



Probing low-x with Drell-Yan events at LHCb

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For the LHCb collaboration

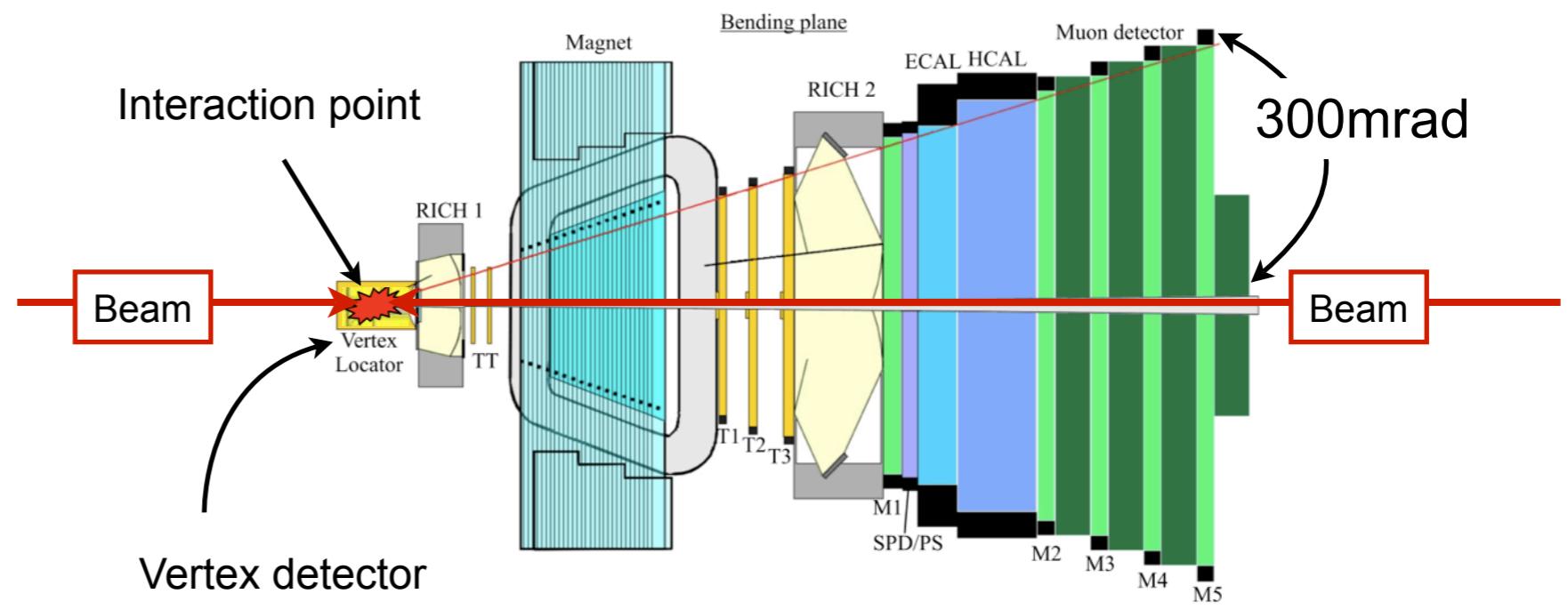
LHCb: a forward spectrometer

Key features:

- Fully instrumented at high rapidities
 - Overlap region with Atlas/CMS ($1.9 < \eta < 2.5$)
 - High rapidities unique to LHCb ($2.5 < \eta < 4.9$)
- Can reconstruct & trigger on low P muons:
 - Reco: $P > 3\text{GeV}$ & $P_T > 0.5\text{GeV}$
 - Trigger: $M_{\mu\mu} > 2.5\text{GeV}$ & $\sum P_T > 1.5\text{GeV}$

Ready for data-taking

300pb^{-1} expected in 2010

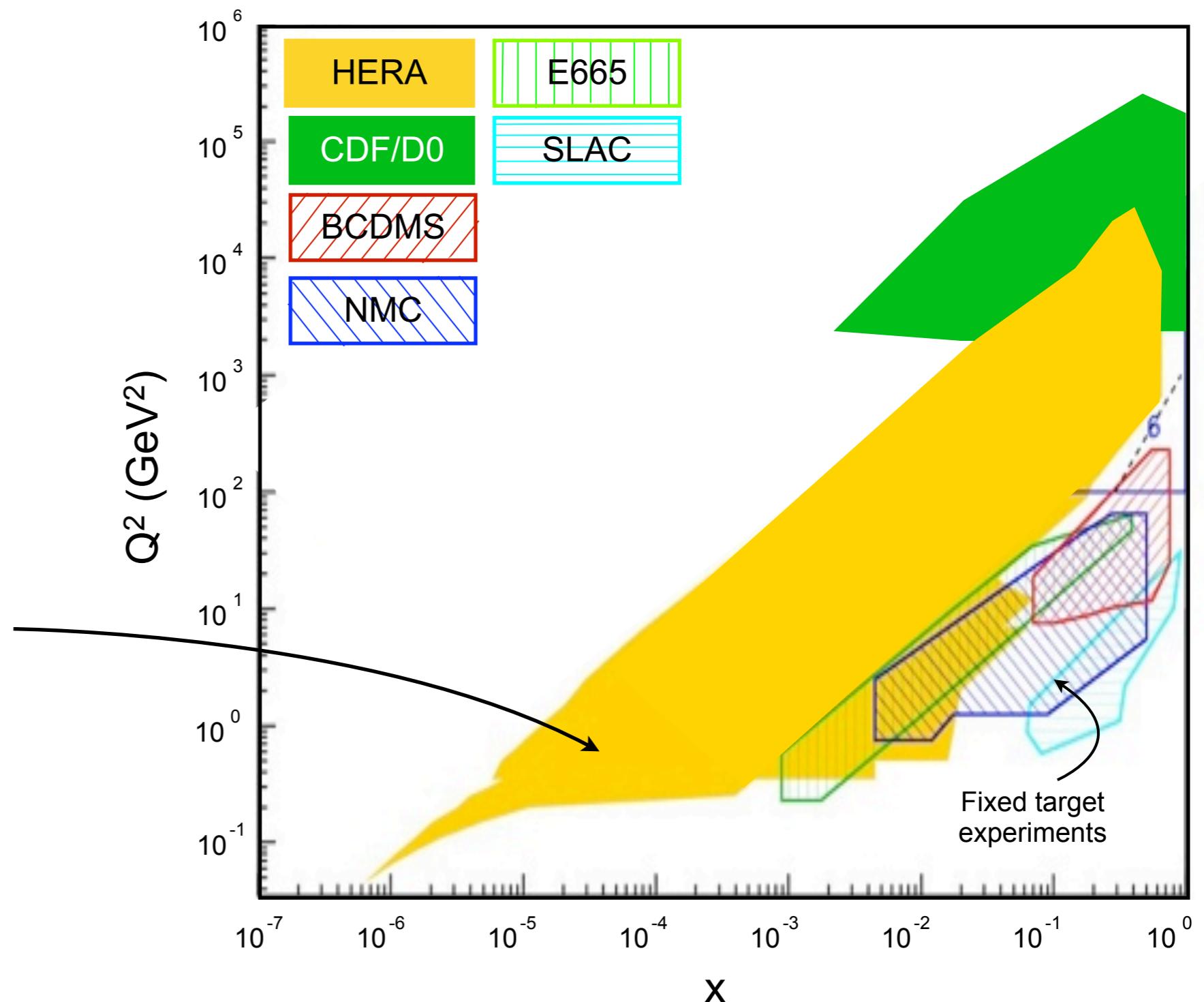




Motivation

Partons: current measurements

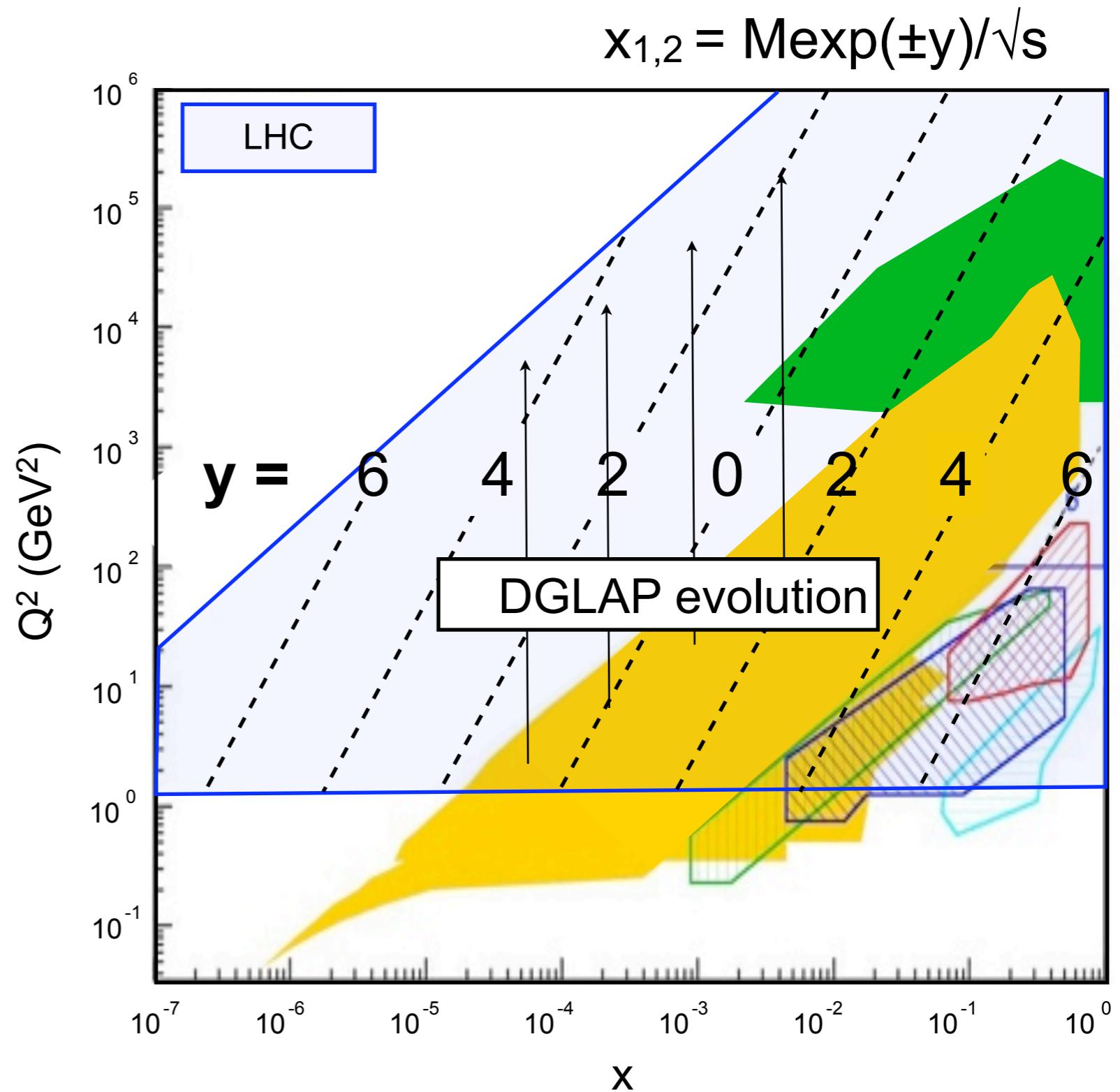
To date low- x only
probed by HERA



Partons at the LHC

Partons must be evolved using DGLAP equations

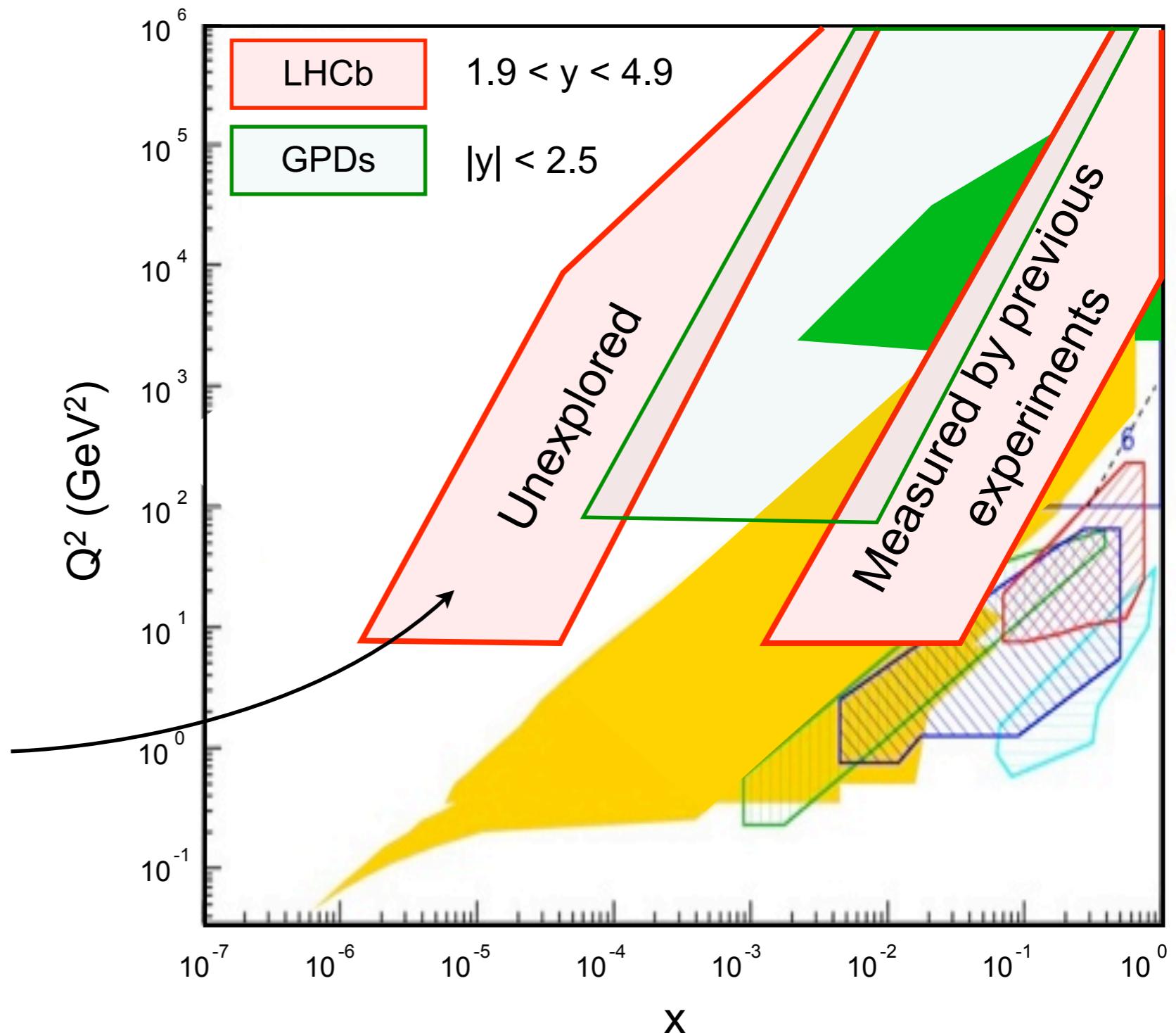
The kinematic region at LHC extends to higher Q^2 and lower x than previous experiments



Regions fully instrumented at LHCb and GPDs

Events at LHCb will probe 2 distinct regions.

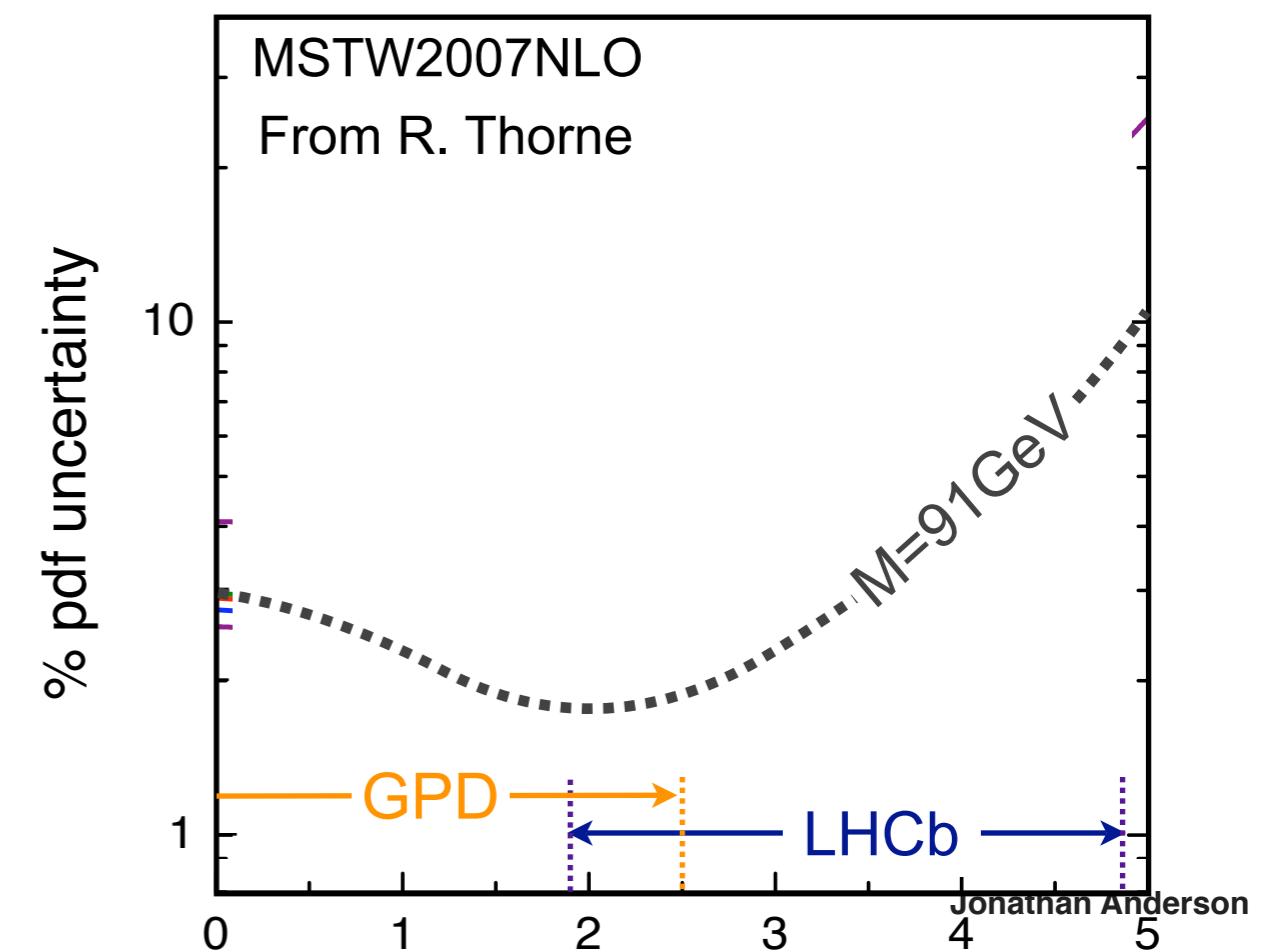
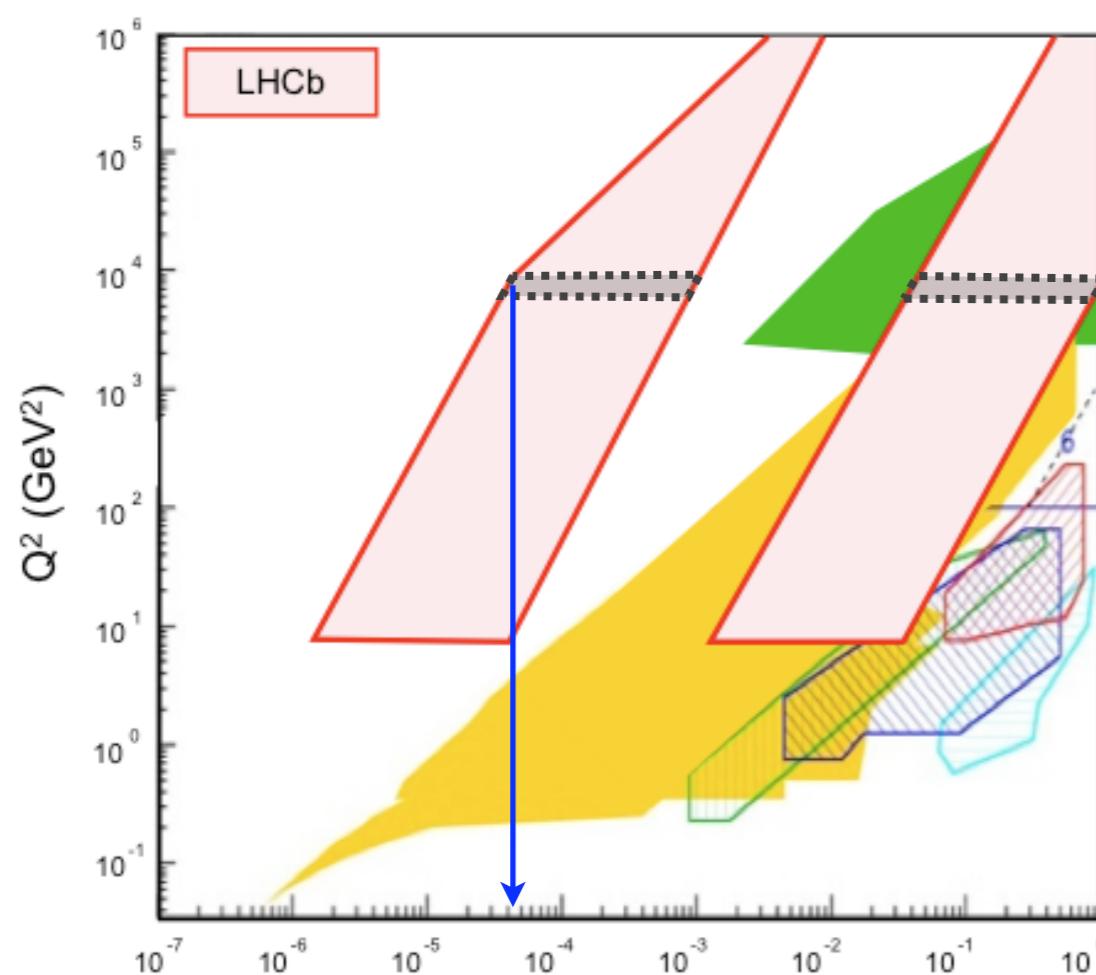
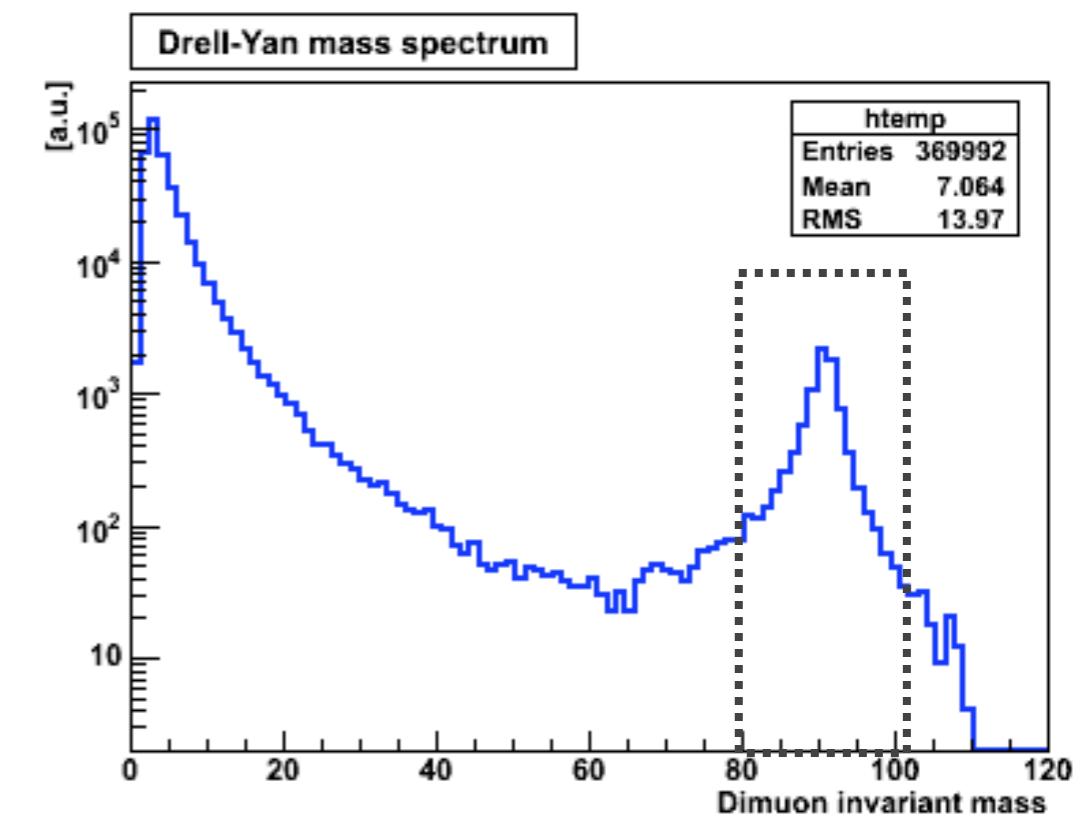
Due to angular acceptance and low trigger thresholds events at LHCb access low-x and low-Q²



