Software for the new scintillator HCAL prototype

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Outline

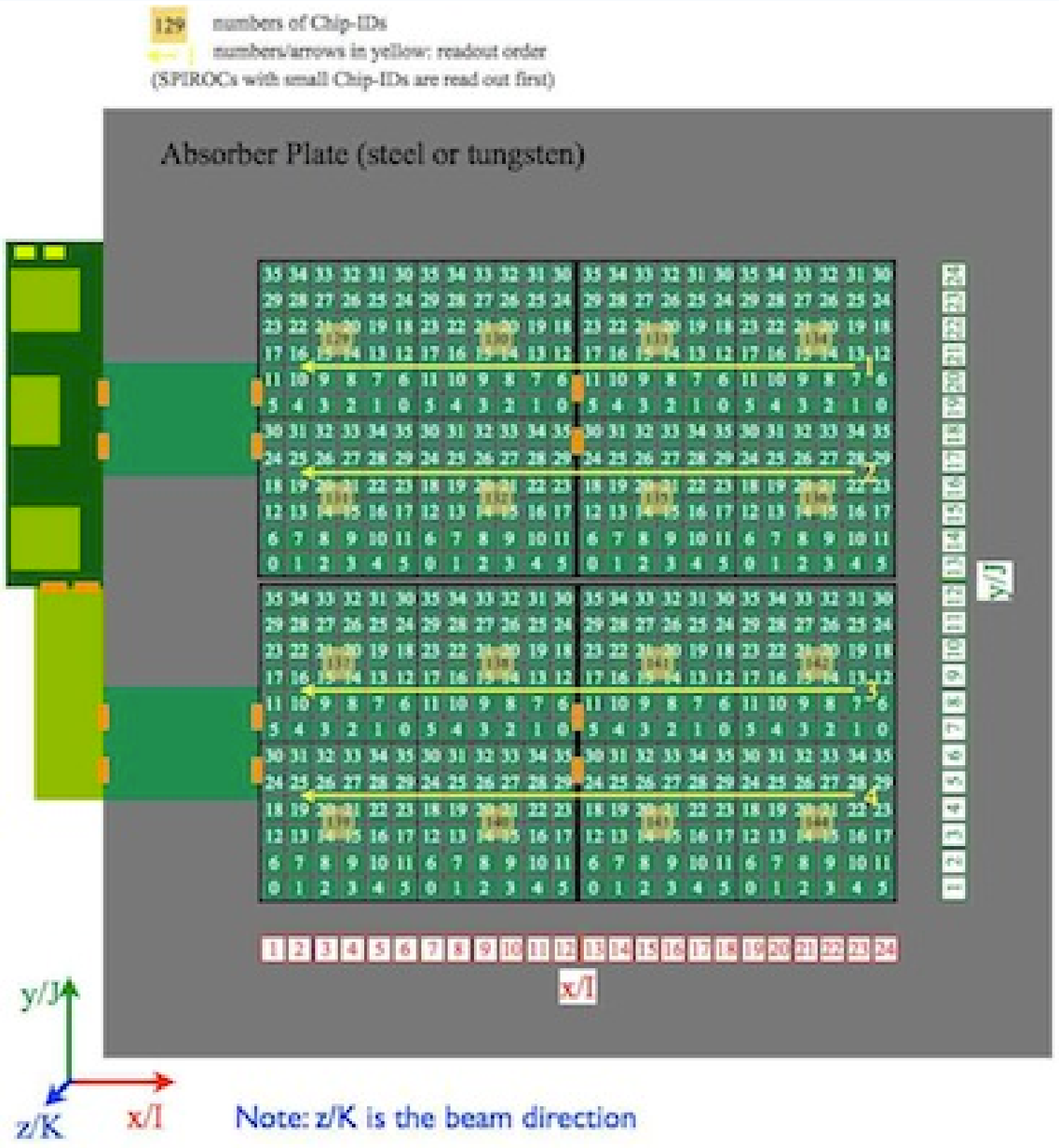
- Introduction of the new scintillator Hcal prototype
- Basic class: Ahc2Mapper and Data structure
- Data format converter and events sorting
- Database maintenance tools for hardware expert
- Reconstruction development and the control plots
- Software design strategy for the new prototype of scintillator Hcal
- The possible application to the new prototype of scintillator Ecal

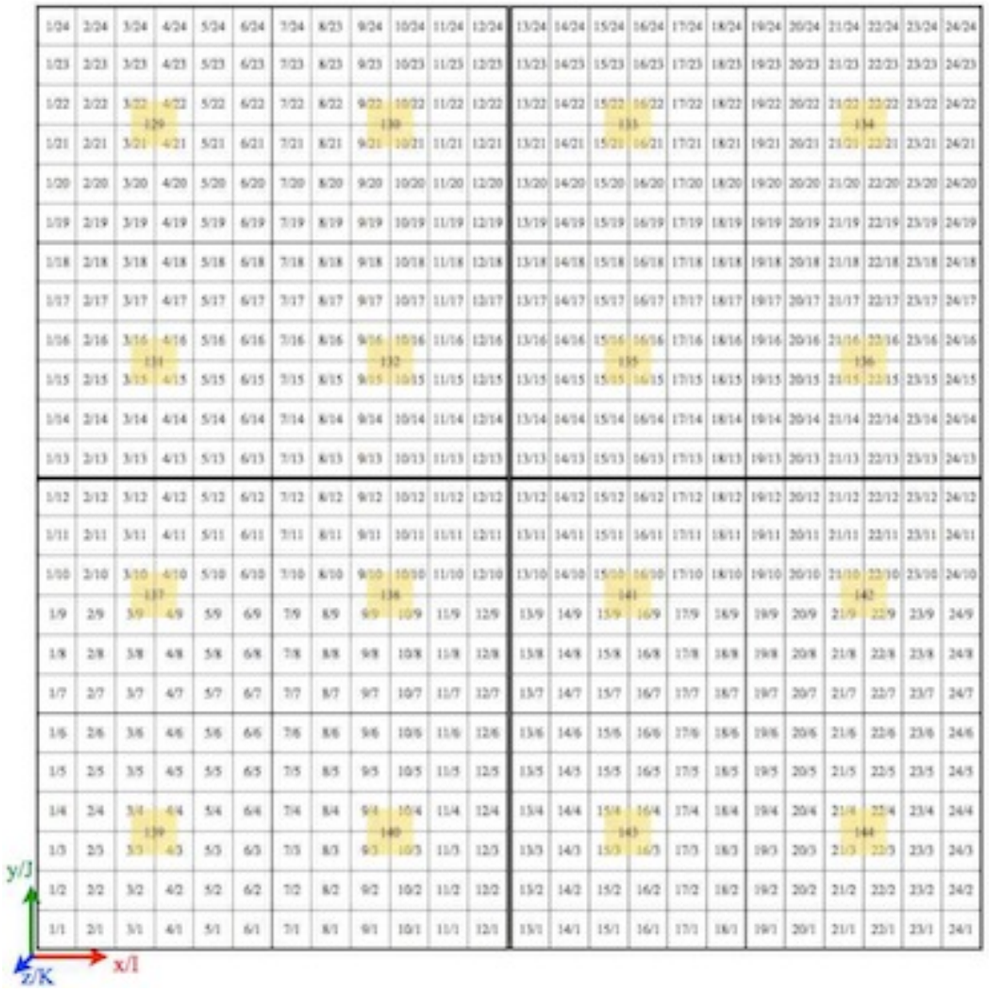
Response persons

- Coordination: Shaojun Lu
- LCIO converter: Shaojun lu
- Slow control data: Oskar Hartbrich
- Database tools: Shaojun Lu
- Reconstruction: Shaojun Lu, Sebastian Laurien

- Basic ideas:
  - Use LCIO, database and Marlin (ilcsoft framework)
  - Reuse as much as possible the existing class, tools, and processors
  - Software design for common usage by other detectors

Hardware mapping





- CERN testbeam hardware setup
- model/chip/channel : I/J/K : x/y/z (right hand coordinator)
- z/K is the beam direction, y/J direction is up.

