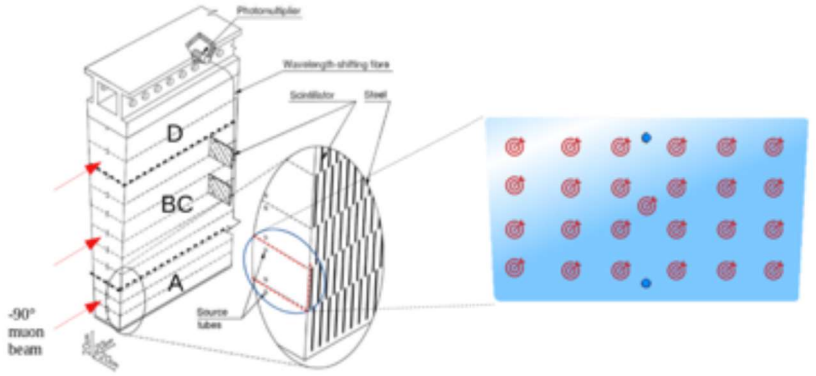
Test Beam Analysis: Muon Data
September TB 2023
November TB 2022

Tamar Djobava, Maia Mosidze
High Energy Physics Institute of Iv. Javakhishvili Tbilisi State University (HEPI TSU)
Tamar Zakareishvili
Instituto de Fisica Corpucsular (IFIC, Valencia)

TileCal Week meeting
10 June, 2024

Muon runs: Nov 2022 TB

Analysis of Nov 2022 TB, Sep 2023 TB muon data is done in order to check the response of the new electronics of Tile Calorimeter (Upgrade-0)



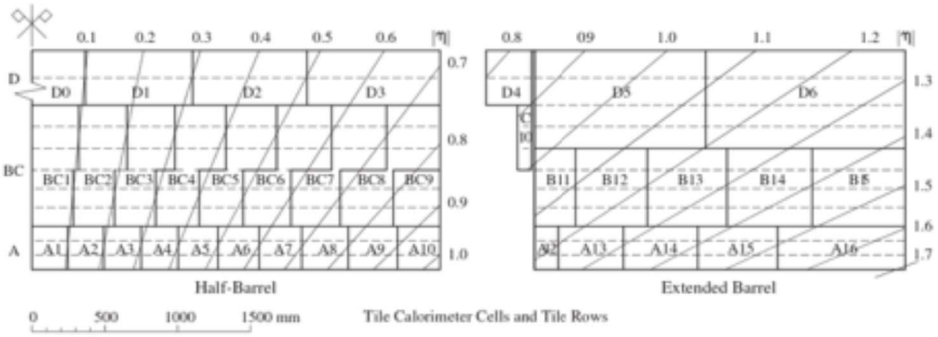
Muon beam hitting each tile row in the centre

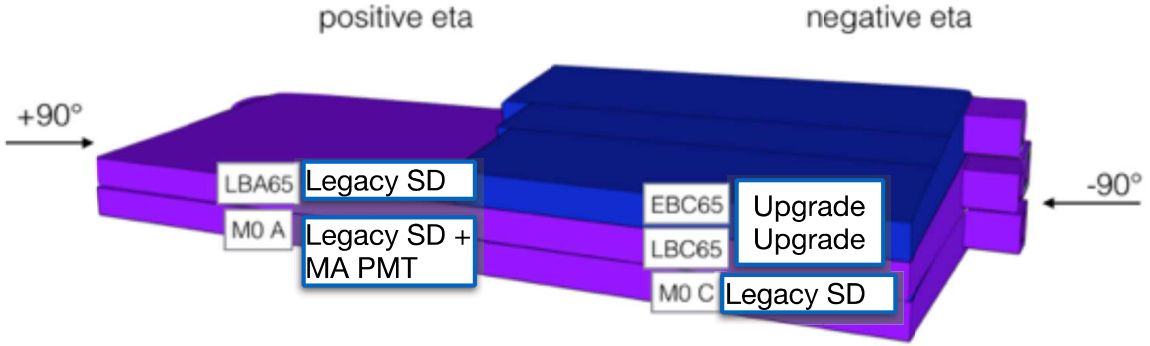
-90 deg. muon beam hitting each tile-raw at center:
Module LBC65 -Upgrade module

- Gain: 5 x Nominal Gain
- Date: 13 Nov, 165 GeV, 2022
- 2 Sep, 160 GeV, 2023

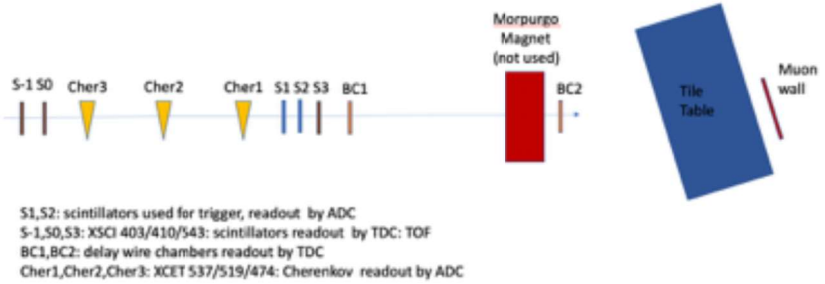
Module EBC65 - Upgrade module

- Gain: 5 x Nominal Gain
- Date: 14 Nov, 165 GeV, 2022
  2 Sep, 160 GeV, 2023





Beam line instrumentation



Muon runs: Nov 2022 TB and Sep 2023 TB

-90 deg. muon raw data of 165 GeV (Nov 2022) and 160 GeV (Sep 2023) for upgrade module LBC65 were reconstructed and analysed the following runs:
1. 2212235 - 2212247 (Nov 2022) for each of 11 rows (~ 50 000 events for each row).
2. 2320122 - 2320132 (Sep 2023) for each of 11 rows (~ 50 000 events for each row).

For EBC65 module were reconstructed and analysed the following runs:
1. 2212260 - 2212272 (Nov 2022) for each of 11 rows (~ 50 000 events for each row).
2.2320138 - 2320148 (Sep 2023) for each of 11 rows (~ 50 000 events for each row).

The data ntuples have been taken at:
/eos/atlas/atlascerngroupdisk/det-tile/testbeam/2022
/eos/atlas/atlascerngroupdisk/det-tile/testbeam/2023-11.v1

TB data were simulated by GEANT (Athena 23.0.49)
for muons of 165 and 160 GeV energy heating each tile row
at -90 deg of LBC65 (~ 50 000 events for each row) .
To simulate muon data when theta = +/-90 degree,
following Z coordinates were used:

Tile row	Z
1	2350
2	2450
3	2550
4	2665
5	2795
6	2925
7	3065
8	3215
9	3365
10	3535
11	3725

In order to shoot to EBC65 module, phi angle was changed. Another shell- script was written with additional phi= -5.625 in 'param' string for simulation

Muon runs: TB Nov 2022 and TB Sep 2023

For upgrade modules LBC65 and EBC65 cells lengths were calculated for each of 11 rows:

Cells lengths were calculated as:
Number of tiles in given cell multiplied on the average period thickness.
average period thickness:
18.2573 mm in barrel
18.2536 in extended barrel
Numbers of tiles in given cell are taken from ATLAS DD Database:
https://atlas-geo.web.cern.ch/show_tagged_node.php?node_id=NTAwMw==&tag_id=MTQ0MDgz&user=QVRMQVNERF9SRUFERVI=

LBC65

A layer
Length_Row1_3[10]={246.473 246.473 255.602 255.602 273.860 282.988 292.117 319.503 337.760 292.115}

BC layer
Length_Row4_9 [9]={301.245, 298.203, 298.203, 316.460, 316.460, 359.060, 365.146, 365.146 319.503}

D layer
Length_Row10_11[4]={730.292, 739.421, 785.064, 912.865}

EBC65

A layer
Length_Row1_3[5]={164.2824,456.340,511.1008,547.608,876.1728}

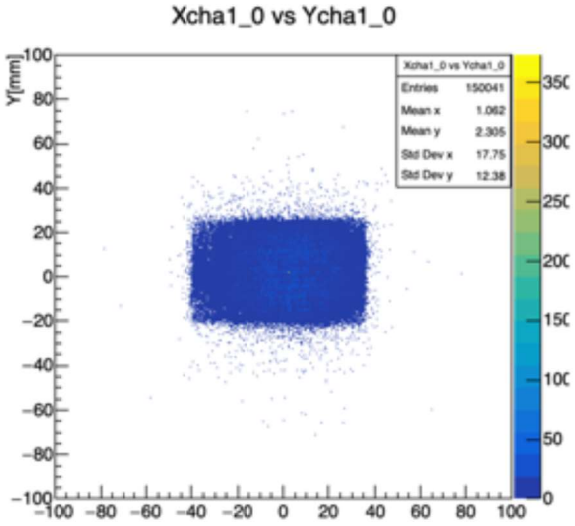
BC layer
Length_Row4_7 [9]={292.0576,492.8472,547.608,584.1152,638.876}

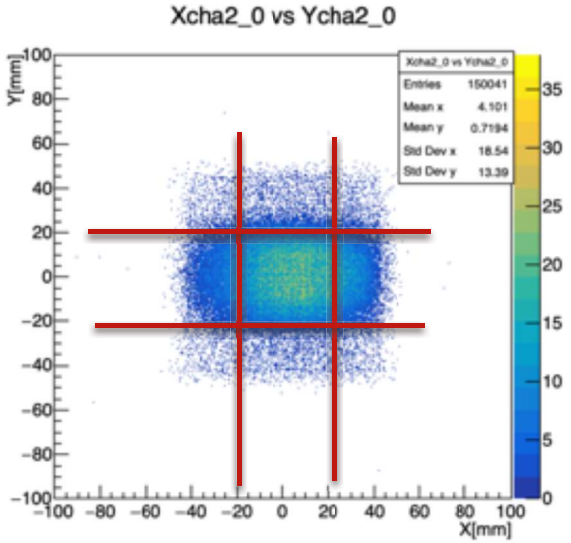
D layer
Length_Row8_9[2]={1186.484,1369.02}
Length_Row10_11[3]={310.3112,1186.484,1369.02}

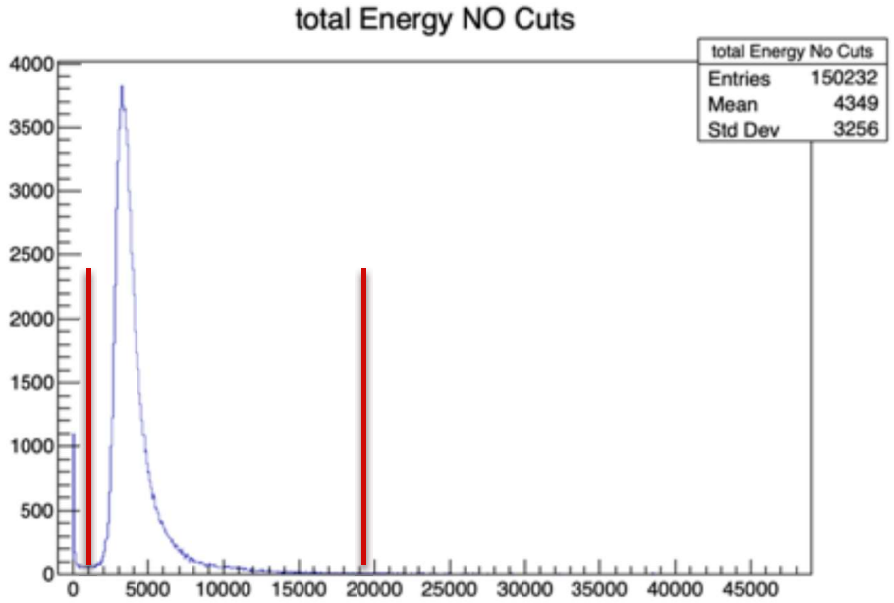
Beam chambers response

LBC 65

Sep 2023

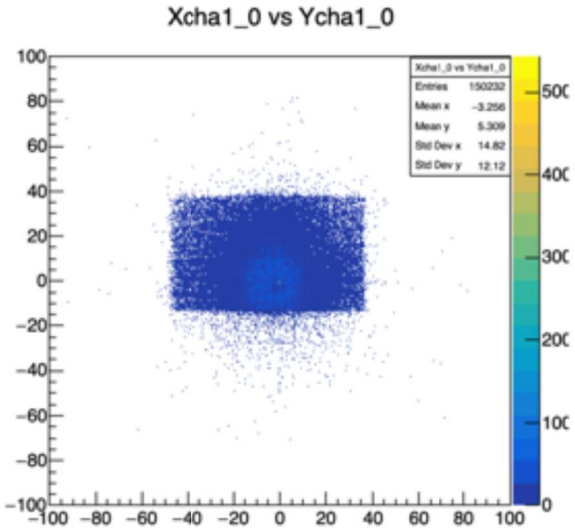


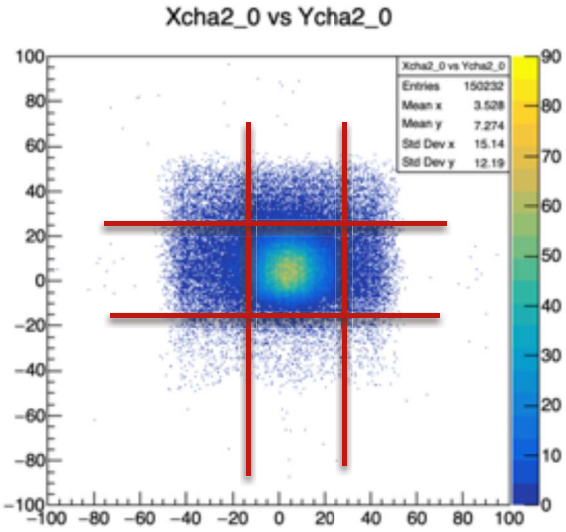




2 < Tot.E < 20 GeV

Nov 2022





Finally collimated beam spot was selected :

1.For Sep 2023 TB data

-20 <X_{BC2} < 20 mm && -20 <Y_{BC2} < 20 mm

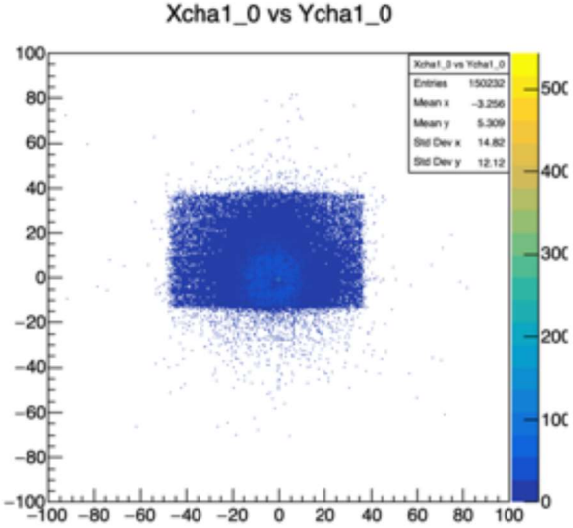
2. For Nov 2022 TB data

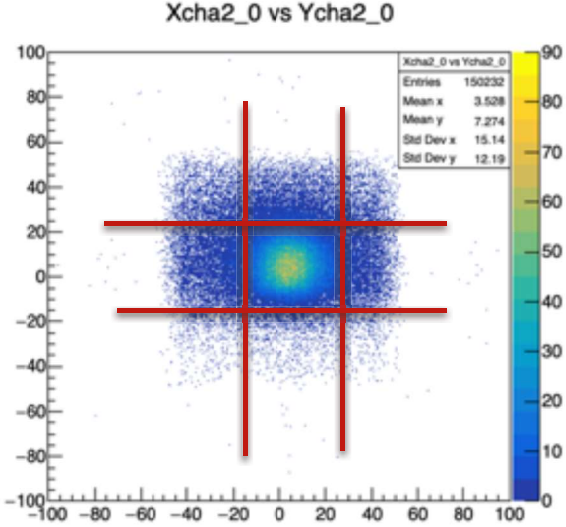
-15 <X_{BC2} < 25 mm && -15 <Y_{BC2} < 25 mm

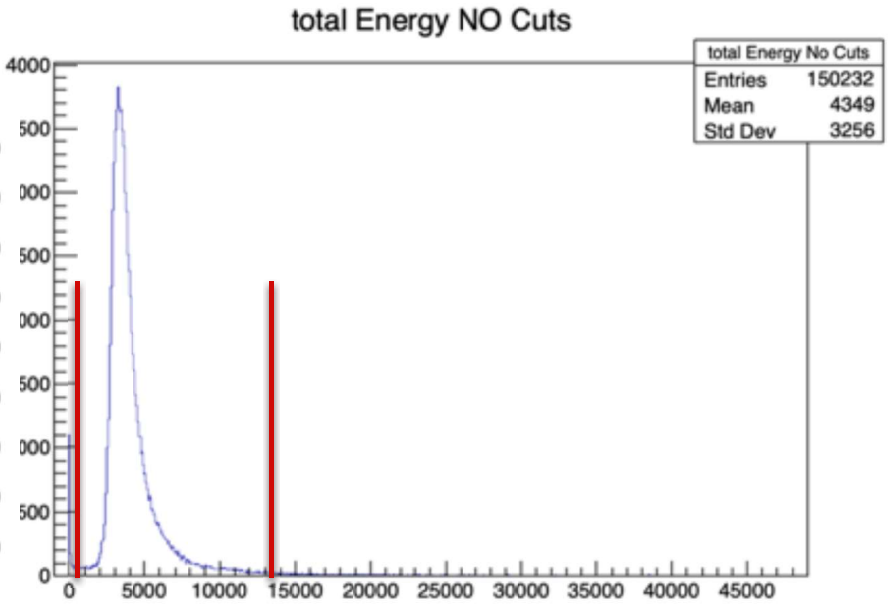
EBC 65

Beam chambers response

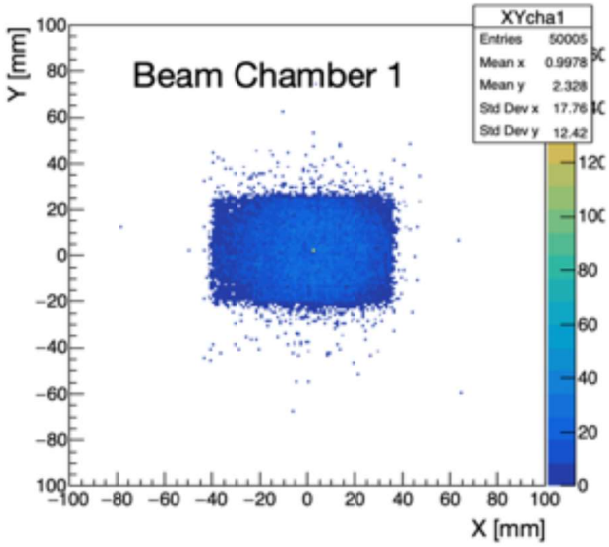
Nov 2022

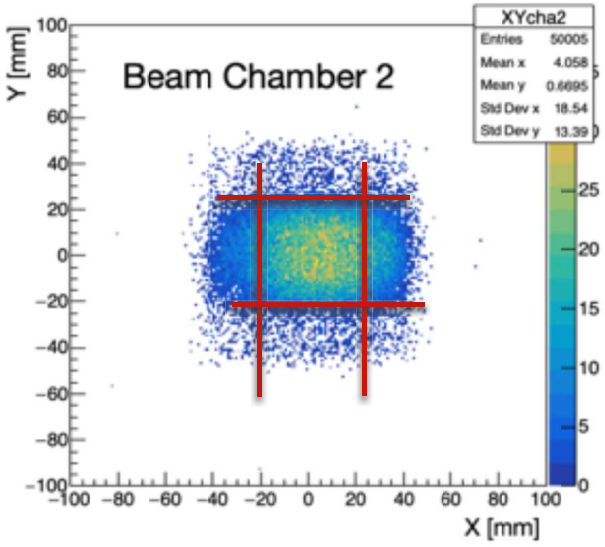






Sep 2023





Finally collimated beam spot was selected :

1.For Sep 2023 TB data

$-20 < X_{BC2} < 20$ mm && $-20 < Y_{BC2} < 20$ mm

2. For Nov 2022 TB data

$-15 < X_{BC2} < 25$ mm && $-15 < Y_{BC2} < 25$ mm

dE/dl vs cell number

- Used reconstruction method: Fit method

- Applied cuts:

  $2 < Tot.E < 20$ GeV

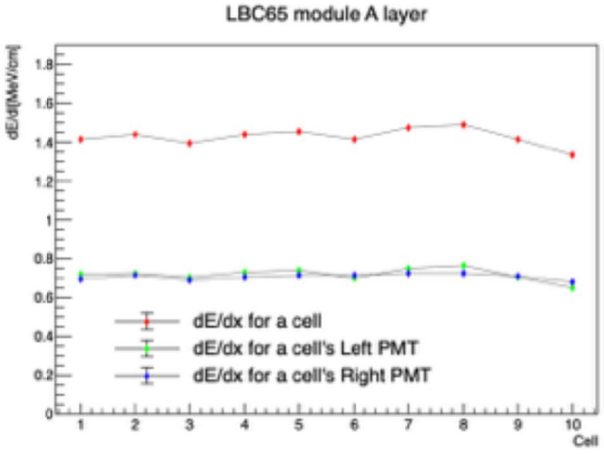
  $-15 < X_{BC2} < 25$ mm && $-15 < Y_{BC2} < 25$ mm (Nov 2022 TB)

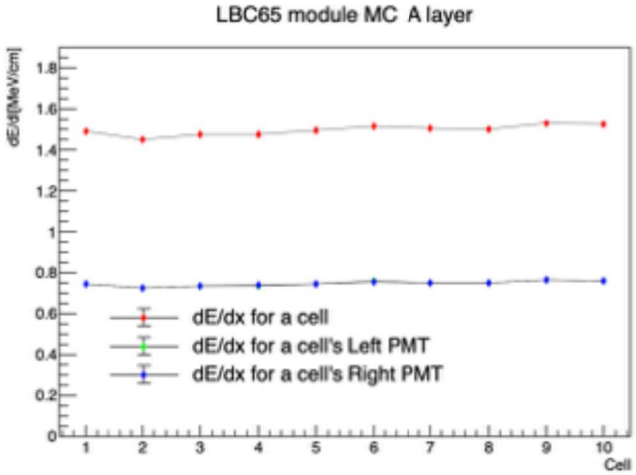
  $-20 < X_{BC2} < 20$ mm && $-20 < Y_{BC2} < 20$ mm (Sep 2023 TB)

  After applying of these cuts, acceptance is 56.8% of events.

