SiWEcal - LCIO Event building

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Development of an event building for the SiWEcal technological prototype in the LCIO format and analysis of the Beam Test data

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Current SiWECal event building process

Currently the process of event building follows the next steps:

- The DAQ produces a raw binary files with all chip readouts.
- The binary files are converted into RawROOT files with all the information in a TTree.
- RawROOT files are converted into ROOT with events built in it (Latest build made by Jonas 04/05/2022).

However the standard ILC Software uses the LCIO data format. Ideally the whole process is condensed into a single program that runs the whole chain. The RawROOT files are needed to create the pedestals, calibrations, etc.

Build algorithm steps - March 2022

Hit Construction:
Loop over the *BuiltFiles* by Jonas and conversion into CalorimeterHits. Dropping the following cases:

- Not comissioned hits
- Hits with the flag $IsHit = false$
- Masked channels
- Hits with $E < 0$

The energy of each hit corresponds to the high gain value until $E > 80(MIP)$ in which case the low gain value of the energy is used.

Build algorithm steps

Construction and writing of the LCEvent:

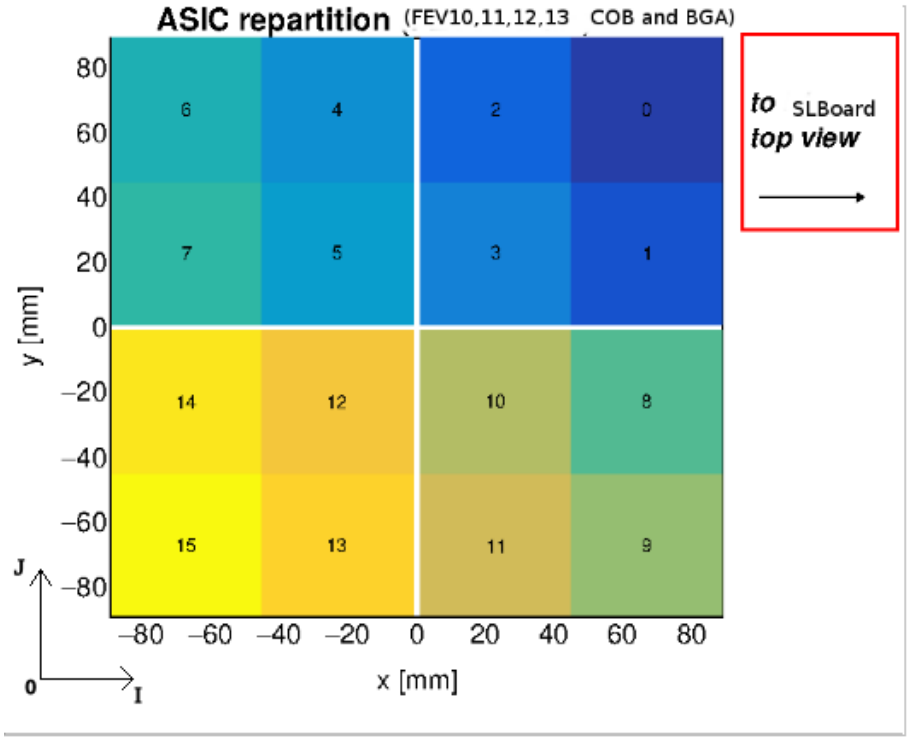
LCIO File (default = SiWEcal_TB2022_${RunNumber}.slcio)

- *LCHeader*
  - *RunNumber*
  - *detectorname* = *ECAL15Slabs_2022*
- *LCEvents*
  - *Eventnumber*
  - *BCID*
  - *Parameters*()
    - *SumEnergy*
    - *NLayers*
    - *NChips*
  - *LCCollection* (default = ECalEvents, type = CalorimeterHit)
    - *Hit_Energy*
    - *Hit_Time*
    - *Hit_Position*
    - *CellIDEncoding* : "I:5,J:5,K:4,CHP:4,CHN:6,SCA:4"

Details - ECal Hit position

Hits position $\vec{x}$ are the center of the pad.

$$I, J \in [0, 31]$$
$$K \in [0, 14]$$
$$CHP \in [0, 15]$$
$$CHN \in [0, 63]$$
$$SCA \in [0, 14]$$



Details - Pedestals and calibration

Pedestals:
The current version uses the updated format of the pedestals then $HG = Charge\_hg - pedestal$. The value of the error is stored in the pedestal map, currently not used but taken into account if needed in the future.

Calibration:
If the mpv value from calibration is less than the $mip\_cutoff = 0.5$ or currently if the error of the channel is negative (Failed fit) then the channel is also dropped. Finally $E = HG/mpv$

Log ROOT File

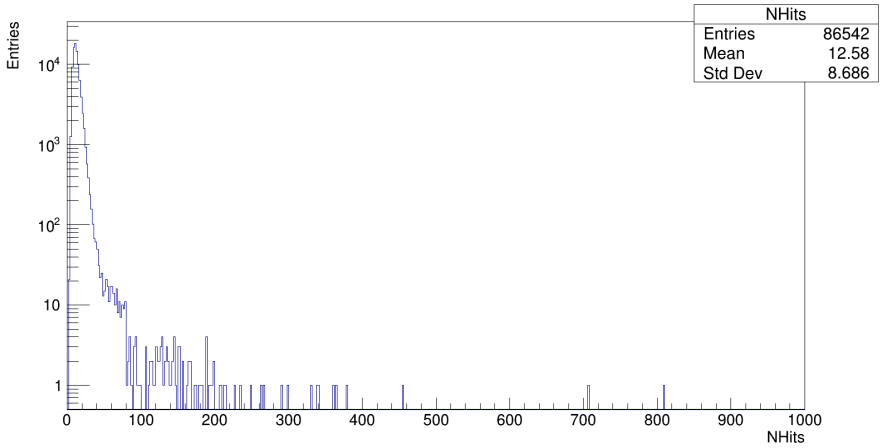
The event builder creates a ROOT File with simple histograms to check that everything run correctly and quickly detect noise or anomalies and access saved statistics.

