Tracking performance: Fast simulation studies

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Outline

Scope of study

What is the effect of different geometries on track resolution using analytical calculation

- Not detector technology
- Not pattern recognition
- Not calorimetry
- Not full simulation, ie. non-Gaussian tails are not included

There is no statistical uncertainty on the curves: If the curves of two designs differ, they are different.

Tool

The tool for this study is SGV:

- Fast simulation based on precise analytical calculation of the Covariance matrix - the Billoir fit, ie. the covariance machinery of the Kalman filter used eg. in MarlinReco. Hence it is not parametric.
- Geometry, B-field, Multiple scattering, point-resolution used as in the Kalman filter.
- Follow the track-helix to find
  - What layers are crossed
  - Where they are crossed
  - and at which angles

  This information is combined to calculate the covariance matrix of the 5 helix parameters

SGV and full simulation

How well does the analytical calculation compare to the full simulation and reconstruction? (Thanks Steve Aplin!)

Momentum resolution

- $\Delta(1/p)$ vs p
- $\Delta(1/p)$ vs Θ

Impact parameter resolution

- σ_{ip} vs p
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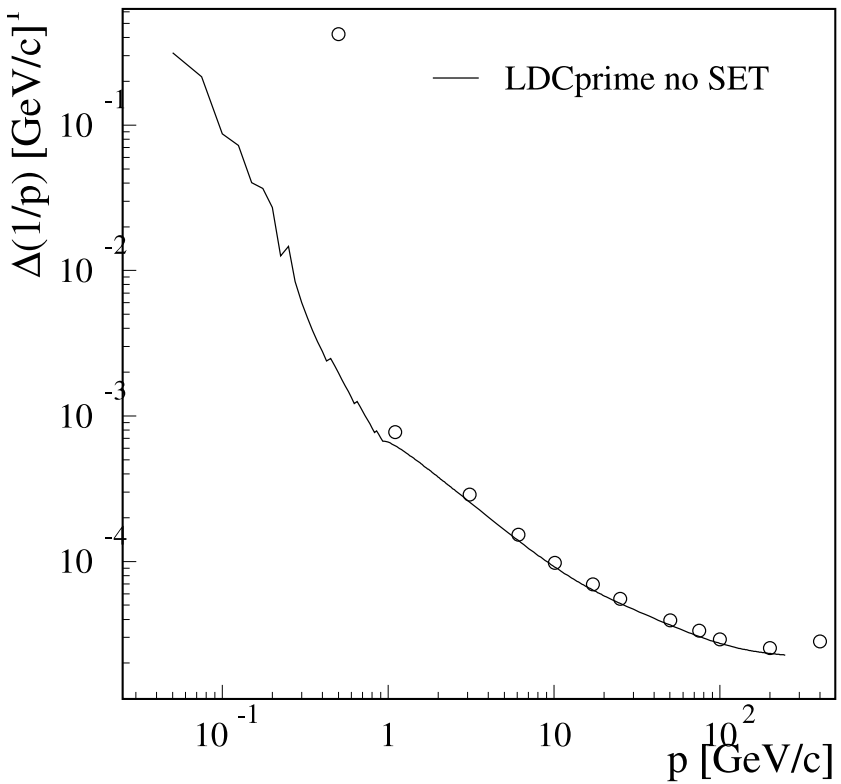

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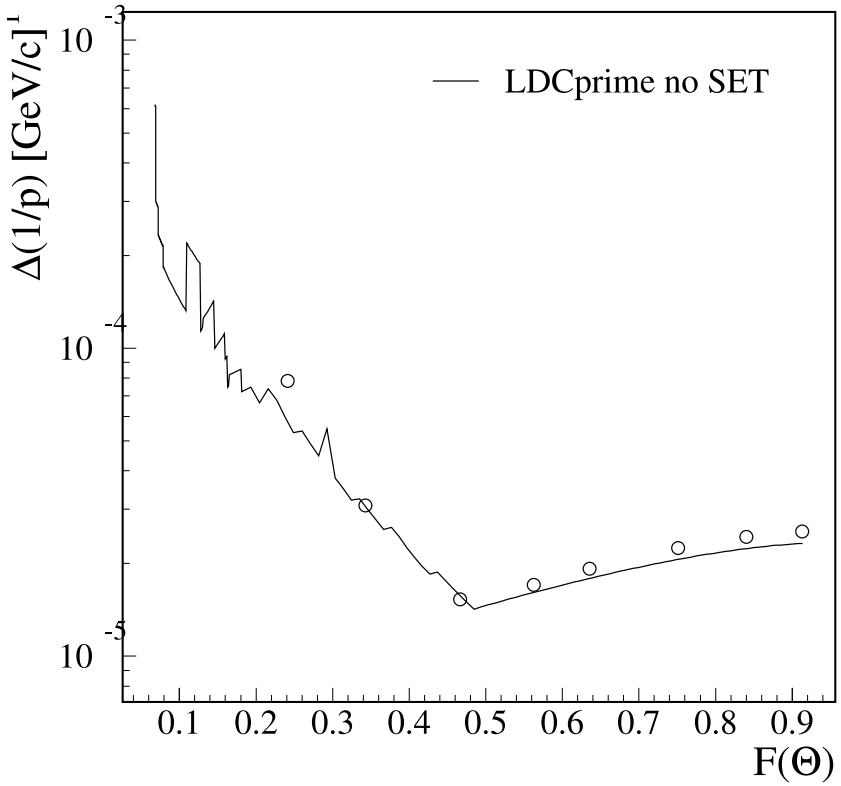

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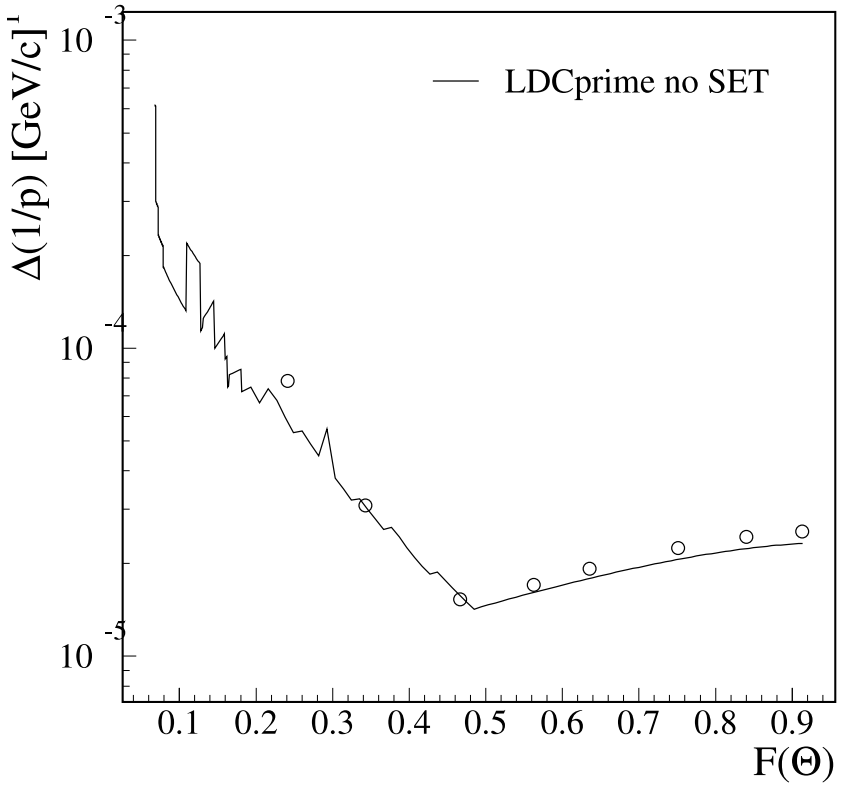

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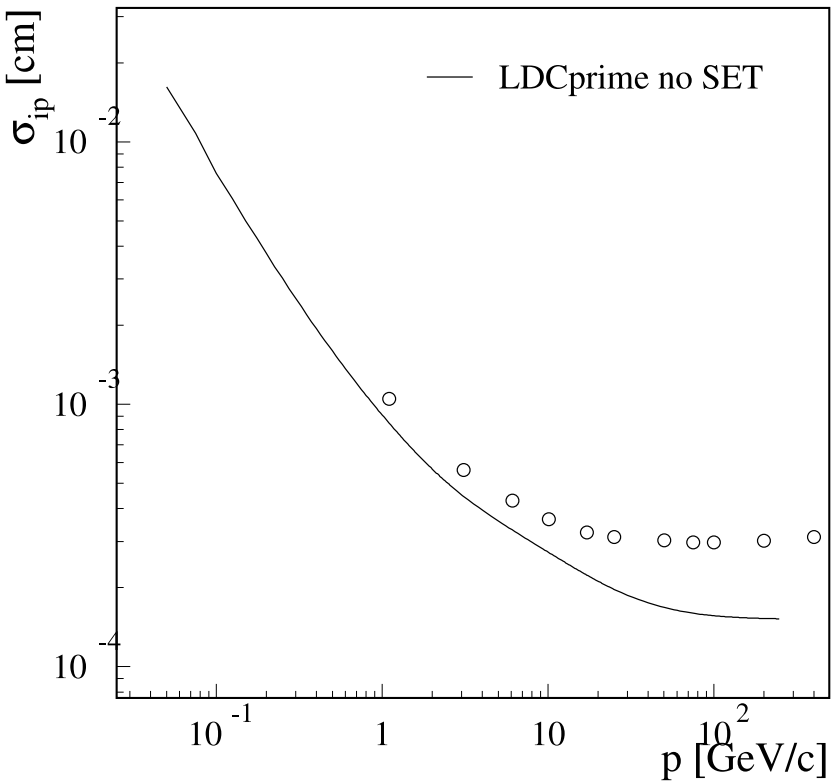

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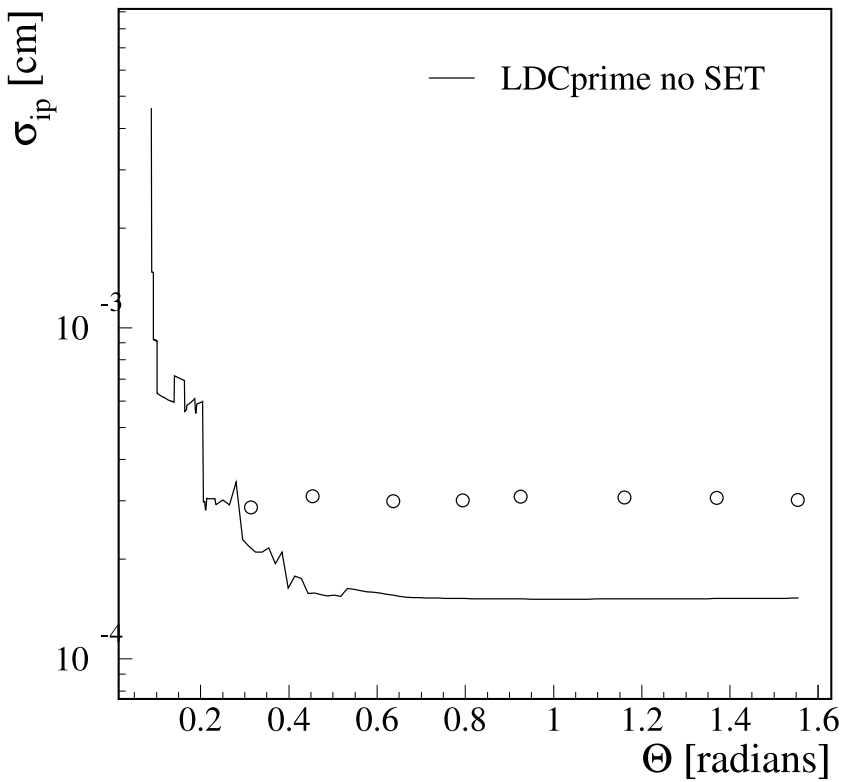

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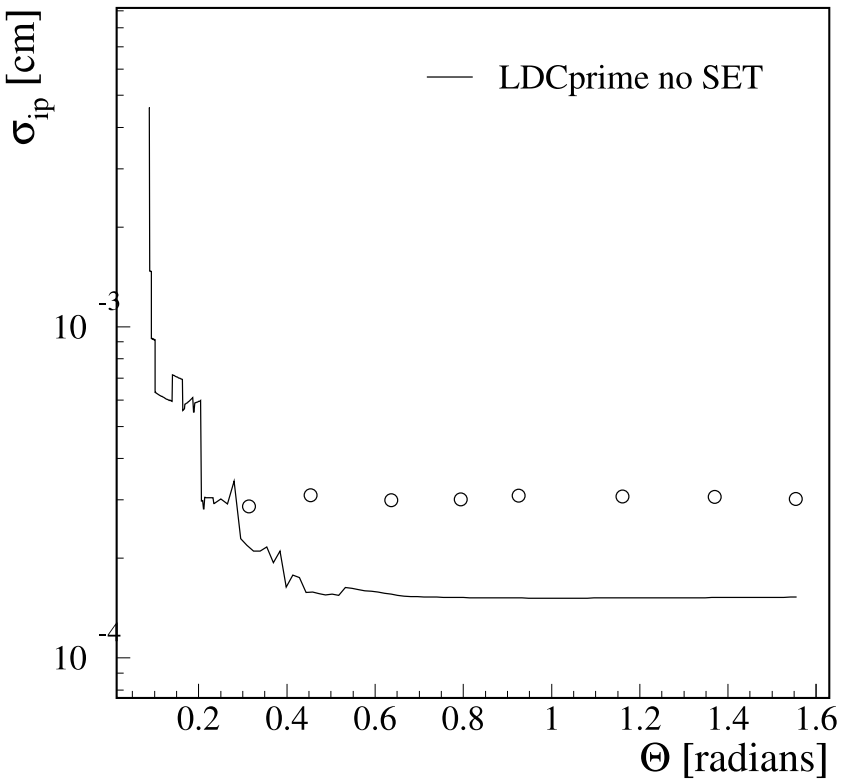

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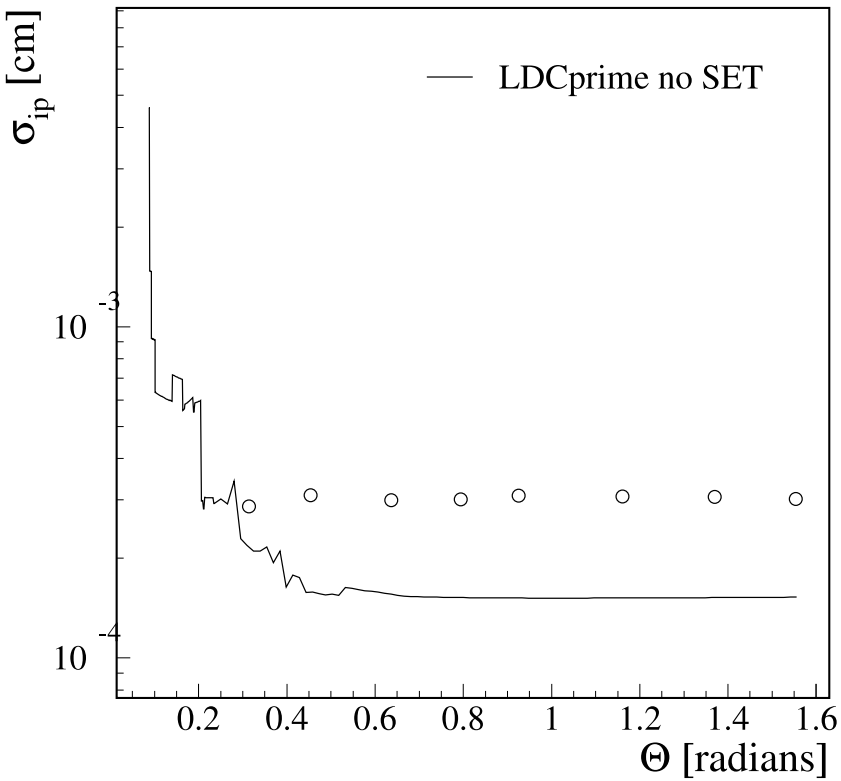

Geometries and variables

- LDC, LDC', LDC-GLD (GLD size LDC), J4LDC (LDC size GLD), GLD' and GLD.
- Geometry as described in the Marlin GEAR files. (VXD described as cylinders, however)
- Take out all differences except geometry (ie. same point res and material budget in all setups.)
- No new elements.
- Adjust geometry somewhat.
- Shuffle sub-detectors
- Plots shown here are $\Delta(1/p)$ and σ_{ip} (in $R\phi$) vs p and Θ.
- Try to make physically relevant plots : $\sigma(p)$, not $\sigma(p_T)$, choose angular variable reflecting differential crossection.
- Then combine to the best compromise.

