Performance of the b-tagging algorithms with an upgraded CMS detector

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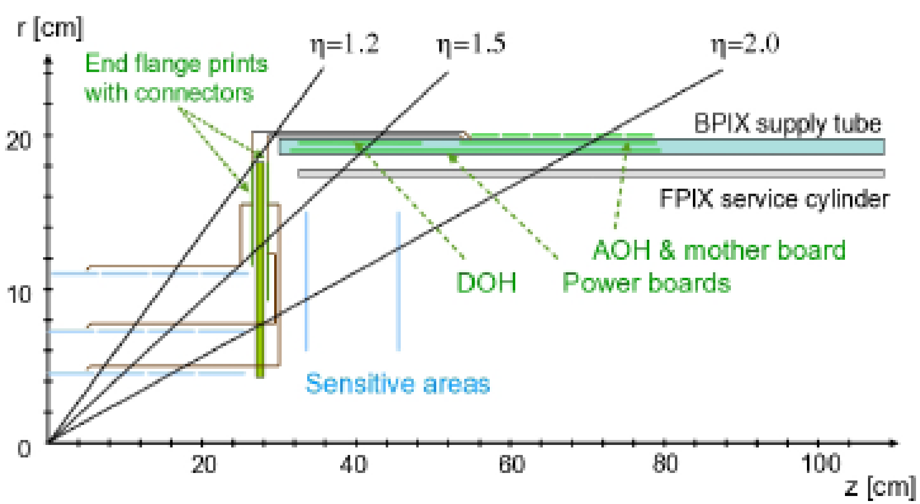
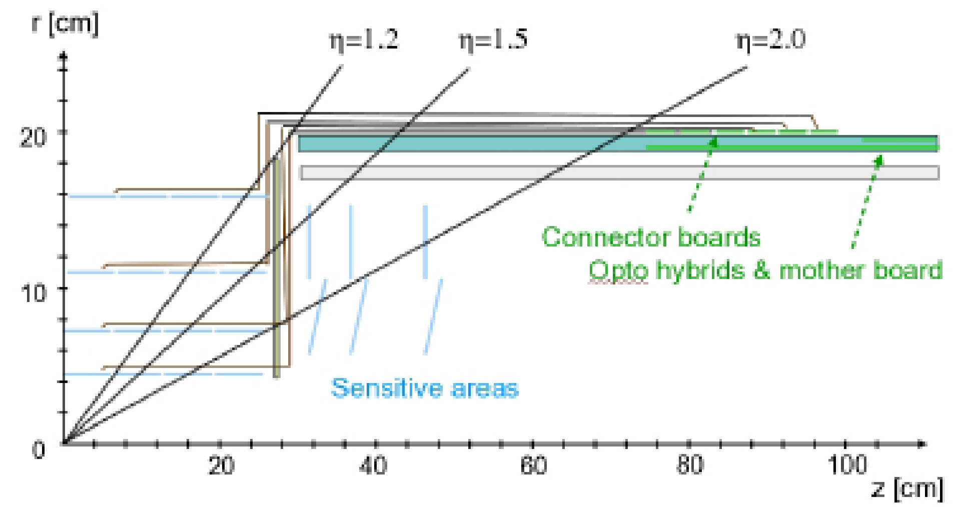
Phase1 Tracker Upgrade



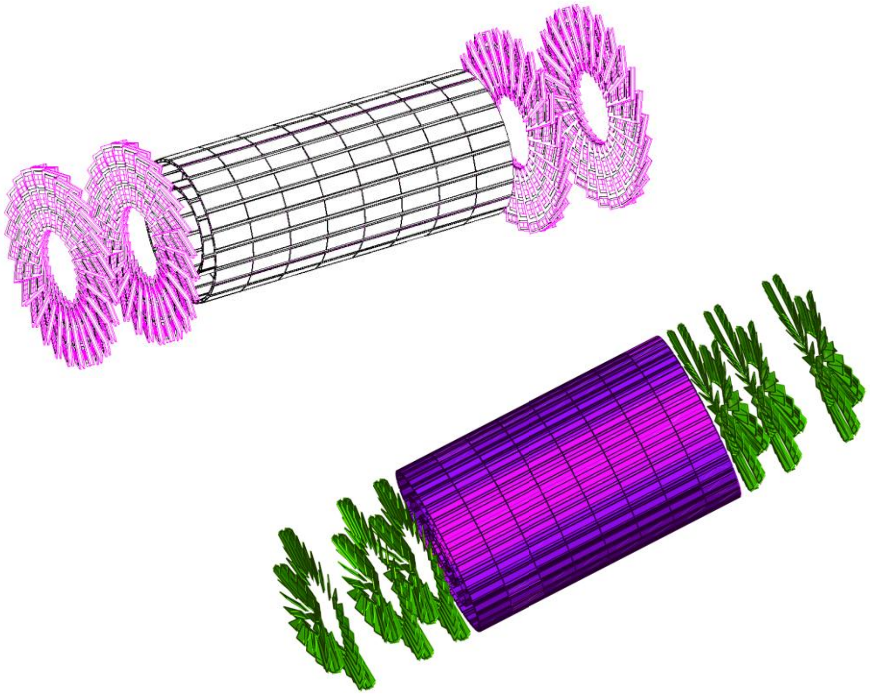


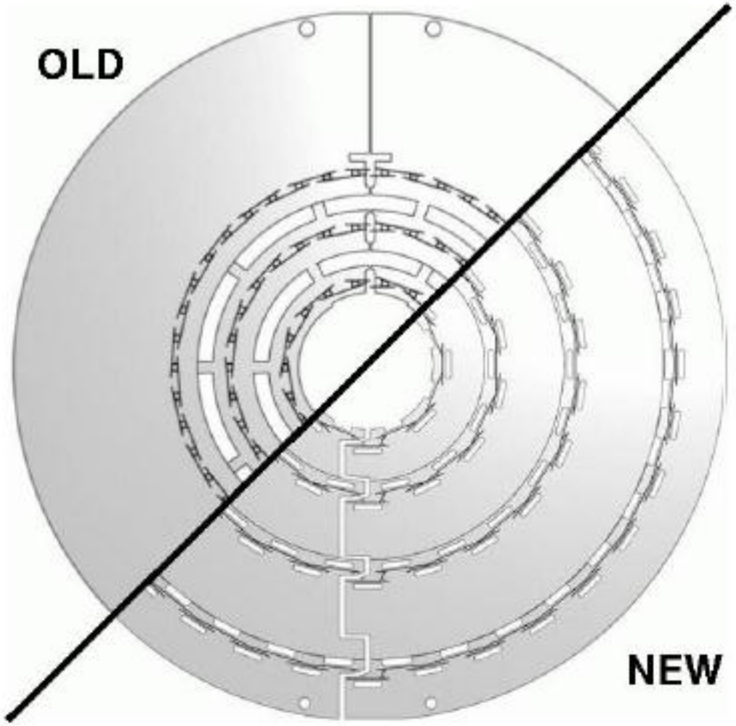
4th Barrel layer, 3rd Forward disk, Altered cooling & electronics …

- Restore current performance in PileUp scenarios above design luminosity
- Redundancy to compensate for data loss
- Take advantage of any other changes
  - Smaller beam pipe

