GEANT4 simulation update for NPOD study

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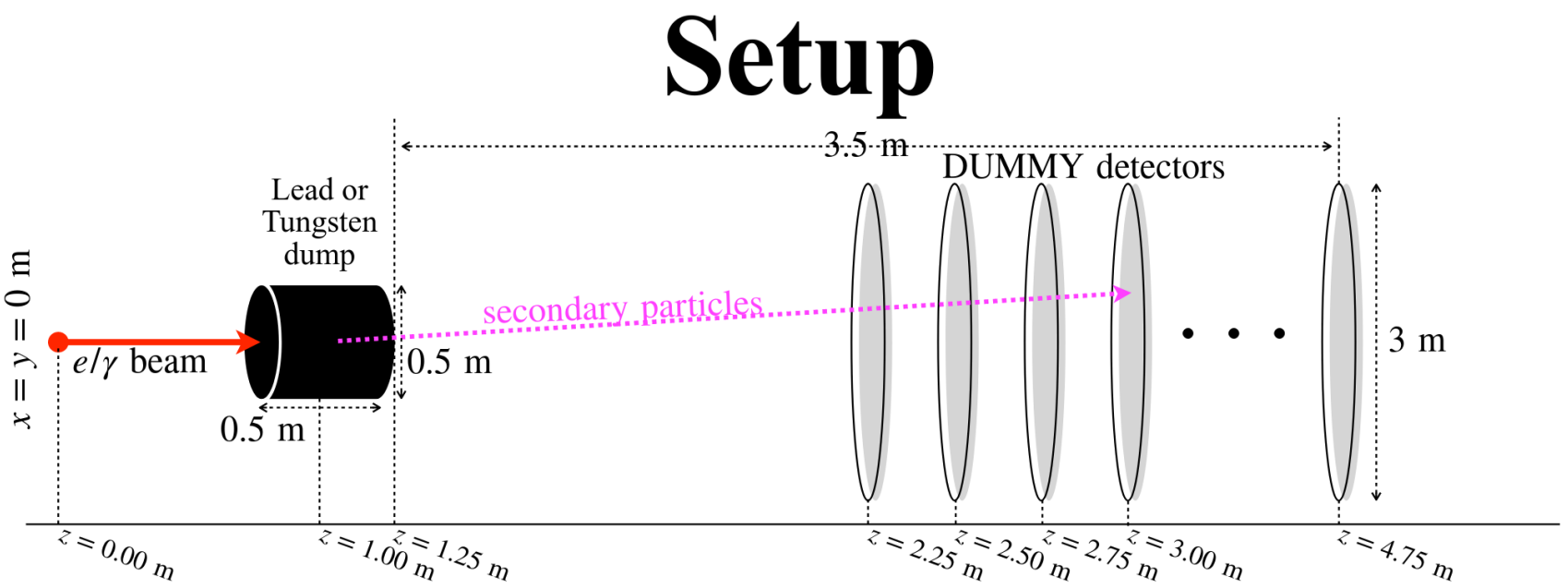
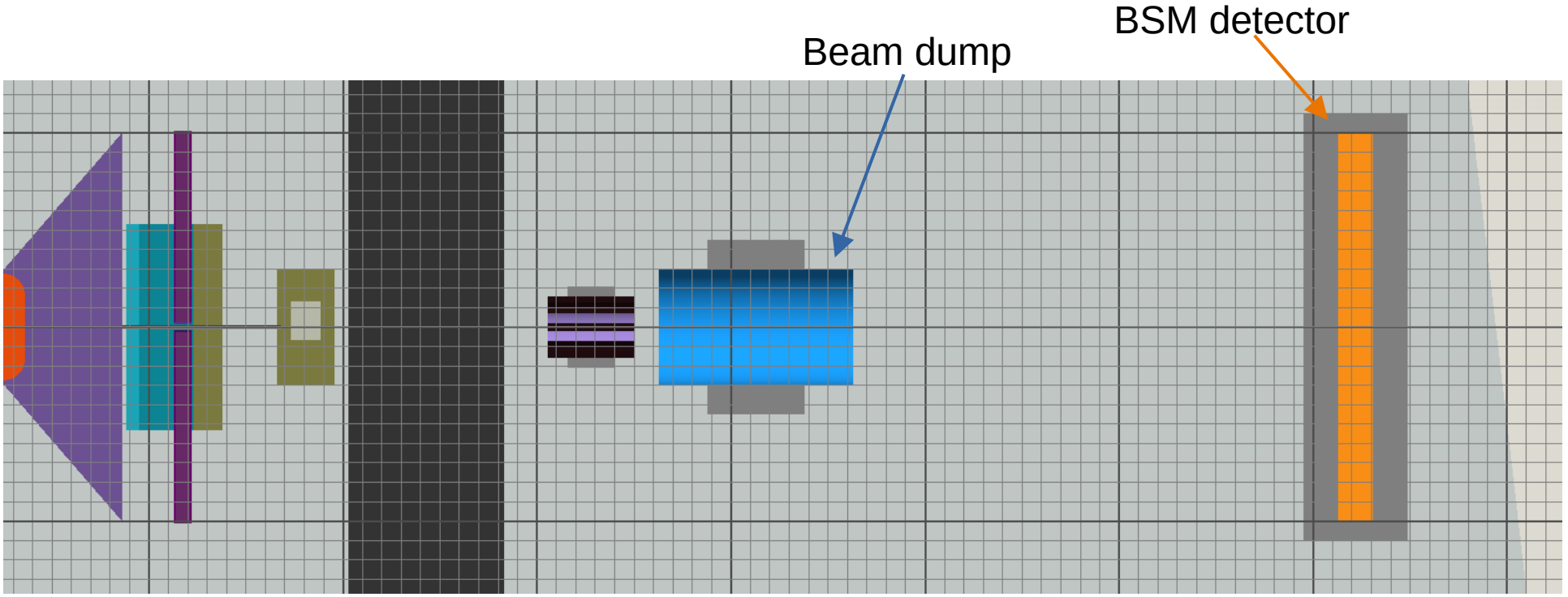
Conceptual LUXE BSM geometry

