Simulation Issues for the Upgrade

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Outline

Goals of simulation for the CMS Upgrade

Challenges (issues) for the simulation

Work on simulation tools

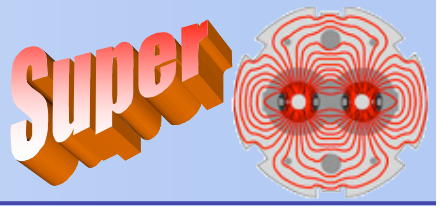
Status of the simulation for upgrade studies

Current scope for tracker upgrade simulation studies

Simulation talks at this workshop

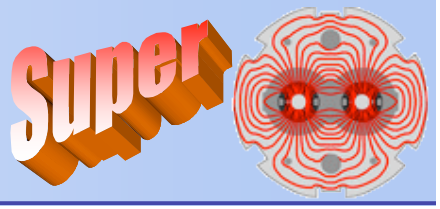
Summary

Goals for the simulation



- Goals of the simulation for the CMS upgrade
  - Simulation studies to help design upgrades for subdetectors, e.g.
    - Study options for Phase 1 pixel replacement/upgrade and help with design and optimization
    - Study options for Phase 2 tracking system
    - Study options for track triggering
  - Simulation studies to help design upgrades for the L1 trigger, e.g.
    - Study smaller L1 trigger towers
    - Study isolation algorithms at high luminosity
    - Study tracking triggering algorithms
  - Simulation of high luminosity data to investigate improvements to existing reconstruction or analysis software algorithms
  - Make simulation studies to contribute real numbers to rationale for proposals

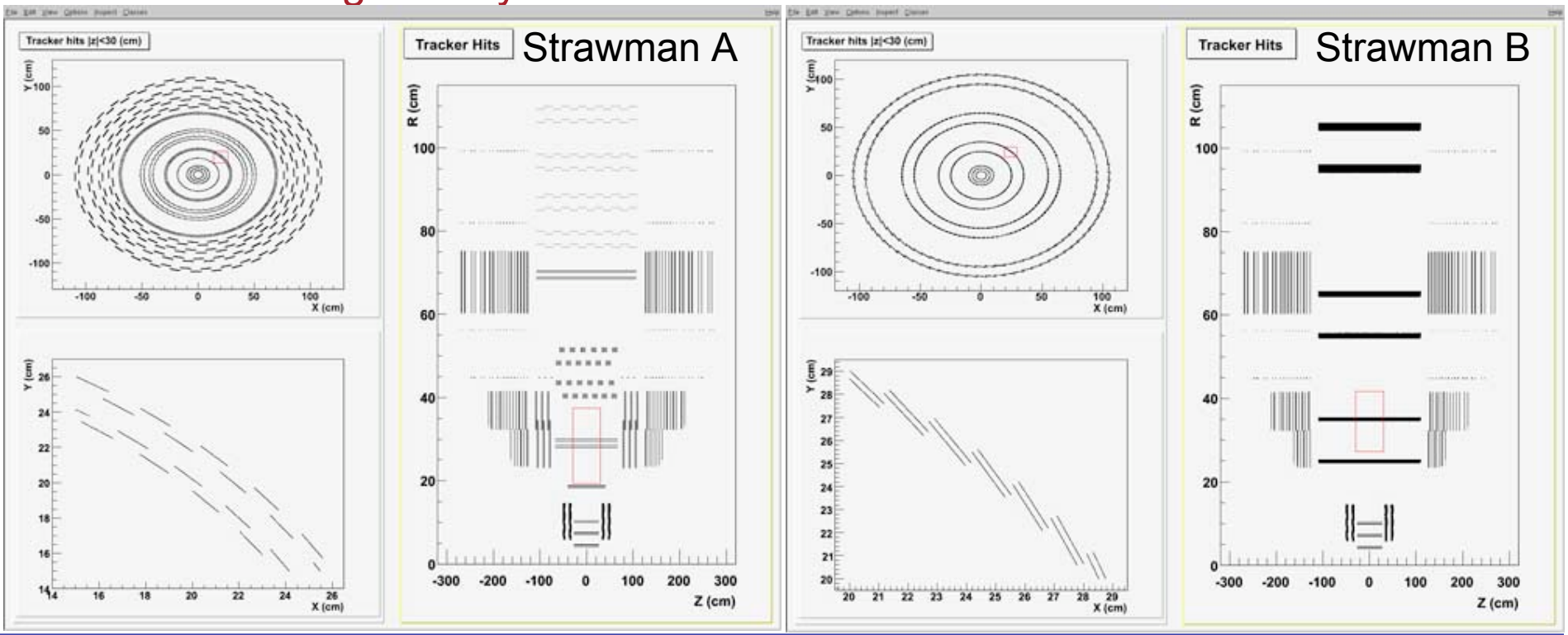
Challenges for the simulation



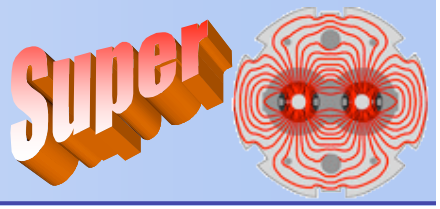
- Challenges for upgrade simulation studies
  - We need to simulate different (tracking system) geometries
  - We need to simulate events fast enough for R&D of geometries
  - We need (relatively) realistic simulations
  - We need to simulate at SLHC luminosities
- We have a Tracker upgrade simulations working group that worked on the tools needed for upgrade simulation studies
  - https://twiki.cern.ch/twiki/bin/view/CMS/SLHCTrackerSimuSoftTools
    HyperNews: hn-cms-slhc-trackersim@cern.ch
  - Eric Brownson *(Vanderbilt U.)*, *Avdhesh Chandra (Riverside)*, *Harry Cheung (FNAL, co-coordinator)*, *Carlo Civinini (Firenze)*, *John Ellison (Riverside)*, *Mario Galanti (Catania)*, *Kevin Givens (Colorado)*, Xingtao Huang *(U. of Puerto Rico)*, *Matthew Jones (Purdue)*, *Mark Pesaresi (Imperial College)*, *Jennifer Sibille (KU)*, *Alessia Tricomi (Catania, co-coordinator)*, *Michael Weinberger (Texas A&M)*
- We have code in CVS to simulate different strawman tracking system geometries, and now starting to do some upgrade simulation studies

Geometry Issues

- We need to simulate different (tracking system) geometries, but…
  - CMS code is hardwired to the standard geometry
  - There are only a few geometry experts who can change the geometry
  - We don't know exactly what geometries we want to simulate
- We created modified code that can simulate example geometries with limited configurability



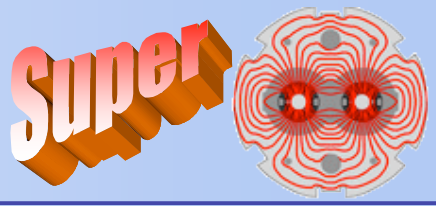
Speed Issues



- We need to simulate events fast enough for R&D
  - A luminosity of 10^{35} (2×10^{34}) $cm^{-2}s^{-1}$ at 25 ns ⇒ average Pileup = 200 (40)
  - We want to study different geometries and optimize layout/designs which calls for simulating a number of different geometries
  - Geant simulation is too slow (factor 2 improvement in speed in version > 1.8.4, and could omit calorimeters and muons for tracking only studies)
  - FastSimulation has complications and needs extra changes (which make it slower)
- Some CPU timings in the FastSimulation and Full (Geant) Simulation
  - Timings per event for $H \rightarrow ZZ \rightarrow 4(\mu$ or e) (based on 1_8_4)
  - Much faster for muon particle gun
  - On cmslpc (2GHz Intel Xeon)

Av. Pileup per crossing	Std Fastsim with tracking (sec/event)	Fullsim (Geant) (sec/event)	
		Digis only	With full track reco
0	0.51	99.0	101.9
5	0.78	119.7	131.3
20	1.84	147.1	341.2
40	3.40	185.3	1527.3
100	7.35	302.6	
200	14.00	539.0 (mem prob)	
400	28.51		

Fastsim Complications: Geom

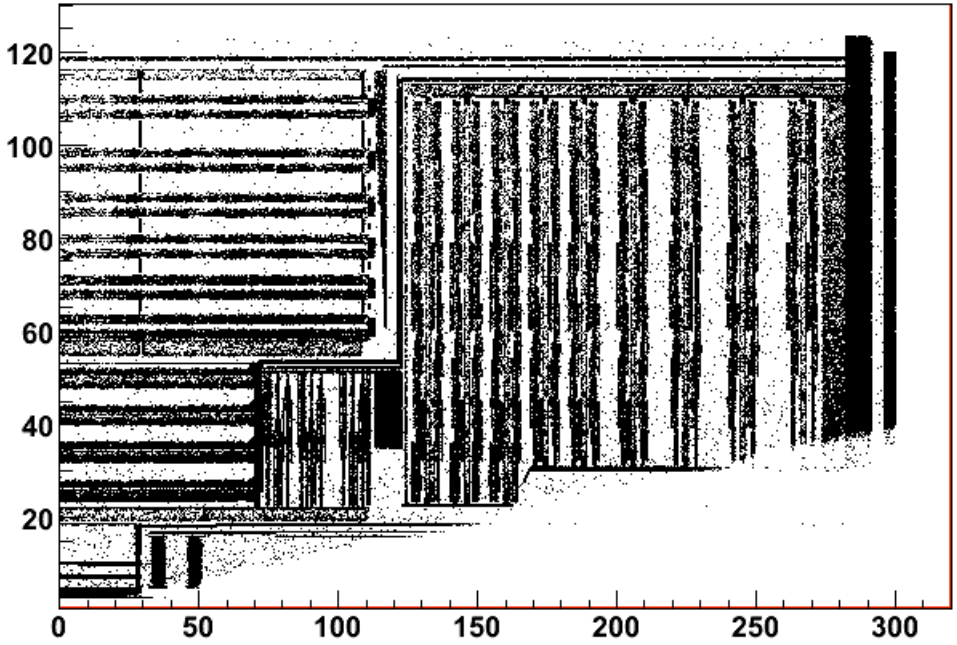


- We need realistic simulations: some complications with FastSimulation
  - Fastsim has two geometries, the normal XML based one used for hits and a second (hard coded) one used for particle propagation
    - Need to modify/maintain second “fastsim interaction geometry”
    - Interaction geometry must have correct material “on average”

