Proposed ECCE Tracker – now reference for Detector 1

(ECCE proposal)

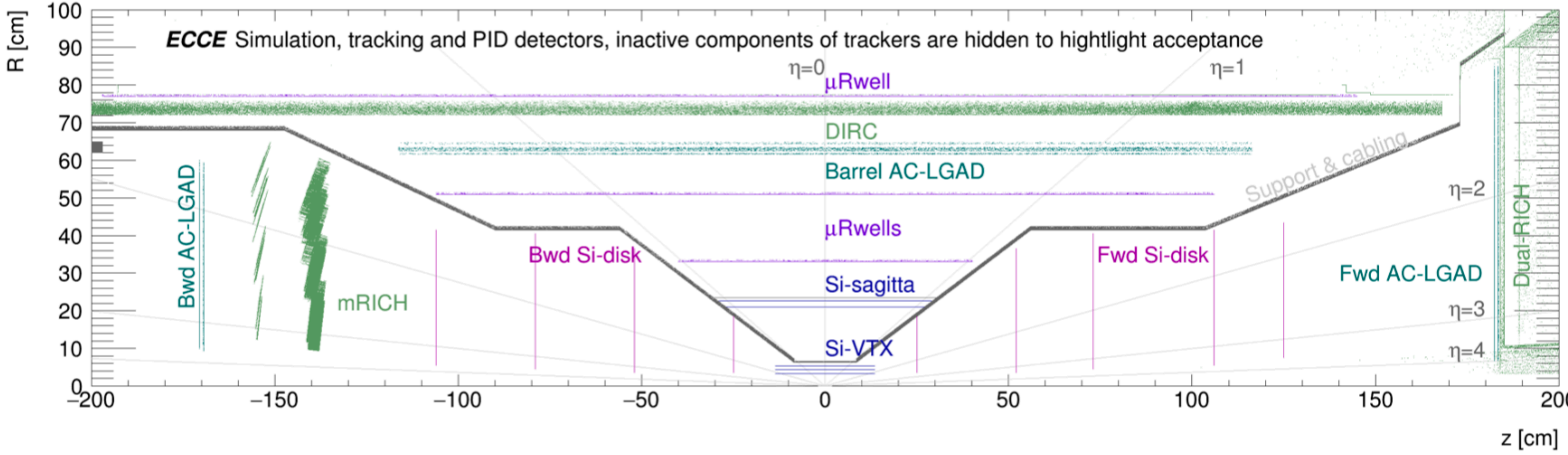


Figure 2.5: Schematic view of the ECCE tracker, including silicon, μRWELL, AC-LGAD, DIRC, mRICH and dRICH detector systems.

- Transition from reference to baseline will entail, if not require, refinement of the tracker configuration and layout,
- Upfront note: in what follows, the colors of curves are not fully consistent between slides.

A reminder of Yellow Report Table 11.2

Table 11.2: Requirements for the tracking system from the physics groups.

