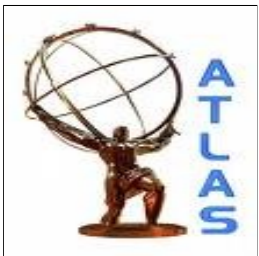




4th HERA and the LHC Workshop



Expectations for QCD with first LHC Data



**On behalf of the ATLAS and CMS Collaborations
Klaus Rabbertz
University of Karlsruhe**





Outline

Q D
C

- **Construction**

- ➔ LHC Racing Rules

- **Practice**

- ➔ Tracks

- **Qualifying**

- ➔ Jets

- **Warming-up**

- ➔ Photons

- **Pit stop**

- ➔ PDFs

- **The Race**

- ➔ New physics

- **Final Score**

The Race will be on soon ...



BUL-PHO-2008-034



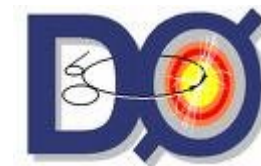
The Audience arrives ...

Q D
C

CERN OpenDays 5./6. April 2008: 76000 Visitors



Blue flag for
CDF and D0



BUL-PHO-2008-034



The Circuit: LHC

Q D
C

Training: End of June
Qualifying: August?

Fuel regulations:

→ Engineering: Low grade 85 fuel:

$E_{cms} = 900 \text{ GeV}$, some days

→ Start-up: 2008 with 90 octane only:

$E_{cms} = 10 \text{ TeV}$, $L_{int} \sim 40/\text{pb}$

→ Race: From 2009 with high grade 95 octane:

$E_{cms} = 14 \text{ TeV}$

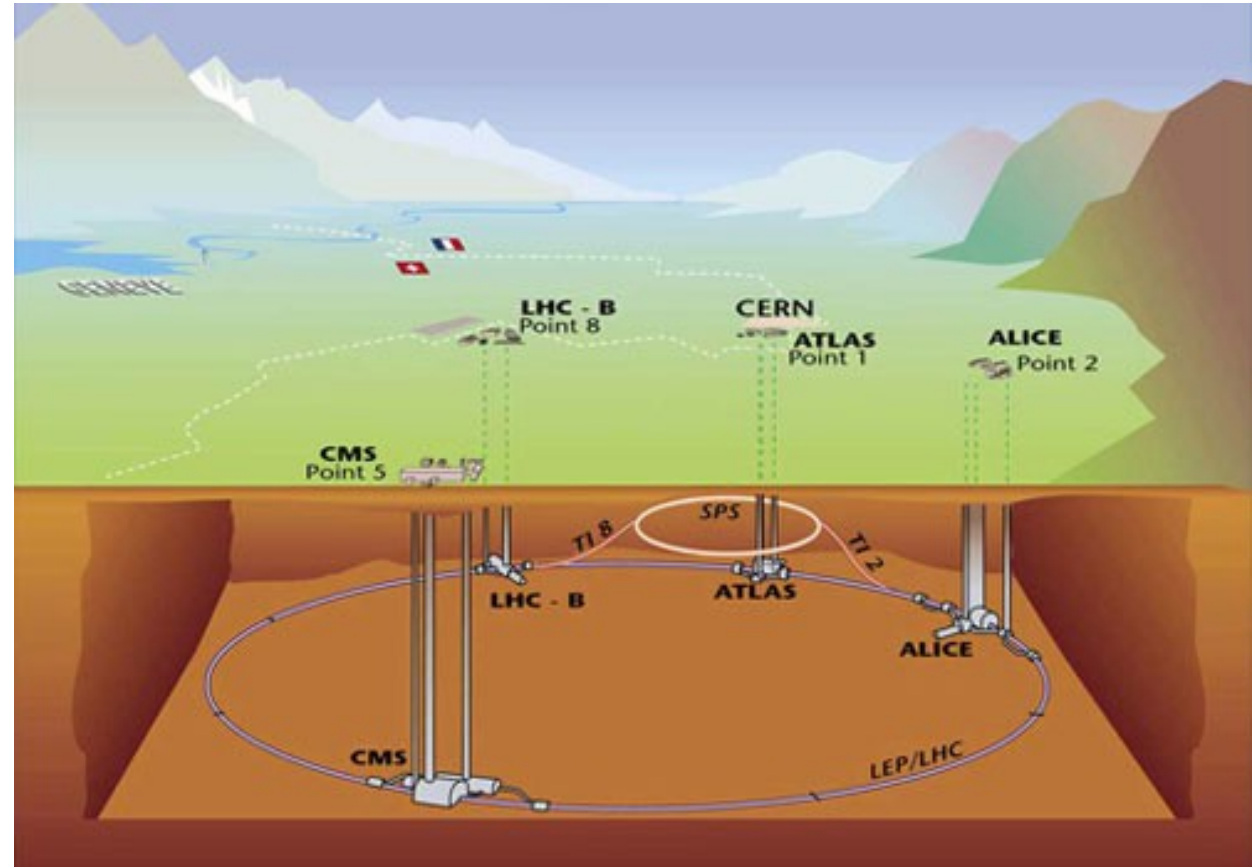
Bunch patterns:

43x43, 156x156

Specific luminosity:

$3 \cdot 10^{30} - 6 \cdot 10^{31} \text{ cm}^{-2} \text{ s}^{-1}$

Most results presented in the following are for 14 TeV! Only exception next slide ...



For the current machine status see talk by M. Lamont

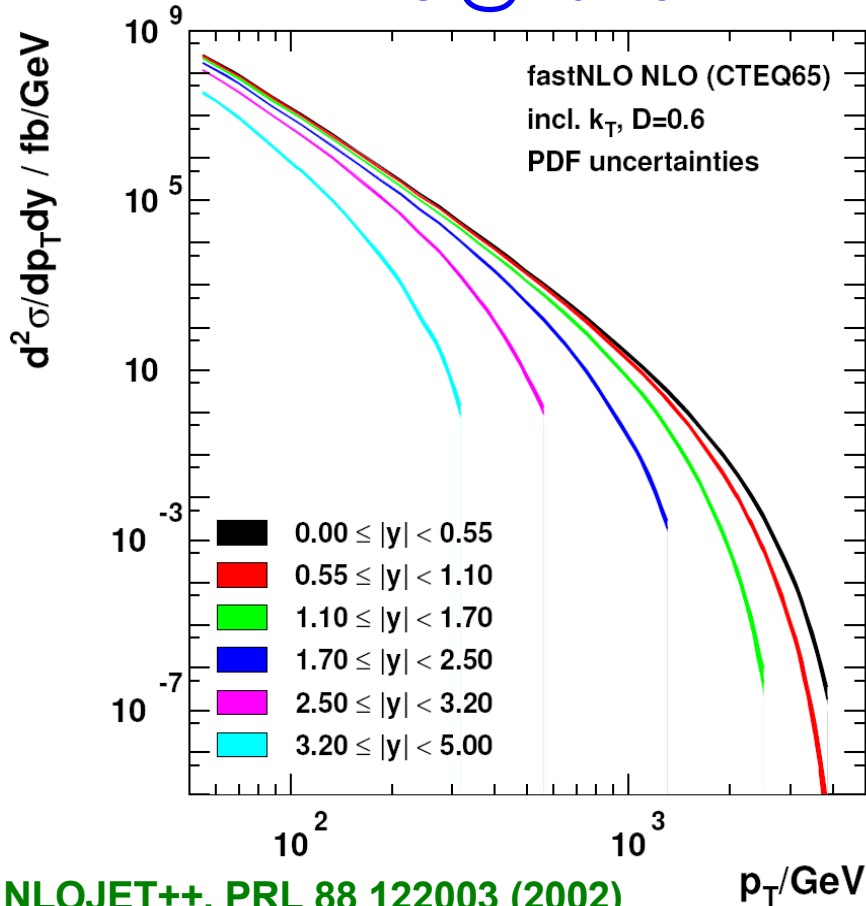


Ratio 10 TeV / 14 TeV

Q D
C

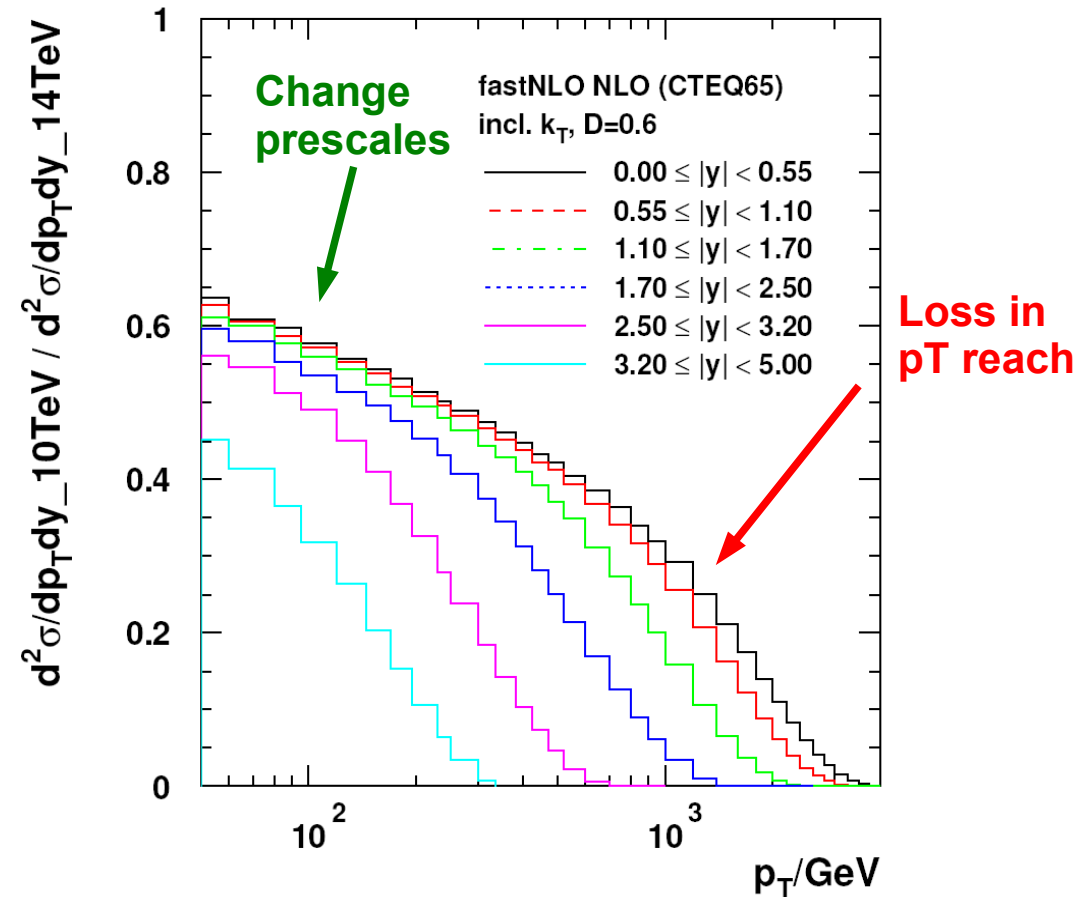
Inclusive k_T cross section in 6 bins in rapidity y , $D = 0.6$

LHC @ 10 TeV



NLOJET++, PRL 88 122003 (2002)
PR D68 094002 (2003)
fastNLO, hep-ph/0609285

10 TeV / 14 TeV



NLO code by NLOJET++, Z. Nagy



Tracks: The Drivers

Q D
C

Track based analyses:

Good candidates for measurements at 900 GeV

➔ Charged hadron spectra

➔ Underlying event from transverse region of charged particle jets

Phys.Lett.Vol.107B, no. 4

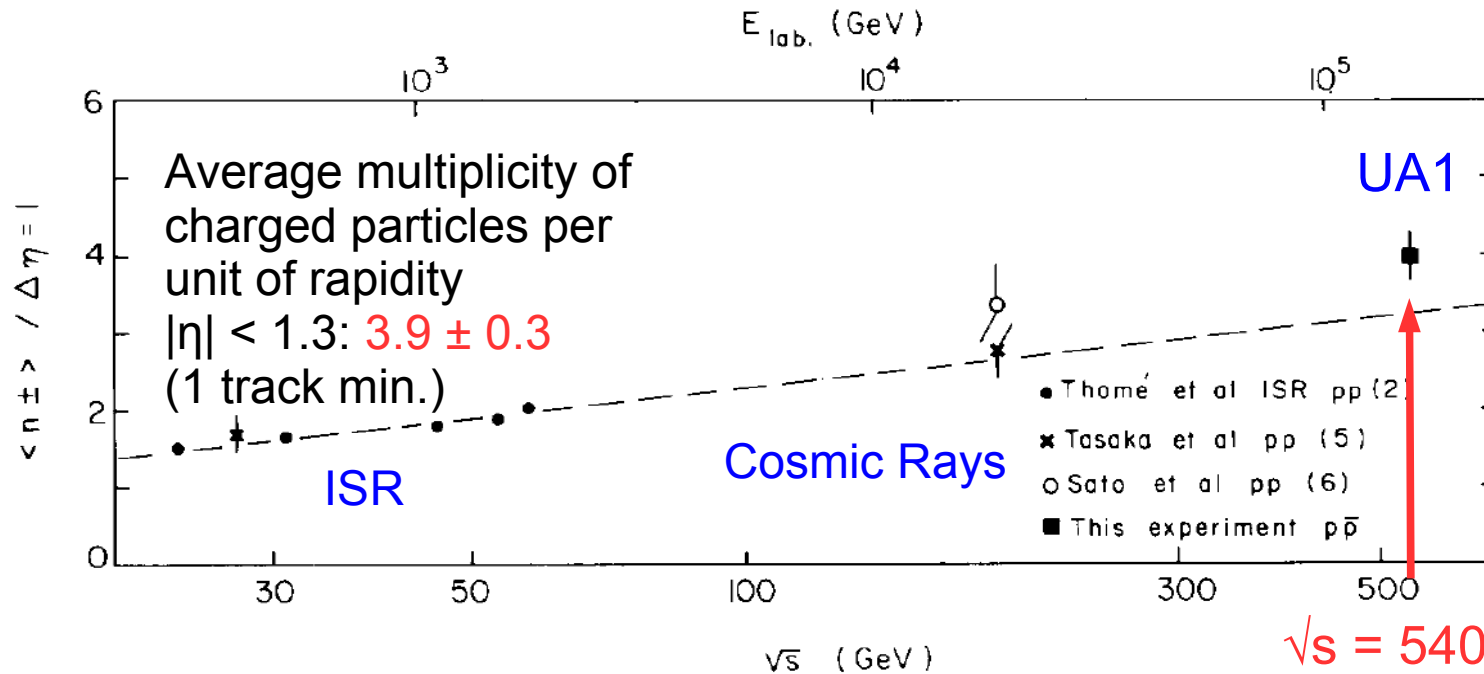
[First UA1 Publication](#)

QCD

17. Dezember 1981

Recall:

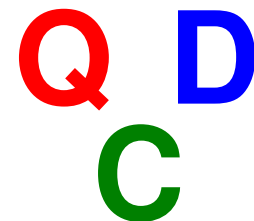
**SOME OBSERVATIONS ON THE FIRST EVENTS
SEEN AT THE CERN PROTON-ANTIPROTON COLLIDER**



$\sqrt{s} = 540 \text{ GeV}$



Charged Hadron Spectra



One of the first analyses possible ...

Technique:

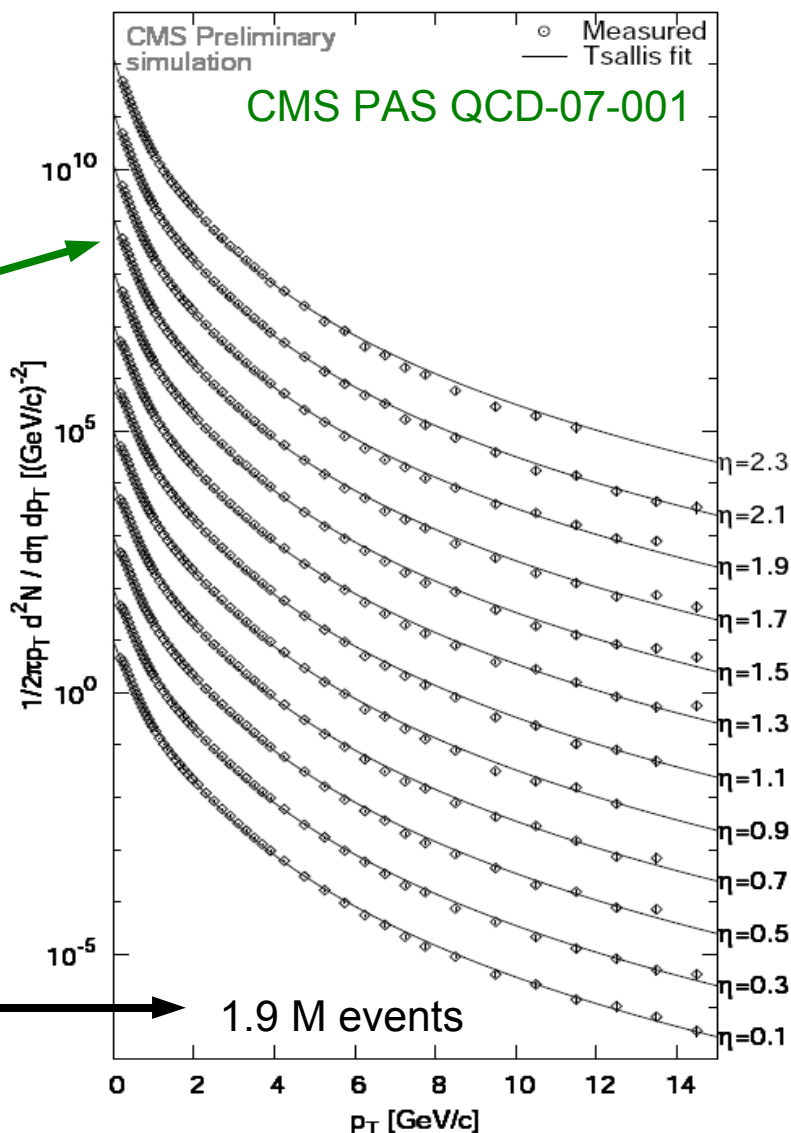
Tracks from pixel hit triplet seeding (Mis-alignment under investigation)

→ Tracking down to p_T of 75 MeV/c

Systematic:

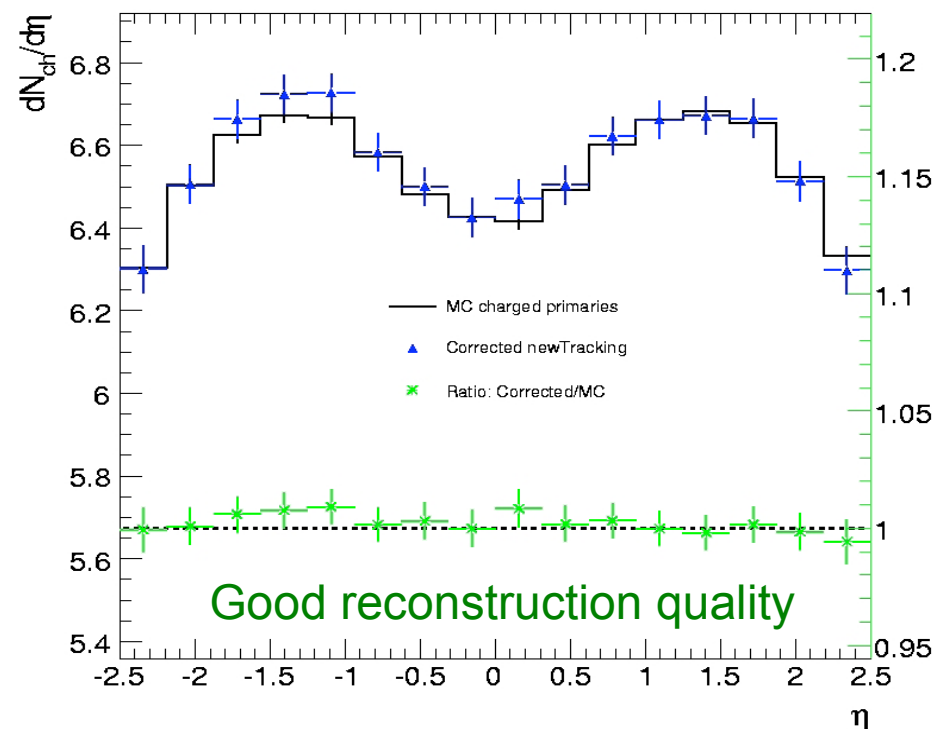
Trigger, feed-down, geom. acceptance, alg. efficiency

