

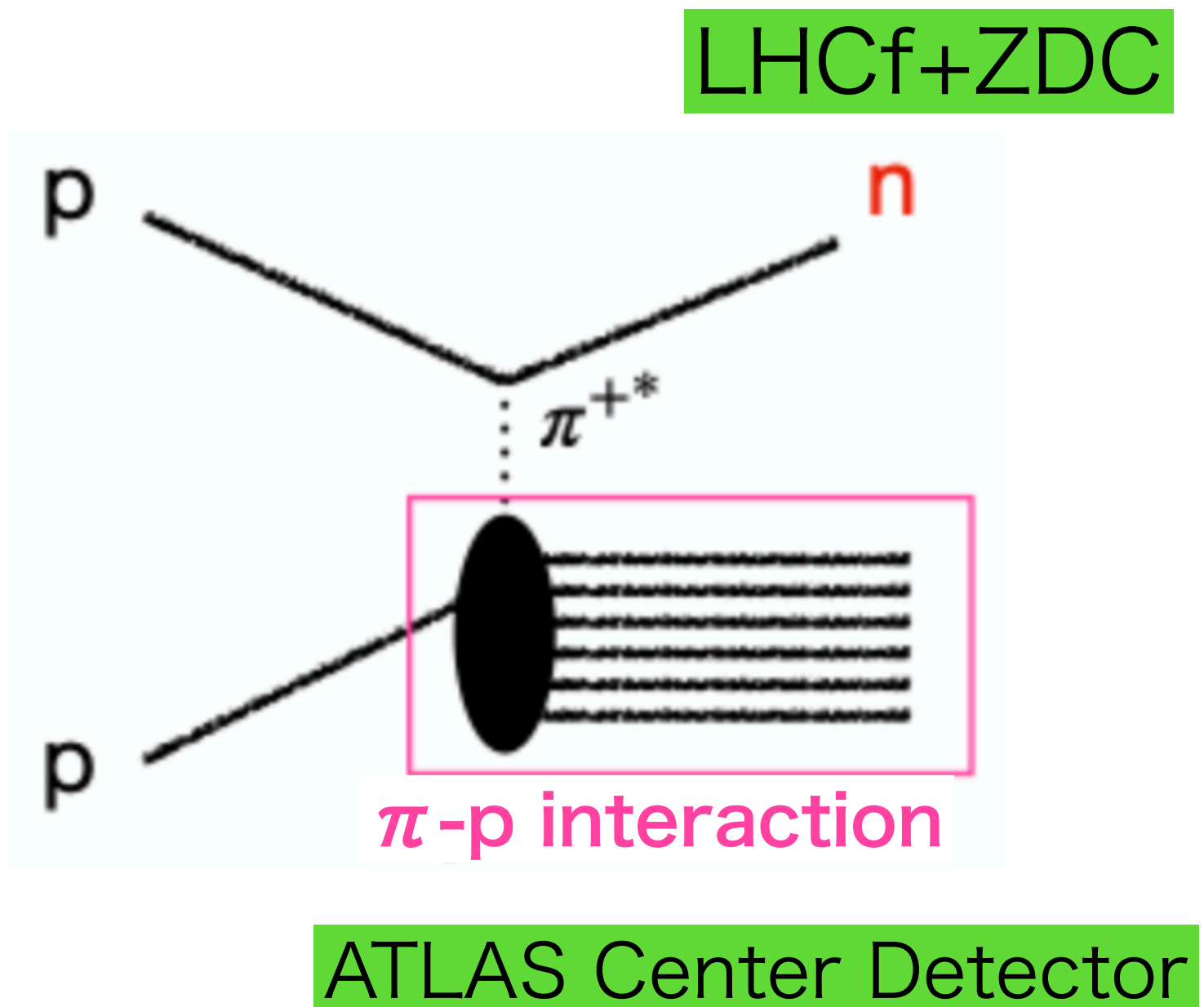
**The neutron analysis
of 2022 operation data
with the LHCf + ATLAS ZDC method**

20240821 Kobayashi Haruka

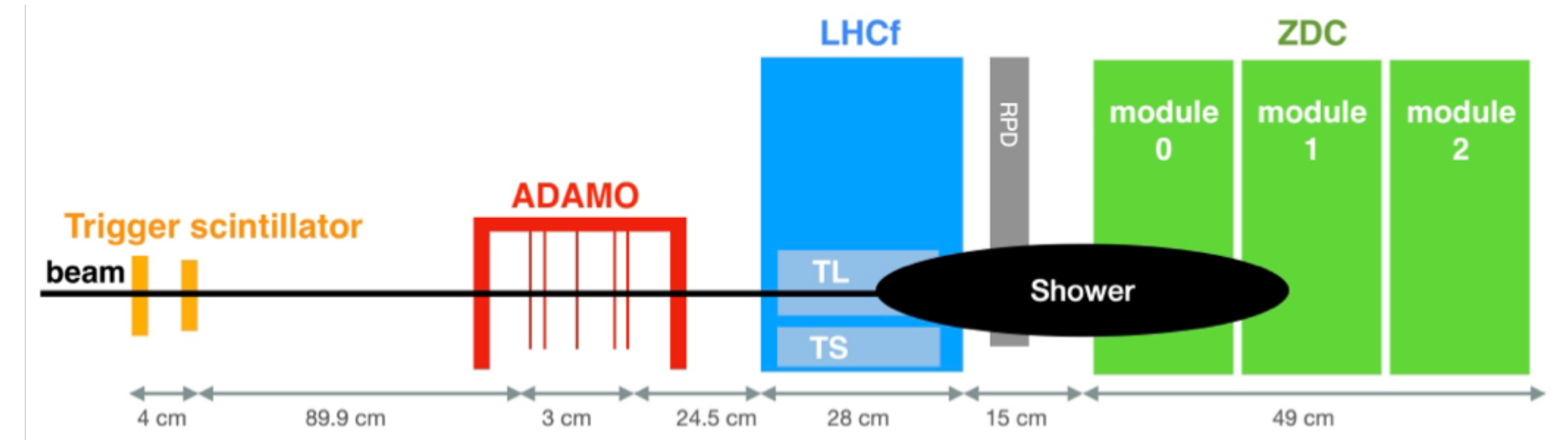
LHCf analysis meeting in Italy

One Pion Exchange

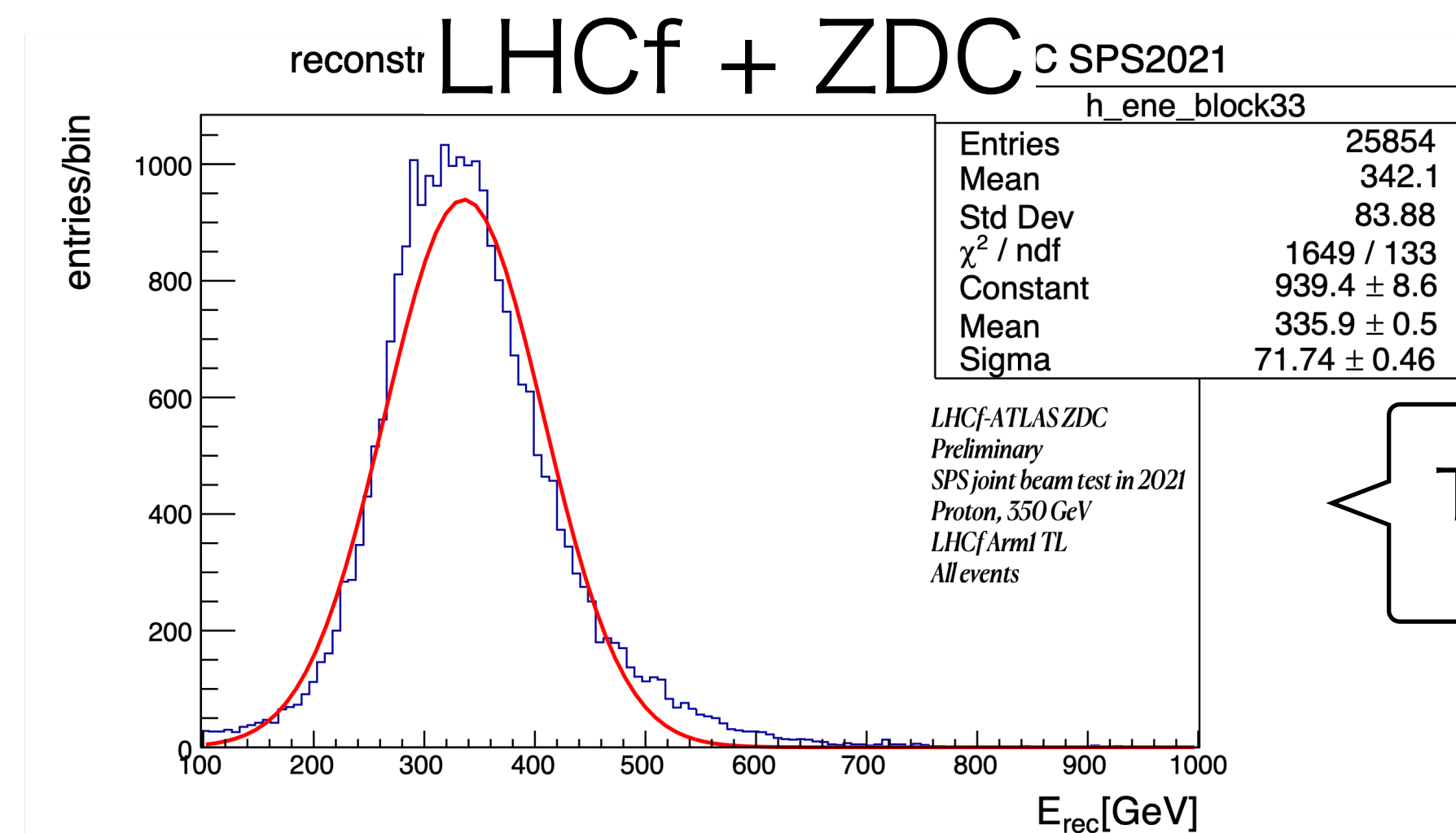
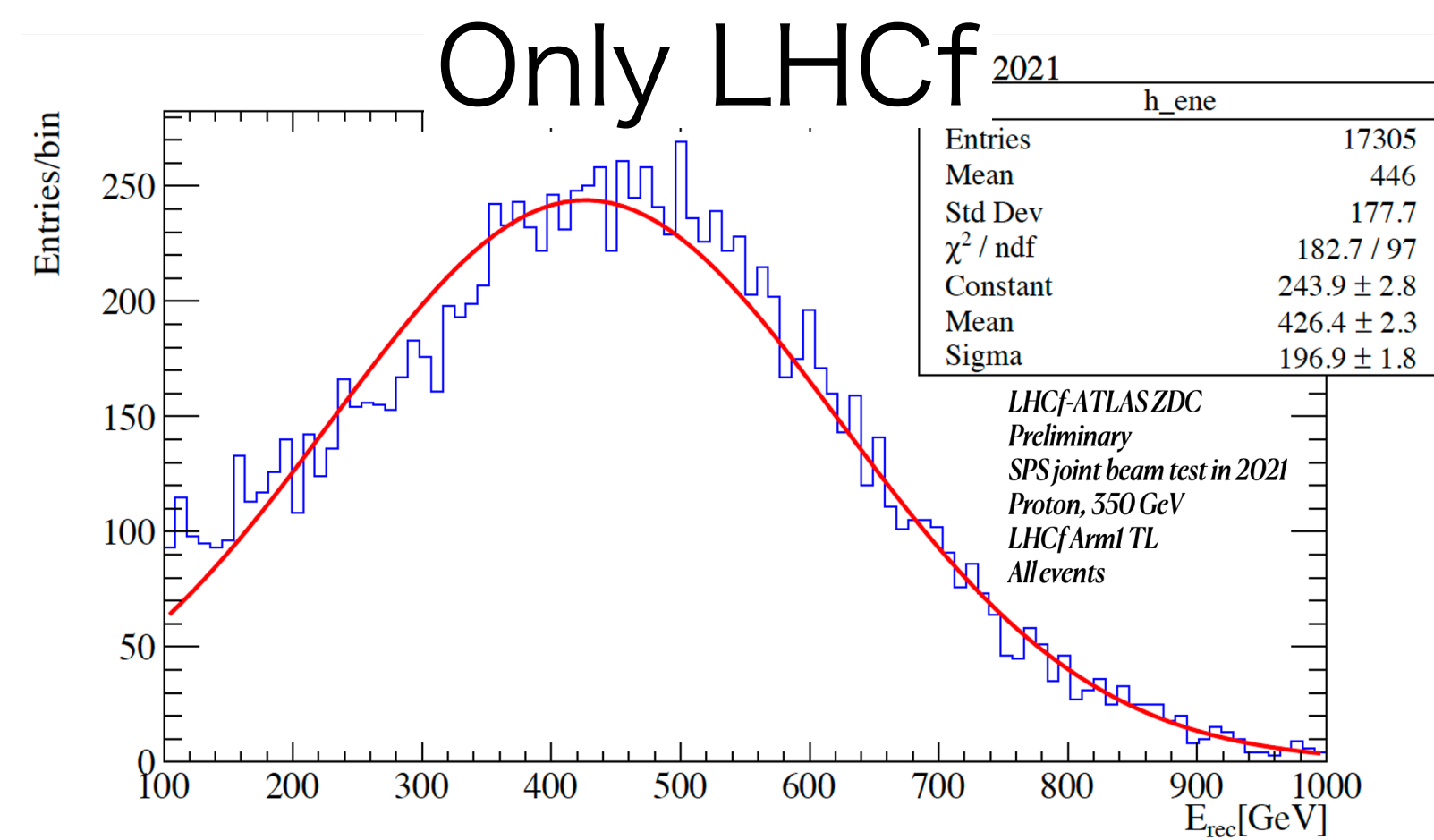
- At the pp collision, a proton becomes a neutron with emitting a virtual pion, which collides with the other proton.
- LHCf+ZDC detects the very forward neutrons from OPE.
- Select the OPE events by neutron energy.
- → Need an accurate measurement of neutron energies
- → LHCf+ATLAS-ZDC



