Measurement of High-$P_\perp$ b-jet Differential Cross Section at $\sqrt{s}$ = 1.96 TeV at DØ

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- The ultimate experimental goal for this search is b-jet cross section extended to a very high P_T region

$$\sigma_b = \frac{N}{L \cdot \Delta p_\perp} \cdot \frac{\varepsilon_{b-Jet}}{P_{b-Jet}} \cdot Corr_{res}$$

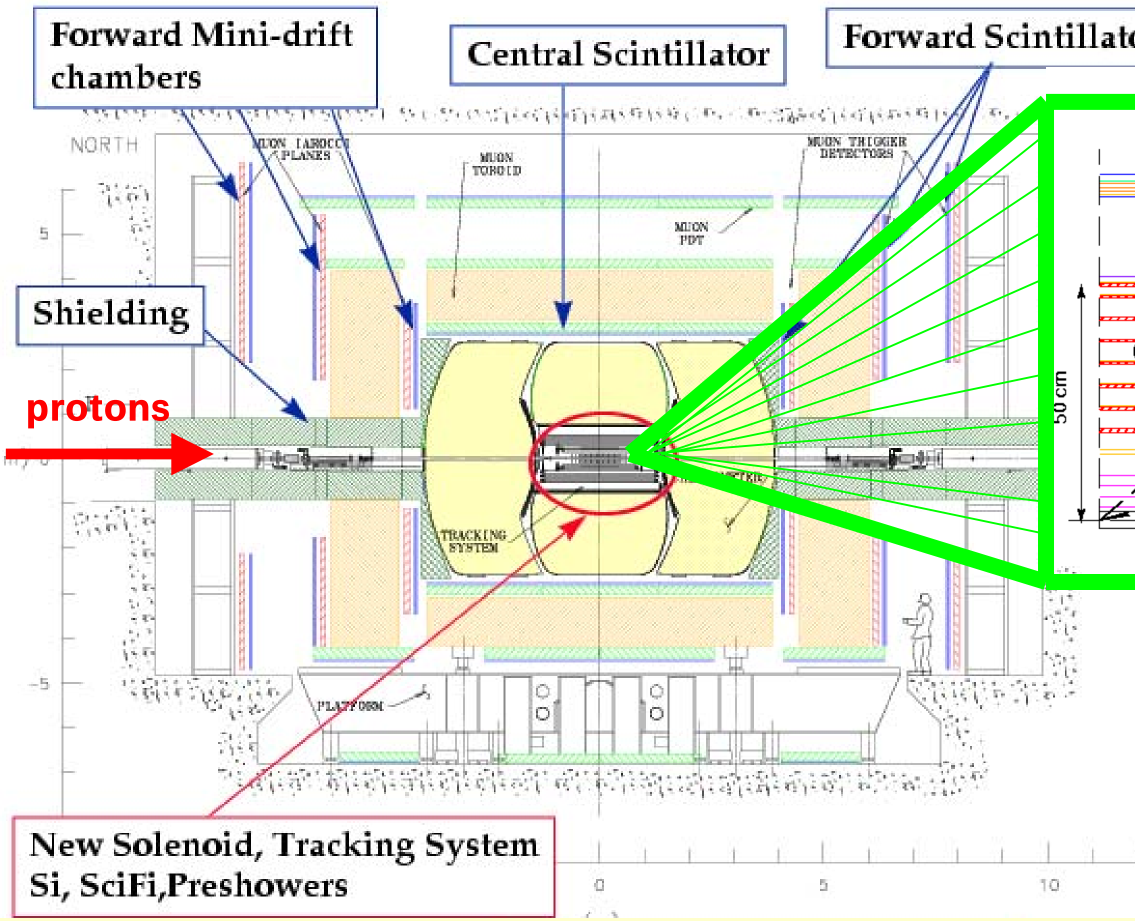
Efficiency here is the cumulative b-jet Efficiency:

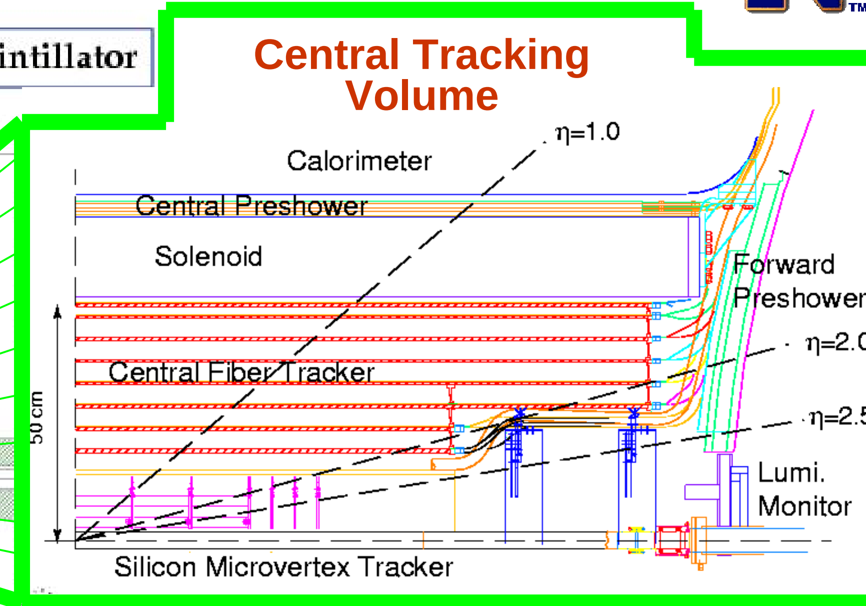
$$\varepsilon_{b-Jet} = \varepsilon_T \varepsilon_{PV} \varepsilon_{Jet} \varepsilon_{NNtag}$$

