Simulation infrastructure for optimisation

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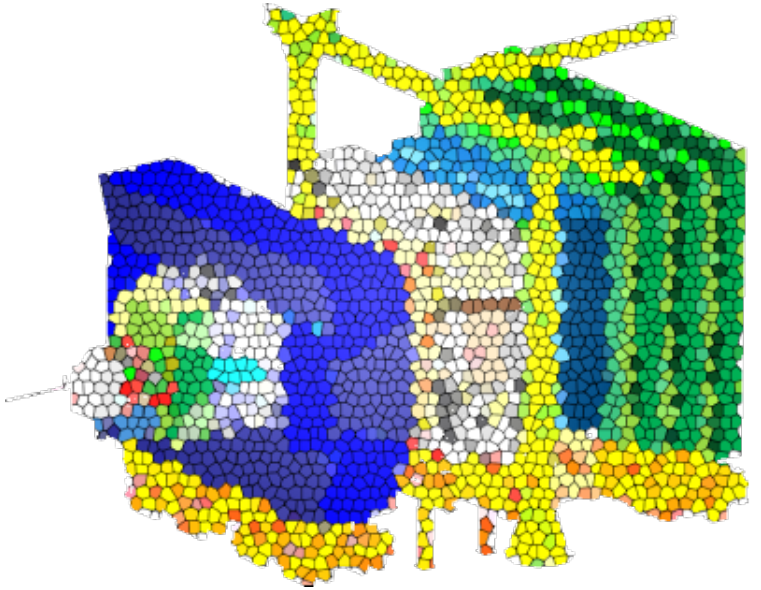
On behalf of the Simulation Project



6th workshop on LHCb Upgrade II

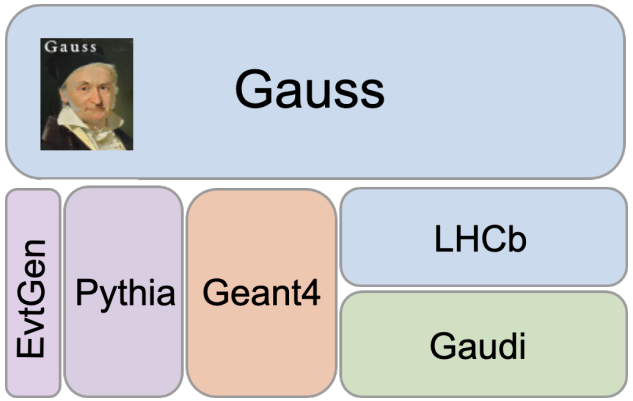
Barcelona 29th-31st March 2023

Science and Technology Facilities Council

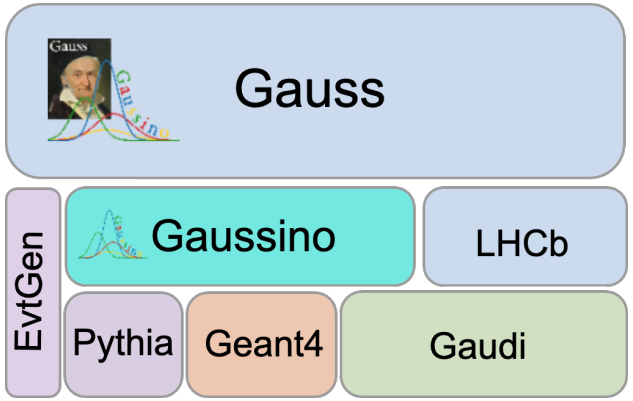
University of Glasgow

Future upgrades

- Focus on the future
  - Upgrade 1b (a.k.a. LS3 Enhancements)
  - Upgrade 2
- For Upgrade 1b, focus on Sim11 for now
  - Build on the DD4Hep Run 3 detector
  - For Boole, some parts of this are still WIP
  - Latest updates in Simulation meeting yesterday
- For Upgrade 2, more changes expected
  - Should use the DD4Hep framework though



