PDF contraints at low-x and jets studies in forward region with LHCb

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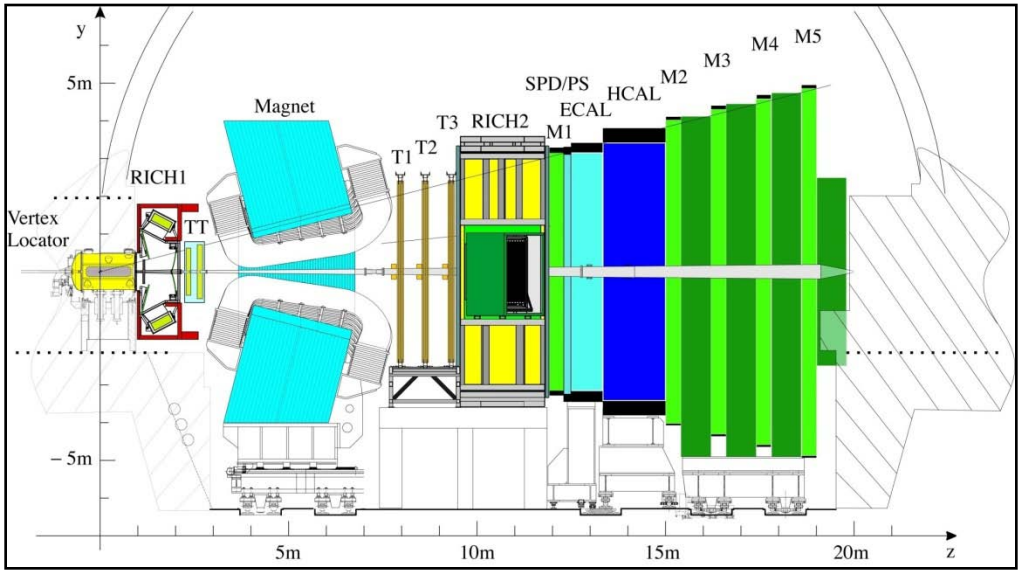
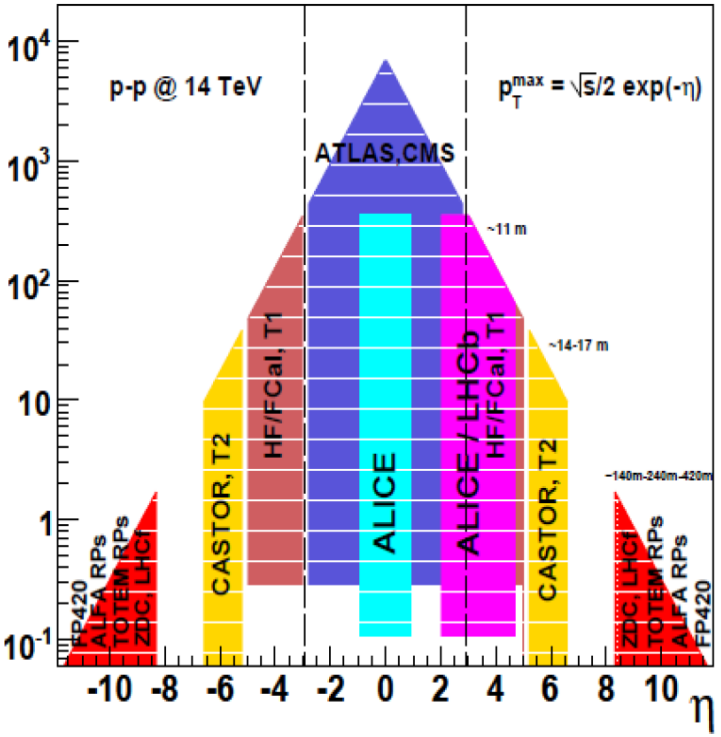
LHCb detector



LHCb extends coverage to $3 \leq \eta \leq 5$
overlaps with ATLAS/CMS at $\eta \in$ (2-3)



