z-Scaling: Inclusive Jet Spectra at RHIC, Tevatron and LHC

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**Nuclear Physics Institute, Řež, Czech Republic

Contents

- Introduction (motivation & goals)
- z-Scaling (ideas, definitions, properties,…)
- Properties of Ψ(z) for hadron production in pp & $p\bar{p}$
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  at RHIC, Tevatron and LHC
- QCD test of z-scaling
- Conclusions

Regularities in high energy interactions

Scaling variables

- $x_{Bj} = -q^2/2(Pq)$ — Bjorken scaling
- $x_F = p^*_{||}/p^*_{||max}$ — Feynman scaling
- $n/\langle n \rangle$ — Polyakov-Koba-Nielsen-Olesen scaling
- t, s, u — Matveev-Muradyan-Tavkhelidze Brodsky-Farrar Quark Counting Rules
- …..

- These scaling regularities have restricted range of validity.
- Violation of the scaling laws can be indication of new physics.

z-Scaling

Universal description of inclusive particle cross sections over a wide kinematical region

(central+fragmentation region, $p_T > 0.5$ GeV/c, $s^{1/2} > 20$ GeV)

z-Scaling reveals self-similar properties in hadron, jet and direct photon production in high energy hadron and nucleus collisions.

Scaling & Universality & Saturation

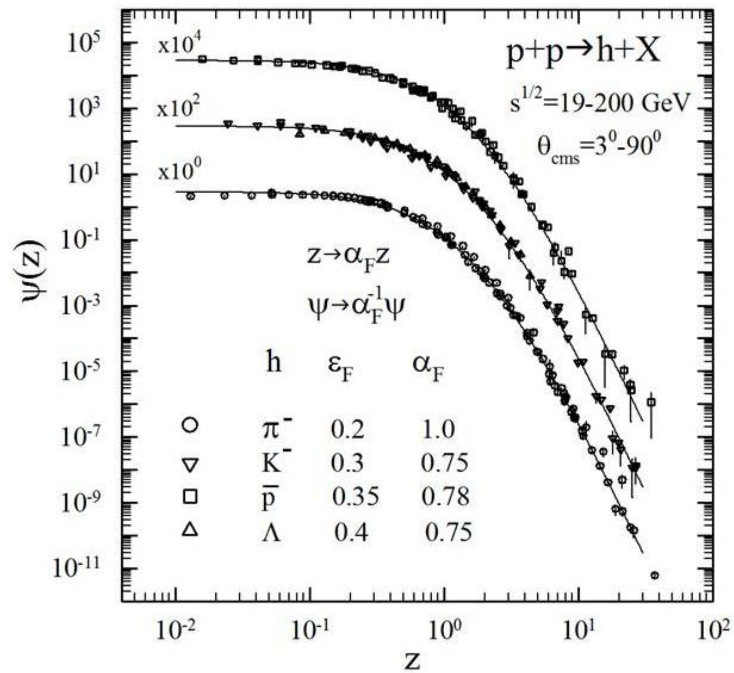
Inclusive cross sections of
π^-, K^-, $\bar{p}$, Λ
in pp collisions

FNAL:
PRD 75 (1979) 764

ISR:
NPB 100 (1975) 237
PLB 64 (1976) 111
NPB 116 (1976) 77
(low p_T)
NPB 56 (1973) 333
(small angles)

STAR:
PLB 616 (2005) 8
PLB 637 (2006) 161
PRC 75 (2007) 064901

Saturation at low z



Power law at high z

Energy scan of spectra
at U70, ISR, S$\bar{p}$pS, SPS, HERA, FNAL(fixed target), Tevatron, RHIC, LHC

MT & I.Zborovsky
Phys.Rev.D75,094008(2007)
Int.J.Mod.Phys.A24,1417(2009)
Int.J.Mod.Phys.A27,1250115(2012)

- Energy & angular independence
- Flavor independence (π, K, $\bar{p}$, Λ)
- Saturation for $z < 0.1$
- Power law $\Psi(z) \sim z^{-\beta}$ for high $z > 4$

Scaling – "collapse" of data points onto a single curve.
Scaled particle yield (Ψ) vs. scaled variable (z).
Universality classes – hadron species (ε_F, α_F).

Motivation & Goals

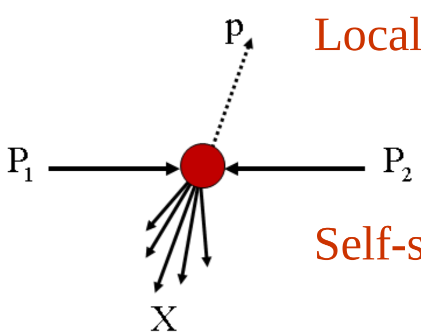
Development of z-scaling approach for description of hadron, direct photon and jet production in inclusive reactions to search for signatures of new physics (phase transitions, quark compositeness, extra dimensions, black holes, fractality of space-time, complementary restrictions for theory,…)

Analysis of experimental data on jet production in pp obtained at LHC to verify properties of z-scaling observed in $\bar{p}p$ collisions at $S\bar{p}pS$, Tevatron.

- Jet is a direct manifestation of hadron structure at a constituent level
- Non-perturbative mechanism of quark, gluon fragmentation into hadrons
- Properties of sub-structure of the colliding objects, interactions of their constituents, and fragmentation process at small scales.
- Jets as objects for identification of particles (t,b production,…)
- Fundamental principles (self-similarity, relativity in jet production,…

z-Scaling

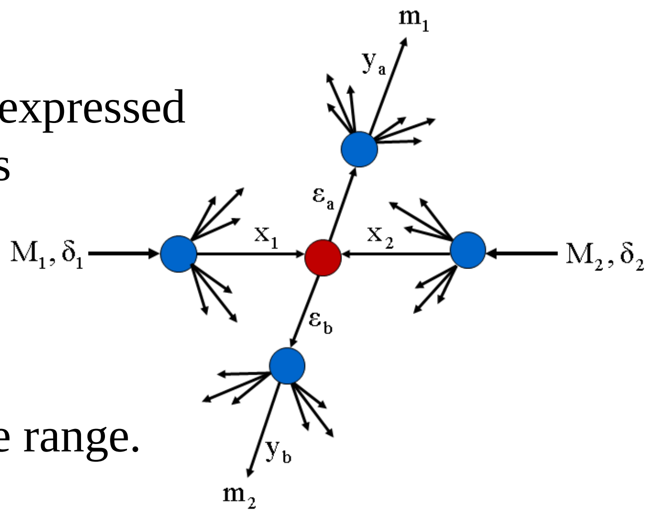
Principles: locality, self-similarity, fractality



Locality: collisions of hadrons and nuclei are expressed via interactions of their constituents (partons, quarks and gluons,...).

Self-similarity: interactions of the constituents are mutually similar.

Fractality: the self-similarity over a wide scale range.



Hypothesis of z-scaling :

$s^{1/2}$, p_T, θ_{cms}

Inclusive particle distributions can be described in terms of constituent sub-processes and parameters characterizing bulk properties of the system.

x_1, x_2, y_a, y_b

$\delta_1, \delta_2, \varepsilon_a, \varepsilon_b, c$

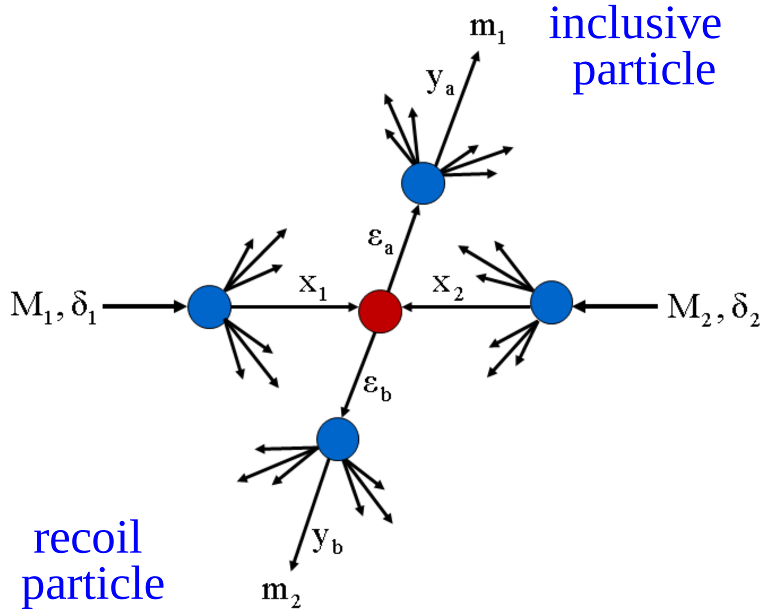
$Ed^3\sigma/dp^3$

Scaled inclusive cross section of particles depends in a self-similar way on a single scaling variable z.