Mapper class

Scintillator ECAL and HCAL create your detector mapper

- Ahc2Mapper.hh/.cc
  - CellID Encoder

    const std::string CellIDEncoding("M:3,S-1:3,I:9,J:9,K-1:6");

    const std::string ModuleEncoding("module:6,chip:4,chan:6,SiPM:16");
  - New software design, use encoder of the Mapper for database tools and reconstruction Marlin processors
  - Geometry Mapping (Filled from the database)
    - module description collection (detector expert)
    - module connection collection (detector expert)
    - Database expert maintenance tools has been implemented, and database have been created.
  - MappingProcessor can process the geometry

Common for Scintillator ECAL and HCAL

Labview DAQ data structure

- Labview DAQ data structure
  - 12 integer:
  - BunchXID/I:CycleNr/I:ChipID/I:ASICNr/I:EvtNr/ I:Channel/I:TDC/I:ADC/I:xPos/I:yPos/I:HitBit/ I:GainBit/I
  - BunchXID & CycleNr ==> Event
  - # Date / Time : Fr, 2. Nov 2012 21:46:45
- Identical output structure for HBU and EBU, except German and Japanese in the text.

HBU: Hadronic calorimeter basic unit, EBU: Electro magnetic calorimeter basic unit

Common for Scintillator ECAL and HCAL

LabviewBlock class

- LabviewBlock.hh/.cc

```
class LabviewBlock : public LCFixedObject<NINT,NFLOAT,NDOUBLE>
    //parameters
    12 integer
    //getFunctions
    int GetBunchXID() const {  return getIntVal(0); }
    int GetCycleNr() const {  return getIntVal(1); }
    int GetChipID() const {  return getIntVal(2); }
    int GetASICNr() const {  return getIntVal(3); }
    int GetEvtNr() const {  return getIntVal(4); }
    int GetChannel() const {  return getIntVal(5); }
    int GetTDC() const {  return getIntVal(6); }
    int GetADC() const {  return getIntVal(7); }
    int GetXPos() const {  return getIntVal(8); }
    int GetYPos() const {  return getIntVal(9); }
    int GetHitBit() const {  return getIntVal(10); }
    int GetGainBit() const {  return getIntVal(11); }
```

Common for Scintillator ECAL and HCAL

LabviewConverter

- Marlin Processor: LabviewConverter
  - Data format; Date /Time; and Events sorting

LCIO format

```
================================================================================
       Event  : 1 - run:  10005 - timestamp 1351889236000000000 - weight 1
================================================================================
 date:      02.11.2012  20:47:16.000000000
 detector : unknown
 event parameters:

 collection name : LabviewData
 parameters:

--------------- print out of LCGenericObject collection ---------------
  flag:  0x80000000
parameter DataDescription [string]: i:BunchXID; i:CycleNr; i:ChipID; i:ASICNr; i:EvtNr; i:Channel; i:TDC; i:ADC; i:XPos; i:YPos; i:HitBit; i:GainBit,
parameter TypeName [string]: LabviewBlock,

[   id   ] i:BunchXID; i:CycleNr; i:ChipID; i:ASICNr; i:EvtNr; i:Channel; i:TDC; i:ADC; i:XPos; i:YPos; i:HitBit; i:GainBit - isFixedSize: true
-----------------------------------------------------------
[00000004] i:19; i:1; i:129; i:0; i:0; i:0; i:989; i:227; i:6; i:7; i:0; i:1;  ----------------------------------------------------
[00000005] i:19; i:1; i:129; i:0; i:0; i:1; i:982; i:240; i:5; i:7; i:0; i:1;  ----------------------------------------------------
[00000006] i:19; i:1; i:129; i:0; i:0; i:2; i:997; i:232; i:4; i:7; i:0; i:1;  ----------------------------------------------------
[00000007] i:19; i:1; i:129; i:0; i:0; i:3; i:988; i:223; i:3; i:7; i:0; i:1;  ----------------------------------------------------
[00000008] i:19; i:1; i:129; i:0; i:0; i:4; i:984; i:251; i:2; i:7; i:0; i:1;  ----------------------------------------------------
[00000009] i:19; i:1; i:129; i:0; i:0; i:5; i:991; i:254; i:1; i:7; i:0; i:1;  ----------------------------------------------------
[0000000a] i:19; i:1; i:129; i:0; i:0; i:6; i:1001; i:233; i:6; i:8; i:0; i:1;  ----------------------------------------------------
[0000000b] i:19; i:1; i:129; i:0; i:0; i:7; i:984; i:256; i:5; i:8; i:0; i:1;  ----------------------------------------------------
[0000000c] i:19; i:1; i:129; i:0; i:0; i:8; i:993; i:245; i:4; i:8; i:0; i:1;  ----------------------------------------------------
[0000000d] i:19; i:1; i:129; i:0; i:0; i:9; i:997; i:238; i:3; i:8; i:0; i:1;  ----------------------------------------------------
[0000000e] i:19; i:1; i:129; i:0; i:0; i:10; i:993; i:230; i:2; i:8; i:0; i:1;  ----------------------------------------------------
[0000000f] i:19; i:1; i:129; i:0; i:0; i:11; i:992; i:226; i:1; i:8; i:0; i:1;  ----------------------------------------------------
[00000010] i:19; i:1; i:129; i:0; i:0; i:12; i:974; i:230; i:6; i:9; i:0; i:1;  ----------------------------------------------------
[00000011] i:19; i:1; i:129; i:0; i:0; i:13; i:990; i:241; i:5; i:9; i:0; i:1;  ----------------------------------------------------
[00000012] i:19; i:1; i:129; i:0; i:0; i:14; i:982; i:236; i:4; i:9; i:0; i:1;  ----------------------------------------------------
[00000013] i:19; i:1; i:129; i:0; i:0; i:15; i:986; i:244; i:3; i:9; i:0; i:1;  ----------------------------------------------------
[00000014] i:19; i:1; i:129; i:0; i:0; i:16; i:985; i:230; i:2; i:9; i:0; i:1;  ----------------------------------------------------
[00000015] i:19; i:1; i:129; i:0; i:0; i:17; i:980; i:237; i:1; i:9; i:0; i:1;  ----------------------------------------------------
[00000016] i:19; i:1; i:129; i:0; i:0; i:18; i:984; i:244; i:6; i:10; i:0; i:1;  ----------------------------------------------------
[00000017] i:19; i:1; i:129; i:0; i:0; i:19; i:984; i:266; i:5; i:10; i:0; i:1;  ----------------------------------------------------
[00000018] i:19; i:1; i:129; i:0; i:0; i:20; i:973; i:232; i:4; i:10; i:0; i:1;  ----------------------------------------------------
[00000019] i:19; i:1; i:129; i:0; i:0; i:21; i:969; i:230; i:3; i:10; i:0; i:1;  ----------------------------------------------------
lines 1-41
```

Common for Scintillator ECAL and HCAL

Converter status

- All information hold by class LabviewBlock
  - Event builder: use “BunchXID” and “CycleNr”
  - Added function: SwapBunchXID() for RampID
  - Added function: SwapEvtNr() for MemCellNr
- Written into collection: LabviewData
- Temperatures: written into collection : TSensor
- Added trigger01 and trigger 02 for “AHC2”
  - When both T01 and T02 are OK, considered as a good event.
- Updated and works for both scintillator Ecal (EBU) and scintillator Hcal (HBU).

