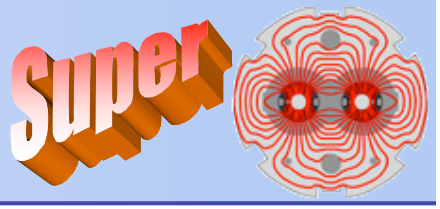
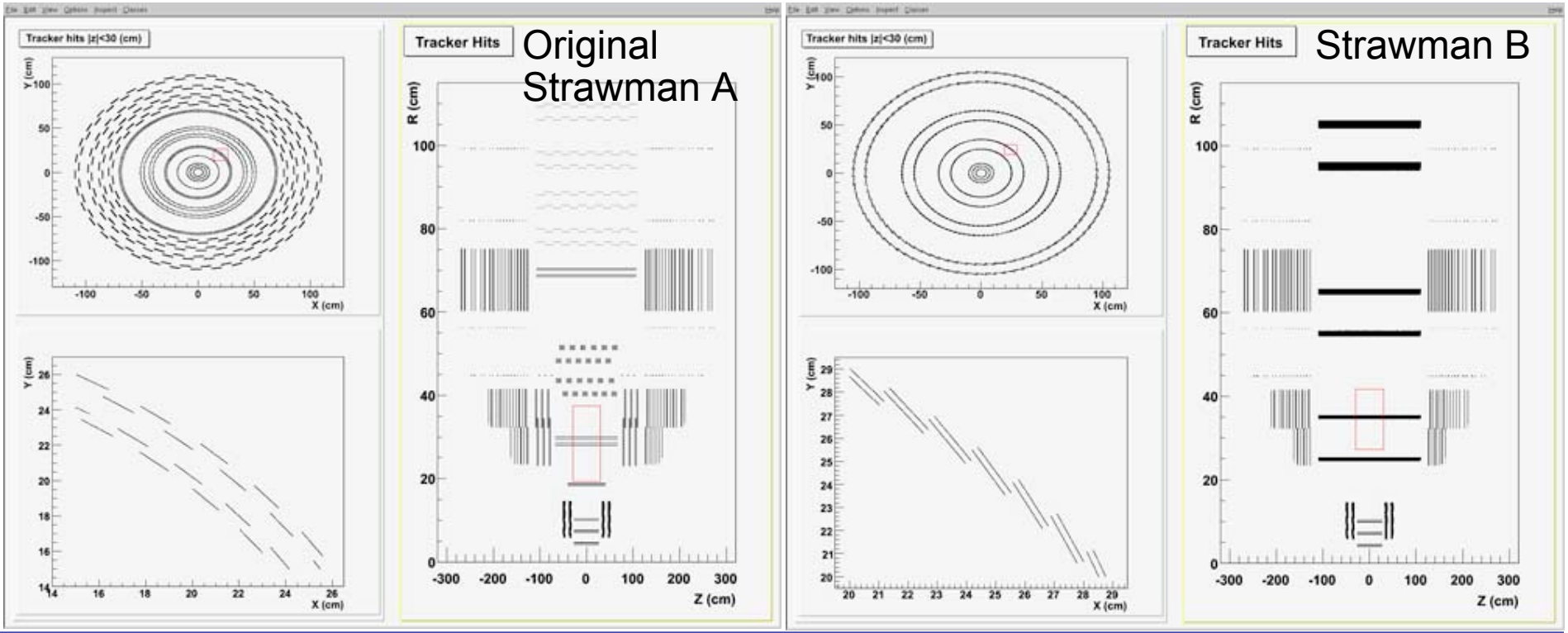


Overview of a Plan for Simulating a Tracking Trigger

Harry Cheung (*Fermilab*)

