Unfolding of Inclusive pAu P_T Data

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[2019/08/01 @ 3 pm JST]

RadLab Meeting

CONTENT

Covariance (error) matrix for the unfolded spectrum using toy MC

⌘ Data covariance matrix used as input to generate toys – matrices compared for kregs.

Covariance (error) matrix on the unfolded spectrum from finite detector matrix statistics

⌘ Unfolded covariance matrix from response matrix with kreg comparisons

Cross-checks for unfolded spectrum

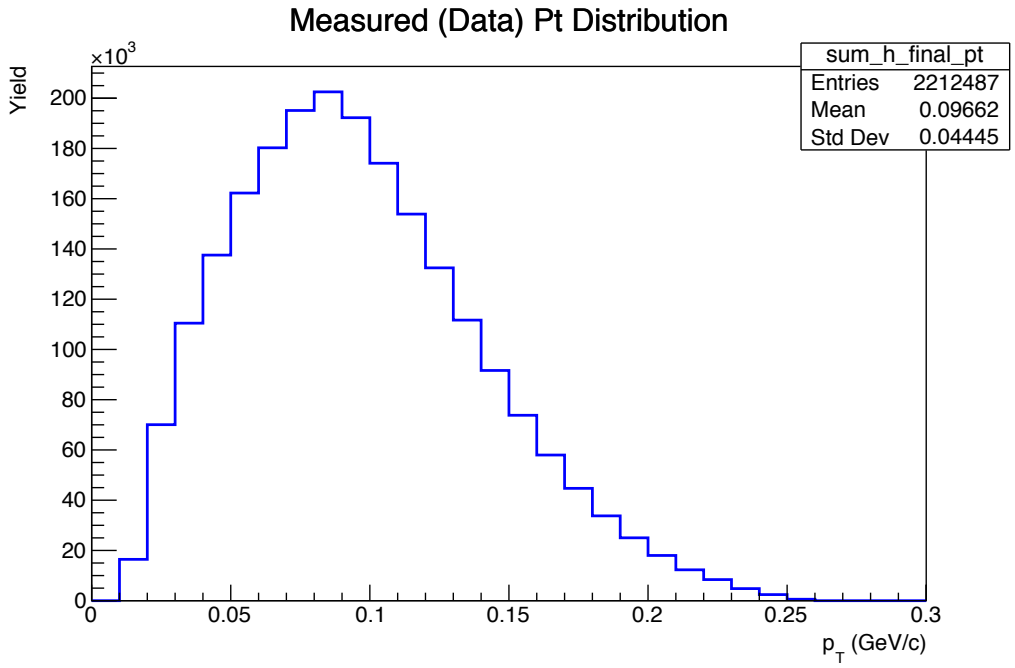
⌘ Cross-check using singular value distribution

⌘ Trivial cross-check using UPC+DPMJET response matrix on UPC sample

Covariance Matrix for Unfolded Spectrum from Measured Spectrum

Three parameters required:

⌘ Covariance matrix on data

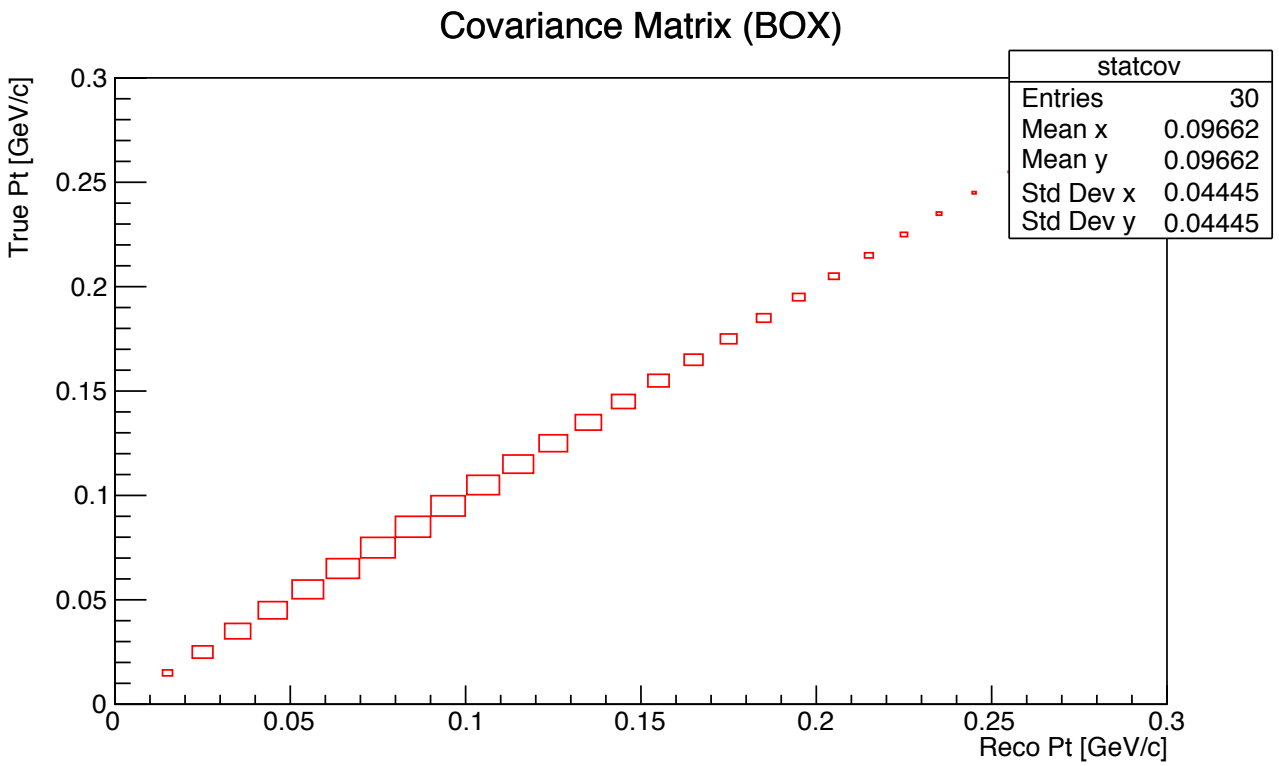


⌘ Pseudo experiments

⌘ Seed for pseudo experiments.

Covariance Matrix for Unfolded Spectrum from Measured Spectrum

- Diagonal covariance matrix from measured spectrum

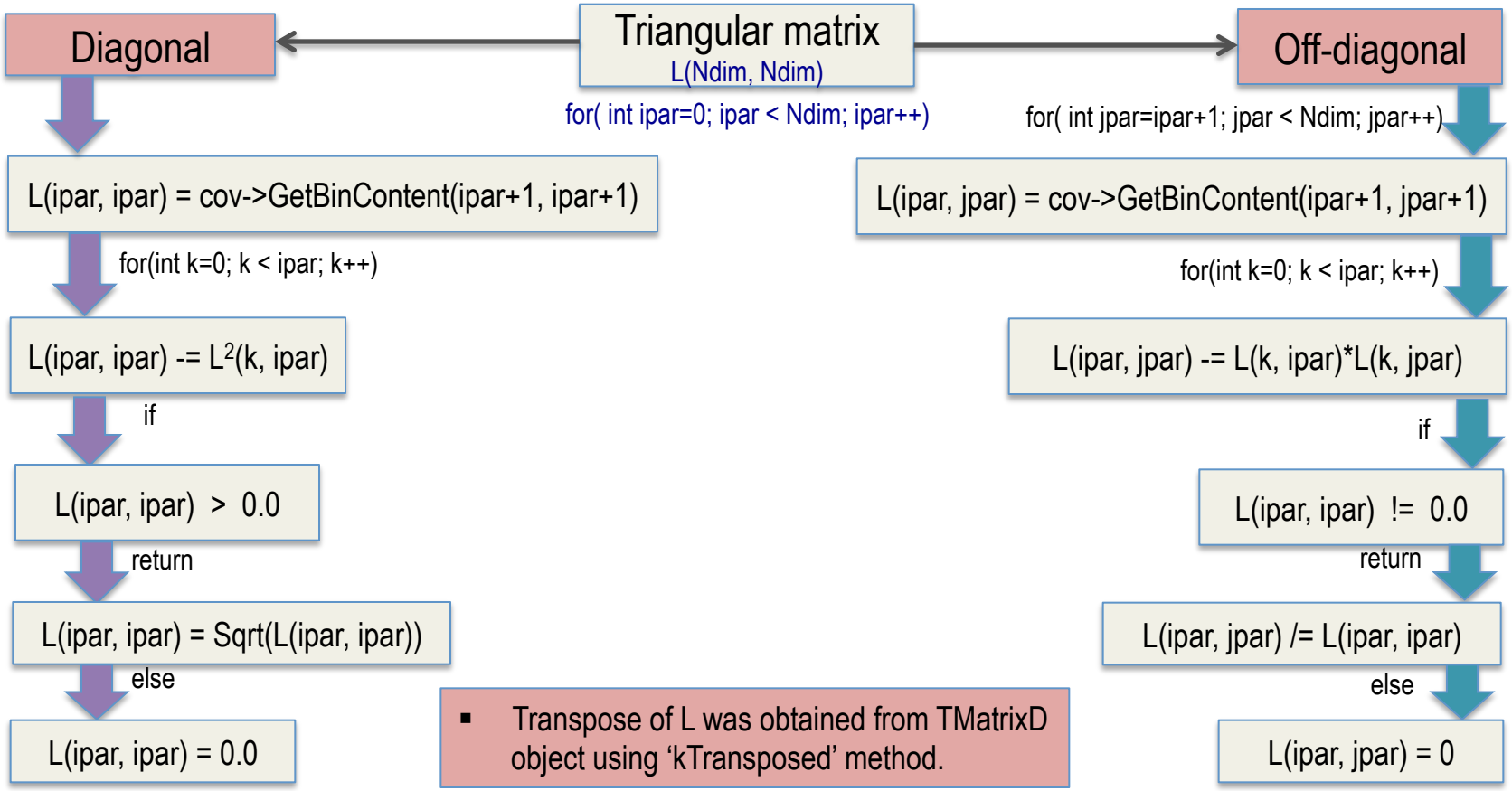


- This covariance matrix was then used to compute error matrix for the unfolded spectrum using toy MC.

Covariance Matrix for Unfolded Spectrum from Measured Spectrum

Toy generation:

- Elements of the upper-triangular matrix, L that give Lt*L= C were calculated with Lt = transpose of L. Triangular matrix such that L = L(Ndim, Ndim) with Ndim = dimension



- Transpose of L was obtained from TMatrixD object using 'kTransposed' method.

Covariance Matrix for Unfolded Spectrum from Measured Spectrum

1D toy histogram is cloned from measured pt distribution (data). Toy mean is obtained obtained by:

- Creating vector of unit Gaussian variables g(k) = random.Gaus(0.,1.)
- Multiplying g(k) by Lt , g(k) *= Lt
- Adding mean value offsets
  toyhistogram->SetBinContent(j, Bdata->GetBinContent(j) + g(j-1))
  toyhistogram->SetBinError(j, Bdata->GetBinError(j))

Then performed unfolding with regularization parameter

- Kreg = 4, 6, 8, 10 with optimal kreg value being 6.
  toymean ->SetBinContent(j, toymean->GetBinContent(j) + unfres->GetBinContent(j)/ntoys

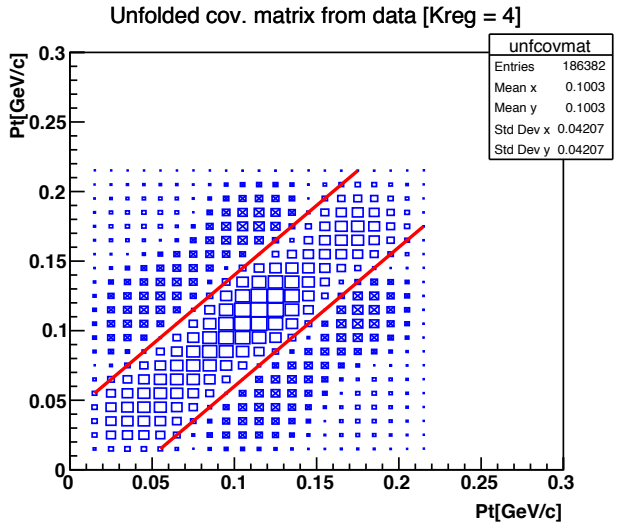
Reset random seed and deal with toys for the covariance matrix.

