

# Hit Rate Studies for Phase 1: Reliability of Simulation

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Hit Rate Studies for Phase 1: Reliability of Simulation  
EPIX / FPIX Workshop 14th & 15th of June 2018

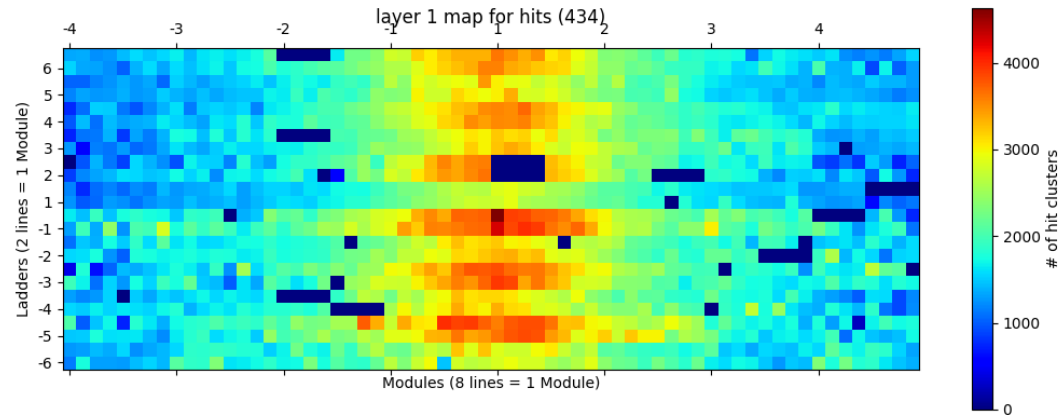
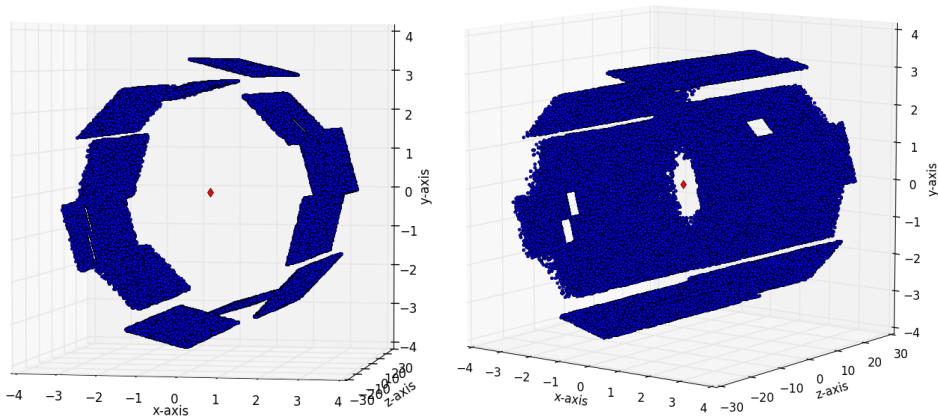
# Introduction

- What's the goal?
  - Verify the reliability of MC simulation for hit rates in the BPix and FPix detector
  - Get estimates of expected hit rates for the phase 2 geometry
- Analysis of 2017 data runs (using dataset: ZeroBias, prompt RECO; CMSSW 9\_2\_x)
  - #303832: 11 LumiBlocks, inst. luminosity:  $0.88\text{-}1.16 \times 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$  (24.09.2017)
  - #304562: 4 LumiBlocks, inst. luminosity:  $1.41\text{-}1.50 \times 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$  (06.10.2017)
  - #306091: 6 LumiBlocks, inst. luminosity:  $1.66\text{-}2.04 \times 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$  (02.11.2017)
- MC simulation file
  - /Min\_Bias\_13TeV\_pythia8\_TuneCUETP8M1/RunIISummer17DRStdmix-FlatPU0to75\_92X\_upgrade2017\_realistic\_v10-v2/GEN-SIM-RECO



# Analysis overview

- Calculation of cluster & pixel hit rates *per LumiBlock*
  - $R = \text{no. of colliding bunches} \cdot \text{frequency of LHC orbit} \cdot \frac{\text{no. of cluster/pixel hits}}{\text{online area}}$
- How to deal with offline/not-working modules and ROCs?
  - create a ROC hitmap for each LB
  - count # of hit clusters/pixel for each ROC → add ROC area only if at least one hit in ROC



