

Beam-Beam Backgrounds @FCC-ee 91 GeV

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University



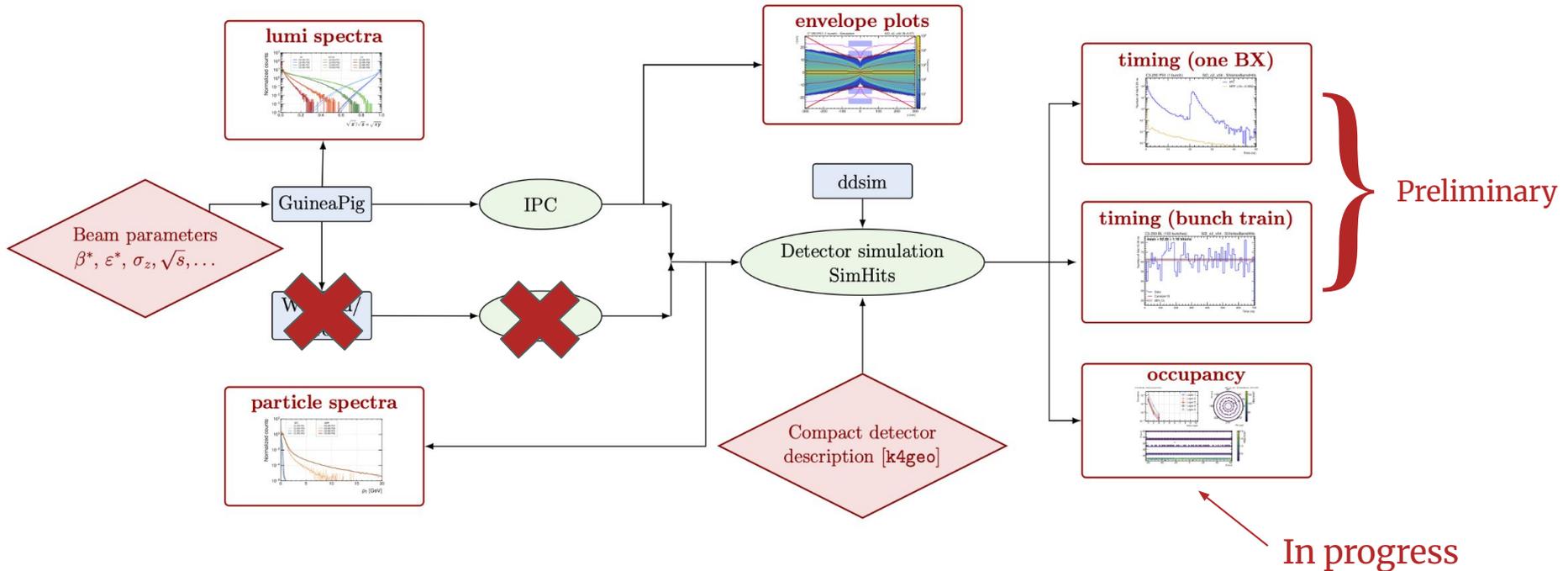
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Simulation Workflow

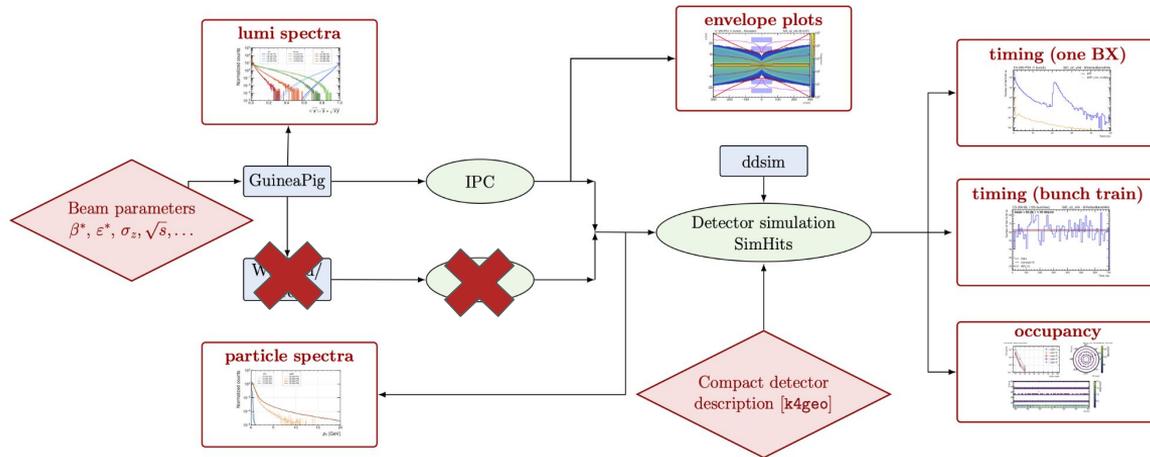
Framework from:
Dimitrios Ntounis et al 2026 JINST 21 P02024



