



PDF Sensitivity Studies using EW processes

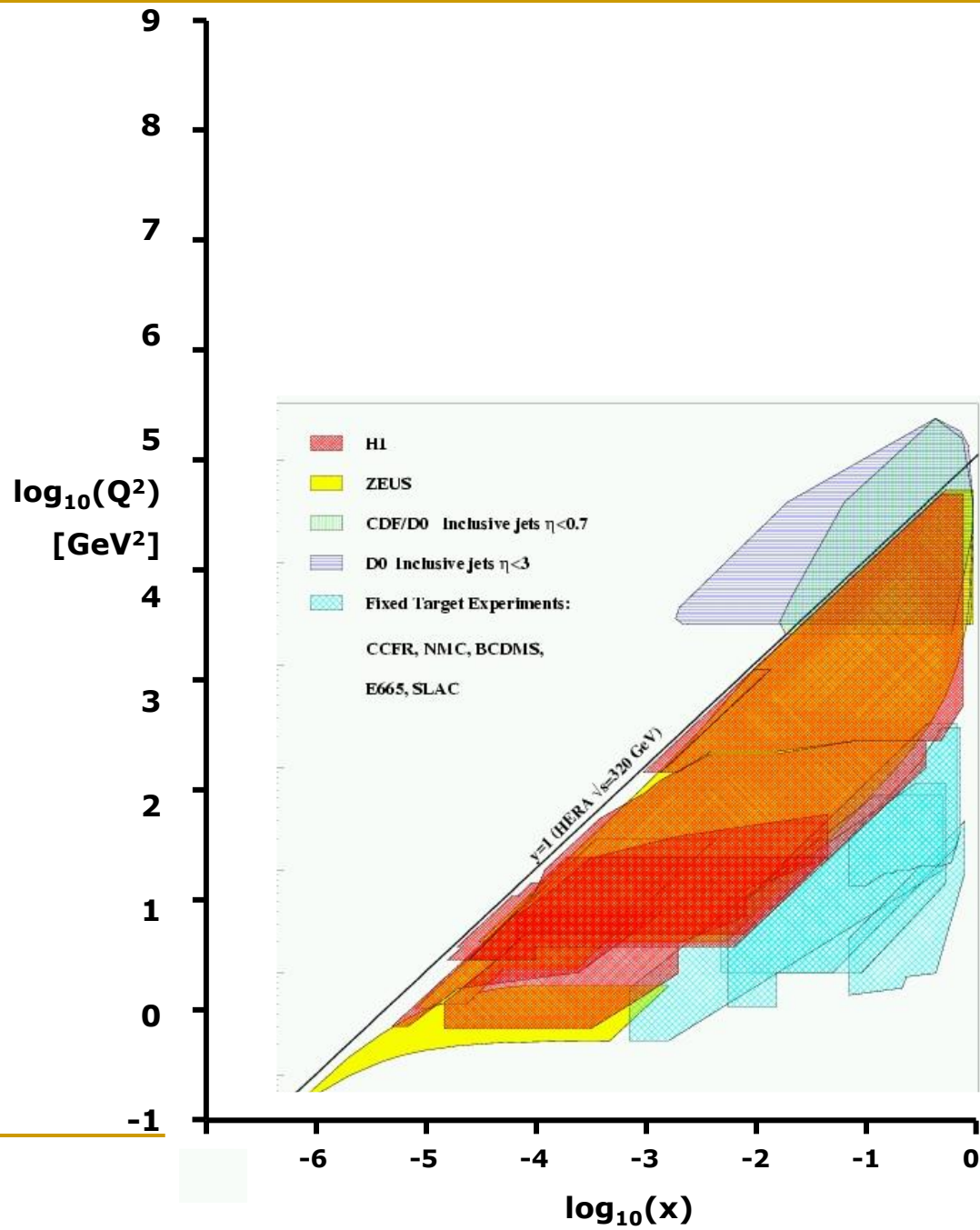
Ronan McNulty
University College Dublin

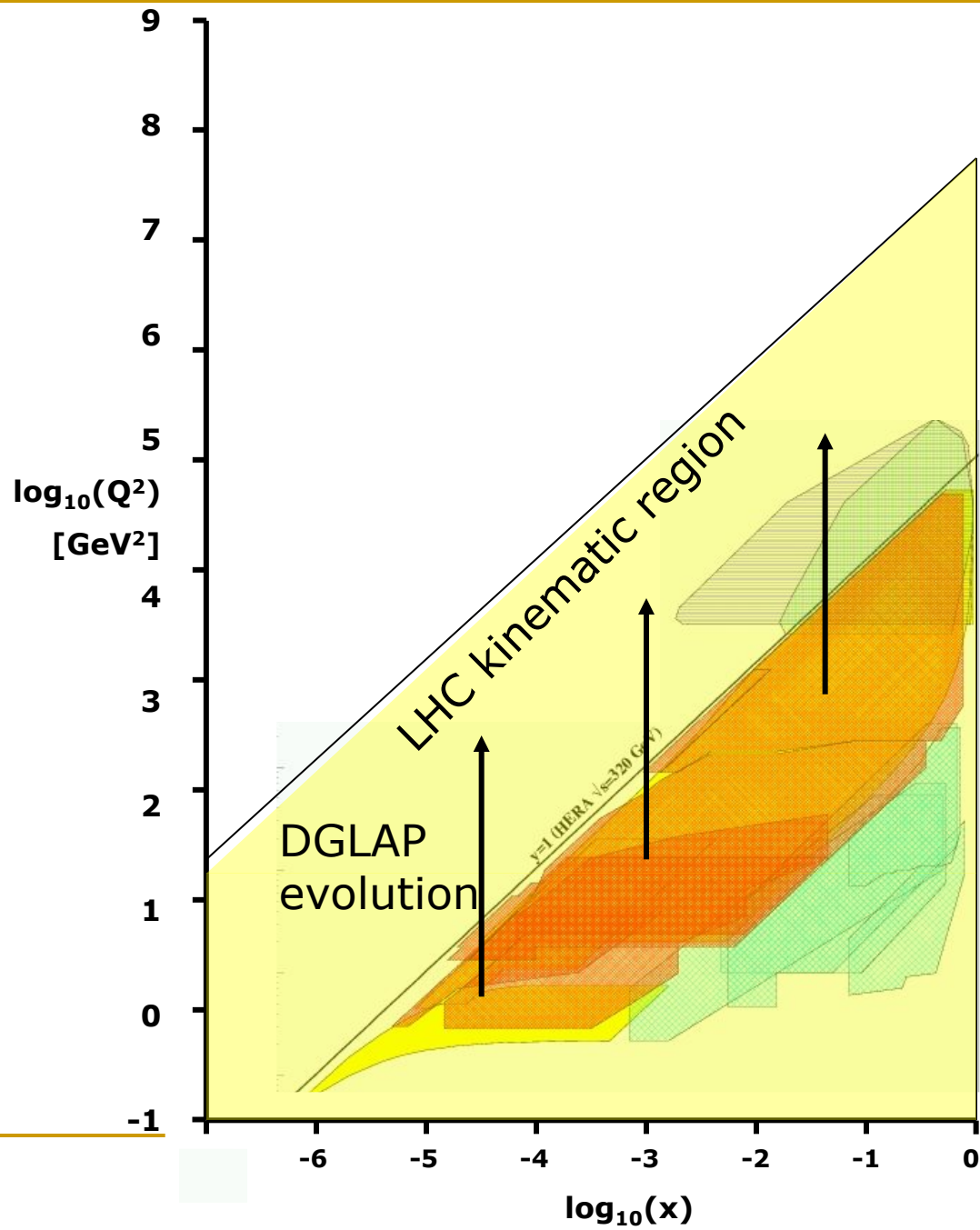
On behalf of the **LHCb** collaboration

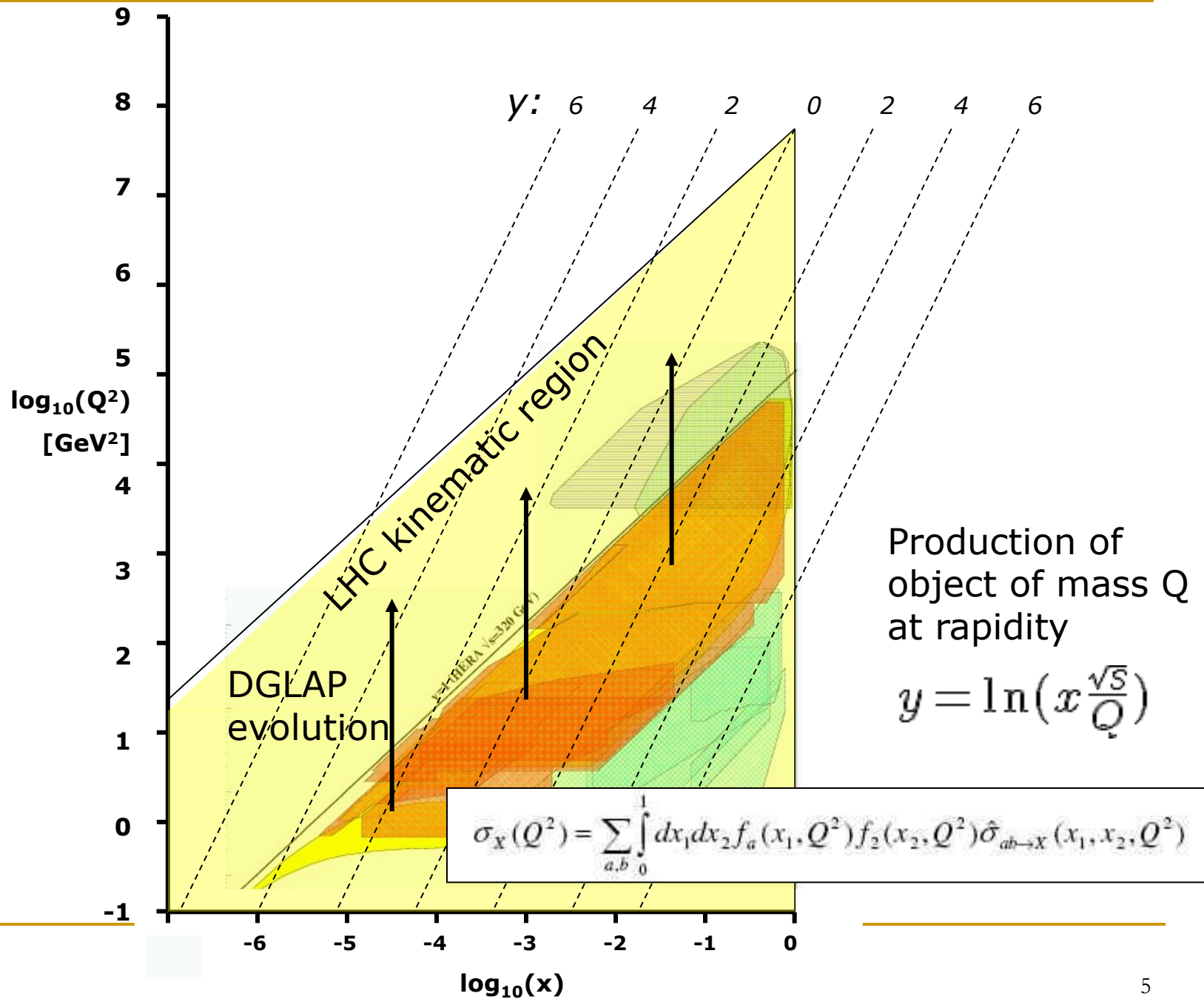


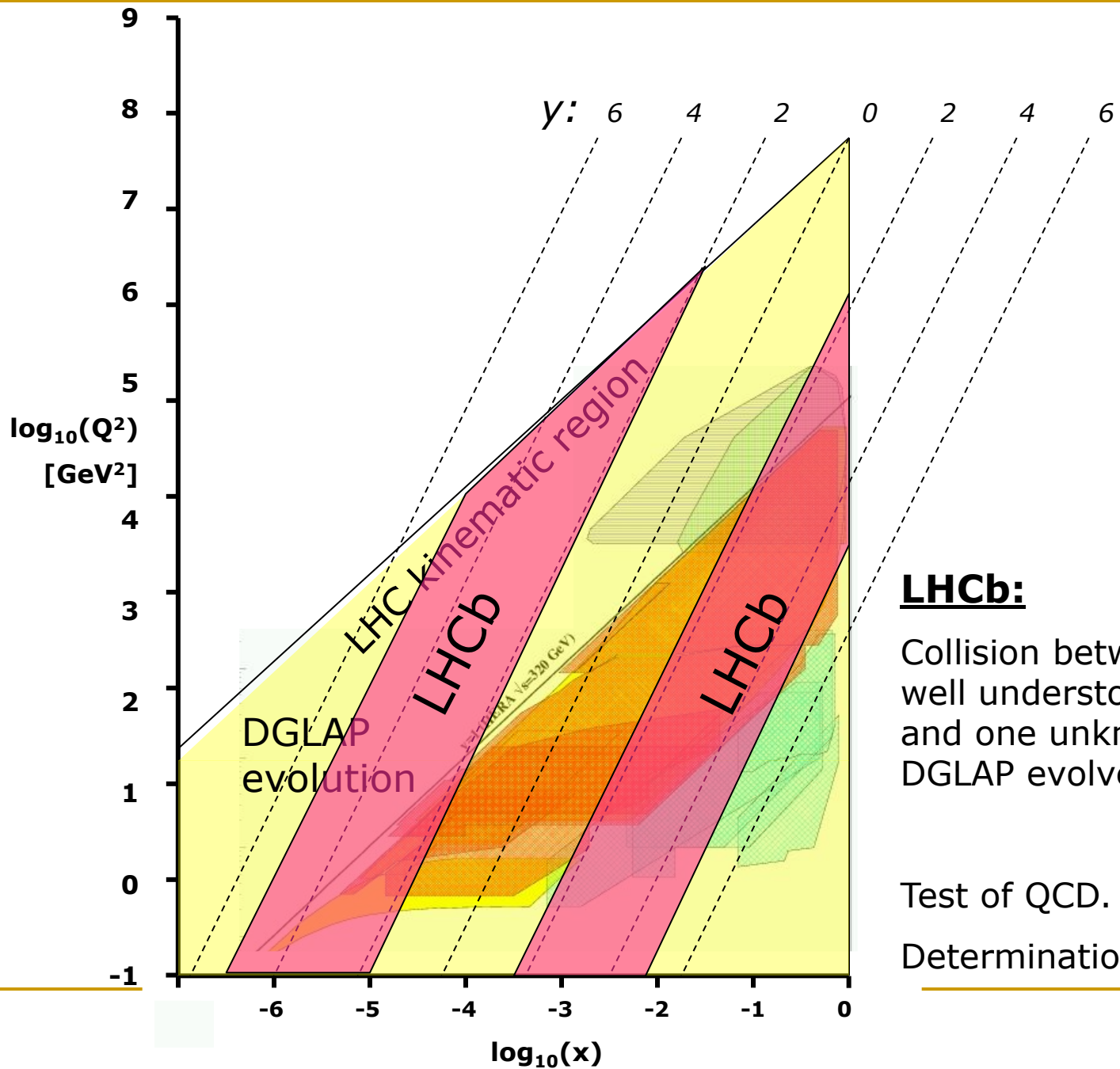
Outline

- Measurements sensitive to low x ($x < \sim 5 \times 10^{-4}$)