Crucial for jet reconstruction

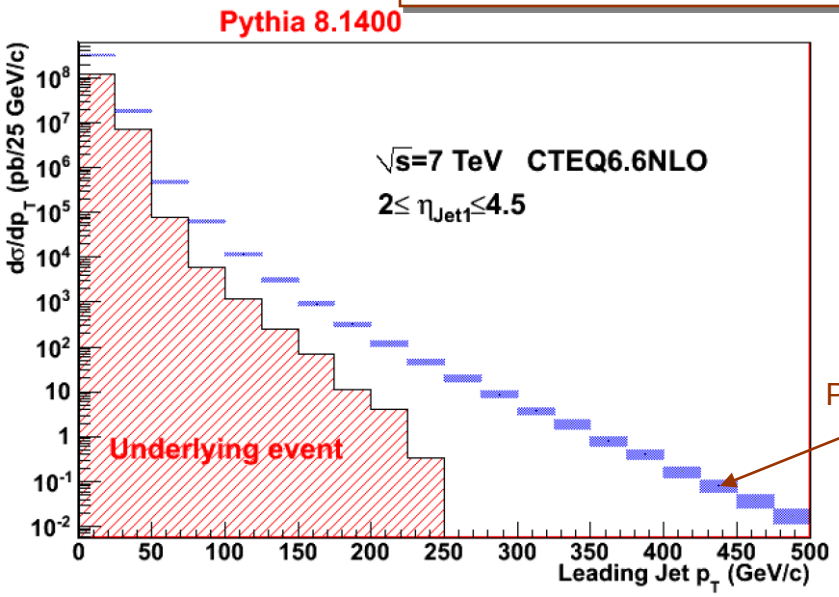
- excellent tracking and vertexing *in $\eta \in$ (2-5)*
- very good particle ID – RICH *(2-100 GeV/c)*
- good separation charged/neutral in calorimeters
- η coverage in the forward region *(2-5)*

TRIGGER: hardware - L0 & software - HLT

- **L0:** 40 MHz $\rightarrow$ 1 MHz *(high p_T μ,e,π^0,h,γ)*
- **HLT:** 1 MHz $\rightarrow$ 2 kHz *(farm of 1800 CPU)*

Physics motivation

Forward jets: unusual mixture of high-x PDF's on low-x PDF's



PDF fit uncertainty

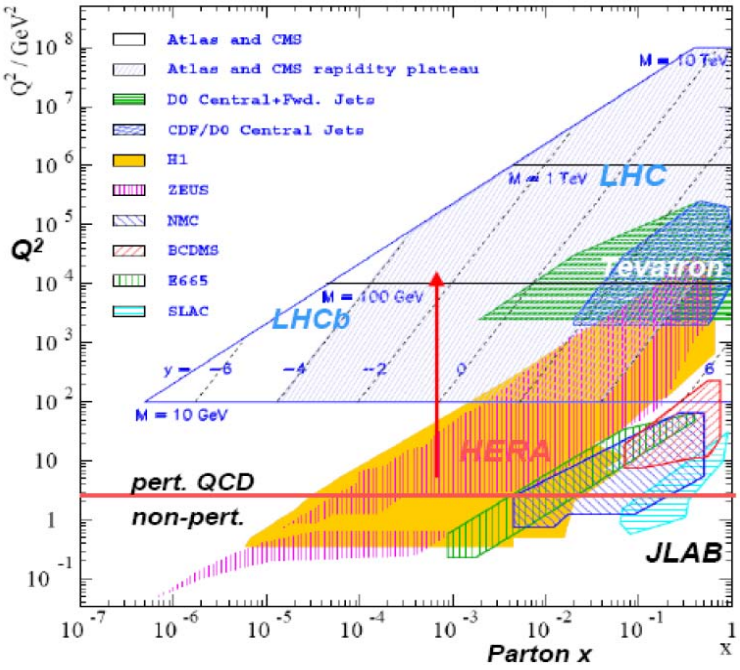
Inclusive jets

- hard QCD
- pp → $qZ^0(\nu\nu)$
- underlaying events

Tagged jets

Fully reconstructed jets

Multiple jets



Forward jet production:

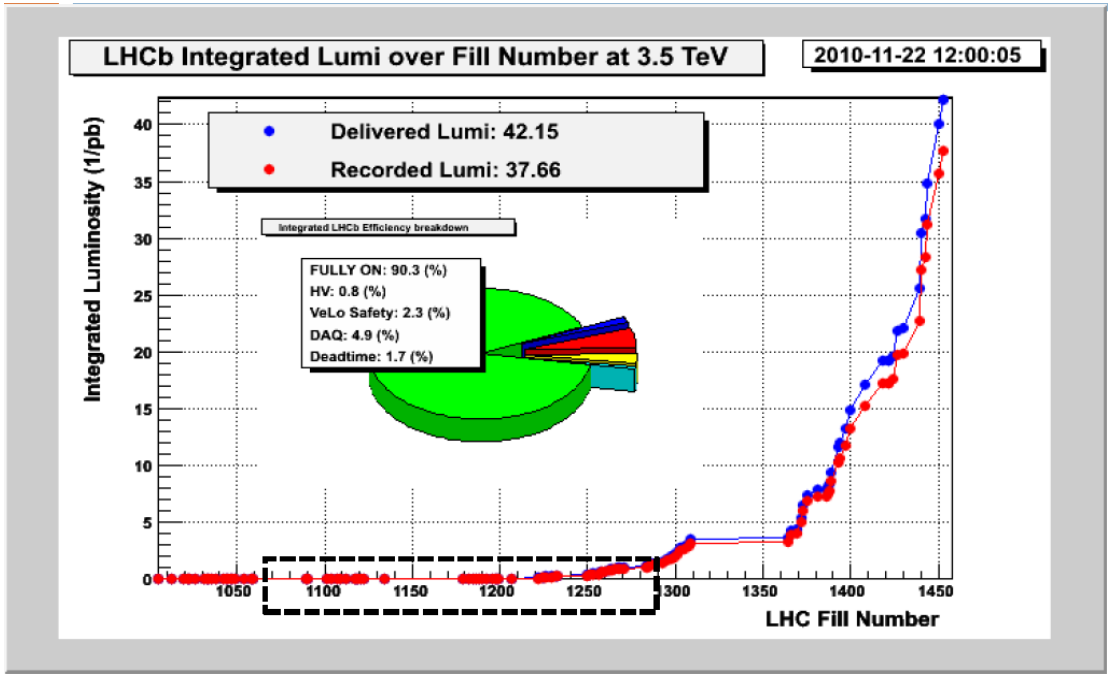
Interesting probe of perturbative QCD, providing important information on underlying parton structure and its dynamical evolution.

Particularly, this provides the information on the gluon density in a regime of low momentum fraction, where standard deep inelastic e-p data can only indirectly constrain its value.

Data sample in preliminary analysis

Preliminary stage of analysis

- check feasibility of jet reconstruction in LHCb
- establish a benchmark with low constraints



Data sample

- 1.02 pb^{-1} pp collisions at 7 TeV
- low pileup
- low L0 trigger cuts
- no HLT trigger

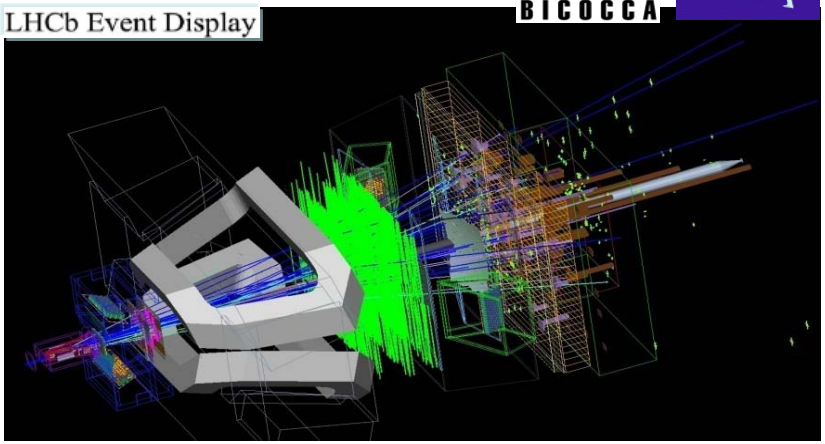
good sample to be considered as a reference

→ **50 nb^{-1}** *(April – July 2010)*: very loose trigger cuts, *jet rec. efficiency (MC): 99.8%*

→ **0.97 pb^{-1}** *(July,12 – August, 8)*: tighter trigger cuts, *jet rec. efficiency (MC): 74.2%*

exactly 1 rec. primary vertex in the event (effiective pp-collision integrated lumi ~500 nb^{-1})

Event selection



Event cuts

- L0 minimum bias trigger
- exactly 1 reconstructed primary vertex
- at least 5 charged tracks

Charged tracks

- χ^2 / ndof < 3
- $|\Delta z_{PV}|$ < 30 mm, $\Delta\rho$ < 0.15 mm
- p_T > 200MeV/c

- tracking eff. > 90%,

- $\delta p/p$=0.35-0.55% for $p \in$ (0.2-140) GeV

- data and MC (tag + probe method): $\delta\varepsilon_{tr}/\varepsilon_{tr} = \pm 4$

