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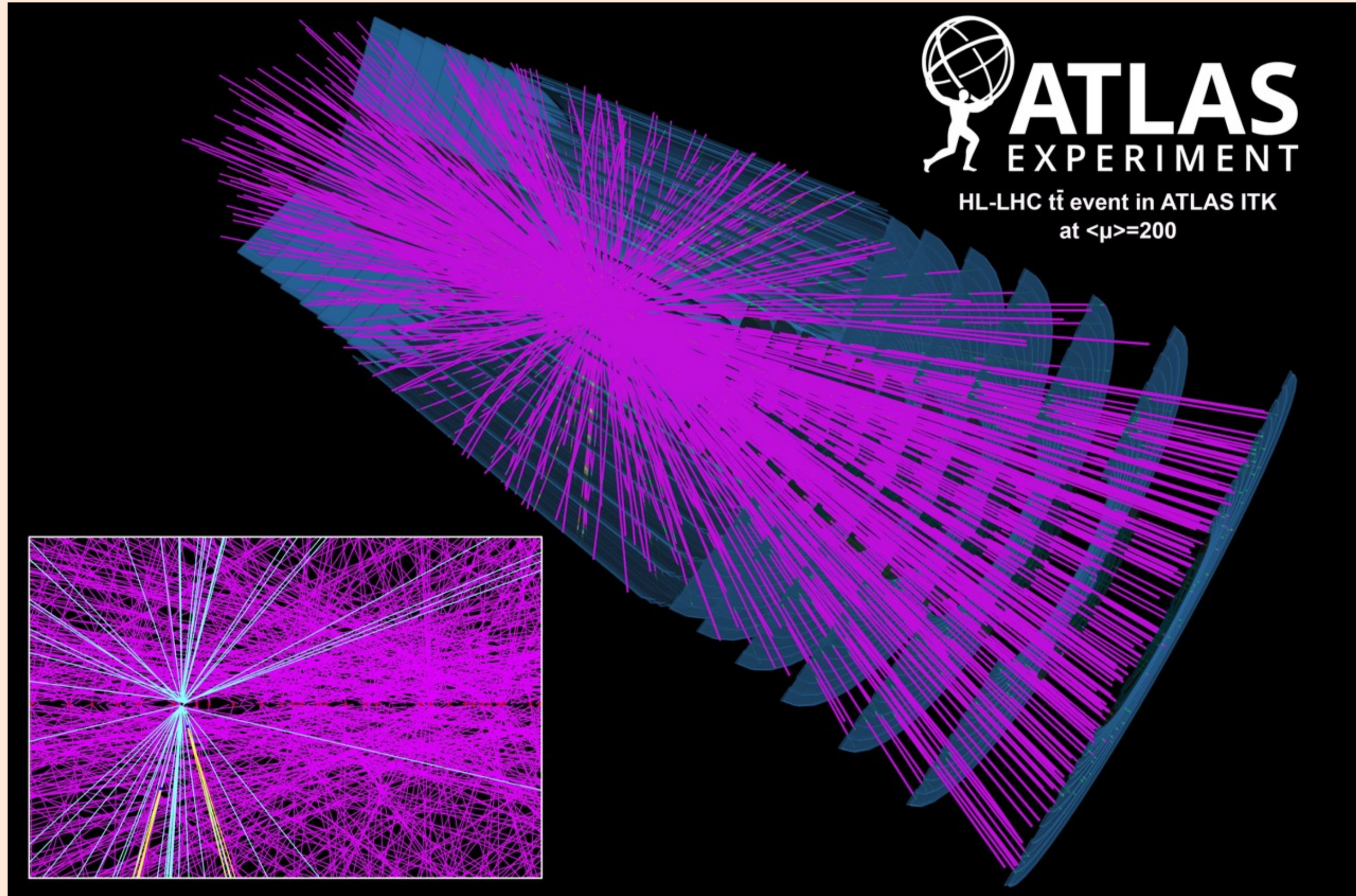
# ATLAS ITk Tracking and Readout Performance