Simulation Workflow

Ongoing efforts with Anna Kinderman, Peter Kicsiny, Spencer Gessner to integrate full ddsim with WarpX

Framework from:
Dimitrios Ntounis et al 2026 JINST 21 P02024



GuineaPig Simulation Setup(s)

```
$PARAMETERS:: FCCee_Z256_2T_grids8
{
  n_x=256;
  n_y=256;
  n_z=257;
  n_t=1;
  cut_x=150*sigma_x.1;
  cut_y=60.0*sigma_y.1;
  cut_z=2.0*sigma_z.1;
  n_m=100000;
  electron_ratio=1;
  do_elloss=1;
  store_beam=0;
  electron_ratio=1.;
  do_photons=1;
  photon_ratio=1.;
  store_photons=1;
  do_pairs=1;
  track_pairs=1;
  store_pairs=1;
  pair_ecut=0.000511;
  hadron_ratio=100000;
  do_hadrons=3;
  store_hadrons=1;
  grids=6;
  beam_size=1;
  pair_q2=2;
  pair_ratio=1.;
  do_lumi=0;
  num_lumi=200000;
  lumi_p=1e-28;
  do_bhabhas=0;
  bhabha_sca1=5*1e-29;
  bhabha_ecmload=91.2;
  rndm_seed=100000;
  load_events=0;
  do_dump=0;
  dump_step=n_z-1;
}
```

Jan

```
$PARAMETERS:: FCCee_Z_LCC_par
{
  n_x=512 ;
  n_y=512 ;
  n_z=129 ;
  n_t=5 ;
  cut_x=150*sigma_x.1;
  cut_y=100.0*sigma_y.1;
  cut_z=4.0*sigma_z.1 ;
  n_m= 100000;
  electron_ratio=1;
  do_elloss = 1 ;
  store_beam=0 ;
  electron_ratio=1. ;
  do_photons=1 ;
  photon_ratio=1. ;
  store_photons=1 ;
  do_pairs= 1;
  track_pairs=1;
  store_pairs=1;
  pair_ecut=0.000511;
  hadron_ratio=100000;
  do_hadrons=3;
  store_hadrons=1;
  grids=7 ;
  beam_size = 1;
  pair_q2 = 2 ;
  pair_ratio = 1. ;
  do_lumi=1 ;
  num_lumi=200000 ;
  lumi_p=1e-28;
  do_bhabhas=0;
  bhabha_sca1=5*1e-29;
  bhabha_ecmload=91.2;
  rndm_seed=997850;
  load_events=0;
}
```

Mirella

Distinct configurations possible:

- Multiple different cards.
- Two different codes (CLIC & Jan).

First LCC Lattice (2025)

```
$ACCELERATOR:: FCCee_Z_LCC_V105
{
  energy=45.6;
  particles=20.20;
  beta_x=90.00;
  beta_y=0.70;
  dist_z.1=0;dist_z.2=0;
  sigma_x=7993.75;
  sigma_y=35.20;
  sigma_z=16700.00;
  offset_x=0.0;
  offset_y=0.0;
  n_b=1;
  f_rep=1;
  angle_x=-0.015;
  charge_sign=-1;
}
```

```
$ACCELERATOR:: FCCee_Z
{energy=45.6;
  particles=17;
  beta_x=150;
  beta_y=0.8;
  sigma_z=12100;
  dist_z.1=0;
  dist_z.2=0;
  sigma_x=6360;
  sigma_y=28.3;
  offset_x=0.0;
  offset_y=0.0;
  n_b=1;
  f_rep=1;
  angle_x=-0.015;
  charge_sign=-1;
}
```

