LHCb VeloPixel fast simulation

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TIMESPOT meeting - WP4

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Lots of inputs

- From WP4 meeting:
  - Different % of pixels hit by 2 particles in Run3 and Run5 (from beam conditions) ✔
  - Test clustering with and without timing
  - Add info for Long tracks and tracks with Nhit >= 4 ✔
  - Performance with no secondaries ✔

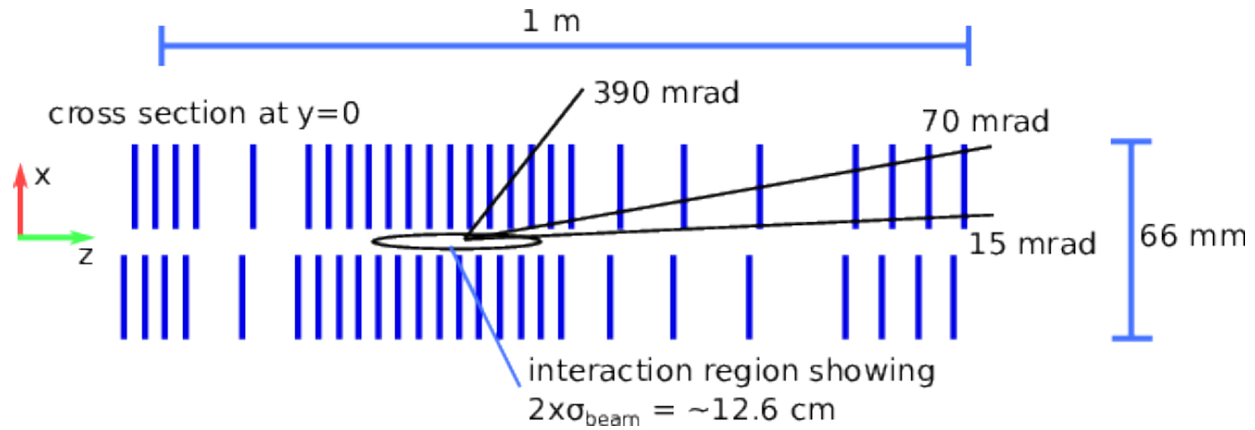
- From VeloU2 and VeloFastSim meetings:
  - Check #PVs for Run3 (it's ok) ✔
  - Switch to BeamSpotGenerator (Stefano's code is equivalent) ✔
  - Estimate cluster time resolution
  - Check v=c ansatz ✔
  - Performance with no secondaries ✔
  - new tracking algorithm

- Others:
  - send input to Marco (still waiting for info)
  - send code to Mickail for a realistic input
  - implement clustering with rawbanks on FPGA (instruction from GBalbi)

Performance FoM

- Velo particle = 2 < eta < 5 and is not an electron

- Long particle = Velo forward particle with **(from Benedetto)**
  12 < |px/pz| < 300 mrad and 12 < |py/pz| < 250 mrad



- Efficiency = # of reconstructed particles / # of reconstructible particles

- Ghost rate = # of non-assigned tracks / # of reconstructed tracks

- Reconstructible = at least 3 or 4 hits in the geometry

Upgrade-II performances

	3hits			4hits		
	εVELO(%)	εLONG(%)	PGHOST(%)	εVELO(%)	εLONG(%)	PGHOST(%)
σ_t = 10 ps	97.5	97.1	0.23	98.5	98.2	0.14
σ_t = 20 ps	97.9	97.6	0.32	98.9	98.7	0.17
σ_t = 30 ps	98.0	97.8	0.42	99.0	98.9	0.20
σ_t = 40 ps	98.1	97.8	0.56	99.0	98.9	0.24
σ_t = 50 ps	98.1	97.8	0.72	99.0	99.0	0.28
σ_t = 60 ps	98.0	97.9	0.90	99.0	99.0	0.33
No Timing	97.8	97.7	4.20	98.7	98.9	1.32

Upgrade-II performances

- Only prompt

	3hits			4hits		
	εVELO(%)	εLONG(%)	PGHOST(%)	εVELO(%)	εLONG(%)	PGHOST(%)
σ_t = 10 ps	98.9	98.8	0.1	99.2	99.1	0.0
σ_t = 20 ps	99.2	99.1	0.1	99.5	99.4	0.0
σ_t = 30 ps	99.3	99.2	0.2	99.5	99.5	0.1
σ_t = 40 ps	99.3	99.3	0.3	99.6	99.6	0.1
σ_t = 50 ps	99.3	99.3	0.4	99.6	99.6	0.1
σ_t = 60 ps	99.3	99.3	0.5	99.5	99.6	0.1
No Timing	99.2	99.2	2.9	99.5	99.5	0.5