The baselines

Comparing the original concepts

- Momentum vs momentum
  - LDC
  - GLD
  - LDC, with no external silicon trackers
- Impact parameter vs momentum
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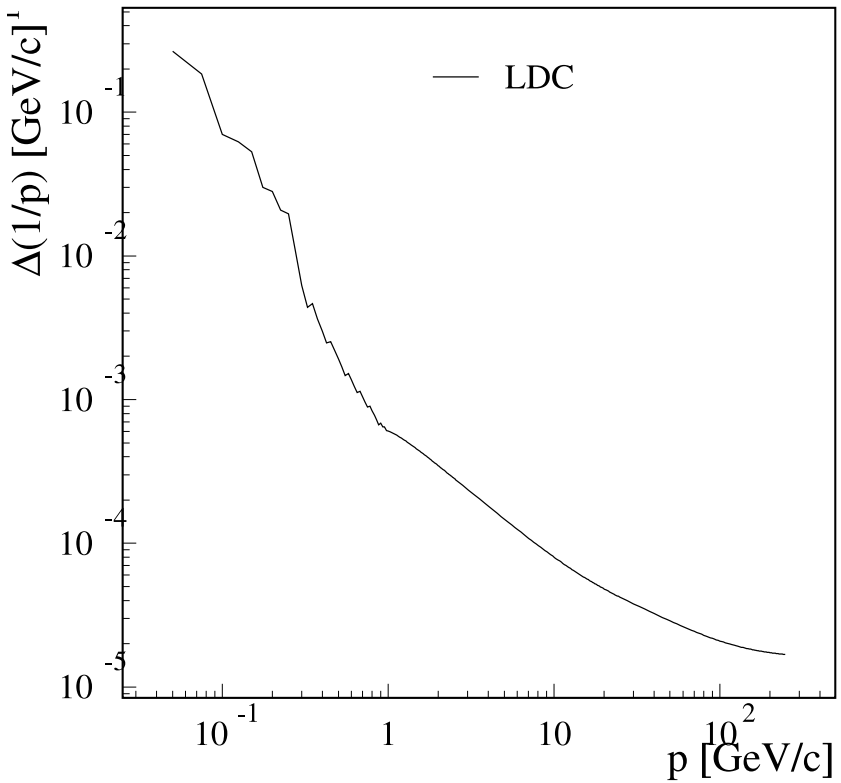

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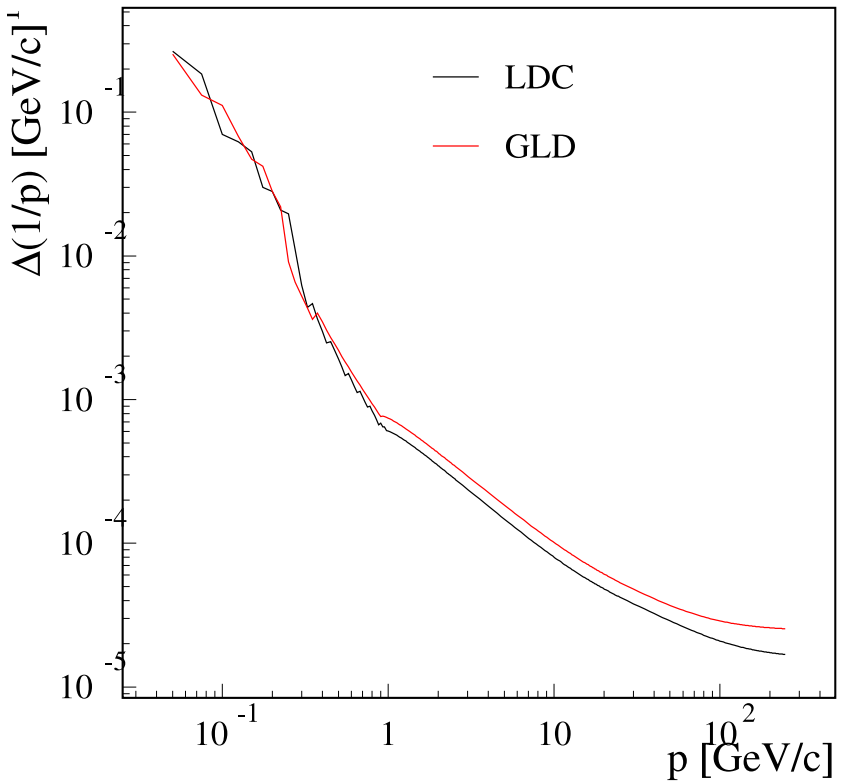

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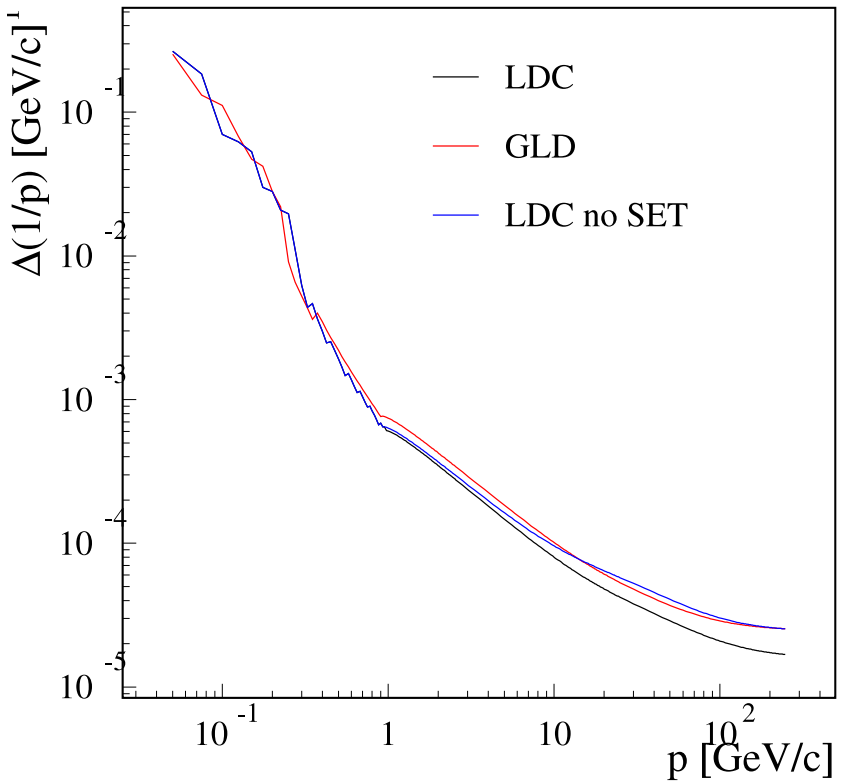

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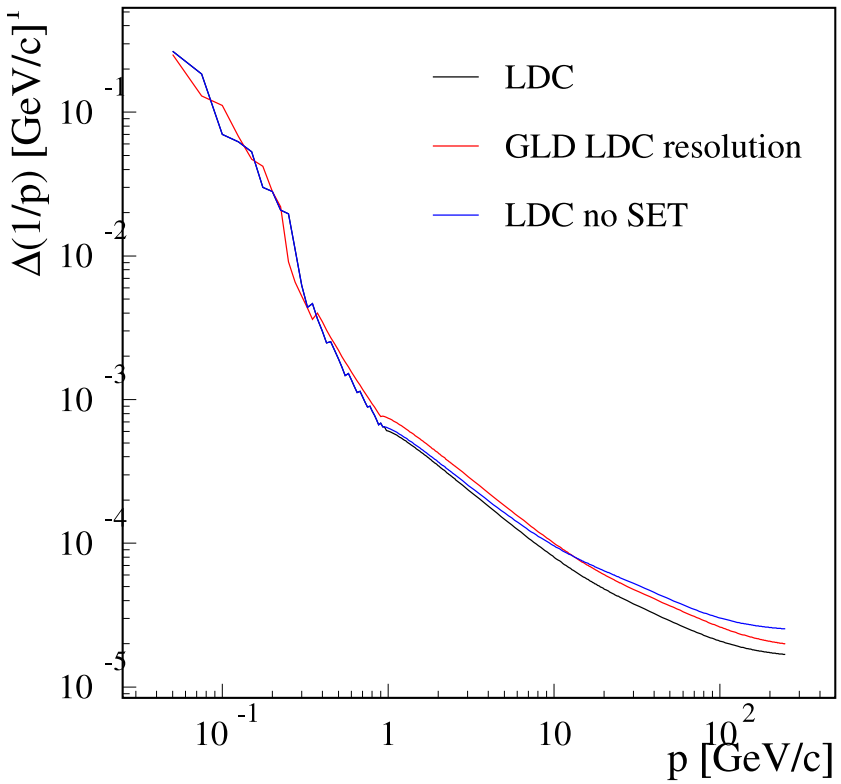

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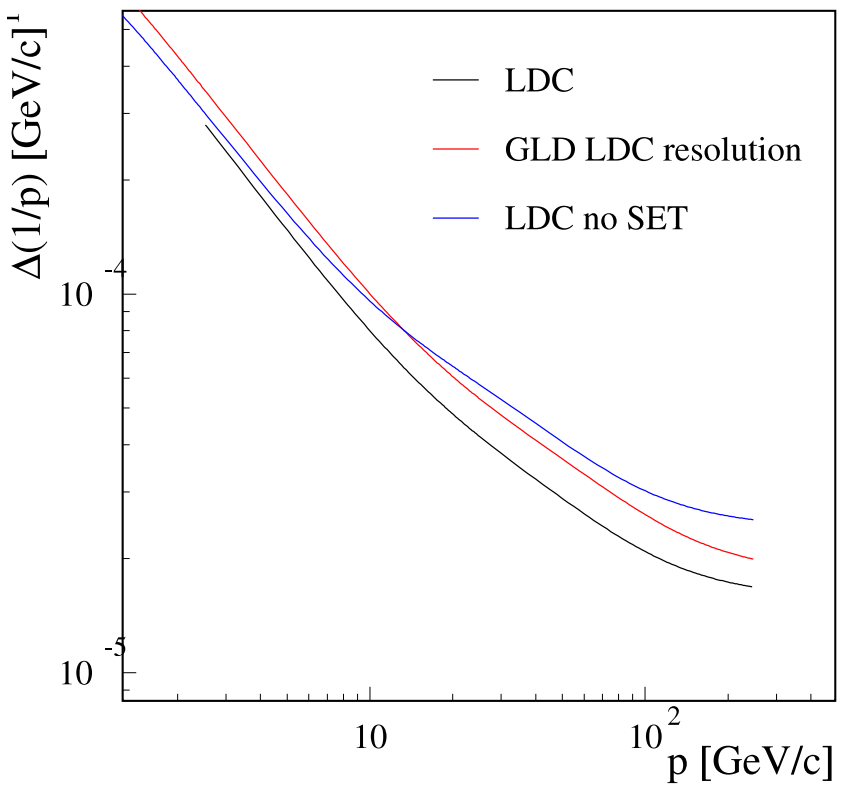

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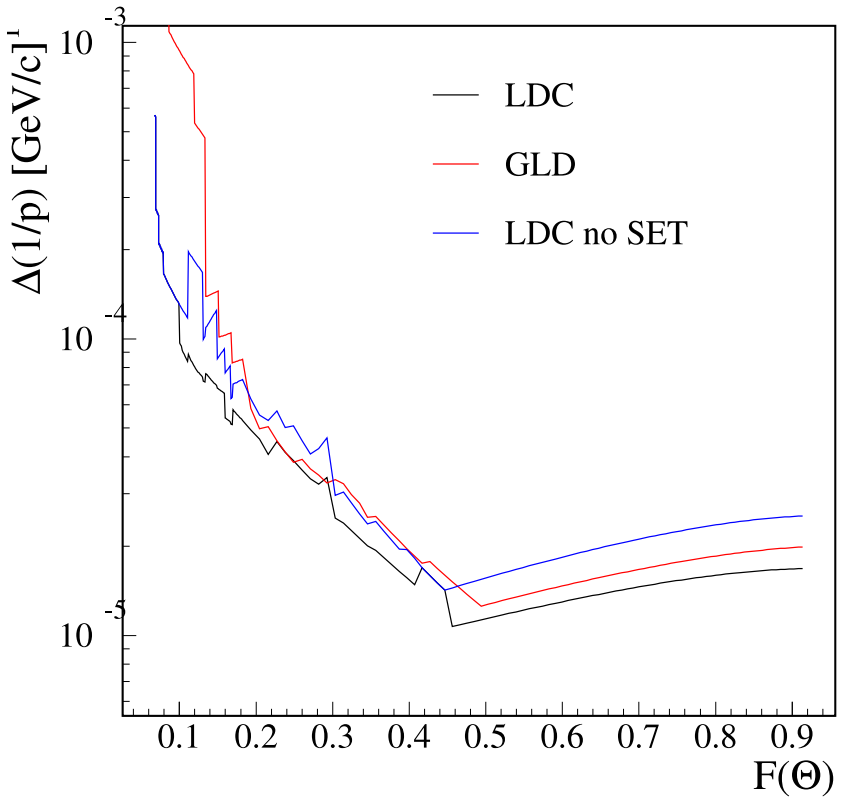

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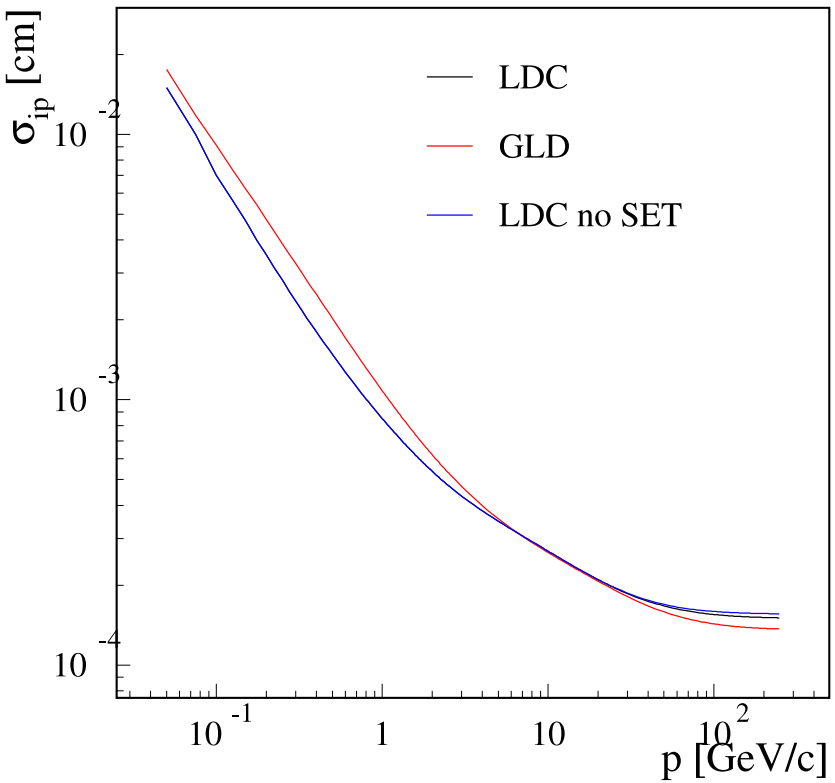

