MEASUREMENT OF DIJET CROSS-SECTIONS IN PP COLLISIONS AT 7 TEV CENTRE-OF-MASS ENERGY USING THE ATLAS DETECTOR

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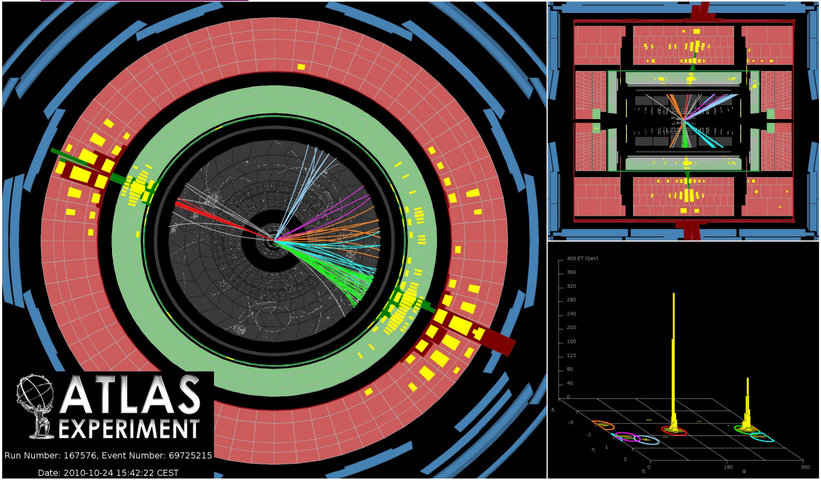
What? - Di-jet events



Why? - Searches

- search for new resonances;
- constrain PDFs;
- measure *pp* $\rightarrow$ *dijet* cross-section.

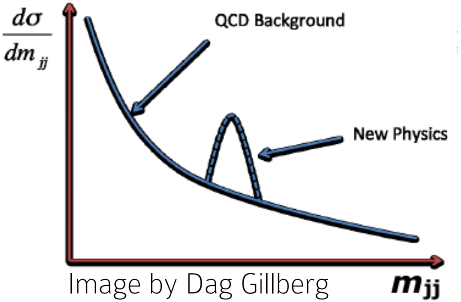
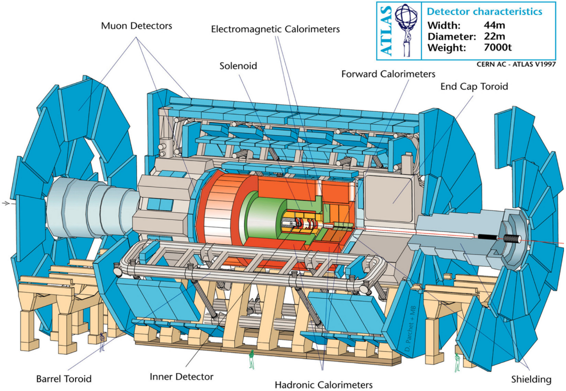


Figure : Peaks on QCD background, indicate the existence of new particles.

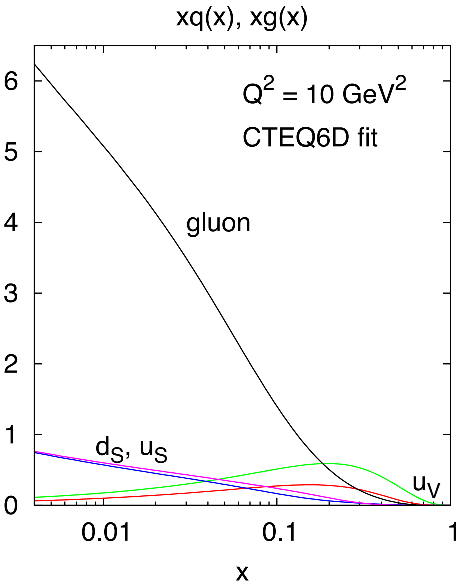
Where? \ Who? \ When? - The ATLAS detector

- 2011 dataset;
- $\sqrt{s} = 7\,TeV$;
- $4.5 fb^{-1}$;



How? - Selection

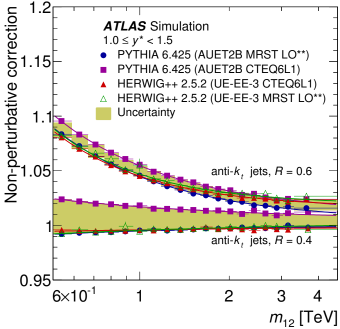
- cut on transverse momentum: $p_T > 100 GeV$ for the primary jet, $p_T > 50 GeV$ for the secondary jet;
- $Anti - k_T$ algortithm used for jet reconstruction with radius paramiter R = 0.4 and R = 0.6;
- measure differential cross-section as a function of invariant mass in different rapidity intervals, (y^*);
- results are compare with calculations based on a variety of PDF parametrizations.