$\Psi(z)$

Locality of hadron interactions

M.T. & I.Zborovský
Part.Nucl.Lett.312(2006)
PRD75,094008(2007)
Int.J.Mod.Phys.A24,1417(2009)
J.Phys.G: Nucl.Part.Phys. 37,085008(2010)



Constituent subprocess

$$(x_1M_1) + (x_2M_2) \Rightarrow (m_1/y_a) + (x_1M_1+x_2M_2+m_2/y_b)$$

Kinematical condition (4-momentum conservation law):

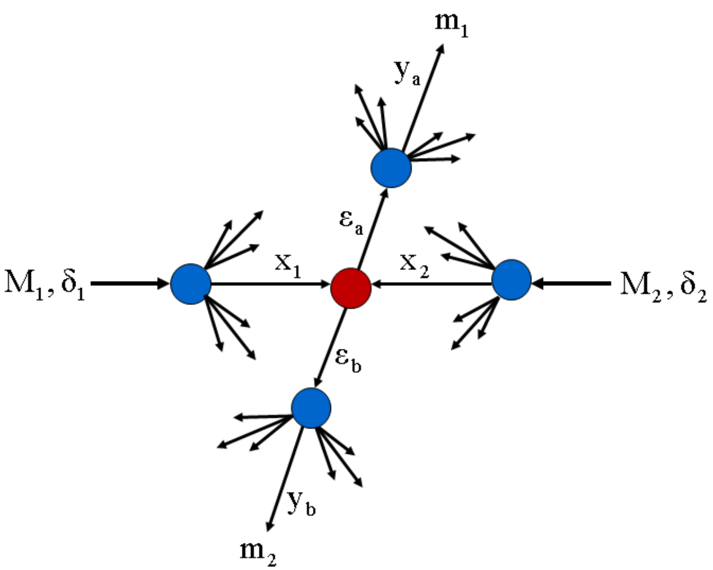
$$(x_1P_1+x_2P_2-p/y_a)^2 = M_X^2$$

Recoil mass: $M_X = x_1M_1+x_2M_2+m_2/y_b$

Self-similarity parameter z

$$z = z_0 \cdot \Omega^{-1}$$

$$z_0 = \frac{s_\perp^{1/2}}{(dN_{ch}/d\eta|_0)^c m}$$



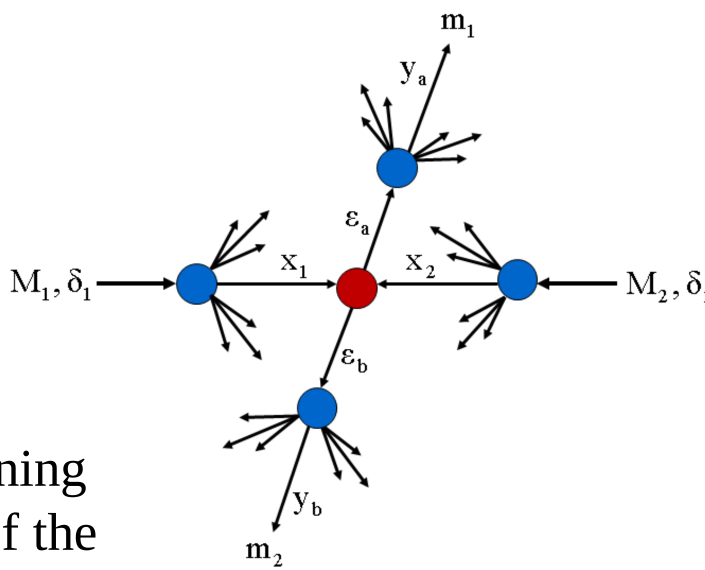
- Ω^{-1} is the minimal resolution at which a constituent subprocess can be singled out of the inclusive reaction
- $s_\perp^{1/2}$ is the transverse kinetic energy of the subprocess consumed on production of m_1 & m_2
- $dN_{ch}/d\eta|_0$ is the multiplicity density of charged particles at $\eta = 0$
- c is a parameter interpreted as a "specific heat" of created medium
- m is an arbitrary constant (fixed at the value of nucleon mass)

Fractal measure z

The fractality is reflected in definition of z

$$z = z_0 \Omega^{-1}$$

$$\Omega = (1-x_1)^{\delta_1}(1-x_2)^{\delta_2}(1-y_a)^{\epsilon_a}(1-y_b)^{\epsilon_b}$$



Ω is relative number of configurations containing a sub-process with fractions x_1, x_2, y_a, y_b of the corresponding 4-momenta

$\delta_1, \delta_2, \epsilon_a, \epsilon_b$ are parameters characterizing structure of the colliding objects and fragmentation process, respectively

$\Omega^{-1}(x_1, x_2, y_a, y_b)$ characterizes resolution at which a constituent sub-process can be singled out of the inclusive reaction

$$z(\Omega)|_{\Omega^{-1}\to\infty} \to \infty$$

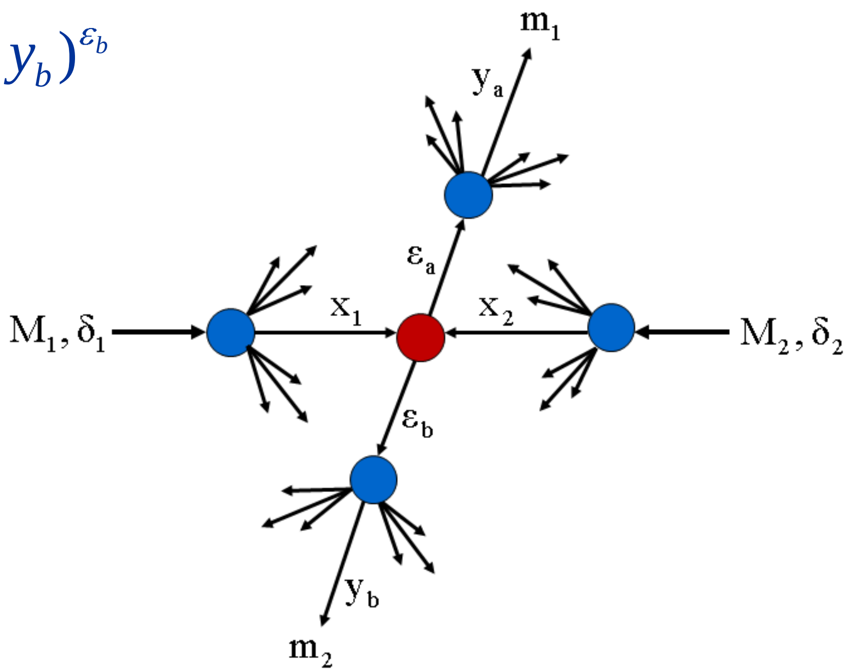
The fractal measure z diverges as the resolution Ω^{-1} increases.

Momentum fractions x_1, x_2, y_a, y_b

Principle of minimal resolution: The momentum fractions x_1, x_2 and y_a, y_b are determined in a way to minimize the resolution Ω^{-1} of the fractal measure z with respect to all constituent sub-processes taking into account 4-momentum conservation:

$$\Omega = (1-x_1)^{\delta_1}(1-x_2)^{\delta_2}(1-y_a)^{\varepsilon_a}(1-y_b)^{\varepsilon_b}$$

$$\begin{cases} \partial\Omega/\partial x_1 \big|_{y_a=y_a(x_1,x_2,y_b)} = 0 \\ \partial\Omega/\partial x_2 \big|_{y_a=y_a(x_1,x_2,y_b)} = 0 \\ \partial\Omega/\partial y_b \big|_{y_a=y_a(x_1,x_2,y_b)} = 0 \end{cases}$$



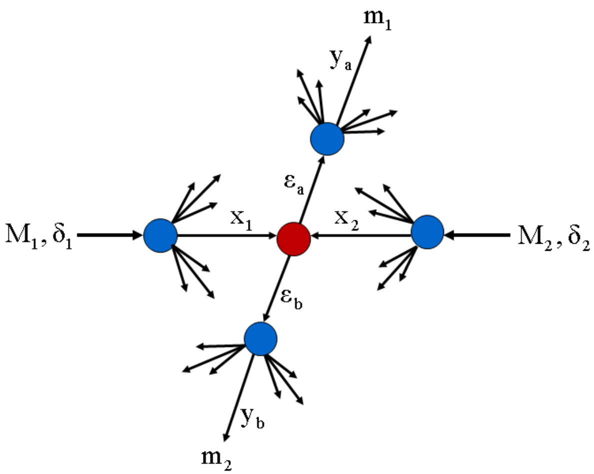
Momentum conservation law)

$$(x_1P_1+x_2P_2-p/y_a)^2 = M_X^2$$

Recoil mass

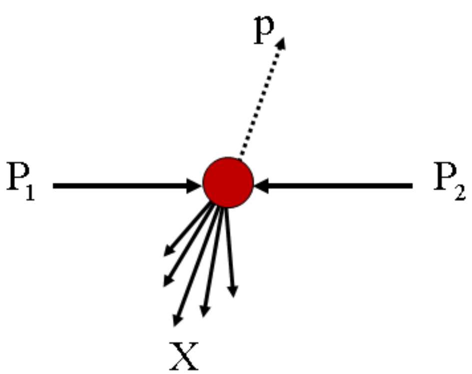
$$M_X = x_1M_1+x_2M_2+m_2/y_b$$

Scaling function $\Psi(z)$



$$\int_0^{\infty} \Psi(z) dz = 1$$

$$z \to \alpha_F z, \quad \Psi \to \alpha_F^{-1} \Psi$$



$$\Psi(z) = \frac{\pi}{(dN/d\eta) \cdot \sigma_{inel}} \cdot J^{-1} \cdot E \frac{d^3\sigma}{dp^3} \Longleftrightarrow \int E \frac{d^3\sigma}{dp^3} dy d^2 p_\perp = \sigma_{inel} \cdot N$$

