Effect of LGAD inside all-si tracker barrel

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To recap

- After W. Fan's presentation last meeting, we wanted to study the impact a Low-Gain Avalanche Detector (LGAD) layer would have on the all-silicon tracker performance.

- Having these detectors placed in the active tracking volume worsens the tracker performance (more material -> more MS).

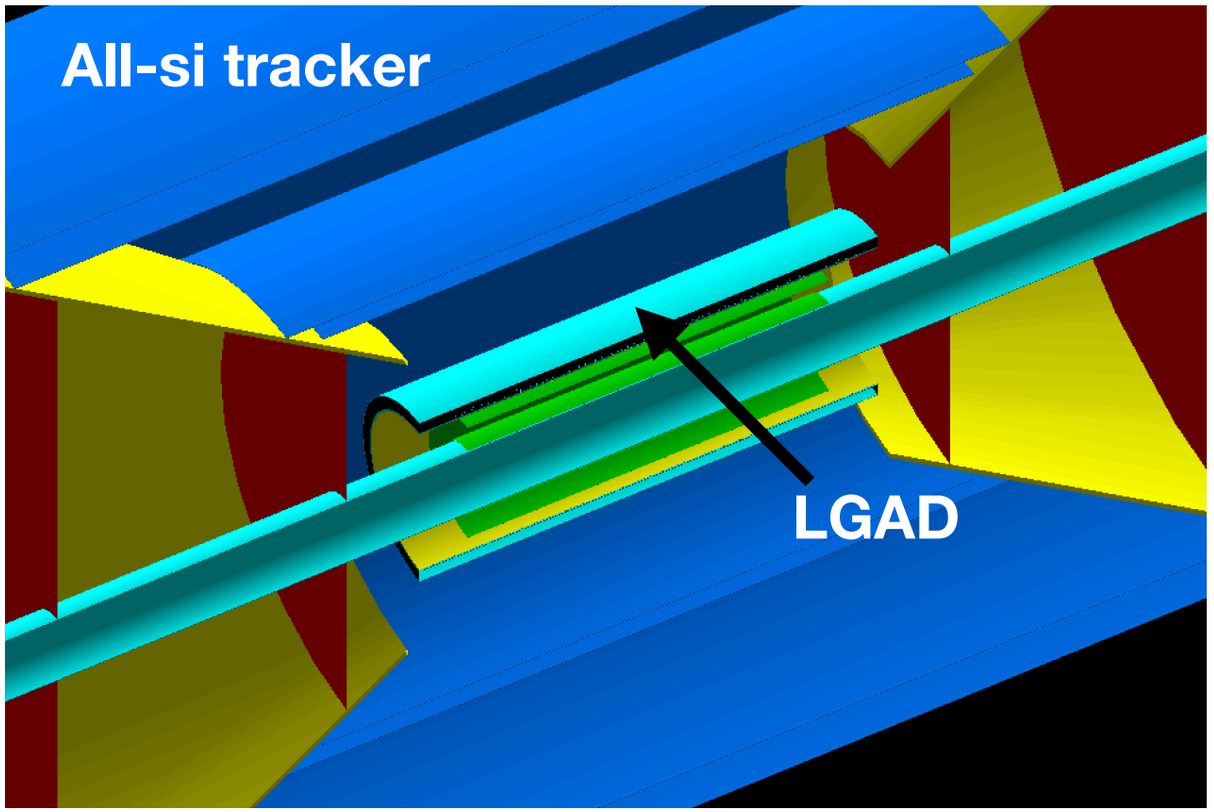
- Having these detectors at larger radii implies larger-area detectors, and limits their PID capabilities.

- Studied all-silicon tracker momentum-resolution impact of placing LGAD layers at different radii inside the all-silicon tracker barrel.

