First Inclusive Pt Unfolding Results

Benard Mulilo (KU/RIKEN)

Spin RadLab Meeting

9 pm Jun 20, 2019 JST

Analysis Process – Neutron Identification Cuts

Neutron Selection Cuts: Energy, Acceptance and the SMD Multiplicity

Following cuts have been used to select neutron events to reconstruct the energy and transverse momentum spectra from a combination of UPC + DPMJET MC samples: [same cuts as data have been applied]

① ZDC total energy: 40 < E < 120 and 2nd ZDC energy/ZDC total energy > 0.03 (i.e. non-zero 2nd ZDC energy)

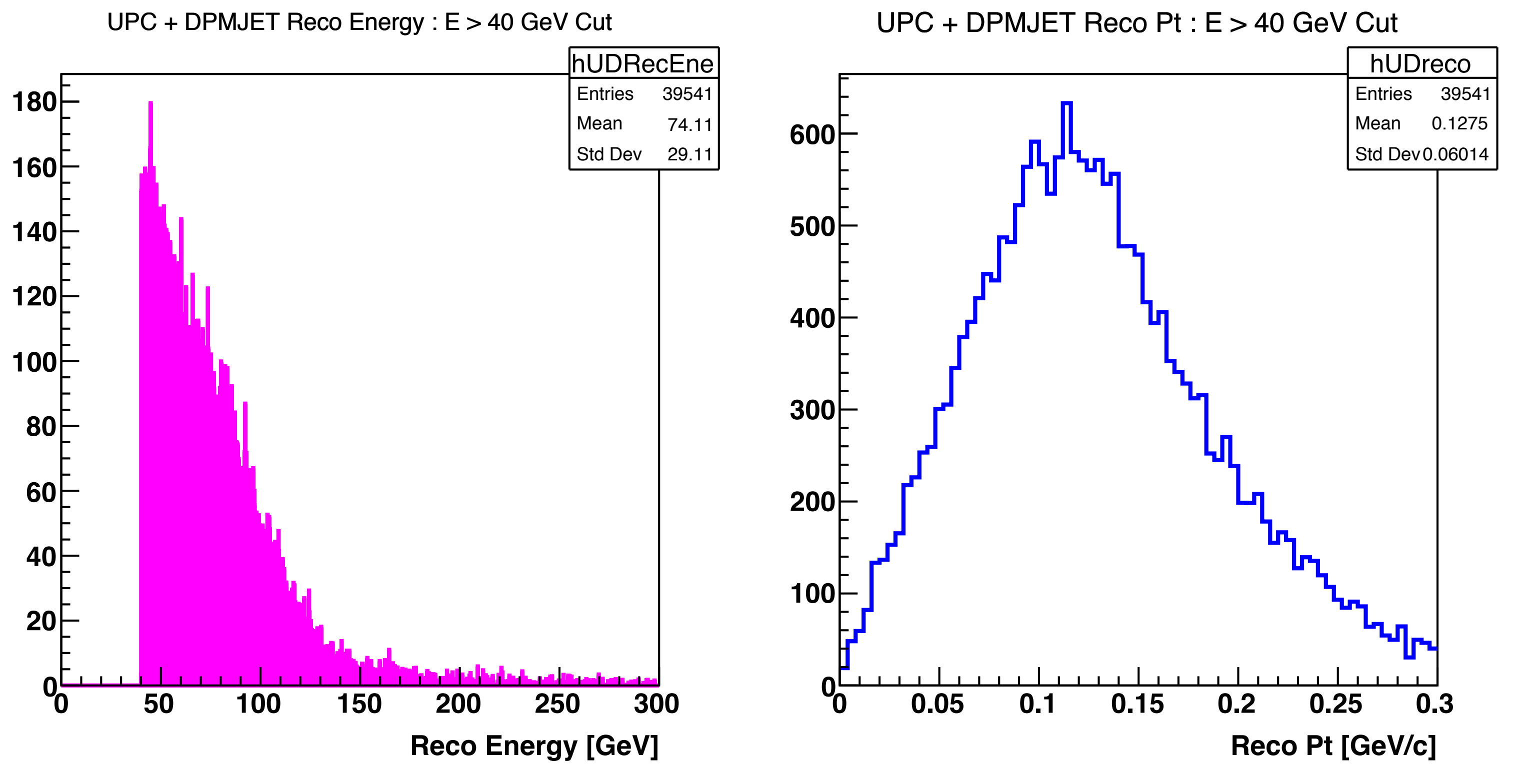
② Acceptance cut: 0.5 < r < 4.0 cm

③ Nxy >= 2 fired SMD strips. That is Nx > 1 and Ny > 1 fired strips above Minimum Ionized Particle (MIP) SMD energy threshold cut.

Analysis Process – Energy Cut > 40 GeV

Slide 3

Energy Cut > 40 GeV

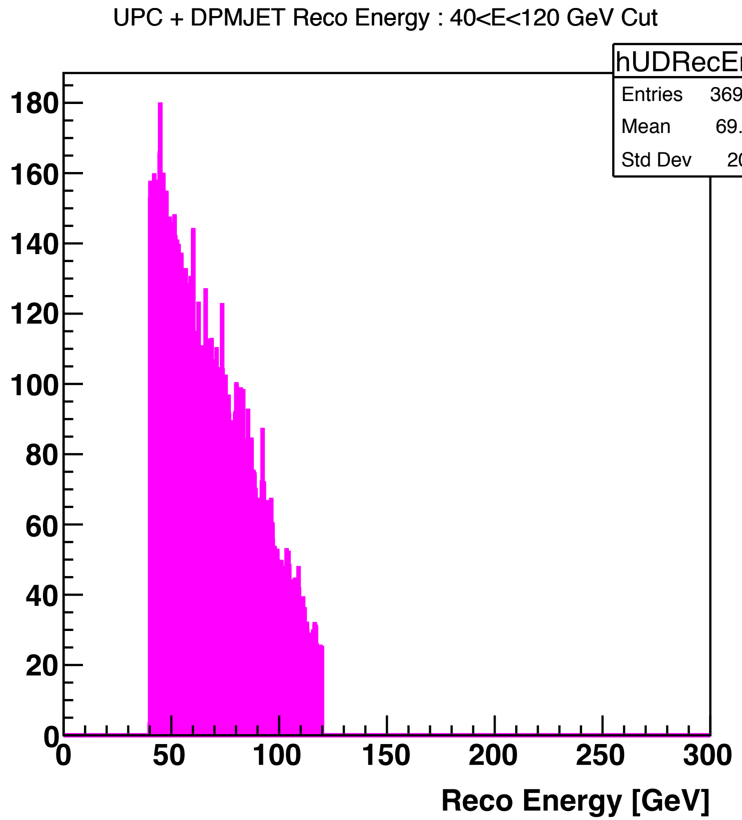


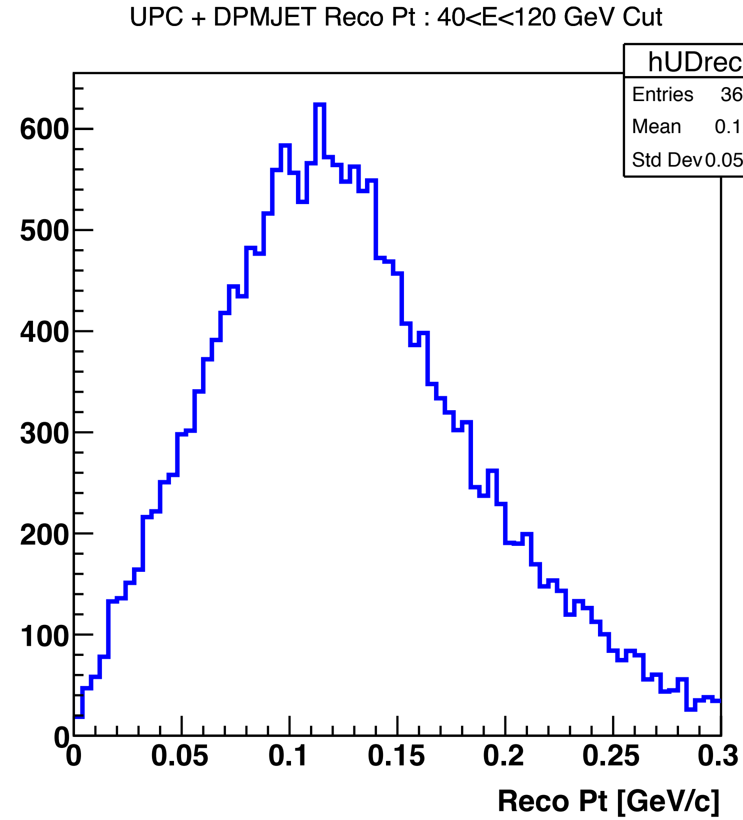
Reconstructed ZDC energy distribution (left panel) and pt distribution (right panel)

Analysis Process – 40 < E < 120 GeV

Slide 4

Energy Cut: 40 < E < 120 GeV

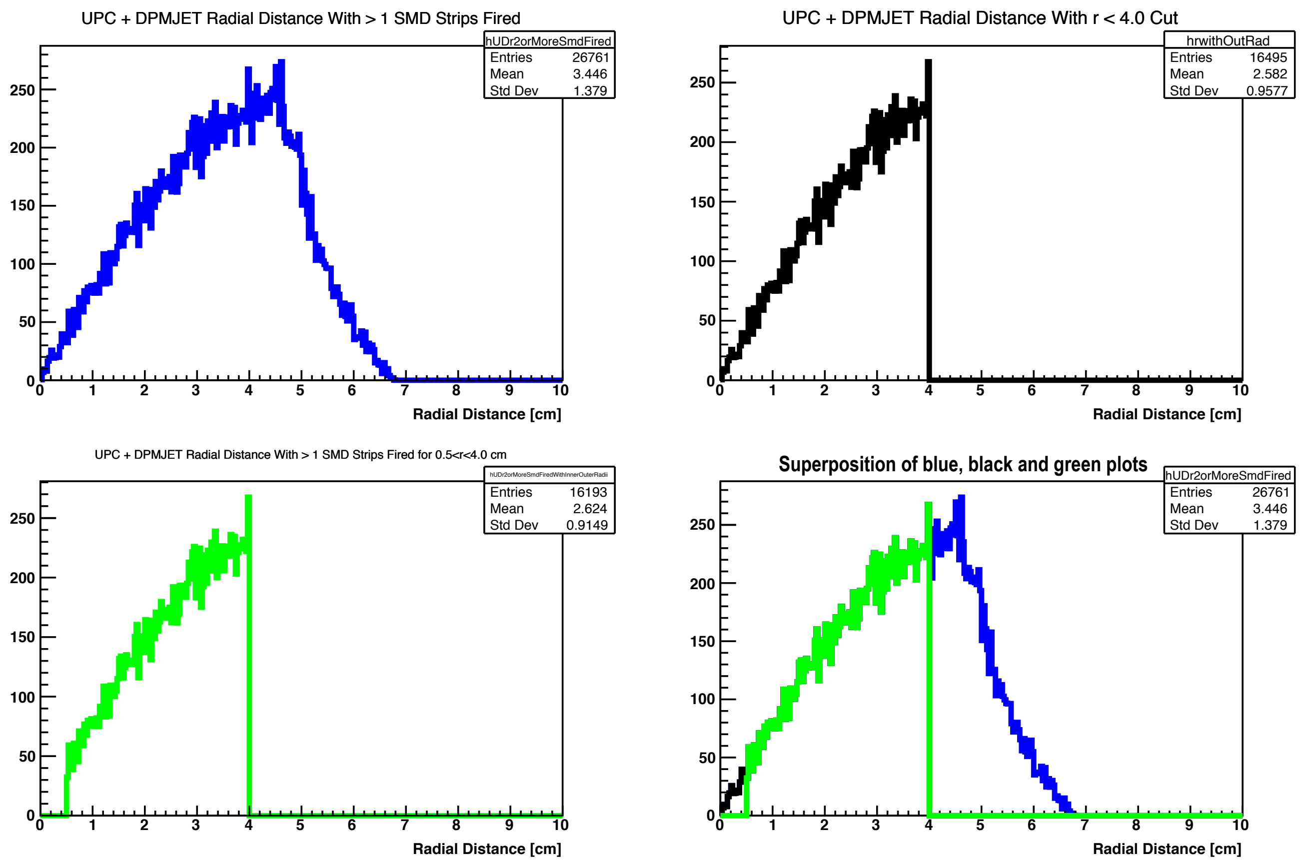




Reconstructed ZDC energy distribution (left panel) and pt distribution (right panel)

Analysis Process – Acceptance cut: 0.5<r<4 cm

Acceptance cut : 0.5 < r < 4.0 cm

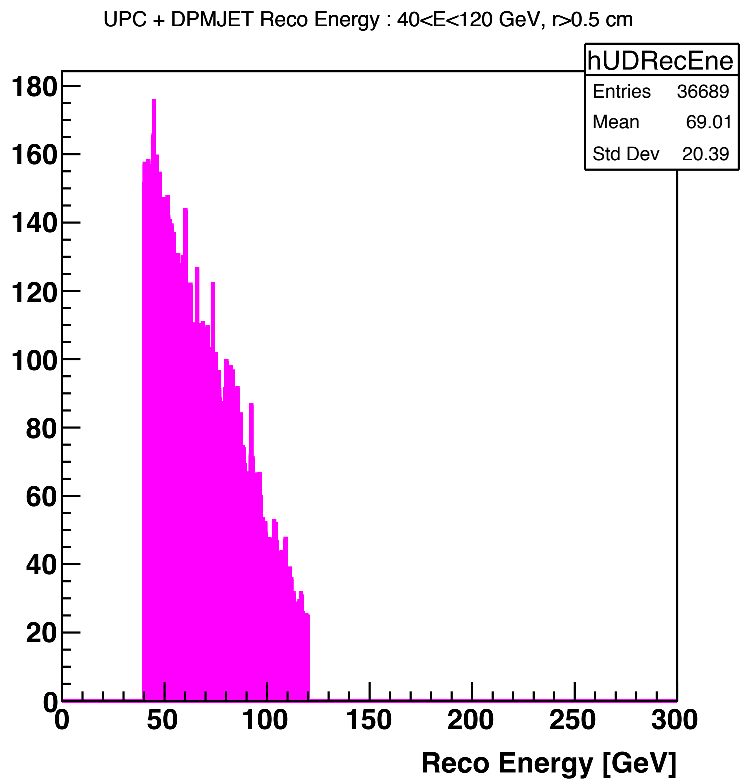


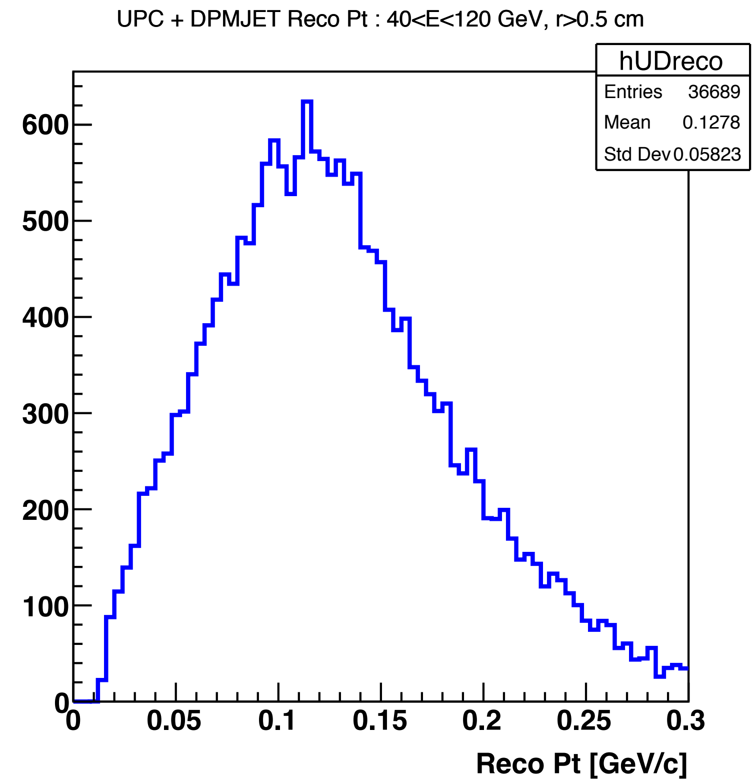
With r reconstructed as the square root of sum of the squares of the reconstructed x and y position variables

