

# **E570 analysis report**

## **In-flight event ratio and its correction**

**Hideyuki Tatsuno**

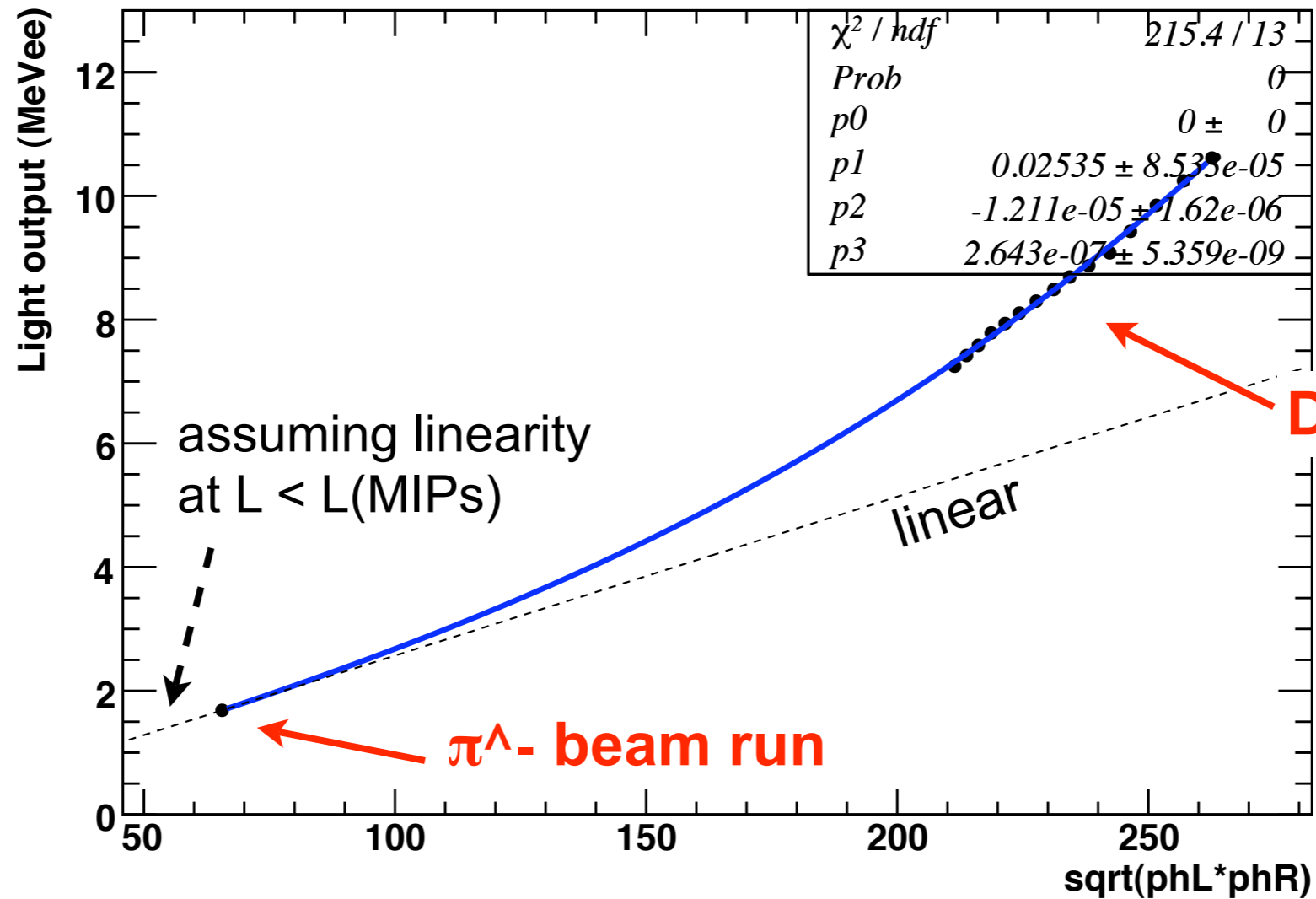
**18-21 Jan 2008**

# T0 tune (1)

Each T0 light output was normalized using a negative pion run (run 246 for 1st cycle and run 515 for 2nd cycle)

## Gain Saturation of T0(3) run 333

Simulated light output  
using GEANT4



Data L(z-vertex)  
(15 points)

$\pi^-$ - beam run

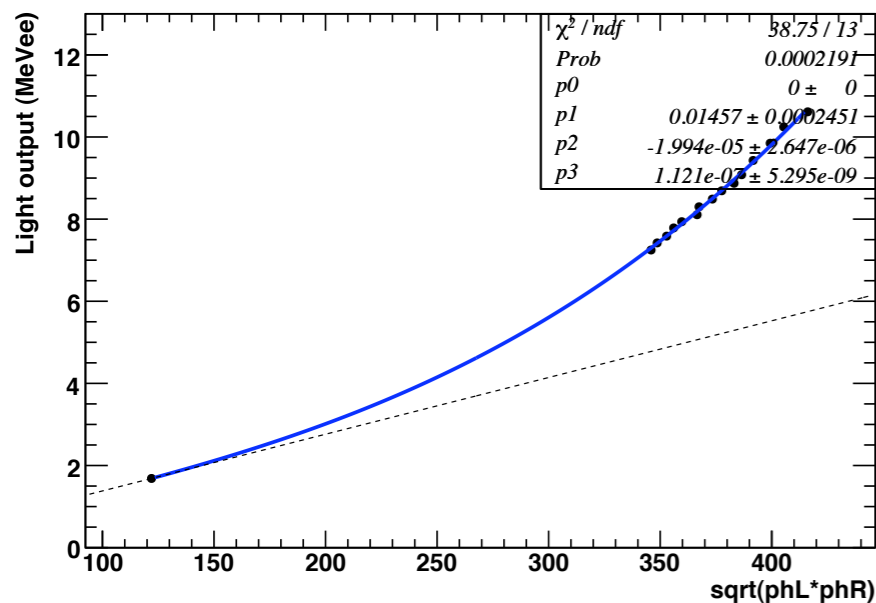
Including Birk's effect

$$\frac{dL}{dx} = \frac{\frac{dE}{dx}}{1 + kB \frac{dE}{dx}} \quad (kB = 0.013)$$

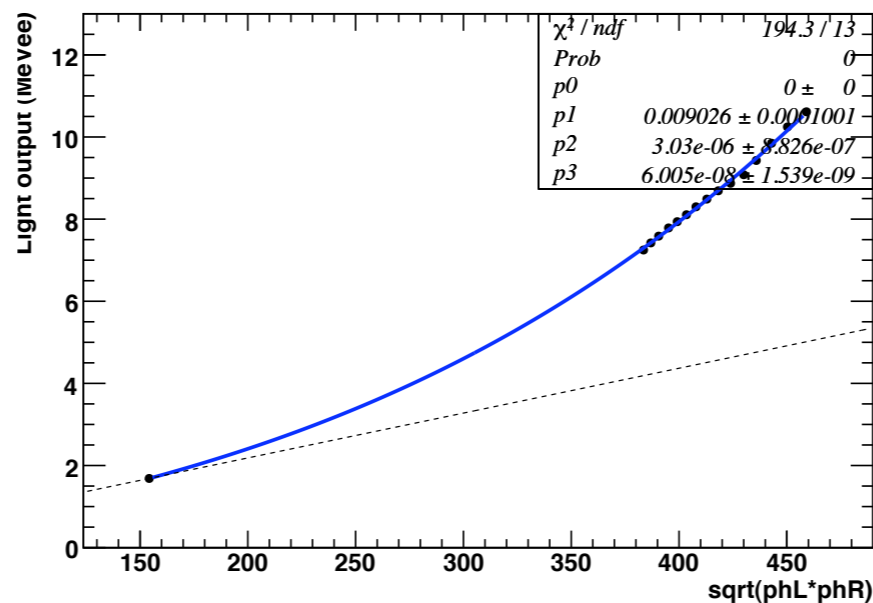
# T0 tune (2)

- run by run tuning
- all fitted curves were checked by eyes

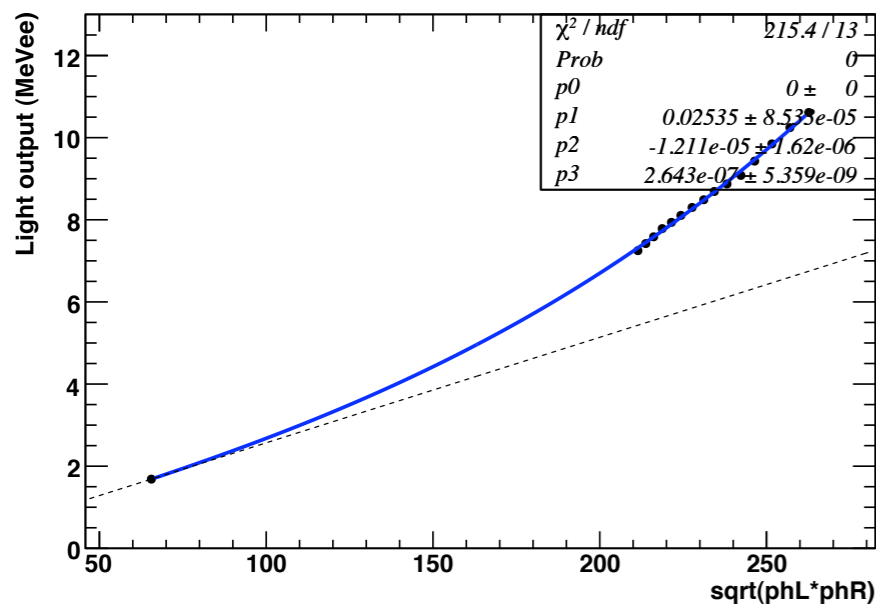
### Gain Saturation of T0(1) run 333



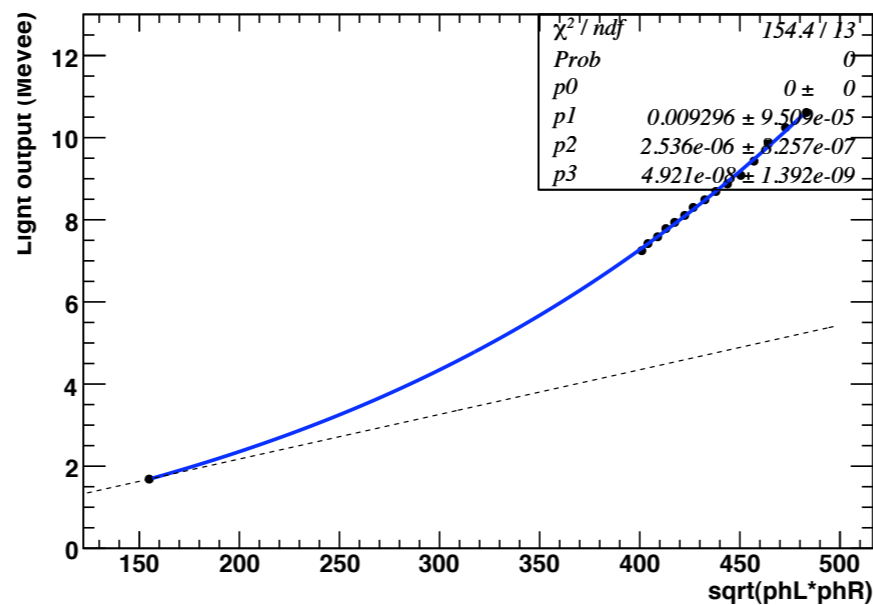
### Gain Saturation of T0(2) run 333



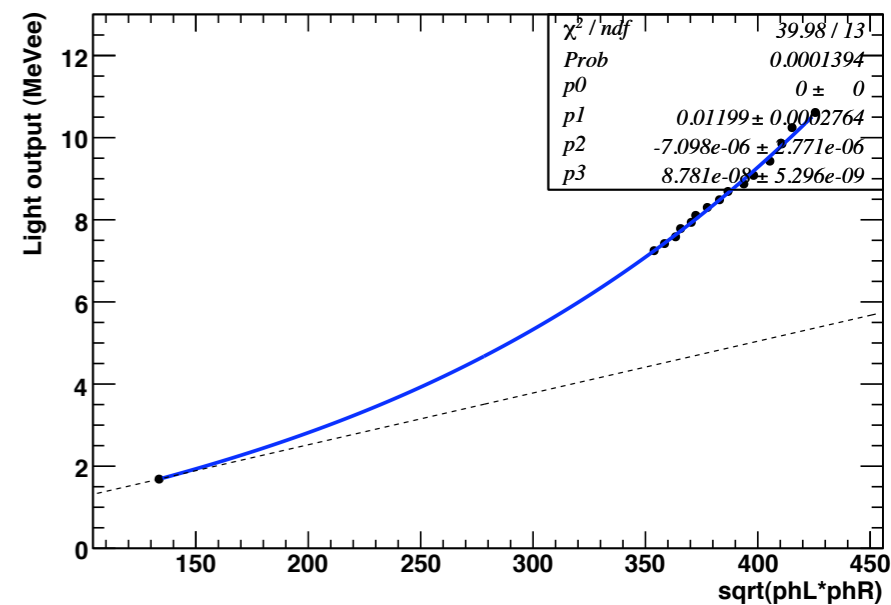
### Gain Saturation of T0(3) run 333



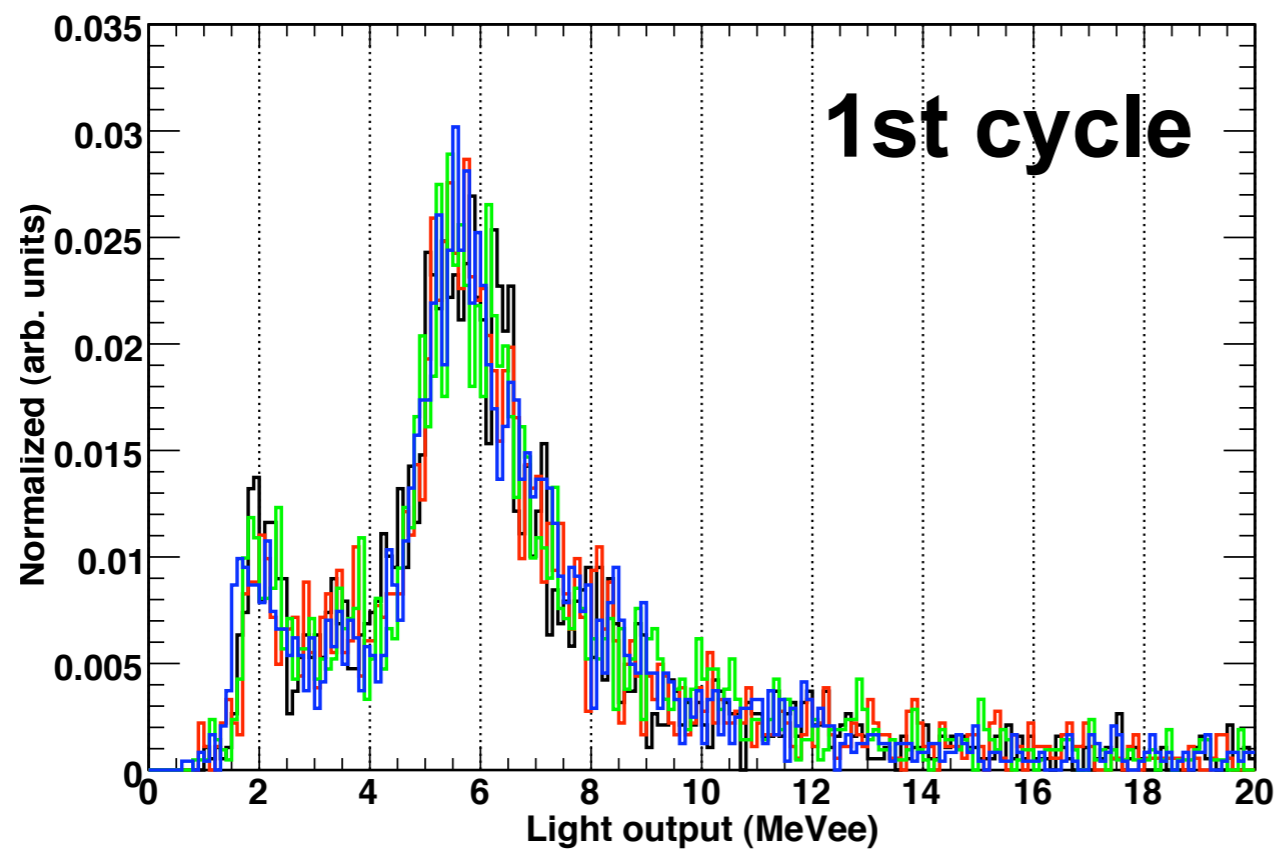
### Gain Saturation of T0(4) run 333



### Gain Saturation of T0(5) run 333



# T0 tune (3)



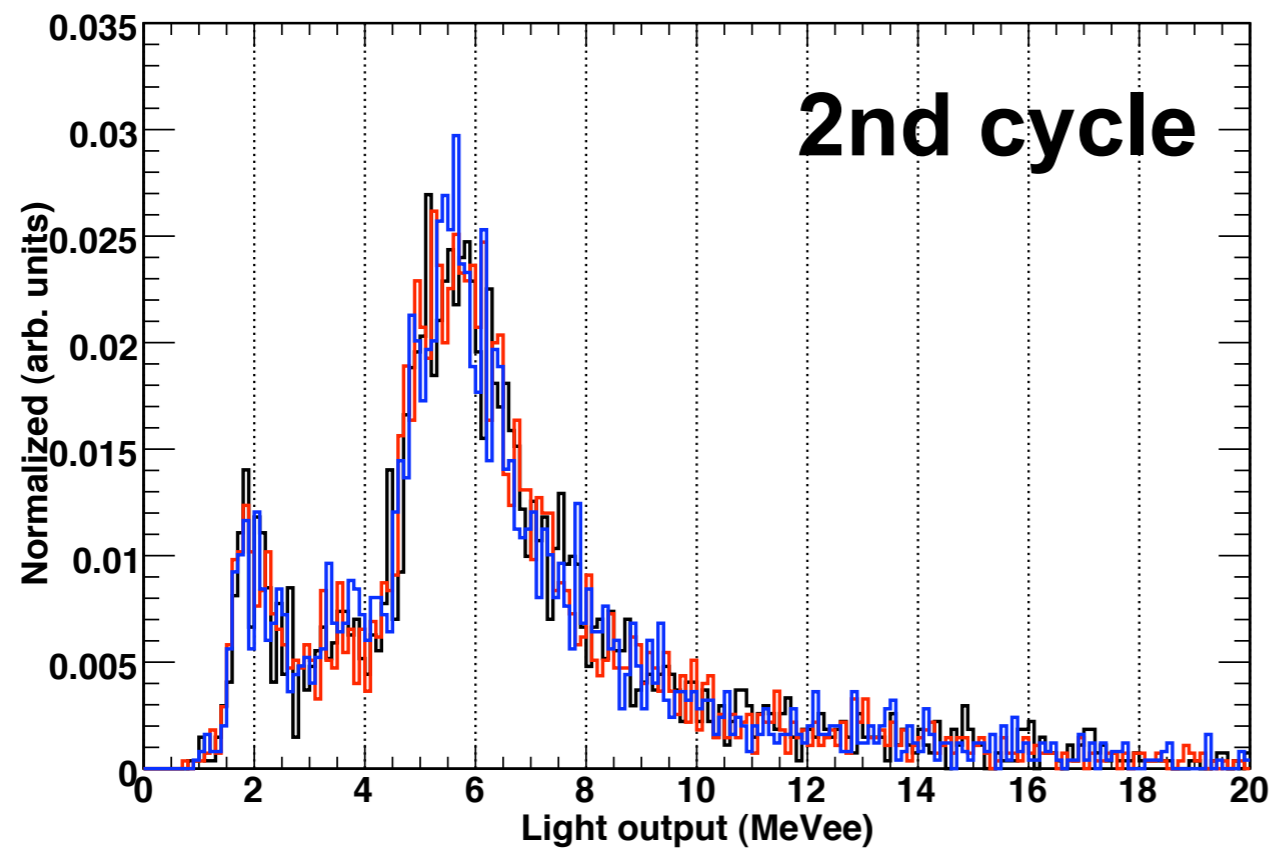
## Beam trigger

run ~50

run ~100

run ~200

run ~300



run ~400

run ~500

run ~580

# IDstopK (1)

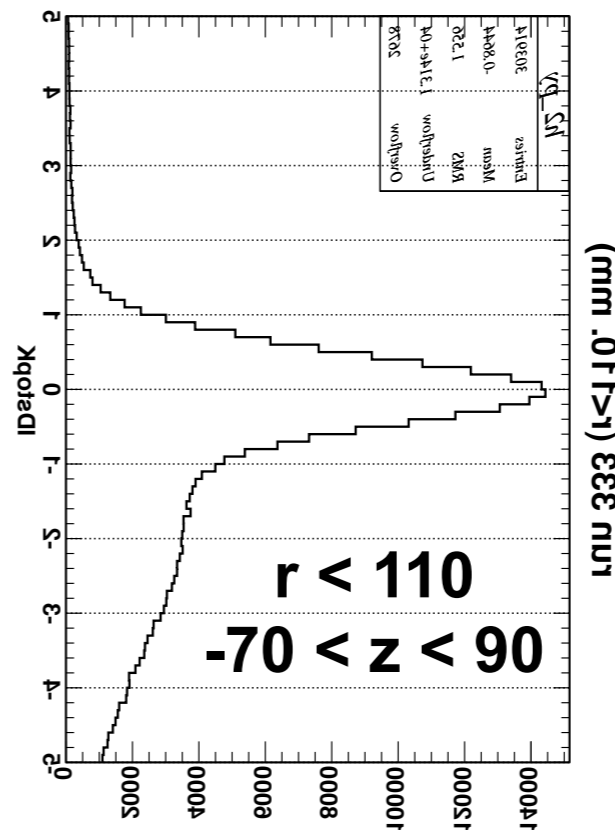
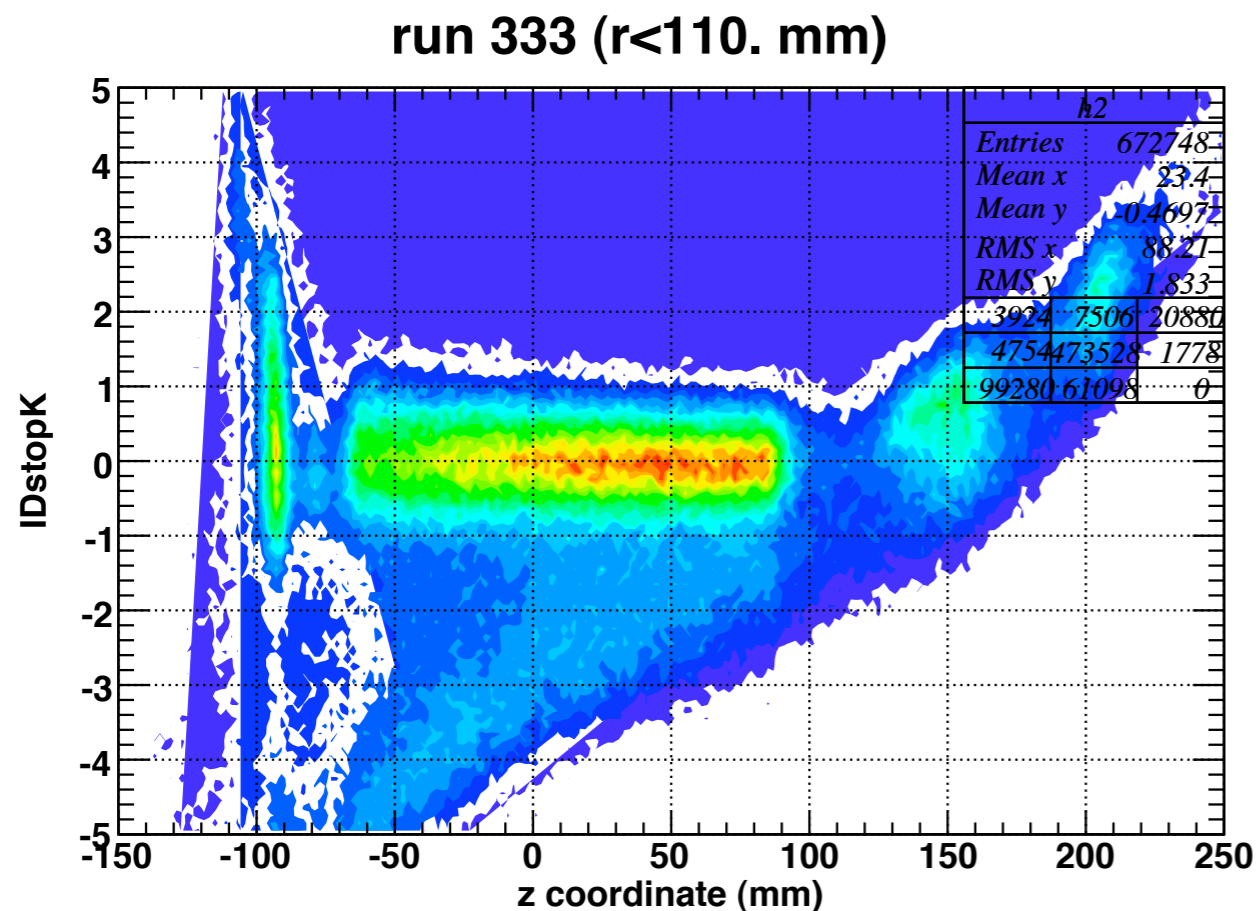
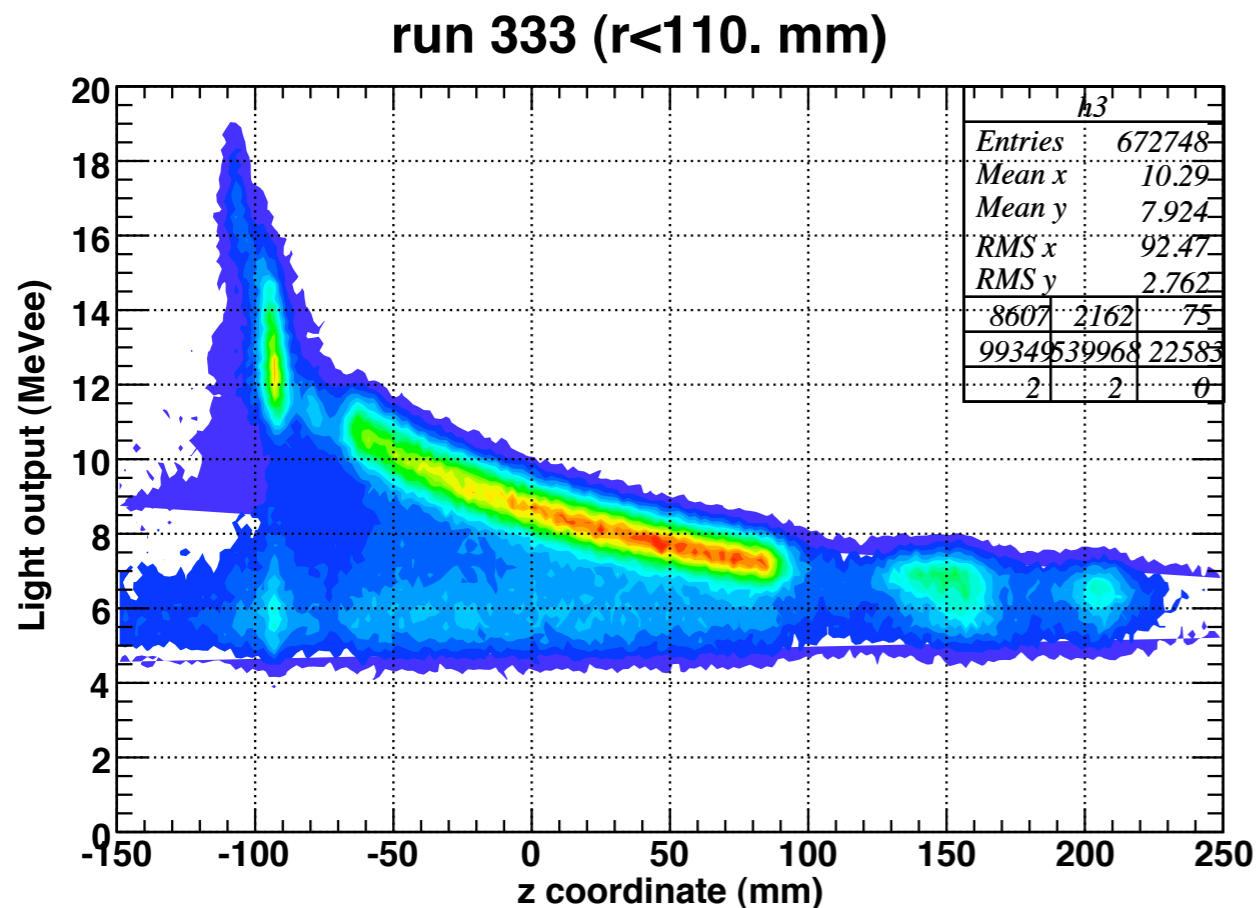
Each T0 light output was normalized using a negative pion run (run 246)