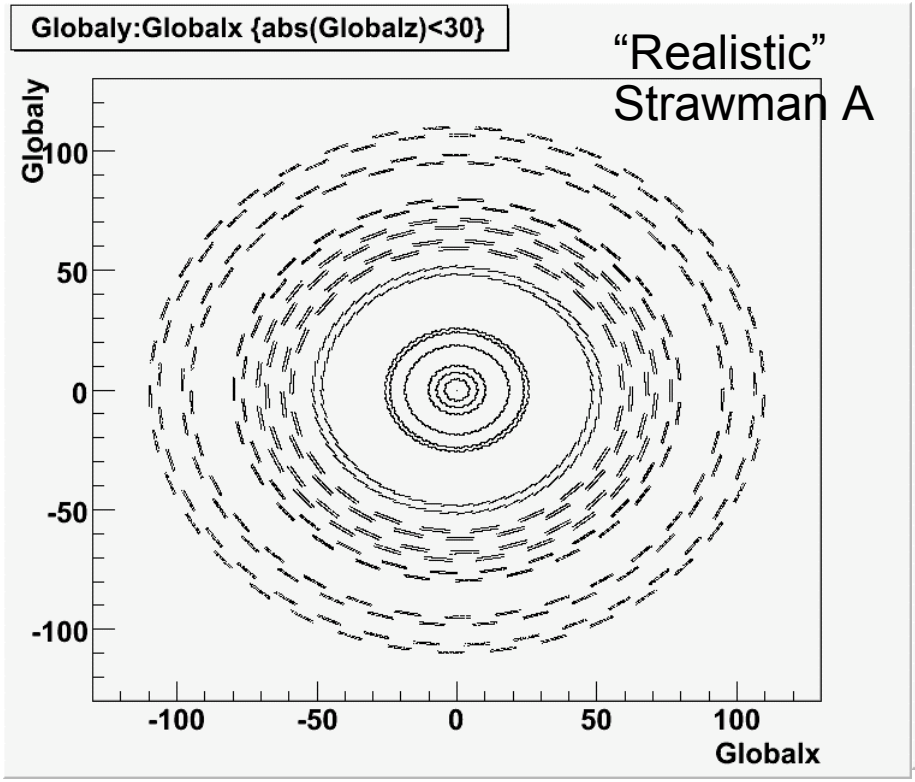
Geometry Layouts

- We have a number of strawman layouts
  - Original and more realistic Strawman A
  - Strawman B with superlayers of doublets
  - Long barrel strawman
  - Phase 1 strawman (pixel detector)

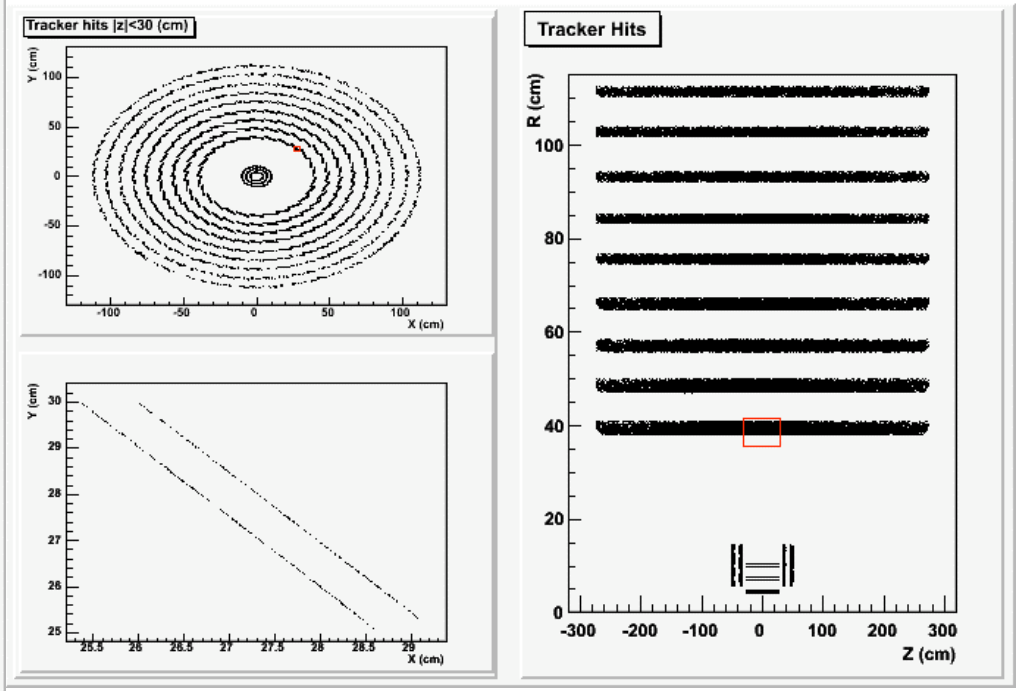


Geometry Layouts

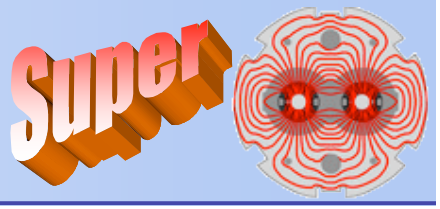
- Strawman Geometry was supposed to limit the phase space
  - Already many geometry layout variations to simulate and study
  - Layout will be much easier once we know what track triggering method we need and what the "trigger layer(s)" look like (Doublet? Cluster shape?)
- Worse for forward region, no track trigger idea yet?