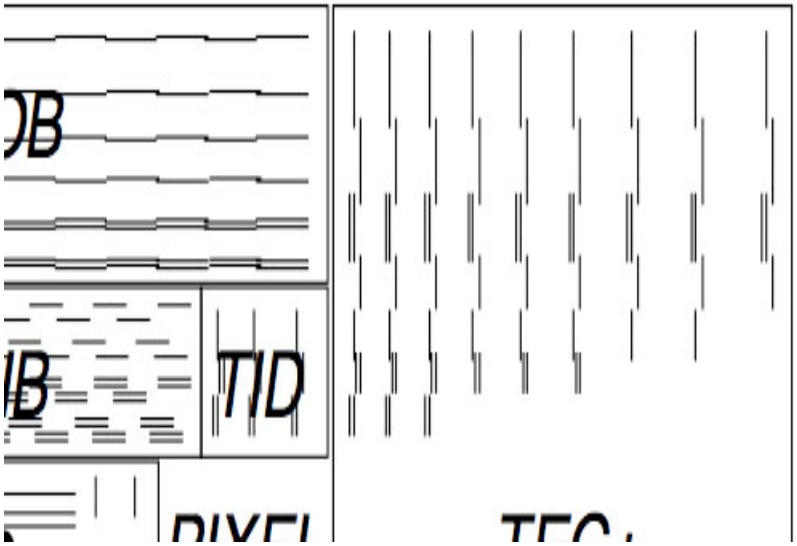
Details: Geometry 1

- The full geometry is specified by a set of XML files and algorithm code
  - Used to set up the Geant4 geometry volumes, very detailed, no overlaps (intended) - used for full simulation (Geant4)
  - Used to set up the Reconstruction (Reco) geometry - just sensitive detectors

Full Tracker radiography



Reco geometry

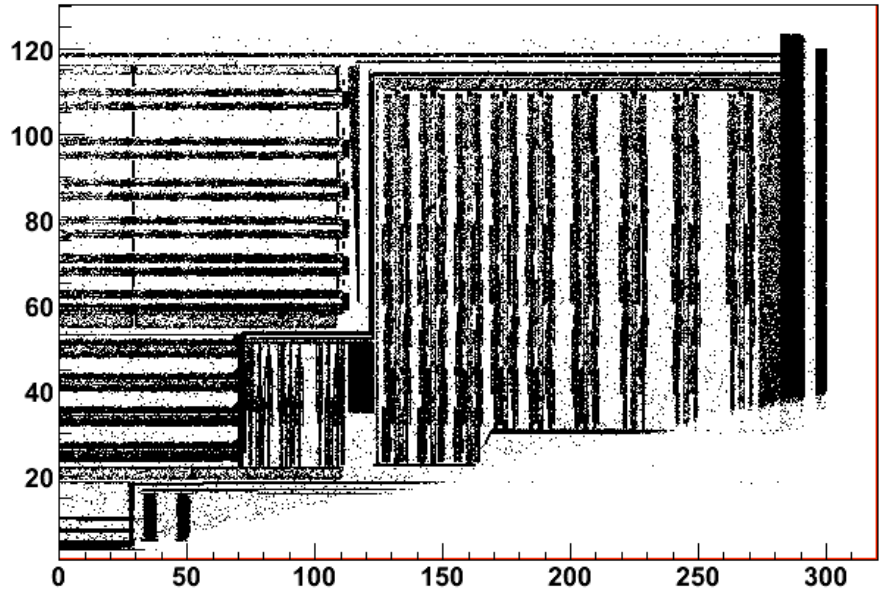


Details: Geometry 2

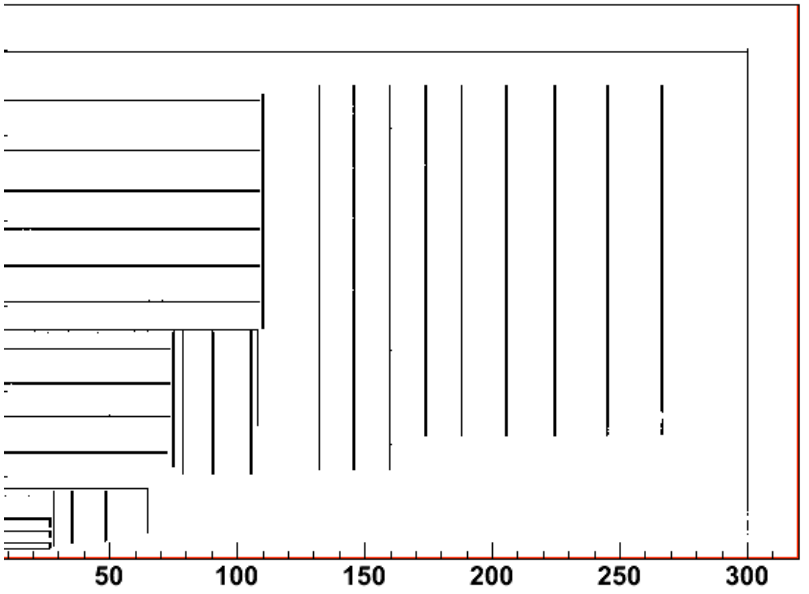
- The FastSimulation geometry uses two geometries
  - Standard Reconstruction (Reco) geometry for location of simhits
  - Separate “interaction geometry” used to trace particles/interactions, consists of nested thin cylinders, “sensor layer” + material layers **tuned and hard coded** to approximate as best as possible the full geometry radiation map
  - We need to get the correct material for each geometry we make

Full Tracker radiography

Geant4 Simulation geometry

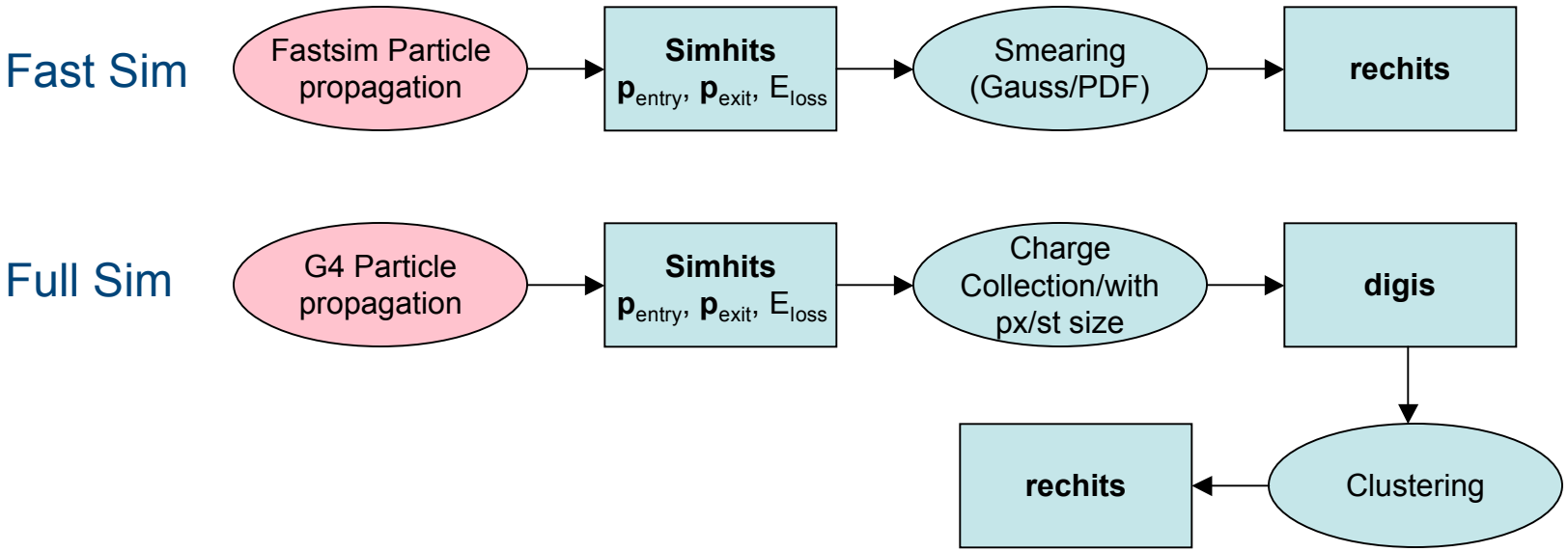


FastSimulation Interaction geometry



Fastsim Complications: digis

- We need realistic simulations: some complications with FastSimulation
  - Fastsim has two geometries, the normal XML based one used for hits and a second (hard coded) one used for particle propagation
    - Need to modify/maintain second "fastsim interaction geometry"
    - Interaction geometry must have correct material "on average"
  - Fastsim does not correctly take into account (a different) tracker granularity
    - Run modified fastsim that makes digis, and modified digi code to have configurable granularity (only at the moment if pixels/mini-strips implemented as a pixel subdet (tracking))



Non-standard FastSimulation

- Some CPU Timings for non-standard fastsim with digis and normal full track pattern recognition
  - Timings per event for H → ZZ → 4(μ or e) (based on 1_8_4)
  - On cmslpc (2GHz Intel Xeon)
- Can optimize tracking for speed (e.g. using seeding with 3 pixel hits)
  - Don't worry too much about timings for current tracking software

Av. Pileup per crossing	**Std Fastsim with tracking (sec/event)**	**Fastsim with Digis (sec/event)**		**Fullsim (Geant) (sec/event)**	
		Digis only	With full track reco	Digis only	With full track reco
0	0.51	0.91	2.38	99.0	101.9
5	0.78	1.27	3.75	119.7	131.3
20	1.84	2.57	11.63	147.1	341.2
40	3.40	4.19	28.48	185.3	1527.3
100	7.35	9.10	162.8	302.6	
200	14.00	17.20	755.3 (seg fault)	539.0 (mem prob)	
400	28.51				

