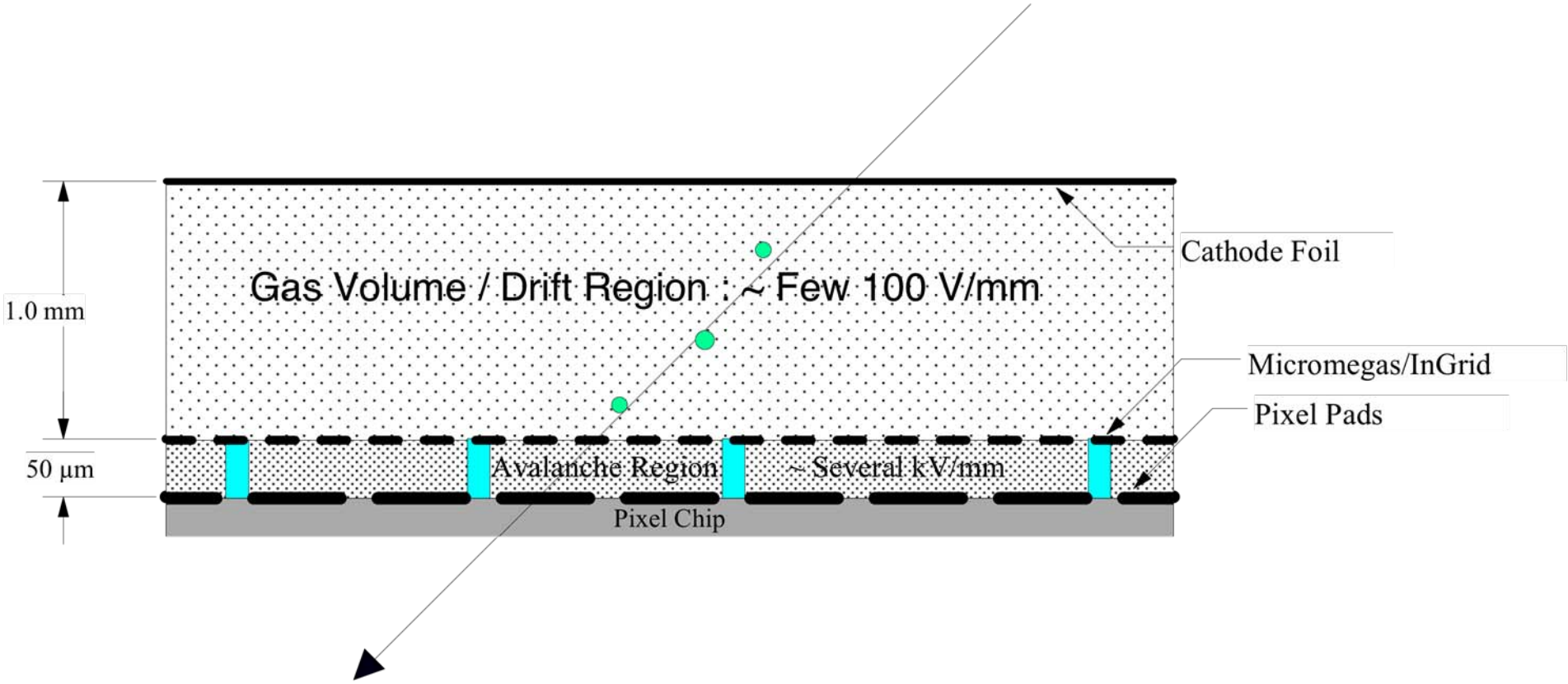
Simulation of GOSSIP/GridPix Nominal Detector, and GOSSIP in ATLAS

GOSSIP BASICS:

(In case you aren't already familiar with it…)

Gas On Slimmed Silicon Pixels



Simulating hits: 4 Steps

1. Use MagBoltz and Heed (From Garfield) to generate electron liberation stats and transport properties for a specific gas [mixture].

