Future Studies of Jet Production and Properties in ATLAS

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on behalf of ATLAS collaboration

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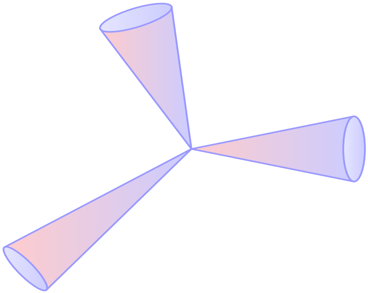
Outline

Introduction

Future Studies of Jet

- Measurement of Coupling Constant
- Radiation in Dijet System
- Contribution of Gluon Splitting
- Jet Substructure
- Multijet Observables

Summary



Outline

ATLAS Inner Detector and Calorimeters

Inner Detector

- Pixel detectors, semiconductor tracker (SCT), transition radiation tracker
  - 87M readout channels, coverage up to $|\eta| < 2.5$
  - Immersed in 2T solenoidal magnetic field

Calorimeters

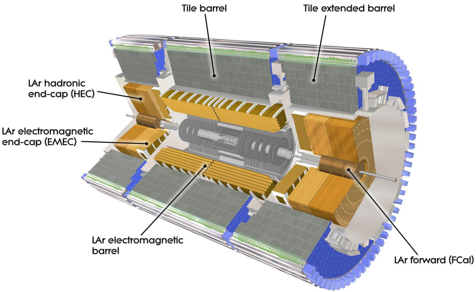
- EM barrel/endcap (LAr-Pb)

  $|\eta| < 1.475$ and $1.375 < |\eta| < 3.2$
- HAD barrel (Fe-scintillator tiles)

  $|\eta| < 1.7$
- HAD endcap (Cu-LAr)

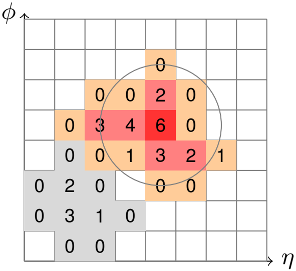
  $1.5 < |\eta| < 3.2$
- EM/HAD forward (Cu-W-LAr)

  $3.1 < |\eta| < 4.9$

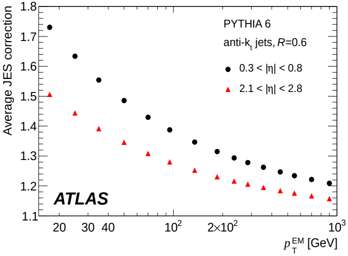


Jet Reconstruction and Calibration

- Jets are reconstructed using anti-k_T jet algorithm with $R = 0.4$ or $R = 0.6$.
- The input objects are 3-D topological clusters, build from calorimeter cells,
  1. Start with a seed cell, which has the highest energy deposit amongst its neighbours and $|E| > 4\sigma_{noise}$
  2. Include neighbouring cells with $|E| > 2\sigma_{noise}$
  3. Include last layer of cells with $|E| > 0\sigma_{noise}$



[ATLAS-CONF-2010-056 , EPJC]



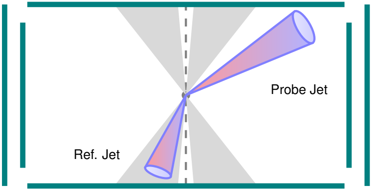
Calorimeter jet response needs to be corrected for :

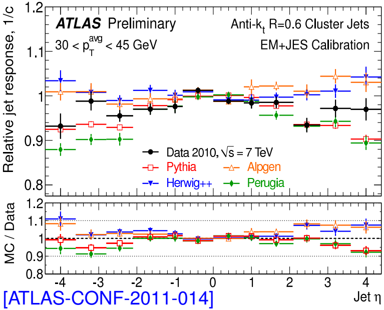
- Non-compensating calorimeters
- Inactive material
- Out-of-cone effects

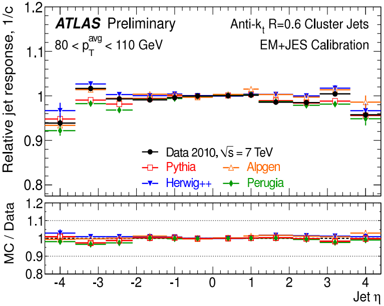
MC-based η, p_T dependent calibration.