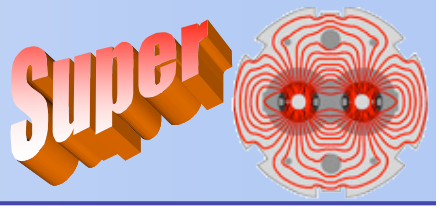
Fastsim Complications: pileup

- We need to simulate at high luminosity
  - Full (Geant4) simulation uses the Mixing Module for pileup
    - Uses min-bias data for pileup from -5 to +3 buckets, merge in simhits
    - Takes lots of memory (improvements in later versions)
  - Fast simulation has only in-time (same bucket) pileup
    - Using min-bias data in same bucket, merge in particles (to generated)
    - Plan to use Mixing Module in a later release
      - Standard uses for simhits ⇒ would need separate minbias files for each new geometry
  - Fastsim tracking detector occupancy differs from Full simulation
    - No out-of-time pileup
    - Fast sim places cuts on minimum track p_t and loopers by default
    - Fast sim does not simulate delta rays
    - Occupancy [%] for pixel layers in MinBias events at pileup ~20 (modified to lower p_t cut and turn on loopers)

	FullSim	FastSim	Ratio	FullSim (in-time)	FastSim (modified)	Ratio
PXB Layer 1	0.01731	0.007713	2.2	0.01627	0.01252	1.2
PXB Layer 2	0.01253	0.00495	2.5	0.01138	0.00853	1.3
PXB Layer 3	0.01024	0.00363	2.8	0.00938	0.00697	1.3

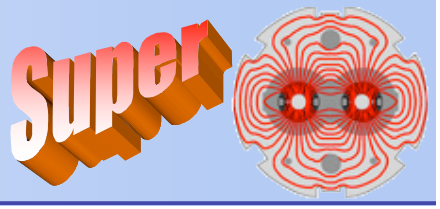
- We still need to deal with pileup and occupancy tuning (for speed)

Work on simulation tools



- Simulation of muons
  - Matthew Jones (Purdue) worked with Martijn Mulders (CERN) to make muon simhits, included in standard Fastsim in 1_7_X, MCS included in 1_8_X
  - Fastsim group still improving muon simulation (e.g. Brem.)
- Simulation of ECAL, HCAL, and preshower
  - Standard Fastsim has shower parameterization
    - Fastsim group still improving shower parameterizations
  - No out-of-time pileup (yet) in standard Fastsim
    - Need input from ECAL+HCAL on how we should do this, and work together
- Other software tools/methods for upgrade simulation studies
  - Detector layout tool (Stefano Mersi, Duccio Abbaneo, Nicoletta De Maio)
    - Software to generate tracker layouts, and get various statistics for layout
  - Data overlap tool (developed by Mike Hildreth)
    - Overlap real data digis instead of MC min-bias
    - Limited to current CMS detector and running conditions
  - Simulation in 1/8th detector (idea of Alexei Safonov, Vadim Khotilovich)
    - Allow use of Full (Geant) simulation but for small fraction of detector (phi slice)
  - Beam induced radiation (Pushpa Bhat, Anih Singh, Nikolai Molchov)
    - Results on radiation dose in subdetectors; (also for accident scenarios at LHC)

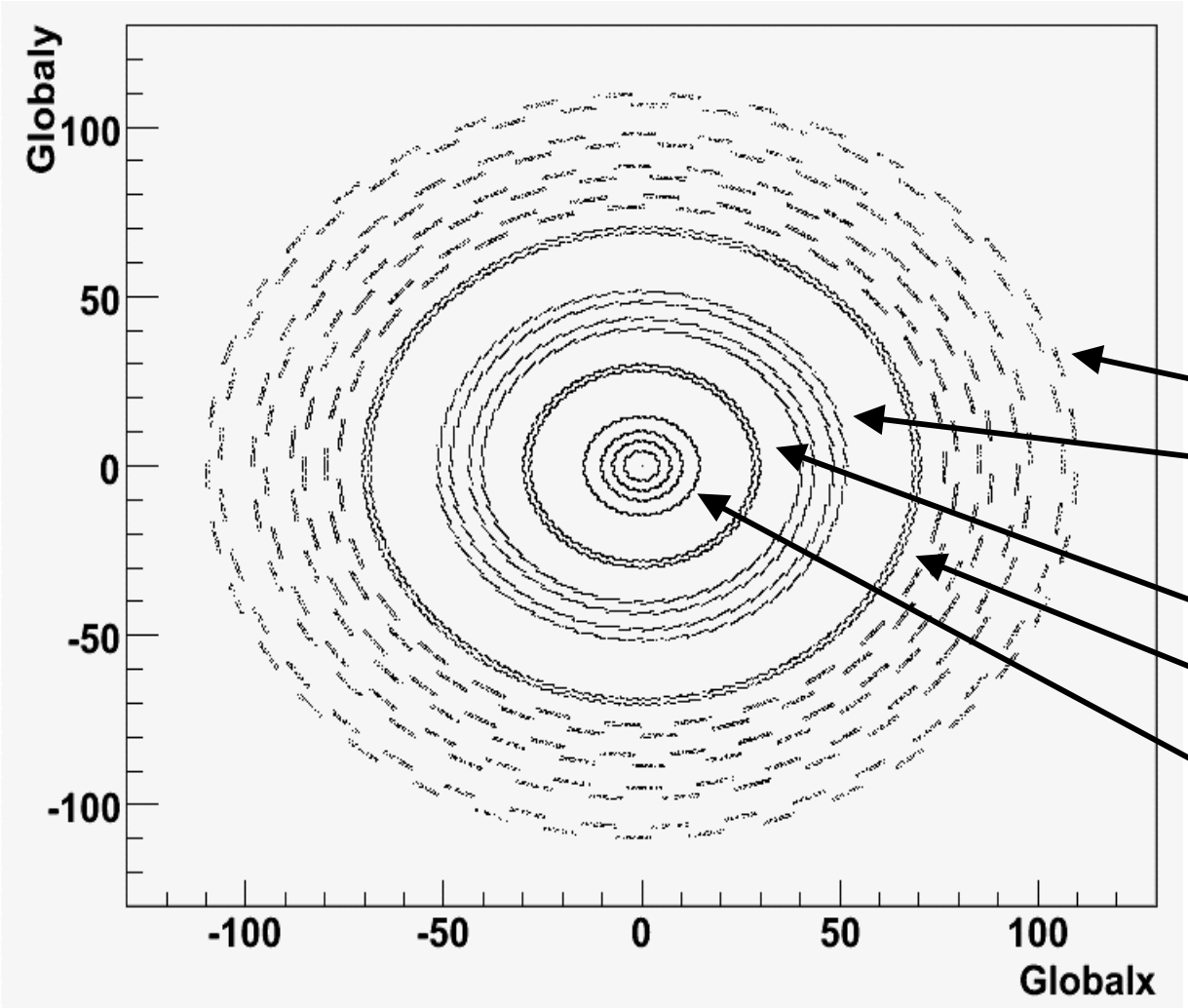
Status of the simulation



- The Tracker upgrade simulations working group has created upgrade simulation software, and is starting simulation studies for layout optimization
  - We have a modified version of the FastSimulation that can properly account for the tracking system granularity (runs faster than the Geant simulation)
  - We have two example strawman geometries set up that can be configured to study various geometry layouts (aimed at Phase 2)
    - Numbers and location in radius of layers
    - Addition of strixels (long pixels), mini-strips, and trigger doublet layers
    - Configurable pixel/strixel granularity in XML files
  - We have a very long barrel detector strawman
    - Not yet in CVS
  - We have a phase 1 geometry with 4 barrel pixel layers
    - A Phase 1 geometry using to Roland's proposal/options 1-5
    - Not yet worked out a forward pixel phase 1 geometry
  - We are using the standard tracking performance validation packages
    - Work to do in simplifying the performance packages for our studies
    - Work to do in enabling fast running at the highest pileup, and more realistic pileup for the FastSimulation

Original Strawman A

- Original strawman A (still in CVS) had too many channels



Implemented by Carlo Civinini, Alessia Tricomi, Mario Galanti

6 ministrip layers

2 trigger doublets

4 pixel layers

Original Strawman A

- Strawman A example geometry channels

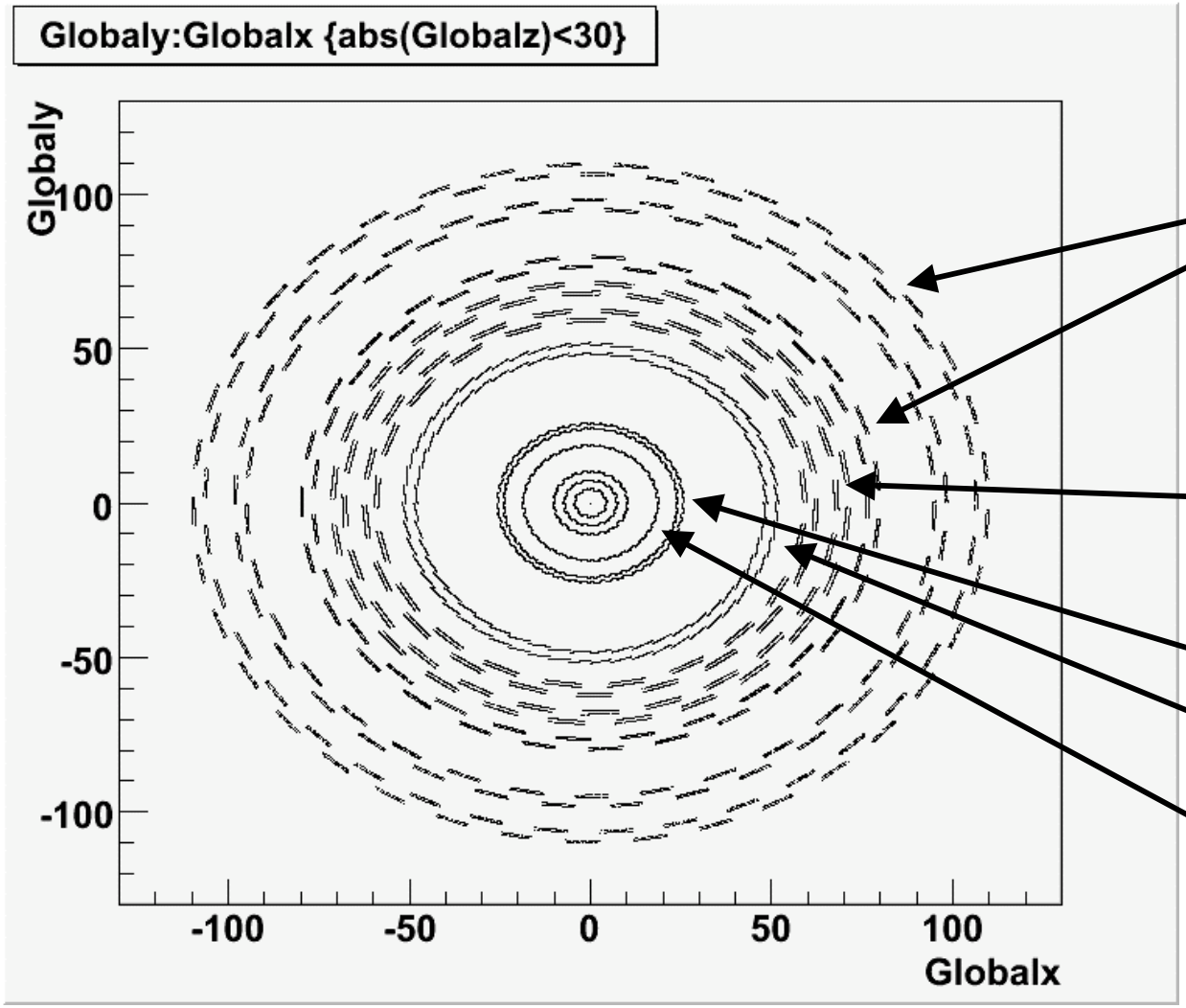
Strawman A	Active Surface [cm2]	# ROCs	# channels	# modules
Barrel - Pixels (PXB)	251522.3	79552	330,936,320	24240
Endcap - Pixels (PXF)	2834.4	4320	17971200	672
Barrel - Strips (TIB + TOB)	616886.2	85968	11,003,904	18132
Endcap - Strips (TID + TEC)	902046.7	34624	4431872	7216

