χ^2 Evaluation of m(t) Using ePump

Sara Sawford
Jarrett Fein
Jason Gombas
Reinhard Schwienhorst

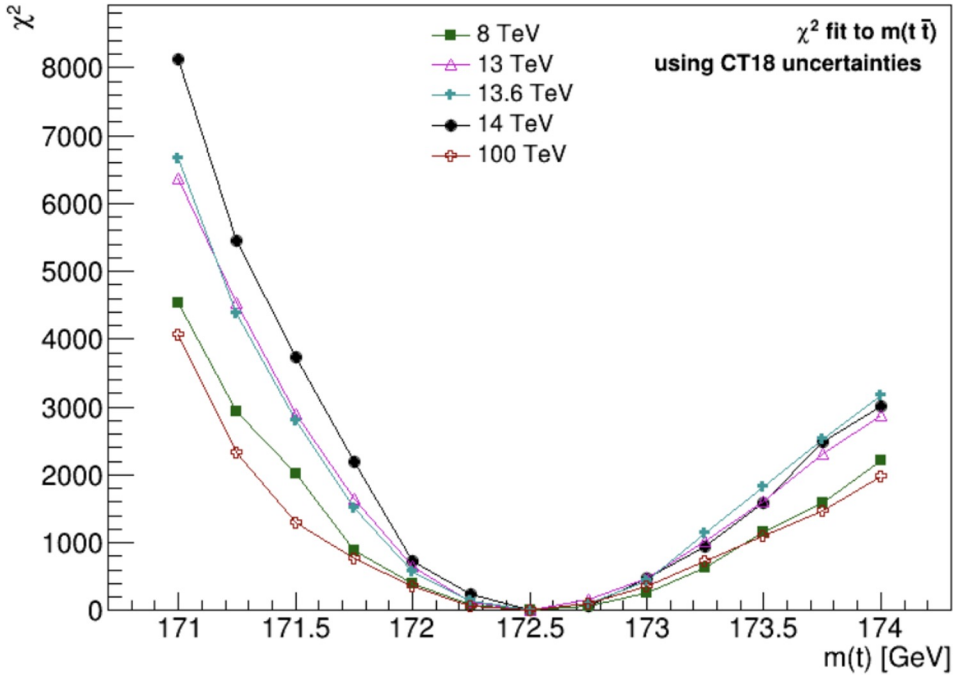
Contribution to “Dependence of the top-quark mass measured in top-quark pair production on the parton distribution functions at the LHC and future colliders”

Michigan State University - MSU

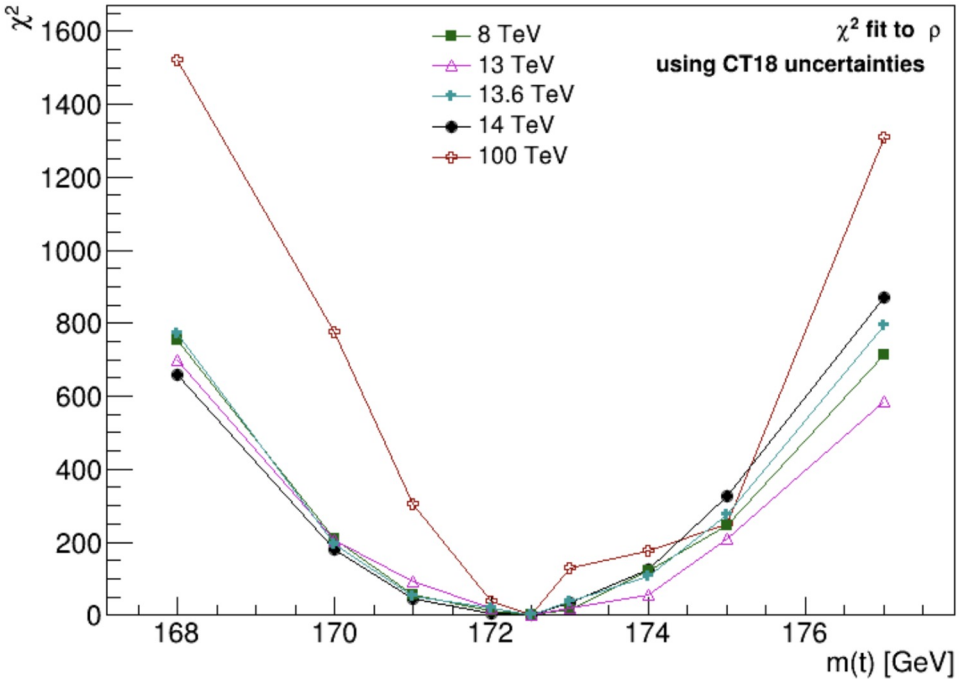
Overview

- Fit m(t) to m($t\bar{t}$) or ρ for $t\bar{t}j$
- Only used PDF uncertainty in a reduction through fit to longitudinal momentum p_z or rapidity η
  - Challenging to study high η in current detector
- Process
  - Data and Theory Files
  - ePump
  - Reducing PDF Uncertainties
  - Chi-Square Evaluation of m(t)

Chi-Square Before Updates With m($t\bar{t}$)



