Pileup studies in run 8 data
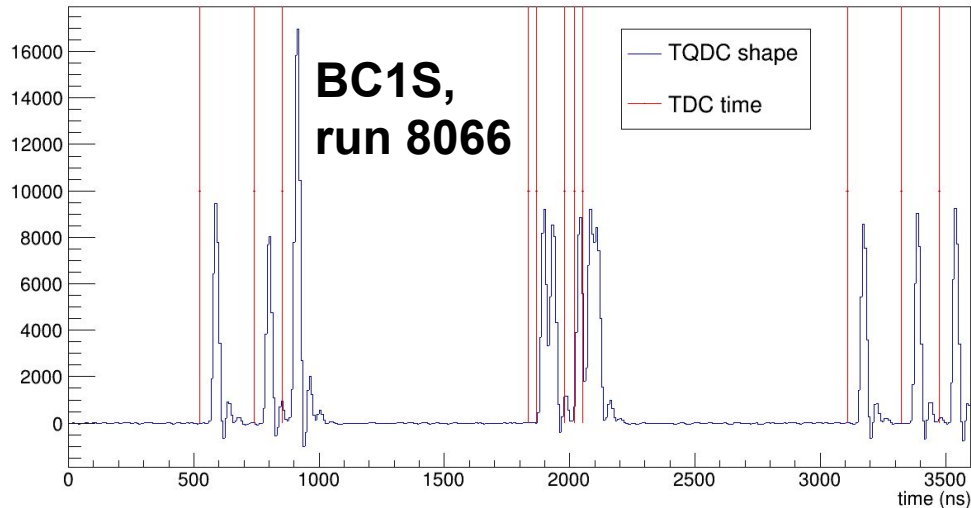
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BM@N Collaboration meeting, 14/05/2024

Aim

- Study frequency and effect of
  - Close pileup (narrow window around mean trigger time)
  - Distant pileup
- Develop a BmnRoot task providing the information about pileup events (time to closest hits in BC, probability of second interaction, etc.)


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Data

- Xe+CsI @ 3.8A GeV (production 02.24)
- Physics runs with mixed trigger
- Technical runs with BT trigger: 7426 and 8281

Analysis procedure

- Collect run-by-run distributions of integrals for single BC1 and FD hits
- Normalize BC1 and FD integrals with means of these distributions
- Plot distributions of normalized BC1 and FD integrals in varying time windows around mean trigger time
- Estimate frequency of multiple BC1 hits and interactions in these narrow windows (close pileup) for different triggers
- Estimate frequency of single interaction in case of close pileup for different triggers
- Estimate the effect of pileup on data analysis (**ongoing**)
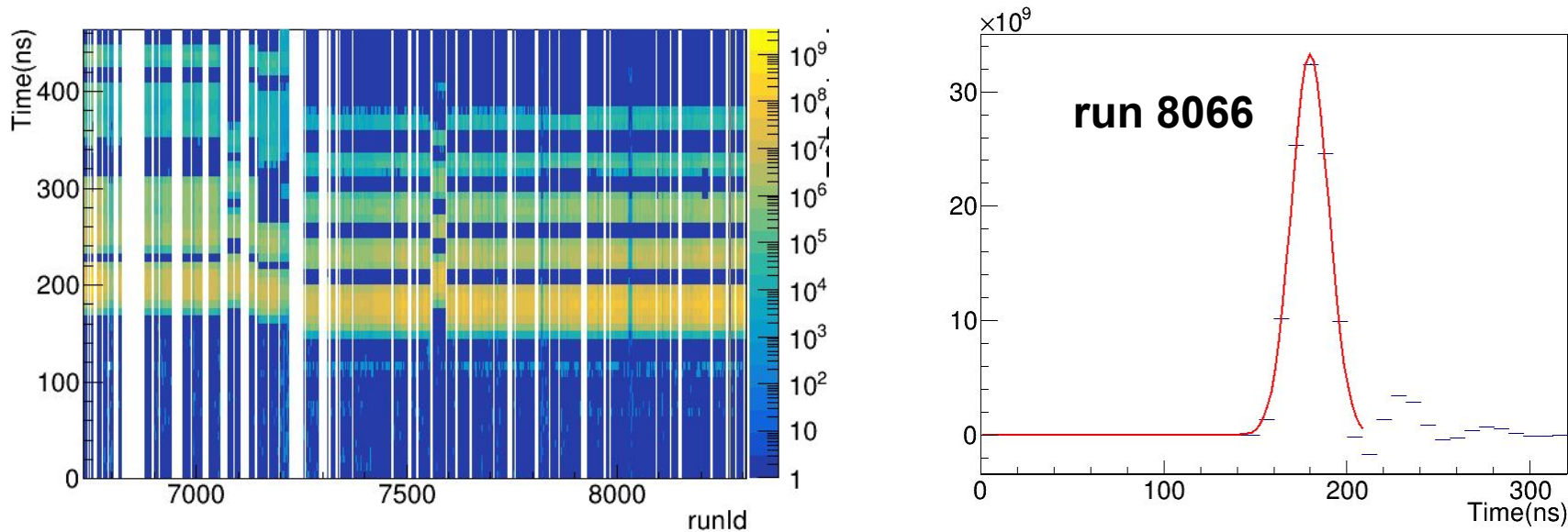
Signal shape relative to single BC1S hit time

