

SAND TPC simulations

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The analysis introduction

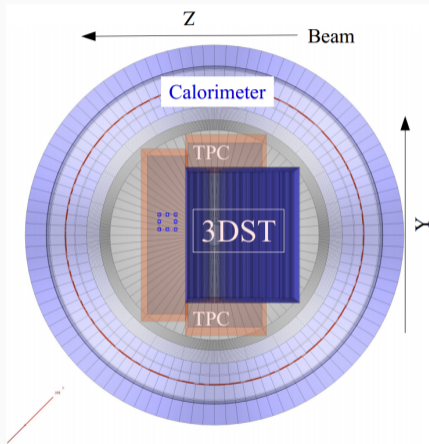
Goals of the analysis

- Estimating the resolution requirements with DUNE beam
- Evaluate the impact of different parameters such as the pad size, charge spreading (RC) and electronics shaping time.

Data used

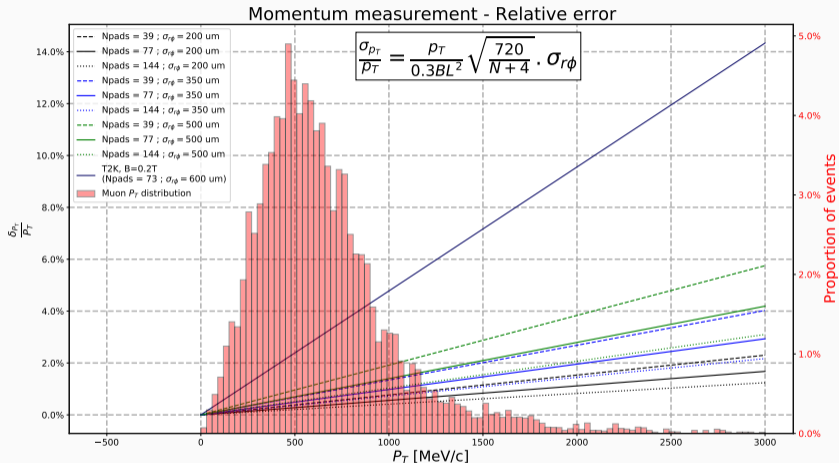
- Only FHC for now
- Interactions simulated in the whole detector (Guang's simulations)

The TPCs in SAND



- 3 TPCs :
 - DOWNSTREAM : (x,y,z)
 $3.3\text{ m} \times 3\text{ m} \times 0.77\text{ m}$
 - BOTTOM and TOP : (x,y,z)
 $3.3\text{ m} \times 0.57\text{ m} \times 1.41\text{ m}$
- Cathode in the middle of the TPCs (x direction)
- 2 readout planes for each tpc

Estimation of P_T resolution



A resolution $< 2\%$ can be achieved if the occupancy is reasonable.

Events generation

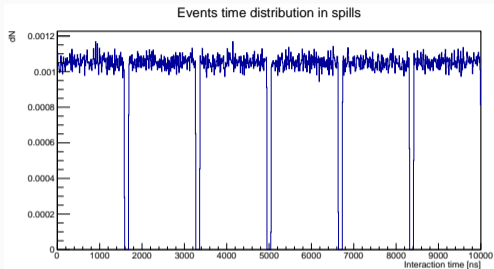
- Events are generated with GENIE.
- Energy deposits in all the active areas of the detector are computed by GEANT.

TPC simulation

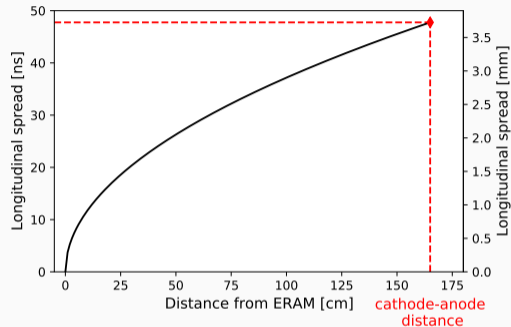
1. Events are given a vertex time according to the beam time profile.
2. Energy deposition segments of charged particles are projected onto ERAMs
3. Drift effects taken into account : drift time, longitudinal spread, transversal spread
4. Fixed charge spreading applied on pads
5. Each pad hit is stored
6. Computing overlaps for each pad in a given time window (proxy for spreading time + shaping time).