D. Bortoletto for the ATLAS collaboration



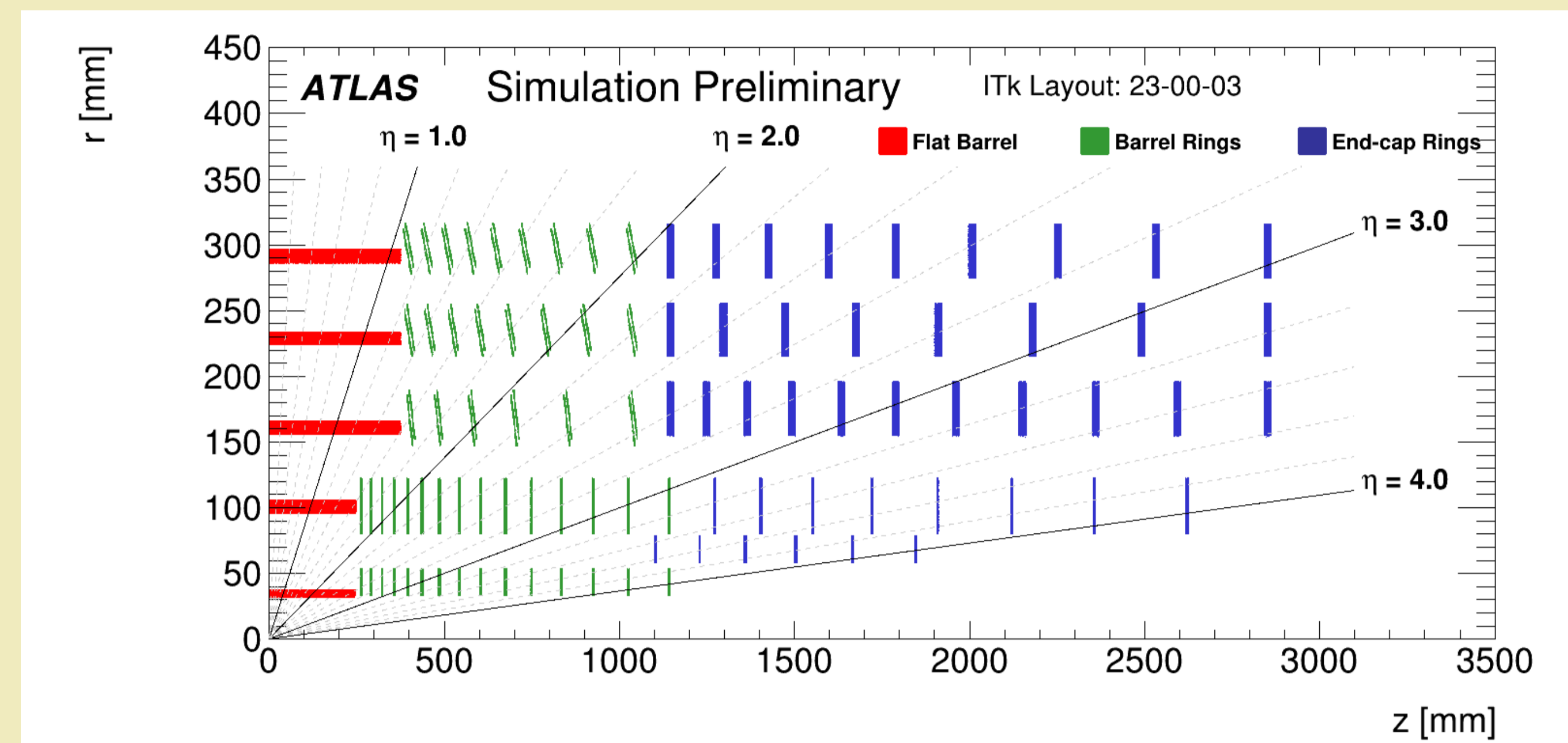
## HI-LHC ENVIROMENT

- Instantaneous luminosity  $7.5 \times 10^{34} \text{ cm}^{-2}\text{s}^{-1}$ ,
- Pile up 200