For the next meetings

- Better understanding of Multiple Scattering effects (check on FullSim) ✔

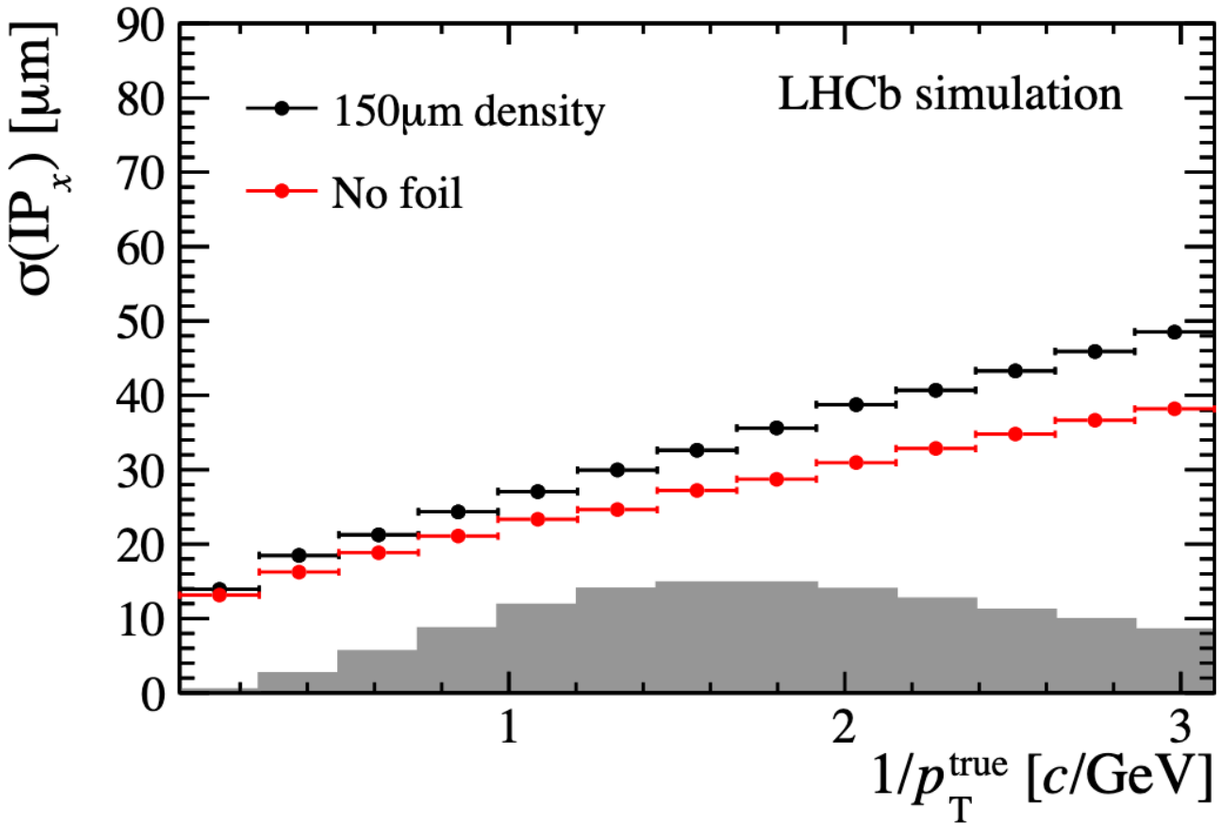
- Implement/check what discussed in meetings

- Moreover:
  - First document for FastSim
  - Release first version of FastSim (almost ready)

Impact of Layers MS non-negligible

- Previous simulation of RF foil Multiple Scattering failed in describing IPx resolution and performances.

- From Laurent slides:

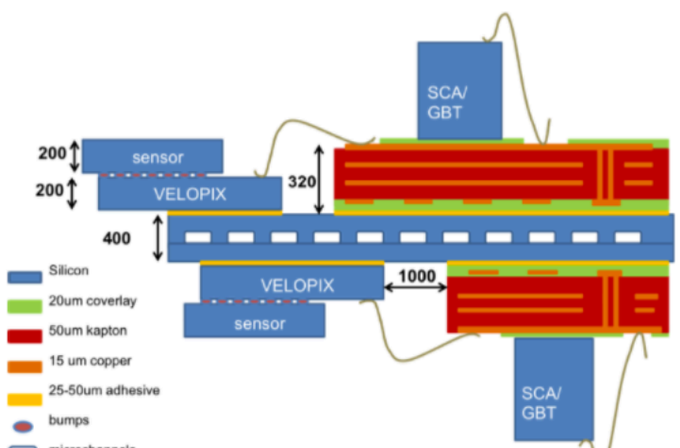


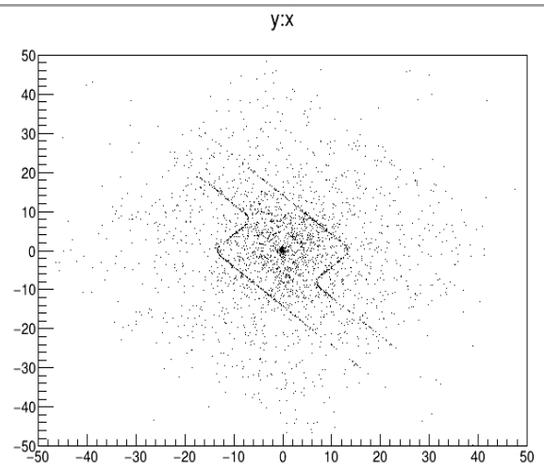
- The impact of the Layers material is non-negligible.

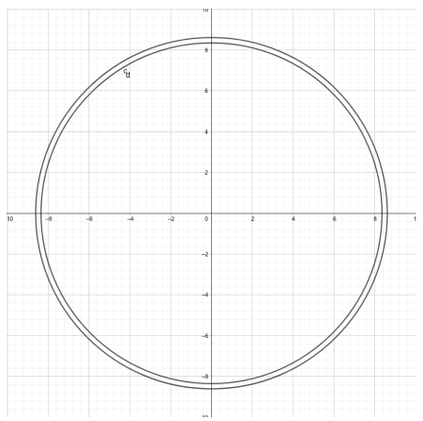
Introducing Multiple Scattering from RF foil and Layers

- RF foil as a *cylinder* of:
  R = 5 mm
  width = 350 μm
  material = Al

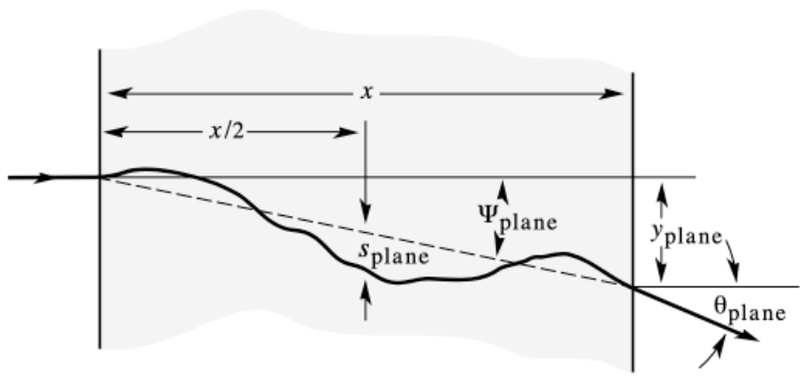
- Layers:
  800 μm of Si







- Momentum scattering is applied to all the particles (in geometrical acceptance) following PDG instructions

