

Plans of the simulation project

Mark Whitehead on behalf of the simulation group

ECAL Upgrade II Workshop, December 2022



Science and
Technology
Facilities Council



University
of Glasgow

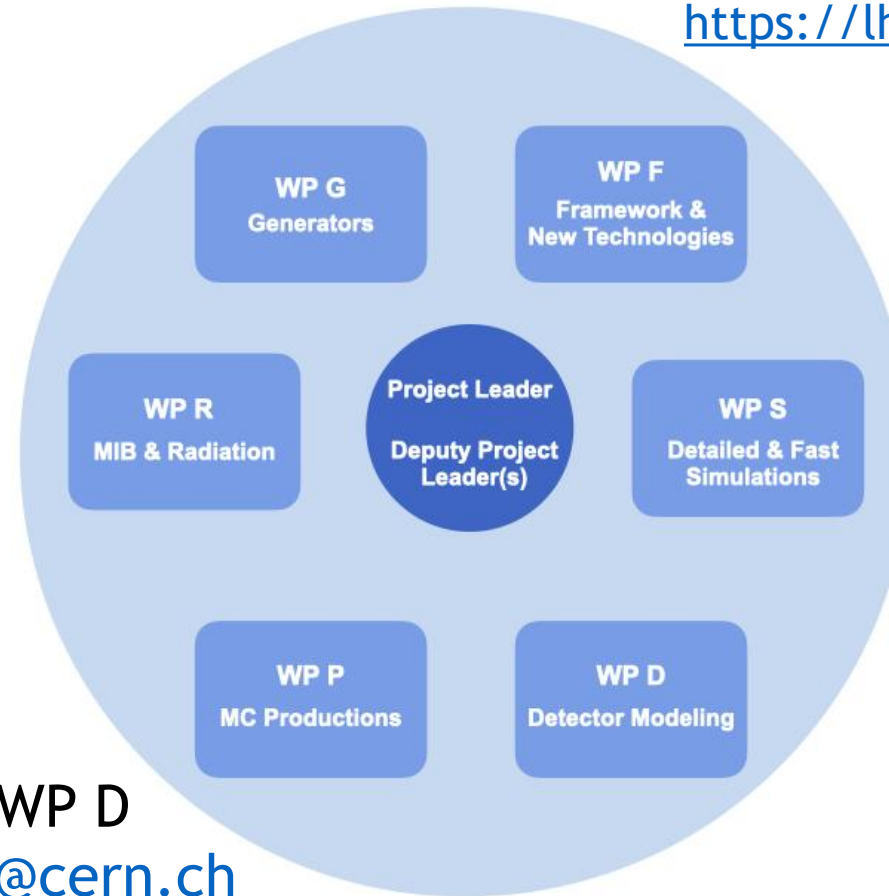
Simulation Project

- Reminder of the structure moving forwards

<https://lhcb-simulation.web.cern.ch/index.html>

- Mattermost channels

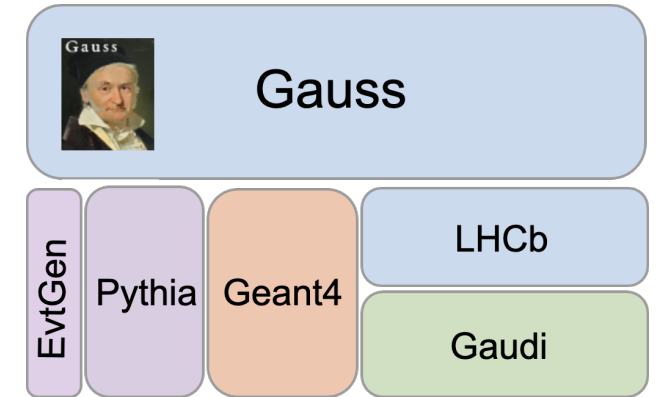
- Gaussino
- Simulation
- Geometry Validation



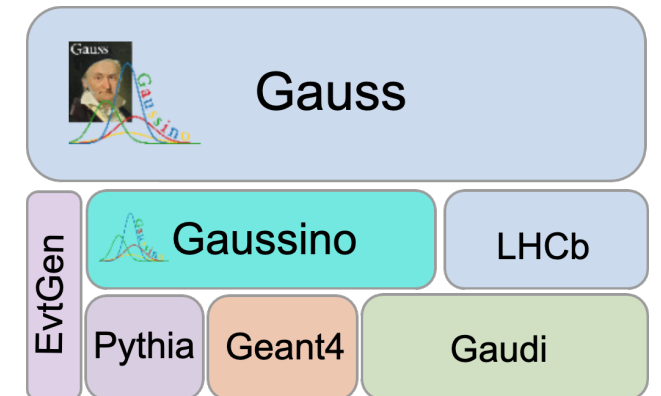
Seeking coordinator for WP F, WP D
contact lhcb-sim-coordination@cern.ch

