SciTil related software updates

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GSI Darmstadt, 8.6.2016

Topics

- PID based on SciTil
- Online T0 algorithm

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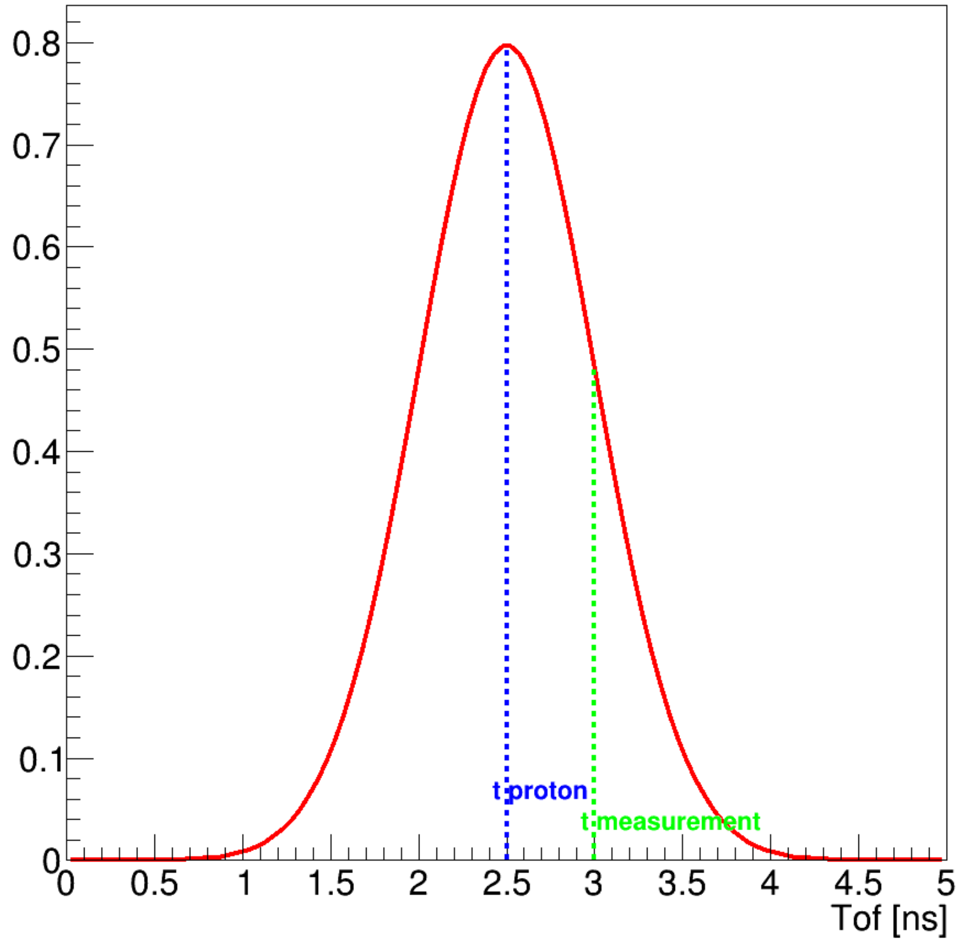
- PID based on SciTil
- Online T0 algorithm

Definition of TOF-PID Probability

- Derive the corresponding "calculated" time-of-flights
  - l → reconstructed track length
  - p → reconstructed momentum
  - m_i → mass assumption
    - Proton, kaon, pion, muon,electron

$$t_i \equiv l \cdot \sqrt{\left(\frac{m_i}{p}\right)^2 + 1}$$

- Generate a normalized Gaussian
  - Around calculated time-of-flight
  - Time-of-flight resolution corresponding to the parameters of the track
    - Resolution in momentum, track length and time
- Probabilities are derived from the Gaussian, at measured time-of-flight
  - Time stamp in SciTil
- Final pdf has to be normalized using the probabilities of all particle species

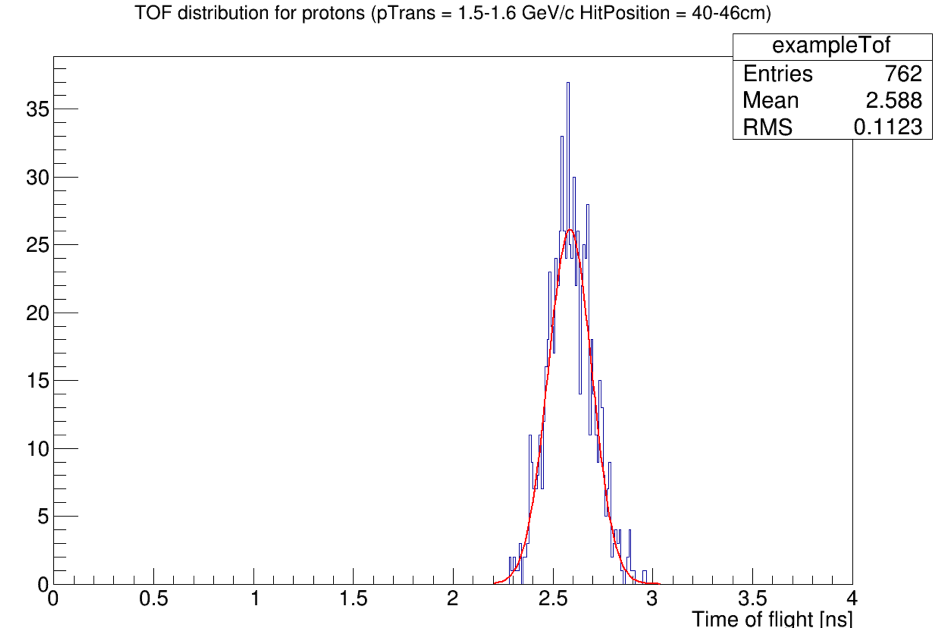


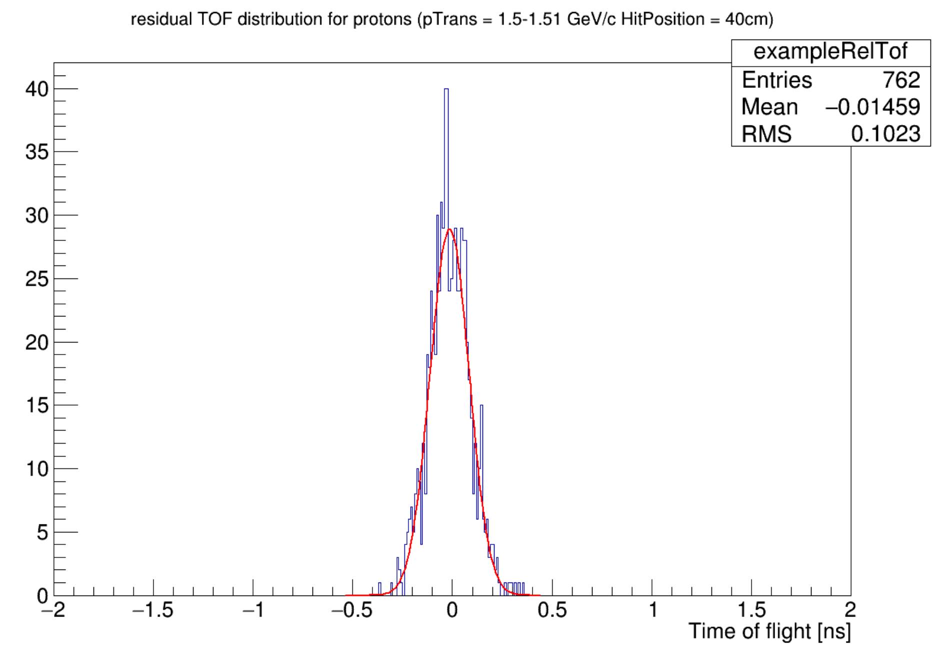
Determination of Time-of-flight resolution