Assuming one month running with 1 Hz allocated bandwidth



ATLAS Track reconstruction

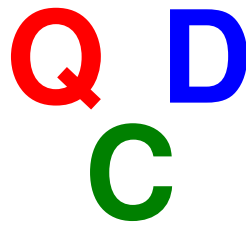
Largest systematic: Mis-alignment



ATLAS

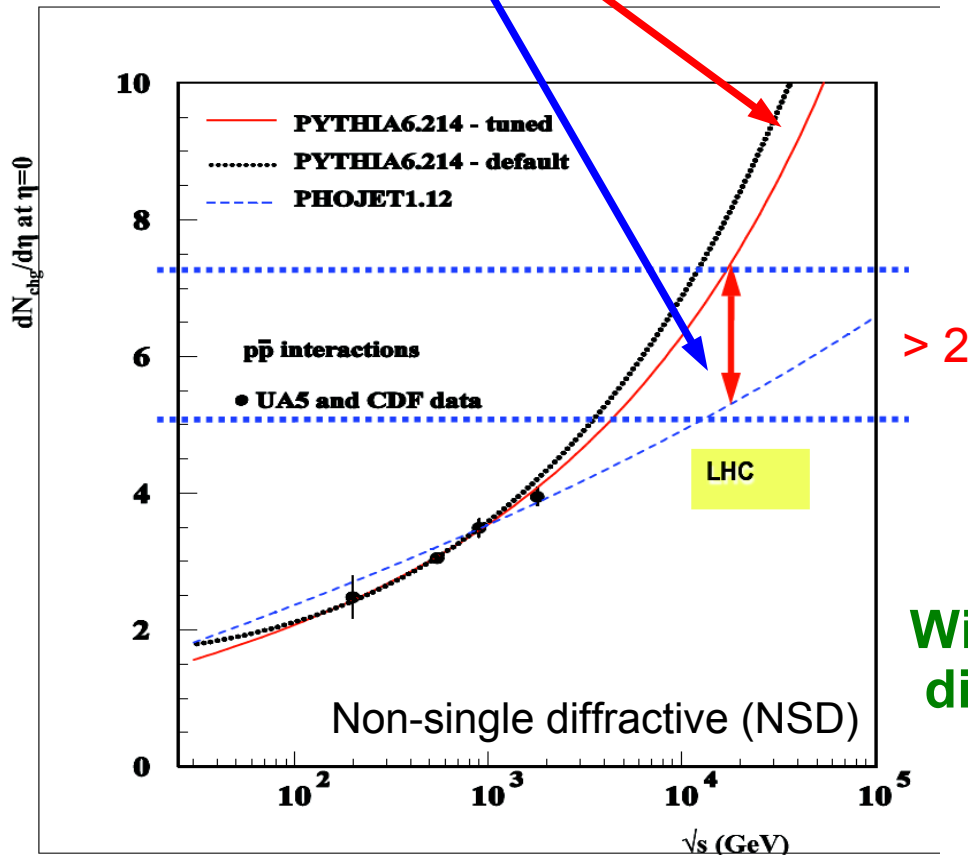


Charged Hadron Spectra



Model expectations for charged particles at $|\eta| = 0$ vs. \sqrt{s} :

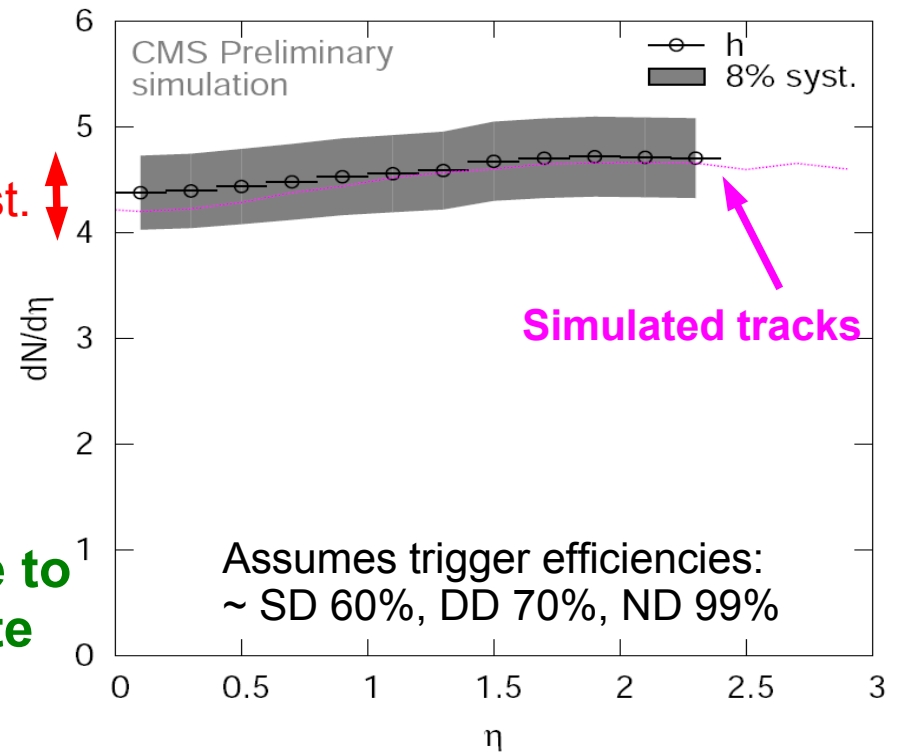
- Pythia: $\sim \ln^2(s)$
- Phojet: $\sim \ln(s)$



Will be able to differentiate

Simulation result from CMS:

- Charged particle pseudo-rapidity distribution
- Pythia tune DWT



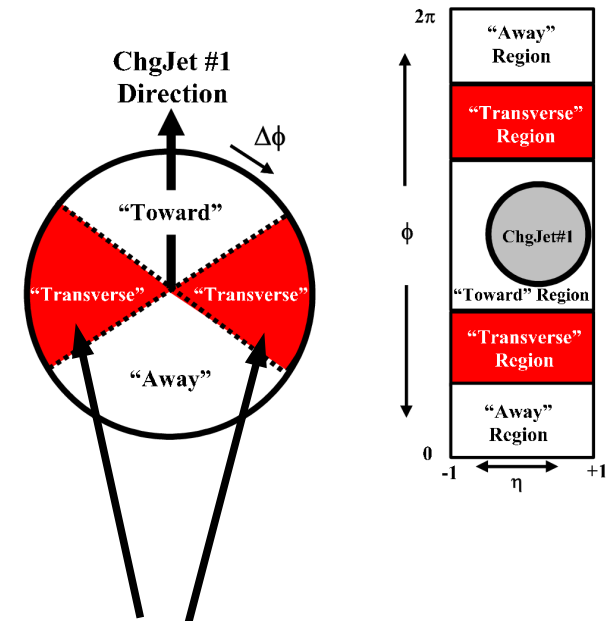
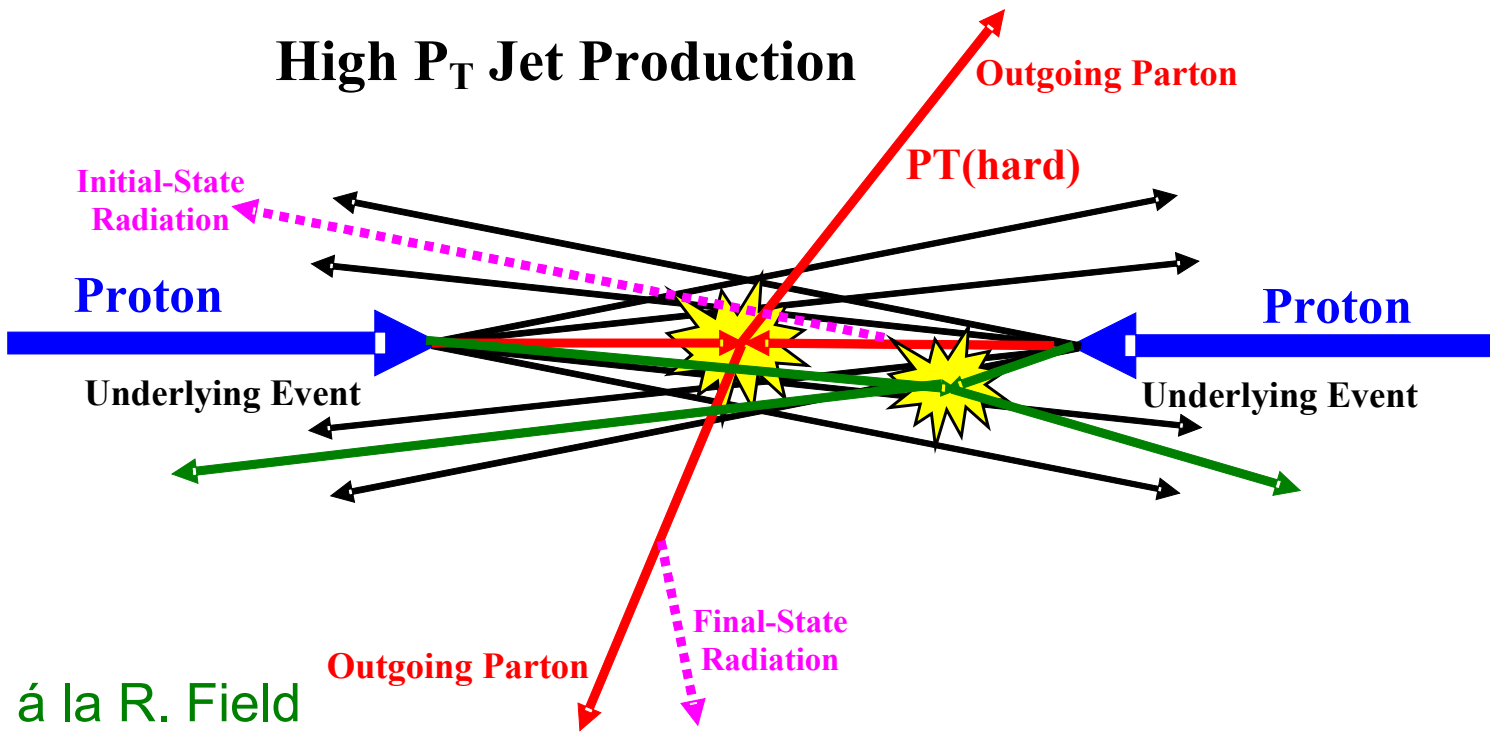


The Underlying Event

Q D
C

The Underlying Event is everything but the hard scatter.

High P_T Jet Production

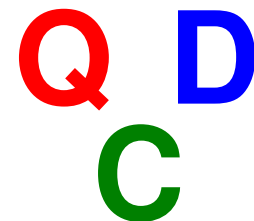


A measurement possibility:
 → Charged particle and P_{tsum} densities in **transverse** region of leading charged jet

See also talks by R. Field and in multi-jets Tuesday morning session!

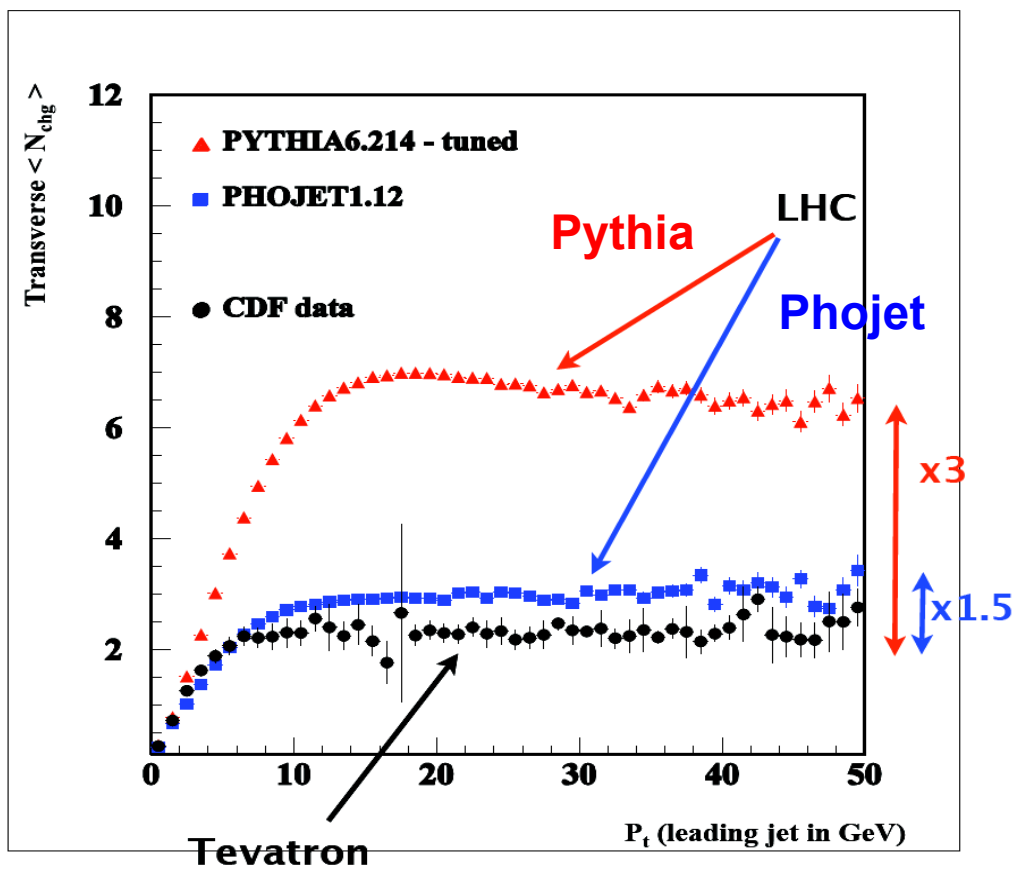


The Underlying Event



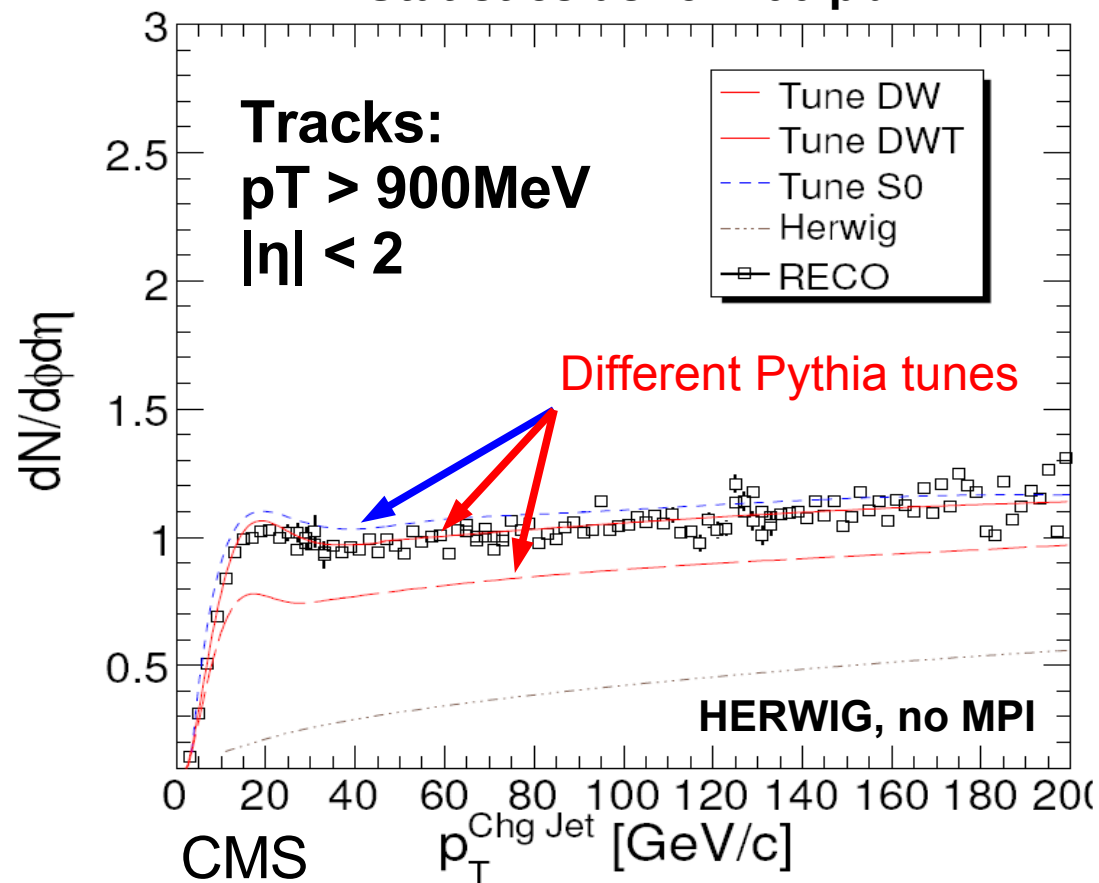
Charged particle density in transverse plane vs. leading charged jet pT

Extrapolation to LHC from CDF data



Comparison of different Pythia tunes

Statistics as for 100/pb

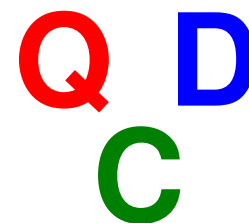


ATLAS

CMS PAS QCD-07-003



Jets: The Drivers



- Jet algorithms

➔ Talks by P.-A. Delsart, Chr. Sander

- Jet energy calibration

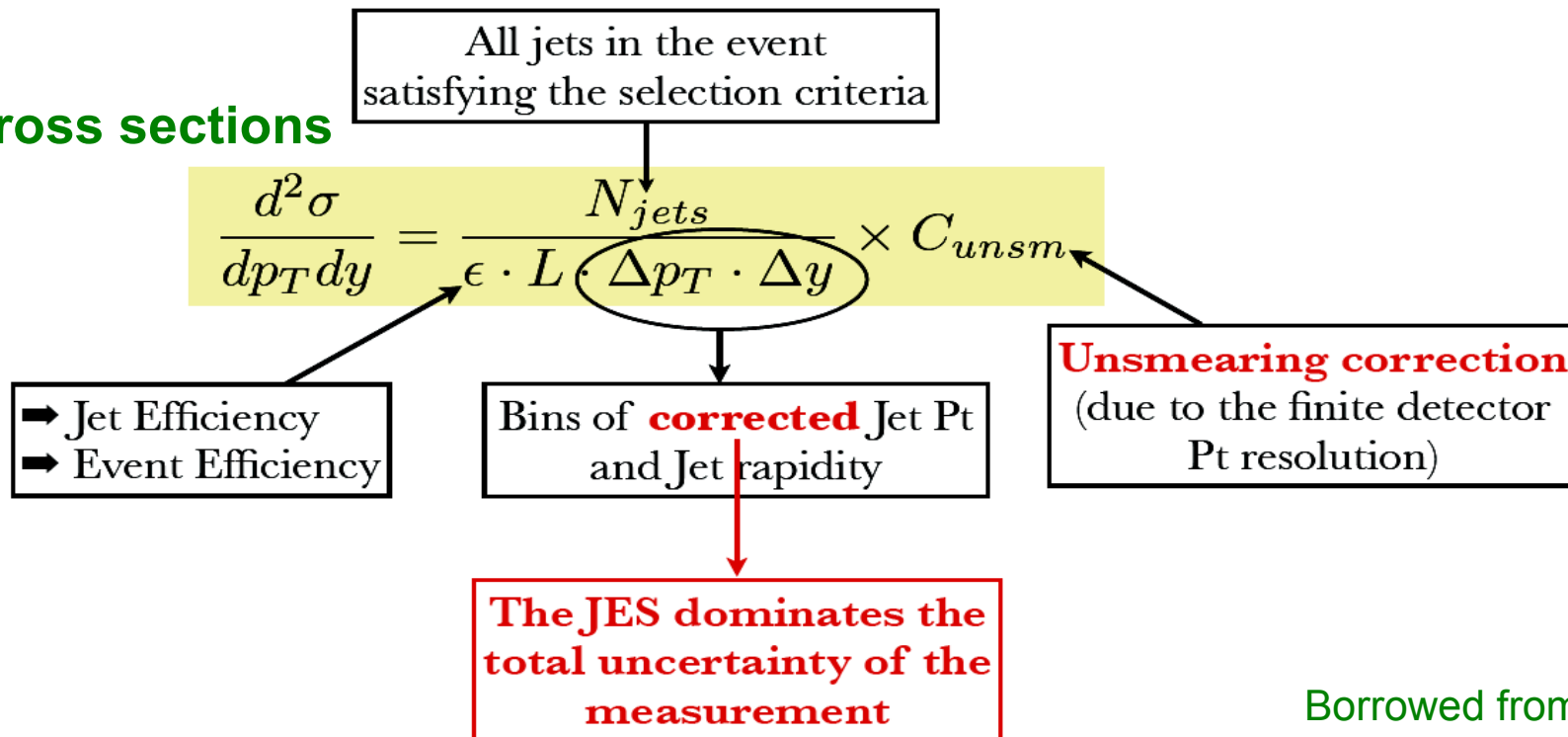
- Jet analyses (calorimeter):

- ➔ **Dijet azimuthal decorrelation**

➔ Talk by M. Dasgupta

- ➔ **Jet shapes**

- ➔ **Inclusive jet cross sections**



Borrowed from K. Kousouris



Jet Algorithms

Q D
C

Avoid pit stops for changing to a safe jet algorithm later ...

