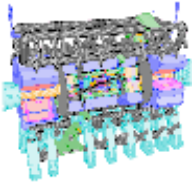


# I: ResBos ntuples in Castor II: CTEQ6.1 error pdf's

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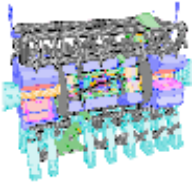
ATLAS SM meeting



# ResBos ntuples



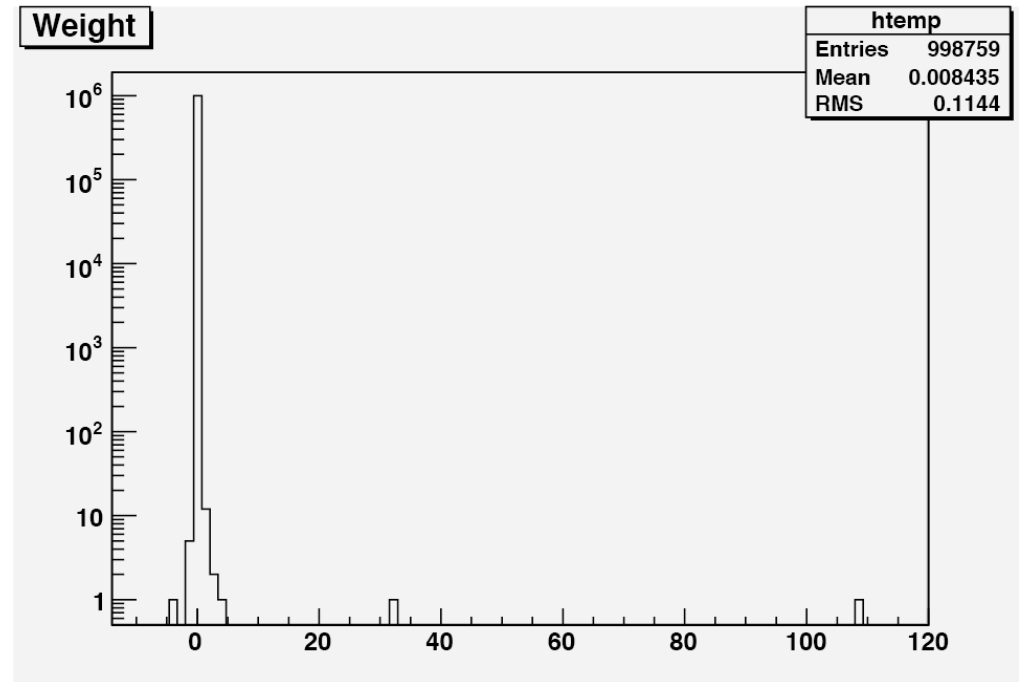
- ResBos is a program that produces  $W, Z$ , Higgs, diphoton final states with NLO and NLL accuracy
- Correct normalization and correct  $p_T$  distributions
- End results are inclusive “events” with 4-vector information and event weight
  - ◆  $W/Z$  4-vectors
  - ◆ decay lepton/neutrino 4-vectors
  - ◆ event weight
- I’ve produced 41 ROOT ntuples with 1E6 events apiece using CTEQ6.1 and the 40 error pdf’s for  $W^+$  and  $W^-$ 
  - ◆ each ntuple ~50 MB
- Currently stored on Castor and available for use
  - ◆ `/castor/cern.ch/atlas/project/smggroup/ResBos`
- Troels is copying similar Z ntuples in same place

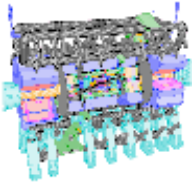


# Weights



- For  $W^-$  with CTEQ6.1, a few events with anomalously high weights that cause some distributions to be spikey
- So I made a cut requiring the weights to be  $< 10$

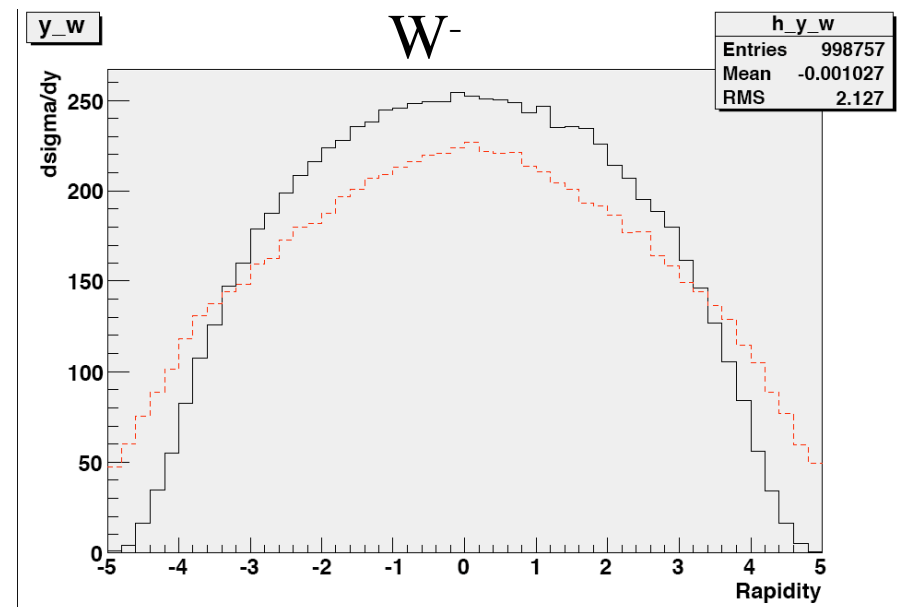
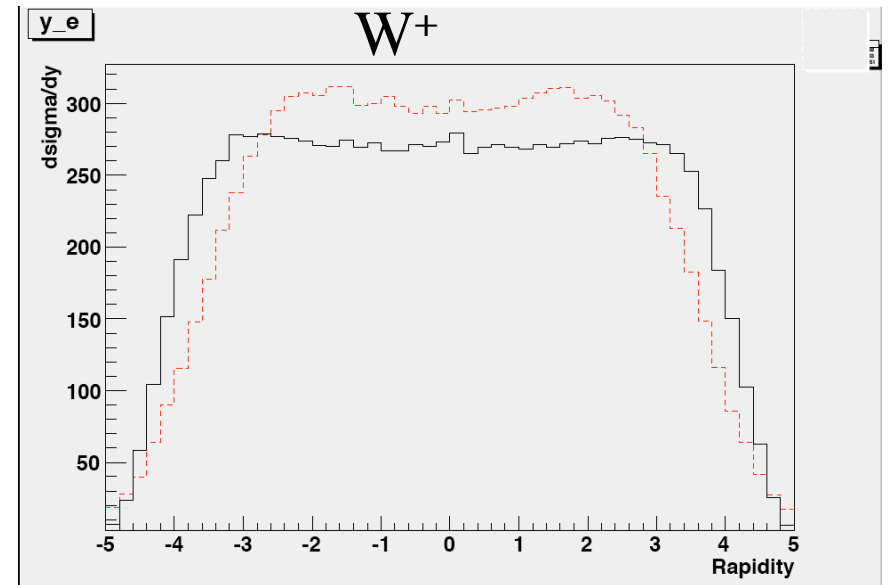


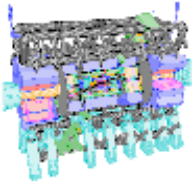


# Rapidity distributions



- Black is  $W$  boson rapidity, red is decay lepton rapidity
- Note that  $e^+$  rapidity is narrower than  $W^+$  rapidity;  $e^-$  rapidity is broader than  $W^-$  rapidity
- $W$ 's are left-handed polarized
  - ◆  $e^+$ 's decay opposite the direction of  $W^+$  travel
  - ◆  $e^-$ 's decay in direction of  $W^-$  travel



