TECHNISCHE UNIVERSITÄT DARMSTADT

Incoming detectors s509/s522

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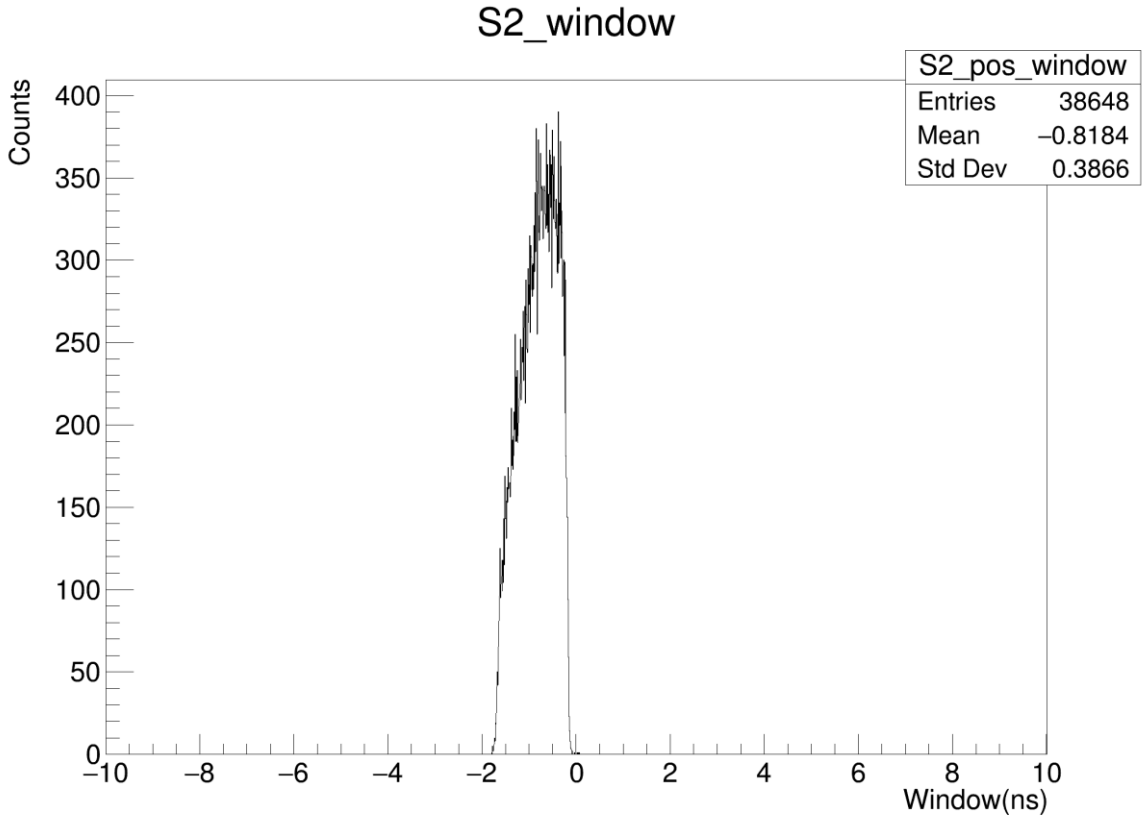
S2-LOS ToF Calibration

S2-LOS ToF Calibration

- Select good position in S2, taking time difference between left and right PMT
- Window obtained from taking Time_Left-Time_Right for mult ==1 events



S2-LOS ToF Calibration

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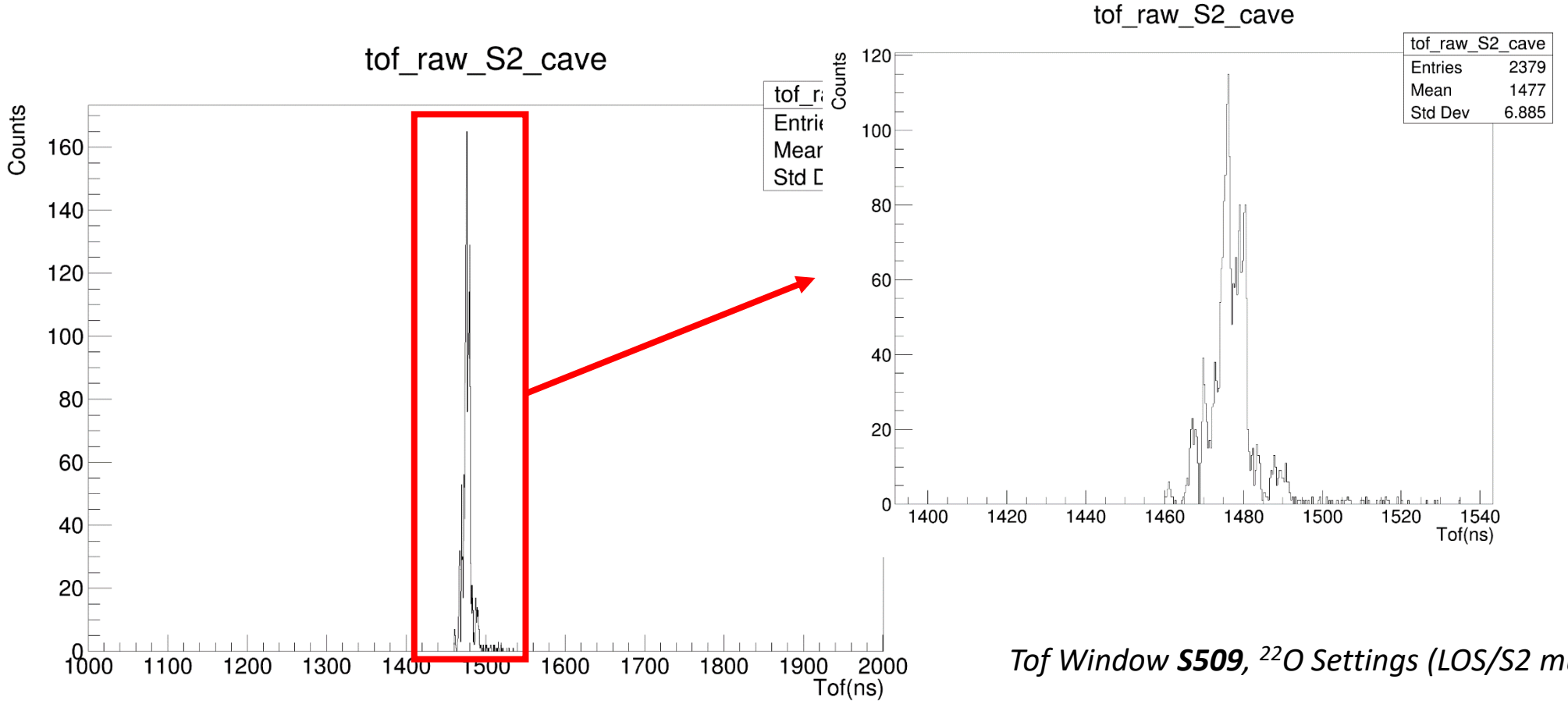
- Obtain a Tof window taking multiplicity == 1 events in LOS and the left – right PMTs of S2.



*Tof Window **S509**, ^{22}O Settings (LOS/S2 mult == 1)*

S2-LOS ToF Calibration

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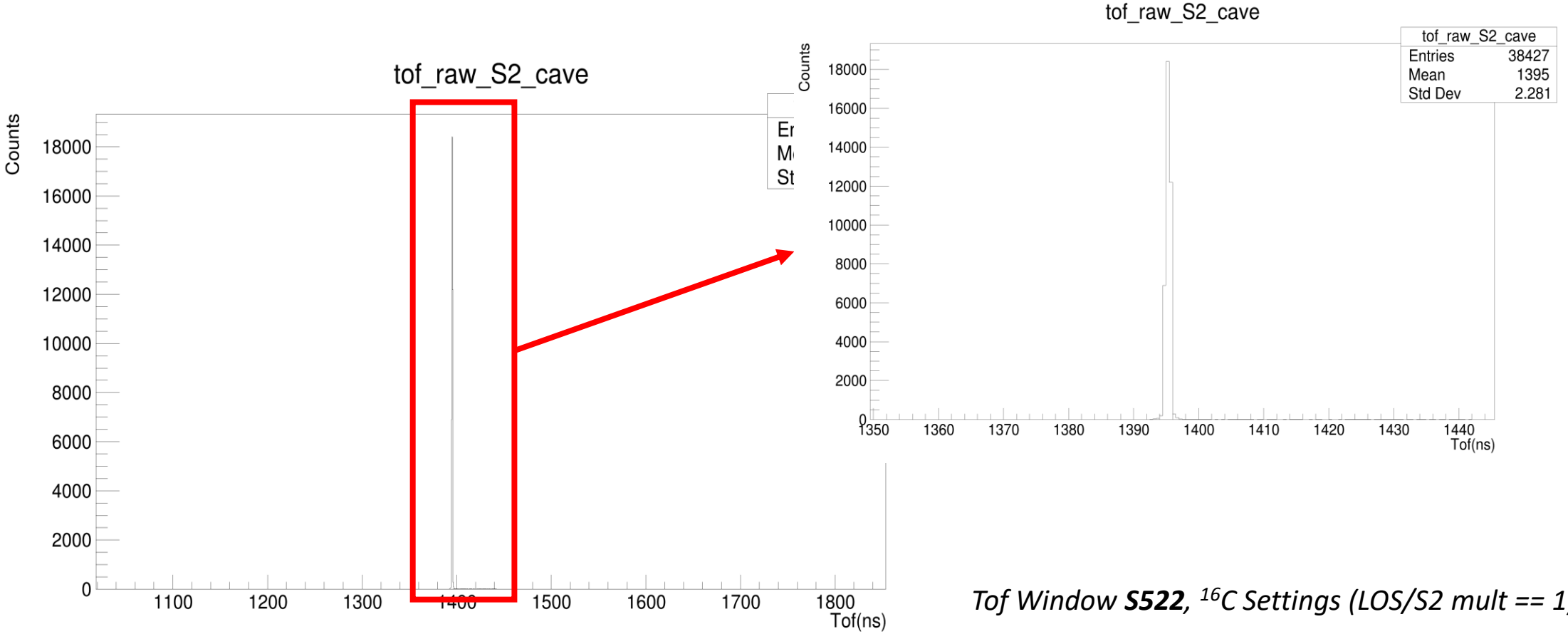
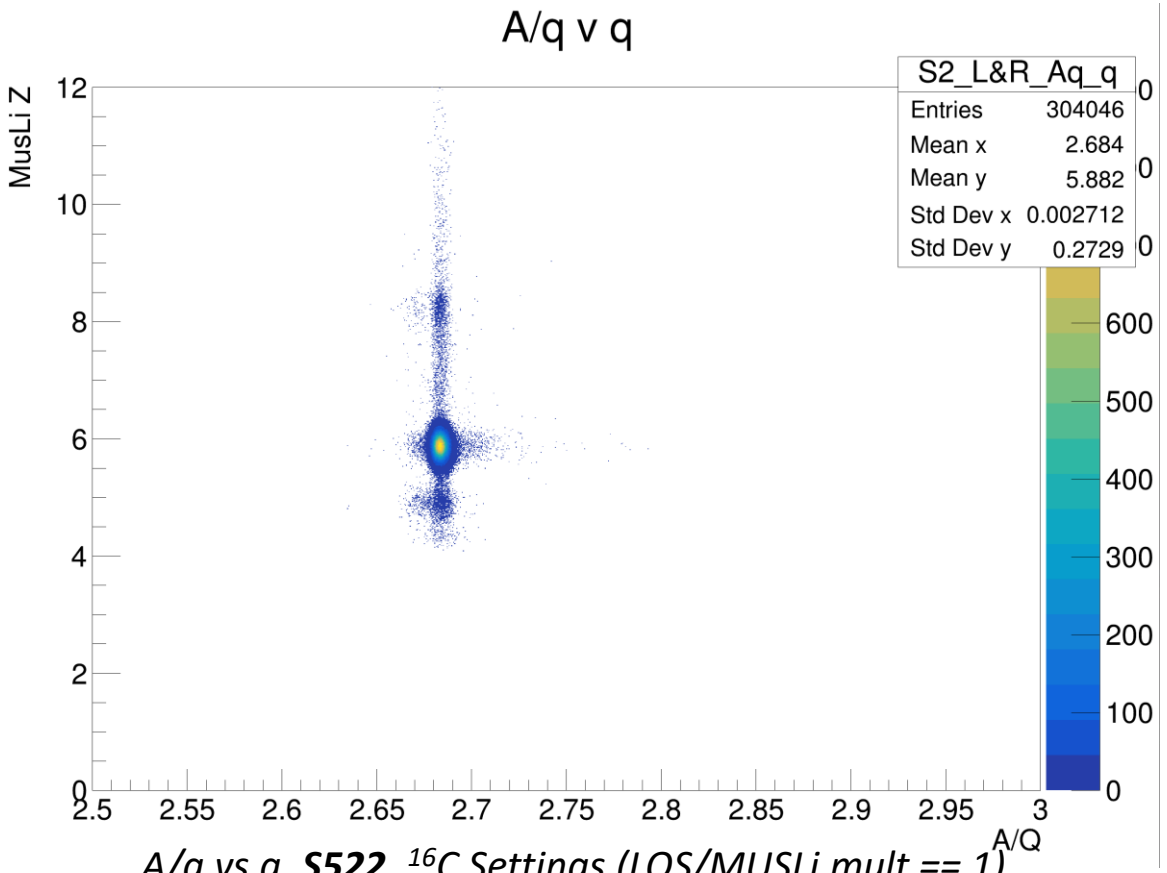
- Obtain a Tof window taking multiplicity == 1 events in LOS and the left – right PMTs of S2.



*Tof Window **S522**, ^{16}C Settings (LOS/S2 mult == 1)*

S2-LOS ToF Calibration

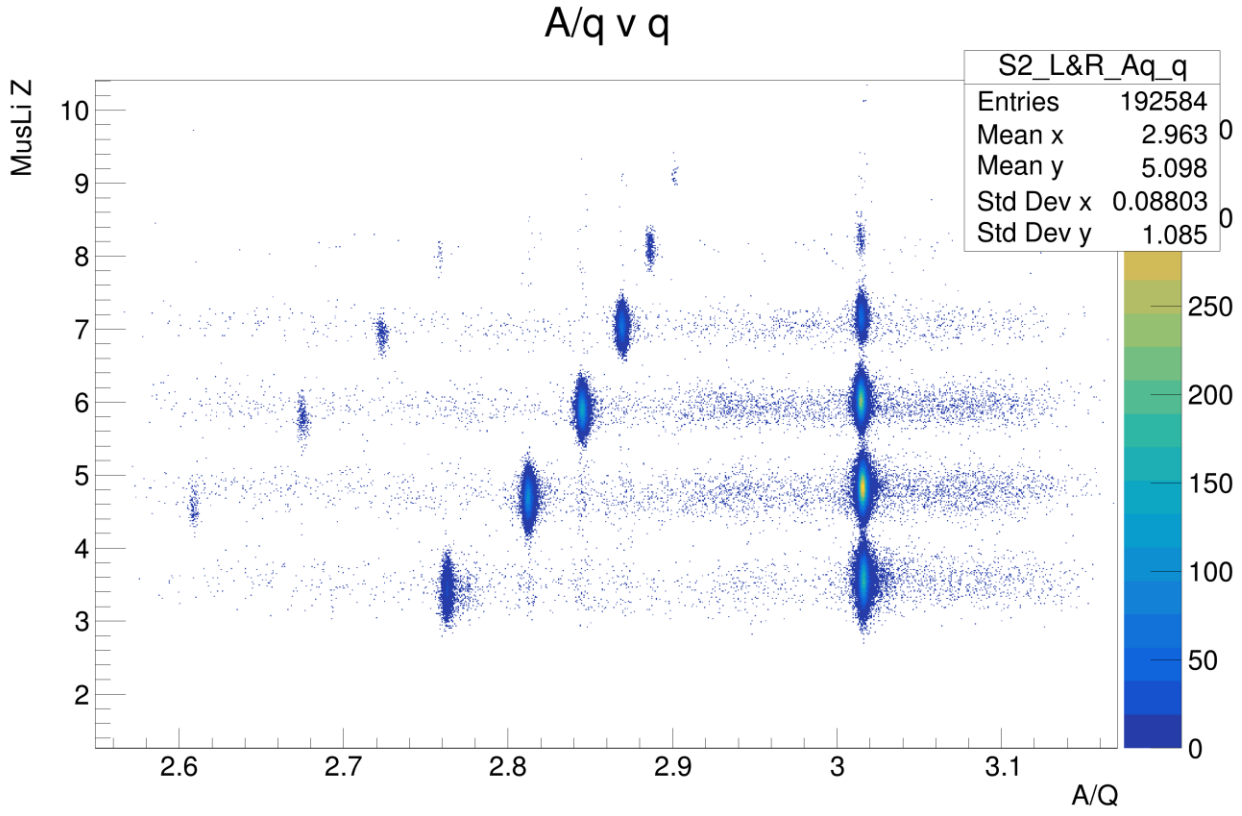
- Calculate all possible Tof per LOS hit. Only one Tof Candidate should satisfy the Tof cut
- Obtain A/q using: $A/q = B\rho_0 \cdot (1 - X_{S2}/D_{S2})/(3.10716 \cdot \beta \cdot \gamma)$



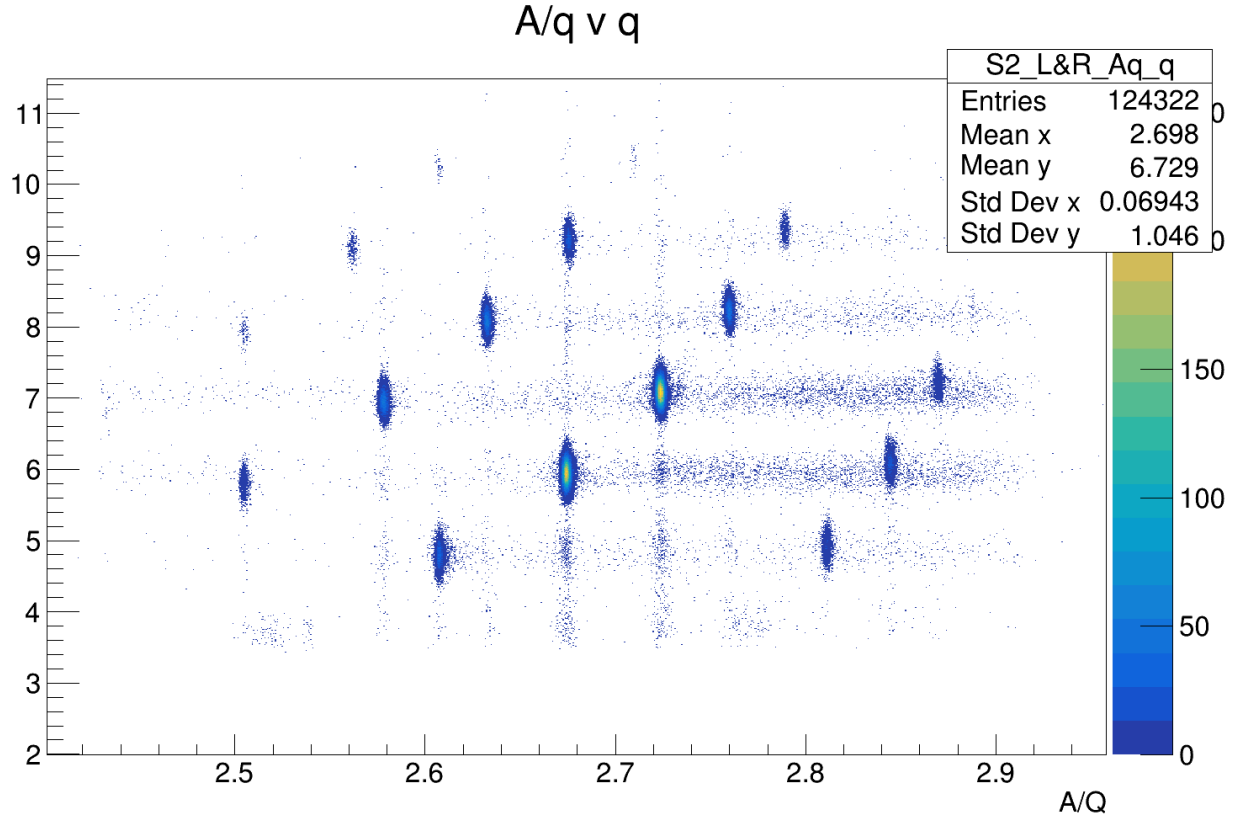
*A/q vs q, **S522**, ^{16}C Settings (LOS/MUSLi mult == 1)*

S2-LOS ToF Calibration

- Calculate all possible Tof per LOS hit. Only one Tof Candidate should satisfy the Tof cut
- Obtain A/q using: $A/q = B\rho_0 \cdot (1 - X_{S2}/D_{S2})/(3.10716 \cdot \beta \cdot \gamma)$