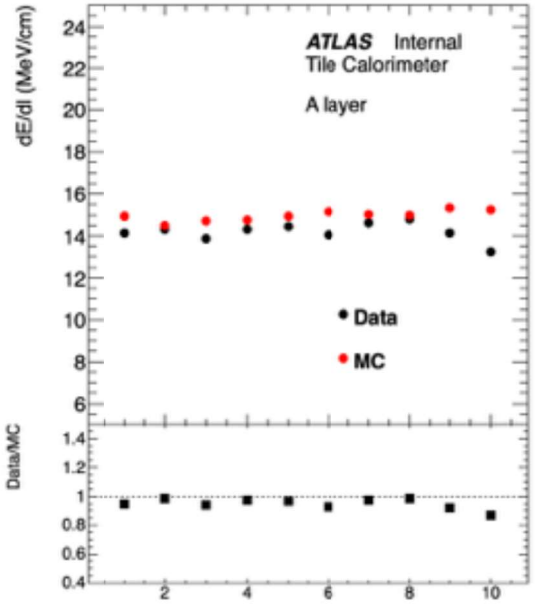
- To calculate dE/dx (energy loss per unit of length) for each cell, as dE value was used truncated mean (97.5%) of the distribution, and as dx was used corresponding cell length.

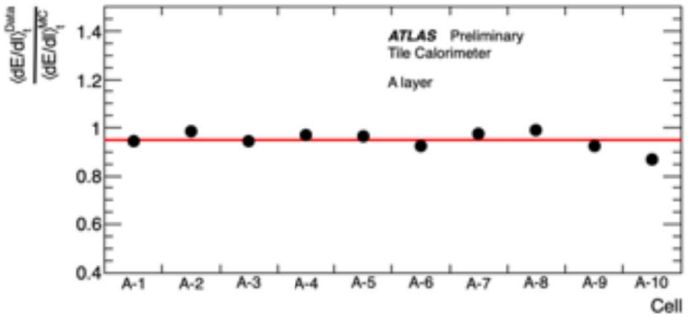
LBC65 - Sep 2023 TB





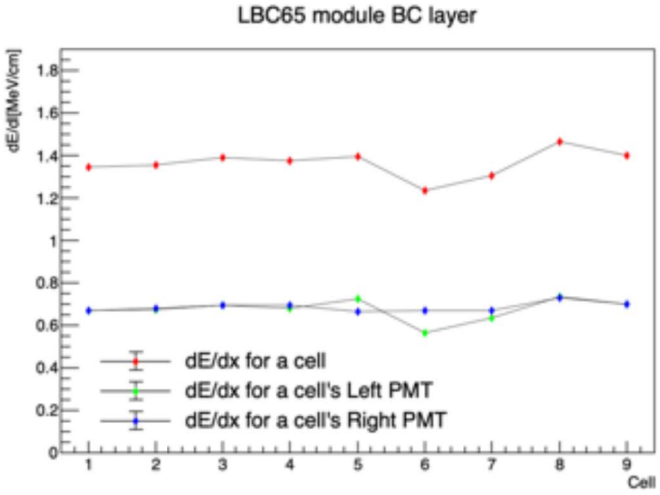
errors on the figures are statistical only and are very small in value.

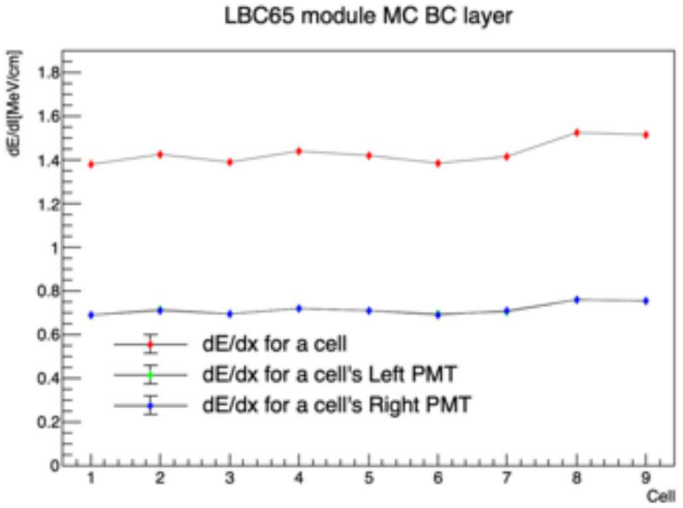




The red horizontal line corresponds to the mean value of determinations for each layer

LBC65 - Sep 2023 TB





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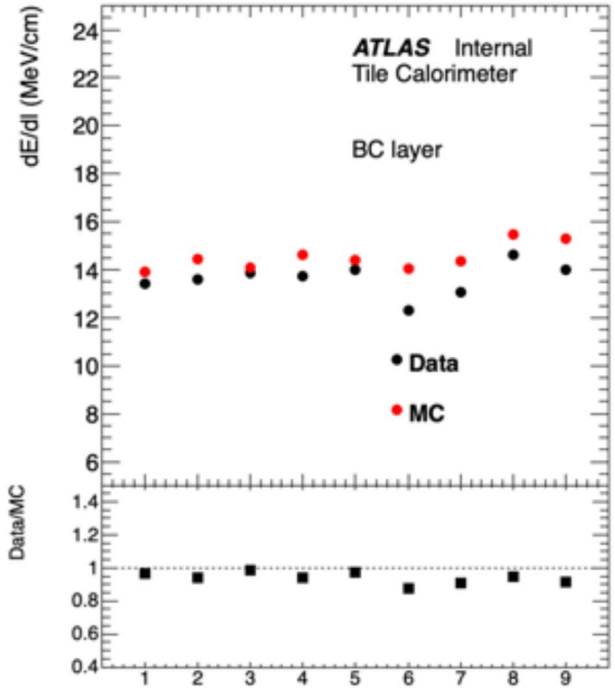

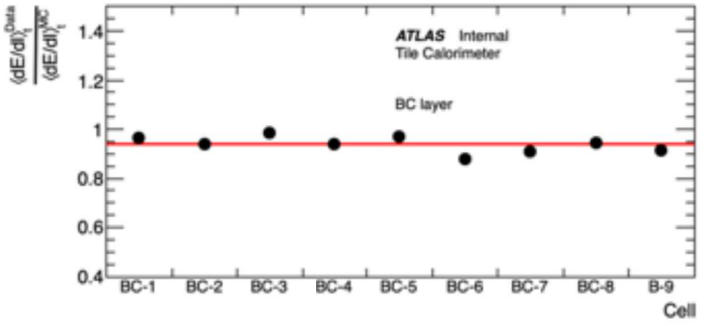

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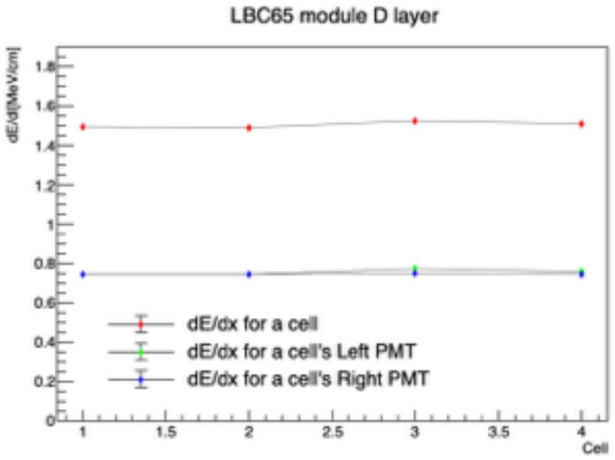

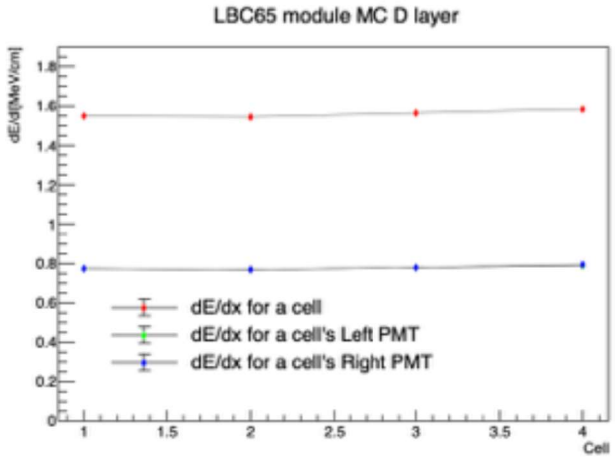

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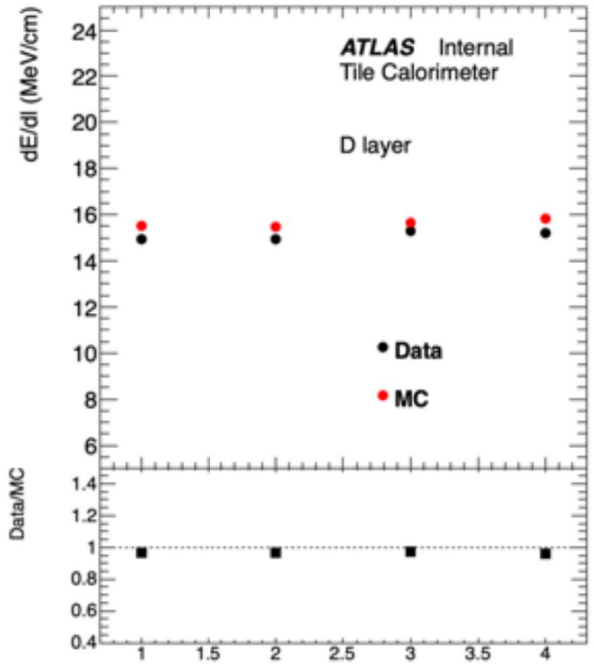

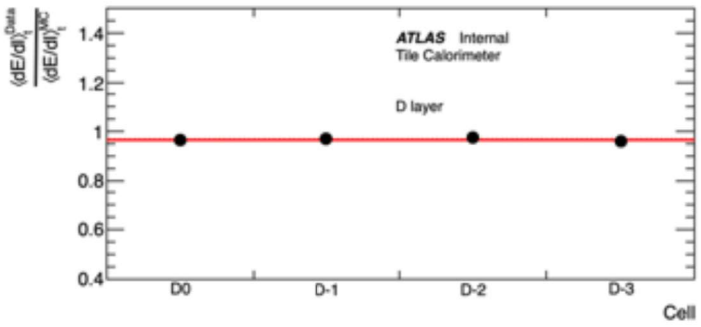

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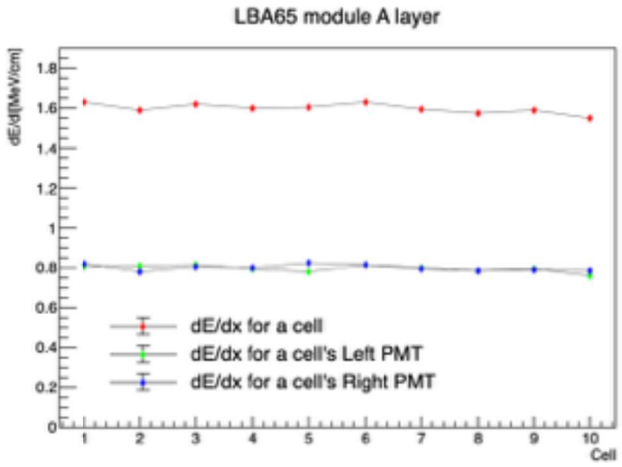
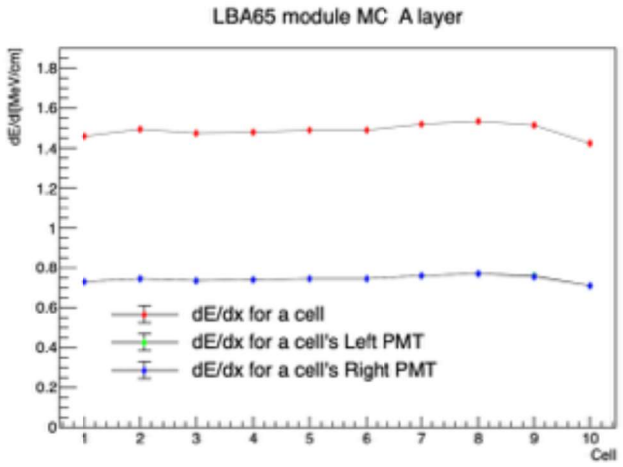
LBA65 - Sep 2023 TB





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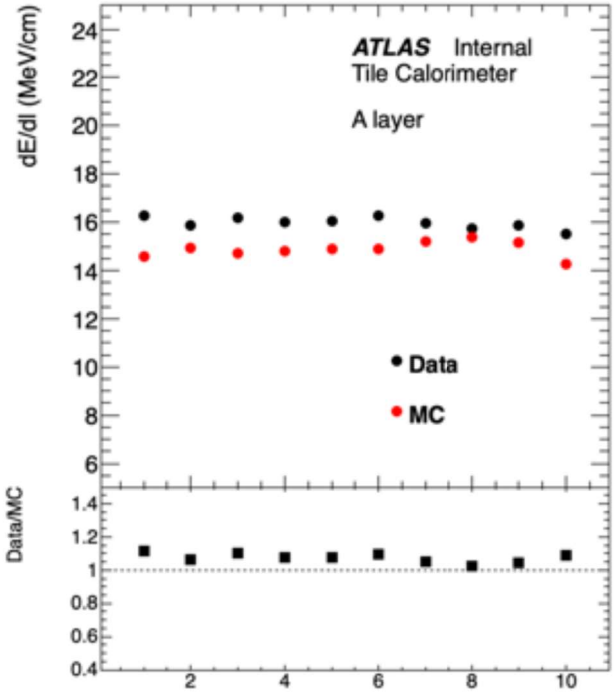

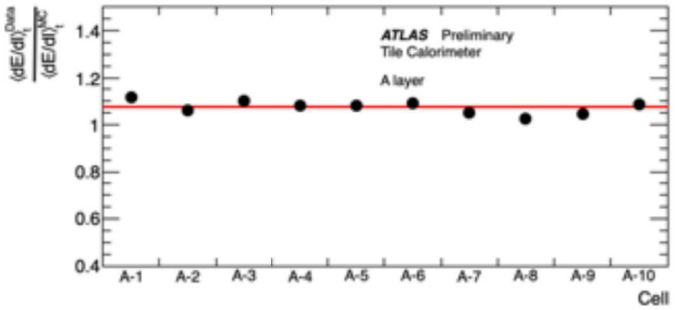

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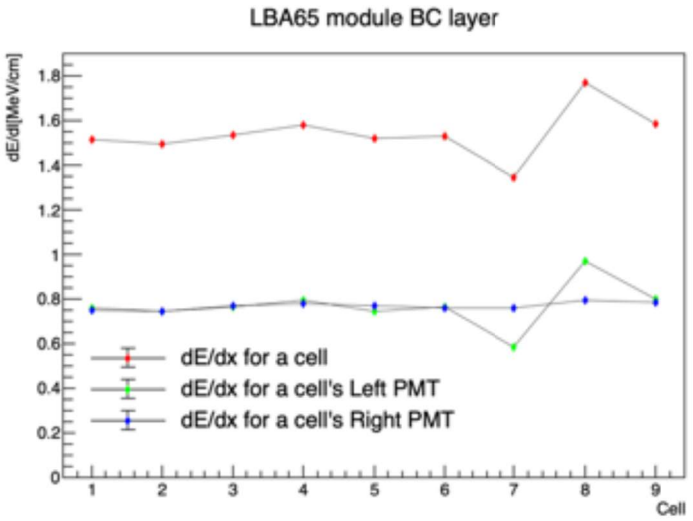

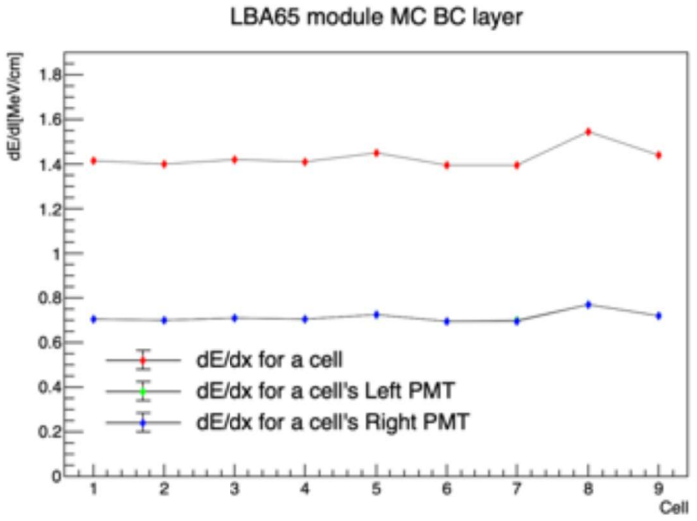

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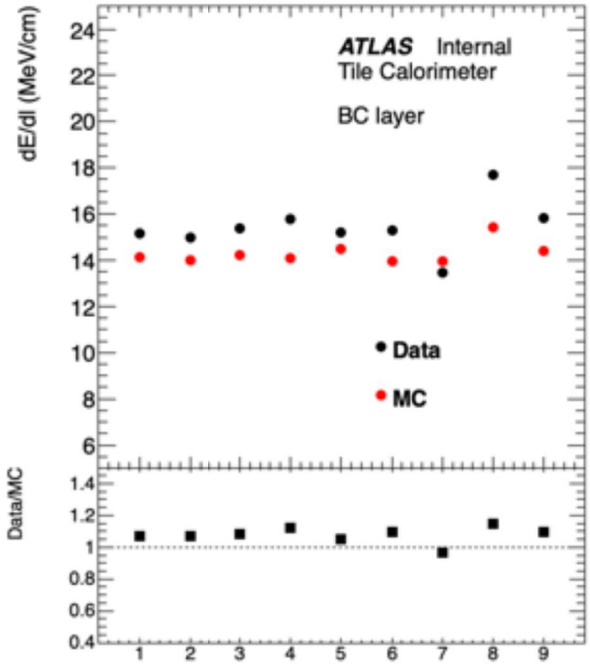

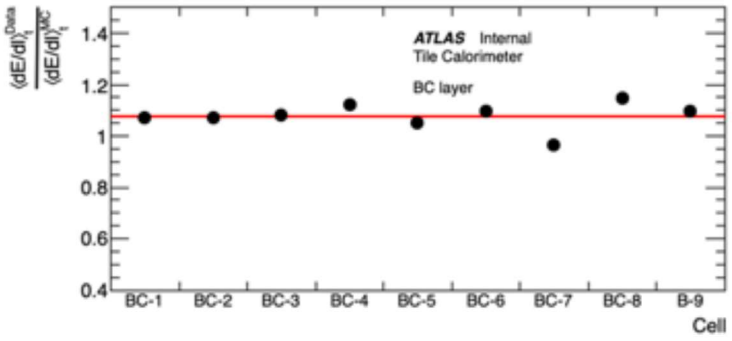

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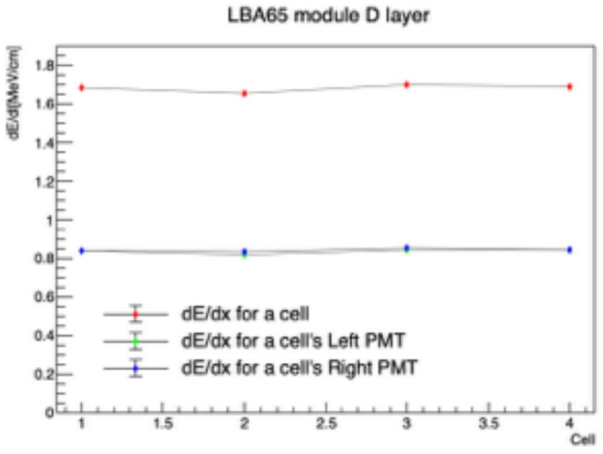

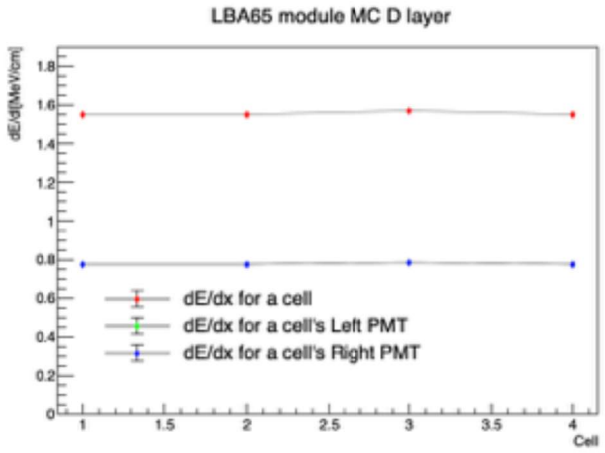

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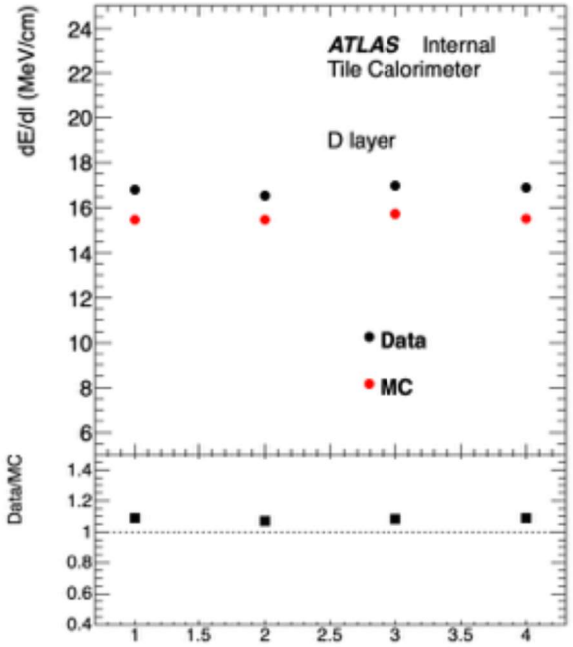

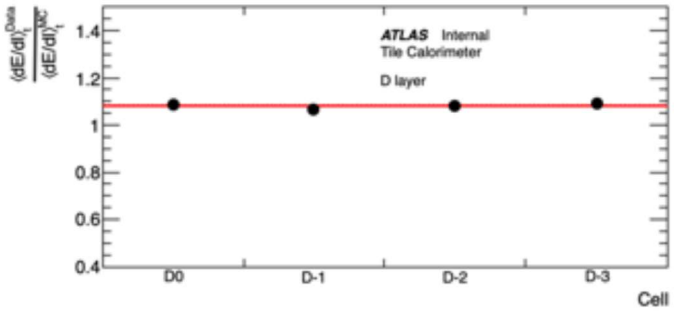

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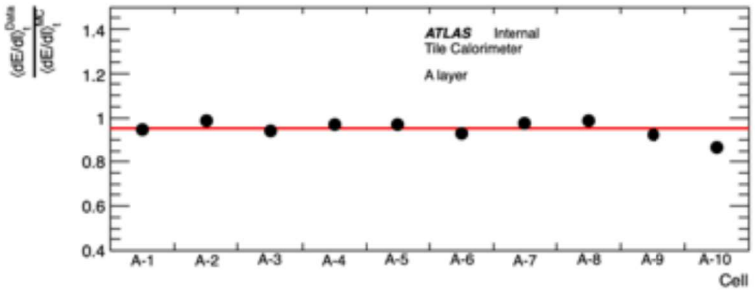

