turbo: no
6   inform:
7   | - someone@cern.ch
8   options:
9   | - make_ntuple.py
10  output: DVNtuple.root
11
12  {%- set datasets = [
13    (11, 3500, '14', '21r1'),
14    (12, 4000, '14', '21'),
15    (15, 6500, '15a', '24r2'),
16    (16, 6500, '16', '28r2'),
17    (17, 6500, '17', '29r2'),
18    (18, 6500, '18', '34'),
19  ]%}
20
21  {%- for year, energy, reco, strip in datasets %}
22  |   {%- for polarity in ['MagDown', 'MagUp'] %}
23
24  My_20{{year}}_{{polarity}}_job:
25    input:
26    |   bk_query: /LHCb/Collision{{year}}/Beam{{energy}}GeV-VeloClosed-{{polarity}}/Real Data/Reco{{reco}}/St
27
28    {%- endfor %}
29  {%- endfor %}

```

Use Jinja templating  
to “render” the YAML



# Fundamentally\* the activity is the same as “production” activities

*\* There are more different configurations used by analysts*

*\* User jobs have much higher failure rates*

- LHCb grid operations consists of very few people
  - Can't have buggy user productions causing chaos
- Use CI/CD to submit productions? Similar but some differences
  - Most CI systems run the same pipeline repeatedly
  - Spikey compute requirements, often need to test  $O(1000)$  different productions
  - Not really pass/fail, often want to closely examine the output of the test to see if it's “reasonable”



- Generally: If one file works, 99%+ of files will
- Submit each test as a separate grid job
  - Can easily handle the spiky demand
  - Output streamed to a web application for quick feedback
- Each test is displayed on a dedicated page
  - View logs
  - Monitor resource usage with prmon
  - Download output data
  - Browse output data with JSROOT
  - Can include post-validation of output data “checks”

Checks

State	Check	Trees	Messages
PASS	turbo_MagUp_2022data_Tuple / B_mass	BsToVG/DecayTree	Histogram of B_M successfully filled from TTree BsToVG/DecayTree (contains 30.0 events)
		BdToVG/DecayTree	Histogram of B_M successfully filled from TTree BdToVG/DecayTree (contains 37.0 events)
		BdToHHG/DecayTree	Histogram of B_M successfully filled from TTree BdToHHG/DecayTree (contains 7.0 events)
		BsToHHG/DecayTree	Histogram of B_M successfully filled from TTree BsToHHG/DecayTree (contains 7.0 events)

LHCb Analysis Productions

Log out Chris Burr

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2018\_Bs2PhiPhi\_MagUp

#5485796

Pipelines / #5485796 / Bd2PhiPhi / 2018\_Bs2PhiPhi\_MagUp

WG	Application	Data Type	Input Type	CondDB tag	DDDB tag	Desired Priority	Output Kept
BnrcC	DaVinci/v44r6	2018	DST	(set elsewhere)	(set elsewhere)	1b	✓

Inputs / Outputs

	Path	Size (this job)	Size (entire sample)
Input	/lhcb/LHCb/Collision18/BHADRONCOMPLETEEVENT.DST/00077054/0001/00077054_00013511_1.bhadroncompleteevent.dst	3.93 GB	75.74 TB
Output	00012345_00006789_1.tuple.root	7.44 MB	~ 143.3 GB

42983 events were processed in 00:16:37 on a — x machine.

Resource Consumption

	Maximum	Average	Largest increase [per 30s]
Resident Set Size	1.64 GB	1.51 GB	544.82 MB at 2 min
Proportional Set Size	1.63 GB	1.5 GB	544.78 MB at 2 min
Swap	—	—	— at 0 min

Browse output

show hidden output

DaVinci\_00012345\_00006789\_1.log

ROOT Browser

1169

2023-04-26 17:43:57 UTC TimingAuditor.T...

INFO \*

Tag\_StdLambdaC2PKP1

0.163

0.151

0.659

1.4

1170

2023-04-26 17:43:57 UTC TimingAuditor.T...