Analysis Process – 40<E120 GeV, r>0.5 cm

Slide 6

Energy Cut: 40 < E < 120 GeV and Acceptance Cut: r > 0.5 cm

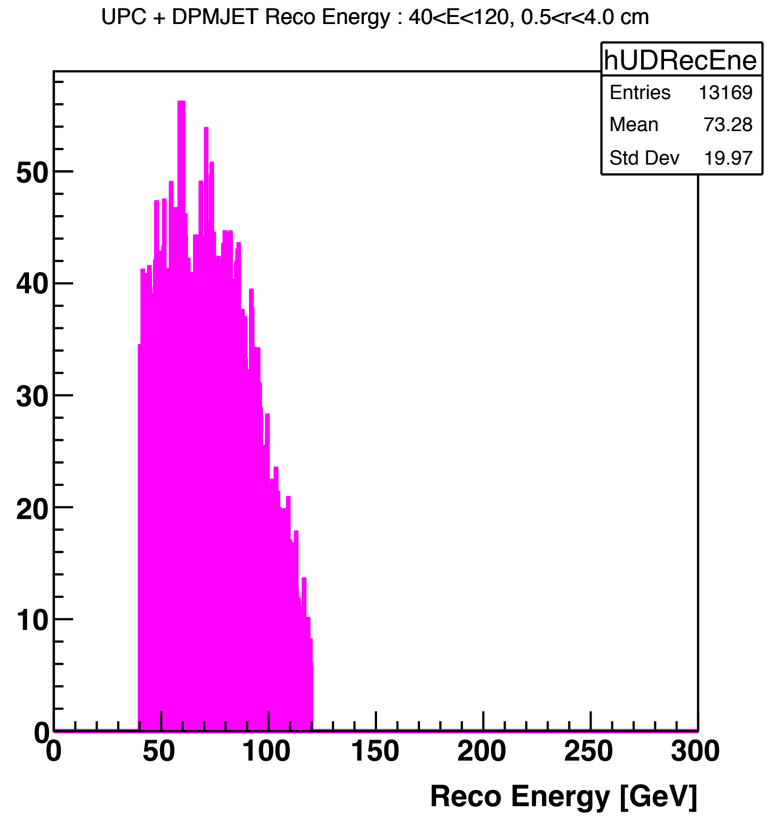


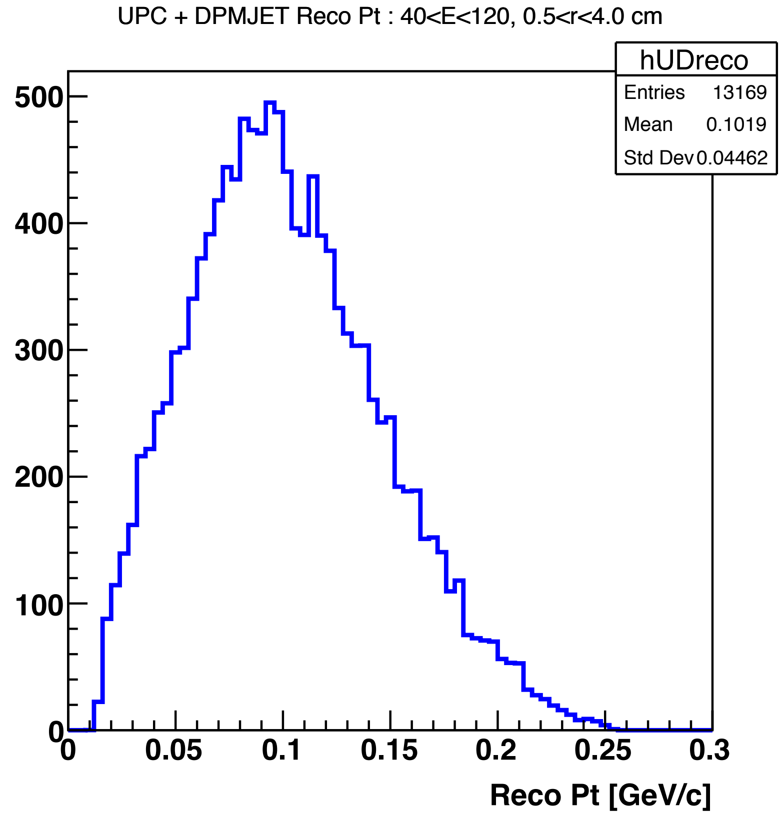


Reconstructed ZDC energy distribution (left panel) and pt distribution (right panel)

Analysis Process – 40<E<120 GeV, 0.5<r<4 cm

Energy cut : 40 < E < 120 GeV and Acceptance cut : 0.5 < r < 4 cm



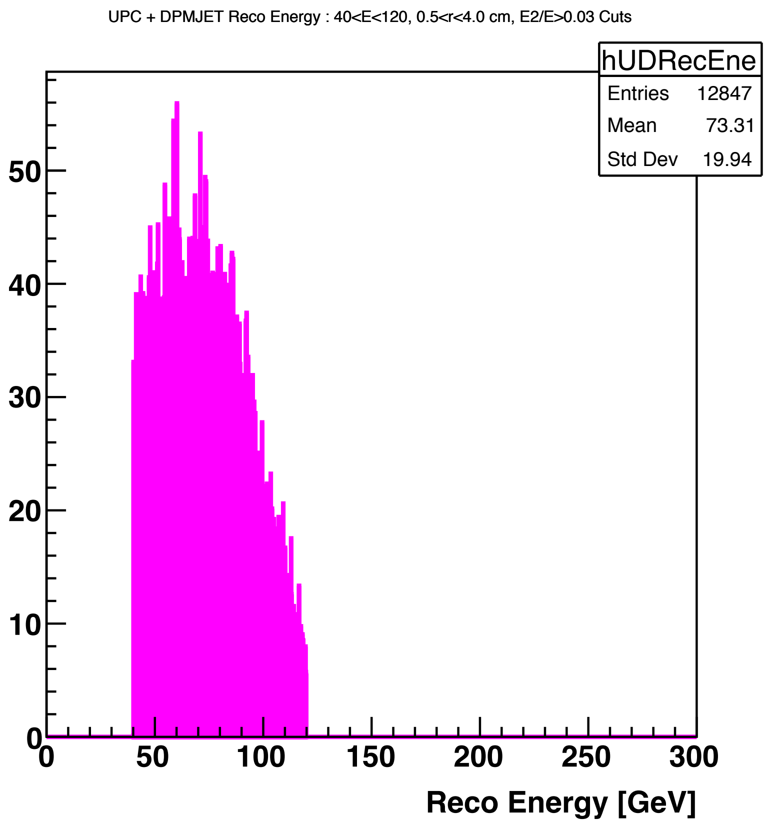


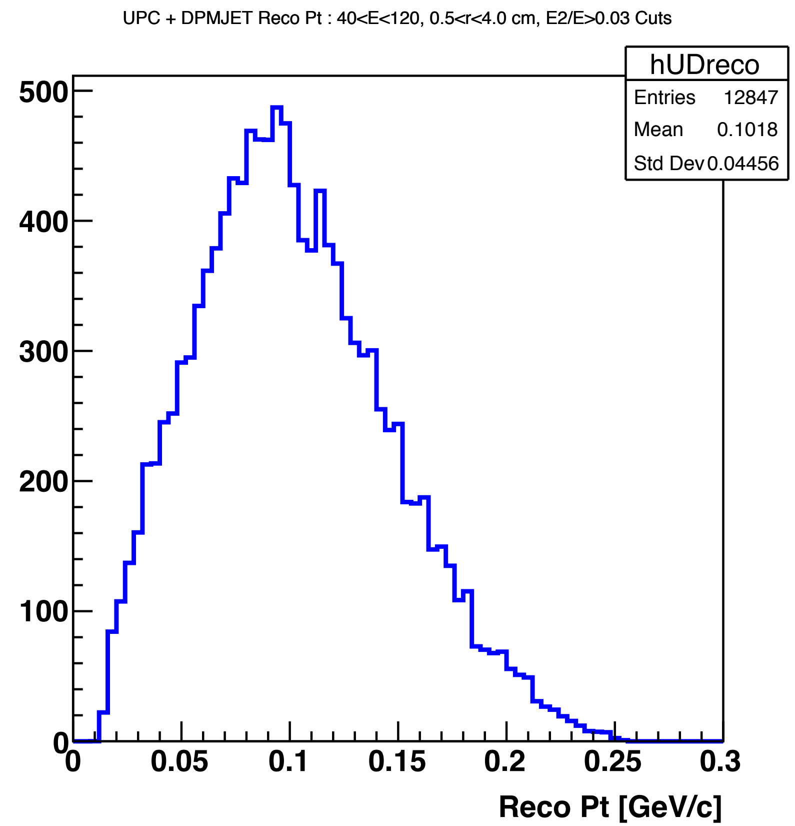
Reconstructed ZDC energy distribution (left panel) and pt distribution (right panel)

Analysis Process – ZDC2 E/ZDC E_T > 0.03

[Ref.: Minjung Analysis Note P14 – Run15 pA Neutron A_N] **Slide 8**

40 < E < 120 GeV with ZDC2 E/ZDC E_T > 0.03 and 0.5 < r < 4 cm Cuts





Reconstructed ZDC energy distribution (left panel) and pt distribution (right panel)

Analysis Process – SMD Particle Shower Position Distributions for Nx/Ny Fired Strips Above MIP Threshold = 0.003 GeV

- First checked the x and y shower position distributions for UPC and DPMJET separately, and before and after applying the cut condition of Nx/Ny >= 2 fired strips above 0.003 GeV MIP threshold value:

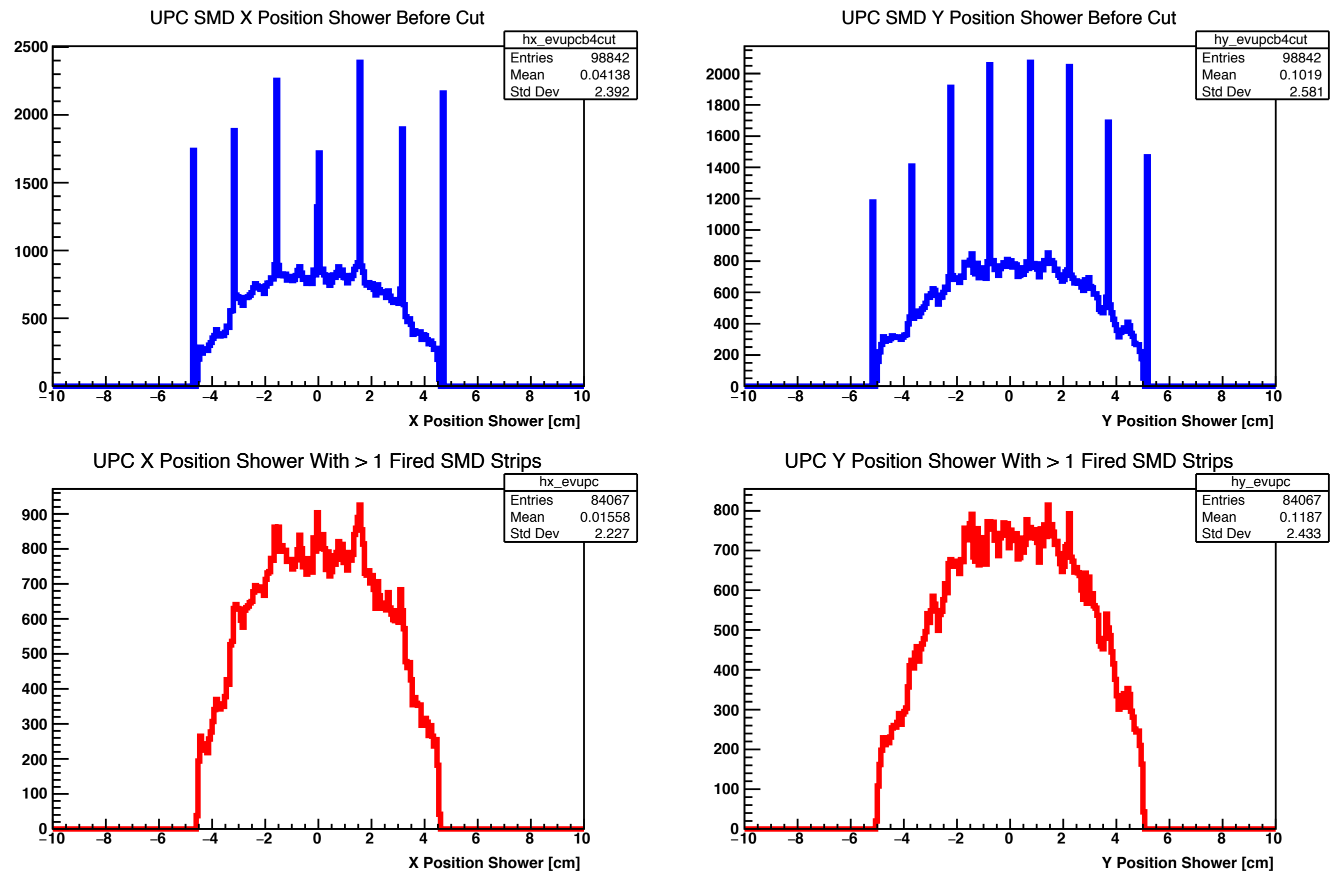
  [*Threshold value reference : Sasha's Analysis note: page 14 – Background and smearing correction for forward neutron* A_N]

- The summed x and y shower position distributions plots for UPC + DPMJET were then obtained.