Eta Inter-calibration with Dijet Balance

- Use central region of calorimeter as the reference region and get the relative response of the probe jet in other region
- $\frac{1}{c} = \frac{p_T^{probe}}{p_T^{ref}}, \; p_T^{avg} = \frac{p_T^{probe} + p_T^{ref}}{2}$







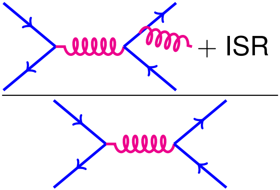
[ATLAS-CONF-2011-014]

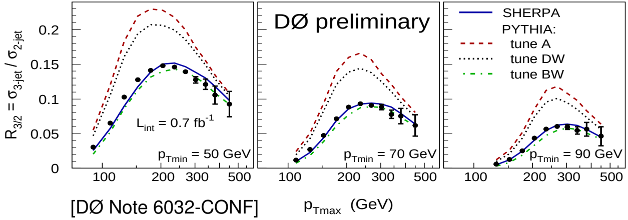
Outline

Measurement of Coupling Constant

- Ratio of inclusive 3-jet and 2-jet cross section is of order $\mathcal{O}(\alpha_s)$

$$R_{3/2}(p_T^{max}) = \frac{d\sigma_{3jet}/dp_T^{max}}{d\sigma_{2jet}/dp_T^{max}}$$



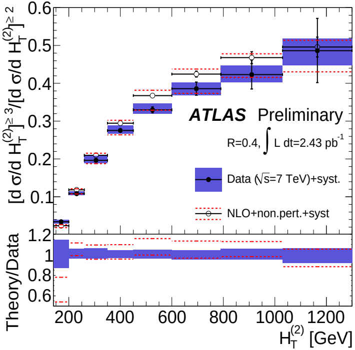


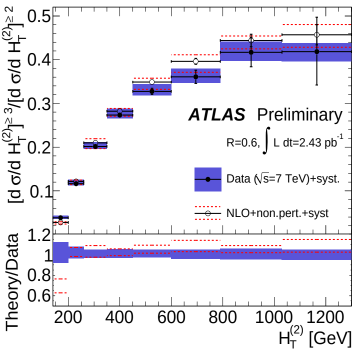
[DØ Note 6032-CONF]

- Ratio of cross-sections with different cone size

Measurement of Coupling Constant ATLAS

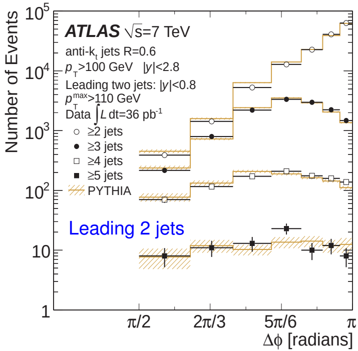
Multijet measurements in ATLAS (ATLAS-CONF-2011-043)



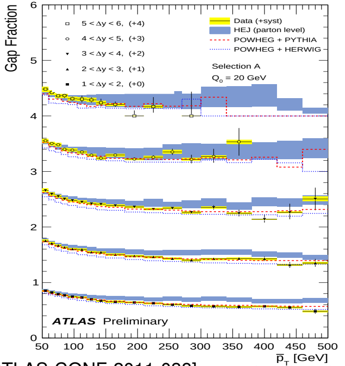


Radiation in Dijet System ATLAS results

- Jet veto vs azimuthal decorrelation. Number and distribution of soft jets. Event-wide variables
  - The fraction of dijet events that do not have an additional jet with a transverse momentum p_T greater than a given veto scale Q0 in the rapidity region bounded by the dijet system



[arXiv:1102.2696]

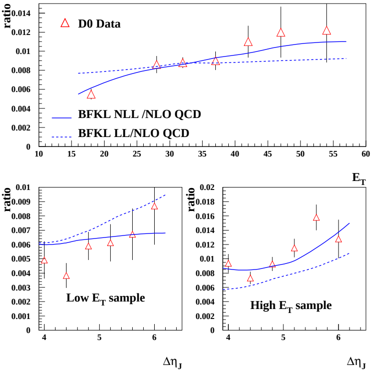


[ATLAS-CONF-2011-038] average p_T

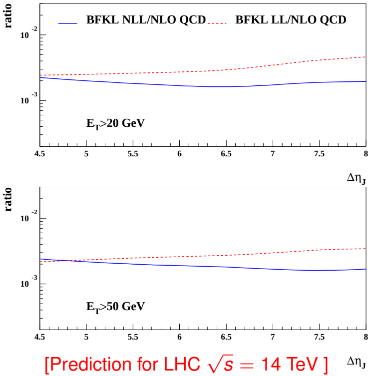
Radiation in Dijet System jet-gap-jet events

