Event reconstruction with Trivent-like programs

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Introduction

SiW-ECAL+SDHCAL

- ECAL ROOT files for September 2018 test beams are on CERN disks at /eos/project/s/siw-ecal/TB2018-09/Common/ECAL
- We were supposed to provide similar set of ROOT files for HCAL (to locate at /eos/project/s/siw-ecal/TB2018-09/Common/HCAL)
- Then, we can provide common ROOT tree based on the plan at `https://twiki.cern.ch/twiki/bin/view/CALICE/SiWEcalBT201809Analysis`

Trivent or EventBuilder

Trivent or EventBuilder

- The raw data output has a collection of LCIO RawCalorimeterHit for each LCEvent. 1 LCEvent = 1 readout = many particle-detector interaction (physics event).
- Trivent (EventBuilder) is the software to split readout LCEvents in physics events.
- It usually also converts raw data to CalorimerHit (with position).
- There are many Trivent codes available.

Trivent used

- GRPC_RawHit_Readout_Analyse : my analysis code, has Trivent capabilities.
- Trivent : Guillaume Garillot's code. Used by Bing.
- Trivent4HEP : Antoine Pingault's code. Used by Antoine and Hector.

Trivent softwares

GRPC_RawHit_Readout_Analyse

- Under development. Will use it for Tricot electronics analysis.
- Add python script to produce ROOT-tuple from Trivent SLCIO output.

Trivent

- Extremly fast trivent, can only deal with SDHCAL.
- Used as reference to check/develop GRPC_RawHit_Readout_Analyse Trivent.
- Using GRPC_RawHit_Readout_Analyse python script to produce ROOT-tuple.

Trivent4HEP

- Produce its own ROOT-tuple.
- Need to understand similarities/differences with other Trivent software.

Trivent comparison

Compare GRPC_RawHit_Readout_Analyse with Trivent

Both reconstruct events from time clustering algorithm.
Both attempt to remove RAM full events (RAMfull channels = ASIC channels 29 and 31 fired)