Introduction

- Reminder of the structure moving forwards
- **Gaussino**
 - New core simulation framework
 - Moved experiment independent components out of Gauss
 - Ideal test-bed for new ideas/developments
- **Gauss-on-Gaussino**
 - New version of the LHCb simulation framework
 - Based on Gaussino's core functionality
 - Includes LHCb-specific parts



(a) Gauss (Sim10) current dependencies

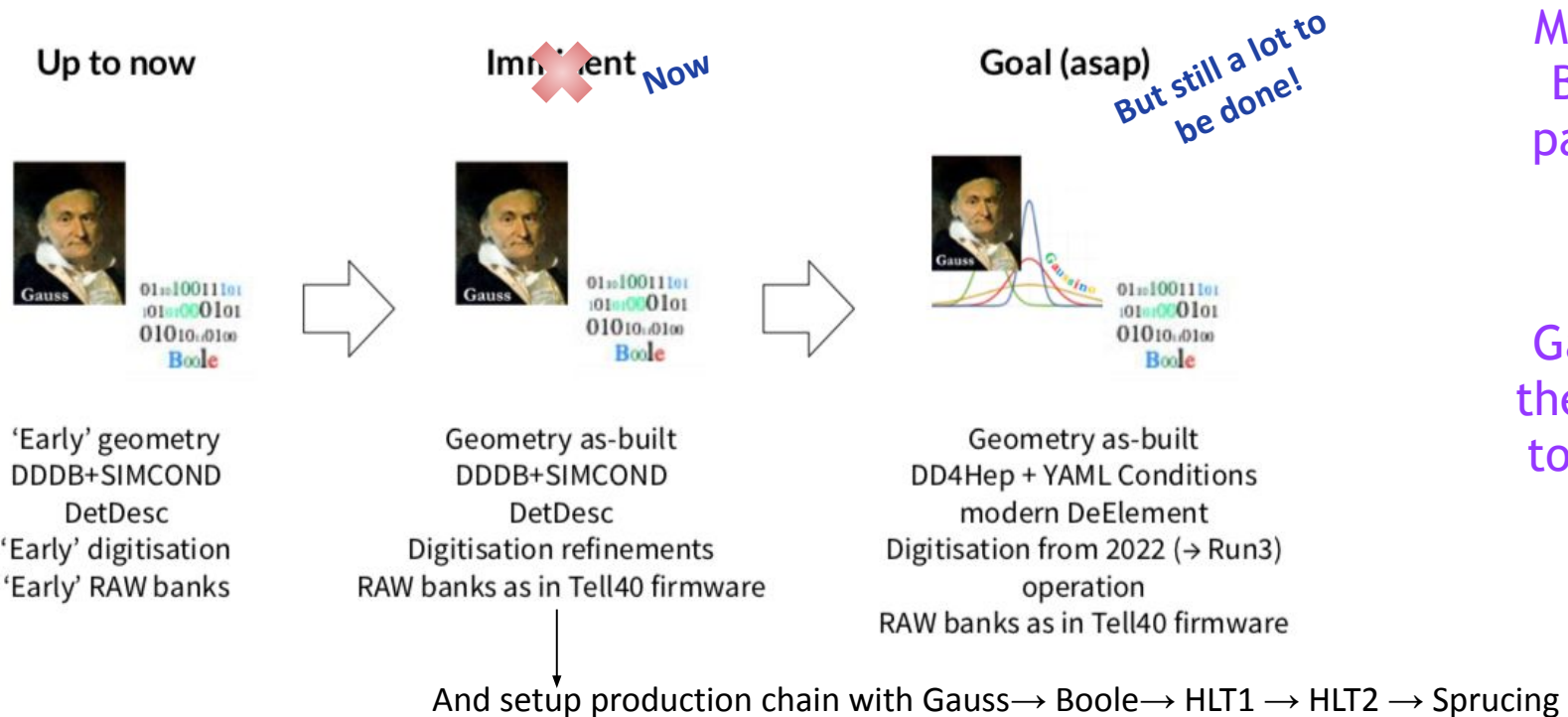


(b) Gauss-on-Gaussino (Sim11) dependencies

Plans

The path to Sim11 - step 1

Run3 Detector Simulation Evolution



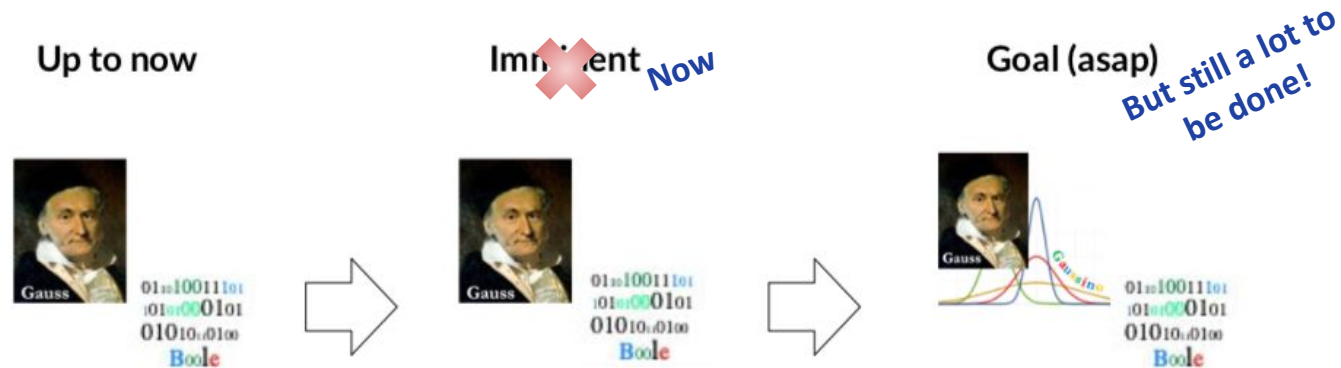
Modernisation of Boole the main part of the to-do list

Gaussino we just the magnetic field to be fixed (after Xmas)

Plans

The path to Sim11 - step 1

Run3 Detector Simulation Evolution



- Developments for Upgrade 1b and 2 should go towards Sim 11
 - Doesn't make sense to aim for Sim 10 with DetDesc descriptions etc

Plans

Run3 Status and Plans (Gauss and G-on-G)

STATUS TABLE		BCM	RMS	PLUME	VELO	RICH	UT	FT	CALO	MUON
Steps in G-on-G	XML description	Not yet	Not yet	Private tests	Done	Done	Done	Done	Private tests	Done