LGAD Material Budget and characteristics

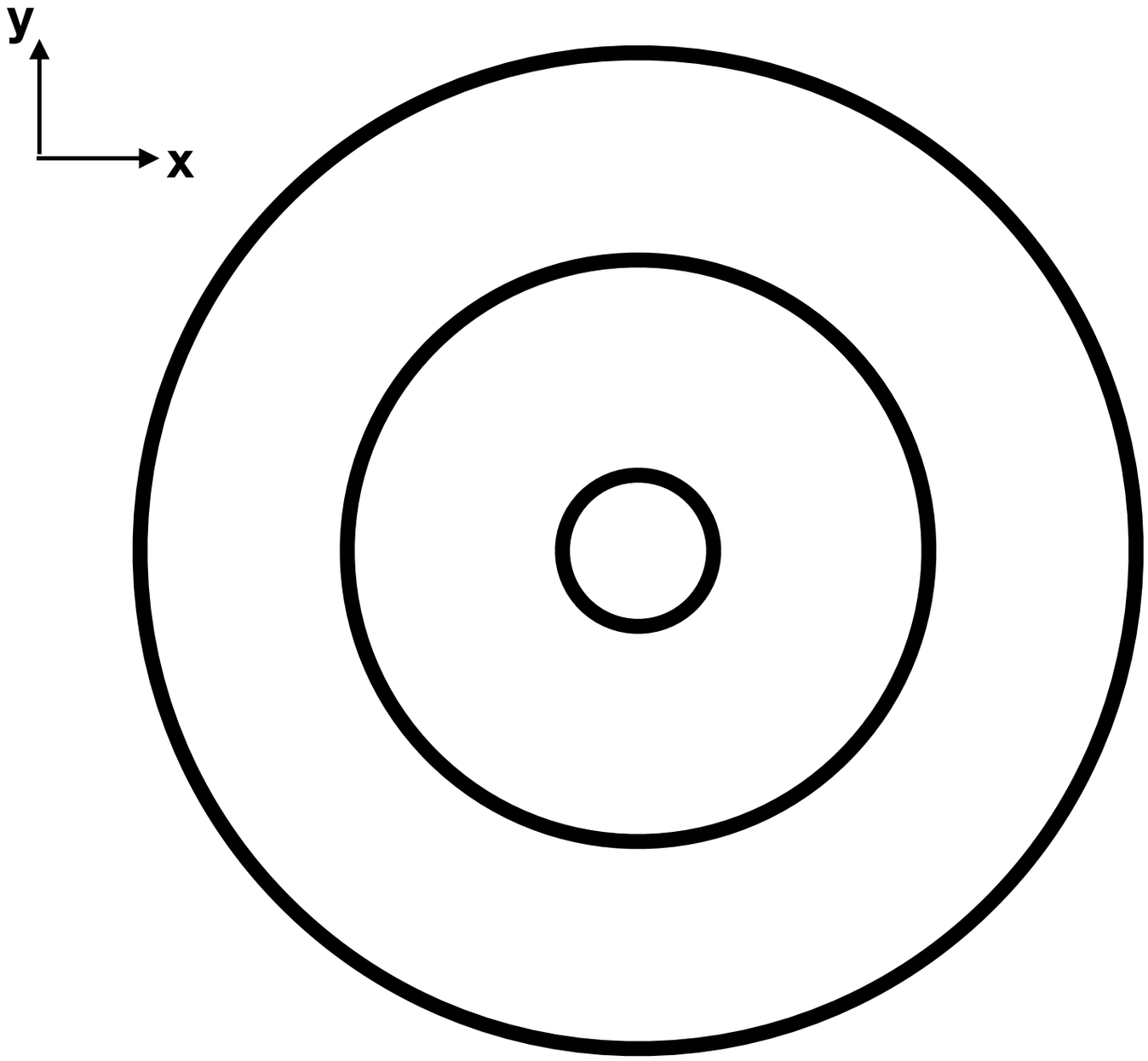
https://github.com/reynier0611/g4lblvtx/blob/master/macros/auxiliary_studies/simplified_geometry/G4_TTL_EIC.C

Resolution: $500\ \mu\mathrm{m}/\sqrt{12}$



Component	Material	Thickness	X/X0 [%]
Silicon Sensor	Silicon	85 μm	0.091
Metal connection	Aluminum	0.15 mm	0.169
HDI	Kapton	0.2 mm	0.0700
Cooling	Water	1 mm	0.277
Support	Graphite	0.5 mm	0.259
Support Gap	Air	1 cm	0.003
Support	Graphite	0.5 mm	0.259
			1.13