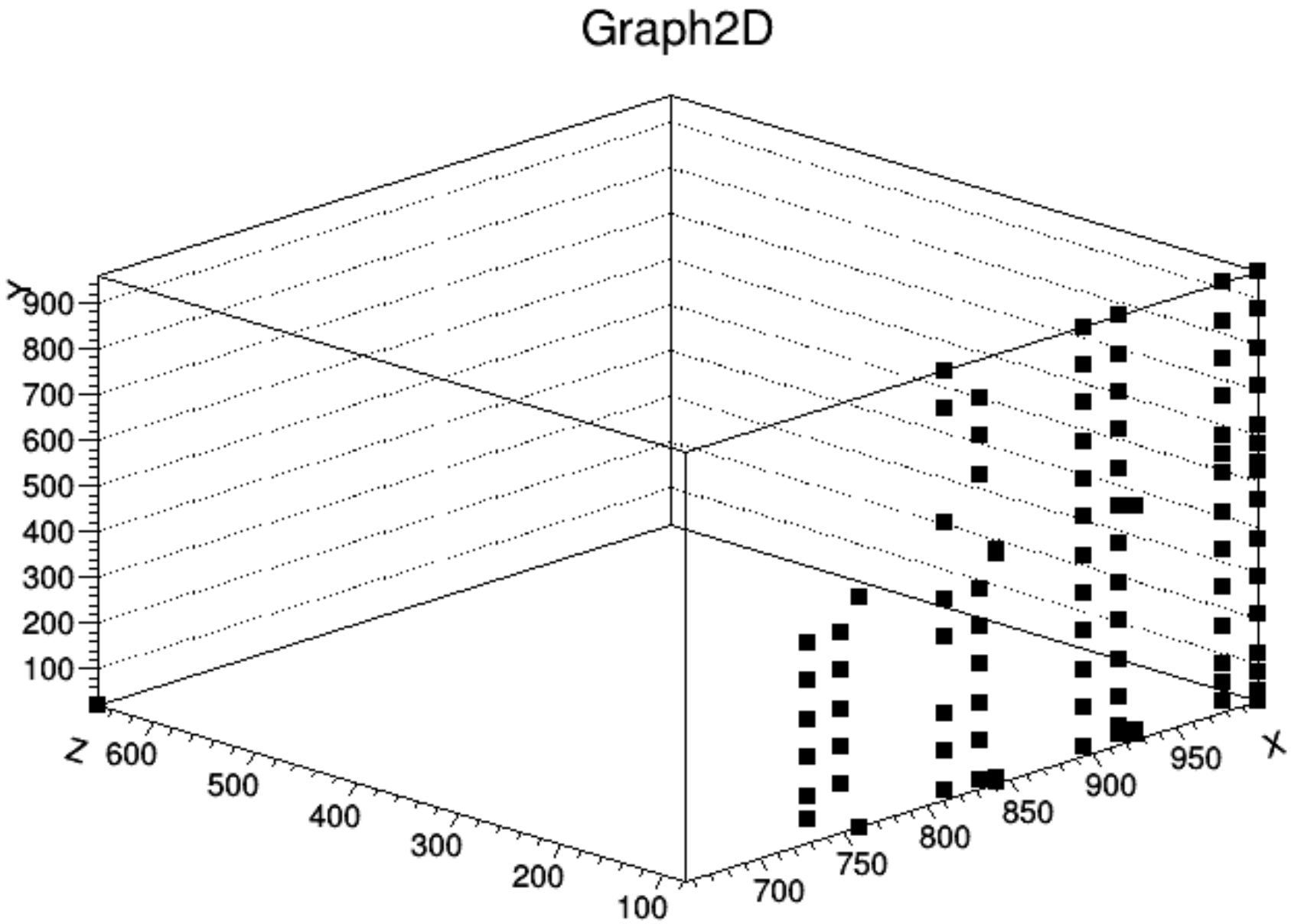
GRPC_RawHit_Readout_Analyse

- Remove RAM full events : A DIF has more than 36 RAMfull channels representing more than 80% of all hits.

Trivent

- Remove RAMfull events : A DIF has more than 70 RAMfull channels.
- Has other cuts

RAM full event

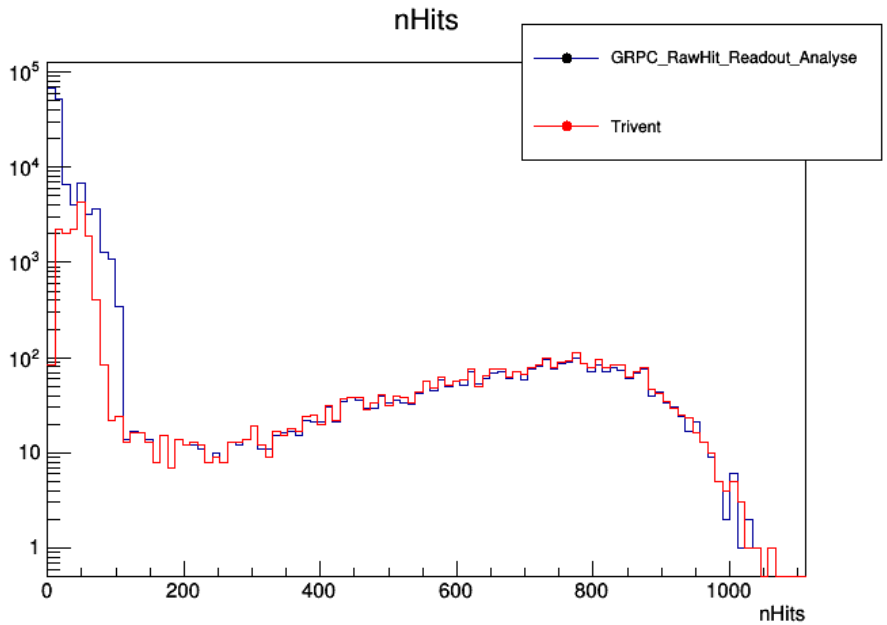


Trivent outputs

Test both programs on run 744193 (pions with ECAL in + tricot + aegis chambers behind SDHCAL)

Number of reconstructed events

- GRPC_RawHit_Readout_Analyse : 149066 (threshold at 7 hits).
- Trivent : 16614 (threshold at 8 hits).