	Python configuration	Not yet	Not yet	Private tests	Done	Done	Done	Done	Private tests	Done
	Extra changes	Not yet	Not yet	Private tests	Done	Done	Done	Done	In progress	In progress
	Hits OK	Not yet	Not yet	Private tests	Done	Done	Done	Done	In progress	In progress
	Histograms	Not yet	Not yet	In progress	Done	Done	Done	Done	To be checked	To be checked
	Physics			needed?		In progress				needed?
Integration Gauss!872	MR Created	Not yet	Not yet	Not yet	Done	Gauss!820	Gauss!827	Gauss!856	Not yet	!850
	MR Reviewed	Not yet	Not yet	Not yet	Done	Changes needed	Changes needed	Changes needed	Not yet	Changes needed
	MR Integrated	Not yet	Not yet	Not yet	Done	Not yet	To be validated	To be validated	Not yet	Not yet
Testing	Validation issue	Not yet	Not yet	Not yet	Gauss#64	Not yet	Gauss#65	Gauss#66	Not yet	Not yet
	Nightlies*	Gauss ready	Gauss ready	Gauss ready	Test ran	Test inactive	Test ran	Test ran	Gauss ready	Test inactive
	LHCbPR**	Gauss ready	Gauss ready	Gauss ready	t.b.v. w/DetDesc	Test inactive	t.b.v. w/DetDesc	t.b.v. w/DetDesc	Gauss ready	Test inactive