Chi-Square Before Updates With ρ



Data and Theory Files

- .data
  - Pseudodata for m=172.5 GeV
  - Uses fixed systematic uncertainties per bin of 1%, 5%, 10%, 15%, 20%
  - Assume negligible statistical uncertainty
- .theory
  - Calculated for each of 59 bins included in CT18NLO
  - Do not include scale uncertainties

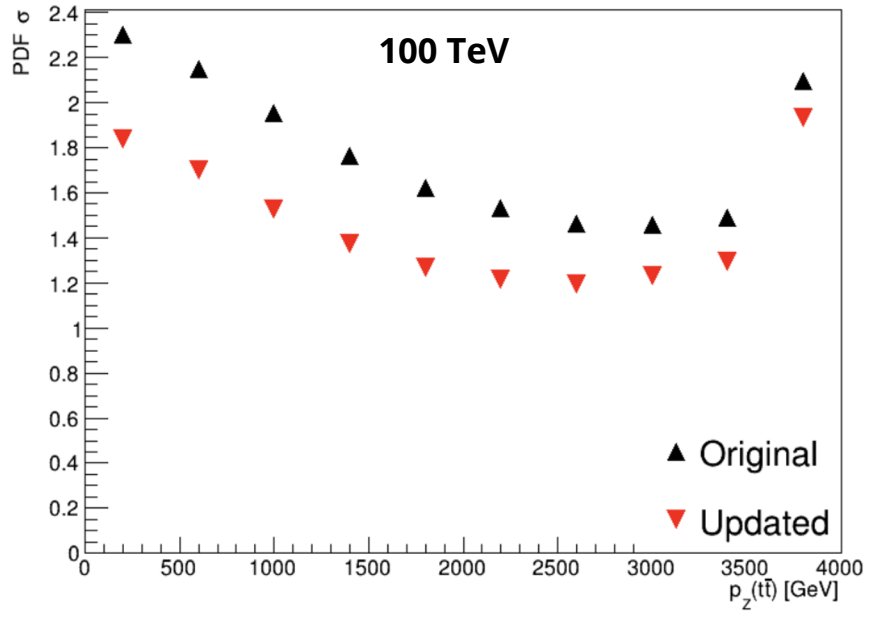
pt	StatErr	uncorSys	e.01	
1.91117e+08	0	1.91117e+06	0	
1.18404e+08	0	1.18404e+06	0	

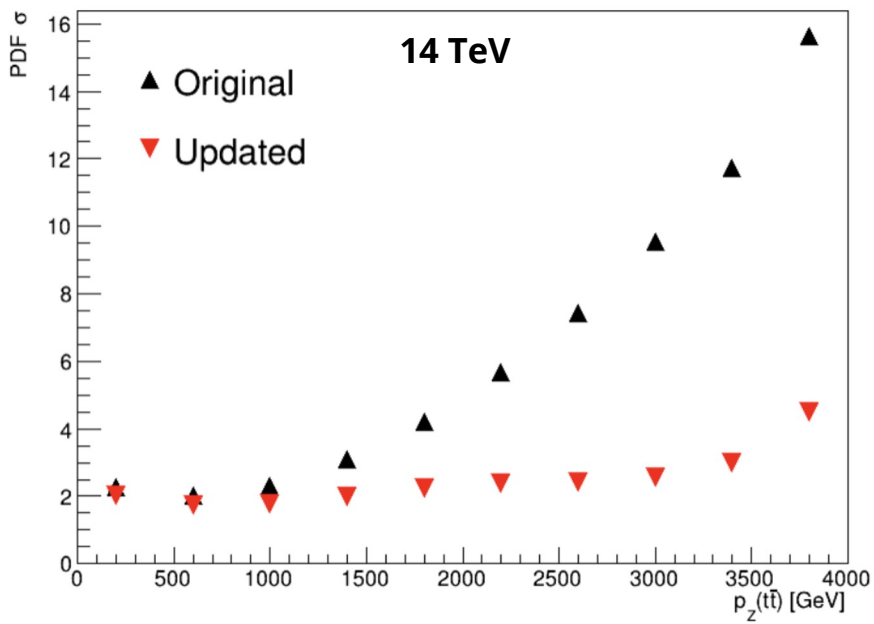
First two entries of .data file for p_z
m = 172.5 GeV, E = 14 TeV