*A/q vs q, **S509**, ^{21}N Settings (LOS/MUSLI mult == 1)*



*A/q vs q, **S509**, ^{22}O Settings (LOS/MUSLi mult == 1)*

S2-LOS ToF Calibration

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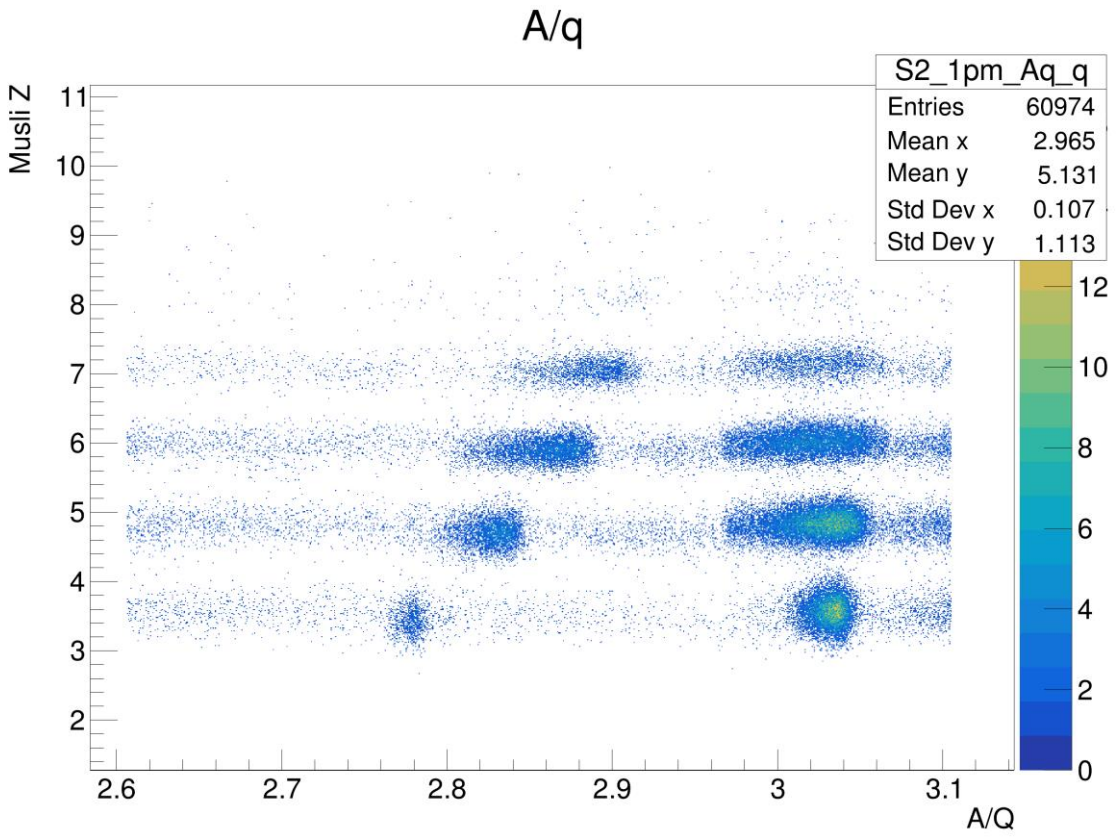
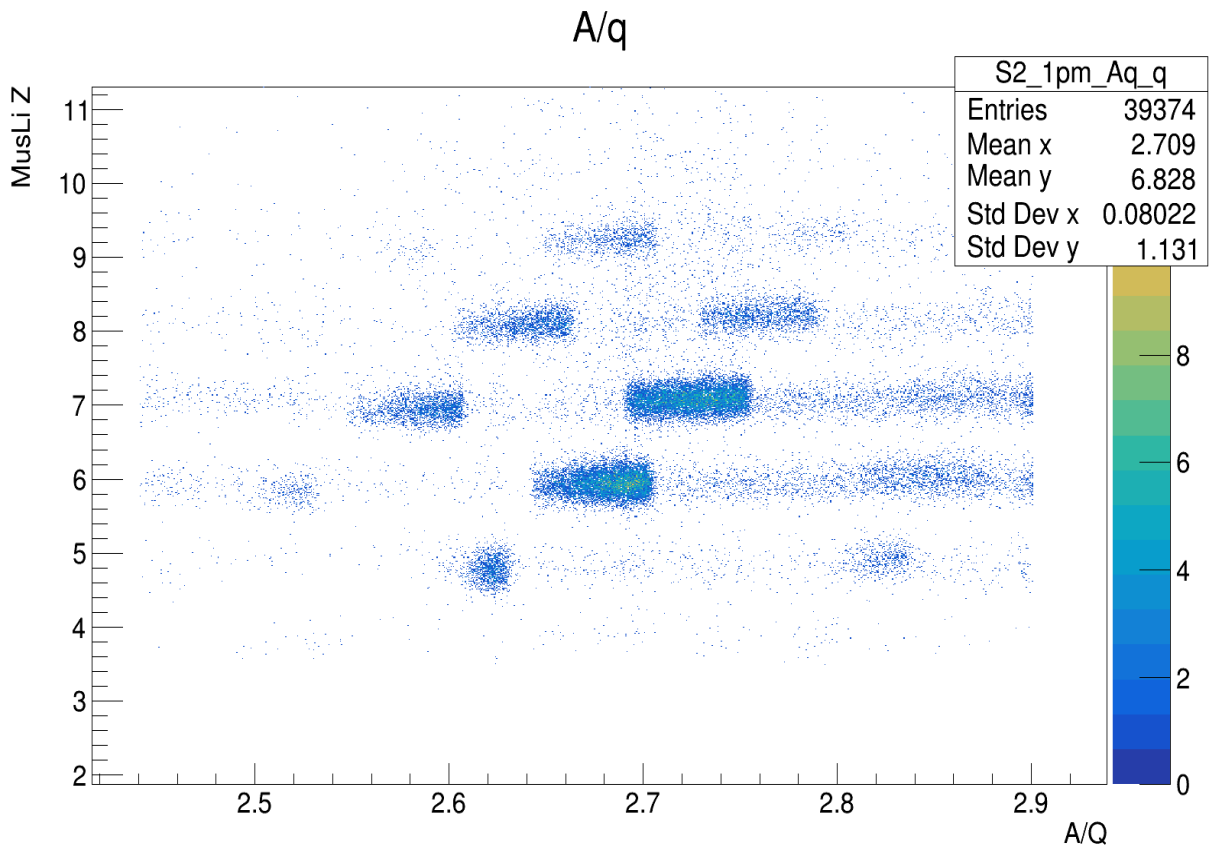
- Problem with statistics in S509 since 1 S2 PMT is missing for many on-spill events
- Cannot find good Tof for many event → Loss of statistics of ~ 25%
- Workaround to use only 1 PMT to find good Tof for those events
- No Bρ reconstruction due to lack of S2 position information (Worse Resolution)

S2-LOS ToF Calibration

Statistics recovery using only one S2 PMT for events with no good Tof.



*A/q vs q, **S509**, ^{21}N Settings (events with bad Tof)*



*A/q vs q, **S509**, ^{22}O Settings (events with bad Tof)*

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LOS Hit Redefinition

LOS Data structure

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Data structure @ Mapped level

Type	Channel
VFTX	1
VFTX	1
VFTX	2
VFTX	2
VFTX	3
VFTX	3
…	…
VFTX	8
TAMEX LE	1
TAMEX LE	1
TAMEX LE	2
TAMEX LE	2
TAMEX LE	3
TAMEX LE	3
…	…
TAMEX LE	8
TAMEX TE	1
TAMEX TE	1
TAMEX TE	2
TAMEX TE	2
TAMEX TE	3
TAMEX TE	3
…	…
TAMEX TE	8

Current LOSMapped2Cal Task:

1. Produce Tcal data converting from TDC to ns units.

2. Define hits by matching VFTX Signals using window of 200ns

3. See if 8 VFTX Are set, then match TAMEX Leading to the VFTX hits by **ORDER**. TAMEX signals from 8 channel must be within 200ns window

4. See if 8 VFTX Are set, then match TAMEX Trailing to the VFTX hits by **ORDER**. TAMEX signals from 8 channel must be within 400ns window

Works pretty well for single multiplicity events and (sometimes) for events with equal hits in VFTX and TAMEX !!!

LOS Hit redefinition

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Not the best solution for high intensity experiments like s522

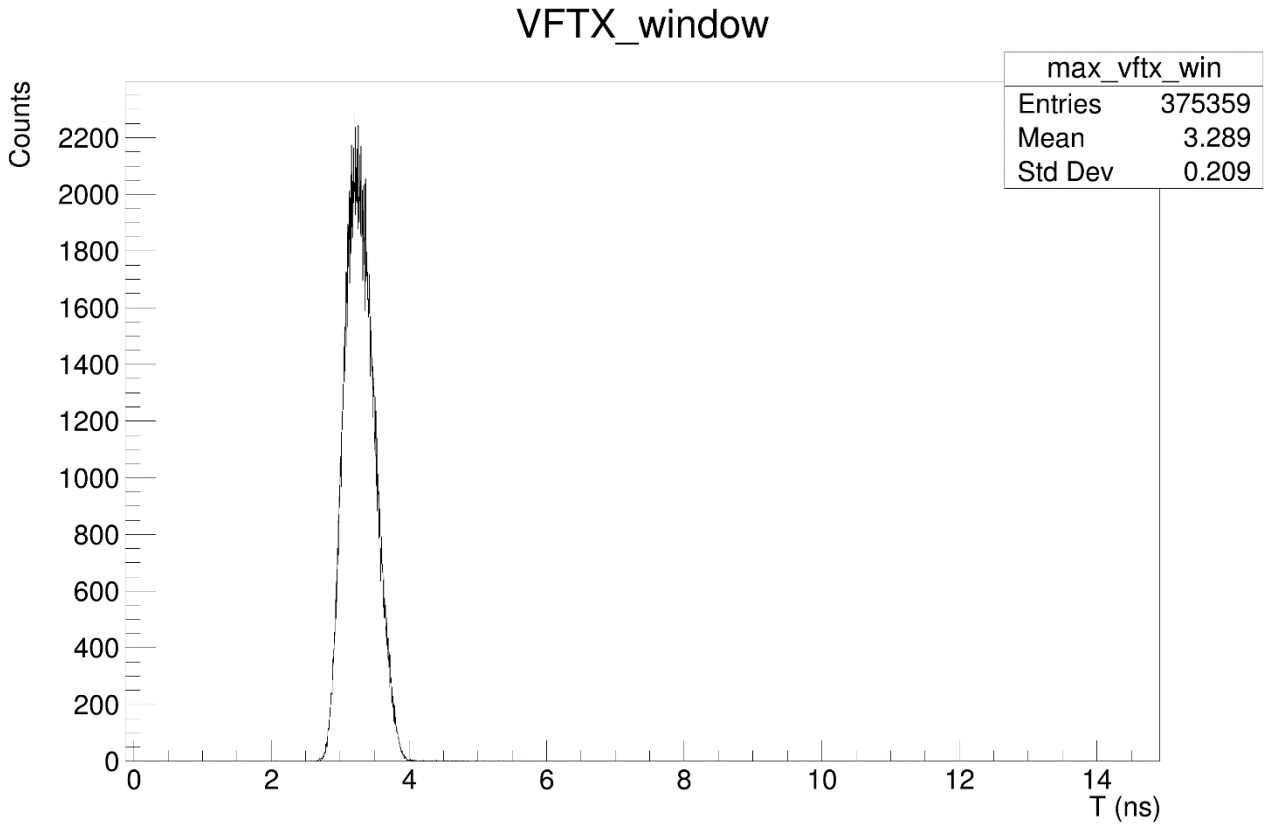
- Lots of events with unequal multiplicities of VFTX and TAMEX signals
- Leads to wrong matching of VFTX and TAMEX signals
- The start time in Cave C given by LosProvideTStart looks for the VFTX time of the first hit in time by ORDER.
- However because of bad data structure some LOS hits missing this VFTX info. Overall loss of statistics ~15%

Developed new methodology of defining hits!

LOS Hit redefinition

- Obtain VFTX signal's maximum coincidence window taking Mult == 1 events

- Match the 8 VFTX signals for all PMTs per hit using his window

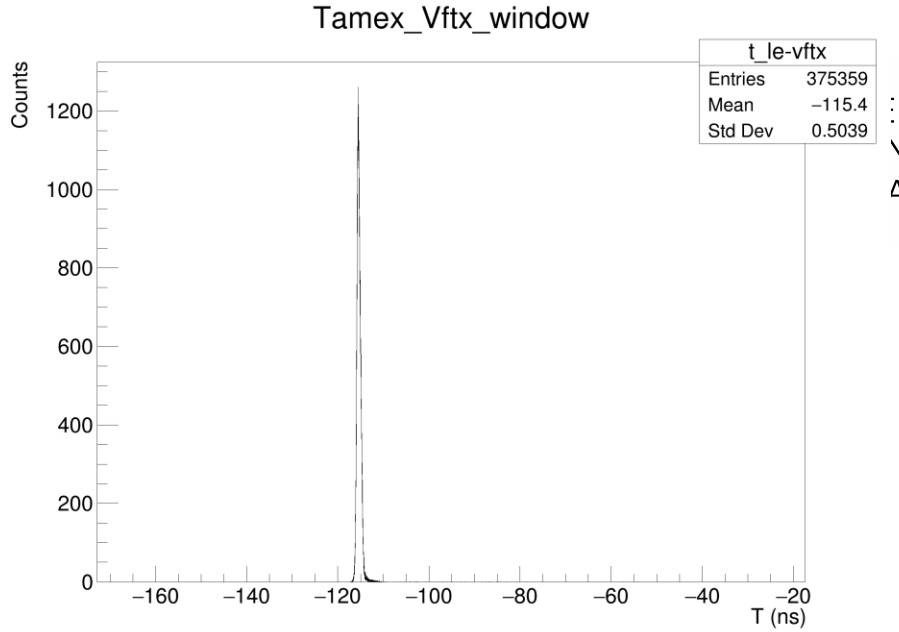


Maximum VFTX time diff between 8 PMTs for mult ==1 events ***S522****, ^{16}C Settings*

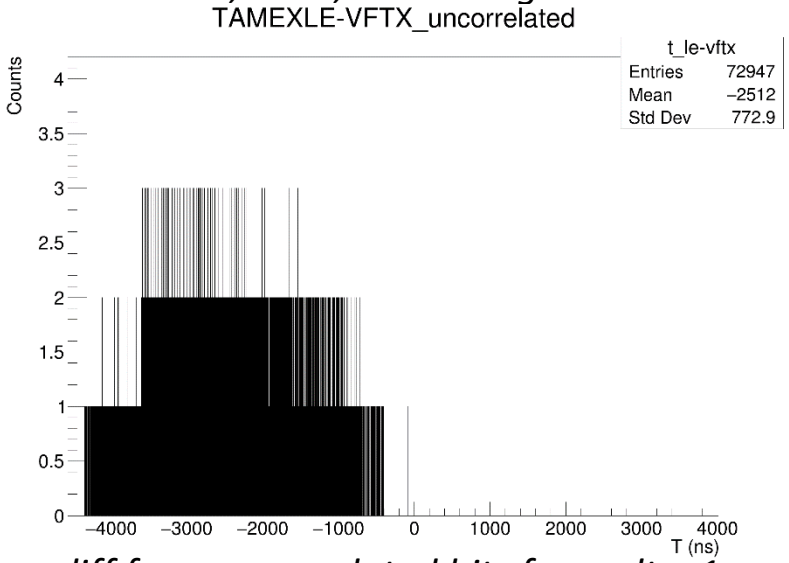
LOS Hit redefinition

- Obtain TAMEX Leading – VFTX time window taking Multiplicity 1 events for all PMT combinations

- Match the 8 TAMEX Leading edge signals for all PMTs using his window



*Average time diff (for 8 PMTs) between TAMEX LE - VFTX for mult ==1 events, **S522**, ^{16}C Settings*

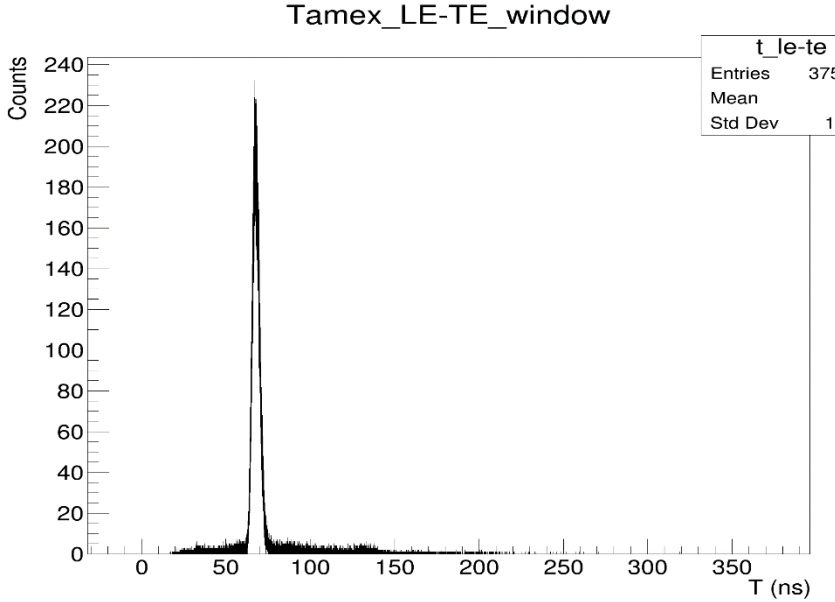


Time diff for non-correlated hits for mult > 1

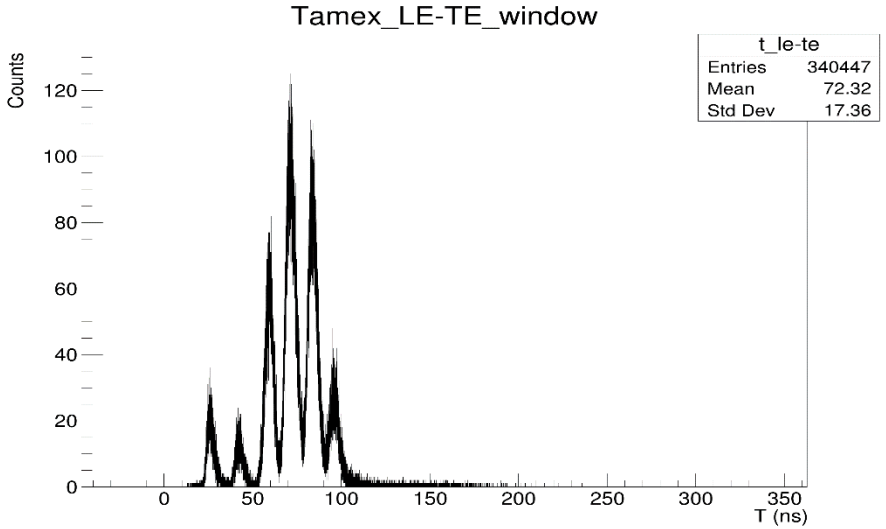
LOS Hit redefinition

- Obtain TAMEX Trailing – TAMEX leading coincidence window taking Multiplicity 1 events for all PMT combinations

- Match the 8 TAMEX Trailing edge signals for all PMTs using his window



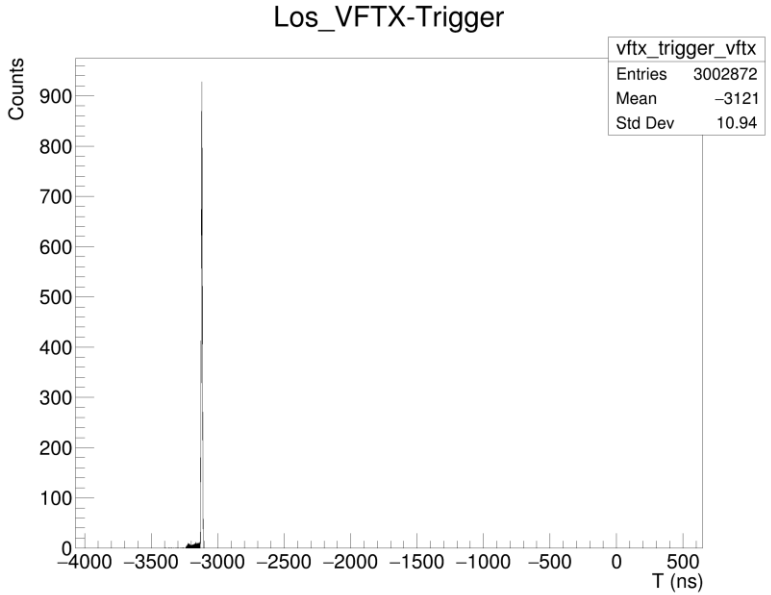
Average time diff (for 8 PMTs) between TAMEX TE – TAMEX LE for mult ==1 events, ***S522****,* ^{16}*C Settings*



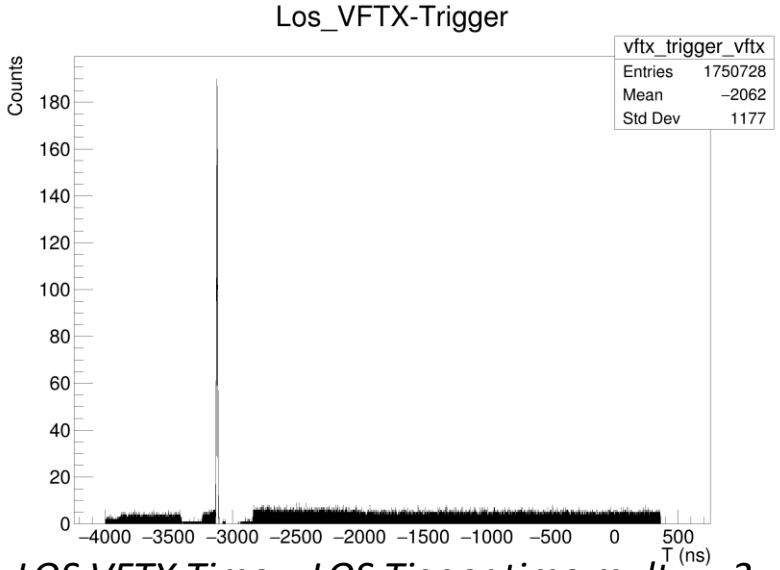
Average time diff (for 8 PMTs) between TAMEX TE – TAMEX LE for mult ==1 events, ***S509****,* ^{21}*N Settings*

LOS Hit redefinition

- To select one good hit per event : update **LosProvideTStart**
- Select hit that triggered event
- Obtained by peak from Los_time – Los_trigger_time



LOS VFTX Time – LOS Tigger time mult == 1, ***S522****, ^{16}C Settings*



LOS VFTX Time – LOS Tigger time mult == 3, ***S522****, ^{16}C Settings*

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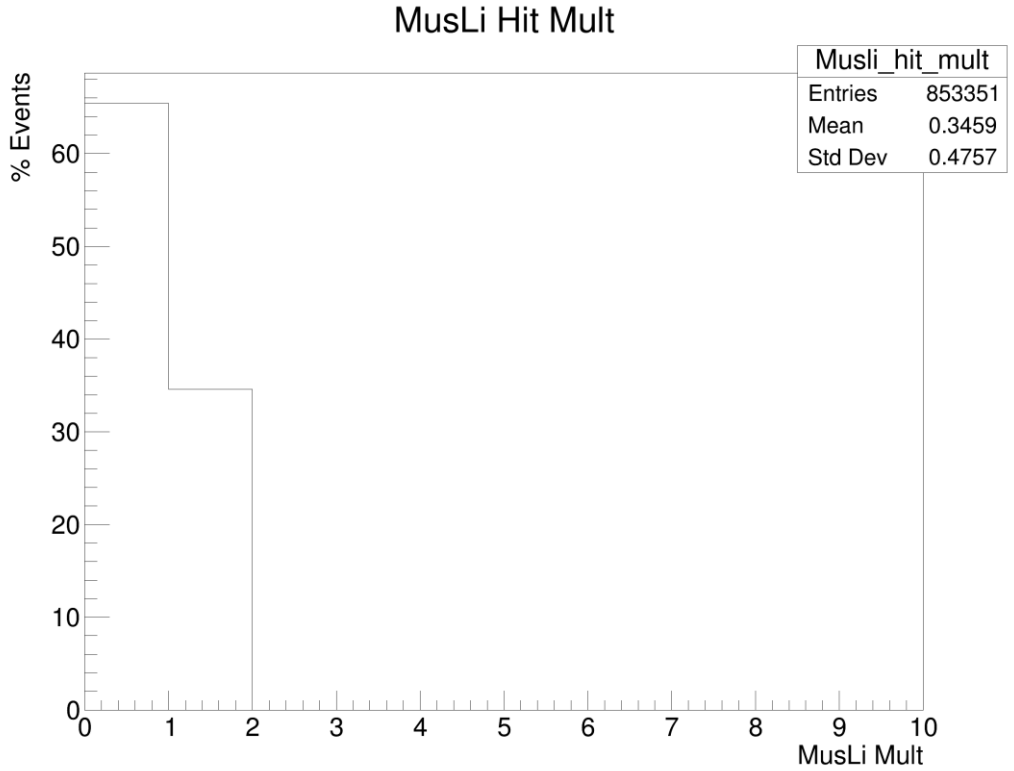
MUSLI Multi-Hit Selection

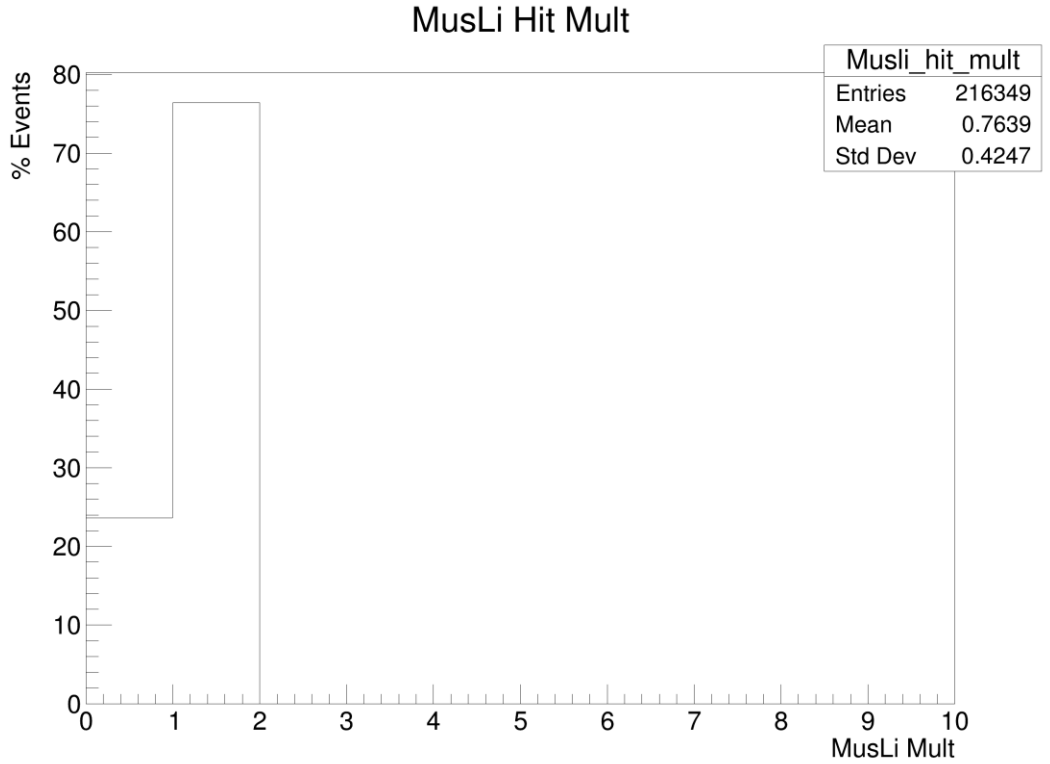
MUSLi Multi-hit selection

The Problem:

- Removal of multi-hit events at Cal and Hit level of the MUSLi tasks
- Huge Loss of statistics for S522!