- *Gaps between jets in hadronic collisions.*
  O. Kepka, C. Marquet, and C. Royon. Phys. Rev. D 83, 034036, 2011
- Implemented parton-level next leading logarithmic (NLL) BFKL calculation into HERWIG

$$R = \frac{\text{NLL BFKL}}{\text{Jet Herwig}} \times \frac{\text{LO QCD}}{\text{NLO QCD}}$$



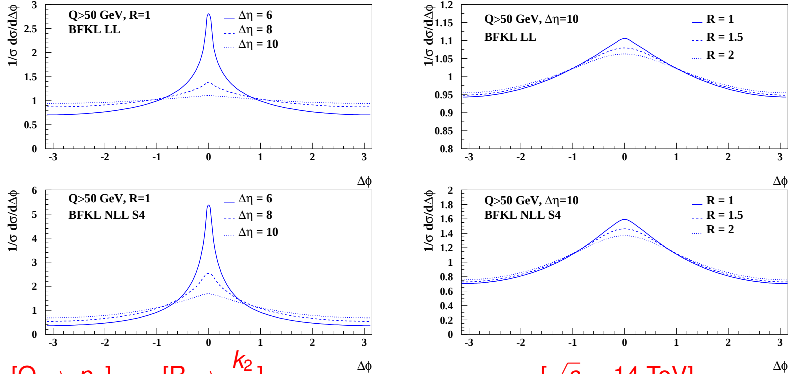
[E_T : second leading jet E_T]



[Prediction for LHC $\sqrt{s} = 14$ TeV]

Radiation in Dijet System   Mueller Navelet jets

- *Azimuthal decorrelation of Mueller-Navelet jets at the Tevatron and the LHC*
  C. Marquet, C. Royon. Phys.Rev.D79:034028
- Mueller-Navelet jets : two jets with a large interval in rapidity and with similar p_T

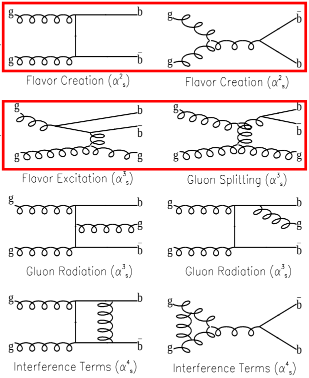


$[Q \rightarrow p_T]$ $[R \rightarrow \frac{k_2}{k_1}]$ $[\sqrt{s} = 14 \text{ TeV}]$

Contribution of Gluon Splitting azimuthal correlations

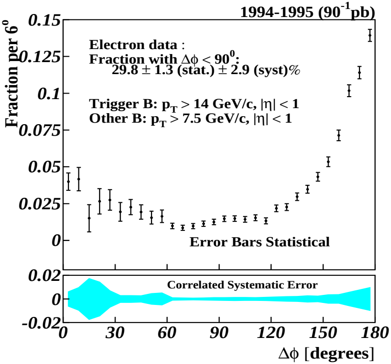
- $b\bar{b}$ azimuthal correlations. CDF. Phys. Rev. D 71, 092001 (2005)
- The leading-order (LO) process : back-to-back
- Flavor excitation and gluon splitting processes are providing very different opening angle distributions from the LO process
- $b\bar{b}$ azimuthal correlations gives additional insight into the effective contributions from higher-order QCD processes to b quark production

