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R^3B COLLABORATION MEETING

S522 FOOT ANALYSIS UPDATE: CALIBRATION, HIT RECONSTRUCTION AND TRACKING

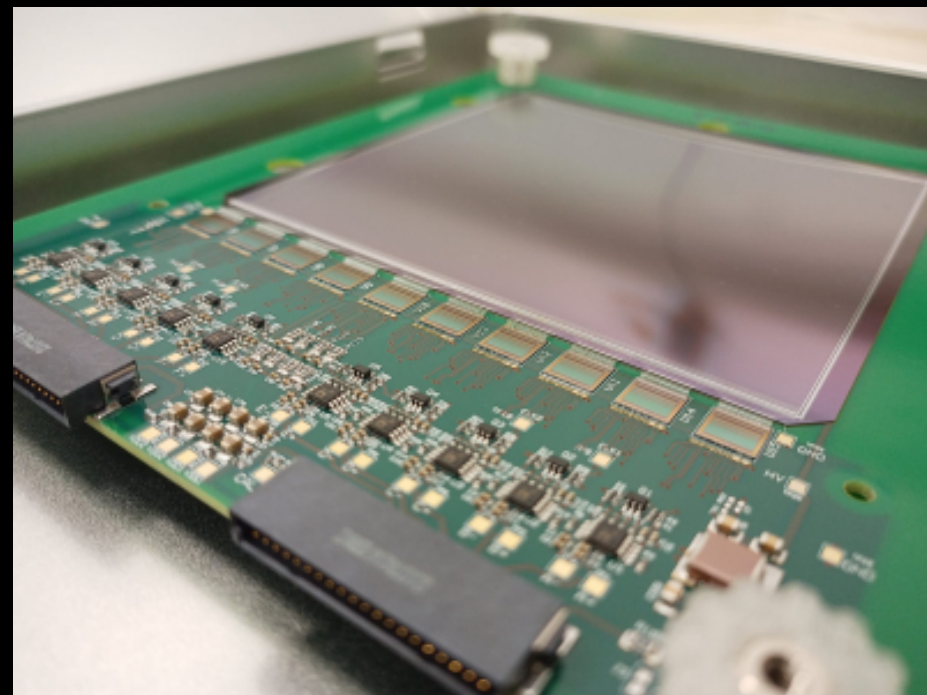
ANDREA LAGNI

CATANIA
17 NOVEMBER 2022

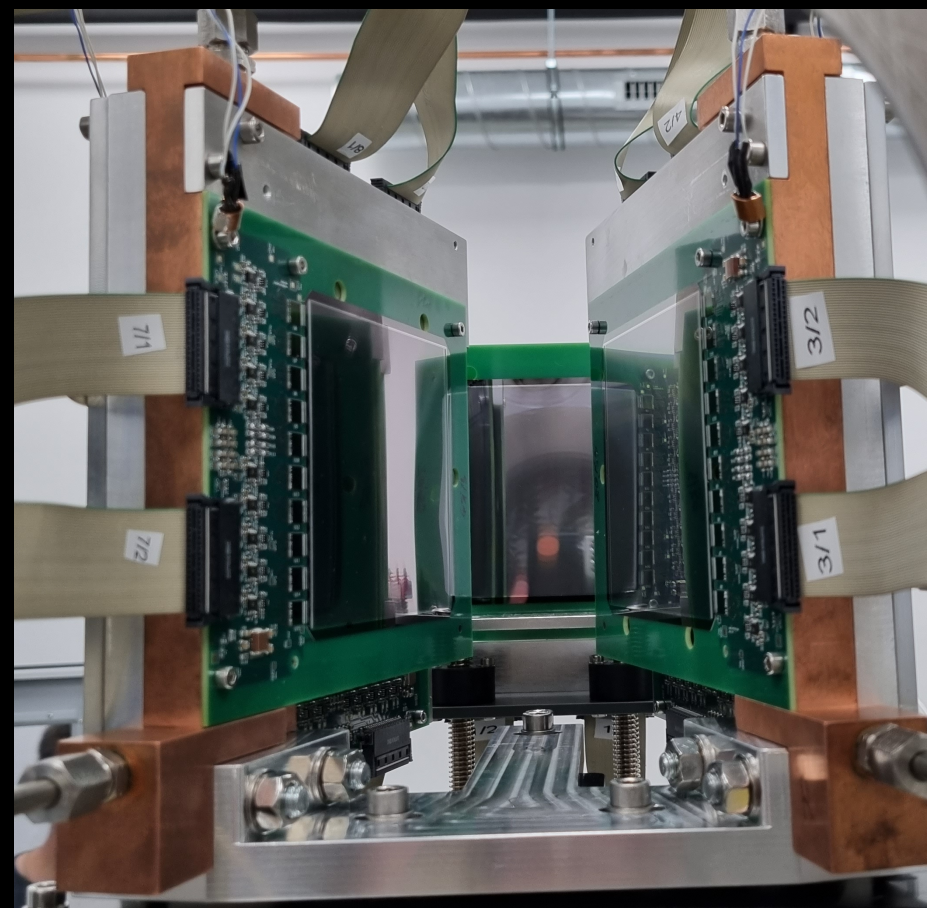
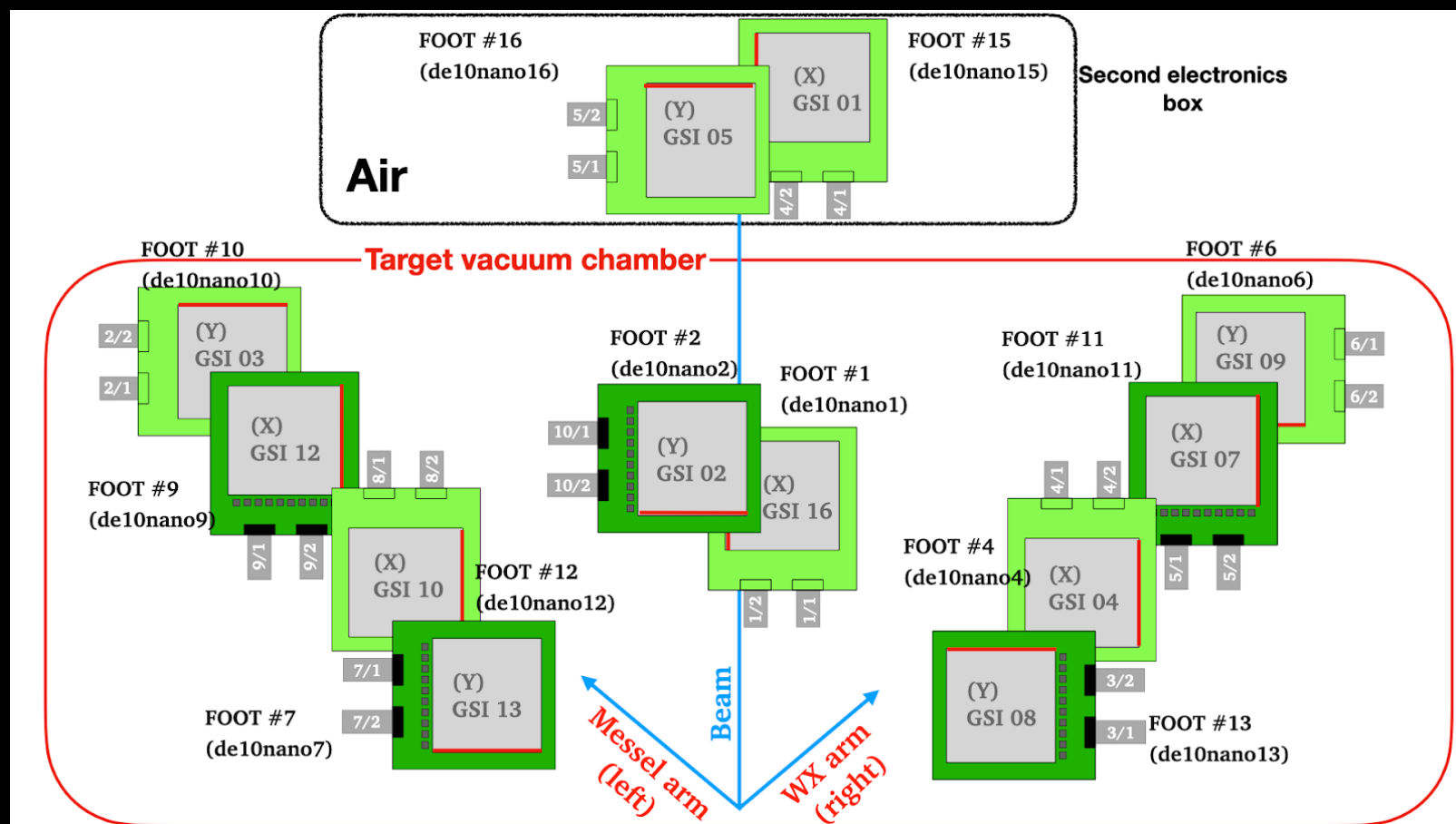


FOOT DETECTORS:

- New single-sided silicon tracking system used for the first time in R^3B for proton tracking, fragments ID and vertex reconstruction ;
- 640 strips, $10 \times 10 \text{ cm}^2$ active area;
- 150 μm thick;

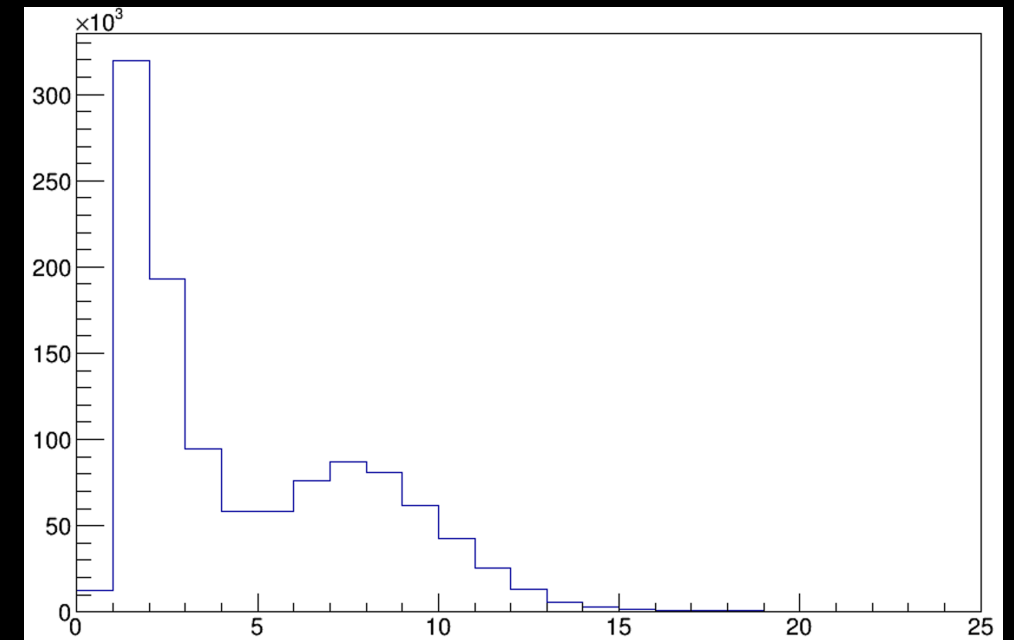
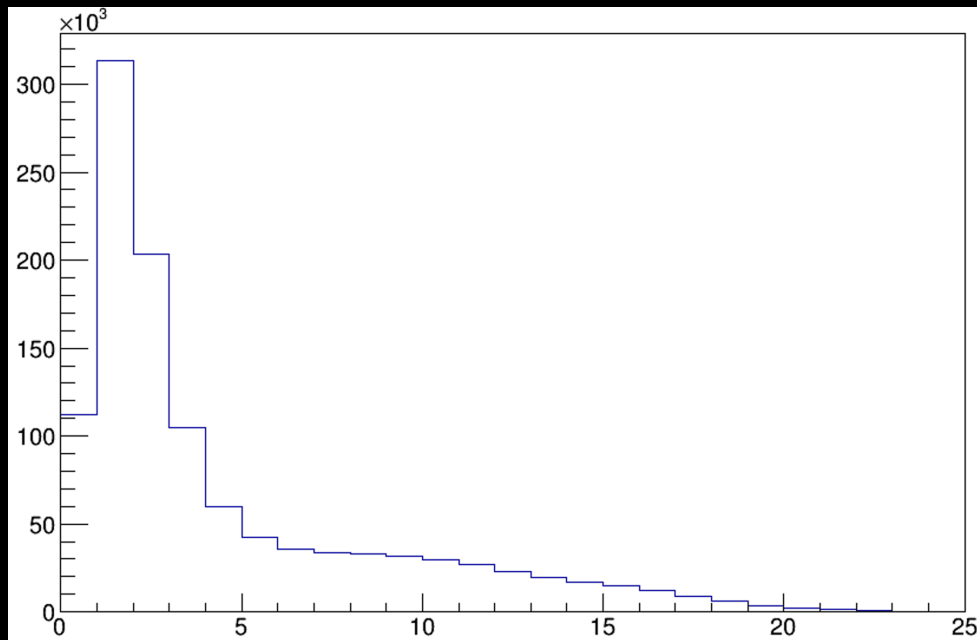


FOOT Mapping s509/s522:

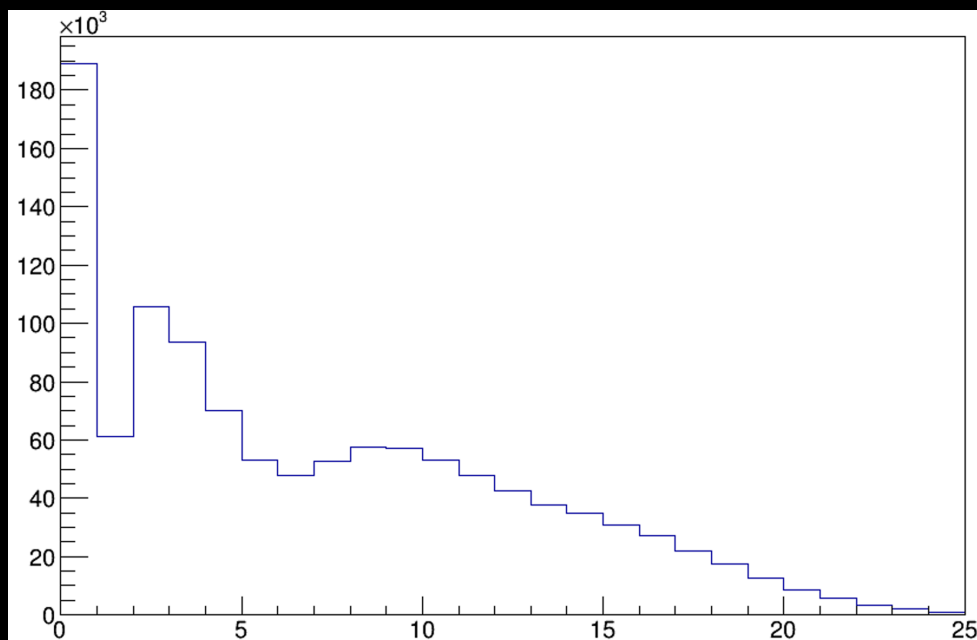


MULTIHIT PROBLEM

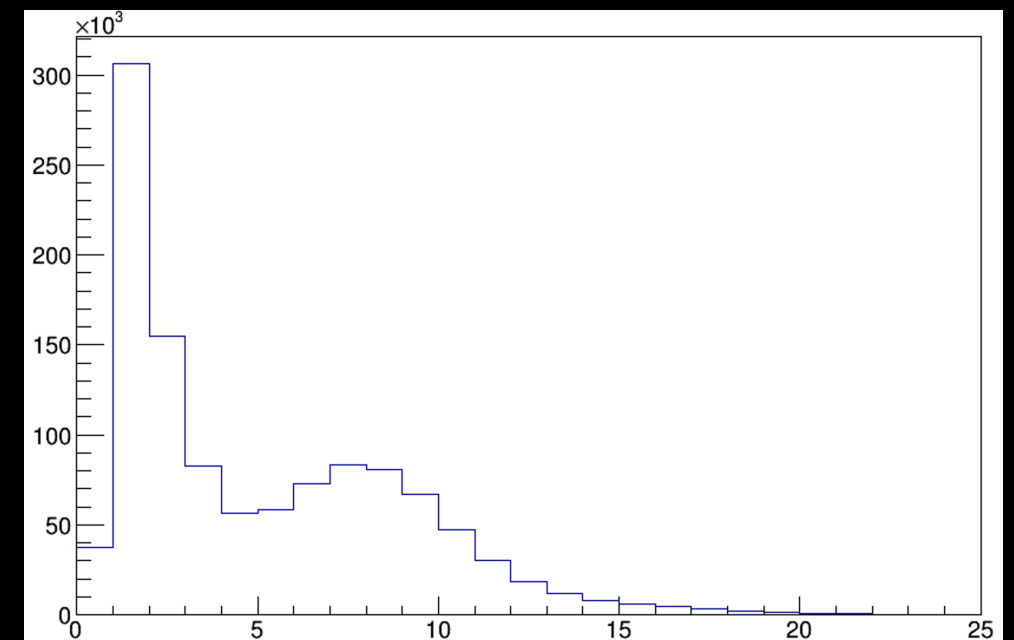
- In-beam FOOT: **High multiplicity** was observed in FOOT in beam;
 - FOOT 0 Mult 1 = 30%
 - FOOT 1 Mult1 = 31%



- FOOT 14 Mult 1 = 5%

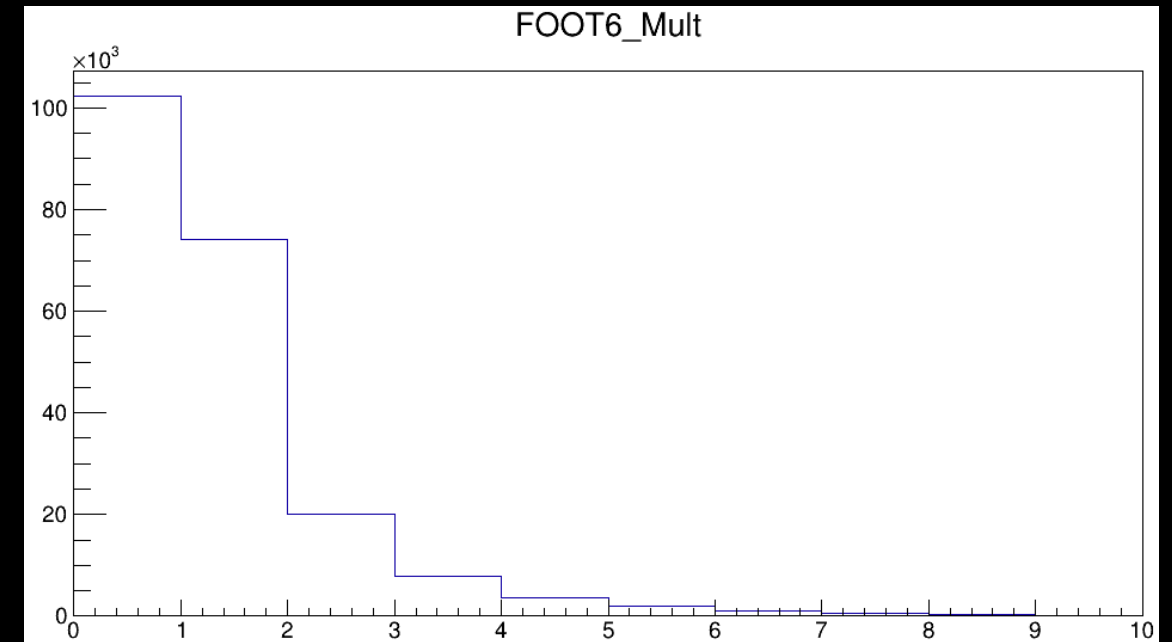
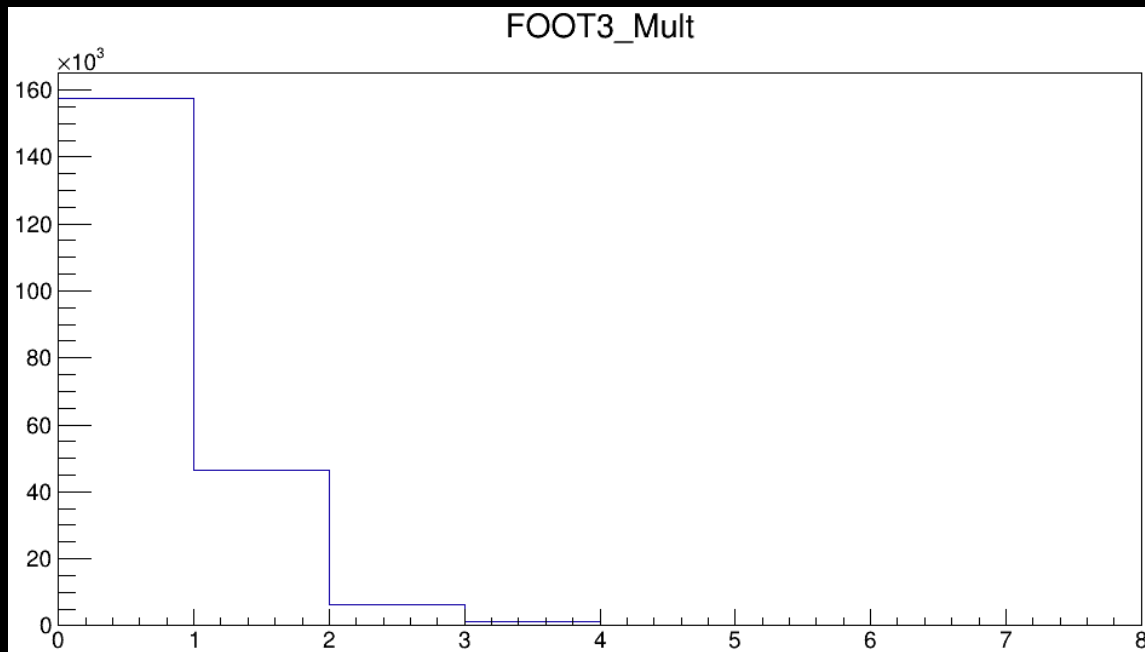


- FOOT 15 Mult1 = 27%

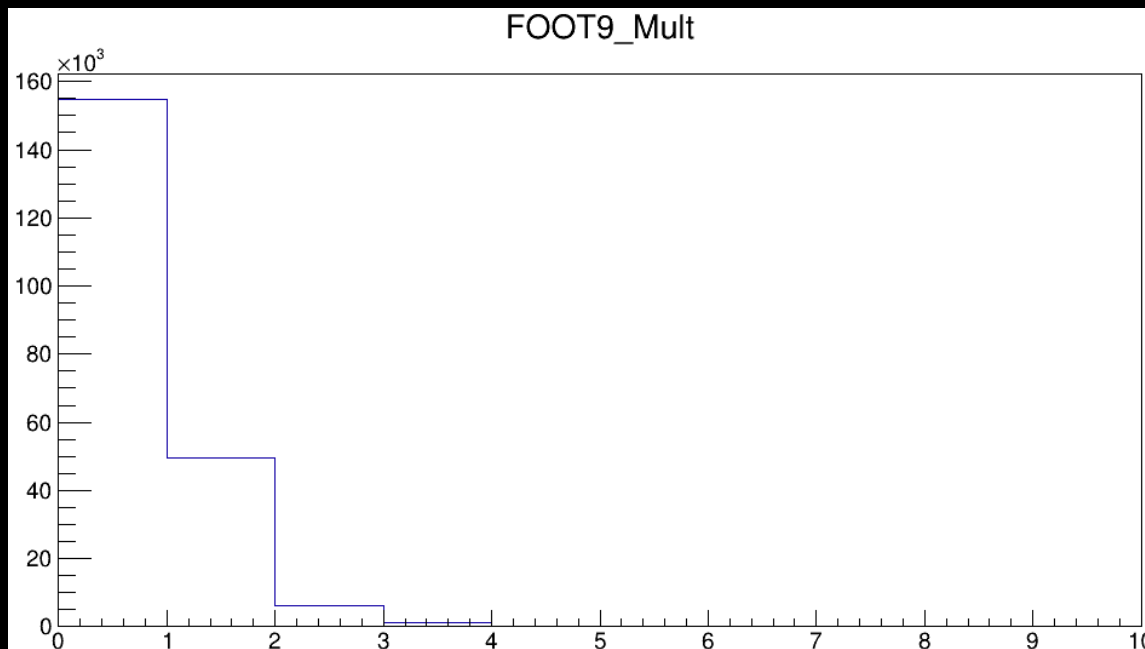


MULTIHIT PROBLEM

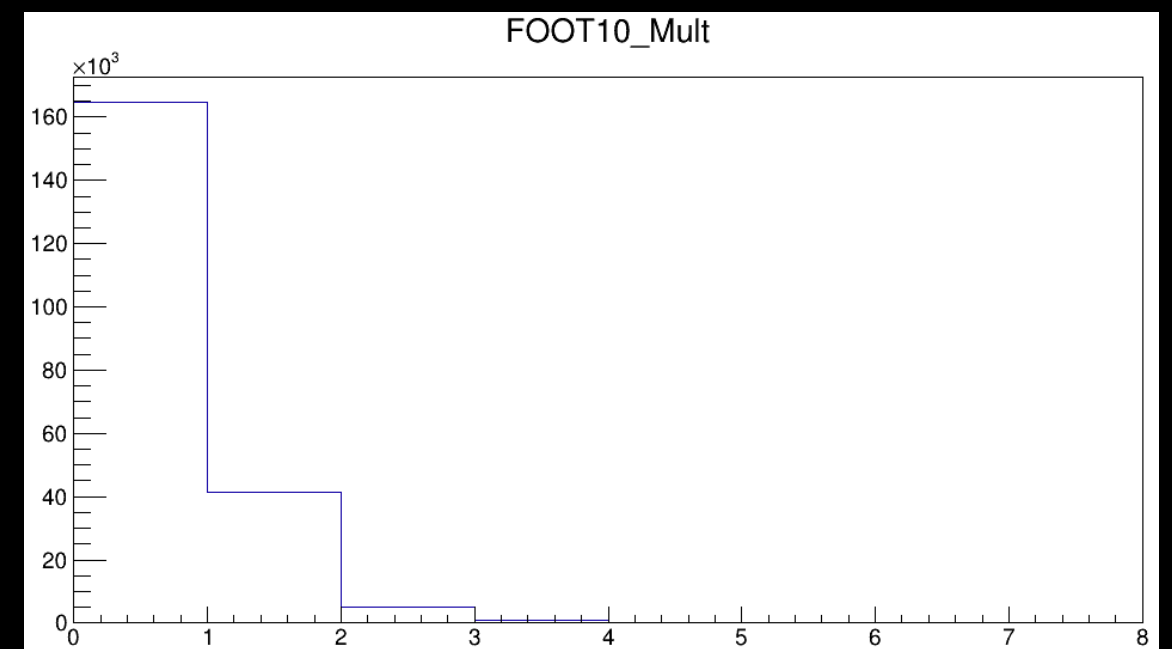
- Arm FOOT (right arm): Most multiplicity 1 events;
 - FOOT 3 Mult 1 = 80%
 - FOOT 6 Mult1 = 83%