It was used to study the background and signal for the paper

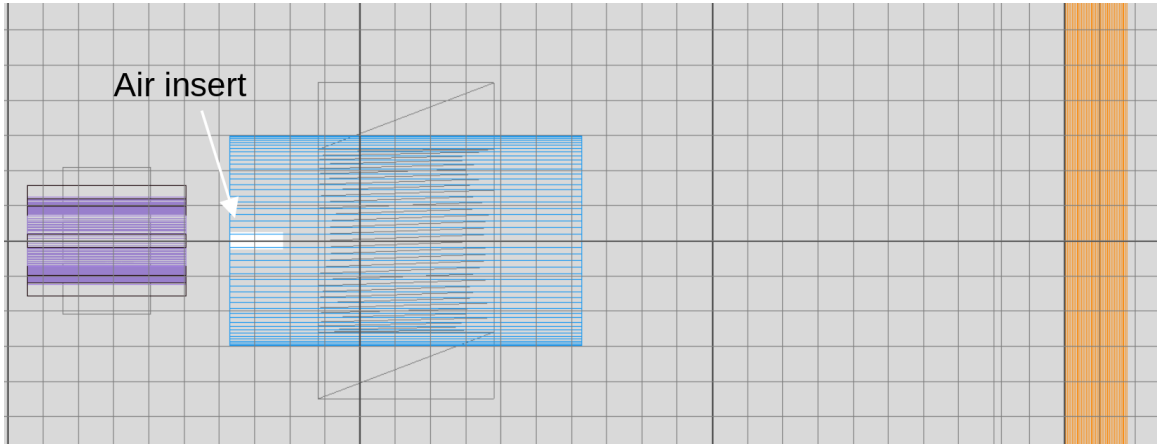


- World is in vacuum, dump is made of lead, several dummy disk-like detectors 0.25 m apart, 1 m after the dump end
- Shoot 1e10 photons with energy distributed according to the Compton photons resulting form the e+laser interaction with τ=120 fs, w_0=10 μm pulse (the new data from Tom)
- Distributions are normalised to one BX (recall that for the photon-beam discussed here: $N_{\gamma \text{ per } e} \simeq 3.5$)
- Particles are kept only if they traverse the dummy detector within $r(x, y) < 1$ m