INFO \*

Tag\_CharmProtonList

0.081

0.097

0.433

0.3

1171

2023-04-26 17:43:57 UTC TimingAuditor.T...

INFO \*

StdAllNoPIDvsProtons

0.163

0.102

0.627

0.4

1172

2023-04-26 17:43:57 UTC TimingAuditor.T...

INFO \*

createBothVeloClusters

3.396

3.278

0.784

7.5

1173

2023-04-26 17:43:57 UTC TimingAuditor.T...

INFO \*

createTICClusters

0.362

0.313

0.659

18.8

1174

2023-04-26 17:43:57 UTC TimingAuditor.T...

INFO \*

createITClusters

0.069

0.090

0.437

0.9

1175

2023-04-26 17:43:57 UTC TimingAuditor.T...

INFO

1176

2023-04-26 17:43:57 UTC ToolSvc.TrackSt...

SUCCESS

Number of counters : 2

1177

| Counter

| #

| sum

| mean/err~

| rms/err~

| min

| max

1178

| "Number of states added"

| 1184

| 84594

| 76.625

| 46.462

| 1.0000

| 200.00

1179

| "Number of tracks seen"

| 42984

| 136800

| 3.1826

| 29.901

| 0.0000

| 239.00

1180

2023-04-26 17:43:57 UTC ToolSvc.properTimeS...

SUCCESS

Number of counters : 1

1181

| Counter

| #

| sum

| mean/err~

| rms/err~

| min

| max

1182

| "Negative Mass covariance"

| 444

| 1.0000

| 0.0000

| 1.0000

| 1.0000

| 1.0000

1183

2023-04-26 17:43:57 UTC ToolSvc.LoKi:D...

SUCCESS

Exceptions/Errors/Warnings/Infos Statistics : 0/0/6/0

1184

2023-04-26 17:43:57 UTC ToolSvc.LoKi:D...

SUCCESS

#WARNINGS = 430

Message = 'There is no convergency-III [Tag\_StdD02KP1P10]'

1185

2023-04-26 17:43:57 UTC ToolSvc.LoKi:D...

SUCCESS

#WARNINGS = 208

Message = 'There is no convergency-III [Tag\_StdD02KP1P11]'

1186

2023-04-26 17:43:57 UTC ToolSvc.LoKi:D...

SUCCESS

#WARNINGS = 1

Message = 'There is no convergency-III [Tag\_StdD02KP1]'

1187

2023-04-26 17:43:57 UTC ToolSvc.LoKi:D...

SUCCESS

#WARNINGS = 70

Message = 'There is no convergency-III [Tag\_StdDp2KP1P1]'

1188

2023-04-26 17:43:57 UTC ToolSvc.LoKi:D...