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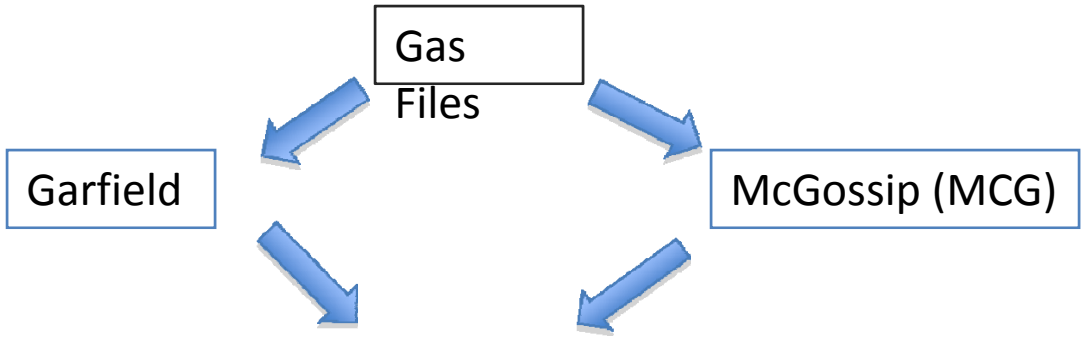


Simulating hits: 2 Generate Tracks

Garfield

- Very mature.
- Very Realistic.
- Includes streamers (delta rays).
- Includes ‘Zero diffusion’.

MCG

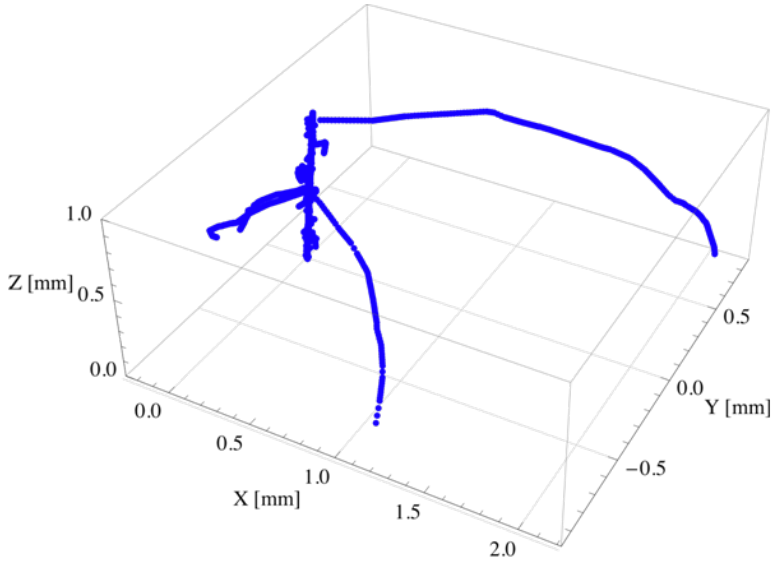
- Very Fast, but:
- Only uses Heed / MagBoltz stats to approximate Garfield (Heed) process.
- No streamers.
- All electrons are created exactly along the track.

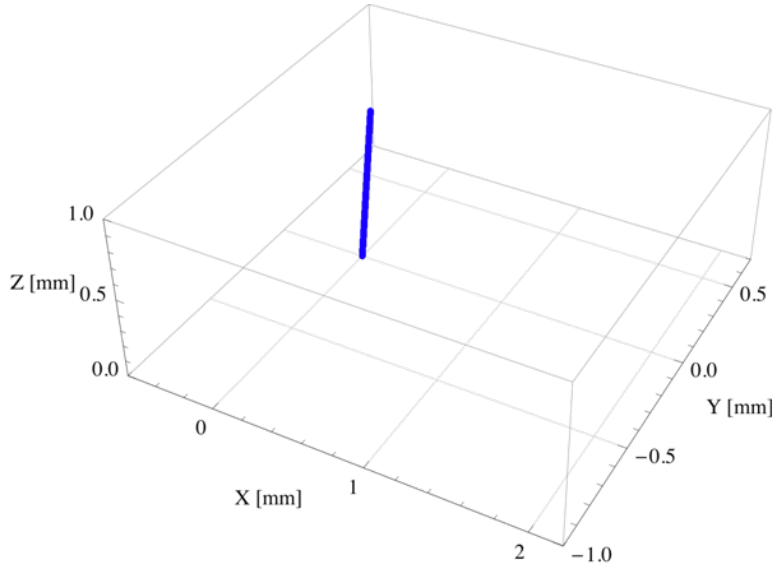
Simulating hits:

Garfield

MCG

Compare electron production: Deltas
DirCos [0.1, 0.0, 0.99]





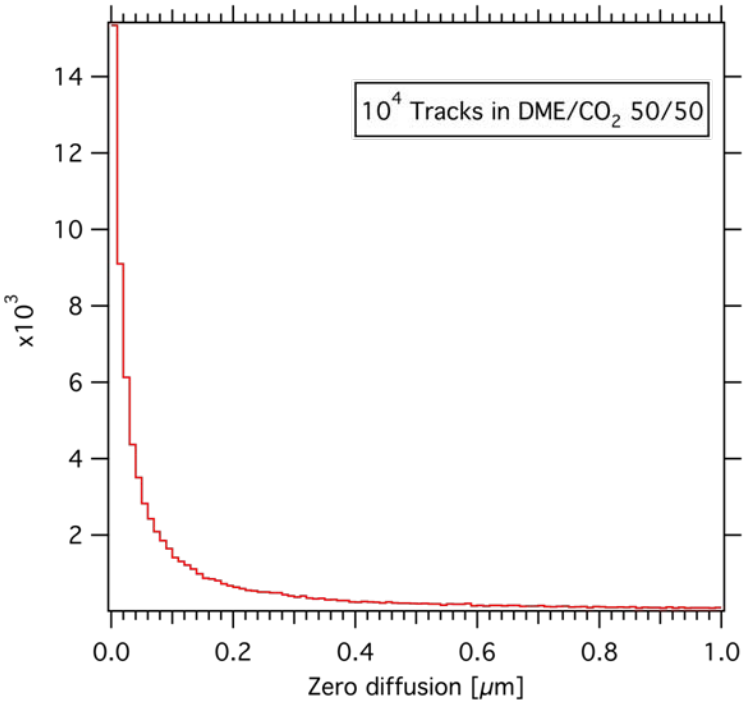
1000 Tracks

Simulating hits:

What about zero diffusion?

Garfield

- Typically < 200 nm



MCG

- Completely Ignored

N/A

Simulating hits: 3 Drift.

Step 3: Drift electrons to grid.

Garfield

MCG

• Compute, microscopically, interactions for drifting electrons to get drift time. (SLOW, but very realistic).

• Can also do it stochastically.

• Compute drift time using transport properties from MagBoltz.
vDrift: [Vx, Vy, Vz]
Diffusion μm/√cm [σ_x σ_y σ_z]

• Very fast.

Simulating hits: 4 Read out.

Step 4: Calculate gain and run shaper.

- MCG or MATLAB script: Iterate over all electrons in a track (event).

1. Does electron make it through the grid?: P~(1-E_{drift}/E_{gain}).
2. Calculate gain (Polya dist.).
3. Which pixel?
4. Add charge to array in correct time bin for pixel, add ion tail.
5. Convolute with shaper function.
6. Convolute some noise with d(shaper)/dt, add to shaped signal.
7. Find TtoT, ToT, once all the electrons have been accounted.
8. Write out hits.

At the End of the Day:

- MCG good for quickly exploring large parameter spaces.

