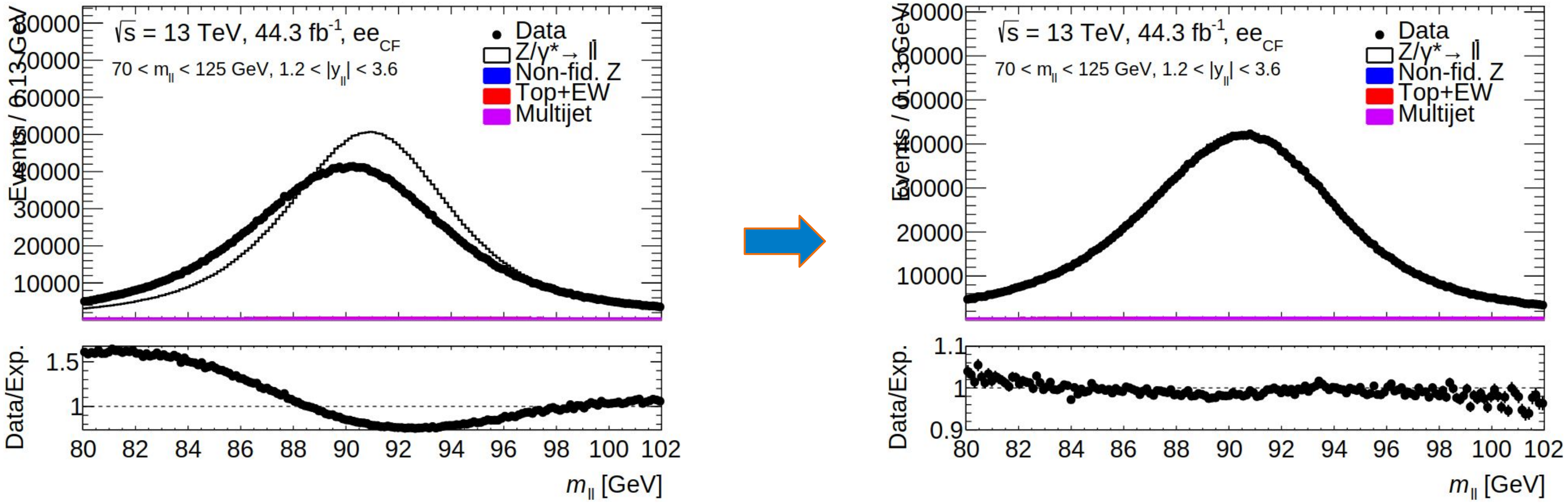
eeCF: Forward Electron Energy Calibration

“In-Situ” Calibration

- fit double-sided crystal ball (DSCB) function folded with Monte-Carlo (MC) expectation to data
- shift observed data by DSCB mean to match MC energy scale
- smear MC with DSCB shape to match observed resolution

$$f(m;\mu,\sigma,\alpha_L,\alpha_U,n_L,n_U) = \begin{cases} A_L \times \left(B_L - \frac{m-\mu}{\sigma}\right)^{-n_L} & \frac{m-\mu}{\sigma} < -\alpha_L \\ \exp\left(-\frac{(m-\mu)^2}{\sigma^2}\right) & -\alpha_L < \frac{m-\mu}{\sigma} < \alpha_U \\ A_U \times \left(B_U - \frac{m-\mu}{\sigma}\right)^{-n_U} & \frac{m-\mu}{\sigma} > \alpha_U \end{cases}$$



