



Test Beam Analysis: Muon data TB 2017 – 2018, Sr data analysis results

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Tile Cal Week

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Overview

Analyzed TB data:

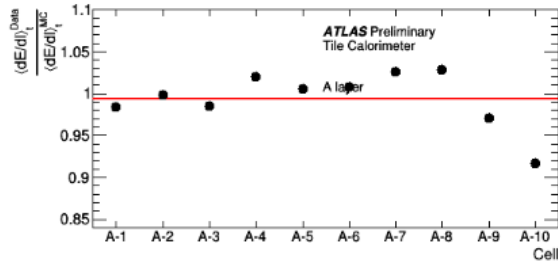
- 2017 TB 165 GeV mu data
- 2018 TB 160 GeV mu data

Analyzed Sr data:

- Sr data set I, II, III, IV

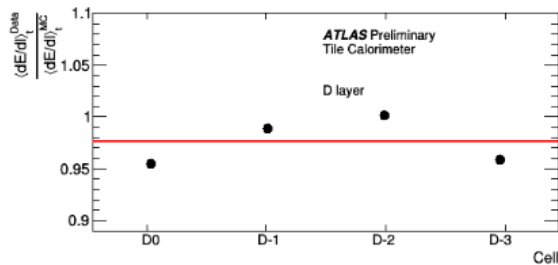
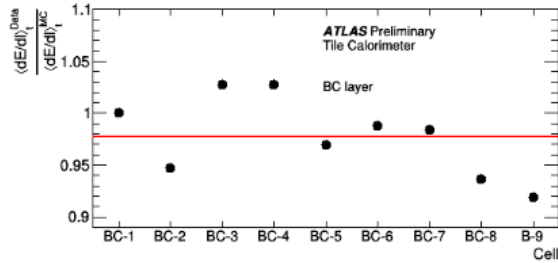
TB data / MC

2017 data



Layer	Mean	St.Dev.
A	0.994	0.032
BC	0.978	0.031
D	0.976	0.031

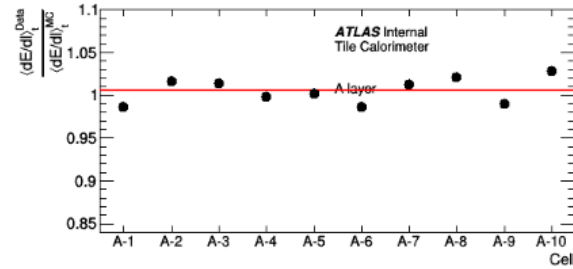
Truncation at 97.5%



Cuts:

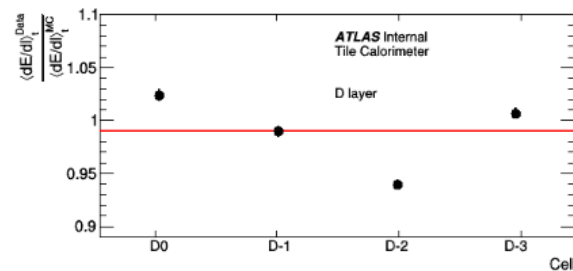
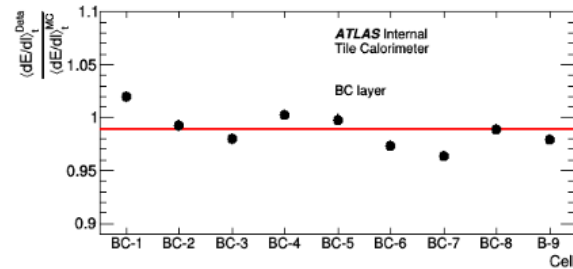
- Signal in last cell of LBC
- BC cuts:
 $|X1| < 10\text{mm}$ && $|Y1| < 10\text{mm}$ &&
 $|X2| < 10\text{mm}$ && $|Y2| < 10\text{mm}$
- $2.5 < \text{Tot.E_Demo} < 20 \text{ GeV}$
- HighGain = 1 in every channel of a layer

2018 data



Layer	Mean	St.Dev.
A	1.006	0.014
BC	0.990	0.017
D	0.990	0.031

Truncation at 97.5%

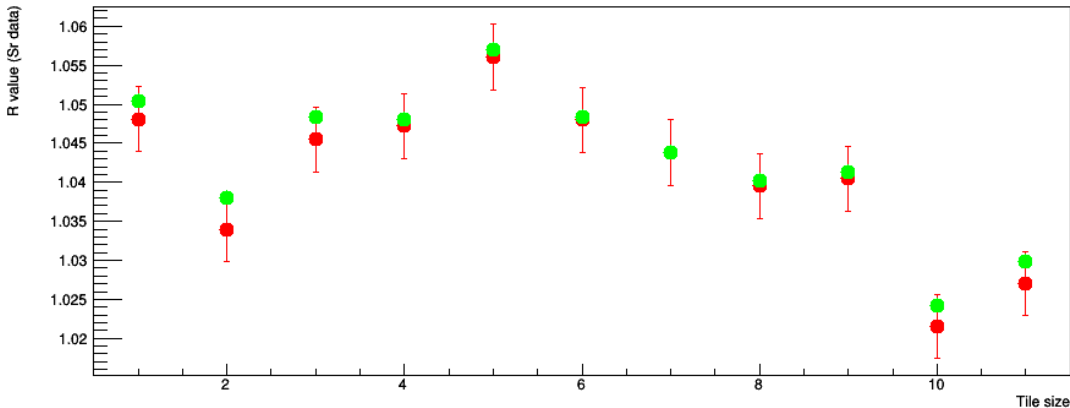


Cuts:

- Signal in last cell of LBC
- BC cuts:
 $|X1| < 10\text{mm}$ && $|Y1| < 10\text{mm}$ &&
 $|X2| < 10\text{mm}$ && $|Y2| < 10\text{mm}$
- $2.5 < \text{Tot.E_Demo} < 20 \text{ GeV}$
- HighGain = 1 in every channel of a layer

Sr data

- Several sets of tile scan Sr data has been analyzed for different materials: PSM and BASF.
- R ratio has been calculated for normal size tiles and cut tiles: R ratio - the mean response of central region (**circle with $r = 2.5\text{cm}$**) of the tile divided by mean response from total surface of the tile.
- Goal is to use these results for **layer correction factors in TileCal** and improve if possible.



Jenya shape cuts – Tile region geometry cuts: -2 mm from all 4 sides, in case of holes cut: -1 mm around two holes.

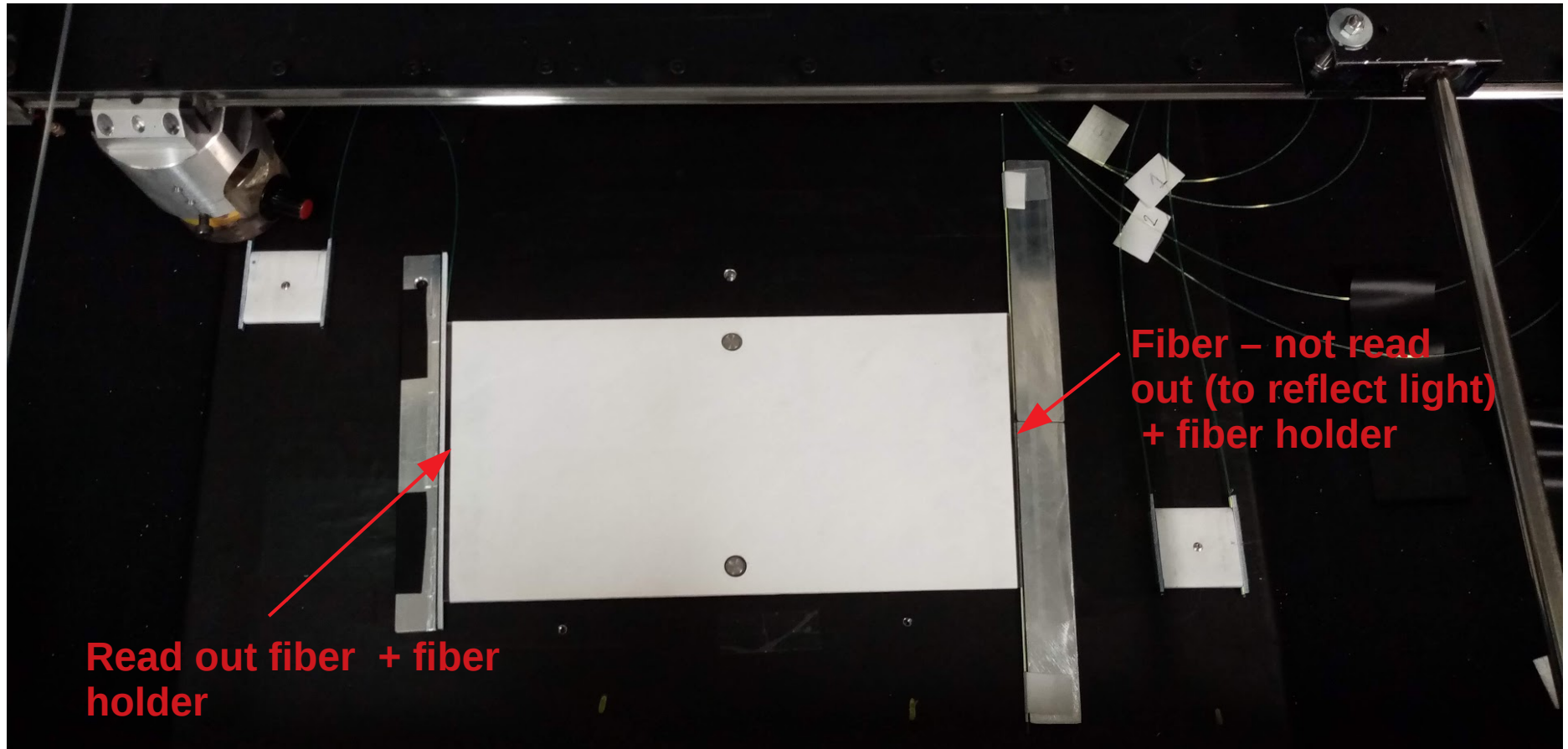
Energy cut: $0 < \text{Signal} - \langle \text{Ped} \rangle < 1$