From then we study the number of tracks with overlaps and the number of overlapping pads for events with more than 2 tracks.

Timing



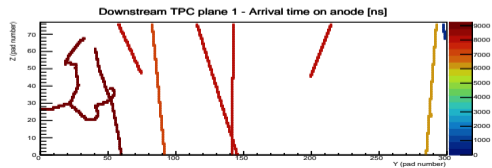
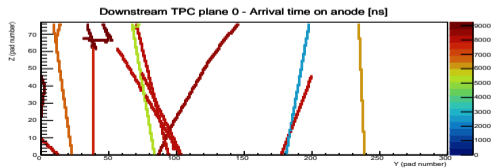
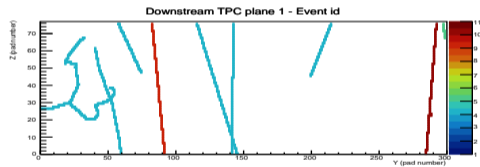
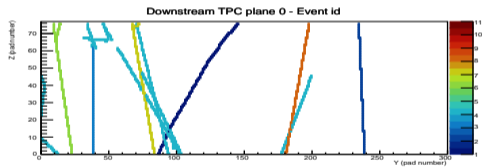
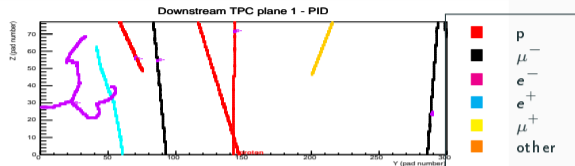
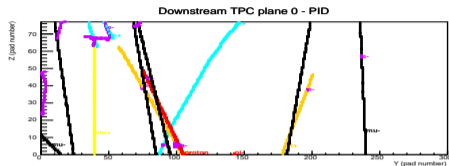
- 10 μs spills of 6 100 ns separated bunches
- Maximum longitudinal spread is ~ 50 ns



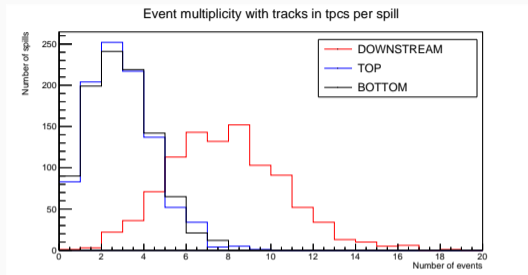
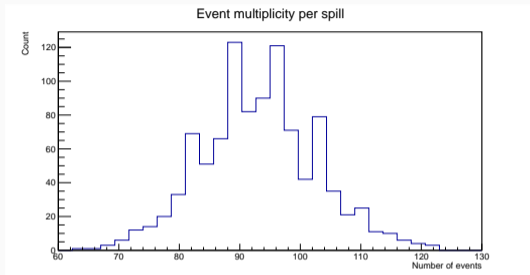
T2K gas parameters :

- $v_{\text{drift}} = 7.8 \text{ cm } \mu\text{s}^{-1}$
- $\sigma_L = 290 \text{ } \mu\text{m} / \sqrt{\text{cm}}$