Reduction of PDF Uncertainties

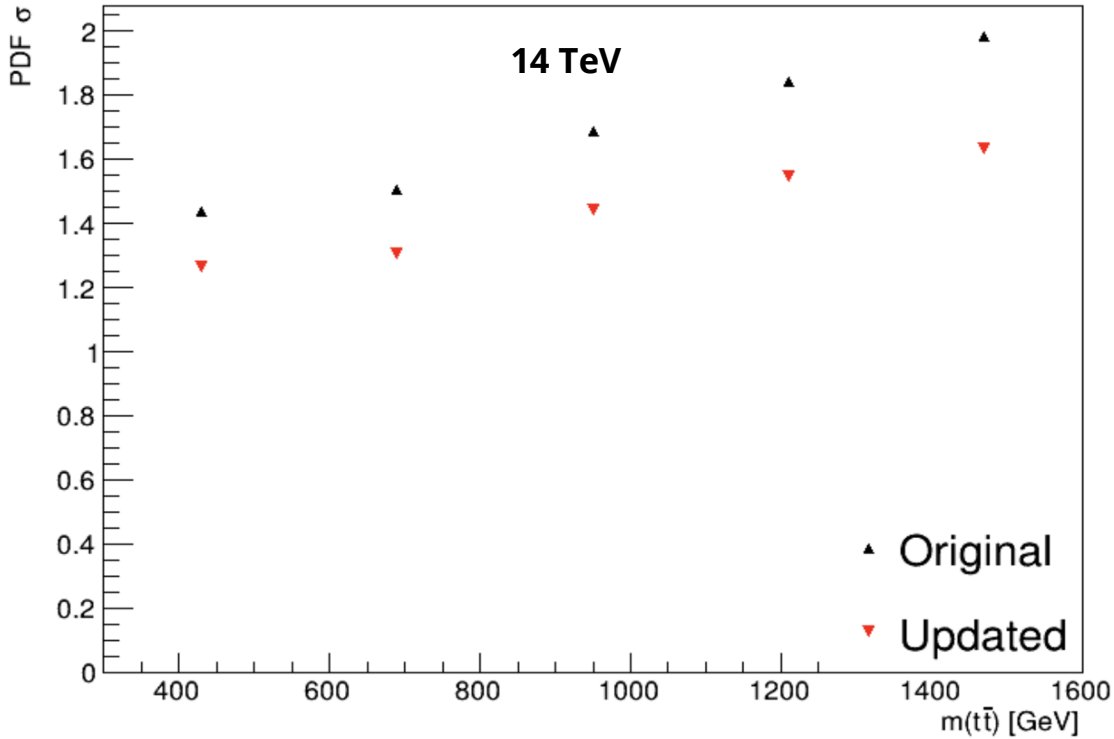
- Reduction of CT18NLO eigenvectors
- Only expect reduction in uncertainty
- Largest reduction at high values of p_z

