

# First attempt at $m_t^{\text{pole}}$ LHC fit from combined tt+j cross sections

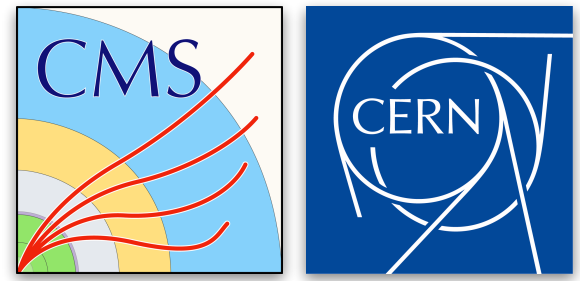
Andrej, Davide, Katerina, Marcel, Matteo, Sebastian

## Goals

- Chi2 fit of top quark pole mass with [PDFs as profiled nuisance parameters](#) (new for both experiments)
- Combined fit at **different centre-of-mass energies**, with consistent theoretical and experimental setup
- Using results currently published (ATLAS 8 TeV, CMS 13 TeV)
- New results can be automatically added once available

Valencia workshop, May 23rd 2024

# Technical implementation



Basic fitting framework in place

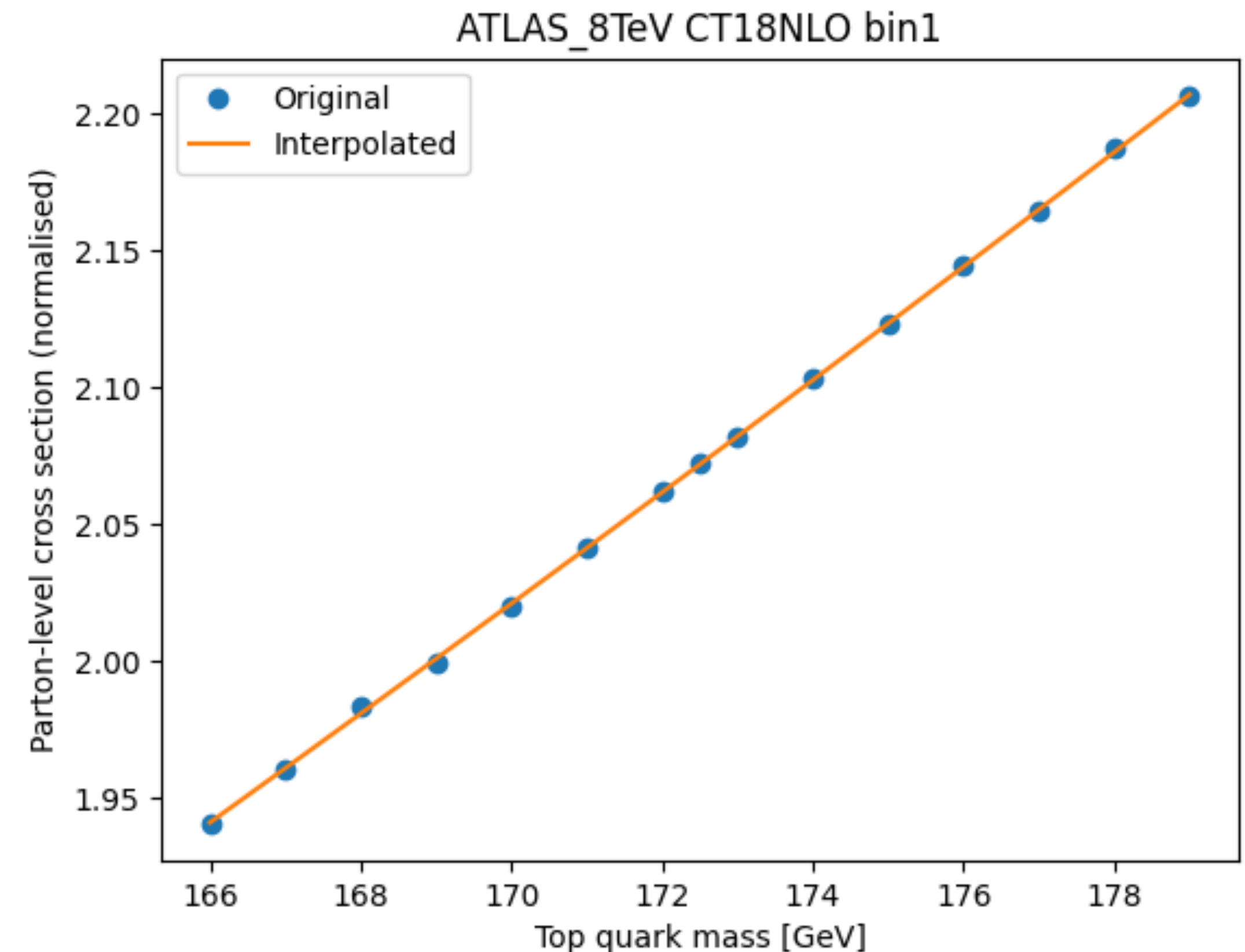
- Fit individual experiments or “**combined**” **8+13 TeV** cross sections (Sebastian, Davide, Marcel)
- Consistent **correlation of PDF** uncertainties between centre-of-mass energies
- Correlated/uncorrelated variation of ME scales

Using NLO tt+j calculations (Andrej):

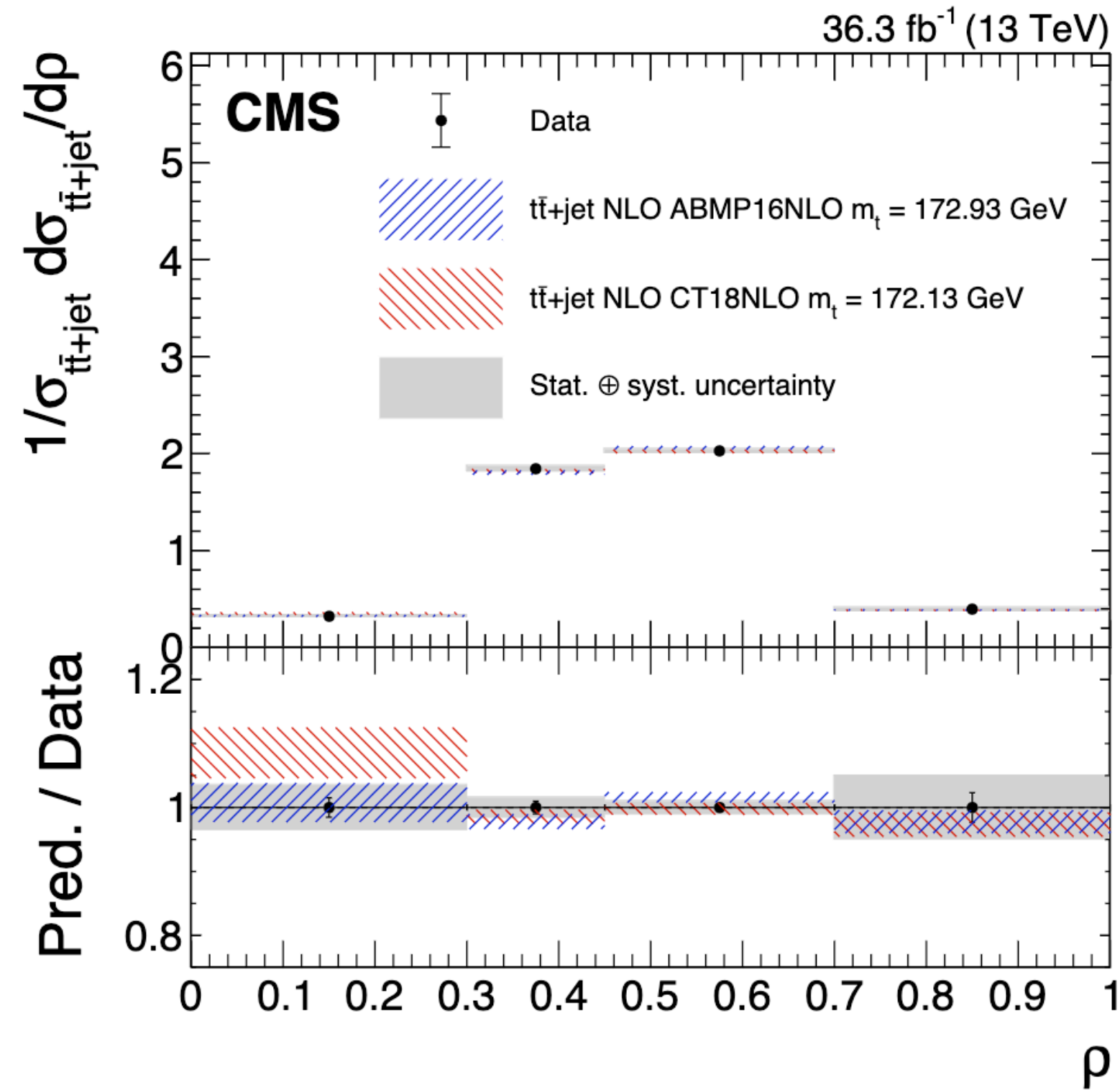
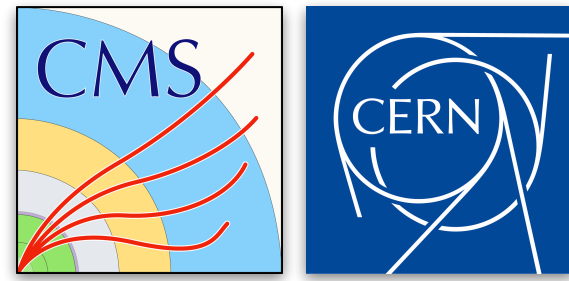
- Powheg FO,  $\alpha_S = 0.118$ , **scale =  $ET/2$**
- Effectively smoothing theory prediction via **polynomial interpolation** of x-sec vs mass in each rho bin