Algorithms in use by ATLAS and CMS

ATLAS:

- Iterative Cone R = 0.4, 0.7
- SIScone in future??
- kT D = 0.4, 0.6

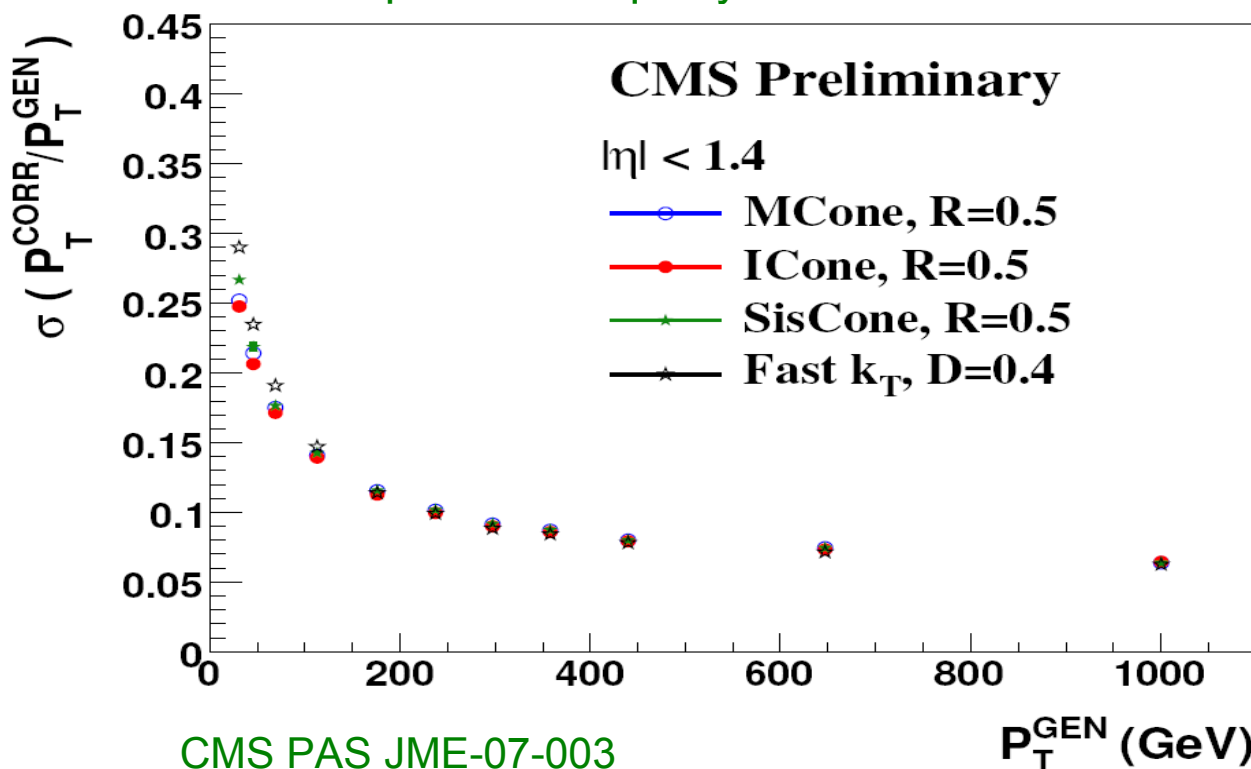
CMS:

- Iterative Cone R = 0.5
- SIScone R = 0.5, 0.7
- kT D = 0.4, 0.6

For many more details, see talk by G. Salam and in multi-jets Tuesday afternoon sessions!

Jet energy resolution from CMS performance study

SIScone performs equally well as MidPoint Cone





Jet Energy Calibration

Q D
C

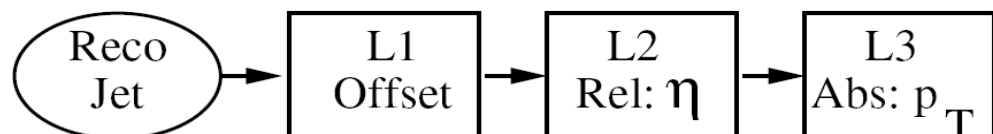
Description simplified, jet energy corrections are a very complex matter!

Factorized multi-level Calibration: CMS

- offset correction for pile-up, noise, thresholds
- relative correction for response variations in η (di-jets)
- absolute correction to particle level (pT balance in $\gamma/Z + \text{jet}$, M_W, M_{top} in $t\bar{t}$ bar \rightarrow WbWb)

Local Hadron Calibration: ATLAS

- calibrate clusters independent of any jet algorithm to individual particle scale
- make jets out of calibrated clusters



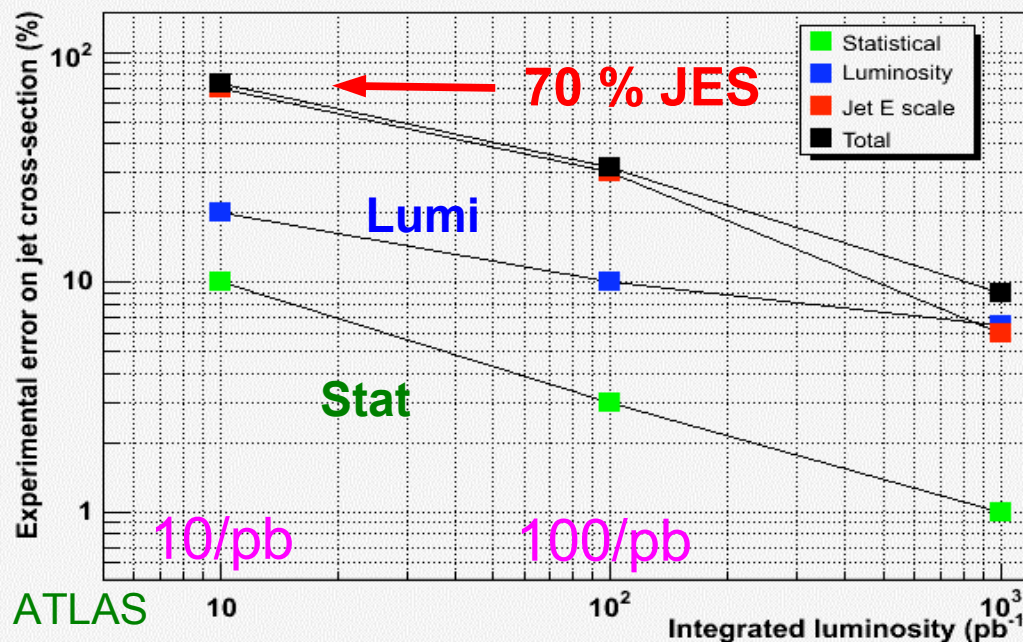
Habitual jet input:

- calorimeter towers (ATLAS & CMS)

Additionally:

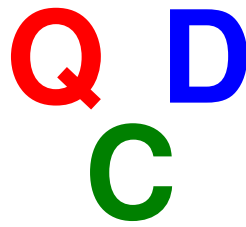
- topological clusters of IAr cells (ATLAS)

Projection of uncertainties on TeV jets (Jets with $p_T = 1$ TeV, $|\eta| < 2$)





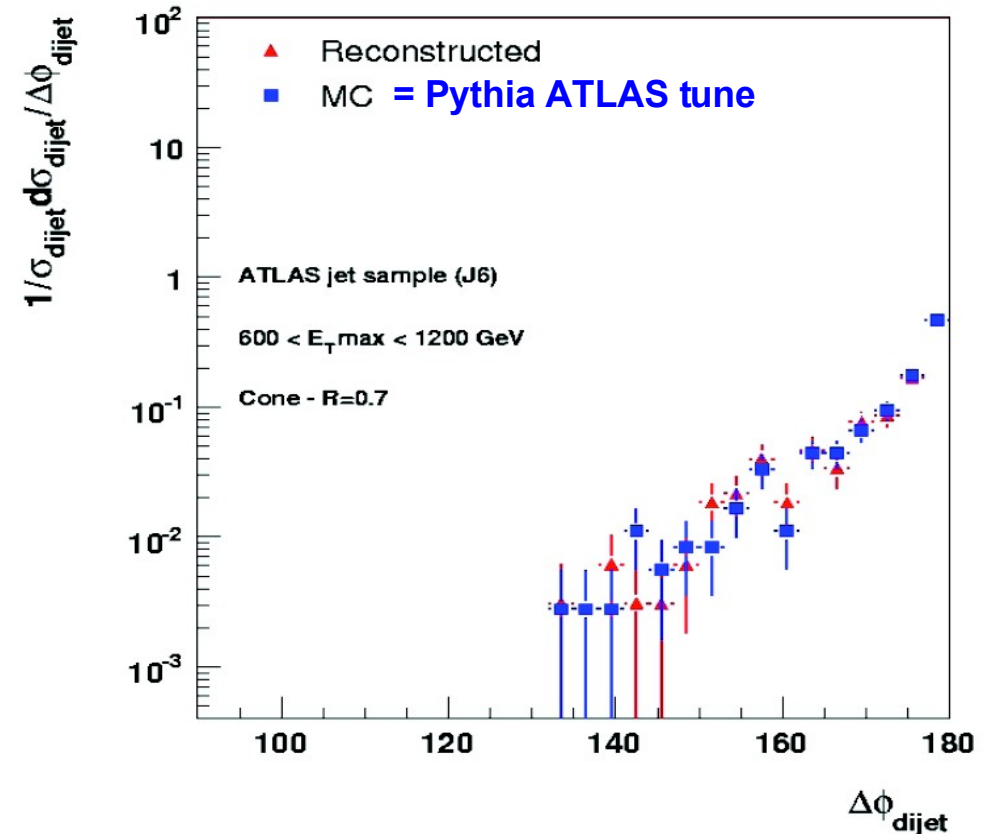
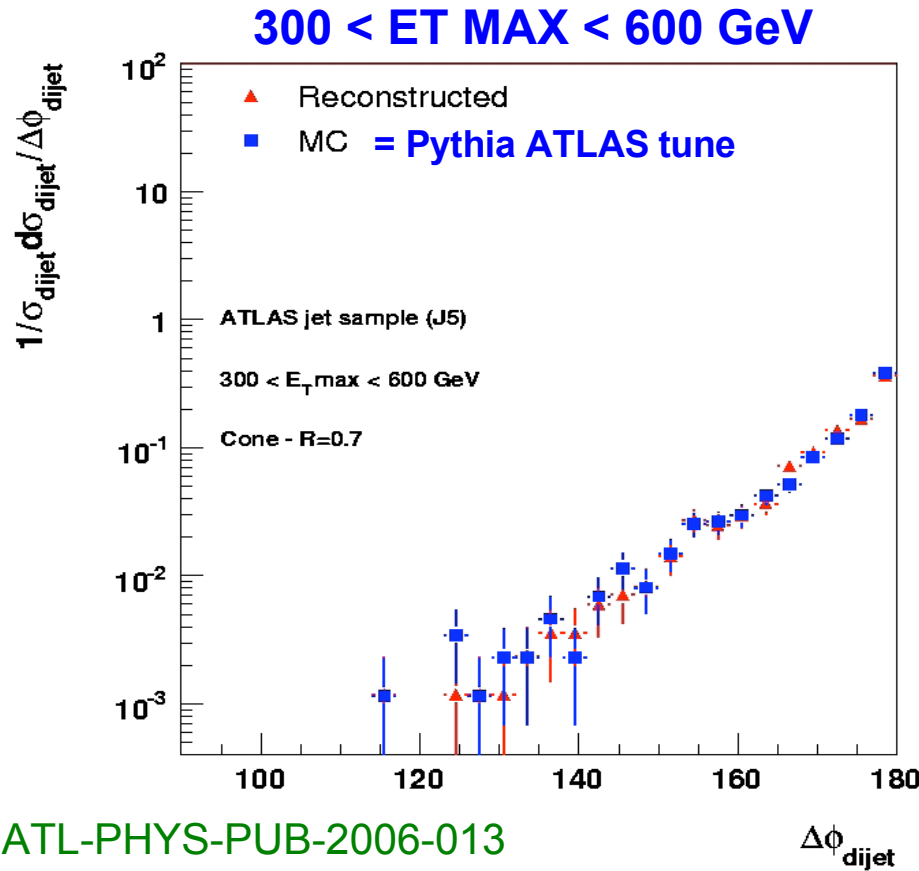
Dijet Azimuthal Decorrelation



ATLAS comparison between generated and reconstructed $\Delta\phi$ in two bins of ET

Cone jet algorithm: $\rightarrow R=0.7$
 $\rightarrow N_{jets} = 2$
 $\rightarrow |\eta_{jet}| < 0.5$
 $\rightarrow ET_{jet \#2} > 80 \text{ GeV}$

$600 < ET \text{ MAX} < 1200 \text{ GeV}$



ATL-PHYS-PUB-2006-013



Jet Shapes

QCD

A possibility to look into details of QCD and jet structure!

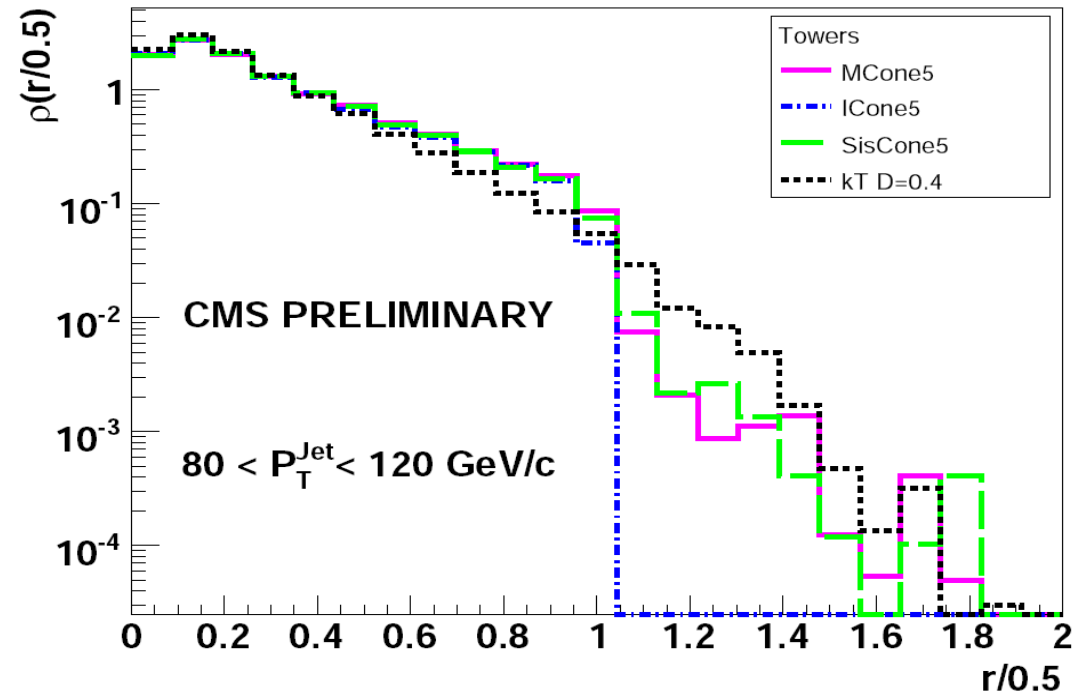
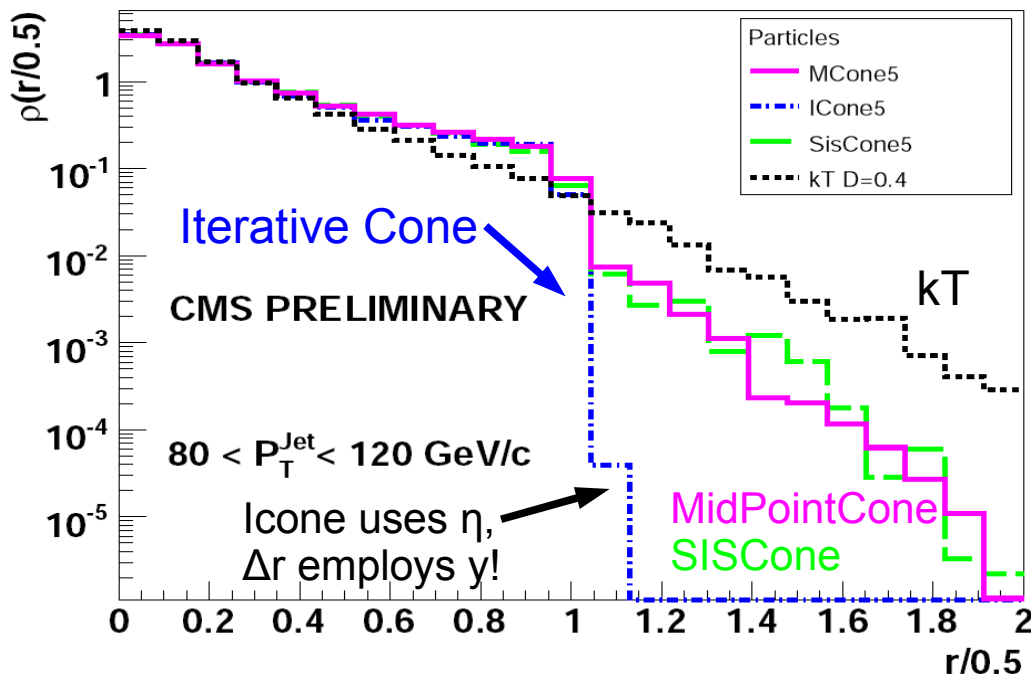
Norm. transverse energy distribution:

$$\rho(r) = \frac{\sum p_T(r - \Delta r/2, r + \Delta r/2)}{\Delta r \sum p_T^{Jet}}$$