ROOT File (default = LogROOT_ECalEventBuilding_runNumber.root)

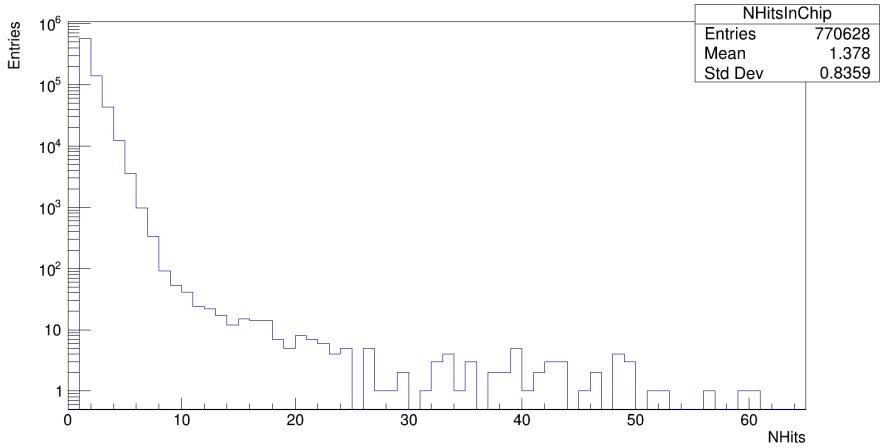
- $\rightarrow$ *NHitsPerReadout*
- $\rightarrow$ *NHitsPerEvent*
- $\rightarrow$ *NHitsPerLayer*
- $\rightarrow$ *NHitsPerChip*
- $\rightarrow$ *NLayers*
- $\rightarrow$ *NChips*
- $\rightarrow$ $I,\ J$ *and* K

Output. MIPScan run: 050449

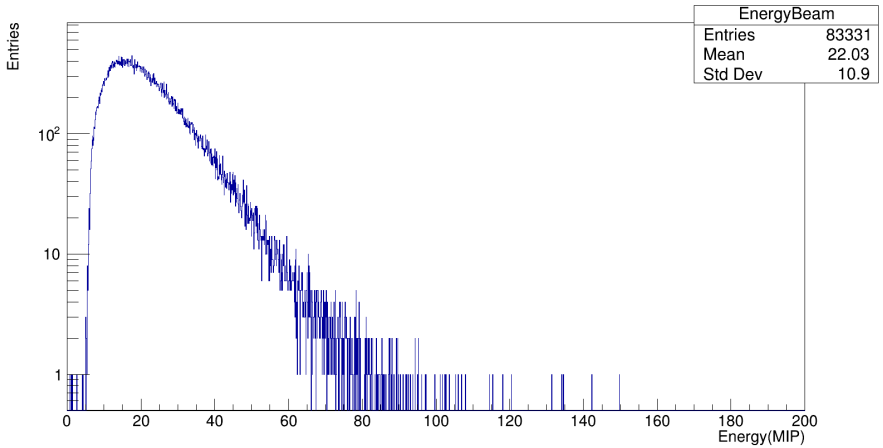
NHits



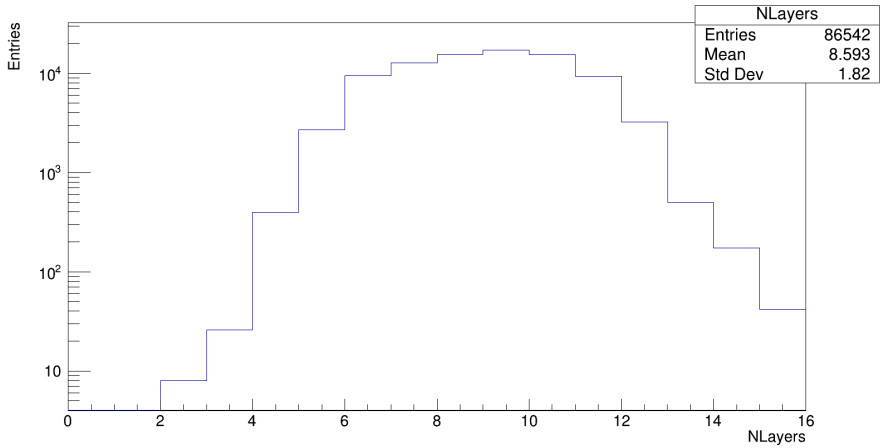
NHits Per Chip



Energy sum



NLayers



Cleanup and beam selection

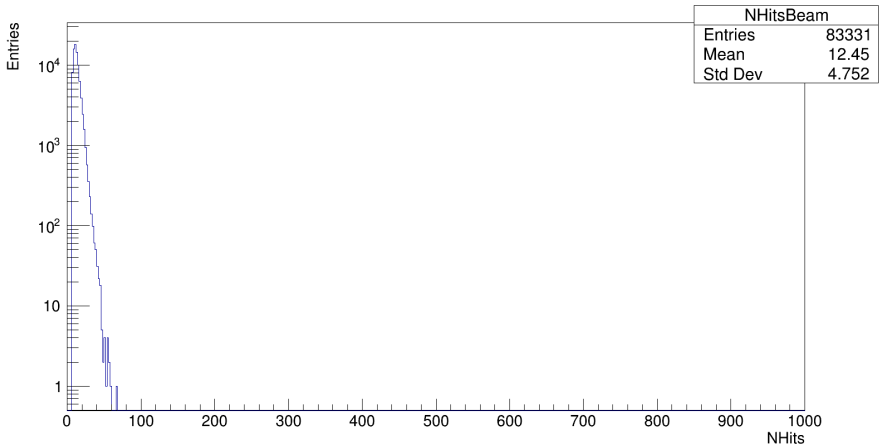
The NHits per Chip distribution show chips with a high number of hits for a MIP scan. The cleanup can be performed by eliminating the isolated chips suspected to be a noisy. A chip is suspected to be noisy if it has more hits than $NoisyChipCut = 10$ and tested with:

$$N_{Hits}^{Pre} = 0 \ \& \ N_{Hits}^{Post} = 0 \implies Cleaned$$
$$N_{Hits}^{Pre} = 0 \ \& \ N_{Hits}^{Post} > NoisyChipCut \ (And\ vice\ versa) \implies Event\ removed.$$

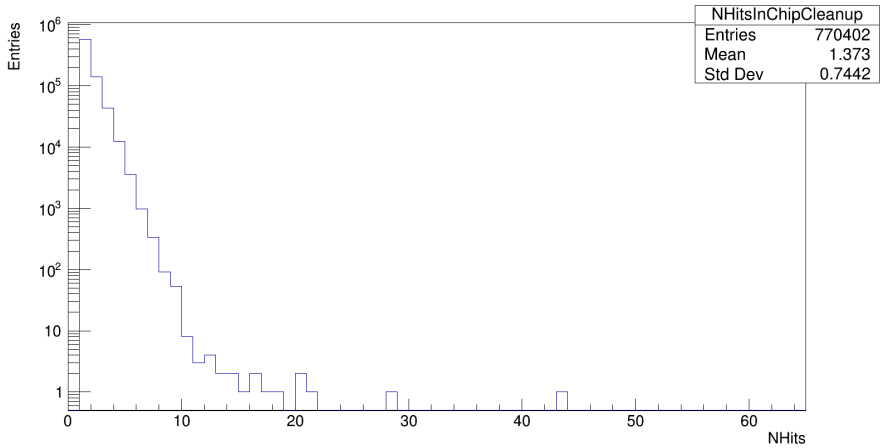
The beam events are selected by requesting at least 5 layers with signal. Not requested at the beginning.