- The following has to be correctly applied to get the final answer
  - Jet $P_\perp$ correction
  - Jet resolution effects (unsmearing)

ε_T	Trigger Efficiency
ε_{PV}	Primary Vertex Eff
ε_{Jet}	Jet Efficiency
ε_{NNTag}	NN Tag Efficiency
L	Luminosity
$\Delta p_\perp$	$P_\perp$ bin width
σ_b	b cross section
$P_{b\text{-}Jet}$	Purity
$\varepsilon_{b\text{-}Jet}$	Combined Efficiency

A Brief DØ Run IIa Detector Overview





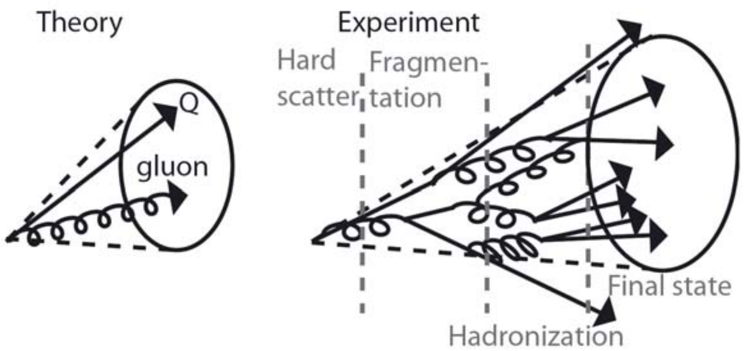
- Muon central and forward scintillator
- Muon central Proportional Drift Tubes (PDT's)
- Muon forward Mini-Drift Tubes (MDT)
- Forward Proton Detector (FPD)
- Shielding
- Front-end readout electronics, trigger, DAQ,…

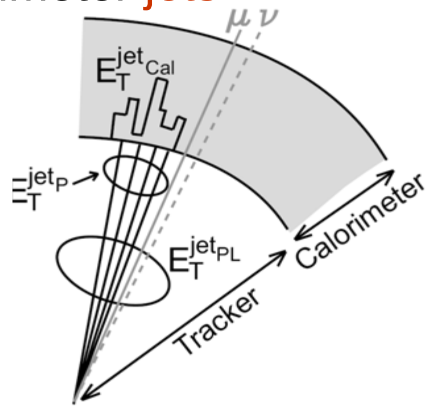
- Silicon Microstrip Tracker (SMT)
- Central Fiber Tracker (CFT)
- Superconducting Solenoid
- Central/Forward Preshowers (PS)
- Inter-Cryostat Detectors (ICD)

All Run IIa major DØ detector subsystems have undergone an extensive upgrades

Jets at DØ

- b-flavor cross Section measurement
  - What we can measure is calorimeter jets

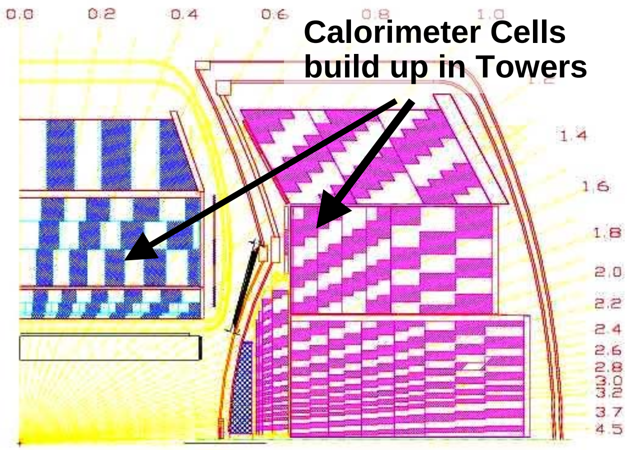




Calorimeter Jet Energy can be unfolded to particle level using Energy Scale

  - There are many algorithms do define jets, we put (η,ϕ) cone around, in this analysis $R_{cone} = 0.5$
  - Experimentally measured b-jets production rate, where jets contain one or more b or $\bar{b}$ quarks and their subsequent products
  - Jets containing b-flavor need to be "tagged"
- b-jet Tagging
  - One of the trickiest parts of analysis
  - A number of options

Jet Reconstruction

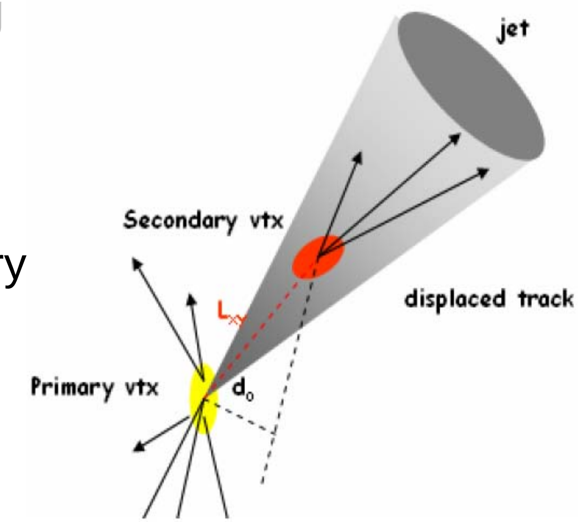


- Clustering of energy depositions in the calorimeter into "towers"
- Towers assembled in Jets
- Highest $E_{\perp}$ tower forms the "seed"
- Pre-clustering in a cone around the seed
- Put a final cone around, use all pre-clusters passed quality cuts
- Direction calculated, all energy deposits included