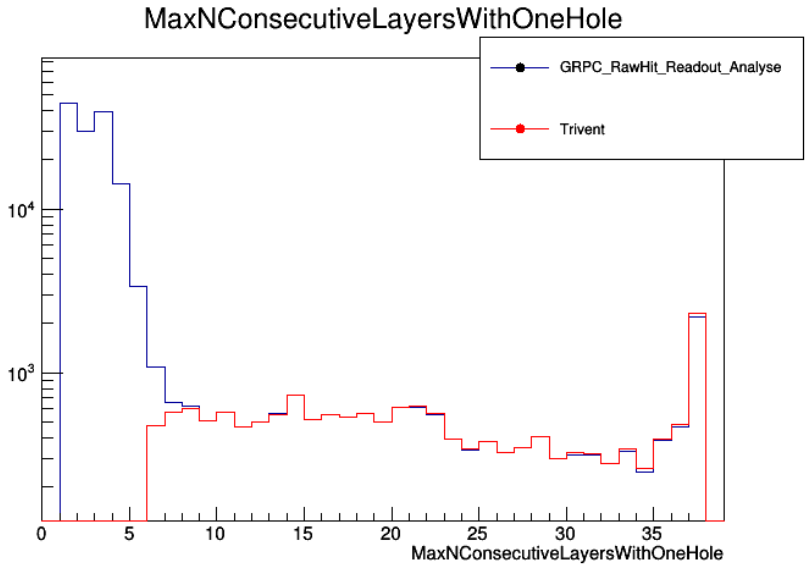
Hadronic showers are reconstructed similarly.

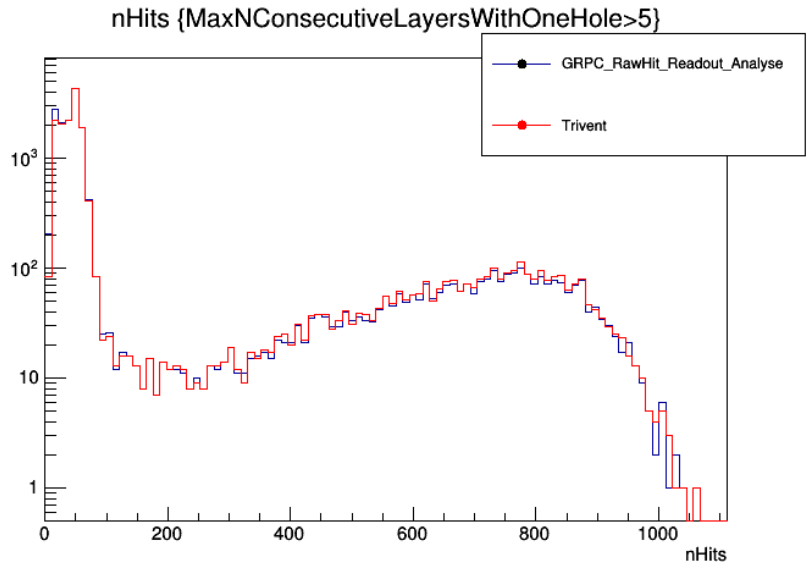
Trivent cuts

Add Trivent selection variable to ROOT tree.