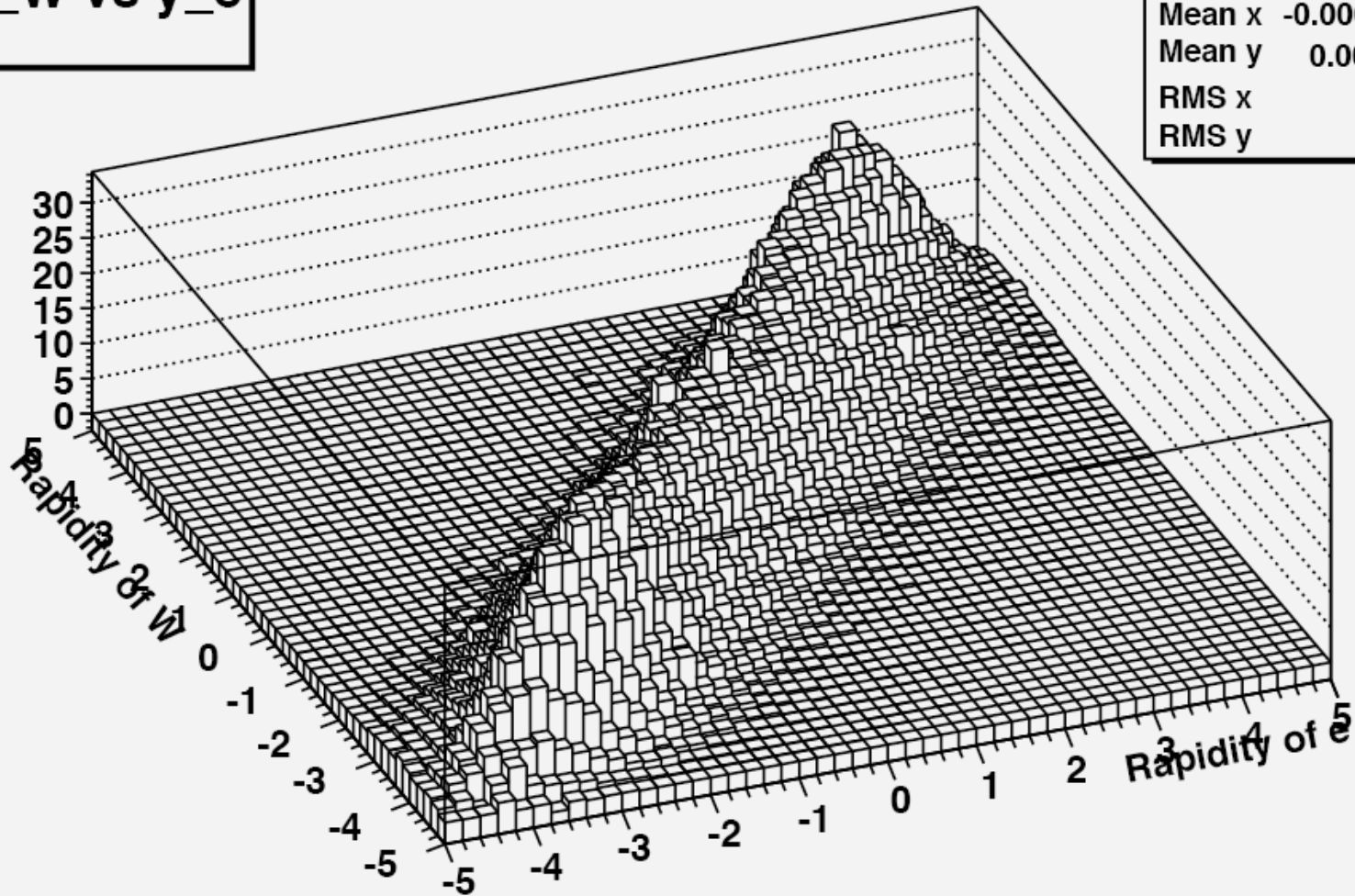


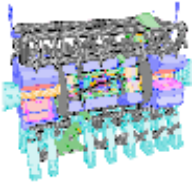
# Correlations



**y<sub>W</sub> vs y<sub>e</sub>**

| h_y_e_w |            |
|---------|------------|
| Entries | 999138     |
| Mean x  | -0.0001283 |
| Mean y  | 0.001258   |
| RMS x   | 2.251      |
| RMS y   | 2.424      |

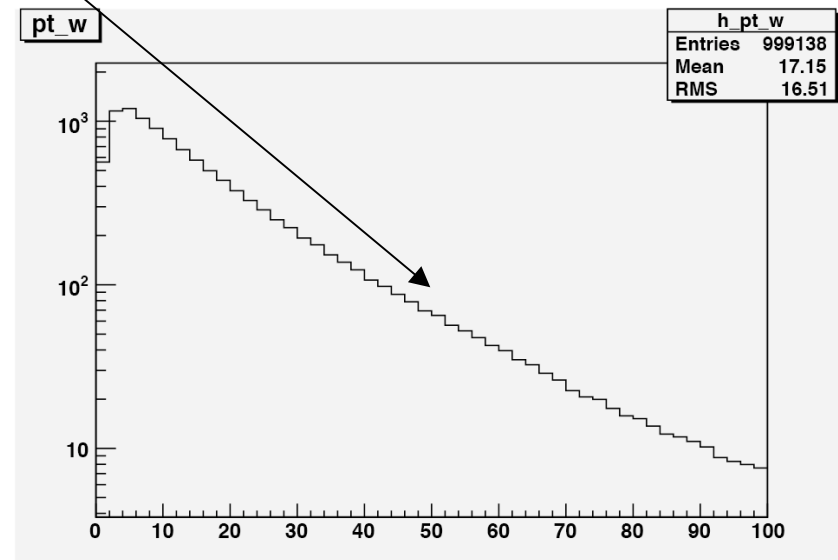
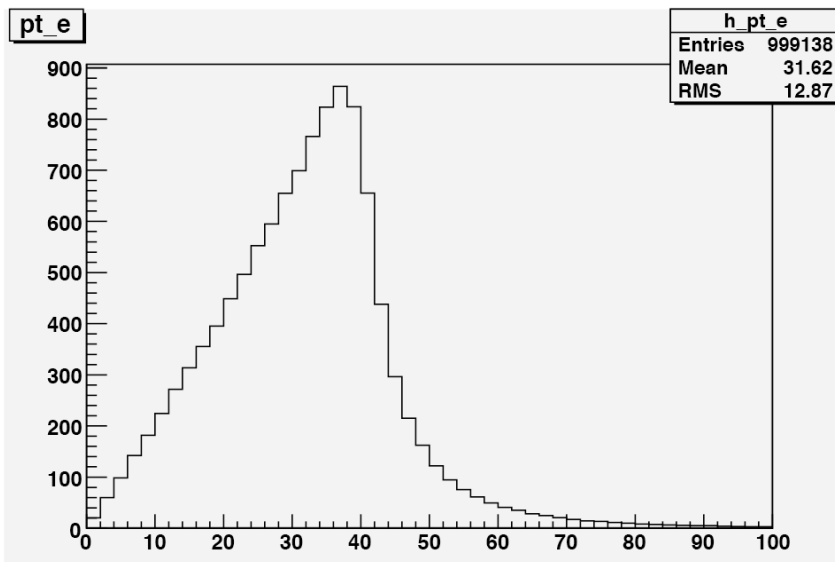
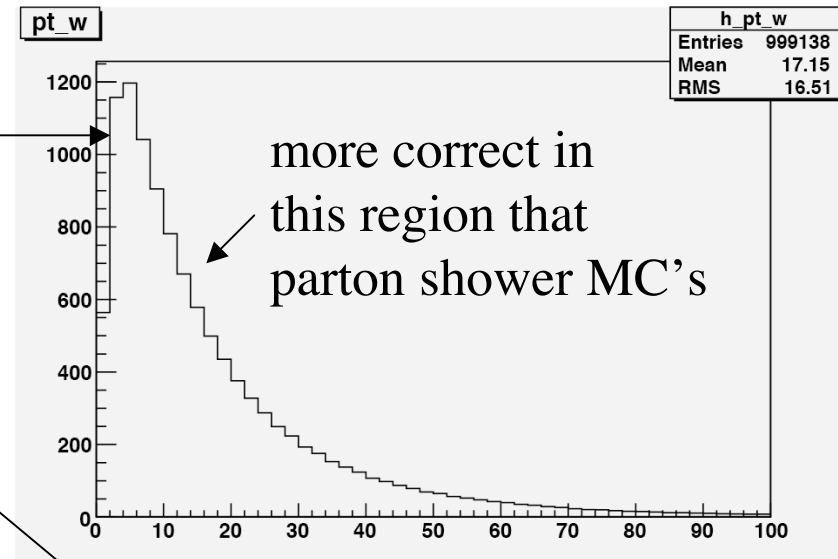