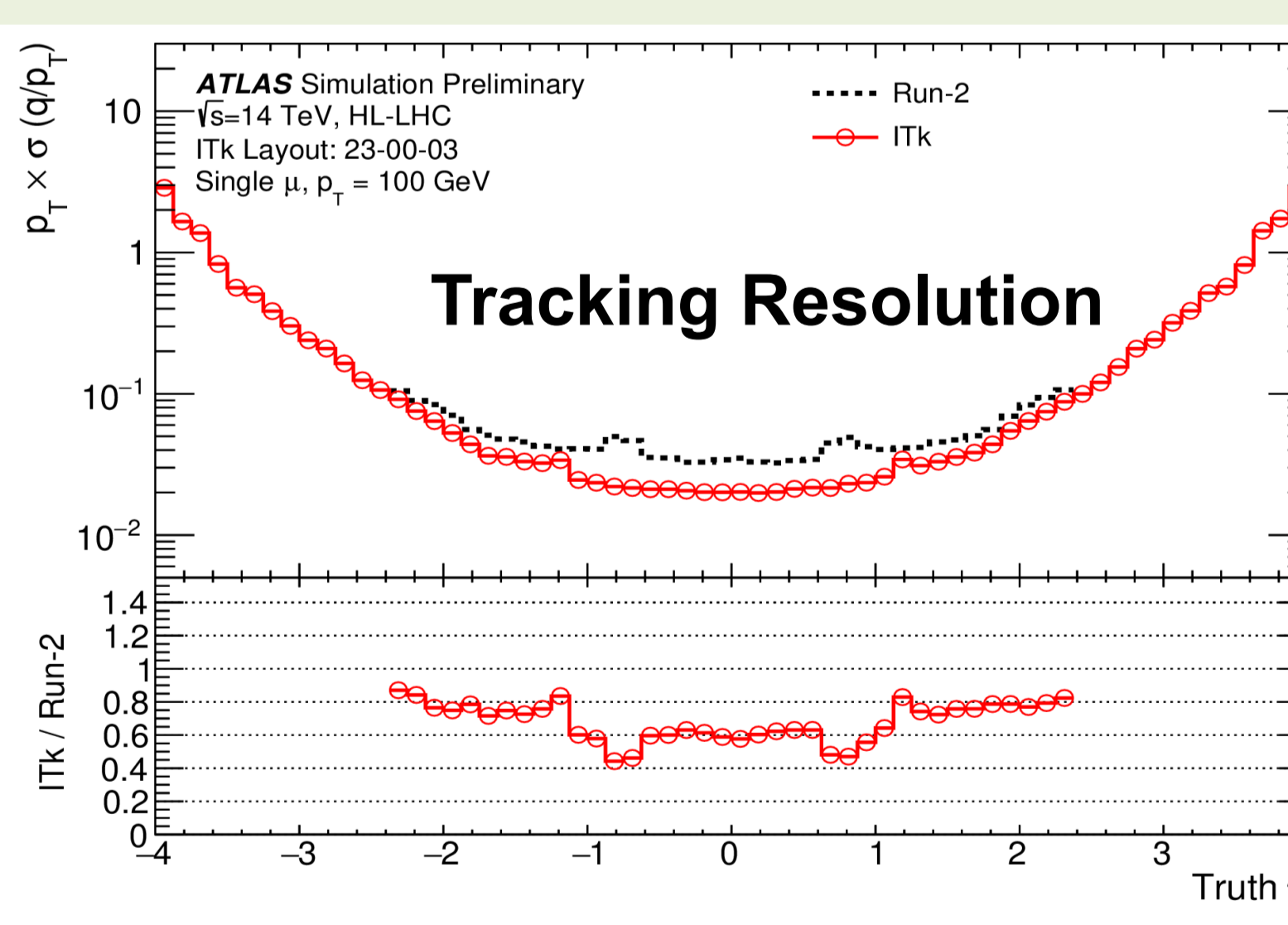
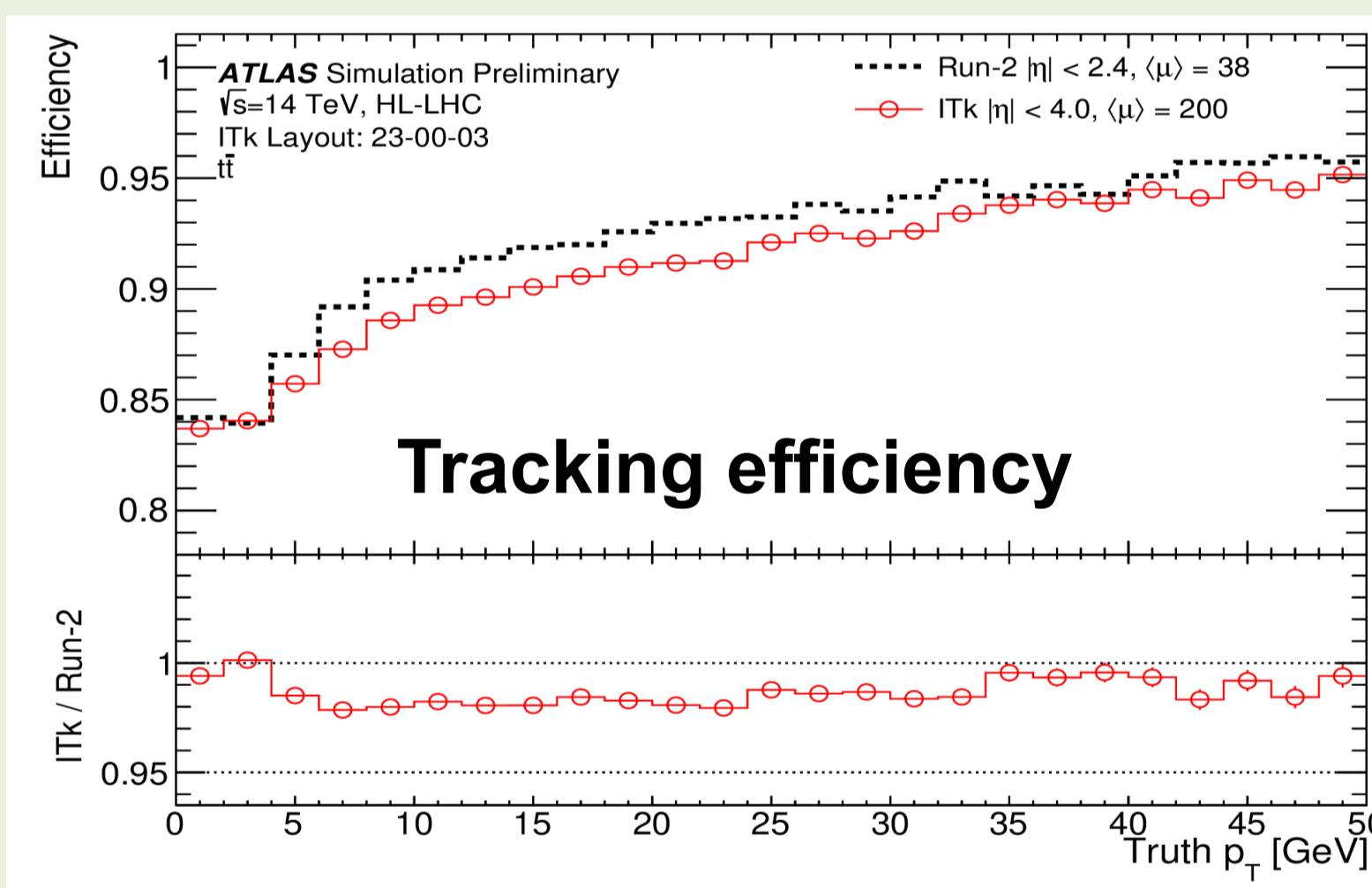