Sr data set I: Three sets for each tile

Tiles 1,2,3 – PSM

Tiles 4,5,6,7,8,9,10,11,12 - BASF

Sr data taking setup: Autumn, 2020



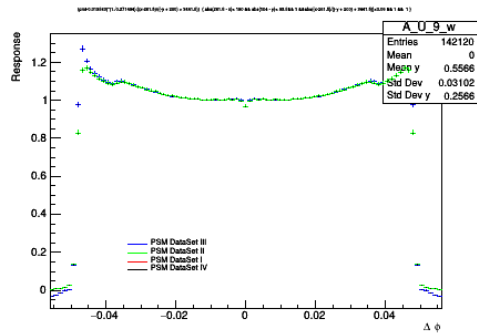
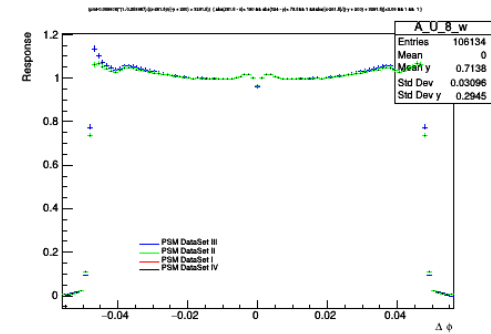
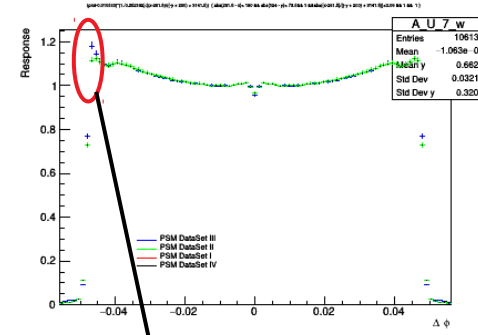
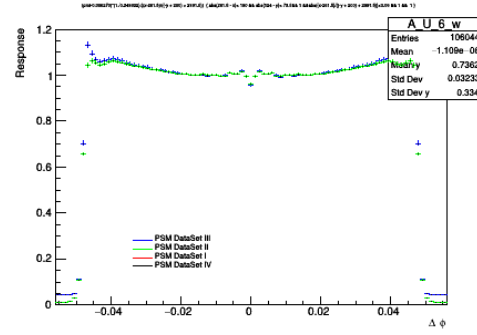
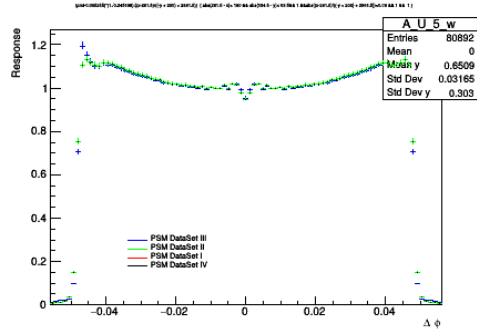
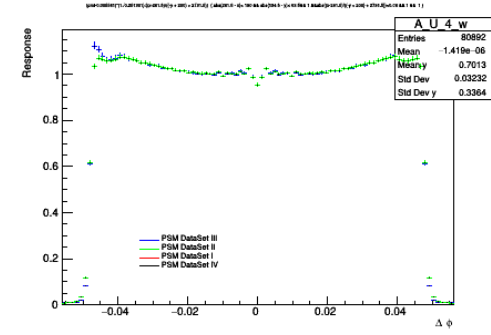
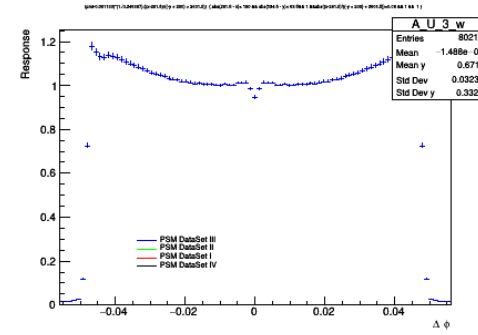
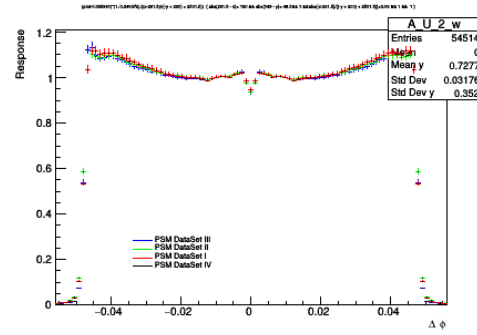
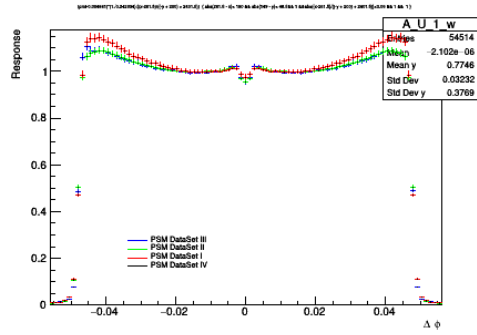
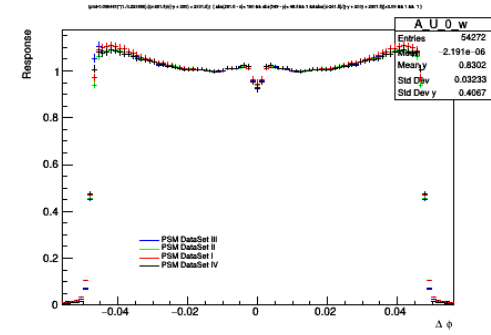
Fiber holder – read out



Fiber holder – not-read out



Sr data: U-shape distributions for each tile size, PSM material



Normalized response:
 Central region
 ($|\Delta\Phi| < 0.01$) is normalized to 1.

Differences on the edge of the tiles (~3mm) in different Sr data sets. Reason is most likely difference in fiber holder.

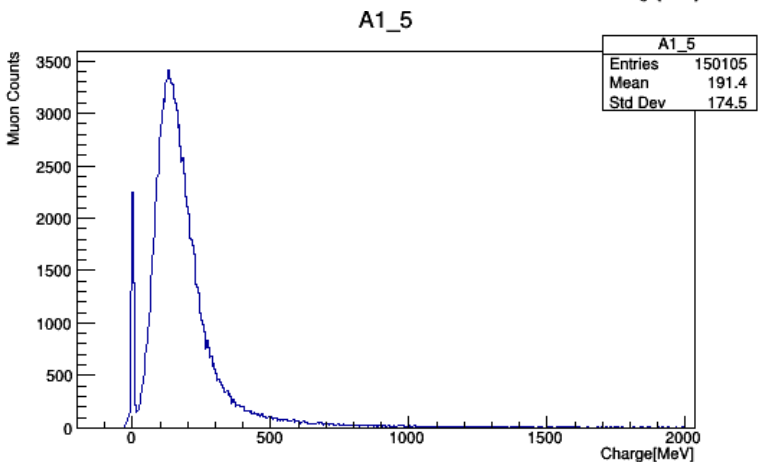
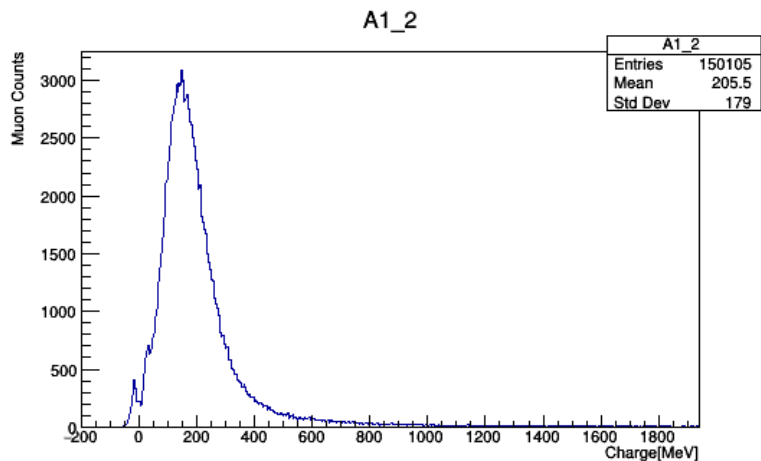
Summary

- Data from 2017 and 2018 TB mu runs are being compared.
- Different sets of tile scan Sr data has been analyzed for different materials: PSM and BASF.
- New Sr data set has been recorded in Autumn, but the plan hasn't been finished - when pandemic situation permits data recordings are planned to renew with newly designed fiber holder.
- R ratio has been calculated for normal size tiles and cut tiles.
- Goal is to use these results for layer correction factors in TileCal and improve if possible.