Good reproduction of general properties (central region $|\eta| < 1$, matched jets)

Jets from generator particles

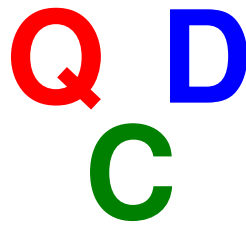
Jets from calorimeter towers



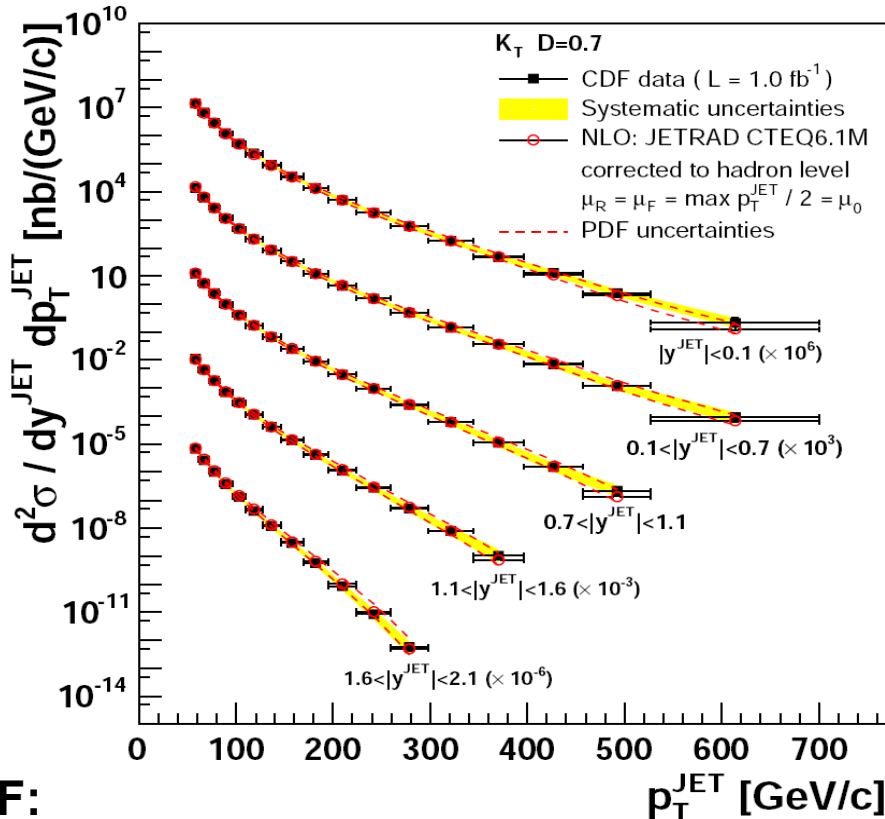
CMS PAS JME-07-003



Inclusive Jets at the Tevatron



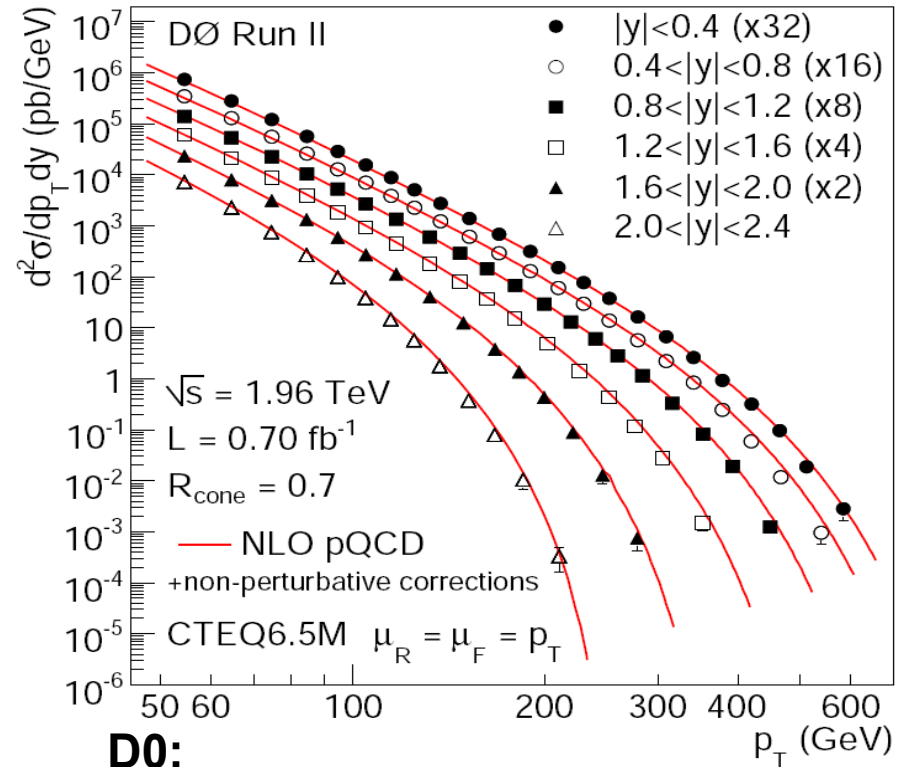
CDF Incl. kT jets, $D=0.7$
Theory: NLO with CTEQ6.1M



Phys.Rev.D75:092006,2007

CDF:
Z+jets (Phys.Rev.Lett.100:102001,2008)
W+jets (Phys.Rev.D77:011108,2008)
Incl. midpoint cone jets (Phys.Rev.D74:071103,2006)

D0 Incl. Midpoint cone jets, $R=0.7$
Theory: NLO with CTEQ6.5M



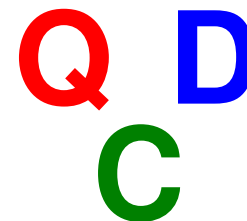
D0:
Gamma + jet + X (arXiv:0804.1107 [hep-ex])

Color code:
Blue: Good description by NLO
Red: Not described by NLO (photons ...)

arXiv:0802.2400 [hep-ex]



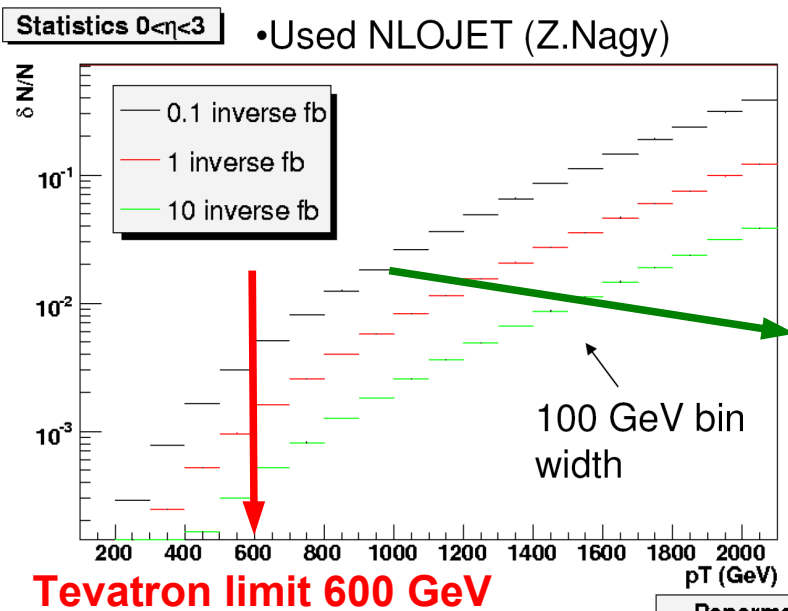
Inclusive Jets at the LHC



Evaluation of jet cross section uncertainties by ATLAS

Jet Energy Scale

- 10% shift
- 5% shift
- 1% shift



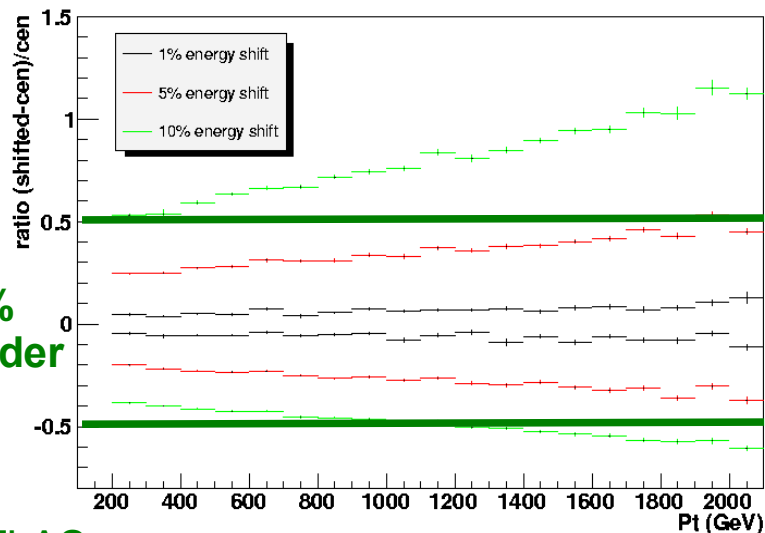
Statistics:

Estimated as $\sqrt{N/N}$ from NLO cross section

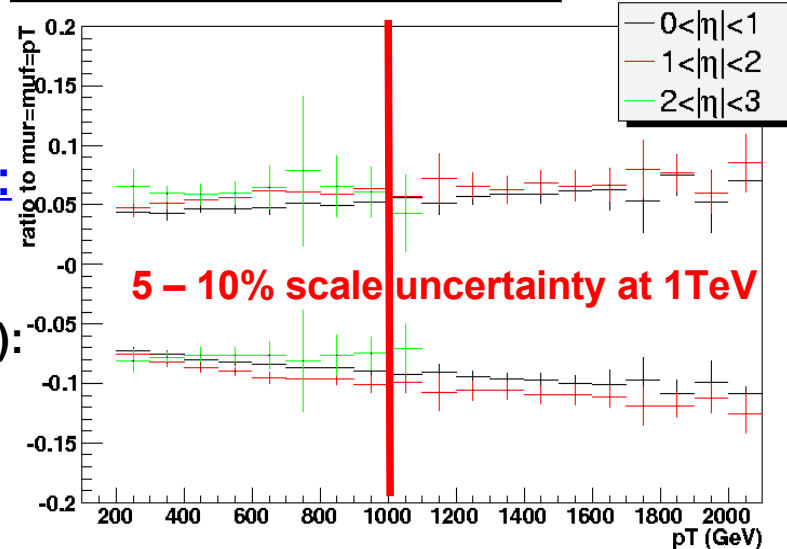
- 10 / fb
- 1 / fb
- 0.1 / fb

100/pb LHC: 2% at 1 TeV
30% at 2 TeV

Jet Energy Scale Errors



Renormalisation/Factorisation Scale Errors



Scale Uncertainty:

By varying $\mu_r = \mu_f$ from $pT/2$ to $2 pT$ (in pseudorapidities):

- $2 < |\eta| < 3$
- $1 < |\eta| < 2$
- $0 < |\eta| < 1$

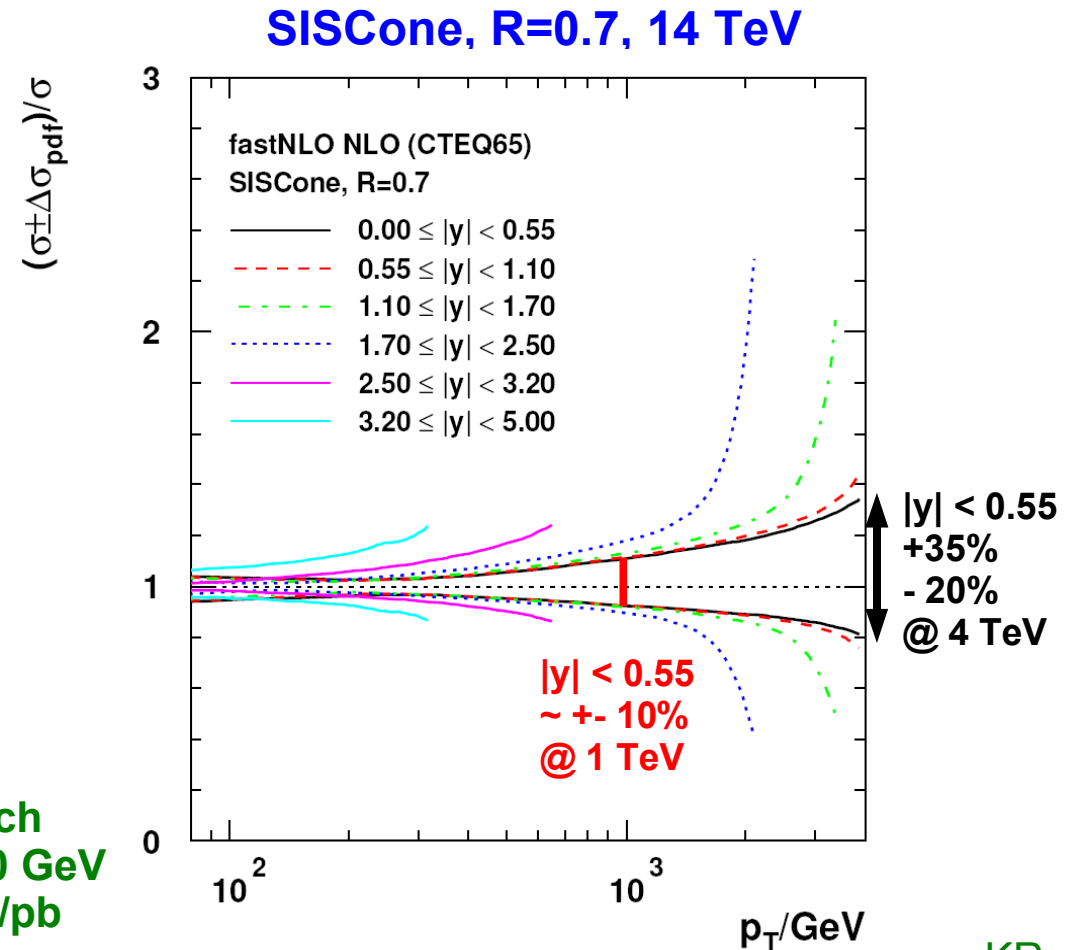
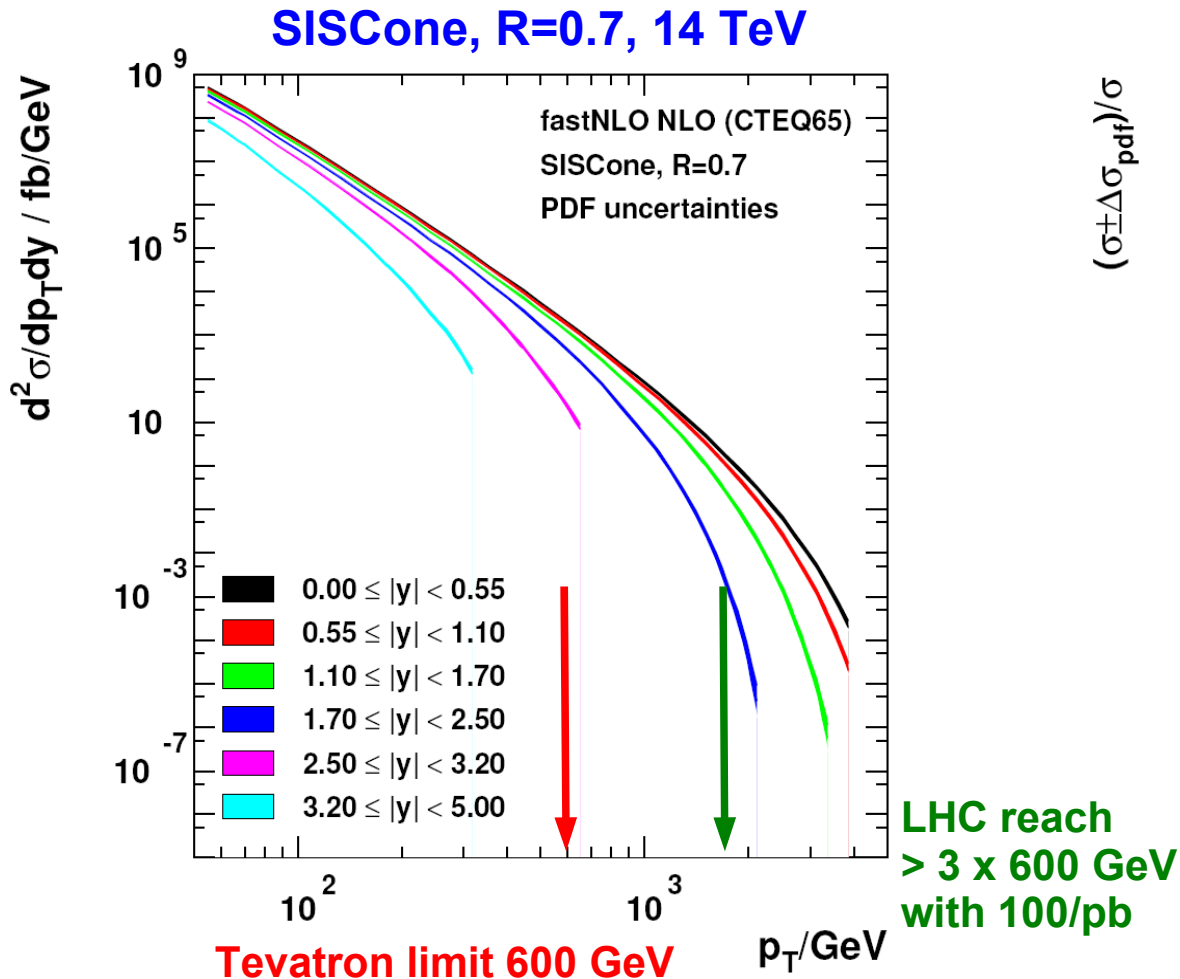
ATLAS



Inclusive Jets at the LHC

Q D
C

Expected PDF uncertainties according to standard procedure with error sets from CTEQ 6.5



KR



Pit Stop: PDF uncertainties

Q D
C

The data are compared with QCD predictions for various sets of parton distribution functions. The cross section for jets with $E_T > 200$ GeV is significantly higher than current predictions based on $O(\alpha_s^3)$ perturbative QCD calculations. ...