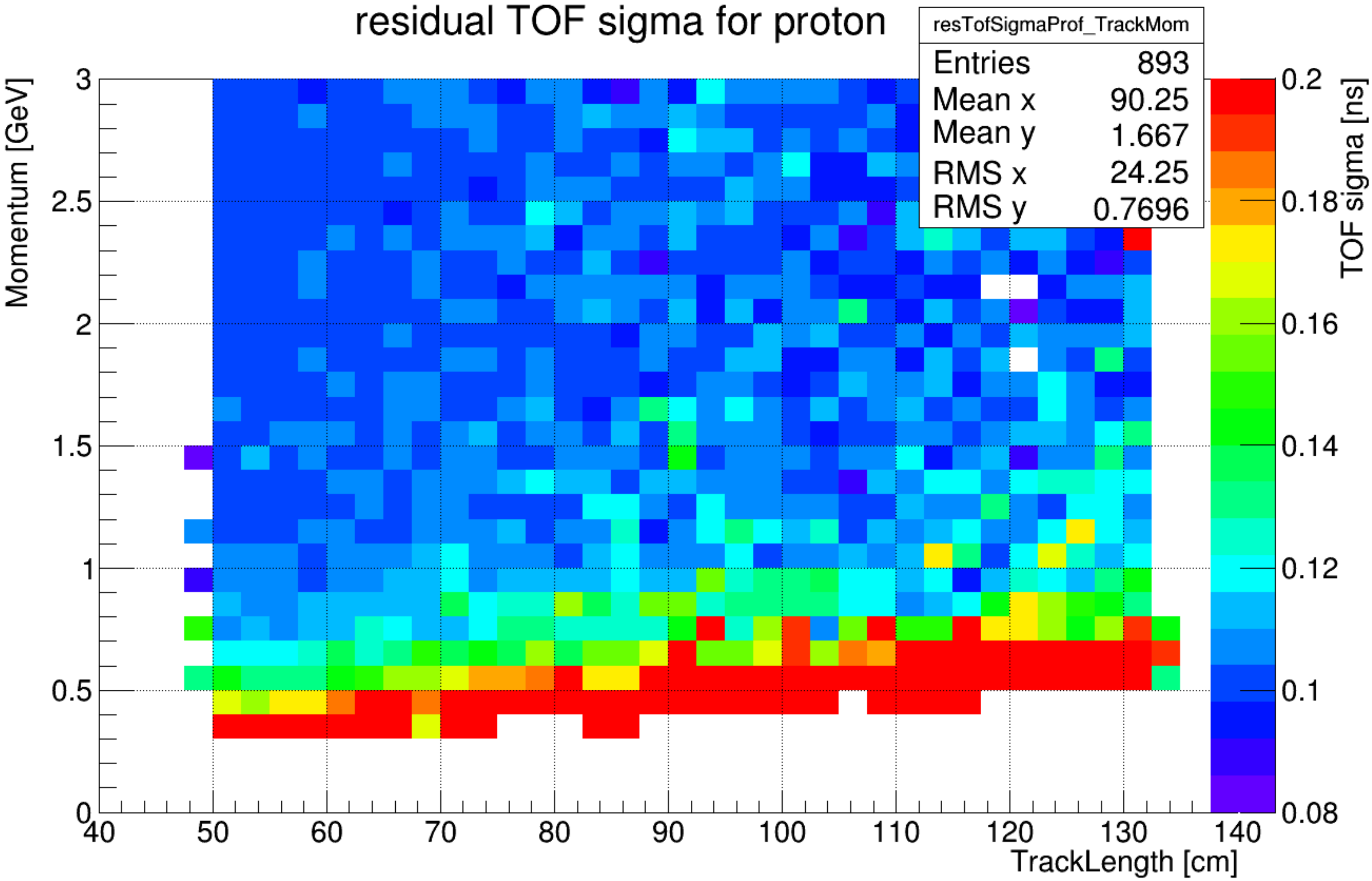
- Tof resolution of effected by:
  - Intrinsic time resolution of SciTil
    - σ = 100 ps (current implementation)
  - Track length resolution
  - Momentum resolution
  - Particle species
- Evaluation of Tof resolution using MC simulations
  - Investigation of Tof σ as a function of the tracking parameters

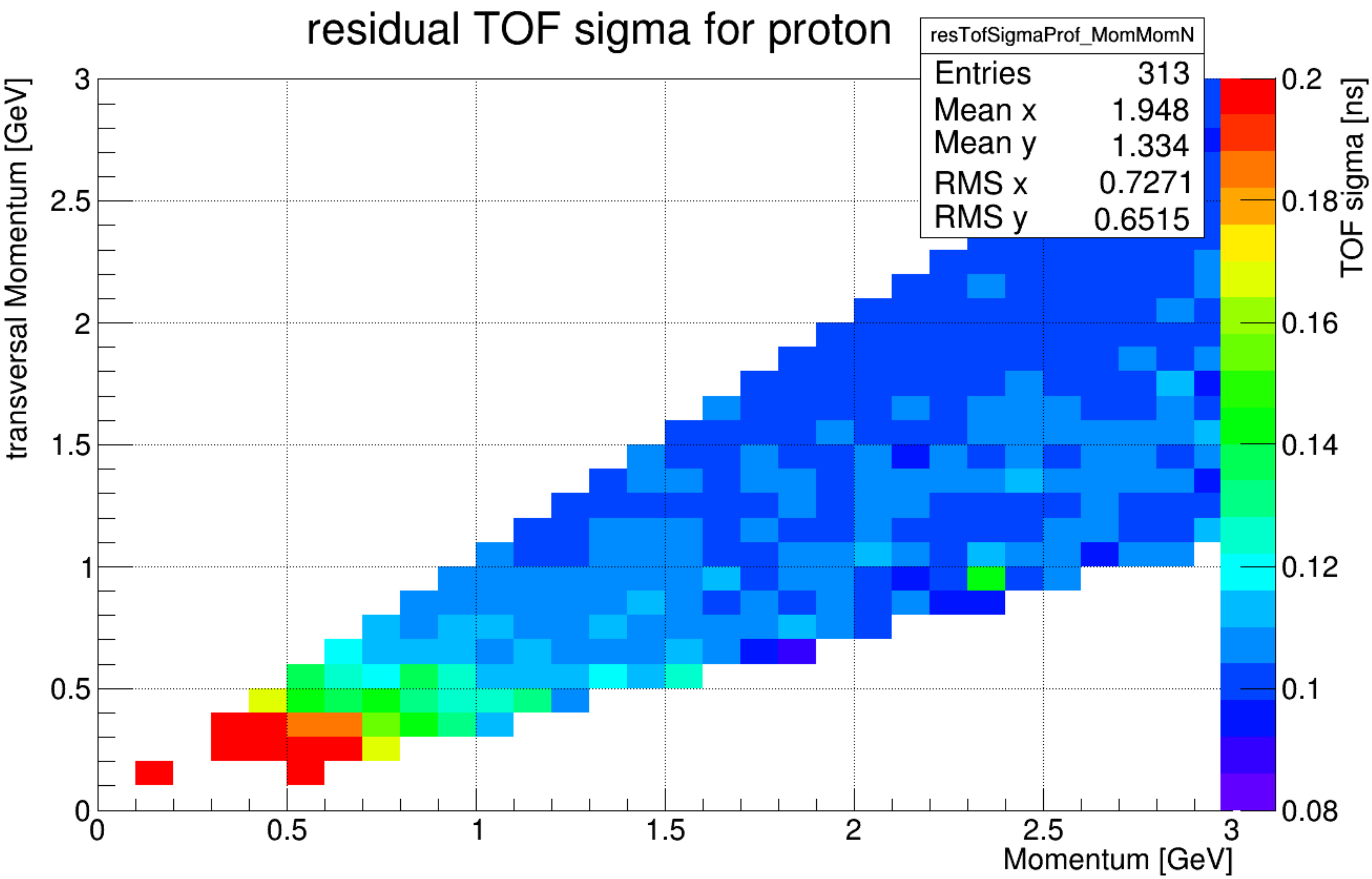
- Pandaroot, trunk 28975
- Full Geometry
- Boxed Generator
  - Proton, kaon, pion, muon, electron
  - 10^6 events
  - 0.05 – 3 GeV/c
  - Θ = 20 – 140
- Perfect T0 estimated

