

A preliminary exploration: adding a timing model to the ILD tracker

A detector for the next flagship project: ILD

14th-16th September, CERN

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- This presentation shows an exploratory work to add timing capabilities to the ILD tracker
- The work gave place to the Final Degree Project of an undergraduate student of mine
 - Announced to Frank Gaede back in December last year
- The main purpose of the work was to get used to Key4Hep and the software of the ILD
 - The choices made are somewhat arbitrary and by no means are not a proposal
 - Just a step for us to gain understanding on the detector software
- The presentation has two parts:
 - Plotting of some basic variables using official samples
 - Implementation of a Timing Model on the Digitization of Tracker Hits.

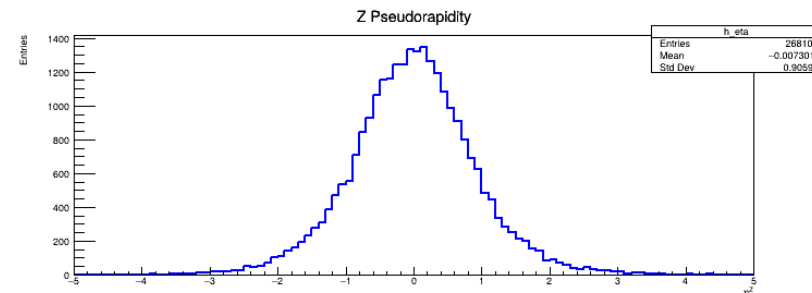
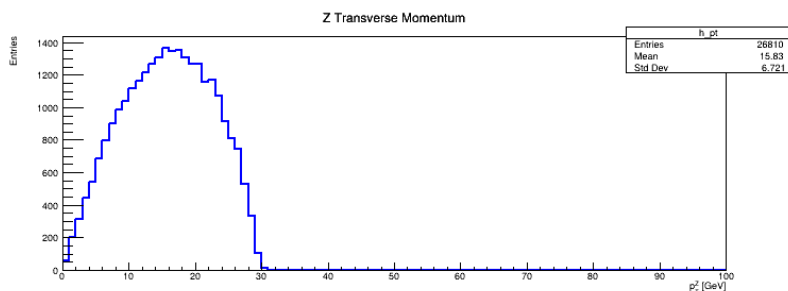
Samples and sanity checks

- Before proceeding with anything else we have been running basic samples as a sanity check
- Using the following sample from the Winter2023 Campaign:

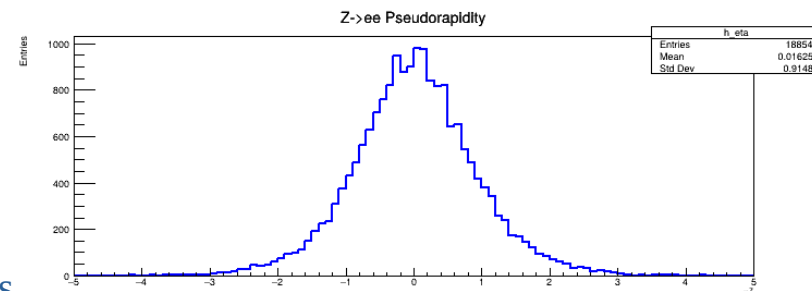
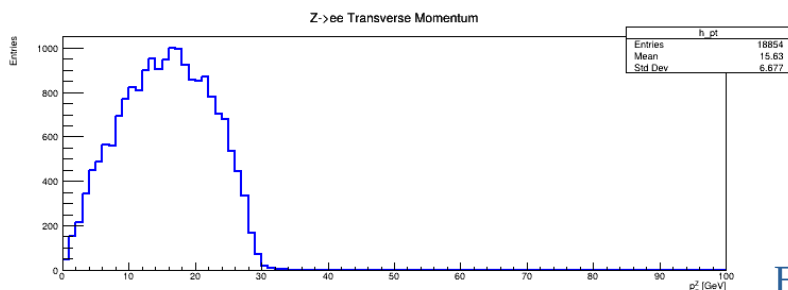
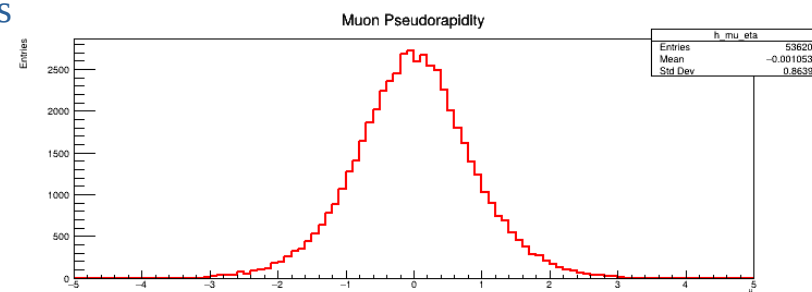
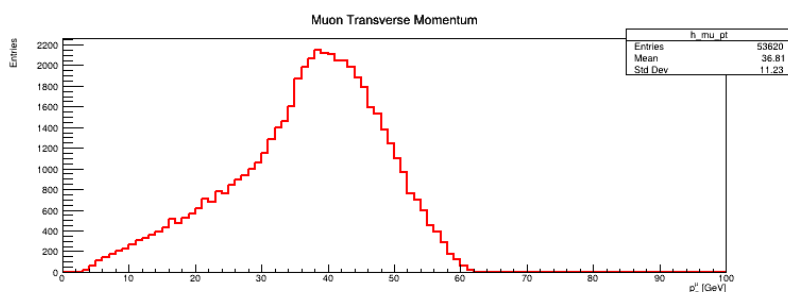
`/eos/experiment/fcc/ee/generation//stdhep//winter2023/wzp6_ee_HZZ_llnunu_ecm125/`

- A filter and selection algorithm implemented to get events with two muons or electrons
 - Based and adapted on *RecoParticleFilter*
- Exploring muons and electrons from the PandorasPFO collections asking for:
 - Leptons with $P_T > 0.5$ GeV
 - Two leptons of opposite charge
 - Invariant mass of leptons $|91.2 - m_{ll}| < 10$ GeV
- Focusing on the reconstruction of the Z mass as a candle to make sure consistency

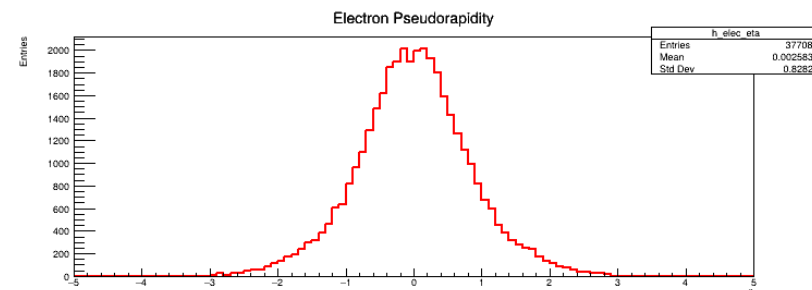
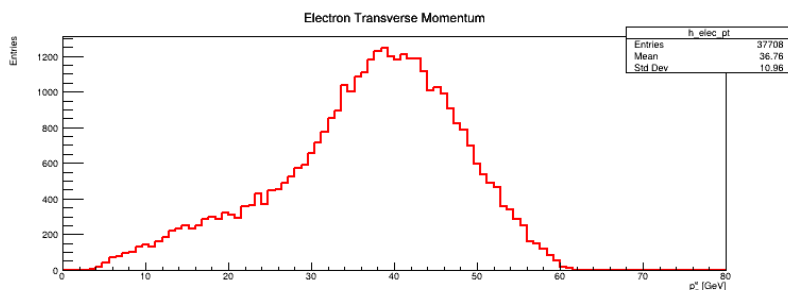
Samples and sanity checks



