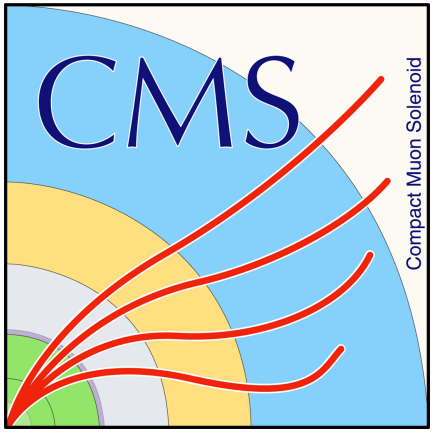

Pixel LA monitoring through PCL

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Marco Musich (University of Nebraska-Lincoln)
Tamas Almos Vami (Johns Hopkins University)

AlCaDB Meeting, September 27th, 2021

Motivation

- Goal: reduce the size of ALCARECO producer for Lorentz Angle (LA) monitoring and develop automated LA measurements in DQM

- The main projects:

    1. Study and apply a looser cut (prescale factor of 100) on the ALCARECO to reduce event size. Implement the prescalse into the new ALCARECO producer **SiPixelCalSingleMuonLoose**.

    2. Develop the Prompt Calibration Loop modules (PCL) for LA
        - PCL Worker: books and fills the charge drift vs depth histograms
        - PCL Havester: fits the histograms and obtain LA

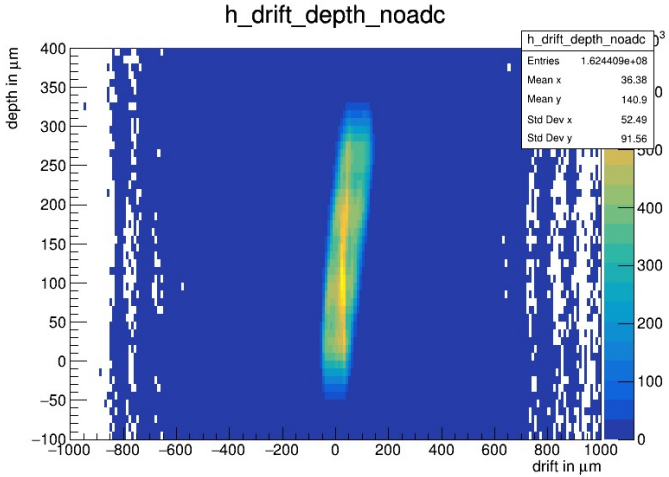
Prescale Study

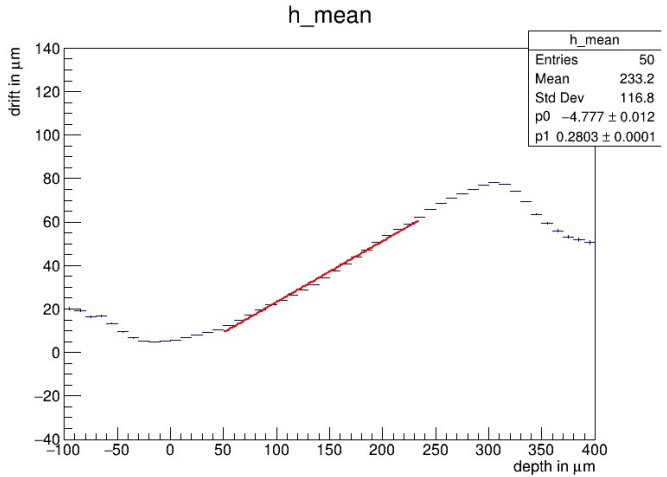
- ALCARECO samples:

  dataset = /SingleMuon/Run2018B-SiPixelCalSingleMuon-ForPixelALCARECO_UL2018-v1/ALCARECO run range: (317080 - 319077)

  dataset = /SingleMuon/Run2018C-SiPixelCalSingleMuon-ForPixelALCARECO_UL2018-v1/ALCARECO run range: (319337 - 320065)

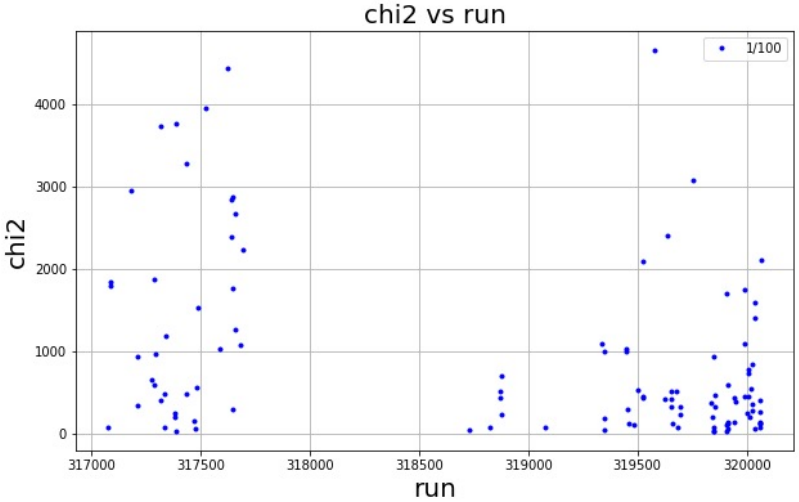
- Drift vs. depth plots & linear fit method