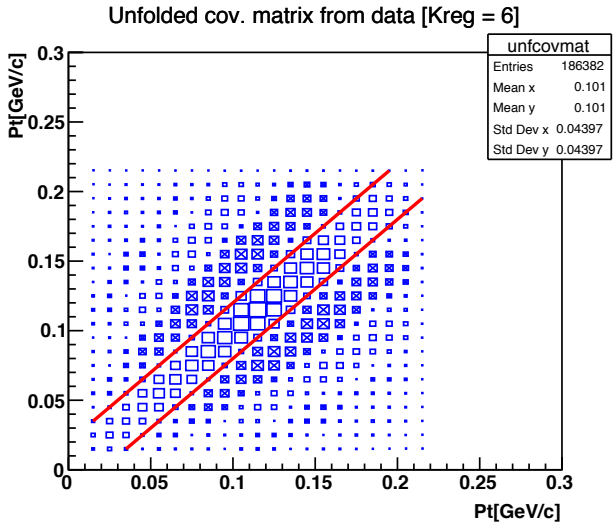
- Created vector of unit Gaussian variables g(k) = random.Gaus(0., 1.)
- Multiplied g(k) by Lt, g(k) *= Lt
- Added mean value offsets

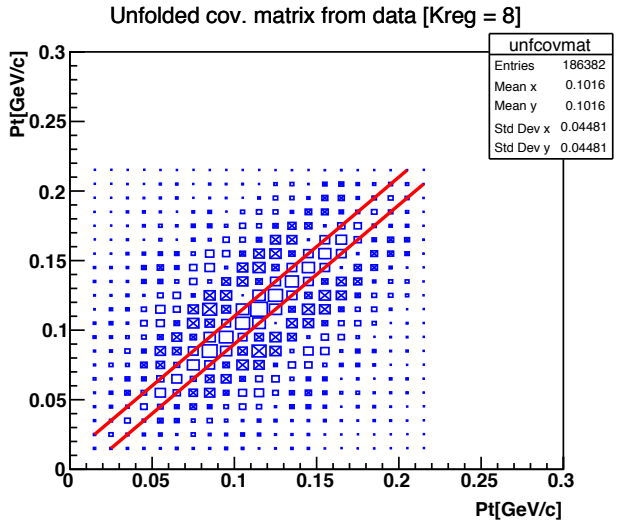
Unfolded with regularization parameter from dvector and stored the unfolded covariance matrix.

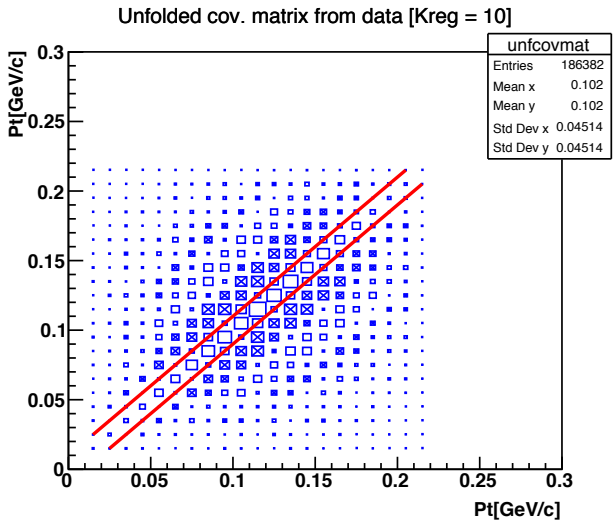
- Used kreg = 4, 6, 8 and 10 for comparison purpose.
- UnfCov->SetBinContent(j, k, UnfCov->GetBinContent(j,k) + ((unfres->GetBinContent(j) – toymean->GetBinContent(j)) * (unfres->GetBinContent(k) – toymean->GetBinContent(k))/(ntoys-1)))

Covariance Matrix for Unfolded Spectrum from Measured Spectrum



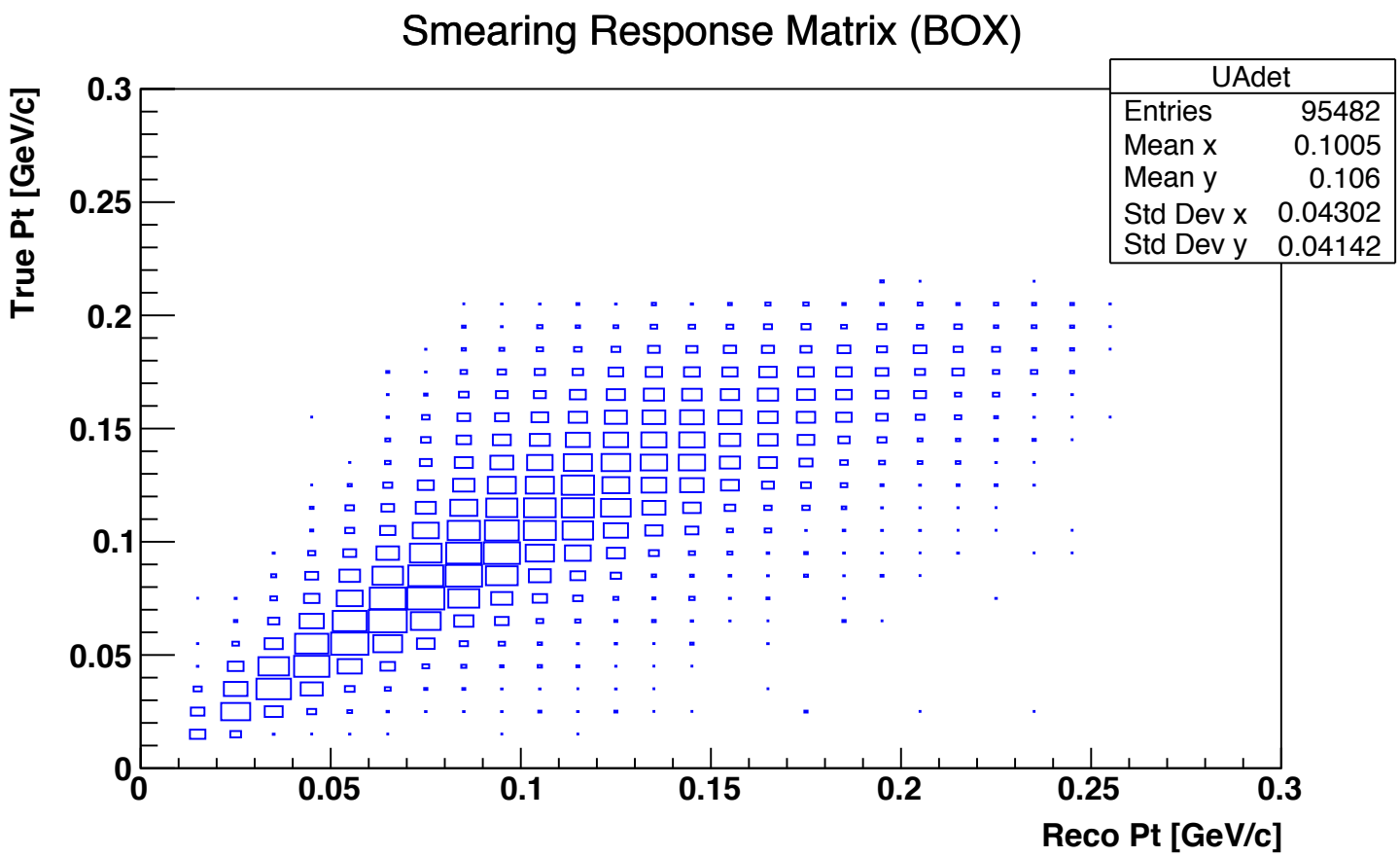






Covariance Matrix for Unfolded Spectrum from Response Matrix

Detector response matrix: 2D histogram extracted from the reco and true pt spectra of UPC+DPMJET MC



Covariance Matrix for Unfolded Spectrum from Response Matrix

Two arguments required: (1) ntoys and (2) random seed for pseudo experiments

- A copy of response matrix is made for unfolded covariance matrix.

Toys for detector response matrix are generated using a TRandom3 generator with seed

- Toy matrix (toymat) is cloned from detector response matrix
- Toy mean 1D histogram is also cloned from true MC distribution.
- Toy matrix is then generated based on toy number and dimension of response matrix using Poisson.
  toymat->SetBinContent(k, m, random. Poisson(ResMat->GetBinContent(k,m)))

Unfolding with appropriate regularization parameter (kreg) is performed

- Kreg = 4, 6 (optimal), 8 and 10 plotted for comparison
- Toy mean (toymean) is stored as:
  toymean->SetBinContent(j, toymean->GetBinContent(j) + unfres->GetBinContent(j)/ntoys

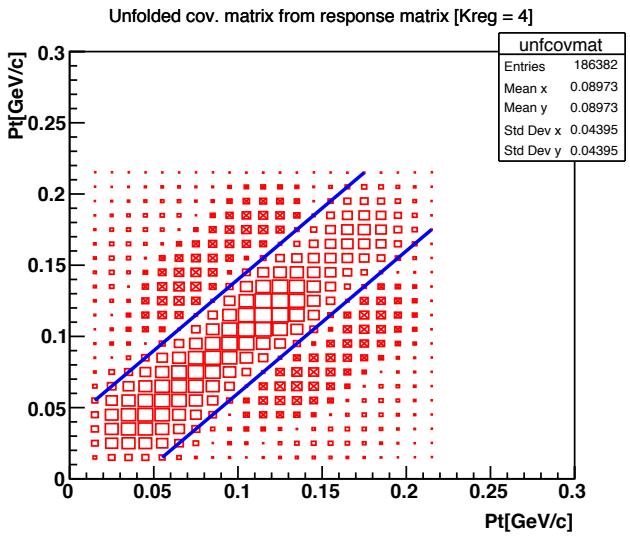
Random seed is reset for unfolded covariance matrix

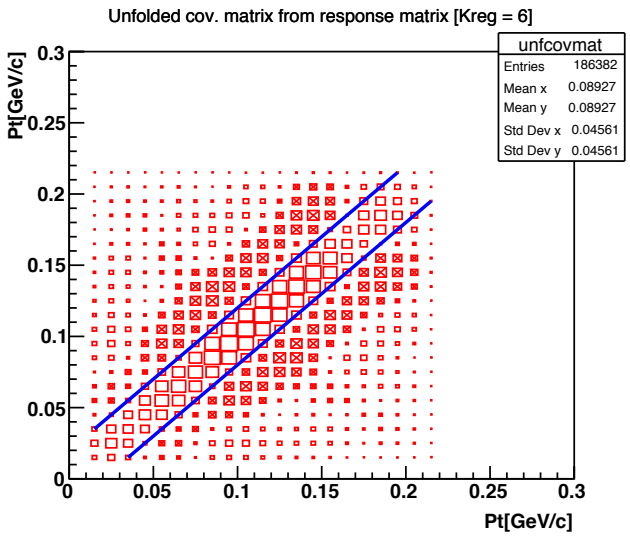
- Toy matrix is generated based on toy number and dimension of response matrix using Poisson
  toymat->SetBinContent(k, m, random. Poisson(ResMat->GetBinContent(k,m)))

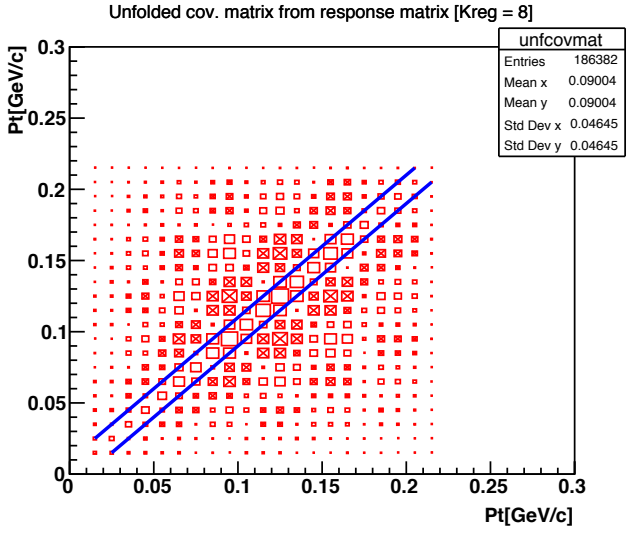
Unfolding is performed with regulization parameter = 4, 6, 8, 10 and unfolded covariance matrix is stored.