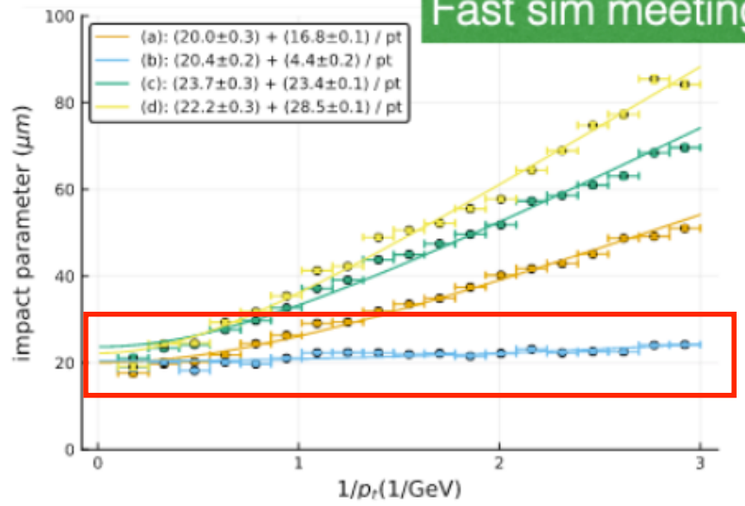


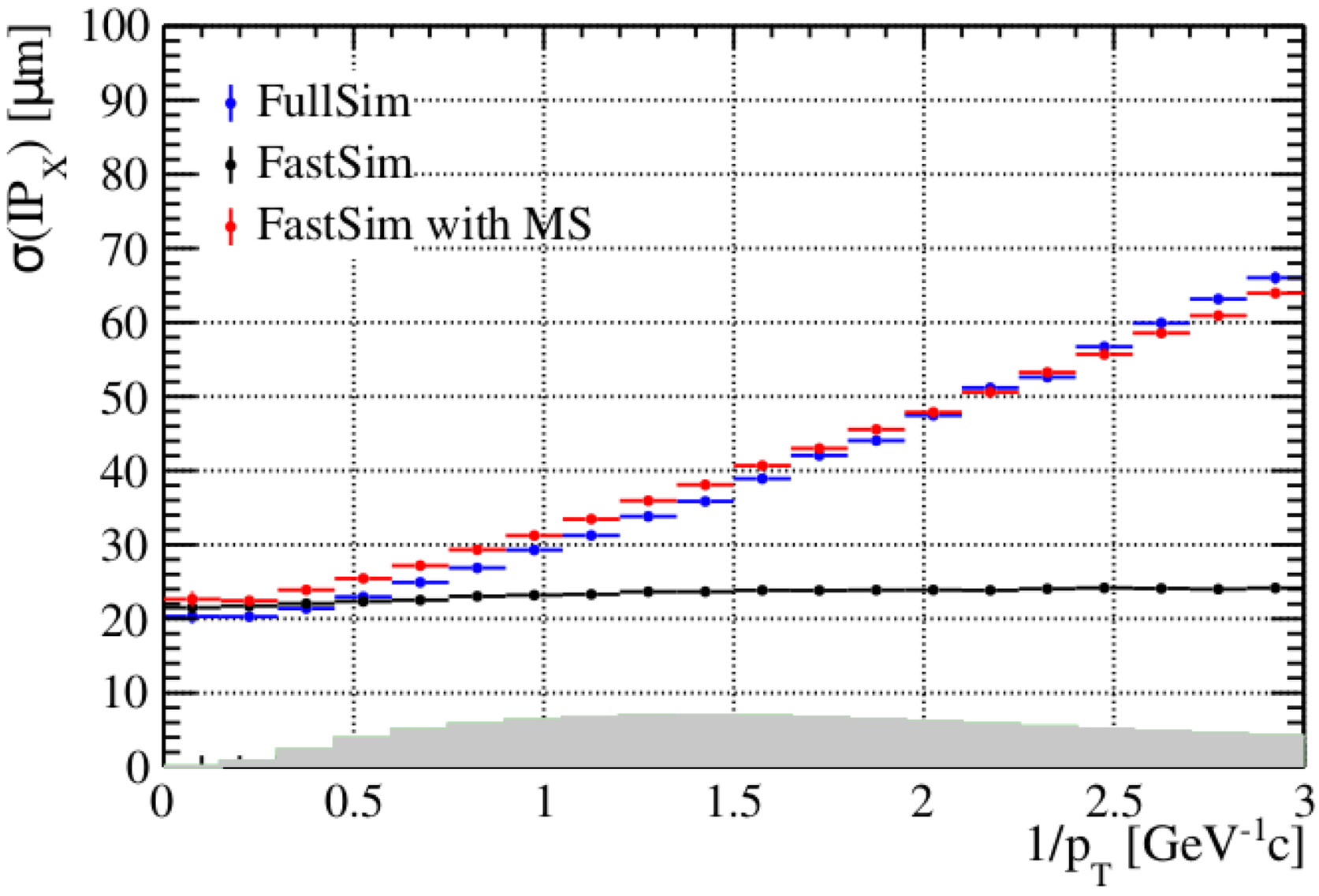
$$
\begin{aligned}
y_{\text{plane}} &= z_1\, x\, \theta_0 (1-\rho_{y\theta}^2)^{1/2}/\sqrt{3} + z_2\, \rho_{y\theta} x\, \theta_0/\sqrt{3} \\
&= z_1\, x\, \theta_0/\sqrt{12} + z_2\, x\, \theta_0/2; \\
\theta_{\text{plane}} &= z_2\, \theta_0.
\end{aligned}
$$