 - W, Z production at LHCb
 - Drell-Yan γ^* production of dimuons (to $Q^2 = 5 \text{ GeV}^2$)
- Unique features of the LHCb Experiment
- First results with LHCb data
- Potential sensitivity to PDFs







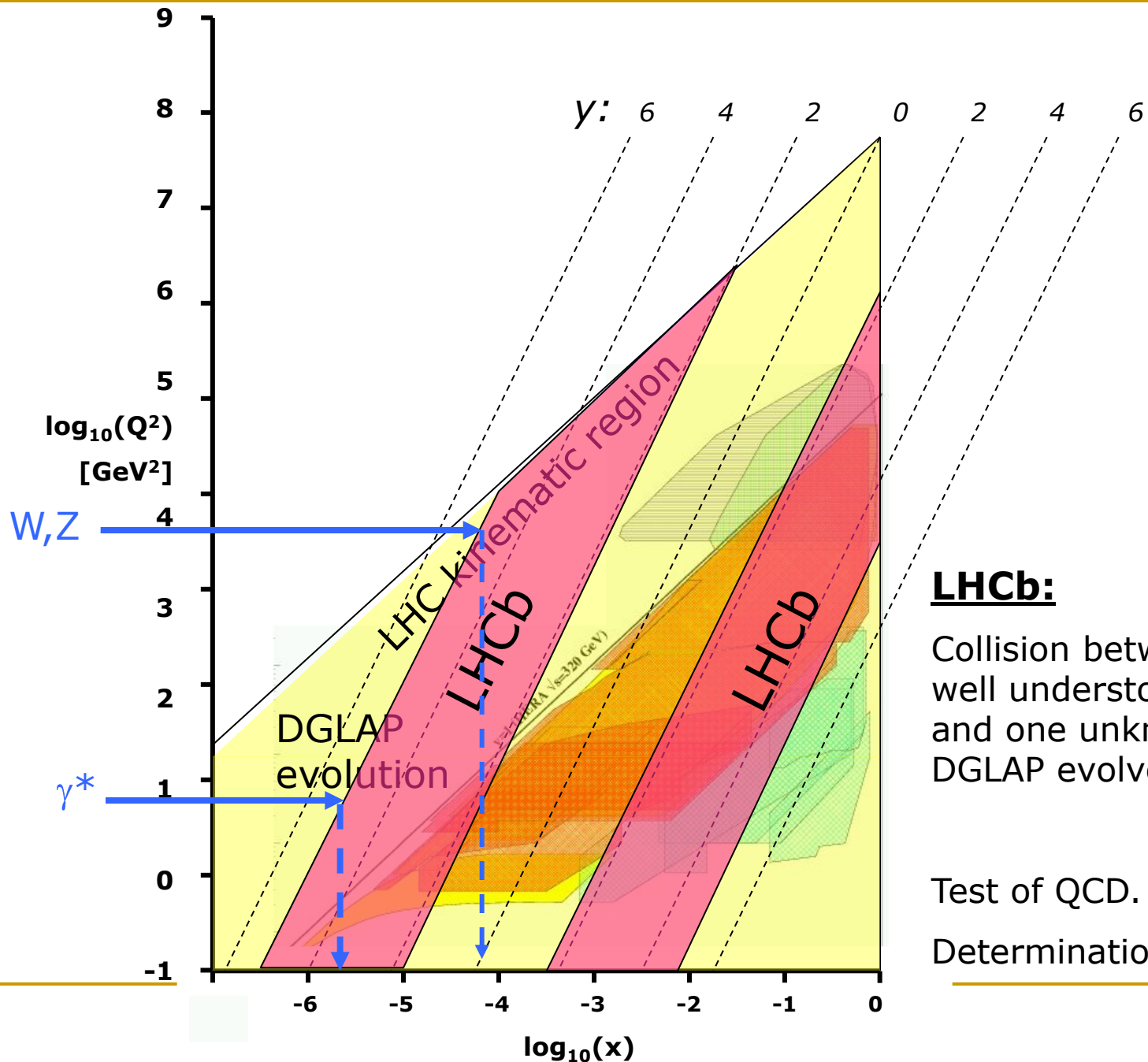


LHCb:

Collision between one well understood parton and one unknown or DGLAP evolved parton.

Test of QCD.