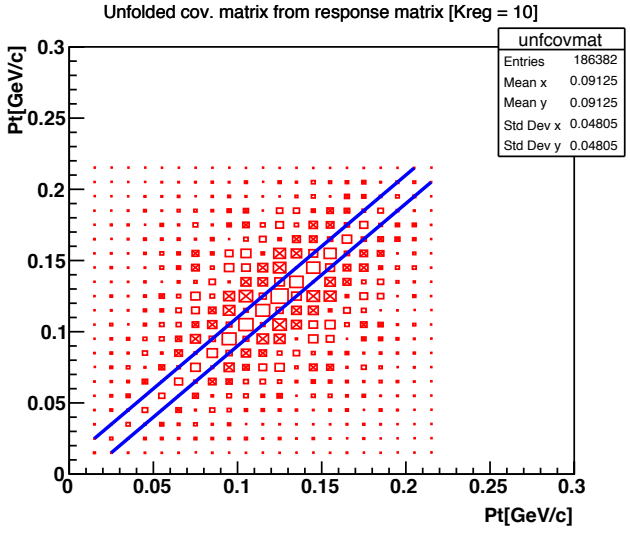
- Unfcov->SetBinContent(j, k, unfcov->GetBinContent(j, k) + ((unfres->GetBinContent(j) – toymean->GetBinContent(j))* (unfres->GetBinContent(k) – toymean->GetBinContent(k))/(ntoys-1))

Covariance Matrix for Unfolded Spectrum from Response Matrix

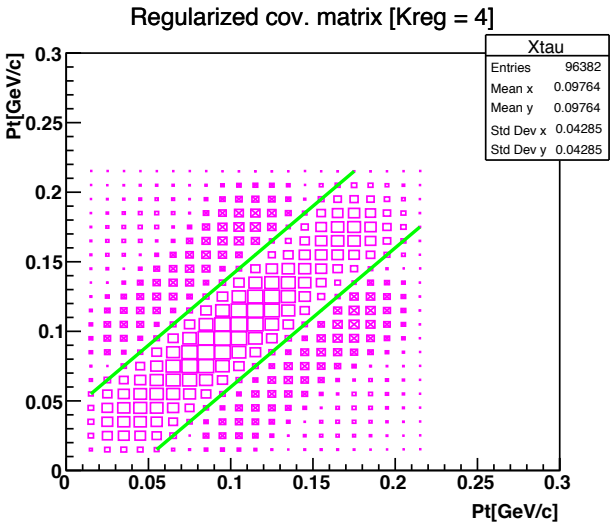


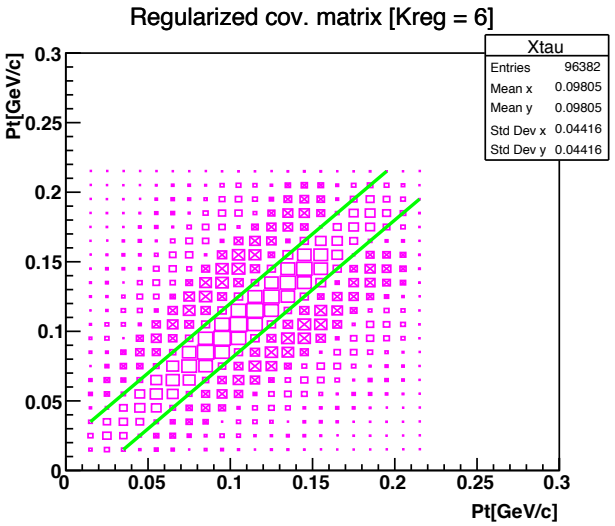


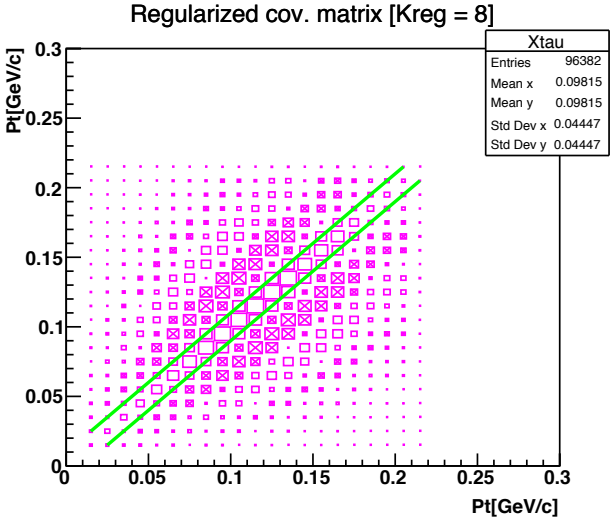


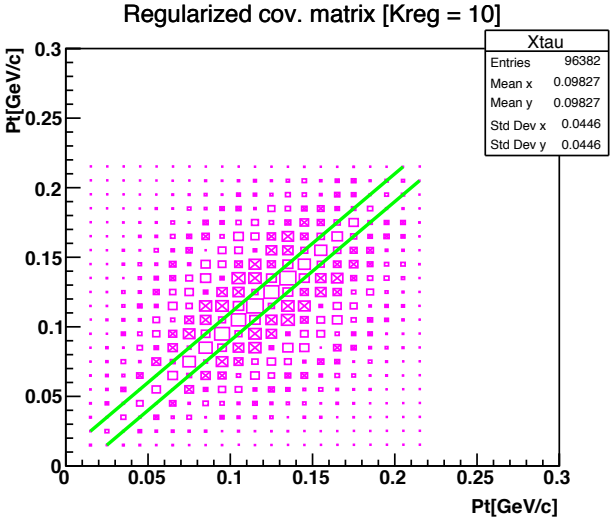


Regularized Covariance Matrix Corresponding to Total Uncertainties on Data

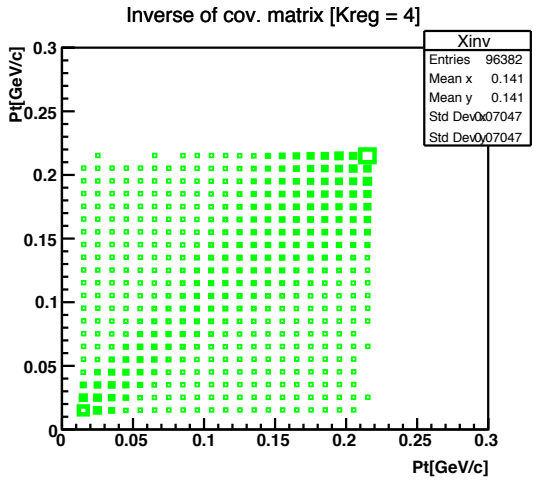


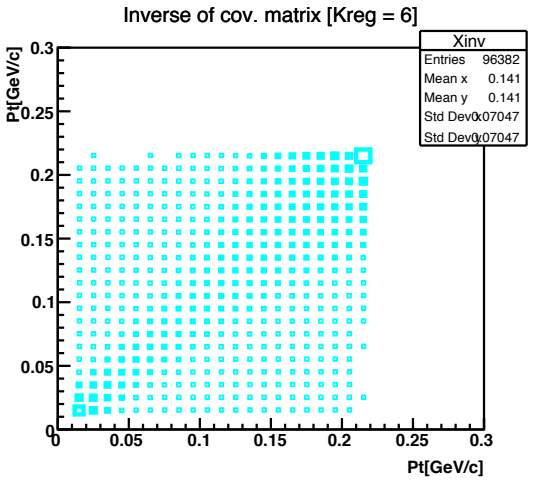


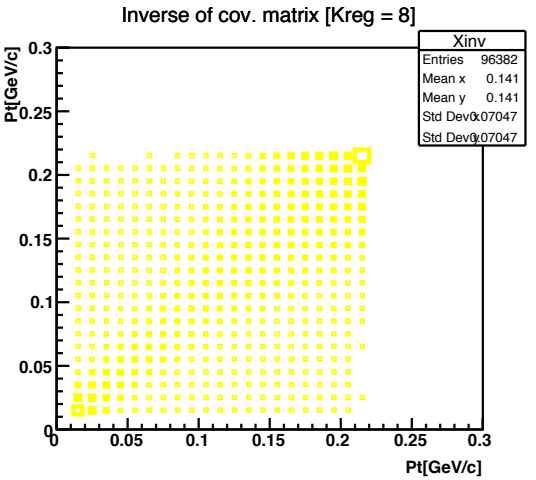


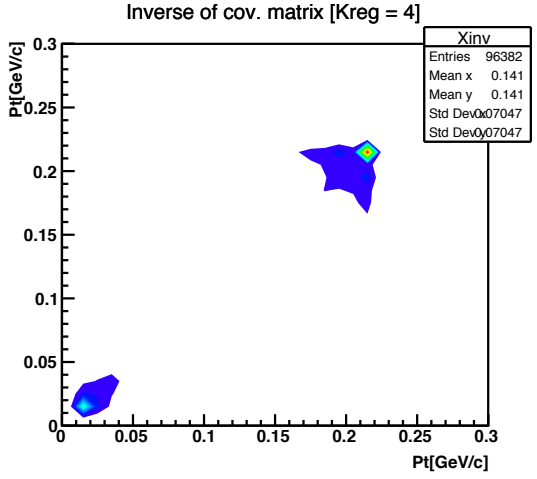


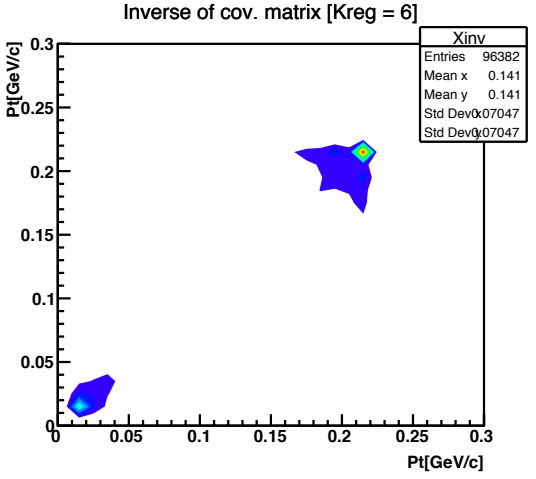
Inverse of Covariance Matrix – Regularization Independent