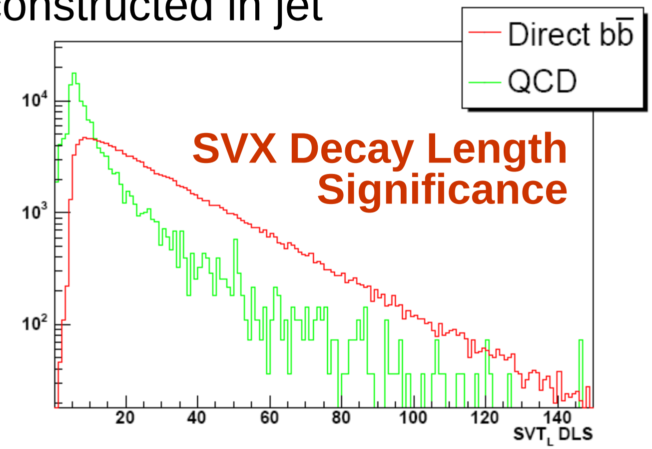
b-Jet Id with the Neural Net

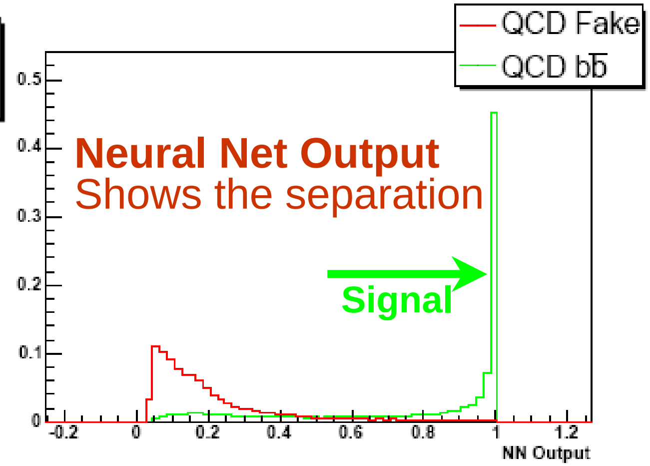
- Tagging exploits certain signatures of heavy flavor production
  - ❖ Many options: μ in jet (10%), jet lifetime probability, etc.
  - ❖ In this analysis a Neural Net is used
- NN uses 7 parameters that have b-flavor distinguishing power (ranked):
  - ❖ Secondary vertex (SVX) decay length significance
  - ❖ Signed impact parameter combined tagging variable
  - ❖ Jet lifetime probability - of all tracks originate at primary vertex (PV)
  - ❖ Primary vertex χ^2/dof
  - ❖ N tracks attached to a PV
  - ❖ Number of tracks used to make a SVX
  - ❖ Number of SVX's reconstructed in jet

Secondary Vertex



- These are some distributions showing the separation and NN output





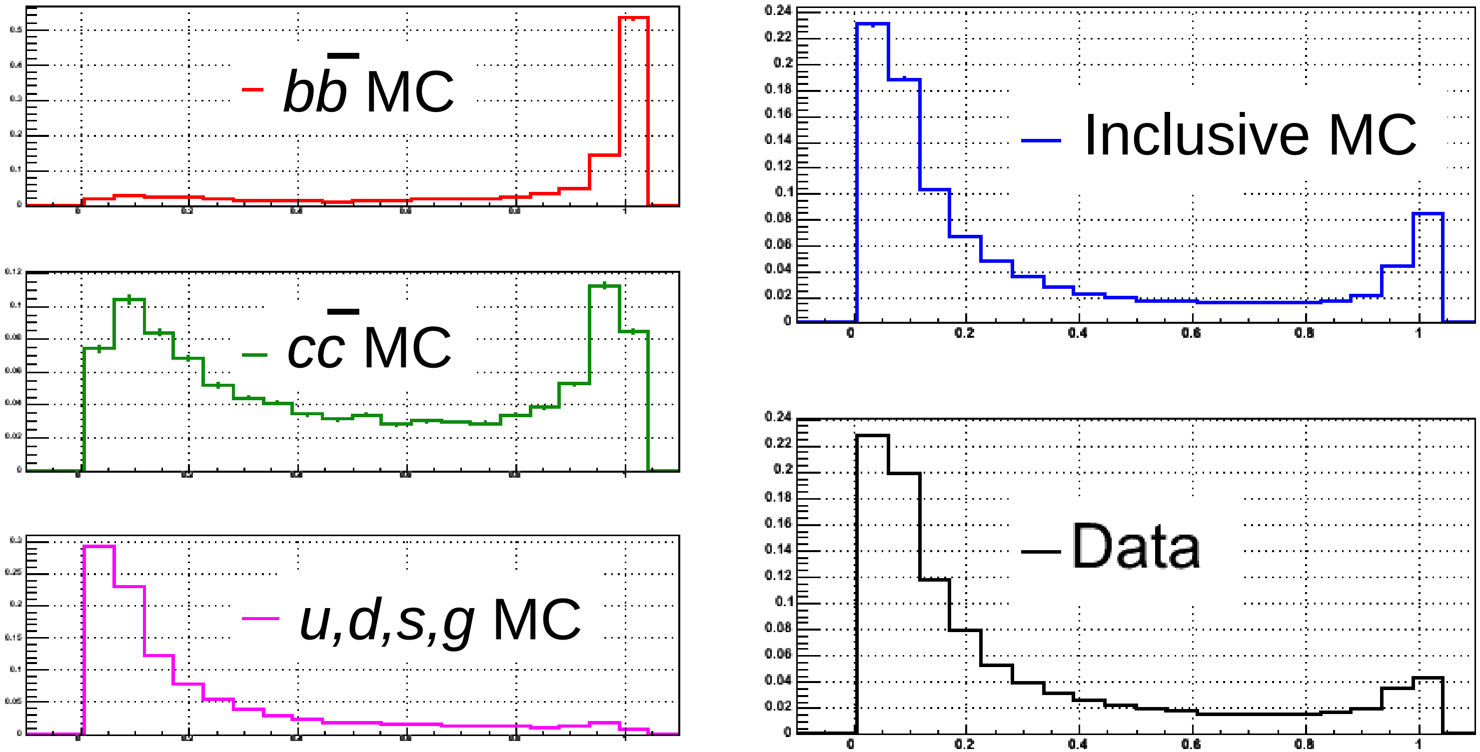
Brief Dataset Description

- Working with DØ Run IIa inclusive jets data
  - ✓ **43,681,935** events total
  - ✓ Luminosity Summary:

Delivered	Recorded	Recorded w/good data quality
426.5 pb^{-1}	**381.9 pb^{-1}**	**312.3 pb^{-1}**

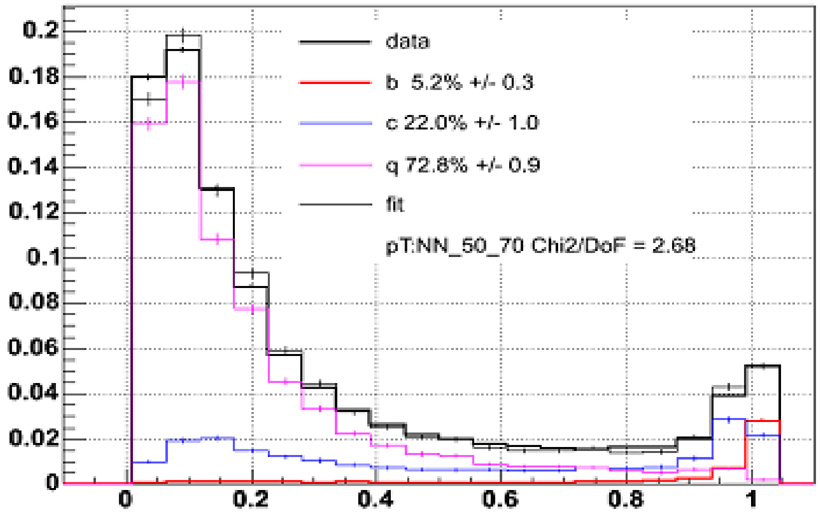
  - ✓ Quality for the detector: removed bad data and duplicate events (~18 % reduction factor)
- Require Jet Triggers
  - ✓ $P_{\perp}$ trigger threshold values: 8, 15, 25, 45, 65, 95 and 125 GeV
- Require at least 2 jets in each event
- Inefficient Trigger cuts (each of the triggers to be > 99% efficient)
- $|y| < 0.8$ (look at central jets)
- Used the NN tagger, requiring in each event either one of the two leading jets have a non-zero NN variable output

NN b-tagging, Purity Determination



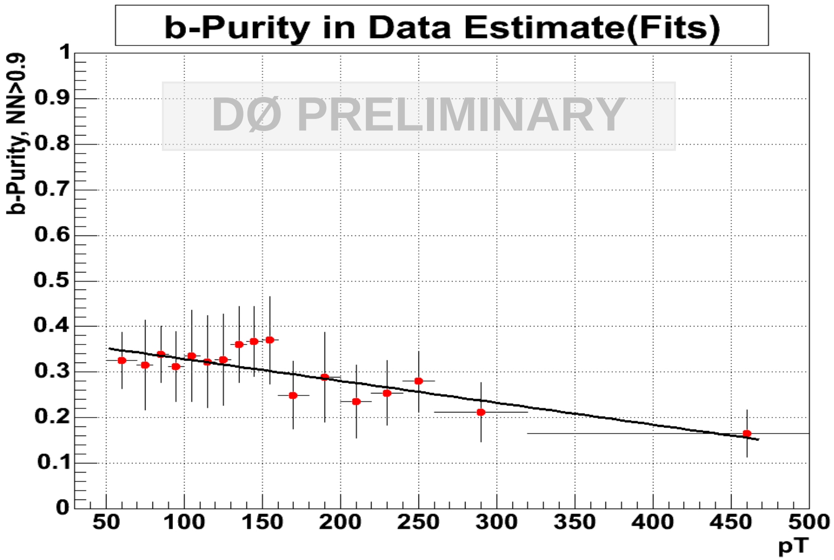
NN Output template shapes for MC and Data

- Use the Neural Net to get templates for b, c, and uds(g) flavors
- Use NN output to fit for fractions to get purity
- I do not cut on NN variable for now, but make MC templates, and fit for fractions, then place the cut



- Fit in 17 $P_\perp$ bins
- MC templates are $p_\perp$-specific to each bin
- I do not cut on NN variable for now, but make MC templates, and fit for fractions
- Place a NN>0.9 cut