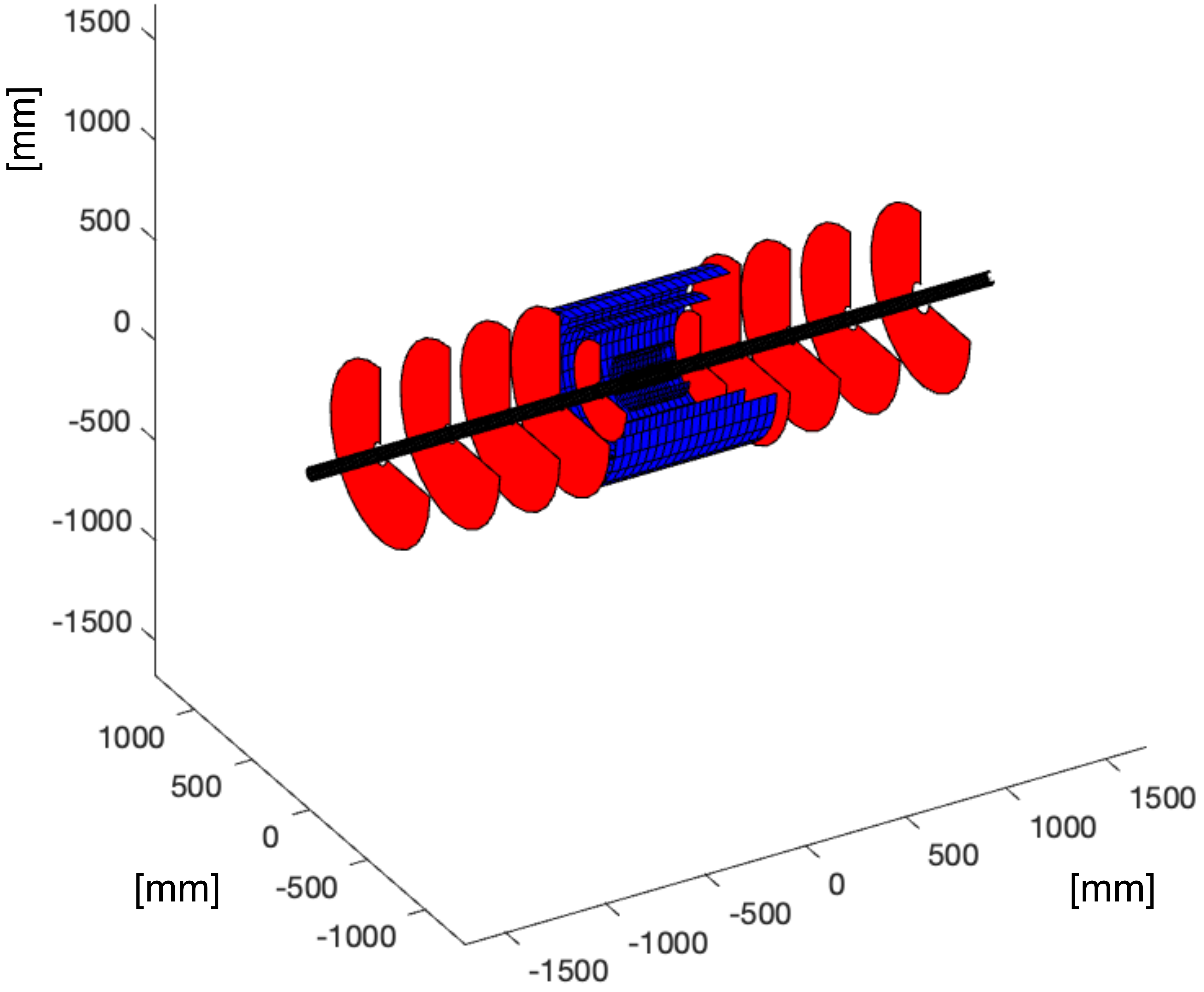
Tracking requirements from PWGs						
			Momentum res.	Material budget	Minimum pT	Transverse pointing res.
η						
-3.5 to -3.0	Central Detector	Backward Detector	σp/p ~ 0.1%×p ⊕ 0.5%	~5% X0 or less	100-150 MeV/c	
-3.0 to -2.5					100-150 MeV/c	dca(xy) ~ 30/pT µm ⊕ 40 µm
-2.5 to -2.0			σp/p ~ 0.05%×p ⊕ 0.5%		100-150 MeV/c	dca(xy) ~ 30/pT µm ⊕ 20 µm
-2.0 to -1.5					100-150 MeV/c	
-1.5 to -1.0					100-150 MeV/c	
-1.0 to -0.5		Barrel	σp/p ~ 0.05%×p ⊕ 0.5%		100-150 MeV/c	dca(xy) ~ 20/pT µm ⊕ 5 µm
-0.5 to 0						
0 to 0.5						
0.5 to 1.0						
1.0 to 1.5		Forward Detector	σp/p ~ 0.05%×p ⊕ 1%		100-150 MeV/c	dca(xy) ~ 30/pT µm ⊕ 20 µm
1.5 to 2.0					100-150 MeV/c	
2.0 to 2.5					100-150 MeV/c	
2.5 to 3.0			σp/p ~ 0.1%×p ⊕ 2%		100-150 MeV/c	dca(xy) ~ 30/pT µm ⊕ 40 µm
3.0 to 3.5					100-150 MeV/c	dca(xy) ~ 30/pT µm ⊕ 60 µm