(a) Gauss **(Sim10)** current dependencies



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

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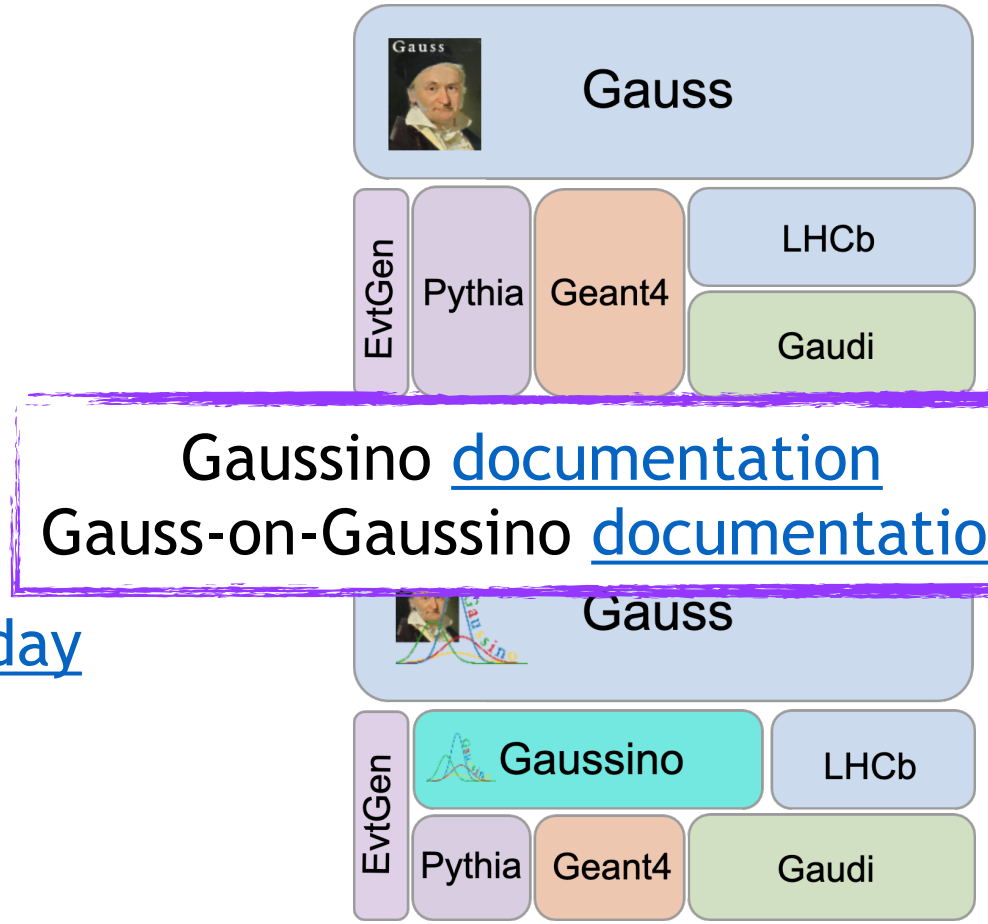
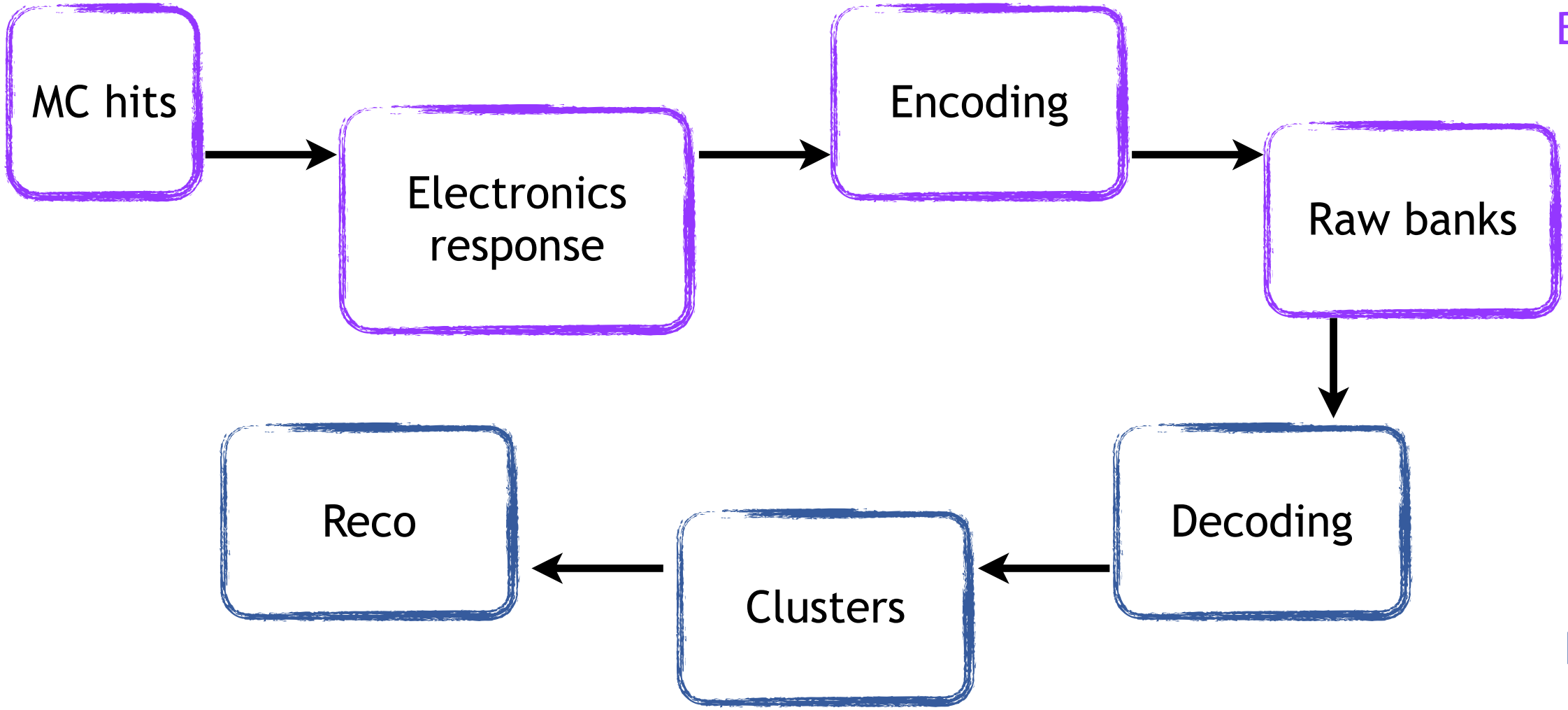