BC1S
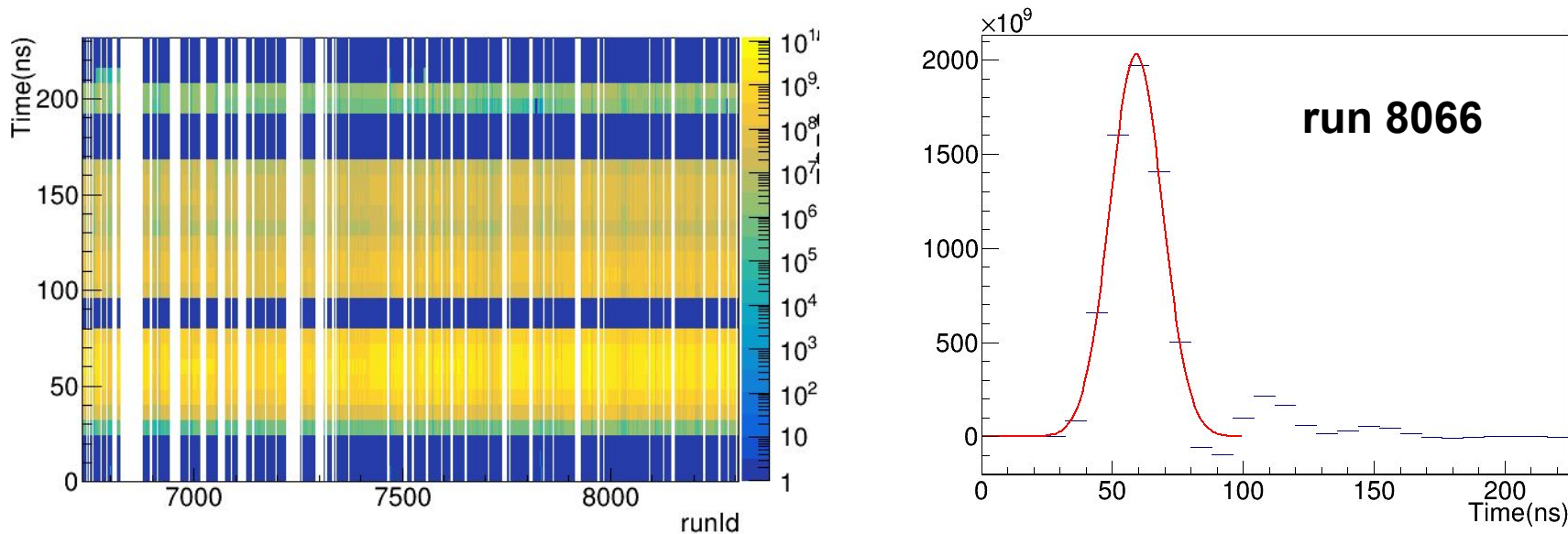
Integral is collected in mean +/- 3 sigma time from BC1S hit time
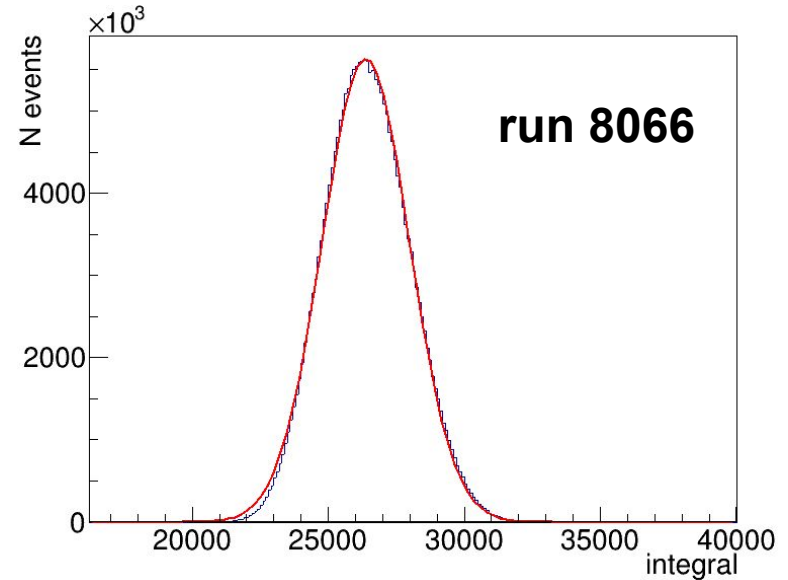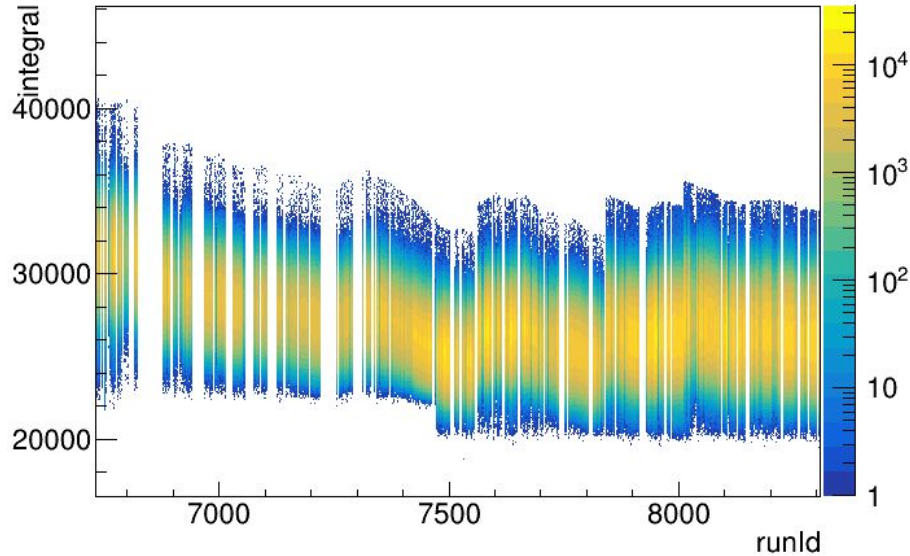
Signal shape relative to single BC1S hit time

FD

run 8066

Integral is collected in mean +/- 3 sigma time from BC1S hit time
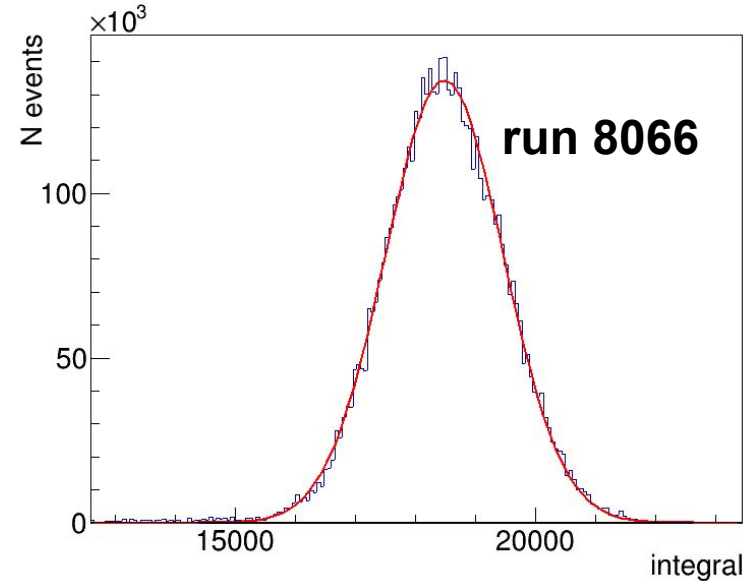
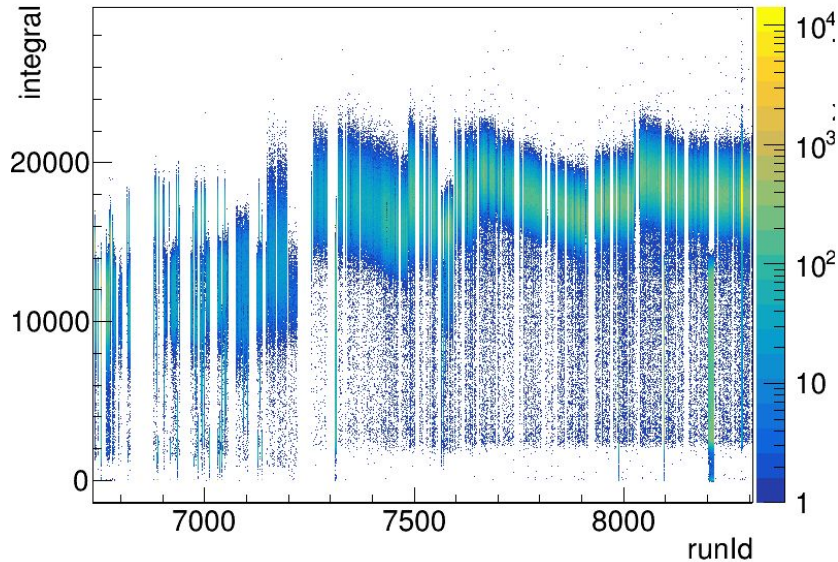# Single hit integral

