Preliminary study of SVT external layers

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External layer design

- Thus far, most focus of SVT group has been on Layer 0, the new layer to be placed at r ~ 1.5 cm
- The working baseline for the external layers has been to use the same design as the current BaBar silicon tracker, but extending the modules out to ± .300 radians in polar angle
- We have now begun investigating if the BaBar configuration (5 layers at radii from 3.3 to 14.2 cm)
  - the first issue being addressed is if there is some gain to removing one or more of the external layers

Motivations for BaBar design

- Two important considerations for the BaBar 5-layer design were 1) standalone tracking and 2) redundancy
  - Standalone tracking: since low-p_T particles will not penetrate in the DCH, they are reconstructed using only SVT information
    - need at least 3 xy-hits and 2 z-hits to make a helix
    - experience has shown that at least 4 hits in the xy-view and 3 hits in the z-view are necessary for robust track reconstruction
  - Redundancy: since access to the SVT was limited, it needed to function reasonably well even if several modules (or even a whole layer) failed.
- The result with a 5-layer design, with layers 1-2 and layers 4-5 close in radius, for redundancy.

BaBar SVT - transverse view

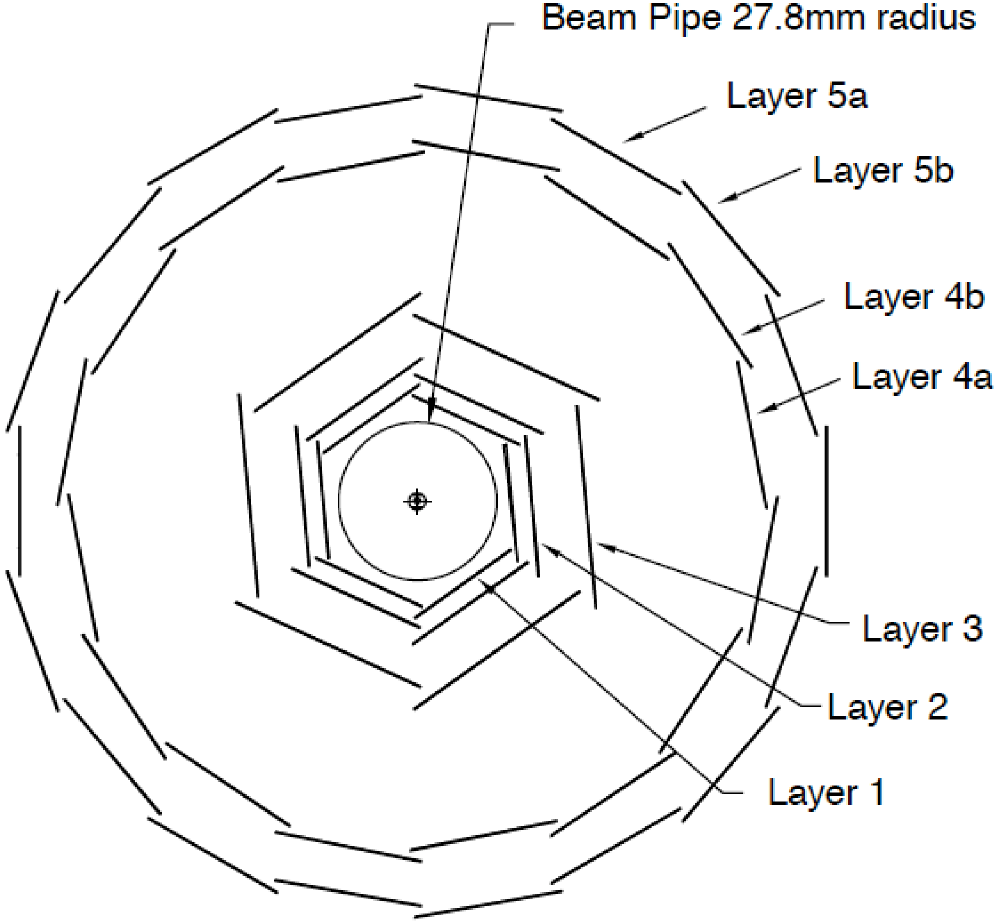


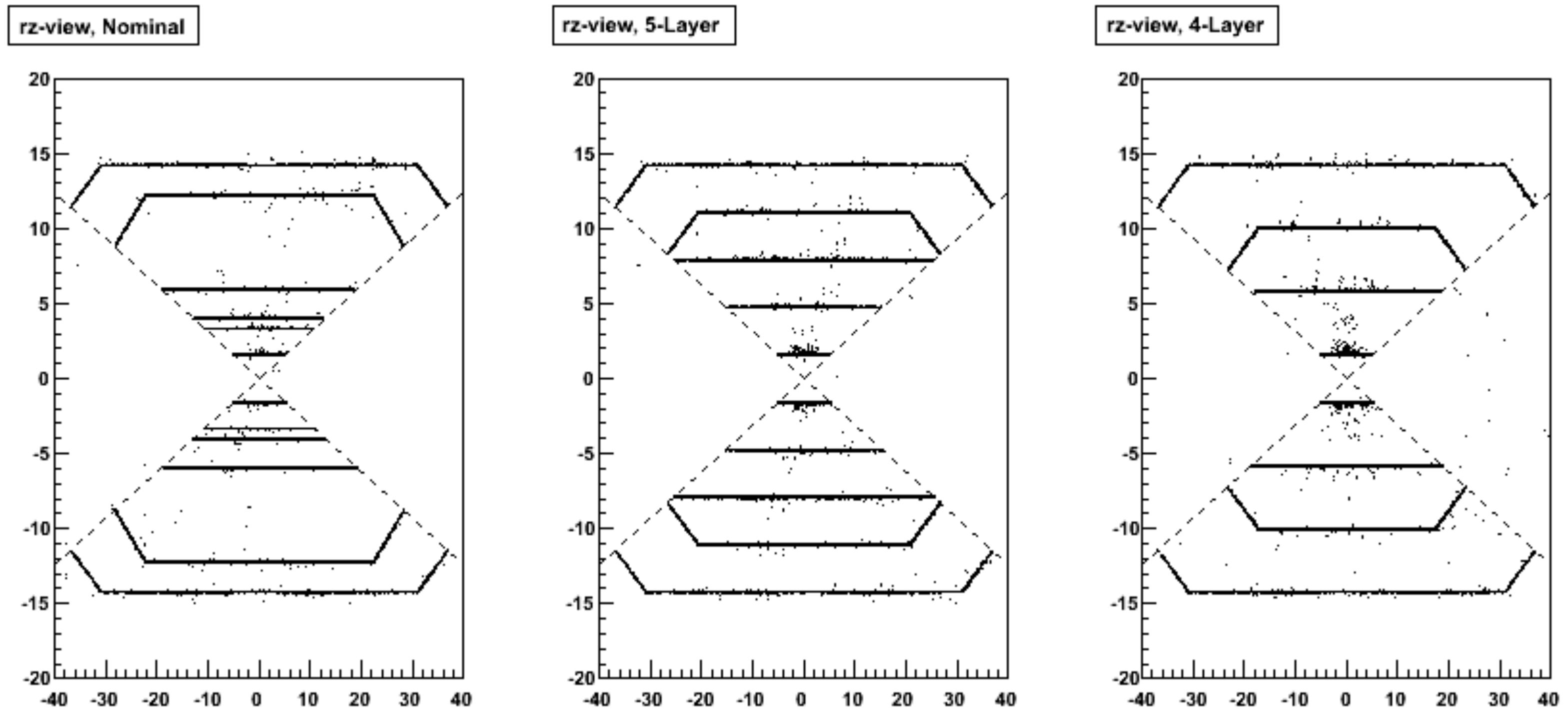
Fig. 18. Schematic view of SVT: tranverse section.

