Time Measurement with the AHCAL

CALICE Collaboration Meeting - Valencia
2022

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FÜR PHYSIK

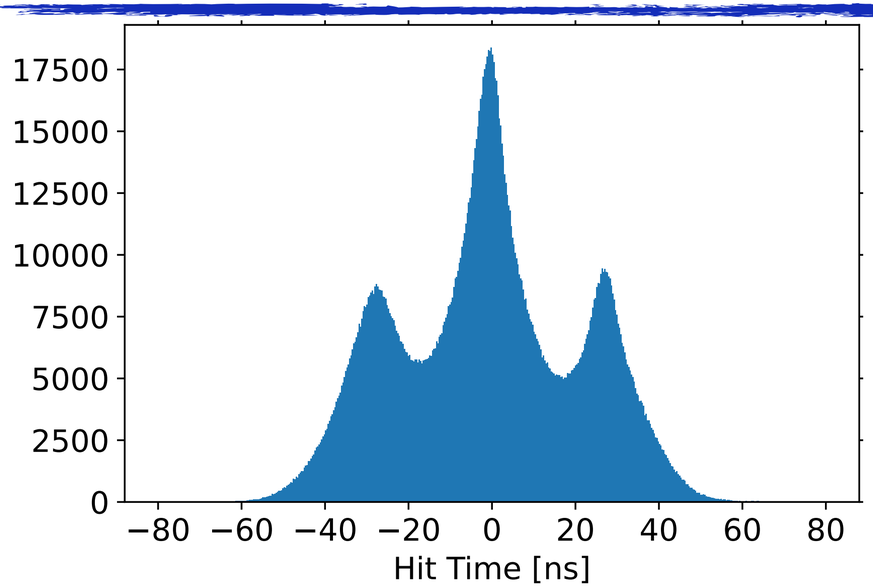
Motivation

Reminder on time measurements with the AHCAL for upcoming SPS test beam:

- Effects seen in 2018 data sets
- Calibration
- Performance
- Expectations and plans for SPS in June 2022

Slides include references to talks with detailed reports

Features Observed in 2018



For details see: Utrecht2019, CERN2019

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Depend on the termination of the read out cycle:

- Terminated by timeout
- Terminated by full ASIC (memory cell 16 filled)

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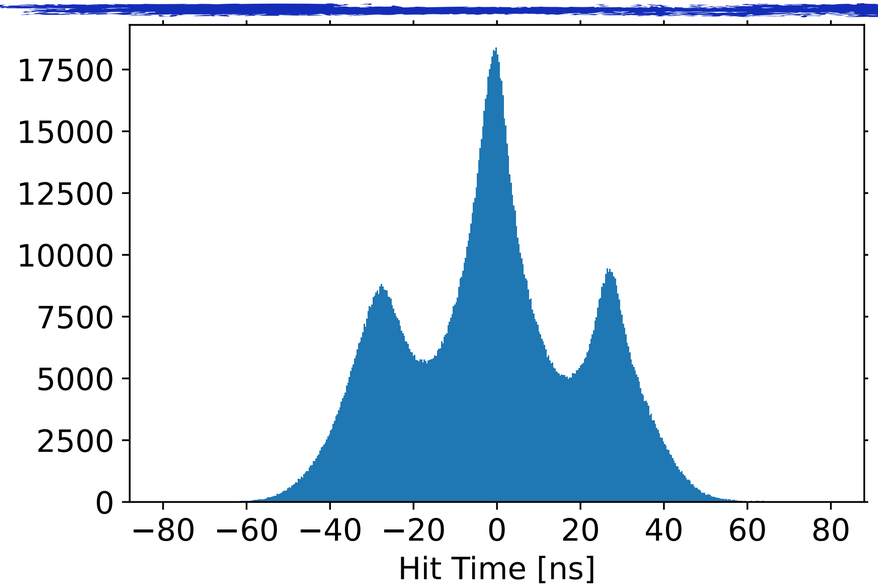

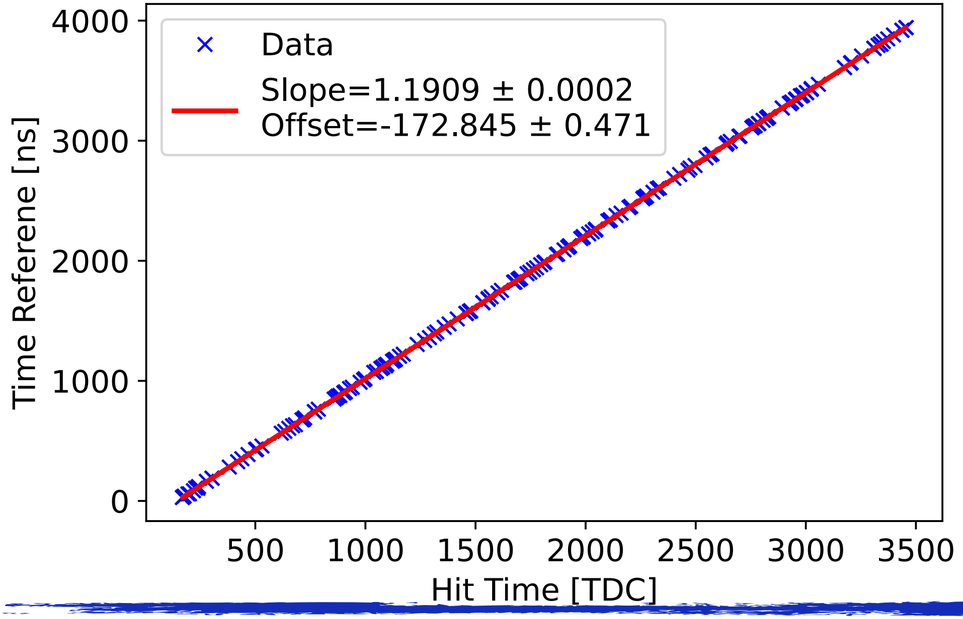

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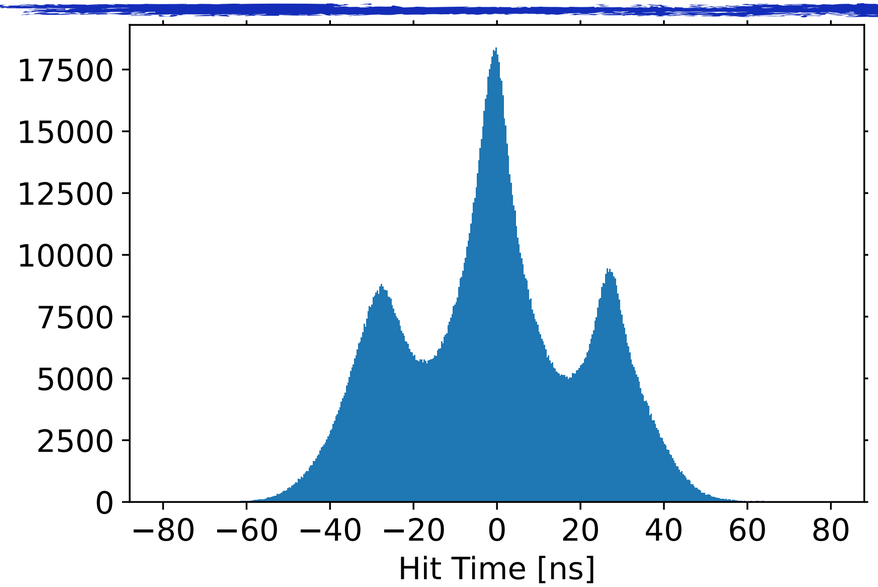

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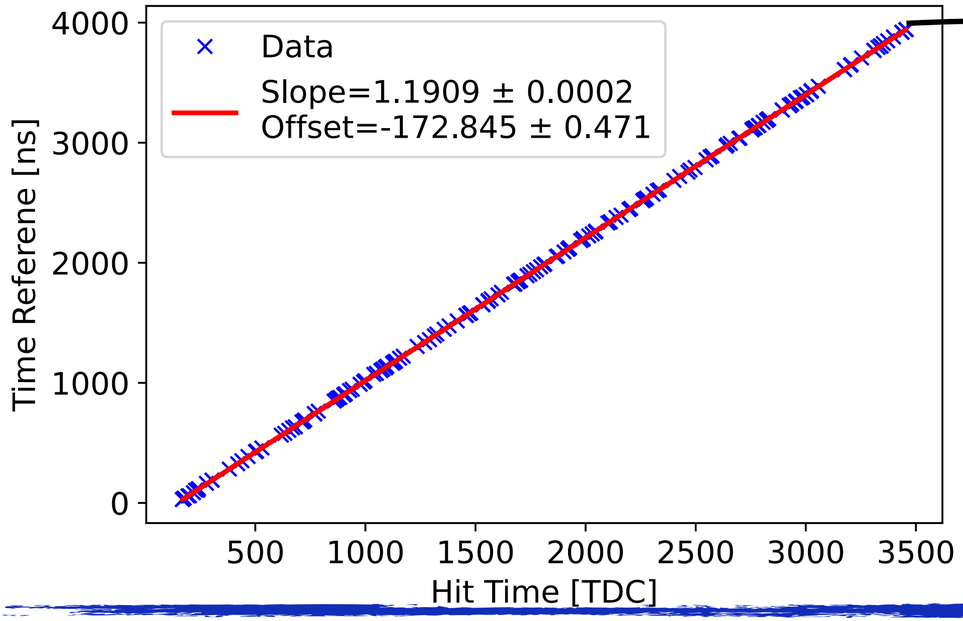

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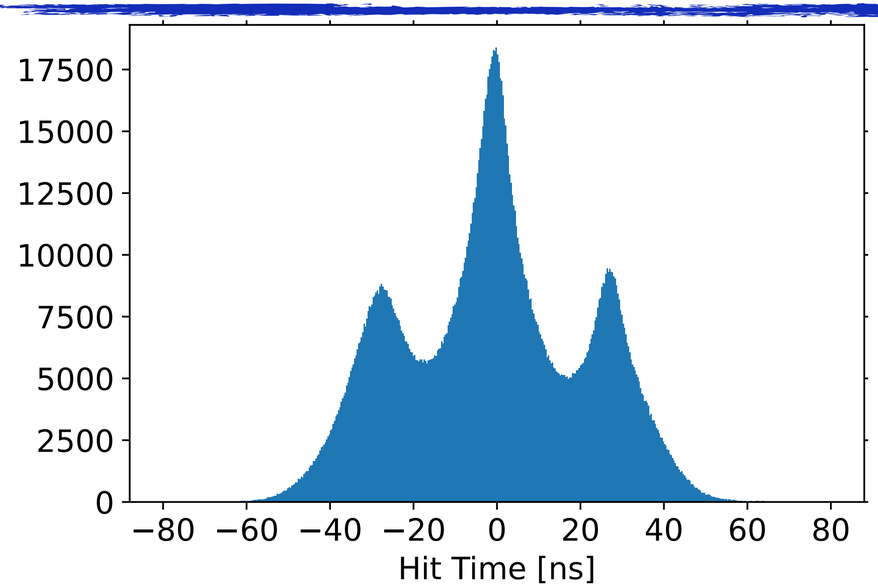

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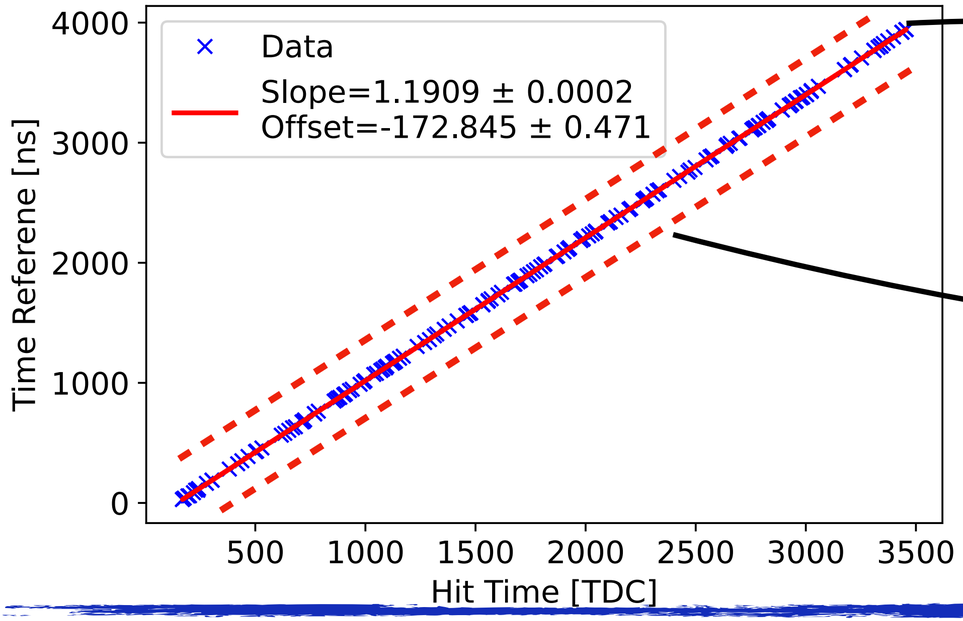

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Correct shifts

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For details see: Utrecht2019, CERN2019