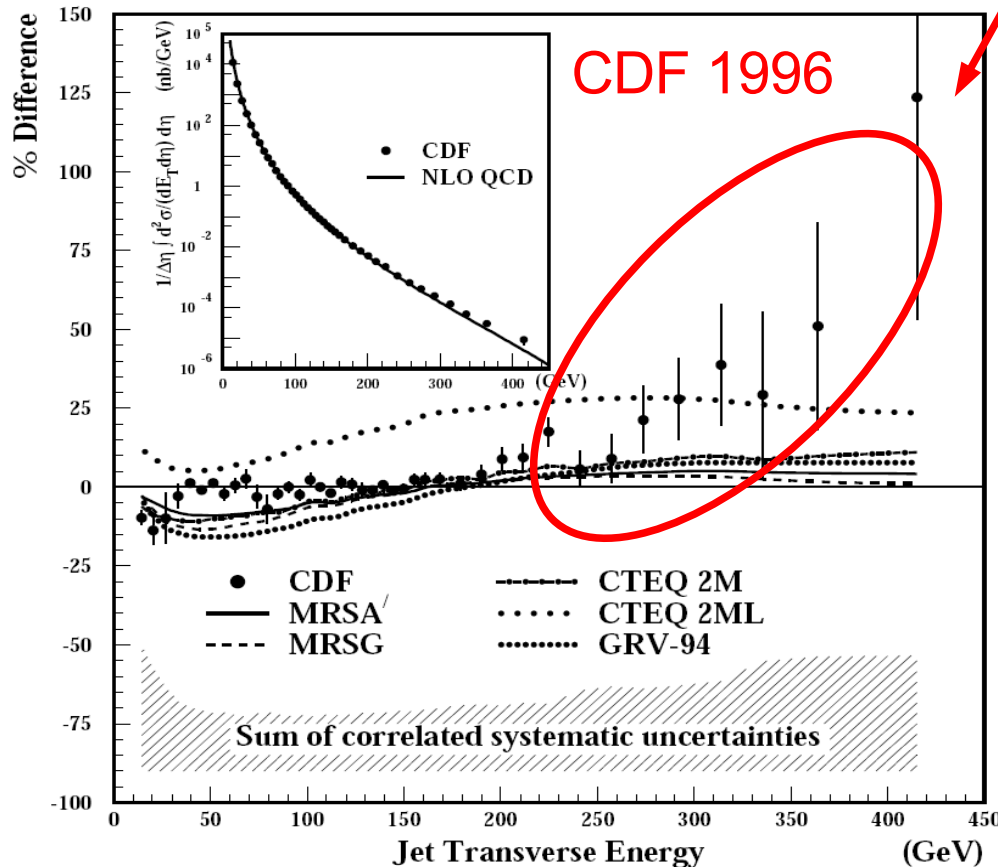
Explained by change in gluon density which then can be constrained by jets!

Today:

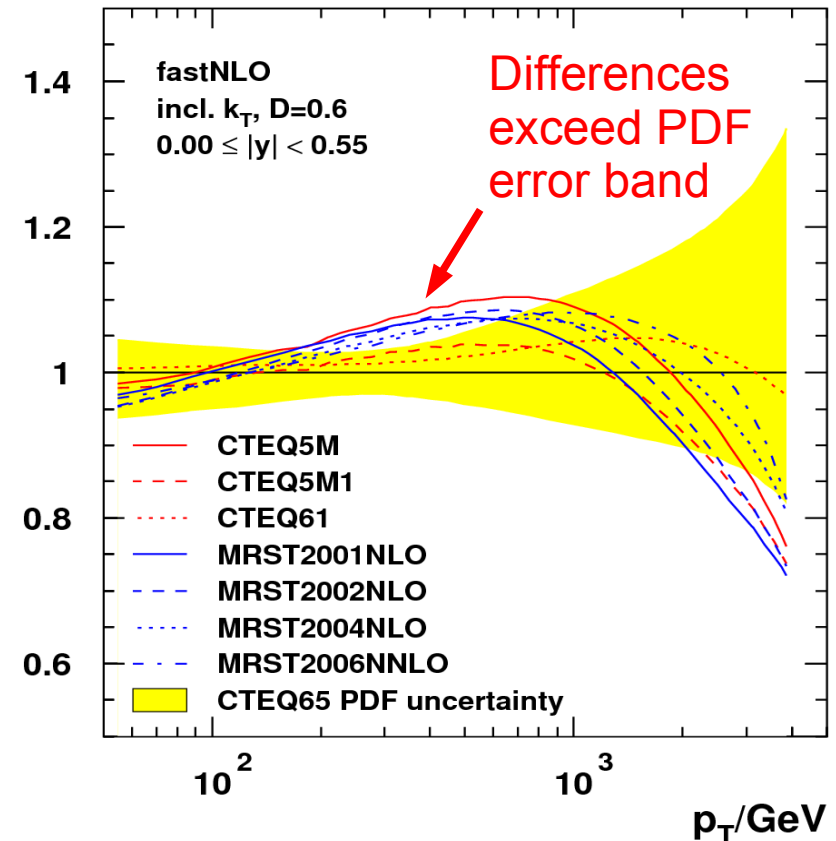
Much better estimates of PDF uncertainties

But still ...

Phys.Rev.Lett. 77 (1996)



$d^2\sigma/dp_T dy_{PDF} / d^2\sigma/dp_T dy_{CTEQ6.5}$



KR



Photons: The Drivers

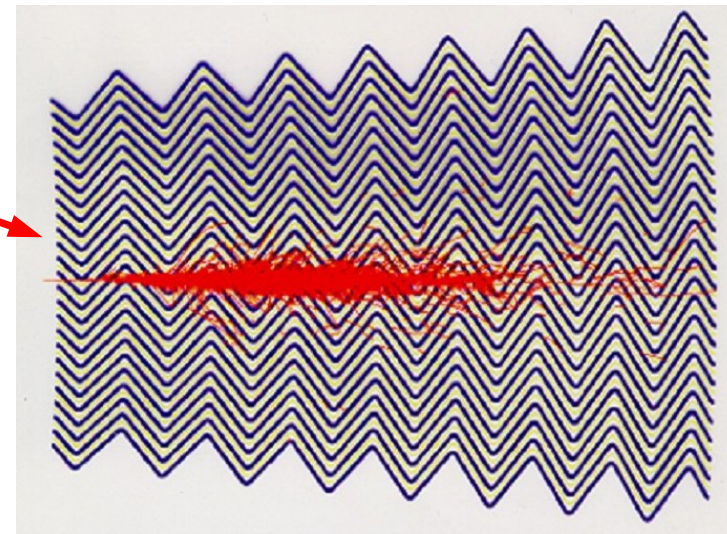
Q D
C

Photon processes:

- ➔ Direct photon production
- ➔ Di-photons
- ➔ Photon + n jets

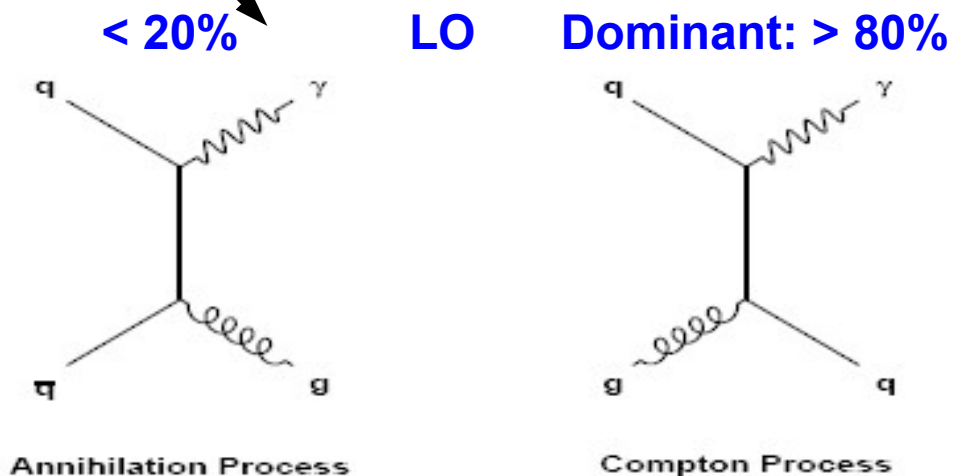
Photons:

- ➔ Experimental
- ➔ Theory



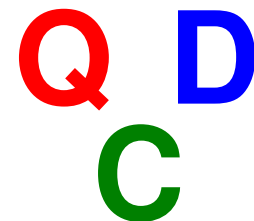
Gauge boson production gives important additional information:

- Luminosity measurement
- Detector calibration
- PDFs
- Background for new physics :-)





Photon Rates



# bunches	β^* (m)	I_b	L ($\text{cm}^{-2}\text{s}^{-1}$)	Pileup	Photons/hour ($p_T > 20 \text{ GeV}$)
1x1	18	10^{10}	10^{27}	low	$3.2 \cdot 10^{-1}$
43x43	18	$3 \cdot 10^{10}$	$3.8 \cdot 10^{29}$	0.05	$1.2 \cdot 10^2$
43x43	4	$3 \cdot 10^{10}$	$1.7 \cdot 10^{30}$	0.21	$5.4 \cdot 10^2$
43x43	2	$4 \cdot 10^{10}$	$6.1 \cdot 10^{30}$	0.76	$2.0 \cdot 10^3$
156x156	4	$4 \cdot 10^{10}$	$1.1 \cdot 10^{31}$	0.38	$3.6 \cdot 10^3$
156x156	4	$9 \cdot 10^{10}$	$5.1 \cdot 10^{31}$	1.9	$1.6 \cdot 10^4$
CMS 156x156	2	$9 \cdot 10^{10}$	$1.1 \cdot 10^{32}$	3.9	$3.6 \cdot 10^5$

Photon rate estimations:

- Photon $p_T > 20 \text{ GeV}$
- Photon $|\eta| < 2.5$

Not taken into account

ATLAS trigger simulation results for $L = 10^{31} \text{ cm}^{-2} \text{ s}^{-1}$:

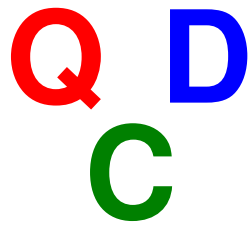
- **Trigger on photon $p_T > 20 \text{ GeV}$ in $|\eta| < 2.4$**
- **Signal sample: γ +jet (γ generated with $p_T > 10 \text{ GeV}$)**
- **Background from jet-jet sample generated with $p_T > 15 \text{ GeV}$ is 7 Hz**

ATLAS

	Jet energy range (GeV)	Trigger Efficiency(%) γ_{20}
1	17-35	75.1 \pm 0.3
2	35-70	83.5 \pm 0.3
3	70-140	89.3 \pm 0.2
4	140-280	91.7 \pm 0.2
5	280-560	94.4 \pm 0.2
6	560-1120	92.4 \pm 1.1



Photon Conversion & Isolation

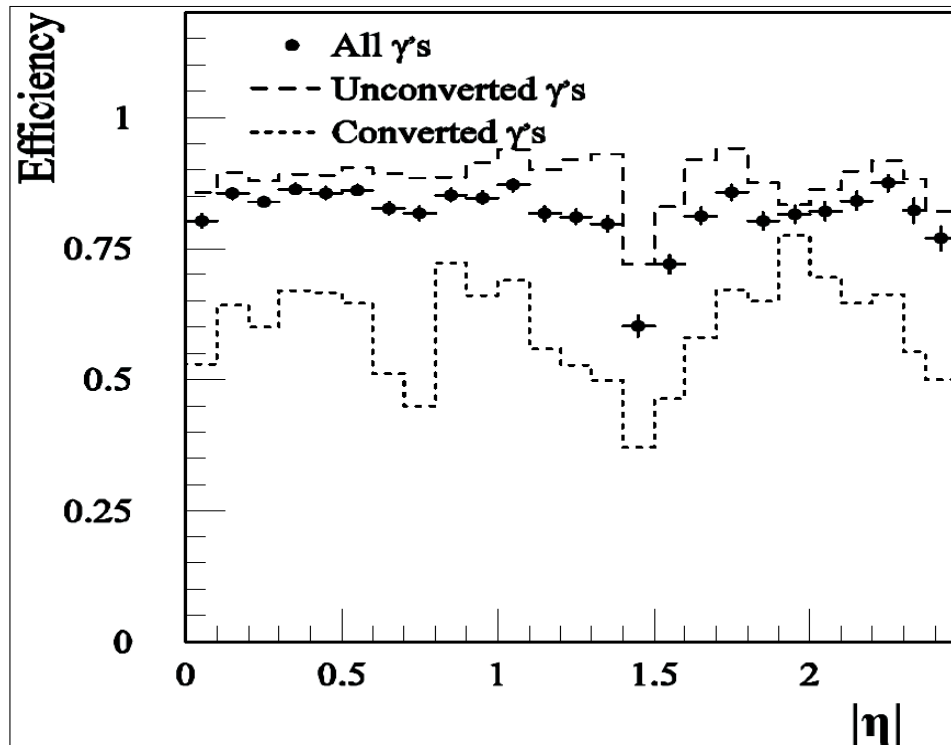


Important steps:

- Good efficiency including photon conversions
- Proper photon isolation to suppress background

ATLAS photon efficiency:

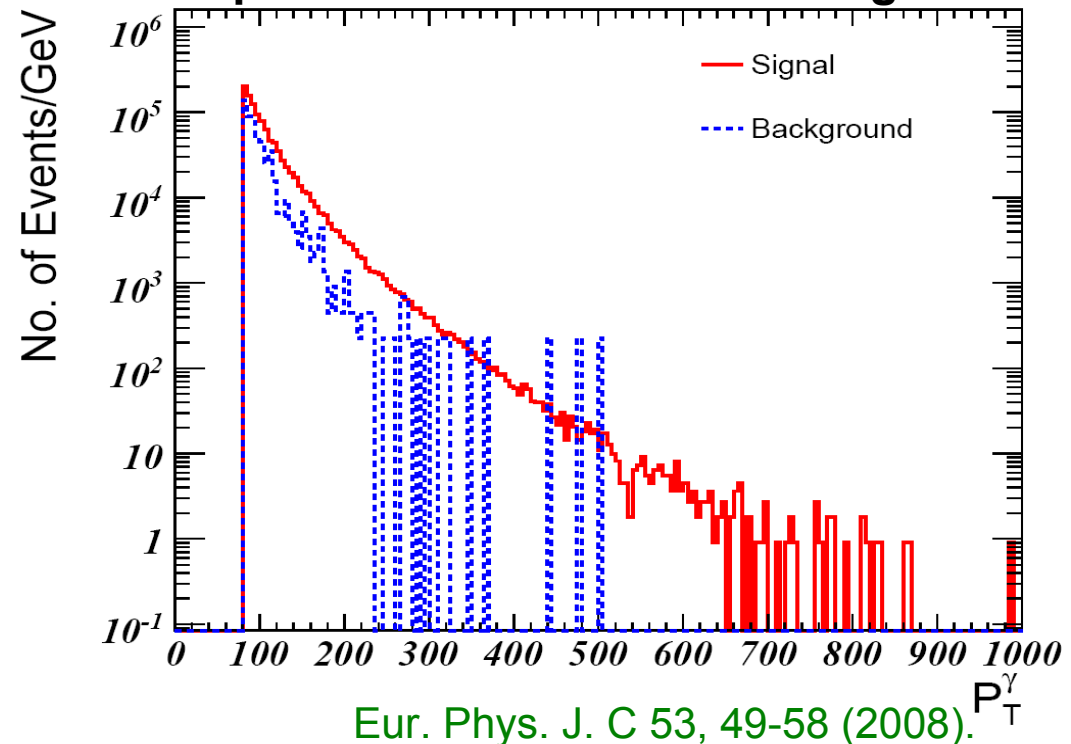
- > 80% at low luminosity
- including **converted** & unconverted photons



ATLAS

CMS photon study:

- Photon p_T spectrum for 1/fb
- Background QCD jets in blue
- **After photon isolation cuts**
- Improves S/B > 2 orders of magnitude



Eur. Phys. J. C 53, 49-58 (2008). P_T^γ



New Physics: The Drivers

Q D
C

New Physics with Jets:

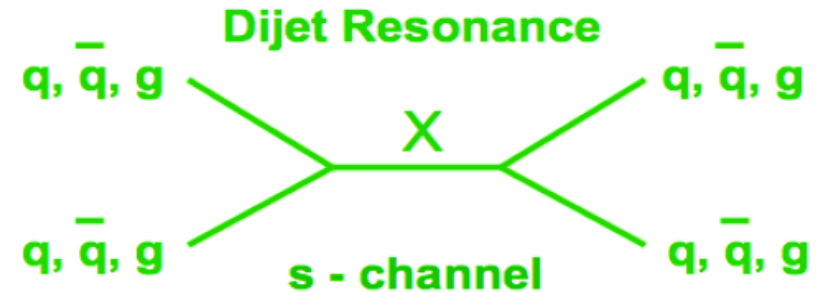
Contact interactions

Di-jet mass distribution

Resonances

- ★ W' & Z' (Grand Unified Theory)
- ★ E_6 diquarks (D) (Superstrings & GUT)
- ★ Excited quarks (q^*) (Compositeness)
- ★ RS Gravitons (G) (Extra Dimensions)
- ★ Colorons (C) & Axigluons (A) (Extra Color)

Need
 $E_{\text{CMS}} > M$



Model	J	Color	Cross Section (pb)					
			M=0.7 TeV		M=2.0 TeV		M=5.0 TeV	
			$ \eta < 1$	$ \eta < 1.3$	$ \eta < 1$	$ \eta < 1.3$	$ \eta < 1$	$ \eta < 1.3$
q^*	1/2	Triplet	7.95×10^2	1.27×10^3	9.01	1.36×10^1	1.82×10^{-2}	2.30×10^{-2}
A,C	1	Octet	3.22×10^2	5.21×10^2	5.79	8.82	1.55×10^{-2}	2.04×10^{-2}
D	0	Triplet	8.11×10^1	1.26×10^2	4.20	5.97	4.65×10^{-2}	5.75×10^{-2}
G	2	Singlet	3.57×10^1	5.47×10^1	1.83×10^{-1}	2.60×10^{-1}	2.64×10^{-4}	3.19×10^{-4}
W'	1	Singlet	1.46×10^1	2.37×10^1	3.49×10^{-1}	5.31×10^{-1}	8.72×10^{-4}	1.17×10^{-3}
Z'	1	Singlet	8.86	1.44×10^1	1.81×10^{-1}	2.77×10^{-1}	5.50×10^{-4}	7.26×10^{-4}

Contact Interactions

- ★ Sensitive to Scale $\Lambda \gg \sqrt{s}$!

$$L_{qq} = \frac{Ag^2}{2\Lambda^2} (\bar{q}_L \gamma^\mu q_L) (\bar{q}_L \gamma_\mu q_L)$$

Contact Interaction





Recent Limits

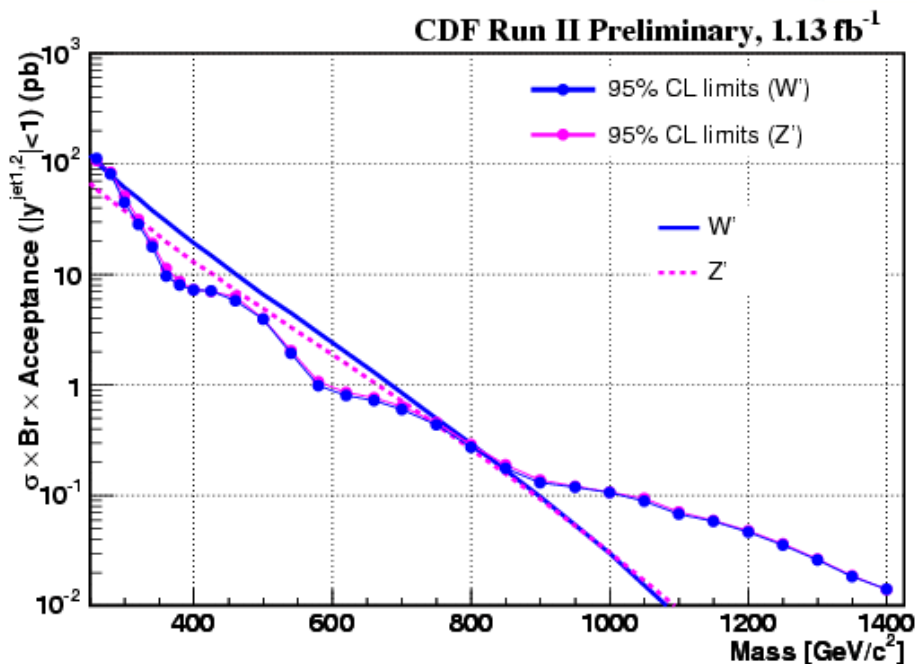
Q D
C

Tevatron limit on contact interaction scale (qqqq): $> 2.4 - 2.7$ TeV

Dijet resonance search

Resonance	Excluded (GeV)	Resonance	Excluded (GeV)
A or C	260 - 1250	D	290 - 630
ρ_{T8}	260 - 1110	W'	280 - 840
q^*	260 - 870	Z'	320 - 740

