



GS12: ^{16}O (200 MEV) ON C_2H_4

TRACKS AND VERTICES RECONSTRUCTION

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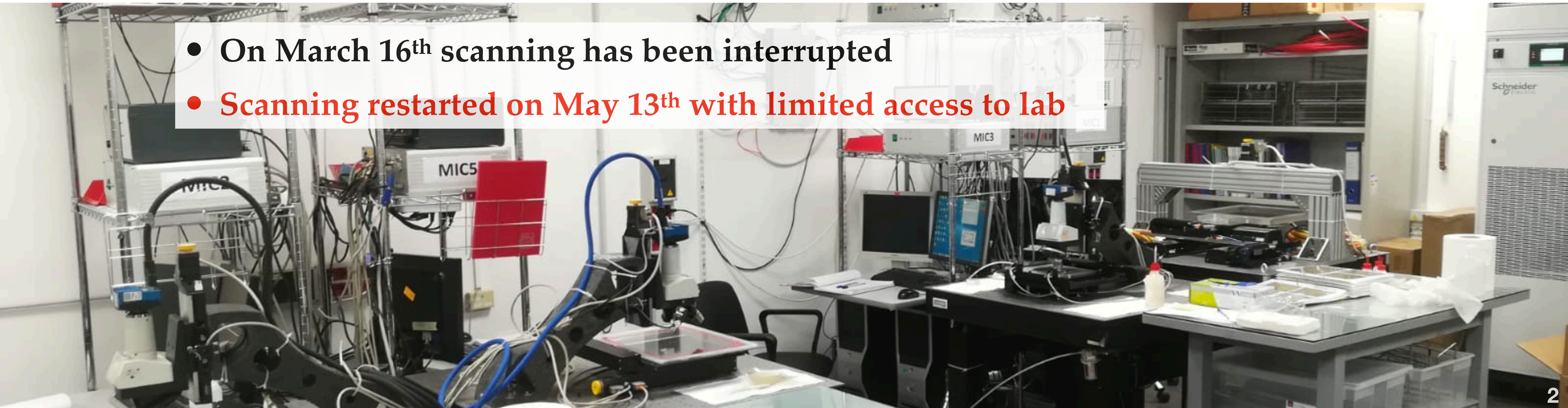
ZOOM General meeting, 11 June 2020

GSI_2019: SCANNING PROGRESS

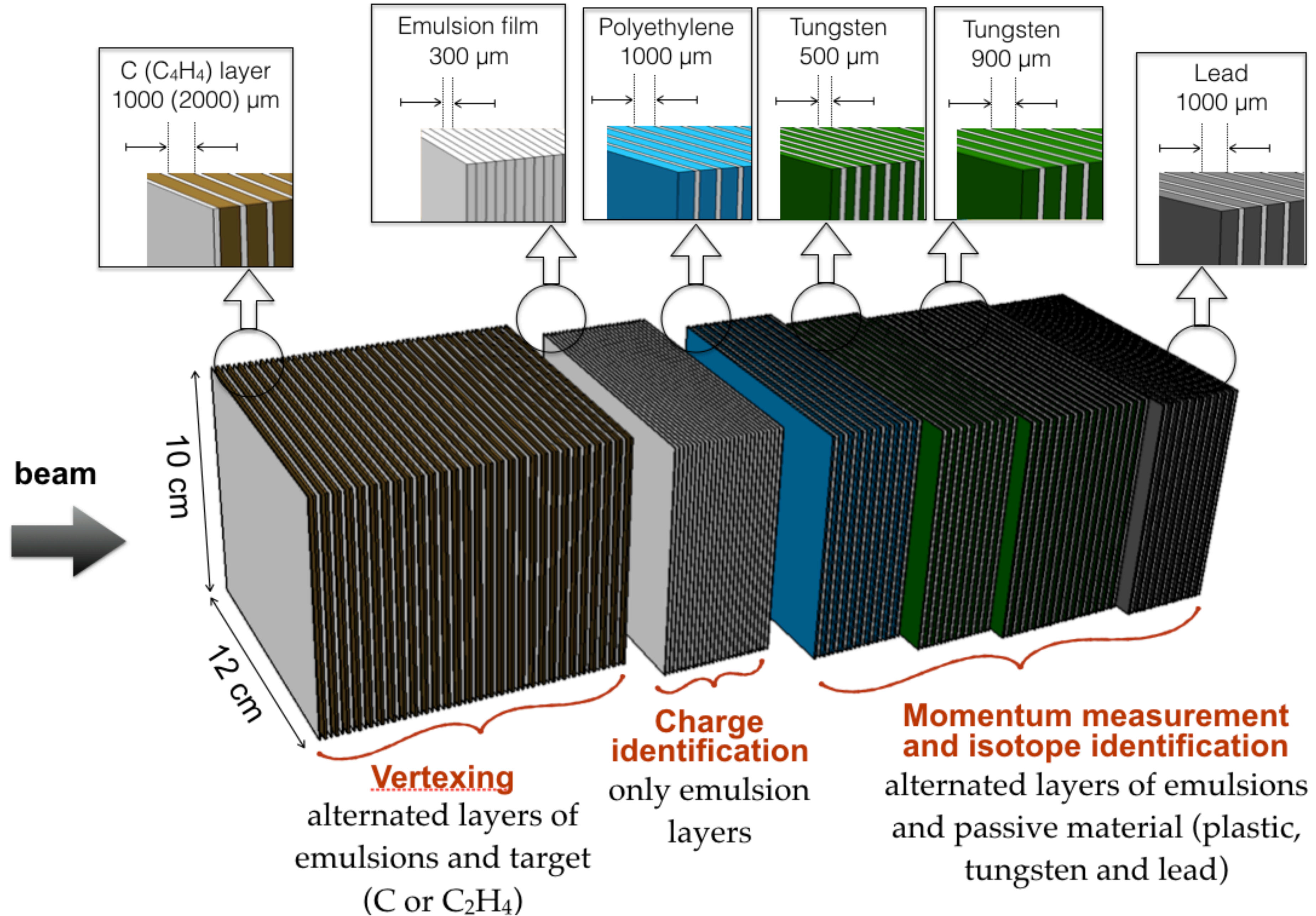
	BEAM	
TARGET	Oxygen 200 MeV/n	Oxygen 400 MeV/n
Carbon	GSI1	GSI3
Polyethylene	GSI2	GSI4

- GSI2: Scanning completed, analysis on-going
- GSI1: Scanning completed, alignment between emulsions completed for S2 and S3
- GSI3: Scanning completed
- GSI4: Scanning on-going (1/2 completed)

- On March 16th scanning has been interrupted
- Scanning restarted on May 13th with limited access to lab

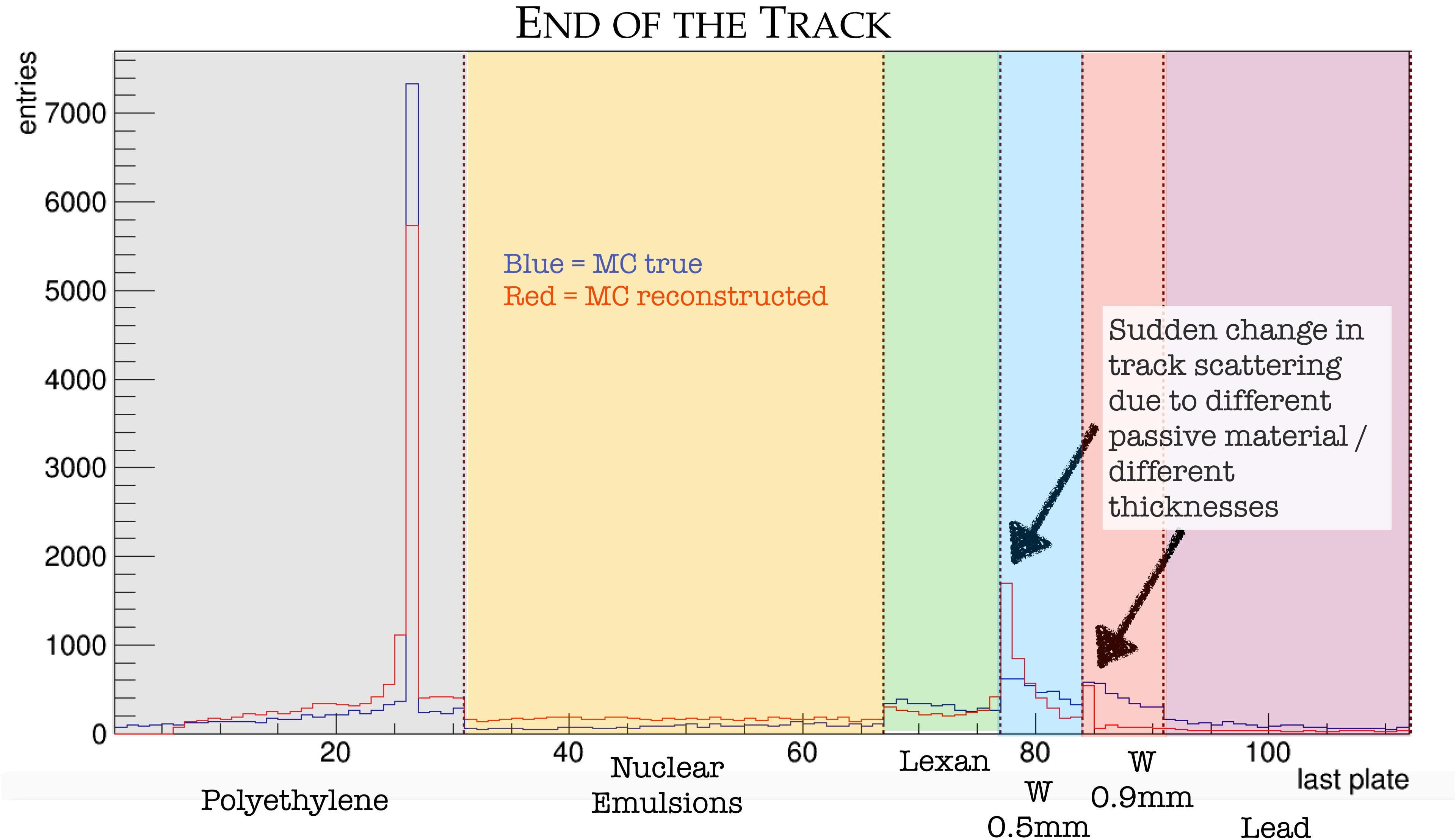


REMINDER OF DETECTOR STRUCTURE



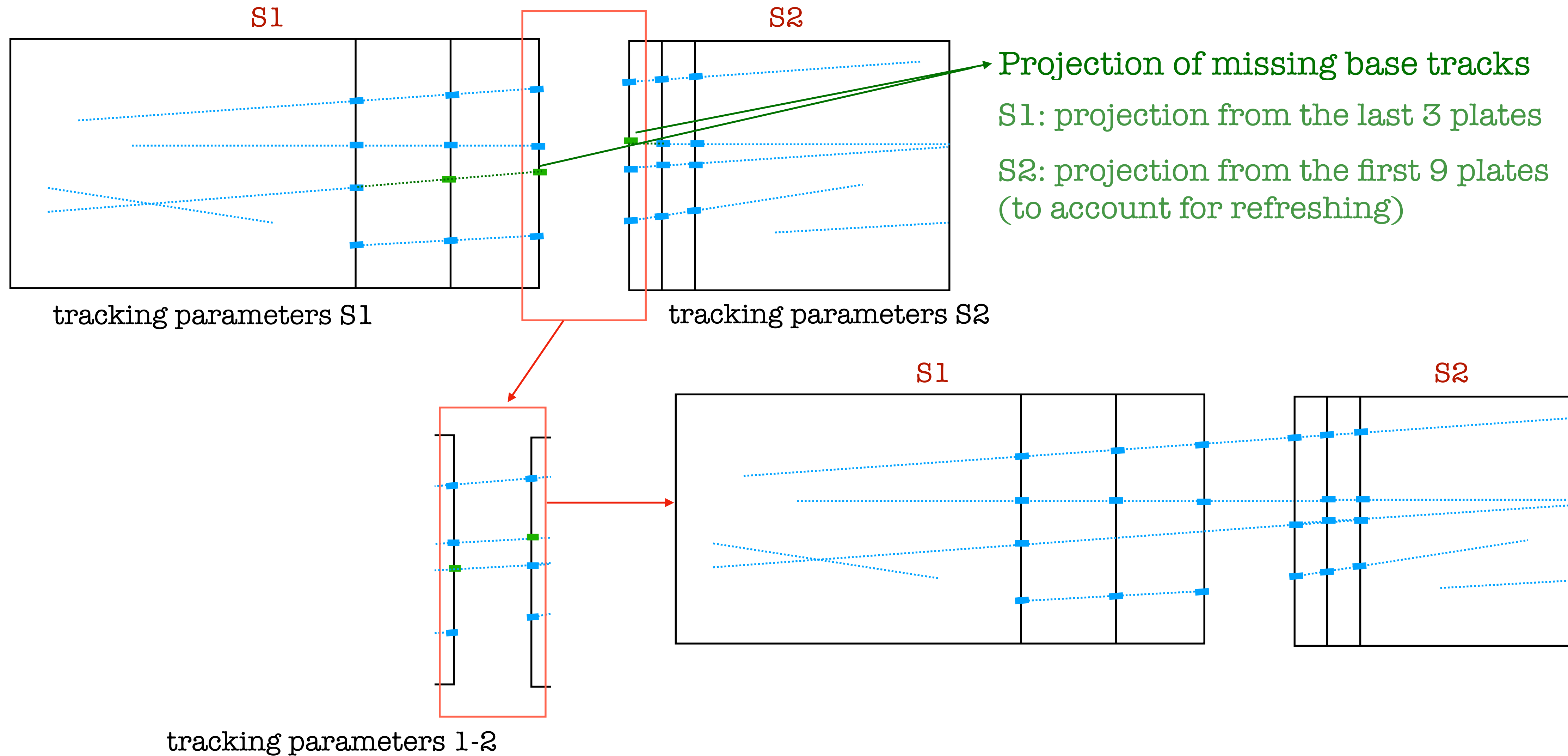
TRACKING VALIDATION WITH MONTE CARLO

- Different materials and thicknesses of passive layers in each section: the same tracking parameters are not efficient for the whole detector



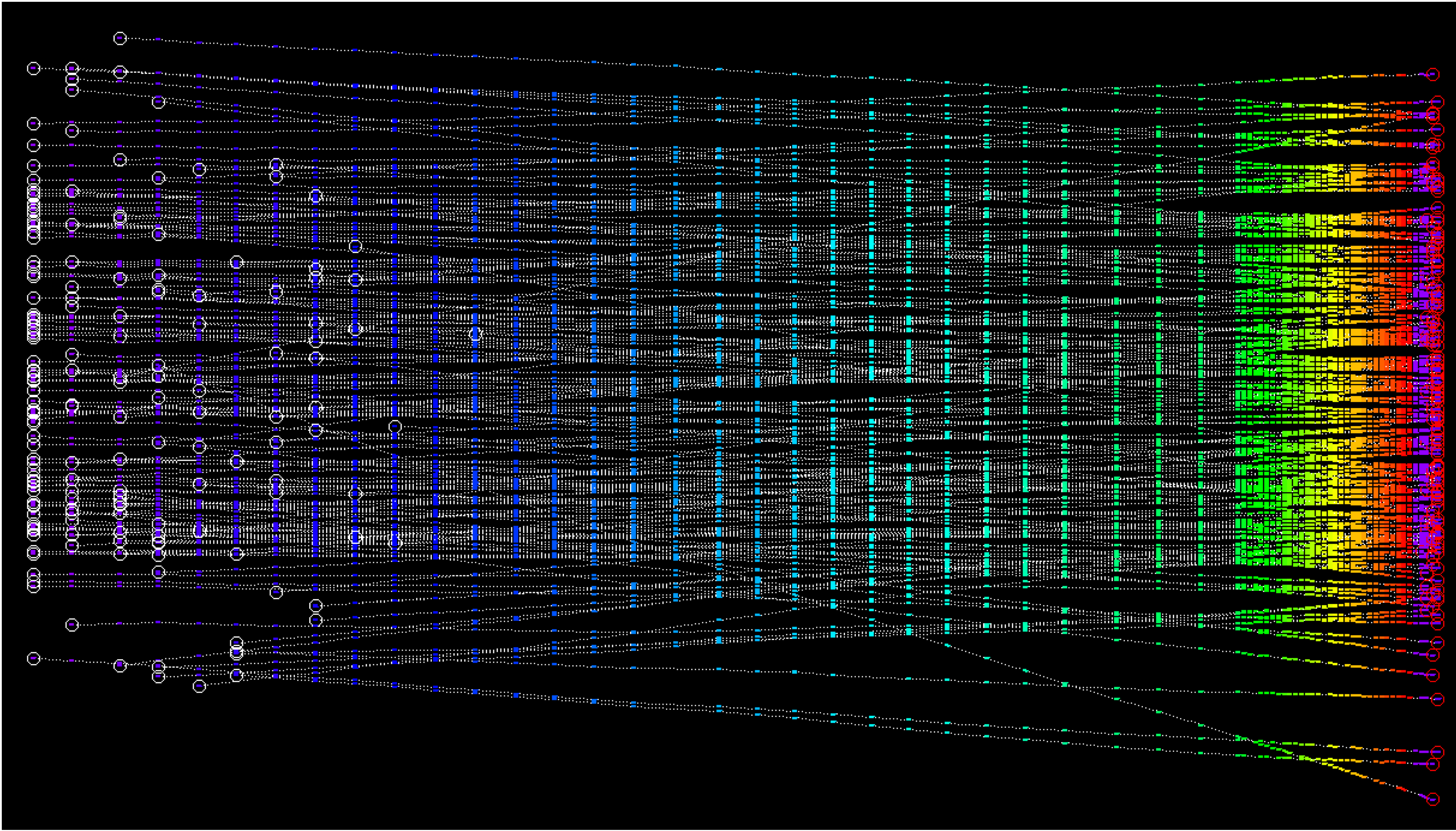
MERGE TRACKINGS ALGORITHM

- Track reconstruction done separately for each section, with appropriate parameters
- Algorithm developed to merge the tracks reconstructed in two sections



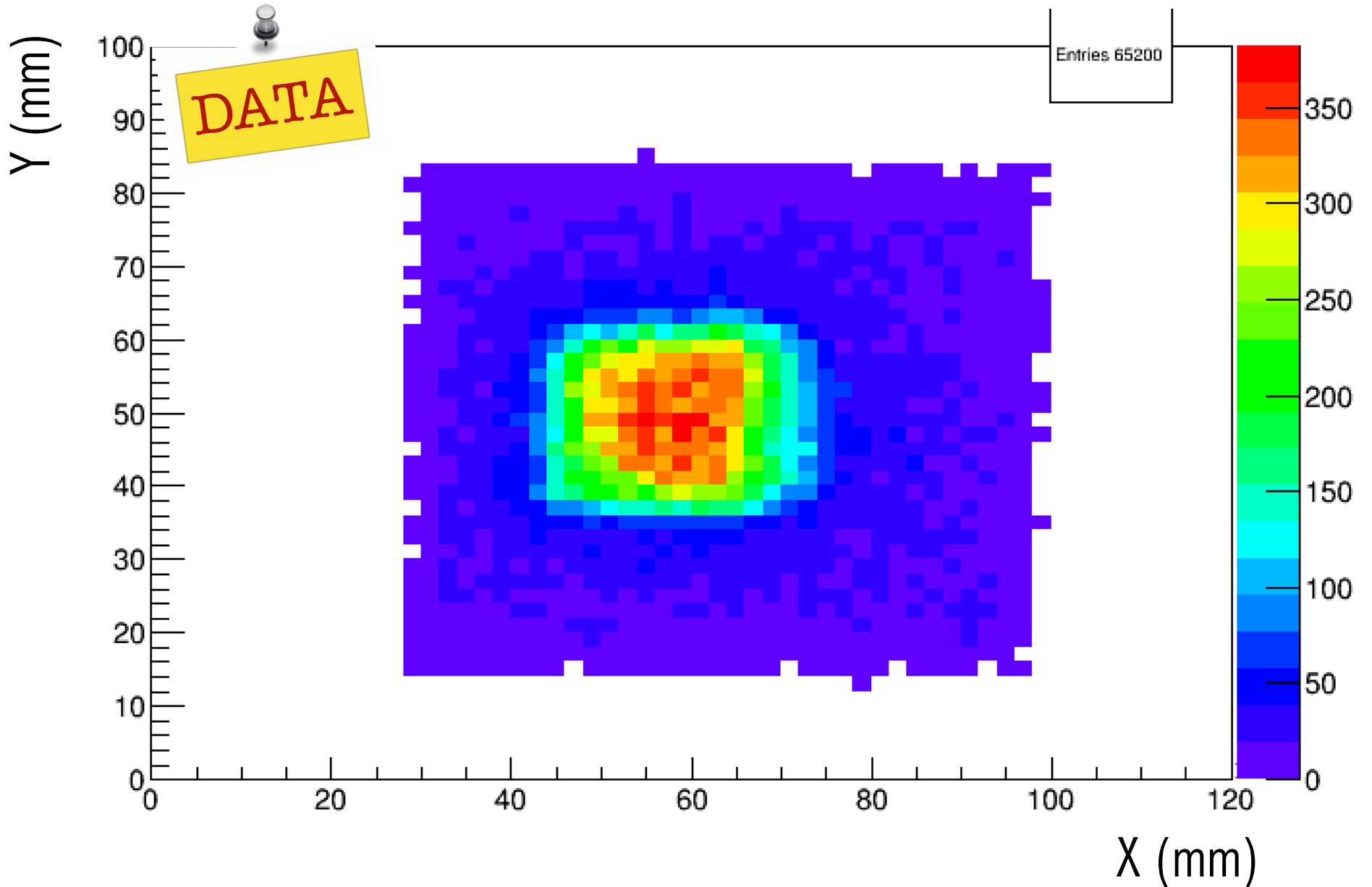
TRACKING: DATA DISPLAY

(Cut: nseg>50)



S1 (~70.5 mm) S2 (~12.6 mm)