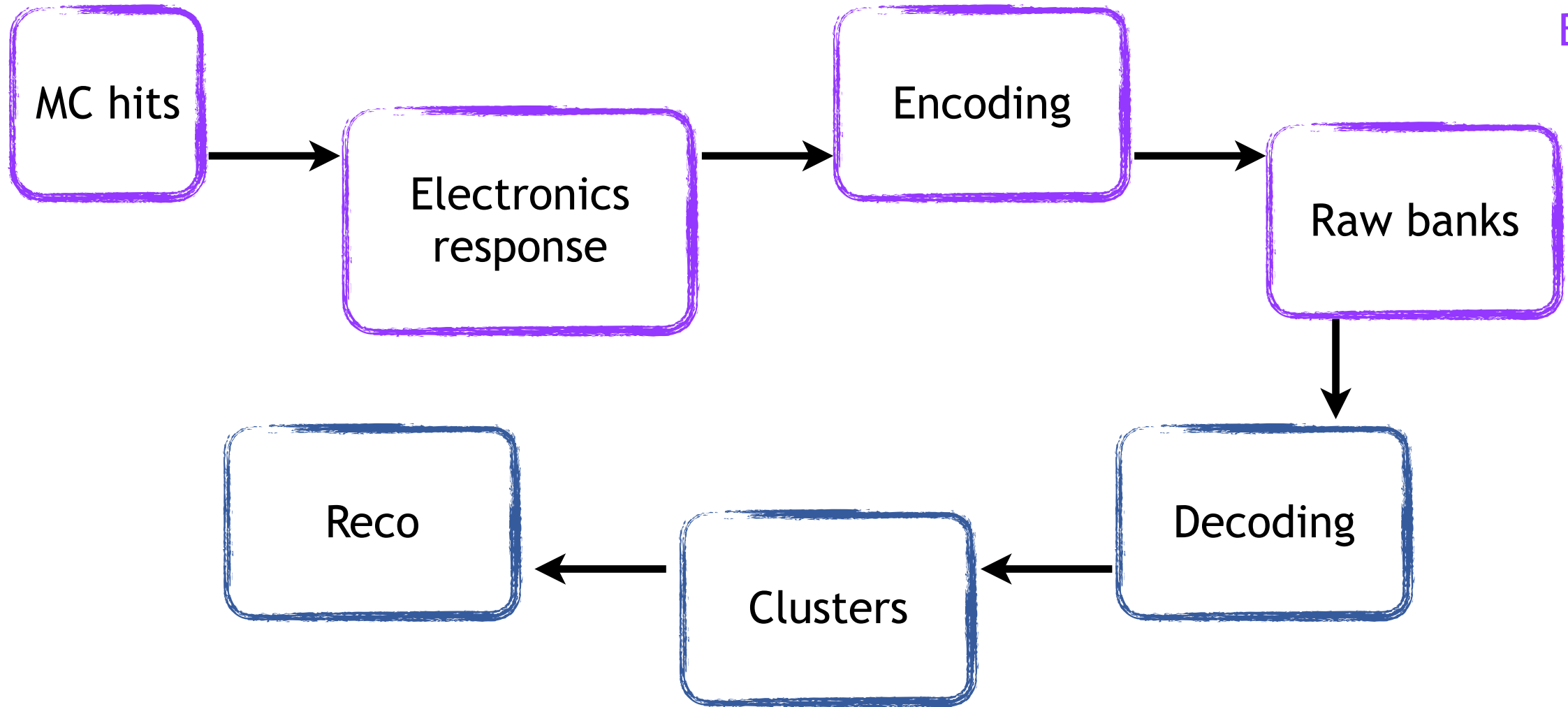
- Thank you to all the persons who contributed!
- We are not there yet

Boole

- Upgrade 1b will eventually build on the Run 3 DD4HEP setup

	A	B	C	D	E	F	G	H	I
1	Boole related activities		PLUME	VELO	RICH	UT	FT	CALO	MUON
2	Data Encoding: SourceID (gitlab link)		In progress	In progress	Done	In progress	Done	In progress	In progress
3	Data Encoding: Firmware version		In progress	Done	Done	In progress	Done	Done	Done
4									
5	Use of Detector: DD4HEP		In progress	In progress	In progress	In progress	In progress	In progress	In progress
6	Use of Detector: YAML conditions		In progress	In progress	Done	In progress	In progress	In progress	Done
7									
8	Digitization: <i>specific for sub-detector</i>		In progress	In progress	Done	In progress	In progress	In progress	Done
9	Digitization: Integration		In progress	In progress	In progress	In progress	In progress	In progress	Done
10									
11	Code Modernization: new Detector Element usage				In progress				MR merged
12	Code Modernization: new Event model				Not yet			In progress	
13									
14	Monitoring: LHCbPR dashboard histos revision		Not yet	In progress	Done	In progress	Done	Done	Not yet
15	Monitoring: Boole in SimDQ - histos wish list (jira link)		Not yet	Done	Done	Done	Done	Done	Done
16	Monitoring: Boole in SimDQ: wish list Implementation		Not yet	Not yet	Not yet	Not yet	Not yet	Not yet	Not yet