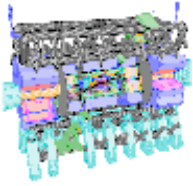


# $p_T$ distributions



- Correct non-perturbative physics at low  $p_T$
- Correct NLO perturbative physics at high  $p_T$
- Correct decay lepton distributions
  - ◆ information on  $W$  mass

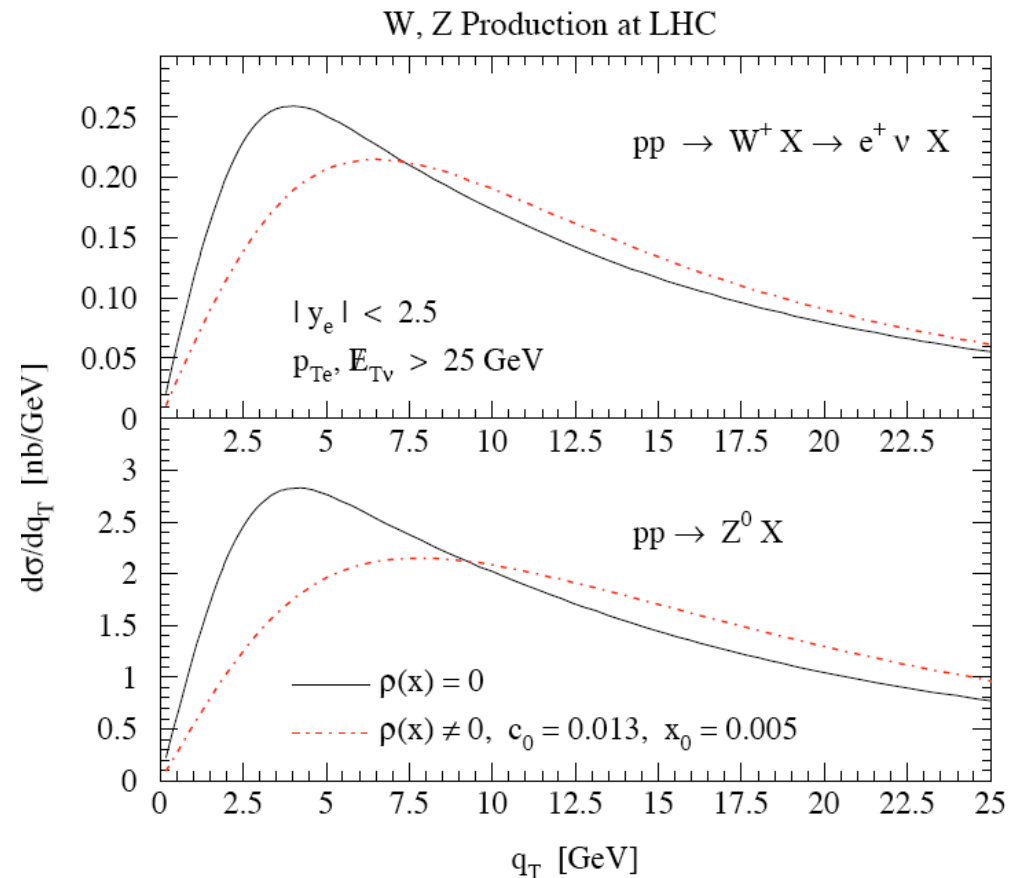


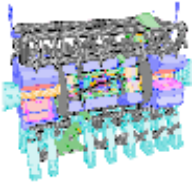


# BFKL and EM effects



- Semi-inclusive DIS at HERA indicate that higher order corrections (like BFKL) may be important at low  $x$
- This has implications for  $p_T$  distributions at the LHC
- Ntuples including these effects will also be generated
- ResBos-A includes effects of photon radiation, important for  $W$  mass determination
  - ◆ can also generate ntuples using this framework

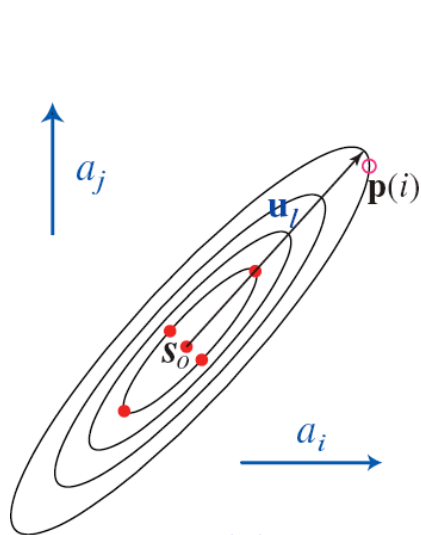




# CTEQ6.1 error pdf's

- There are 20 free pdf parameters in the CTEQ6.1 global pdf fit
  - ◆ for u,d,g, d-bar/u-bar,d-bar+u-bar
- With Hessian method, a 20X20 matrix is diagonalized resulting in 20 eigenvalues and 20 orthonormal eigenvectors

*2-dim (i,j) rendition of d-dim (~16) PDF parameter space*

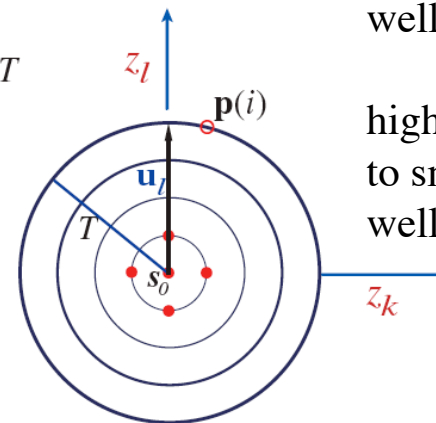


*Original parameter basis*

*contours of constant  $\chi^2_{\text{global}}$   
 $\mathbf{u}_l$ : eigenvector in the  $l$ -direction  
 $\mathbf{p}(i)$ : point of largest  $a_i$  with tolerance  $T$   
 $s_0$ : global minimum*

*diagonalization and  
rescaling by  
the iterative method*

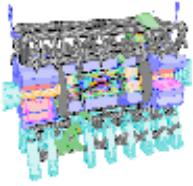
- *Hessian eigenvector basis sets*



*Orthonormal eigenvector basis*

low # eigenvectors correspond to large eigenvalues, well-determined directions

high # eigenvectors correspond to small eigenvalues, less well-determined directions



# CTEQ6.1 error pdf's



- There are 20 free pdf parameters in the CTEQ6.1 global pdf fit
  - ◆ for u,d,g, d-bar/u-bar,d-bar+u-bar
- With Hessian method, a 20X20 matrix is diagonalized resulting in 20 eigenvalues and 20 orthonormal eigenvectors

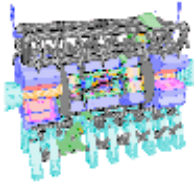
2->d-valence  
1->u-valence  
0->gluon  
-1->d-bar/u-bar  
-2->d-bar+u-bar

- Functional form used in CTEQ fits is:

- ◆  $xf(x, Q_0) = A_0 x^{A_1} (1-x)^{A_2} e^{A_3 x} (1 + A_4 x)^{A_5}$ 
  - ▲  $Q_0 = 1.3$  GeV (below any data used in fit)
    - easier to do forward evolution than backward
    - MRST starts at 1 GeV (- gluon distribution)
  - ▲ functional form arrived at by adding a 1:1 Padé expansion  $xf)/dx$
  - ▲ more versatile than form used in CTEQ5 or MRST
  - ▲ there are 20 free parameters used in the global fit
    - MRST has 15 free parameters