Cleanup and beam selection. MIPScan run: 050449

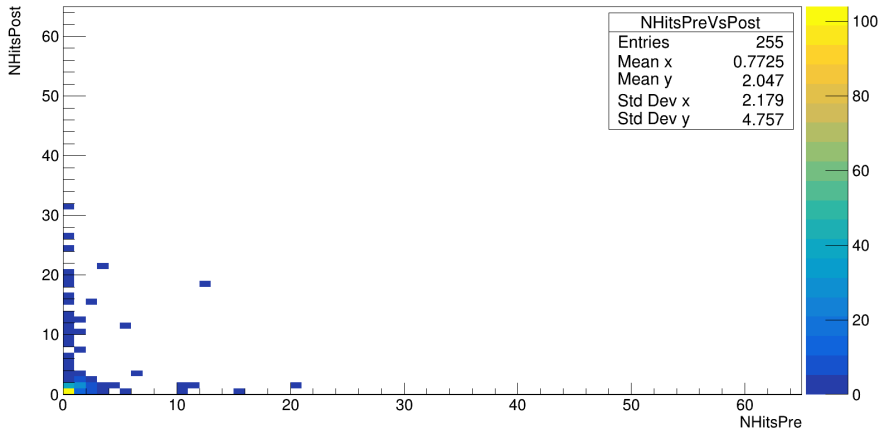
NHits



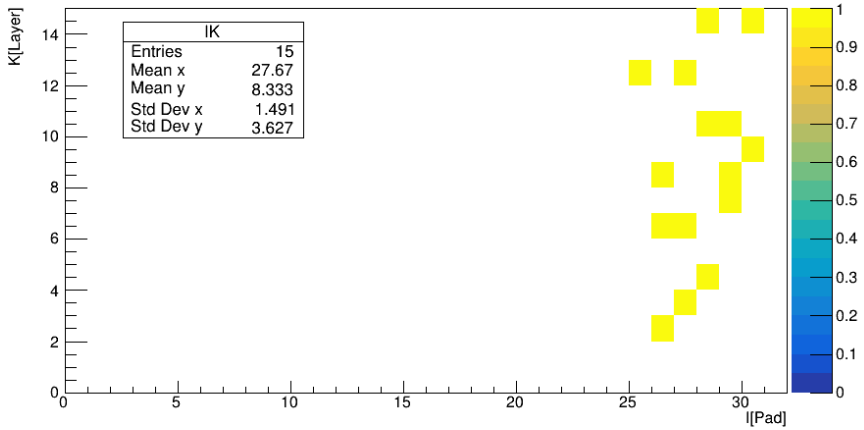
NHits Per Chip

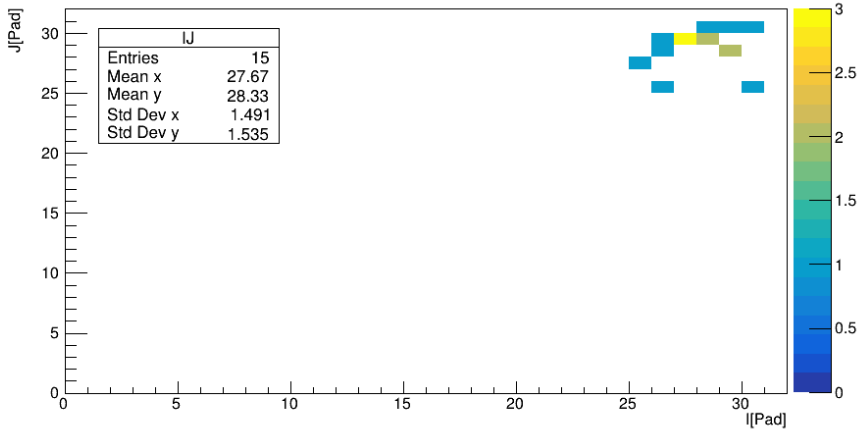


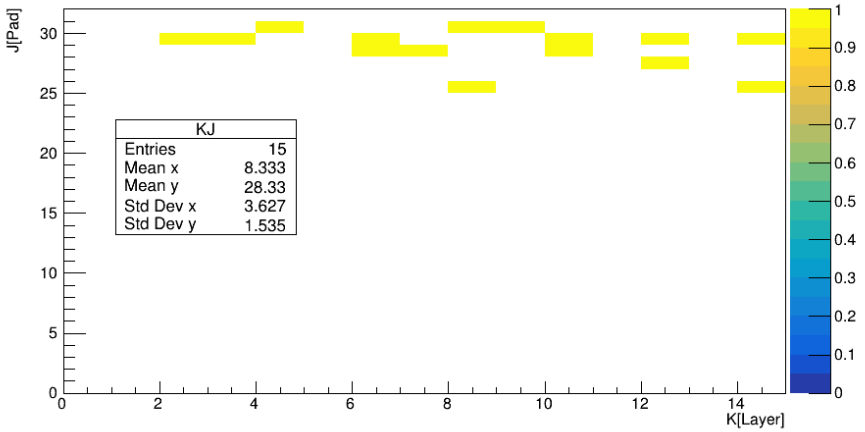
PreVsPost



MIPScan run: 050449. Event Displays