BC1S

run 8066

Single integral mean is used to normalize integral distribution
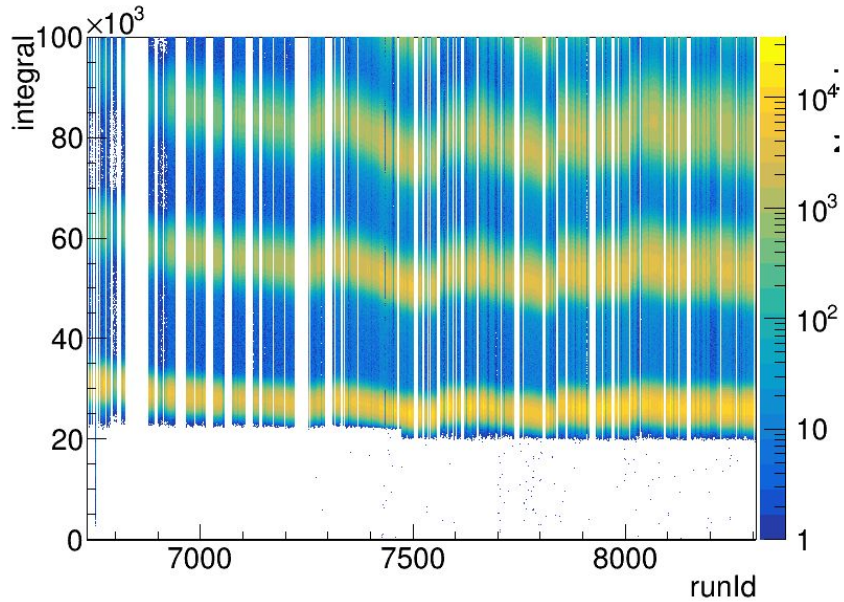
Single hit integral
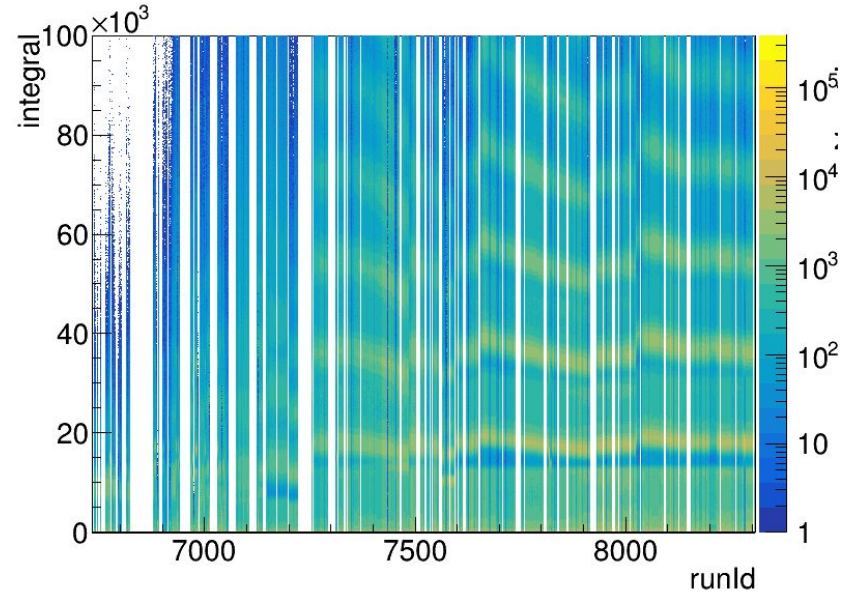
FD (BT after reduction)