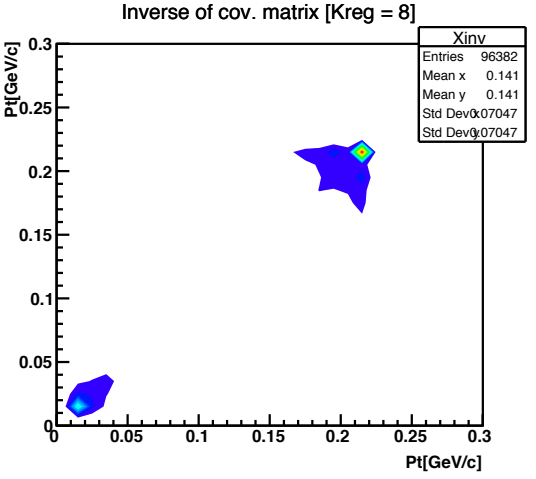




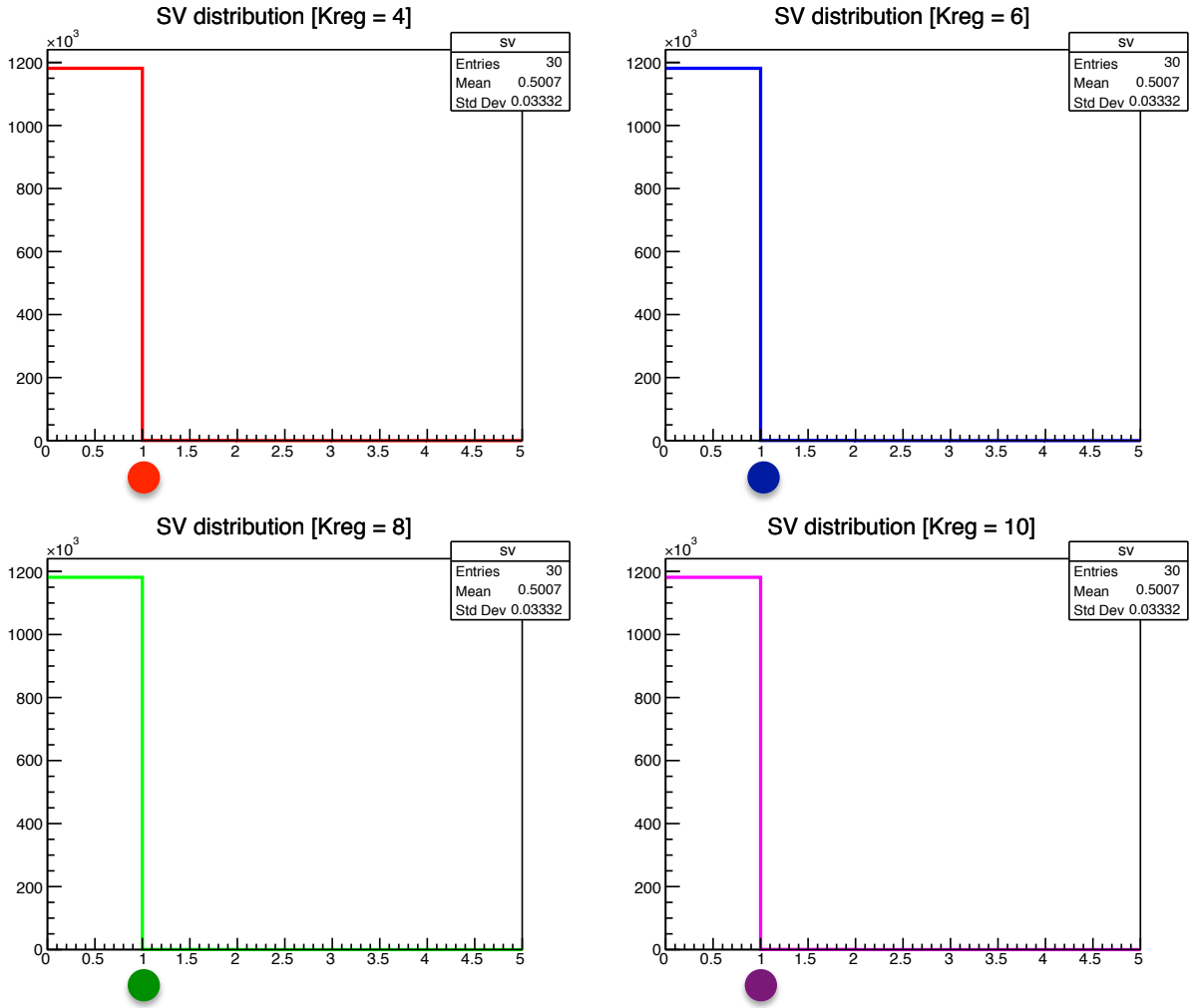






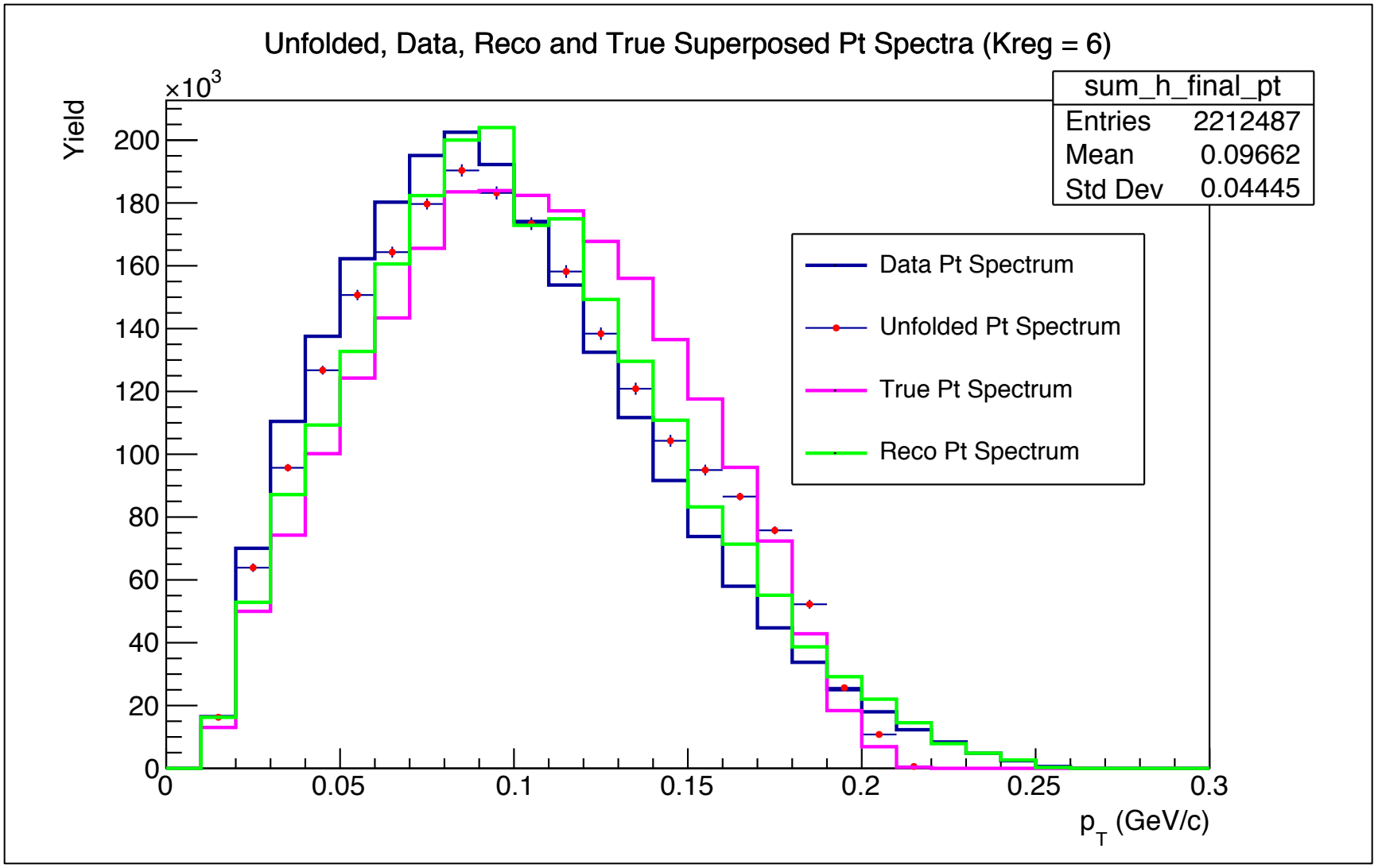


Singular Value Distributions – Unfolding Cross-check

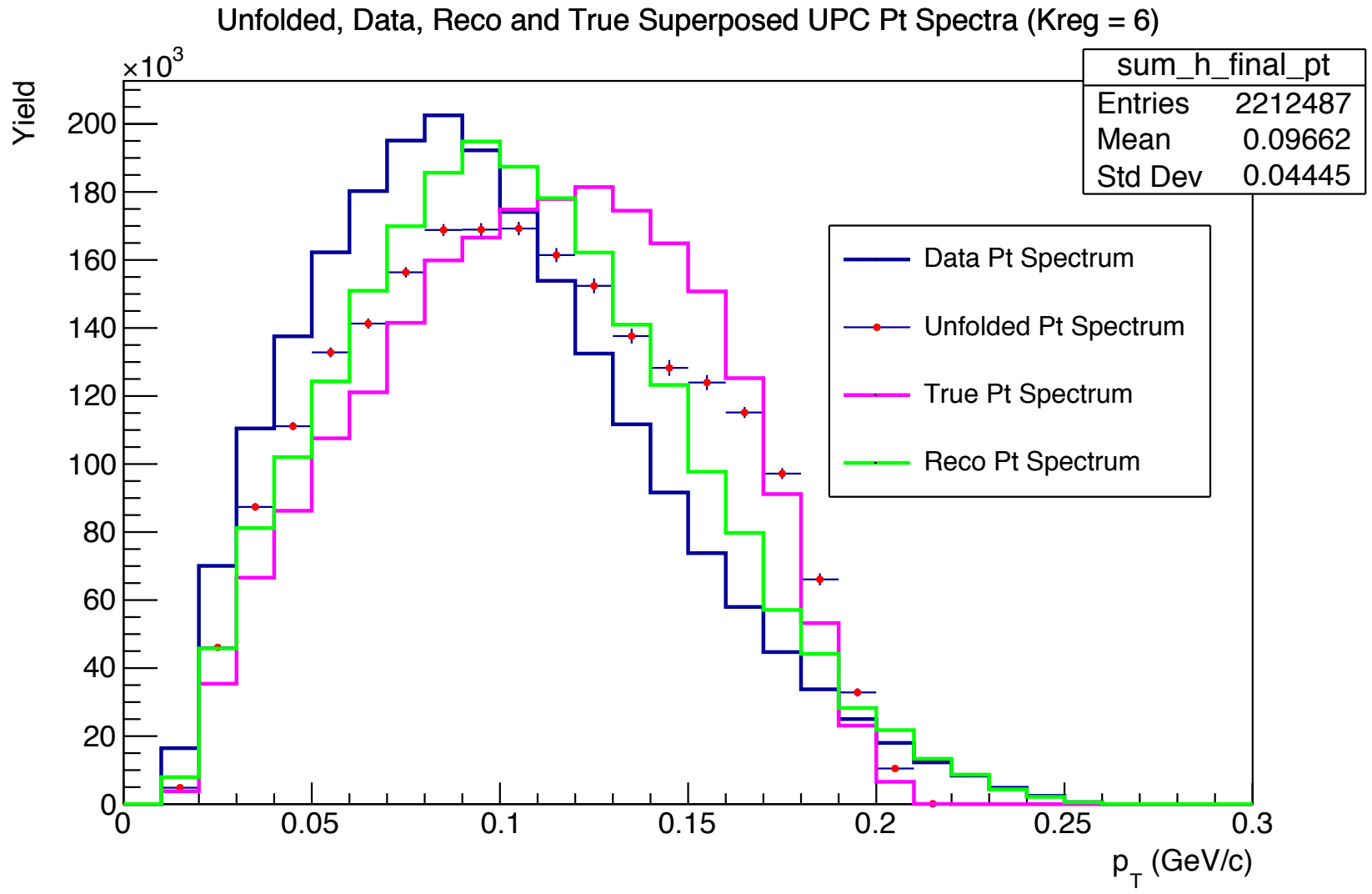


Singular values are distributed as expected and are regularization independent.

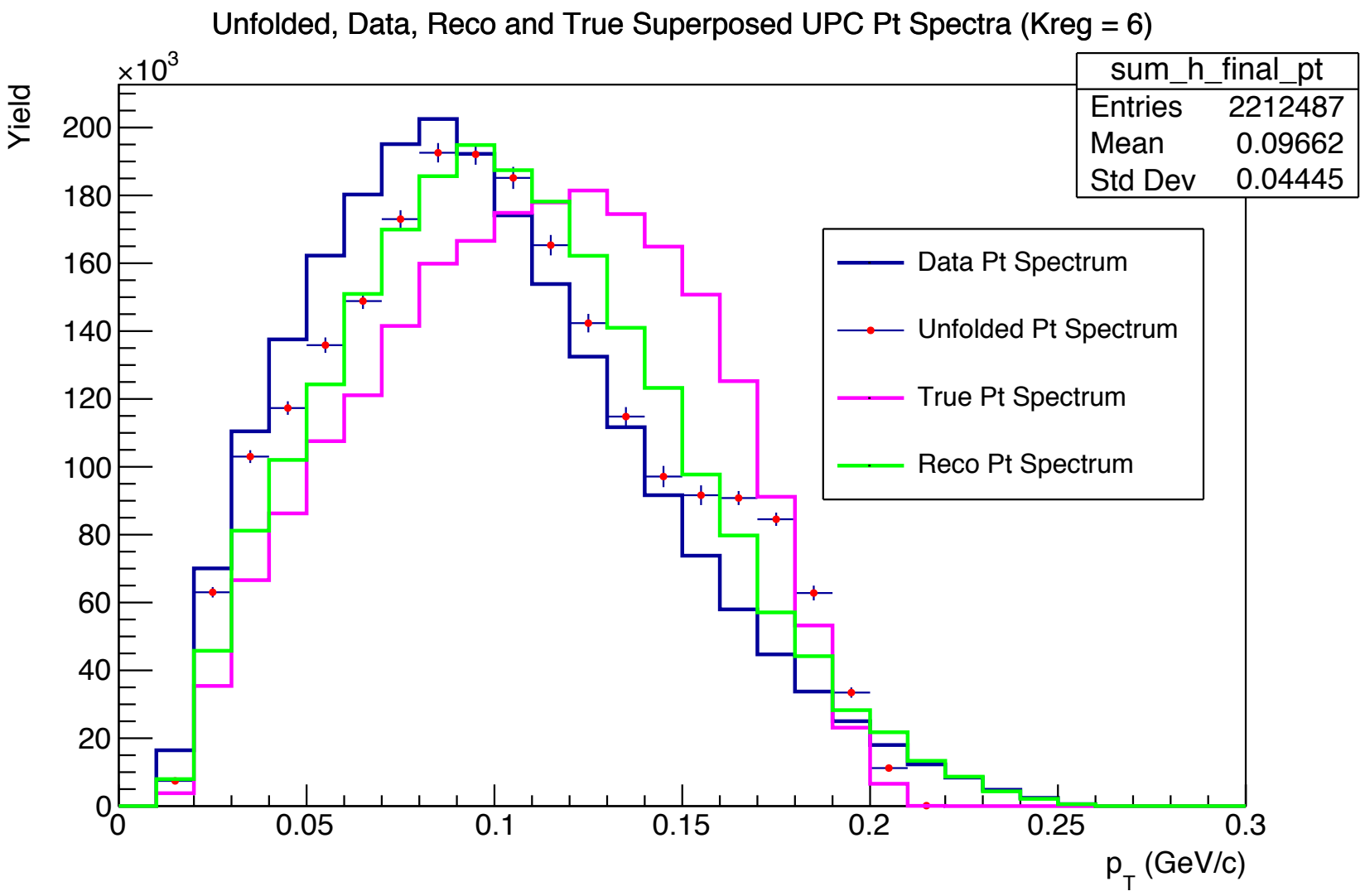
Trivial Unfolding Cross-check – UPC+DPMJET
Response Matrix on UPC+DPMJET