Trivent event selection

- RAMfull events.
- No ASIC fully fired (with 64 channels fired).
- Max number of hits in a single layer < 400
- At least 6 consecutive fired layers (allowing one hole)

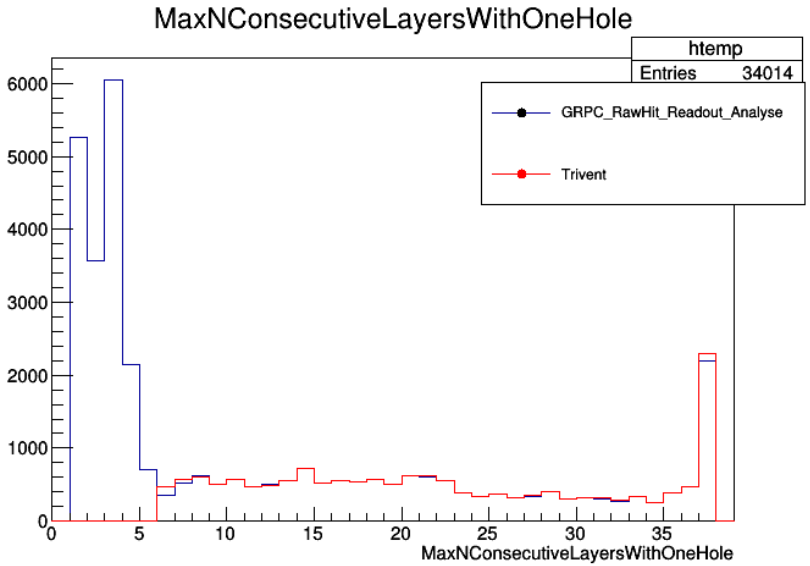


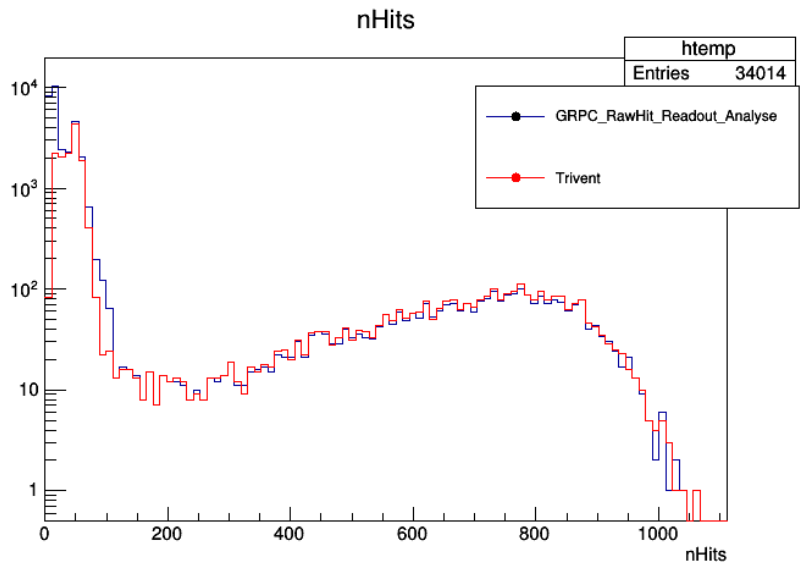


Cut OK for muon or hadrons, will kill EM leakage study.

GRPC_RawHit_Readout_Analyse cut

Reject RAMfull events and events with less than 6 fired consecutive layers unless there are hits in the first 3 layers.





ROOT TREE variables

In red, the variables not available from Trivent.

time variable (in 5 MHz clock tick units = 200 ns)

- triggerCounter = Readout number.
- BCID = Readout time since DIF has resume acquisition.
- AbsBCIDup = Upper 24 bits of the time since last configure.
- AbsBCIDdown = Lower 24 bits of the time since last configure.
- spillNumber = SPS line spill number (starts at 1 for the first spill of the run)
- clockCountInSpill = time of the event since the spill start.

Spill determination

- A new spill is considered when the previous readout had occured more than 10 seconds earlier.
- The oldest recorded hit in a new spill readout is taken as the start spill time.

WARNING : in Trivent, made from Trivent output, in GRPC_RawHit_Readout_Analyse, made from full readout (more precise).