- FOOT 9 Mult 1 = 86%



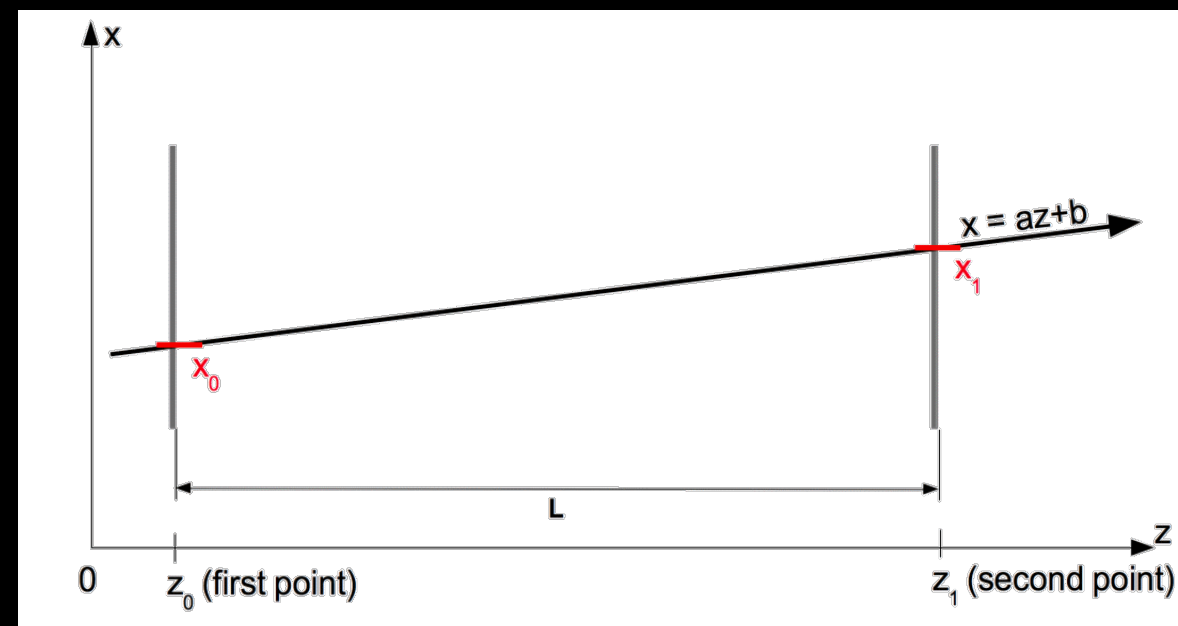
- FOOT 10 Mult1 = 71%



- Decrease high multiplicity events using MWPC:

MWPC:

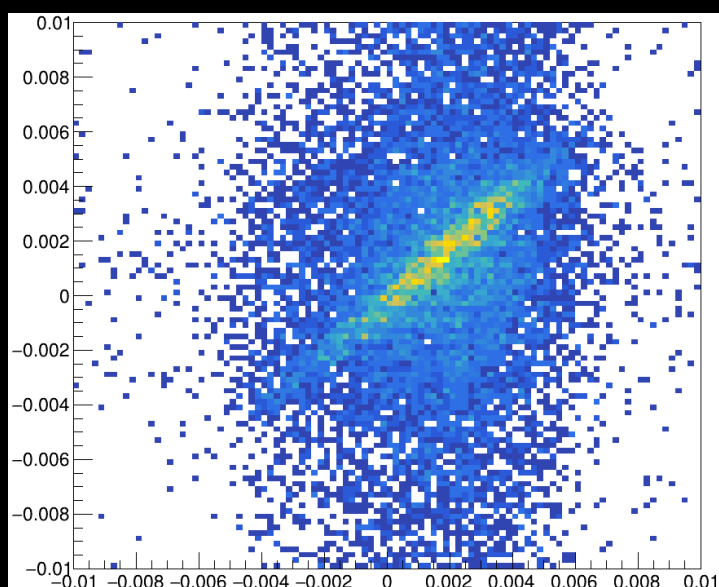
- $aX_{mwpc} = (mw0x - mw1x)/(mw0z - mw1z);$
- $aY_{mwpc} = (mw0y - mw1y)/(mw0z - mw1z);$
- $bX_{mwpc} = mw1x - aX_{mwpc}*mw1z;$
- $bY_{mwpc} = mw1y - aY_{mwpc}*mw1z;$



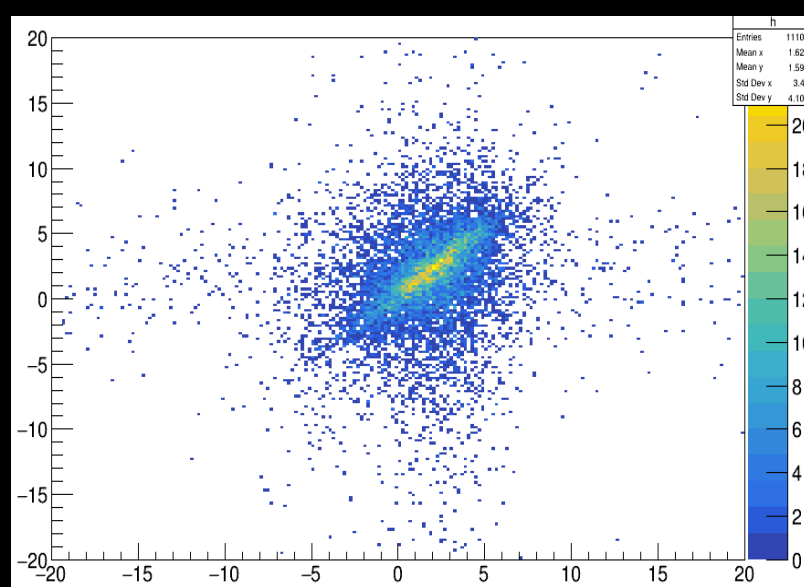
FOOT:

- $aX_{beam} = (ClusterPosX[0] - ClusterPosX[14])/(ClusterPosZ[0] - ClusterPosZ[14]);$
- $aY_{beam} = (ClusterPosY[1] - ClusterPosY[15])/(ClusterPosZ[1] - ClusterPosZ[15]);$
- $bX_{beam} = ClusterPosX[0] - aX_{beam}*ClusterPosZ[0];$
- $bY_{beam} = ClusterPosY[1] - aY_{beam}*ClusterPosZ[1];$

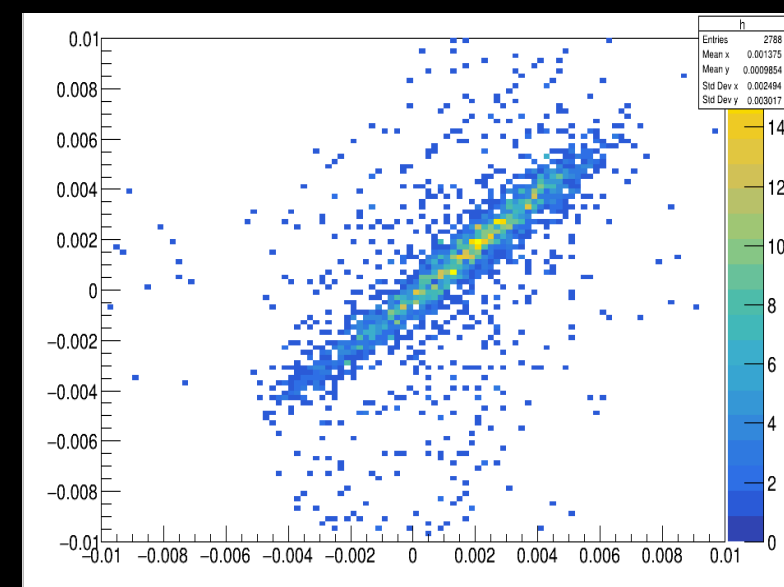
aX_{beam} vs aX_{mwpc}



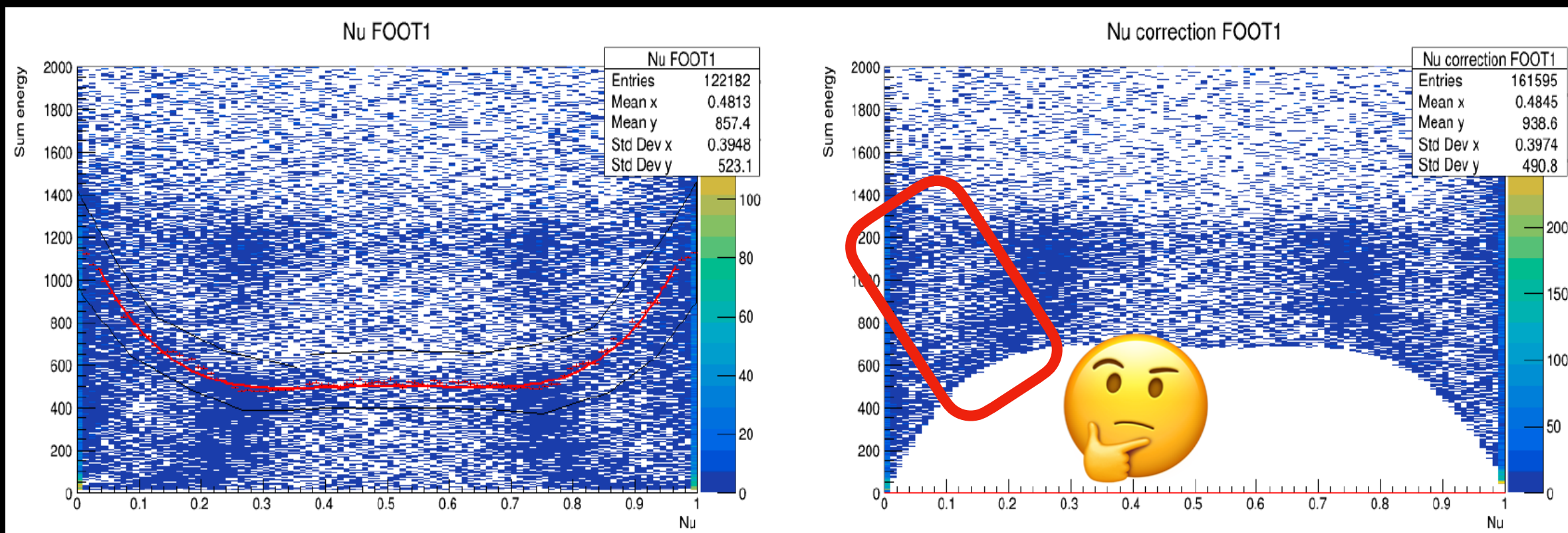
bX_{beam} vs bX_{mwpc}



bX_{beam} vs bX_{mwpc} Mult = 1



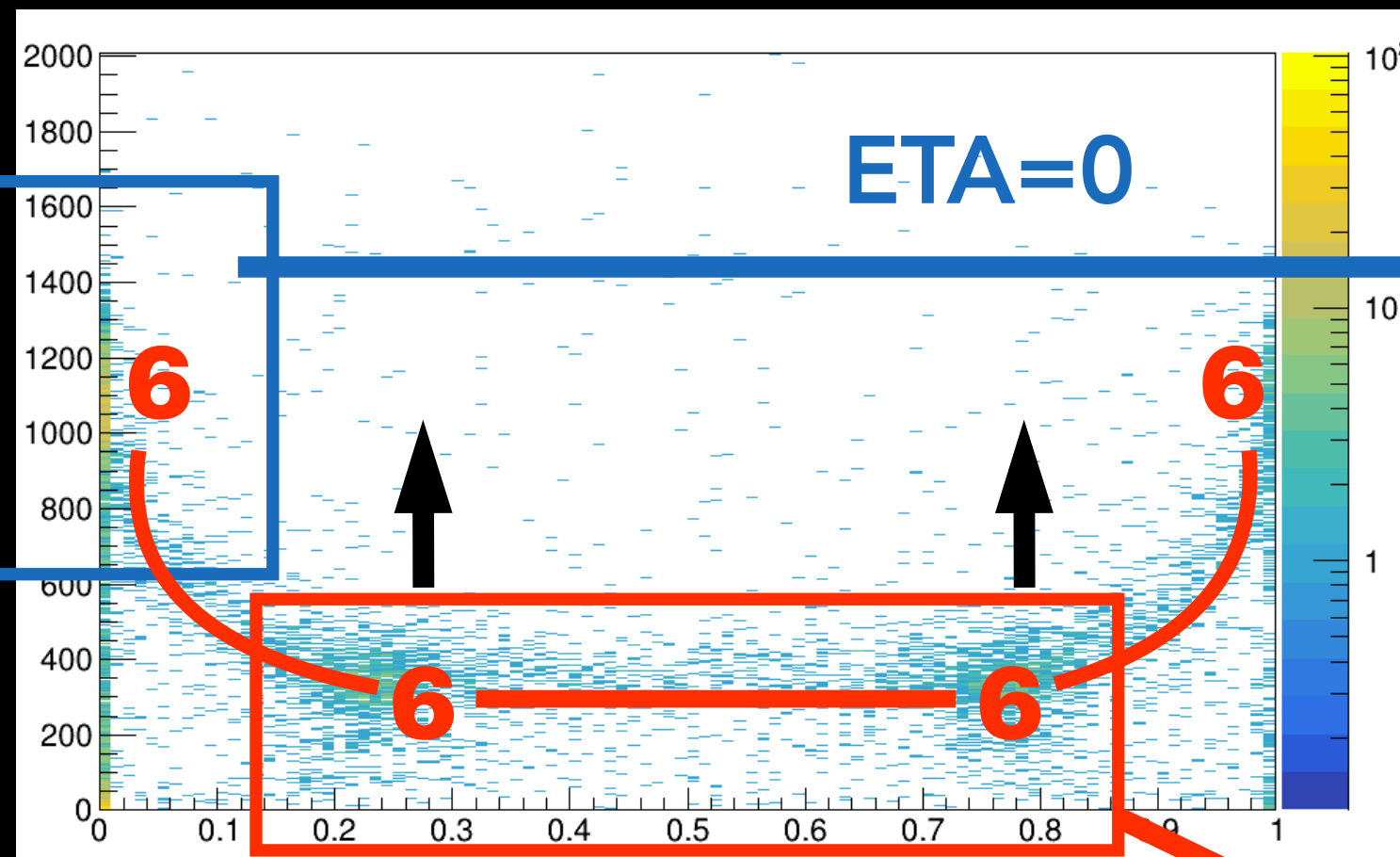
- In order to decrease the multiplicity we decided to use FOOT energy correlations;
- It exists a relation between energy loss and hit position. We need to correct this effect before starting the correlations;
- In s509 the energy loss in FOOT is higher than s522, the eta-energy correction can be done in a different way since it is easier to distinguish the fragments and beam components in the eta-energy plot;



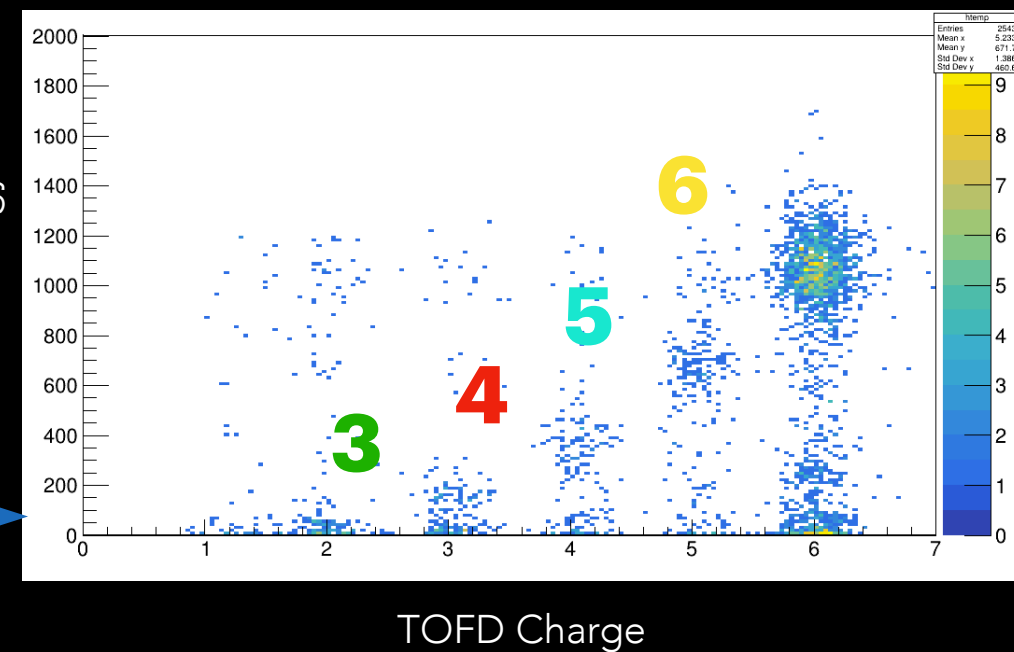
ETA-ENERGY CORRECTION

- $\text{ETA}=0$ is the energy deposited in a single strip, we use as a reference for the correct energy of the hit;
- Align the energies for $\text{ETA}>0$ to the $\text{ETA}=0$ reference value;

- Multiplicity 1 in FOOT 0;
- Multiplicity 1 in TOFD, only considering plane 1;