Slow control data

- Slow Control Class and test has been done by Oskar

  //parameters

  68 parameters / chip

  //getFunctions

  getPACapacitor() getPAEnable() getPATestCapacitor()

  … …

  more coming, Oskar will fully implement them
- Will save into database (only once per run)
  - with start and stop timestamp
  - implement into lcio converter step

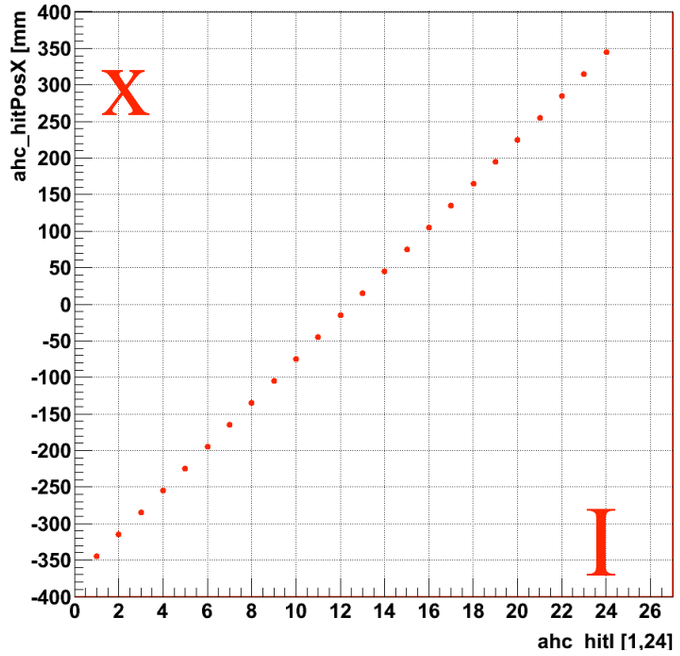
Reconstruction overview

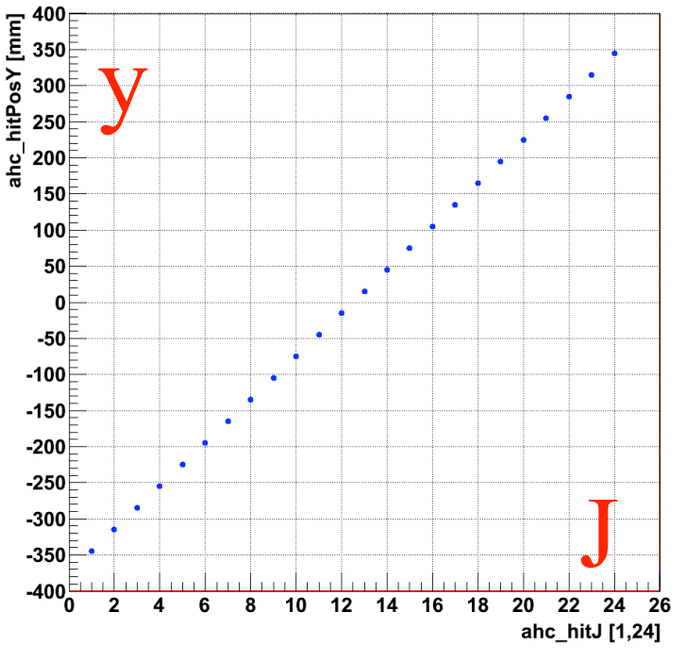
Common for Scintillator ECAL and HCAL

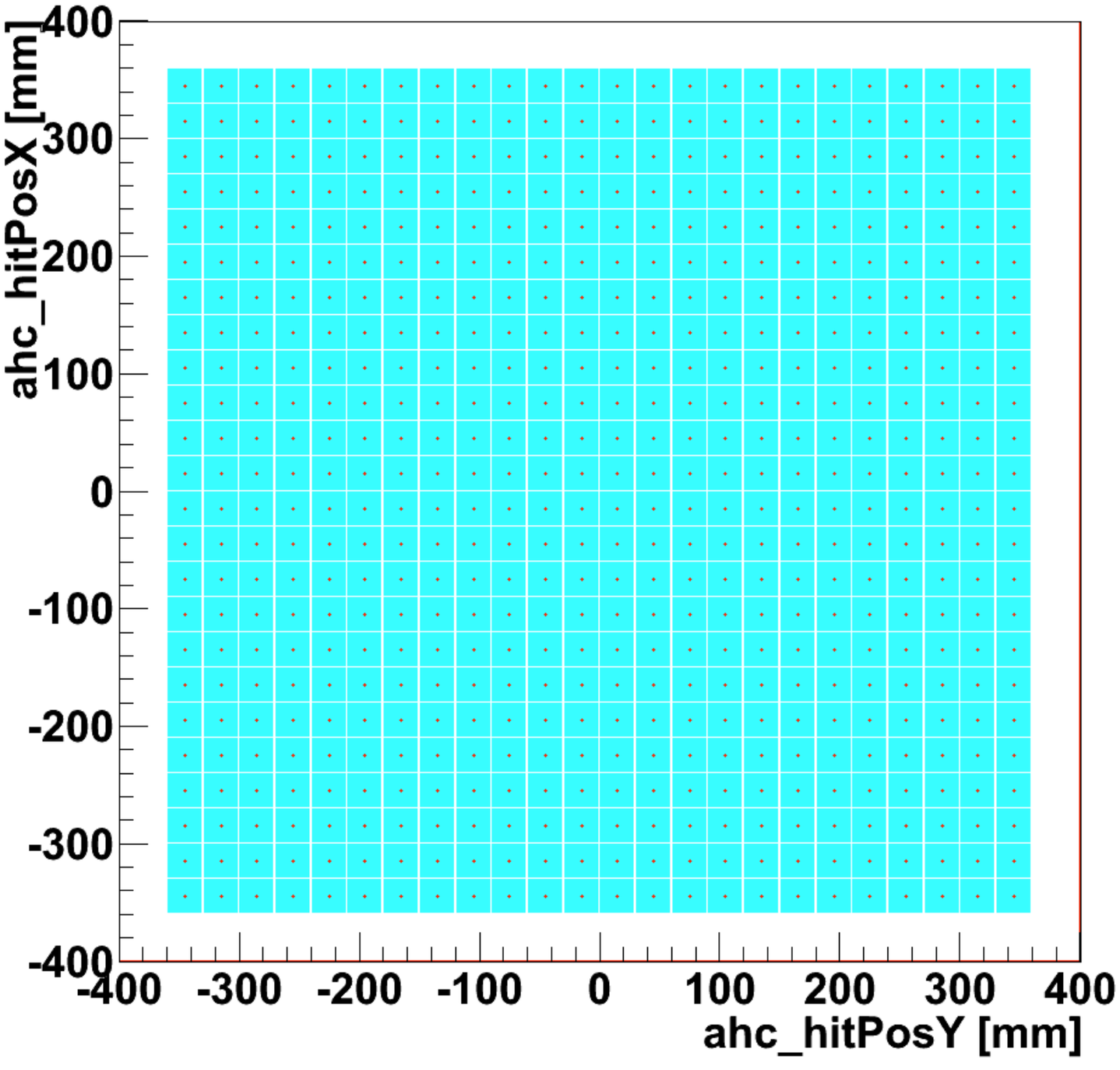
- USE ILCsoftware framework:
  - LCIO for data, and Marlin Processors for algorithm:
  - Read/create geometry mapping and condition/calibration constants from database
    - ModuleDescription, ModuleConnection, Pedestal, MIP, Gain ... ...
- Apply to the converted data in LCIO format
  - use encoder of the Mapper, (module,chip,channel)
- Write out as CalorimeterHit in LCIO format
  - Reconstructed CellID,x,y,z,E,t ...
- Analysis the data and write into root for final plots