PDF uncertainties on DY at LHCb

At Z mass:

- Reach $x = 5 \times 10^{-5}$
- Uncertainty $\sim 2\text{-}3\%$
- Lowest at $y = 2$
- $>6\%$ at large y



DY measurement at the Z mass

see talks by F. De Lorenzi
and S. Traynor for more

Selection:

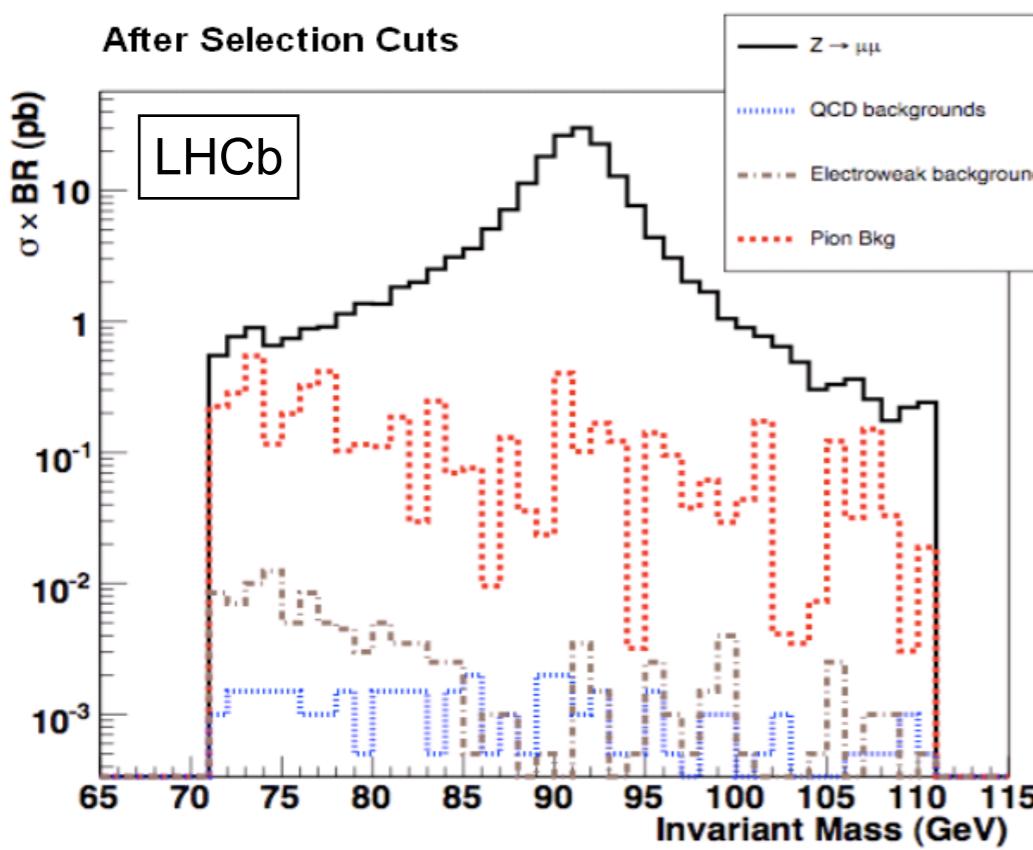
Robust

- based on muon IP and momentum

Purity > 97%; Efficiency ~90%

Trigger & reco efficiency ~80%

Systematics small ($O(1\%)$)



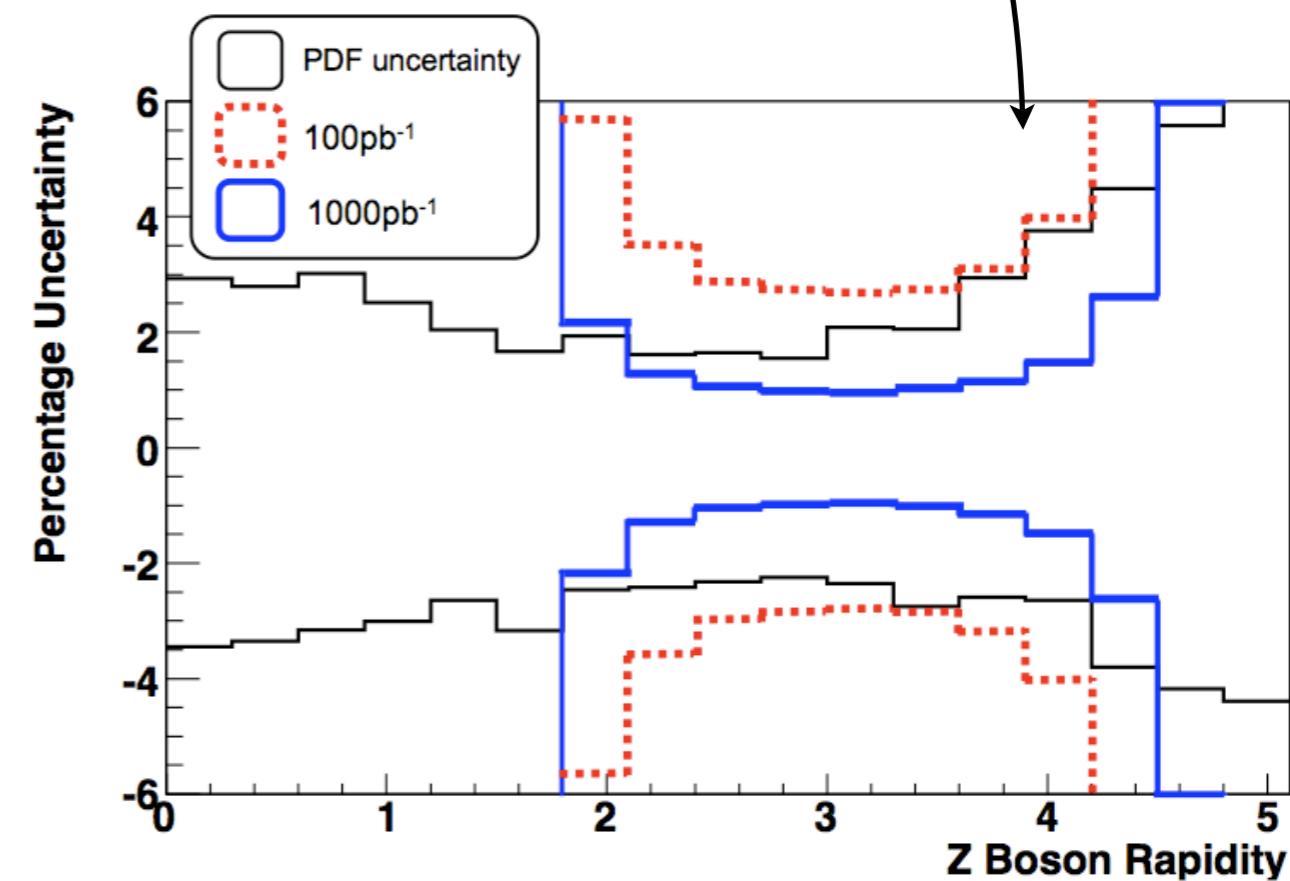
Useful for:

Luminosity measurement

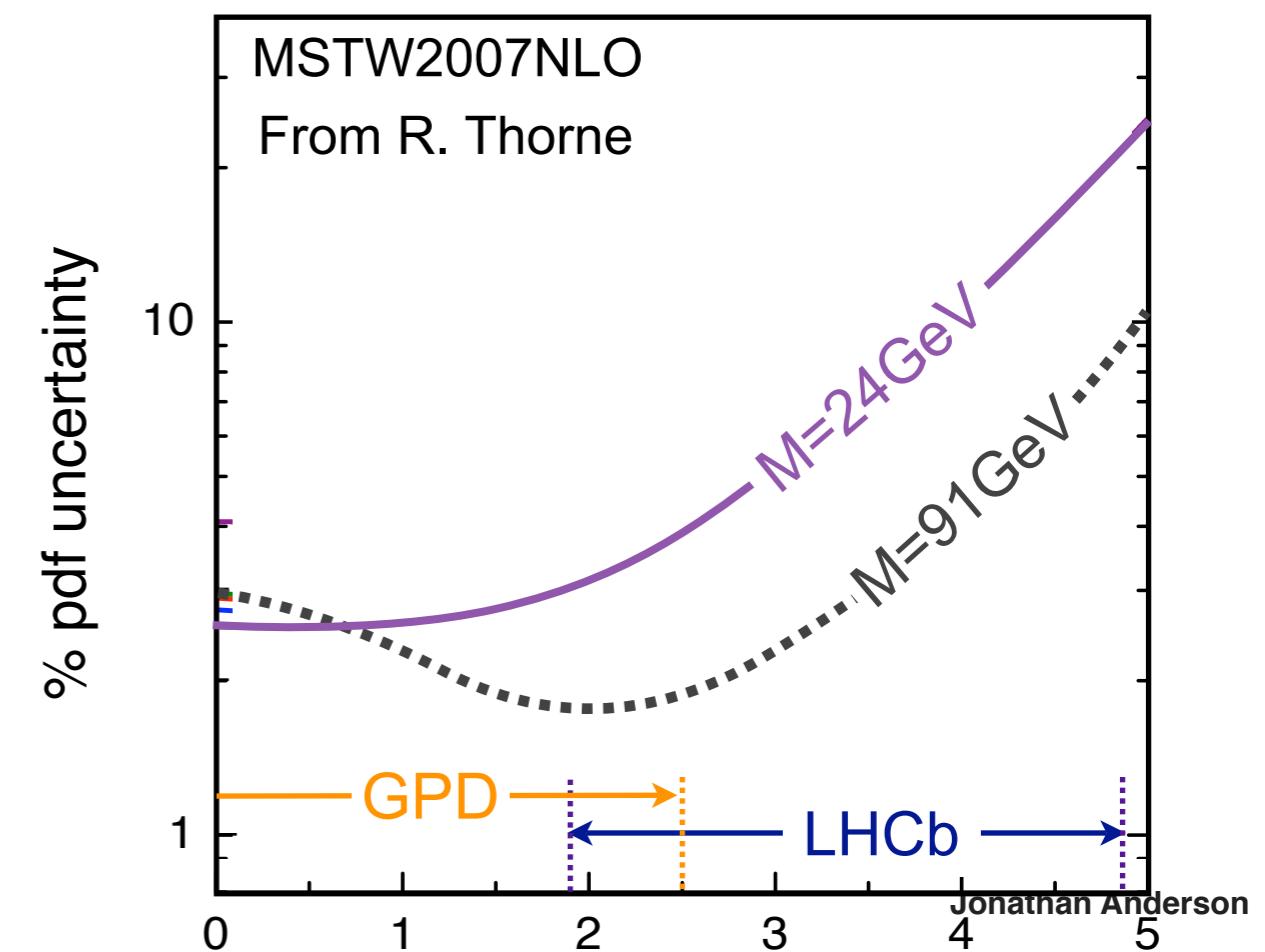
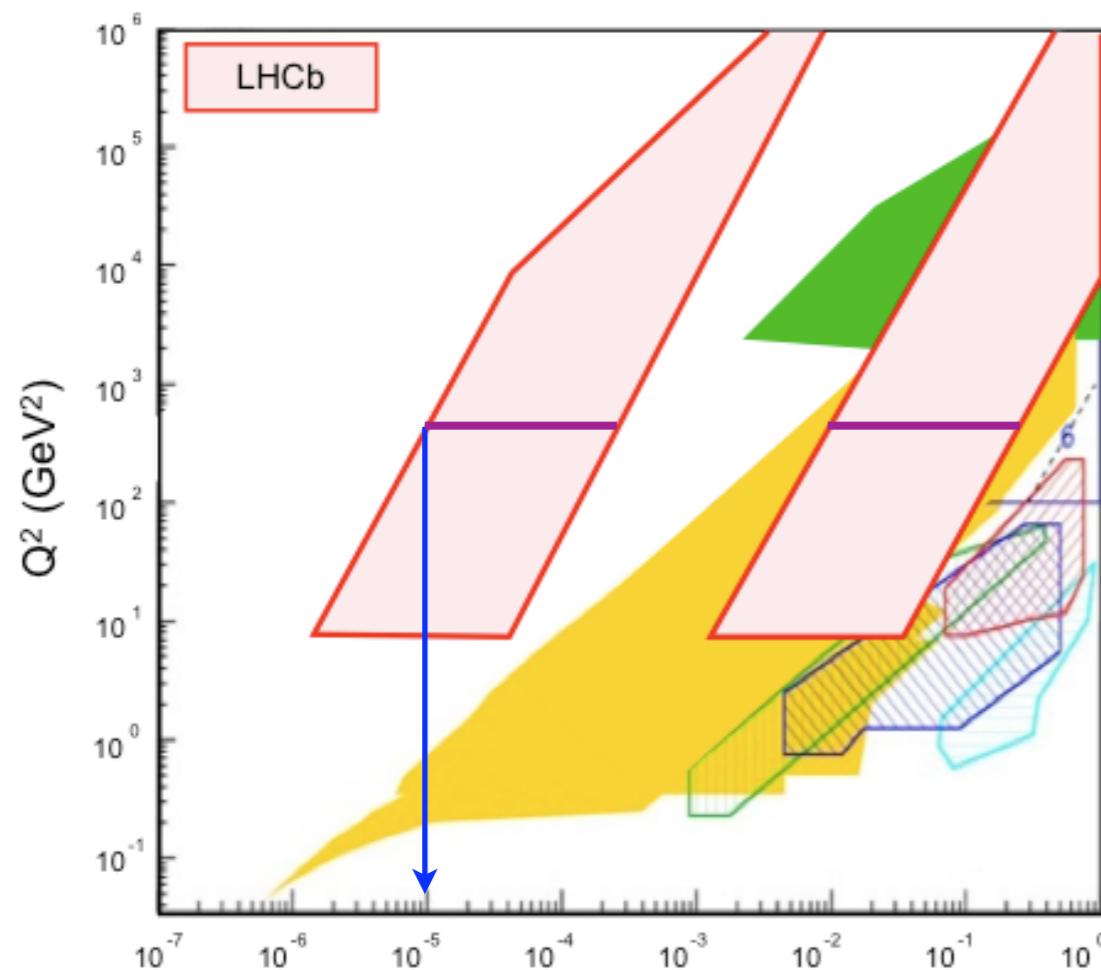
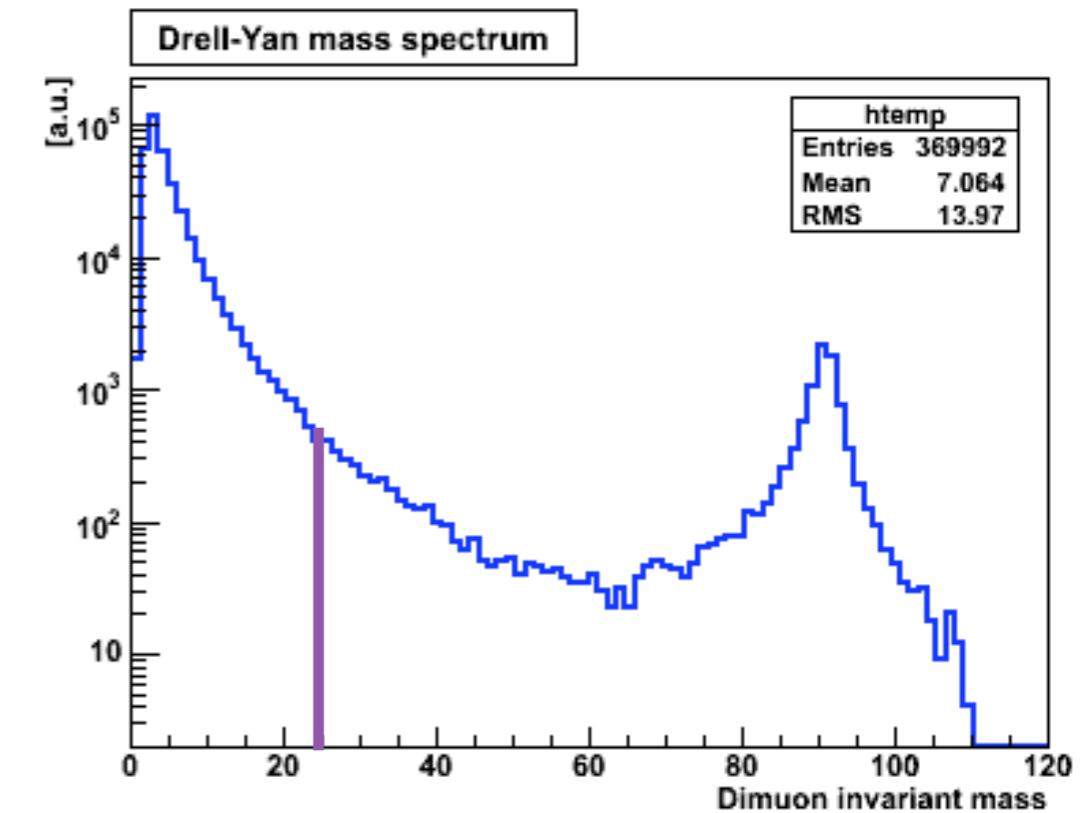
Testing QCD

Constraining pdfs

(down to $x = 5 \times 10^{-5}$)



