Impact of tracker layout on track reconstruction with high pileup

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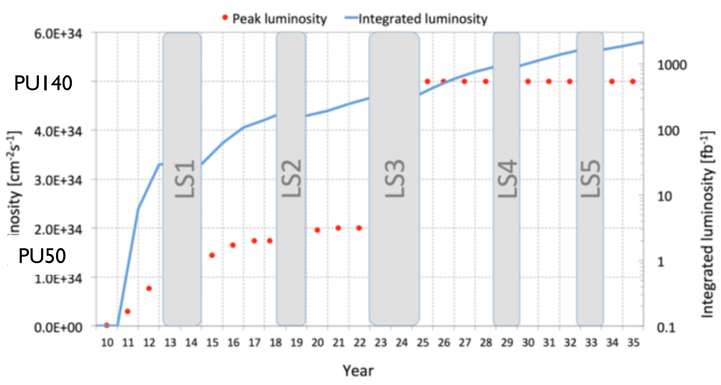
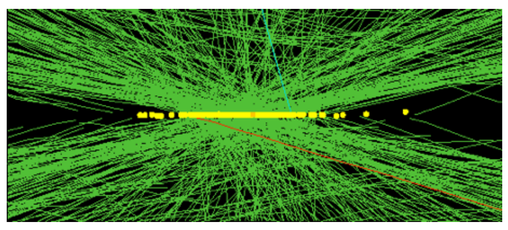
- High-luminosity LHC operations are expected to be with mean pileup up to 200
- CPU cost of charged particle tracking is a significant fraction of total computing cost and is comparable to tracking detector construction cost
- Fast track pattern recognition can replace Kalman-filter based one, which is used in traditional tracking and is responsible for over 1/2 of tracking time
- Tracker layout with grouped layers can improve tracking: faster pattern recognition from reduced combinatorics; improve locality for parallel execution

High pileup



PU~100 actual event with 78 vertices
CMS-PHO-EVENTS-2012-006



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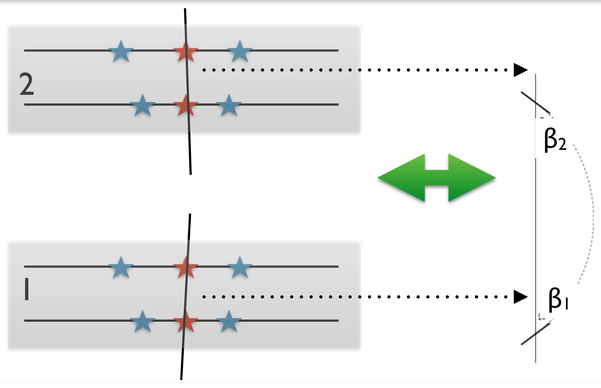
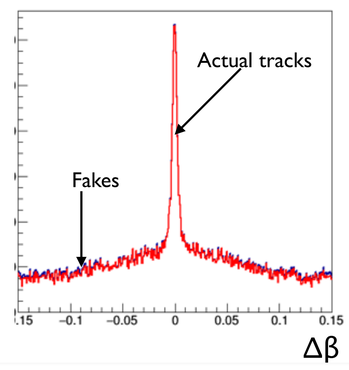
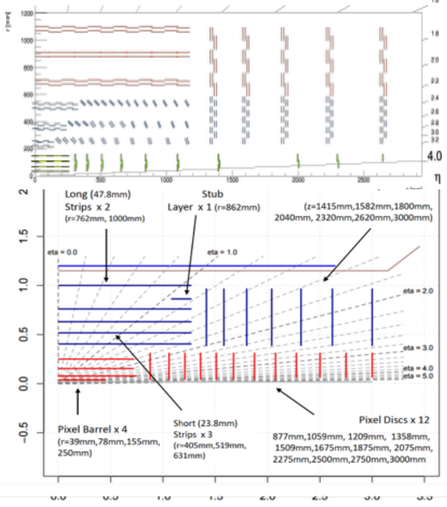
Faster tracking: segment linking

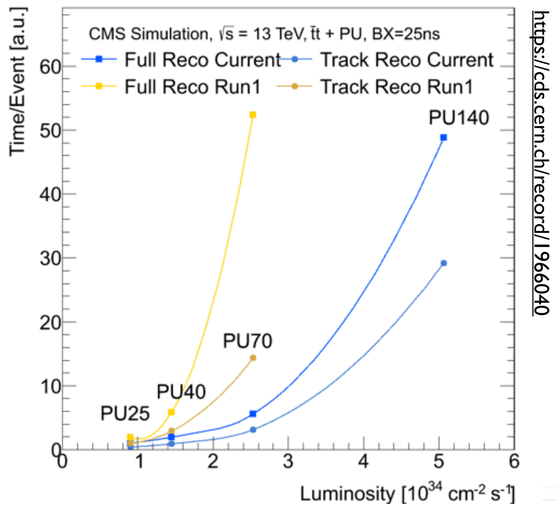




- Segment building is a local step (highly parallelizeable)
- Segment linking delivers tracklet for pattern recognition
- Tracklets can be combined fast into full track patterns