5 parameters

$A_1$   
 $A_2$   
 $A_3$   
 $A_4$   
 $A_5$

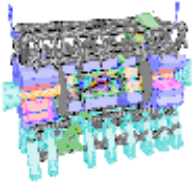


# Eigenvectors 1 (pdf's 1 and 2)



| Sets | Shape | Parameter | Component |
|------|-------|-----------|-----------|
| 1, 2 | BP(   | 2, 1)     | 0.057911  |
| 1, 2 | BP(   | 2, 2)     | -0.022688 |
| 1, 2 | BP(   | 2, 3)     | 0.015496  |
| 1, 2 | BP(   | 2, 4)     | 0.035277  |
| 1, 2 | BP(   | 2, 5)     | frozen    |
| 1, 2 | BP(   | 1, 1)     | 0.888833  |
| 1, 2 | BP(   | 1, 2)     | -0.161942 |
| 1, 2 | BP(   | 1, 3)     | 0.118204  |
| 1, 2 | BP(   | 1, 4)     | 0.268405  |
| 1, 2 | BP(   | 1, 5)     | 0.276392  |
| 1, 2 | BP(   | 0, 1)     | 0.038555  |
| 1, 2 | BP(   | 0, 2)     | -0.006610 |
| 1, 2 | BP(   | 0, 3)     | frozen    |
| 1, 2 | BP(   | 0, 4)     | -0.017717 |
| 1, 2 | BP(   | 0, 5)     | frozen    |
| 1, 2 | BP(   | -1, 1)    | -0.007668 |
| 1, 2 | BP(   | -1, 2)    | 0.012745  |
| 1, 2 | BP(   | -1, 3)    | 0.001851  |
| 1, 2 | BP(   | -1, 4)    | frozen    |
| 1, 2 | BP(   | -1, 5)    | 0.001004  |
| 1, 2 | BP(   | -2, 1)    | 0.117517  |
| 1, 2 | BP(   | -2, 2)    | -0.008357 |
| 1, 2 | BP(   | -2, 3)    | 0.006504  |
| 1, 2 | BP(   | -2, 4)    | frozen    |
| 1, 2 | BP(   | -2, 5)    | frozen    |

- $A_1$  of u-valence

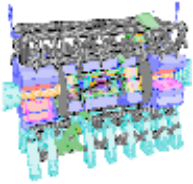


## Eigenvector 2 (pdf's 3 and 4)



| Sets | Shape | Parameter | Component |
|------|-------|-----------|-----------|
| 3, 4 | BP(   | 2, 1)     | 0.534572  |
| 3, 4 | BP(   | 2, 2)     | -0.060817 |
| 3, 4 | BP(   | 2, 3)     | 0.048568  |
| 3, 4 | BP(   | 2, 4)     | 0.147316  |
| 3, 4 | BP(   | 2, 5)     | frozen    |
| 3, 4 | BP(   | 1, 1)     | -0.150957 |
| 3, 4 | BP(   | 1, 2)     | 0.049411  |
| 3, 4 | BP(   | 1, 3)     | -0.034701 |
| 3, 4 | BP(   | 1, 4)     | -0.069113 |
| 3, 4 | BP(   | 1, 5)     | -0.076226 |
| 3, 4 | BP(   | 0, 1)     | 0.260365  |
| 3, 4 | BP(   | 0, 2)     | -0.026767 |
| 3, 4 | BP(   | 0, 3)     | frozen    |
| 3, 4 | BP(   | 0, 4)     | -0.134198 |
| 3, 4 | BP(   | 0, 5)     | frozen    |
| 3, 4 | BP(   | -1, 1)    | 0.007113  |
| 3, 4 | BP(   | -1, 2)    | -0.009573 |
| 3, 4 | BP(   | -1, 3)    | -0.002074 |
| 3, 4 | BP(   | -1, 4)    | frozen    |
| 3, 4 | BP(   | -1, 5)    | 0.000531  |
| 3, 4 | BP(   | -2, 1)    | 0.749432  |
| 3, 4 | BP(   | -2, 2)    | -0.025296 |
| 3, 4 | BP(   | -2, 3)    | 0.022403  |
| 3, 4 | BP(   | -2, 4)    | frozen    |
| 3, 4 | BP(   | -2, 5)    | frozen    |

- $A_1$  of d-valence
- eigenvectors 1 and 2 most important for  $W$  mass determination at Tevatron
- $A_1$  of sea quarks



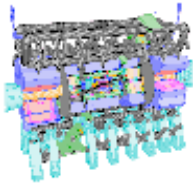
## Eigenvector 3 (pdf's 5 and 6)



| Sets | Shape | Parameter | Component |
|------|-------|-----------|-----------|
| 5, 6 | BP(   | 2, 1)     | 0.729081  |
| 5, 6 | BP(   | 2, 2)     | -0.115037 |
| 5, 6 | BP(   | 2, 3)     | 0.087851  |
| 5, 6 | BP(   | 2, 4)     | 0.245516  |
| 5, 6 | BP(   | 2, 5)     | frozen    |
| 5, 6 | BP(   | 1, 1)     | -0.052133 |
| 5, 6 | BP(   | 1, 2)     | -0.013602 |
| 5, 6 | BP(   | 1, 3)     | 0.011509  |
| 5, 6 | BP(   | 1, 4)     | 0.001209  |
| 5, 6 | BP(   | 1, 5)     | 0.016813  |
| 5, 6 | BP(   | 0, 1)     | -0.178356 |
| 5, 6 | BP(   | 0, 2)     | 0.010860  |
| 5, 6 | BP(   | 0, 3)     | frozen    |
| 5, 6 | BP(   | 0, 4)     | 0.086536  |
| 5, 6 | BP(   | 0, 5)     | frozen    |
| 5, 6 | BP(   | -1, 1)    | 0.010554  |
| 5, 6 | BP(   | -1, 2)    | -0.012484 |
| 5, 6 | BP(   | -1, 3)    | -0.003501 |
| 5, 6 | BP(   | -1, 4)    | frozen    |
| 5, 6 | BP(   | -1, 5)    | 0.001064  |
| 5, 6 | BP(   | -2, 1)    | -0.586497 |
| 5, 6 | BP(   | -2, 2)    | 0.010390  |
| 5, 6 | BP(   | -2, 3)    | -0.010337 |
| 5, 6 | BP(   | -2, 4)    | frozen    |
| 5, 6 | BP(   | -2, 5)    | frozen    |

●  $A_1$  of d-valence

●  $A_1$  of sea

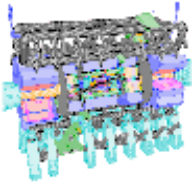


## Eigenvector 4 (pdf's 7 and 8)



| Sets | Shape | Parameter | Component |
|------|-------|-----------|-----------|
| 7, 8 | BP(   | 2, 1)     | -0.752967 |
| 7, 8 | BP(   | 2, 2)     | 0.060530  |
| 7, 8 | BP(   | 2, 3)     | -0.054401 |
| 7, 8 | BP(   | 2, 4)     | -0.182276 |
| 7, 8 | BP(   | 2, 5)     | frozen    |
| 7, 8 | BP(   | 1, 1)     | -0.340934 |
| 7, 8 | BP(   | 1, 2)     | 0.046241  |
| 7, 8 | BP(   | 1, 3)     | -0.063284 |
| 7, 8 | BP(   | 1, 4)     | -0.158932 |
| 7, 8 | BP(   | 1, 5)     | -0.166989 |
| 7, 8 | BP(   | 0, 1)     | -0.353673 |
| 7, 8 | BP(   | 0, 2)     | 0.078916  |
| 7, 8 | BP(   | 0, 3)     | frozen    |
| 7, 8 | BP(   | 0, 4)     | 0.241120  |
| 7, 8 | BP(   | 0, 5)     | frozen    |
| 7, 8 | BP(   | -1, 1)    | -0.055777 |
| 7, 8 | BP(   | -1, 2)    | 0.117030  |
| 7, 8 | BP(   | -1, 3)    | 0.007300  |
| 7, 8 | BP(   | -1, 4)    | frozen    |
| 7, 8 | BP(   | -1, 5)    | 0.014702  |
| 7, 8 | BP(   | -2, 1)    | 0.079294  |
| 7, 8 | BP(   | -2, 2)    | 0.053953  |
| 7, 8 | BP(   | -2, 3)    | -0.044072 |
| 7, 8 | BP(   | -2, 4)    | frozen    |
| 7, 8 | BP(   | -2, 5)    | frozen    |