# Analysis overview

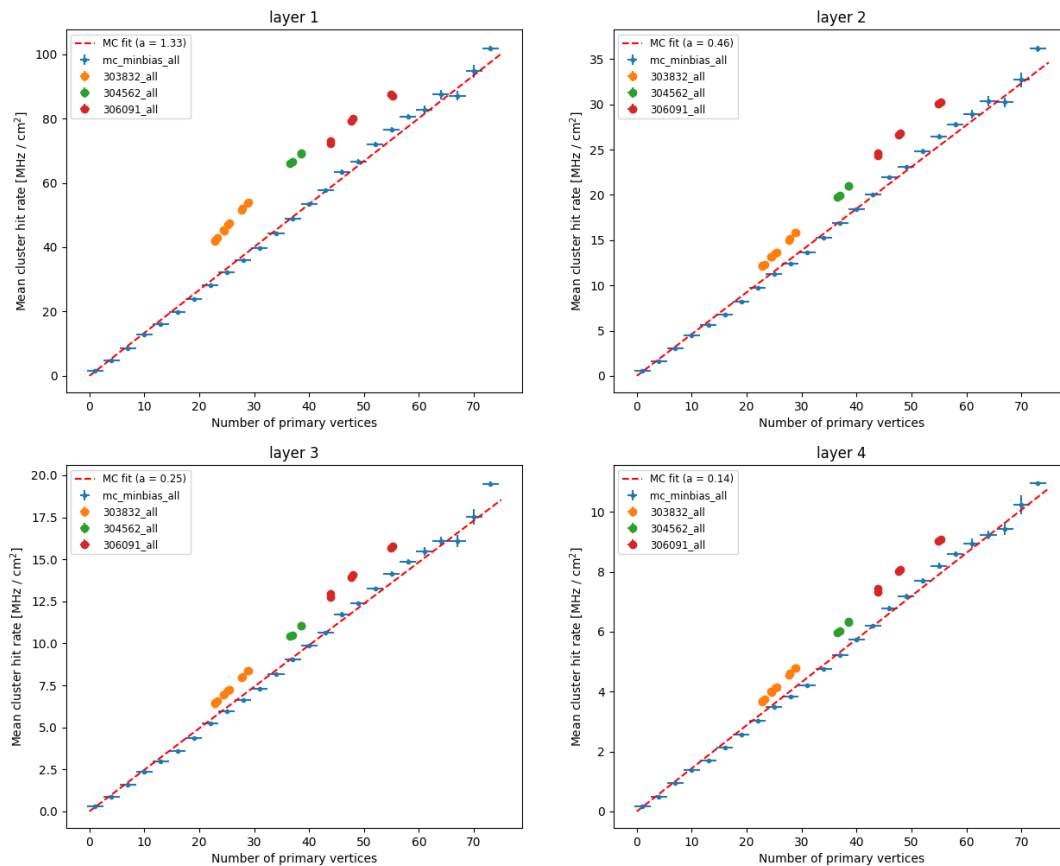
- Analysis was done in two different ways
  - on all reconstructed clusters of an event (“all”)
  - on clusters associated to a reconstructed track (“tracks”)
- MC sample analyzed in the same ways
  - cluster/pixel hit rates as a function of primary number of vertices (PV)
- Comparison of data and MC
  - data rates also as a function of PV (instead of inst. luminosity)



# Comparison in BPix – clusters

- Cluster hit rate is higher than expected
- Trend is the same in data and MC
- Deviation (data/MC)
  - layer 1:  $\sim 30\%$
  - layer 2-4:  $\sim 15\text{-}20\%$
- Deviation in L1 higher due to inefficiencies splitting up clusters ( $\rightarrow$  higher number of clusters)