Moving to Central Samples



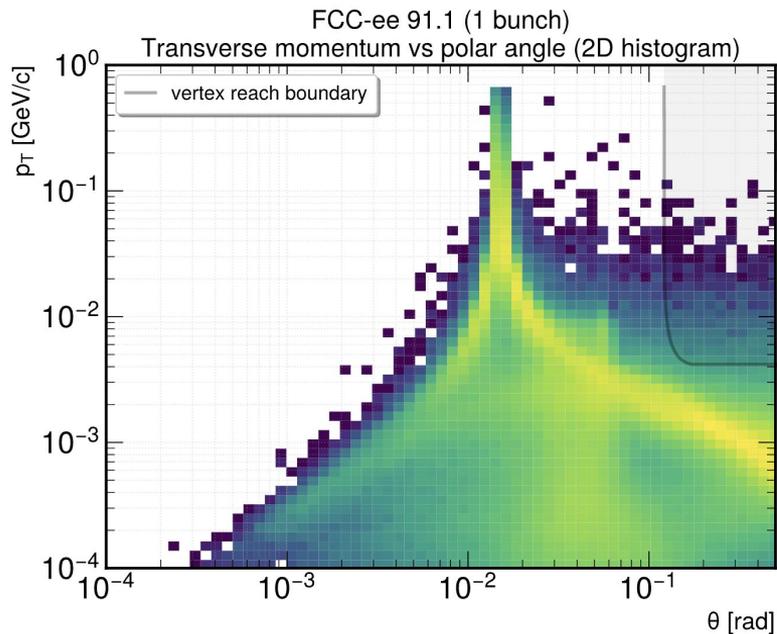
To make use of high stats, we use the LCC IPC files.

```
[[dntounis@lxplus993 ~]$ cd /eos/project/f/fcc-ee-mdi/BIB
[[dntounis@lxplus993 BIB]$ ls
GHC  LCC  README.md
[[dntounis@lxplus993 BIB]$ du -sh *
6.9G  GHC
1.8G  LCC
2.5K  README.md
```

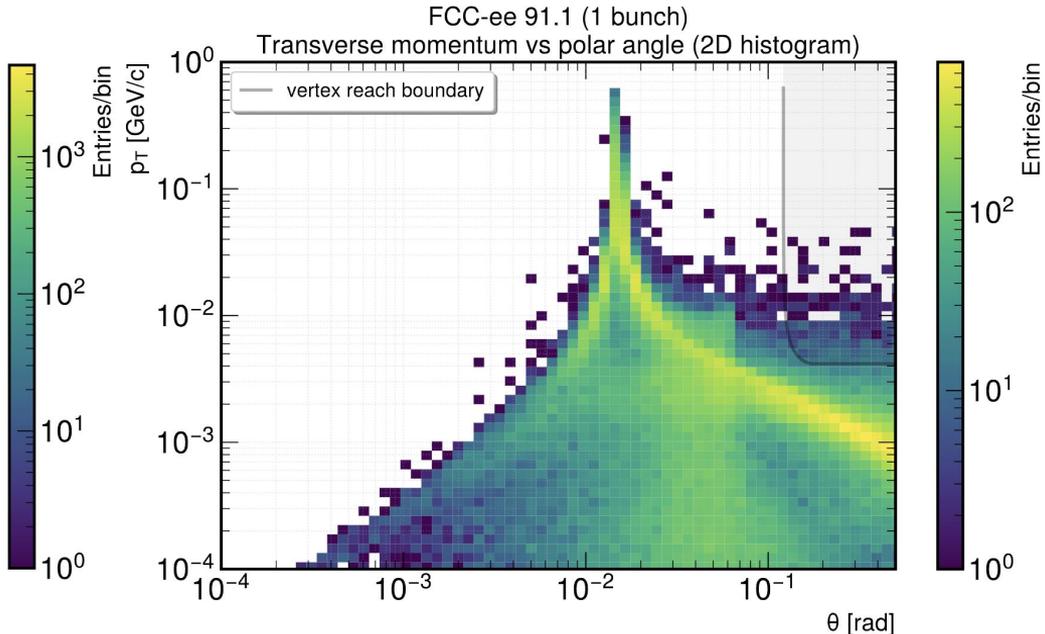
```
$ACCELERATOR:: FCCee_Z_LCC_V105
{
energy=45.6;
particles=20.20;
beta_x=90.00;
beta_y=0.70;
dist_z.1=0;dist_z.2=0;
sigma_x=7993.75;
sigma_y=35.20;
sigma_z=16700.00;
offset_x=0.0;
offset_y=0.0;
n_b=1;
f_rep=1;
angle_x=-0.015;
charge_sign=-1;
}
```

IPP Production

Central Samples (1000 seeds)



Our Samples (60 seeds)



Identical modulo stats.