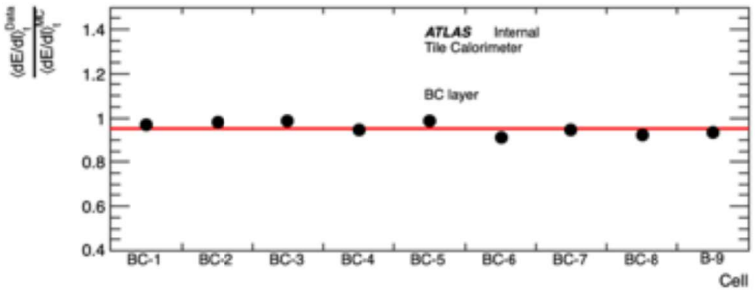

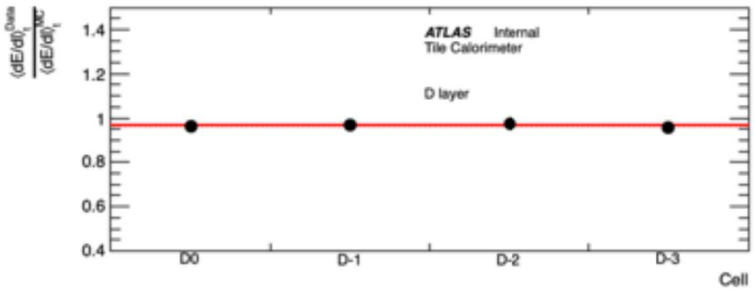

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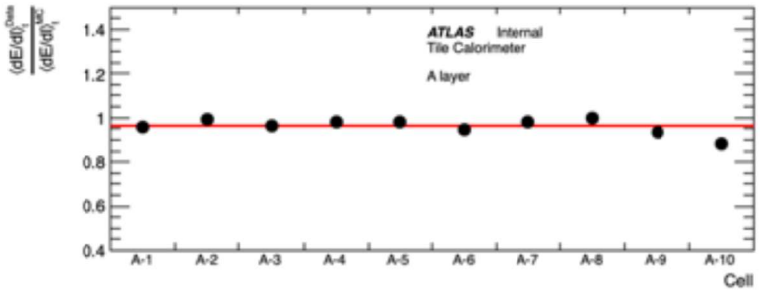

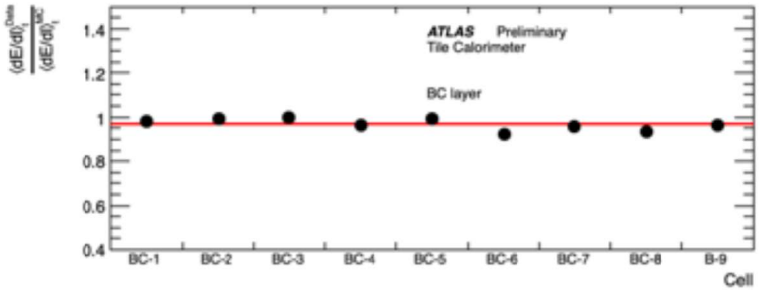

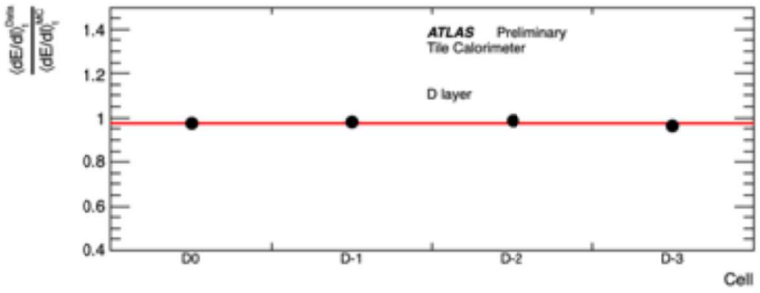

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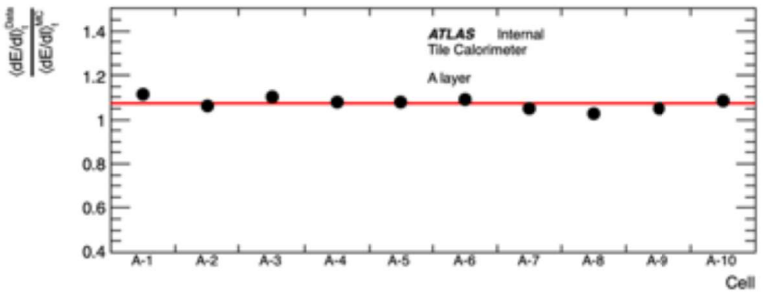

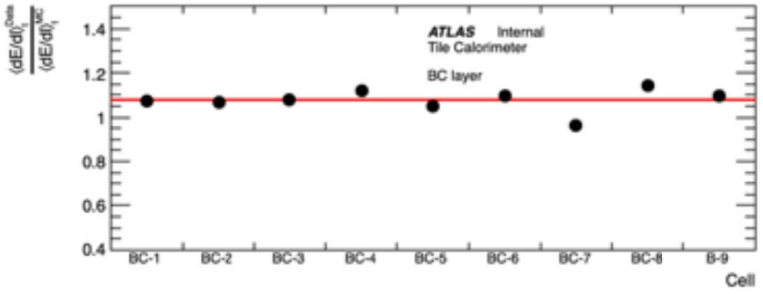

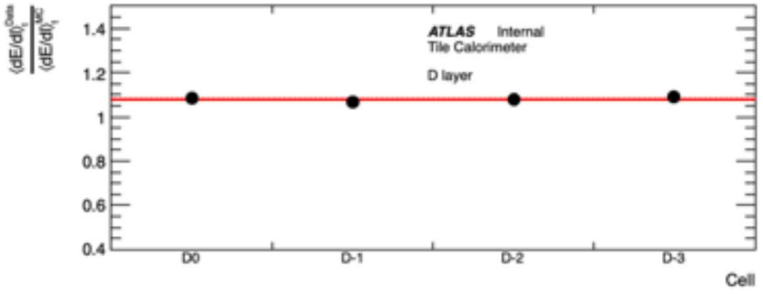

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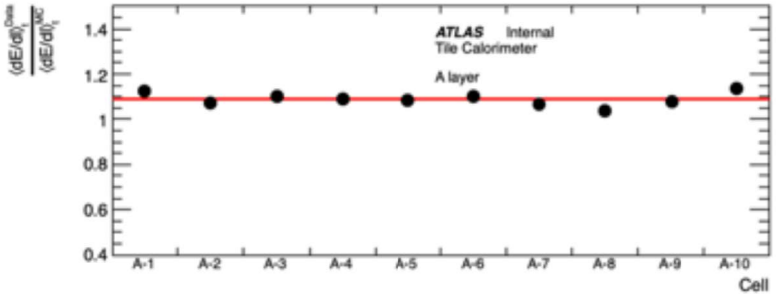
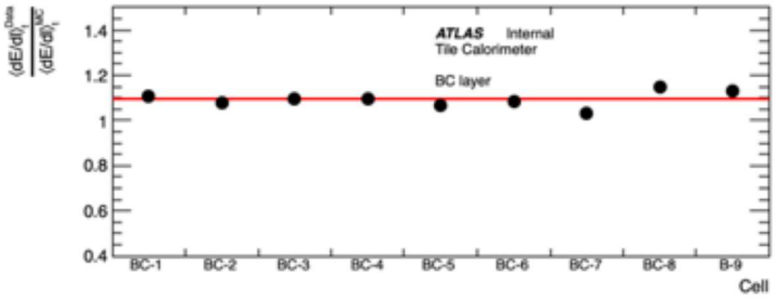
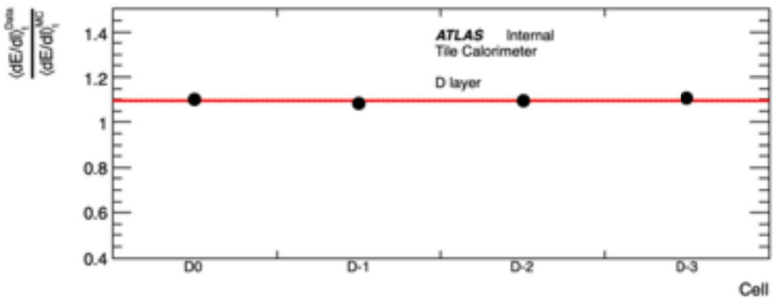
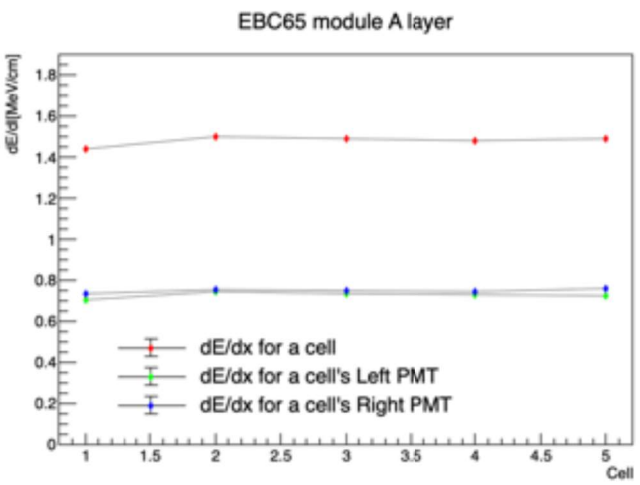


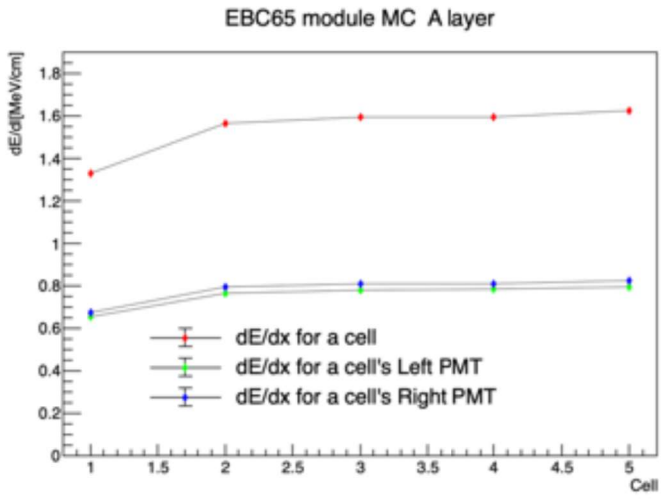




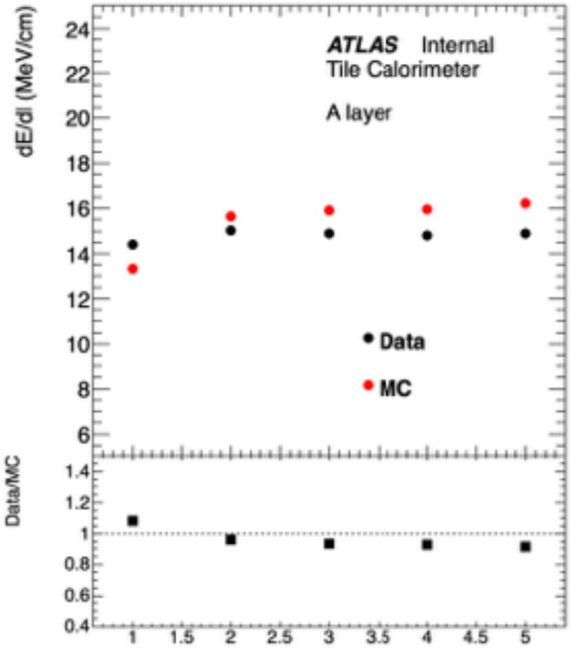
The red horizontal line corresponds to the mean value of determinations for each layer

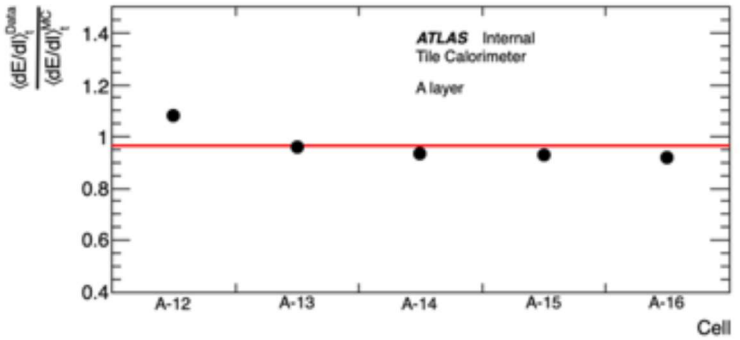
EBC65 - Sep 2023 TB





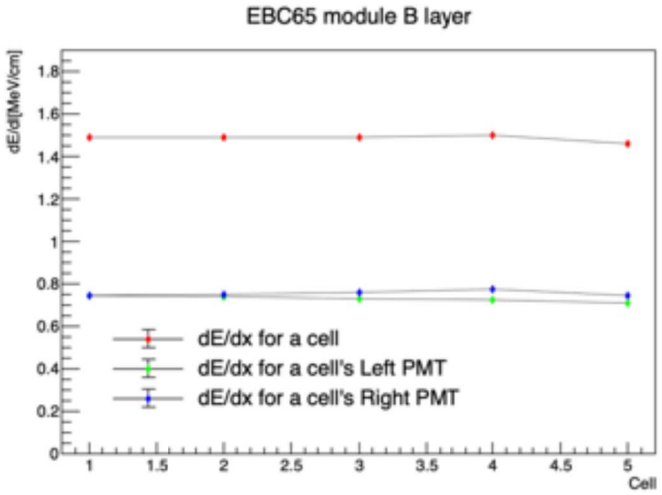
errors on the figures are statistical only and are very small in value.

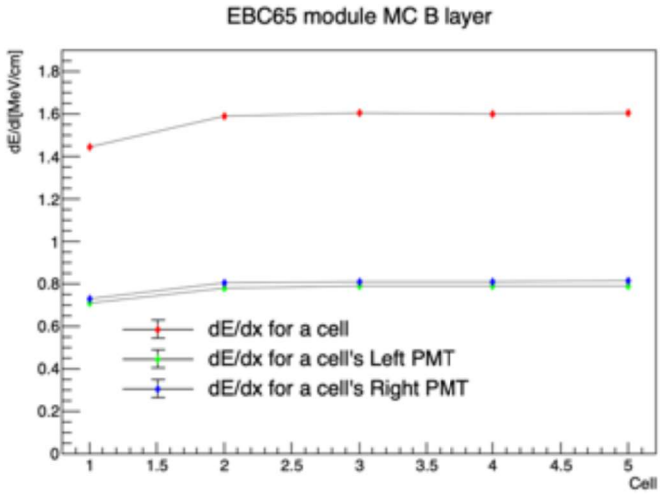




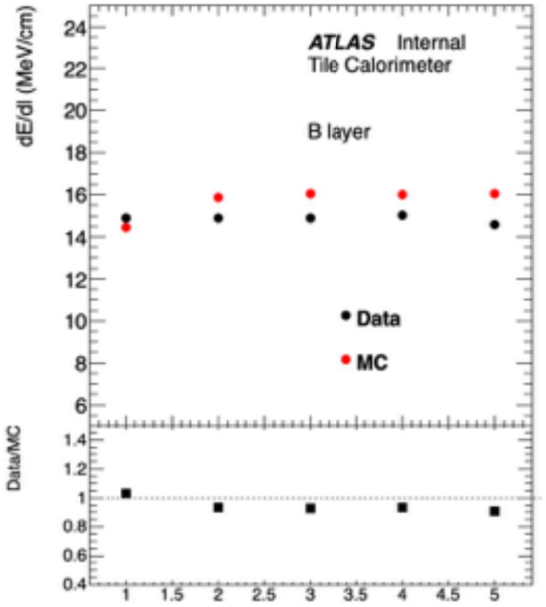
The red horizontal line corresponds to the mean value of determinations for each layer

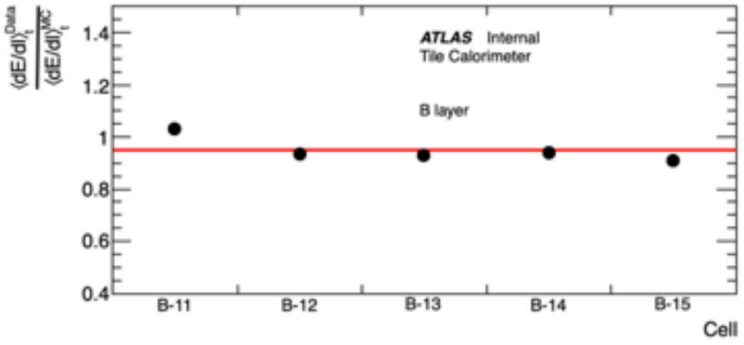
EBC65 - Sep 2023 TB





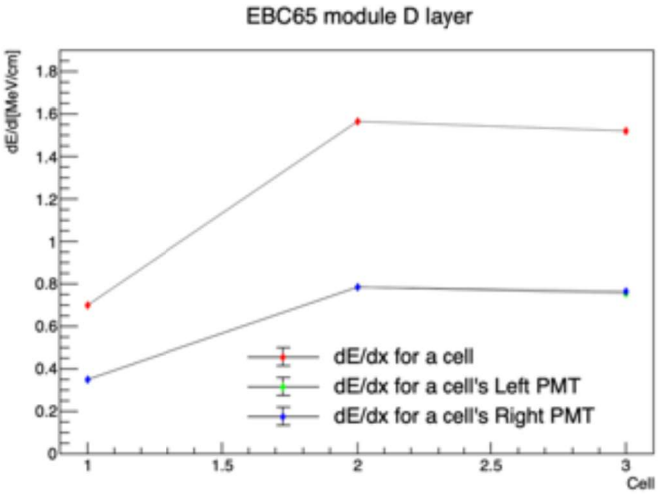
errors on the figures are statistical only and are very small in value.

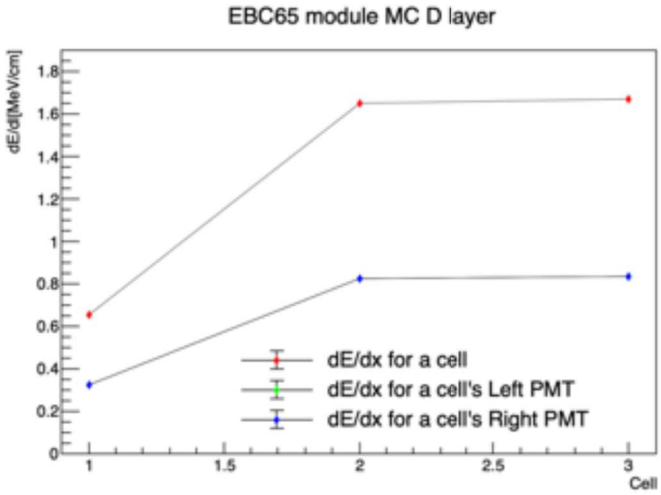




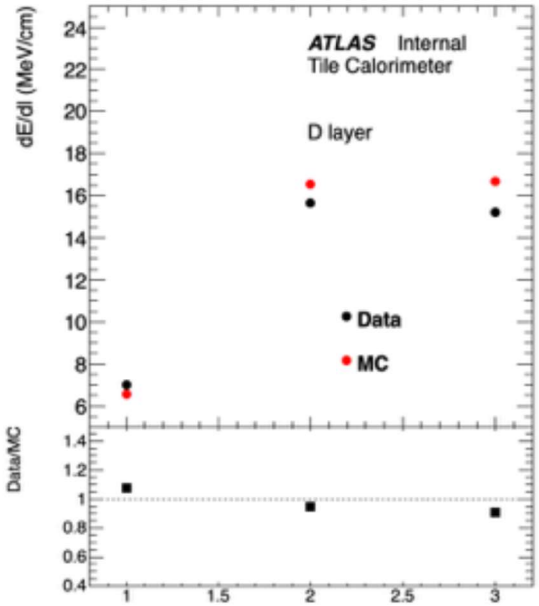
The red horizontal line corresponds to the mean value of determinations for each layer

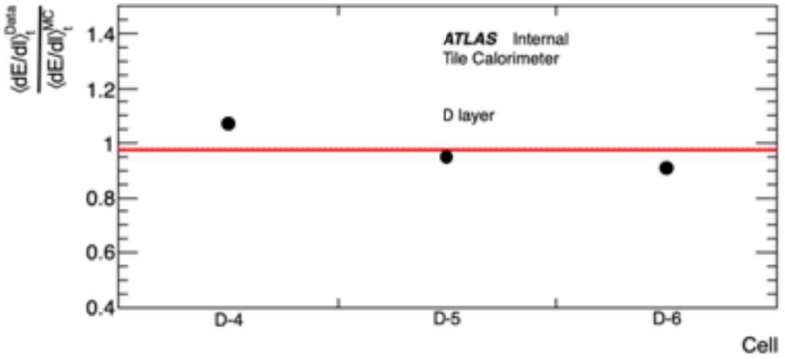
EBC65 - Sep 2023 TB





errors on the figures are statistical only and are very small in value.





The red horizontal line corresponds to the mean value of determinations for each layer

Determinations of the Row/layer responses. For each Row/layer the mean value for Data/MC and corresponding errors are presented

LBC65 – module, Sept 2023, 160 GeV

Layer	Mean	Error	Row	Mean	Error
A	0.866	0.004	1		
A	1.041	0.005	2	0.949	0.004
A	0.945	0.004	3		
BC	0.951	0.004	4		
BC	0.943	0.004	5		
BC	0.962	0.004	6		
BC	0.954	0.005	7	0.950	0.005
BC	0.982	0.005	8		
BC	0.934	0.005	9		
D	0.981	0.007	10	0.967	0.007
D	0.954	0.007	11		

LBC65 – module, November 2022, 165 GeV

Layer	Mean	Error	Row	Mean	Error
A	0.878	0.004	1		
A	1.049	0.005	2	0.961	0.004
A	0.960	0.004	3		
BC	0.968	0.005	4		
BC	0.950	0.004	5		
BC	0.980	0.005	6		
BC	0.962	0.005	7	0.965	0.005
BC	1.006	0.005	8		
BC	0.941	0.005	9		
D	0.985	0.007	10	0.976	0.007
D	0.967	0.007	11		

LBC65 – module, Sept 2023, 160 GeV

Layer	Mean	Error
A	0.949	0.004
BC	0.950	0.005
D	0.967	0.007

LBC65 – module, November 2022, 165 GeV

Layer	Mean	Error
A	0.961	0.004
BC	0.965	0.005
D	0.976	0.007

Offset for Data/MC for Rows 1-11/layers A, BC, D

LBC65 – module, Sept 2023, 160 GeV

Layer	Row	LBC65	LBC65
A	1	13.4%	5.1%
A	2	4.1%	
A	3	5.5%	
BC	4	4.9%	6.2%
BC	5	5.7%	
BC	6	3.8%	
BC	7	4.6%	
BC	8	1.8%	
BC	9	6.6%	
D	10	1.9%	3.3%
D	11	4.6%	

In LBC65 module offset of max 13.4% is observed for Data/MC for Row 1 of A layer, while for Rows 2-11 max of offset is within 2-7%.