In this talk:

- Validated CMS vs published result + ATLAS updated fit
- **First look at LHC combination**
- Consistency between ATLAS and CMS results
- Some preliminary checks on correlation assumptions



# Check #1: published CMS result



Using the same setup as the CMS analysis and the public info (PDF variations as part of covariance matrix)

PDFs in cov:

**172.08 +/- 1.36 (PDF+exp) GeV**

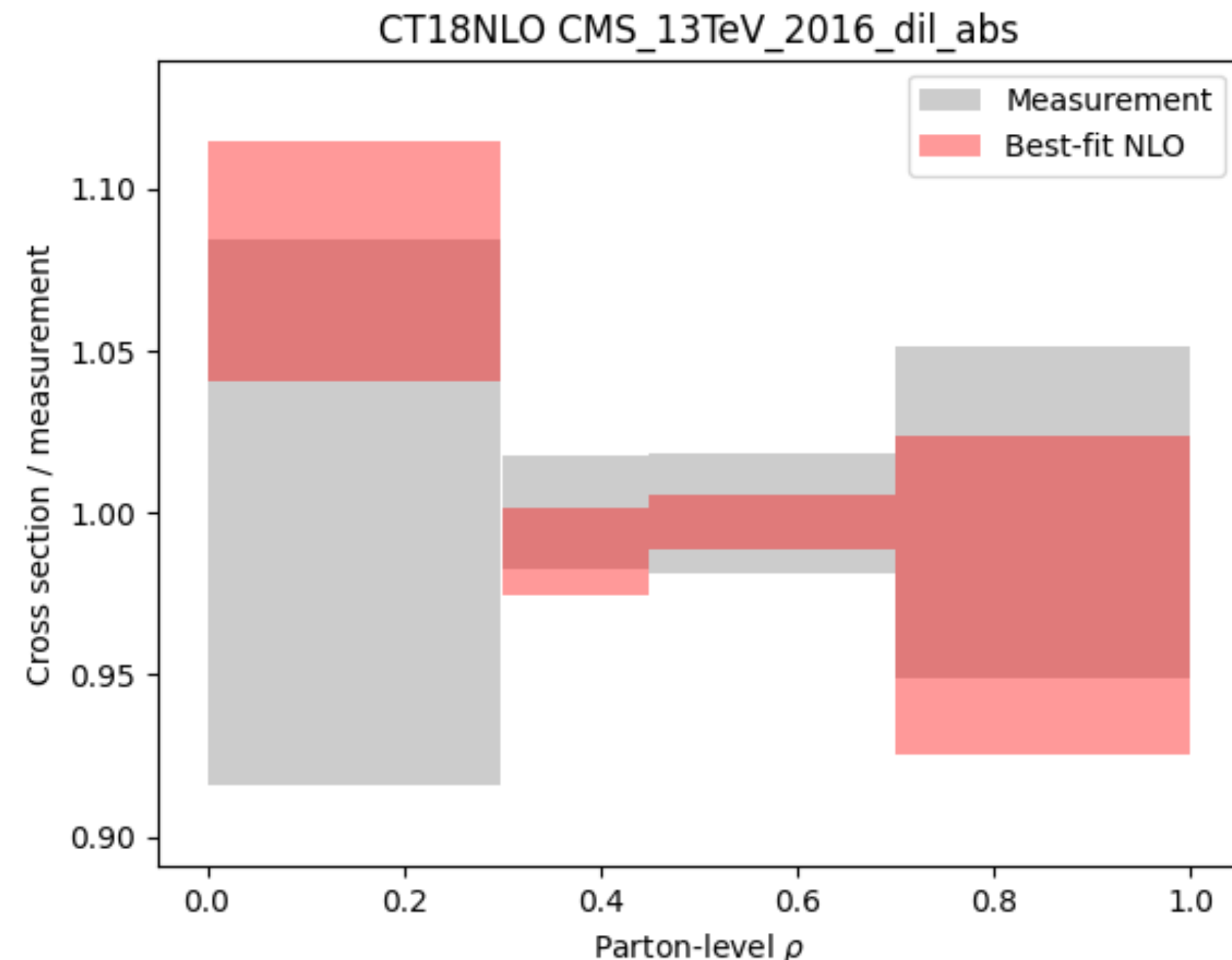
Profiling the PDFs:

Full fit:

**mt = 172.08 +/- 1.29 (exp) +/- 0.41 (PDF) GeV**  
**scale uncertainty = +0.32 -0.43 GeV**

CT18 NLO (scale = HT/2)

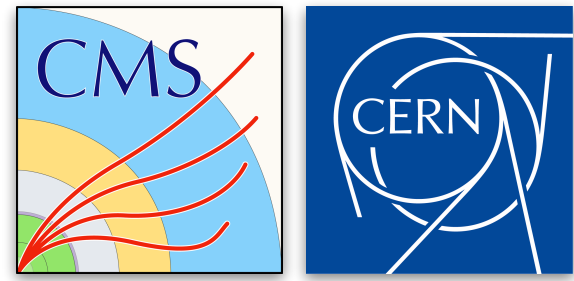
$$m_t^{\text{pole}} = 172.13 \pm 1.34 (\text{fit}) {}^{+0.50}_{-0.40} (\text{scale}) \text{ GeV.}$$