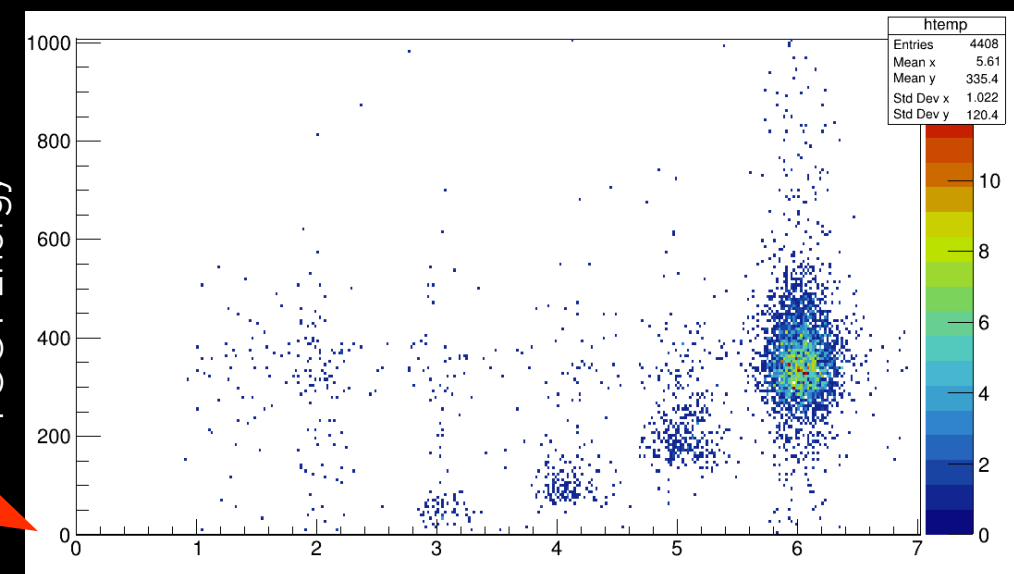


FOOT Energy



TOFD Charge

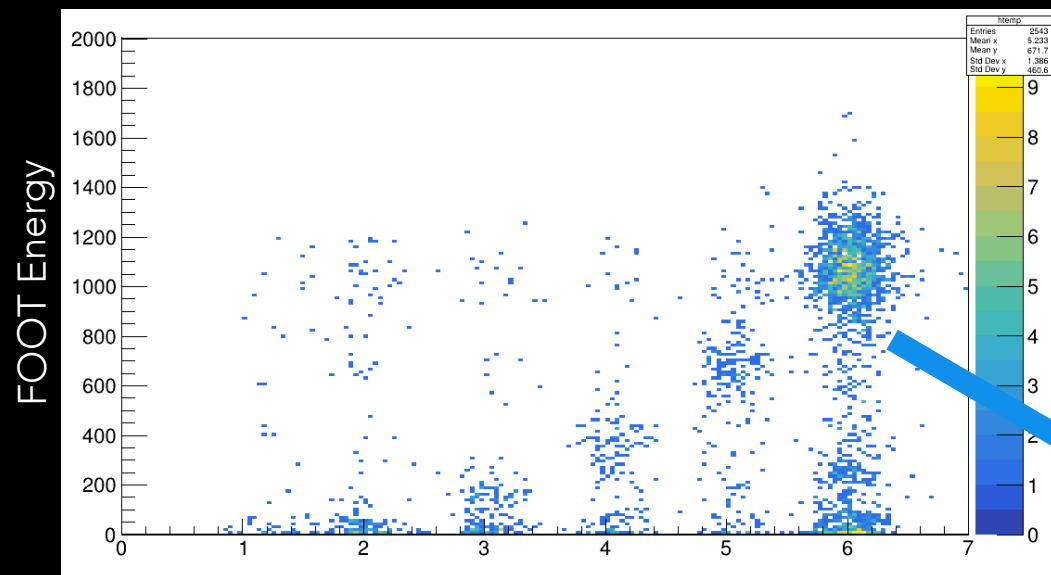
FOOT Energy



TOFD Charge

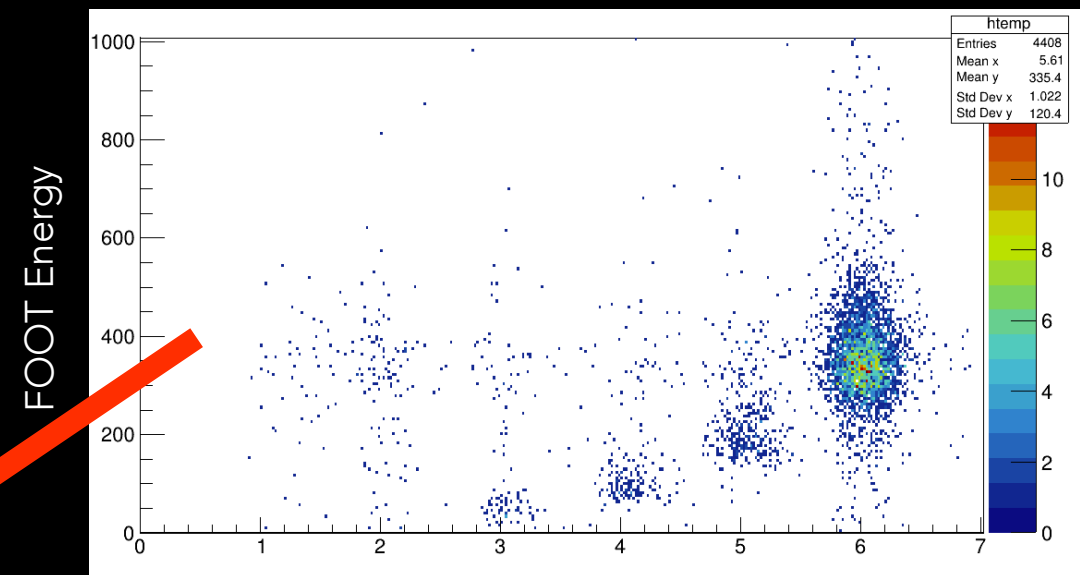
Flat line-> $0.15 < \text{ETA} < 0.85$

ETA=0



TOFD Charge

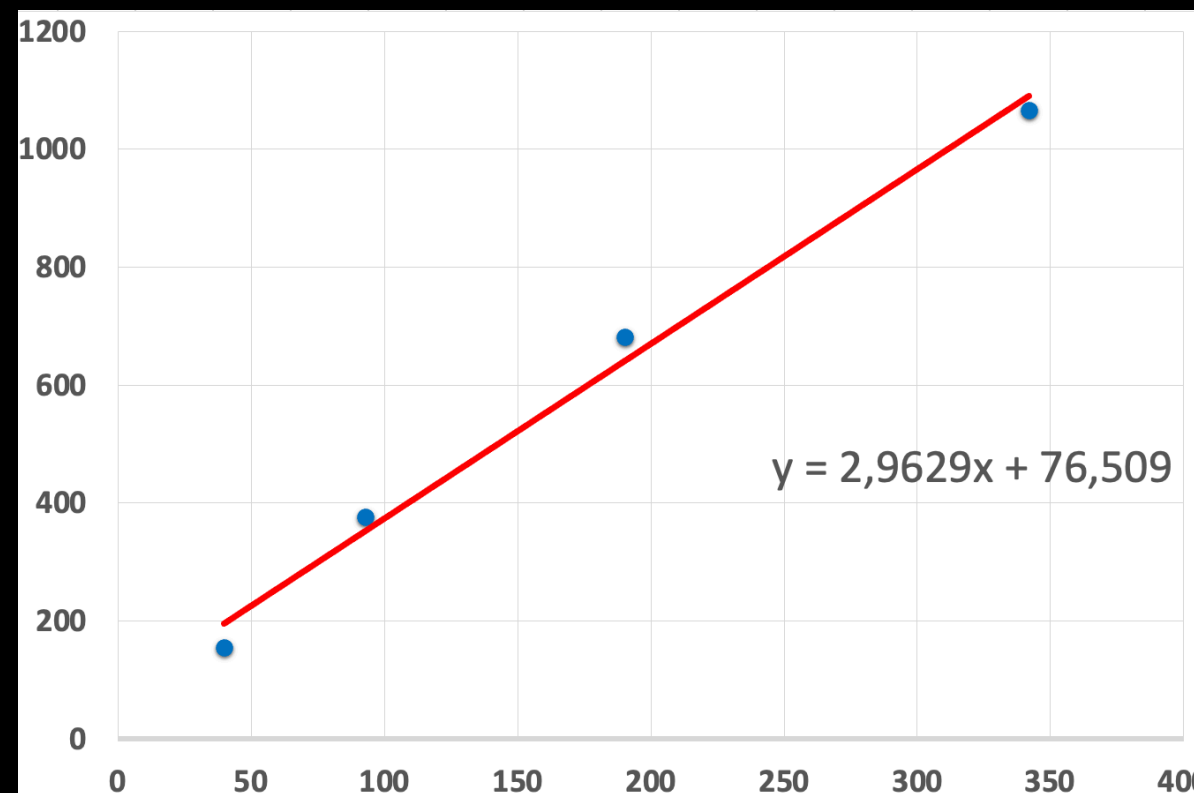
0.15<ETA<0.85



TOFD Charge

$$ClusterENew[i] = ClusterE[l] * a + b$$

ETA=0



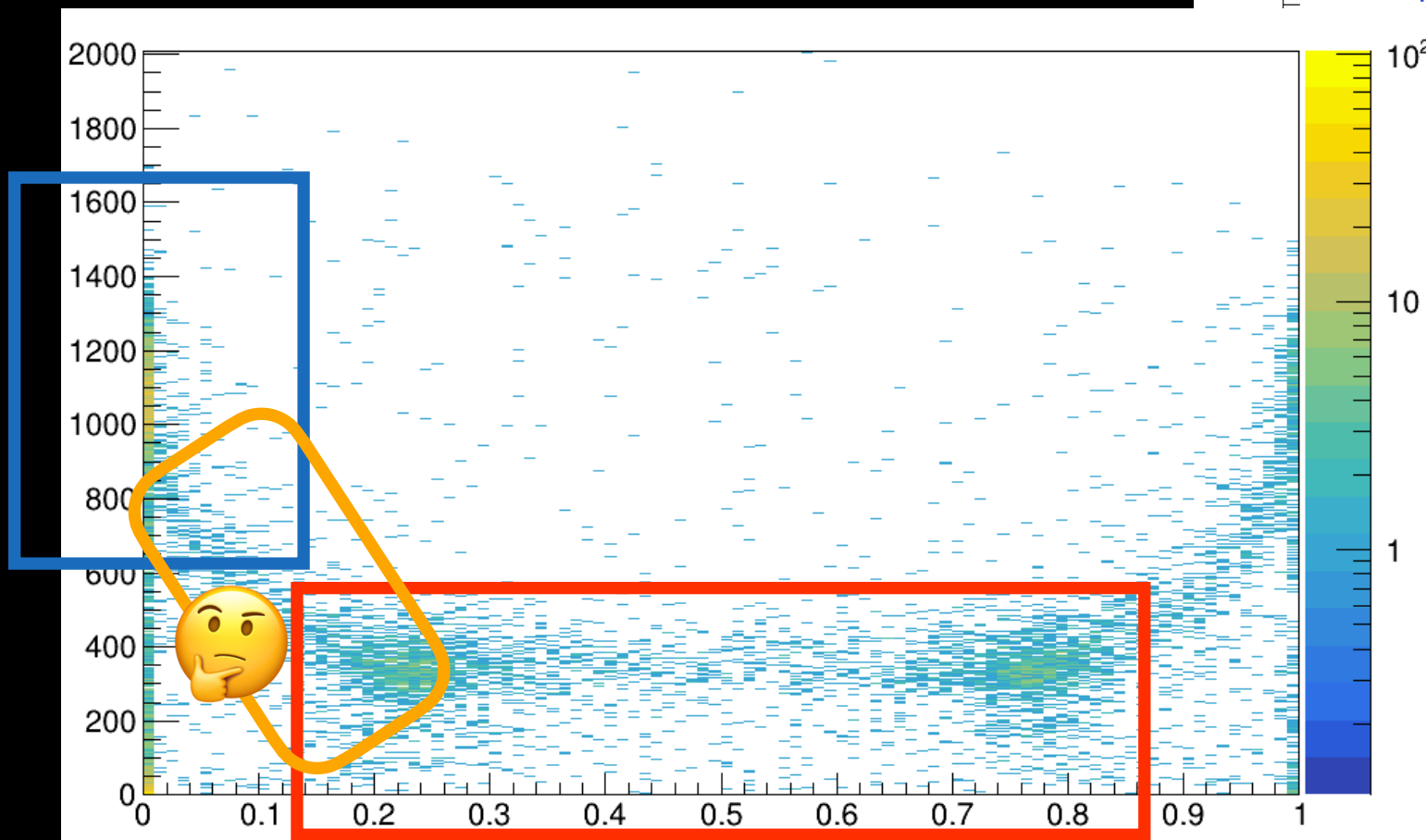
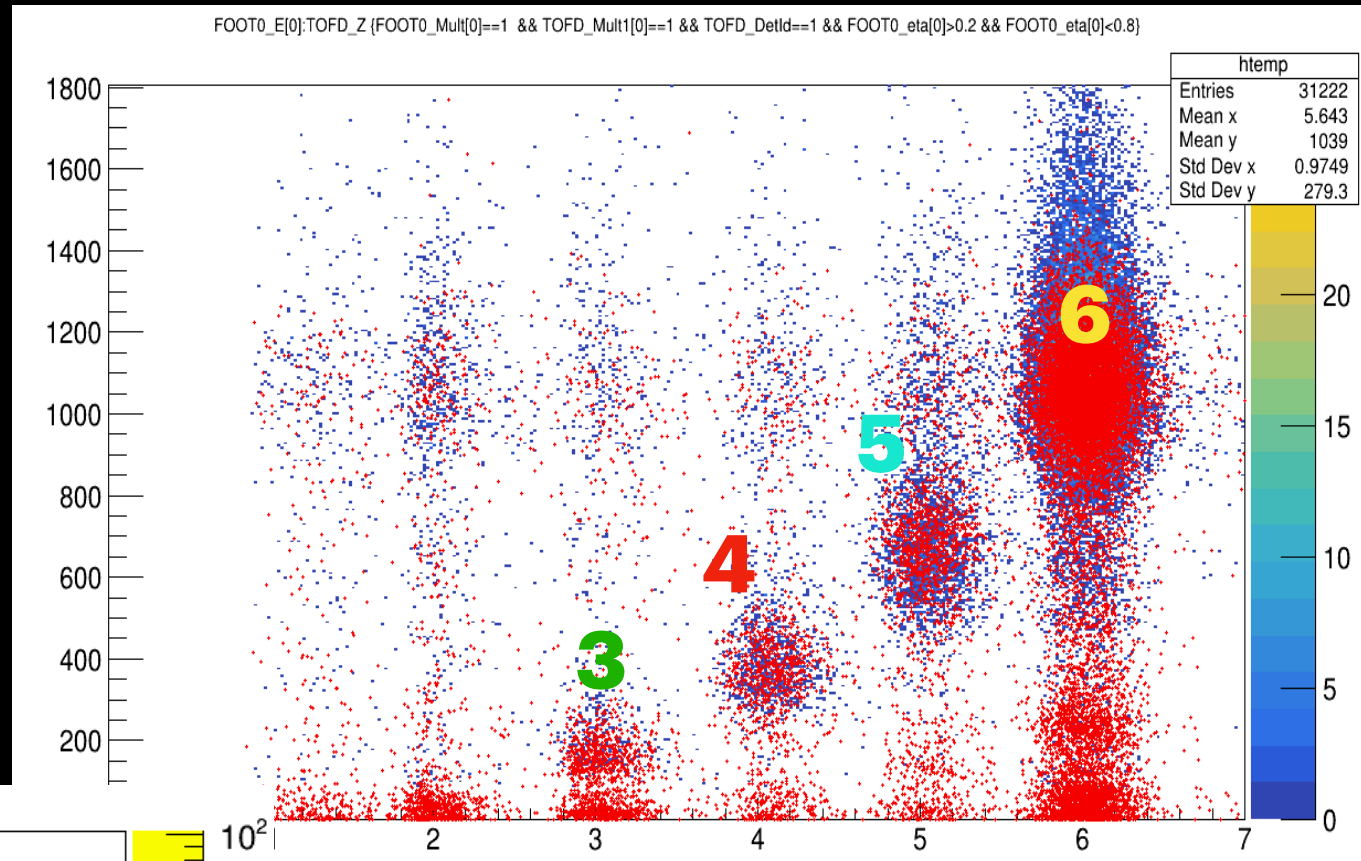
0.15<ETA<0.85

ETA-ENERGY CORRECTION

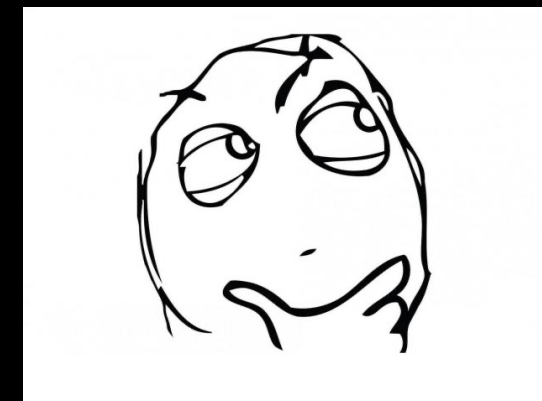
- $\text{ETA}=0$
- $0.15 < \text{ETA} < 0.85$



FOOT Energy

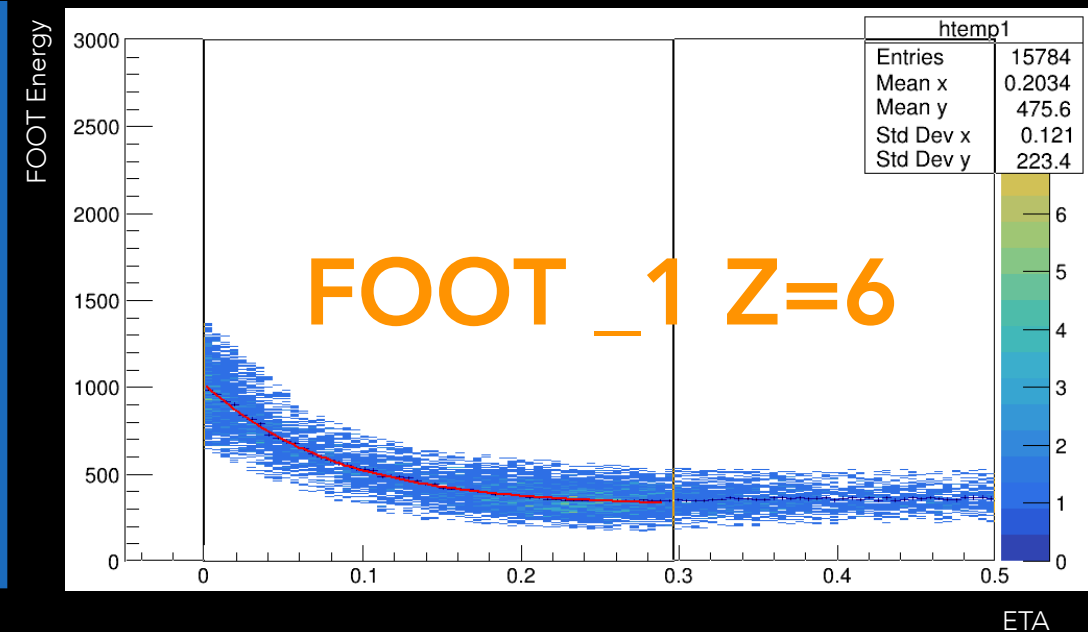


- $0 < \text{ETA} < 0.15$



TOFD Charge

- Symmetric behaviour;
- $0 < \text{ETA} < 0.5$;
- From 0.5 - 1 the trend is symmetric to 0 - 0.5;
- Cut using TOFD charge information;
- Charge 6, 5, 4;
- Fit with exp+pol0->3 calibration parameters for each charge;

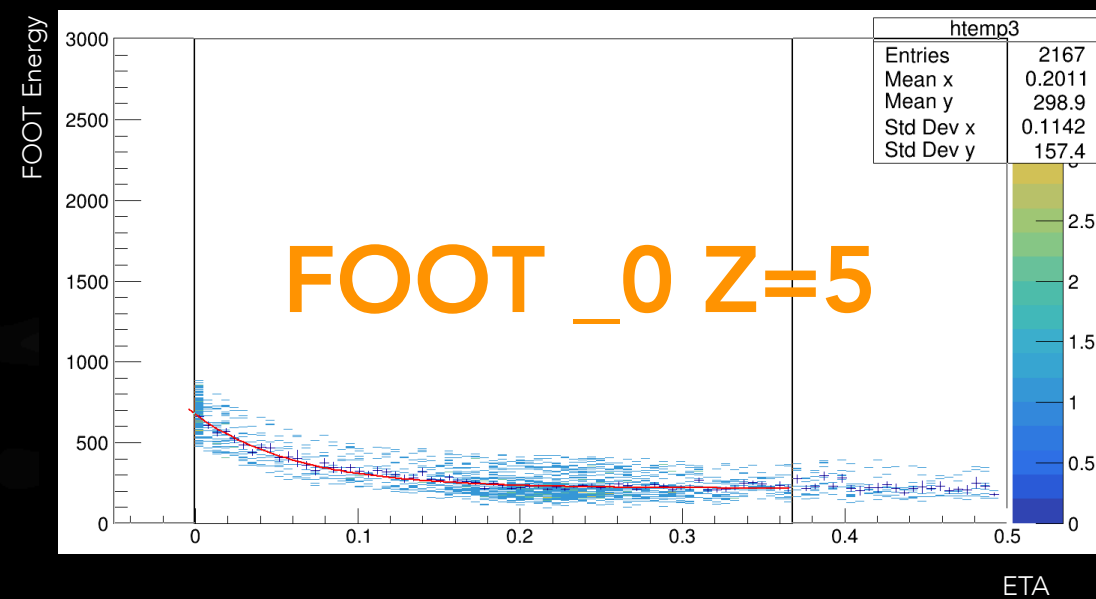


EXT NO.	PARAMETER NAME	VALUE	ERROR	STEP SIZE	FIRST DERIVATIVE
1	p0	6.59235e+00	3.64642e-03	3.66854e-05	-8.94712e-03
2	p1	-1.38799e+01	1.18434e-01	6.73779e-04	-1.45277e-04
3	p2	3.24633e+02	1.00192e+00	5.88986e-03	6.55427e-05

```

TF1 *fZ4 = new TF1("fZ4", "TMath::Exp(5.34286-22.9916*x)+101.193", 0., 0.5);
TF1 *fZ5 = new TF1("fZ5", "TMath::Exp(6.12994-15.9781*x)+216.47", 0., 0.5);
TF1 *fZ6 = new TF1("fZ6", "TMath::Exp(6.59235-13.8799*x)+324.633", 0., 0.5);
TF1 *fZ7 = new TF1("fZ7", "TMath::Exp(6.95883-10.7827583*x)+381.679", 0., 0.5);
TF1 *fZ4NoOff = new TF1("fZ4NoOff", "TMath::Exp(5.34286-22.9916*x)", 0., 0.5);
TF1 *fZ5NoOff = new TF1("fZ5NoOff", "TMath::Exp(6.12994-15.9781*x)", 0., 0.5);
TF1 *fZ6NoOff = new TF1("fZ6NoOff", "TMath::Exp(6.59235-13.8799*x)", 0., 0.5);
TF1 *fZ7NoOff = new TF1("fZ7NoOff", "TMath::Exp(6.95883-10.7827583*x)", 0., 0.5);

```



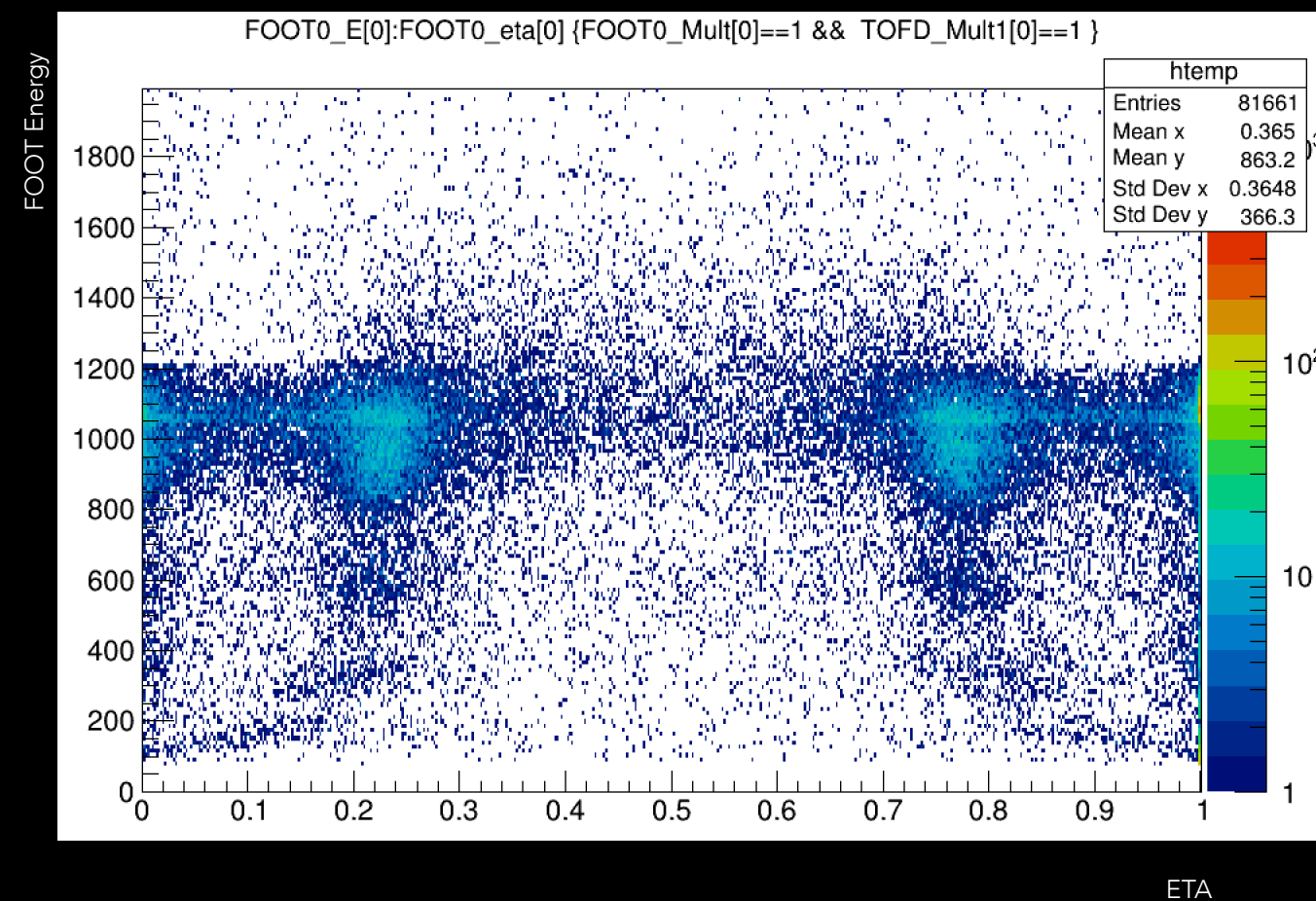
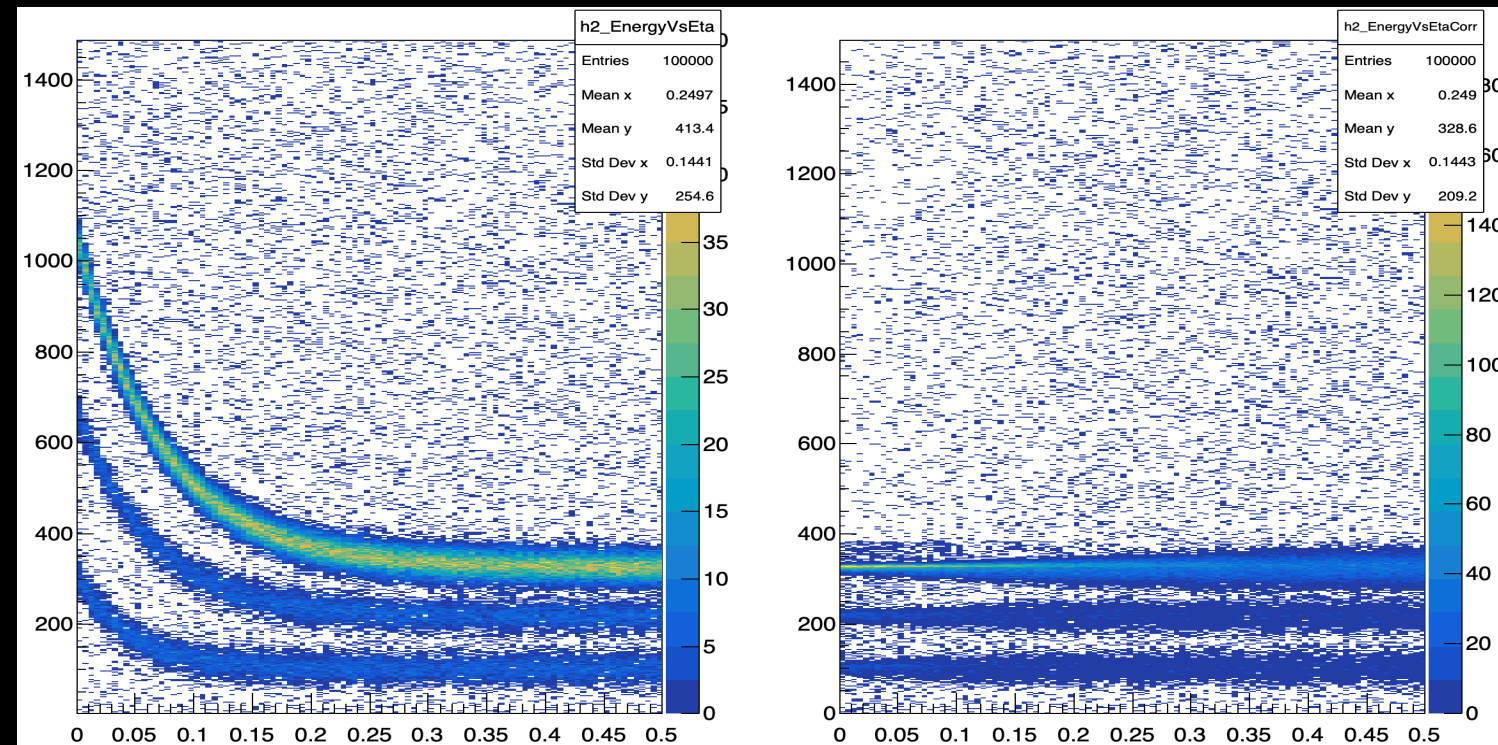
ETA-ENERGY CORRECTION

- EtaCorr() Function;
- Input: Exp+pol0 fit functions, Energy, Eta;
- Output: Energy corrected;

```

1- if(Energy > EZ5 && Energy < EZ6)
2- GAP= (EZ6-EZ5);
3- Prop= (Energy-EZ5)/GAP;
4- Corr1= 1 - fZ6->Eval(Eta);
   Corr2= 1 - fZ5->Eval(Eta);
5- ECorr = Energy+prop*corr1+(1.-prop)*corr2.

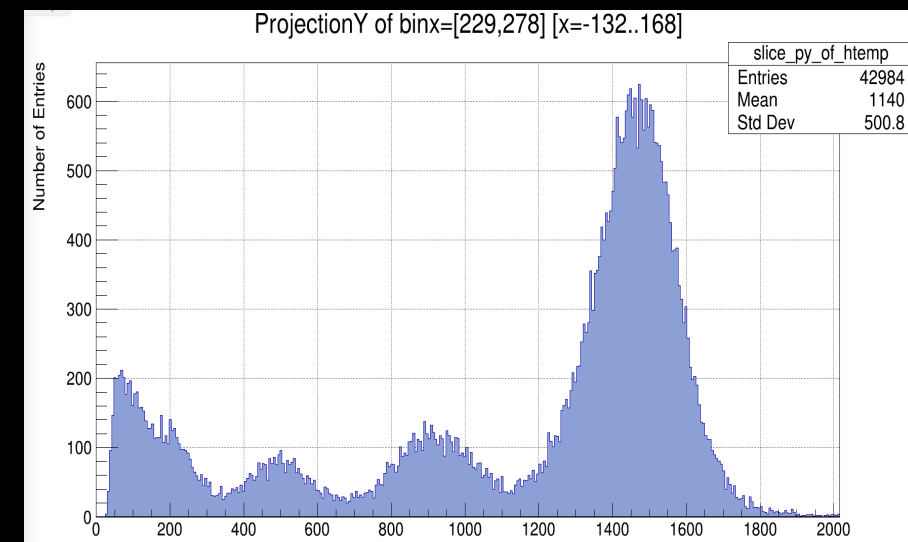
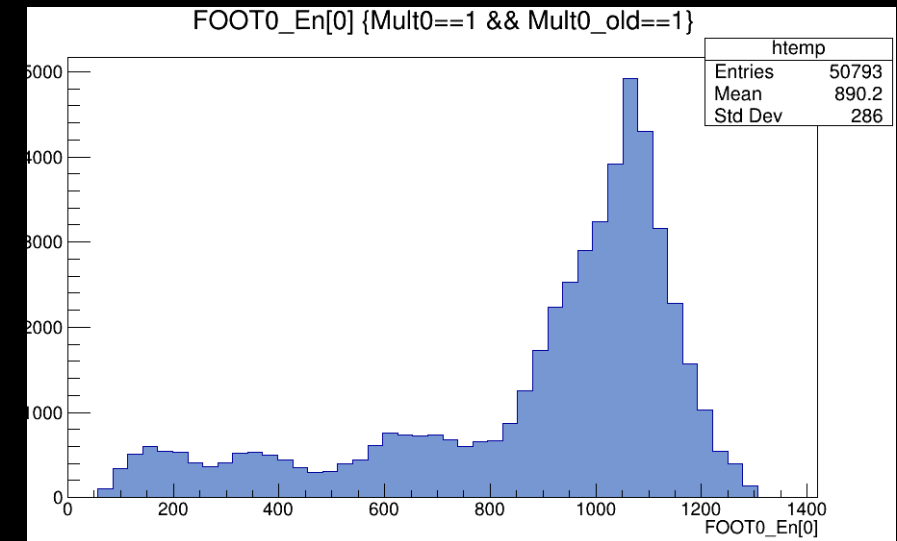
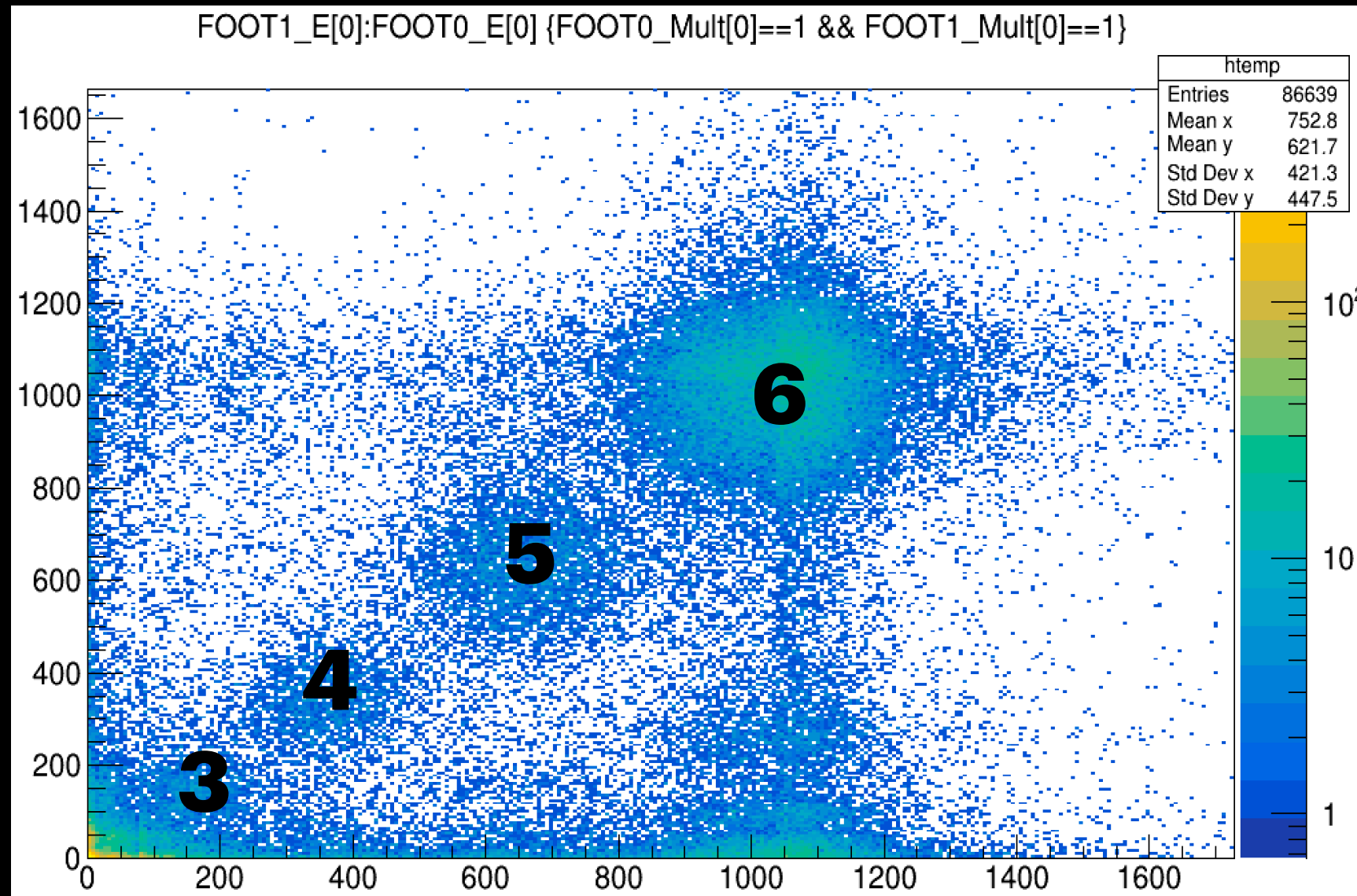
```