All-silicon tracker barrel layout

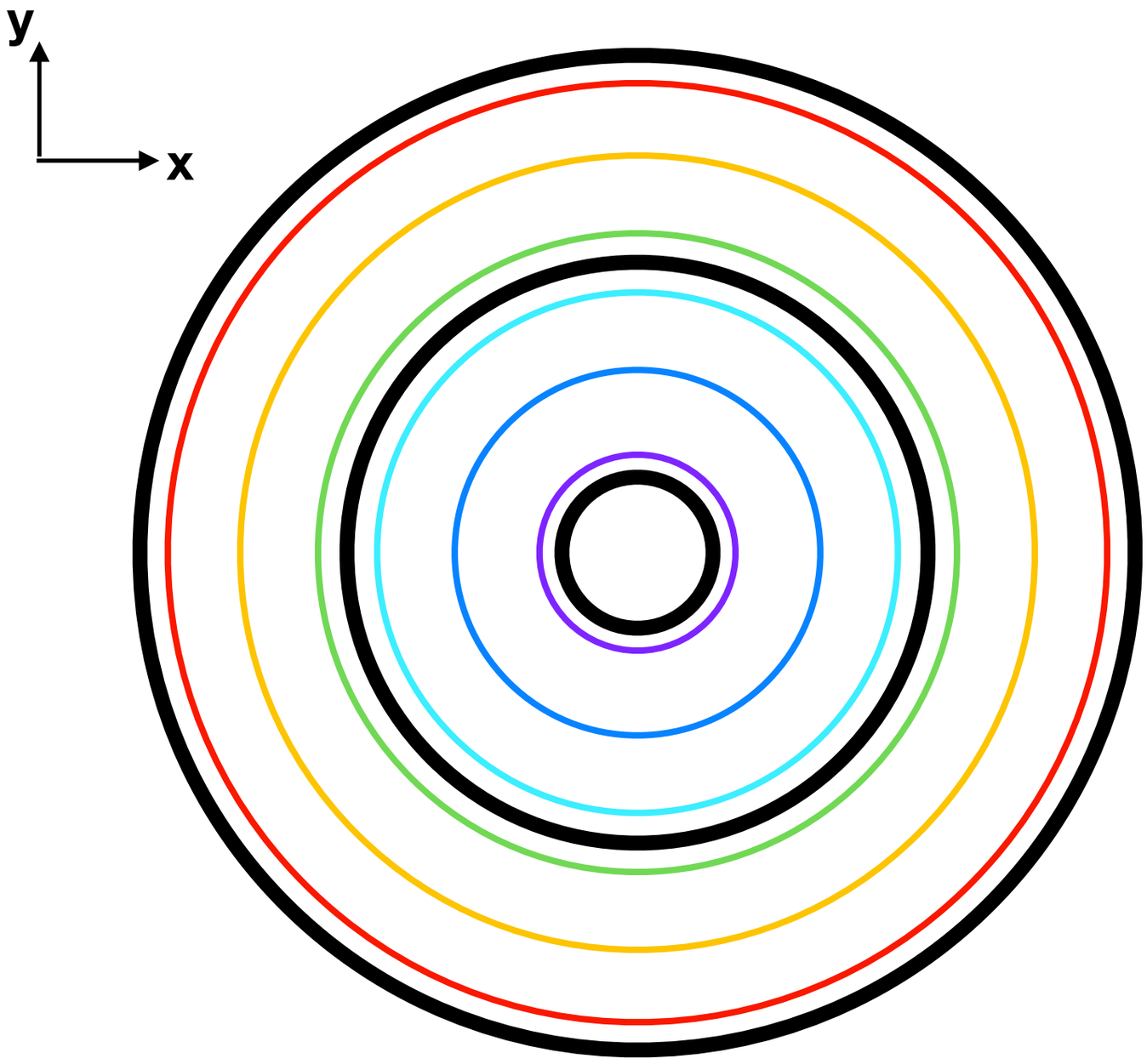


Black: all-si layers

All-silicon tracker layers

Barrel layer	radius [cm]
1	3.30
2	5.70
3	21.00
4	22.68
5	39.30
6	43.23

LGAD Placement



Black: all-si layers

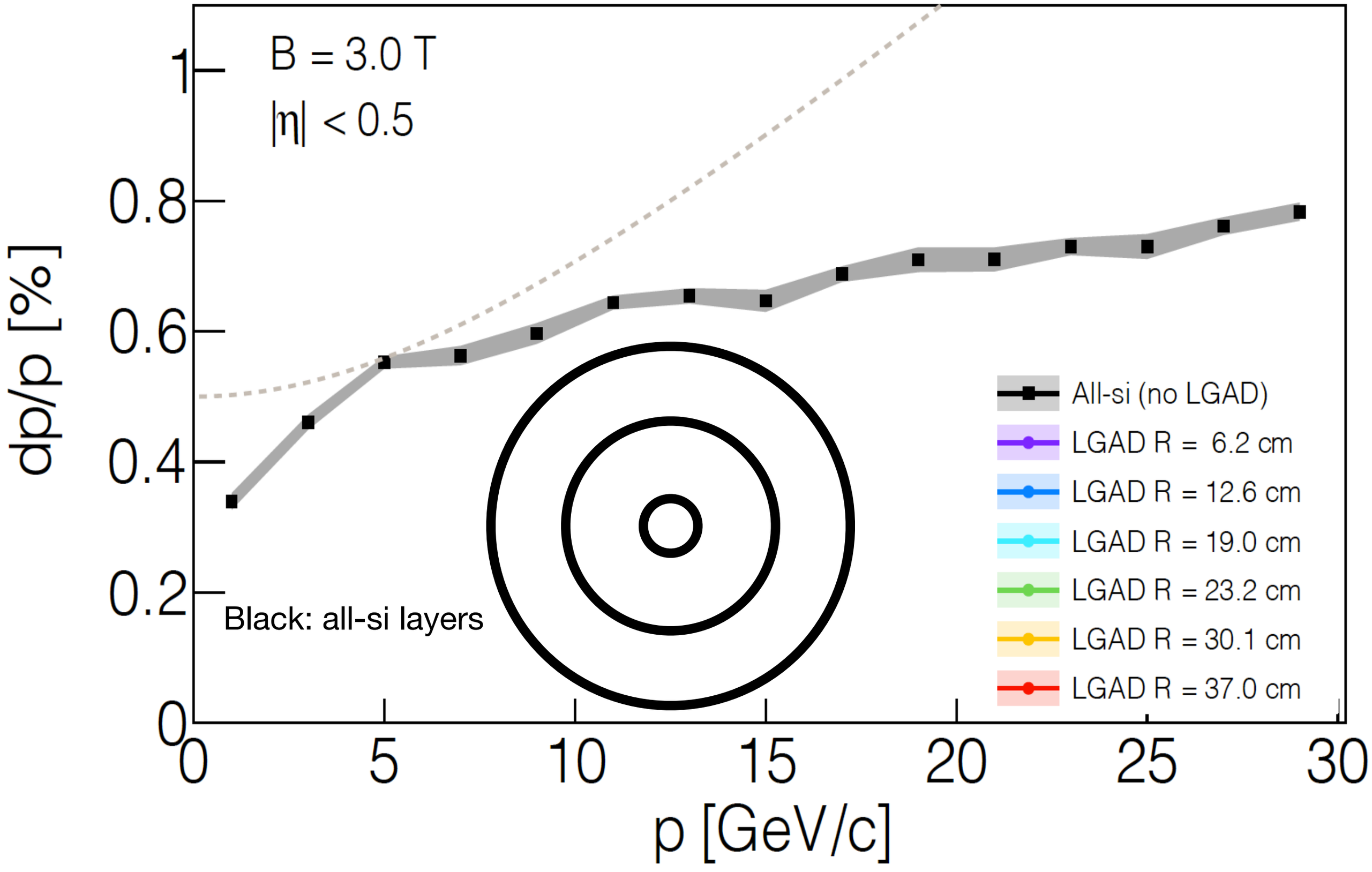
Colored: different placements of LGAD

All-silicon tracker layers

Barrel layer	radius [cm]
1	3.30
2	5.70
3	21.00
4	22.68
5	39.30
6	43.23

R_{LGAD} = 6.2 cm
R_{LGAD} = 12.6 cm
R_{LGAD} = 19.0 cm
R_{LGAD} = 23.2 cm
R_{LGAD} = 30.1 cm
R_{LGAD} = 37.0 cm