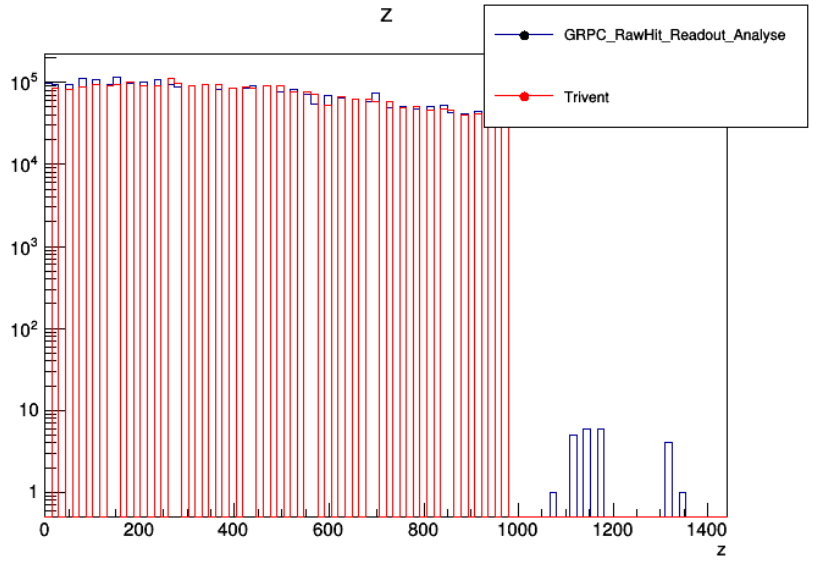
ROOT TREE variables (II)