Full spill example

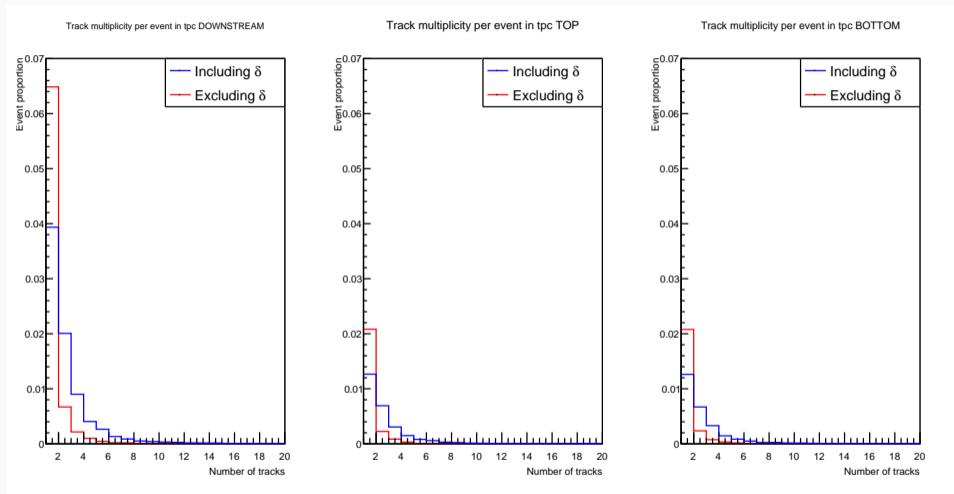


Statistics about events



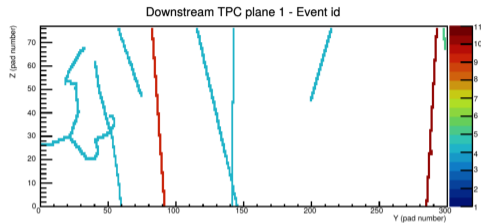
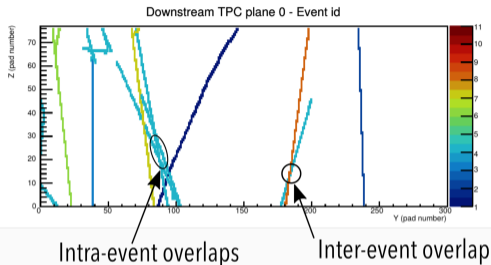
- 93,017 simulated events in 1,000 spills
- Only 1,714 interactions inside 3DST
- 1,363 3DST interactions lead to at least 1 track in a TPC
- 8,104 ECAL+KLOE interactions lead to at least 1 track in a TPC

Track multiplicity per event



Events with 0 tracks are not shown but are taken into account in the event proportions.

Overlaps

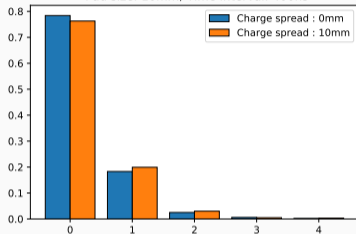


2 different kind of overlaps are considered

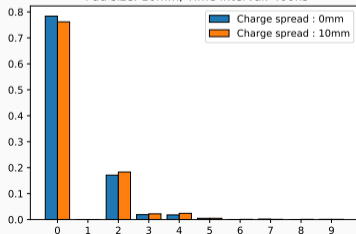
- inter-event overlaps : overlaps between tracks of two different events from the same spill
- intra-event overlaps : overlaps between tracks of the same event

Evolution of inter-events overlaps with charge spread - DOWNSTREAM

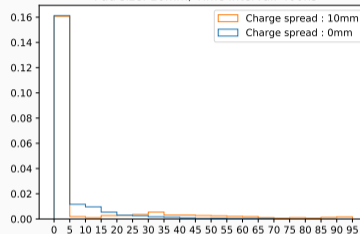
Number of overlapping events per spill DOWNSTREAM -
Pad size: 10mm; Time interval: 400ns



Number of overlapping tracks per spill DOWNSTREAM -
Pad size: 10mm; Time interval: 400ns