Standard Geometry	Active Surface [cm2]	# ROCs	# channels	# modules
Barrel - Pixels (PXB)	7558.26	11520	47,923,200	768
Endcap - Pixels (PXF)	2834.36	4320	17971200	672
Barrel - Strips (TIB + TOB)	1103896.7	38160	4,884,480	7932
Endcap - Strips (TID + TEC)	902046.7	34624	4431872	7216

Numbers from Carlo Civinini

More Realistic Strawman A

- More realistic strawman A is now implemented



Implemented by
Carlo Civinini

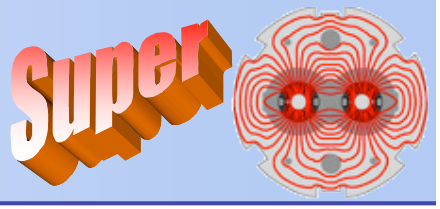
3 ministrip layers

2 stereo strip layers

2 trigger doublets

4 pixel layers

More Realistic Strawman A



- More Realistic Strawman A example geometry channels
  - Still large numbers of channels - what is realistic?
  - Work with new Layout Task Force to help define realistic geometries

Realistic Strawman A	Active Surface [cm2]	# ROCs	# channels	# modules
Barrel - Pixels (PXB)	59447.9	41408	172,257,280	5860
Endcap - Pixels (PXF)	4251.6	6480	26,956,800	1008
Barrel - Strips (TIB + TOB)	829242.6	98208	12,570,624	21192
Endcap - Strips (TID + TEC)	902046.7	34624	4431872	7216

Standard Geometry	Active Surface [cm2]	# ROCs	# channels	# modules
Barrel - Pixels (PXB)	7558.26	11520	47,923,200	768
Endcap - Pixels (PXF)	2834.36	4320	17,971,200	672
Barrel - Strips (TIB + TOB)	1103896.7	38160	4,884,480	7932
Endcap - Strips (TID + TEC)	902046.7	34624	4431872	7216

Numbers from Carlo Civinini

Strawman B Status

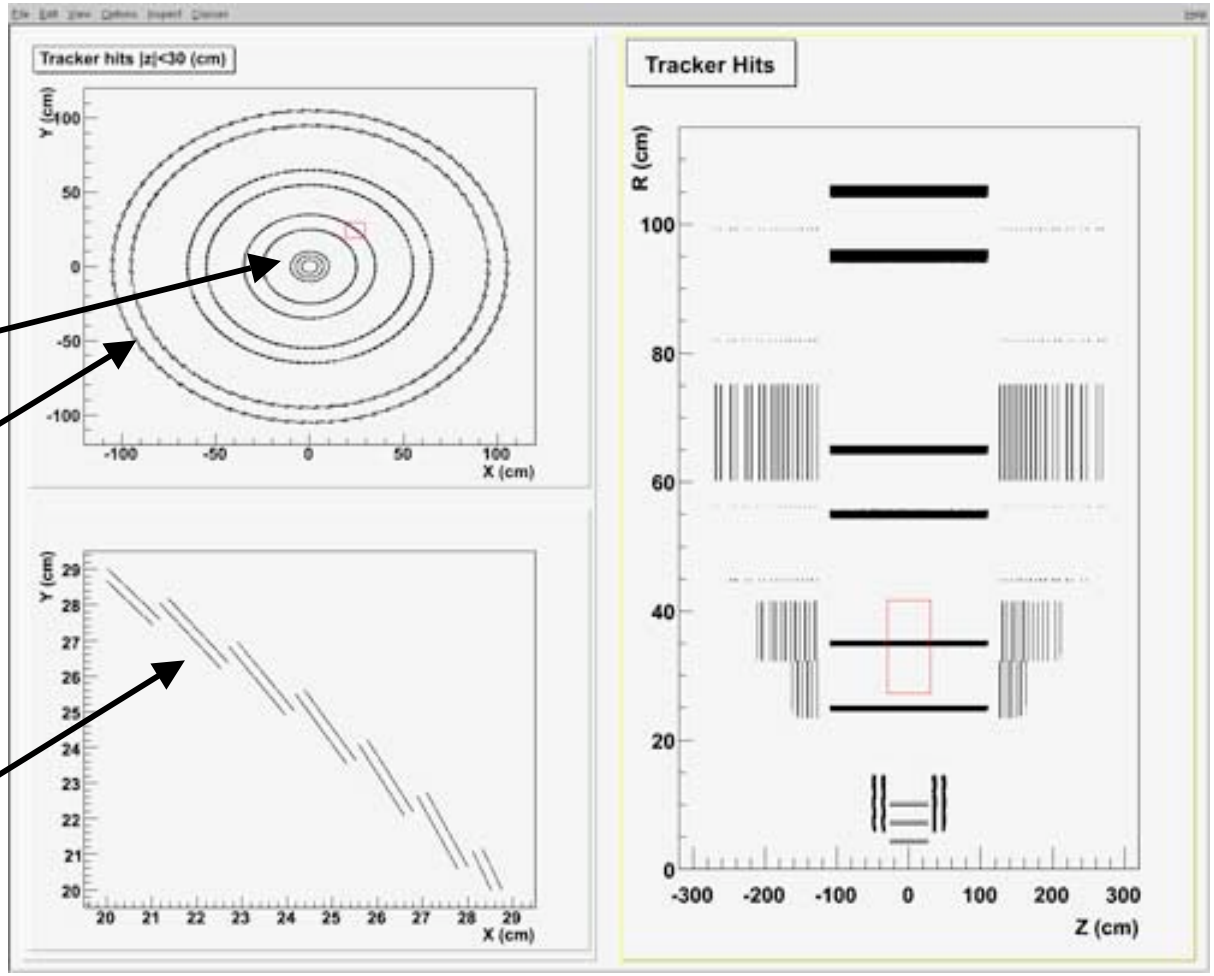
- Strawman B example geometry with limited configurability

Implemented by Mark Pesaresi, Harry Cheung, Mike Weinberger, Xingtao Huang

3 inner pixel layers

3 superlayers (each with 2 doublets)

Zoom of single doublet



Strawman B Status

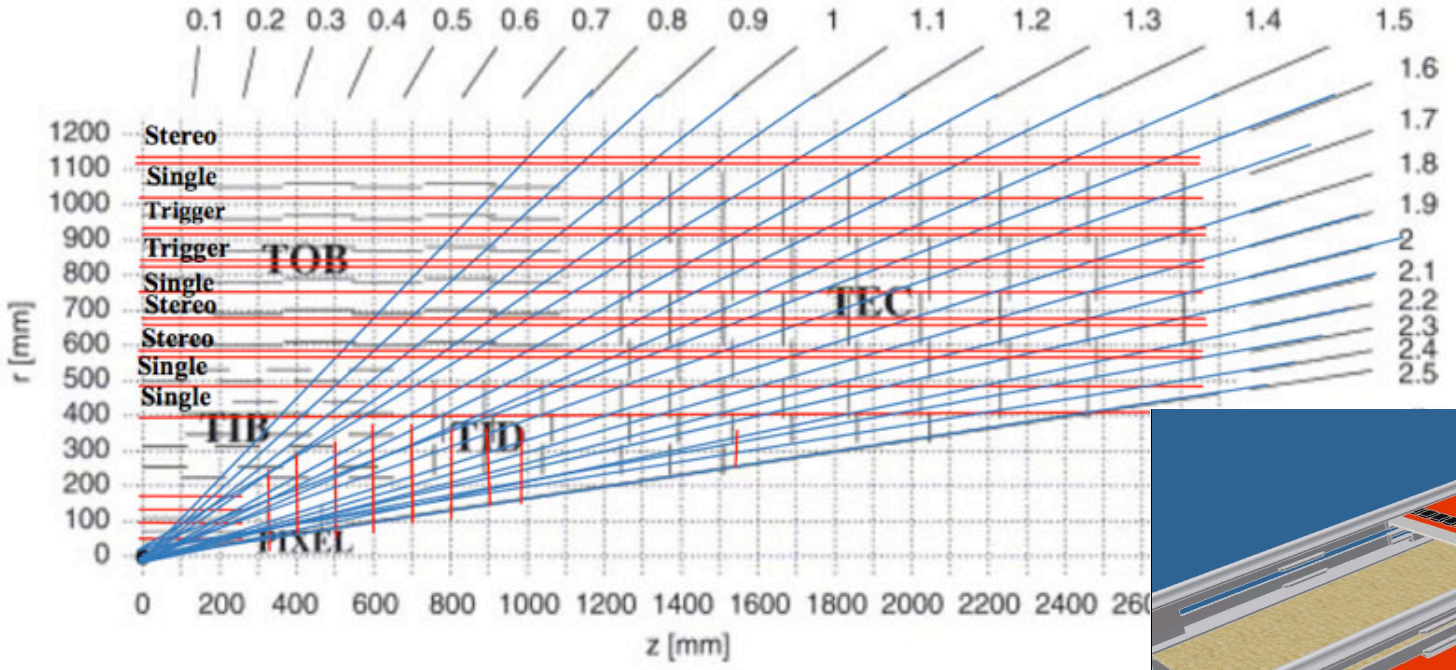
- Strawman B example geometry channels
  - Used for simulation studies of both trigger doublet performance and tracking performance
  - Work with new Layout Task Force to define realistic doublet structure