*MUSLi Anodes Hit Mult, **S522**, ^{16}C Settings*

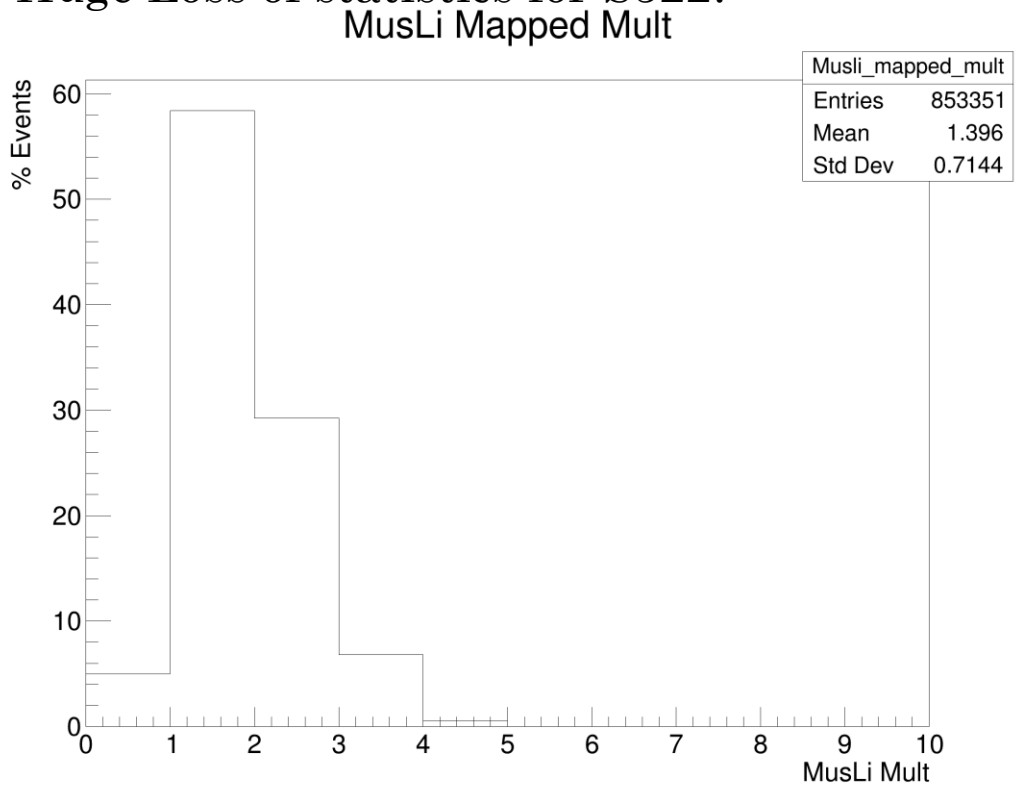


*MUSLi Anodes Hit Mult, **S509**, ^{22}O Settings*

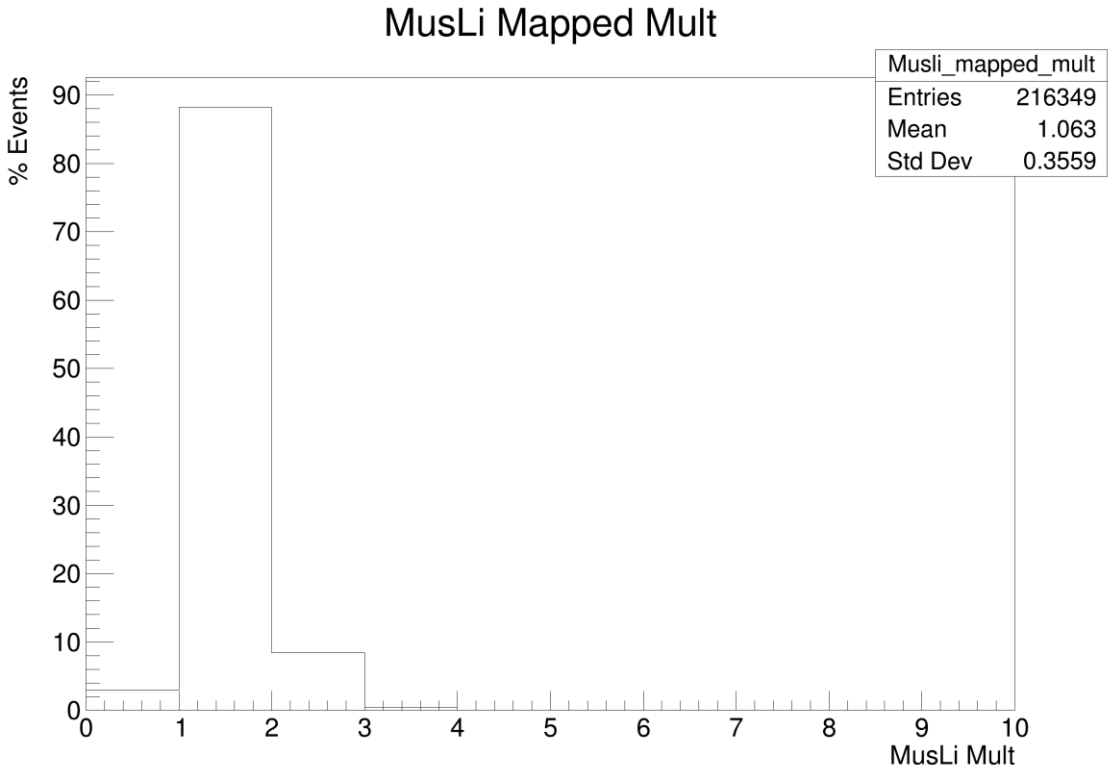
MUSLi Multi-hit selection

The Problem:

- Removal of multi-hit events at Cal and Hit level of the MUSLi tasks
- Huge Loss of statistics for S522!



*MUSLi Anodes Mapped Mult, **S522**, ^{16}C Settings*



*MUSLi Anodes Mapped Mult, **S509**, ^{22}O Settings*

MUSLi Multi-hit selection

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MUSLi Data structure @ Mapped level

- 16 preamp signals from 16 Anodes of ¼ of TWIN MUSIC. Averaged Signals as input to MDPP16

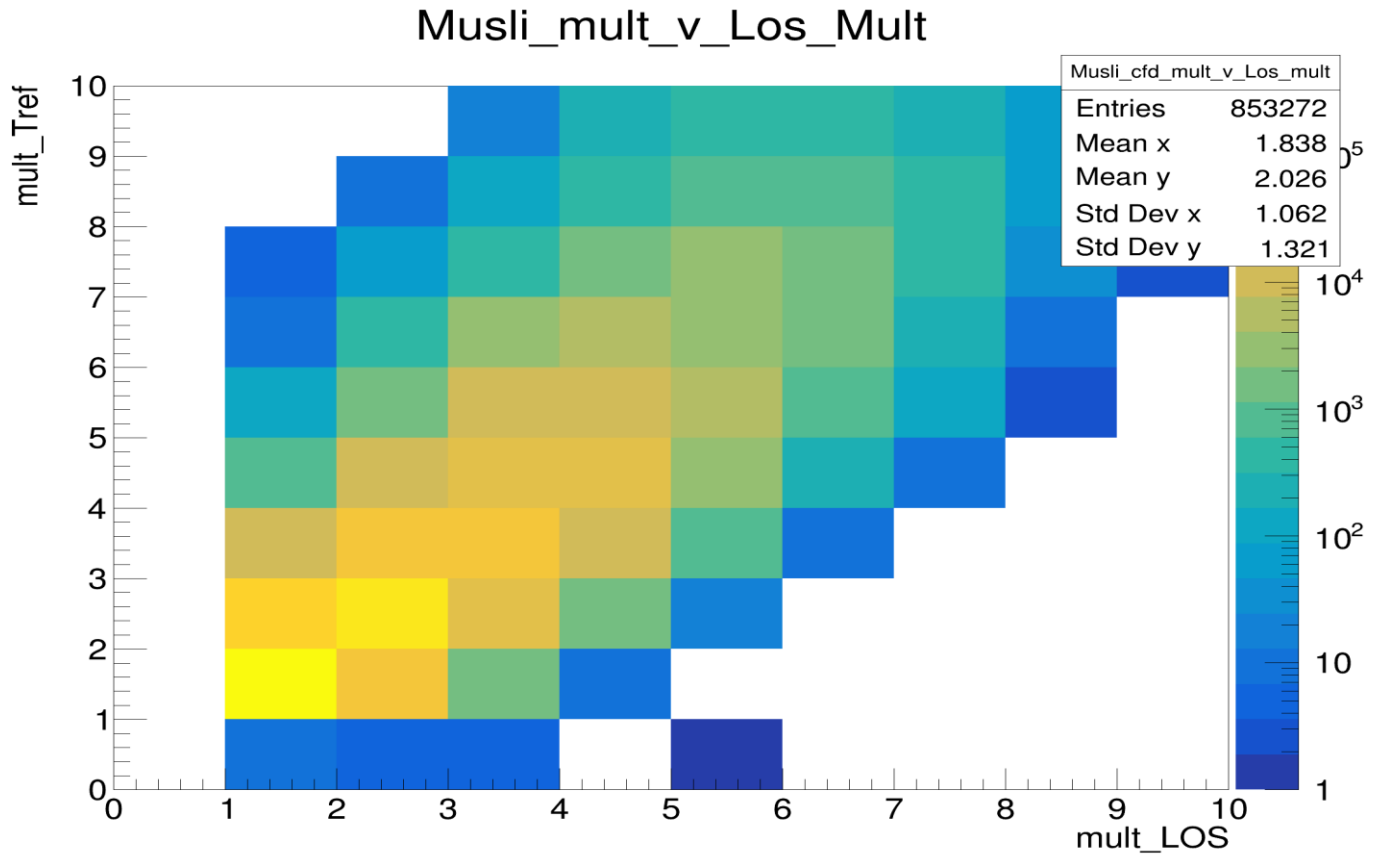
- Output format in the form of averaged anode signals:
  - Ch0 - Ch7, average of two anodes
  - Ch8 - Ch11, average of 4 anodes
  - Ch12 - Ch13, average of 8 anodes
  - Ch14, average of 16 anodes
  - Ch16, CFD (Tref) signal from LOS

Methodology described here for Ch14 but can be easily extended to others

MUSLi Multi-hit selection

Lack of correlation of LOS signal and LOS CFD signal in MUSLi,

→ Cant correlate hits by order!!

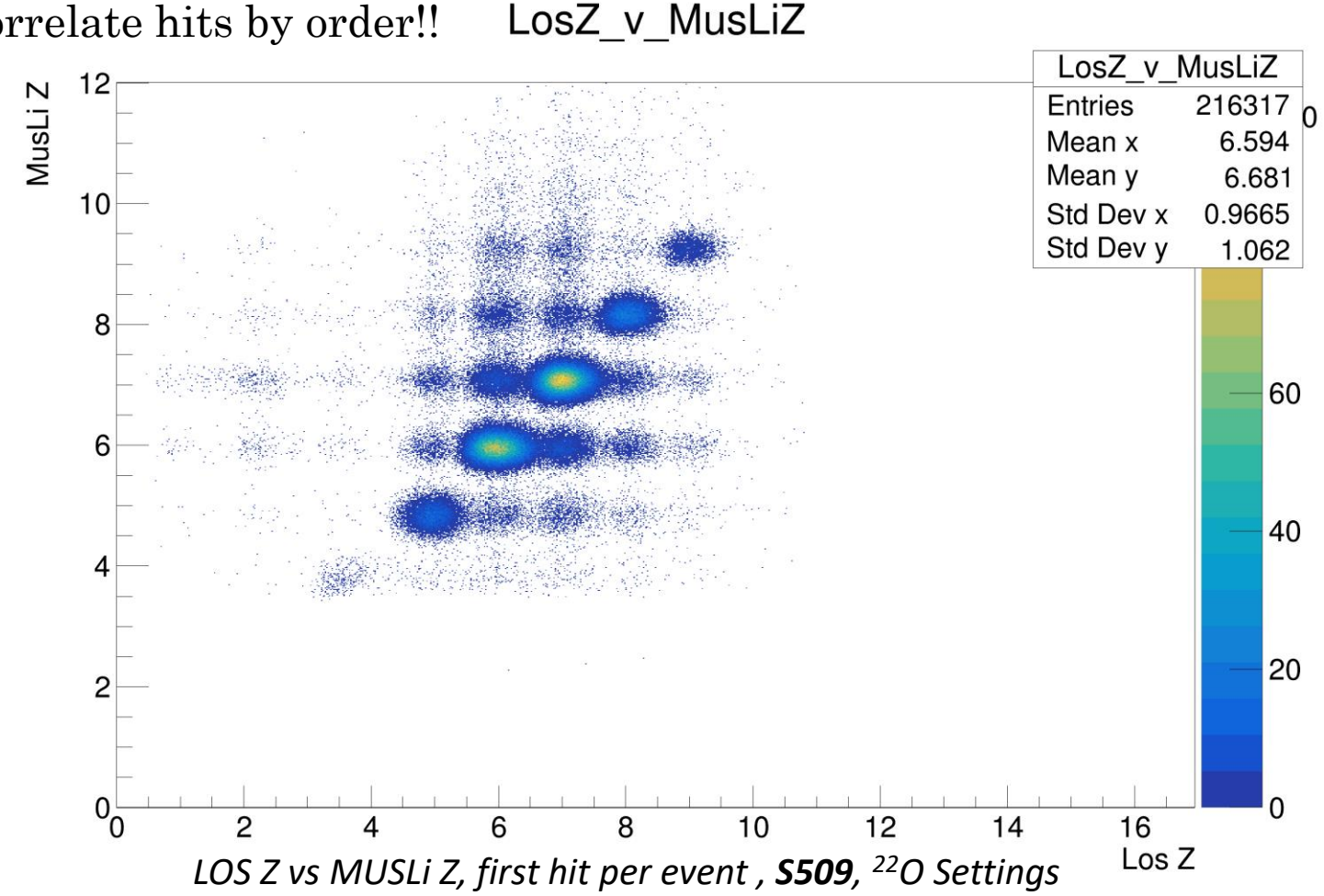


LOS Mult vs MUSLi Ch16 (LOS CFD signal), ***S522****,* ^{16}*C Settings*

MUSLi Multi-hit selection

Lack of charge correlation taking only first hit,

→ Cant correlate hits by order!!

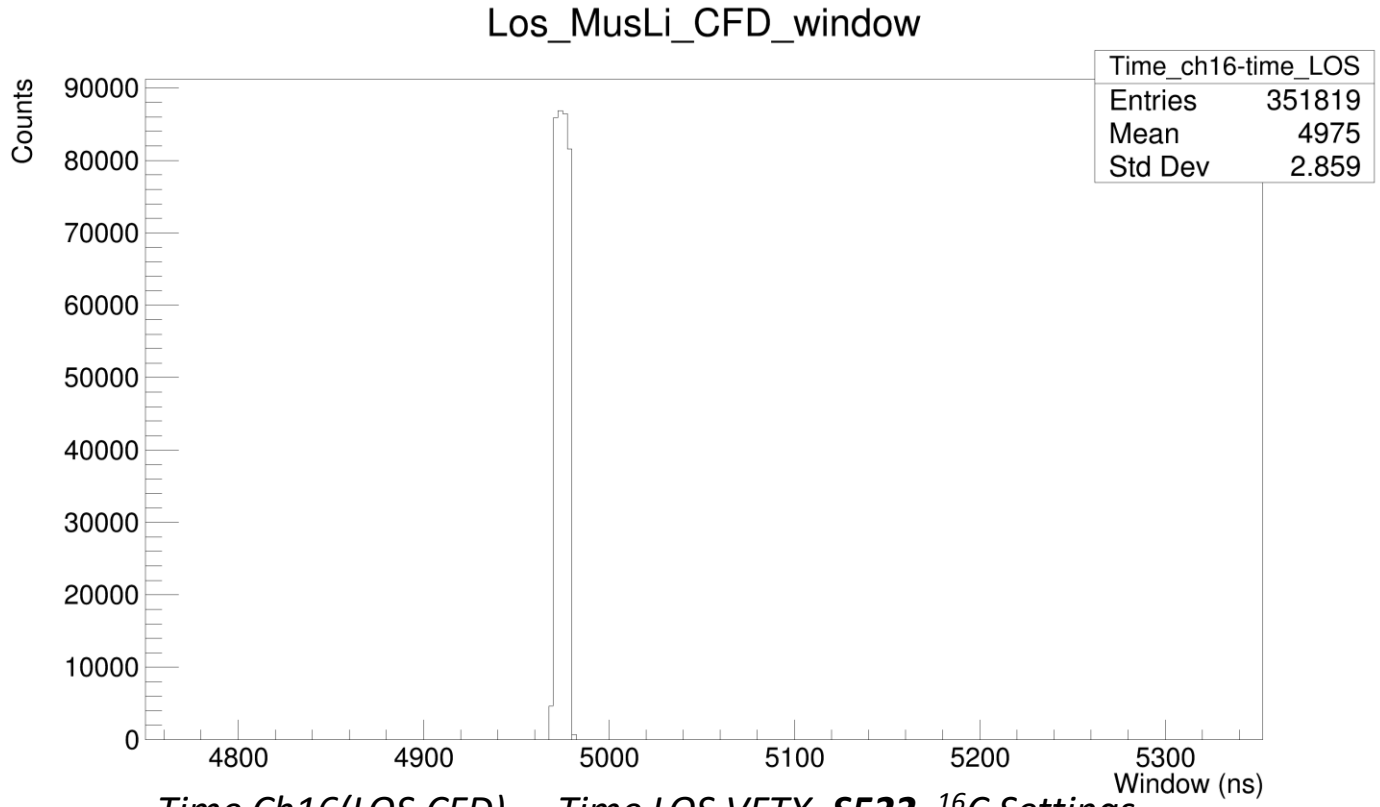


*LOS Z vs MUSLi Z, first hit per event , **S509**, ^{22}O Settings*

MUSLi Multi-hit selection

The Solution:

- Use of dedicated time windows using time information from LOS and MUSLi
- Time_CH16(LOS CFD) – LOS VFTX time



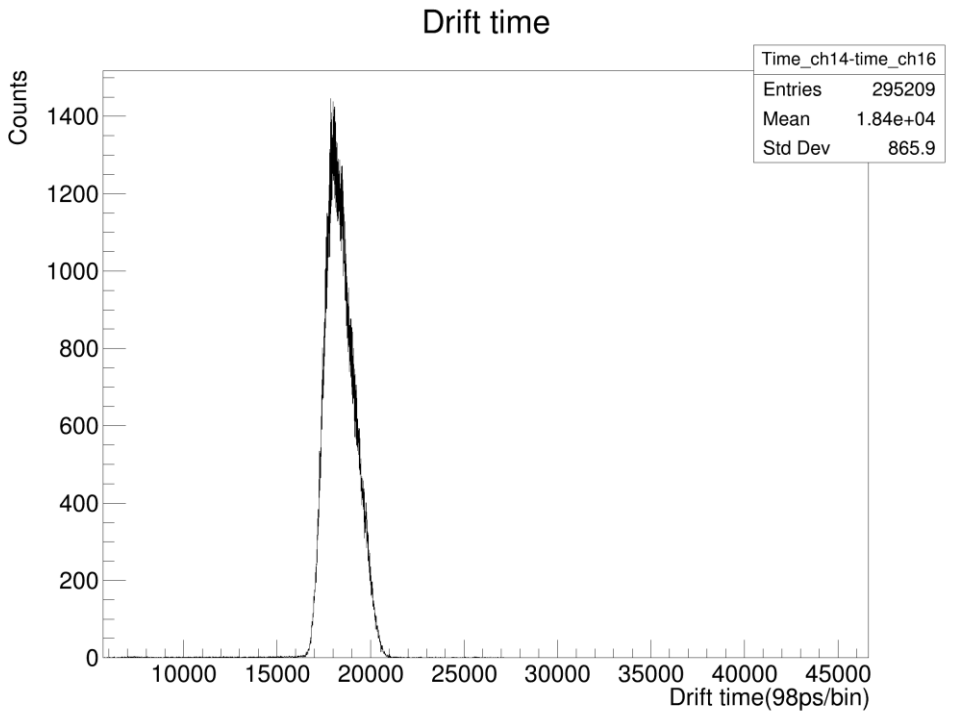
*Time Ch16(LOS CFD) – Time LOS VFTX, **S522**, ^{16}C Settings*