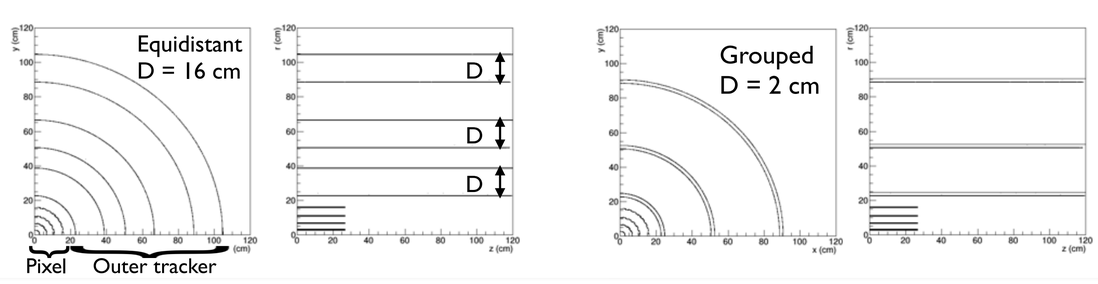
Tracker and tracking costs





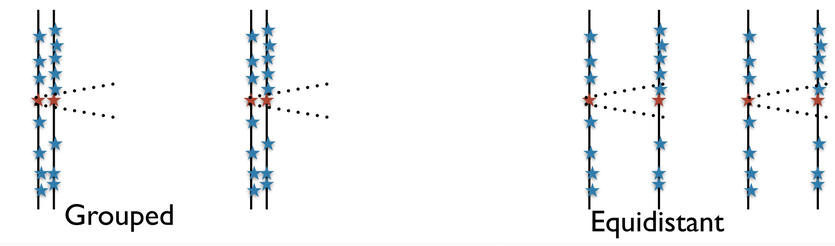
- Tracking time is a major part of CPU budget
- New tracking detectors are being designed for upgrades
- Opportunity to combine tracking detector and algorithm design considerations for more optimal total cost

Grouped layer layout



- Simplified simulation of tracker layout
- Barrel region used to illustrate the benefits

Impact of grouped layer layout

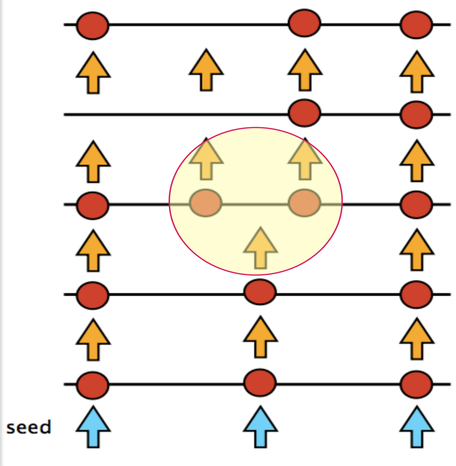


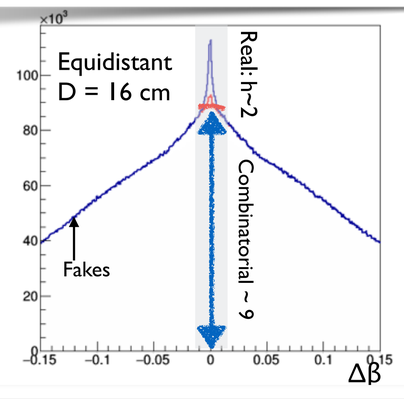
- Grouping reduces combinatorial source of fake segments
- Few cm grouping is enough for good direction resolution

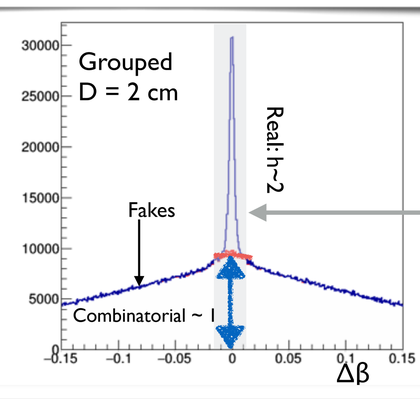
Combinatorial problem in Tracking

- Natural parts of tracking: pattern recognition (PR) and final track fit
- Traditional tracking uses Kalman fit/filter (KF) approach both in pattern recognition and in track fit
- KF math is rather complex = CPU
- KF PR requires progressive building with multiple candidates kept to the end = fast growth with increasing pileup
- Faster PR with increased locality can replace KF PR

New candidate for each ambiguity
Candidates kept to the end
Pick the best at the end







Plots for pileup 140, with segment selections: $p_T > 1$ GeV in the barrel ($|\eta| \lesssim 1.6$)

Shaded band is for passing combinations

- Combinatorial component is a measure of CPU wasted
- With grouping, the CPU waste is reduced by about 9 while the efficiency is preserved

Grouped layer layout is expected to reduce computing costs, with substantial impact for tracking outside the (inner) precision pixel detector