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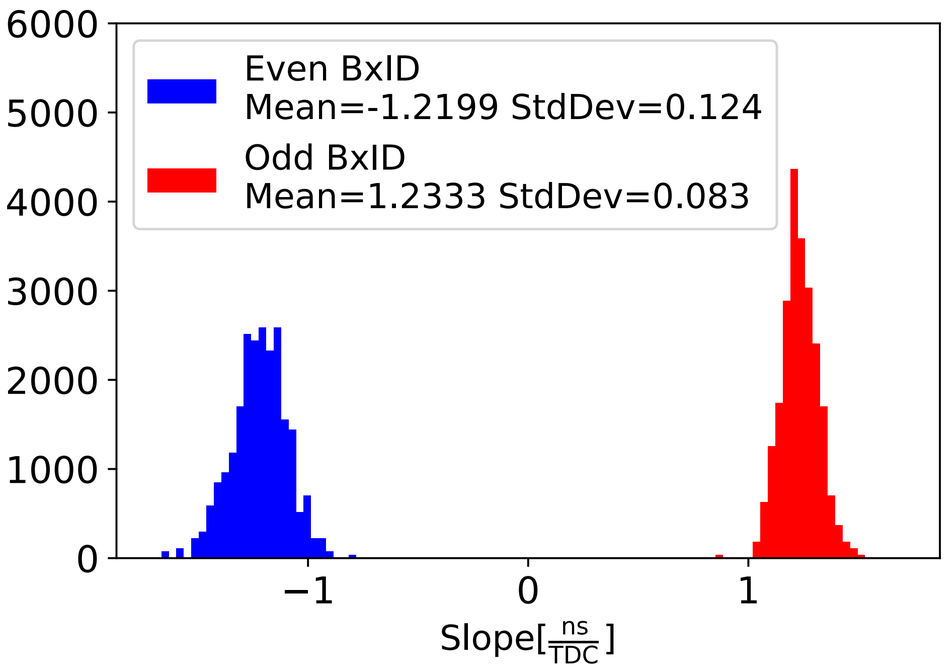

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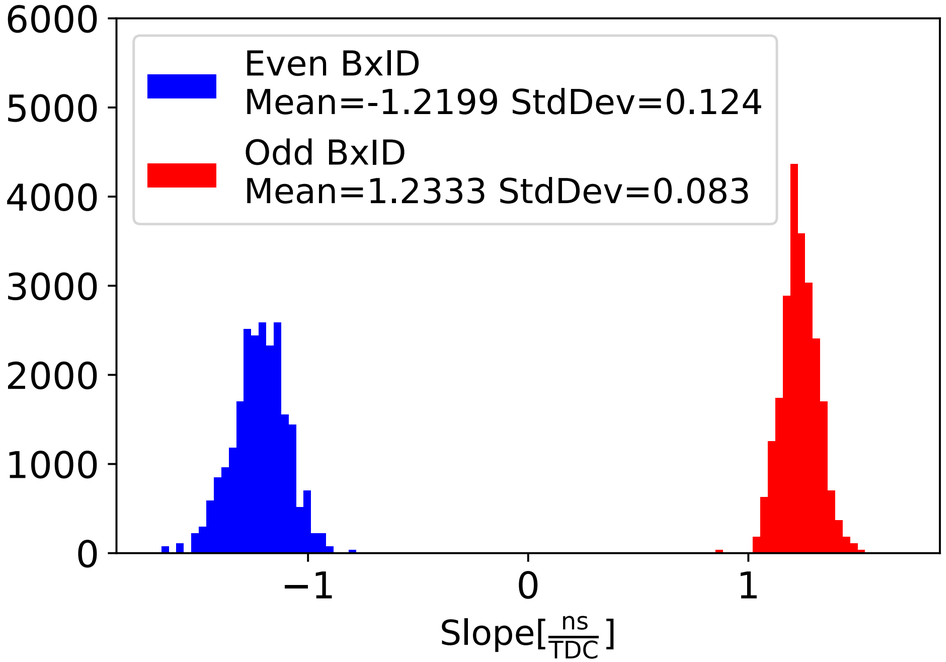

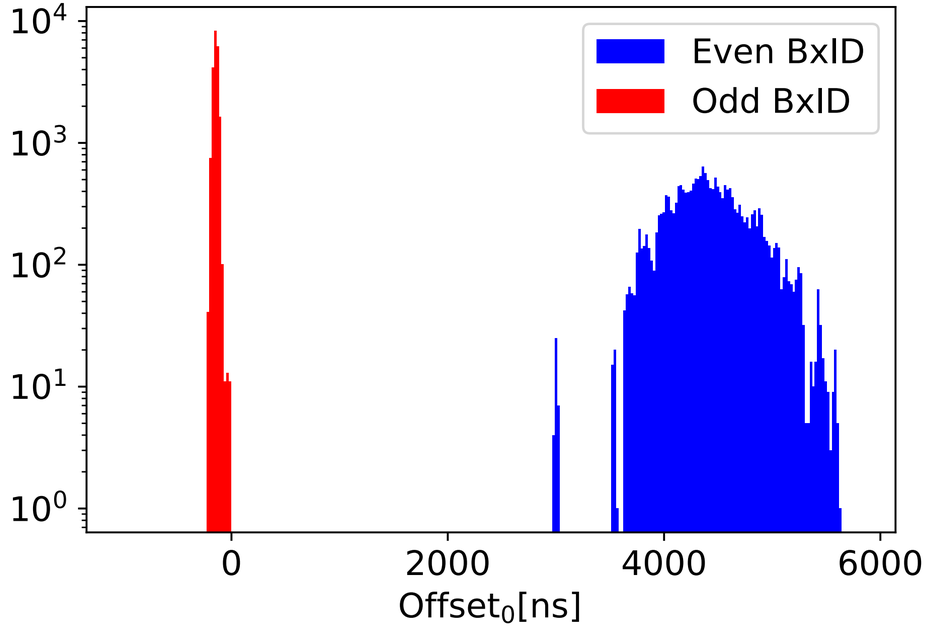

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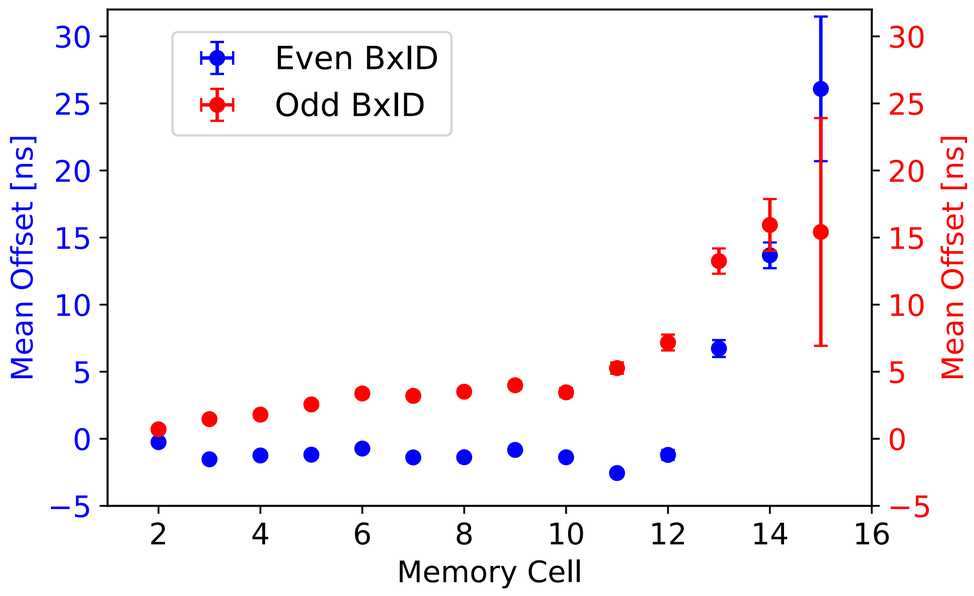

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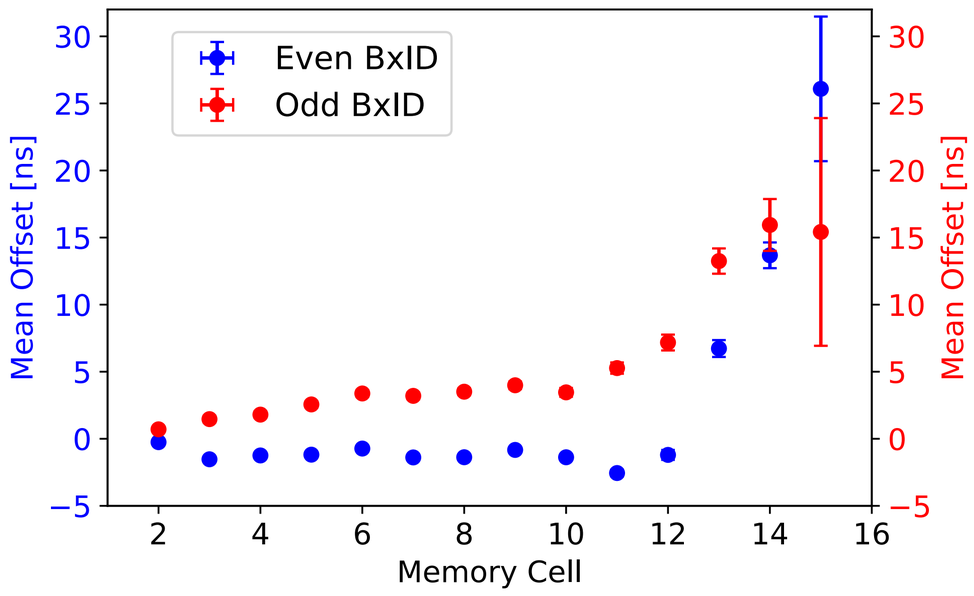
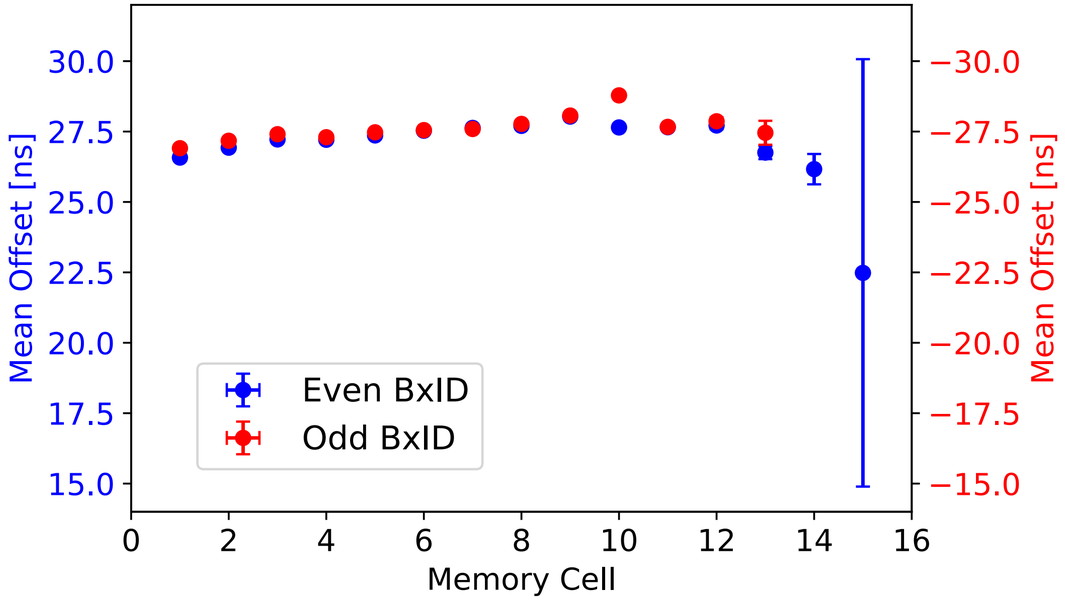
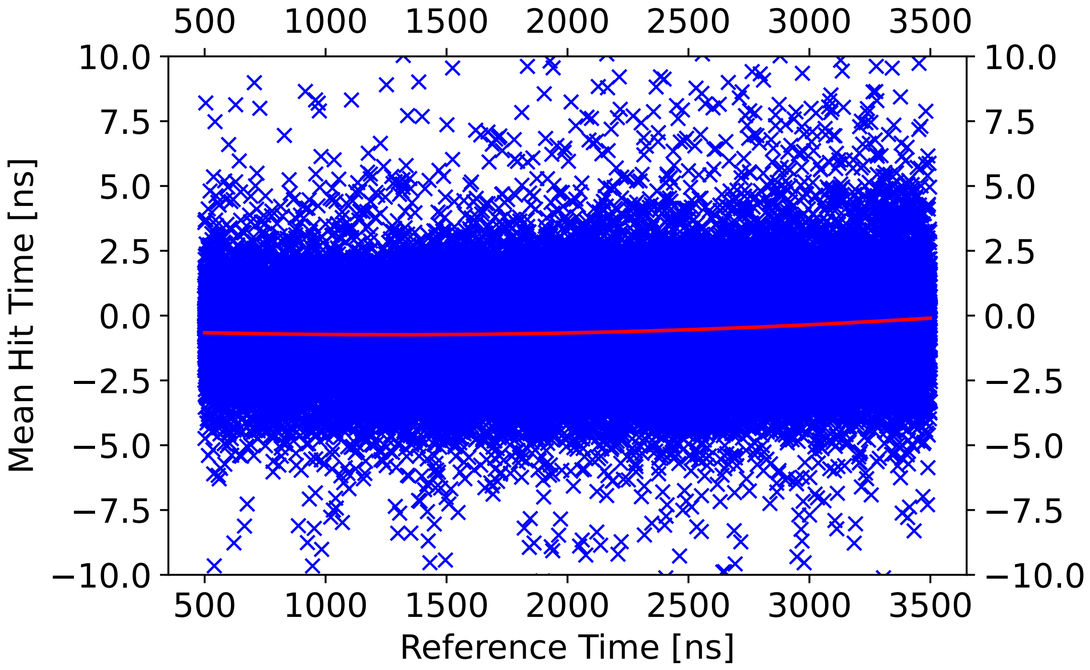
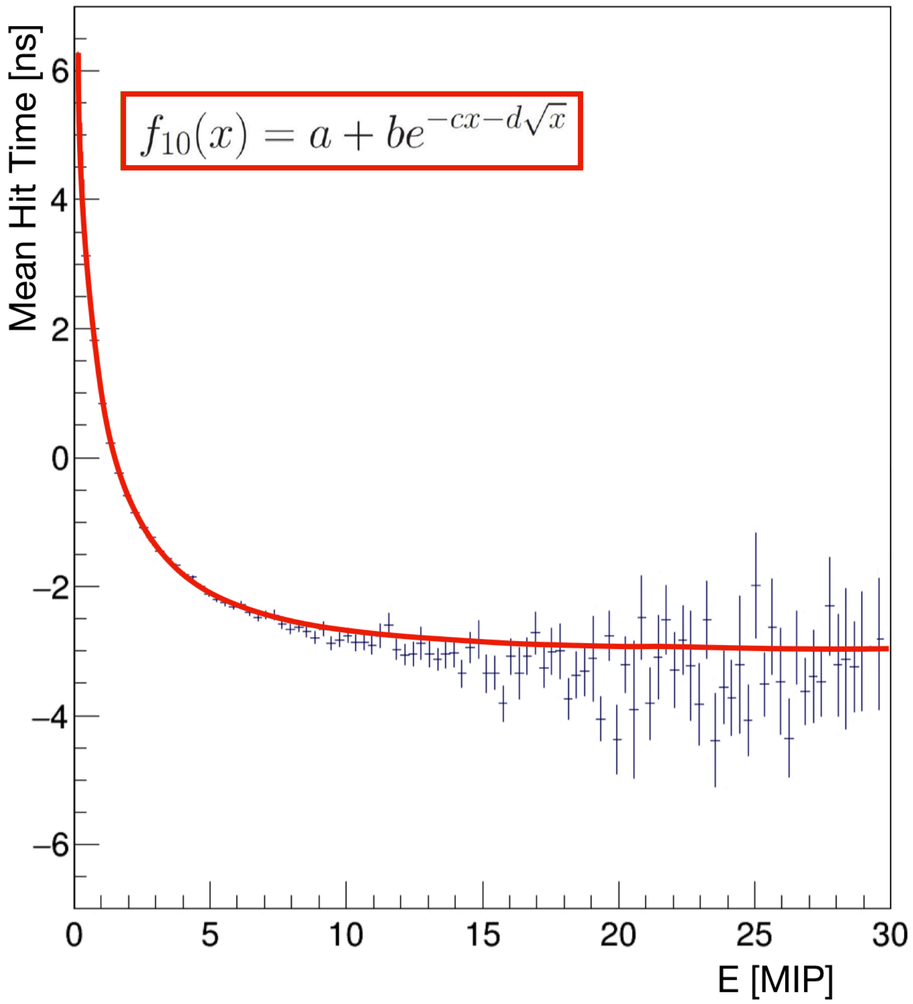