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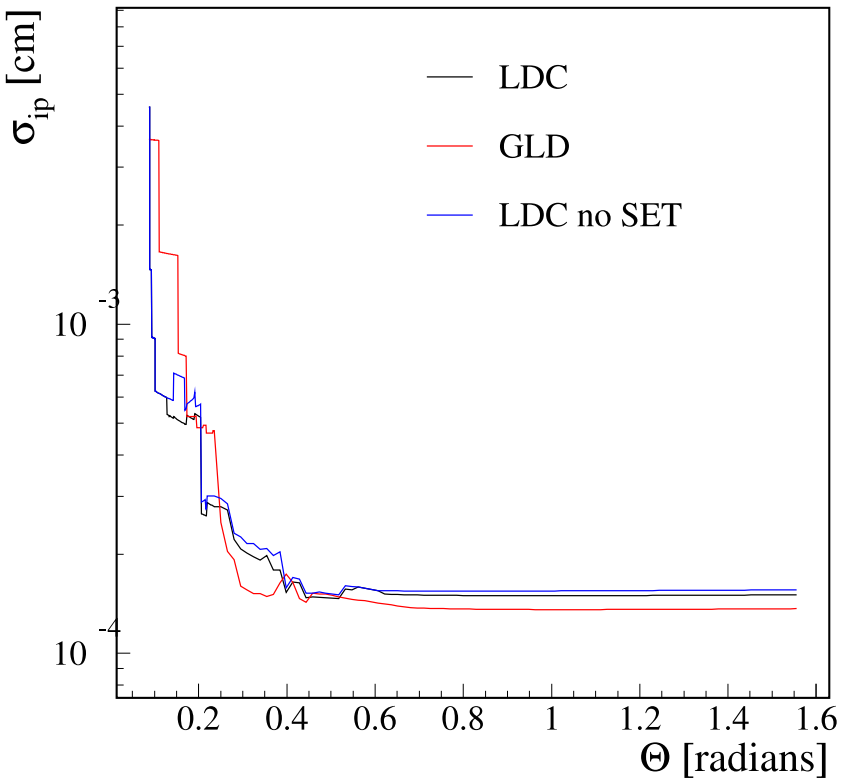

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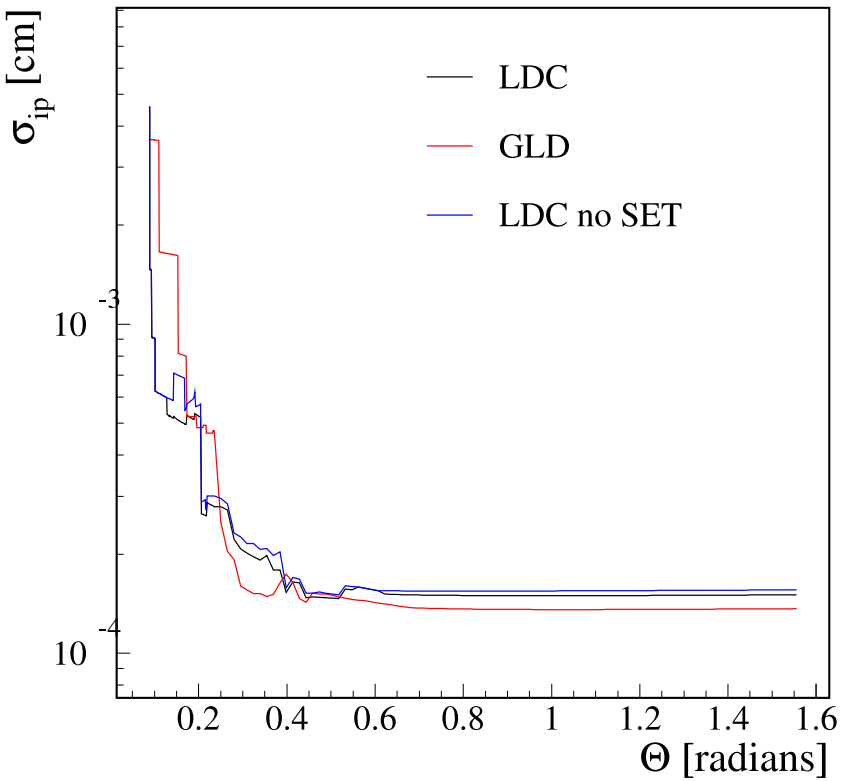

LDC better in $\Delta(1/p)$, GLD in σ_{ip}. The SET and the LDC FTD are useful. The LDC ETD also is at low angles.

Geometry

Comparing changes in size for a single concept:

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  - LDC-GLD
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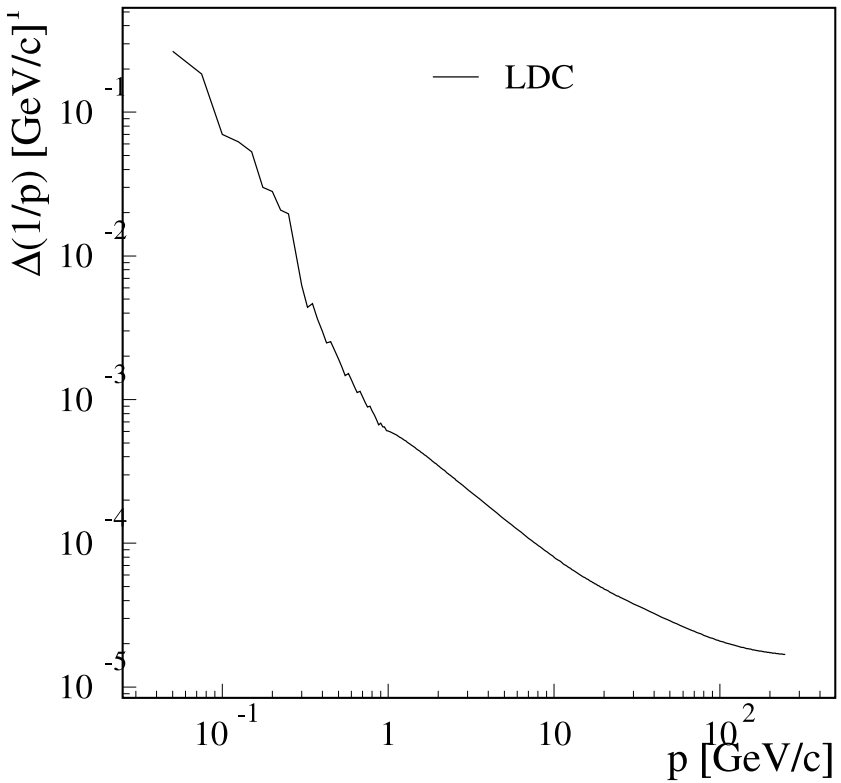

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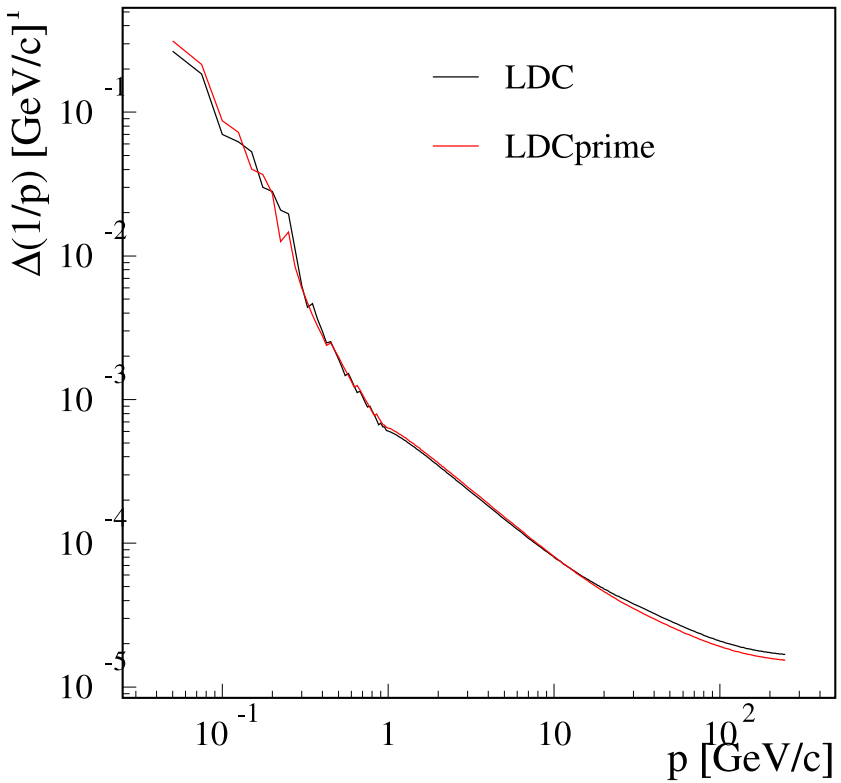

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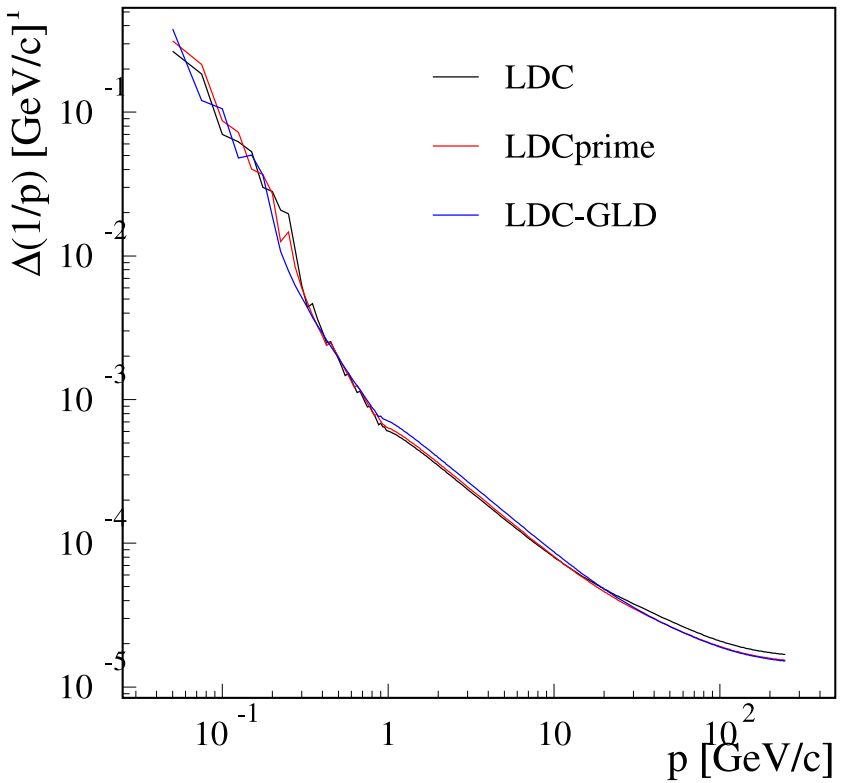

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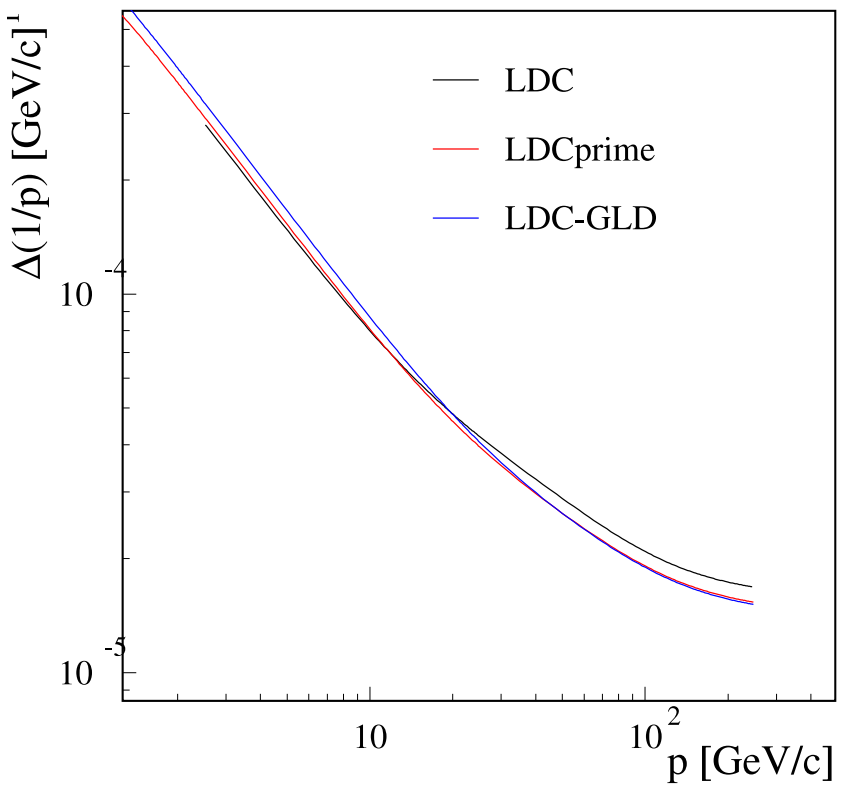

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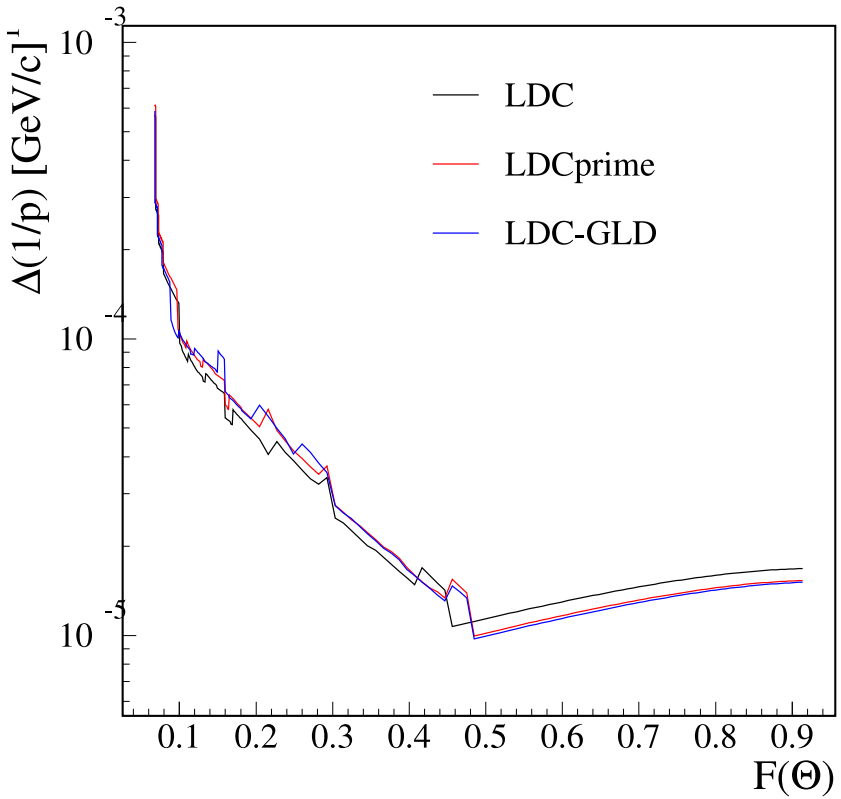