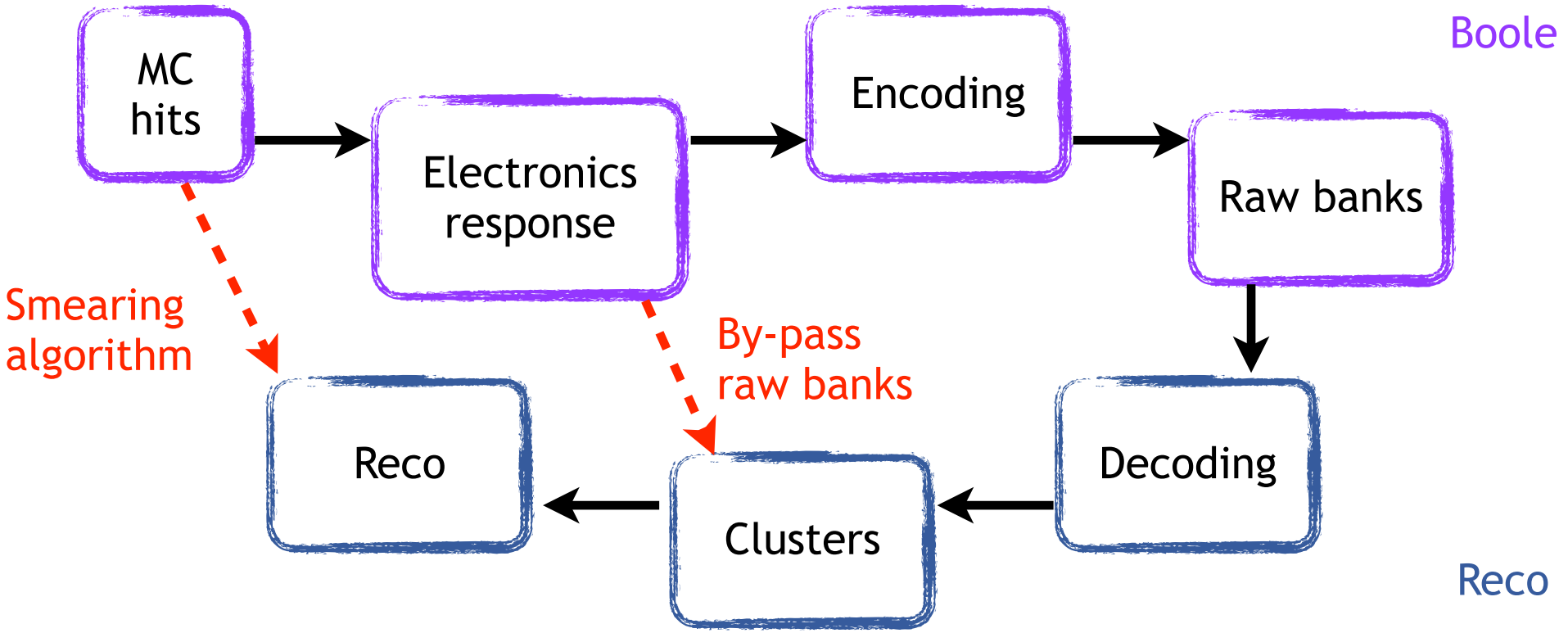
(b) Gauss-on-Gaussino **(Sim11)** dependencies

