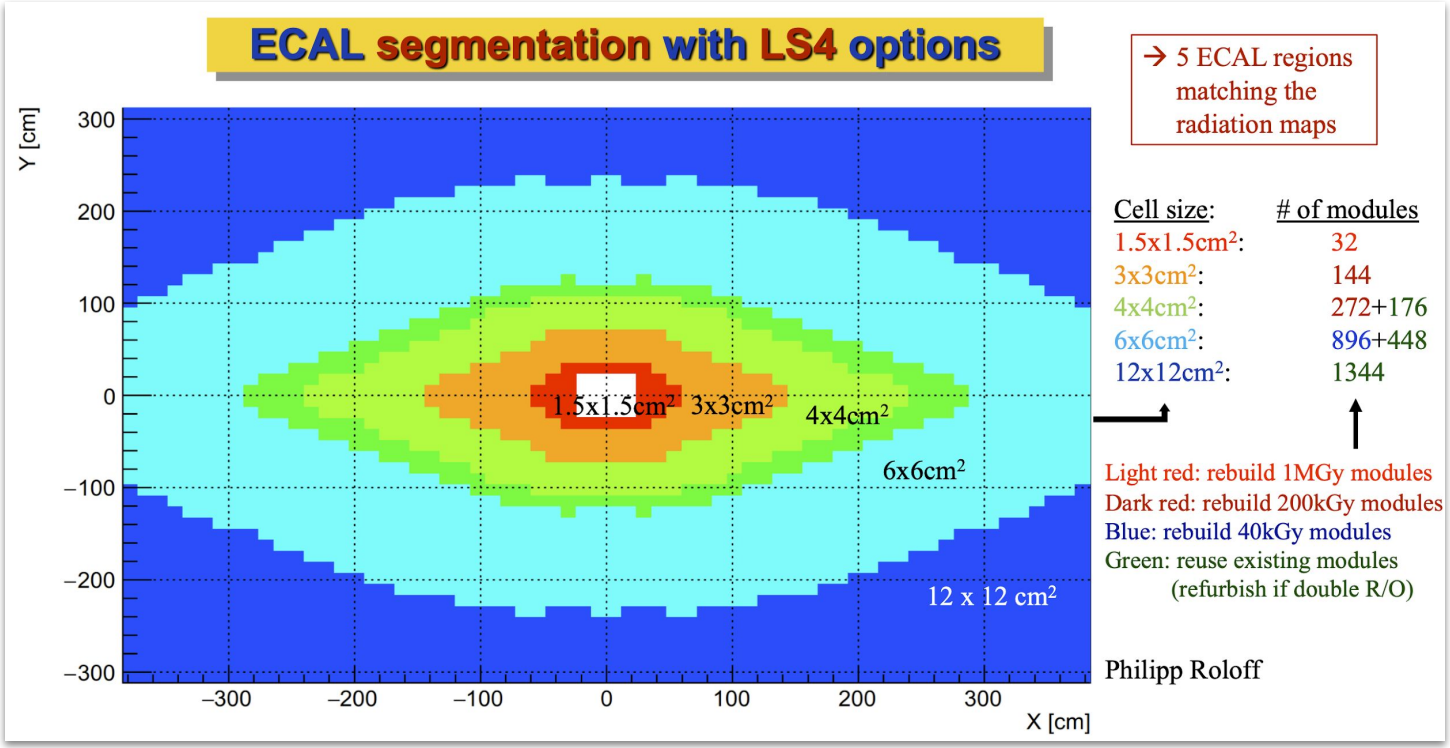
# Multiple module types

Up-scaling the Hybrid-MC framework is necessary to allow for the **full simulation of the entire ECAL**