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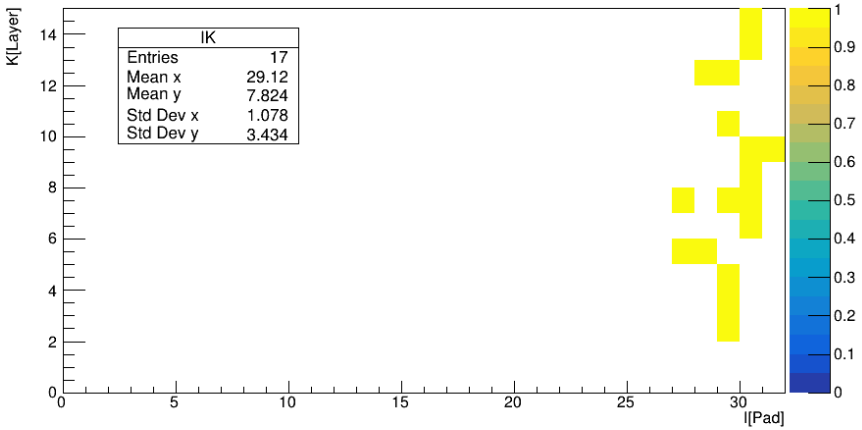
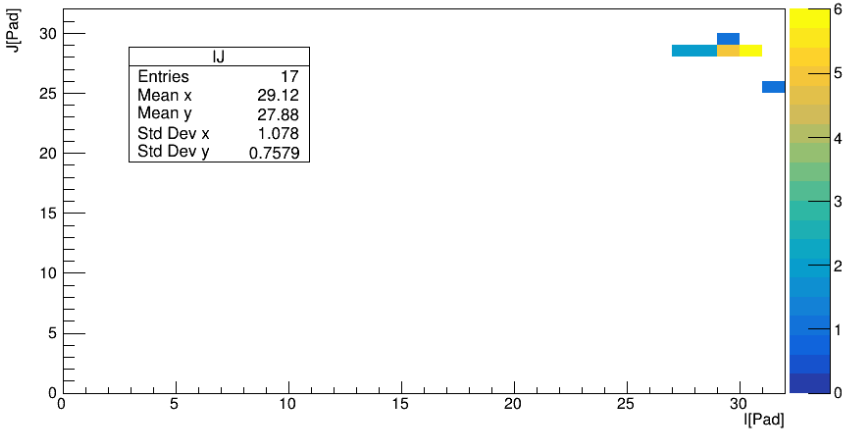
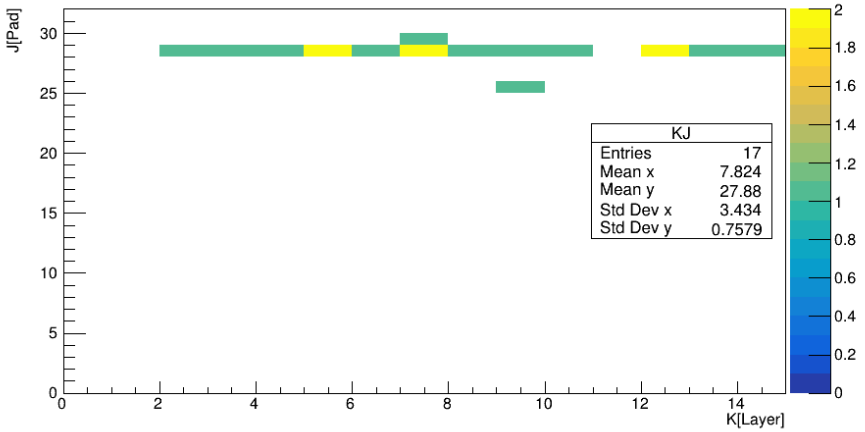
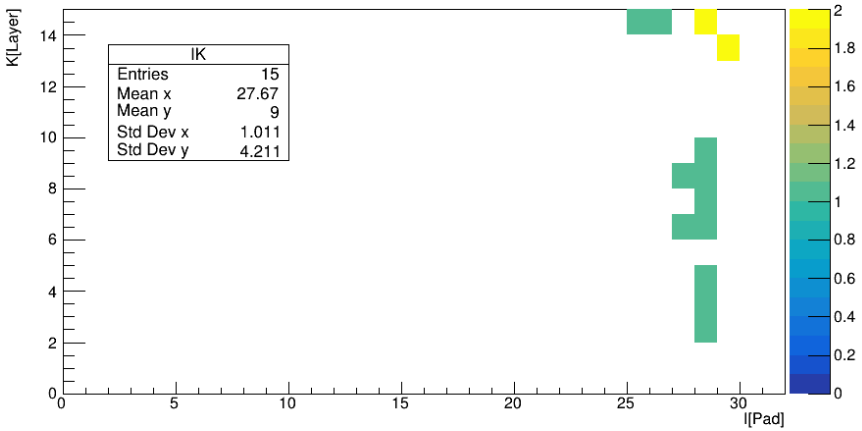
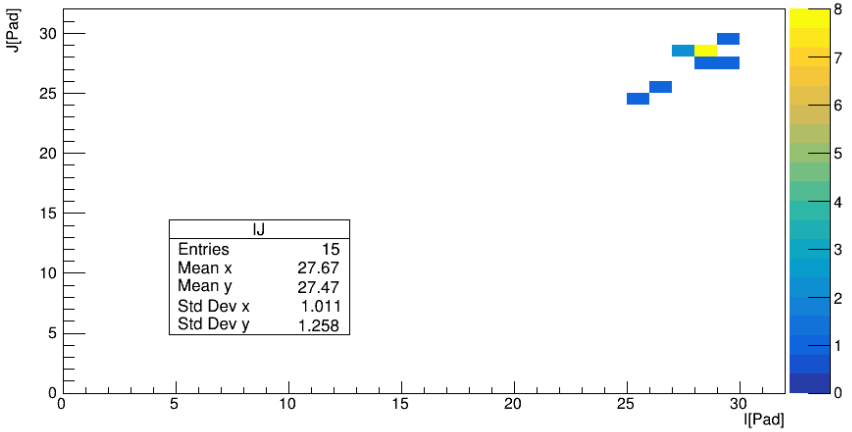