Reduction of PDF Uncertainties for p_z Using $t\bar{t}$

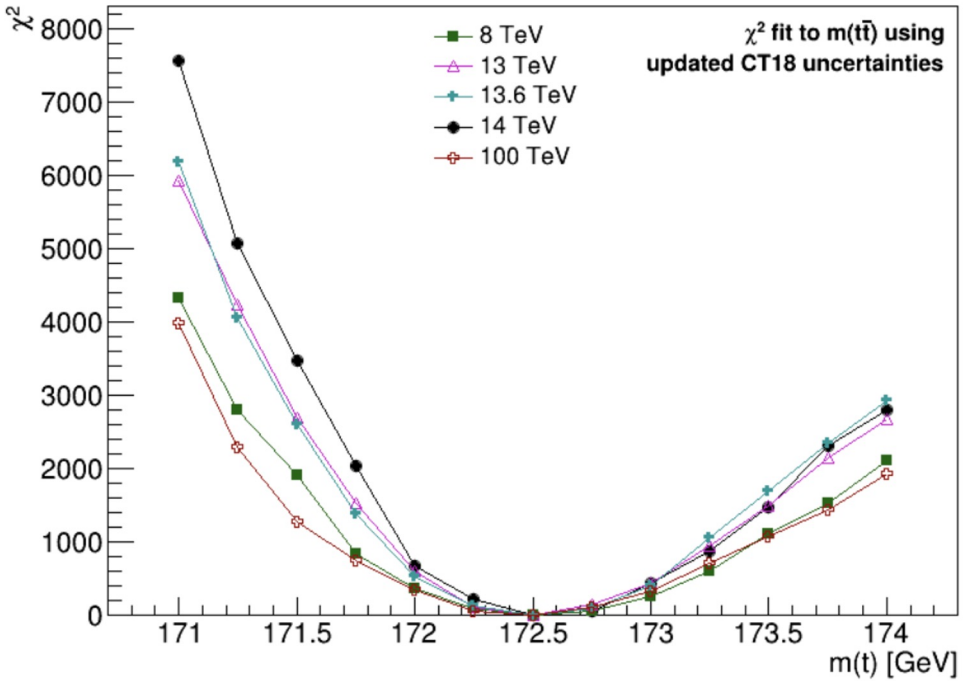




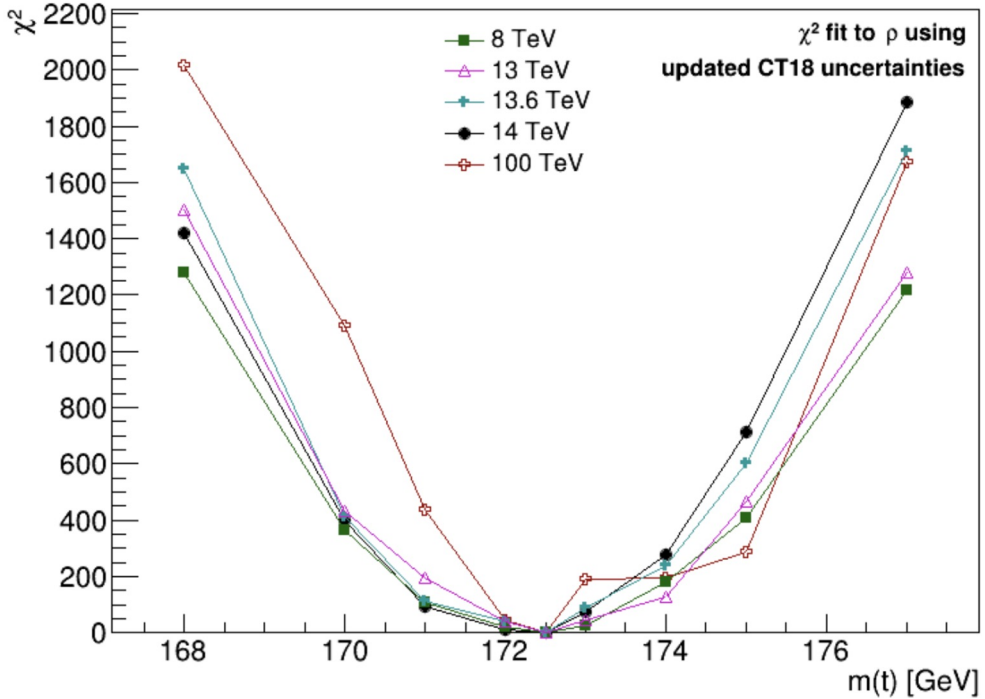
Reduction of PDF Uncertainties for m($t\bar{t}$)



Chi2-Square Evaluation Using m($t\bar{t}$)



Chi2-Square Evaluation Using ρ



Conclusions

- See reduction of m(t) by a factor of two with 1% uncertainty
- No constraint with 20% uncertainty
- Crossing PDF fits does not result in a better fit on m(t)
  - i.e. Applying constraint from p_z ($t\bar{t}$) to ρ($t\bar{t}j$) does not improve m(t) uncertainty compared to using p_z ($t\bar{t}$j)
- Future studies
  - Use highest bin in ρ

Cross Section Tables

Cross Section for $t\bar{t}, m = 172.5GeV$

Energy (TeV)	Cross Section (pb)
8	201.3
13	657.3
13.6	728.1
14	780.7
100	29000.0

Cross Section for $t\bar{t}j, m = 172.5GeV$

Energy (TeV)	Cross Section (pb)	Uncertainty
8	110	± 1.9
13	370	± 7.9
13.6	410	± 9.0
14	440	± 9.3
100	16000	± 620

tt Chi2-Widths

$\eta(t)$

Energy (TeV)	Before Updating Chi2	Updated Chi2				
		1%	5%	10%	15%	20%
8.0	0.027	0.021	0.026	0.026	0.026	0.027
13.0	0.023	0.019	0.023	0.023	0.023	0.023
13.6	0.023	0.019	0.022	0.022	0.022	0.022
14.0	0.021	0.018	0.021	0.021	0.021	0.021
100.0	0.030	0.024	0.028	0.028	0.028	0.028

$p_z(t\bar{t})$

Energy (TeV)	Before Updating Chi2	Updated Chi2				
		1%	5%	10%	15%	20%
8.0	0.027	0.022	0.026	0.026	0.026	0.027
13.0	0.023	0.020	0.023	0.023	0.023	0.023
13.6	0.023	0.019	0.022	0.022	0.022	0.022
14.0	0.021	0.018	0.021	0.021	0.021	0.021
100.0	0.030	0.023	0.028	0.028	0.028	0.028

$p_z(t\bar{t}) for\ \eta(t) < 2.5, \eta(\bar{t}) < 2.5$

Energy (TeV)	Before Updating Chi2	Updated Chi2				
		1%	5%	10%	15%	20%
8.0	0.027	0.022	0.026	0.026	0.026	0.027
13.0	0.023	0.020	0.023	0.023	0.023	0.023
13.6	0.023	0.020	0.022	0.022	0.022	0.022
14.0	0.021	0.018	0.021	0.021	0.021	0.021
100.0	0.030	0.024	0.028	0.028	0.028	0.028

ttj Chi2-Widths (All Bins)

$\eta(t)$

Energy (TeV)	Before Updating Chi2	Updated Chi2				
		1%	5%	10%	15%	20%
8.0	0.167	0.126	0.156	0.158	0.159	0.159
13.0	0.179	0.125	0.160	0.165	0.166	0.166
13.6	0.162	0.114	0.146	0.150	0.150	0.151
14.0	0.163	0.116	0.147	0.151	0.152	0.152
100.0	0.122	0.109	0.118	0.118	0.118	0.118

$p_z(t\bar{t}j)$

Energy (TeV)	Before Updating Chi2	Updated Chi2				
		1%	5%	10%	15%	20%
8.0	0.167	0.128	0.153	0.157	0.159	0.159
13.0	0.179	0.121	0.154	0.162	0.165	0.166
13.6	0.162	0.110	0.140	0.148	0.149	0.150
14.0	0.163	0.111	0.141	0.149	0.151	0.151
100.0	0.122	0.107	0.118	0.118	0.118	0.118