Neutrals

- reconstructed pions with p_T > 2 GeV/c

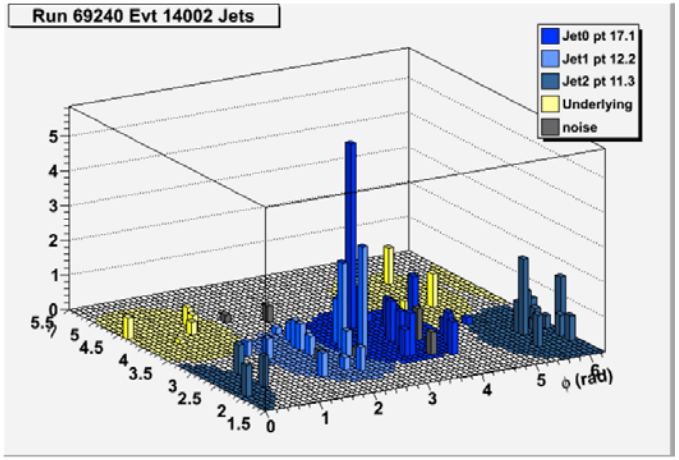
- max. efficiency > 50%

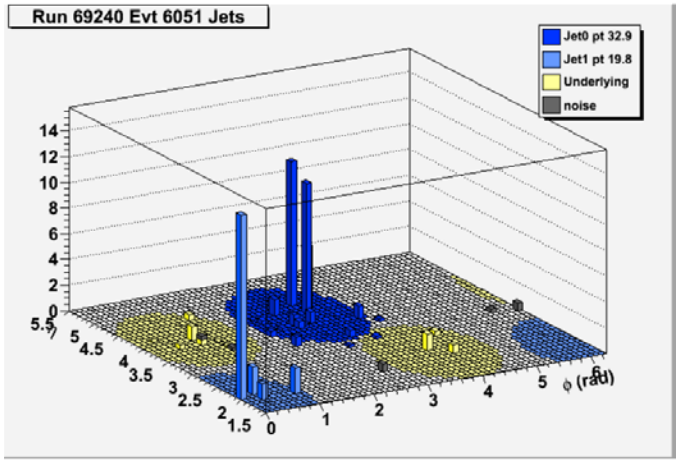
Jet reconstruction

- charged tracks and rec. pions *(Particle Flow Jet)*
- k_T algotithm *(E-recombination scheme, R=0.7)*
- at least 1 jet with p_T > 10 GeV/c

- RAW: *uncorrected for acceptance, energy scale and resolution*

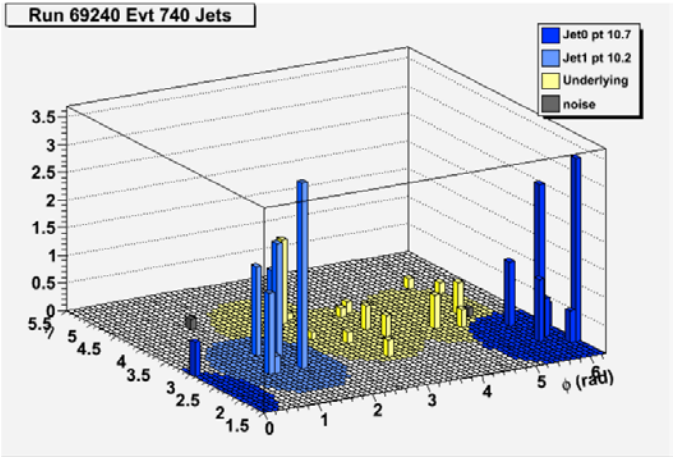
Examples of jets in LHCb

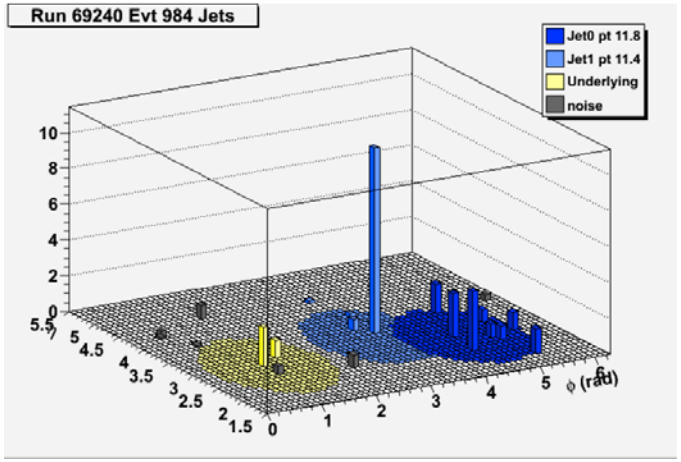




k_T algorithm

- E-recombination scheme
- cone sixe R = 1.0
- leading jet p_T > 10 GeV *(no jet energy correction)*