Some sample fits examples in Data, NN existence

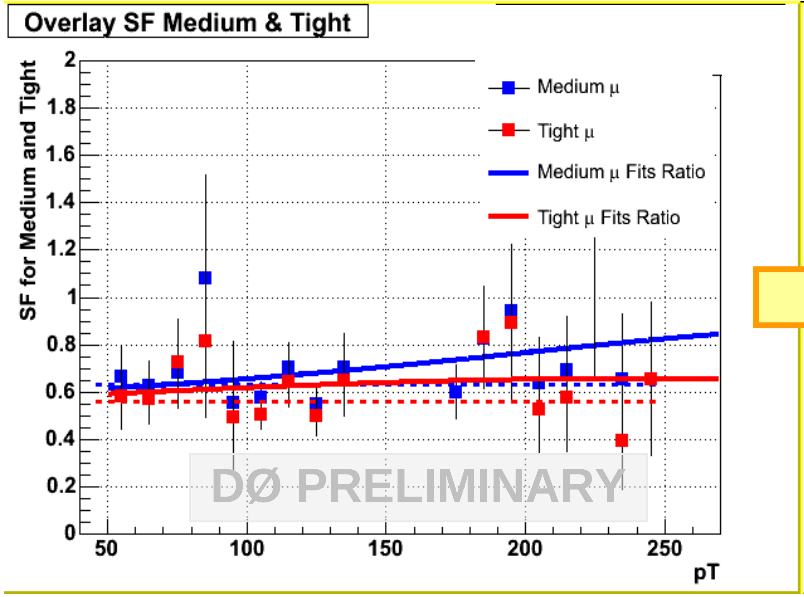


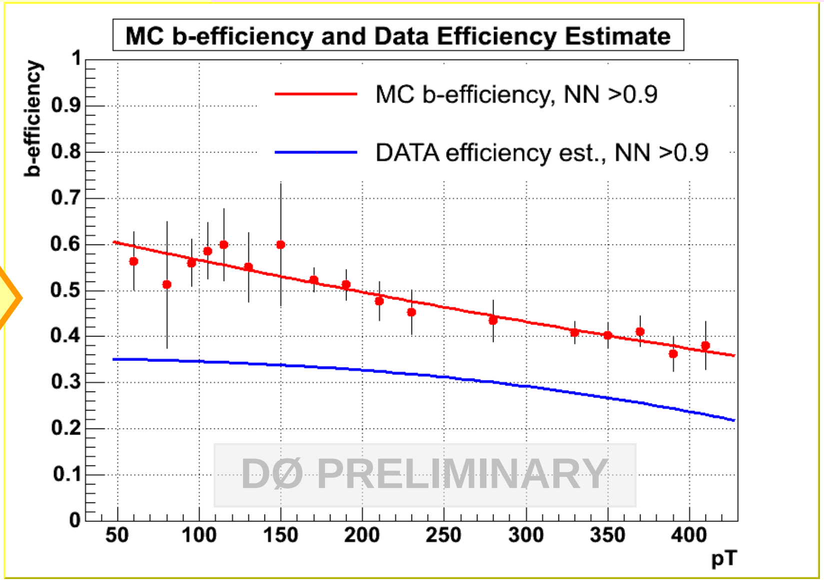
- Fit over all $P_\perp$ ranges (17 ranges)
- Calculate b-fraction w/NN>0.9 cut
  - ❖ Strategy to determine the uncertainty
  - ❖ Fit with different settings and starting points to ensure stability

Efficiency and MC/Data Scale Factor

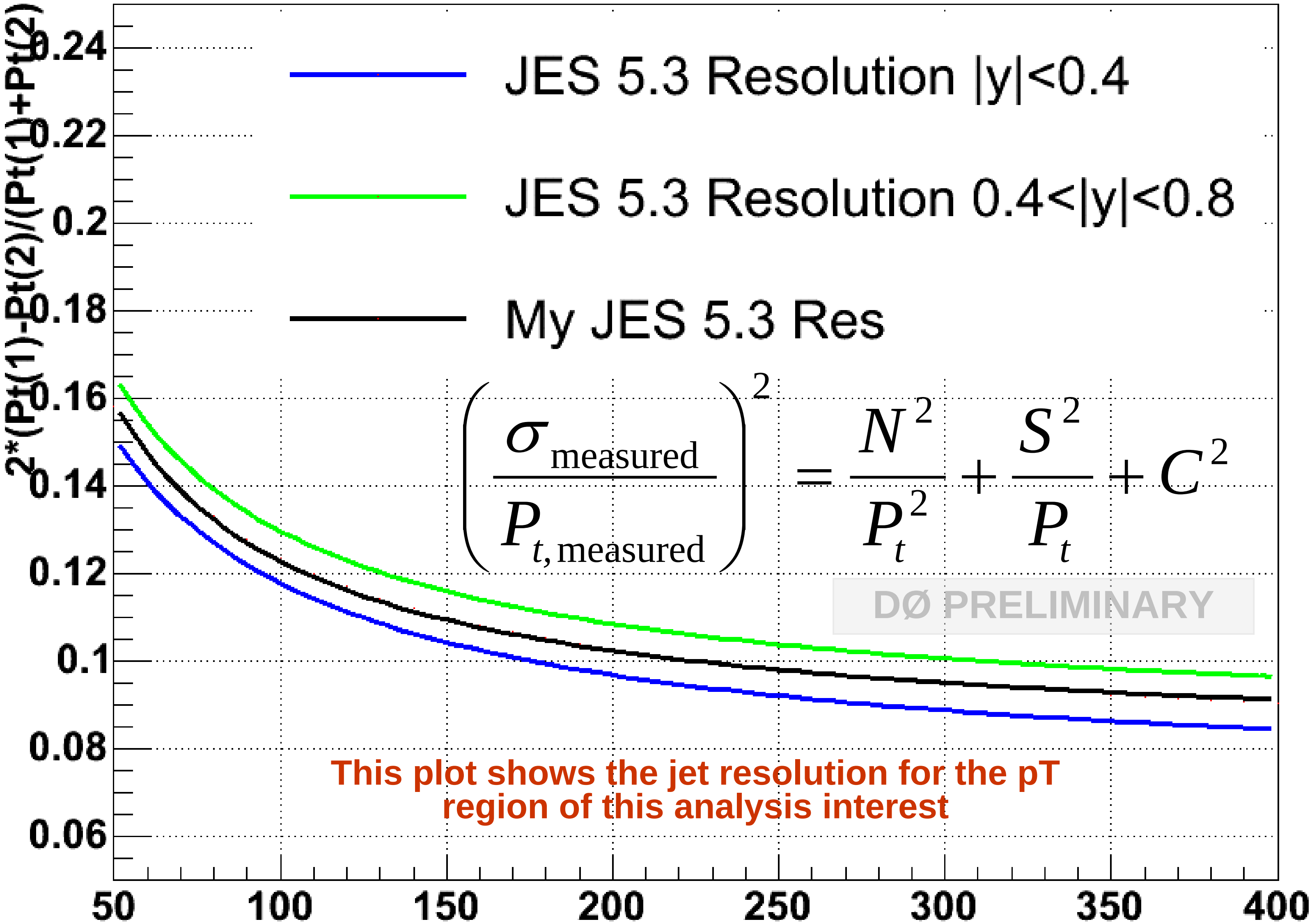
- Efficiency of b-tagging is based on MC
- Efficiency is NOT expected to be the same in data
  - No one before worked with NN at this kinematic range, so no tag rate functions to use to get the efficiency
  - Come up with the scale factor (SF) myself to correct MC to data
  - The presence of a muon as an independent fraction-changing cut is exploited