SPS2021 analysis

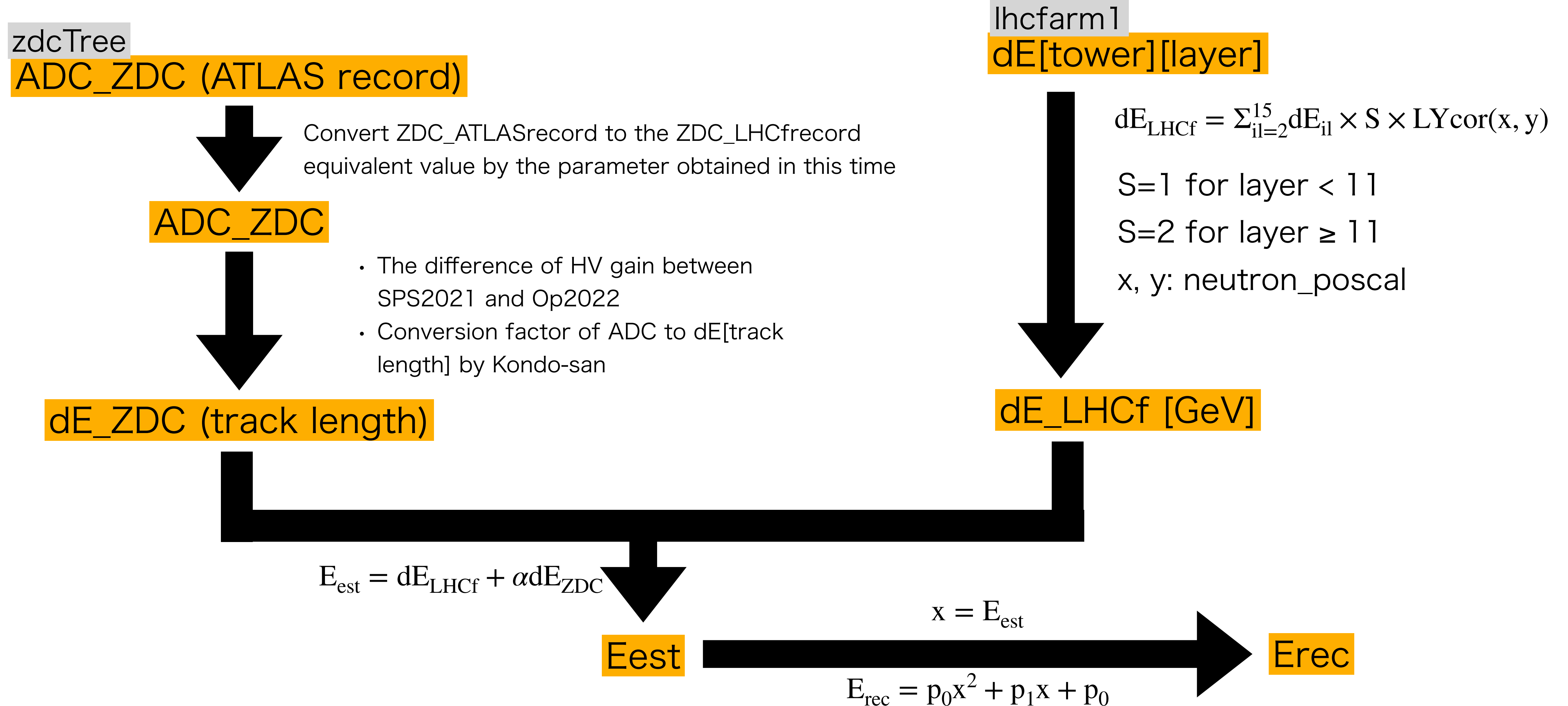


- Proton 350 GeV,
- The energy resolution was improved by LHCf + ZDC analysis.

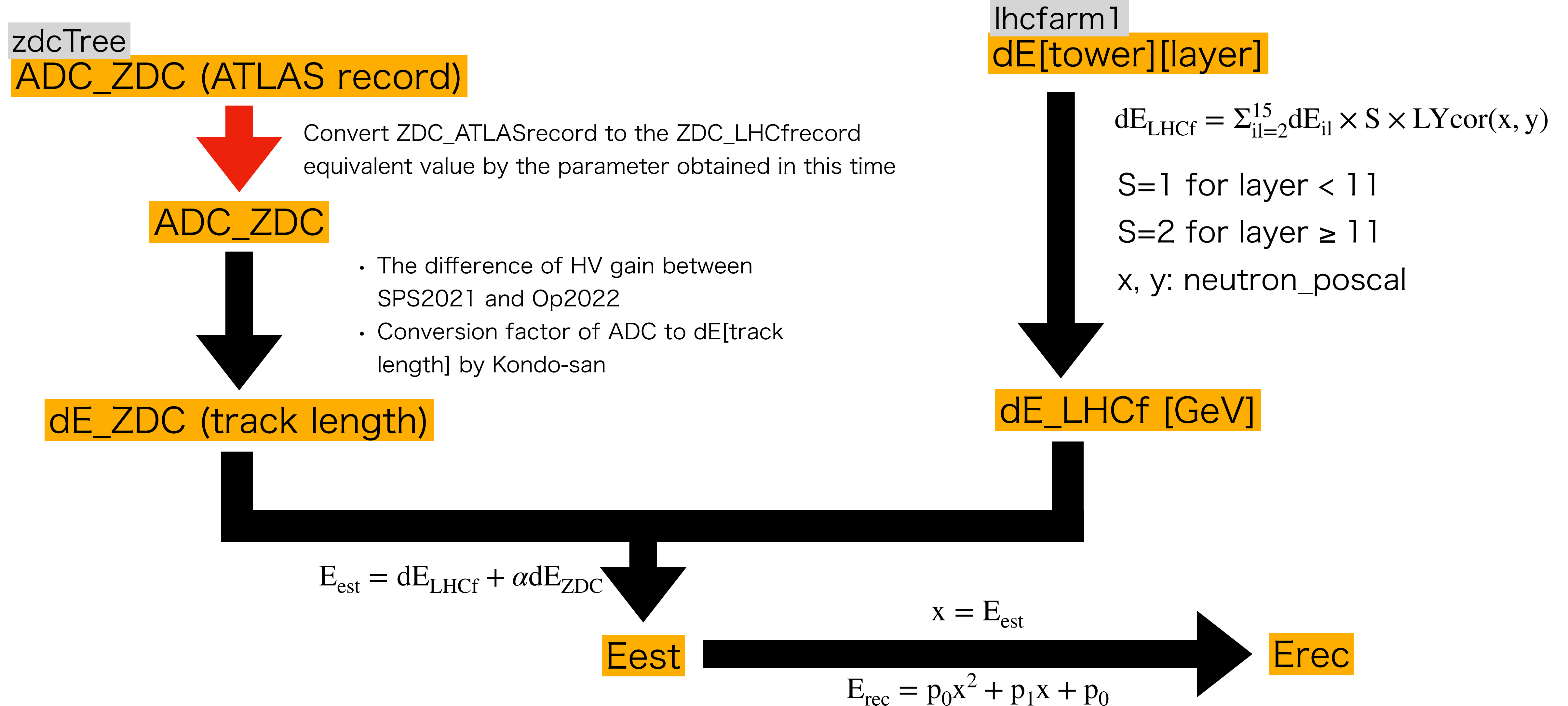


TL, 16mm < x < 24mm

Op2022 neutron analysis flow

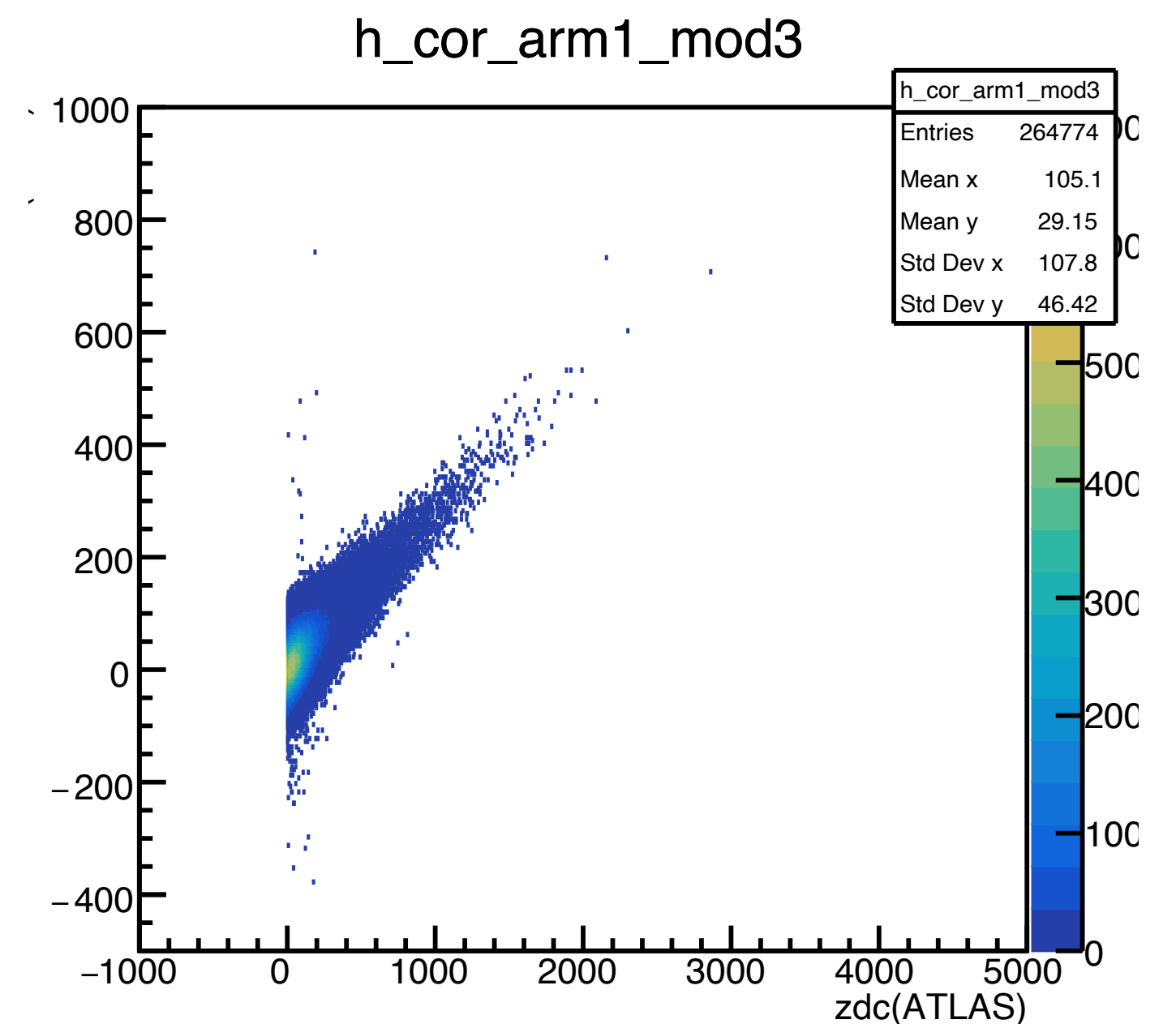
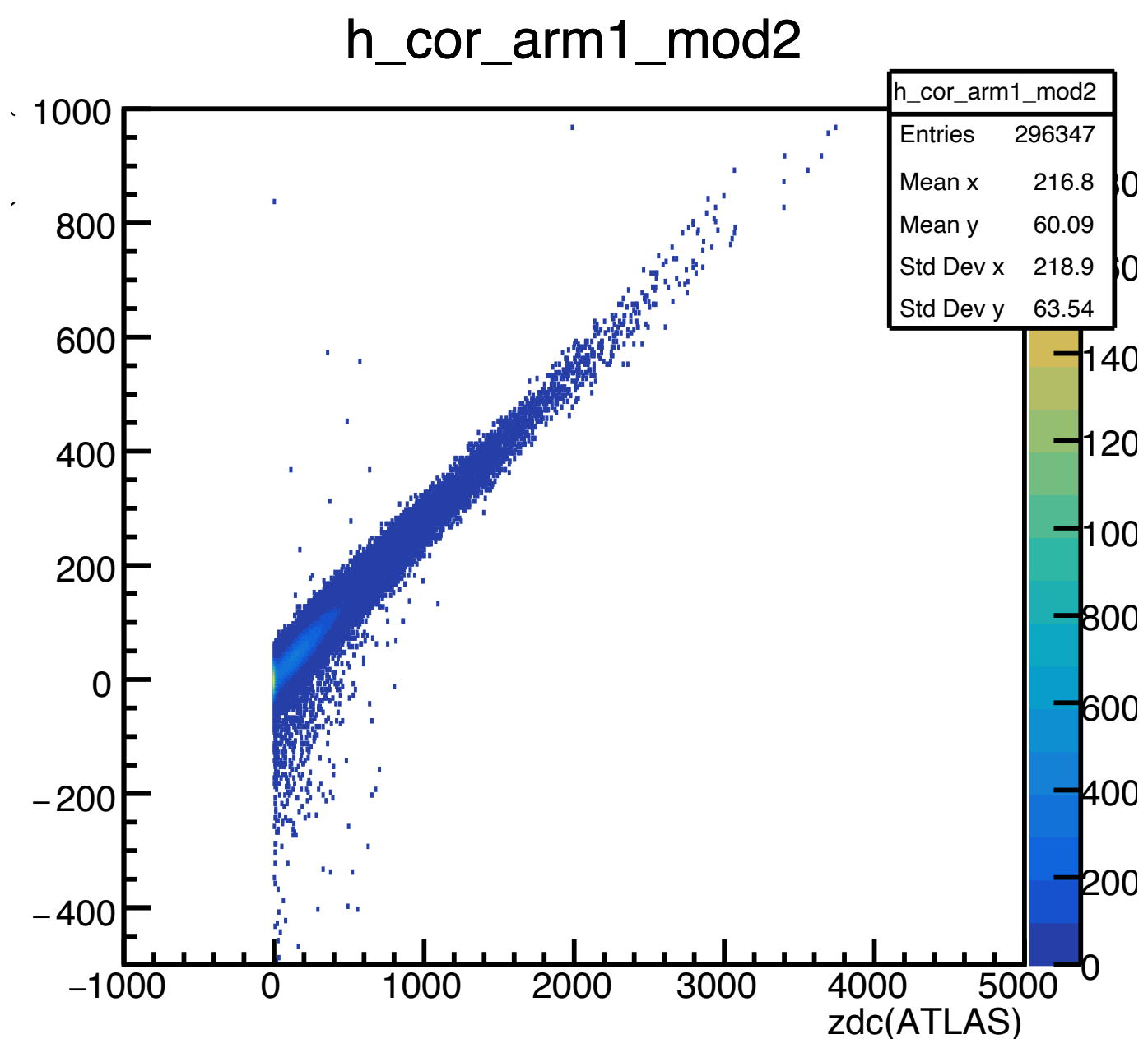
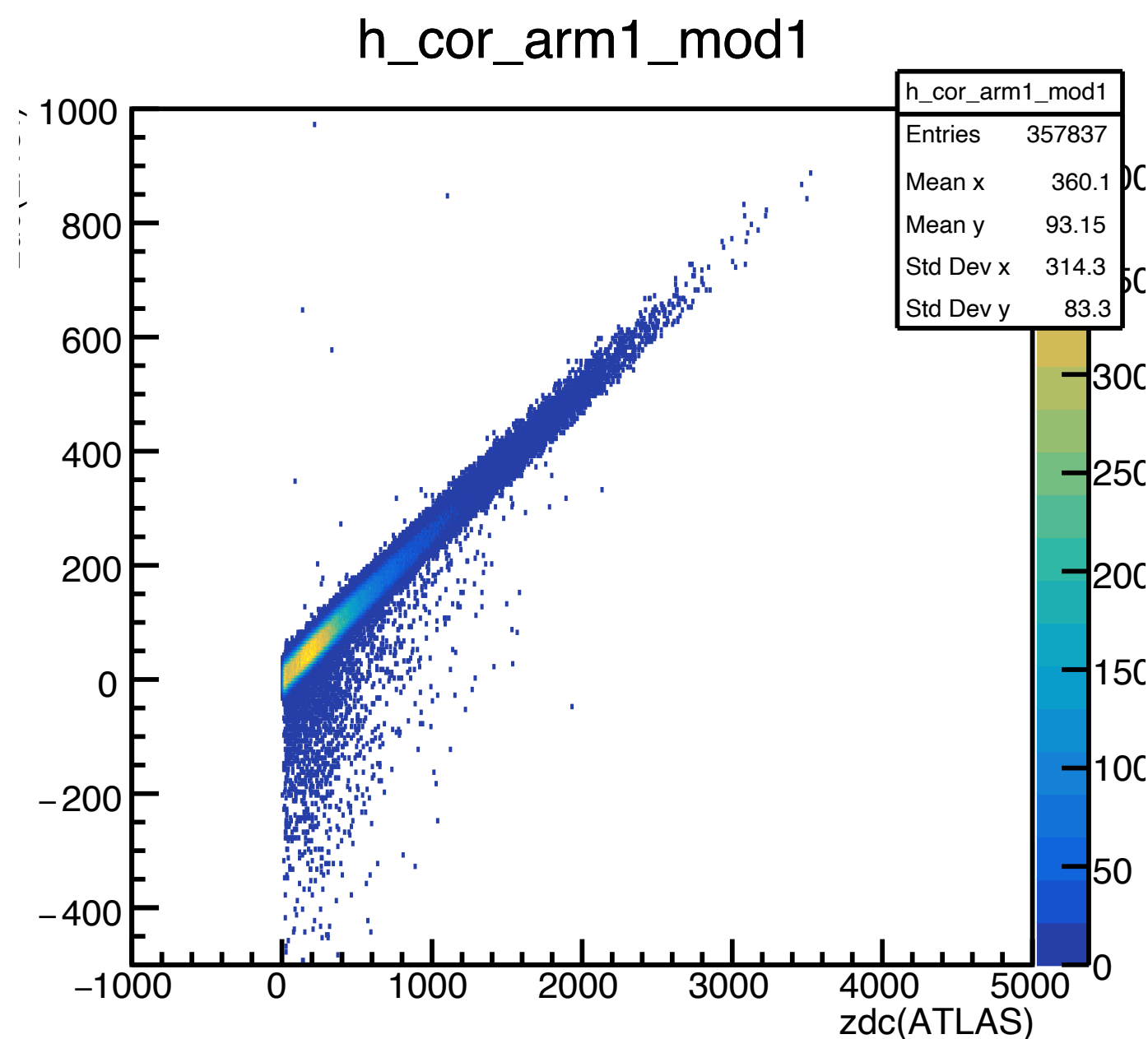
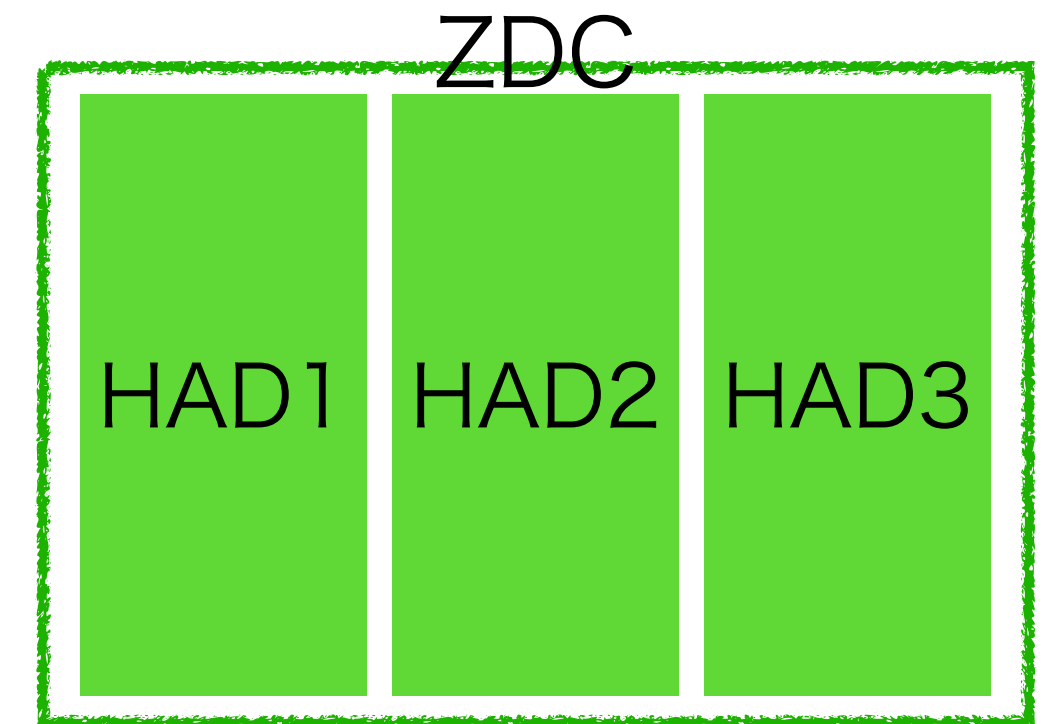