SuperB design

- Default is L_0 + BaBar SVT, *i.e.,* a 6-layer device
- Do we need 6 layers?
- Is there an advantage to having fewer than 6 layers?
  - physics motivation
  - other considerations (money, effort, etc.)
- Compare performance of nominal SuperB design with two alternatives:
  - 5-layer device
  - 4-layer device

Alternative designs

- Rules for 4- and 5-layer designs:
  - L_0 same as for nominal SuperB: hybrid pixels at r=1.6 cm (but I've also looked at striplets)
  - L_5 same as for nominal SuperB: lampshade geometry, r=14.22 cm
  - Add in remaining layers with equal spacing between layers
    - note: no attempt to optimize spacing (yet)



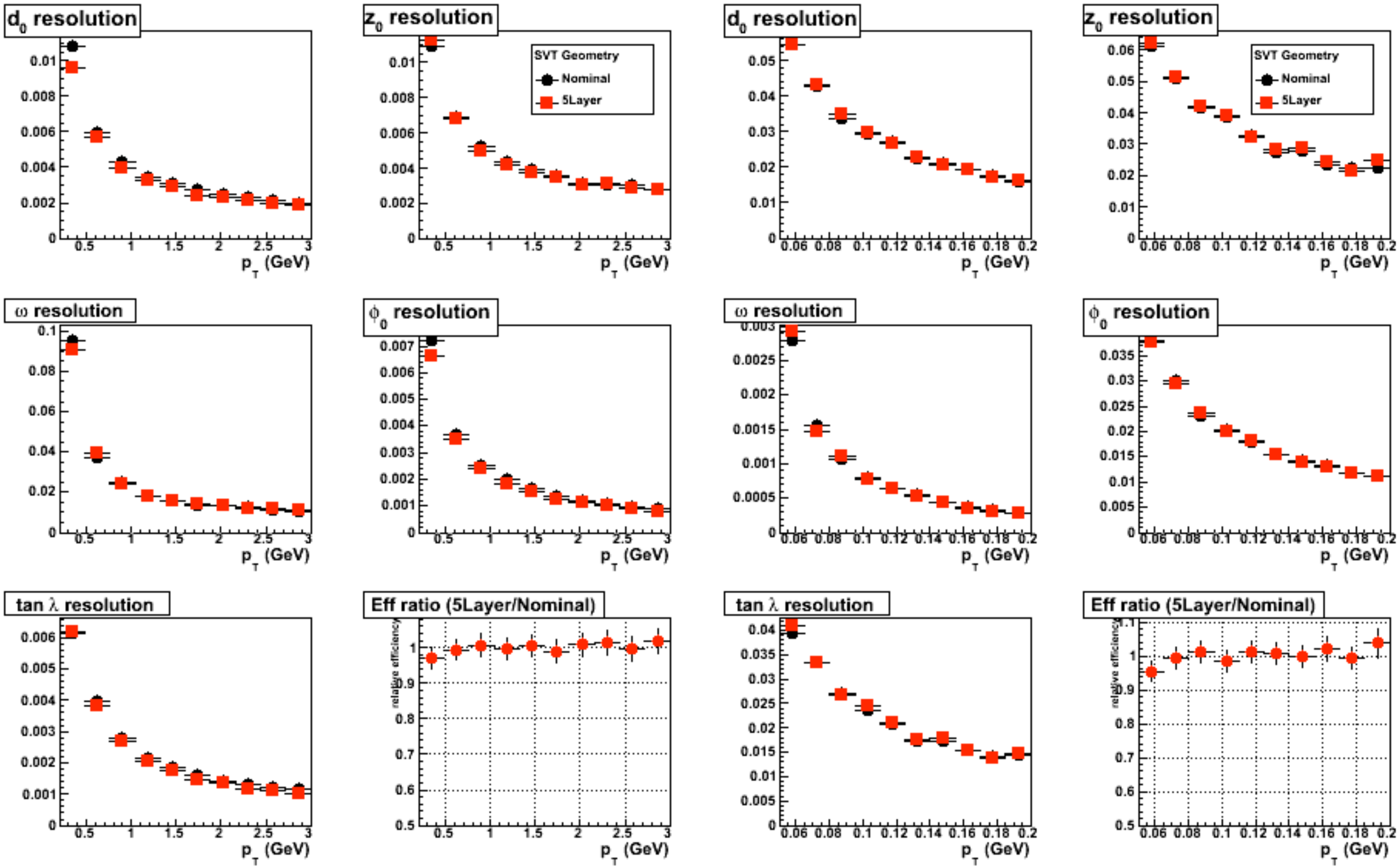
Figures of merit

- Track parameters: compare resolution in track parameters, by fitting reco-MCtruth difference
  - fits are simple (single Gaussian). Good enough for comparison of geometries
  - compare as function of p_T in two separate p_T ranges:
    - 50 - 200 MeV
    - 200 - 3000 MeV
- Kinematic variables and efficiency in $B \rightarrow D^*K$ decays
  - $\Delta m = m(D^*) - m(D^0)$
  - ΔE
  - $\varepsilon(B \rightarrow D^*K)$ - acceptance and track efficiency:
    - nsvt>=8 OR ndch>=15

Nominal v. 5-Layer (track pars)