run 8066

Single integral mean is used to normalize integral distribution

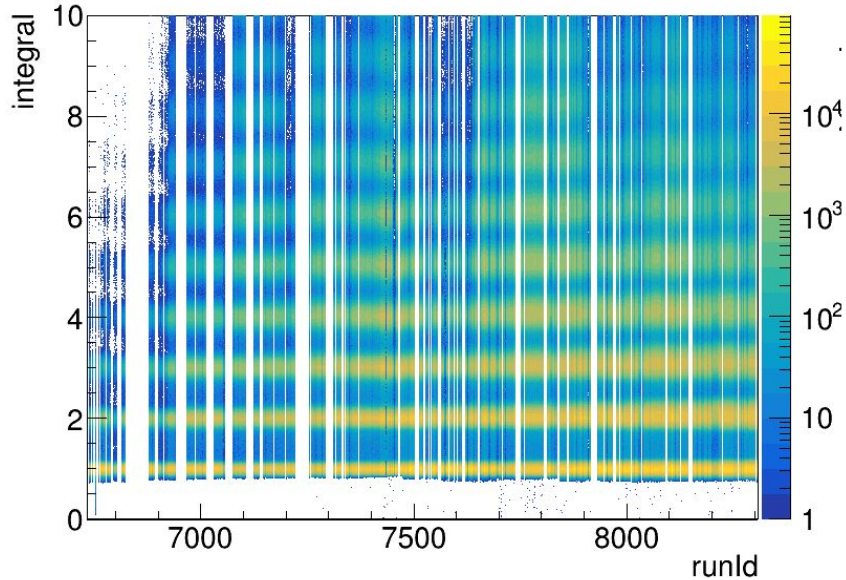# Integral distributions

BC1S

FD

Normalized integral distributions

BC1S

FD
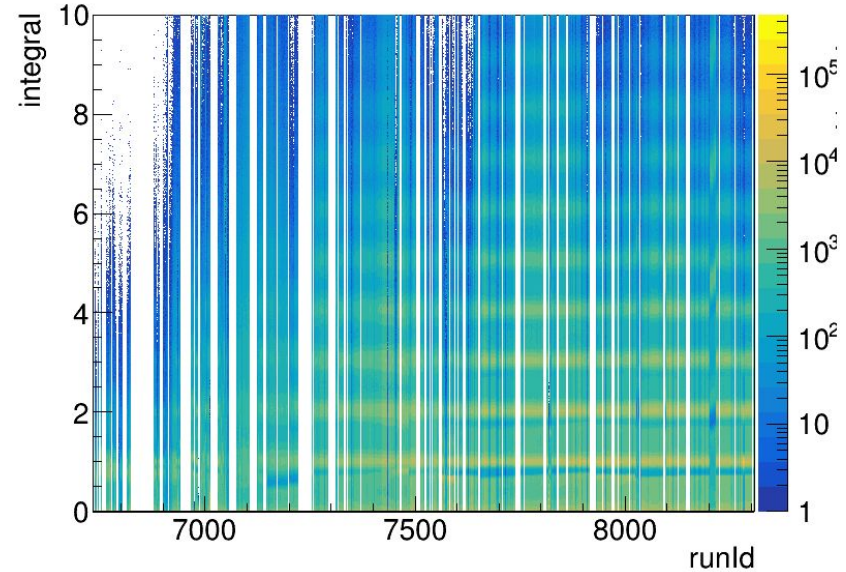
BC1S normalization deteriorates with time.
Reducing resolution due to scintillator radiation damage?

Single BC1S hit time

run 8066
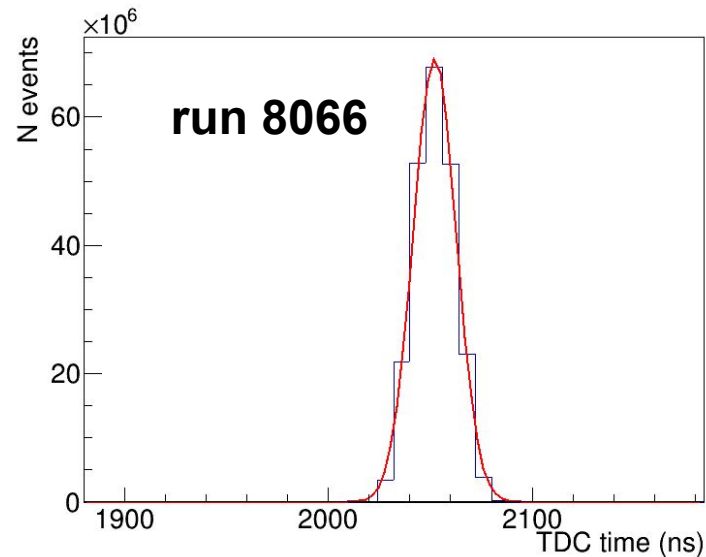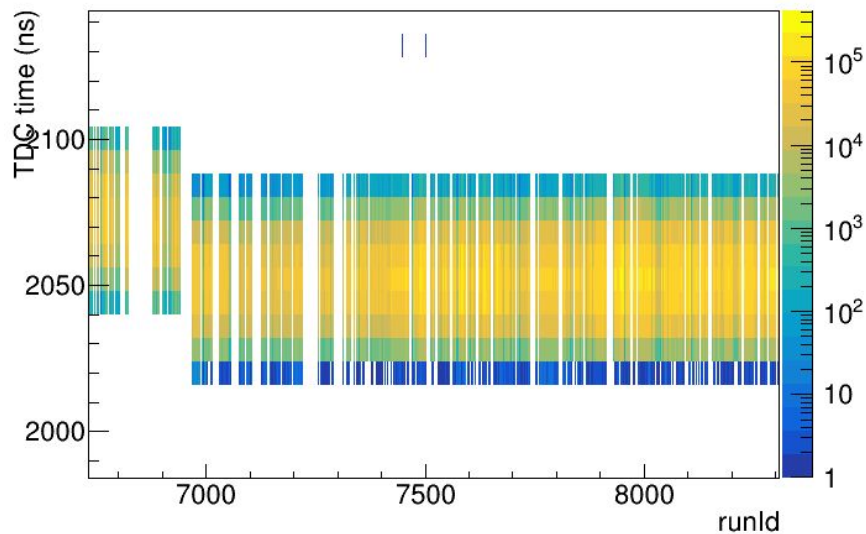
Close pileup is estimated in a narrow time window around BC1S hit closest to mean

Estimation of close pileup

run 7426, BT
360 ns time window
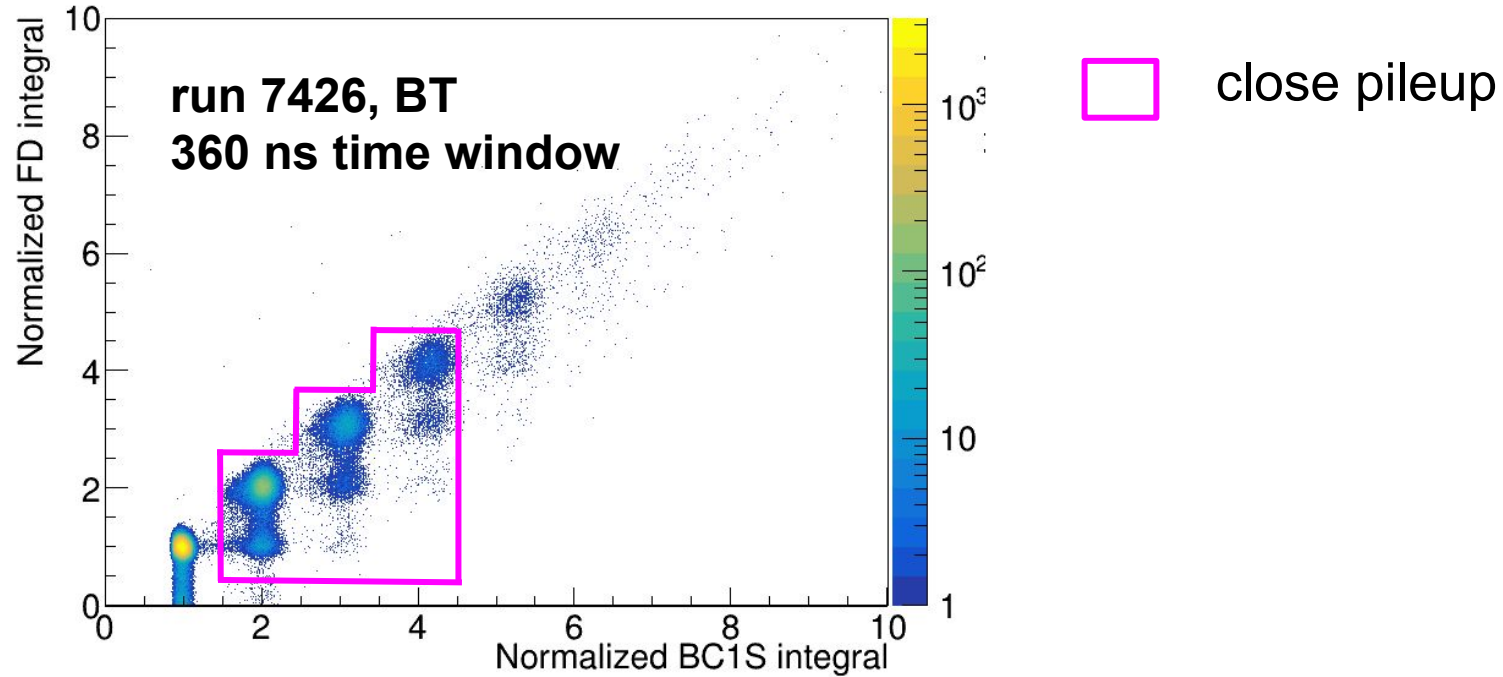
close pileup