Placement of LGAD layer inside the tracking volume



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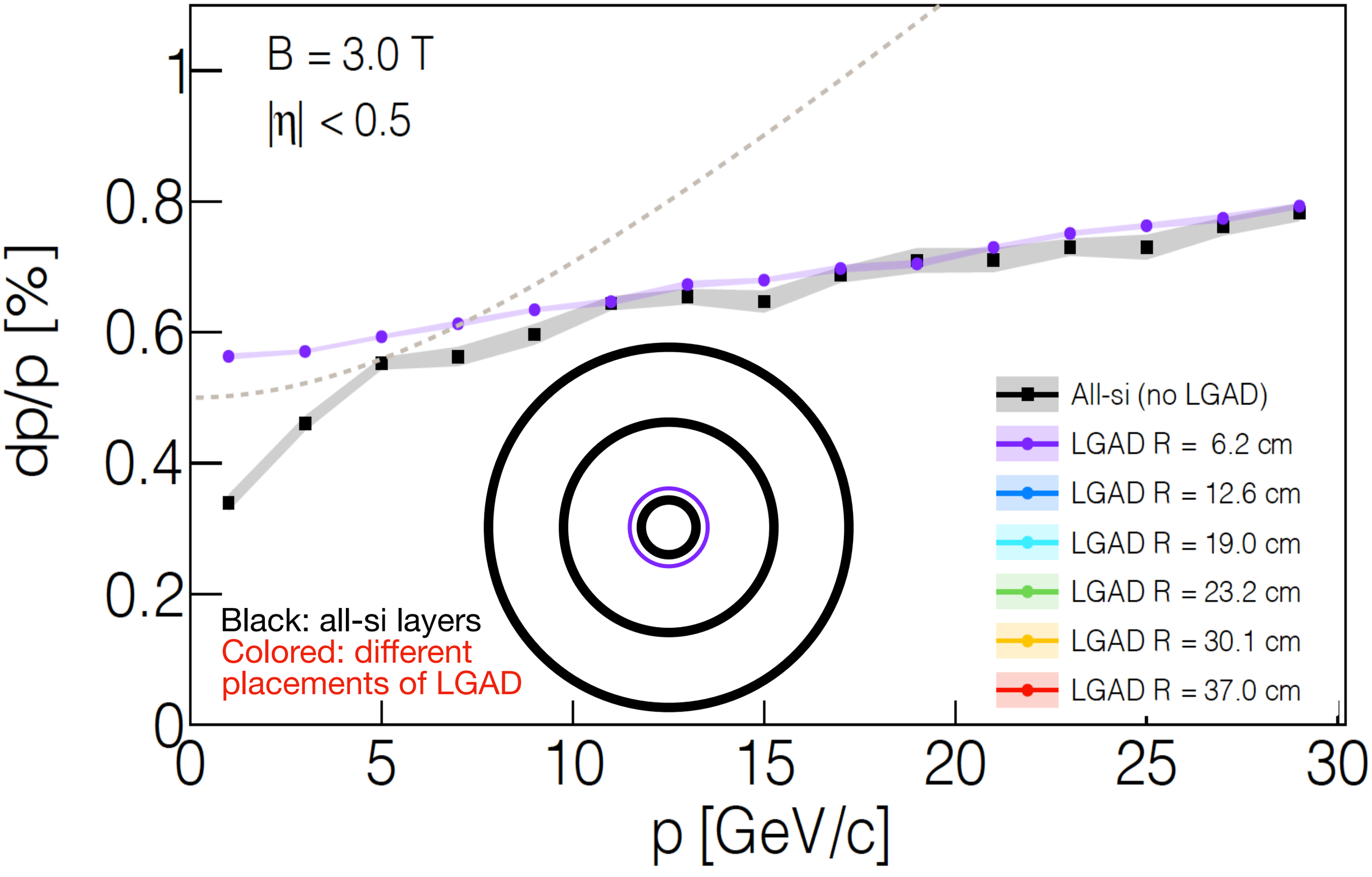