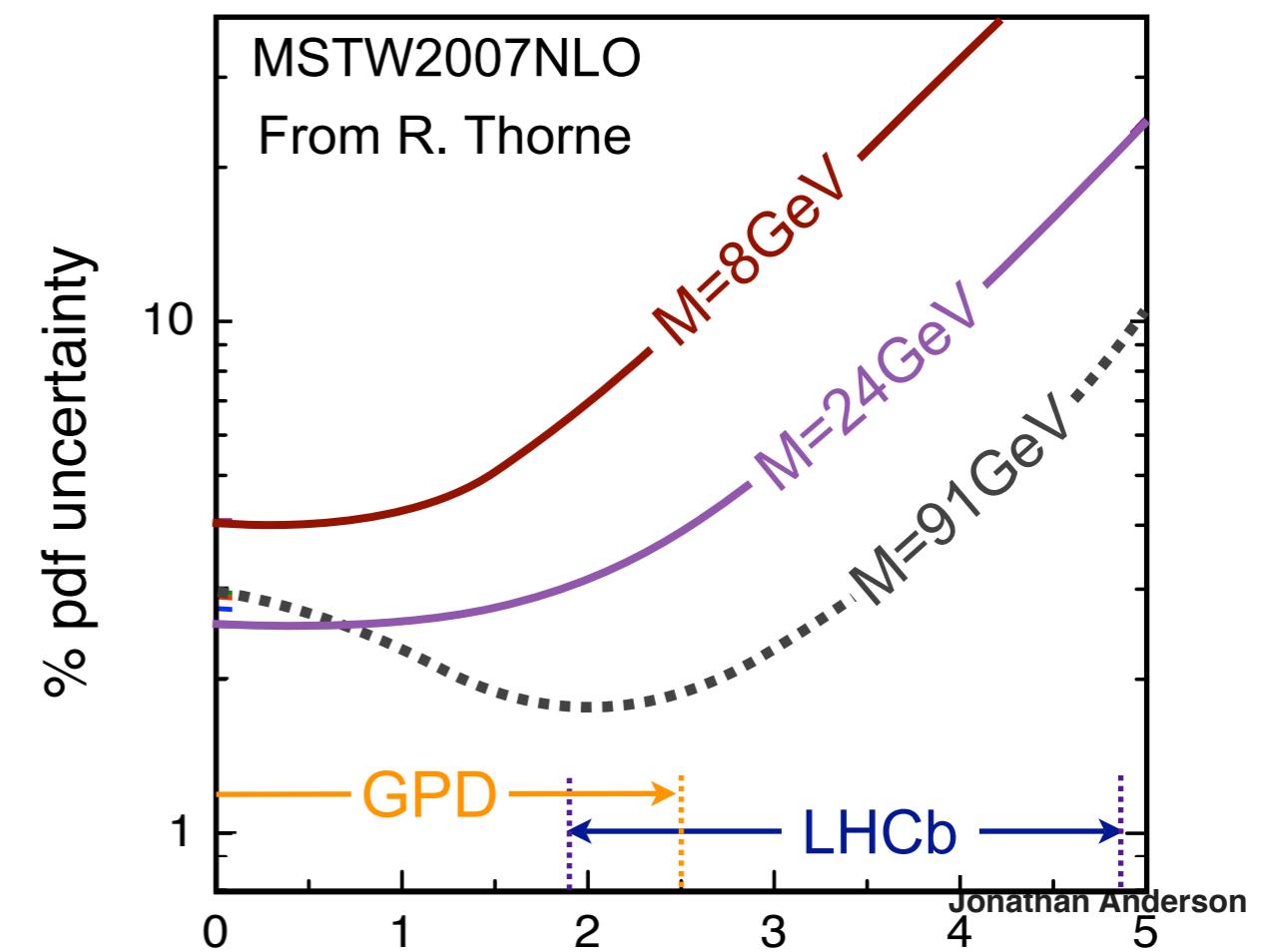
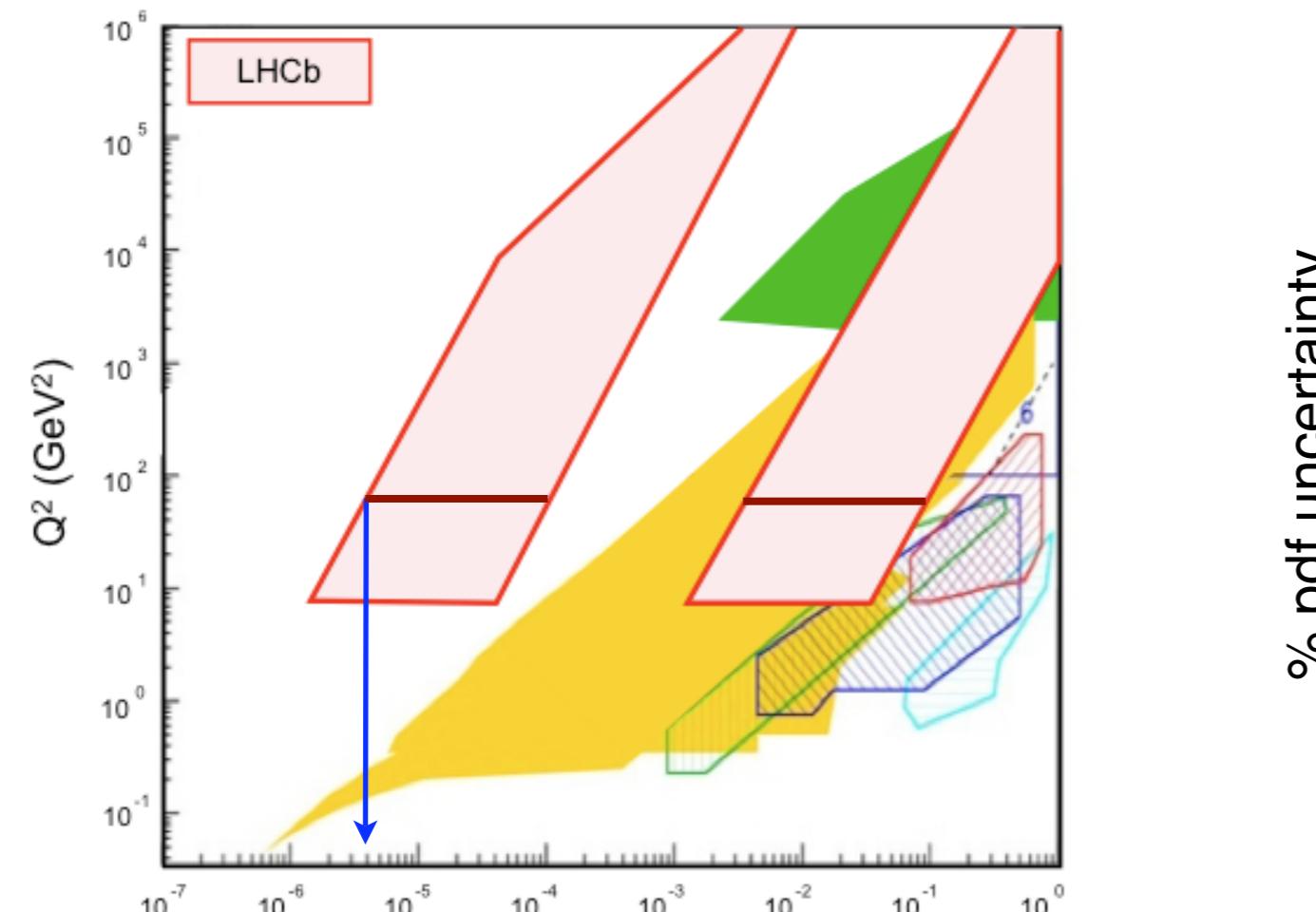
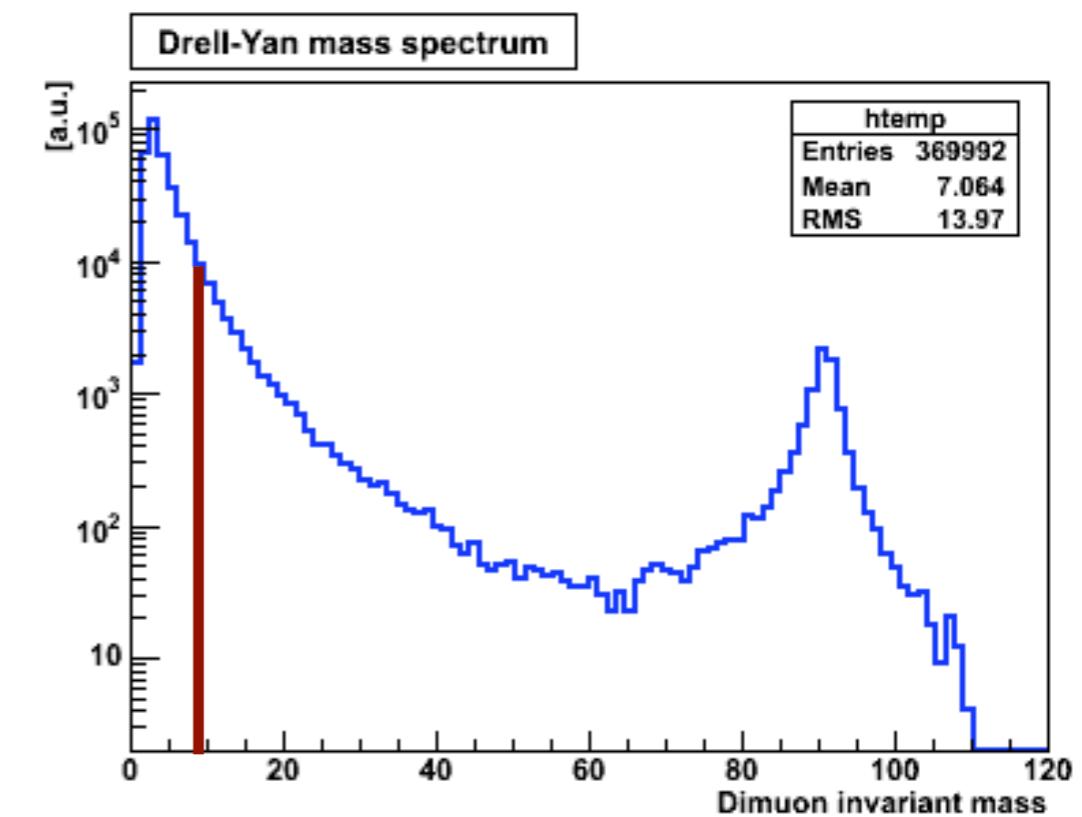
PDF uncertainties on DY at LHCb



PDF uncertainties on DY at LHCb

PDF uncertainty increases for lower masses and higher rapidities

Due to acceptance and lower trigger thresholds, a measurement of low mass DY events at LHCb can constrain PDFs substantially



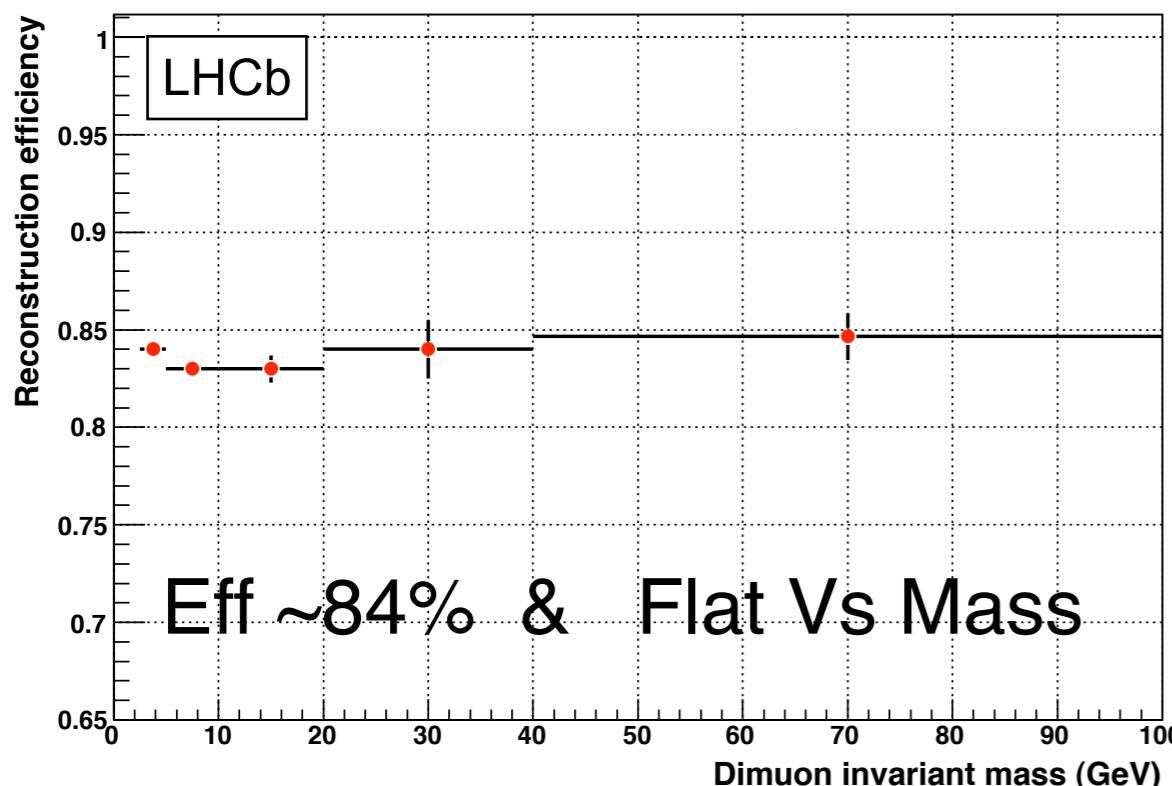


Low mass DY events at LHCb

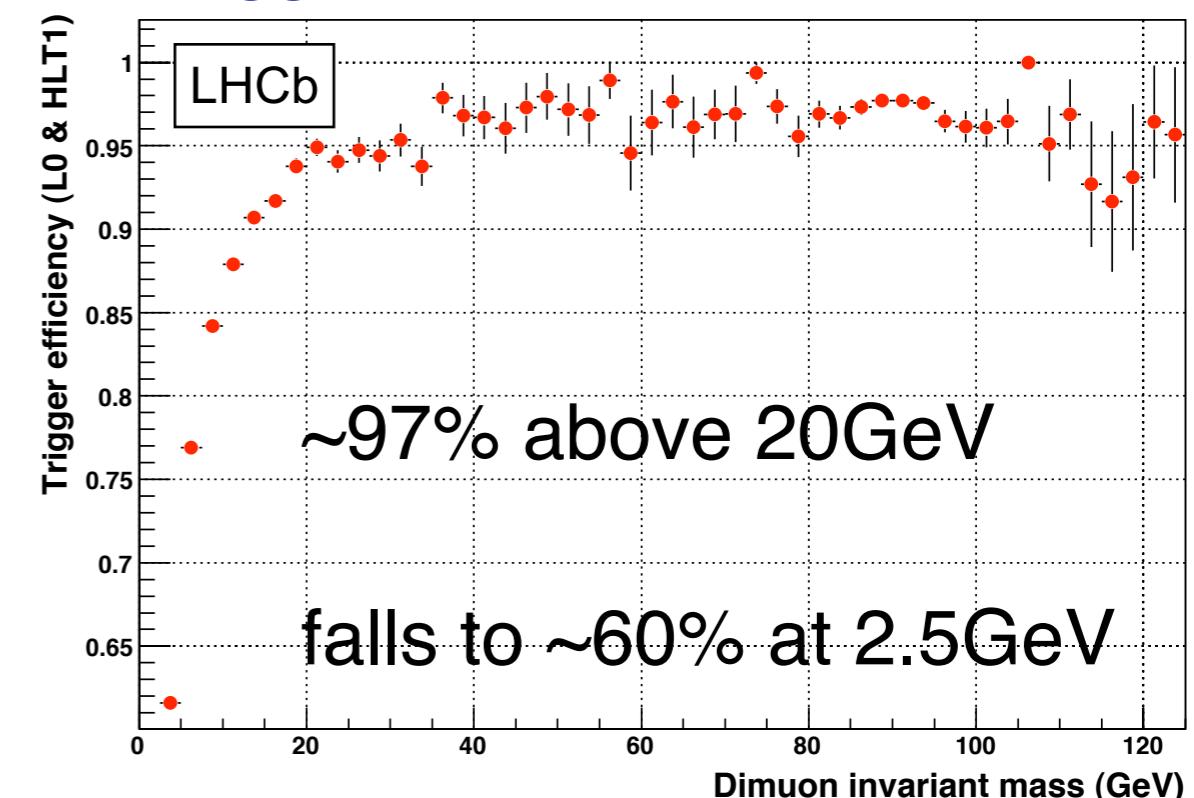
Drell-Yan efficiencies at LHCb

For DY events with two muons inside $1.9 < \eta < 4.9$

Reconstruction



Trigger



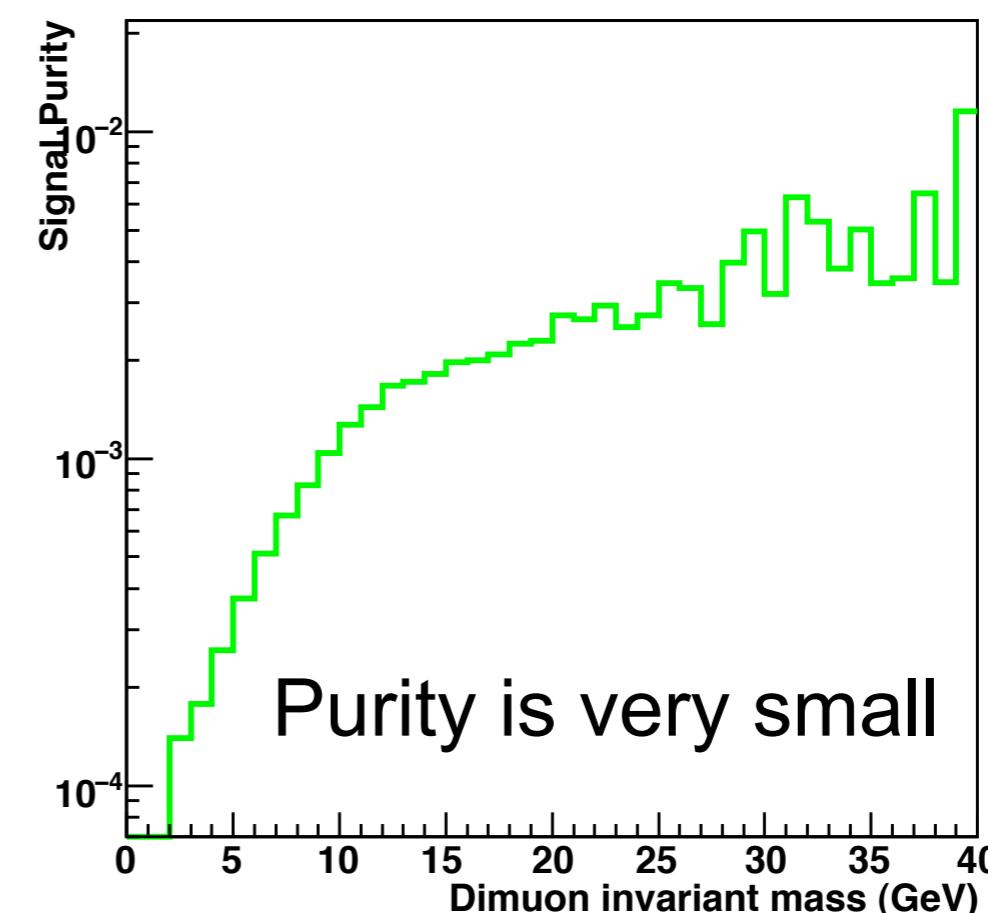
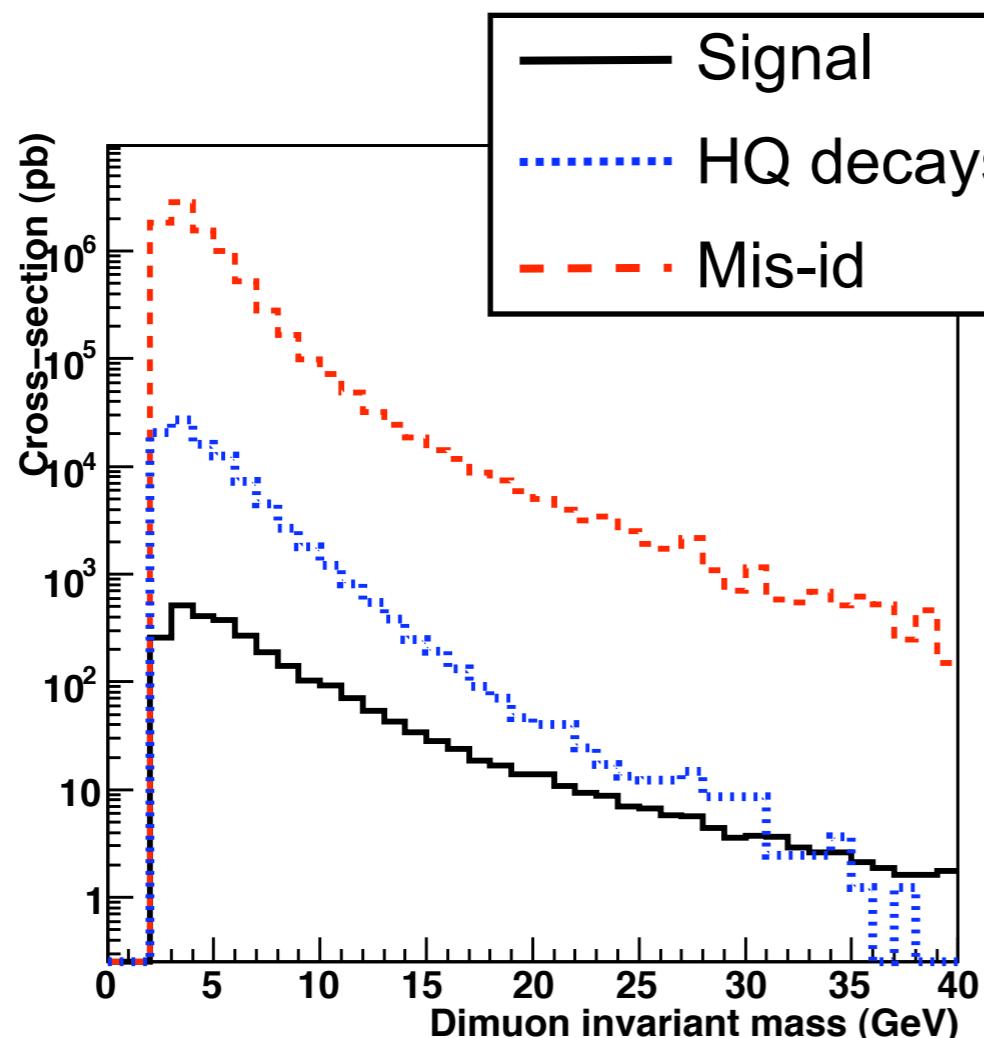
Efficiencies can be accurately assessed using resonances
(J/Psi, Upsilon, Z)

Background rejection

Backgrounds examined:

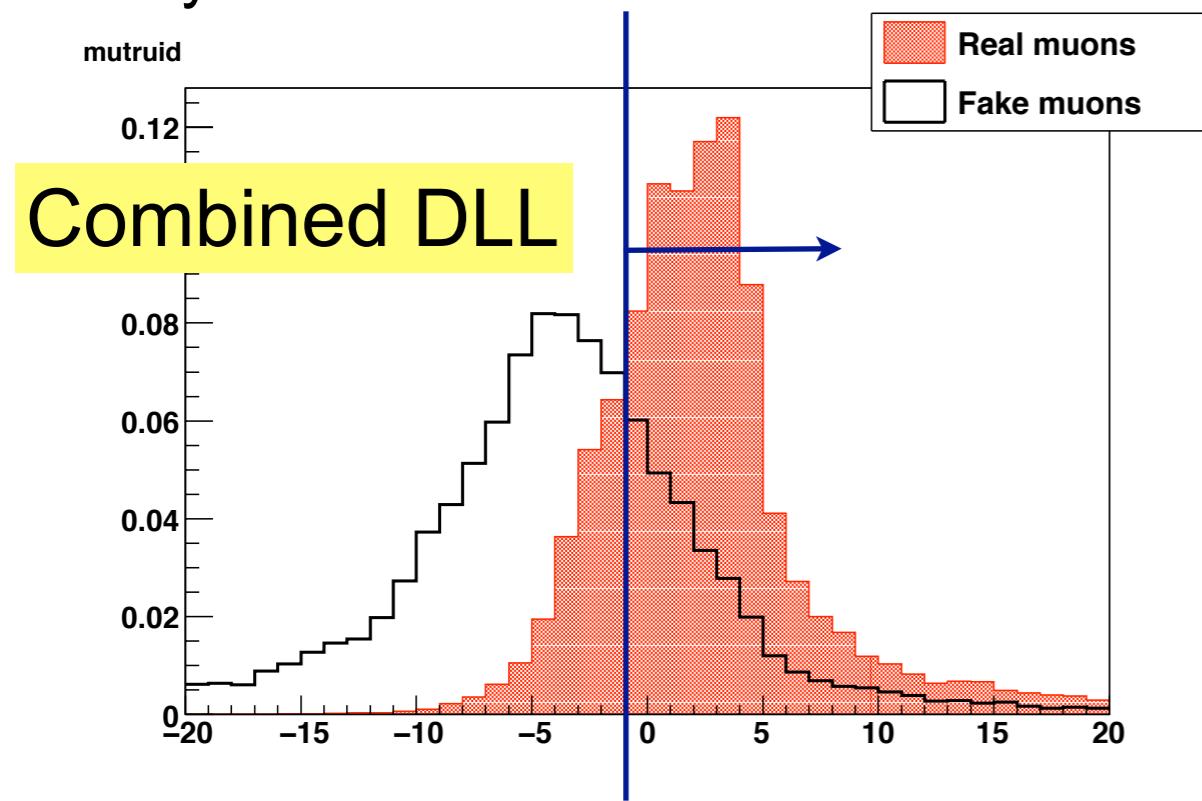
- Fake muons (hadron decay in flight & punch-through)
- Real muons from heavy quark decays

After trigger and reconstruction about 1 event in 5000 is DY :(

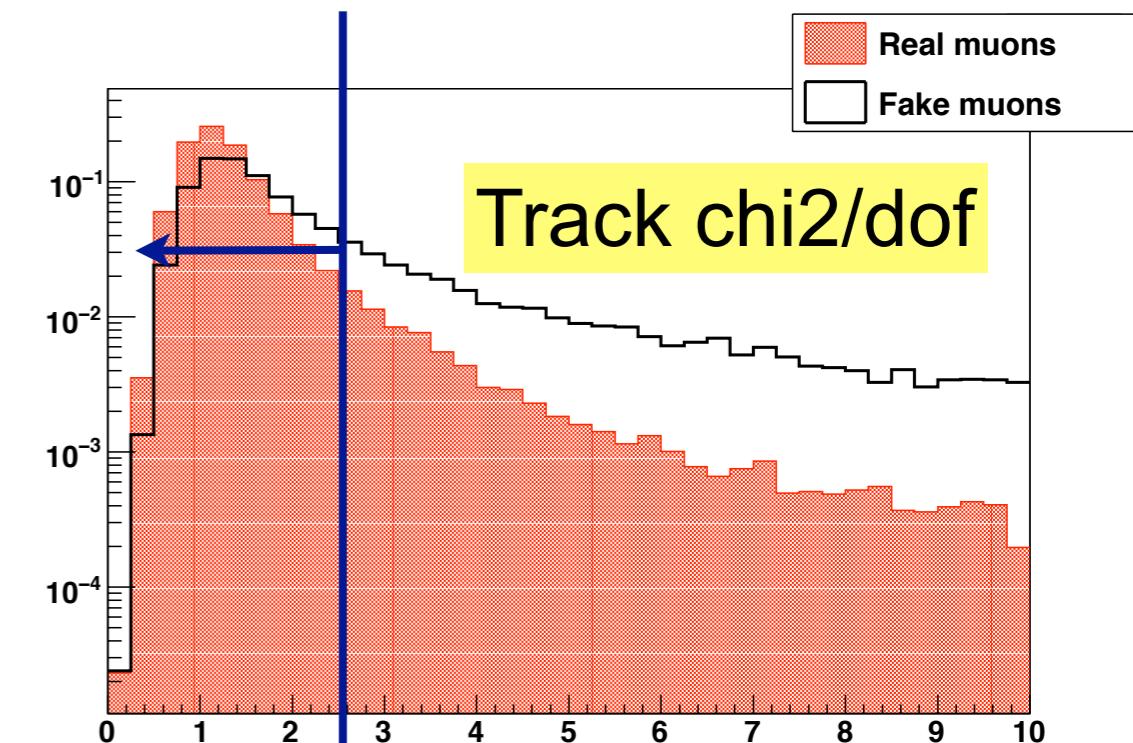


Preselection - tight muon id requirements

Info from calorimeters and muon system is combined into a DLL

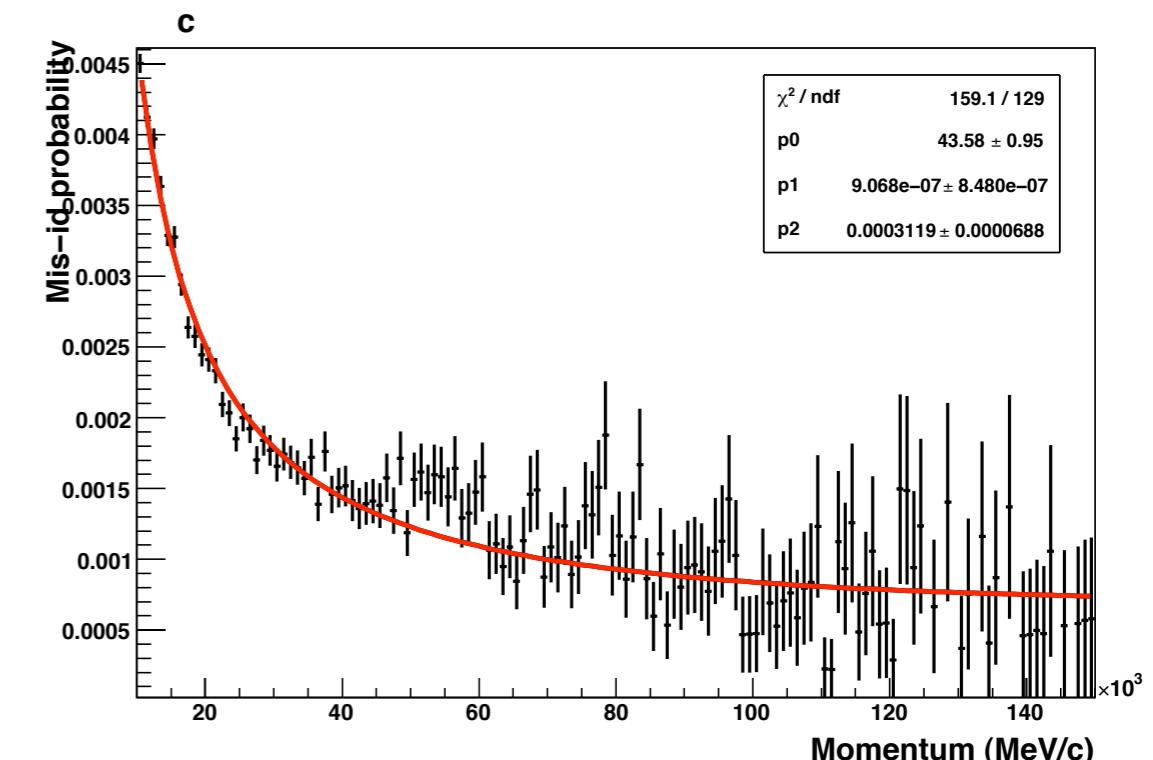


To reduce ghost track component, cut on track chi2 and the number of shared hits



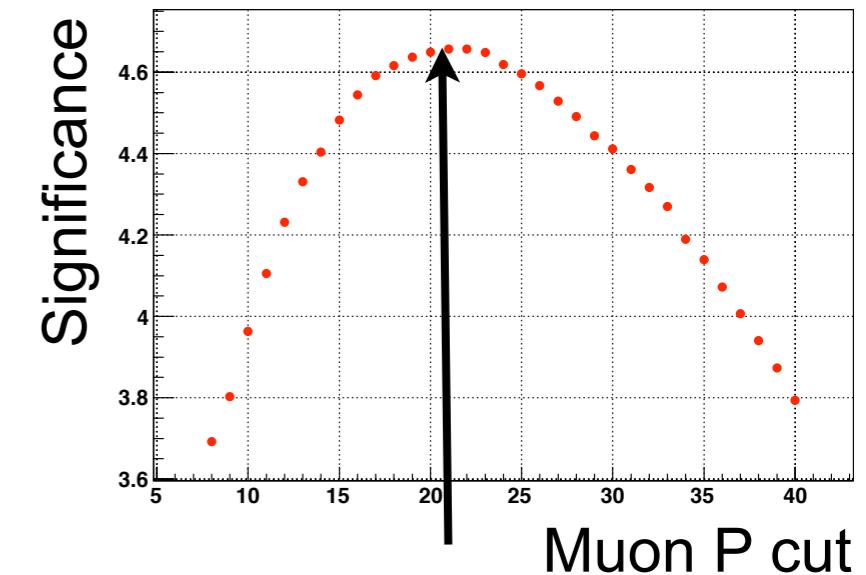
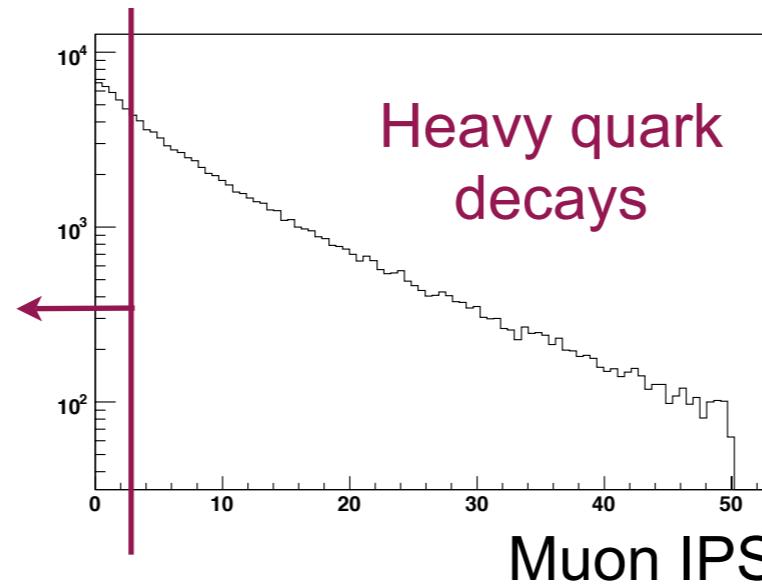
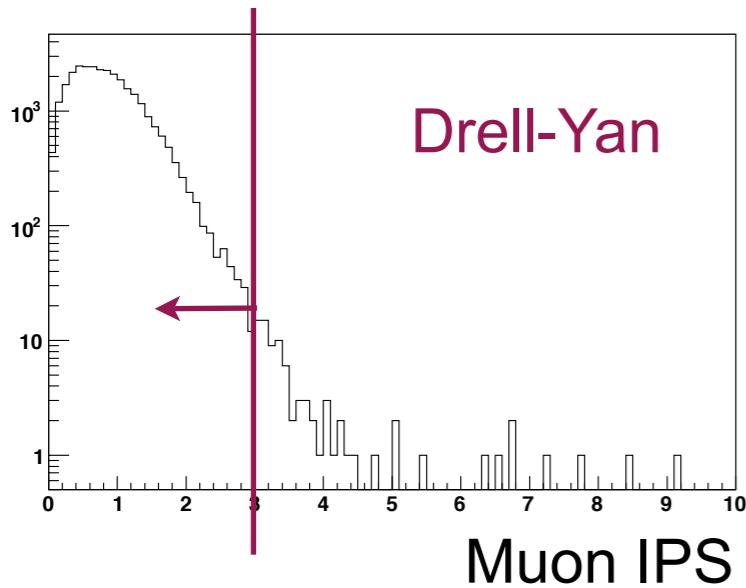
Reduces mis-id prob. by a factor of 10
The ID efficiency falls from 90% to 70%

ID requirements/efficiency will be calibrated/measured using data
(e.g. $\Lambda \rightarrow \pi p$ & $J/\psi \rightarrow \mu\mu$)



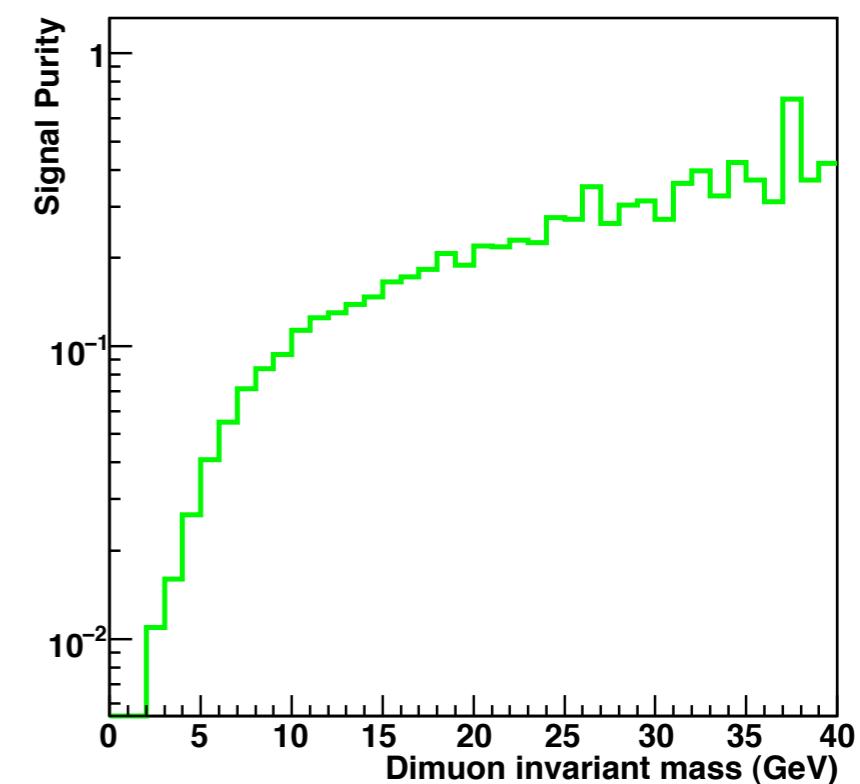
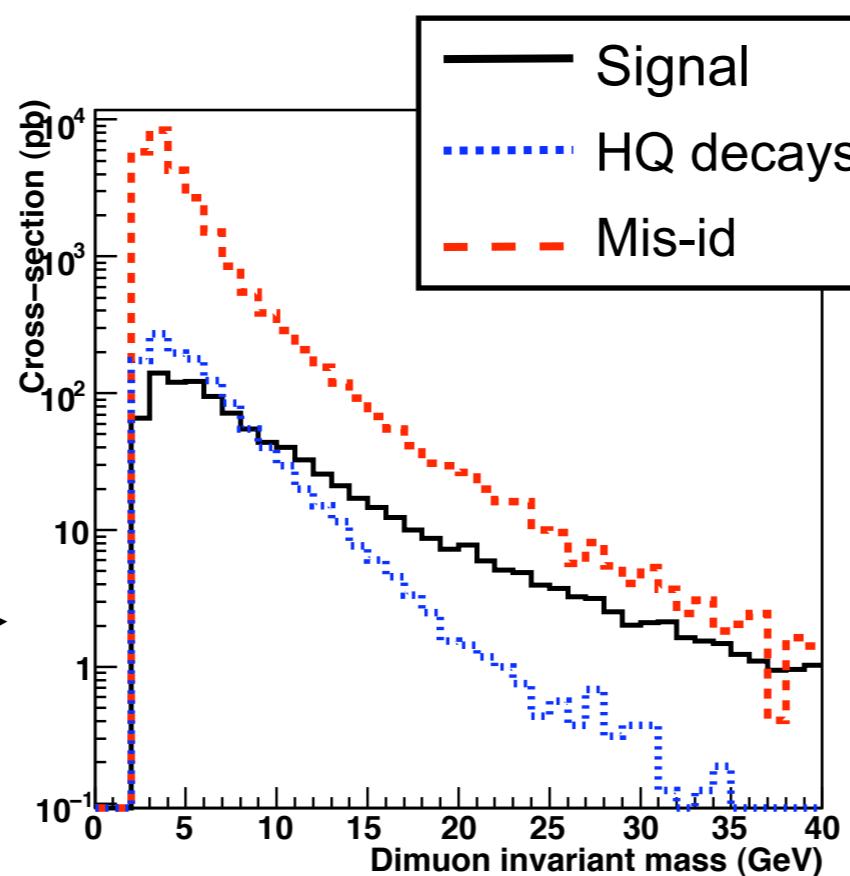
Preselection