Determination of PDFs



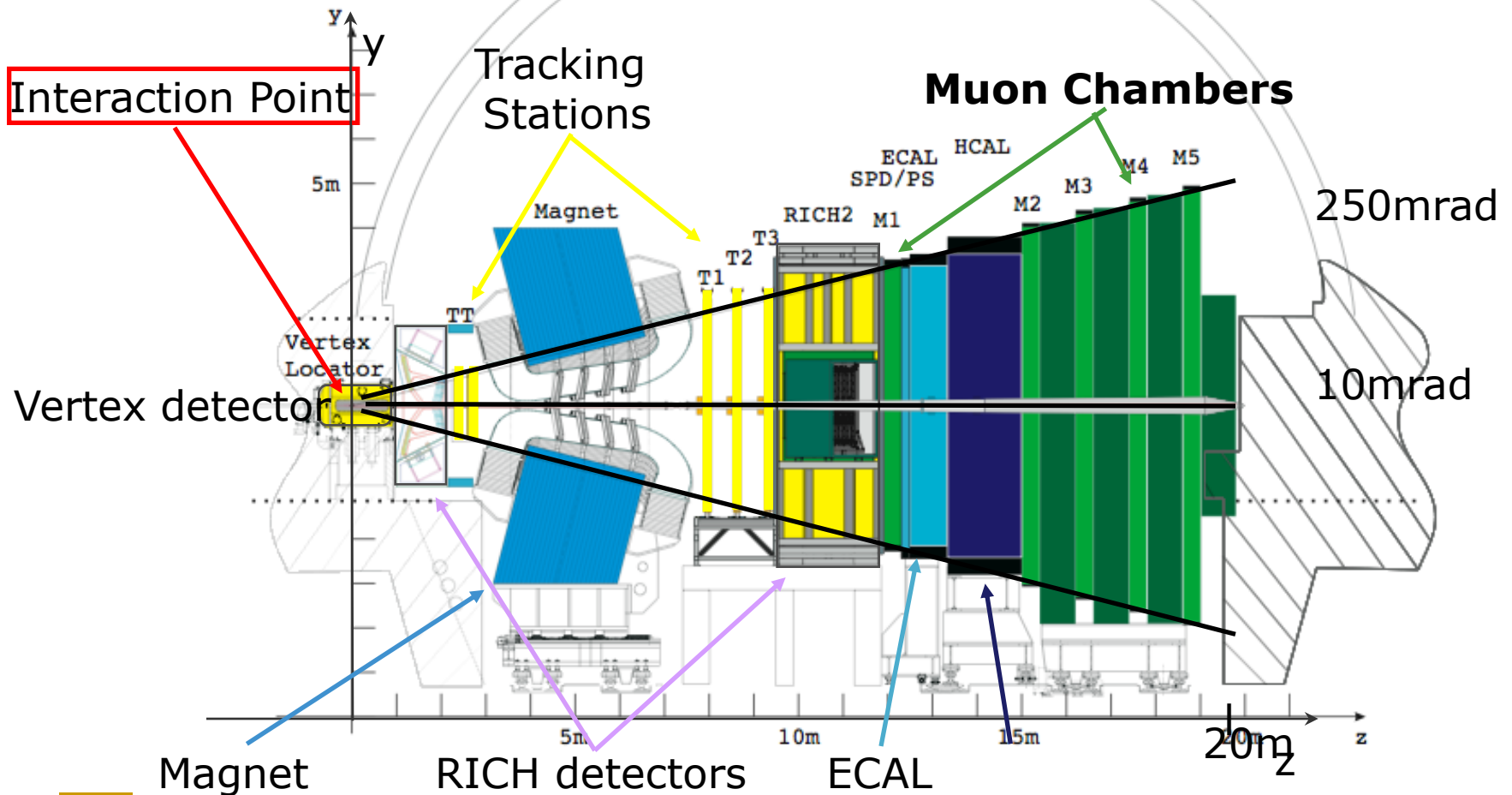
LHCb:

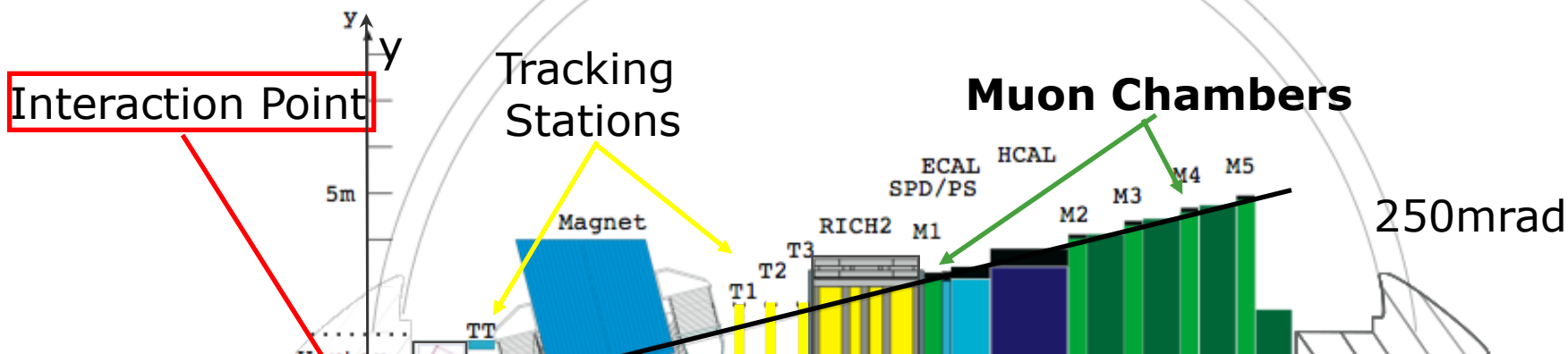
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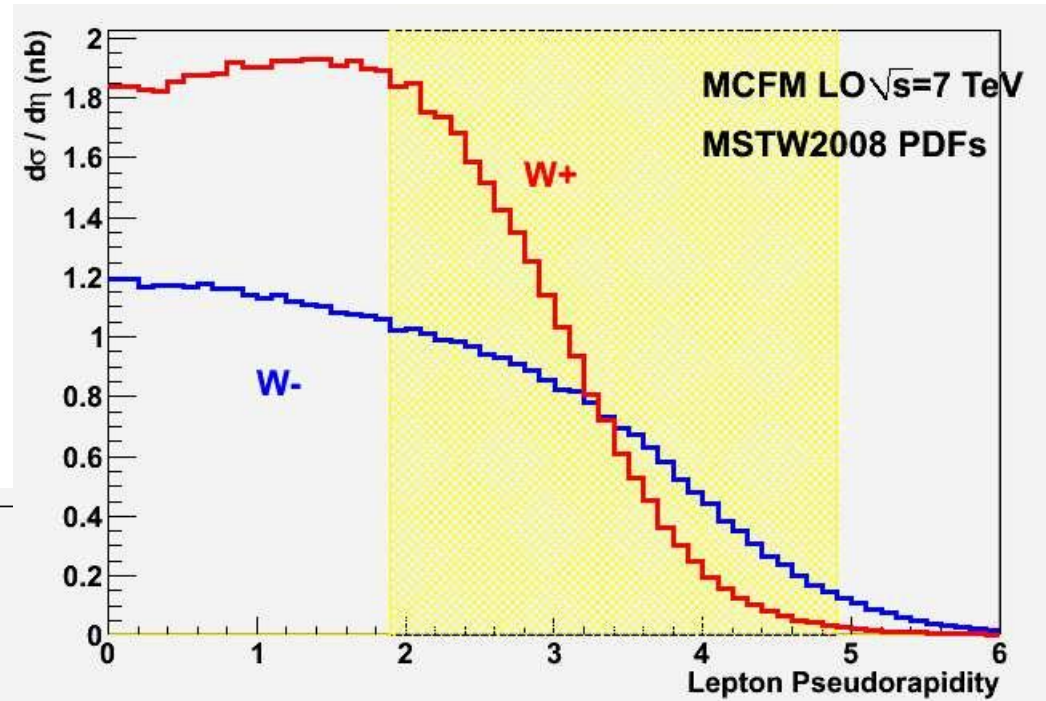
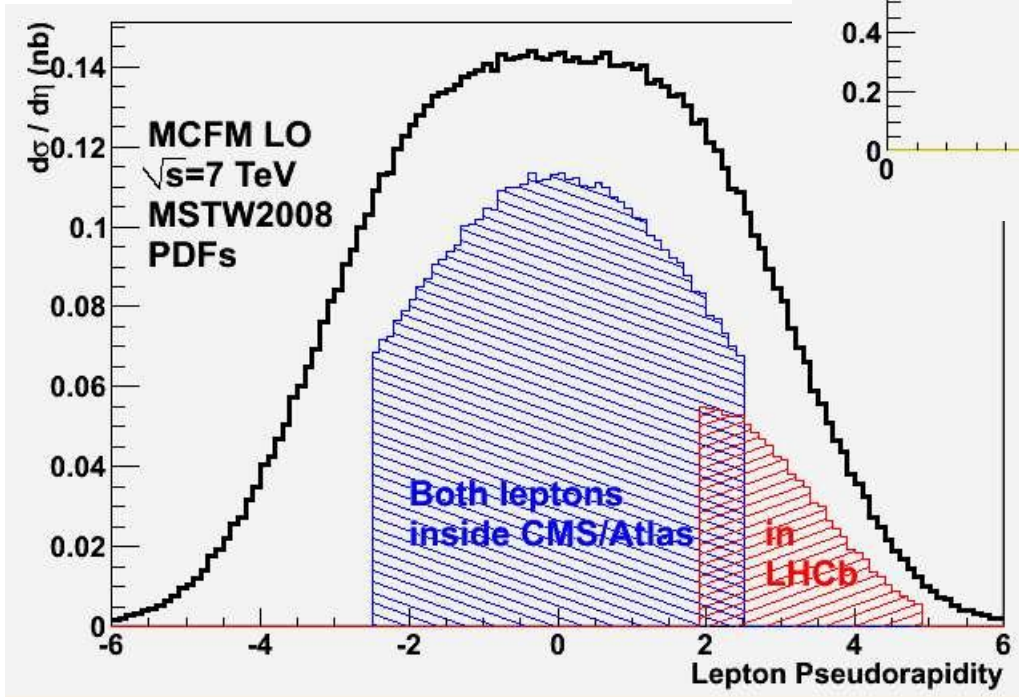
LHCb: a forward spectrometer