MUSLi Multi-hit selection

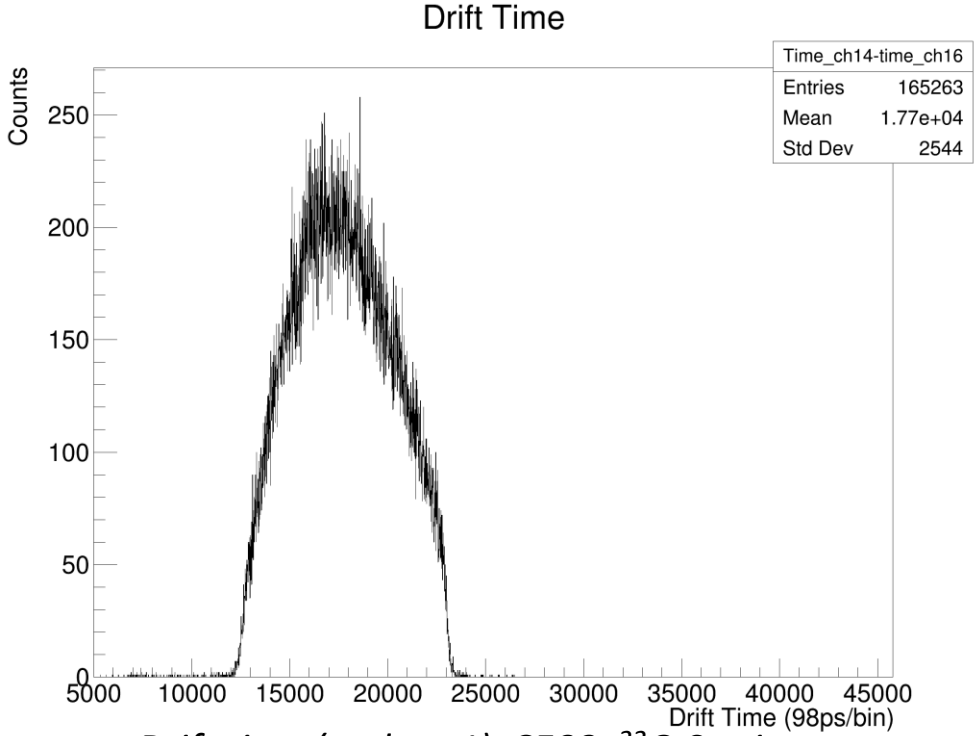
The Solution:

- Use of dedicated time windows using time information from LOS and MUSLi
- Time_CH16(LOS CFD) – LOS VFTX time
- Use the Drift time peak for Mult ==1 as a window,

$$Drift\ Time = Time\ Anode\ - Time\ Ch16$$



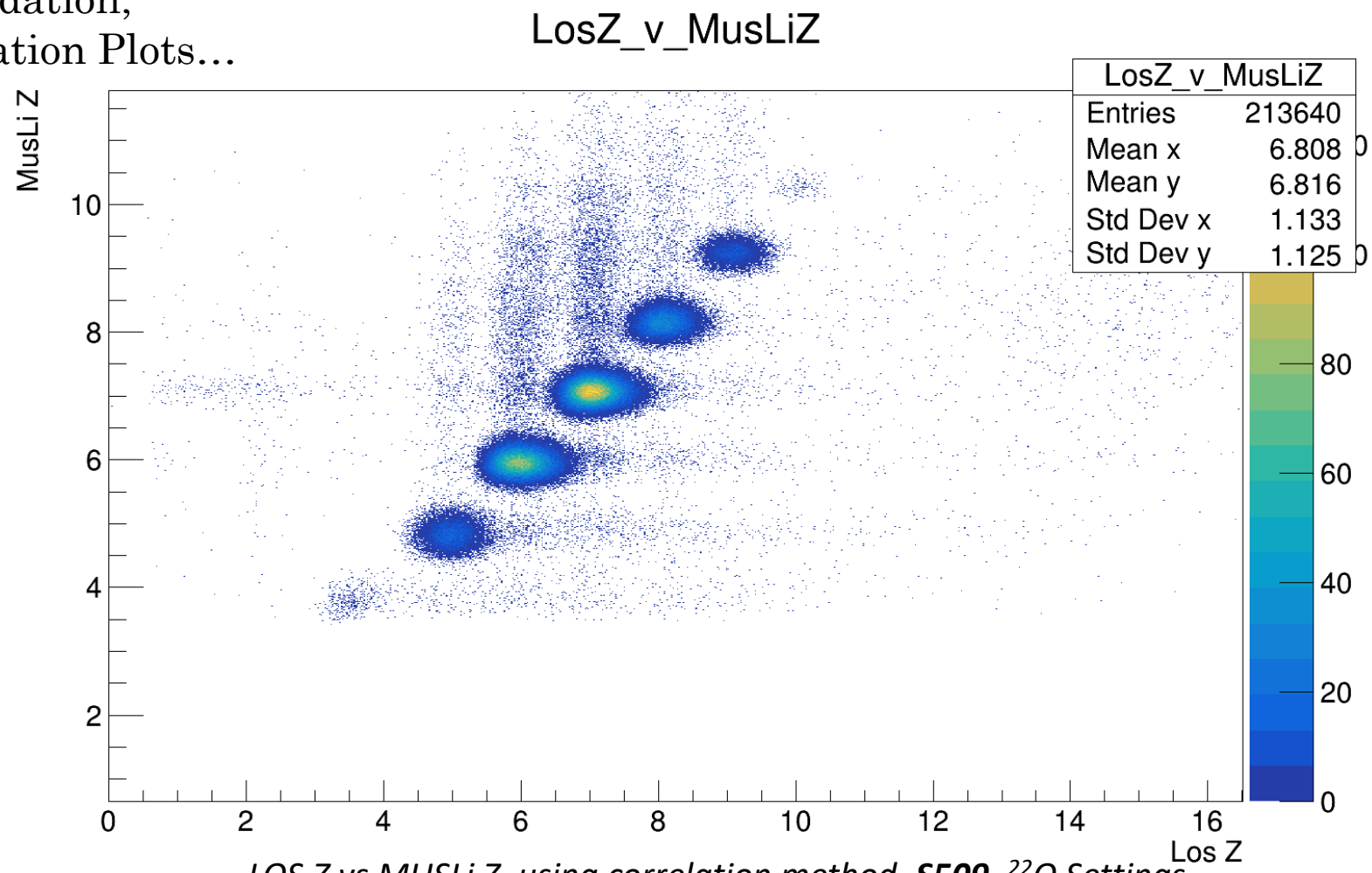
*Drift time (mult ==1), **S522**, ^{16}C Settings*



*Drift time (mult ==1), **S509**, ^{22}O Settings*

MUSLi Multi-hit selection

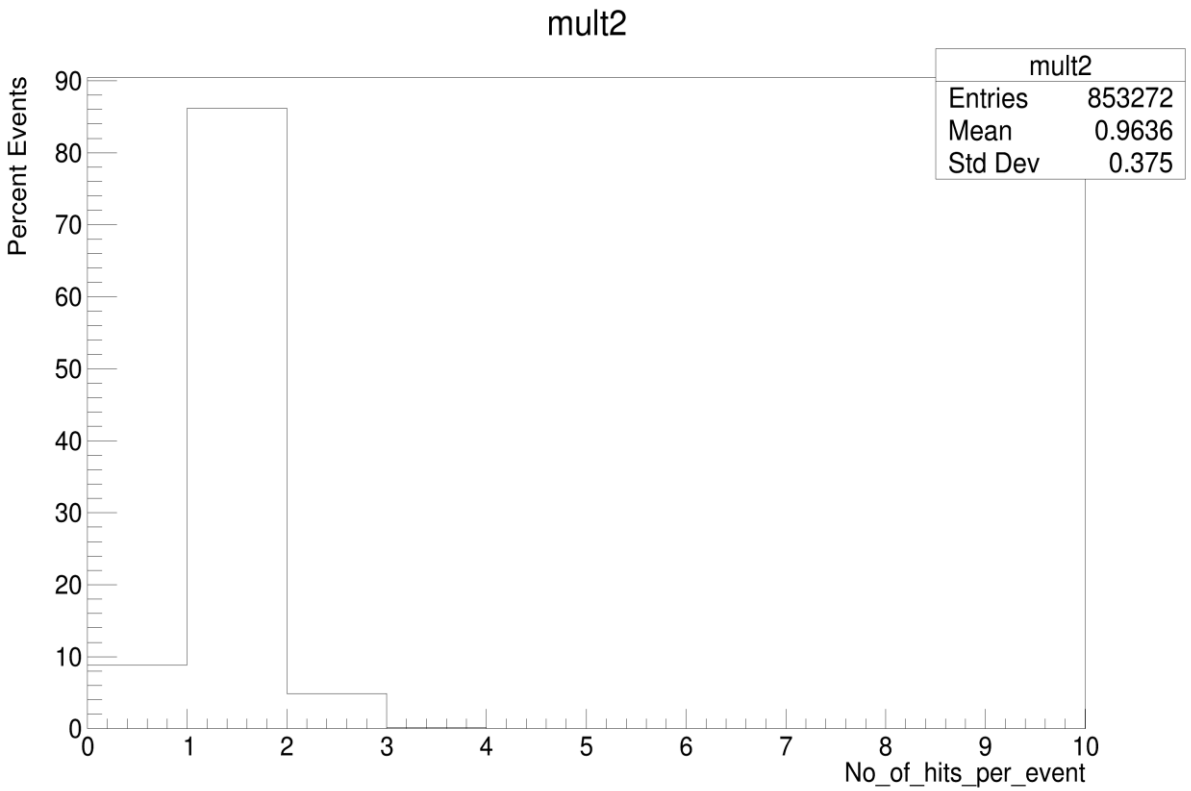
Method Validation,
Some correlation Plots…



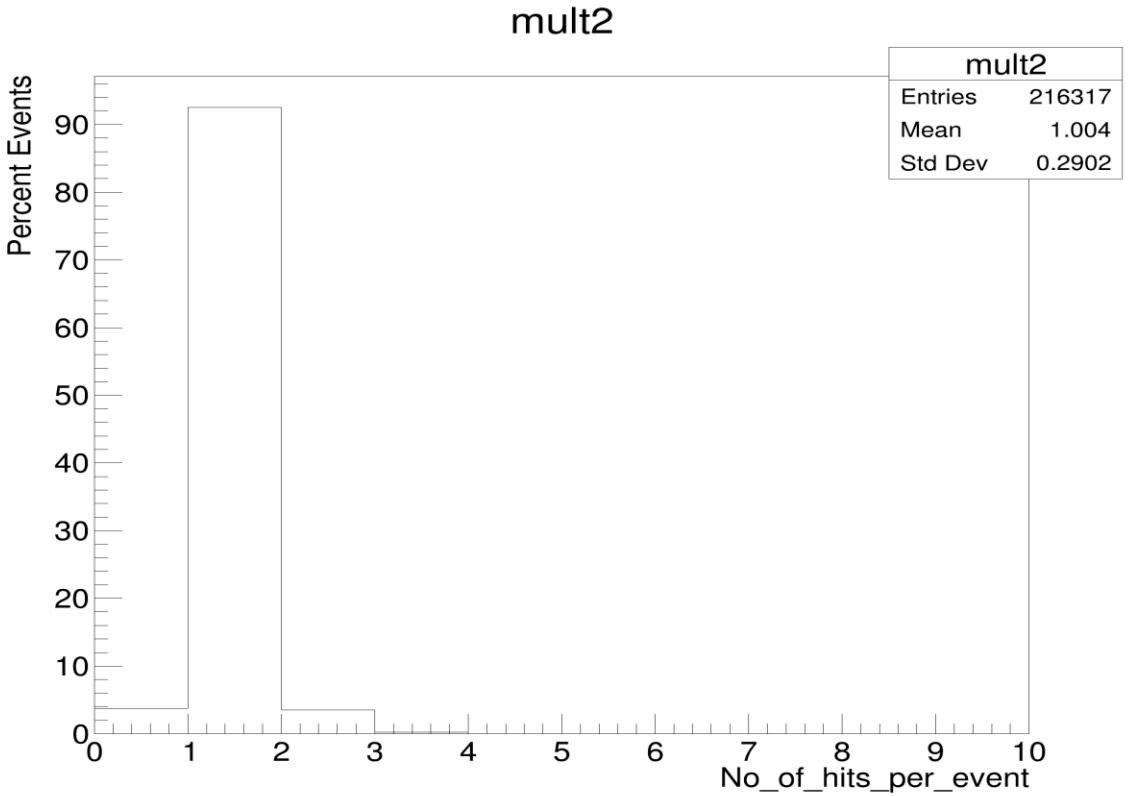
*LOS Z vs MUSLi Z, using correlation method, **S509**, ^{22}O Settings*

MUSLi Multi-hit selection

MUSLi Multiplicity after event correlations,



*MUSLi correlated multiplicity , **S522**, ^{16}C Settings*



*MUSLi correlated multiplicity , **S509**, ^{22}O Settings*

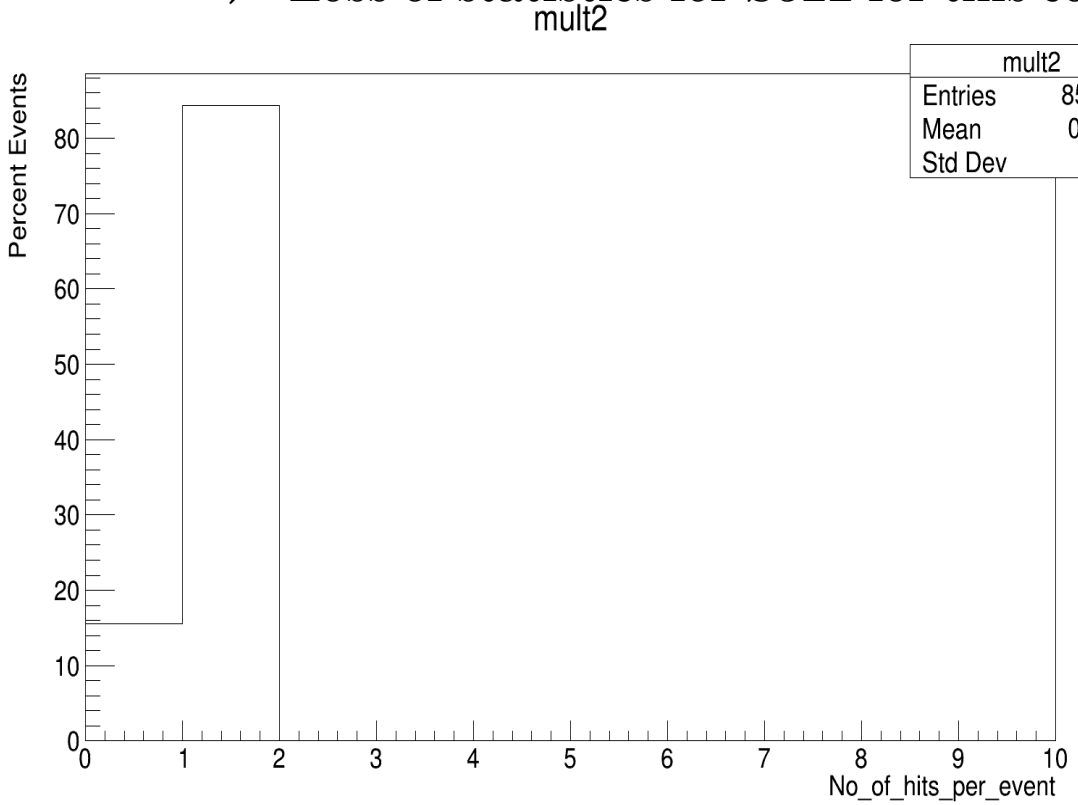
~90% of events with at least one good hit per event for S522!!

MUSLi Multi-hit selection

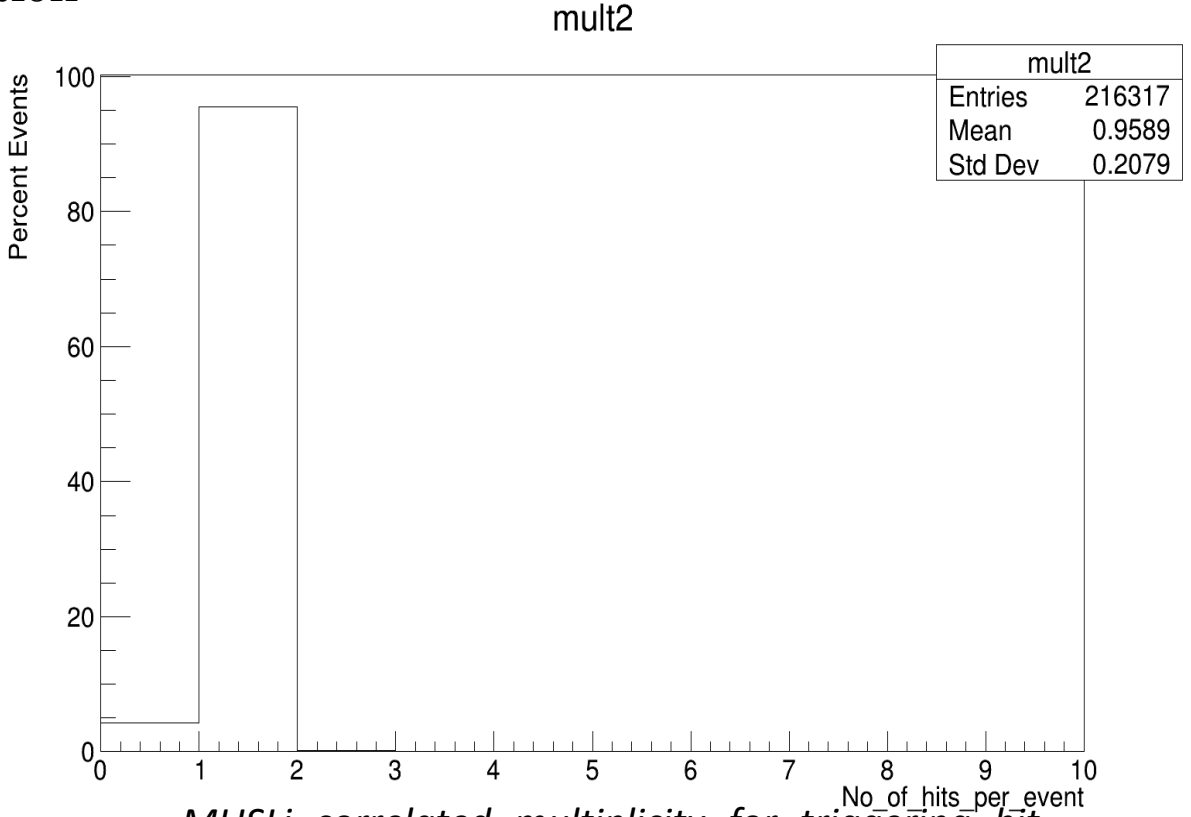
Some Problems…

MUSLi Good hits per event should include triggering hit.

→ Loss of statistics for S522 for this condition

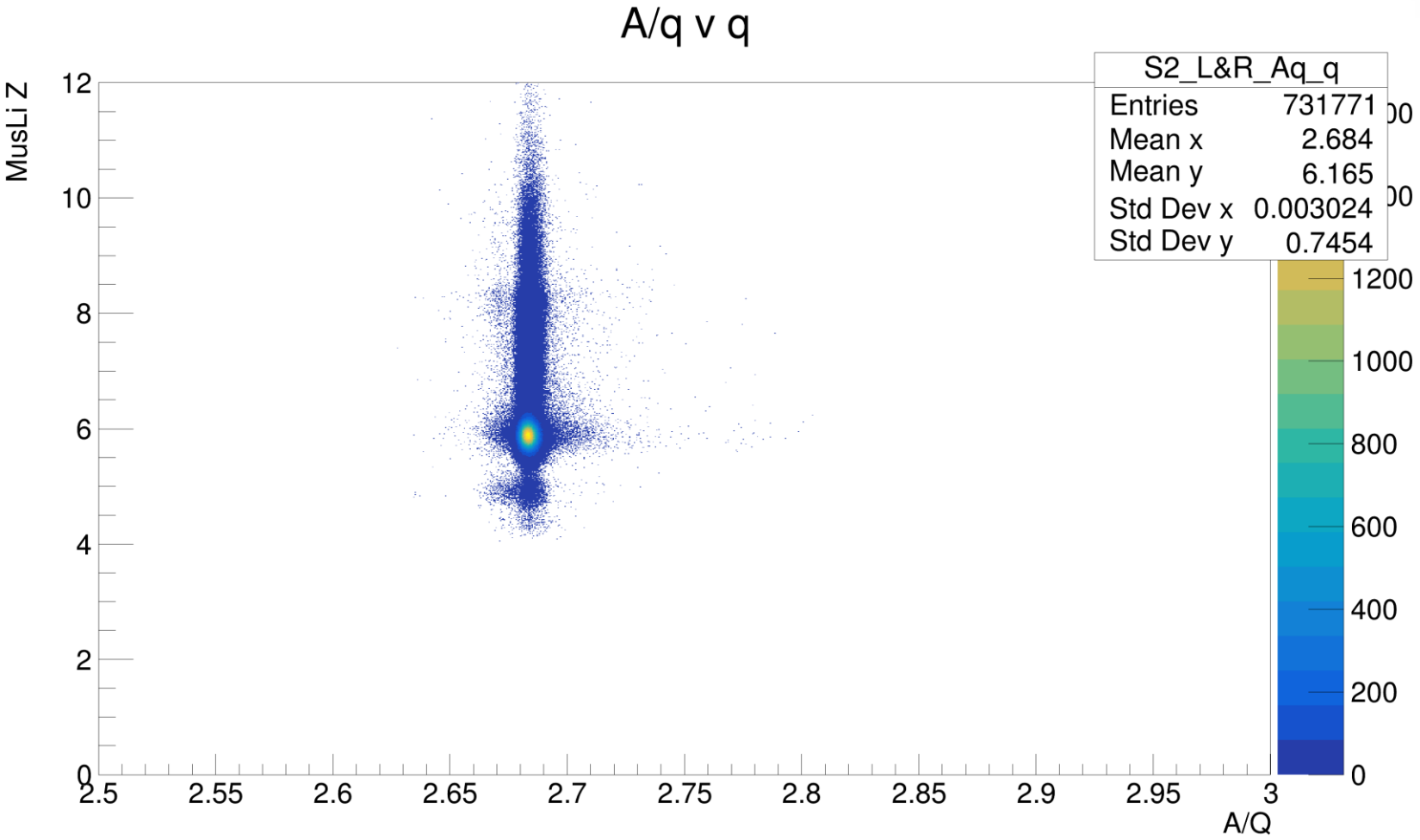


MUSLi correlated multiplicity for triggering hit ***S522****, ^{16}C Settings*



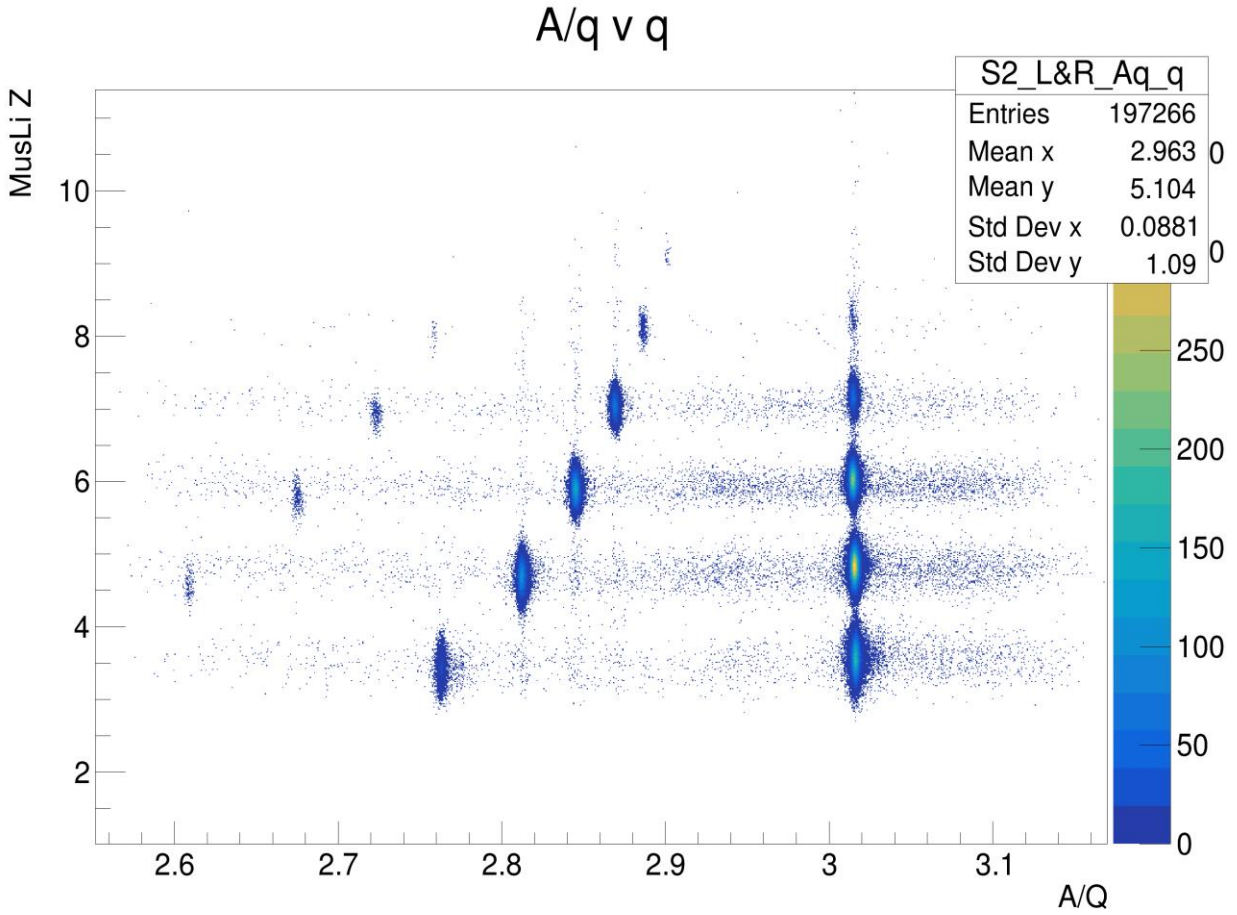
MUSLi correlated multiplicity for triggering hit ***S509****, ^{22}O Settings*