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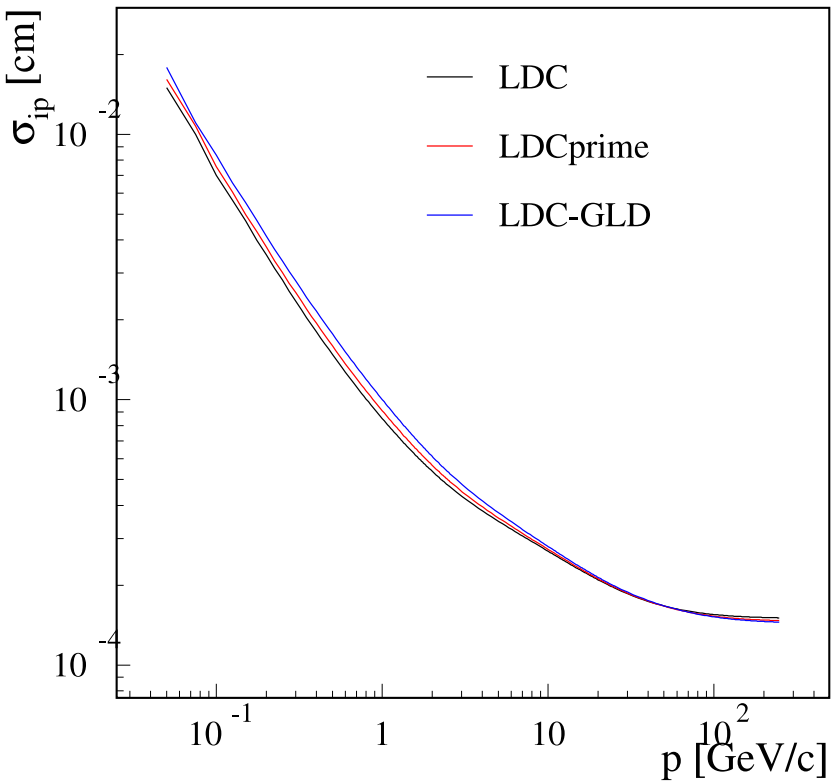

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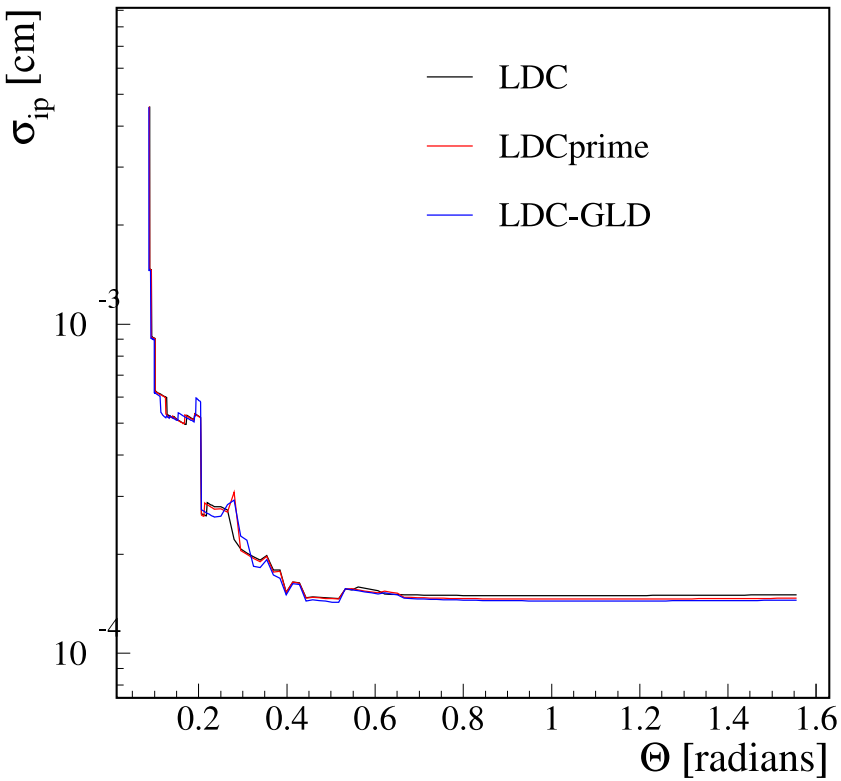

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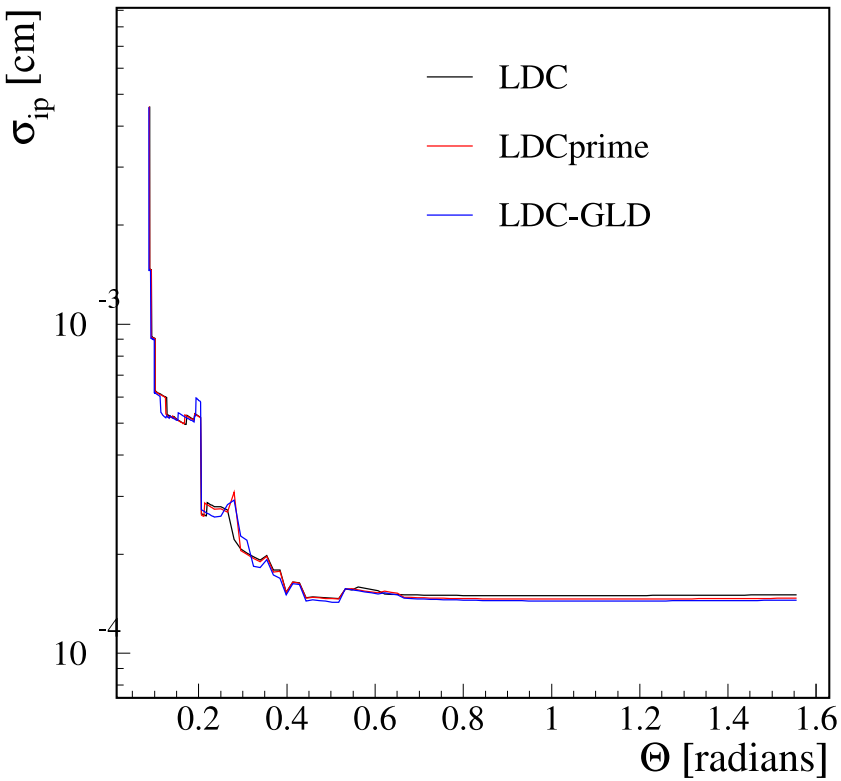
Very similar, but LDC performs slightly worse.



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Why is LDC worse ?

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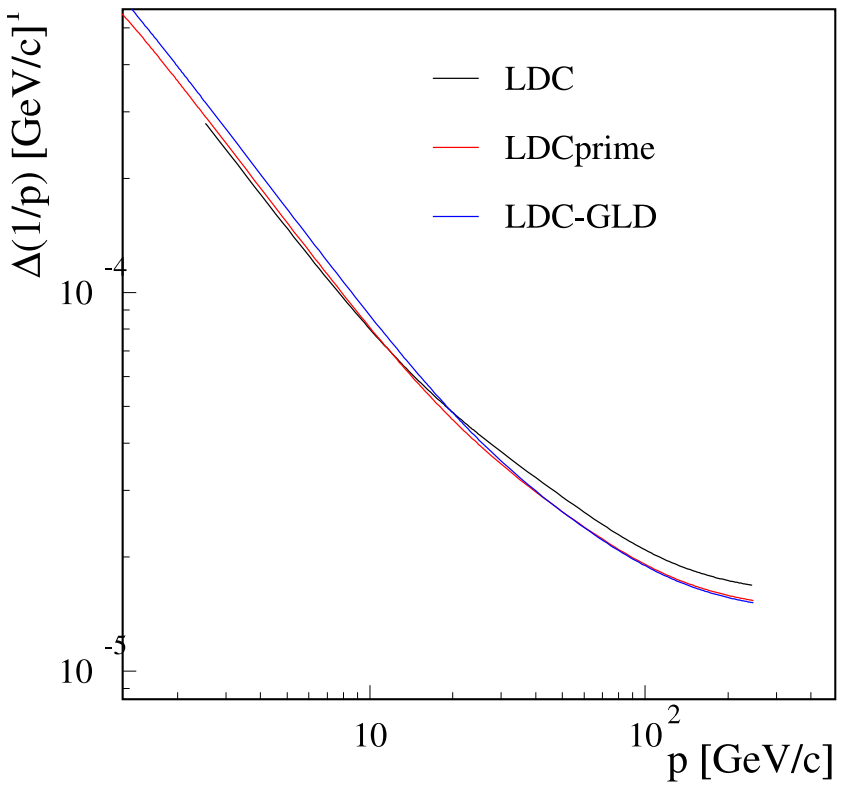
- LDCprime at 3.1 T
- LDC-GLD at 2.5 T



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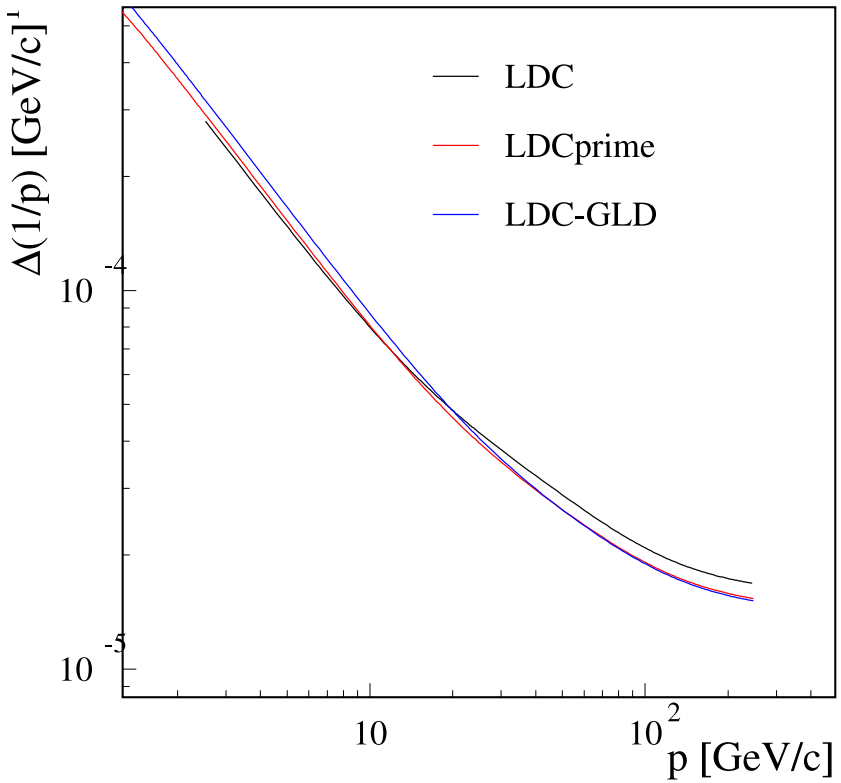

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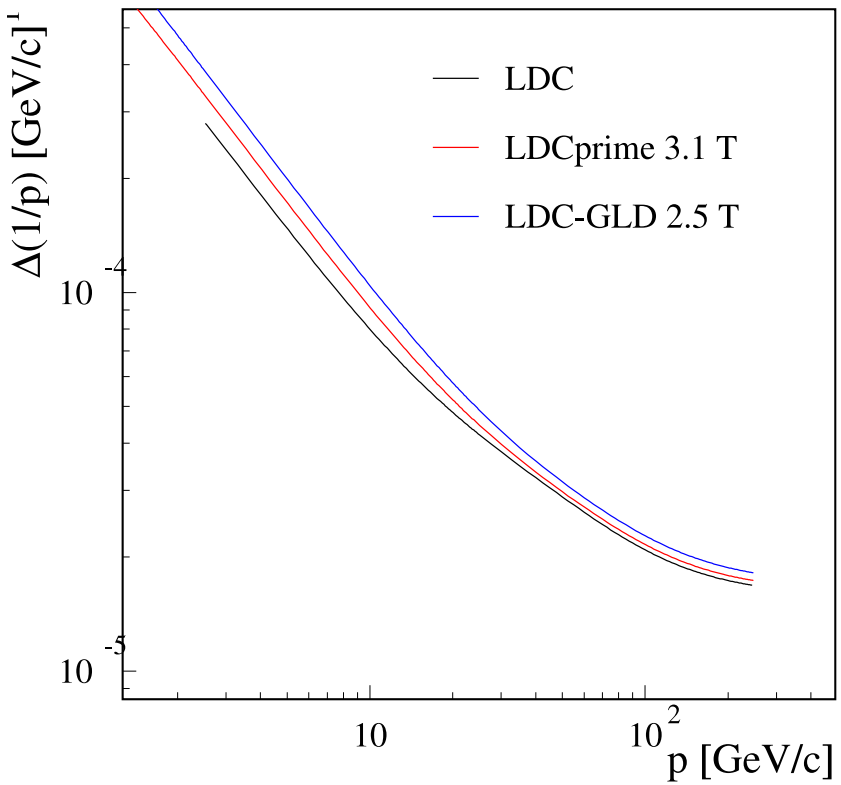

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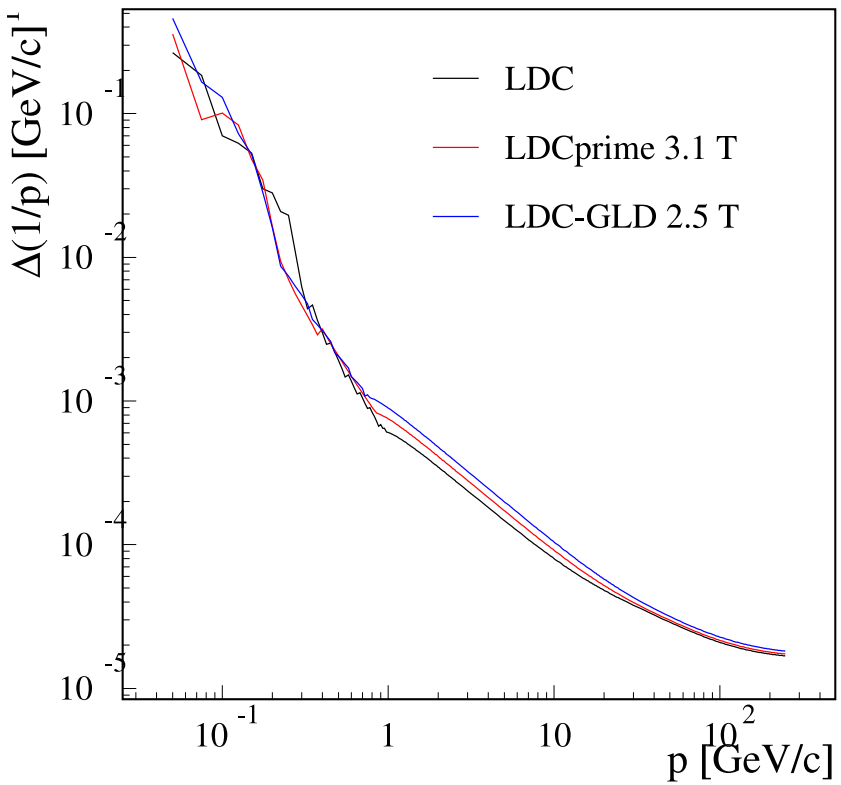

