Simulation Acceleration Efforts

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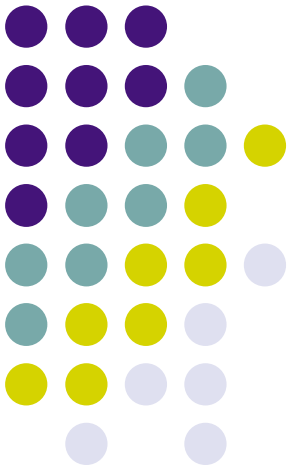
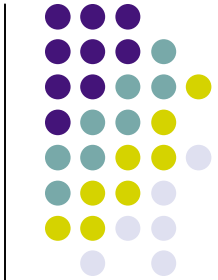
SLAC Physics Retreat

5 March 2007



Our Shared Problem

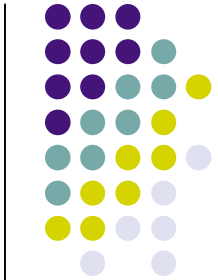


- ATLAS wishes to simulate 20% of the data
- The simulation is 4-5x slower than estimated
- Right now that means 5% of the data will be simulated
- We should work towards a faster simulation, and it MUST be a many-pronged approach
  - One solution will not work for everyone
  - Some groups can take performance degradation
  - Some studies just need something *fast*

Searching for a Solution

- Two general approaches will be (briefly) discussed
  - Top down: start with our (G4) simulation and make it faster
    - Parameterization, Shower Libraries, Sim Core
  - Bottom up: create a “new” simulation (very much ATLAS based) that you *know* will be faster
    - ATLFAST II, FATRAS (?)
- Generally speaking, the second will tend to be much faster and the former will tend to be more accurate
  - Again, it’s not always clear how accurate is “sufficient”
  - I hope there are exceptions to that rule!!

Top Down: First Questions



- Where is all that time going??

Element	Per Event [s]
Pixel	3
Tracker	39
EMB	105
EMEC	482
Tile Cal	28
HEC	44
FCal	147
Muon Sys	60
Other Sys	109
Total Event	**1018**
e+/-	445
gamma	291
other particles	282

Calorimeters = 75%!

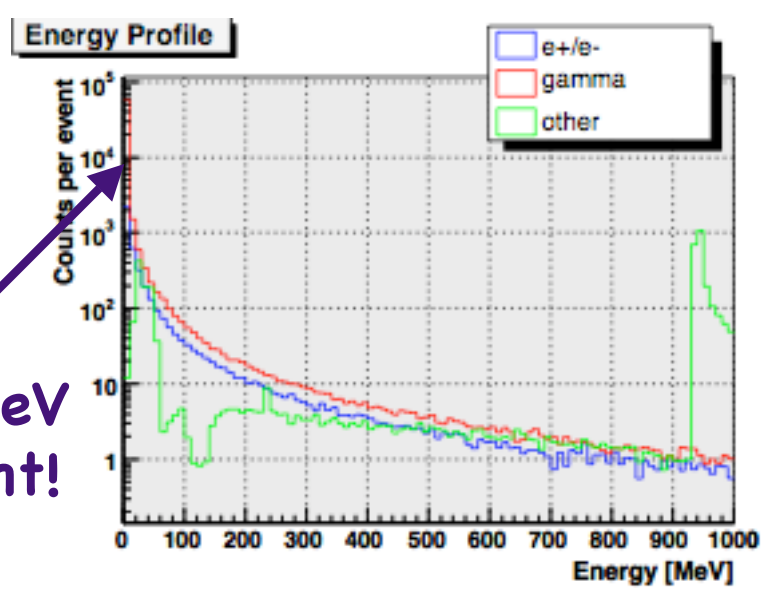
EM Showers = 75%!