leading jet p_T > 10 GeV $\Rightarrow$ many dijet events

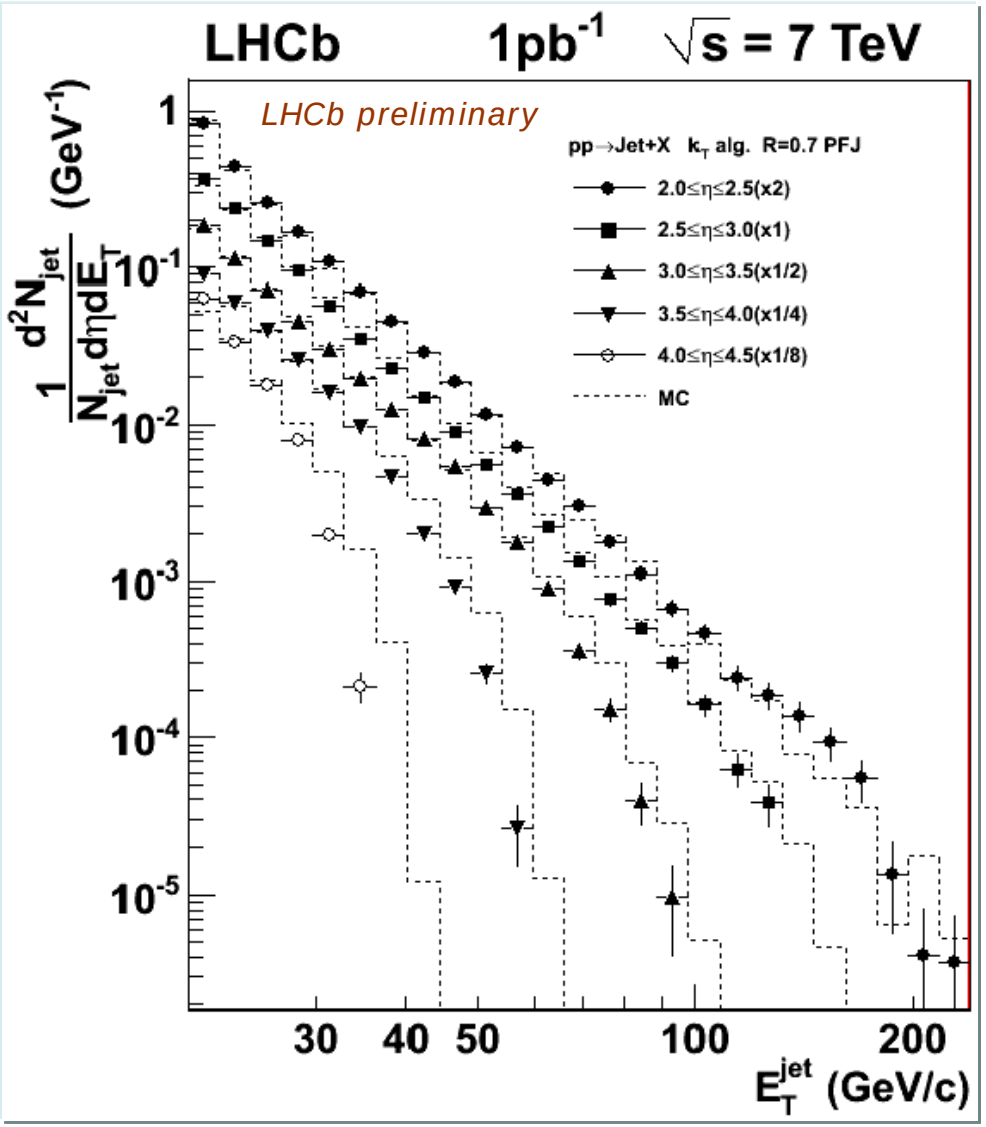
Inclusive jets spectra

Inclusive jet spectrum

- inclusive jets E_T
- uncorrected for acceptance, jet energy scale and resolution