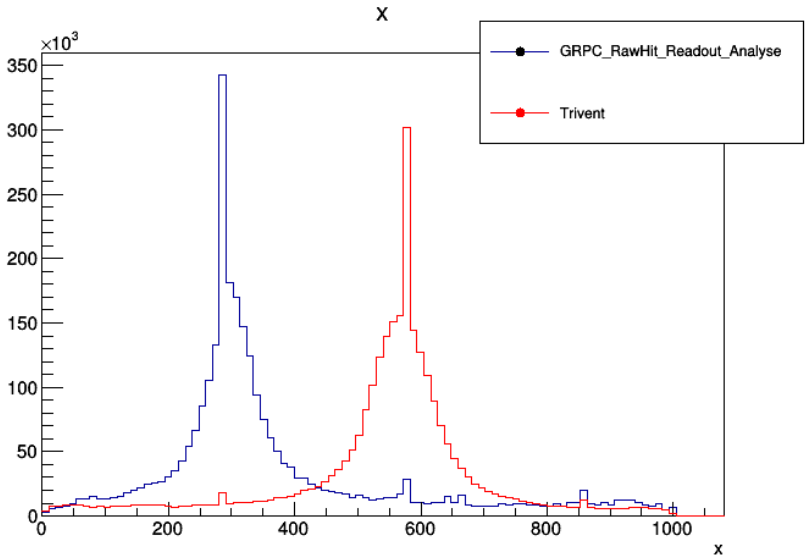
Reconstructed variables

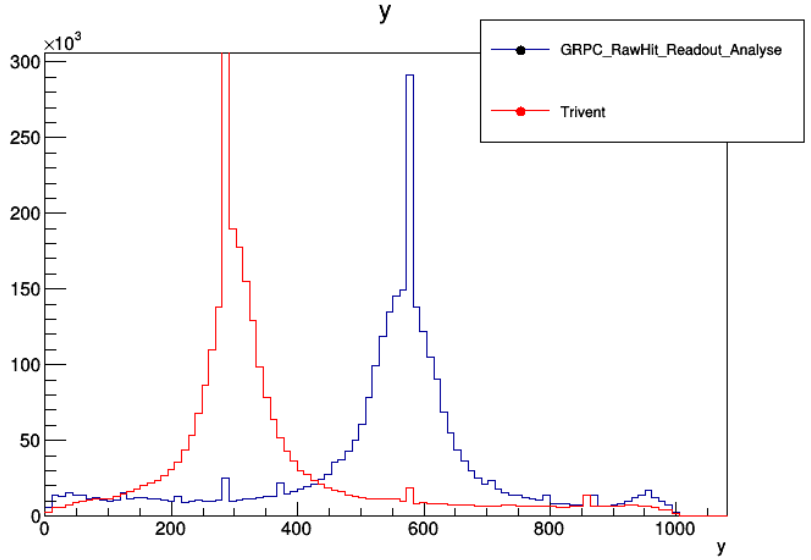
- cerenkovFlag : the BIF signal.
- nHits : number of hits in the events.
- plan[nHits] : the layer for each hits.
- threshold[nHits] : See warning
- timestamp[nHits] : the time (in clock tick) separating the hit time and the readout time.
- timeSinceResumeAcq_s[nhit] : (BCID-timestamp[nHits])*200e-9
- timeSinceRunStart_s[nhit] : (AbsoluteBCID-timestamp[nHits])*200e-9
- x[nHits], y[nHits], z[nHits] : See warning

ROOT TREE warnings

- For the threshold, should we correct the bit 1-bit 2 inversion ? (done in Trivent, not in GRPC...Analyse)
- x and y axis inverted between Trivent and GRPC...Analyse.
- Tricot and AEGIS z not yet OK.
- Tricot x,y not yet implemented.







Antoine's Trivent

github packages

There are 2 packages in Antoine's github, Trivent4HEP and Trivent. The latter has a second branch named CommonEcalSdhcal (used by Hector). Not straightforward to run.

Antoine's Trivent

In both branch, do the time clustering (min 10 hits in a clock tick), reject RAMfull events (reject if RAMfull channels in one DIF > 48) and events with full ASIC. Both branches are producing a ROOT Tree.

master branch

- Produce SLCIO output file.
- Has a cut on number of Fired Layers (at least 10).

CommonEcalSdhcal

- Bug : ROOT Tree NHits variable not set. Hector has a fix.

Antoine's ROOT Tree global variables

- DetId = 100 (SDHCAL)
- TrigNum = GRPC....Analyse triggerCounter
- TrigBcid = GRPC....Analyse AbsBCIDup and AbsBCIDdown
- TrigLength = GRPC....Analyse BCID
- EvtNum = not set in branch CommonEcalSdhcal
- EvtBcid = timeStamp of the event time center (time peak)
- EvtRevBcid = TrigLength-EvtBcid
- NHits = number of hits (not set in branch CommonEcalSdhcal)
- HitCogX, HitCogY, HitCogZ = hit distribution barycenter.

Antoine's ROOT Tree hit variables

- HitI, HitJ, HitK : hardware coordinates, HitK=layer number
- HitX, HitY, HitZ
- HitBcid : the hit timestamp, GRPC...Analyse timestamp
- HitRevBcid : TrigLength-HitBcid, this is GRPC...Analyse timeSinceResumeAcq_s in clock tick units.
- HitThresh : hit threshold corrected for the bit1-bit2 inversion.

The (x,y,z) frame

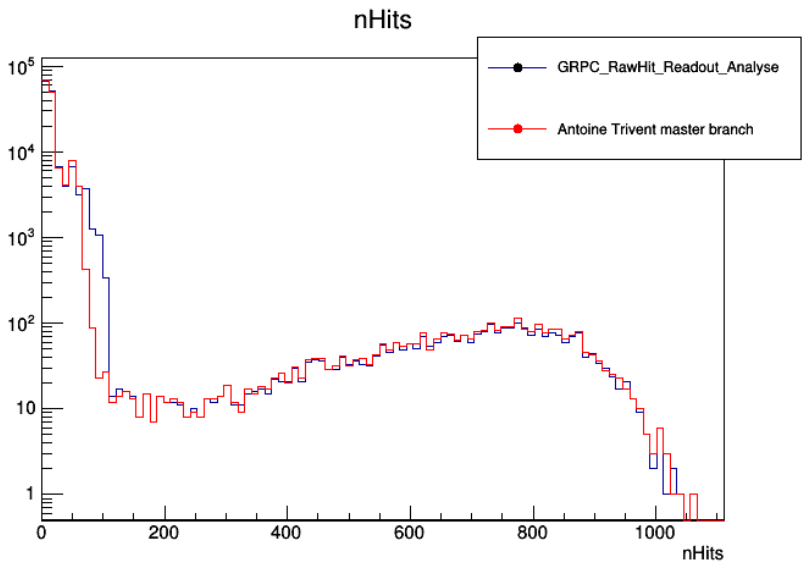
- x and y axis corresponds to GRPC....Analyse choice.
- Compared to GRPC....Analyse, y axis is oriented in reversed direction and its origine is on the other side of the SDHCAL