IP_x resolution vs $1/p_T$

Fast sim meeting

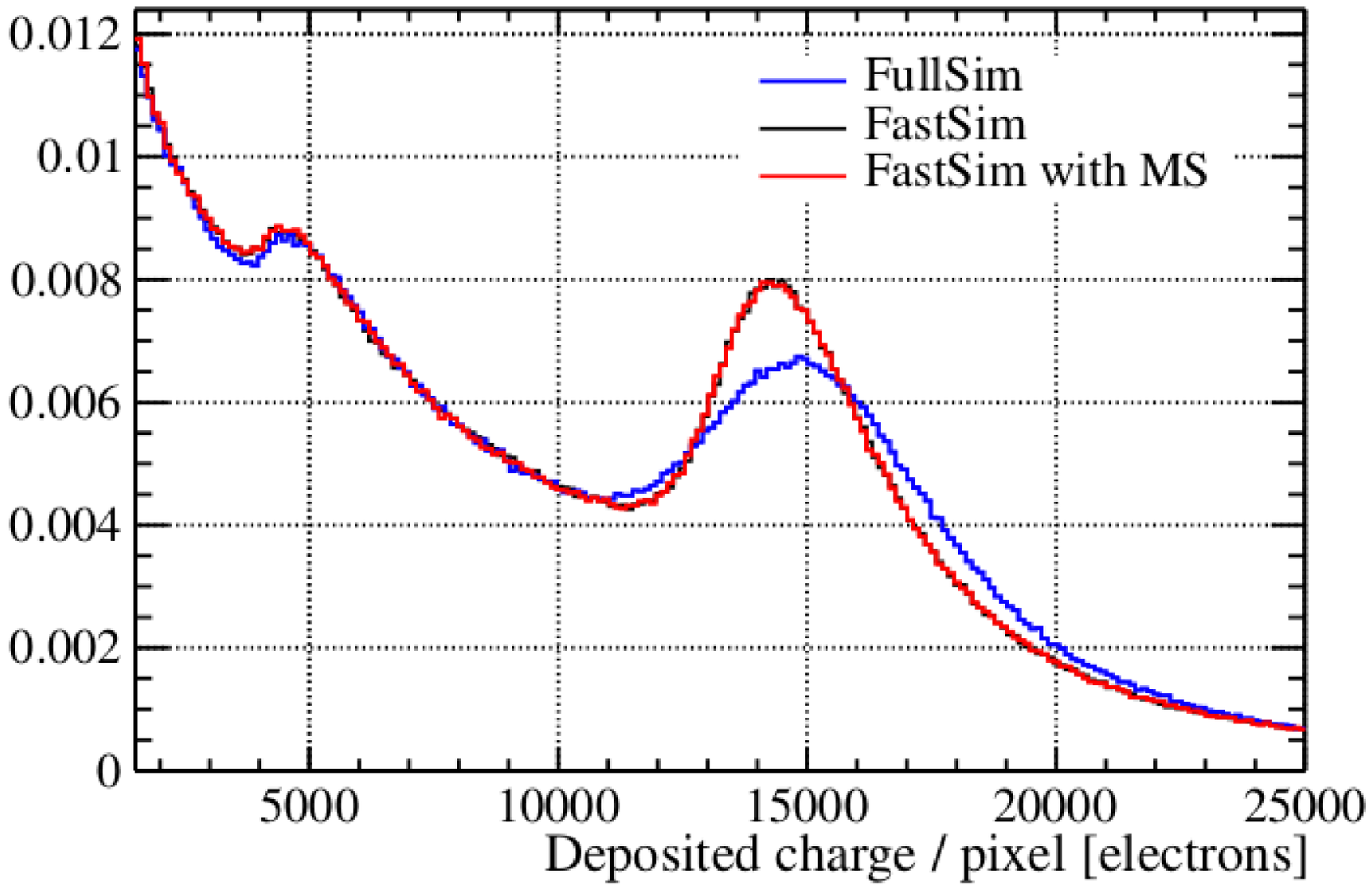
$$\sigma_{IP}^2 = \frac{r_1^2}{p_T}\left(0.0136\,\mathrm{GeV}/c\sqrt{\frac{x}{X_0}}\left(1+0.038\ln\frac{x}{X_0}\right)\right)^2 + \left(\frac{\Delta_{02}^2\sigma_1^2\Delta_{01}^2\sigma_2^2}{\Delta_{12}^2}\right)$$
$$= \sigma_{MS}^2 + \sigma_{extrap}^2.$$





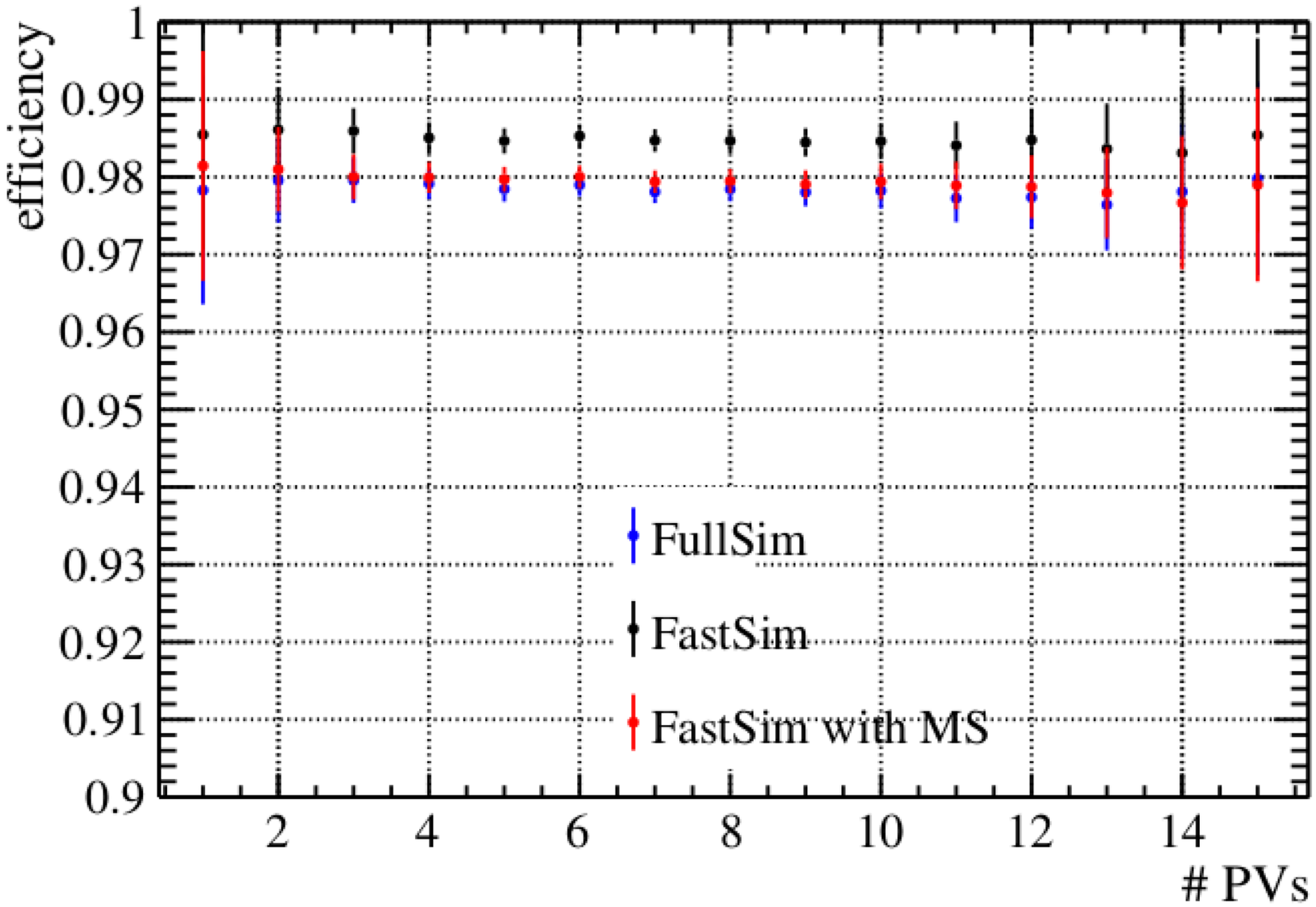
Validation plots (Upgrade-I)