- σ_{in} - inelastic cross section
- N - average multiplicity of the corresponding hadron species
- $dN/d\eta$ - pseudorapidity multiplicity density at angle θ (η)
- $J(z,\eta;p_T^2,y)$ - Jacobian
- $Ed^3\sigma/dp^3$ - inclusive cross section

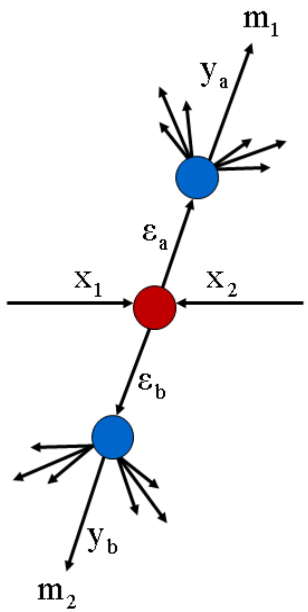
The scaling function $\Psi(z)$ is probability density to produce an inclusive particle with the corresponding z.

Transverse kinetic energy $s_{\perp}^{1/2}$

$$s_{\perp}^{1/2} = \underbrace{y_1(s_{\lambda}^{1/2} - M_1\lambda_1 - M_2\lambda_2) - m_1}_{\text{energy consumed for the inclusive particle } m_1} + \underbrace{y_2(s_{\chi}^{1/2} - M_1\chi_1 - M_2\chi_2) - m_2}_{\text{energy consumed for the recoil particle } m_2}$$

energy consumed for the inclusive particle m_1

energy consumed for the recoil particle m_2



Fraction decomposition: $x_{1,2} = \lambda_{1,2} + \chi_{1,2}$

$$\lambda_{1,2} = \kappa_{1,2}/y_1 + \nu_{1,2}/y_2$$

$$\chi_{1,2} = (\mu_{1,2}^2 + \omega_{1,2}^2)^{1/2} \mp \omega_{1,2}$$

$$\omega_{1,2} = \mu_{1,2} U, \quad U = \frac{\alpha - 1}{2\sqrt{\alpha}}\xi, \quad \alpha = \frac{\delta_2}{\delta_1}$$

$$\xi^2 = (\lambda_1\lambda_2 + \lambda_0)/[(1-\lambda_1)(1-\lambda_2)]$$

$$\kappa_{1,2} = \frac{(P_{2,1}p)}{(P_2P_1)}, \quad \nu_{1,2} = \frac{M_{2,1}m_2}{(P_2P_1)}$$

$$\mu_{1,2}^2 = \alpha^{\pm 1}(\lambda_1\lambda_2 + \lambda_0)\frac{1-\lambda_{1,2}}{1-\lambda_{2,1}}$$

$$\lambda_0 = \bar{\nu}_0/y_2^2 - \nu_0/y_1^2$$

$$\bar{\nu}_0 = \frac{0.5m_2^2}{(P_1P_2)}, \quad \nu_0 = \frac{0.5m_1^2}{(P_1P_2)}$$

$$s_{\lambda} = (\lambda_1P_1 + \lambda_2P_2)^2$$

$$s_{\chi} = (\chi_1P_1 + \chi_2P_2)^2$$

The scaling variable z and scaling function $\Psi(z)$ are expressed via relativistic invariants.

Properties of $\Psi(z)$ in pp & $\bar{p}$p collisions

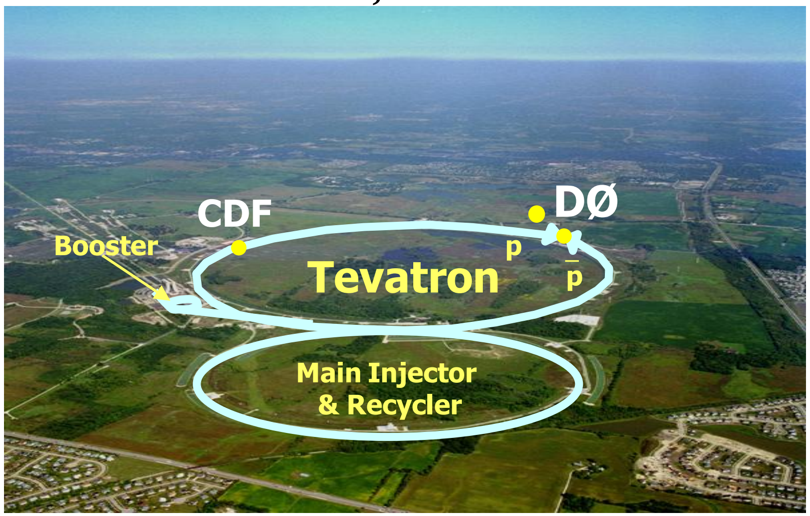
- Energy independence of $\Psi(z)$ ($s^{1/2} > 20$ GeV)
- Angular independence of $\Psi(z)$ ($\theta_{cms}=3^0$-90^0)
- Multiplicity independence of $\Psi(z)$ ($dN_{ch}/d\eta=1.5$-26)
- Power law, $\Psi(z) \sim z^{-\beta}$, at high z ($z > 4$)
- Flavor independence of $\Psi(z)$ (π,K,φ,Λ,..,D,J/ψ,B,Υ,…)
- Saturation of $\Psi(z)$ at low z ($z < 0.1$)

These properties reflect self-similarity, locality,
and fractality of the hadron interaction at constituent level.
It concerns the structure of the colliding objects, interactions
of their constituents, and fragmentation process.

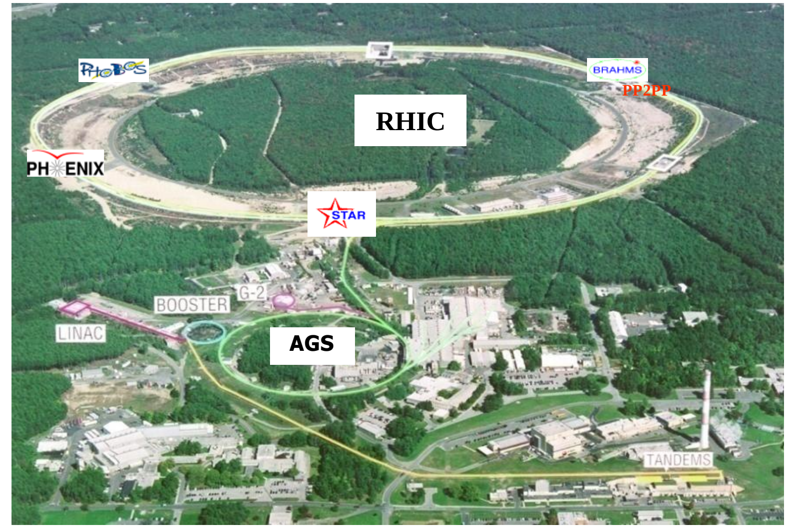
M.T. & I.Zborovsky
Phys.At.Nucl. 70,1294(2007)
Phys.Rev. D75,094008(2007)
Int.J.Mod.Phys. A24,1417(2009)
J. Phys.G: Nucl.Part.Phys. 37,085008(2010)
J.Mod.Phys. 3,815 (2012)
Int.J.Mod.Phys. A27,1250115(2012)
………………