Must be backed up by studies

3rd Disk & 4th Layer





Different shape to the disks

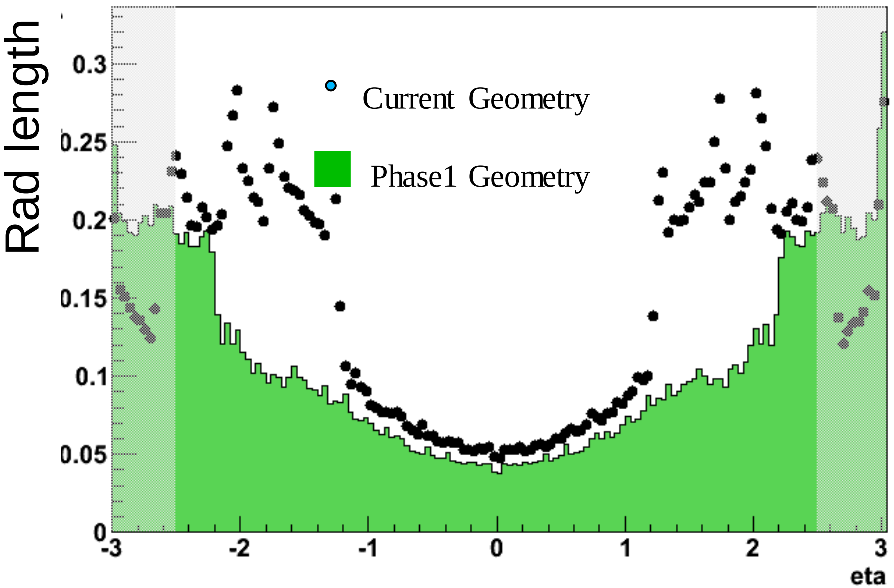
- Larger coverage in η

Different spacing between the Barrel layers

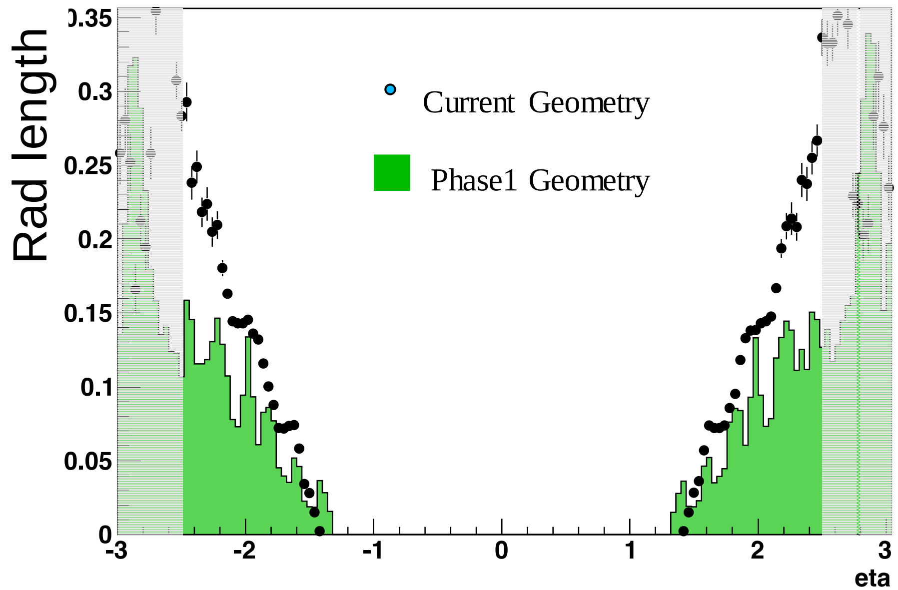
- Closer to IP & TIB

Material Budget

Barrel + Forward



Forward only

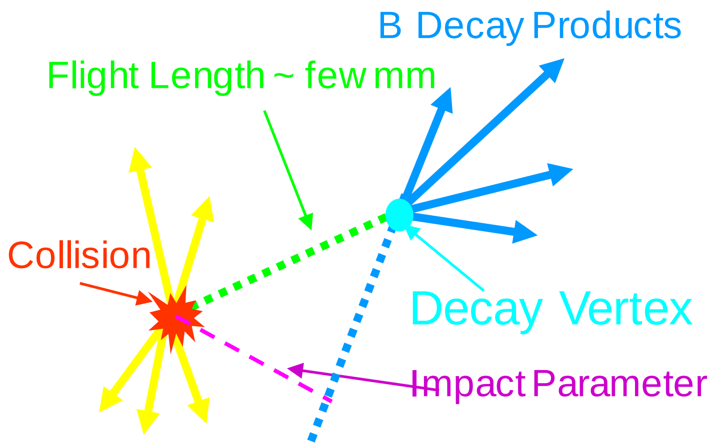


More sensors in more layers

- In general move material out and away from IP
- CO_2 cooling
- Lower the material budget

Less interaction with the pixel tracker

b-tagging

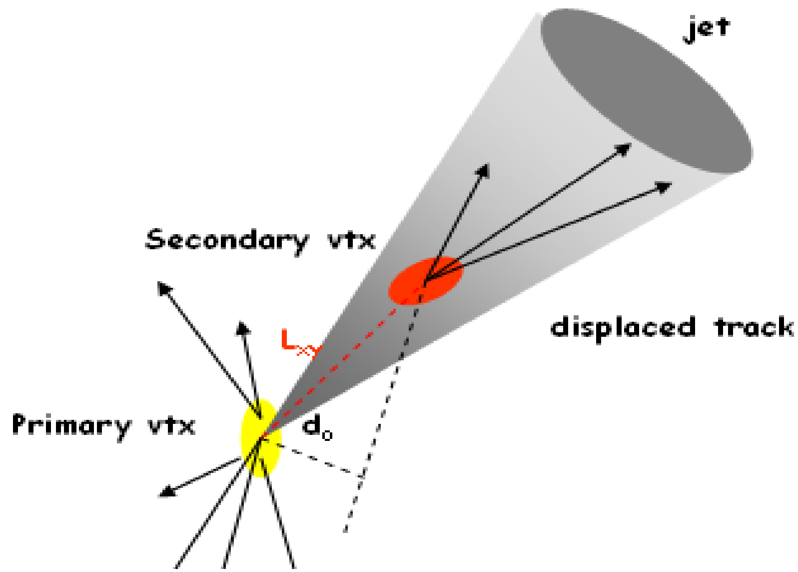


Exploit the properties of b hadrons to distinguish b-jets from light (u,d,s,g) jets:

- Large lifetime ~1.5 ps (large decay length: 20 GeV B-hadron decays after ~2 mm)
  - Search for tracks or vertexes displaced w.r.t. primary vertex
- Large mass ~5 GeV
  - Search for leptons, from semileptonic b decays, with large transverse momentum w.r.t. jet axis