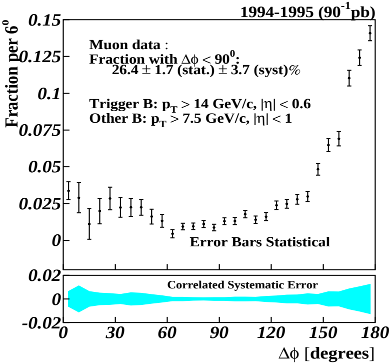
b-jet production



Contribution of Gluon Splitting azimuthal correlations

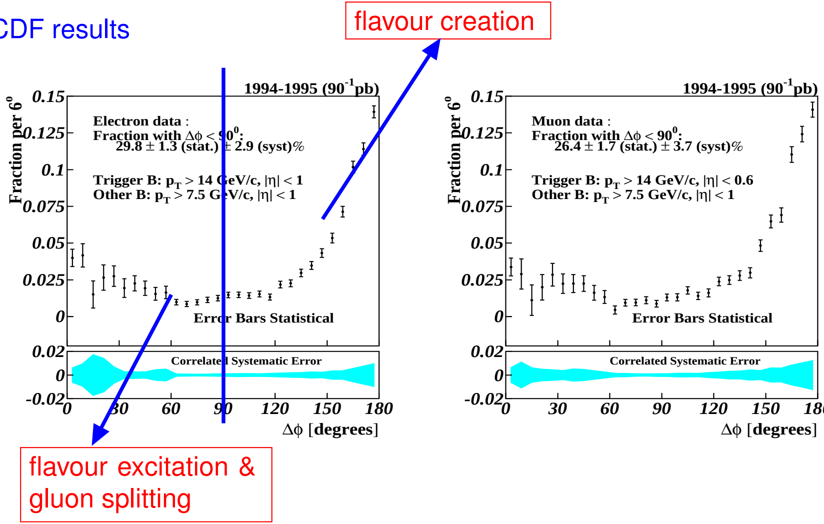
CDF results





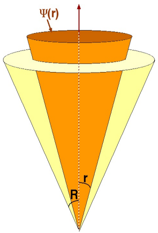
Contribution of Gluon Splitting azimuthal correlations

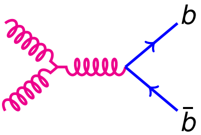
CDF results



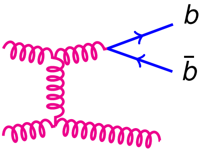
Contribution of Gluon Splitting   b-jet shape

- Measurement of b-jet shapes at CDF. Phys.Rev.D78:072005,2008
- Gluon splitting : two b-quark in one jet $\rightarrow$ fat jet.
- Flavour creation : one b-quark in one jet.
- The shapes of b-jets are sensitive to the relative fraction of gluon splitting and flavour creation





flavour creation



gluon splitting

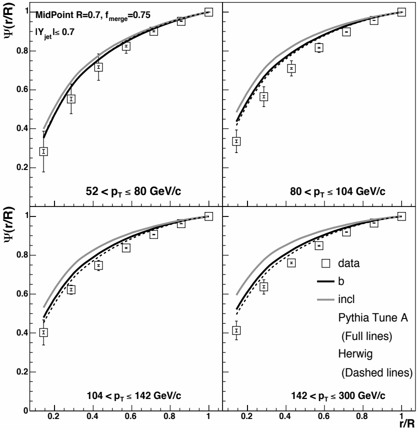
- To check whether the fraction of b-jet from gluon splitting is well described by Monte Carlo.

Contribution of Gluon Splitting b-jet shape

$$\Psi(r/R) = \left\langle \frac{p_T(0 \to r)}{p_T(0 \to R)} \right\rangle$$

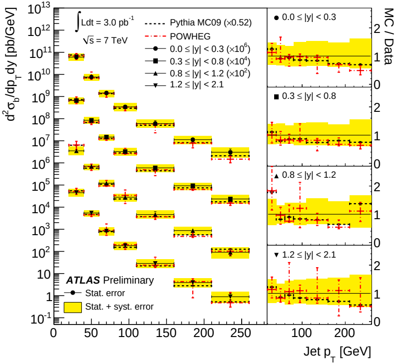
where $p_T(0 \to r)$ is the scalar sum of the transverse momenta of all objects inside a sub-cone of radius r around the jet axis. The integrated shapes are by definition normalized such that $\Psi(r/R = 1) = 1$.

[CDF]

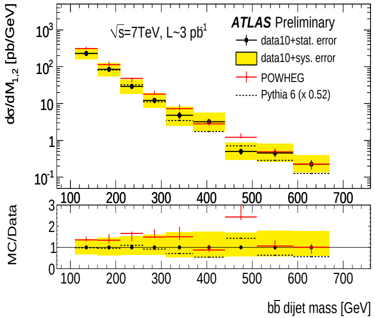


b-jets Cross Section in ATLAS

- First ATLAS inclusive and dijet cross section for b-jets
- Jets are reconstructed using anti-k_T with $R = 0.4$. Contains secondary vertices
- Selection : $|y| < 2.1$ Inclusive jet p_T : all jets $p_T > 20$ GeV Dijet : both jets $p_T > 40$ GeV



[ATLAS-CONF-2011-056]

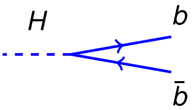


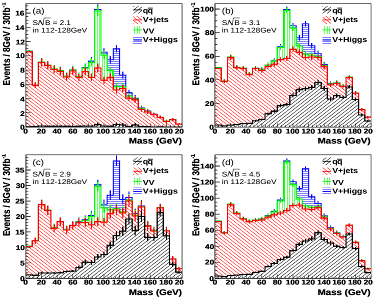
- Correct the data to physics b-jet using bin-by-bin unfolding method

Jet Substructure

- *Jet Substructure as a New Higgs-Search Channel at the Large Hadron Collider.* J. Butterworth, A. Davison, M. Rubin and G. Salam. Phys.Rev.Lett. 100, 242001