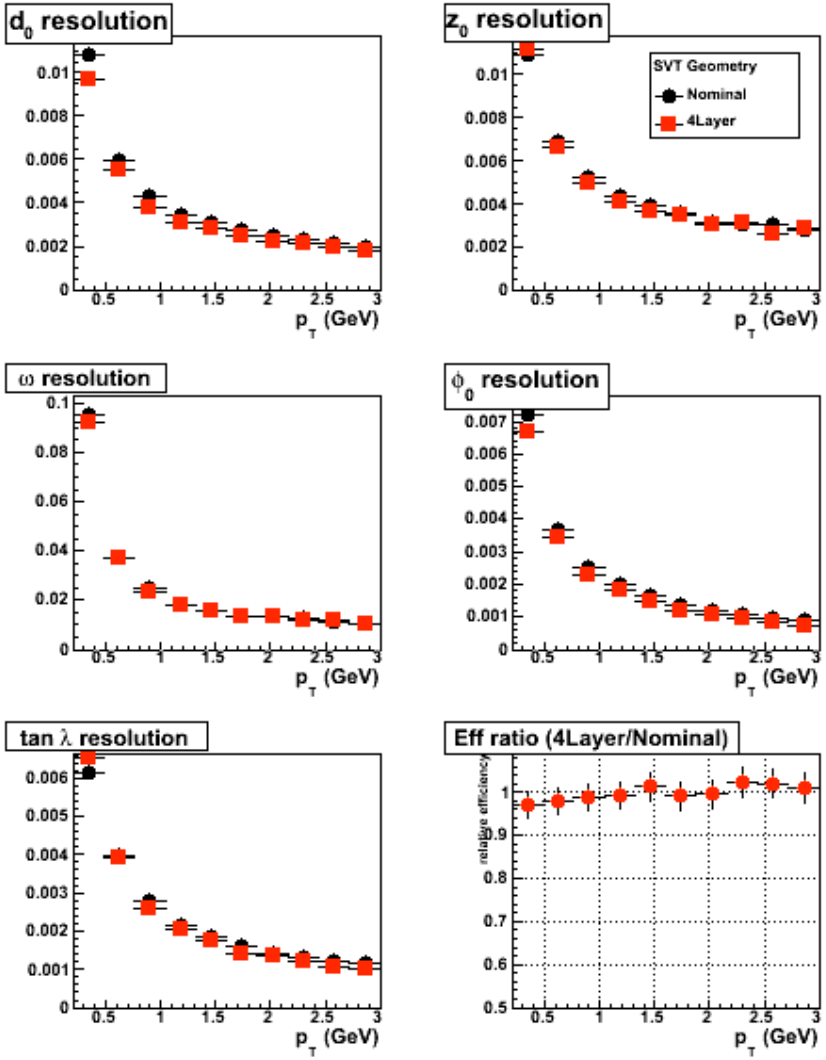
200 < p_T < 3000 MeV

50 < p_T < 200 MeV

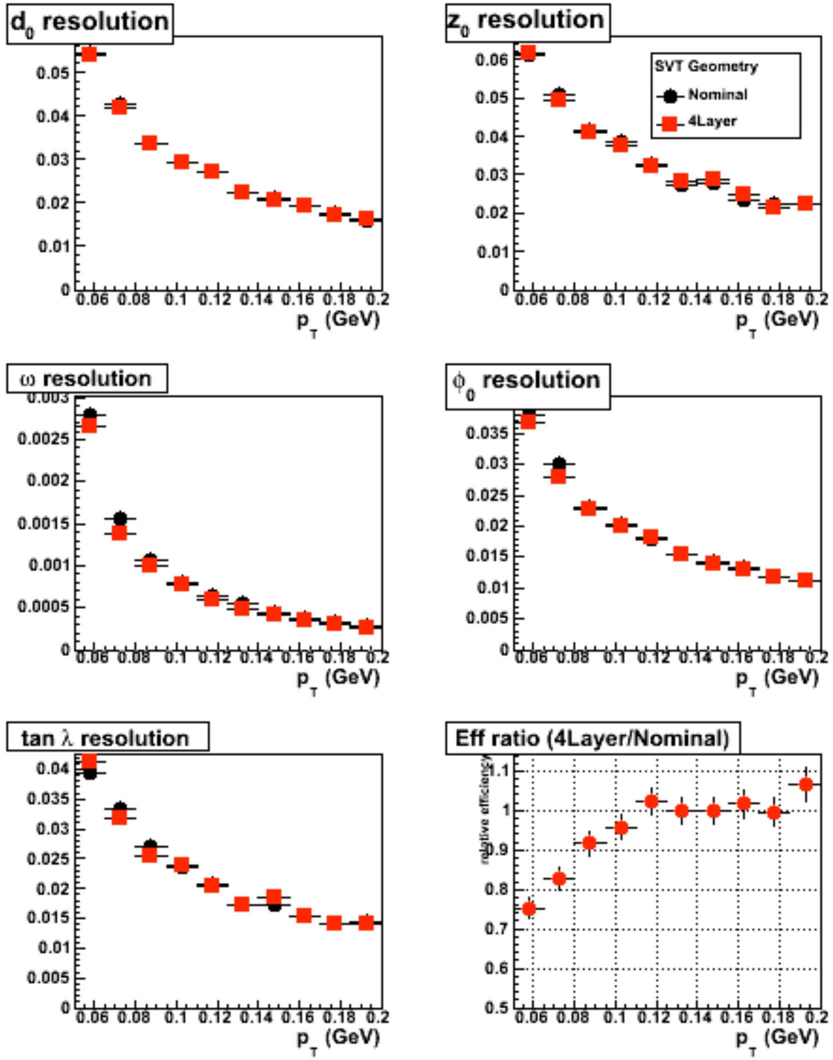


Nominal v. 4-Layer (track pars)

200 < p_T < 3000 MeV



50 < p_T < 200 MeV



Non-perfect detector

- The previous plots were made assuming a fully functional detector with hit efficiency ≥ 95%
- We know from BaBar experience that modules sometimes fail
  - For Run 1-2 in BaBar: ⇨
  - Some were recovered later

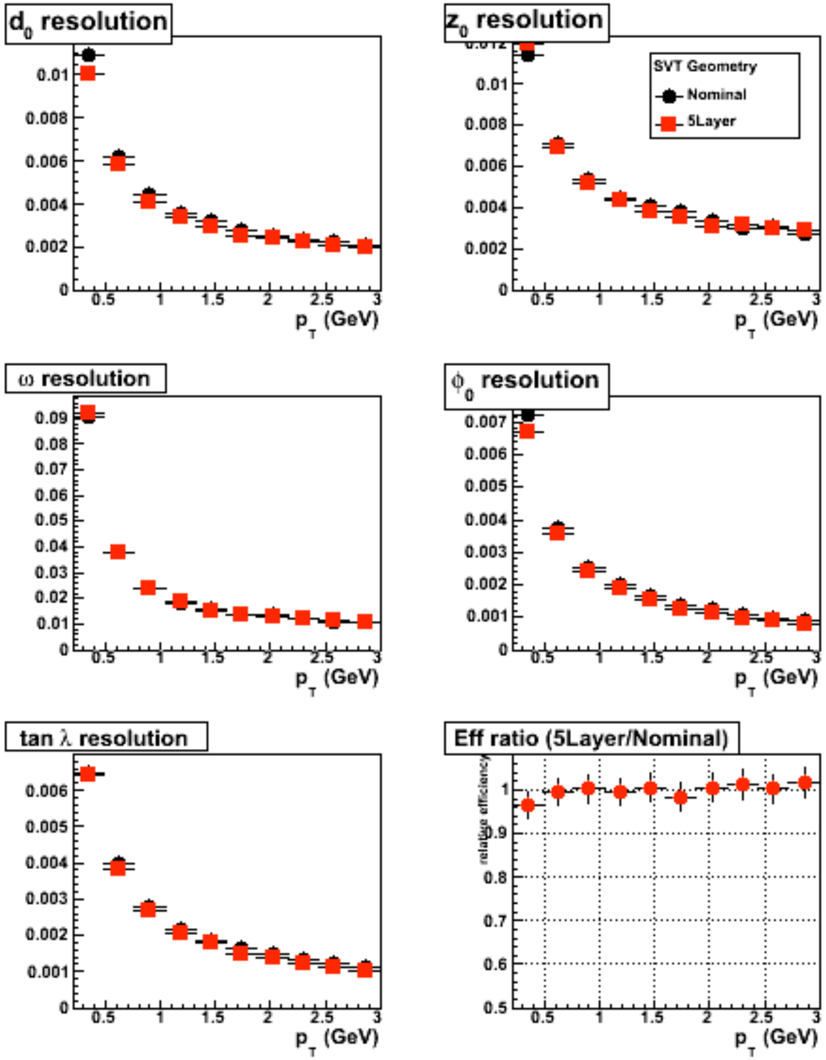
Layer	% dead ϕ	% dead z
1	0	0
2	8	8
3	0	25
4	0	6
5	3	6

- Model this in fastsim as hit inefficiency
  - fastsim inputs:

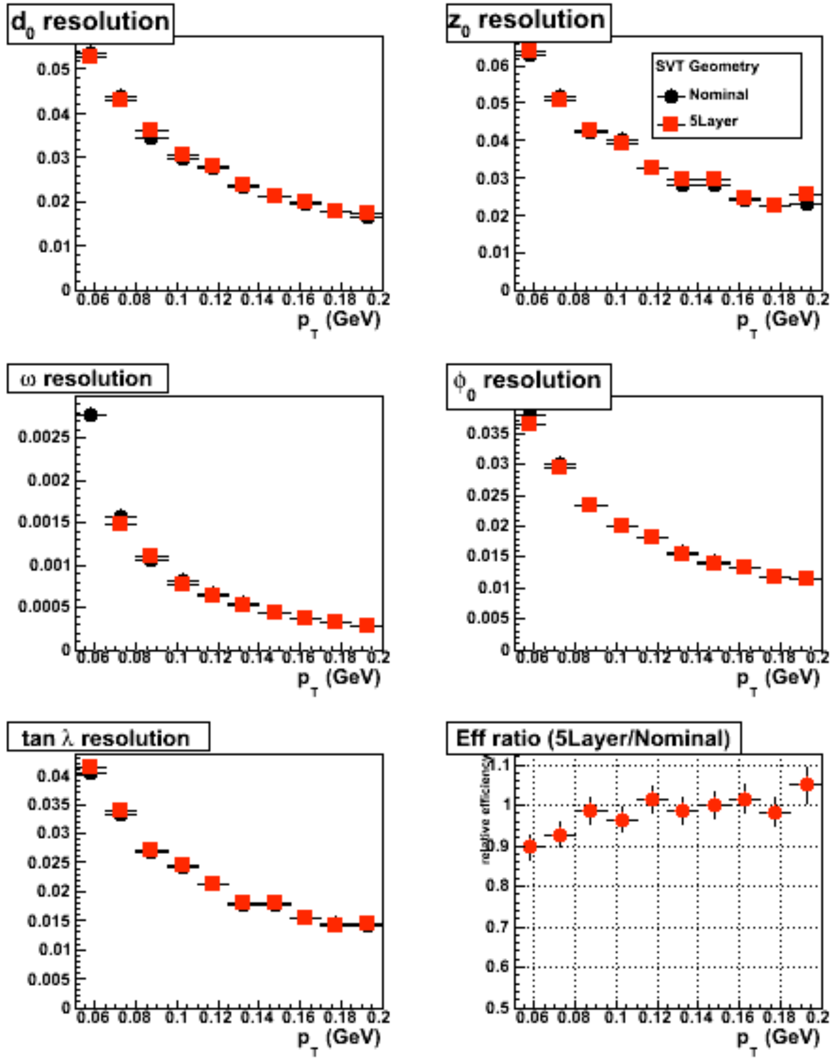
Layers	ϕ efficiency	z efficiency
0-2	.93	.91
3	.89	.70
4-5	.95	.89