Incoming PID S522

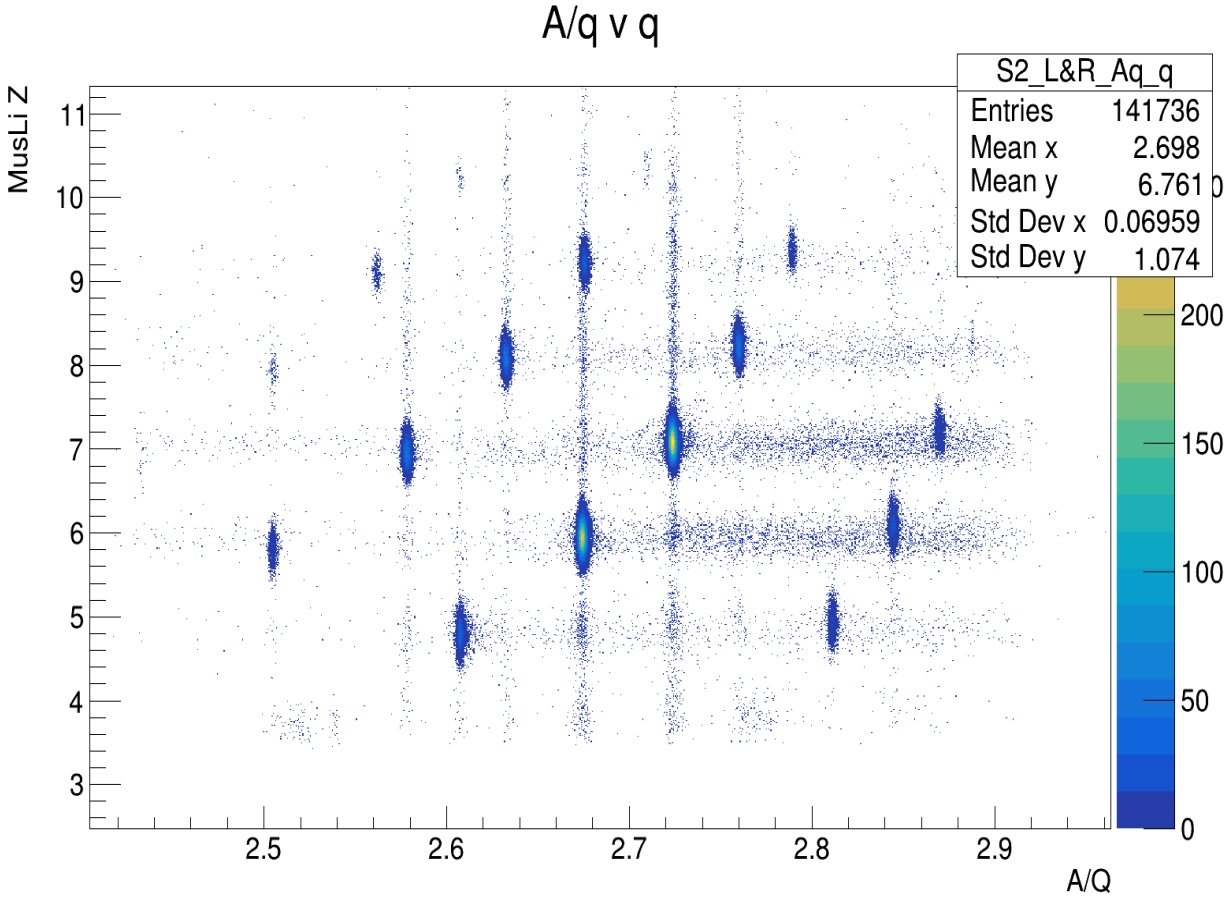


A/q vs q, ***S522****, ^{16}C Settings (All multiplicities)*

Incoming PID S509



*A/q vs q, **S509**, ^{21}N Settings (All multiplicities)*



*A/q vs q, **S509**, ^{22}O Settings (All multiplicities)*

OUTLOOK

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- Sci2-LOS Tof calibration in good condition.
- Defined new calibration methodology for hit definition in LOS with proper matching of signals
- MUSLi Multi-hit Selection done. Will try to improve statistics.
- Not Covered
  - MUSLi charge calibration almost done
  - MUSLi position calibration underway
- TO DO
  - Identify cause for weird charge distribution in MUSLi for S522
  - Check of MWPC calibration
  - R3BRoot implementation

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Thank you

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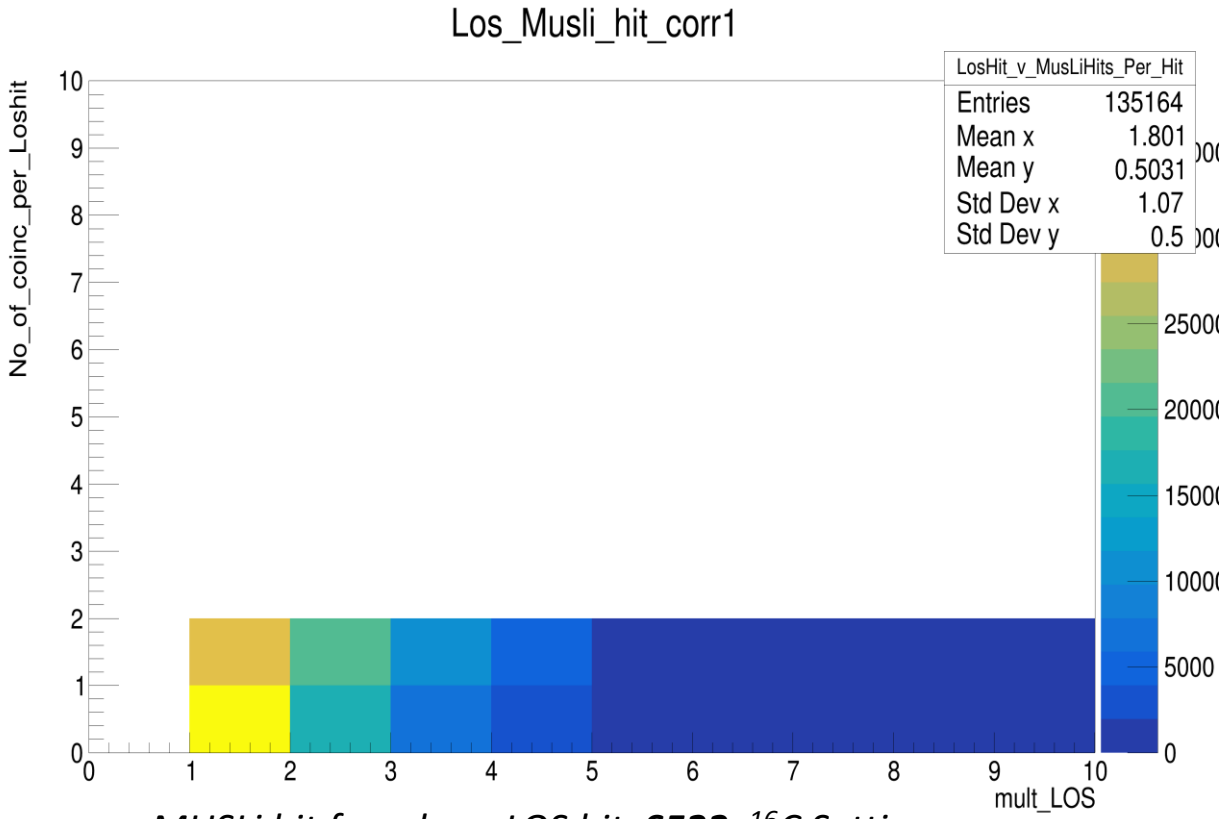
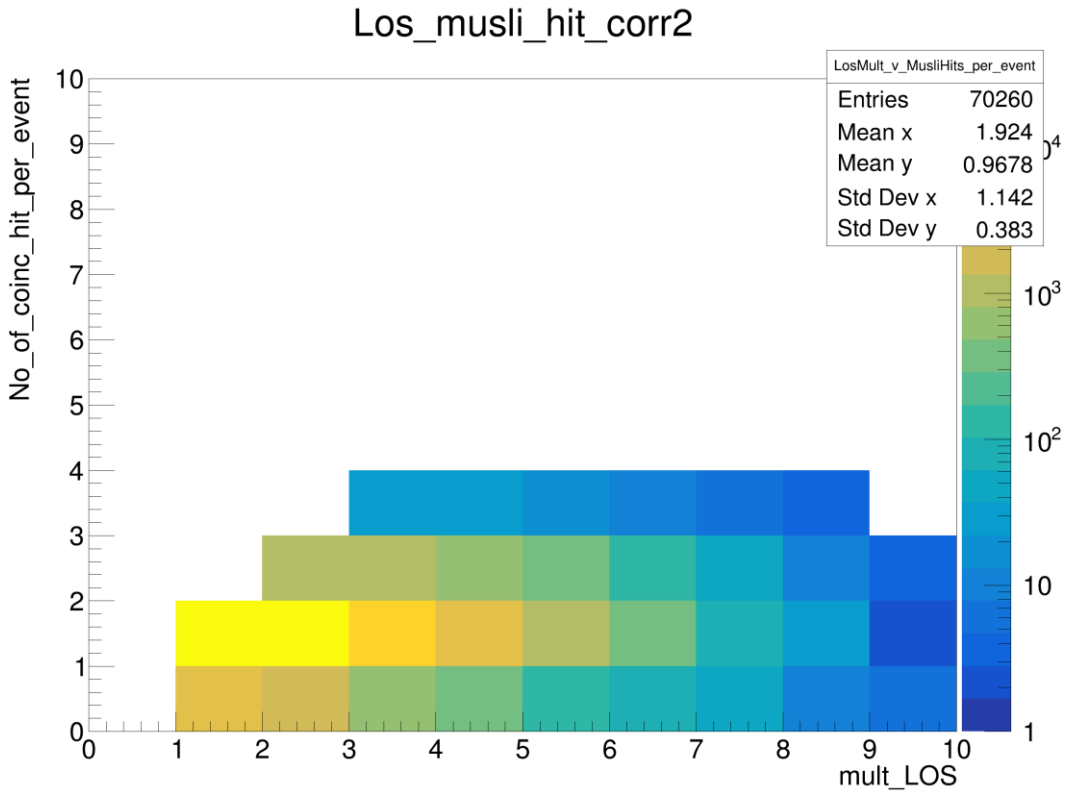
Extra Slides

MUSLi Multi-hit selection

Method Validation,
Some correlation Plots…



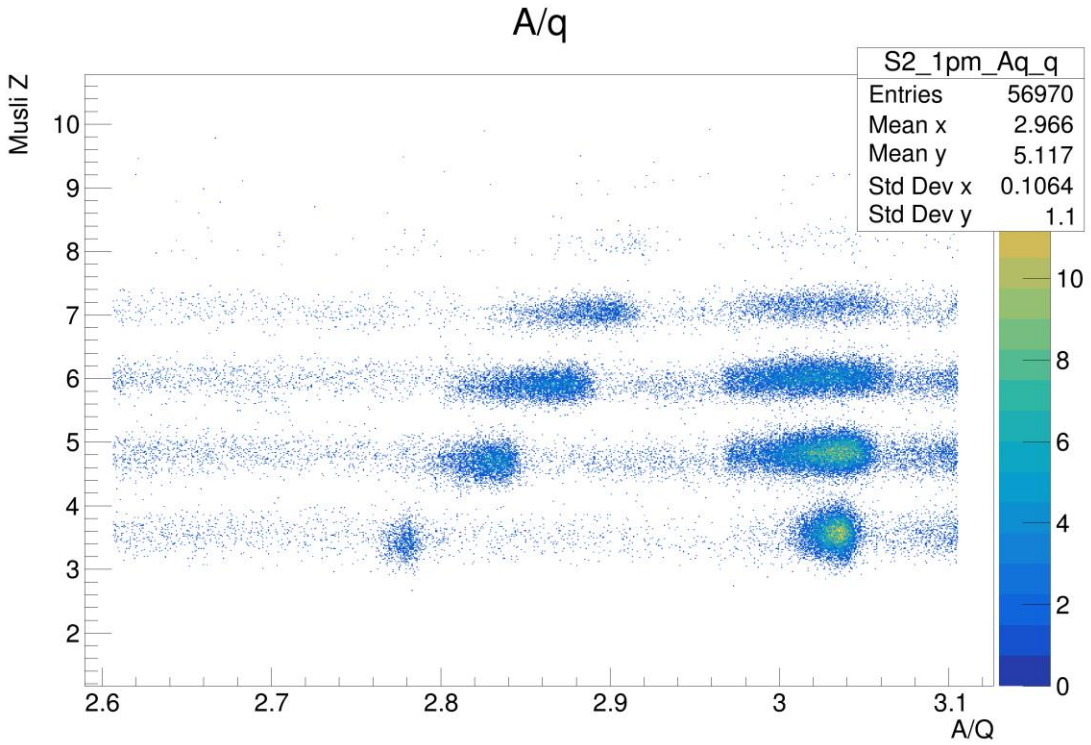
*MUSLi hit found per LOS hit, **S522**, ^{16}C Settings*



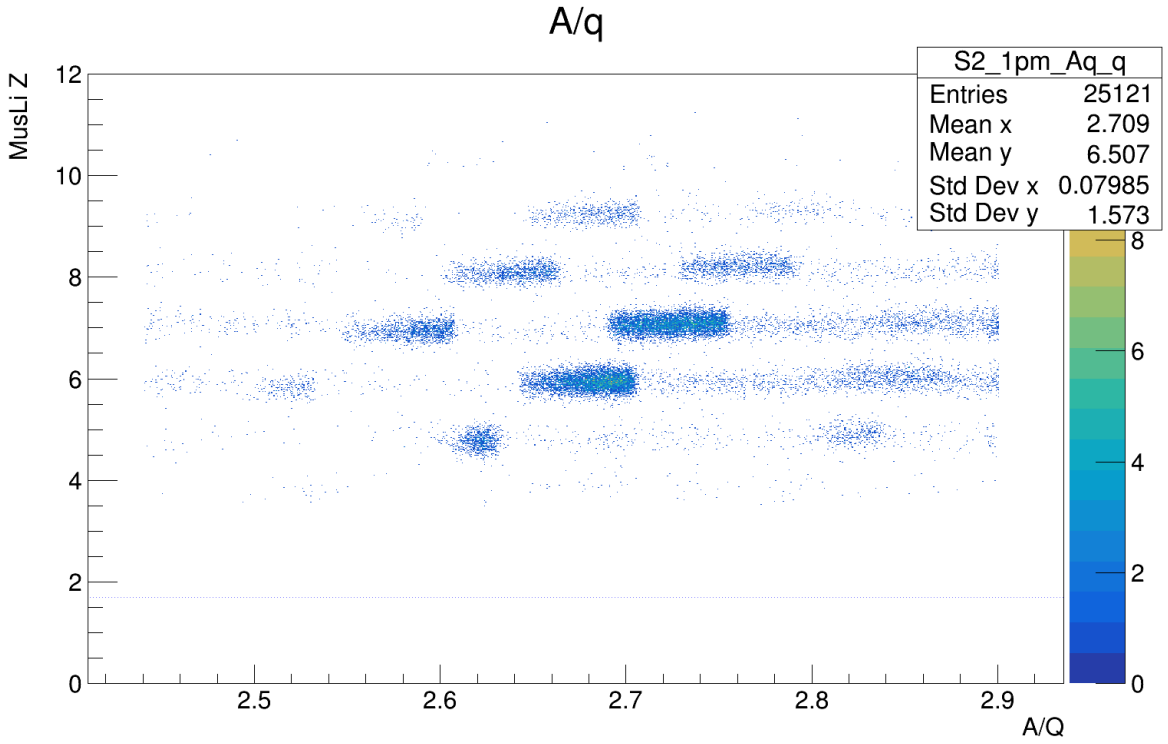
*MUSLi hit found per event vs LOS multiplicity, **S522**, ^{16}C Settings*

S2-LOS ToF Calibration

Statistics recovery using only one S2 PMT for events with no good Tof.

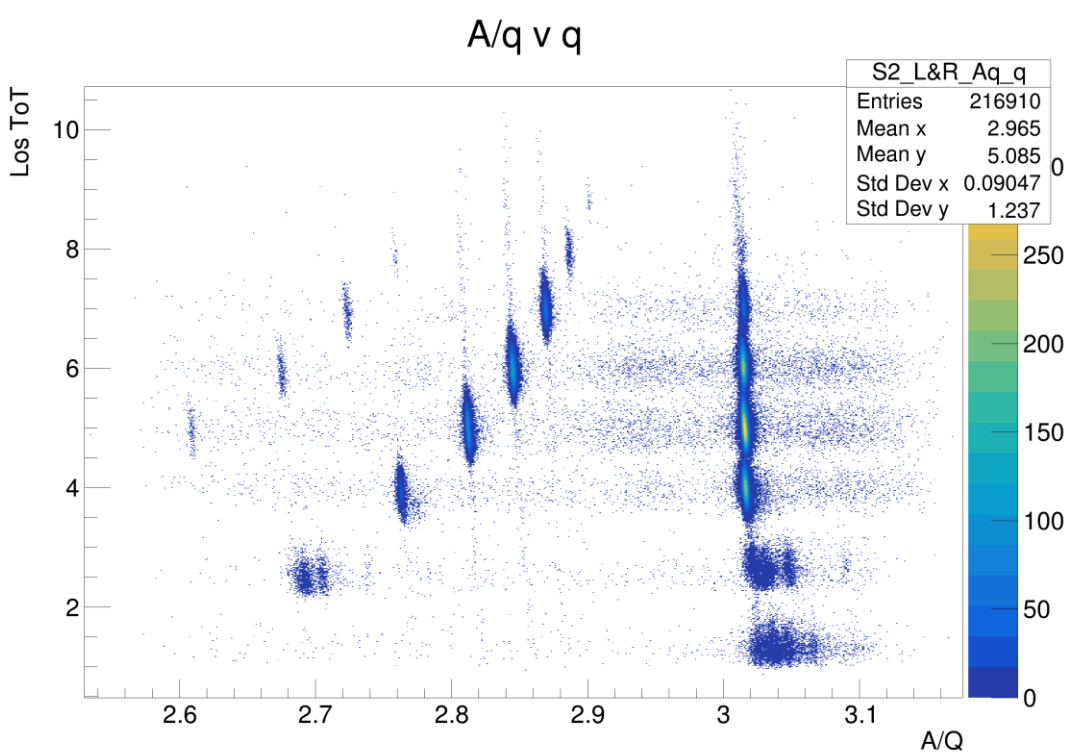


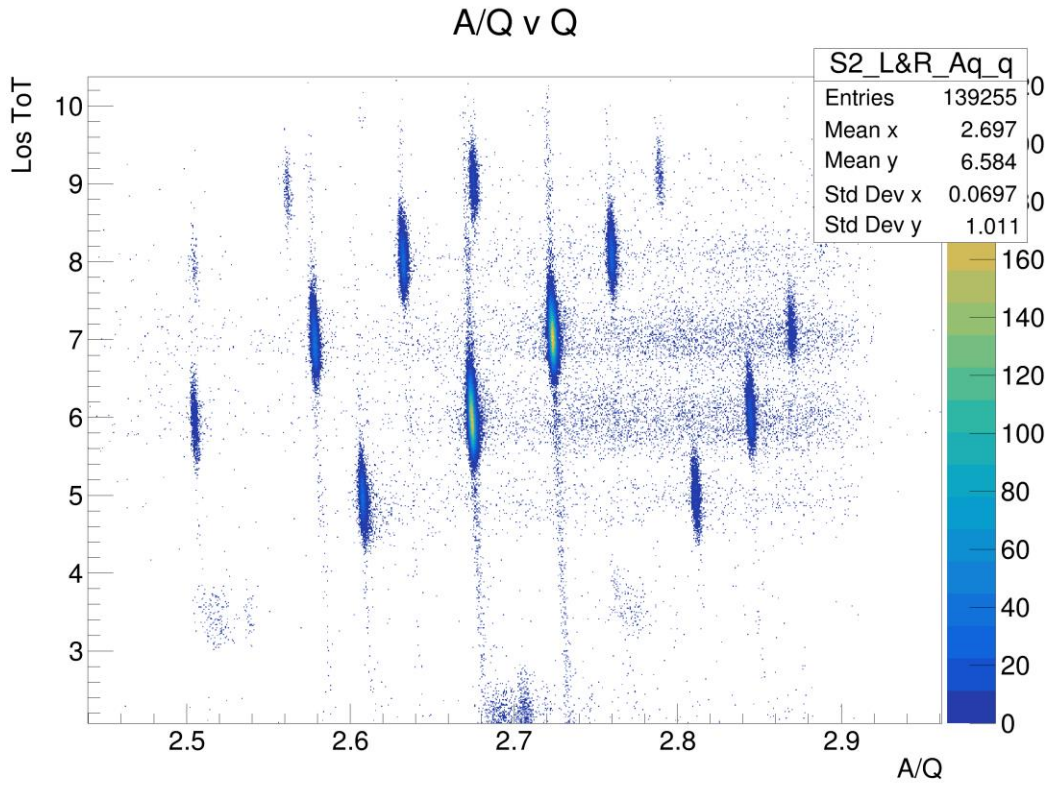
*A/q vs q, **S509**, ^{21}N Settings (events with bad Tof)*