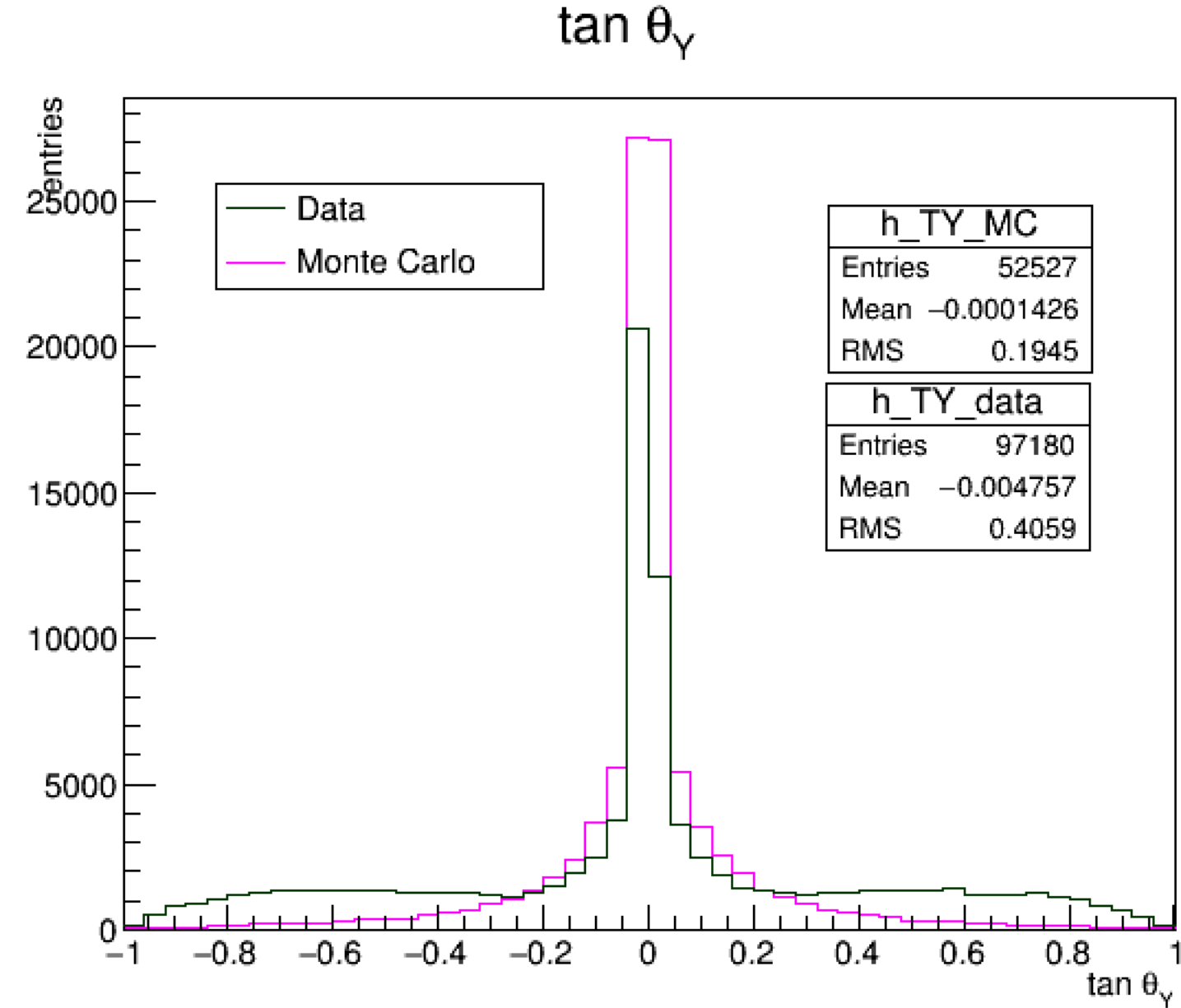
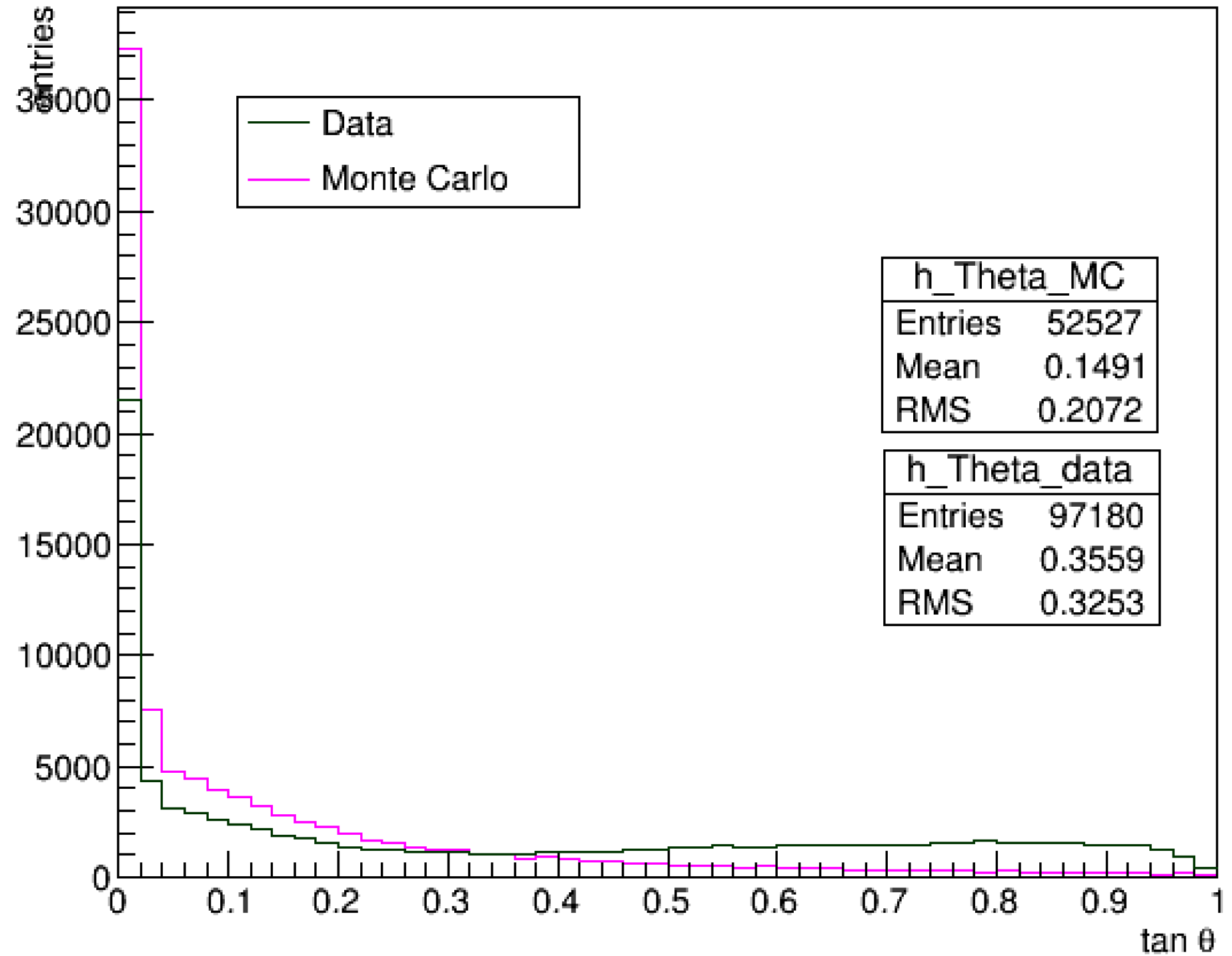
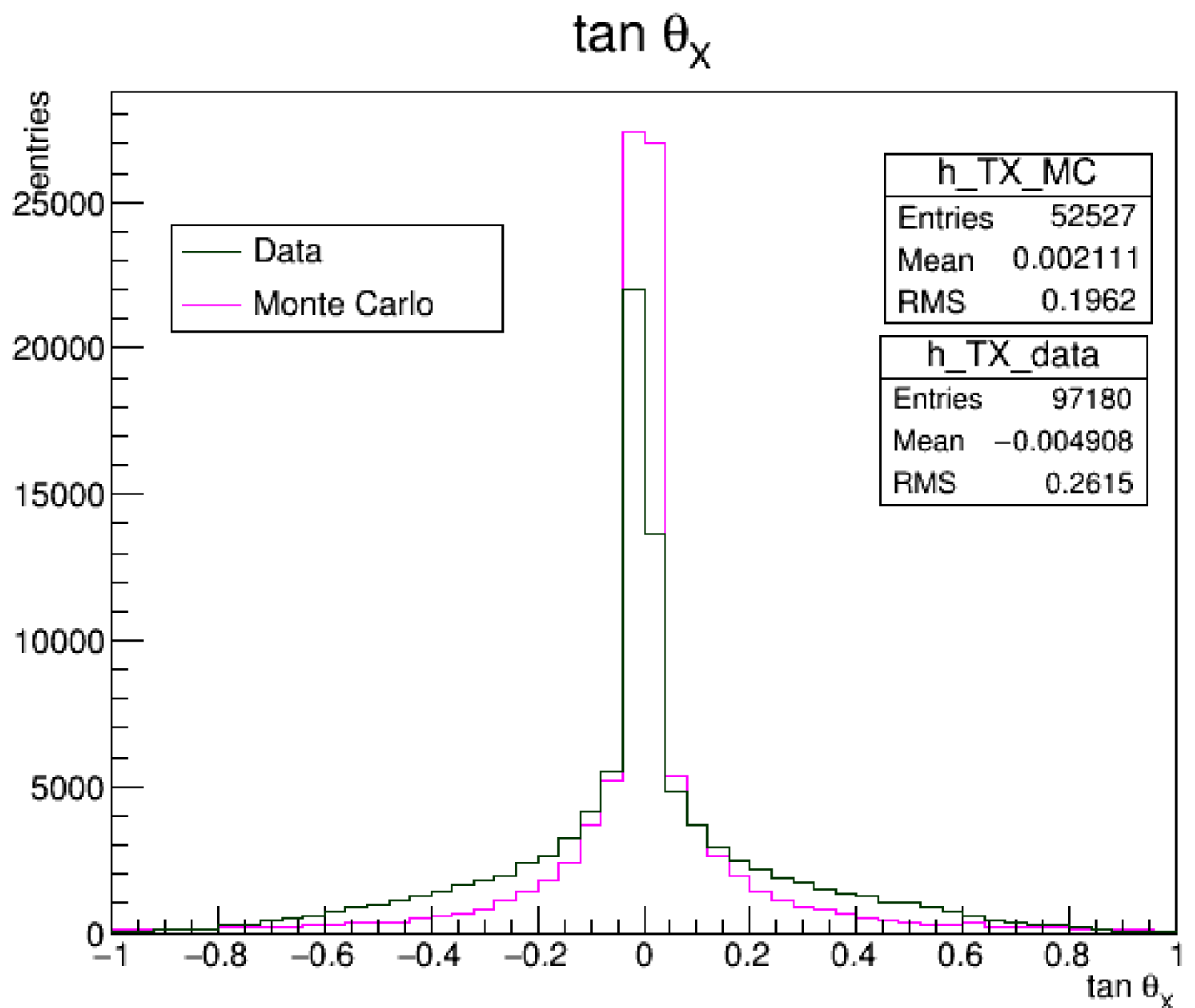
SPATIAL AND ANGULAR DISTRIBUTIONS



(MC normalised to DATA)

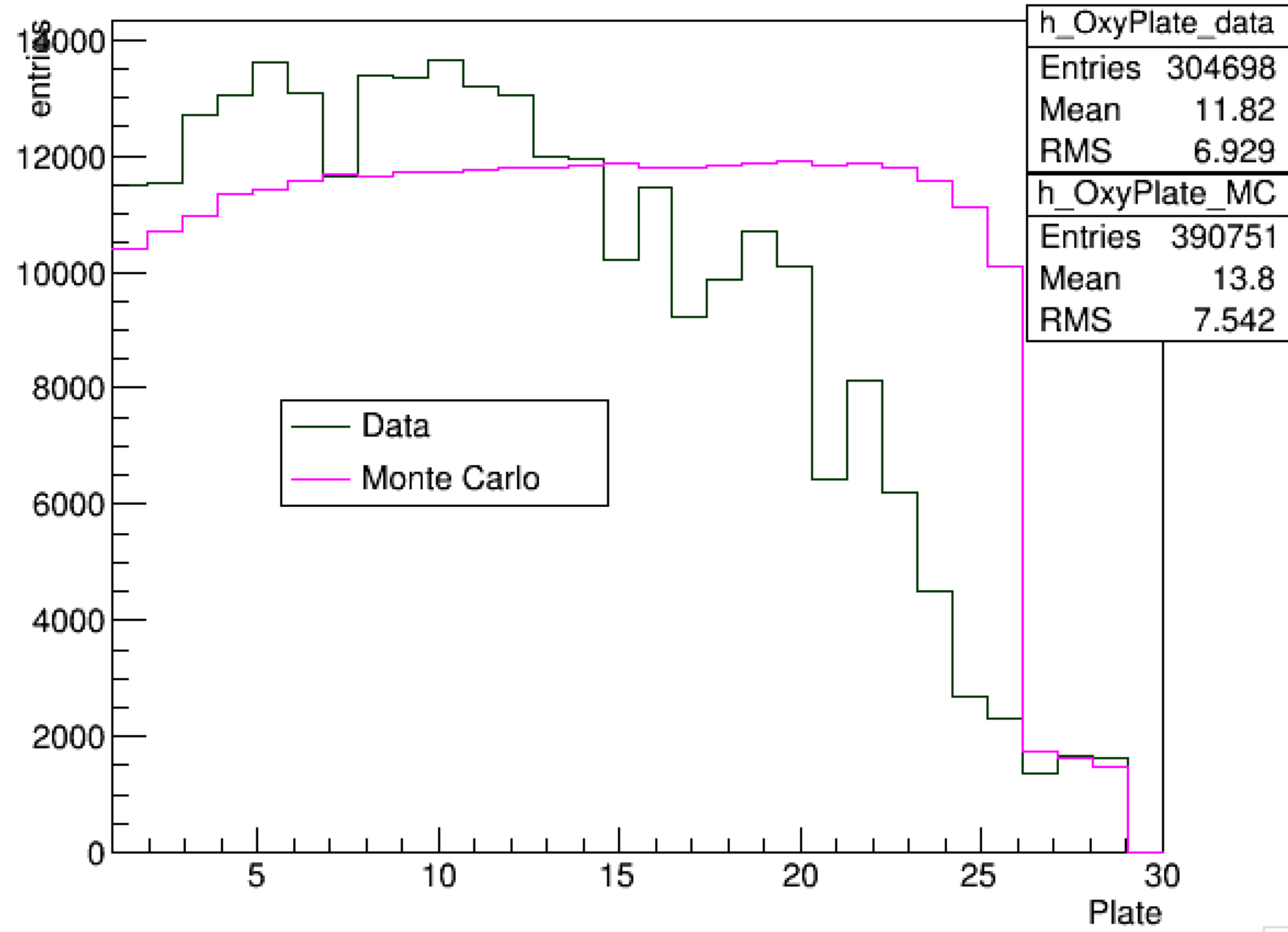
nseg>3 to avoid instrumental background

tan θ

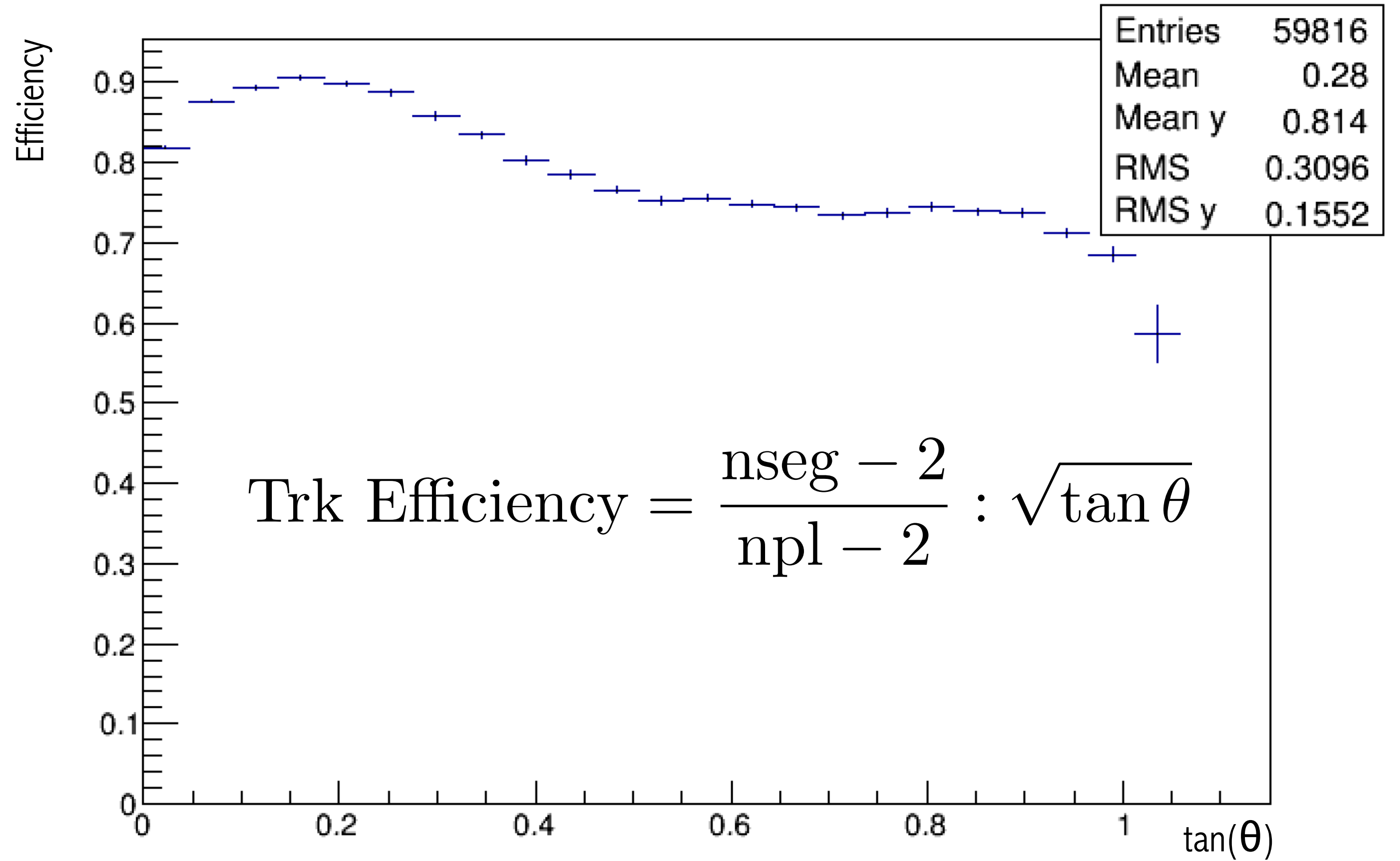


EFFICIENCY S1

Plate Oxy segments



(MC normalised to DATA)



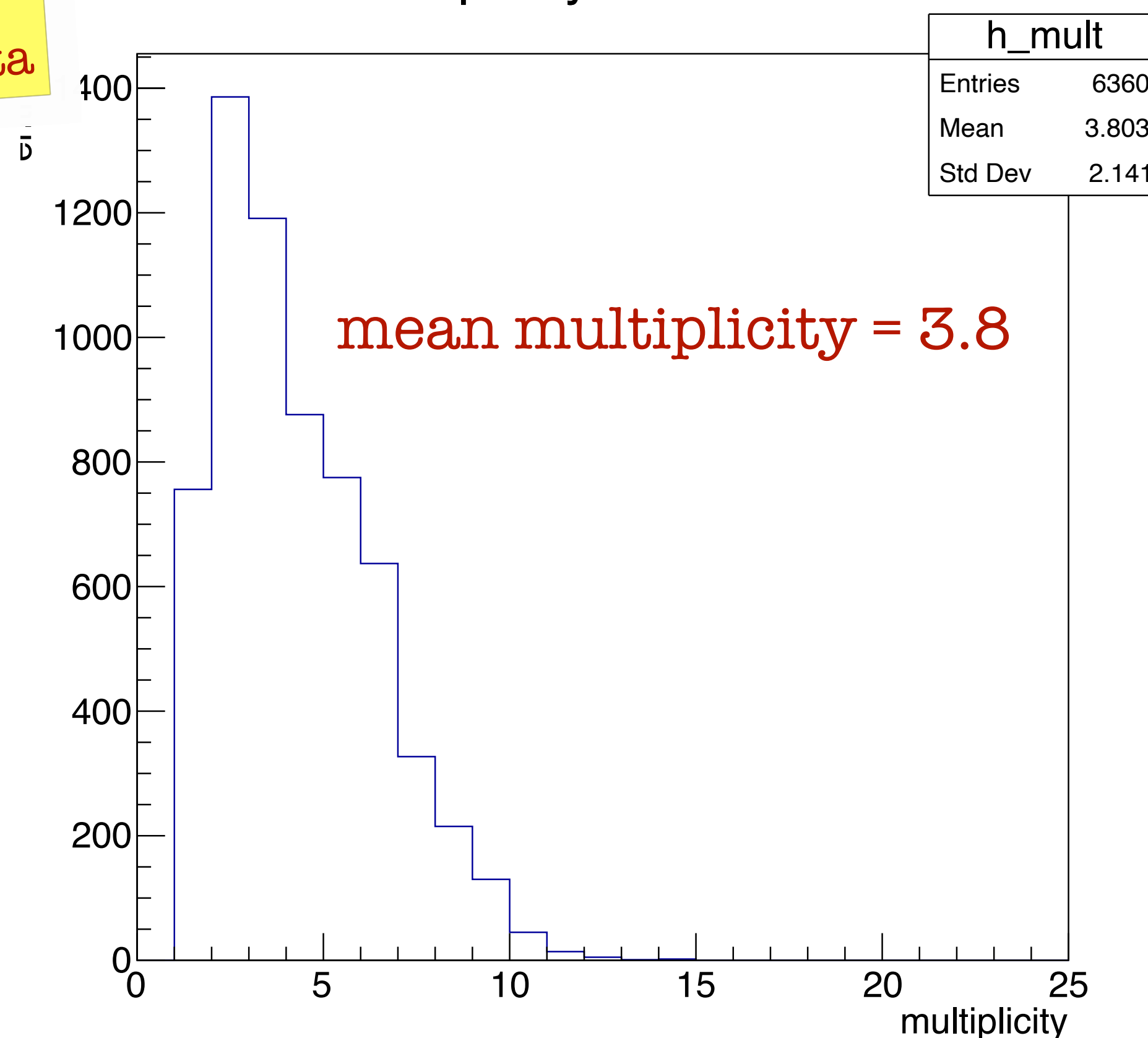
MONTECARLO SIMULATION

Beam particles	19988	
Oxy arriving on S1	19880	99.5%
VTX in S1	6552	32.8%

Same
statistic
as in Data

Total products	24186
Exit lateral	3.72%
Exit at the end	2.04%
Contained	94.3%
Absorbed in S1	40.0%
Arriving in S2	14511
Absorbed in S2	12.3%

Multiplicity distribution

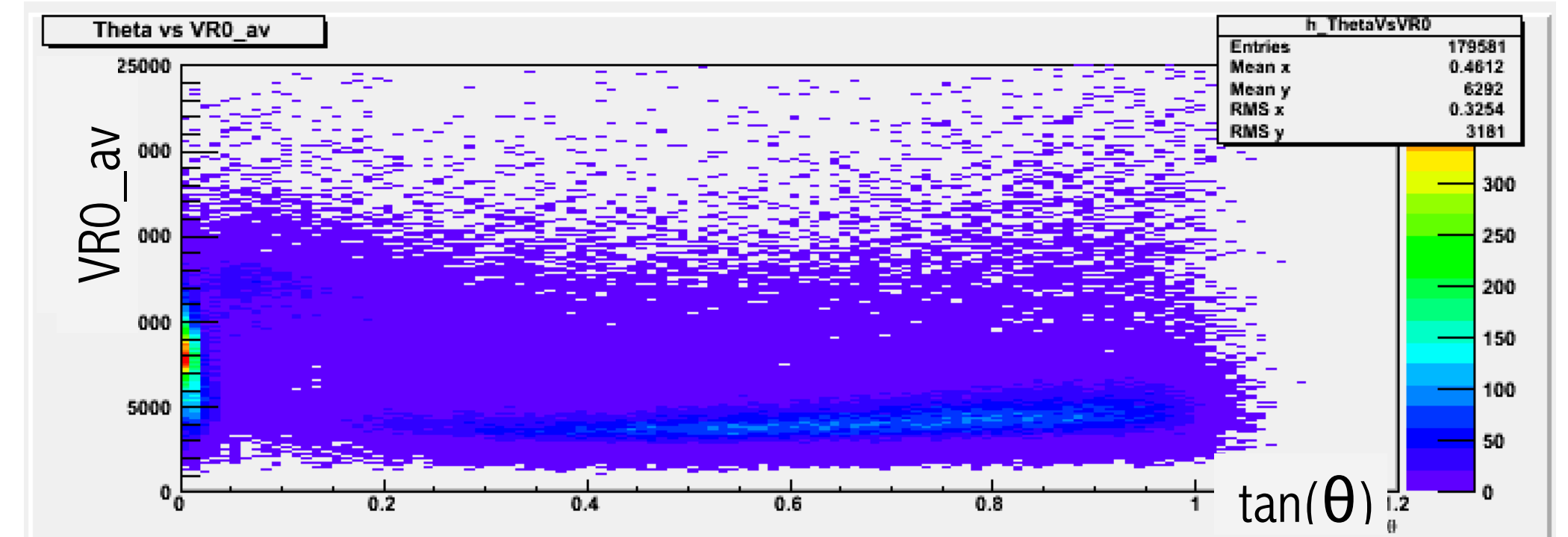
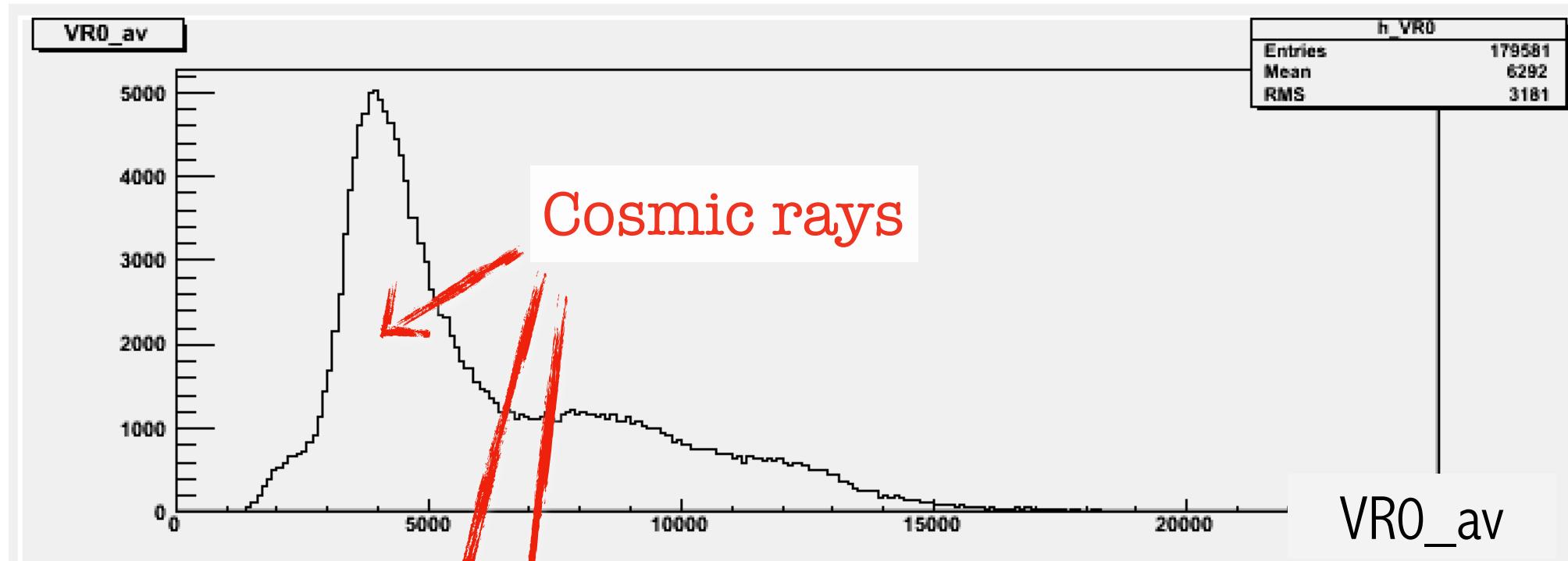


- EXIT LATERAL = last segment coordinates at 0.5 cm from the edge
- EXIT AT THE END = end point in the last 2 plates
- CONTAINED = not exiting laterally nor at the end