Thanks to everyone who contributed!

Backup

2017 TB data

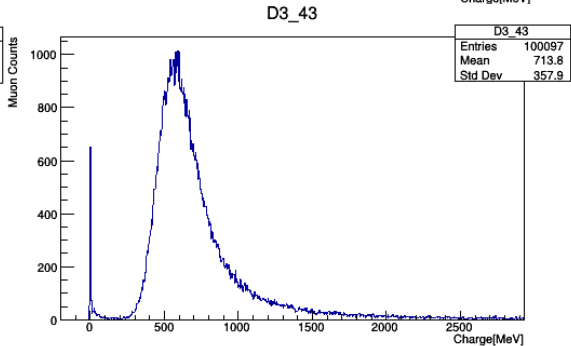
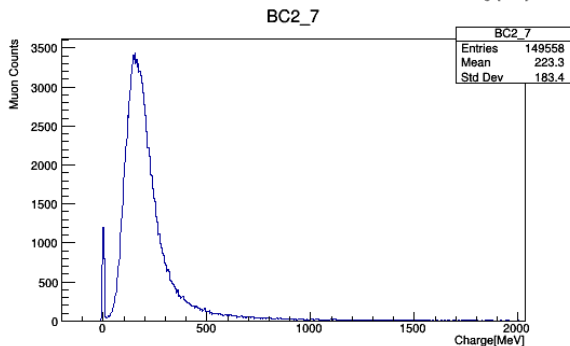
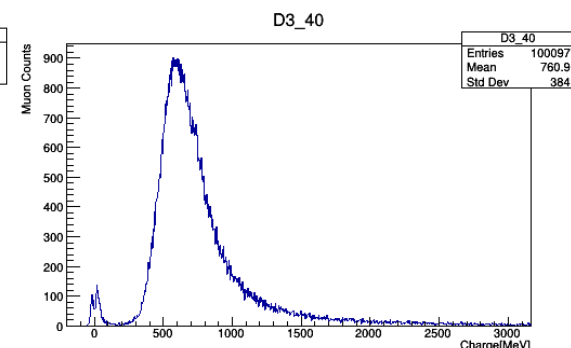
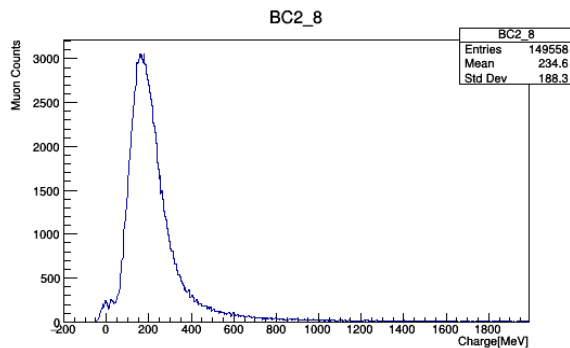


Double peak structure in every Left PMT of every layer for A layer runs!

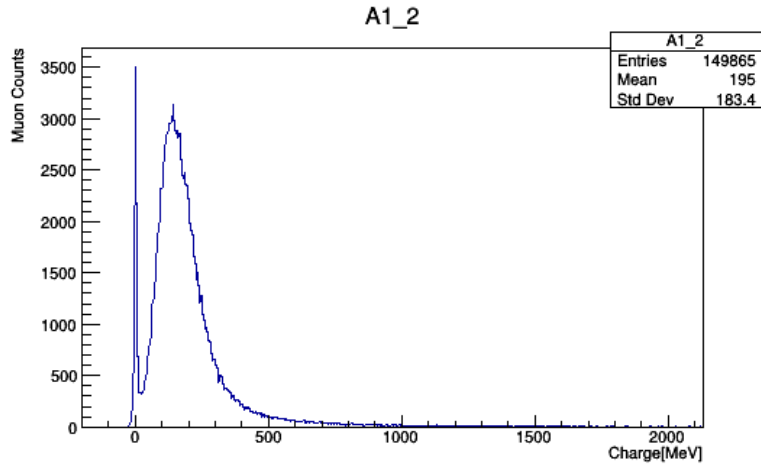
Ntuples used:

/eos/atlas/atlascerngroupdisk/det-tile/testbeam/2017.v3

NO cuts applied



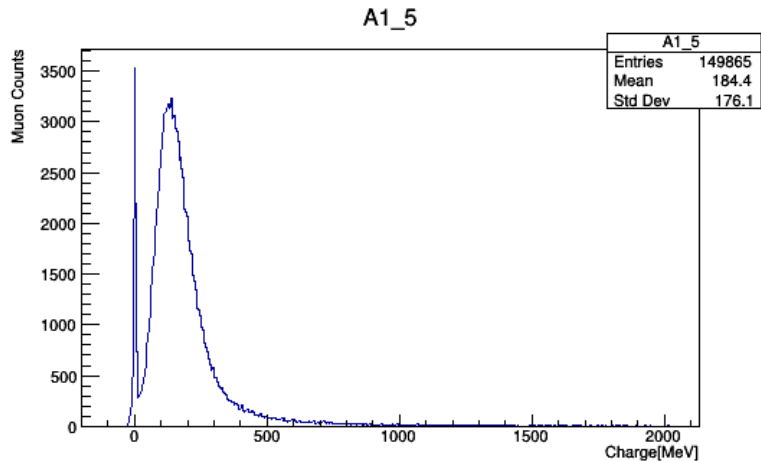
2018 TB data



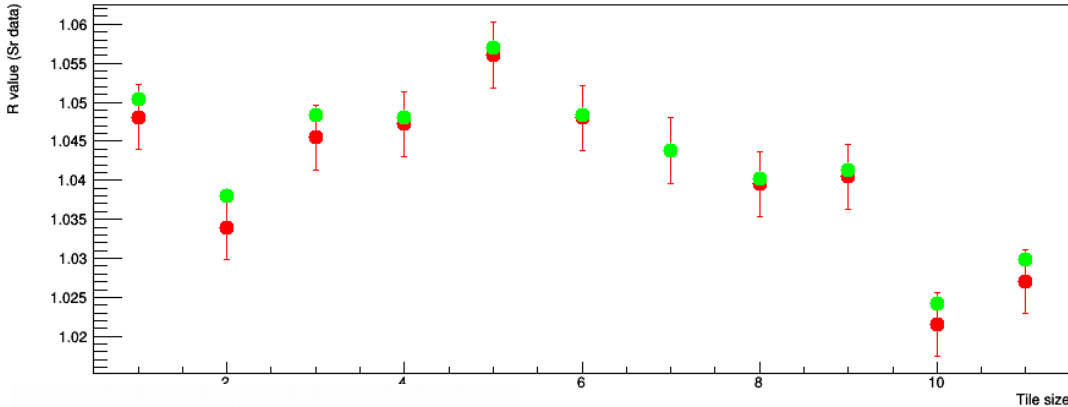
Double peak structure isn't visible for 2018 TB data.

Ntuples used:
`/eos/atlas/atlascerngroupdisk/det-tile/testbeam/2018.v3`

NO cuts applied



R ratios: Jenya's results / our results



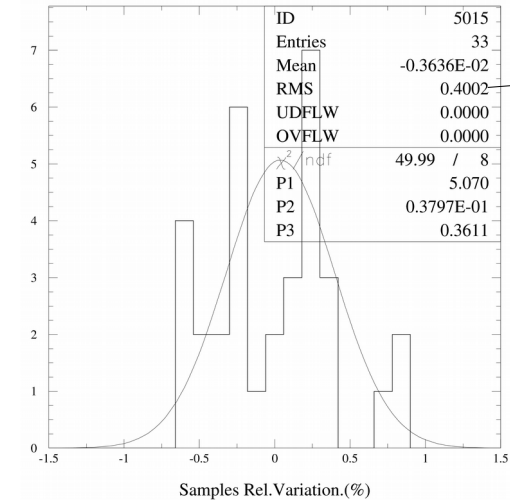
Jenya shape cuts – Tile region geometry cuts: -2 mm from all 4 sides, in case of holes cut: -1 mm around two holes.