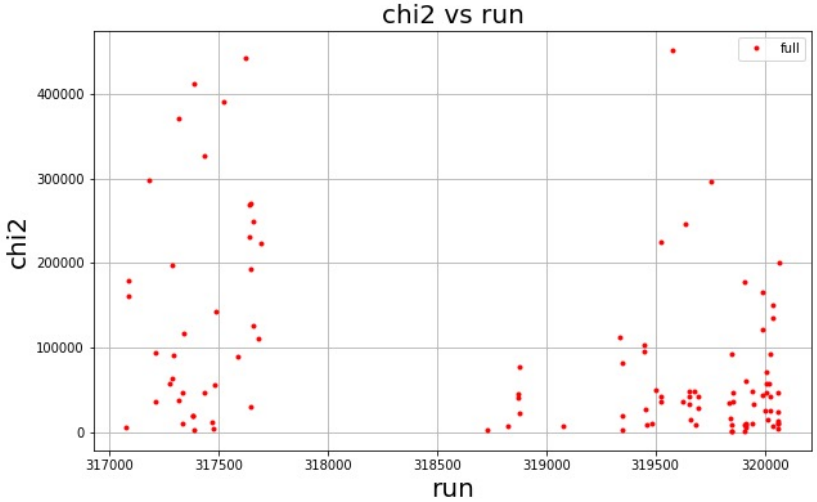




Chi squared

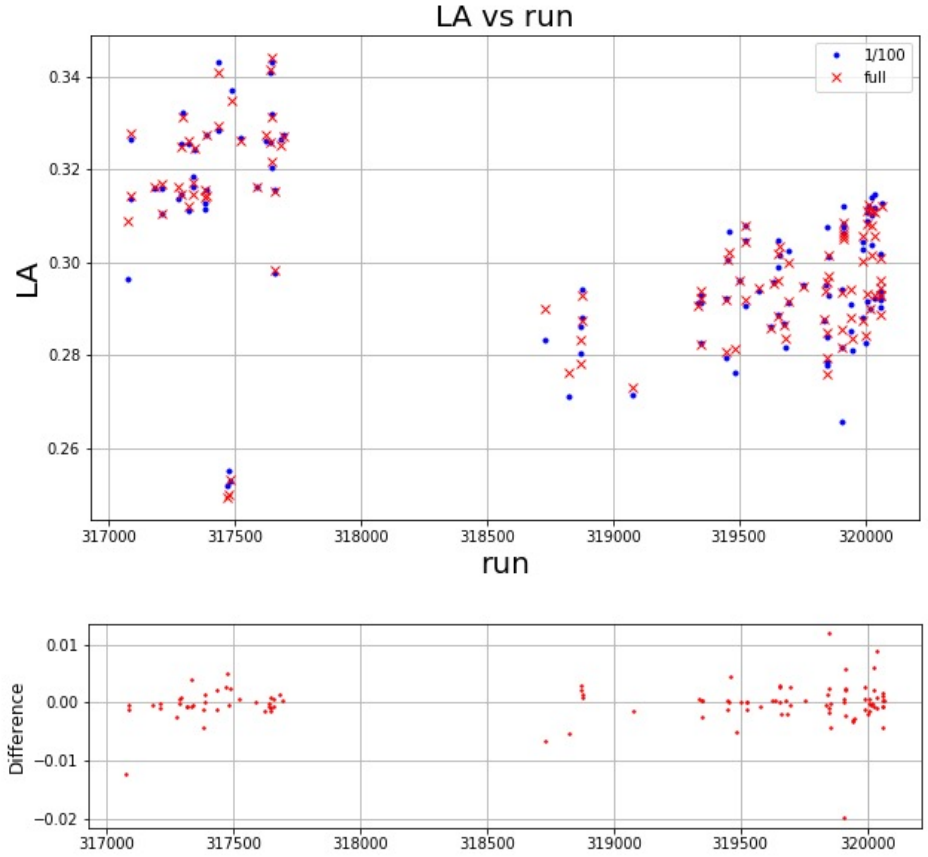
- Chi squared vs. run for full and 1/100 statistics





LA

- LA vs. run for full and 1/100 statistics



- The prescale 100 could be applied in the ALCARECO producer as the results remain consistent with the those of the full statistics.
- More comparison plots and results can be found in the previous talks (1, 2, 3) in the Pixel offline meeting.

New ALCARECO

- Since the prescale 100 is applicable, we continued the development of **SiPixelCalSingleMuonLoose.**

- Marco has implemented the factor in this ‘Loose’ producer. Test and validation is shown here.

- Now by specifying the AlCa producer as **SiPixelCalSingleMuonLoose** we can obtain events with smaller size without affecting the results for performance measurements.

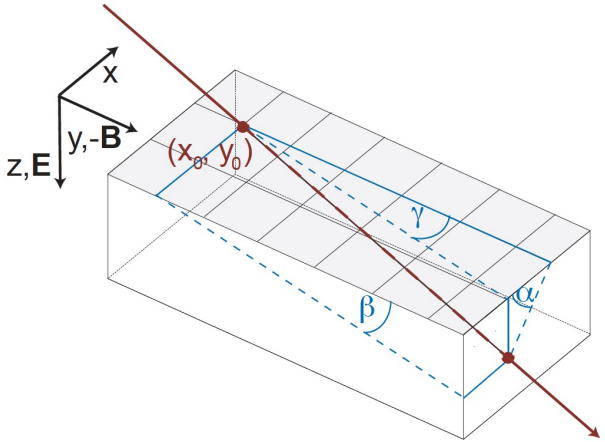
```
cmsDriver.py -s RAW2DIGI,RECO,ALCA: SiPixelCalSingleMuonLoose
 --conditions 110X_dataRun2_v9 --eventcontent=ALCARECO --datatier ALCARECO -n 100 --
no_exec --era Run2_2018 --python_filename=SingleMuon_2018_v1.py --nThreads=8 --
filein=root://cms-xrd-
global.cern.ch//store/data/Run2018C/SingleMuon/RAW/v1/000/320/191/00000/FEC2-FC5C-FE8D-
E811-B559-FA163EF38B4B.root
```

- Next: PCL development

PCL Worker (Bpix only now)

- PCL Worker: books and fills the charge drift vs depth histograms

- Updates:
  1. Add improved selections (from Morris) for Bpix
  2. Apply bowing correction and surface deformation correction



- cluster charge $\leq 120000e$
- cluster size Y ≥ 4

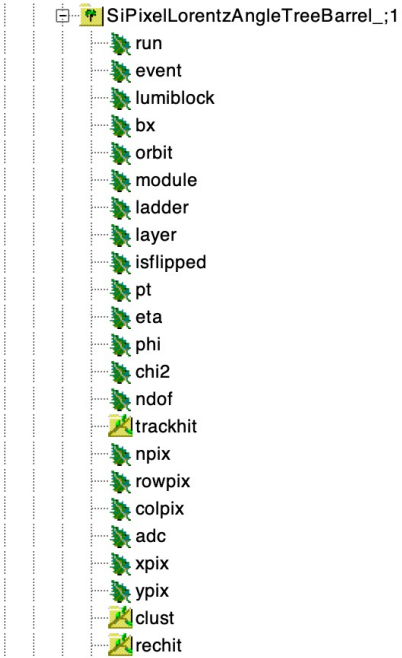
- cluster charge $\leq 50000e \times \frac{track\ path}{thickness}$
- Layer ≤ 3, cluster size Y ≥ 4
  else, cluster size Y ≥ 3
- |cotbeta| $>$ cotbeta min ($\propto$ clustersize Y min)
- cluster size X < 5.0

PCL Worker (Bpix only now)

- Updates:
  3. Add TTree production and make TTree production optional

```
SiPixelLorentzAnglePCLWorker =
DQMEDAnalyzer(
    "SiPixelLorentzAnglePCLWorker",
    folder =
cms.string('AlCaReco/SiPixelLorentzAngle'),
    notInPCL = cms.bool(False),
    fileName = cms.string('testrun.root'),
    …
)
```