SUCCESS

#WARNINGS = 67

Message = 'There is no convergency-III [Tag\_StdLambdaC2PKP1]'

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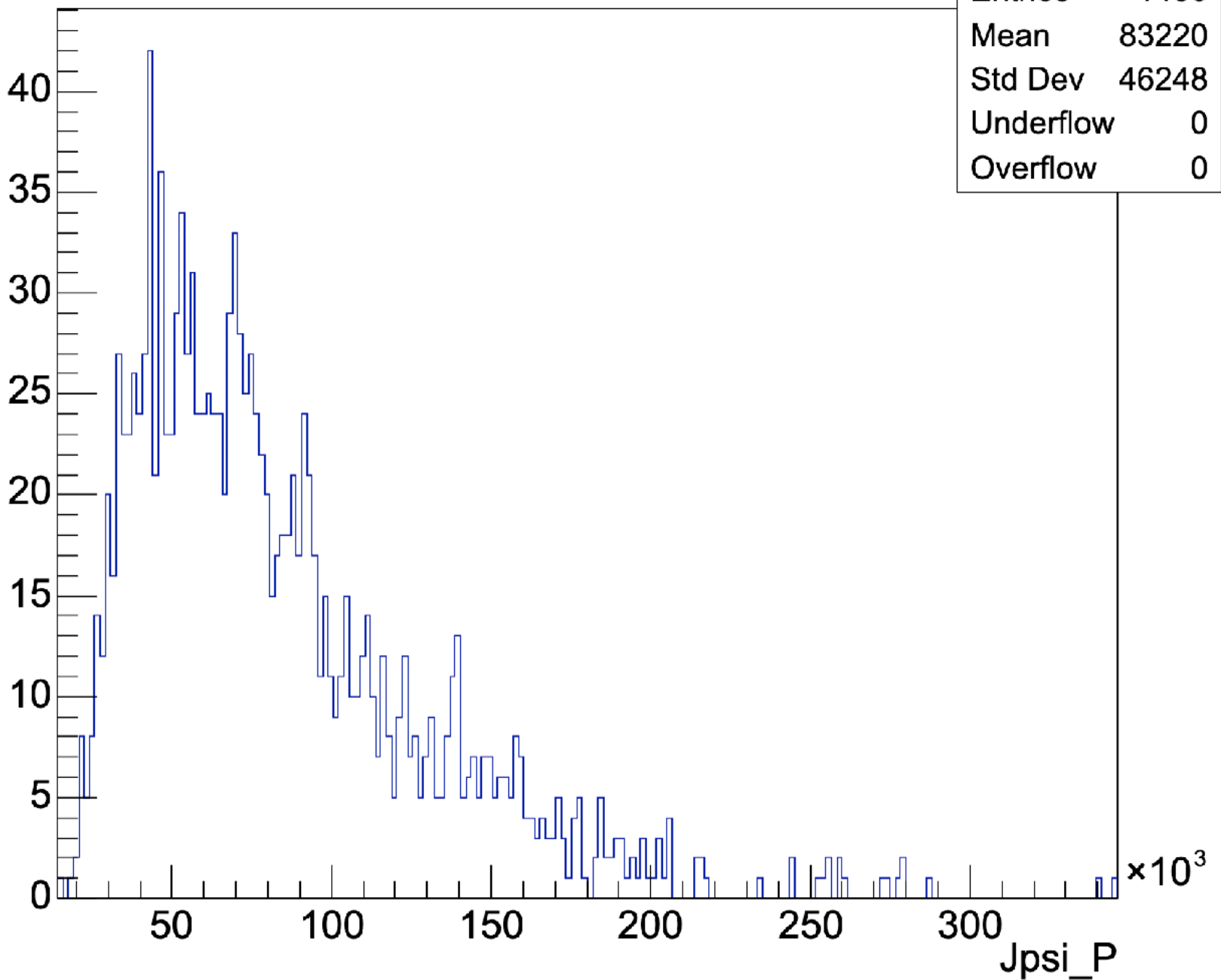


DaVinci\_00012345\_00006789\_1.log ROOT Browser

Read a ROOT file

- JSROOT version 7.2.0 11/08/2022
- Bp\_Hlt1\_Hlt1TrackMuonMVA
- Bp\_Hlt1\_Hlt1TwoTrackMVAD
- Bp\_Hlt1\_Hlt1TwoTrackMVAD
- Jpsi\_ID
- Jpsi\_KEY
- Jpsi\_PT
- Jpsi\_SUM\_PT
- Jpsi\_MIN\_PT
- Jpsi\_MAX\_PT
- Jpsi\_PX
- Jpsi\_PY
- Jpsi\_PZ
- Jpsi\_E
- Jpsi\_P
- Jpsi\_SUM\_P
- Jpsi\_MIN\_P
- Jpsi\_MAX\_P
- Jpsi\_M
- Jpsi\_FOURMOMENTUME
- Jpsi\_FOURMOMENTUMX
- Jpsi\_FOURMOMENTUMY
- Jpsi\_FOURMOMENTUMZ
- Jpsi\_BPVDIRA
- Jpsi\_BPVFD
- Jpsi\_BPVFDCHI2
- Jpsi\_BPVIPCHI2
- Jpsi\_MINIPCHI2
- Jpsi\_MINIP
- Jpsi\_DOCA
- Jpsi\_DOCACHI2
- Jpsi\_CHI2
- Jpsi\_CHI2VXNDOF
- Jpsi\_BPVVDRHO
- Jpsi\_BPVLTIME
- Jpsi\_ETA
- Jpsi\_PHI
- Jpsi\_PVX
- Jpsi\_PVY
- Jpsi\_PVZ

drawing branch 'Jpsi\_P' from DecayTree



JSROOT based browser

Checks

State	Check	Trees	Messages
PASS	turbo_MagUp_2022data_Tuple / B_mass	BsToVG/DecayTree	Histogram of B_M successfully filled from TTree BsToVG/DecayTree
		BdToVG/DecayTree	Histogram of B_M successfully filled from TTree BdToVG/DecayTree
		BdToHHG/DecayTree	Histogram of B_M successfully filled from TTree BdToHHG/DecayTree
		BsToHHG/DecayTree	Histogram of B_M successfully filled from TTree BsToHHG/DecayTree

les will

b

2

3

4

5

6

7

LHCb Analysis Productions

Log out Chris Burr

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2018\_Bs2PhiPhi\_MagUp

#5485796