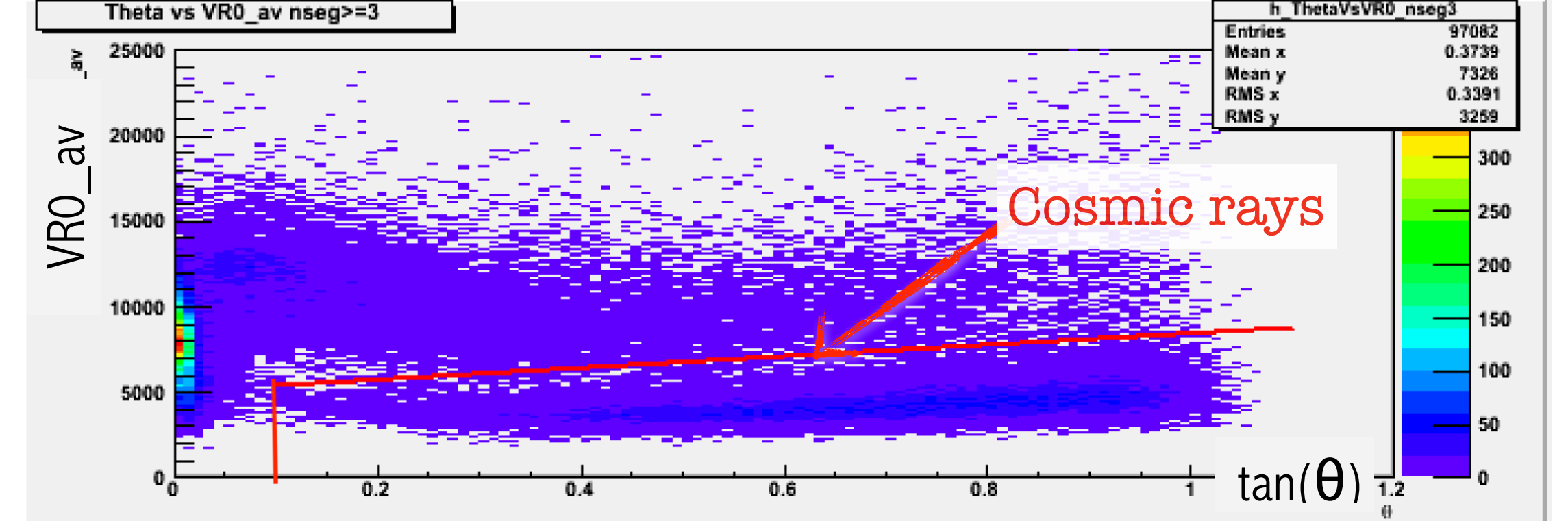
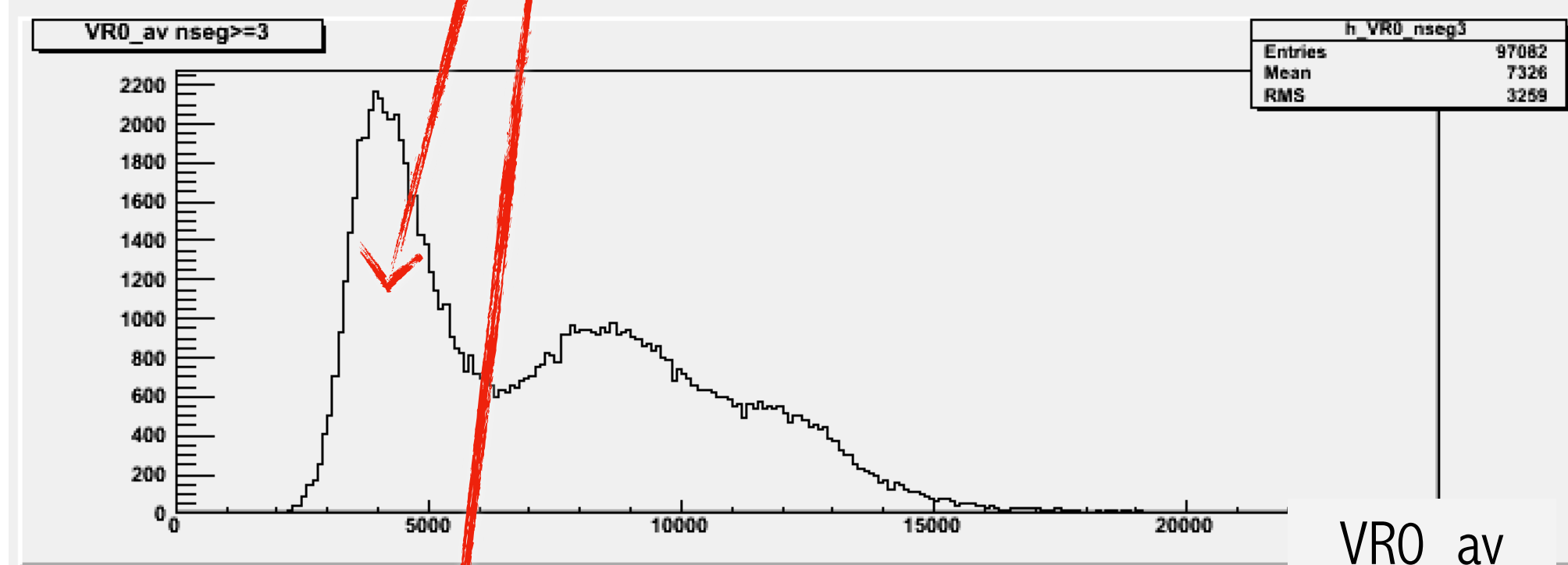
COSMIC RAYS DISCARDED

- When identified through their ionisation, cosmic rays are discarded
- Information from charge analysis in S2 (see our other talk) and, when not available, from S1

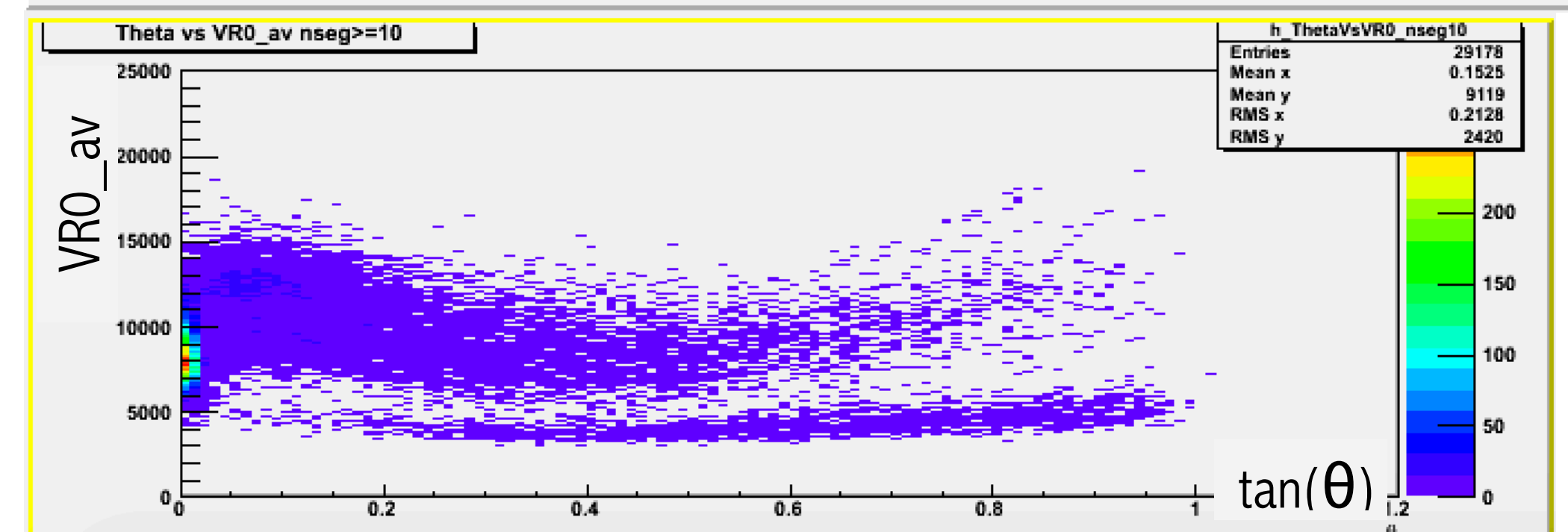
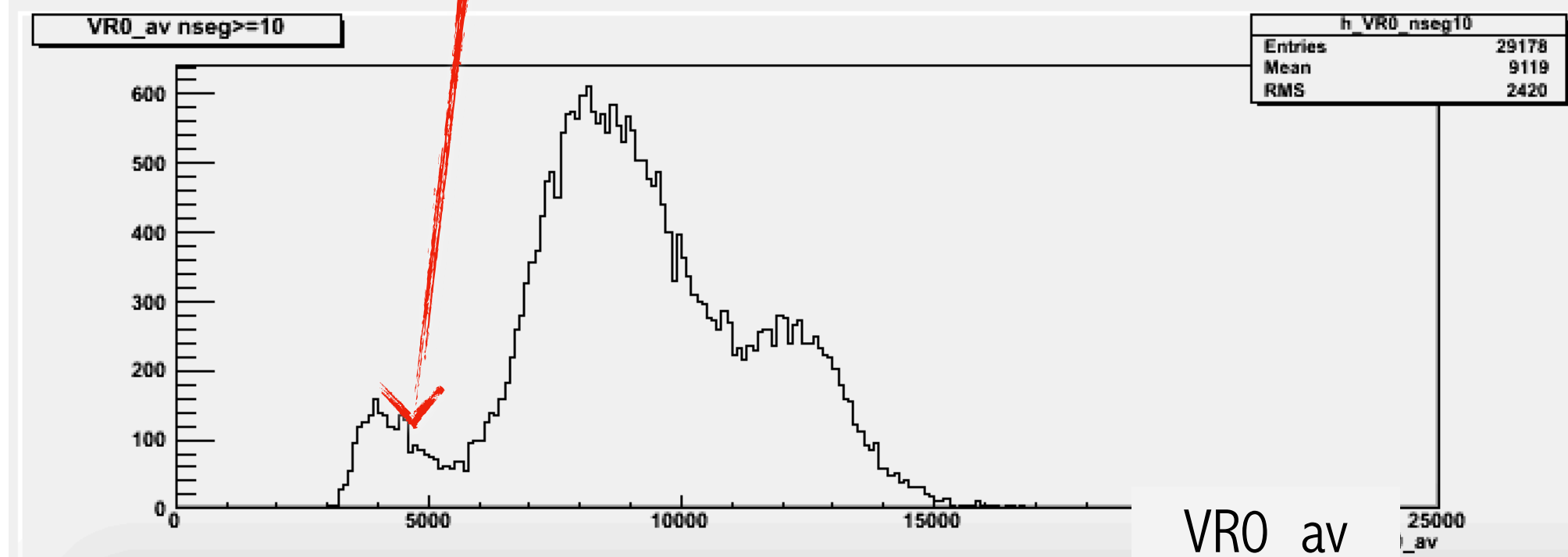
All tracks



nseg>=3

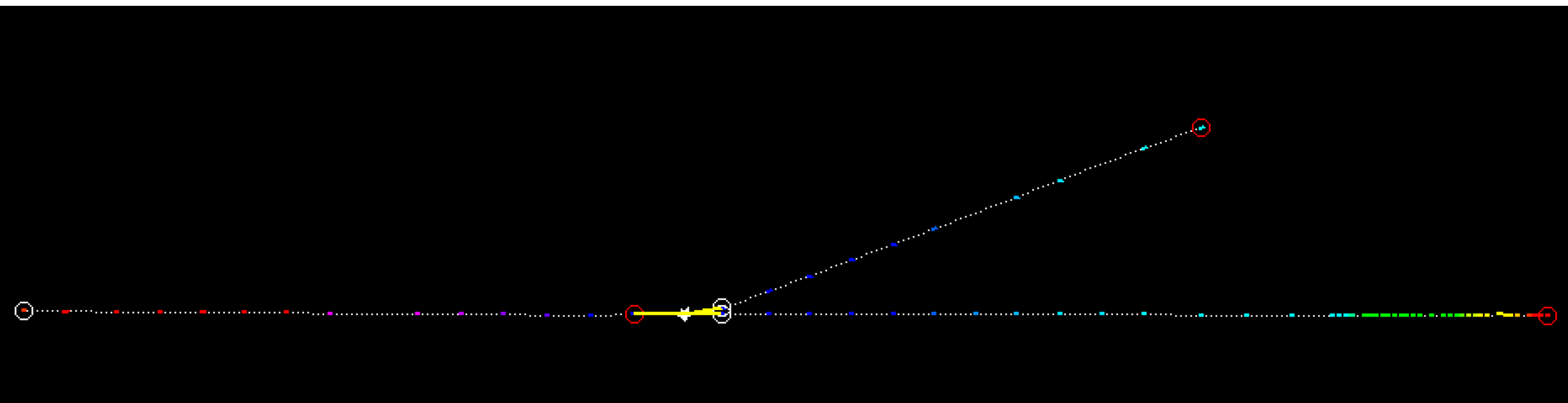
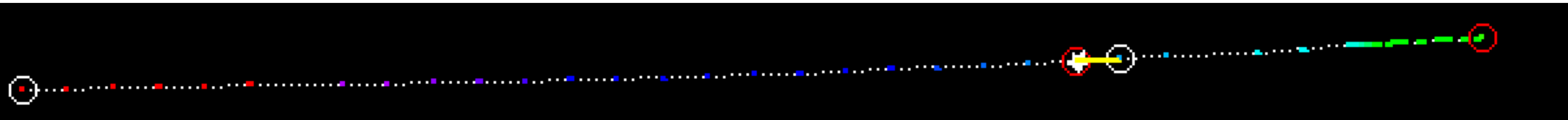


nseg>=10



SPLITTING TRACKS BEYOND BRAGG PEAK

- Some Oxygen tracks are attached to their daughter and reconstructed as a unique track
- Bragg peak is in layer 26: we can recognize this kind of events when we see a track within 0.04 mrad, starting within the first 5 layers that goes beyond layer 26
- Looking at the basetracks angles we find where the interaction took place and we split the track into two tracks



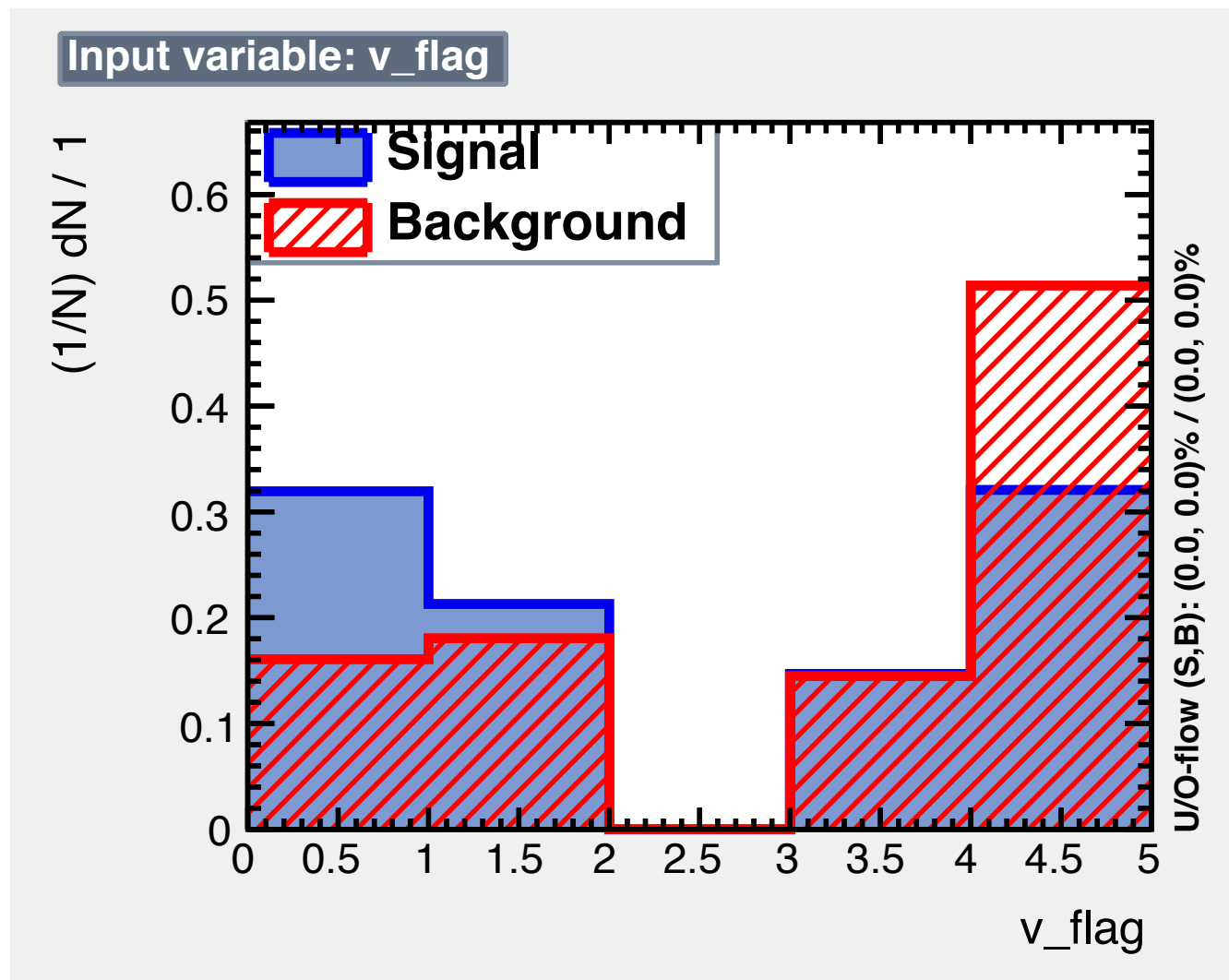
- MC
 - ➔ 1357 tracks splitted
 - ➔ 95.4% of cases correctly splitted
- DATA: 729 tracks splitted

VERTICES SELECTION: MC AND DATA SAMPLES

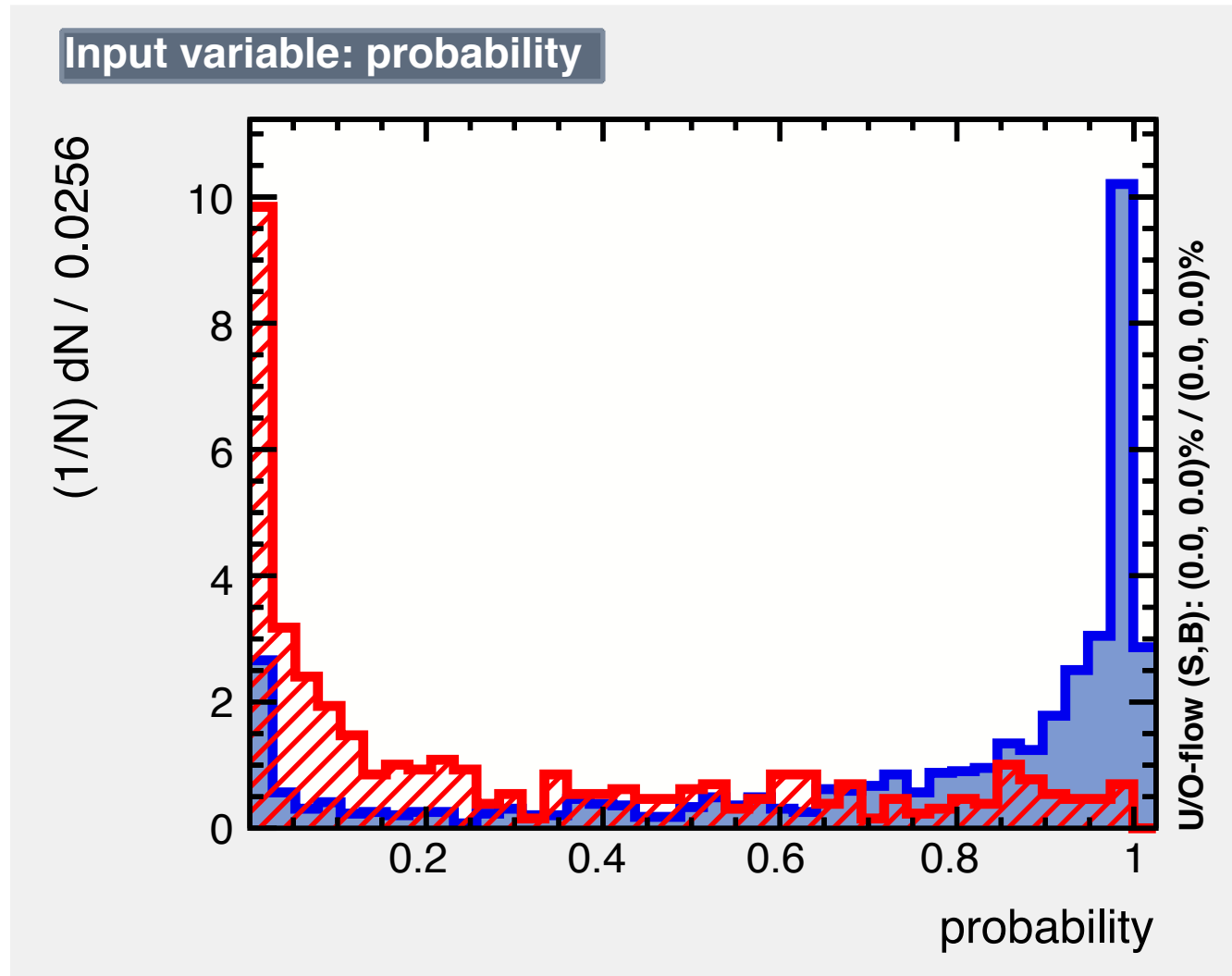
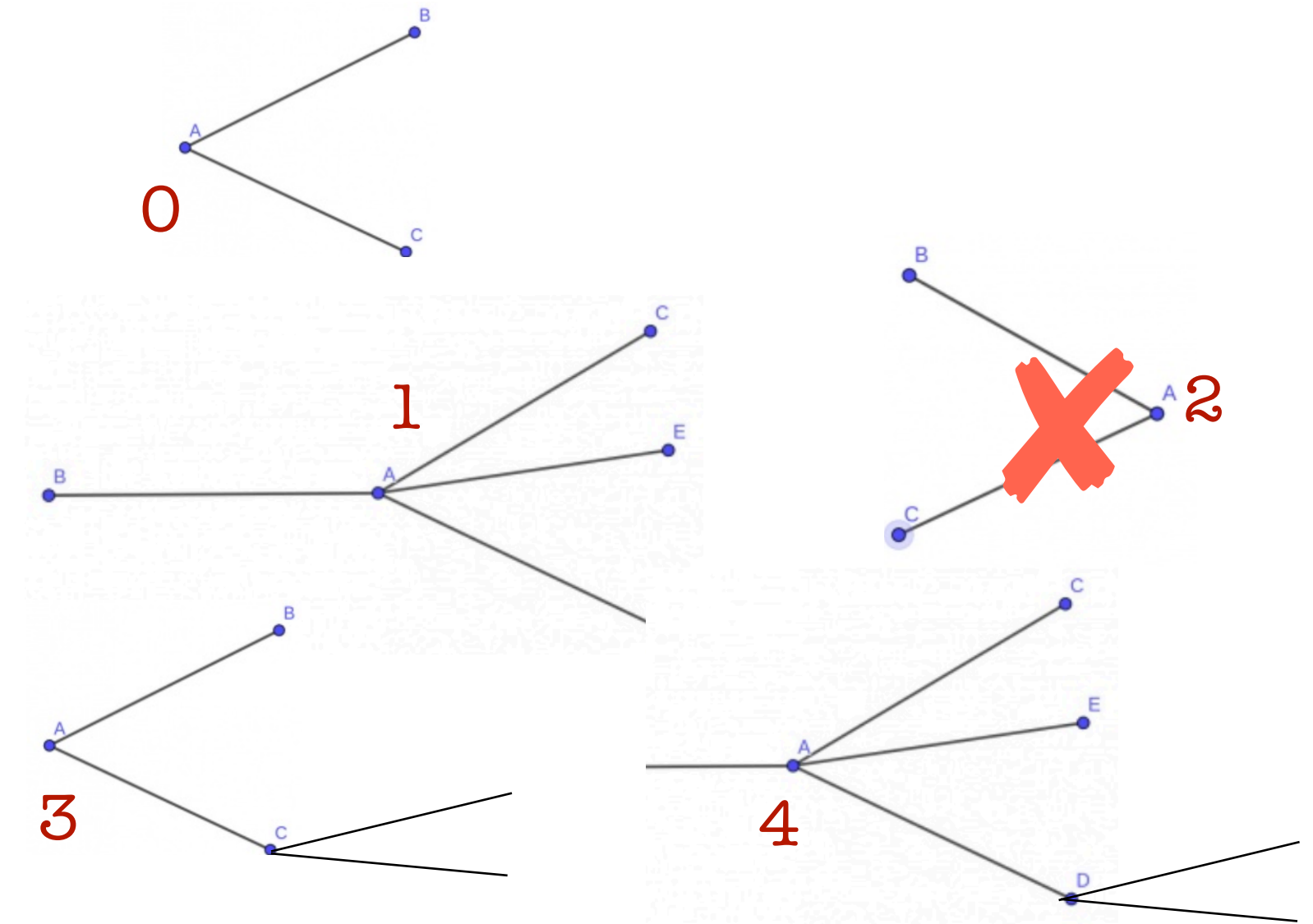
	MC	Data
Entries	8469	33975
$n \geq 3$	4033	6858
vtx good	3024	
vtx fake	1009	

- Many vertices reconstructed: not all of them are true ones
- Boosted Decision Tree (BDT) method to classify good and fake vertices
Ref: https://root.cern/doc/v614/classTMVA_1_1MethodBDT.html
- Only vertices with at least 3 tracks (incoming or outgoing from the vertex) are considered for the moment
- A MC vertex is considered good if it has at least 3 tracks belonging the same MC event