Detector Simulation

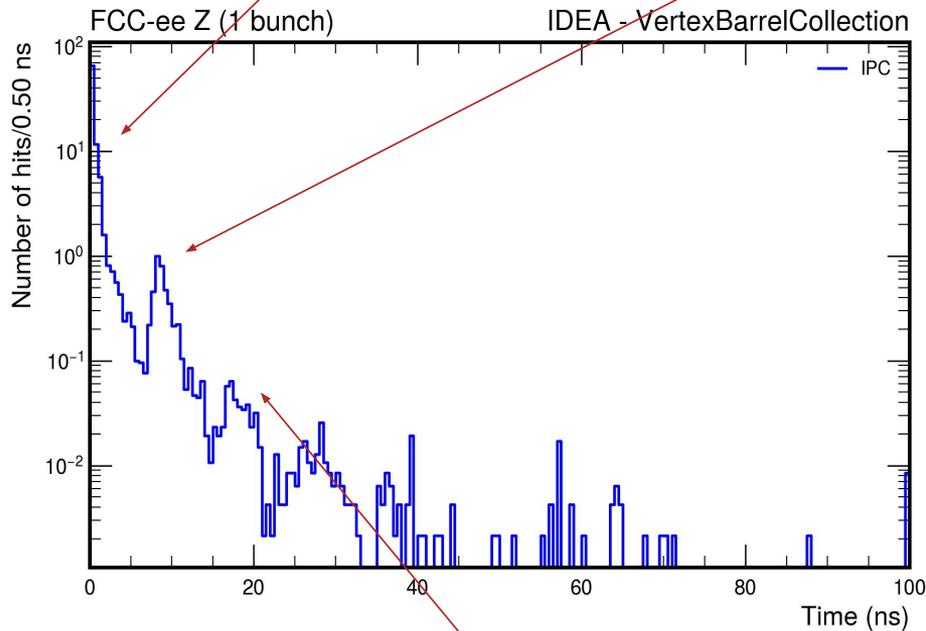
- Run Geant4-based full ddsim using the Key4Hep software stack.
- We select the IDEA detector geometry.
 - IDEA_o1_v03 from Key4Geo
- Crossing angle boost = 15mrad
- Using ~1000 seeds for this talk.



Timing Distribution Within a BX (VXD Barrel)

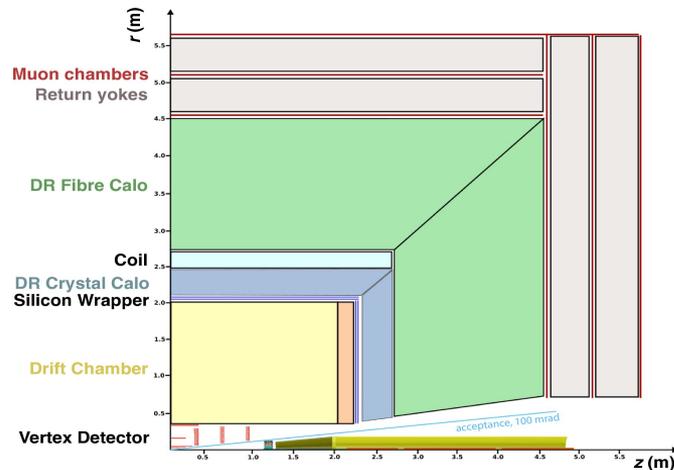
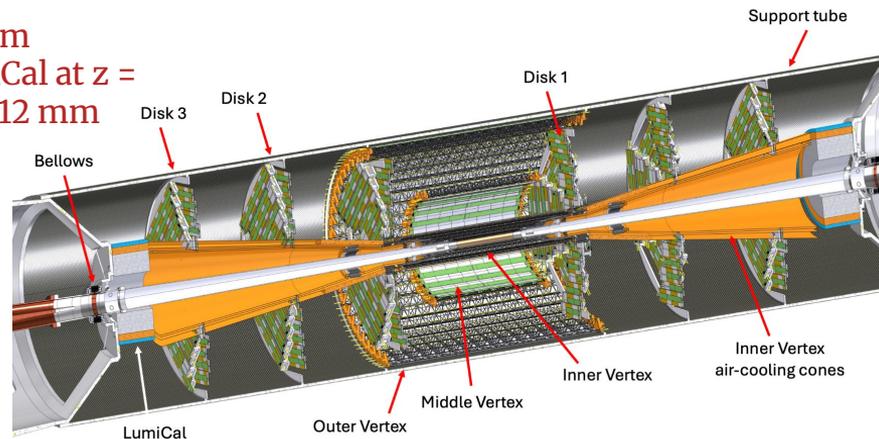
Virtually all hits contained in time within the bunch spacing.