CDF Preliminary 03/2008



Exclusion limits for W' and Z'



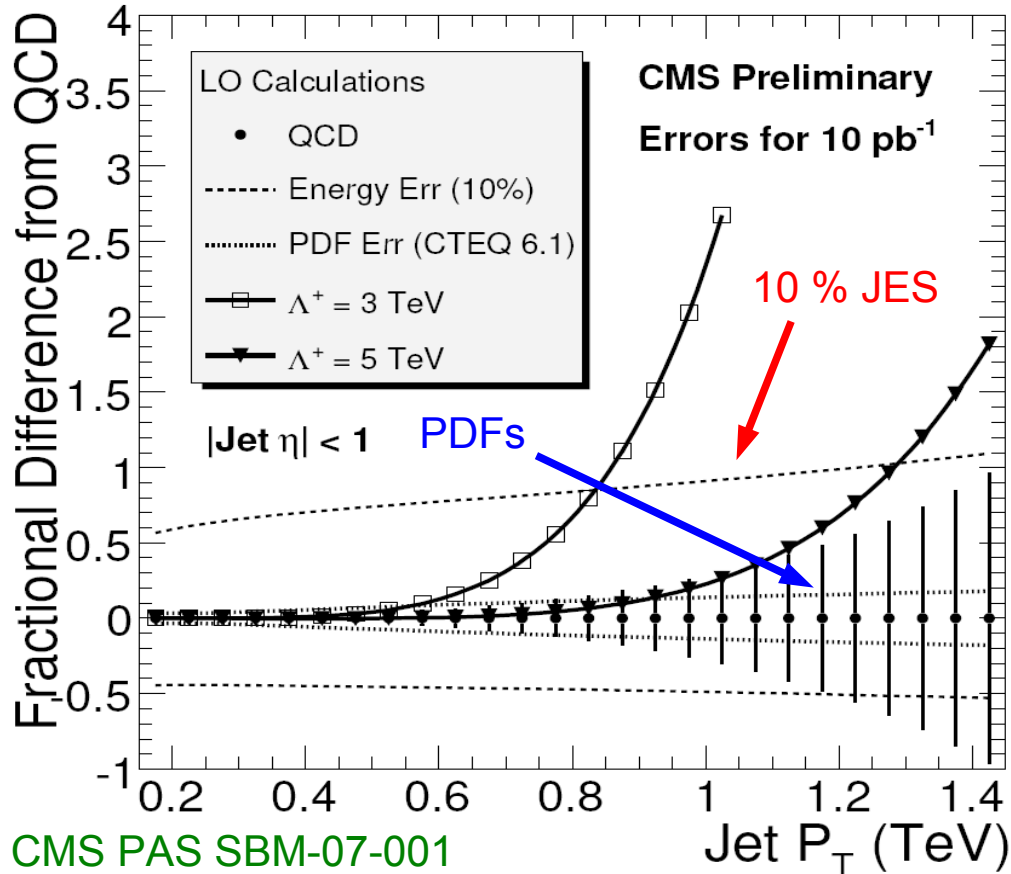
New Physics from Di-jets

QCD

Search for deviation from expected event rate:

- ➔ QCD from PYTHIA (here) or NLO
- ➔ Contact interaction: PYTHIA or LO

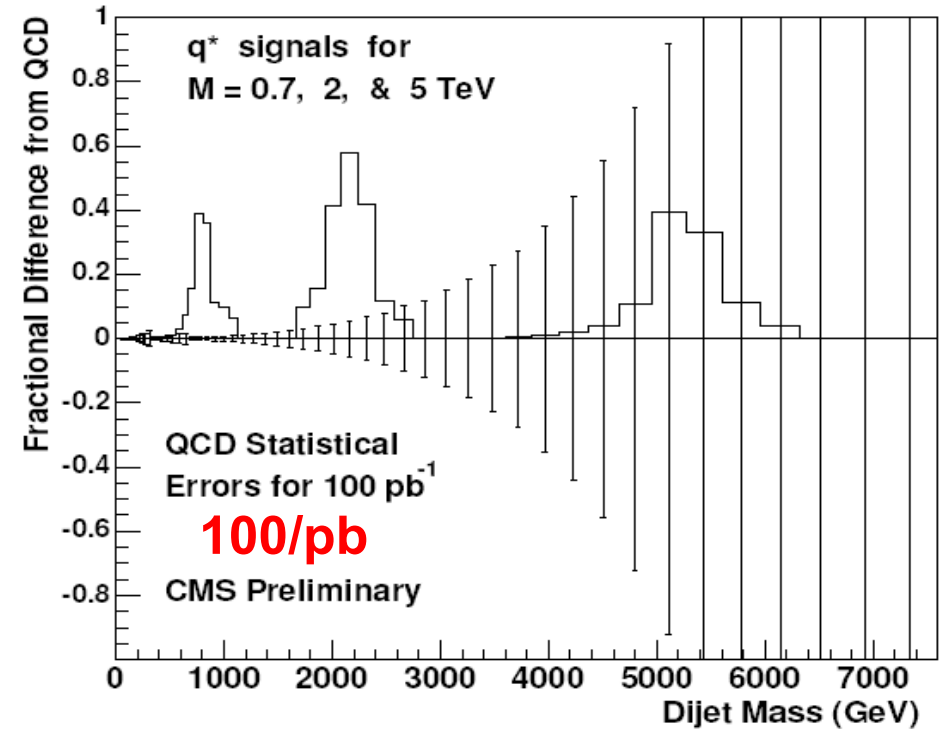
Cross section ratios



CMS PAS SBM-07-001

Search for resonances

Possible signals of q^* relative to QCD prediction, visible for < 2 TeV (statistical uncertainty only!)



One means to avoid systematics is by looking into cross section ratios in η



Spare Cars

Q D
C

• Very important to have ...

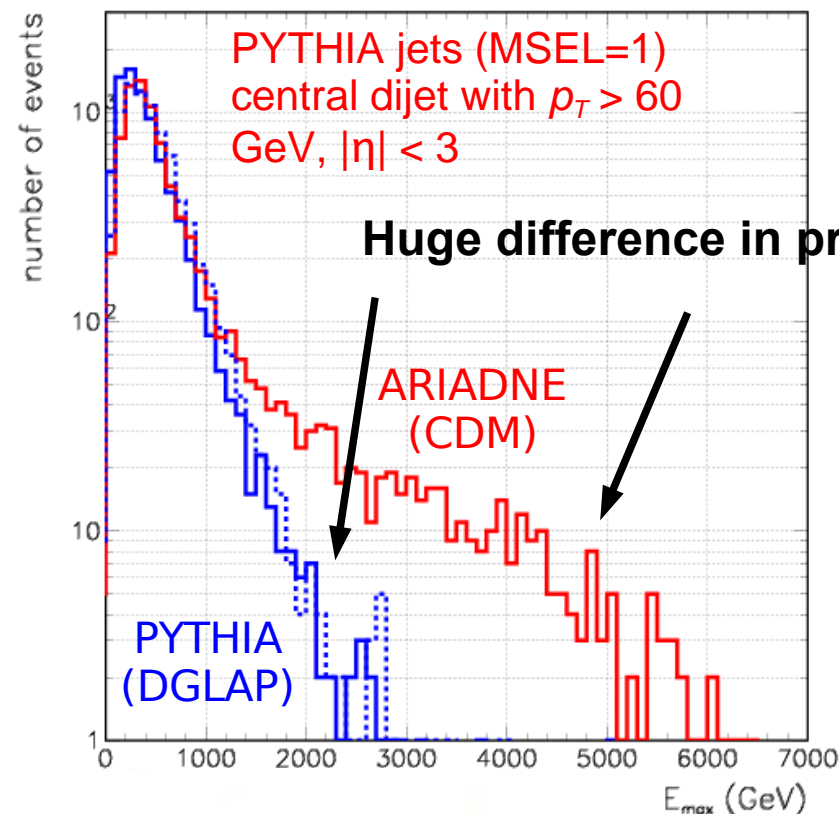
• Only test drive today:

➔ Forward jets:

- ➔ Fwd jets in HF, $3 < |\eta| < 5$
probe $x \sim 10^{-4}$
- ➔ Fwd jets in CASTOR, $5.1 < |\eta| < 6.5$
probe x down to 10^{-6}
- ➔ Sensitivity to possible PDF saturation effects

➔ Many talks during this workshop!

“Jet energy” in forward detector (CASTOR)



CMS





Spare Cars

Q D
C

- Very important to have ...
- But did not race at all this time:
 - ➔ Drell-Yan
 - ➔ Event shapes
 - ➔ 3-jets, 3-jet rates
 - ➔ 4-jets:
 - ➔ From QCD
 - ➔ From double parton interactions
 - ➔ From $t\bar{t}$ → $b\bar{b} q\bar{q}' l\nu_l$
 - ➔ Double parton interactions in $\gamma + 3$ jets
 - ➔ ...



➔ Talk by G. Luisoni

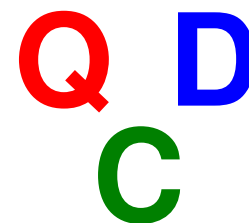
➔ Talk by D. Treleani

➔ Talk by F. Bechtel

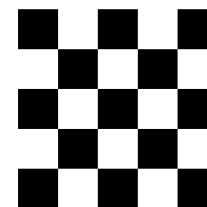




Outlook



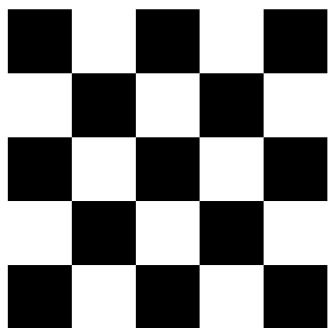
- **Team ATLAS and Team CMS are preparing for first LHC data soon!**
- **Some tough experimental systematics to deal with**
 - ➔ Trigger, alignment, jet energy scale, photon isolation, ...
- **LHC will explore unknown territory in QCD**
- **First measurements, even with low grade 900 GeV fuel, will be QCD:**
 - ➔ **Minimum Bias tracks, Underlying Event**
 - ➔ **Important for detector alignment and MC tuning**
- **Measurements of jets and photons are important tests of QCD:**
 - ➔ **Angular distributions, inclusive jets, di-jets, photon+jets, di-photons, forward jets**
 - ➔ **Calibration of the calorimeters**
 - ➔ **Better understanding of dominant background to many new physics channels**
 - ➔ **Constraints on PDFs**
- **New physics might be just ahead!**



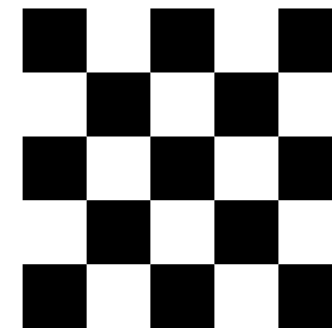


Final Score

Q D
C



It's a race! It's a race!



And QCD is in the Pole Position!

What about you?

Thanks to all colleagues helping in preparing this presentation!

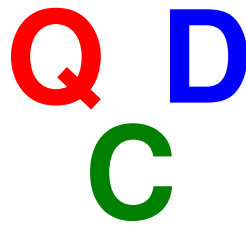


Backups

Q D
C



ATLAS Detector



Inner Detector (ID) tracker:

- Si pixel and strip + transition rad. tracker
- $\sigma(d_0) = 15\mu\text{m}@20\text{GeV}$
- $\sigma/p_T \approx 0.05\%p_T \oplus 1\%$

Calorimeter

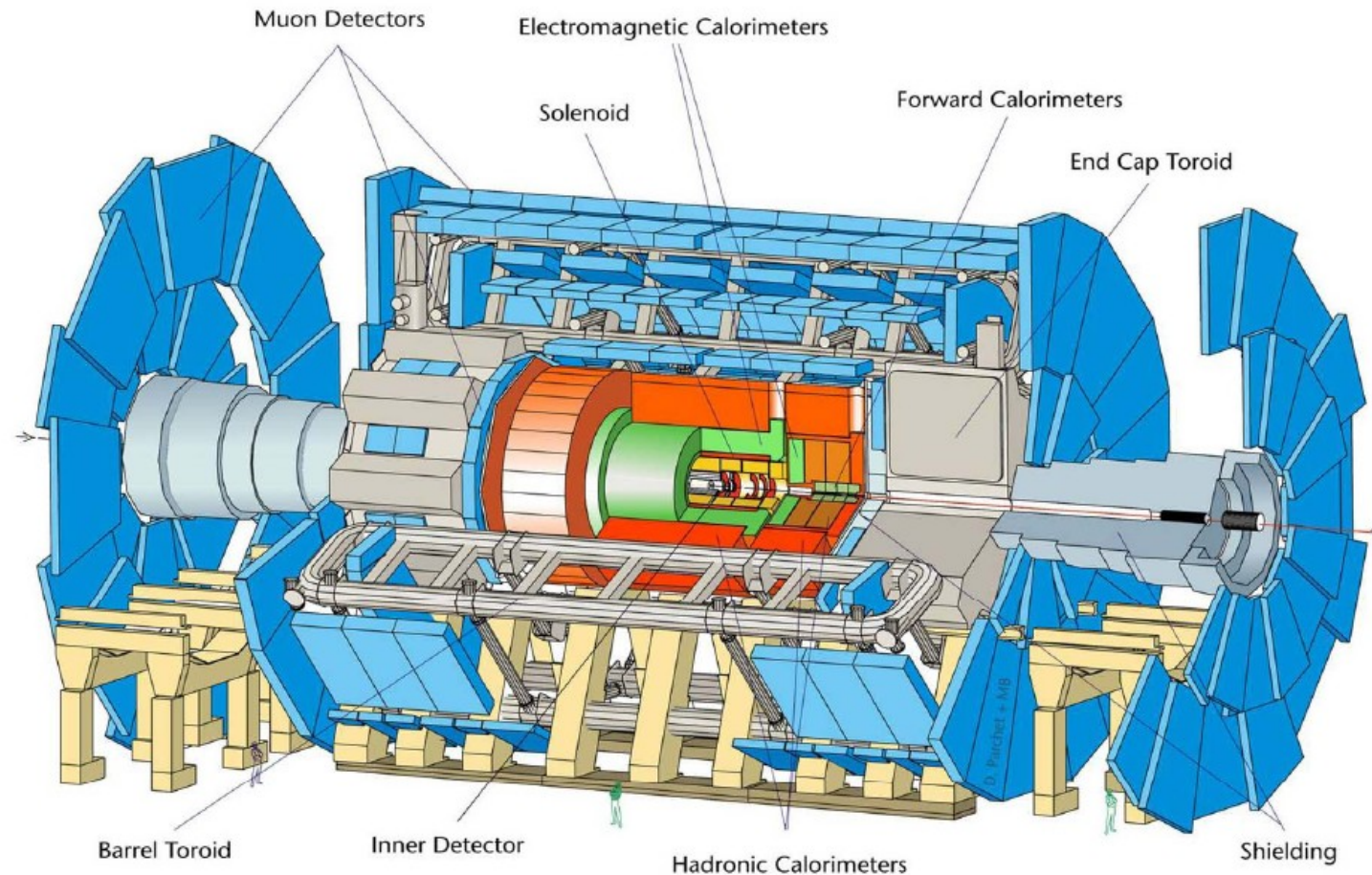
- Liquid Ar EM Cal, Tile Had. Cal
- EM: $\sigma_E/E = 10\%/\sqrt{E} \oplus 0.7\%$
- Had: $\sigma_E/E = 50\%/\sqrt{E} \oplus 3\%$

Muon spectrometer

- Drift tubes, cathode strips: precision tracking +
- RPC, TGC: triggering
- $\sigma/p_T \approx 2\text{-}7\%$

Magnets

- Solenoid (ID) $\rightarrow 2\text{T}$
- Air toroids (muon) \rightarrow up to 4T



Full coverage for $|\eta| < 2.5$, calorimeter up to $|\eta| < 5$

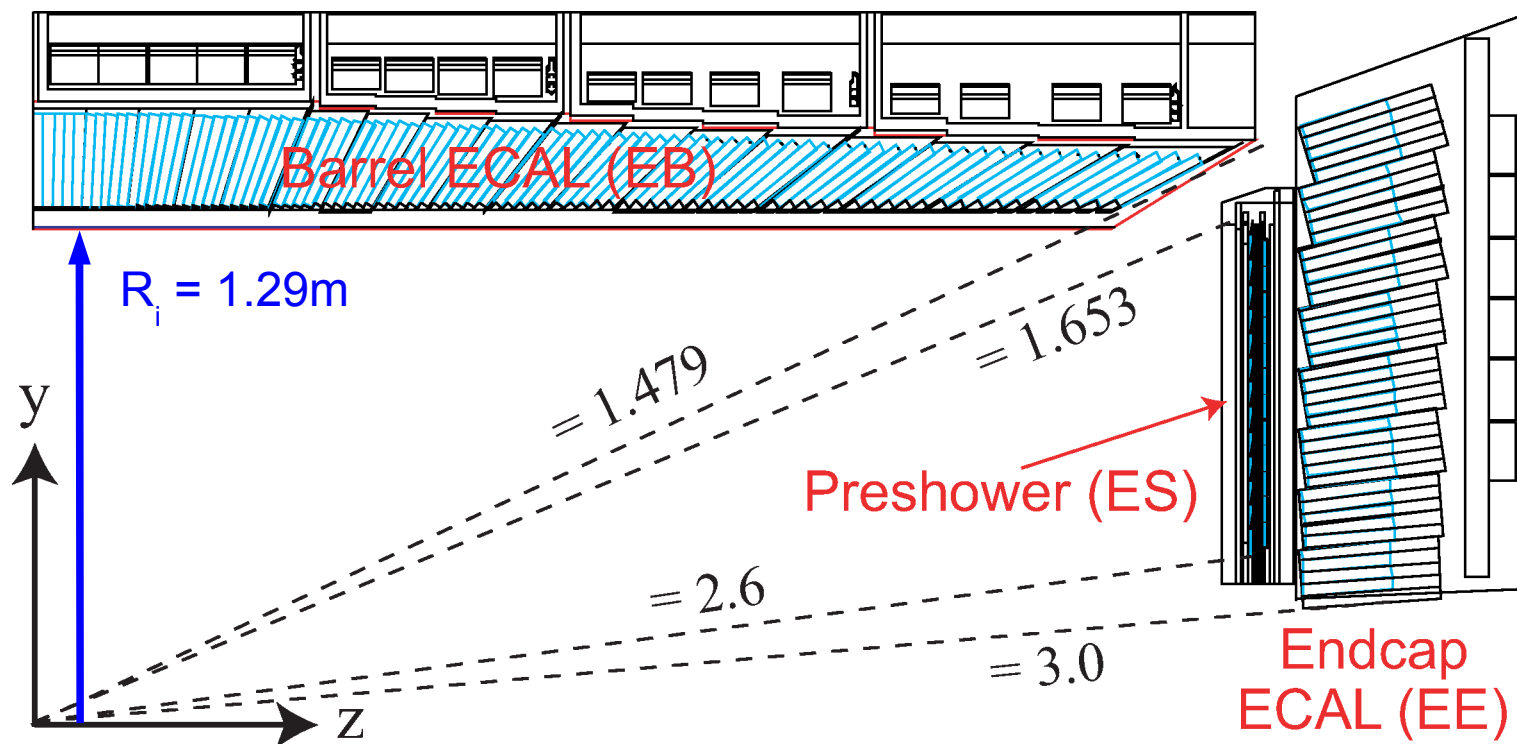


CMS Electromagnetic Calorimeter

Q D
C

Barrel (EB):