- Charge deposit



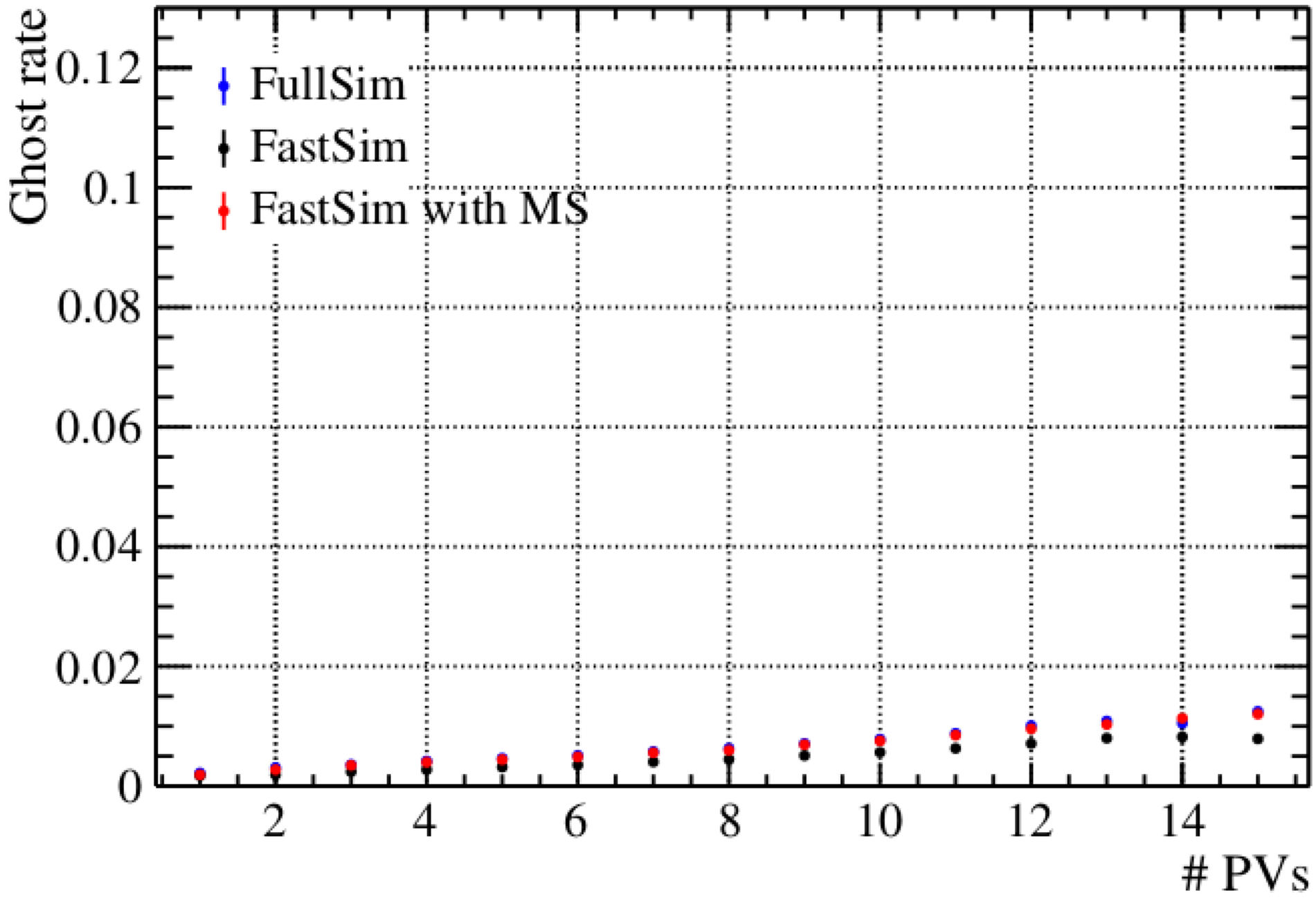
Validation plots (Upgrade-I)

- Efficiency



Validation plots (Upgrade-I)