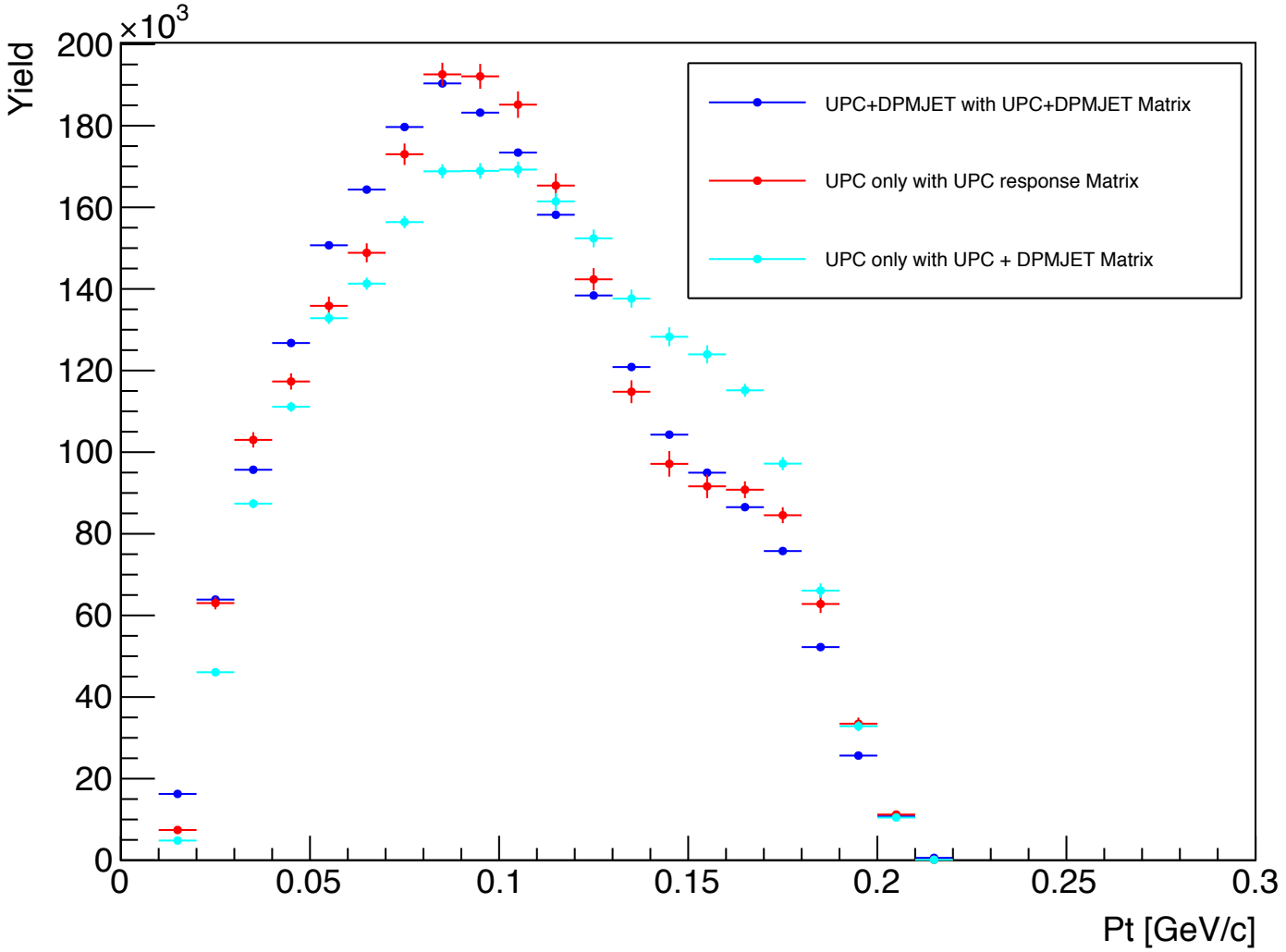
Trivial Unfolding Cross-check – UPC+DPMJET Response Matrix on UPC



Trivial Unfolding Cross-check – UPC Response Matrix on UPC



Trivial Unfolding Cross-check – Unfolded Spectra Comparison



Next Task

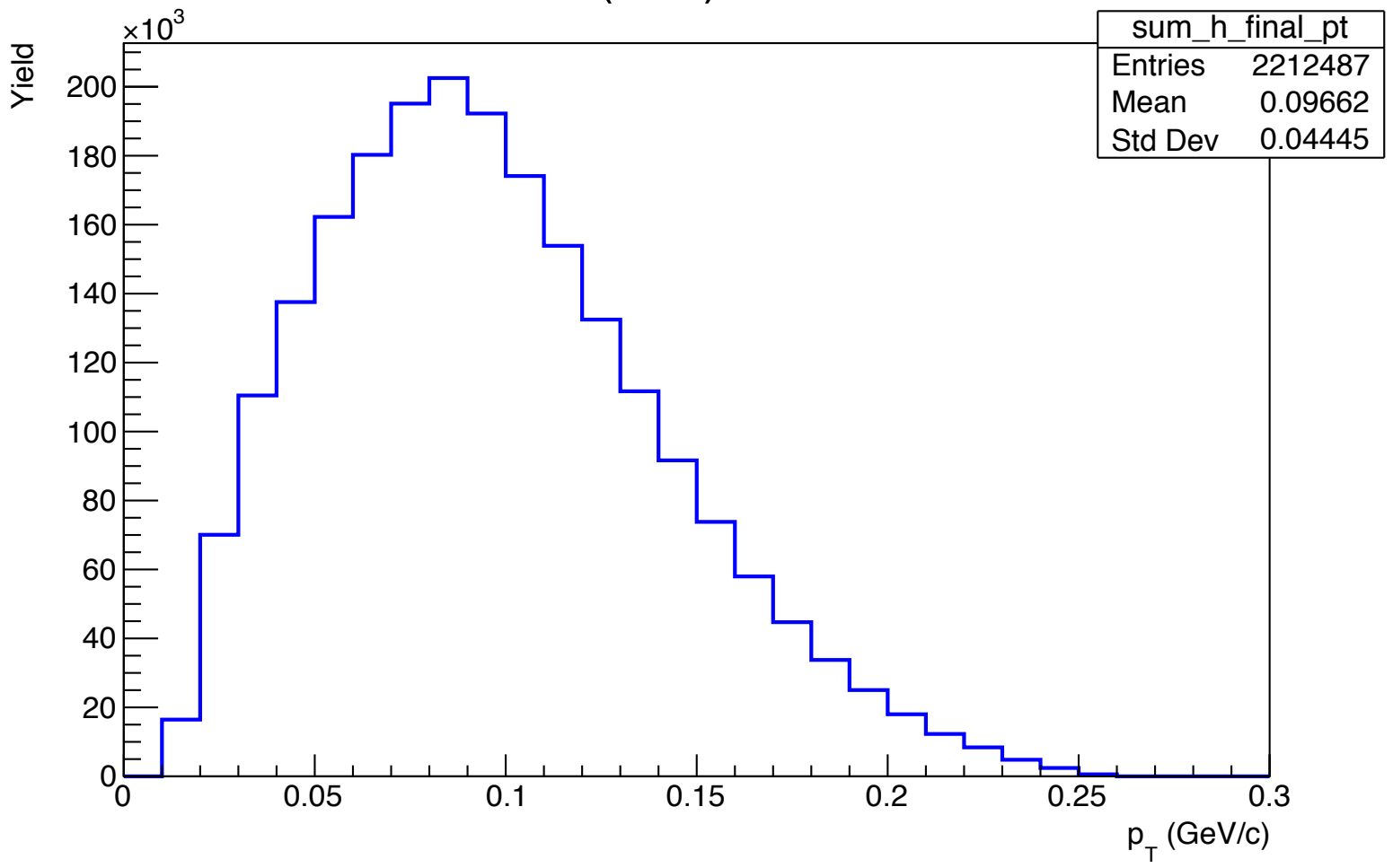
Slide 17

- Way forward to be decided depending on the outcome of this update

BACKUP

Unfolding Input – Measured Spectrum

① Data to unfold: Run 15 inclusive pAu transverse momentum data at $\sqrt{s_{NN}} = 200$ GeV



Unfolding Input – Reco Spectrum

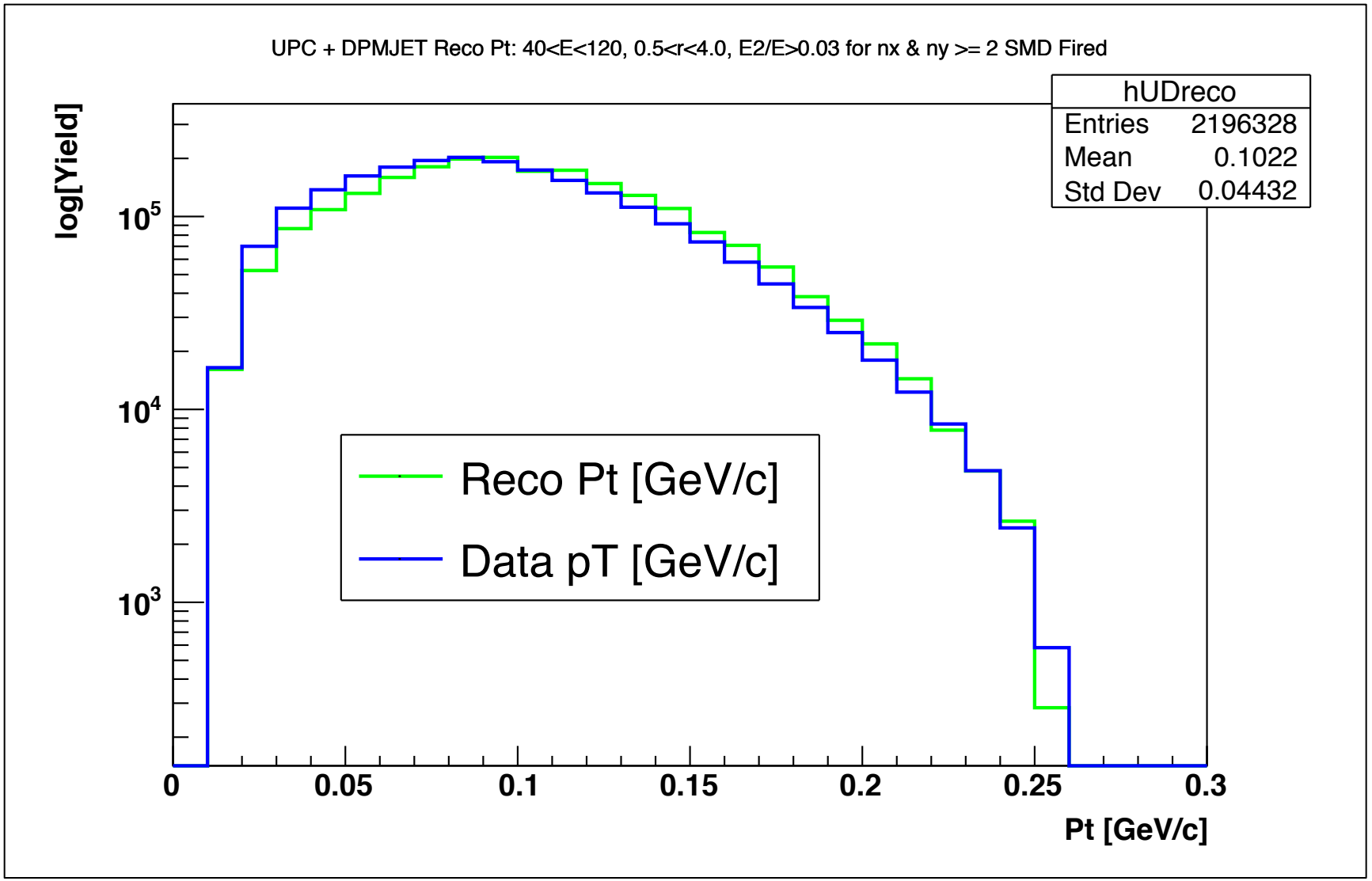
② Reconstructed spectrum: pAu reconstructed pt spectrum from a combination of UPC (EM) + DPMJET (HAD) MC samples.

Neutron Selection Cuts

Following cuts were utilized for neutron identification and rejection of photon events. Same cuts as data.