Theory band includes  
 PDFs + mtpole post-fit  
 uncertainty

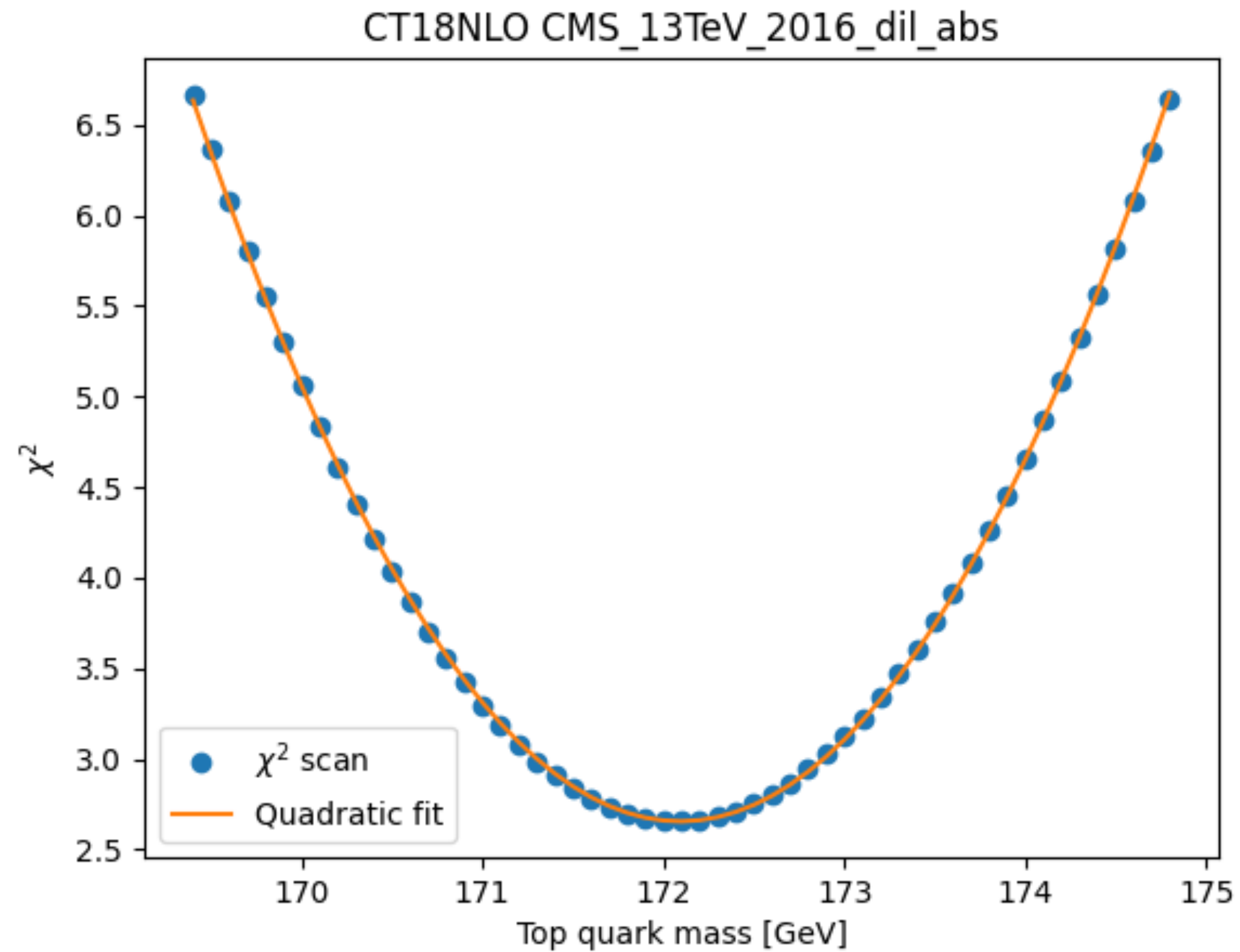


# Checking the CMS fit

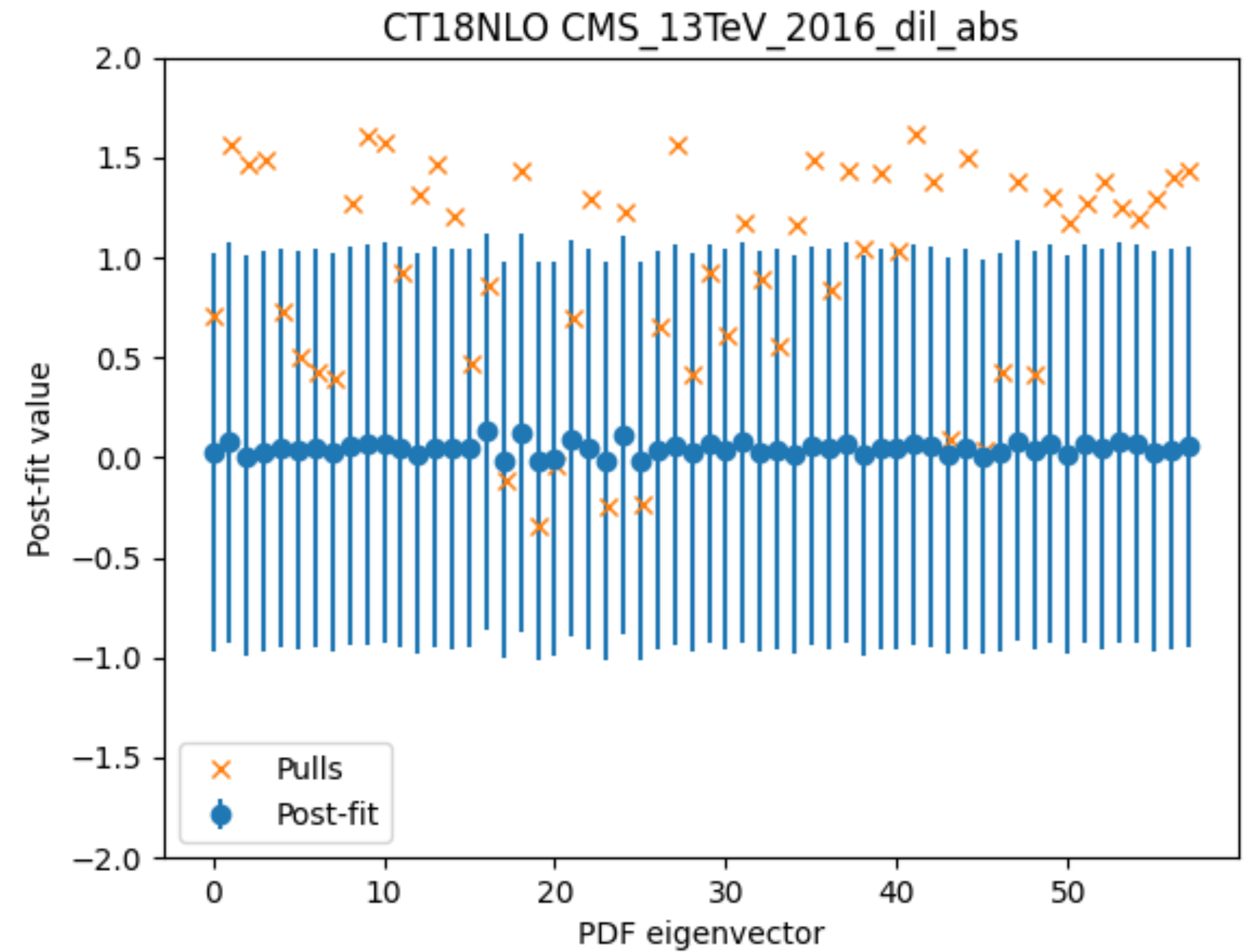


$$\text{pull} = \frac{\theta - \theta_0}{\sqrt{\sigma_{\theta_0}^2 - \sigma_{\theta}^2}}$$

