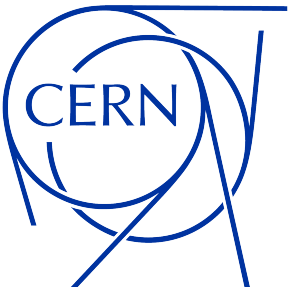


# Towards a Geant4 ATLAS LAr Barrel Validation Test

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Simulation bi-weekly meeting  
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# About a Geant4 ATLAS LAr barrel test

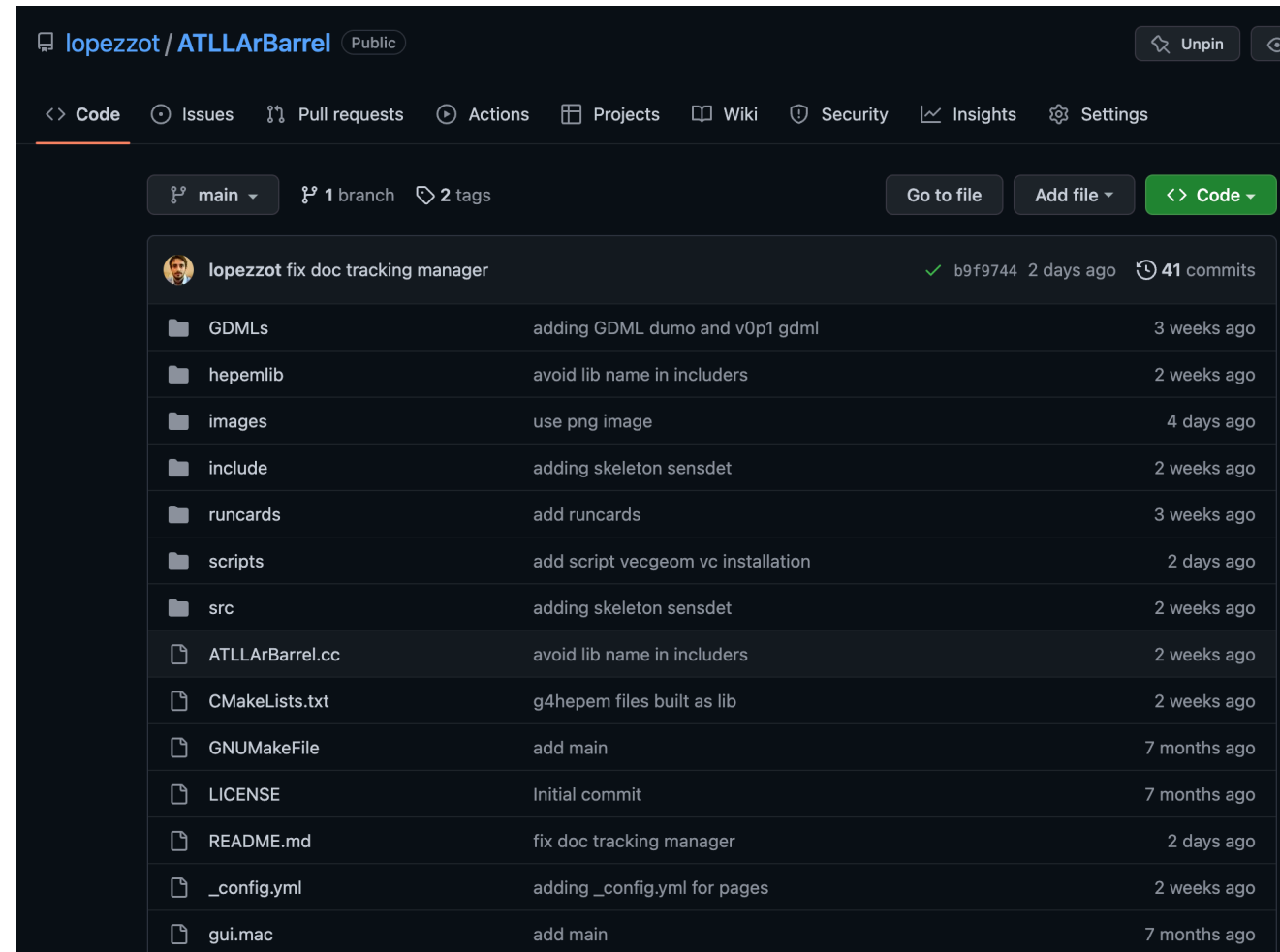
- ◆ A JIRA [ticket](#) to *create realistic setup for testing of EM showers in ATLAS EM-Barrel geometry* is open on [GEANT4-SIM JIRA](#) since 2017.
- ◆ The ATLAS LAr test-beam setup is the ideal framework to accomplish it.
- ◆ However, as far as I know, ATLAS is no longer using/validating the simulation of the LAr barrel test-beam → little expertise preservation.
- ◆ A standalone Geant4 test can only target:
  - ❖ Geant4 version control and
  - ❖ physics list comparison (EMZ, EMY, ...)
- ◆ Most EM-shower generation happens in the LAr barrel geometry → there is where we have to speed up the simulation the most.
  - ❖ We need a testbed for testing our speeding up solutions.
  - ❖ Both Adept and Celeritas expressed their interest for such a test ([ATLASAdept-presentation](#), [Celeritas-presentation](#)).