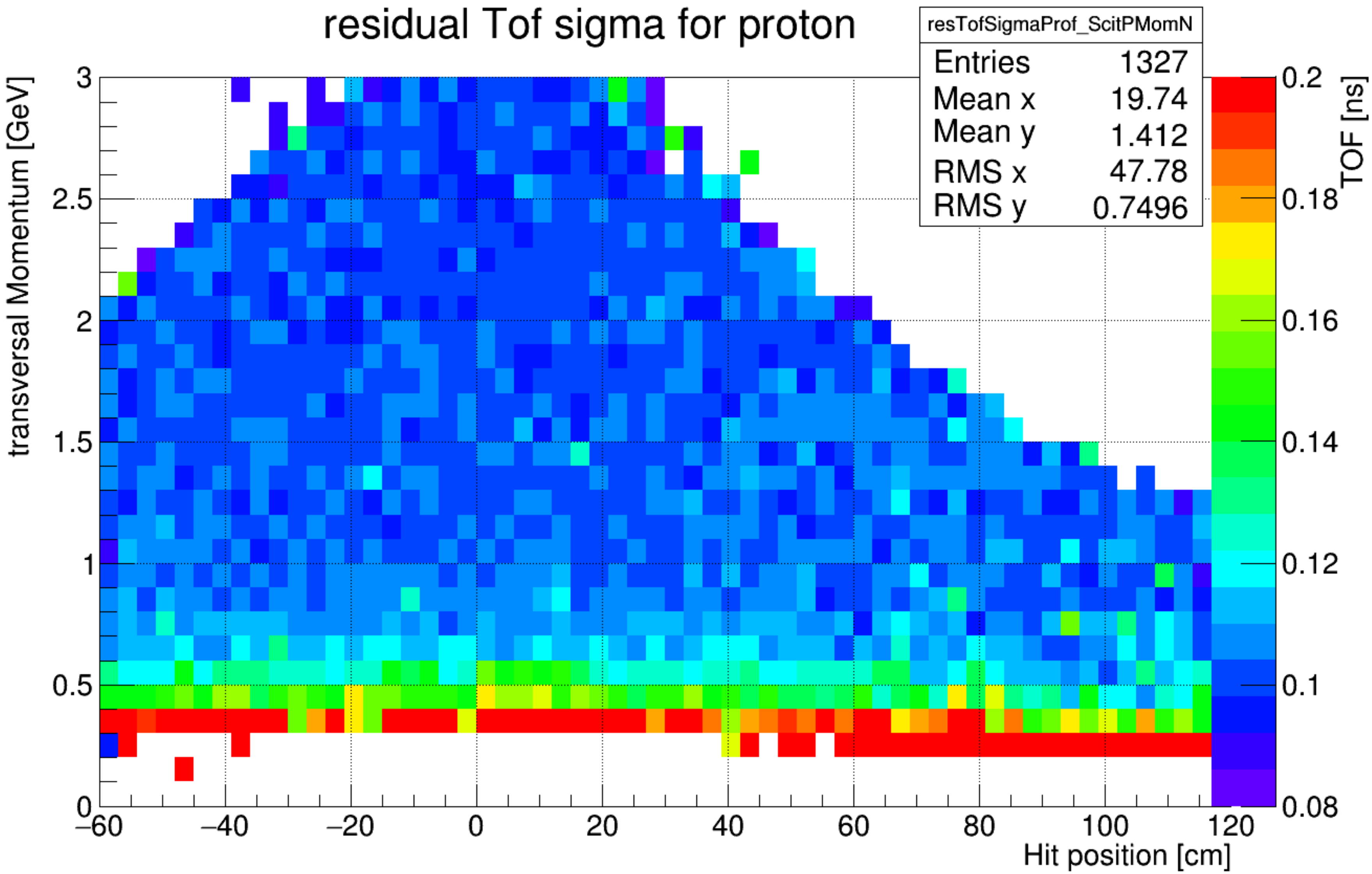
- Evaluation of Tof resolution effected by binning effects
  - e.g.: momentum range, track length range, . . .
- "Residual Tof"
  - $t_{res} = t_{measured} - t_{calculated}$