Including Birk's effect

$$\frac{dL}{dx} = \frac{\frac{dE}{dx}}{1 + kB \frac{dE}{dx}} \quad (kB = 0.013)$$

ID stopk difinition

$$ID_{\text{stopK}} = L - L_{\text{sim}}(z)$$



# IDstopK (2)

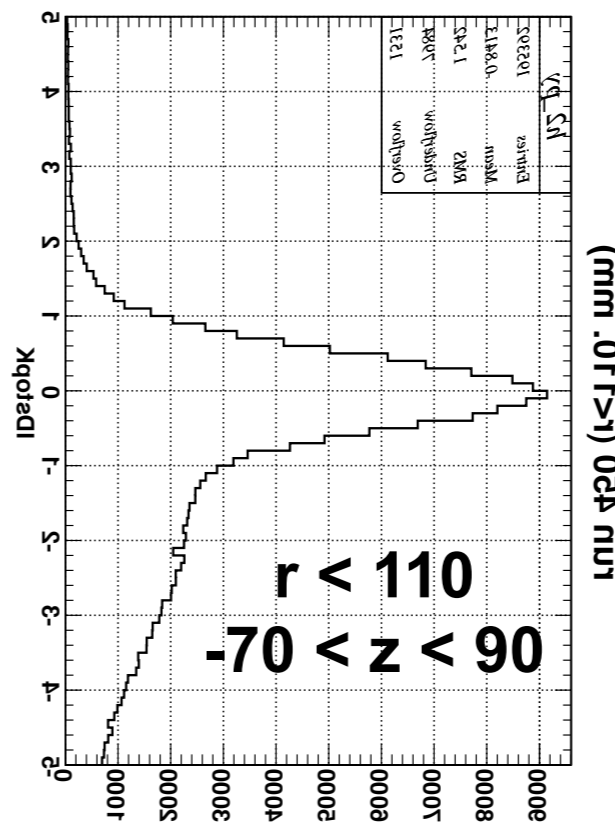
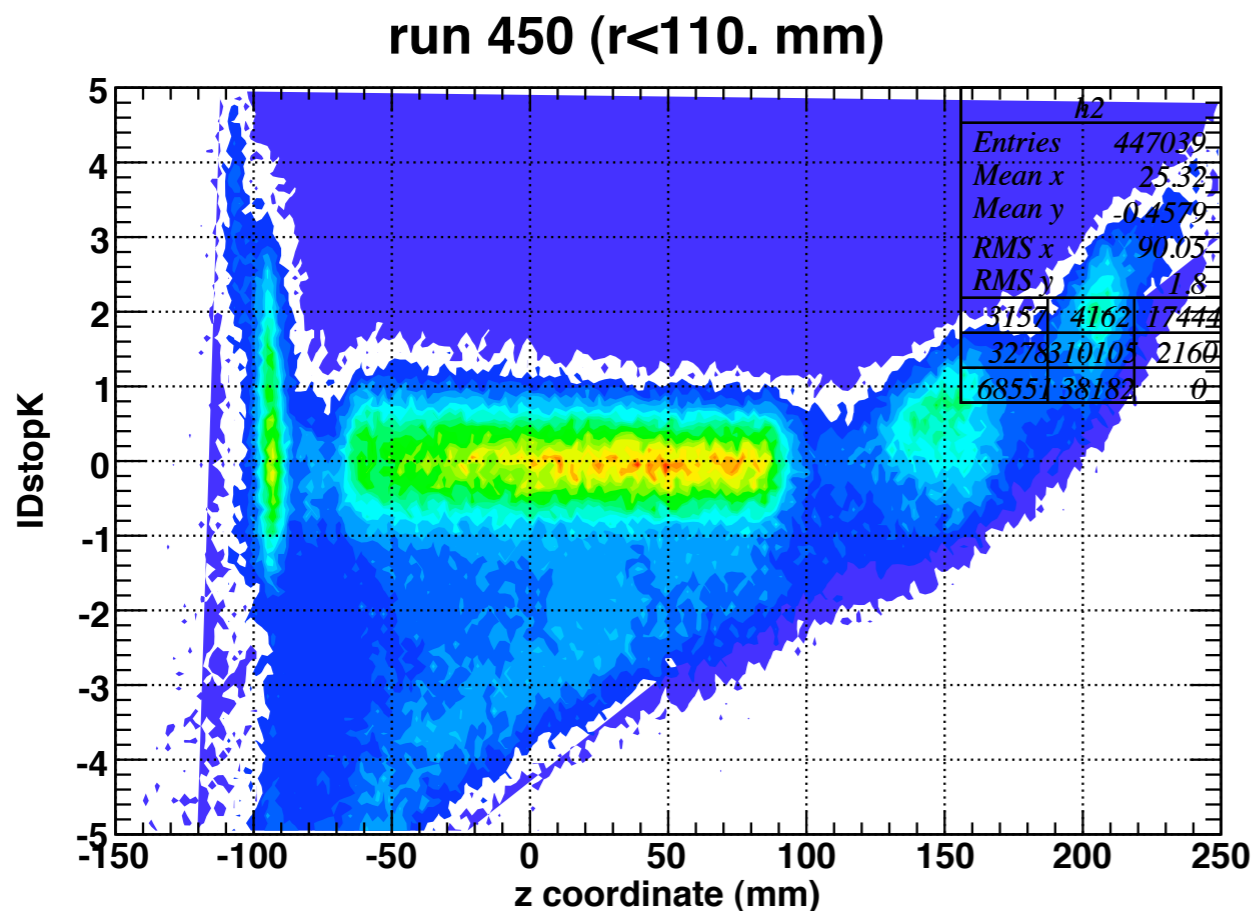
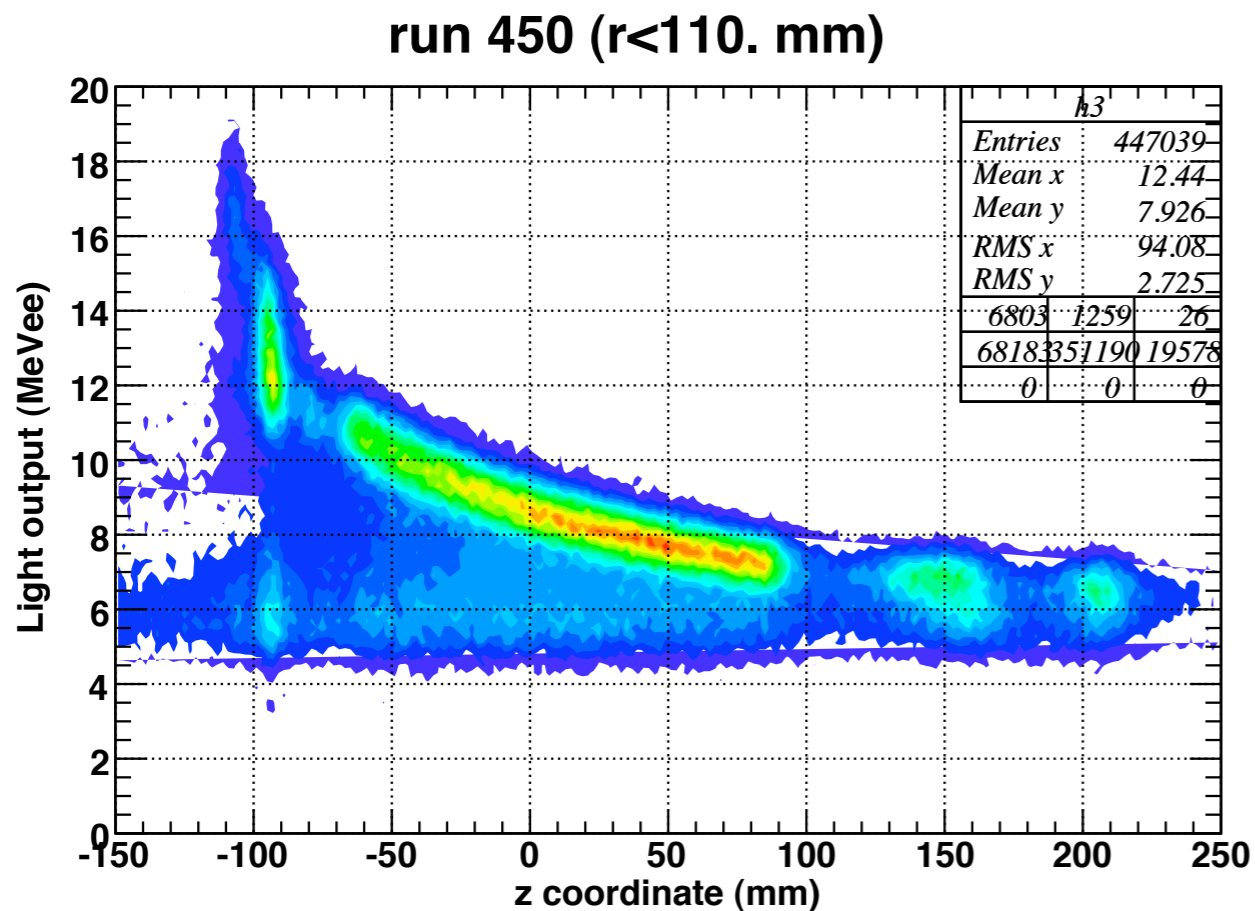
Each T0 light output was normalized using a negative pion run (run 515)

Including Birk's effect

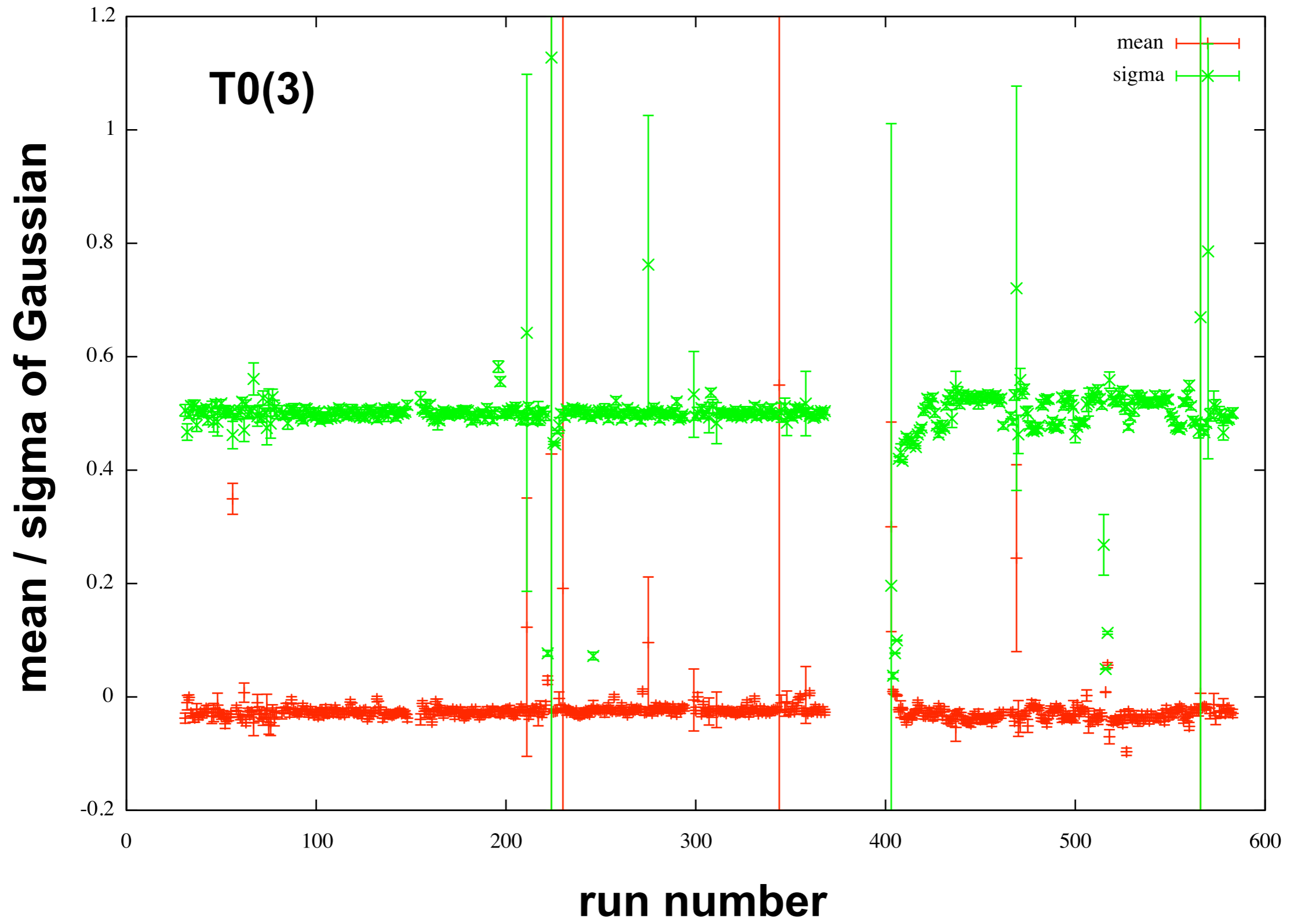
$$\frac{dL}{dx} = \frac{\frac{dE}{dx}}{1 + kB \frac{dE}{dx}} \quad (kB = 0.013)$$

ID stopk difinition

$$ID_{\text{stopK}} = L - L_{\text{sim}}(z)$$



*IDstopK mean and sigma fitted by a Gaussian*



(not production runs data show jumps)

# T0 resolution

$$\frac{\Delta L}{L} = \frac{c}{\sqrt{L}}$$

$\Delta L$  : *sigma of Gaussian response*

GEANT4 simulation with Gaussian smearing

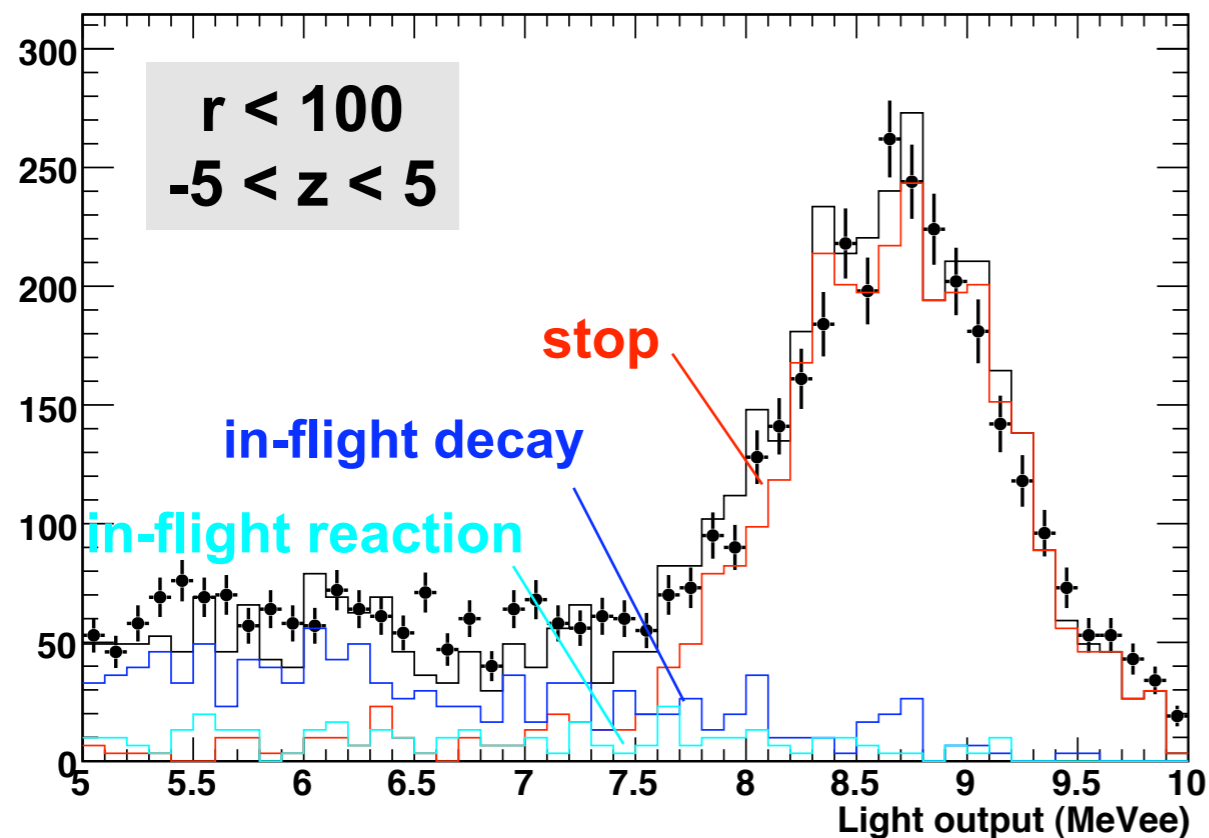
*Chi2Test*\* between data and MC simulation to determine the constant  $c$

**$c \sim 0.16$**

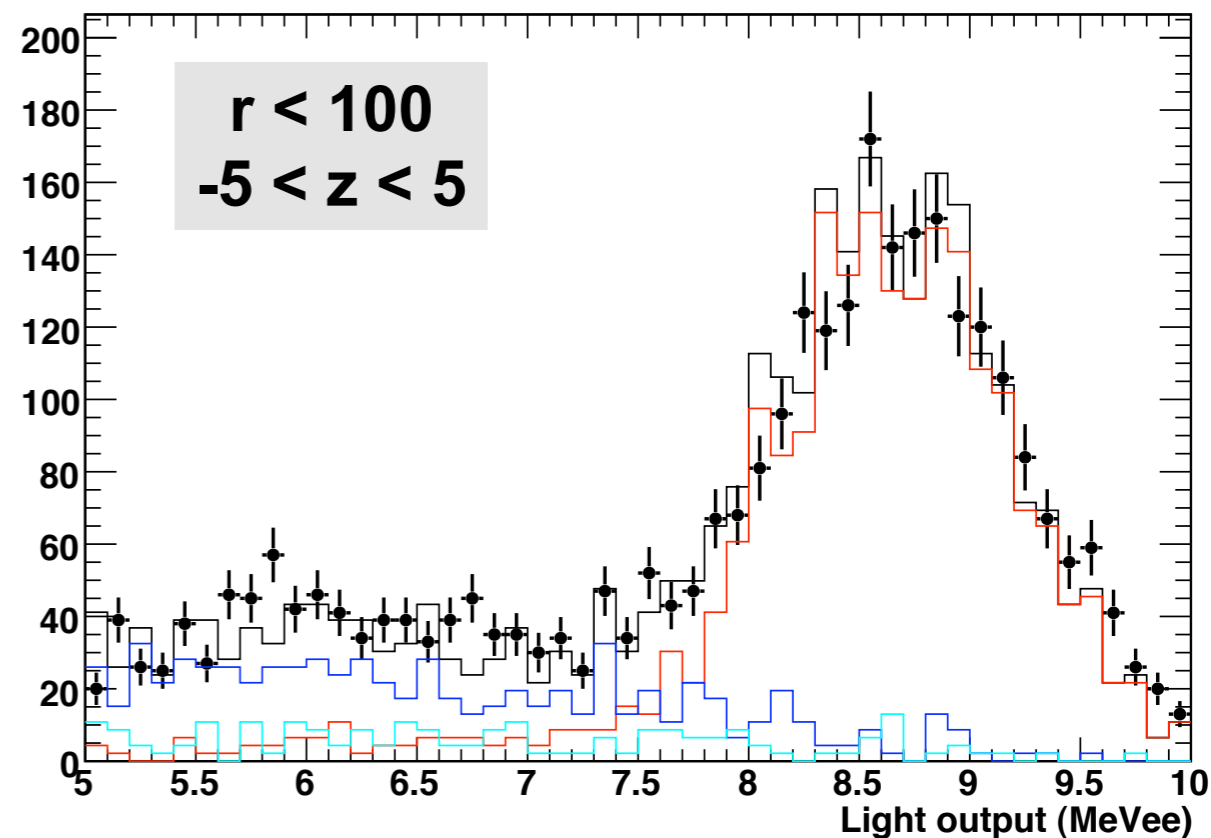
\* *chi2test* : Comparison weighted and unweighted histograms  
[arxiv:physics/0605123]



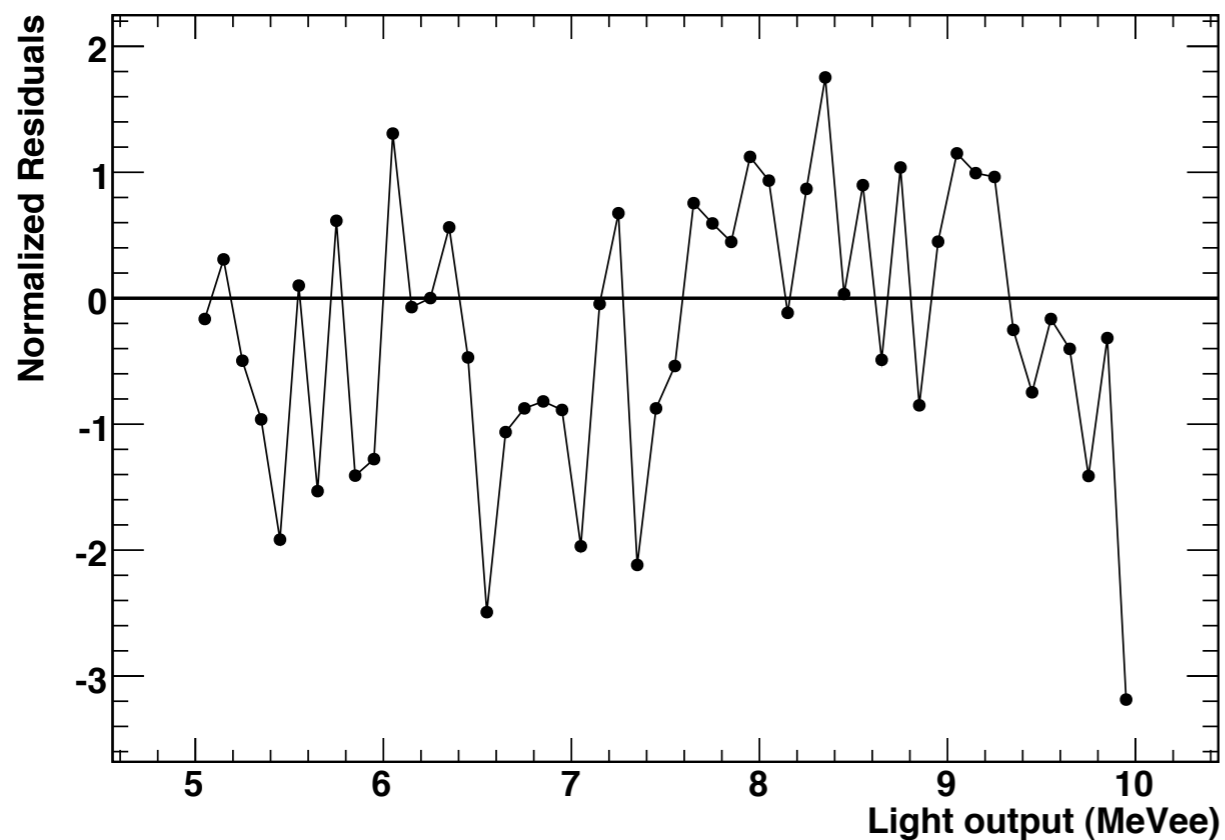
Light output at T0(2) run 333 (c=0.16)