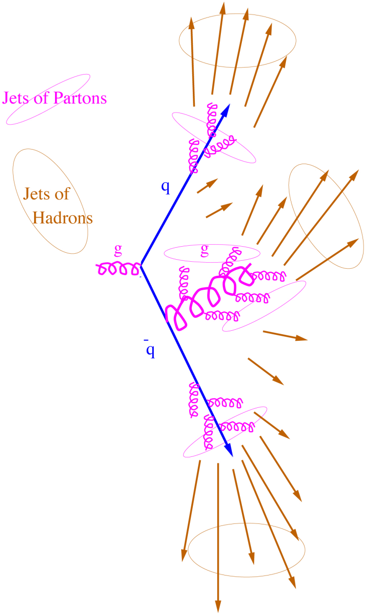


How? - Unfolding

$$\left[\frac{d\sigma}{dm_{12}}\right]_{bin\ i\ m_{12},\ bin\ j\ y^*} = \frac{N_{i,j}^{evts}}{\Delta m_{12}\cdot\mathcal{L}}\cdot C_{i,j}^{MC}$$

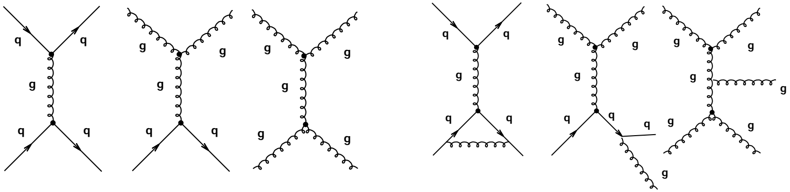
$$C_{i,j}^{MC} = \frac{N_{i,j}^{particles,MC}}{N_{i,j}^{reco,MC}}$$





How? - Perturbative calculations

Calculation of the hard scattering cross-section up to NLO
$(A \cdot \alpha_S^2 + B \cdot \alpha_S^3 + H.O.)$



Measurements and calculations are split into rapidity intervals, (y^*) for more accurate comparison (Bjorken x).

$$\sigma_X = \sum_{a,b} \int_0^1 dx_a dx_b f(x_a, flav_a, Q^2) f(x_b, flav_b, Q^2) \cdot \sigma_{ab \to X}(x_a, x_b, Q^2).$$

Sum over initial partonic states a,b

Parton Density Function

hard scattering cross-section

Results - Cross section

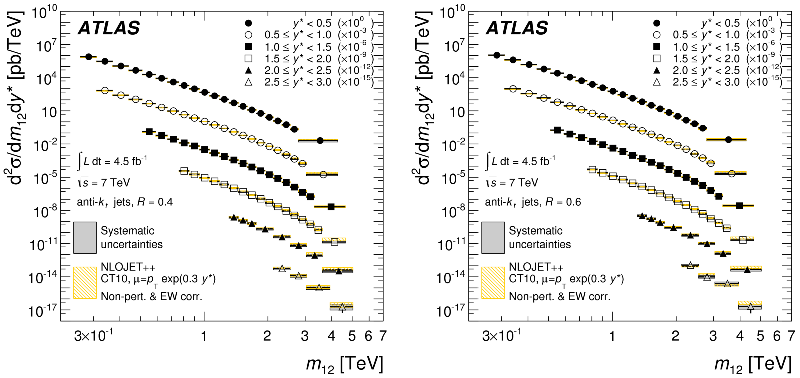


Figure : Dijet double-differential cross-section for *anti-k_t* jets with radius parameter R = 0.4 and R = 0.6, shown as a function of dijet mass in different ranges of y^*.

Results - Theory/Data

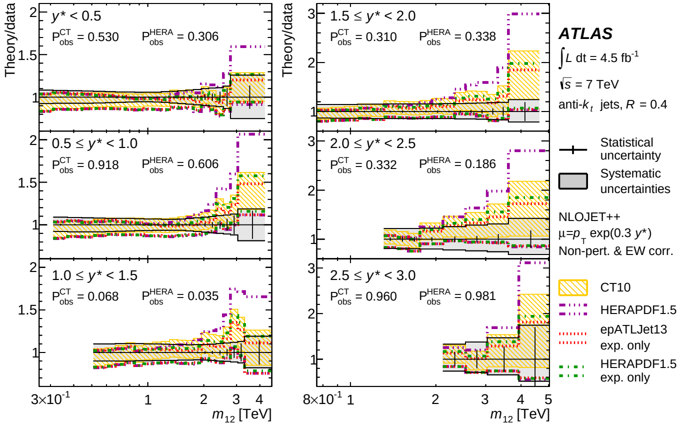


Figure : Ratio of the NLO QCD predictions of NLOJet++ to the measurements of the dijet double-differential cross-section as a function of dijet mass in different ranges of y^*.