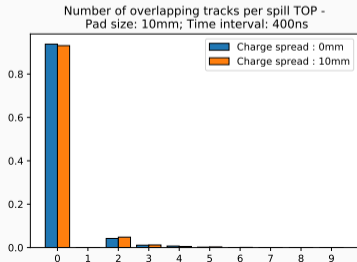
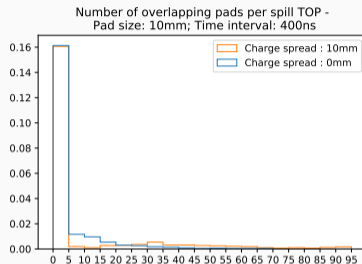
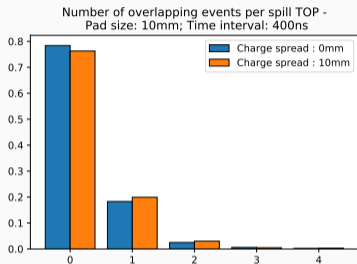
Number of overlapping pads per spill DOWNSTREAM -
Pad size: 10mm; Time interval: 400ns



- 10 mm charge spread on each side
⇒ 3 pads multiplicity.

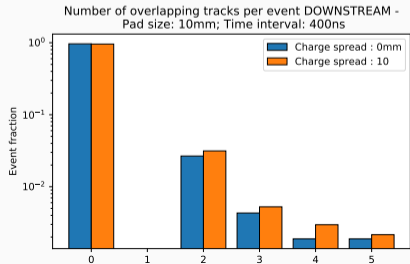
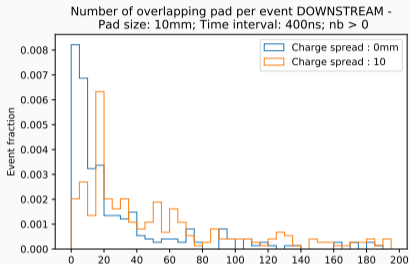
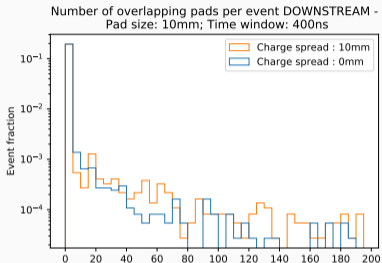
The introduction of charge spreading slightly increases the number of inter-events overlaps.

Evolution of inter-events overlaps with charge spread - TOP



We see the same kind of effect for the TOP tpc but with less importance.

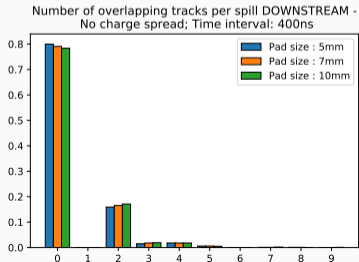
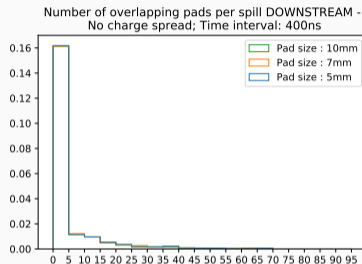
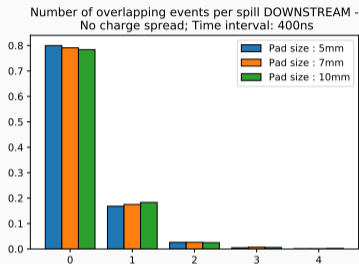
Evolution of intra-event overlaps with charge spread - DOWNSTREAM



Only events with at least 1 track in the TPC are considered.

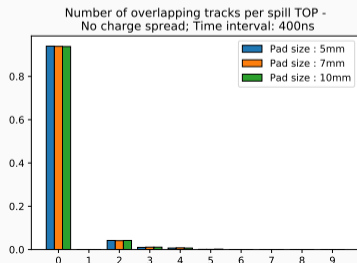
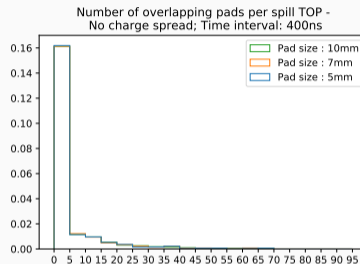
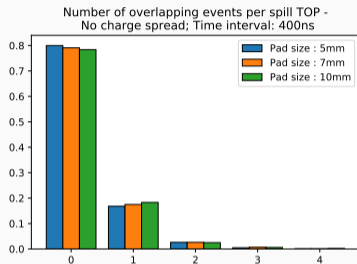
Charge spreading increases the amount of overlapping pads.