Special geometry settings with the distance of 2.5 m between the beam dump and BSM detecor

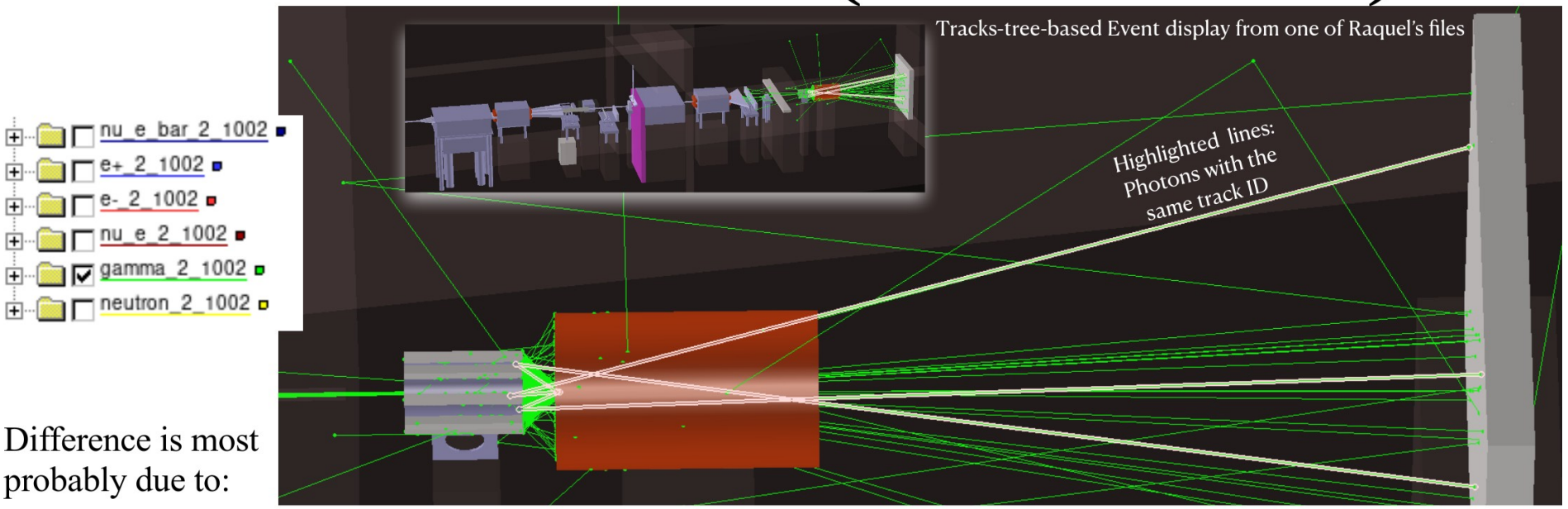


Regular geometry settings where the beam dump contains air insert



Event display of 1k Compton photon events

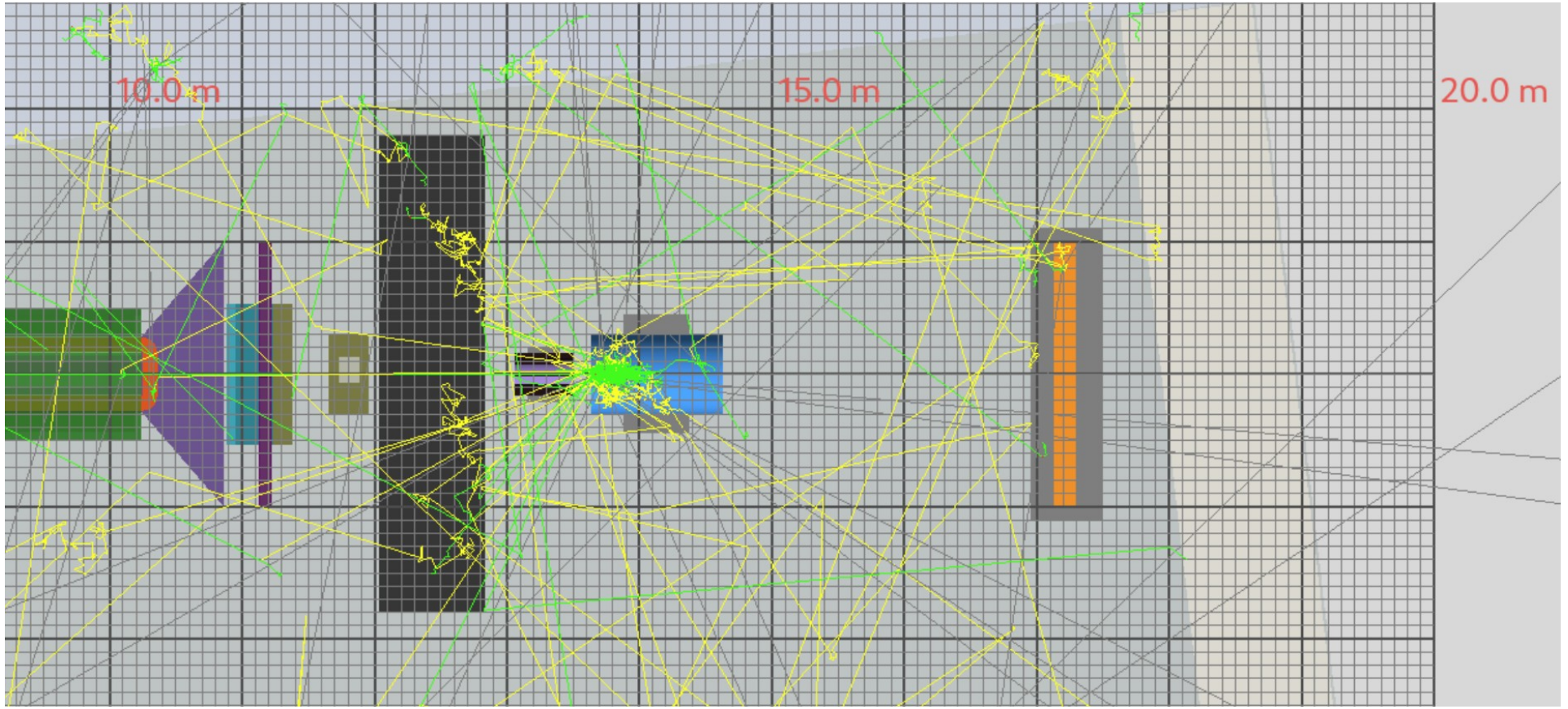
NPOD studies (Sasha: new)



Difference is most probably due to:

- photons produced very close to the beginning of the dump, backscattered to the negative z direction
- then re-scattered from other materials, e.g. the backscattering calo (wasn't in the pheno paper) to the positive z direction
- intermediate steps are not recorded in the Tracks tree so it appears as if the photons travel in the dump to the detector, but this is not the case