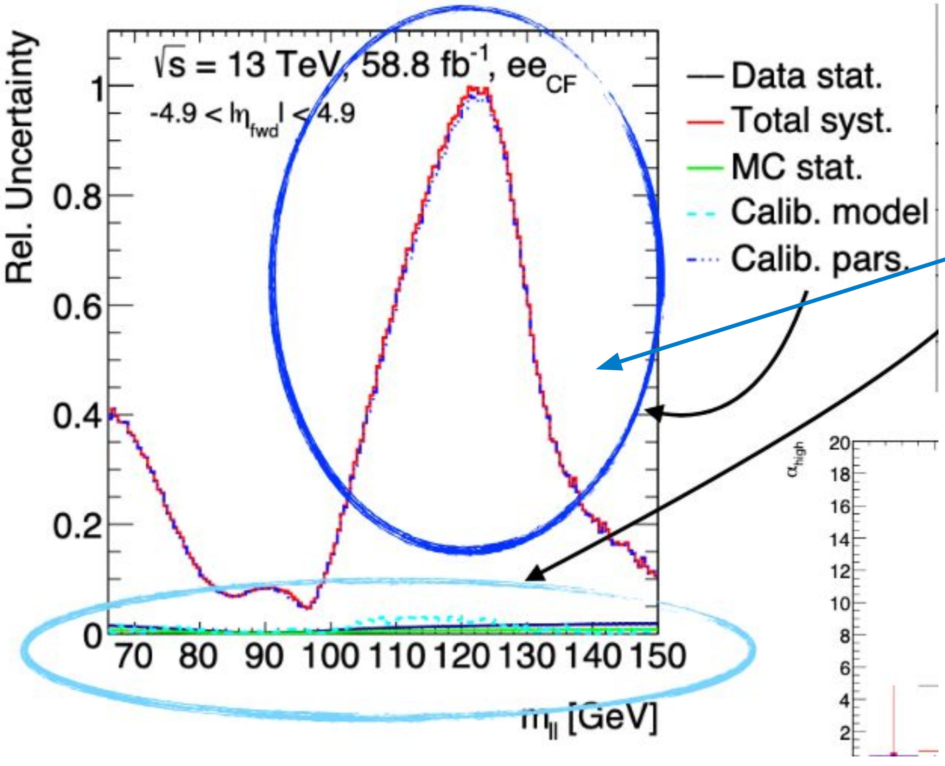
Recent Improvement:

- new accept-reject algorithm to sample smearing value from DSCB
  - reproducible on an event by event basis (using hashed reseeding)
  - statistically correct
  - ~ 200 times faster than previous iteration

eeCF: Forward Electron Energy Calibration

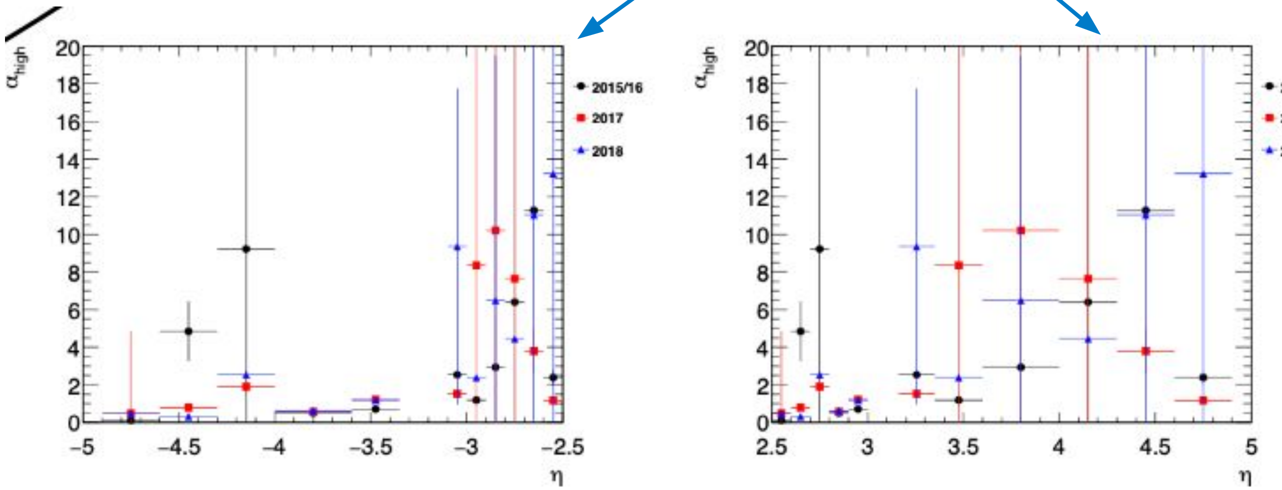
“In-Situ” Calibration Uncertainty

$$f(m;\mu,\sigma,\alpha_L,\alpha_U,n_L,n_U) = \begin{cases} A_L \times (B_L - \frac{m-\mu}{\sigma})^{-n_L} & \frac{m-\mu}{\sigma} < -\alpha_L \\ \exp\left(-\frac{(m-\mu)^2}{\sigma^2}\right) & -\alpha_L < \frac{m-\mu}{\sigma} < \alpha_U \\ A_U \times (B_U - \frac{m-\mu}{\sigma})^{-n_U} & \frac{m-\mu}{\sigma} > \alpha_U \end{cases}$$



dominating uncertainty, especially off-peak!

several parameters unconstrained by the fit resulting in huge variations!