Proposed layouts based on radiation maps

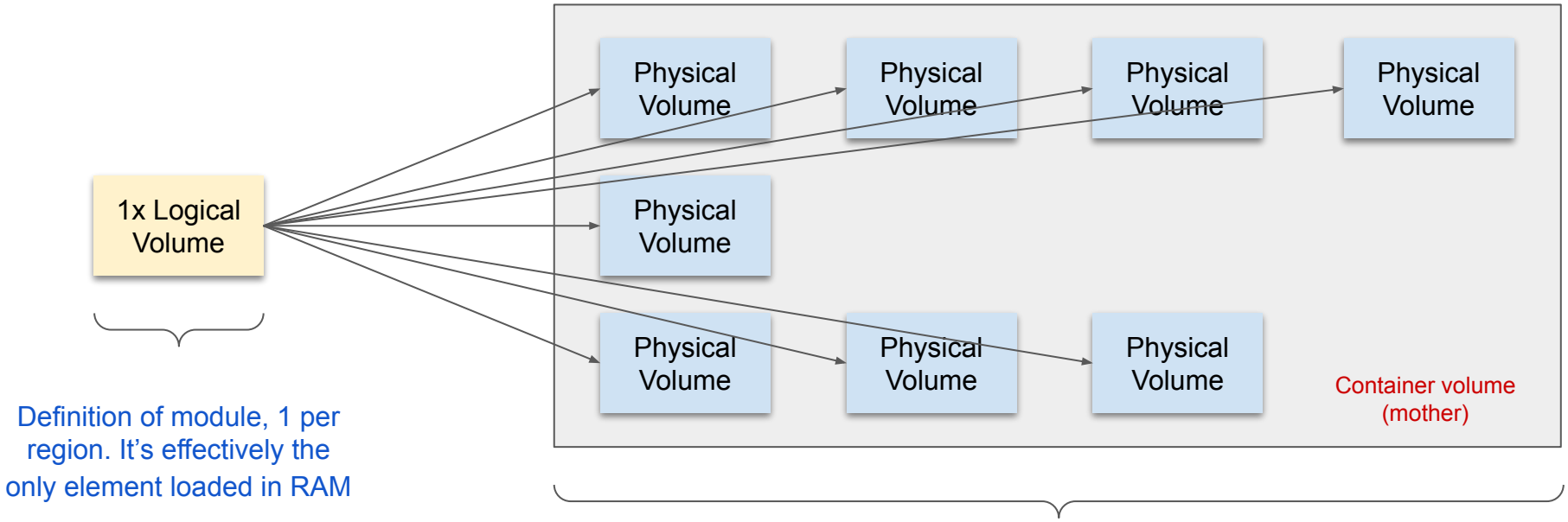
Modules differ among regions, in terms of technology (SPACAL, Shashlik, ...) granularity, crystals, etc..

*ECAL layout proposed by Philipp Roloff (https://twiki.cern.ch/twiki/bin/view/LHCb/SimRecEcalU2)*

marco.pizzichemi@cern.ch

# Multiple module types

➔ Creating each module individually in Geant4 is possible, but computationally prohibitive:
- ➢ 20-30 modules would already fill a typical 16 GB RAM space, and ECAL will have more than 3000 modules
- ➢ Need to **replicate modules**, nothing new in Geant4, but non trivial in our configuration



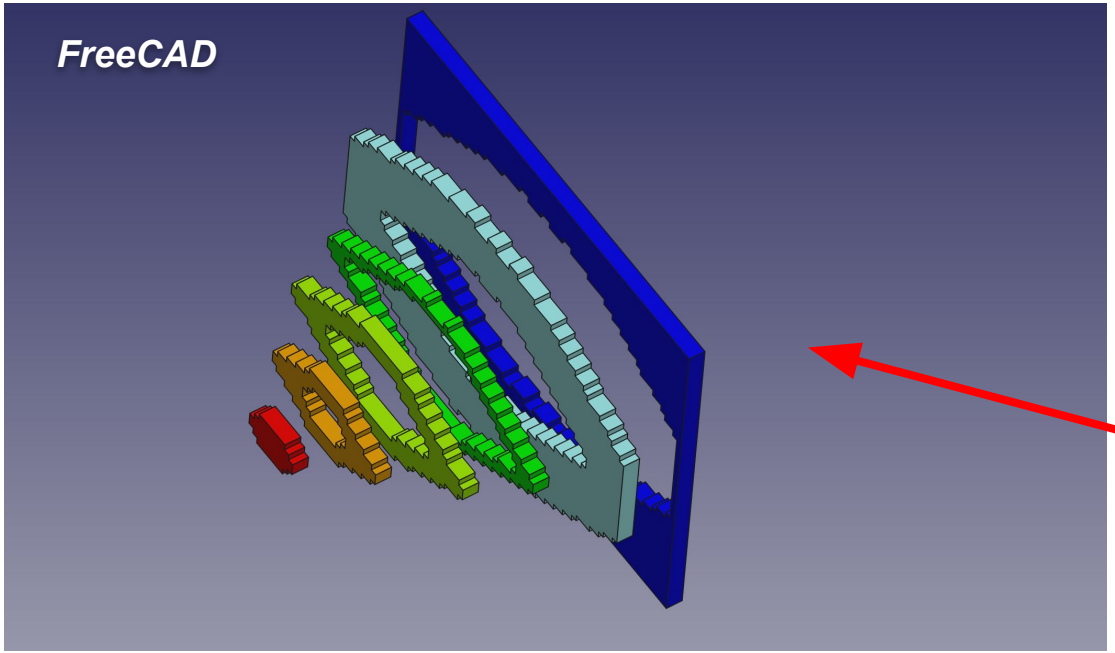

Definition of module, 1 per region. It's effectively the only element loaded in RAM