- notInPCL = True, produce Tree

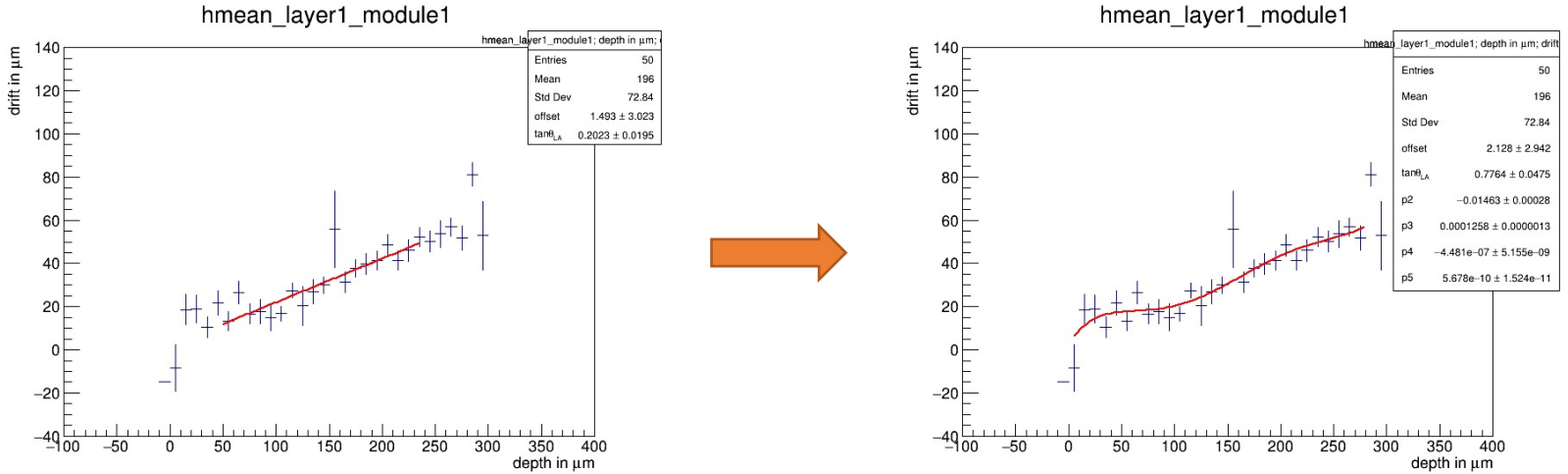


- notInPCL = False, produce only DQM output for PCL worker

PCL Harvester (Bpix only now)

- PCL Harvester: fits the histograms and obtain LA
- Updates:
  1. Change from linear fit into higher order polynomial fit
     - Range $(50, 235) \rightarrow (5, 280)\ \mu m$
     - Function $f = p_0 + p_1 x$

$$\rightarrow f = p_0 + p_1 x + p_2 x^2 + p_3 x^3 + p_4 x^4 + p_5 x^5$$



Other: Create the new module DetId list

- The list of new module name

BPix_BmI_SEC7_LYR2_LDR12F_MOD1 r/phi/z = 6.89899/-1.0098/-3.35 layer/ladder/module 2/24/4
BPix_BmI_SEC8_LYR2_LDR14F_MOD1 r/phi/z = 7.12399/-1.4586/-3.35 layer/ladder/module 2/22/4
BPix_BmO_SEC3_LYR2_LDR5F_MOD1 r/phi/z = 6.89899/2.58059/-3.35 layer/ladder/module 2/12/4
BPix_BmO_SEC3_LYR2_LDR5F_MOD2 r/phi/z = 6.89899/2.58059/-10.05 layer/ladder/module 2/12/3
BPix_BmO_SEC3_LYR2_LDR5F_MOD3 r/phi/z = 6.89899/2.58059/-16.75 layer/ladder/module 2/12/2
BPix_BpO_SEC1_LYR2_LDR1F_MOD1 r/phi/z = 7.12399/1.683/3.35 layer/ladder/module 2/8/5
BPix_BpO_SEC1_LYR2_LDR1F_MOD2 r/phi/z = 7.12399/1.683/10.05 layer/ladder/module 2/8/6
BPix_BpO_SEC1_LYR2_LDR1F_MOD3 r/phi/z = 7.12399/1.683/16.75 layer/ladder/module 2/8/7

- New modules will behave differently, and we want to separate them from the others.
- We will make a group of new histograms for these modules and calculate the LA

Extract DetIds

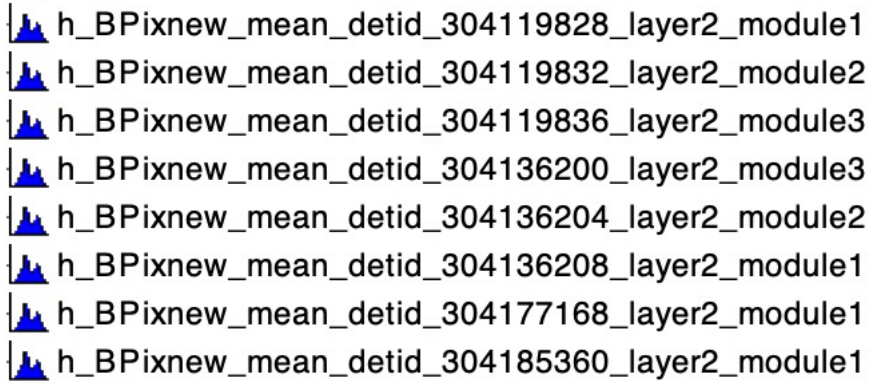
- Pass new module names in the configuration file and obtain the corresponding DetId

```
SiPixelLorentzAnglePCLWorker = DQMEDAnalyzer(
    "SiPixelLorentzAnglePCLWorker",
    folder = cms.string('AlCaReco/SiPixelLorentzAngle'),
    notInPCL = cms.bool(False),
    fileName = cms.string('testrun.root'),
    newmodulelist = cms.vstring(
    "BPix_BmI_SEC7_LYR2_LDR12F_MOD1",
    "BPix_BmI_SEC8_LYR2_LDR14F_MOD1",
    "BPix_BmO_SEC3_LYR2_LDR5F_MOD1",
    "BPix_BmO_SEC3_LYR2_LDR5F_MOD2",
    "BPix_BmO_SEC3_LYR2_LDR5F_MOD3",
    "BPix_BpO_SEC1_LYR2_LDR1F_MOD1",
    "BPix_BpO_SEC1_LYR2_LDR1F_MOD2",
    "BPix_BpO_SEC1_LYR2_LDR1F_MOD3"),
```