Reconstructed geometry

- Geometry reconstructed for 180GeV Muon

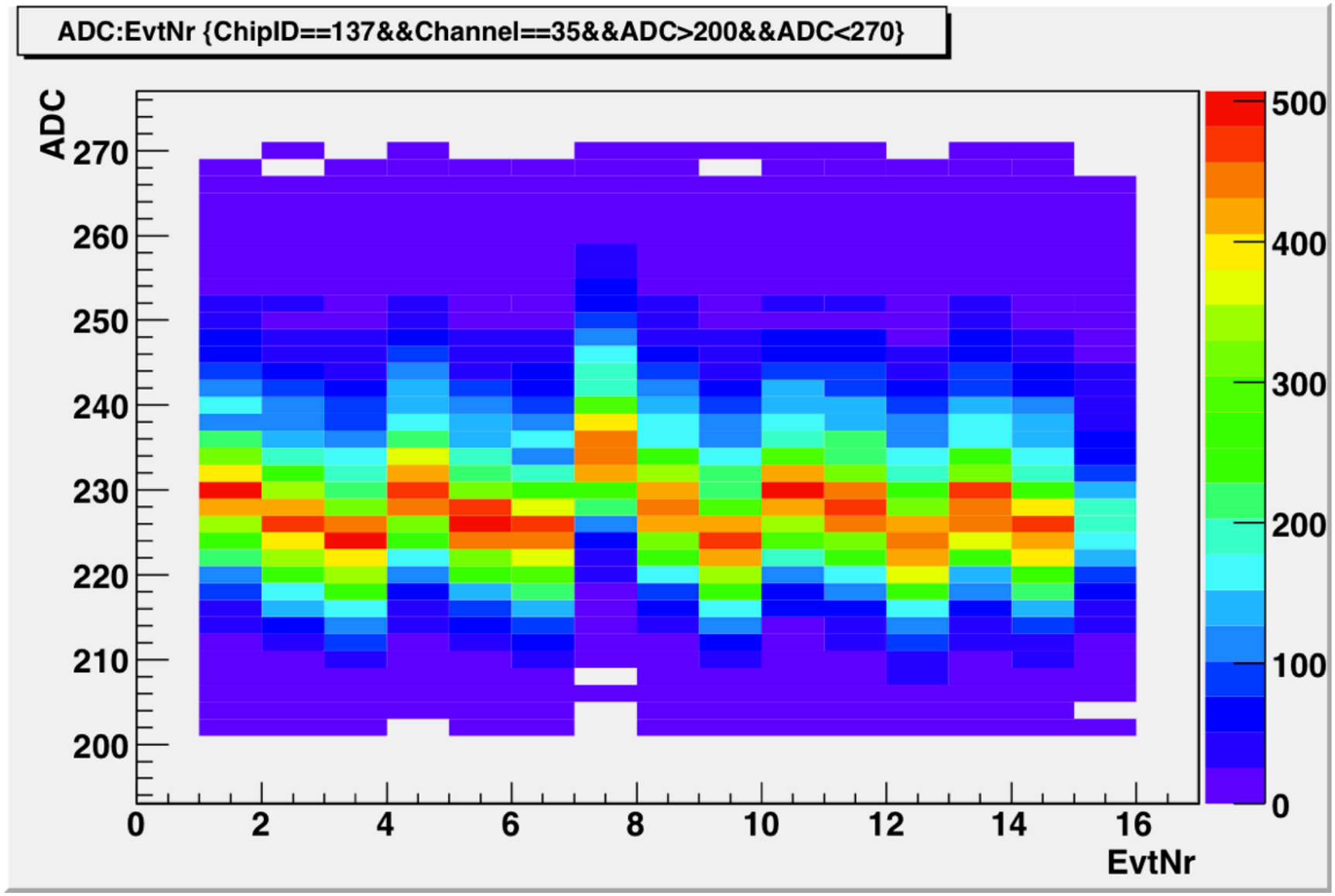






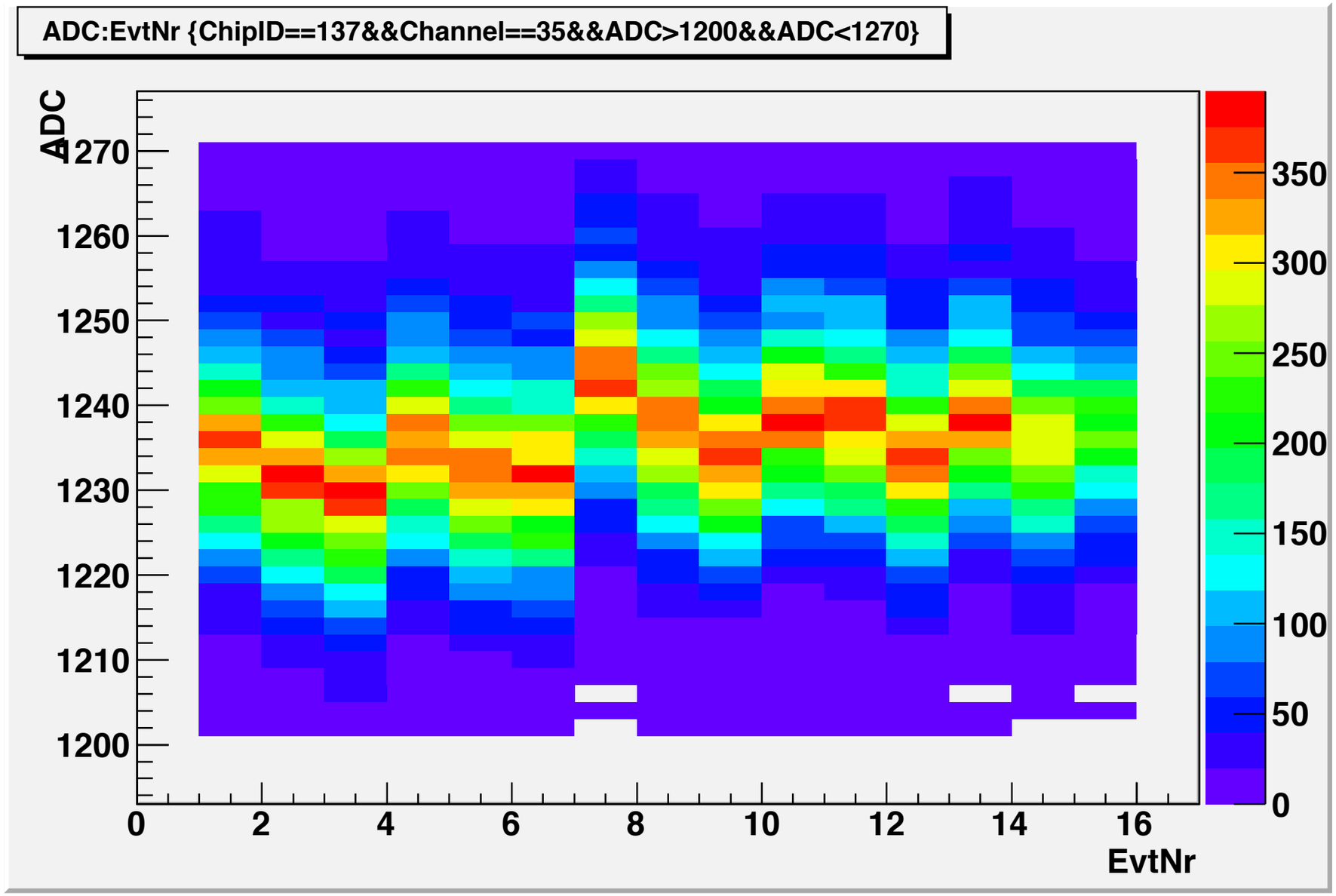
Pedestal offset

- Run: Pedestal run
- Pedestal offset shown in one cell (T02 channel)
- First memory cell got high statistic



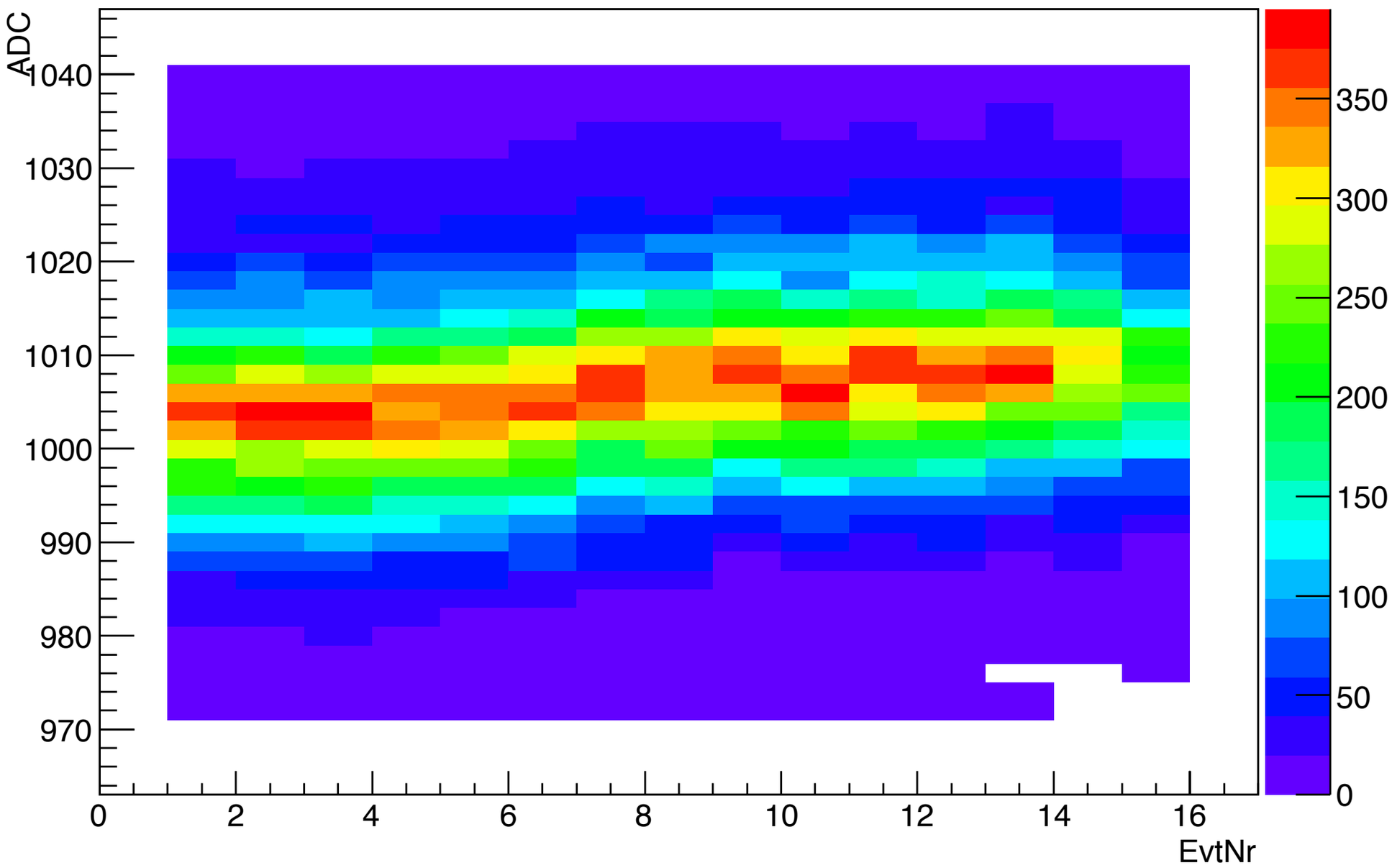
The effect of pedestal offset

- Run: 180GeV pion run
- The effect on the signal from pedestal offset
  - A way to study this effect with CERN test beam data
  - Both signal stable and pedestal offset effect confirmed