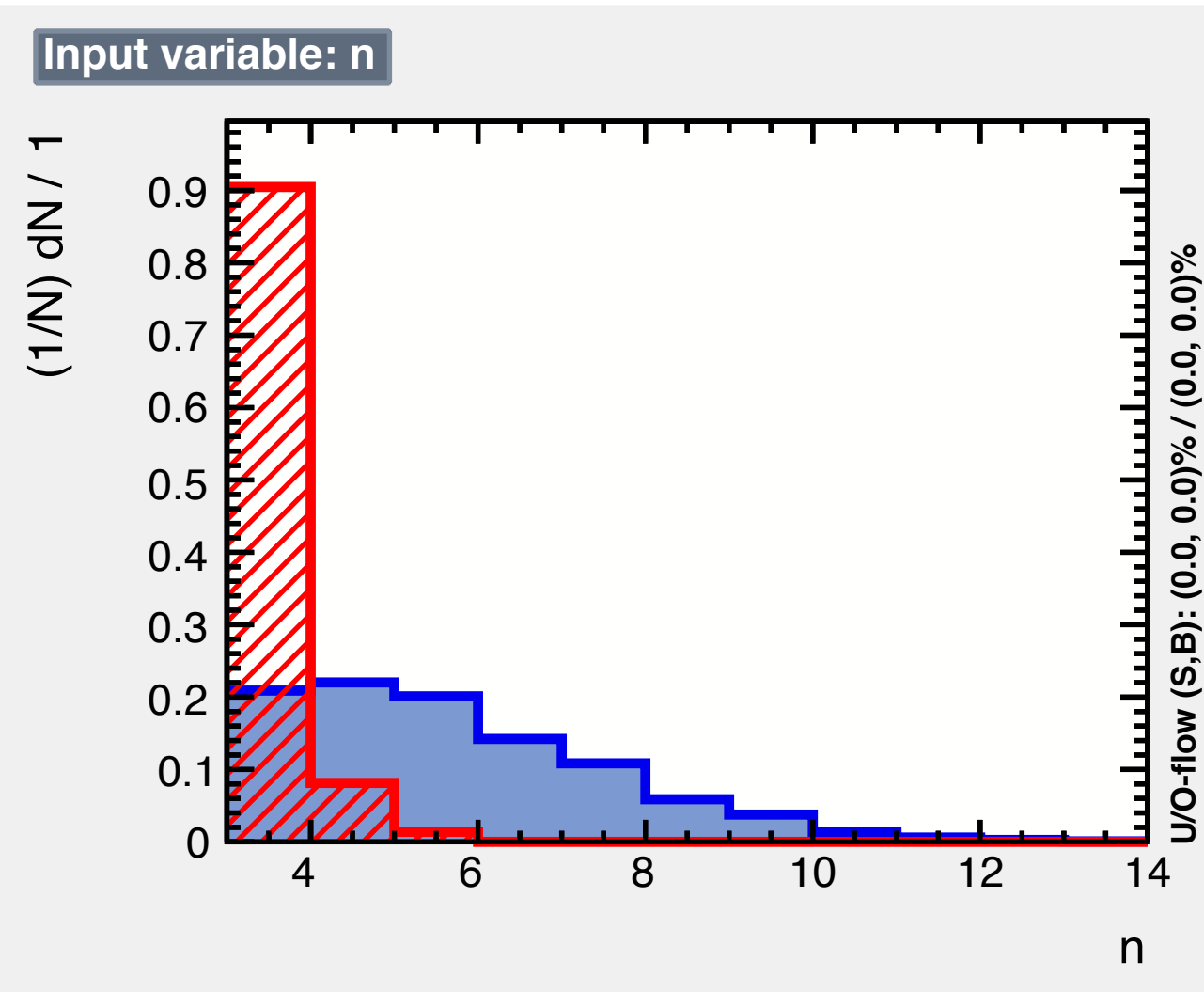
INPUT VARIABLES



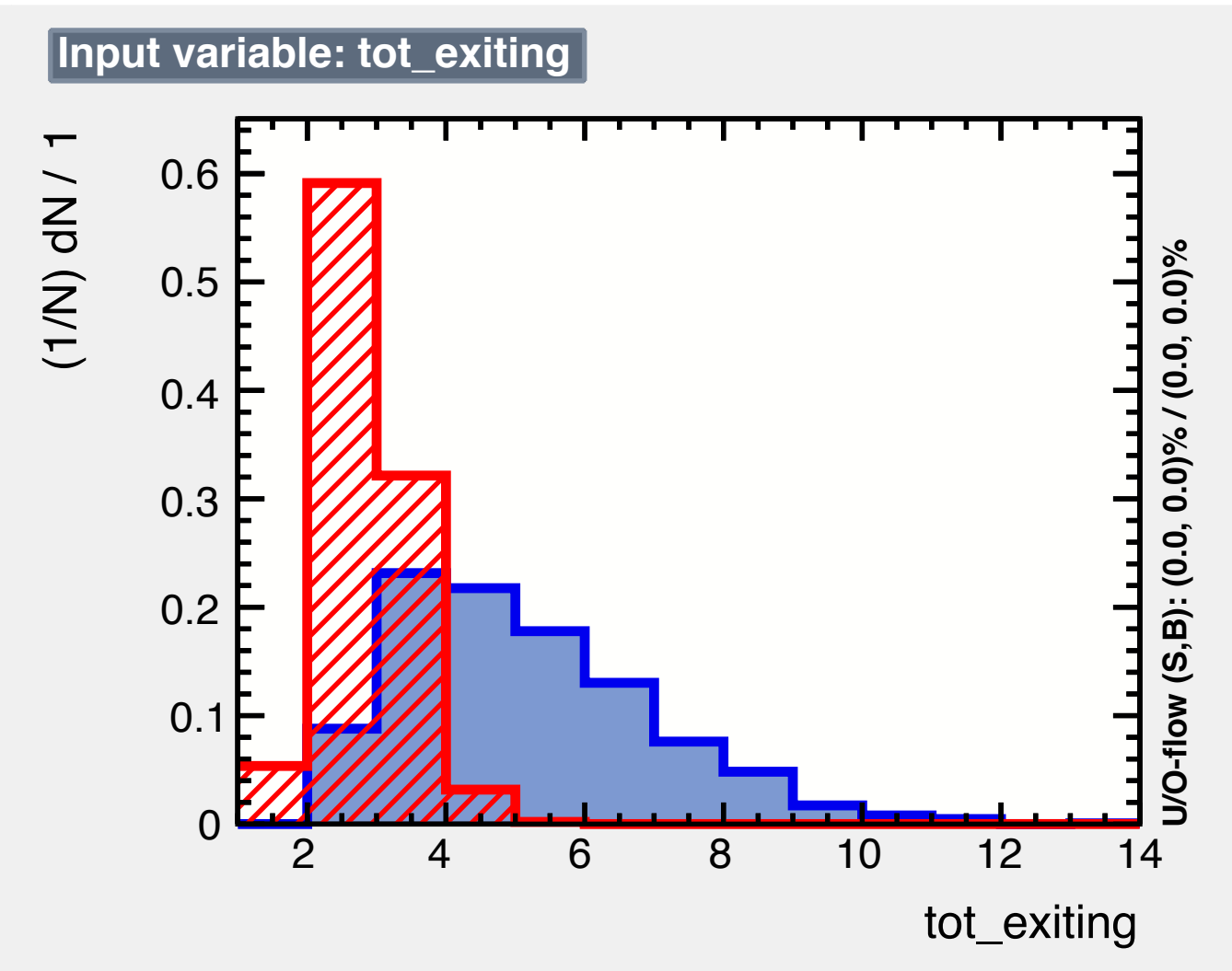
- flag 0: neutral
- flag 1: charge
- flag 2: back neutral (discarded)
- flag 3: neutral, linked
- flag 4: charge, linked



vertex probability



number of tracks attached to the vertex



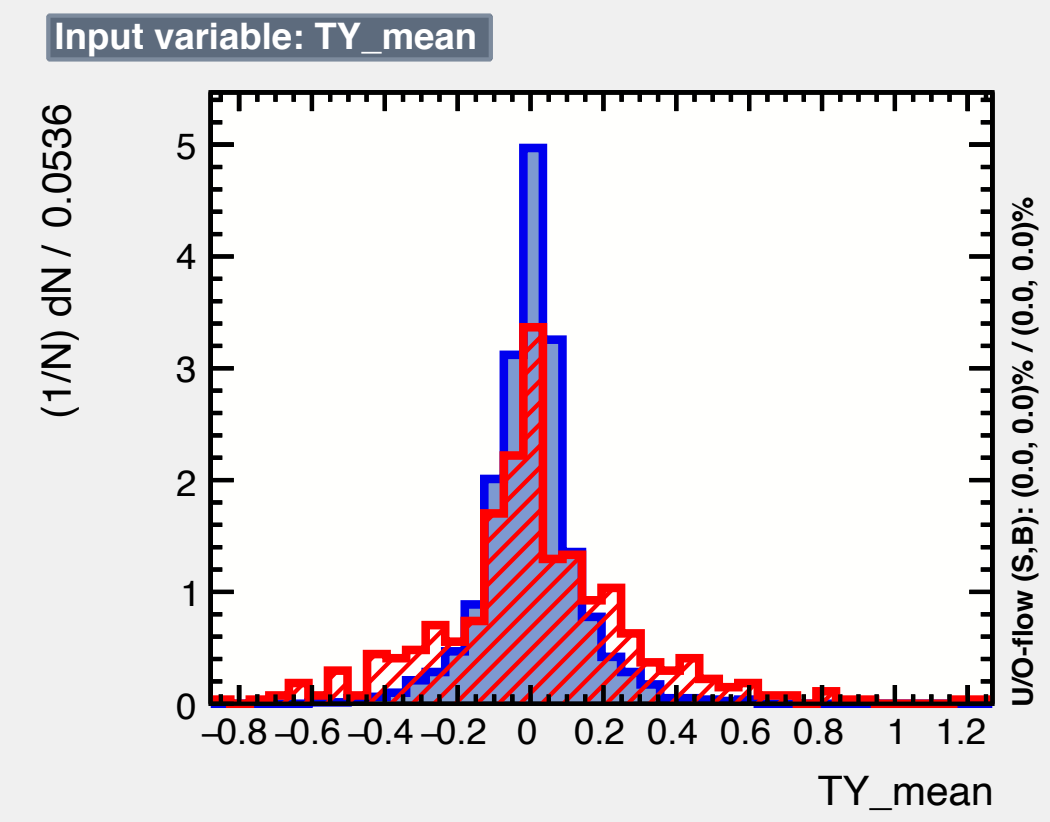
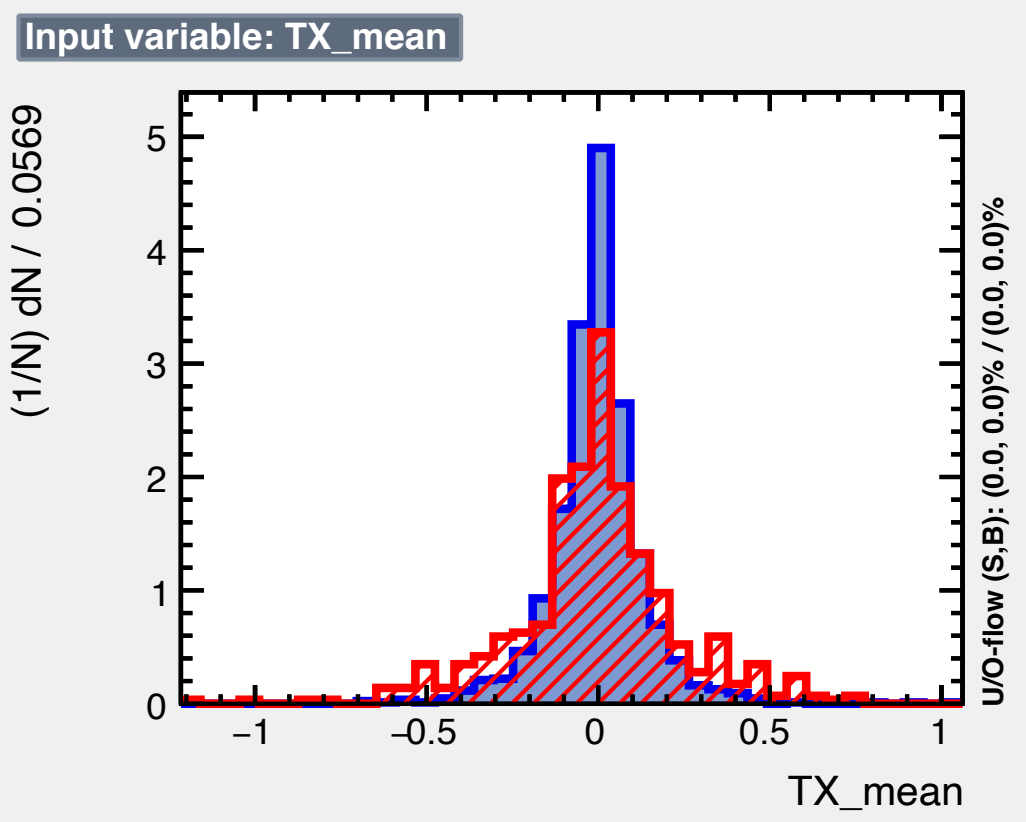
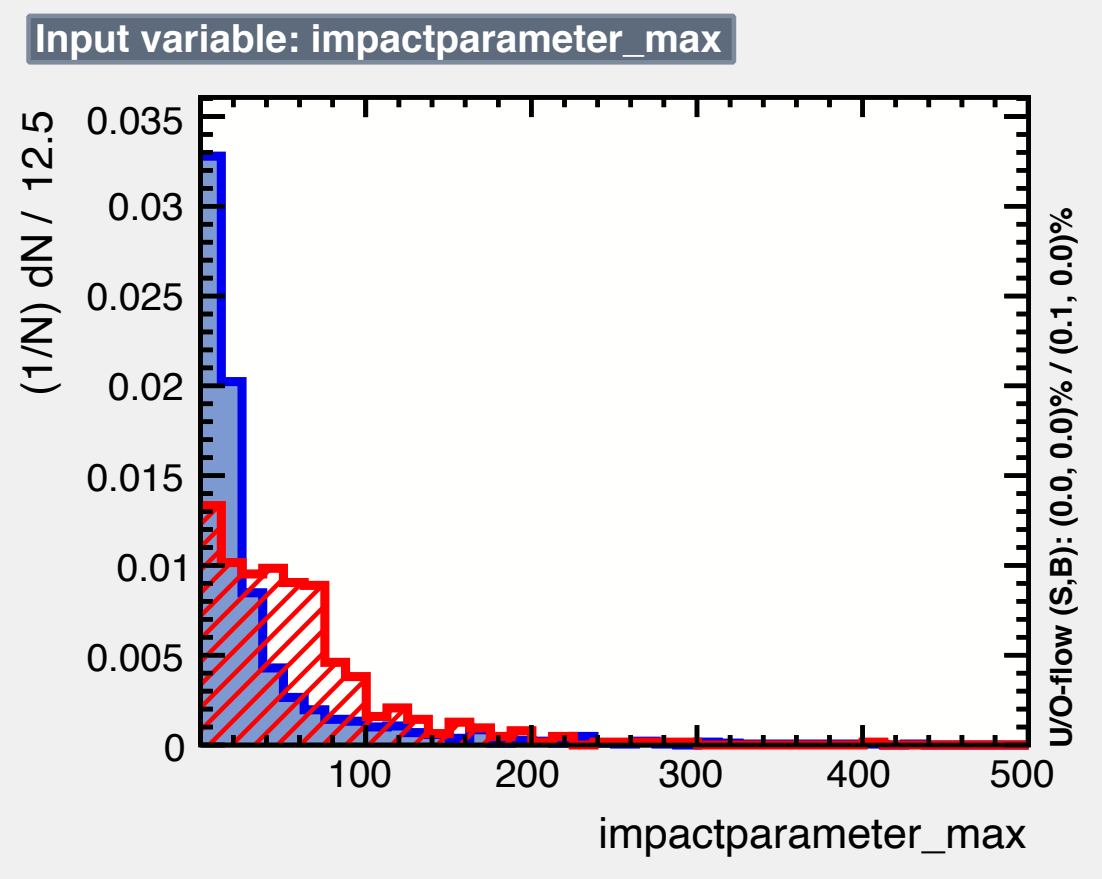
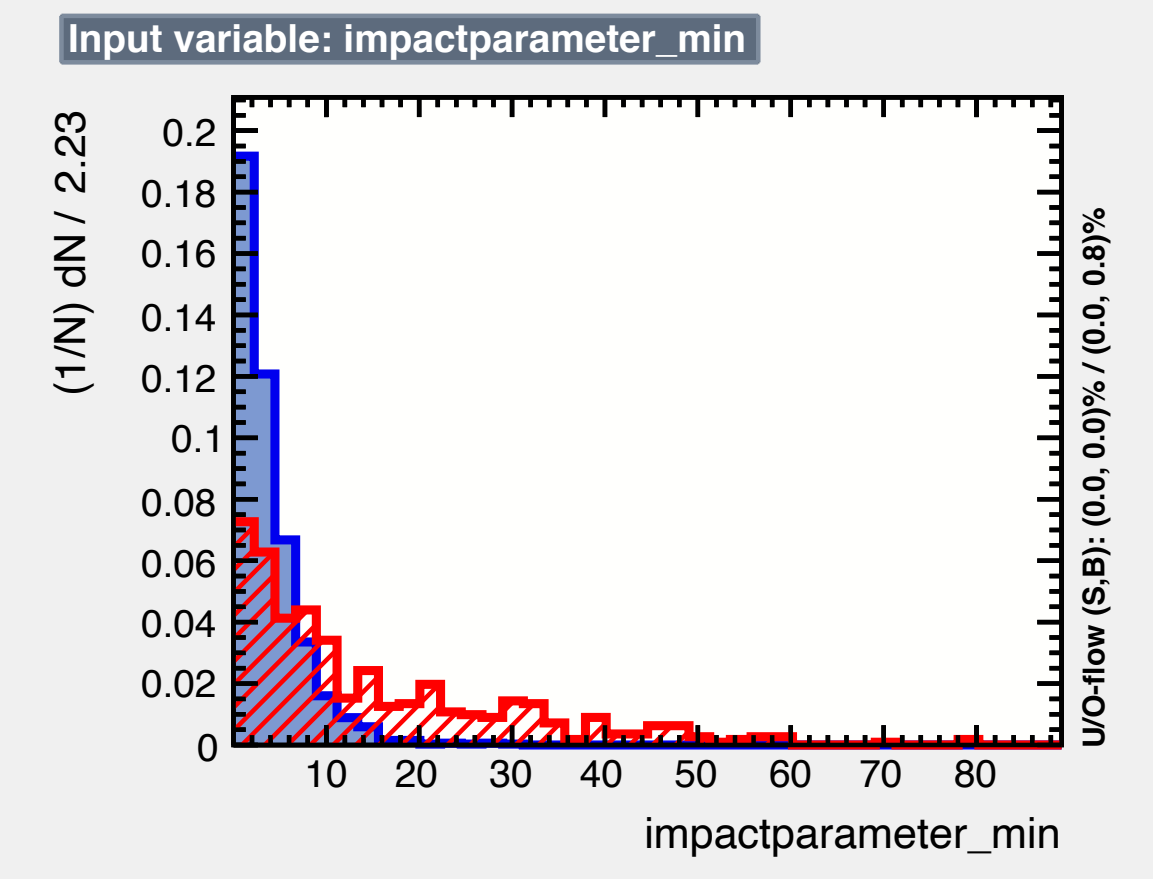
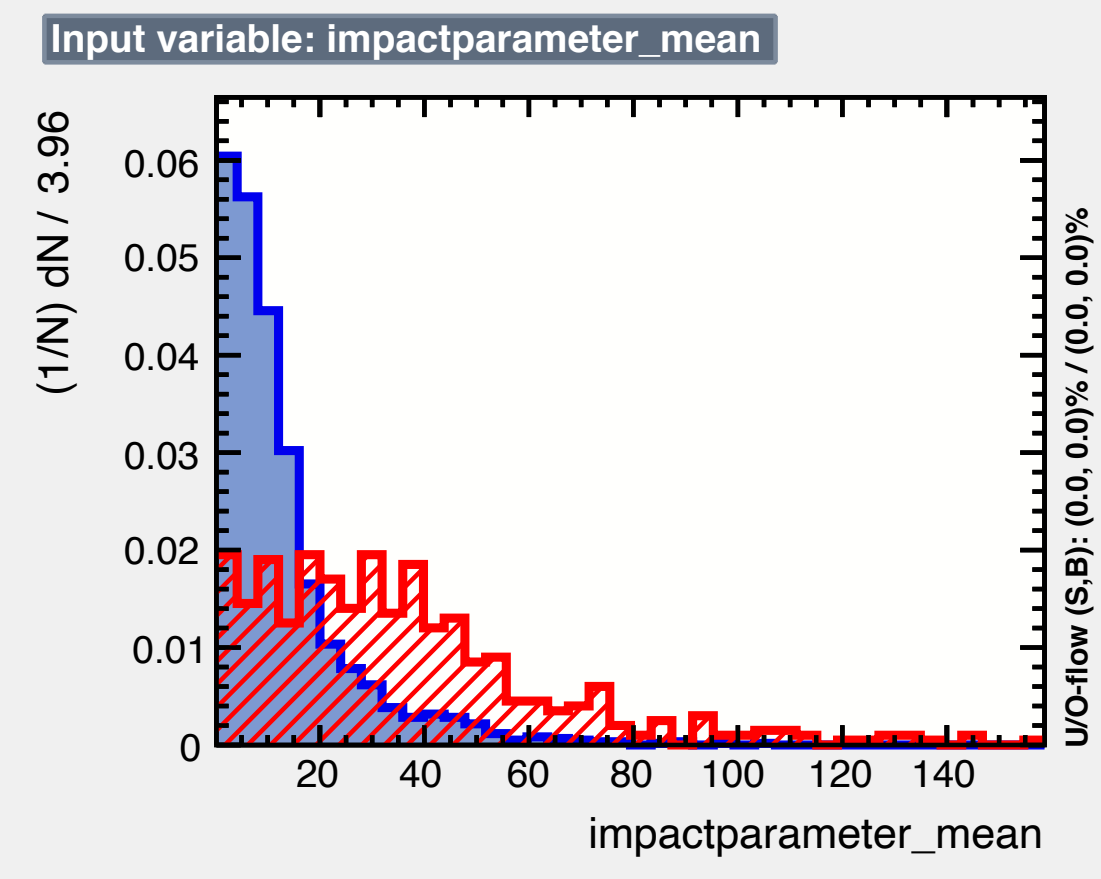
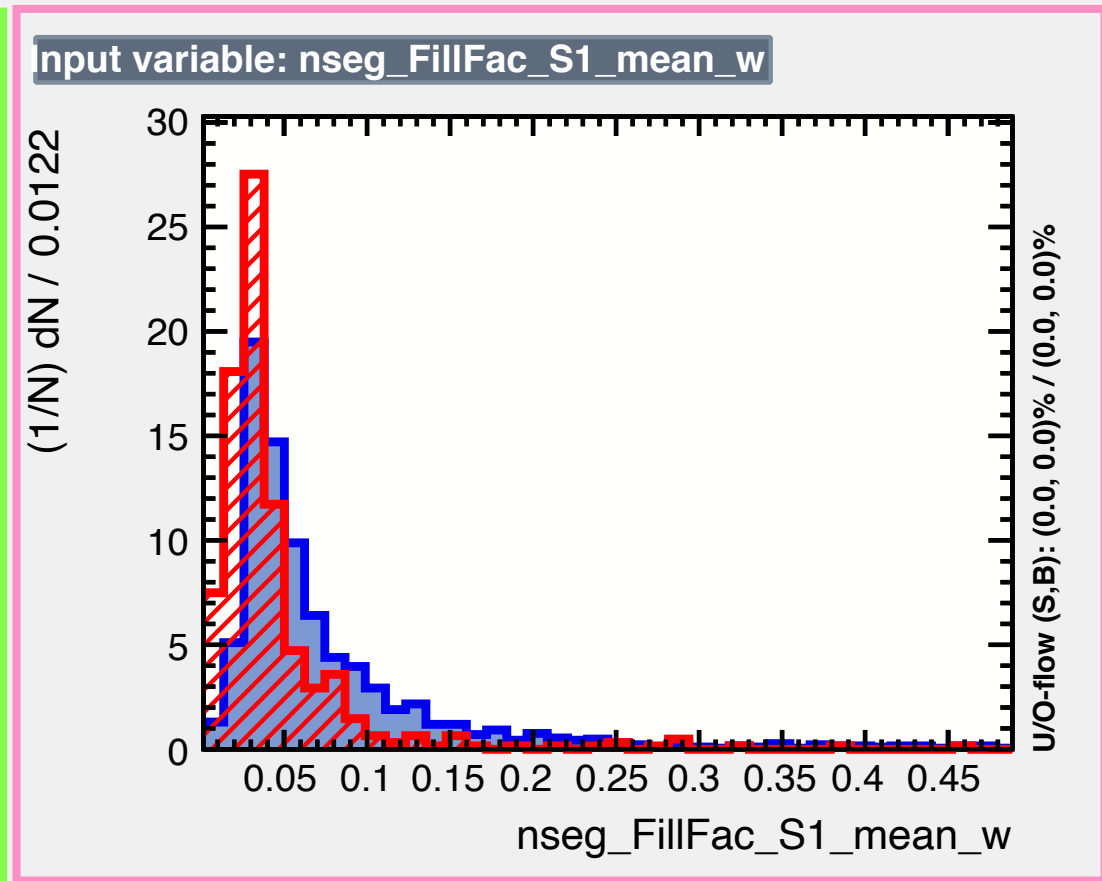
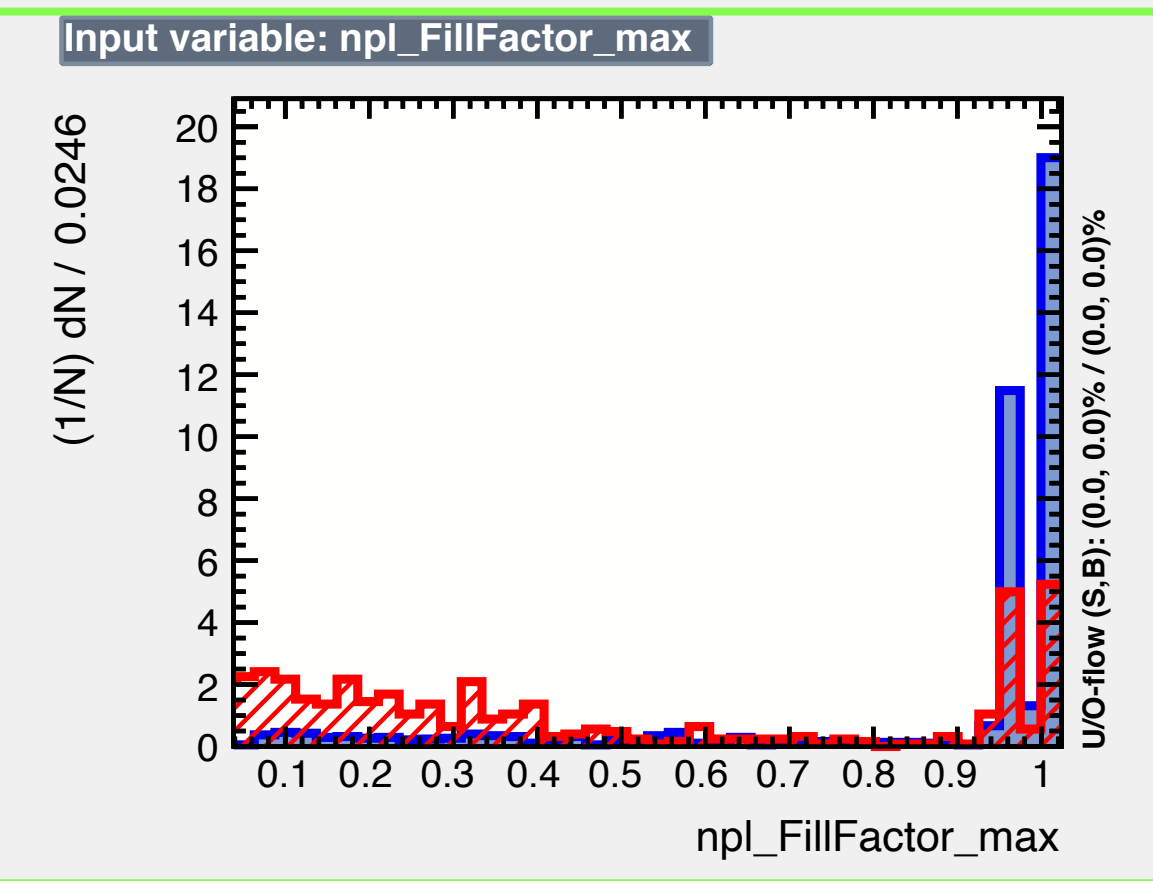
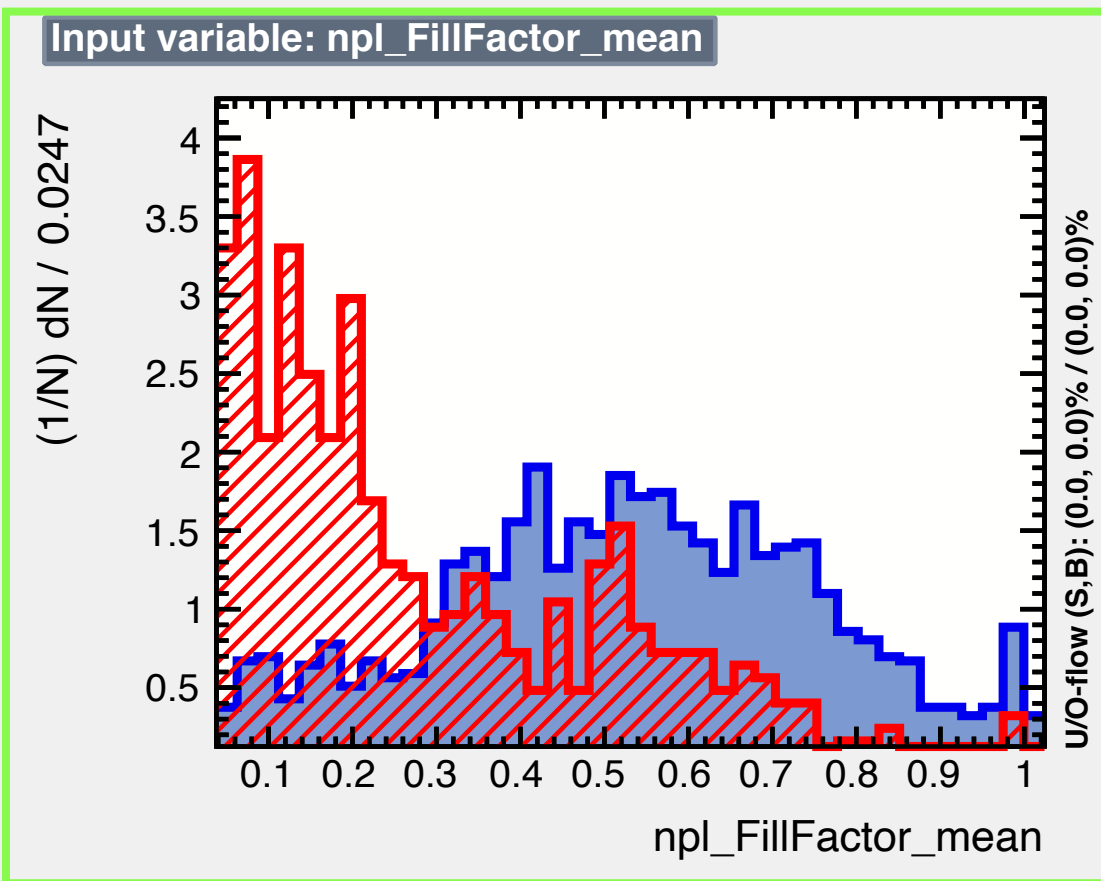
number of tracks outgoing from the vertex