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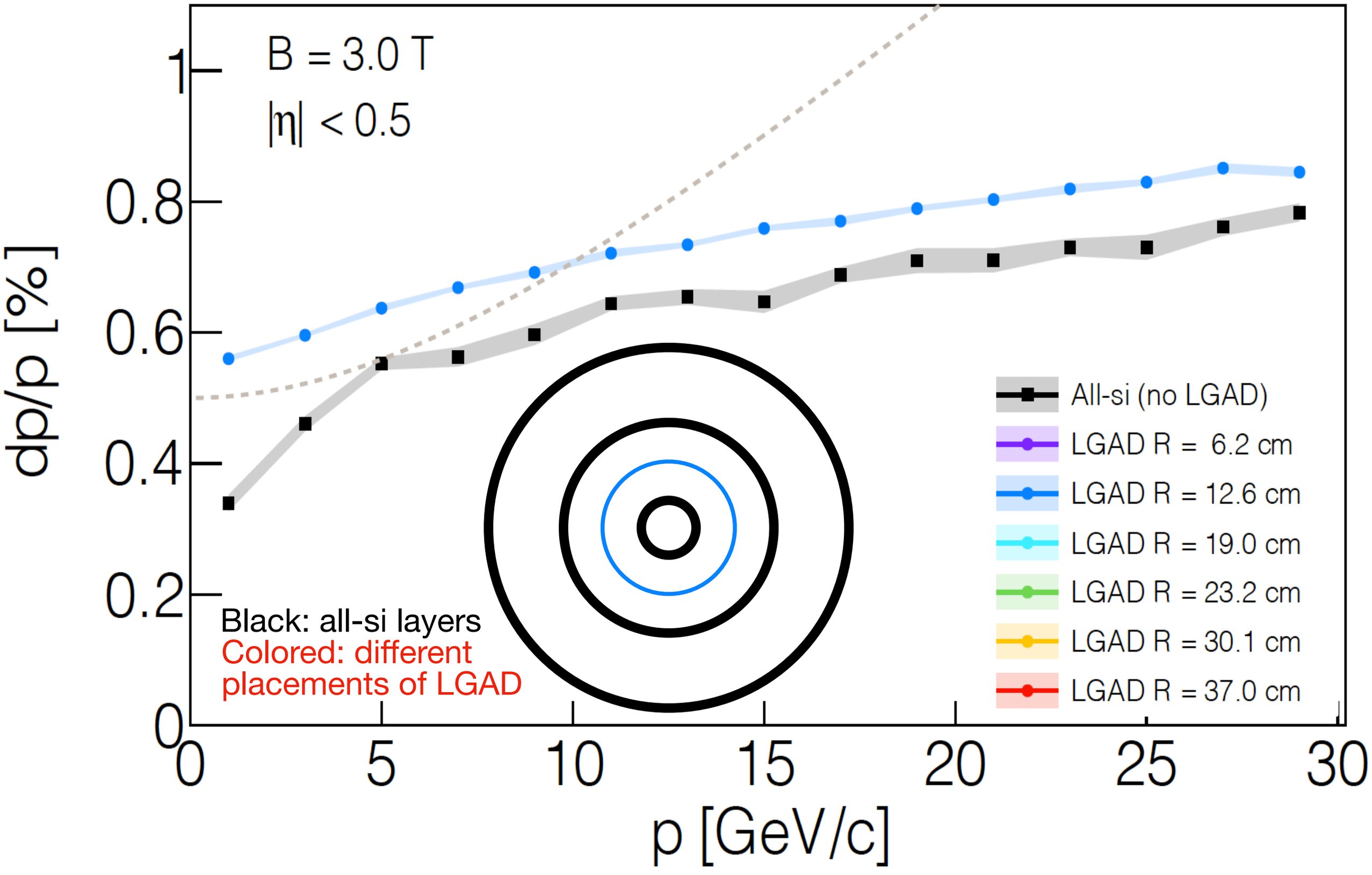