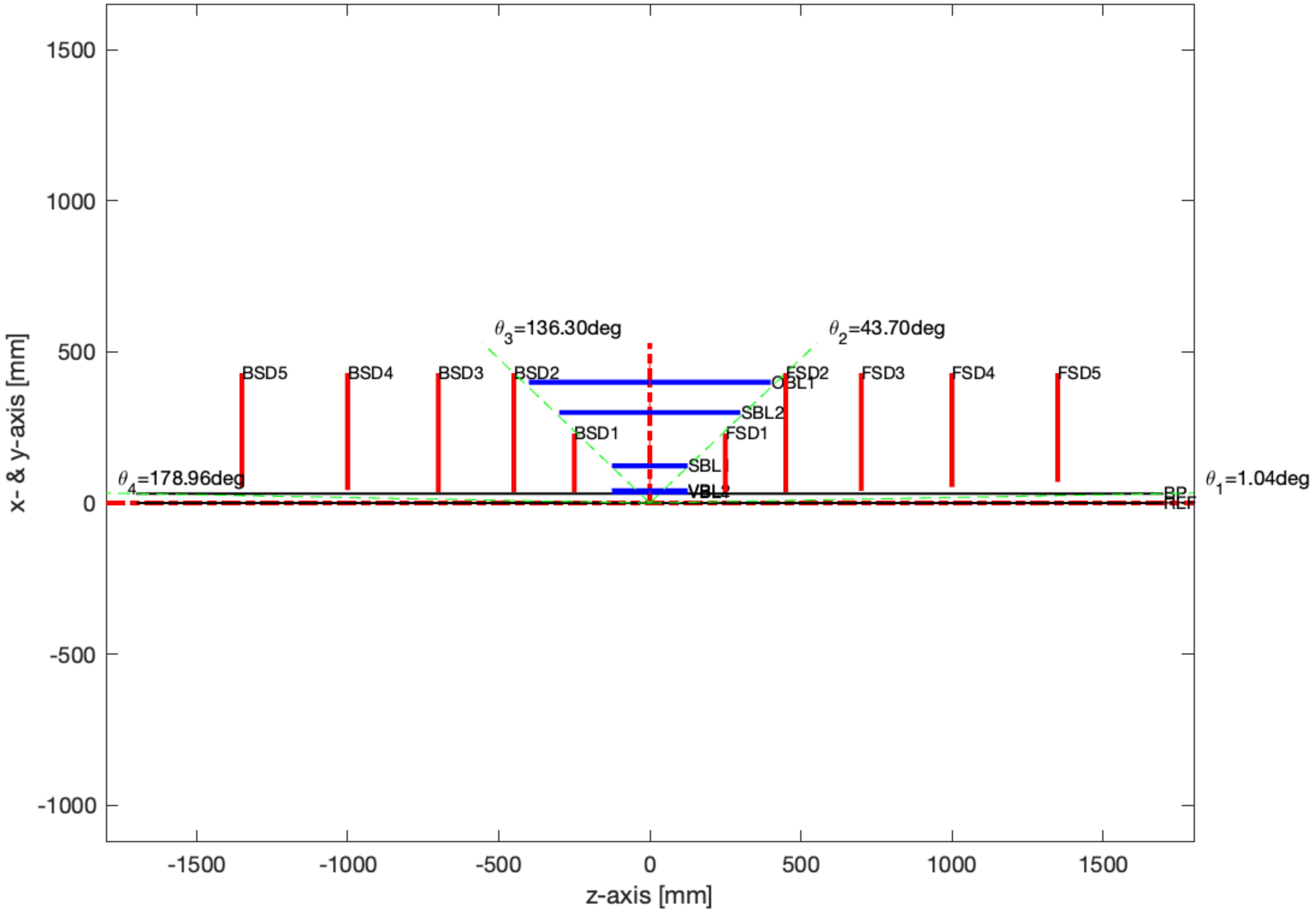
The requirements for the tracking in an EIC detector are derived from the physics simulations and are represented by the detector requirements table shown in Table 11.2. The ranges in pseudorapidity are accompanied with requirements for relative momentum resolution, allowed material budget in terms of radiation length, minimum p_T cutoff, transverse and longitudinal pointing resolutions. These requirements form the basis of the designs and concepts that are presented.

- dp/p is a combination of the constant and proportional term,
- Both matter over most of the EIC range, but the trade-offs can be different,
- E.g. in the central barrel, the terms are balanced for p = 10 GeV/c; in the (very) forward region this is for p = 20 GeV/c, and in the backward region for p = 5 GeV/c.
- Transitions are, of course, not as hard as suggested by the table.

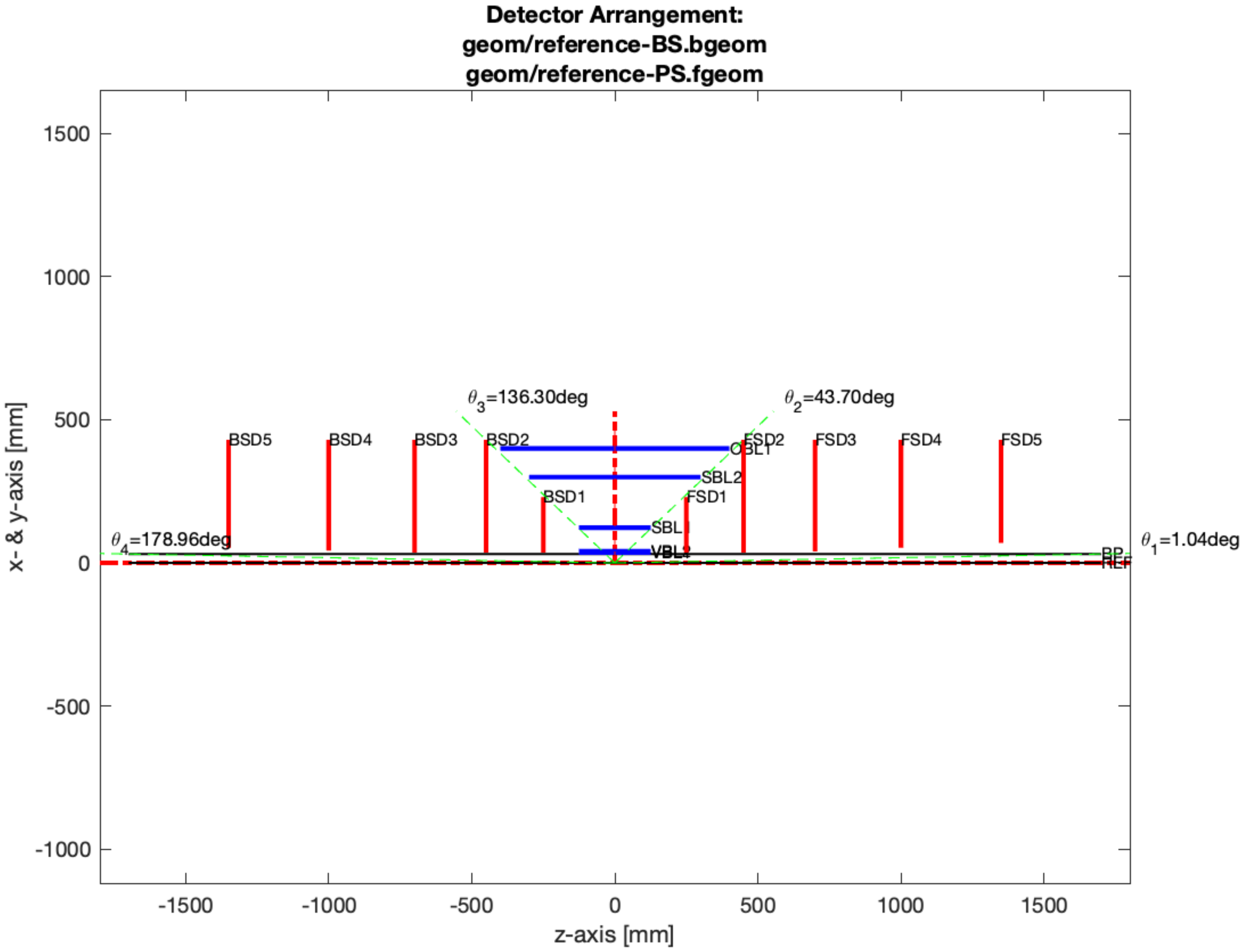
Is the YR mid-rapidity performance recoverable in 1.4T?