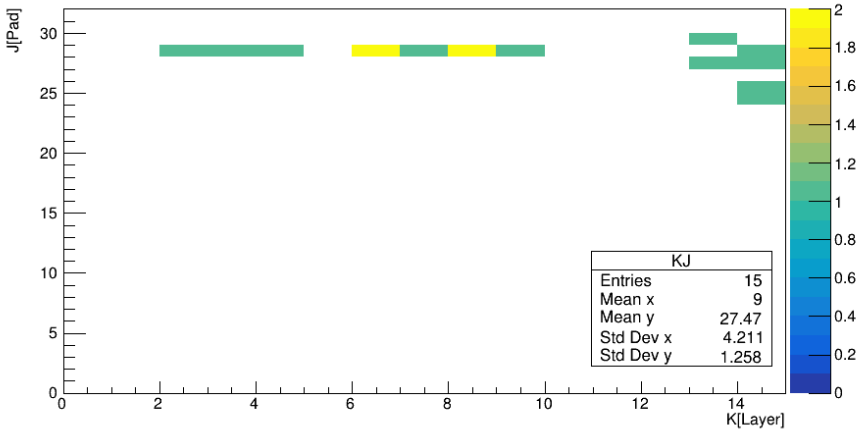




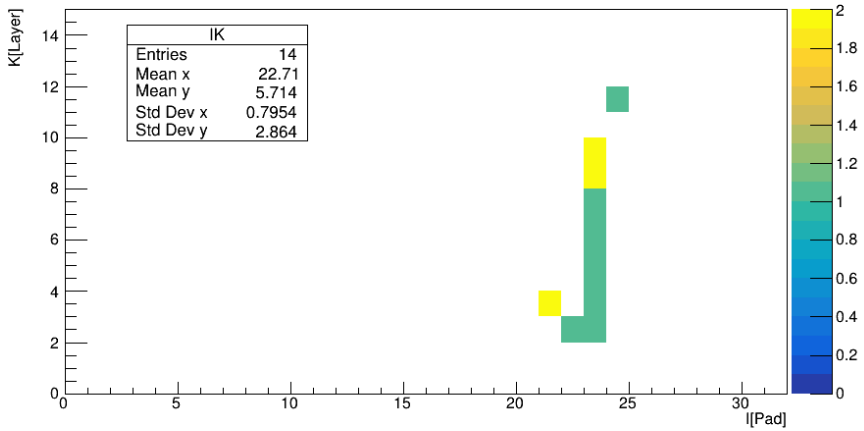
MIPScan run: 050449. Event Displays

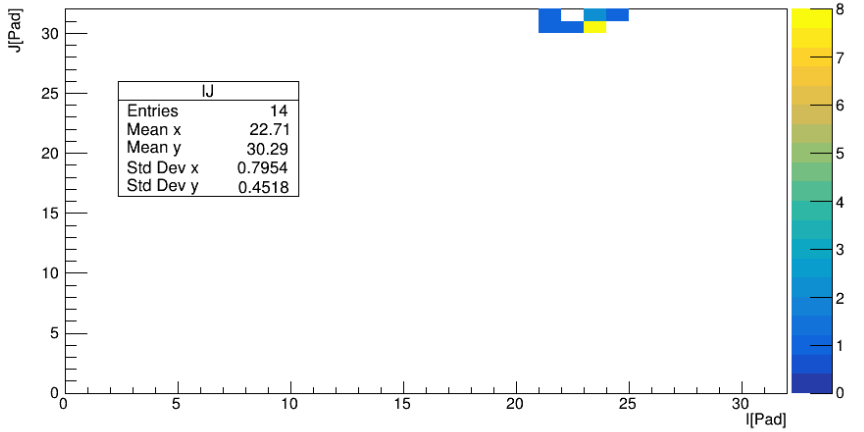


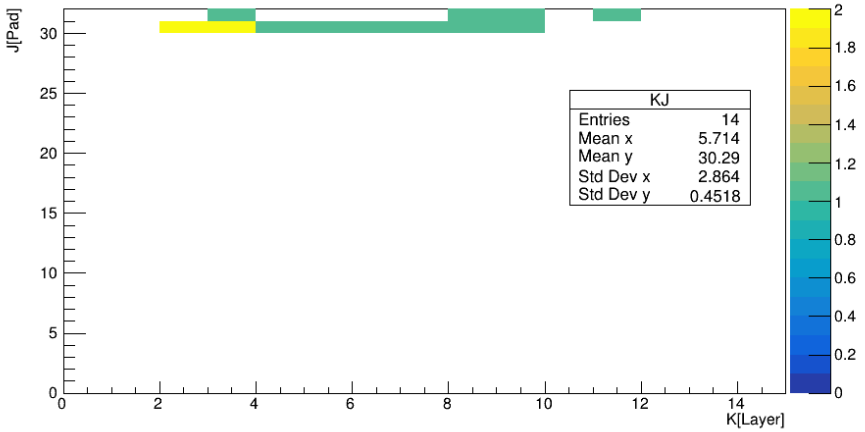




MIPScan run: 050449. Event Displays







Conclusion

Advantages:

- LCIO is the standard format of the ILC collaboration. Future events whith synchronization between different modules will use this common framework.
- Adapting prototype simulation analysis, in the context of ilcsoft framework, to beam test data will require simple changes of the processors.
- Access to all high level analysis processor already implement in ilcsoft.

Disadvantages:

- Fast and testing analysis is cumbersome due to the setup of the Marlin Processors. Particularly for newcomers.
- LCIO files are usually heavier than simple ROOT files.

NEXT STEPS:

- Start the conversion chain from the binary file.
- Study and include error propagation

Conclusion

- The migration of SDHCAL analysis based in geometry is relatively simple. Event building and format being the main differences.
- The hit mapping looks odd in the X, requieres revision.
- Suggestions?

Backup

Compiling and running

The software can be found in the SiWECAL-LCIO-Analysis repository. The code of the event builder is in the *eventbuilding* folder.

Building:

- source ${ILCSoftPath}/init_ilcsoft.sh (REQUIRED) (VERSION v02_02_02)
- run ./script/build.sh [Full]

Dependencies: CMake >= 2.6 and C++17

Produces an *app* folder with the executable *ECal_EventBuilding*.