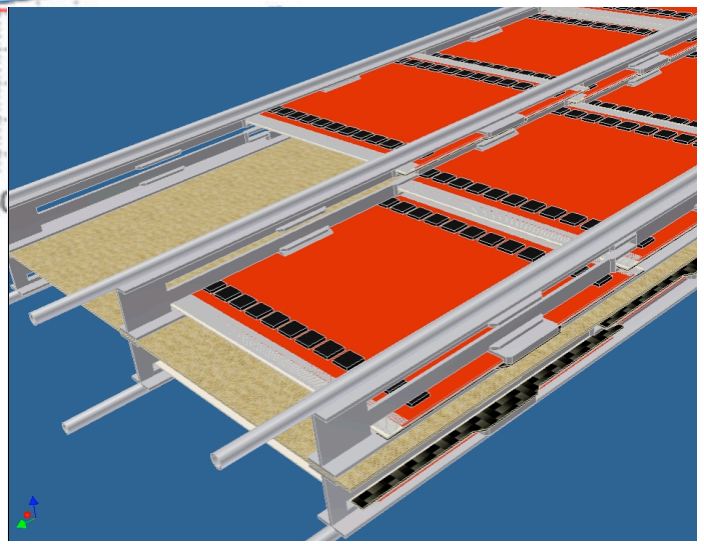
Strawman B	Active Surface [cm2]	# ROCs	# channels	# modules
Barrel - Pixels (PXB)	1,325,456.6	568,576	226,181,120	35,584
Endcap - Pixels (PXF)	2834.4	4320	17,971,200	672
Barrel - Strips (TIB + TOB)	0	98208	12,570,624	21192
Endcap - Strips (TEC)	833452.0	30208	3,866,624	7216

Standard Geometry	Active Surface [cm2]	# ROCs	# channels	# modules
Barrel - Pixels (PXB)	7,558.26	11520	47,923,200	768
Endcap - Pixels (PXF)	2834.36	4320	17,971,200	672
Barrel - Strips (TIB + TOB)	1103896.7	38160	4,884,480	7932
Endcap - Strips (TID + TEC)	902046.7	34624	4,431,872	7216

Long Barrel Strawman

- Very long barrel strip detector idea presented by Wim de Boer in July Strawman discussion





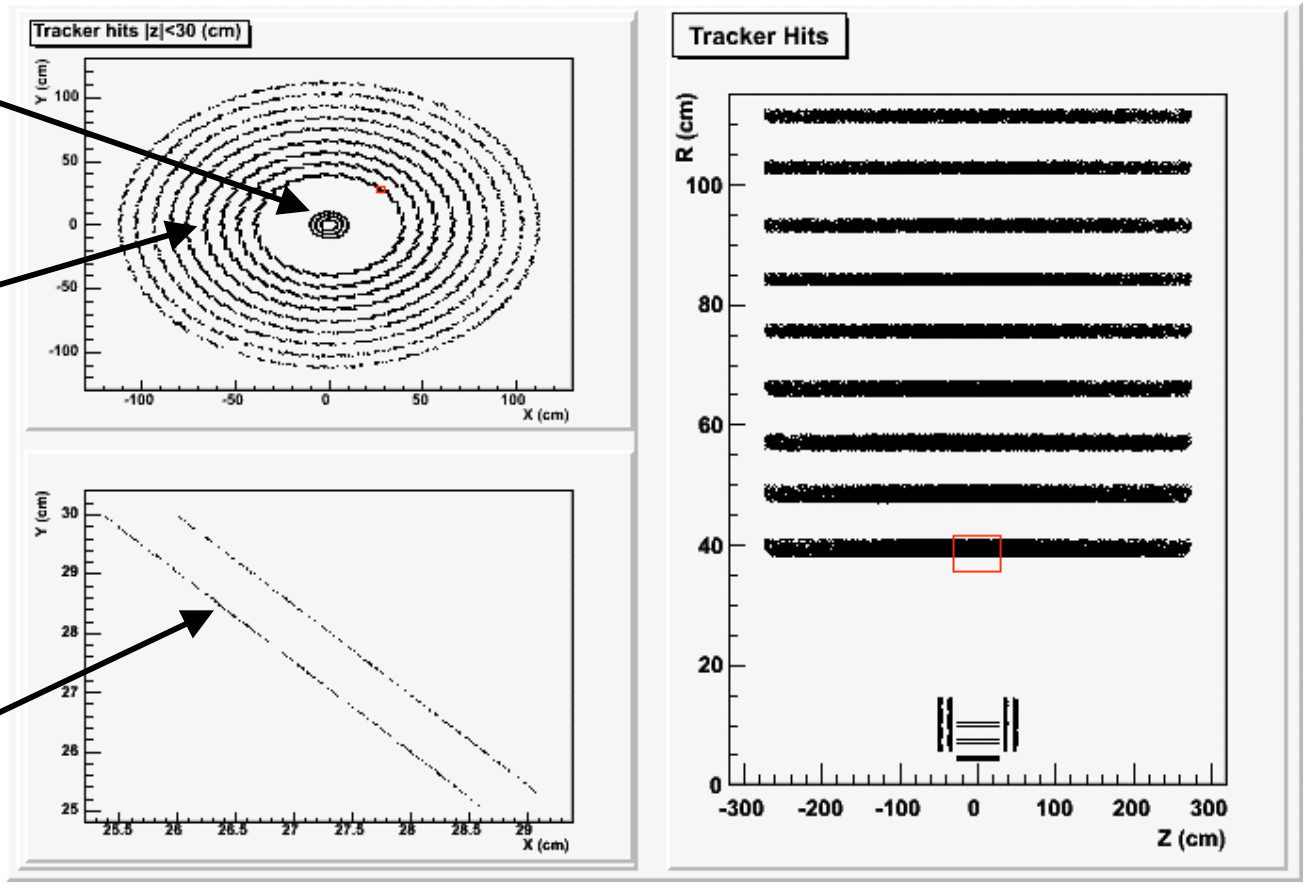
Long Barrel Strawman

- Very long barrel strawman being setup by Mike Weinberger, (e.g. study long barrel *vs.* endcap)
  - No strip disks included yet

3 inner pixel layers

9 strip layers, including 3 stereo and 2 trigger doublets

Zoom of layer



Phase 1 Strawman

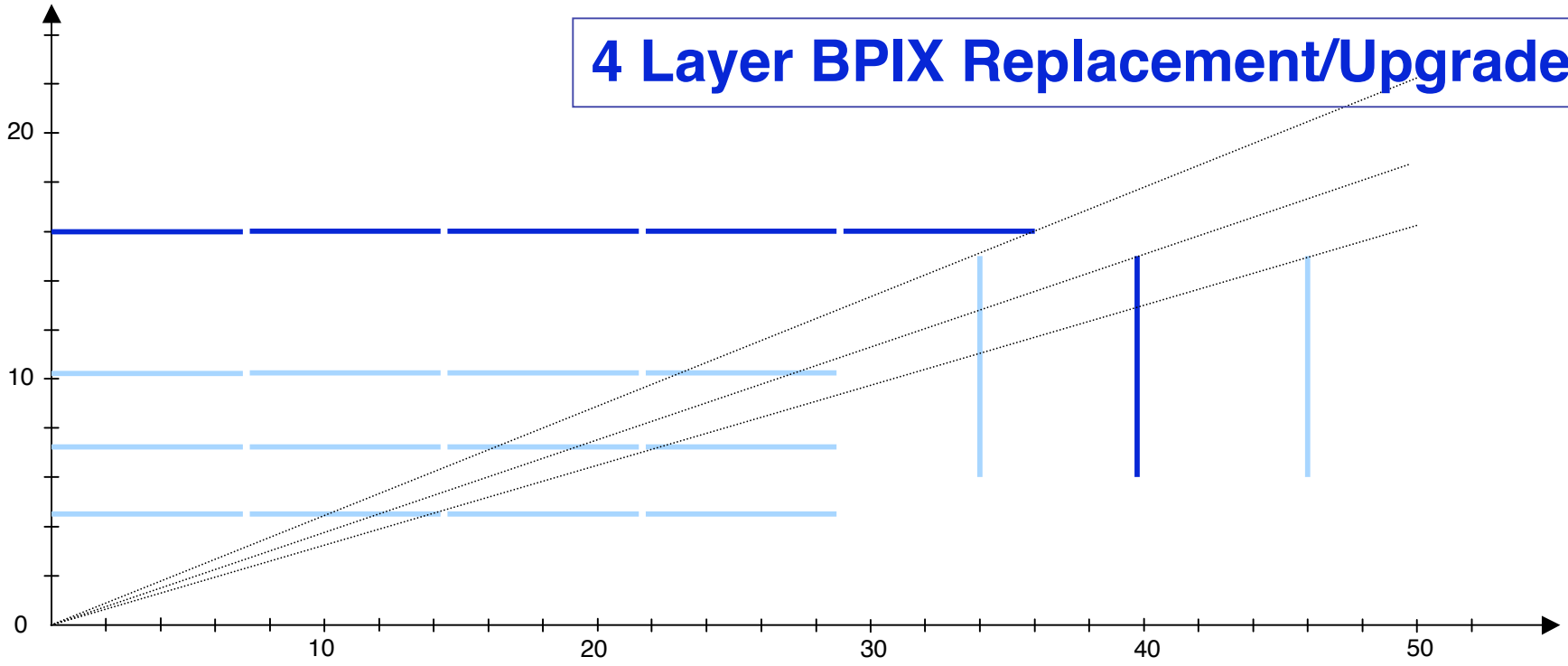
- Have setup Phase 1 geometry with material changes and 4th layer
  - Had to be ported to version 2_1_X to get more realistic pixel geometry (support/services) (Done by Alessia Tricomi)
  - Re-weight current detector to get material changes