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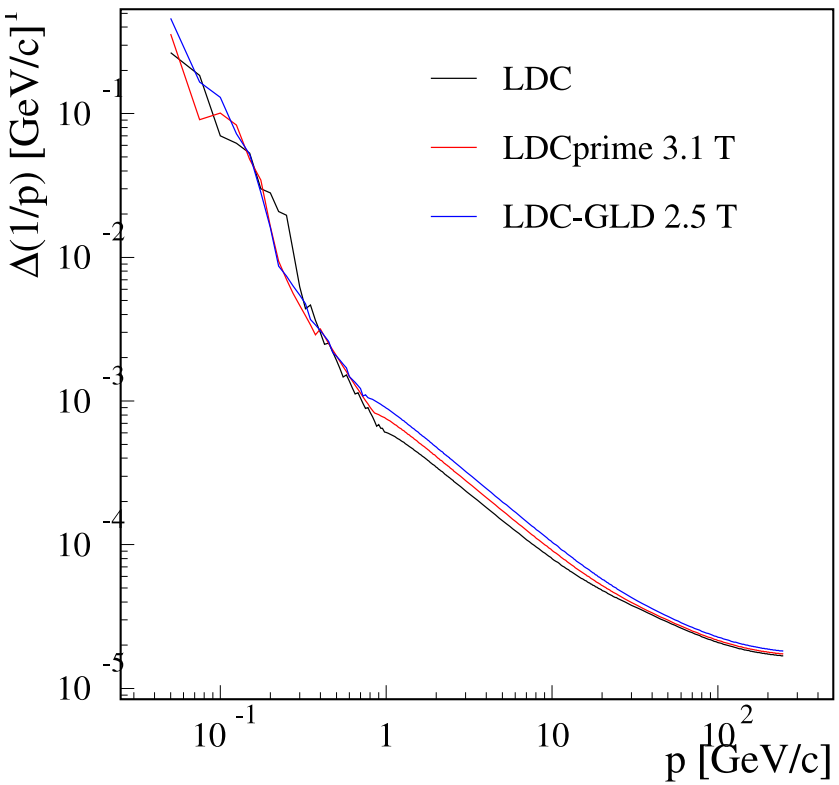

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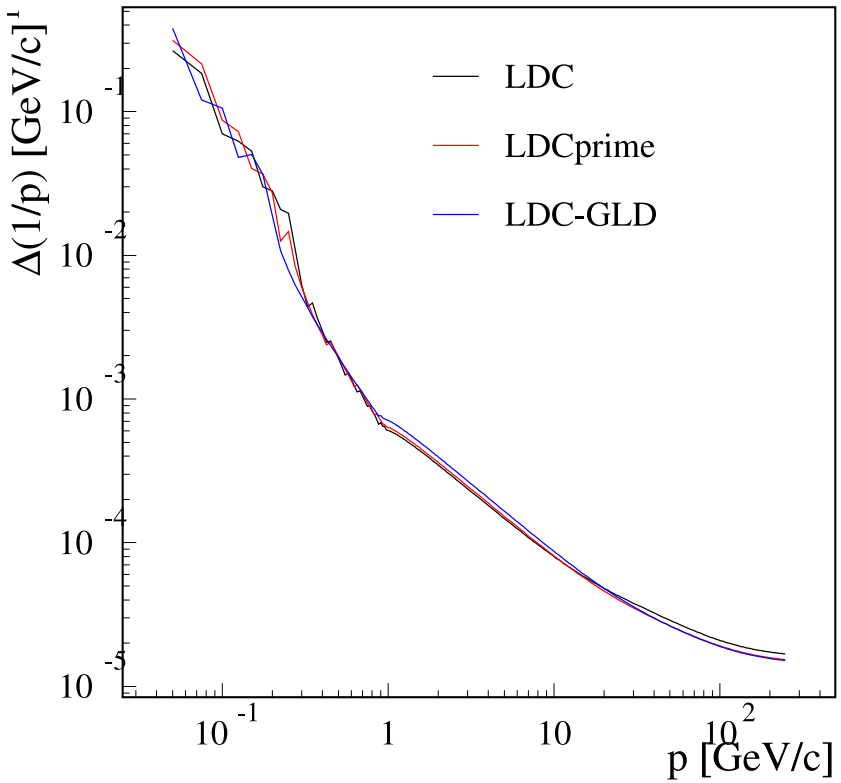

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Larger TPC $\longrightarrow$ larger total signal in the TPC.

It can be exploited by :

- More pads, ie more points.
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Which is best ?

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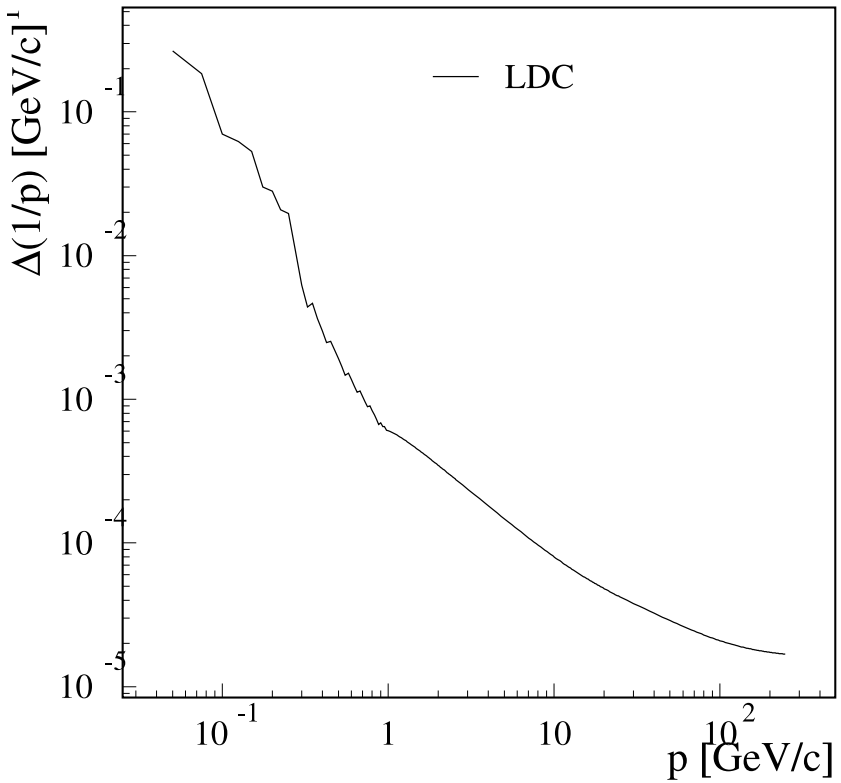

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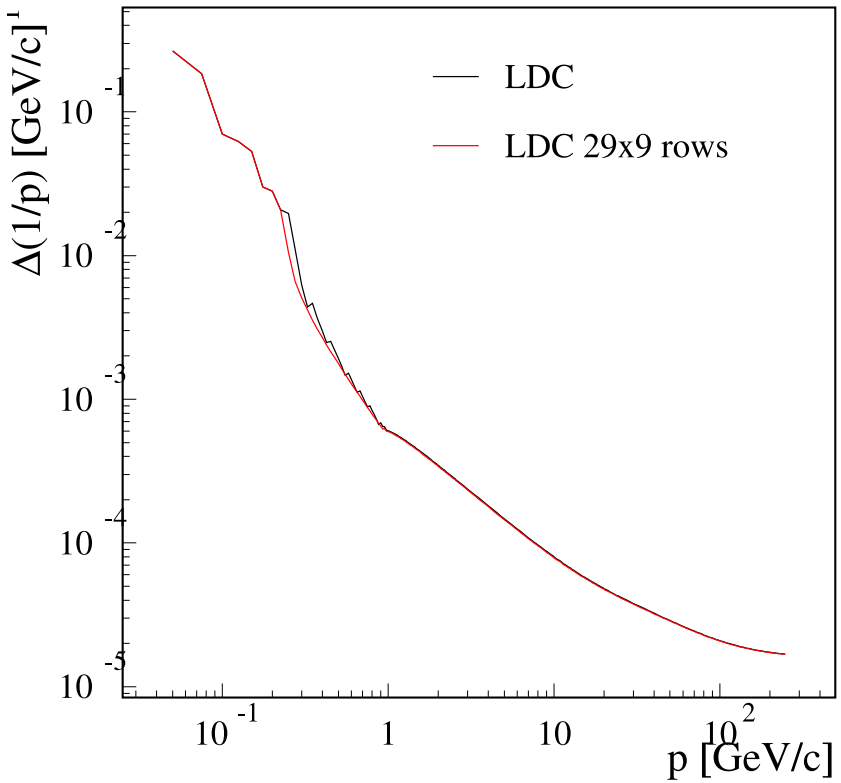

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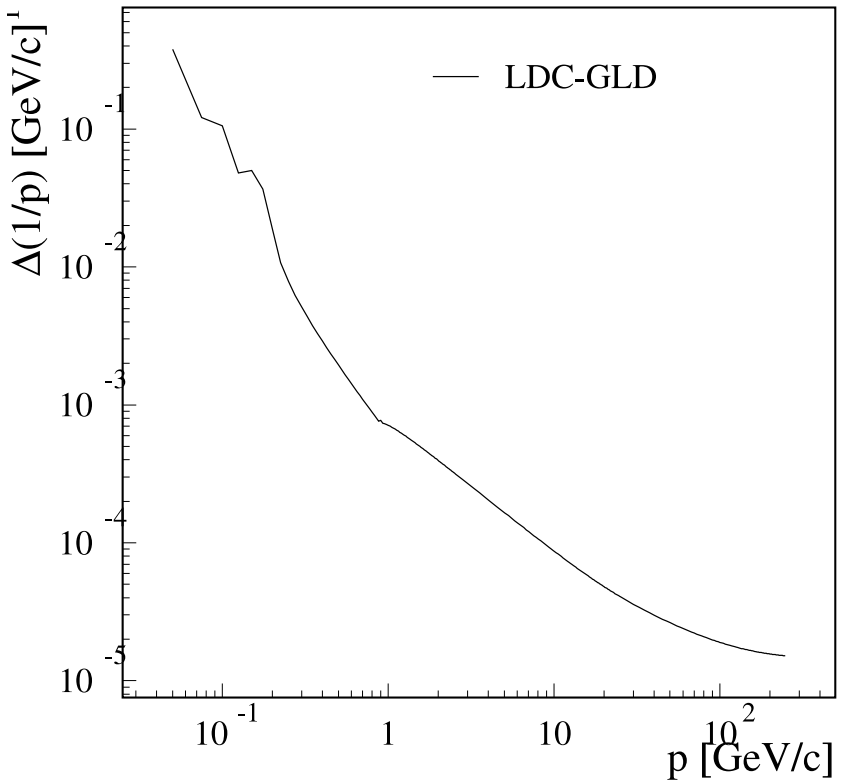

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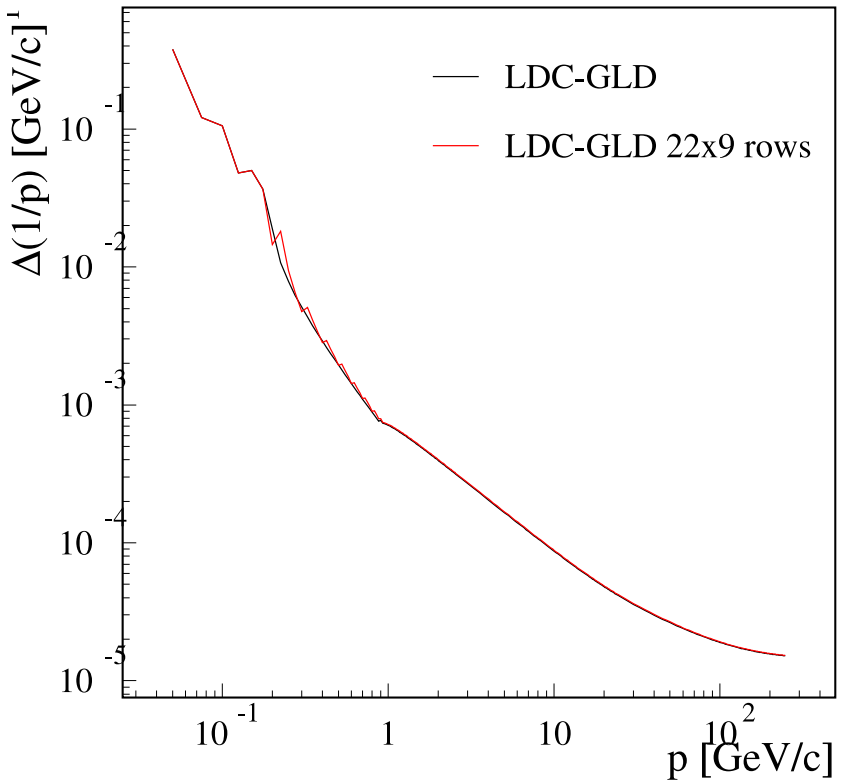