Compiling and running

Running: *./app/ECal_EventBuilding –help* for a description of all options.
The only one required is the name of the RawROOT file.

```
hecgc@hecgc-GL62M-7REX [~/Physics/Repos/SiWECAL-TB-analysis/eventbuilding] (slboard_TB2021_ILCSoft) $ ./app/ECal_EventBuilding --help
Usage: ECal_EventBuilding [OPTION...] -i INPUTFILENAME
Program to convert the RawROOTFiles from SiWEcal Beam Test 2021

  -c, --comissioning_folder=COMFOLDER
                             Path to the comissioning folder
      --configuration_file=CONFIG
                             Layer configuration of the calorimeter
  -i, --in_file_name=INFILENAME   Input file name
  -m, --exc_mode=EXCMODE     Execution mode of this program: default ->
                             executes with minimal output ; debug -> executes
                             with all output ; setup -> only reads and prints
                             all the input files
      --mapping_file=MAPFILE Mapping file name
      --mapping_file_cob=MAPFILECOB
                             Mapping file name for the cob layers
      --masked_file=MASKFILE Masked channels file name
      --mip_calibration_file=MIPFILE
                             Mip calibration file name
  -n, --max_entries=MAXENTRIES   Number of entries to process from the input
                             file
  -o, --out_file_name=OUTFILENAME
                             Output file name
      --out_col_name=OUTCOLNAME   Output collection name
      --pedestals_file=PEDFILE   Pedestals file name
  -r, --run_number=RUNNUMBER Run number. By default -1
  -t, --in_tree_name=INTREENAME   Input TTree name
  -?, --help                 Give this help list
      --usage                Give a short usage message
  -V, --version              Print program version

Mandatory or optional arguments to long options are also mandatory or optional
for any corresponding short options.

Report bugs to Hector.Garcia2@ciemat.es -- NO SPAM.
```

Build algorithm steps - November 2021

Hit Construction:

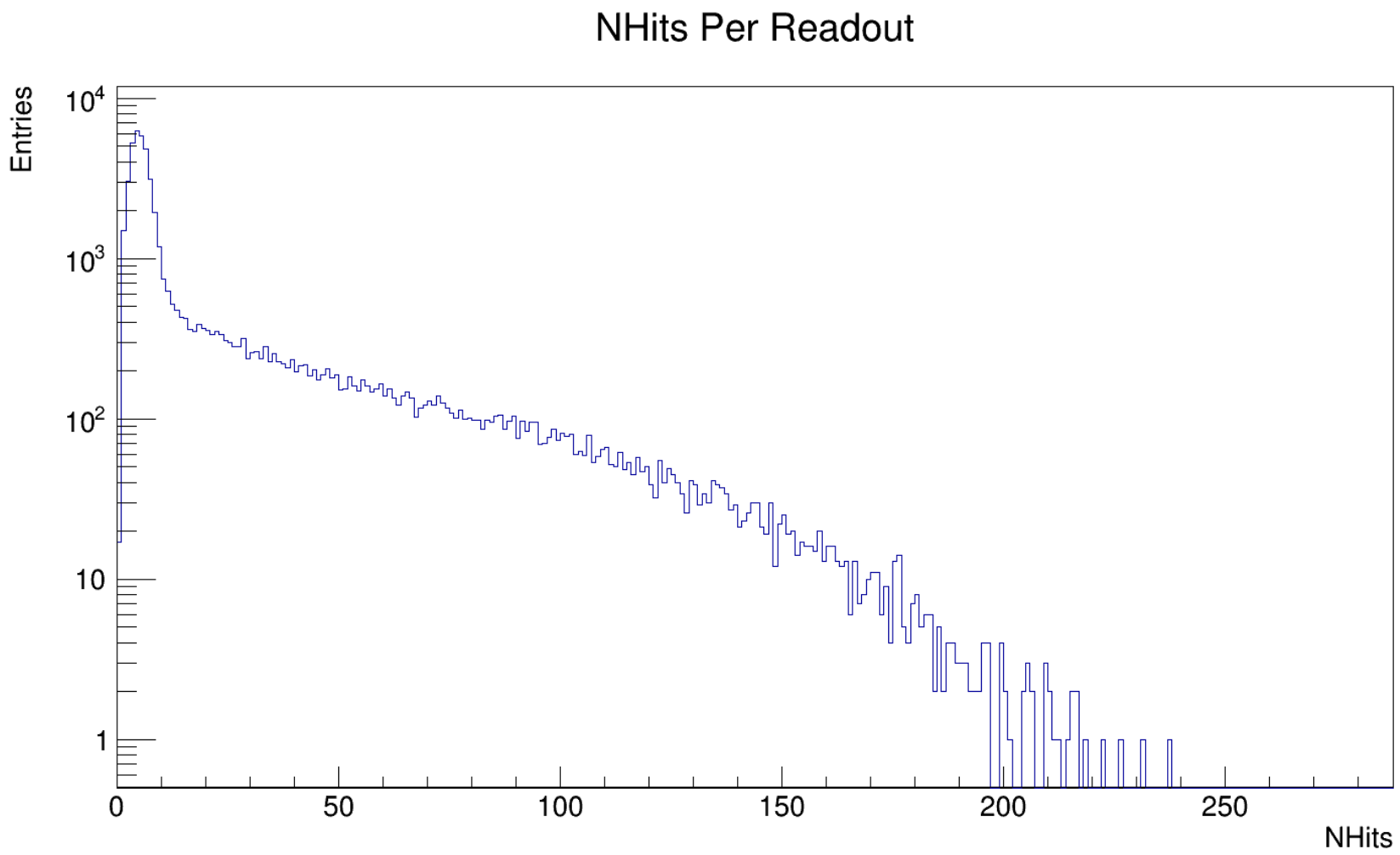
Loop over the *RawROOTFile* and construction of the ECal hit with mapping, pedestal substraction and calibration. Dropping the following cases:

- Layers with $slot = -1$
- Chips with $chipid = -1$
- Hits with $gain\_hit\_high <= 0$
- Masked hits
- Very low MIP values < 0.5

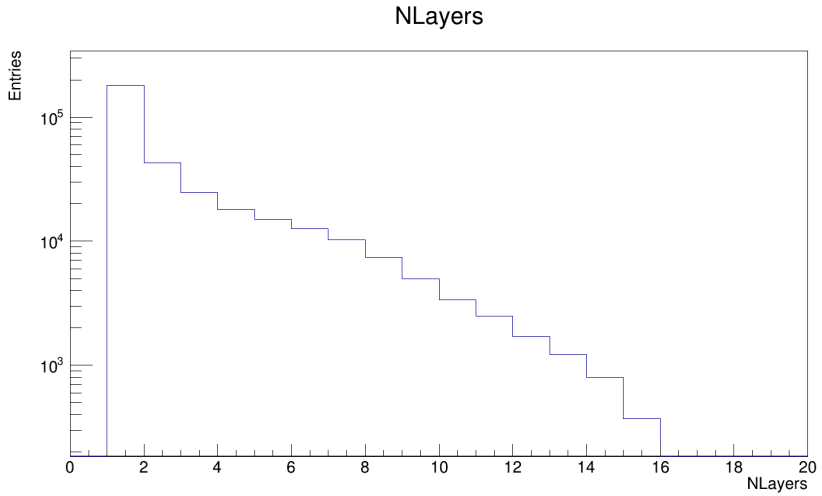
BCID Map construction and merging:

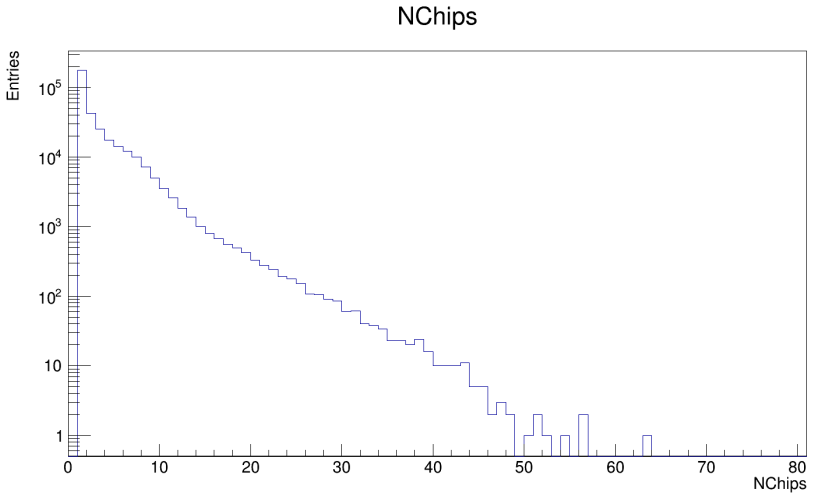
Each ECal hit is appended to a vector in a BCID map using the *corrected_bcid* value taking into account the clock overflow. Then the BCIDs are merged into a single event concatenating a window of 3 BCIDs. The final BCID of the event is the one in the map with maximum number of hits. Dropping events with large number of hits > 8000