Energy cut: $0 < \text{Signal} - \langle \text{Ped} \rangle < 1$

Sr data set I: Three sets for each tile

Tiles 1,2,3 – PSM

Tiles 4,5,6,7,8,9,10,11,12 - BASF



Jenya's updated results (red points):
0.4% of R = Error

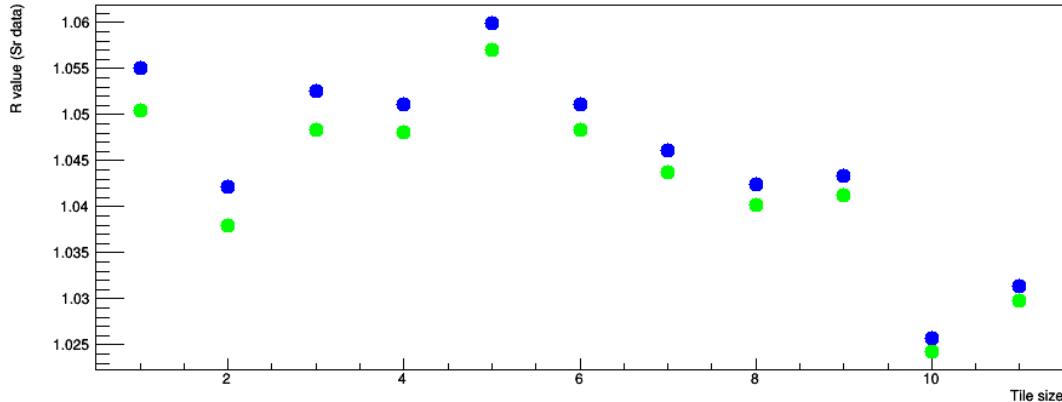
for tile 1 R = 1.0481 +- 0.0041924
 for tile 2 R = 1.034 +- 0.004136
 for tile 3 R = 1.0455 +- 0.004182
 for tile 4 R = 1.0472 +- 0.0041888
 for tile 5 R = 1.0561 +- 0.0042244
 for tile 6 R = 1.048 +- 0.004192
 for tile 7 R = 1.0438 +- 0.0041752
 for tile 8 R = 1.0395 +- 0.004158
 for tile 9 R = 1.0405 +- 0.004162
 for tile 10 R = 1.0215 +- 0.004086
 for tile 11 R = 1.027 +- 0.004108
 A_mean=1.04253 +- 0.00433218 BC_mean=1.04585
 +- 0.00248096 D_mean=1.02425 +- 0.00275
<A>/<BC> = 0.996829 +- 0.00476969
<A>/<D> = 1.01785 +- 0.00503566

Our results with Jenya's shape cuts (green points):
Error = StDev(N of measurements)/N

for tile 1 R = 1.05046 +- 0.000369665
 for tile 2 R = 1.03801 +- 0.000377251
 for tile 3 R = 1.0484 +- 0.000276446
 for tile 4 R = 1.0481 +- 0.000441135
 for tile 5 R = 1.05697 +- 0.000186607
 for tile 6 R = 1.0483 +- 0.000160301
 for tile 7 R = 1.04375 +- 0.000326099
 for tile 8 R = 1.04018 +- 0.000156418
 for tile 9 R = 1.04123 +- 0.00011317
 for tile 10 R = 1.02425 +- 0.000151731
 for tile 11 R = 1.0298 +- 0.000333678
 A_mean=1.04562 +- 0.00314615 BC_mean=1.04642
 +- 0.00230152 D_mean=1.02703 +- 0.0019634
<A>/<BC> = 0.999234 +- 0.00372419
<A>/<D> = 1.01811 +- 0.00362939

A Rel. Variatiion $V = (\langle R_{\text{sample}} \rangle - R_{\text{tile}}) / \langle R_{\text{sample}} \rangle$
All 11 tiles taken into account

R ratios – with/without hole cuts



Jenya shape cuts – Tile region geometry cuts: -2 mm from all 4 sides, in case of holes cut: -1 mm around two holes.

Energy cut: $0 < \text{Signal} - \langle \text{Ped} \rangle < 1$

Sr data set I: Three sets for each tile

Tiles 1,2,3 – PSM

Tiles 4,5,6,7,8,9,10,11,12 - BASF

Our results with Jenya's shape cuts (green points):

Error = $\text{StDev}(\text{N of measurments})/\sqrt{\text{N}}$

for tile 1 R = 1.05046 +- 0.000369665

for tile 2 R = 1.03801 +- 0.000377251

for tile 3 R = 1.0484 +- 0.000276446

for tile 4 R = 1.0481 +- 0.000441135

for tile 5 R = 1.05697 +- 0.000186607

for tile 6 R = 1.0483 +- 0.000160301

for tile 7 R = 1.04375 +- 0.000326099

for tile 8 R = 1.04018 +- 0.000156418

for tile 9 R = 1.04123 +- 0.00011317

for tile 10 R = 1.02425 +- 0.000151731

for tile 11 R = 1.0298 +- 0.000333678

A_mean=1.04562 +- 0.00314615 BC_mean=1.04642

+ - 0.00230152 D_mean=1.02703 +- 0.0019634

<A>/<BC> = 0.999234 +- 0.00372419

<A>/<D> = 1.01811 +- 0.00362939

Our results with Jenya's shape cuts, HOLES included (blue points):

Error = $\text{StDev}(\text{N of measurments})/\sqrt{\text{N}}$

for tile 1 mean = 1.055 +- 0.000311127

for tile 2 mean = 1.04211 +- 0.000411528

for tile 3 mean = 1.0525 +- 0.000272764

for tile 4 mean = 1.05105 +- 0.000411537

for tile 5 mean = 1.05989 +- 0.000189522

for tile 6 mean = 1.05115 +- 0.000148549

for tile 7 mean = 1.0461 +- 0.000323419

for tile 8 mean = 1.04242 +- 0.000153213

for tile 9 mean = 1.0433 +- 0.000115566

for tile 10 mean = 1.02572 +- 0.00014184

for tile 11 mean = 1.03132 +- 0.000341793

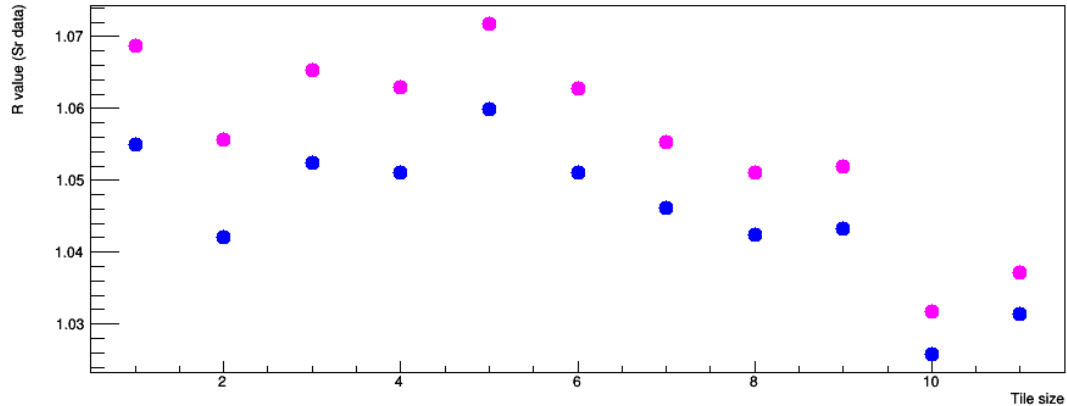
A_mean=1.04987 +- 0.00322234 BC_mean=1.04898

+ - 0.0024244 D_mean=1.02852 +- 0.00197872

<A>/<BC> = 1.00084 +- 0.00384538

<A>/<D> = 1.02076 +- 0.00369757

R ratios – without hole cuts, our cuts



Our shape cuts – Tile region geometry cuts: -0 mm from all 4 sides.
Energy cut: $0 < \text{Signal} - \langle \text{Ped} \rangle < 1$

Sr data set I: Three sets for each tile

Tiles 1,2,3 – PSM

Tiles 4,5,6,7,8,9,10,11,12 - BASF

Our results with Jenya's shape cuts, HOLES included (blue points):

Error = $\text{StDev}(\text{N of measurments})/\sqrt{\text{N}}$

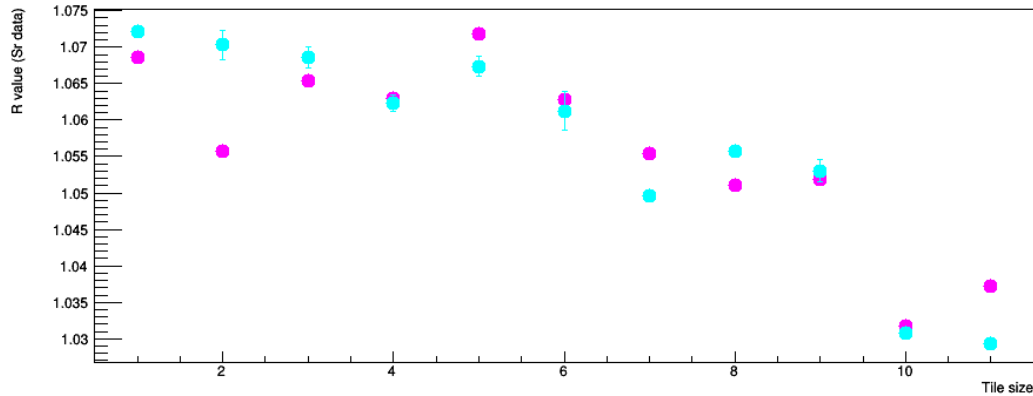
for tile 1 mean = 1.055 +- 0.000311127
 for tile 2 mean = 1.04211 +- 0.000411528
 for tile 3 mean = 1.0525 +- 0.000272764
 for tile 4 mean = 1.05105 +- 0.000411537
 for tile 5 mean = 1.05989 +- 0.000189522
 for tile 6 mean = 1.05115 +- 0.000148549
 for tile 7 mean = 1.0461 +- 0.000323419
 for tile 8 mean = 1.04242 +- 0.000153213
 for tile 9 mean = 1.0433 +- 0.000115566
 for tile 10 mean = 1.02572 +- 0.00014184
 for tile 11 mean = 1.03132 +- 0.000341793
 A_mean=1.04987 +- 0.00322234 BC_mean=1.04898
 +- 0.0024244 D_mean=1.02852 +- 0.00197872
<A>/<BC> = 1.00084 +- 0.00384538
<A>/<D> = 1.02076 +- 0.00369757