- Preserve the inner cone angle of approx. 45^{o}, at least for now,
- Consider increasing the radius of the outermost vertexing layer while preserving its length of approximately 12 cm,
- Replace the two sagitta layers with a more conventional stave-based design with two half-lengths of $X/X_0 \sim 0.25\%$ (or 0.05%, if feasible) at a radius of approximately 21 cm, and optimize this radius,
- Complement with a large-radius, $r_{out} \sim 0.4$ m, conventional stave-based design, with an overall length of about 0.8 m,





Is the YR mid-rapidity performance recoverable in 1.4T?

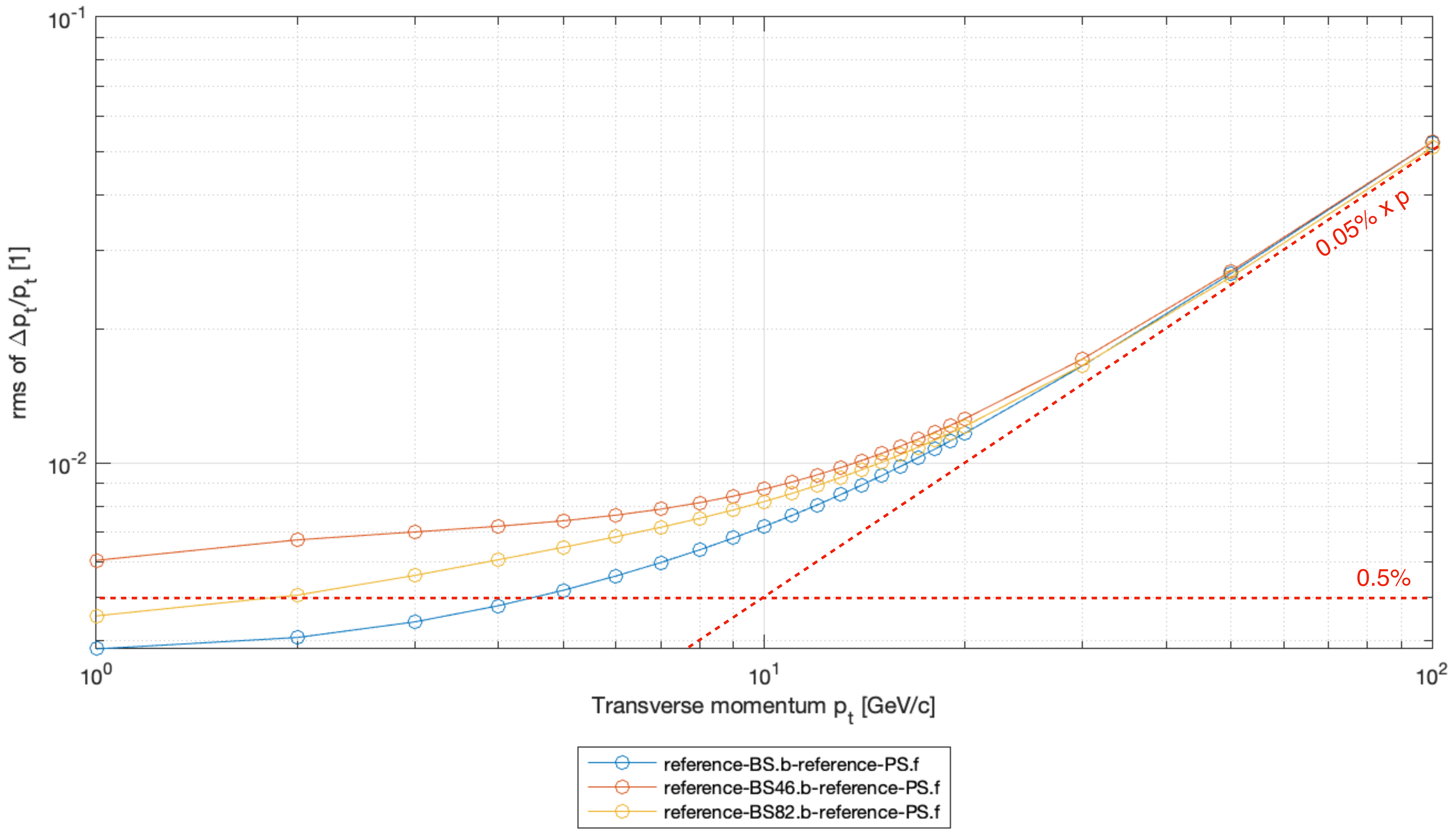


Following the previous steps, we could consider:

- Outer barrel layer at r = 400 mm,
- 45 degree cone,
- Single sagitta layer at r = 300 mm with $X/X_0 \sim 0.25\%$
- Outer (third) vertex barrel layer with increased radius to r = 123 mm

Note: The lengths assume reticle lengths of 25 mm.
Services and service routing will need attention.

YR mid-rapidity performance in 1.4T



Single pion tracks, exactly vertical,

- Blue curve is the r_{vtx} = 123 mm and r_{sag} = 300 mm from the previous slide,
- Yellow has r_{vtx} = 82 mm and r_{sag} = 250 mm,
- Red has r_{vtx} = 46 mm and r_{sag} = 250 mm,

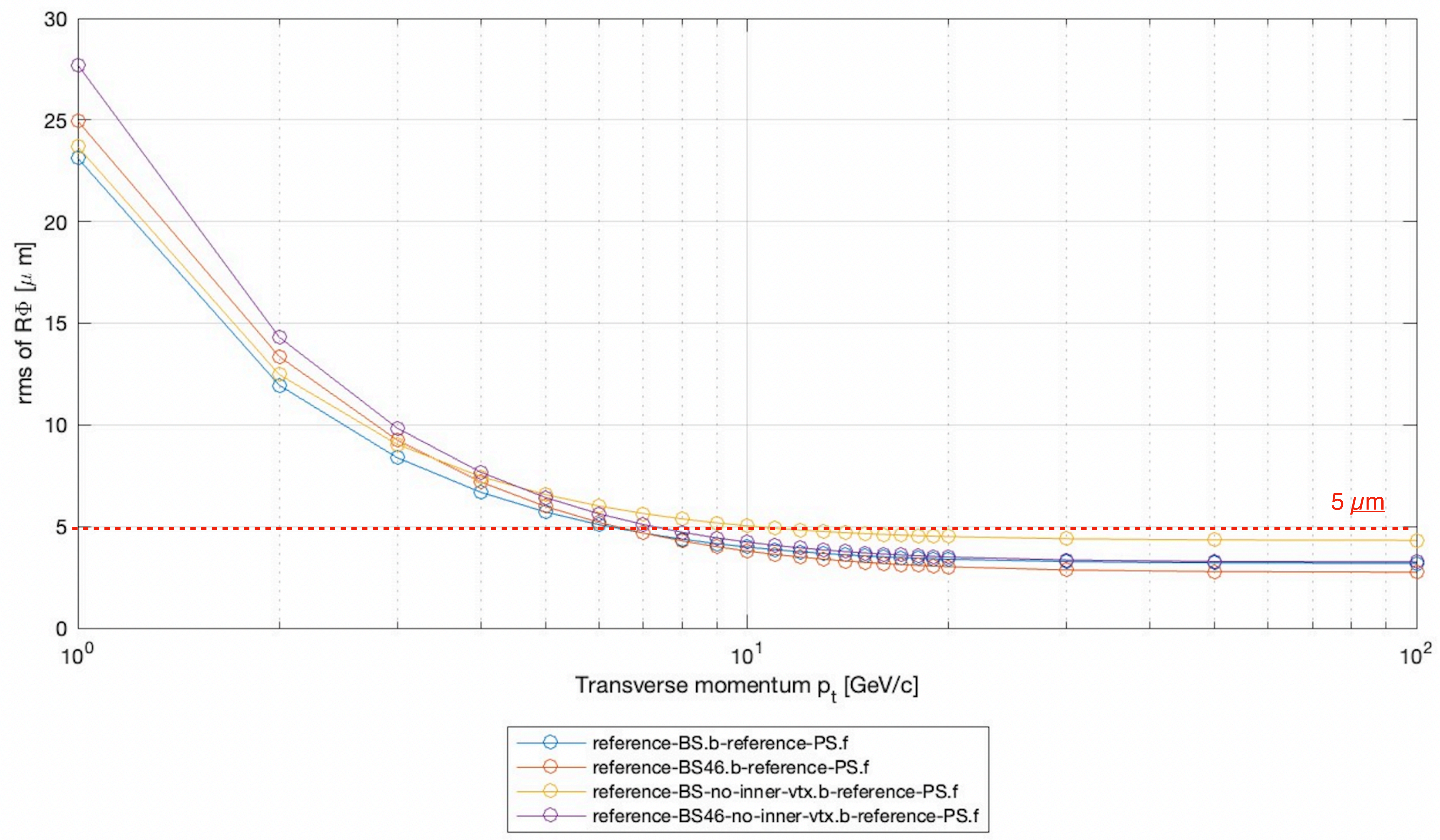
The different r_{sag} come from optimization, factoring in an assumed 25 mm reticle size,