LBC65 – module, November 2022, 165 GeV

Layer	Row	LBC65	LBC65
A	1	12.2%	3.9%
A	2	4.9%	
A	3	4.0%	
BC	4	3.2%	3.5%
BC	5	5.0%	
BC	6	2.0%	
BC	7	3.8%	
BC	8	0.6%	
BC	9	5.9%	
D	10	1.5%	2.4%
D	11	3.3%	

In LBC65 module offset of max 12.2% is observed for Data/MC for Row 1 of A layer, while for Rows 2-11 max of offset is within 1-6%.

Determinations of the Row/layer responses. For each Row/layer the mean value for Data/MC and corresponding errors are presented

LBA65 – module,Sept 2023, 160 GeV

Layer	Mean	Error	Row	Mean	Error
A	0.993	0.004	1		
A	1.156	0.005	2	1.074	0.005
A	1.077	0.005	3		
BC	1.084	0.005	4		
BC	1.096	0.006	5		
BC	1.057	0.005	6	1.077	0.006
BC	1.072	0.006	7		
BC	1.067	0.006	8		
BC	1.059	0.005	9		
D	1.083	0.008	10	1.081	0.008
D	1.081	0.008	11		

LBA65 – module,November 2022, 165 GeV

Layer	Mean	Error	Row	Mean	Error
A	1.013	0.005	1		
A	1.169	0.005	2	1.089	0.005
A	1.090	0.005	3		
BC	1.100	0.005	4		
BC	1.109	0.006	5		
BC	1.080	0.005	6	1.095	0.006
BC	1.090	0.006	7		
BC	1.094	0.006	8		
BC	1.077	0.006	9		
D	1.097	0.008	10	1.097	0.008
D	1.097	0.008	11		

LBA65 – module,Sept 2023, 160 GeV

Layer	Mean	Error
A	1.074	0.005
BC	1.077	0.006
D	1.081	0.008

LBA65 – module, November 2022, 165 GeV

Layer	Mean	Error
A	1.089	0.005
BC	1.095	0.006
D	1.097	0.008

Offset for Data/MC for Rows 1-11/layers A, BC, D

LBA65 – module, Sept 2023, 160 GeV

Layer	Row	LBA65	LBA65
A	1	0.7%	7.4%
A	2	15.6%	
A	3	7.7%	
BC	4	8.4%	7.7%
BC	5	9.6%	
BC	6	5.7%	
BC	7	7.2%	
BC	8	6.7%	
BC	9	5.9%	
D	10	8.3%	8.1%
D	11	8.1%	

In LBA65 module offset of max 15.6% is observed for Data/MC for Row 2 of BC layer, while for Rows 1, 3-11 max of offset is within 1-10%.

LBA65 – module, November 2022, 165 GeV

Layer	Row	LBA65	LBA65
A	1	1.3%	8.9%
A	2	16.9%	
A	3	9.0%	
BC	4	10.0%	9.5%
BC	5	10.9%	
BC	6	8.0%	
BC	7	9.0%	
BC	8	9.4%	
BC	9	7.7%	
D	10	9.7%	9.7%
D	11	9.7%	

In LBA65 module offset of max 16.9% is observed for Data/MC for Row 2 of BC layer, while for Rows 1, 3-11 max of offset is within 1-10%.

Determinations of the Row/layer responses. For each Row/layer the mean value for Data/MC and corresponding errors are presented

EBC65 – module,Sept 2023, 160 GeV

Layer	Mean	Error	Row	Mean	Error
A	0.917	0.006	1		
A	0.962	0.006	2	0.947	0.006
A	0.928	0.006	3		
B	0.942	0.006	4		
B	0.923	0.006	5	0.932	0.006
B	0.979	0.006	6		
B	0.886	0.005	7		
D	0.902	0.009	8		
D	0.992	0.010	9	0.966	0.008
D	0.927	0.008	10		
D	0.968	0.008	11		

EBC65 – module, November 2022, 165 GeV

Layer	Mean	Error	Row	Mean	Error
A	0.980	0.006	1		
A	1.033	0.007	2	0.964	0.006
A	0.998	0.006	3		
B	0.955	0.006	4		
B	0.939	0.006	5	0.948	0.006
B	1.001	0.006	6		
B	0.898	0.005	7		
D	0.912	0.009	8		
D	1.009	0.010	9	0.977	0.008
D	0.935	0.008	10		
D	0.978	0.008	11		

EBC65 – module, Sept 2023, 160 GeV

Layer	Mean	Error
A	0.947	0.006
B	0.932	0.006
D	0.966	0.008

EBC65 – module, November 2022, 165 GeV

Layer	Mean	Error
A	0.964	0.006
BC	0.948	0.006
D	0.977	0.008

Offset for Data/MC for Rows 1-11/layers A, B, D

EBC65 – module, Sept 2023, 160 GeV

Layer	Row	EBC65	EBC65
A	1	8.3%	5.3%
A	2	3.8%	
A	3	7.2%	
B	4	5.8%	6.8%
B	5	7.7%	
B	6	2.1%	
B	7	11.4%	
D	8	9.8%	3.4%
D	9	0.8%	
D	10	7.3%	
D	11	3.2%	

In EBC65 module offset of max 11.4% is observed for Data/MC for Row 7 of B layer, while for Rows 1-6, 8-11 max of offset is within 1-10%.

EBC65 – module, November 2022, 165 GeV

Layer	Row	EBC65	EBC65
A	1	2.0%	3.6%
A	2	3.3%	
A	3	0.2%	
B	4	4.5%	5.2%
B	5	6.1%	
B	6	0.1%	
B	7	10.2%	
D	8	8.8%	2.3.%
D	9	0.9%	
D	10	6.5%	
D	11	2.2%	

In EBC65 module offset of max 10.2% is observed for Data/MC for Row 7 of B layer, while for Rows 1-6, 8-11 max of offset is within 1-9%.

Summary

- -90 deg. muon raw data Sept 2023 TB and Nov 2022 TB of 160, 165 GeV for upgrade modules LBC65 and EBC65 reconstructed for each of 11 rows, from which 3 layers are formed : A, BC/B and D respectively.

- ~ 50 000 events for each row the following runs have been analysed: LBC65: 2212235 - 2212247 (Nov 2022), 2320122 - 2320132 (Sep 2023) ; EBC65 : 2212260 - 2212272(Nov 2022),2320138 - 2320148 (Sep 2023)
- Corresponding MC samples have been simulated (50 000 events for each row).

- The cells lengths were calculated for each of 11 rows (A, BC/B and D layers) of LBC65, LBA65 and EBC65 modules. Fit method was used as reconstruction method and following cuts were applied to experimental and simulated data: 2< Tot.E < 20 GeV;
  $-15 < X_{BC2} < 25$ mm && $-15 < Y_{BC2} < 25$ mm (November 2022 TB)
  $-20 < X_{BC2} < 22$ mm && $-20 < Y_{BC2} < 20$ mm (September 2023 TB)

- Muon energy loss per unit of length (dE/dx) in LBC65, LBA65 and EBC65 modules were evaluated. To calculate dE/dx for each cell, as dE value was used truncated mean (97.5%) of the distribution, and as dx was used corresponding cell length.

- The ratio between the experimental and simulated truncated means was defined for each calorimeter cell and the ratios as a function of the cell number for each of 11 rows / 3 layers A, BC/B, D for LBC65, LBA65 and EBC65 were obtained. A satisfactory agreement (fit) between the Data and MC simulations was obtained.

- In LBC65 module is observed:
  offset of 5.1% for Data/MC for A layer, 6.2% for B layer and 3.3% for D layer for September 2023 TB data.
  offset of 3.9% for Data/MC for A layer, 3.5% for B layer and 2.4% for D layer for November 2022 TB data.

- In LBA65 module is observed :
  offset of 7.4% for Data/MC for A layer, 7.7% for B layer and 8.1% for D layer for September 2023 TB data.
  offset of 8.9% for Data/MC for A layer, 9.5% for B layer and 9.7% for D layer for November 2022 TB data.

Summary

- In EBC65 module is observed :
  offset of 5.3% for Data/MC for A layer, 6.8% for B layer and 3.4% for D layer for September 2023 TB data.
  offset of 3.6% for Data/MC for A layer, 5.2% for B layer and 2.3% for D layer for November 2022 TB data.

Future Plans

- Study of systematics
- Finalise of analysis of TB muon data of Sept 2023, November 2022

Thank you for your attention

Back up

Determinations of the Row/layer responses. For each Row/layer the mean value for Data/MC and corresponding errors are presented

LBC65 – module, Sept 2023, 160 GeV

Layer	Mean	Error	Row	Mean	Error
A	0.866	0.004	1		
A	1.041	0.005	2	0.949	0.004
A	0.945	0.004	3		
BC	0.951	0.004	4		
BC	0.943	0.004	5		
BC	0.962	0.004	6		
BC	0.954	0.005	7	0.950	0.005
BC	0.982	0.005	8		
BC	0.934	0.005	9		
D	0.981	0.007	10	0.967	0.007
D	0.954	0.007	11		

LBA65 – module,Sept 2023, 160 GeV

Layer	Mean	Error	Row	Mean	Error
A	0.993	0.004	1		
A	1.156	0.005	2	1.074	0.005
A	1.077	0.005	3		
BC	1.084	0.005	4		
BC	1.096	0.006	5		
BC	1.057	0.005	6	1.077	0.006
BC	1.072	0.006	7		
BC	1.067	0.006	8		
BC	1.059	0.005	9		
D	1.083	0.008	10	1.081	0.008
D	1.081	0.008	11		

LBC65 – module, Sept 2023, 160 GeV

Layer	Mean	Error
A	0.949	0.004
BC	0.950	0.005
D	0.967	0.007

Layer	Mean	Error
A	0.961	0.004
BC	0.965	0.005
D	0.976	0.007

LBA65 – module, Sept 2023, 160 GeV

Layer	Mean	Error
A	1.074	0.005
BC	1.077	0.006
D	1.081	0.008

Offset for Data/MC for Rows 1-11/layers A, BC, D

LBC65 – module, Sept 2023, 160 GeV

Layer	Row	LBC65	LBC65
A	1	13.4%	5.1%
A	2	4.1%	
A	3	5.5%	
BC	4	4.9%	6.2%
BC	5	5.7%	
BC	6	3.8%	
BC	7	4.6%	
BC	8	1.8%	
BC	9	6.6%	
D	10	1.9%	3.3%
D	11	4.6%	

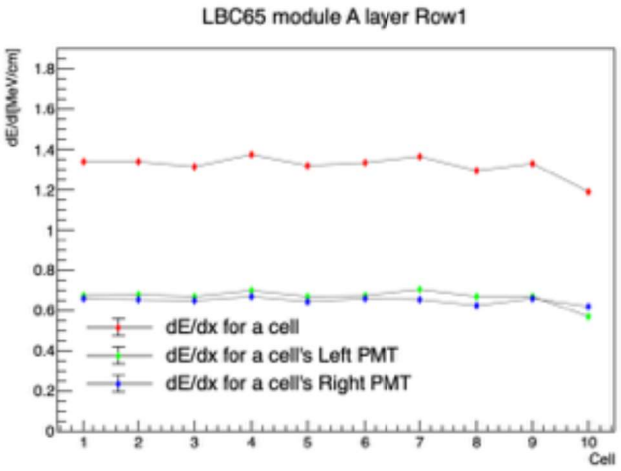
In LBC65 module offset of max 13.4% is observed for Data/MC for Row 1 of BC layer, while for Rows 2-11 max of offset is within 2-7%.

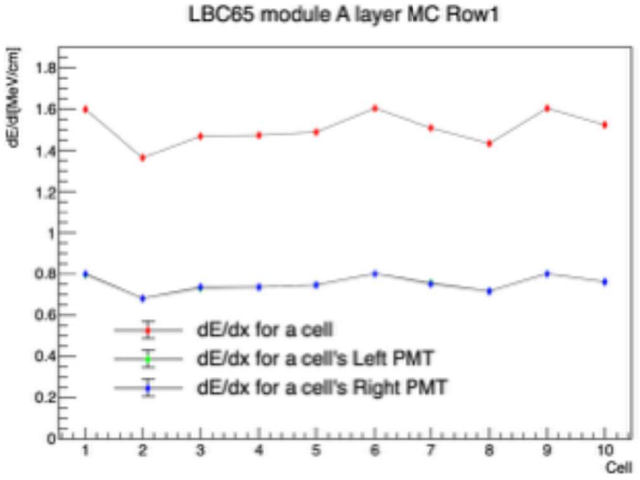
LBA65 – module, Sept 2023, 160 GeV

Layer	Row	LBA65	LBA65
A	1	0.7%	7.4%
A	2	15.6%	
A	3	7.7%	
BC	4	8.4%	7.7%
BC	5	9.6%	
BC	6	5.7%	
BC	7	7.2%	
BC	8	6.7%	
BC	9	5.9%	
D	10	8.3%	8.1%
D	11	8.1%	

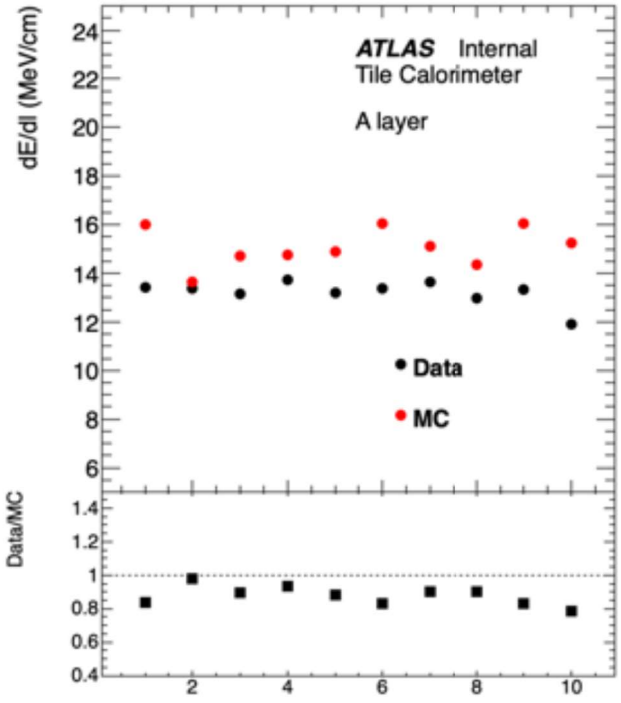
In LBA65 module offset of max 15.6% is observed for Data/MC for Row 2 of BC layer, while for Rows 1, 3-11 max of offset is within 1-10%.

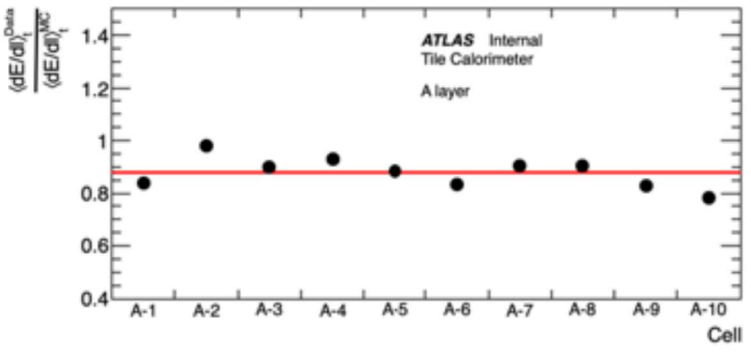
LBC65 - Nov 2022 TB - Row 1





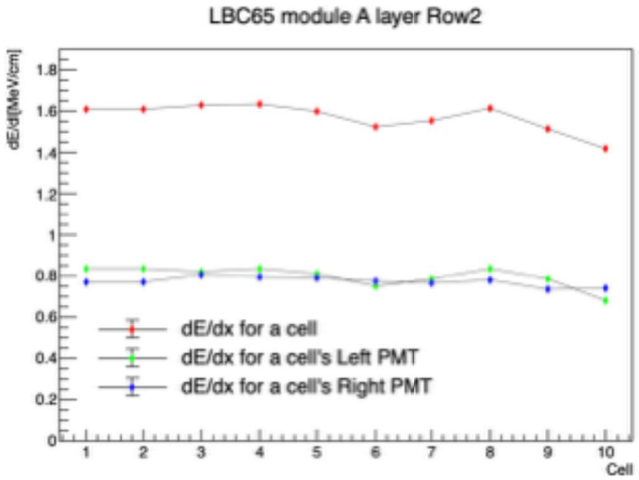
errors on the figures are statistical only and are very small in value.

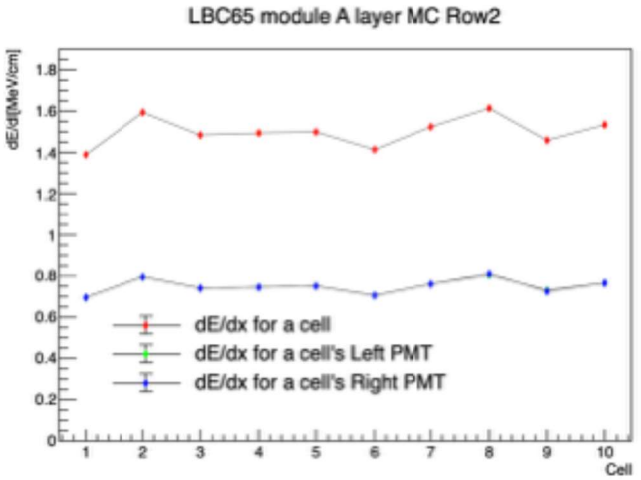




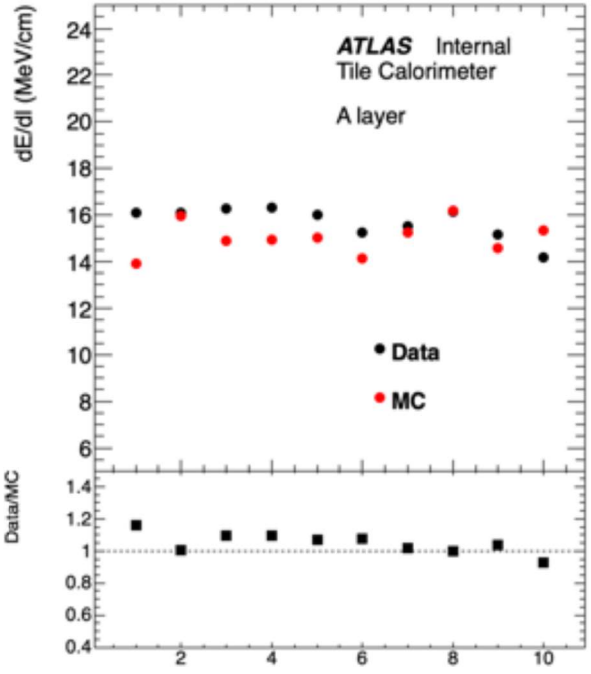
The red horizontal line corresponds to the mean value of determinations for each layer

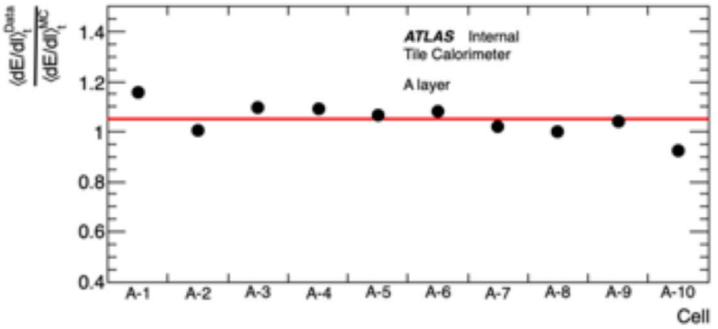
LBC65 - Nov 2022 TB - Row 2





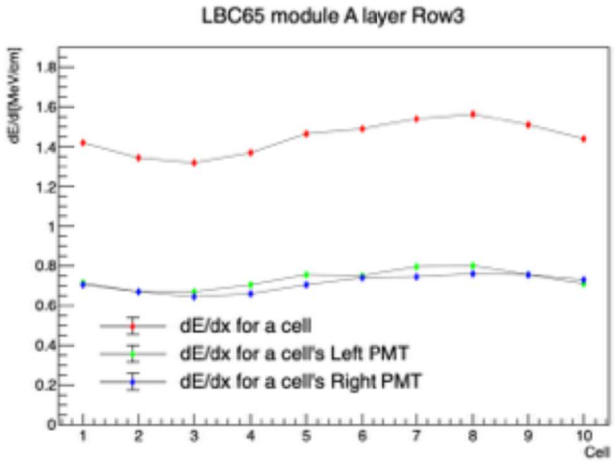
errors on the figures are statistical only and are very small in value.