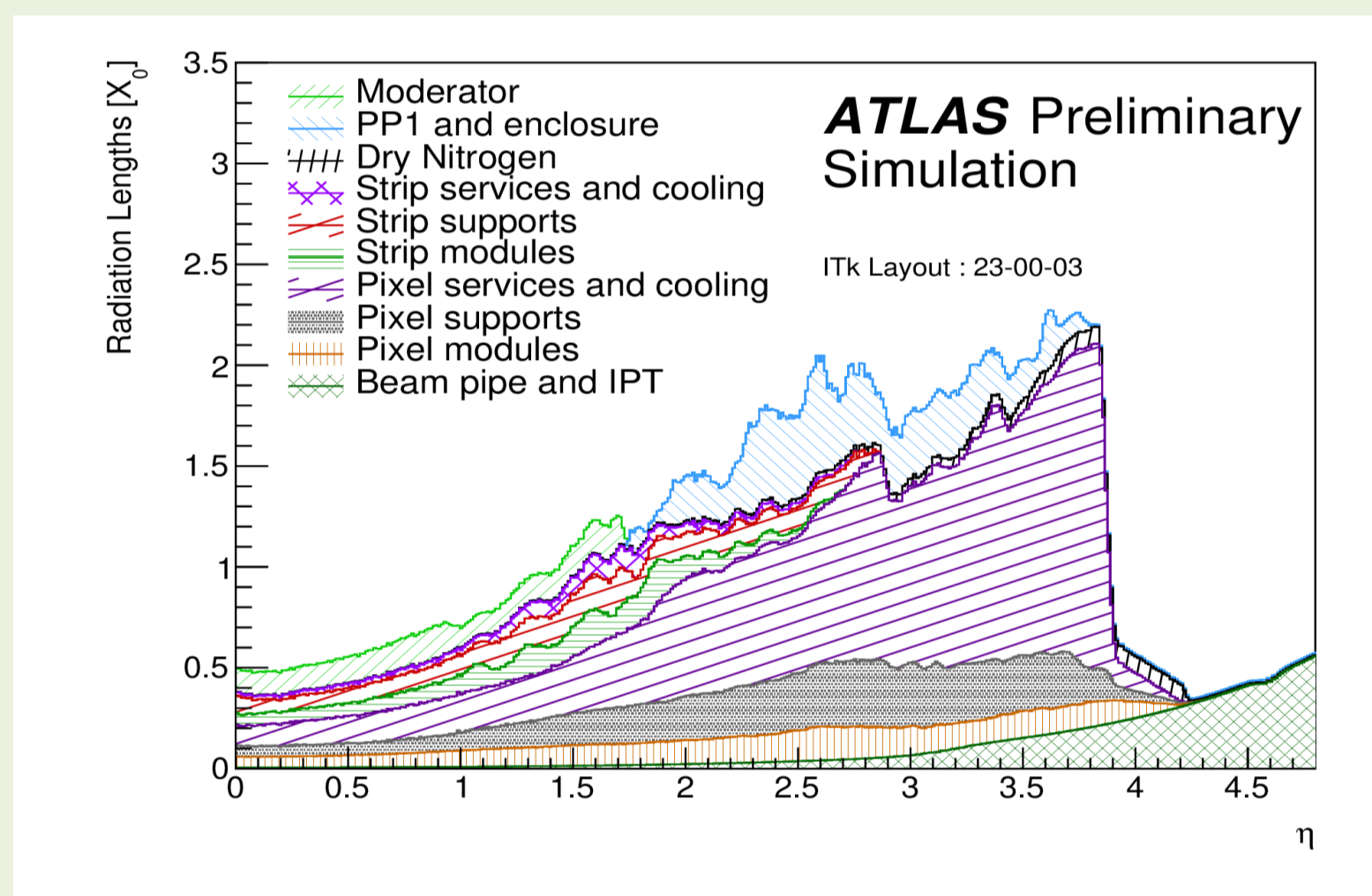