Jets at Hadron Colliders

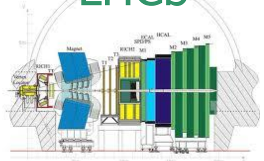
Batavia, Illinois



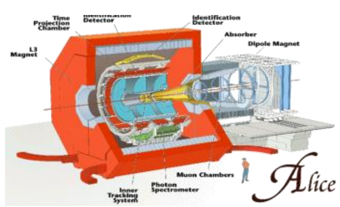
Upton, Long Island, New York



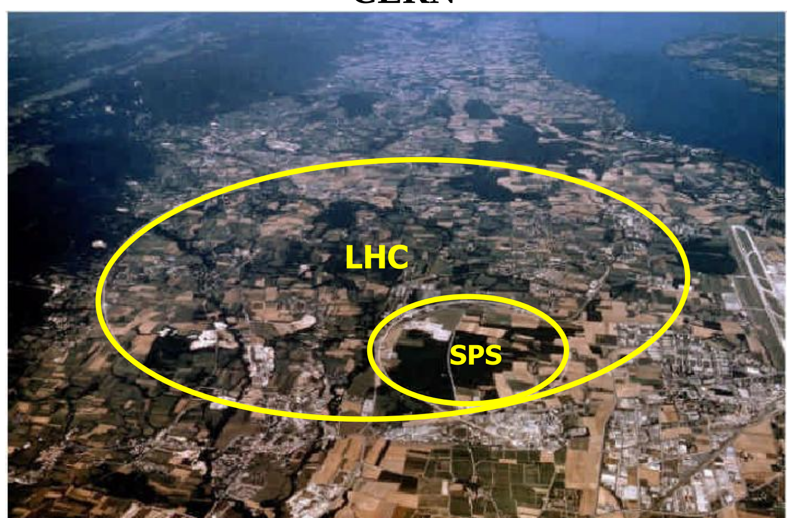
LHCb



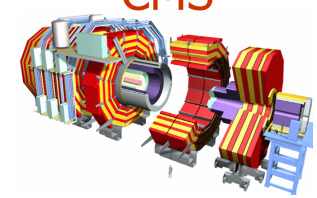
ALICE



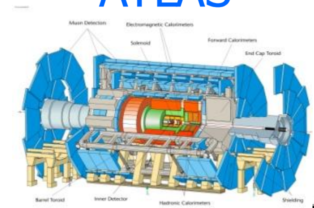
CERN



CMS

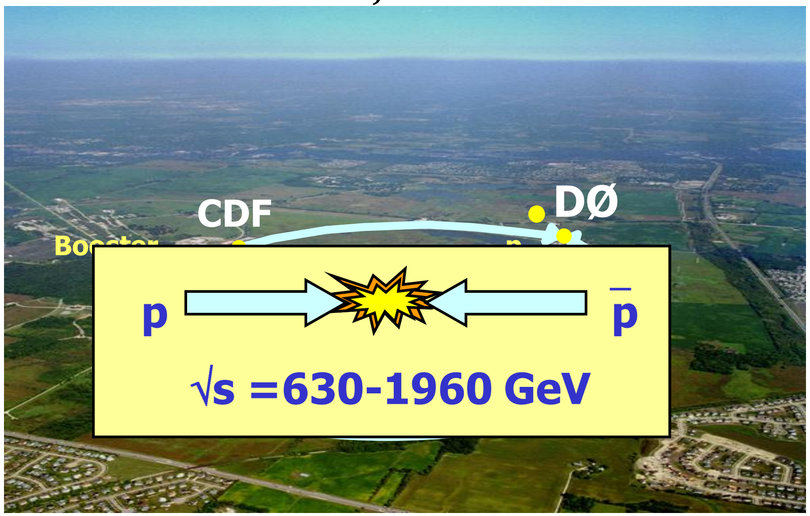


ATLAS



Jets at Hadron Colliders

Batavia, Illinois



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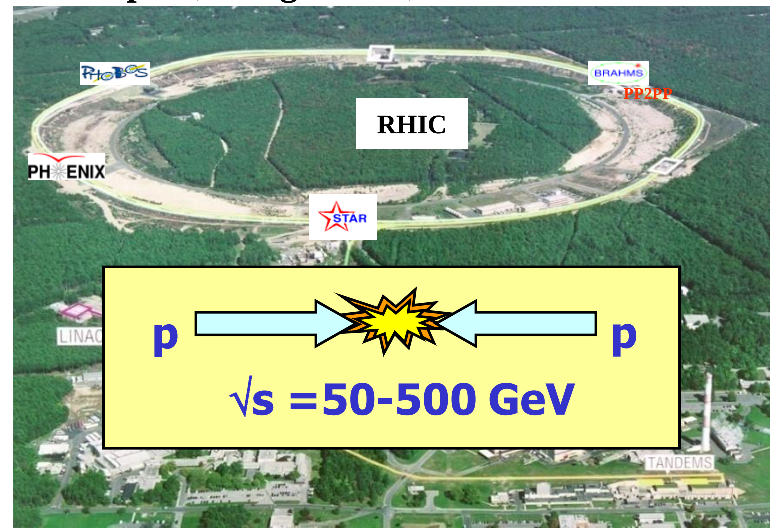
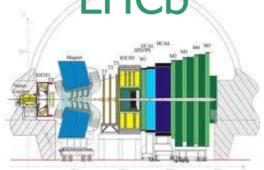
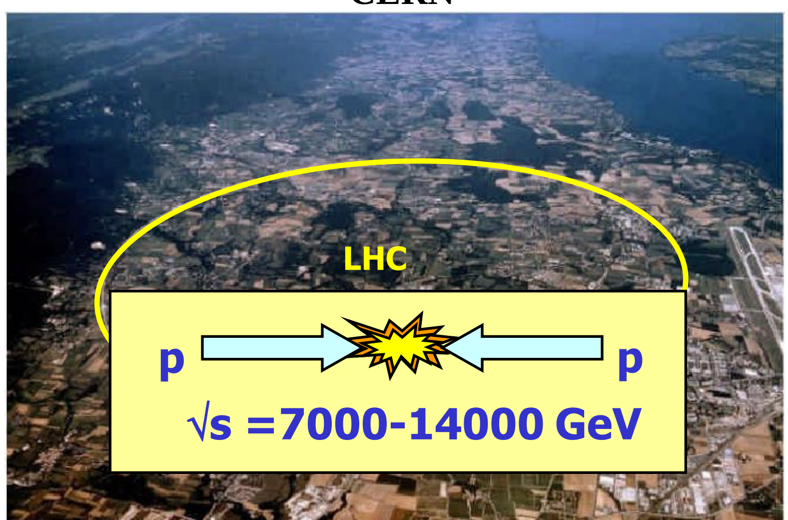


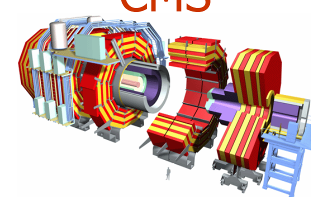
LHCb



CERN



CMS



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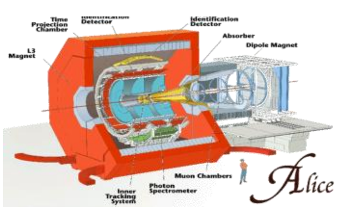
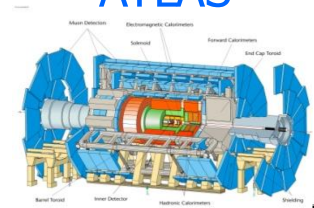


ATLAS



JINR

Era of QCD precision measurements at hadron colliders

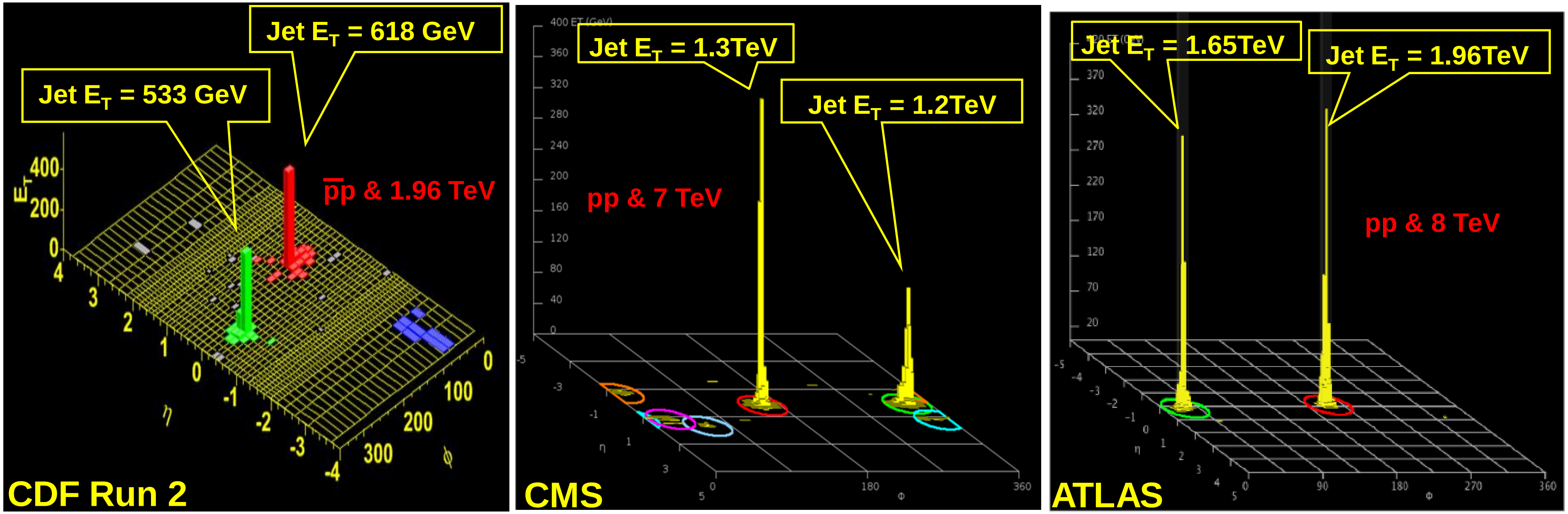
What is jet ?