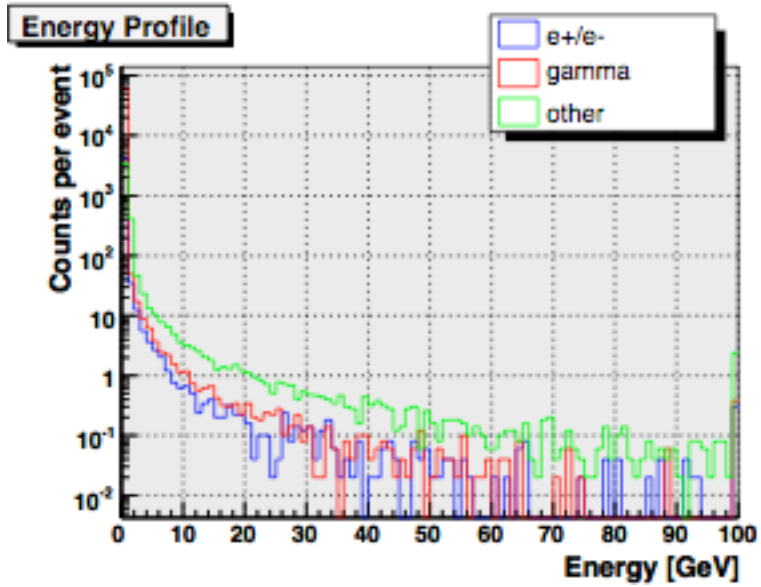
Dijet Event (CSC J5 005014)

Our first thought:
Parameterize showers!

Parameterizing Showers

- We use a parameterization based on Grindhammer & Peters hep-ex/0001020, good down to about 1 GeV
- But are those the particles we're working with???

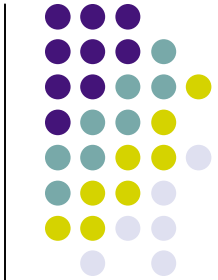




10^5 <10 MeV γ per event!

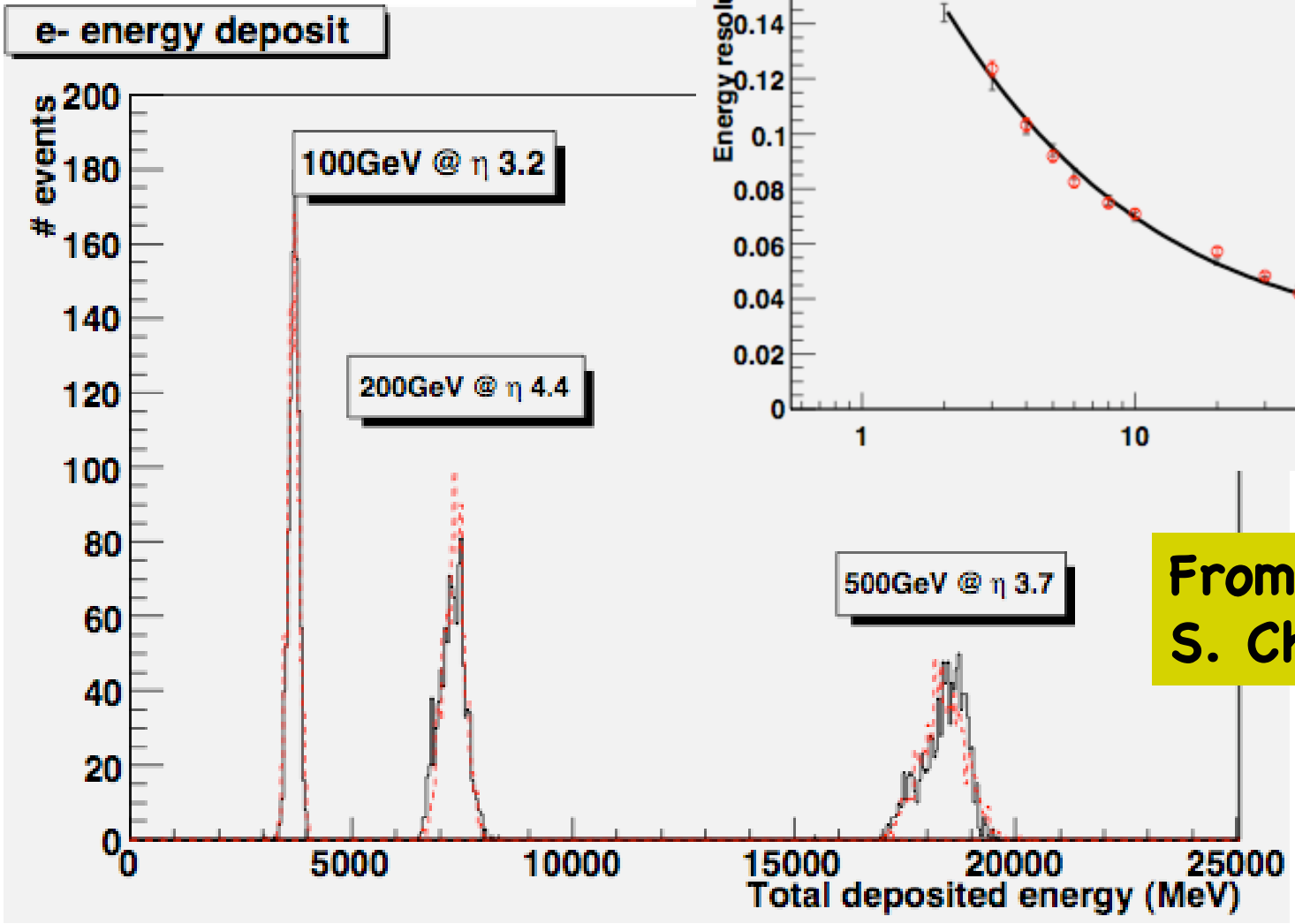
Energy of particles ***entering*** the (EMB, EMEC, FCal) in a Dijet Event (CSC J5 005014)