Nominal v. 5-Layer: non-perfect SVT

200 < p_T < 3000 MeV

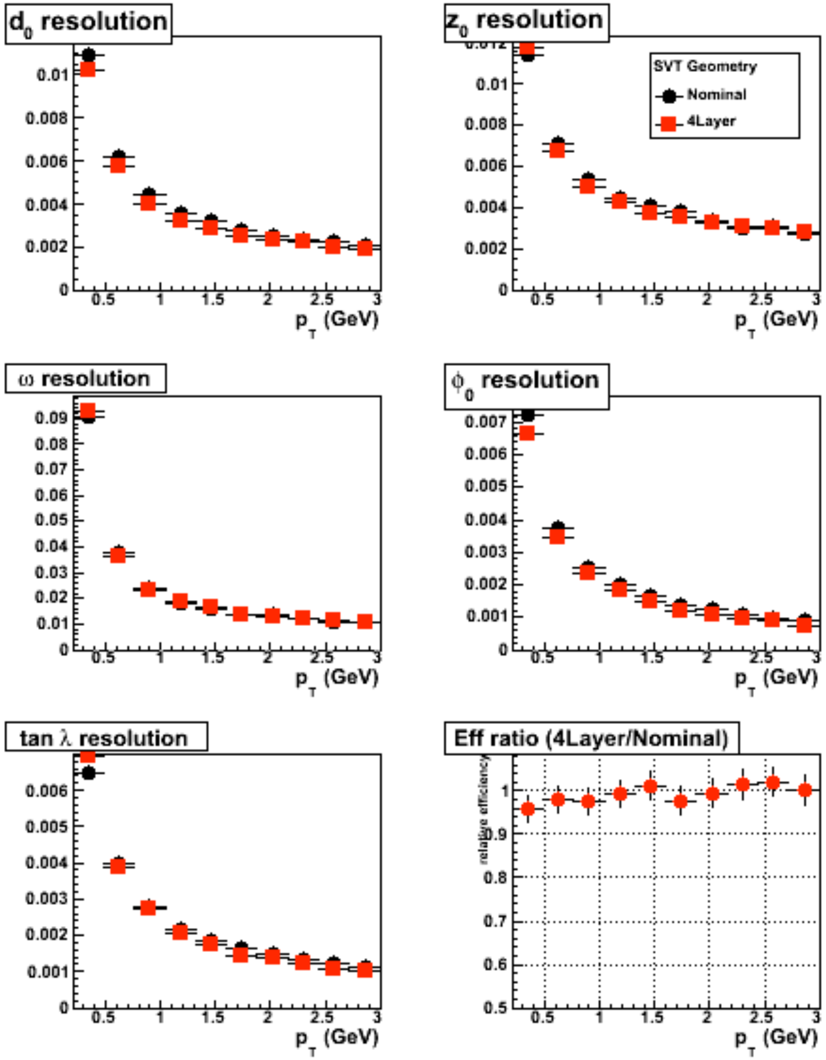


50 < p_T < 200 MeV

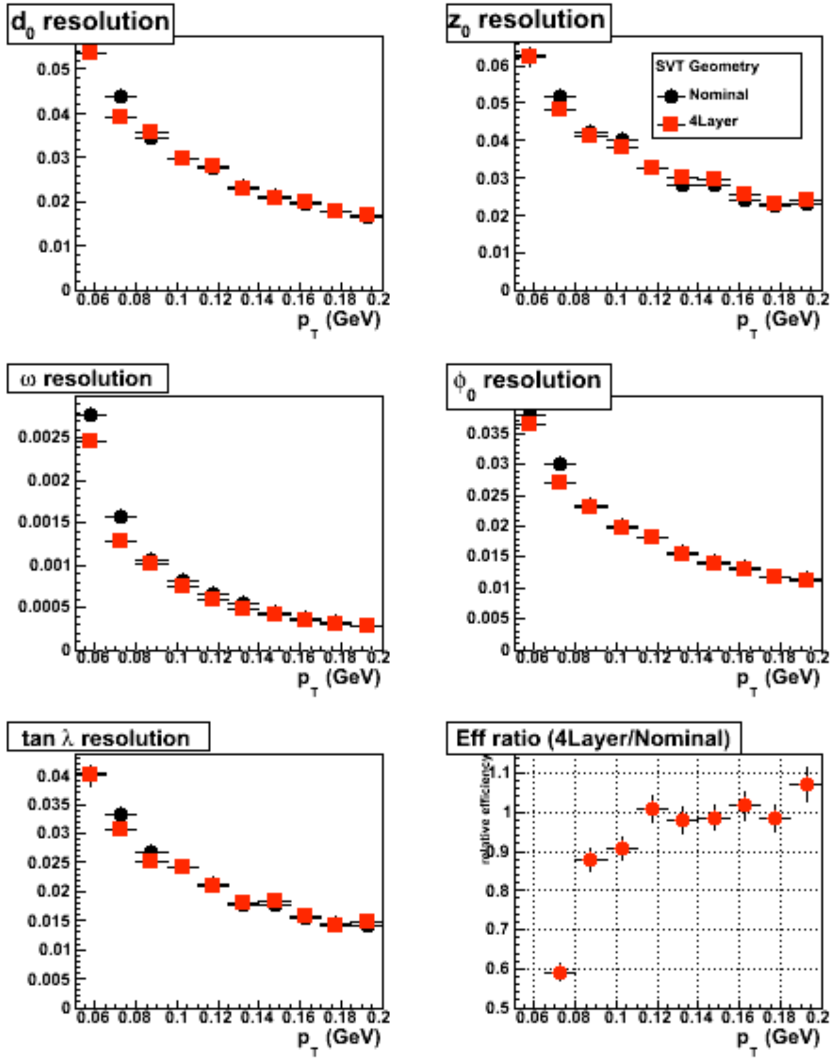


Nominal v. 4-Layer: non-perfect SVT

200 < p_T < 3000 MeV



50 < p_T < 200 MeV



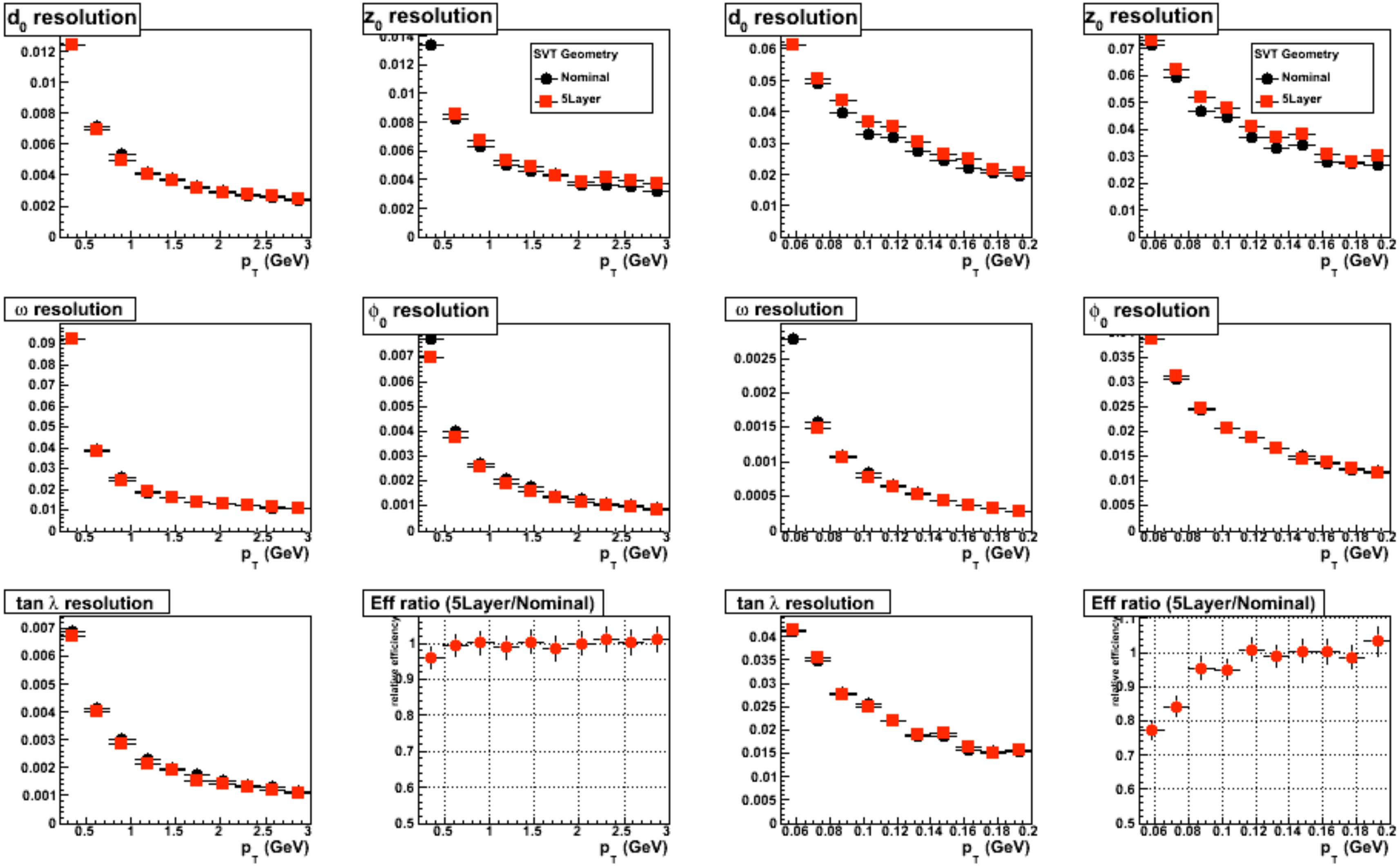
High-background scenario

- We can also consider the scenario where backgrounds are higher than expected in L_0
- This can lead to significant loss of efficiency with both L_0 technologies:
  - hybrid pixels: readout inefficiency
  - striplets: shadowing due to out-of-time background hits
- Compare geometries with L_0 efficiency set to 60%