(g) Fitted α_U for $\eta < 0$.

(h) Fitted α_U for $\eta > 0$.

Work in Progress:

- reducing In-Situ calibration uncertainty by
  - rebinning data and providing reasonable starting parameters to aid the fit
  - setting limits on fit parameters, preventing a runaway

eeCF: Systematic Uncertainties

Work in Progress:

- we are implementing, fixing or re-evaluating many systematic variations of variables, that are specific to the eeCF channel
- investigating treatment of multijet background uncertainties from statistical sources:

Multijet Background Uncertainties

control region: on peak, failing ID (nLon)

Multijet = data - MC

analysis binning (p_T,y_Z or m_{ll},y_Z)
→statistical uncertainty in control region is systematic uncertainty **uncorrelated** between analysis bins!

currently not implemented

$$F = \frac{N_{\mathrm{MJ}}^{\mathrm{IDoff}}}{N_{\mathrm{MJ}}^{\mathrm{nLoff}}}$$

binned in fwd. el. η and p_T
→statistical uncertainty of FF is systematic uncertainty **correlated** between analysis bin!

currently implemented as uncorrelated uncertainties

signal region: on peak, passing ID (IDon)

Multijet estimate

Trigger for CF Channel

Single Electron Trigger on Central Electron

single electron > 26 GeV

no d0 requirement
(track distance from primary vertex)

HLT_e26_lhtight_nod0_ivarloose or **HLT_e60_lhmedium_nod0** or **HLT_e140_lhloose_nod0**

High-Level Trigger

tight ID requirement
for electron likelihood

loose requirements on
isolation in variable cone

used to be medium in Run1;
more pileup in Run2 → need tighter electron ID

Trigger for CF Channel

Trigger Scale-Factors

- trigger efficiency is different for data vs Monte-Carlo → need to correct with scale-factor

$$\epsilon = \epsilon_{\text{reco}} \cdot \epsilon_{\text{ID}} \cdot \epsilon_{\text{trigger}} = \frac{N_{\text{reco}}}{N_{\text{all}}} \cdot \frac{N_{\text{ID}}}{N_{\text{reco}}} \cdot \frac{N_{\text{trigger}}}{N_{\text{ID}}}$$

depends on combination of online and offline ID!

- online ID: part of trigger requirement
- offline ID: part of Aidy event selection