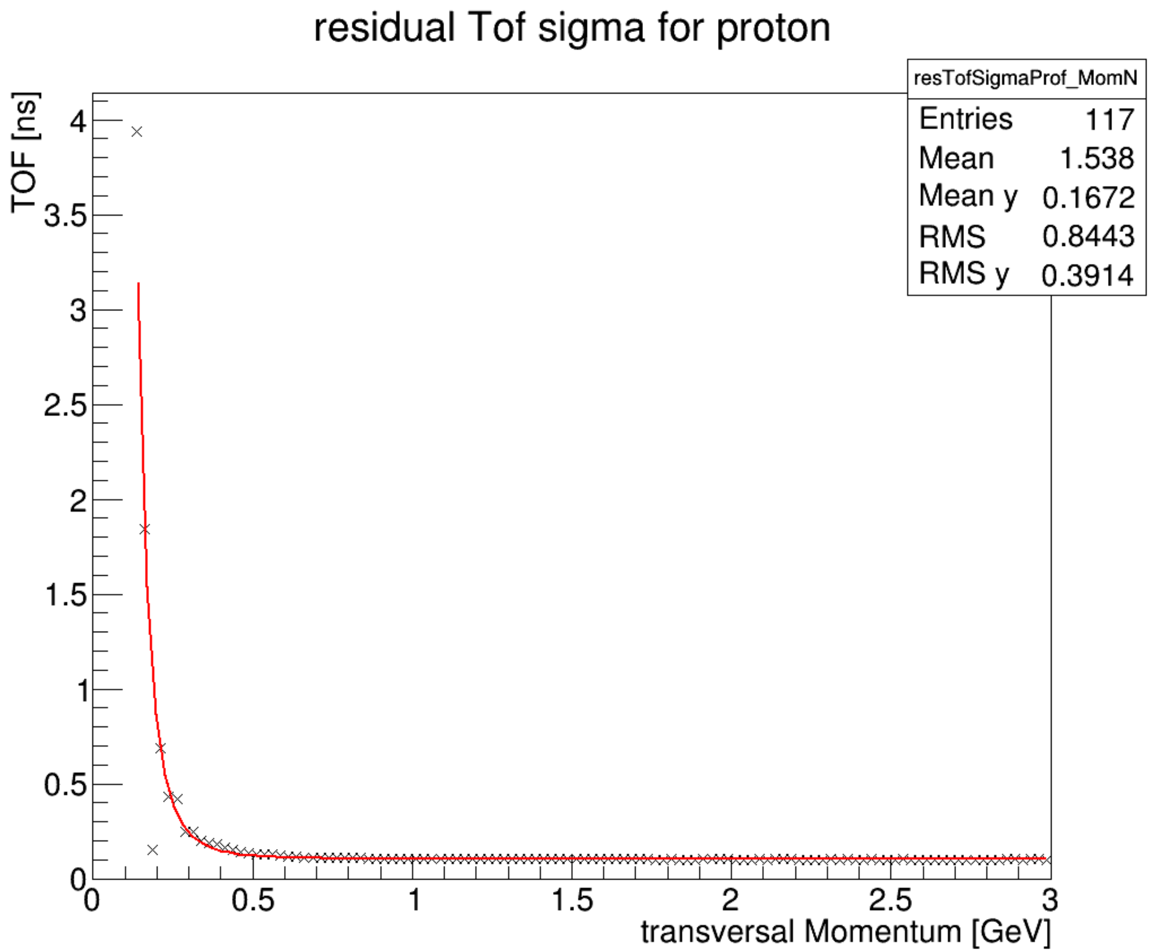



residual TOF sigma for proton
resTofSigmaProf_TrackMom
Entries 893
Mean x 90.25
Mean y 1.667
RMS x 24.25
RMS y 0.7696
Momentum [GeV]
TrackLength [cm]
TOF sigma [ns]
0
0.5
1
1.5
2
2.5
3
40
50
60
70
80
90
100
110
120
130
140
0.08
0.1
0.12
0.14
0.16
0.18
0.2

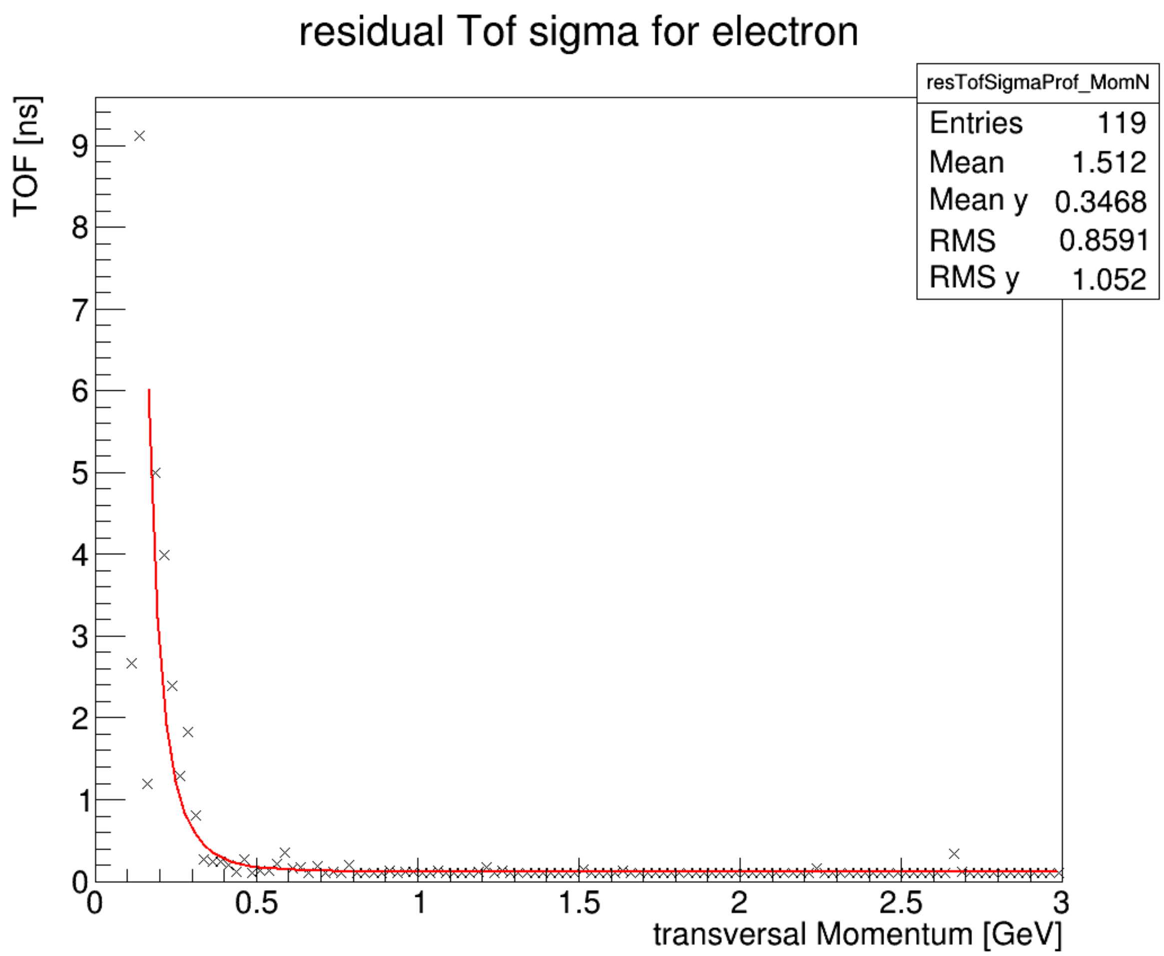

residual TOF sigma for proton
resTofSigmaProf_MomMomN
Entries 313
Mean x 1.948
Mean y 1.334
RMS x 0.7271
RMS y 0.6515
transversal Momentum [GeV]
Momentum [GeV]
TOF sigma [ns]
0
0.5
1
1.5
2
2.5
3
0.08
0.1
0.12
0.14
0.16
0.18
0.2


residual Tof sigma for proton
resTofSigmaProf_ScitPMomN
Entries 1327
Mean x 19.74
Mean y 1.412
RMS x 47.78
RMS y 0.7496
transversal Momentum [GeV]
Hit position [cm]
TOF [ns]
0
0.5
1
1.5
2
2.5
3
−60
−40
−20
0
20
40
60
80
100
120
0.08
0.1
0.12
0.14
0.16
0.18
0.2

- $P_{trans} > 0.5$ GeV/c
  - $\sigma_{Tof} \sim 110$ ps
- $P_{trans} < 0.5$ GeV/c
  - Particle with low p_{trans} can't reach the SciTil directly
  - $$Tof\ \sigma \approx \frac{1.4 * 10^{-3}}{p_{trans}^4} + 0.103$$
  - Statistic for low p_{trans} is rather low!