## NEW ITk LAYOUT

- Reduced radius of innermost layers
  - Barrel pixel layer (Layer 0) from 39 mm to 34 mm
  - End-cap rings (Ring Layer 0) from 36 mm to 33.2 mm
- Adopted
  - 150  $\mu\text{m}$  thick planar sensors with  $50 \times 50 \mu\text{m}^2$  pixels (100  $\mu\text{m}$  thick in Layer 1, 3D sensors with  $25 \times 100 \mu\text{m}^2$  pixels in Layer 0 and  $50 \times 50 \mu\text{m}^2$  in Ring Layer 0)
  - Quads modules with 4 chips bump-bonded to planar sensor (triplets in Layer 0)
- Reoptimized ring positions and increased clearances for easier integration
- Reduced number of barrel staves from 16 down to 12
- Improved material description



## Material distribution in ITk: $X_0$ versus $|\eta|$

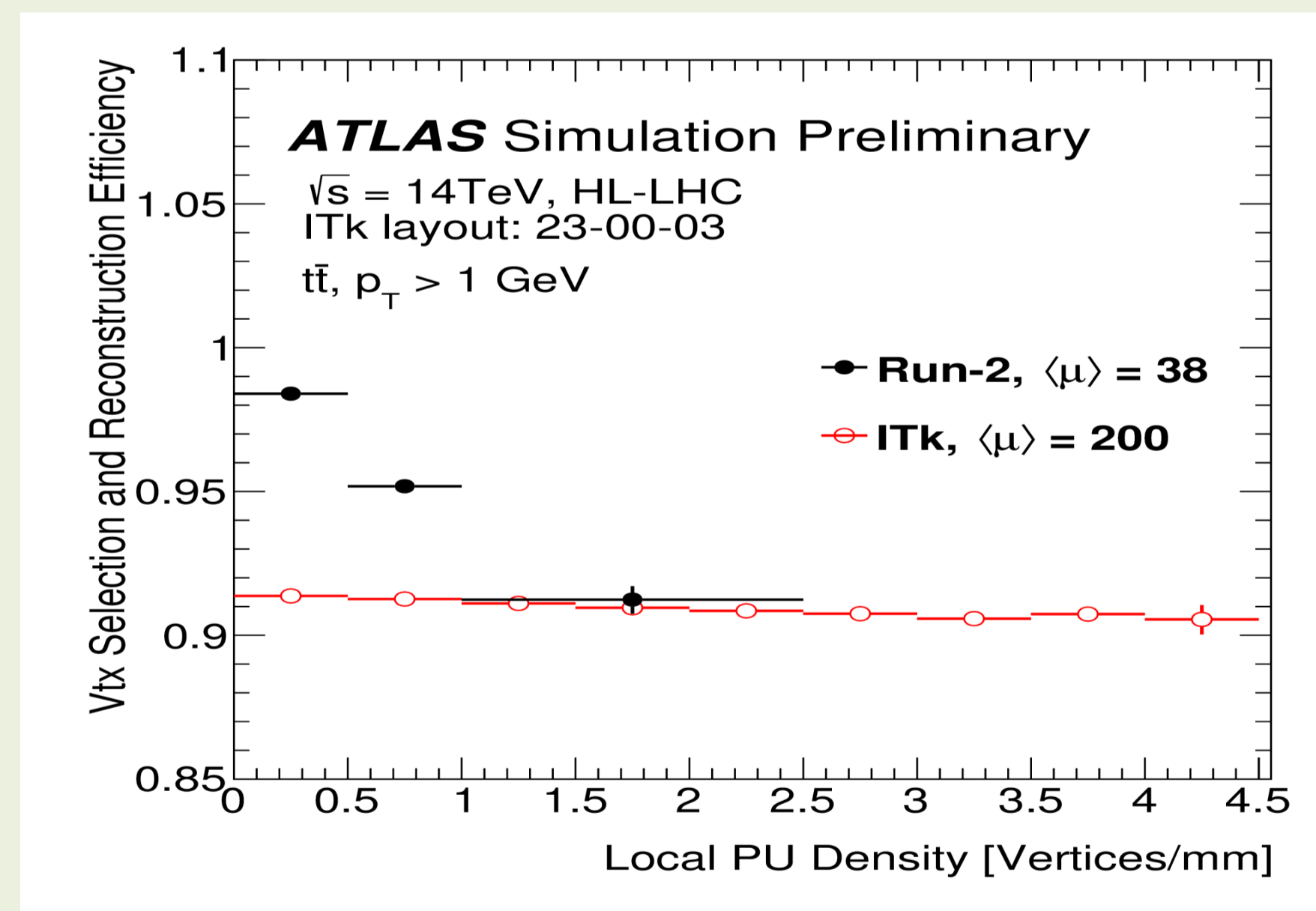


## PERFORMANCE

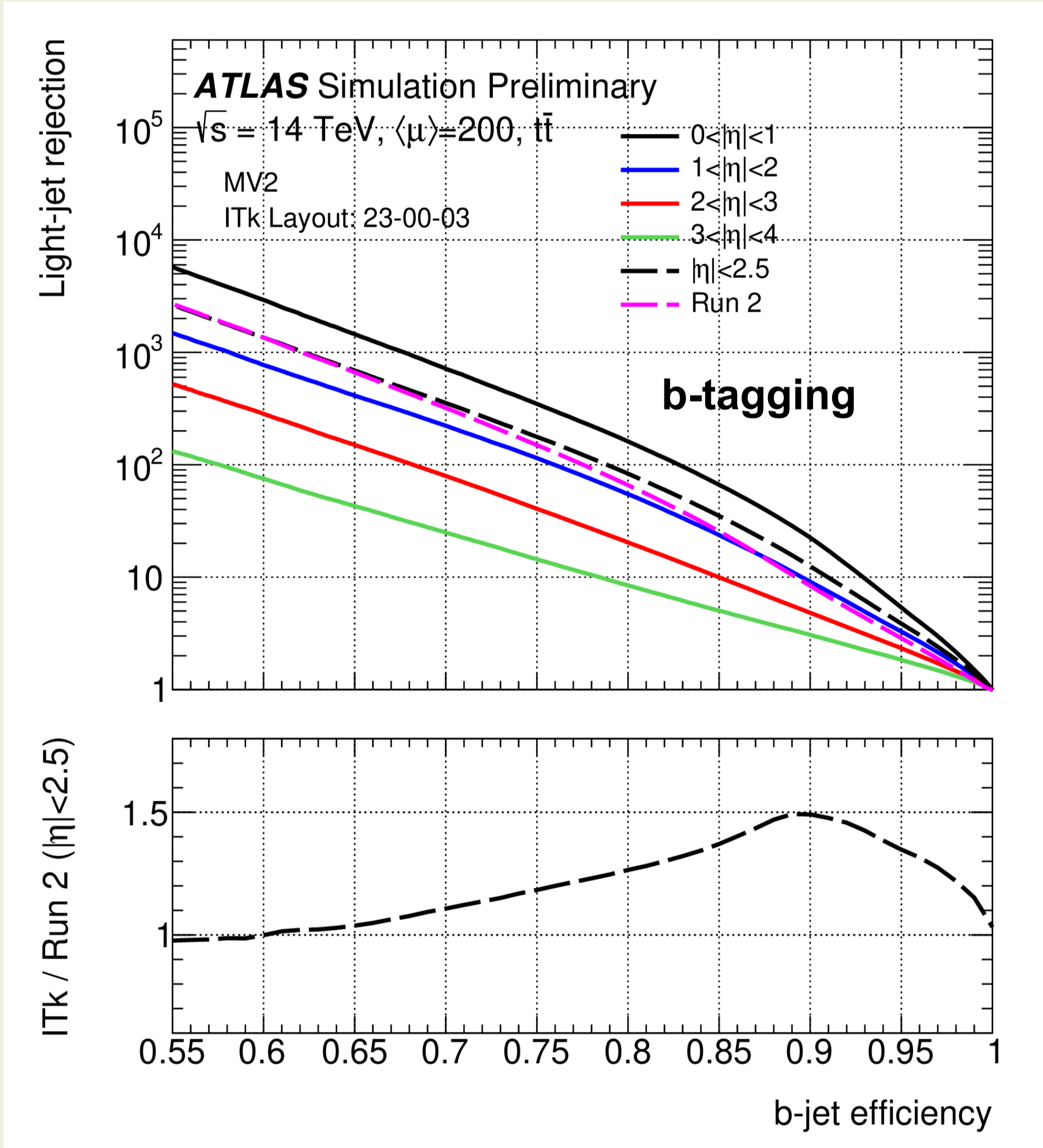
Compare  $t\bar{t}$  events with 200 pileup events in updated ITk layout to Run 2 Inner Detector with average pileup of 38

Requirements	Pseudorapidity interval		
	$ \eta  < 2.0$	$2.0 <  \eta  < 2.6$	$2.6 <  \eta  < 4.0$
pixel + strip hits	$\geq 9$	$\geq 8$	$\geq 7$
pixel hits	$\geq 1$	$\geq 1$	$\geq 1$
holes	$\leq 2$	$\leq 2$	$\leq 2$
$p_T$ [MeV]	$> 900$	$> 400$	$> 400$
$ d_0 $ [mm]	$\leq 2.0$	$\leq 2.0$	$\leq 10.0$
$ z_0 $ [cm]	$\leq 20.0$	$\leq 20.0$	$\leq 20.0$