Results with our shape cuts, HOLES included (violet points):

Error = $\text{StDev}(\text{N of measurments})/\sqrt{\text{N}}$

for tile 1 mean = 1.06865 +- 0.000569919
 for tile 2 mean = 1.05574 +- 0.000406721
 for tile 3 mean = 1.0654 +- 0.000238762
 for tile 4 mean = 1.06299 +- 0.000482563
 for tile 5 mean = 1.07183 +- 0.000150727
 for tile 6 mean = 1.06281 +- 0.000141421
 for tile 7 mean = 1.05533 +- 0.000343155
 for tile 8 mean = 1.05112 +- 0.000144094
 for tile 9 mean = 1.05187 +- 0.000110588
 for tile 10 mean = 1.0318 +- 0.000137948
 for tile 11 mean = 1.03716 +- 0.000383522
 A_mean=1.06326 +- 0.00316459 BC_mean=1.05933
 +- 0.0029851 D_mean=1.03448 +- 0.00189387
<A>/<BC> = 1.00371 +- 0.0041139
<A>/<D> = 1.02782 +- 0.0035915

R ratios – Sr data set I and II comparison



Our shape cuts – Tile region geometry cuts: -0 mm from all 4 sides.

Energy cut: $0 < \text{Signal} - \langle \text{Ped} \rangle < 1$

Sr data set I: Three sets for each tile

Sr data set II: Three samples and three sets for each tile

Tiles 1,2,3 – PSM

Tiles 4,5,6,7,8,9,10,11,12 - BASF

Results with our shape cuts, HOLES included (violet points):

Error = $\text{StDev}(\text{N of measurments})/\sqrt{\text{N}}$

for tile 1 mean = 1.06865 +- 0.000569919

for tile 2 mean = 1.05574 +- 0.000406721

for tile 3 mean = 1.0654 +- 0.000238762

for tile 4 mean = 1.06299 +- 0.000482563

for tile 5 mean = 1.07183 +- 0.000150727

for tile 6 mean = 1.06281 +- 0.000141421

for tile 7 mean = 1.05533 +- 0.000343155

for tile 8 mean = 1.05112 +- 0.000144094

for tile 9 mean = 1.05187 +- 0.000110588

for tile 10 mean = 1.0318 +- 0.000137948

for tile 11 mean = 1.03716 +- 0.000383522

A_mean=1.06326 +- 0.00316459 BC_mean=1.05933

+ - 0.0029851 D_mean=1.03448 +- 0.00189387

<A>/<BC> = 1.00371 +- 0.0041139

<A>/<D> = 1.02782 +- 0.0035915

Results with our shape cuts, HOLES included (light blue points):

Error = $\text{StDev}(\text{N of measurments})/\sqrt{\text{N}}$

for tile 1 mean R = 1.0722 +- 0.000781565

for tile 2 mean R = 1.07032 +- 0.00202565

for tile 3 mean R = 1.06867 +- 0.00144547

for tile 4 mean R = 1.06228 +- 0.00112688

for tile 5 mean R = 1.06736 +- 0.00140084

for tile 6 mean R = 1.06123 +- 0.0026468

for tile 7 mean R = 1.04964 +- 0.00071547

for tile 8 mean R = 1.05565 +- 0.000572054

for tile 9 mean R = 1.05302 +- 0.00152541

for tile 10 mean R = 1.03085 +- 0.000288232

for tile 11 mean R = 1.02939 +- 0.000419878

A_mean=1.0704 +- 0.00102097 BC_mean=1.0582

+ - 0.00268555 D_mean=1.03012 +- 0.000733889

<A>/<BC> = 1.01153 +- 0.00274243

<A>/<D> = 1.0391 +- 0.00123707

Comparison of different types of tiles – using Sr data set II

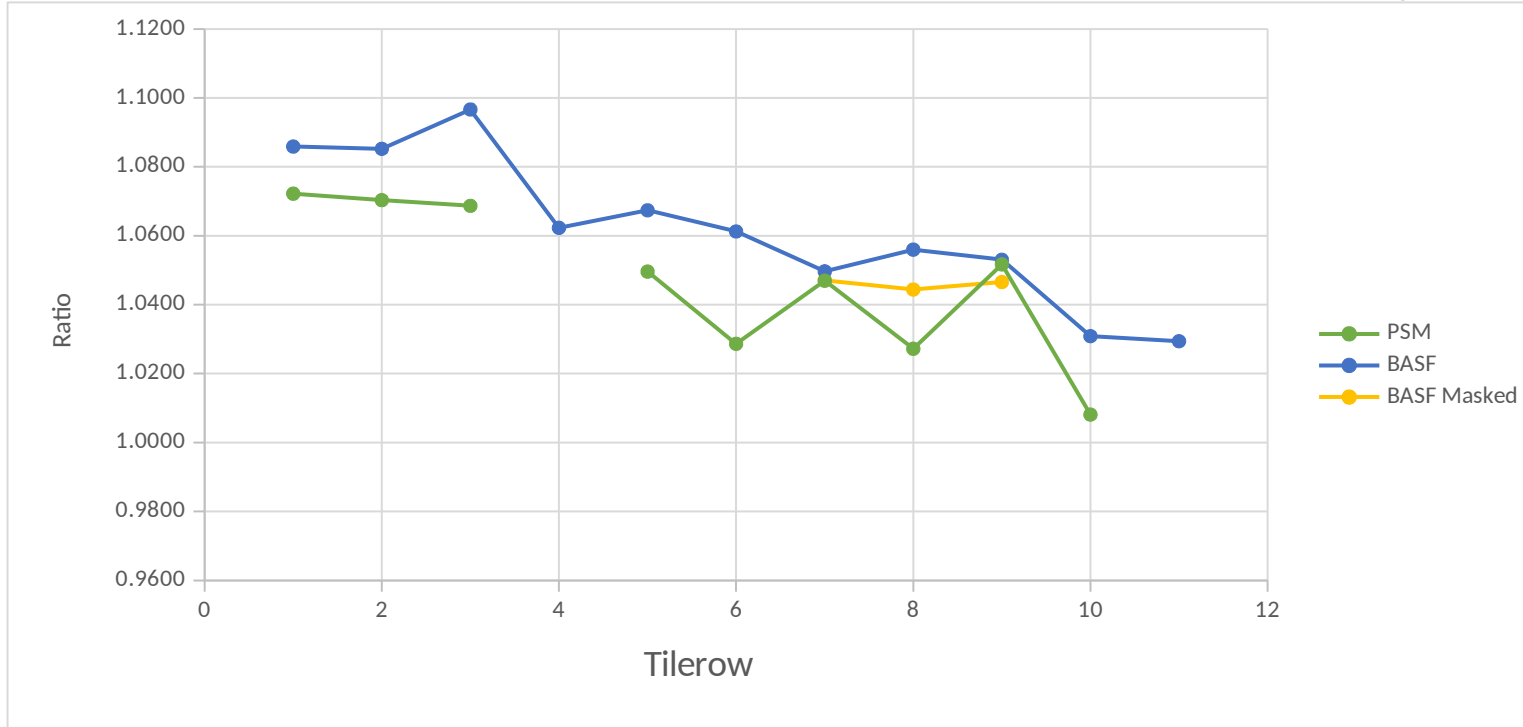
Our shape cuts – Tile region geometry cuts:

-0 mm from all 4 sides.