Non Linearities



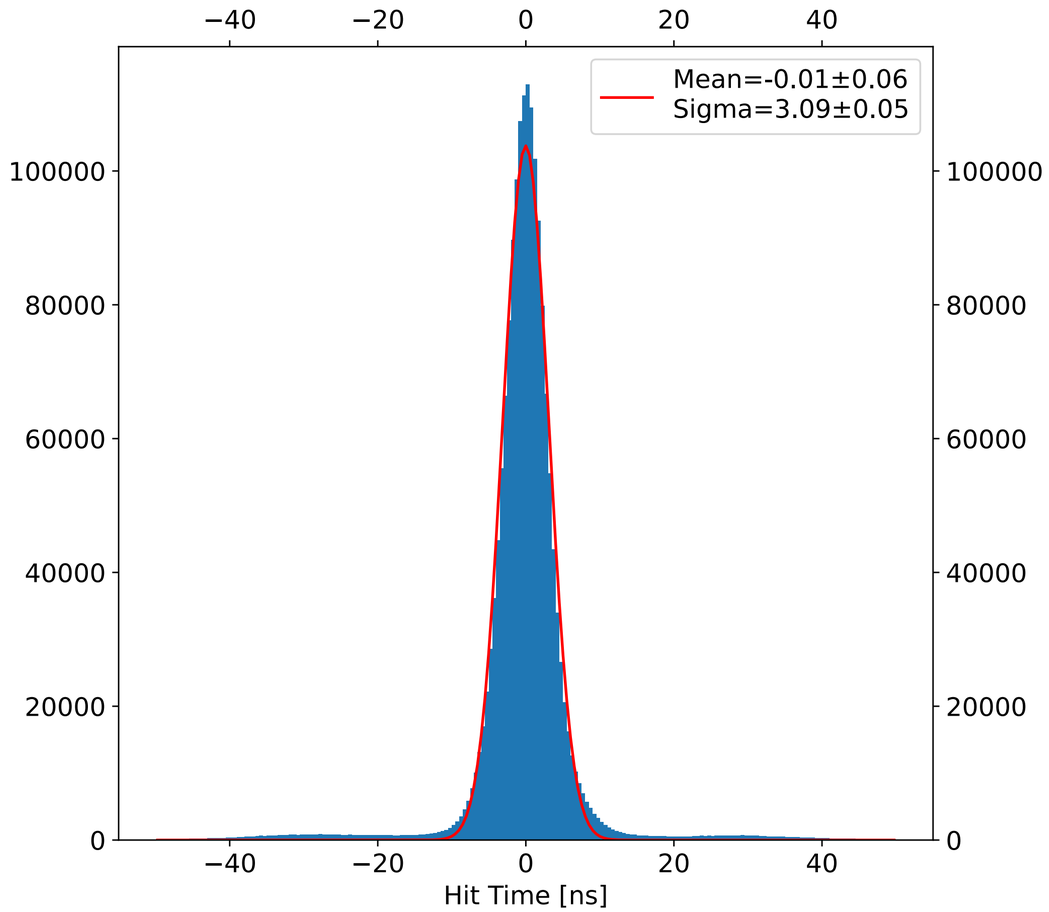


Improved linearity compared to previous prototype

Corrected Time

Shifts could be corrected, but needs large set of calibration constants: ~2.2 Mio

Especially memory cells 15 and 16 have very small data sets to calibrate



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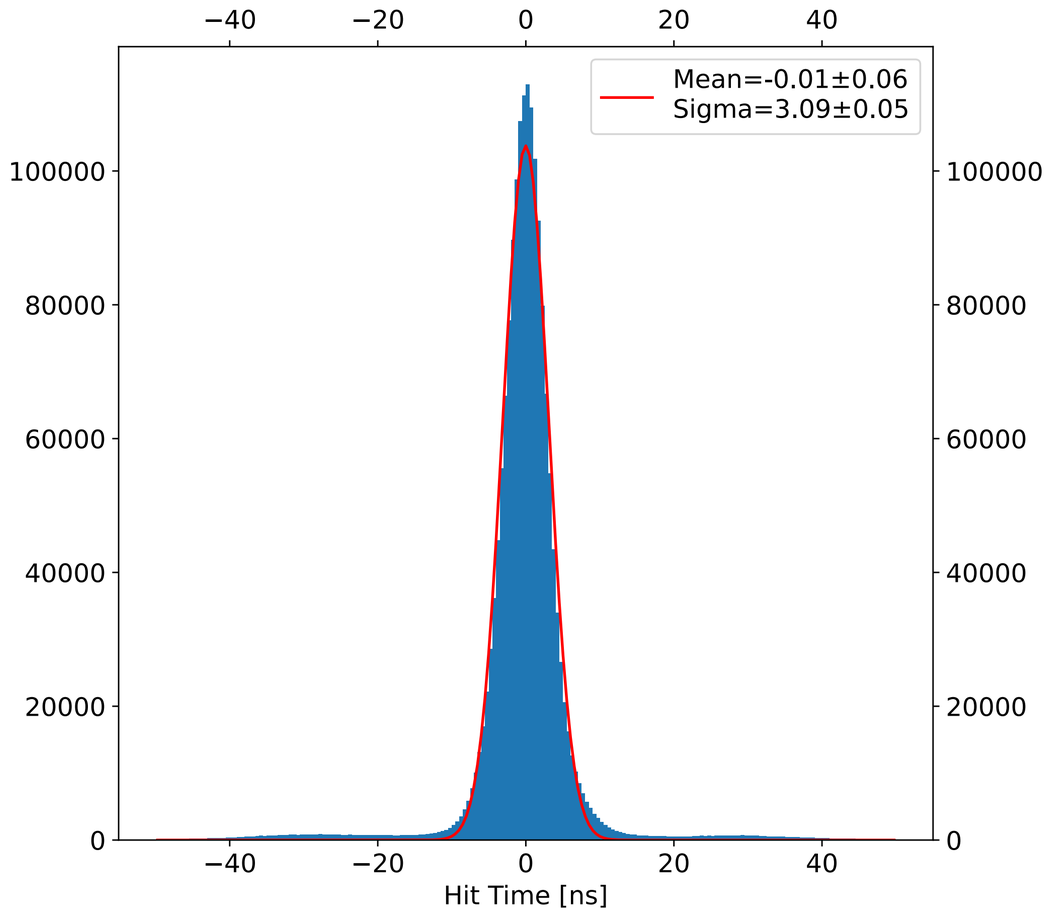

Shift is now prevented in DAQ, for upcoming TB:

- expect decrease of amount of constants by ~1.4 Mio
- expect more efficient use of available data for calibration, because of fewer event categories

ILC Mode

Data taken in August 2019 at DESY:

- Taken with updated DAQ software, no shifts
- Sub ns resolution for MIPs reached

Question for upcoming TB:

- How does ILC mode perform for hadron showers and high chip occupancy?

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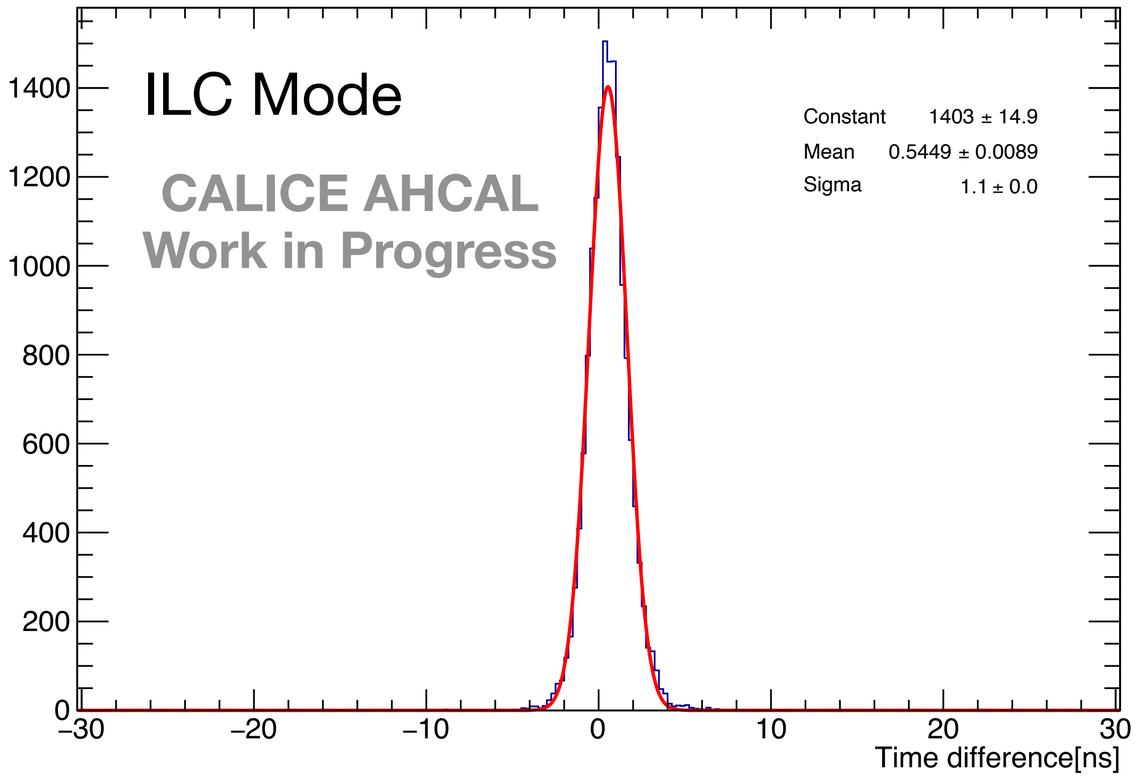