Additional requirements: $\mu \text{IPS} < 3$ & $P_\mu > 21 \text{ GeV}$

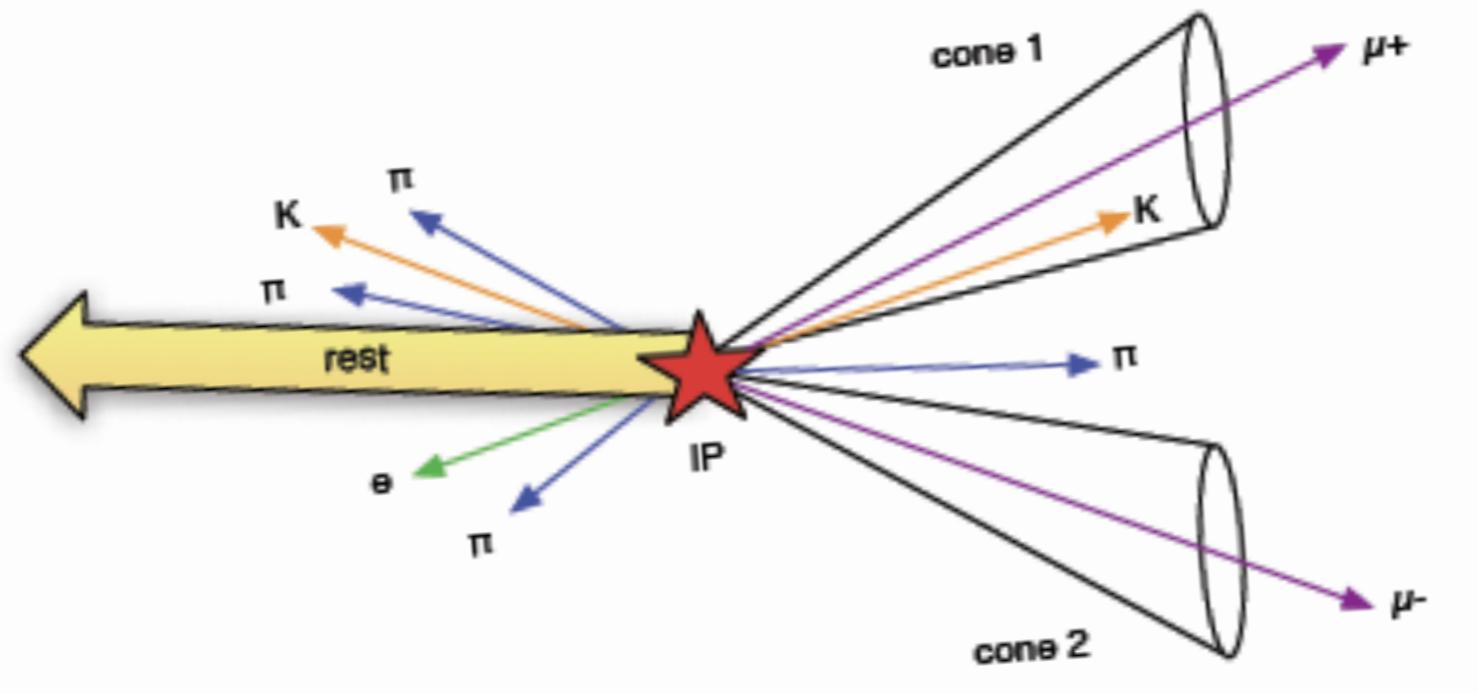


After Preselection

$S/B \sim 0.01$



Cone based selection



Selection is based on a number of asymmetry variables

$$A(P_{\mu 1}, P_{\text{cone}1})$$

$$A(P_{\mu 2}, P_{\text{cone}2})$$

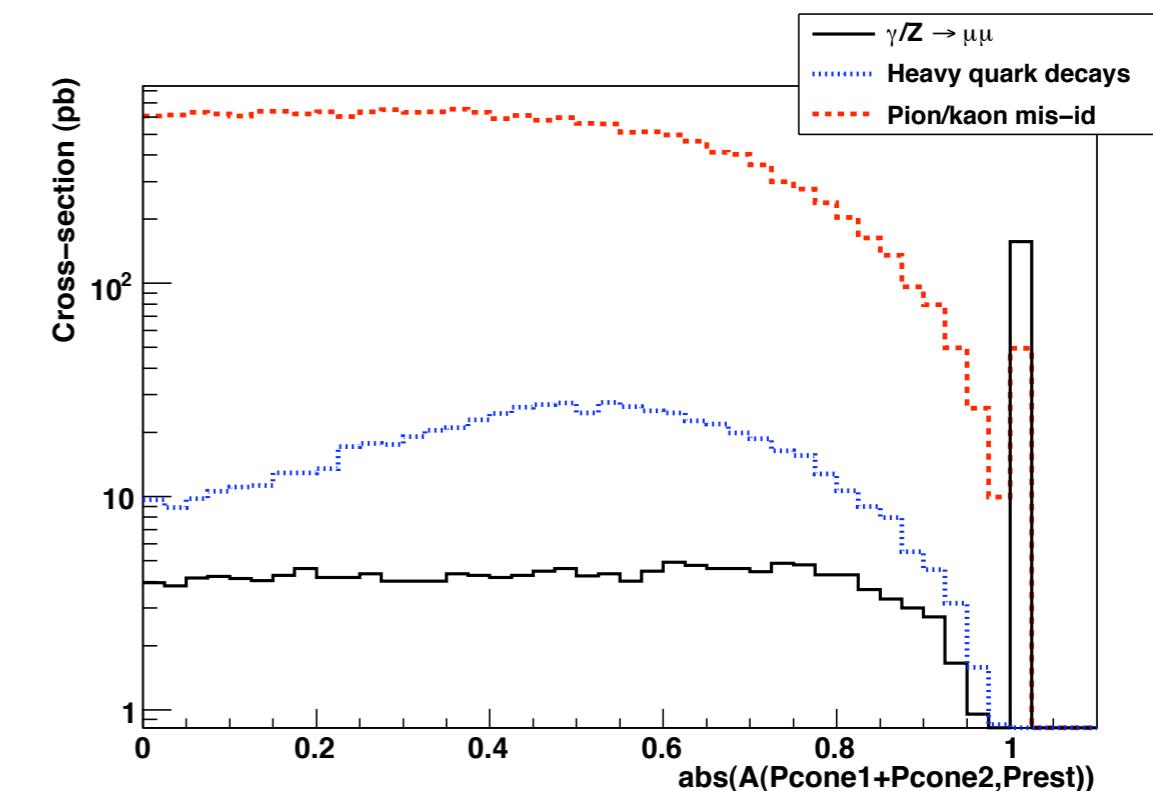
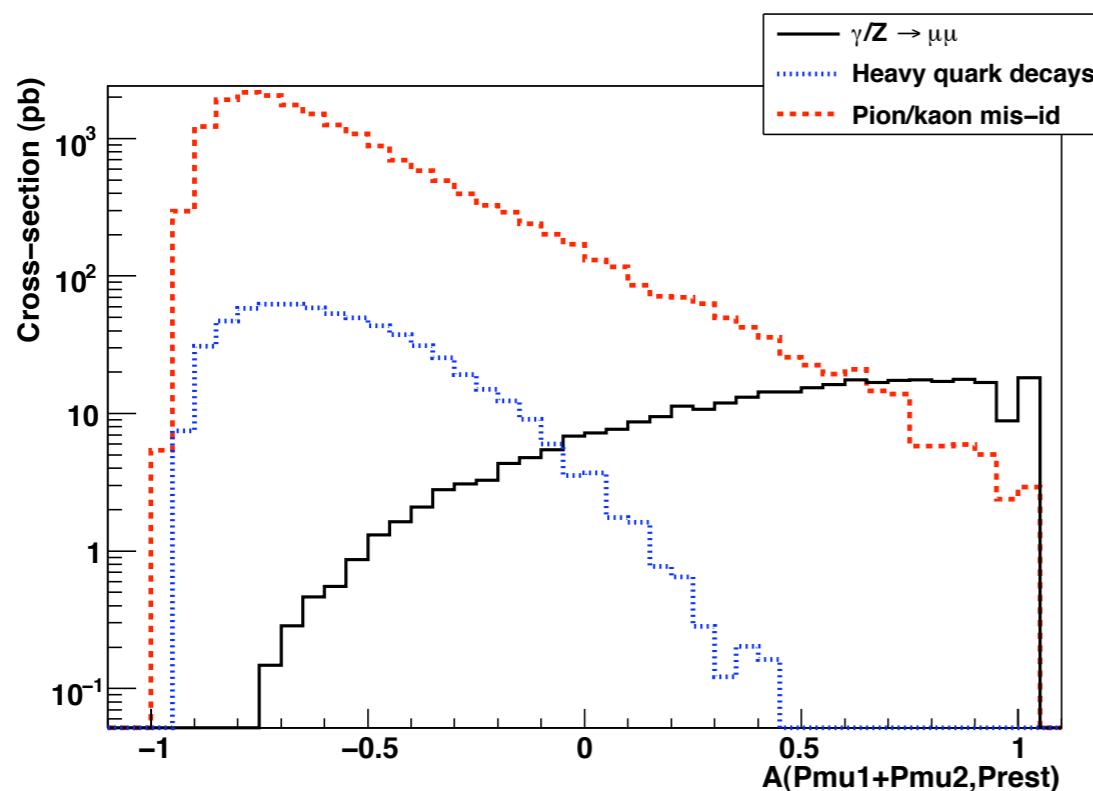
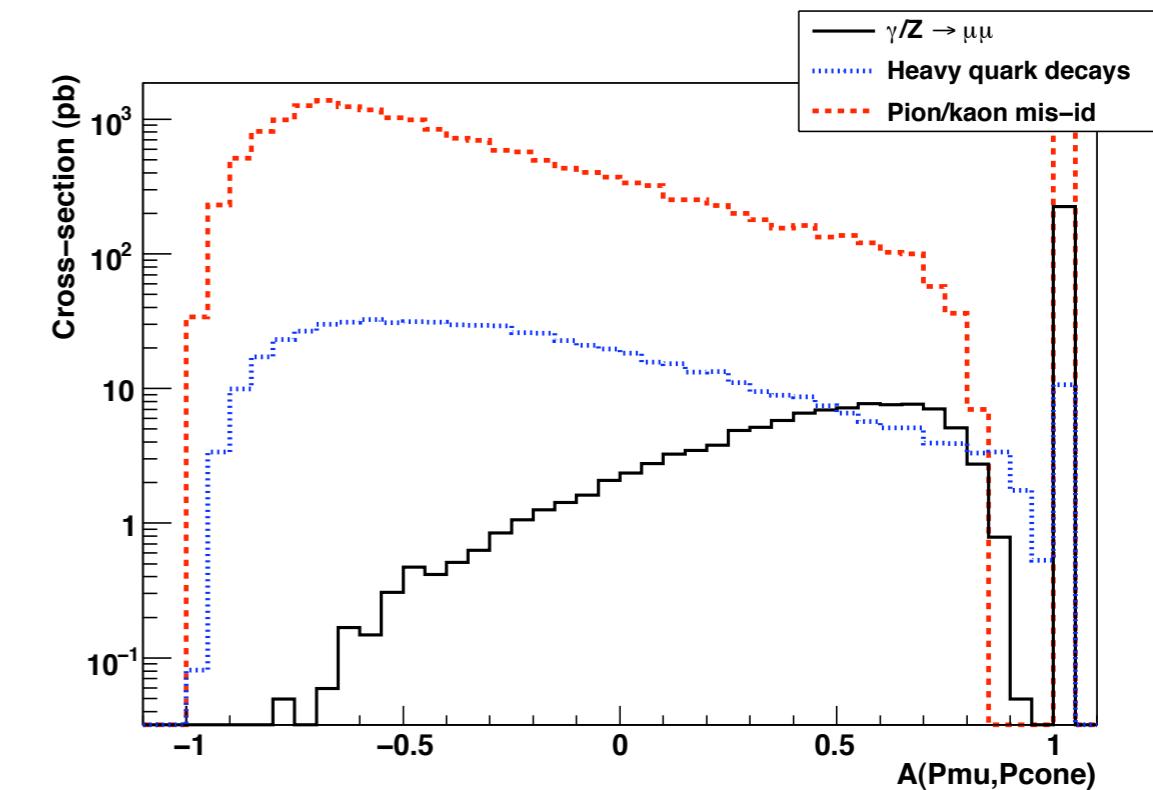
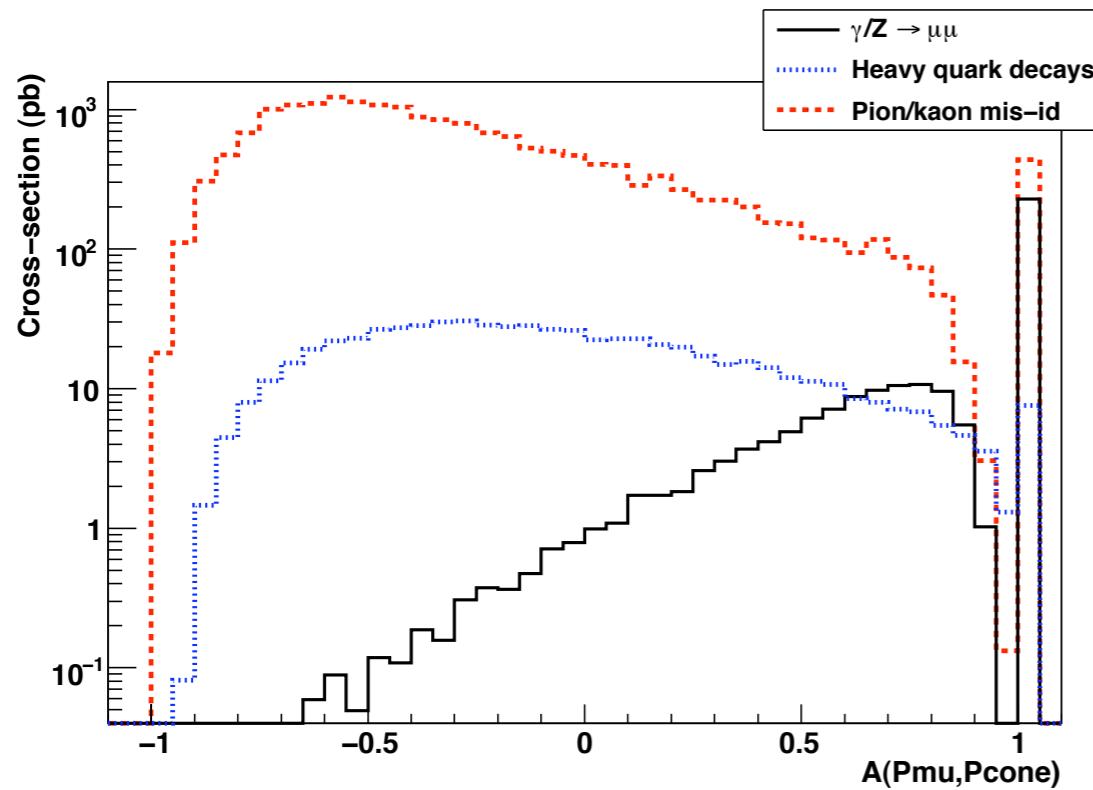
$$A(P_{\mu 1} + P_{\mu 2}, P_{\text{rest}})$$

$$A(P_{\text{cone}1} + P_{\text{cone}2}, P_{\text{rest}})$$

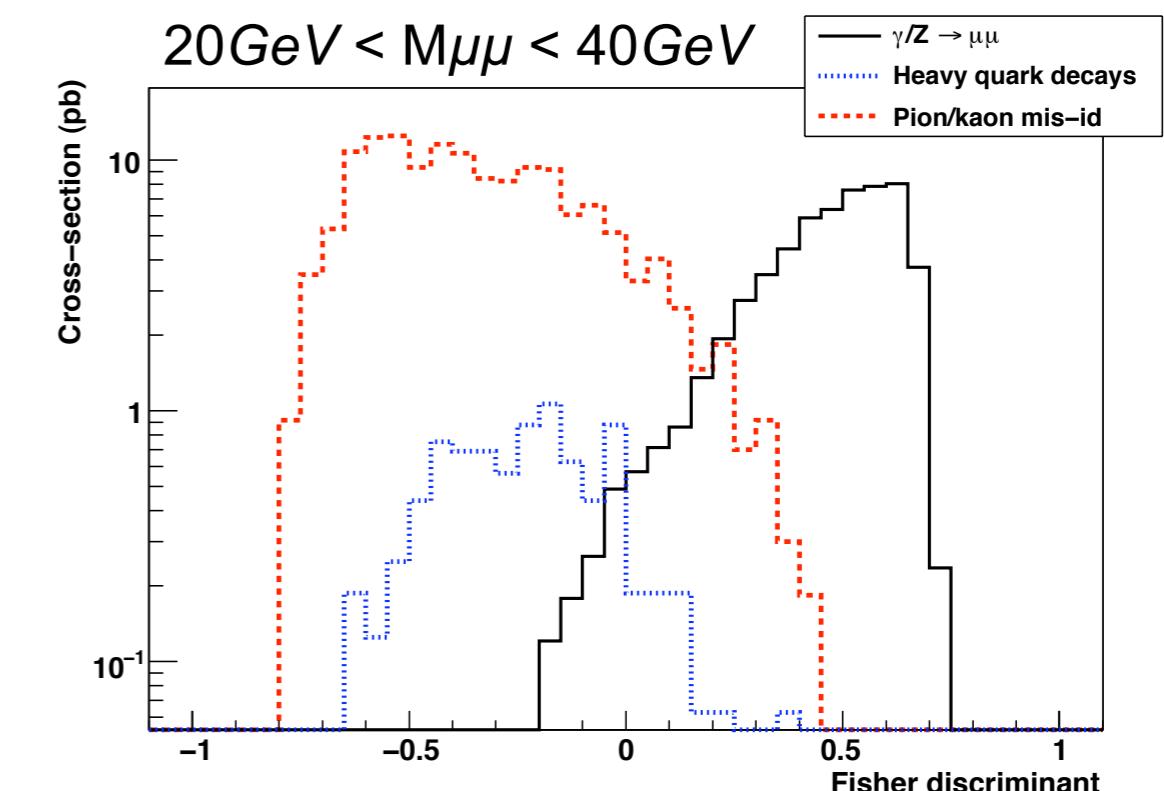
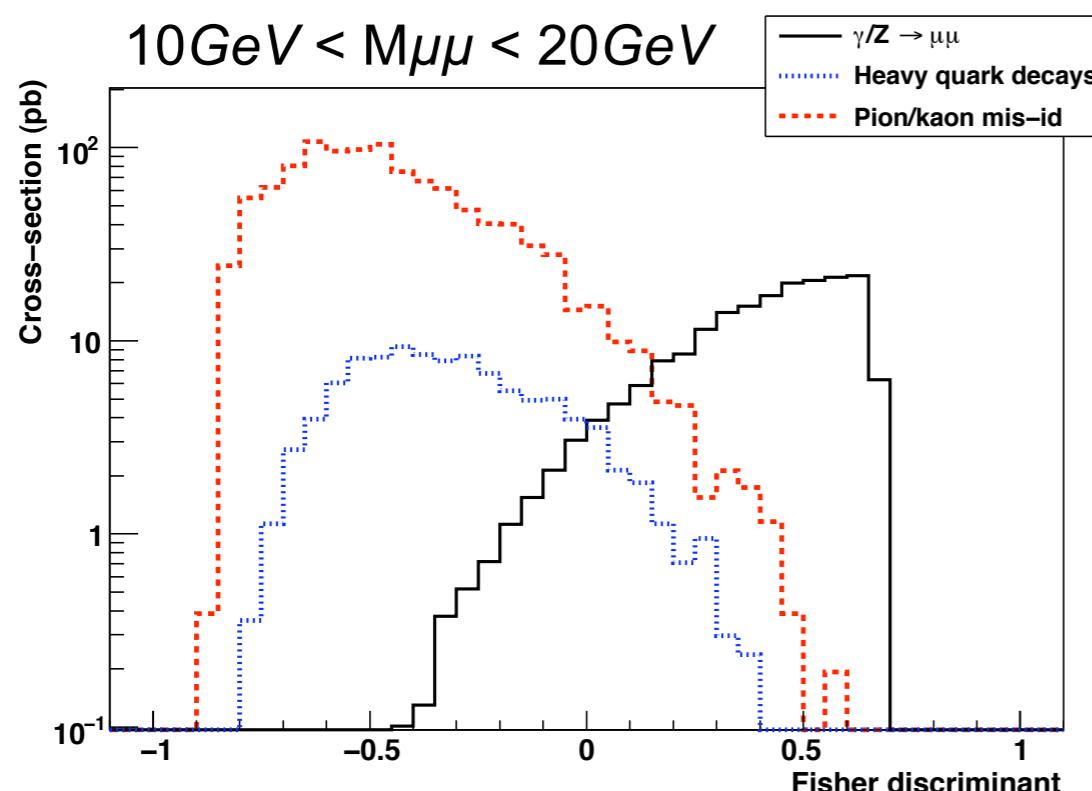
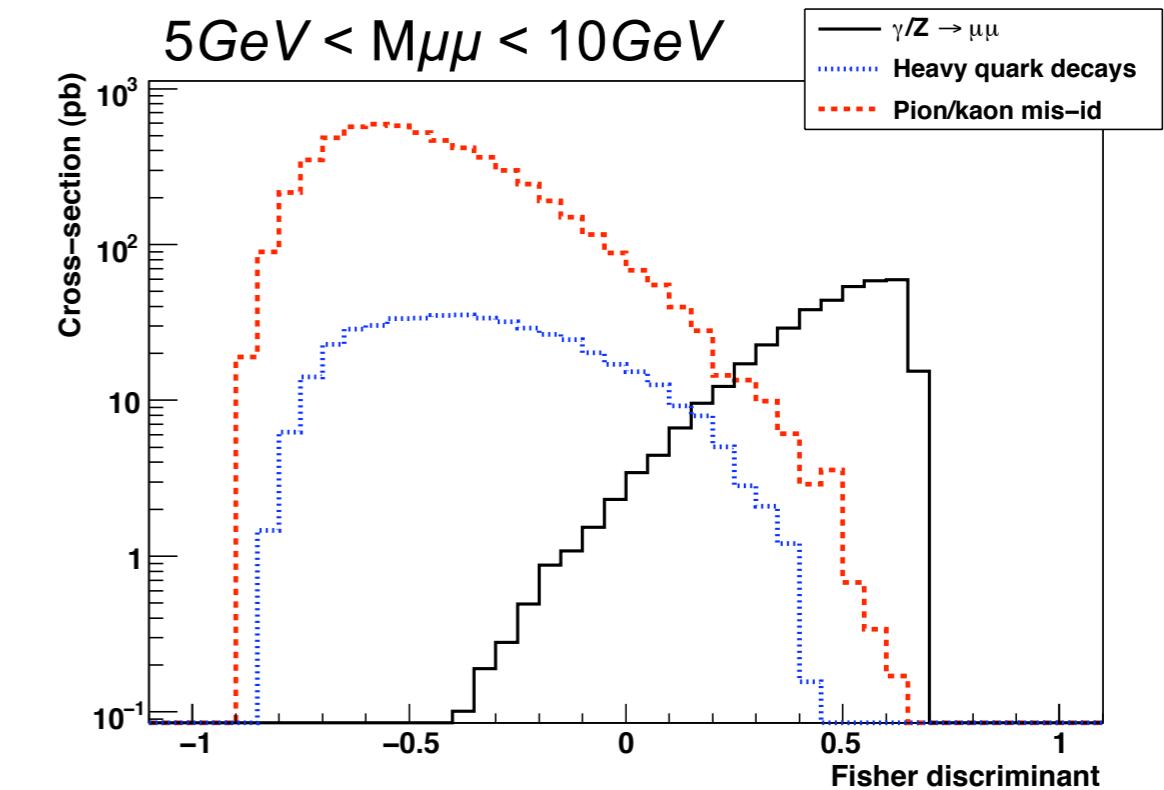
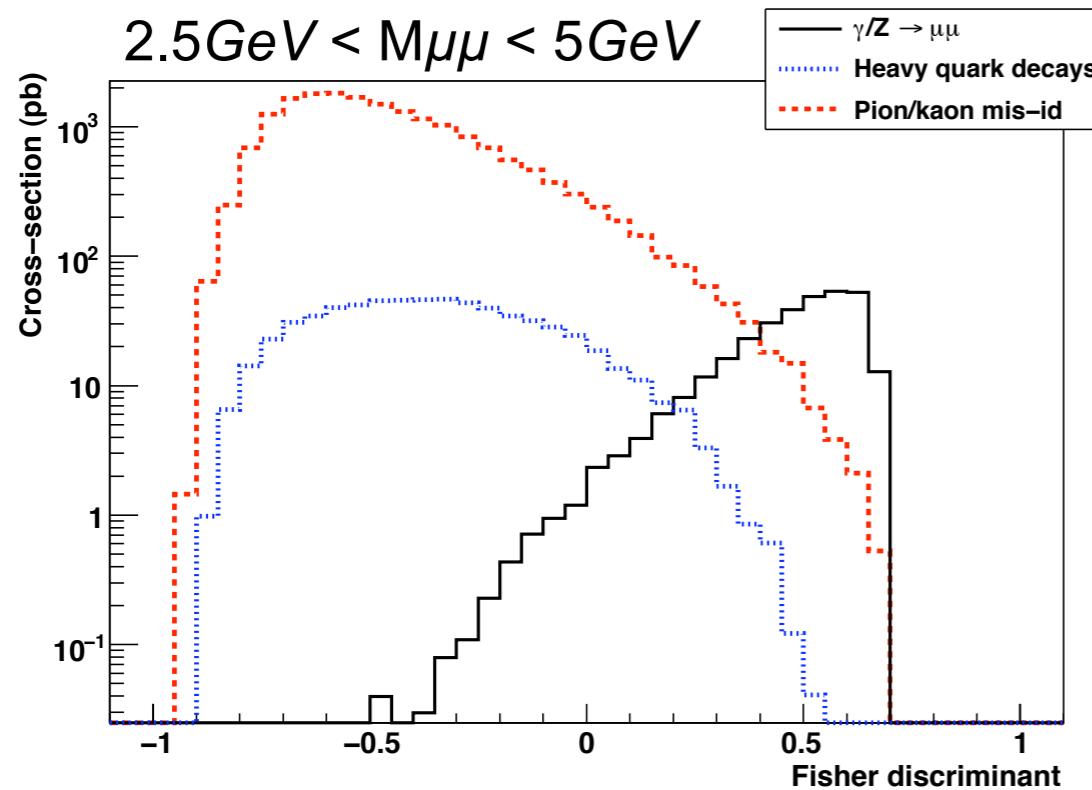
$$A(x, y) = \frac{x - y}{x + y}$$