$p_z(t\bar{t}j) for\ \eta(t) < 2.5, \eta(\bar{t}) < 2.5$

Energy (TeV)	Before Updating Chi2	Updated Chi2				
		1%	5%	10%	15%	20%
8.0	0.167	0.129	0.155	0.158	-	-
13.0	0.179	0.126	0.161	0.165	-	-
13.6	0.162	0.115	0.146	0.150	-	-
14.0	0.163	0.116	0.147	0.151	-	-
100.0	0.122	0.108	0.118	0.118	-	-

ttj PDFs on tt Chi2-Widths (All Bins)

$\eta(t)$

Energy (TeV)	Before Updating Chi2	Updated Chi2				
		1%	5%	10%	15%	20%
8.0	0.027	0.020	0.026	0.026	0.026	0.027
13.0	0.023	0.019	0.023	0.023	0.023	0.023
13.6	0.023	0.019	0.022	0.022	0.022	0.022
14.0	0.021	0.018	0.021	0.021	0.021	0.021
100.0	0.030	0.024	0.028	0.028	0.028	0.028

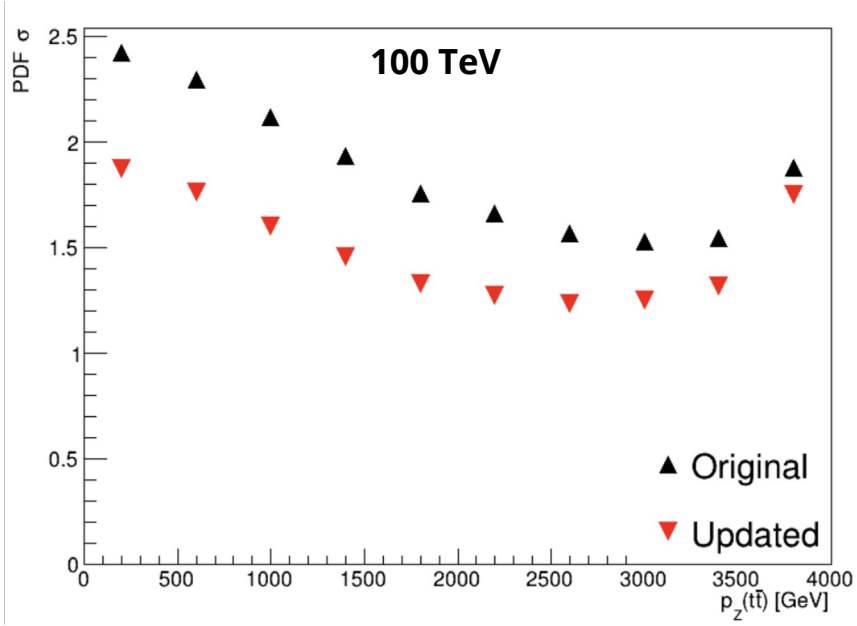
$p_z(t\bar{t}j)$

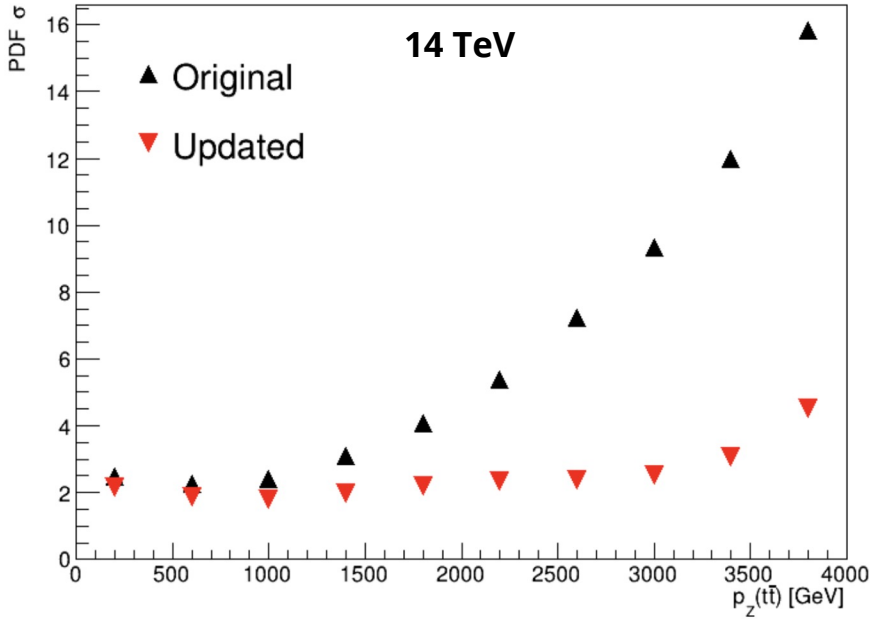
Energy (TeV)	Before Updating Chi2	Updated Chi2				
		1%	5%	10%	15%	20%
8.0	0.027	0.021	0.026	0.026	0.026	0.026
13.0	0.023	0.020	0.023	0.023	0.023	0.023
13.6	0.023	0.019	0.022	0.022	0.022	0.022
14.0	0.021	0.018	0.021	0.021	0.021	0.021
100.0	0.030	0.023	0.028	0.028	0.028	0.028