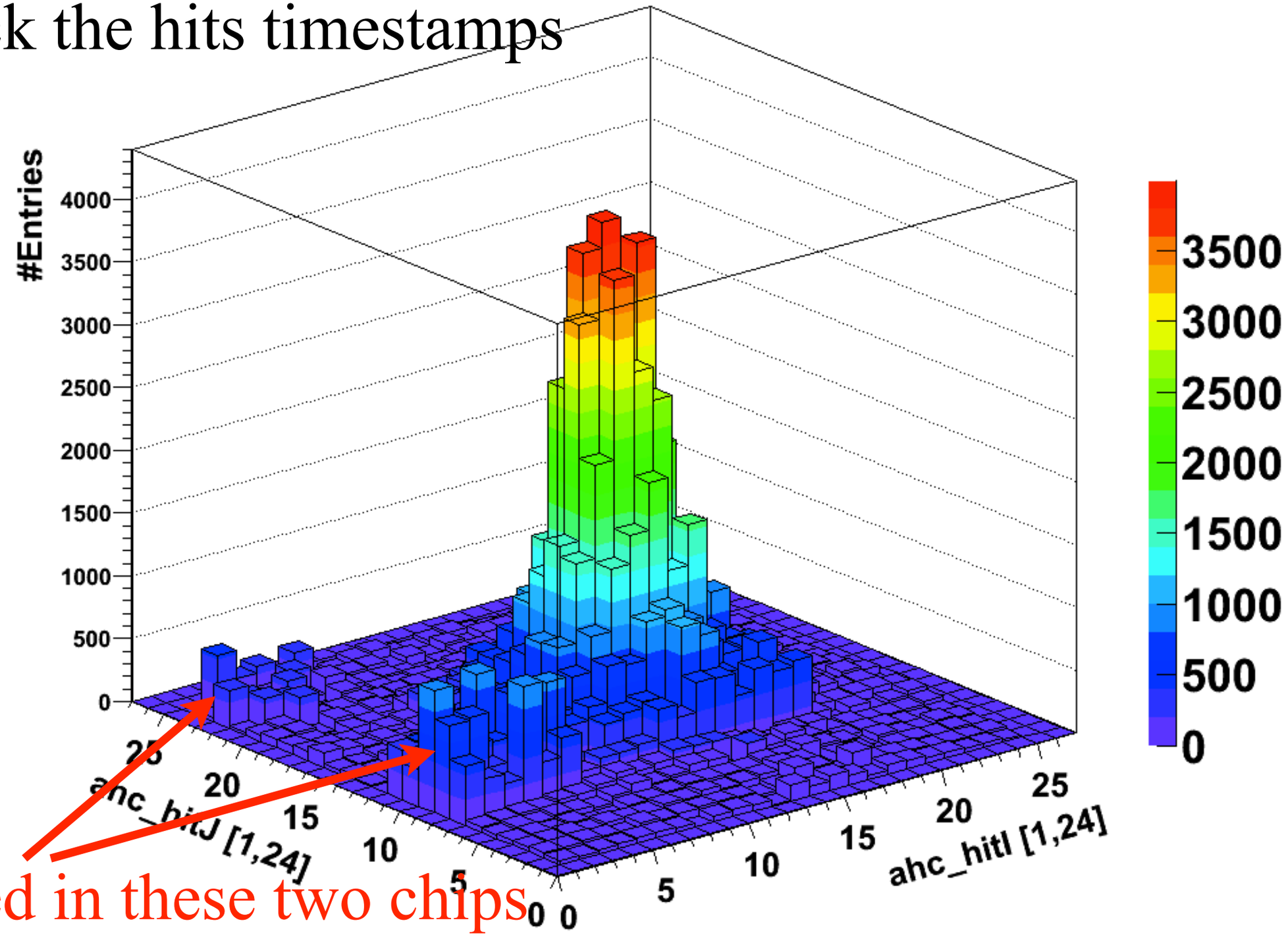
Pedestal offset correction

- Run: 180GeV pion run
- The pedestal offset correction has been implemented



Timestamp reconstruction

- Ahc2 hits distribution in 180GeV Pions testbeam run
- Check the hits timestamps