*A/q vs q, **S509**, ^{22}O Settings (events with bad Tof)*

S2-LOS ToF Calibration





S2-LOS ToF Calibration

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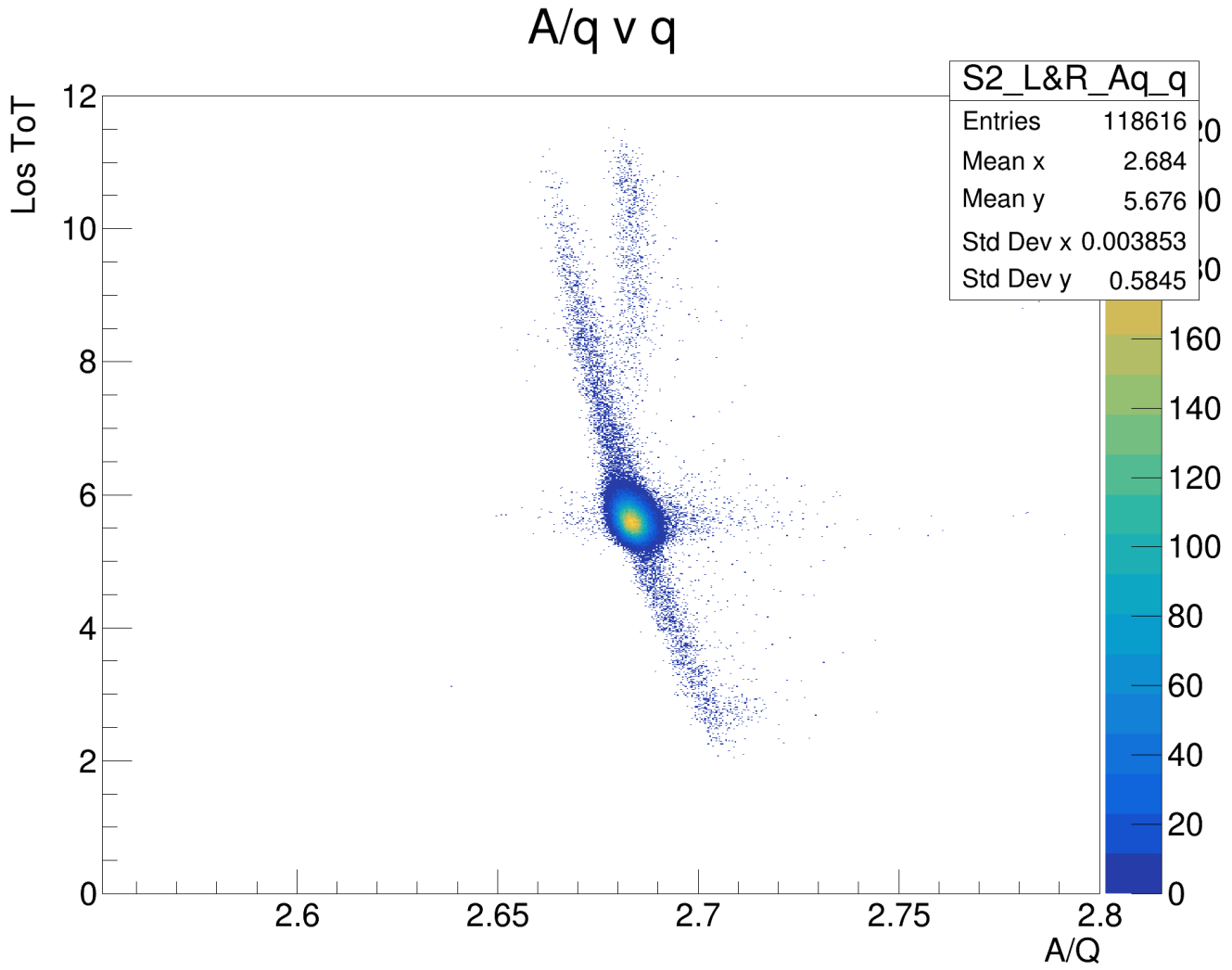
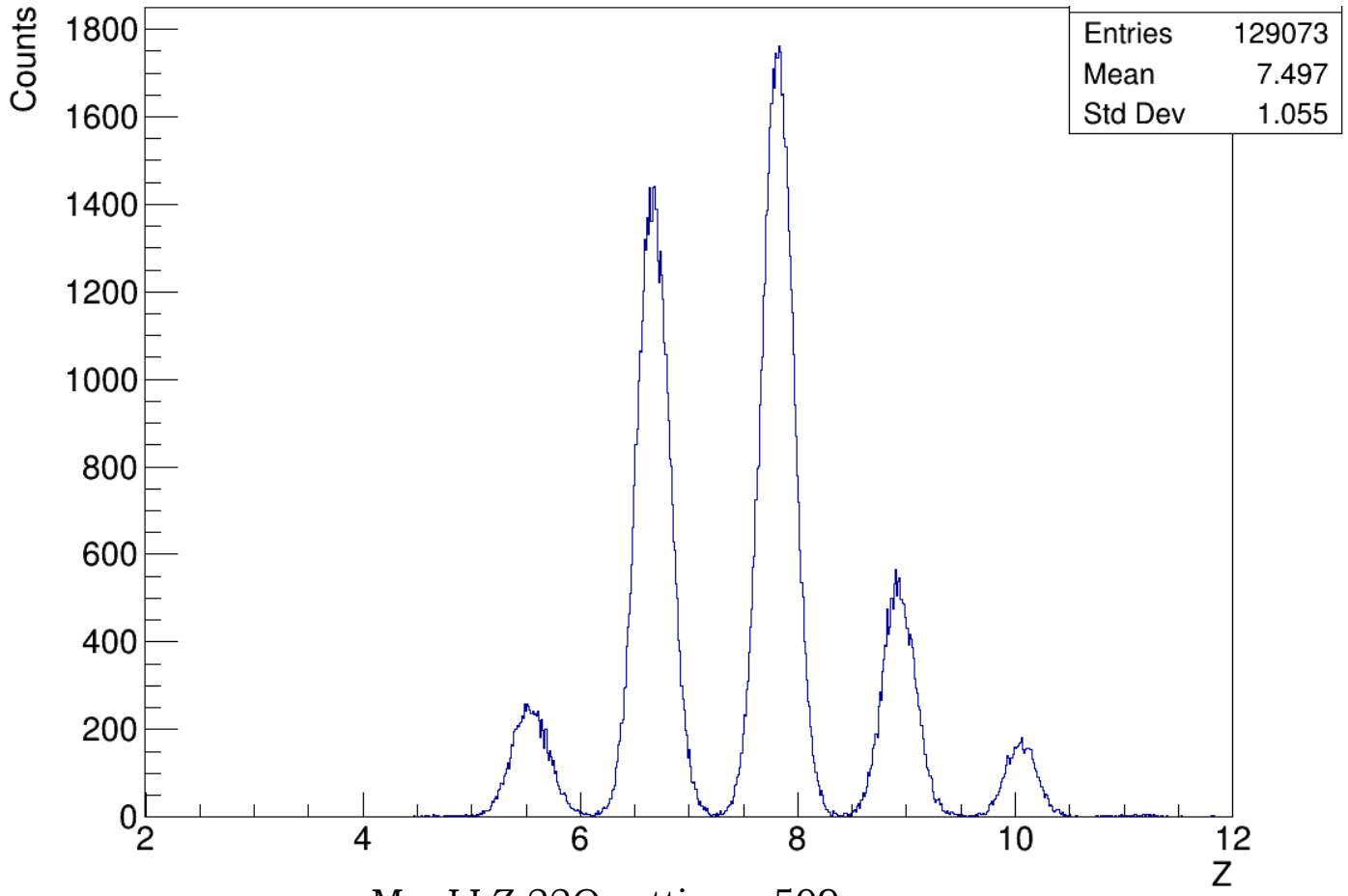


MusLi Charge Calibration

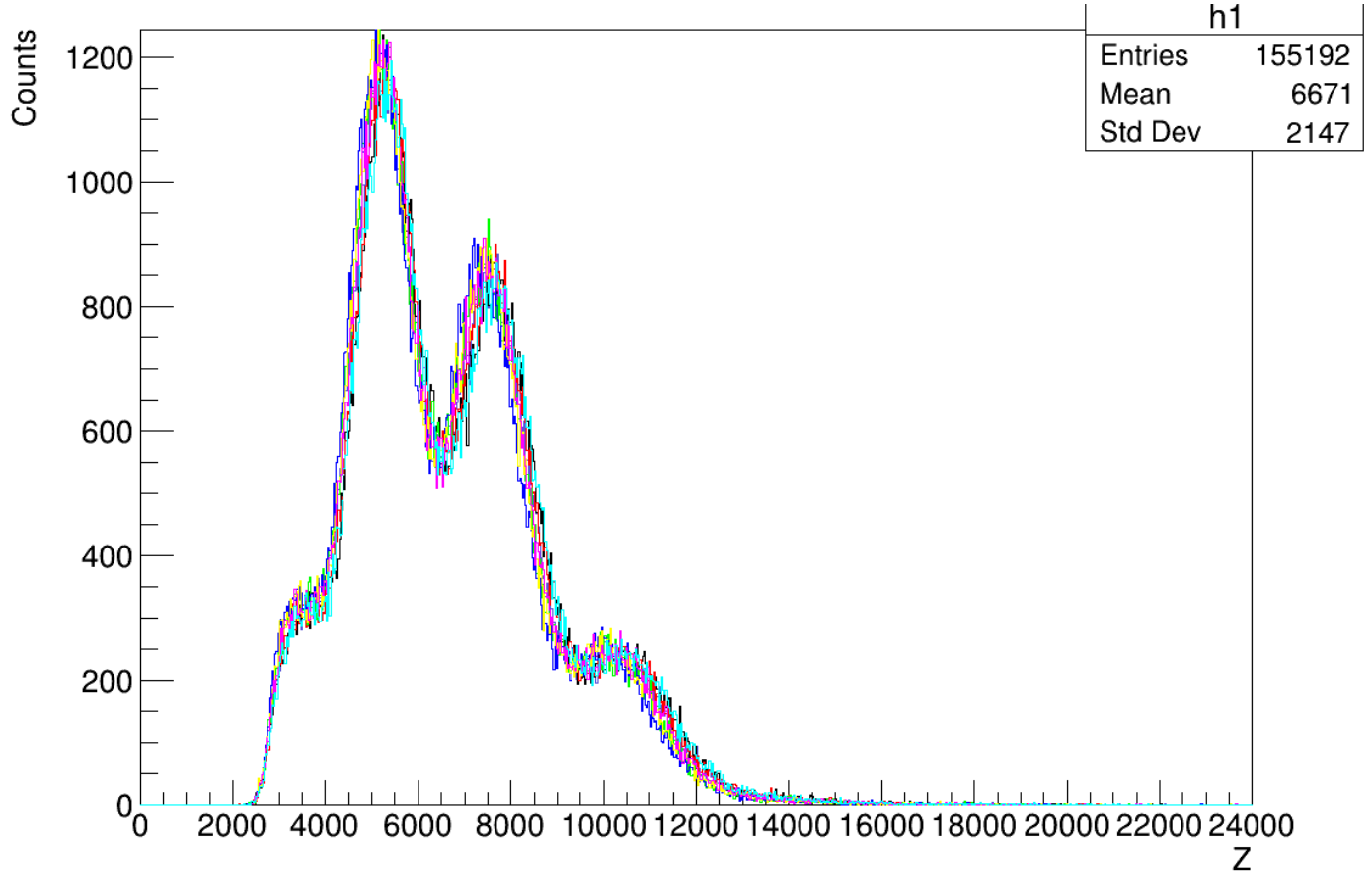
Energy alignment of anodes already at acceptable level



MusLI Z 22O setting, s509

MusLi Charge Calibration

Energy alignment of anodes already at acceptable level

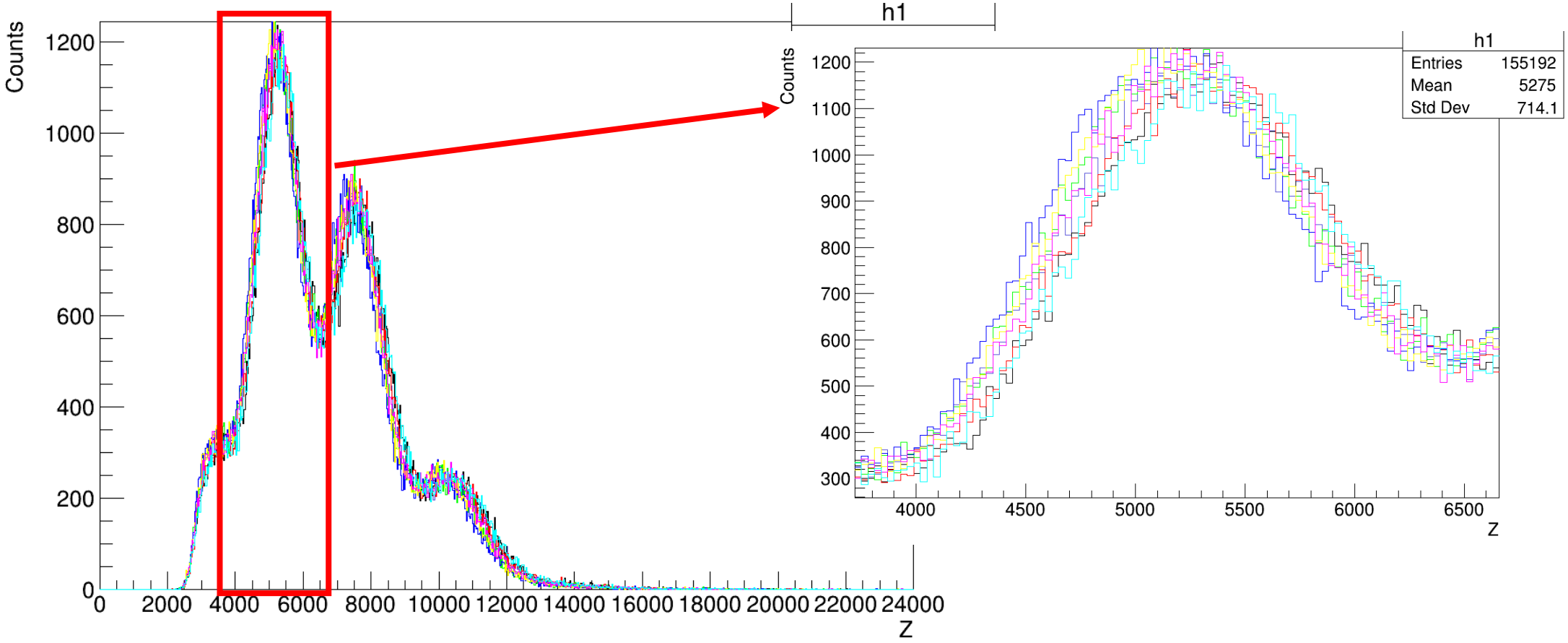


Uncalibrated 8 Anode combination energies 21N setting, s509

MusLi Charge Calibration

Energy alignment of anodes already at acceptable level

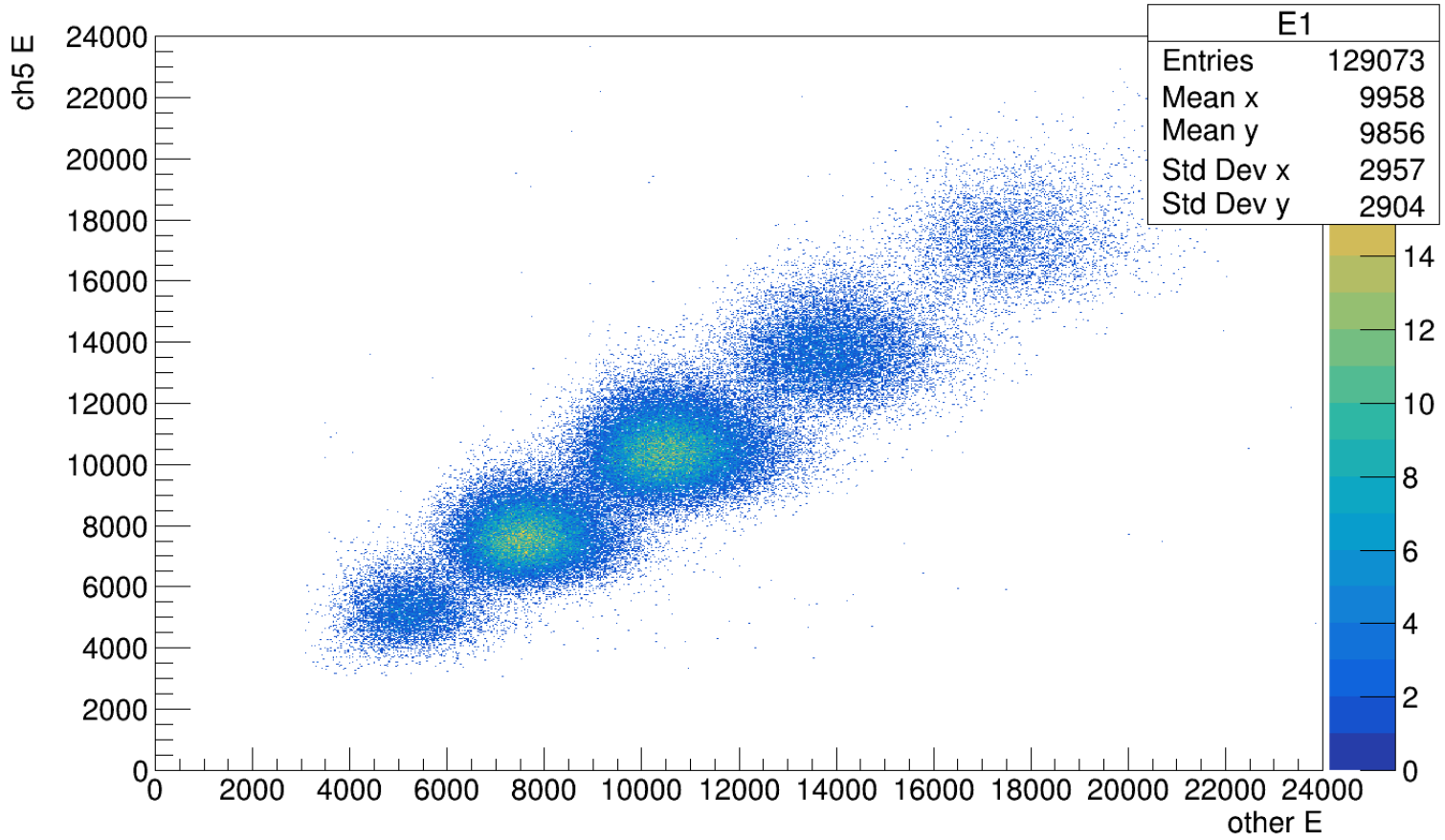
- But can be improved



Uncalibrated 8 Anode combination energies 21N setting, s509

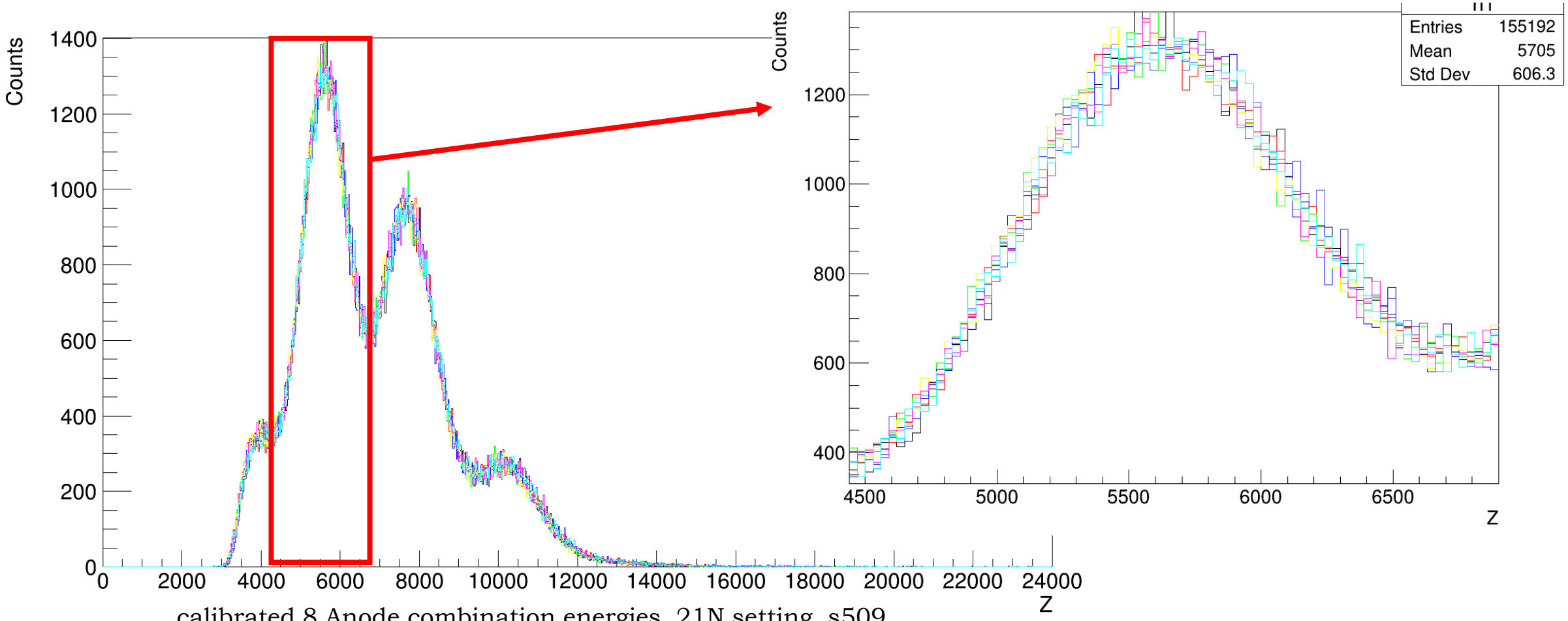
MusLi Charge Calibration

- Plot energy of all anodes vs 1 eg Anode 5
- Fit with Pol1 → 8 Slopes and Intercepts