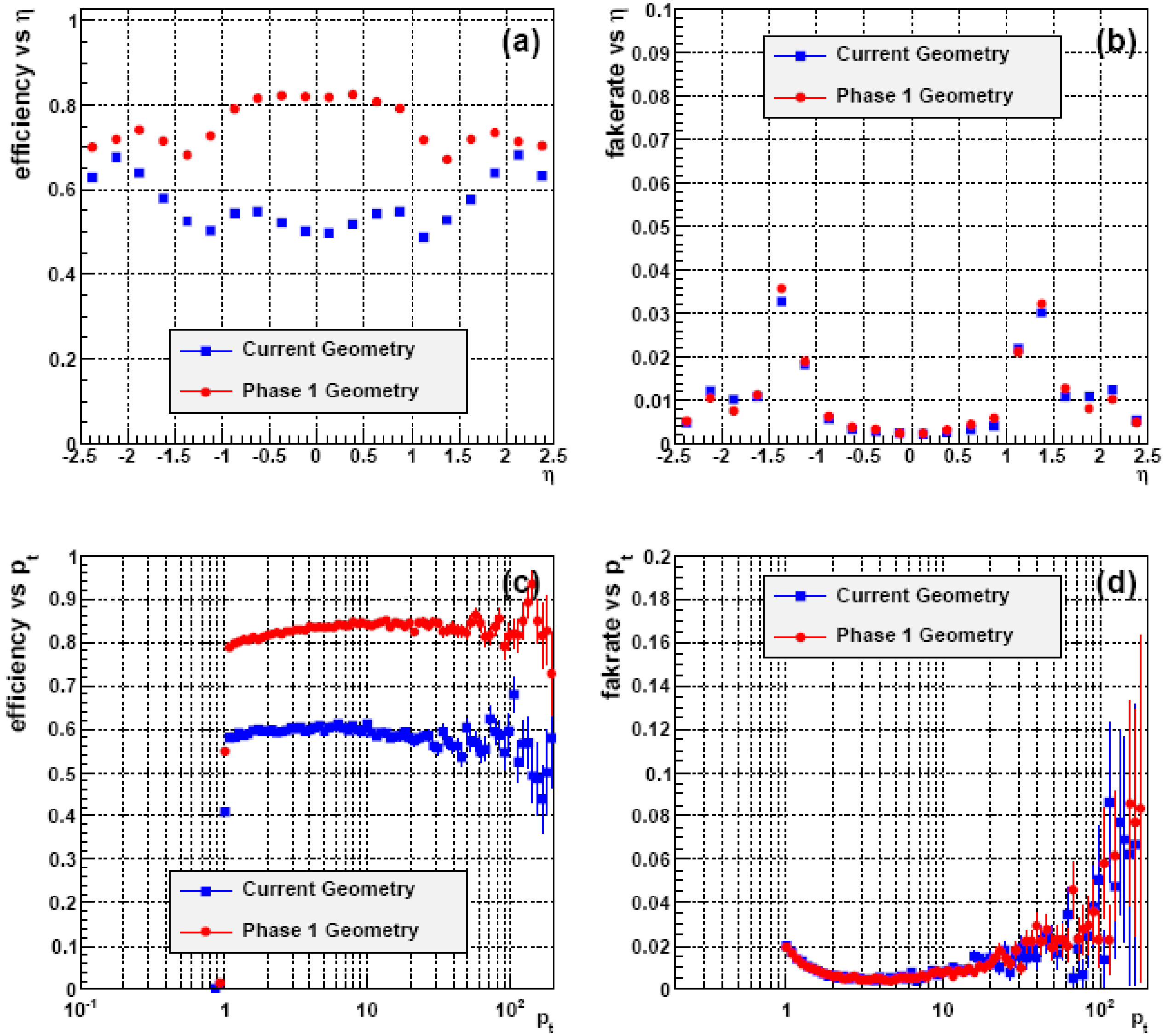
Good tracking & Vertex reconstruction are needed

b-tagging algorithm



- Find jets in the Ecal & Hcal
- Find High Quality Tracks with the Tracker
  - Calculate ImpactParameter
- Match the Tracks to the jets
- Build the discriminator

Track Finding at High PileUp



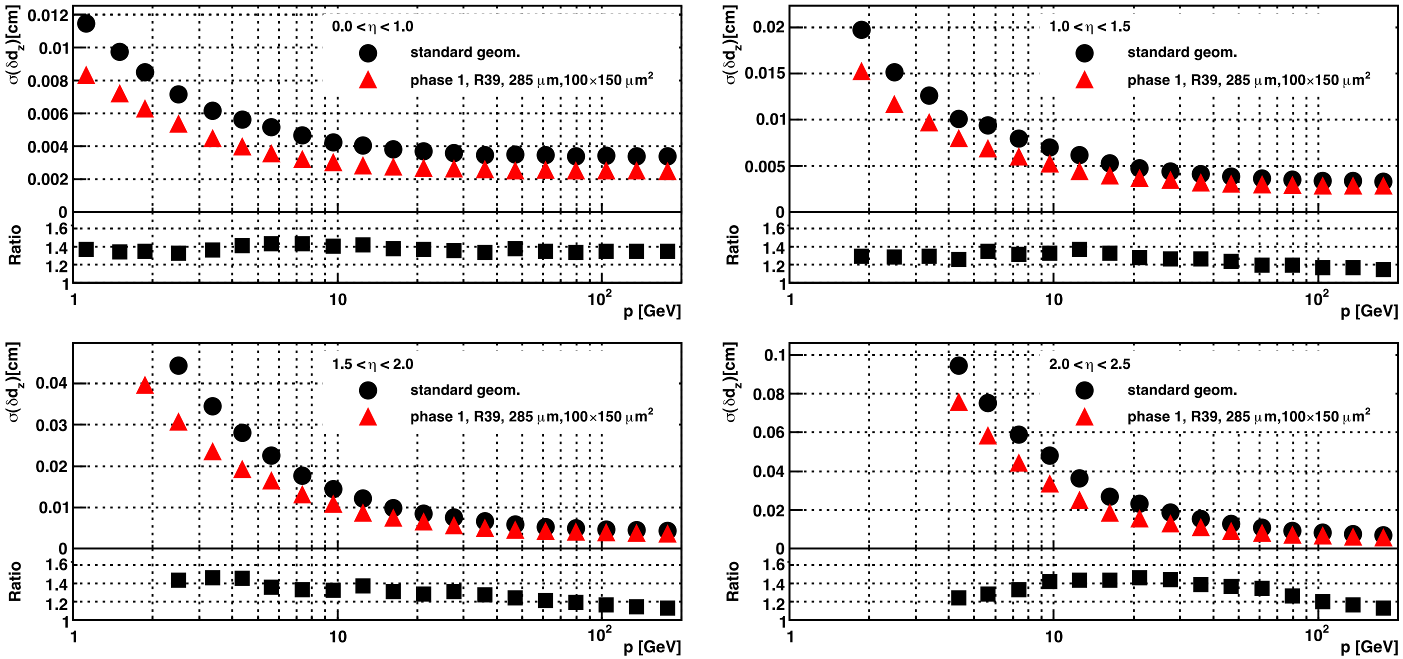
High Luminosity → Read out inefficiencies & Fake Tracks