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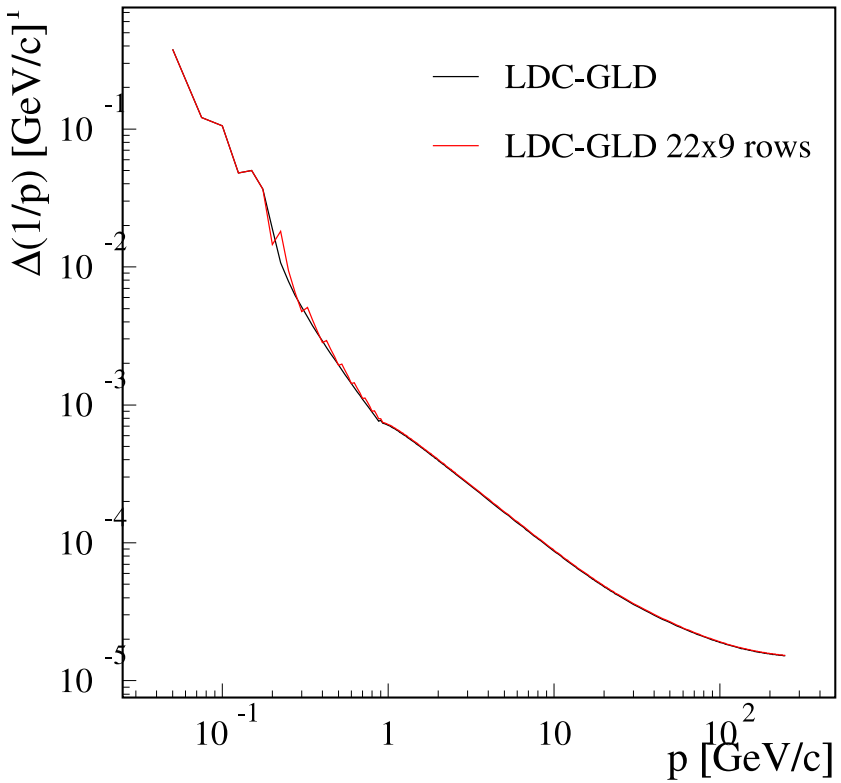
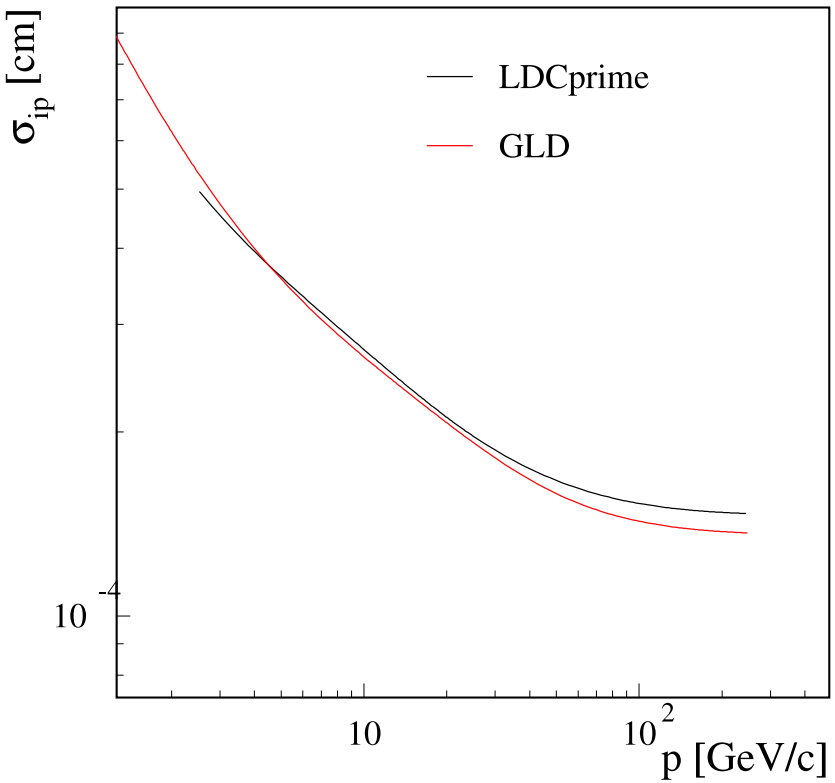


Vertex detector

Noticeably better resolution in GLD

- LDC-GLD
- GLD



Vertex detector

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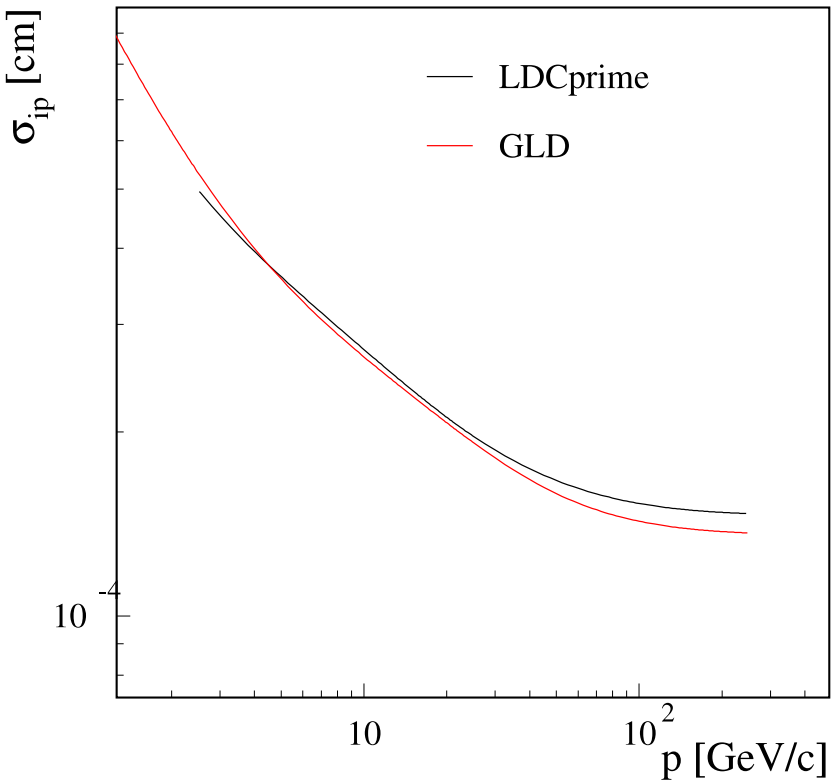
Swap the LDC VXD by the GLD one in LDC-GLD: Even better!



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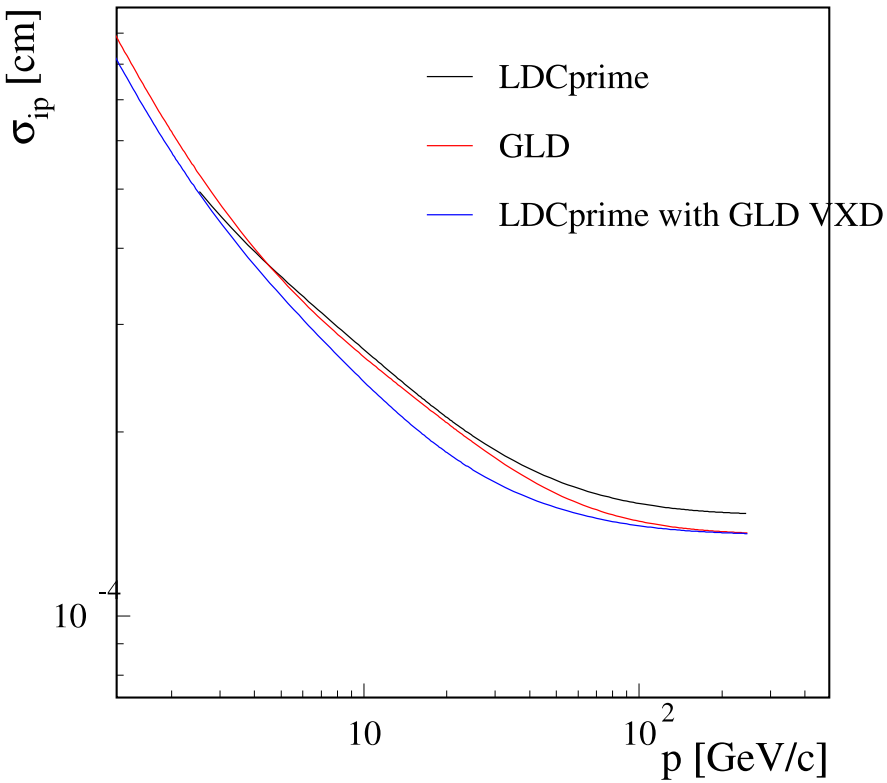

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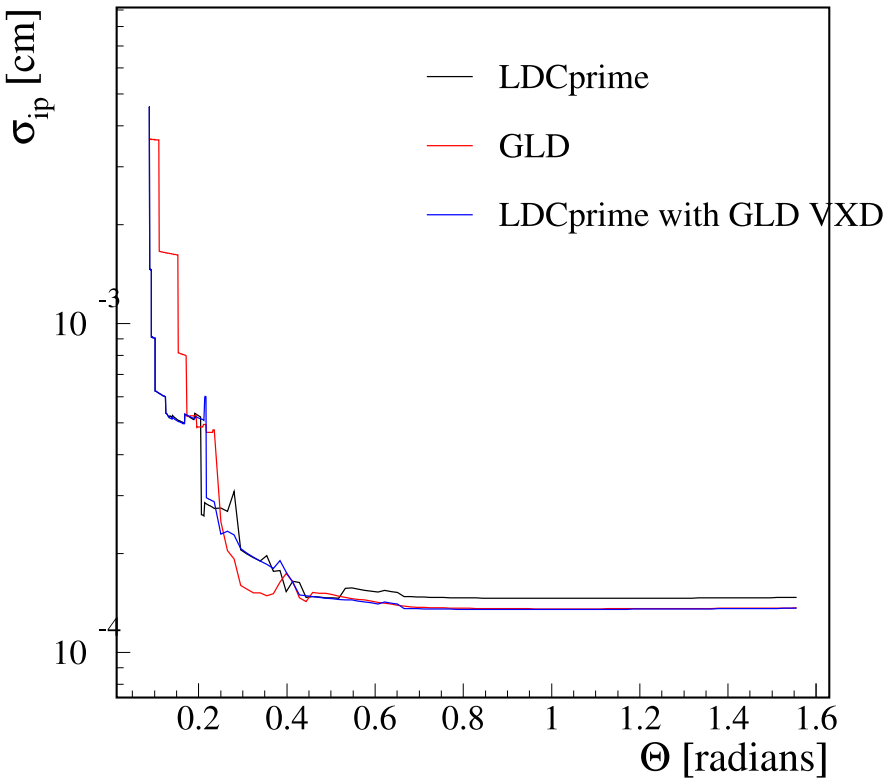

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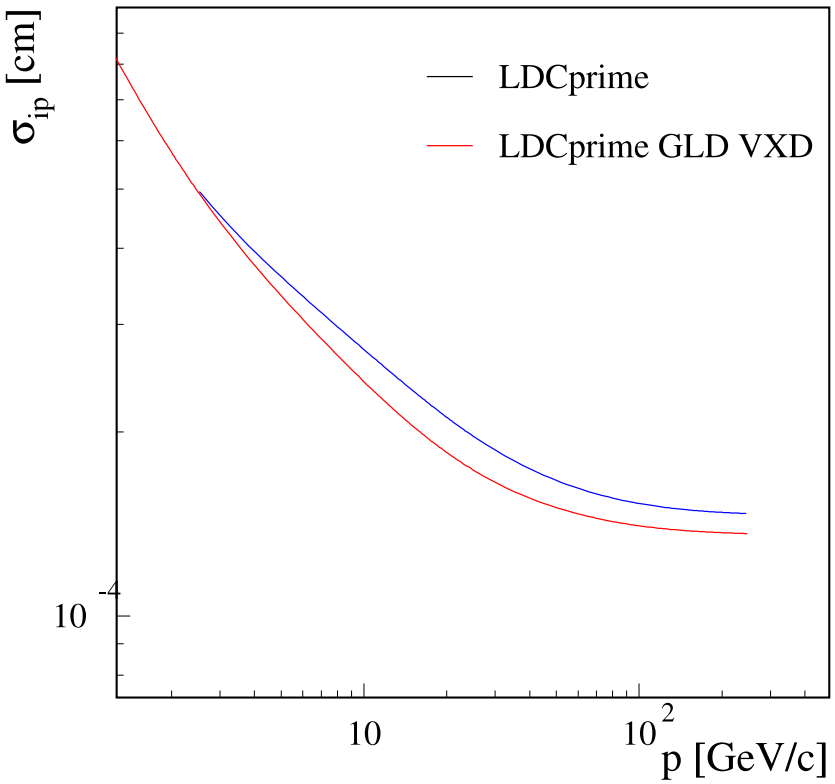
Noticeably better resolution in GLD: Why

- 6 against 5 points ?
- GLD model has no support and cooling structures



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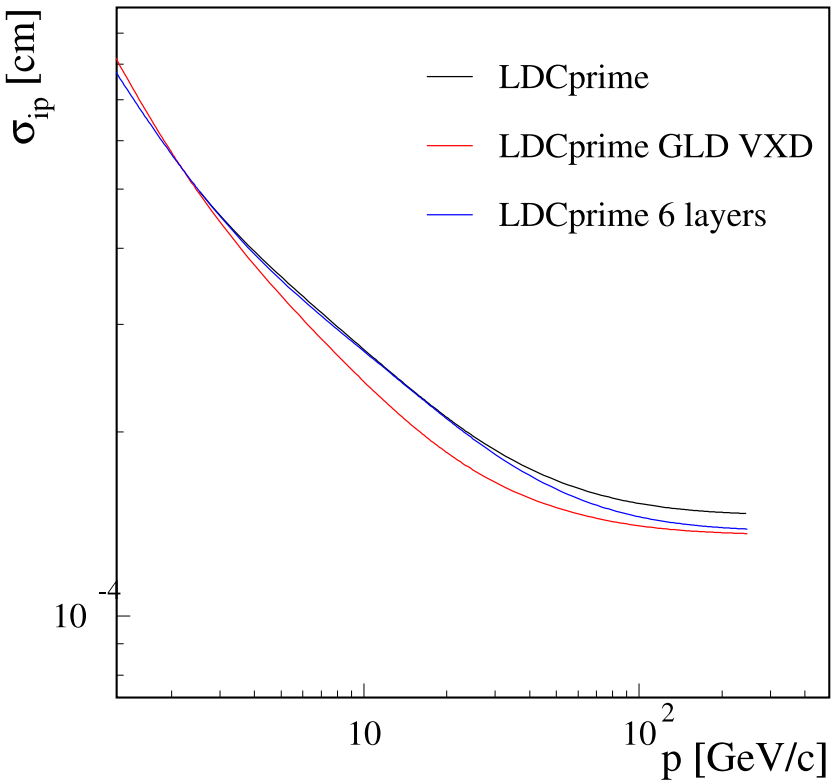

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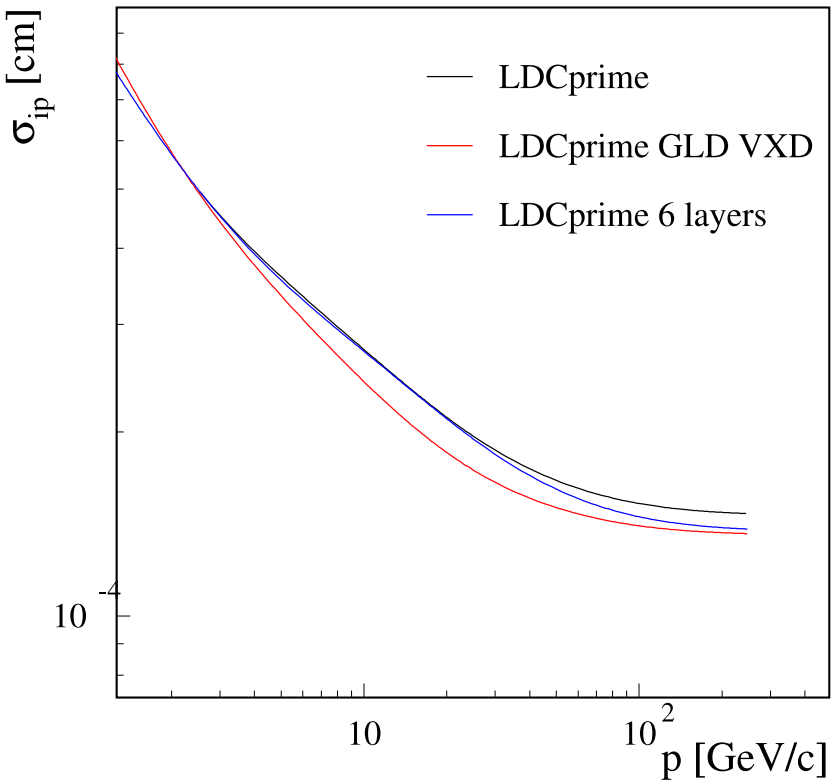