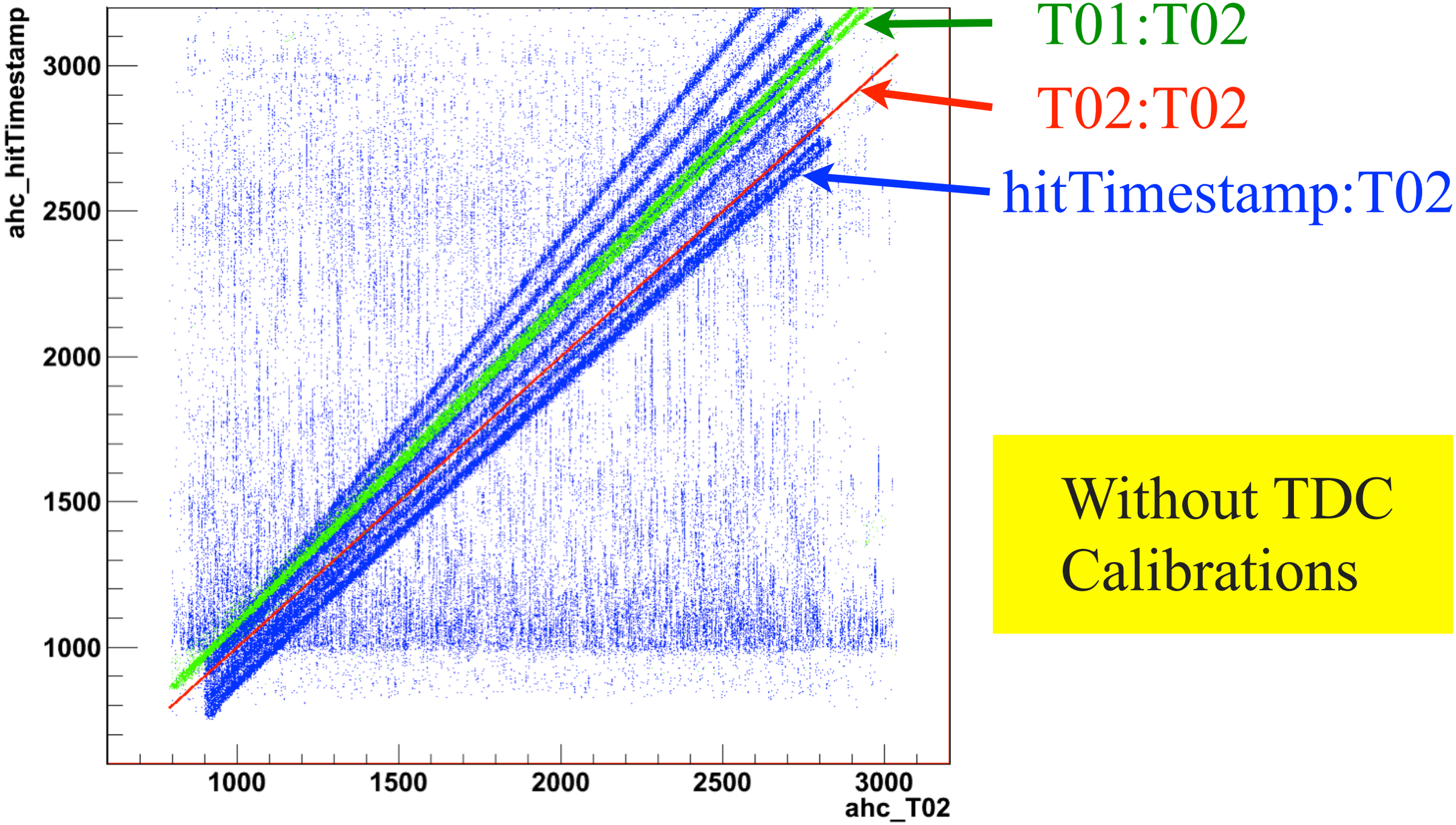


T0 located in these two chips

Timestamp reconstruction

- Timestamp TDC

180GeV Pions

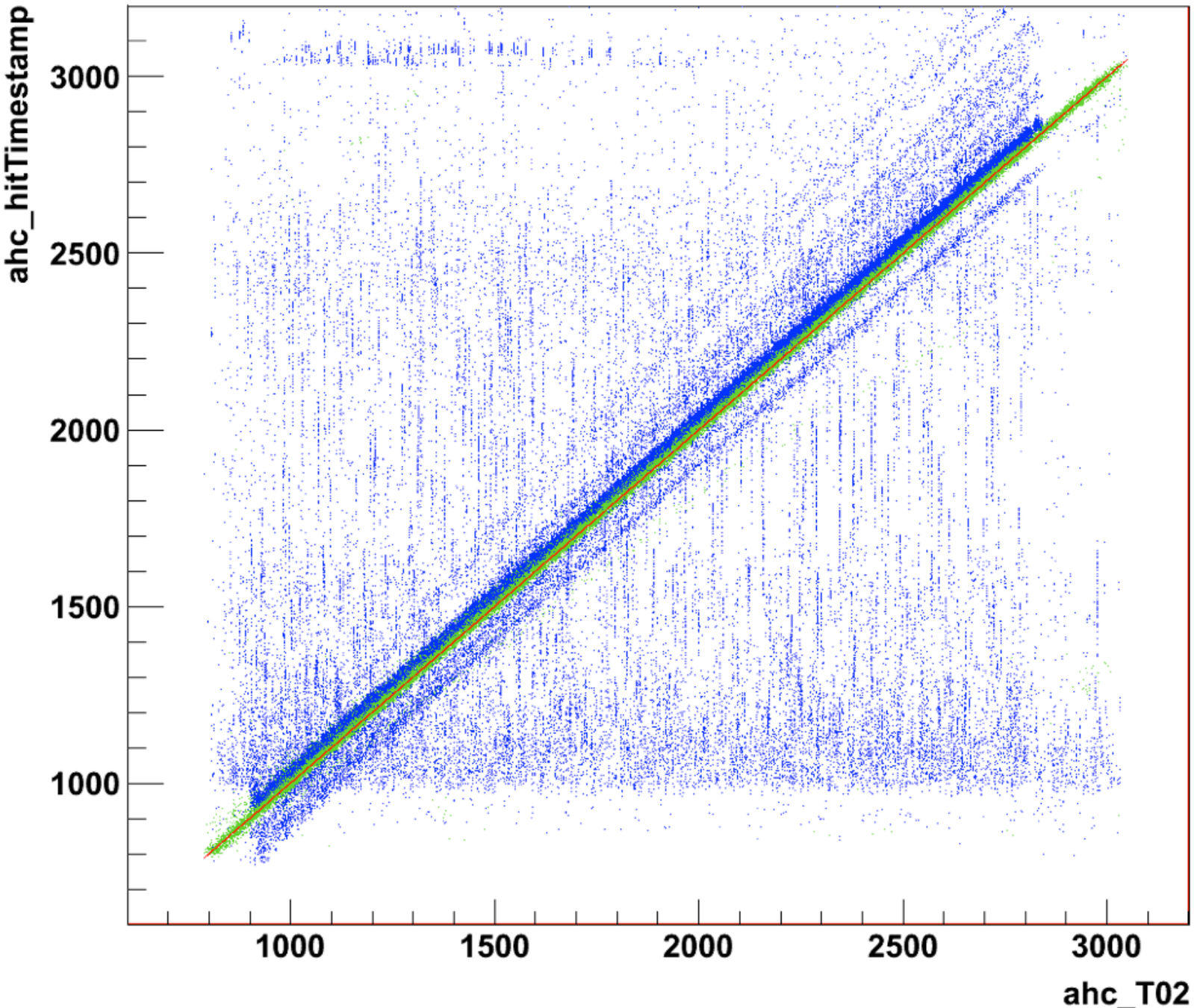


Without TDC Calibrations

Timestamp reconstruction

- Timestamp TDC

180GeV Pions



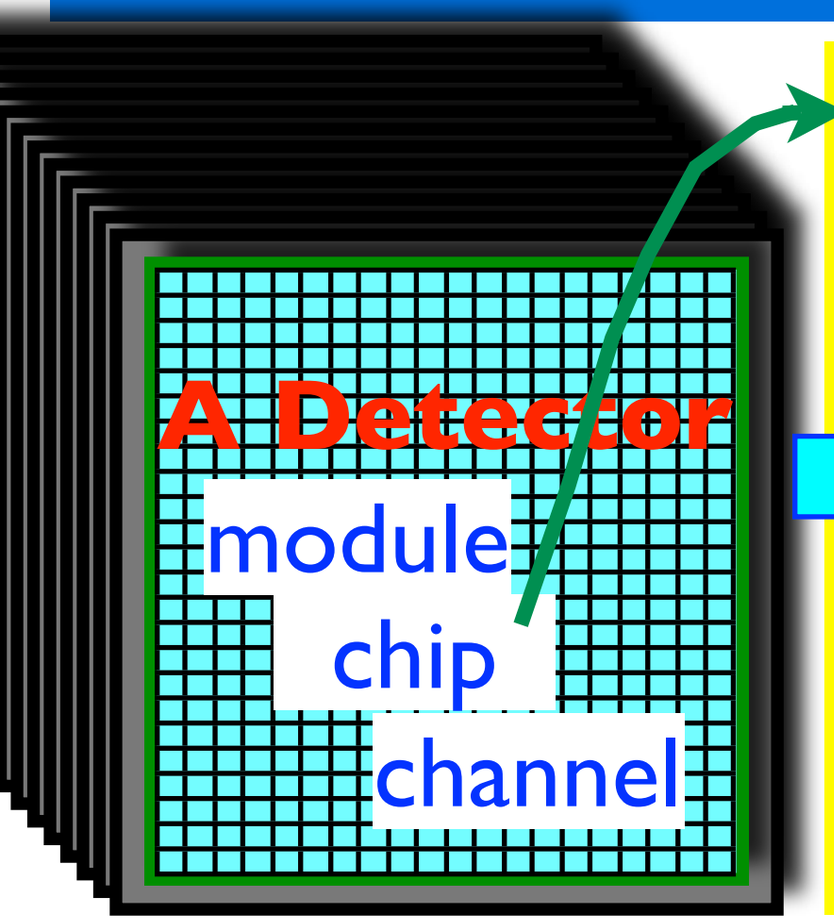
T01:T02

T02:T02

hitTimestamp:T02

After TDC Calibration
For the centre 4 chips

Software design strategy



encoding /Mapper

one/two experts

MySQL LCCD database

index: const1 + encodingString
index: const2 + encodingString
index: constn + encodingString

MarlinProcessor1
container:
index: CC1, CC2, ... CCn
encoding: Check encodingString identical or error/stop

DAQ

module/chip/channel value

MarlinProcessor2
module/chip/channel value CC1 ...

How to extend to Scint ECAL

- Use the same converter, which could be work out with cooperation of scintillator ECAL and scintillator HCAL detector hardware experts.
- Reconstruction development
  - Geometry: need ECAL Mapper, and database for module
  - To update MarlinProcessor add ECAL Mapper
  - Follow same reconstruction process, for database and Marlin processors, which could work out by cooperation of scintillator ECAL and HCAL software developers
- A lot of common software tools may share between scintillator ECAL and scintillator HCAL, since they share the a lot of common hardware, and DAQ.

Summary and outlook

- For scintillator Hcal new prototype, the software framework has been setup.
  - Basic class Ahc2Mapper and Labview data structure have been done.
  - New prototype Ecal needs to create Ecal Mapper only, and the Labview data structure is identical
- Converter has been done to move “train” back onto the track.
  - The software development will be within the ilcsoftware framework.
  - Converter works for both scintillator Hcal new prototype and scintillator Ecal new prototype
- Reconstruction process has been built
  - It needs to finalize the calibration constants.
  - New Scintillator Ecal may follow this process.