Workflow reminder, Boole/Reco



Workflow reminder, Boole/Reco

- Would like a lightweight digitisation for future upgrade studies
  - MC hits -> Reco
  - Skip raw banks
  - …



- Implementation
  - Implement into Gauss, lightweight intermediate layer or start of reconstruction?
  - To run stand alone or in a hybrid Boole to include full digitisation where available

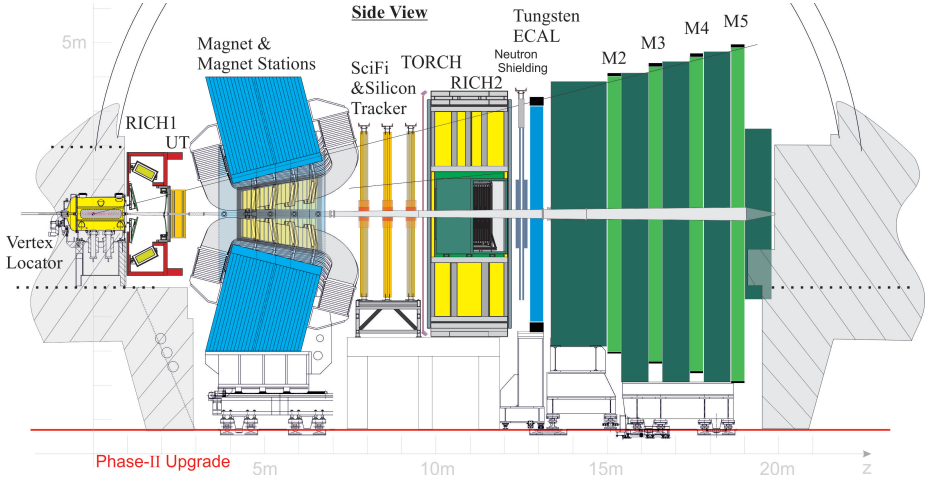
Versioning of detector/conditions

- Need to support all of the Run 3, Upgrade 1b and Upgrade 2 detectors
  - Upgrade 1b builds on the Run 3 setup
  - Upgrade 2 more a complete change

- Slides from Ben in the future upgrade simulation meeting
  - First preparations and scaffolding underway
  - Need to make sure what is implemented doesn't clash elsewhere
  - Ensure it is kept in sync with Run 3 geometry and detector class updates when relevant
  - Further discussions and trial implementations should prove valuable

Coherent approach

- Clear we need to do our best to support stand-alone studies
  - Some things in place, happy to include your developments too!
- Be mindful of different timescales involved
  - Upgrade 1b/LS3 enhancements are on a shorter timescale
- Important to also have a more combined/full simulation
  - Must be kept in mind as we move towards scoping document
  - E.g. tracking system comprised of several sub-detectors
  - Simulation meetings the forum for this



Fast simulation

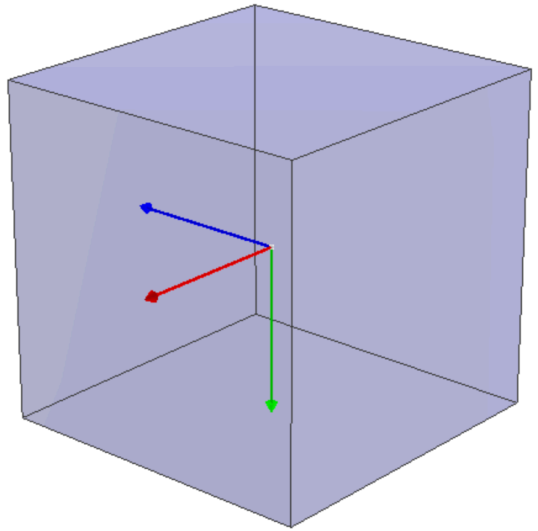
- Gaussino provides infrastructure for fast simulations
  - Can interface with libraries such as Geant4 and machine learning methods
  - All in a coherent and robust way
  - More details in Michal's talk from December LHCb week parallel