Estimation of close pileup

run 7426, BT
360 ns time window

close pileup

no interaction

Estimation of close pileup

run 7426, BT
360 ns time window

close pileup

no interaction

one interaction
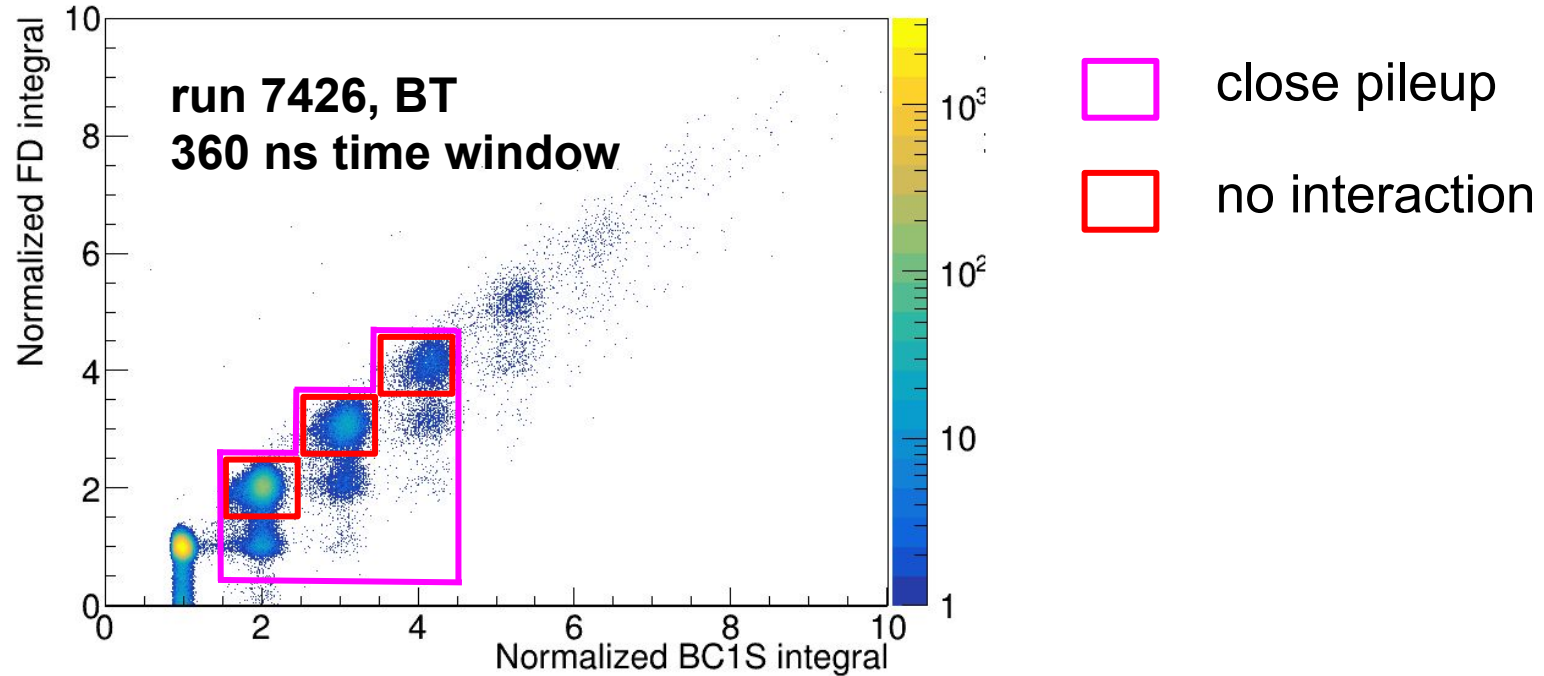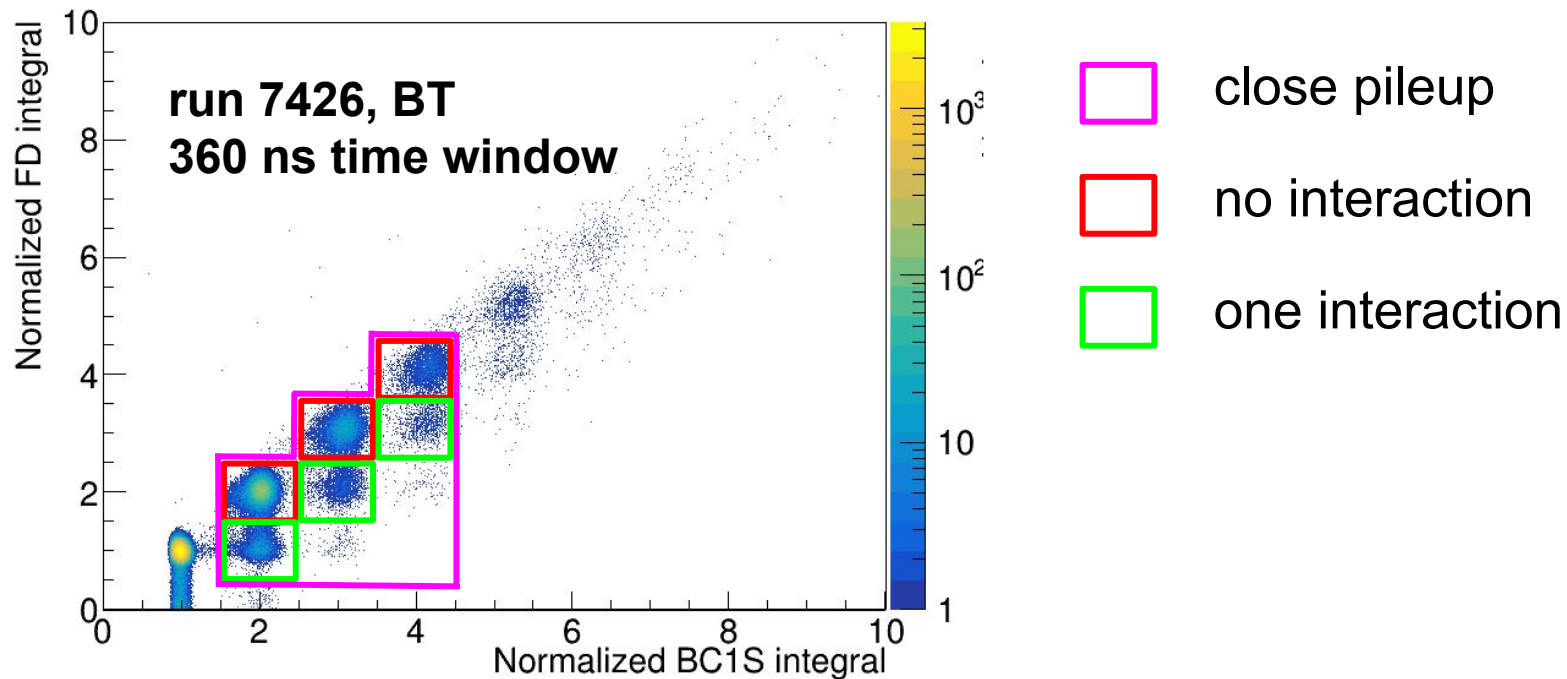
Aim: to find the share of each type of events for different triggers