Secondary peak (~10 ns) from back-scattering off of LumiCal at $z = 1074\text{--}1187\text{ mm}$ and $r = 55\text{--}112\text{ mm}$

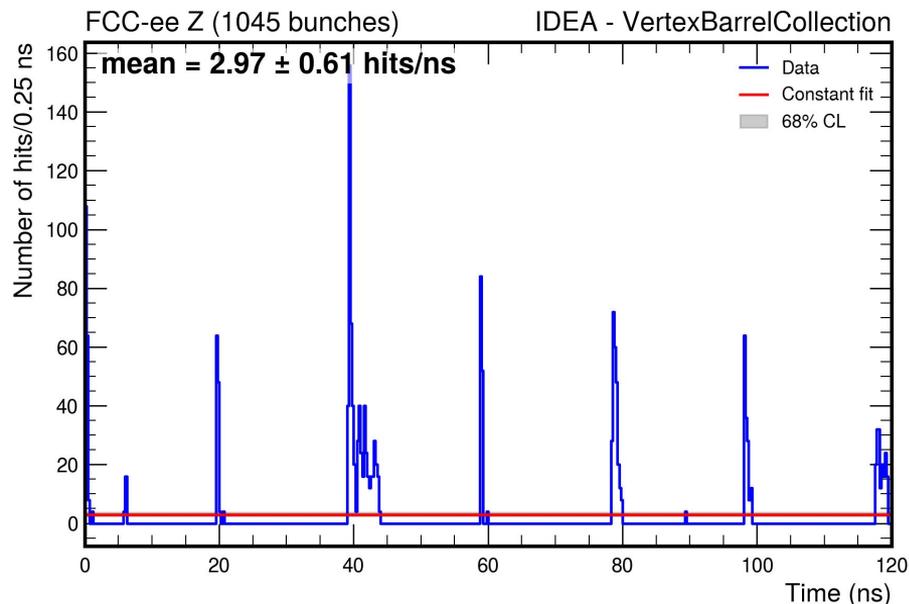
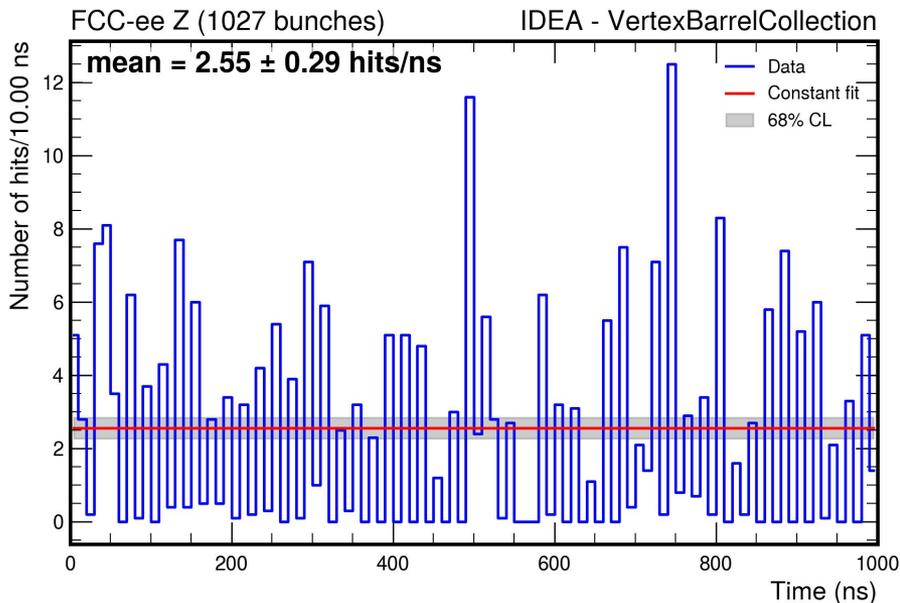