- As a quick and dirty crosscheck with the existing ntuples:
  - look at the number of secondaries of all photons produced in the dump as a rough proxy to the number of interactions
  - require that these photons have zero or at most 1 secondaries (what we see in the NPOD ntuples with the striped-off geometry)
  - this requirement reduces the number of photons by a factor of ~O(600) or ~O(20) respectively
  - most of these are ultra-low-energy photons (<1 MeV), but there will be some with higher energies

G4 16.5 GeV photon event



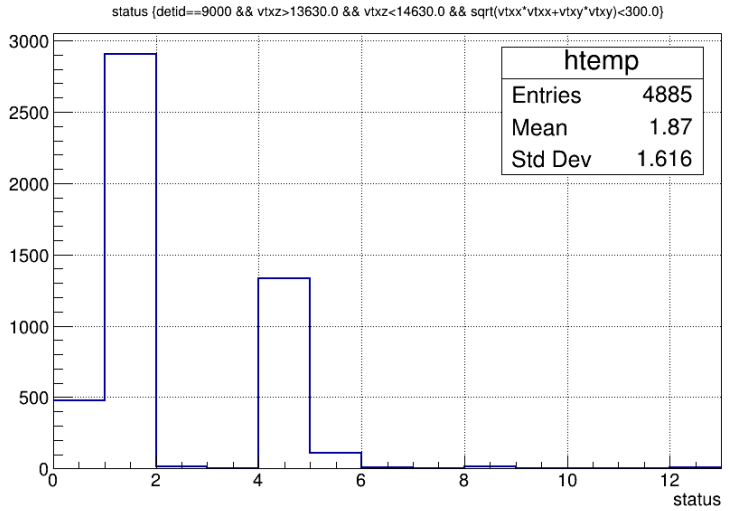
Tagging particles which escape from the the beam dump

