Simulation and MC request in LHCb

LHCb Starterkit 2024

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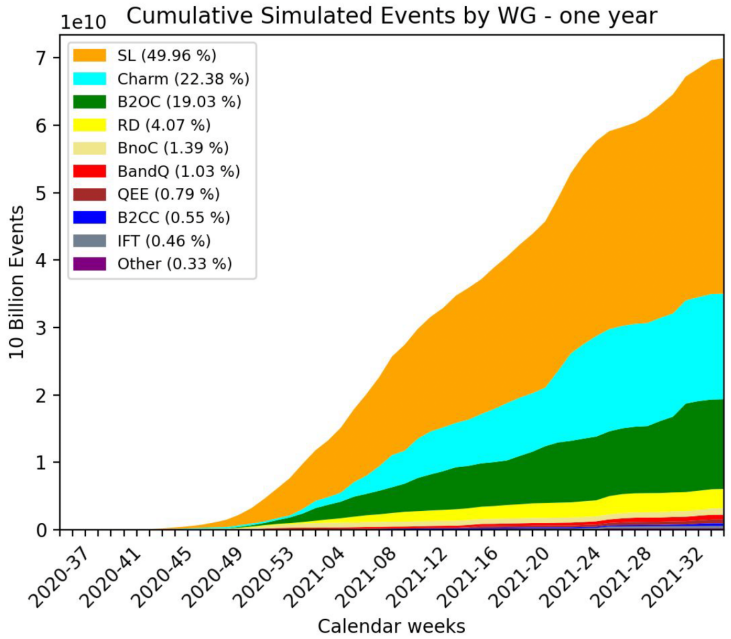
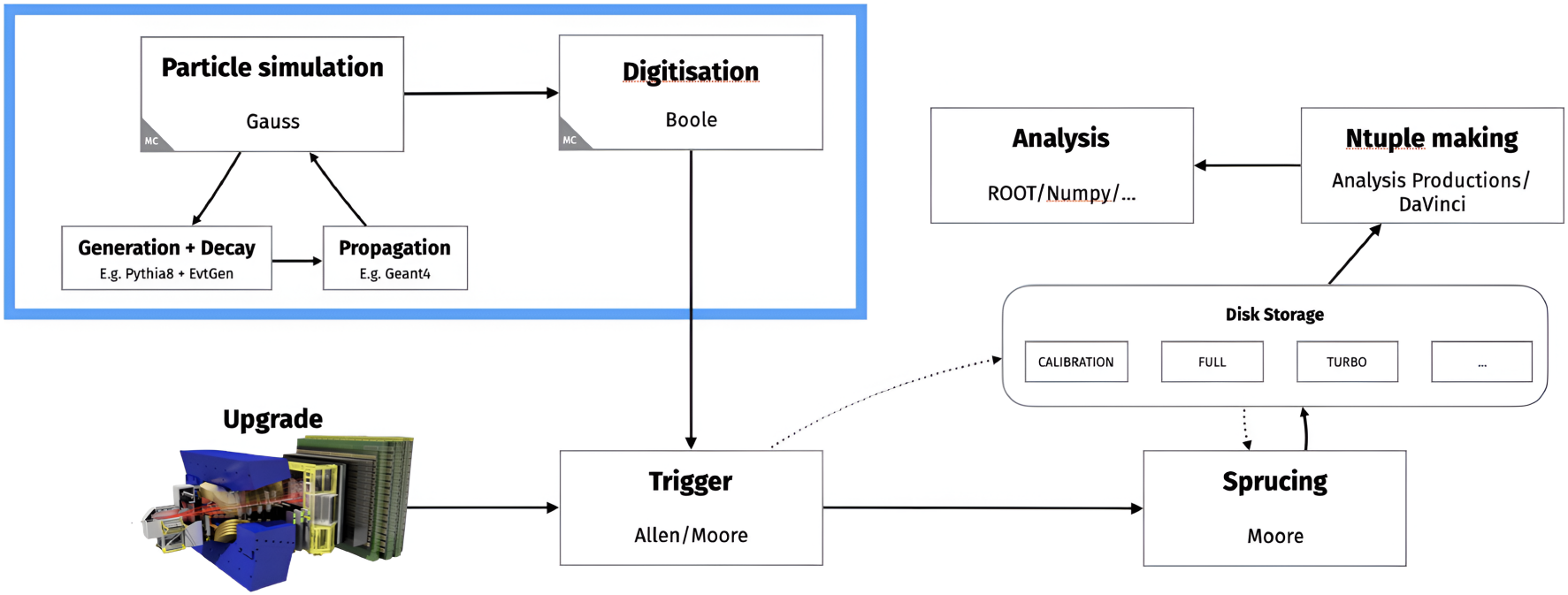
Introduction