Choosing the width of time window around trigger

run 7426, MBT
no interaction
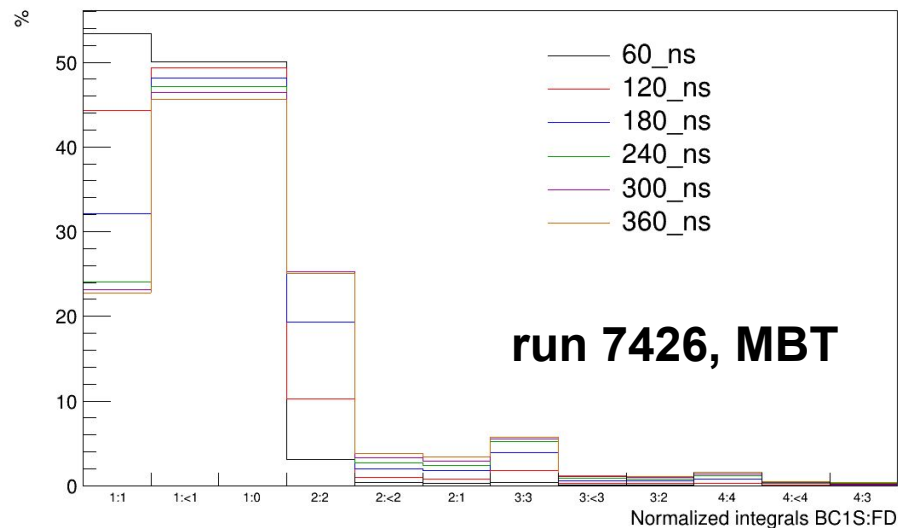
run 7426, MBT

Curves converge after 240 ns. Choosing 360 ns window for now.

360 ns time window, runs 7426 and 8281
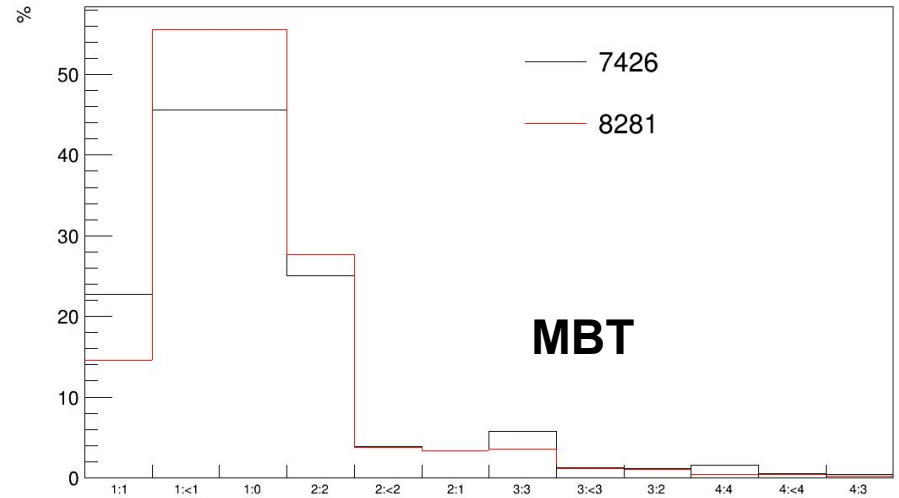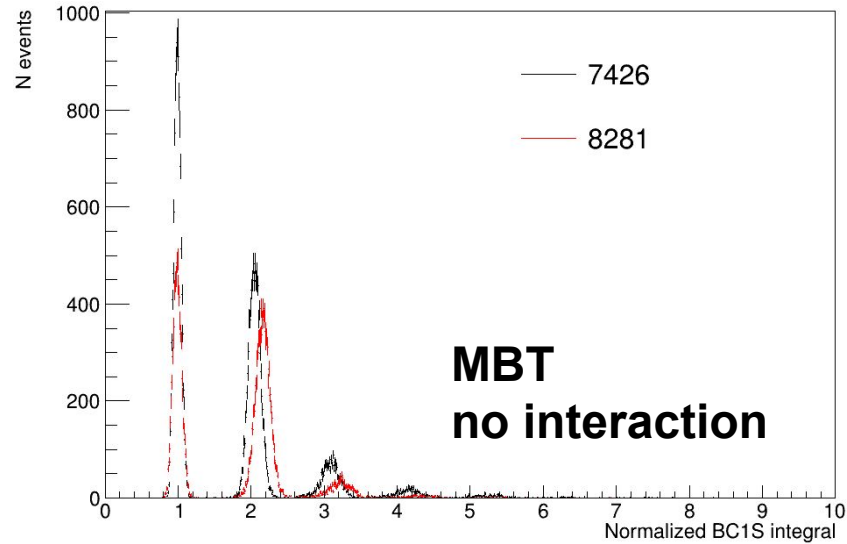
More close pileup for the later run.