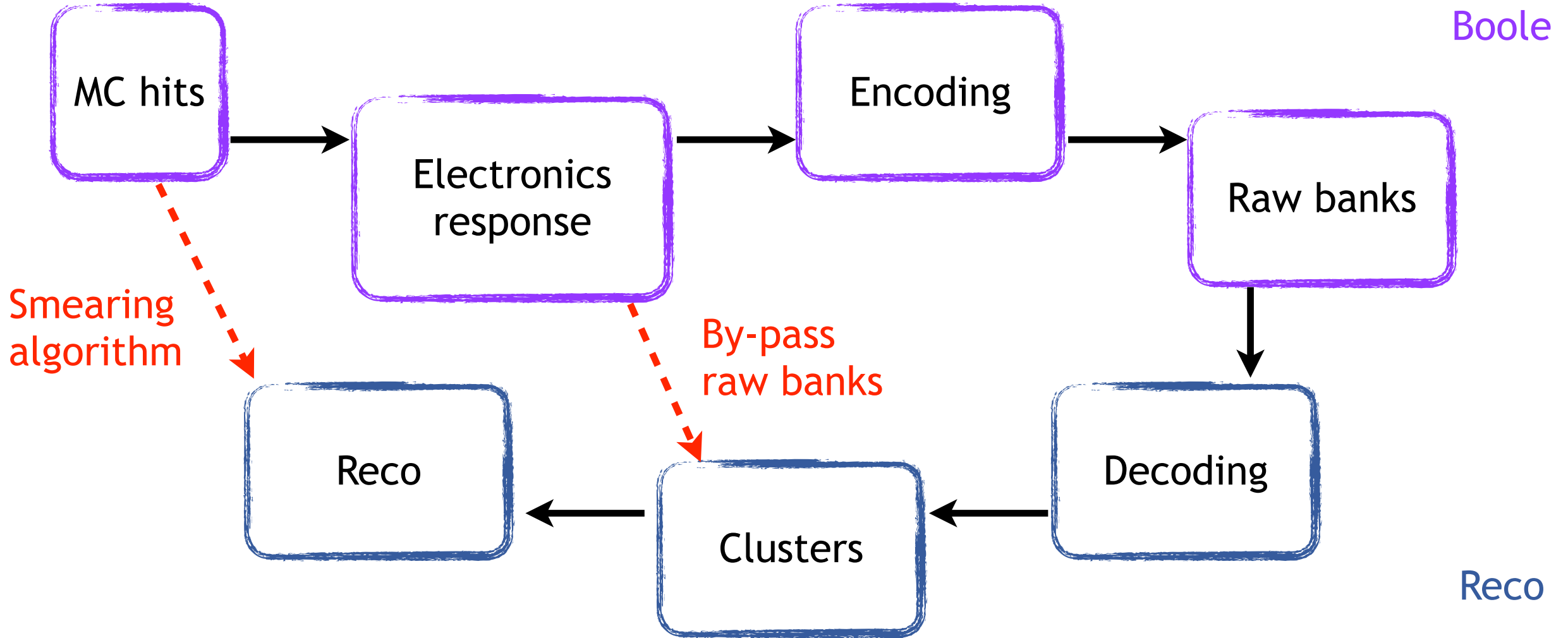
Workflow, Boole/Reco



Boole

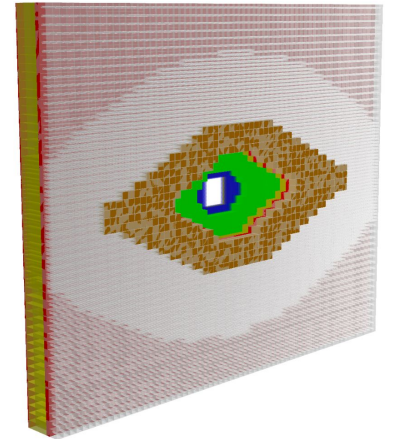
Reco

Workflow, Boole/Reco



(New) Detectors in Boole

- What is needed to be done for new detectors in Upgrade 1b/2?
 - **Detector** - geometry model implemented using **DD4HEP**
 - Handling of **MC hits** in sensitive detector elements
 - Configuration in Gauss
 - Event model classes (if necessary)
 - Translation of MC hits into objects for the reconstruction to use
- We provide the basic infrastructure
 - Limited person power
 - Detector specifics need to come from the **detector groups**