INPUT VARIABLES

$$\text{npl Fill Factor} = \frac{\text{number of plate crossed}}{\text{number of layers available}}$$

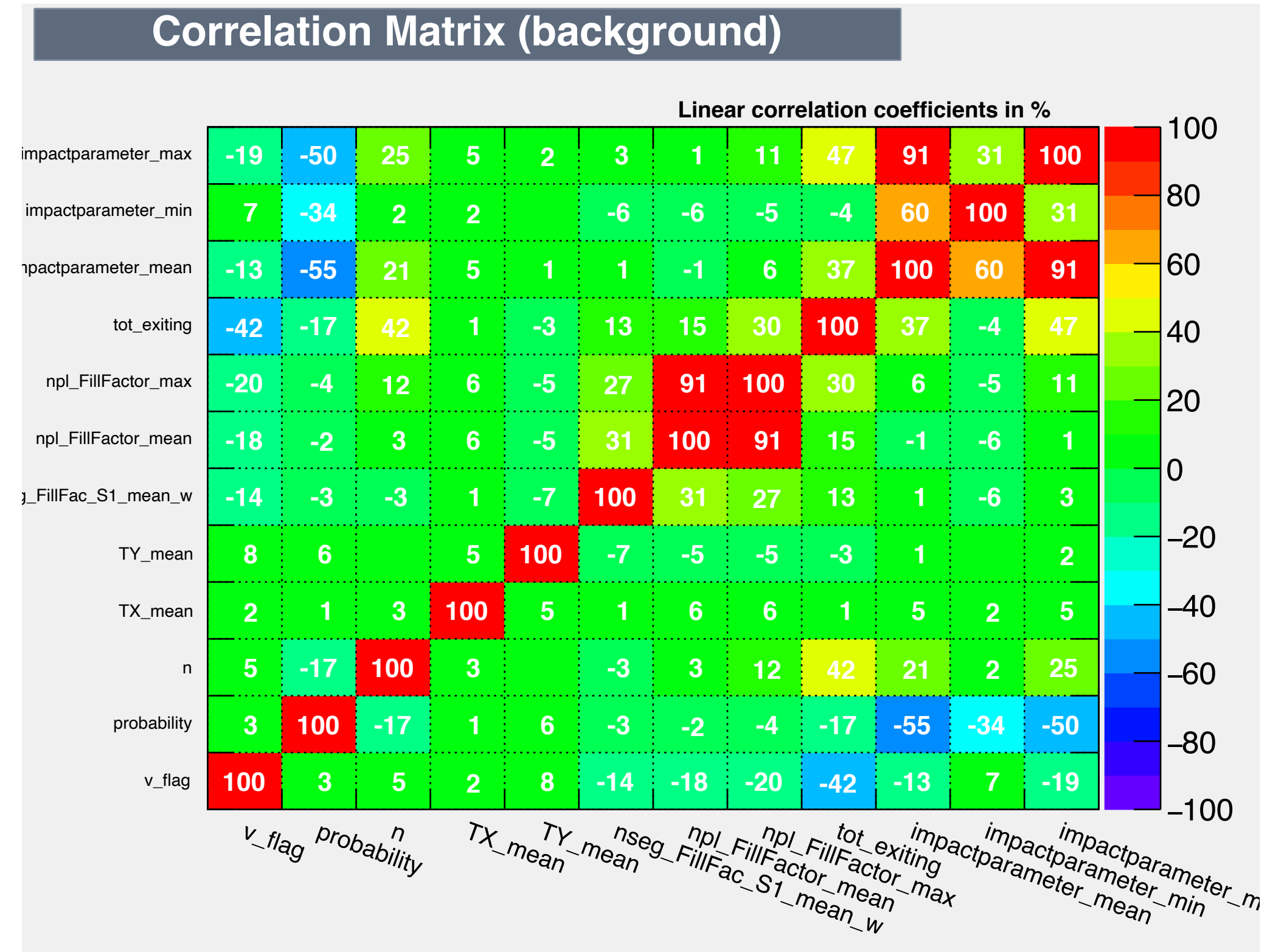
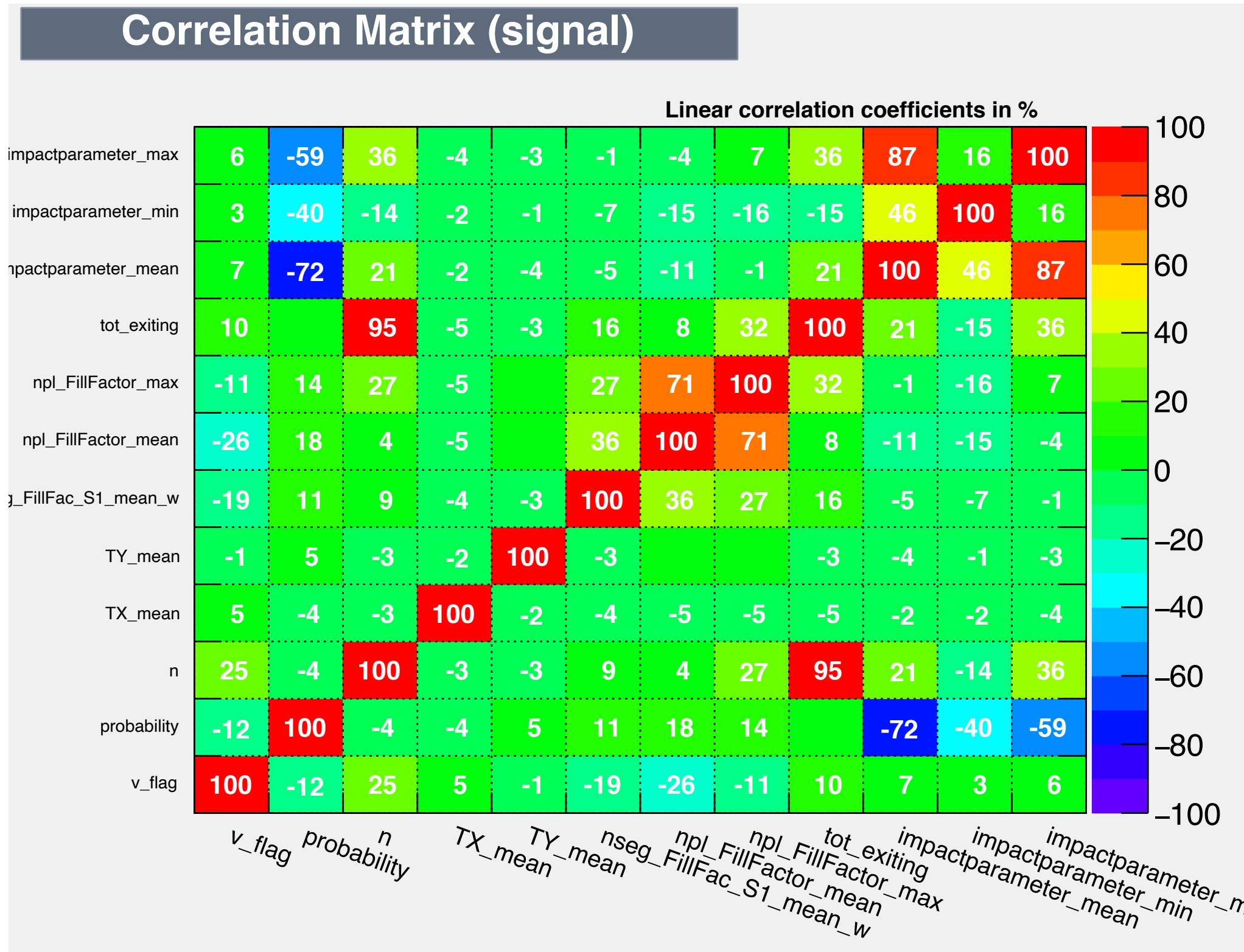
$$\text{nseg Fill Factor S1 weighted} = \frac{\text{number of segments}}{\text{number of layers available} \times \text{vertex layer}}$$

Tracks' impact parameter
respect to the vertex
(mean, min, max)



Mean of daughter tracks' $\tan(\theta_X)$ and $\tan(\theta_Y)$

CORRELATION BETWEEN VARIABLES

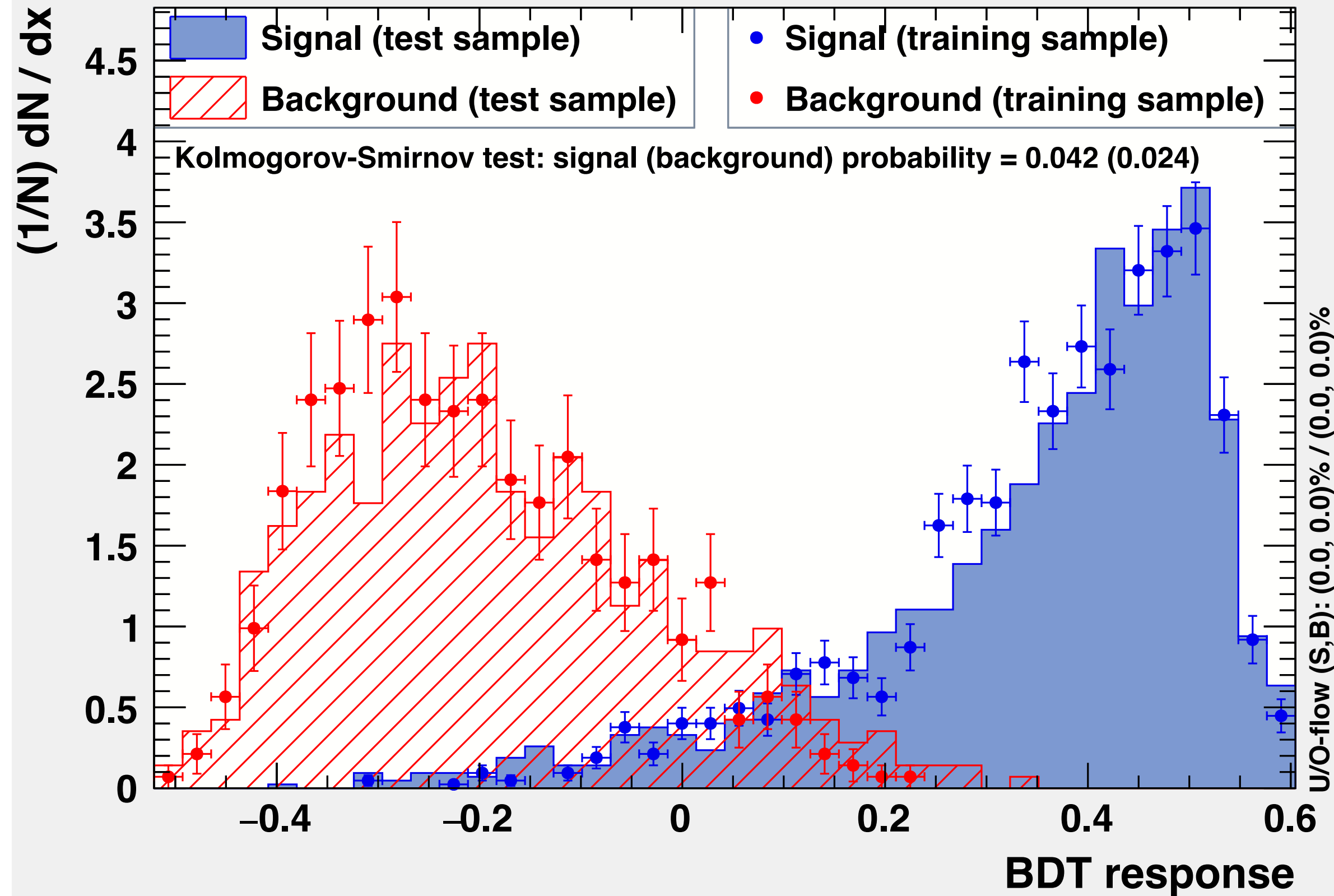


Rank : Variable : Variable Importance

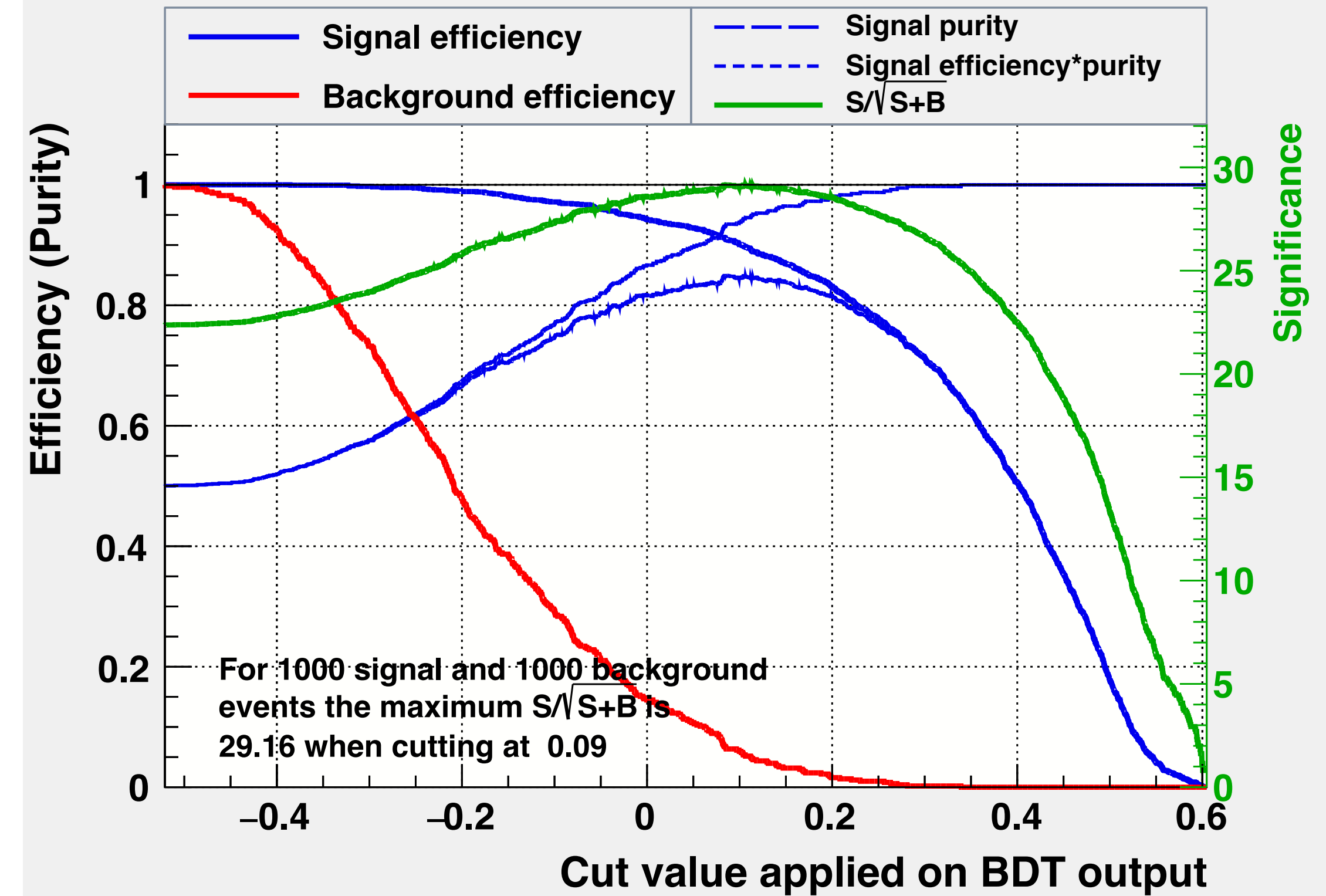
- 1 : probability : 1.073e-01
- 2 : impactparameter_mean : 9.393e-02
- 3 : TY_mean : 9.320e-02
- 4 : npl_FillFactor_mean : 9.252e-02
- 5 : n : 8.873e-02
- 6 : impactparameter_min : 8.700e-02
- 7 : TX_mean : 8.470e-02
- 8 : npl_FillFactor_max : 8.402e-02
- 9 : nseg_FillFac_S1_mean_w : 7.179e-02
- 10 : tot_exiting : 7.172e-02
- 11 : impactparameter_max : 6.633e-02
- 12 : v_flag : 5.880e-02

TRAINING RESULTS

TMVA overtraining check for classifier: BDT



Cut efficiencies and optimal cut value

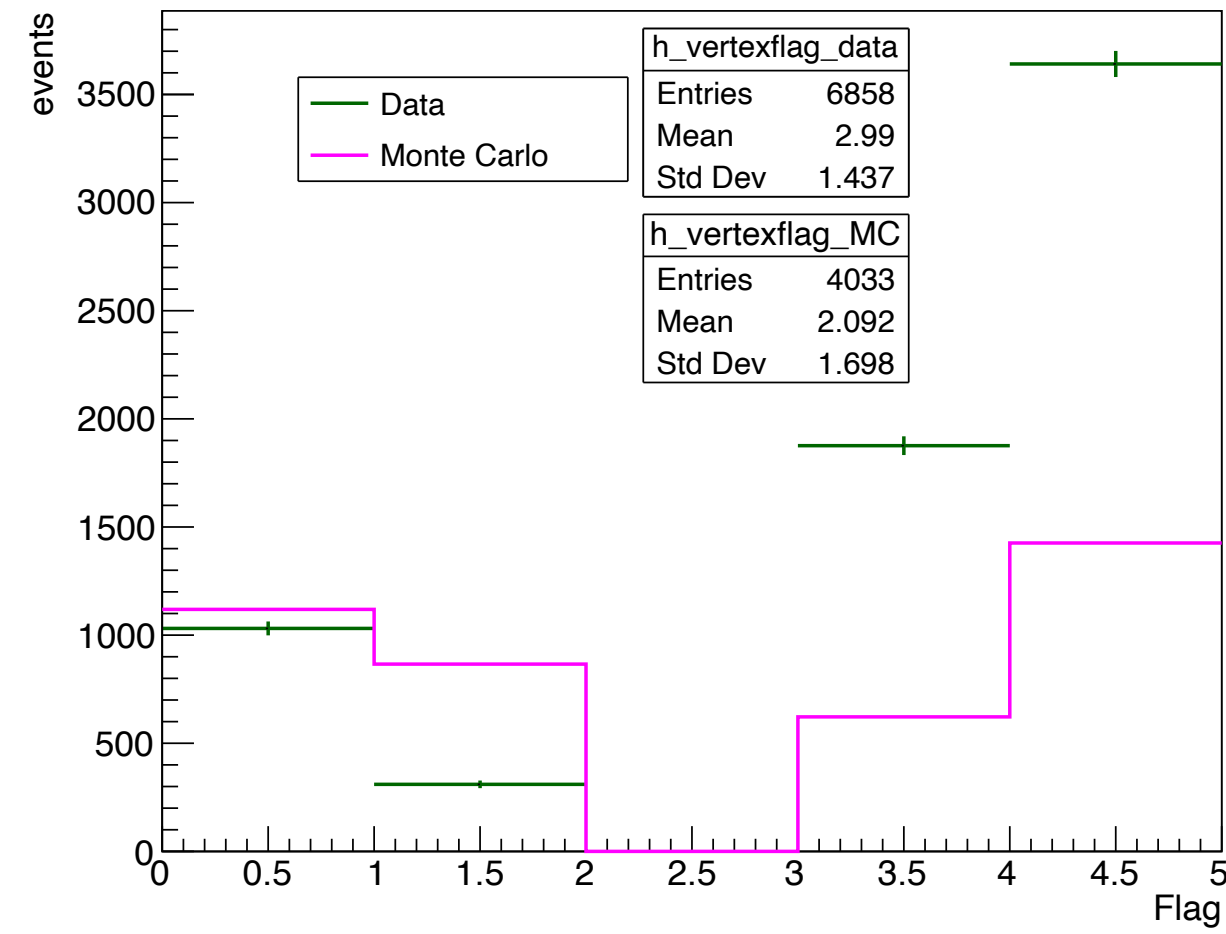


- nTrain_Signal=1512 (half sample)
- nTrain_Background=504 (half sample)

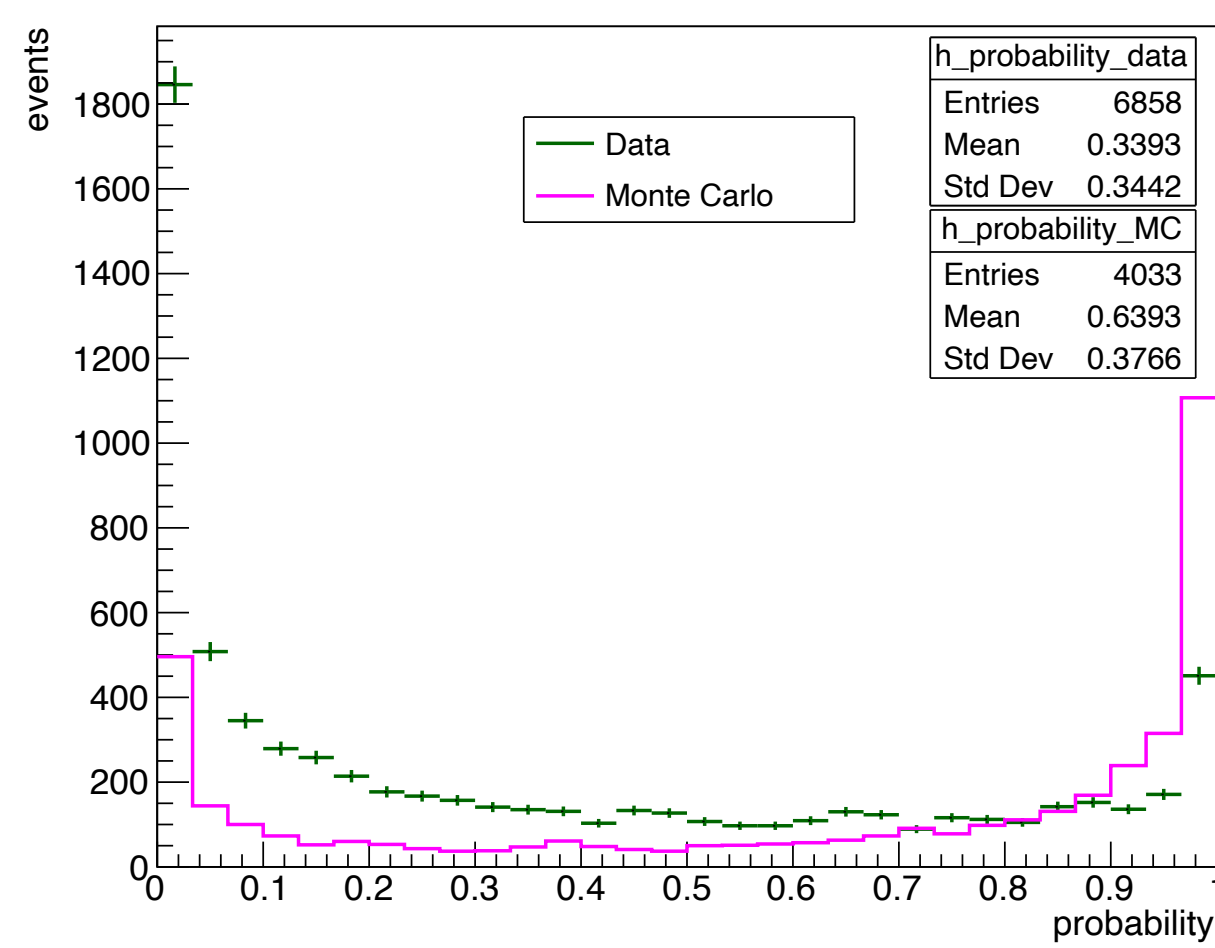
- NTrees=600
- MinNodeSize=2.5%
- MaxDepth=3