- Ghost rate



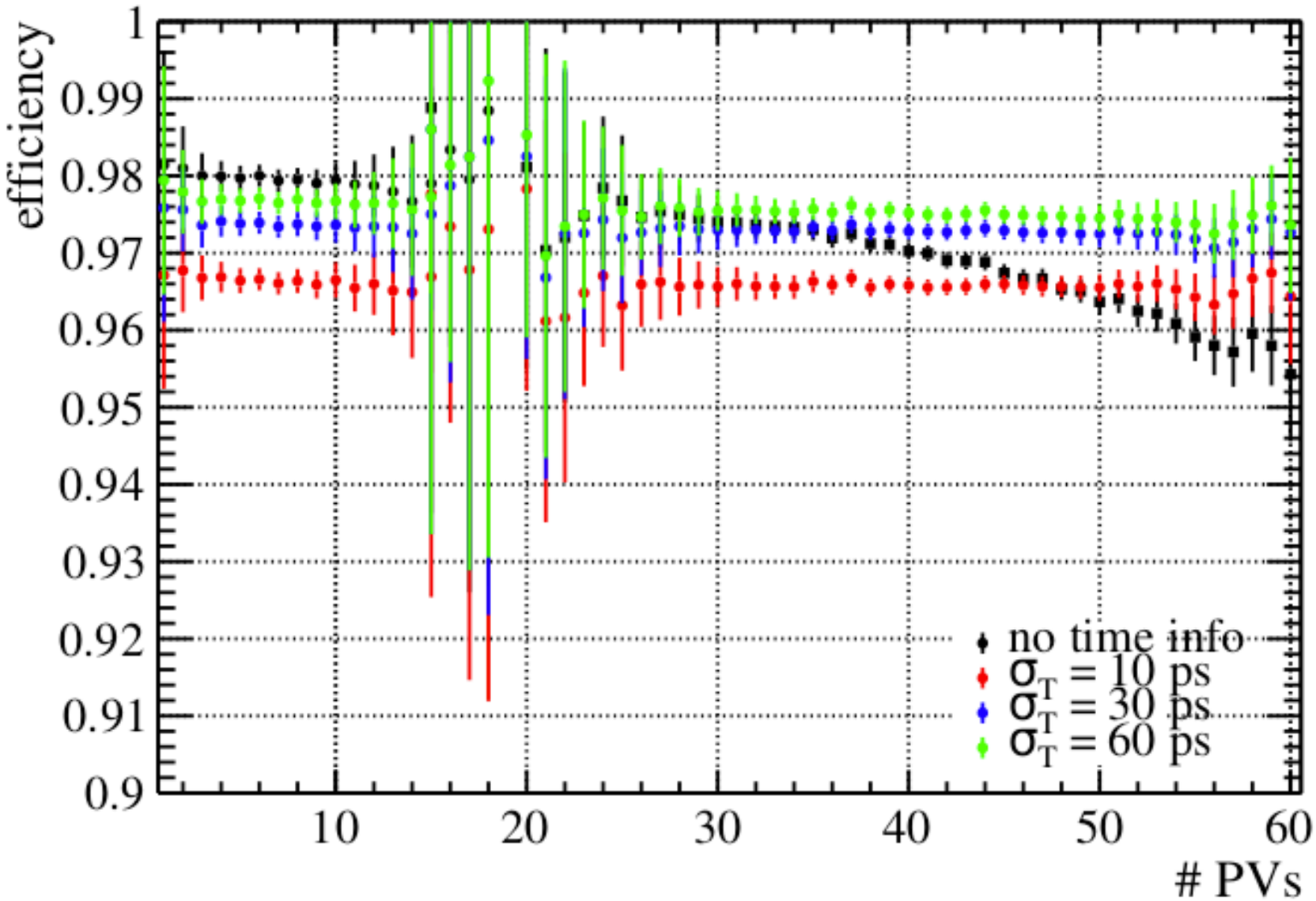
Integrated values

- Comparison with FullSim and Laurent U2 talk

	Run3	
	εVELO(%)	**PGHOST(%)**
FastSim withMS	**98.0**	**0.5**
FullSim	**97.8**	**0.44**
150μm Foil [Laurent U2 talk]	**98.1**	**0.5**