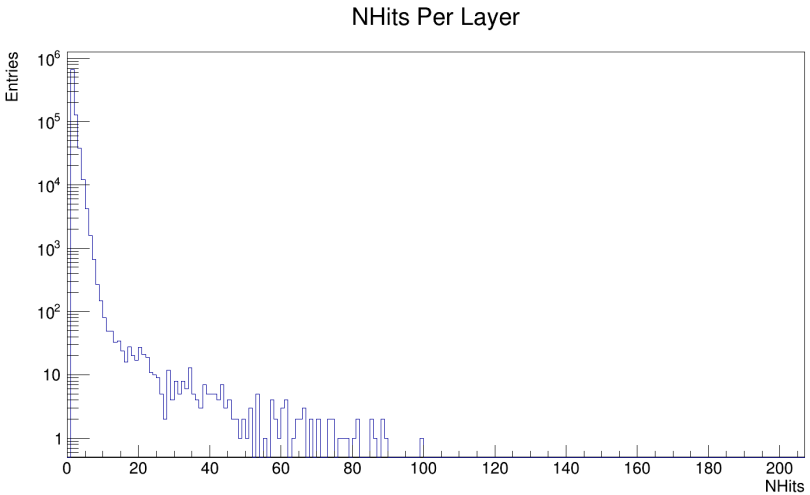
Log ROOT File. MIPScan run: 050084

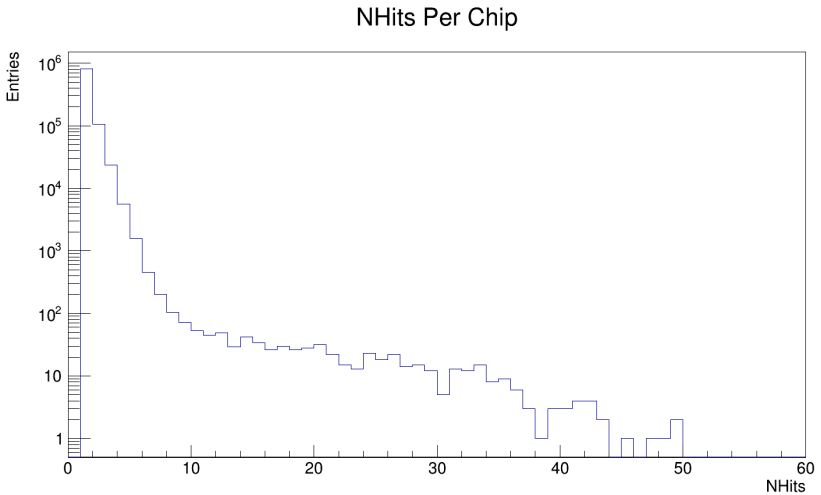


Log ROOT File. MIPScan run: 050084



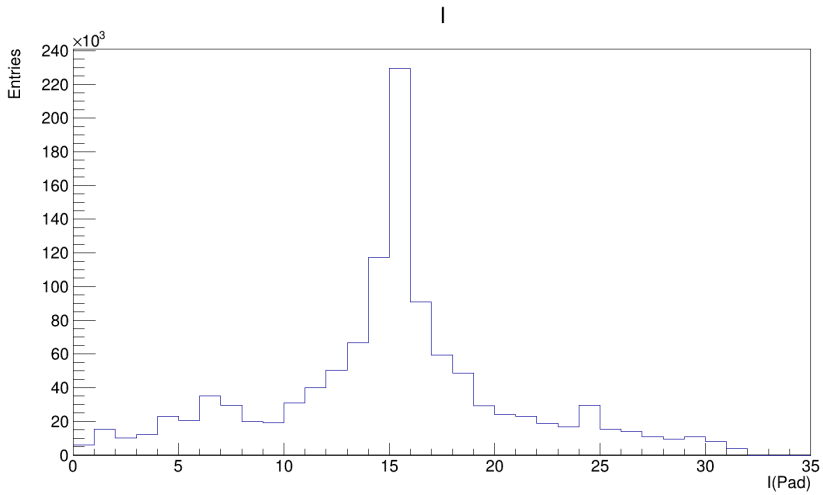


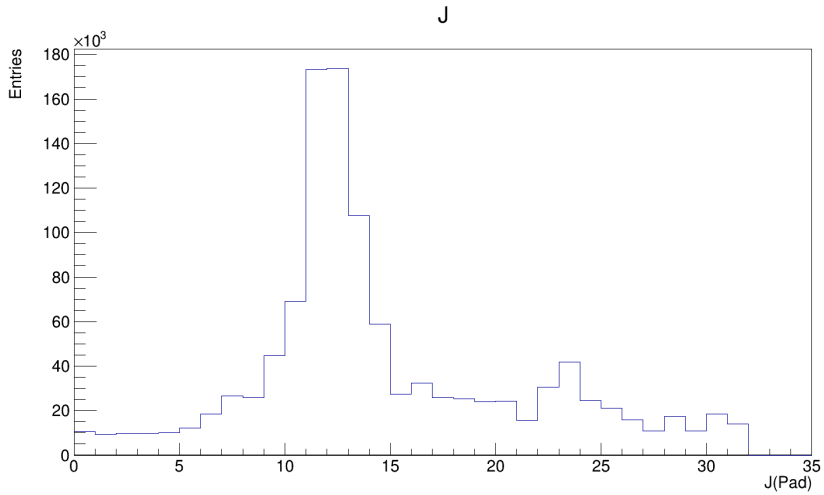




Log ROOT File. MIPScan run: 050084 - W22degree5GeV: 050187

050084





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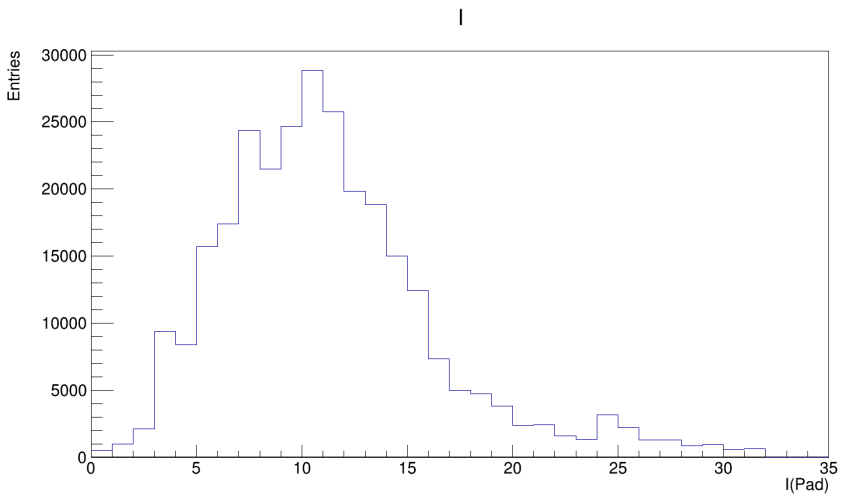
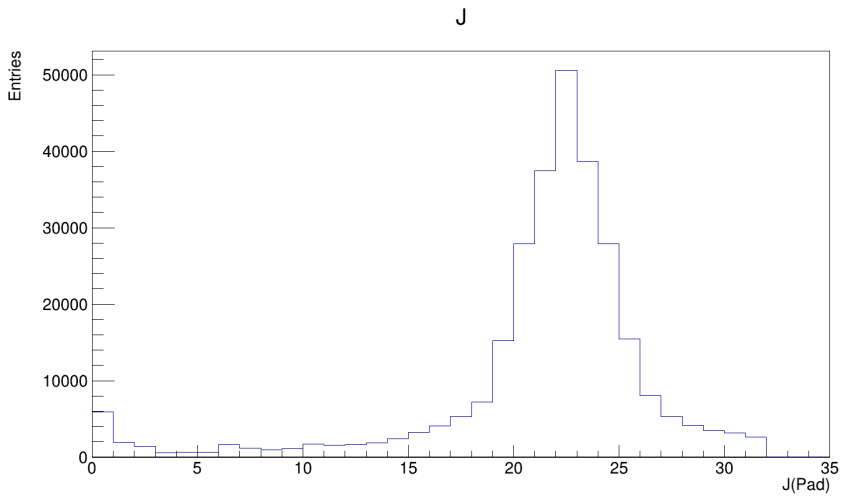
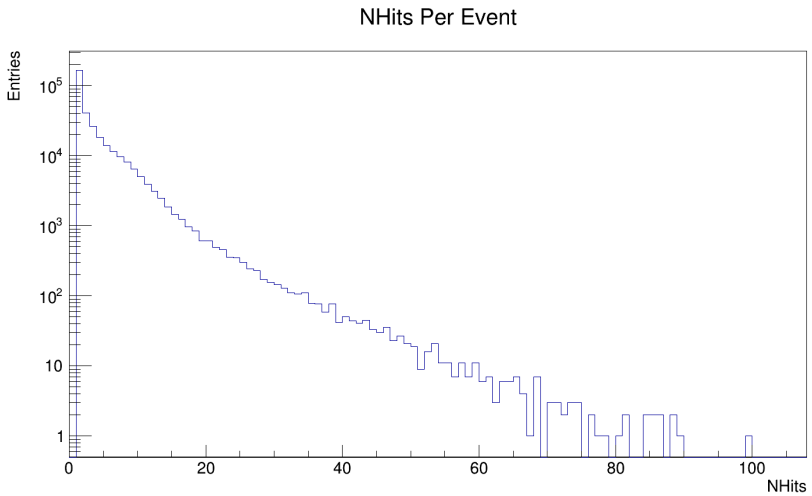
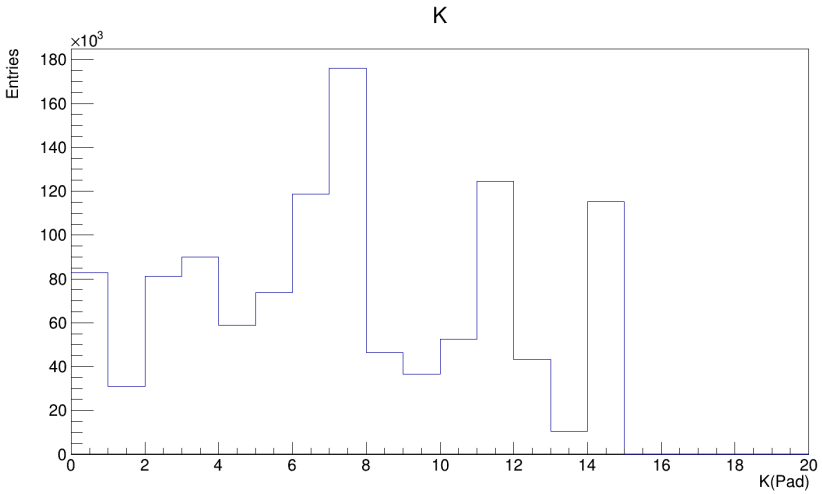




Log ROOT File. MIPScan run: 050084 - W22degree5GeV: 050187

050084





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