Long Barrel Strawman



Track Trigger Layers



- Top priority 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
    - Want to study both a single doublet and a "stack" of 2 doublets
  - Mark Pesaresi is studying trigger doublet performance in Strawman B
    - Studying p_T thresholds for both a single doublet and pair of doublets
    - See Mark's talk from yesterday's Tracker session (layout and simulation)

Mark Pesaresi's Doublet Study

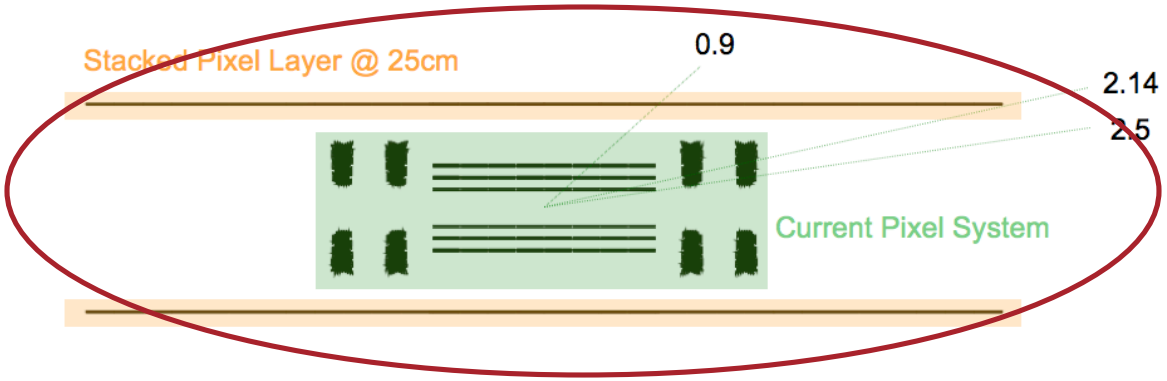
Geometry

Considering a single stacked pixel layer at r=25cm, length=221cm

Current pixel system included in geometry

Outer geometry unnecessary at this point

Using latest version of Strawman B in CMSSW_1_8_4



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Mark Pesaresi's Doublet Study

Sensor Geometry

Strawman B parameters modified in pixbar.xml and trackerStructureTopology.xml

Sensor choice: **tilted at 23°** – to reduce cluster width by minimizing Lorentz drift