- Jet is strong correlated group of particles in space-time.
- Jet is a product of hard scattering of hadron constituents.
- Definition of jet in experiment and theory is a basis for understanding of transition mechanism from quark and gluon to hadronic degrees of freedom.
- QCD evolution schemes based on DGLAP, BFKL, CCFM equations are widely used.
- Large systematic errors in theoretical calculations is due to uncertainties of pdf's and mainly to gluon distribution function.

Experimental verification and QCD test of z-scaling of jet production in hadron collisions to search for new phenomena and establish new constraints (gluons, Q^2-evolution etc.) on theory.

Era of QCD precision measurements at hadron colliders

Jets at Tevatron and LHC

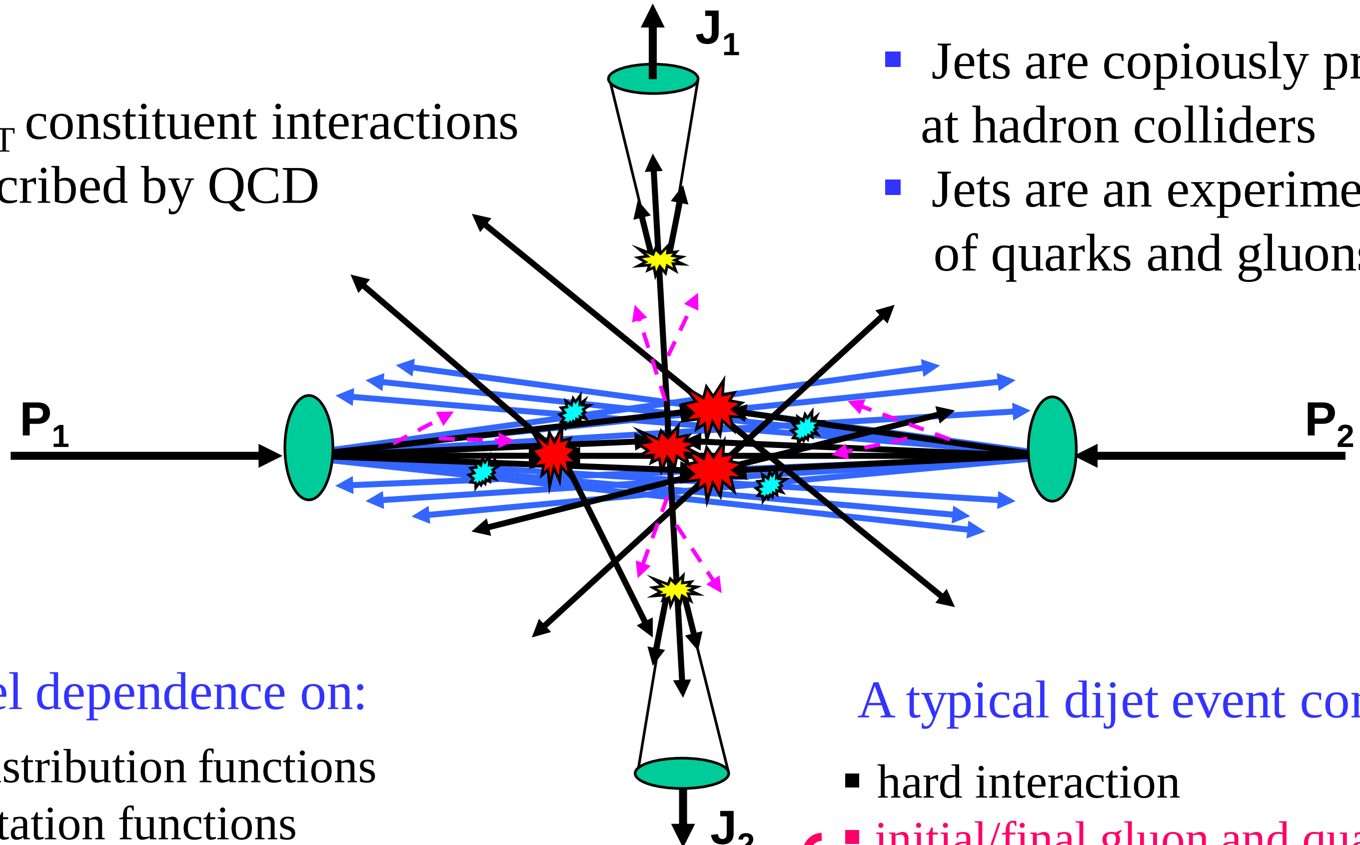


Experimental verification and QCD test of z-scaling of jet production in hadron collisions to search for new phenomena and establish new constraints (gluons, Q^2-evolution etc.) on theory.

Jet Topology

- High-p_T constituent interactions are described by QCD

- Jets are copiously produced at hadron colliders
- Jets are an experimental signature of quarks and gluons



Model dependence on:

- Parton distribution functions
- Fragmentation functions
- Higher order corrections
- Renormalization, factorization and fragmentation scales
- QCD evolution scheme

A typical dijet event consists of:

- hard interaction
- initial/final gluon and quark radiation
- secondary semi-hard interactions
- interaction between remnants
- hadronization
- jet formation

Underlying event

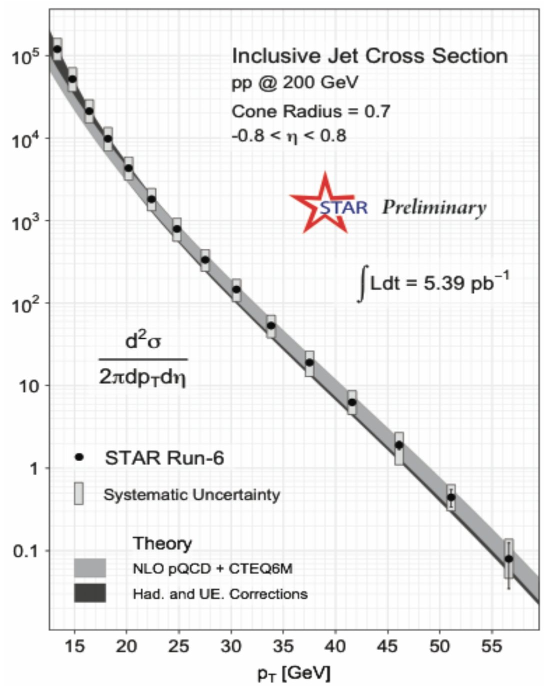
Jets at ISR, FNAL, Sp$\bar{p}$S, RHIC & z-Scaling

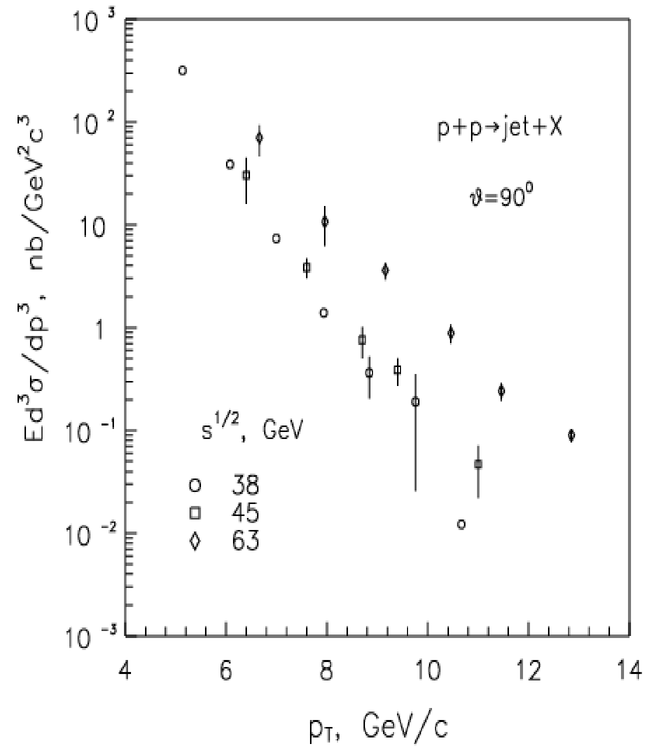
BNL: STAR
M.Calderon,
Extrem QCD, San Carlos,
Mexico, July 18-20, 2011

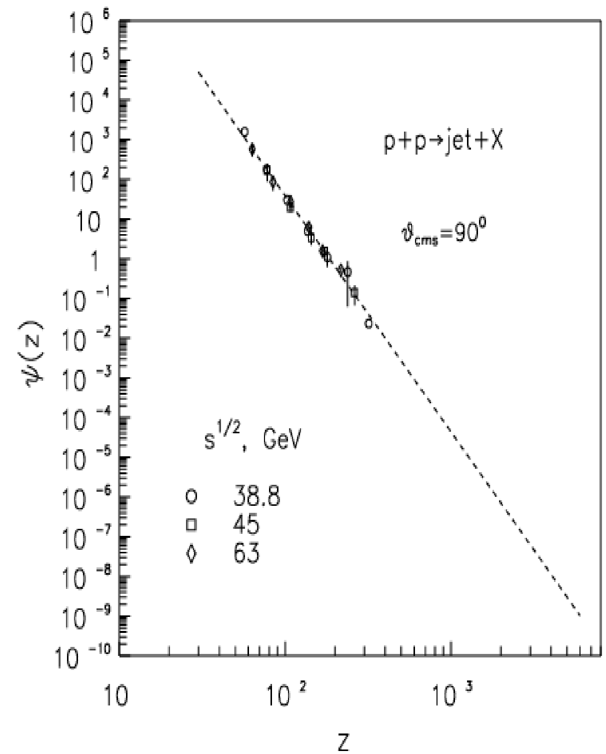
CERN: AFS
PLB118(1982)185
PLB118(1982)193
PLB123(1983)133