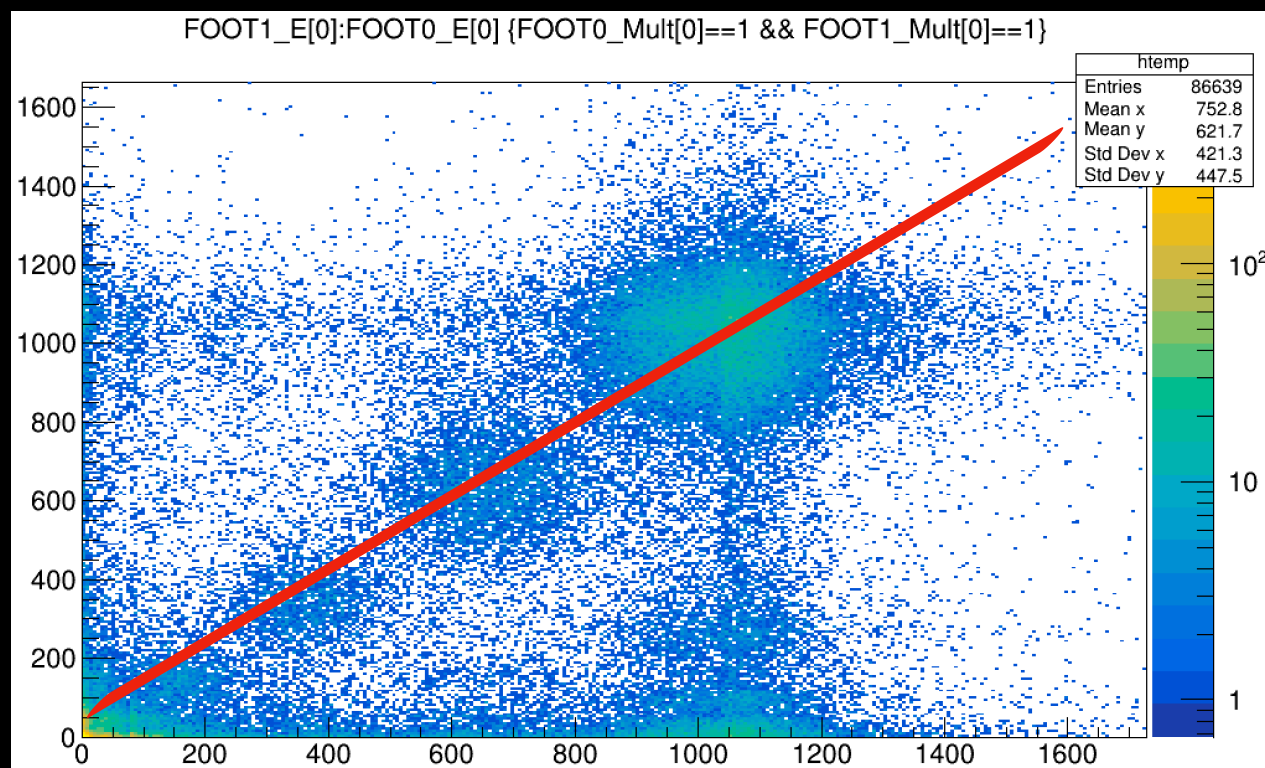
2 steps correction process:

1. Use EnergyCorr function.
-> `ClusterENew = EnergyCorr(Energy, Eta ...);`
2. Apply ETA energy correction
-> `ClusterENew = ClusterENew*a+b;`

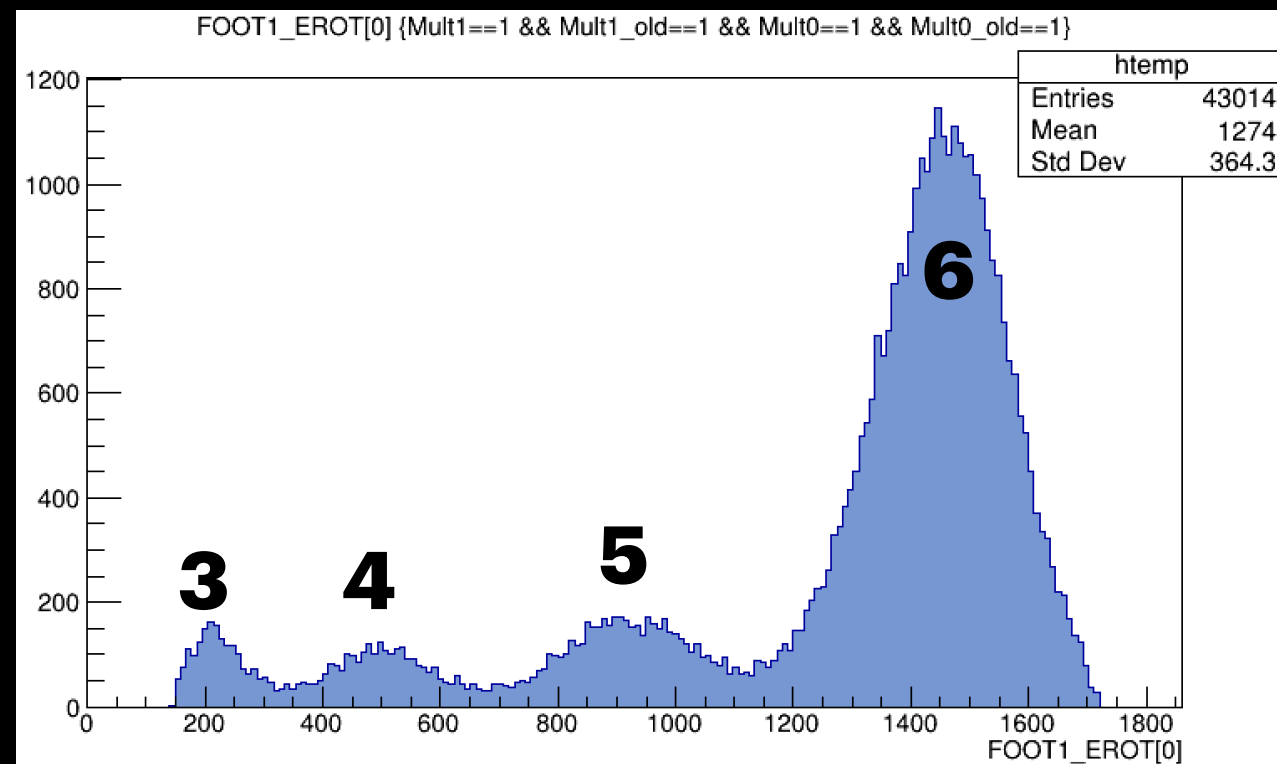
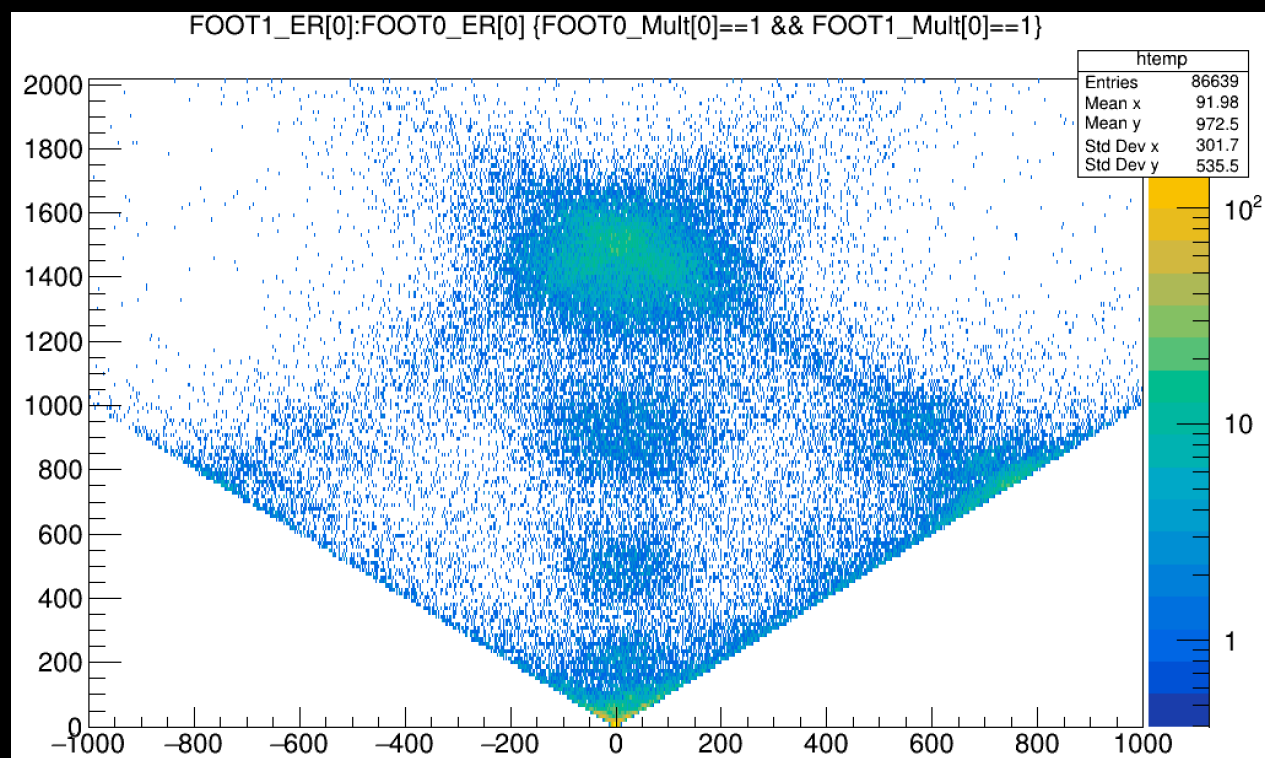
- Energy correlation FOOT 0 and FOOT 1 (in beam FOOT);



ENERGY CORRELATIONS



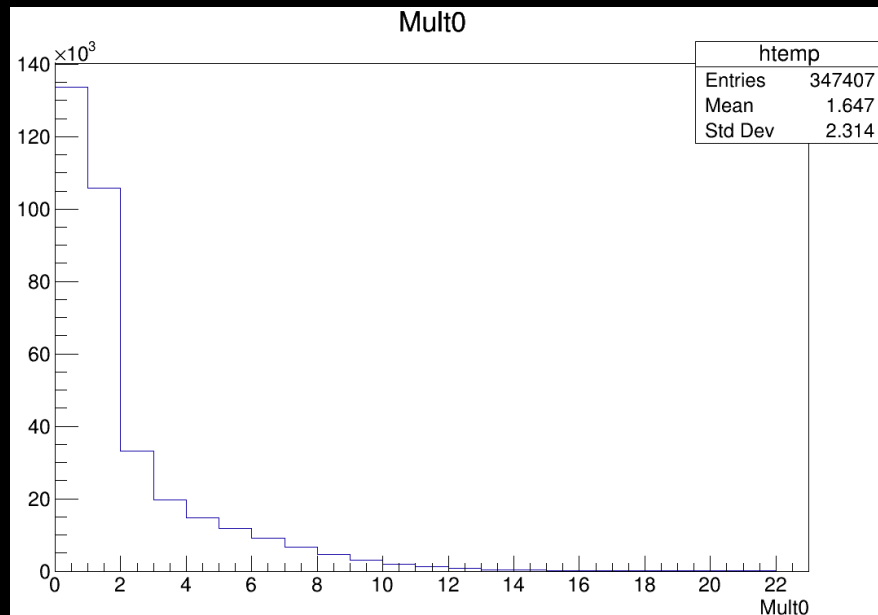
- Energy correlation FOOT 0 and FOOT 1 (In beam FOOT);
- Projection on $y=x$ axis to separate better the charges;
- Apply cut to reduce the high multiplicity events;



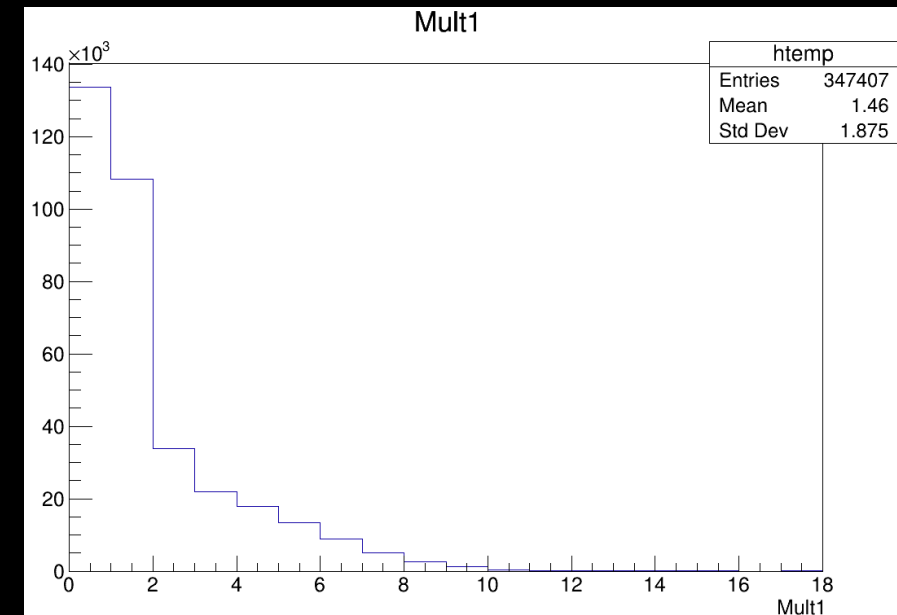
MULTIHIT PROBLEM

- In-beam FOOT after energy correlation cut:

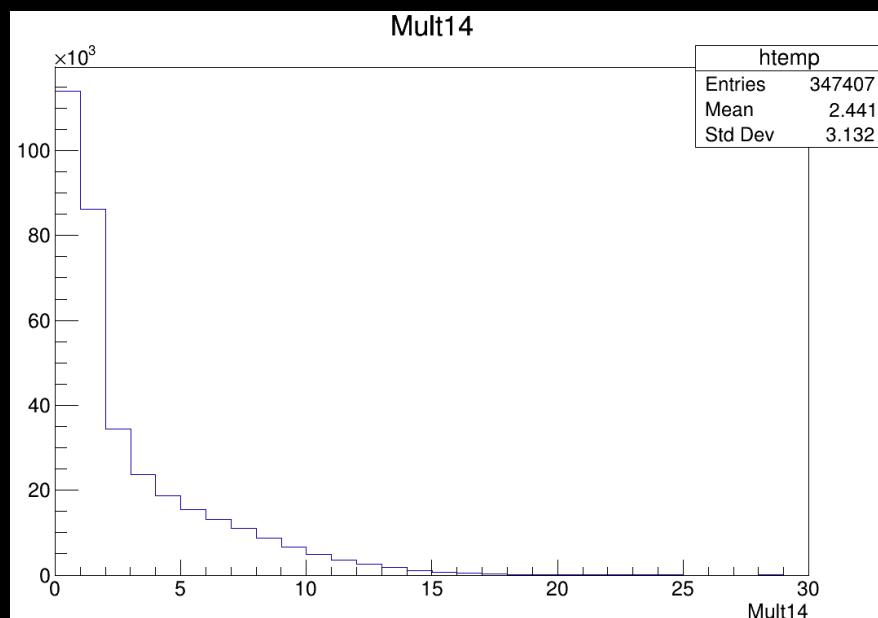
- FOOT 0 Mult 1 from 30% to 50%



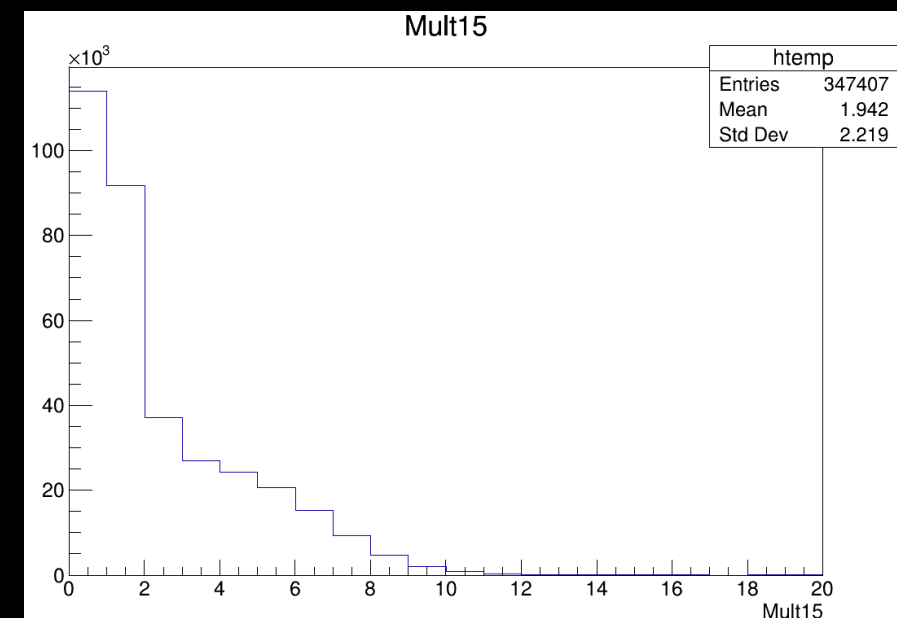
- FOOT 1 Mult1 from 31% to 45%



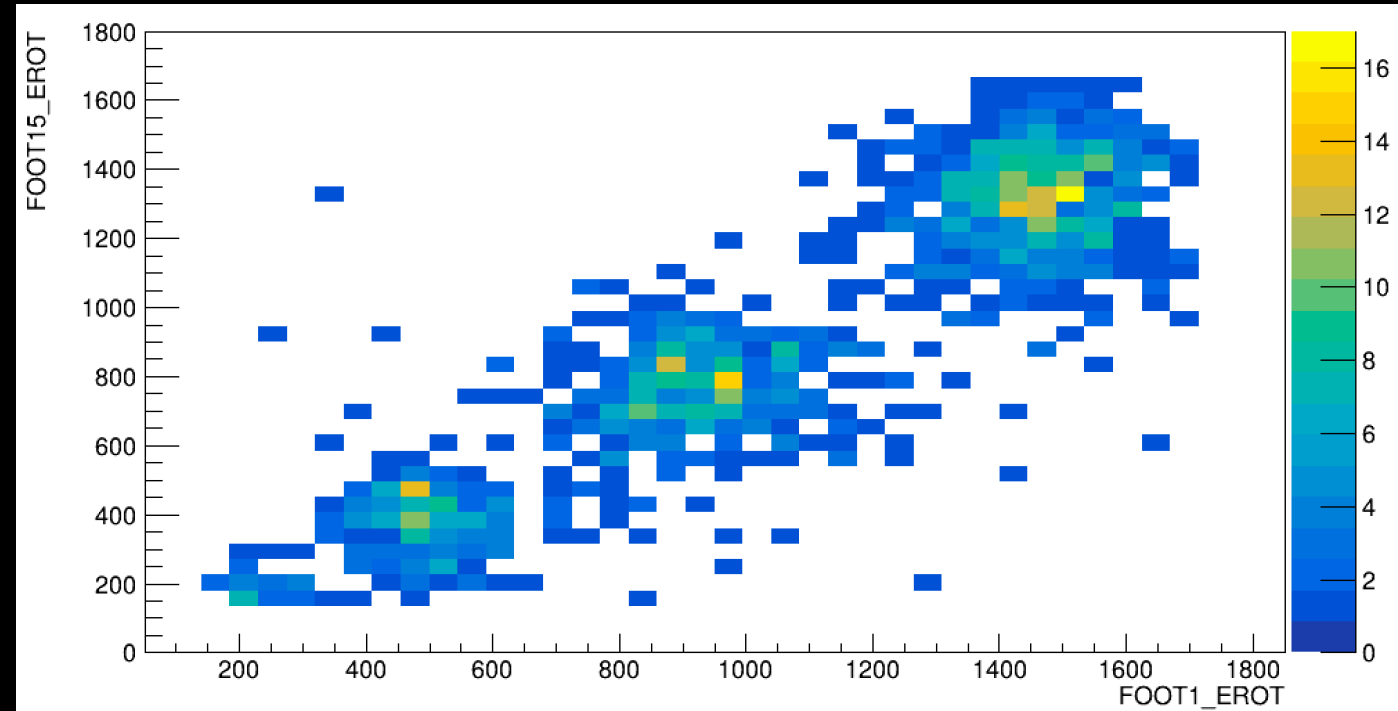
- FOOT 14 Mult 1 from 5% to 37%



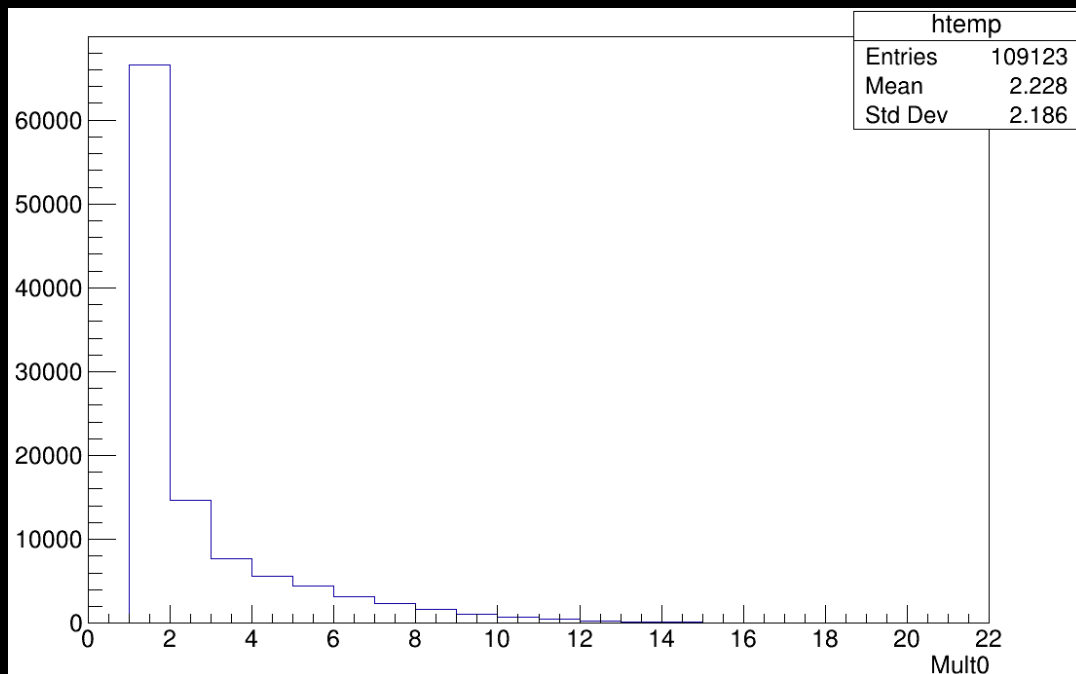
- FOOT 15 Mult1 from 27% to 39%



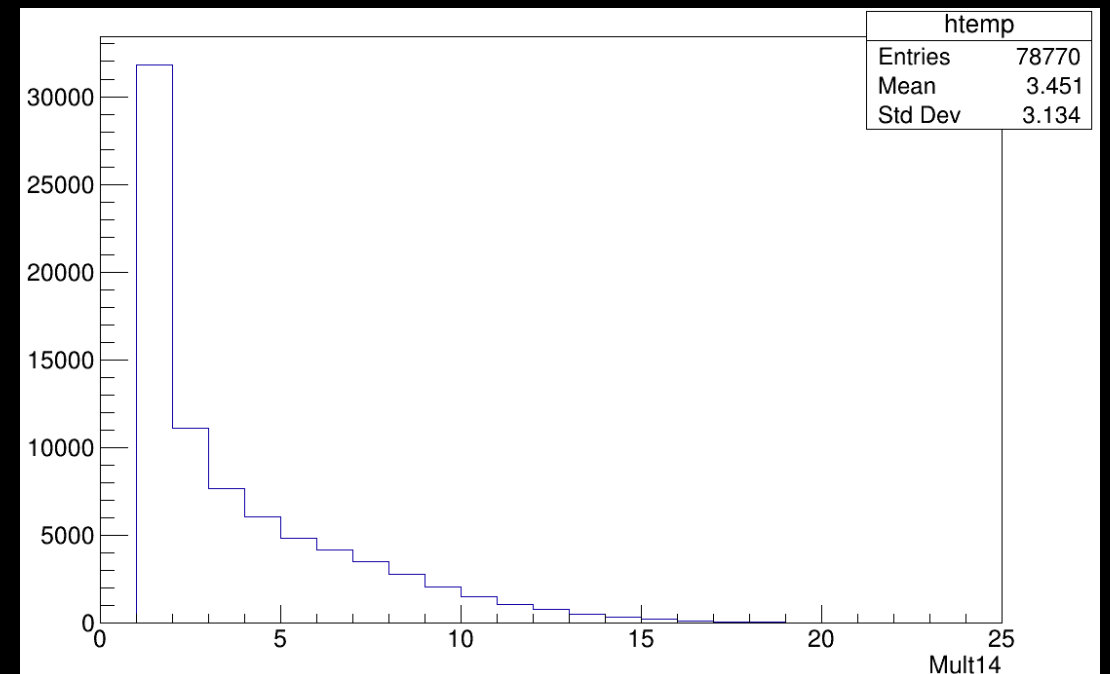
- Energy correlation between all 4 in beam FOOT;
- Selected only events within an energy cut: Multiplicity 1 increased.