DATA AND MC COMPARISON (GOOD + FAKE VERTICES)

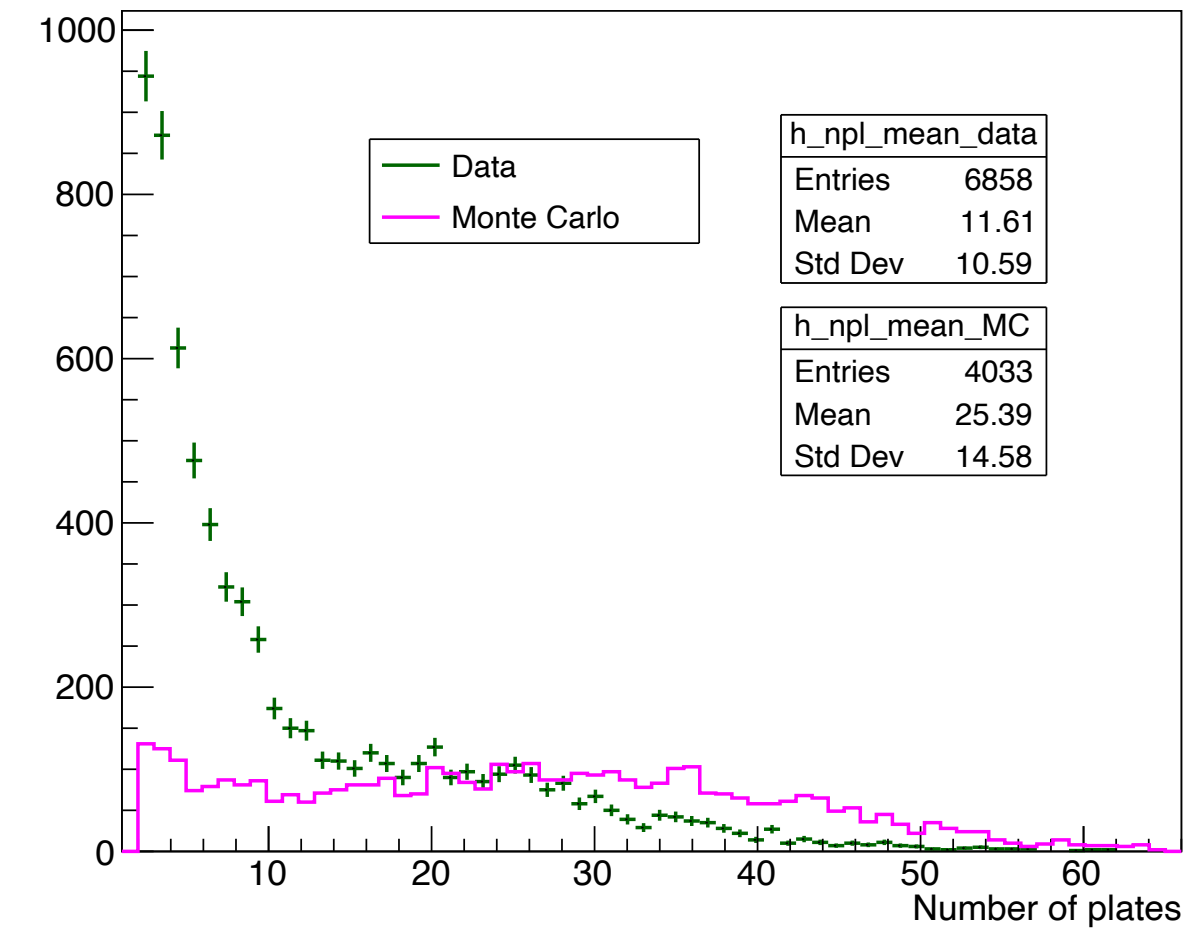
Flag vertex



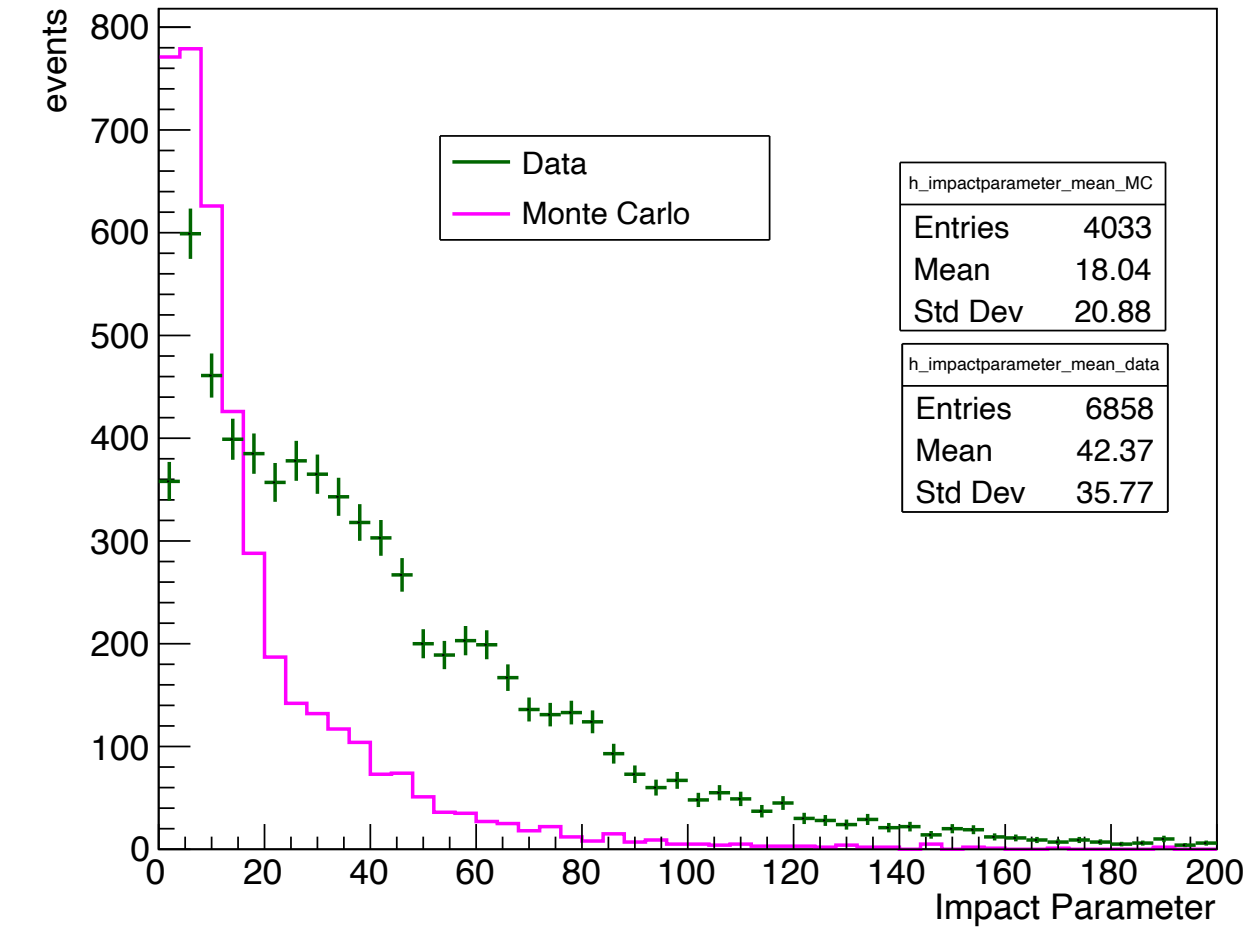
Vertex Probability



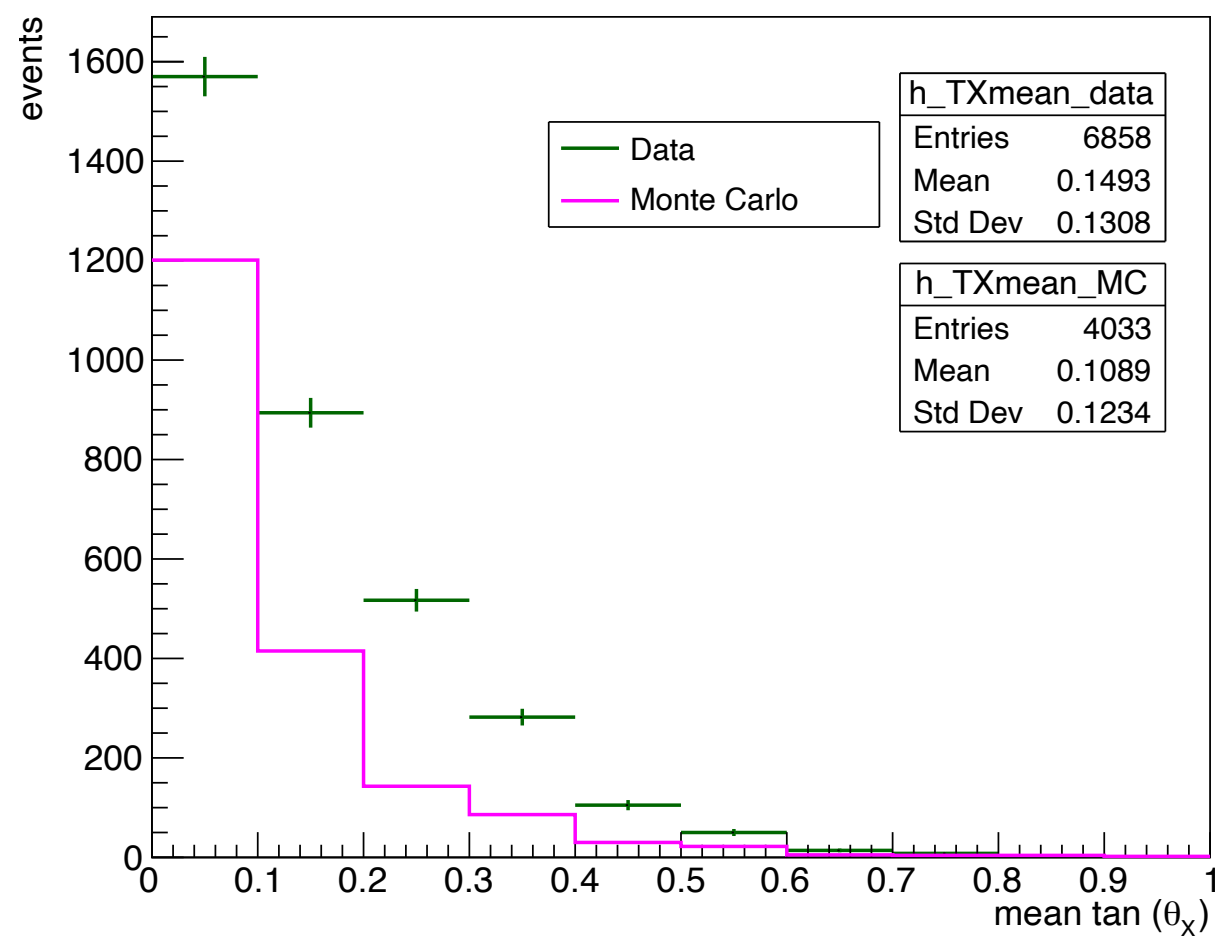
N_{pl}



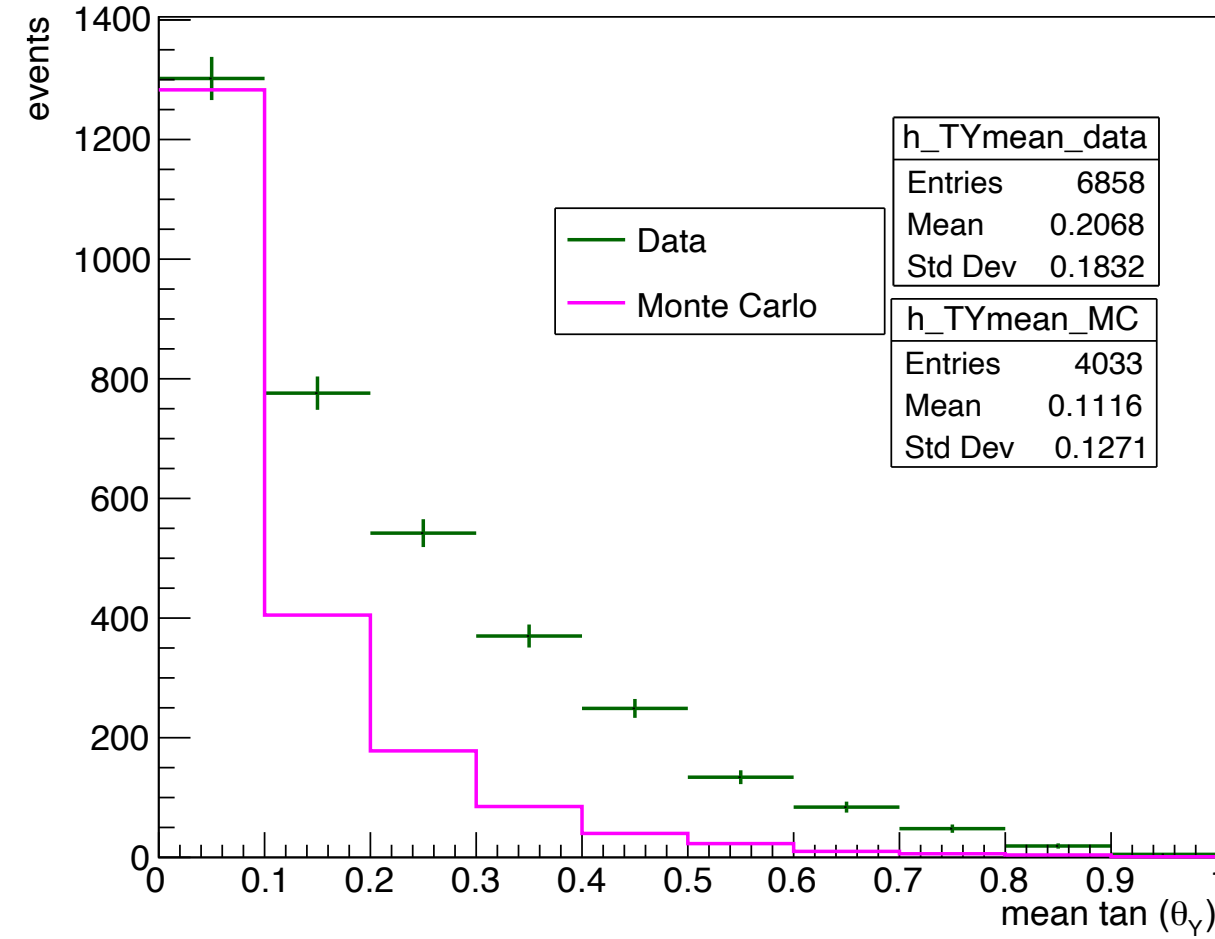
Impact Parameter



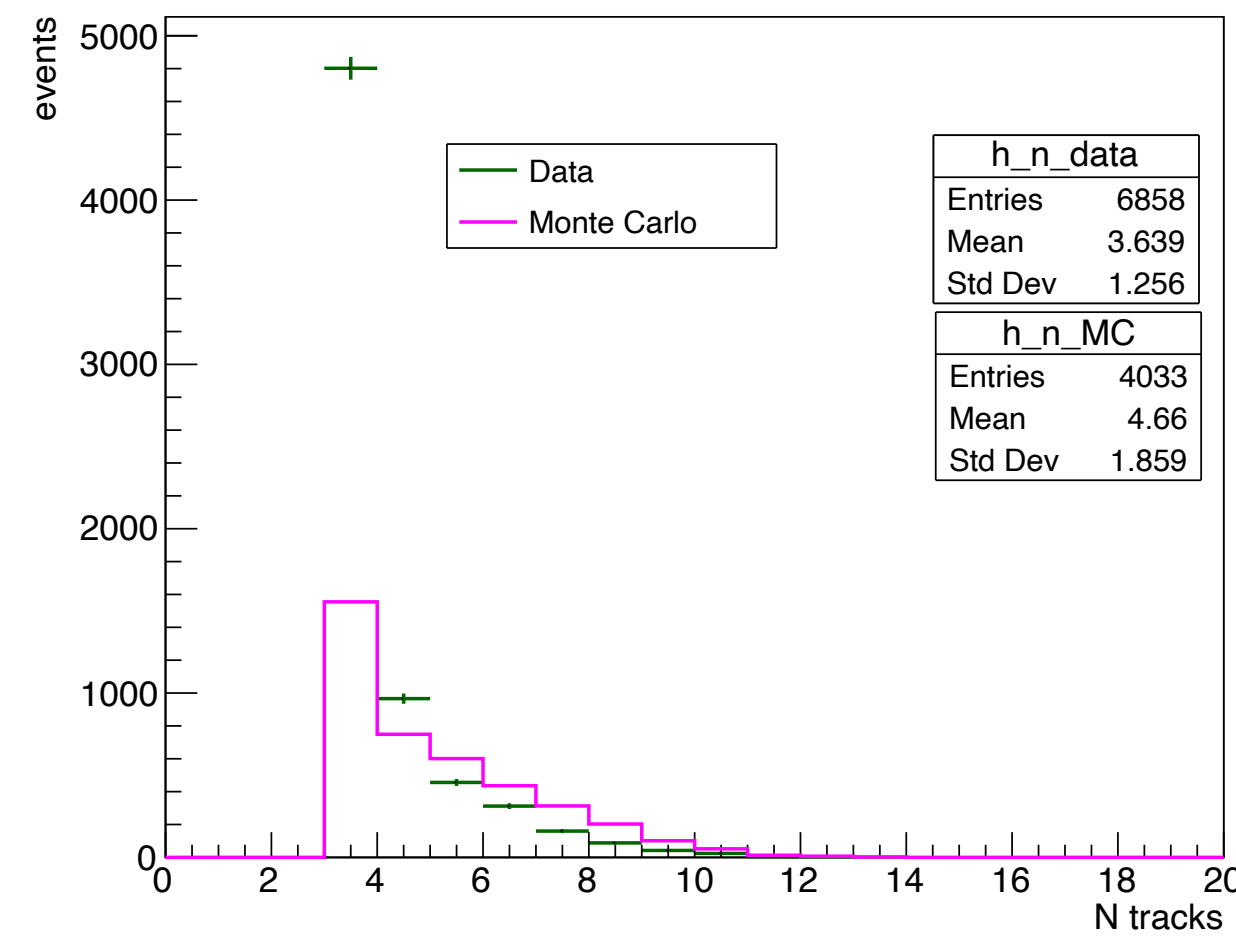
Theta X



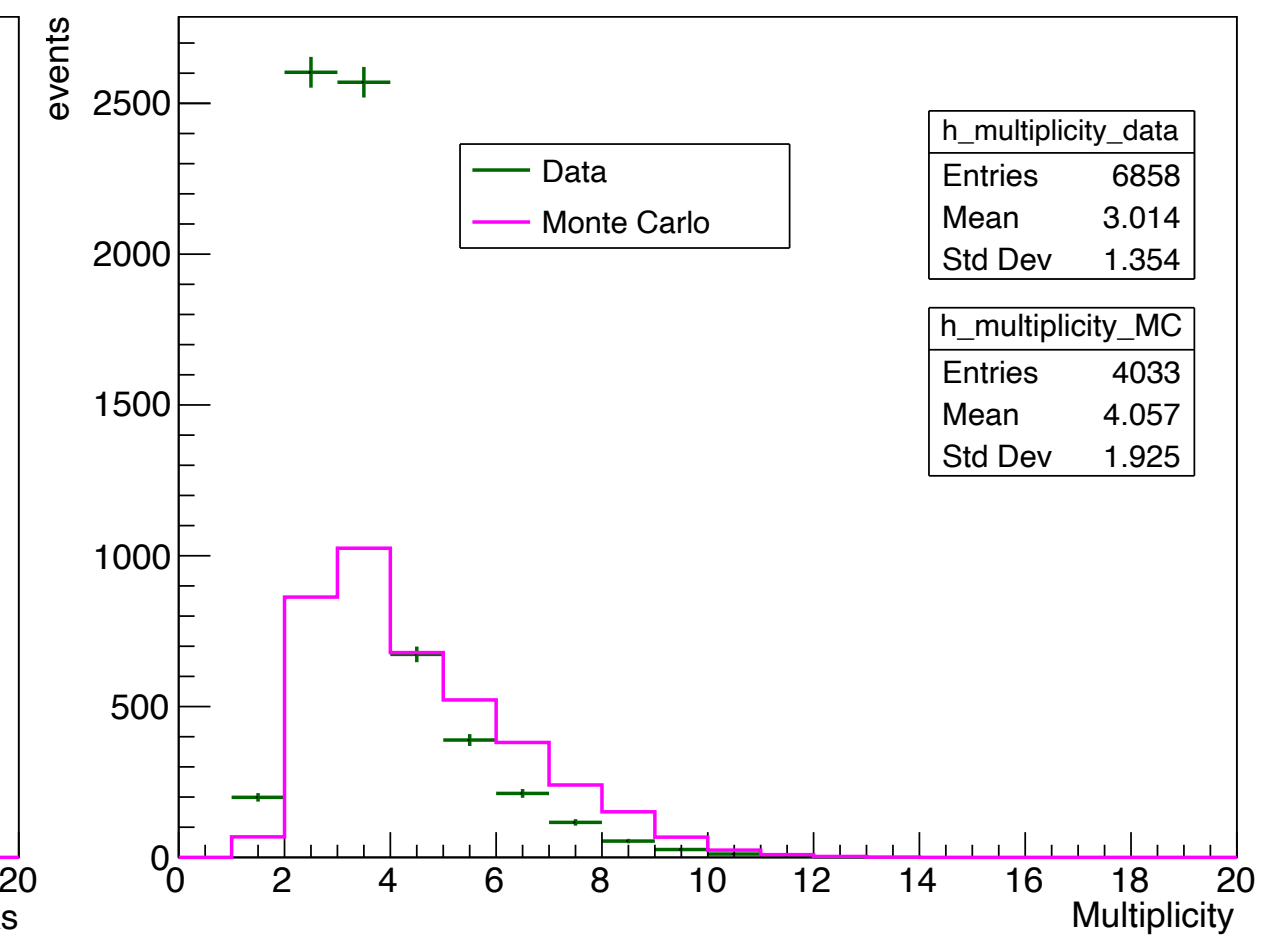
Theta Y



Tracks attached to a vertex (incoming+exiting)