- **Simulation** is an imitative representation of a process or system that could exist in the real world.
- It plays a key role in LHCb analysis:
  - Helps to parametrize an hypothetical signal.
  - Capture the response of the detector to this concrete signal.
- Remember: You are never alone!

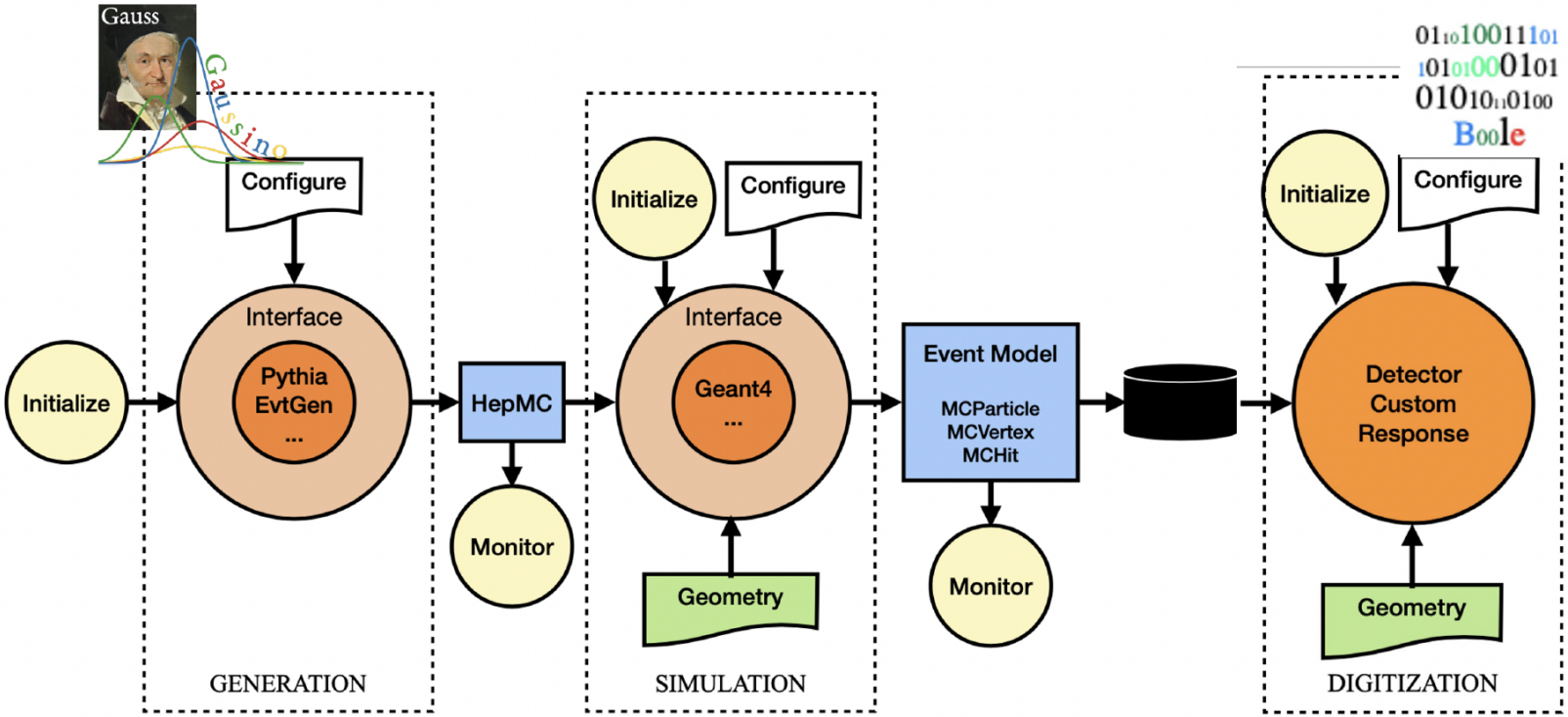


LHCb data-flow in Run3

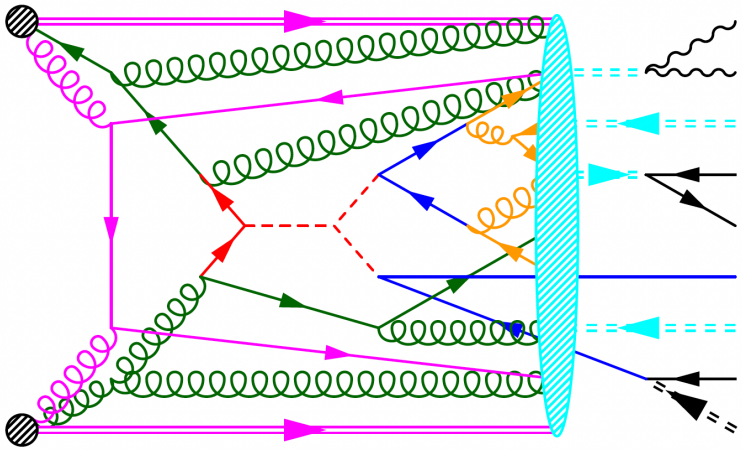


- Simulation is by far the most time-consuming step: tries to represent reality as much as possible.
- Gauss App. is the general manager of this stage.