Analysis Process – **SMD X and Y Position Shower Distributions (UPC)**

Slide 10

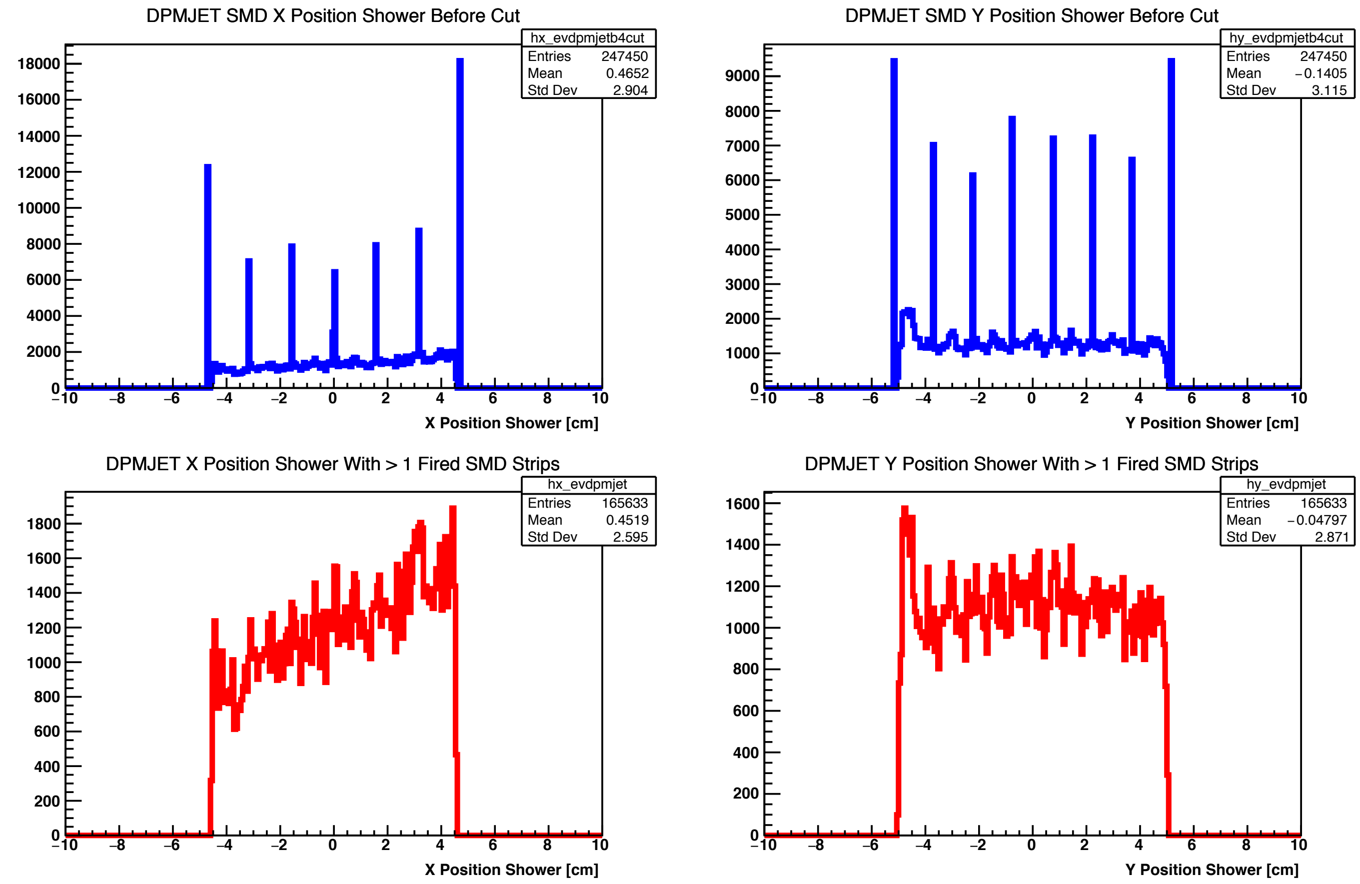
- The top panels are UPC x and y particle shower distributions before the SMD multiplicity condition is applied. Nx = 7 and Ny = 8 SMD strips are clearly visible before application of the multiplicity cut condition.



- The bottom panels depict x and y shower position distributions after applying the multiplicity cut condition.

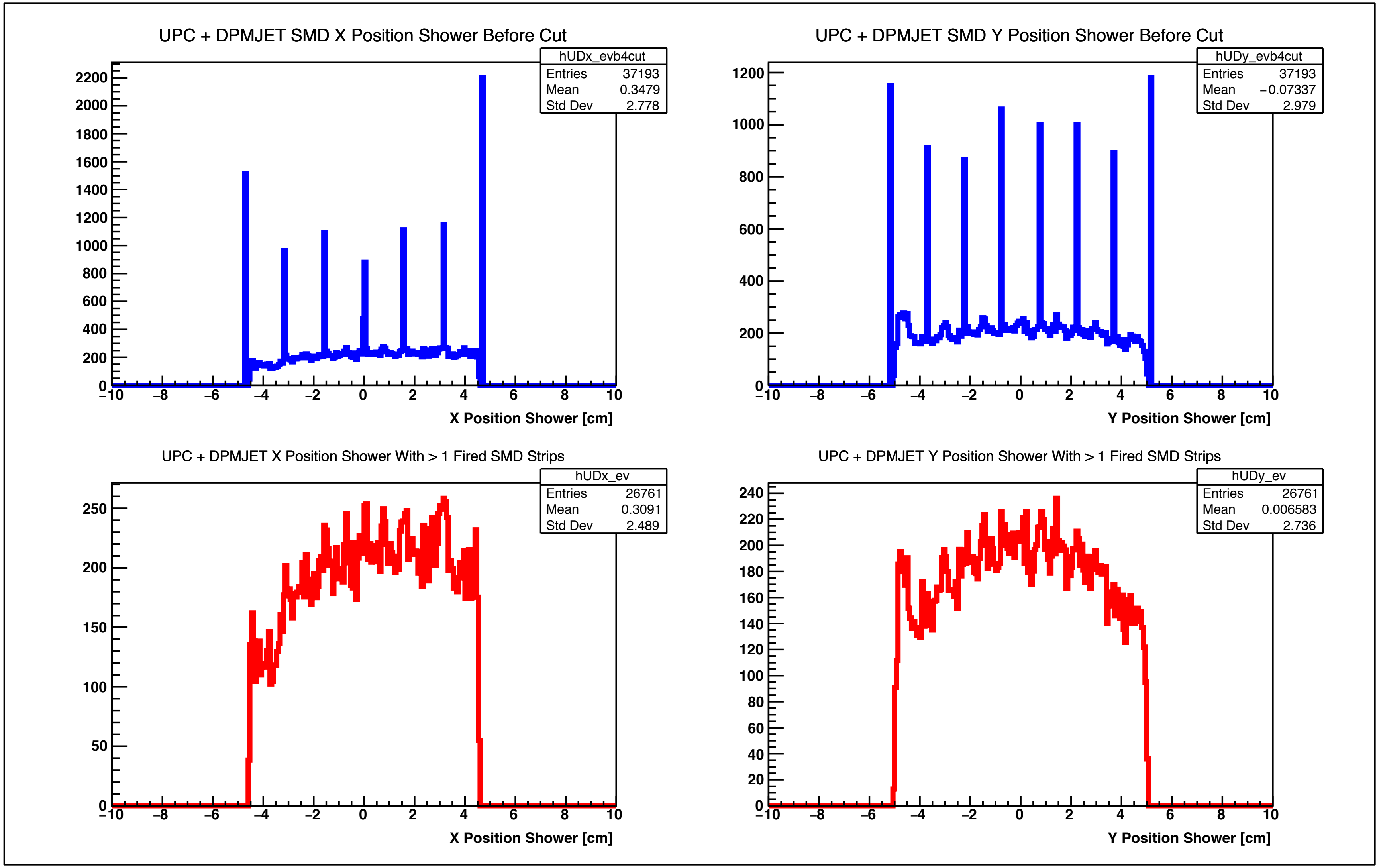
Analysis Process – SMD X and Y Position Shower Distributions (DPMJET)

Slide 11



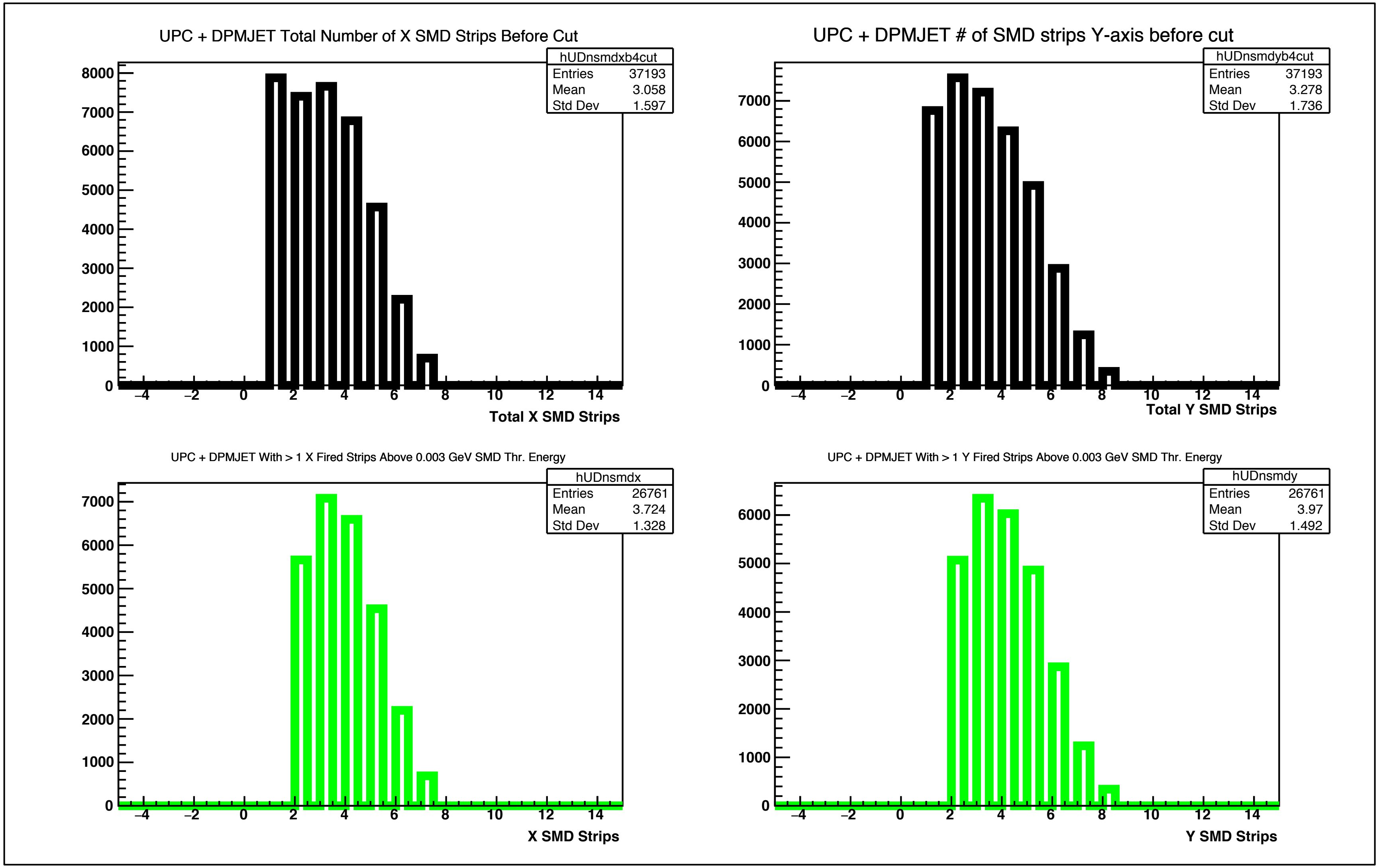
Nx = 7 and Ny = 8 SMD strips in the top left and right panels, respectively are clearly visible before Nx/Ny >= 2 fired strips cut is applied. The bottom panels depict x and y shower position distributions after applying this cut condition.