Evolution of inter-events overlaps with pad size - DOWNSTREAM



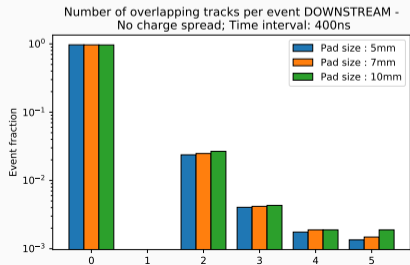
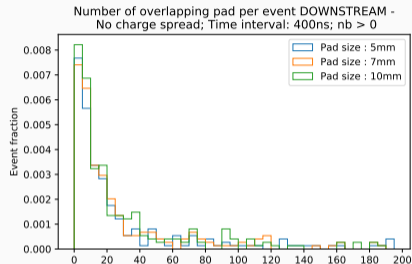
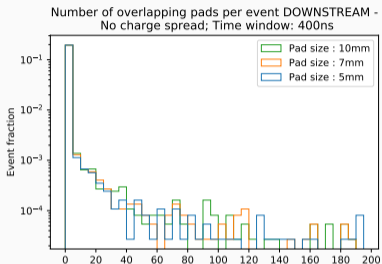
Using smaller pads only slightly reduces the number of inter-events overlaps.

Evolution of inter-events overlaps with pad size - TOP



We see the same kind of effect for the TOP tpc but with less importance.

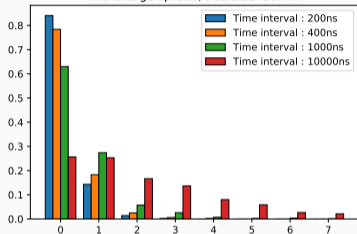
Evolution of intra-event overlaps with pad size - DOWNSTREAM



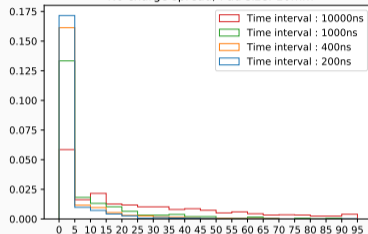
Pad size seems not to impact largely the number of overlaps.

Evolution of inter-events overlaps with time interval - DOWNSTREAM

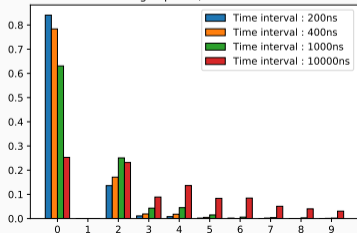
Number of overlapping events per spill DOWNSTREAM
No charge spread; Pad size: 10mm



Number of overlapping pads per spill DOWNSTREAM
No charge spread; Pad size: 10mm

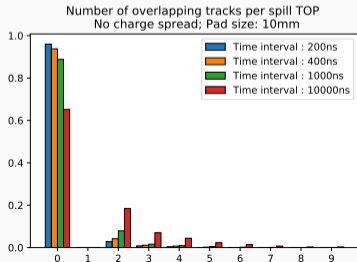
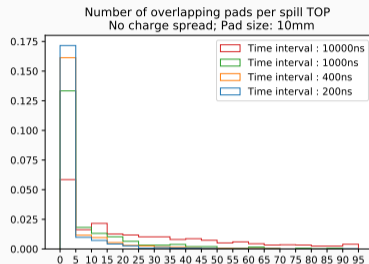
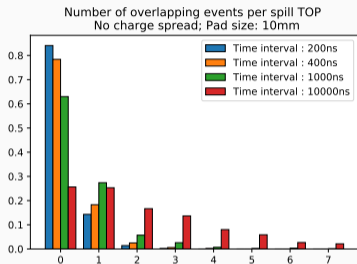