ttbar events at $2x10^{34}cm^{-2}s^{-1}$, <PU>=50 @ 25ns

High quality tracks similar to the requirements that are used in b-tagging

Vertexing

μ–gun Sample



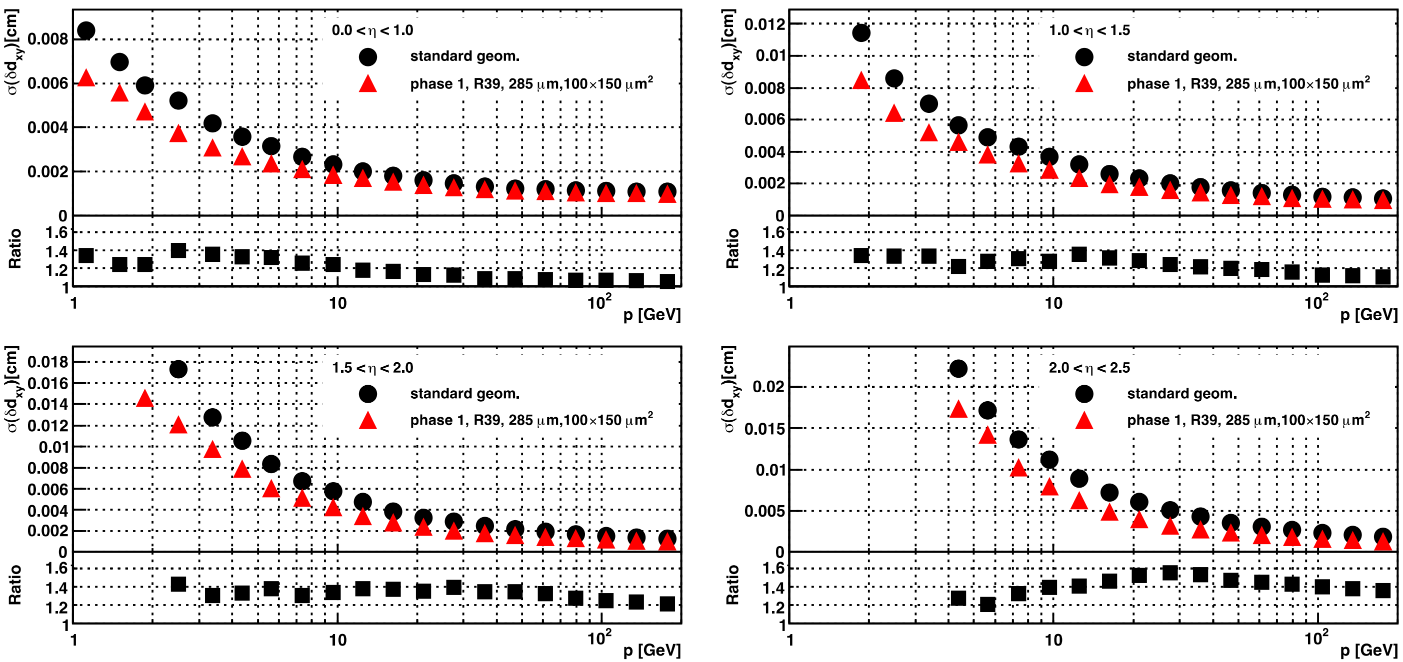
Longitudinal Impact Parameter for all vertices

- Improve with higher P_T
- Does best in central η regions
- Phase1 Tracker provides improvement in vertexing

Same story for the Transverse Impact Parameter…

Vertexing

μ–gun Sample

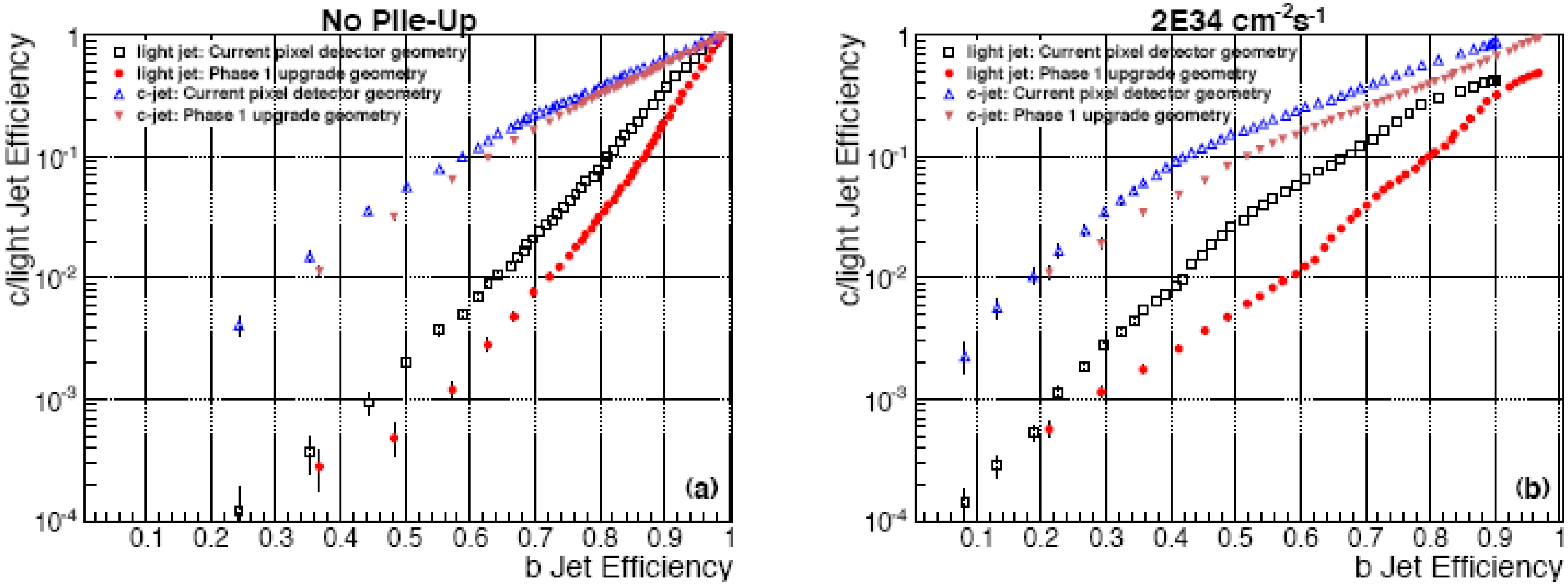


Transverse Impact Parameter for all Vertices

- Slight improvement on Longitudinal
- Phase1 provides most improvement for lower P_T tracks

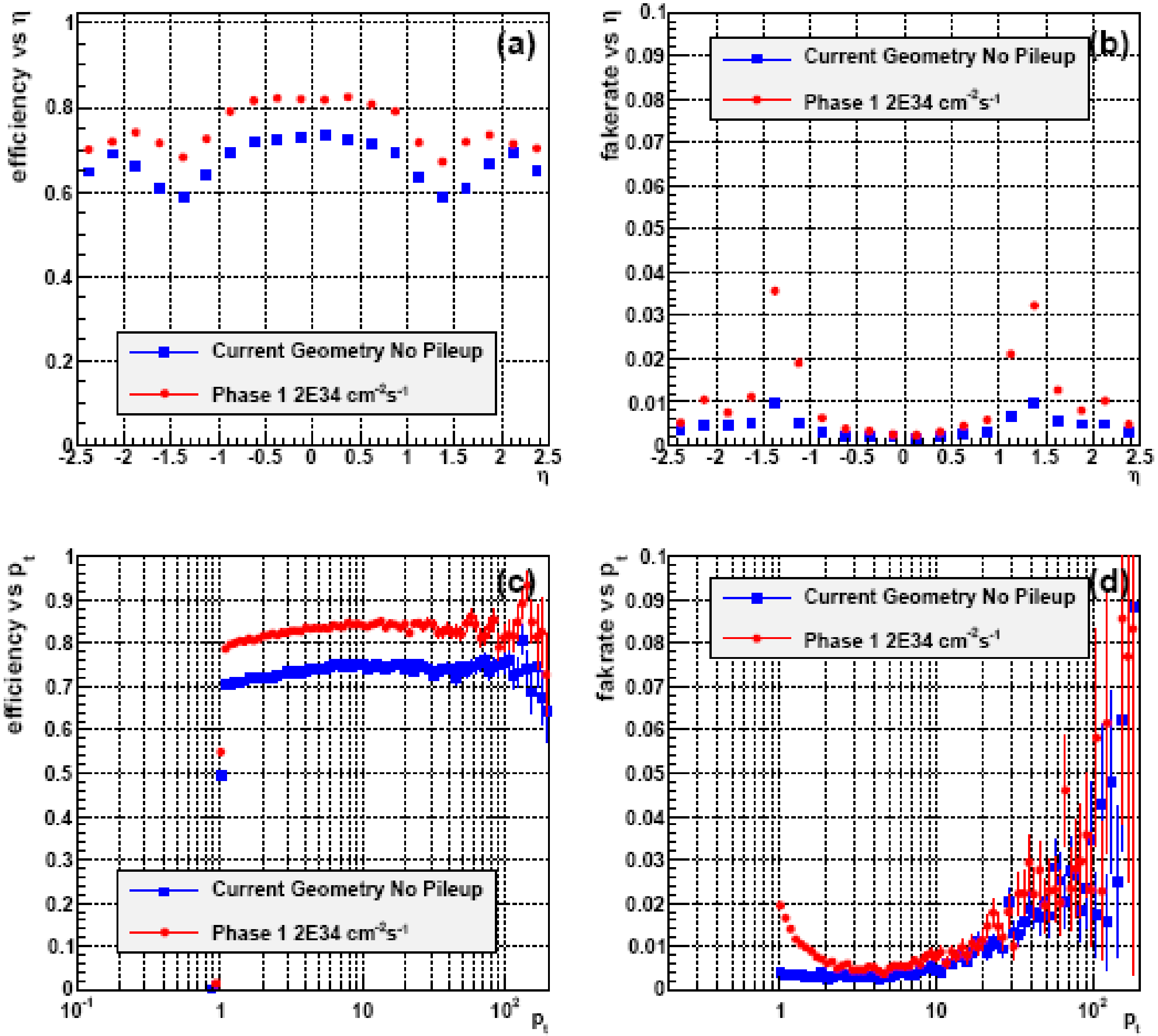
The secondary vertices, together with other lifetime information obtained from the tracks you get …