Op2022 neutron analysis flow



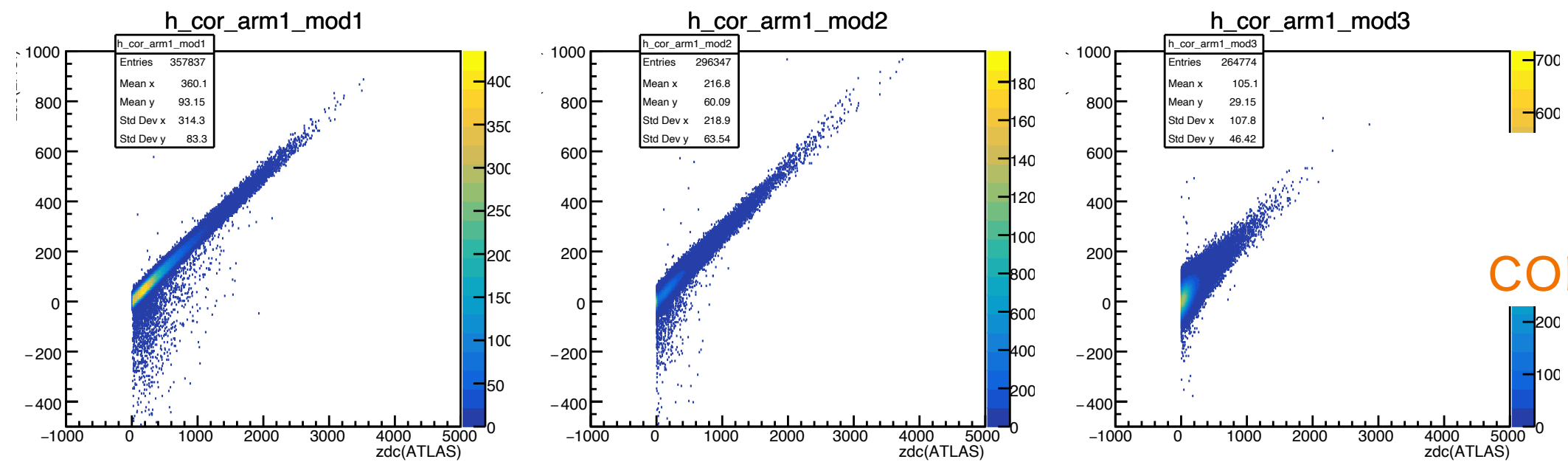
Correlation of zdc value recorded in LHCf and ZDC

- Arm1 side (side A)
- Run 80262 (850k event)
- X axis: recorded by ATLAS (ADC)
- Y axis: recorded by LHCf (ADC)

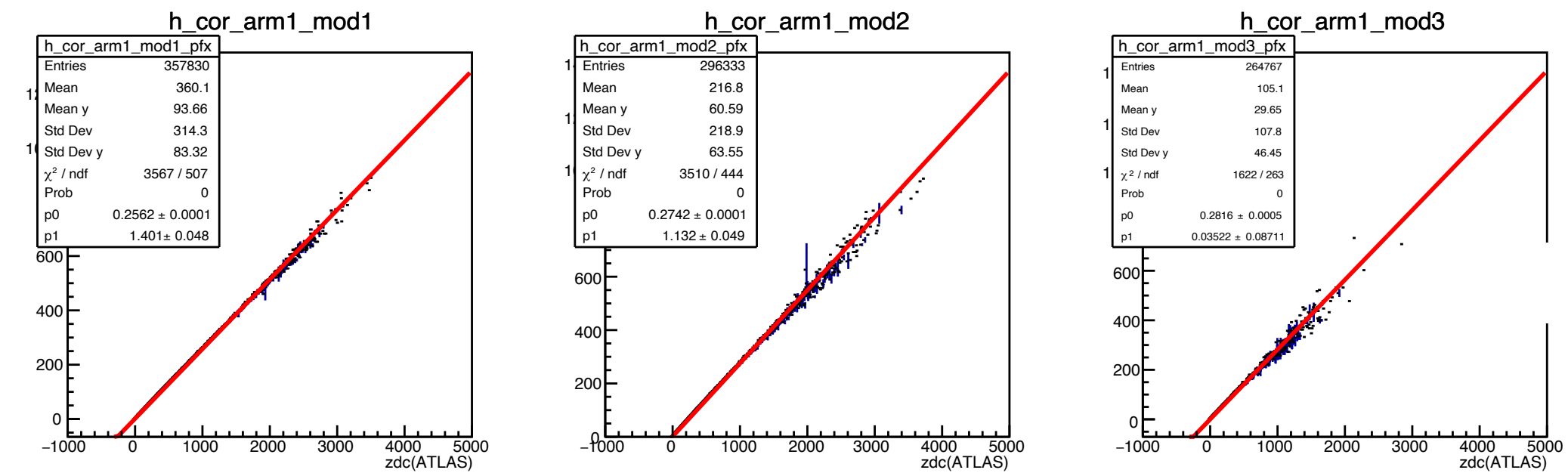


Correlation of zdc value recorded in LHCf and ZDC

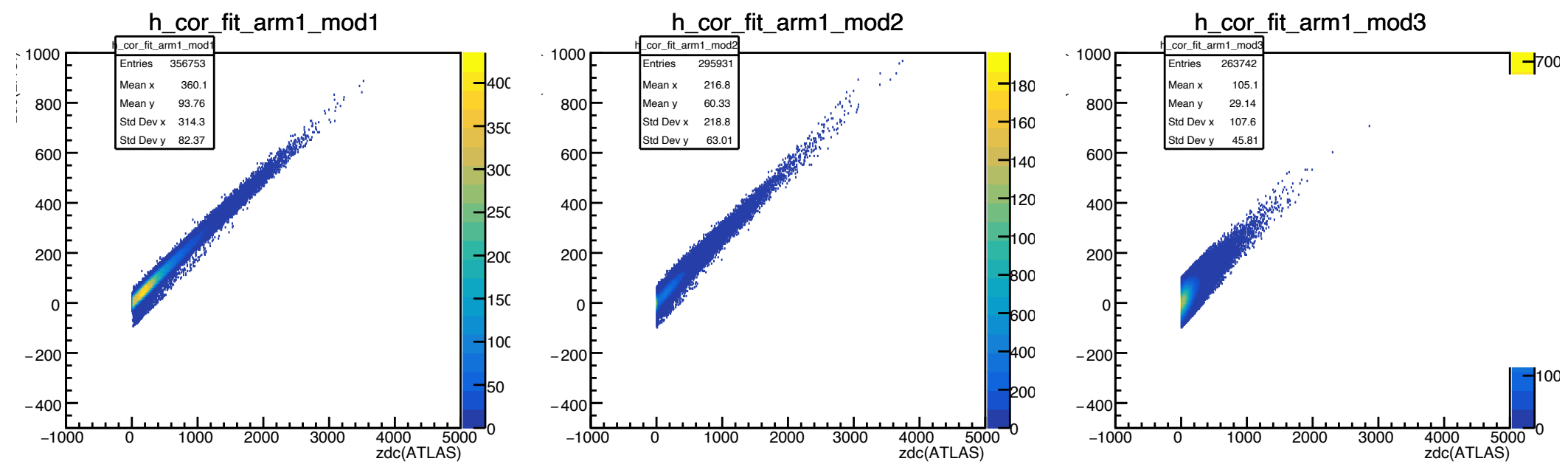
- Arm1 side (side A)
- Run 80262 (850k event)
- X axis: recorded by ATLAS (ADC)
- Y axis: recorded by LHCf (ADC)