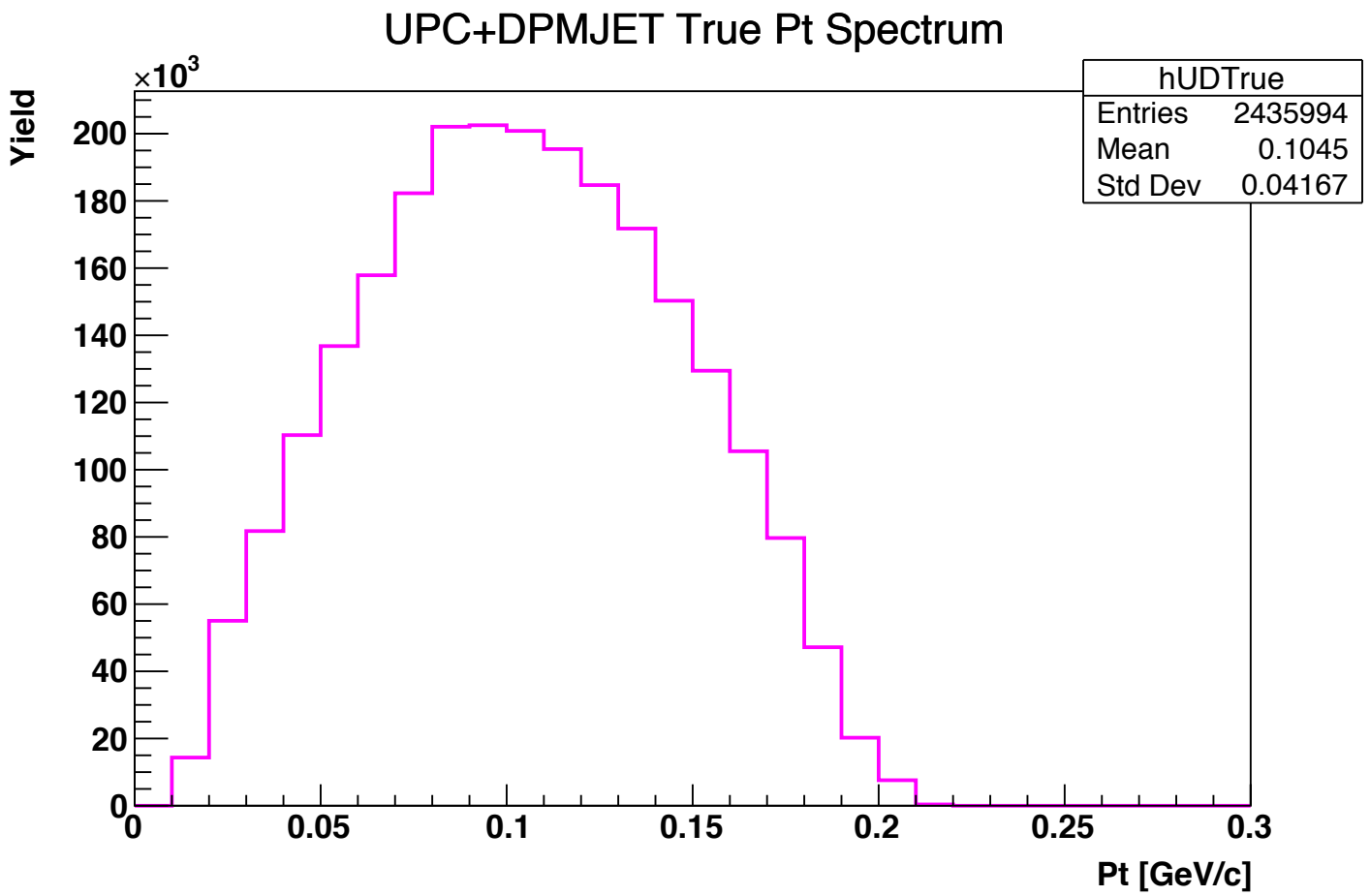
- ZDC total energy: 40 < E < 120 and 2nd ZDC energy/ZDC total energy > 0.03 (i.e. non-zero 2nd ZDC energy)
- Acceptance cut: 0.5 < r < 4.0 cm
- SMD multiplicity: Nx/Ny >= 2 fired SMD strips. That is Nx and Ny > 1 fired strips above Minimum Ionized Particle (MIP) energy threshold cut.

Unfolding Input – Reco Spectrum



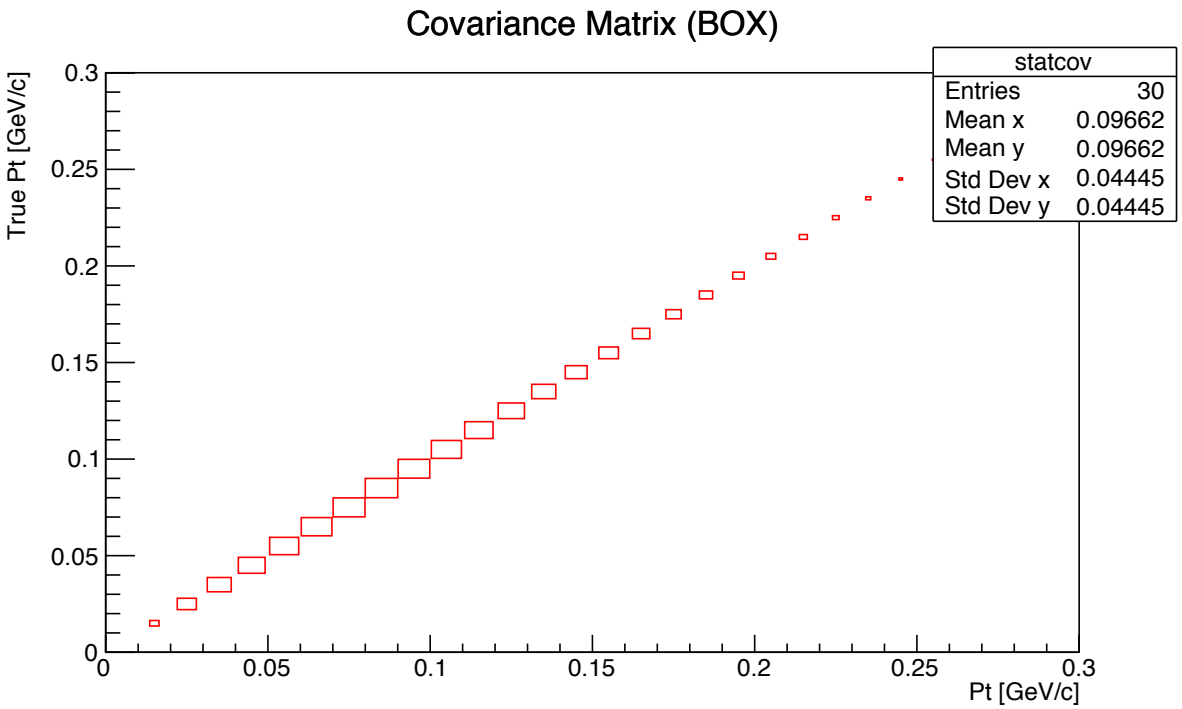
Unfolding Input – True Spectrum

③ True spectrum: True pt spectrum from addition of UPC (EM) + DPMJET (HAD) MC samples.



Unfolding Input – Covariance Matrix: BOX

⑤ Covariance matrix: 2D histogram extracted from the measured pt spectrum.



Finally created a TSVDUnfold object to perform unfolding of the measured spectrum

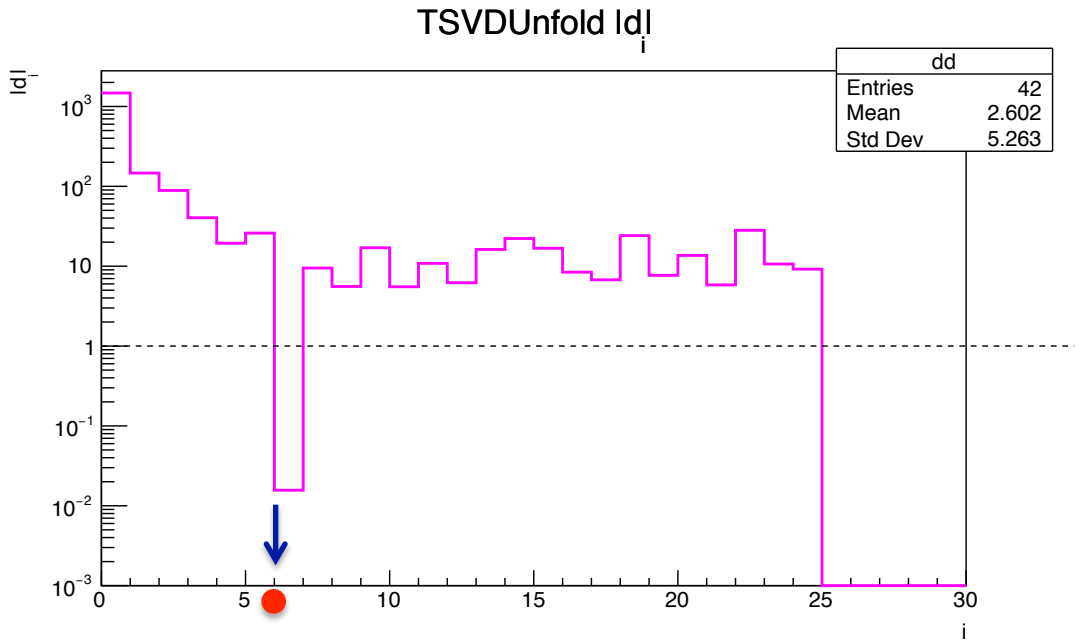
```
TSVDUnfold *tsvdunf = new TSVDUnfold( hdata, statcov, hUDreco, hUDTrue, UAdet );
```

Ready

1 2 3 4 5

Unfolding Output – Distribution of dVector

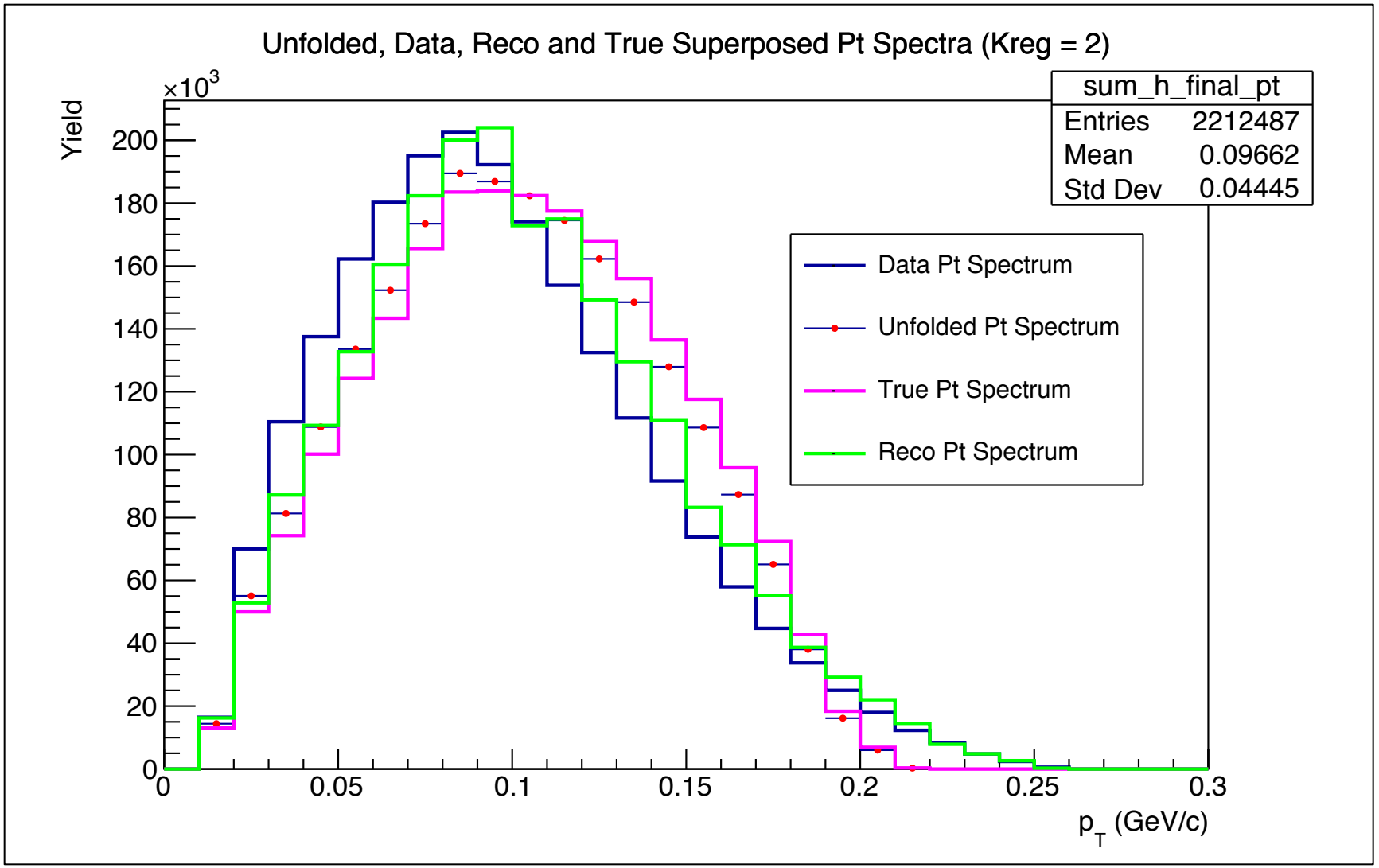
- Performed unfolding with the regularization parameter (kreg = 6 as optimum).