Single channel MIP resolution: 1.1/√2 = 0.78ns

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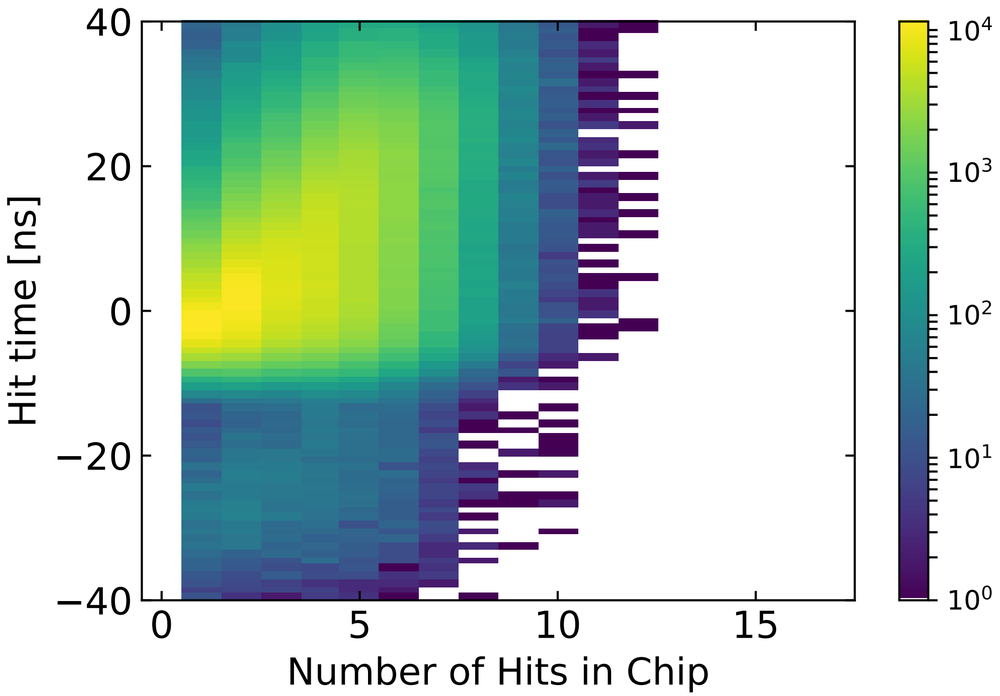
Additional time shifts/smearing observed for rising occupancy in 2018:

- Affects showers, especially in the core region



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Further Information: Montreal2020

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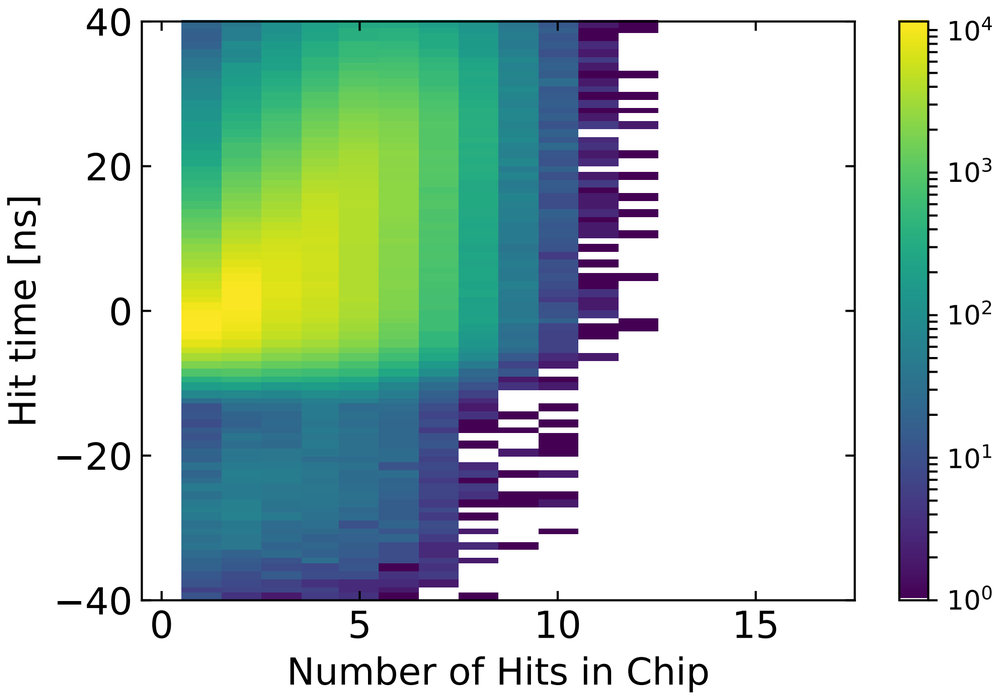

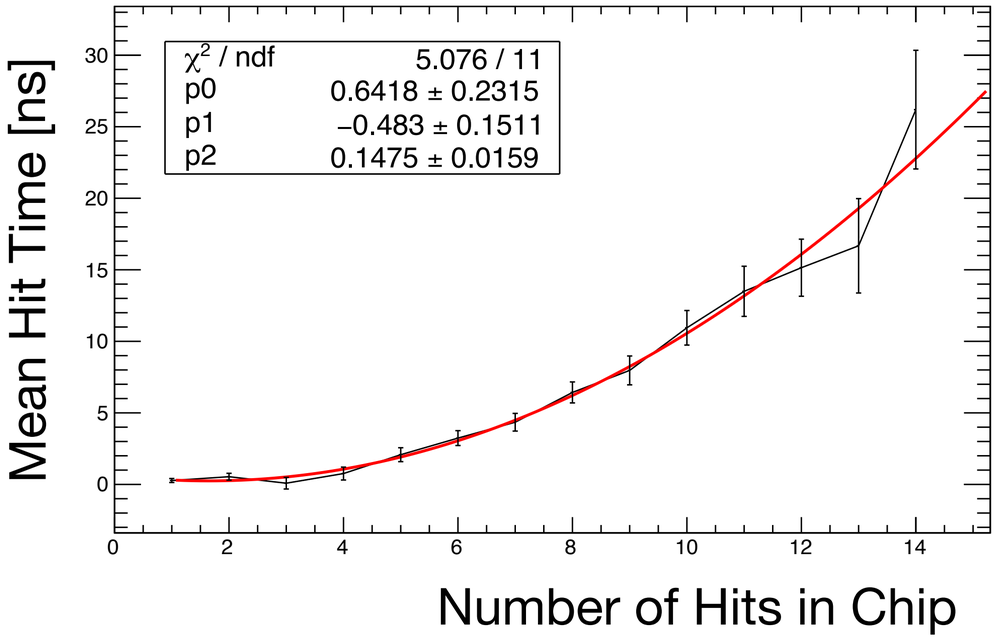

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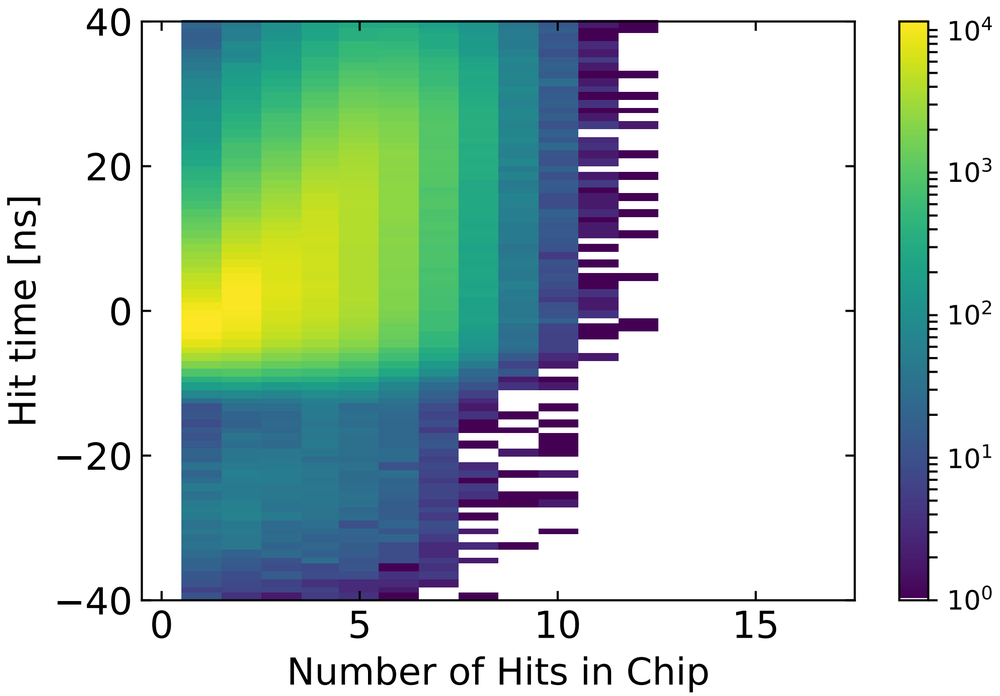