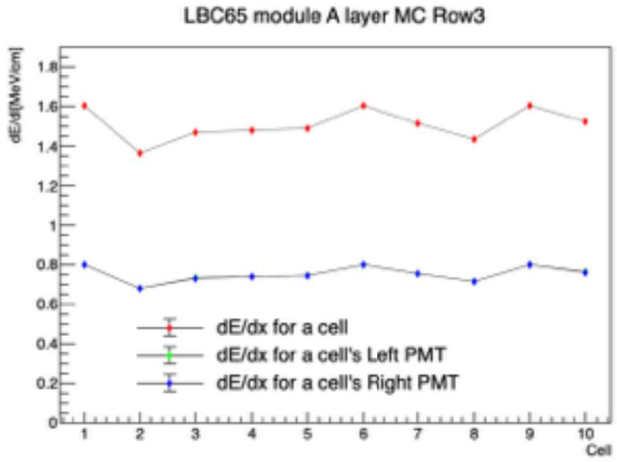




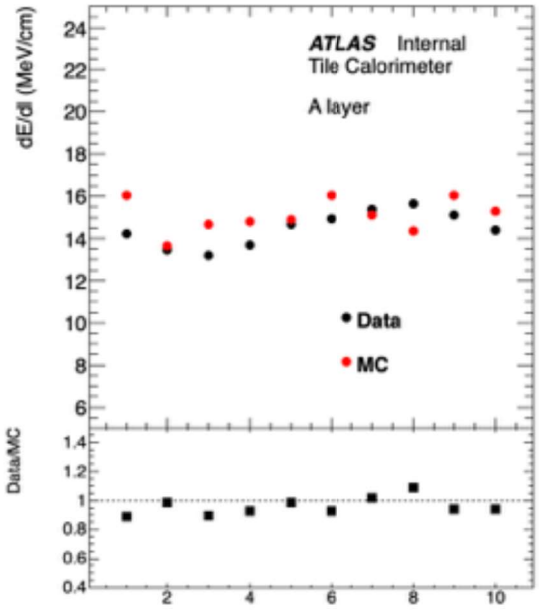
The red horizontal line corresponds to the mean value of determinations for each layer

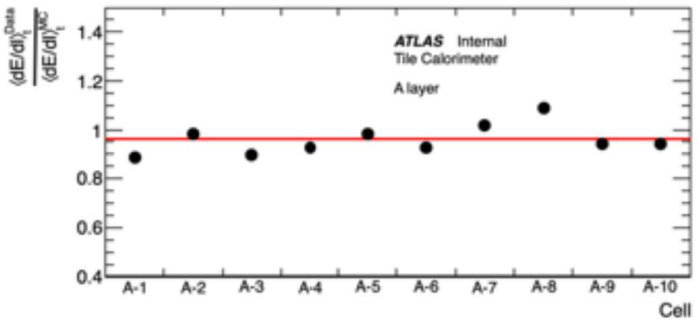
LBC65 - Nov 2022 TB - Row 3





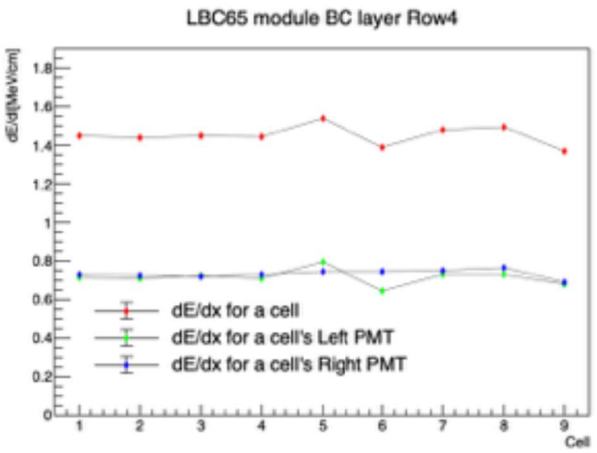
errors on the figures are statistical only and are very small in value.

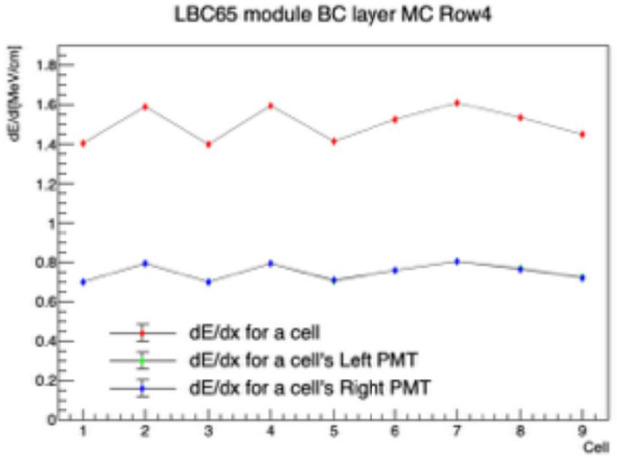




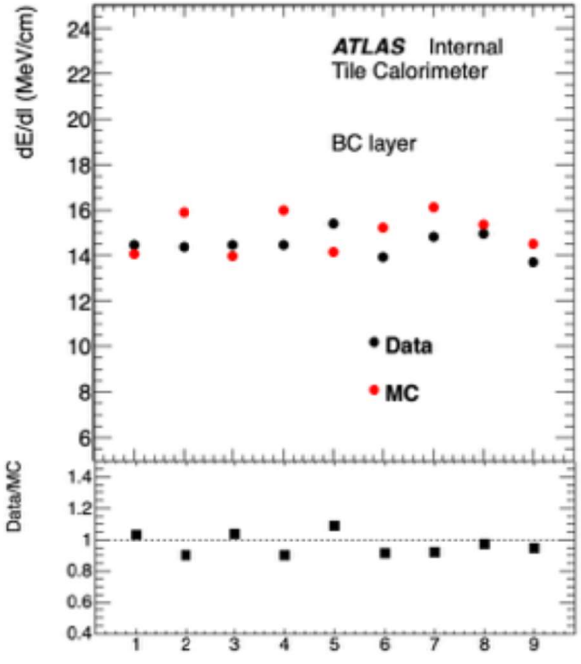
The red horizontal line corresponds to the mean value of determinations for each layer

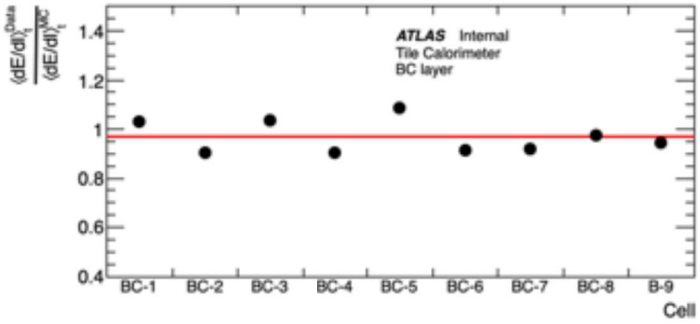
LBC65 - Nov 2022 TB - Row 4





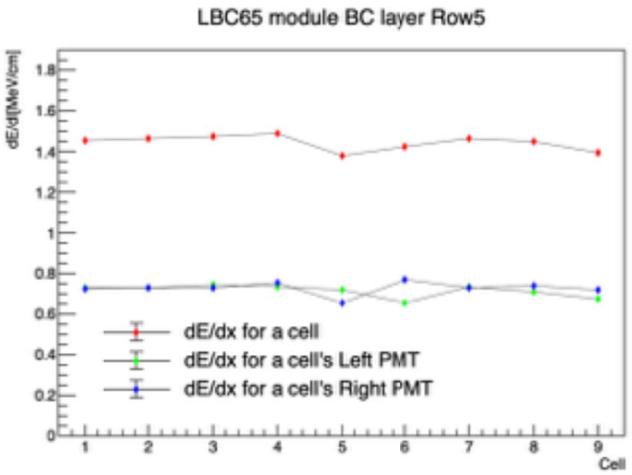
errors on the figures are statistical only and are very small in value.

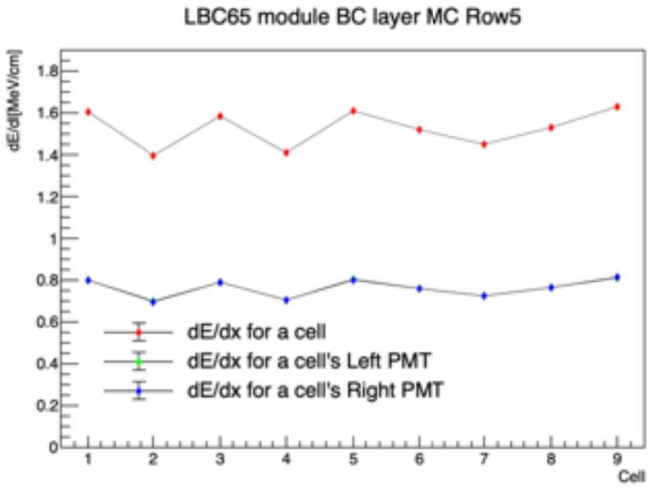




The red horizontal line corresponds to the mean value of determinations for each layer

LBC65 - Nov 2022 TB - Row 5





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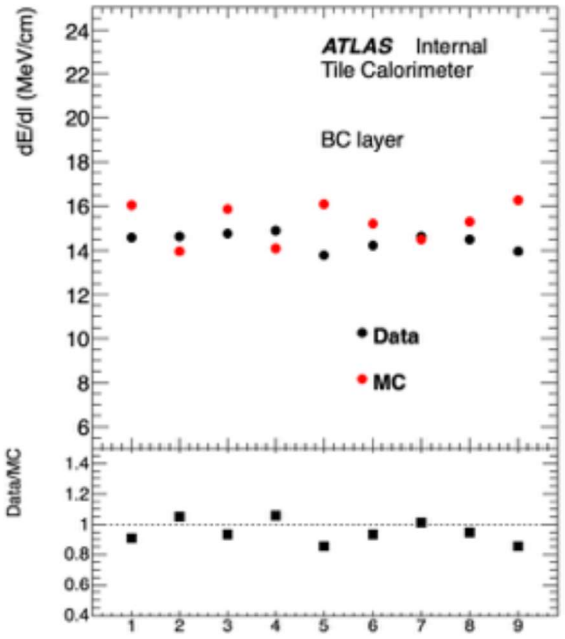
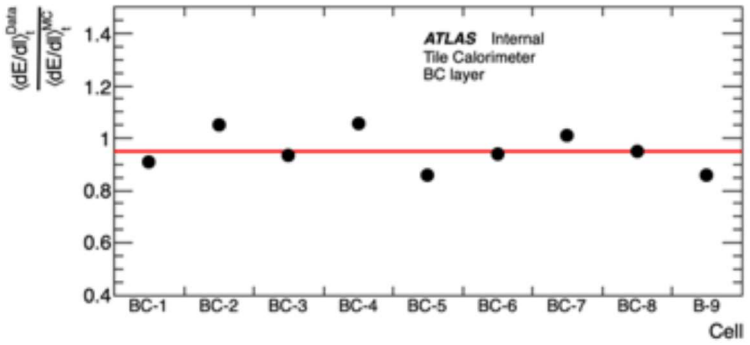
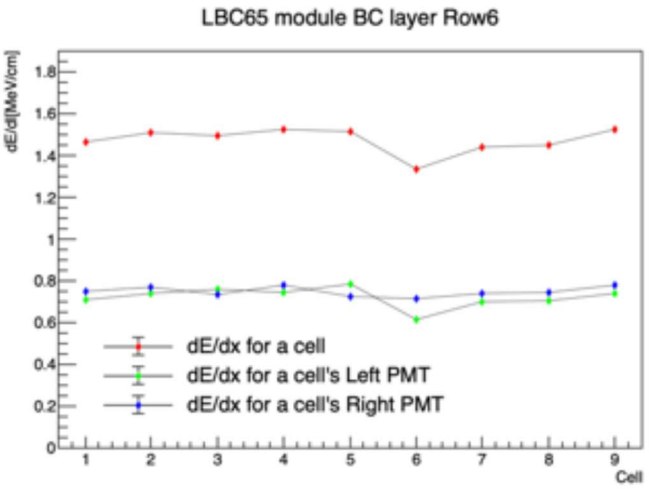
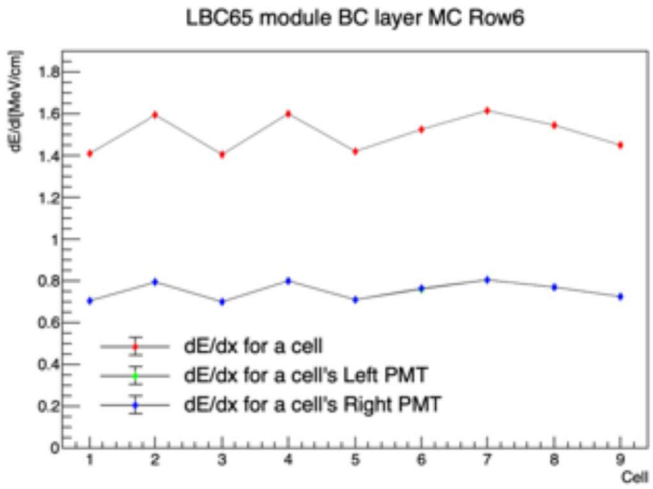




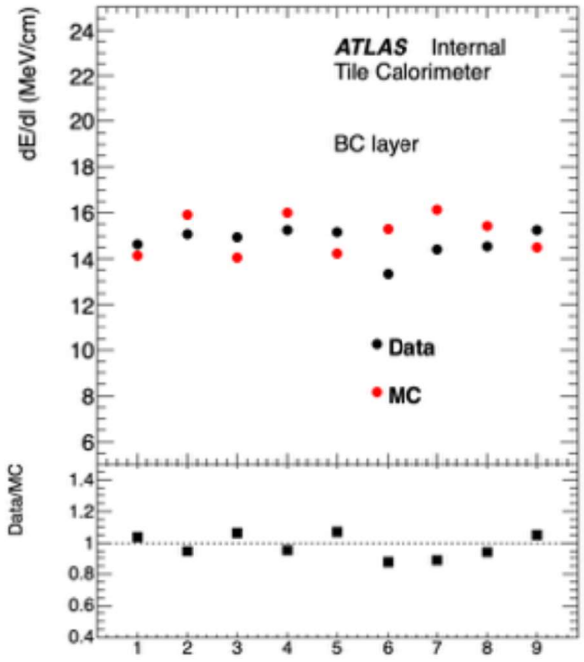
The red horizontal line corresponds to the mean value of determinations for each layer

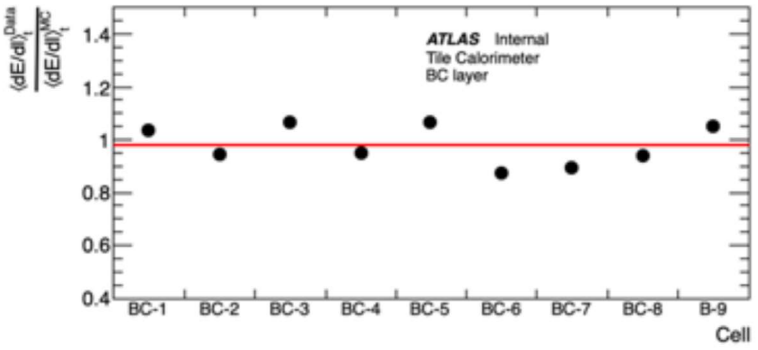
LBC65 - Nov 2022 TB - Row 6





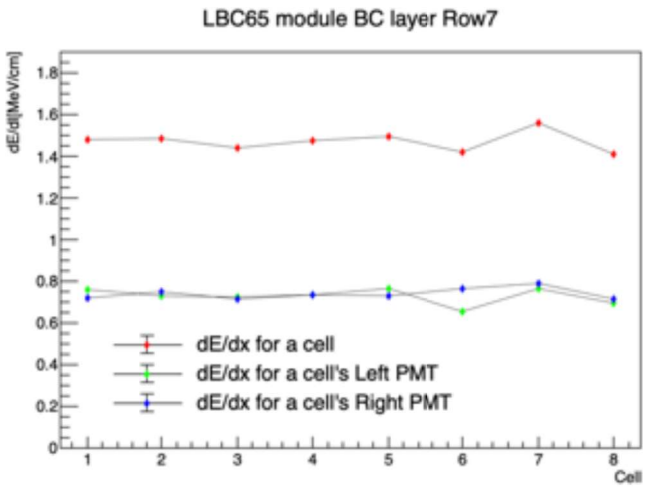
errors on the figures are statistical only and are very small in value.

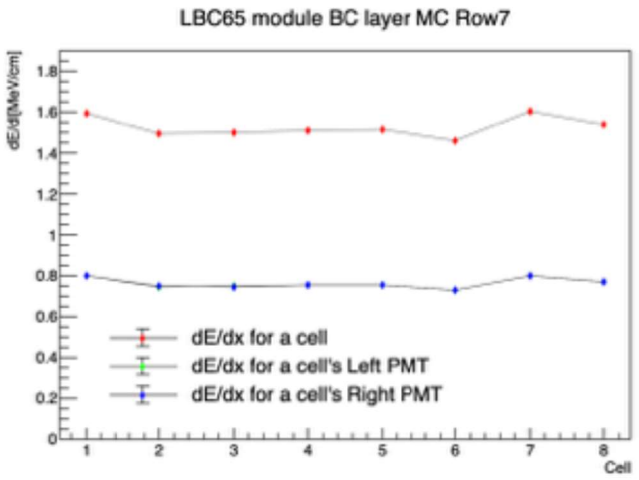




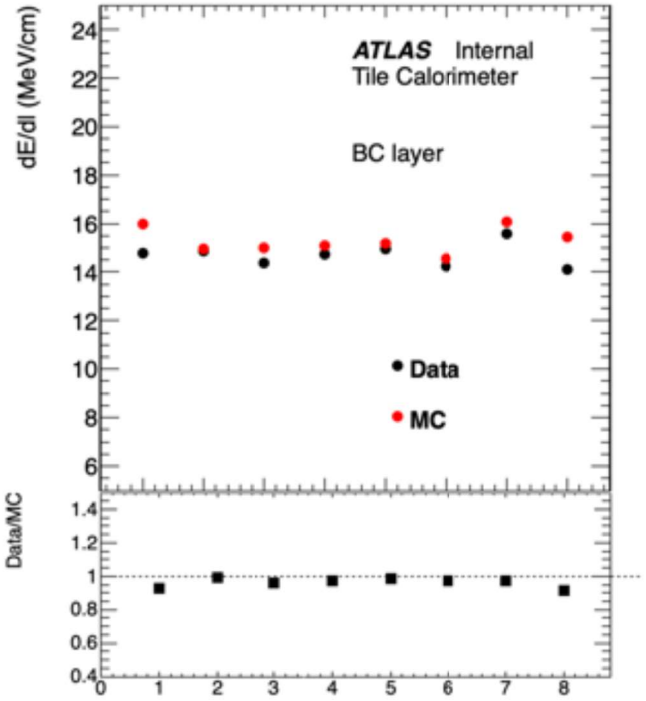
The red horizontal line corresponds to the mean value of determinations for each layer

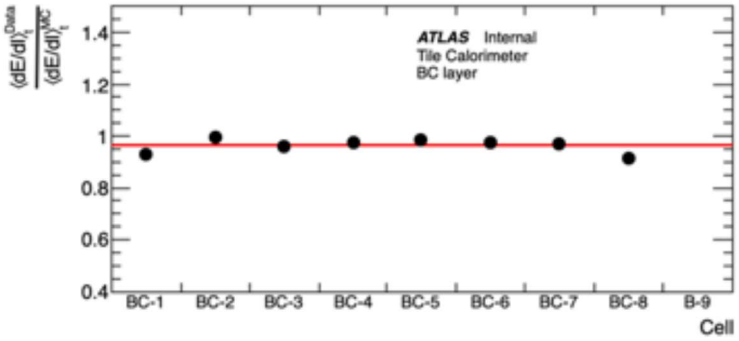
LBC65 - Nov 2022 TB - Row 7





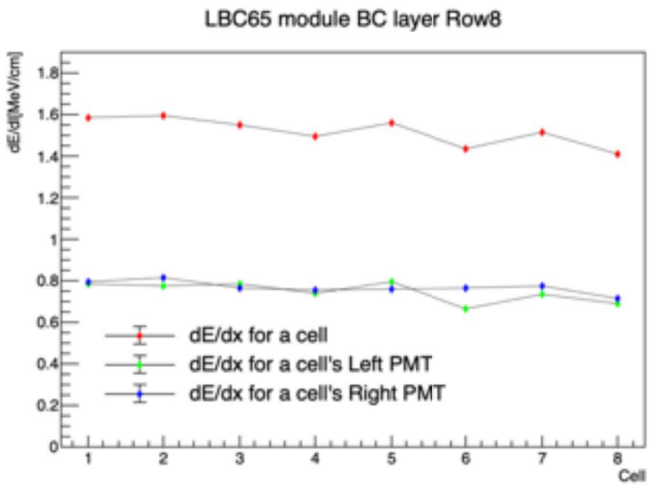
errors on the figures are statistical only and are very small in value.

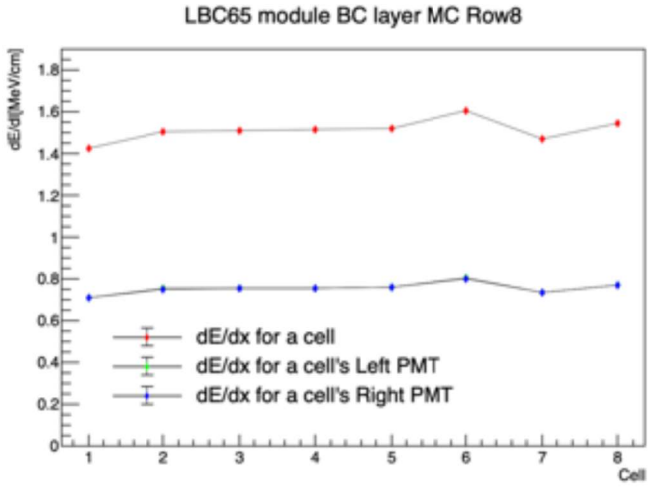




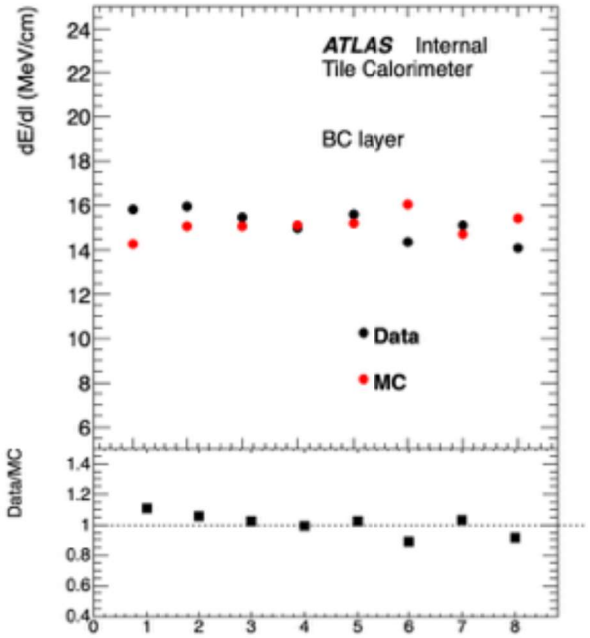
The red horizontal line corresponds to the mean value of determinations for each layer

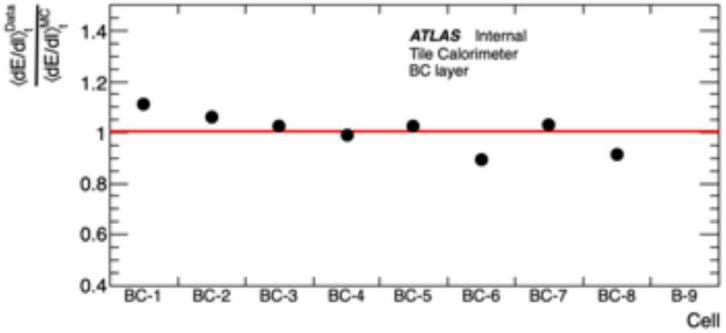
LBC65 - Nov 2022 TB - Row 8





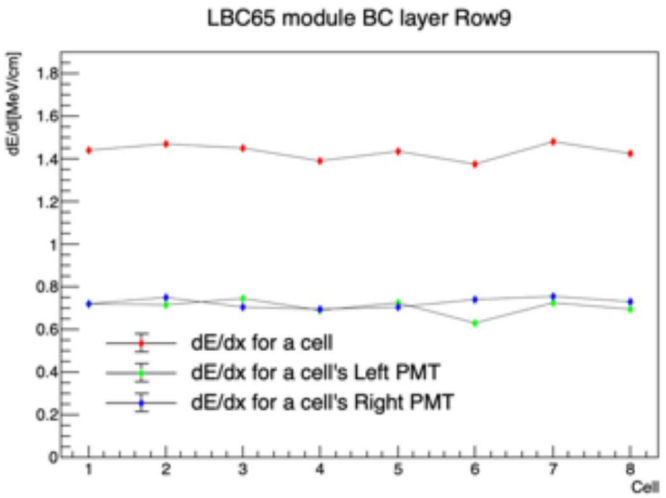
errors on the figures are statistical only and are very small in value.