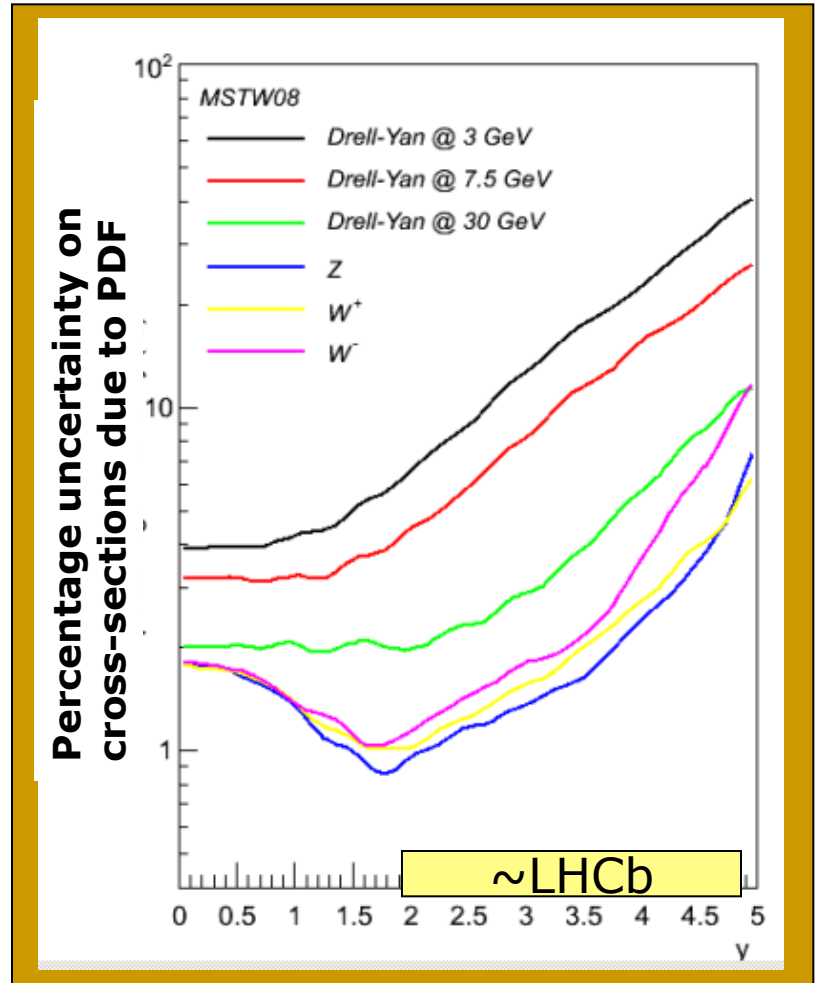
- Fully instrumented, $1.9 < \eta < 4.9$
 - 1.9-2.5 Complementary to CMS/ATLAS
 - > 2.5 Unique to LHCb
- Trigger on low momentum muons
 - $p > 8\text{GeV}$, $p_T > 1\text{GeV}$
- Access to unique range of (x, Q^2)

W,Z production



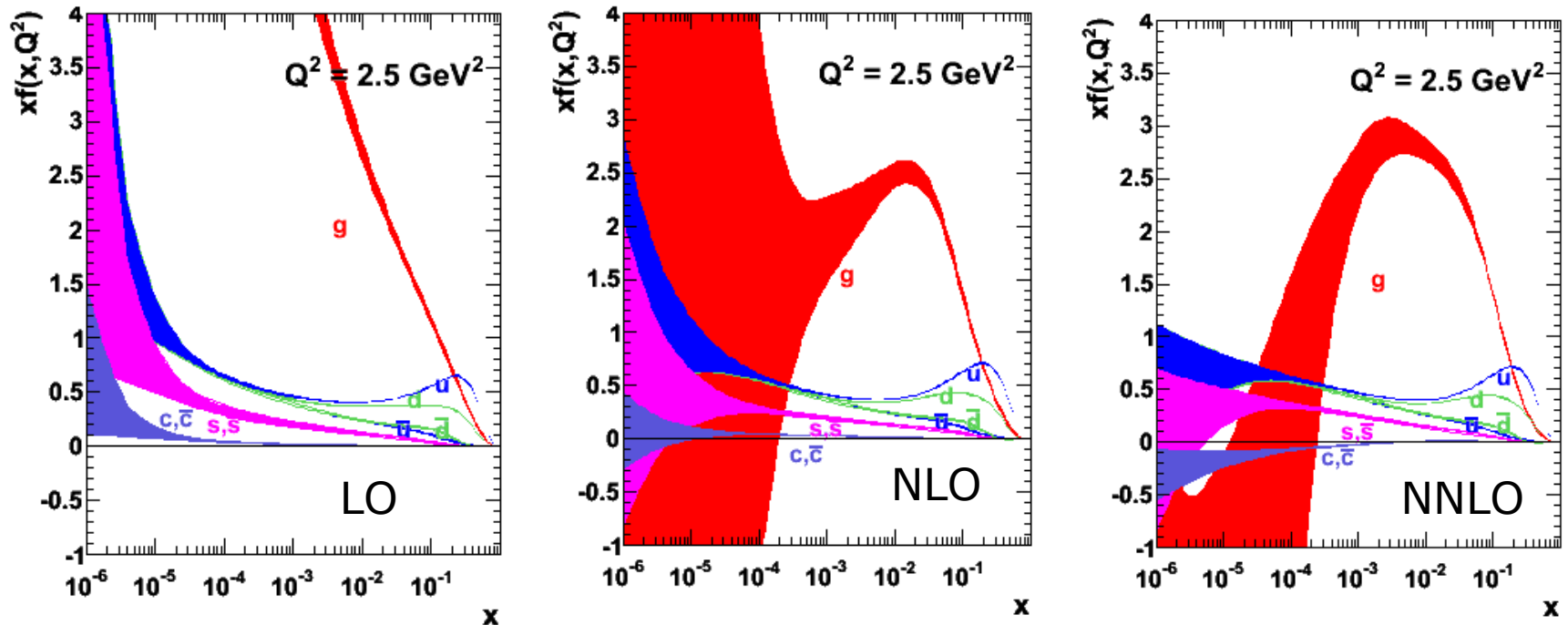
Effect of PDF uncertainties on cross-sections

- Regions where the most precise EW tests can be made.
- High rapidity, low mass dimuon production sensitive to gluon PDF.



PDF uncertainties at low- x , low- Q^2

MSTW08. (Thanks to Graeme Watt)



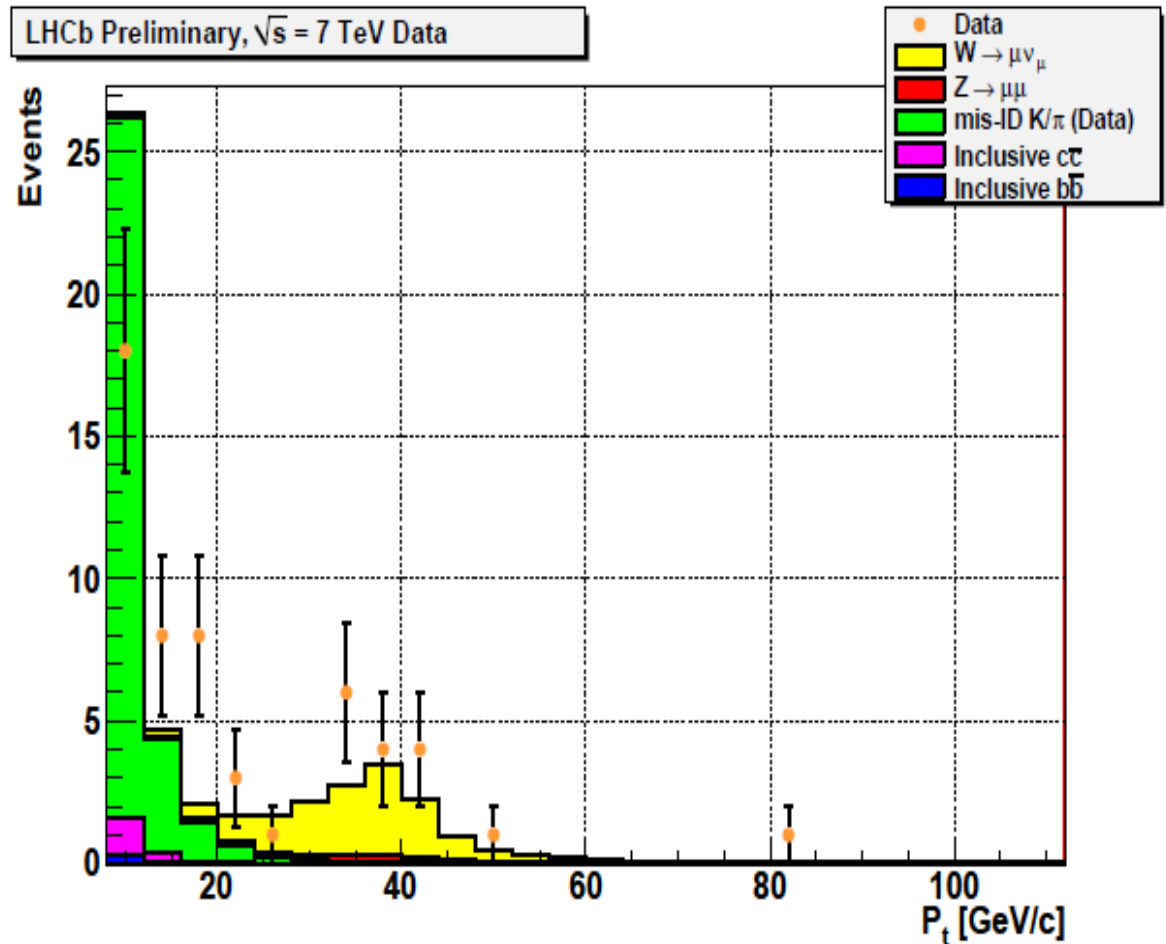
Different behaviour and uncertainty with order of calculation.