Simulation Blocks



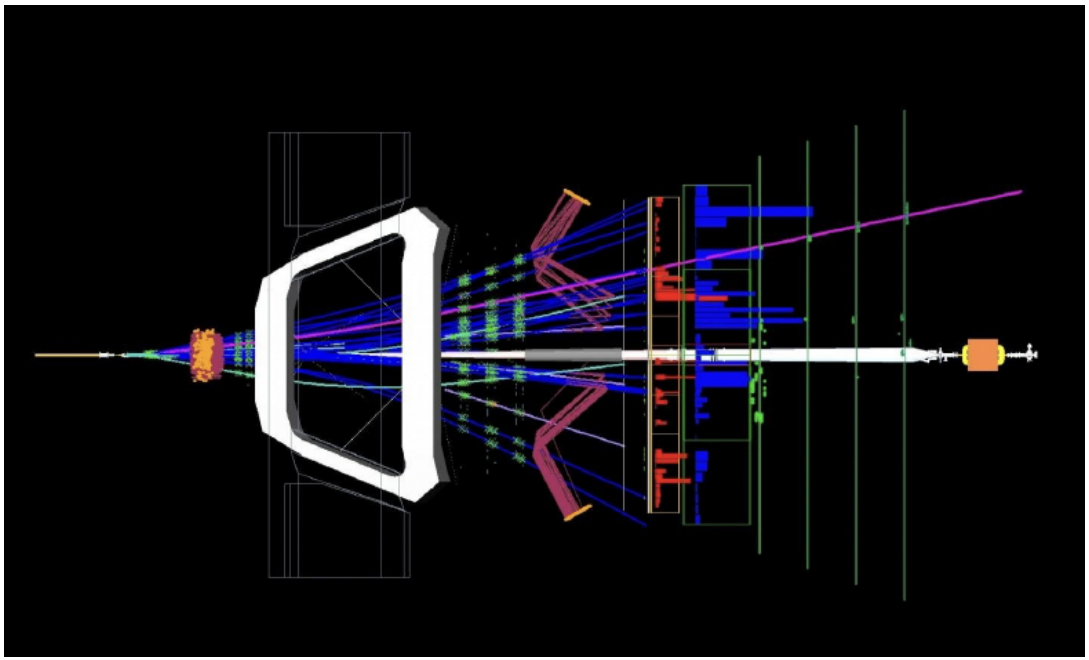
Generation



- A pp interaction is created, and the products are hadronized.
- Realistic approach: Hard QCD proccesses are combined with underlying event properties.
- Lots of generators: Pythia, Sherpa, MadGraph...

- EvtGen is responsible of creating a desired decay.
- It is controlled by DecFiles.
- Possibility of including cuts before the full detector simulation $\rightarrow$ saves time!

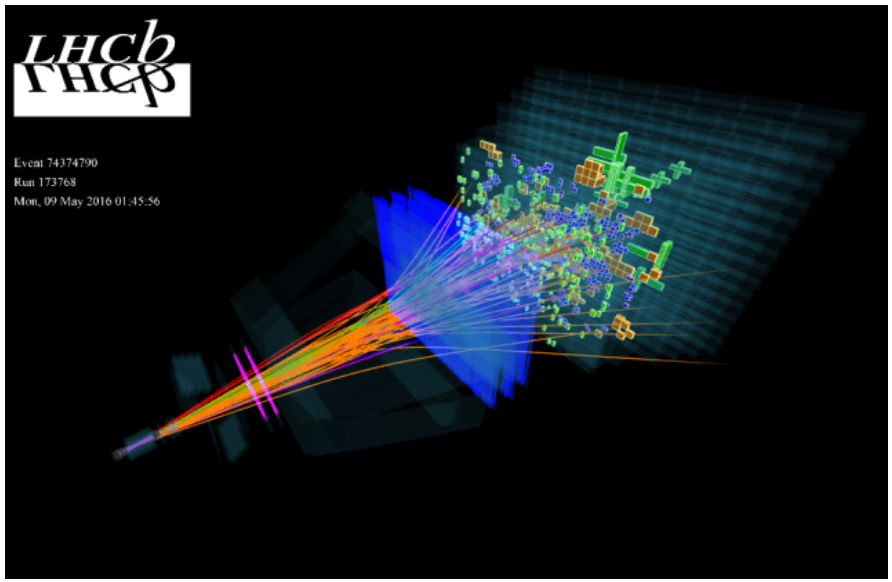
Detector Simulation



- Final products are propagated through the detector: Geant4.
- Don't worry! $\rightarrow$ a full geometry is already prepared!

Digitisation

- Digitisation is carried out by Boole.
- In LHCb we don't see particles, we see the electronic response (**hits**) of each subdetector.
- Signal trayectories and parameters (tracking) are built of the pre-stored hits.



MC Requests

- Luckily all the steps are run centrally:
  - Step-by-step checks.
  - Pre-processed volume definition.
  - Code made public.
- Each PAWG is responsible of submitting the mc provided analysis needs.
- A very active and nice group of people (Liaisons) always happy to help!

- **QEE:** Jiuzhao Li, Emilio X. Rodríguez.
- **B&Q:** Ning Qin, Gabriele Romolini.
- **Charm:** Francesco Terzuoli, Jianyu Zhang.
- **RD:** Thomas Long, Jan Peter Wagner.
- **BtoC:** Zhihong Shen.
- **B2noC:** Edoardo Mariani.
- **B2OC:** Aleksandrina Docheva, Tianwen Zhou.
- **Semileptonic:** Bogdan Kutsenko, Federico Manganella.
- **IFT:** Chenxi Gu, Qiuchan Lu, Federica Fabiano.
- **Flavour Tagging:** John Wendel.
- **EMTF:** Gregory Ciezarek.