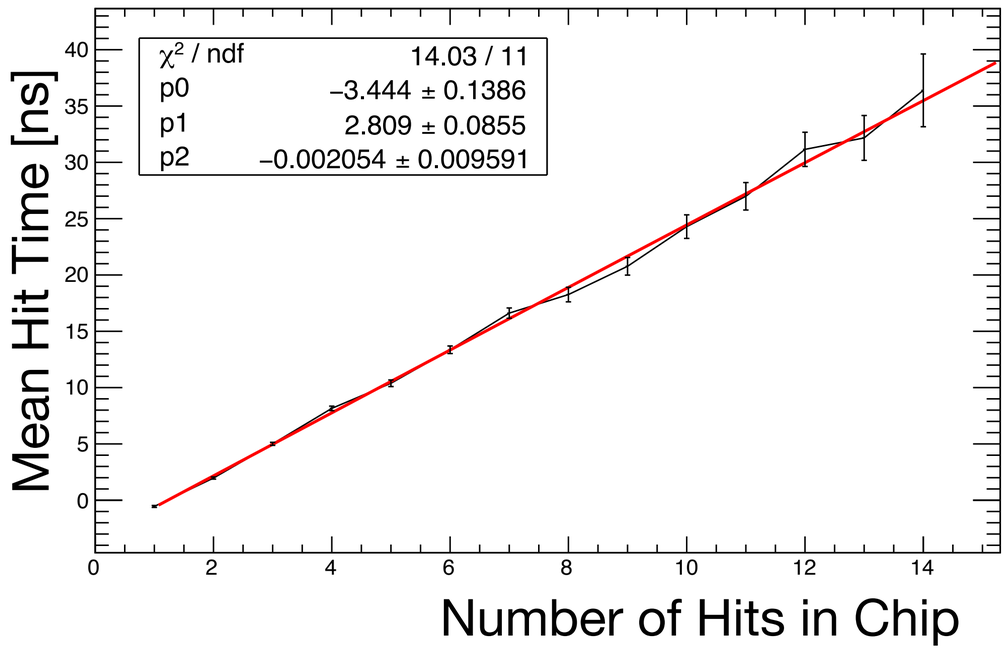

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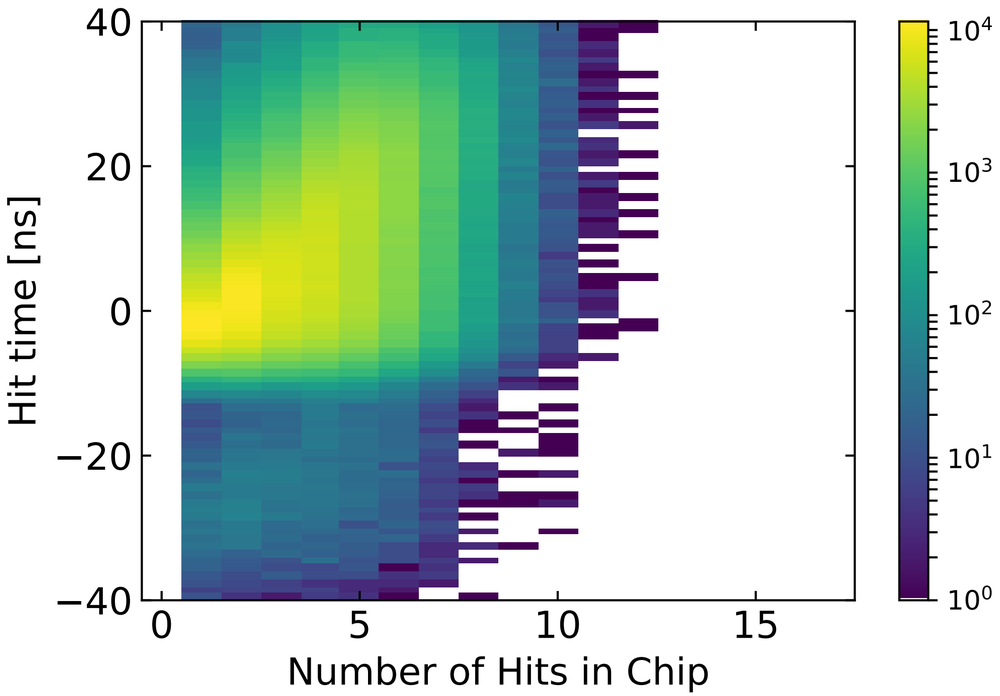
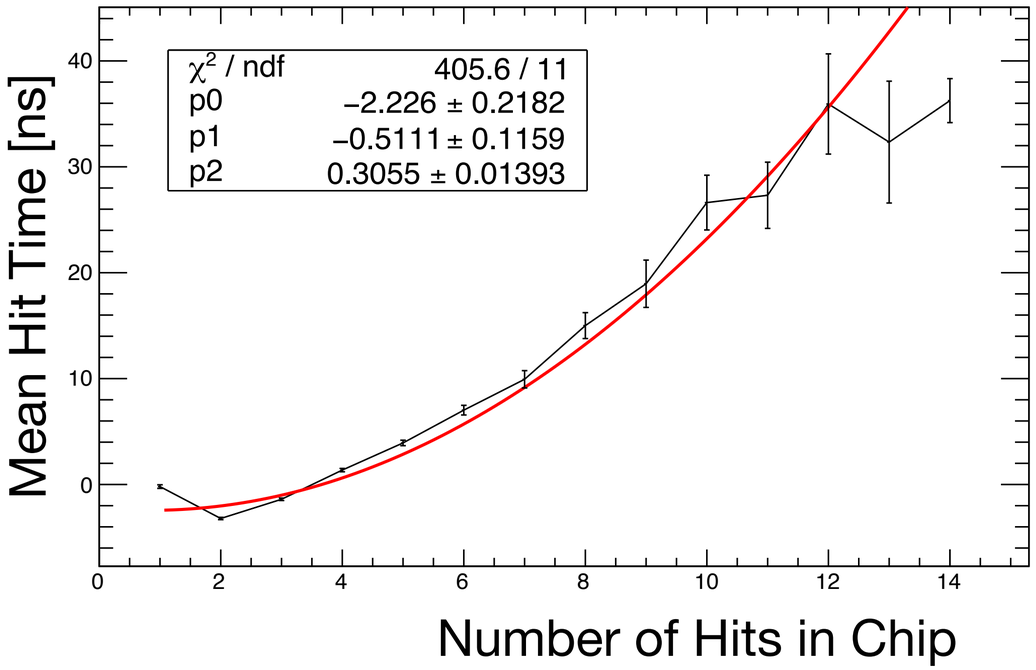
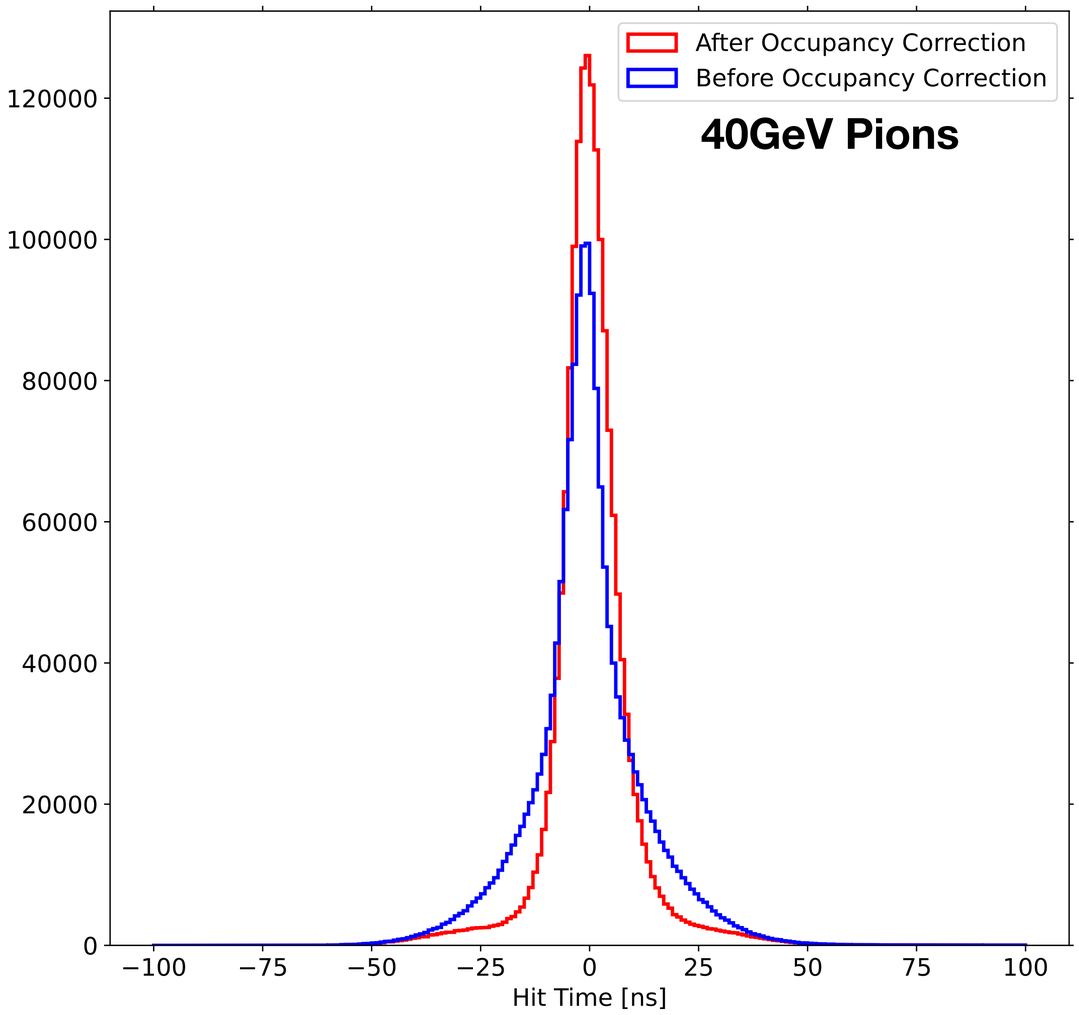




Channel to channel variations observed, including pedestal shifts

Occupancy Correction



Correction improves the performance:

- Mode of time distribution is moved closer to 0
- Width is decreased

Correction is technically difficult because of different shower development:

- High occupancy in first layers typically small
- Electrons don’t extend to deeper layers
- Pions produce delayed hits that influence calibration

Thoughts on Upcoming CERN TB

Hit time shifts fixed in DAQ software (already for 2019 DESY TB):

- reduce number of calibration constants by 1.400.000
- Probable “cross-talk” of calibrations mitigated, esp. in channels with low statistics

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Muon data to confirm the MIP time resolution measured at DESY in 2019:

- Preferably scan the detector volume
- Calibration is done on memory cell level for even and odd BxID, statistics needed

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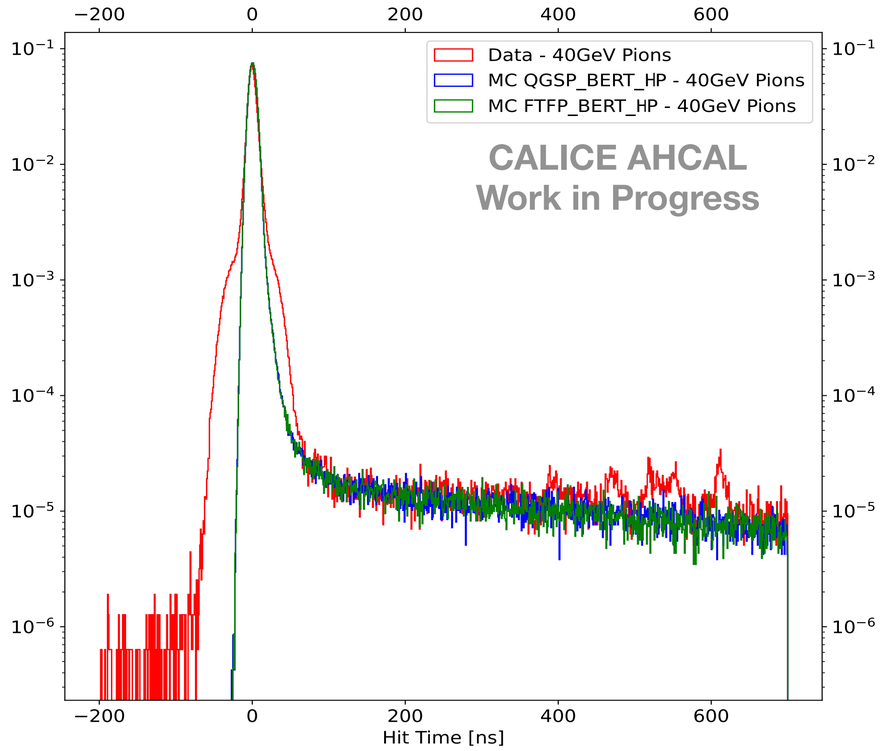
- Does the width of the time distribution, for high occupancy, decrease in ILC mode?
- Does the shift of the mean hit time decrease in ILC mode?



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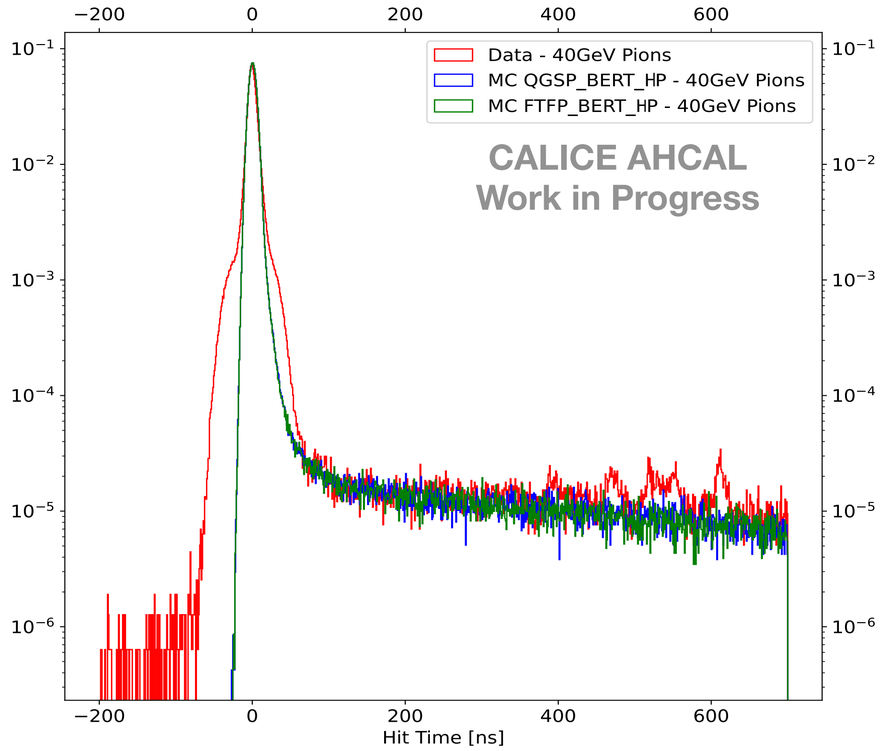

Pion data needed to reach deeper layers of the calorimeter:

- Recorded statistics hard to estimate because of hadronic fluctuations
- Occupancy caused by late energy depositions distorts the calibration

Backup

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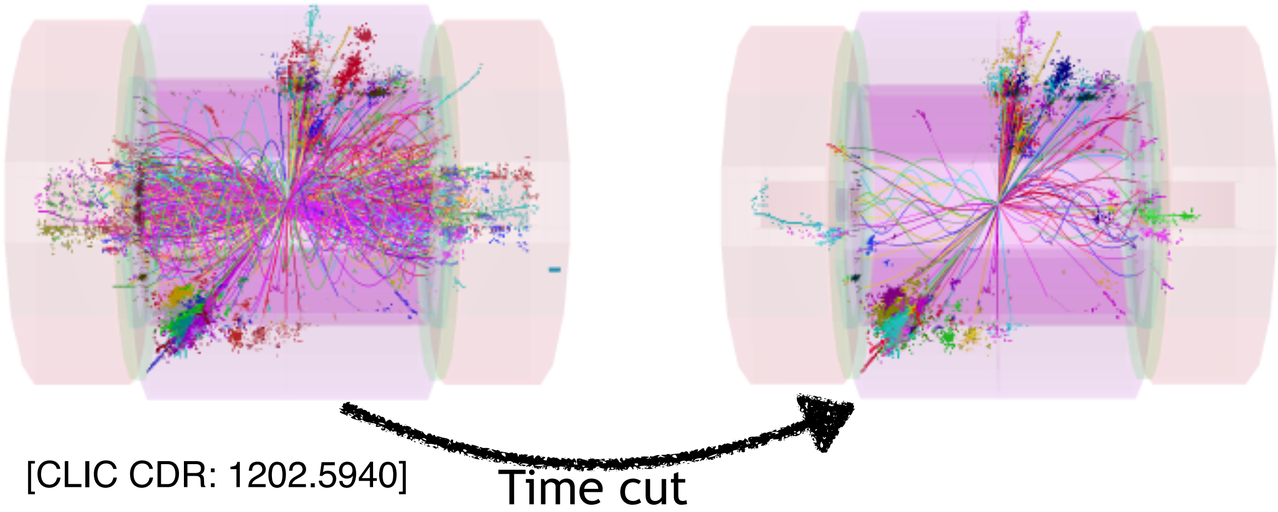

[CLIC CDR: 1202.5940]