100μm thickness

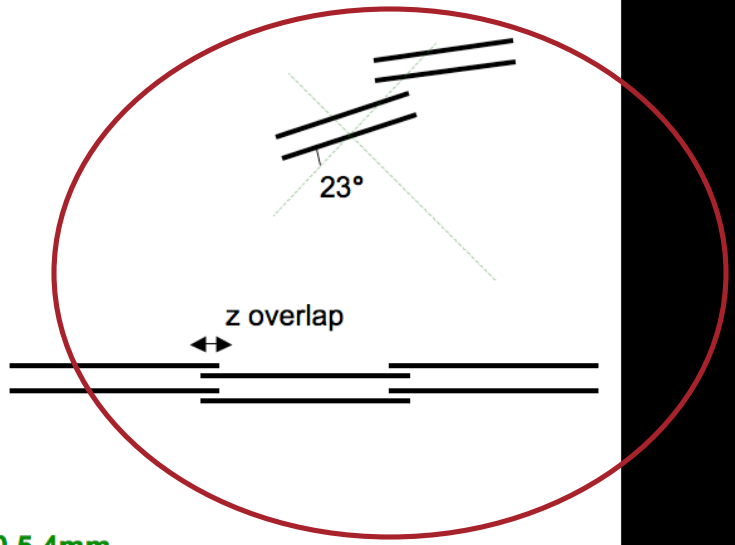
28mm x 72.8cm sensor dimensions

z overlap – to fill gaps in z

100 μm x 2.37mm pixel pitch

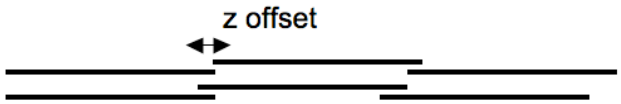
256 x 30 pixels per module

Sensor separation varied between 0.5-4mm



Modification made to geometry to aid trigger studies – not yet part of StrawmanB

z offset – to match columns in top and bottom sensors with increasing eta



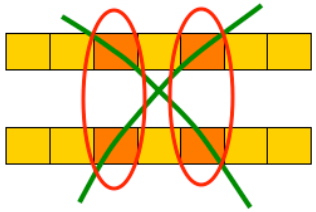
Mark Pesaresi's Doublet Study

Algorithm Performance

Separation [mm]	Max Efficiency [%]	Fake [%] (or average number/event)	Reduction Factor
0.5	99.05	0.73 (12.22)	8.04
1.0	99.35	4.14 (25.58)	22.26
2.0	97.745	17.83 (18.74)	95.99
3.0	96.00	39.08 (23.76)	210.28
4.0	92.95	47.27 (32.39)	254.35

Performance of a detector stack at r=25cm for sensors with pitch 100μmx2.37mm.
Correlation cuts optimised for high efficiency

Max Efficiency: Average maximum efficiency for a high p_t track to form a stub. Inefficiencies due to sensor doublet acceptances and algorithmic efficiency (window cuts)



Fake: Average fraction of stubs per event generated by correlating hits from different tracks

Reduction Factor: Average data rate reduction factor per event (N_{Stubs} / N_{Digis}) where N_{Digis} is number of hits with charge >adc_{digi} for the whole stacked layer

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Mark Pesaresi's Doublet Study

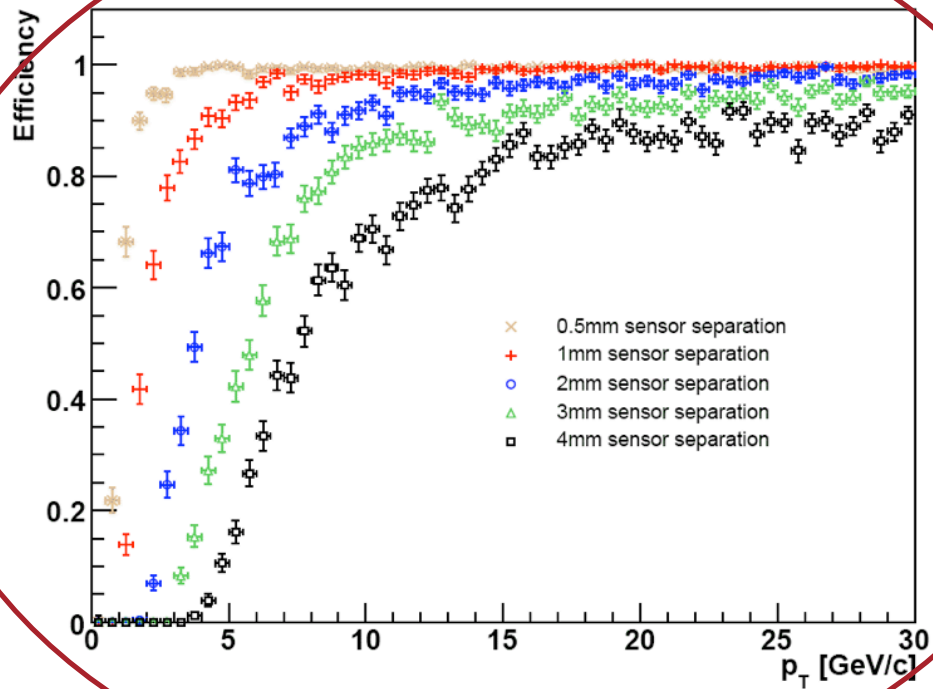
Algorithm Performance

Sensor separation is again an effective cut on p_t – as with the stacked strips

Again, the width of the transition region increases with separation. Due to:

- pixel pitch
- sensor thickness
- charge sharing
- track impact point

Efficiencies decrease with sensor separation due to the larger column window cuts – sensor acceptances and fake containment are issues



p_T discriminating performance of a stacked layer at r=25cm for various sensor separations using 10,000 di-muon events with smearing

Cuts optimised for high efficiency:
Row window = 2 pixels
Column window = 2 pixels @ 0.5mm; 3 pixels @ 1mm, 2mm;
4 pixels @ 3mm; 6 pixels @ 4mm