b-tagging



- CombinedSecondaryVertex tagger
- Without PileUp the Phase1 tracker only provides gains w.r.t. the Current tracker
- At 2E34 $cm^{-2}s^{-1}$ (2x Design Luminosity) the Phase1 shows some improvement on the Current tracker

Restore Tracking at High PU

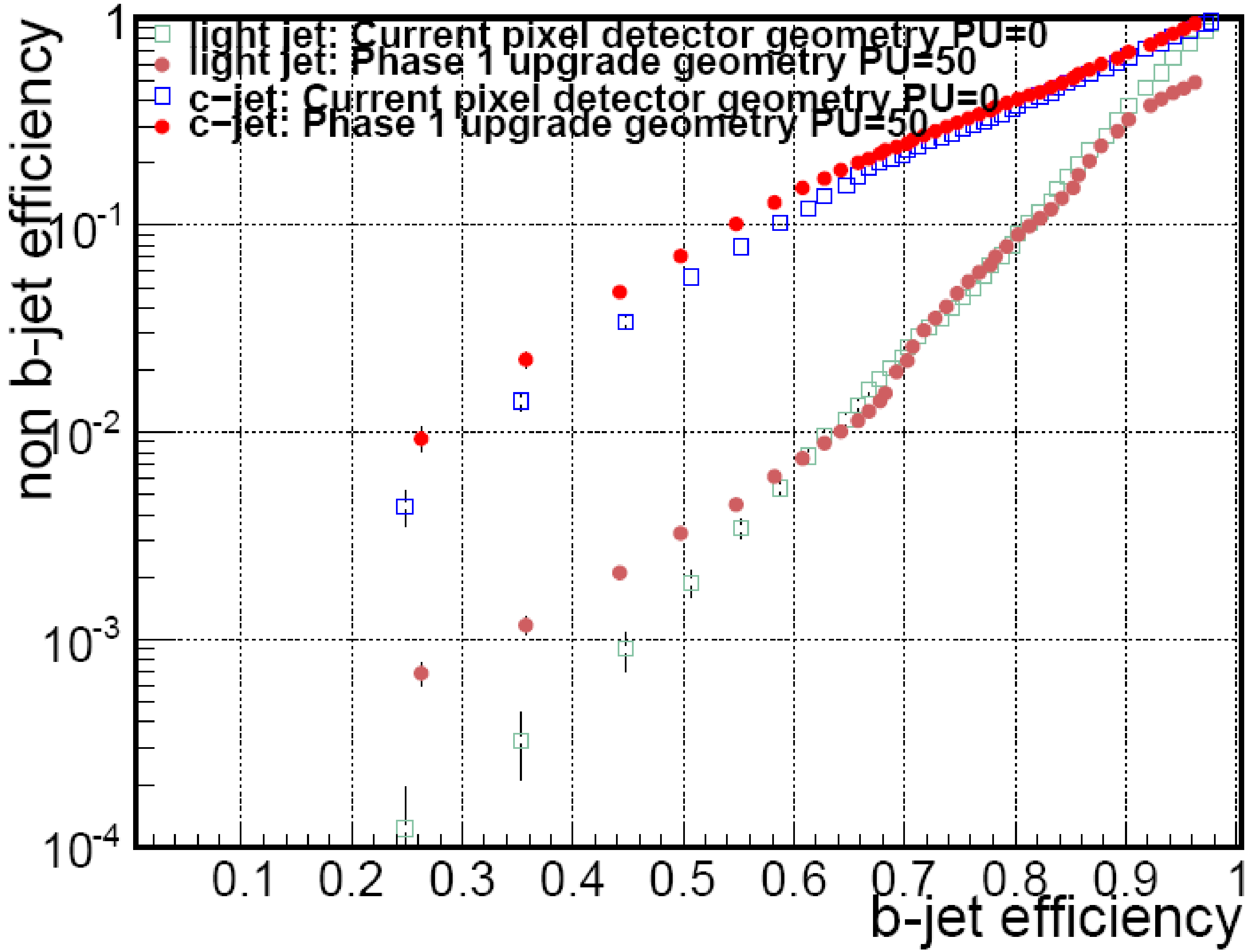


High quality tracks similar to the requirements that are used in b-tagging

ttbar events at PileUp=0 for Current Geometry & $2x10^{34}cm^{-2}s^{-1}$ for Phase1 Tracker