- Using two distinct muon quality settings, we determine SF's between MC and Data
- Take the tightest setting, and the loosest one estimates the uncertainty





Jet resolution



$$\left(\frac{\sigma_{\text{measured}}}{P_{t,\text{measured}}}\right)^2 = \frac{N^2}{P_t^2} + \frac{S^2}{P_t} + C^2$$

Unsmearing: Taking Out Resolution Effects

A brief outline of the procedure

- The observed spectrum can then be written as:

$$F(p_\perp) = \int_0^{\frac{\sqrt{s}}{2}} dp'_\perp \cdot f(p'_\perp) \cdot G(p'_\perp - p_\perp, p'_\perp)$$

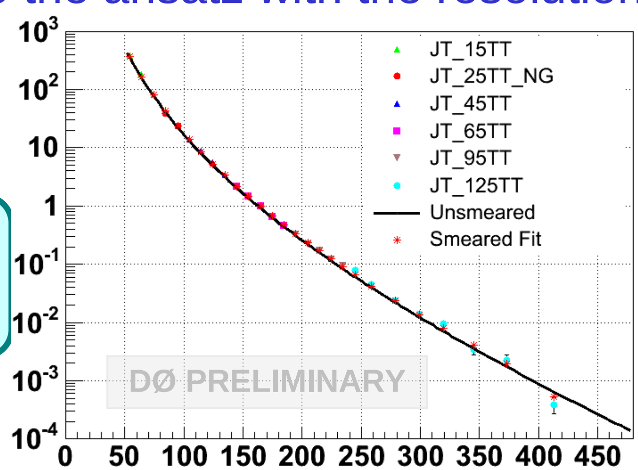
  – The smearing function is assumed to be a Gaussian

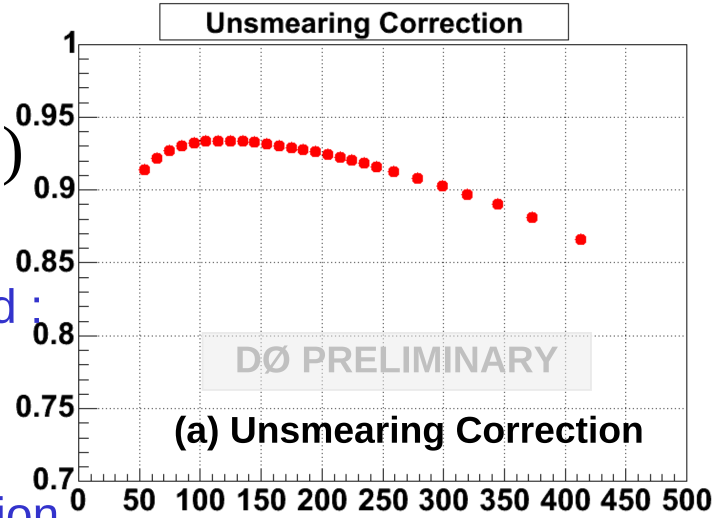
- The particle level truth function can be parameterized :

$$f(p_\perp) = f_3(p_\perp; N, \alpha, \beta) = N \cdot p_\perp^{-\alpha} \cdot e^{-\frac{p_\perp}{\beta}}$$

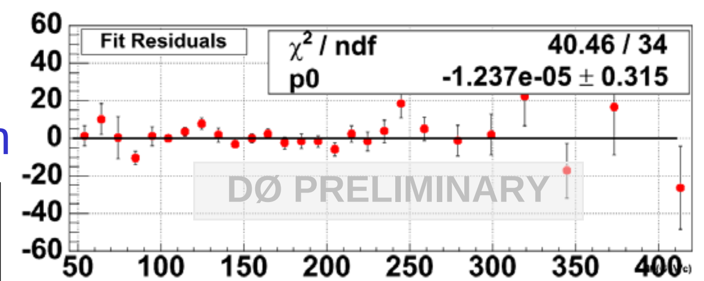
- Idea is to insert this function into the smearing equation and minimize the difference between the smeared equation and the data
- The data was then fit to the ansatz with the resolution function folded in
- This fit is shown:

$$RESCorr = \frac{\text{"Truth"}}{Smeared(Fit)}$$





(a) Unsmearing Correction



(b) Fit Residuals

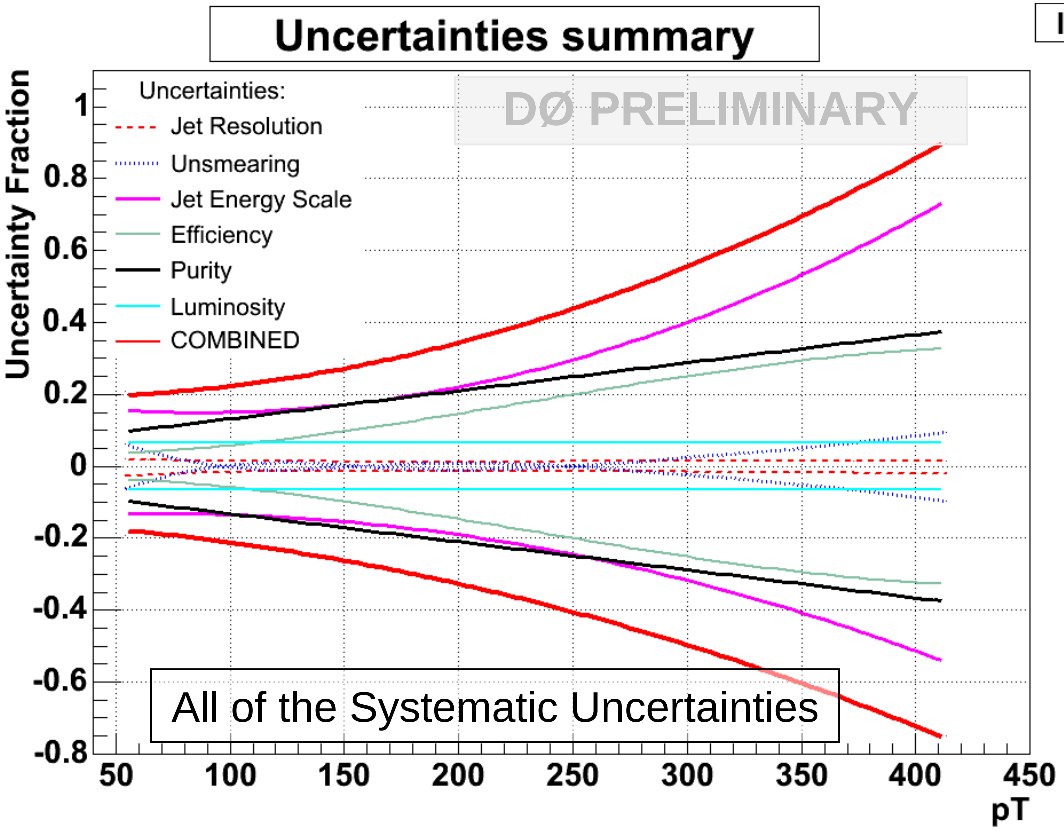
Correct the data by the ratio of $f(p_t)/F(p_t)$ and determine the corrected and unsmeared result

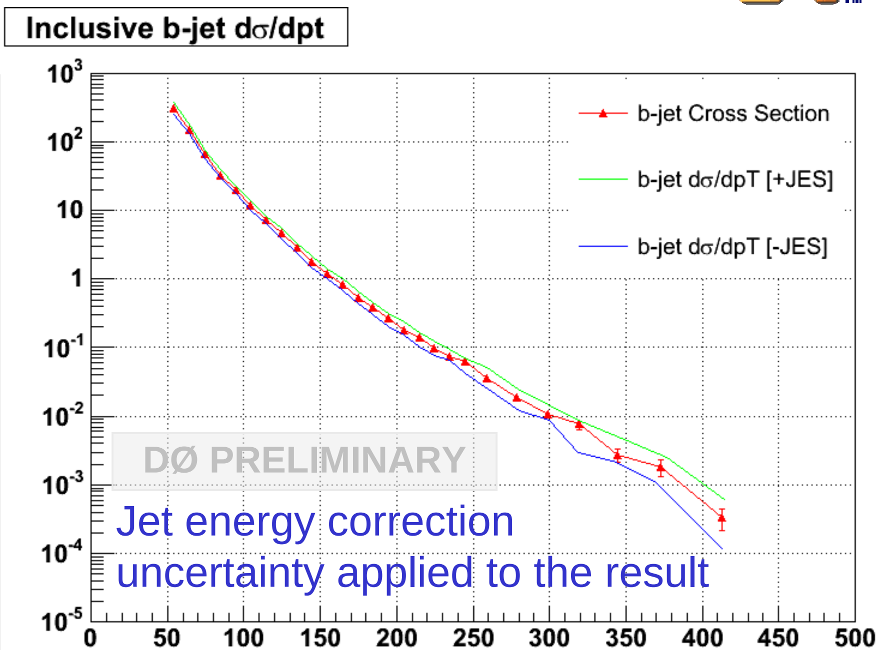
Uncertainties Summary

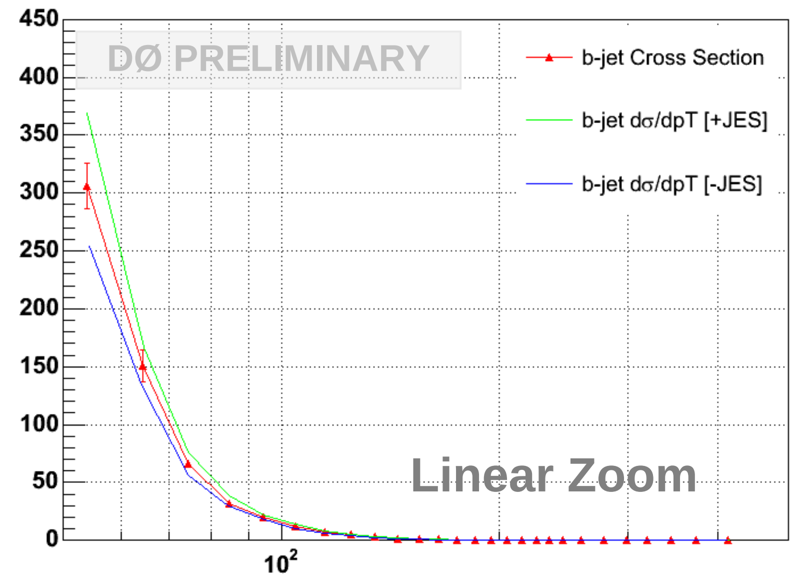
$$\frac{d\sigma}{dp_\perp} = \frac{N}{\Delta p_\perp \cdot L} \cdot \frac{Efficiency}{Purity} \cdot RESCorr$$