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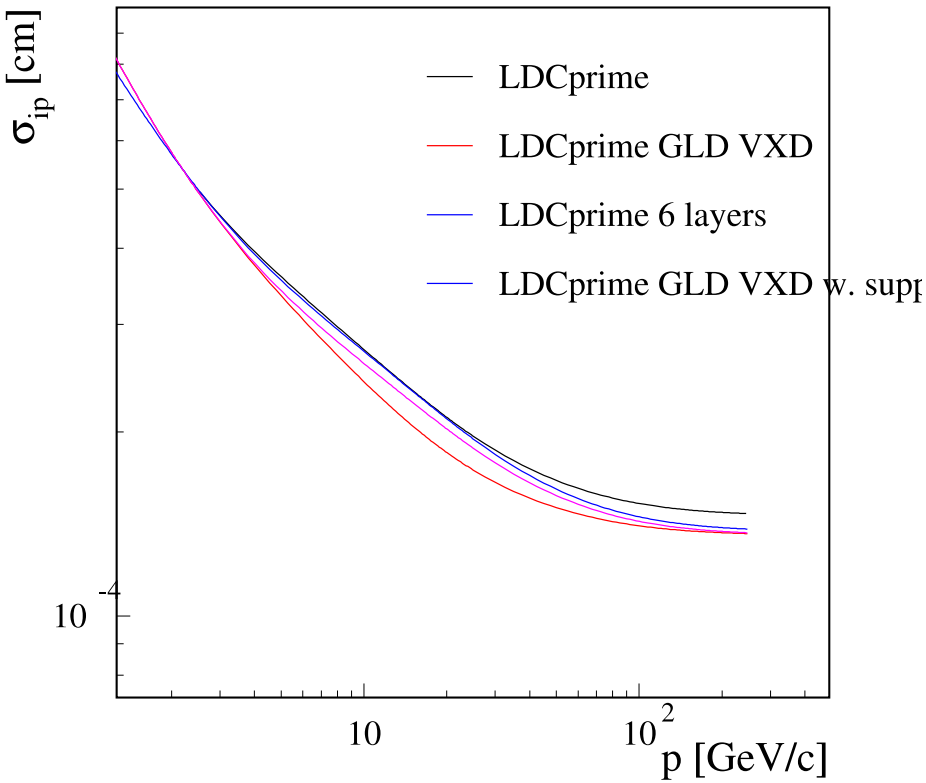

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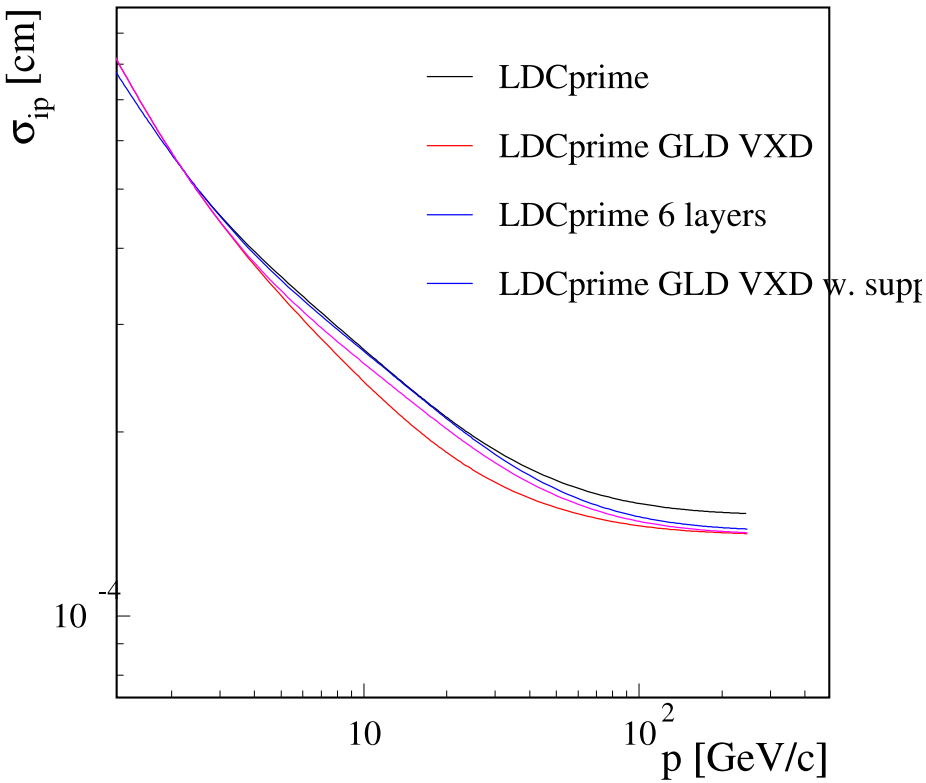
Also an effect, but still GLD is the best.
Probably a better first point ($\sqrt{2}$!) ?
To be studied.



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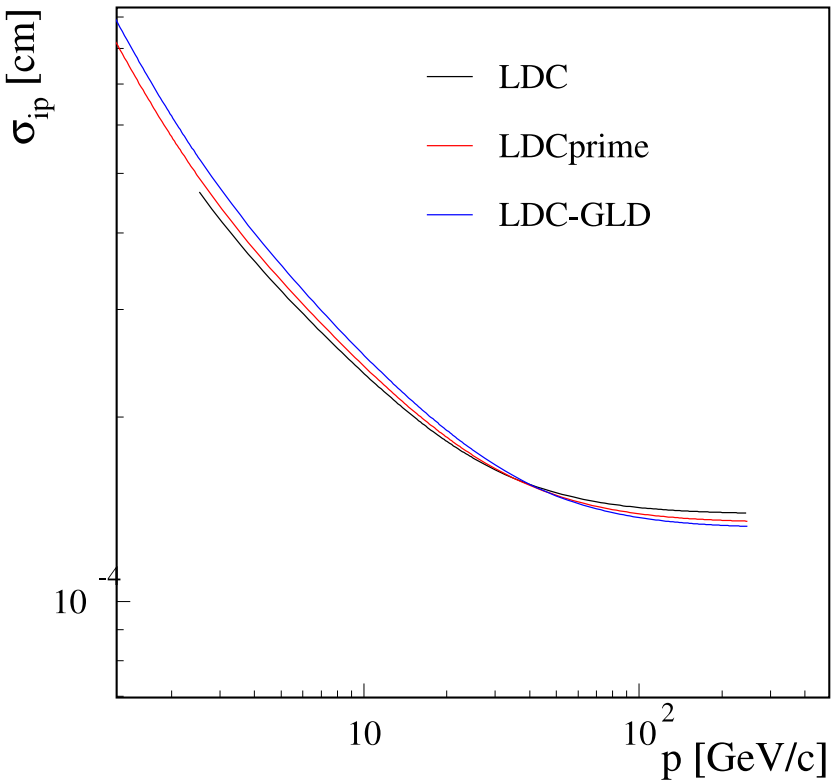
Note that LDC is better than LDC-GLD. Why ?

- Radius of first layer ?



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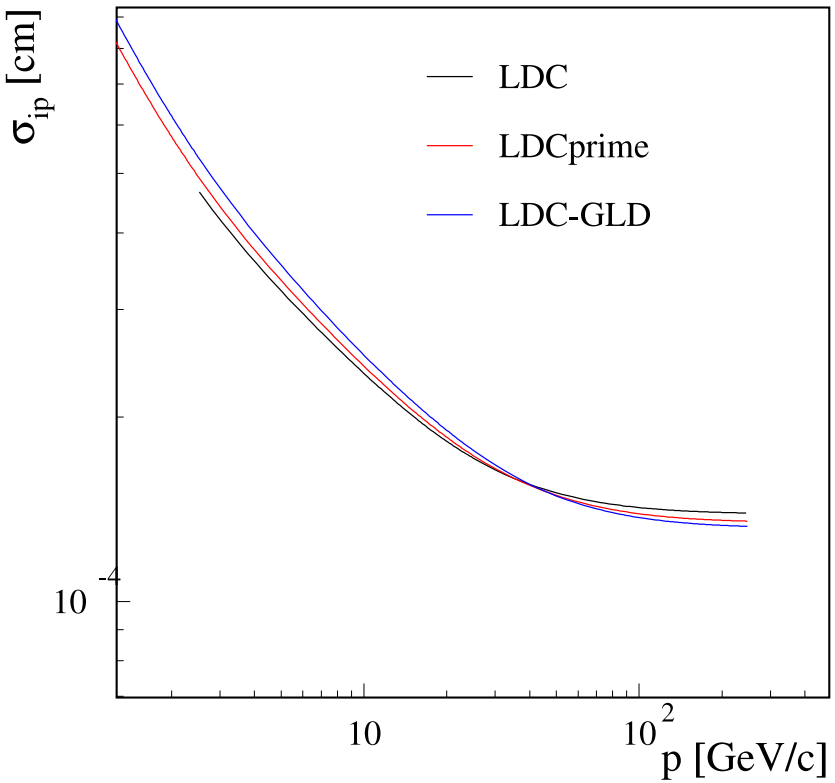

Vertex detector

Note that LDC is better than LDC-GLD. Why ?

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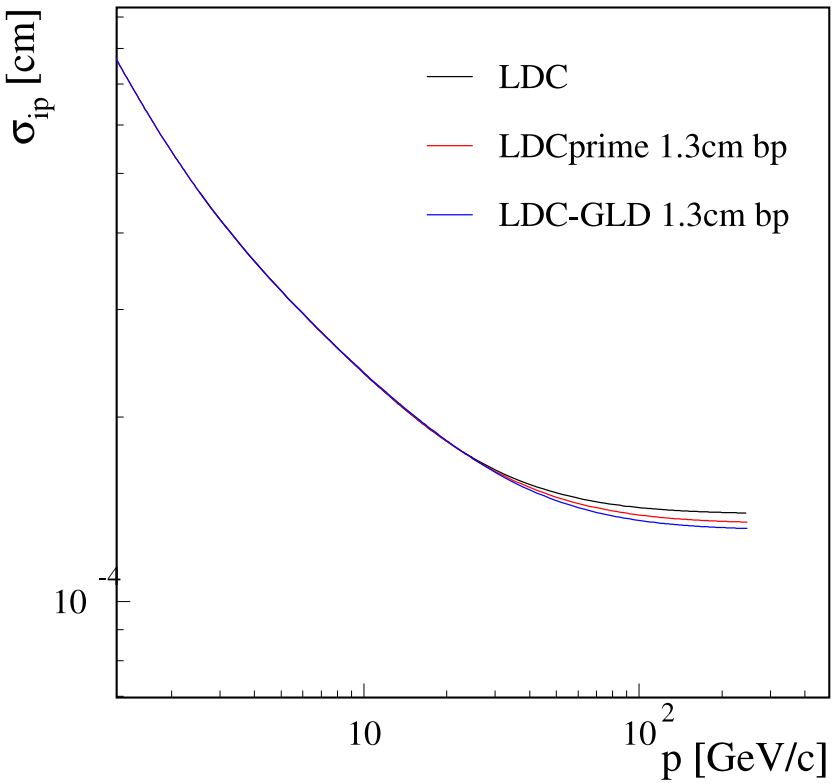
Yes. This completely explains the difference.



TPC inner radius

The GLD models have larger inner radius of the TPC, and consequently larger internal trackers. What effect does that have ?

- LDC-GLD
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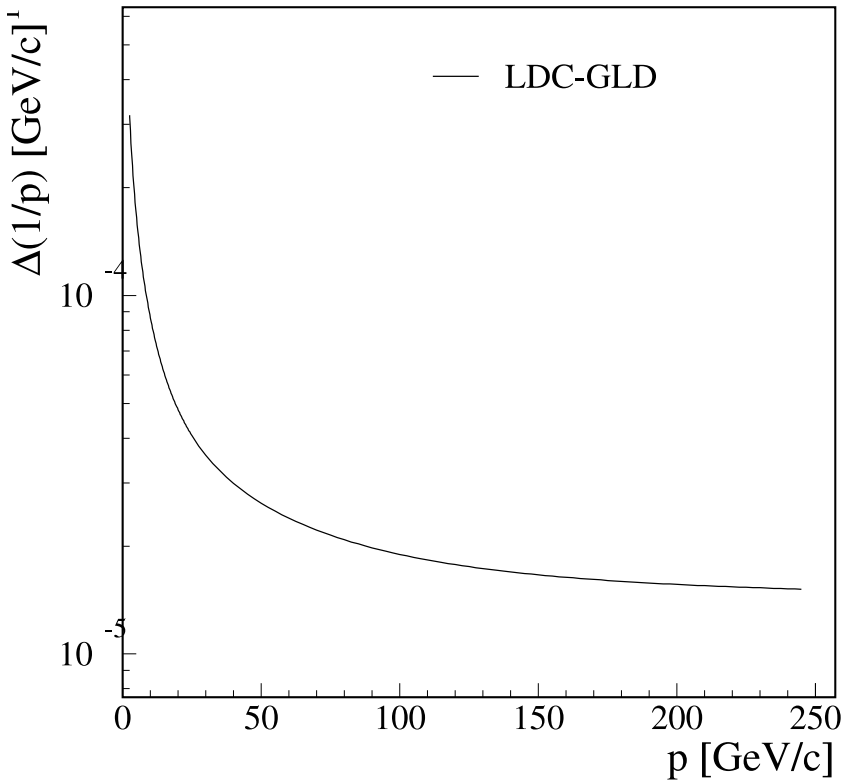

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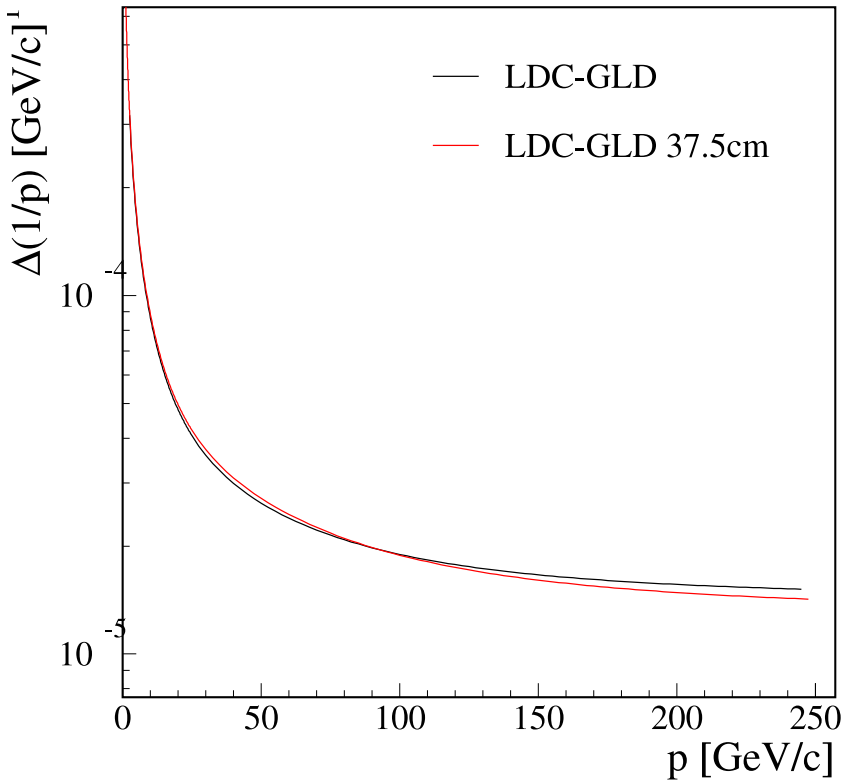

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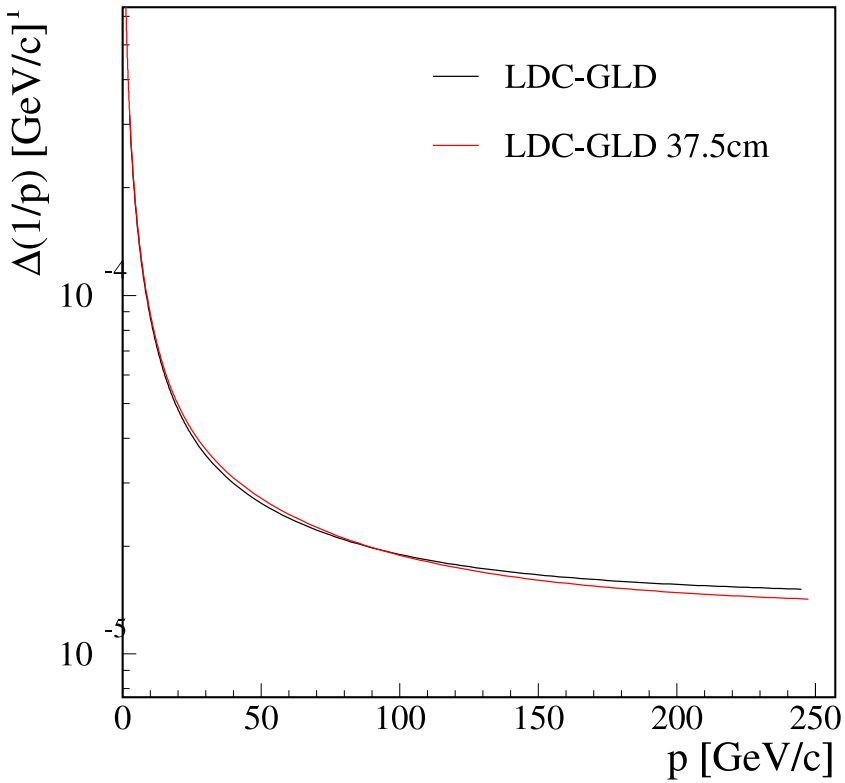
A slight amelioration of the momentum resolution.