Roland's options 1-5 for Phase 1 barrel pixel replacement/ upgrade

	Option	Layer/Radii	Modules	Cooling	Pixel ROC	Readout	Power
as 2008	0	4, 7, 11cm	768	C_6F_{14}	PS46 as now	analog 40MHz	as now
	1	4, 7, 11cm	768	C_6F_{14}	2x buffers	analog 40MHz	as now
	2	4, 7, 11cm	768	CO_2	2x buffers	analog 40MHz	as now
	3	4, 7, 11cm	768	CO_2	2x buffers	analog 40MHz μ-tw-pairs	as now
	4	4, 7, 11cm	768	CO_2	2xbuffer, ADC 160MHz serial	digital 320MHz μ-tw-pairs	as now
	5	4, 7, 11, 16cm	1428	CO_2	2xbuffer, ADC 160MHz serial	digital 640 MHz μ-tw-pairs	DC-DC new PS

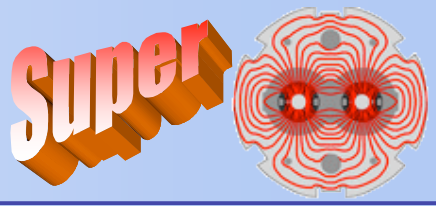
Phase 1 Strawman

- We can start simulation studies of this Phase 1 strawman to study Roland's BPIX Option 1-5
  - Will not build exactly the same disks as current FPIX
  - Do not have a Phase 1 forward pixel detector geometry, we need one!



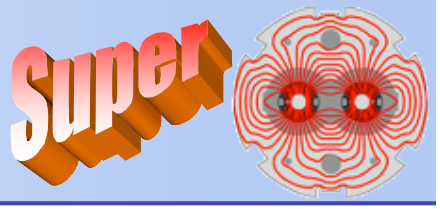
Roland's proposed 4th pixel & 3rd forward disk layout

Status of the simulation



- We now have many example strawman geometries and each can be configurable, leading to too large a phase space to investigate
- The Tracker upgrade group has formed a new Layout Task Force
  - A formalized way to help interaction and communication between the upgrade simulation group and other upgrade working groups
  - Will work with upgrade working groups to help define a tracking system layout: realistic ladder and module structures; realistic material budgets and cooling layout; possible channel counts; overall detector construction, etc.
  - Task Force will guide the simulation studies and geometries to be studied
  - This group is newly formed and will begin work soon
- Plans in fast simulation and full simulation
  - We are currently working in 1_8_4, will have to move to 2_1_X “sometime”
    - More realistic material for pixel detector and services
    - Some simulation study code only runs in later versions (e.g. L1 muon rates plot)
  - Many improvements to FastSimulation for matching to data and to run HLT
  - Many improvements in full simulation: simulation speed; memory and CPU performance for pileup mixing module
    - When we have a baseline geometry we would use the full (Geant) simulation

Current scope for simulation



- Current simulation studies with limited manpower: simulation studies we expect to make progress in the next few months

1. Studies to see whether a (buildable) trigger doublet would work, how many are needed and what their parameters should be
   - This can be studied in any of the strawman geometries
   - Currently looking at the L1 single muon trigger rate
2. Studies of a Phase 1 strawman (Roland's options for pixel replacement/upgrade)
   - Including a study of a 4th barrel pixel layer
   - We need to define the Phase 1 Forward Pixel detector
3. Studies of a very long barrel detector of (mini-)strips
   - Study Phase 2 forward region options
4. Some studies of the tracking performance of strawman A and B variations, (including the forward region), at 10^{35} compared to the standard CMS geometry at 10^{34} to work towards a baseline geometry
   - Currently lower priority: need results from study 1
   - Need more ideas for the forward region in these strawman geometries
   - Need to work with Layout Task Force to define realistic layouts

Twiki Page Task Table

- Tracker upgrade simulations WG Task table
  - We need more people! (Most contributers below are part-time)

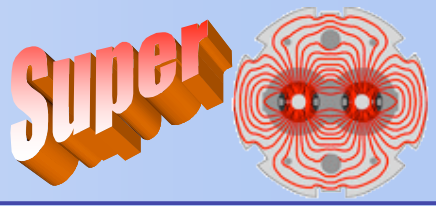
Simulation Studies Table

Task	People working on it	Document link
Performance of 1-2 pixel doublet(s) for L1 Muon Trigger	Eric Brownson, Harry Cheung, Mike Weinberger	L1 Muon Track Trigger Studies ?
Performance for an extra 4th inner barrel pixel layer	Carlo Civinini, Kevin Givens, Xingtao Huang, Alessia Tricomi	4th Pixel Layer Studies ?
Tracking performance of strawman A	Carlo Civinini, Alessia Tricomi	Strawman A Studies ?
Tracking performance of strawman B	Mark Pesaresi	Strawman B Studies ?
Tracking performance of long barrel strawman	Mike Weinberger	Long Barrel Studies ?
Study Roland's option 1 to 4 for Phase 1 pixel upgrade	Carlo Civinini, Alessia Tricomi	
Study performance of CMS for Phase 1 luminosity	Carlo Civinini, Mario Galanti, Alessia Tricomi	
Performance of cluster size based L1 tracking trigger	Fabrizio Palla	

Simulation Software and Performance Benchmark Tools Table

Task	People working on it	Document link
Create tracker performance benchmark package	See linked page	Performance Benchmarks
Create and maintain strawman and baseline tracker geometry	See linked page	Example Strawman Geometry
Create TPG interface code	Mike Weinberger	Trigger Primitive Generator ?
Produce code for correct pileup simulation in the FastSimulation	?	Pileup for SLHC ?
Produce code for L1 ECAL objects in the FastSimulation	?	

We welcome more people

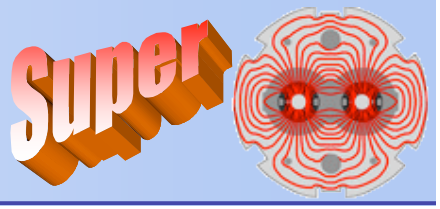


- Shamelessly recruiting USCMS people: because I am talking here; of course we welcome collaborators from any country/institution
  - We have a critical mass of people either at the Fermilab LPC, close by, or who visit often, they are able to make important contributions
    - Harry Cheung, Mike Weinberger, and Xingtao Huang have created a large fraction of the tracking system upgrade simulation code
    - Matthew Jones created the muon simhits for the FastSimulation
    - Eric Brownson and Matthew Jones are studying the L1 muon trigger rates in the FastSimulation and will study the tracking trigger doublet for L1
    - Avdhesh Chandra and John Ellison have contributed to creating a upgrade tracking performance package, and found bugs in the FastSimulation
    - Kevin Givens has created a geometry and material debugging package
    - Jennifer Sibille is contributing to understanding the MC timings
    - Mike Weinberger has contributed to trigger primitives
    - Alexei Safonov and Vadim Khotilovich have developed a nice idea to use the full simulation for upgrade studies by simulating 1/8th of the detector
    - Mike Hildreth has a data overlap tool that could be useful for upgrade studies
  - We have built important expertise at the LPC for upgrade studies: but we need more people to do the simulation studies, please join us!
- Of course also many important contributions from other CMS collaborators in the upgrade simulation WG not listed here

Simulation talks

- Simulation related talks at this upgrade workshop
  - Wednesday 19th Tracking WG: Layout and Simulations
    - 16:30 - Study of trigger doublets (Mark Pesaresi)
    - 16:50 - Status of studies of a long barrel detector (Mike Weinberger)
    - 17:05 - Geometry Layout tool (Duccio Abbaneo)
    - 17:20 - Simulation in part of a detector to handle high pileup (Vadim Khotilovich)
    - 17:35 - Data overlap tool (Mike Hildreth)
  - Thursday 20th HCAL WG
    - 9:55 - Simulation Progress (Shuichi Kunori)
  - Thursday 20th Muon WG
    - 10:40 - Triggering CSC Muons in High Pileup Conditions (Vadim Khotilovich)
    - 11:00 - Simulation/software tools for upgrade studies/geometries (Mike Weinberger)
    - 11:20 - Progress on studying SLHC muon trigger rates with FastSim (Eric Brownson)
  - Thursday 20th Trigger WG
    - 11:20 - Simulation of upgrade tracker layout (Harry Cheung)
    - 11:40 - Simulation of trigger architectures (Dave Newbold)
    - 12:00 - Simulation of trigger primitives (Steve Stroiney)
    - 15:40 - Overview of plans for simulating a tracking trigger (Harry Cheung)
  - Thursday 20th Software and Computing Discussion
    - 18:00 - Data overlay tools (Mike Hildreth)
    - 18:20 - HCAL pileup and overlap tools (Edmund Berry)
    - 18:40 - High luminosity pileup simulation (Alexei Safonov)

Summary



- A substantial amount of work has been done by the upgrade simulation working group to create software to run upgrade simulations (I would like to thank all the people who contributed over the time on this!)
  - We can generate simulations for a number of tracking strawman geometries
  - We have started some simulation studies but have limited manpower
  - Still some issues to deal with for SLHC simulations
    - FastSimulation: out-of-time pileup, occupancy, port geometry to 2_1_X
    - FullSimulation: CPU and memory performance, port geometry to 2_1_X
- Have definite proposal for Phase 1 pixel barrel detector
  - Need a Phase 1 forward pixel detector proposal
  - Need to study Phase 1 pixel detector performance
- Many choices for Phase 2 tracking system layouts
  - A Layout Task Force has been formed to guide tracker layout design
  - Need to know constraints placed by tracking trigger (e.g. use doublets? #?)
- Current scope for upgrade simulation studies is limited by manpower
  - We welcome more collaborators to join in and contribute