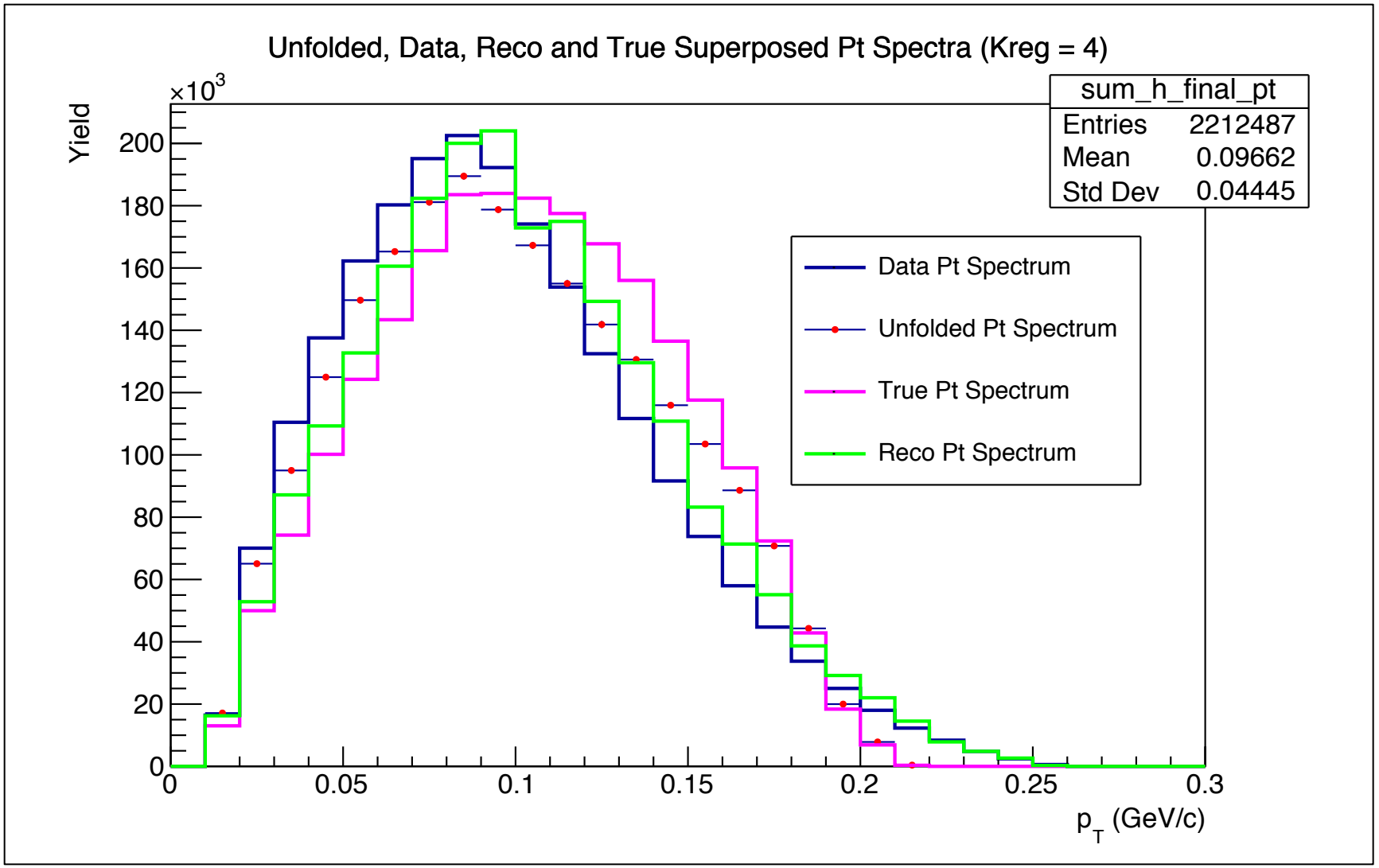
- This distribution helps us cross-check the quality of our unfolding regularization.

- Regularization is chosen as the point where | d_i | stop being statistically significantly >> 1. It is the point where regularization is considered optimal.

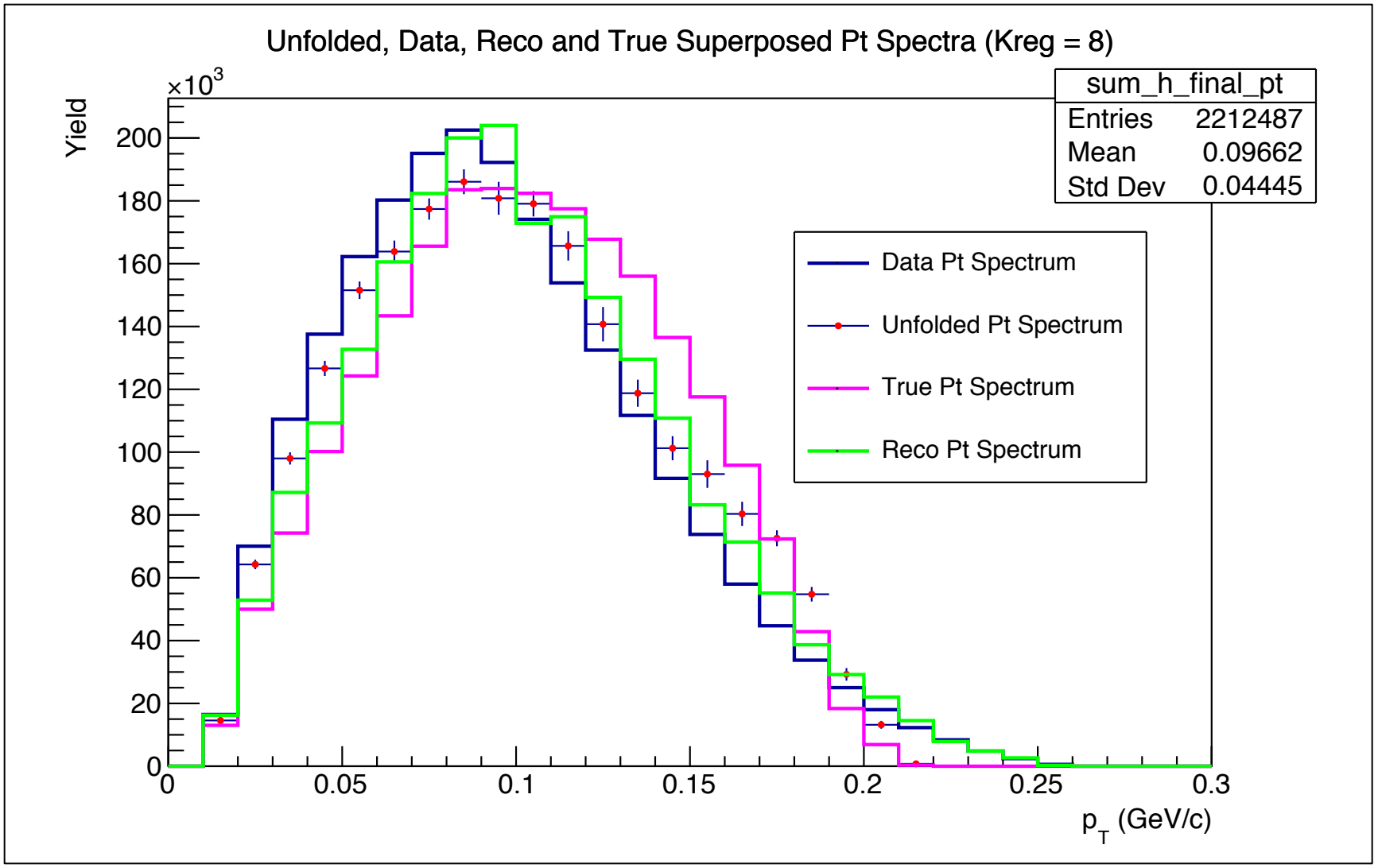
Unfolding Output – Unfolded Distribution



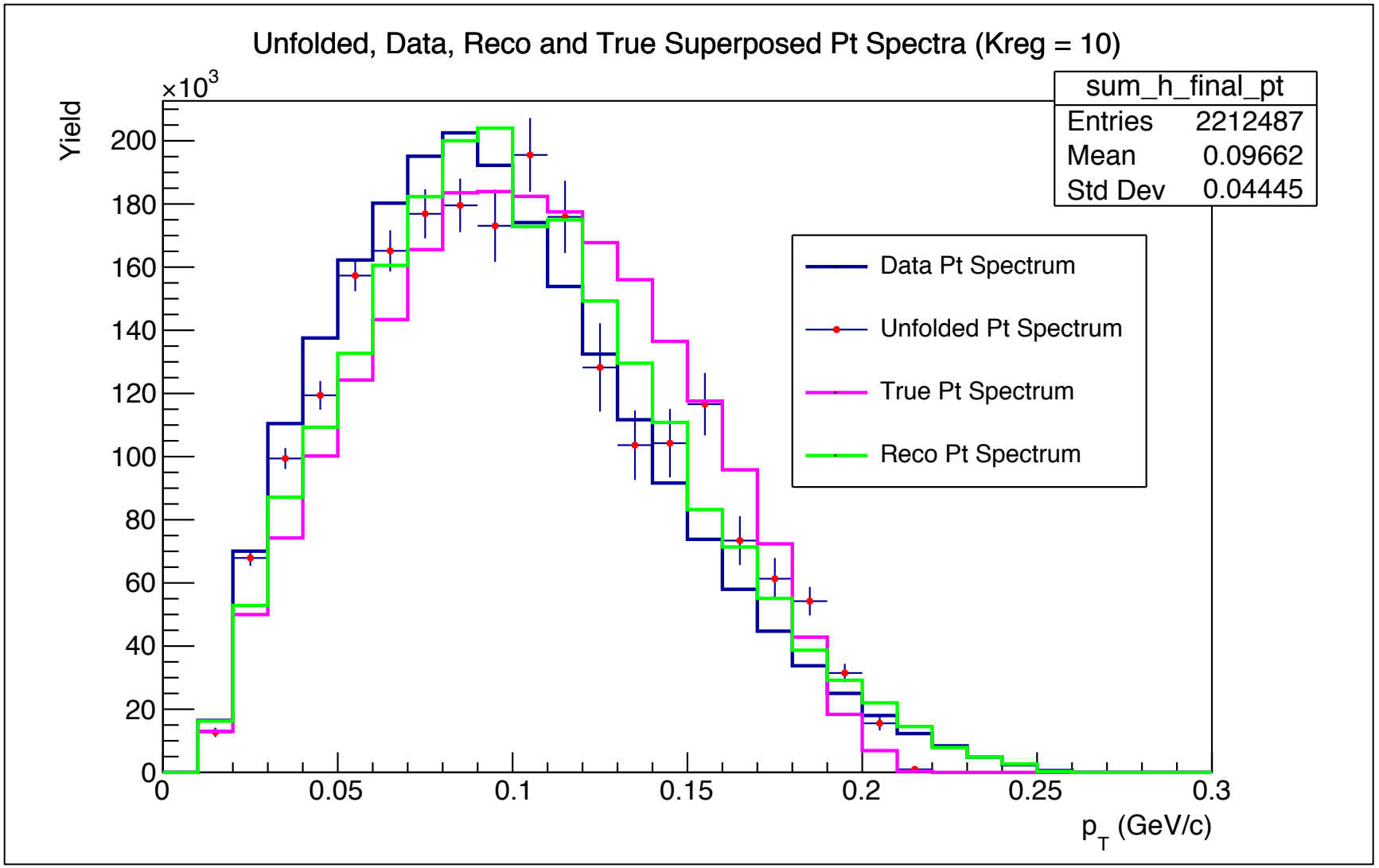
Unfolding Output – Unfolded Distribution



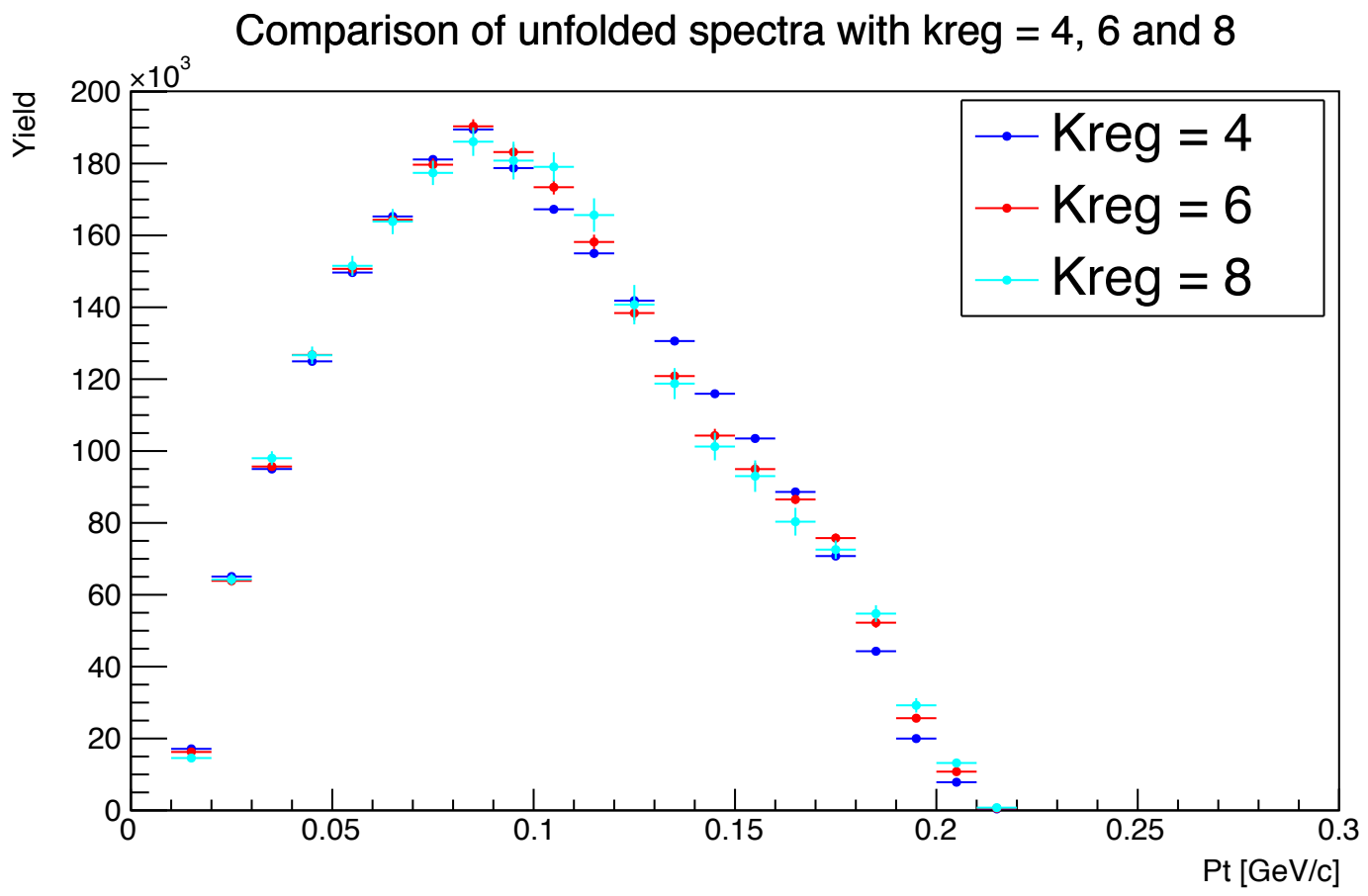
Unfolding Output – Unfolded Distribution