DetId: 304185360
DetId: 304177168
DetId: 304136208
DetId: 304136204
DetId: 304136200
DetId: 304119828
DetId: 304119832
DetId: 304119836

Fill the histograms and Obtain LA

- Apply the same nonlinear fit and obtain LA for each new module

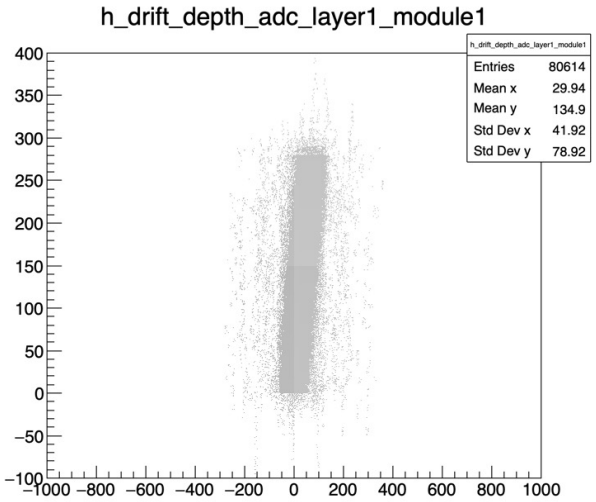


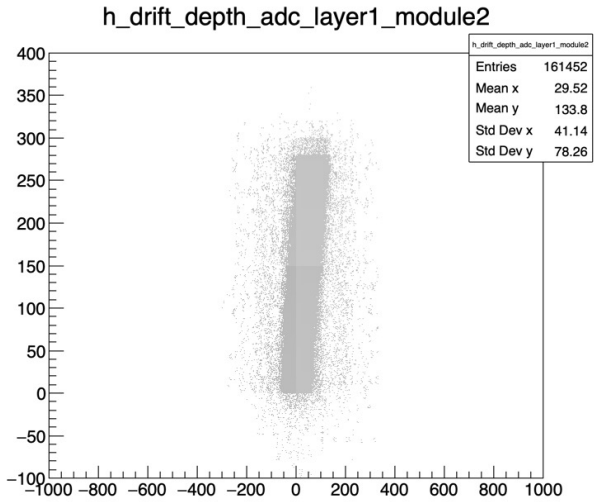
module	layer	offset	e0	slope	e1	rel.error	DetId
1	2						304185360
1	2						304177168
1	2						304136208
2	2						304136204
3	2						304136200
1	2						304119828
2	2						304119832
3	2						304119836

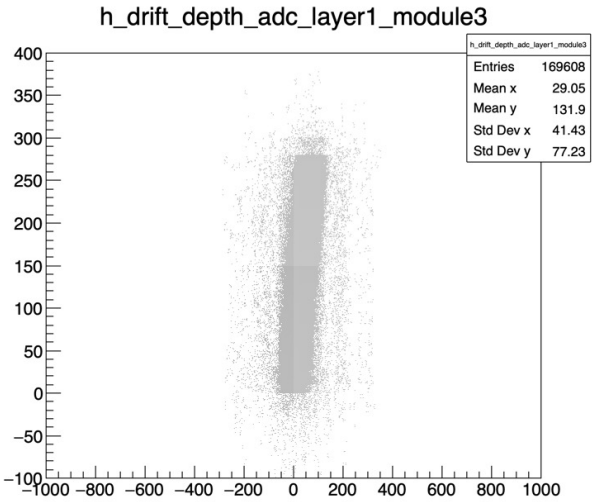
These will be produced together with the other results in the PCL Worker and Harvester

PCL Worker test

- Run on 50000 events from /store/data/Run2018D/SingleMuon/ALCARECO/SiPixelCalSingleMuon-ForPixelALCARECO_UL2018-v1/230000/F33B7CA6-256A-B34F-9536-7594FBC6F75B.root