The blue curve meets the YR requirements within the all-silicon tracker silicon area with seemingly reasonable extensions of ongoing R&D.

It seems sensible to simulate this in Fun4All already now, even though other changes will be needed. Volunteers ;-)?

There is likely to exist at least one path towards recovering YR mid-rapidity performance.

YR mid-rapidity performance in 1.4T



Potential concern could be "what if?" the innermost vertexing layer were inefficient. Or, put differently, would such a new configuration with in-effect two vertexing layers be "robust" against the change in pointing?

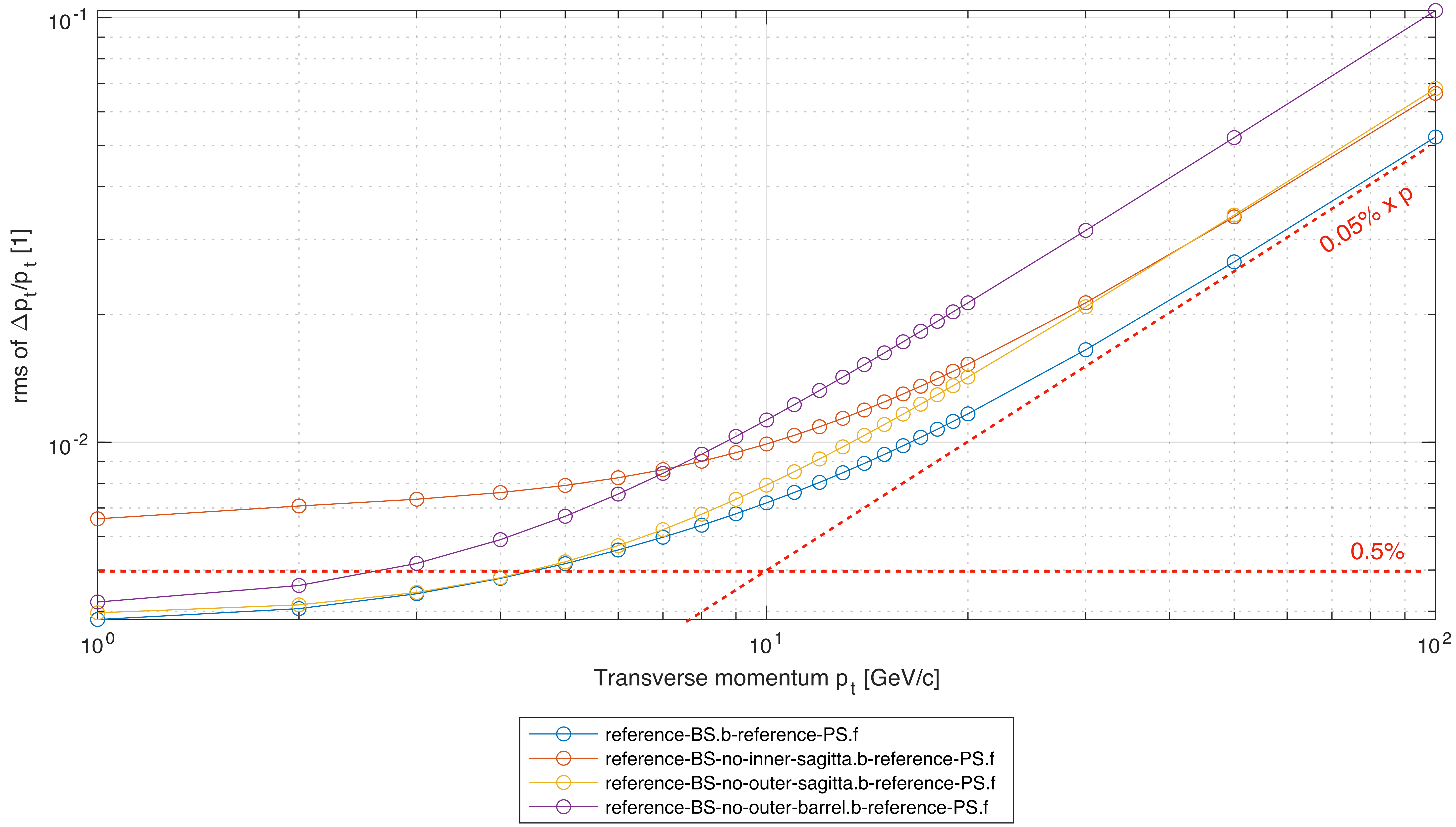
Red versus blue is the default 3-layer barrel versus a 2-layer barrel with r = 123 mm third (outer) layer,