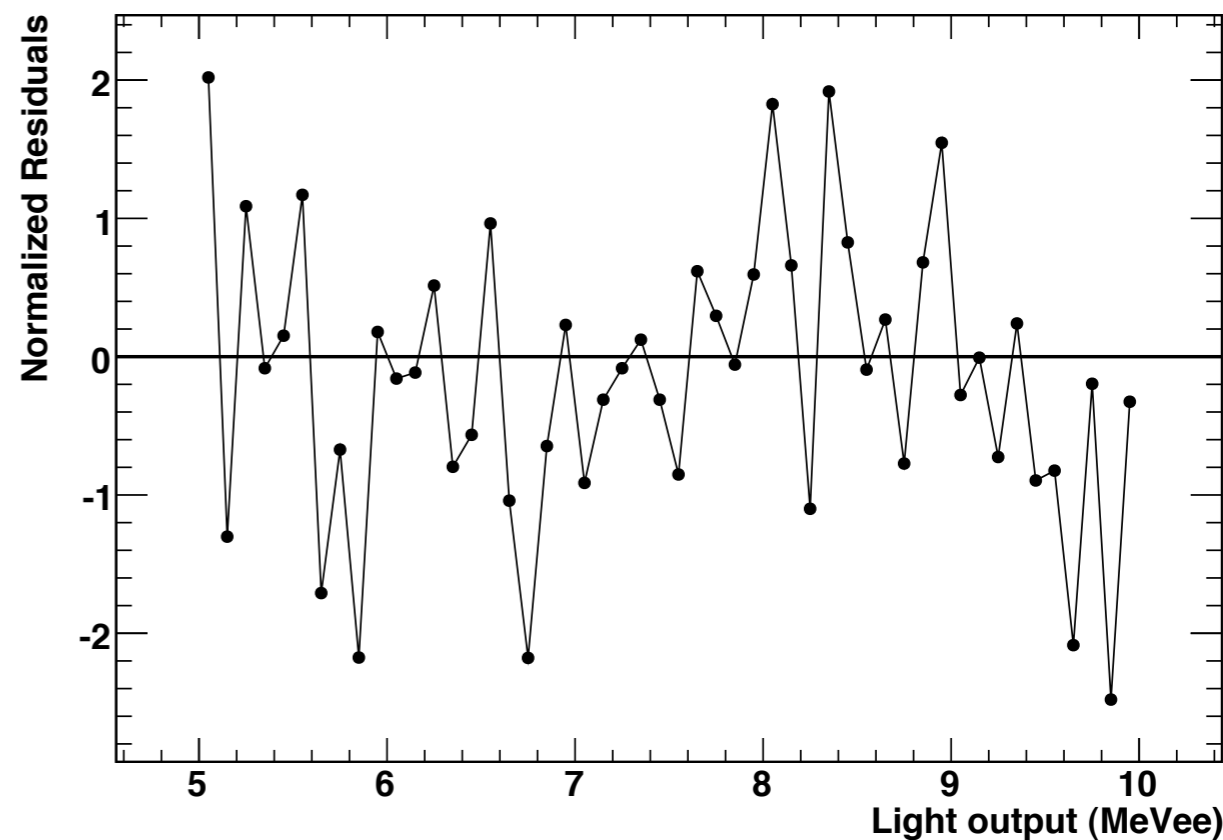
Light output at T0(2) run 450 (c=0.16)



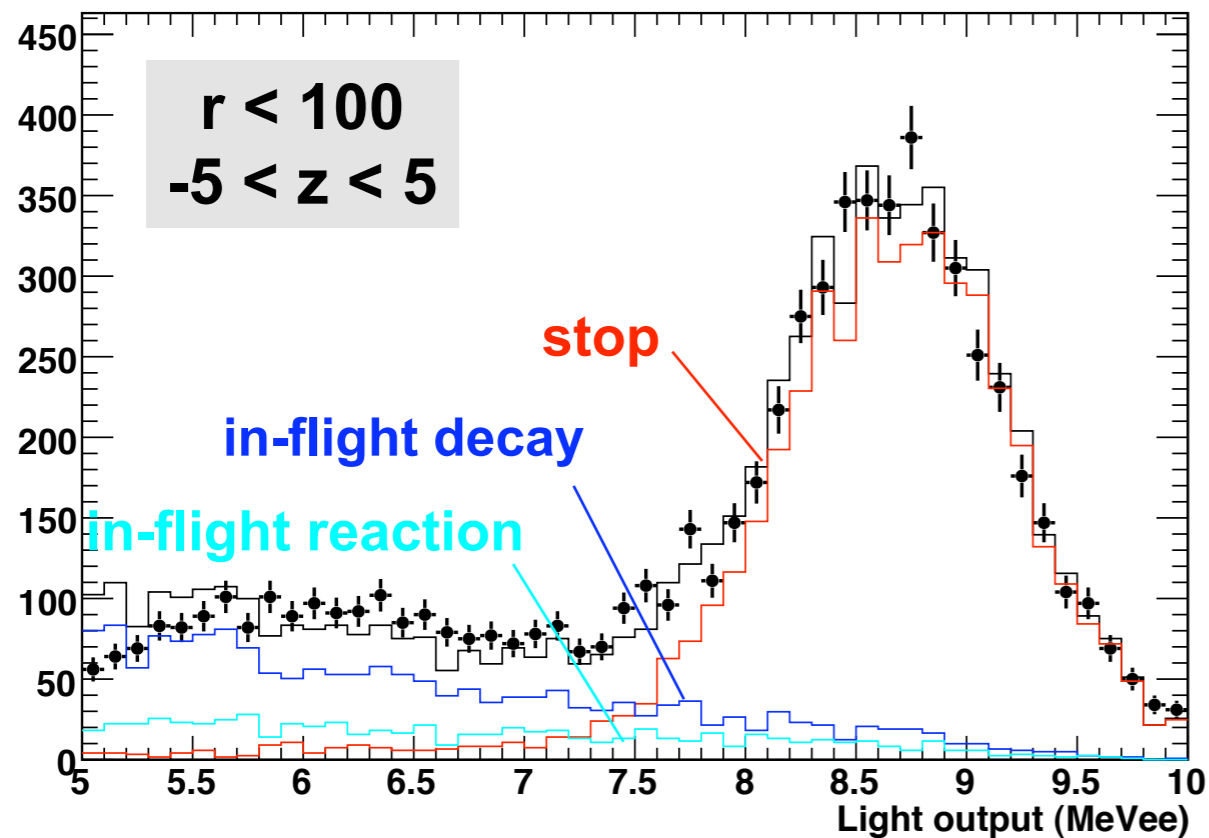
Normalized Residuals T0(2) run 333 (c=0.16)



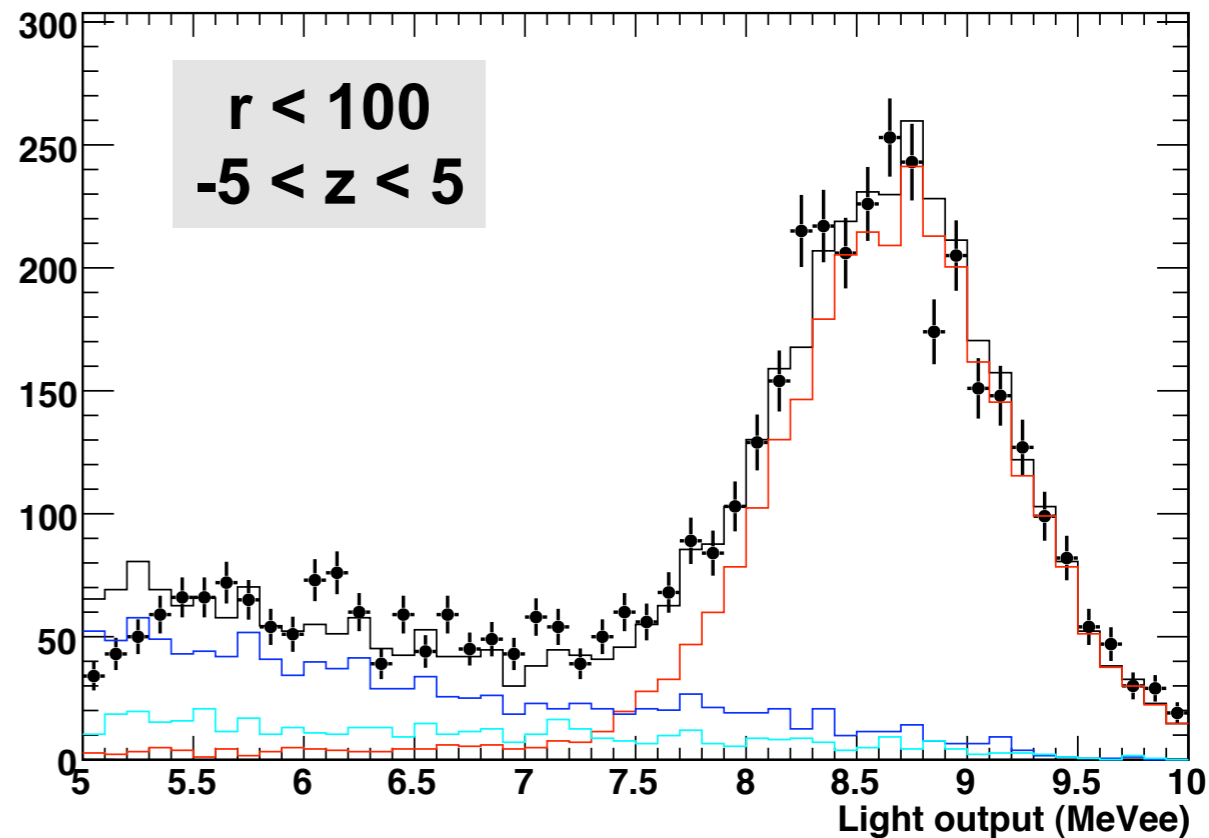
Normalized Residuals T0(2) run 450 (c=0.16)



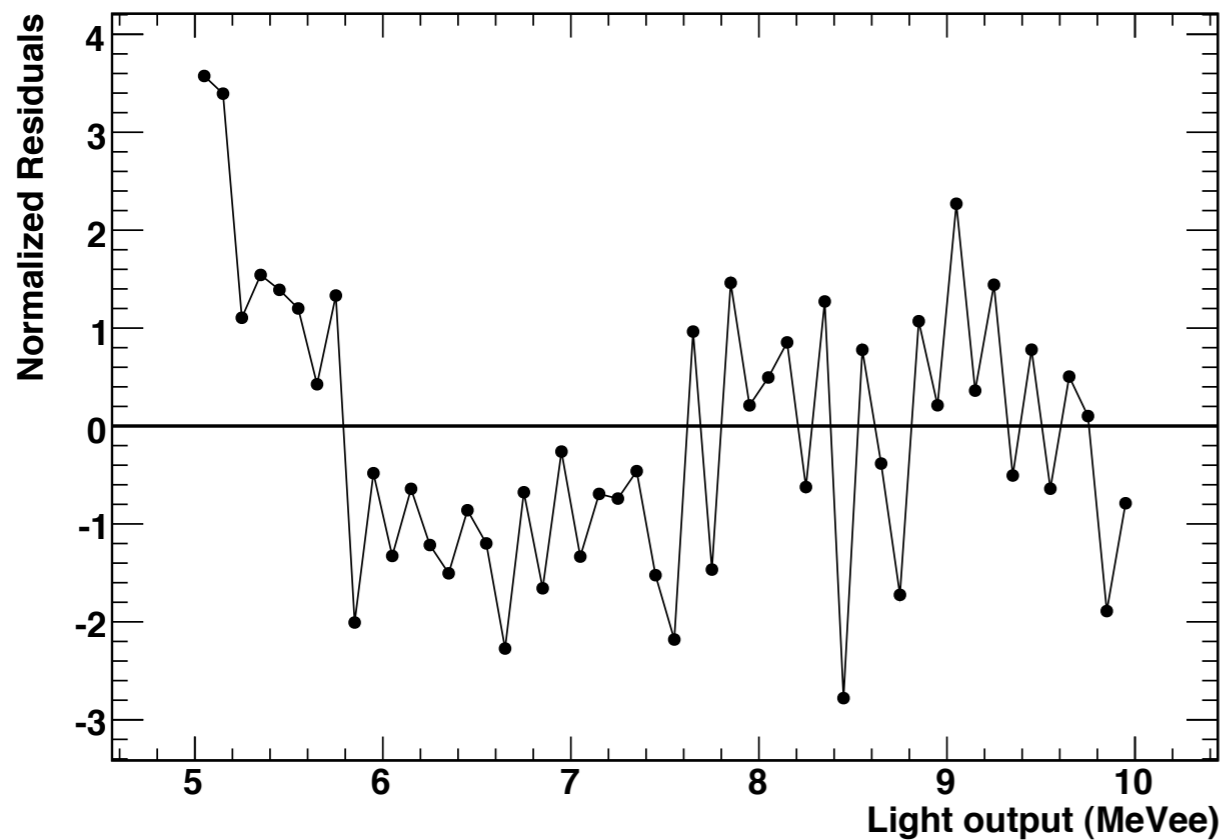
Light output at T0(3) run 333 ( $c=0.16$ )



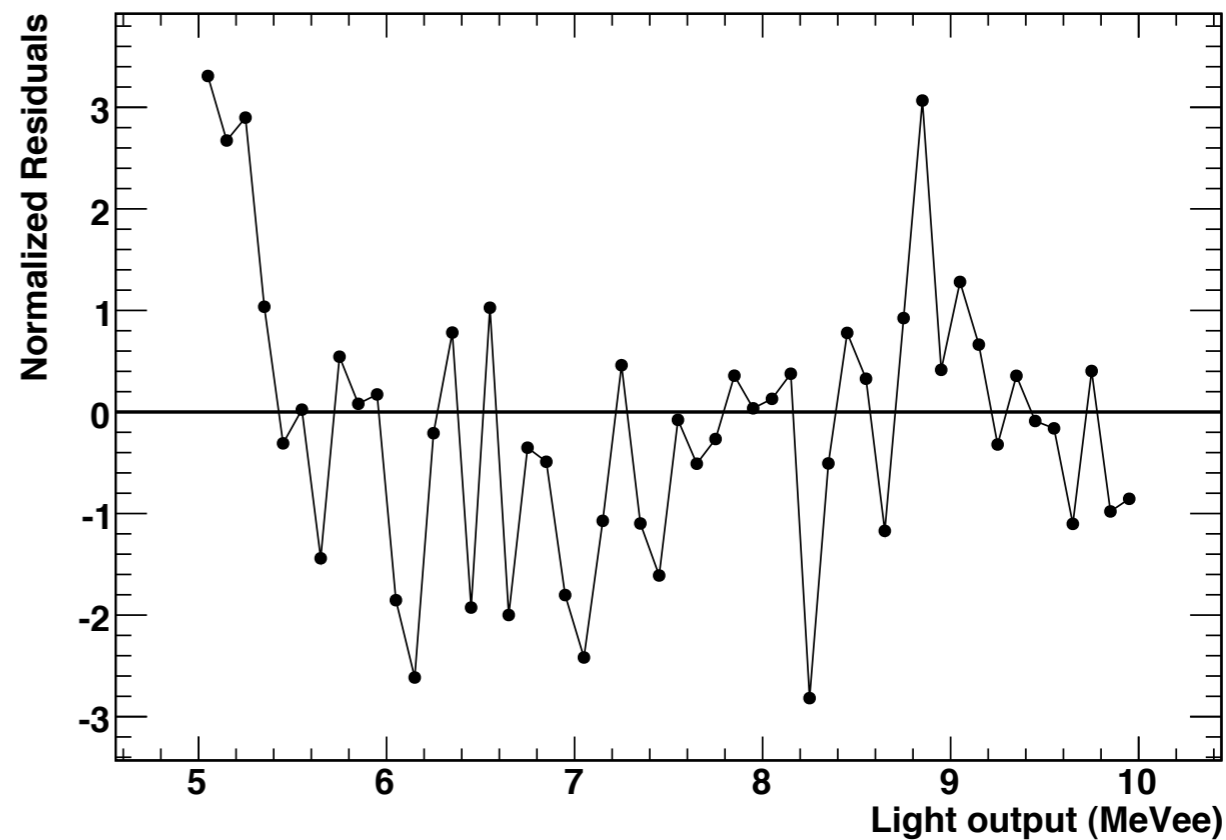
Light output at T0(3) run 450 ( $c=0.16$ )



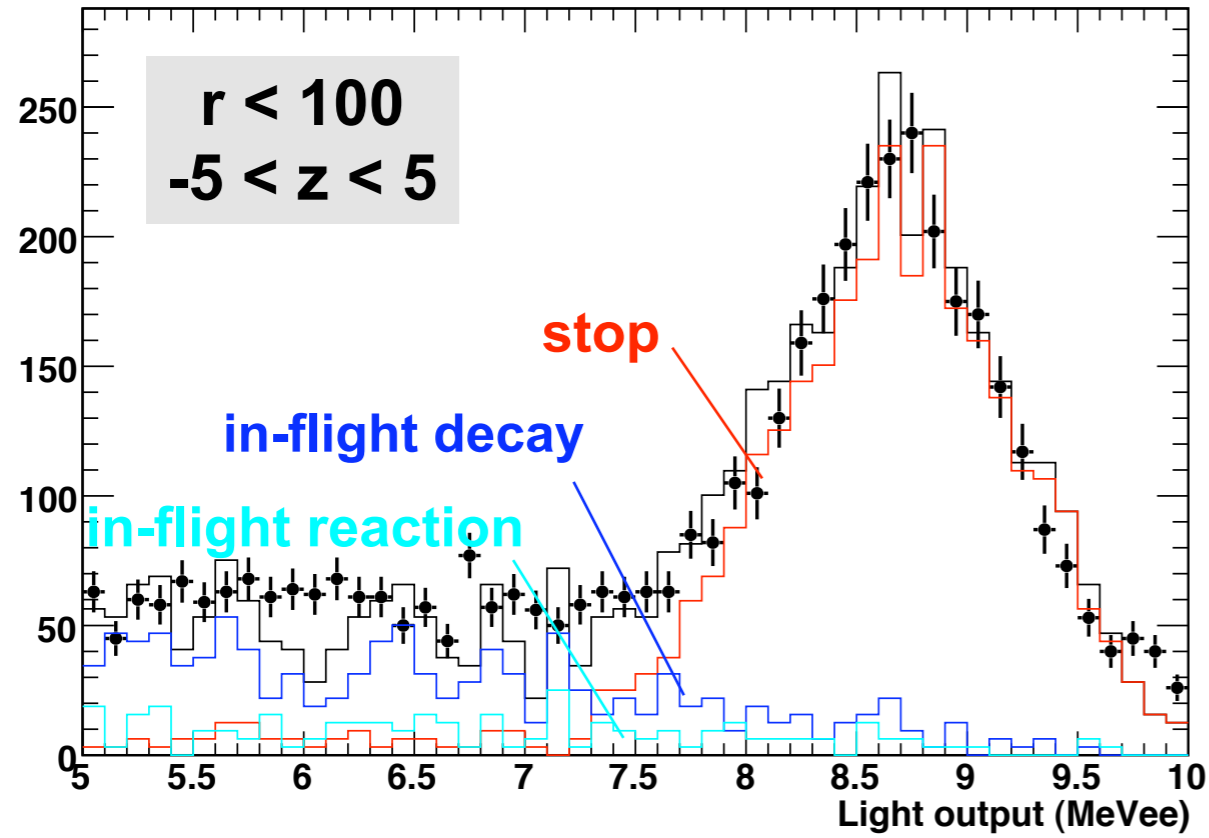
Normalized Residuals T0(3) run 333 ( $c=0.16$ )



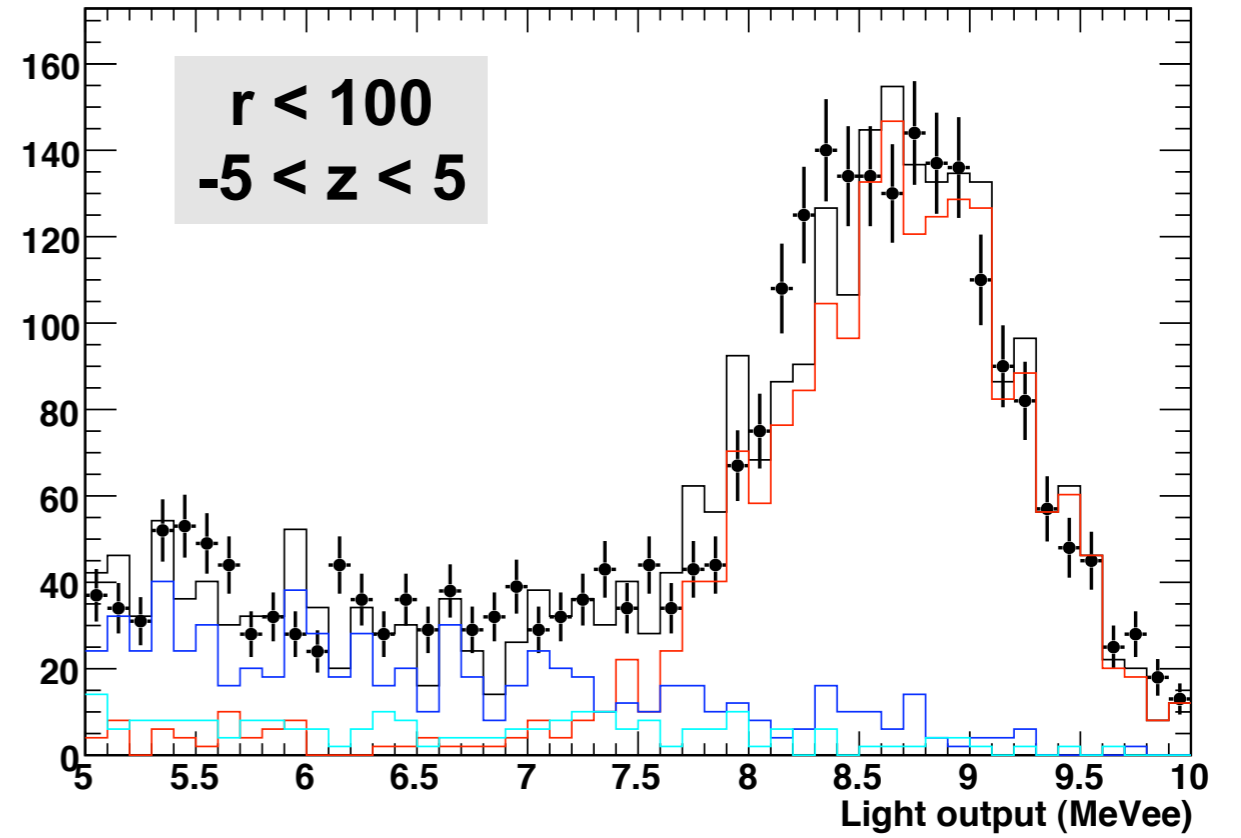
Normalized Residuals T0(3) run 450 ( $c=0.16$ )



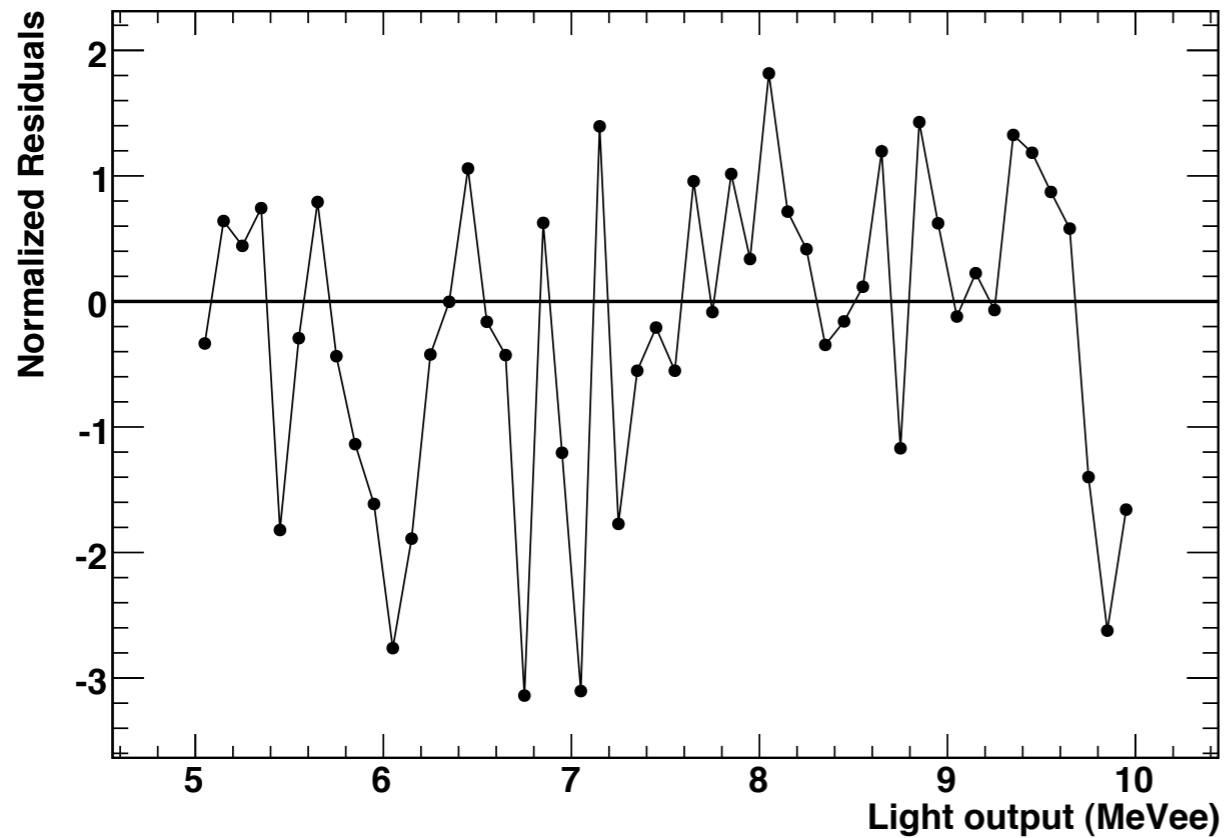
Light output at T0(4) run 333 (c=0.16)