Energy cut:

$0 < \text{Signal} - \langle \text{Ped} \rangle < 1$

PSM: Tileros 4 and 11 are missing, We have to understand the big oscillations in the region $5 \leq \text{Tilerow} \leq 10$



R values on the next slide

Comparison of different types of tiles – using Sr data set II

BASF - Results with our shape cuts, HOLES included (blue points):

Error = StDev(N of measurments)/√N

for tile 1 mean R = 1.08587 +- 0.00184578

for tile 2 mean R = 1.08521 +- 0.000663304

for tile 3 mean R = 1.09663 +- 0.000705016

for tile 4 mean R = 1.06228 +- 0.00112688

for tile 5 mean R = 1.06736 +- 0.00140084

for tile 6 mean R = 1.06123 +- 0.0026468

for tile 7 mean R = 1.04964 +- 0.00071547

for tile 8 mean R = 1.05565 +- 0.000572054

for tile 9 mean R = 1.05302 +- 0.00152541

for tile 10 mean R = 1.03085 +- 0.000288232

for tile 11 mean R = 1.02939 +- 0.000419878

A_mean=1.08924 +- 0.00370177 BC_mean=1.0582

+ - 0.00268555 D_mean=1.03012 +- 0.000733889

<A>/<BC> = 1.02933 +- 0.00436593

<A>/<D> = 1.05739 +- 0.00367165

PSM - Results with our shape cuts, HOLES included (green points):

Error = StDev(N of measurments)/√N

for tile 1 mean R = 1.0722 +- 0.000781565

for tile 2 mean R = 1.07032 +- 0.00202565

for tile 3 mean R = 1.06867 +- 0.00144547

for tile 4 mean R = 0 +- 0

for tile 5 mean R = 1.04958 +- 0.00164773

for tile 6 mean R = 1.02864 +- 0.00113767

for tile 7 mean R = 1.04695 +- 0.000425703

for tile 8 mean R = 1.0272 +- 0.00195938

for tile 9 mean R = 1.05167 +- 0.00228536

for tile 10 mean R = 1.0081 +- 0.000320982

for tile 11 mean R = 0 +- 0

A_mean=1.0704 +- 0.00102097 BC_mean=1.04081

+ - 0.00531975 D_mean=1.0081 +- 0.000320982

<A>/<BC> = 1.02843 +- 0.00534721

<A>/<D> = 1.06179 +- 0.0010677

BASF Masked - Results with our shape cuts, HOLES included (orange points):

Error = StDev(N of measurments)/√N

for tile 7 mean R = 1.04708 +- 0.00117369

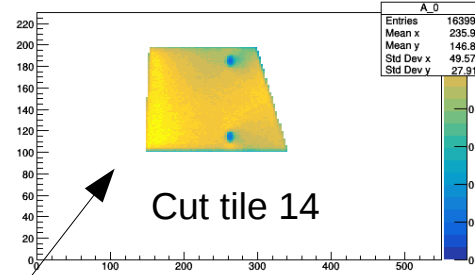
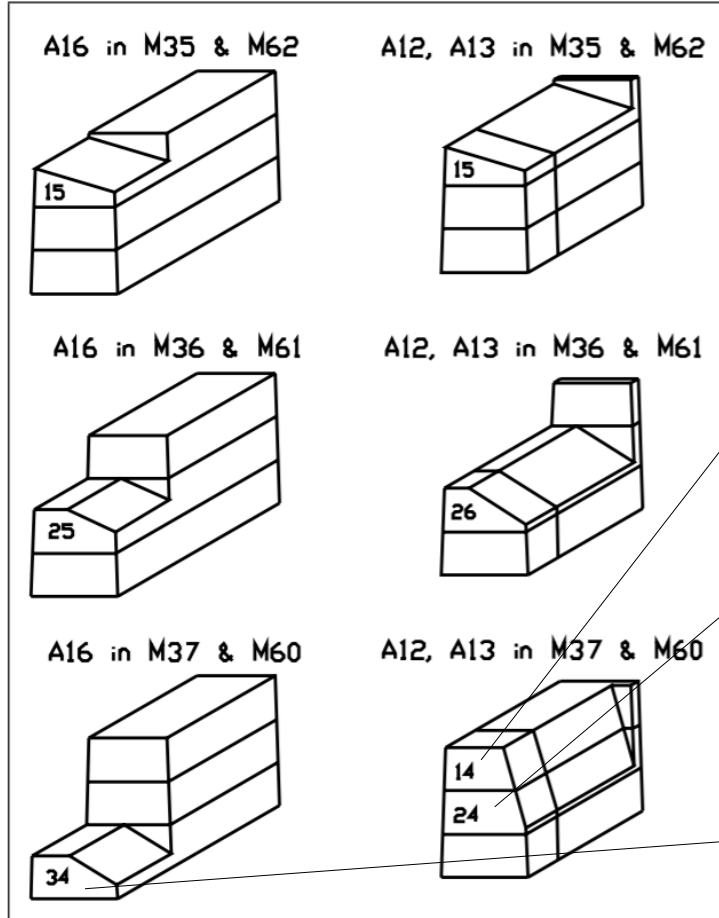
for tile 8 mean R = 1.04439 +- 0.00100103

for tile 9 mean R = 1.04654 +- 0.00128677

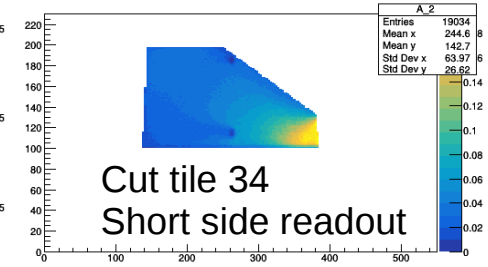
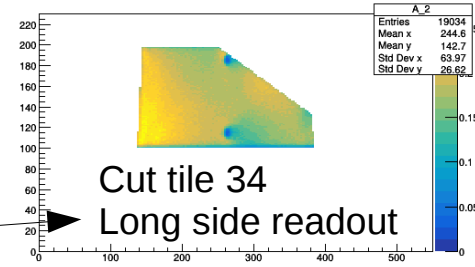
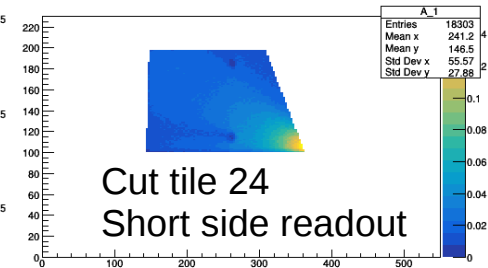
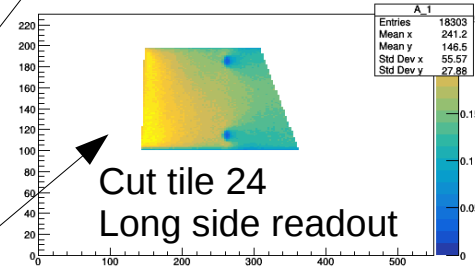
Sr data set II: Three samples and three sets for each tile

R ratios for cut tiles

Sr data set II: Three samples and three sets for each tile's long and short readout

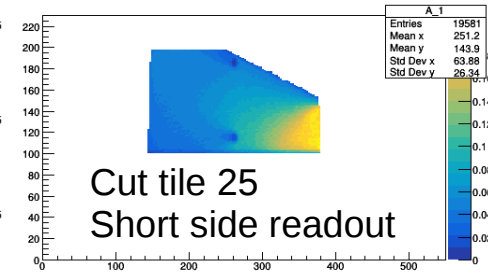
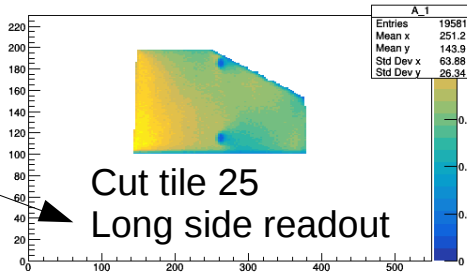
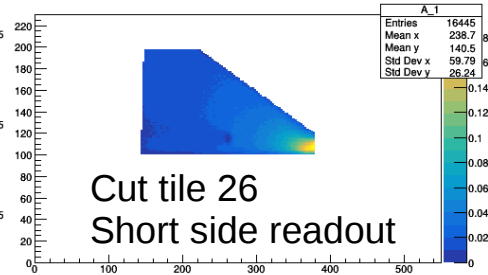
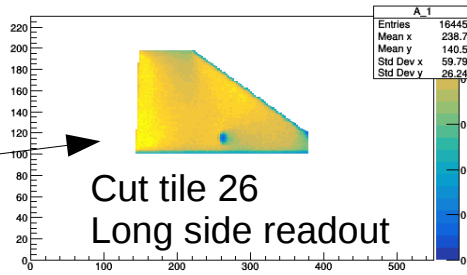
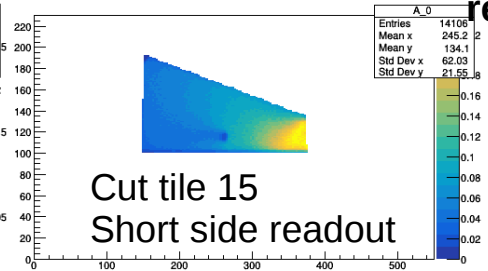
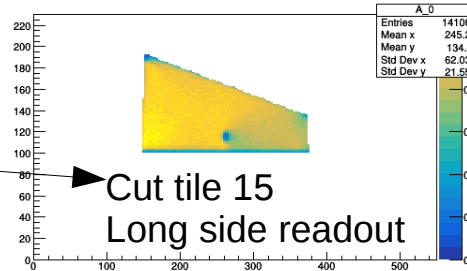
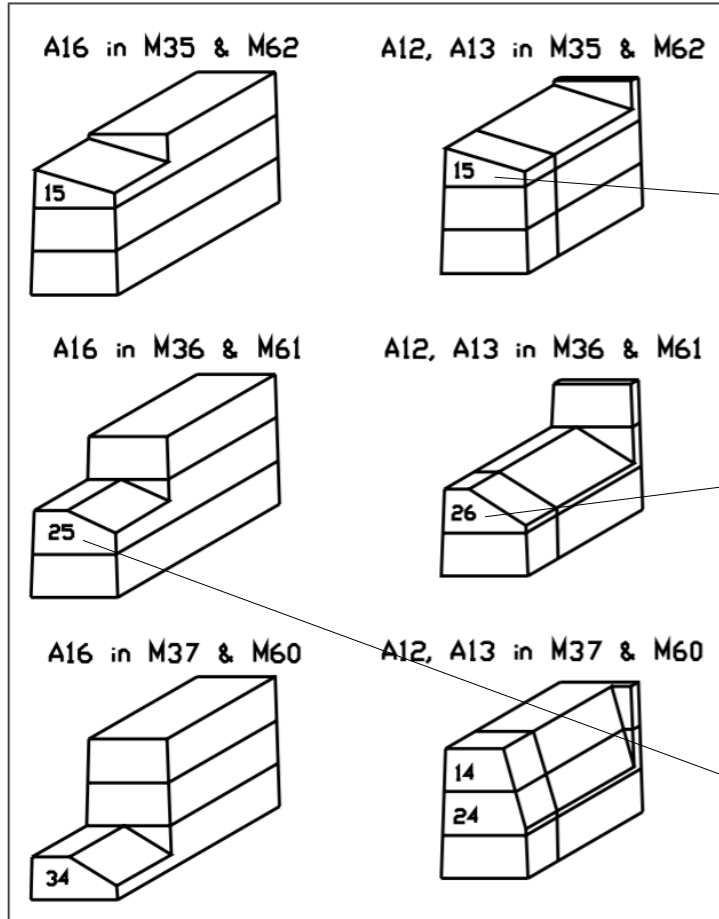