$$R = \sqrt{(\Delta\phi)^2 + (\Delta\eta)^2} = 0.8$$

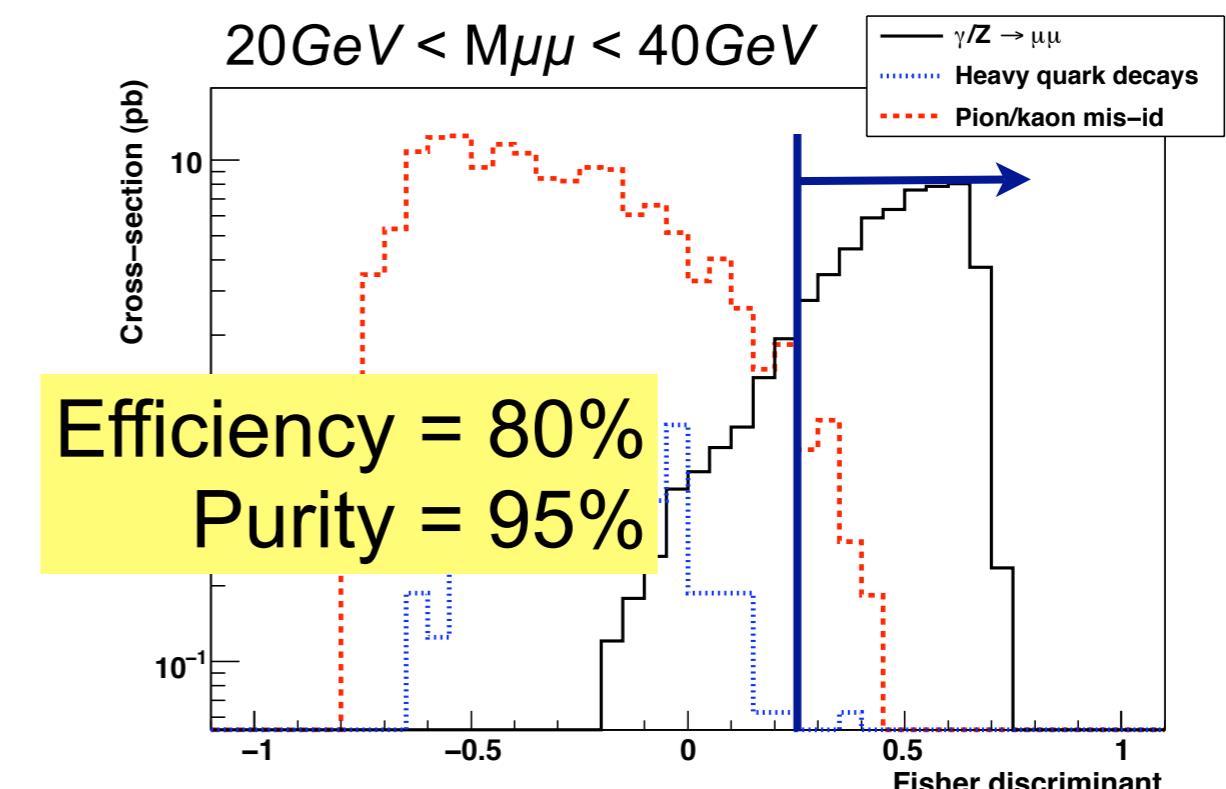
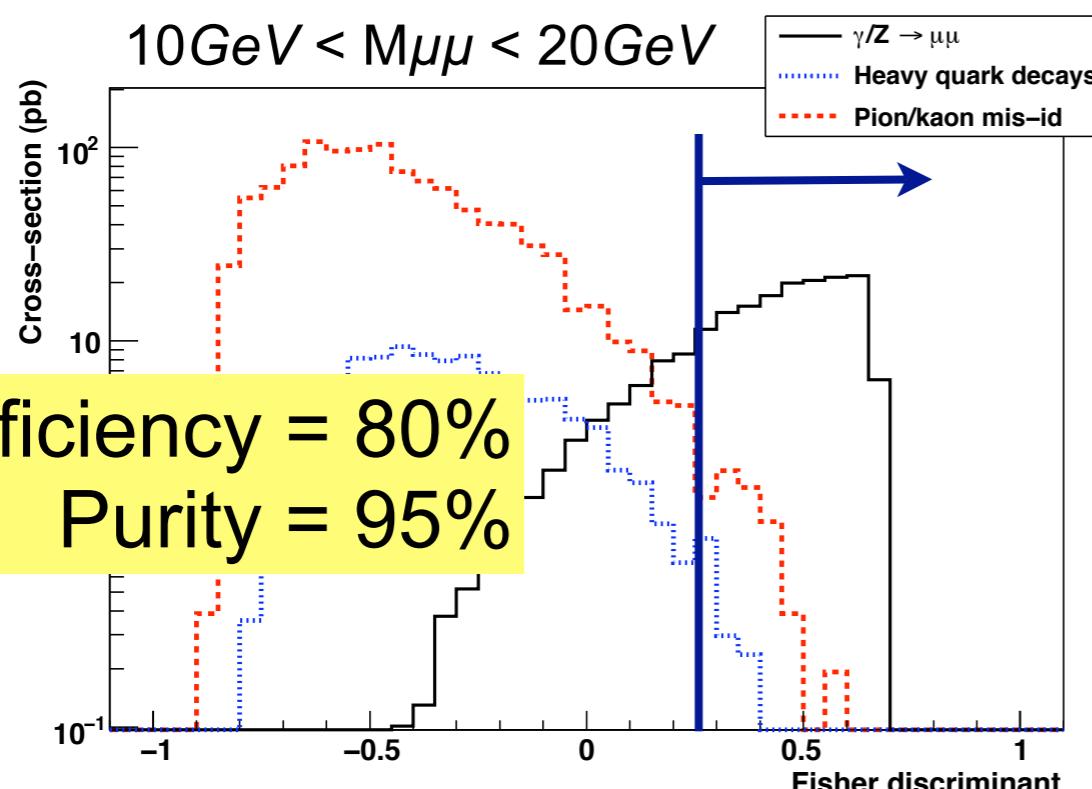
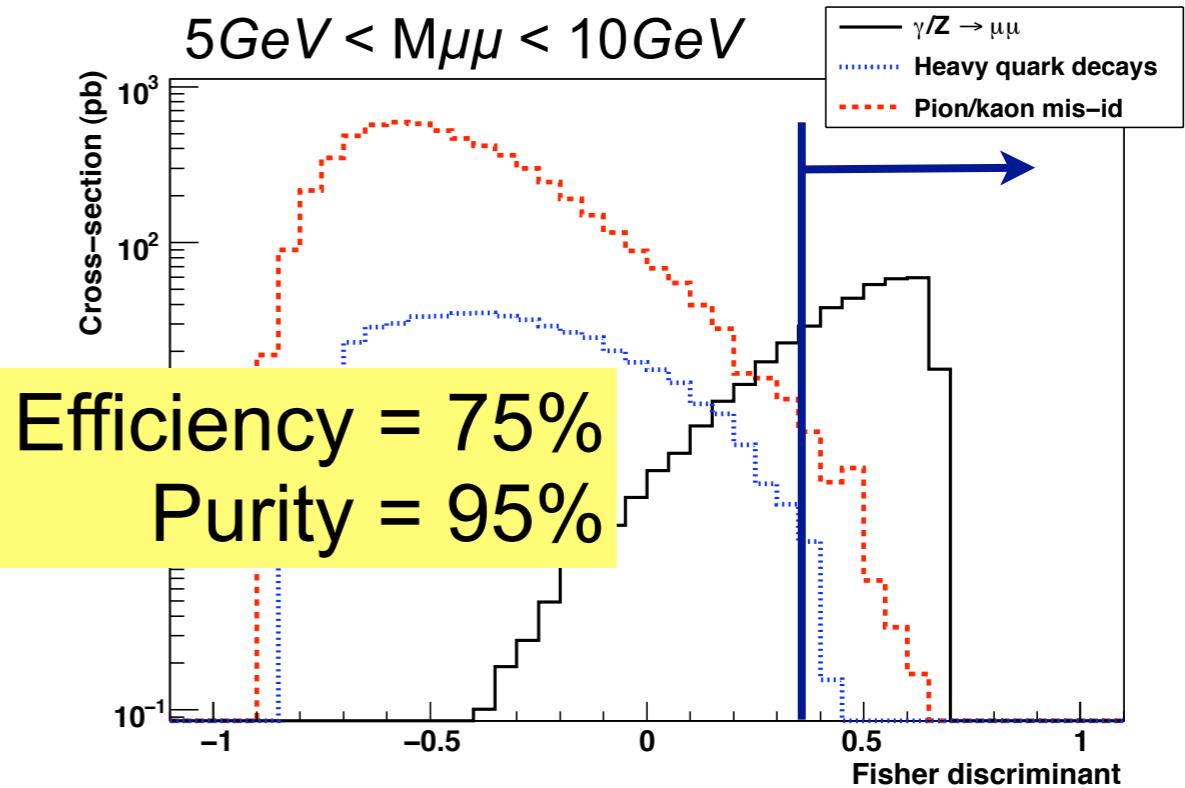
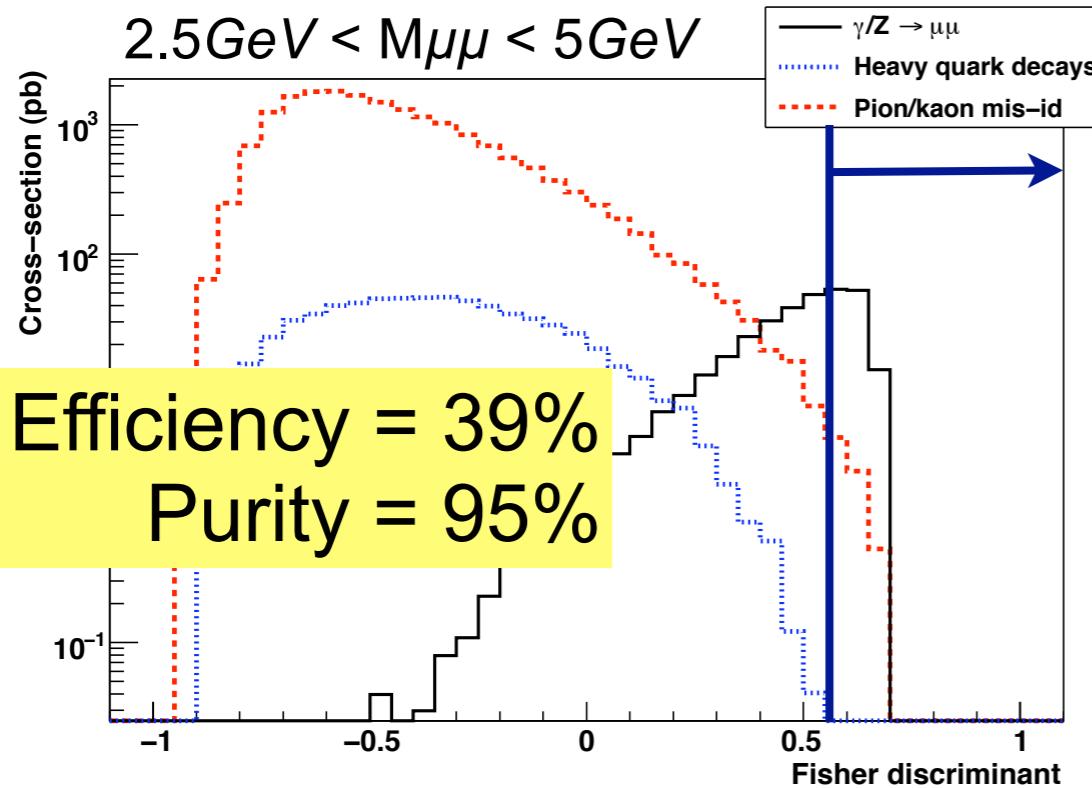
Asymmetry distributions ($2.5\text{GeV} < M_{\mu\mu} < 5\text{GeV}$)



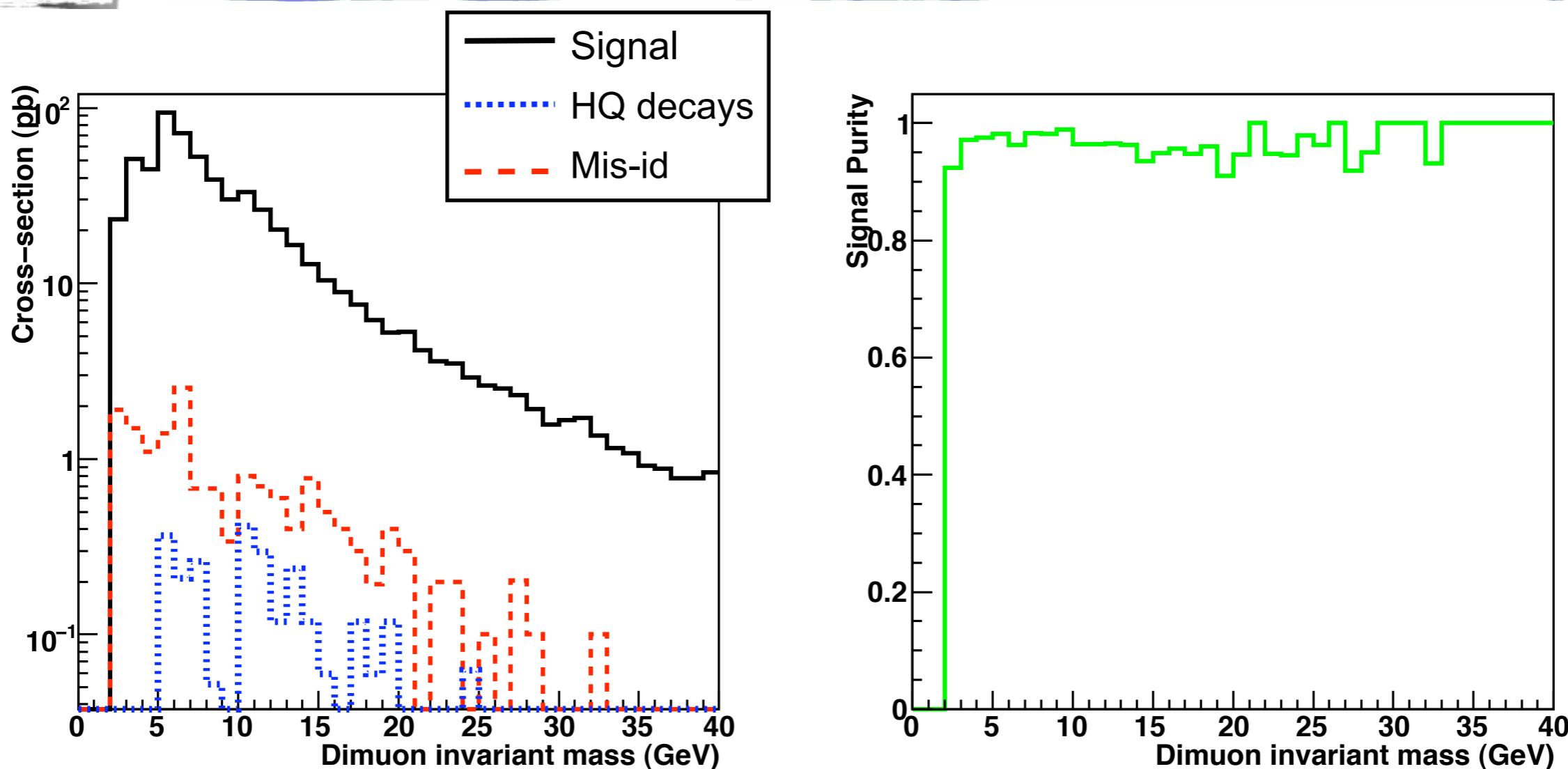
Combine variables into Fisher discriminant



Combine variables into Fisher discriminant

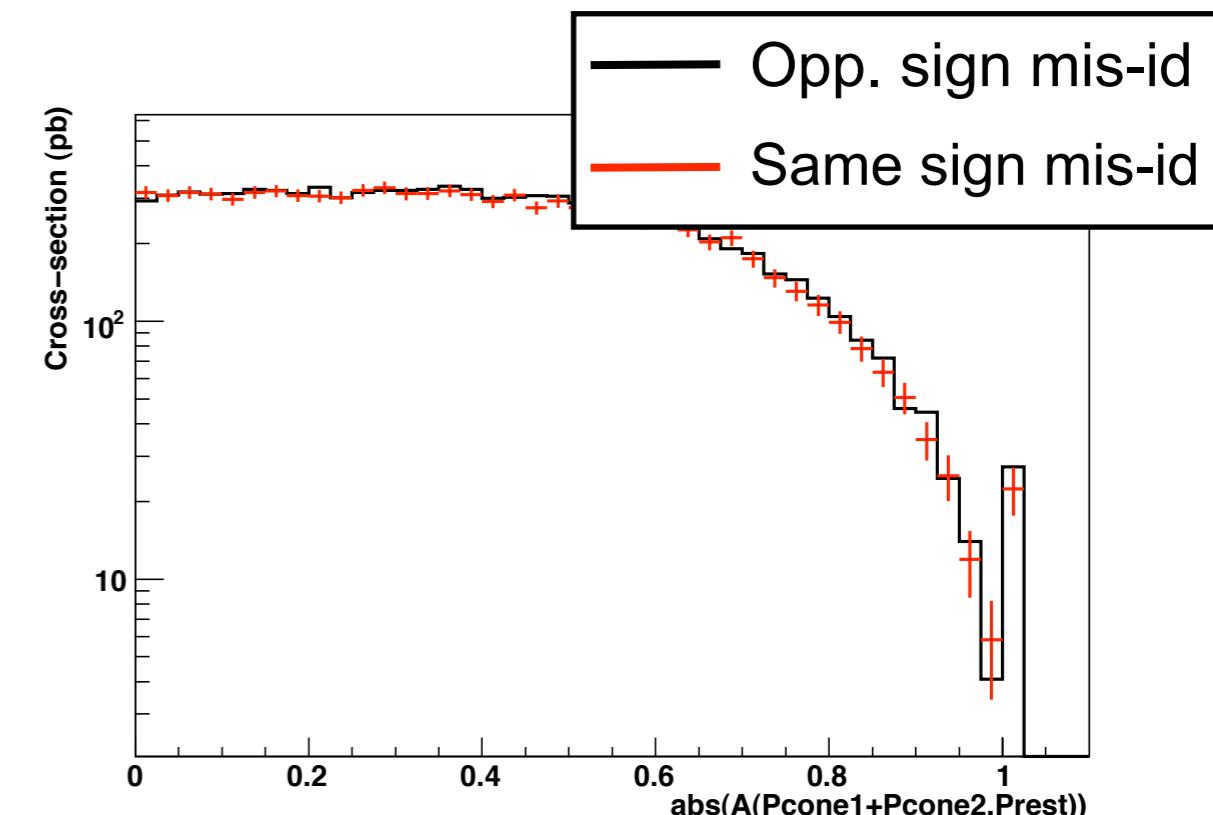
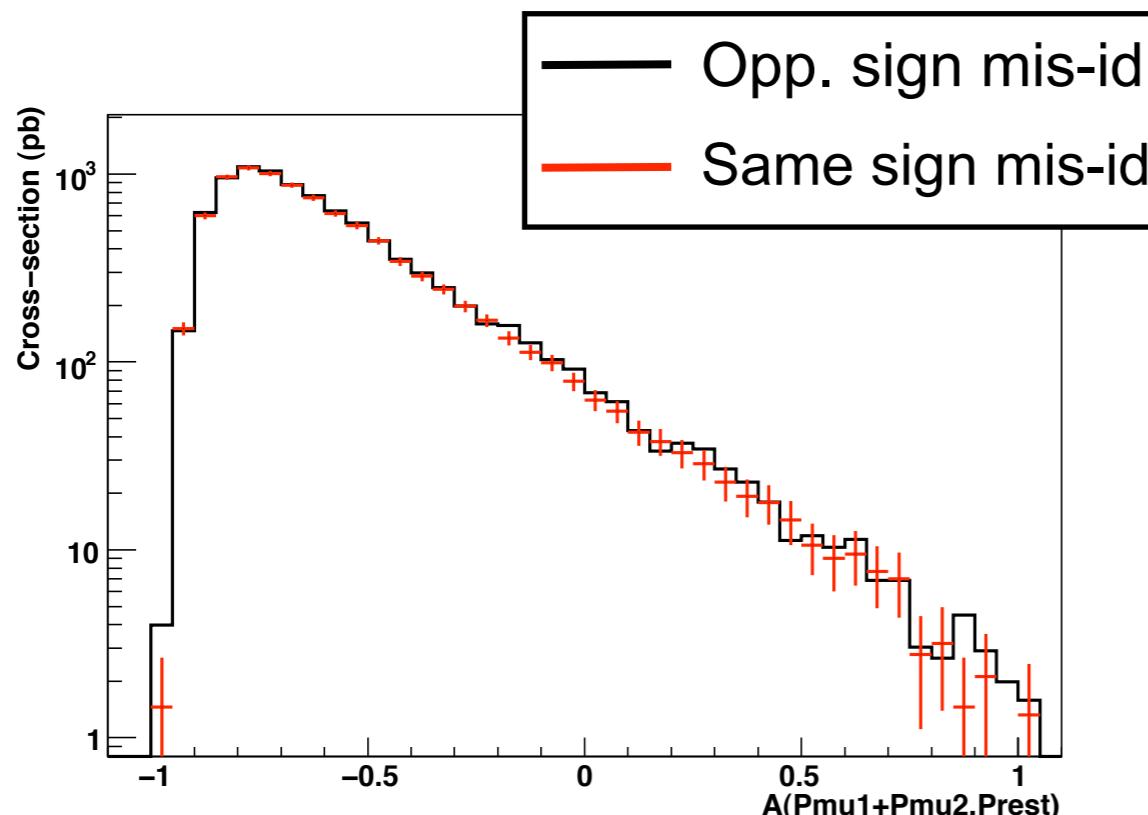
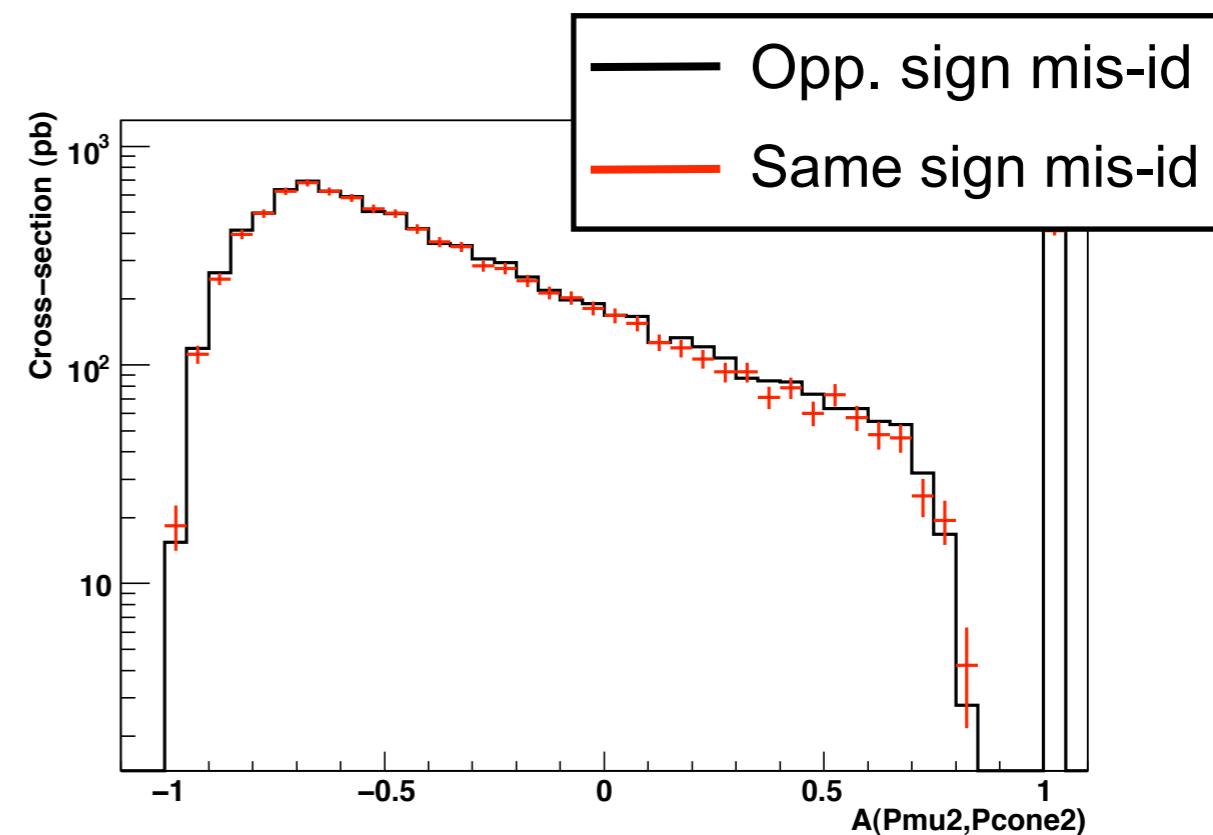
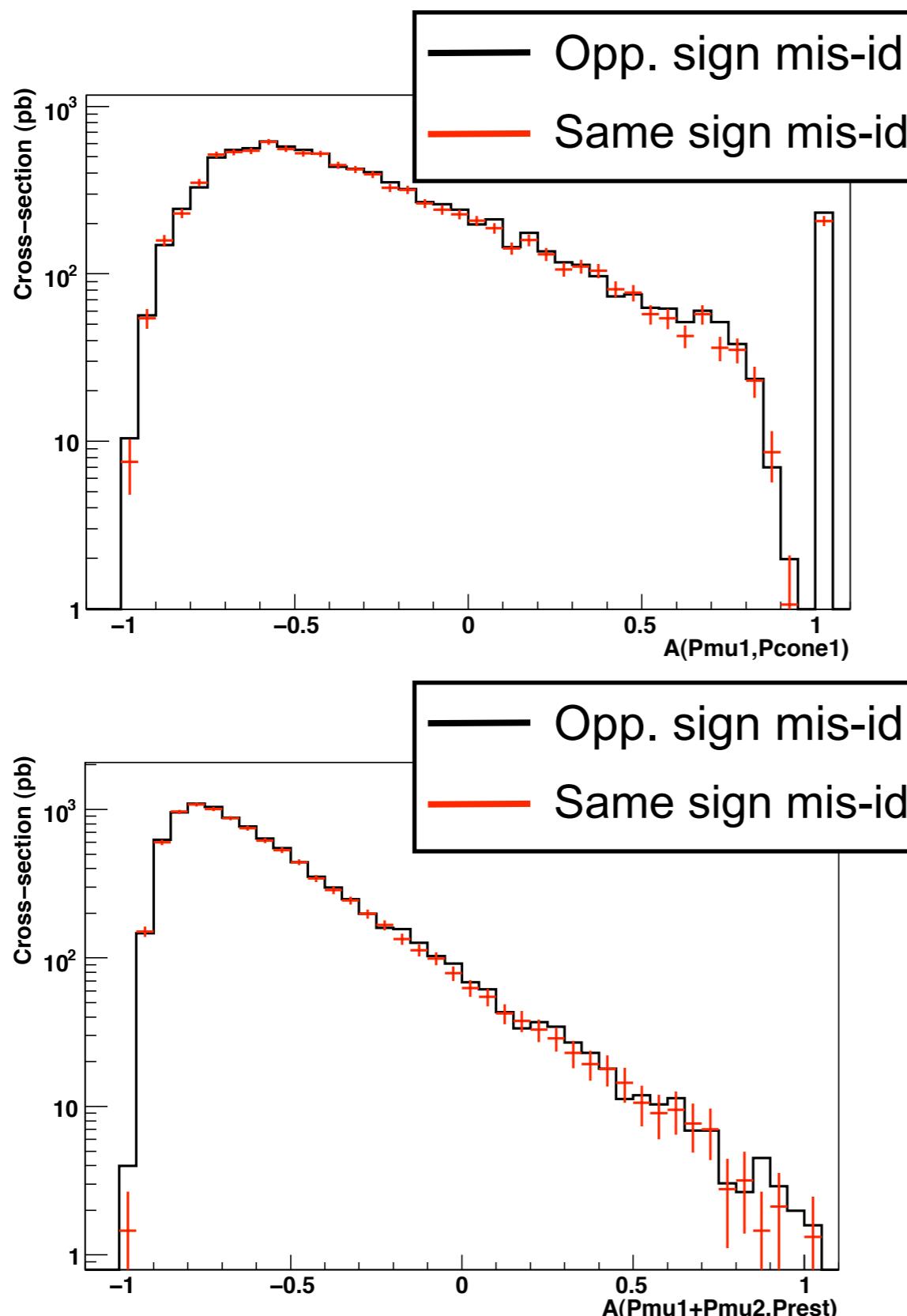