Results - Theory/Data

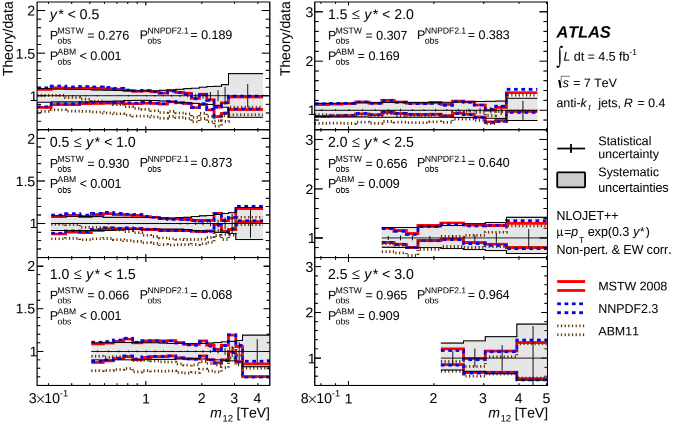


Figure : Ratio of the NLO QCD predictions of NLOJet++ to the measurements of the dijet double-differential cross-section as a function of dijet mass in different ranges of y^*.

Conclusions

- no hints of new particles;
- good agreement with PDF parametrizations (except for one...);
- possible future application of this method (highest energy dijet cross-section measurement so far).

The End

BACKUP SLIDES

Pseudo-rapidity $\rightleftarrows$ rapidity

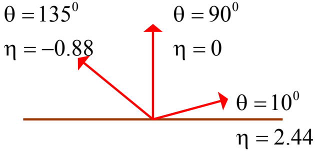
$$y = \ln \frac{E + p_L}{\sqrt{p_T^2 + m^2}}$$

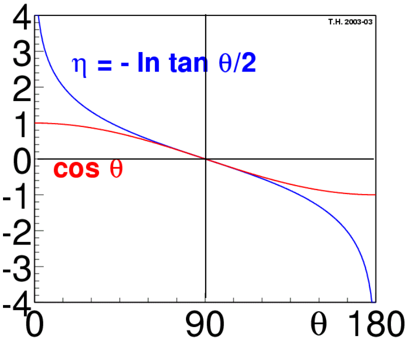
$m << E, p_L$

$$\to \ln \frac{E + E\cos\theta}{E\sin\theta}$$

$$= \ln \frac{2\cos^2\frac{\theta}{2}}{2\sin\frac{\theta}{2}\cos\frac{\theta}{2}}$$

$$= -\ln\tan\frac{\theta}{2} = \eta$$





Rapidity invariance under longitudinal boosts

$$y = \frac{1}{2}\ln\frac{E+p_L}{E-p_L} = \ln\frac{\sqrt{E+p_L}}{\sqrt{E-p_L}}\cdot\frac{\sqrt{E+p_L}}{\sqrt{E+p_L}} = \ln\frac{E+p_L}{\sqrt{E^2-p_L^2}}$$

$$= \ln\frac{E+p_L}{\sqrt{p_T^2+m^2}}$$

Boost along z axis:

$$y' = \ln\frac{E'+p'_L}{\sqrt{p_T^2+m^2}} = \ln\frac{\gamma(E+\beta p_L)+\gamma(p_L+\beta E)}{\sqrt{p_T^2+m^2}}$$

$$= \ln[\gamma(1+\beta)\frac{E+p_L}{\sqrt{p_T^2+m^2}}] = y + \ln\gamma(1+\beta)$$

- rapidity intervals are invariant under longitudinal boost

$$y_1 - y_2 \to y_1' - y_2' = y_1 - y_2$$

$$\frac{\partial\sigma}{\partial y'} = \frac{\partial\sigma}{\partial y}$$

Algorithm specification: Anti-k_t

- $d_{i,j} = min(\frac{1}{p_{T,i}^2}, \frac{1}{p_{T,i}^2}) \frac{\Delta R^2}{D^2}$;

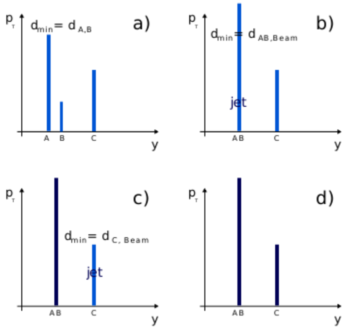
  $d_{i,Beam} = \frac{1}{p_{T,i}^2}$
- D : algorithm parameter
- Iterate:

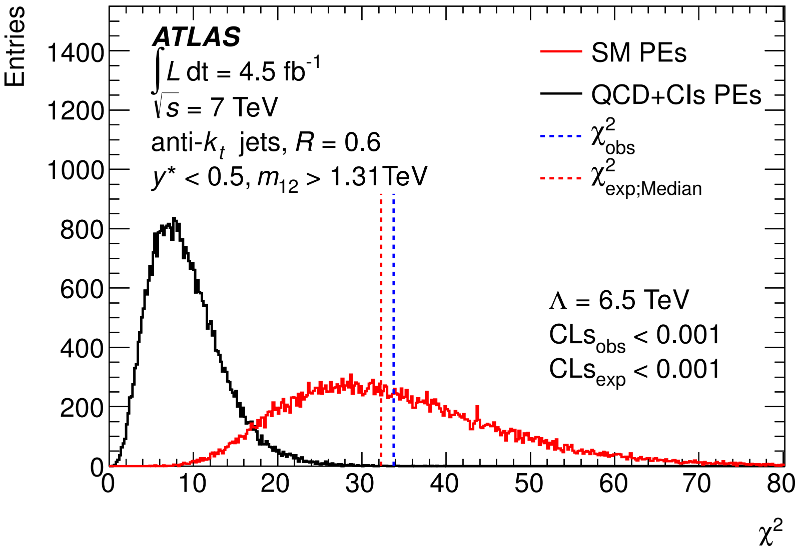
1. For every pair of objects i, j calculate $d_{min} = min(d_{i,j}, d_{i,beam})$
2. If $d_{min} = d_{i,j}$ recombine objects
   Else i is a jet, remove it from list [a]

- Recombination starts from hard objects

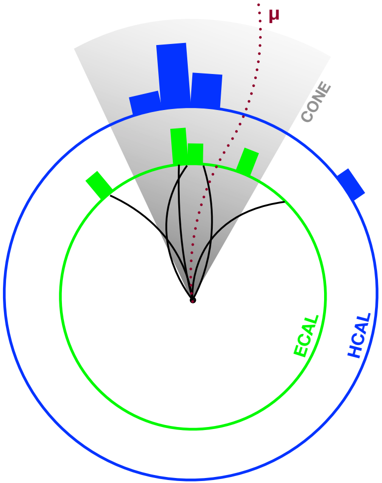
[a] ATLAS default: inclusive algorithm

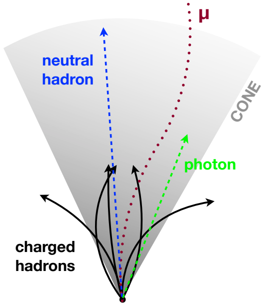
Idea:





ATLAS
$\int L\,dt = 4.5\ \mathrm{fb}^{-1}$
$\sqrt{s} = 7$ TeV
anti-k_t jets, $R = 0.6$
$y^* < 0.5$, $m_{12} > 1.31$ TeV
SM PEs
QCD+CIs PEs
χ^2_{obs}
$\chi^2_{exp;Median}$
$\Lambda = 6.5$ TeV
$CLs_{obs} < 0.001$
$CLs_{exp} < 0.001$
Entries
χ^2
0
200
400
600
800
1000
1200
1400
0
10
20
30
40
50
60
70
80


μ
CONE
ECAL
HCAL


μ
neutral
hadron
CONE
photon
charged
hadrons

$f_i(x,Q^2)$ $\begin{cases} i = u_v, d_v, g \text{ and sea} \\ x = p_{parton} / E_{beam} \quad \textbf{parton momentum fraction} \\ Q^2 = \textbf{momentum transfer} \end{cases}$

How are PDF's determined?

QCD predicts the scale dependence of $f_i(x,Q^2)$ through DGLAP evolution equations BUT does not accurately predict the x-dependence which has non perturbative origin

1. the x-dependence is parameterised at a fixed scale Q_0^2:
   - **valence quarks: $f \sim x^{\lambda} (1-x)^{\eta} P(x)$**
   - **sea/gluon: $f \sim x^{-\lambda} (1-x)^{\eta} P(x)$**

   different parameterisations and no.of free parameters used
2. $f_i(x,Q^2)$ is evolved from Q_0^2 to any other Q^2 by numerically solving the DGLAP equations to various orders (LO,NLO, NNLO)
3. the free parameters are determined by fit to data from experimental observables **(data from HERA experiments H1, ZEUS ,fixed target DIS experiments ,CDF, D0)**