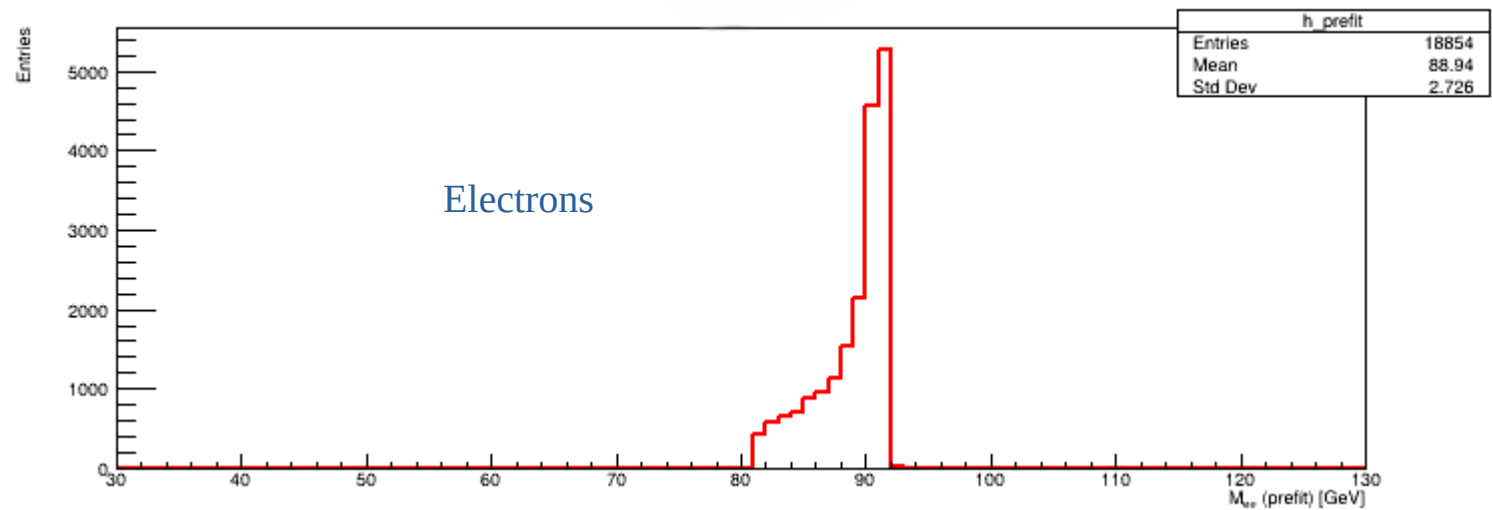
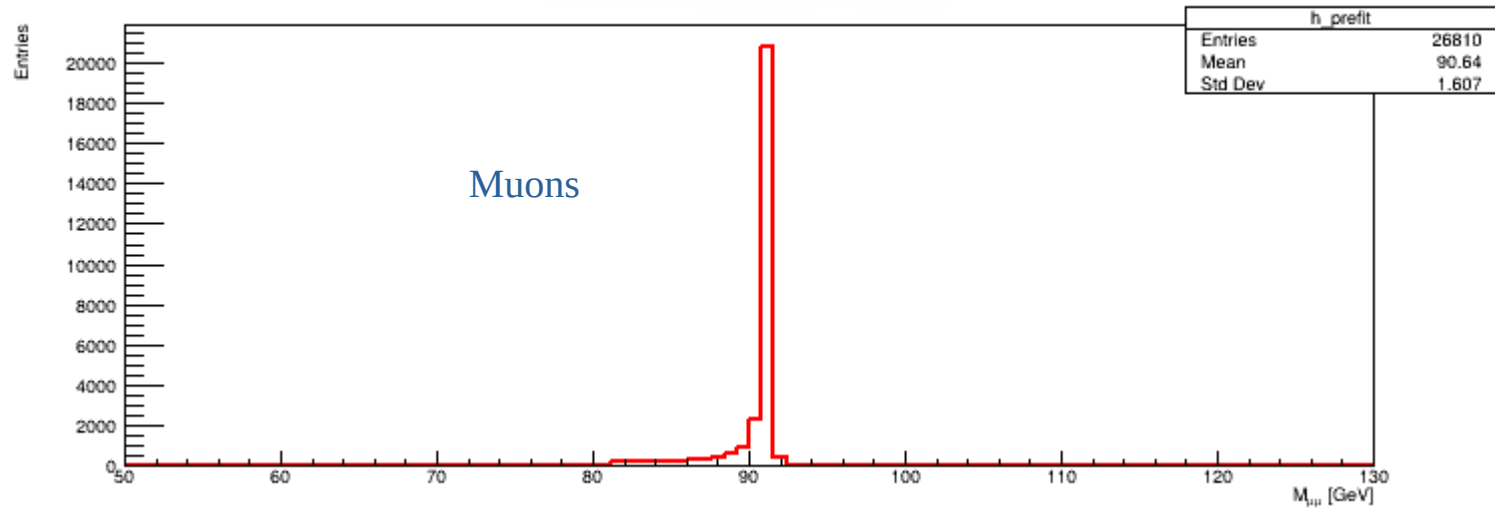
Muons