- $A_1$  of d-valence



## Eigenvector 5 (pdf's 9 and 10)



| Sets  | Shape | Parameter | Component |
|-------|-------|-----------|-----------|
| 9, 10 | BP(   | 2, 1)     | -0.073740 |
| 9, 10 | BP(   | 2, 2)     | -0.001261 |
| 9, 10 | BP(   | 2, 3)     | -0.000242 |
| 9, 10 | BP(   | 2, 4)     | -0.006397 |
| 9, 10 | BP(   | 2, 5)     | frozen    |
| 9, 10 | BP(   | 1, 1)     | 0.081017  |
| 9, 10 | BP(   | 1, 2)     | 0.143655  |
| 9, 10 | BP(   | 1, 3)     | -0.090463 |
| 9, 10 | BP(   | 1, 4)     | -0.087878 |
| 9, 10 | BP(   | 1, 5)     | -0.152997 |
| 9, 10 | BP(   | 0, 1)     | 0.745961  |
| 9, 10 | BP(   | 0, 2)     | -0.085072 |
| 9, 10 | BP(   | 0, 3)     | frozen    |
| 9, 10 | BP(   | 0, 4)     | -0.445408 |
| 9, 10 | BP(   | 0, 5)     | frozen    |
| 9, 10 | BP(   | -1, 1)    | -0.099854 |
| 9, 10 | BP(   | -1, 2)    | 0.189535  |
| 9, 10 | BP(   | -1, 3)    | 0.017860  |
| 9, 10 | BP(   | -1, 4)    | frozen    |
| 9, 10 | BP(   | -1, 5)    | 0.021630  |
| 9, 10 | BP(   | -2, 1)    | -0.345311 |
| 9, 10 | BP(   | -2, 2)    | 0.001261  |
| 9, 10 | BP(   | -2, 3)    | -0.000159 |
| 9, 10 | BP(   | -2, 4)    | frozen    |
| 9, 10 | BP(   | -2, 5)    | frozen    |

$A_1$  for gluon

has impact on  $W$   
rapidity at LHC

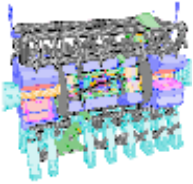


# Eigenvector 6 (pdf's 11 and 12)



| Sets   | Shape | Parameter | Component |
|--------|-------|-----------|-----------|
| 11, 12 | BP(   | 2, 1)     | 0.035925  |
| 11, 12 | BP(   | 2, 2)     | -0.012237 |
| 11, 12 | BP(   | 2, 3)     | 0.018609  |
| 11, 12 | BP(   | 2, 4)     | 0.067254  |
| 11, 12 | BP(   | 2, 5)     | frozen    |
| 11, 12 | BP(   | 1, 1)     | 0.308375  |
| 11, 12 | BP(   | 1, 2)     | 0.565735  |
| 11, 12 | BP(   | 1, 3)     | -0.288742 |
| 11, 12 | BP(   | 1, 4)     | -0.121771 |
| 11, 12 | BP(   | 1, 5)     | -0.376906 |
| 11, 12 | BP(   | 0, 1)     | -0.274883 |
| 11, 12 | BP(   | 0, 2)     | 0.018489  |
| 11, 12 | BP(   | 0, 3)     | frozen    |
| 11, 12 | BP(   | 0, 4)     | 0.133876  |
| 11, 12 | BP(   | 0, 5)     | frozen    |
| 11, 12 | BP(   | -1, 1)    | -0.228245 |
| 11, 12 | BP(   | -1, 2)    | 0.426085  |
| 11, 12 | BP(   | -1, 3)    | 0.042785  |
| 11, 12 | BP(   | -1, 4)    | frozen    |
| 11, 12 | BP(   | -1, 5)    | 0.048392  |
| 11, 12 | BP(   | -2, 1)    | 0.070613  |
| 11, 12 | BP(   | -2, 2)    | -0.031272 |
| 11, 12 | BP(   | -2, 3)    | 0.025976  |
| 11, 12 | BP(   | -2, 4)    | frozen    |
| 11, 12 | BP(   | -2, 5)    | frozen    |

- $A_2$  for u-valence

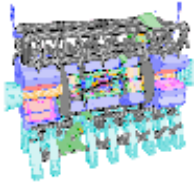


## Eigenvector 7 (pdf's 13 and 14)



| Sets   | Shape | Parameter | Component |
|--------|-------|-----------|-----------|
| 13, 14 | BP(   | 2, 1)     | -0.008774 |
| 13, 14 | BP(   | 2, 2)     | -0.091687 |
| 13, 14 | BP(   | 2, 3)     | 0.048585  |
| 13, 14 | BP(   | 2, 4)     | 0.073030  |
| 13, 14 | BP(   | 2, 5)     | frozen    |
| 13, 14 | BP(   | 1, 1)     | -0.160484 |
| 13, 14 | BP(   | 1, 2)     | -0.468723 |
| 13, 14 | BP(   | 1, 3)     | 0.191678  |
| 13, 14 | BP(   | 1, 4)     | -0.034792 |
| 13, 14 | BP(   | 1, 5)     | 0.161237  |
| 13, 14 | BP(   | 0, 1)     | -0.032960 |
| 13, 14 | BP(   | 0, 2)     | -0.009484 |
| 13, 14 | BP(   | 0, 3)     | frozen    |
| 13, 14 | BP(   | 0, 4)     | 0.024775  |
| 13, 14 | BP(   | 0, 5)     | frozen    |
| 13, 14 | BP(   | -1, 1)    | -0.387409 |
| 13, 14 | BP(   | -1, 2)    | 0.713283  |
| 13, 14 | BP(   | -1, 3)    | 0.074907  |
| 13, 14 | BP(   | -1, 4)    | frozen    |
| 13, 14 | BP(   | -1, 5)    | 0.076564  |
| 13, 14 | BP(   | -2, 1)    | 0.044443  |
| 13, 14 | BP(   | -2, 2)    | -0.016096 |
| 13, 14 | BP(   | -2, 3)    | 0.007877  |
| 13, 14 | BP(   | -2, 4)    | frozen    |
| 13, 14 | BP(   | -2, 5)    | frozen    |

- $A_2$  for sea quark ratio

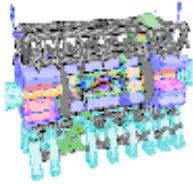


# Eigenvector 8 (pdf's 15 and 16)



| Sets   | Shape | Parameter | Component |
|--------|-------|-----------|-----------|
| 15, 16 | BP(   | 2, 1)     | 0.196388  |
| 15, 16 | BP(   | 2, 2)     | 0.387704  |
| 15, 16 | BP(   | 2, 3)     | -0.226202 |
| 15, 16 | BP(   | 2, 4)     | -0.411440 |
| 15, 16 | BP(   | 2, 5)     | frozen    |
| 15, 16 | BP(   | 1, 1)     | -0.193195 |
| 15, 16 | BP(   | 1, 2)     | 0.356604  |
| 15, 16 | BP(   | 1, 3)     | 0.018064  |
| 15, 16 | BP(   | 1, 4)     | 0.468888  |
| 15, 16 | BP(   | 1, 5)     | 0.376180  |
| 15, 16 | BP(   | 0, 1)     | 0.016734  |
| 15, 16 | BP(   | 0, 2)     | -0.026136 |
| 15, 16 | BP(   | 0, 3)     | frozen    |
| 15, 16 | BP(   | 0, 4)     | -0.016537 |
| 15, 16 | BP(   | 0, 5)     | frozen    |
| 15, 16 | BP(   | -1, 1)    | -0.176169 |
| 15, 16 | BP(   | -1, 2)    | 0.136337  |
| 15, 16 | BP(   | -1, 3)    | 0.074431  |
| 15, 16 | BP(   | -1, 4)    | frozen    |
| 15, 16 | BP(   | -1, 5)    | -0.030040 |
| 15, 16 | BP(   | -2, 1)    | -0.014533 |
| 15, 16 | BP(   | -2, 2)    | -0.067391 |
| 15, 16 | BP(   | -2, 3)    | 0.049273  |
| 15, 16 | BP(   | -2, 4)    | frozen    |
| 15, 16 | BP(   | -2, 5)    | frozen    |