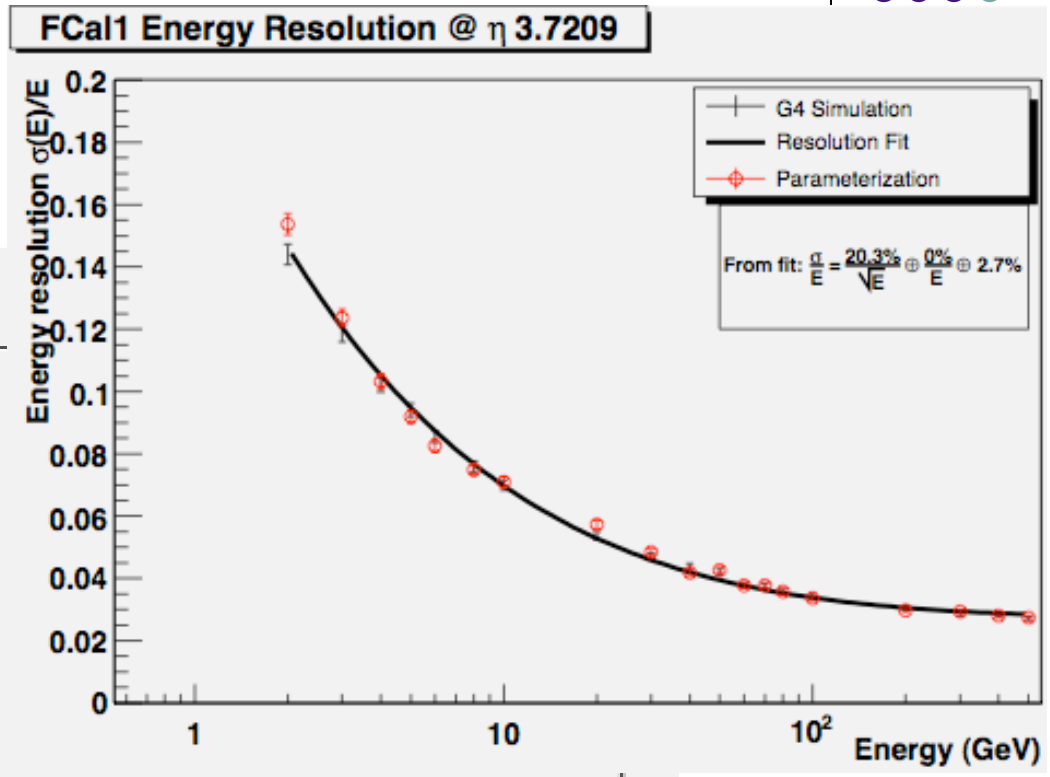
What Else Can We Do??