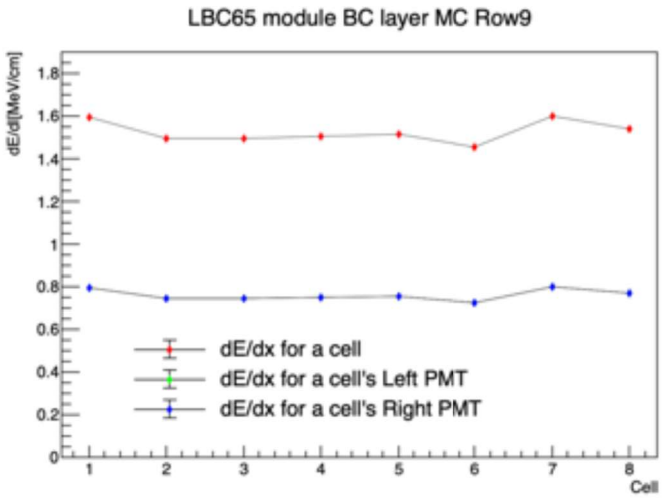




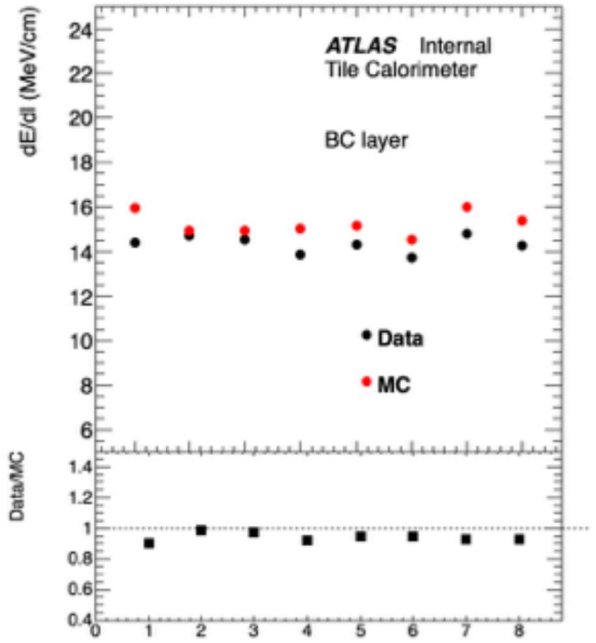
The red horizontal line corresponds to the mean value of determinations for each layer

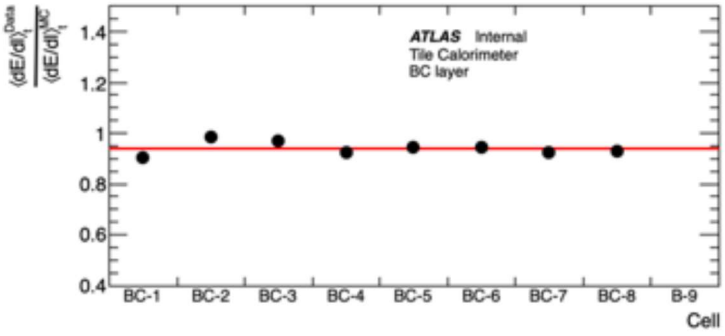
LBC65 - Nov 2022 TB - Row 9





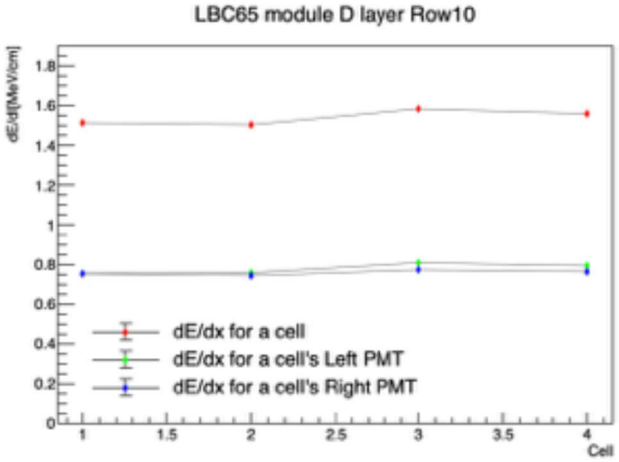
errors on the figures are statistical only and are very small in value.

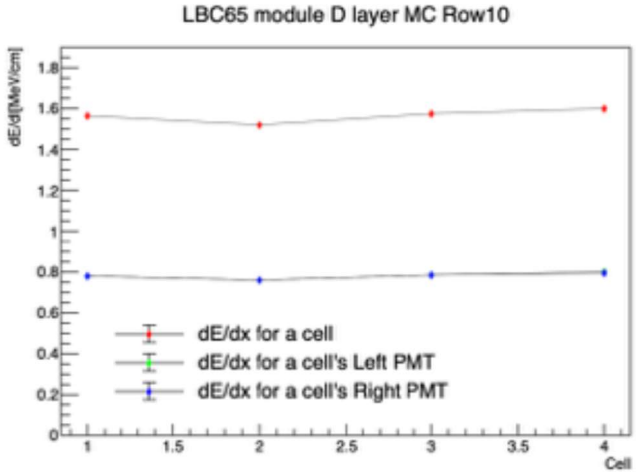




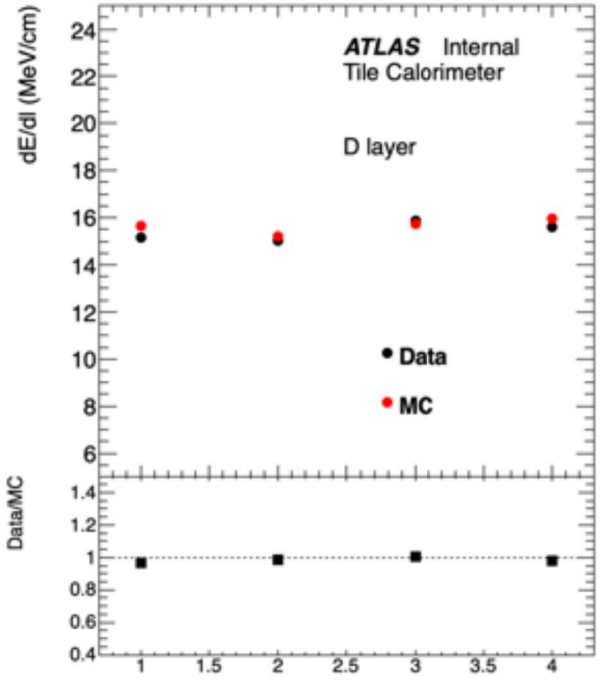
The red horizontal line corresponds to the mean value of determinations for each layer

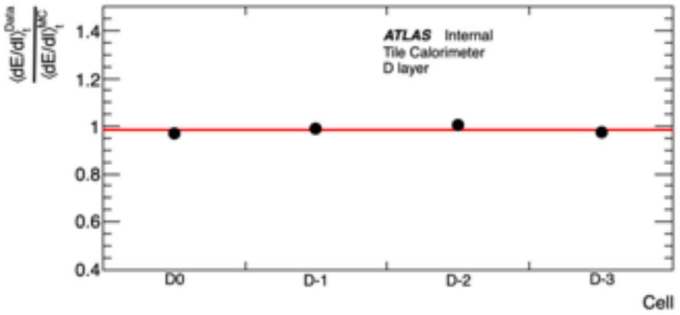
LBC65 - Nov 2022 TB - Row 10





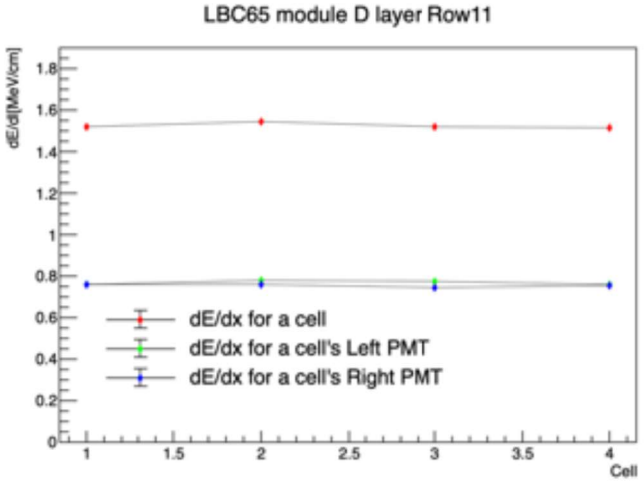
errors on the figures are statistical only and are very small in value.

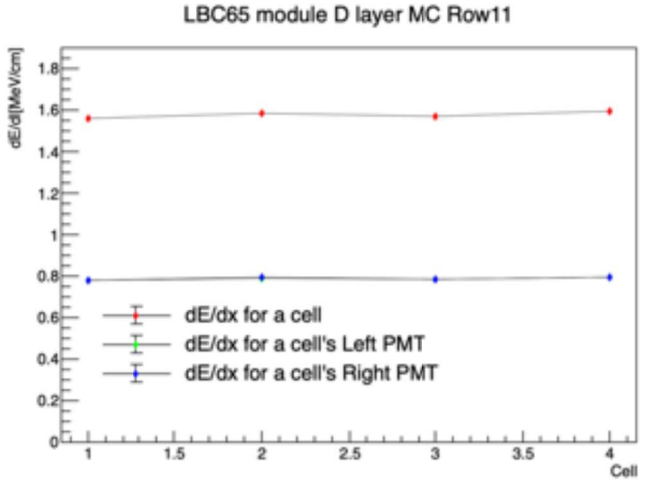




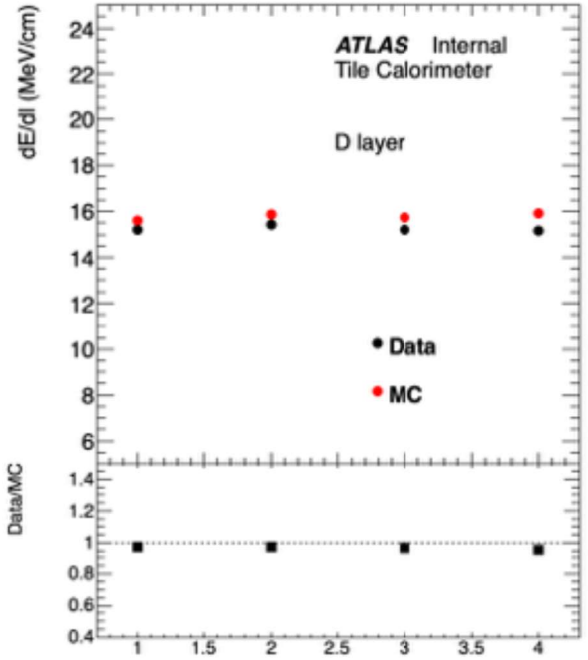
The red horizontal line corresponds to the mean value of determinations for each layer

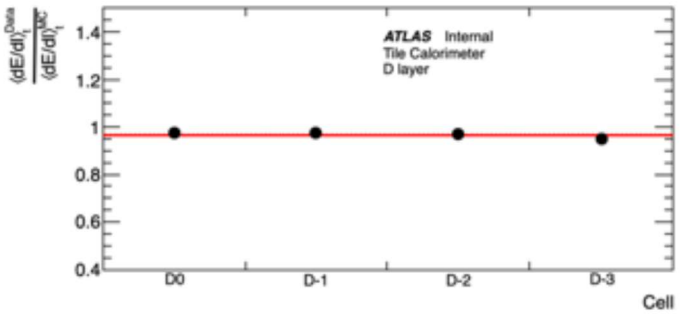
LBC65 - Nov 2022 TB - Row 11





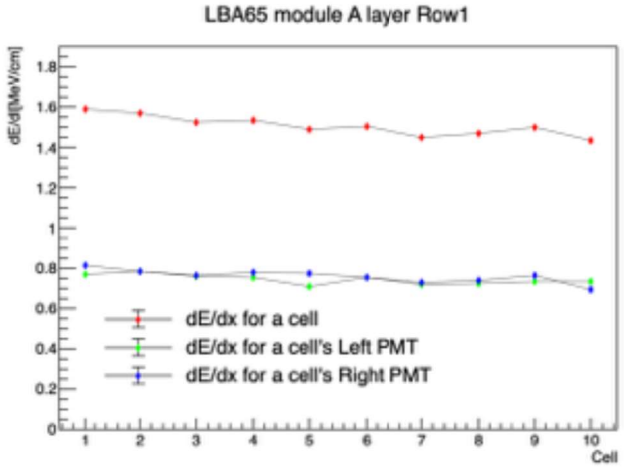
errors on the figures are statistical only and are very small in value.

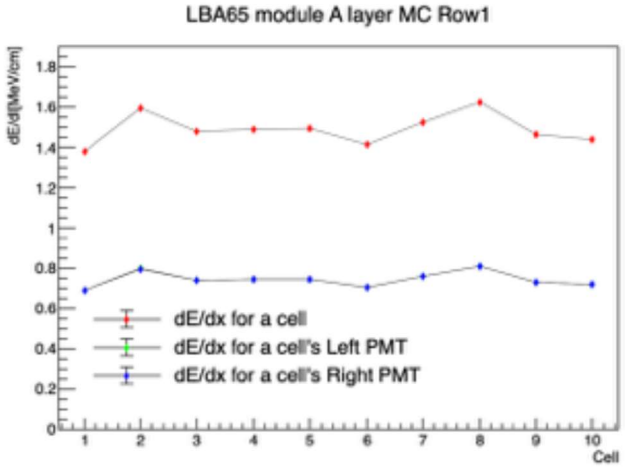




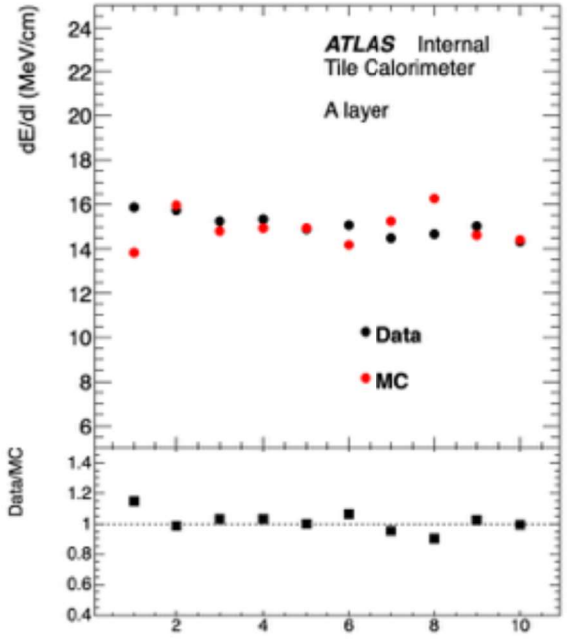
The red horizontal line corresponds to the mean value of determinations for each layer

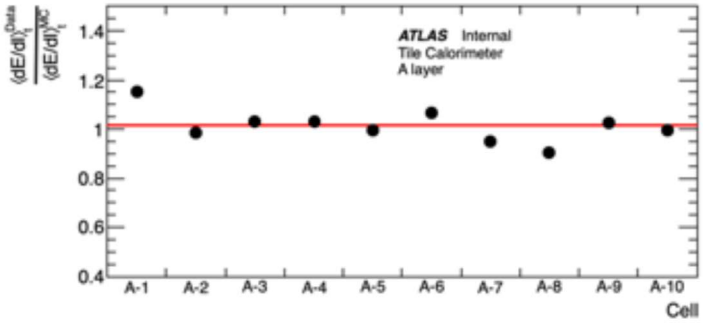
LBA65 - Nov 2022 TB - Row 1





errors on the figures are statistical only and are very small in value.





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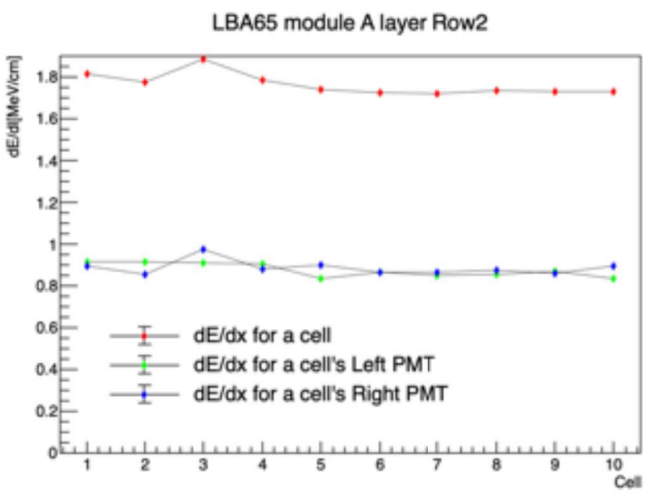
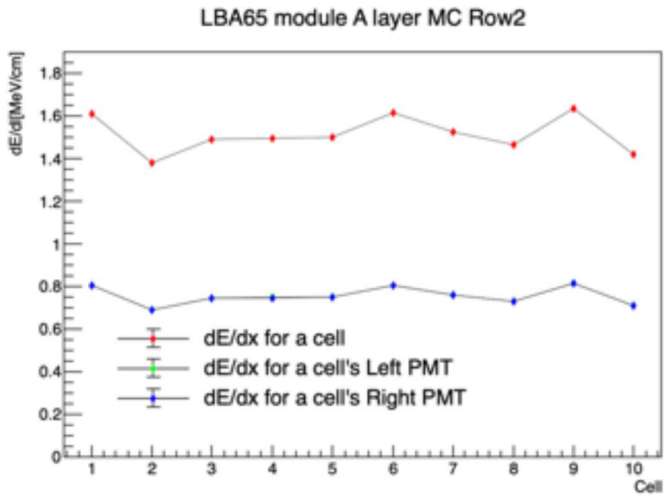
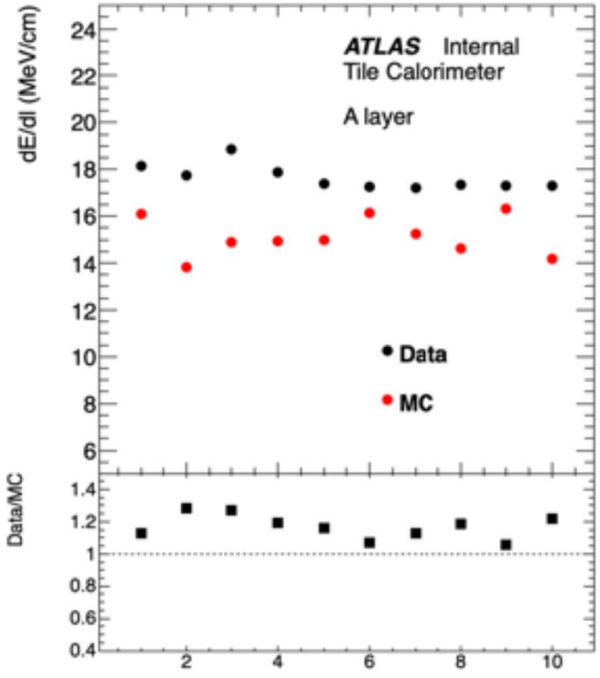
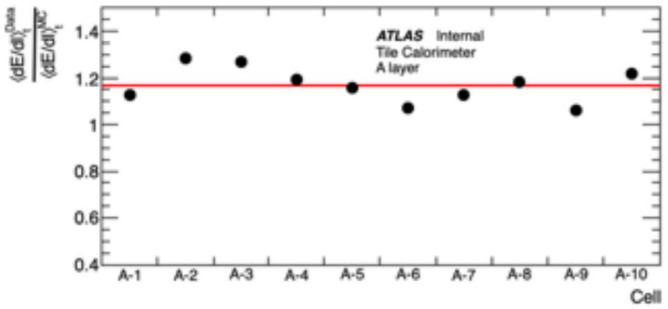
LBA65 - Nov 2022 TB - Row 2





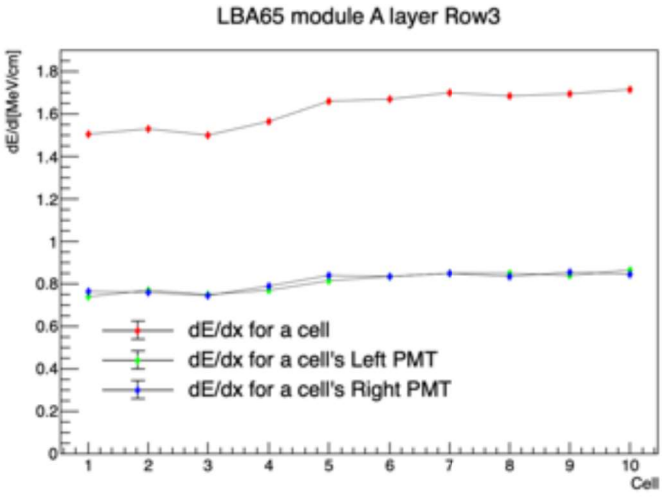
errors on the figures are statistical only and are very small in value.