Original correlation plot



1st fitting

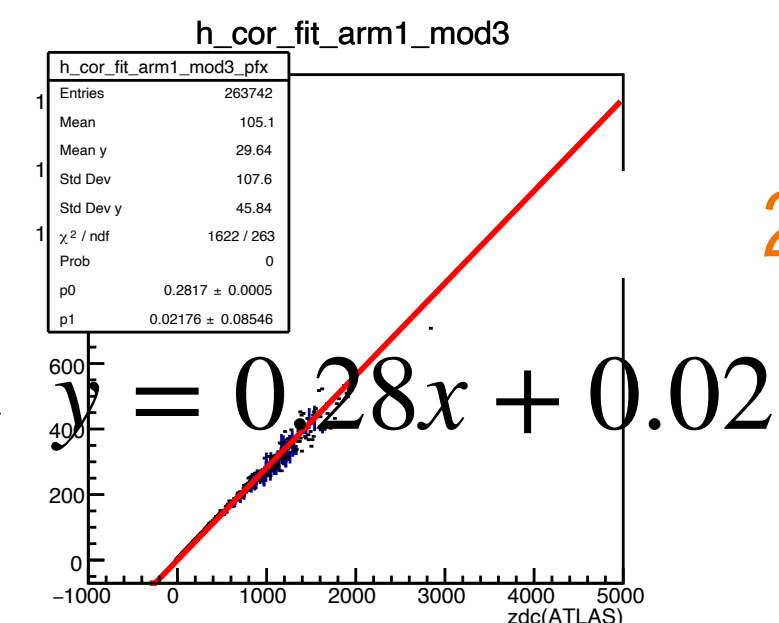
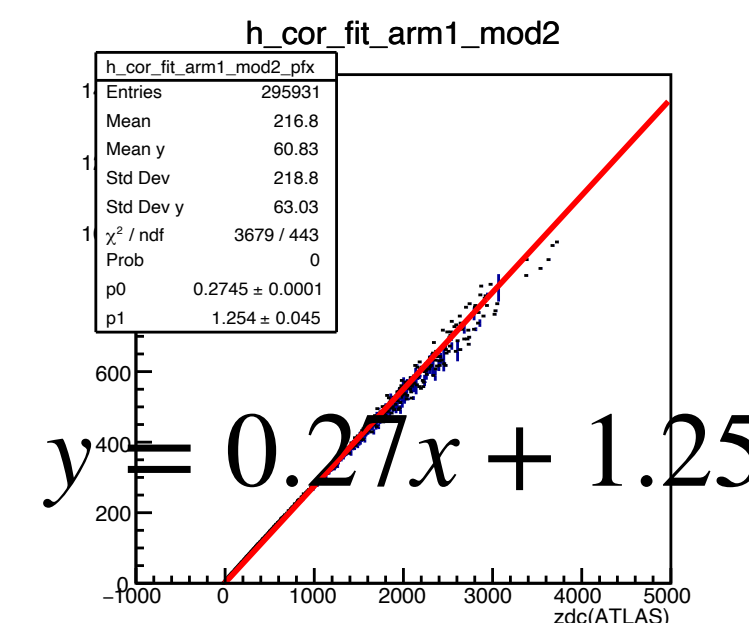
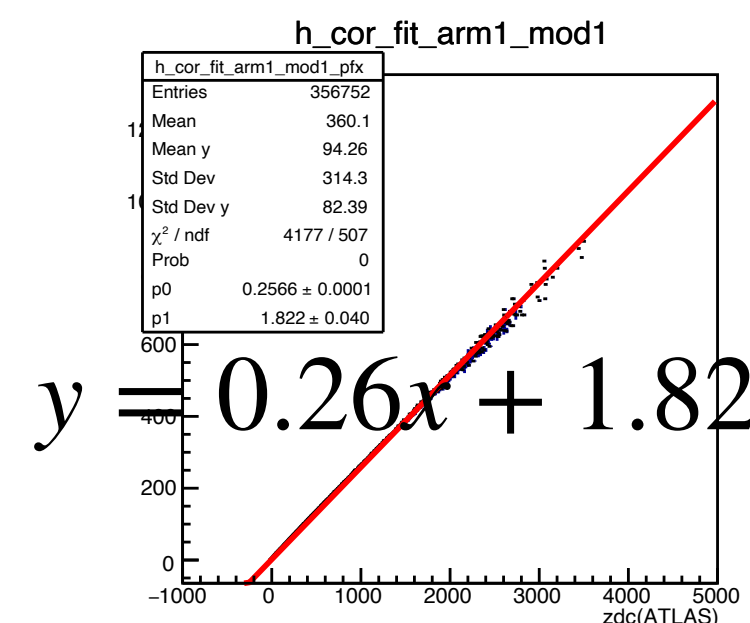


Exclude the event that $|f(x) - y| > 100$

Use this fit parameter

Fit parameter: p0 and p1

$$y = p0 * x + p1$$

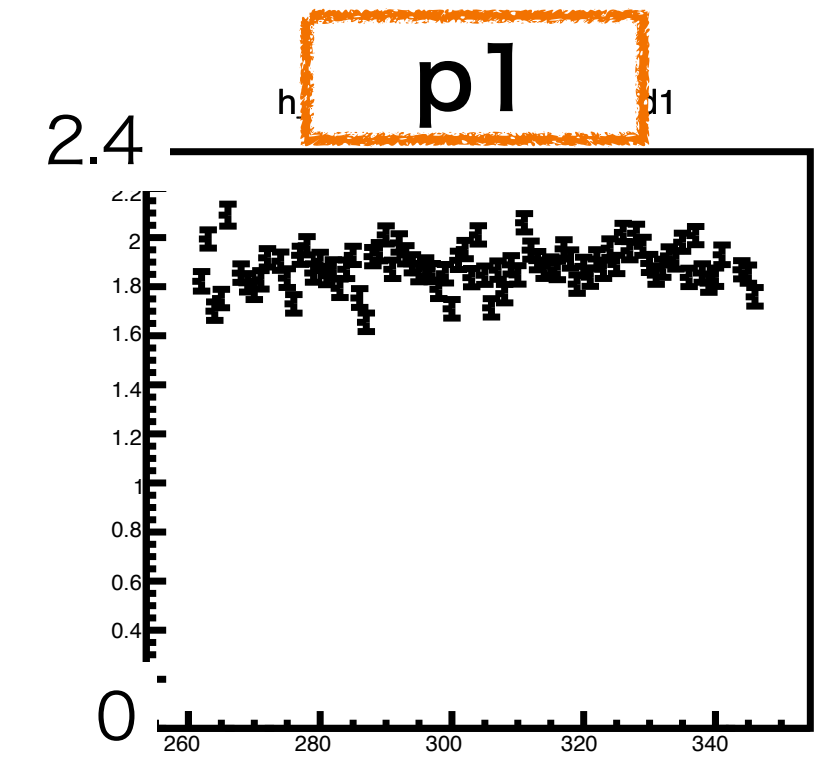
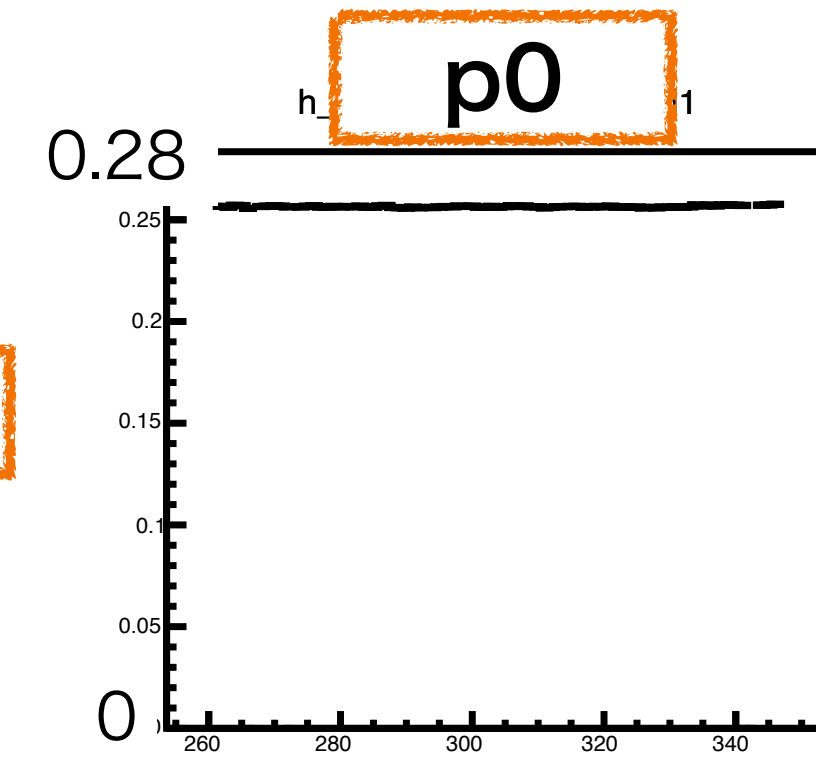


2nd fitting

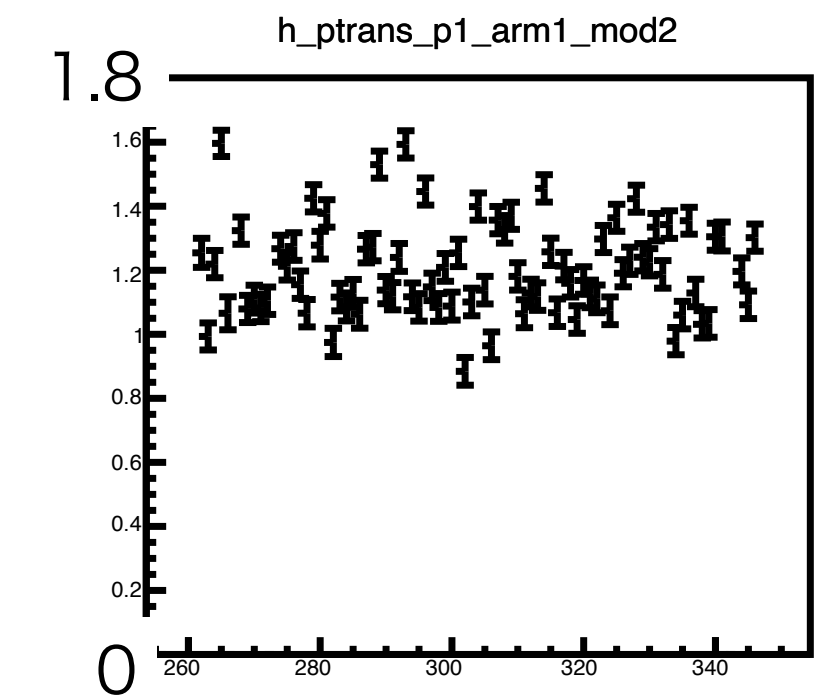
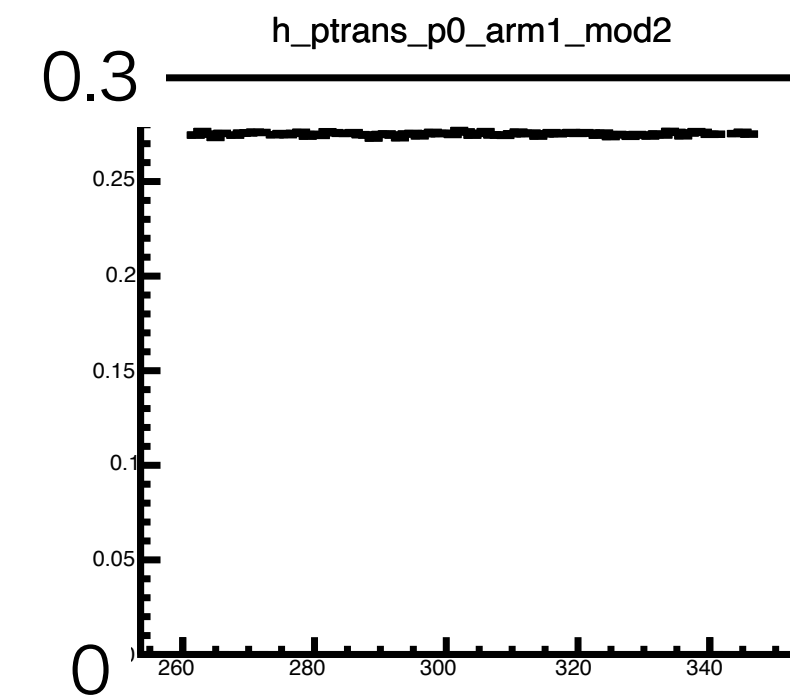
Correlation of zdc value recorded in LHCf and ZDC

- Arm1 side
- Time transition of fit parameter (run 80262 - 80346)
- X axis: LHCf run
- Y axis: parameter value