Versioning of detector/conditions

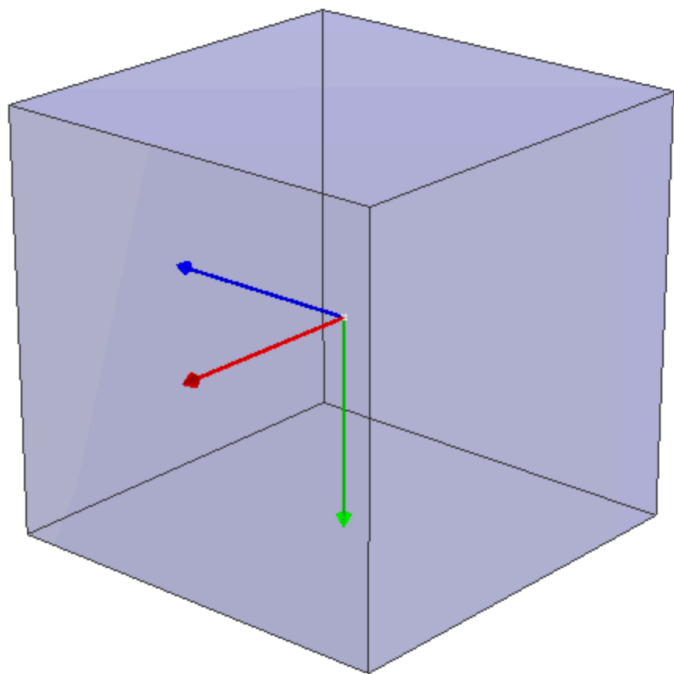
- Need to support Run 3, Upgrade 1b and Upgrade 2
 - Upgrade 1b builds on the Run 3 setup, accurate **MT bolt-on** studies are urgent
 - Upgrade 2 more a complete change
- Should be possible to contrast/compare different detector options
 - Different geometries, technologies, conditions etc
 - Parallel studies for Upgrade 1b and Upgrade 2 for some sub-systems
- Use of namespaces in Detector project
 - Everything should target the **master branch** with the correct namespaces
 - **Upgrade1b::** and **Upgrade2::**

Boole

- Upgrade 1b will eventually build on the Run 3 DD4Hep setup
 - This will be the **Sim11** release
- Before this is ready, some options for early studies
 - Bolt-on DD4Hep geometry to DetDesc simulation by importing it as GDML and adding active volumes by hand (**short-term solution if all sub detectors needed**)
 - Might end up being quite cumbersome for complex geometries?
- Are considering a **lightweight alternative** during development
 - Aimed at Upgrade 1b/2 digitisation studies (though 1b studies may already be more advanced)
 - Either slotted into Gauss or as a lightweight second layer - **to be seen**

Test beams

- Simulation for test beam programmes can be implemented in Gaussino
 - Geometry can be included in python/GMDL/DD4HEP
 - Very basic [example](#) in the Gaussino documentation



```
# adding external detectors
from Configurables import ExternalDetectorEmbedder
external = ExternalDetectorEmbedder("Testing")
from GaudiKernel.SystemOfUnits import m
from Gaudi.Configuration import DEBUG
external.Shapes = {
    "MyCube": {
        "Type": "Cuboid",
        "xSize": 1. * m,
        "ySize": 1. * m,
        "zSize": 1. * m,
        "OutputLevel": DEBUG,
    },
}
```

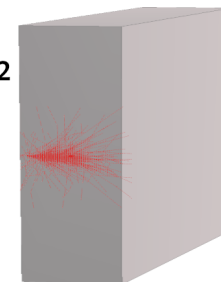
```
# Write to GDM
SimPhase().ExportGDM = {
    "GDMFileName": "ExternalCube.gdm",
    "GDMFileNameOverwrite": True,
    "GDMExportEnergyCuts": True,
    "GDMExportSD": True,
}
```