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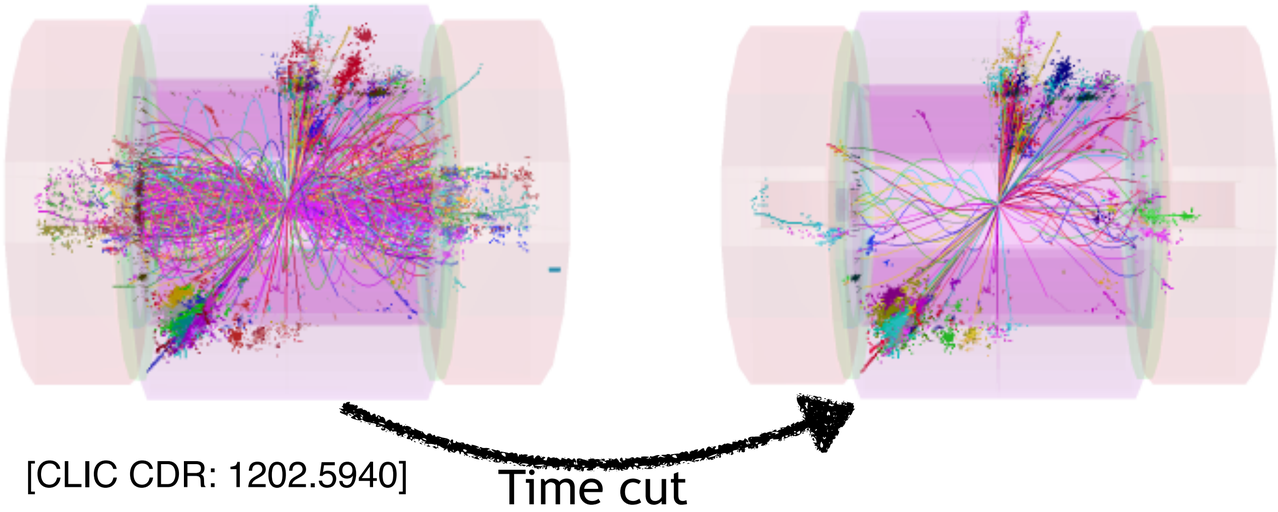
- Use in software compensation to identify components of hadronic showers?



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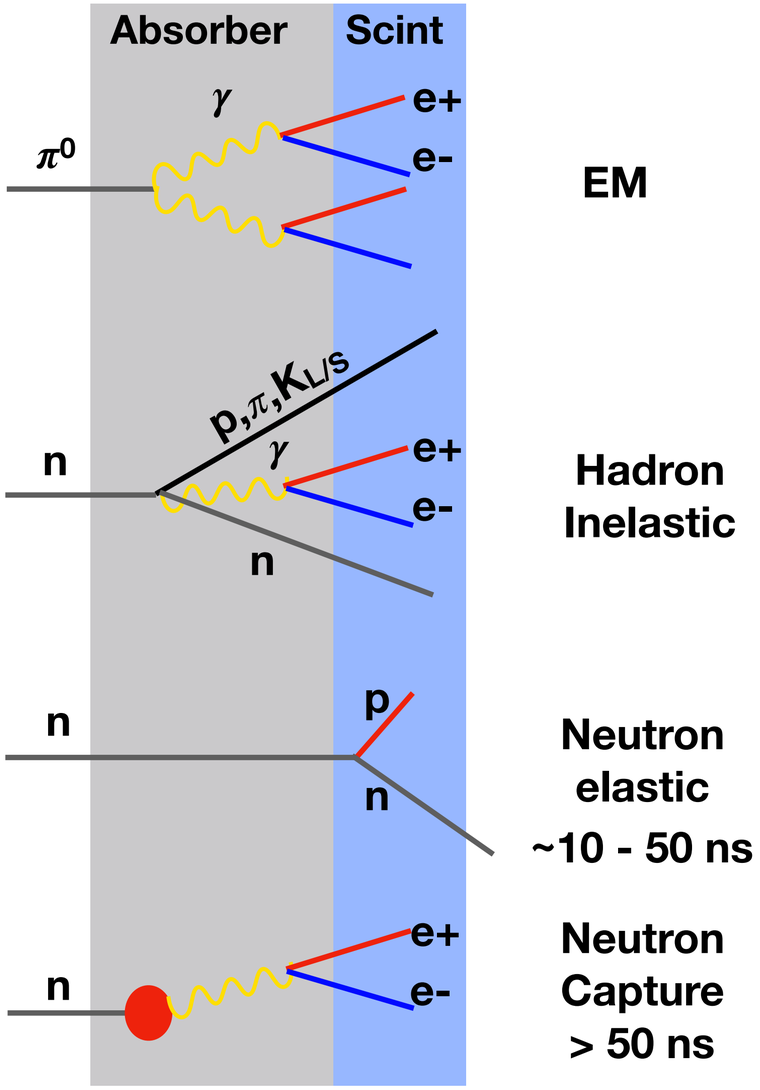

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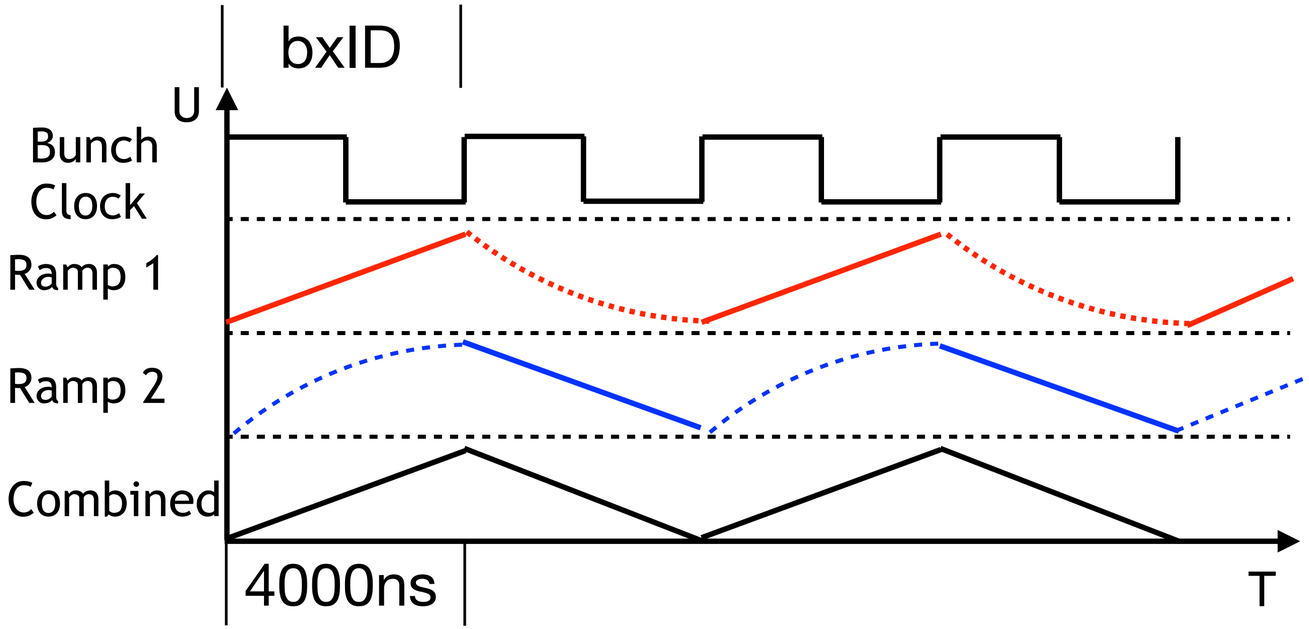

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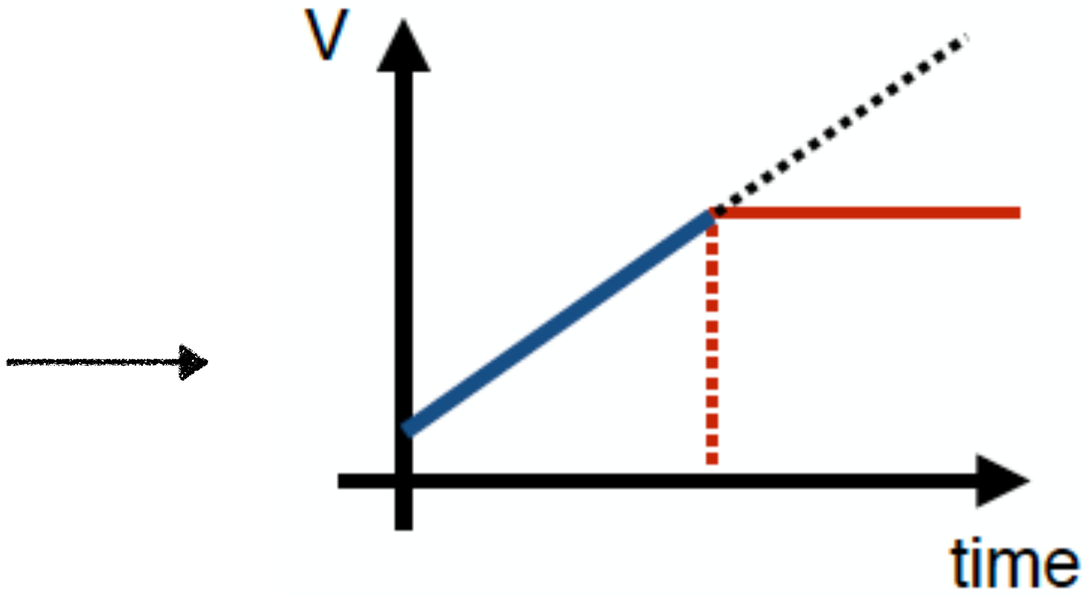

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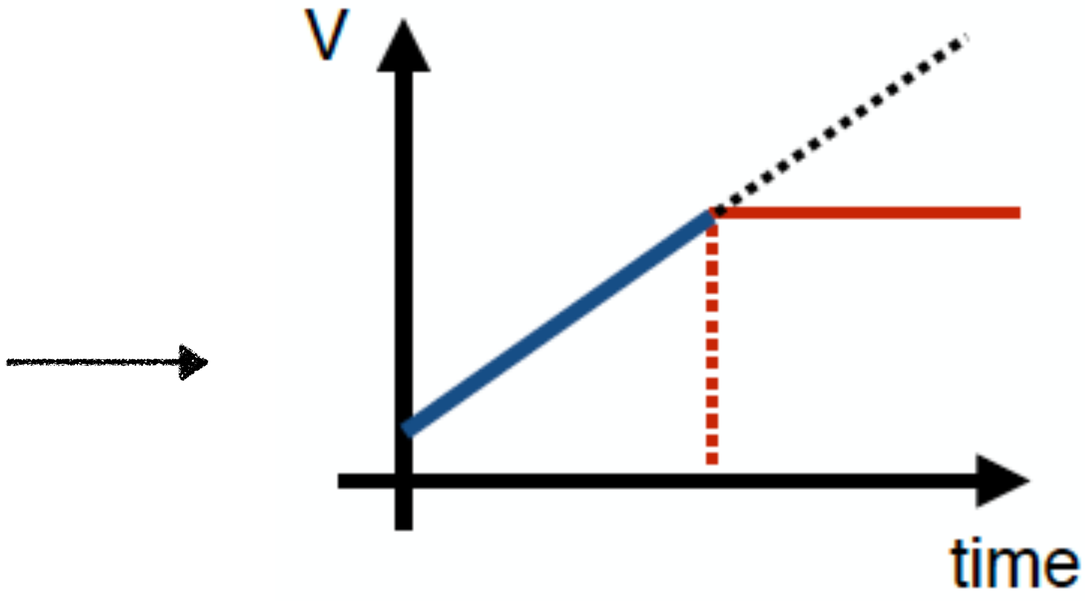

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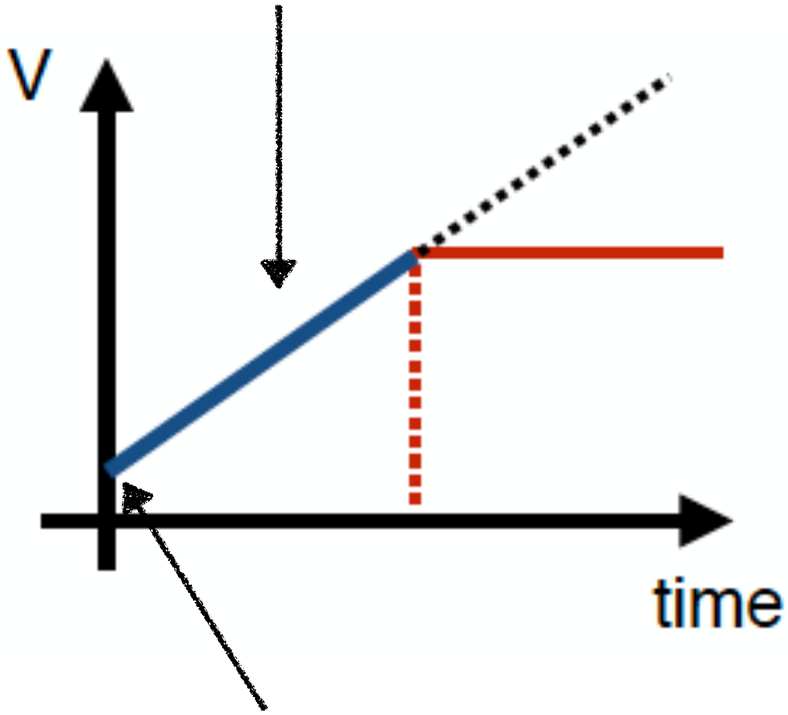
Slope is common to all channels on a chip