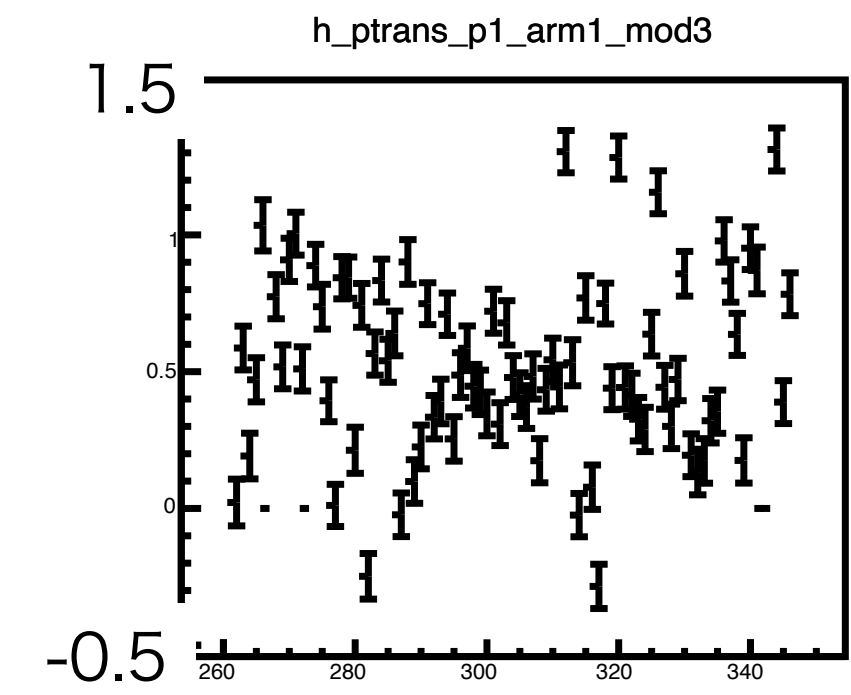
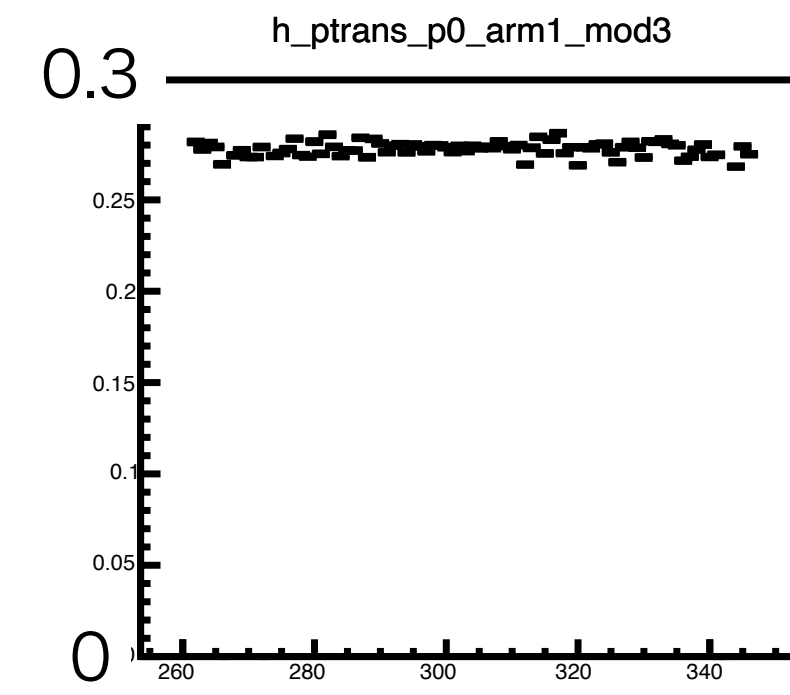
HAD1



HAD2

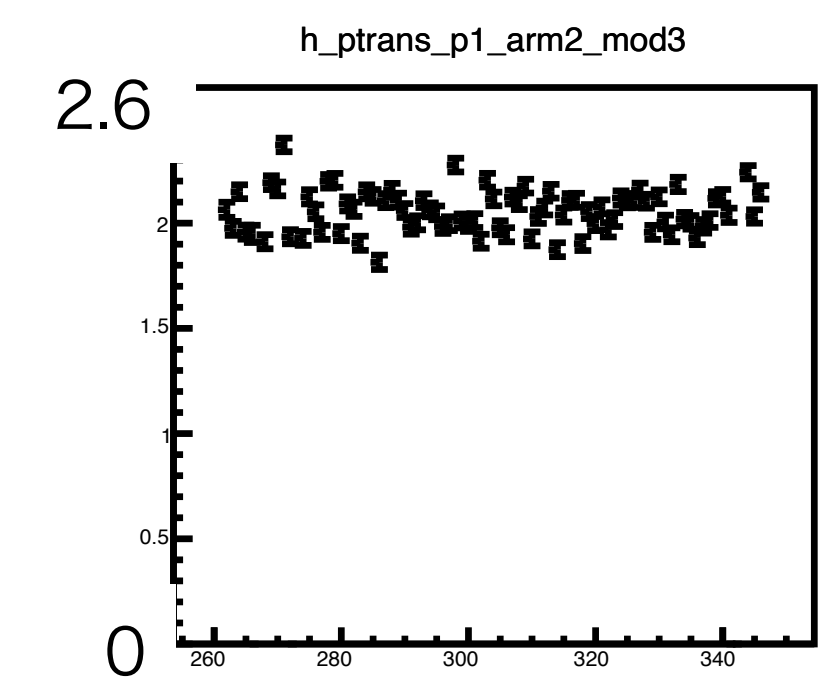
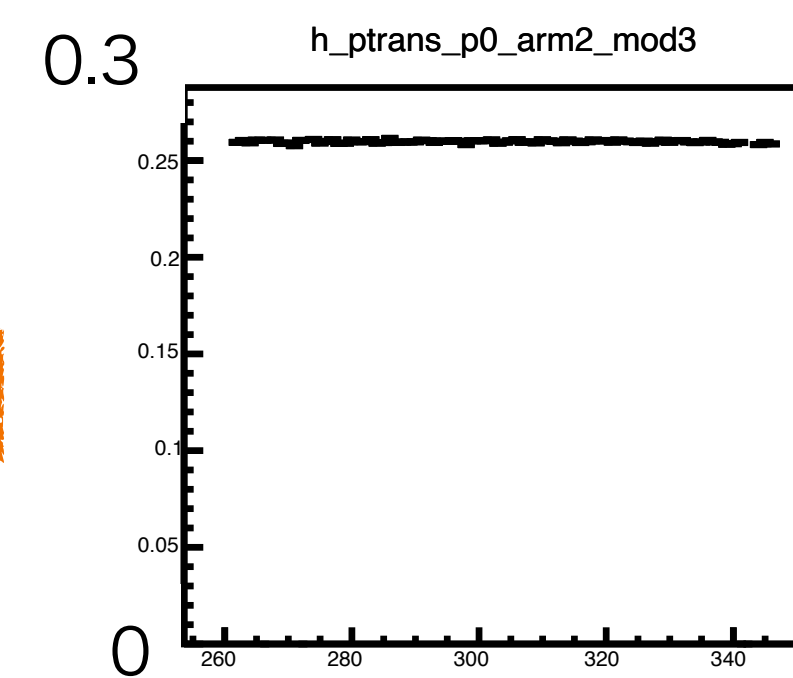
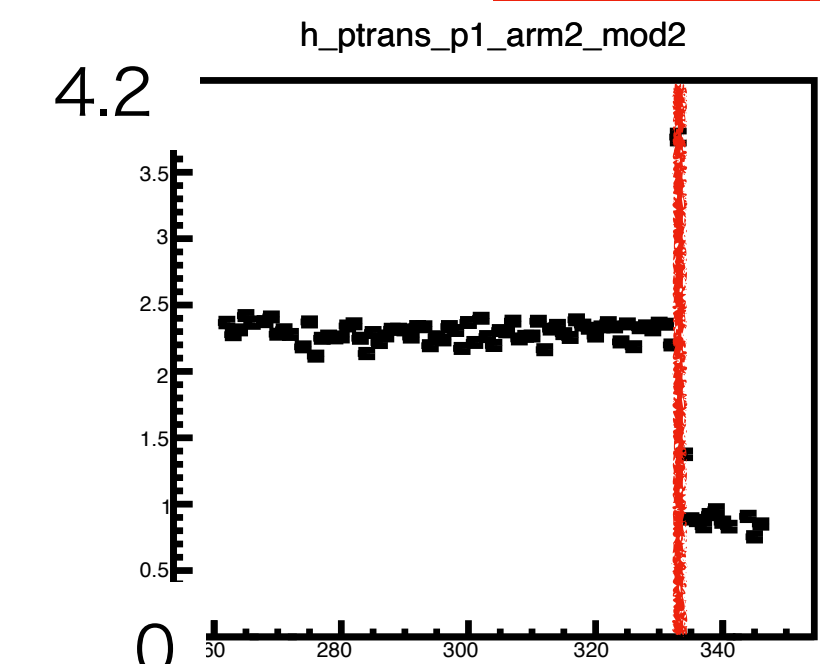
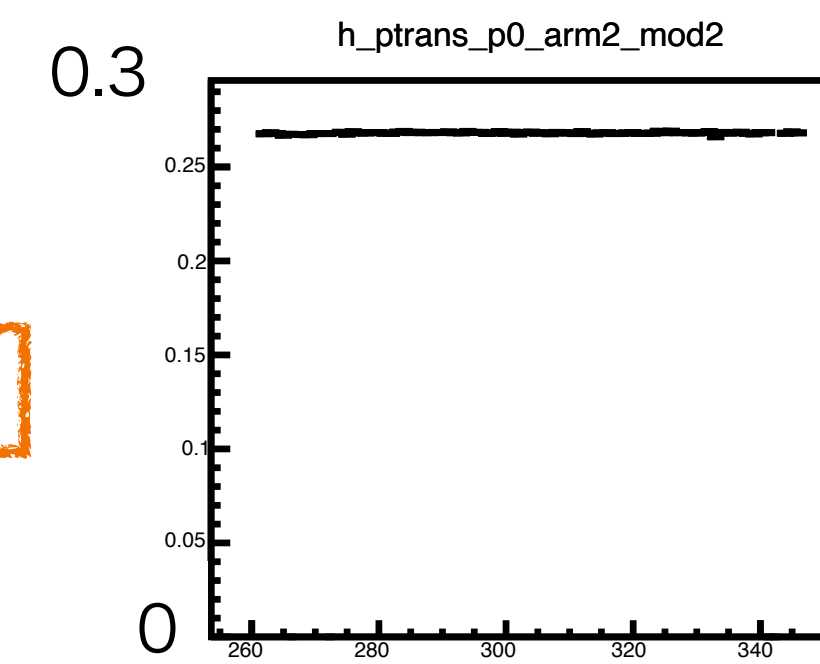
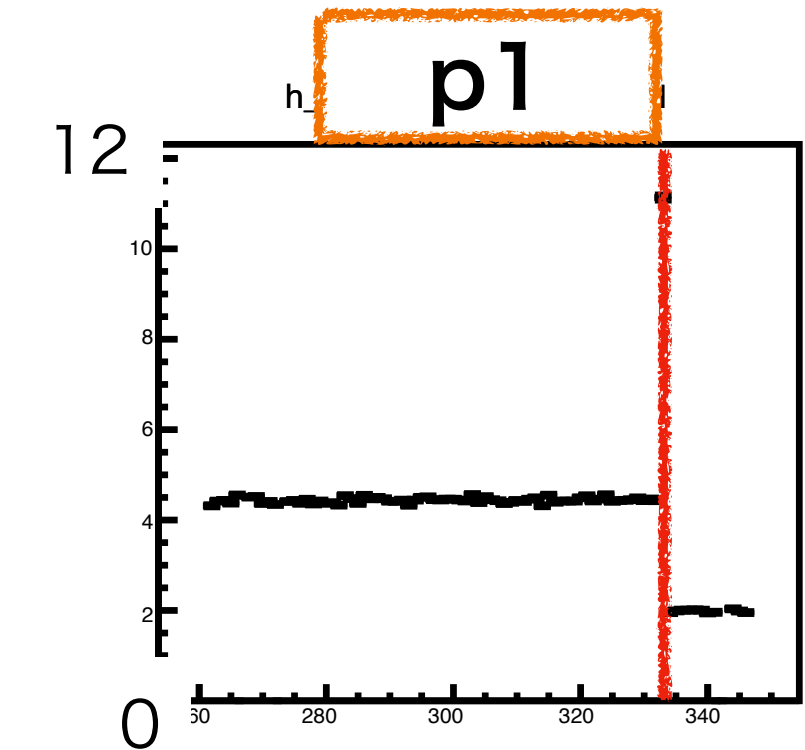
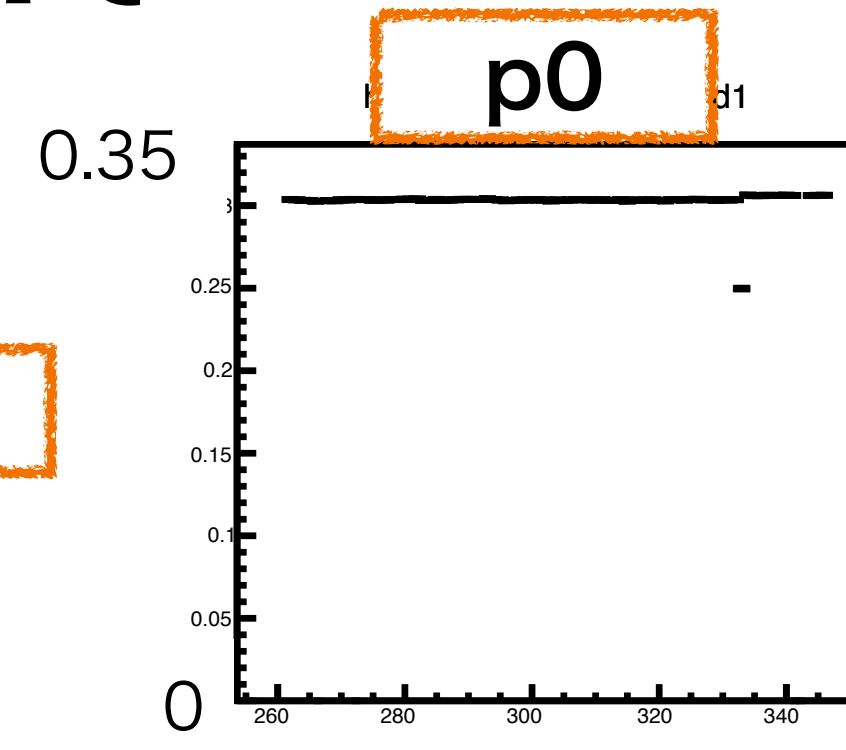