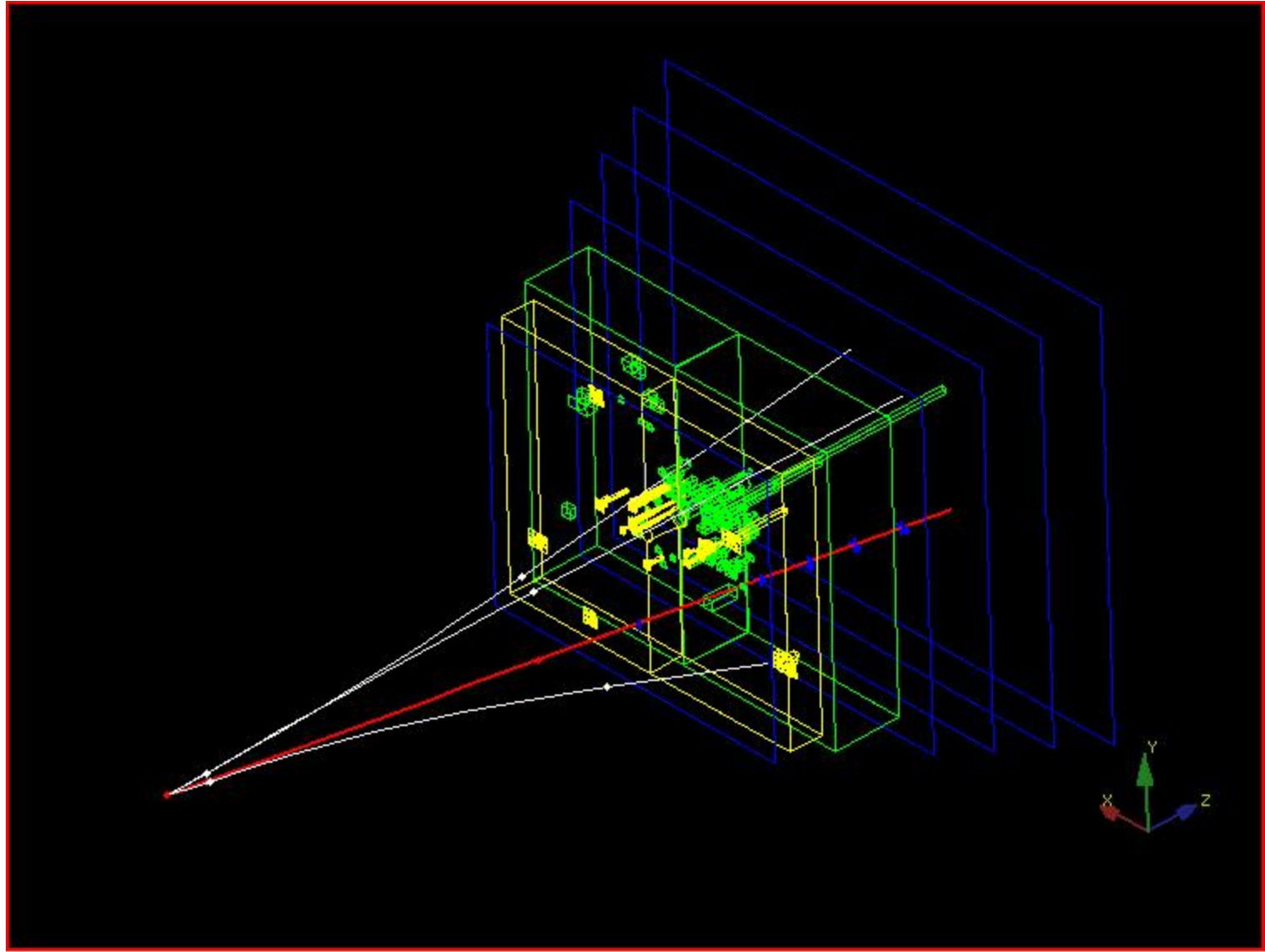
Gluon essentially unconstrained by data below 10^{-4}

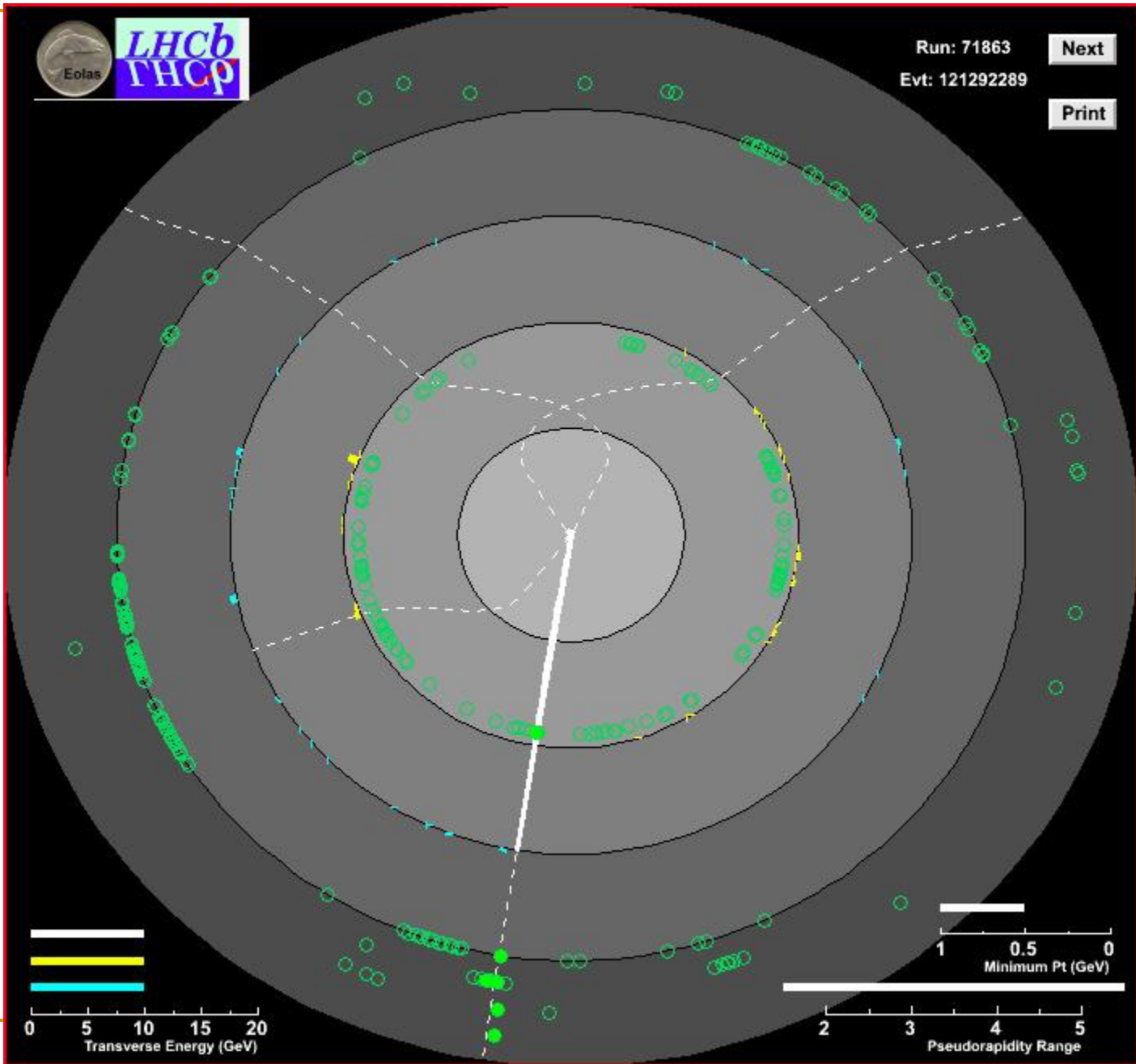
DGLAP evolution not trustworthy in this region. Gluon re-summation effects. Possibly entering saturation regime.

First data. Analyses using 14.6 nb^{-1}

- $W \rightarrow \mu\nu$
 - Requires high transverse momentum muon with little other activity in the event.
- Above 20 GeV, observe 20 candidates.



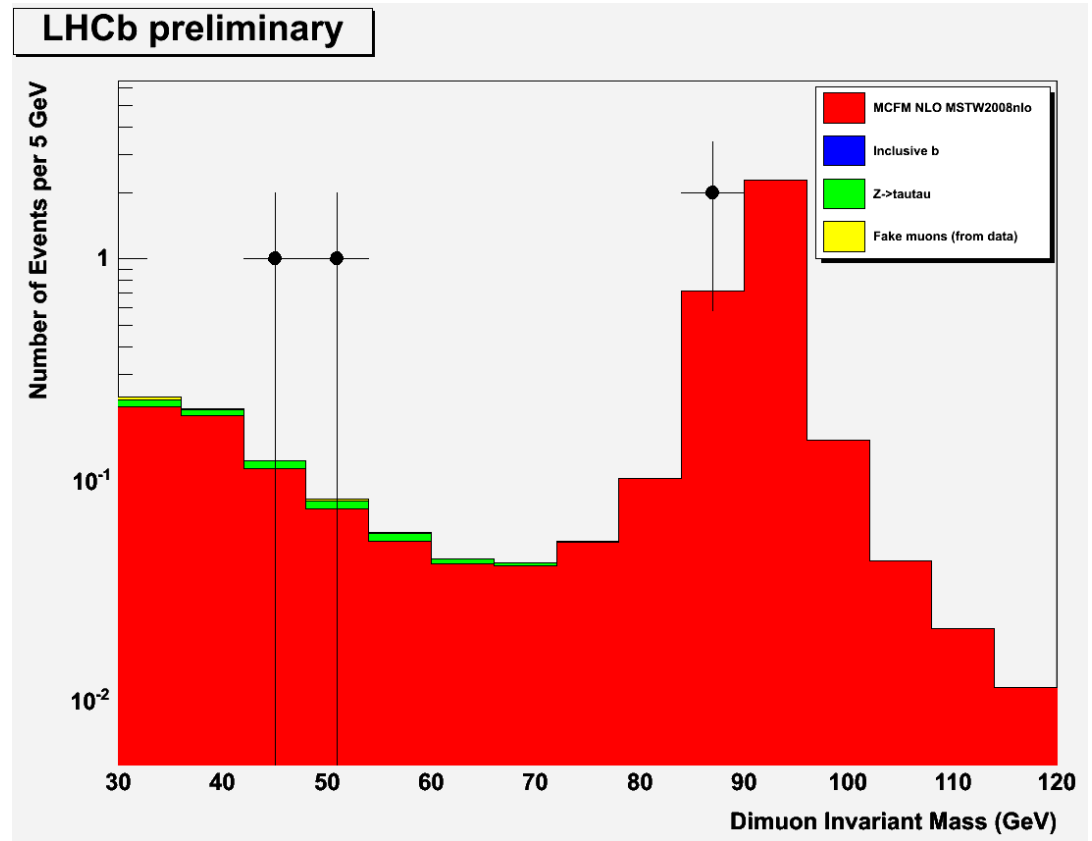




First data. Analyses using 37 nb^{-1}

■ Z- $\rightarrow\mu\mu$

- Requires two high transverse momentum muon with little other activity in the event.