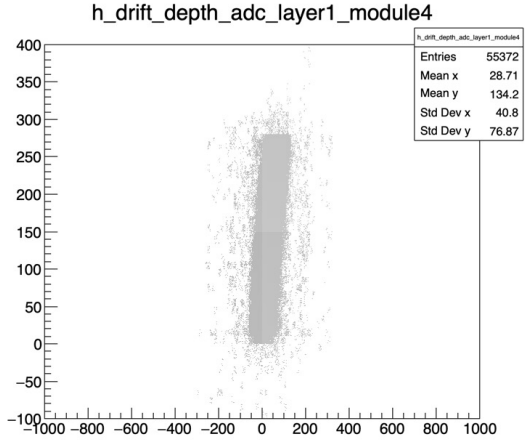


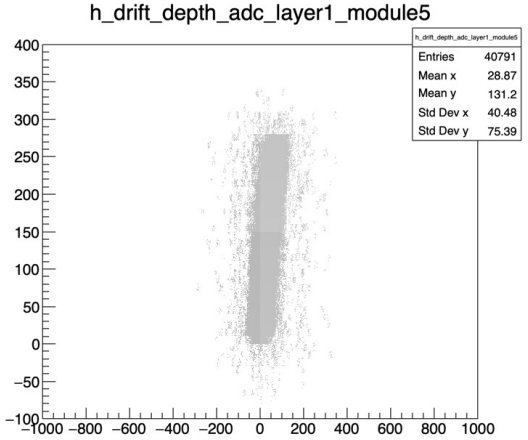


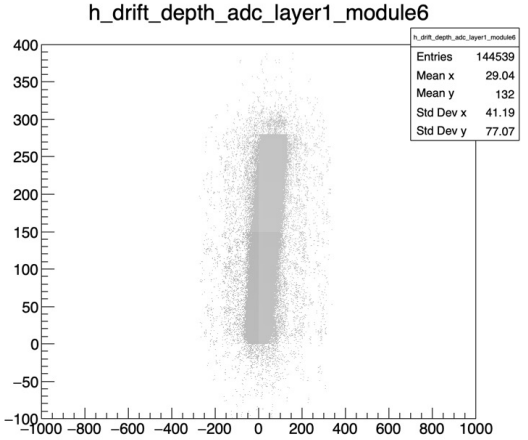
X: drift in um
Y: depth in um

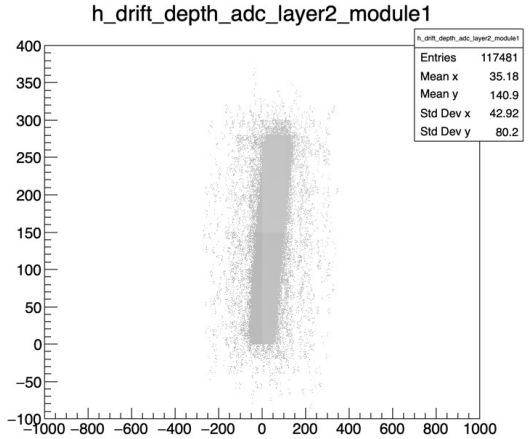
X: drift in um
Y: depth in um

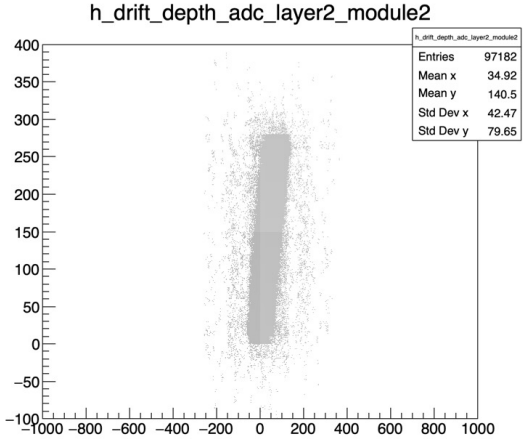
PCL Worker test

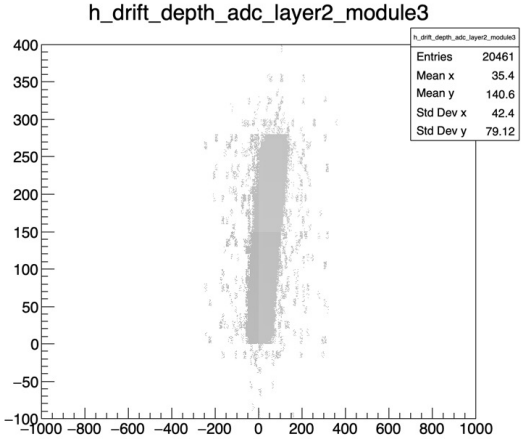






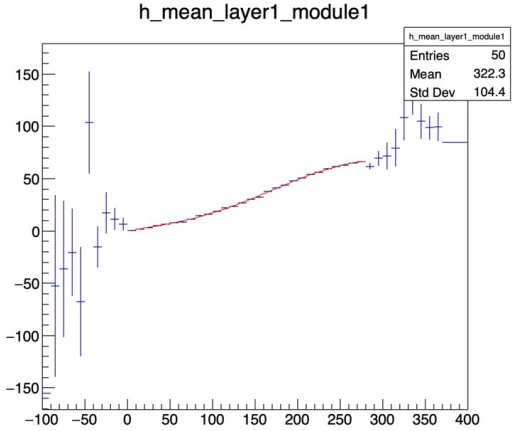


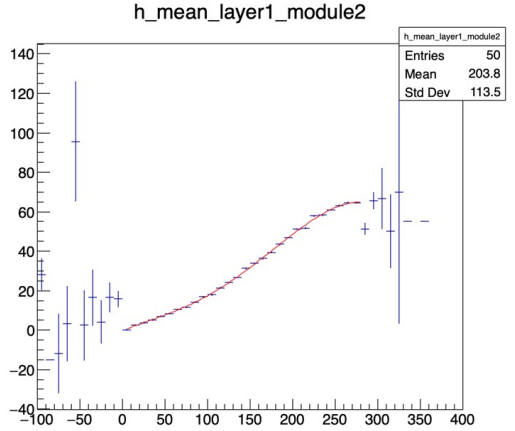


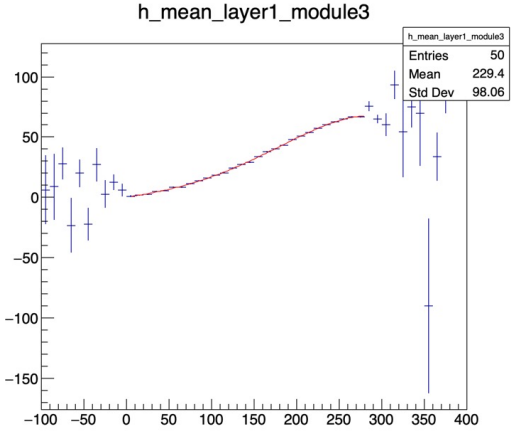


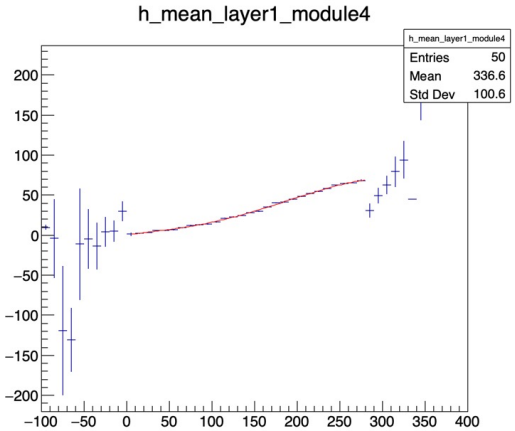
X: depth in um
Y: drift in um

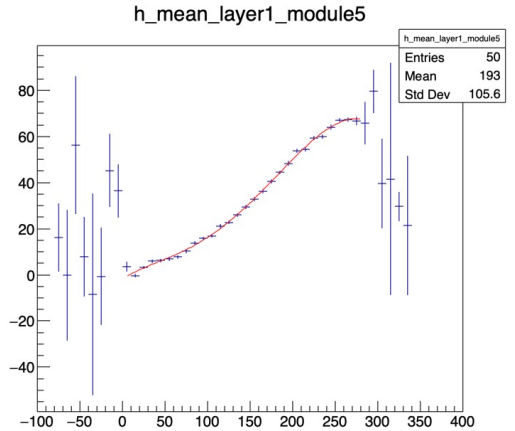
PCL Harvester test

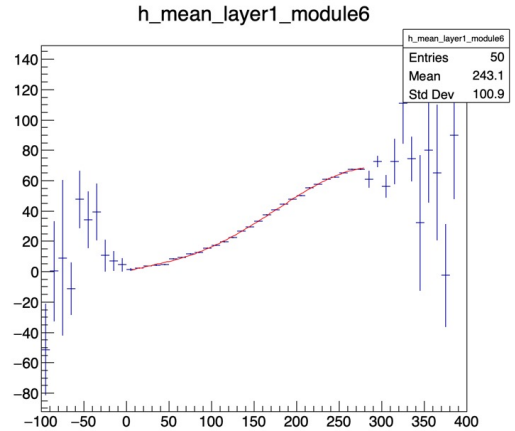






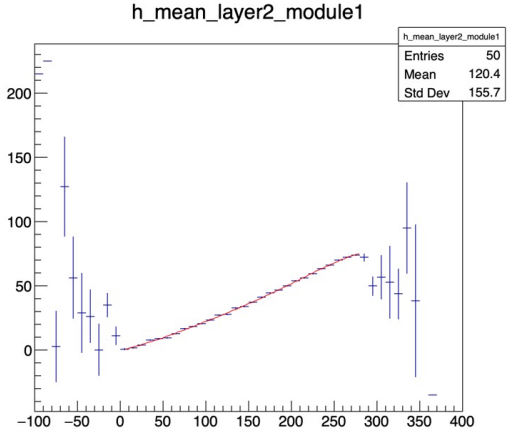


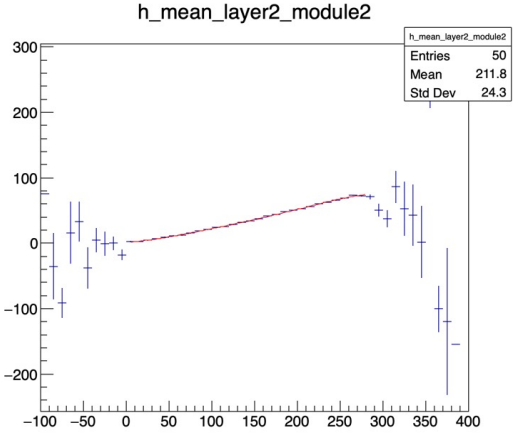


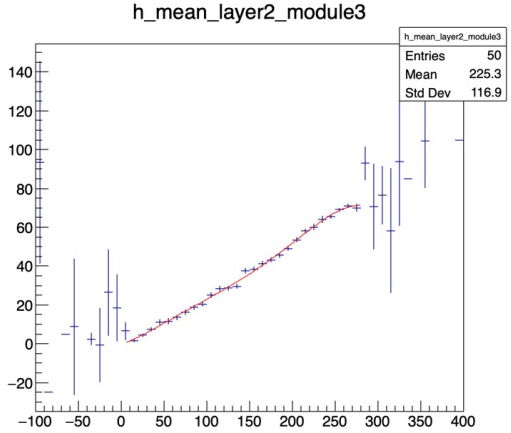


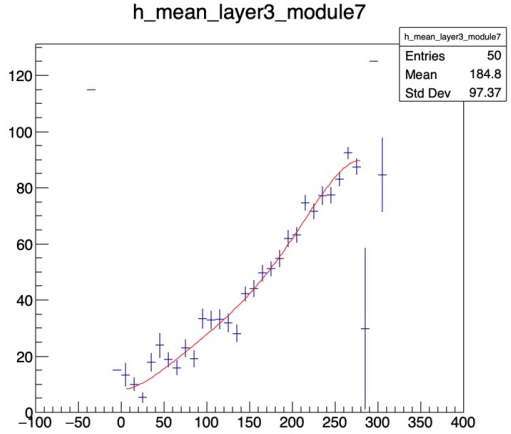
X: depth in um
Y: drift in um

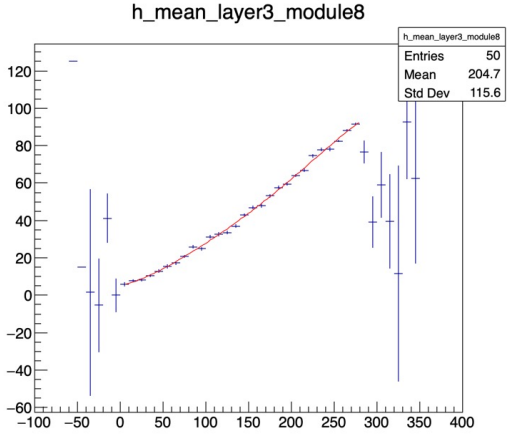
PCL Harvester test

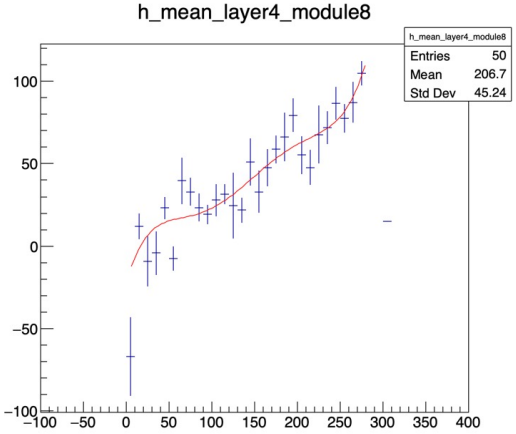












LA test results

module	layer	offset	e0	slope	e1	rel.error
1	1	-0.4155	0.3268	0.1819	0.0061	3.3300
2	1	-0.3525	0.2347	0.1858	0.0043	2.3300
3	1	-0.0002	0.2309	0.1116	0.0043	3.8500
4	1	0.2844	0.4015	0.1497	0.0075	5.0100
5	1	-1.6960	0.4591	0.2252	0.0087	3.8700
6	1	0.2202	0.2491	0.1544	0.0046	3.0100
7	1	-0.0729	0.2307	0.1702	0.0043	2.5100
8	1	0.4851	0.3021	0.0806	0.0056	6.9900
1	2	-0.4011	0.2666	0.1357	0.0049	3.6400
2	2	1.2590	0.2995	0.0715	0.0055	7.6900
3	2	-0.2829	0.6450	0.1541	0.0122	7.9300
4	2	-6.5530	4.6480	0.5241	0.0685	13.1000