- FOOT 0 Mult 1 from 50% to 60%

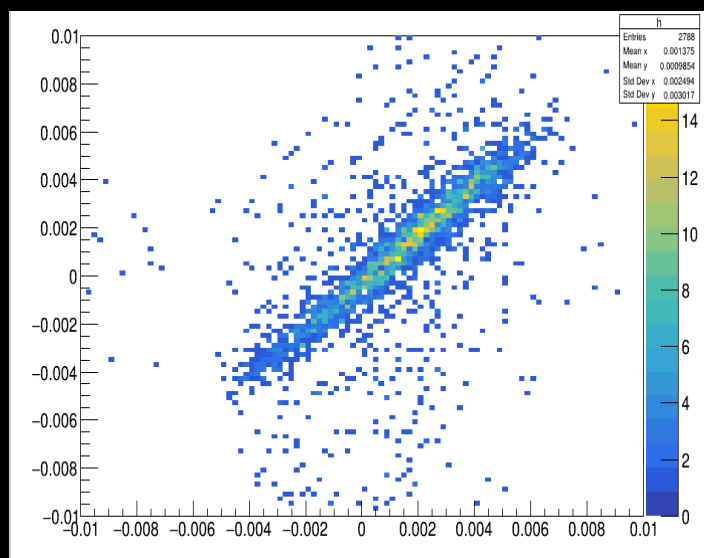


- FOOT 14 Mult 1 from 37% to 40%

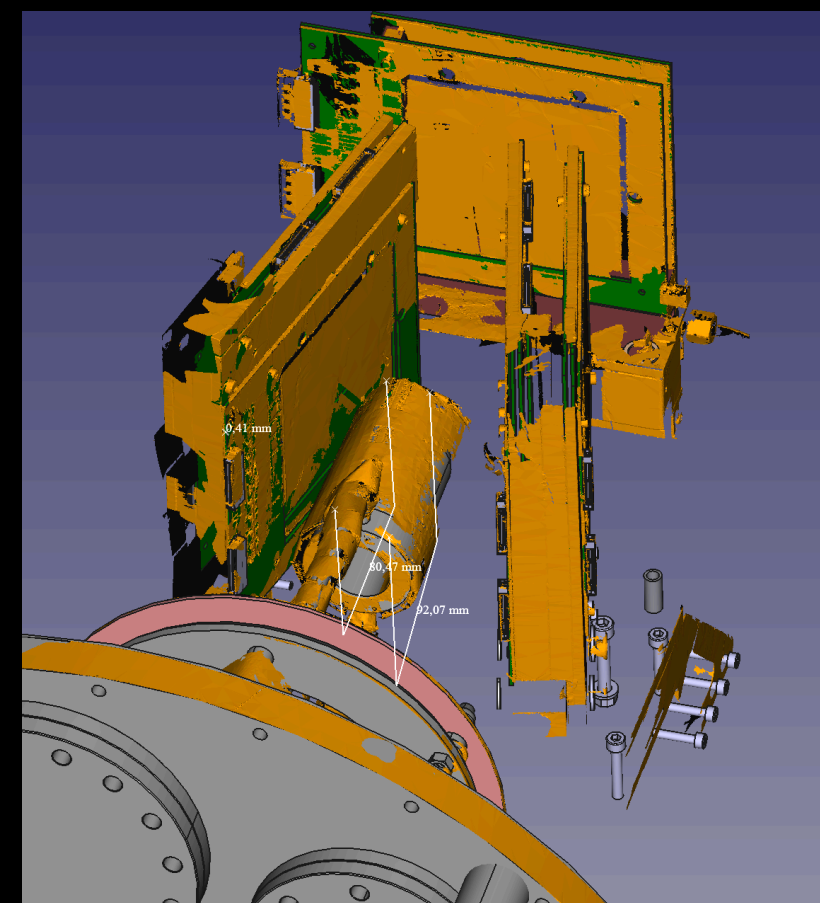
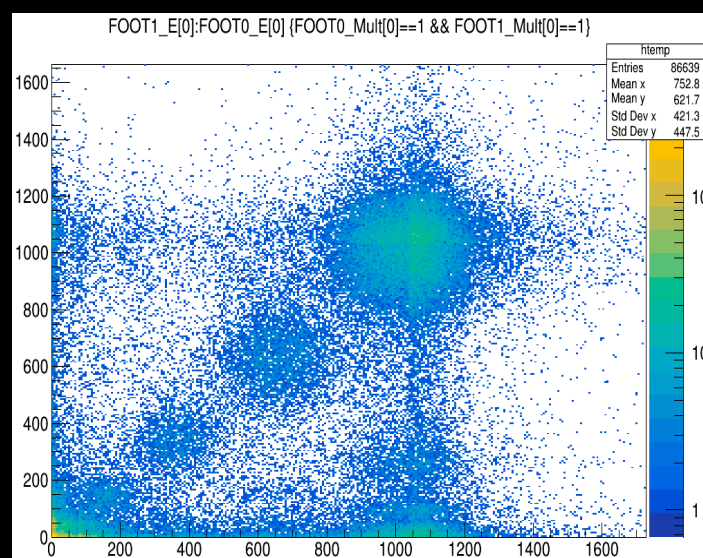


- **Mult = 1 in FOOT is under control:**
 - Ready to investigate proton track in arm FOOT and vertex reconstruction;
 - Geometry informations from CAD model;
- **Mult > 1:**
 - Correlations FOOT 0/1 and FOOT 14/15 as a tool to reject uncorrelated clusters;
 - Make use of information from MWPCs;

• bX_beam vs bX_mwpc Mult =1



• Energy Correlations

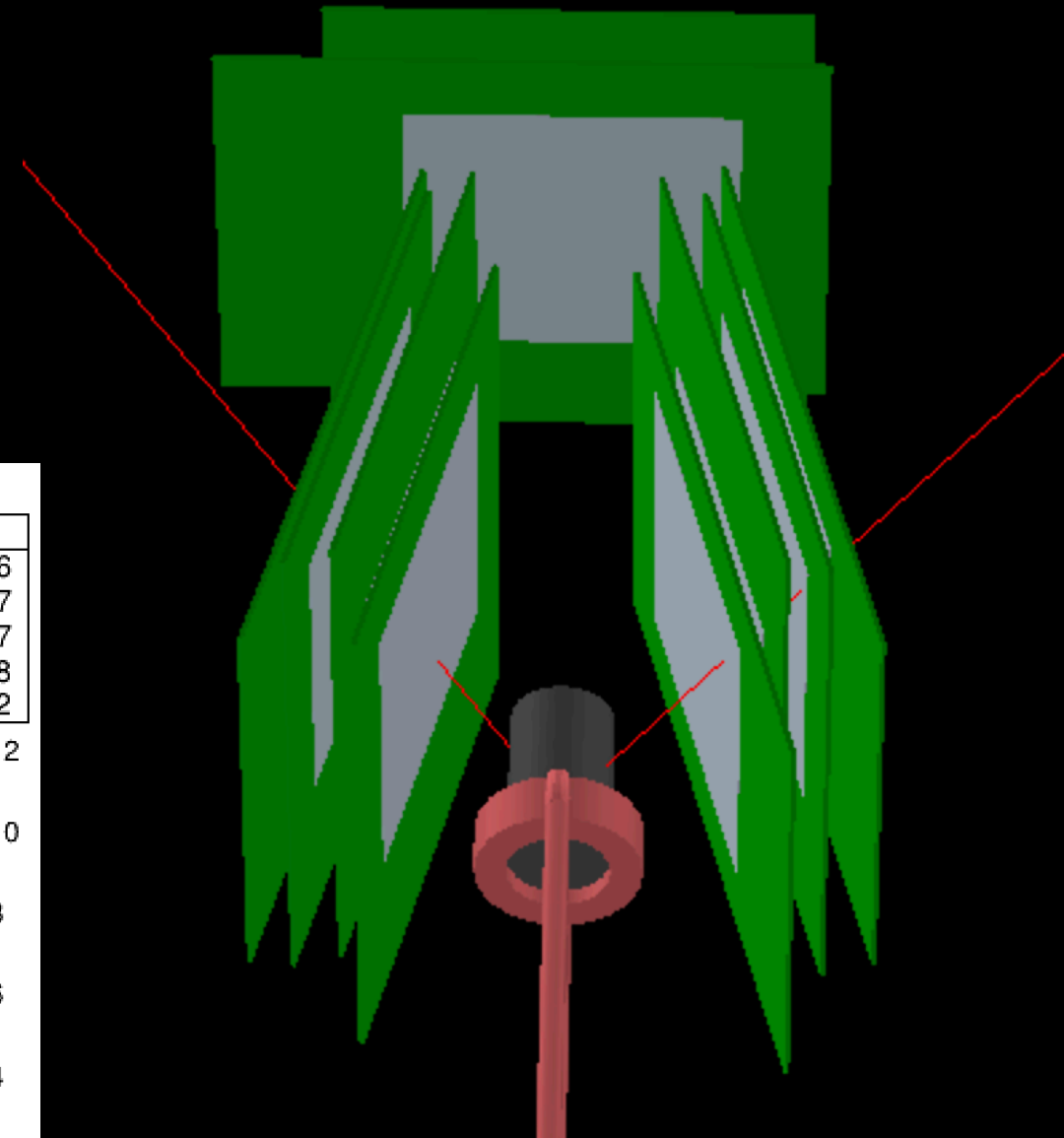
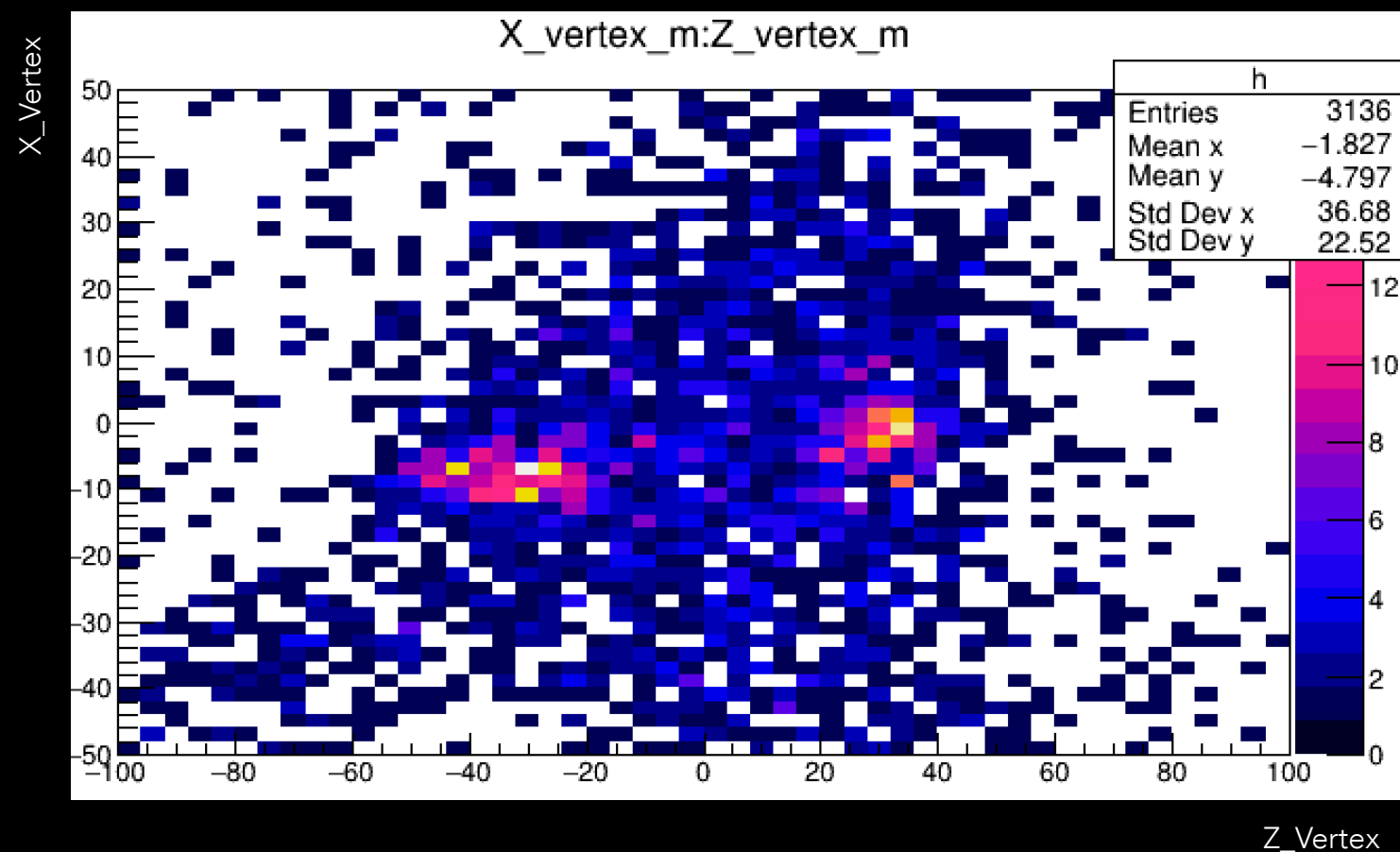


Alignment of Laser scan with CAD Model

- Minimum distance between all possible combinations of FOOT tracks from the left arm and right arm;

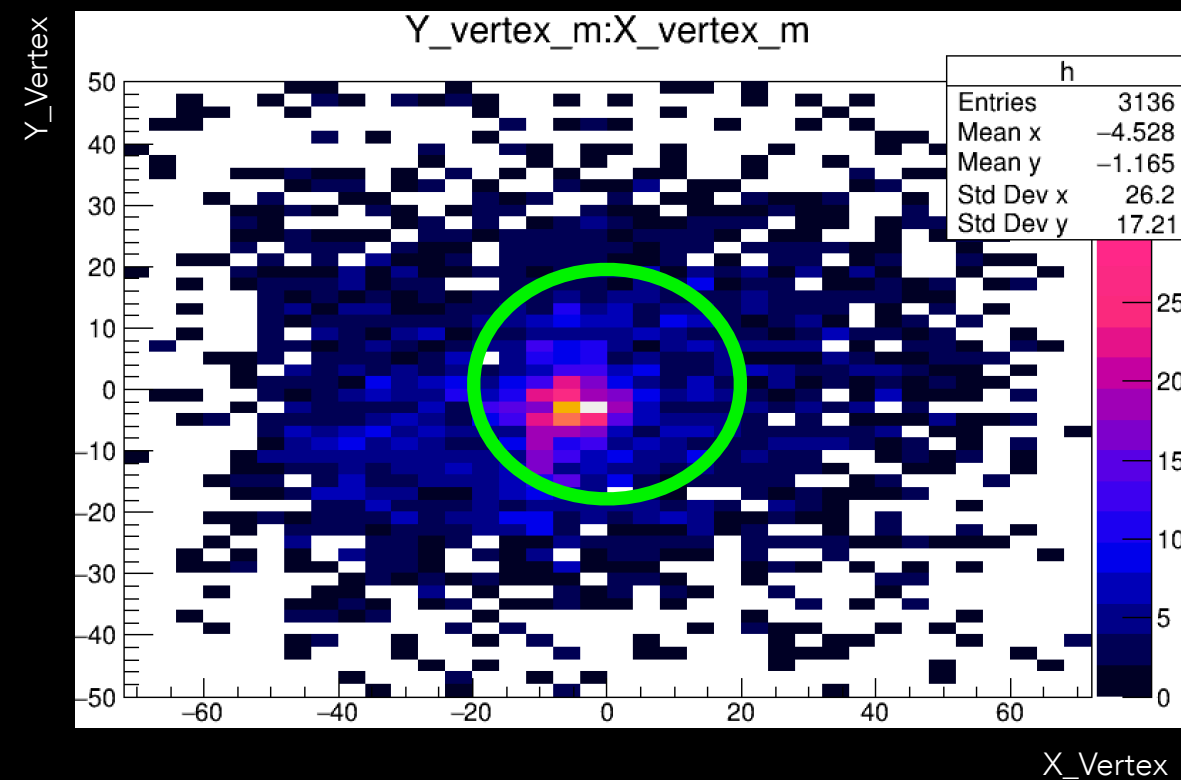
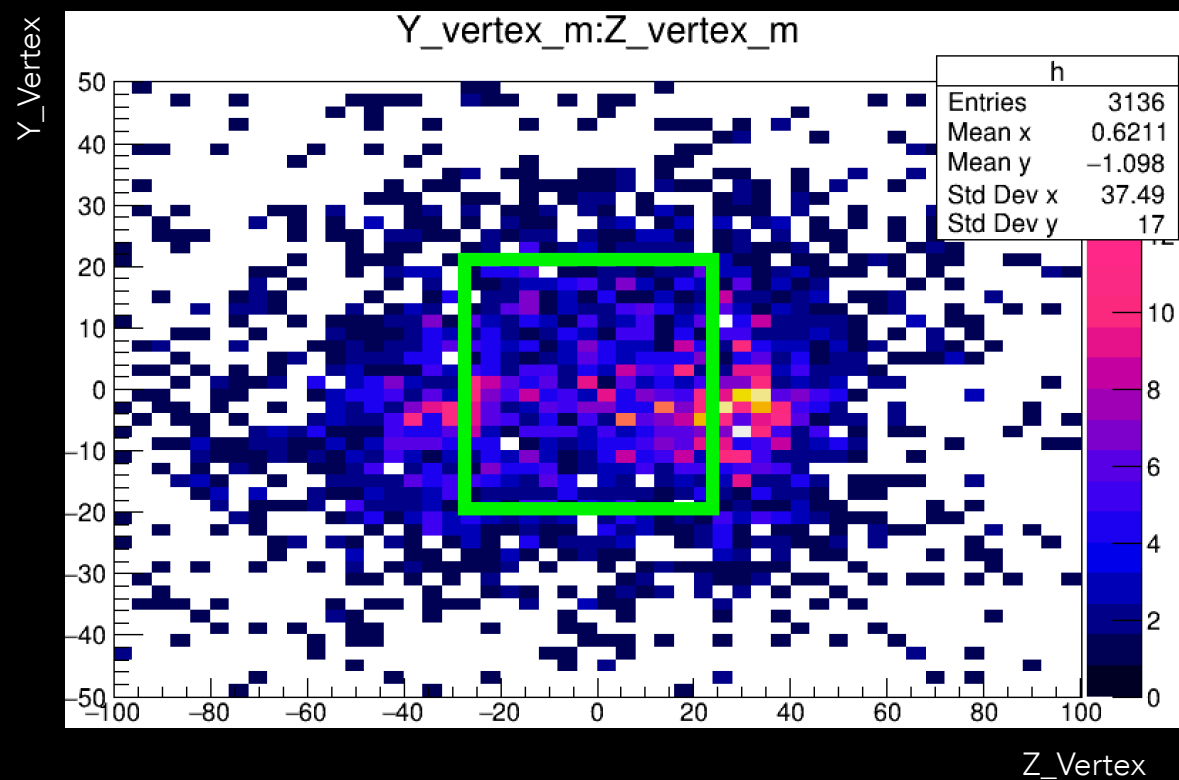
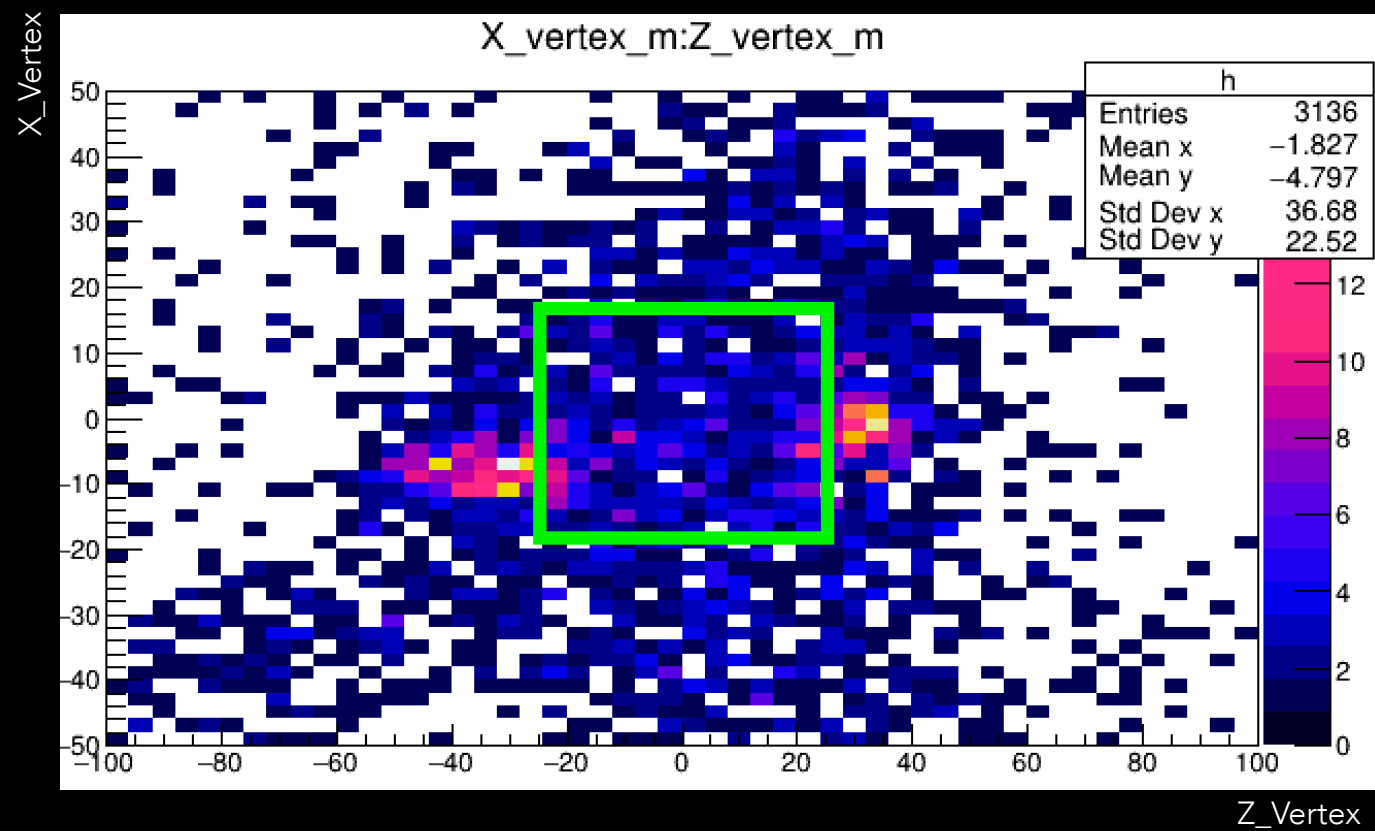
Important quantities:

- **X_Vertex;**
- **Z_Vertex;**
- **Y_Vertex;**
- **Dist min;**

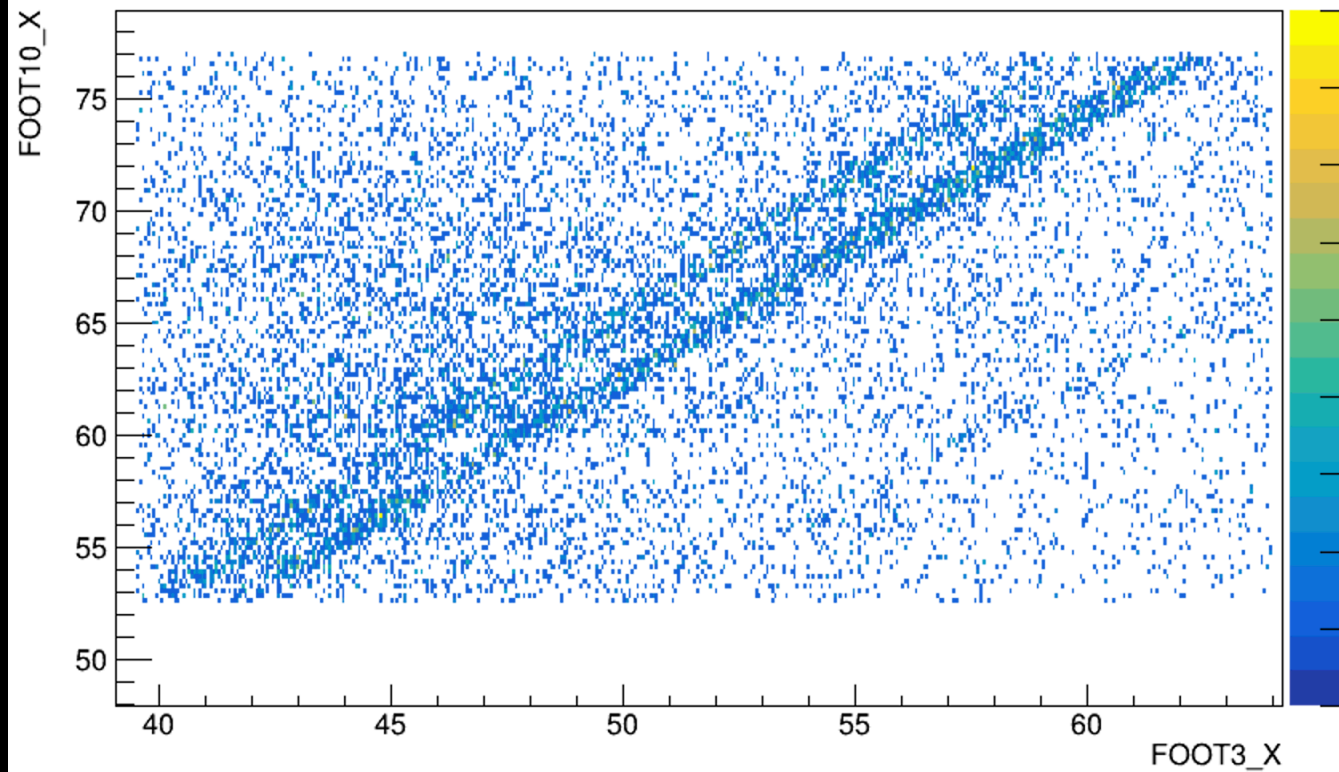


New Geometry for FOOT simulations in R3BRoot

VERTEX RECONSTRUCTION



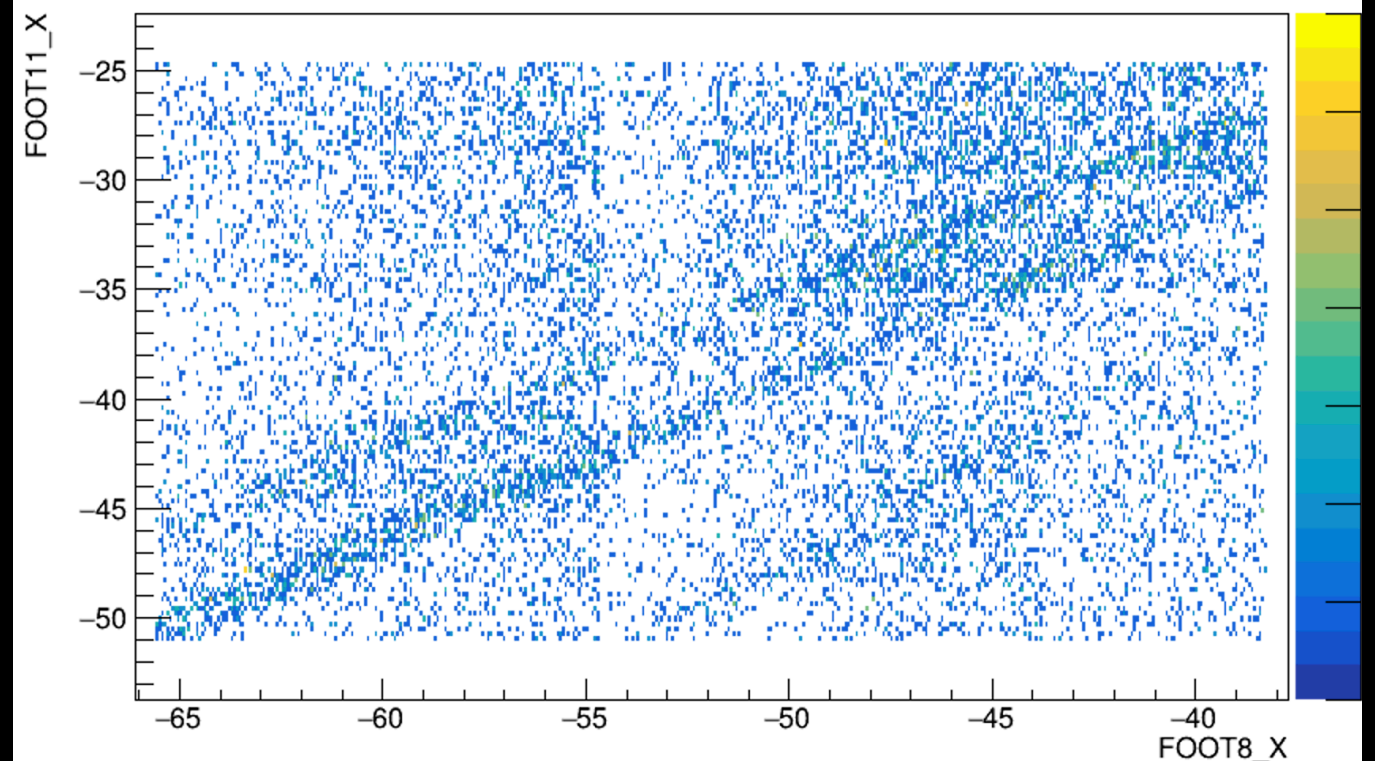
FOOT10_X:FOOT3_X

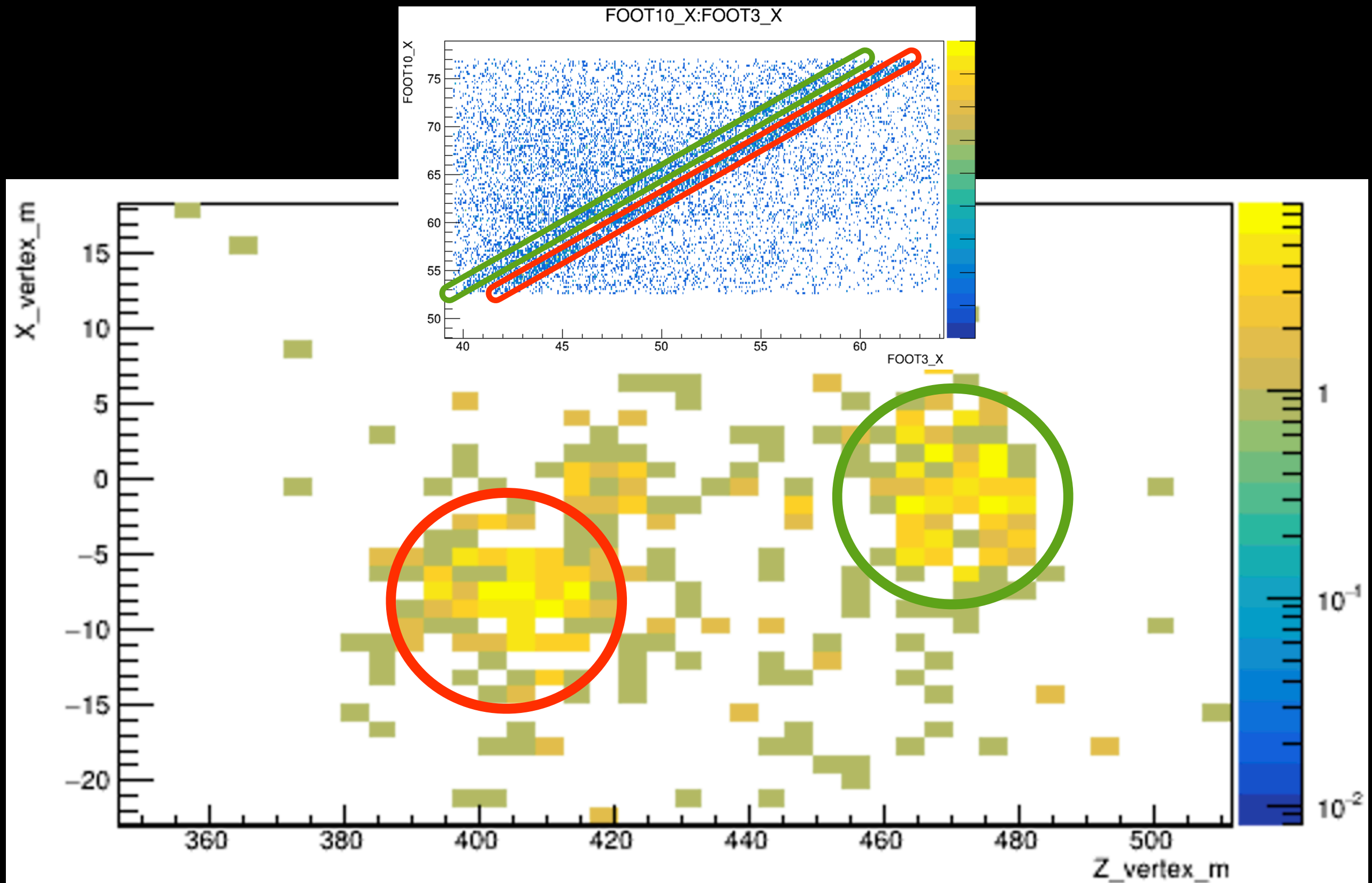


- X position correlation FOOT 3 and FOOT 10;

- X position correlation FOOT 8 and FOOT 11;

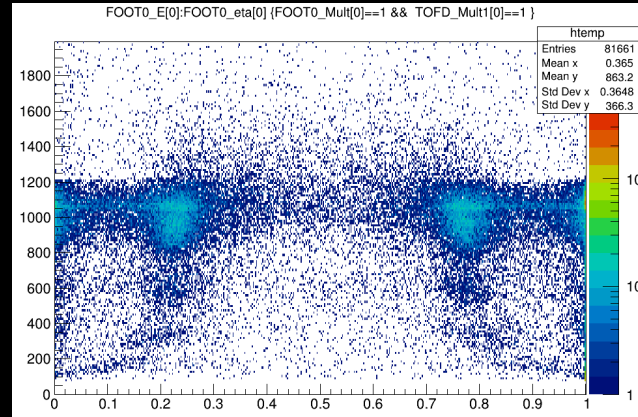
FOOT11_X:FOOT8_X



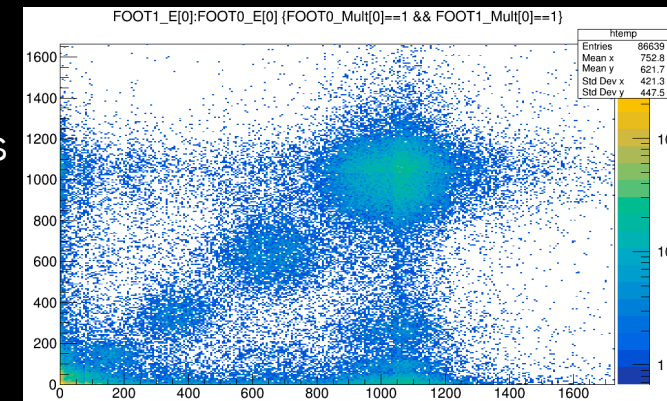


CONCLUSIONS

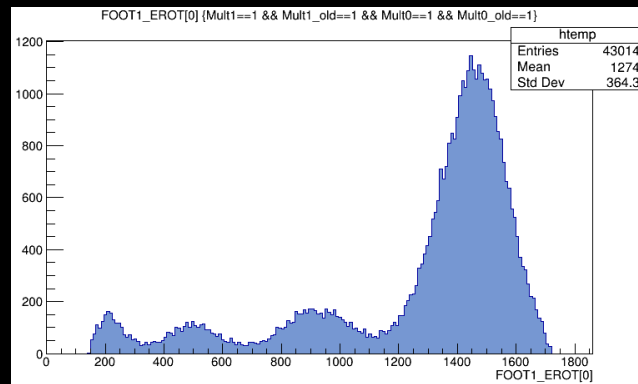
- New s522 calibration for Energy-eta dependence;



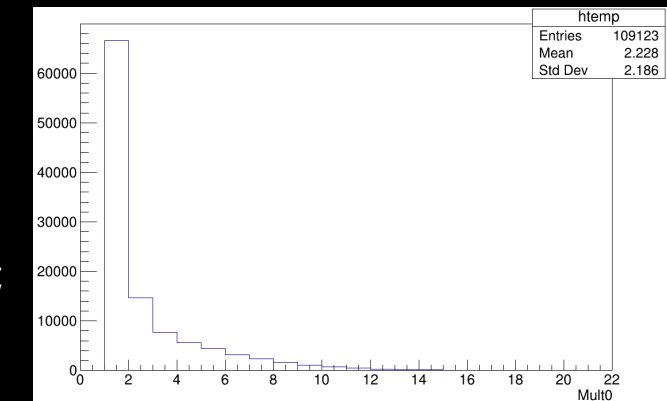
- FOOT Energy correlations to investigate multihit problem;



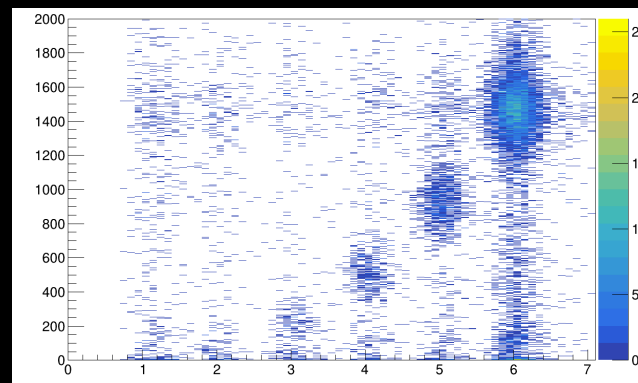
- FOOT Energy correlations to obtain a better energy separation;



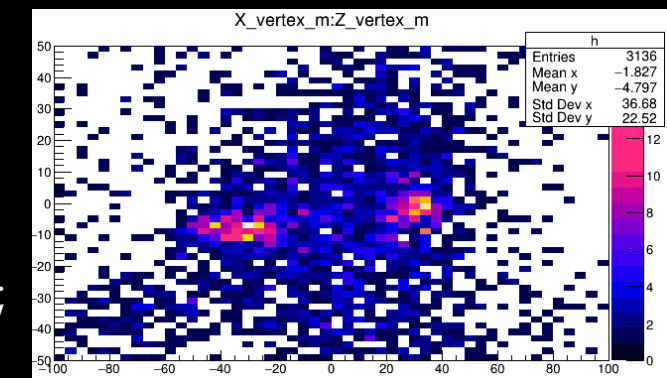
- Cut on energy correlation on all in beam FOOT decreased the multiplicity;



- Good correlation of in beam FOOT with TOFD energy loss;



- Vertex reconstruction still not well understood;
 - Noisy ASICs?;
 - Mapping problem?;



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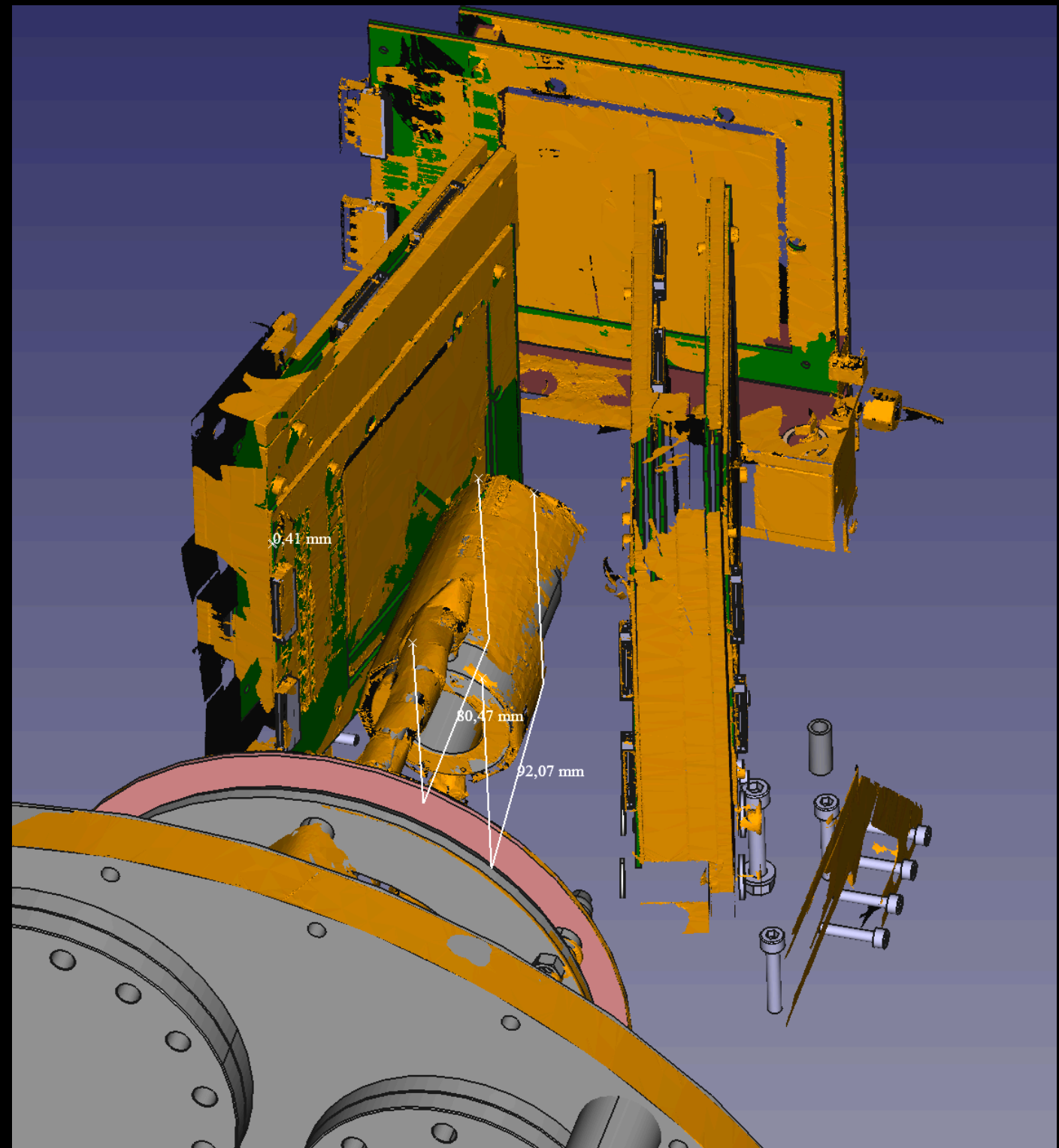
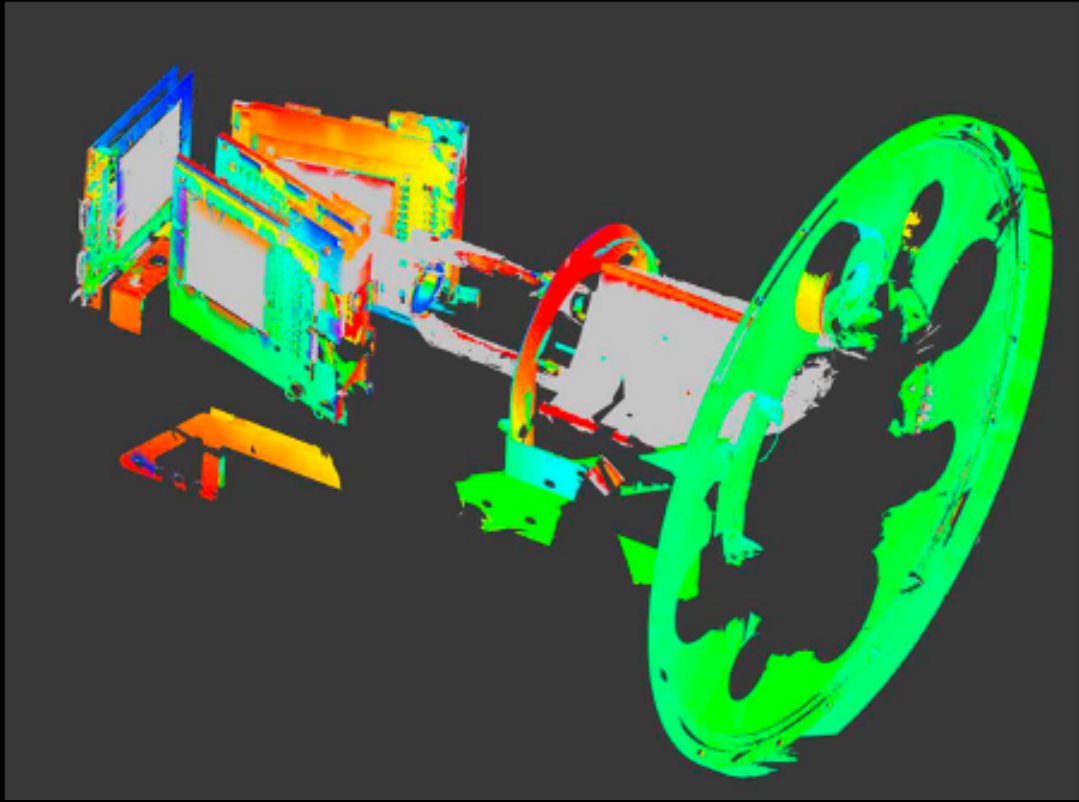
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THANKS FOR YOUR
ATTENTION



BACKUP SLIDES

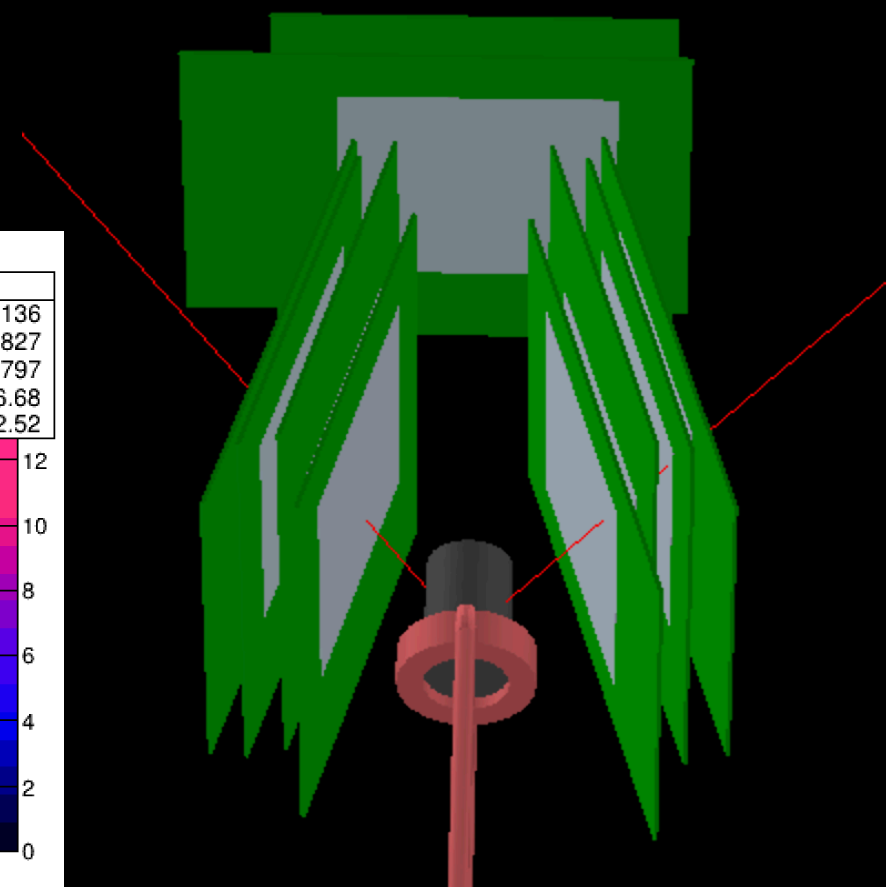
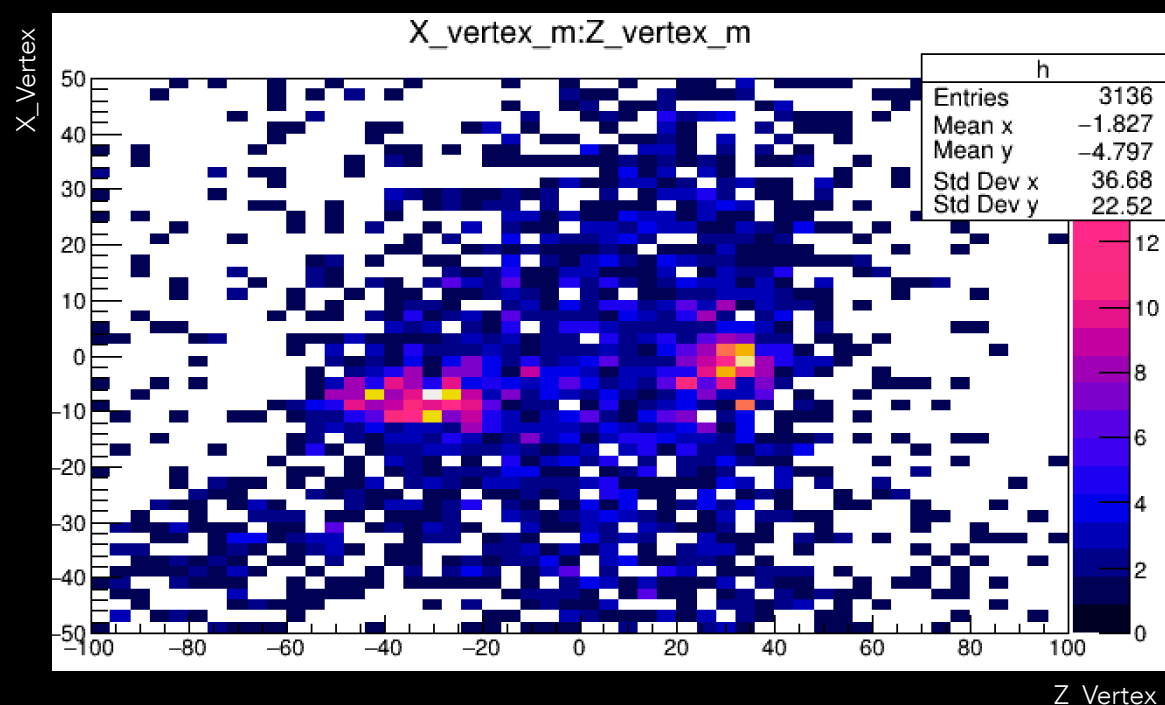
- Important quantities for analysis after clustering algorithm:
 - **Cluster energy**: energy information of the cluster (eta-energy dependence correction);
 - **Eta coefficient (ETA)**: impact parameter, which characterises the interstrip position of the hit;
 - When 0, it means that the hit is exactly in the center of the readout strip and 1 means the hit is in the center of the next readout strip;
 - **Cluster position**: position obtained from the signal-weighted center-of-gravity;
 - **Cluster Multiplicity**: number of cluster per events in each FOOT (Multiplicity);
 - High multiplicity was observed in FOOT in beam, development a specific treatment necessary to recover multihit events;