HAD3



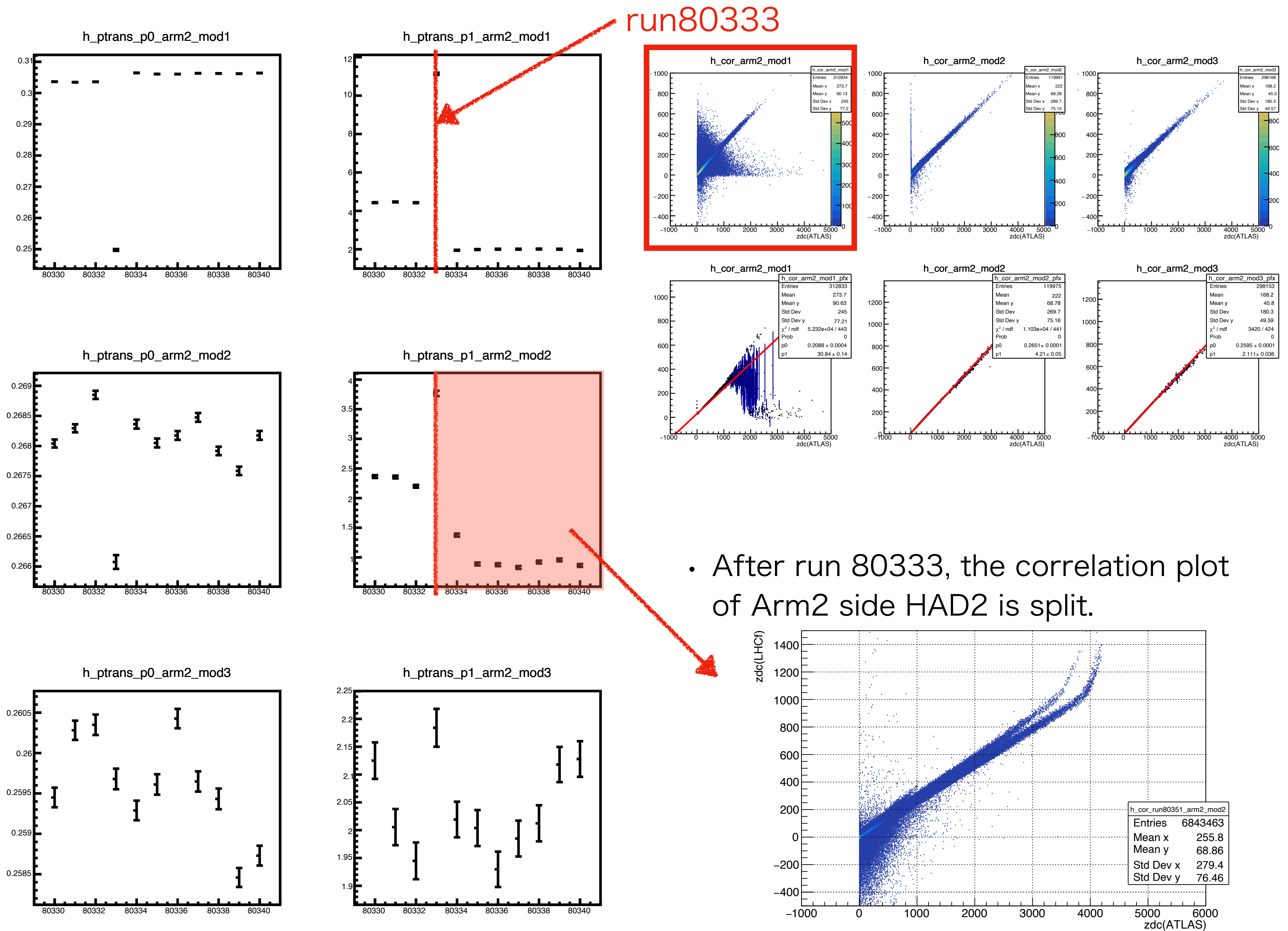
Correlation of zdc value recorded in LHCf and 7DC

- Arm2 side
- Time transition of fit parameter (run 80262 - 80346)
- X axis: LHCf run
- Y axis: parameter value



Correlation of zdc value recorded in LHCf and ZDC

Arm2 side
Run80330-80340



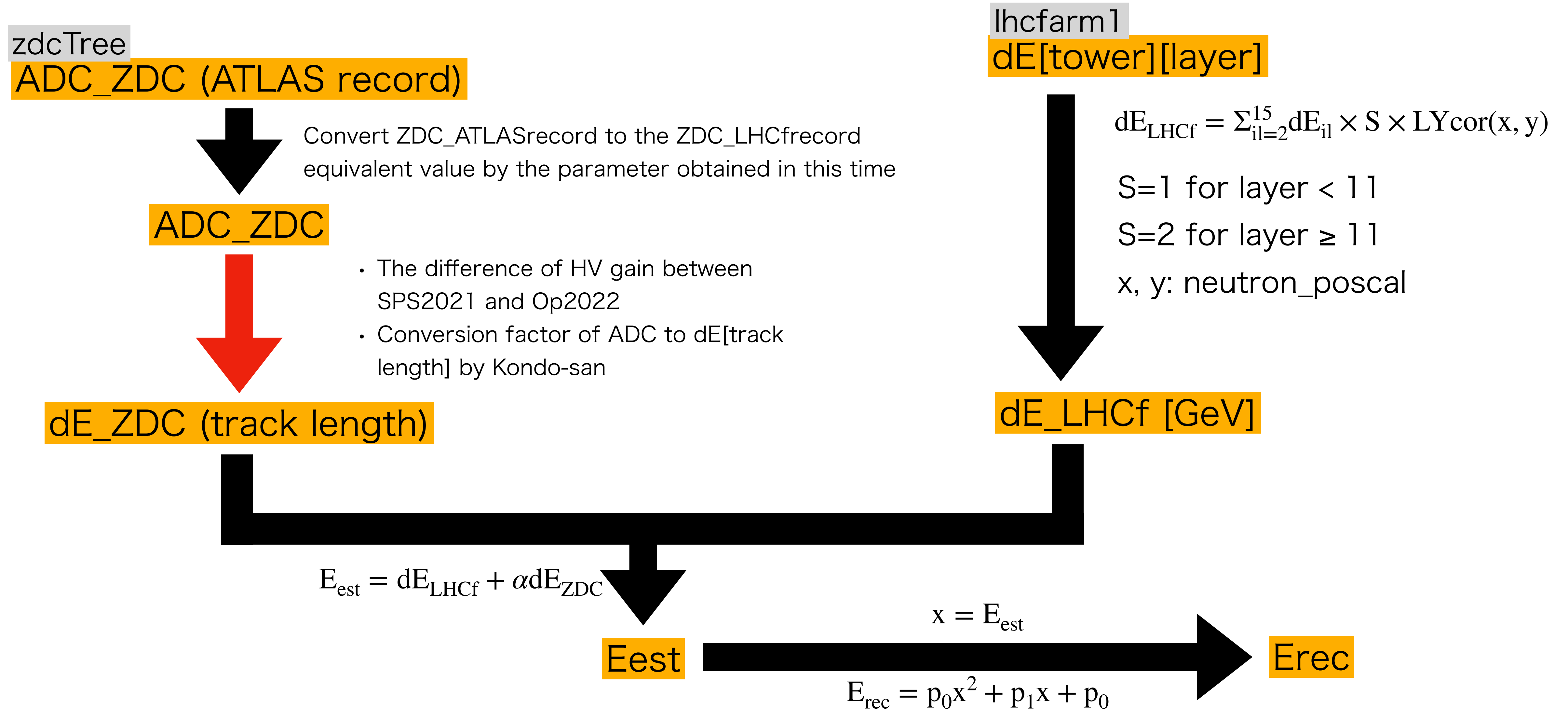
- After run 80333, the correlation plot of Arm2 side HAD2 is split.

Correlation of zdc value recorded in LHCf and ZDC

- According to log book of ATLAS,
- they changed the cables of HAD1 and HAD2.
- This may be this issue.

- Now we discuss about this issue with ATLAS ZDC group.

Op2022 neutron analysis flow



Convert ADC to dE of ZDC

- From Kondo-san's study,
- Conversion factor of HV gain between SPS2021 and Op2022
 - HAD1: 7.92, HAD2: 3.2, HAD3: 3.32
- Multiplied by 8 because I use the wide range value. In SPS analysis,
I use narrow range value.
- Conversion factor of ADC to dE[track length] by comparing MC to SPS2021 (Kondo-san).
 - HAD1: 0.15, HAD2: 0.23, HAD3: 0.31

Selection criteria of neutron event

- $r < 6$ mm
 - r is the distance from beam center.
- Hadron trigger of LHCf
 - The trigger turns on when there was energy deposit in three consecutive layers between layer 10 to 15
- Software trigger
 - The trigger is on when $dE > 0.6$ GeV in 3 consecutive layers.
- PID cut
 - `neutron_pid` of LHCf reduction tree is true.

Selection criteria

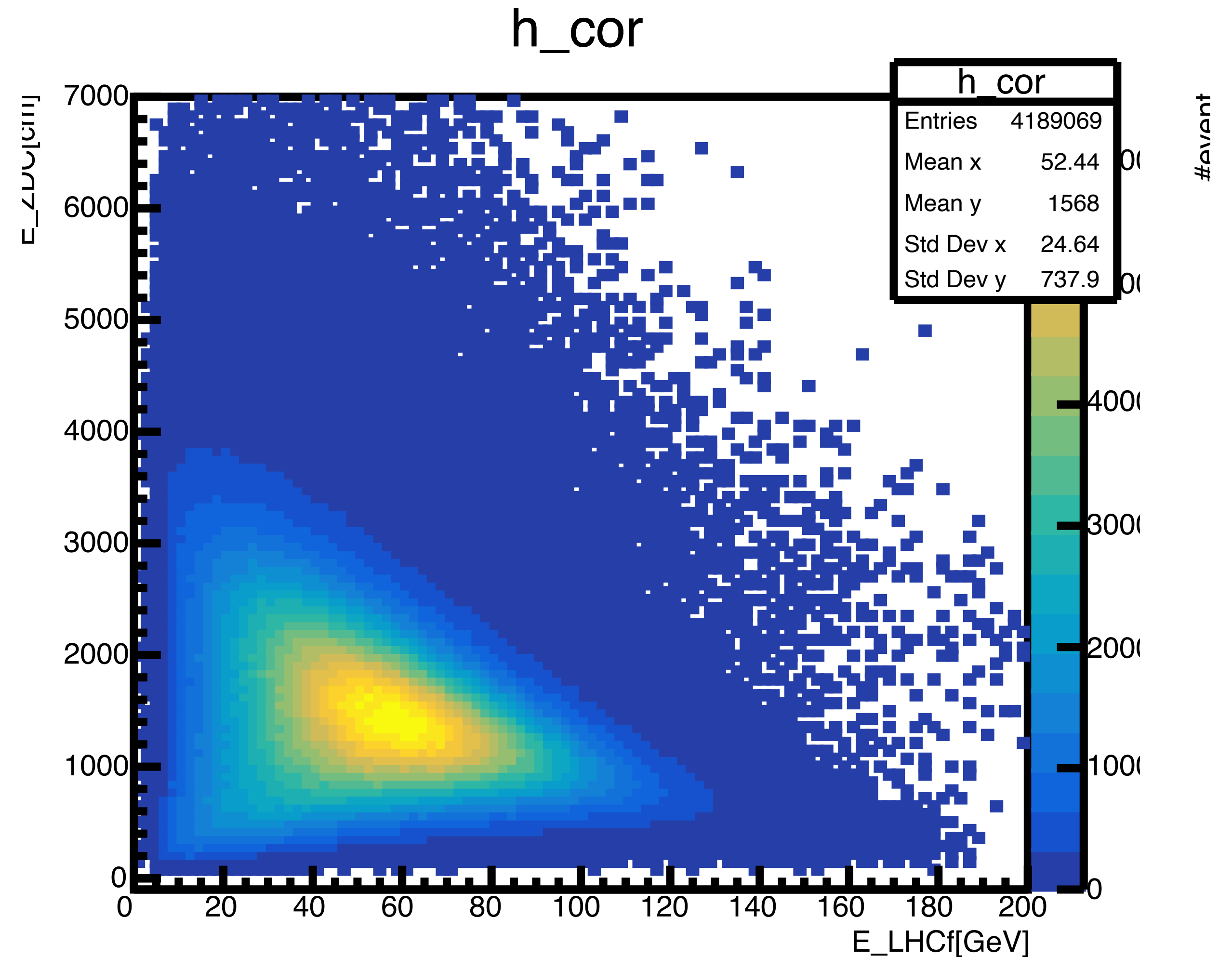
- $r < 6$ mm
- Hadron trigger
- Software trigger
- PID cut