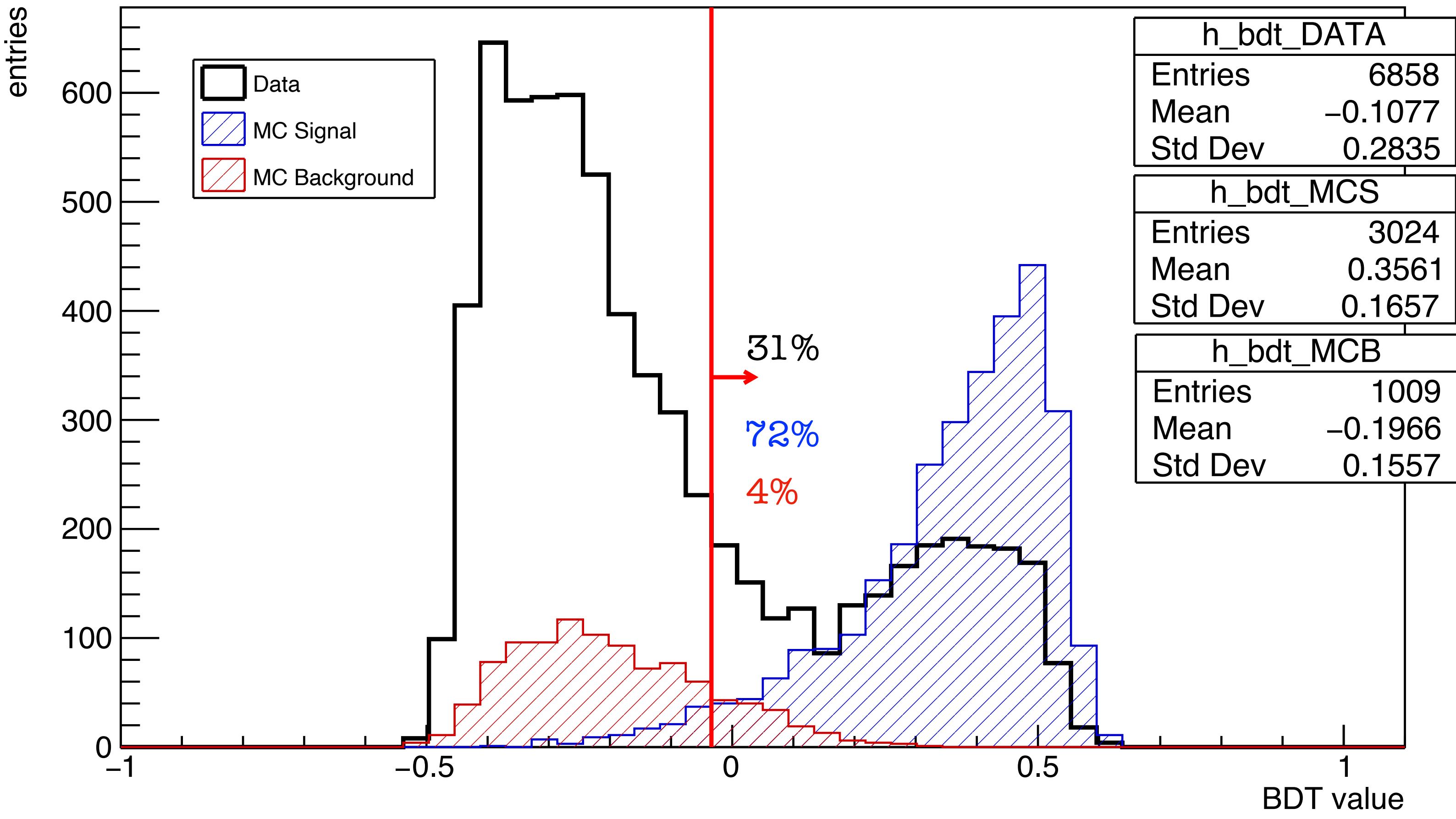
Multiplicity



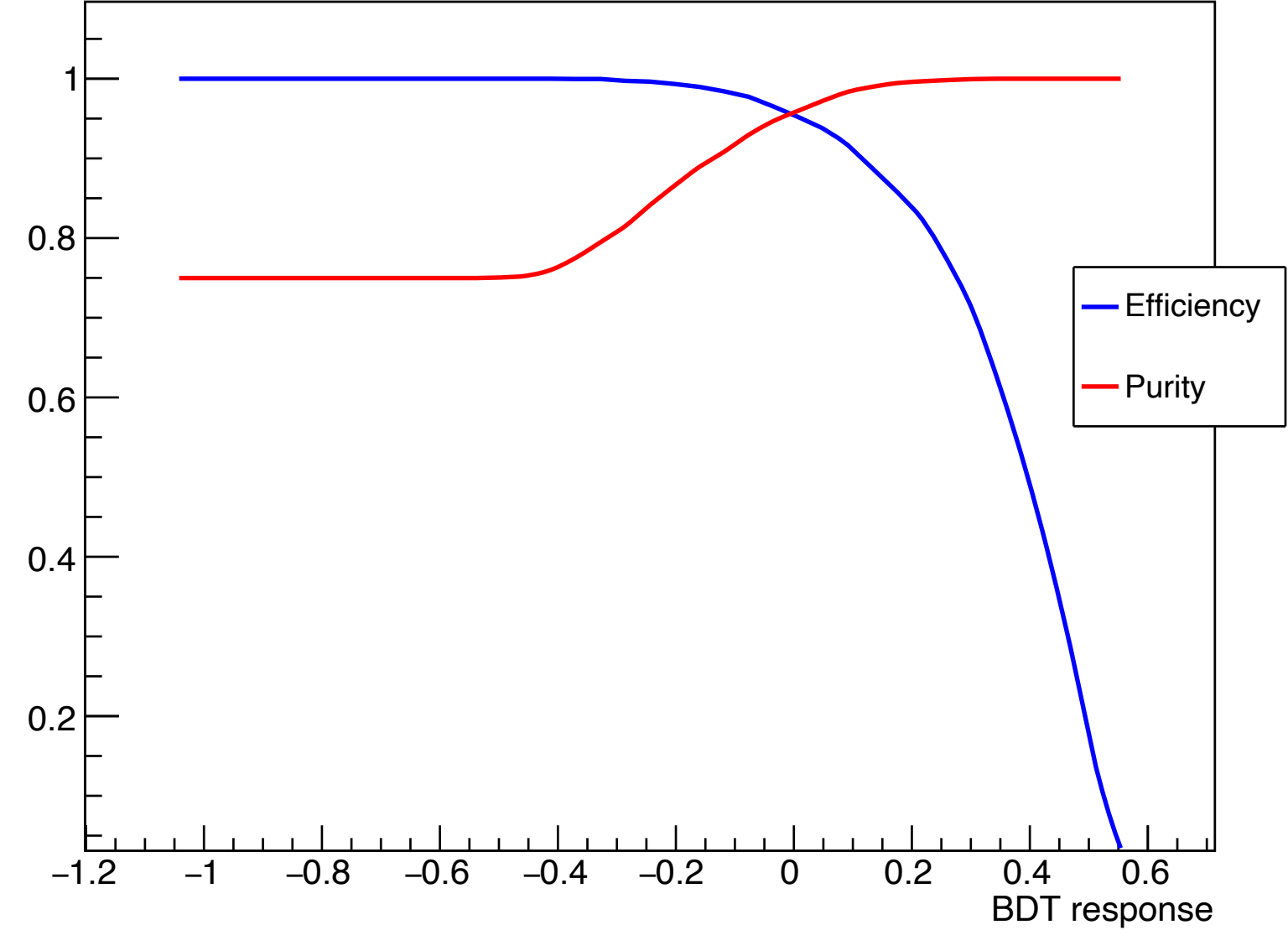
(MC and DATA normalised to beam particles)

APPLICATION ON DATA

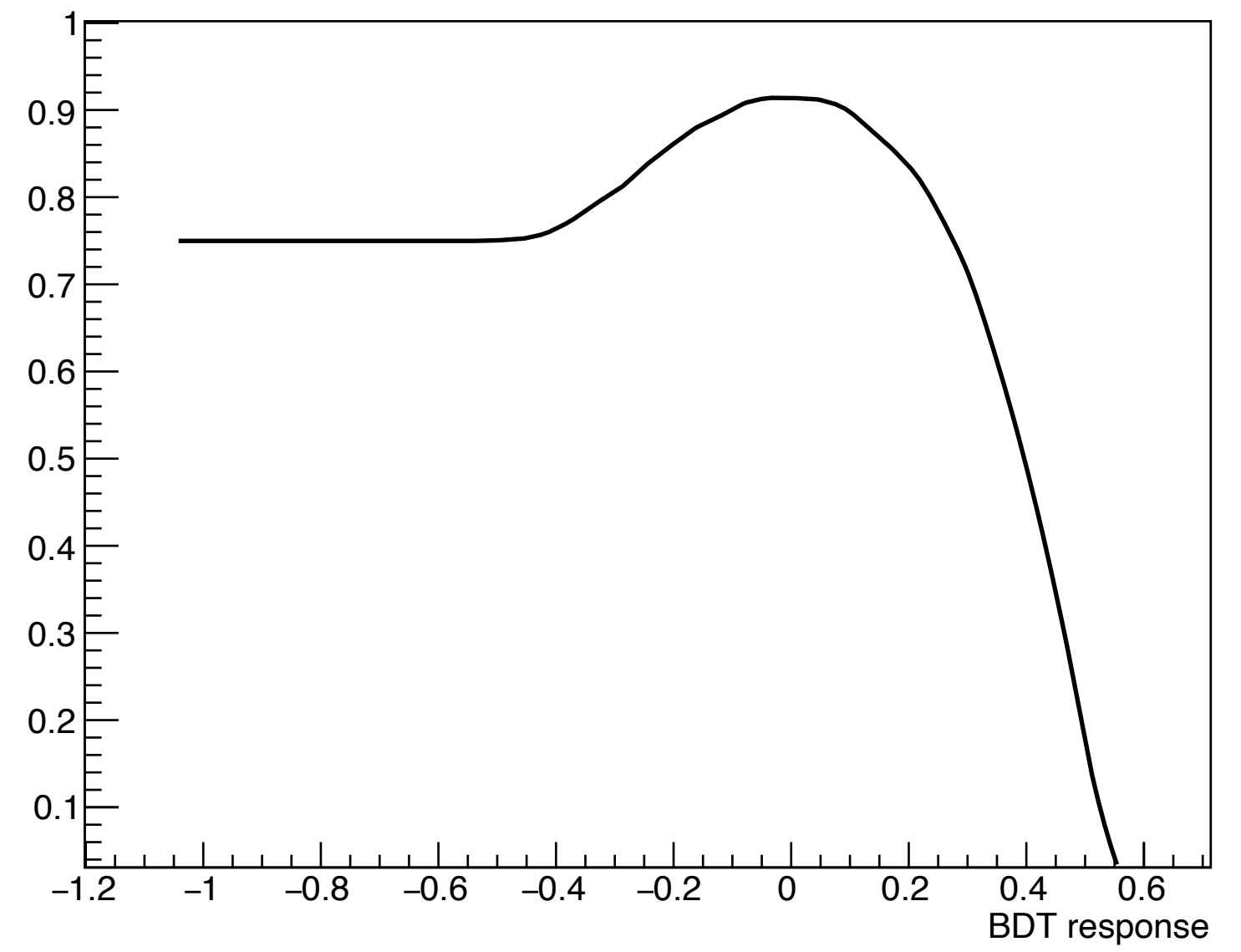
BDT Response



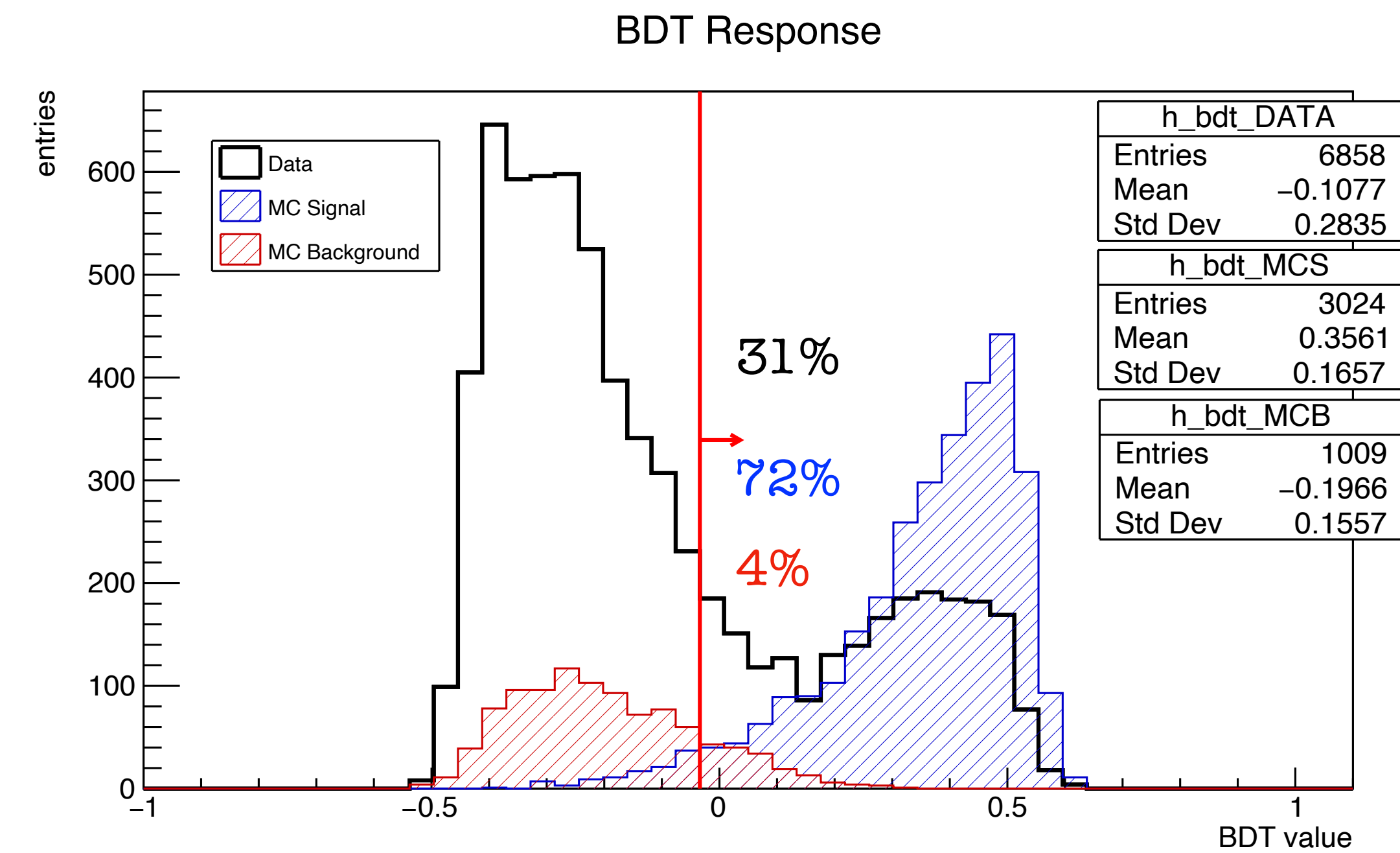
Efficiency and Purity vs cut



Efficiency*Purity



MC AND DATA SAMPLES



	MC true	MC after BDT selection	Data
Entries	8469		33975
$n \geq 3$	4033		6858
vtx good	3024	3081	2112
vtx fake	1009	952	4746

VERTICES DISTRIBUTIONS AFTER BDT SELECTION (DATA AND MC COMPARISON)

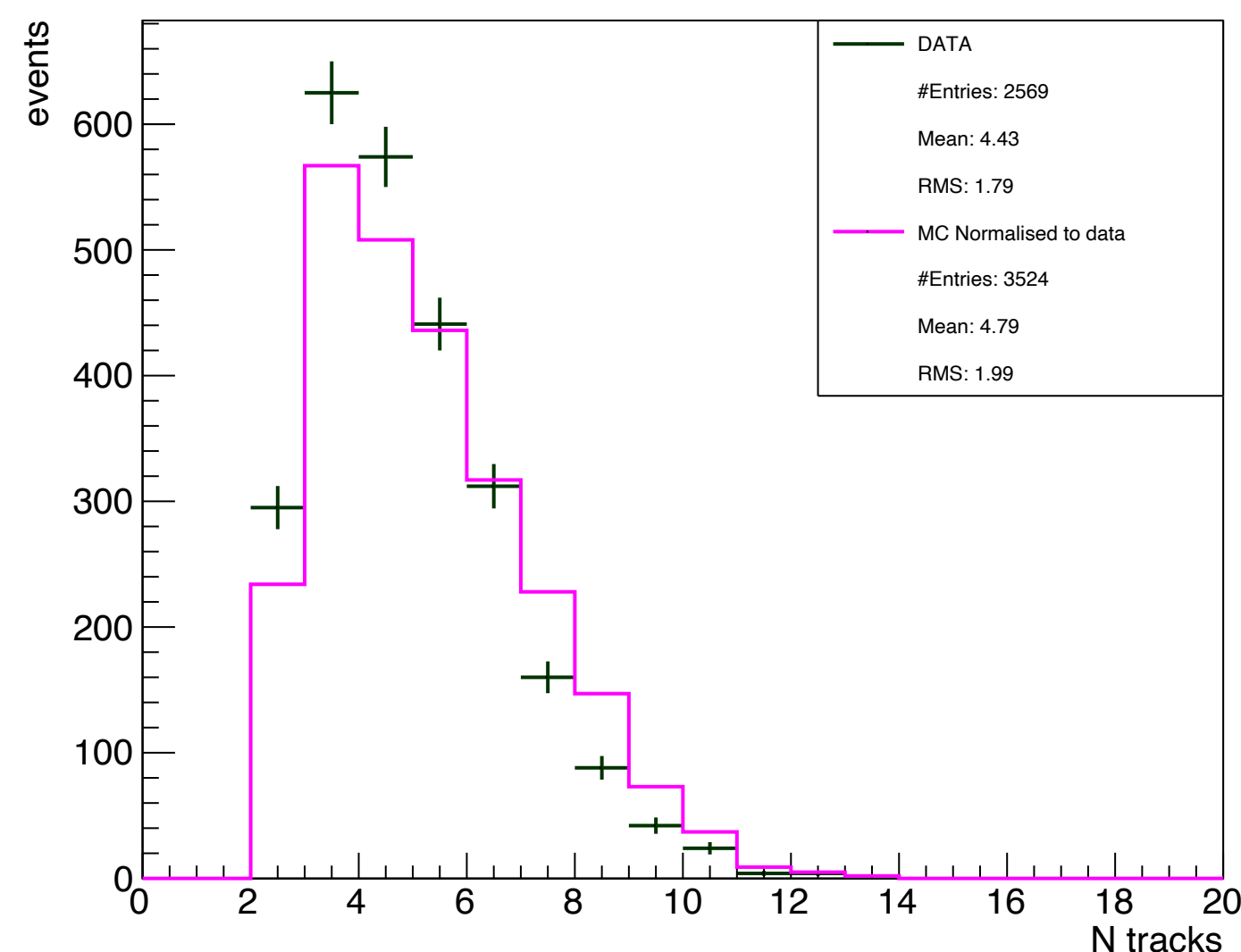
- Entries:

- ➔ MC: 3081 (BDT) + 443 (2 prong manual selection) = 3524

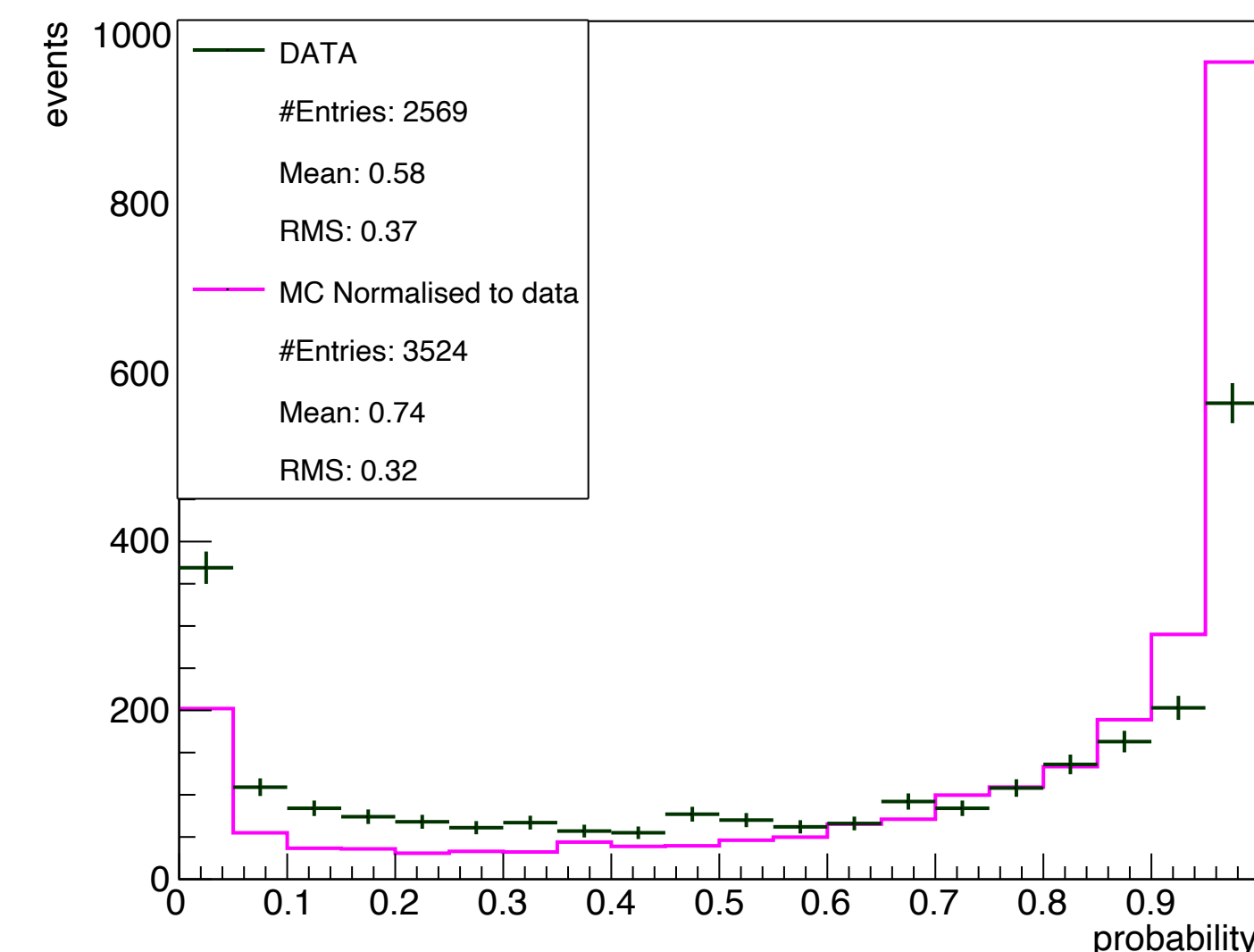
- ➔ DATA: 2112 (BDT) + 457 (2 prong manual selection) = 2569

- Better agreement between DATA and MC after vertices selection with BDT

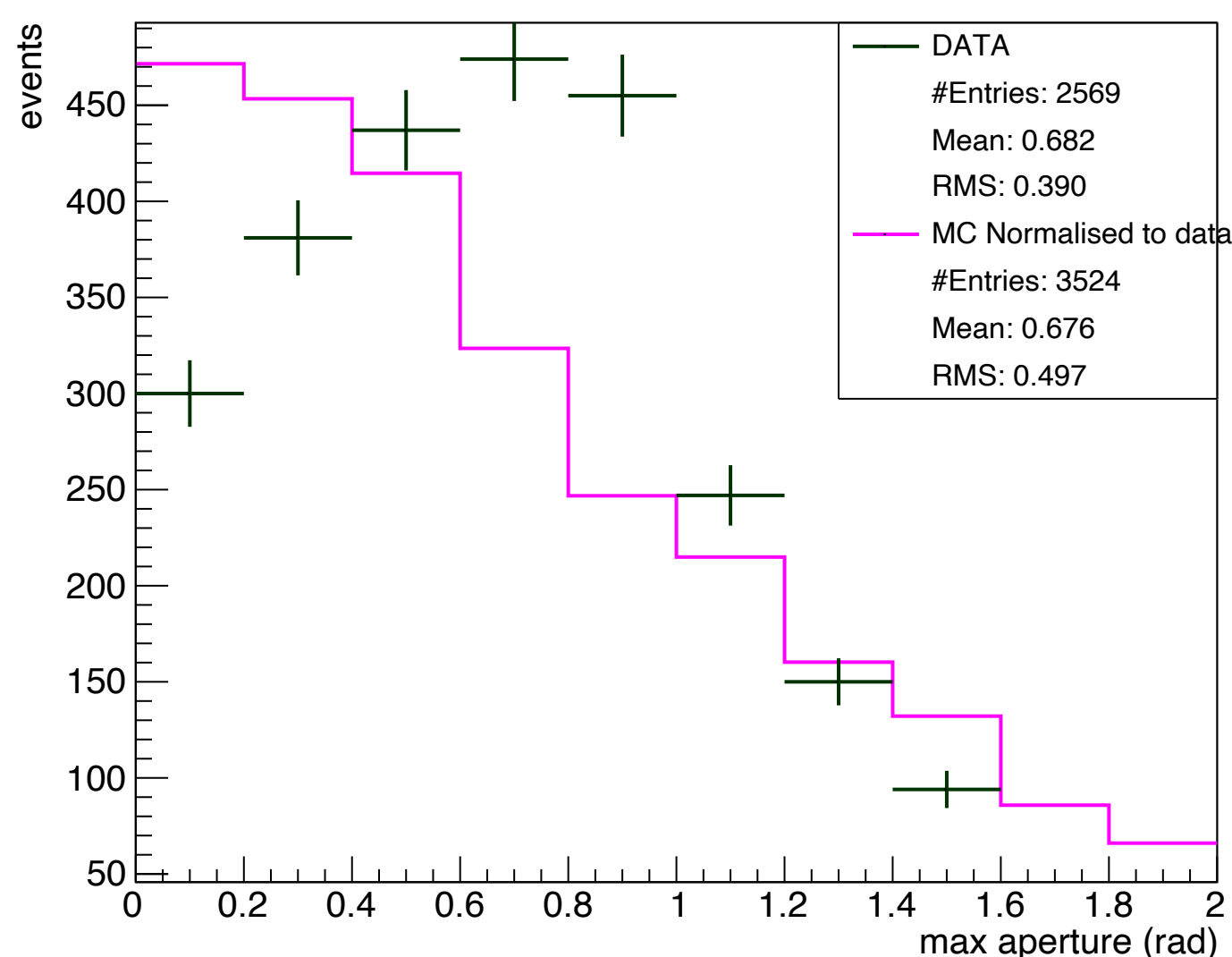
Tracks attached to a vertex (incoming+exiting)