Parallel Geometries

- Nice feature of Gaussino to compare different options at the same time
 - Compare materials, layouts etc
- Useful for fast simulations
 - E.g. replace a part of the detector with a parallel volume that is used to do the fast simulation
- For more please see [here](#) and [here](#)

Parallel World 2

ParallelPlane2
(Pb)



Parallel World 1

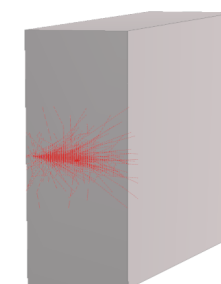
ParallelPlane1
(Vacuum)



Mass Geometry

MassPlane
(Pb)

1GeV γ



Parallel Geometries

- Nice feature of G
 - Compare materi
- Useful for fast sim
 - E.g. replace a pa
 - with a parallel v
 - used to do the fa
- For more please

at the same time

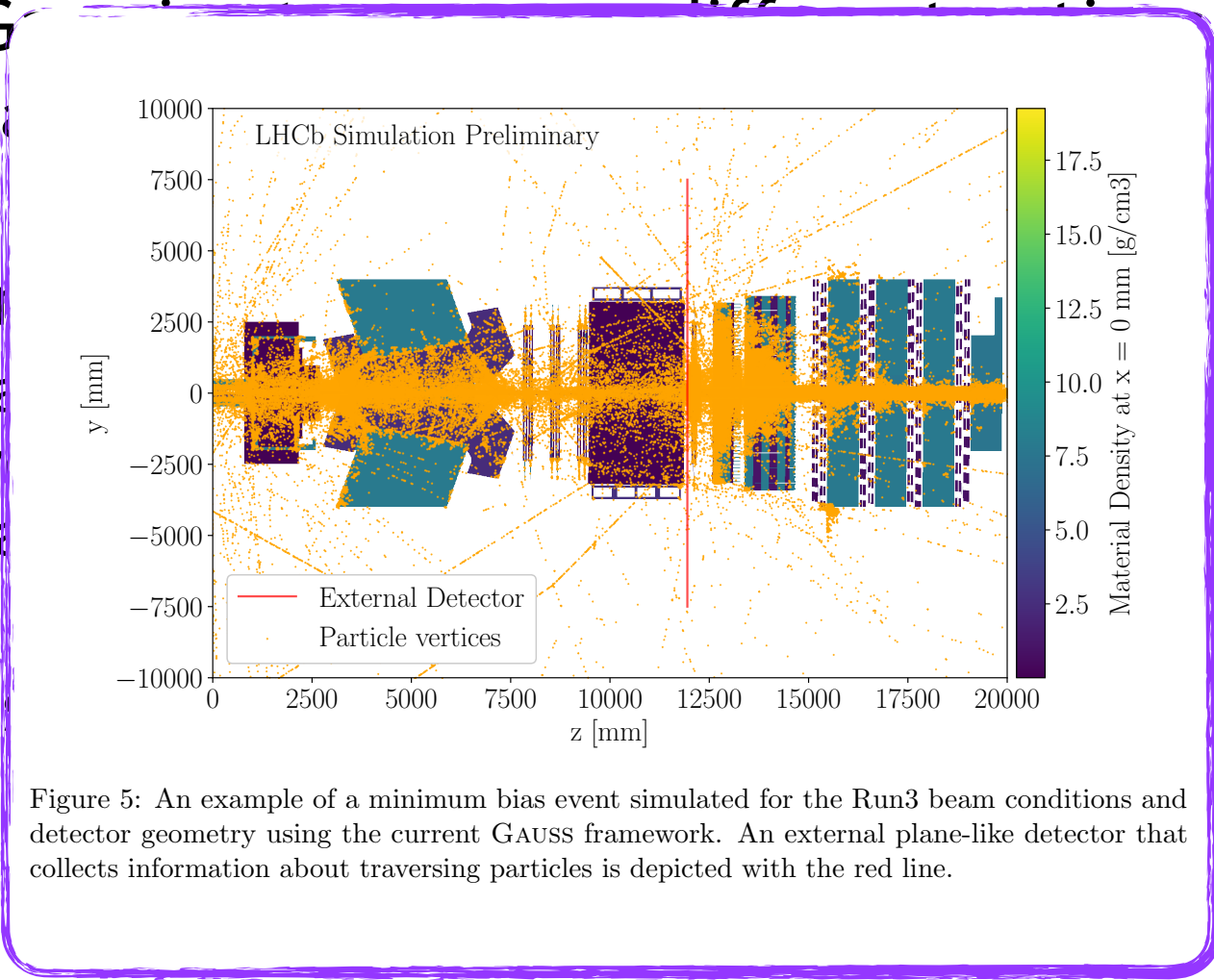
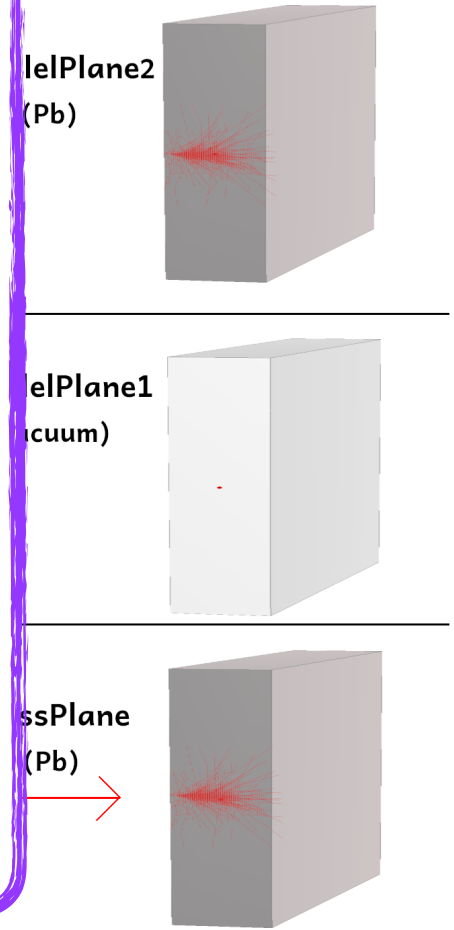