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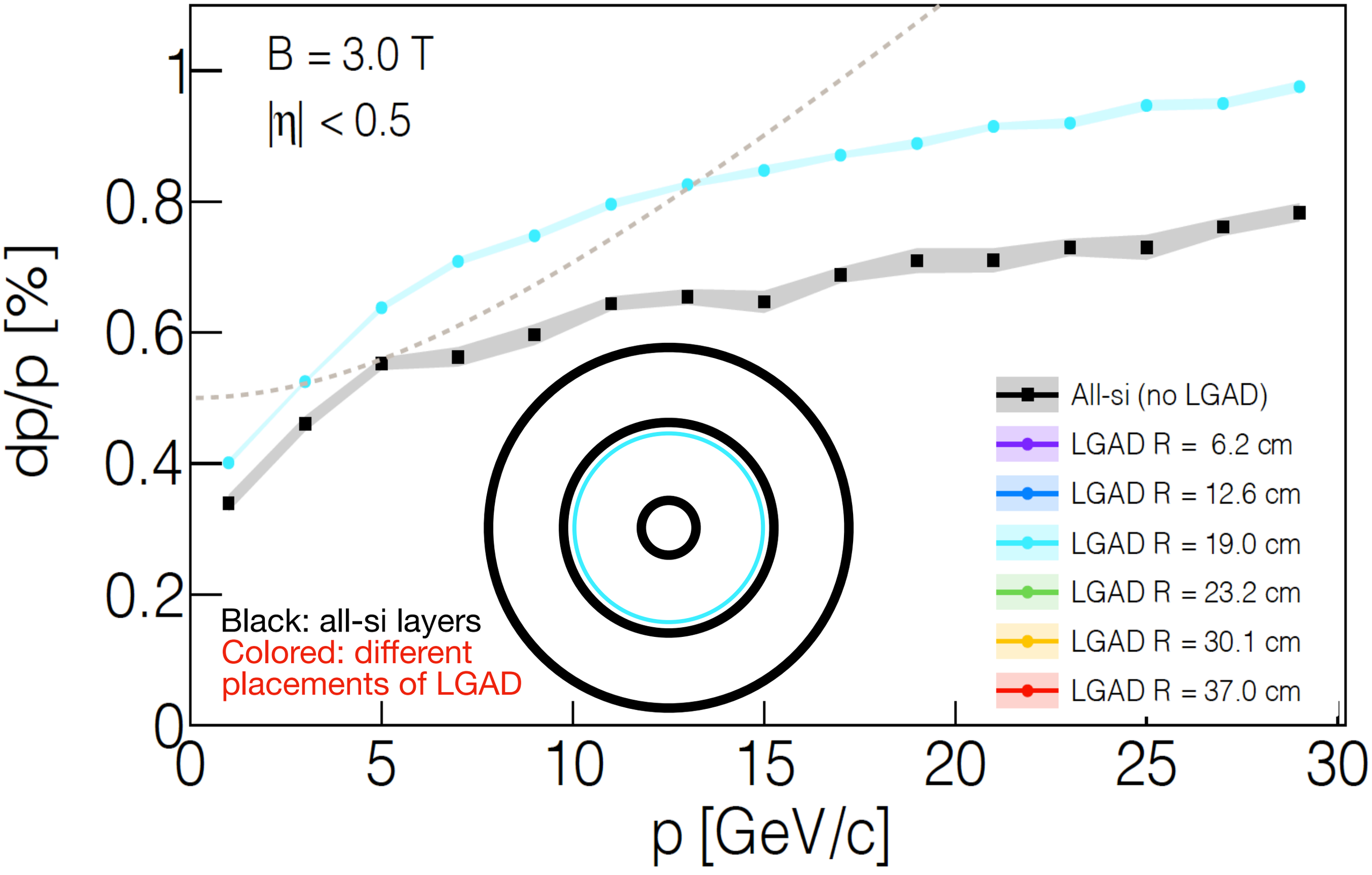
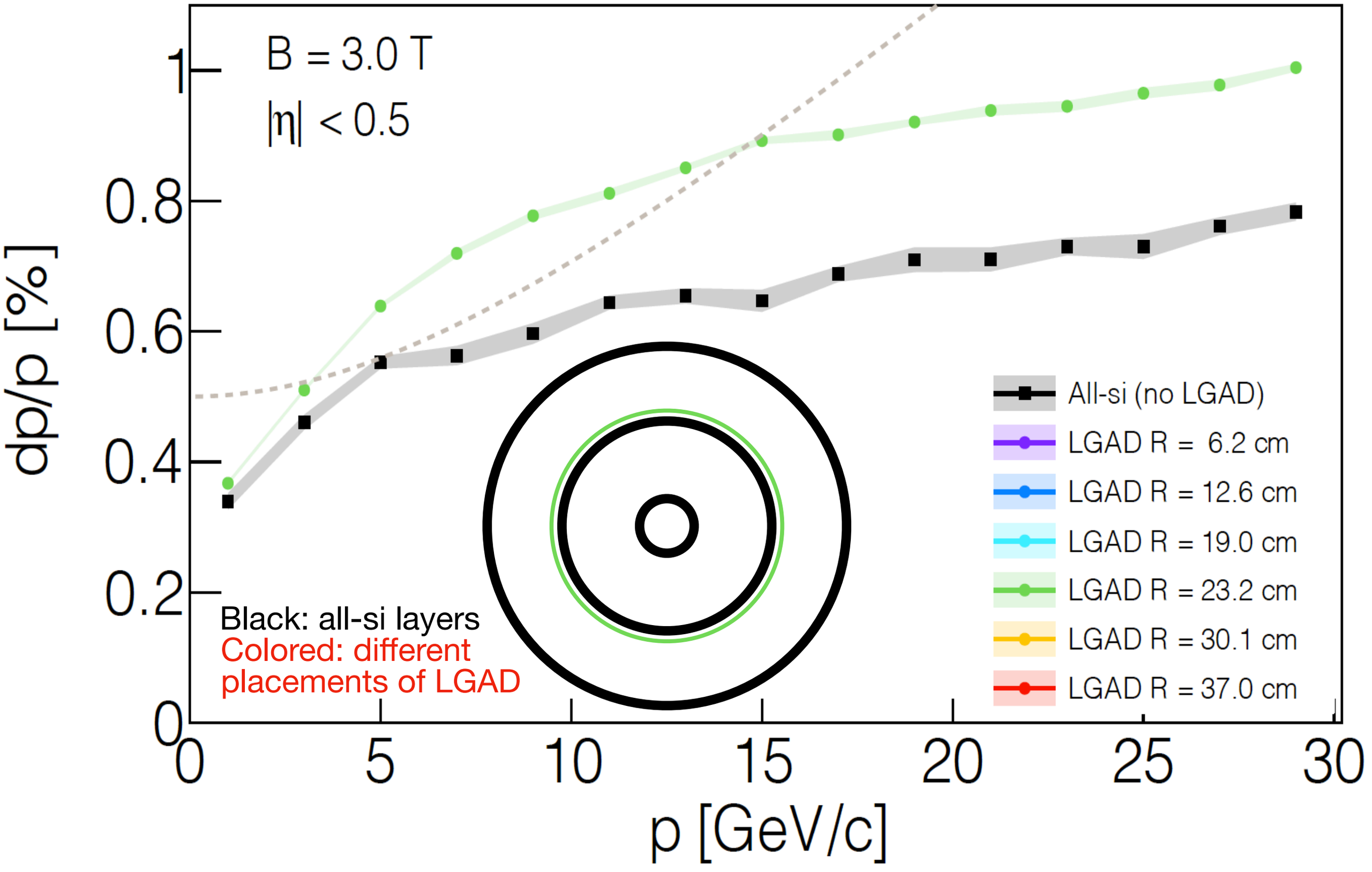
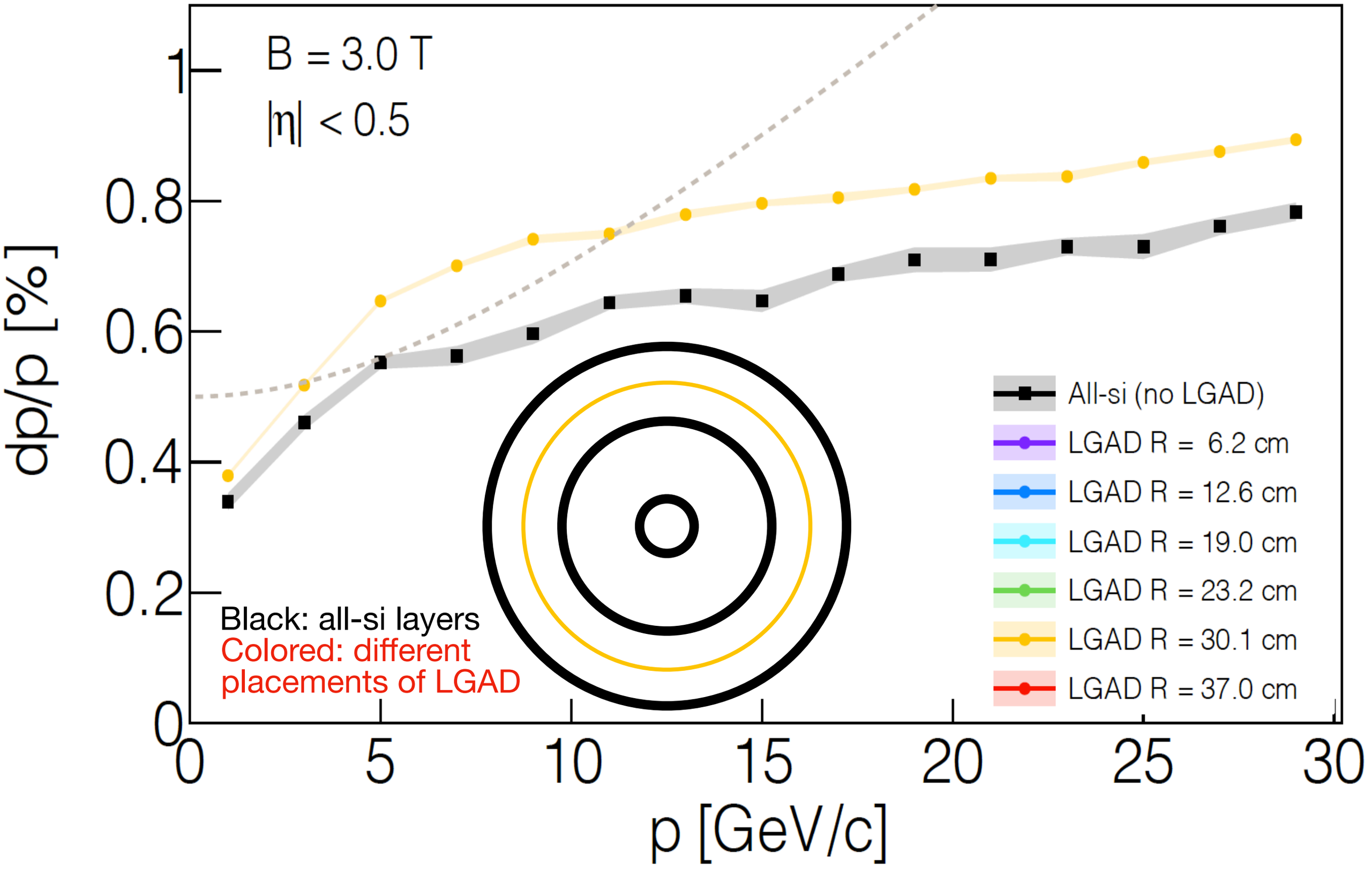