- 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

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



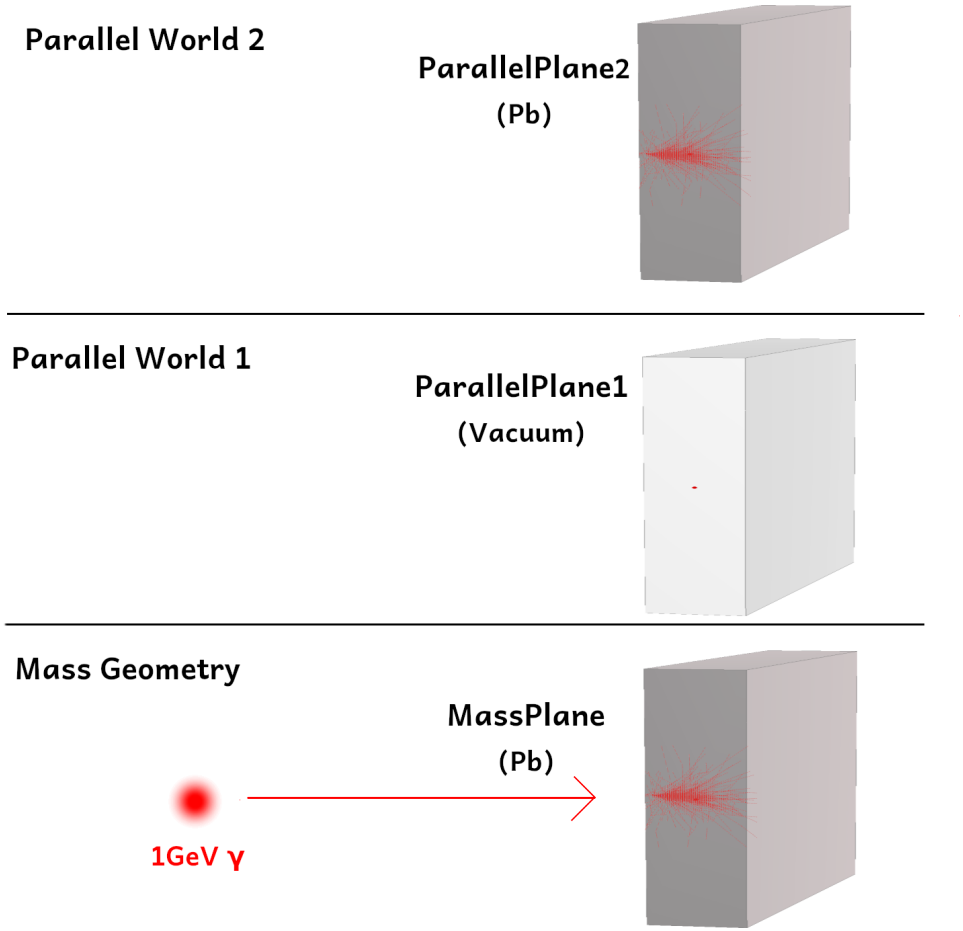
```python
# adding external detectors
from Configurables import ExternalDetectorEmbedder
external = ExternalDetectorEmbedder("Testing")
from GaudiKernel.SystemOfUnits import m
from Gaudi.Configuration import DEBUG
external.Shapes = {
    "MyCube": {
        "Type": "Cuboid",
        "xSize": 1. * m,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