Pipelines / #5485796 / Bd2PhiPhi / 2018\_Bs2PhiPhi\_MagUp

WG	Application	Data Type	Input Type	CondDB tag	DDDB tag	Desired Priority	Output Kept
WG	DaVinci/v44r6	2018	DST	(set elsewhere)	(set elsewhere)	1b	✓

Inputs / Outputs

	Size (this job)	Size (entire sample)
	3.93 GB	75.74 TB
	7.44 MB	~ 143.3 GB

Log highlighting, search and filtering

Browse output

show less output

DIRAC.log

DaVinci\_00012345\_00006789\_1.log

bookkeeping\_00012345\_00006789\_1.xml

jobDescription.xml

pool\_xml\_catalog.xml

prmon.json

prmon.txt

prodConf\_DaVinci\_00012345\_00006789\_1.json

summaryDaVinci\_00012345\_00006789\_1.xml

ROOT Browser

Counter

16 matches

303 HDRFilter\_BuToJpsiKplus\_Detached

INFO Number of counters : 1

304 | Counter

| #

| sum

| mean/eff\*

| rms/err\*

| min

| max

|

306 ParticleUnpacker

INFO Number of counters : 2

307 | Counter

| #

| sum

| mean/eff\*

| rms/err\*

| min

| max

|

310 RawBankSizeFilter

INFO Number of counters : 2

311 | Counter

| #

| sum

| mean/eff\*

| rms/err\*

| min

| max

|

314 RecSummaryUnpacker

INFO Number of counters : 1

315 | Counter

| #

| sum

| mean/eff\*

| rms/err\*

| min

| max

|

317 RecVertexUnpacker

INFO Number of counters : 1

318 | Counter

| #

| sum

| mean/eff\*

| rms/err\*

| min

| max

|

320 ToolSvc.HltFactory

INFO Number of counters : 1

321 | Counter

| #

| sum

| mean/eff\*

| rms/err\*

| min

| max

|

323 Tuple

INFO Number of counters : 12

324 | Counter

| #

| sum

| mean/eff\*

| rms/err\*

| min

| max

|

384 XMLSummarySvc

INFO filling counters...