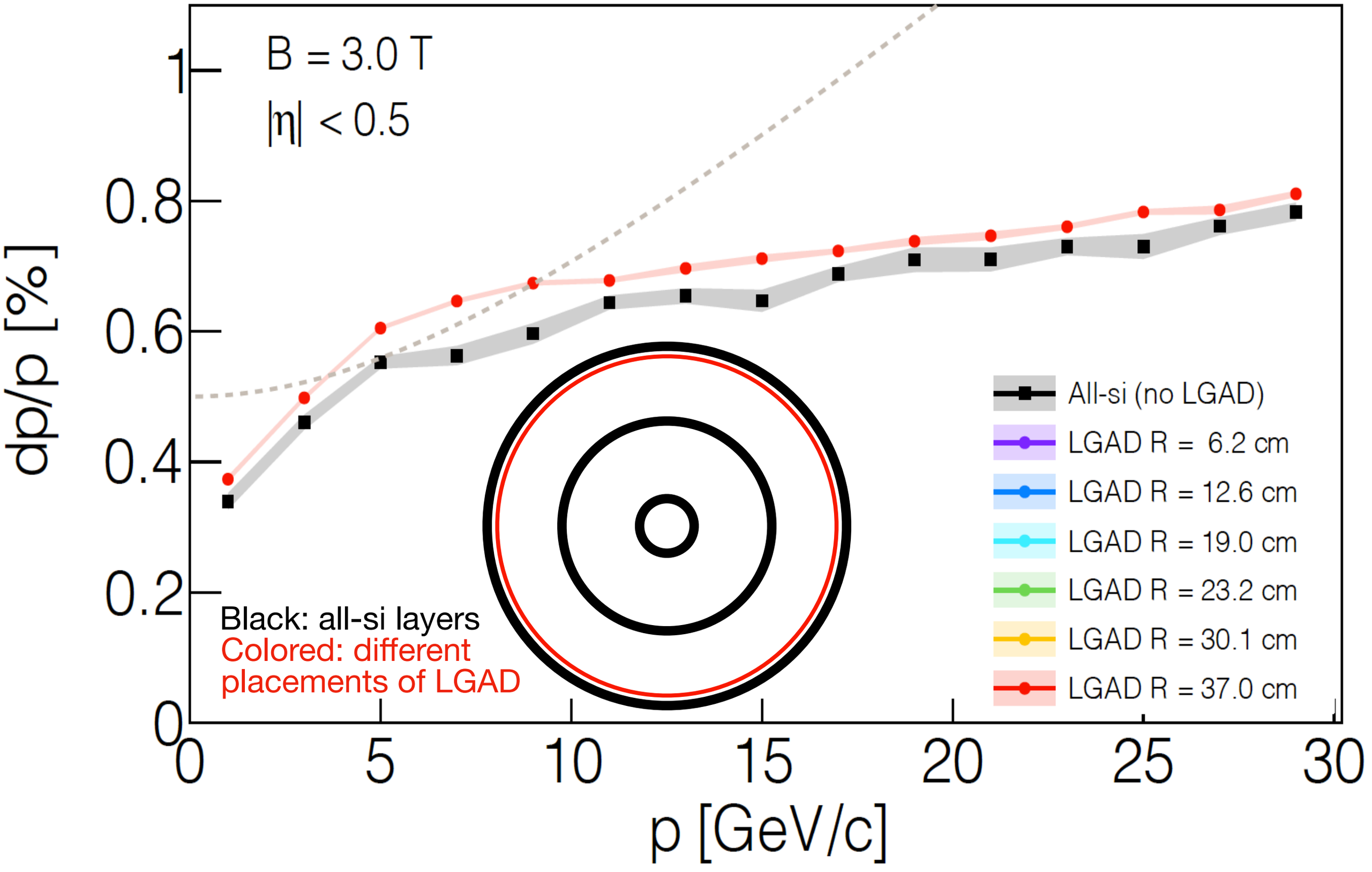
Placement of LGAD layer inside the tracking volume