Electrons

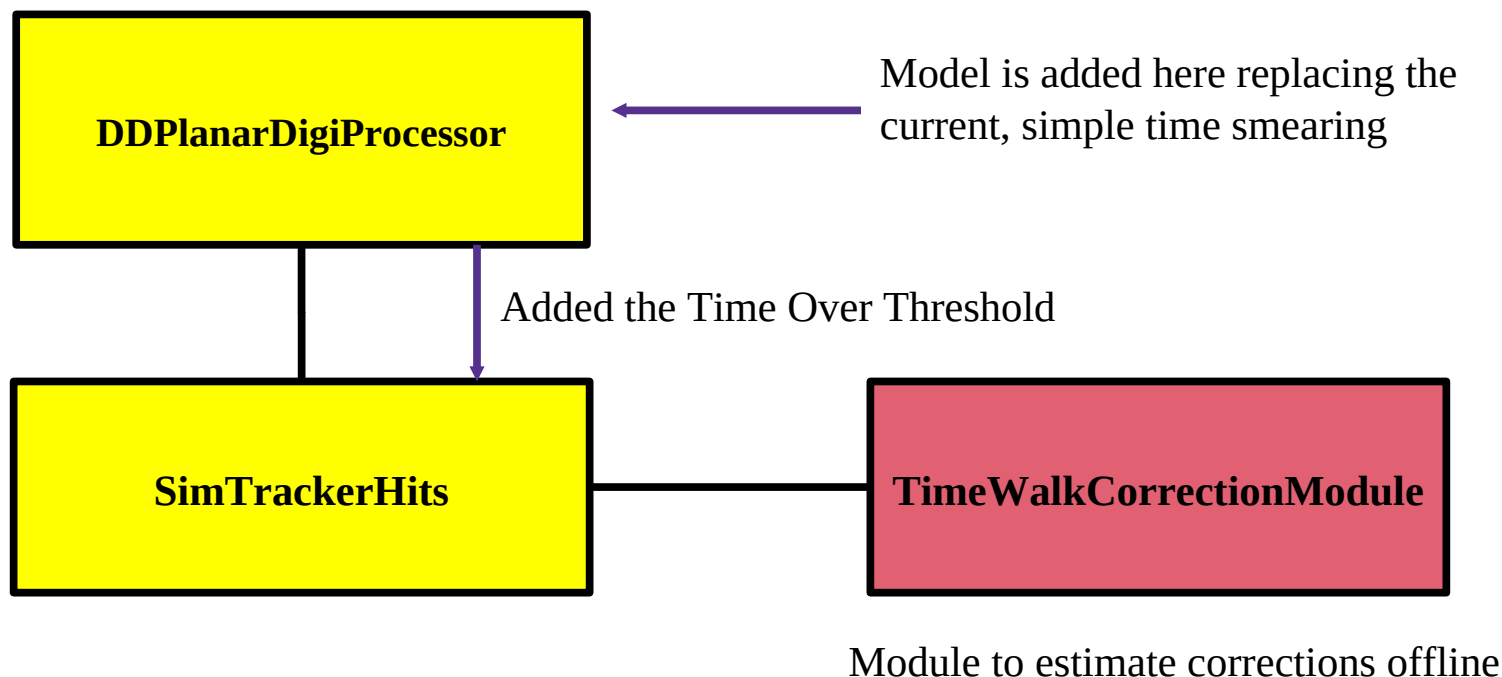


Samples and sanity checks



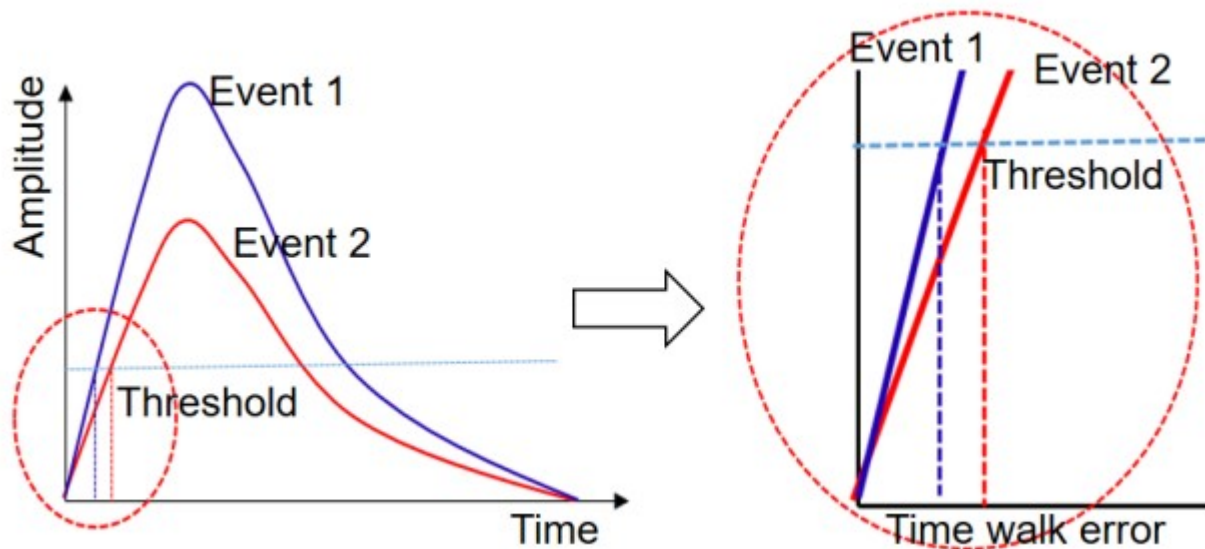
A timing model for the tracker digitization

- Implemented a digitization model for a possible timing measurement in the silicon sensors
- The model is inspired by the Endcap Timing Layer of CMS based on LGAD technology
 - Just a reminder: this is not a proposal, just playing with the code and learning
- The code structure is as follows:



The timing model

- Signal shapes are assumed to have the form $V(t) = V_0 \exp(-t/\tau_1)(1 - \exp(-t/\tau_2))$
- The shape is normalized to the total charge deposited in the sensor and a threshold is defined