Preparing a MC request: First questions to answer

- Are there avaliable samples matching our needs?
- Are there decfiles?
- What should I include in the decfile?
- Simulation version?
- Filtered request?
- Stripping?
- Year? Polarity? Number of events?

Decfile Preparation

```
# EventType: 12115088
#
# Descriptor: [B+ -> K+ mu+ mu- pi+ pi-]cc
#
# NickName: B+_K+mmpipi=DecProdCut
#
#
# Cuts: DaughtersInLHCb
#
# Documentation: Decay file for B+ -> mu+ mu- pi+ pi- K+
# EndDocumentation
#
# PhysicsWG: Exotica
# Tested: Yes
# Responsible: Emilio X. Rodriguez
# Email: emilio.xose.rodriguez.fernandez@cern.ch
# Date: 20240521
# CPUTime: <1min
#
Decay B+sig
1.000   K+  mu+  mu-  pi+  pi-  PHSP;
Enddecay
CDecay B-sig
#
End
#
```

- Eventtype: Unique 8-digit number identifier.
- Important: Comments are also passed to Gauss!
- We can always force a specific decay taking place in a reasonible way.
- Also important: Model to generate the decay.

Decfile Preparation

```
# InsertPythonCode:
# from Configurables import LoKi__FullGenEventCut
# Generation().addTool( LoKi__FullGenEventCut, "TightCuts" )
# tightCuts = Generation().TightCuts
# tightCuts.Code = "( count ( hasGoodB ) > 0 )"
#
# tightCuts.Preambulo += [
#       "from GaudiKernel.SystemOfUnits import GeV"
#     , "hasGoodMu         = GINTREE(( 'mu+' == GABSID ) & ( GPT > 0.95*GeV  ) & ( GP > 5.70*GeV ))"
#     , "hasGoodD0         = GINTREE(( 'D0'  == GABSID ) & ( GNINTREE(( 'K-' == GABSID ) & ( GPT > 0.23*GeV ) & ( GP > 1.9*GeV ), HepMC.descenda
#     , "hasGoodDst0       = GINTREE(( 'D*(2007)0' == GABSID ) & hasGoodD0 )"
#     , "hasGoodB          = ( GBEAUTY & GCHARM & hasGoodDst0 & hasGoodMu )"
#      ]
# EndInsertPythonCode
```

- Bussiness turn difficult when we want to include cuts at generator level.
- Useful to reduce computiational time.
- LHCb acceptance widely used: allows to see products within the geometric acceptance.

Simulation Types

- **Full Simulation:** Full detector simulation for each pp interaction proccess.
- **ReDecay:** Saves the underlying event N times, whereas it is producing a signal decay each time.
- **Particle Gun:** No pp collision, throws a single particle with desired kinematics.
- **Tracker only:** Turn of calo and muon systems.

Output File Types

The different simulation outputs can be summarized as follows:

- **SIM:** Only Gauss output.
- **DIGI:** Samples with Boole digitisation.
- **XDIGI:** Extended info from Gauss saved in a DIGI file.
- **(m)DST:** Output with Reconstruction information.
- **XDST:** Extended info from Gauss and Boole.
- **LDST:** Samples with reco and additional linker tables.
- **MDF:** Samples emulating real data taking samples.

Simulation Version

- Based on analysis requirements, different Sim types are available.
- New realeases include not only relevant processing configs, but also updated detector simulation.
- Rule-to(often)-Use: Choose the latest release.
- Types:
  - Sim09: Supports Run 1,2 until stripping. The most widely used during Run2. Will become deprecated soon.
  - Sim10: Until Stripping. New detector geometry definition. **Official** version for Run 2. Also oriented to Upgrade studies.
  - Sim11: Updated LHCb requirements after Upgrade 1 (geometry, luminosity conditions...).