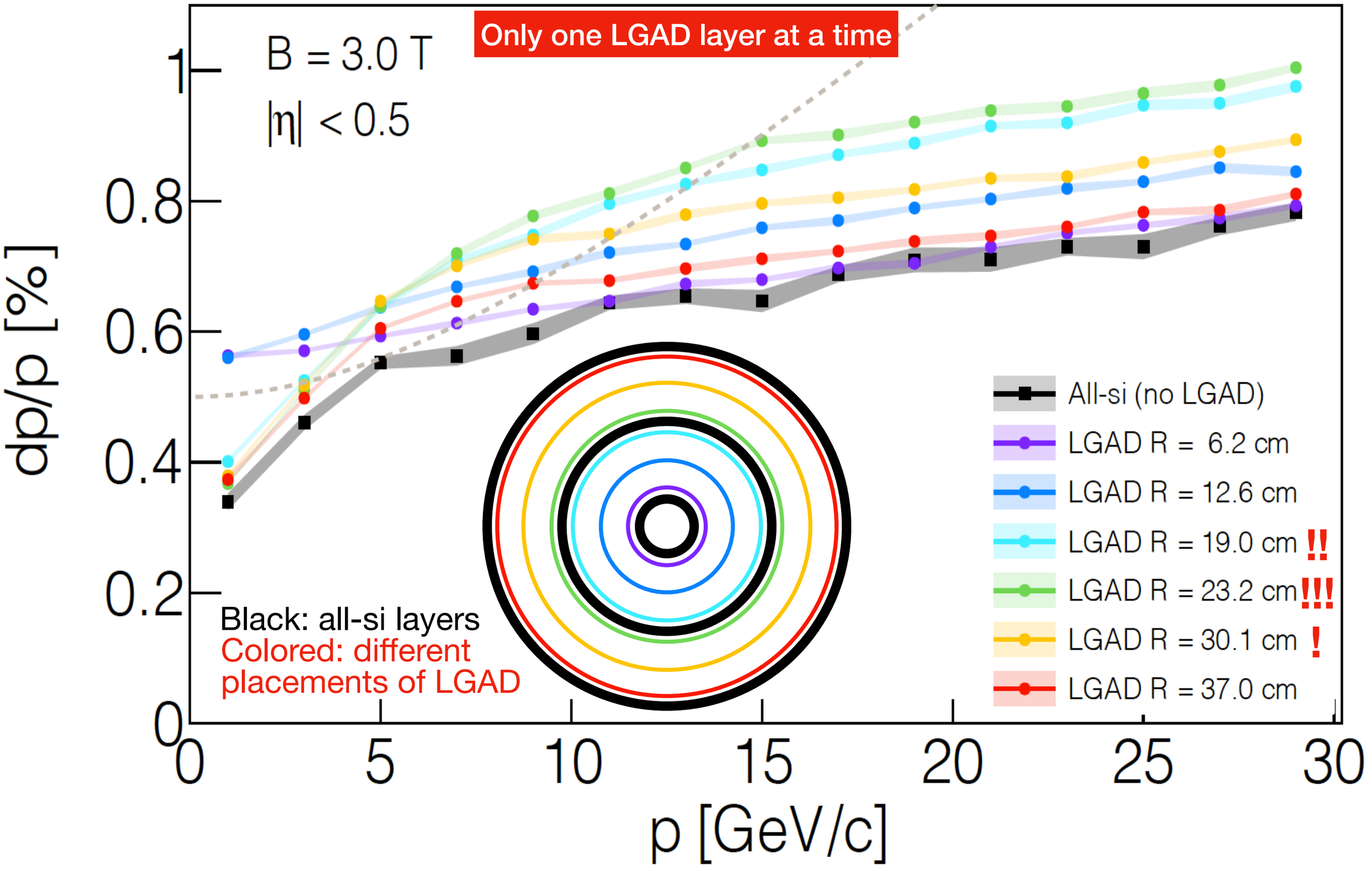
Placement of LGAD layer inside the tracking volume



Placement of LGAD layer inside the tracking volume



Placement of LGAD layer inside the tracking volume



Summary and Conclusions

- Momentum resolution most (negatively) impacted when LGAD layer is placed near the central barrel layers

- As the LGAD layer is moved away from the sagitta (in either direction), its impact on the momentum resolution decreases

- For LGAD layers placed symmetrically about the sagitta, the momentum resolution in the configuration where the LGAD has a larger radius provides a systematically larger momentum resolution

- At low momentum, the smaller radii LGAD layers have a more significant impact on momentum resolutions

- This study does not take into account the extra material that would need to live within the tracker to service the LGAD layer

- Not shown, but also studied: whether the LGAD layers are included in the Kalman filter or not, the results don't change