Primary vertex combined reconstruction and selection efficiency

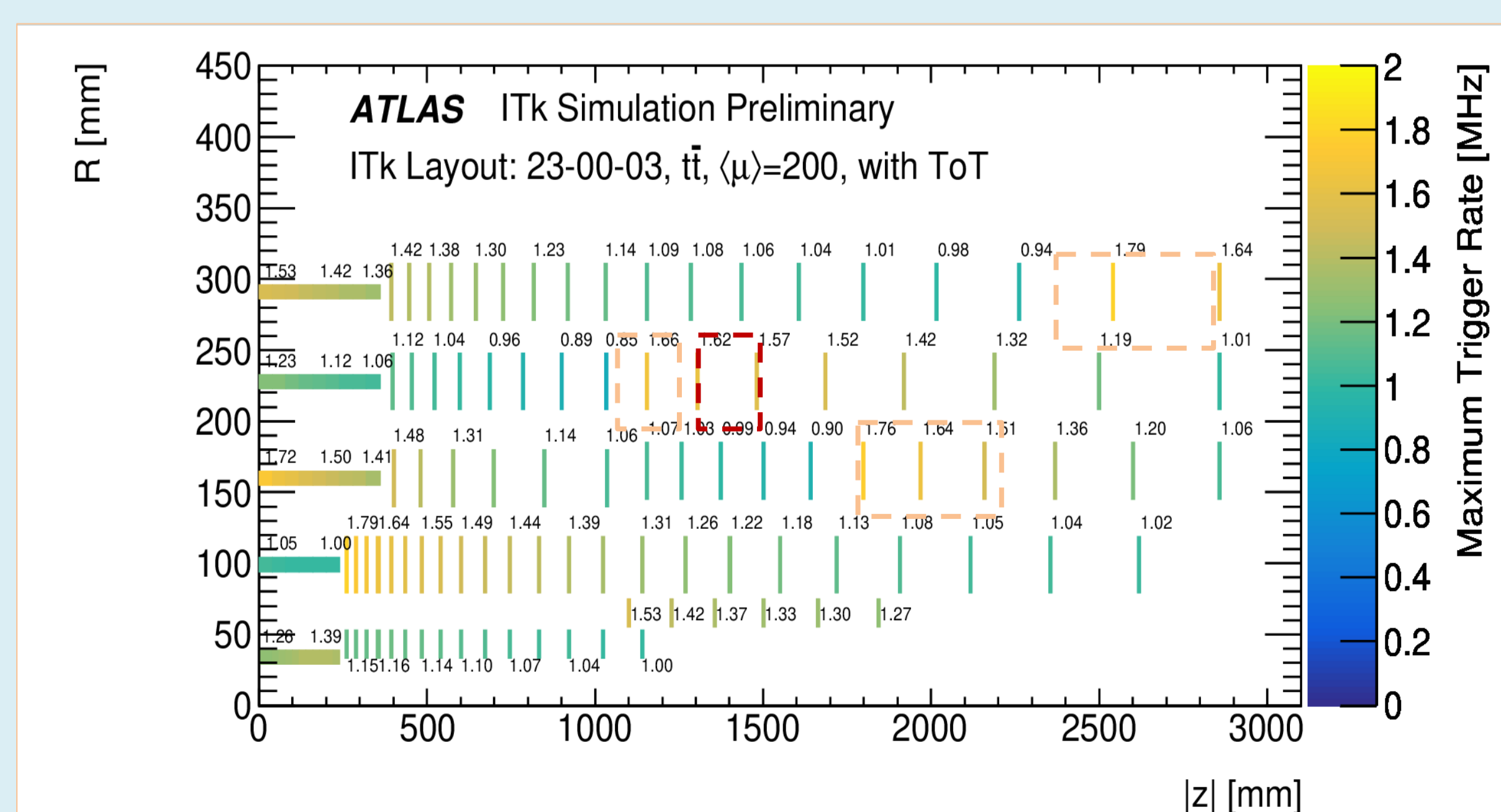


Excellent performance achieved in highly challenging pile up environment

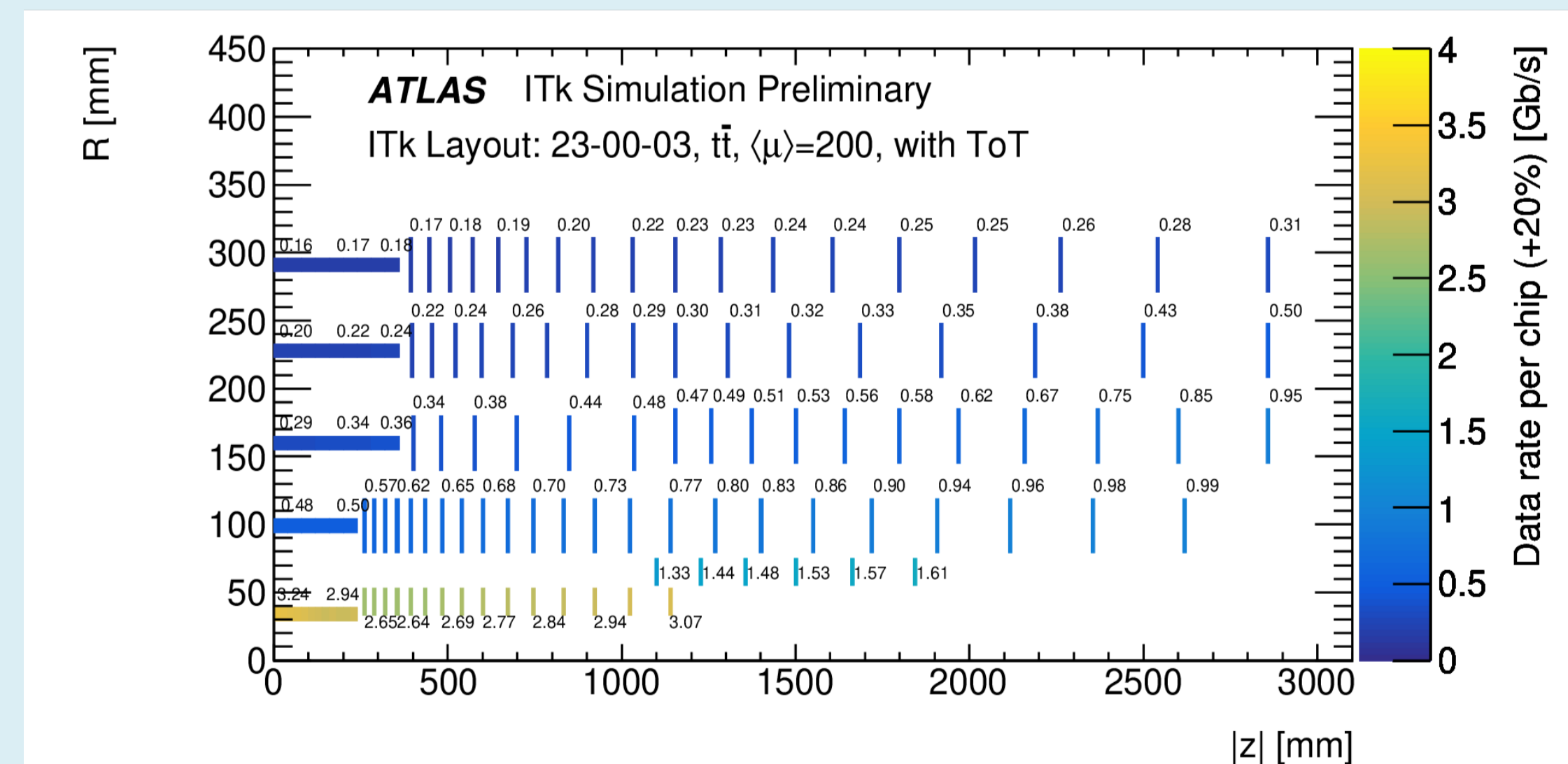


## EXPECTED PIXEL READOUT RATE

Maximum Trigger Rates (including a 20% safety factor)



Data rates (including a 20% safety factor)



## Conclusions:

- A few barrel and end-cap rings are just below 1 MHz rate
- Two Layer-3 end-cap rings miss the target by  $>10\%$
- Handles to recover the 1 MHz rate:
  - Increasing pixel threshold to 2.5 ke (7-15% increase in rate)
  - Dropping ToT from the output stream (20-60% increase but disfavoured due to loss of info)

More information on New ITK Layout and Expected Data rates in:  
[ATL-PHYS-PUB-2021-024](#)  
[ATL-ITK-PUB-2022-001](#)

Data rate evaluated to ensure achievability of 1 MHz L0 trigger rate

- Developed a dedicated algorithm to emulate the ITKPix chip data encoding from channels fired in GEANT4 simulated events.
  - Estimates agree with results obtained using the VEPIX53 Universal Verification Methodology
- Assumptions:
  - ITKPix Discriminator threshold of 600 e (900 e for Layer 0)
  - RMS noise of 75 e (110 e for Layer 0)
  - Maximum trigger rate assumes an 80% link occupancy limit for all links
  - Scale factors introduced to account for Aurora 64b/66b protocol (4%) and link sharing (3%)
- Data rate dependence on material evaluated:
  - A material increase of 20% leads to an increase in data rate between 3-5% in the barrel and 10% in endcaps