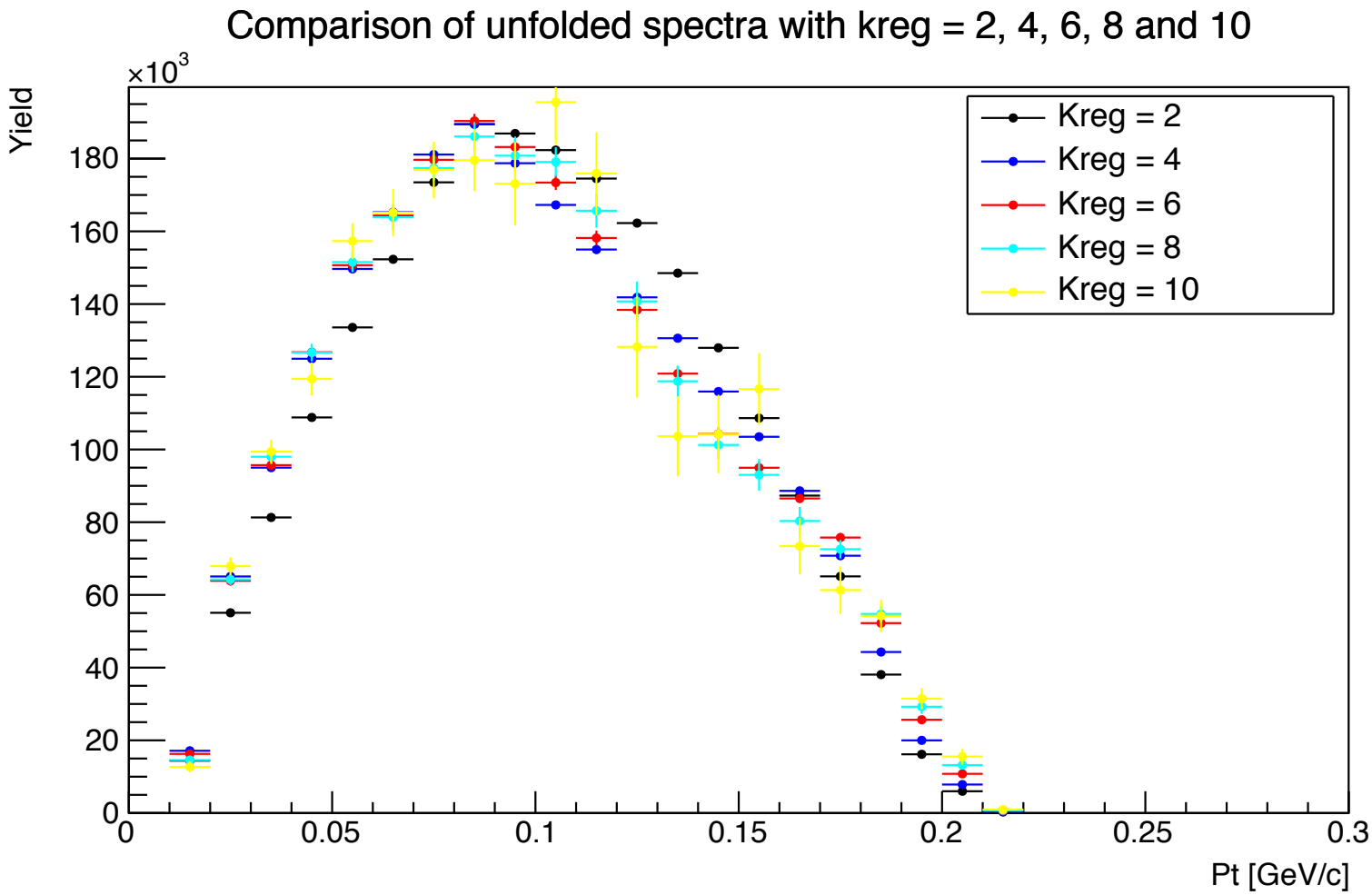
BACKUP – Unfolded Distribution



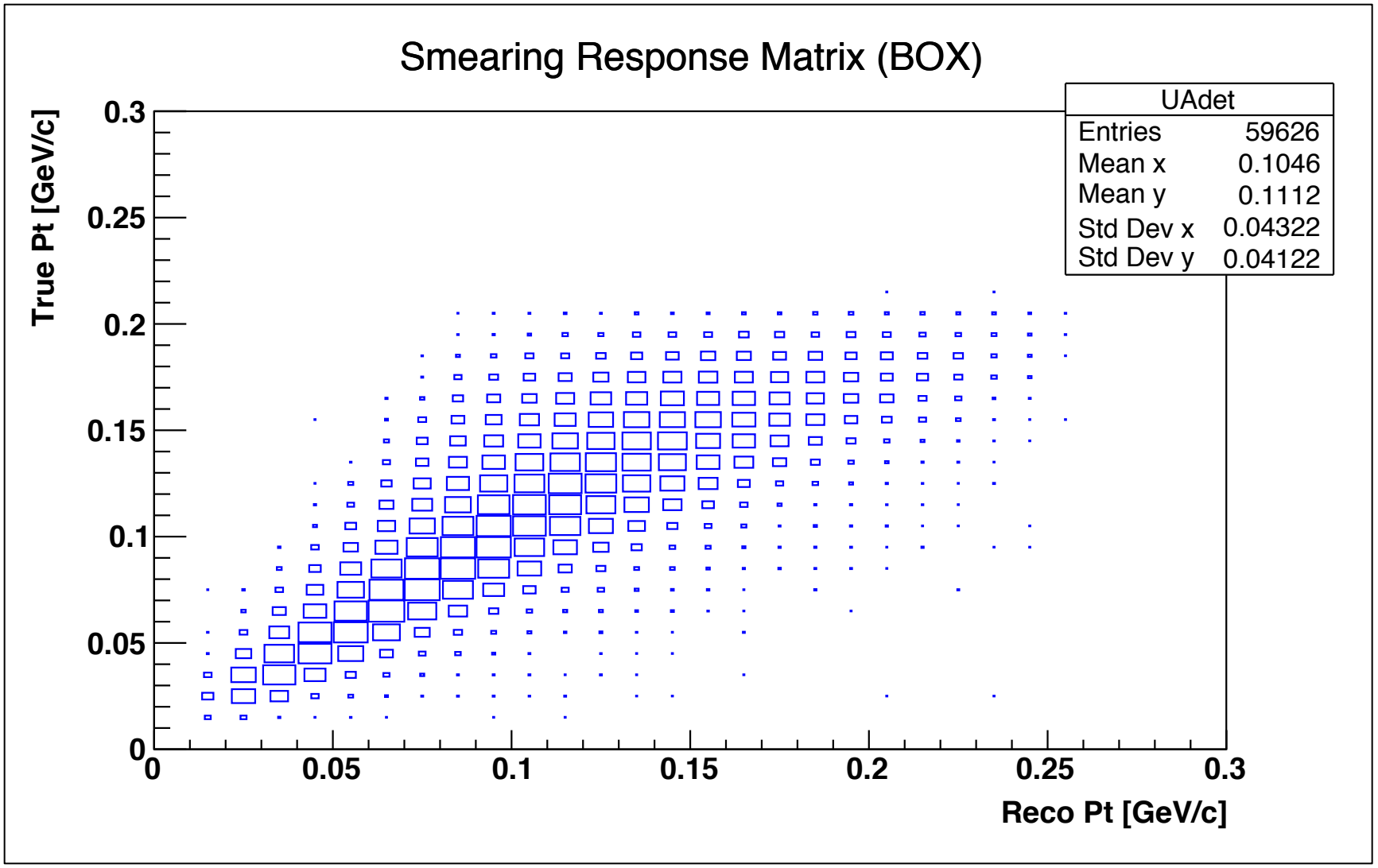
Unfolded Inclusive pAu P_T Data – Spin PWG



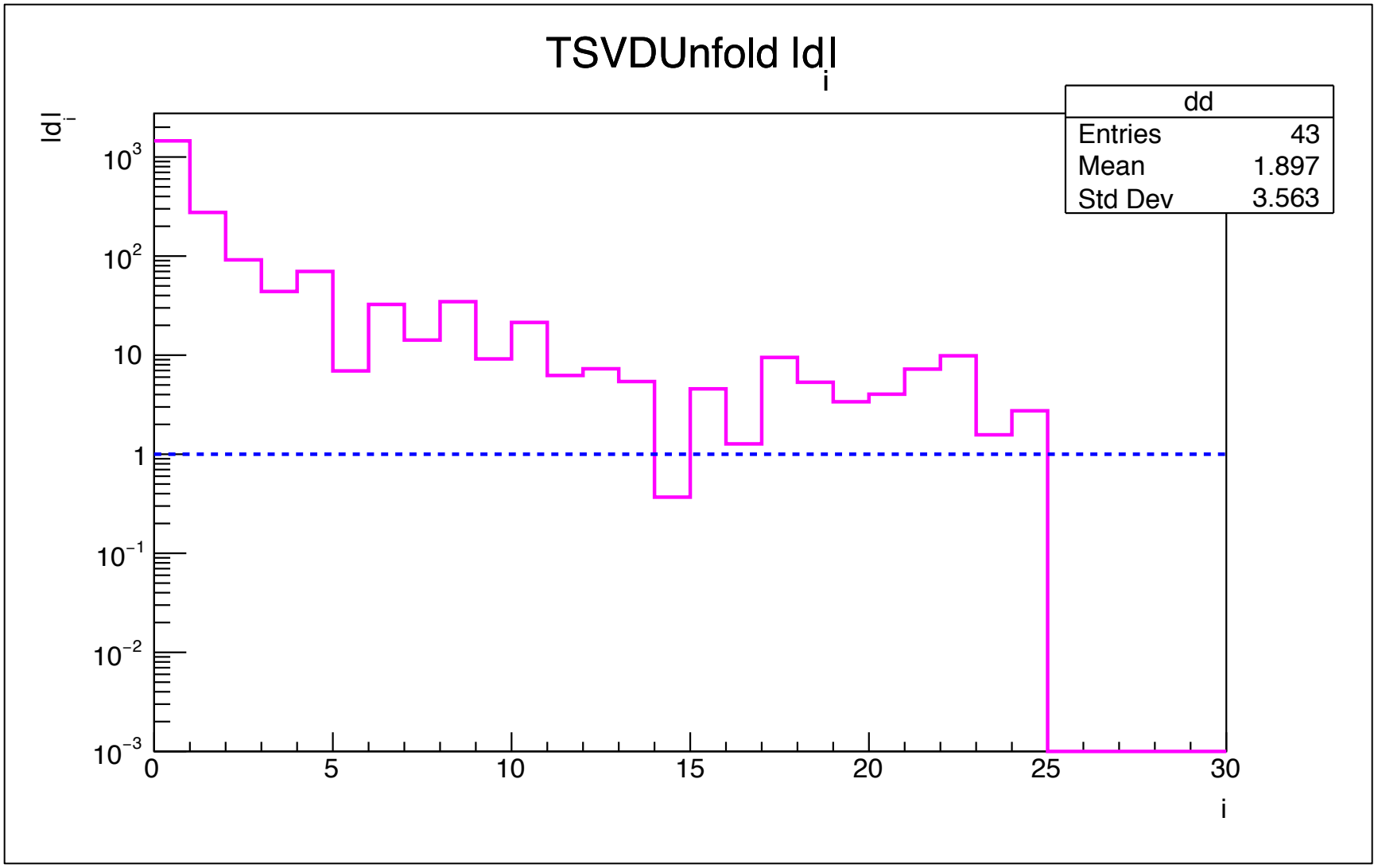
Unfolding Output – Unfolded Distribution



Detector Response Matrix - UPC



Detector Response Matrix – UPC d Vector



Unfolding Output – Unfolded Distribution