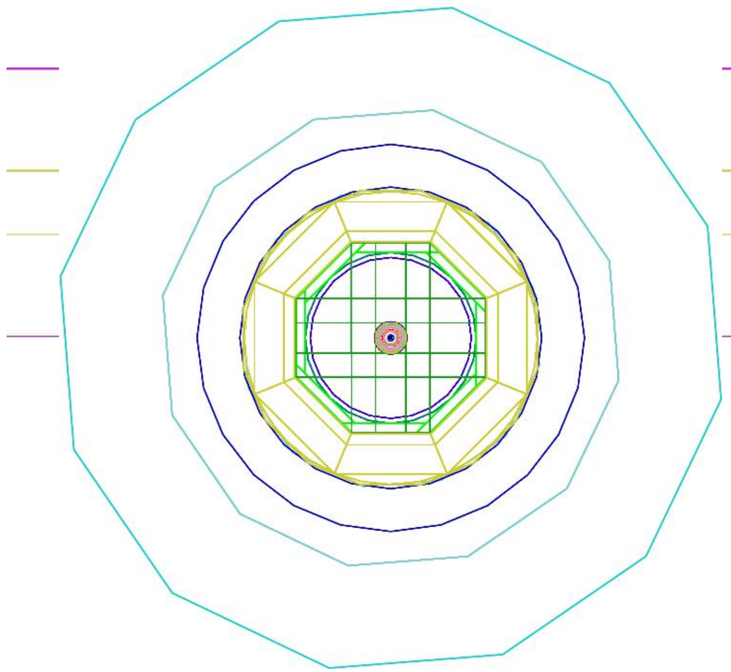
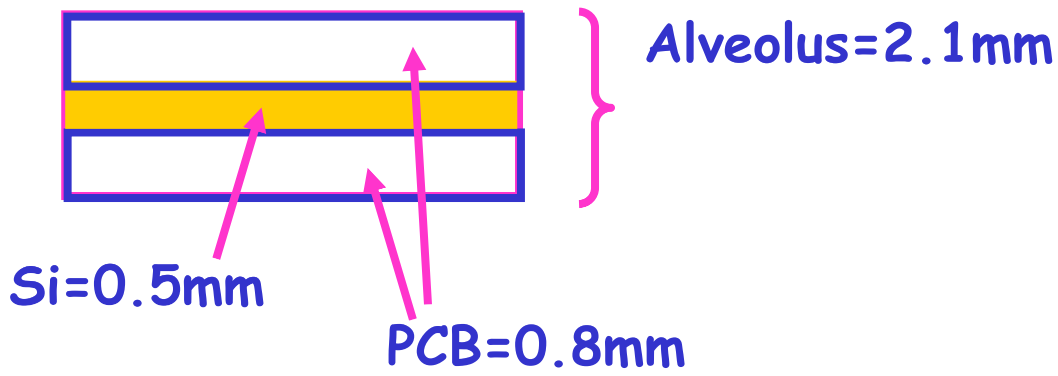
Geant4 Simulation of MAPS

- Geant4/Mokka application has flexible way to change Si thickness, pixel size ☺
- Thickness: default is 500μm, "sensitive" and "physical" equivalent
  - Need to separate these two, initially 20μm sensitive, 480μm substrate (easier comparison with standard simulation)
- … But only 1 x 32-bit int used for encoding "cell ID"
- OK for 1cm^2 pixels, ~4.10^7 in whole detector
- Number of MAPS sensors >2.10^9
  - Need 2 ints

- Want flexibility to study varying pixel size and digitisation efficiently
- Simulation of detector/interactions much slower than digitistion, so 2 stage process
  1. Simulate detector
  2. Implement digitisation as pre-processor to analysis/reconstruction
- Several possibilities…

Alveolus in LDC01/Ecal02





- Simple layer structure
- Sensitive and physical Si equivalent

SimCalorimeterHit

- Public Member Functions

virtual int getCellID0 () const=0

Returns the detector specific (geometrical) cell id.