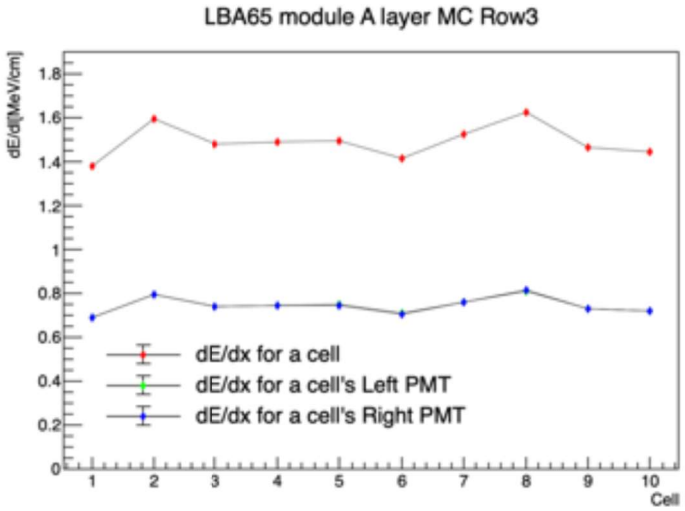




The red horizontal line corresponds to the mean value of determinations for each layer

LBA65 - Nov 2022 TB - Row 3





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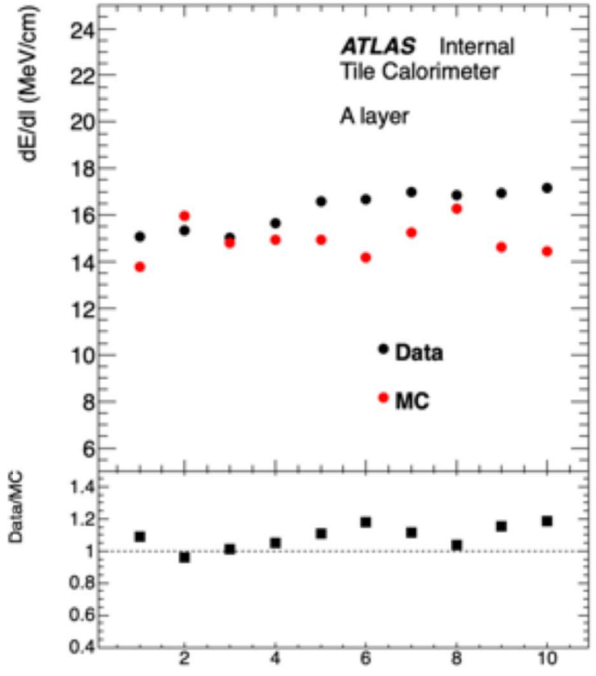
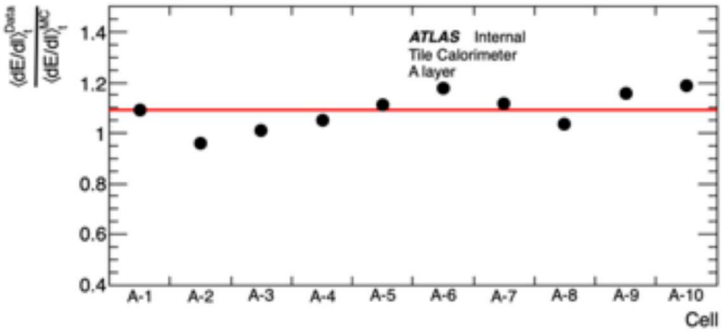
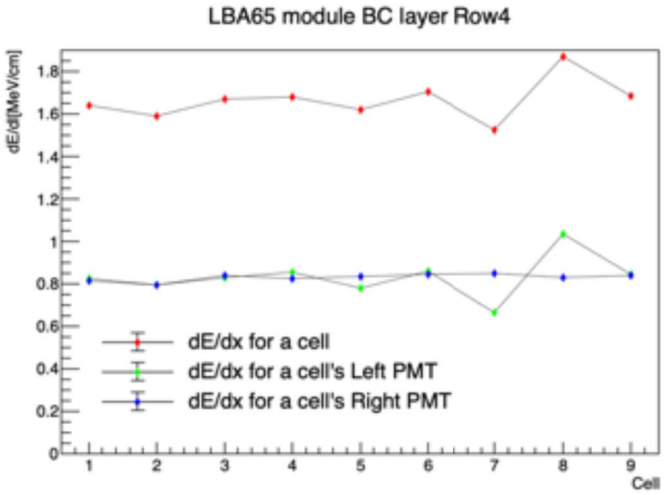
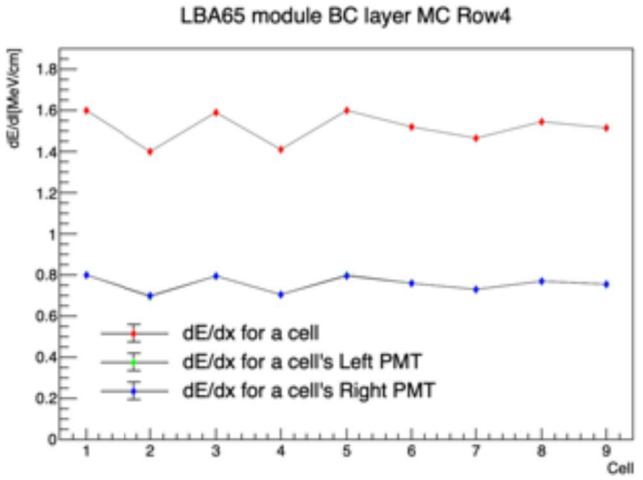




The red horizontal line corresponds to the mean value of determinations for each layer

LBA65 - Nov 2022 TB - Row 4





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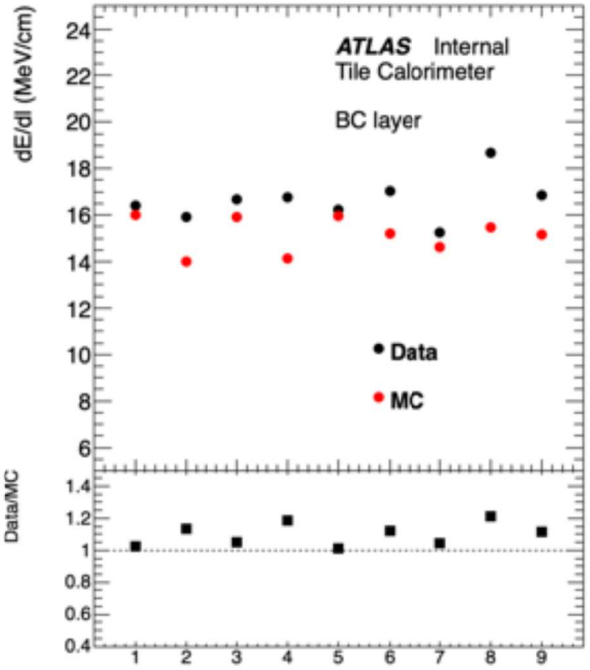

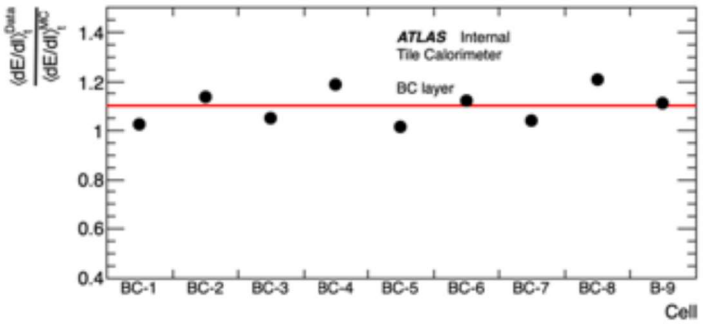

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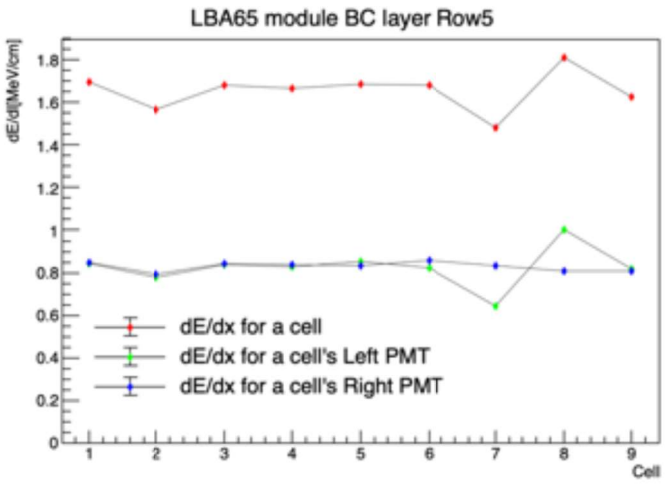
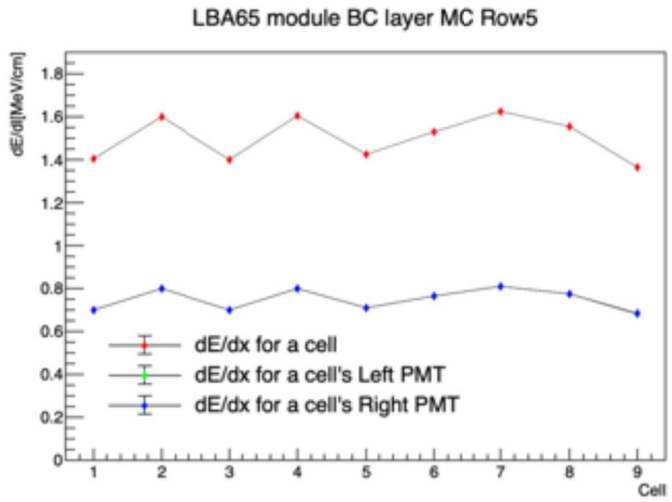
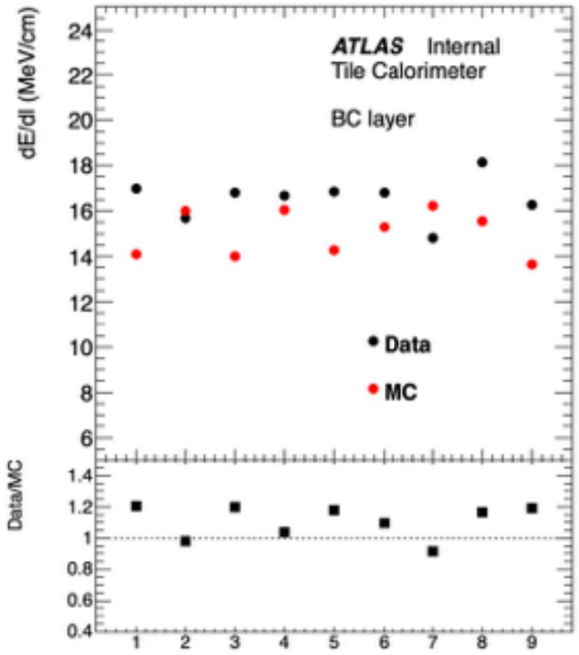
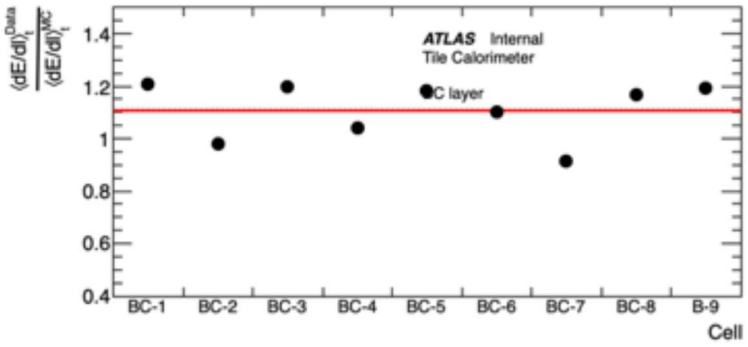
LBA65 - Nov 2022 TB - Row 5





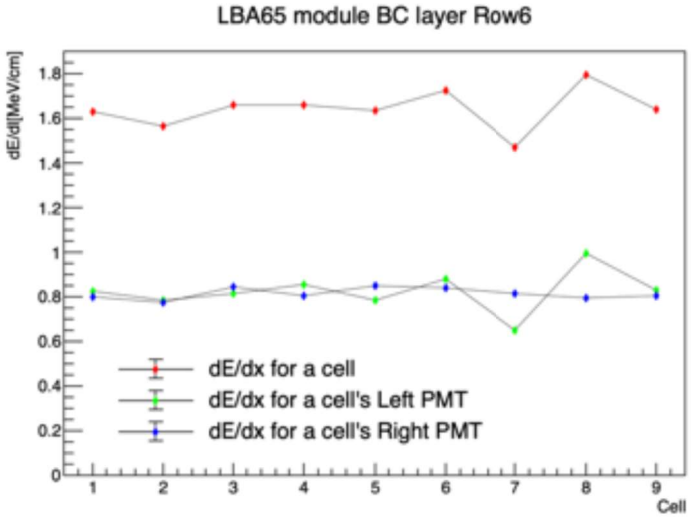
errors on the figures are statistical only and are very small in value.

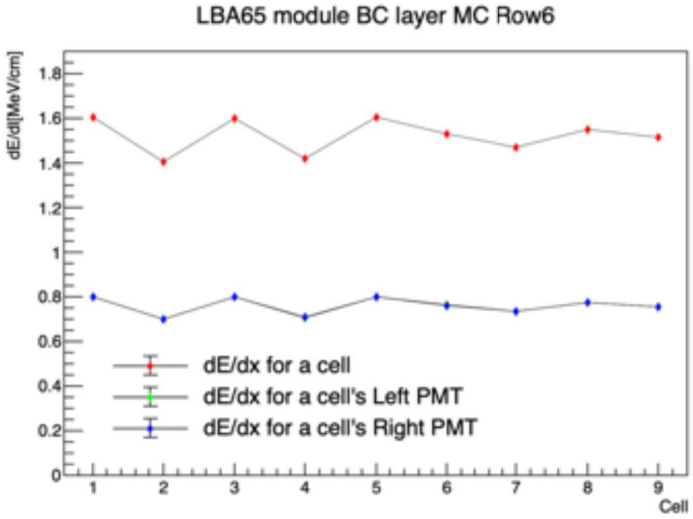




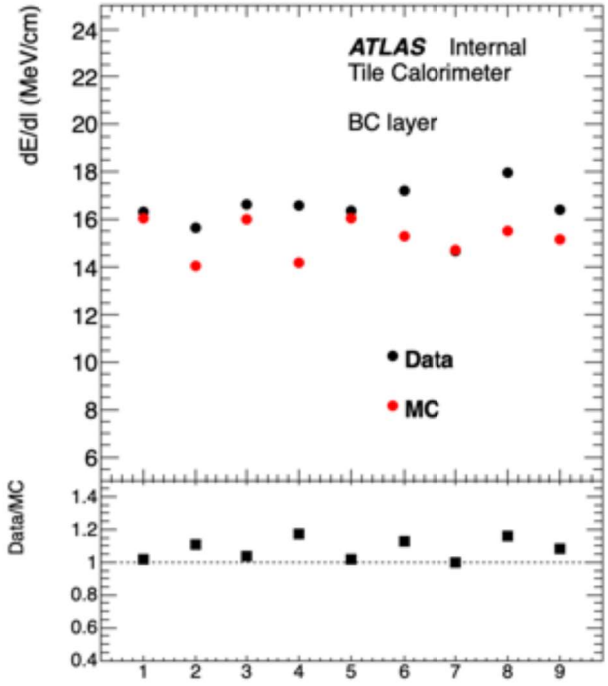
The red horizontal line corresponds to the mean value of determinations for each layer

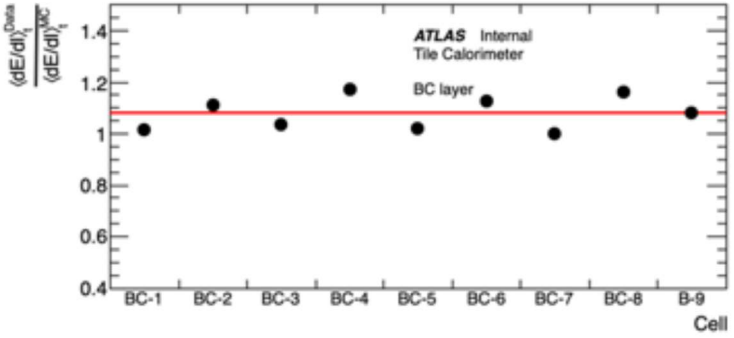
LBA65 - Nov 2022 TB - Row 6





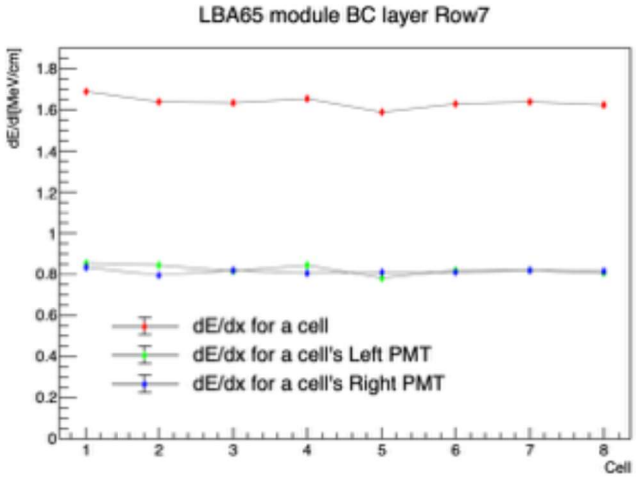
errors on the figures are statistical only and are very small in value.

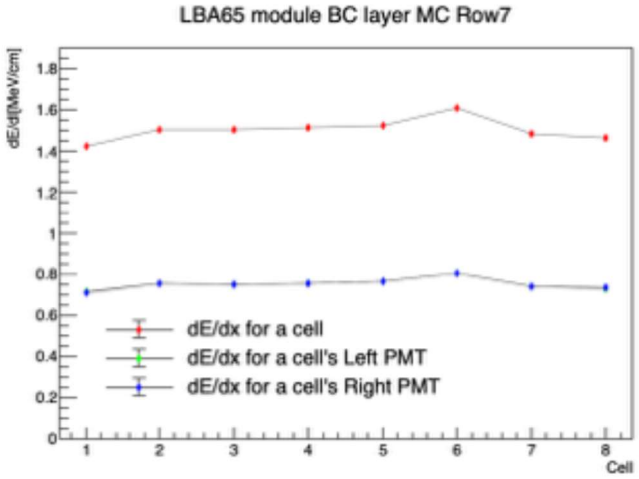




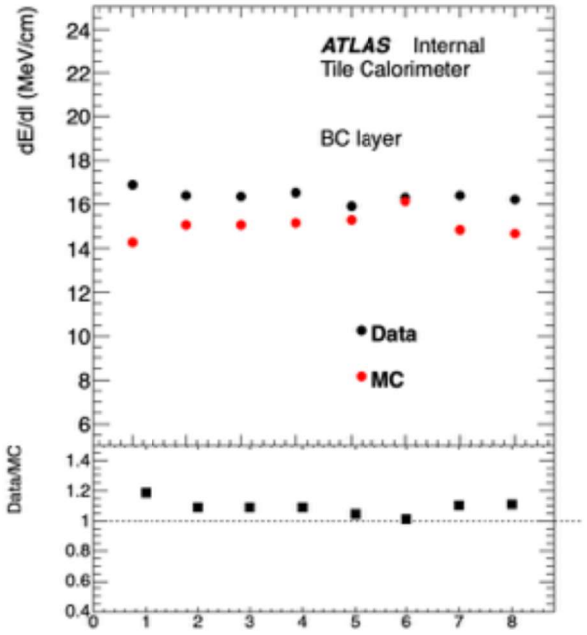
The red horizontal line corresponds to the mean value of determinations for each layer

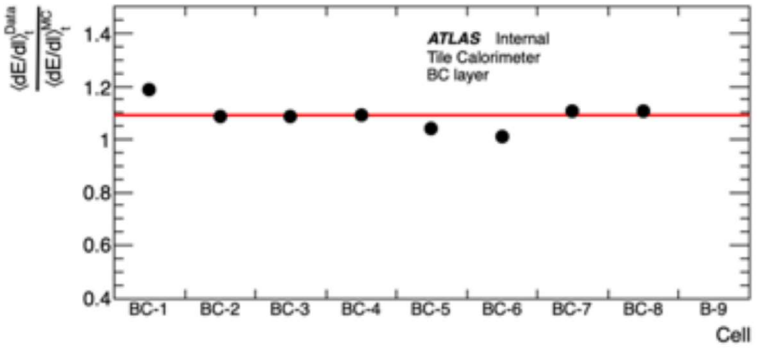
LBA65 - Nov 2022 TB - Row 7





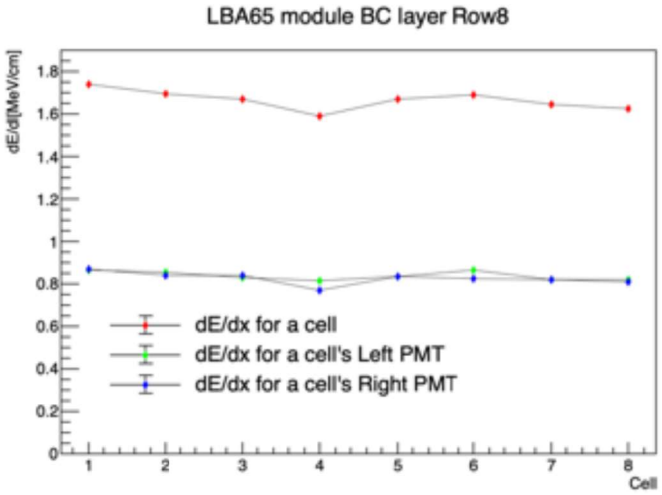
errors on the figures are statistical only and are very small in value.