Purity after selection

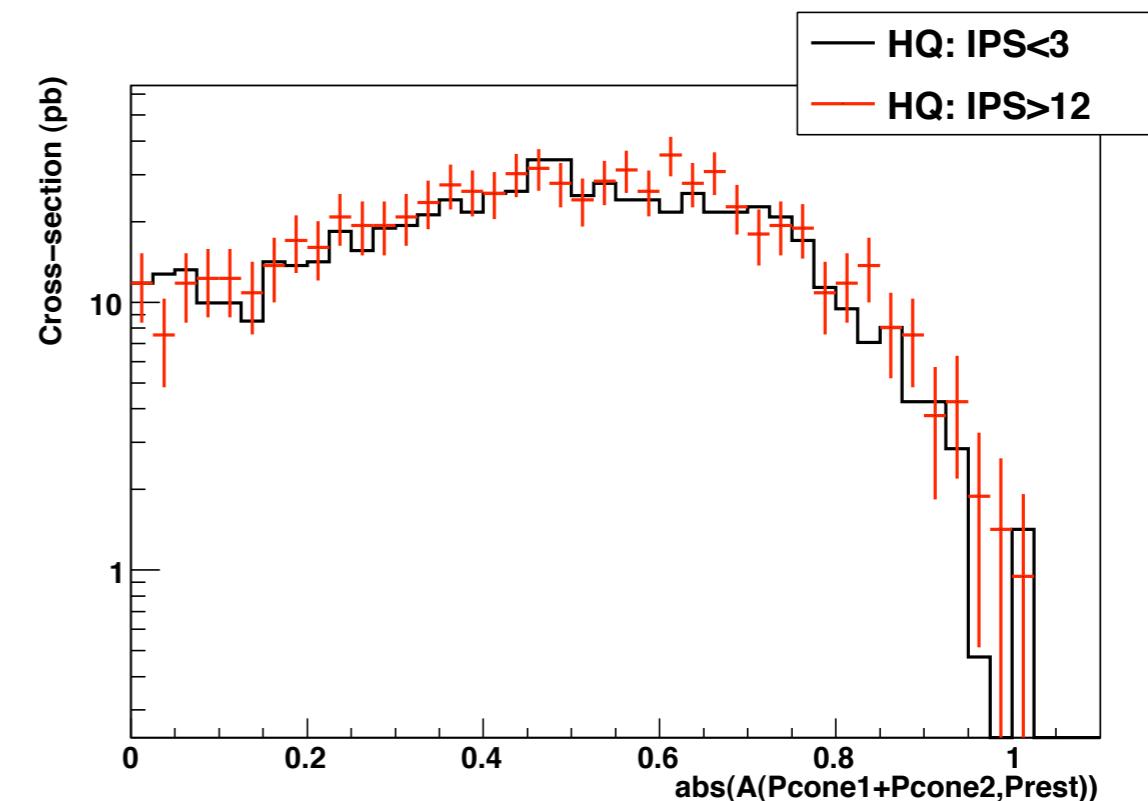
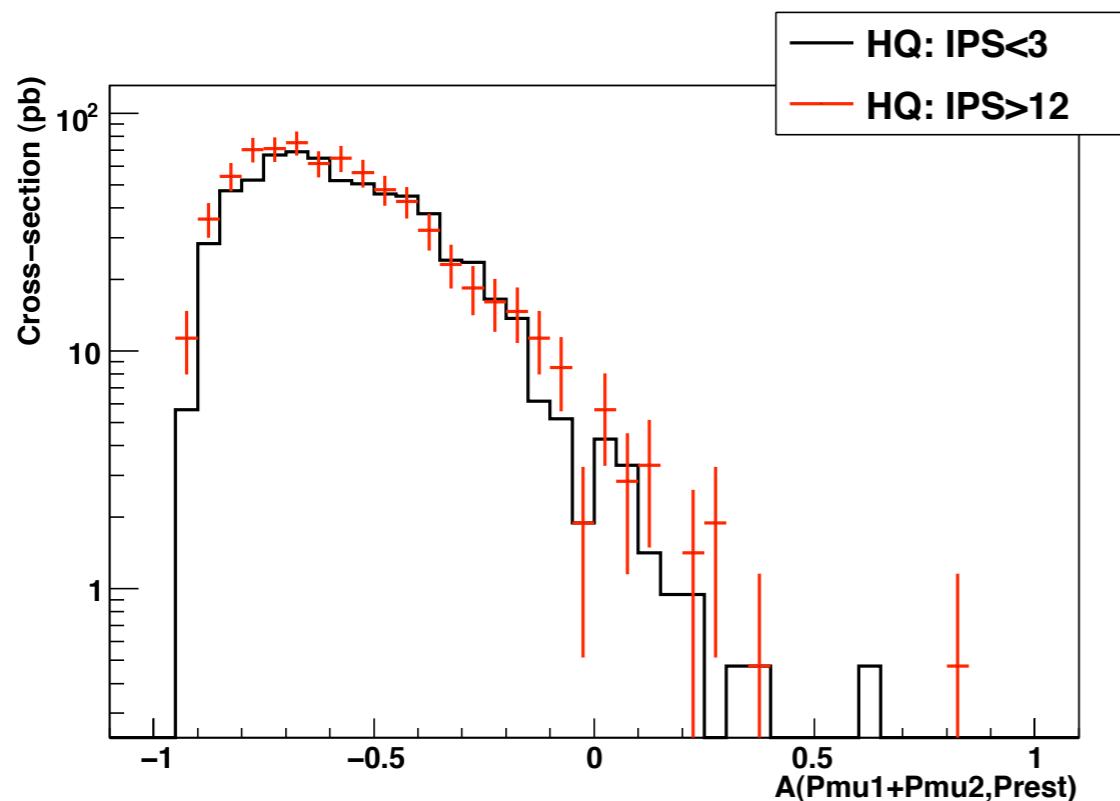
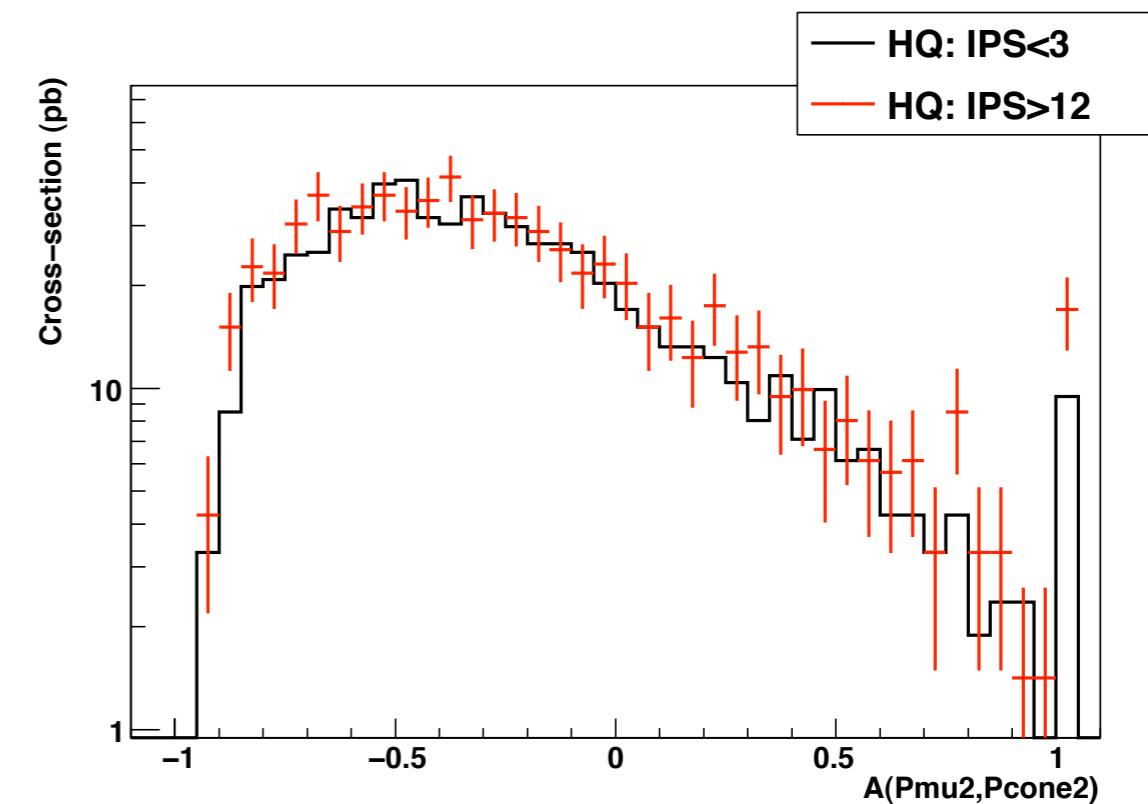
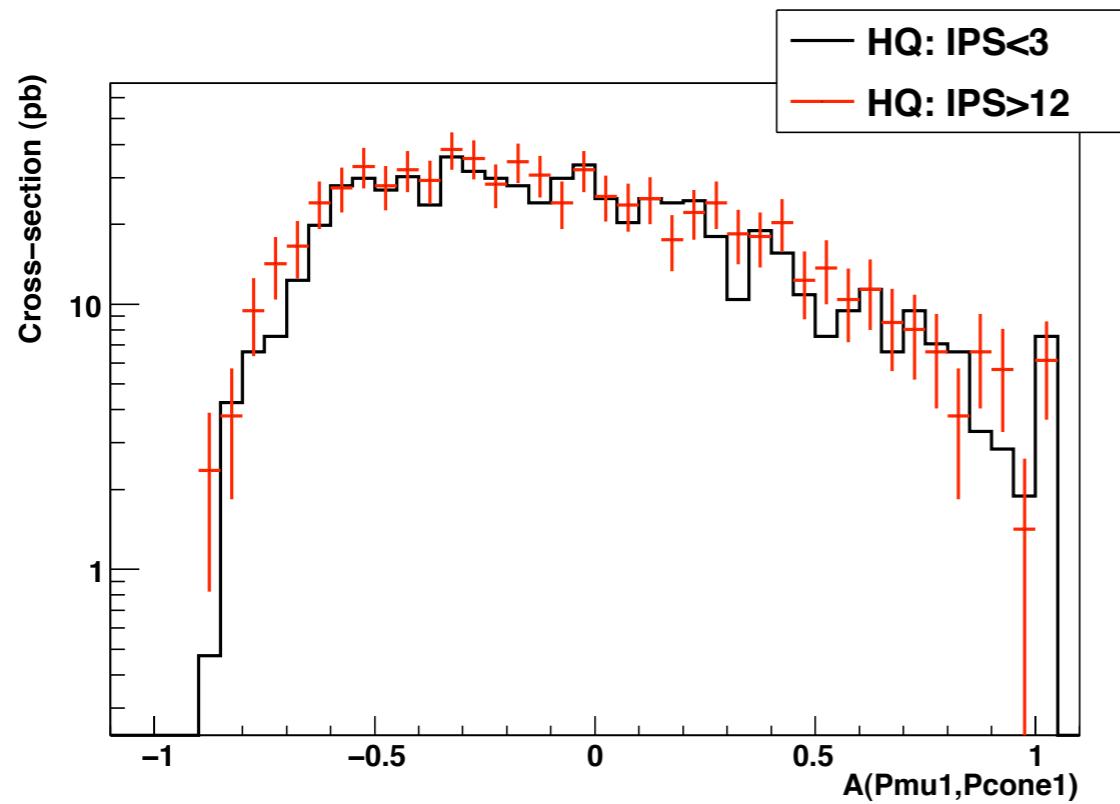


Mass range (GeV)	Events/pb-1
$2.5 < M_{\mu\mu} < 5$	119.1 ± 1.0
$5 < M_{\mu\mu} < 10$	287.3 ± 1.6
$10 < M_{\mu\mu} < 20$	147.6 ± 0.9
$20 < M_{\mu\mu} < 40$	42.3 ± 0.4