385 XMLSummarySvc

INFO counters filled OK

2023-04-26 17:43:57 UTC ToolSvc.LoKi::D... SUCCESS WARNINGS = 78 Message = 'There is no convergency-111 [Tag\_StdB2XP1P1]'

2023-04-26 17:43:57 UTC ToolSvc.LoKi::D... SUCCESS WARNINGS = 81 Message = 'There is no convergency-111 [Tag\_StdB2XP1P1]'

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- Not practical to verify hundred of tests
- Summarise key statistics
  - Peak memory usage
  - Output data size
  - Warning/Error messages

“I often use the CI instead of local tests  
because it's so much easier to read”

- Associated CLI tooling
  - Run tests locally before committing
  - Interactively reproduce a CI test

The screenshot displays the LHCb Analysis Productions web interface. The top navigation bar includes 'Home', 'Productions', 'Pipelines', 'Settings', and 'Documentation'. The main content area shows the 'Lb2LII' pipeline details for run #5469954. A green status bar indicates 'Looks good! 720 jobs completed successfully.' Below this, two tables provide summary statistics. The 'Test summary statistics' table shows 405,678 events processed, 146.62 GB of input data, 11.47 GB of output data, and a 4.09 GB memory footprint. The 'Full production statistics' table shows 63.01 TB of input data and an estimated 4.97 TB of output data. A note states that statistics are aggregated over successful jobs only. A 'Jobs (showing 12 of 720)' section includes a filter for 'lb2lmm\_tuple' and a '25 per page' dropdown. A table lists 12 jobs with columns for Job Name, Events Processed, Output Size, Runtime, Memory, Log messages (Warn, Error, Fatal), Estimated output (Total Size, Kept), and a status checkmark. The bottom section, 'Configuration', shows a 'Rendered YAML' snippet with settings for application, output, wg, and inform.

Test summary statistics				Full production statistics		
	Events Processed	Input Data	Output Data	Memory Footprint	Input Data	Output Data (estimate)
Total	405678	146.62 GB	11.47 GB	4.09 GB	63.01 TB	~ 4.97 TB

Job Name	Test job statistics				Log messages			Estimated output	
	Events Processed	Output Size	Runtime	Memory	Warn	Error	Fatal	Total Size	Kept
MC_2018_MagUp_Lb2Lmm_tuple	697	25.21 MB	00:13:29	2.2 GB	182	—	—	20.79 GB	✓
MC_2018_MagDown_Lb2Lmm_tuple	666	24.05 MB	00:08:02	2.18 GB	179	—	—	19.77 GB	✓
MC_2017_MagUp_Lb2Lmm_tuple	650	23.49 MB	00:10:45	2.27 GB	154	—	—	15.59 GB	✓
MC_2017_MagDown_Lb2Lmm_tuple	689	25.87 MB	00:08:02	2.28 GB	223	—	—	18.2 GB	✓
MC_2016_MagUp_Lb2Lmm_tuple	709	26.24 MB	00:12:05	2.25 GB	158	—	—	15.88 GB	✓
MC_2016_MagDown_Lb2Lmm_tuple	697	25.26 MB	00:09:05	2.12 GB	157	—	—	16.97 GB	✓
MC_2015_MagUp_Lb2Lmm_tuple	666	24.94 MB	00:14:52	2.22 GB	145	10	—	3.05 GB	✓
MC_2015_MagDown_Lb2Lmm_tuple	602	22.62 MB	00:10:27	2.31 GB	264	10	—	2.77 GB	✓
MC_2012_MagUp_Lb2Lmm_tuple	699	26.44 MB	00:14:35	2.36 GB	134	—	—	10.41 GB	✓
MC_2012_MagDown_Lb2Lmm_tuple	722	27.49 MB	00:20:13	2.45 GB	238	—	—	10.87 GB	✓
MC_2011_MagUp_Lb2Lmm_tuple	759	26.83 MB	00:08:47	2.06 GB	217	—	—	4.5 GB	✓
MC_2011_MagDown_Lb2Lmm_tuple	805	28.07 MB	00:10:14	2.43 GB	231	—	—	4.72 GB	✓

```
1 defaults:
2   application: DaVinci/v46r4
3   output: RD_LBTOL0LL_DVNTUPLE.ROOT
4   wg: RD
5   automatically_configure: yes
6   inform:
```



- Once the tests are passing, use a standard git merge request flow
  - Each “working group” has liasons responsible for reviewing/merging
  - Review is only for technical issues or identifying duplication
- Once merged a second CI pipeline starts:
  - The repository is tagged automatically
  - Dependencies are deployed to CVMFS
  - Productions are submitted
  - Open a ticket for tracking any processing problems that might arise
- The repository is automatically cleaned after each submission
  - No value keeping fails in the main branch - potentially misleading
  - Have tools for checking out past versions of productions for making revisions
- If no files are unprocessable, the process is fully automated



- Group data sets into an “analysis”
  - Automatically created when productions are submitted
  - Namespace split by area of the physics program
  - Each analysis is owned by a group of people
- Pre-existing samples can also be added

Adding new samples to DPA/test-analysis2

The analysis already contains 5 samples.