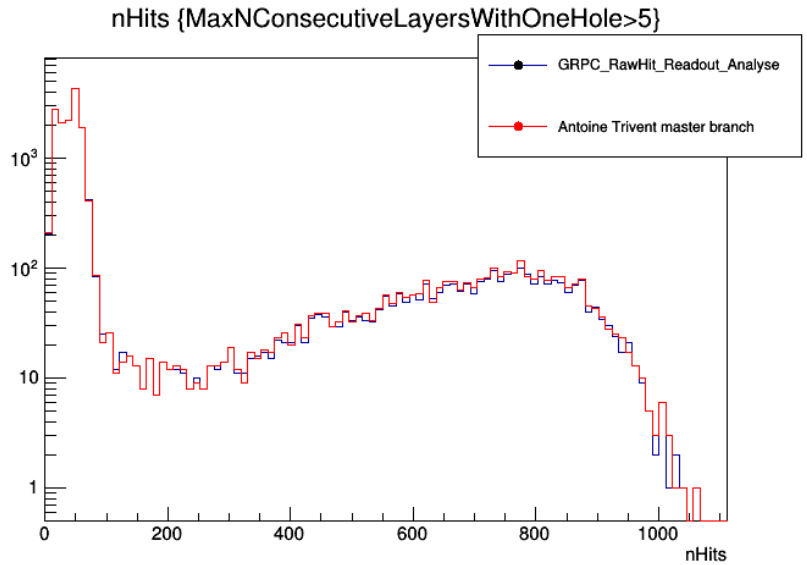
$$y_{Antoine} \simeq \text{SDHCAL width} - y_{GRPC....Analyse}$$

- This frame is likely more in line with the spec of `https://twiki.cern.ch/twiki/bin/view/CALICE/SiWEcalBT201809Analysis`

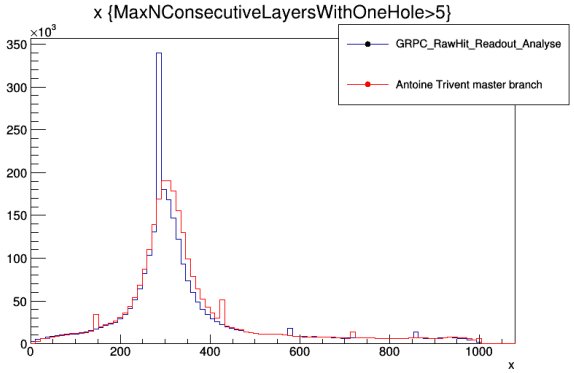
Comparison with GRPC_RawHit_Readout_Analyse

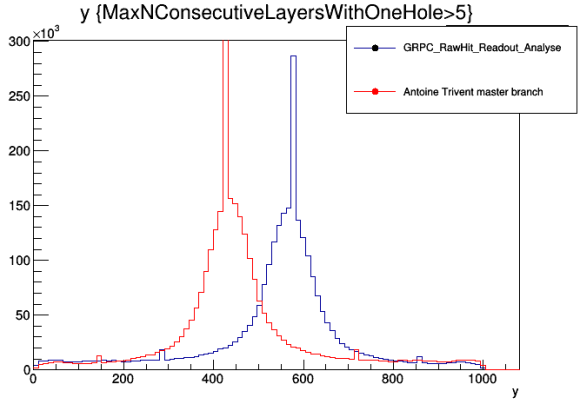
Adapt GRPC_RawHit_Readout_Analyse python script to produce ROOT tree from Antoine's trivent master branch slcio output (suppressing the number of fired layer cut).