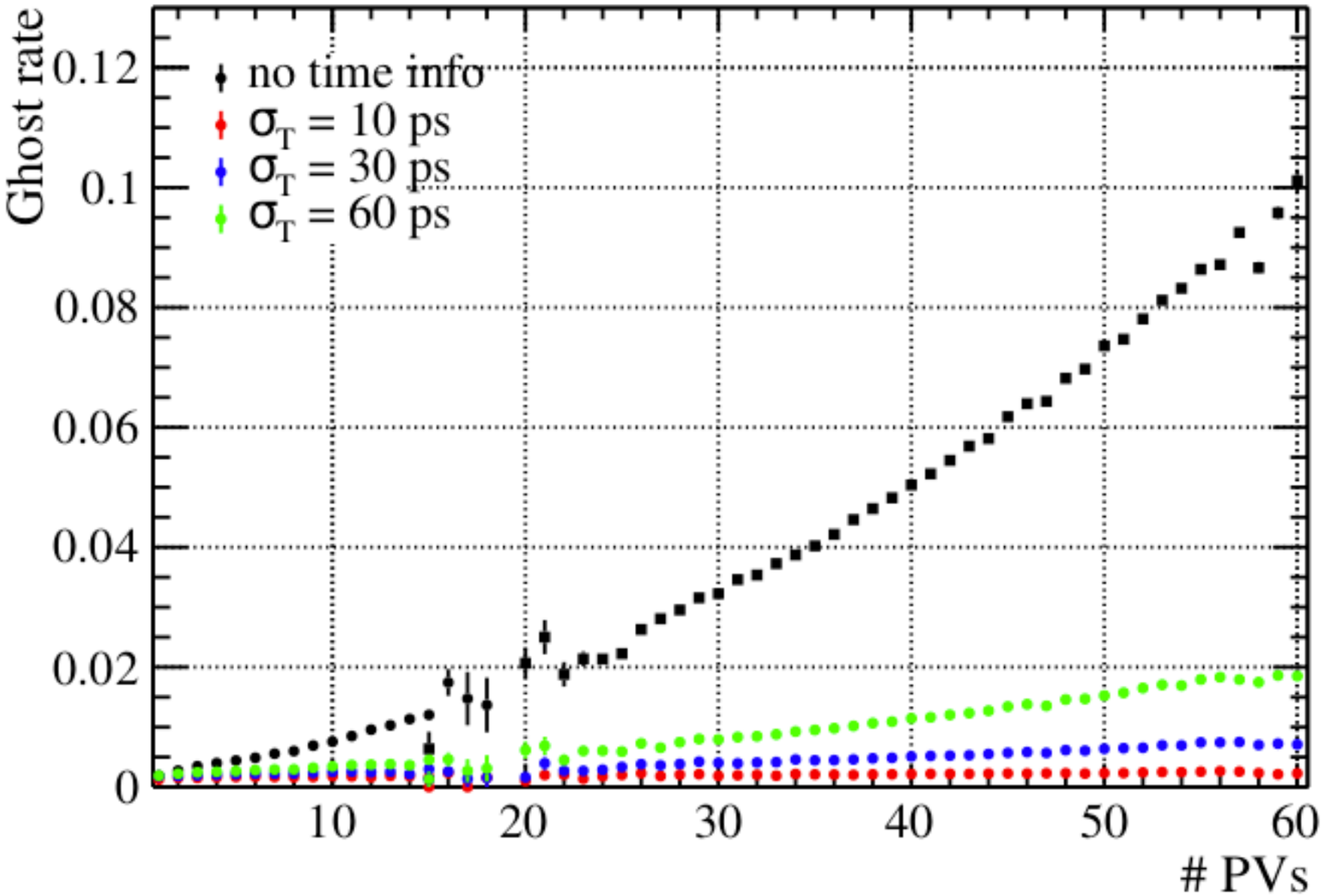
Performances

- Efficiency



Performances

- Ghost rate



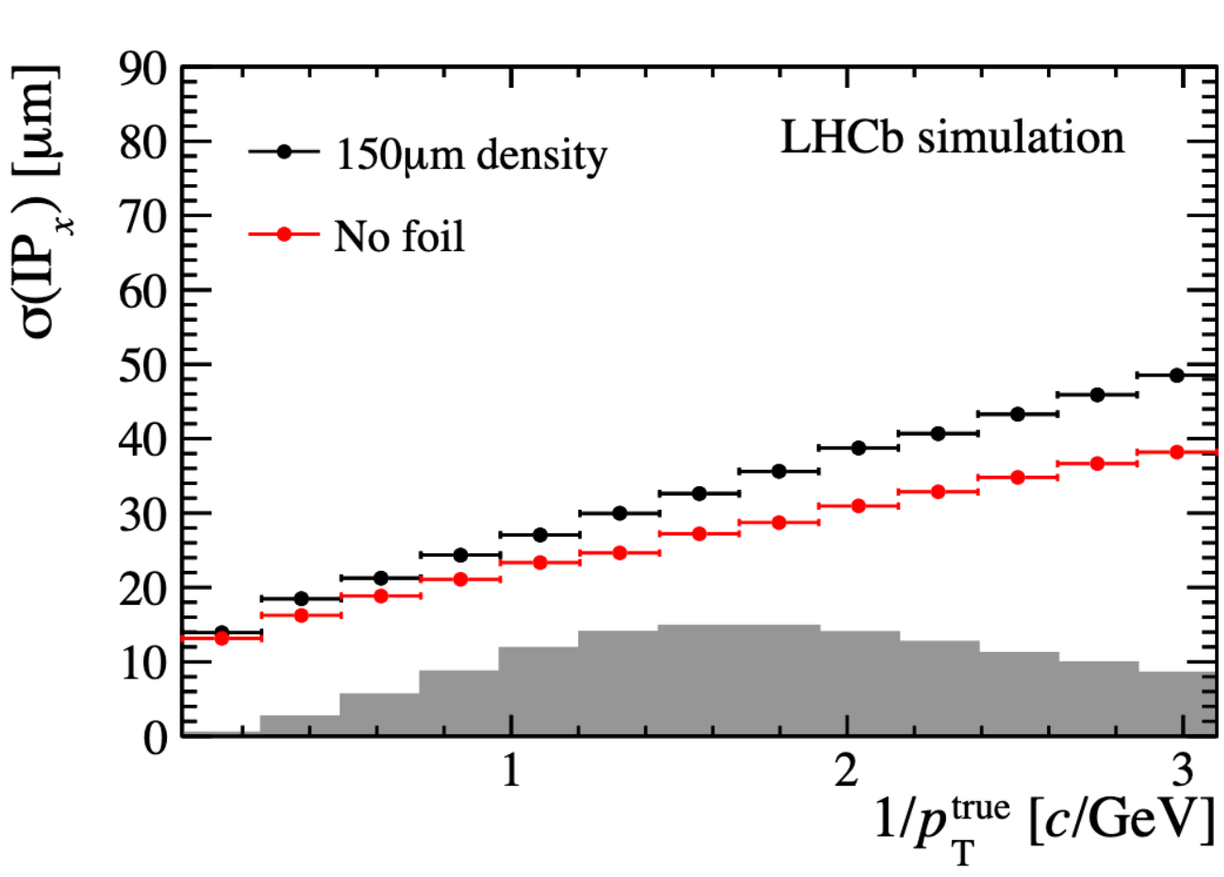
Upgrade-II performances

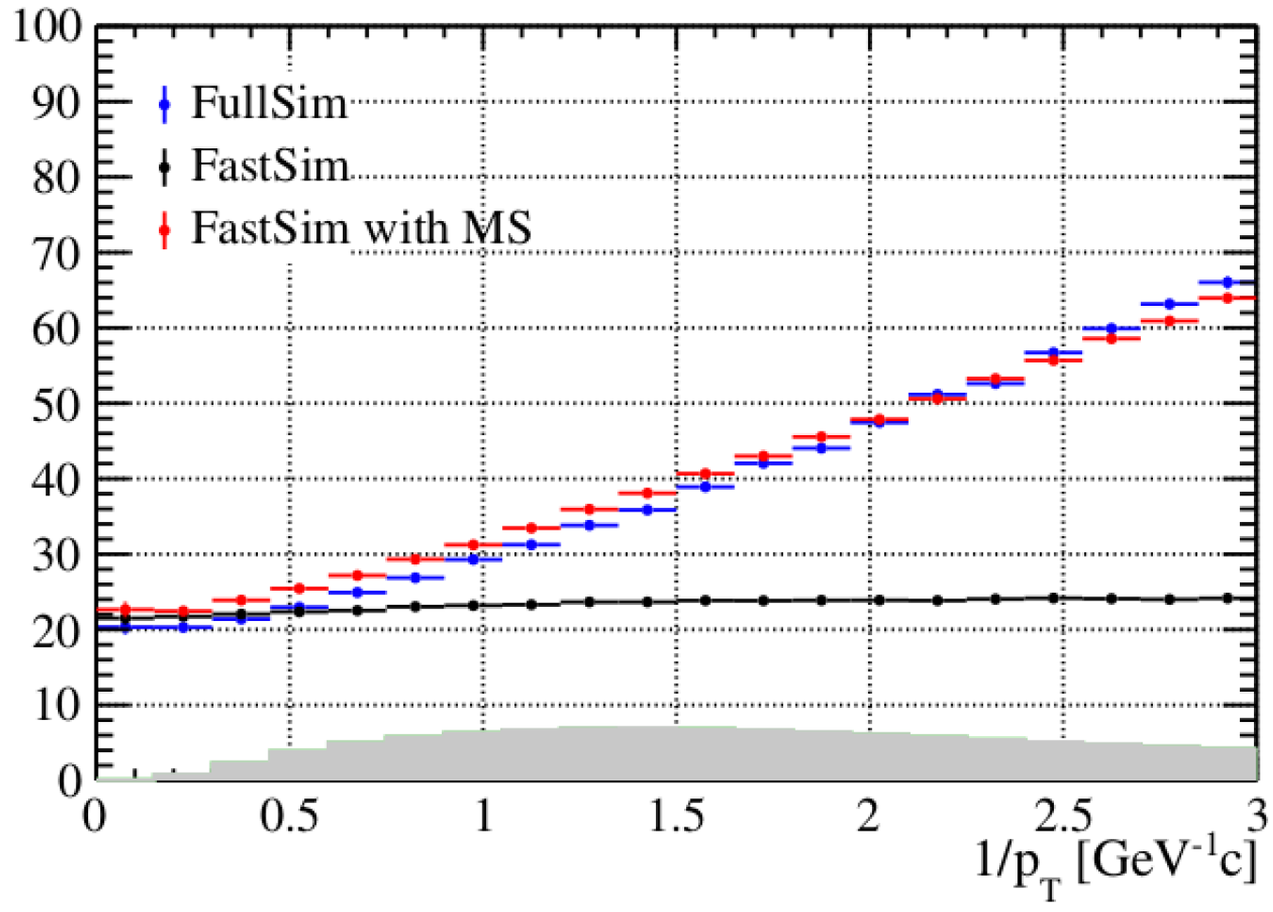
- with Multiple Scattering

	3hits			4hits		
	εVELO(%)	εLONG(%)	PGHOST(%)	εVELO(%)	εLONG(%)	PGHOST(%)
σ_t = 10 ps	96.6	95.8	0.2	98.1	97.7	<0.1
σ_t = 20 ps	97.1	96.4	0.3	98.4	98.1	0.1
σ_t = 30 ps	97.3	96.7	0.5	98.5	98.2	0.1
σ_t = 40 ps	97.4	96.9	0.7	98.6	98.3	0.1
σ_t = 50 ps	97.5	97.0	0.9	98.6	98.3	0.2
σ_t = 60 ps	97.5	97.0	1.2	98.6	98.3	0.2
No Timing	96.9	96.9	5.1	98.0	98.2	1.6

Matching with Laurent plot (WIP)

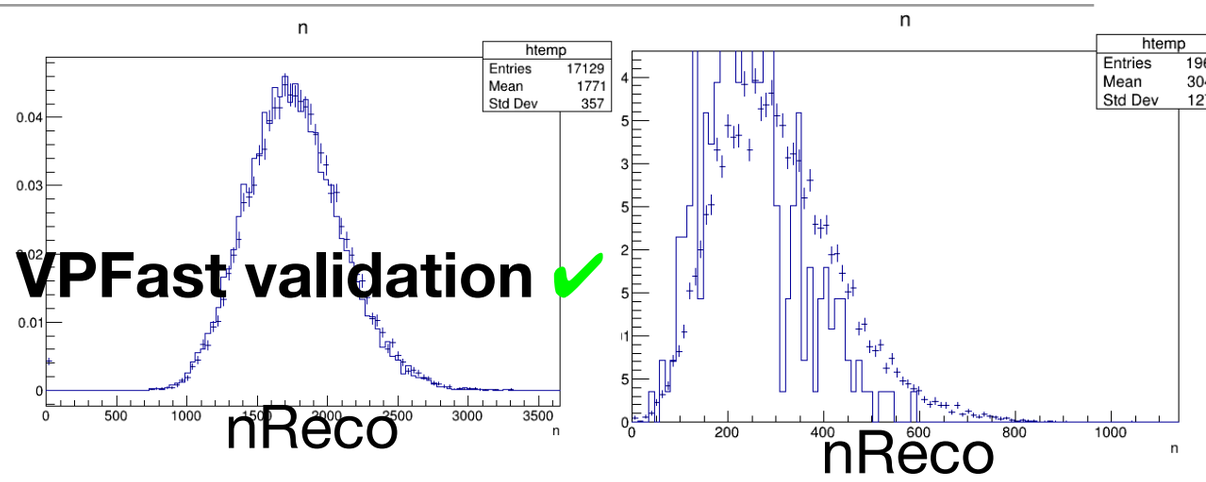
- Different sample of tracks used, i.e. different 1/pT distribution…
  Ongoing flux of emails…





VPfast and next steps

- Status of the public code:
  https://gitlab.cern.ch/acarbone/vpfastsim
  - Validated for no MS and with T
  - To be fixed with MS and with T
  - if you want to add sensor efficiency



- Use/check input from Benedetto with different geometries (within a few days)

- Clustering with and without timing

- Study clustering algorithm done so far with raw banks and how to implement on FPGA

- ——> results to be presented to next Velo U2 meeting

- Implement clustering with rawbanks (from VPFast) on FPGA
  (instruction from GBalbi)