5	2	-5.2380	4.1350	0.8185	0.0897	11.0000
6	2	2.2490	1.3630	0.0077	0.0545	708.0000
7	2	0.8499	0.3067	0.0673	0.0056	8.3400
8	2	1.9490	0.2718	0.0081	0.0050	61.4000

module	layer	offset	e0	slope	e1	rel.error
1	3	2.7210	0.3798	0.1437	0.0071	4.9200
2	3	0.7789	1.1590	0.3375	0.0204	6.0400
3	3	-22.0200	37.4900	2.0700	1.8500	89.3000
4	3	empty fit				
5	3	empty fit				
6	3	151.8000	5.5610	-5.3390	0.1710	-3.2000
7	3	8.2260	1.3990	-0.0041	0.0258	-635.0000
8	3	5.4420	0.4216	0.0828	0.0077	9.3300
1	4	-11.2500	3.6330	0.6586	0.0750	11.4000
2	4	-5.7950	303.7000	0.3687	1.6400	445.0000
3	4	245.0000	67.8100	-0.2542	1.5500	-610.0000
4	4	empty fit				
5	4	empty fit				
6	4	empty fit				
7	4	empty fit				
8	4	-23.0500	5.2360	1.8830	0.0909	4.8300

Summary

- Summary of the LA statistical study
  1. Studied the performance of the prescale 100 and obtained consistent results with respect to the full statistics. (April 7th, 2021) ✓
  2. Implemented the factor 100 into the new ALCARECO producer **SiPixelCalSingleMuonLoose**. (April 7th, 2021) ✓
- Summary of LA@PCL development
  1. Developed the general workflow of PCL worker and Harvester for BPix. (June 30th, 2021) ✓
  2. Added Tree production and made it optional for other purposes. (June 30th, 2021) ✓
  3. Applied improved selections and changed into a higher order polynomial fit to obtain LA. (July 28th, 2021) ✓
  4. Passed the new module DetIds in PCL, made histograms and fit the LA for each of them. (August 25th, 2021) ✓

- Next step
  1. Fill in the treatment for FPix.