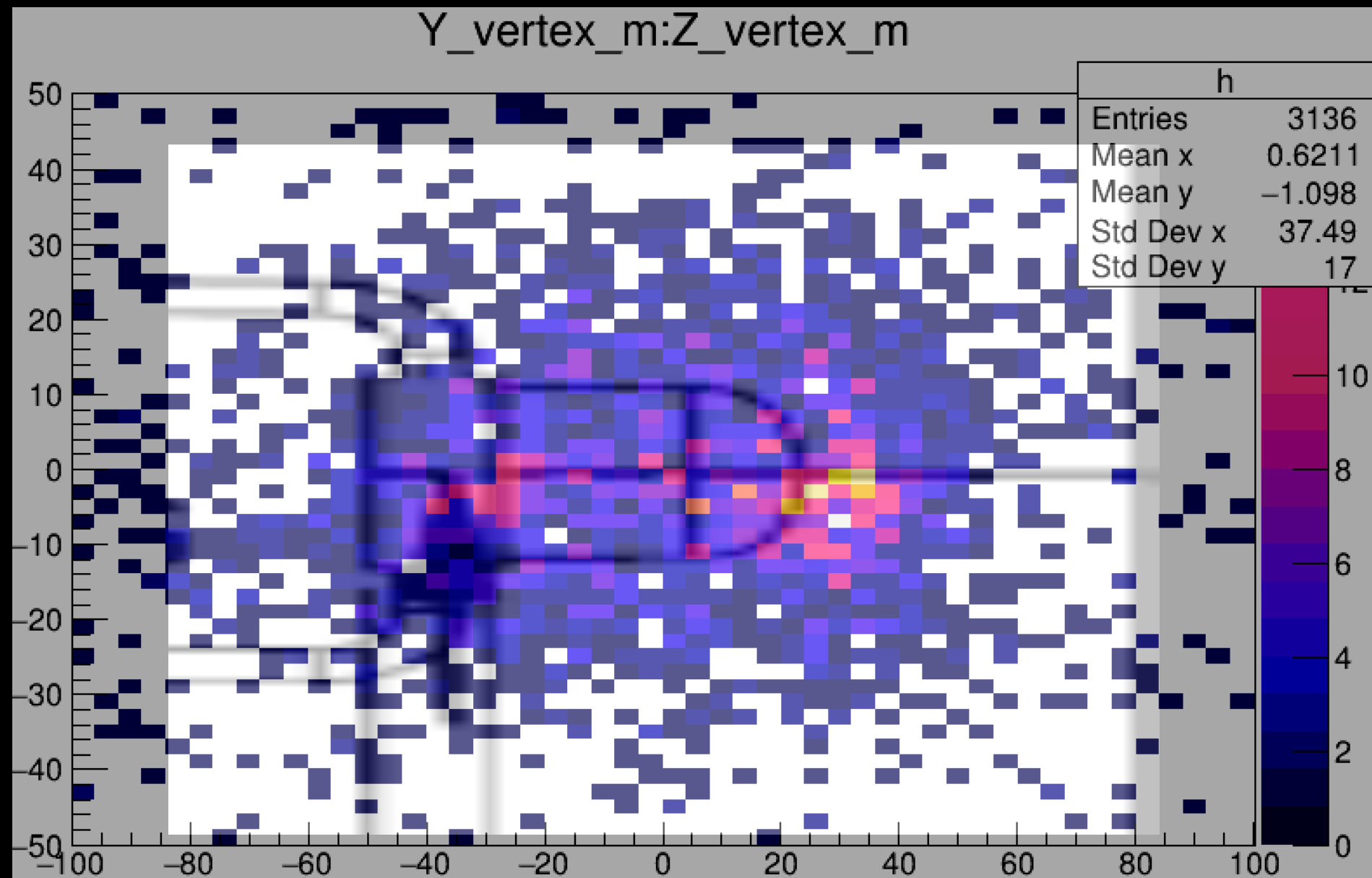
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Important quantities:

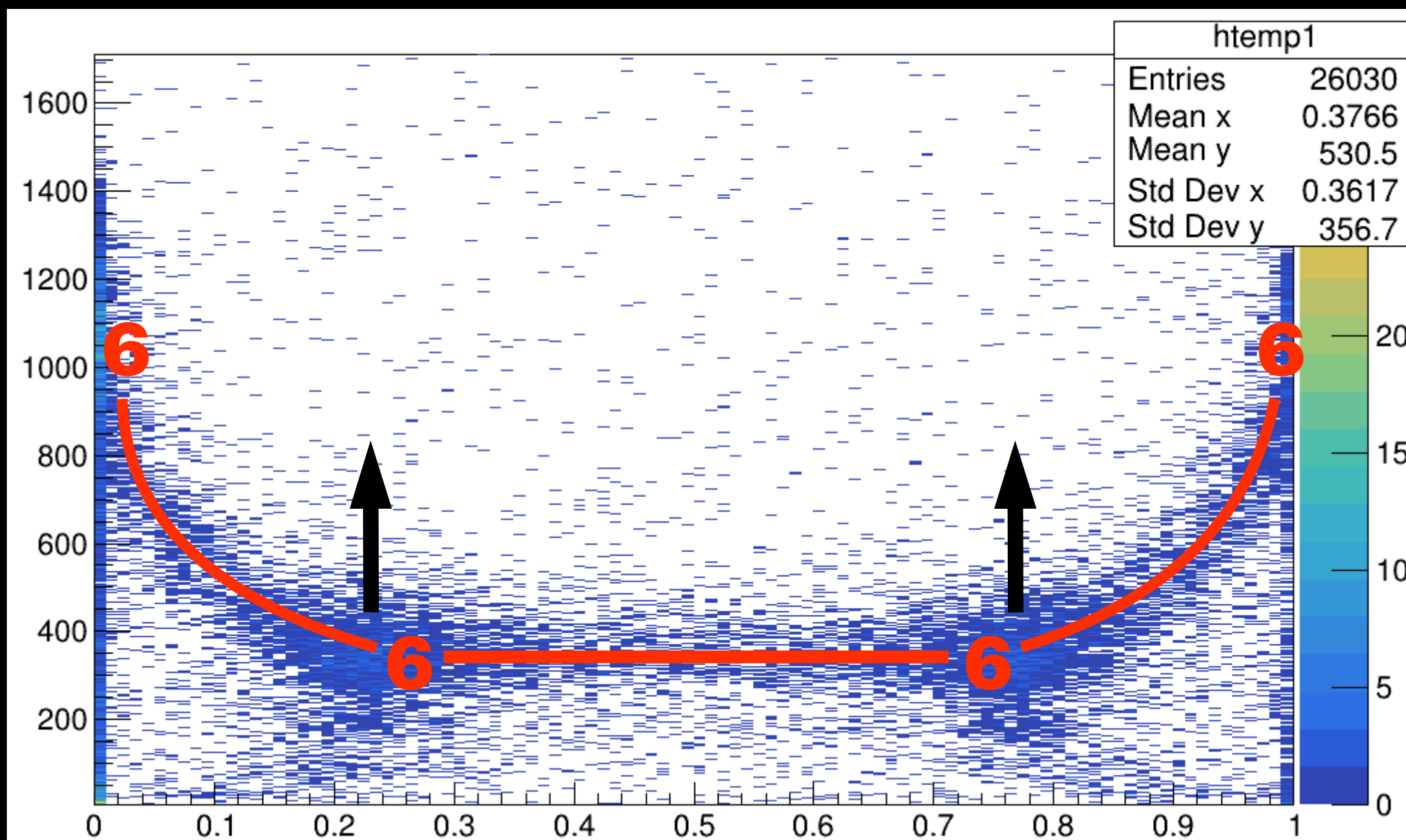
- **X_Vertex;**
- **Y_Vertex;**
- **Z_Vertex;**
- **Dist min;**

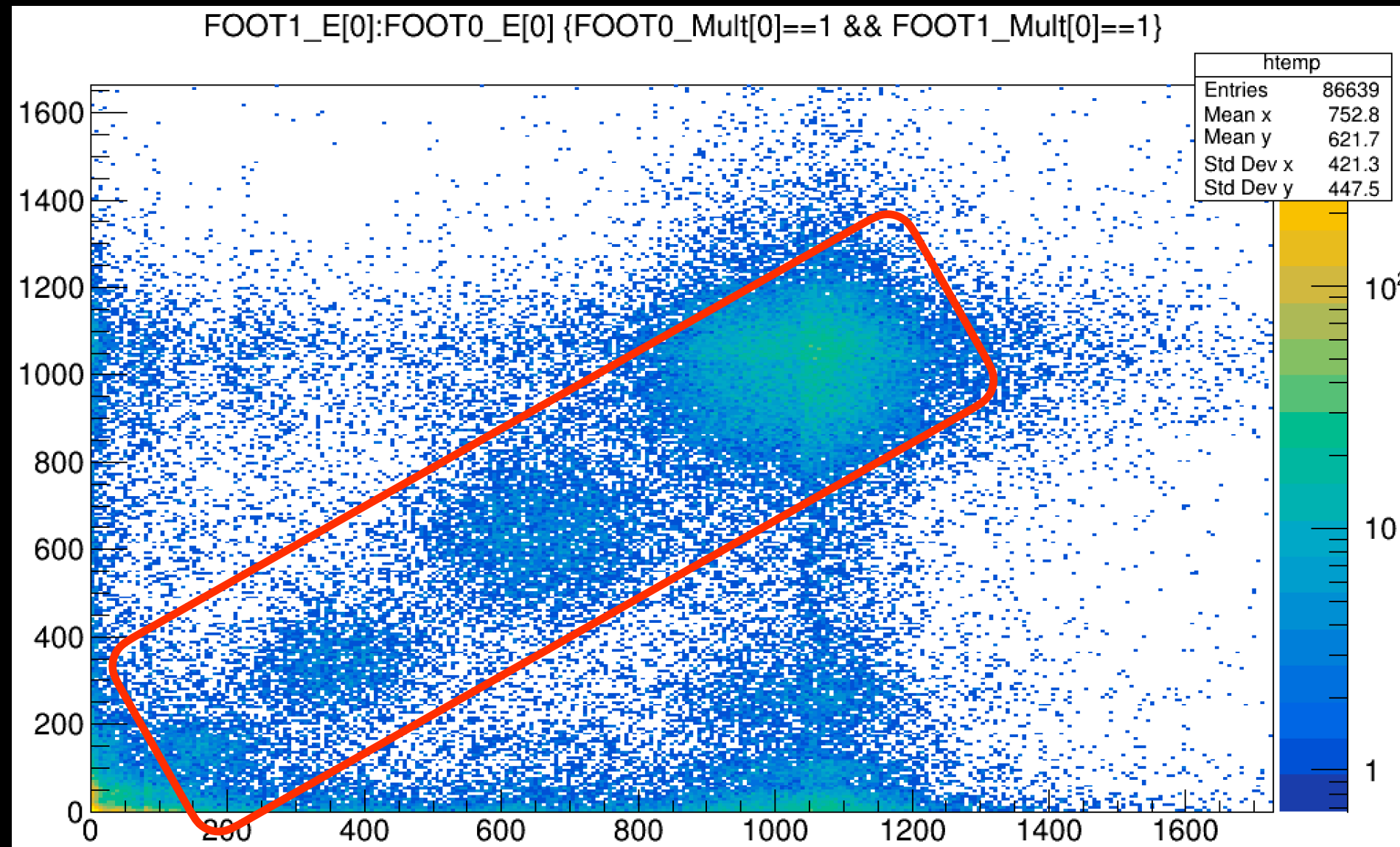


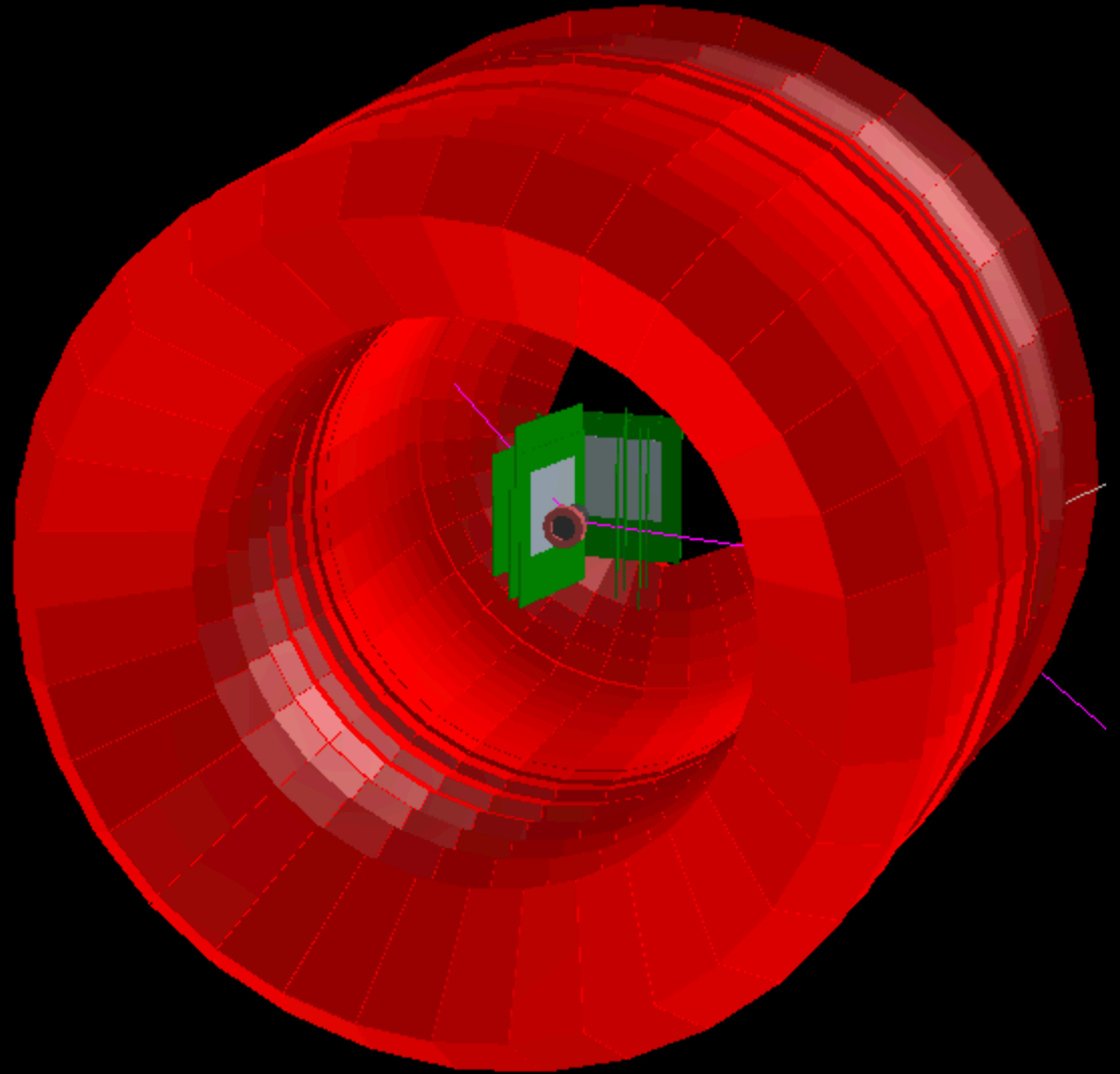
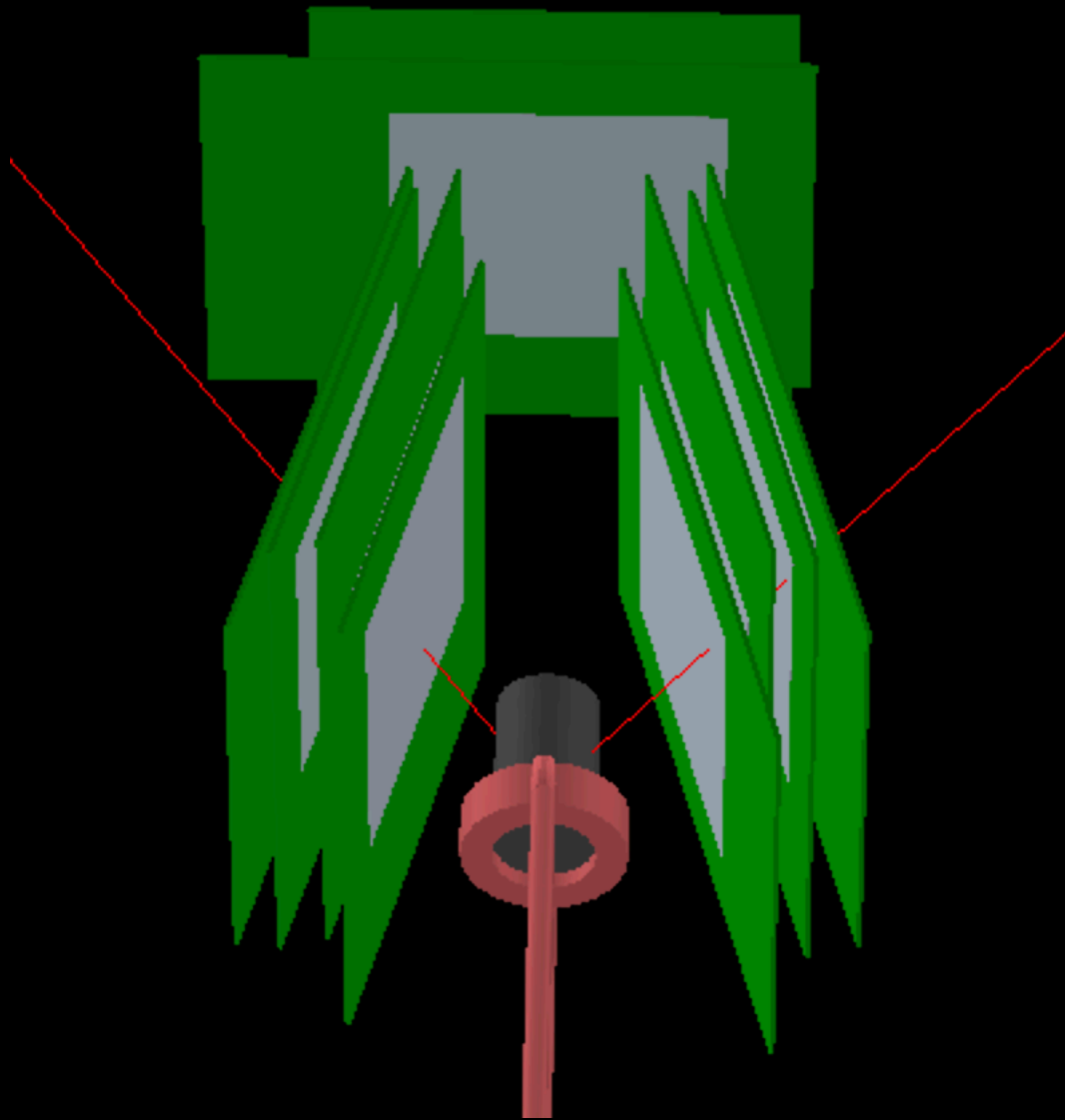
- Comparison between CAD drawing and YZ Vertex reconstruction:



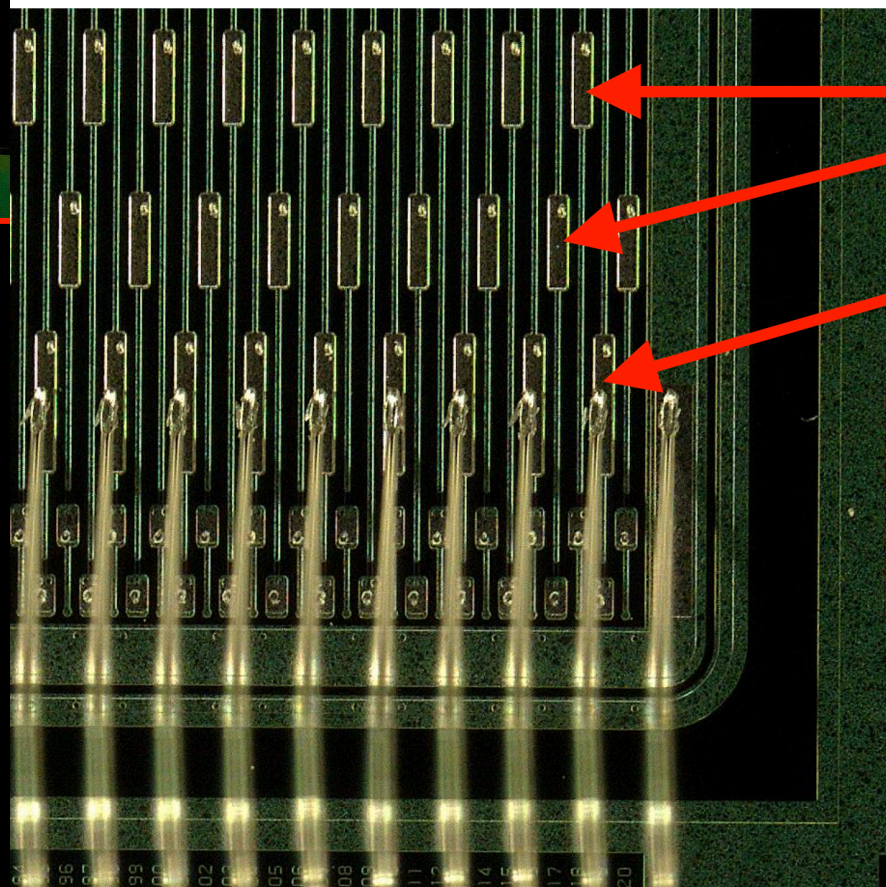
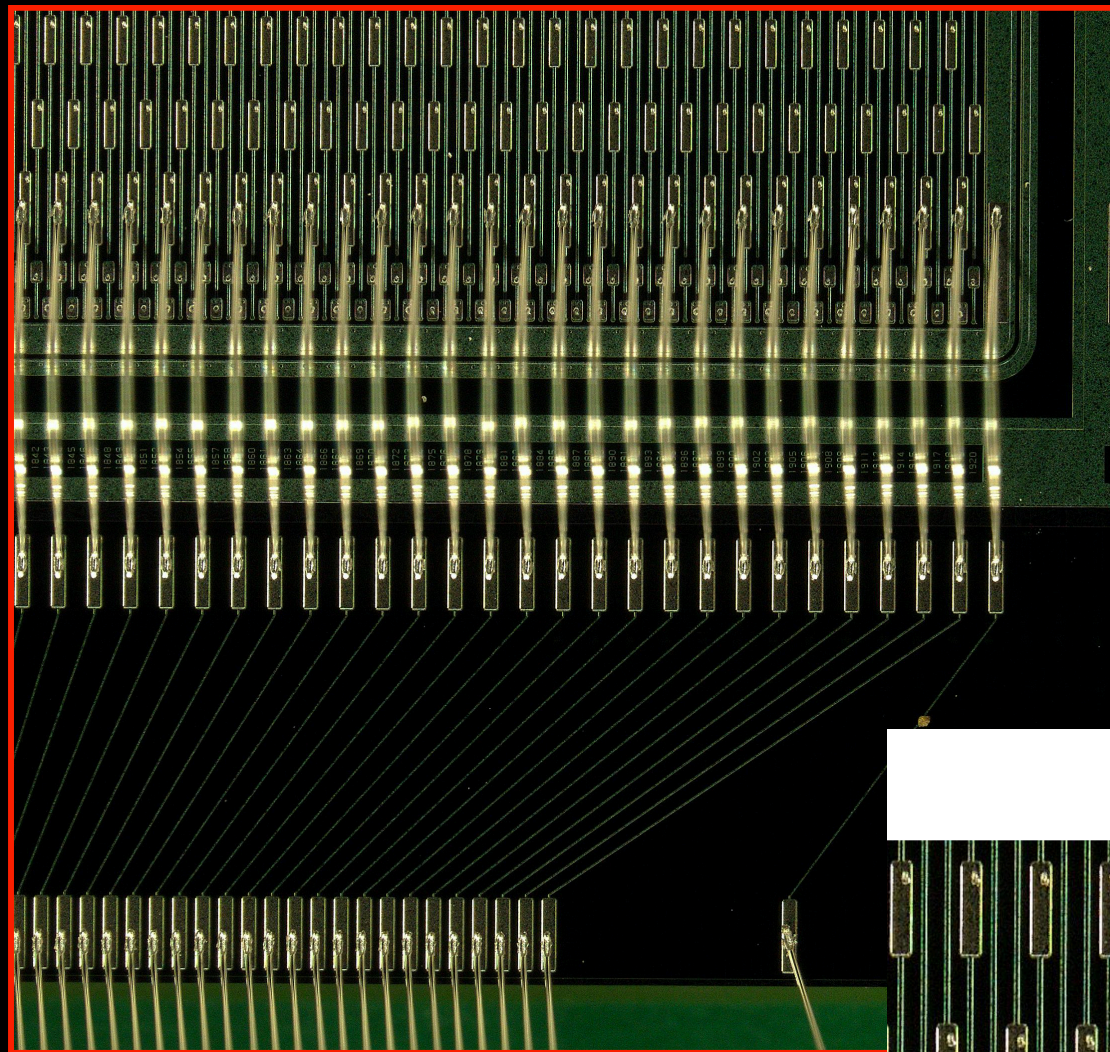
- $\text{ETA}=0$ is the energy deposited in a single strip, we use as a reference for the correct energy of the hit;
- Align the energies for $\text{ETA}>0$ to the $\text{ETA}=0$ reference value;