● mixed

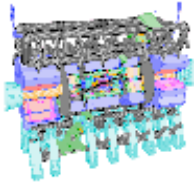


# Eigenvector 9 (pdf's 17 and 18)



| Sets   | Shape | Parameter | Component |
|--------|-------|-----------|-----------|
| 17, 18 | BP(   | 2, 1)     | -0.247023 |
| 17, 18 | BP(   | 2, 2)     | -0.430411 |
| 17, 18 | BP(   | 2, 3)     | 0.274839  |
| 17, 18 | BP(   | 2, 4)     | 0.479617  |
| 17, 18 | BP(   | 2, 5)     | frozen    |
| 17, 18 | BP(   | 1, 1)     | -0.175731 |
| 17, 18 | BP(   | 1, 2)     | 0.377177  |
| 17, 18 | BP(   | 1, 3)     | 0.039077  |
| 17, 18 | BP(   | 1, 4)     | 0.358692  |
| 17, 18 | BP(   | 1, 5)     | 0.343065  |
| 17, 18 | BP(   | 0, 1)     | 0.110430  |
| 17, 18 | BP(   | 0, 2)     | -0.011005 |
| 17, 18 | BP(   | 0, 3)     | frozen    |
| 17, 18 | BP(   | 0, 4)     | 0.105679  |
| 17, 18 | BP(   | 0, 5)     | frozen    |
| 17, 18 | BP(   | -1, 1)    | -0.015644 |
| 17, 18 | BP(   | -1, 2)    | 0.002111  |
| 17, 18 | BP(   | -1, 3)    | 0.008707  |
| 17, 18 | BP(   | -1, 4)    | frozen    |
| 17, 18 | BP(   | -1, 5)    | -0.010930 |
| 17, 18 | BP(   | -2, 1)    | 0.017115  |
| 17, 18 | BP(   | -2, 2)    | -0.049859 |
| 17, 18 | BP(   | -2, 3)    | 0.020649  |
| 17, 18 | BP(   | -2, 4)    | frozen    |
| 17, 18 | BP(   | -2, 5)    | frozen    |

● mixed

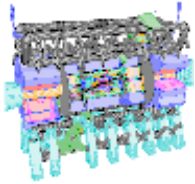


# Eigenvector 10 (pdf's 19 and 20)



| Sets   | Shape | Parameter | Component |
|--------|-------|-----------|-----------|
| 19, 20 | BP(   | 2, 1)     | 0.053930  |
| 19, 20 | BP(   | 2, 2)     | -0.037710 |
| 19, 20 | BP(   | 2, 3)     | 0.000702  |
| 19, 20 | BP(   | 2, 4)     | -0.107709 |
| 19, 20 | BP(   | 2, 5)     | frozen    |
| 19, 20 | BP(   | 1, 1)     | 0.015993  |
| 19, 20 | BP(   | 1, 2)     | 0.074127  |
| 19, 20 | BP(   | 1, 3)     | 0.033887  |
| 19, 20 | BP(   | 1, 4)     | -0.028340 |
| 19, 20 | BP(   | 1, 5)     | 0.046064  |
| 19, 20 | BP(   | 0, 1)     | 0.237369  |
| 19, 20 | BP(   | 0, 2)     | 0.356864  |
| 19, 20 | BP(   | 0, 3)     | frozen    |
| 19, 20 | BP(   | 0, 4)     | 0.335569  |
| 19, 20 | BP(   | 0, 5)     | frozen    |
| 19, 20 | BP(   | -1, 1)    | -0.033990 |
| 19, 20 | BP(   | -1, 2)    | 0.043029  |
| 19, 20 | BP(   | -1, 3)    | 0.001910  |
| 19, 20 | BP(   | -1, 4)    | frozen    |
| 19, 20 | BP(   | -1, 5)    | -0.024028 |
| 19, 20 | BP(   | -2, 1)    | 0.017777  |
| 19, 20 | BP(   | -2, 2)    | 0.640600  |
| 19, 20 | BP(   | -2, 3)    | -0.513488 |
| 19, 20 | BP(   | -2, 4)    | frozen    |
| 19, 20 | BP(   | -2, 5)    | frozen    |

- $A_2$  for sea quarks
- important for W rapidity at LHC

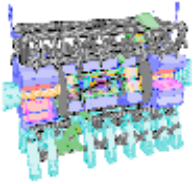


# Eigenvector 11 (pdf's 21 and 22)



| Sets   | Shape | Parameter | Component |
|--------|-------|-----------|-----------|
| 21, 22 | BP(   | 2, 1)     | -0.004555 |
| 21, 22 | BP(   | 2, 2)     | 0.290076  |
| 21, 22 | BP(   | 2, 3)     | -0.085217 |
| 21, 22 | BP(   | 2, 4)     | 0.173982  |
| 21, 22 | BP(   | 2, 5)     | frozen    |
| 21, 22 | BP(   | 1, 1)     | 0.015944  |
| 21, 22 | BP(   | 1, 2)     | -0.102621 |
| 21, 22 | BP(   | 1, 3)     | -0.075810 |
| 21, 22 | BP(   | 1, 4)     | 0.006882  |
| 21, 22 | BP(   | 1, 5)     | -0.085882 |
| 21, 22 | BP(   | 0, 1)     | 0.410492  |
| 21, 22 | BP(   | 0, 2)     | 0.151380  |
| 21, 22 | BP(   | 0, 3)     | frozen    |
| 21, 22 | BP(   | 0, 4)     | 0.691901  |
| 21, 22 | BP(   | 0, 5)     | frozen    |
| 21, 22 | BP(   | -1, 1)    | 0.073927  |
| 21, 22 | BP(   | -1, 2)    | 0.024390  |
| 21, 22 | BP(   | -1, 3)    | -0.035971 |
| 21, 22 | BP(   | -1, 4)    | frozen    |
| 21, 22 | BP(   | -1, 5)    | 0.092571  |
| 21, 22 | BP(   | -2, 1)    | -0.035202 |
| 21, 22 | BP(   | -2, 2)    | -0.329180 |
| 21, 22 | BP(   | -2, 3)    | 0.242236  |
| 21, 22 | BP(   | -2, 4)    | frozen    |
| 21, 22 | BP(   | -2, 5)    | frozen    |

- $A_4$  for gluon

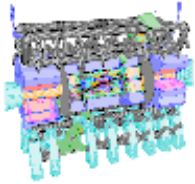


# Eigenvector 12 (pdf's 23 and 24)



| Sets   | Shape | Parameter | Component |
|--------|-------|-----------|-----------|
| 23, 24 | BP(   | 2, 1)     | 0.020042  |
| 23, 24 | BP(   | 2, 2)     | -0.289155 |
| 23, 24 | BP(   | 2, 3)     | 0.054320  |
| 23, 24 | BP(   | 2, 4)     | -0.189645 |
| 23, 24 | BP(   | 2, 5)     | frozen    |
| 23, 24 | BP(   | 1, 1)     | -0.032520 |
| 23, 24 | BP(   | 1, 2)     | -0.281766 |
| 23, 24 | BP(   | 1, 3)     | -0.367472 |
| 23, 24 | BP(   | 1, 4)     | 0.464075  |
| 23, 24 | BP(   | 1, 5)     | -0.362261 |
| 23, 24 | BP(   | 0, 1)     | 0.057345  |
| 23, 24 | BP(   | 0, 2)     | -0.054044 |
| 23, 24 | BP(   | 0, 3)     | frozen    |
| 23, 24 | BP(   | 0, 4)     | 0.110389  |
| 23, 24 | BP(   | 0, 5)     | frozen    |
| 23, 24 | BP(   | -1, 1)    | -0.351640 |
| 23, 24 | BP(   | -1, 2)    | -0.192536 |
| 23, 24 | BP(   | -1, 3)    | 0.207373  |
| 23, 24 | BP(   | -1, 4)    | frozen    |
| 23, 24 | BP(   | -1, 5)    | -0.304075 |
| 23, 24 | BP(   | -2, 1)    | -0.003839 |
| 23, 24 | BP(   | -2, 2)    | -0.002087 |
| 23, 24 | BP(   | -2, 3)    | 0.019694  |
| 23, 24 | BP(   | -2, 4)    | frozen    |
| 23, 24 | BP(   | -2, 5)    | frozen    |