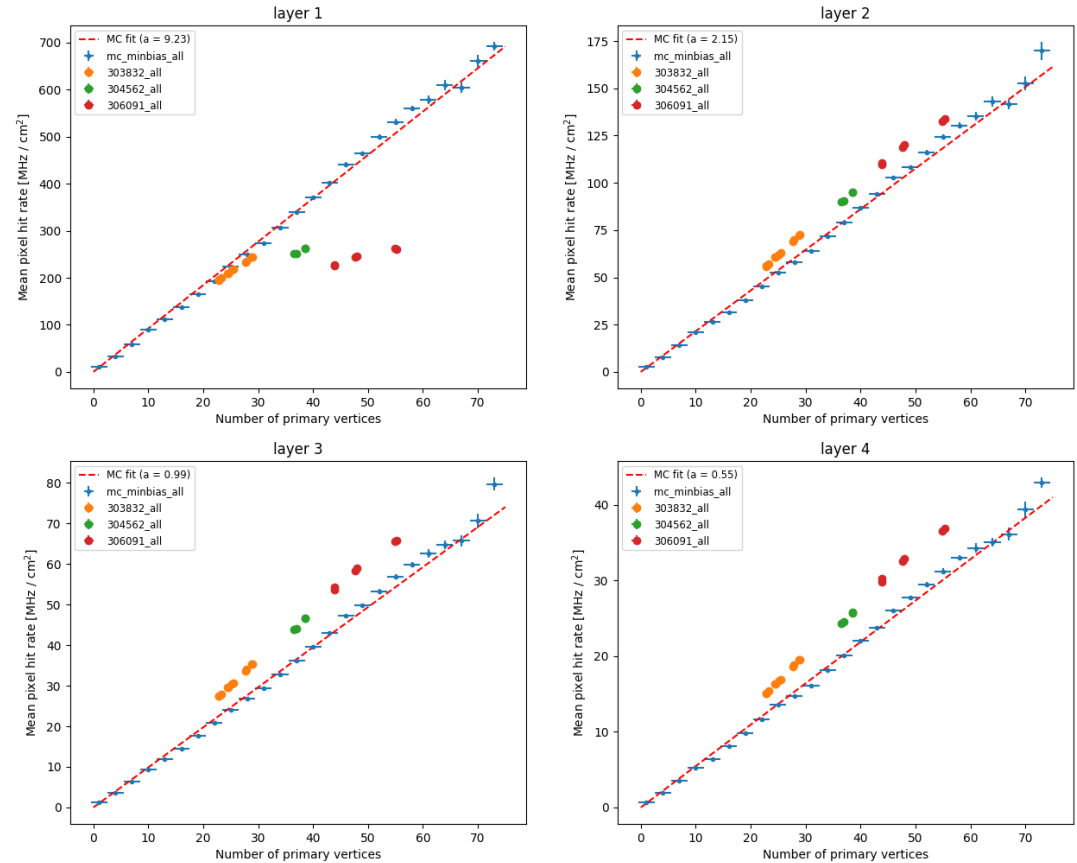
Mean cluster hit rate vs. number of PV (all)



# Comparison in BPix – pixels

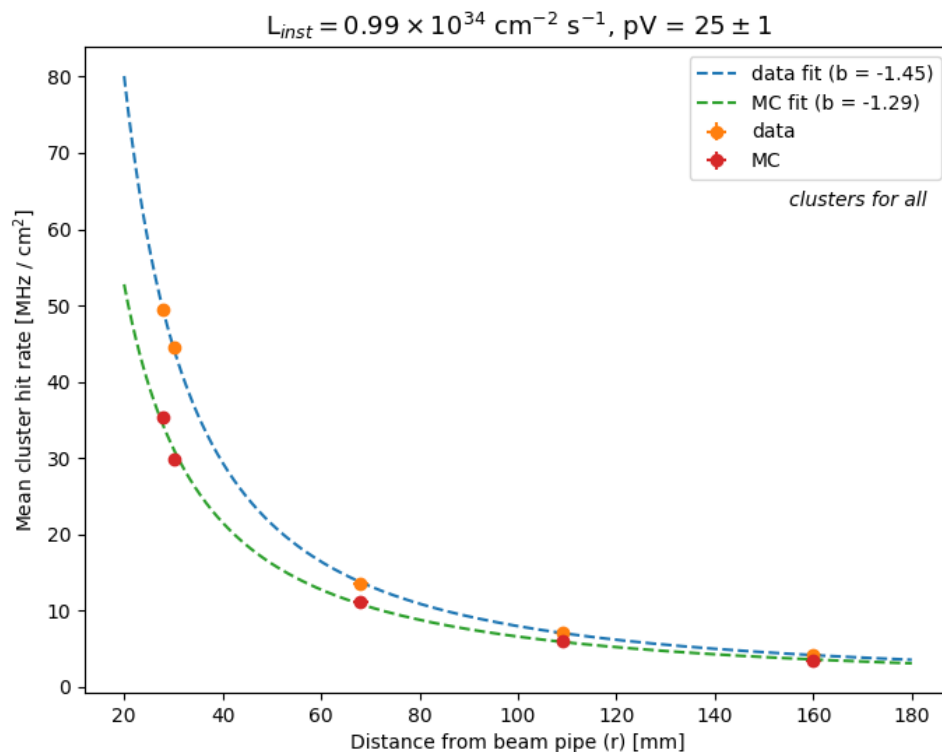
- Layer 1 pixel hit rate lower than other layers
- Inefficiencies in L1 for runs 304562 and 306091 (known)
- deviation (data/MC)
  - layer 2-4: ~ 20%