Chi2 scan at the minimum



PDF pulls and post-fit values



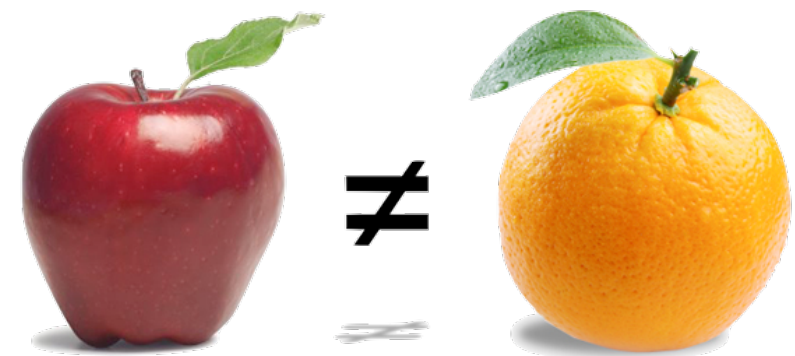
# ATLAS result

$$m_t^{\text{pole}} = 171.1 \pm 0.4 \text{ (stat)} \pm 0.9 \text{ (syst)} {}^{+0.7}_{-0.3} \text{ (theo)} \text{ GeV.}$$

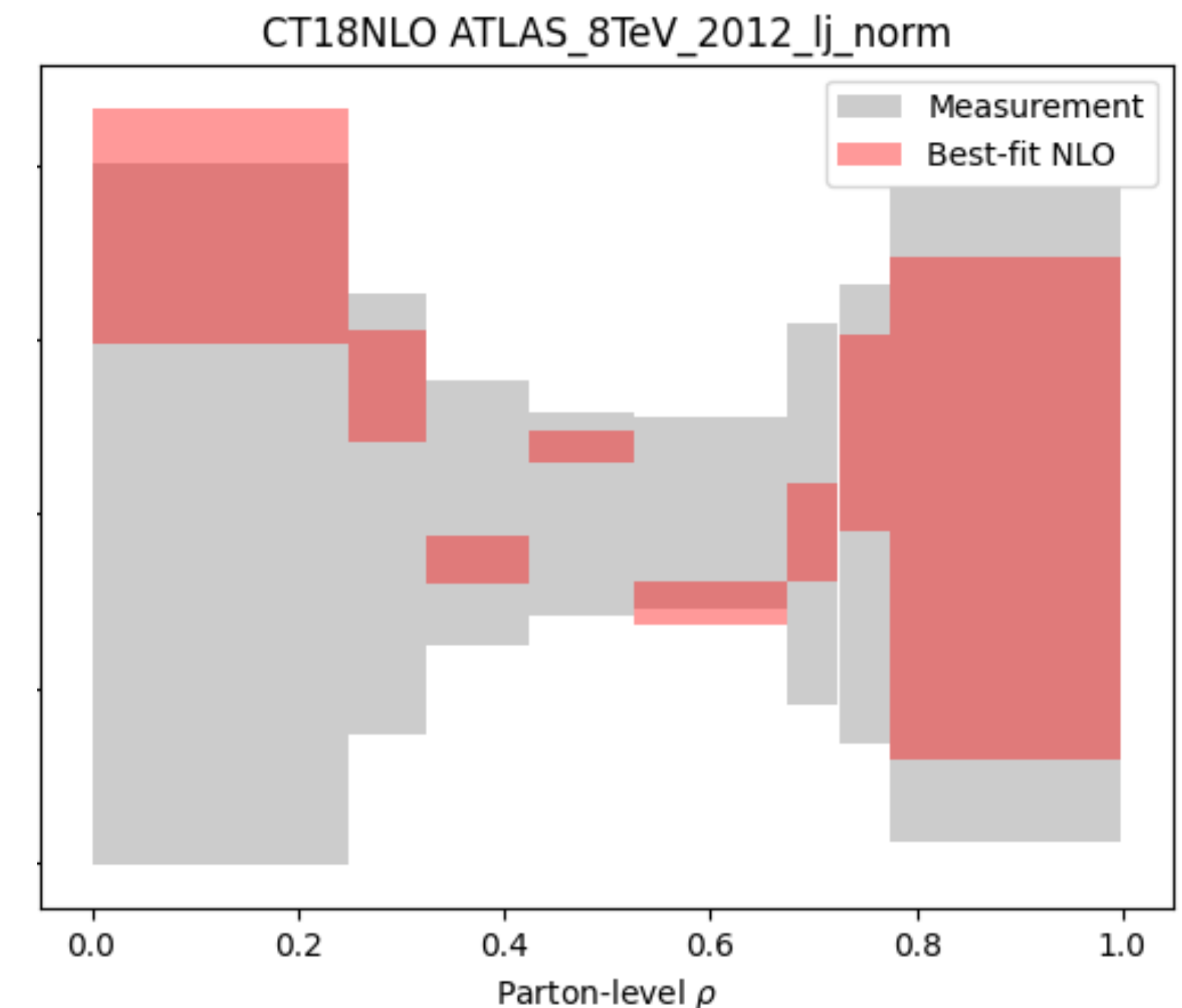
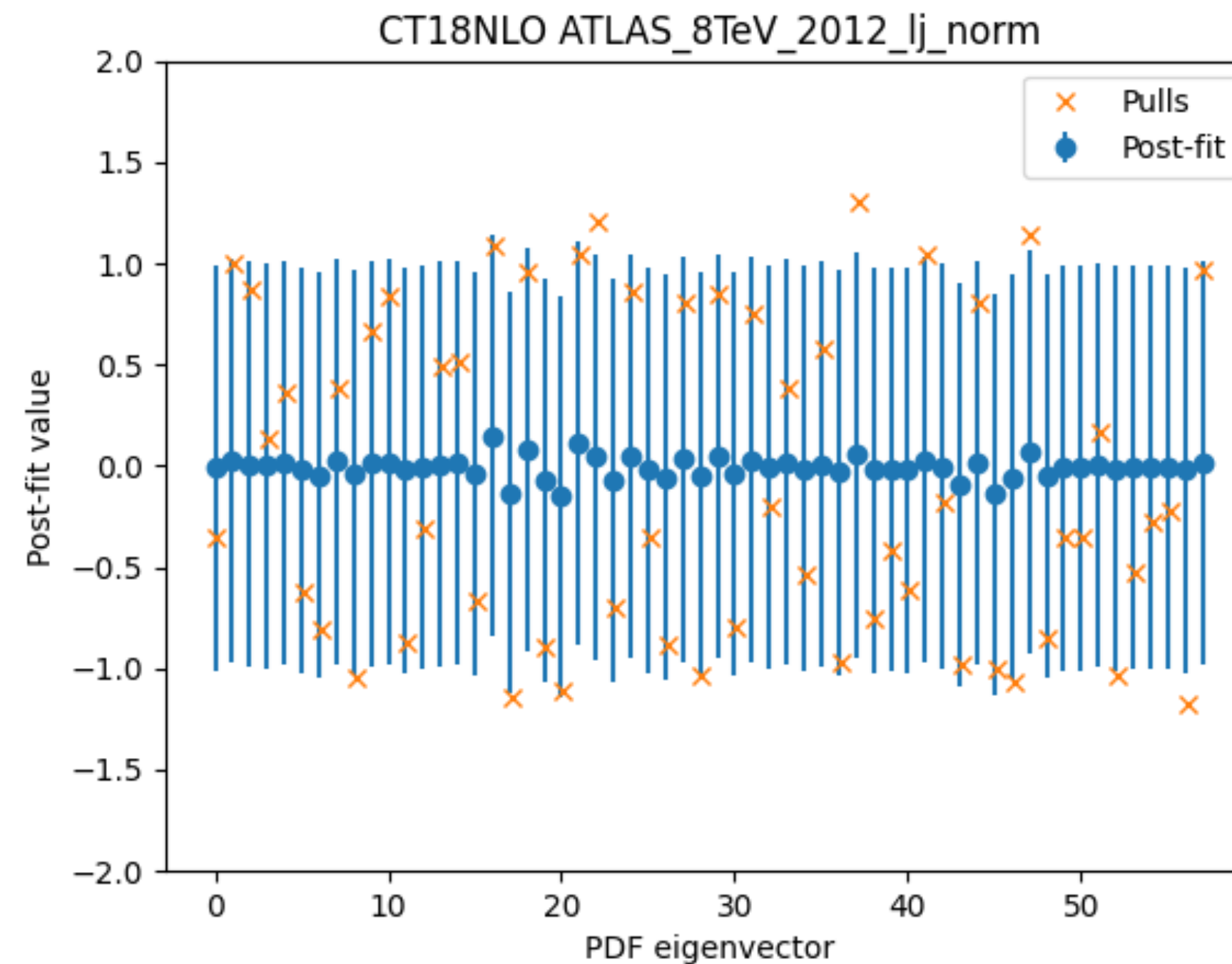
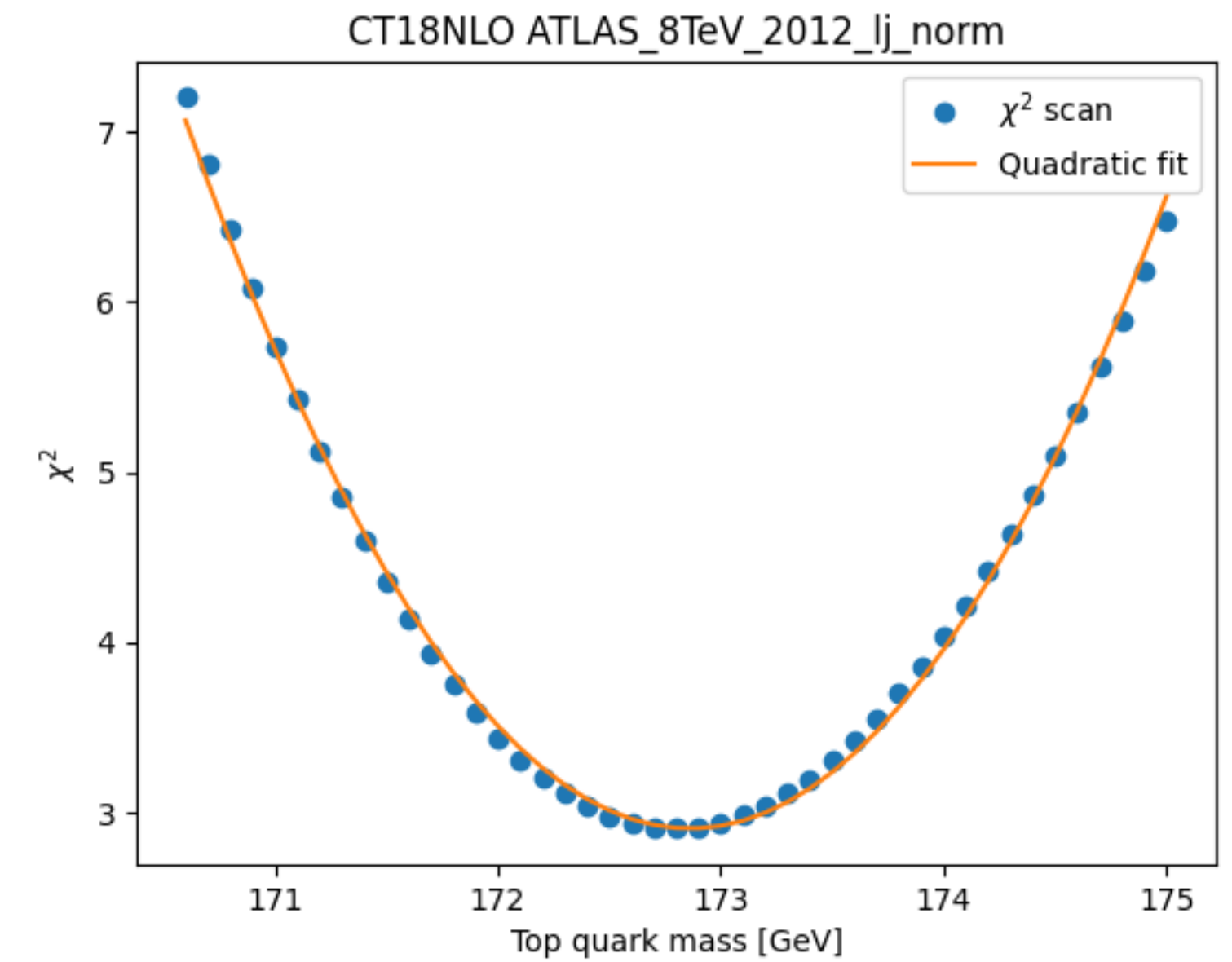
PDFs in cov: **172.82 $\pm$ 1.05 (PDF+exp) GeV**