Correlation of dE_LHCf and dE_ZDC

- Arm1
- Run80262-80346

Selection criteria

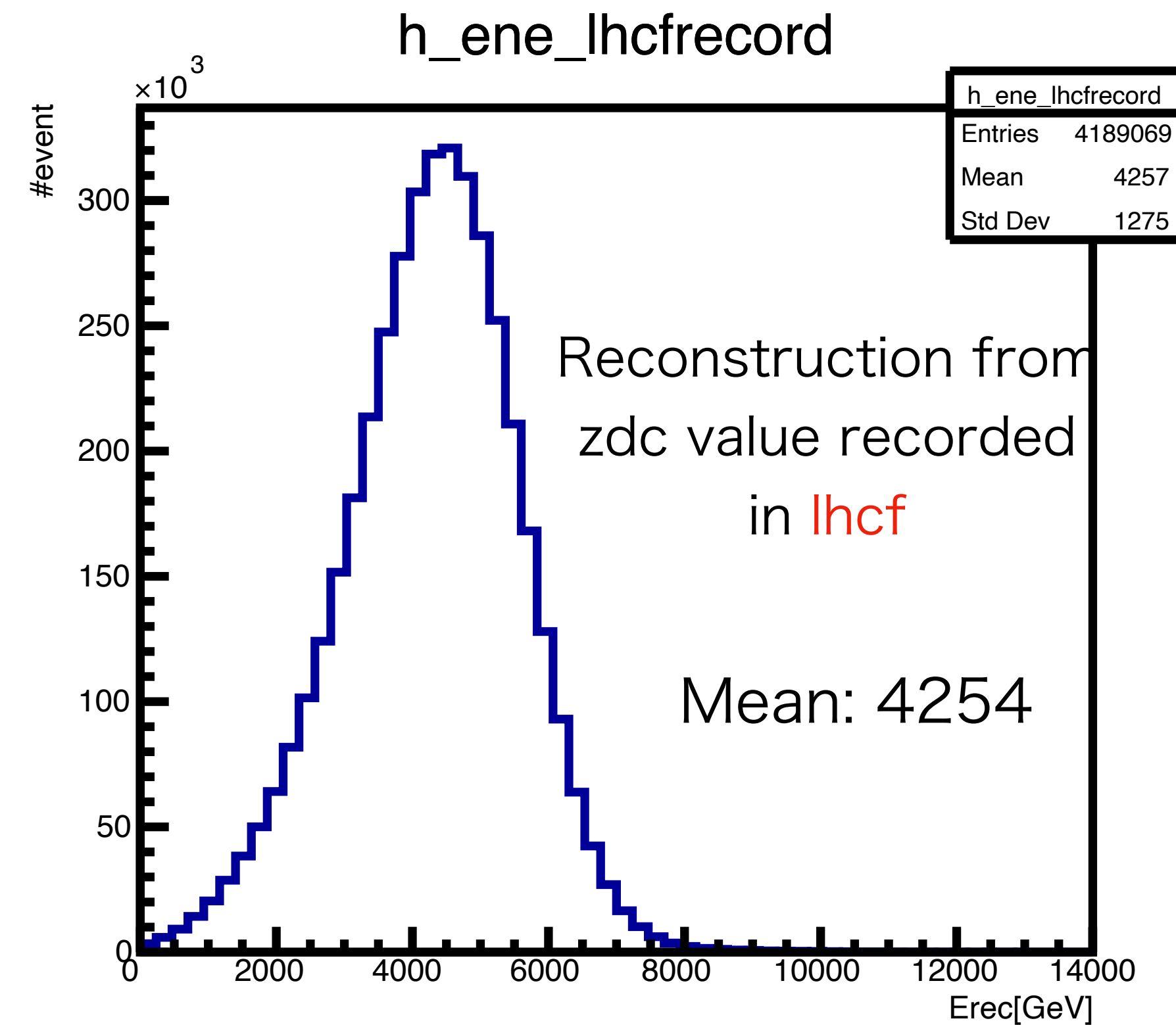
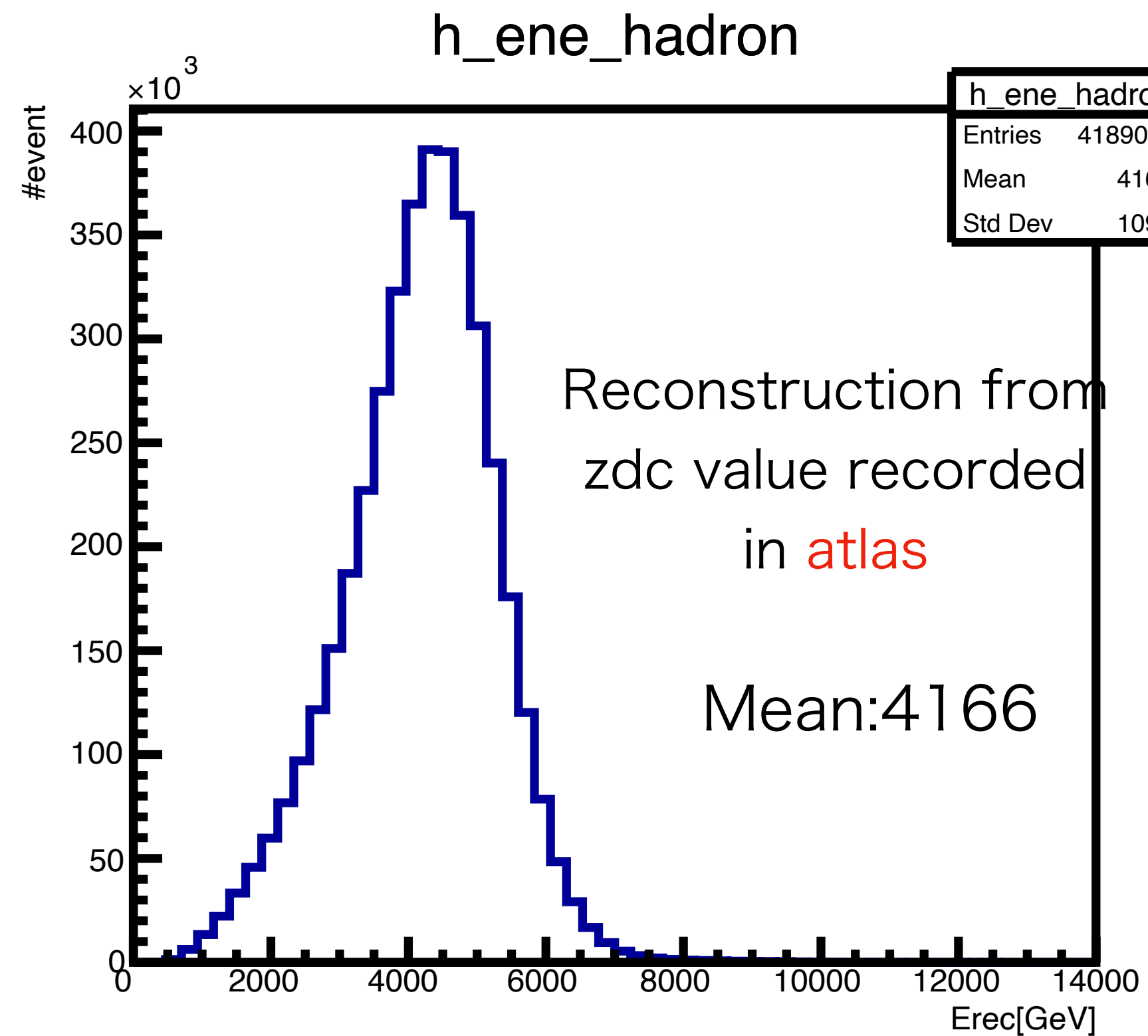
- $r < 6$ mm
- Hadron trigger
- Software trigger
- PID cut



Neutron energy spectrum

- Selection criteria
- $r < 6$ mm
 - Hadron trigger
 - Software trigger
 - PID cut