No SHORT side data, only LONG side

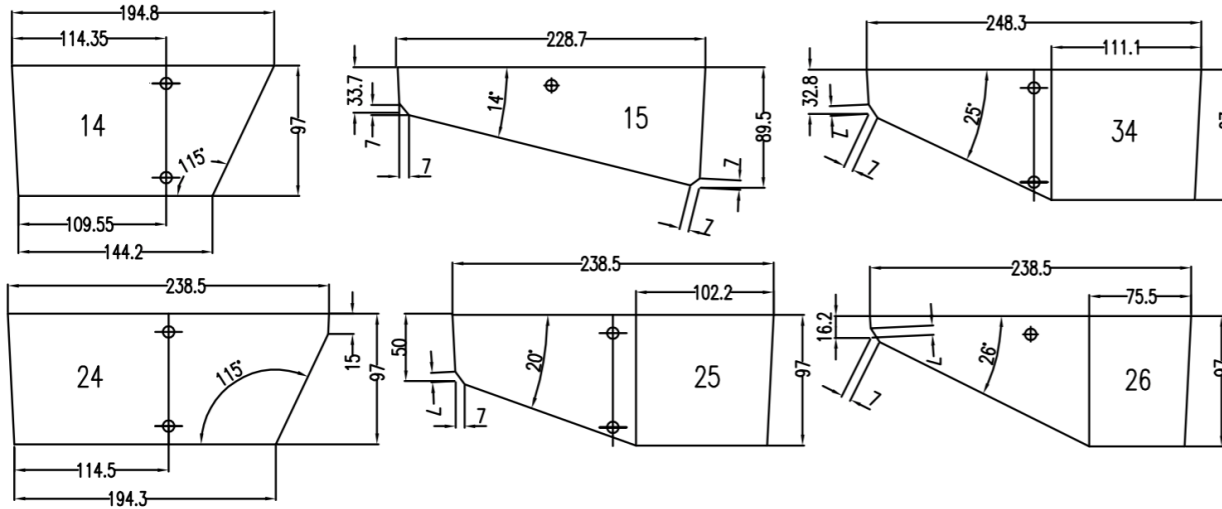


R ratios for cut tiles

Sr data set II: Three samples and three sets for each tile's long and short readout



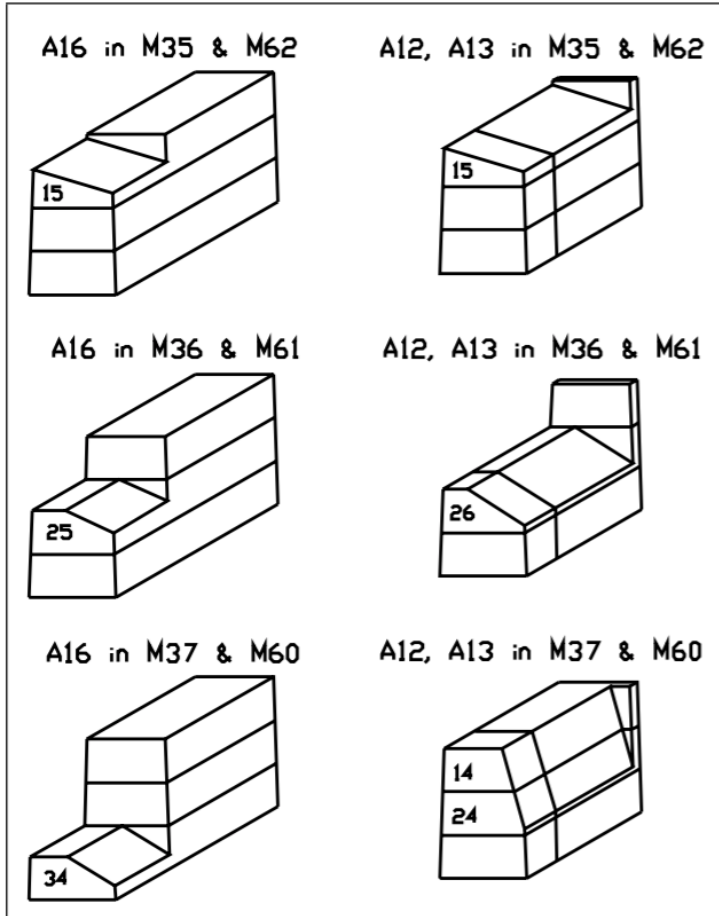
R ratios for cut tiles



Each value is a mean value of R of short and long readout

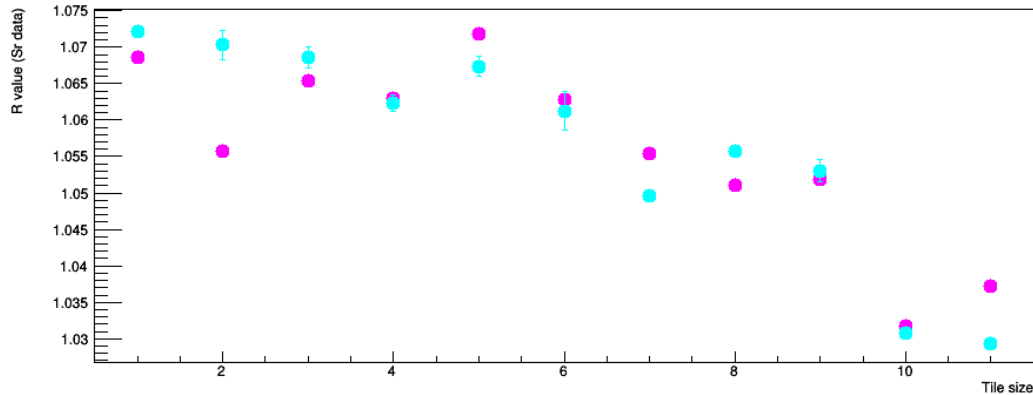
- Cut 26: for tile 2 mean R = 1.015003 +/- 0.064547000
- Cut 15: for tile 1 mean R = 1.0315725 +/- 0.031472500
- Cut 25: for tile 2 mean R = 0.9957015 +/- 0.000590498
- Cut 14: for tile 1 mean R = 1.02881 +/- 0.00195056
- Cut 24: for tile 2 mean R = 1.031353 +/- 0.041427000
- Cut 34: for tile 3 mean R = 0.970399 +/- 0.004207003

Table for cut tiles



Cut cell	Periods cut	Total N of periods
A12	9	9
A13	23	25
A16	16	48

R ratios – Sr data set I and II comparison



Our shape cuts – Tile region geometry cuts: -0 mm from all 4 sides.