Purple and yellow show results with an inefficient innermost vertex layer (i.e. material is kept, resolution lost) for these configurations,

Slight trade-offs; better low-p_T performance and somewhat worse at high-p_T (within 5 μm goal) for the r = 123 mm configuration,

For reference, YR: 20 μm/p_T $+^2$ 5 μm

YR mid-rapidity performance in 1.4T



Illustrative to consider also the “what ifs?” if MAPS layers outside of the innermost vertexing layers were inefficient,

The blue curve is again the (my) default r = 123 mm and r = 300 mm sagitta layer configuration with an outer barrel layer at r = 400 mm,

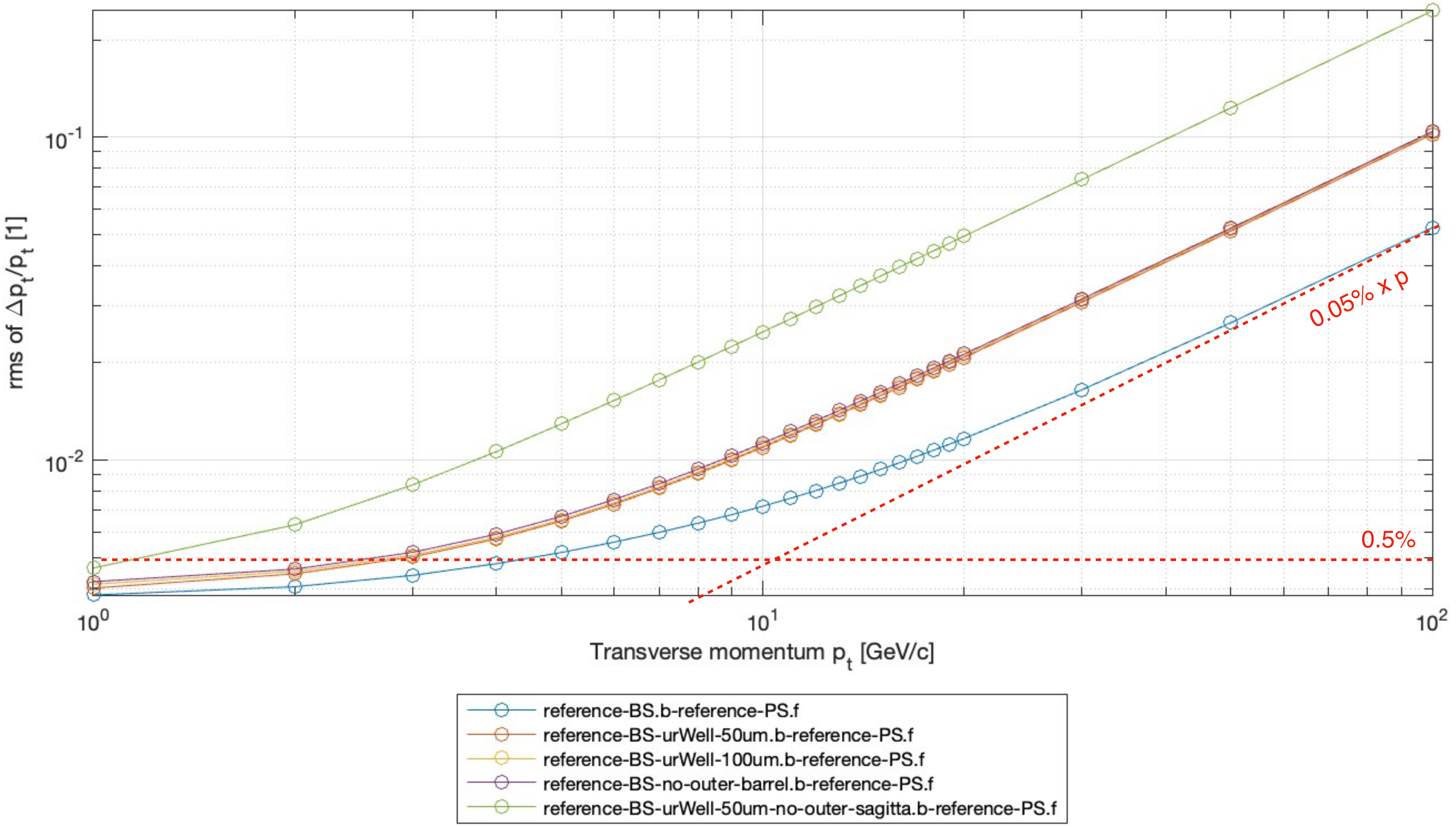
Red - layer at r = 123 mm inefficient,

Yellow - layer at r = 300 mm inefficient,

Purple - layer at r = 400 mm inefficient,

Fairly intuitive results; the outer barrel matters most for high-p_T, the inner r = 123 mm sagitta does so for low-p_T