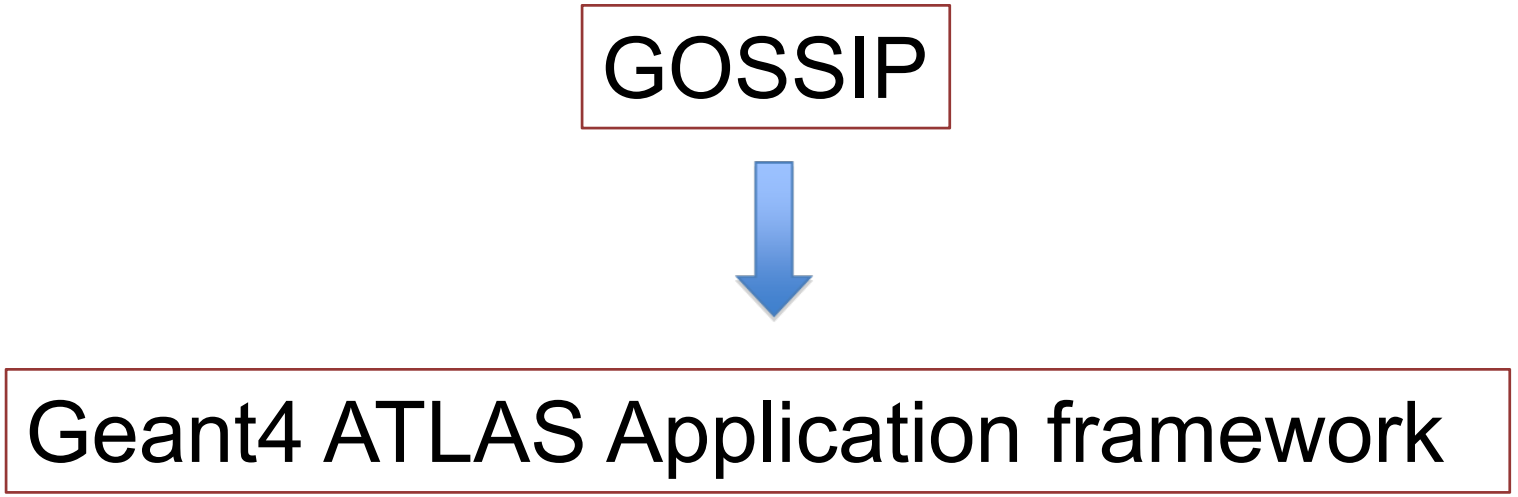
- Garfield is what you want when you find the region of parameter space where you want to look more closely.

- Currently assume constant E field in drift and gain gaps.

  Need to include the actual E field configuration in GOSSIP, and especially around the grid. This should be done with garfield and an FEM package.

Next Task:

- Simulate GOSSIP for the ATLAS upgrade.



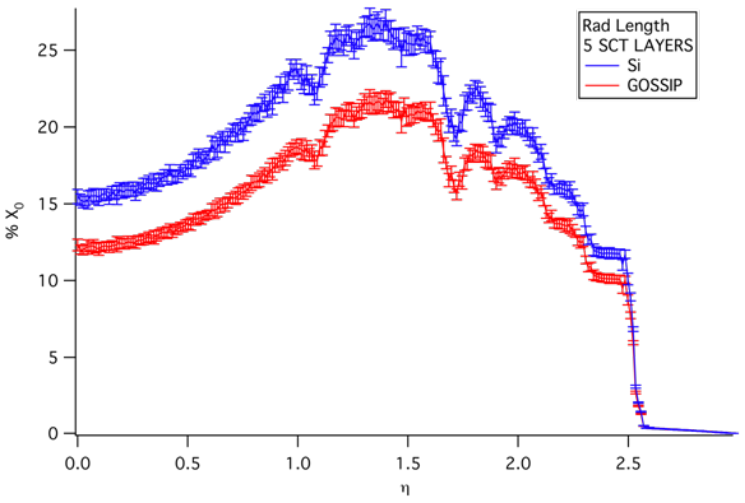
Scheme of Geant4 Atlas Apps

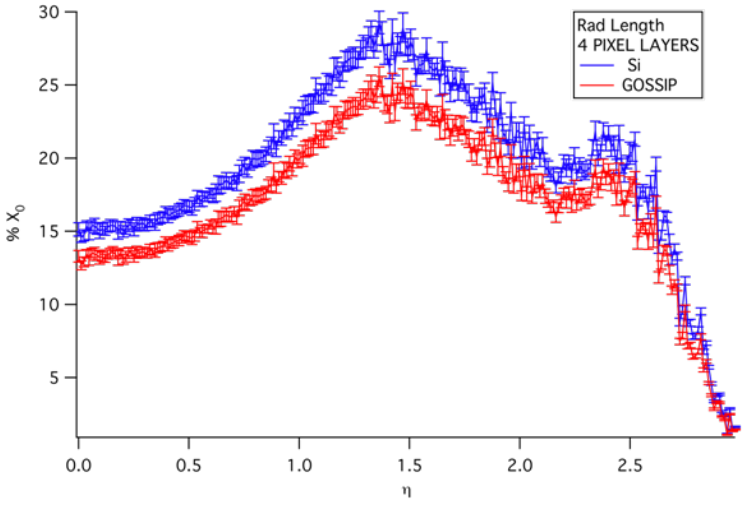
1. Define detector geometries and materials.
2. Simulate high energy particles passing through material -> Energy loss + location.
3. Digitise: Simulate detector output, given info from G4. -> Hit with coordinate.
4. Tracking routines.