figures denote real data

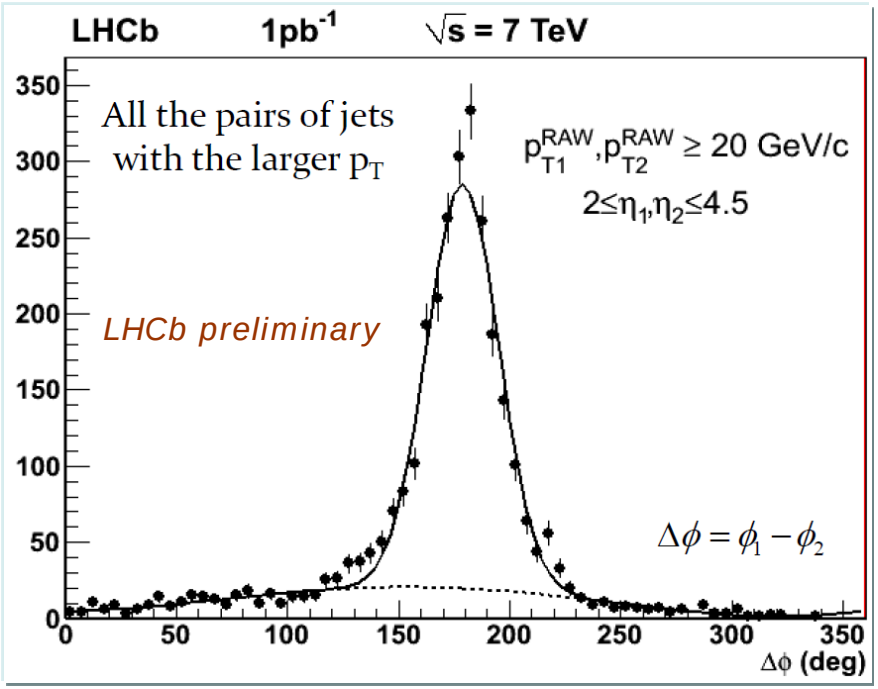
dashed lines are for MC using Pythia 6.4 generator with PDF CTEQ6 LO where the best LHCb detector was employed

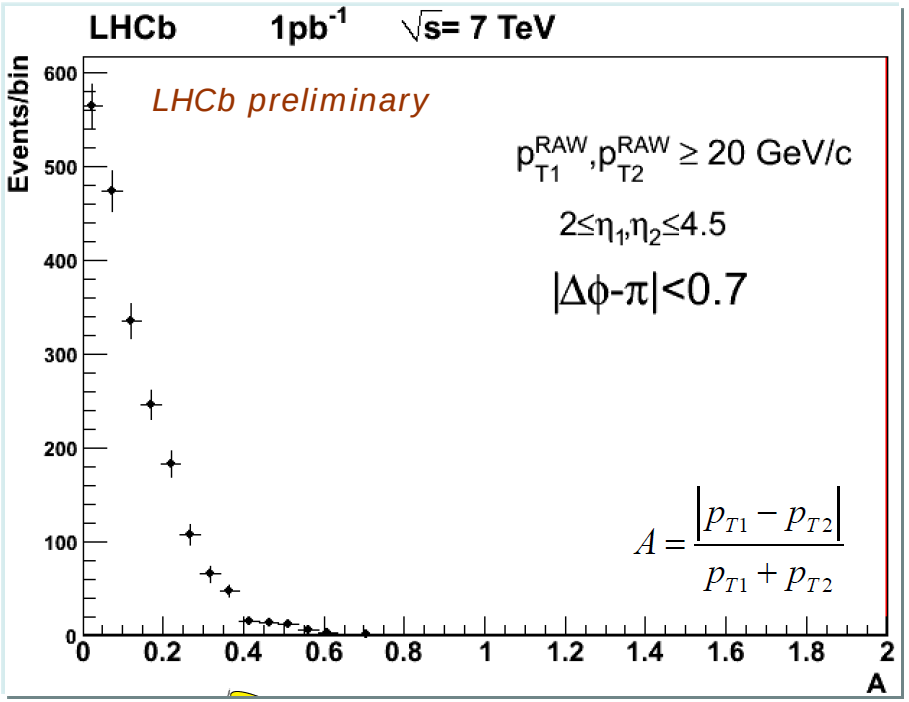


Signal from partonic dijets

Signal of back-to-back dijet events

- *left:* $|\Delta\varphi| = |\varphi_{jet1} - \varphi_{jet2}|$ for 2 leading jets
- *right:* asymmetry parameter $A = |p_{T,1} - p_{T,2}| / (p_{T,1} + p_{T,2})$
  (for events with two jets where $|\Delta\varphi - \pi| < 0.7$)