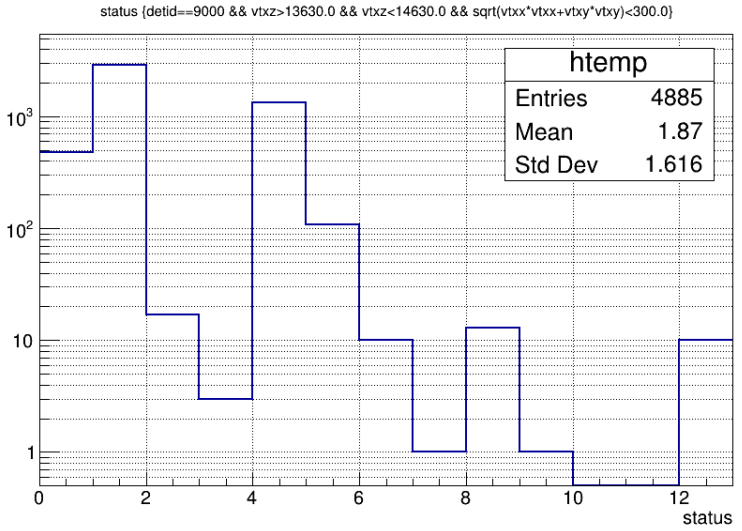
It was easy to implement particle tagging in simulation with modified BSM geometry:

- The status branch was added to the Tracks and HitTracks trees,
- It is 32-bits unsigned integer.

- Bit 0: particle exits the beam dump through the front plane;
- Bit 1: particle's parent (grant parent, any generation in the past) exited the beam dump through the front plane;
- Bit 2: particle exits the beam dump through the side surface;
- Bit 3: particle's parent (grant parent, any generation in the past) exited the beam dump through the side surface.

status branch in short test simulation with PTarmigan Compton photons





Summary

- High number of low energy particles observed in BSM detector are presumably related to the particles which reached the detector after interactions with materials of the LUXE setup including walls, shielding, etc;
- The tagging status branch was implemented in the Tracks and HitTracks for investigating the low energy particles in BSM detector;
- Similar strategy can be used to tag particles which were produced in ECAL by the neutrons which entered the volume of the calorimeter.

Acts

Acts – A Common Tracking Software

Reading LUXE geometry in Acts using ROOT TGeoManager:

```
#include <TGeoManager.h>
#include "CommonOptions.hpp"

#include <boost/program_options.hpp>

using namespace ActsExamples;

int main(int argc, char* argv[]) {
  // Setup and parse options
  auto desc = Options::makeDefaultOptions();
  desc.add_options()( "gdml-file",
                      boost::program_options::value<std::string>()->default_value(""),
                      "GDML detector file.");

  auto vm = Options::parse(desc, argc, argv);

  if (vm.empty()) {
    return EXIT_FAILURE;
  }
  auto gdmlFile = vm["gdml-file"].as<std::string>();

  TGeoManager *tgman = TGeoManager::Import(gdmlFile.c_str());
  if (gGeoManager) {std::cout << "Loaded geometry from " << gdmlFile << std::endl;}


  return 0;
}
```

Acts

Reading LUXE geometry in Acts using G4 GDML parser:

```
#include "GdmlDetectorConstruction.hpp"

#include <G4GDMLParser.hh>

using namespace ActsExamples;

GdmlDetectorConstruction::GdmlDetectorConstruction(std::string path)
    : G4VUserDetectorConstruction(), m_path(std::move(path)) {}

G4VPhysicalVolume* GdmlDetectorConstruction::Construct() {
  if (m_world == nullptr) {
    G4GDMLParser parser;
    // TODO how to handle errors
    parser.Read(m_path);
    m_world = parser.GetWorldVolume();
  }
  return m_world;
}
```