Number of overlapping tracks per spill DOWNSTREAM
No charge spread; Pad size: 10mm



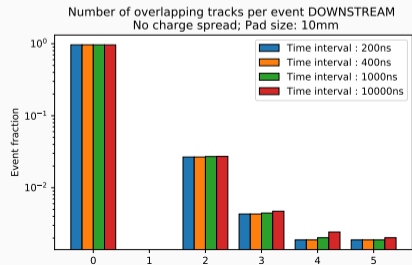
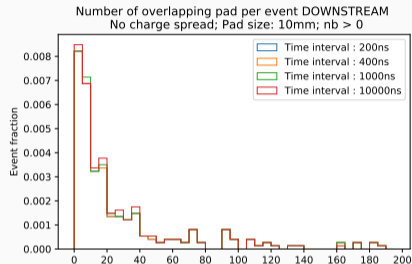
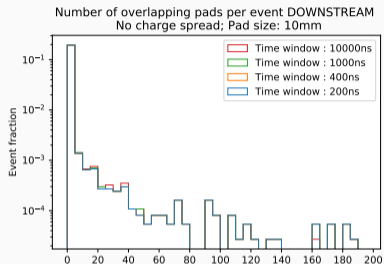
The shaping time is very important to discriminate the tracks in time and impacts a lot inter-events overlaps.

Evolution of inter-events overlaps with time interval - TOP



We see the same kind of effect for the TOP tpc but with less importance.

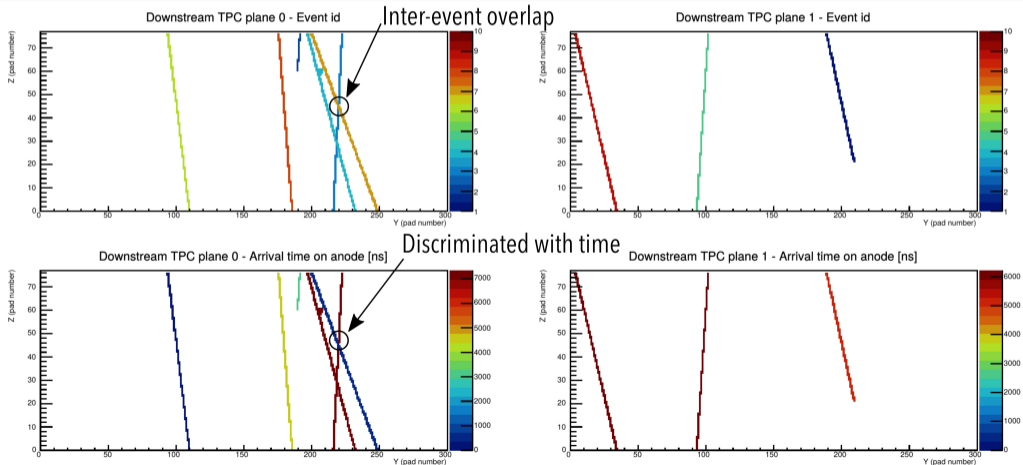
Evolution of intra-event overlaps with time interval - DOWNSTREAM



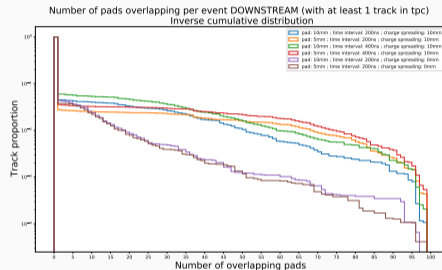
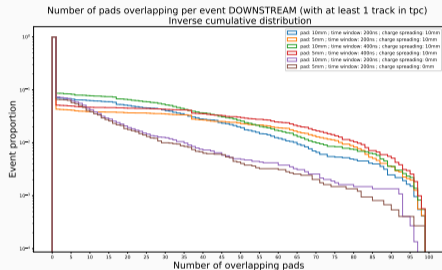
Time window has no effect on the number of overlapping pads for intra-event overlaps.