Results for 360 ns time window, %

Run 7426

	close_pileup	no_interaction	one_interaction
MBT	26.9	24.0	2.6
CCT2	17.3	13.1	3.5
CCT1	18.6	16.2	2.3
BT	10.9	9.8	1.0

%

Run 8281

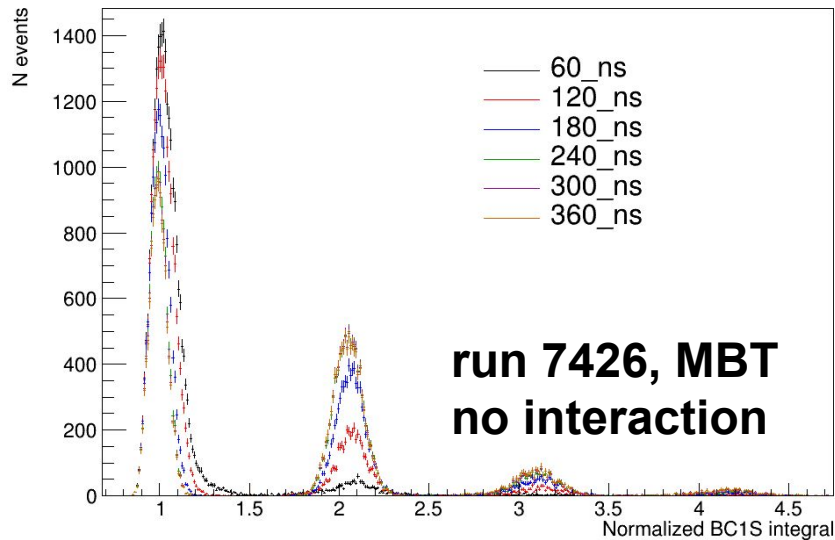|	close_pileup	no_interaction	one_interaction
MBT	26.2	23.9	1.9
CCT2	11.6	9.1	2.0
CCT1	9.8	8.4	1.4
BT	5.2	4.5	0.6

%

Numbers discussed at the reconstruction meeting, it was decided to shift to 100 ns window proposed by the Troitsk group based on the resolution of the Forward Quartz Hodoscope (slides).

Results for 100 ns time window, %

Run 7426   **Run 8281**

	close_pileup	no_interaction	one_interaction
MBT	4.1	3.5	0.4
CCT2	4.6	3.7	0.7
CCT1	11.3	10.0	1.3
BT	5.0	4.6	0.4

%

	close_pileup	no_interaction	one_interaction
MBT	7.0	6.0	0.9
CCT2	3.1	2.3	0.7
CCT1	4.8	4.1	0.7
BT	2.1	1.8	0.3

%

Limited consistency between earlier and later runs.

Results for 100 ns time window, %

Runs with BT trigger

	close_pileup	no_interaction	one_interaction
MBT	5.4	4.7	0.6
CCT2	3.9	3.0	0.7
CCT1	8.3	7.2	1.0
BT	3.5	3.2	0.3

%

Physics runs

|	close_pileup	no_interaction	one_interaction
MBT	7.6	6.4	0.6
CCT2	4.1	3.0	0.5
CCT1	11.2	9.6	1.3
BT	5.2	4.5	0.5

%

More or less consistent for technical BT and physics runs.

Effect of pileup at digitized data level

- Choose events with 2 hits in BC1S (most of pileup cases)
- Define trigger hit as closest to mean time for single BC1S events.
- For different event types plot mean number of digits as a function of time difference from additional to trigger hit for:
  - "Fast" detectors (TOF400, TOF700)*.
  - "Slow" detectors (SILICON, GEM)
- Compare the values with those for events with single hit in BC1S.