Mark Pesaresi's Doublet Study

Double Stack Geometry

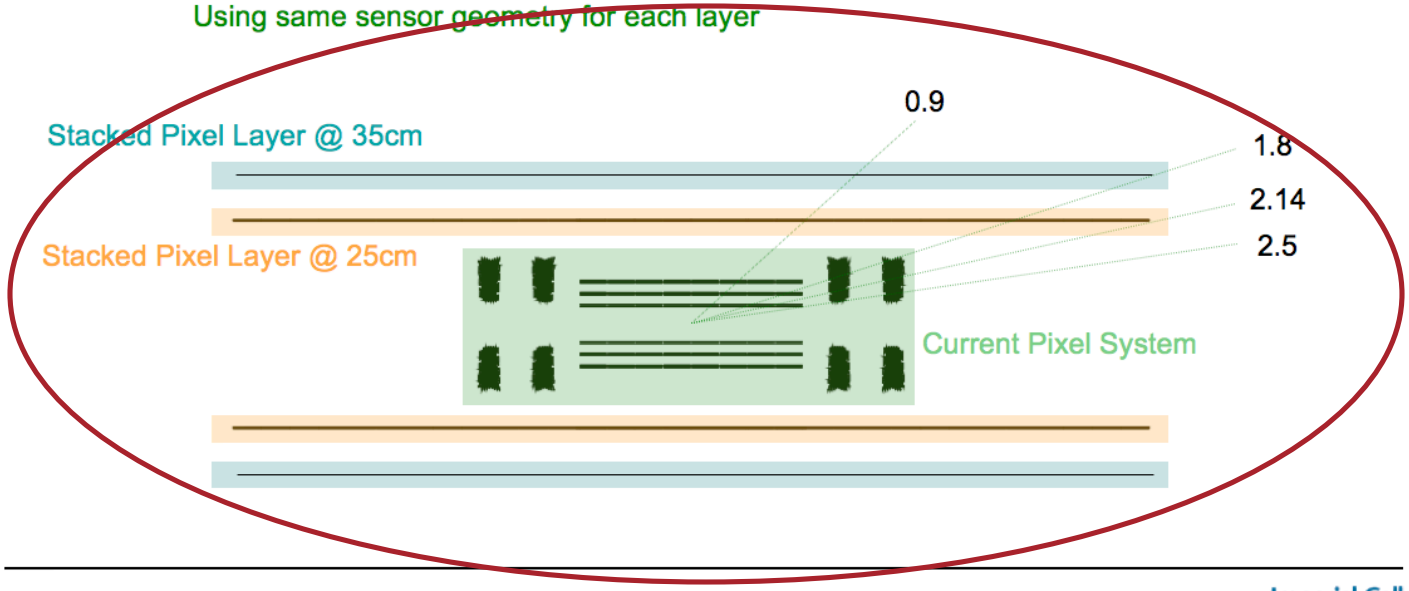
Considering now two stacked pixel layers at:

r=25cm, length=221cm
r=35cm, length=221cm

Current pixel system included in geometry

Outer geometry unnecessary at this point

Using same sensor geometry for each layer



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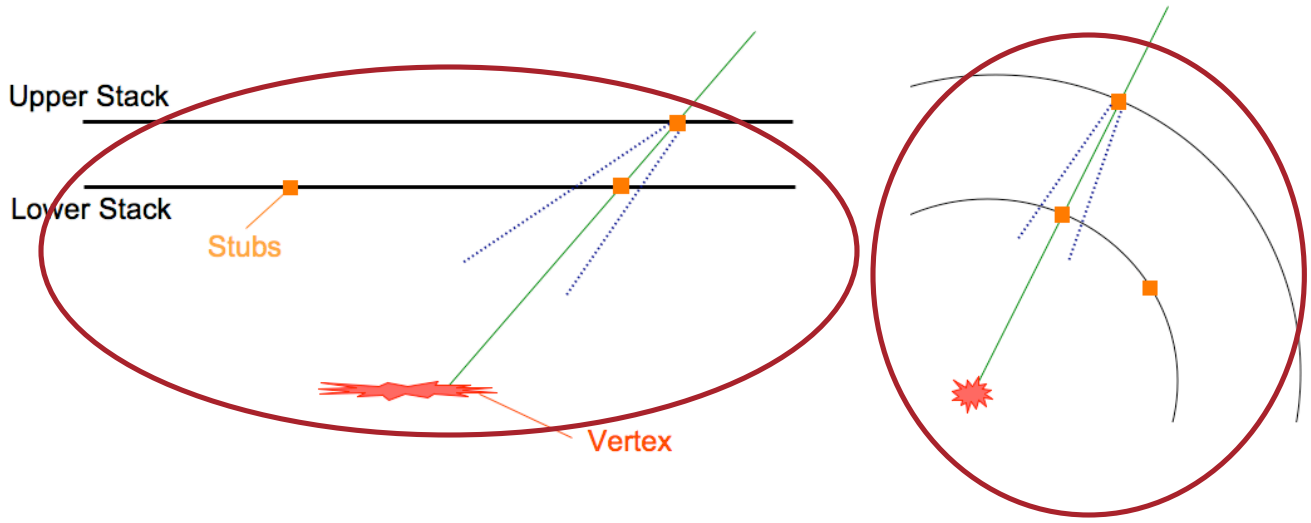
Mark Pesaresi's Doublet Study