Conclusion on inter-events overlaps

- The amount of inter-events overlaps is driven by the choice of the shaping time.
- Charge spreading and pad size only have a moderate effect for this case of overlaps.

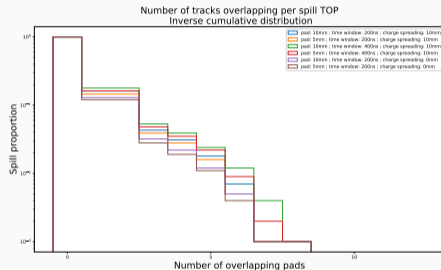
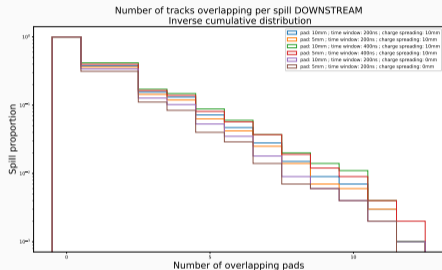


Total number of overlaps - DOWNSTREAM



Depending on the configuration, from 4 % to 9 % of events have at least one overlapping pad (3 % to 6 % of tracks).

Total number of overlaps



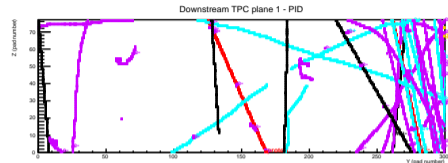
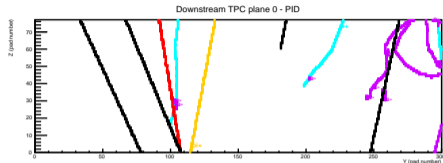
Depending on the configuration, from 3 % to 4 % of spills have overlapping tracks in DOWNSTREAM TPC (1 % to 2 % of tracks for TOP TPC).

Conclusions

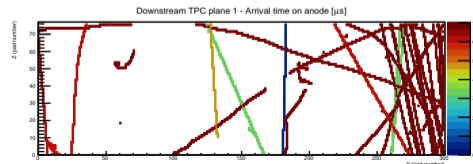
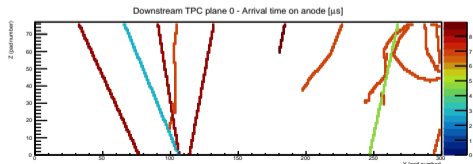
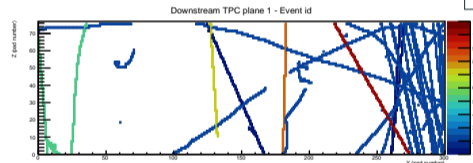
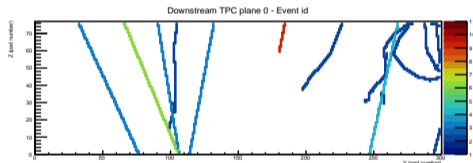
- Choosing a low enough shaping time is necessary to ensure event separation in a given spill.
- Charge spreading increases the amount of overlaps mostly inside given events.
- Pad size seems to have only little effect on the overlaps (at least in the considered range).
- Reducing pad size allows to reach better p_T resolutions but the resolution seems already good for 1cm pads.

Backup slides

Understanding events with a lot of overlapping pads



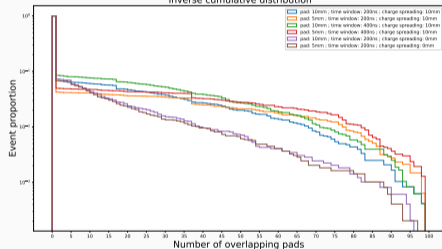
p
 μ^-
 e^-
 e^+
 μ^+
other



Electromagnetic shower from ECAL interaction

Total number of overlaps - TOP/BOTTOM

Number of pads overlapping per event TOP/BOTTOM (with at least 1 track in tpc)
Inverse cumulative distribution



Number of pads overlapping per event TOP/BOTTOM (with at least 1 track in tpc)
Inverse cumulative distribution