$p_z(t\bar{t}j) for\ \eta(t) < 2.5, \eta(\bar{t}) < 2.5$

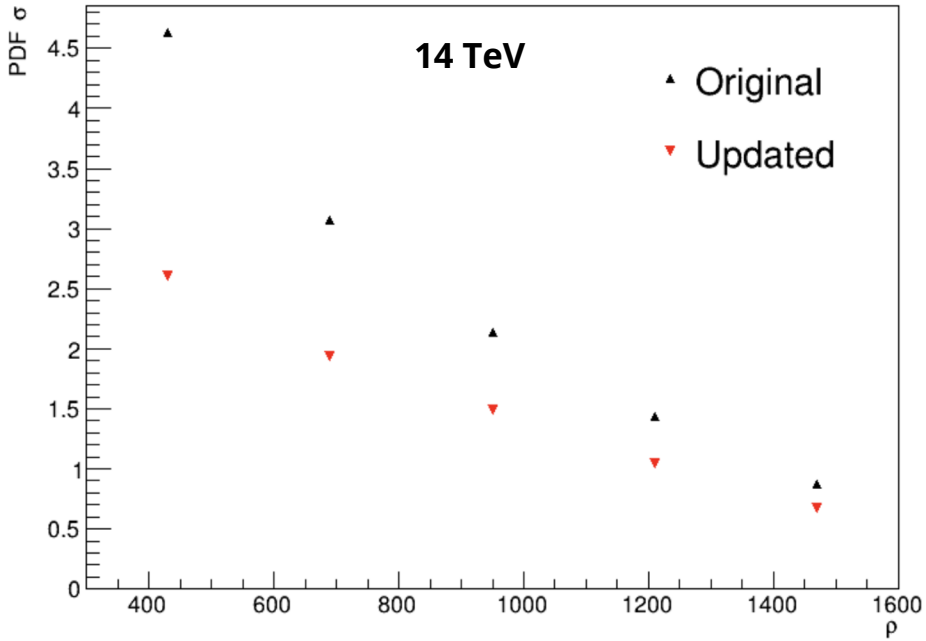
Energy (TeV)	Before Updating Chi2	Updated Chi2				
		1%	5%	10%	15%	20%
8.0	0.027	0.021	0.026	0.026	0.026	0.027
13.0	0.023	0.021	0.026	0.027	0.027	0.027
13.6	0.023	0.021	0.027	0.027	0.027	0.027
14.0	0.021	0.020	0.025	0.025	0.025	0.025
100.0	0.030	0.026	0.027	0.027	0.027	0.027