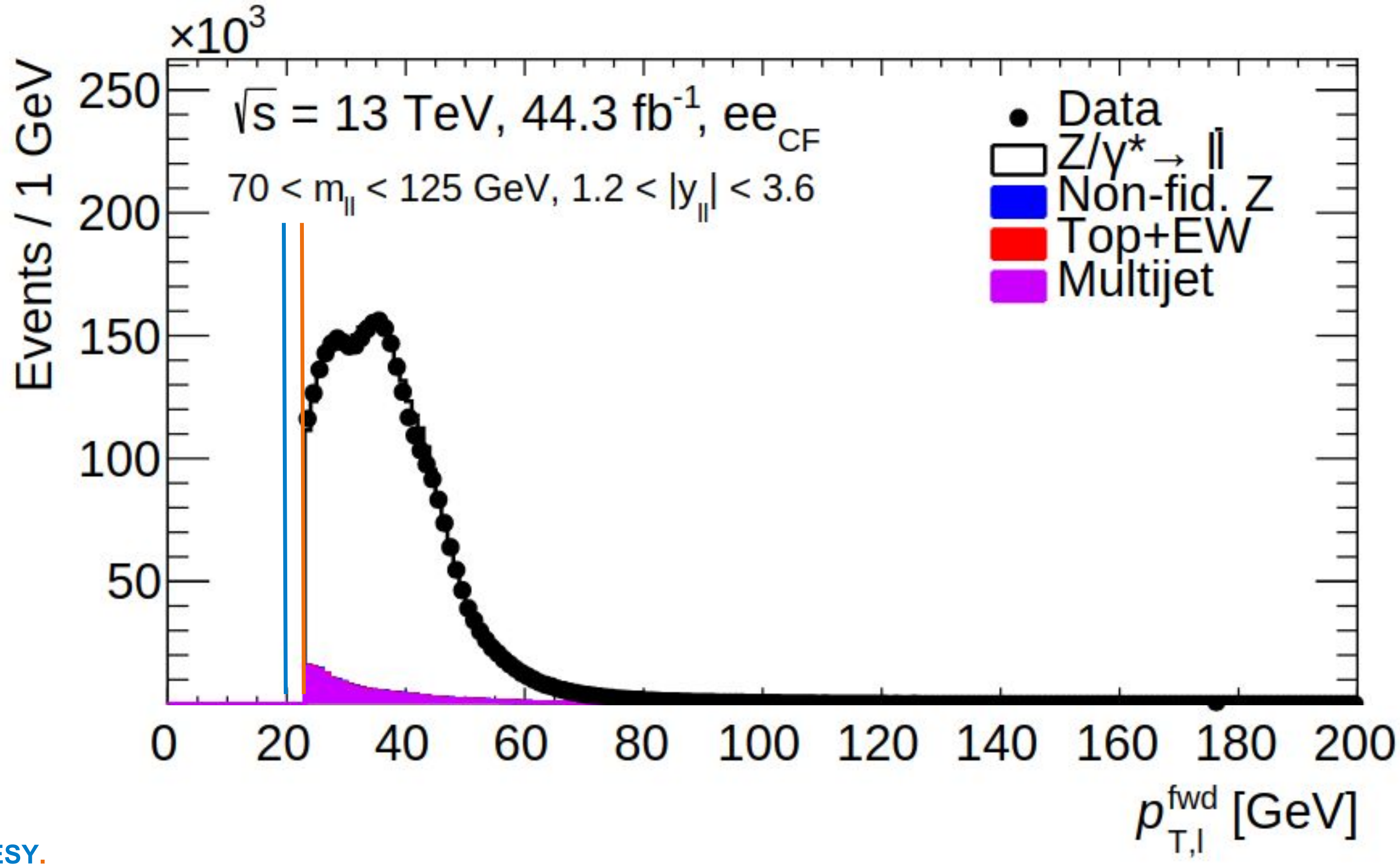
- offline ID needs to be tighter than online ID
  - tightest online ID is e26_lhtight
  - offline ID has to be tight as well
- we don't use a tight isolation requirement
- so we need Tight_NoIso trigger scale-factors (not currently saved in ntuple CFv23 → fix for CFv25)

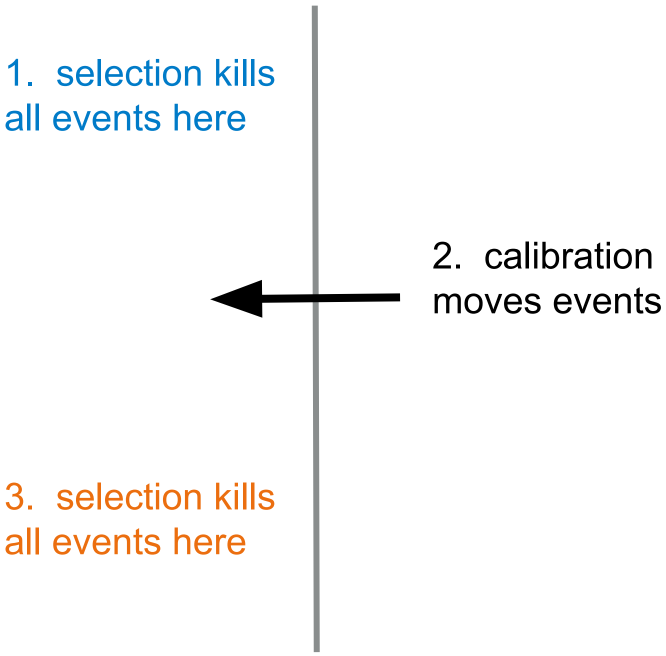
Transverse Momentum Threshold

for the forward electron

1. event selection during ntuple production
2. forward electron energy calibration
3. event selection during aidy scans

If both thresholds were the same, calibration could move events out of the selected pt range but not into it!!!