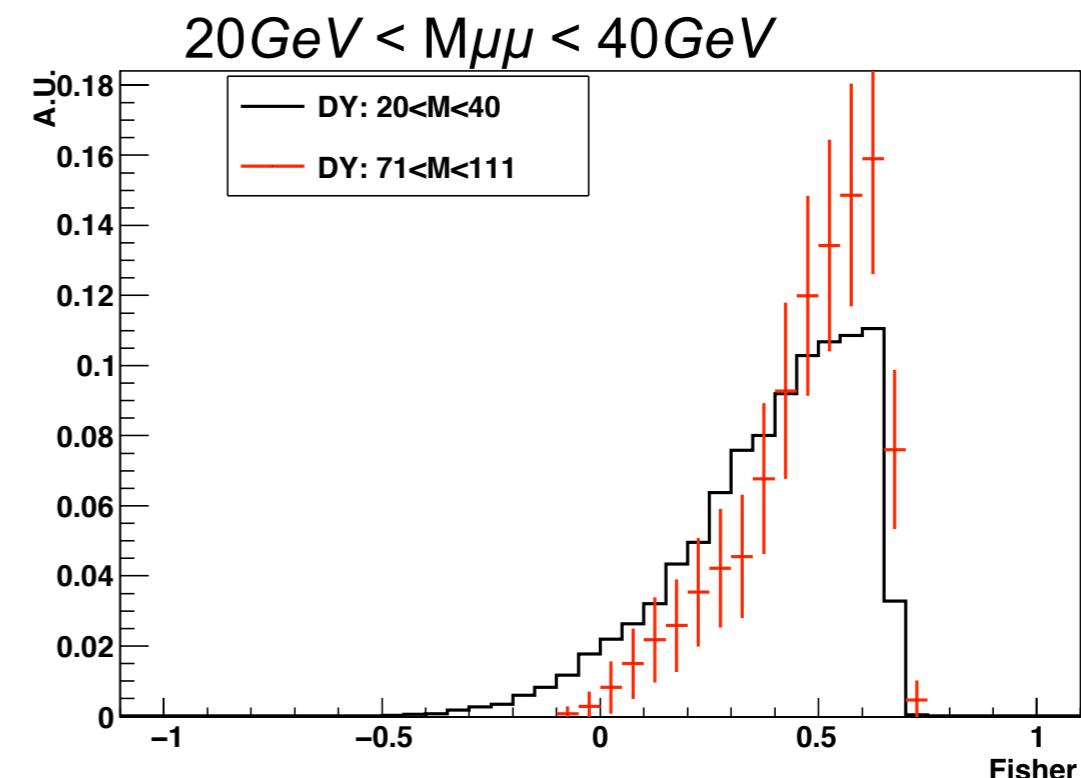
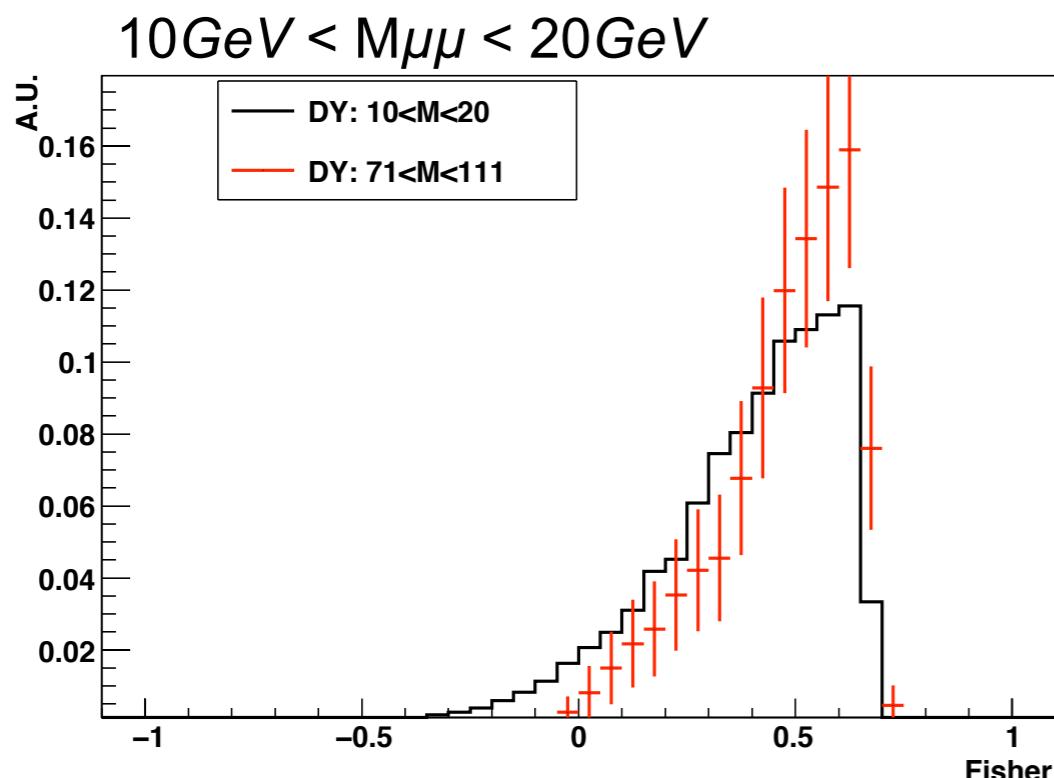
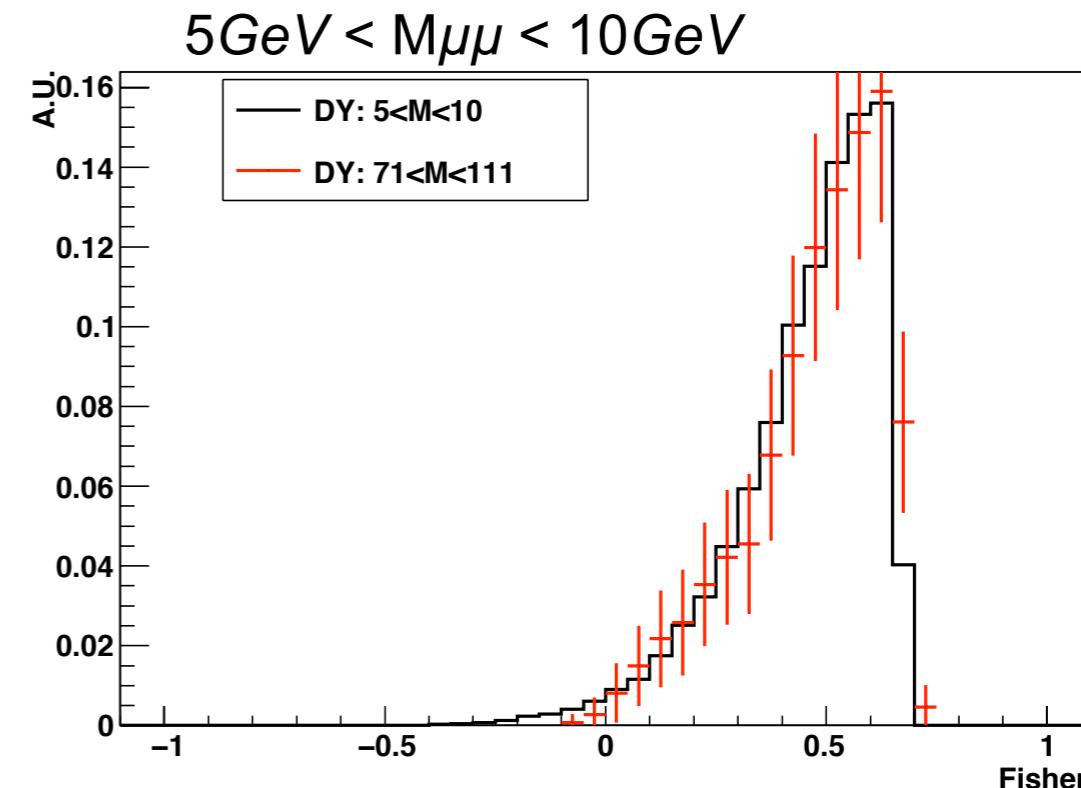
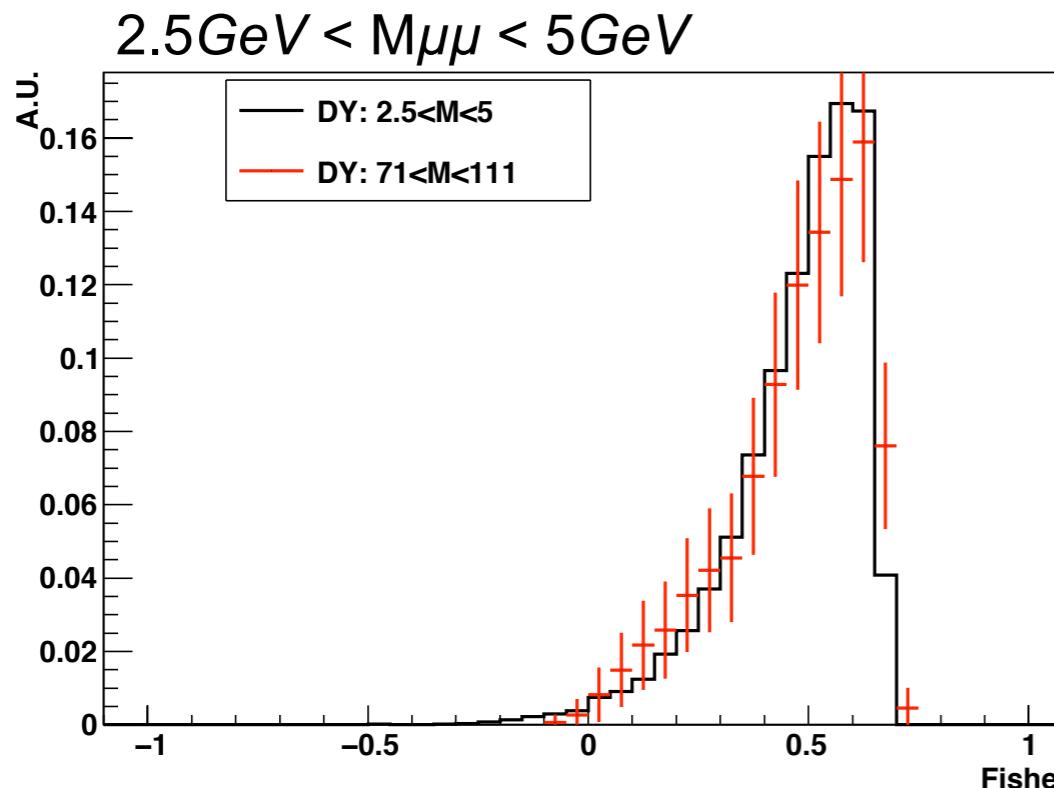
Understanding backgrounds with data



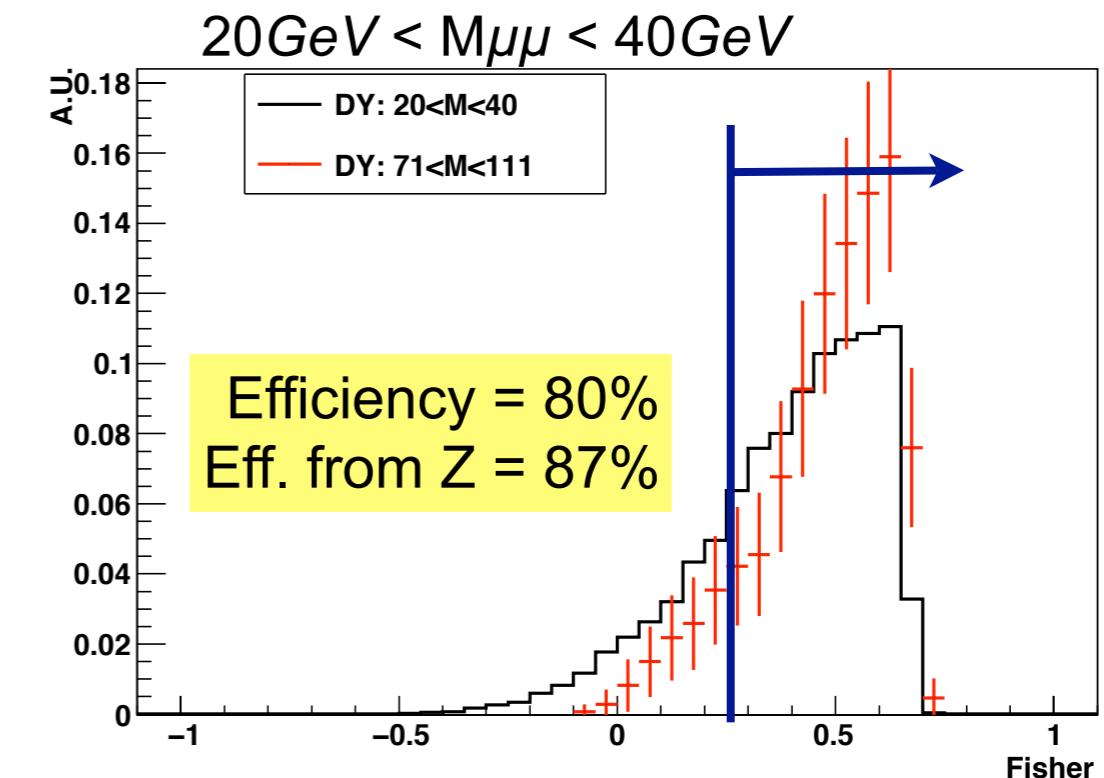
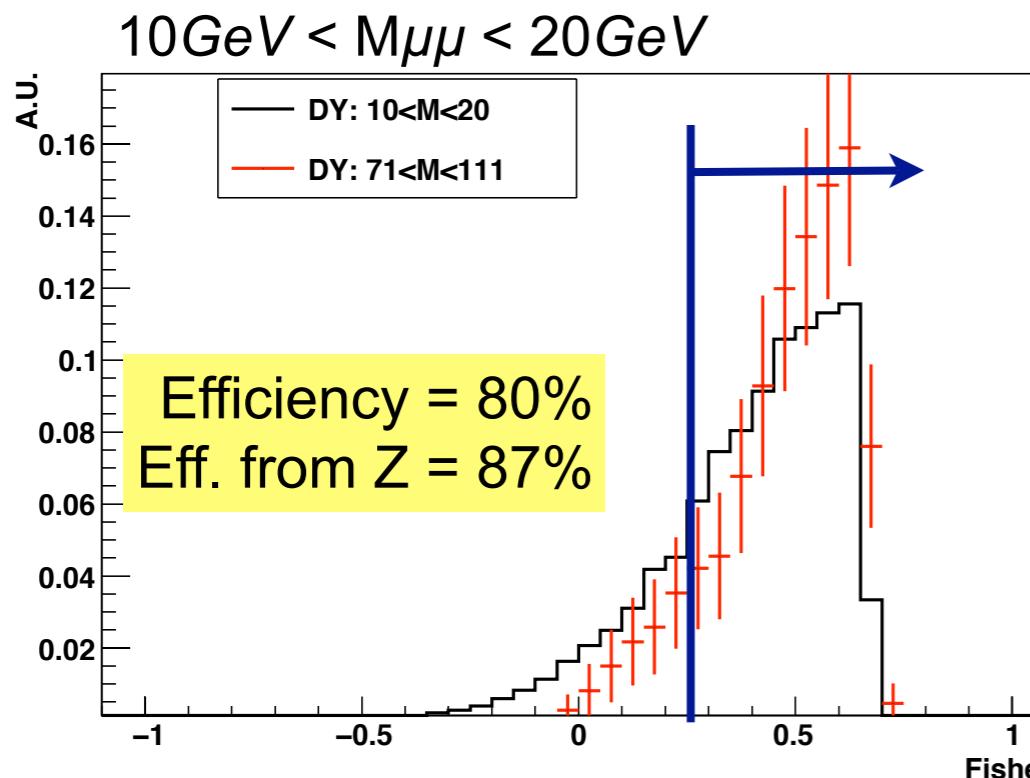
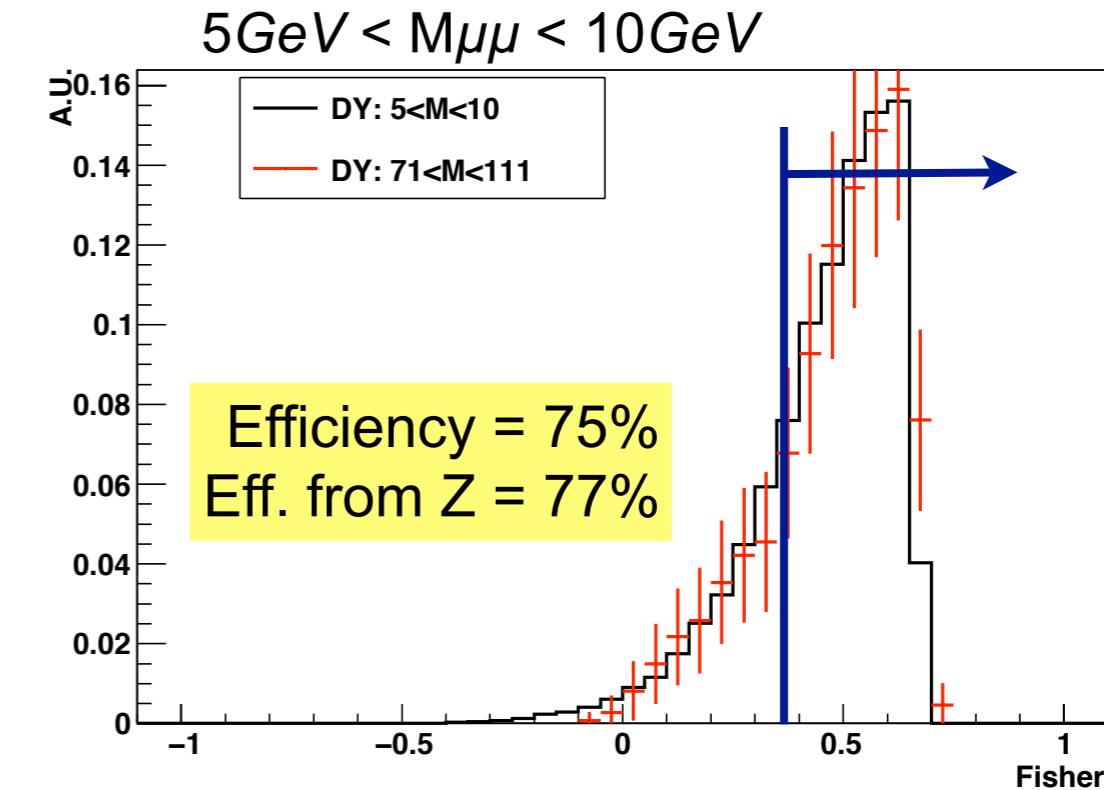
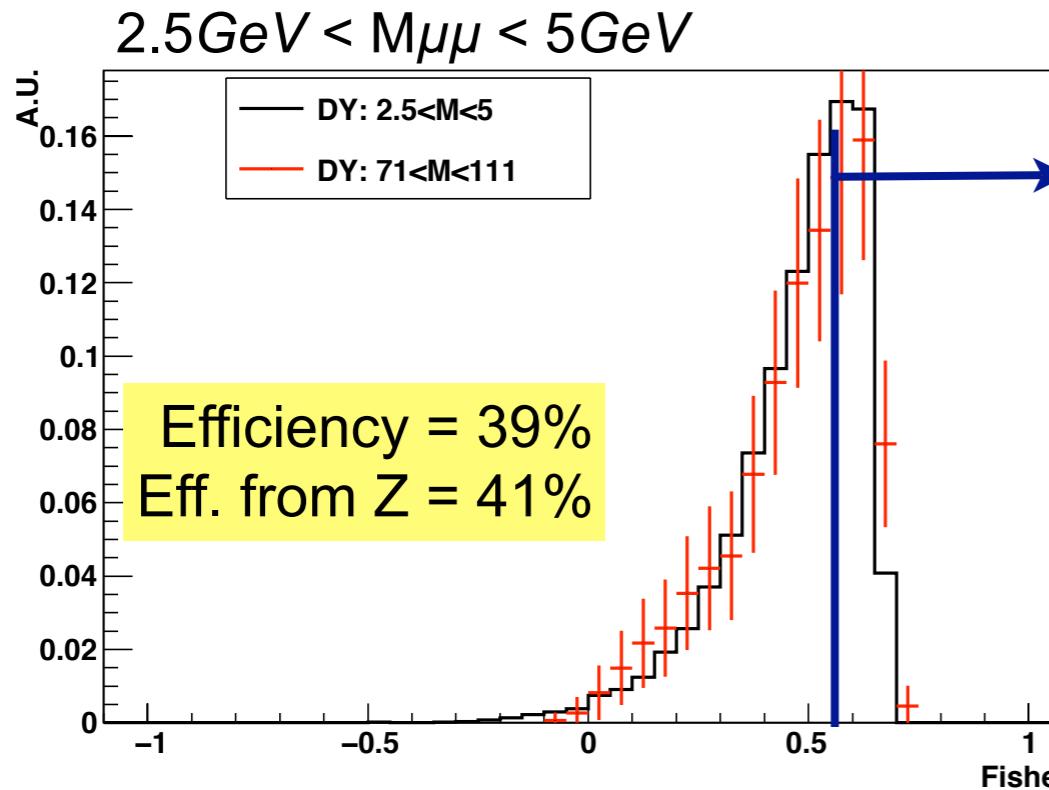
Understanding backgrounds with data



Do Z shapes match lower masses?



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Expected impact on PDFs

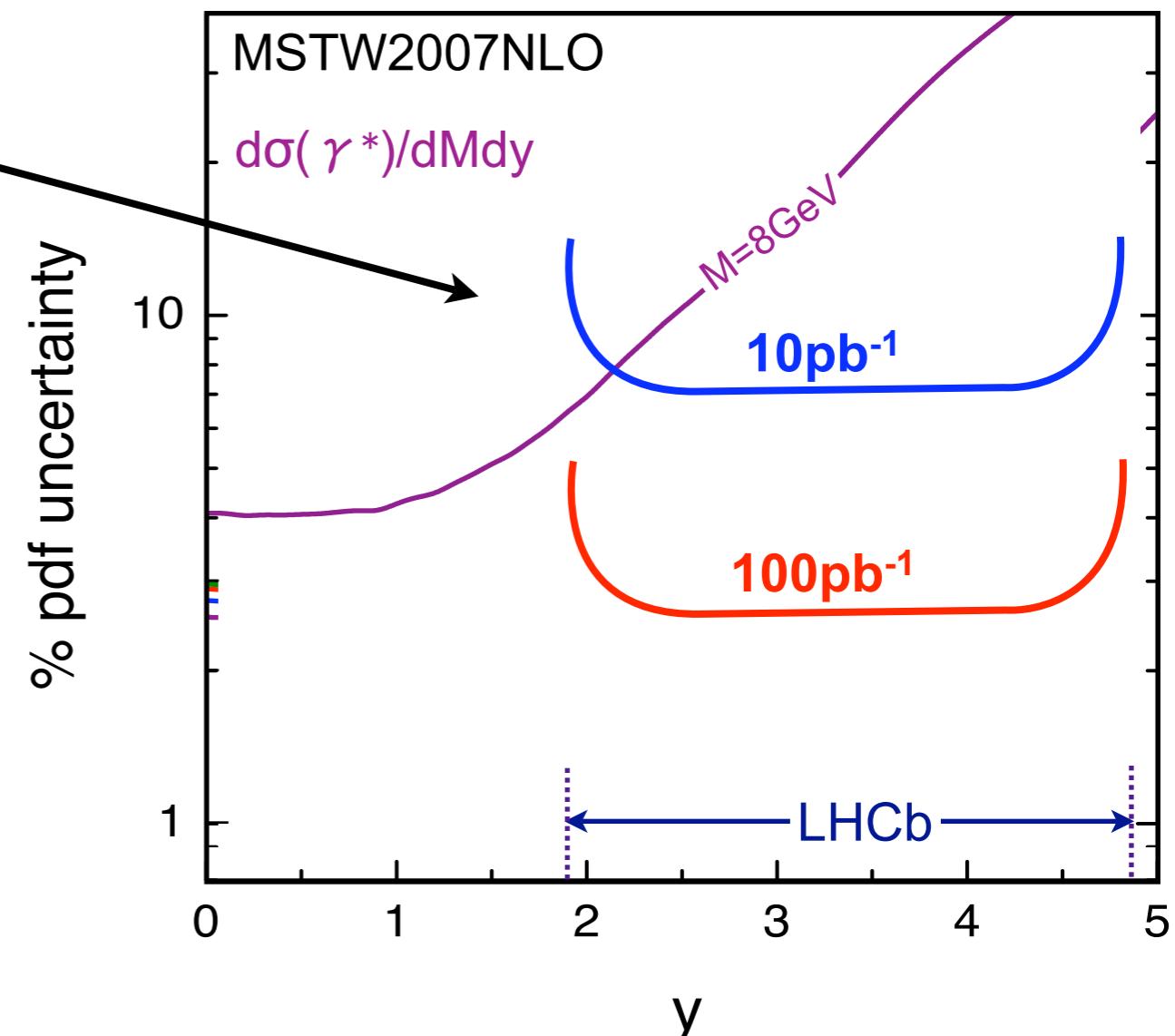
Expected statistical uncertainties

for $5\text{GeV} < M < 10\text{GeV}$

(assuming 10 bins in y)

Systematic uncertainties will come from:

- PDFs (kinematic acceptance)
- Determination of efficiencies
- Backgrounds
- Luminosity (if normalisation is desired)



Work needed on systematics but O(3%) seems reasonable

(Non-lumi systematics on Z measurement O(1%))

Conclusions

LHCb can reconstruct and trigger on DY events with

- $M_{\mu\mu} > 2.5 \text{ GeV}$
- $1.9 < y < 4.9$

These events will probe x values down to 1.5×10^{-6}

- Large improvements to PDFs can be expected

An offline selection has been devised

- High purities and reasonable efficiencies down to $M_{\mu\mu} = 2.5 \text{ GeV}$

Some remaining issues concerning calibration