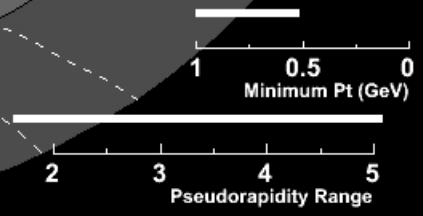
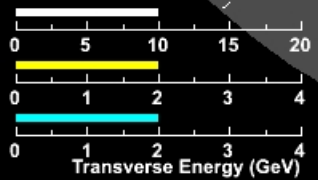
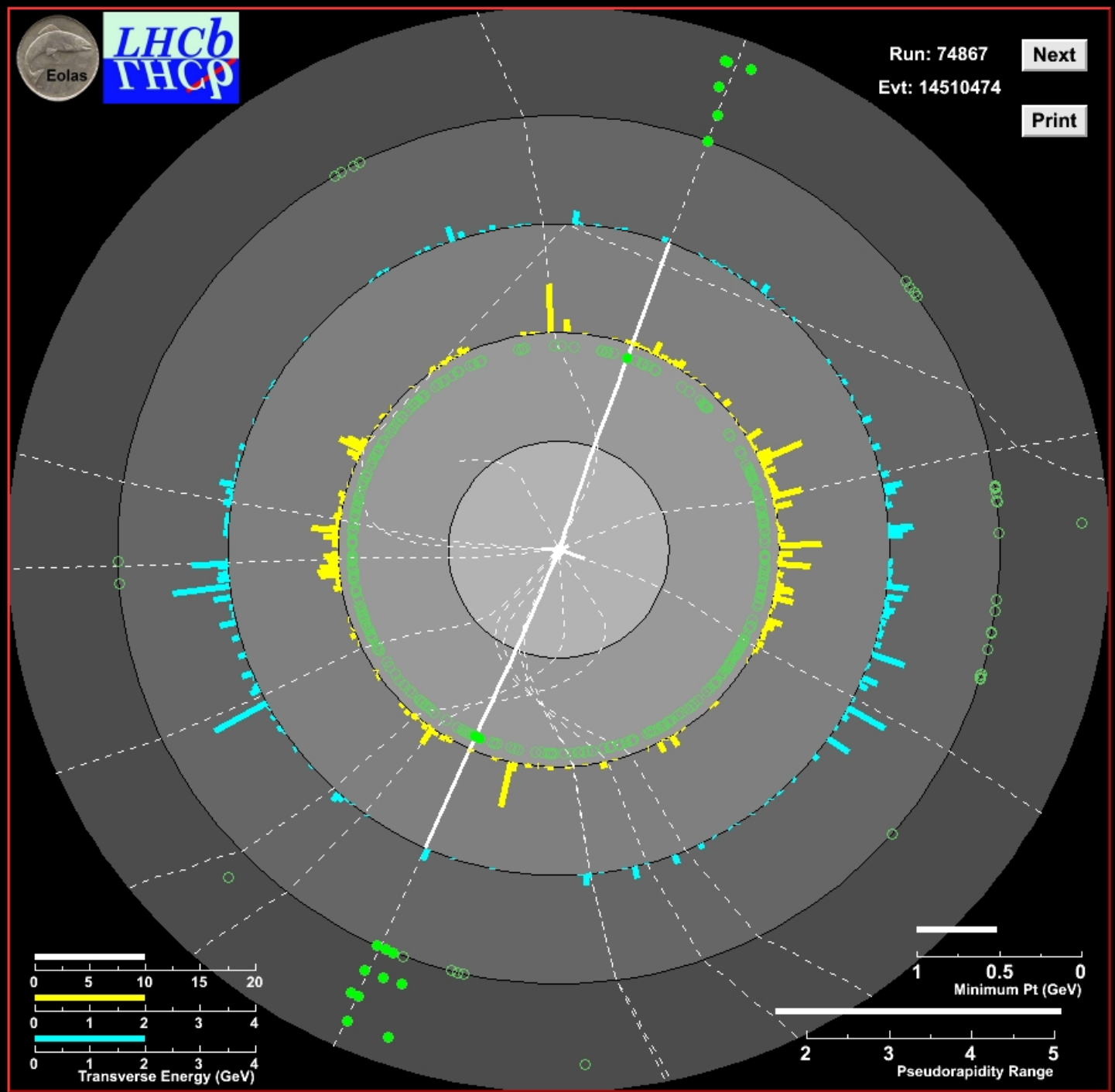
LHCb
THCP