Backup

LabviewConverter on ECAL

```
================================================================================
       Event  : 1 - run:  994 - timestamp 1351391019000000000 - weight 1
================================================================================
 date:      28.10.2012  02:23:39.000000000
 detector : unknown
 event parameters:

 collection name : LabviewData
 parameters:

-------------- print out of LCGenericObject collection --------------

  flag:  0x80000000
 parameter DataDescription [string]: i:BunchXID; i:CycleNr; i:ChipID; i:ASICNr; i:EvtNr; i:Channel; i:TDC; i:ADC; i:XPos; i:YPos; i:HitBit; i:GainBit,
 parameter TypeName [string]: LabviewBlock,

 [   id   ] i:BunchXID; i:CycleNr; i:ChipID; i:ASICNr; i:EvtNr; i:Channel; i:TDC; i:ADC; i:XPos; i:YPos; i:HitBit; i:GainBit - isFixedSize: true
 ---------------------------------------------------
 [00000006] i:2170; i:1; i:130; i:0; i:15; i:0; i:2030; i:252; i:0; i:0; i:0; i:1;  ----------
 [00000007] i:2170; i:1; i:130; i:0; i:15; i:1; i:2038; i:248; i:0; i:0; i:0; i:1;  ----------
 [00000008] i:2170; i:1; i:130; i:0; i:15; i:2; i:2033; i:238; i:0; i:0; i:0; i:1;  ----------
 [00000009] i:2170; i:1; i:130; i:0; i:15; i:3; i:2017; i:237; i:0; i:0; i:0; i:1;  ----------
 [0000000a] i:2170; i:1; i:130; i:0; i:15; i:4; i:2018; i:240; i:0; i:0; i:0; i:1;  ----------
 [0000000b] i:2170; i:1; i:130; i:0; i:15; i:5; i:2012; i:230; i:0; i:0; i:0; i:1;  ----------
 [0000000c] i:2170; i:1; i:130; i:0; i:15; i:6; i:2015; i:236; i:0; i:0; i:0; i:1;  ----------
 [0000000d] i:2170; i:1; i:130; i:0; i:15; i:7; i:2023; i:236; i:0; i:0; i:0; i:1;  ----------
 [0000000e] i:2170; i:1; i:130; i:0; i:15; i:8; i:2014; i:243; i:0; i:0; i:0; i:1;  ----------
 [0000000f] i:2170; i:1; i:130; i:0; i:15; i:9; i:2009; i:259; i:0; i:0; i:0; i:1;  ----------
 [00000010] i:2170; i:1; i:130; i:0; i:15; i:10; i:2005; i:240; i:0; i:0; i:0; i:1;  ----------
 [00000011] i:2170; i:1; i:130; i:0; i:15; i:11; i:1994; i:250; i:0; i:0; i:0; i:1;  ----------
 [00000012] i:2170; i:1; i:130; i:0; i:15; i:12; i:2001; i:257; i:0; i:0; i:0; i:1;  ----------
 [00000013] i:2170; i:1; i:130; i:0; i:15; i:13; i:1976; i:230; i:0; i:0; i:0; i:1;  ----------
 [00000014] i:2170; i:1; i:130; i:0; i:15; i:14; i:0; i:285; i:0; i:0; i:1; i:1;  ----------
 [00000015] i:2170; i:1; i:130; i:0; i:15; i:15; i:1971; i:236; i:0; i:0; i:0; i:1;  ----------
 [00000016] i:2170; i:1; i:130; i:0; i:15; i:16; i:1950; i:243; i:0; i:0; i:0; i:1;  ----------
 [00000017] i:2170; i:1; i:130; i:0; i:15; i:17; i:1950; i:240; i:0; i:0; i:0; i:1;  ----------
 [00000018] i:2170; i:1; i:130; i:0; i:15; i:18; i:1943; i:244; i:0; i:0; i:0; i:1;  ----------
 [00000019] i:2170; i:1; i:130; i:0; i:15; i:19; i:1931; i:246; i:0; i:0; i:0; i:1;  ----------
 [0000001a] i:2170; i:1; i:130; i:0; i:15; i:20; i:1923; i:247; i:0; i:0; i:0; i:1;  ----------
 [0000001b] i:2170; i:1; i:130; i:0; i:15; i:21; i:1904; i:237; i:0; i:0; i:0; i:1;  ----------
 [0000001c] i:2170; i:1; i:130; i:0; i:15; i:22; i:1895; i:228; i:0; i:0; i:0; i:1;  ----------
 [0000001d] i:2170; i:1; i:130; i:0; i:15; i:23; i:1875; i:243; i:0; i:0; i:0; i:1;  ----------
 [0000001e] i:2170; i:1; i:130; i:0; i:15; i:24; i:1874; i:240; i:0; i:0; i:0; i:1;  ----------
 [0000001f] i:2170; i:1; i:130; i:0; i:15; i:25; i:1858; i:252; i:0; i:0; i:0; i:1;  ----------
 [00000020] i:2170; i:1; i:130; i:0; i:15; i:26; i:1844; i:248; i:0; i:0; i:0; i:1;  ----------
 [00000021] i:2170; i:1; i:130; i:0; i:15; i:27; i:1817; i:233; i:0; i:0; i:0; i:1;  ----------
 [00000022] i:2170; i:1; i:130; i:0; i:15; i:28; i:1807; i:230; i:0; i:0; i:0; i:1;  ----------
 [00000023] i:2170; i:1; i:130; i:0; i:15; i:29; i:1792; i:245; i:0; i:0; i:0; i:1;  ----------
 [00000024] i:2170; i:1; i:130; i:0; i:15; i:30; i:1773; i:234; i:0; i:0; i:0; i:1;  ----------
```

Scintillator Ecal new prototype

converted to LCIO as same as “Ahc2”

Reconstruction development and status

- Geometry implementation:
  - Database:
    - ModuleLocationReference
    - ModuleConnection
    - ModuleDescription
    - DetecterTransfermation
- Marlin Processor
  - MappingProcessor
  - CellDescriptionProcessor
  - Handle x,y,z,I,J,K

AHC2 DONE!

Reconstruction development and status

- Amplitude implementation:
- Database:
  - Pedestal[NMEMCELLS]
  - MIPConstants
  - MIPSlopes
  - GainConstants
  - GainSlopes
  - InterCalibConstants
  - SiPMResponseCurve
  - CellQuality
  - TempSensorCalib
- Marlin Processor
  - CalibrationsProcessor
  - CalibrateProcessor
  - Handle Energy
  - ADC/MIP

Constants in test
To be updated!

AHC2 DONE!

Reconstruction development and status

- Timestamp implementation:
- Database:
  - TDCSlopes[Chip][Ramp]
  - TDCOffset[Chip][Ramp]
  - TDCCellOffset_129[NMEMCELLS]
    TDCCelloffset_137[NMEMCELLS]
  - TDCCellSloperCorr_129[NMEMCELLS]
- Marlin Processor
  - CalibrationsProcessor
  - CalibrateProcessor
- Handle TDC

Database folders to be created!

Database tools status

Database tools

1. write ModuleDescription
2. write ModuleLocationReference
3. write ModuleConnection
4. write DetectorTransformation
5. write Constants (MIP, Gain ...)
6. write Slopes (MIP, Gain ...)
7. write IC
8. write SimpleValue (Pedestal)
9. write SiPMResponseCurve

DONE!

Database tools

1. write CellQuality
2. write TempSensorCalib
3. write SiPMResponseScaling
4. write TDC calibrations

Analysis tools

1. MIP fit
2. Gain fit
3. IC fit

1. TDCSlope fit
2. TDCOffset fit

ONGOING!

More detail

- The database tools for the new prototype have been created as needed
- Most of the database folders have been created for the new prototype for the data reconstruction, more are in progress.
- The Labview data structure class and the converter have been done. (Keep it as original as possible, and only sorting event)
  - And more Marlin processors have/will be created
    - to monitor the known issue, (EventChecker)
    - to correct the Labview output data (may break the rule to keep it as original as possible, but the correct is first.)
    - to clean up the data. (may apply at reconstruction phase)

More detail

- For the reconstruction: the database tools, database folders, basic class for the new prototype data structure
  - More development is ongoing
  - All the database, class, processor and known issue will be checked.
  - Working through all the calibration constants and the database folders step by step.
- Try to reuse as much as possible existing class, database tools and Marlin processors, or try to generate common tools
  - Analyze calibration runs
  - Create database folder for the new prototype
  - Create database tools if needed
  - Create Marlin processor if needed