FNAL: E557
PRD41 (1980) 1371
Fermilab-Pub-90/22E (1990)

CERN: UA1
PLB172(1986)461
NPB309(1988)405







- Energy independence of $\Psi(z)$
- Power behavior of $\Psi(z) \sim z^{-\beta}$, $\beta \approx 5.95$
- RHIC confirms z-scaling found at ISR and FNAL

M. T.&T. Dedovich,I.Zborovsky
Int.J. Mod. Phys.A15 (2000) 3495
Int.J.Mod.Phys.A27(2012)1250115

Jets at ISR, FNAL, Sp$\bar{p}$S, RHIC & z-Scaling

BNL: STAR
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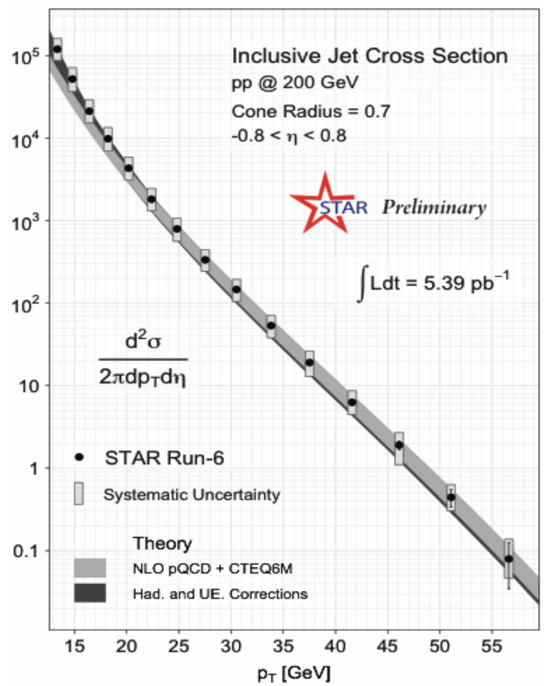

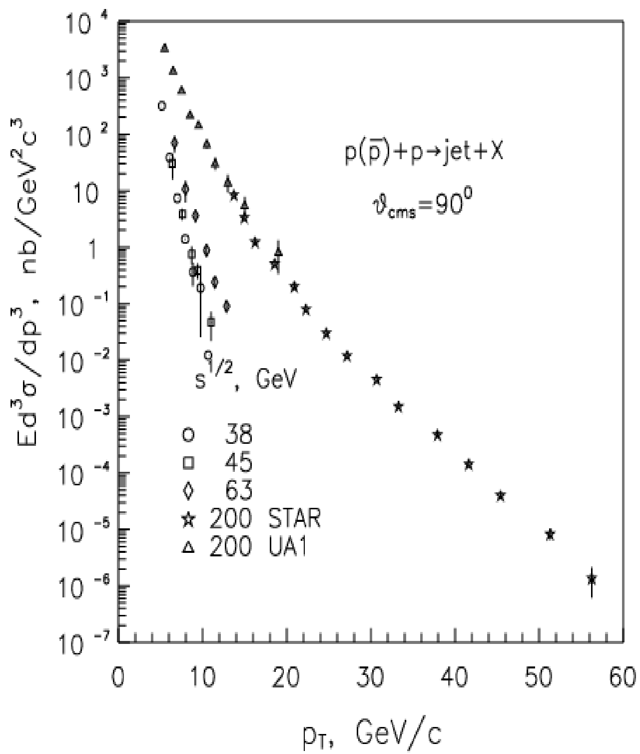

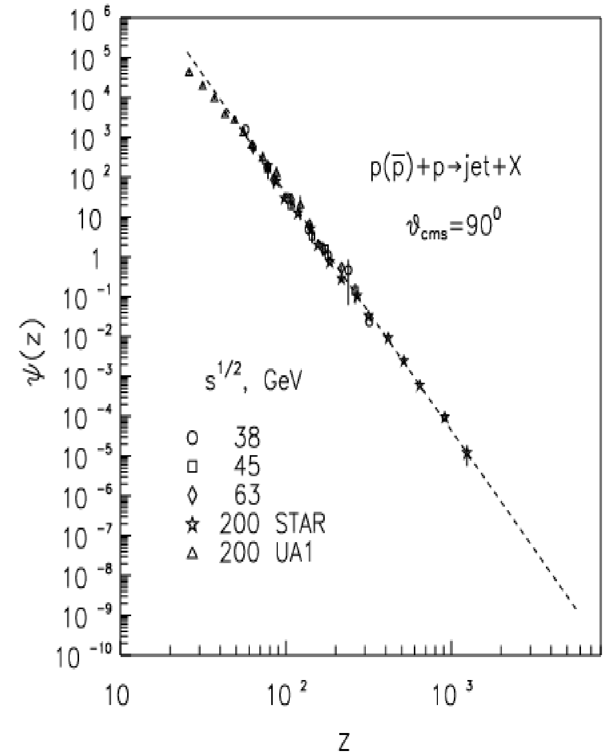

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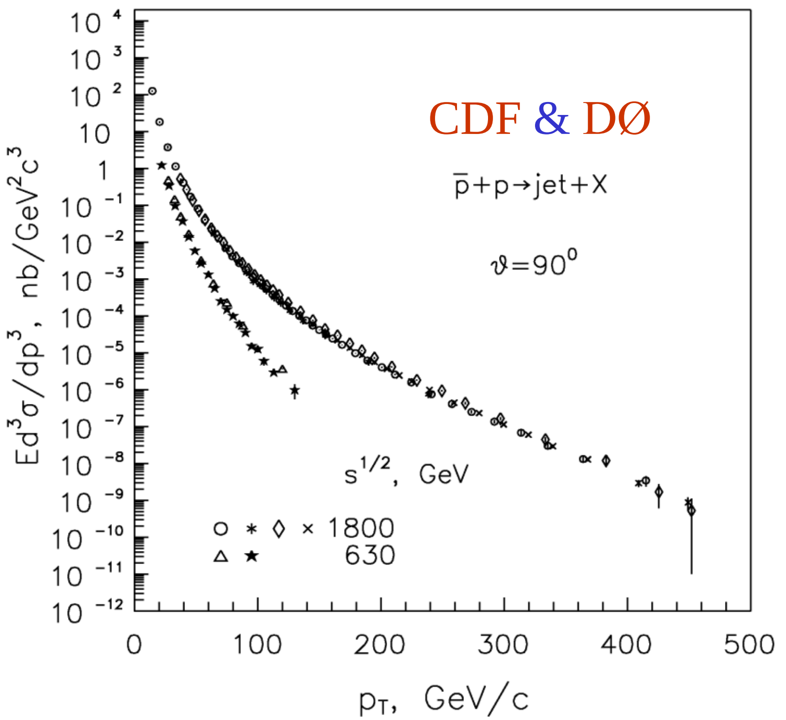
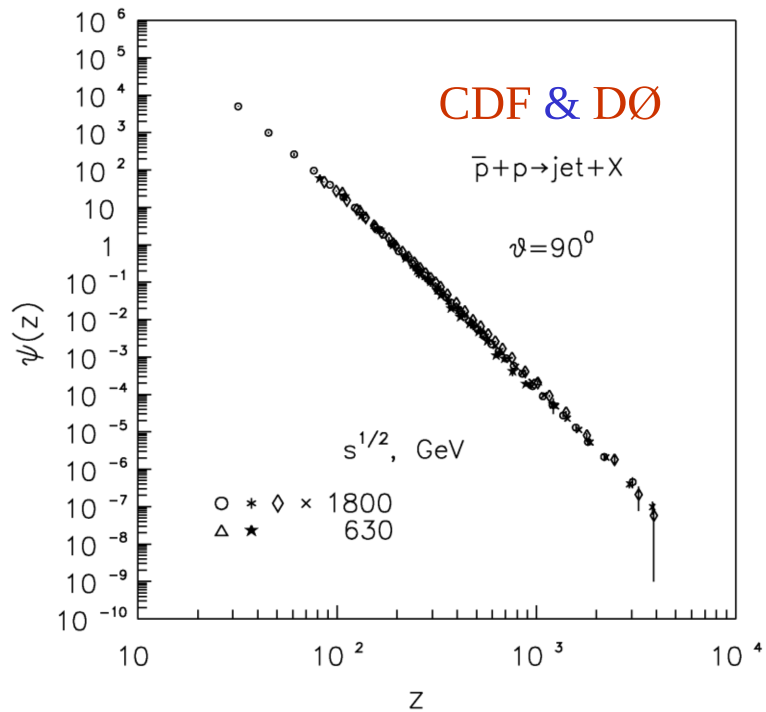
Int.J.Mod.Phys.A27(2012)1250115