config:lhcb

datatype:2022

polarity

eventtype

version

wg:charm

analysis

109387data22\_veloclosedmagdown\_alignv9\_tuple v0r0p5326402

109232data22\_veloopen\_magup\_hlt1kslinescommissioning\_tuple v0r0p5324209

109231data22\_veloopen\_magdown\_hlt1kslinescommissioning\_tuple v0r0p5324209

109230data22\_veloclosed\_magup\_hlt1kslinescommissioning\_tuple v0r0p5324209

108296data22\_veloclosedmagup\_allchannels\_align16feb23\_tuple v0r0p5241973

108295data22\_veloopenmagdown\_allchannels\_align16feb23\_tuple v0r0p5241973

108294data22\_veloclosedmagdown\_allchannels\_align16feb23\_tuple v0r0p5241973

Showing 104 of the 12313 requests available.

Clear selection

Add 4 samples

## test-analysis2

DPA

[Productions](#) / [DPA](#) / test-analysis2

### Ownership

This analysis is currently owned by:

### 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.

Grouped tags ☒ config ☒ datatype ☒ eventtype ☒ mytag ☒ polarity

Drag to sort ☐ mytag ☐ config ☐ datatype ☐ eventtype ☐ polarity

test-analysis2 5			
value3 3	othervalue 2		
mc 3	mc 2		
2018 1	2012 1	2012 2	
15124102	12265044	12265042	12265028
1	1	1	1
2016 1			
15124102			
1			

### Sample display

5 datasets (5 shown).