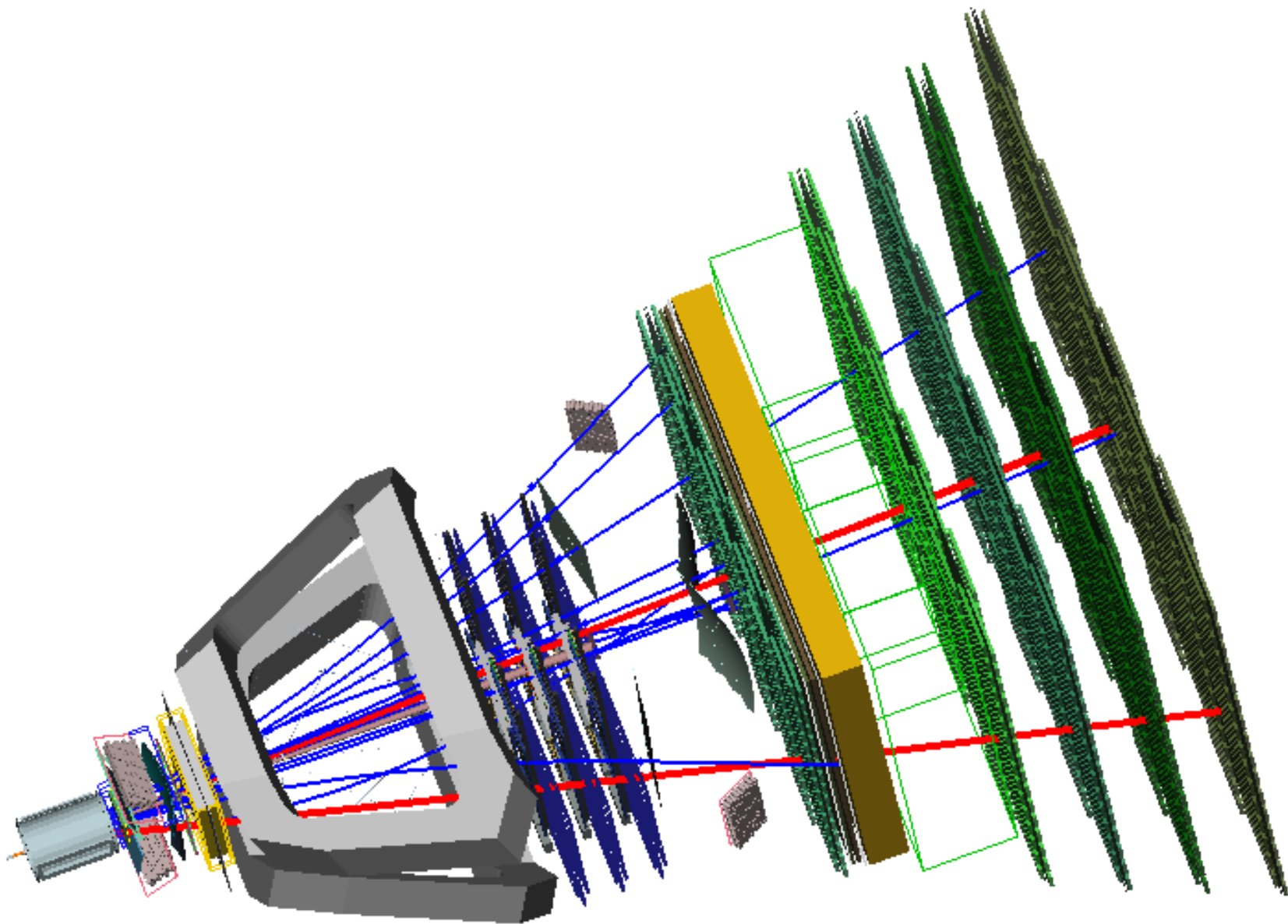
Run: 74867

Next

Evt: 14510474

Print

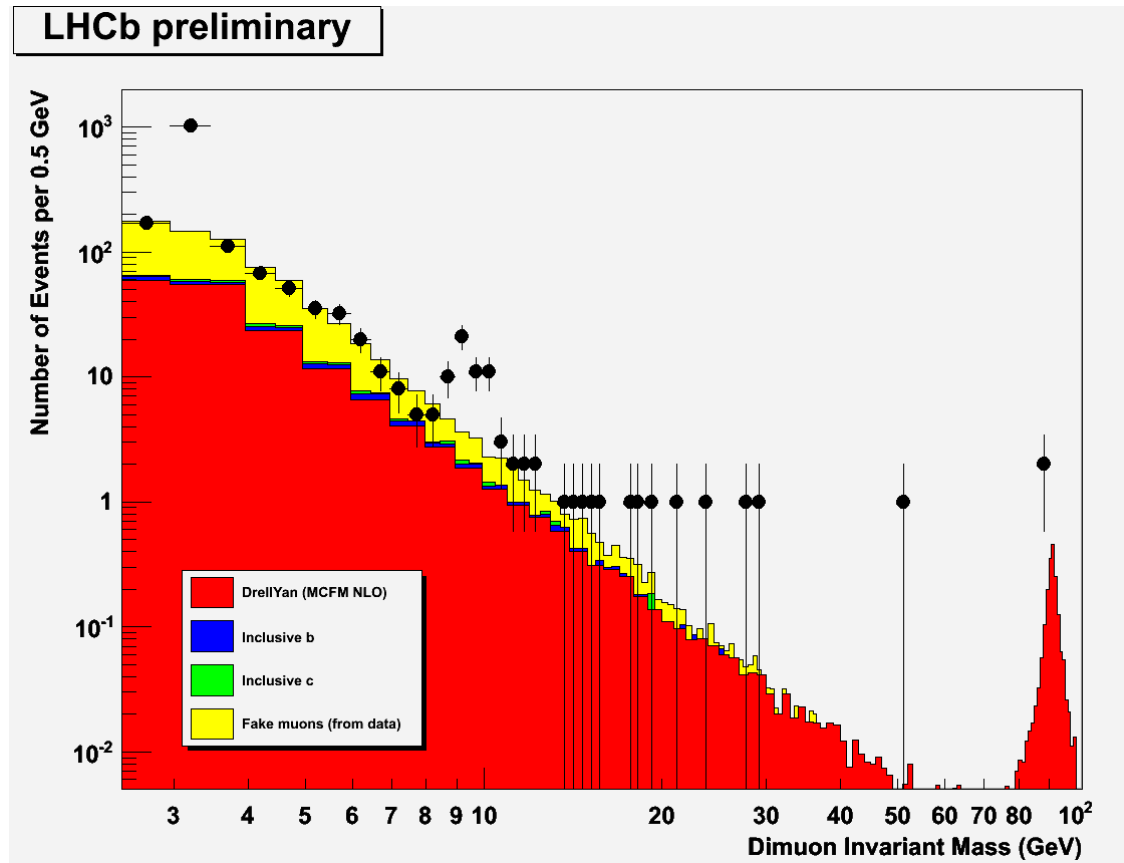




First data. Analyses using 37 nb^{-1}

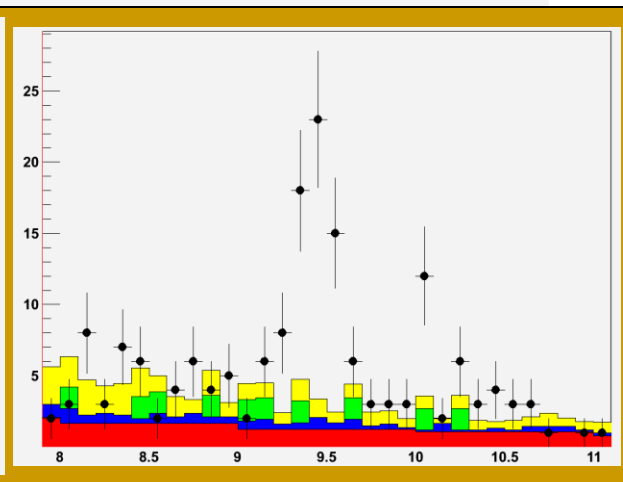
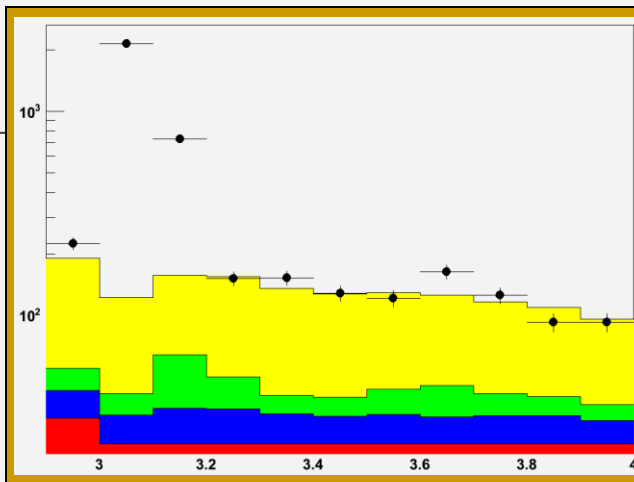
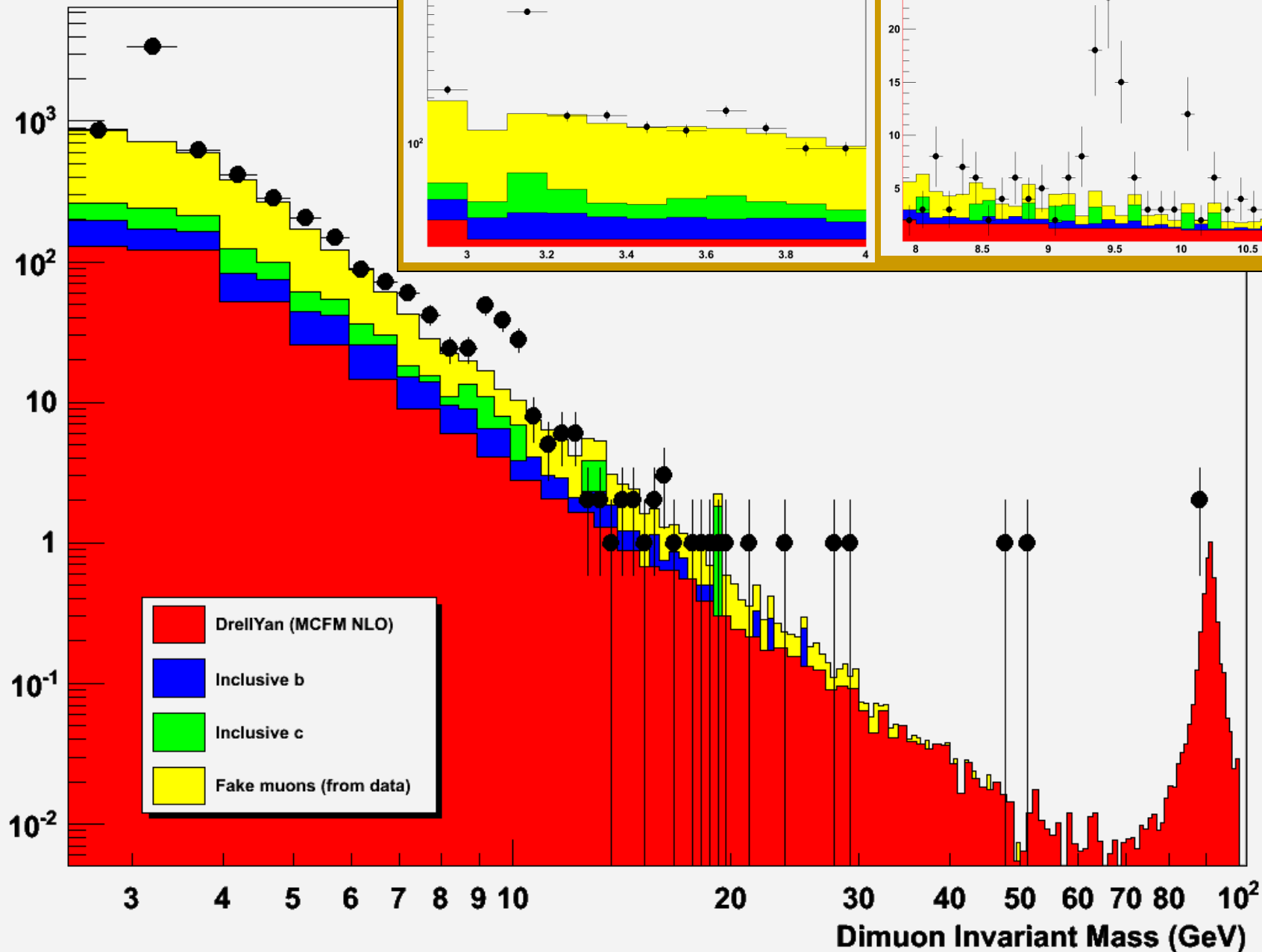
■ $\gamma^* \rightarrow \mu\mu$

- Require two isolated muons $p_t > 1 \text{ GeV}$ consistent with primary vertex.
- b,c background taken from simulation
- Muon misidentified tracks taken from **data**: pions and kaons in Minimum Bias triggered event scaled with misidentification probability.



Sample of DY events can be identified with reasonably high purity

Number of Events per 0.5 GeV



How can LHCb help constrain PDFs?

From global fits, PDFs described by a set of orthogonal eigenvectors, which which have a 'central' value \vec{e}_0 , and 'uncertainties' \vec{e}_i .

$$\frac{d\sigma}{dy}(\delta_1, \delta_2 \dots \delta_N) = \frac{d\sigma}{dy}(\vec{e}_0) + \sum_i^N \delta_i \left\{ \frac{d\sigma}{dy}(\vec{e}_i) - \frac{d\sigma}{dy}(\vec{e}_0) \right\}$$

(where δ_i is #sigmas along e_i)

Current knowledge of PDFs mapped out by sampling δ_i from unit multinomial distribution.

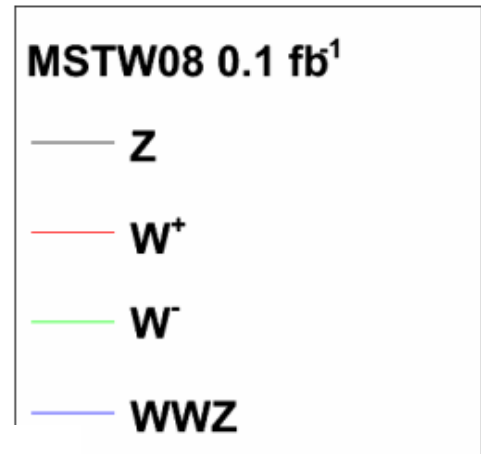
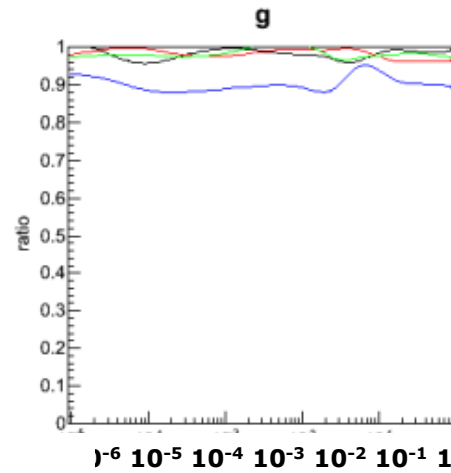
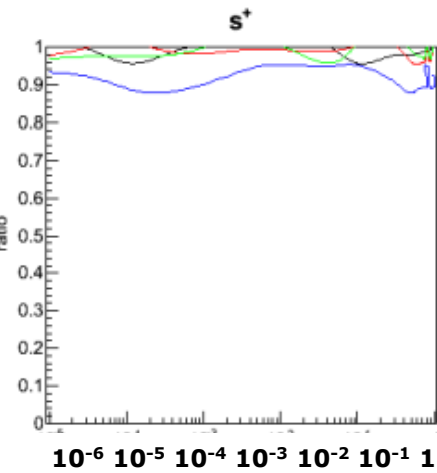
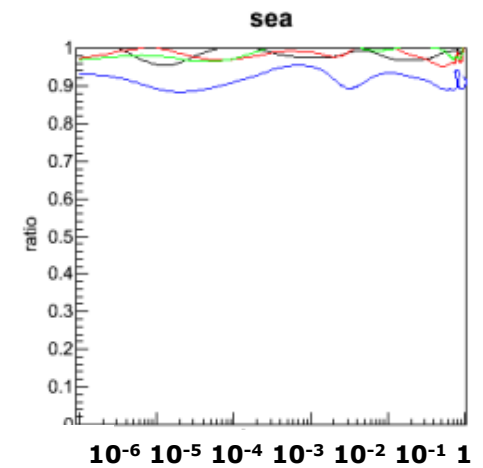
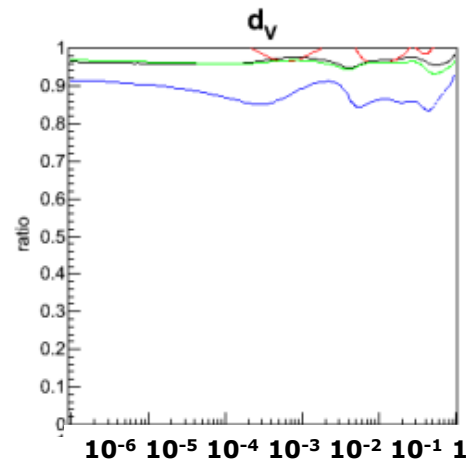
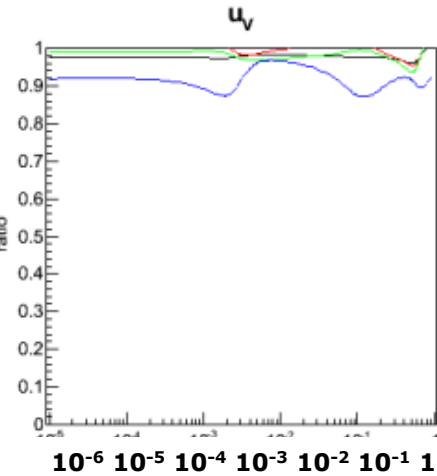
We have performed pseudo-experiments, generating LHCb data and fitting for δ_i , to see how eigenvector knowledge improves.