Reduction of PDF Uncertainties for p_z Using ttj

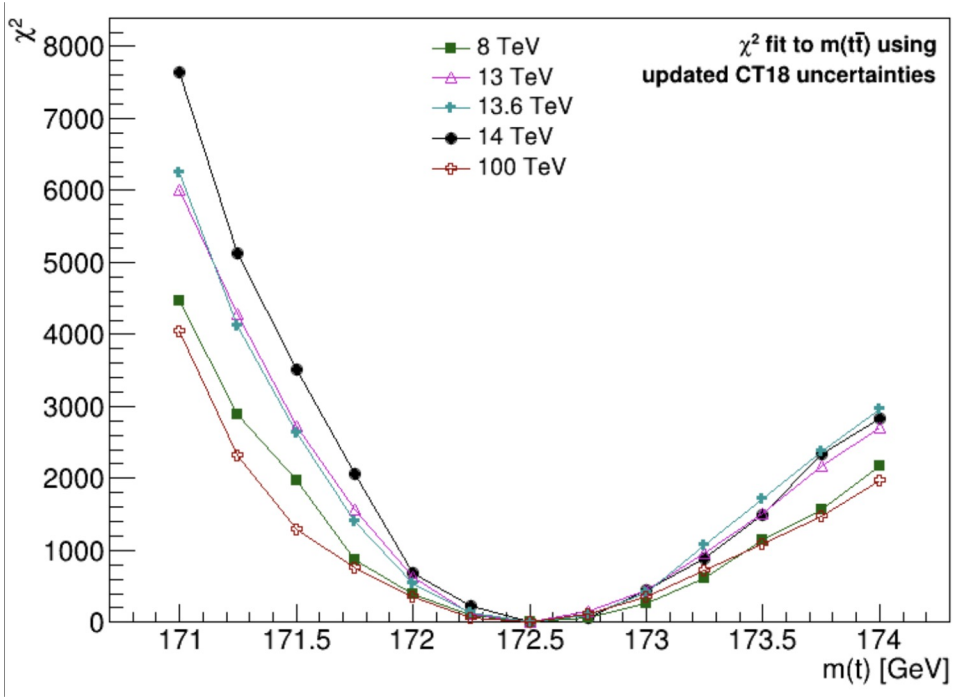




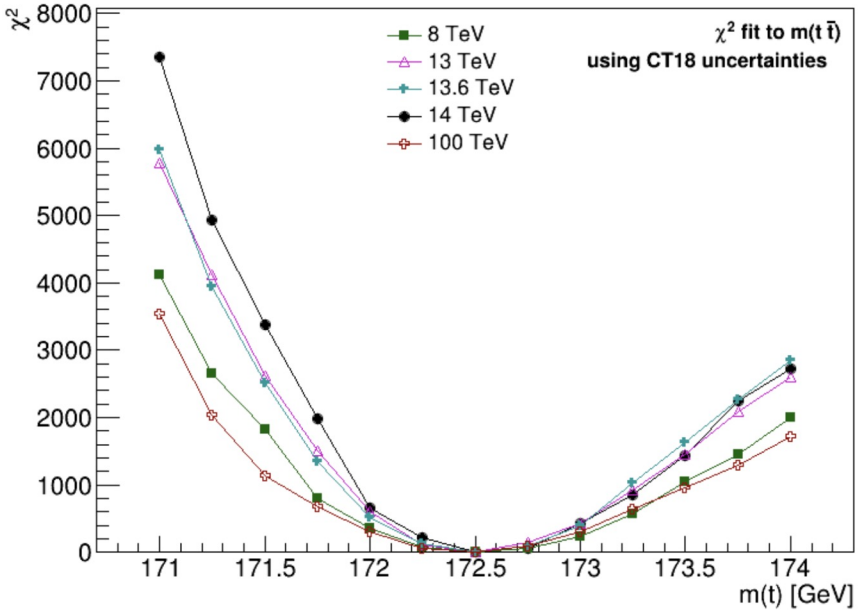
Reduction of PDF Uncertainties for ρ

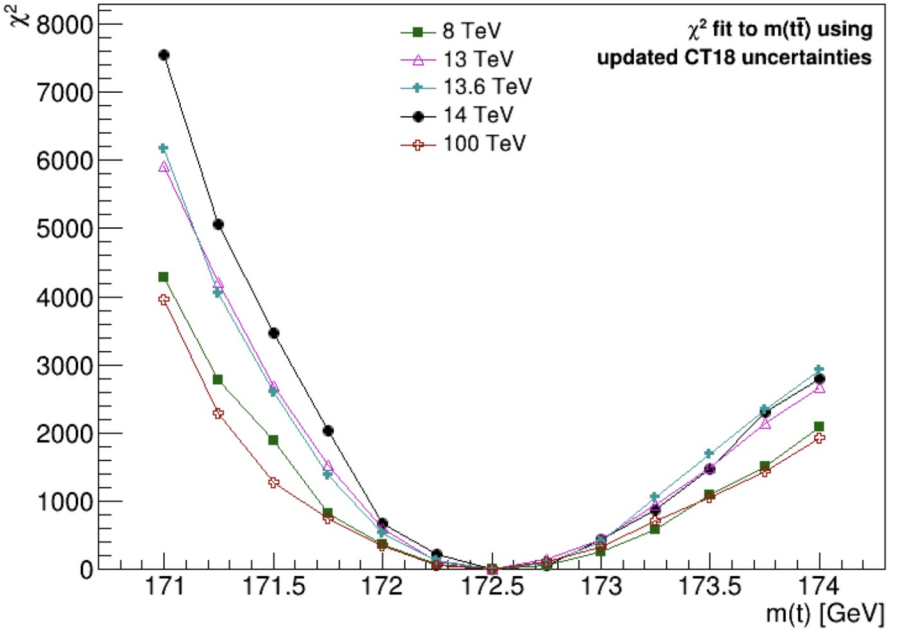


Chi2-Square Evaluation Using m(tt) , 5%

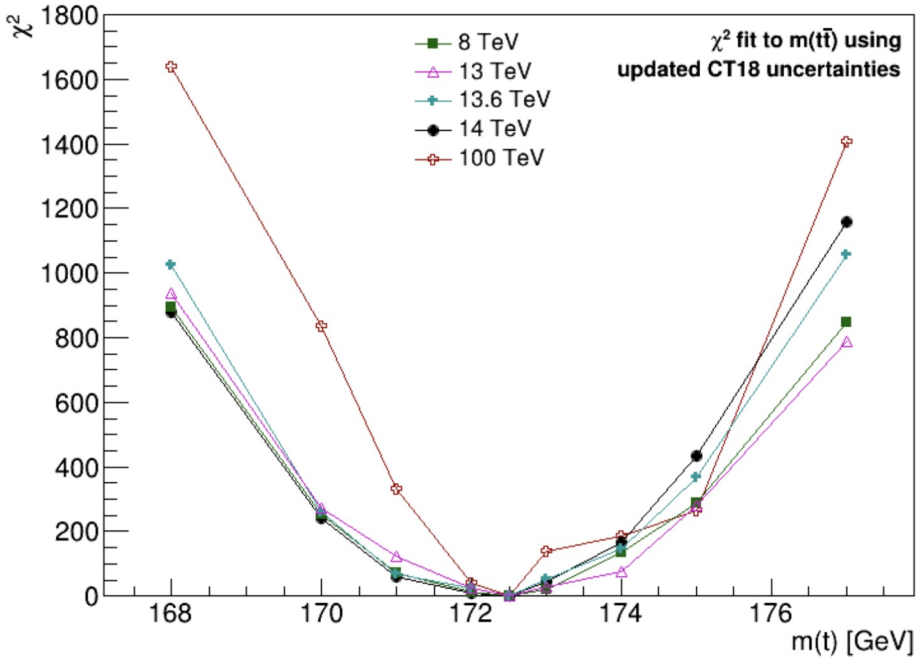


Chi2-Square Evaluation Using m(tt) , 20%

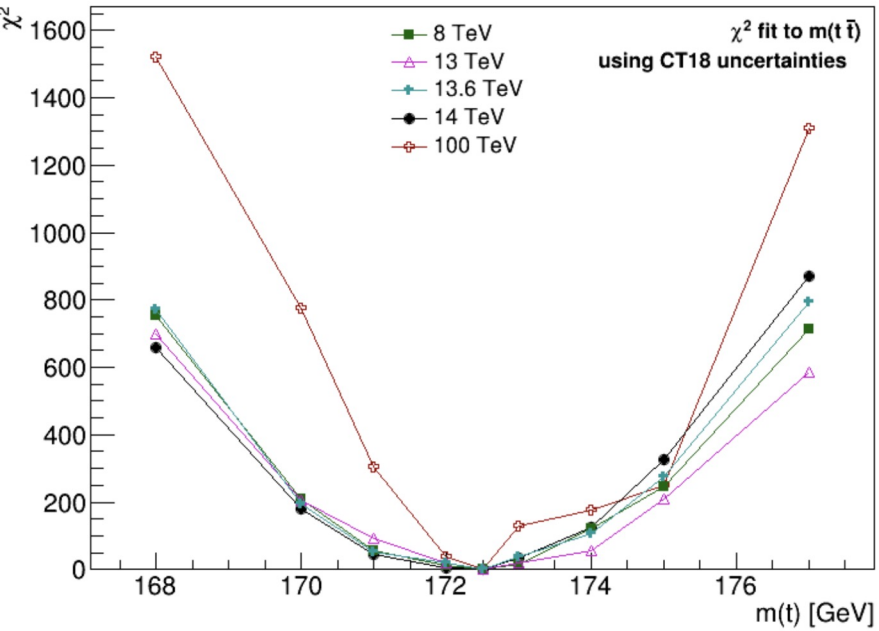


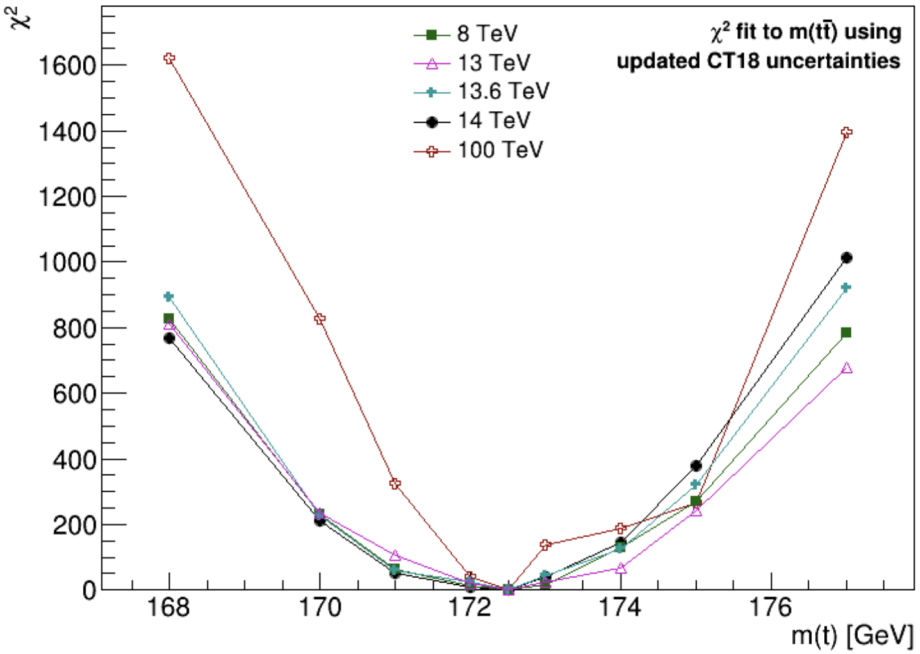


Chi2-Square Evaluation Using ρ , 5%



Chi2-Square Evaluation Using ρ , 20%





Example ePump Input File

```
+++ N(EV pairs)                        N(Data Sets)    PDFtype(C/L/N)  Dyn_Tol?(Y/N)  Tol_squared
    29                                        2              L              N             100.0
+++ ObservableFile                                    N(Observables)  Data?(Y/N)      Error_type     Weight          PS:
  Data/variable_rho/tabs/one_percent/ttj_pz_full_172.5_7000.0                    10              Y              1          1.0
  Data/variable_rho/tabs/one_percent/ttj_variable_rho_172.5_7000.0               10              N
+++     PDFin              PDFout
  PDFs/CT18NLO/CT18NLO   Data/updated_ttj_full_pdfs/updated_ttj_full_pdfs


+++     Extras:
  Data/variable_rho/tabs/E545.If1363                    185             Y              1          1.0
  Data/variable_rho/tabs/E566.If1363                      5             Y              1          1.0
```

Using ePump Output File

	a	X[a]	DXsym[a]	DXasym[a]	
Old	1	1.9289E+09	7.8458E+07	-8.2872E+07	+7.6906E+07
New	1	1.9289E+09	7.8320E+07	-8.2735E+07	+7.6765E+07

First two entries of .out file for p_z
m = 172.5 GeV, E = 14 TeV