```python
# Write to GDML
SimPhase().ExportGDML = {
    "GDMLFileName": "ExternalCube.gdml",
    "GDMLFileNameOverwrite": True,
    "GDMLExportEnergyCuts": True,
    "GDMLExportSD": True,
}
```

Tutorial from Michal on Gaussino and Gauss-on-Gaussino at LHCb week (talk)

Parallel Geometries

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



Parallel Geometries

- Nice feature of G… …at the same time
  - Compare materi…
- Useful for custom…
  - E.g. replace a pa… with a parallel v… used to do the c… simulation
- For more please…

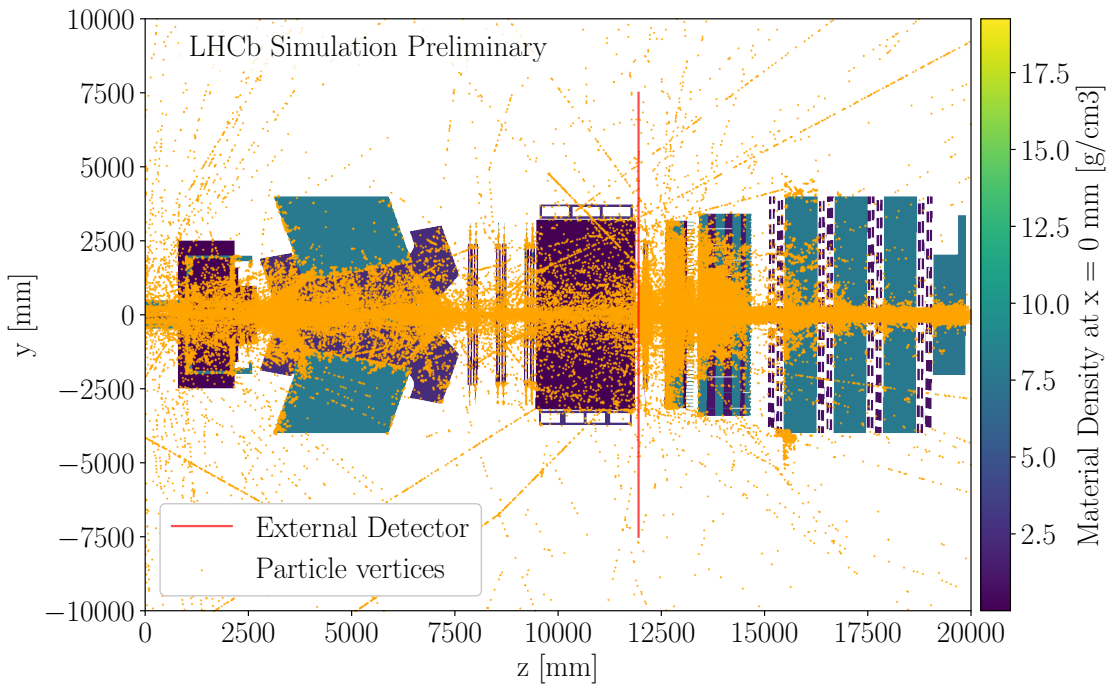
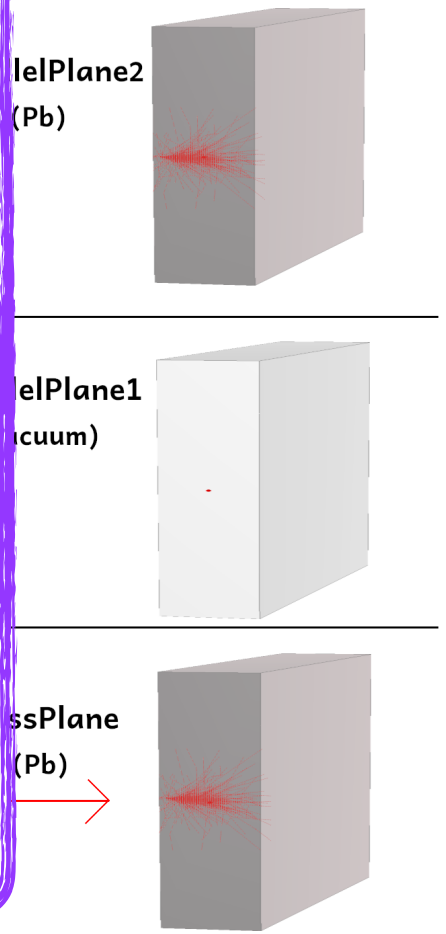


Figure 5: An example of a minimum bias event simulated for the Run3 beam conditions and detector geometry using the current GAUSS framework. An external plane-like detector that collects information about traversing particles is depicted with the red line.



Pileup and spillover

- Areas to start thinking about
  - Pileup - number of PVs in each bunch crossing
  - Spillover - effects from interactions in previous/future bunch crossing
- Why do we need to think about it?
  - Expecting pileup of around 40-50 interactions per bunch crossing!
  - Not feasible to just carry on as we are (no factor 10 in CPU pledges nor speed)
- May require a variety of implementations
  - See Gloria's talk on Friday for a few more thoughts on this topic

Conclusion

- Lots going on, but lots more to do
  - Need inputs from the detectors to finalise the Run 3 Sim11, for Boole especially
- Gaussino and Gauss(-on-Gaussino) under active development
  - Ask on mattermost if you need help running latest versions (after checking the documentation!)
  - Should be ready for some future upgrade studies
- Get in touch and let us know your needs
  - Also let us know if you have standalone code of general interest to include

- Mattermost channels
  - Gaussino
  - Simulation
  - Geometry Validation

- See Gloria's talk on Friday morning for more details