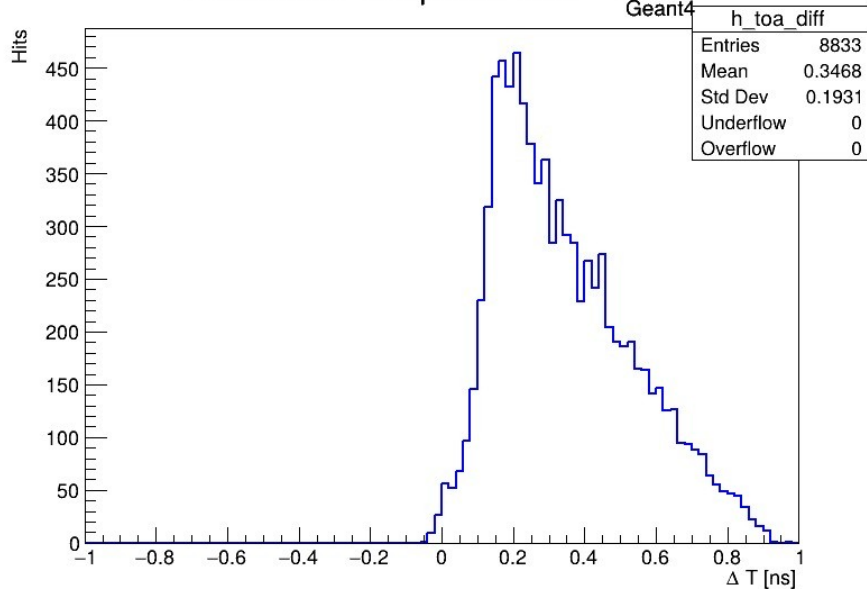


- First threshold crossing → Time Of Arrival, the second defines the Time Over Threshold
- Landau fluctuations implicitly taking into account by the scaling but additional resolution:
 - Additional Gaussian smearings to cover for: jitter and TDC
 - Everything adjusted to be in the 30 ps ball park after time walk correction

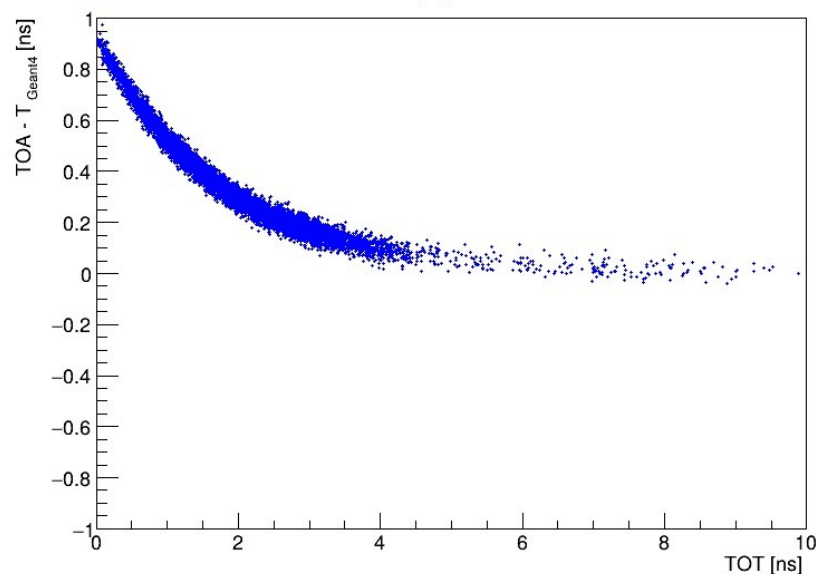
The timing model: raw distributions

- The TimeWalkCorrectionModule studies the raw distributions and estimates the TWC
 - Reading directly the information in the TrackerSimHits
- All time resolution effects taking into account but no correction in these plots