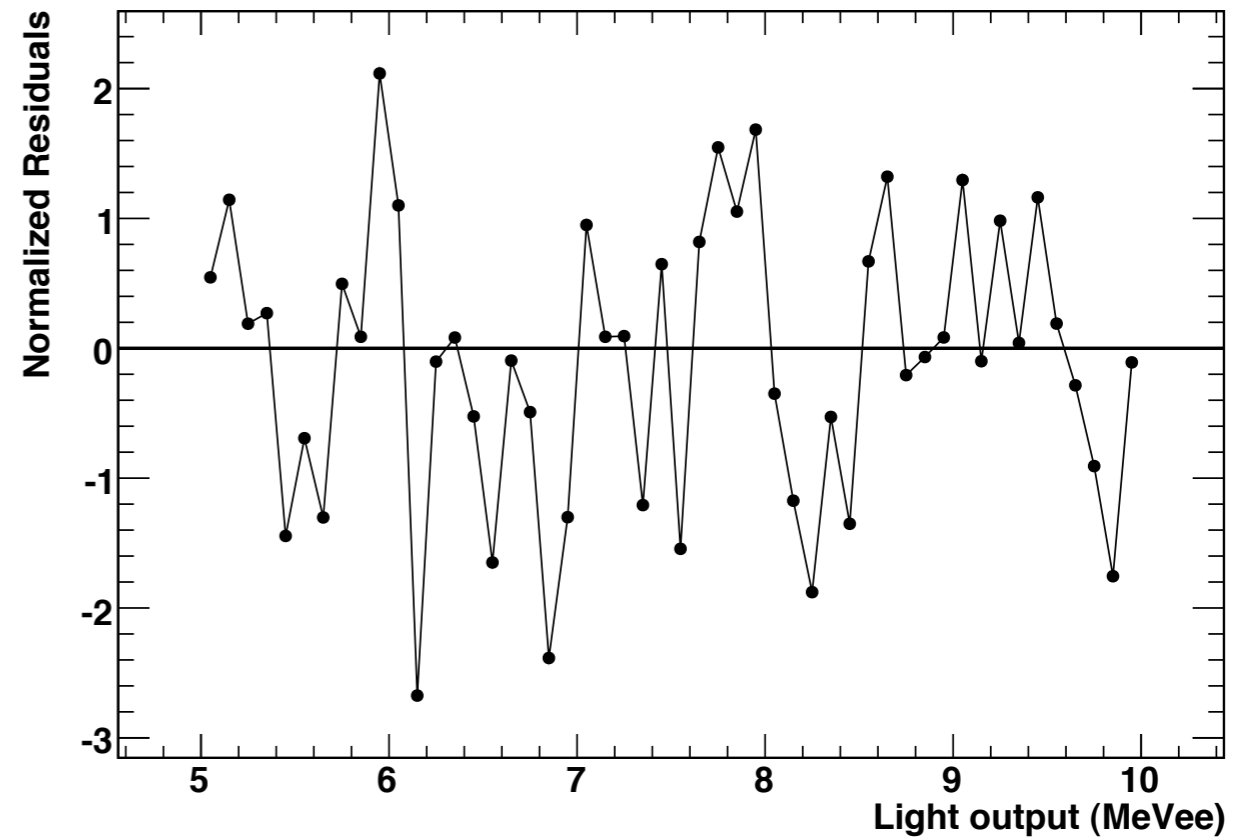
Light output at T0(4) run 450 (c=0.16)



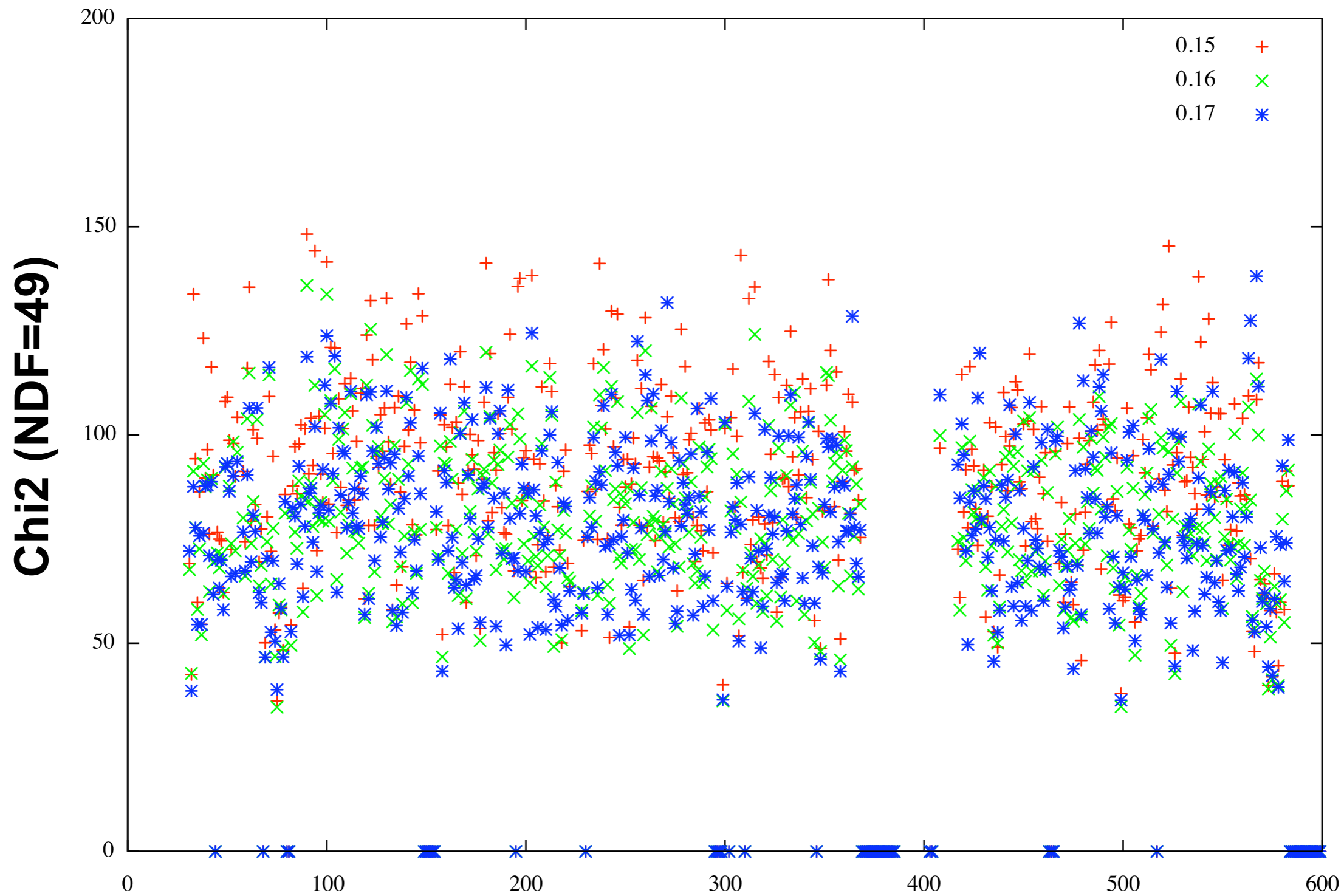
Normalized Residuals T0(4) run 333 (c=0.16)



Normalized Residuals T0(4) run 450 (c=0.16)



# *Chi2Test\** between data and MC simulation



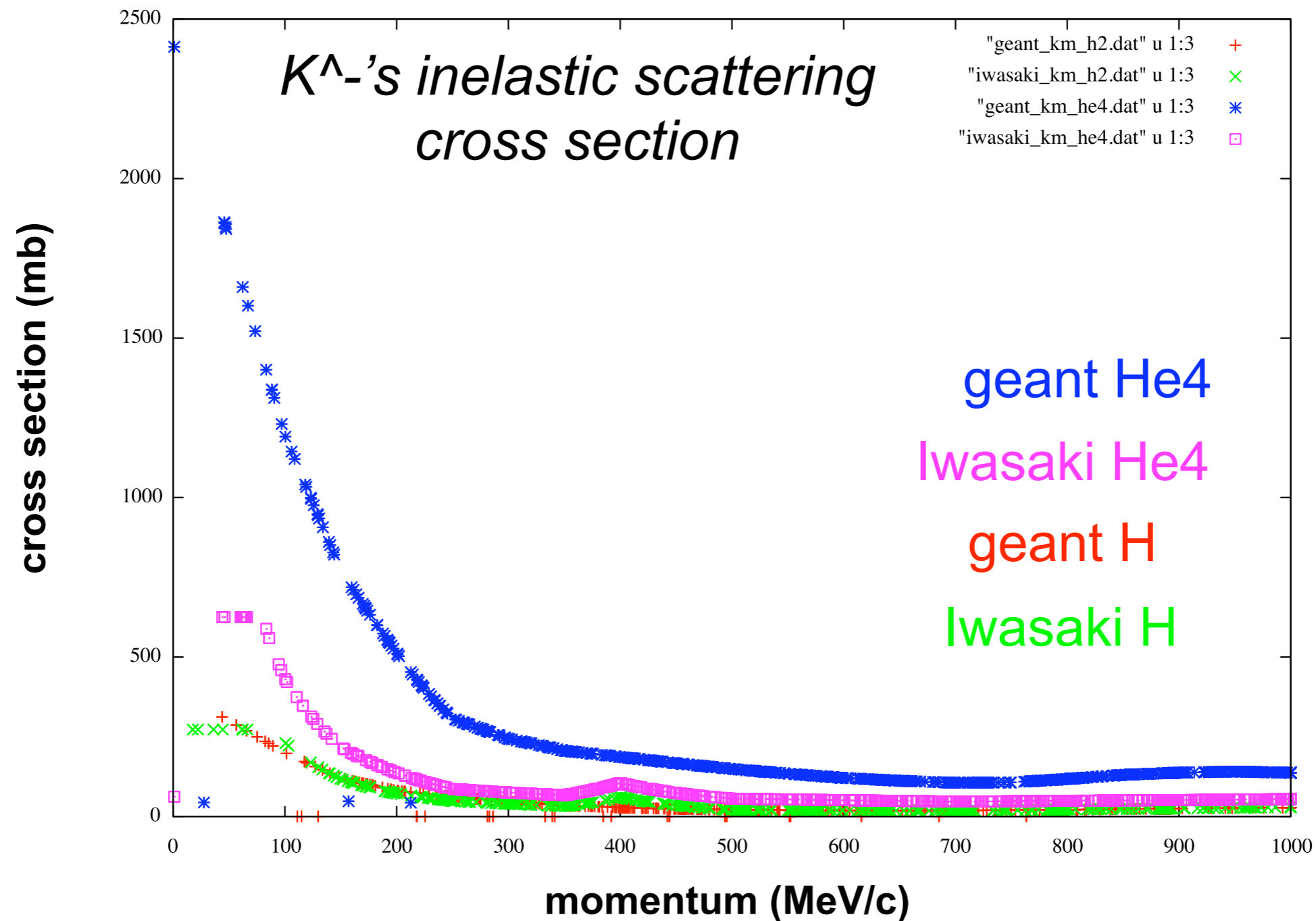
$$\frac{\Delta L}{L} = \frac{c}{\sqrt{L}}$$

run number

**$c \sim 0.16$**

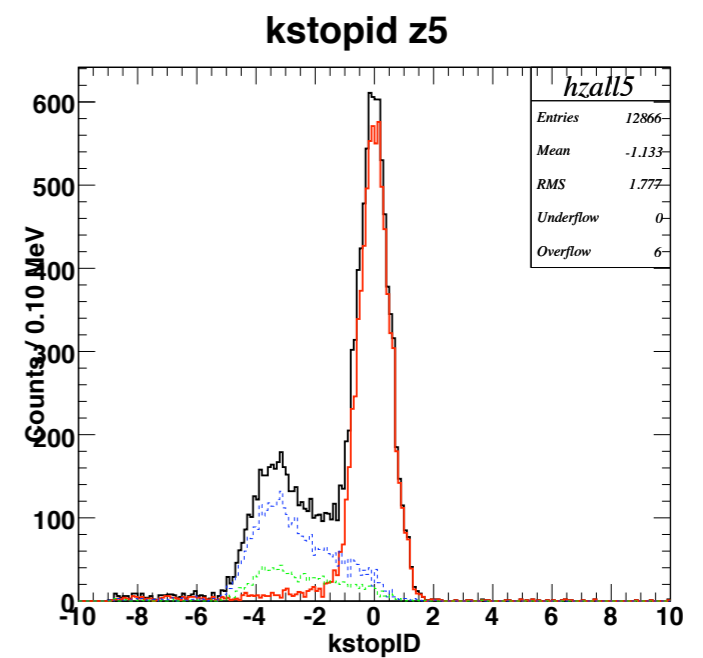
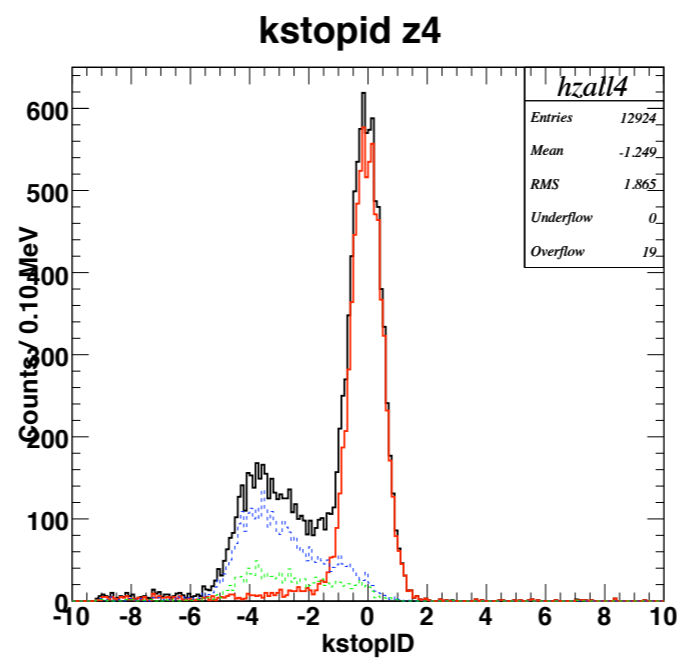
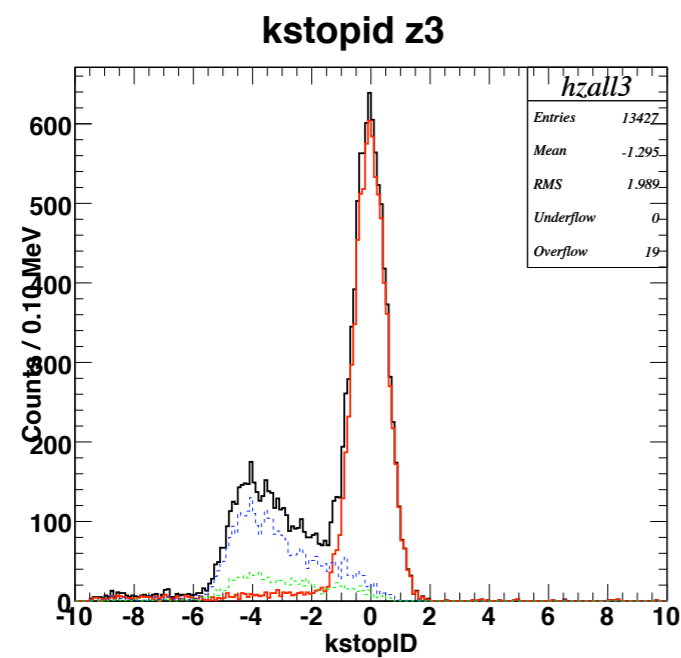
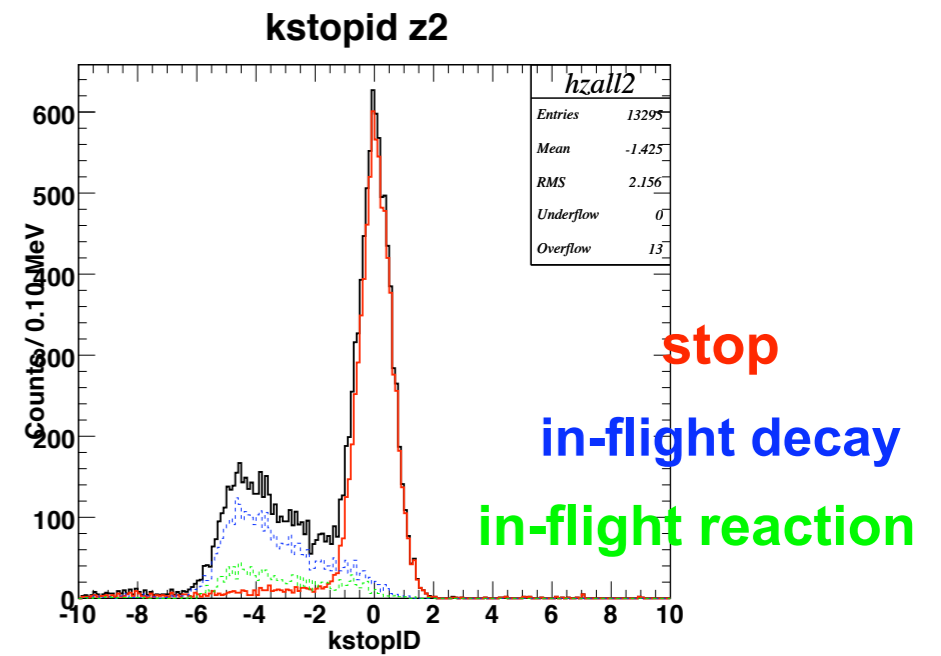
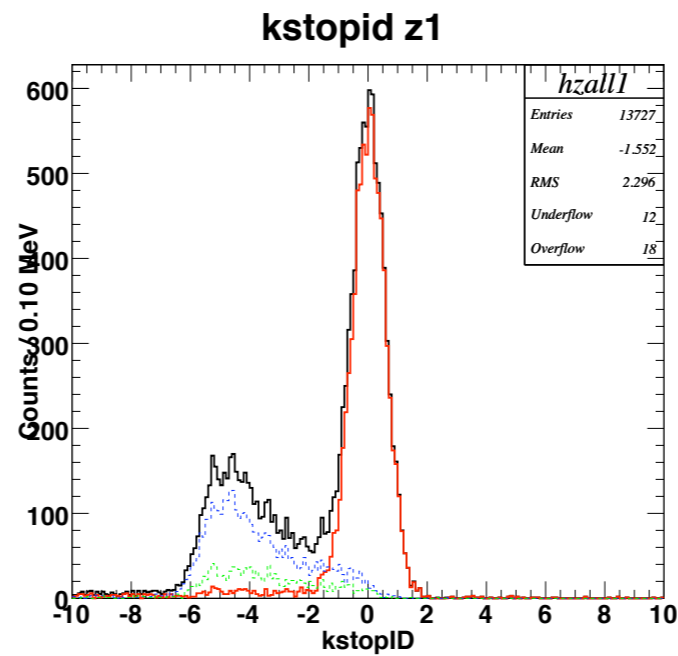
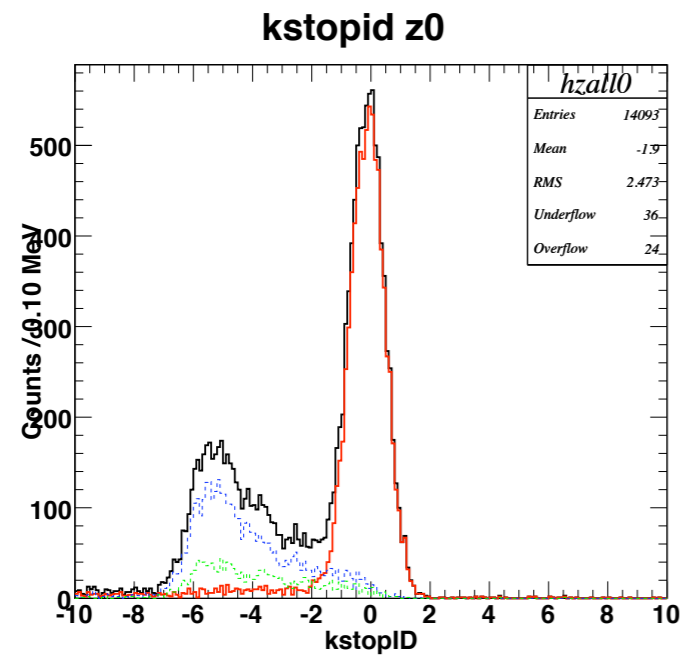
# \* GEANT4 simulation with Iwasaki routine cross section

(negative and positive kaons cross sections were implemented in GEANT4)