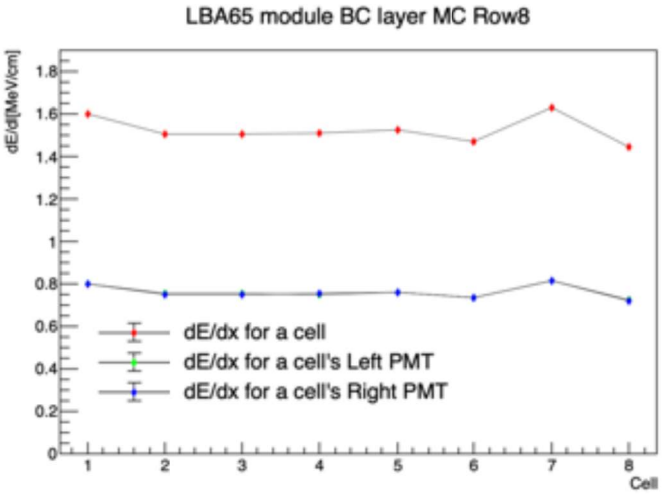




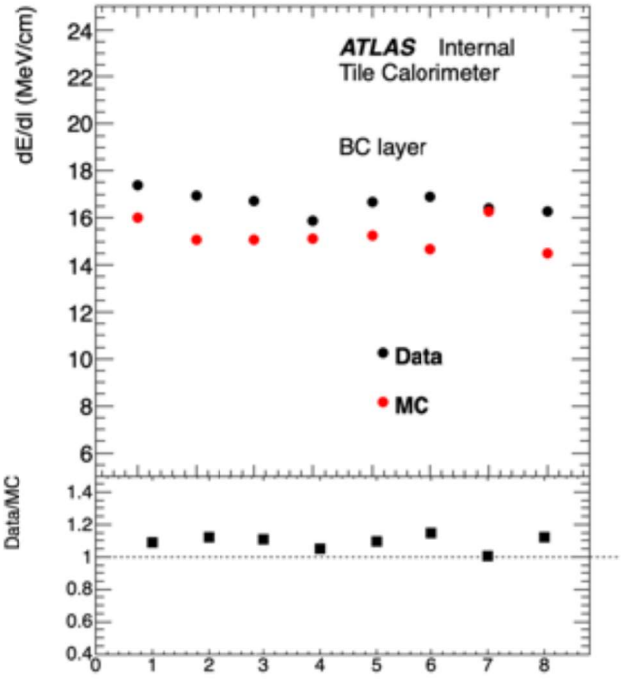
The red horizontal line corresponds to the mean value of determinations for each layer

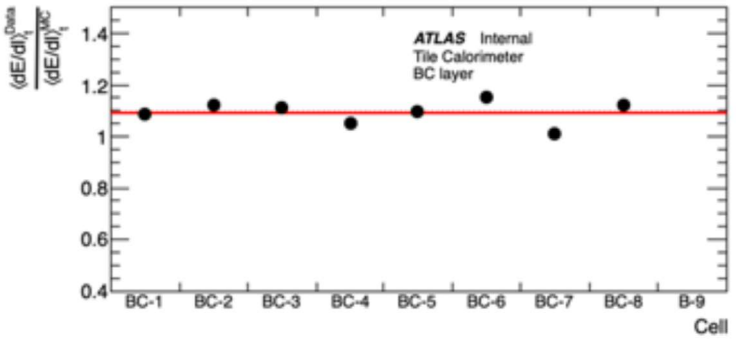
LBA65 - Nov 2022 TB - Row 8





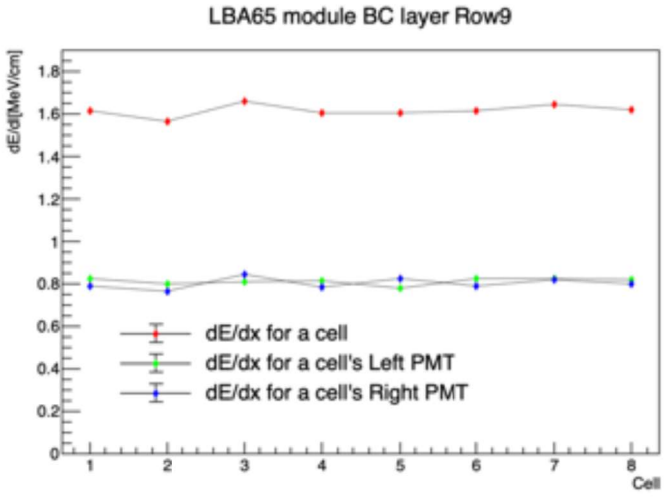
errors on the figures are statistical only and are very small in value.

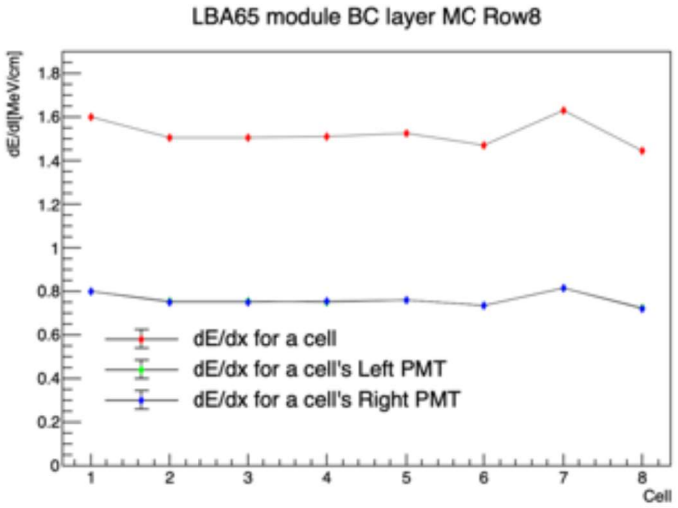




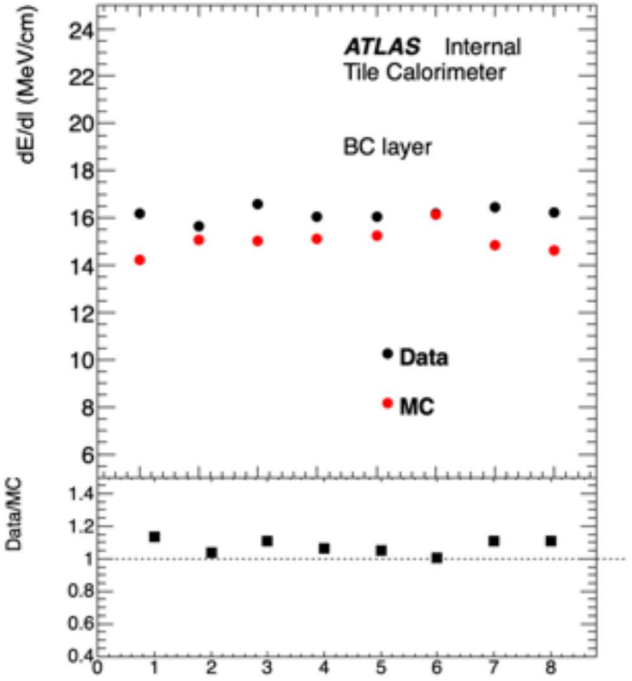
The red horizontal line corresponds to the mean value of determinations for each layer

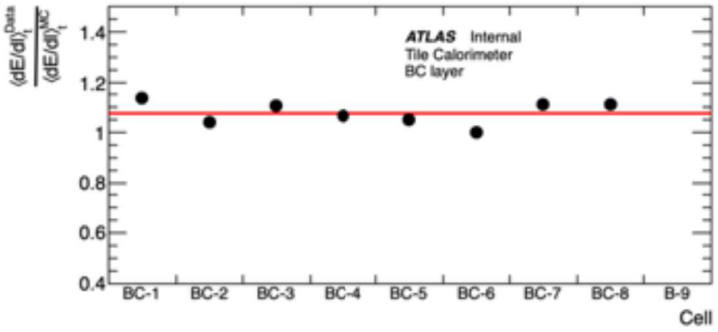
LBA65 - Nov 2022 TB - Row 9





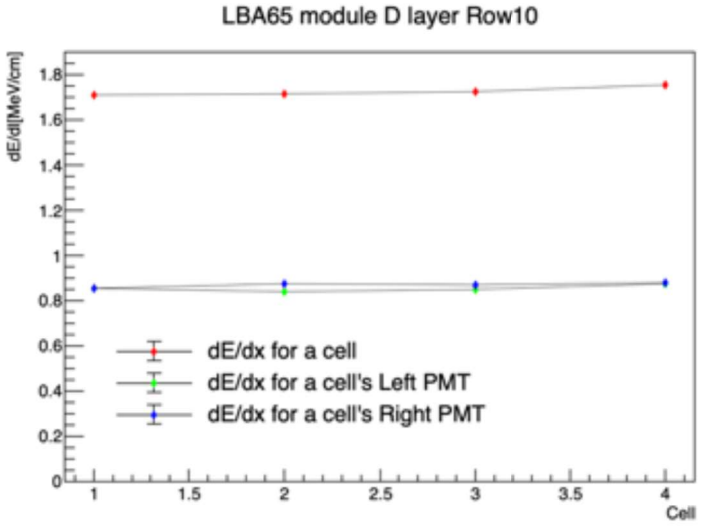
errors on the figures are statistical only and are very small in value.

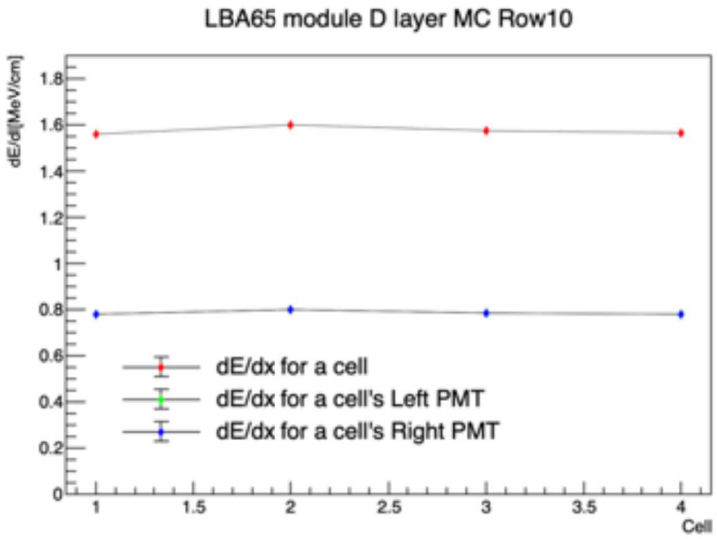




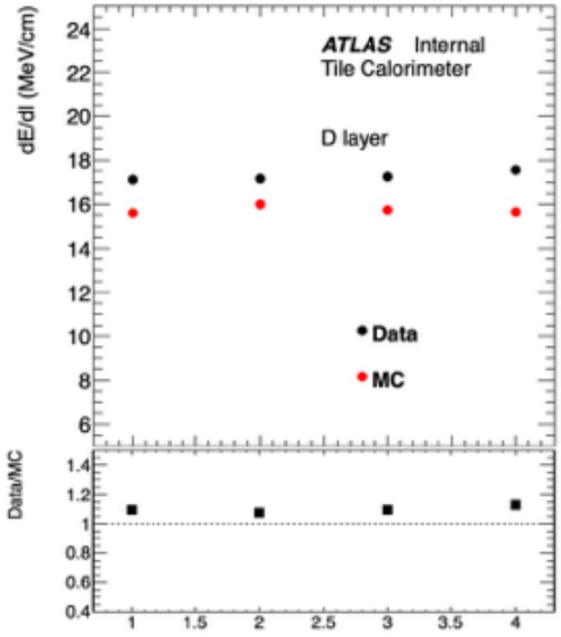
The red horizontal line corresponds to the mean value of determinations for each layer

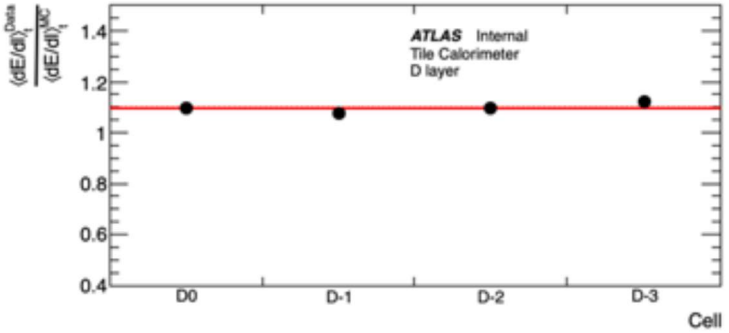
LBA65 - Nov 2022 TB - Row 10





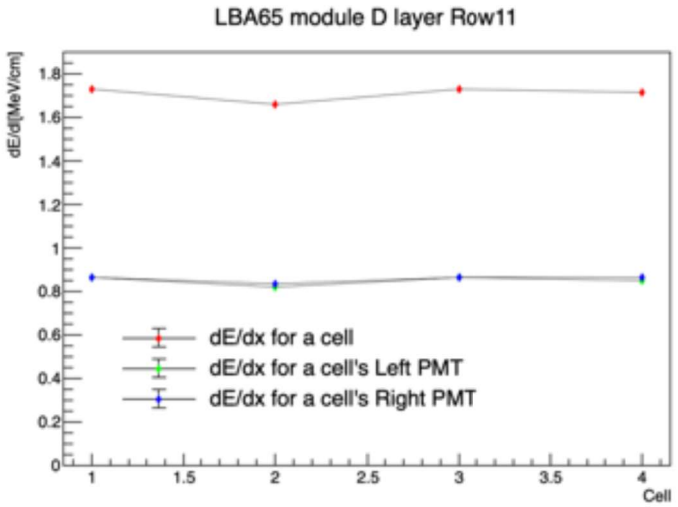
errors on the figures are statistical only and are very small in value.

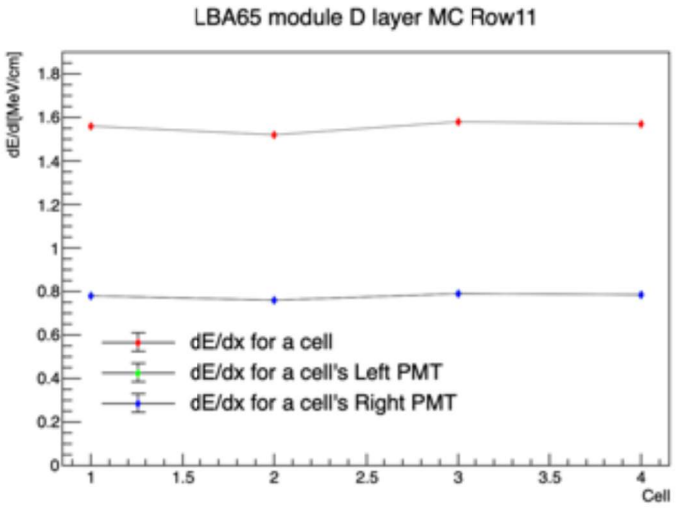




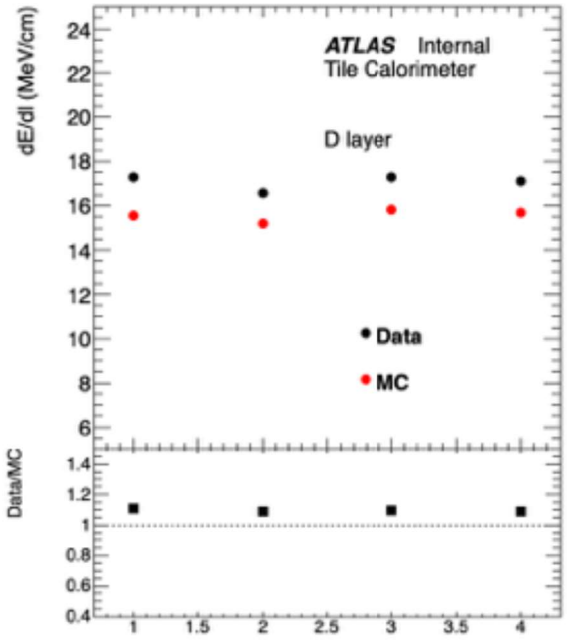
The red horizontal line corresponds to the mean value of determinations for each layer

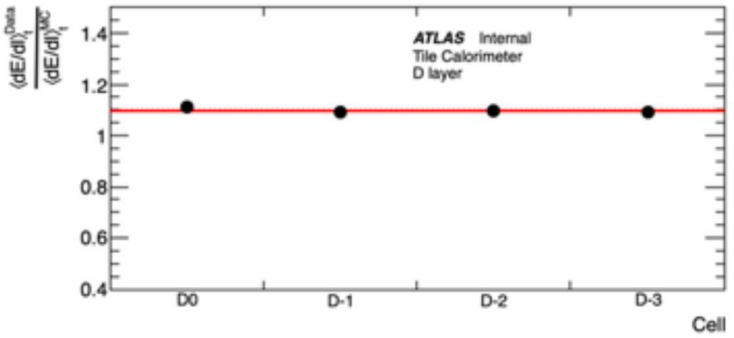
LBA65 - Nov 2022 TB - Row 11





errors on the figures are statistical only and are very small in value.

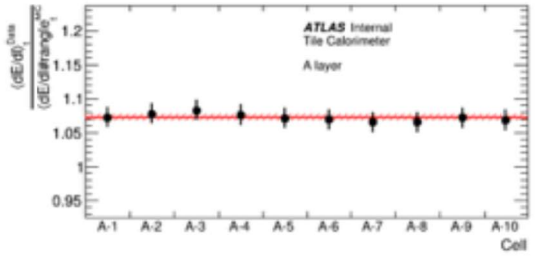




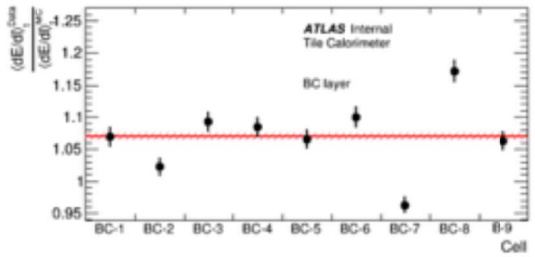
The red horizontal line corresponds to the mean value of determinations for each layer

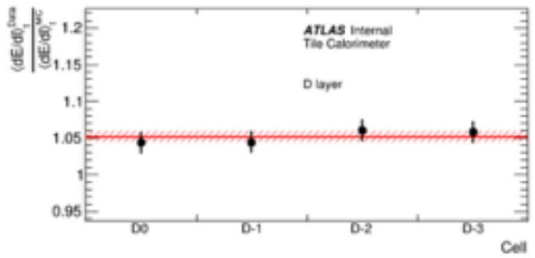
Results from previous TBs - Data vs MC

2018 May data – 160 GeV, LBC65



Layer	Mean	Error
A	1.014	0.005
BC	0.998	0.005
D	1.004	0.007





Cuts:
2 < Tot.E < 20 GeV
BC: |X1|<10mm && |Y1|<10mm

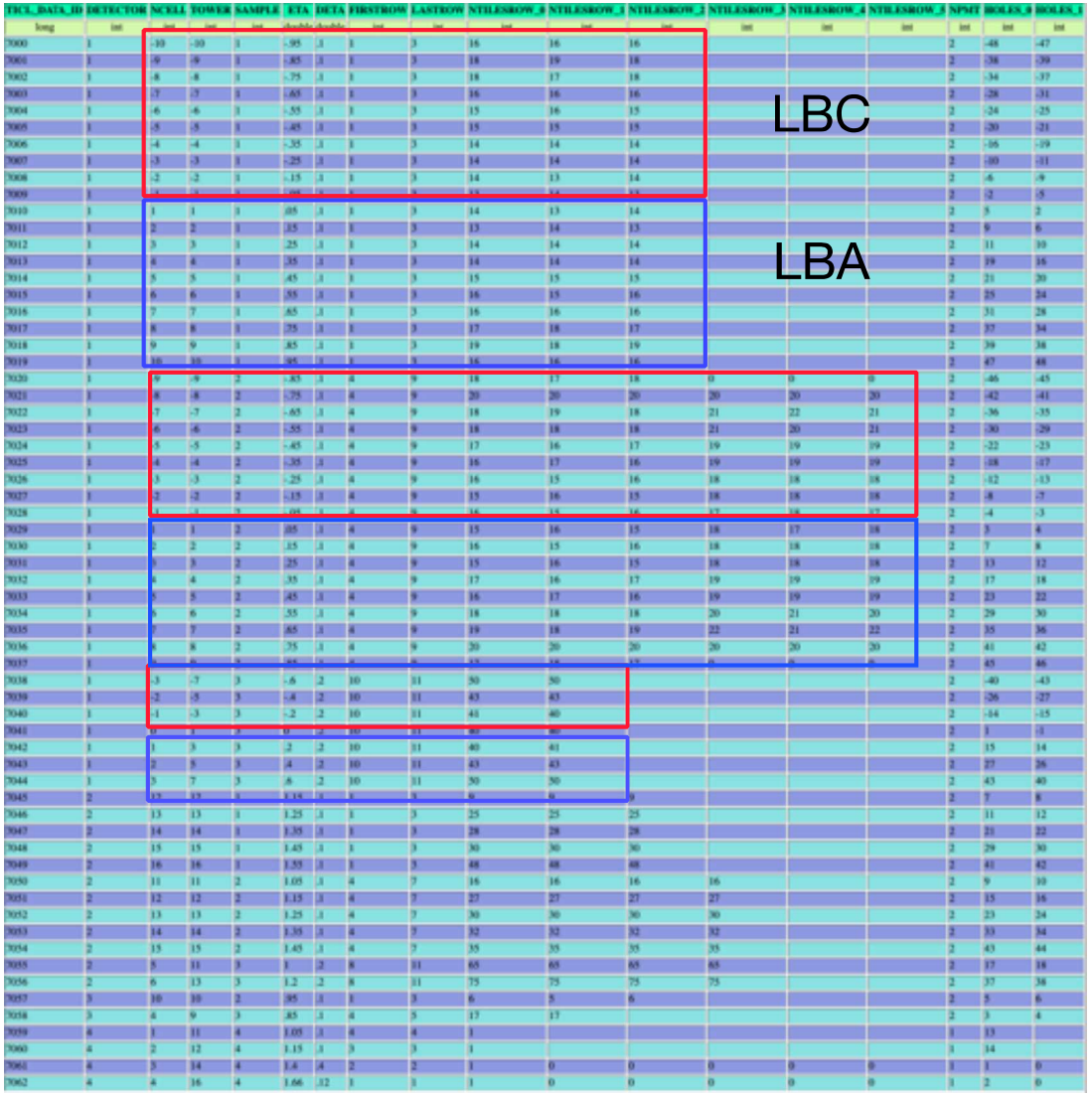
Muon runs: Sep 2023 TB

https://atlas-geo.web.cern.ch/show_tagged_node.php?node_id=NTAwMw==&tag_id=MTQ0MDgz&user=QVRMQVNERF9SRUFERVI=

For upgrade module LBC65 and legacy module LBA65 cells lengths were recalculated for each of 11 rows:
Cells lengths were calculated as:

Number of tiles in given cell multiplied on the average period thickness;

average period thickness:
(5640-20-20+5)/307= 18.2573 mm in barrel
(259.5-20-15)/140=2555.5/140=18.2536 in extended barrel



Column name	Description
TICL_DATA_ID	Unique identifier
DETECTOR	1=Central Barrel, 2=Extended Barrel, 3=ITC, 4=Gap/Crac
NCELL	Cell number
TOWER	Tower
SAMPLE	Sample
ETA	Eta position
DETA	Eta width
FIRSTROW	First tilerow
LASTROW	Last tilerow
NTILESROW_0	Number of tiles in row 0
NTILESROW_1	Number of tiles in row 1
NTILESROW_2	Number of tiles in row 2
NTILESROW_3	Number of tiles in row 3
NTILESROW_4	Number of tiles in row 4
NTILESROW_5	Number of tiles in row 5
NPMT	Number of PMTs
HOLES_0	First hole
HOLES_1	Second hole