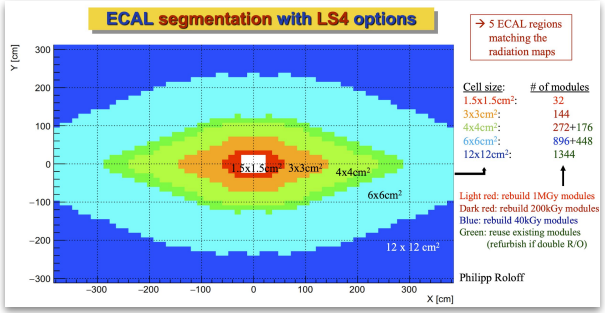
Several placements of the same module in a container volume.
**LIMITATION**: only 1 logical volume can be replicated in a container

marco.pizzichemi@cern.ch

# Multiple module types

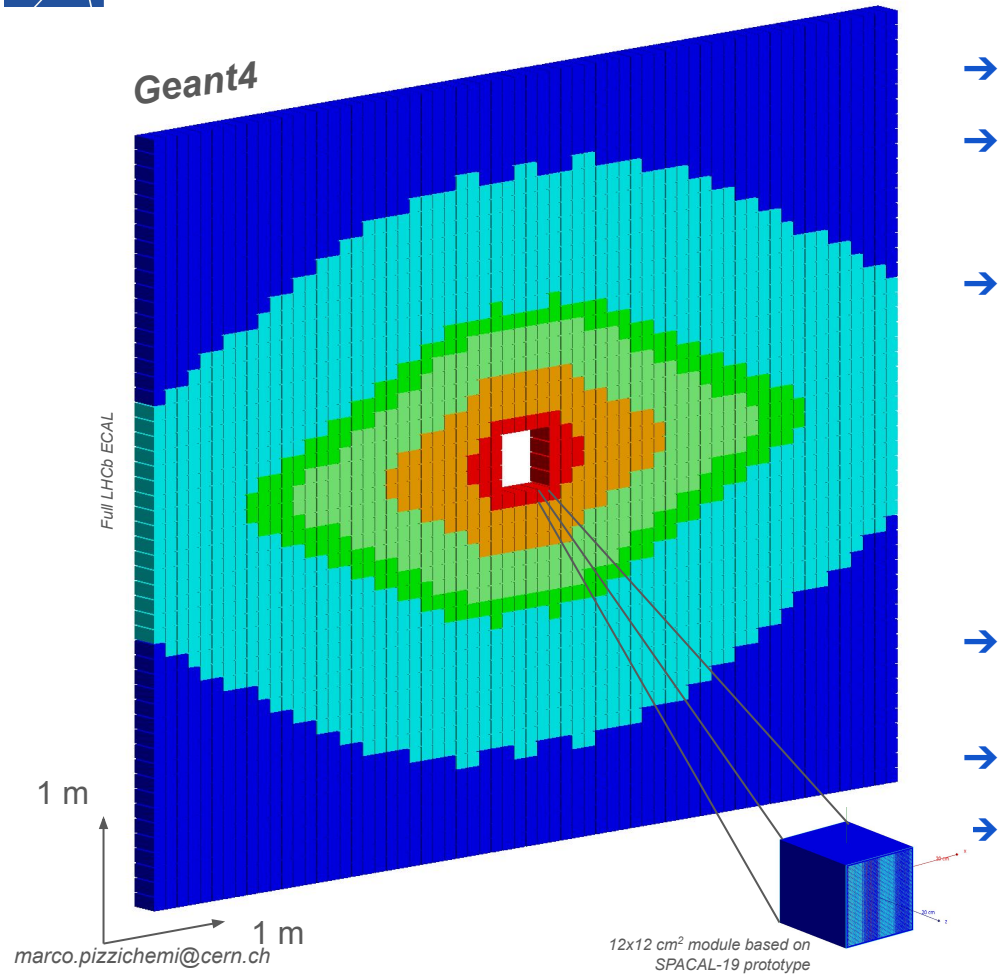
- We cannot place the 5(6) different Logical module in the same container (the calorimeter itself)
  - Calorimeter needs to be logically segmented in subvolumes matching the 5(6) regions
  - Basically impossible to create our 5(6) regions with boolean operations from basic geometrical shapes
  - Only solution is to **draw the regions in CAD** and import them in Geant4




Drawing with **FreeCAD**, but any CAD software is equally ok

# Multiple module types




- Importing in Hybrid-MC framework **implemented**
- User needs to provide the **CAD drawings** of the regions, and a **ROOT file** with ECAL layout
- Example of full ECAL geometry in Hybrid-MC
  - SPACAL-2019 (1.5 cm Moliere radius)
  - SPACAL with lead absorber (3 cm Moliere radius)
  - SPACAL with 2 mm crystal pitch, GAGG fibers
  - SPACAL with 3 mm crystal pitch, YAG fibers
  - SPACAL with 4 mm crystal pitch, GAGG fibers
  - SPACAL with 5 mm crystal pitch, YAG fibers
- 3312 modules, each 12x12 $cm^2$ , but **low RAM footprint** (3% of 16 GB)
- No impact on intrinsic simulation time
- SPACAL module class fully encapsulated -> it becomes “trivial” to add **other module structures** to the simulation, e.g. Shashlik

marco.pizzichemi@cern.ch