Analysis Process – SMD X and Y Position Shower Distribution (UPC + DPMJET)

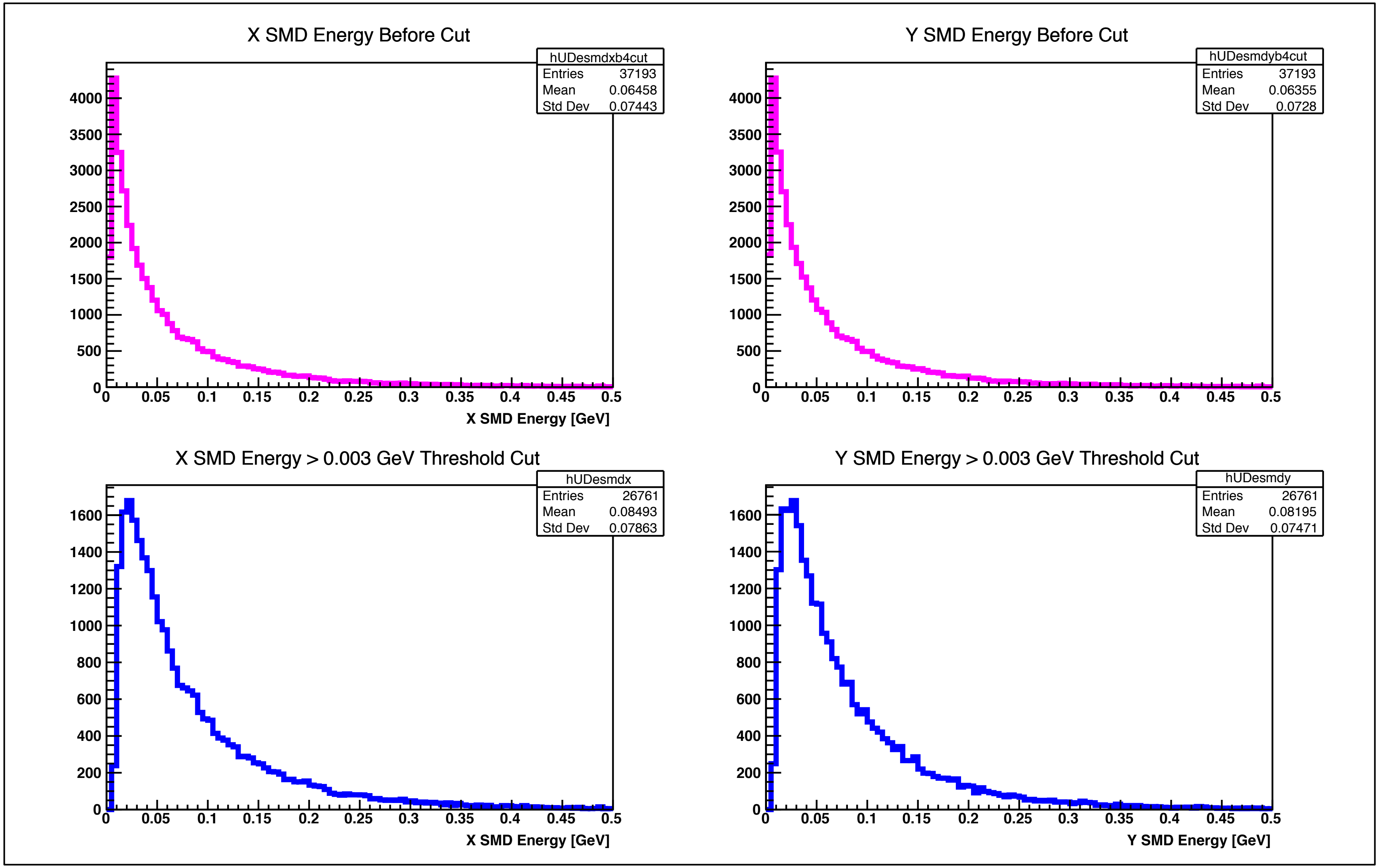


Analysis Process – Nx/Ny Before (Top) and After (Bottom) MIP Threshold Cut

Slide 13

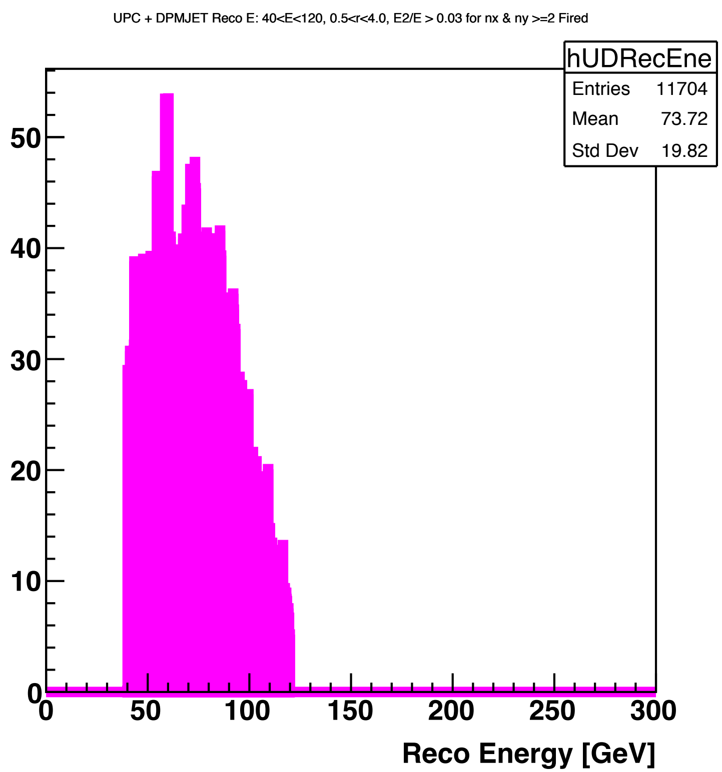


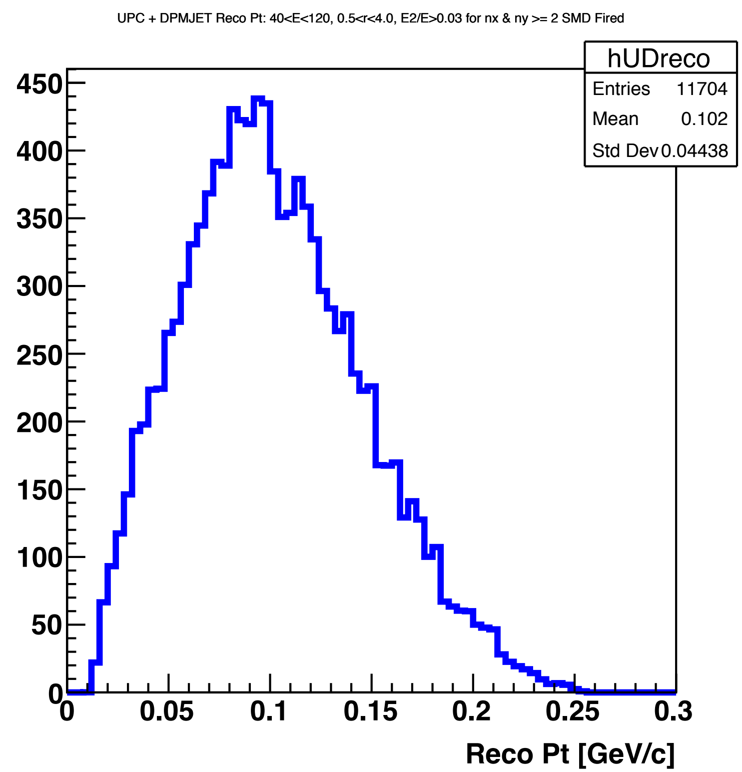
Analysis Process – SMD Energy Before (Top) and After (Bottom) MIP Threshold Cut



Analysis Process – Final Un-normalized Pt and Energy Spectra With All Cuts Applied

40<E<120 GeV with ZDC2 E/ZDC E_T > 0.03; 0.5 < r < 4 cm and NxNy >= 2 Fired

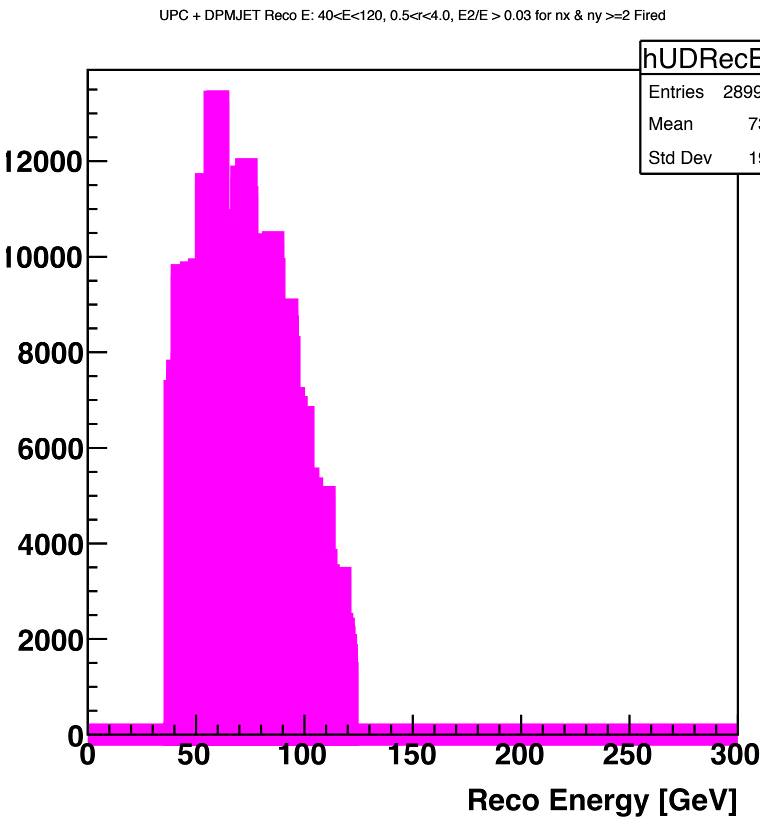


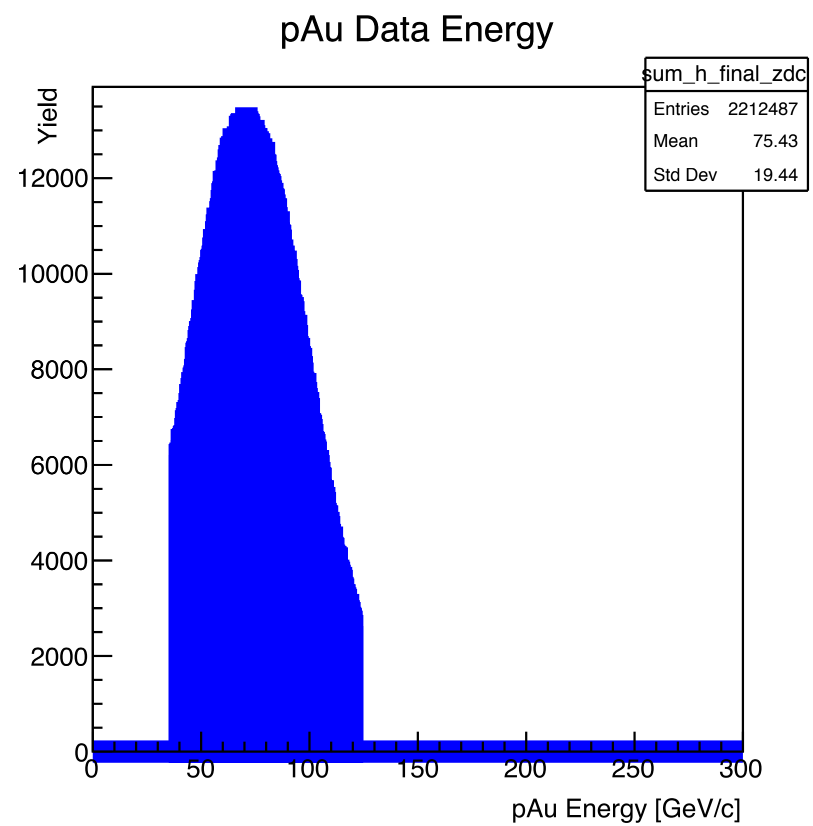


Reconstructed ZDC energy distribution (left panel) and pt distribution (right panel) with all cuts

Analysis Process – Final Normalized Reco Energy Side by Side With Data

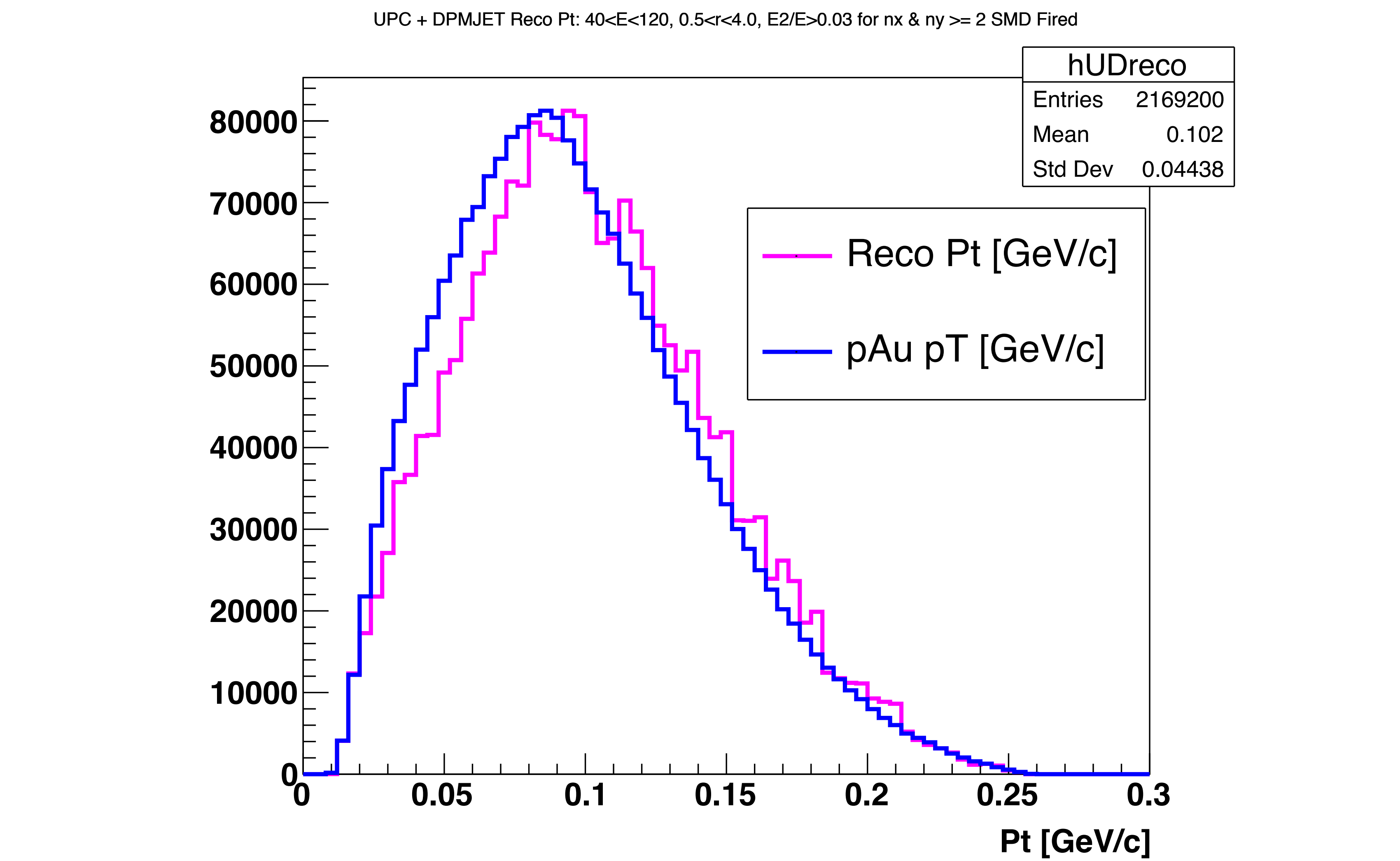
Slide 16





Final reconstructed ZDC energy distribution (left panel) and ZDC pAu data energy distribution (right panel)