Backup Slides

Upgrade simulation WG

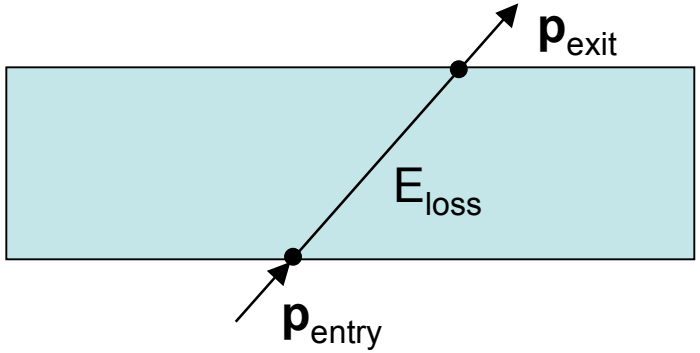
- Tracker upgrade simulation working group
  - https://twiki.cern.ch/twiki/bin/view/CMS/SLHCTrackerSimuSoftTools
    HyperNews: hn-cms-slhc-trackersim@cern.ch

Tracker Upgrade Simulations Working Group

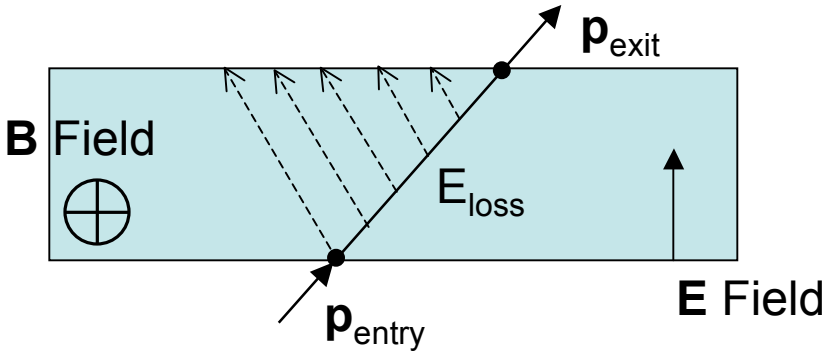
Alice Bean (KU), Avdhesh Chandra (Riverside),
Harry Cheung (FNAL, co-coordinator), Carlo Civinini (Firenze),
John Ellison (Riverside), Kevin Givens (Colorado),
Erik Gottschalk (FNAL), Xingtao Huang (U. of Puerto Rico),
Teruki Kamon (Texas A&M), Matthew Jones (Purdue),
Hector Mendez *(U. of Puerto Rico), Mark Pesaresi (Imperial College),*
Roberto Rossin (UCSB), Jennifer Sibille (KU), Scott Swain (UCSB),
Alessia Tricomi (Catania, co-coordinator), Michael Weinberger (Texas A&M)

Details: Granularity 1

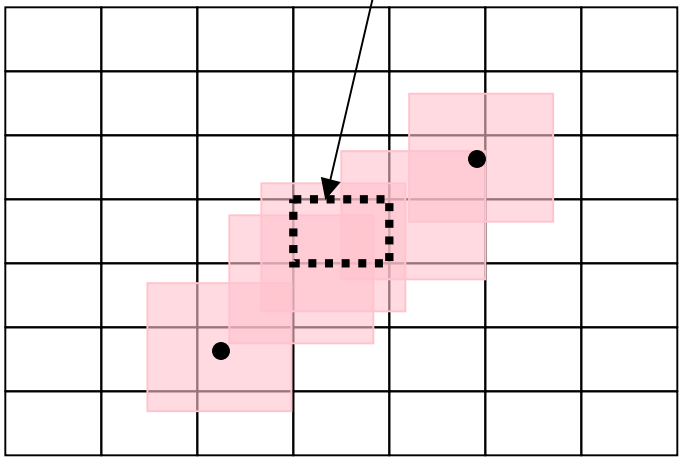
- Particle propagation and making simulated hits:
  - Propagate particle to sensitive volume: "simhit" (p_{entry}, p_{exit}, E_{loss})



  - Simulation of charge deposition: "digis"



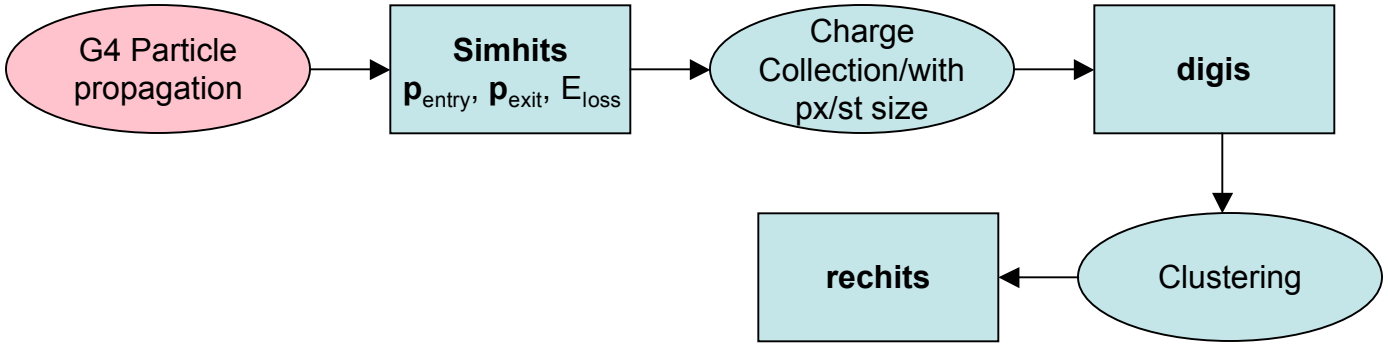
Sum charge clouds to get charge on each pixel/strip



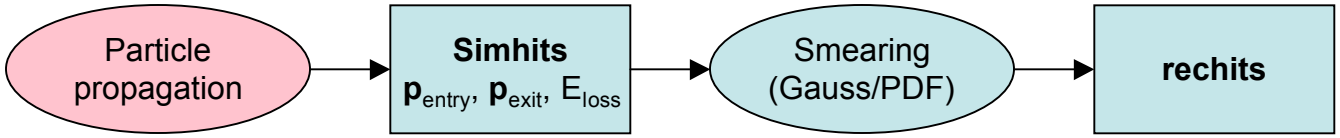
  - Cluster pixels/strips and get positions: "rechits"

Details: Granularity 2

- Types of hits within the full and fast simulations:
  - Full simulation:



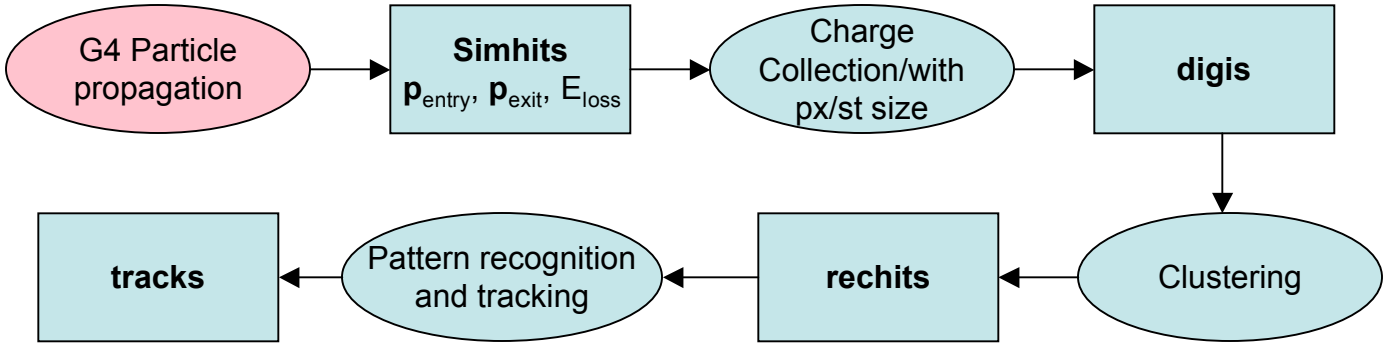
  - FastSimulation: (digis too slow for FastSimulation)



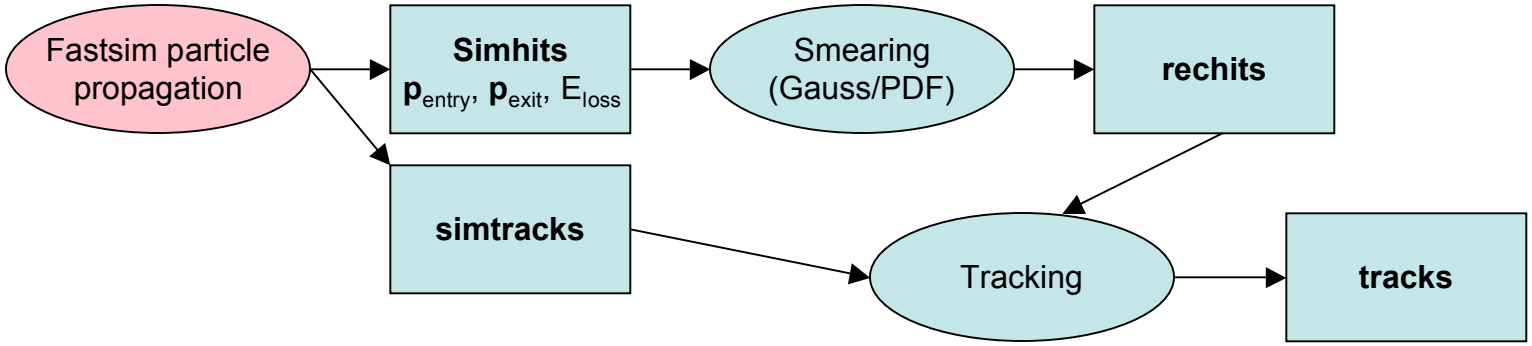
  - Fastsim: multiple simhits within one pixel/strip give multiple rechits
    - We want to make digis for tracker upgrade/trigger upgrade studies

Details: Pattern Recognition

- FastSimulation cheats on Tracking:
  - Full simulation:

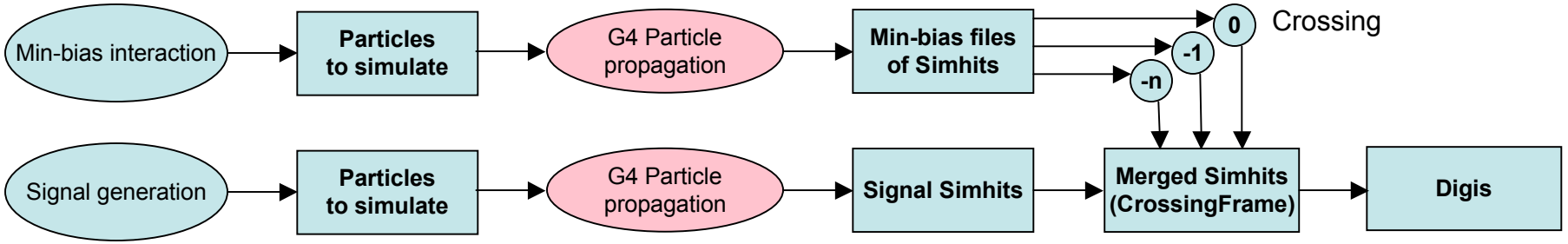


  - Fastsimulation: (Full pattern recognition option now available)

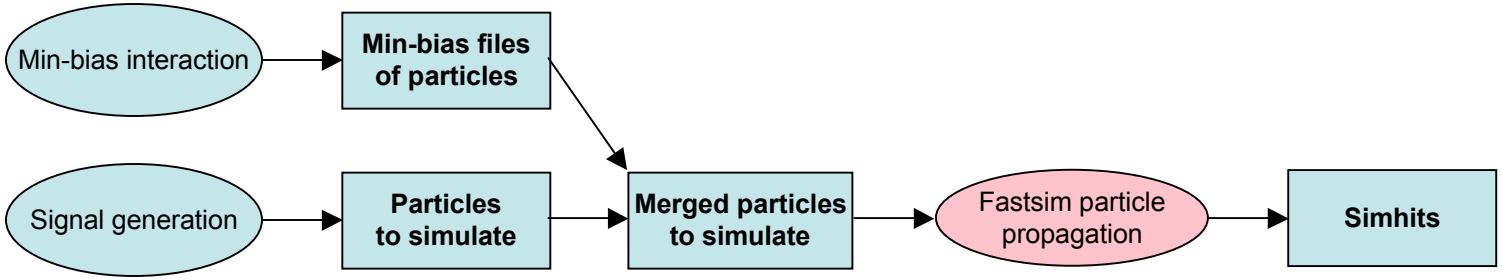


Details: Pileup Simulation

- Pileup is done by merging min-bias collisions
  - Full simulation: Mixing Module for in-time and out-of-time pileup



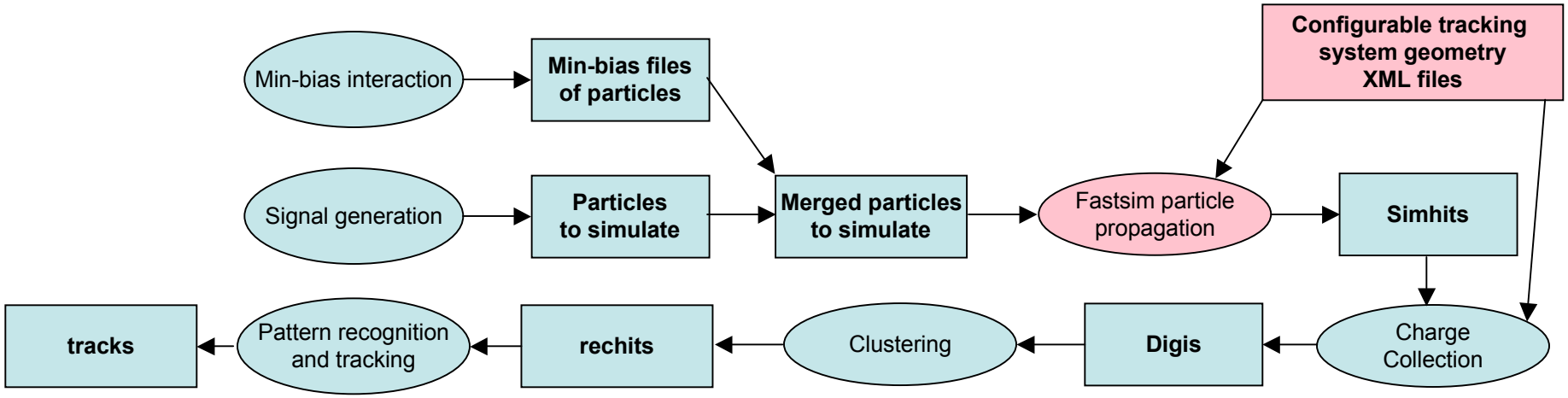
  - FastSimulation uses in-time pileup: (Mixing Module option coming)



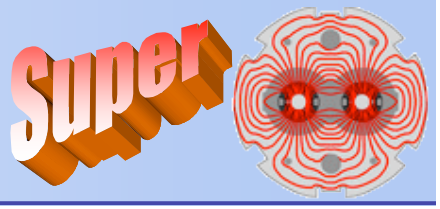
  - Tracker upgrade simulations:
    - Fastsim in-time pileup ok for tracking (at 50ns crossing time), but other sub-detectors should need out-of-time pileup (depends on occupancy)
    - For Mixing Module: need new min-bias files for each geometry!

Configurable Geometry

- Tracker upgrade simulations:
  - Use FastSimulation but with configurable geometry and digis



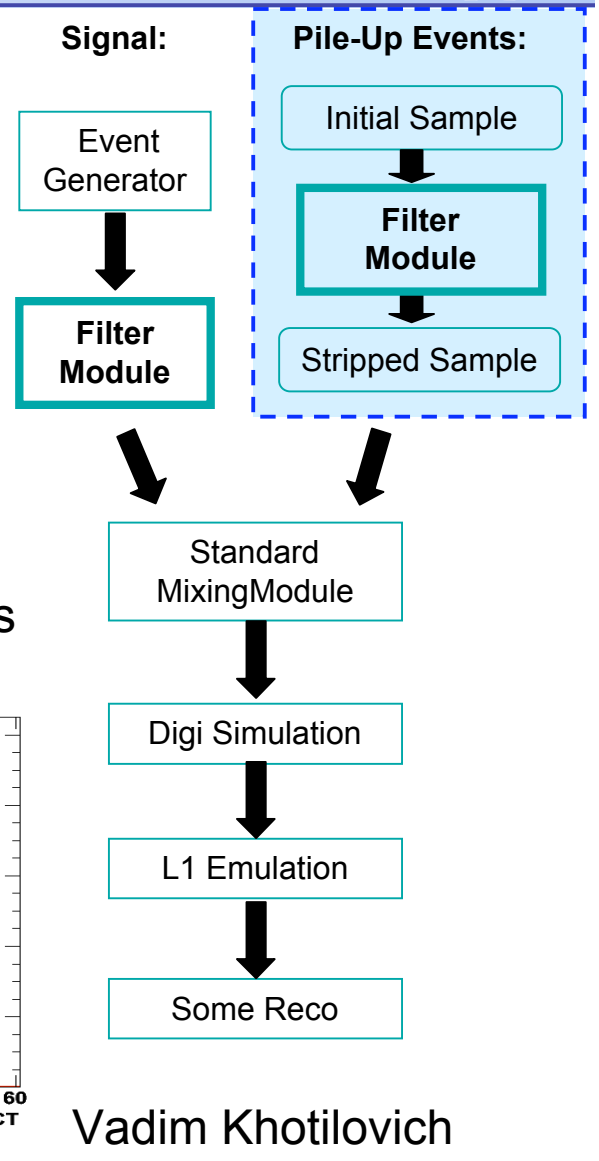
Example of Things to Study



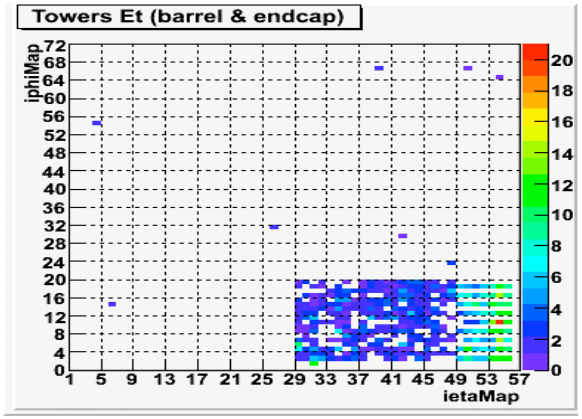
- Simulation studies of this Phase 1 strawman geometry should include studies of
  - Occupancies and data rates
  - Track quality
  - Track reconstruction efficiency and fake rates
  - Material and conversion effects; integration with other systems
  - Trigger possibilities (HLT; even L1 multiplicity?)
- Variations for what? Need input (Layout Task Force)
  - Location of layers and disks
  - Phi rotation vs. upper & lower layers; Lorentz angle compensation
  - Granularity of pixel layers
  - Long barrel vs forward disks

Fullsim: Coping With High Pileup

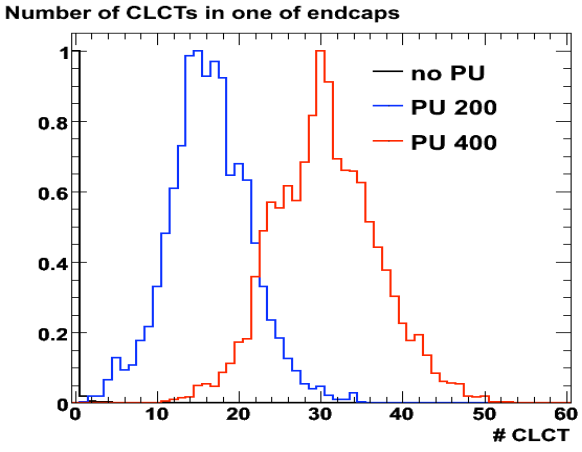
- Challenging conditions: N_{pileup}~100-400 exhausts all memory on a typical machine
- Solution: to limit studies to a part of detector and/or to fully simulate only select objects of interest
- Simple **filter module** allows to do it with high degree of customization
  - Filtering only Sim Hits/Tracks/Vertices of interest
- Constrained detector region allows studies of efficiencies and rates for local triggers, and reasonable estimates for global triggers
- So far worked well for muon and tau trigger studies:



Z →TauTau event energy towers snapshot (pileup is in 1/8 of detector):



CLCT occupancy shapes over ½ of detector:



Vadim Khotilovich

Example of Things to Study

- Talk on beam induced radiation in the CMS detector
  - See talk from Pushpa Bhat
    http://indico.cern.ch/conferenceDisplay.py?confId=36583