Bunch spacing ~ 19.6ns

Peak (17 ns) from back-scattering off of Preshower/Solenoid



Timing Distribution Over Multiple BX (VXD Barrel)



Crossing angle boost = 15mrad

Layer Occupancy

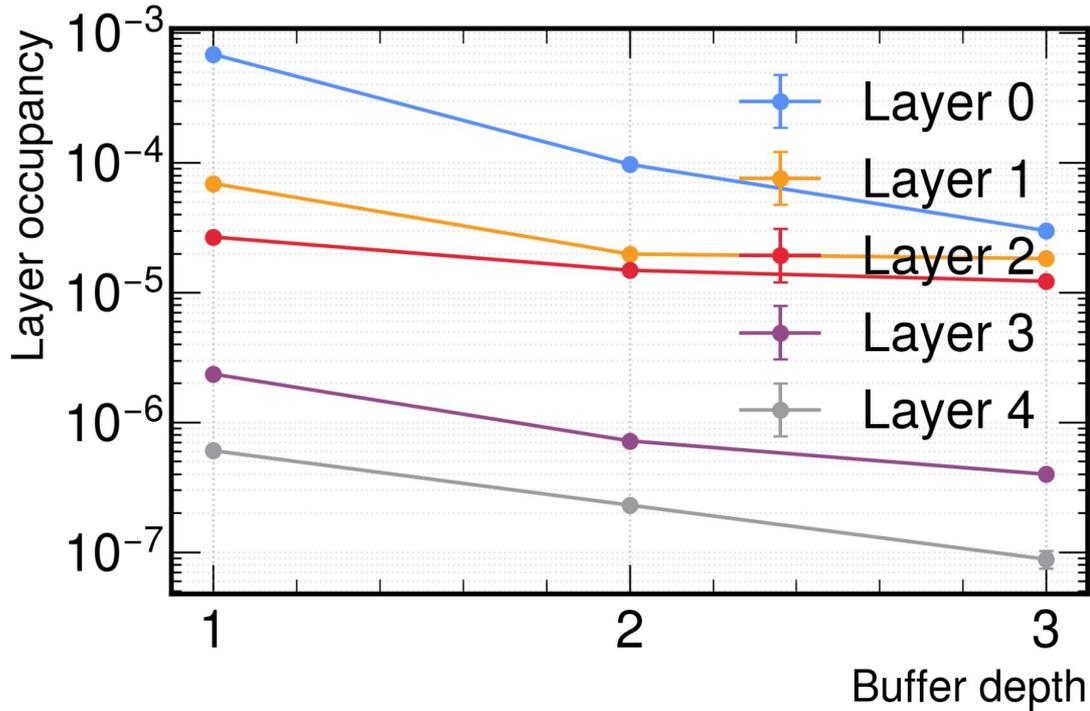
We define the layer occupancy as:

$$\text{layer occupancy}(\ell_D, \text{BD}) = S_D \cdot C_D \cdot \frac{\# \text{ of cells in } \ell_D \text{ with } \geq \text{BD hits}}{\# \text{ of cells in } \ell_D}$$

- ℓ_D is the detector layer under consideration.
- BD is the buffer depth.
 - Max number of hits that can be stored.
- S_D, C_D , are the safety and cluster size factors:
 - S_D set to 2.
 - C_D set to 3 for VXD, 2 otherwise.

Characterizes the fraction of “dead” cells that receive a number of hits exceeding their buffer depth after an entire bunch train.

Layer Occupancy (VXD Barrel)



- Integrated over 510 bunches:
 - 10 μ s readout window
- Fairly low occupancy environment.
- Below general recommendations at $O(10^{-4})$ - $O(10^{-3})$.

Next Steps

- Use the full sample.
- Investigate and validate more detector layers.
- Move onto H, ttbar operation?



Thank you! Questions?

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Timing Distribution Within a BX (VXD Endcap)