Mean pixel hit rate vs. number of PV (all)



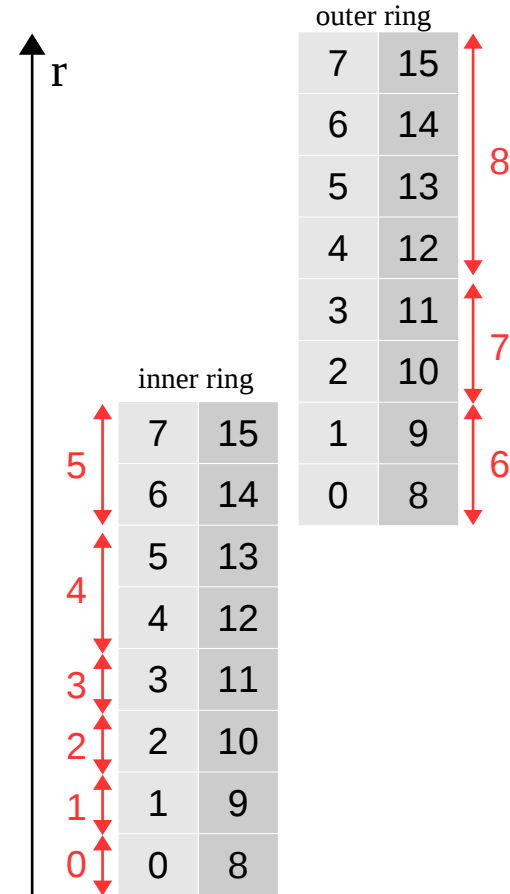
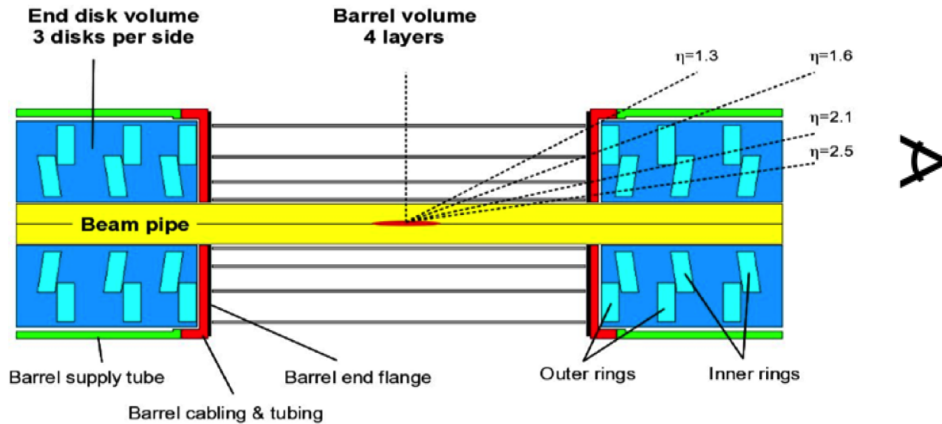
# Dependency of hit rate on radius from beampipe

- How does the hit rate depend on the distance (= radius) to the beampipe?
  - fit function:  $R = a \cdot r^b$
- Fit results:
  - data:  $b = -1.5$
  - MC:  $b = -1.3$
- can be used for extrapolation