Fast-moving low mass SM higgs decays to $b\bar{b}$

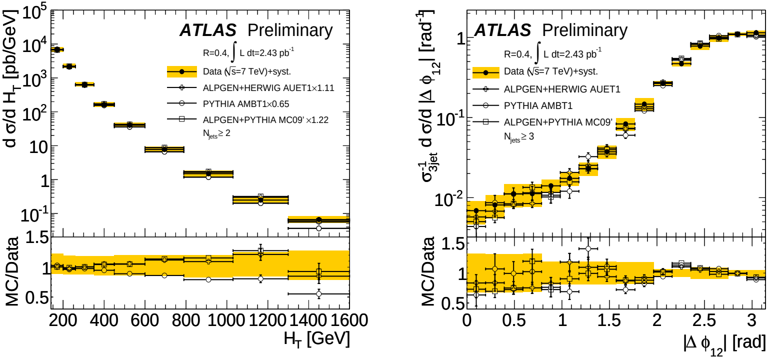




- Has the potential to transform the high-p_T WH, ZH ($H \to b\bar{b}$) channel into one of the best channels for discovery of a low mass Standard Model Higgs

Multijet Observables ATLAS

Multijet measurements in ATLAS (ATLAS-CONF-2011-043)



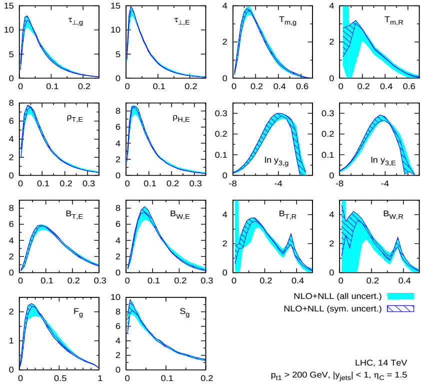
$H_T = \sum p_T$ $\qquad$ $|\Delta\phi_{12}| \rightarrow \Delta\phi$ between leading and next leading jet

Multijet Observables

- *Phenomenology of event shapes at hadron colliders*.

  A. Banfi, G. Salam, G. Zanderighi. JHEP 1006:038, 2010

- First NLO+NLL predictions
- There are lots of observables which can be measured.



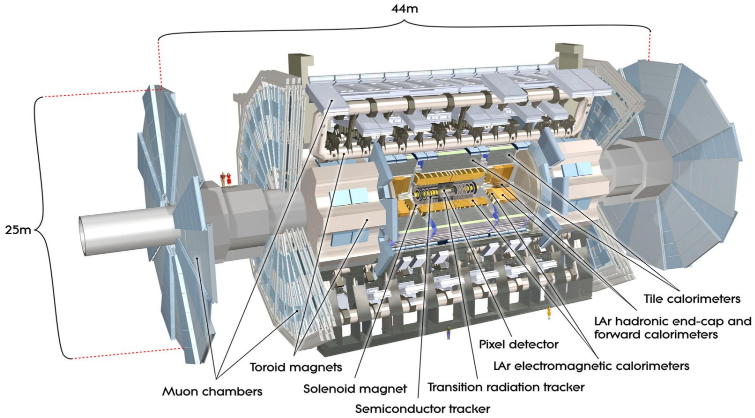
Outline

Summary

- Several jet measurements are there in ATLAS using 2010 data
- Still can do lots of measurement and searches in the next step
  - Measure running coupling constant
  - Radiation in dijet system
  - B-jet measurements
  - Jet substructure and higgs search
  - Different observables for event shape

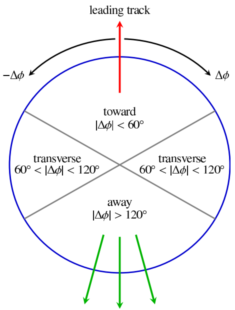
backup

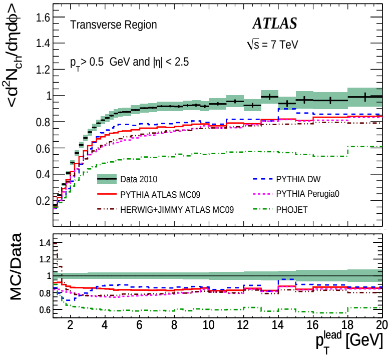
ATLAS Detector



Underlying Event (LHC Environment)

All particles from single particle collision except those from the process of hard interactions





The transverse regions are most sensitive to the underlying event, since they are generally perpendicular to the axis of hardest scattering and hence have the lowest level of activity from this source

Jet Response