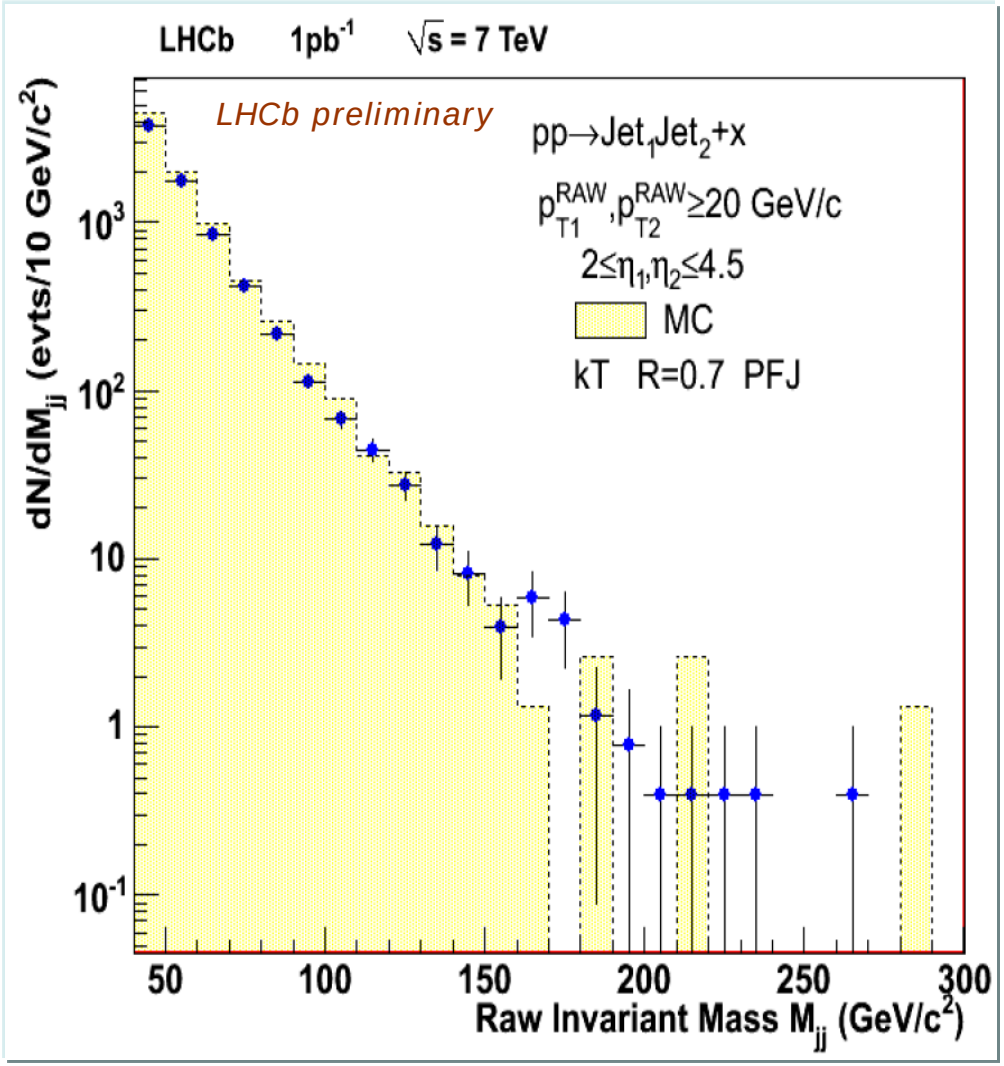




Asymmetry spread: long range QCD effects

- initial & final state radiation
- multiple partonic interactions

Dijet invariant mass



- Dijet invariant mass reconstructed from the sum of 4-vectors of two jets
  - No corrections used
  - MC: Pythia 6.4 CTEQ6LO generator with LHCb detector description