Double Stack Correlation Algorithm

Correlate stubs in upper sensor with stubs in lower sensor – use upper sensor as seed (fewer stubs, fewer fakes)



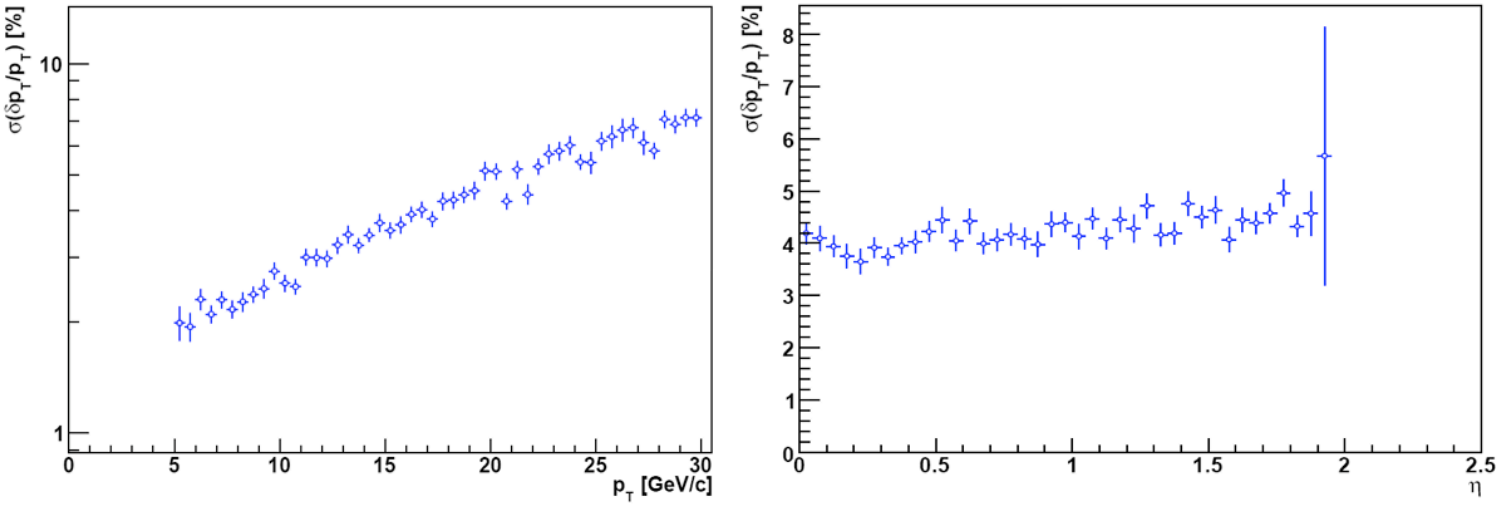
Window cut in η applied – wide enough to allow for vertex smearing

Window cut in ϕ applied – wide enough to allow for low p_t tracks and scattering

Mark Pesaresi's Doublet Study

Double Stack Algorithm Performance

If the stubs are correlated, we can use the two stubs plus the vertex as r,ϕ points for a 3-point track p_t measurement – assumes track originates from (0,0)



Tracklet p_t resolution vs. track p_t and η when using a 3-point pt reconstruction measurement for 10,000 0-30GeV di-muon events with smearing

Using double stack correlation window cuts
$|\Delta\eta| < 0.2$, $|\Delta\phi| < 0.015$