[Add samples](#)

[Select...](#)

State	Name	Created	Updated	Production ID	Sample ID	Deployment Version
READY	mc_2018_magdown_lb2lee_tuple value3	16 hours ago	13 hours ago	112481	14116	v0r0p5469954
READY	mc_2016_magdown_lb2lee_tuple value3	12 hours ago	13 hours ago	112485	14117	v0r0p5469954
READY	2012_12265044_magdown	12 hours ago	1 year ago	97072	14119	v0r0p3675801
READY	2012_12265042_magdown	12 hours ago	1 year ago	97076	14121	v0r0p3675801
READY	2012_12265028_magdown	12 hours ago	1 year ago	97080	14122	v0r0p3675801

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- We provide a tool named **apd** (analysis productions data)
- Look up data based on “meaningful tags” (year/magnet polarity/detector state/decay products)
- Provides provenance between the grid and local worlds
  - Simple interface which can provide local caching, authentication, long-term reproducibility
  - Well suited to analysis facilities
- All metadata is versioned with time to it's possible to see the past state
- See “Facilitating the preservation of LHCb analyses” in Track 8



- Review from liaisons is an opportunity for knowledge transfer
- Source of reference configurations
- Opportunities for static analysis
  - Both before and after data is processed



## An Ntuple production service for accessing LHCb Open Data: the Ntuple Wizard

9th May 2023, 15:00

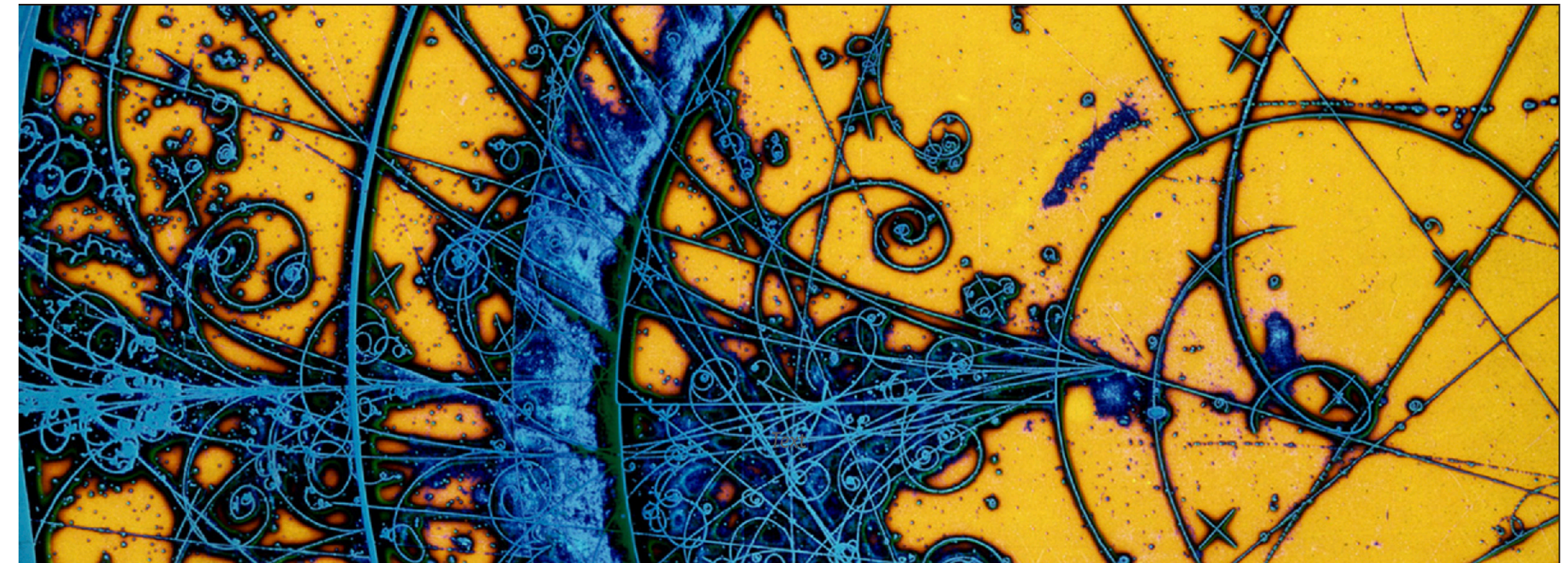


### An Ntuple production service for accessing LHCb Open Data: the Ntuple Wizard

Dillon S. Fitzgerald on behalf of the LHCb collaboration

[arXiv:2302.14235](https://arxiv.org/abs/2302.14235) [hep-ex]

May 9, 2023



### LbMCSUBmit: A new flexible and scalable request submission system for LHCb simulation

Chris Burr on behalf of the LHCb Computing and Simulation projects  
9th May 2023



Image: CERN-EX-66954B © 1998-2018 CERN

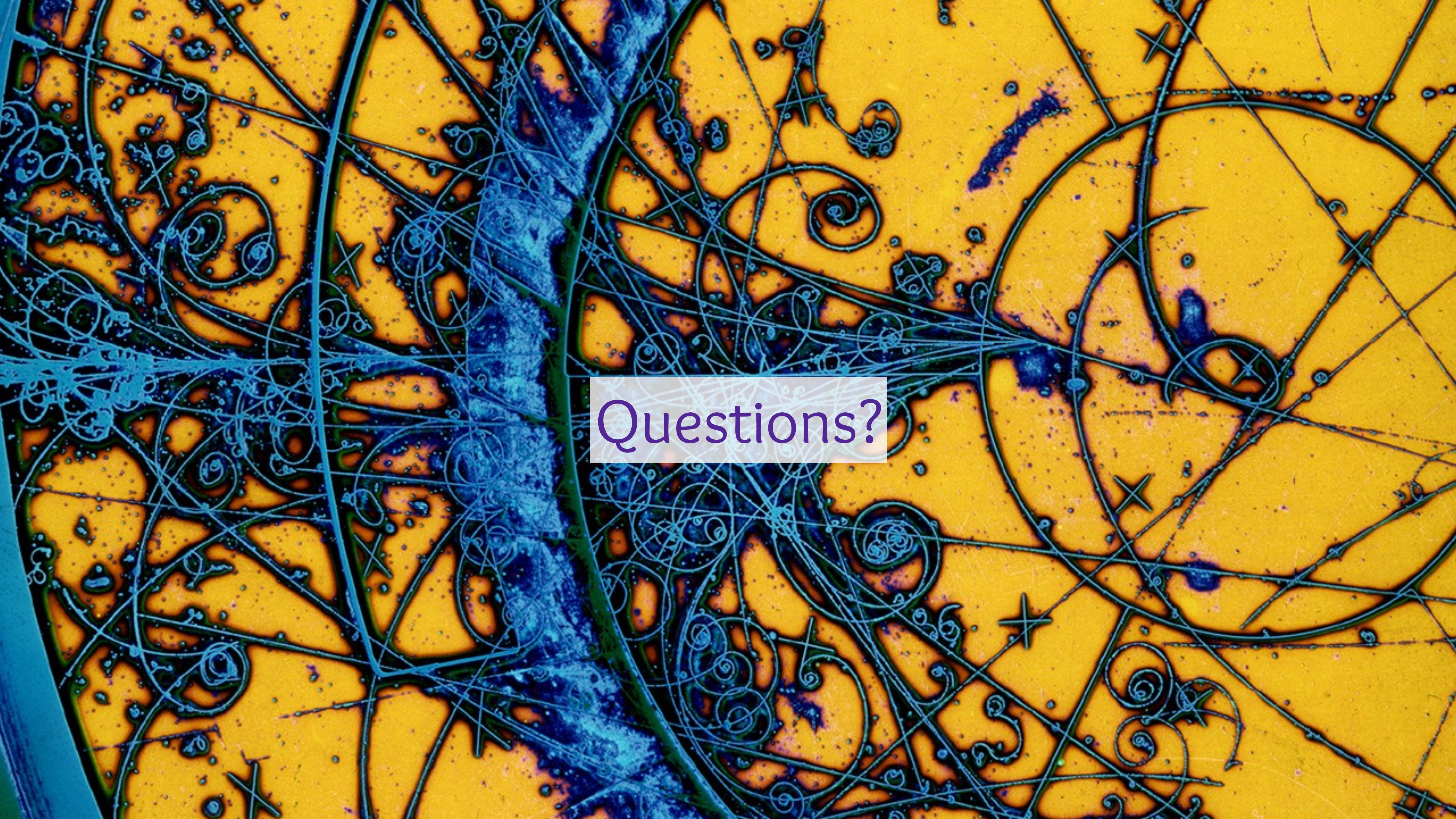
## LbMCSUBmit: A new flexible and scalable request submission system for LHCb simulation

9 May 2023, 17:15



- A new system for processing LHCb data has evolved over the last 5 years
- Has been used for running over 12,000 productions
  - For running over real and simulated data from LHC Run 1, 2 and 3
- Bridges the gap between grid and “user” worlds
  - Well suited to adapt to future changes (analysis facilities/protocols/authentication/...)





Questions?