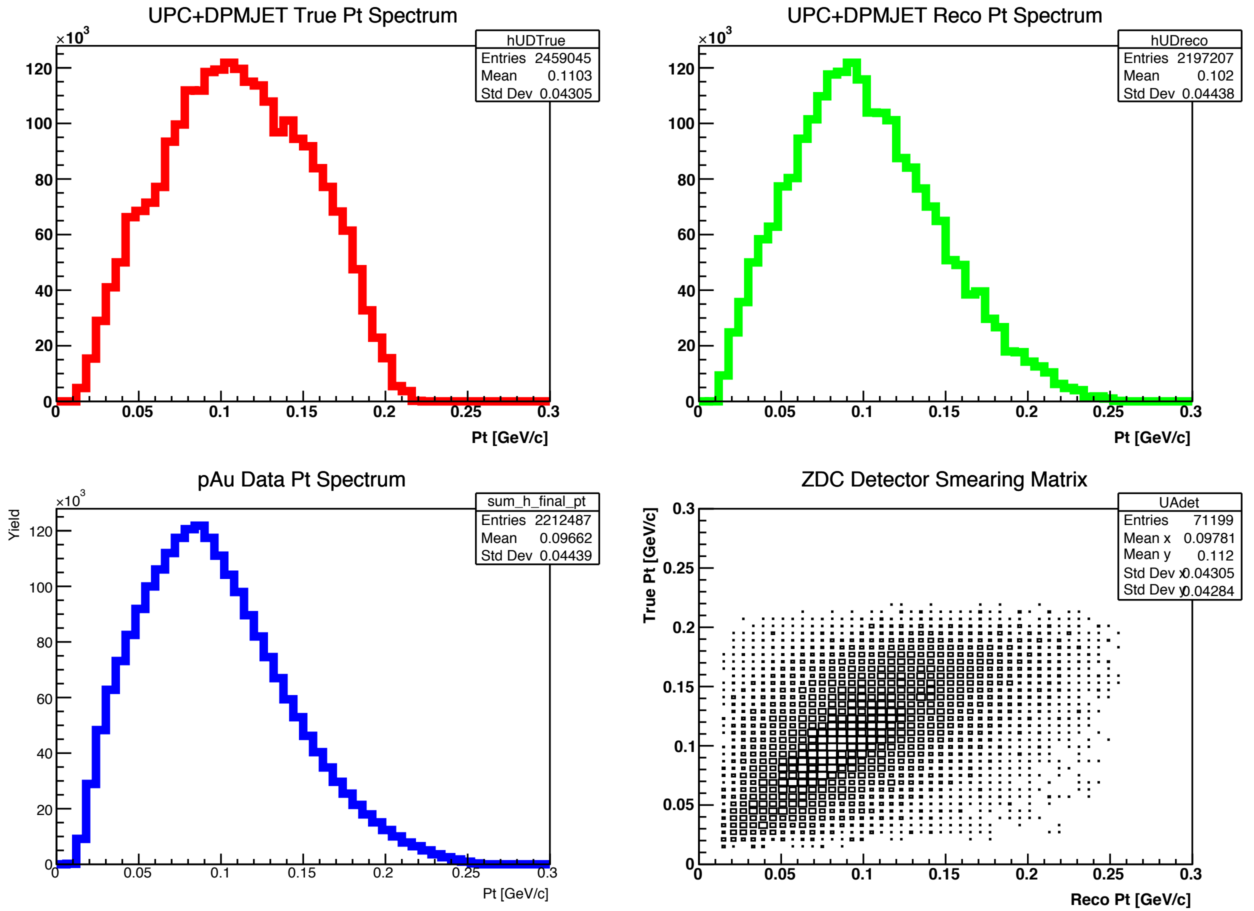
Analysis Process – Final Normalized Reco Pt Compared with Data Pt Spectrum



TSVD Unfolding Inputs – Analysis Process

Slide 18

- True pt, reconstructed pt, data pt and the detector smearing matrix



TSVD Unfolding Regularization – Analysis Process

- Since smearing matrix is not very diagonal, we have to apply regularization to get a corrected diagonal covariance matrix of the reconstructed pt vs. true pt spectrum from the detector smearing matrix.

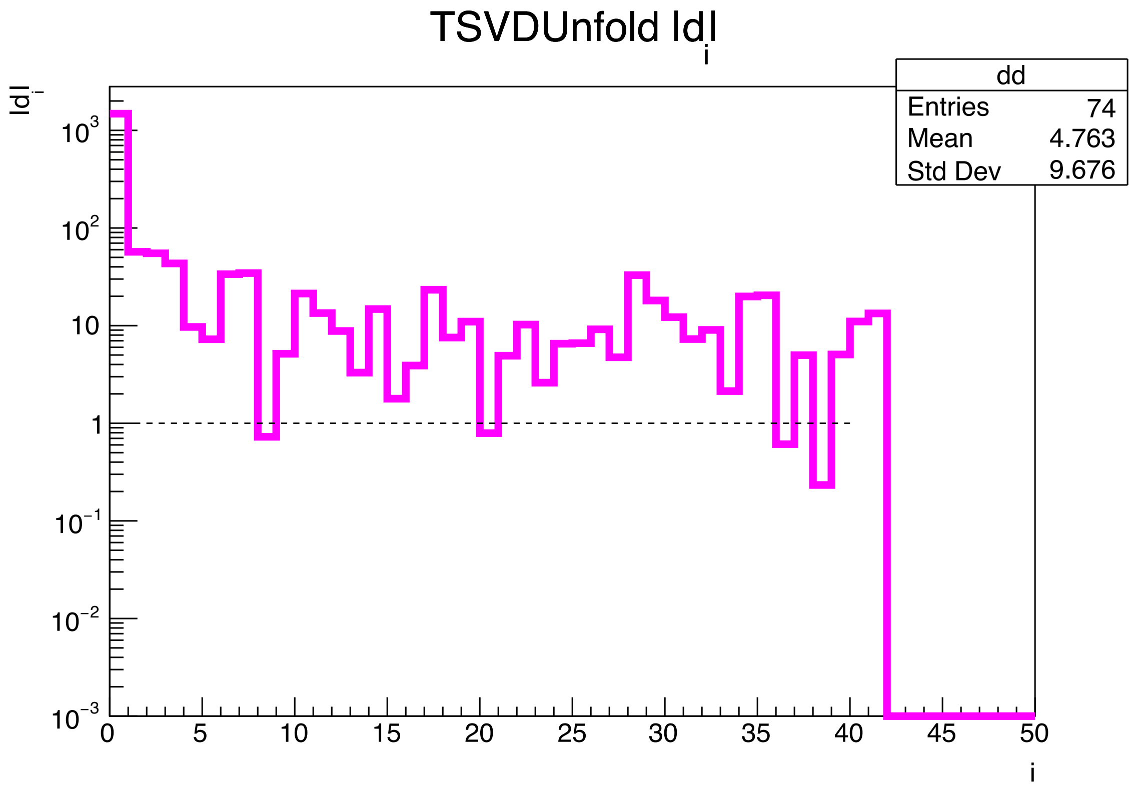
- This is successfully achieved by performing unfolding with regularization parameter called kReg to the TUnfold object.

- To obtain an optimum value of the kReg parameter, we have to make use of the dVector.

- The optimum value is normally the absolute value of the minimum of the log of $d_i >> 1$, i.e.: $\log|d_i|$ or $l|d_i|$ or first minimum.

TSVD Unfolding Results – The dVector

❖ Normally the larger the kReg, the finer grained is unfolding but more fluctuations occur.

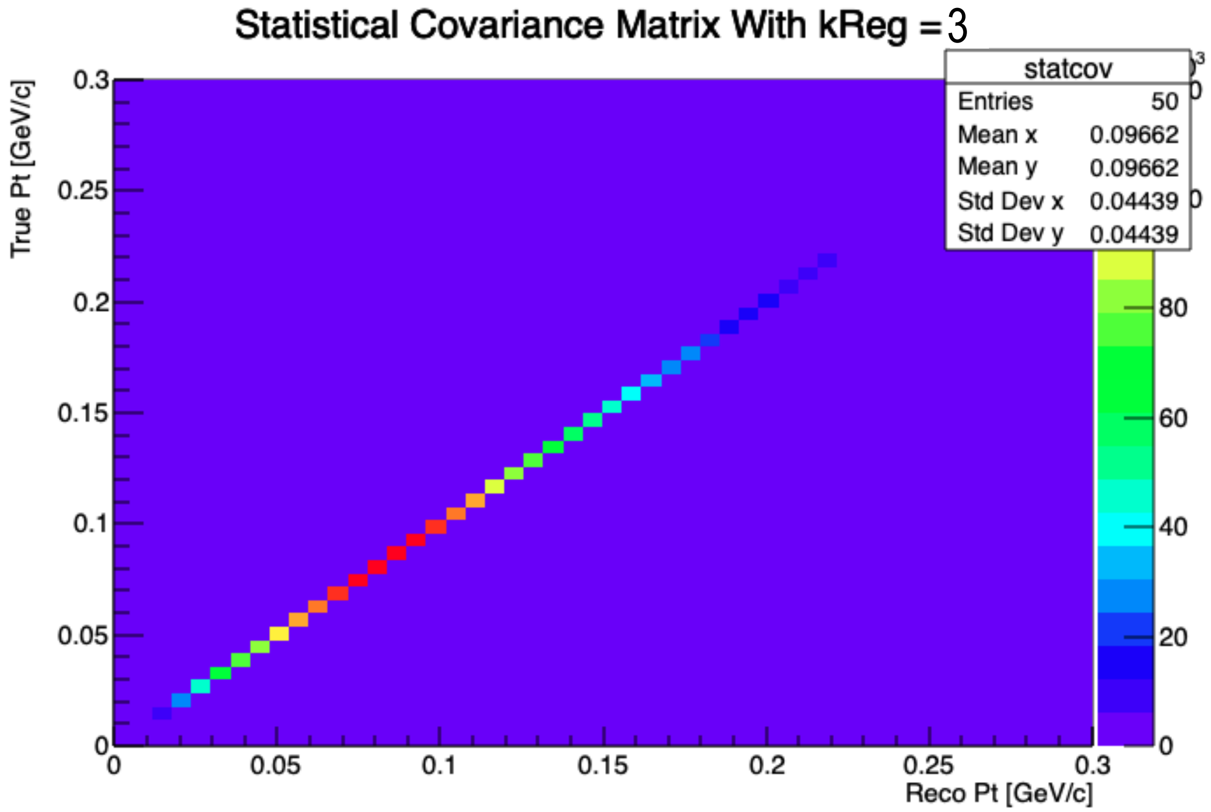


❖ And the smaller the kReg parameter, the stronger is the regularization and the bias.

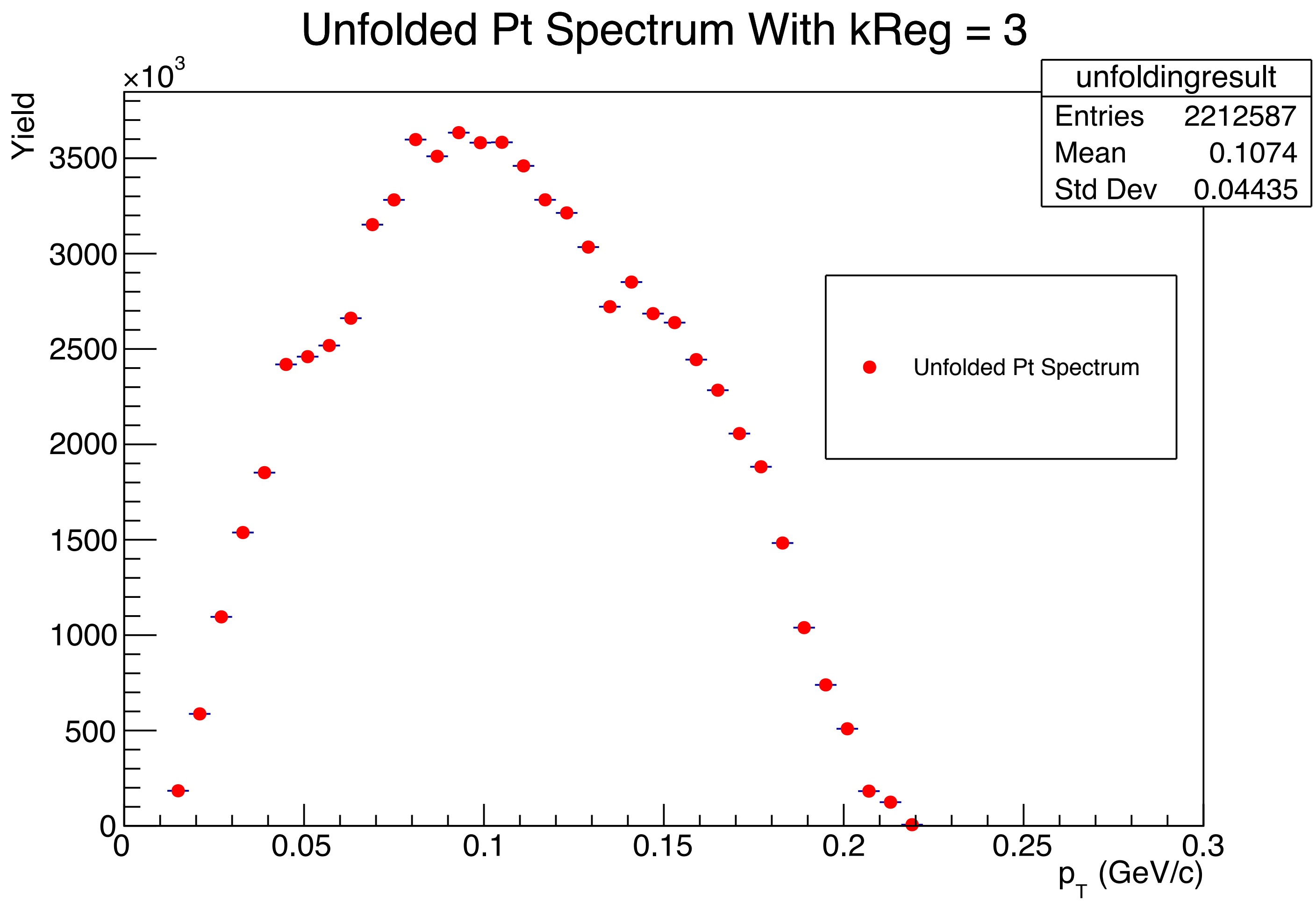
TSVD Unfolding Results – Covariance Matrix

Slide 21

❖ The optimum value I obtained from the dVector is kReg = 3 and the resulting corrected covariance matrix obtained from the detector smearing matrix is displayed below:



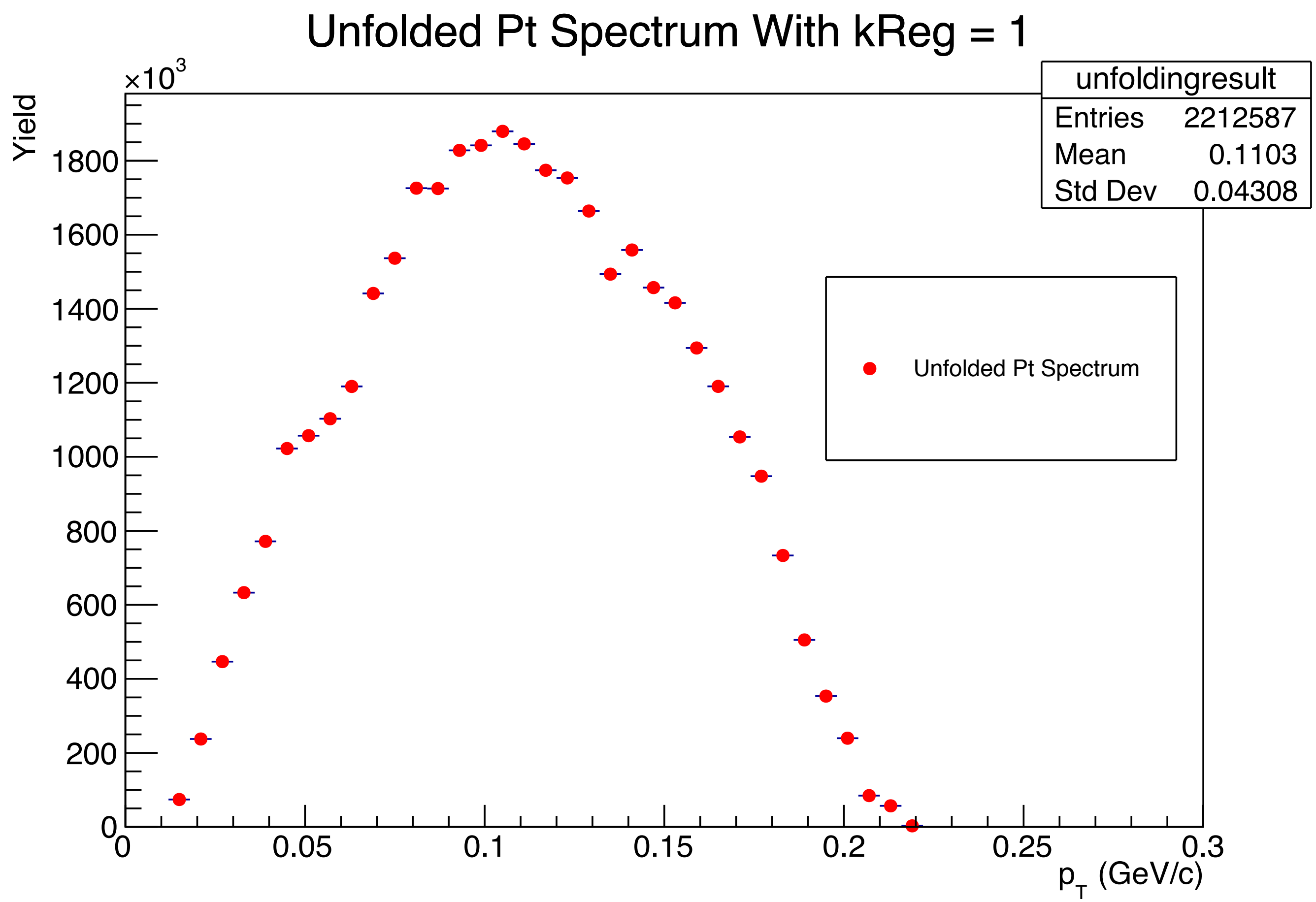
TSVD Unfolding Results – Unfolded Spectrum



❖ The optimum value of kReg = 3 was chosen from the dVector plot considering log | d_i | >> 1

TSVD Unfolding Results – Unfolded Spectrum

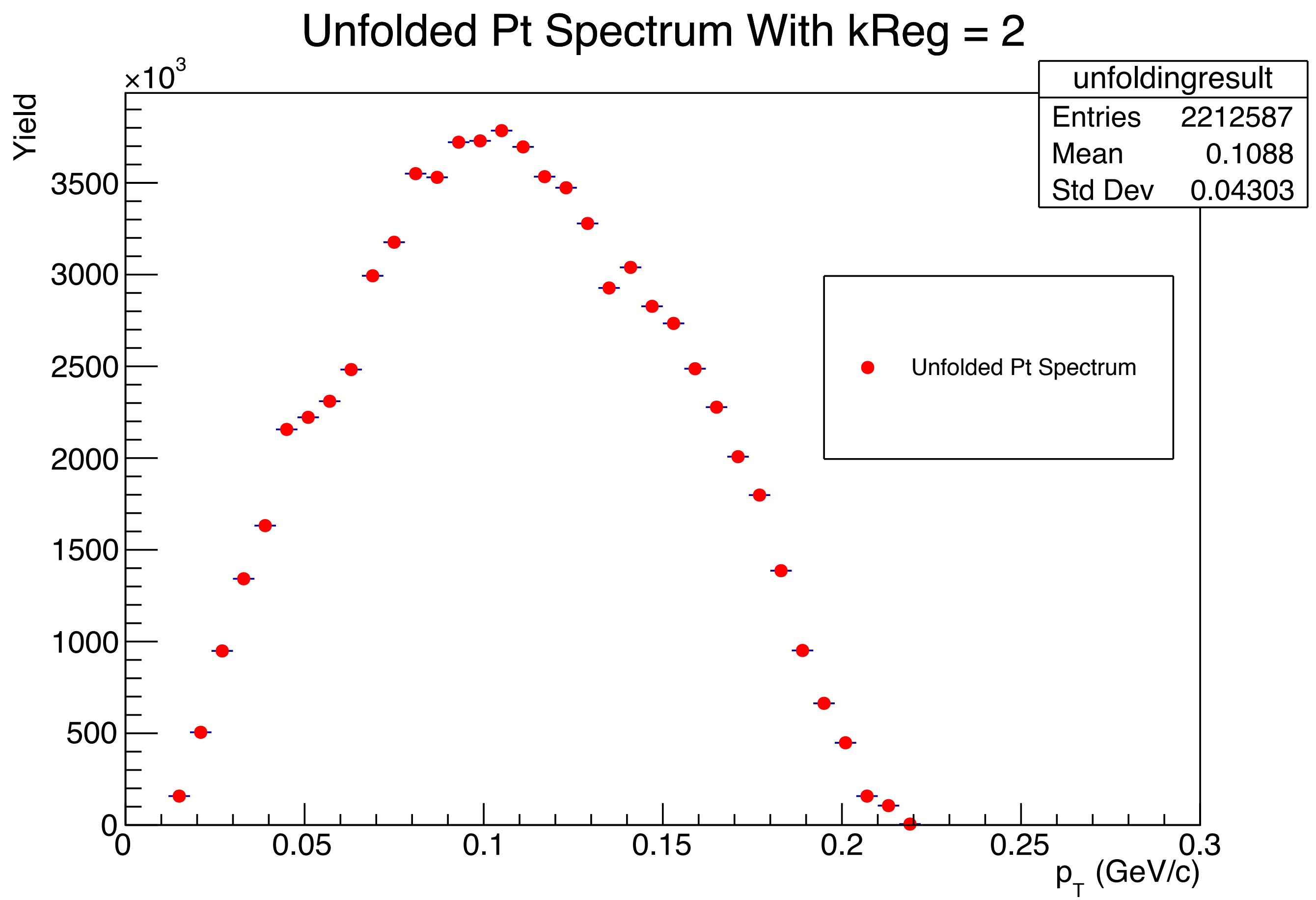
- Checking unfolding when kReg is very small, regularization is stronger and more biased



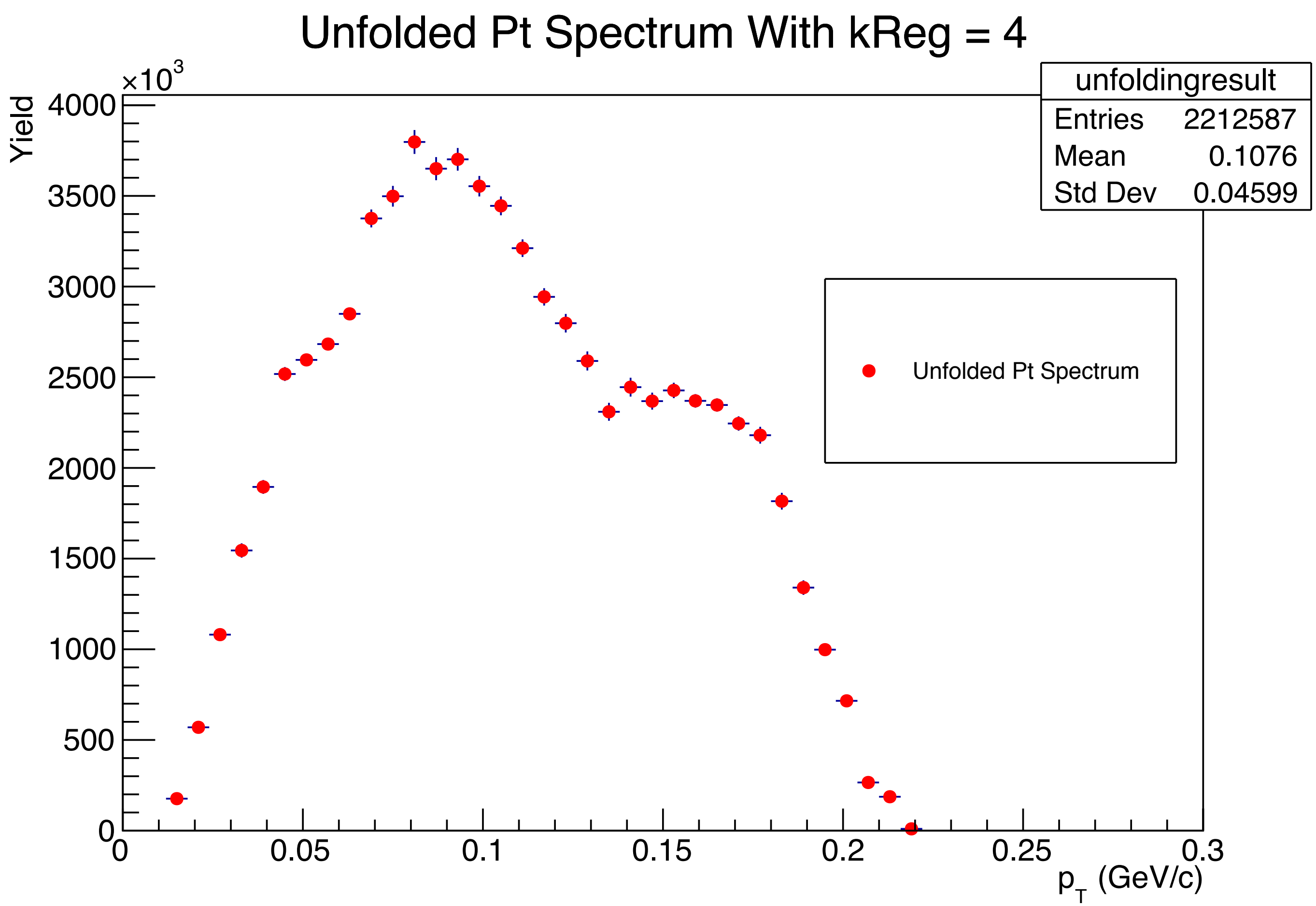
TSVD Unfolding Results – Unfolded Spectrum

Slide 24

- Checking unfolding when kReg is very small, regularization is stronger and more biased



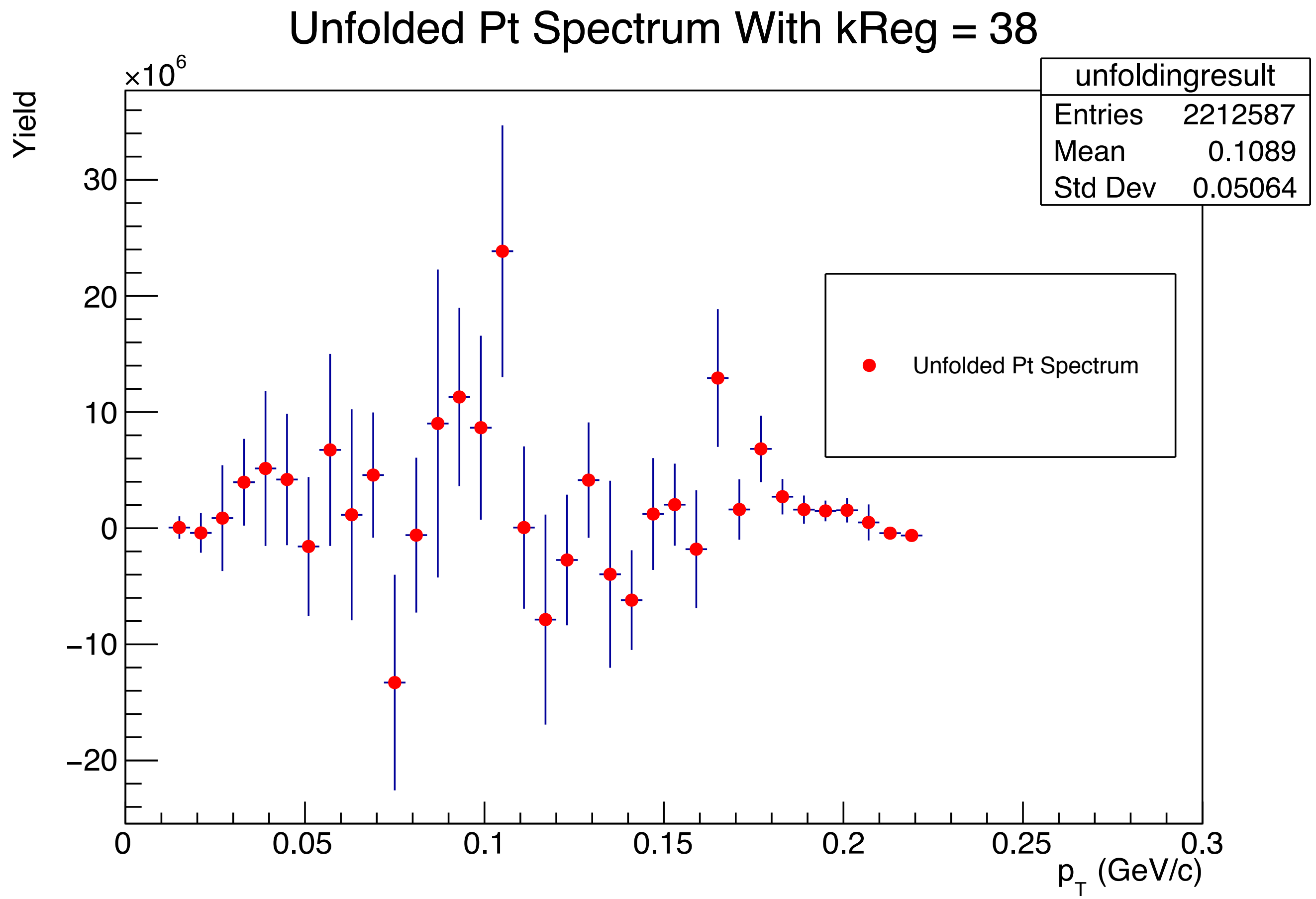
TSVD Unfolding Results – Unfolded Spectrum