E Anode 1 vs E Anode 5

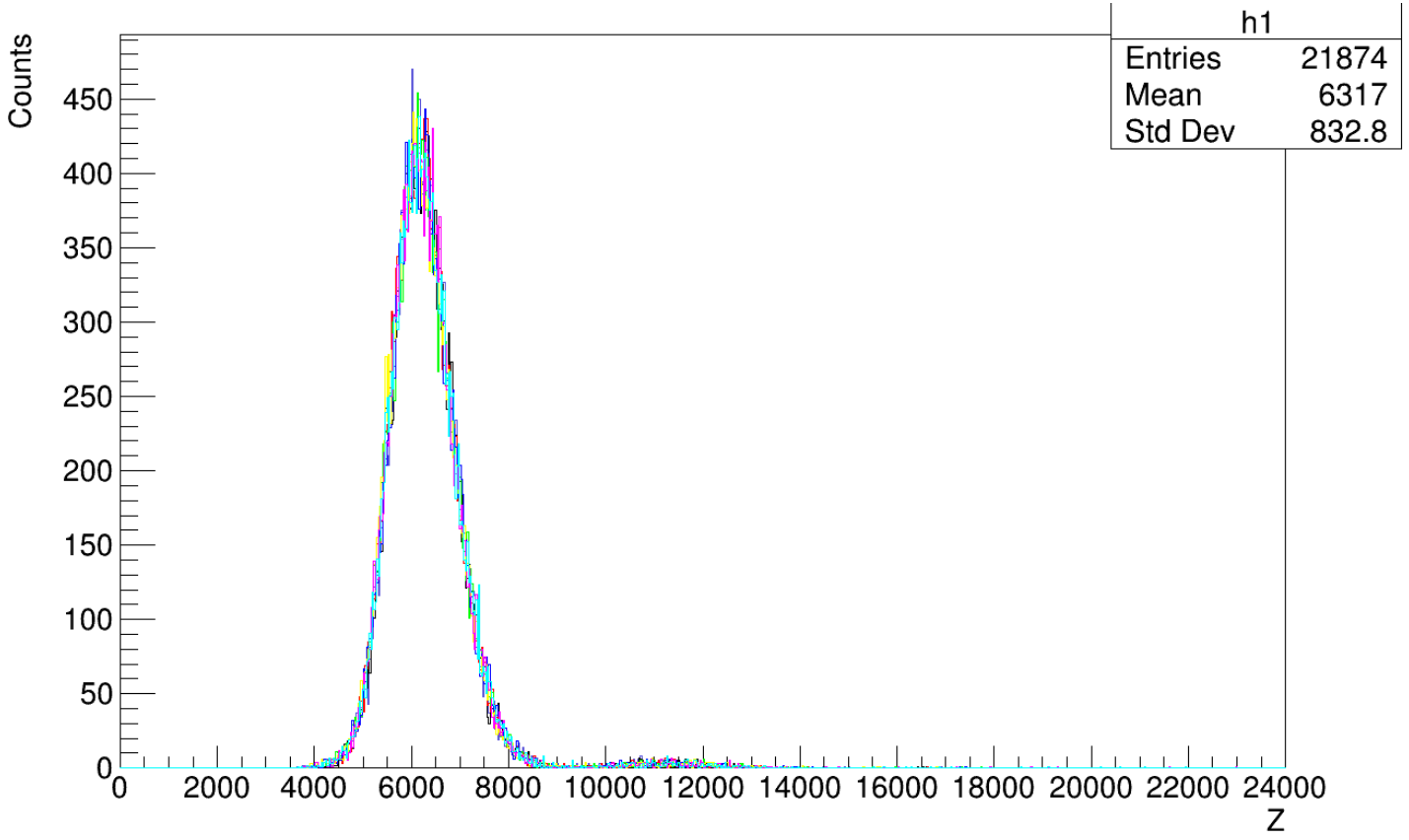
MusLi Charge Calibration



calibrated 8 Anode combination energies 21N setting, s509

MusLi Charge Calibration

- Same values can be directly applied to 16C s522



calibrated 8 Anode combination energies 16C setting, s522

MusLi Charge Calibration

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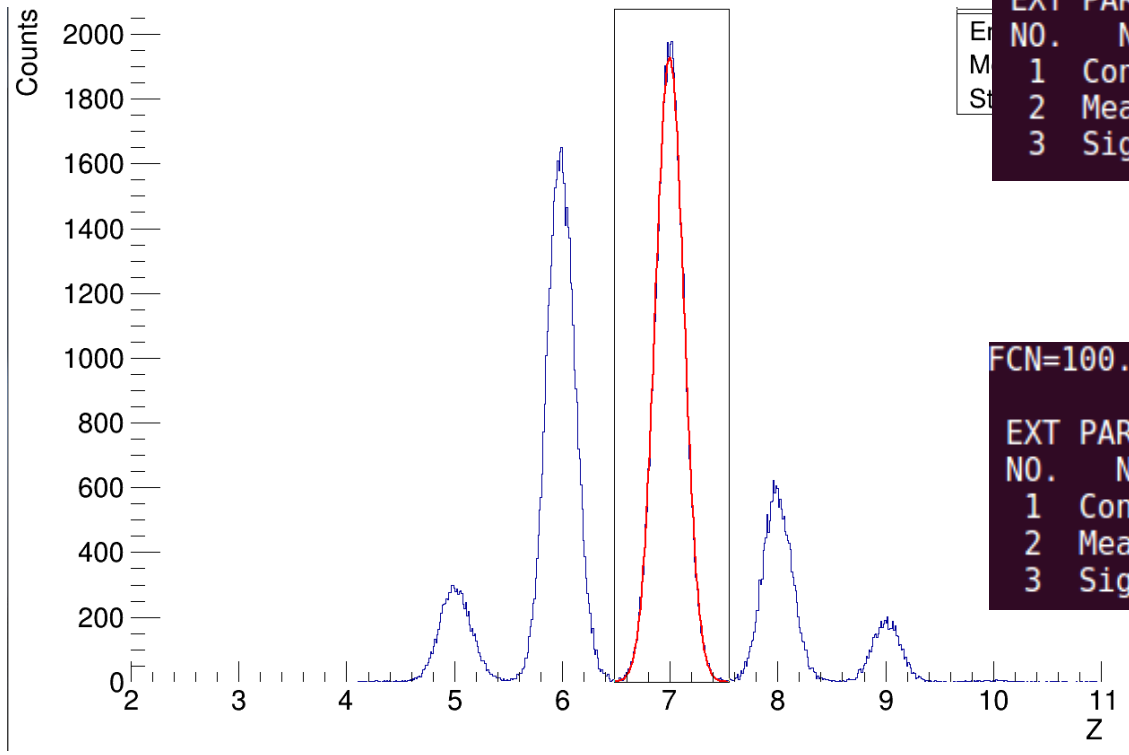
Improvement in sigma values



BEFORE CALIBRATION

```
FCN=100.376 FROM MIGRAD    STATUS=CONVERGED      60 CALLS          61 TOTAL
                     EDM=5.36839e-08    STRATEGY= 1      ERROR MATRIX ACCURATE
 EXT PARAMETER                                   STEP         FIRST
 NO.   NAME      VALUE            ERROR          SIZE      DERIVATIVE
  1  Constant     1.75107e+03   9.45845e+00   3.72616e-02  -3.55522e-05
  2  Mean         7.05405e+00   6.32629e-04   3.36363e-06   1.84408e-02
  3  Sigma        1.45967e-01   4.72641e-04   4.24060e-06  -3.59403e-01
```

AFTER CALIBRATION

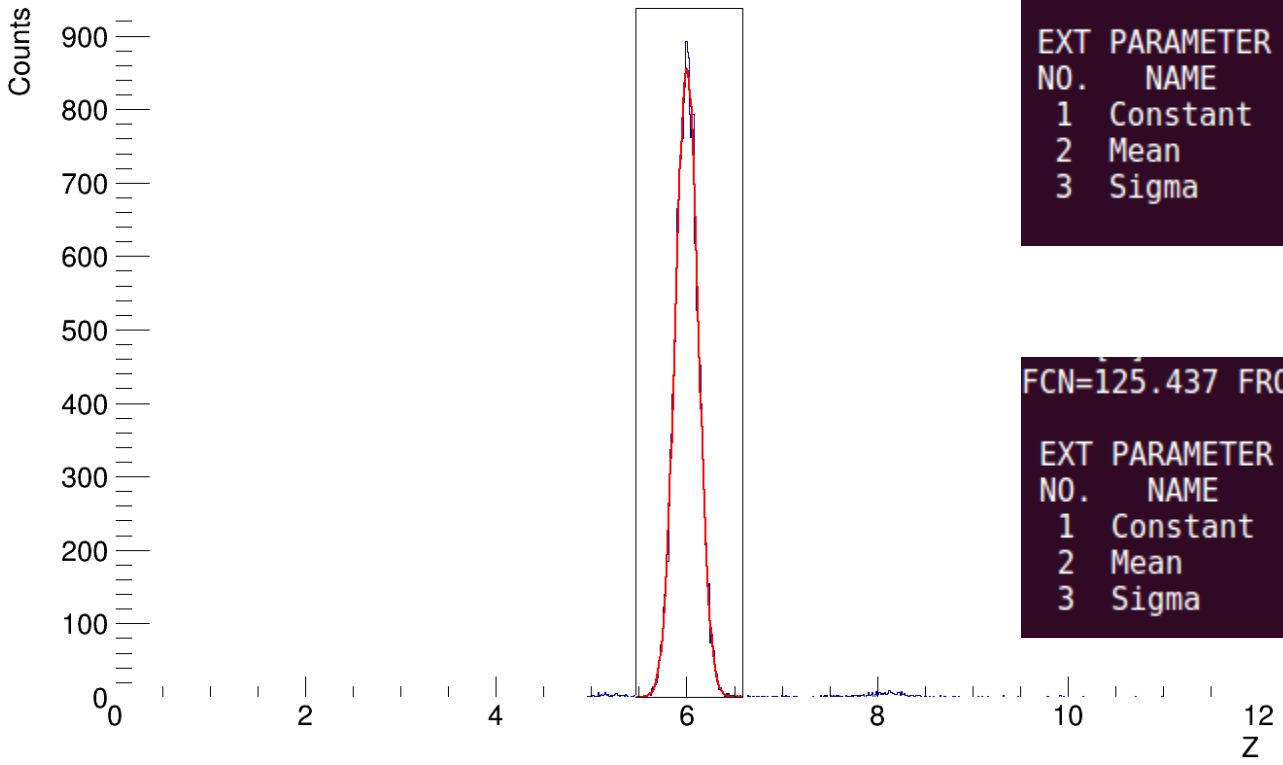
```
FCN=100.865 FROM MIGRAD    STATUS=CONVERGED      60 CALLS          61 TOTAL
                     EDM=3.28863e-08    STRATEGY= 1      ERROR MATRIX ACCURATE
 EXT PARAMETER                                   STEP         FIRST
 NO.   NAME      VALUE            ERROR          SIZE      DERIVATIVE
  1  Constant     1.92895e+03   1.04324e+01   4.11376e-02  -2.58973e-05
  2  Mean         6.99541e+00   5.73938e-04   3.33567e-06  -1.52063e-01
  3  Sigma        1.32538e-01   4.30395e-04   4.25439e-06  -2.50636e-01
```

MusLI Z 22O setting, s509

MusLi Charge Calibration

TECHNISCHE UNIVERSITÄT DARMSTADT

Improvement in sigma values



BEFORE CALIBRATION

```
FCN=128.517 FROM MIGRAD    STATUS=CONVERGED      58 CALLS          59 TOTAL
                     EDM=1.81761e-07    STRATEGY= 1      ERROR MATRIX ACCURATE
 EXT PARAMETER                                          STEP         FIRST
 NO.   NAME      VALUE            ERROR                 SIZE      DERIVATIVE
  1  Constant     7.49133e+02   6.31253e+00   2.84953e-02   1.15610e-04
  2  Mean         5.85201e+00   9.36418e-04   5.20122e-06   8.07452e-02
  3  Sigma        1.36496e-01   6.73602e-04   7.38961e-06   3.07835e-01
```

AFTER CALIBRATION

```
FCN=125.437 FROM MIGRAD    STATUS=CONVERGED      66 CALLS          67 TOTAL
                     EDM=4.91445e-10    STRATEGY= 1      ERROR MATRIX ACCURATE
 EXT PARAMETER                                          STEP         FIRST
 NO.   NAME      VALUE            ERROR                 SIZE      DERIVATIVE
  1  Constant     8.55622e+02   7.15015e+00   3.21428e-02   1.71070e-06
  2  Mean         5.99857e+00   8.19035e-04   4.49295e-06  -2.01210e-02
  3  Sigma        1.19524e-01   5.74089e-04   7.14008e-06  -1.07040e-02
```

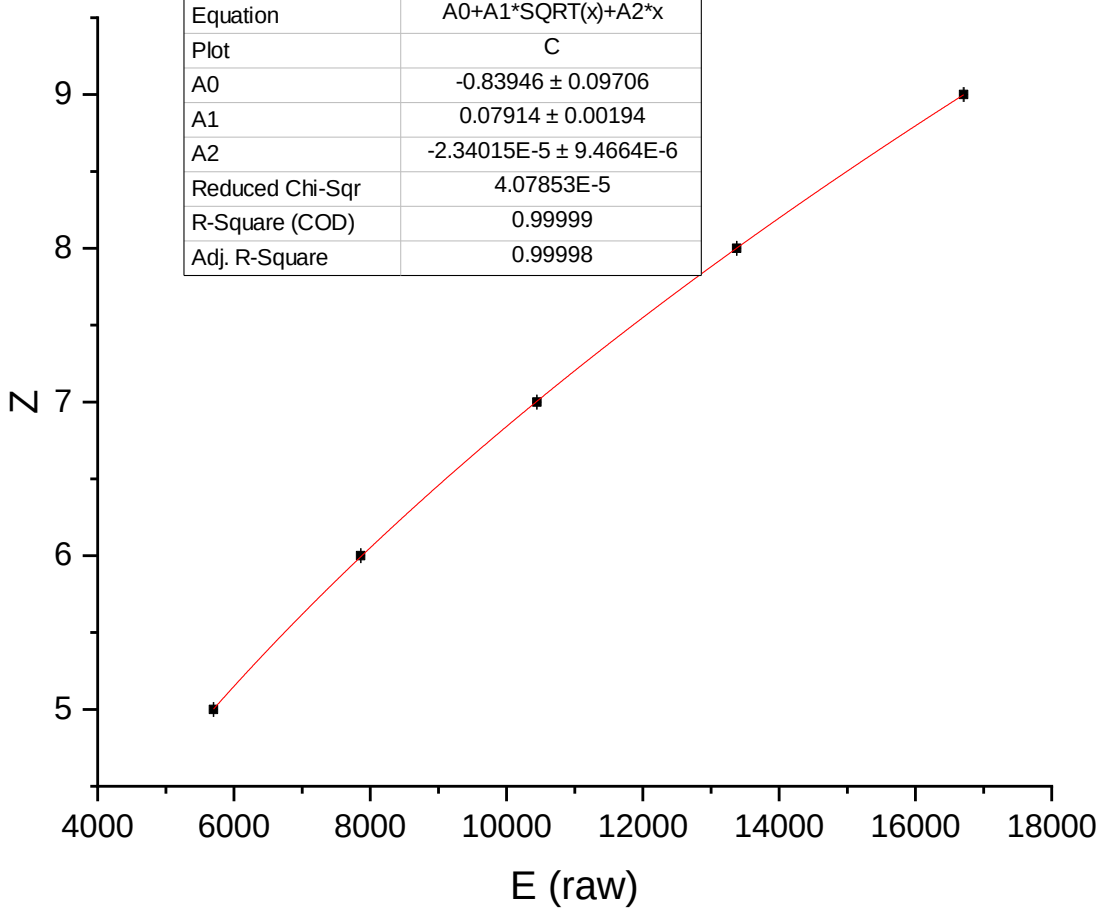
MusLI Z 16C setting, s522

MusLi Charge Calibration

Energy calibration of E_sum

- Fit with $A0 + A1 \times \sqrt{x} + A2 \times x$

Model	NewFunction3 (User)
Equation	A0+A1*SQRT(x)+A2*x
Plot	C
A0	-0.83946 ± 0.09706
A1	0.07914 ± 0.00194
A2	-2.34015E-5 ± 9.4664E-6
Reduced Chi-Sqr	4.07853E-5
R-Square (COD)	0.99999
Adj. R-Square	0.99998



Calibration plot of 22O setting, s509

MusLi Charge Calibration

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Energy calibration of E_sum

- Fit with $A0 + A1 \times \sqrt{x} + A2 \times x$
- Calibration parameters
- 21N settings:

A0 =-2.0208 ± 0.43458
A1 = 0.10293 ± 0.00999
A2 = -1.38575E-4 ± 5.55415E-5

- 22O Settings

A0 = -0.60266 ± 0.02568
A1 = 0.07435 ± 2.46895E-4
A2 =0.0

- 16C Settings: only one calibration point equation in form of $A1 \times \sqrt{x}$

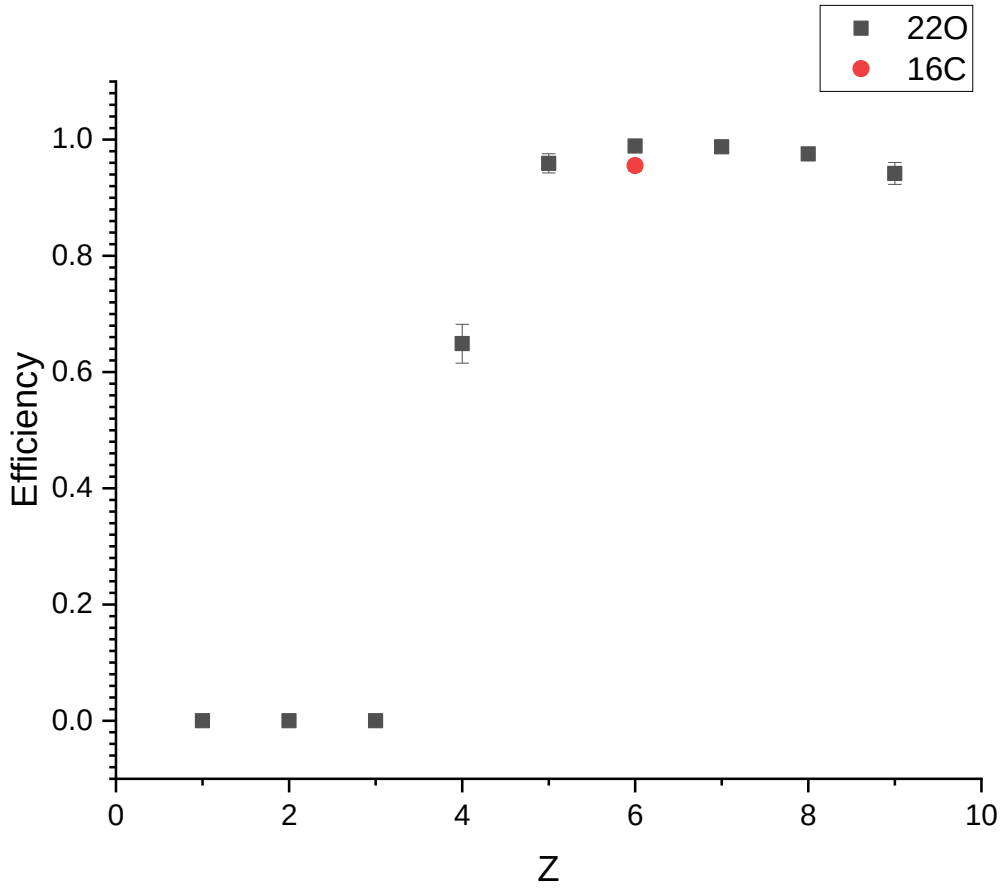
A0 = 0.0
A1 = 0.075861 ± 3.92E-4
A2 = 0.0

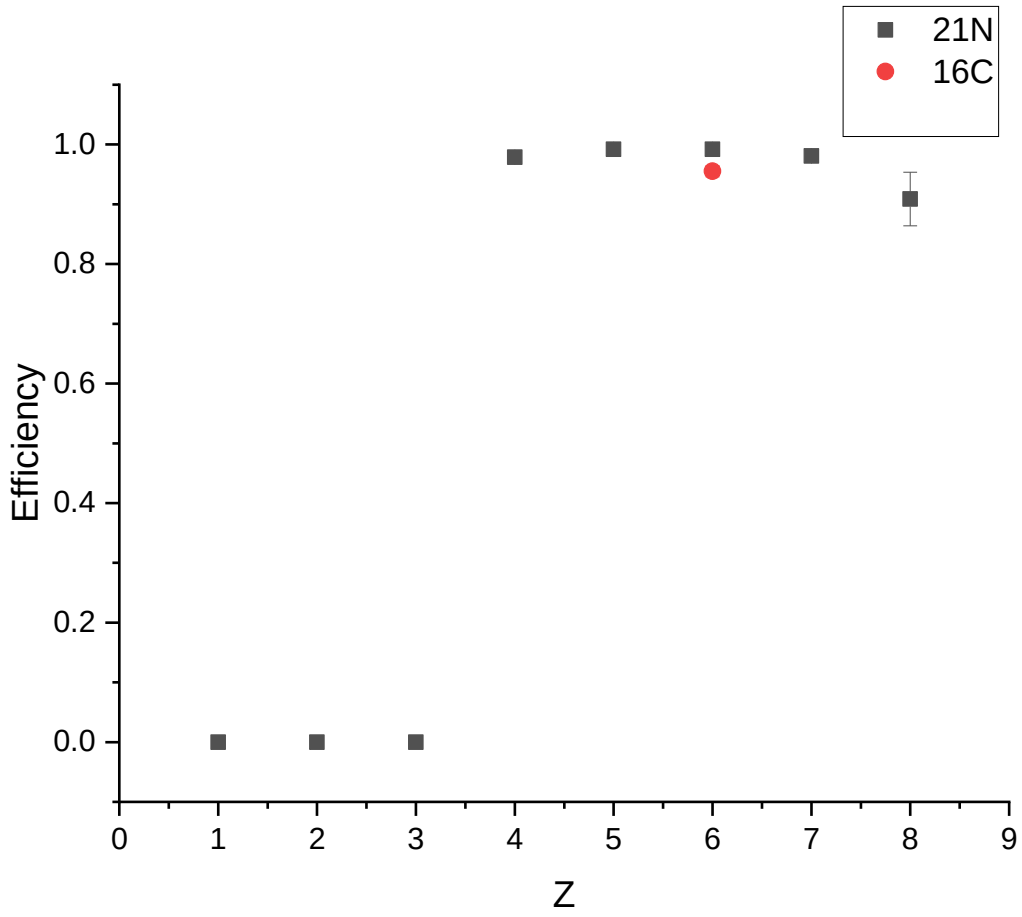
Calibration plot of 22O setting, s509

MusLi Charge Calibration

MusLi Z Efficiency vs charge

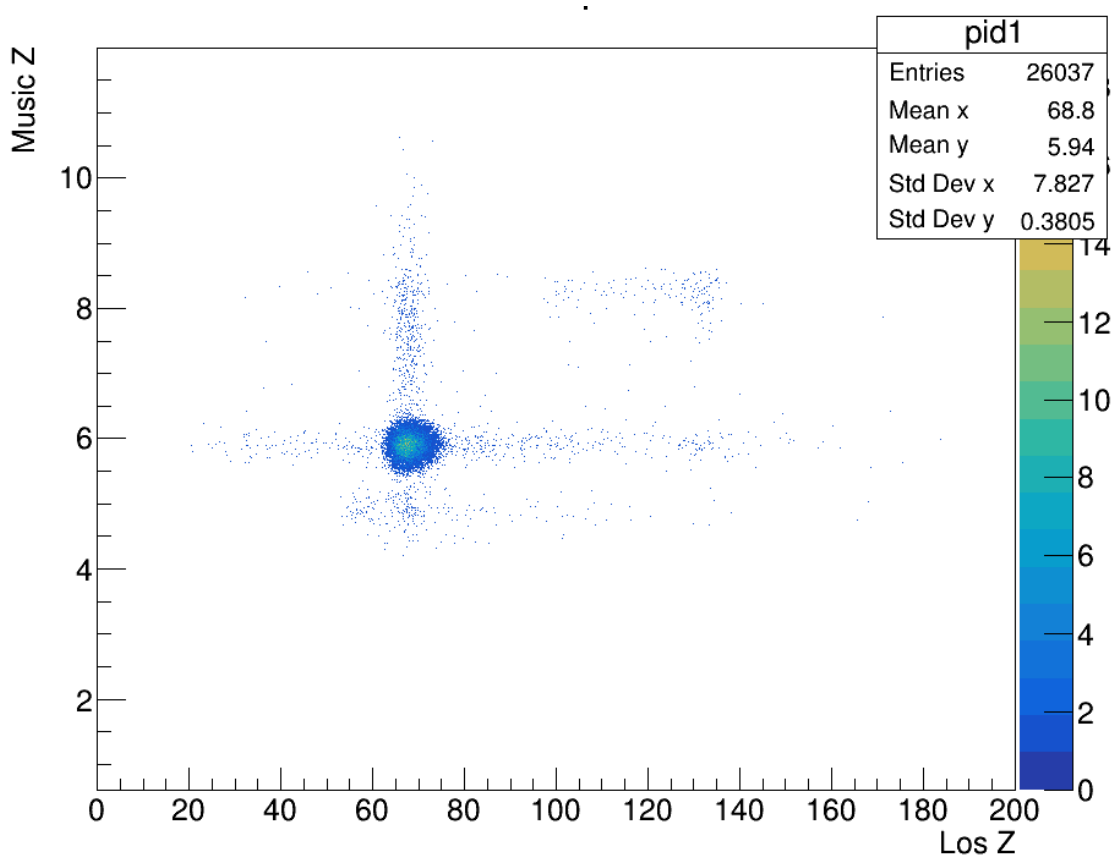
- Calculated relative to Los counts at respective Z