- η segments: 2x85
- ϕ segments: 360
- 61200 crystals (PbWO₄, 26 X₀)
- $\Delta\eta \times \Delta\phi \approx 0.0174 \times 0.0174$



Energy resolution from test beam:

$S = 3.63\%$, $N = 124 \text{ MeV}$, $C = 0.26\%$

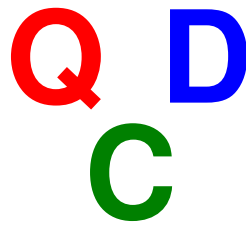
$$\left(\frac{\sigma}{E}\right)^2 = \left(\frac{S}{\sqrt{E}}\right)^2 + \left(\frac{N}{E}\right)^2 + C^2$$

Endcaps (EE):

- (x,y) grid on two halves
- front face 28 x 28 mm²
- 2 x 2 x 3662 crystals = 14648 (PbWO₄, 25 X₀)



CMS Hadronic Calorimeter



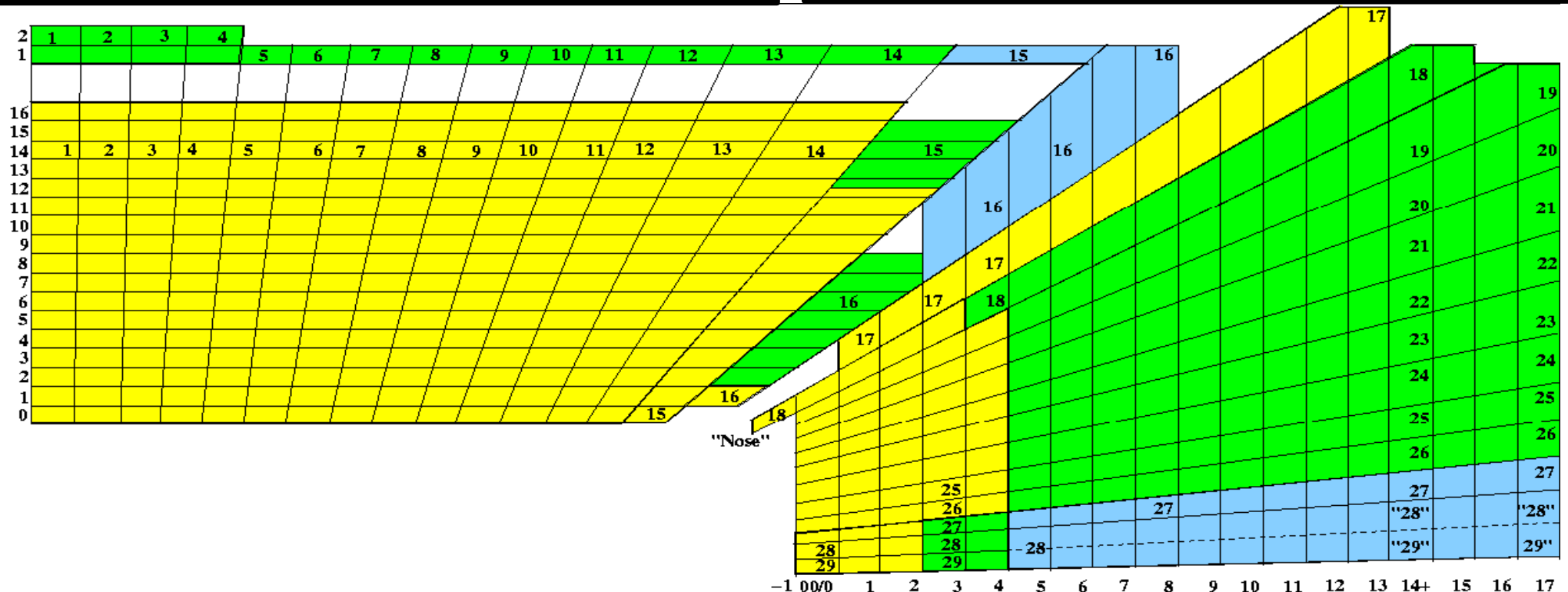
HCAL (tower structure):

- Barrel (HB): $|\eta| < 1.4$, 2304 towers
- Endcaps (HE): $1.3 < |\eta| < 3.0$, „ towers
- Outside coil (HO): $|\eta| < 1.26$ (tail catcher)
- 4608 towers (Plastic scintillator tiles, $\approx 10 \lambda_N$)
- $\Delta\eta \times \Delta\phi \approx 0.087 \times 0.087 \rightarrow 0.350 \times 0.175$

- Forward (HF): $2.9 < |\eta| < 5.0$ (not shown)
- 2 x 900 towers (Quartz fibers, $\approx 10 \lambda_N$)
- $\Delta\eta \times \Delta\phi \approx 0.111 \times 0.175 \rightarrow 0.302 \times 0.350$

CASTOR calorimeter (not shown):

- $5.1 < |\eta| < 6.5$, $\approx 22 X_0$, $\approx 10 \lambda_N$





CMS Pixel Triplets

Q D
C

One of the first analyses possible ...

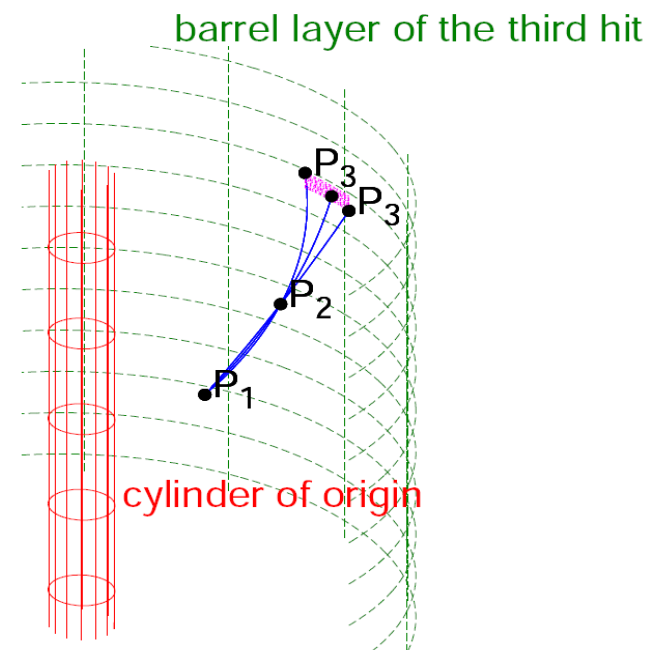
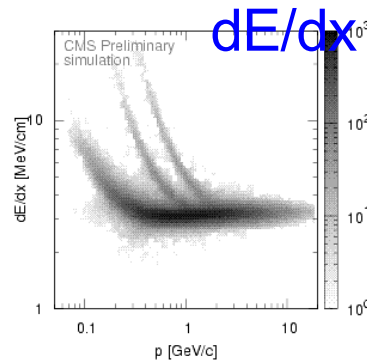
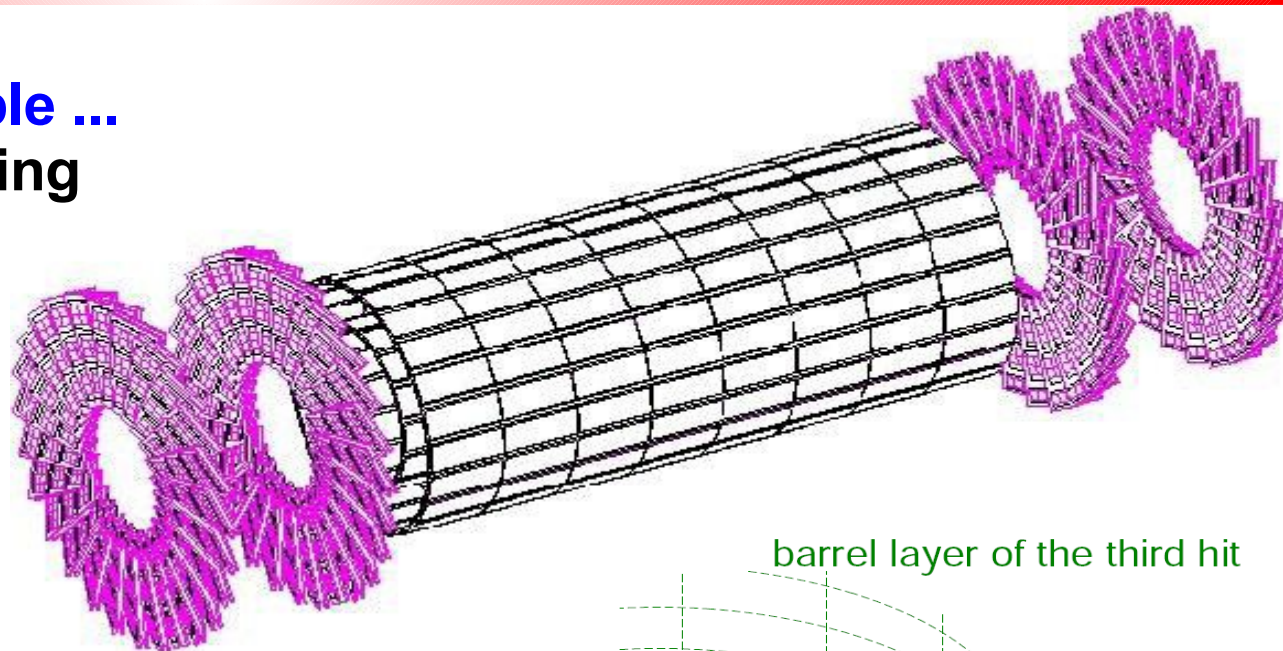
Here: 1.9 million events, assuming one month of running with 1 Hz allocated bandwidth

● CMS pixel detector:

- 3 barrel layers (4, 7 and 10 cm radii) and 2 endcap on each side
- $100 \times 150 \mu\text{m}^2$ pixels, 2% occupancy even at $dN/dch = 5000$

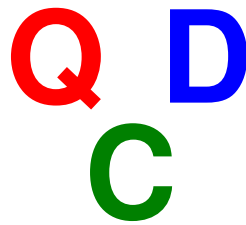
● Hit triplets:

- Use pixel hit triplets instead of pairs, loss of acceptance but lower fake rate
- Reconstructing down to $p_T = 0.075 \text{ GeV}/c$





Hadron Spectra Systematics



CMS Pixel triplets

$$\Delta N_{\text{corrected}} = \frac{(1 - \text{fakeRate}) \cdot (1 - \text{feedDown})}{\text{geomAccep} \cdot \text{algoEffic} \cdot (1 - \text{multiCount})} \cdot \Delta N_{\text{measured}}$$

ATLAS track reconstruction

Summary of systematic uncertainties

Correction	Dependence on			Corr. [%]	Syst.
	kine	part	mult		
Trigger	no	no	yes	15	5
Geometrical acceptance	yes	yes	no	10-20	2
Algorithmic efficiency	yes	yes	no	10-20	2
Multiple track counting	yes	no	no	small	small
Fake track rate	yes	no	yes	small	small
Feed-down	yes	yes	no	2-15	1-2
η, p_T resolution	no	no	no	1-5	1-5
Total	yes	yes	yes		7-9

Track selection cuts	2%
Mis-estimate of secondaries	1.5%
Vertex reconstruction	0.1%
Mis-alignment	6%
Beam-gas & pile-up	1%
Particle composition	2%
Diffractive cross-sections	0.1%
Total:	6.9%

CMS PAS QCD-07-001

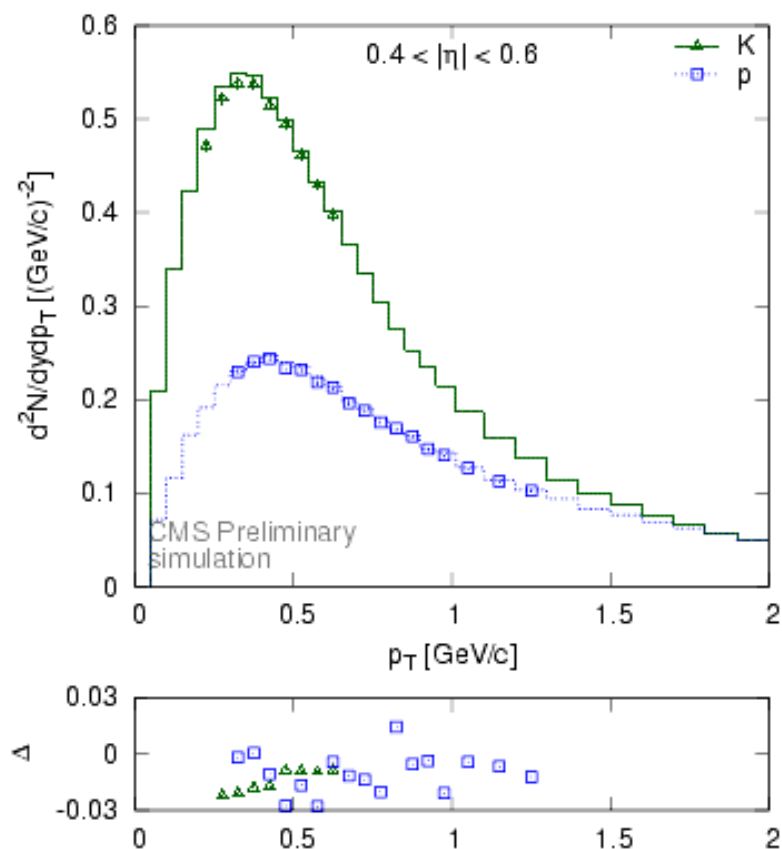
ATLAS



Hadron Spectra: dE/dx

Q D
C

Kaon and proton spectra with dE/dx analysis



CMS PAS QCD-07-001



Tracking Performance

Q D
C

Comparison of tracking performance for:

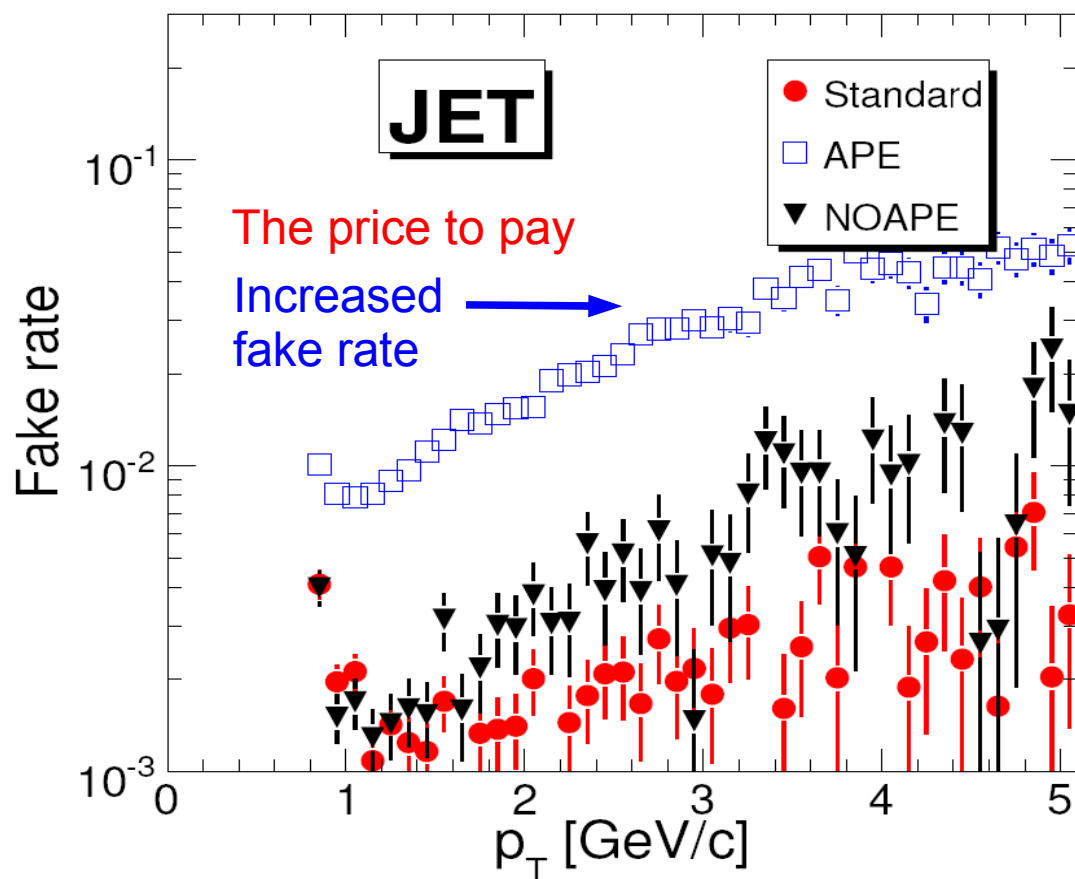
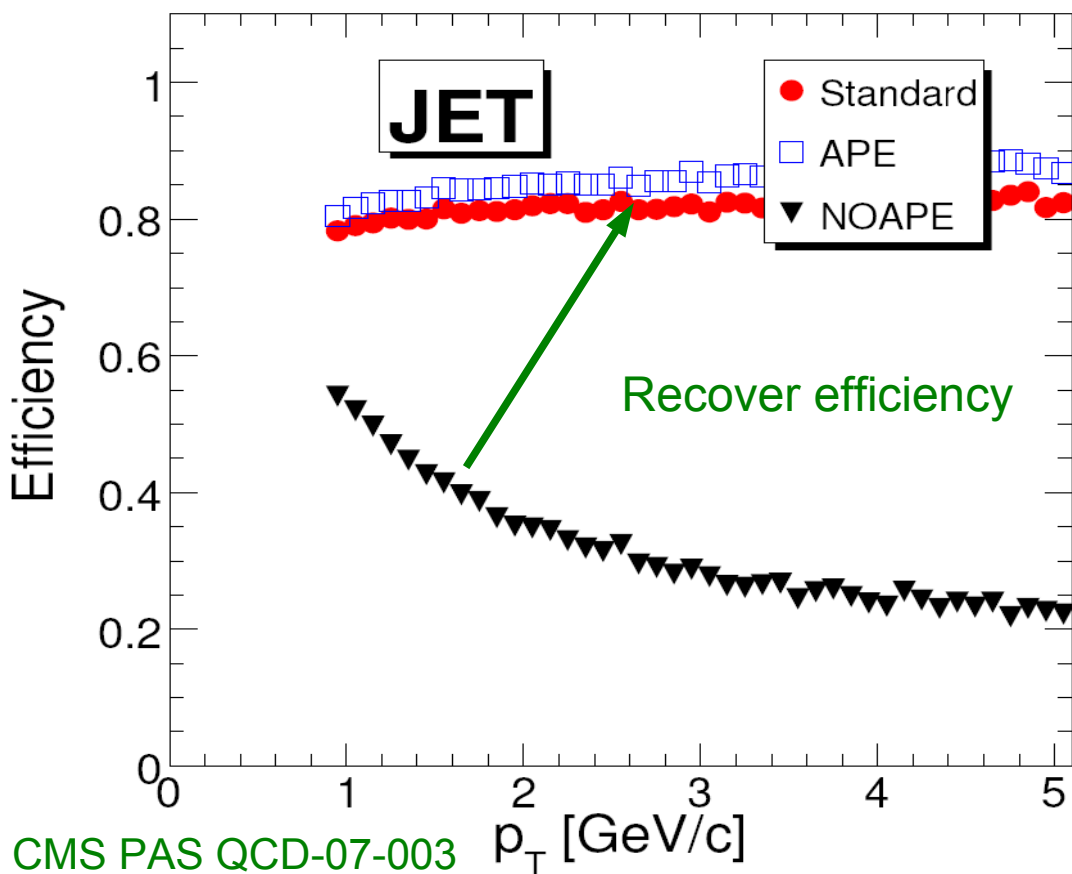
● Ideal conditions