● mixed

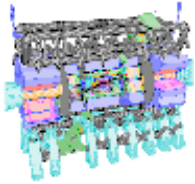


# Eigenvector 13 (pdf's 25 and 26)



● mixed

| Sets   | Shape | Parameter | Component |
|--------|-------|-----------|-----------|
| 25, 26 | BP(   | 2, 1)     | -0.039687 |
| 25, 26 | BP(   | 2, 2)     | 0.244584  |
| 25, 26 | BP(   | 2, 3)     | -0.035526 |
| 25, 26 | BP(   | 2, 4)     | 0.260779  |
| 25, 26 | BP(   | 2, 5)     | frozen    |
| 25, 26 | BP(   | 1, 1)     | -0.073083 |
| 25, 26 | BP(   | 1, 2)     | -0.176777 |
| 25, 26 | BP(   | 1, 3)     | -0.266594 |
| 25, 26 | BP(   | 1, 4)     | 0.485490  |
| 25, 26 | BP(   | 1, 5)     | -0.221735 |
| 25, 26 | BP(   | 0, 1)     | -0.096576 |
| 25, 26 | BP(   | 0, 2)     | 0.145961  |
| 25, 26 | BP(   | 0, 3)     | frozen    |
| 25, 26 | BP(   | 0, 4)     | -0.217276 |
| 25, 26 | BP(   | 0, 5)     | frozen    |
| 25, 26 | BP(   | -1, 1)    | 0.426024  |
| 25, 26 | BP(   | -1, 2)    | 0.284823  |
| 25, 26 | BP(   | -1, 3)    | -0.320546 |
| 25, 26 | BP(   | -1, 4)    | frozen    |
| 25, 26 | BP(   | -1, 5)    | 0.073870  |
| 25, 26 | BP(   | -2, 1)    | 0.012726  |
| 25, 26 | BP(   | -2, 2)    | 0.148066  |
| 25, 26 | BP(   | -2, 3)    | -0.077794 |
| 25, 26 | BP(   | -2, 4)    | frozen    |
| 25, 26 | BP(   | -2, 5)    | frozen    |

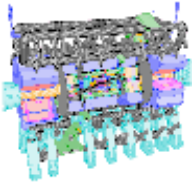


# Eigenvector 14 (pdf's 27 and 28)



| Sets   | Shape | Parameter | Component |
|--------|-------|-----------|-----------|
| 27, 28 | BP(   | 2, 1)     | -0.088817 |
| 27, 28 | BP(   | 2, 2)     | 0.516152  |
| 27, 28 | BP(   | 2, 3)     | -0.070427 |
| 27, 28 | BP(   | 2, 4)     | 0.554356  |
| 27, 28 | BP(   | 2, 5)     | frozen    |
| 27, 28 | BP(   | 1, 1)     | -0.000298 |
| 27, 28 | BP(   | 1, 2)     | -0.040381 |
| 27, 28 | BP(   | 1, 3)     | -0.038742 |
| 27, 28 | BP(   | 1, 4)     | -0.039134 |
| 27, 28 | BP(   | 1, 5)     | 0.029399  |
| 27, 28 | BP(   | 0, 1)     | -0.081313 |
| 27, 28 | BP(   | 0, 2)     | 0.101099  |
| 27, 28 | BP(   | 0, 3)     | frozen    |
| 27, 28 | BP(   | 0, 4)     | -0.172979 |
| 27, 28 | BP(   | 0, 5)     | frozen    |
| 27, 28 | BP(   | -1, 1)    | -0.421130 |
| 27, 28 | BP(   | -1, 2)    | -0.250702 |
| 27, 28 | BP(   | -1, 3)    | 0.289171  |
| 27, 28 | BP(   | -1, 4)    | frozen    |
| 27, 28 | BP(   | -1, 5)    | -0.125863 |
| 27, 28 | BP(   | -2, 1)    | 0.010632  |
| 27, 28 | BP(   | -2, 2)    | 0.108209  |
| 27, 28 | BP(   | -2, 3)    | -0.098291 |
| 27, 28 | BP(   | -2, 4)    | frozen    |
| 27, 28 | BP(   | -2, 5)    | frozen    |

● mixed



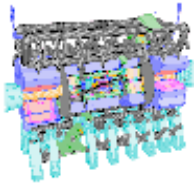
## Eigenvector 15 (pdf's 29 and 30)



```
29, 30    BP(  2,  1)    0.012701
29, 30    BP(  2,  2)   -0.162018
29, 30    BP(  2,  3)    0.018666
29, 30    BP(  2,  4)   -0.111238
29, 30    BP(  2,  5)    frozen
29, 30    BP(  1,  1)   -0.003049
29, 30    BP(  1,  2)   -0.001074
29, 30    BP(  1,  3)   -0.034151
29, 30    BP(  1,  4)   -0.005735
29, 30    BP(  1,  5)    0.032812
29, 30    BP(  0,  1)   -0.045923
29, 30    BP(  0,  2)   0.873418
29, 30    BP(  0,  3)    frozen
29, 30    BP(  0,  4)   -0.241822
29, 30    BP(  0,  5)    frozen
29, 30    BP( -1,  1)   -0.071419
29, 30    BP( -1,  2)   -0.067488
29, 30    BP( -1,  3)    0.100283
29, 30    BP( -1,  4)    frozen
29, 30    BP( -1,  5)    0.179551
29, 30    BP( -2,  1)   -0.009441
29, 30    BP( -2,  2)   -0.196100
29, 30    BP( -2,  3)    0.211281
29, 30    BP( -2,  4)    frozen
29, 30    BP( -2,  5)    frozen
```

- $A_2$  for gluon

- affects high  $p_T$  jet production at Tevatron and LHC

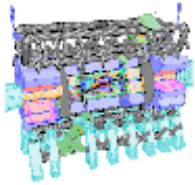


# Eigenvector 16 (pdf's 31 and 32)



| Sets   | Shape | Parameter | Component |
|--------|-------|-----------|-----------|
| 31, 32 | BP(   | 2, 1)     | 0.001680  |
| 31, 32 | BP(   | 2, 2)     | -0.054733 |
| 31, 32 | BP(   | 2, 3)     | -0.057728 |
| 31, 32 | BP(   | 2, 4)     | -0.011556 |
| 31, 32 | BP(   | 2, 5)     | frozen    |
| 31, 32 | BP(   | 1, 1)     | -0.017824 |
| 31, 32 | BP(   | 1, 2)     | -0.064727 |
| 31, 32 | BP(   | 1, 3)     | -0.185219 |
| 31, 32 | BP(   | 1, 4)     | 0.107376  |
| 31, 32 | BP(   | 1, 5)     | -0.005273 |
| 31, 32 | BP(   | 0, 1)     | -0.008472 |
| 31, 32 | BP(   | 0, 2)     | -0.200453 |
| 31, 32 | BP(   | 0, 3)     | frozen    |
| 31, 32 | BP(   | 0, 4)     | 0.018027  |
| 31, 32 | BP(   | 0, 5)     | frozen    |
| 31, 32 | BP(   | -1, 1)    | -0.074489 |
| 31, 32 | BP(   | -1, 2)    | -0.155384 |
| 31, 32 | BP(   | -1, 3)    | 0.246839  |
| 31, 32 | BP(   | -1, 4)    | frozen    |
| 31, 32 | BP(   | -1, 5)    | 0.892123  |
| 31, 32 | BP(   | -2, 1)    | 0.005440  |
| 31, 32 | BP(   | -2, 2)    | 0.093455  |
| 31, 32 | BP(   | -2, 3)    | -0.085541 |
| 31, 32 | BP(   | -2, 4)    | frozen    |
| 31, 32 | BP(   | -2, 5)    | frozen    |