Effect on MSTW08, CTEQ6.5, ALEKHIN2002, NNPDF2.0 studied.

Improvement to **MSTW08 PDFs** with 0.1fb^{-1} of high mass vector bosons at 7TeV

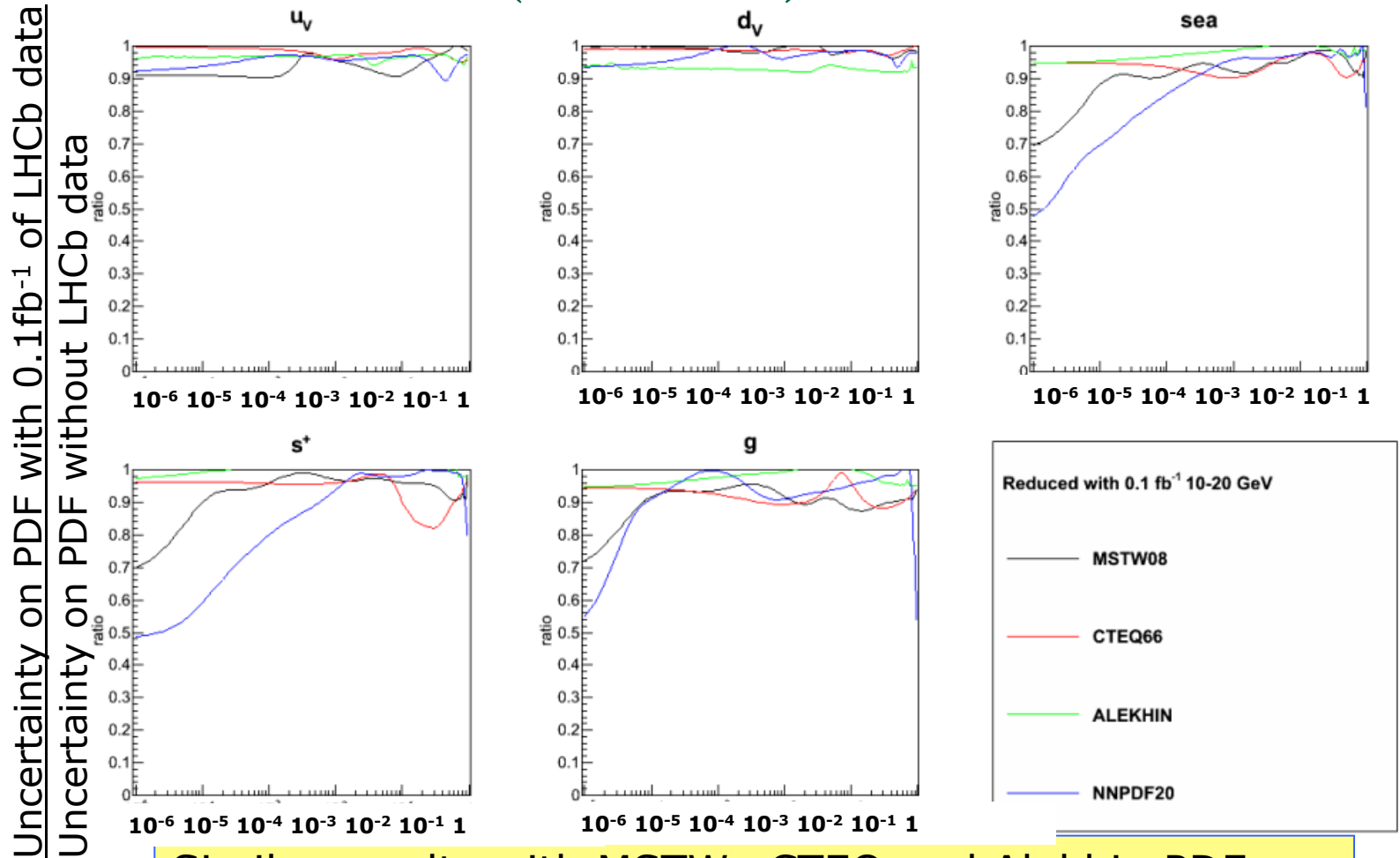
Uncertainty on PDF with 0.1fb^{-1} of LHCb data

Uncertainty on PDF without LHCb data



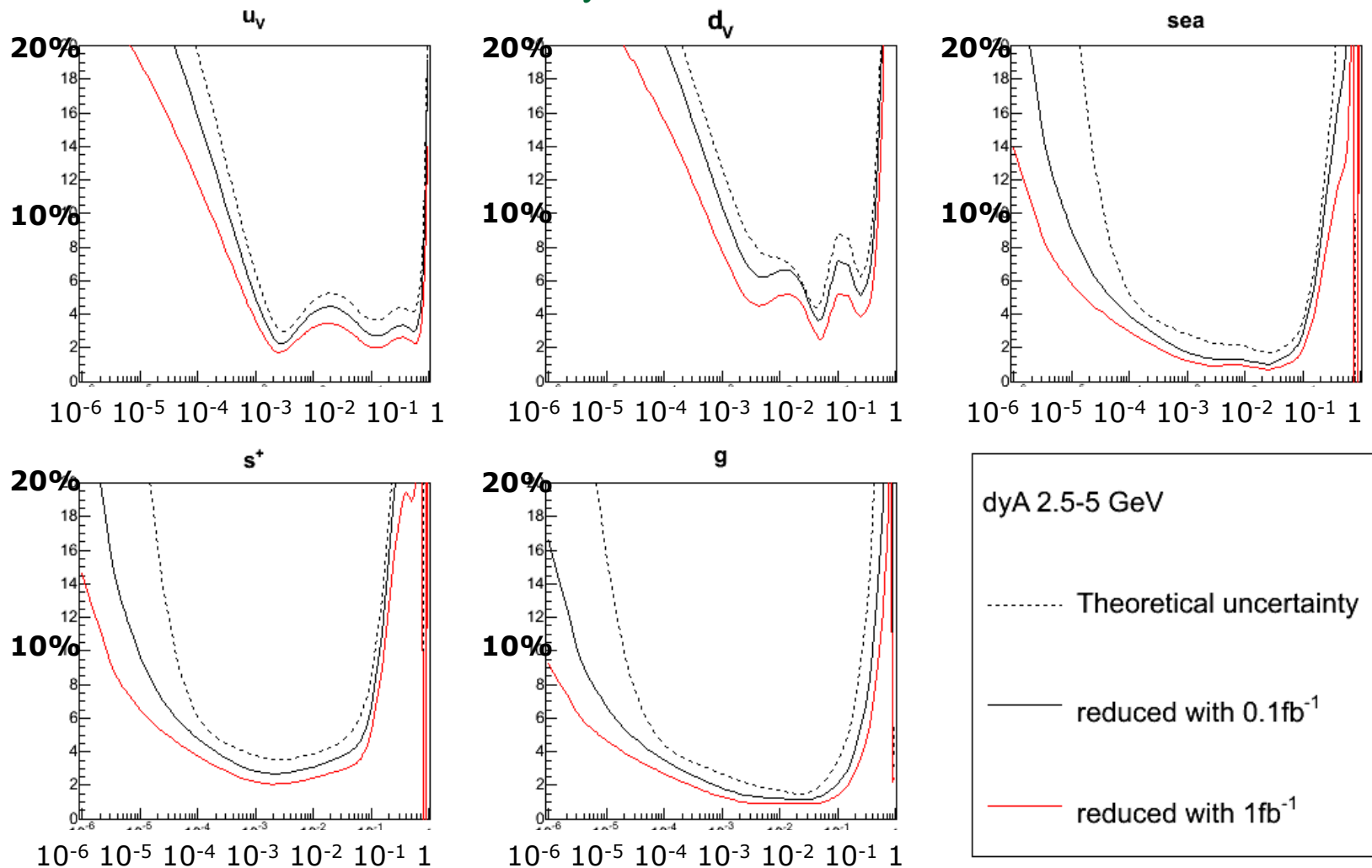
Similar results with CTEQ, NNPDF, Alekhin (Best used to test SM)

Improvement to different **PDF** sets with 0.1fb^{-1} of low invariant mass muons (10-20GeV) at 7TeV



Similar results with MSTW, CTEQ and Alekhin PDFs.
Sensitivity exists to distinguish between models.

Current uncertainty on **MSTW08 PDFs** and projections with 0.1fb^{-1} , 1fb^{-1} of very low invariant mass muons at 7TeV



— Significant improvements possible with modest amount of data

Summary

- For low luminosity W,Z , PDFs well known.
- Significant improvements to gluon PDF in the near future, probing the previously unexplored, and theoretically interesting region down to $x=10^{-6}$.
- First data from LHCb have allowed samples of W,Z and low mass DY to be isolated.