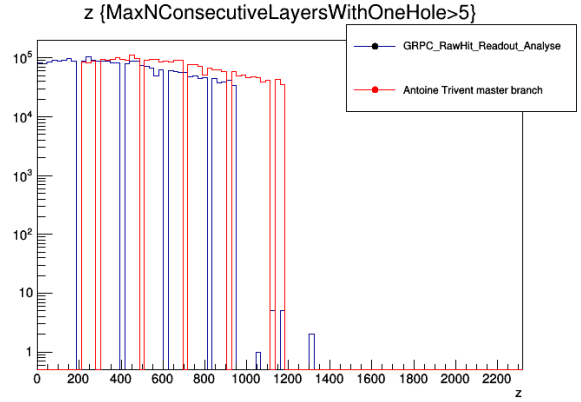




Comparison with GRPC_RawHit_Readout_Analyse (II)







Roughly same distribution in x (peak absence is a ROOT artefact).

Y axis oriented in opposite direction.

Shift in z (Antoine's Trivent parameter).

Changing frame in GRPC_RawHit_Readout_Analyse is rather easy.

Outlook

- Working on ROOT TREE production for ECAL+HCAL.
- The trees will be usable for other analysis.
- Which tree to choose : Antoine's Trivent or GRPC_RawHit_Readout_Analyse ? need to agree on common language (trigger length is DIF BCID for our DAQ experts)
- Things to discuss :
  - threshold value corrected or not ?
  - frame orientation
- Then : merge the ECAL and HCAL trees into a single Tree (Hector?)

Backup

Data reconstruction

Trivent or EventBuilder

- The raw data output has a collection of LCIO RawCalorimeterHit for each LCEvent. 1 LCEvent = 1 readout = many particle-detector interaction (physics event).
- Trivent (EventBuilder) is the software to split readout LCEvents in physics events.
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- There are many Trivent codes available.

Streamout

- Streamout is the conversion of raw data buffers into LCIO RawCalorimeterHit collection.
- Now done by the DAQ.
- Step needed offline to reprocess older data.

Trivent

- `https://github.com/ggarillot/Trivent` Marlin Processors, include streamout, used for latest SDHCAL test beam analysis (Guillaume Garillot, Bing Liu), SDHCAL proto only. (C++)
- `https://github.com/apingault/Trivent4HEP` Marlin processors, include streamout, used for Antoine Pingault's analysis. (C++)
- `https://github.com/SDHCAL/EventBuilder` Original Trivent, Marlin processors, bloated code, some support for CMS strip electronics, no more in use. (C++)
- `https://github.com/flagarde/GRPCAnalysor/tree/master/src` used by Franois Lagarde analysis at GIF++ (pad+CMS strip), depends only on ROOT (will install LCIO and a lightweight Marlin (Marlino)), include streamout. (C++)
- `https://github.com/SDHCAL/GRPC_RawHit_Readout_Analyse`, depends on LCIO and ROOT only, supports PAD+CMS strip (partially)+Tricot (Coming soon) electronics. No streamout. Used by G.G. for analysis. (C++ & Python)

Trivent software summary

Code	dependence	streamout	electronics	status
Trivent	full ilcsoft	yes	PAD in SDHCAL	recent
Trivent4HEP	full ilcsoft	yes	PAD	???
EventBuilder	full ilcsoft	yes	PAD	abandoned
GRPCAnalysor	ROOT	yes	PAD+strip	recent
GRPC_RawHit_ Readout_Analyse	ROOT, LCIO	no	PAD+strip+tricot	active