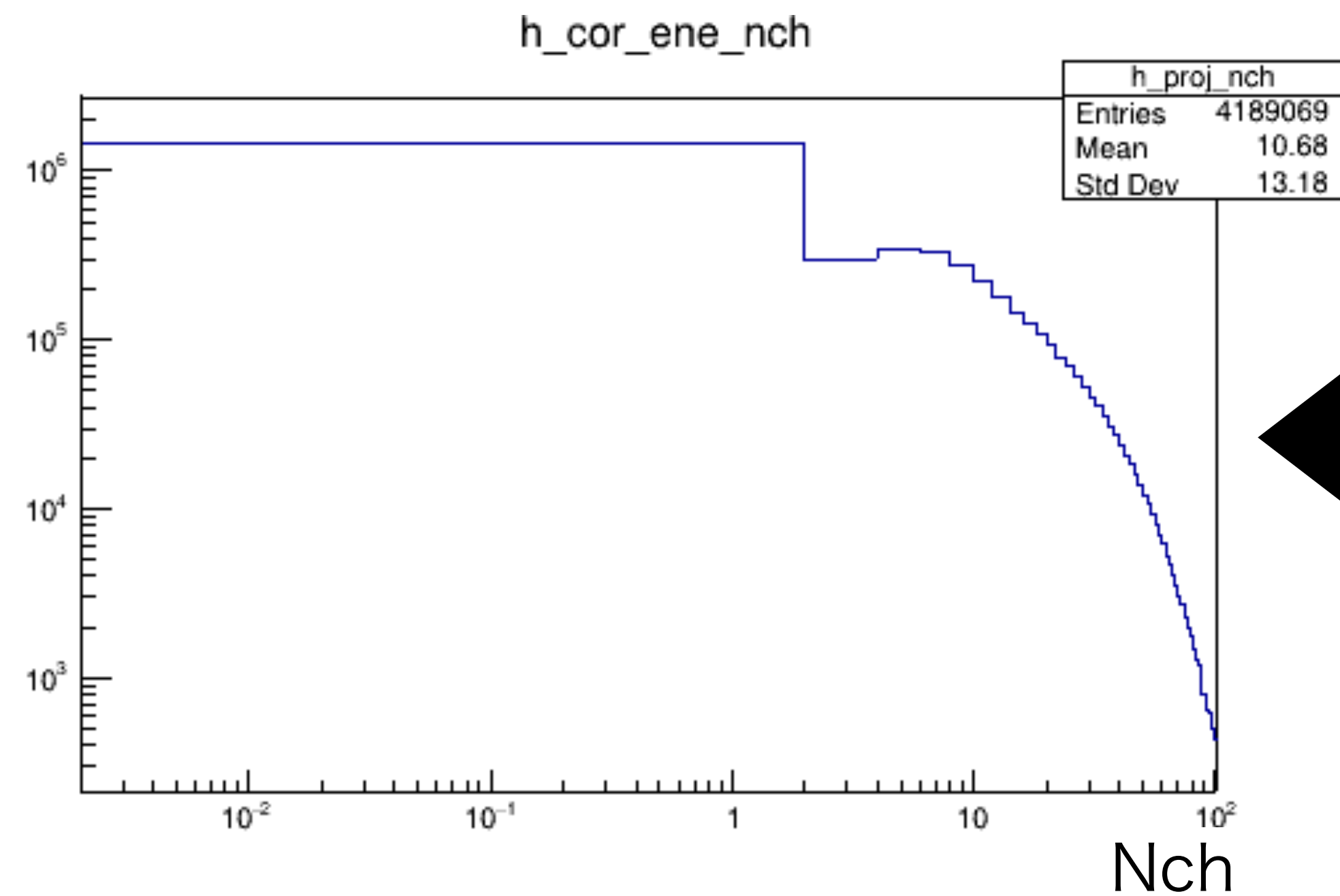
Energy distribution become shaper



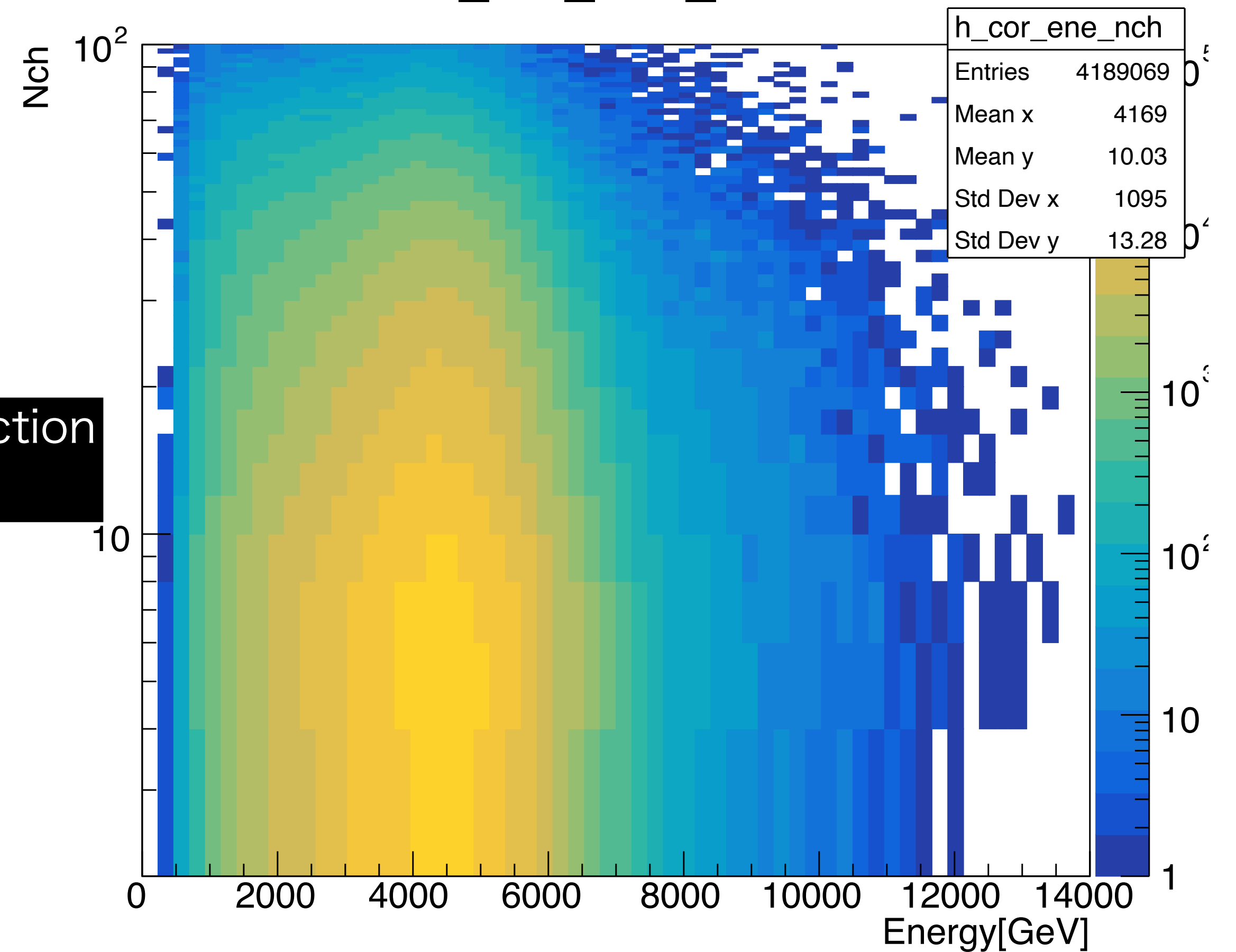
Multiplicity and energy

- Run 80262 - 80346

h_cor_ene_nch

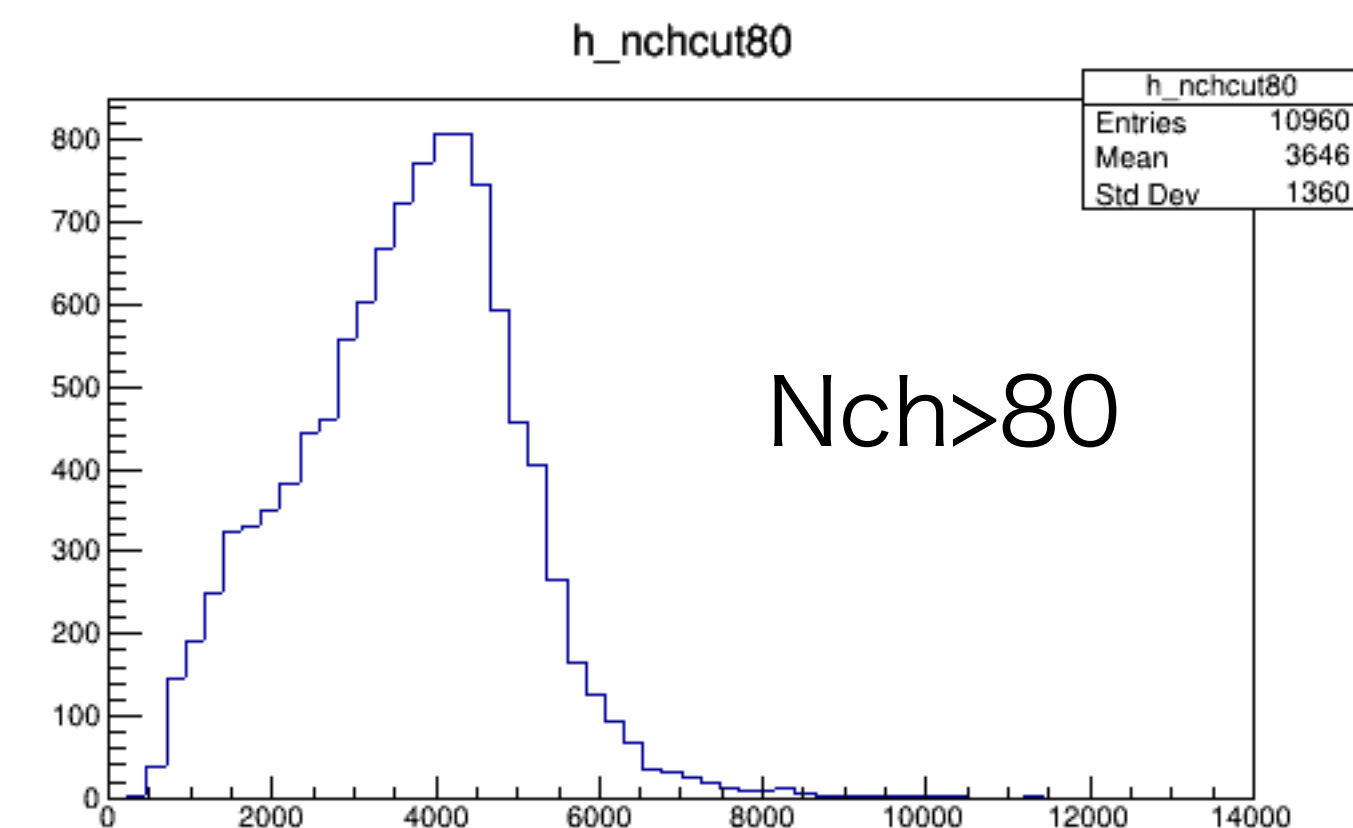
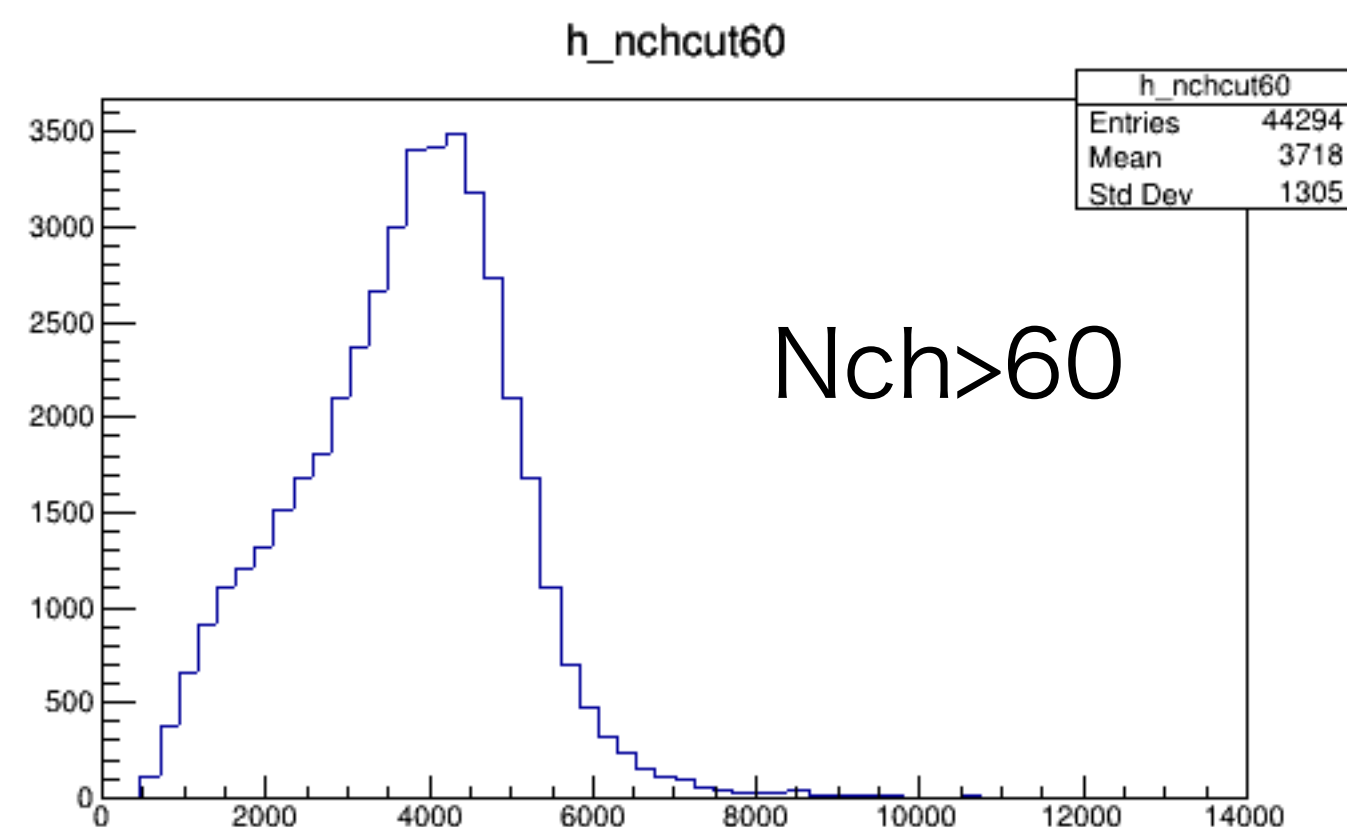
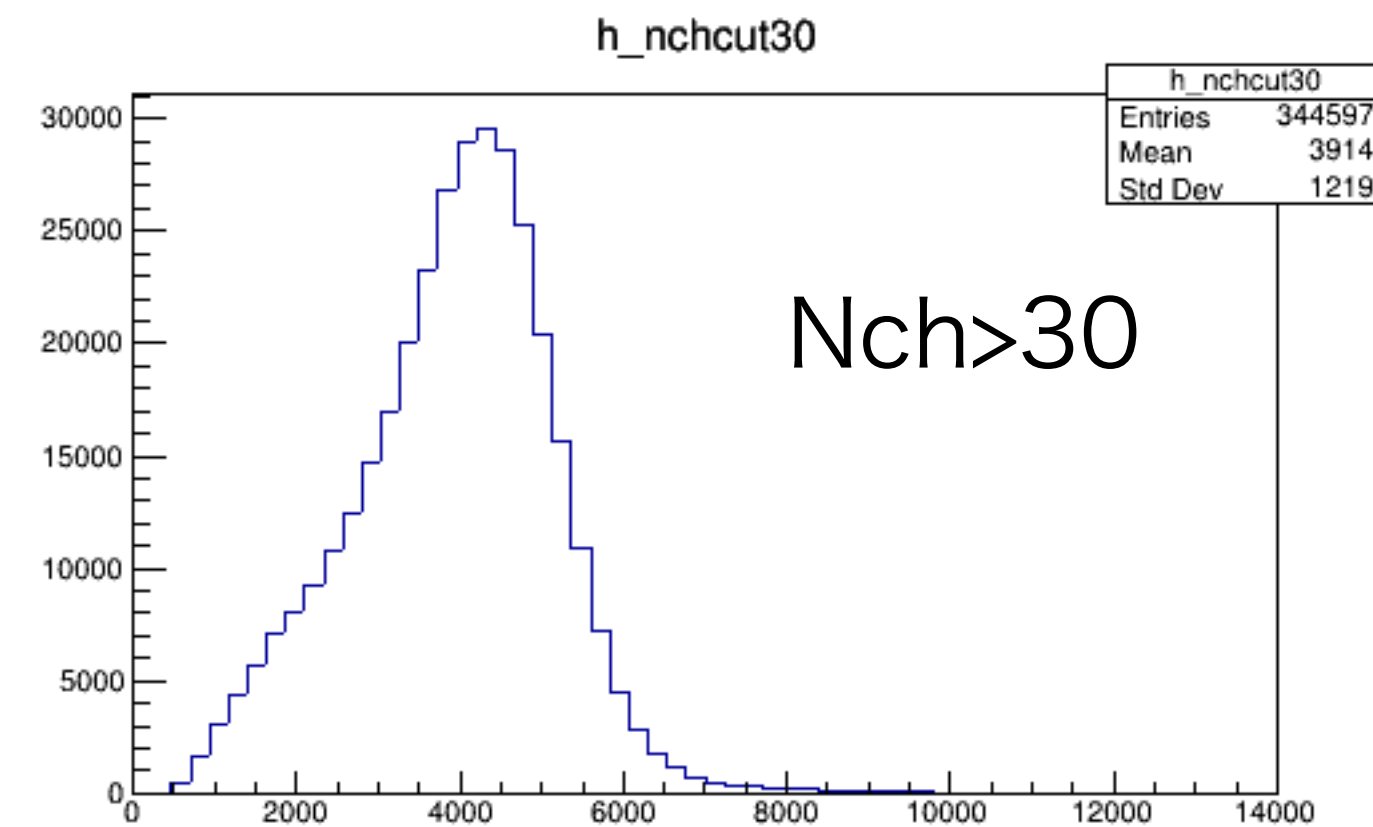
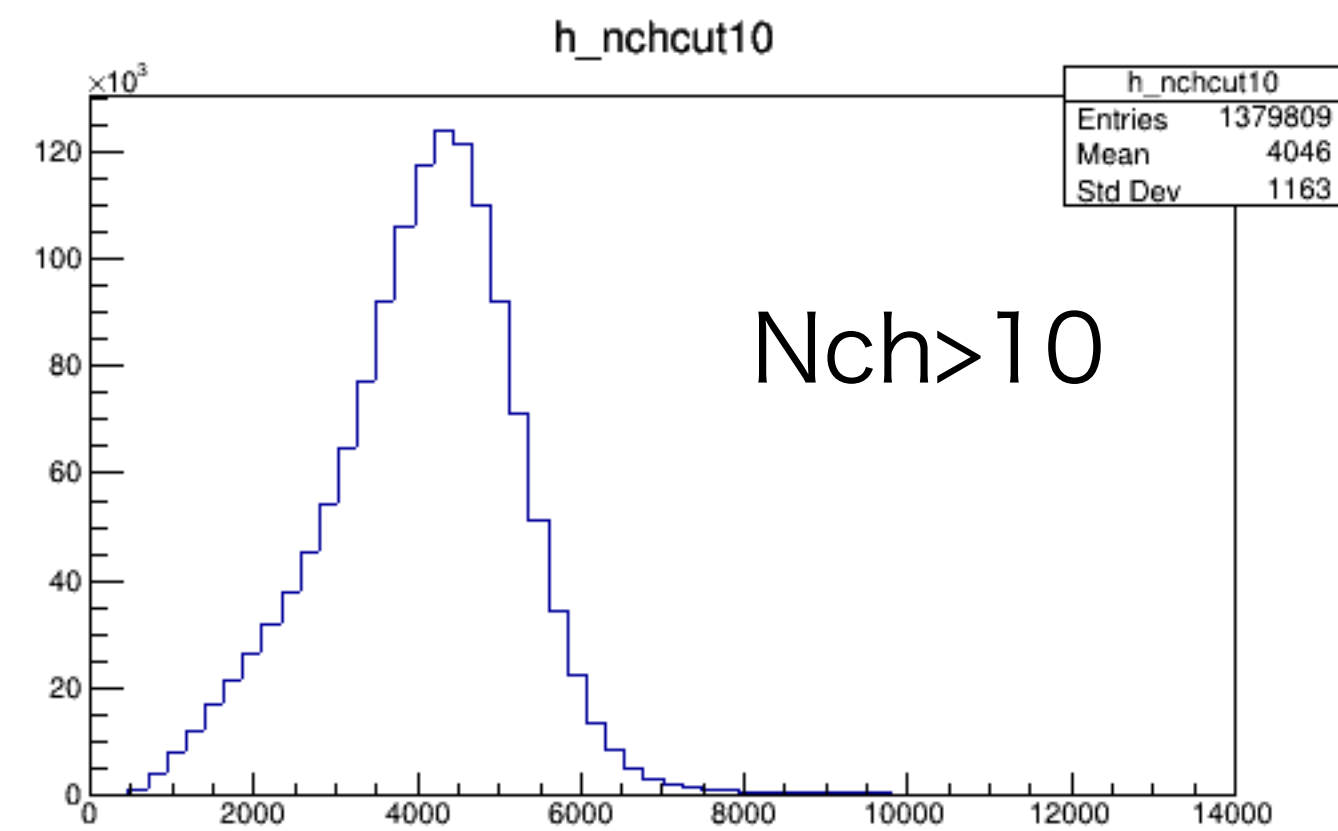


Projection
Y



Neutron energy spectrum with multiplicity cut

- N_{ch} : the number of particles detected in ATLAS central detector
- OPE event will have high multiplicity (Ohashi-san, ICRC2021 proceedings)



Future

- Unfolding of Op2022 data
 - I have to do 2D unfolding of neutron energy and N_track of ATLAS.
 - I made the MC that only neutrons are injected. (TS: 2M events, TL: 4M events)
- Calibration of LHCf Arm1 deeper layer
 - I want idea for this calibration.
- L2D distribution for neutron PID with MC of Op2022
 - I did reconstruction of the MC events made by Menjo-san (EPOSLHC, pp 13.6 TeV).