# How...

- ◆ Start from the ATLAS LAr [original code](#) (same code used for the new Geant4 ATLAS HEC validation).
- ◆ Isolate the LAr barrel test-beam geometry (by G. Unal *et al.*) from the other detectors.
- ◆ Remove GeoModel dependency → use only G4Solids.
- ◆ Remove ATLAS Detector Description Database dependency → hardcode numbers.
- ◆ Make Geant4 the only **REQUIRED** package
  - ✿ Add optional dependencies of interest, *e.g.*
    - ◆ G4HepEM
    - ◆ VecGeom

# ATLLArBarrel

- ◆ New Github [repo](#) contains our work in progress.
- ◆ Currently in pre-release:
  - ❖ geometry completed,
  - ❖ tested with  $10^6$  events with no crashes and no warnings,
  - ❖ added G4HepEm related files as optional library compiled with
    - ❖ `-DWITH_G4HepEm=0N`
    - ❖ `-DWITH_G4HepEmTracking=0N`
  - ❖ tested with VecGeom with both scalar and vector backend.
- ◆ Need guidance from ATLAS for SensitiveDetector implementation.



The screenshot shows the GitHub repository page for 'lopezzot / ATLLArBarrel'. The repository is public and has 1 branch (main) and 2 tags. The commit history is displayed, showing a recent commit by 'lopezzot' titled 'fix doc tracking manager' (commit b9f9744, 2 days ago) with 41 total commits. The commit history table is as follows:

File	Commit Message	Time
GDMLs	adding GDML dumo and v0p1 gdml	3 weeks ago
hepemlib	avoid lib name in inclusions	2 weeks ago
images	use png image	4 days ago
include	adding skeleton sensdet	2 weeks ago
runcards	add runcards	3 weeks ago
scripts	add script vecgeom vc installation	2 days ago
src	adding skeleton sensdet	2 weeks ago
ATLLArBarrel.cc	avoid lib name in inclusions	2 weeks ago
CMakeLists.txt	g4hepem files built as lib	2 weeks ago
GNUmakeFile	add main	7 months ago
LICENSE	Initial commit	7 months ago
README.md	fix doc tracking manager	2 days ago
_config.yml	adding _config.yml for pages	2 weeks ago
gui.mac	add main	7 months ago

# The geometry

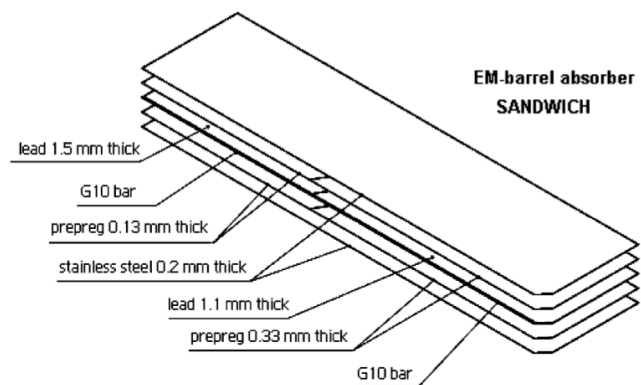
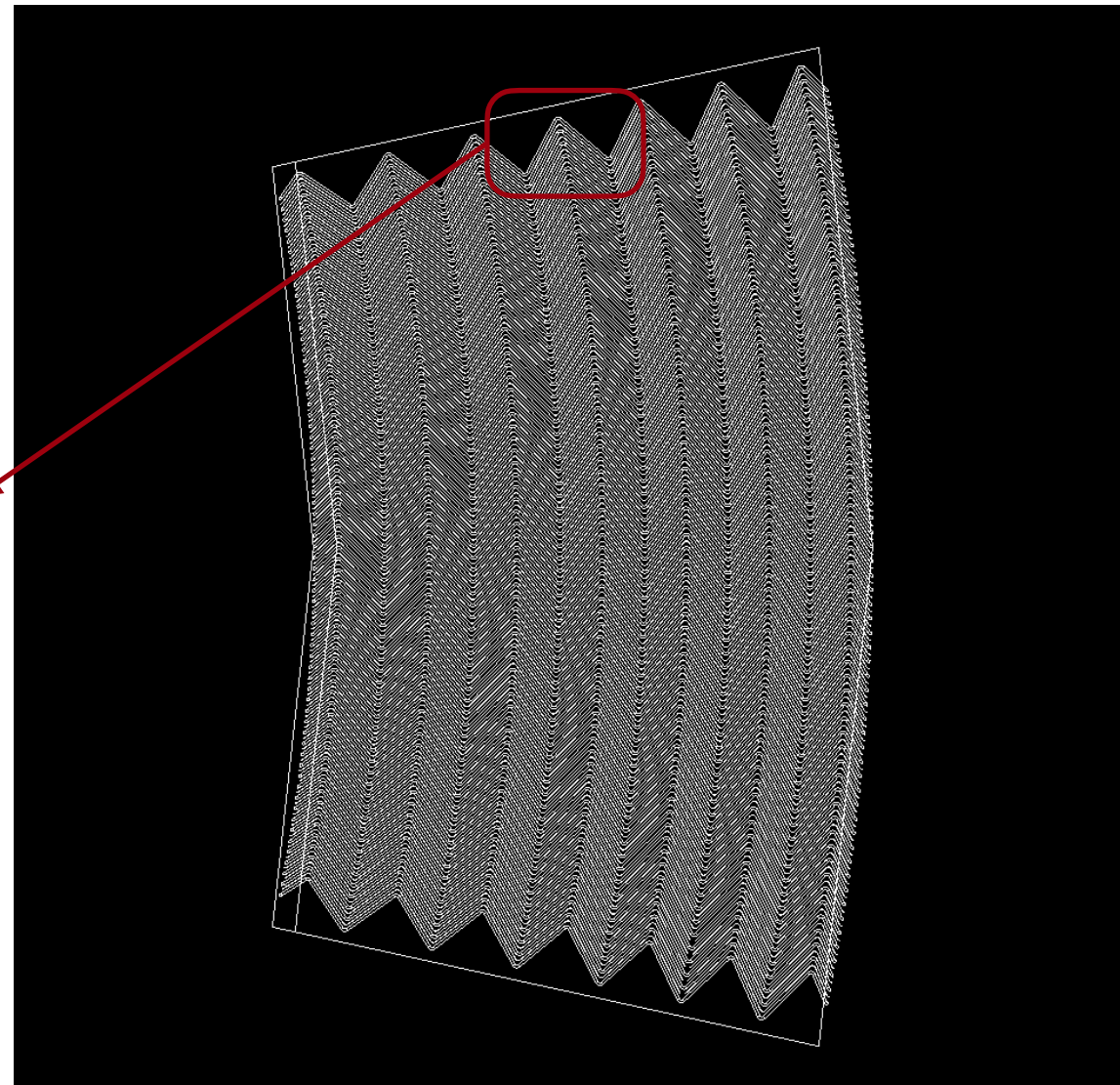