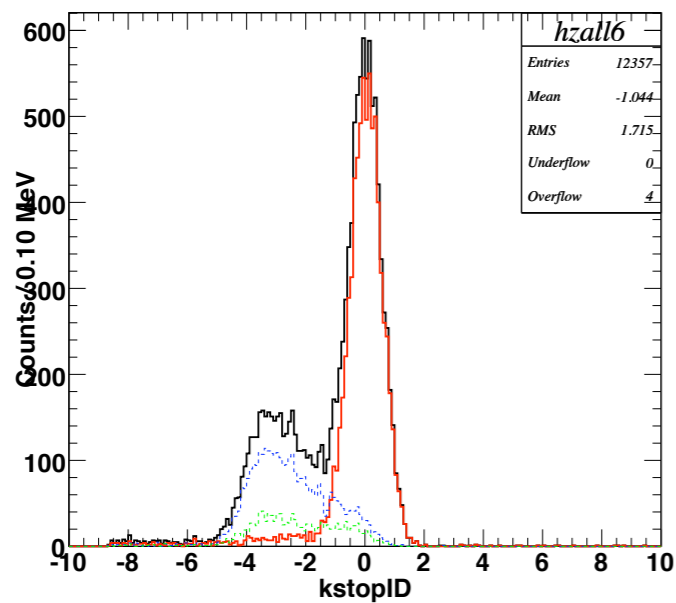


# IDstopK simulation : z-dependent spectra

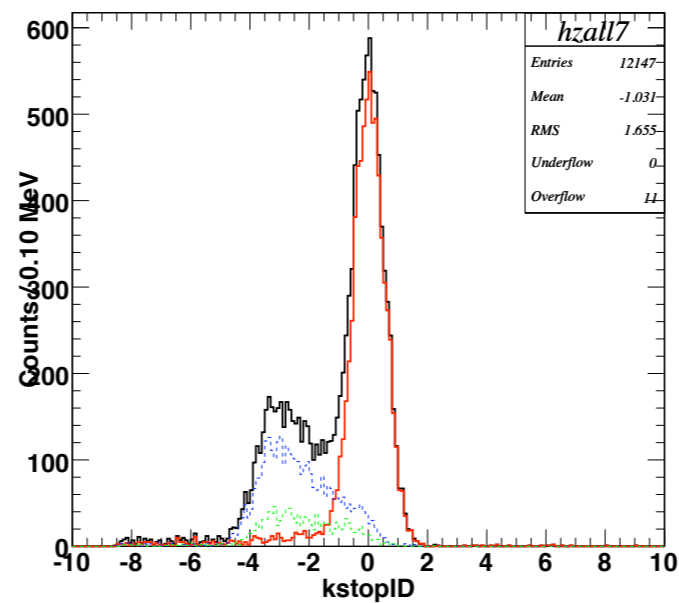
pencil beam, target radius < 100 mm



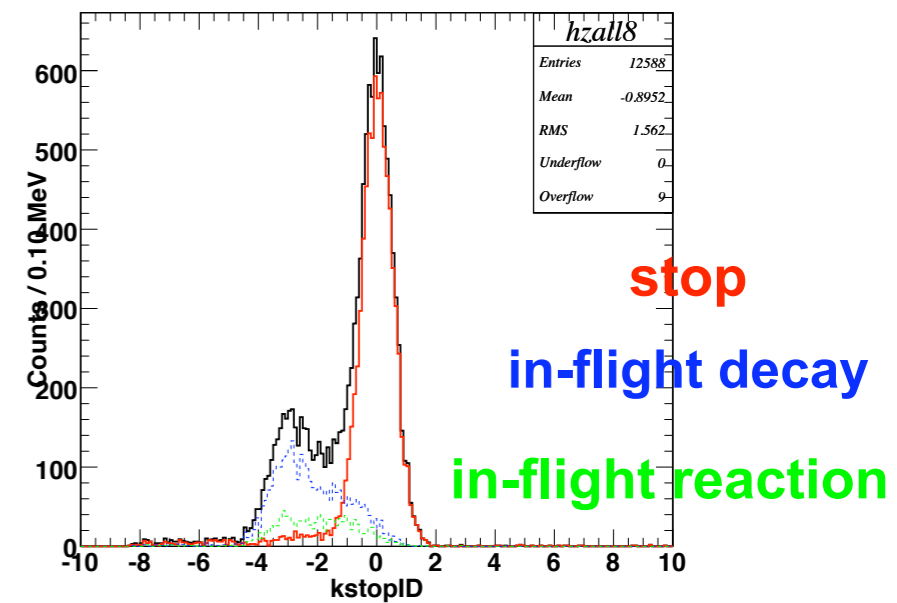
kstopid z6



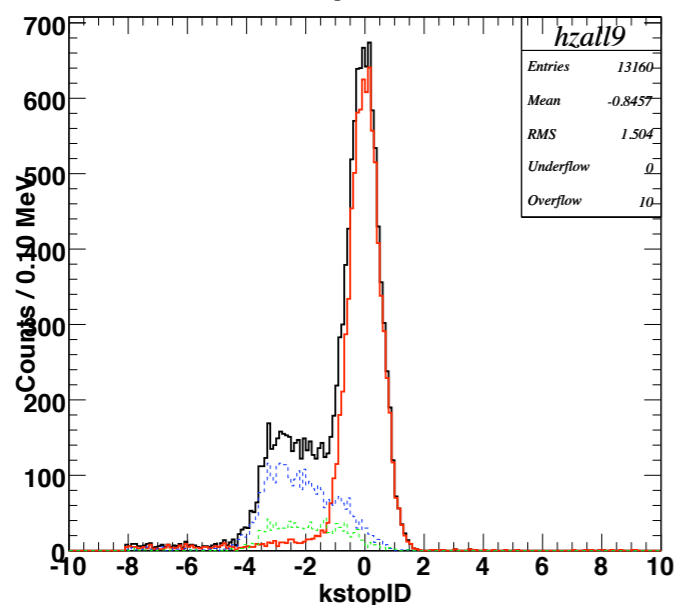
kstopid z7



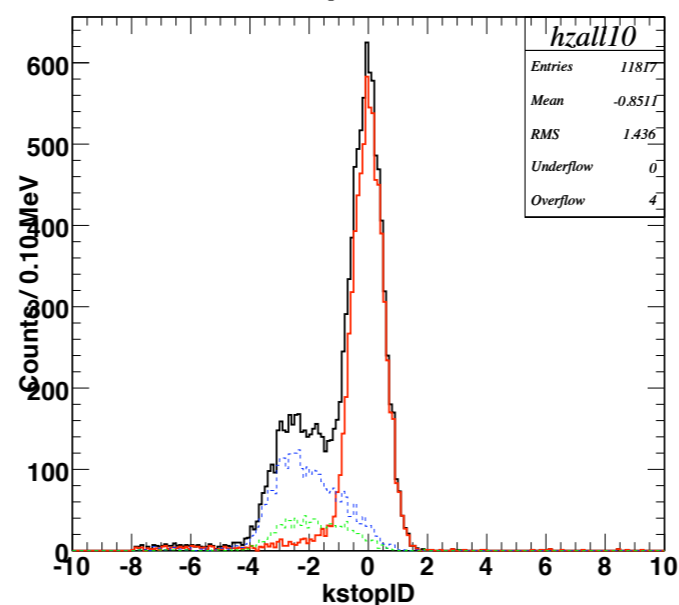
kstopid z8



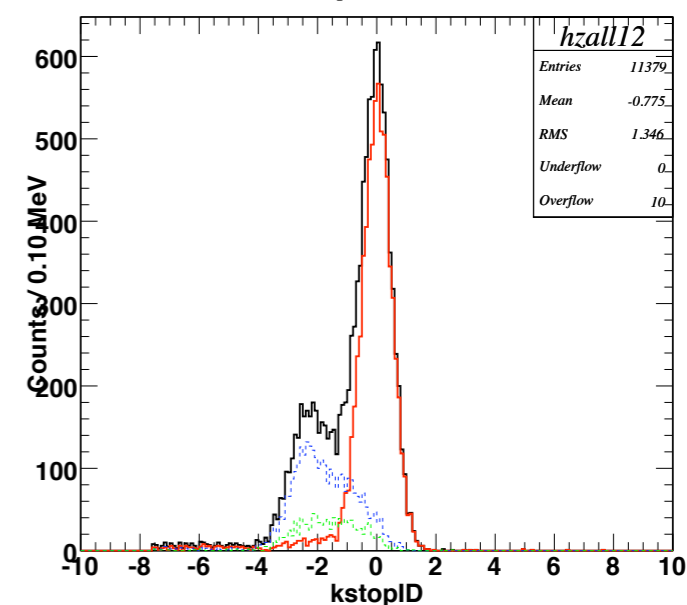
kstopid z9



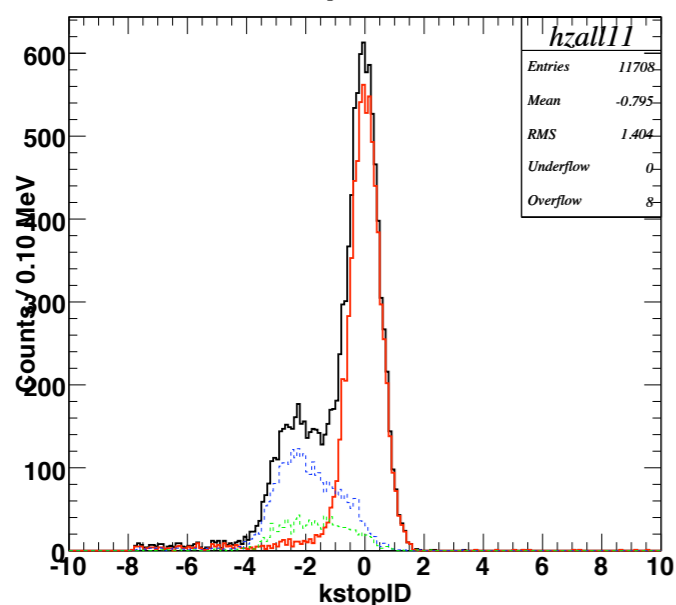
kstopid z10



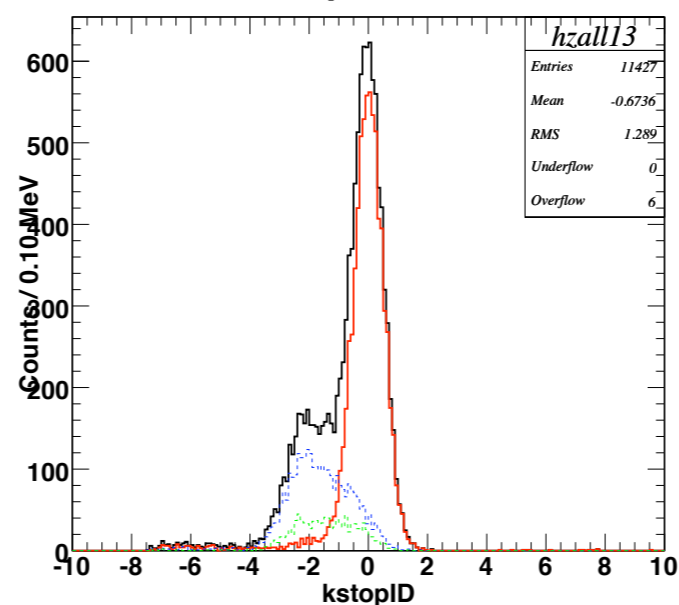
kstopid z12



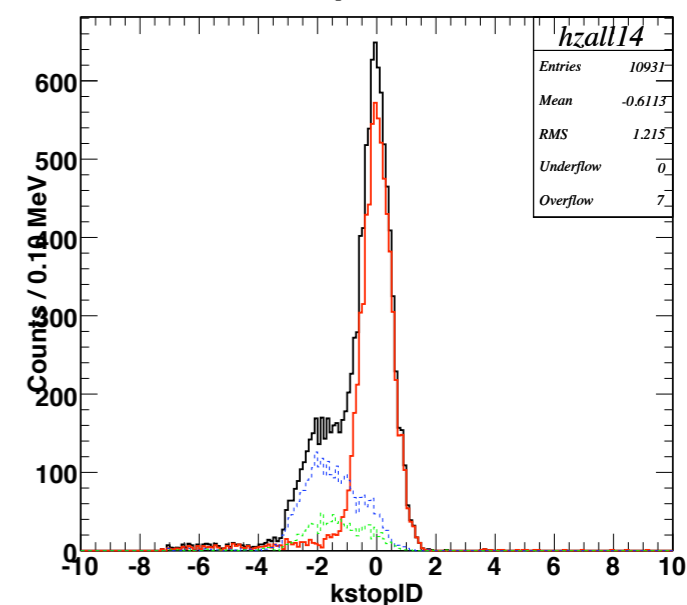
kstopid z11



kstopid z13



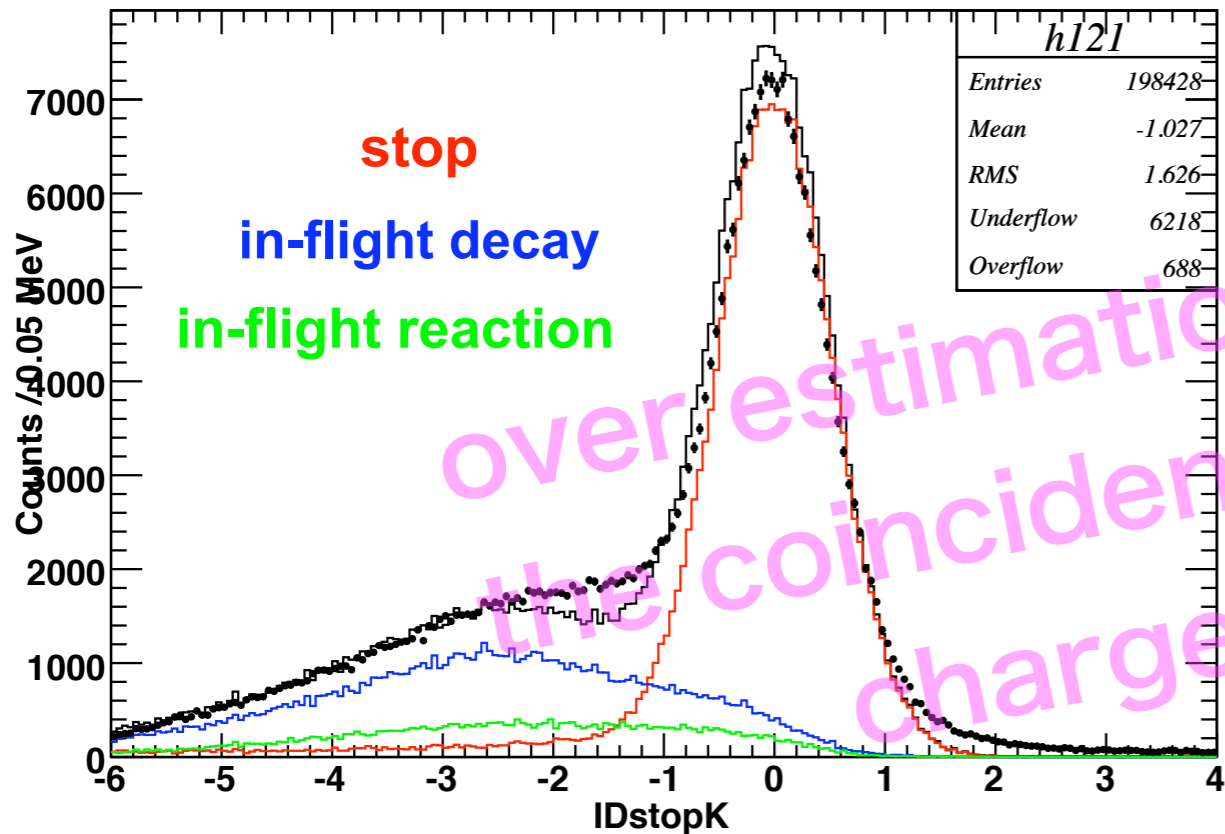
kstopid z14



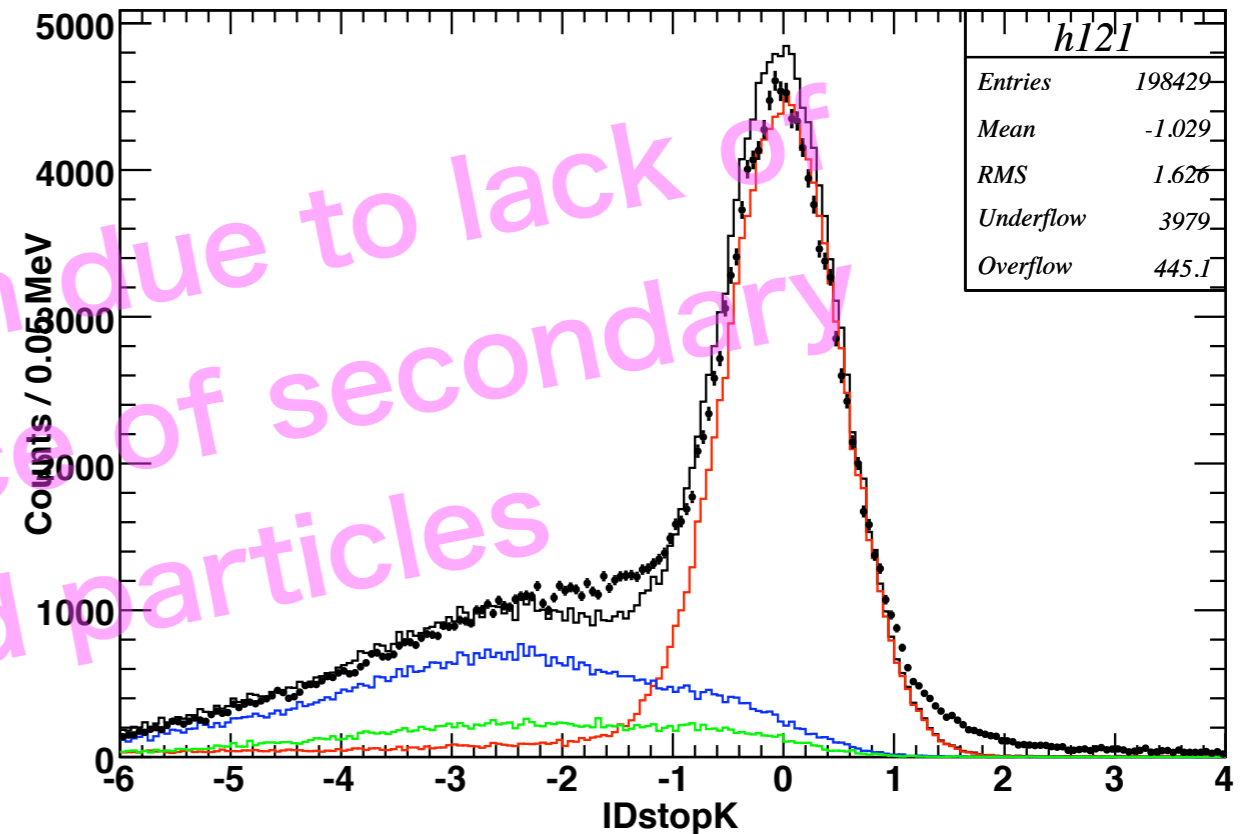
# IDstopK summed up

$r < 110$   
 $-70 < z < 90$

IDstopK (run 333) and simulation



IDstopK (run 450) and simulation



over estimation due to lack of  
 the coincidence of secondary  
 charged particles

$$\frac{\Delta L}{L} = \frac{c}{\sqrt{L}}$$

$\Delta L$  : sigma of Gaussian response  
 ( $c = 0.16$ )

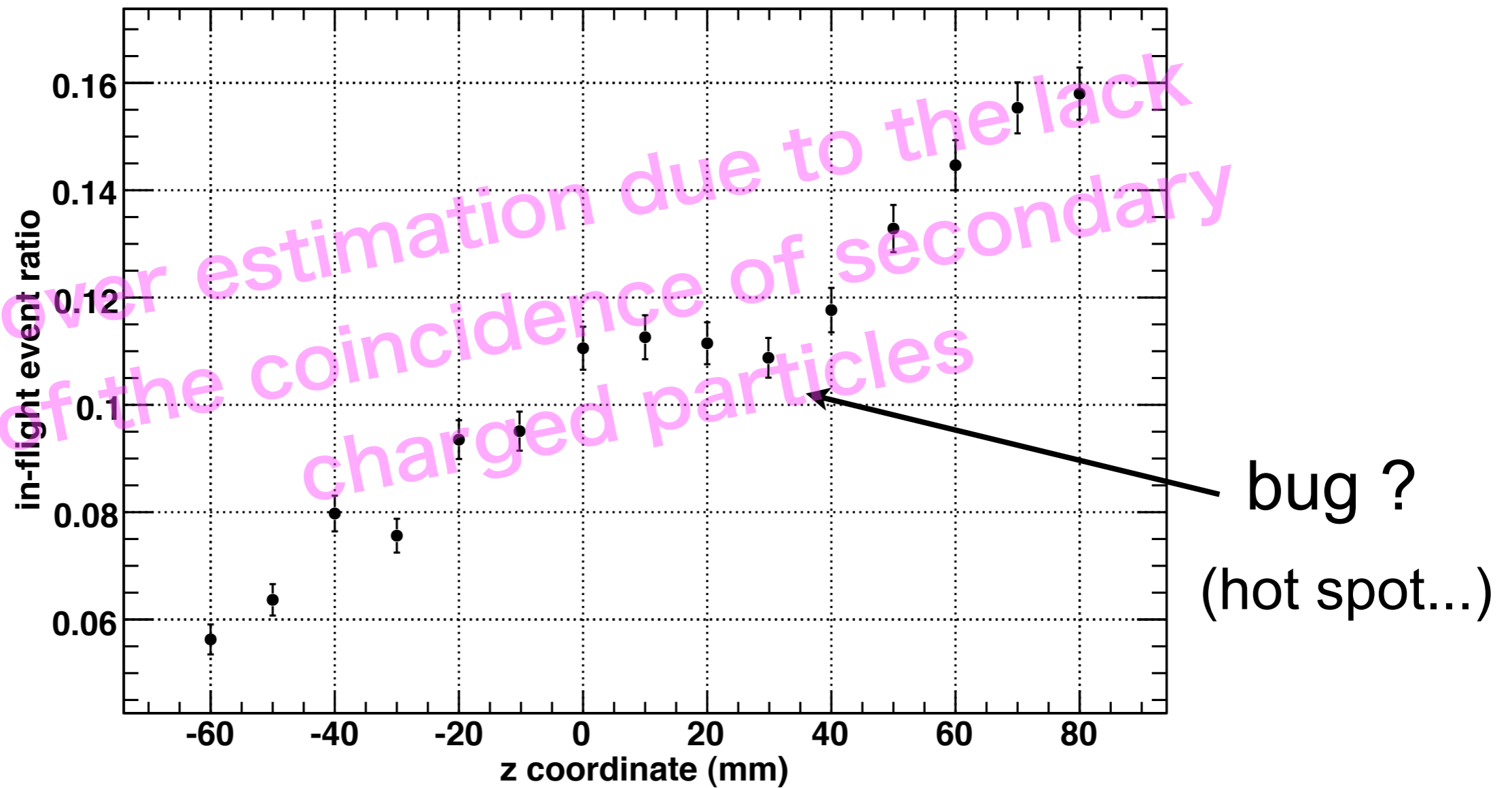
**in-flight event ratio**  
 $\sim 12.9 \pm 1\%$   
 (IDstopK > -1.2)



# In-flight event ratio (z dependence)

IDstopK > -1.2

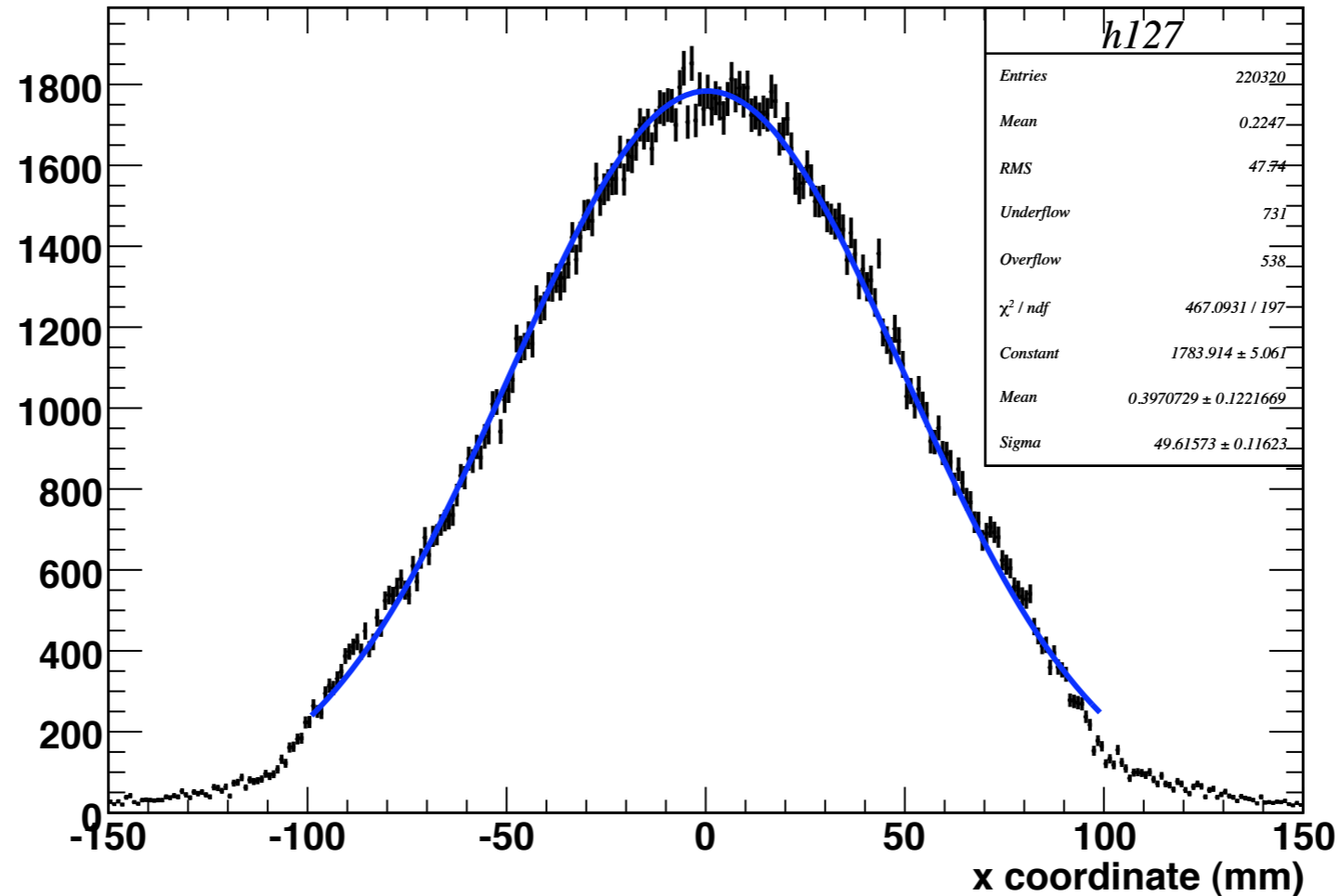
## In-flight event ratio (simulation)



# Stopped kaon distribution

## run 333

x vertex



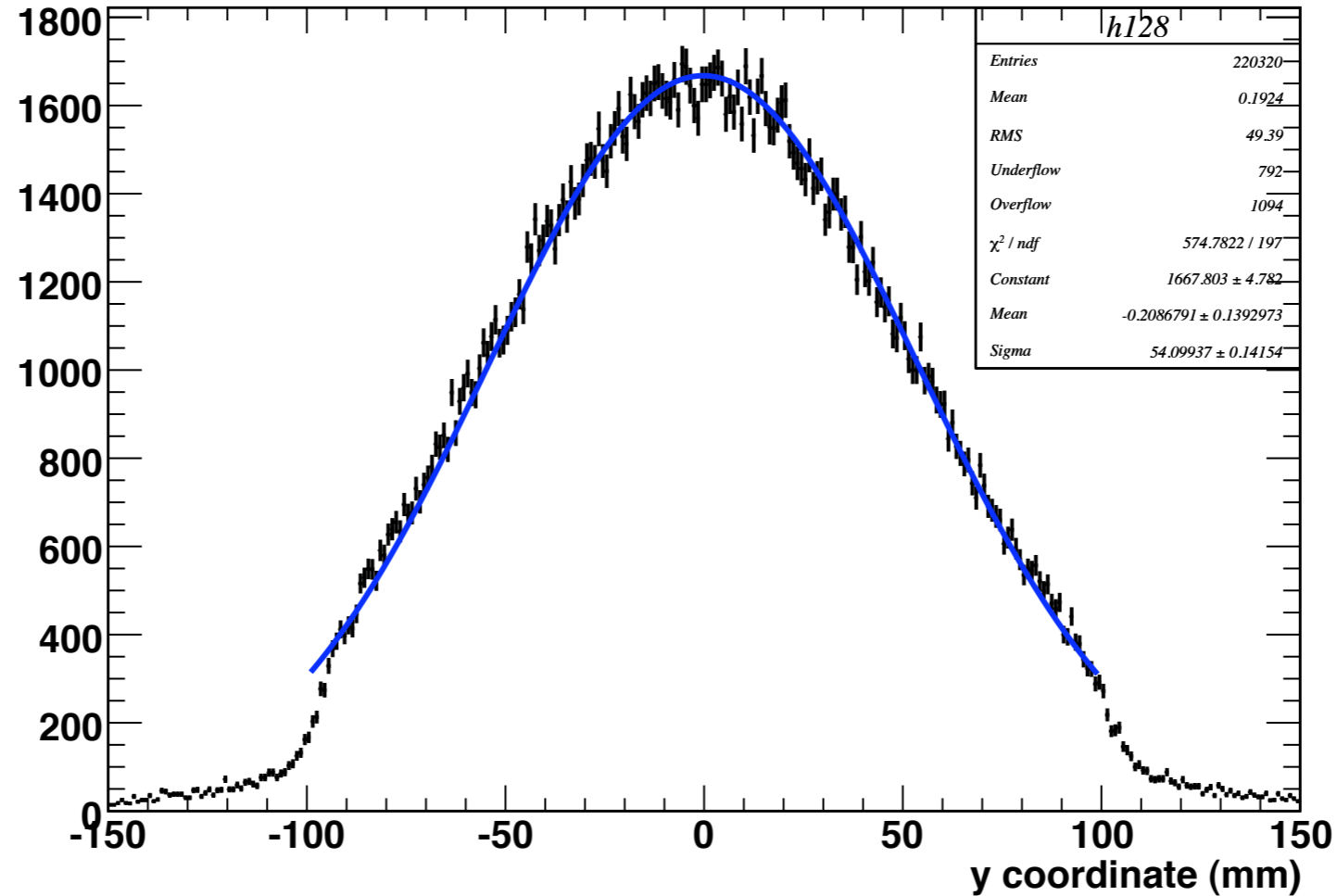
FCN=467.093 FROM MINOS STATUS=SUCCESSFUL 60 CALLS 137 TOTAL  
EDM=1.84241e-05 STRATEGY= 1 ERROR MATRIX ACCURATE  
EXT PARAMETER PARABOLIC MINOS ERRORS

| NO. | NAME     | VALUE       | ERROR       | NEGATIVE     | POSITIVE    |
|-----|----------|-------------|-------------|--------------|-------------|
| 1   | Constant | 1.78391e+03 | 5.06075e+00 | -5.07095e+00 | 5.05057e+00 |
| 2   | Mean     | 3.97073e-01 | 1.22166e-01 | -1.22071e-01 | 1.22263e-01 |
| 3   | Sigma    | 4.96157e+01 | 1.16229e-01 | -1.15693e-01 | 1.16769e-01 |