Nominal v. 5-Layer: non-perfect + ineff L_0

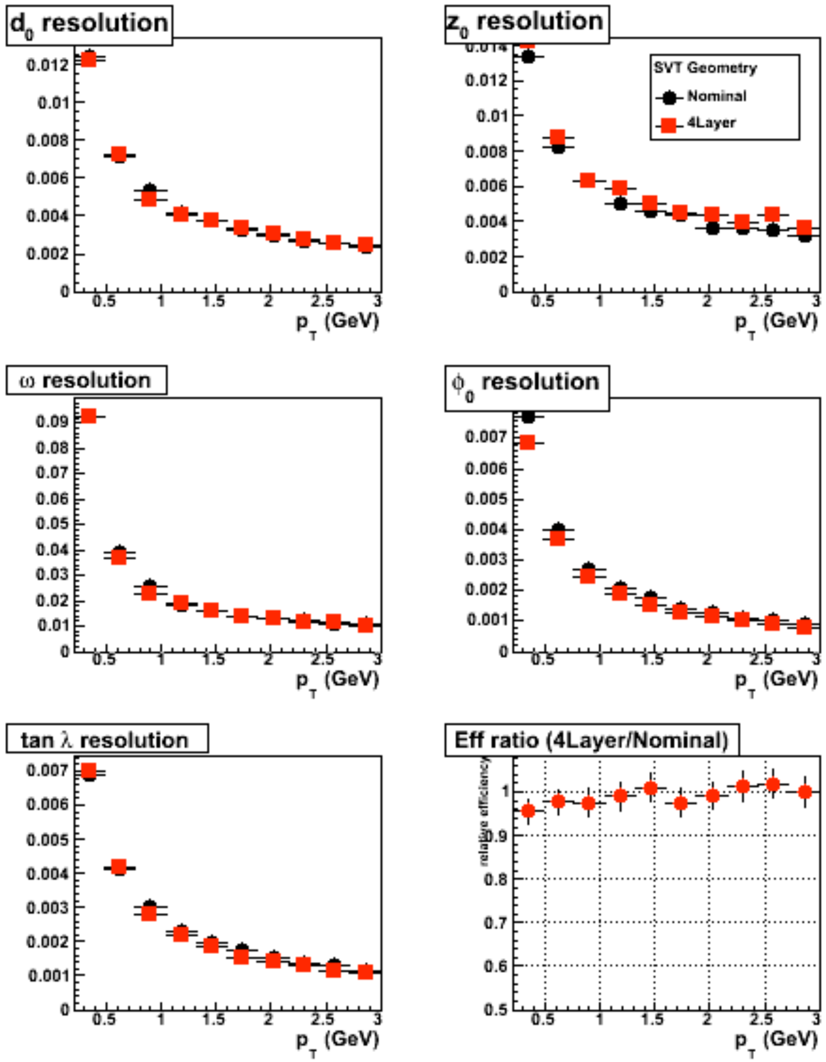
200 < p_T < 3000 MeV

50 < p_T < 200 MeV

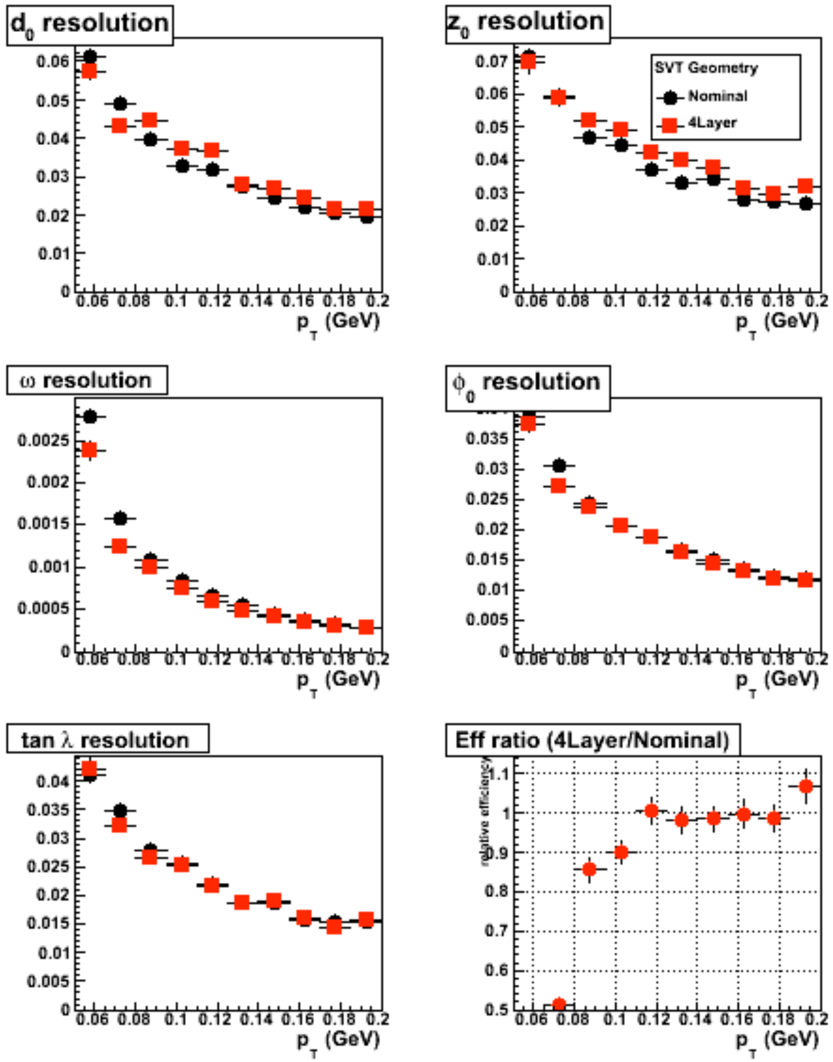


Nominal v. 4-Layer: non-perfect + ineff L_0

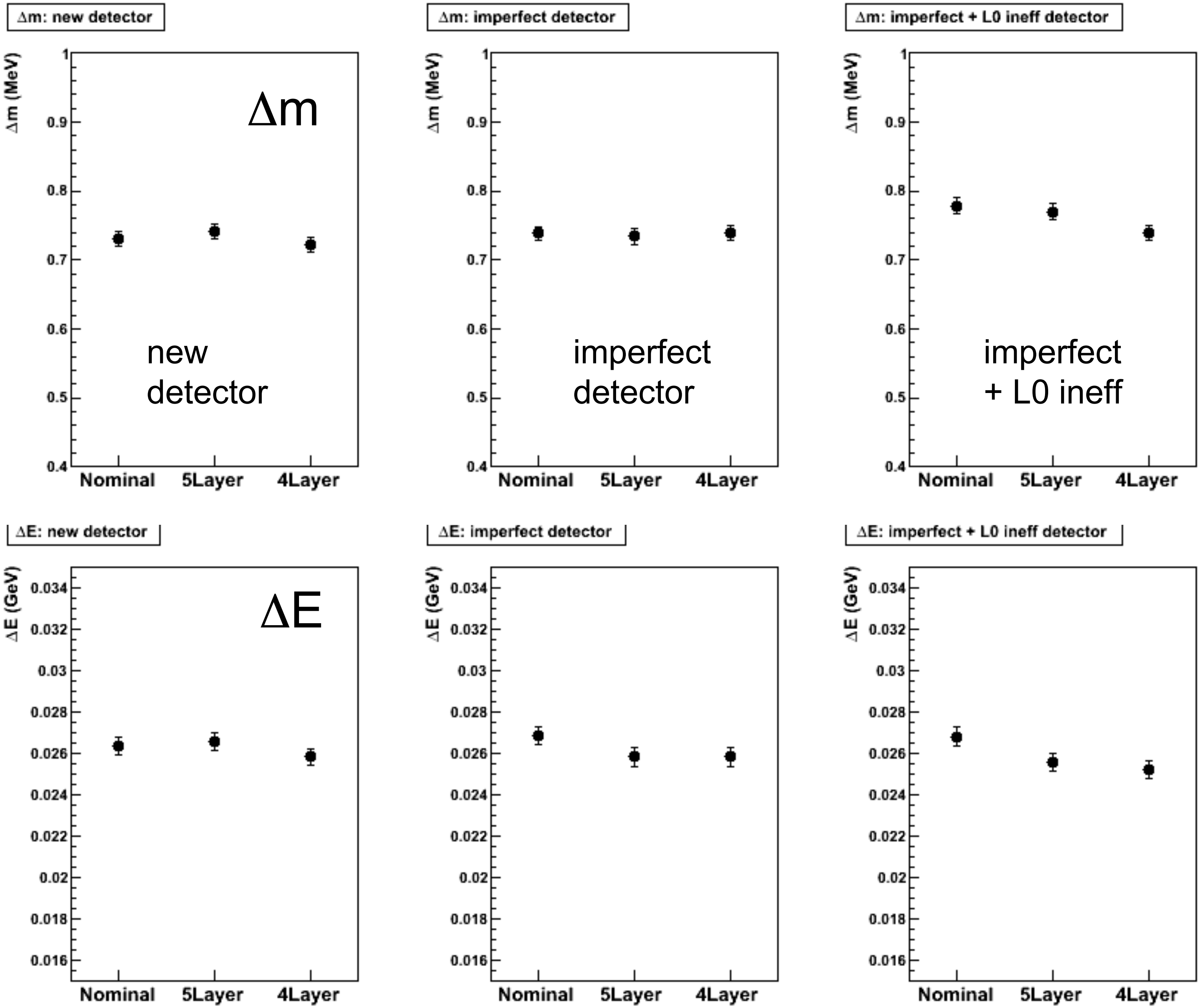
$200 < p_T < 3000$ MeV



$50 < p_T < 200$ MeV

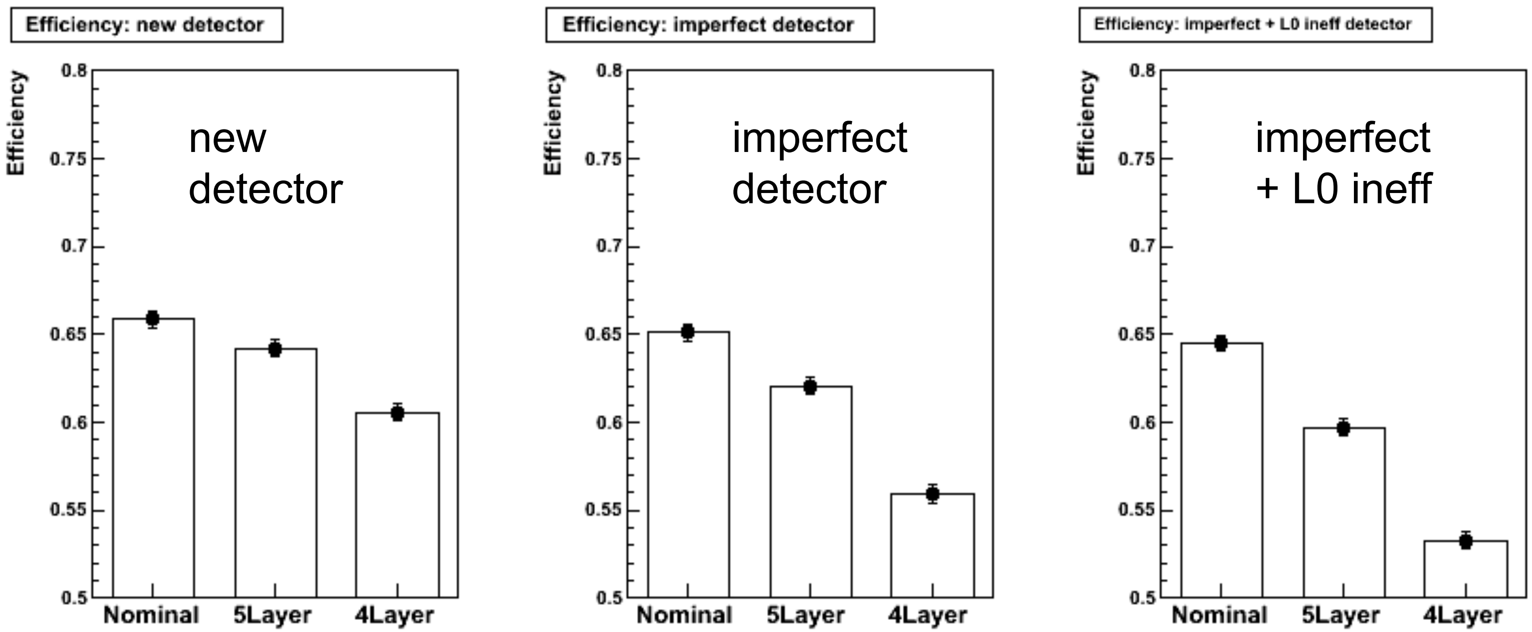


Δm and ΔE in B→D*K



Reco efficiency in B→D*K

- "Efficiency" here means geometrical acceptance plus tracking efficiency
  - nsvt>=8 OR ndch>=15
- Remember: no pattern recognition in FastSim



Summary

- Studied the performance of 5-Layer and 4-Layer SVT geometry using track parameter resolution and $B \rightarrow D^*K$ kinematic variables and efficiency
- We have considered various detector conditions: new, some damaged modules, high background
- Also evaluated performance when striplets technology used for L_0 (see Backup slides)
- In all cases, gains in tracking performance in going to 4- or 5-Layer device are modest (in many cases absent)
- Efficiency for tracks and B reconstruction is reduced for the 4- and 5-Layer devices
- These results are very fresh, but it appears that the current 6-Layer design is superior to the alternatives investigated