- For light particles more complicated
  - σ_{Tof} depens also on p_{total}
    - Scattering probability
- Investigations are ongoing

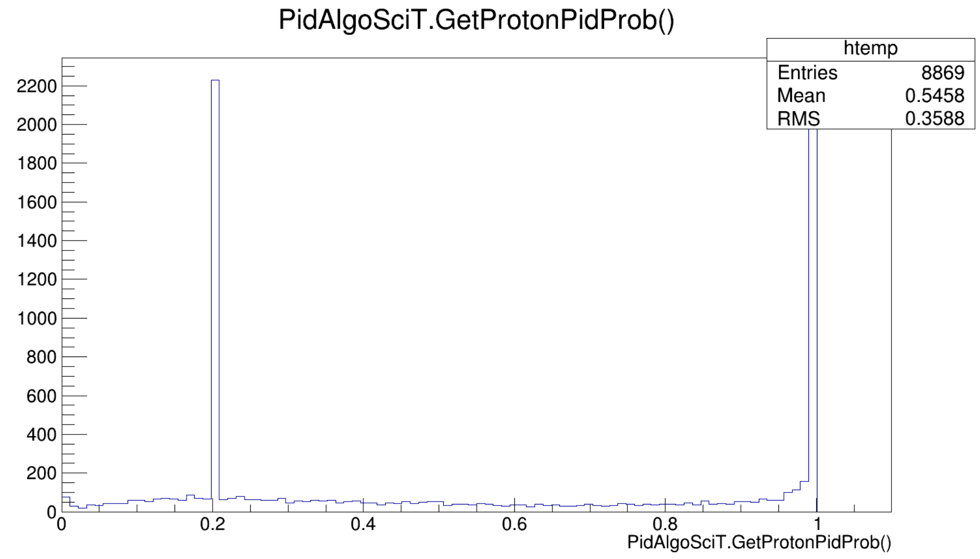


Implementation in Pandaroot

- First version of SciTil based PID implemented in Pandaroot
  - "residual TOF method"
  - Resolution of the TOF system set to a fixed value
    - σ_{Tof} = 110 ps
    - Good estimation for particle which can "directly escape"
  - Still perfect T0 estimated

PID stage

- Add new task
  - PndPidSciTAssociatorTask *assSciT= new PndPidSciTAssociatorTask();
  - fRun->AddTask(assSciT);



Outlook

- Updating implementation according to current detector development
  - Current test beam results
    - Intrinsic time resolution → 54 ps
- Check (and improve) the track propagation to the SciTil
  - $P_{trans} < 0.5$ GeV/c
- Evaluating σ_{Tof} function for all particle species
  - Implementation in Pandaroot
- Investigate the separation in σ
  - Different particle species

Topics

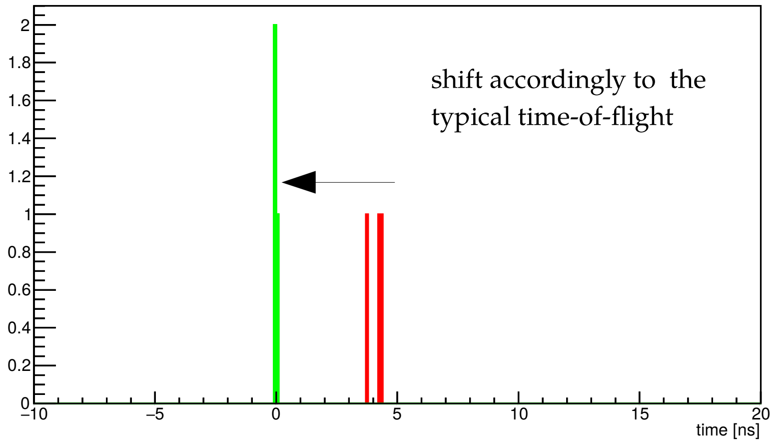
- PID based on SciTil
- Online T0 algorithm

Motivation

- Decent time information of $p\bar{p}$ annihilation with target (=t0) is necessary
  - for TOF, PID, pattern recognition, event sorting, ..
- T0 is needed online even with a limited precision for an event selection
- TOF counters (SciTil and FTOF) have the best time resolutions hence they have a high potential to play an indispensable role to deduce (online) t0.

Basic principle

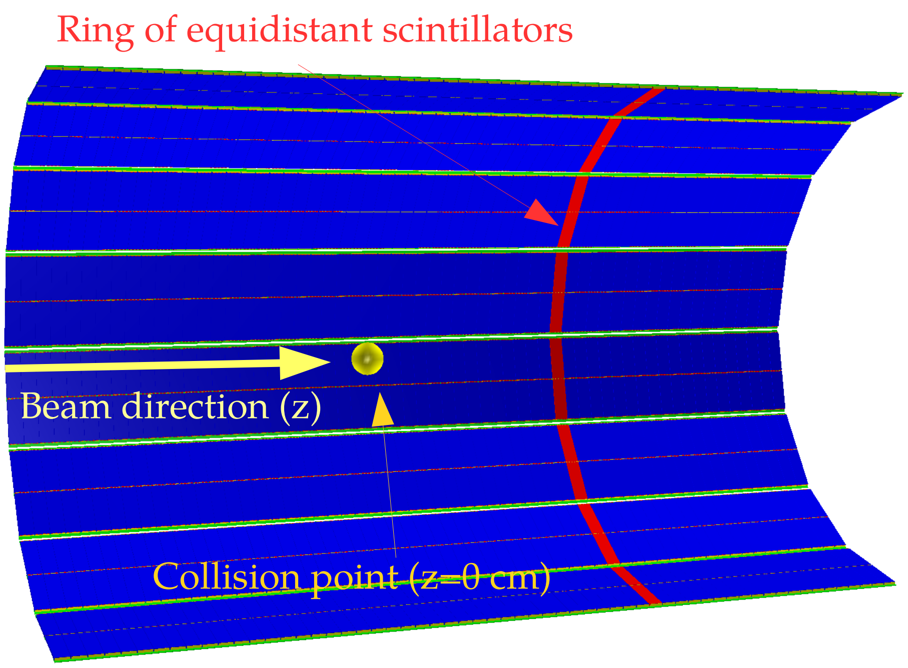
- For calculation of t0 it needs:
  - tracking information, PID, mass and momentum
- Assuming just average values
  - Δt0 ~ 1 ns
- Calculating t0 using the most typical path length and momentum is equivalent to shifting the time stamp distribution by a typical time-of-flight to t0.
  - SciTil
    - Flight path ~ 0.5 - 1.5 m
    - Flight time ~ 2 - 6 ns



We study the potential performance of the online t0 calculation using TOF counter, also taking into account the influence of secondary particles