- Dealing with high energy particles in the calorimeter is insufficient
  - We're trying to apply shower libraries for $e^{+/-}/\gamma$ below 1 GeV
- Even if the calo time is reduced to zero, we only get a factor of 4!
  - We need to worry about other options, tricks, and *detectors*
- Revise our goal:
  - Have a baseline set of changes we believe will not affect physics performance in any way
  - Have a series of knobs (switches?) a user can turn to sacrifice some physics in favor of performance

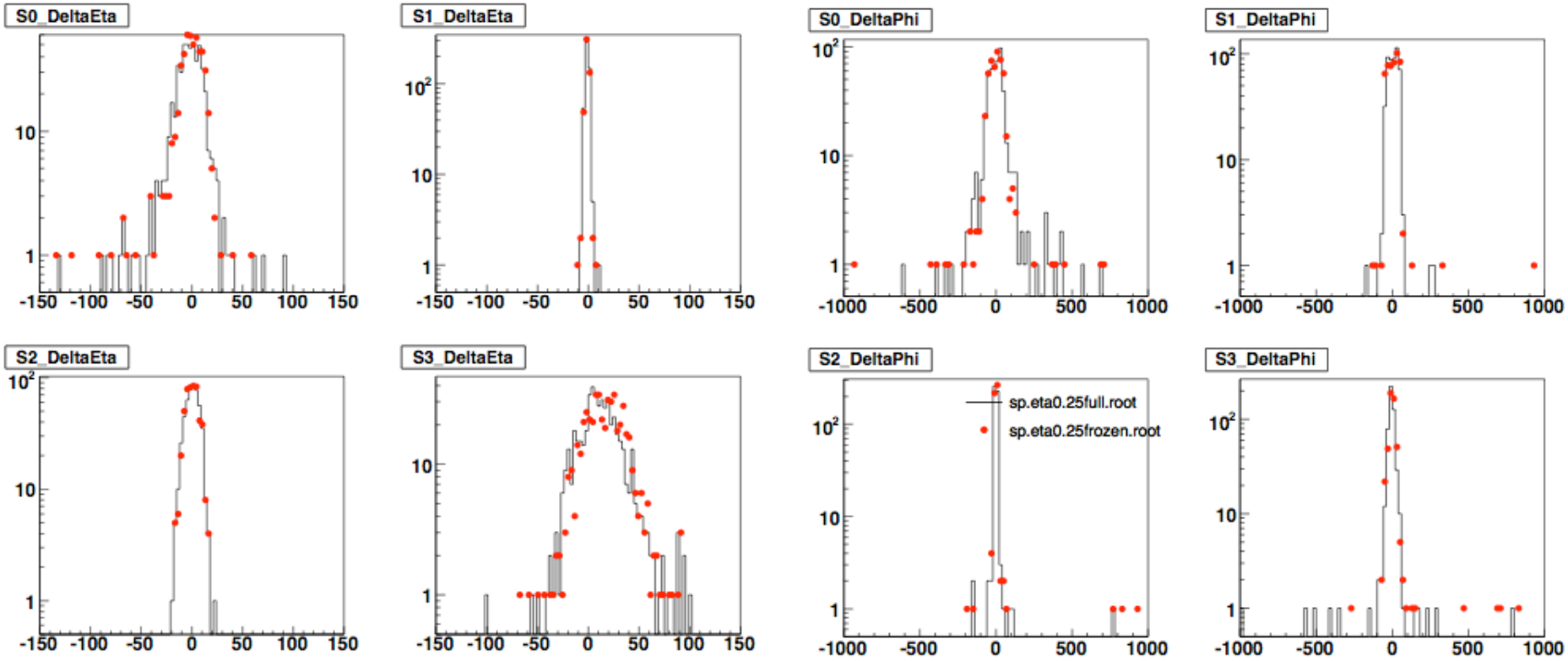
FCAL Layer 1 (EM) Parameterization





From Talk by S. Cheung

EMB - Simulation Level - Resolution



→ resolution in η and ϕ looks good

N.B.: 5% Energy deposition problem from this talk was just fixed!