❖ The optimum value of kReg = 4 was chosen from the dVector plot considering log | idl | >> 1

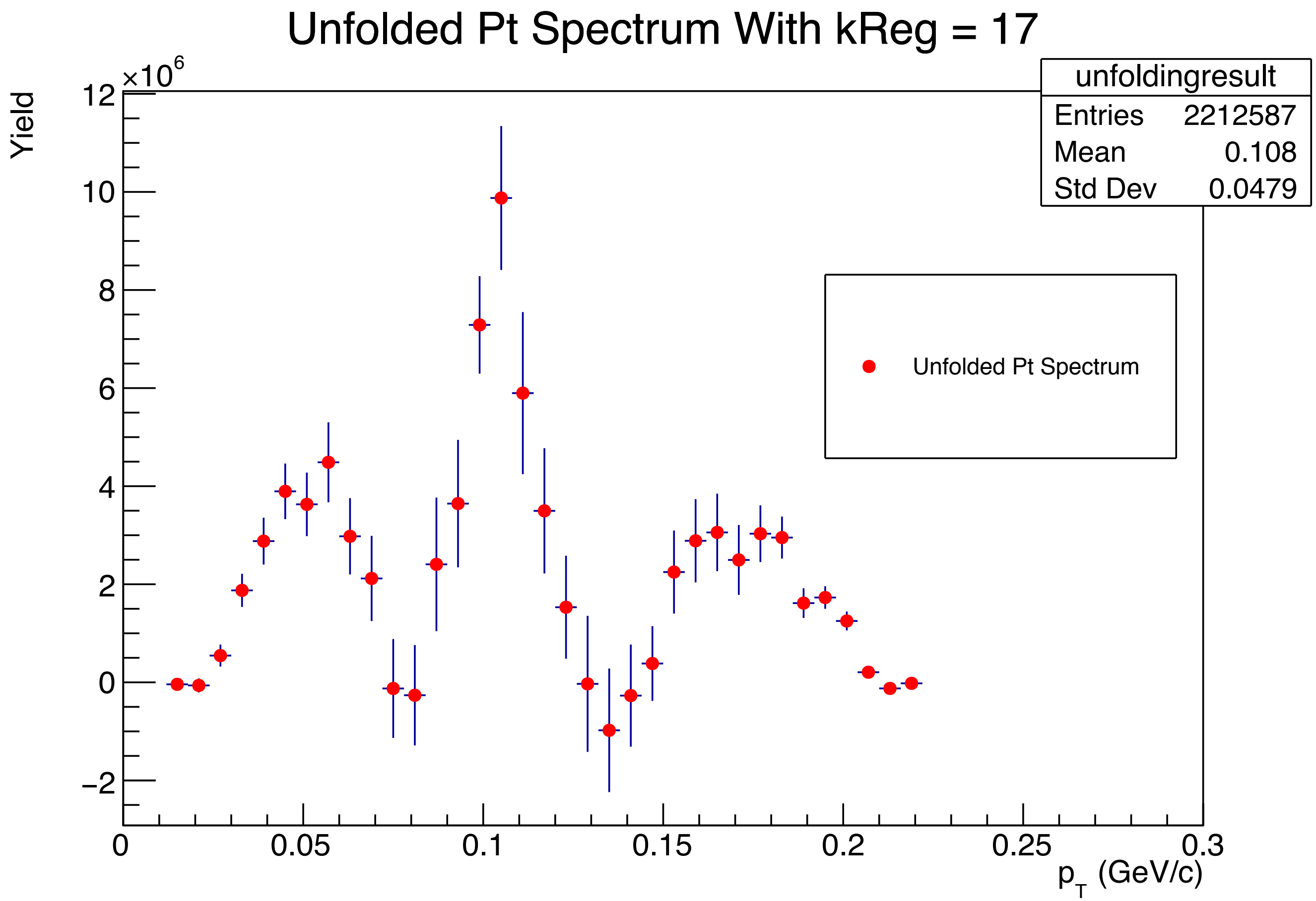
TSVD Unfolding Results – Different kReg

- Checking unfolding when regularization value (kReg) is large, more fluctuations occur.



TSVD Unfolding Results – Different kReg

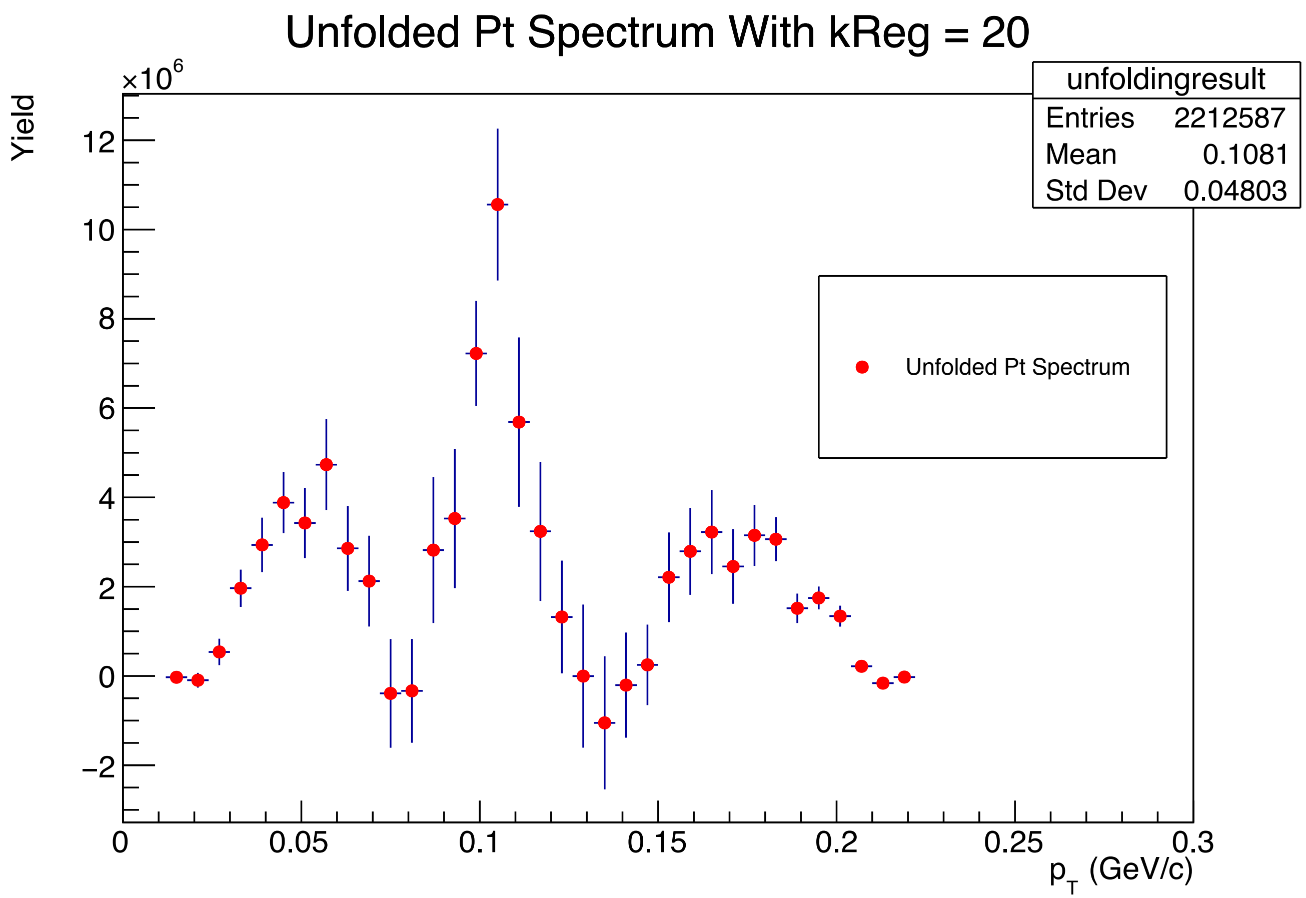
- Checking unfolding when regularization value (kReg) is large, fluctuations do occur.



TSVD Unfolding Results – Different kReg

Slide 28

- Checking unfolding when regularization value (kReg) is large, fluctuations do occur.



Next Task

Slide 30

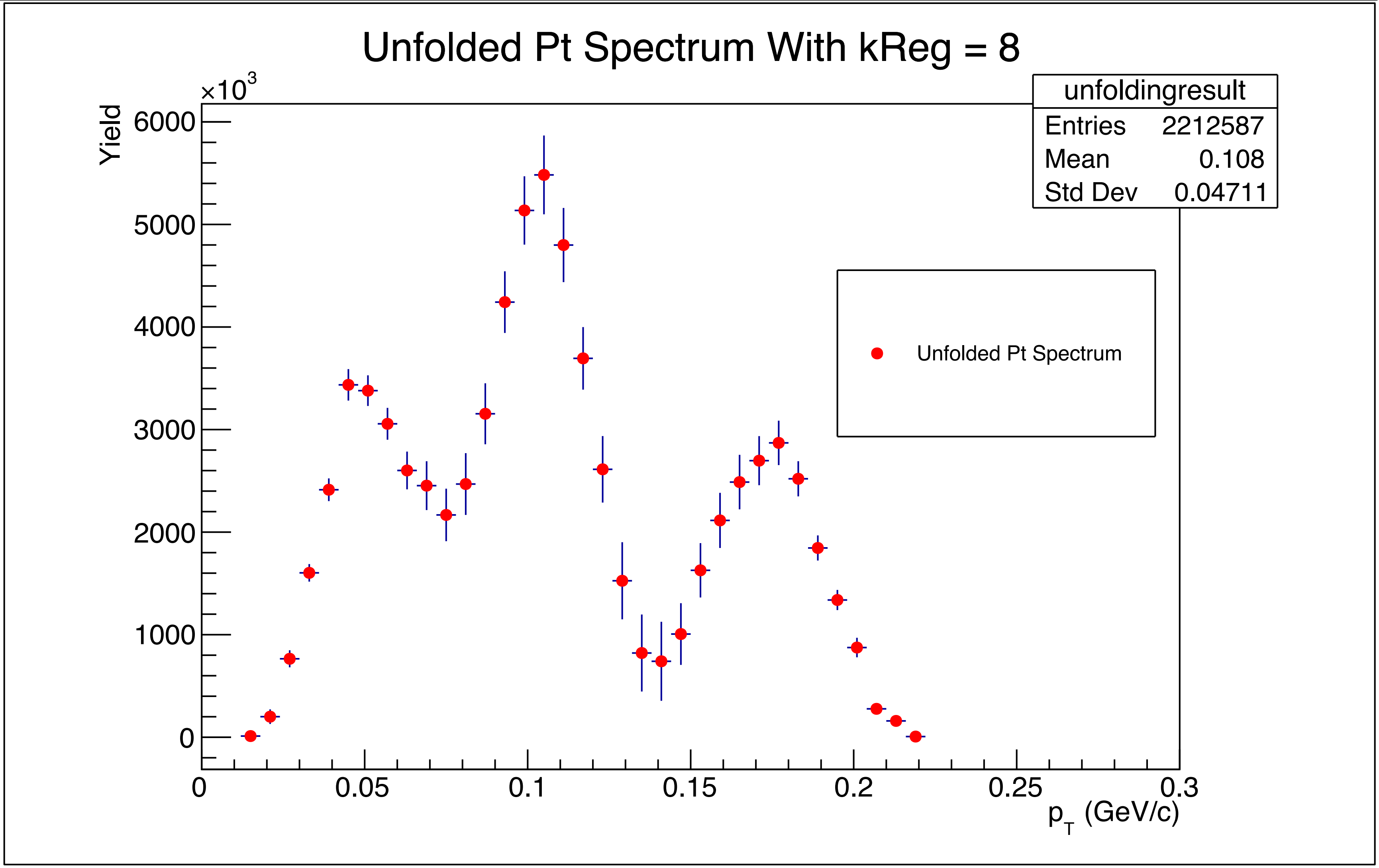
- ❖ Compare the unfolded results properly with each other to see how they correlate for different kReg parameters.

- ❖ Check thoroughly until this stage that everything has been done correctly and make adjustments whenever necessary.