Filtered MC

- Good solution for analysis looking for a balance between number of events being requested and computational time.
- Saves disk space by only writing events verifying a particular trigger/stripping decisions.
- Specific roadmap for Filtered MC Requests.

Last checks

- Check the number of events you need: both with supervisors and/or liaisons.
- Request only what you need: think that central productions can be delayed as user-traffic increases.
- Limits:
  - 4M events for DST files.
  - 20M per year for mDST.
  - Bigger requests would need PPG approval, which may delay the proccess.

The MC Request

```yaml
sim-version: 09
name: Multimuons puzzle
inform:
  - emrodrig
  - jiuzhao
  - jcidvida
  - hvc
  - tmombach
  - tlong
WG: QEE
file-format: DST

samples:
  - event-types:
      - 12115045
      - 12115066
      - 12115077
      - 12115058
      - 12115085
      - 12115099
      - 12115040
      - 12115052
      - 12115072
      - 12115074
      - 12115063
    data-types:
      - 2018
      - 2016
    num-events: 500k
    priority: 1b
```

- Request via Gitlab project.
- Very comprehensive arrangement of options.
- It automatically autocompletes: the rest of options are generated in line.
- Checks are run automatically with a pipeline. Once it is done, the request can be sent.

When a MC Request Fails

Draft: W wme

Closed **Emilio Xose Rodriguez Fernandez** requested to merge `WWme` into `main` 4 months ago

Overview 1 | Commits 5 | Pipelines 3 | Changes 2

👍 0 | 👎 0 | ☺

Pipeline #7688668 failed

Pipeline failed for `582238d3` on `WWme` 4 months ago

Requires 2 approvals from liasons and conveners.

Closed by Emilio Xose Rodriguez Fernandez 4 months ago — Reopen

Merge details

- The changes were not merged into **main**.

When a MC Request Suceeds

Multimuons new

Merged **Emilio Xose Rodriguez Fernandez** requested to merge `Multimuons_new` into `main` 5 months ago

Overview 11 | Commits 16 | Pipelines 10 | Changes 1

This MR represents the completion of the puzzle in mass/lifetime space for Multimuon final states through potential long-lived intermediators. Several particularities are the following ones:

1. Sim09 request -> analysis could profit from the simulation of a similar previous analysis (search for B24mu decays) that had very similar needs. The overlap is large (maybe 50%) in simulation samples
2. As this summer is being targeted as a potential deadline, we ask for priority 1b, since otherwise all the production could delay everything.
3. Total events requested: 37M

Edited 5 months ago by Emilio Xose Rodriguez Fernandez

👍 0 👎 0 ☺

Pipeline #7585056 passed

Pipeline passed for `1df0c6bd` on `Multimuons_new` 5 months ago

Approved by you and others

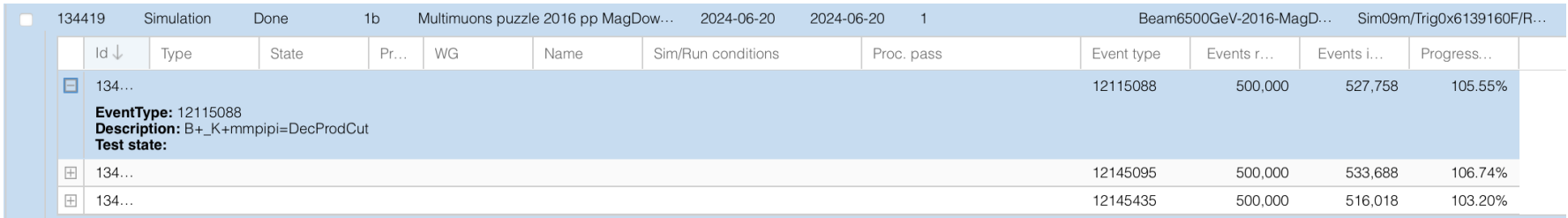
Merged by Emilio Xose Rodriguez Fernandez 5 months ago Cherry-pick

Merge details

- Changes merged into `main` with `0c09f6c9` (commits were squashed).
- Deleted the source branch.