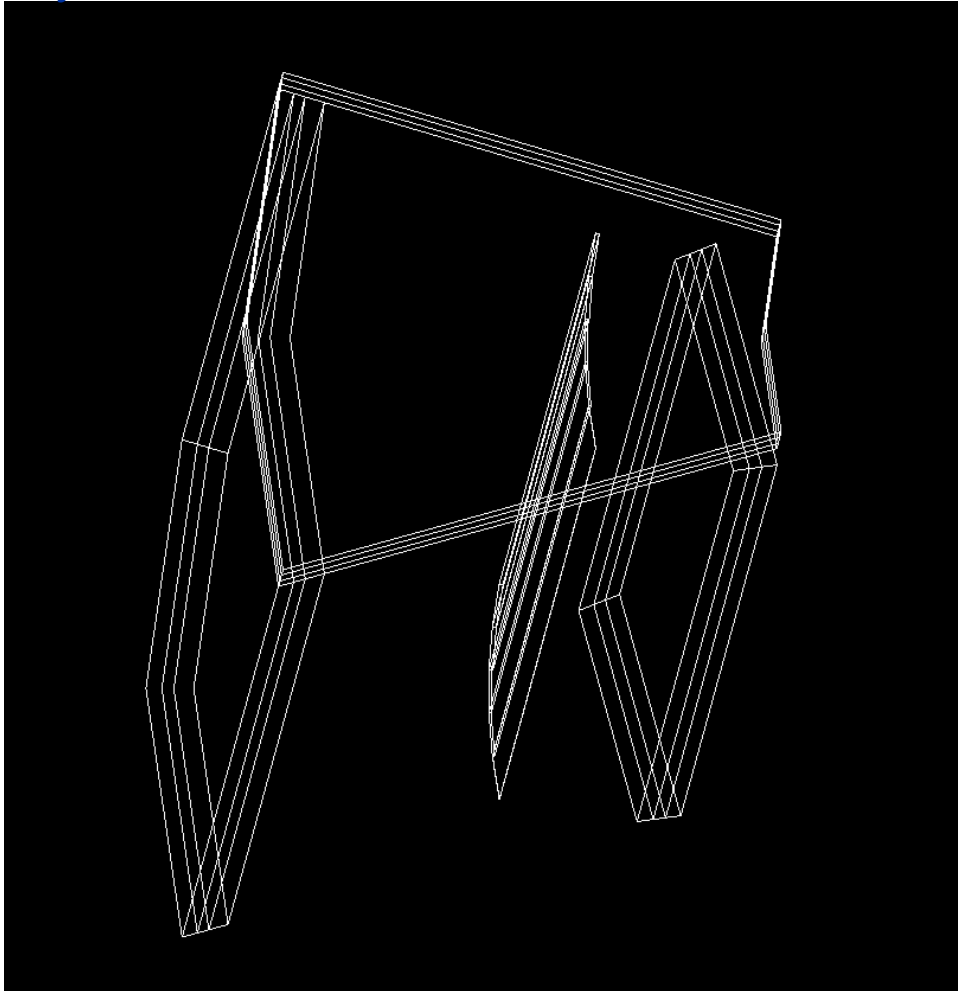
Fig. 3. The upper figure shows the absorber profile and a sketch of a stack of five absorbers. The lower figure shows the piling up of the absorber sandwich with the two lead thicknesses, before folding the absorber in an accordion shape.