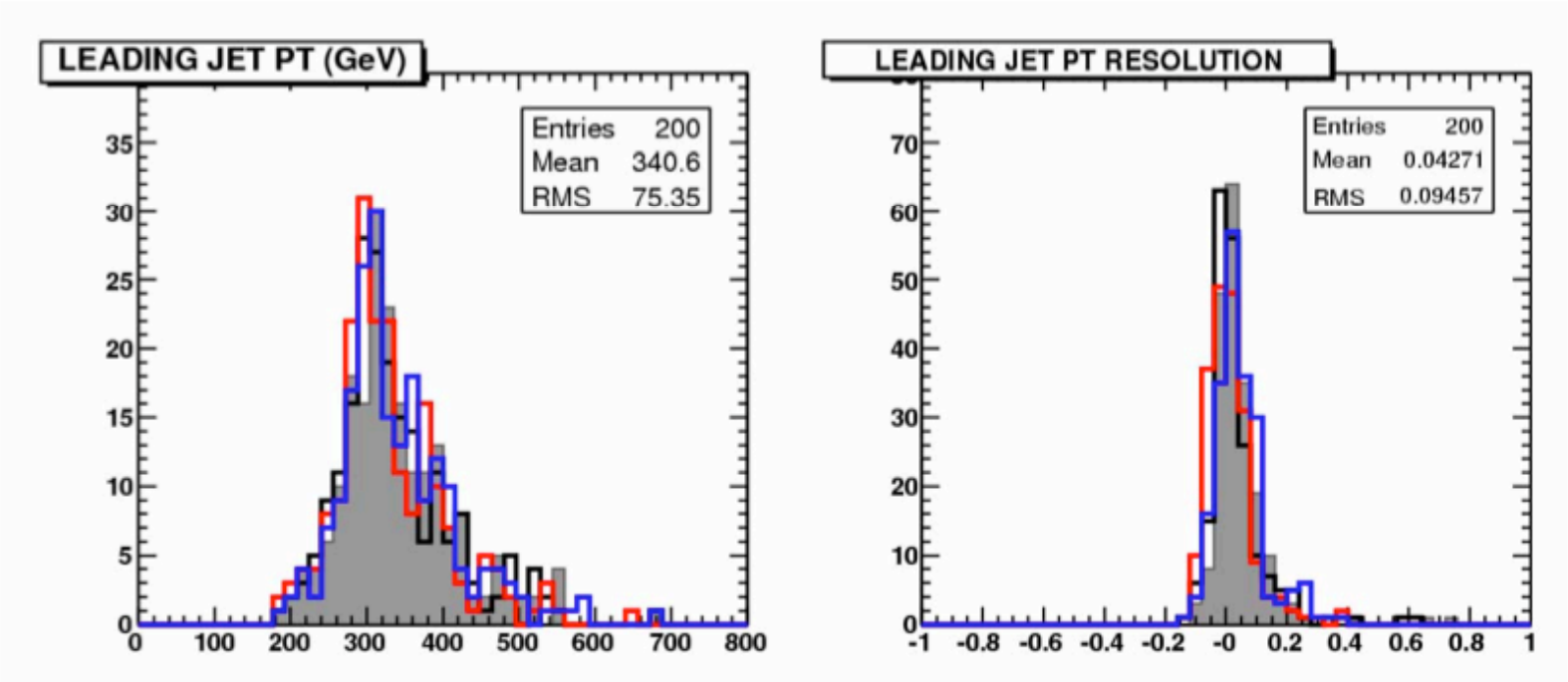
From Talk by W. Ehrenfeld

Photon cut: leading jet pt

From F. Legger

- Very loose selection
  - Pt(jet) > 10 GeV
  - Eta(jet) < 5

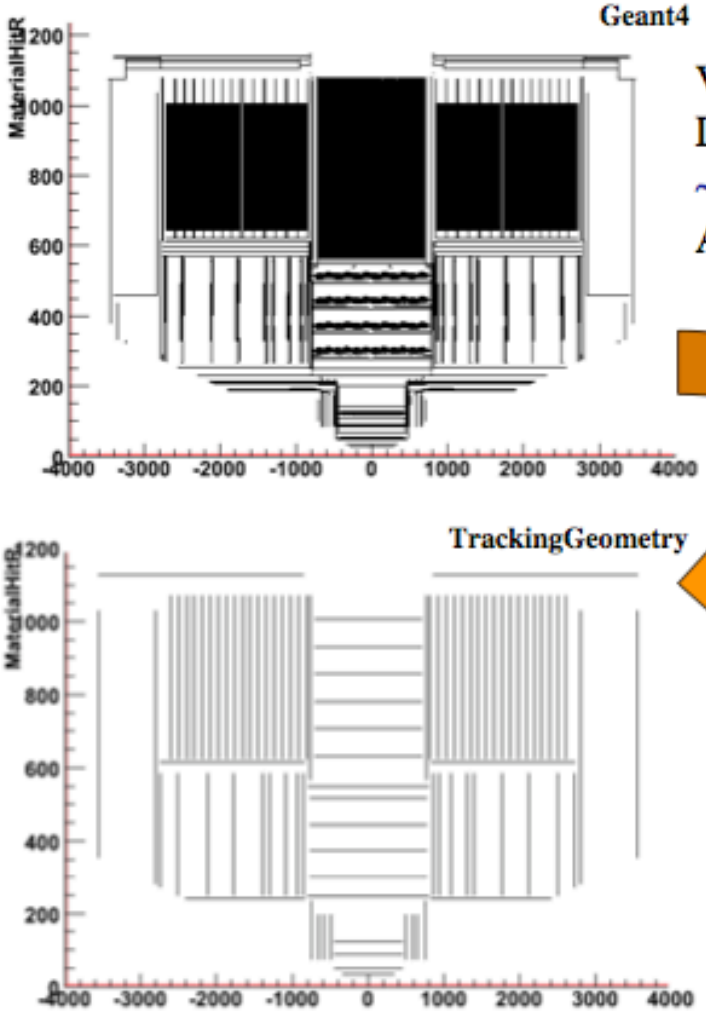
No cuts
Photon (0.01 m) and electron (1 m) cuts
Photon (0.05 m) and electron (1 m) cuts
Photon (0.10 m) and electron (1 m) cuts