Next Steps

- The status of the production can be checked in the Transformation Monitor: access through DIRAC portal.
- A bunch of (sometimes nasty) mails will inform in real time about the status.
- Once in the GRID the liaisons/conveners/user lost control of the production.



134419	Simulation	Done	1b	Multimuons puzzle 2016 pp MagDow…	2024-06-20	2024-06-20	1	Beam6500GeV-2016-MagD…	Sim09m/Trig0x6139160F/R…

Id ↓	Type	State	Pr…	WG	Name	Sim/Run conditions	Proc. pass	Event type	Events r…	Events i…	Progress…
134…								12115088	500,000	527,758	105.55%
134…								12145095	500,000	533,688	106.74%
134…								12145435	500,000	516,018	103.20%

EventType: 12115088
Description: B+_K+mmpipi=DecProdCut
Test state:

Final: Statistic Tables

12115008 (B+_K+1a2mumumumu,ma1=1.75GeV,ta1=10ps,ma2=3.0GeV,ta2=0fs,DecProdCut)
Gauss v49r22 - DecFiles v30r70 - APPCONFIG v3r408
DDDB dddb-20170721-3 - SIMCOND sim-20170721-2-vc-md100
Sim09-Beam6500GeV-2016-MagDown-Nu1.6-25ns-Pythia8
Thu Feb 10 22:31:50 2022

Interaction Counters

Mean Number of generated Pile-Up interactions	Mean Number of non-empty generated Pile-Up interactions	Mean Number of accepted Pile-Up interactions	total cross-section [mb]	b cross-section [mb]	Double b cross-section [mb]	c cross-section [mb]	Double c cross-section [mb]	Prompt D cross-section [mb]	b and c cross-section [mb]
1.59762	2.00282	2.4673	100.305	0.79210	0.012266	9.0712	1.26700	0.24181	0.21184
± 0.00016	± 0.00022	± 0.0051	± 0.070	± 0.00055	± 0.000069	± 0.0018	± 0.00070	± 0.00031	± 0.00029

Hadron Counters

Generator level cut efficiency	Fraction of accepted B0	Fraction of accepted B+	Fraction of accepted Bs0	Fraction of accepted b-Baryon	Fraction of accepted D0	Fraction of accepted D+	Fraction of accepted Ds+	Fraction of accepted c-Baryon	Fraction of accepted B	Fraction of accepted B*	Fraction of accepted B**	Fraction of accepted D	Fraction of accepted D*	Fraction of accepted D**
0.15408	0.4029	0.3931	0.11906	0.08492	0.3671	0.34157	0.18007	0.11122	0.20872	0.61880	0.17248	0	0	0
± 0.00035	± 0.0012	± 0.0012	± 0.00079	± 0.00068	± 0.0010	± 0.00099	± 0.00081	± 0.00066	± 0.00071	± 0.00085	± 0.00066	± 0	± 0	± 0

Signal Counters

particle cut efficiency	anti-particle cut efficiency
0.15461	0.15356
± 0.00050	± 0.00050

Number of accepted events/generated events: 323189 / 128711306 = 0.002511
Number of interactions in accepted events/generated interactions: 797402 / 257785269 = 0.003093
Statistics generated from 1001 jobs log for **Sim09l** Prod. ID: 155863; Req. ID: 95774.

Script version: 20210427

- PAWG liaisons prepare the statistic tables, which can be acessed here for SIM09 and here for SIM10.

Conclusions

- Simulation is not an easy task: a lot of information, options, outputs...can make your life very difficult.
- As said: you are not alone! Liaisons always happy to help you.

- Now the adventure of Simulation starts for you!