JINR

z-Scaling & Jets at Tevatron in Run I

Energy dependence of jet production in $p\bar{p}$ collisions





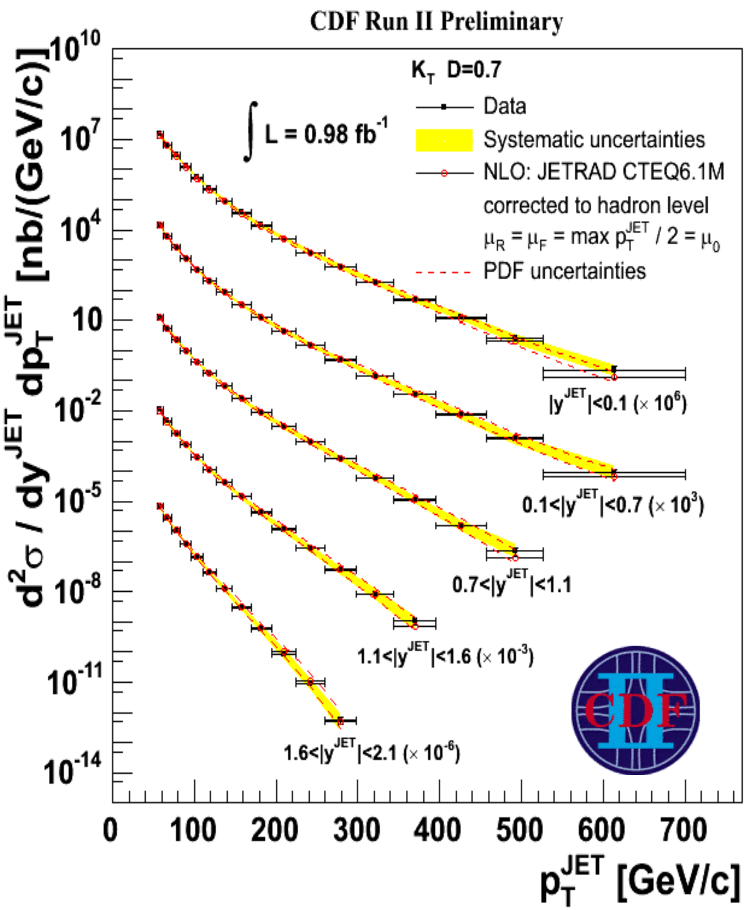
M. T.
T. Dedovich
Int. J. Mod. Phys.
A15 (2000) 3495

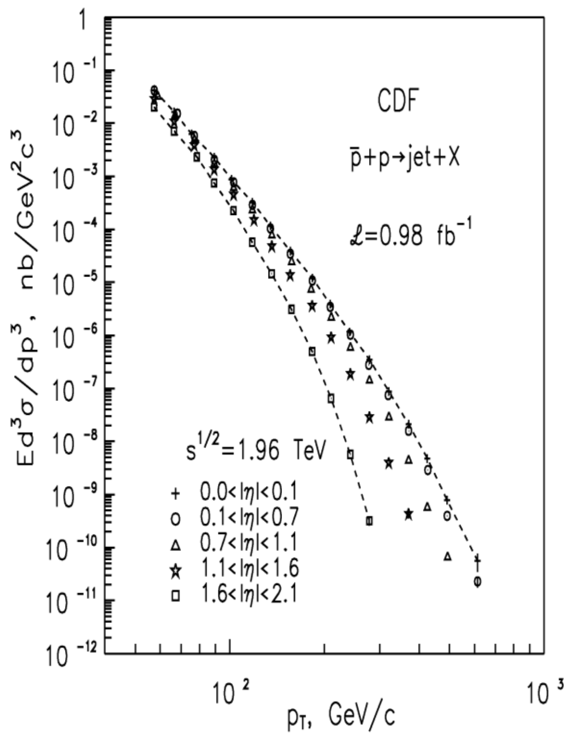
Data are in agreement with each other in the momentum range p_T =10 - 450 GeV/c.

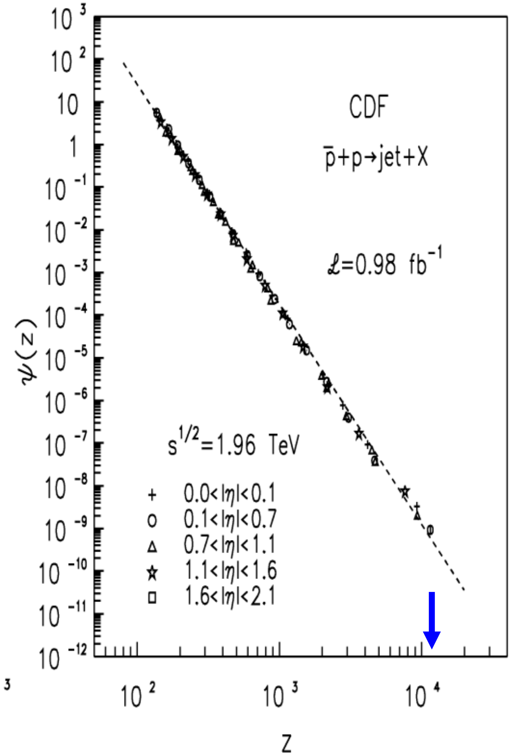
- Energy independence of $\Psi(z)$
- Power law, $\Psi(z) \sim z^{-\beta}$, $\beta \approx 5.5$

Self-similarity of jet production in proton-antiproton collisions

z-Scaling & Jets at Tevatron in Run II







- Angular independence of $\Psi(z)$
- Power law, $\Psi(z) \sim z^{-\beta}$

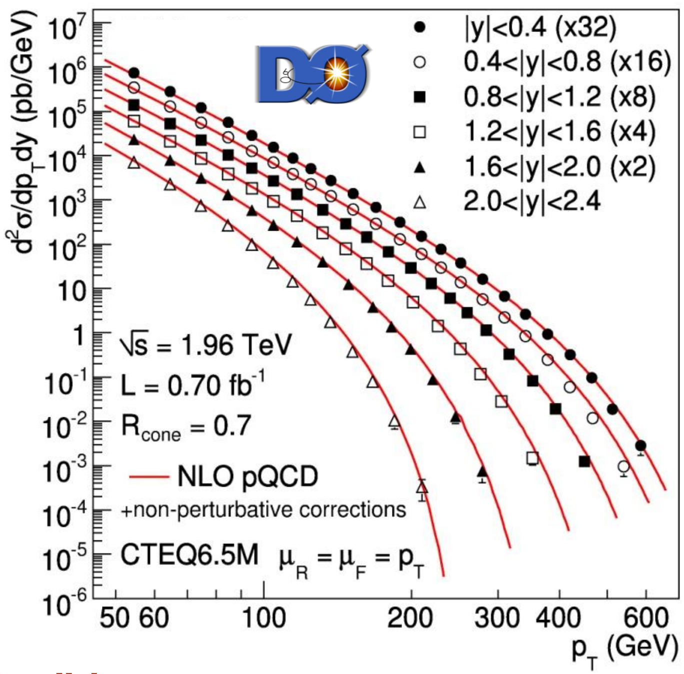
CDF collaboration

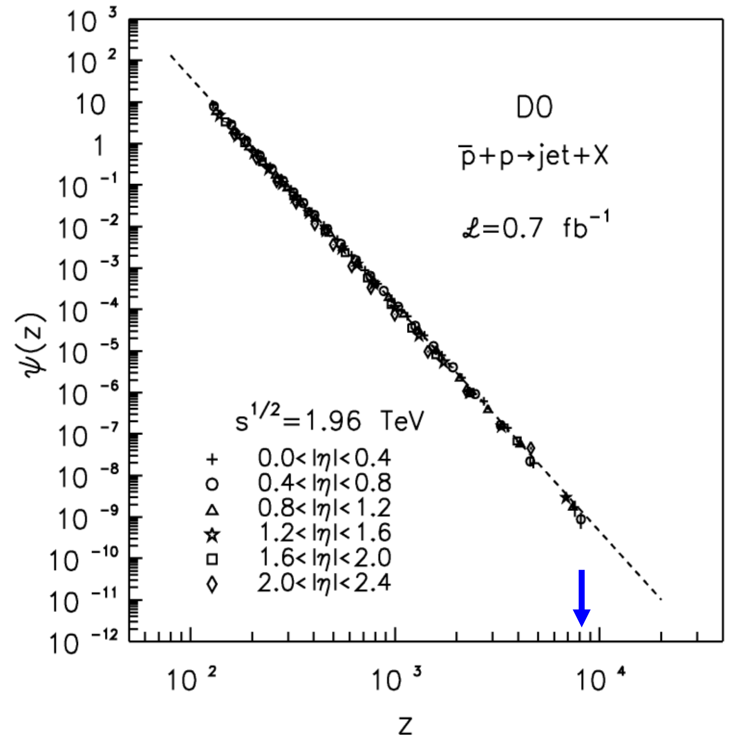
A.Abulencia et al., Phys.Rev.D75, 092006, 2007