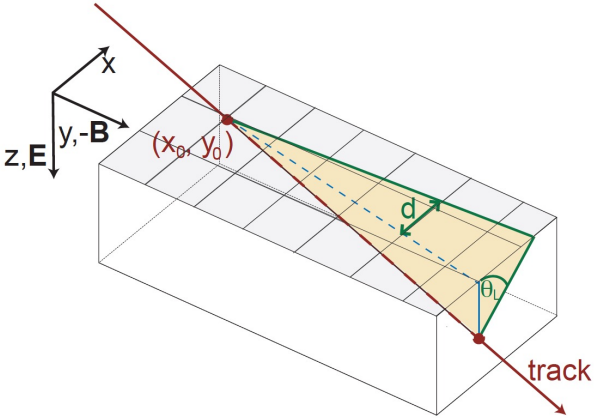
THANKS!

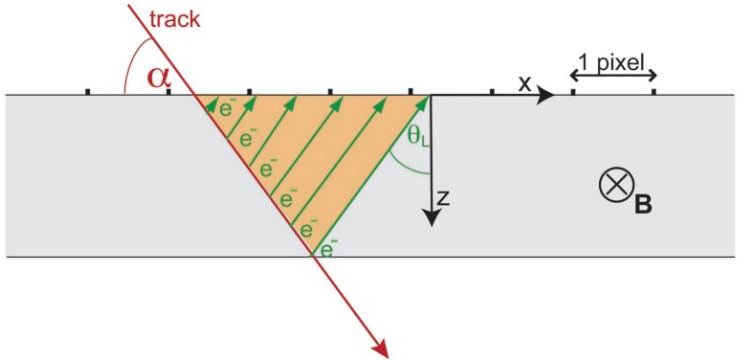
Backup

- When charged particles transverse the pixel sensors, electrons and holes are produced and deflect under magnetic and electric fields
- LA is defined as

$$\tan(\theta_L) = \frac{drift\ distance}{production\ depth}$$

- LA is highly affected by radiation damage on the silicon sensors, which then reduces the hit resolution.





Backup

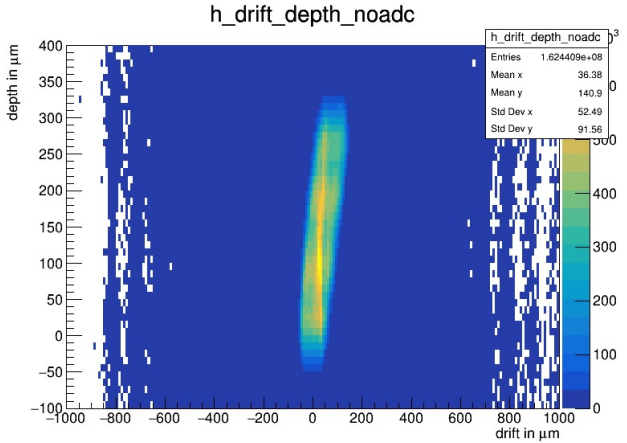
- Original selections on the single muon events

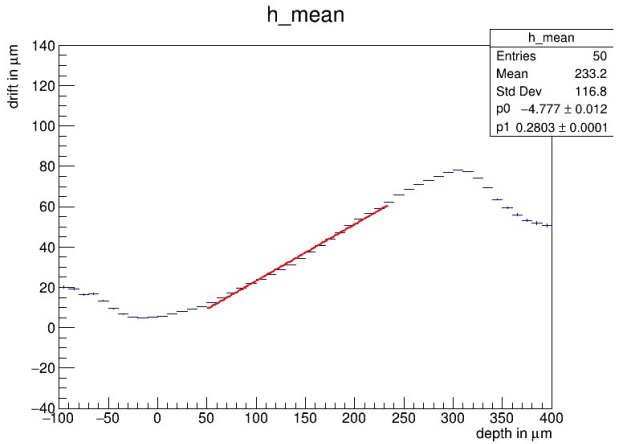
- Track selection
  1. $p_T \geq 3$ GeV
  2. Reduced $\chi^2 < 2$

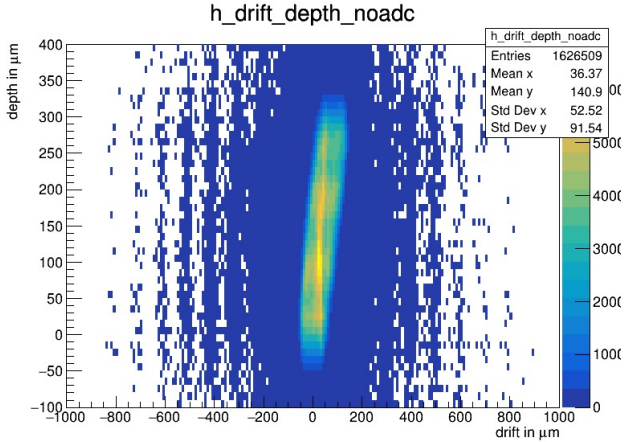
- Cluster selection
  1. Cluster charge $\leq 120000e$
  2. Cluster size Y ≥ 4