# FPIX analysis

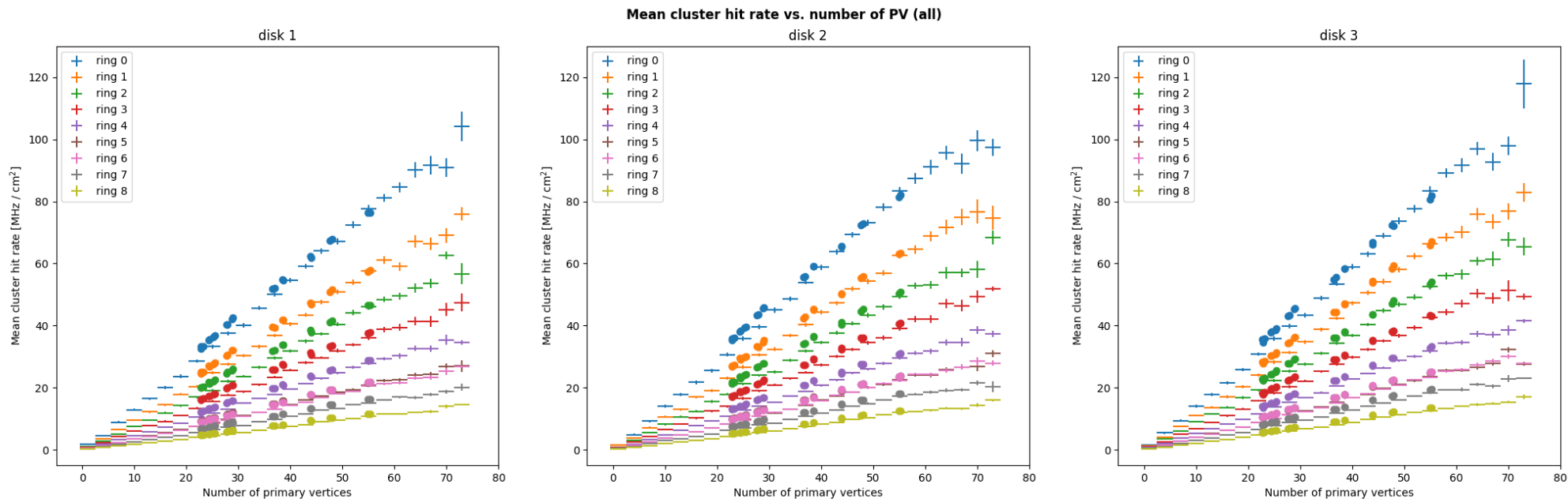
- Hit rates in FPIX as a function of radius
  - divide modules in 9 rings
- Calculation of rates like in BPix but for rings 0-8 instead of layers 1-4