  * digits are counted in a fixed window relative to BC1S hit time

Effect of pileup on TOF 400
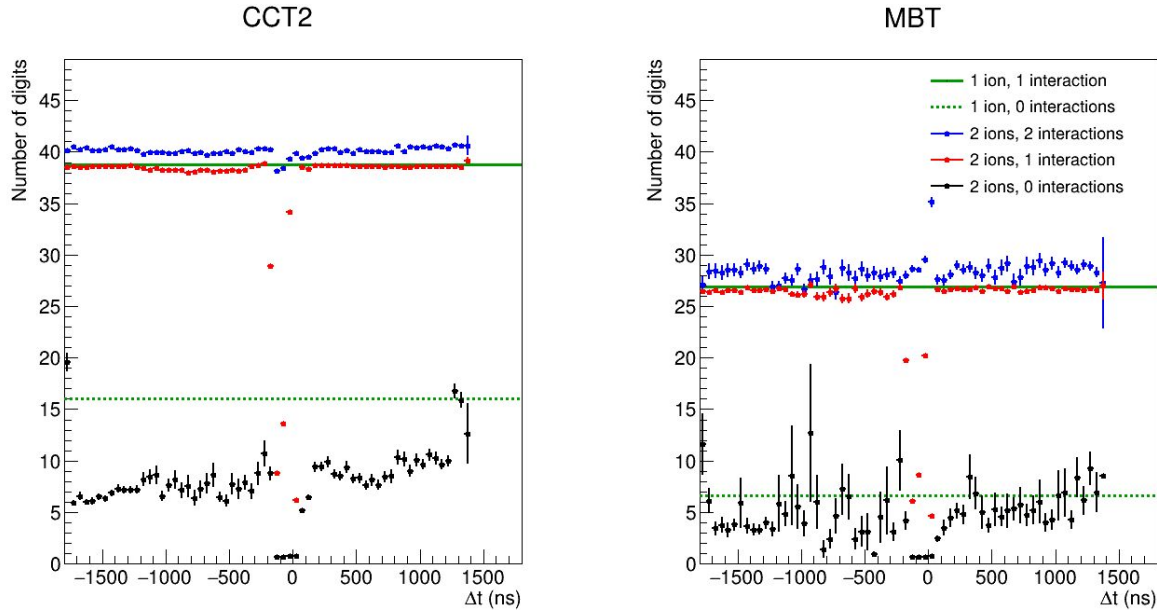
CCT2

MBT

- Significant effect at ~200 ns from trigger hit
- 2 interactions do not double the amount of digis like it was expected
- Too little digis in case of 0 interactions - more accurate event classification needed?
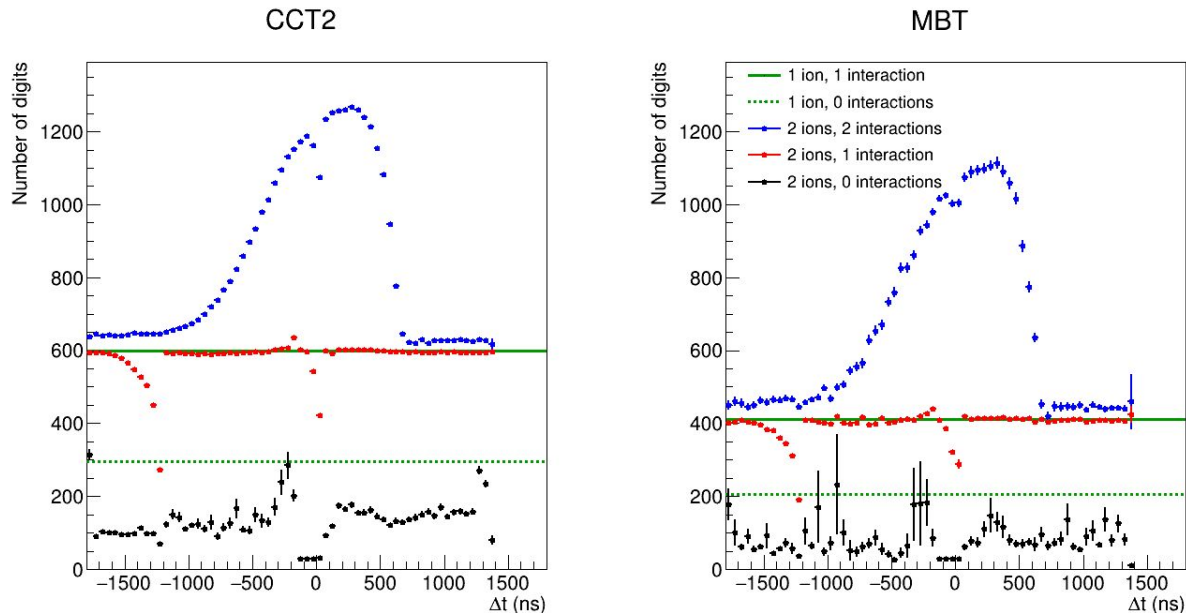
Effect of pileup on TOF 700
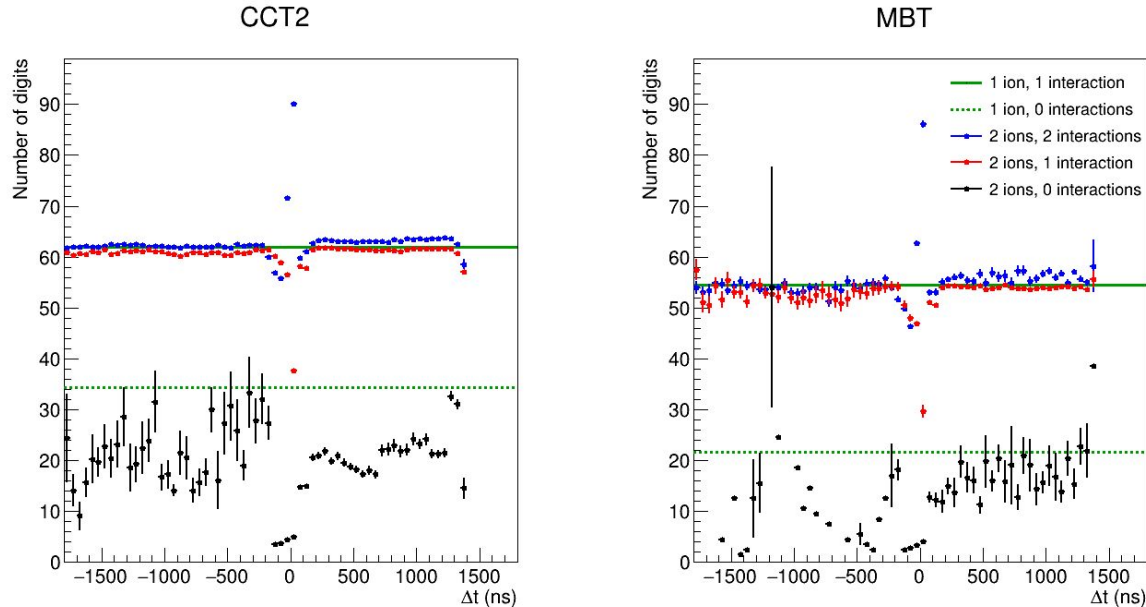
- Significant effect at ~200 ns from trigger hit
- 2 interactions do not double the amount of digis like it was expected
- Too little digis in case of 0 interactions - more accurate event classification needed?

Effect of pileup on SILICON

CCT2

MBT

- In case of one interaction significant effect at ~300 ns from trigger hit + additional structure at -1200 ns.
- Amount of digits is doubled in case of second interaction around 1 us.

Effect of pileup on GEM
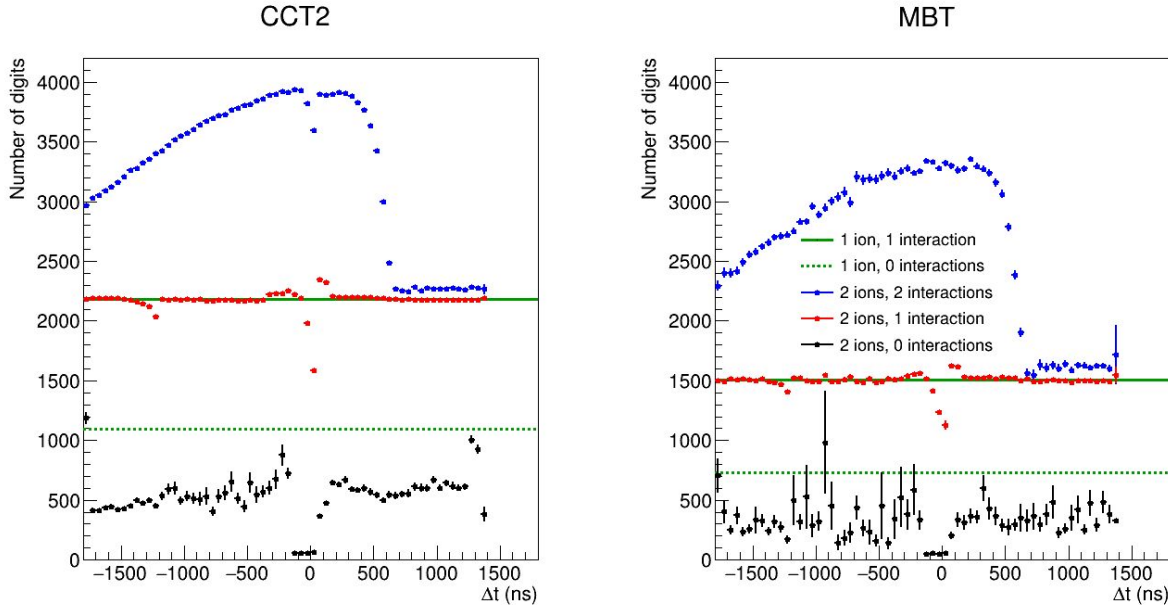
- In case of one interaction significant effect at ~300 ns from trigger hit + additional structure at -1200 ns.
- Amount of digits is doubled in case of second interaction around 1 us.

Summary

- BmnRoot task for classification of pileup events is being developed and tested.
- Incidence of close pileup at 100 ns window is ~3%.
- Indications of significant effect of distant pileup on digitized data from tracking detectors. The analysis will be extended to the reconstructed data.
- Additional information should be used to fully understand the results
  - BD data to exclude off-target events
  - before/after-protection settings.