→ Start-up (misaligned)

■ Alignment Position Error application

Track reconstruction efficiency

Fake rate



CMS PAS QCD-07-003

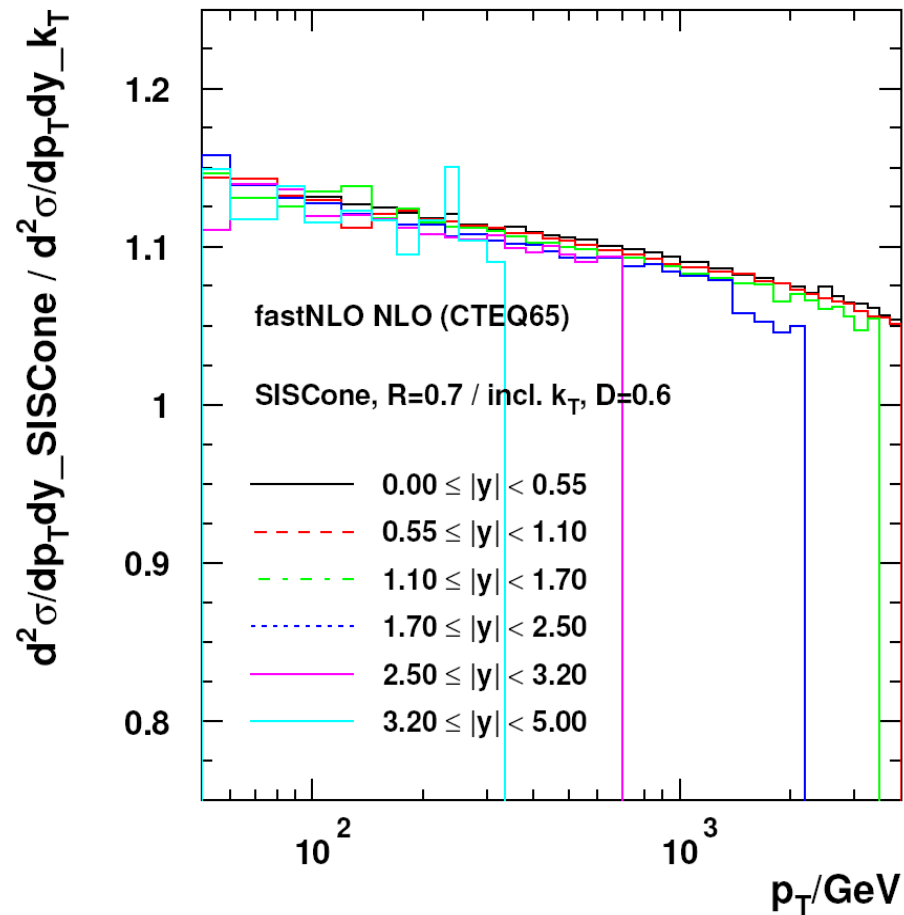


SISCone / k_T

Q D
C

SISCone, $R=0.7 / k_T$, $D=0.6$

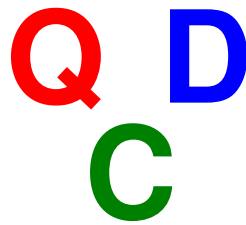
About 12 – 8% higher x section compared to k_T



KR



Jet Input



Habitual jet input:

- calorimeter towers (ATLAS & CMS)

Additionally:

- topological clusters of IAr cells (ATLAS)

Pro's & Con's

Towers

- + fixed size $\Delta\phi \times \Delta\eta \approx 0.1 \times 0.1$
- + no seeds – all cells end up in towers
- - no noise or pile-up suppression
- - do not contain showers

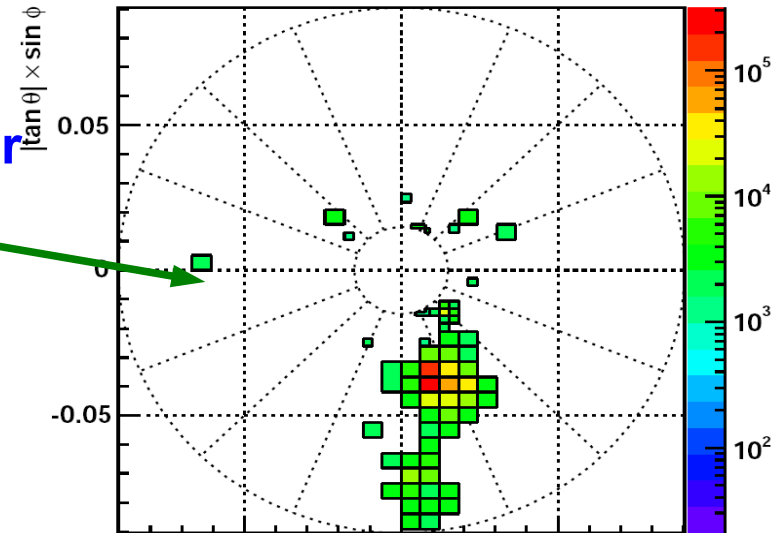
Clusters

- + provide efficient noise and pile-up suppression
- + optimized to contain showers of individual hadrons
- - typically have detector region dependent size

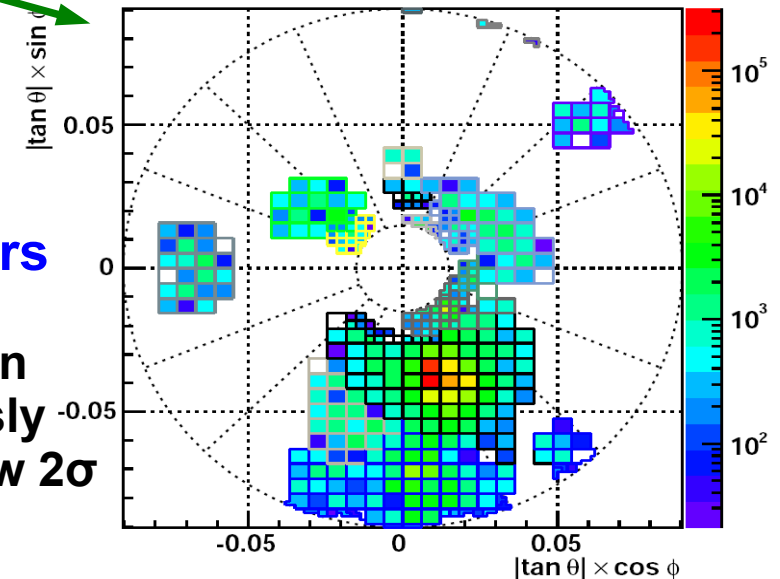
4 σ noise cut to seed cluster maker

Colors show $|E_{\text{cell}}|$ on log scale in MeV

FCal1C



FCal1C



Determines topological clusters

Cells in signal region reintegrate previously cut noise cells below 2 σ

ATLAS



Constraining PDFs

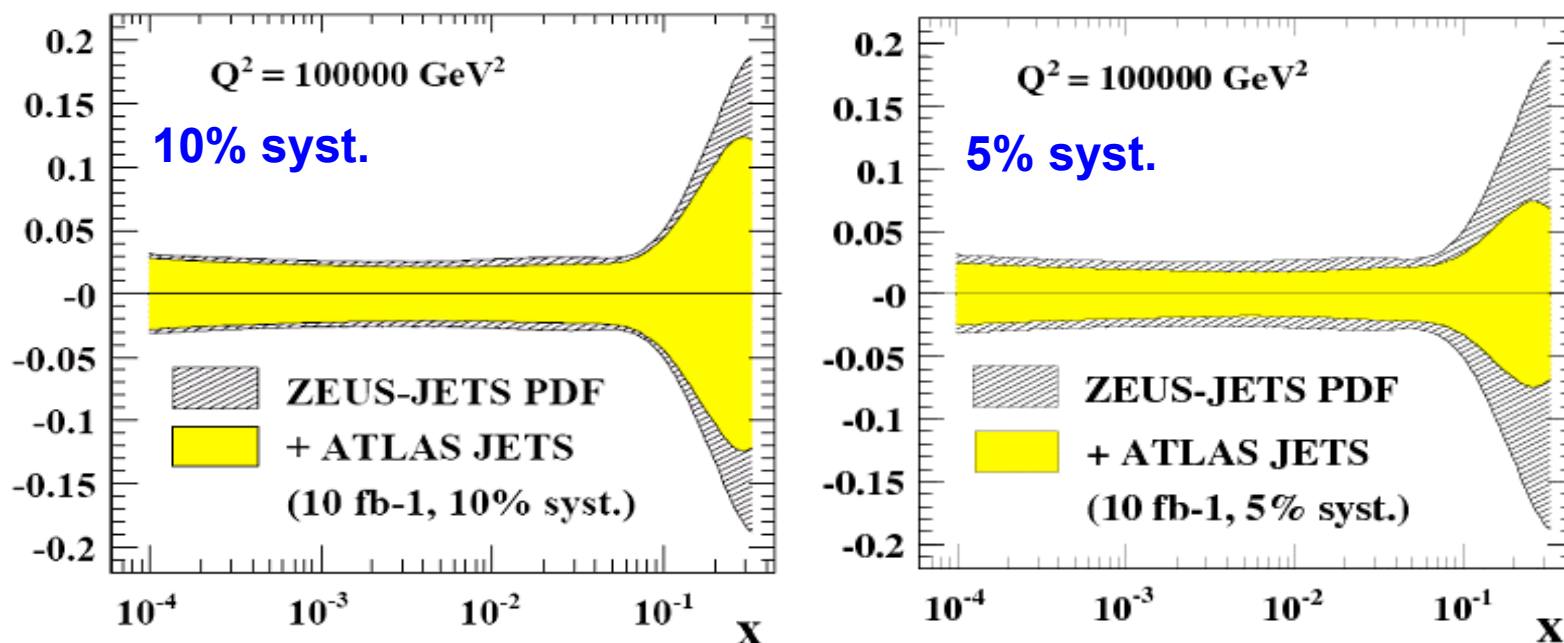
Q D
C

One example:

Include in ZEUS fit:

ATLAS pseudo jet data,
 $0 < \eta < 1, 1 < \eta < 2, 2 < \eta < 3,$
 p_T up to 3 TeV, $L_{int} = 10/\text{fb}$

Gluon fractional uncertainty



Did not mention:

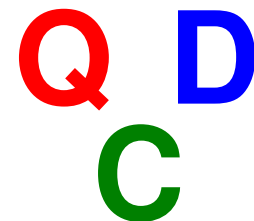
Drell-Yan
Forward jets
Photon + jets ...

➔ Previous talk and PDF sessions
on Wednesday

Reduced systematics has larger effect than just statistics



Recent Limits



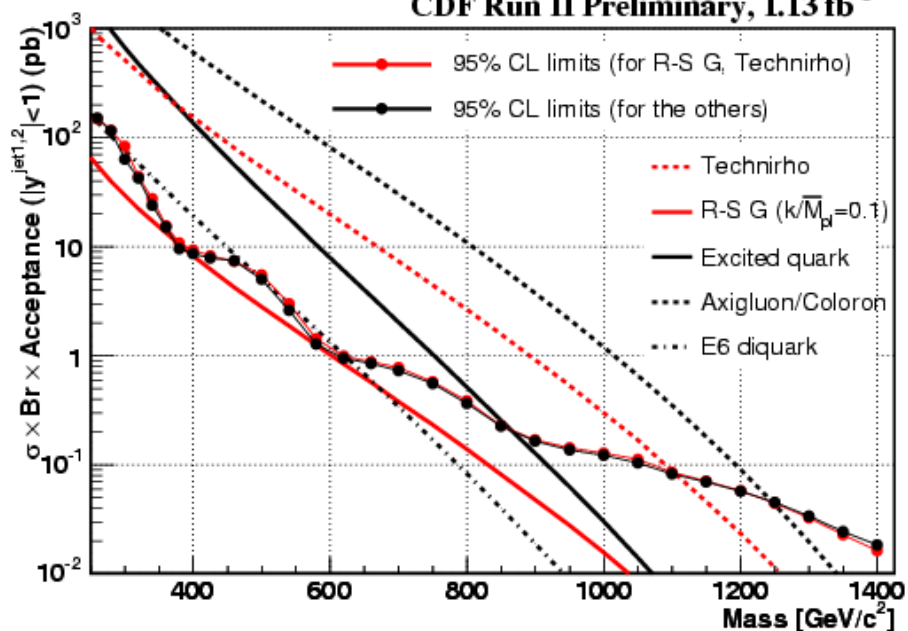
Tevatron limit on contact interaction scale (qqqq): $> 2.4 - 2.7$ TeV

Dijet resonance search

CDF Preliminary 03/2008

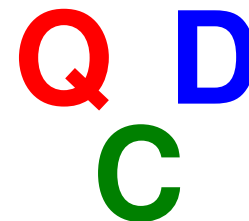
Resonance	Excluded (GeV)	Resonance	Excluded (GeV)
A or C	260 - 1250	D	290 - 630
ρ_{T8}	260 - 1110	W^*	280 - 840
q^*	260 - 870	Z^*	320 - 740

CDF Run II Preliminary, 1.13 fb⁻¹

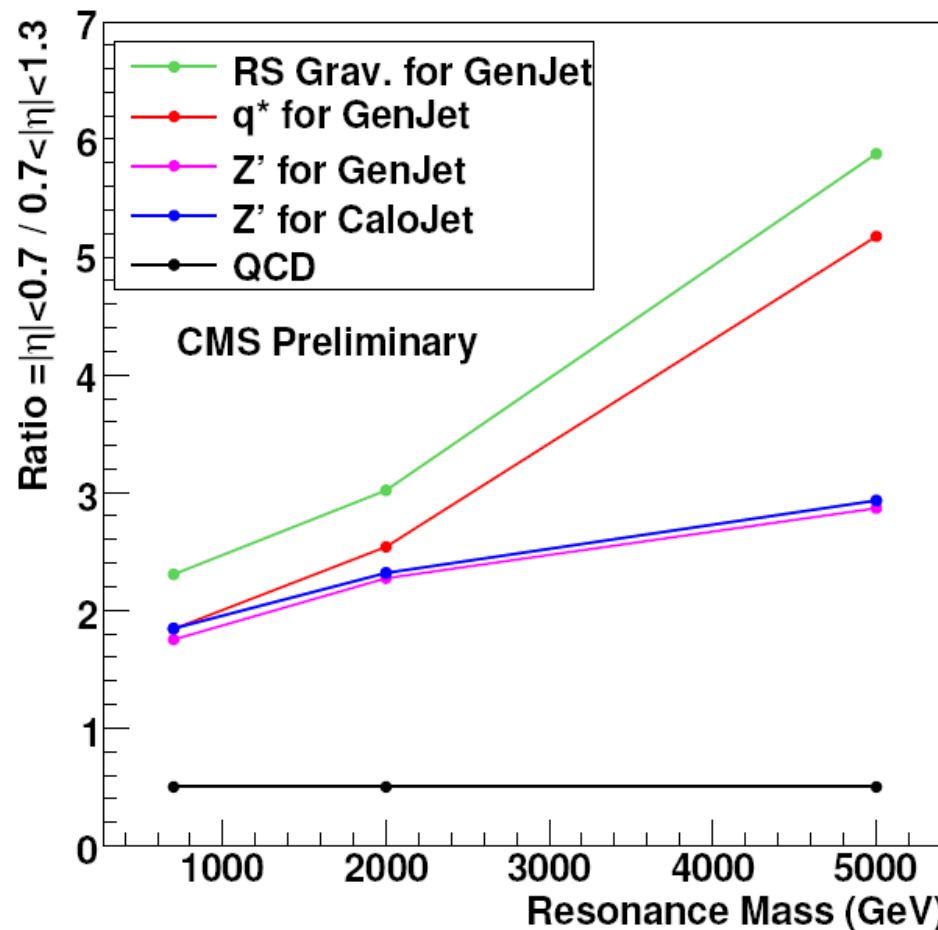
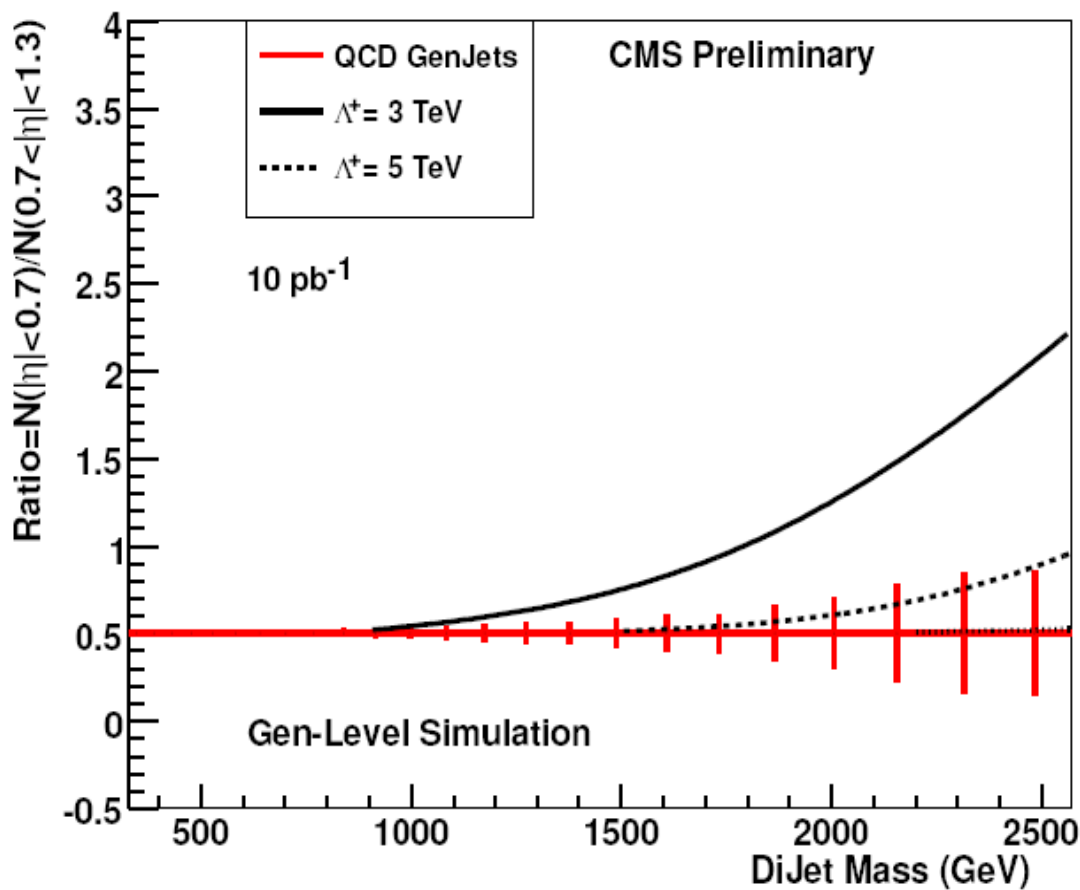




Dijet Ratios

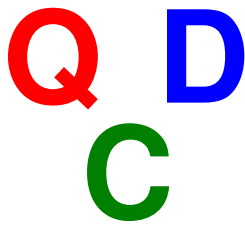


Sensitivity to new physics from dijet ratios in pseudo-rapidity





Some UA1 Quotations



→ Quotations from Phys. Lett. Vol. 107B, no. 4:

- ... dipole magnet which produces a field of **0.7 T** over a volume of 7m x 3.5m x 3.5m ...
- ... yields space points at **centimetre** intervals on the detected tracks
- ... two short accelerator development periods in October and November 1981 ...
- The events were **scanned by physicists** on a Megatek display.
- ... was examined independently by all physicists who participated in the scanning. The combined effect of the **scanner variations** ...