Restore current tracking ability

Restore b-Tagging at High PU



Restore current performance at twice the design luminosity scenarios

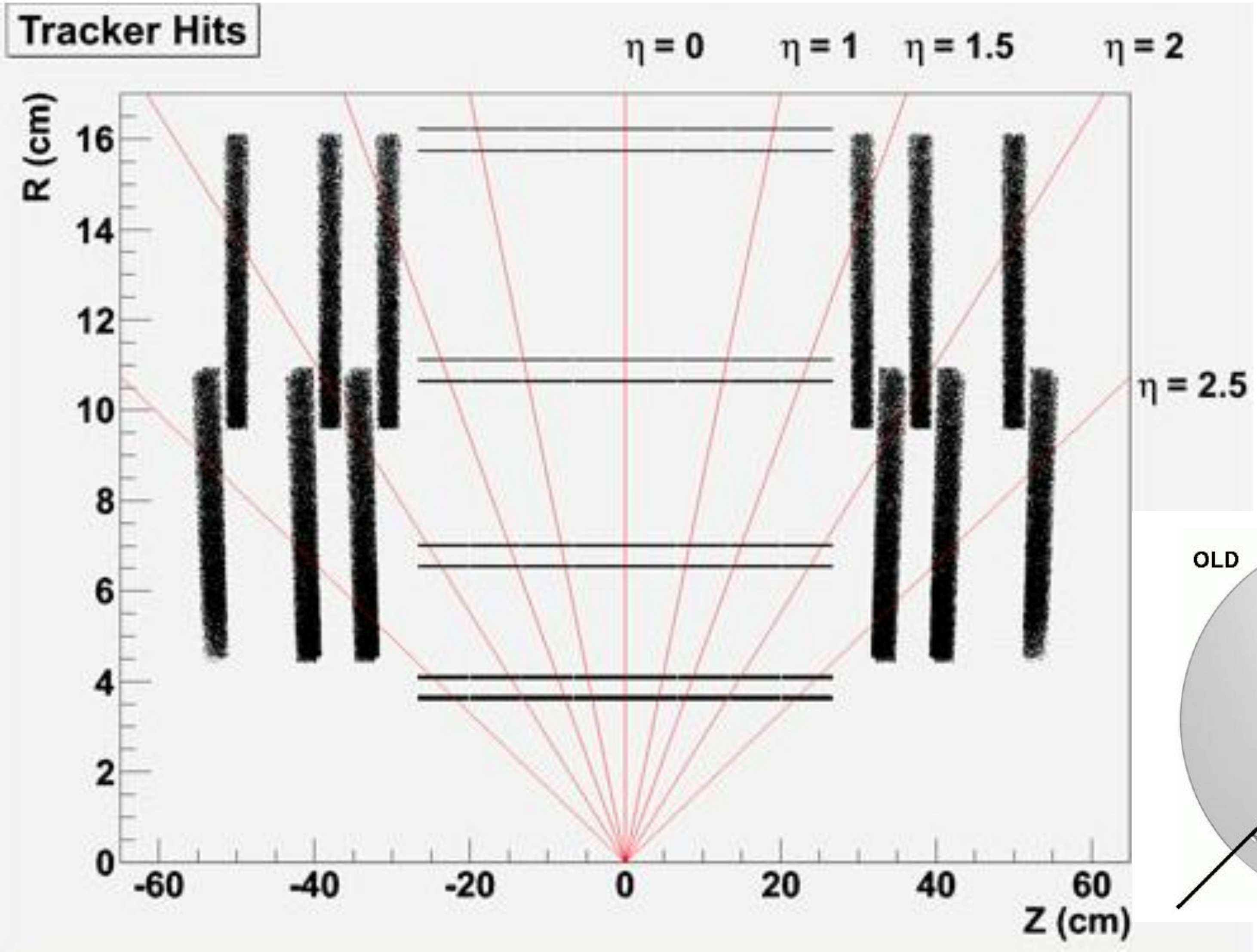
Open → PileUp=0 for Current Geometry

Filled→ $2x10^{34}cm^{-2}s^{-1}$ for Phase1 Tracker

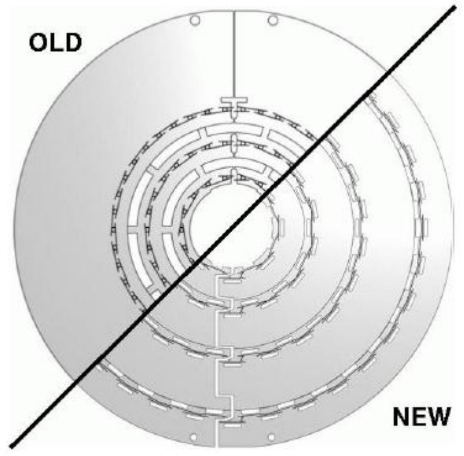
Conclusions

- 2x design luminosity provides challenges for tracking
  - Increased fake track rates
  - Increased data loss
  - Reduced b-tagging
- Plans are underway to compensate & restore our current level of performance
  - 4^{th} Pixel Barrel Layer & 3^{rd} Pixel Disk
    - Redundancy
  - Pixels both closer to and further from IP
    - Information from closer to IP & longer lever arms for fitting
  - Minimize material budget
    - Move as much as possible away from IP
  - More is under study
    - Better understand data loss, alter size & placement of pixels, develop algorithms for high PU and more…

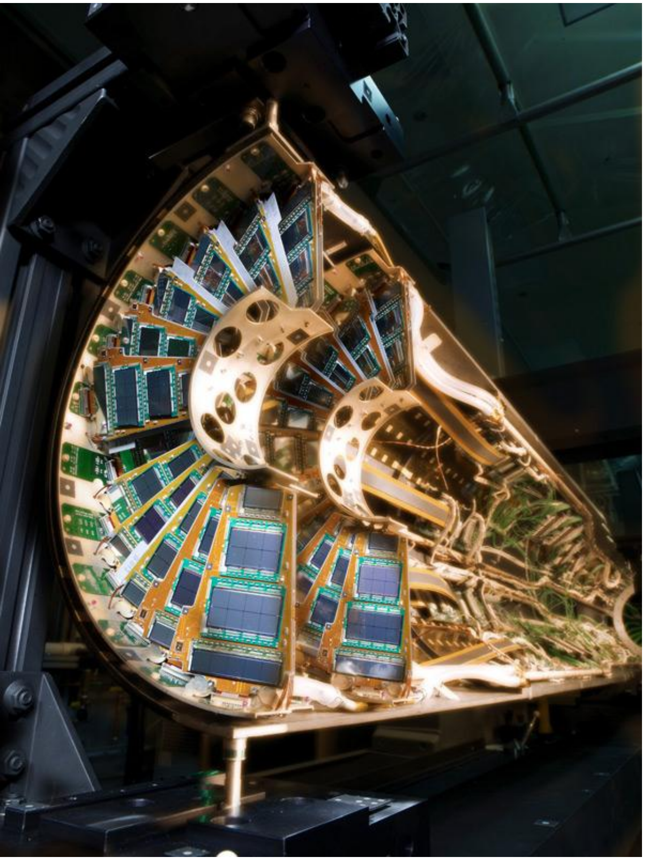
Backup Slides



Reconstructed hits in the Phase1 Pixel Detector

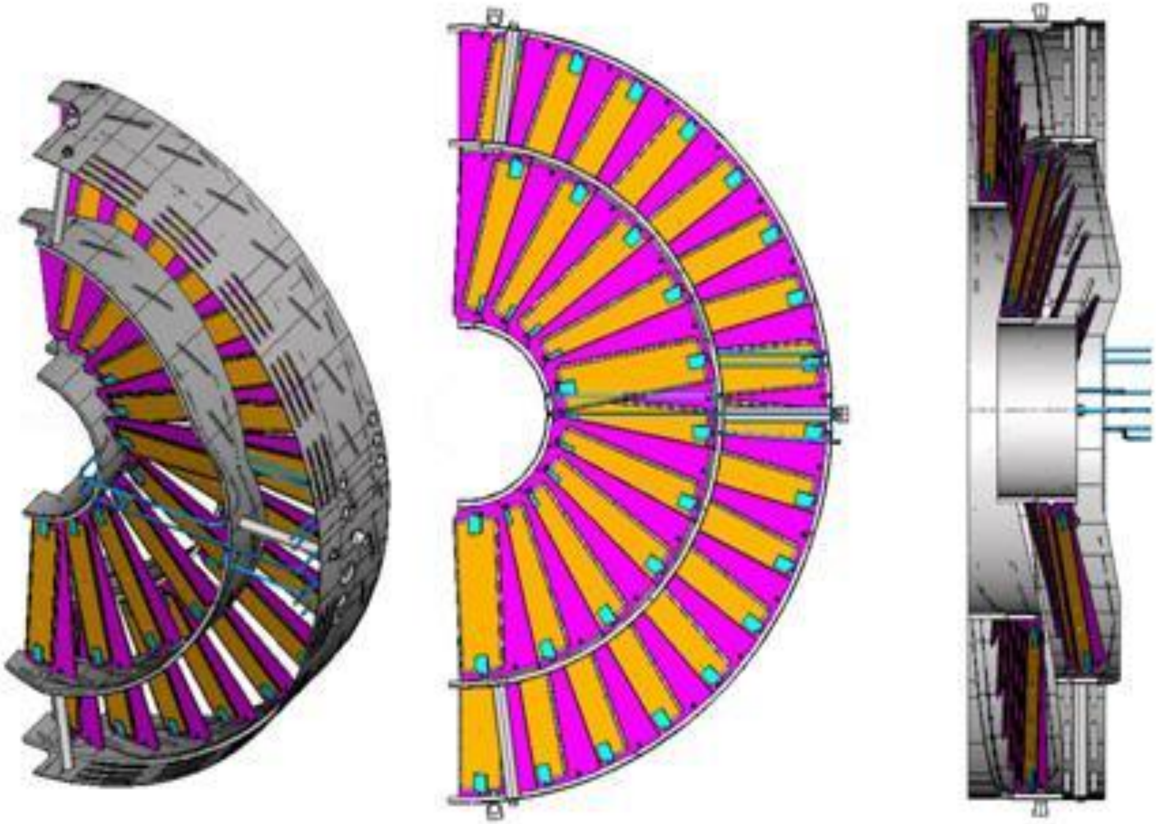


Current:

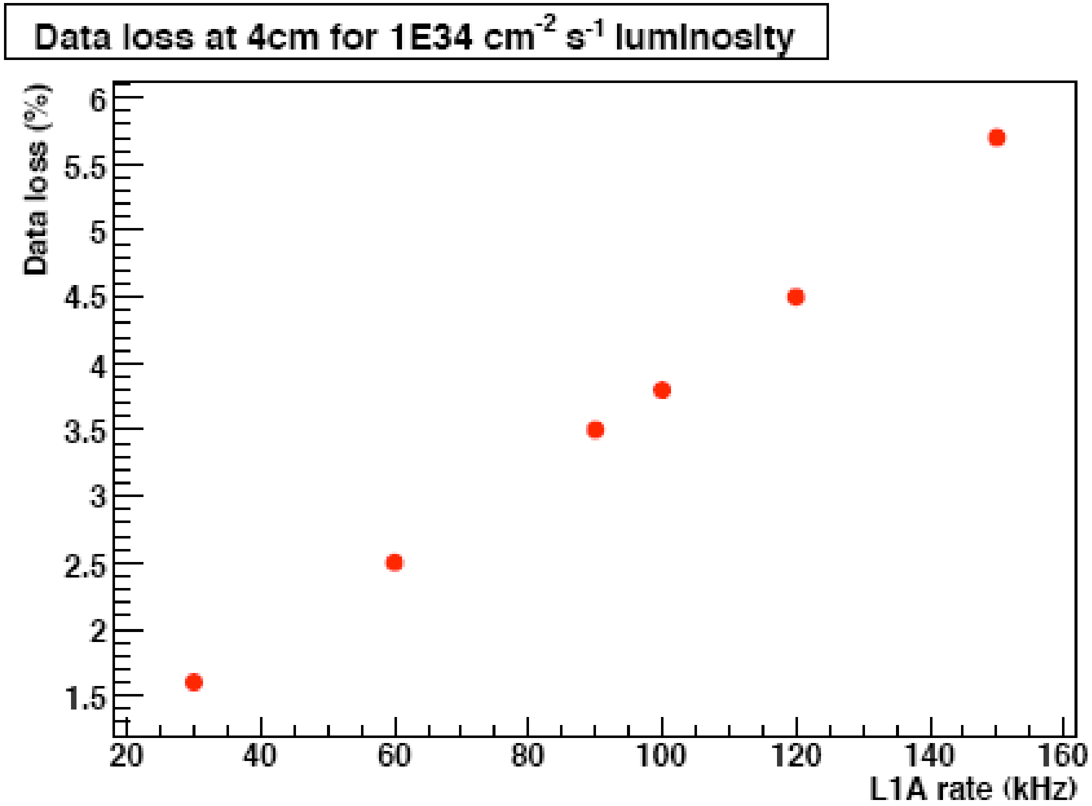


View of the current Forward Pixel detector

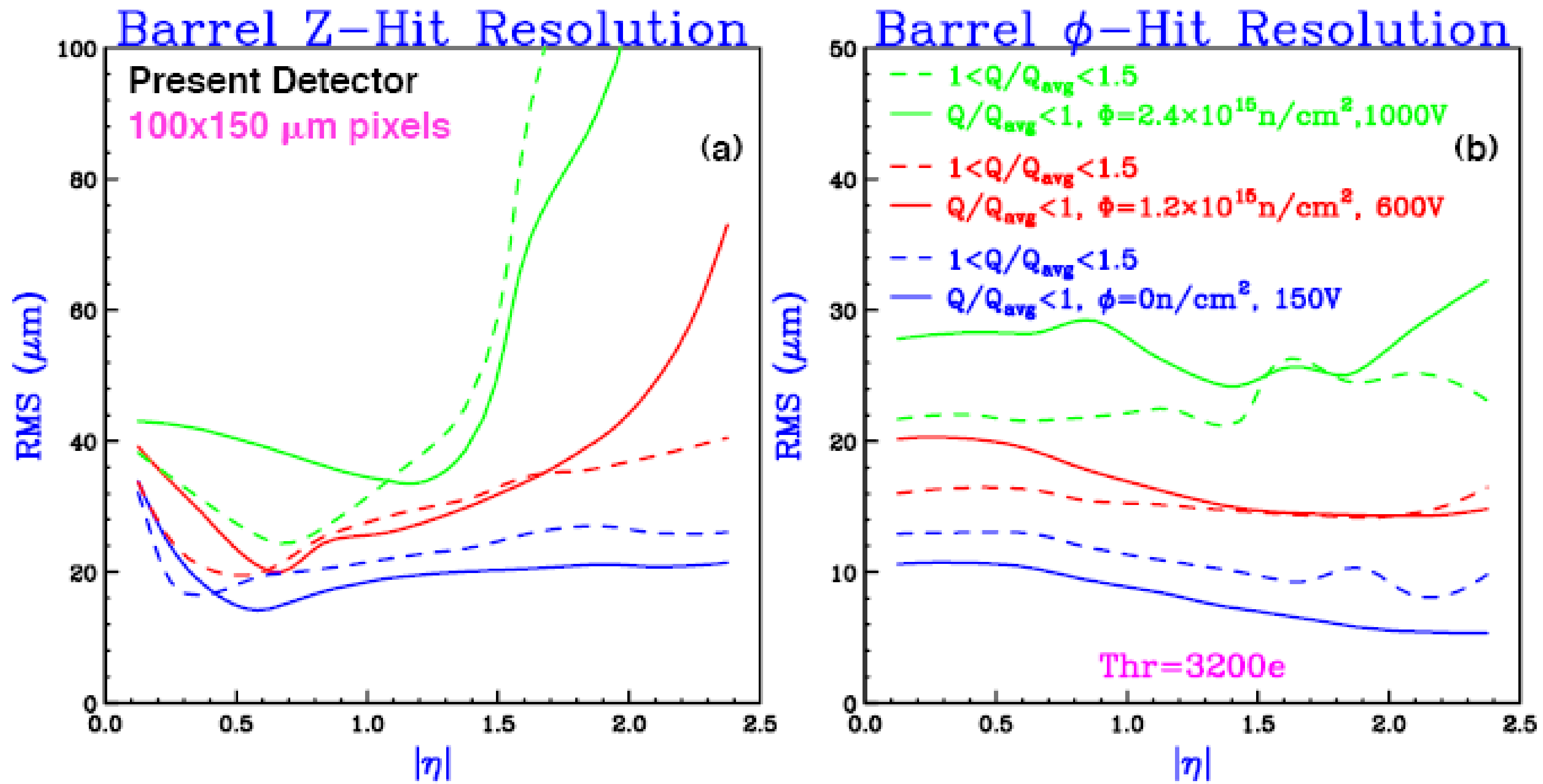
Phase1 Tracker:



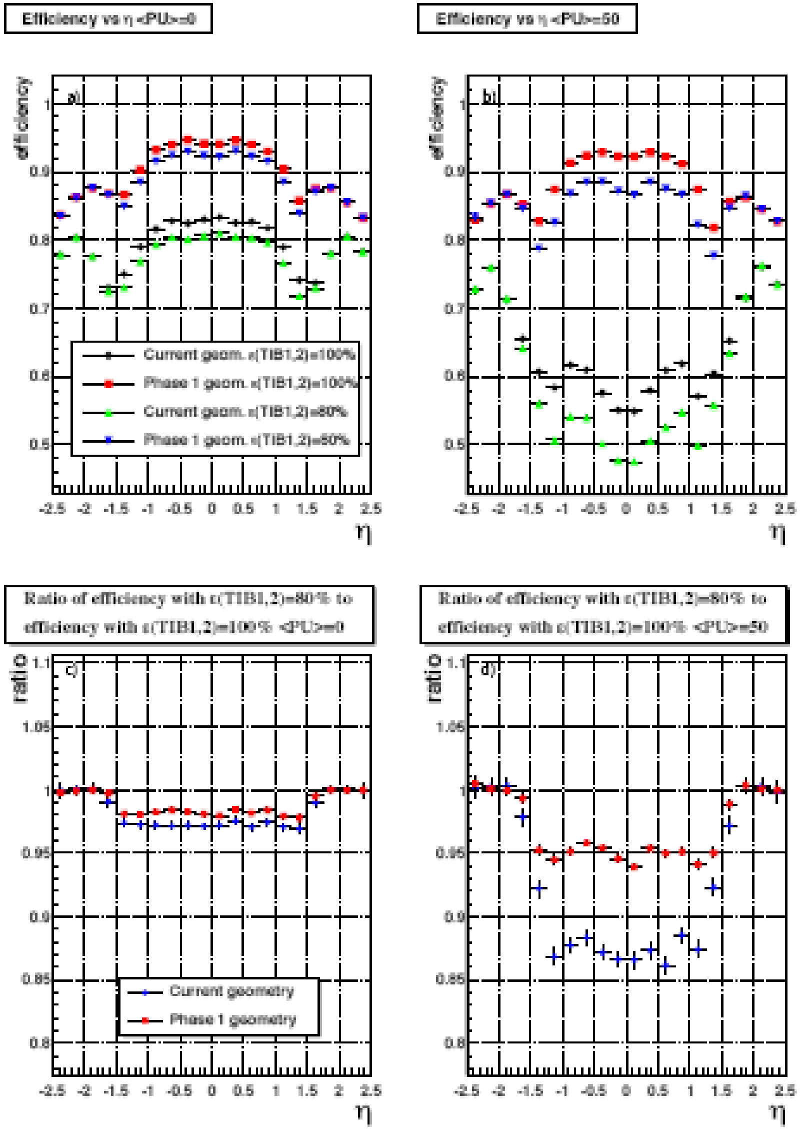
Half disk consists of one inner blade assembly and one outer blade assembly and they are assembled next to each other



Data losses as a function of the L1 accept rate of the innermost layer of the current pixel detector. The instantaneous luminosity is 1E34 $cm^{-2}s^{-1}$ and the bunch spacing is 25 ns. CMS has been designed for maximum average L1 trigger rates of 100 kHz. The data points beyond this rate in the plot simply illustrate the linear nature of this data loss at this particular instantaneous luminosity with the PSI46v2 readout chip.

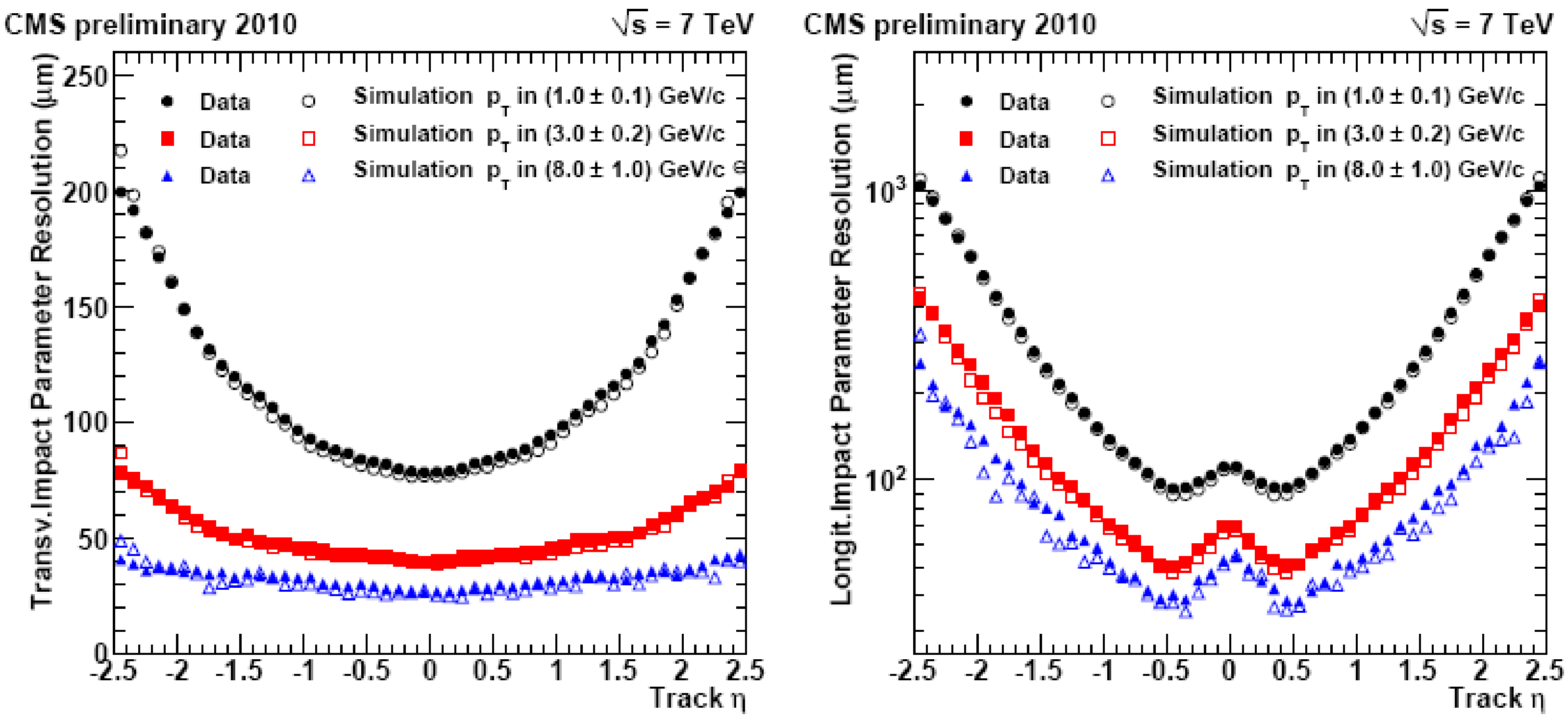


Hit position resolution (RMS) as function of the track pseudorapidity for an unirradiated (blue lines) and irradiated detectors (red and green lines). Longitudinal (a) and transverse hit resolution (b) are shown separately. The solid lines correspond to hits with total charge Q below the average charge. Dashed lines correspond to hits with total charge 1 < Q/Qavg < 1.5.



Effect of a 20% loss in efficiency of the TIB. The efficiency loss in track reconstruction is shown in (a) and (b) for low luminosities and 1E34 $cm^{-2}s^{-1}$. In (c) and (d), the ratios of efficiencies are shown. For the higher luminosities, this 20% loss in TIB efficiency would result in an overall relative reduction of 5% in the barrel region of the upgraded detector, but a 13% reduction in the current detector.

Vertex Reconstruction



- 1.0 ± 0.1 GeV/c (circles), 3.0 ± 0.2 GeV/c (squares) & 8.0 ± 1.0 GeV/c (triangles)
- Filled and open symbols correspond to results from data and simulation
- CMS PAS TRK 10-005