EMB::STAC

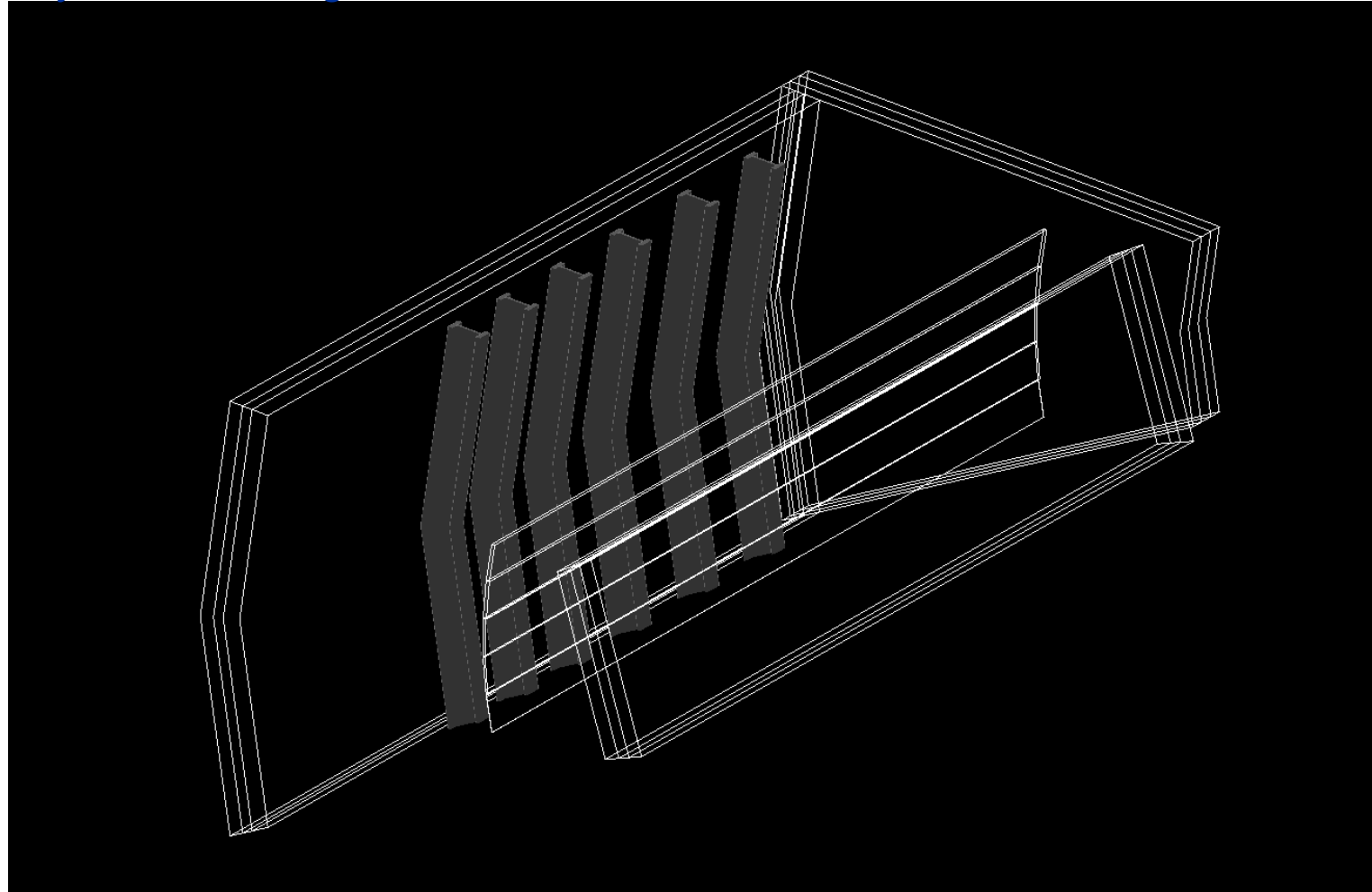


# The geometry

Cryostat

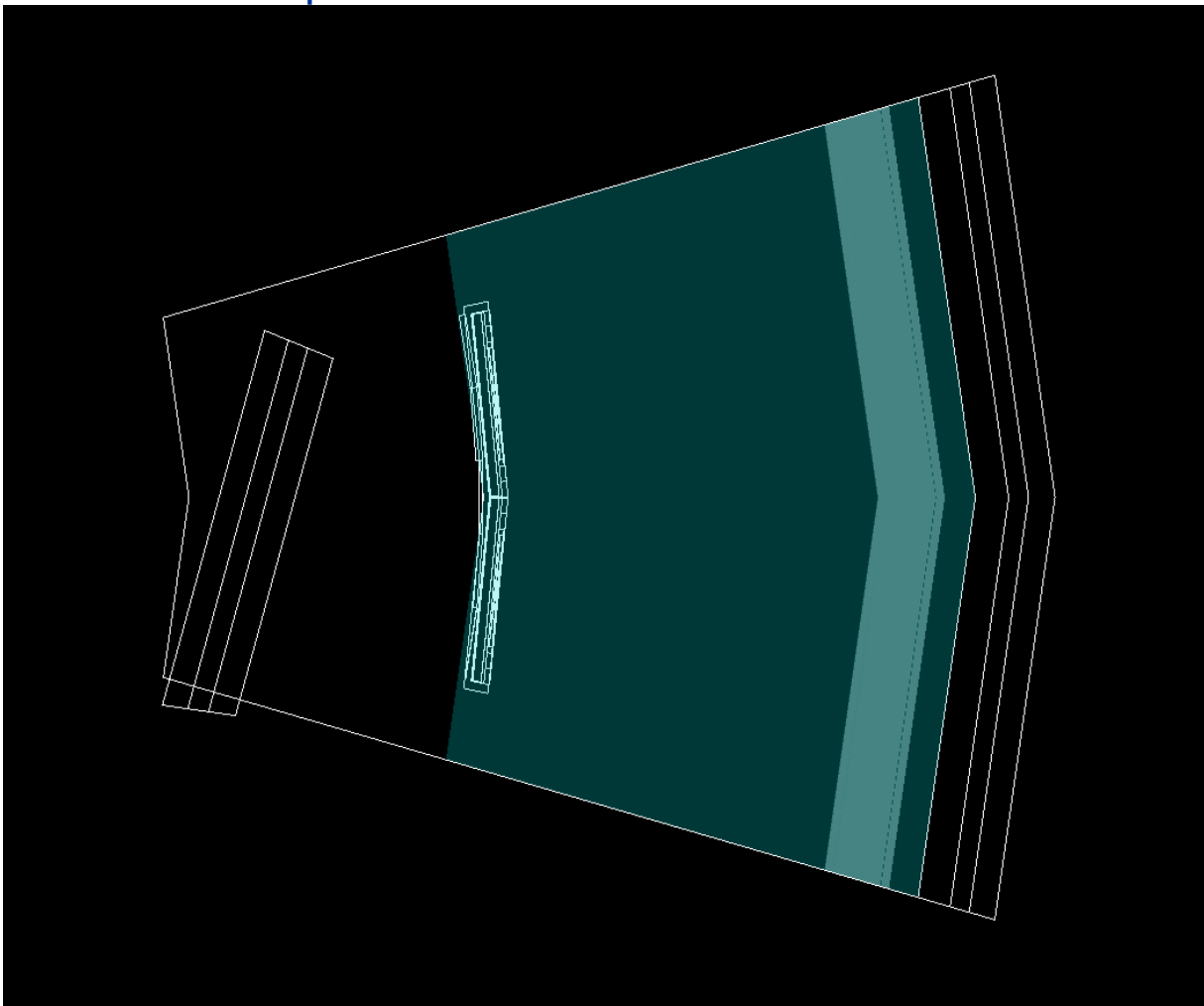


Cryostat + 6 Rings

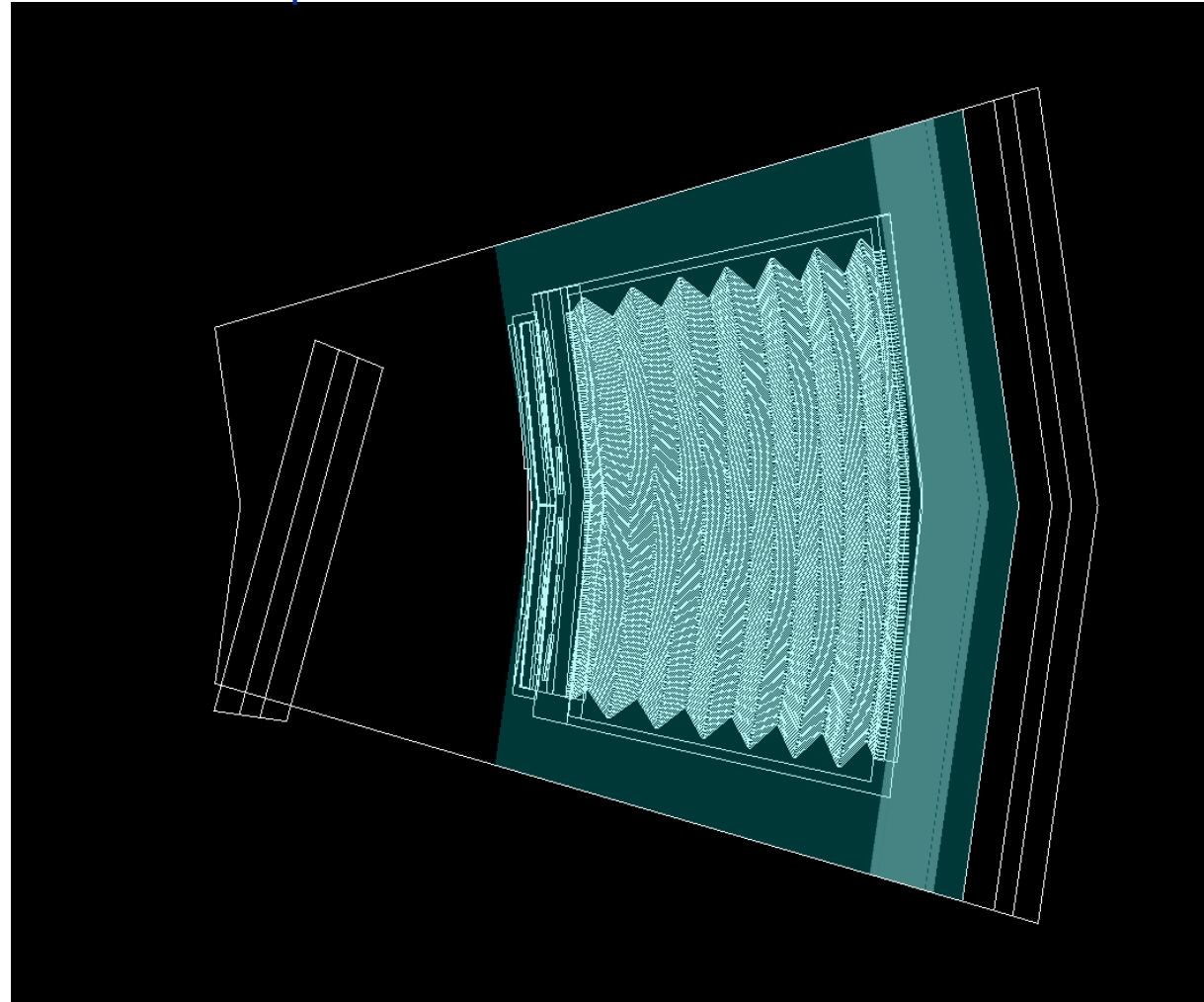