- Δ L = 6.5% independent of $P_\perp$
- Δ Jet Energy Correction: vary JEC±(1σ) and re-run analysis with these values
- Δ Unsmearing: Use the different fitting ansatz function
- Δ Jet Resolution: Vary the Resolution curve within errors, and propagate the result into the cross section answer
- Δ Efficiency
  - Δ Scale Factor MC/Data: Vary Muon Quality
  - Δ Kinematic Cuts (PVz, NN cut, RECO, Jet Quality): known, very small as because of the Neural Net requirement
  - Δ Trigger Efficiency: taken as defined, very high ~100%

Summary of the Uncertainties

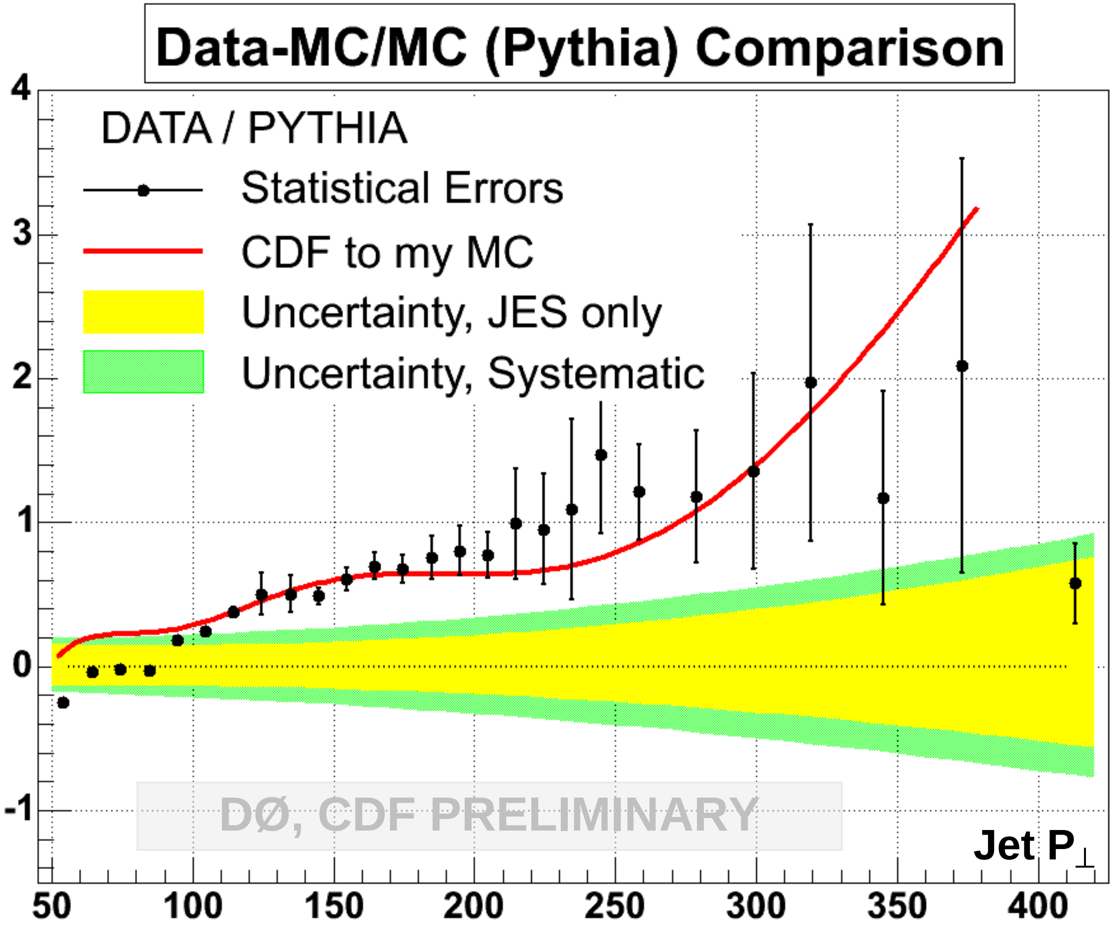






- The dominating systematic uncertainties:
  - ❖ Jet energy correction
  - ❖ Purity (Fitting Procedure) systematics
  - ❖ Efficiency (Scale Factor) determination
- The largest contribution is Jet energy correction

Comparison to Theory and Experiment



- Work is in progress
- Proper comparison can be made only when the same jet algorithm applied to Monte Carlo (A complicated task)
- Time limitations
- MC b-jet cross section is obtained out of inclusive Pythia simulations
- No good agreement was observed
- CDF has done similar preliminary analysis measuring b-jet cross section
  - ❖ CDF result curve has been parameterized and compared to my MC sample

❖ Results show to agree reasonably with the CDF measurement
❖ Both DØ and CDF results are in disagreement with my MC
❖ More work is being done on MC

Summary of the Analysis

- Measurement of high-$p_\perp$ b-jet differential cross section at DØ is well advanced
- The preliminary measurement agrees with CDF preliminary results
- The data to Monte Carlo comparison does not agree
  - Monte Carlo simulation needs work and being fixed
- Related analyses with approximately twice the data will be ready soon