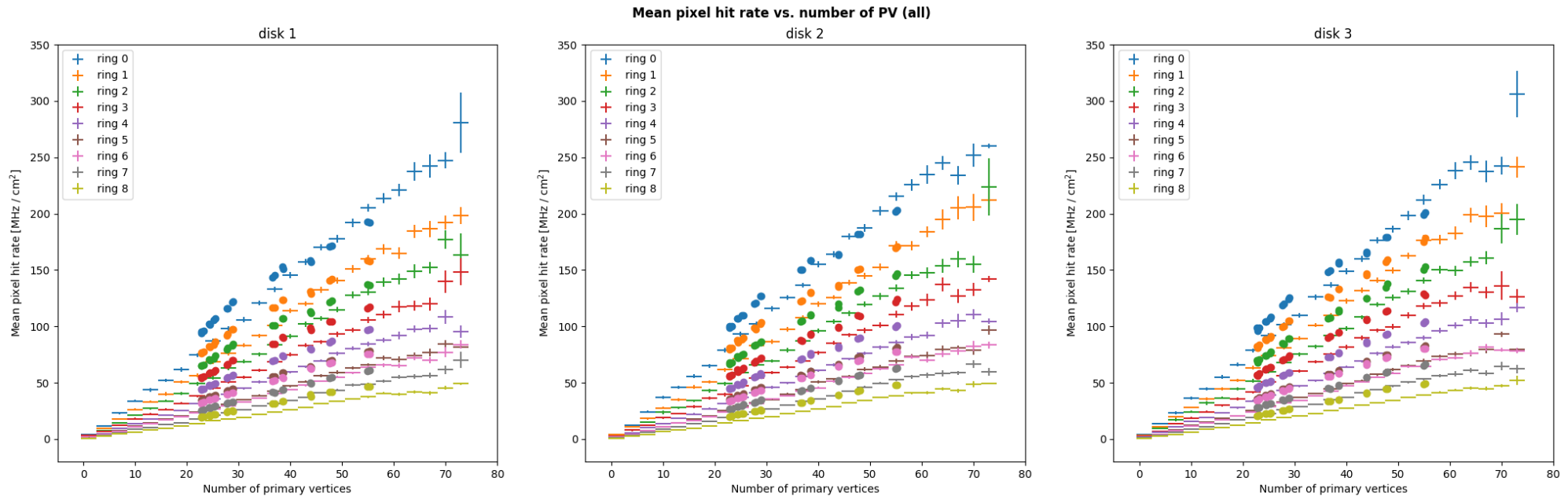
# Comparison in FPIX – clusters

- Hit rates higher for rings nearer to the beam axis → dependency on  $r$
- No significant difference between disks → no dependency on  $z$
- Deviation Data/MC:  $\sim 5\text{-}13\%$



# Comparison in FPIX – pixels

- Results for pixel hit rates look similar as for clusters
- Data/MC ratio higher for pixels than for clusters, but trend is right
  - deviation  $\sim 15\text{-}30\%$



# Conclusion

- Goal: Prove reliability of simulation in phase 1
- Results:
  - in BPix, simulation models data well with an underestimation of  $\sim 20\%$
  - in FPix, underestimations of  $\sim 10\%$  for clusters,  $\sim 15\text{-}30\%$  for pixels
- Conclusion:
  - We can trust simulation, but have to take into account a slight underestimation of hit rates.