Part of Acts

"User" code in Acts examples:

```
GdmlDetectorConstruction *gdmldet = new GdmlDetectorConstruction(gdmlFile);
G4VPhysicalVolume *wvol = gdmldet->Construct();
```

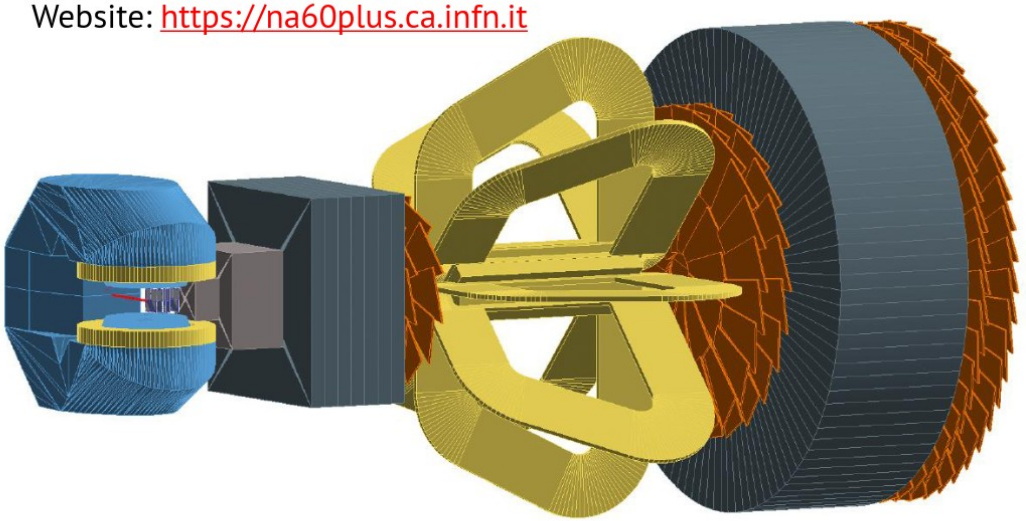
Acts GDML example

148th Meeting of the SPSC at CERN

A new heavy-ion collision experiment at CERN: NA60+

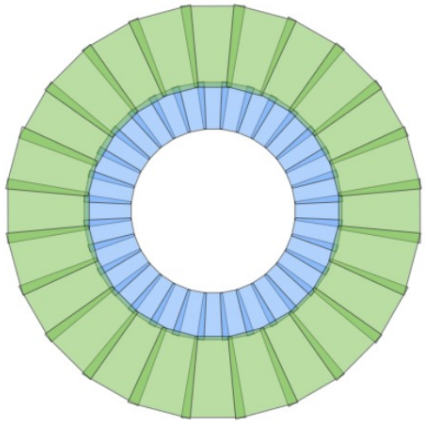
Letter of Intent: CERN-SPSC-2022-036 ; SPSC-I-259
(also arXiv:2212.14452)

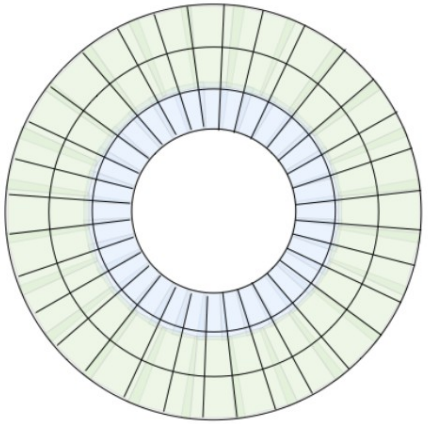
Website: https://na60plus.ca.infn.it



E. Scomparin (INFN Torino, Italy)
G. Usai (Università and INFN Cagliari, Italy)

`DiscLayer`
with two rows of modules





2-dimensional [r,phi] binning
(equidistant)

Acts manual

Backup