# The geometry

LAr + Presampler

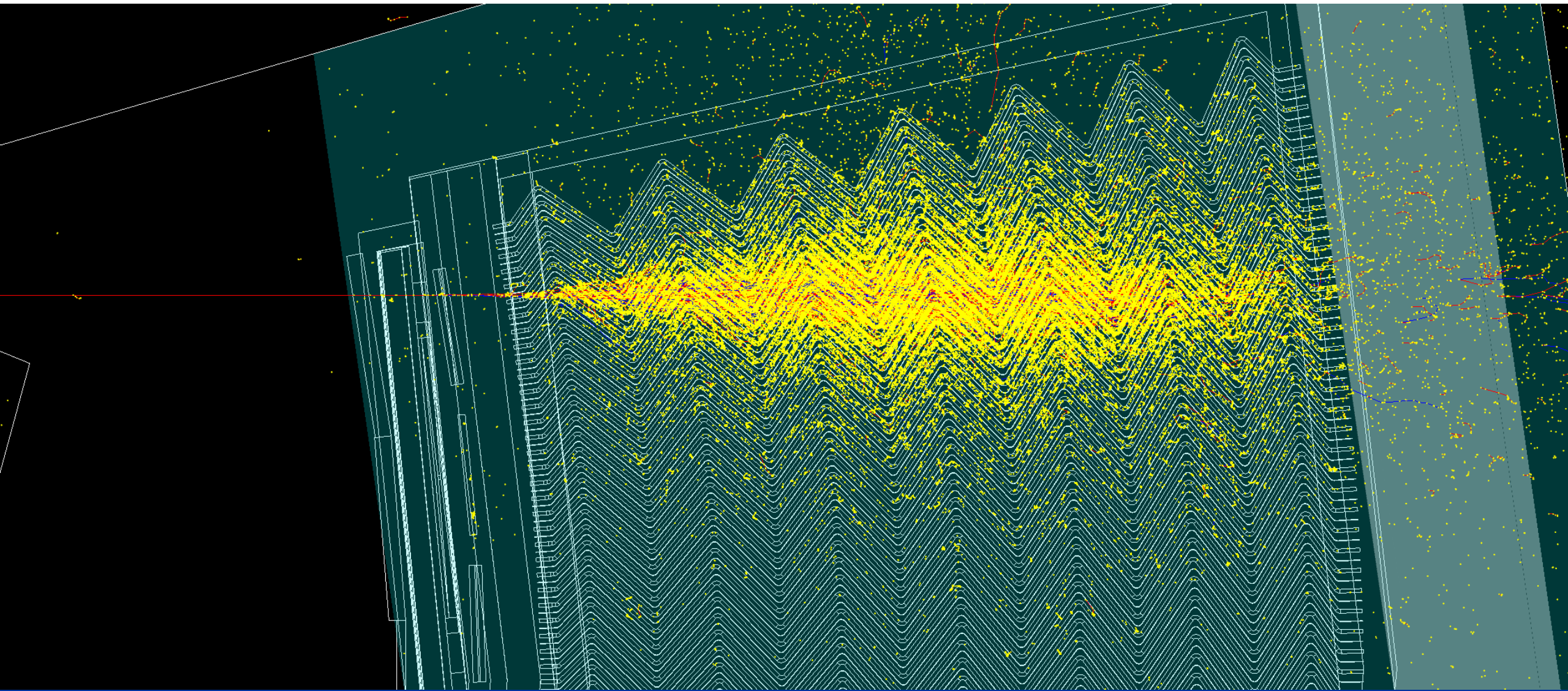


LAr + Presampler + EMB::STAC





# 100 GeV $e^-$ event display

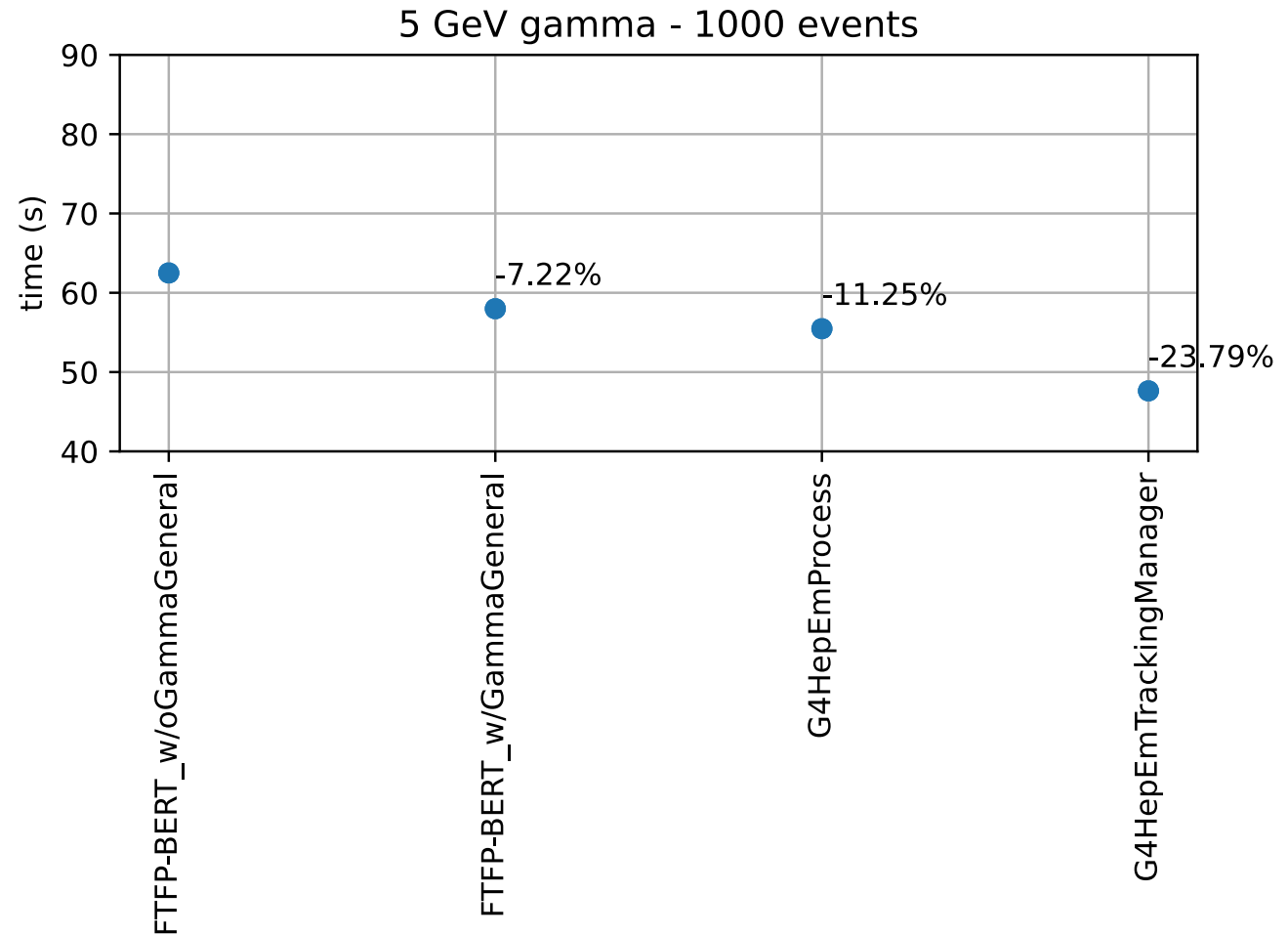




# Testing speedup solutions - G4HepEm

◆ 1000 events, 5 GeV  $\gamma$ :

- ✿ Using Geant4-11.1
- ✿ Time taken by G4Timer between BeginOfRunAction and EndOfRunAction.
- ✿ CPU: Apple M1 Pro @3.2 GHz, using a single thread.
- ✿ No SensitiveDetector, no hit, no SteppingAction, no EventAction.
- ✿ **Note:** GammaGeneral process is not included in G4HepTrackingManager nor in G4HepEmProcess.