What degradation in the resolution is considered acceptable?

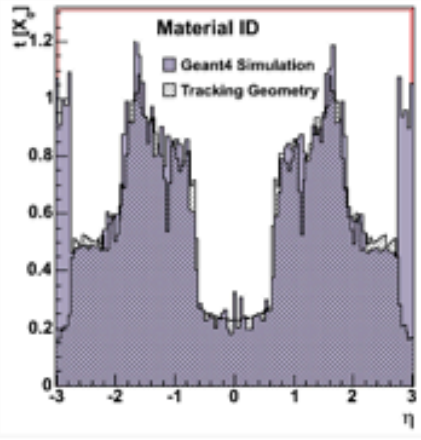
TrackingGeometry: material budget

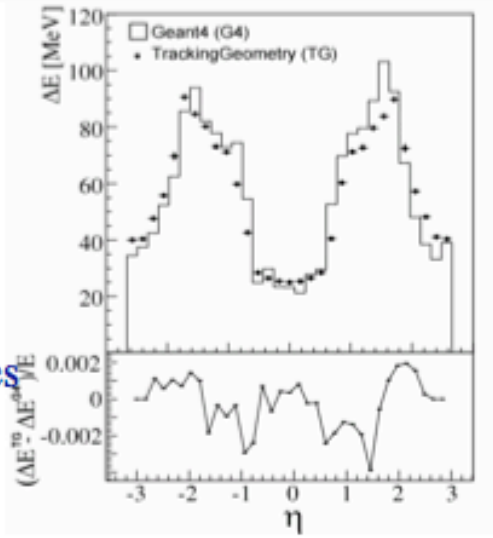
A. Salzburger



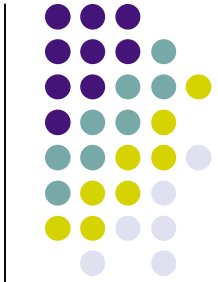
Very complex full Detector geometry
~ 10^6 volumes in the ATLAS Inner Detector (ID)