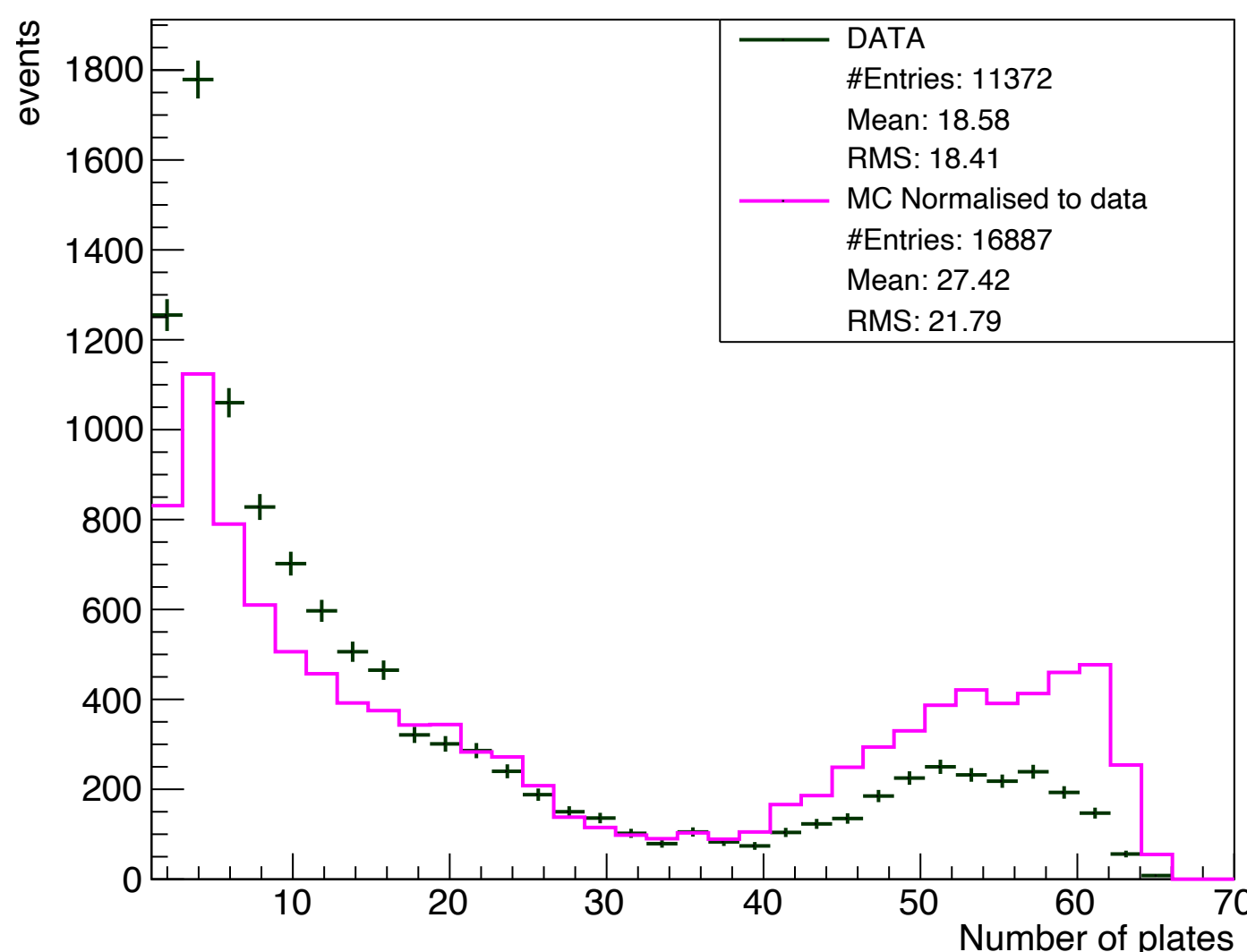
Vertex Probability



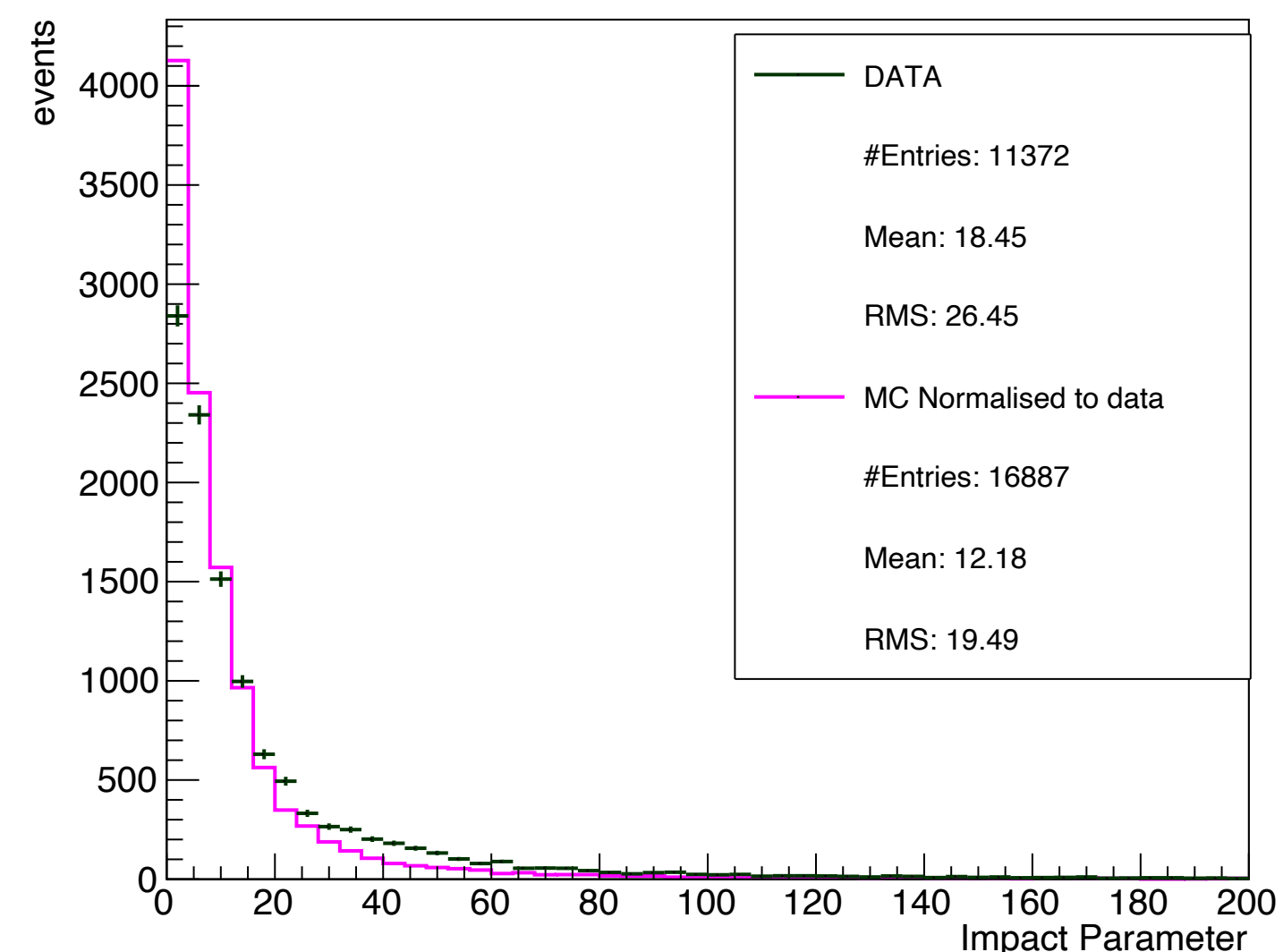
Max Aperture



N_{pl}



Impact Parameter



(MC normalised to DATA)

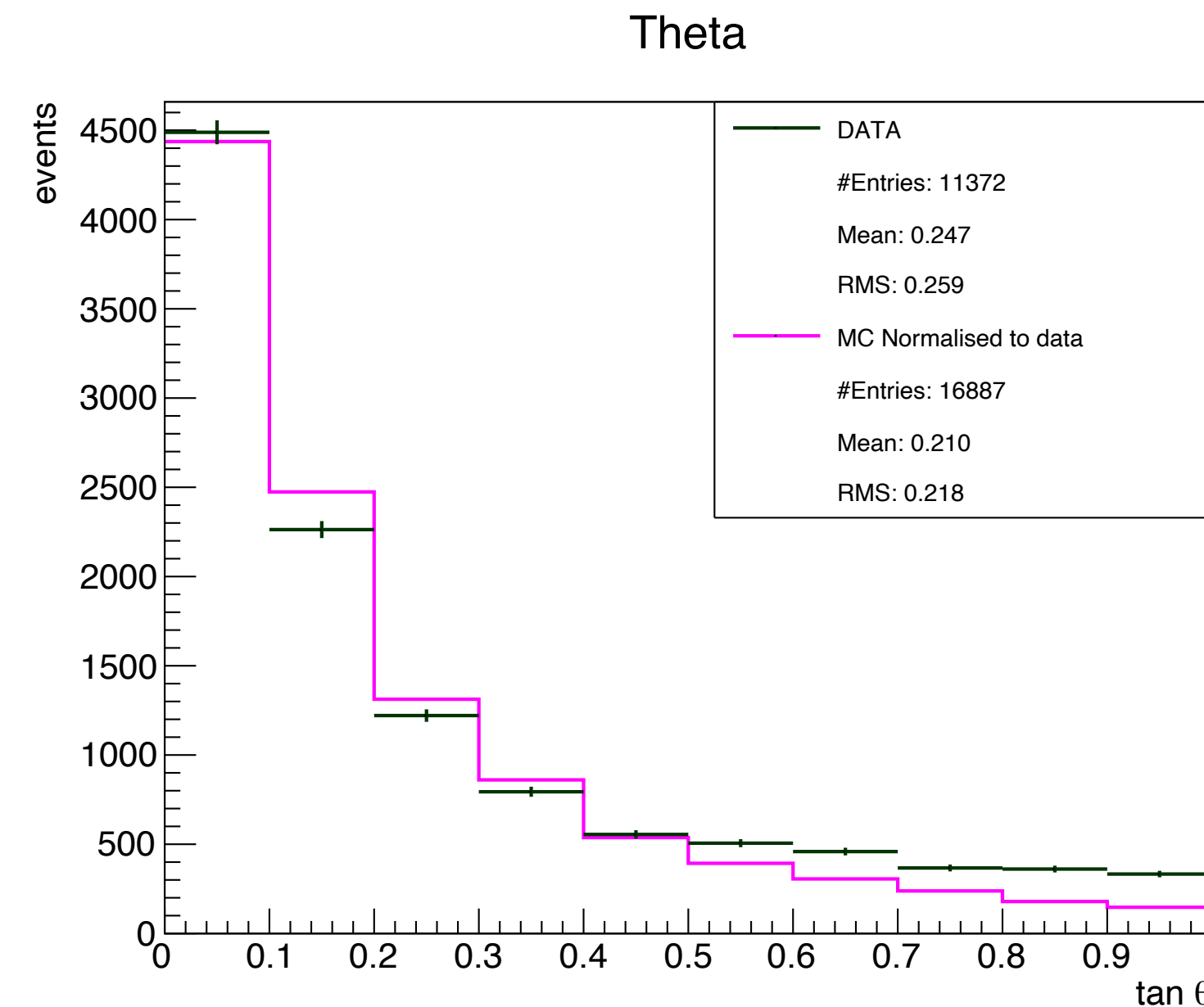
VERTICES DISTRIBUTIONS AFTER BDT SELECTION (DATA AND MC COMPARISON)

- Entries:

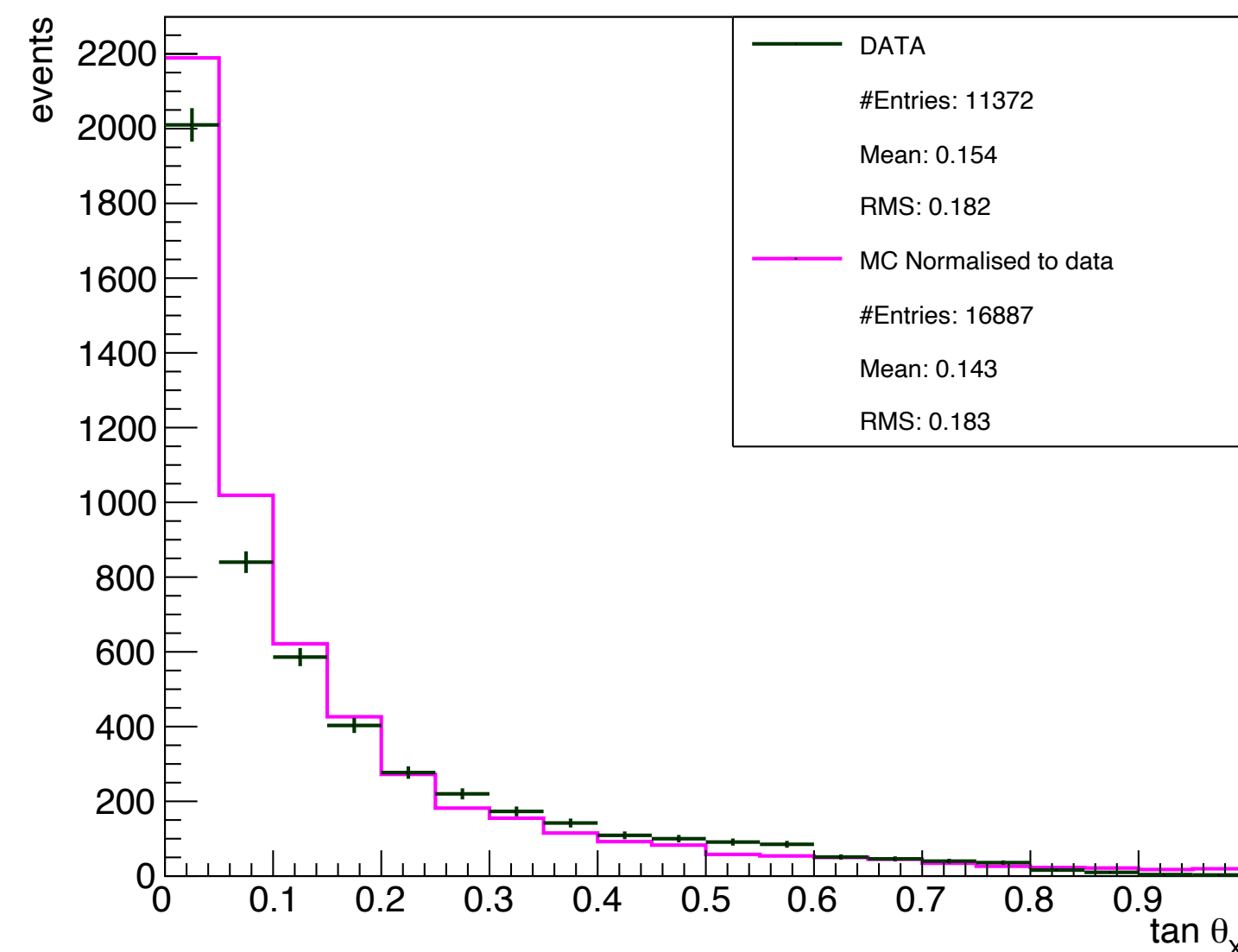
- ➔ MC: 3081 (BDT) + 443 (2 prong manual selection) = 3524

- ➔ DATA: 2112 (BDT) + 457 (2 prong manual selection) = 2569

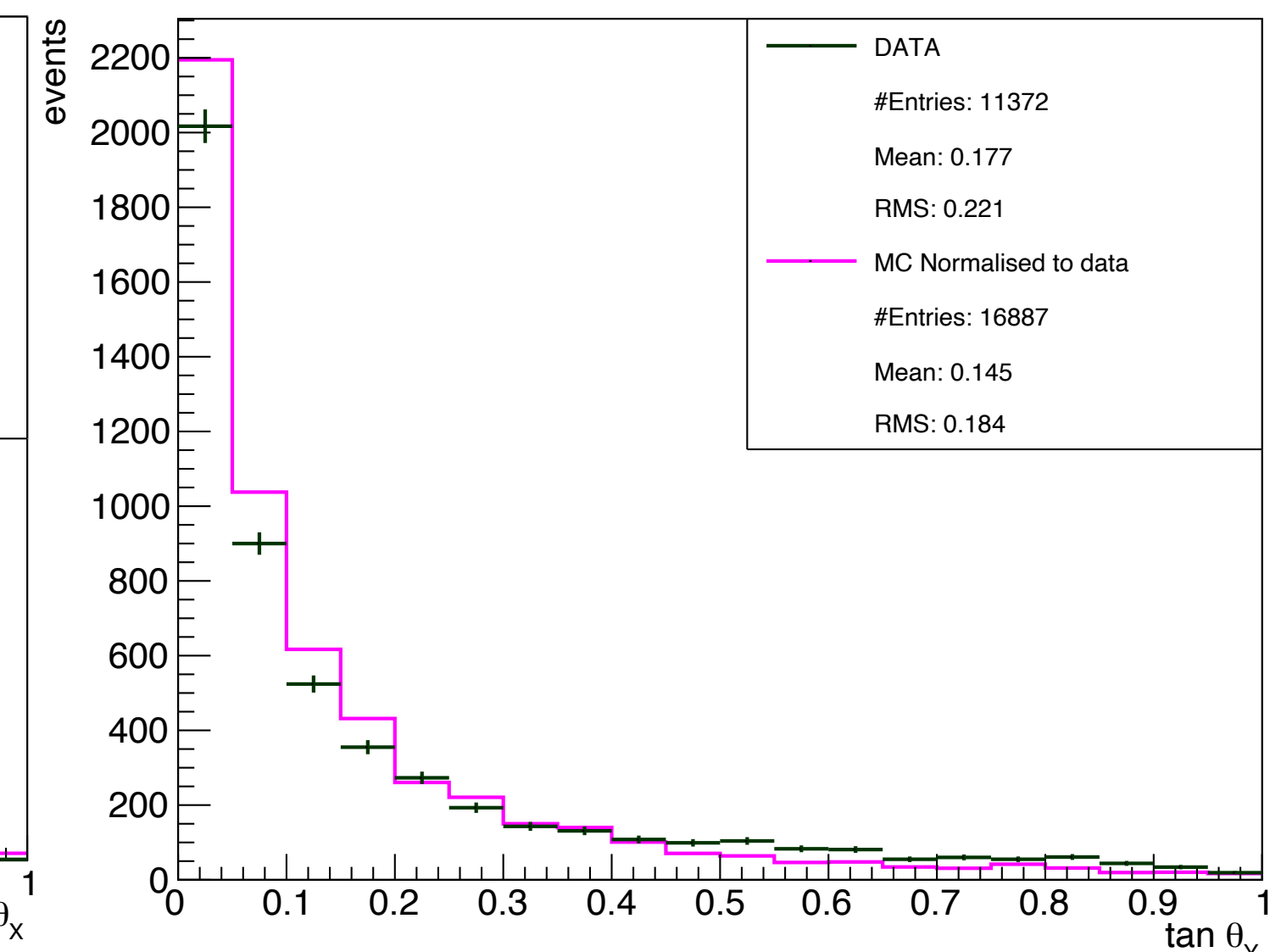
- Better agreement between DATA and MC after vertices selection with BDT



tan θ_x (all tracks)



tan θ_y (all tracks)



(MC normalised to DATA)

CONCLUSIONS

- Track reconstruction done separately for each section, with appropriate parameters
- Algorithm developed to merge the tracks reconstructed in two sections:
 - ▶ 65200 tracks reconstructed with more than 5 segments
 - ▶ 13026 tracks reconstructed crossing more than 30 layers
- BDT multivariate analysis to select good vertexing out of background ones:
 - ▶ MC: 72% of true vertices selected
 - ▶ DATA: ~ 40% of expected vertices reconstructed. Better agreement between data and MC after selection
- Vertex search to be improved



BACK UP SLIDES

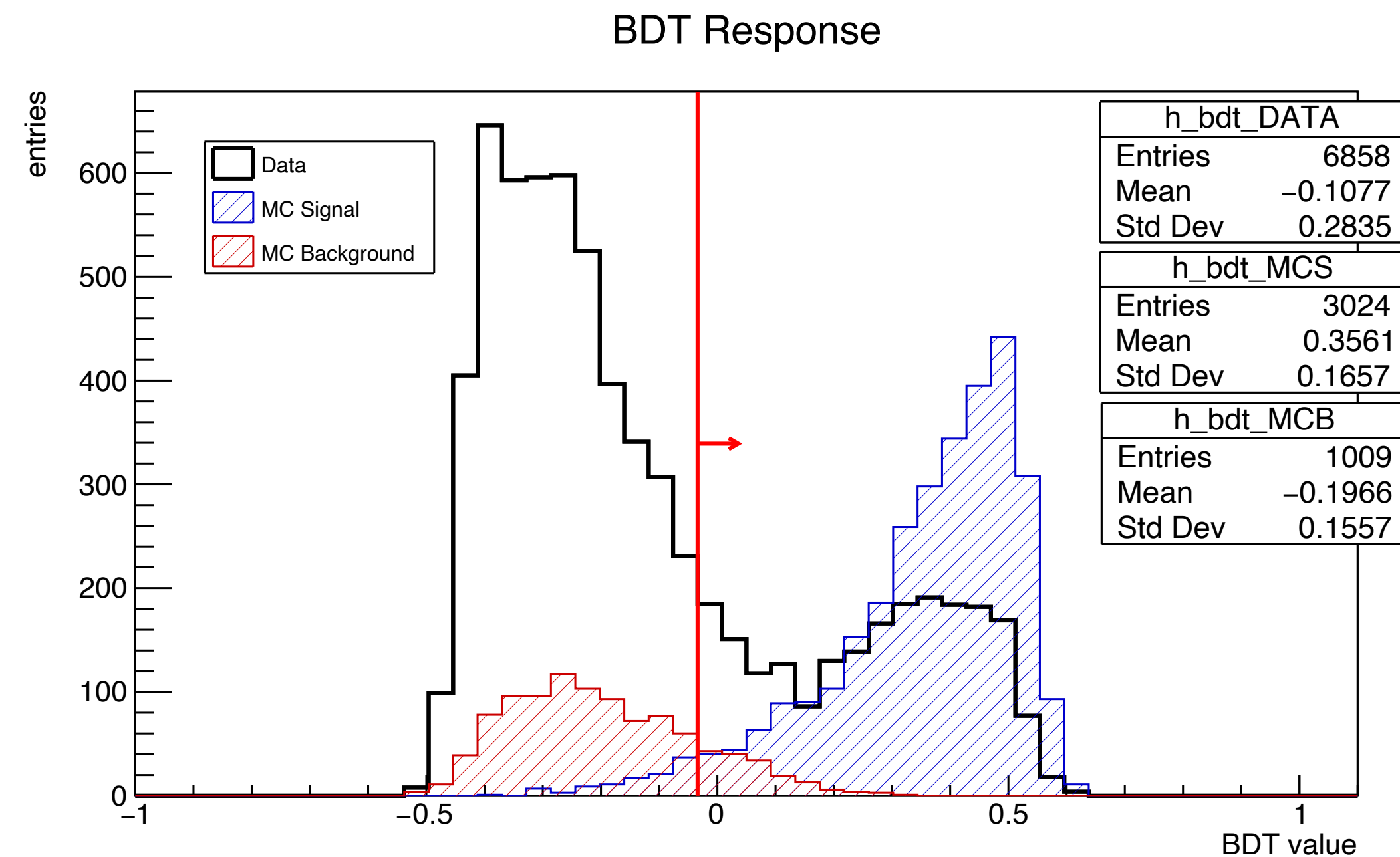
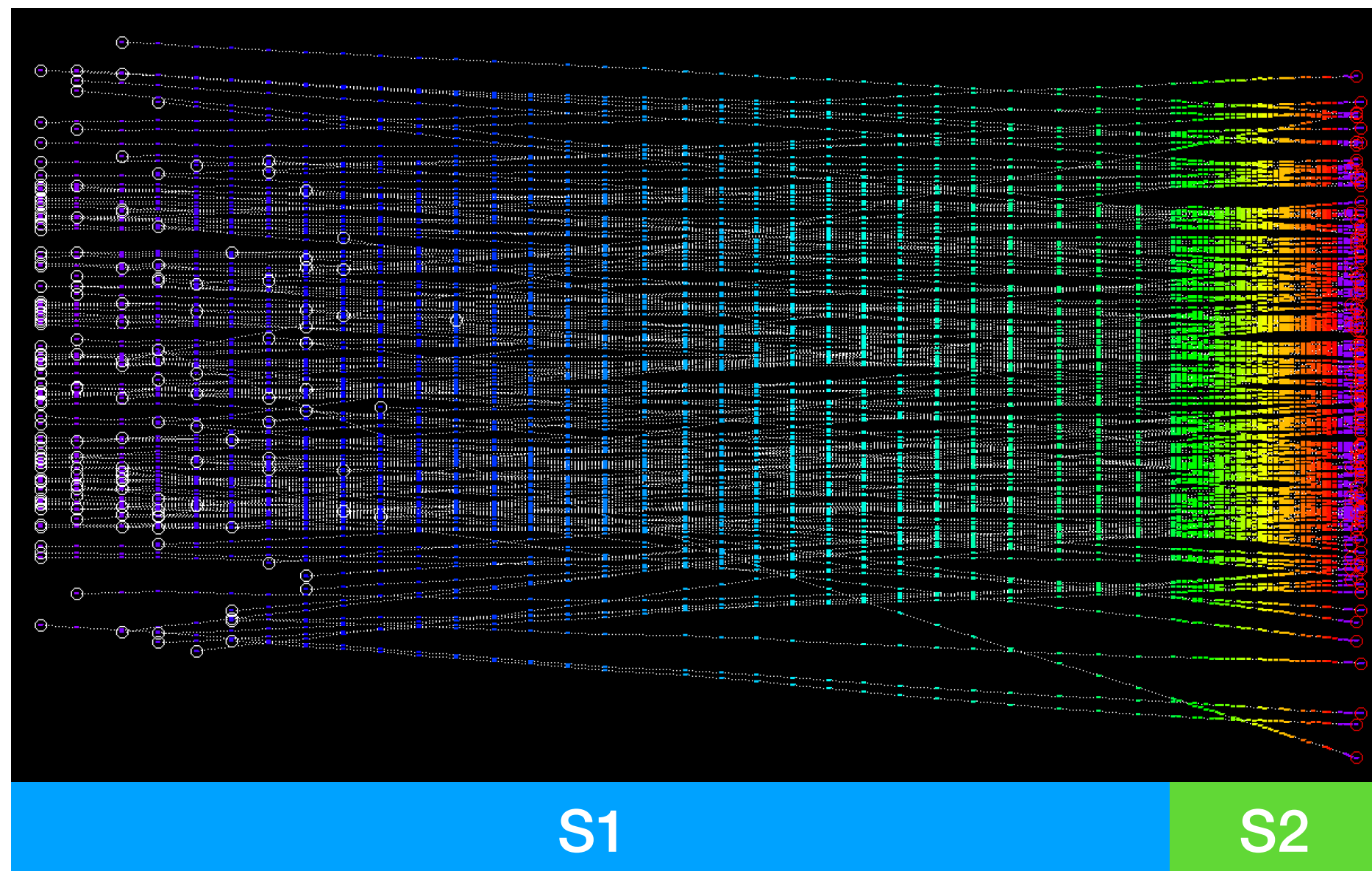
DETECTOR STRUCTURE (GSI2 UNDER ANALYSIS)

Oxygen 200 MeV/n	
S1	C2H4 (30x2mm) + 30 emu
S2	Emu (36)
S3	Lexan (10x1mm)+10emu
S4	W (7x0.5mm)+7emu
S5	W (7x0.9mm)+7emu
S6	Pb (20x1mm)+20emu
S7	Pb (9x2mm)+10emu



SUMMARY SLIDE

TRACKS AND VERTICES RECONSTRUCTION



- Track reconstruction done separately for each section, with appropriate parameters
- Algorithm developed to merge the tracks reconstructed in two sections: 13026 tracks reconstructed crossing more than 30 layers
- BDT multivariate analysis to select good vertexing out of background ones:
 - ▶ MC: 72% of true vertices selected
 - ▶ DATA: ~ 40% of expected vertices reconstructed
- Vertex search to be improved