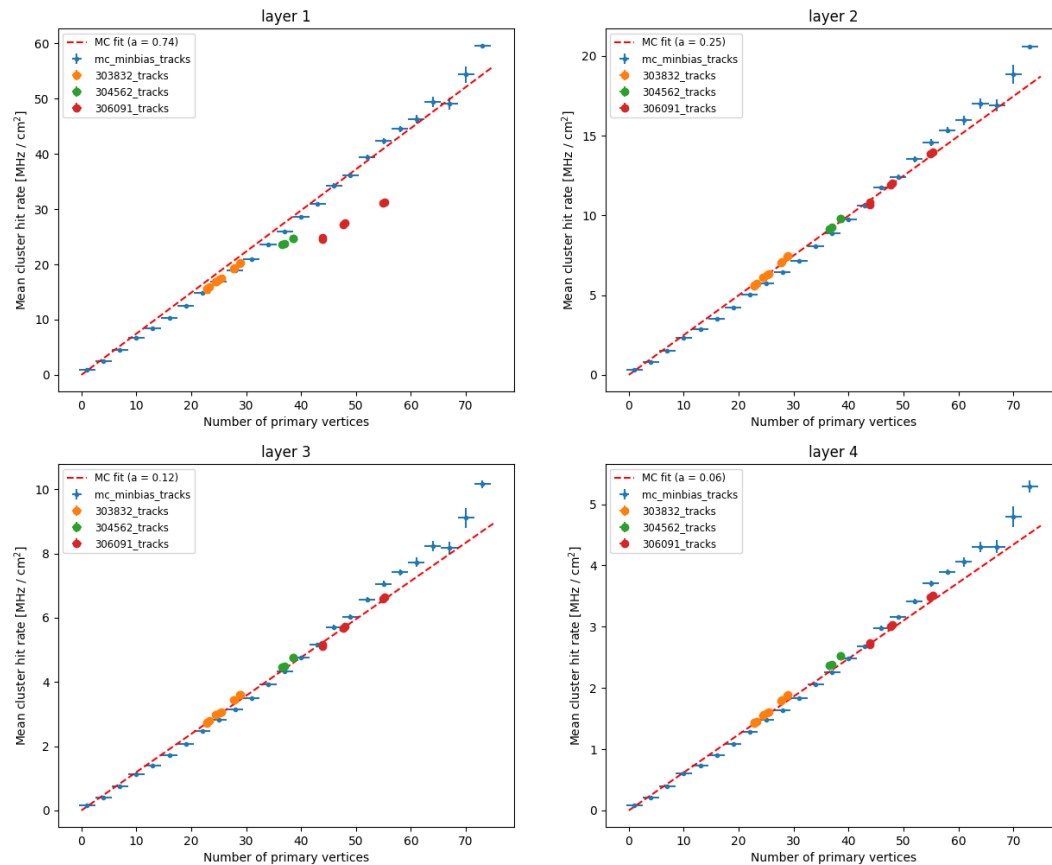
# Backup



# Comparison in BPix – clusters onTrack

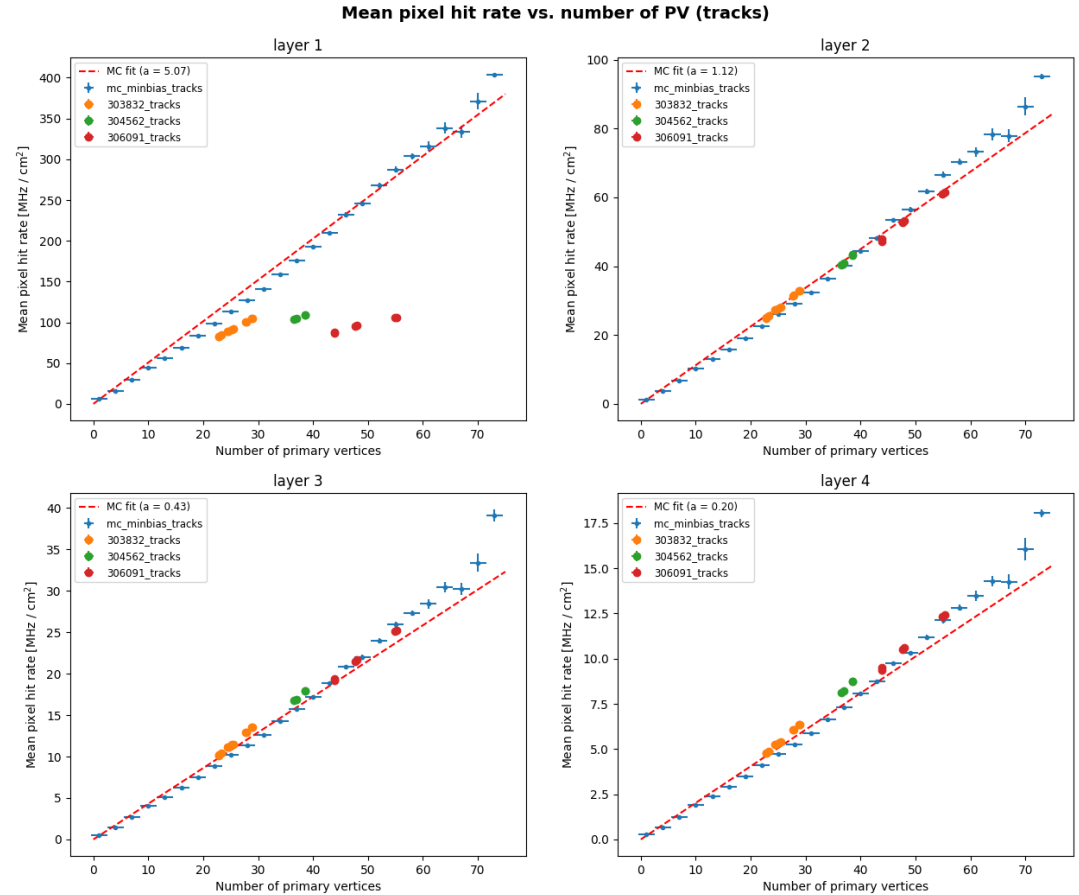
- Agreement of MC and data
- inefficiencies in run 306091 (known)
- Splitting of clusters has no significance on cluster rate  
→ only 1 cluster associated to the track

Mean cluster hit rate vs. number of PV (tracks)



# Comparison in BPix – pixels onTrack

- Agreement of MC and data for layers 2-4
- Layer 1: lose pixels in split clusters (only 1 cluster associated to the track)



# Cluster size in FPix