Simplified reconstruction geometry (TrackingGeometry)
~ 50 ("complex") volumes





Works In Progress or Done

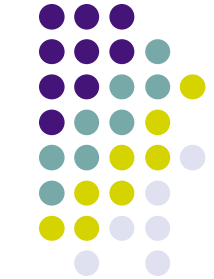


- Physics level changes:
  - Remove ν from simulation
  - Remove out of time particles (>1 μs)
  - Remove low energy particles in dead material
- Code level changes:
  - Change the stepper
    - Different steppers / step conditions for different particles
  - Optimize code (esp. code that gets executed every step!)
  - Implement faster geometries (in all senses)
- ***None of these should affect your physics***

Where Are We?

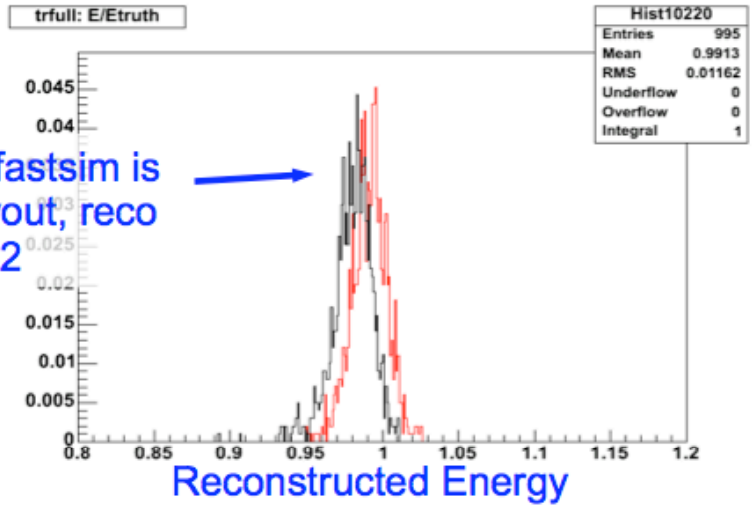
- It looks like we have a factor of two in the bag
  - That's still not enough!!
  - N.B.: I'm balking on showing numbers because we're still validating 12.5.0 (and G4.8) - and because so much is in development
- Validation progressing to reconstruction level
  - We started validation at simulation level
  - We need to completely validate at Reco. Level
    - In a way that corresponds to physics groups' work
  - The more knobs we add, the harder the validation effort becomes