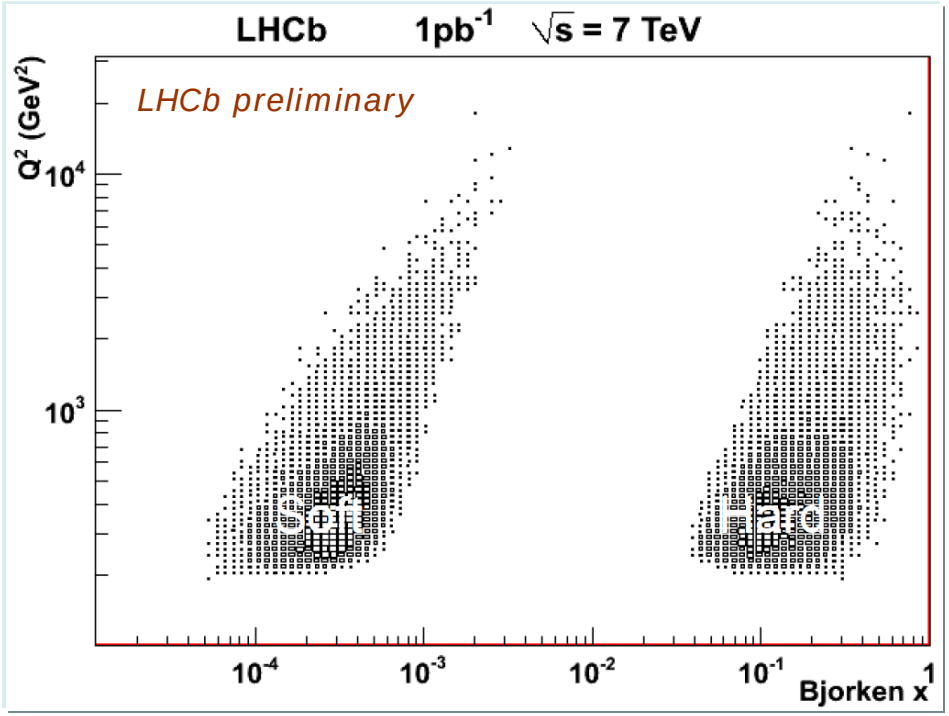
Dijet selection

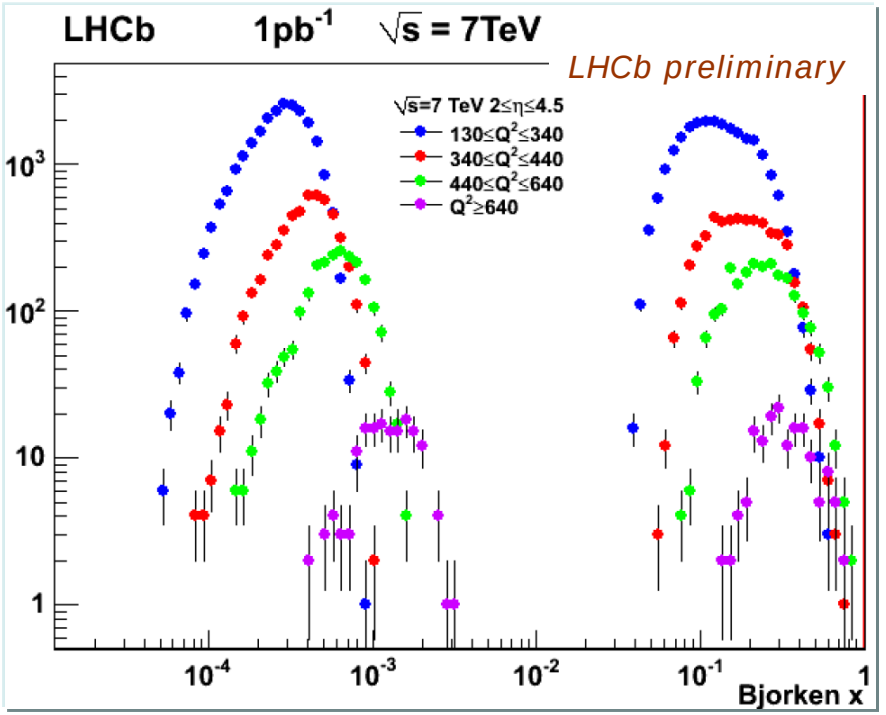
$||\varphi - \varphi| - \pi| < 0.7$

$A < 0.2$

QCD with dijets

Plots showing experimentally the range accessible to LHCb





Measurements employing relations:

$$x_{1,2} = \frac{2p_{T1,2}}{\sqrt{s}} e^{\pm \bar{y}} \cosh\frac{\Delta y}{2} \quad \text{with} \quad \bar{y} = \frac{y_1 + y_2}{2} \quad \text{and} \quad \Delta y = y_1 - y_2 \qquad Q^2 = p_{T1} p_{T2}$$

are used to determine kinematics of 2 partons

Conclusions

- Preliminary results show the feasibility of jet reconstruction in LHCb
  - 1 pb^{-1} sample at 7 TeV analysed
  - 1/40th of total integrated luminosity
- It may be seen that LHCb has a potential to measure inclusive jets and dijets parameters within the $\eta \in (2 - 5)$
- Large statistics already collected in 2010
  - interesting results on perturbative QCD expected at low momentum fraction $x \leq 10^{-3}$