Full fit: **mt = 172.79  $\pm$  1.06 (exp)  $\pm$  0.30 (PDF) GeV**  
**scale uncertainty = +0.13 -0.06 GeV**

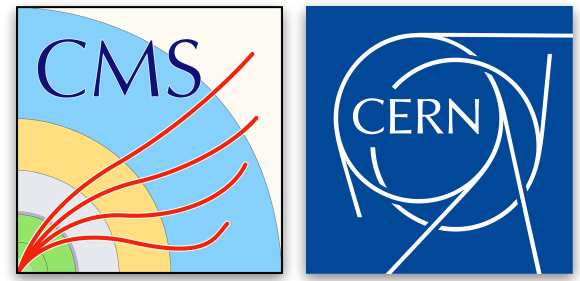
- Results not directly comparable due to different fit and theoretical setups



Matteo M. Defranchis (CERN)



# First attempt at LHC (8+13 TeV) combination

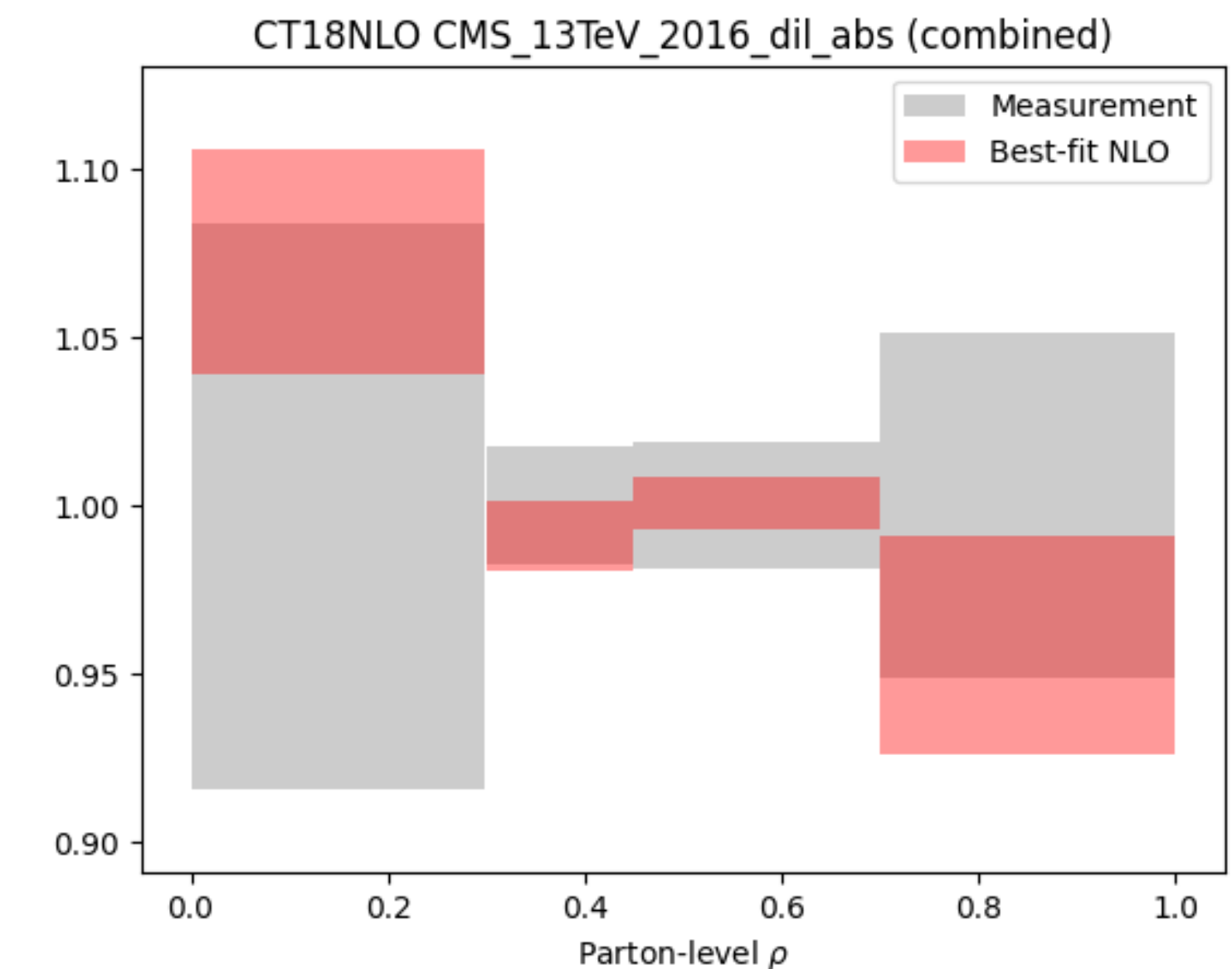
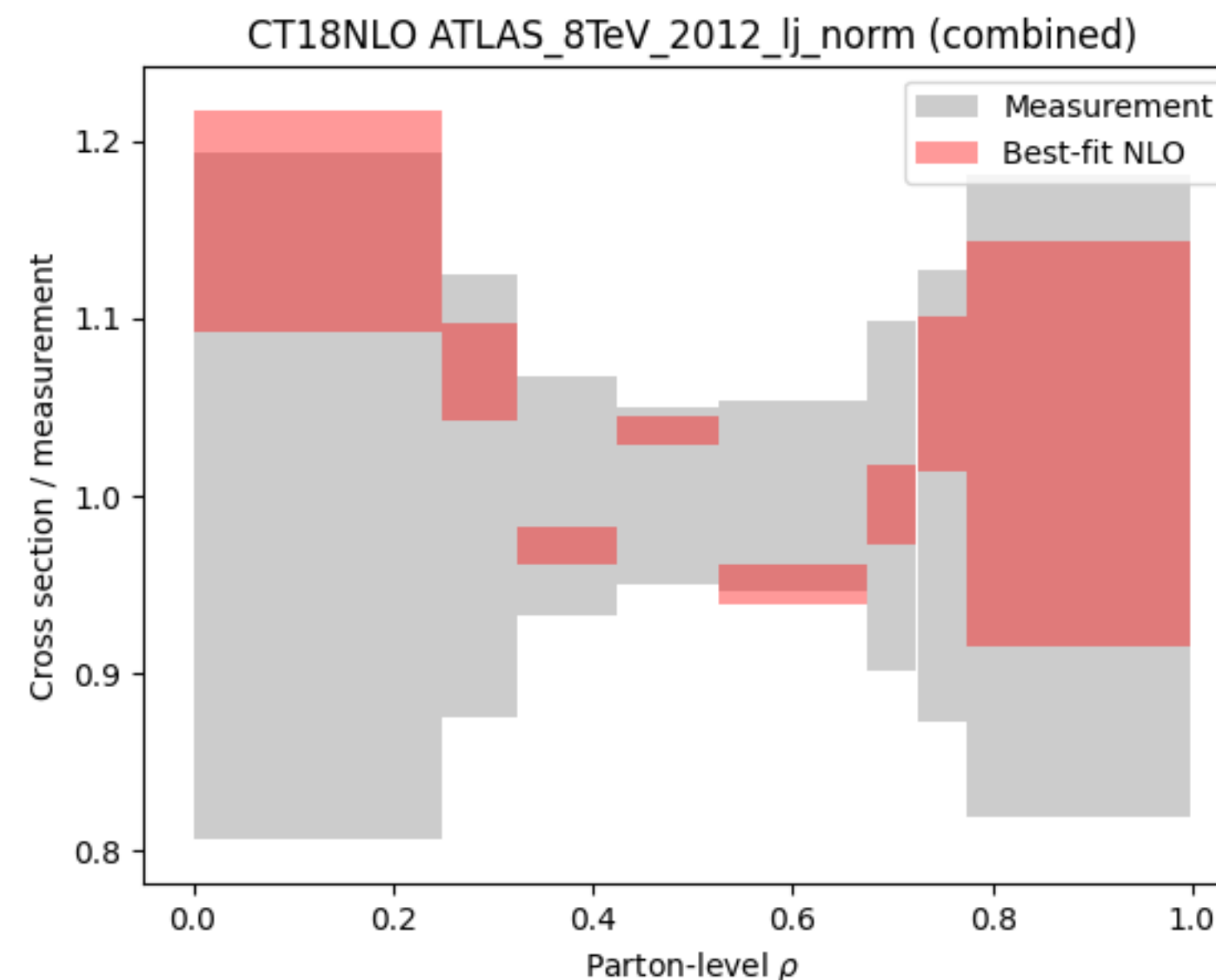
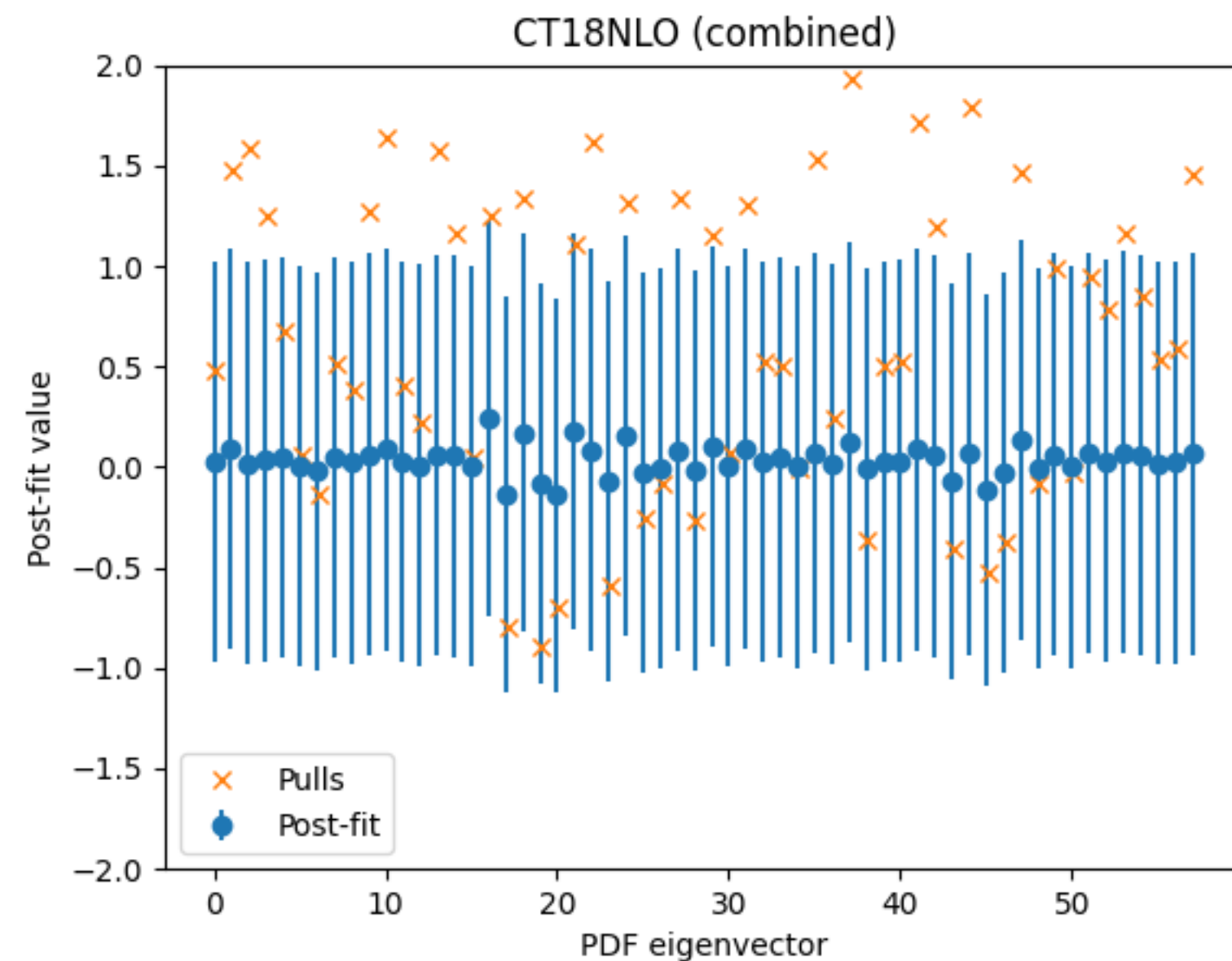
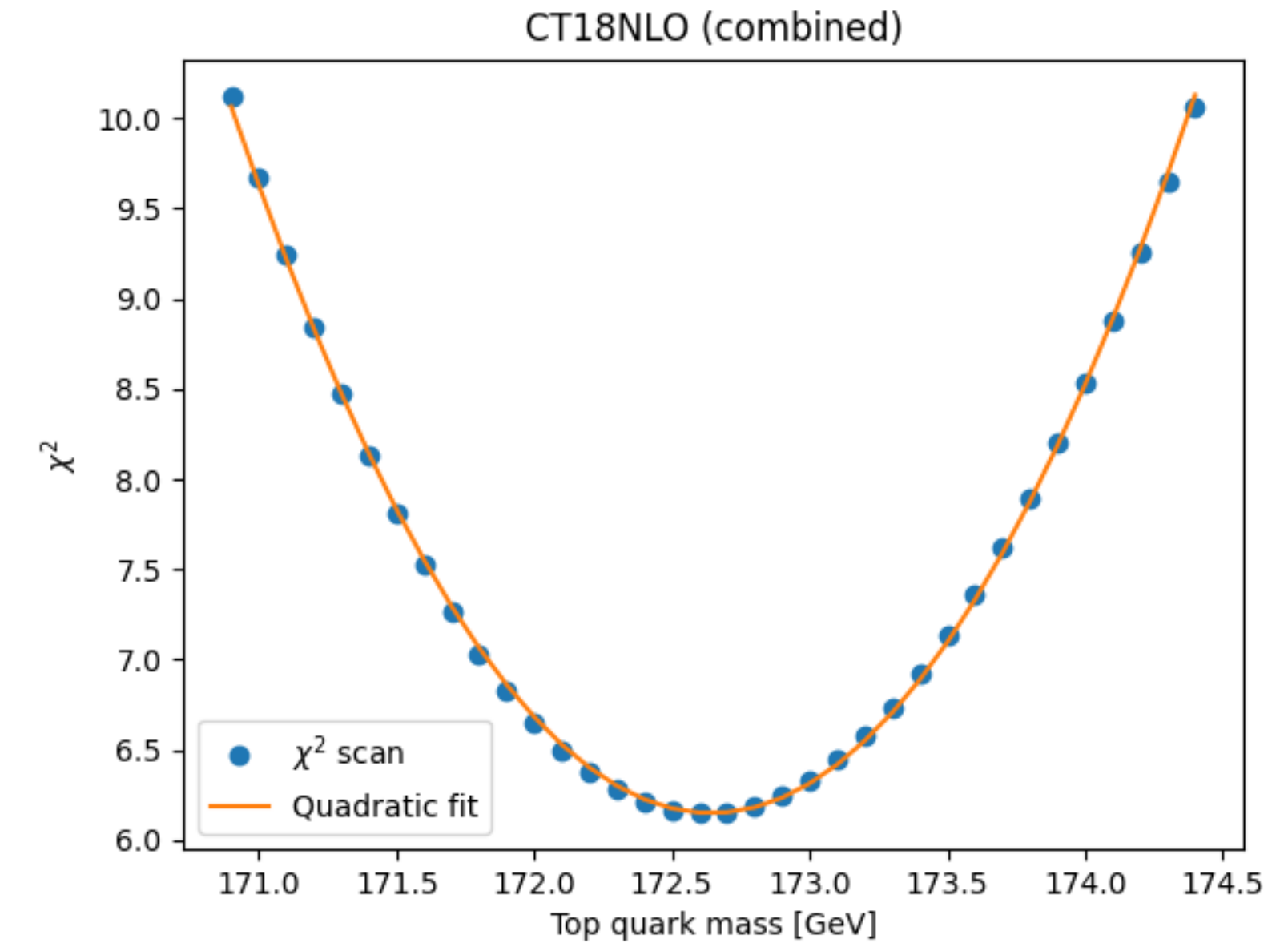