Resolucion Temporal: TOA - T_{Geant4}



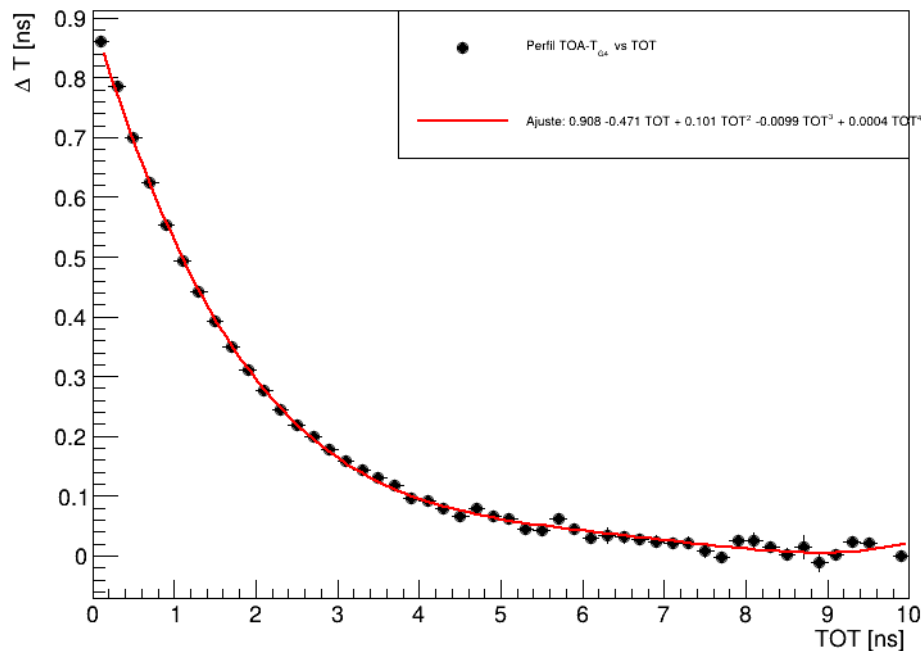
TOA - T_{Geant4} vs TOT



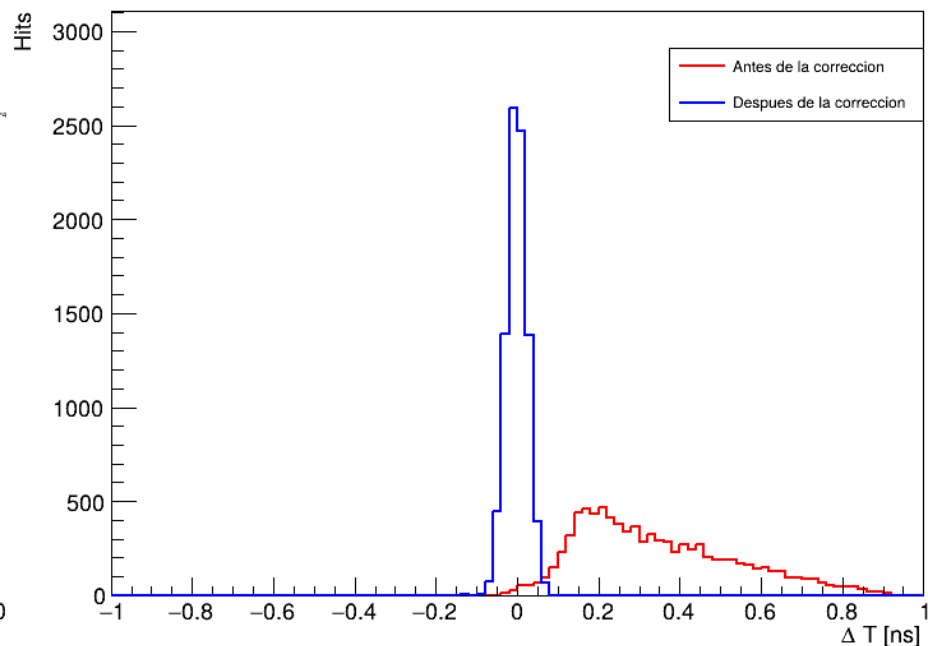
The timing model: raw distributions

- The Time Walk Correction uses a 4th degree polynomial to find corrections
- Reaching the expected 30 ps resolution in the TOA

Perfil TOA - T_{Geant4} vs TOT



TOA - T_{Geant4} despues de la correccion



- Interest in studying the possibility of 4D tracking in the ILD and its implications
- A first “toy” implemented just as an exercise to acquire the needed skills
 - Adding timing to silicon sensors with a model inspired on LGAD sensors
 - A successful Final Degree Project presented on this by an undergraduate student
 - The student is interested in continuing working on the topic
- Looking forward to synchronizing with the software group on these topics