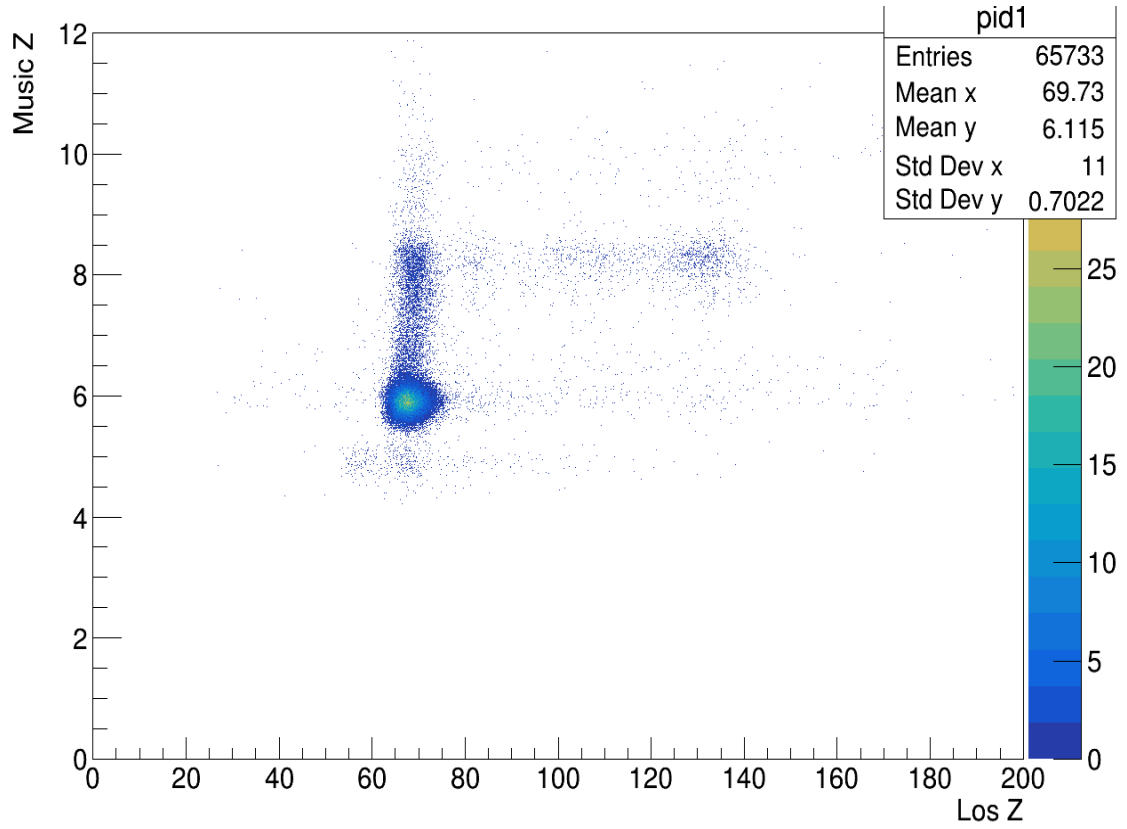


Efficiency Plots

MusLi Charge Calibration

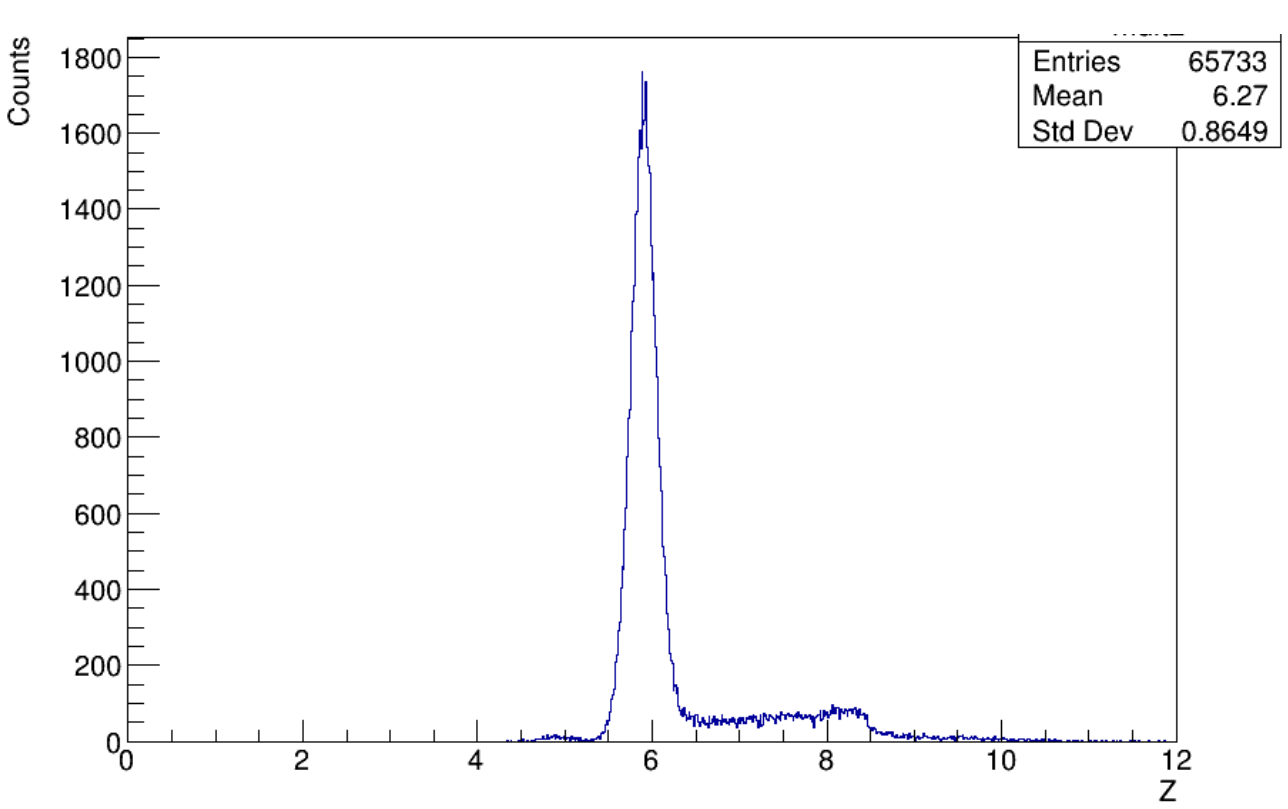


Los Z vs MusLi Z 16C setting, s522
MusLI_CH16(LOS CFD) Mult ==1
LOS mult ==1

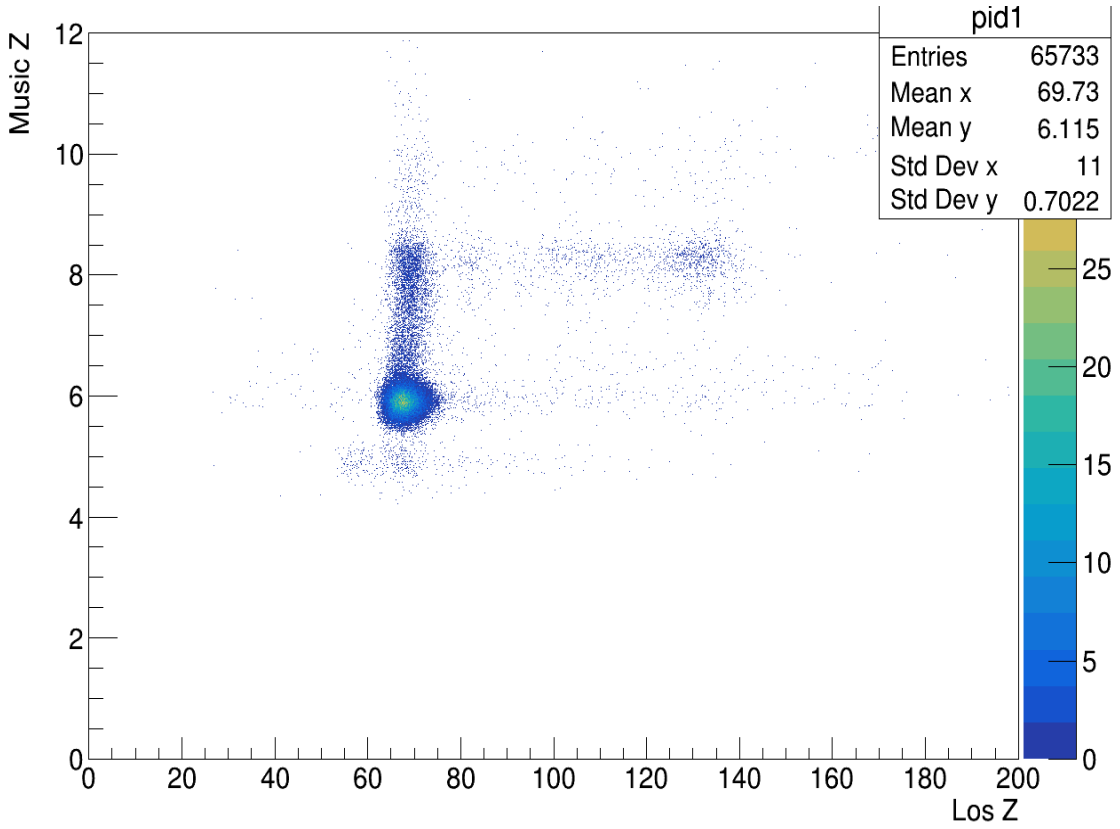


Los Z vs MusLi Z 16C setting, s522

MusLi Charge Calibration



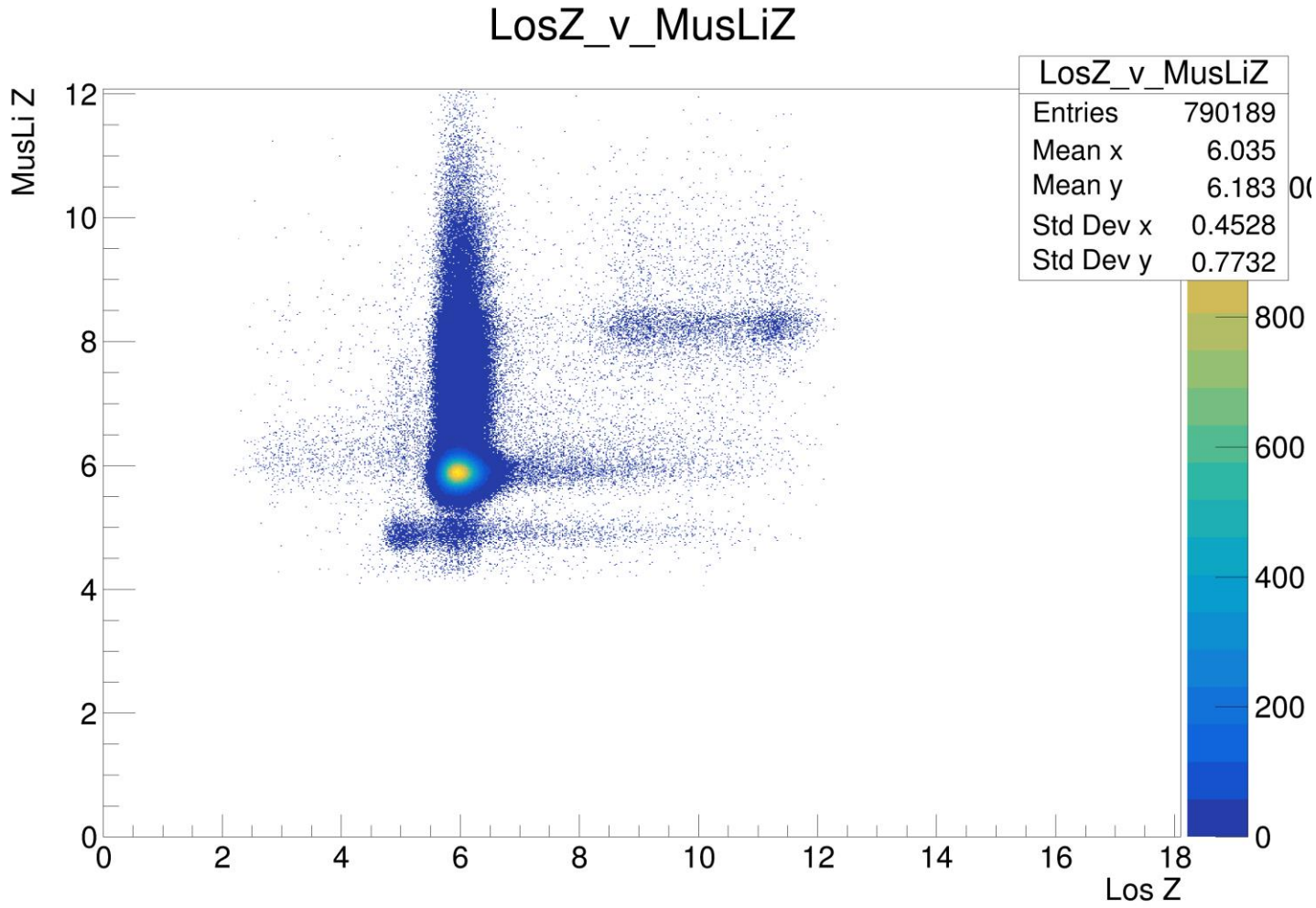
MusLi Z 16C setting, s522



Los Z vs MusLi Z 16C setting, s522

MusLi Charge Calibration

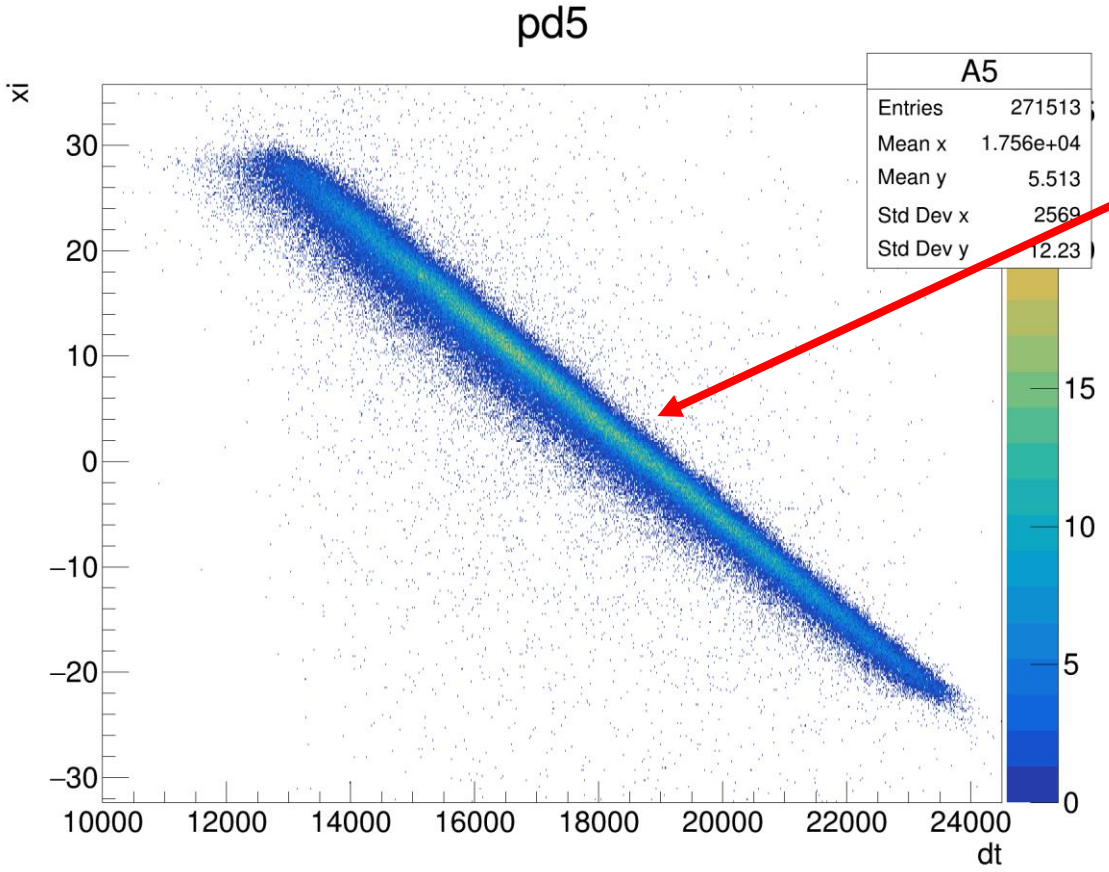
TECHNISCHE UNIVERSITÄT DARMSTADT



MusLi Position Calibration

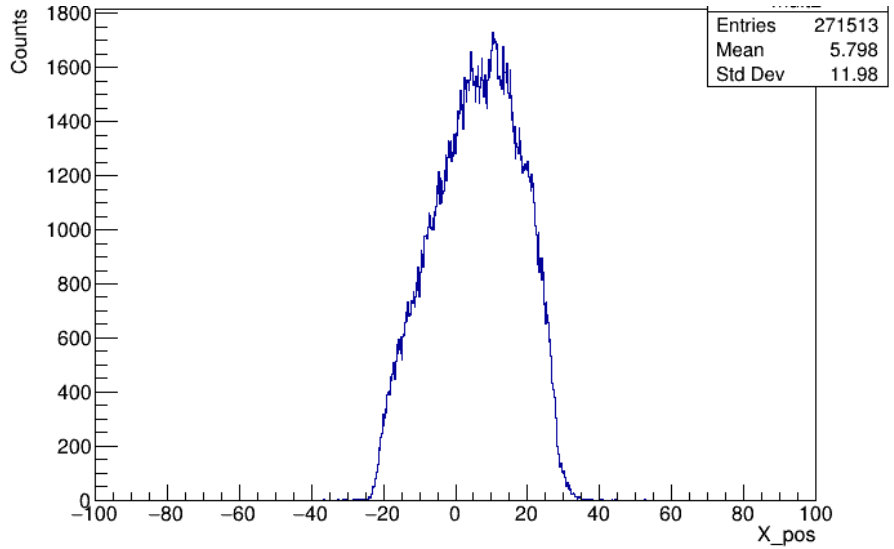
Position calibration of Drift time

- Obtain extrapolated X position at MusLi anode using MWPC positions
- Plot extrapolated X position vs Drift time
- Fit with Pol1, 8 slopes and intercepts to get $X_{aligned}$



TOO BROAD!!!

Problem in next step

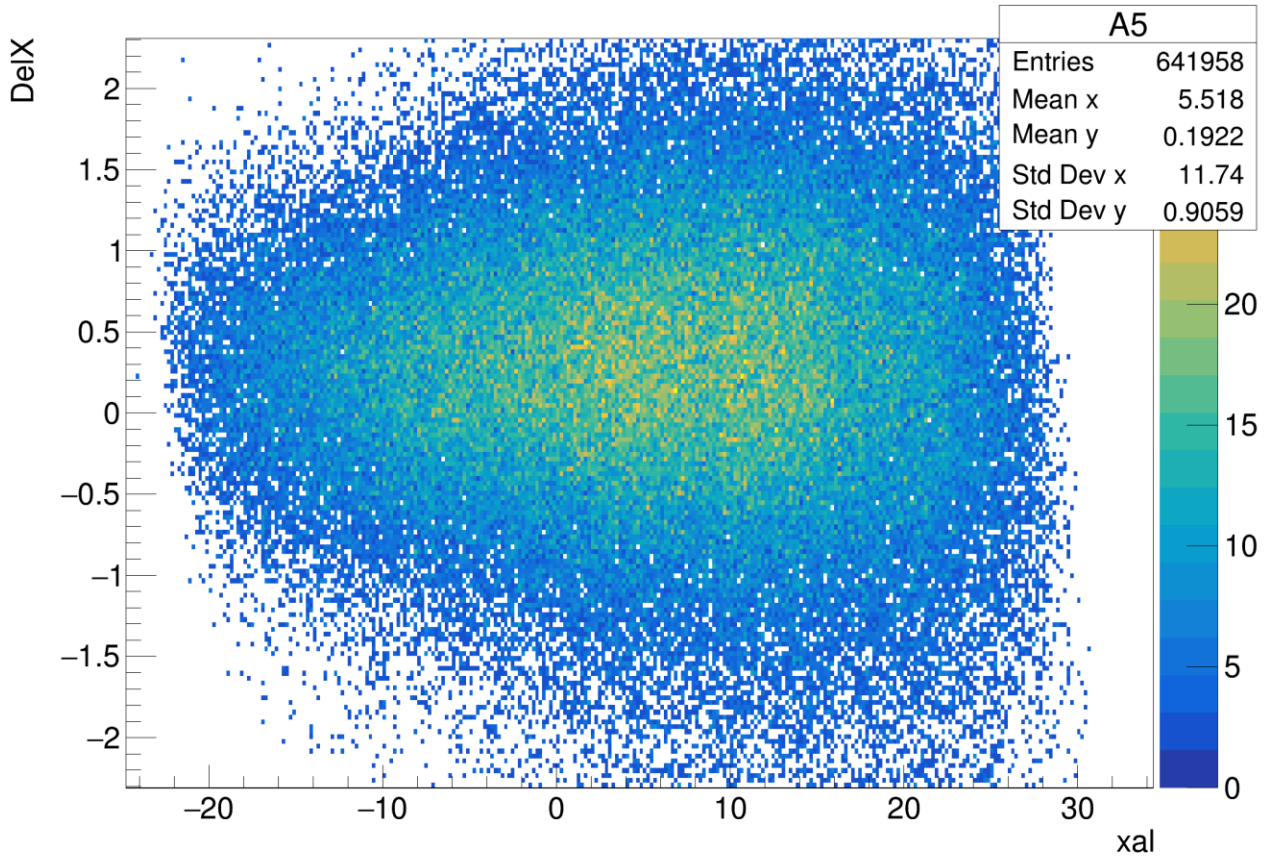


Calibrated X position 22O setting, s509

MusLi Position Calibration

Position calibration of Drift time

- Using the calibrated positions obtain a tracking through the musli anodes
- Fit this tracking and obtained $\Delta X = X_{fit} - X_{aligned}$
- Plot ΔX vs $X_{aligned}$



MusLi Position Calibration

MWPC0 vs MPWC1 X is very broad too