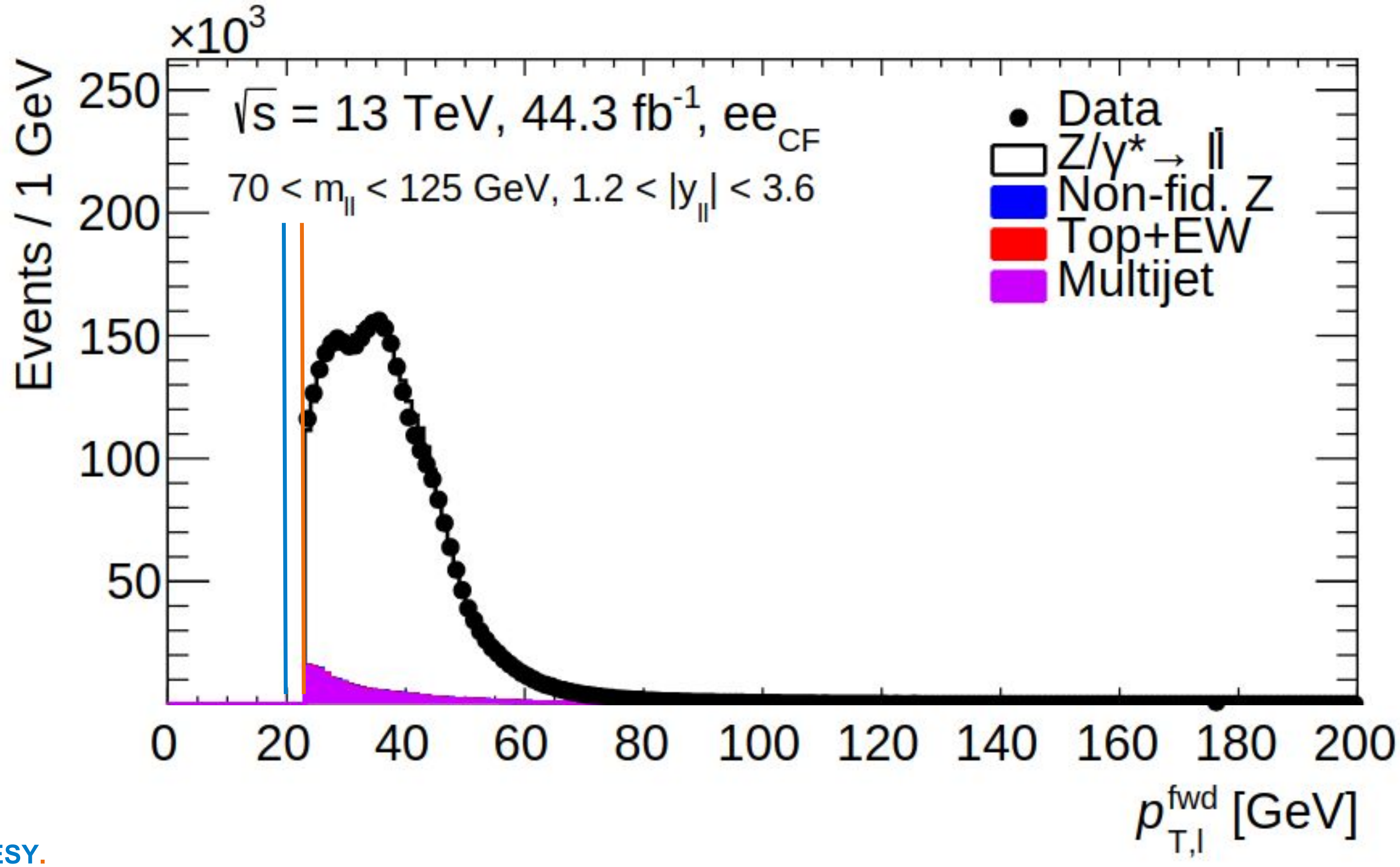


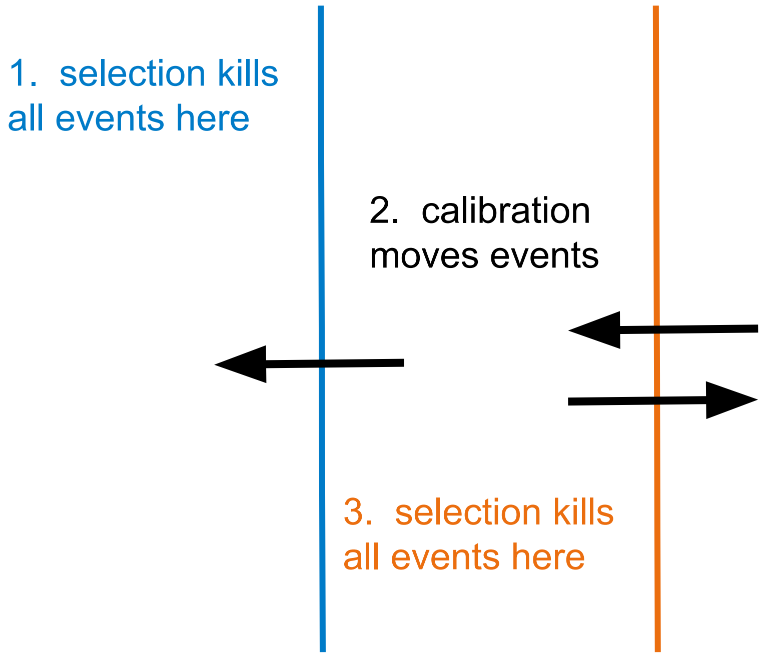
Transverse Momentum Threshold

for the forward electron

1. event selection during ntuple production
2. forward electron energy calibration
3. event selection during aidy scans

Different thresholds allow calibration to move events in both directions → no bias!