Backup slides

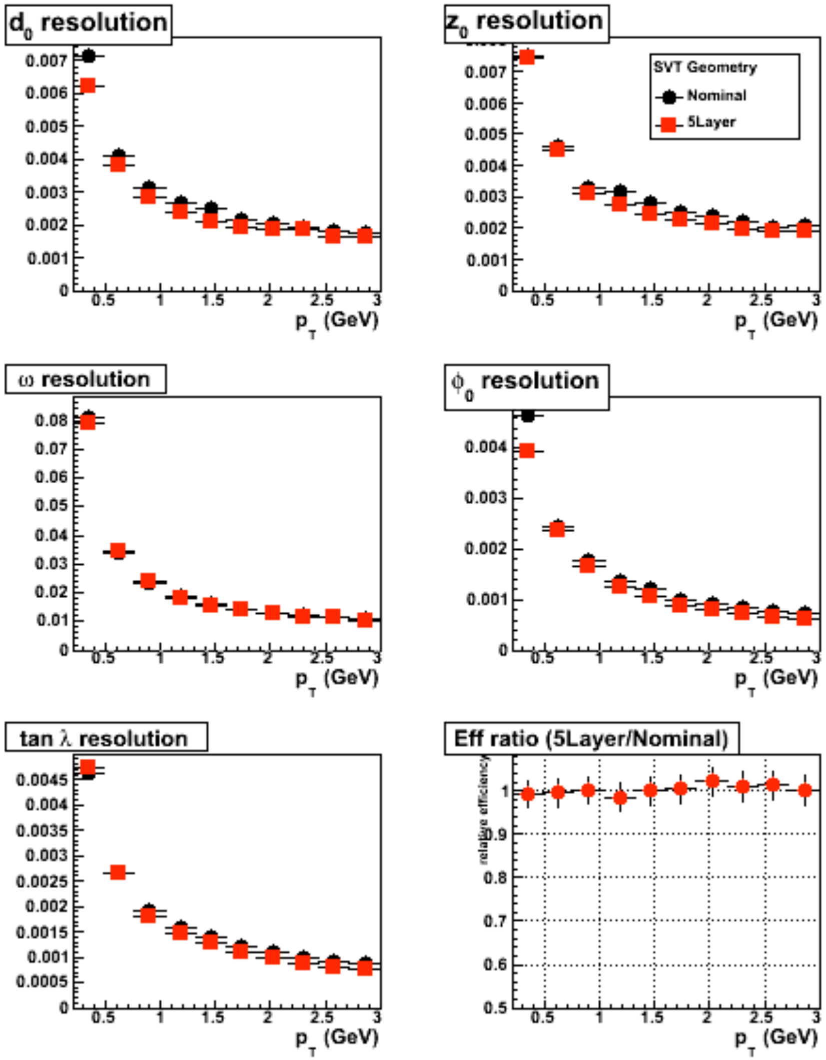
Striplets for L_0

- If striplet technology is adopted for L_0, the overall material budget for the SVT will be significantly lower
- In this case, a layer removed will represent a larger proportion of the overall SVT material
- So, perhaps a design with 4 or 5 layers will have larger gains in this case

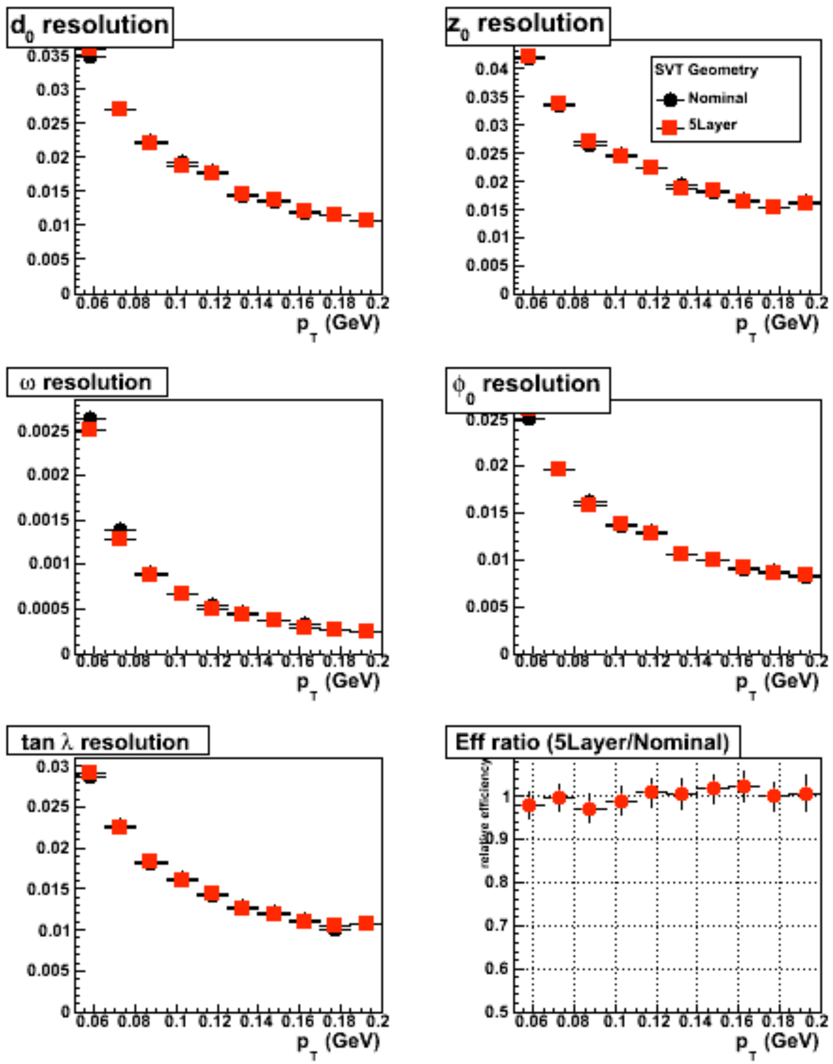
Nominal v. 5-Layer: L_0 striplets

(new detector)