Offset is extracted for every memory cell

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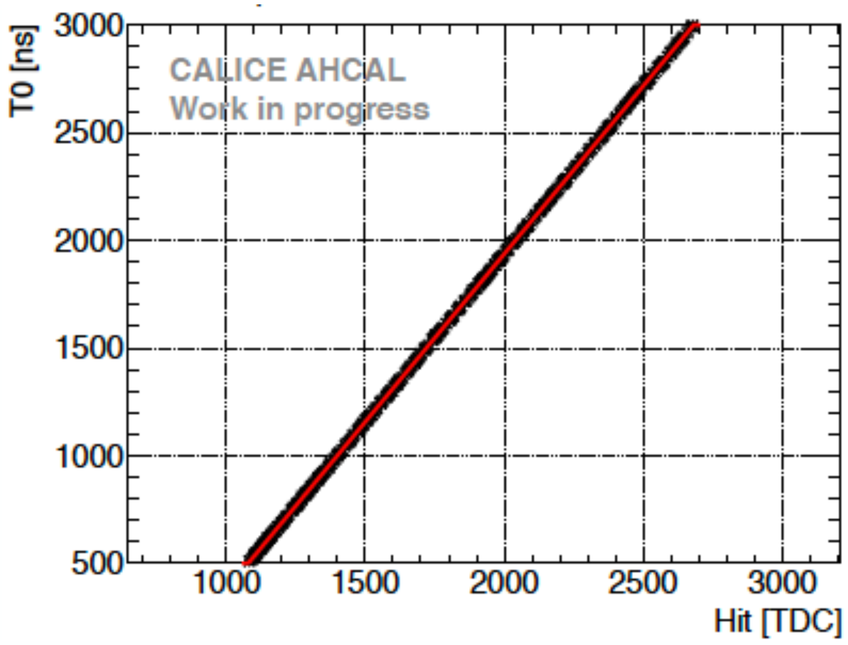

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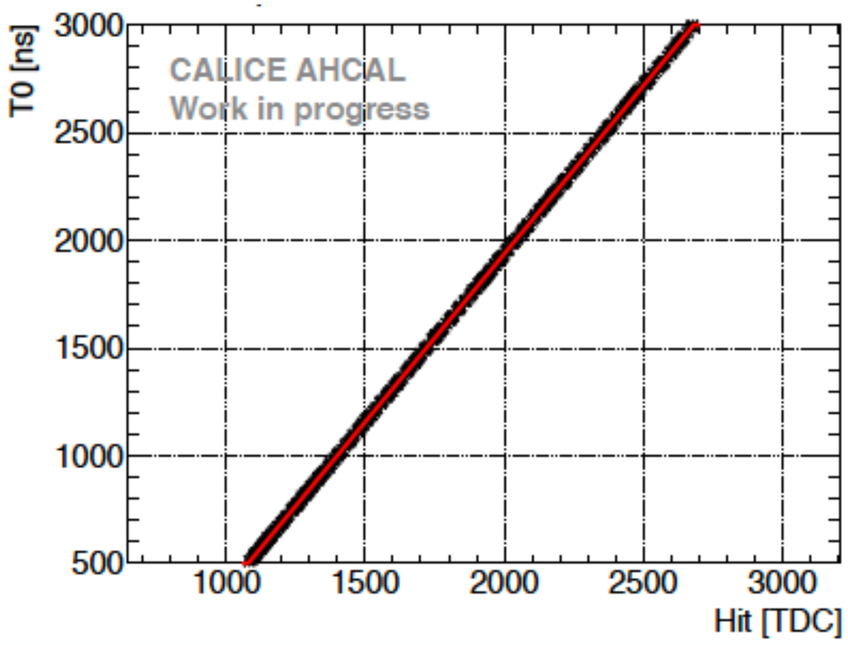

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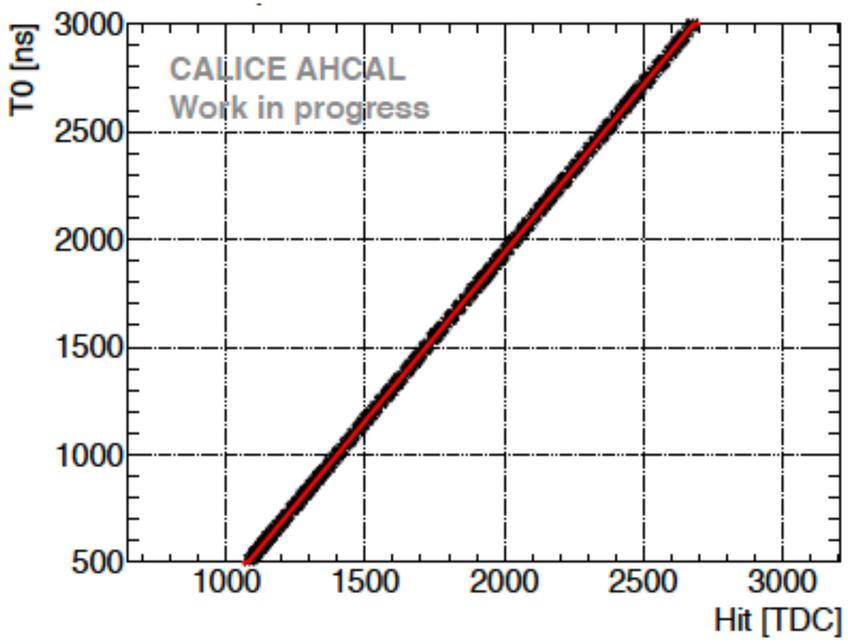
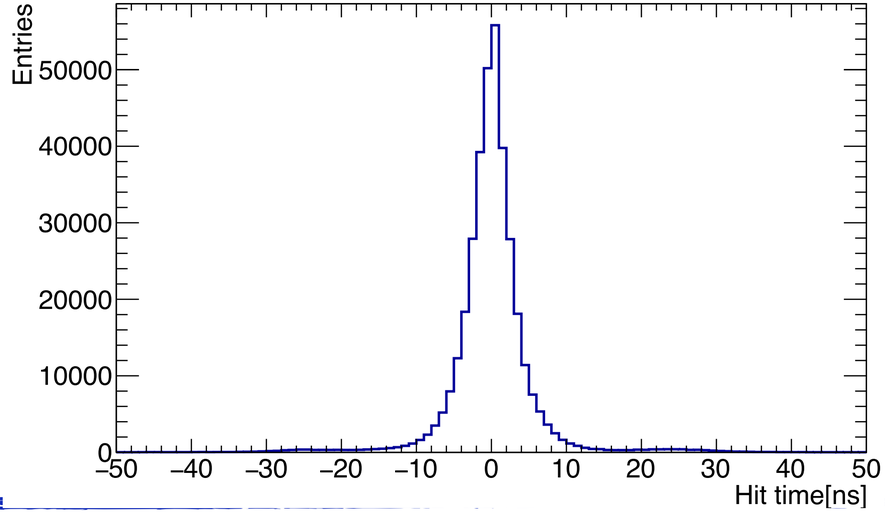


Hit time distribution



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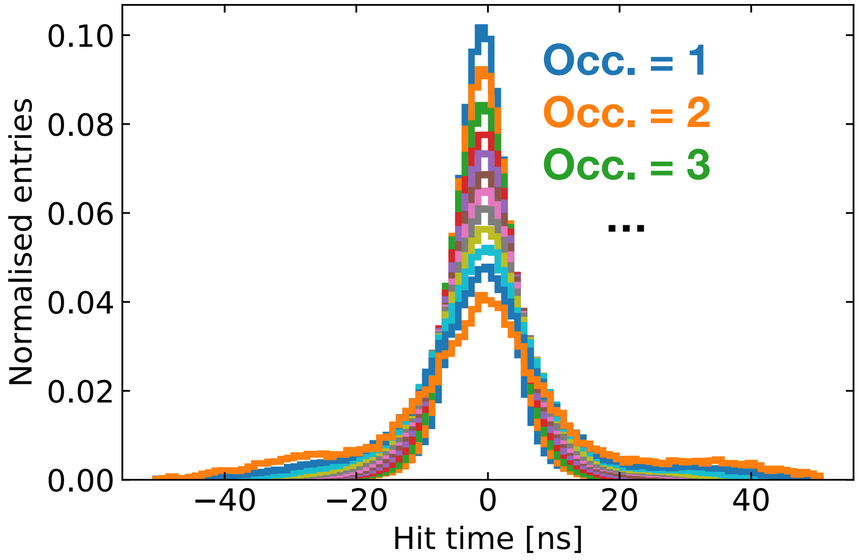

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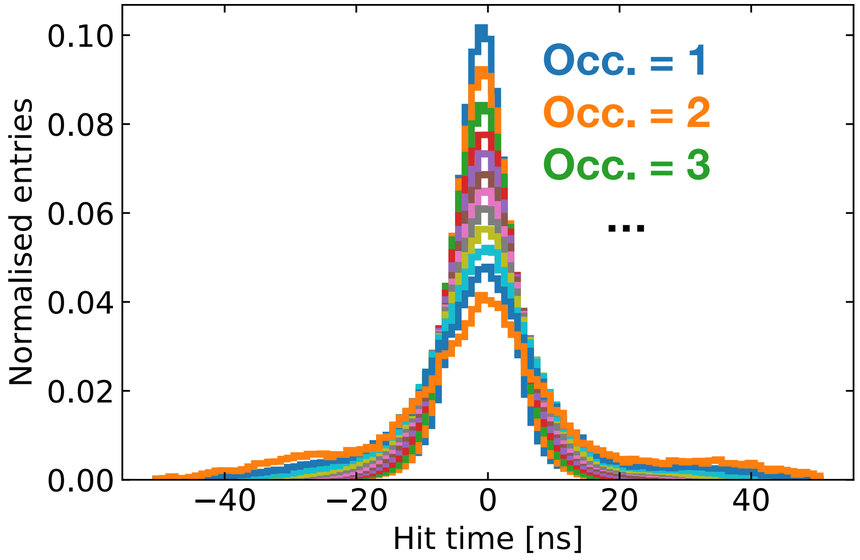