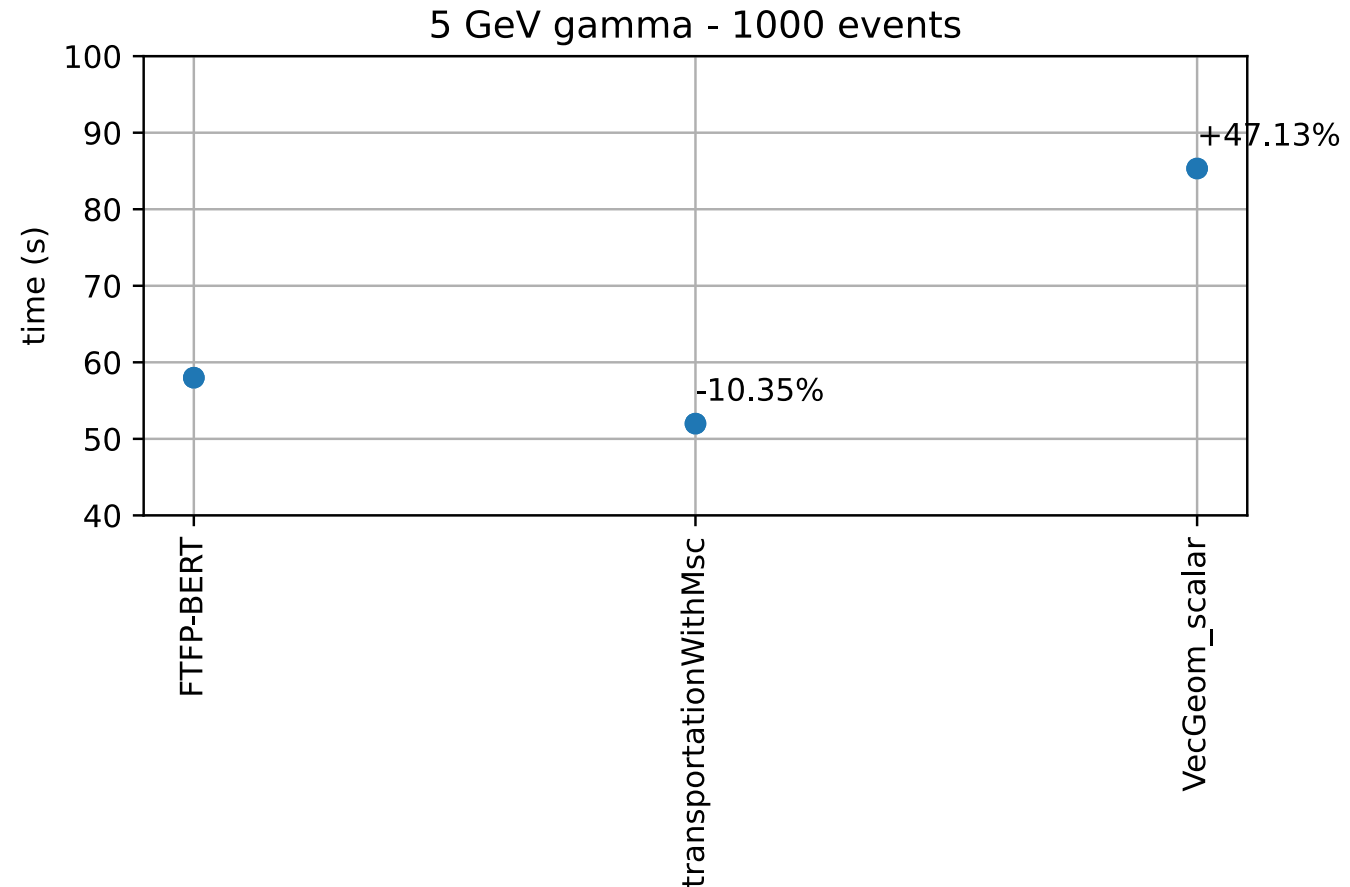


# Testing speedup solutions - Others

◆ 1000 events, 5 GeV  $\gamma$ :

- ✿ Using Geant4-11.1
- ✿ Time taken by G4Timer between BeginOfRunAction and EndOfRunAction.
- ✿ CPU: Apple M1 Pro @3.2 GHz, using a single thread.
- ✿ No SensitiveDetector, no hit, no SteppingAction, no EventAction.
- ✿ **Note:**  
We found that special cases of G4Trap to be less optimized in VecGeom.

Some of the G4Trap can be replaced with G4Box, in this optimized geometry VecGeom is 20.06% slower.





# Conclusion

- ◆ We believe it is possible to include a realistic ATLAS LAr Barrel validation test to geant-val:
  - ✿ geometry is done (and partially optimized G4Trap → G4Box),
  - ✿ need to understand how to implement realistic sensitive detectors and hits.
- ◆ We found impressive speed up, up to  $\simeq 24\%$ , using recently developed tools.
- ◆ Using VecGeom slows down the simulation, however the relative impact depends on the actual geometry implementation (it ranges from  $\simeq 20\%$  to  $\simeq 50\%$ ).
- ◆ The relative speedup/down is:
  - ✿ Consistent when executing the simulation on multiple threads, and
  - ✿ is crosschecked on an AMD Ryzen 3900 @3.1 GHz cpu.