$200 < p_T < 3000$ MeV



$50 < p_T < 200$ MeV

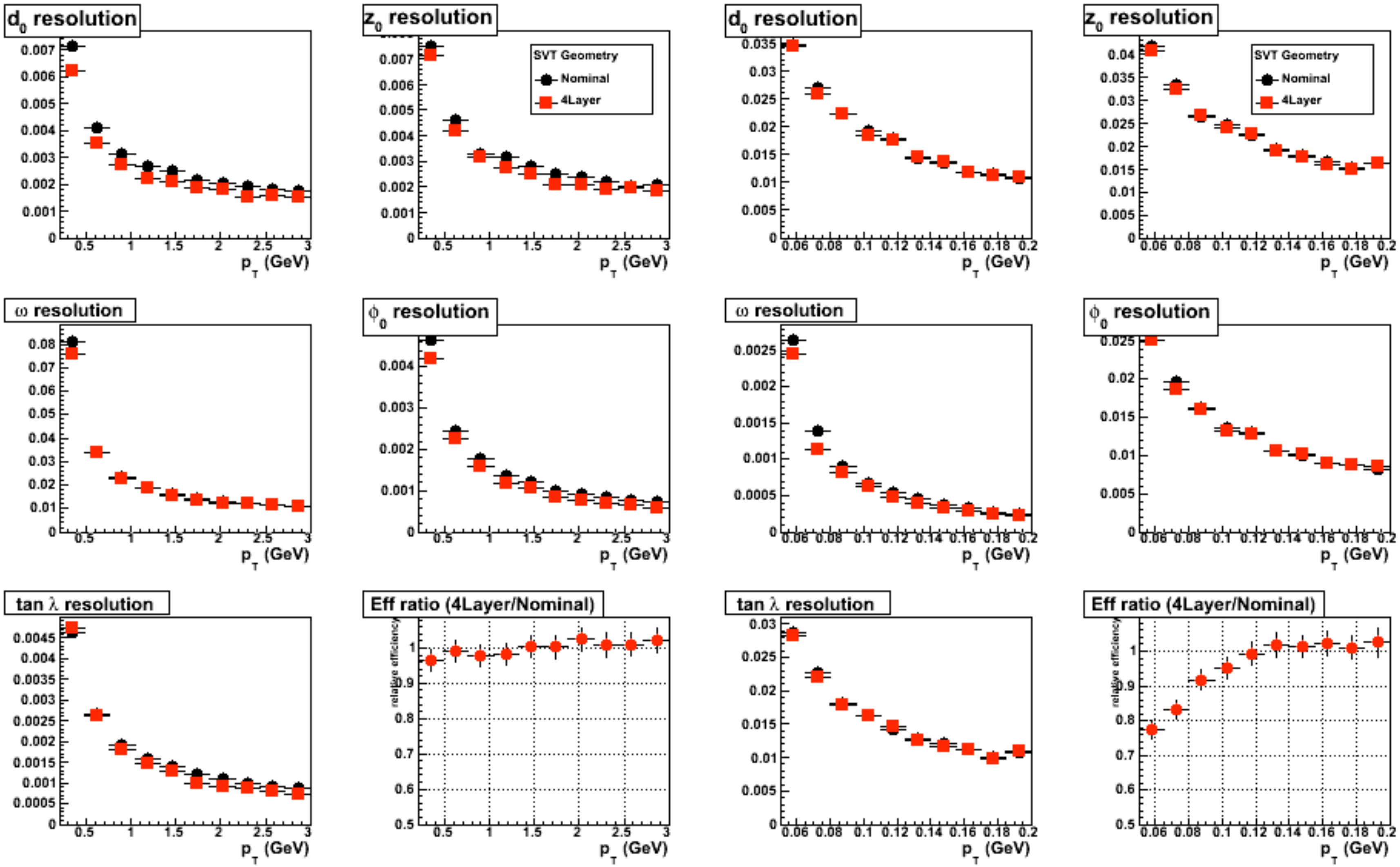


Nominal v. 4-Layer: L_0 striplets

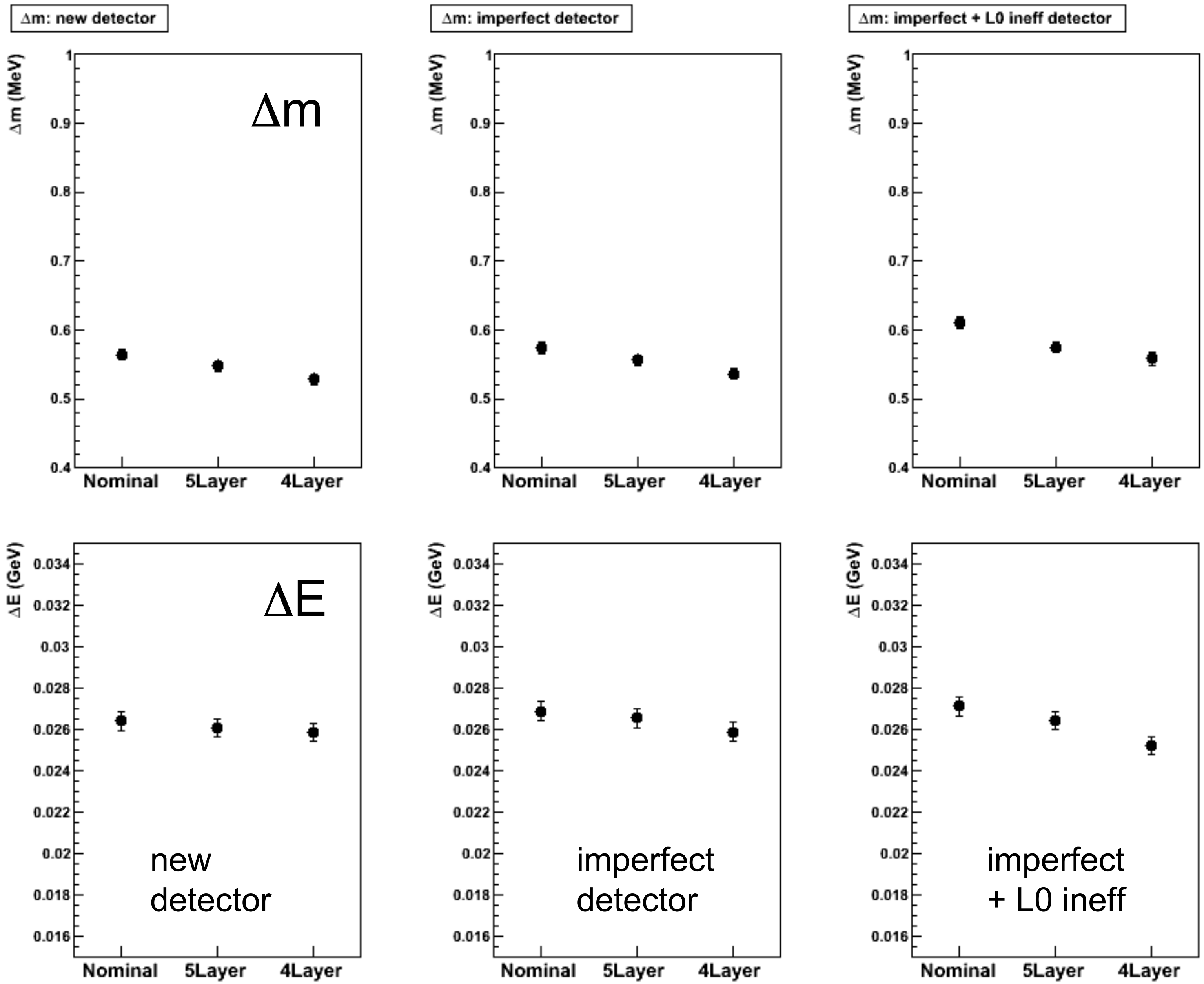
(new detector)

$200 < p_T < 3000$ MeV

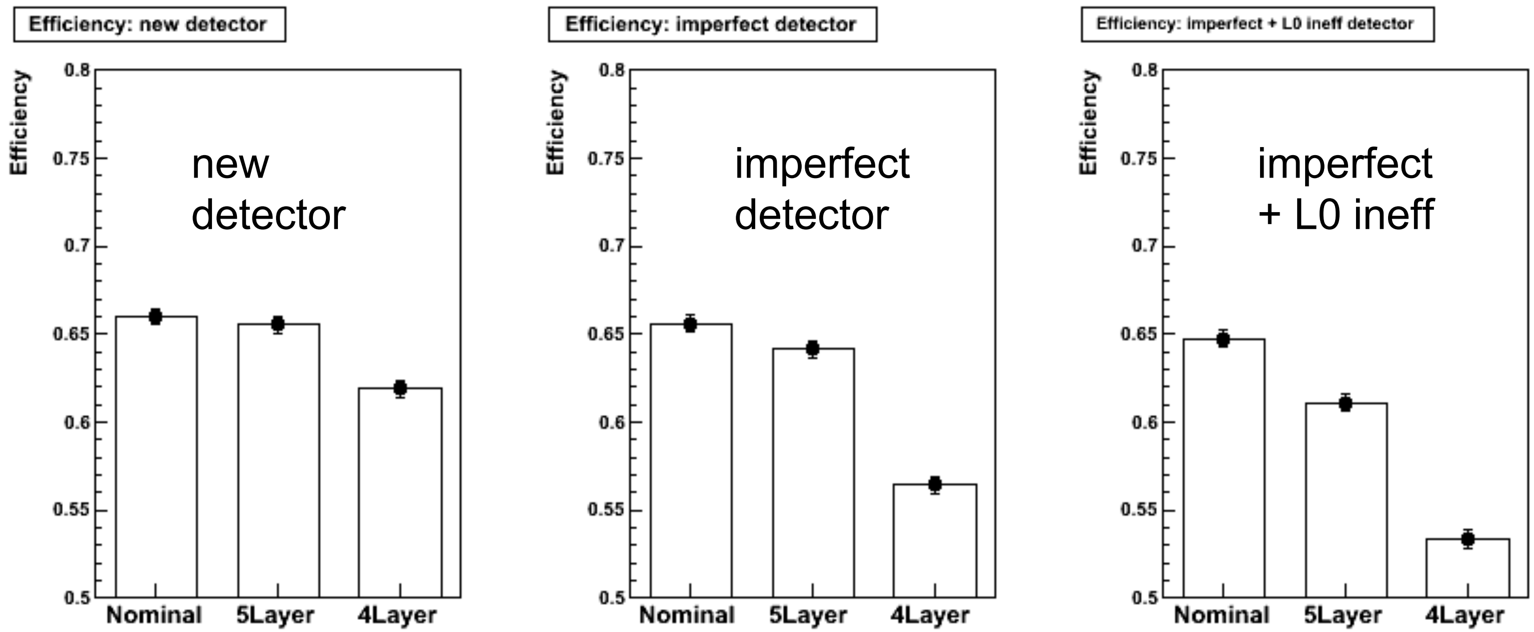
$50 < p_T < 200$ MeV



Δm and ΔE in $B \to D^*K$: L_0 striplets



Efficiency in B→D*K: L_0 striplets



SVT layer radii

Nominal

Layer	Radius (cm)
0	1.6
1	3.32
2	4.02
3	5.92
4	12.22
5	14.22

5-Layer

Layer	Radius (cm)
0	1.6
1	4.76
2	7.91
3	11.07
4	14.22

4-Layer

Layer	Radius (cm)
0	1.6
1	5.81
2	10.01
3	14.22