Mark Pesaresi's Doublet Study

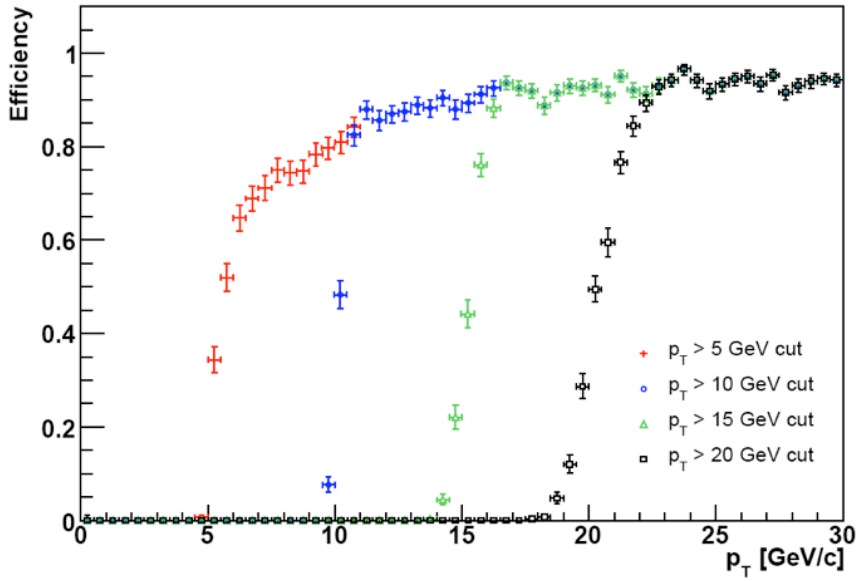
Double Stack Algorithm Performance

With a momentum measurement using two stacks, an effective cut on track p_t can be placed

Maximum efficiency is still determined by that of the single stack

A better track pt resolution using the double stack means that the transition region can be reduced

We would like to have better efficiencies at low p_t – this would require stacks with smaller sensor separations (or larger windows) increasing the number of stubs per layer and the number of combinatorics for the double stack algorithm



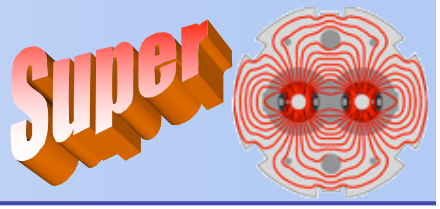
p_T discriminating performance using double stacks for 10,000 0-30GeV di-muon events with smearing

Using double stack correlation window cuts
$|\Delta\eta| < 0.2$, $|\Delta\phi| < 0.015$

Track Trigger Layers

- Top priority 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
    - Want to study both a single doublet and a "stack" of 2 doublets
  - Mark Pesaresi is studying trigger doublet performance in Strawman B
    - Studying p_T thresholds for both a single doublet and pair of doublets
  - Eric Brownson and Matthew Jones looking at the L1 single muon trigger rate with Fastsim,
    - Will study effectiveness of Mark's trigger doublet points and vectors
- How much does the performance of trigger doublets depend on
  - Exact Structure of the doublets?
  - Material of doublets and whole construction?
  - Need a robust trigger…
- What are workable alternatives?
  - Fabrizio Palla is studying track triggering using cluster shapes
- Must tackle the forward region for track triggering!

Tracking System Layout



- Once we know what the triggering layers should look like we can start narrowing the tracking system layout variations to decide on a baseline layout
  - Geometry layout tool will be very useful to quickly compare layouts: can compare many statistics (including surface, channels, occupancy, power, cost, bandwidth)
  - Tracker Layout Task Force will have an important role to help us converge to a viable baseline layout geometry (e.g. define realistic ladder and module structures; realistic material budgets and cooling layout; possible channel counts; overall detector construction, etc.)
  - What do we do about track triggering in forward region?
    - Can we give guidelines regarding what is feasible? E.g.
      - Is there more possibility to take data off-detector than in the barrel?
      - Use same technology for correlating forward disks as stacks of doublets?
      - Can we consider a cone/"elliptical" forward detector?
- Setting up a new geometry layout in the simulation
  - Once we have an idea of what the baseline layout looks like we can build the new layout relatively easily
    - How much configurability? Make fastsim more realistic

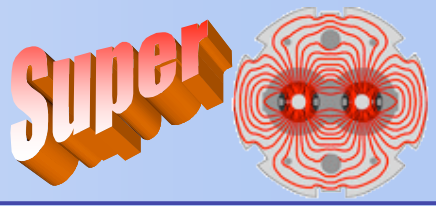
What Plan?