# Stopped kaon distribution

## run 333

### y vertex



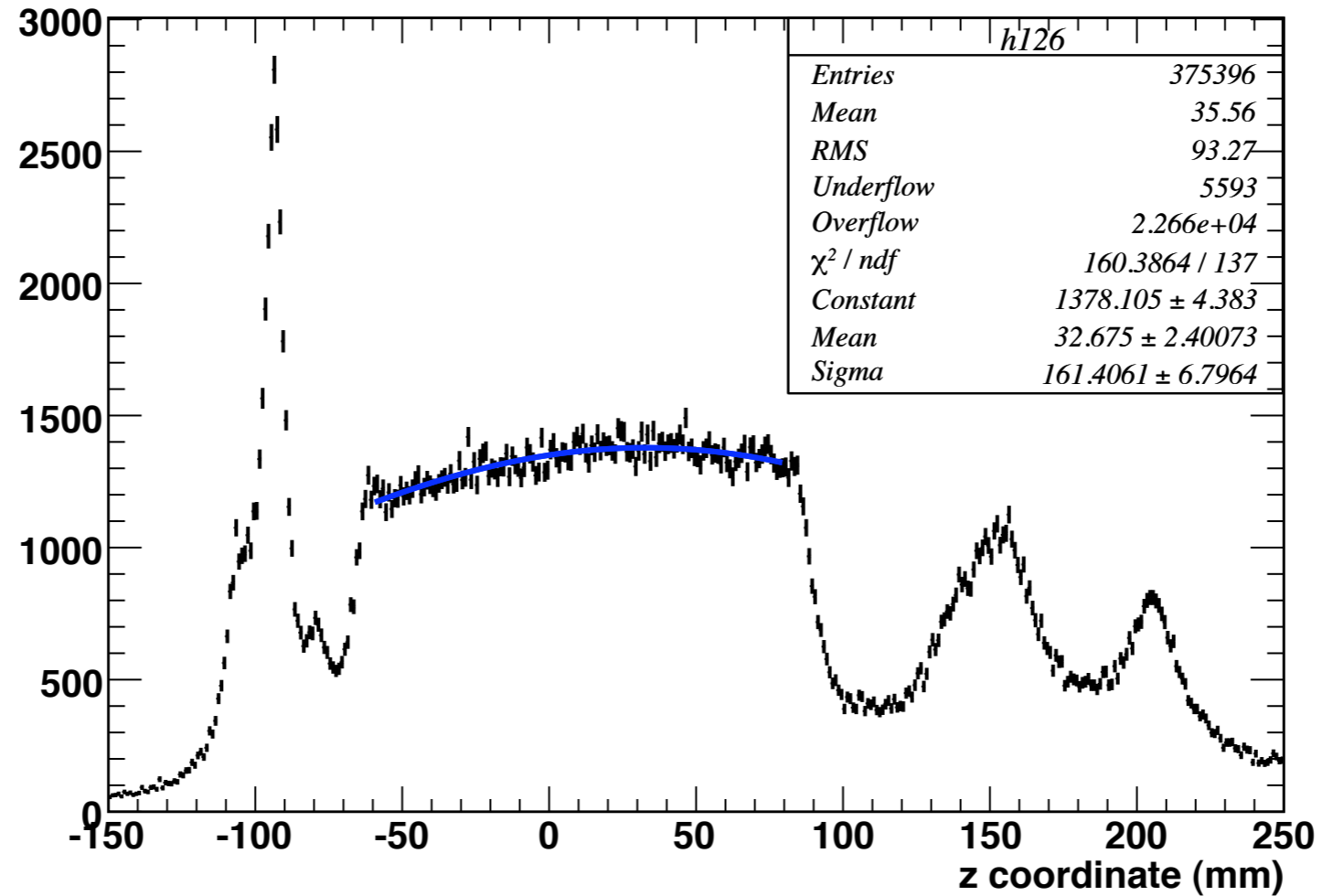
FCN=574.782 FROM MINOS      STATUS=SUCCESSFUL      60 CALLS      145 TOTAL  
EDM=1.57907e-09      STRATEGY= 1      ERROR MATRIX ACCURATE  
EXT PARAMETER      PARABOLIC      MINOS ERRORS

| NO. | NAME     | VALUE        | ERROR       | NEGATIVE     | POSITIVE    |
|-----|----------|--------------|-------------|--------------|-------------|
| 1   | Constant | 1.66780e+03  | 4.78185e+00 | -4.78024e+00 | 4.78338e+00 |
| 2   | Mean     | -2.08679e-01 | 1.39297e-01 | -1.39282e-01 | 1.39312e-01 |
| 3   | Sigma    | 5.40994e+01  | 1.41542e-01 | -1.41196e-01 | 1.41888e-01 |

# Stopped kaon distribution

## run 333

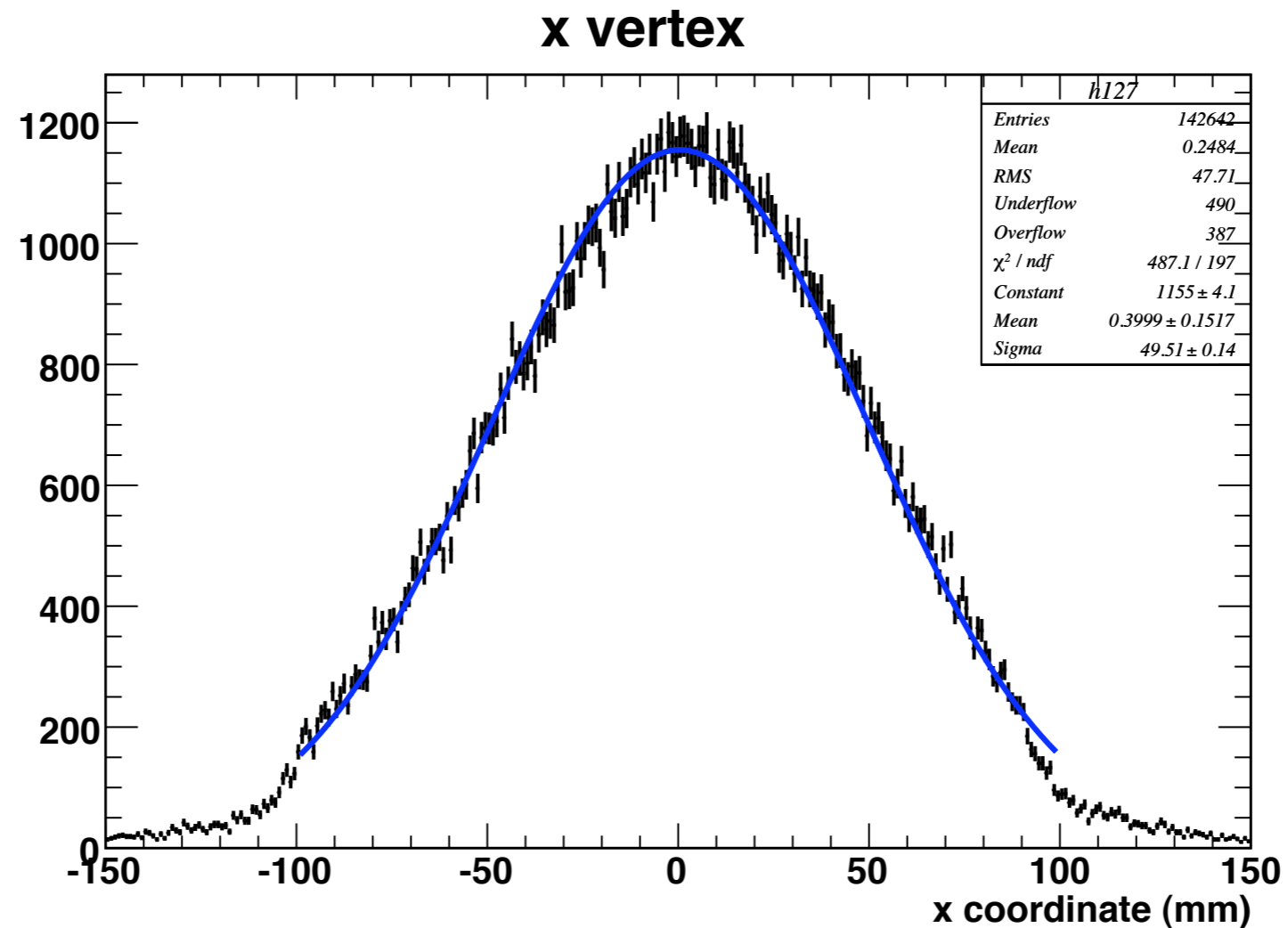
### z vertex



```
FCN=160.386 FROM MINOS      STATUS=SUCCESSFUL      132 CALLS      305 TOTAL
                        EDM=5.12532e-08      STRATEGY= 1      ERROR MATRIX ACCURATE
EXT PARAMETER              PARABOLIC              MINOS ERRORS
NO.  NAME      VALUE      ERROR      NEGATIVE      POSITIVE
1  Constant    1.37811e+03    4.38291e+00    -4.37651e+00    4.38983e+00
2  Mean        3.26750e+01    2.38741e+00    -2.24763e+00    2.55383e+00
3  Sigma       1.61406e+02    6.76525e+00    -6.37231e+00    7.22053e+00
```

# Stopped kaon distribution

## run 450



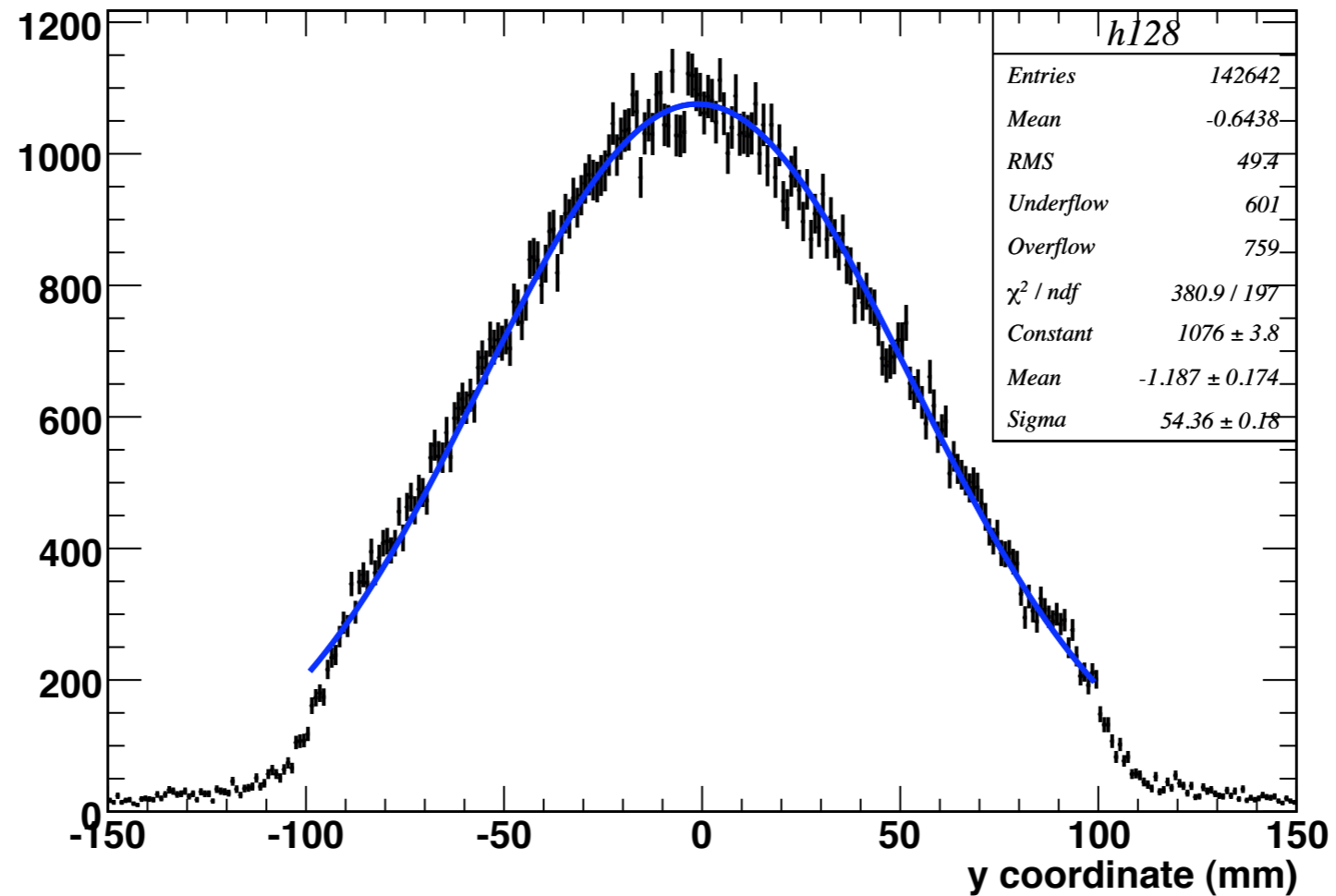
FCN=487.084 FROM MINOS      STATUS=SUCCESSFUL      60 CALLS      137 TOTAL  
EDM=8.56365e-06      STRATEGY= 1      ERROR MATRIX ACCURATE  
EXT PARAMETER      PARABOLIC      MINOS ERRORS

| NO. | NAME     | VALUE       | ERROR       | NEGATIVE     | POSITIVE    |
|-----|----------|-------------|-------------|--------------|-------------|
| 1   | Constant | 1.15532e+03 | 4.06764e+00 | -4.07291e+00 | 4.06233e+00 |
| 2   | Mean     | 3.99882e-01 | 1.51681e-01 | -1.51710e-01 | 1.51655e-01 |
| 3   | Sigma    | 4.95149e+01 | 1.43262e-01 | -1.42654e-01 | 1.43876e-01 |

# Stopped kaon distribution

## run 450

### y vertex



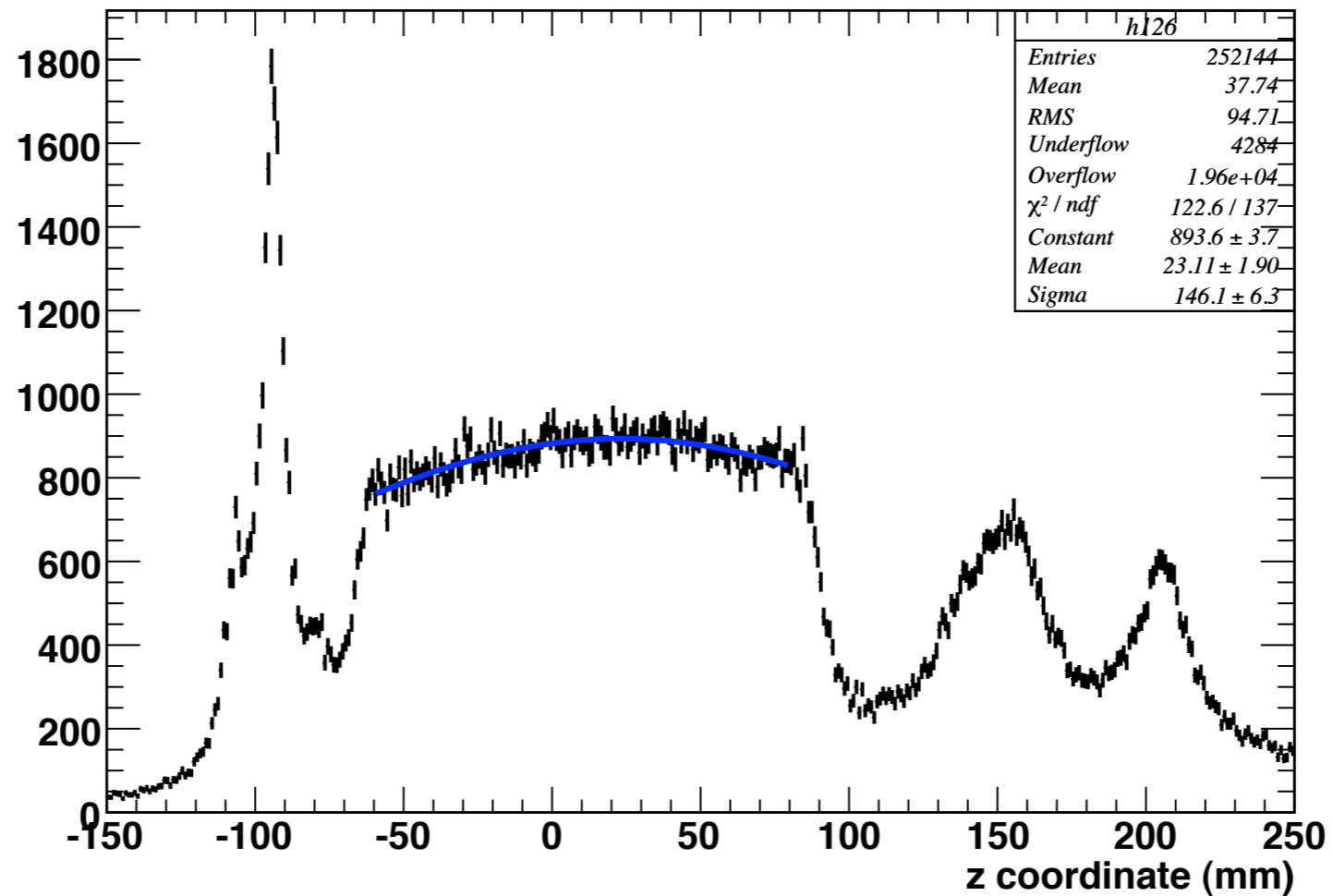
FCN=380.925 FROM MINOS      STATUS=SUCCESSFUL      60 CALLS      147 TOTAL  
EDM=6.45249e-07      STRATEGY= 1      ERROR MATRIX ACCURATE  
EXT PARAMETER      PARABOLIC      MINOS ERRORS

| NO. | NAME     | VALUE        | ERROR       | NEGATIVE     | POSITIVE    |
|-----|----------|--------------|-------------|--------------|-------------|
| 1   | Constant | 1.07579e+03  | 3.84839e+00 | -3.84637e+00 | 3.85034e+00 |
| 2   | Mean     | -1.18750e+00 | 1.74306e-01 | -1.74388e-01 | 1.74225e-01 |
| 3   | Sigma    | 5.43599e+01  | 1.79257e-01 | -1.78691e-01 | 1.79824e-01 |

# Stopped kaon distribution

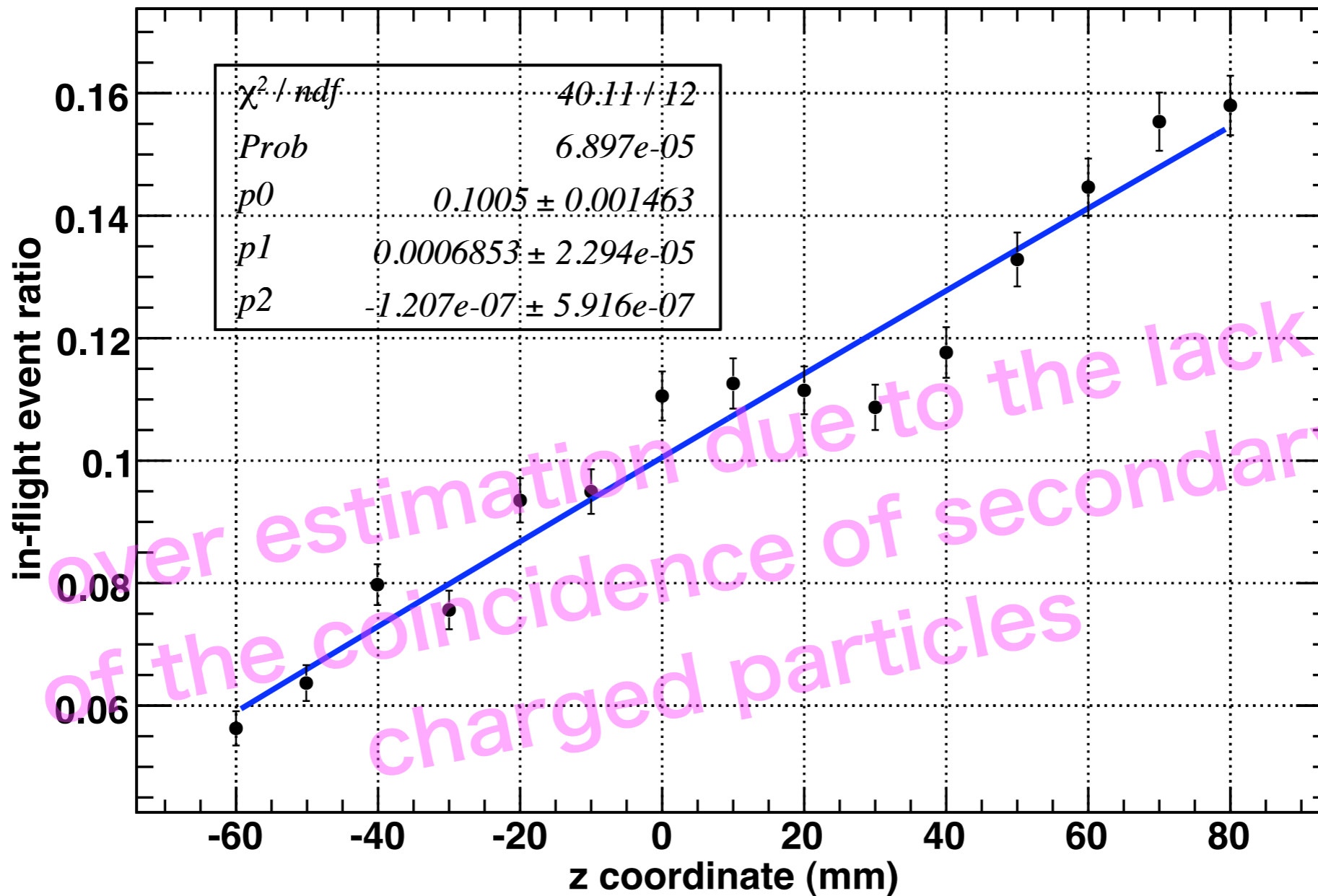
## run 450

### z vertex



```
FCN=122.615 FROM MINOS      STATUS=SUCCESSFUL      129 CALLS      285 TOTAL
                        EDM=4.43118e-06      STRATEGY= 1      ERROR MATRIX ACCURATE
EXT PARAMETER              PARABOLIC              MINOS ERRORS
NO.  NAME      VALUE      ERROR      NEGATIVE      POSITIVE
1  Constant    8.93577e+02    3.70976e+00    -3.70454e+00    3.71550e+00
2  Mean        2.31059e+01    1.88933e+00    -1.80719e+00    1.98979e+00
3  Sigma       1.46116e+02    6.24743e+00    -5.87406e+00    6.68246e+00
```

## In-flight event ratio (simulation)



*must to take into account this in-flight ratio  
to get the “pure” stopped K distribution*

$$F(z) = \text{Gauss}(z_0, \sigma_z) \times (1 - f_{\text{infl}}(z)) \quad \rightarrow \quad \textbf{simulation to get acceptance curve}$$