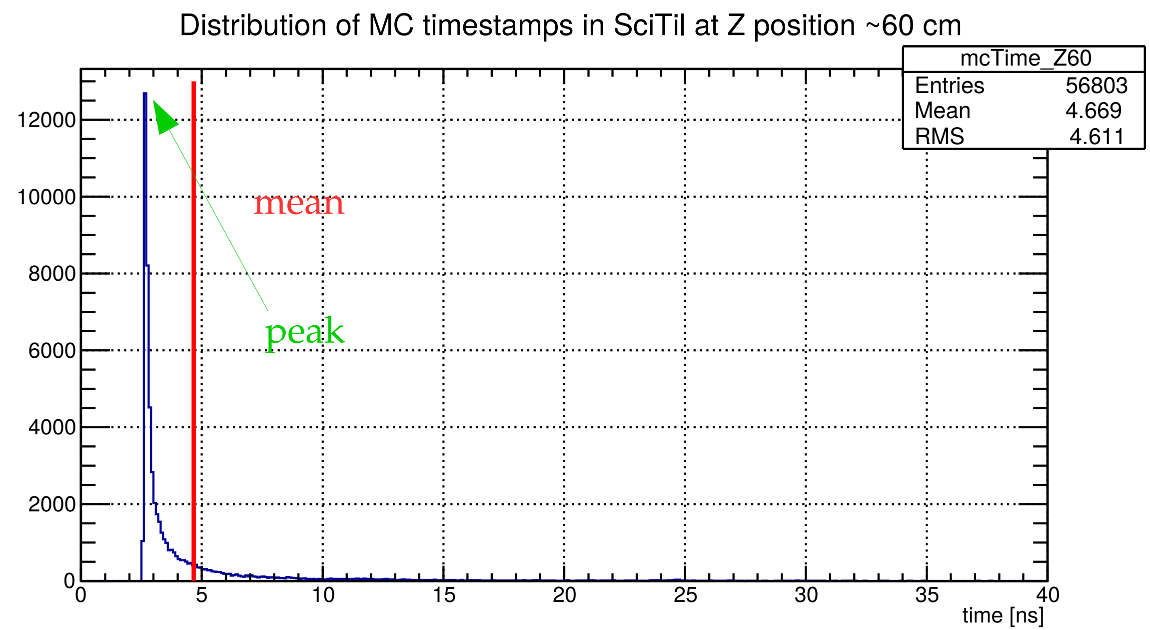
Time stamp distribution for equidistant tiles

- Typical time-of-flight is correlated with the production theta angle at the collision point
  - corrected shift on the time stamps respective to z-position of the hit
- Evaluate the typical time-of-flight for every z-position
  - Detector is sliced into 60 rings of equidistant scintillating tiles
  - The time stamp distribution for every ring was simulated to receive the typical time of flight



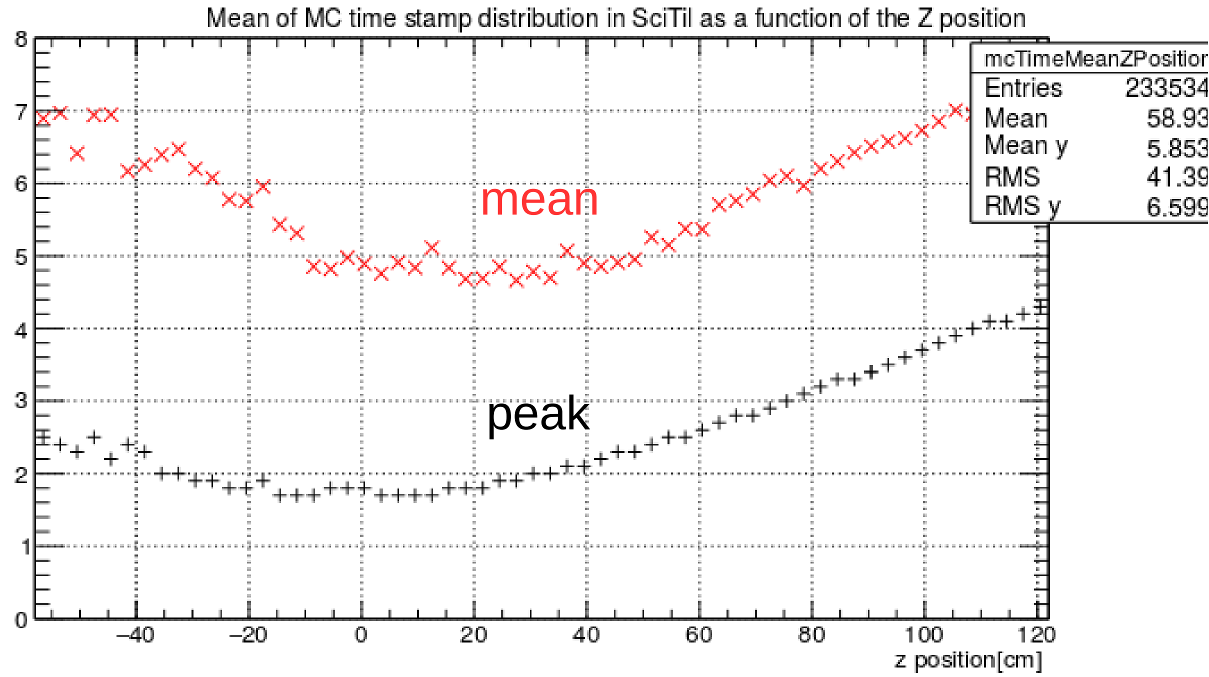
Time stamp distribution for equidistant tiles

- A typical distribution for an equidistant ring
  - Including secondaries
  - Mean = 4.7 ns, Peak = 2.6 ns
  - σ = 4.6 ns, FWHM = 0.3 ns
- Secondaries support this structure
  - For more details join the SciTil session