- $A_5$  for sea quark ratio

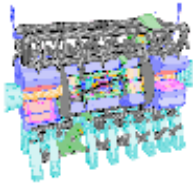


# Eigenvector 17 (pdf's 33 and 34)



| Sets   | Shape | Parameter | Component |
|--------|-------|-----------|-----------|
| 33, 34 | BP(   | 2, 1)     | -0.002675 |
| 33, 34 | BP(   | 2, 2)     | 0.020434  |
| 33, 34 | BP(   | 2, 3)     | -0.016349 |
| 33, 34 | BP(   | 2, 4)     | 0.025711  |
| 33, 34 | BP(   | 2, 5)     | frozen    |
| 33, 34 | BP(   | 1, 1)     | -0.007879 |
| 33, 34 | BP(   | 1, 2)     | 0.114798  |
| 33, 34 | BP(   | 1, 3)     | 0.777760  |
| 33, 34 | BP(   | 1, 4)     | 0.291044  |
| 33, 34 | BP(   | 1, 5)     | -0.523095 |
| 33, 34 | BP(   | 0, 1)     | 0.004246  |
| 33, 34 | BP(   | 0, 2)     | 0.020090  |
| 33, 34 | BP(   | 0, 3)     | frozen    |
| 33, 34 | BP(   | 0, 4)     | 0.003058  |
| 33, 34 | BP(   | 0, 5)     | frozen    |
| 33, 34 | BP(   | -1, 1)    | -0.057605 |
| 33, 34 | BP(   | -1, 2)    | -0.049340 |
| 33, 34 | BP(   | -1, 3)    | 0.044648  |
| 33, 34 | BP(   | -1, 4)    | frozen    |
| 33, 34 | BP(   | -1, 5)    | 0.112027  |
| 33, 34 | BP(   | -2, 1)    | -0.000679 |
| 33, 34 | BP(   | -2, 2)    | 0.018496  |
| 33, 34 | BP(   | -2, 3)    | 0.033020  |
| 33, 34 | BP(   | -2, 4)    | frozen    |
| 33, 34 | BP(   | -2, 5)    | frozen    |

- $A_3$  for u-valence

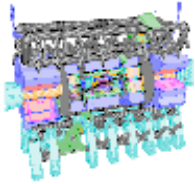


# Eigenvector 18 (pdf's 35 and 36)



| Sets   | Shape | Parameter | Component |
|--------|-------|-----------|-----------|
| 35, 36 | BP(   | 2, 1)     | 0.010231  |
| 35, 36 | BP(   | 2, 2)     | 0.274023  |
| 35, 36 | BP(   | 2, 3)     | 0.752924  |
| 35, 36 | BP(   | 2, 4)     | -0.171721 |
| 35, 36 | BP(   | 2, 5)     | frozen    |
| 35, 36 | BP(   | 1, 1)     | 0.001088  |
| 35, 36 | BP(   | 1, 2)     | -0.016372 |
| 35, 36 | BP(   | 1, 3)     | 0.000705  |
| 35, 36 | BP(   | 1, 4)     | 0.022654  |
| 35, 36 | BP(   | 1, 5)     | -0.035628 |
| 35, 36 | BP(   | 0, 1)     | -0.004803 |
| 35, 36 | BP(   | 0, 2)     | 0.021800  |
| 35, 36 | BP(   | 0, 3)     | frozen    |
| 35, 36 | BP(   | 0, 4)     | -0.012599 |
| 35, 36 | BP(   | 0, 5)     | frozen    |
| 35, 36 | BP(   | -1, 1)    | -0.019055 |
| 35, 36 | BP(   | -1, 2)    | -0.017865 |
| 35, 36 | BP(   | -1, 3)    | -0.016128 |
| 35, 36 | BP(   | -1, 4)    | frozen    |
| 35, 36 | BP(   | -1, 5)    | 0.060069  |
| 35, 36 | BP(   | -2, 1)    | 0.000694  |
| 35, 36 | BP(   | -2, 2)    | -0.360704 |
| 35, 36 | BP(   | -2, 3)    | -0.437100 |
| 35, 36 | BP(   | -2, 4)    | frozen    |
| 35, 36 | BP(   | -2, 5)    | frozen    |

●  $A_3$  for d-valence

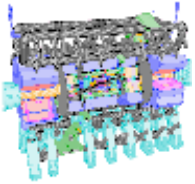


# Eigenvector 19 (pdf's 37 and 38)



| Sets   | Shape | Parameter | Component |
|--------|-------|-----------|-----------|
| 37, 38 | BP(   | 2, 1)     | 0.003214  |
| 37, 38 | BP(   | 2, 2)     | 0.184834  |
| 37, 38 | BP(   | 2, 3)     | 0.493131  |
| 37, 38 | BP(   | 2, 4)     | -0.099835 |
| 37, 38 | BP(   | 2, 5)     | frozen    |
| 37, 38 | BP(   | 1, 1)     | -0.000316 |
| 37, 38 | BP(   | 1, 2)     | -0.002101 |
| 37, 38 | BP(   | 1, 3)     | -0.021101 |
| 37, 38 | BP(   | 1, 4)     | -0.015015 |
| 37, 38 | BP(   | 1, 5)     | 0.023139  |
| 37, 38 | BP(   | 0, 1)     | 0.009251  |
| 37, 38 | BP(   | 0, 2)     | -0.031799 |
| 37, 38 | BP(   | 0, 3)     | frozen    |
| 37, 38 | BP(   | 0, 4)     | 0.023966  |
| 37, 38 | BP(   | 0, 5)     | frozen    |
| 37, 38 | BP(   | -1, 1)    | -0.153766 |
| 37, 38 | BP(   | -1, 2)    | -0.066501 |
| 37, 38 | BP(   | -1, 3)    | -0.218296 |
| 37, 38 | BP(   | -1, 4)    | frozen    |
| 37, 38 | BP(   | -1, 5)    | 0.075845  |
| 37, 38 | BP(   | -2, 1)    | -0.001733 |
| 37, 38 | BP(   | -2, 2)    | 0.492060  |
| 37, 38 | BP(   | -2, 3)    | 0.621451  |
| 37, 38 | BP(   | -2, 4)    | frozen    |
| 37, 38 | BP(   | -2, 5)    | frozen    |

●  $A_3$  for sea

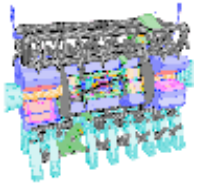


# Eigenvector 20 (pdf's 39 and 40)



| Sets   | Shape | Parameter | Component |
|--------|-------|-----------|-----------|
| 39, 40 | BP(   | 2, 1)     | 0.000248  |
| 39, 40 | BP(   | 2, 2)     | 0.069038  |
| 39, 40 | BP(   | 2, 3)     | 0.173137  |
| 39, 40 | BP(   | 2, 4)     | -0.029044 |
| 39, 40 | BP(   | 2, 5)     | frozen    |
| 39, 40 | BP(   | 1, 1)     | 0.000920  |
| 39, 40 | BP(   | 1, 2)     | -0.001493 |
| 39, 40 | BP(   | 1, 3)     | 0.008380  |
| 39, 40 | BP(   | 1, 4)     | 0.000153  |
| 39, 40 | BP(   | 1, 5)     | -0.008078 |
| 39, 40 | BP(   | 0, 1)     | 0.003339  |
| 39, 40 | BP(   | 0, 2)     | -0.010965 |
| 39, 40 | BP(   | 0, 3)     | frozen    |
| 39, 40 | BP(   | 0, 4)     | 0.008411  |
| 39, 40 | BP(   | 0, 5)     | frozen    |
| 39, 40 | BP(   | -1, 1)    | 0.479314  |
| 39, 40 | BP(   | -1, 2)    | 0.190673  |
| 39, 40 | BP(   | -1, 3)    | 0.796917  |
| 39, 40 | BP(   | -1, 4)    | frozen    |
| 39, 40 | BP(   | -1, 5)    | -0.131794 |
| 39, 40 | BP(   | -2, 1)    | -0.000408 |
| 39, 40 | BP(   | -2, 2)    | 0.136504  |
| 39, 40 | BP(   | -2, 3)    | 0.163995  |
| 39, 40 | BP(   | -2, 4)    | frozen    |
| 39, 40 | BP(   | -2, 5)    | frozen    |

- $A_3$  for sea quark ratio



## Other stuff



- I'm almost finished with a review article related with LHC physics
  - ◆ I'd appreciate feedback
- North American ATLAS SM and Higgs workshop at Argonne April 26-28
- Mini-workshop on jet algorithms for LHC in July at CERN, right before the LHC Monte Carlo workshop