Figure 5: An example of a minimum bias event simulated for the Run3 beam conditions and detector geometry using the current GAUSS framework. An external plane-like detector that collects information about traversing particles is depicted with the red line.



Fast simulation

- Gaussino provides infrastructure for fast simulations
 - Can interface with libraries such as [Geant4](#) and [machine learning](#) methods
 - All in a coherent and robust way
 - More details in [Michal's](#) talk from LHCb week parallel
- Effort already quite advanced (and appreciated)!

Model	Generation	Decay	Propagation	Status in G-on-G
ReDecay	✓	✓	✓	done
ParticleGun	✓	✓	✓	done
SplitSim	✓	✗	✓	done
RICHless	✗	✗	✓	under tests
TrackerOnly	✗	✗	✓	under tests
Lamarr	✗	✗	✓	(NEW) in progress
Point library	✗	✗	✓	(NEW) in progress
GANs	✗	✗	✓	(NEW) in progress

Fast simulation

- Generative Adversarial Networks (GANs)
 - Talk from [A. Rogachev](#) in the simulation developments meeting
- Shower/point library
 - Extract points from a full simulation sample and transforms/extrapolate them in fast simulation to match a given particle trajectory

Model	Generation	Decay	Propagation	Status in G-on-G
ReDecay	✓	✓	✓	done
ParticleGun	✓	✓	✓	done
SplitSim	✓	✗	✓	done
RICHless	✗	✗	✓	under tests
TrackerOnly	✗	✗	✓	under tests
Lamarr	✗	✗	✓	(NEW) in progress
Point library	✗	✗	✓	(NEW) in progress
GANs	✗	✗	✓	(NEW) in progress

Feedback

- We'd be very happy to have any of your developments included!
 - If you have standalone code that could be generally used it would be great to get it in to [Gauss/Gaussino/Lamarr](#) where possible
 - The [Hybrid MC framework](#) presented yesterday by [Marco](#) a prime example which should already be able to fit into Gauss-on-Gaussino
- Looks like there are plenty of discussions on-going
 - [Gaussino](#) and [fast-sim](#) talks in the ECAL parallel at the last LHCb week
- Some examples available
 - If you need more, please let us know so we can produce them

Conclusion

- Lots going on, but lots more to do
 - Need inputs from the detectors to finalise the Run 3 Sim11 releases
 - Especially for Boole with DD4HEP geometry and new conditions
- Gaussino and Gauss-on-Gaussino under active development
 - See the [documentation](#) for the latest guide to running them
 - Get in touch on [mattermost](#) incase development out-paces documentation
- Let us know if you need anything else
 - We will always [try](#) to accommodate the needs to the detector groups!