- Already, after 2 working days, G4AtlasApps seem to be quite flexible:

  Can change material, density, dimensions of ID elements.

- Good for looking at material budget.



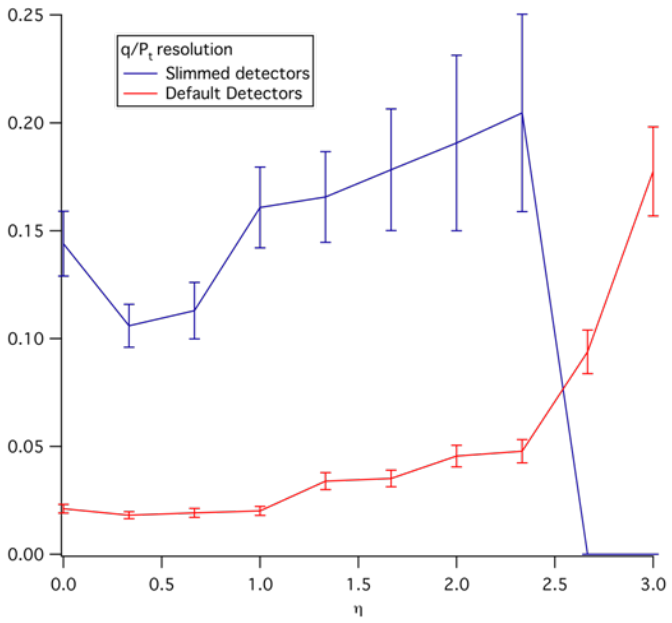


- But tracking not working properly.

Geant4 makes hits in the gas or slimmed Si.

BUT:

Digitisation not quite compatible (losing hits in pixel layers).



q/P_t Resoution Vs. η

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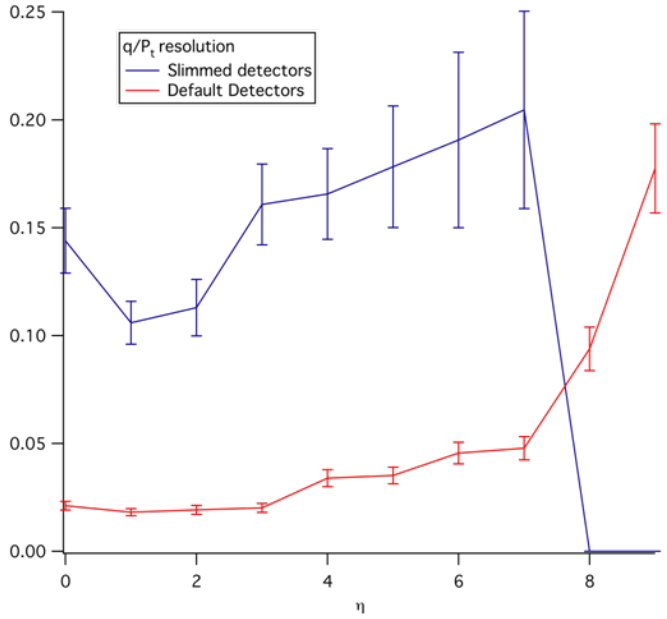

That's OK!

Already more than I expected at this point.

To Do for GOSSIP in ATLAS G4 Atlas Apps

- Define proper geometry elements for GOSSIP to replace pixel layers, SCT.

- Completely re-write digitisation routines.

Some aspects already fairly well developed from MCG

Summary

- Simulation of nominal GOSSIP fairly well developed.
- Could still benefit from proper E-field modeling and avalanche simulation. => Go with Garfield + FEM.
- Integration into the existing G4 Apps is next step, work is under way.