Energy cut: $0 < \text{Signal} - \langle \text{Ped} \rangle < 1$

Sr data set I: Three sets for each tile

Sr data set II: Three samples and three sets for each tile

Tiles 1,2,3 – PSM

Tiles 4,5,6,7,8,9,10,11,12 - BASF

Results with our shape cuts,

HOLES included (violet points):

Error = $\text{StDev}(\text{N of measurments})/\sqrt{\text{N}}$

for tile 1 mean = 1.06865 +- 0.000569919
 for tile 2 mean = 1.05574 +- 0.000406721
 for tile 3 mean = 1.0654 +- 0.000238762
 for tile 4 mean = 1.06299 +- 0.000482563
 for tile 5 mean = 1.07183 +- 0.000150727
 for tile 6 mean = 1.06281 +- 0.000141421
 for tile 7 mean = 1.05533 +- 0.000343155
 for tile 8 mean = 1.05112 +- 0.000144094
 for tile 9 mean = 1.05187 +- 0.000110588
 for tile 10 mean = 1.0318 +- 0.000137948
 for tile 11 mean = 1.03716 +- 0.000383522
 A_mean=1.06326 +- 0.00316459 BC_mean=1.05933
 +- 0.0029851 D_mean=1.03448 +- 0.00189387
<A>/<BC> = 1.00371 +- 0.0041139
<A>/<D> = 1.02782 +- 0.0035915

Results with our shape cuts,

HOLES included (light blue points):

Error = $\text{StDev}(\text{N of measurments})/\sqrt{\text{N}}$

for tile 1 mean R = 1.0722 +- 0.000781565
 for tile 2 mean R = 1.07032 +- 0.00202565
 for tile 3 mean R = 1.06867 +- 0.00144547
 for tile 4 mean R = 1.06228 +- 0.00112688
 for tile 5 mean R = 1.06736 +- 0.00140084
 for tile 6 mean R = 1.06123 +- 0.0026468
 for tile 7 mean R = 1.04964 +- 0.00071547
 for tile 8 mean R = 1.05565 +- 0.000572054
 for tile 9 mean R = 1.05302 +- 0.00152541
 for tile 10 mean R = 1.03085 +- 0.000288232
 for tile 11 mean R = 1.02939 +- 0.000419878
 A_mean=1.0704 +- 0.00102097 BC_mean=1.0582
 +- 0.00268555 D_mean=1.03012 +- 0.000733889
<A>/<BC> = 1.01153 +- 0.00274243
<A>/<D> = 1.0391 +- 0.00123707

New Sr data is being recorded:

HOLES included (light blue points):

Error = $\text{StDev}(\text{N of measurments})/\sqrt{\text{N}}$

for tile 1 <R> = 1.0609 +- 0.00374839 (samples 1-5 means ave.)
 for tile 2 <R> = 1.05794 +- 0.00157764 (samples 1-3 means ave.)
 for tile 3 <R> = 1.05752 +- 0.00172787 (samples 1-3 means ave.)

New Sr data results

for tile 1 $R = 1.05802 \pm 0.000298775$ (sample 1 - 3 scans averaged)

for tile 1 $R = 1.04962 \pm 0.00097983$ (sample 2 - 3 scans averaged)

for tile 1 $R = 1.06511 \pm 0.000321605$ (sample 3 - 3 scans averaged)

for tile 1 $R = 1.07213 \pm 0.000284722$ (sample 4 - 3 scans averaged)

for tile 1 $R = 1.05962 \pm 0.000832217$ (sample 5 - 3 scans averaged)

for tile 1 $\langle R \rangle = 1.0609 \pm 0.00374839$ (samples 1-5 means averaged)

for tile 2 $R = 1.0568 \pm 0.000756165$ (sample 1 - 3 scans)

for tile 2 $R = 1.05596 \pm 0.00110535$ (sample 2 - 3 scans)

for tile 2 $R = 1.06106 \pm 0.000278847$ (sample 3 - 3 scans)

for tile 2 $\langle R \rangle = 1.05794 \pm 0.00157764$ (samples 1-3 means averaged)

for tile 3 $R = 1.05408 \pm 0.000685927$ (sample 1 - 3 scans)

for tile 3 $R = 1.05951 \pm 0.000330331$ (sample 2 - 3 scans)

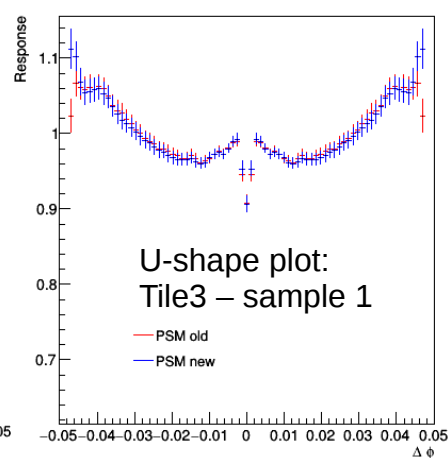
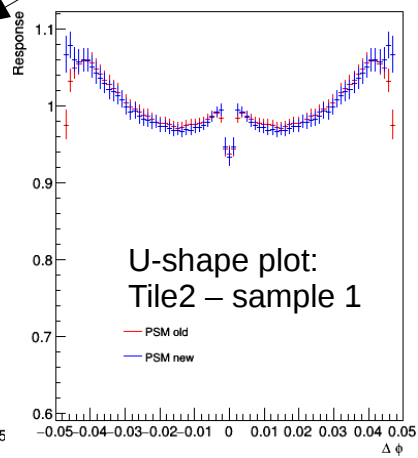
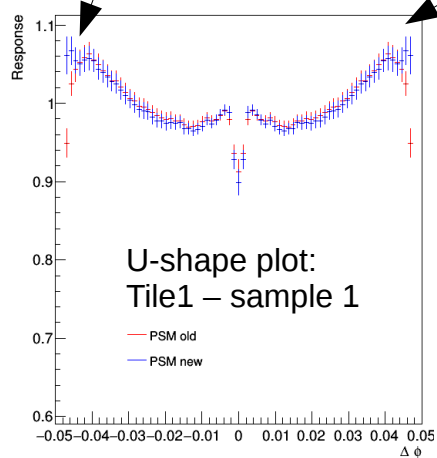
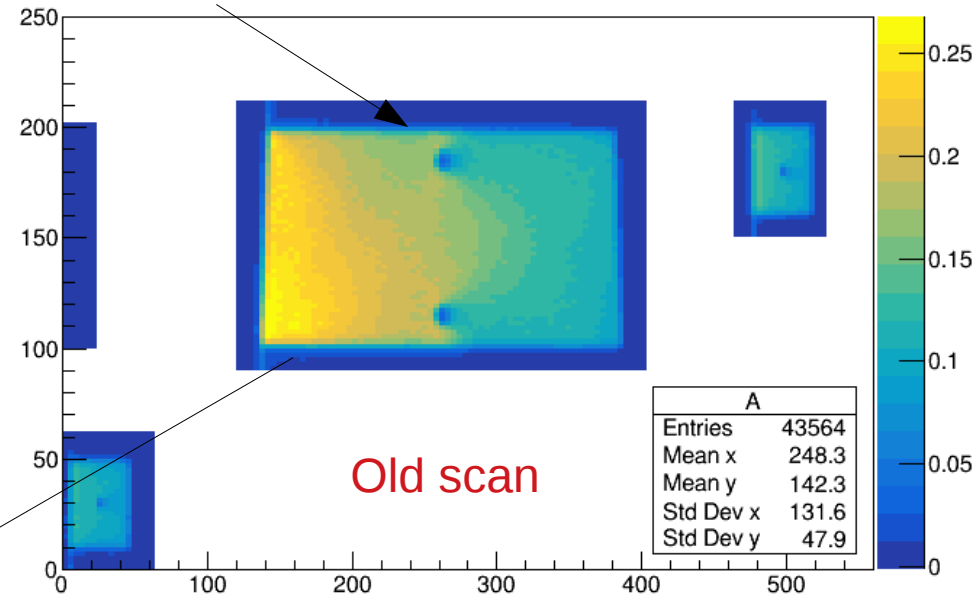
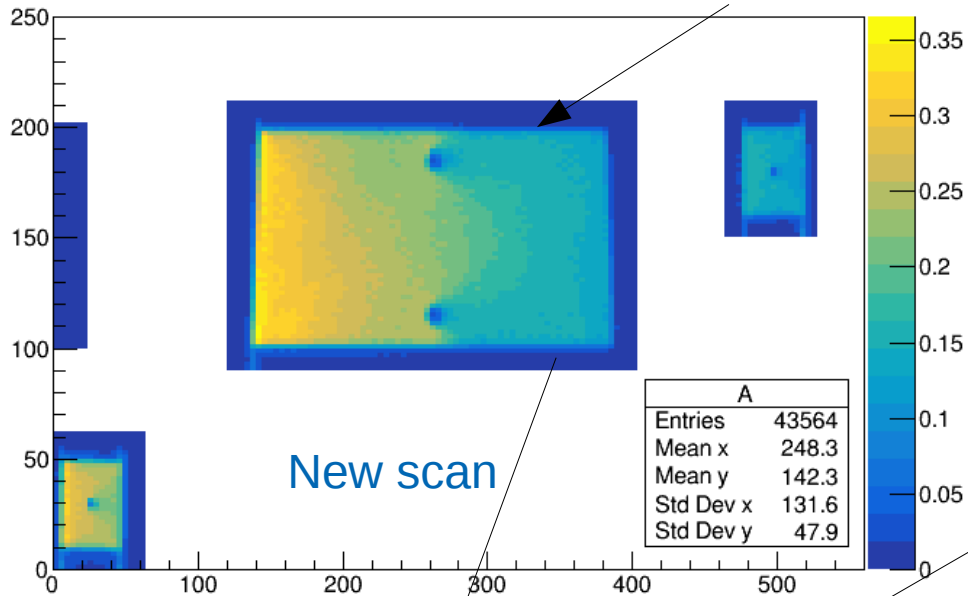
for tile 3 $R = 1.05896 \pm 0.000168413$ (sample 3 - 3 scans)

for tile 3 $\langle R \rangle = 1.05752 \pm 0.00172787$ (samples 1-3 means averaged)

pmt:y:x

Tile size 1: same tiles used

pmt:y:x



Difference in R ratio values between old and new measurements could be because of different response on tile edges – reason for that could be fiber attachment