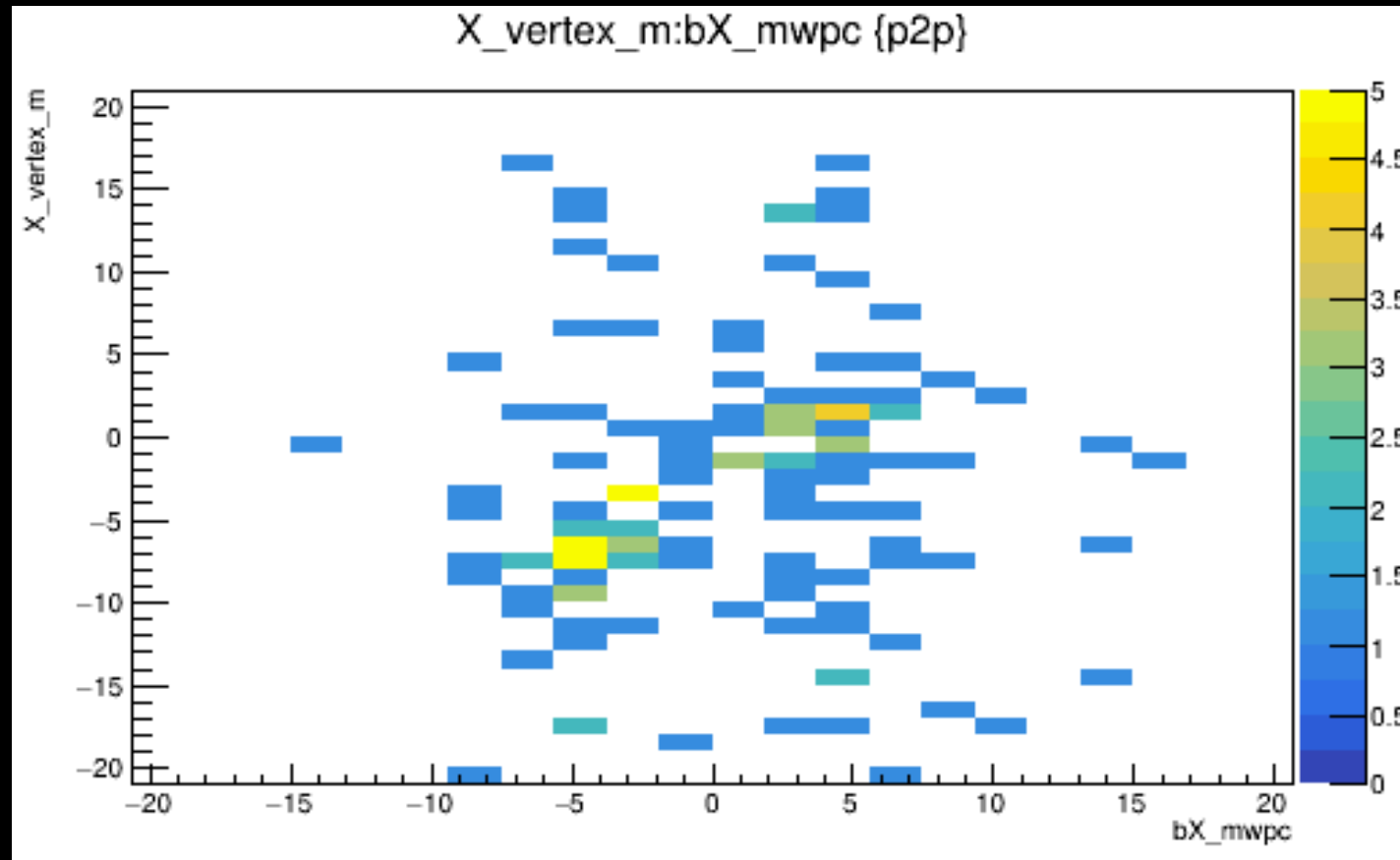
STRIP CONFIGURATION



non-bonded strips

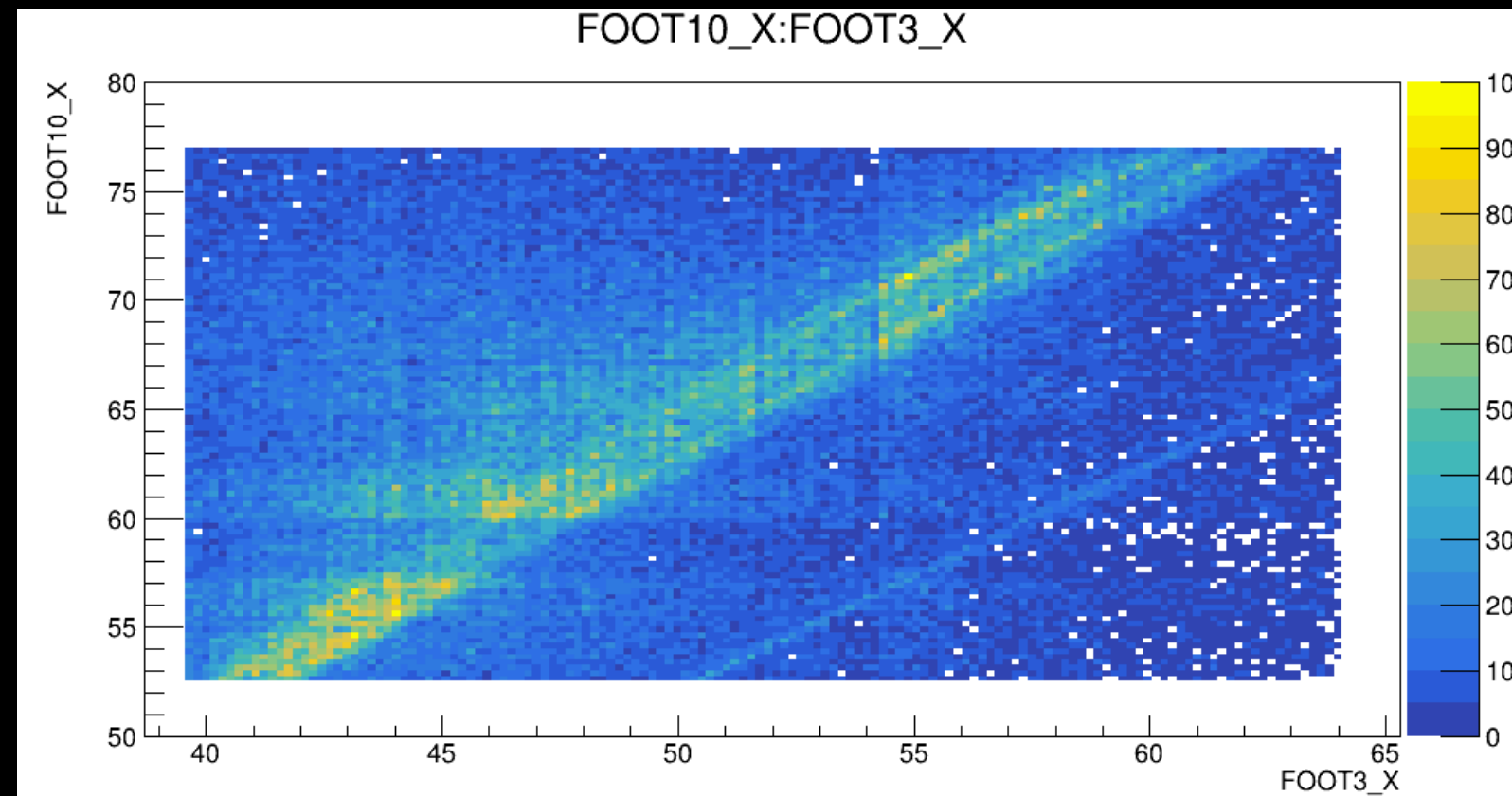
bonded strip

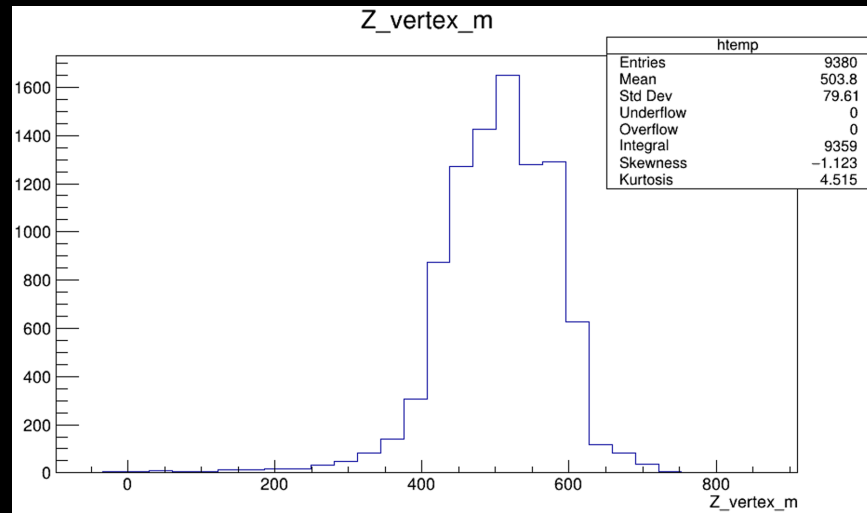
V. Panin presentation



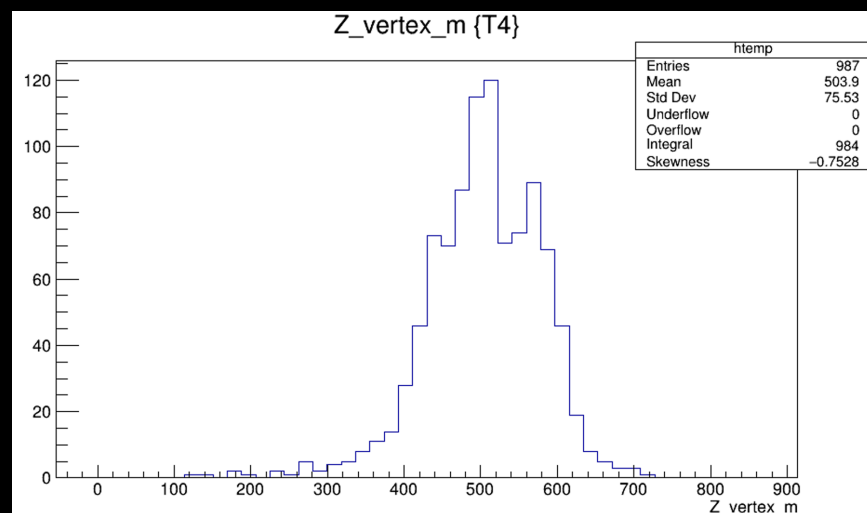
- Correlation X Vertex with bX MWPC;
- p2p condition;

- X position correlation FOOT 3 and FOOT 10;

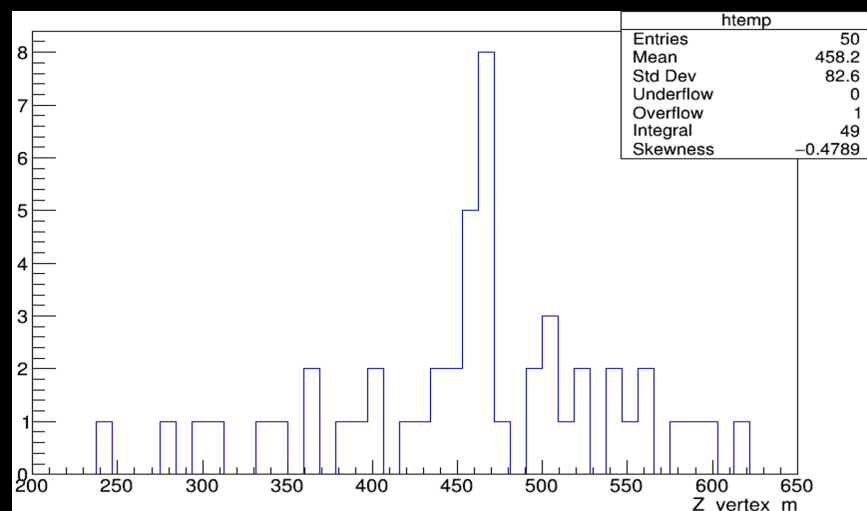




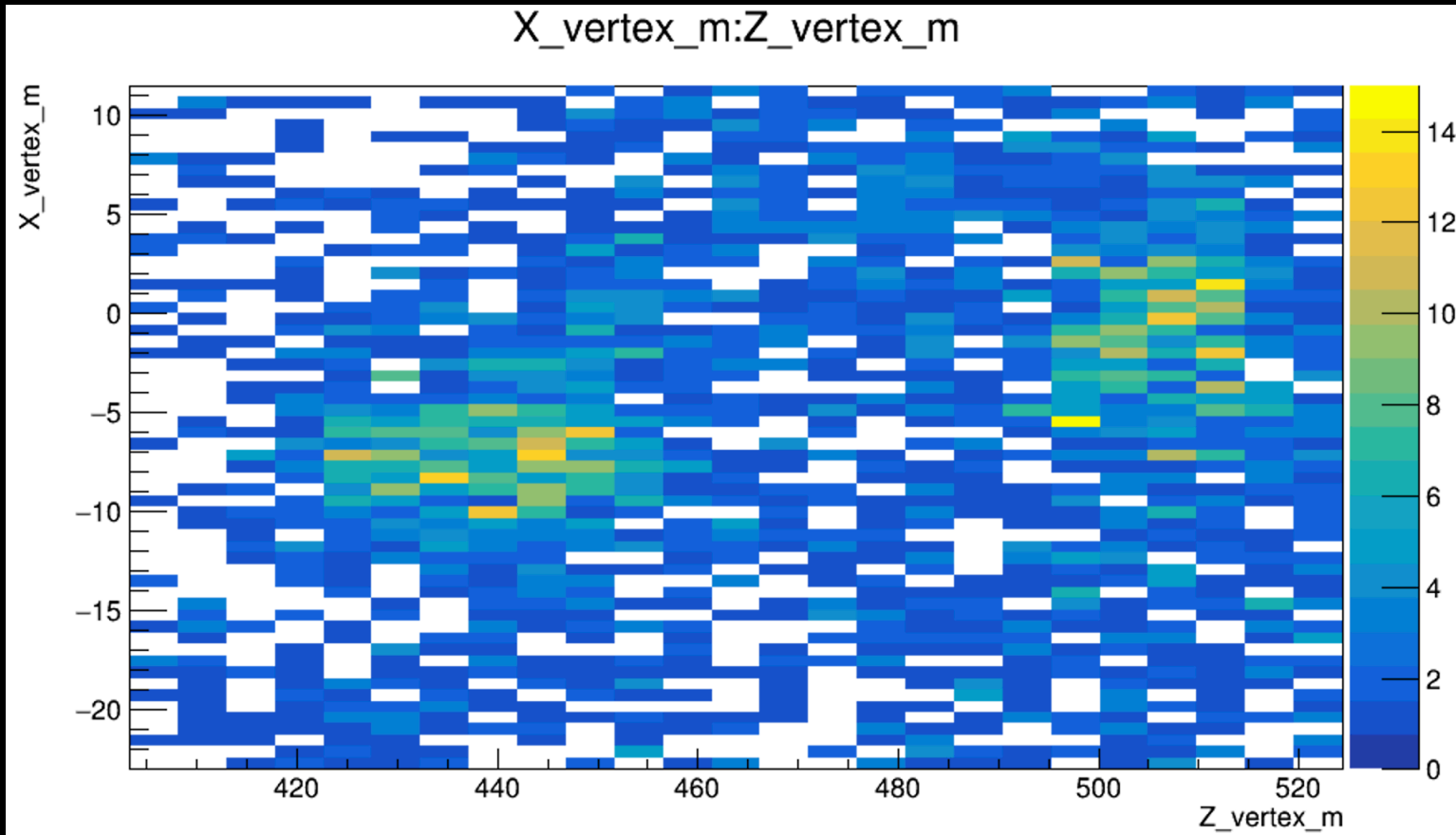
- Z Vertex without p2p condition;
- Integral = 9359;



- Z Vertex with p2p condition:
- Integral = 984;

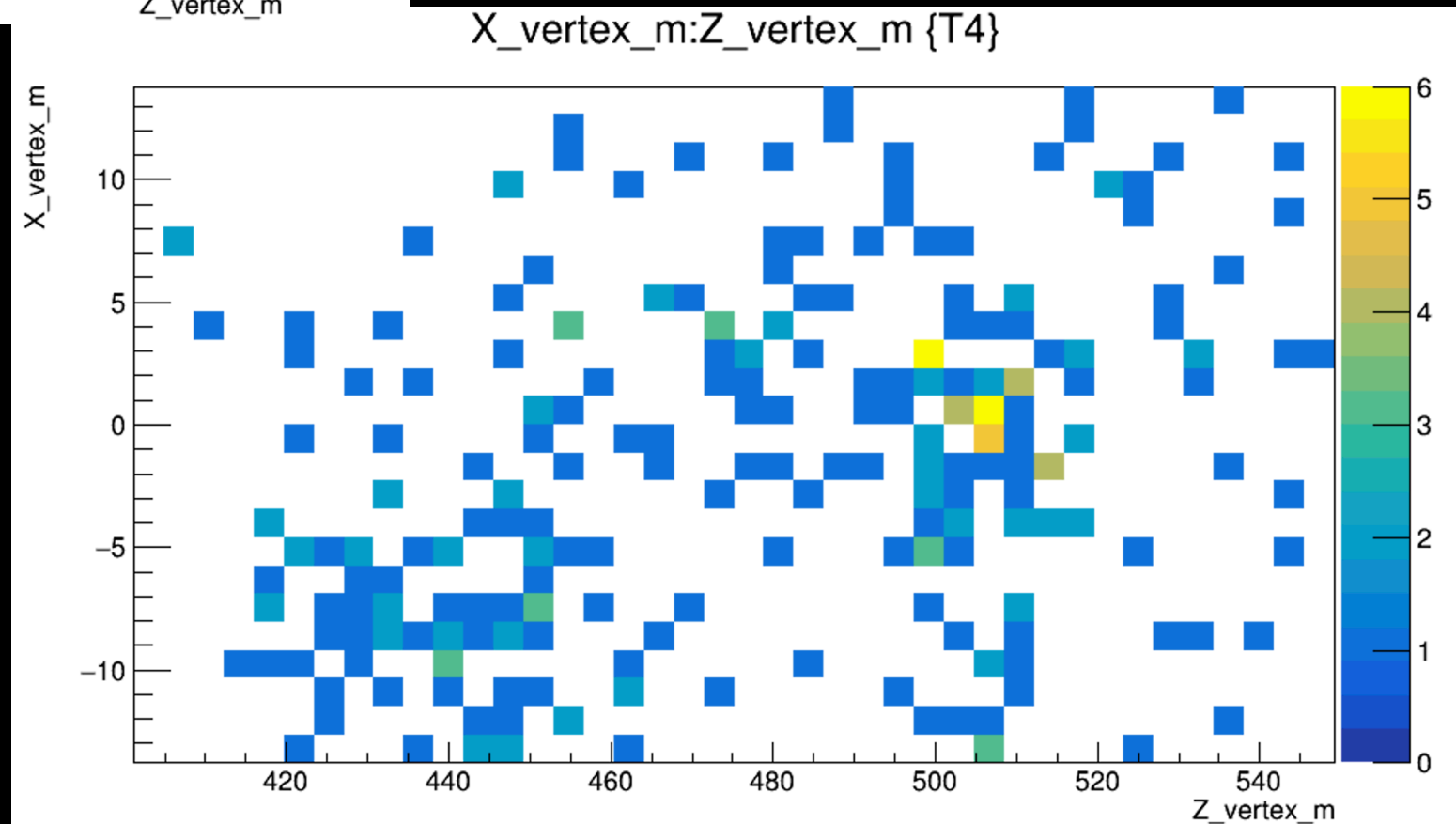


- Z Vertex with p2p condition and TOFD Z=5;
- Integral = 49;

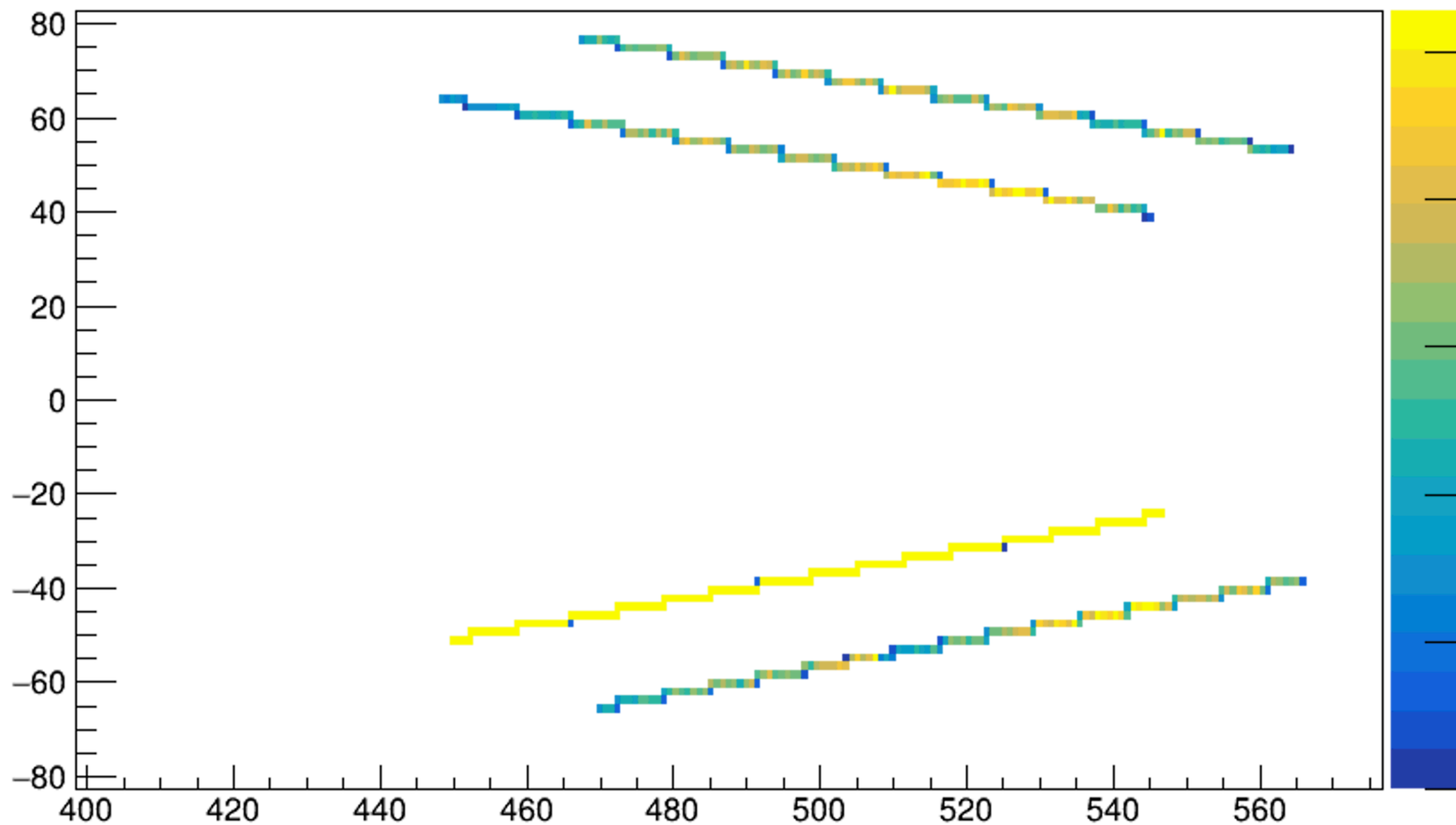


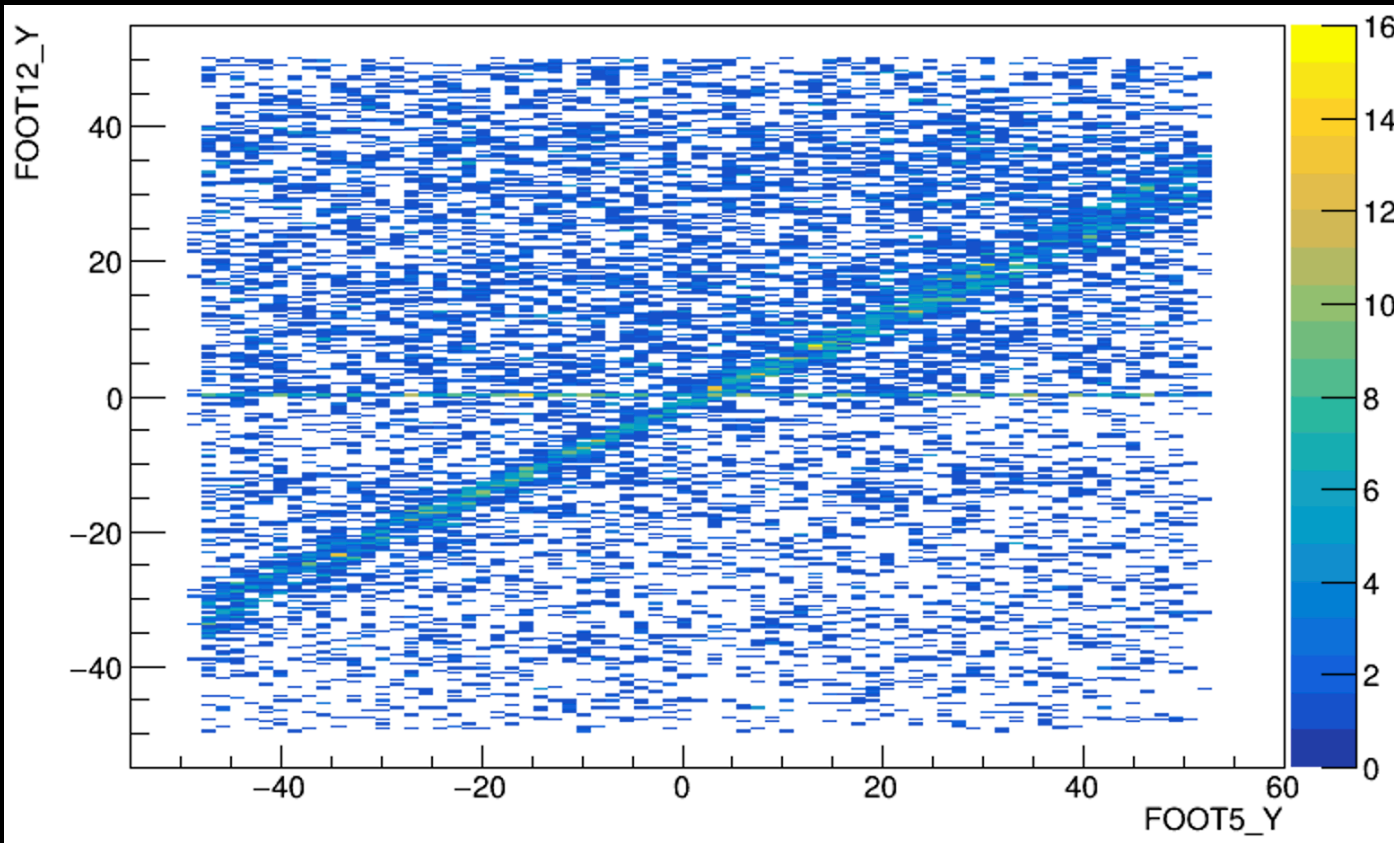
- Z Vertex vs X Vertex without p2p condition;

- Z Vertex vs X Vertex with p2p condition;



FOOT POSITIONS





- Y position correlation
FOOT 5 and FOOT 12;

- X vertex vs Z vertex
with cuts;