Transverse Momentum Threshold

for the forward electron

1. event selection during ntuple production
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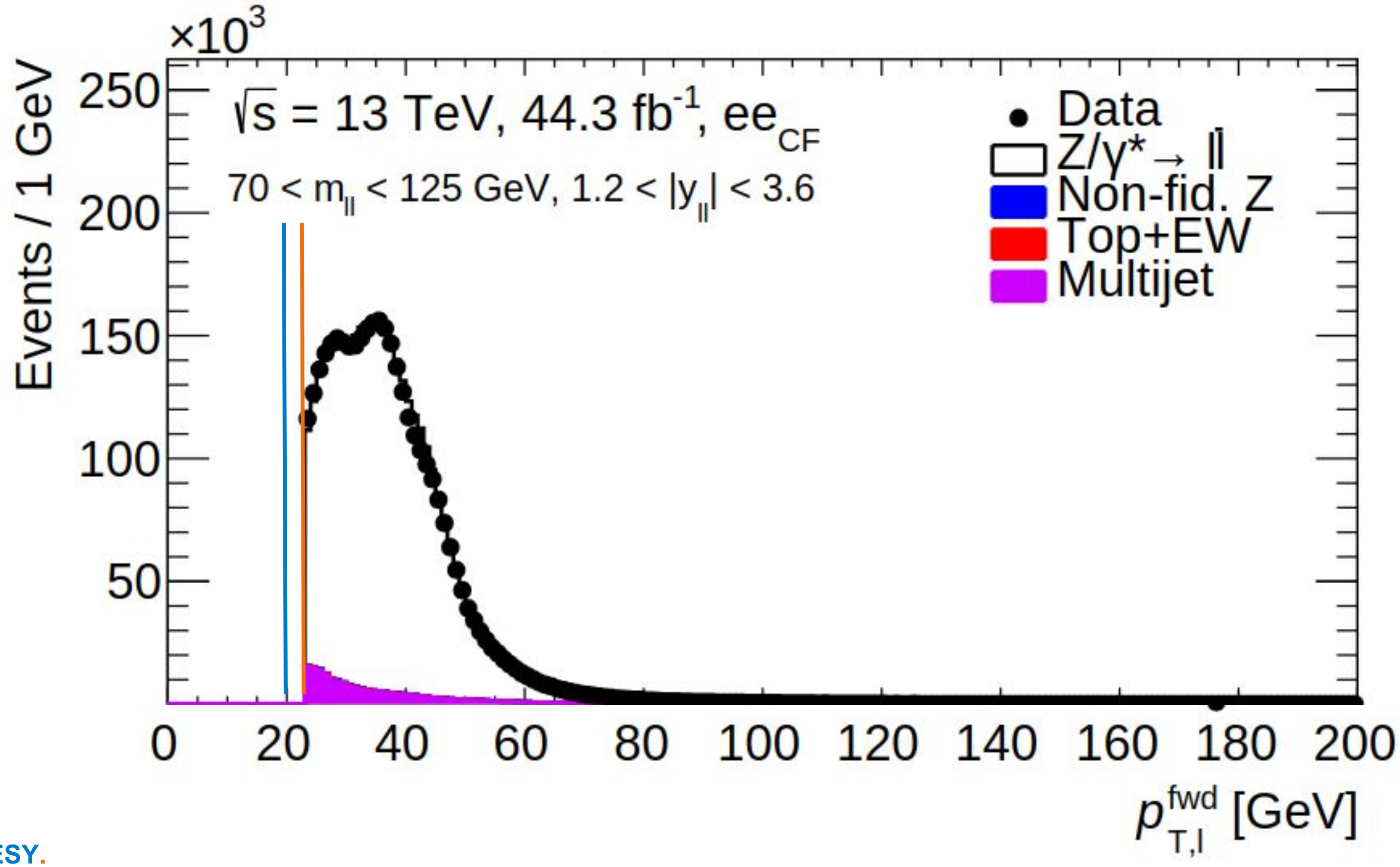
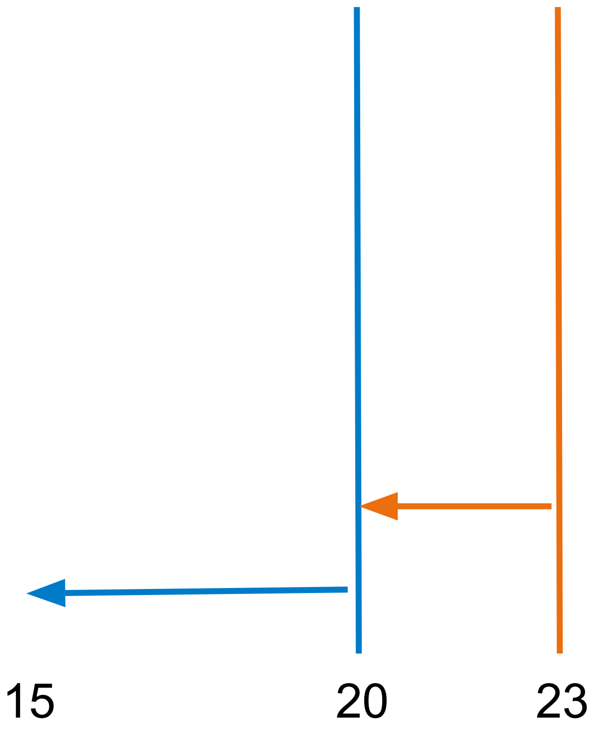


But we can lower both thresholds a bit to increase statistics at low fwd pt!



eeCF: New Ntuple Production

v25

I also fixed central ID variations

just need to run the ntuple production now

Aidy: TNG

Development Plans for a New Version of our Analysis Software

- Aidy has become messy, error-prone and difficult to work with
  - therefore we started developing a new version of Aidy to fix that

- Aidy TNG (The Next Generation) shall be
  - well documented, easy to use and debug
  - backwards compatible
  - faster!

- To achieve this, we are planning to use
  - clean formatting guidelines + flake8
  - continuous integration with
    small-scale physics and performance tests
  - RDataframe for high performance
  - Uproot+Matplotlib for easy plotting
  - modular structure

4 Parts:

1. xAOD → Ntuples
   a. using the Ntuplemaker (as is)
2. Ntuples → optimized Ntuples (oNtuples)
   a. assigning flags and weights to events
   b. using RDateframe (or related software)
3. oNtuples → Histograms
   a. using uproot (or related software)
4. Histograms → Plots