BACKUP

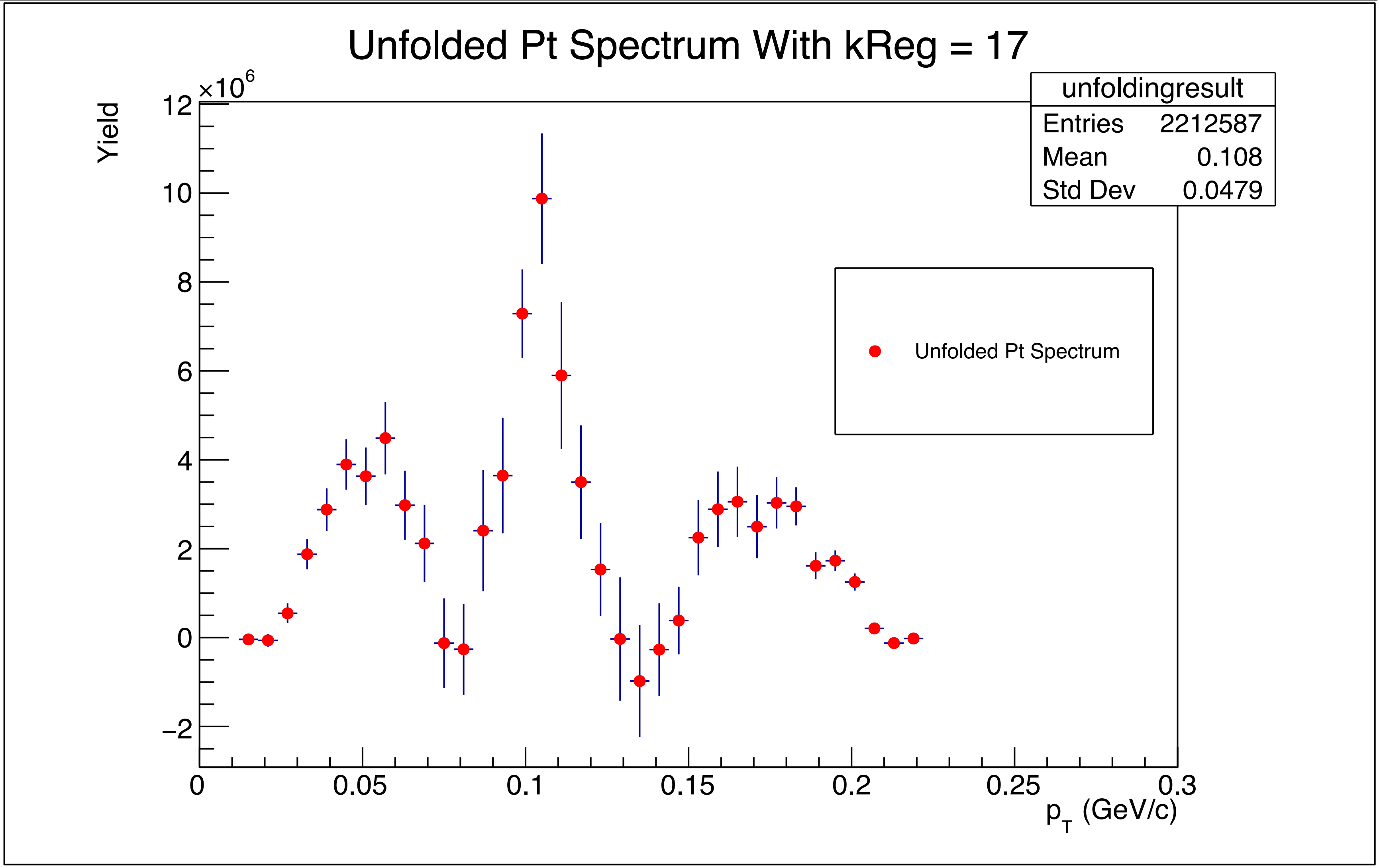
BACKUP – Inclusive Pt Unfolded Results

Slide 1



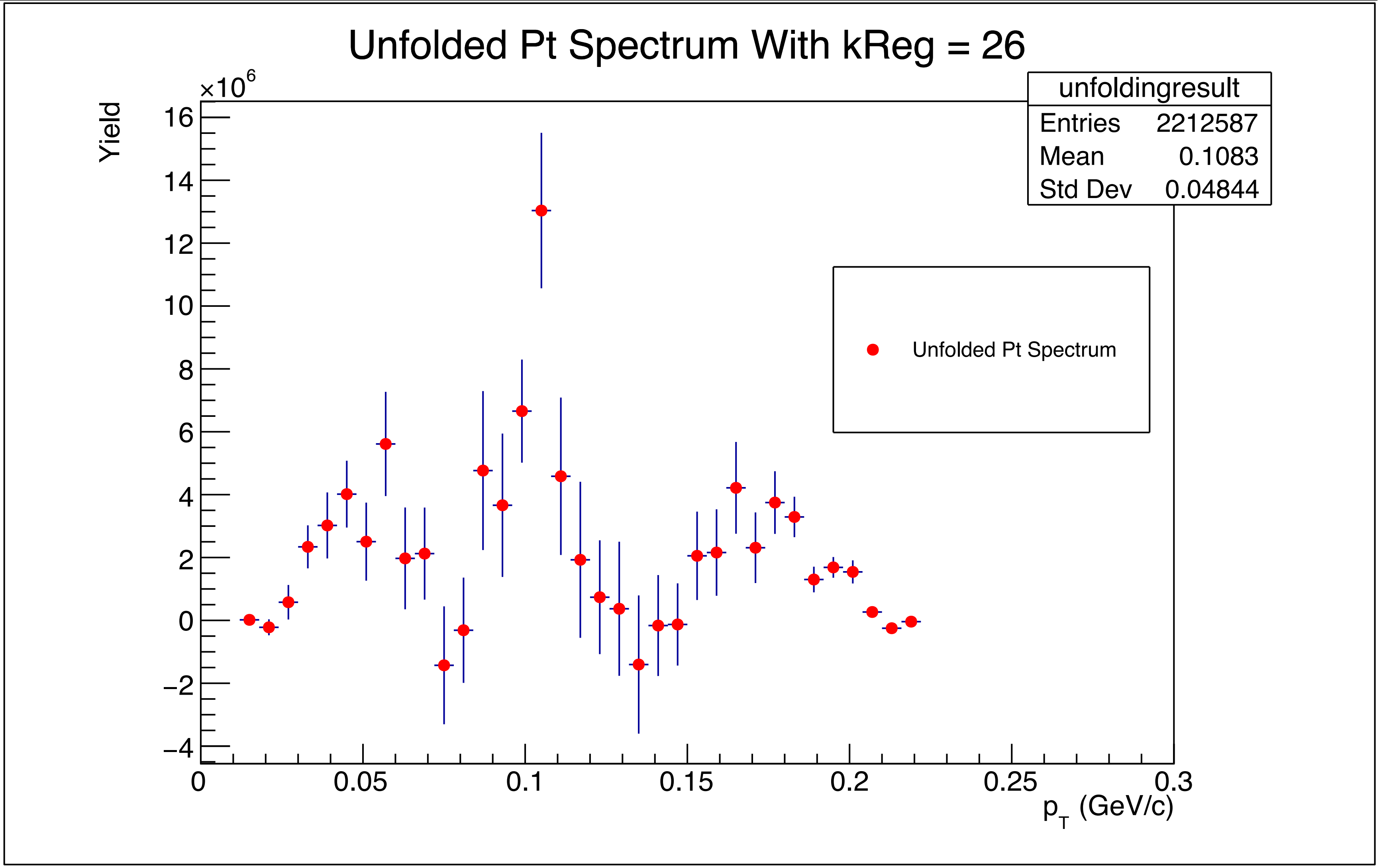
BACKUP – Inclusive Pt Unfolded Results

Slide 2

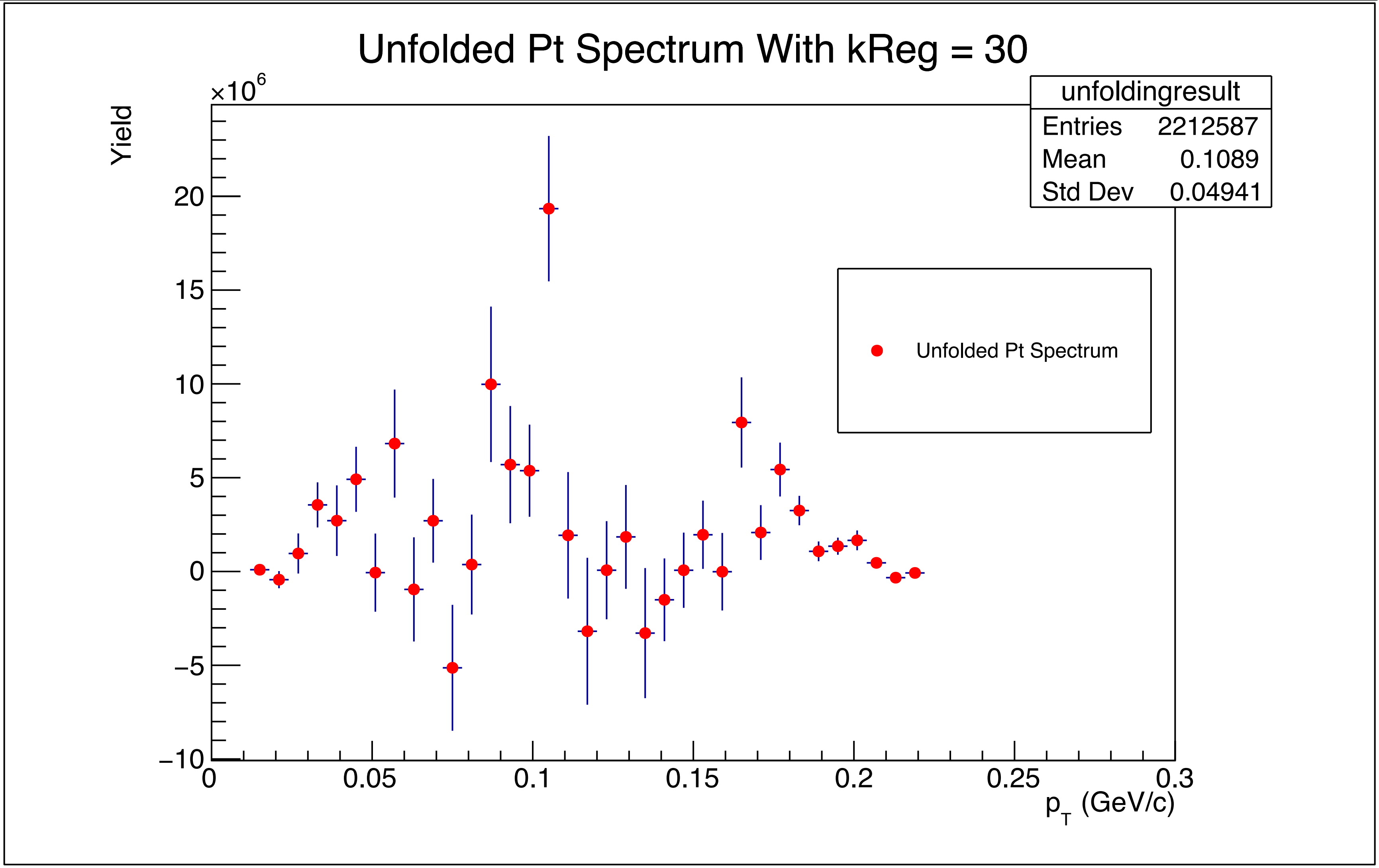


BACKUP – Inclusive Pt Unfolded Results

Slide 3

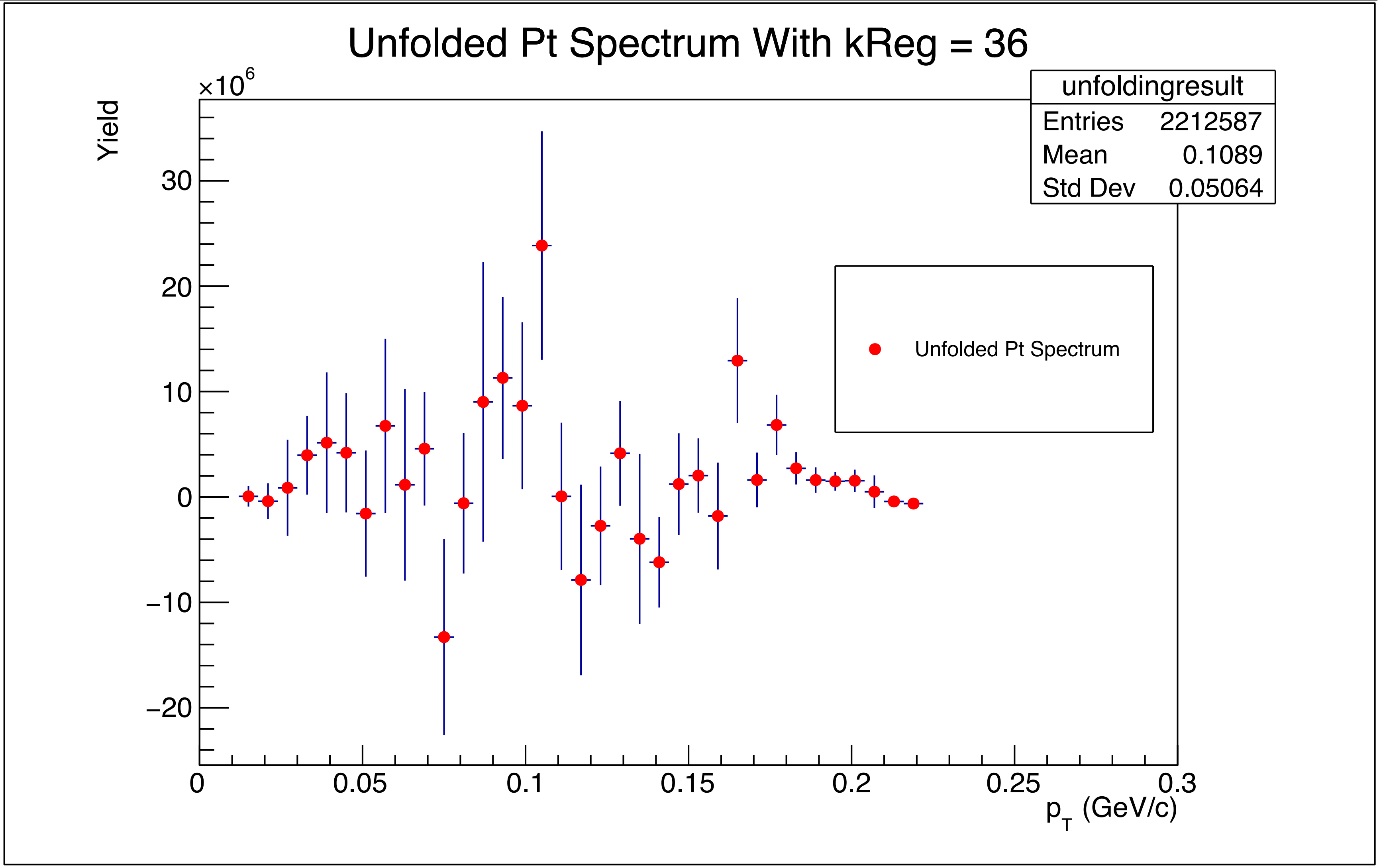


BACKUP – Inclusive Pt Unfolded Results



BACKUP – Inclusive Pt Unfolded Results

Slide 5

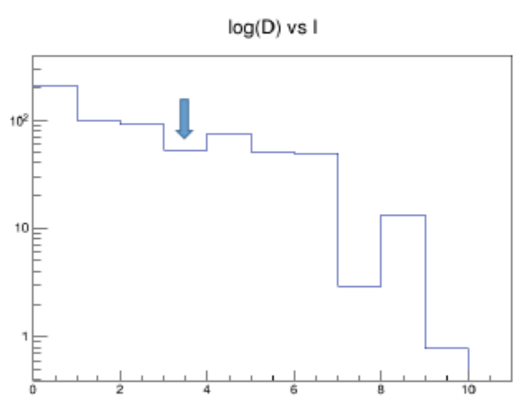


BACKUP – John and Milap Spin PWG Meeting

John and Milap Patel : Today's Spin PWG Meeting

Unfolding to Cross Section

- Unfold counts using SVD unfolding, scale to $d\sigma/dp_T$ (pb/GeV)
- Compare to theory for |eta|<0.35 scaled to |eta|<0.15
  - New theory calculations with scale error band on the way
- Errors calculated from statistical error in data and response matrix statistics
  - Using sqrt of diagonal elements in covariance matrix



D-vector kreg value controls the regularization

Larger value implies larger range of bin sharing and less sensitivity to input shape.

Smaller value limits bin sharing but increases sensitivity to input shape.

Usually take the first minimum in the d-vector distribution (k=3)