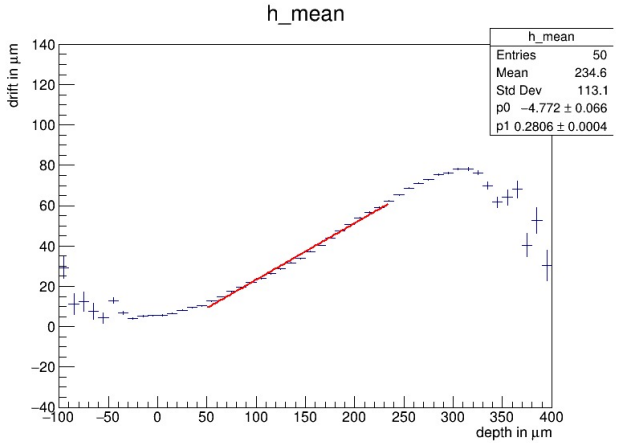
Backup

- Compare LA: run 31934
  - Full stats
  - 1/100



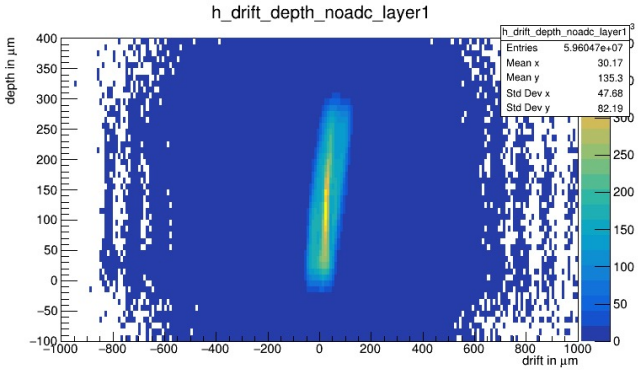


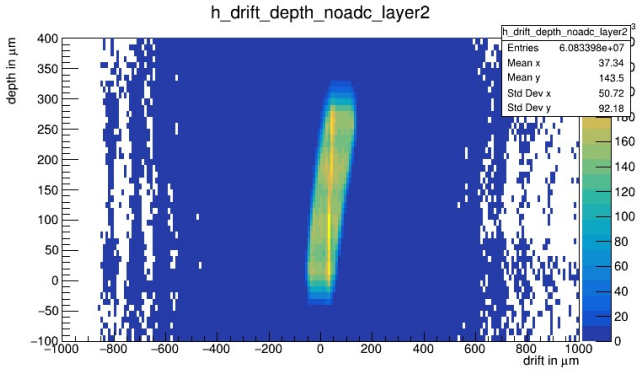


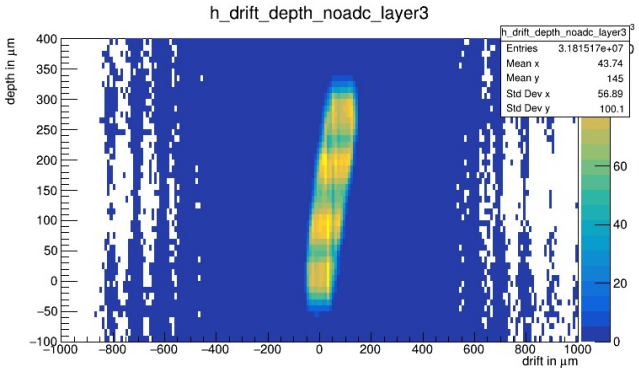


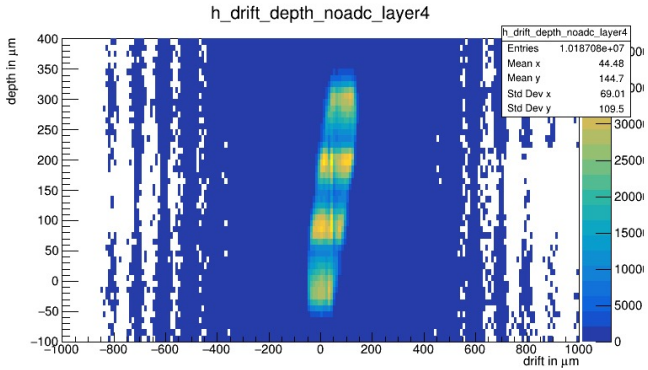
Backup

- Observe the ‘band’ structure in drift vs depth plots, especially L4



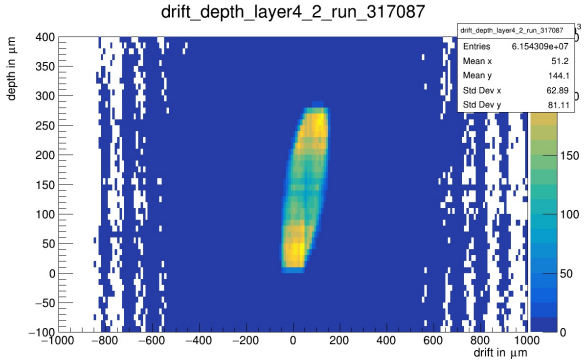


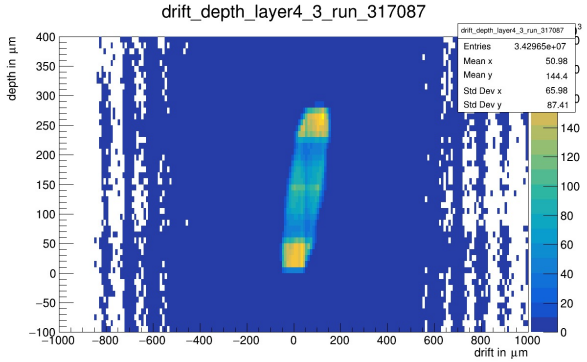


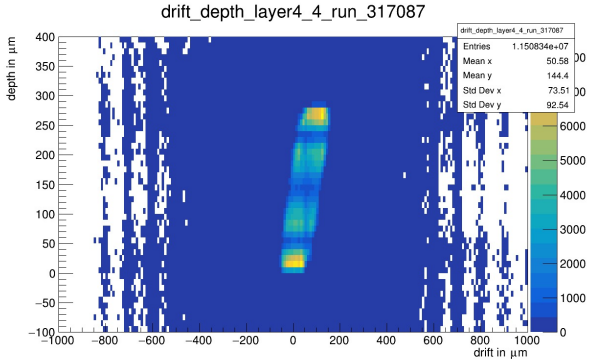


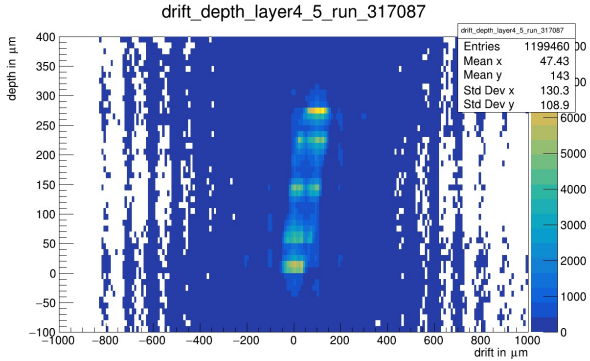
Backup

- Try different cluster size cuts on L4









- Layer4_2 : clust_.size_y >= 2
- Layer4_3 : clust_.size_y >= 3
- Layer4_4 : clust_.size_y >= 4
- Layer4_5 : clust_.size_y >= 5