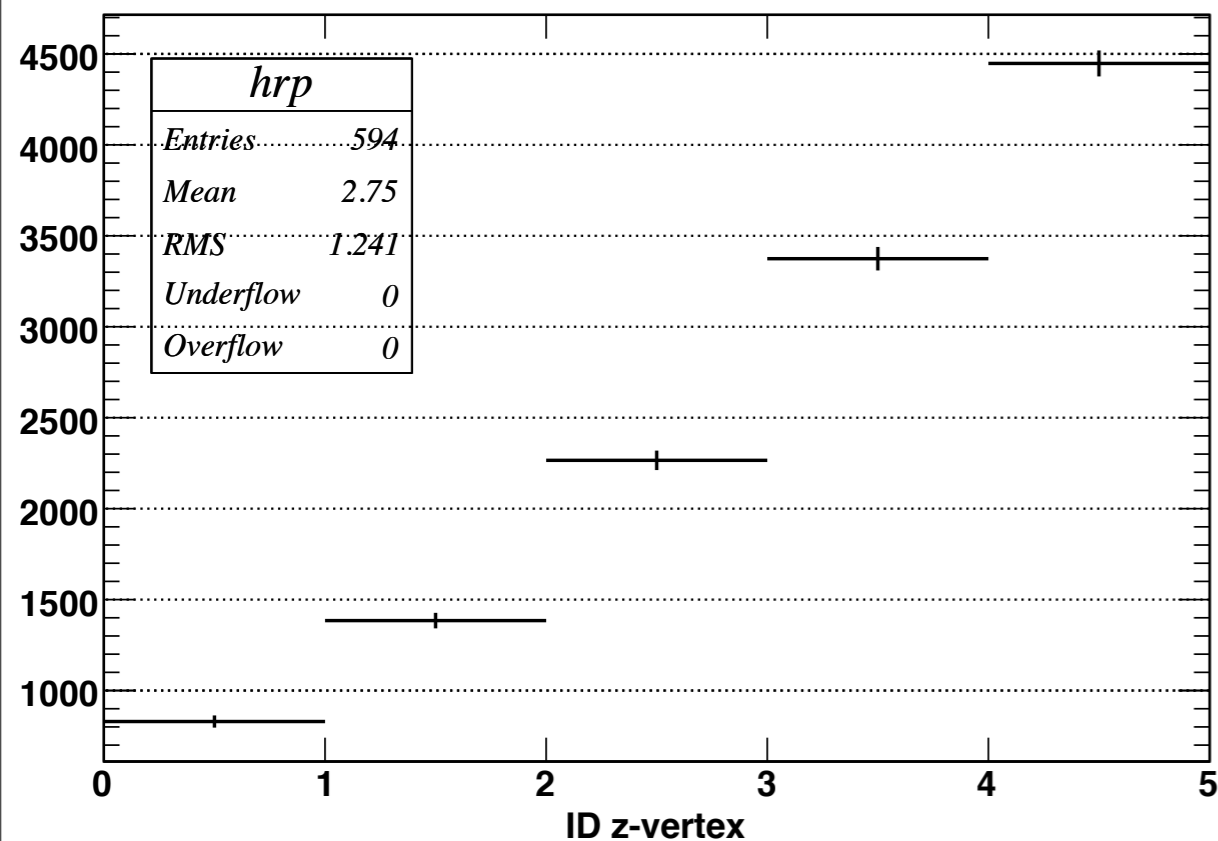
**Now Simulation is running.....  
please wait the final result**

# Normalization

Compare (Counts/NstopK)  
in BG/L-alpha region with  
acceptance correction

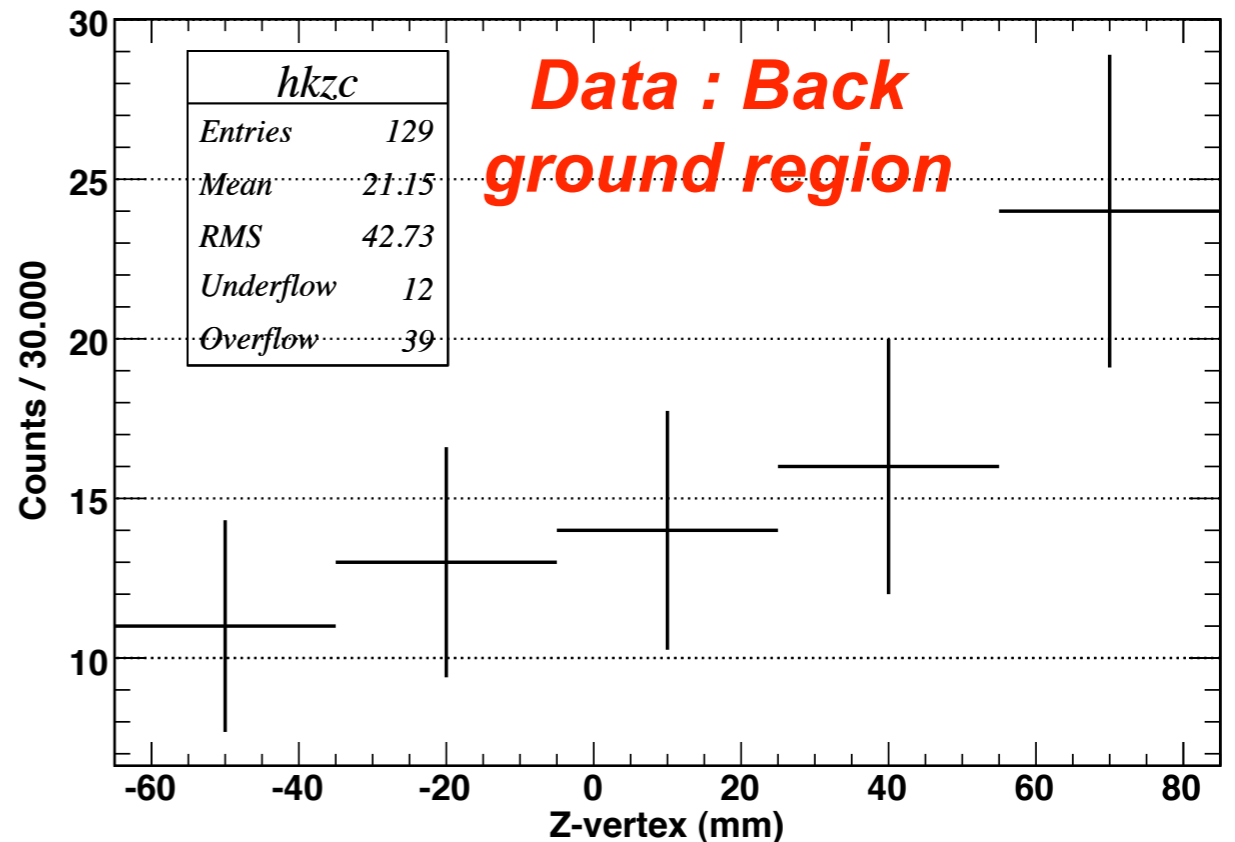
\* preliminary (the statistics is still  
small to correct the acceptance)

number of stopped kaons (w/ acceptance correction for KHeX La)

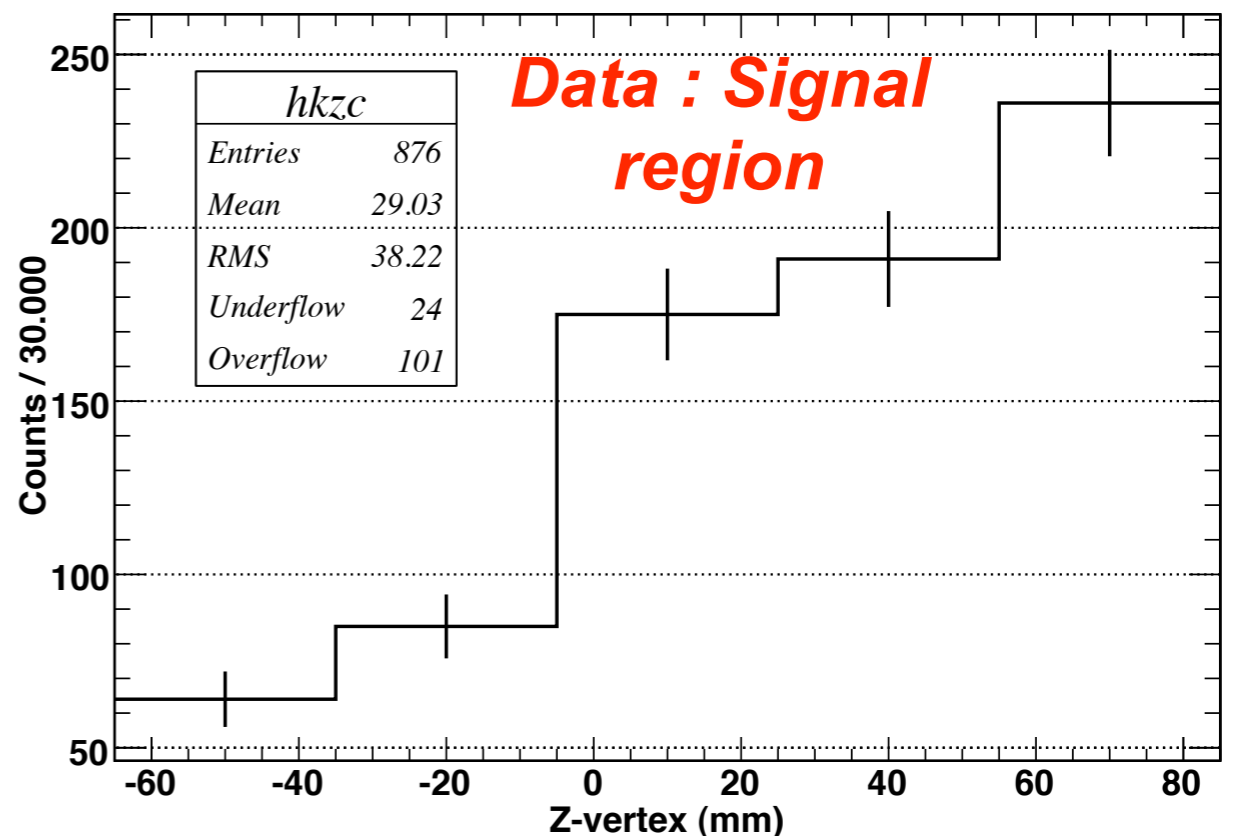


*with in-flight events removing*

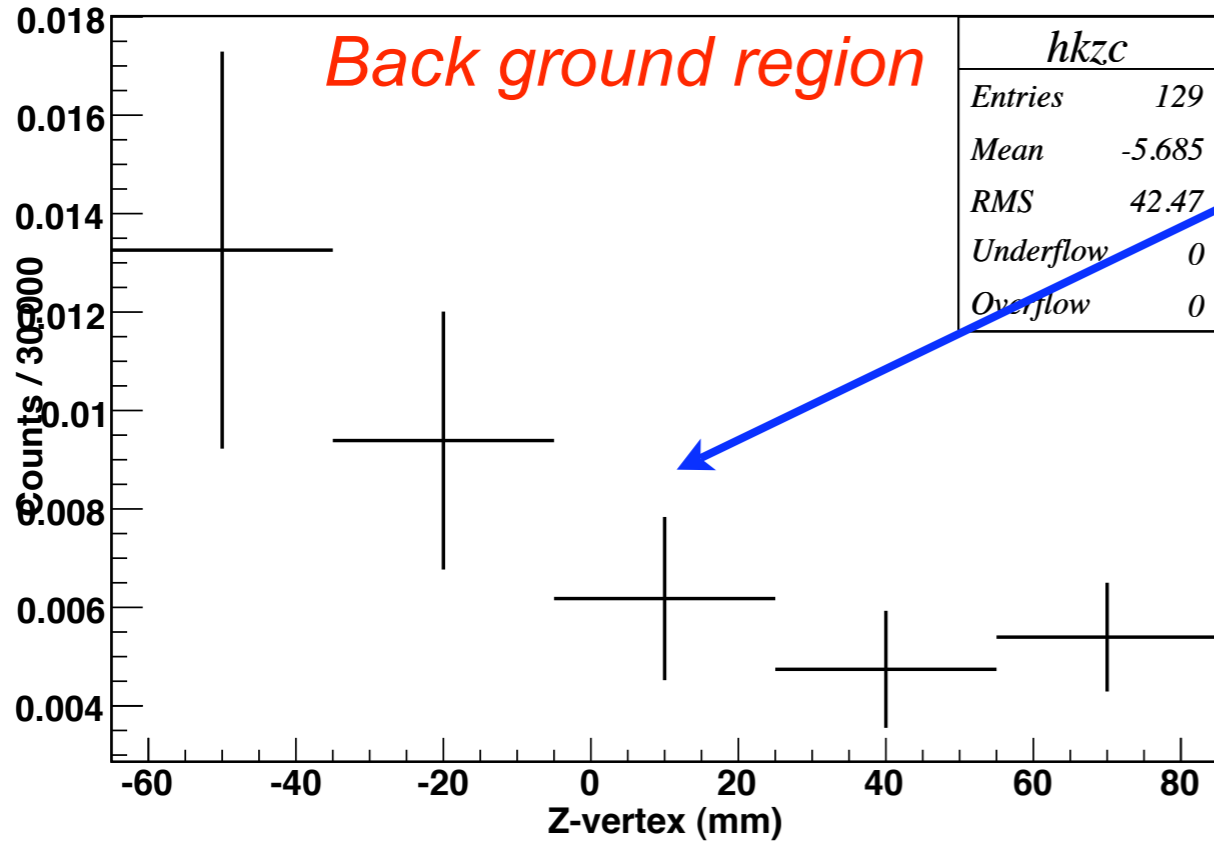
BG (5.7 keV < E < 6.0 keV)



Signal (6.3 keV < E < 6.6 keV)



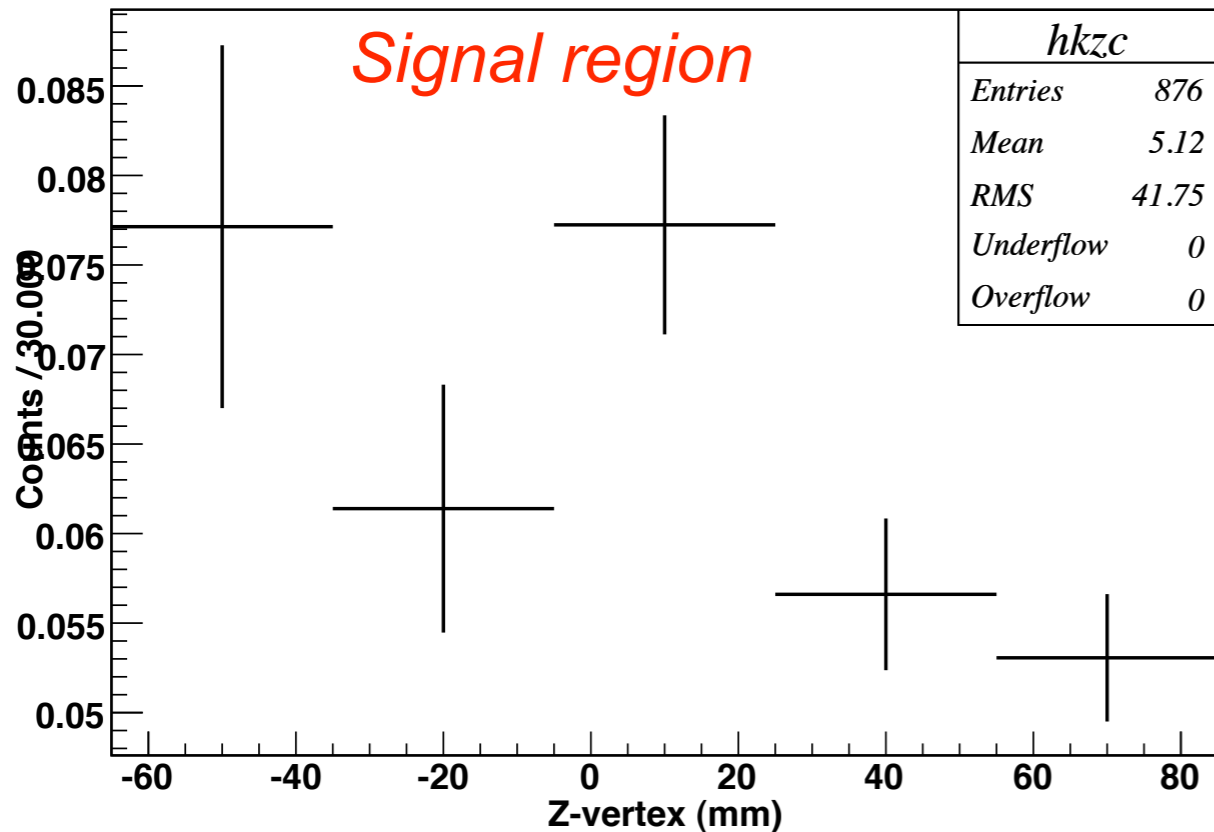
**BG (5.7 keV < E < 6.0 keV)**



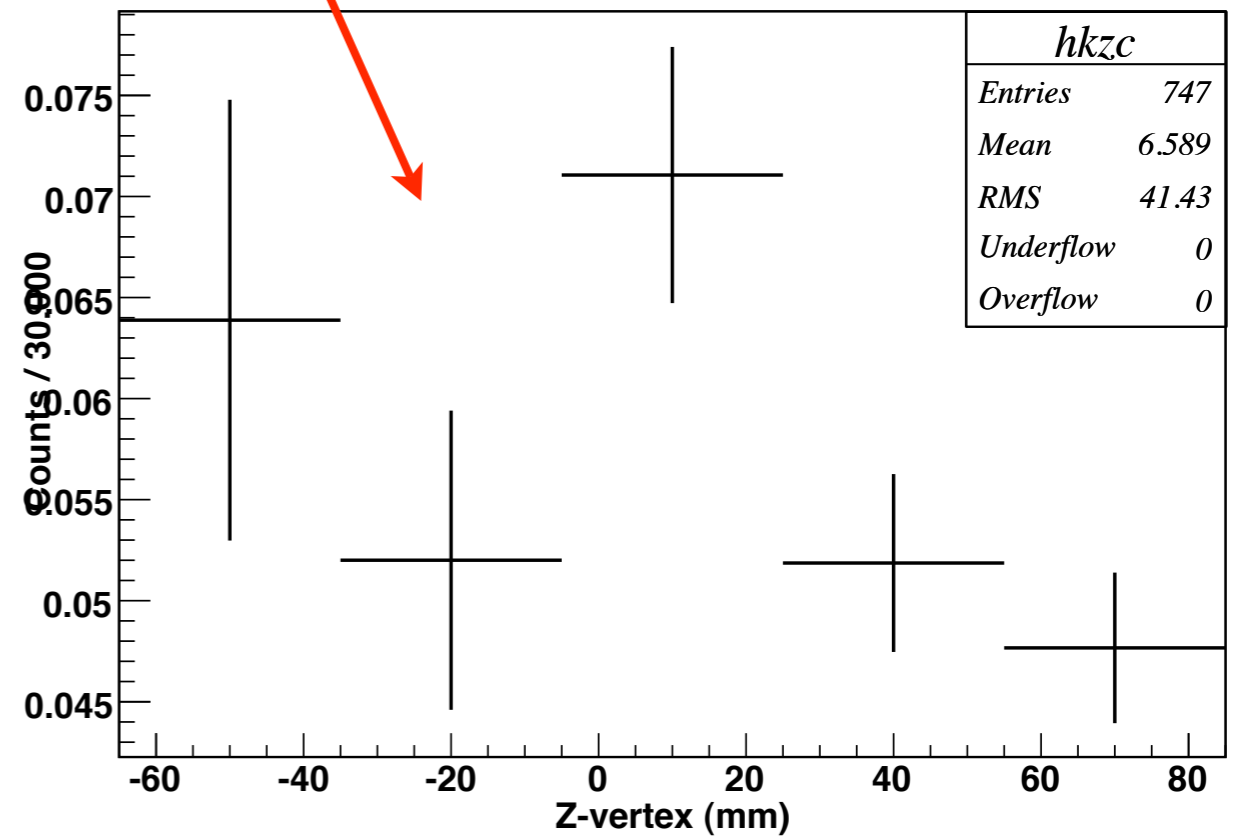
**Background shows a z-dependent curve !**

**If regard this “z-dependence” as a fluctuation, the statistical error is ~4.5%**

**Signal (6.3 keV < E < 6.6 keV)**



**Signal - BG**



**(assuming flat BG shape)**

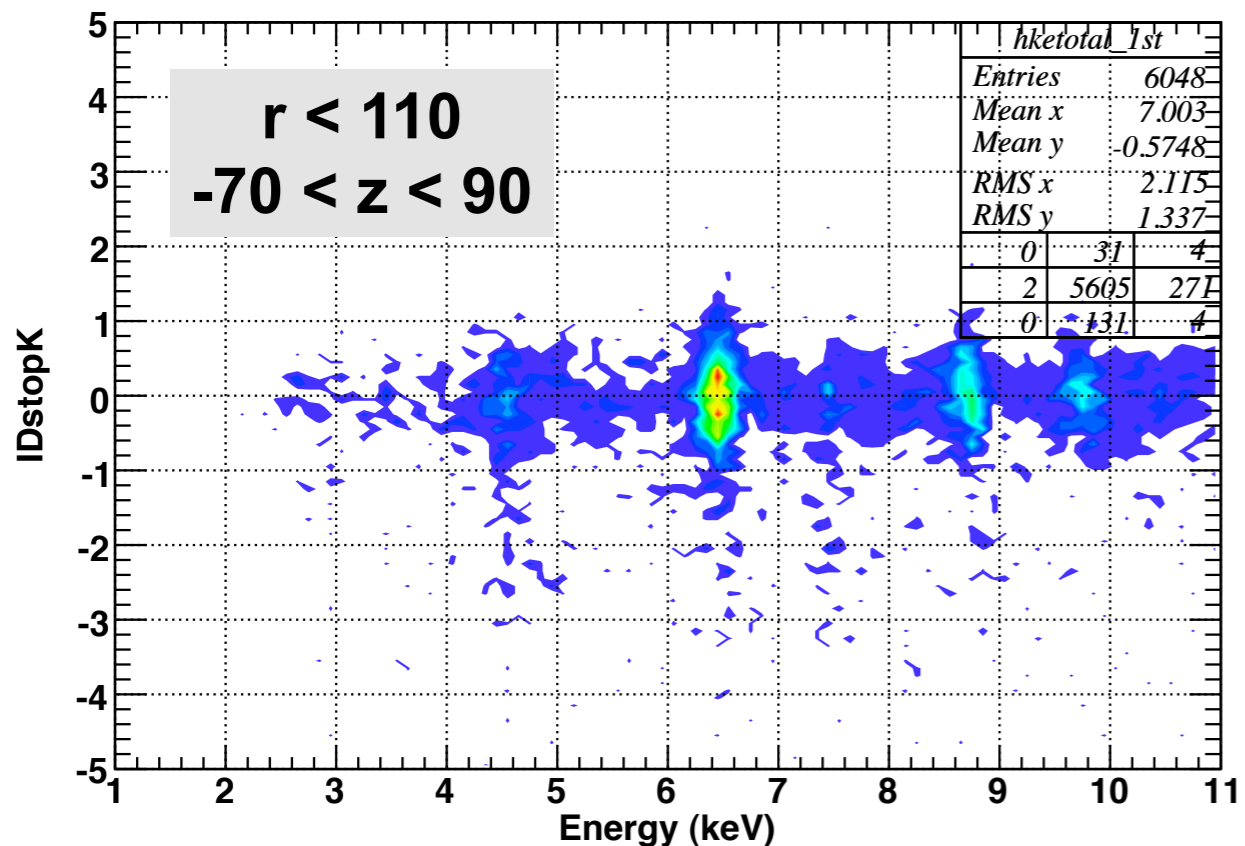
# Summary

- **To evaluate the amount of in-flight contamination, a MC simulation was done with**
  - T0 tuning (Birk's effect and gain saturation),*
  - Energy resolution of T0 ( $\Delta L \sim 0.16 \text{ sqrt}(L)$ )*
- **But secondary-charged-particles coincidence condition is NOT included, so this is over estimation.**
  - now checking this with TC, Pstart and Pstop (especially for decay events evaluation)
- **Even so the situation was not improved clearly, moreover the background just under the x-ray peak was likely to have a z-dependence ! *Removing the background is important.***
- **When we regard the “z-dependence” as a fluctuation, the statistical error is ~4.5% (preliminary).**