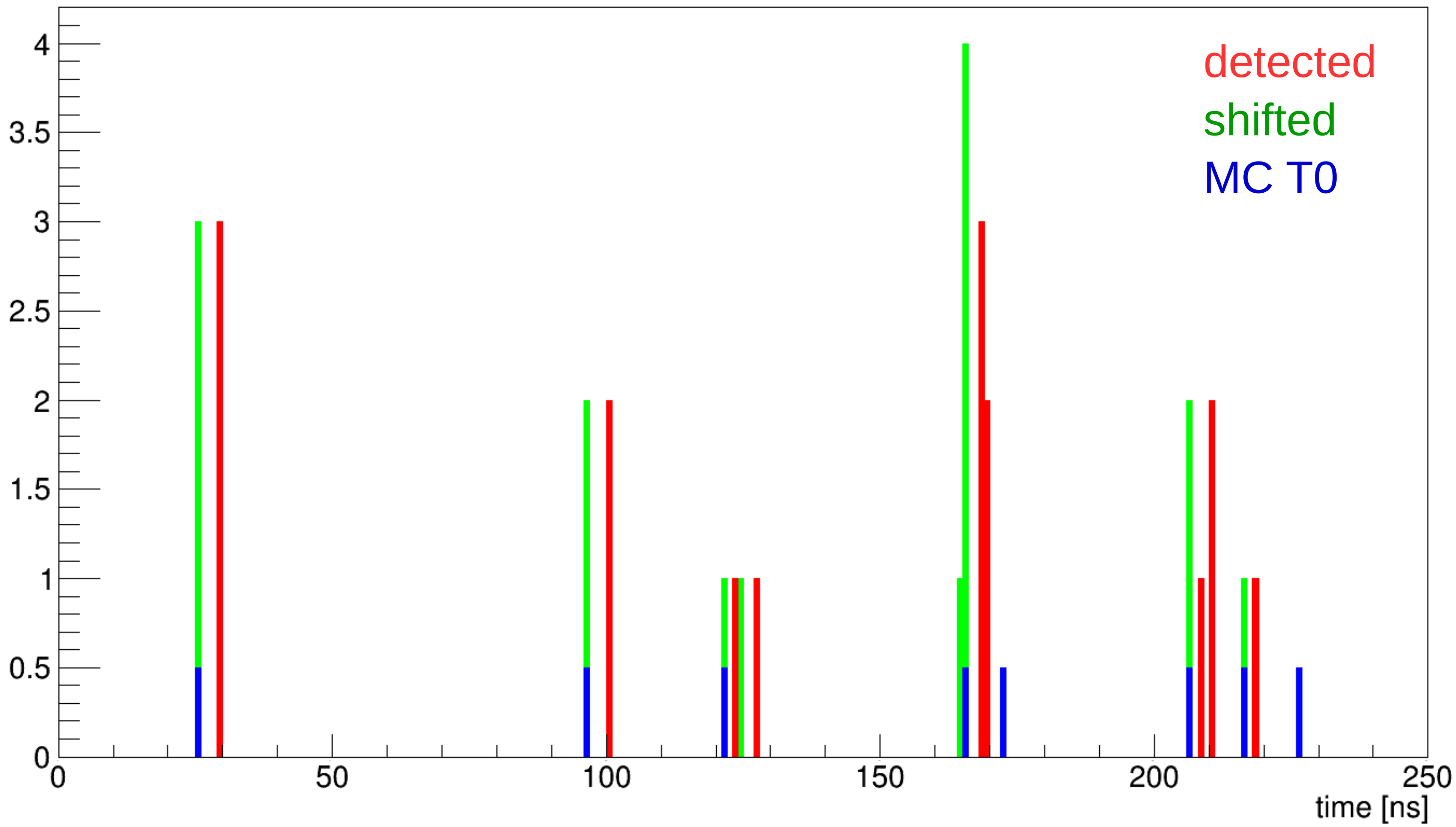
Time shift parameters

- Mean and peak position as a function of the z position
- The used value of central tendency must be chosen accordingly to the used algorithm to determine t0



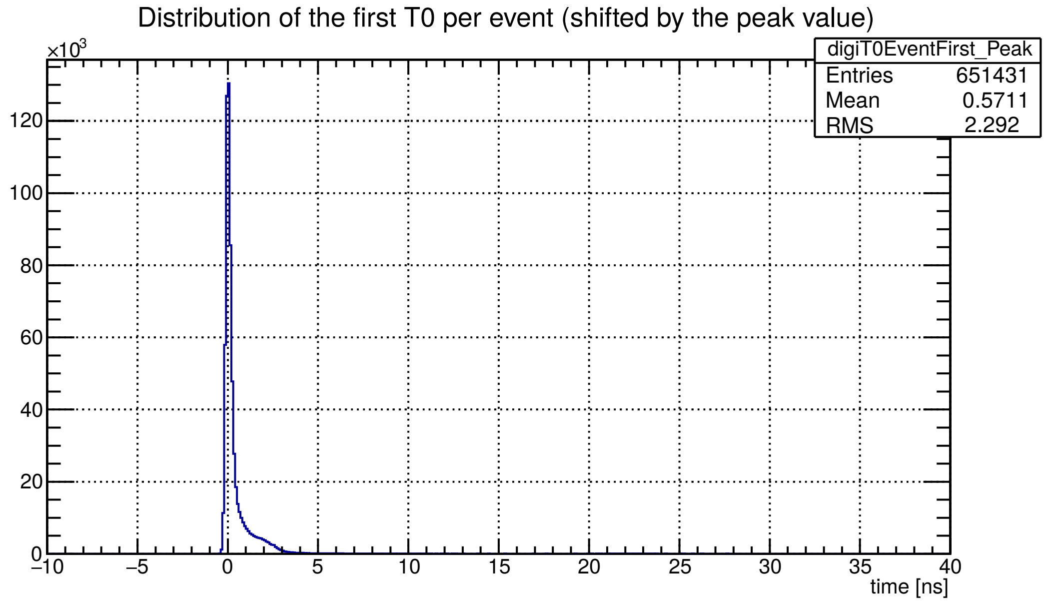
Time based simulation

Distribution of measured and peak aligned timestamps



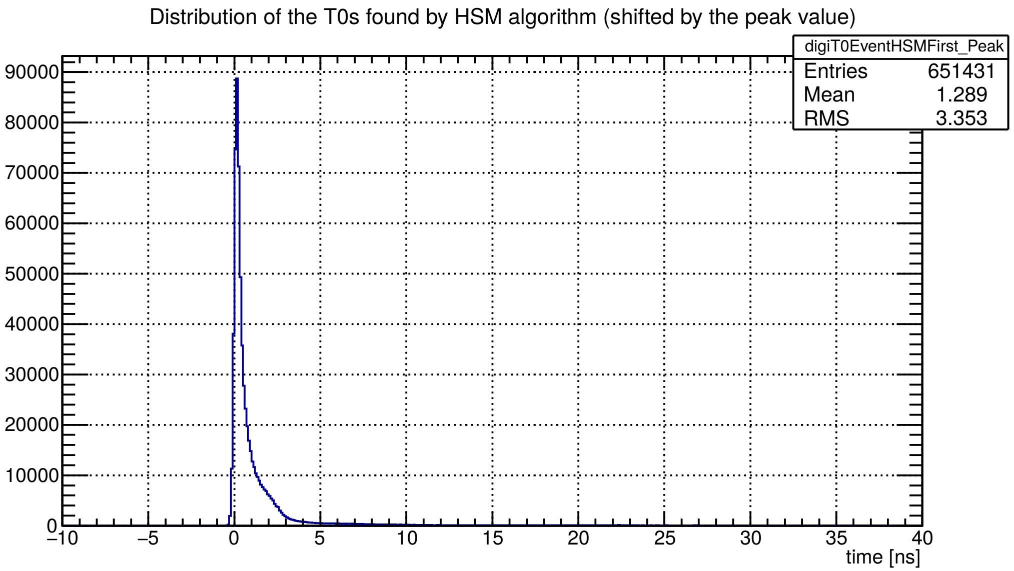
First time stamp method

- A very simple an good estimator of the peak position and therefore of t0 is the first "peak-aligned" time stamp per event
  - The plot shows the distribution of the final t0s per event using the fastest "peak-aligned" time stamp
    - Mean = 0.6 ns, Peak = 0.0 ns
    - σ = 2.3 ns, FWHM = 0.3 ns
- Only taking into account the SciTil a t0 time resolution of σ = 2.3 ns is achieved