YR mid-rapidity performance in 1.4T

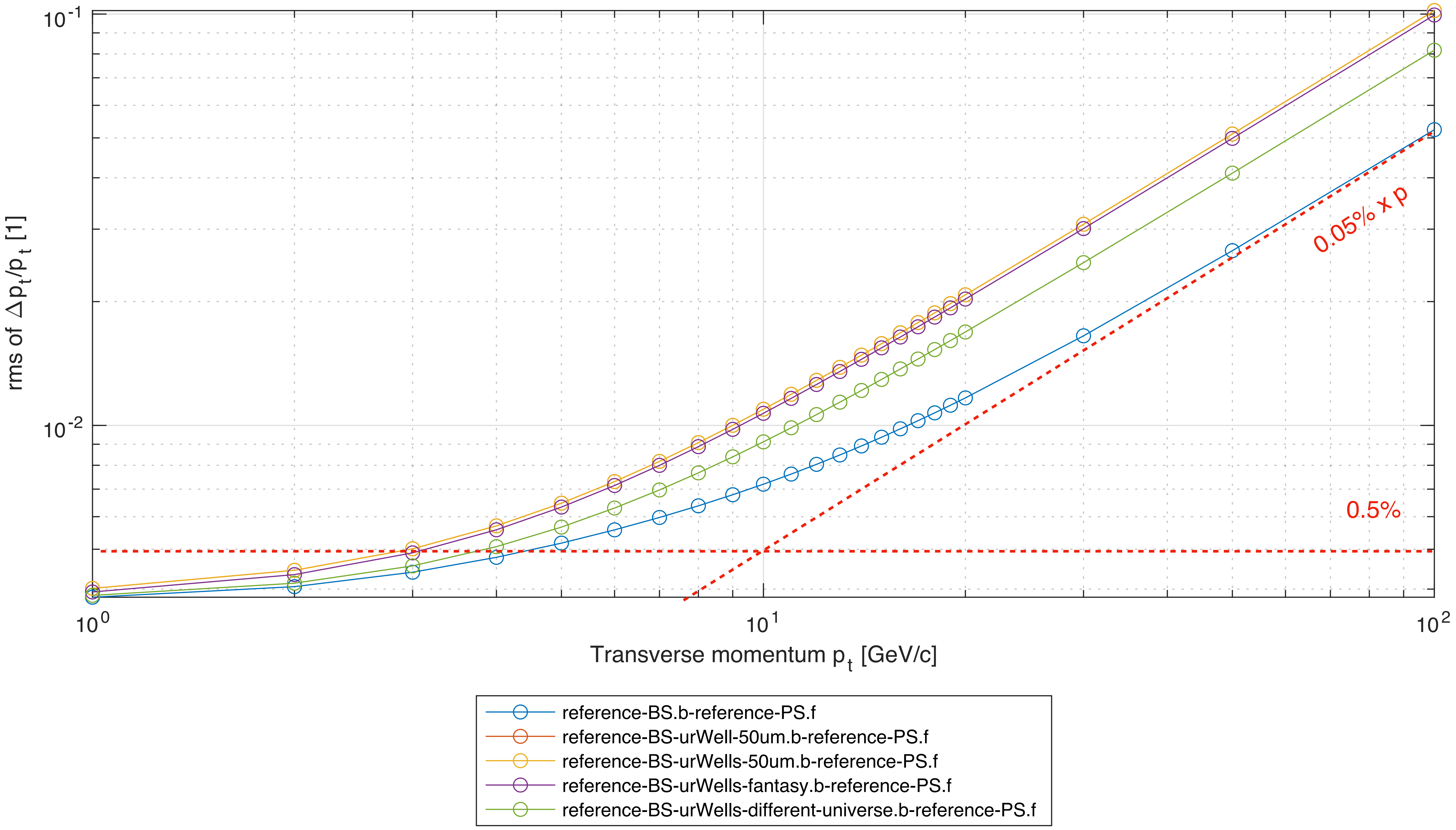


Consider an alternative with an MPGD outer barrel with 50 — 100 μm Gaussian point resolution at r = 400 mm (instead of the MAPS outer barrel layer),

Results are not too surprising; in essence, dp/p is determined by MAPS in this case (c.f. overlapping curves),

Configuration not very “robust” to inefficiencies in the MAPS part of this configuration (c.f. green curve).

YR mid-rapidity performance in 1.4T



There is more space than r = 400 mm, so "what if" we use this and put another MPGD at r = 650 mm, basically just inside of the DIRC,

A story of yet more overlapping curves - the difference in point resolution is hard to overcome, despite the longer lever-arm (~ L^2),

Blue - all MAPS configuration
Green - MAPS in vertex and sagitta layers, plus 10 μm resolution hypothetical "MPGDs",
Overlap - various combinations with 50—100 μm assumed MPGD resolutions,

Hard to find a way around a MAPS outer barrel layer while maintaining YR performance; quite obviously can restrict the kinematic range etc.