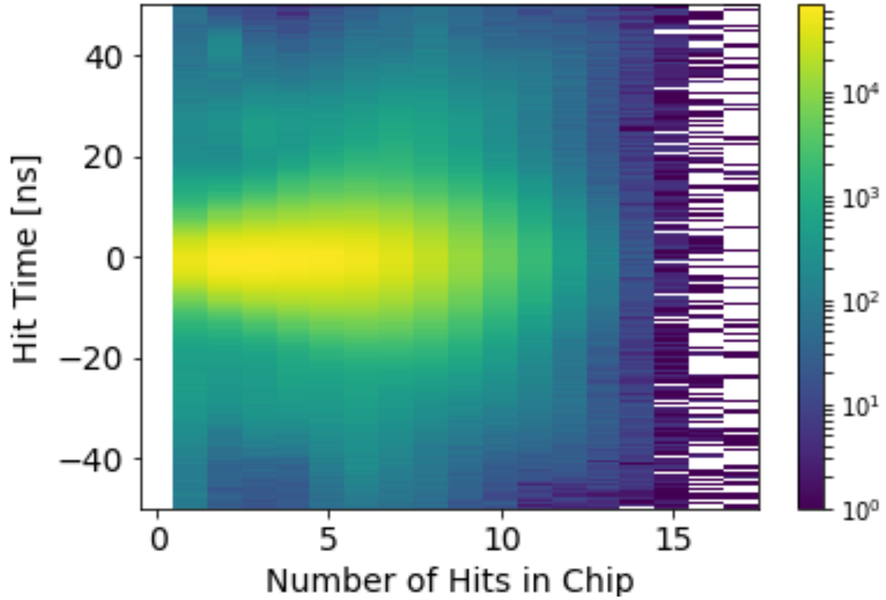

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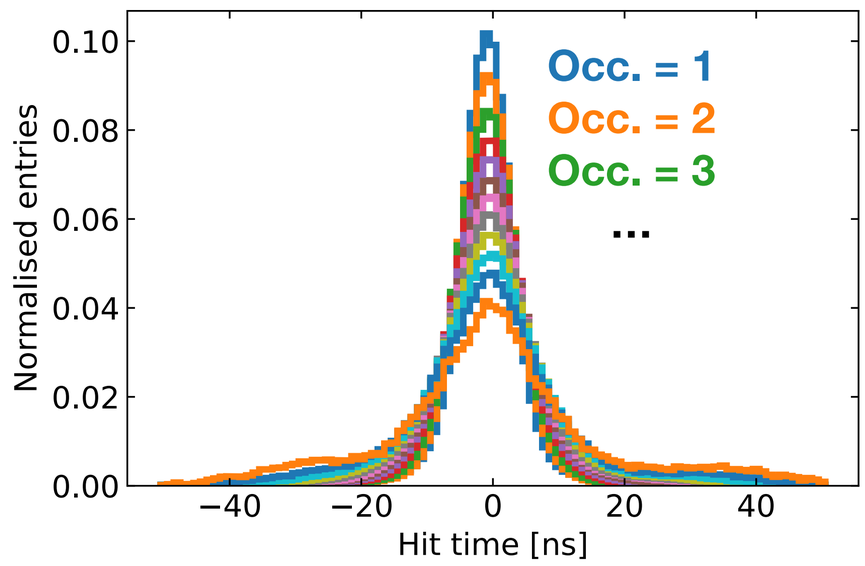
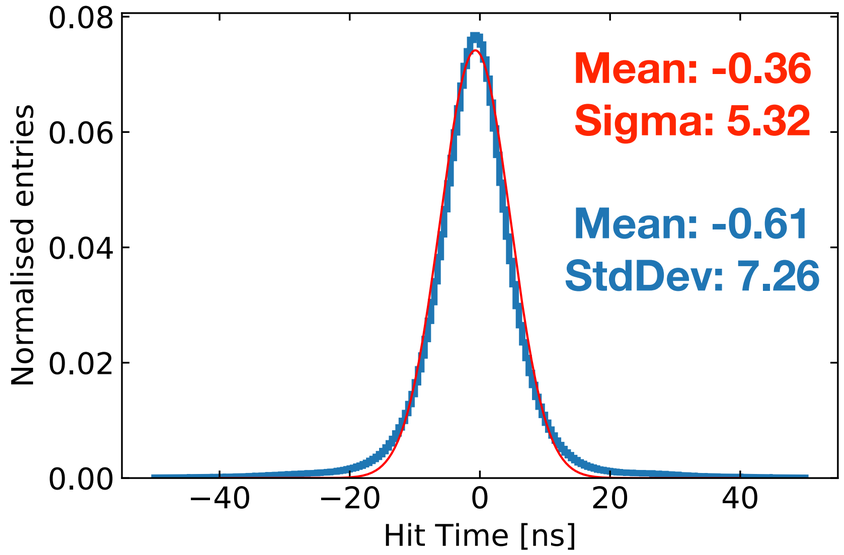
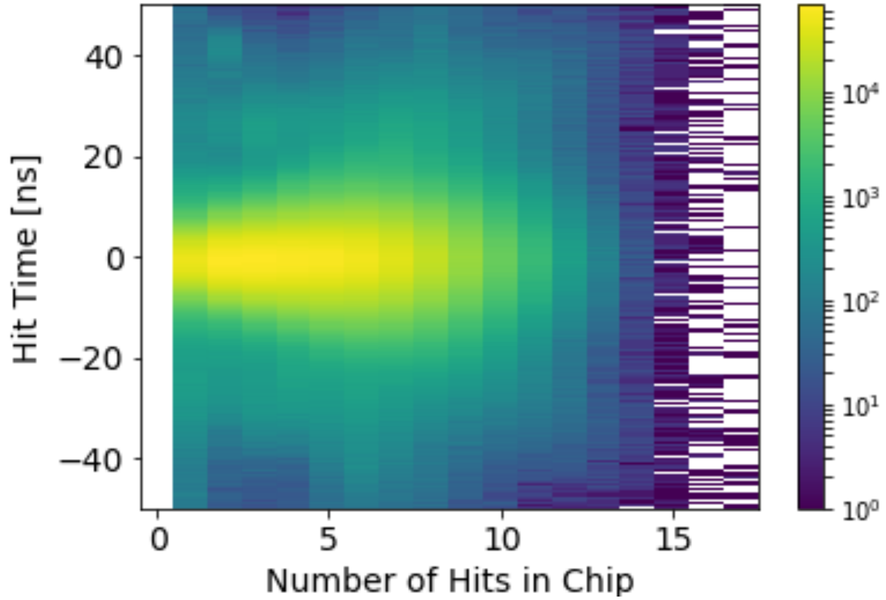
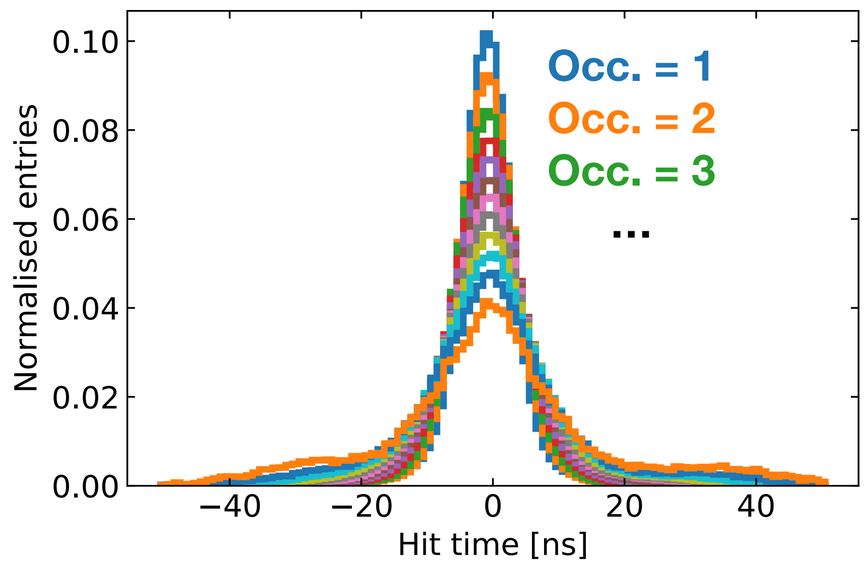
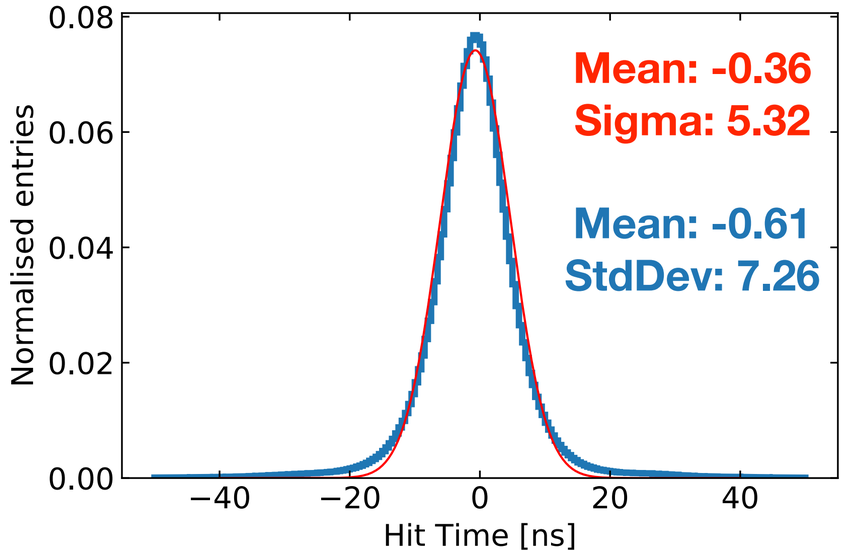


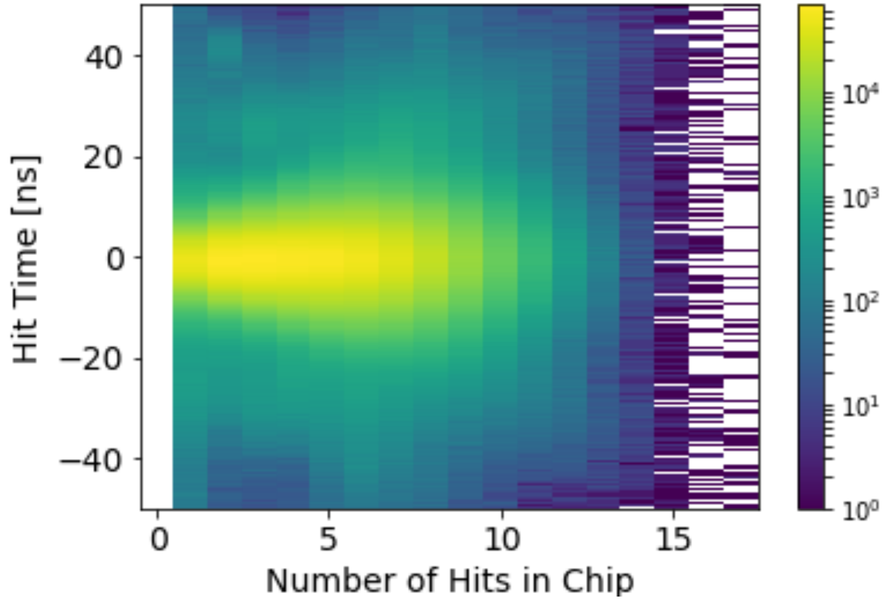




Correction on Channel Level







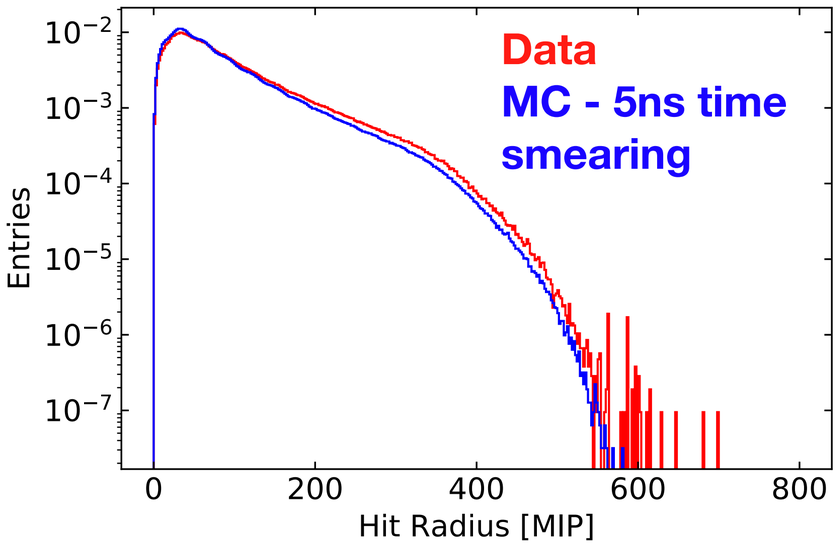
Channel wise correction outperforms global correction by ~1ns

<u>Problem:</u> Electromagnetic showers don't extend over the full depth

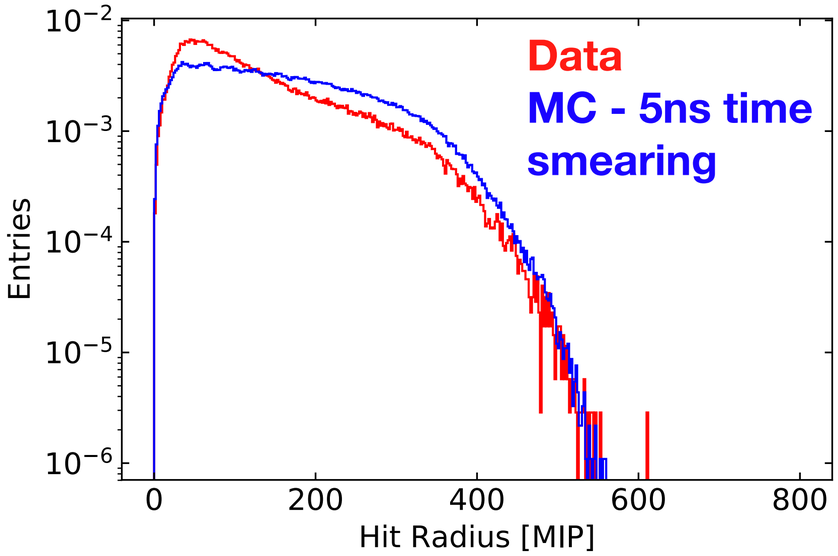
$\Longrightarrow$Try using Pions

A Look at Pions - Hit Energy

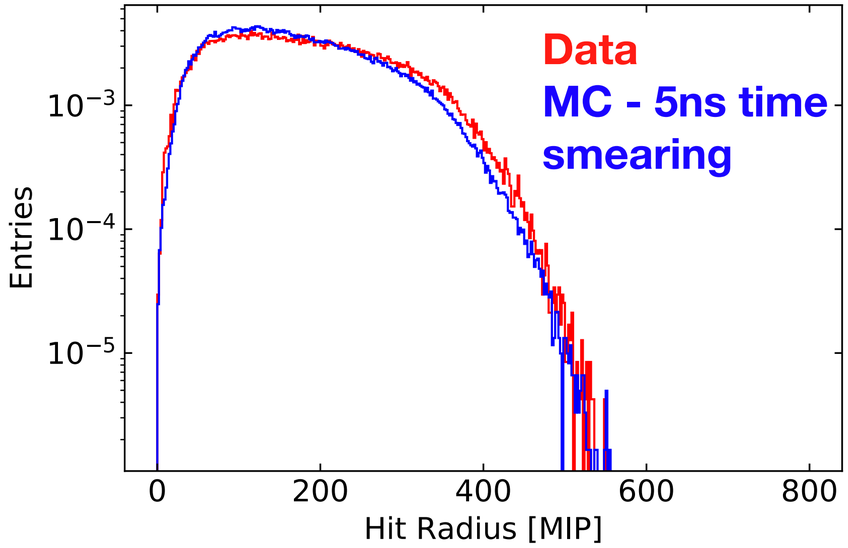
Prompt: hit time <10ns



Elastic:10ns< hit time<50ns



Capture: hit time >50ns



Overlap of prompt and elastic part in data

Similar shape of data and MC in the capture part