The best choice

Take the best choice for all the sub-detectors. Compare with the best baseline for each of the quantities.

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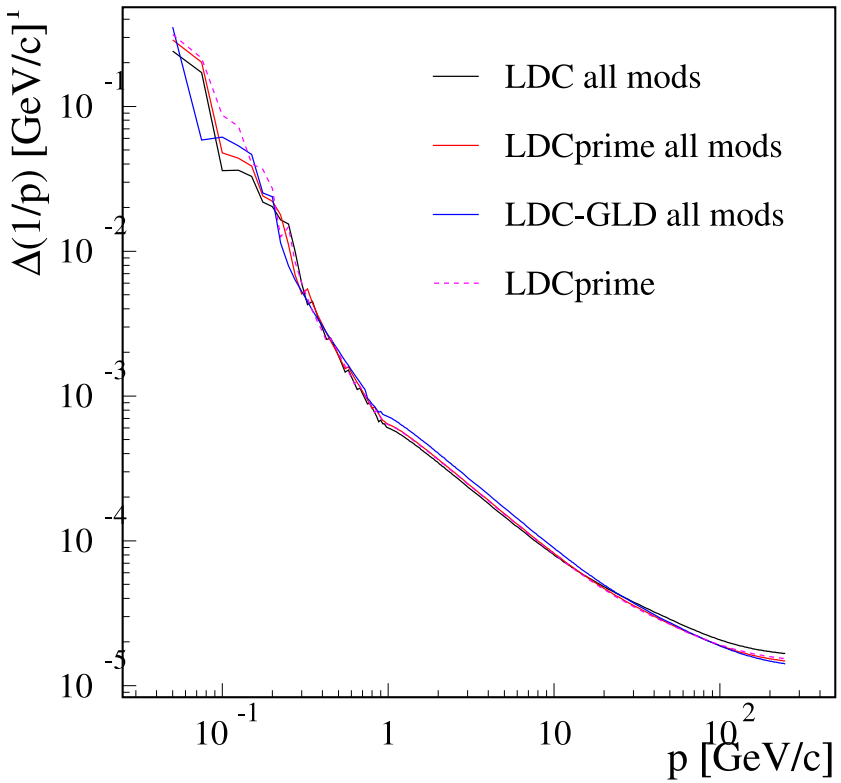

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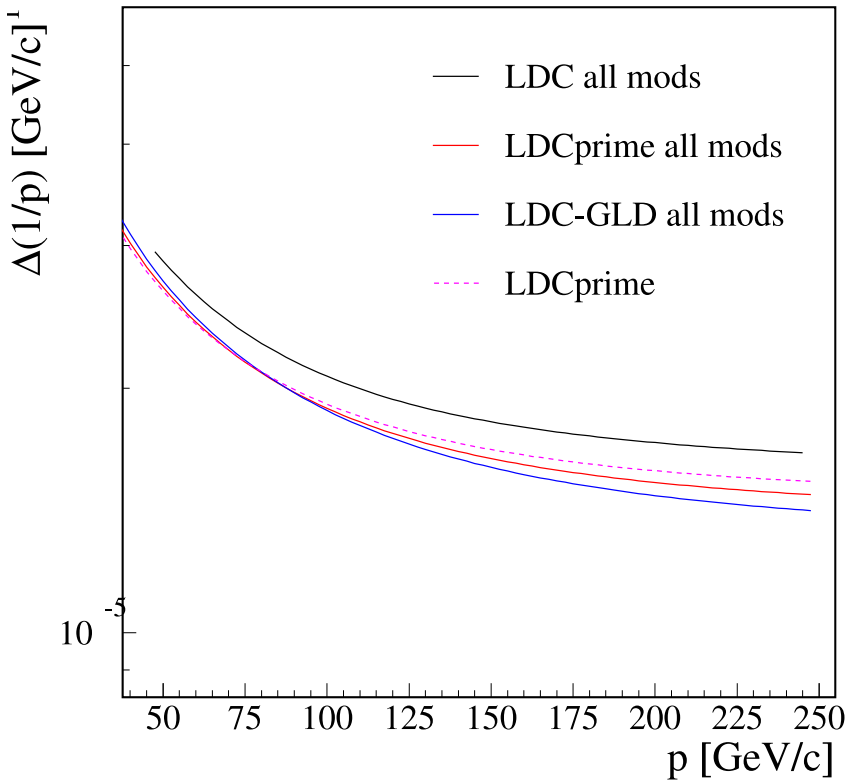

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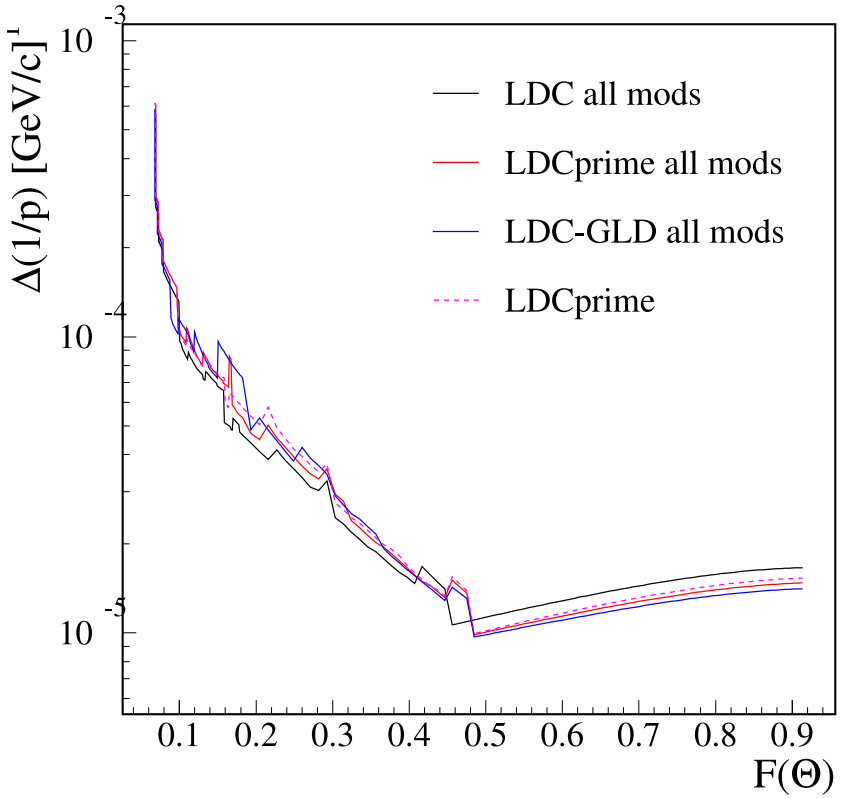

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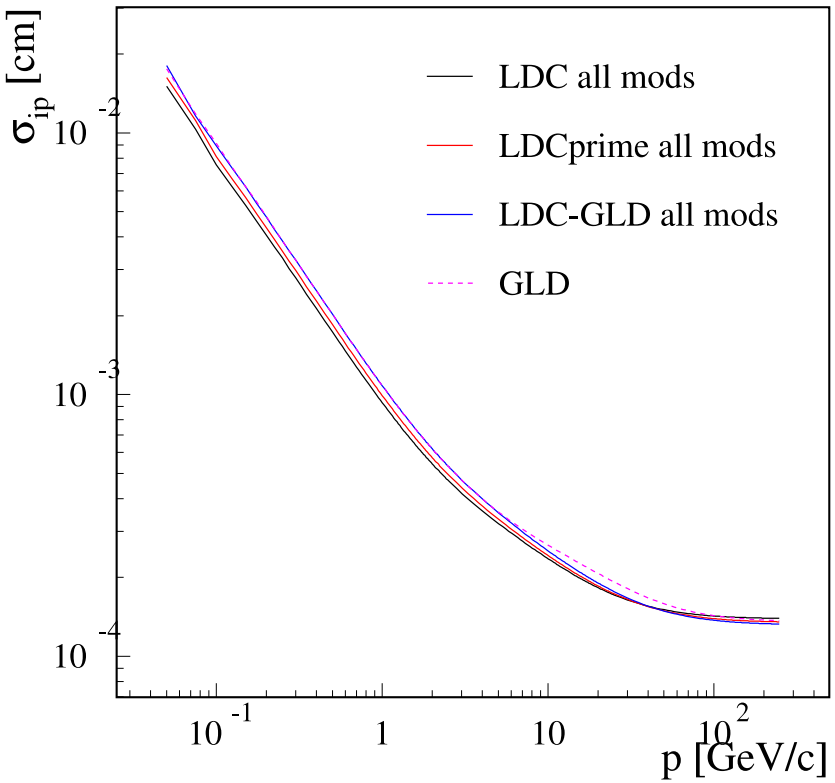

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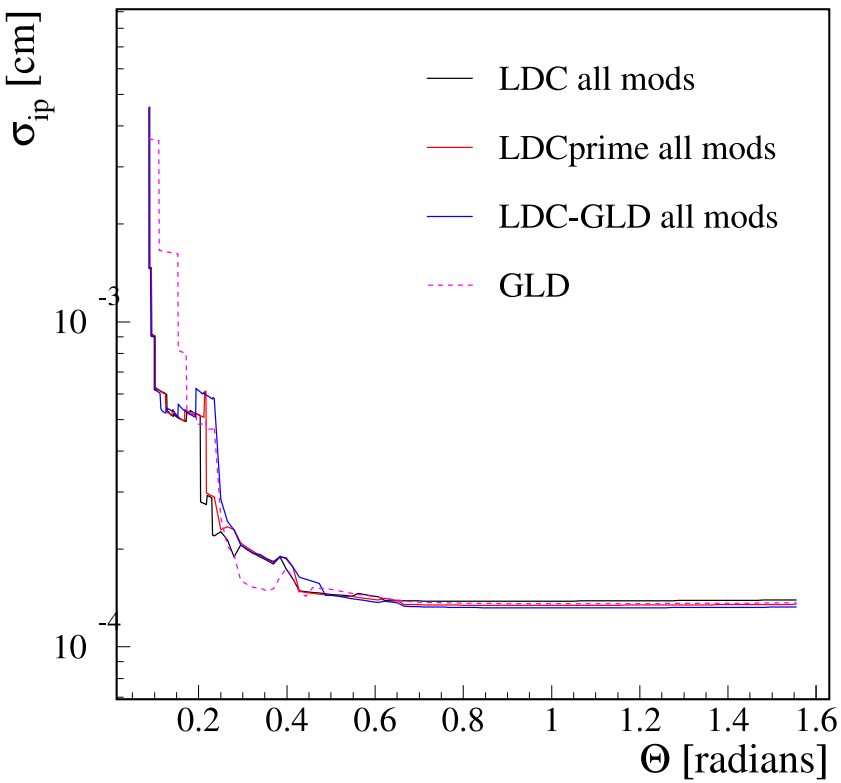

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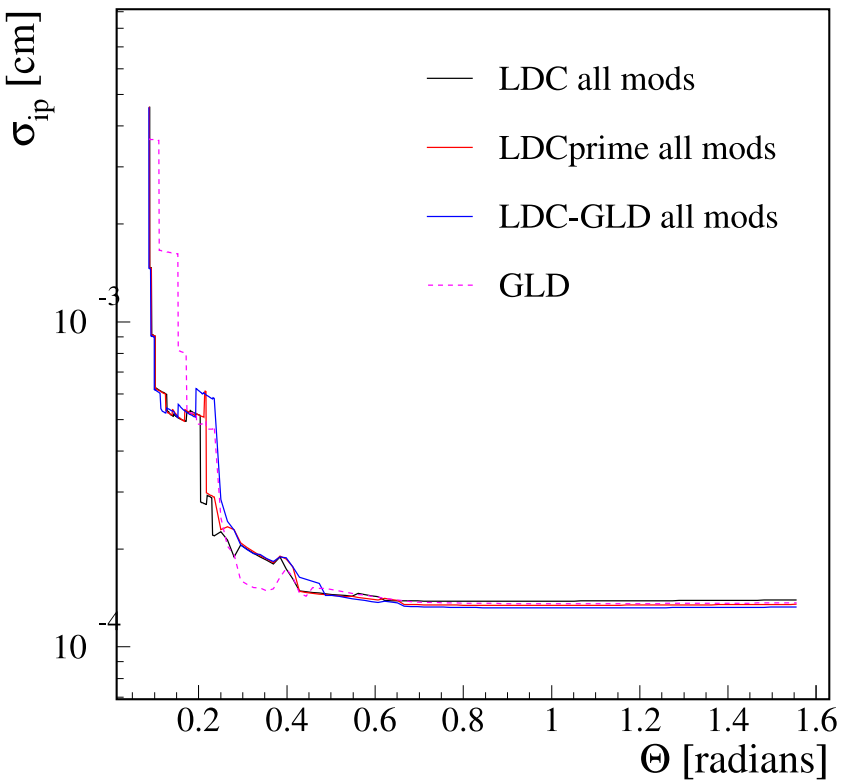
The combination does better than the best original design in at all places. The largest detector does best.



Conclusions

My conclusions on the optimal detector from the pure track resolution point-of-view:

- GLD vertex detector.
- LDC forward tracker.
- LDC external tracker in barrel.
- If B vs R is as in the models, the largest detector is preferable. .
- If $R^2 B$ is held constant, the smallest detector is preferable.
- If a large option is chosen, the GLD dimensions of the TPC are preferable.
- With a TPC end-plate as thin as in the study, LDCs external forward tracker is useful.
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