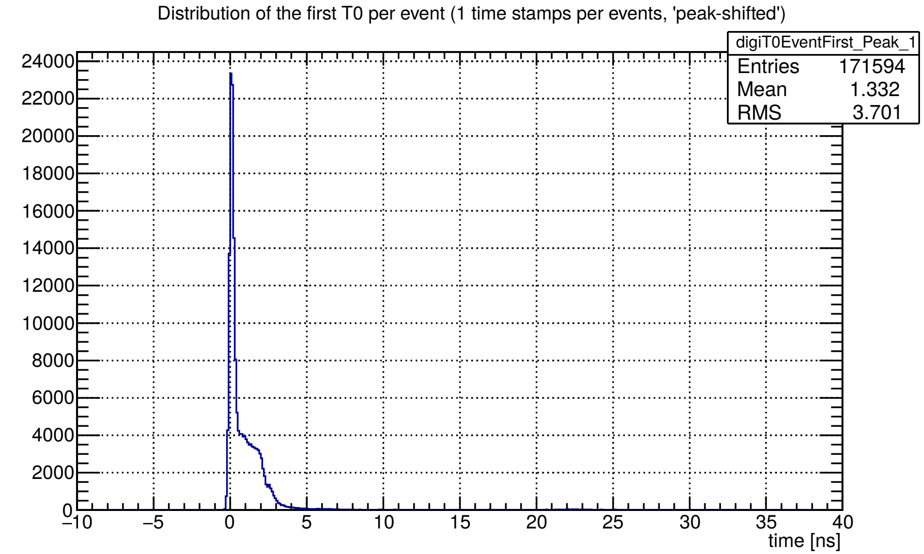
Half sample mode

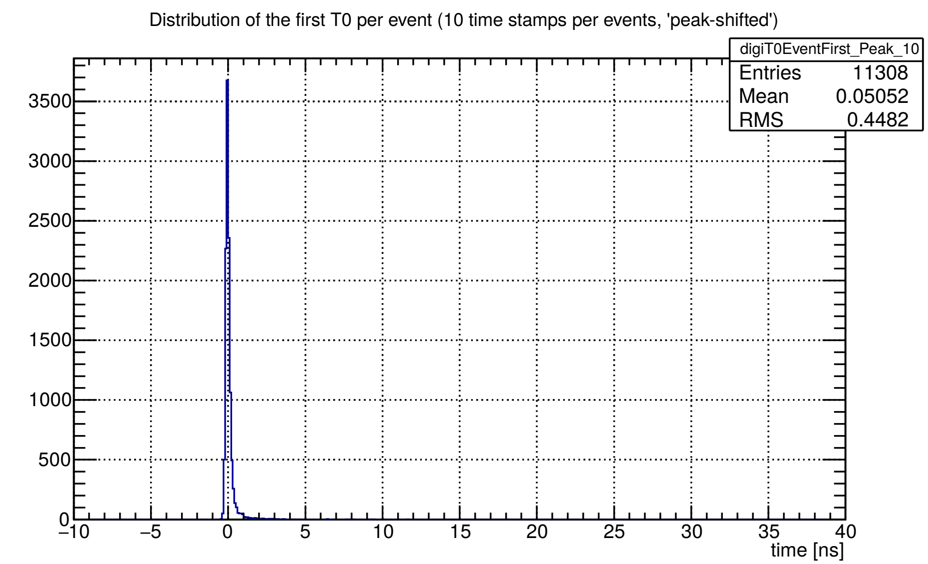
- No previous event separation in online reconstruction
- “half sample mode” (HSM)
  - Simple cluster finding algorithm
  - Search for the shortest interval which is containing half of the timestamps in a defined interval
  - Iteratively repeat on the so found intervals till only 2 time stamps are left
  - The first one is chosen as T0 for the event
- Advantage of HSM (and similar) is the functionality in a continuously read out
- HSM for single events
  - Mean = 1.3 ns, Peak = 0.1 ns
  - σ = 3.4 ns, FWHM = 0.4 n



Influences of particle multiplicity in SciTil

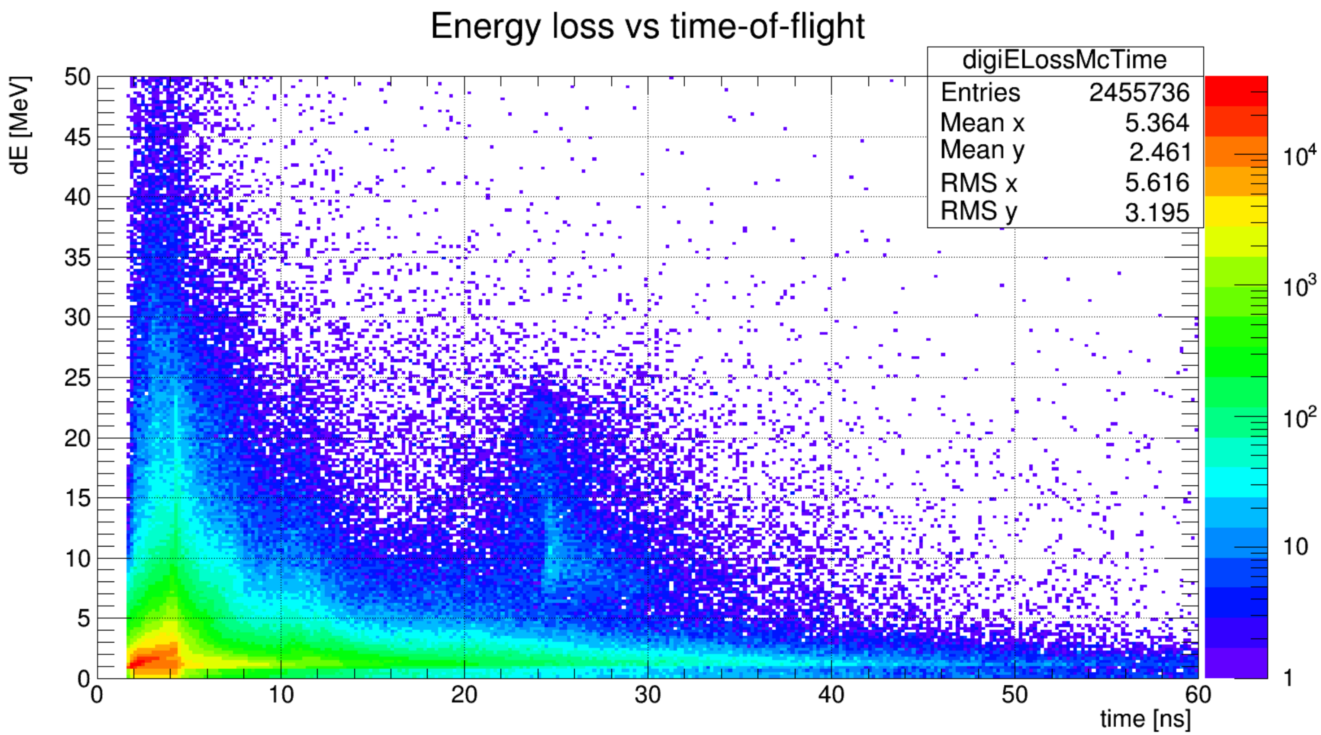
- First time stamp method
  - $\sigma_1 = 3.7$ ns => $\sigma_{10} = 0.4$ ns
- => including the time stamps of the FTOF should increase the accuracy further





Suppress slow particles

- Distinguish between fast and slow particles by energy loss in SciTil
  - No correlation between the energy loss and the flight time of the particles is observed



Summary

- We studied an simple and fast algorithm to estimate t0 based on the timing information of the TOF counters
  - Due to the limited scope of this study only the SciTil was taken into account
- It is evident that the secondaries provide an additional and useful information for the t0 estimation
- It was shown that T0 can be calculated by using the position information of the SciTil and the corresponding typical time of flight
  - Using the "first time stamp method" a t0 resolution of σ = 2.3 ns was achieved.
- Using the additional energy loss information provided by the SciTil lead to no enhancement so far
- Increase in accuracy is expected once the FTOF information is taken into account

Thank you for your attention

for more information
please join the SciTil Session