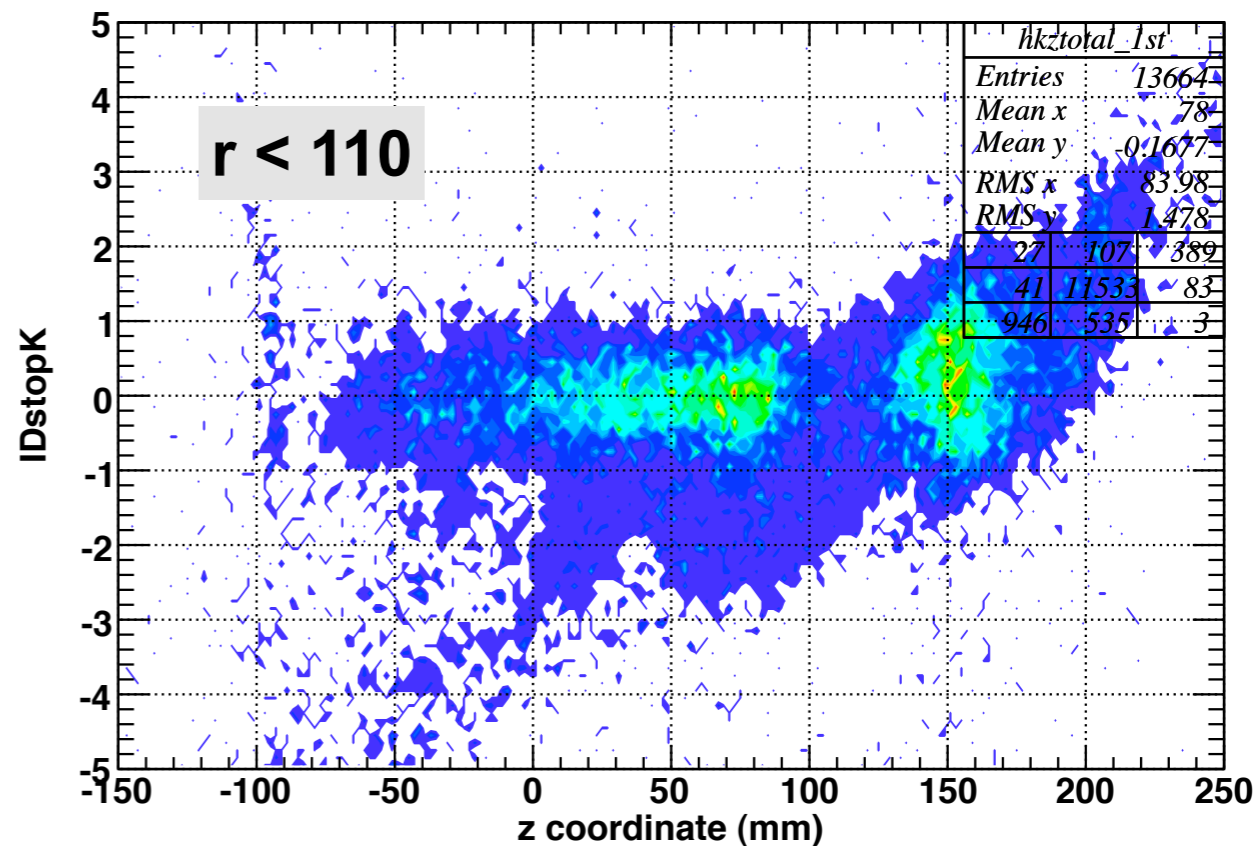
**spare**

**not used in this report ...**

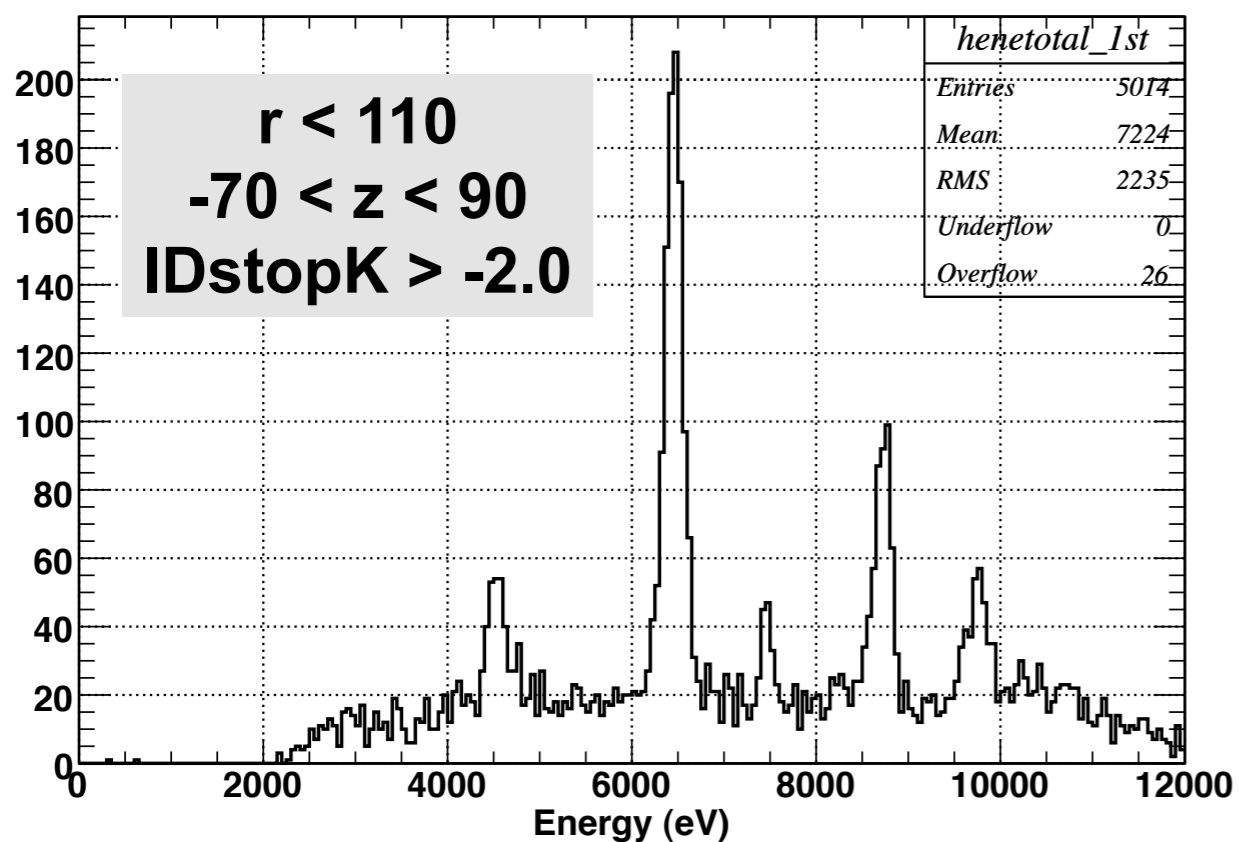
hketotal\_1st



hkztotal\_1st



henetotal\_1st

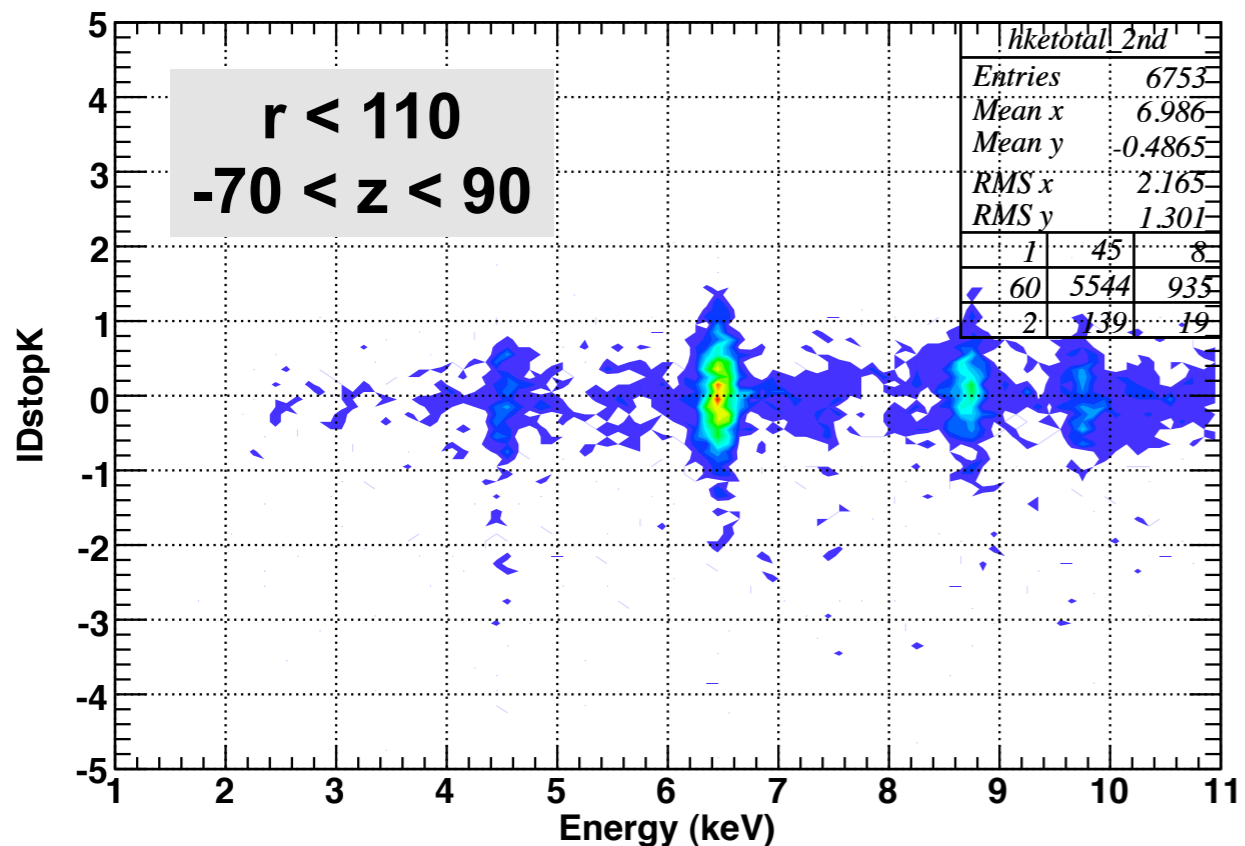


***IDstopK cut (for SDD hit data)***

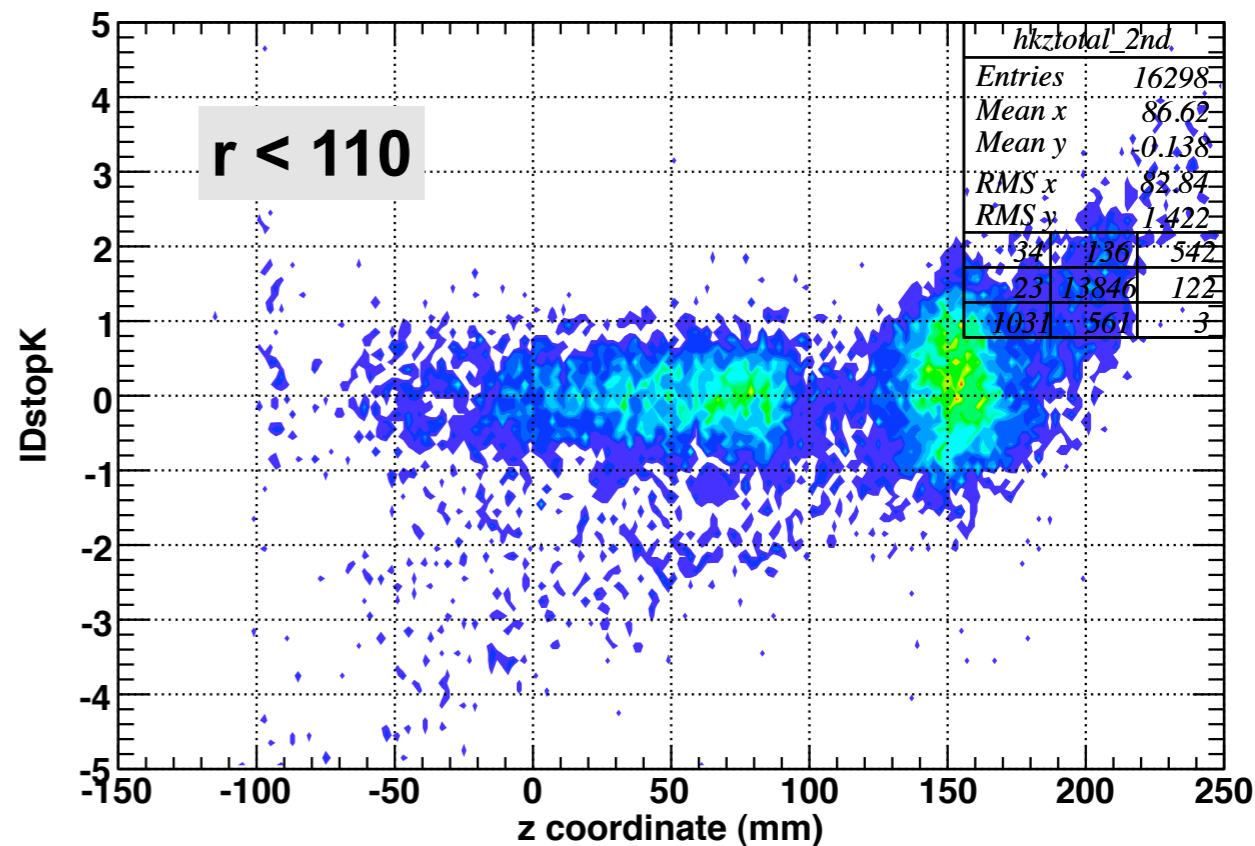
**Contour plots  
and  
energy spectrum**

**E570 1st cycle**

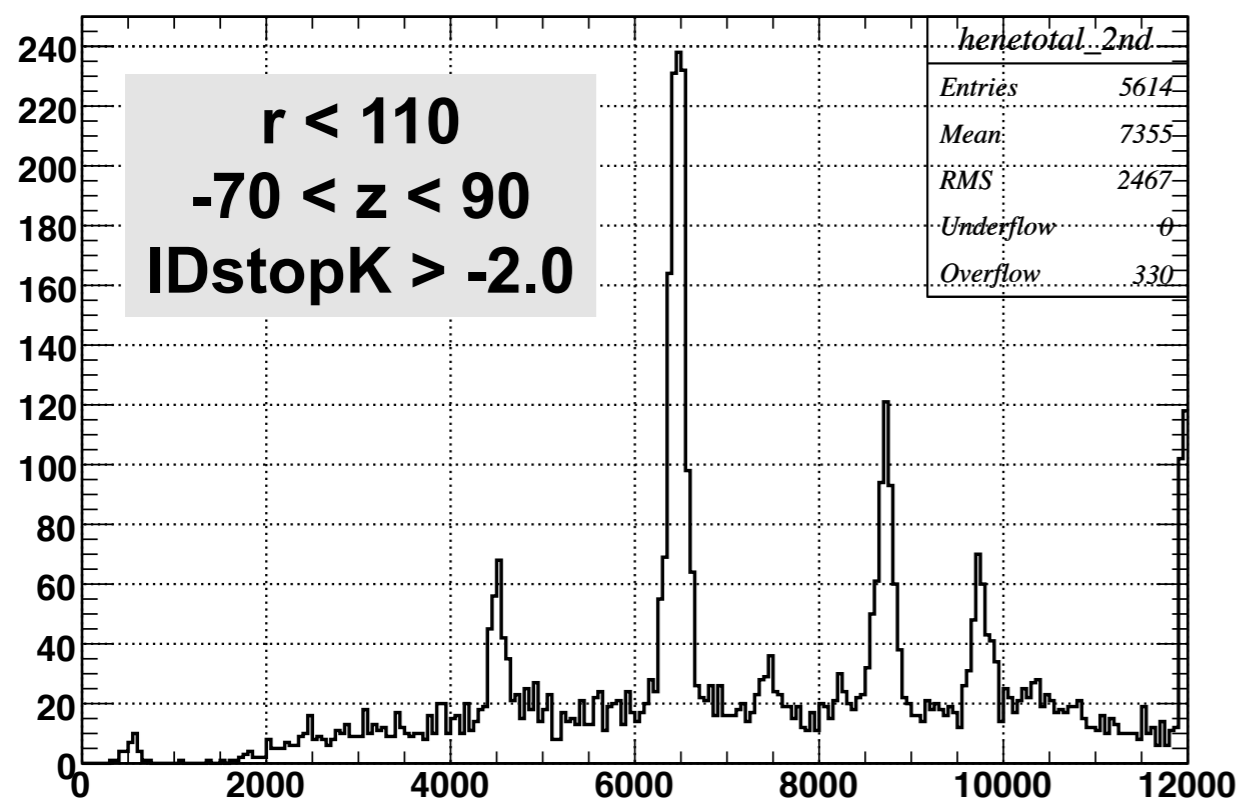
hketotal\_2nd



hkztotal\_2nd



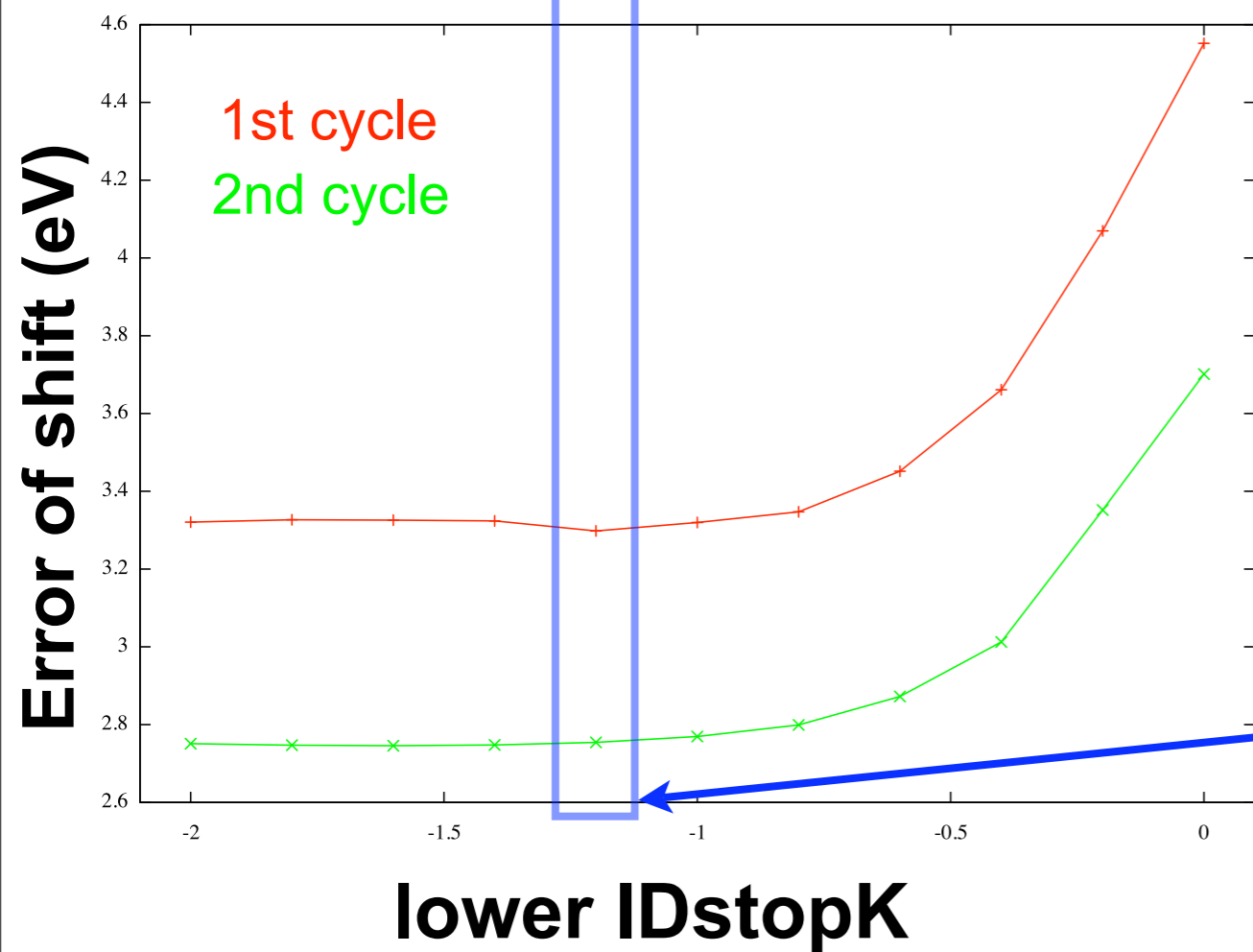
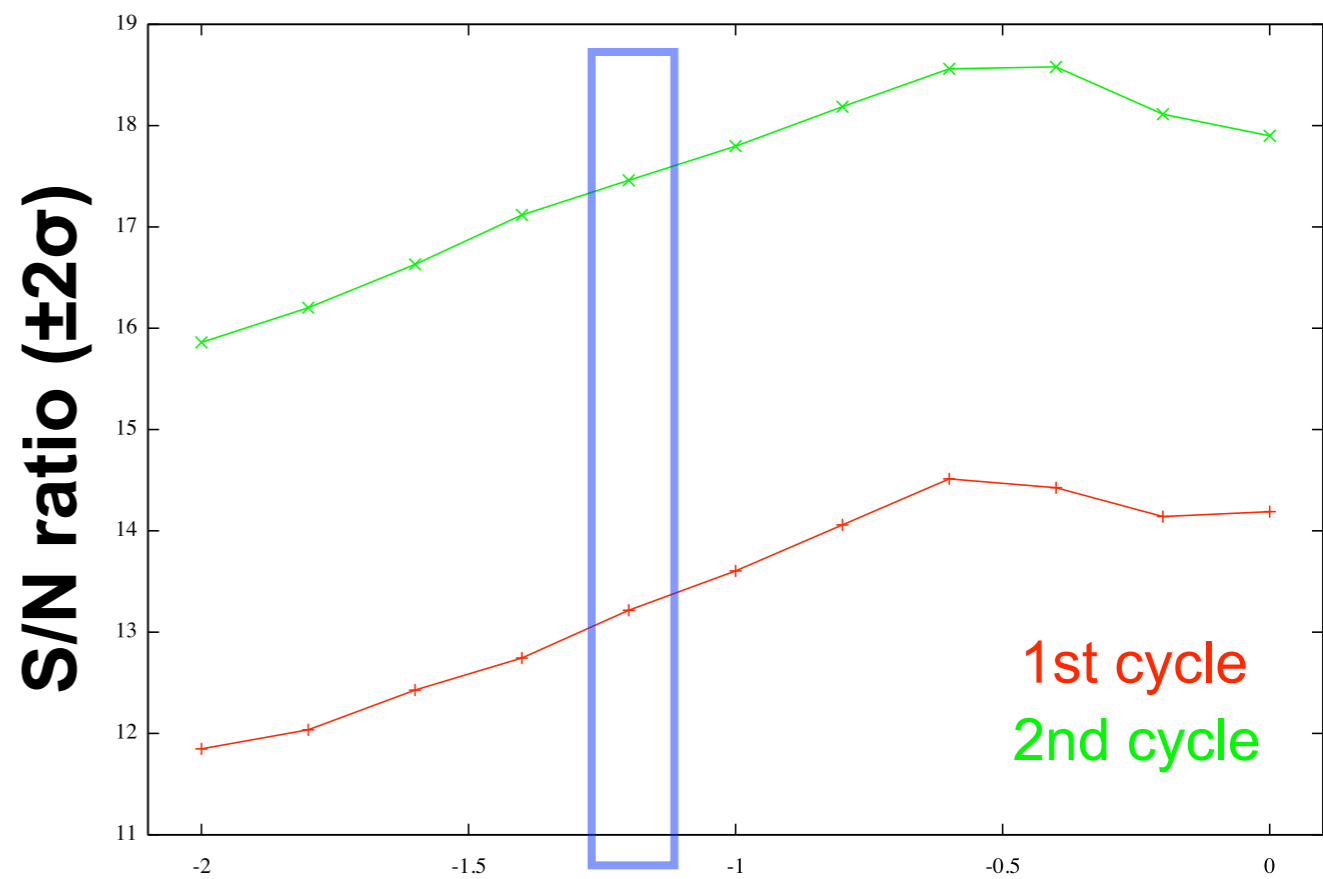
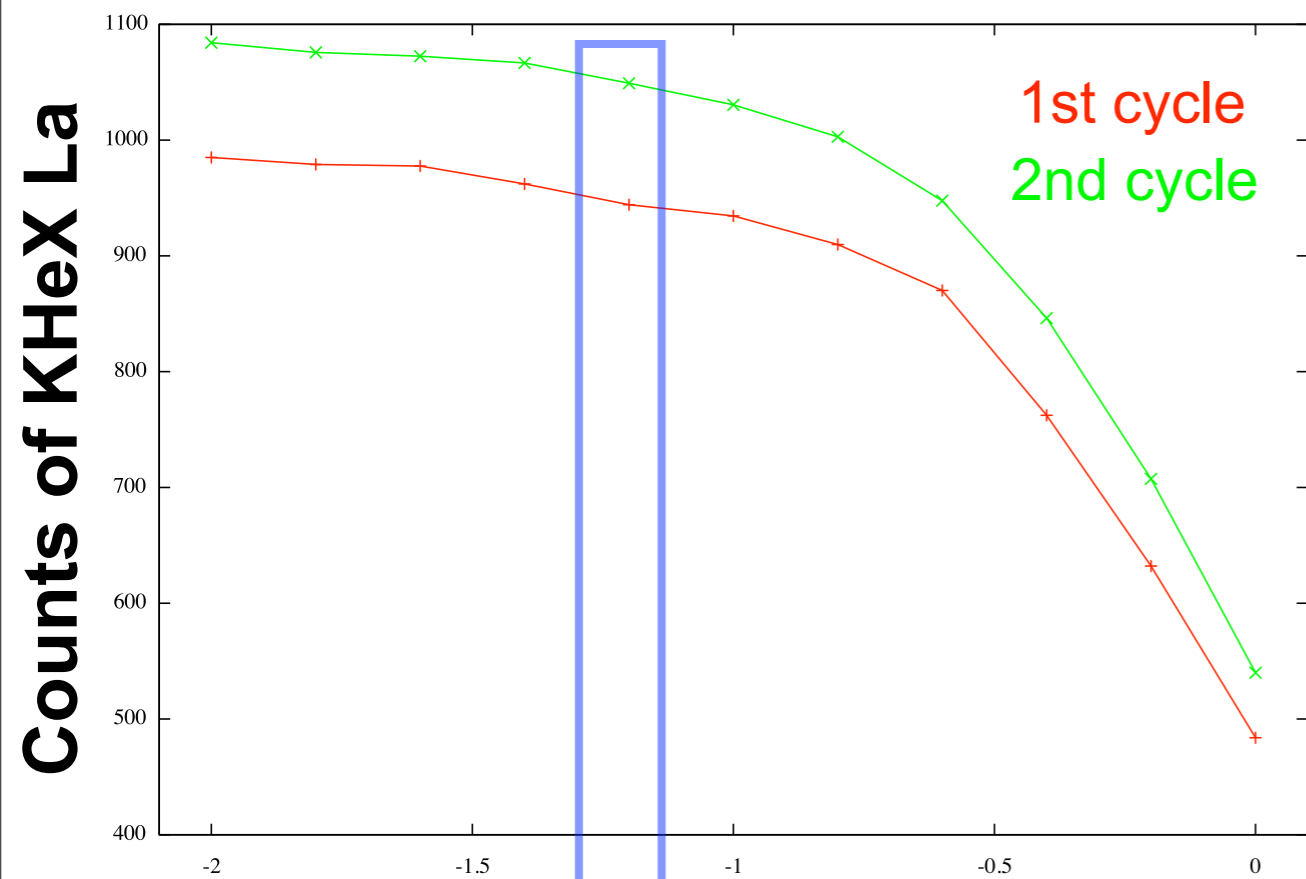
henetotal\_2nd



***IDstopK cut (for SDD hit data)***

**Contour plots  
and  
energy spectrum**

**E570 2nd cycle**



lower IDstopK

*IDstopK cut*

**IDsropK > -1.2**

**Criterion : statistical error of shift takes priority over S/N ratio**