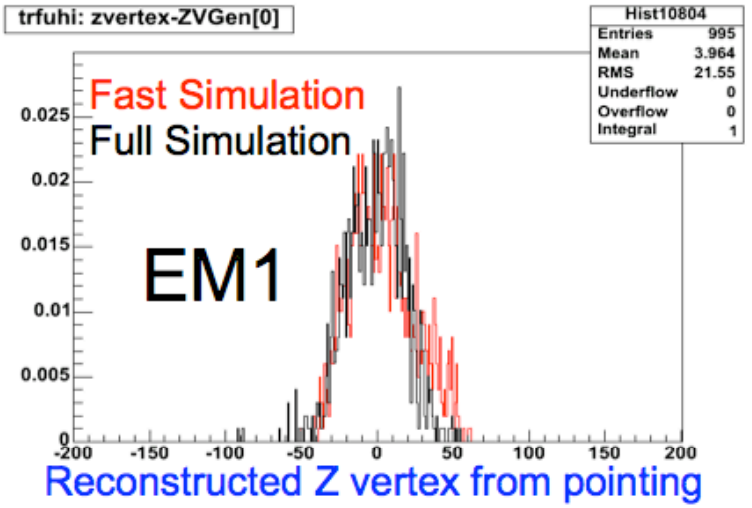
Bottom Up Approaches: ATLFAST II

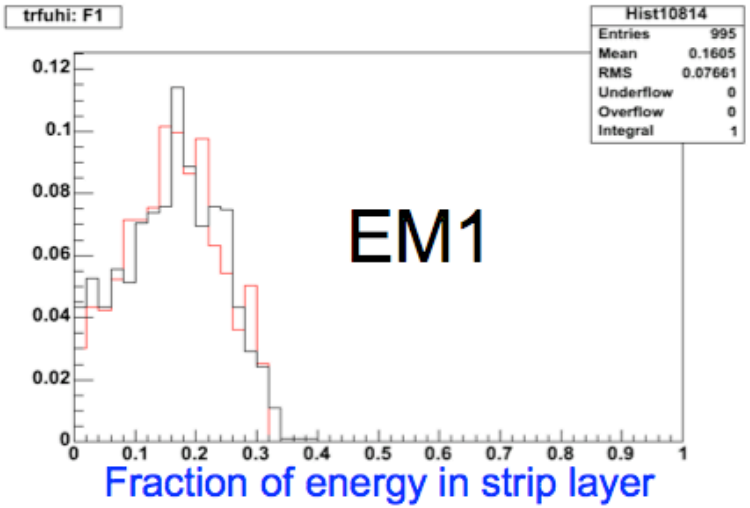


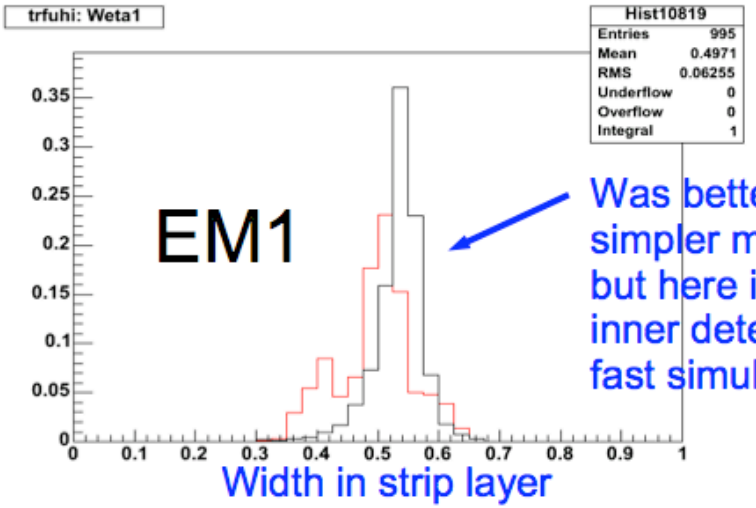
- Runs standard Athena Reconstruction
- It *is fast* (~1s / event)
- Validation starts at reconstruction level
  - Jets look good
  - e/γ not quite there yet
  - Shapes are too narrow
- Improvements are ongoing
  - Already includes several kinds of EM Calo descriptions

Results of fast photon simulation : E=100 GeV, eta=0.2, EGamma reconstruction







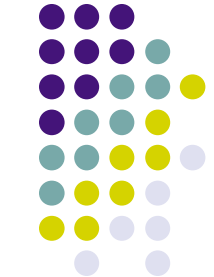


From Talk by M. Duehrssen

What's Next?

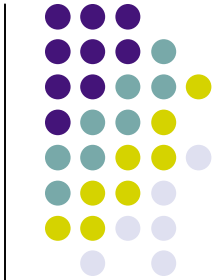
- We will try to keep you all informed about where we stand
- You get to think about where you most need a "full" simulation, and where you might cut corners
  - E.g.: Fake missing E_T analyses probably need something with detector cracks built in
  - E.g.: b-tag people probably just need calorimeter matching in a very general way
  - Tell us what's most important to you, so that we can validate / check it, perhaps tune for it
- Can these approaches be combined? Probably!
  - But again, more knobs mean more (and harder) validation!!
  - You may need to check your own data in the end, but you'll still save time!

Conclusions



- We are well on our way through several different approaches to a faster simulation
- Your use depends most on your application and your physics
  - We hope to provide a guide of some kind, probably through validation plots
- Anyone is welcome to contribute to the task
  - In particular now that other detectors must be attacked!
- Validation will require help from many people on various levels - you are all welcome!!

References



Parameterised Geant Workshop (16 Feb 07):

http://indico.cern.ch/conferenceDisplay.py?confId=11671

Shower Param (Fast Sim) Group TWiki Page

https://twiki.cern.ch/twiki/bin/view/Atlas/AtlasShowerParam

Shower Param Group Meetings

http://indico.cern.ch/categoryDisplay.py?categId=1175

Shower Param Group Email

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