virtual int getCellID1 () const=0

Returns the second detector specific (geometrical) cell id.

virtual float getEnergy () const=0

Returns the energy of the hit in [GeV].

virtual const float * getPosition () const=0

Returns the position of the hit in world coordinates.

virtual int getNMCParticles () const=0

Returns the number of MC contributions to the hit.

virtual int getNMCContributions () const=0

Returns the number of MC contributions to the hit.

virtual float getEnergyCont (int i) const=0

Returns the energy in [GeV] of the i-th contribution to the hit.

virtual float getTimeCont (int i) const=0

Returns the time of the i-th in [ns] contribution to the hit.

virtual int getPDGCont (int i) const=0

Returns the PDG code of the shower particle that caused this contribution.

virtual MCParticle * getParticleCont (int i) const=0

Returns the MCParticle that caused the shower responsible for this contribution to the hit.

SimTrackerHit

- Public Member Functions

virtual int getCellID () const=0

Returns the detector specific (geometrical) cell id.

virtual const double * getPosition () const=0

Returns the hit position in [mm].

virtual float getdEdx () const=0

Returns the dE/dx of the hit in [GeV].

virtual float getTime () const=0

Returns the time of the hit in [ns].

virtual MCParticle * getMCParticle () const=0

Returns the MC particle that caused the hit.

virtual const float * getMomentum () const=0

Returns the 3-momentum of the particle at the hits position in [GeV] - optional, only if bit LCIO::THBIT_MOMENTUM is set.

Option 0

- Reduce (sensitive detector) pixel size, treat each MAPS sensor ~$50x50\mu m^2$ pixel as SimCalorimeterHit
- Need to implement 2 x CellIDs
- Class provides hit position (world coordinate system) at cell centre
  - Problem: need position ~$5x5\mu m^2$ to use Giulio's efficiency mapping
  - Had originally planned to apply this in simulation (which *may* have been easier)

Option 1a

- Do not reduce (sensitive detector) pixel size, keep simulated segmentation as 1x1cm^2
- Use SimTrackerHit class for hits in epi-layer
  - Retain exact hit position in LCIO output file
- Apply Giulio's mapping in analysis
- Use the same, single CellID for all MAPSTrackerHits in same 1x1cm^2 pixel (can be used to determine cell centre via CGA)
- Use position as local coordinates in reference frame of 1x1cm^2 pixel
  - Very easy to apply efficiency mapping ☺
  - Need to provide modified methods for e.g. event display tools ☹
  - Need to either use CGA to convert from CellID to world coordinates, or generate associated SimCalorimeterHit in Si substrate
  - Easy to relate individual hits from same pixels (int comparisons)

Option 1b

- Do not reduce (sensitive detector) pixel size, keep simulated segmentation as 1x1cm^2
- Use SimTrackerHit class for hits in epi-layer
  - Retain exact hit position in LCIO output file
- Apply Giulio's mapping in analysis
- Use single CellID to define which 5x5μm^2 area track hits
- Use position as world coordinate of hit
  - Very easy to apply efficiency mapping ☺
  - No need to provide modified methods for e.g. event display tools ☹
  - Difficult to relate hits from same MAPS pixel or 1cm^2 pixel – need to know about rotations, etc. of whole detector, many fp comparisons

Option 1c

- Do not reduce (sensitive detector) pixel size, keep simulated segmentation as 1x1cm^2
- Use SimTrackerHit class for hits in epi-layer
  - Retain exact hit position in LCIO output file
- Apply Giulio's mapping in analysis
- Use single CellID to define which 5x5μm^2 area track hits
- Use position as world coordinate of CENTRE OF 1X1cm^2 CELL
  - Very easy to apply efficiency mapping ☺
  - No need to provide modified methods for e.g. event display tools ☹
  - Less difficult to relate hits from same MAPS pixel, but need to get coordinates of 1cm^2 cell for each MAPS hit