Full fit

$m_t = 172.62 \pm 0.83$  (exp)  $\pm 0.29$  (PDF) GeV  
 $= 0.88$  (total) GeV

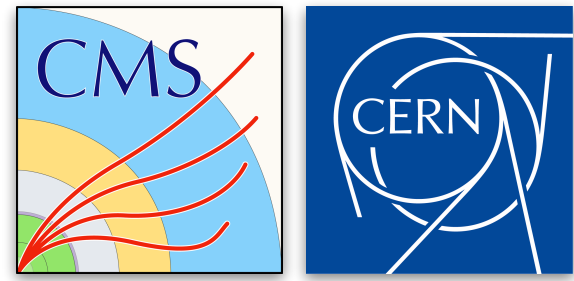
Correlated scale =  $+0.18 -0.14$  GeV  
Uncorrelated scale =  $+0.10 -0.14$  GeV

20% improvement  
wrt to ATLAS 8 TeV  
(Most precise input)





# Consistency check: one parameter per exp

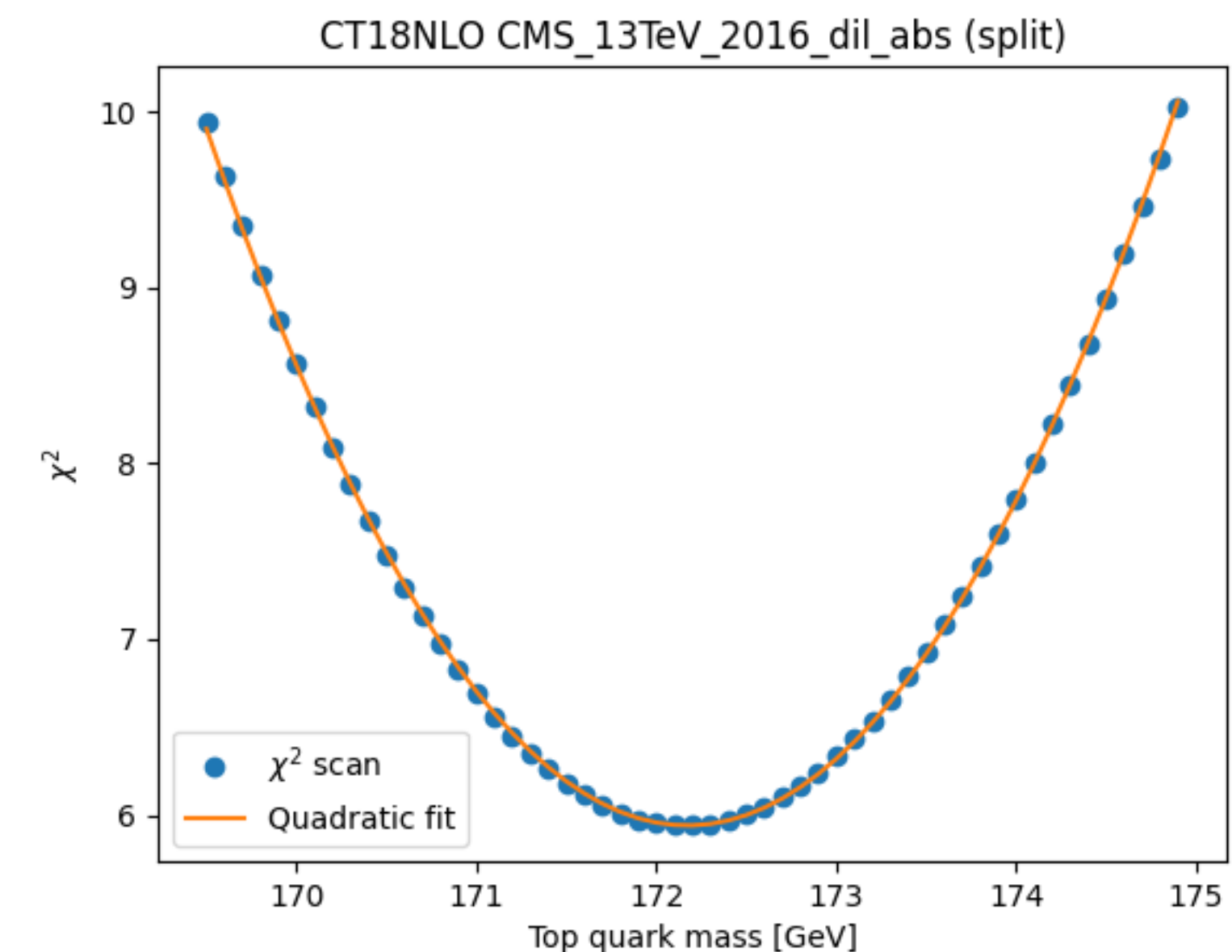
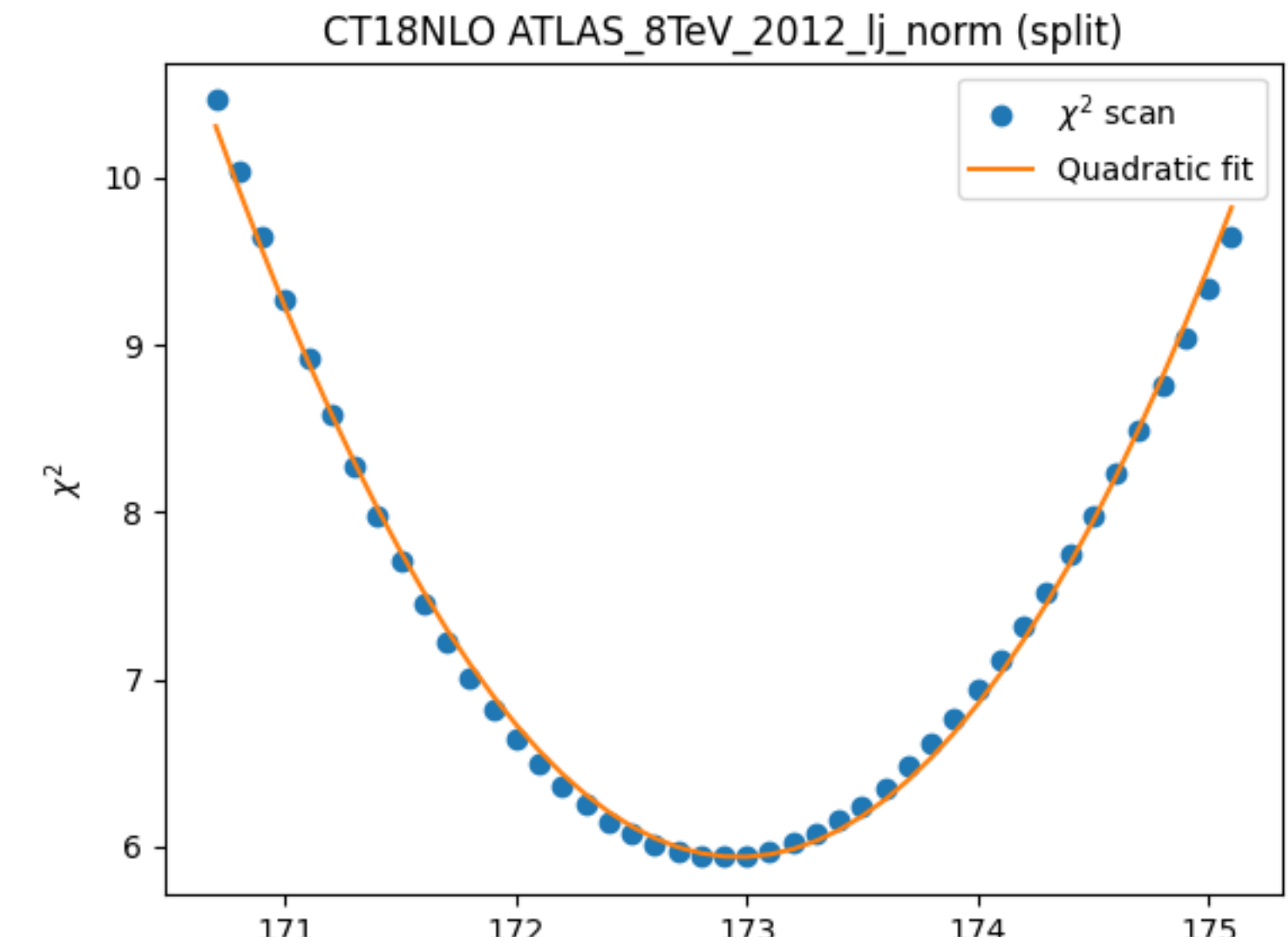


Two separate mass parameters fit **simultaneously** to ATLAS and CMS, taking correlations into account

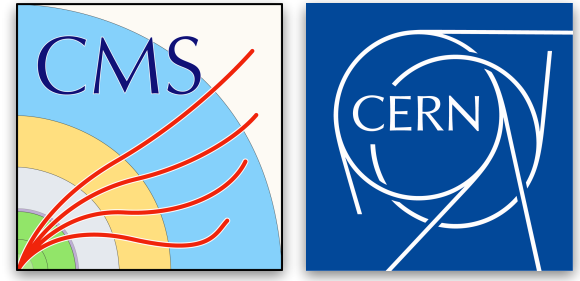
mt CMS =  $172.15 \pm 1.28$  (exp)  $\pm 0.41$  (PDF) GeV  
mt ATLAS =  $172.89 \pm 1.05$  (exp)  $\pm 0.26$  (PDF) GeV

correlation =  $11.7\%$   
difference =  $-0.7 \pm 1.6$  GeV  
ratio =  $0.996 \pm 0.009$

- Correlation includes experimental (tt+Oj, JES, modelling) and PDF's
- Mass values **compatible within uncertainties**



# Dependence on correlation assumptions



Very mild dependence on (presumably leading) systematics investigated so far

JES only:  $m_t = 172.57 \pm 0.81$  (exp)  $\pm 0.30$  (PDF) GeV

JES+modelling:  $m_t = 172.62 \pm 0.83$  (exp)  $\pm 0.30$  (PDF) GeV

JES+modelling+tt0j:  $m_t = 172.62 \pm 0.83$  (exp)  $\pm 0.29$  (PDF) GeV

## Outlook

- Precision can significantly improve with the inclusion of upcoming 13 TeV results
- Any feedback is very welcome :)