- No grand plan yet for plan of work beyond initial studies
  - Alessia Tricomi, Harry Cheung (Tracker Upgrade Simulations WG), Dave Newbold (Trigger Upgrade - Simulations WG), Anders Ryd, John Jones (Trigger Upgrade - Track Trigger WG) have discussed working together on the initial steps to make progress
  - Need to involve other WG: Sridhara Dasu, Jane Nachtman (Trigger Upgrade - Calorimeter Trigger WG), Tracker Upgrade - Muon Trigger (no-one yet)
    - Did not manage to make it to other WG sessions in this workshop, will need to talk together
  - Work with and guidance from Tracker Layout Task Force (headed by Duccio Abbaneo)
    - Group has not yet met, will have important contribution to plan/schedule
  - Work with other groups that might spring up, e.g. Cluster shape group led by Fabrizio Palla
  - The next slides that contain plans are my opinion

Working together

- The Tracker upgrade and Trigger upgrade simulations groups have worked together already to create the code to interface the simulated tracker information to the trigger code framework (to get TPG)
- Any plan should include how people in the various working groups, groups, or individuals can successfully work together
  - E.g. Ecal electrons sensitive to trigger layer placement (larger radius?)
- Any plan should not discourage innovations (that may be discovered in areas outside the immediate plan)
- Plan should include common tools so we can compare
  - Single set of SLHC software
- Before we work out the details people should be able to continue work
  - E.g. Trigger upgrade group work with generator 4-vectors
  - E.g. Tracker upgrade simulation group using private trigger primitive code to make progress (e.g. Mark Pesaresi's studies)

Scope of Initial Tasks



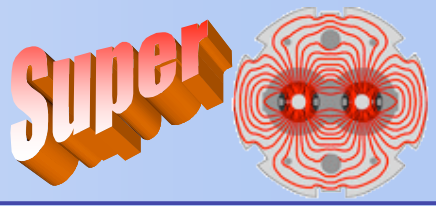
- Current simulation studies with limited manpower: simulation studies we expect to make progress in the next few months

1. Studies to see whether a (buildable) trigger doublet would work, how many are needed and what their parameters should be
   - Mark Pesaresi's doublet study is very encouraging
   - Still work to be done, e.g. study efficiency in pileup conditions
   - Need to work out realistic/buildable doublet structures
   - Will look track doublet info for the L1 single muon trigger rate
2. Studies of a very long barrel detector of (mini-)strips
   - Study Phase 2 forward region options and doublet at large radius?
3. 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 and possible forward detector (but that is external to simulation groups)

Tasks after the initial work

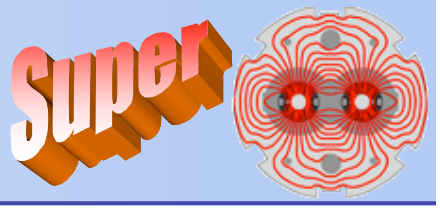
- Of course these studies could be/are in parallel with more manpower
- Trigger using cluster shapes (studies already ongoing - Fabrizio Palla)
- Work out track trigger scheme in the forward region
  - Now we are only looking at a very long barrel
  - Will need input from the Tracking group to make a plan
- For doublet schemes
  - Any vertex information for pair of doublets?
  - Interest in standalone track vectors triggers?
- Moving to a newer CMSSW version and get the improvements with the latest version

Tracking Layout in ~6 months



- Once we know what the triggering layers should look like we can start narrowing the tracking system layout variations to decide on a baseline layout
  - Results from doublet study in L1 Muon trigger by March/April 2009 if possible
  - Geometry layout tool will be very useful to quickly compare layouts: can compare many statistics (including surface, channels, occupancy, power, cost, bandwidth)
    - Can we get the tool to output the geometry for use in the simulation in the timescale we want?
  - Tracker Layout Task Force will have an important role to help us converge to a viable baseline layout geometry (e.g. define realistic ladder and module structures; realistic material budgets and cooling layout; possible channel counts; overall detector construction, etc.)
    - What do we do about track triggering in forward region?
    - Will need lots of input from different WGs (what is the forum?)
  - Work on other needed tools: more realistic fastsim (pileup, etc.)

Plans after 6 months?



- Make the baseline geometry!
  - Do the needed simulation studies
    - Trigger performance
    - Tracking performance
  - Work on making simulation more realistic
    - Not only the tools, but also any hardware constraints
  - Work on making the baseline layout more realistic
- Learn when we get real data and feedback into simulations

Summary

- We have a short term focused plan
  - On studying trigger doublet performance
  - On the Phase 1 pixel layout
- There is a plan to get a baseline layout in mid-2009
  - If we take Peter Sharp's proposal to use Marcello Mannelli's layout we can start building the geometry (it is a variation of strawman B)
    - Need exact documentation on the proposed geometry
  - Can spend the time to converge on realistic structures/materials
  - Need a forum, etc. for WGs to work together (just layout task force)
- Plan to use real data to feedback to simulations