T.Aaltonen et al., Phys.Rev.D78, 052006, 2008

Tevatron data confirm z-scaling in jet production in $\bar{p}p$

z-Scaling & Jets at Tevatron in Run II





DØ Collaboration
V.M.Abazov et al.,
Phys.Rev.Lett.101,062001(2008)

Jet transverse spectra are measured up to 600 GeV/c

- Angular independence of $\Psi(z)$
- Power law, $\Psi(z) \sim z^{-\beta}$

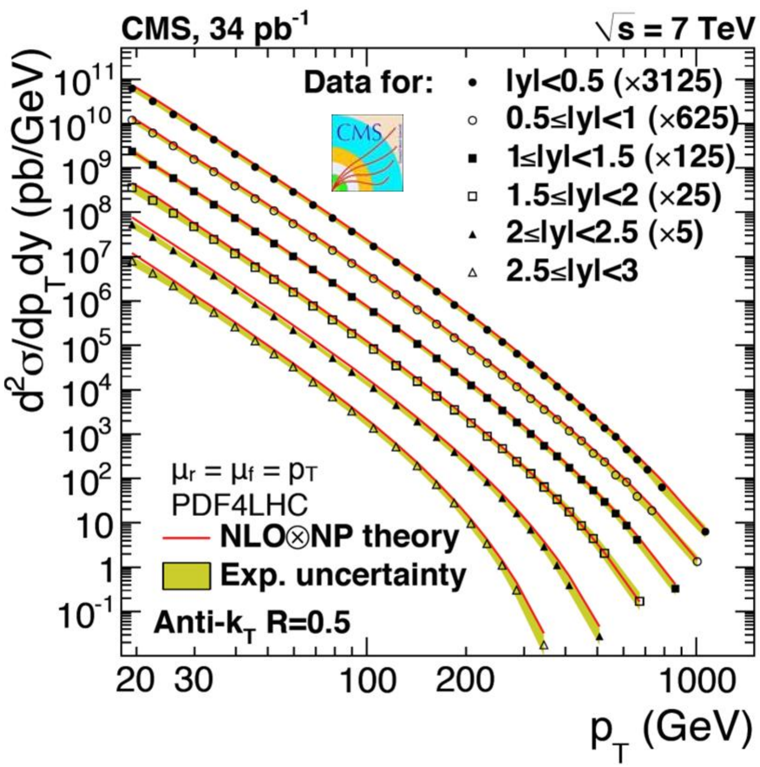
Self-similarity of jet production in proton-antiproton collisions

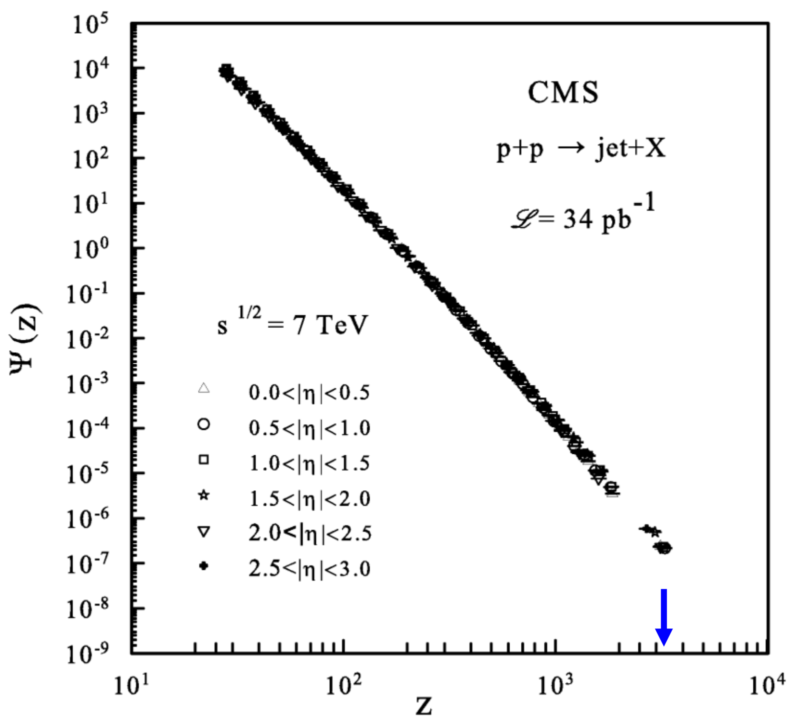
Tevatron data confirm
z-scaling in jet production in $p\bar{p}$ collisions

RHIC data confirm
z-scaling in jet production in pp collisions

What about z-scaling
in jet production in pp collisions at LHC ?

Inclusive Jets at CMS & z-Scaling





MT
T.Dedovich
I.Zborovsky
IJMP A27(2012) 1250115

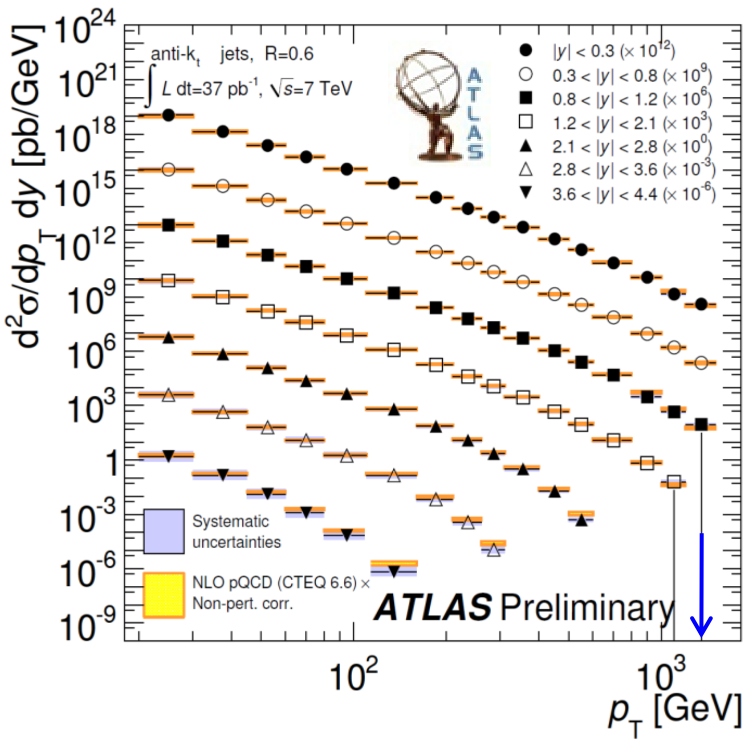
Measurements of inclusive jet cross sections:
- Probing large momentum $18 < p_T < 1100$ GeV/c
- Rapidity region $|y| < 3$
- Agreement with NLO pQCD

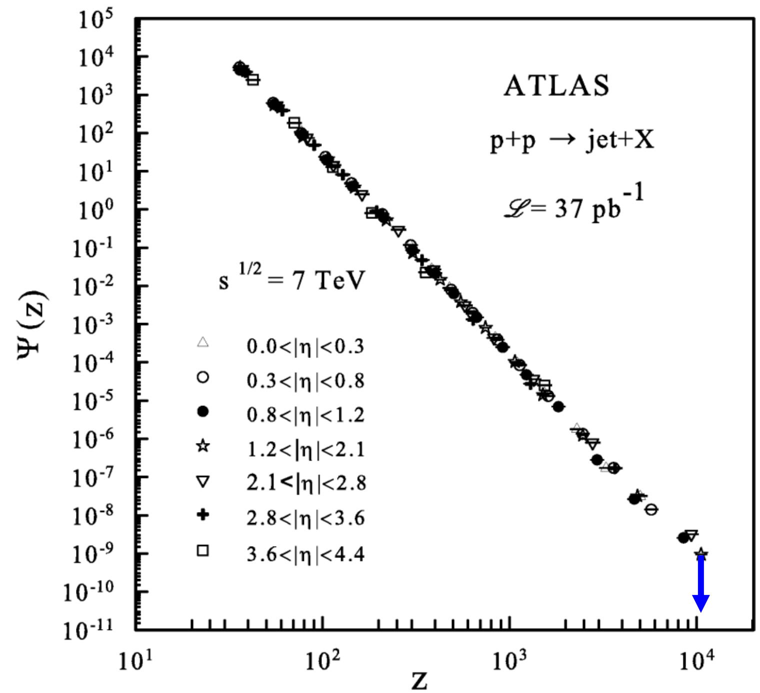
- Angular independence of Ψ(z)
- Power law, $\Psi(z) \sim z^{-\beta}$, up to $z \approx 3\cdot10^3$
- Self-similarity of jet production

CMS data confirm z-scaling of jet production in pp

CMS Collaboration,
Phys.Rev.Lett.107,132001,2011

Inclusive Jets at ATLAS & z-Scaling





MT
T.Dedovich
I.Zborovsky
IJMP A27(2012) 1250115

Measurements of inclusive jet cross sections:

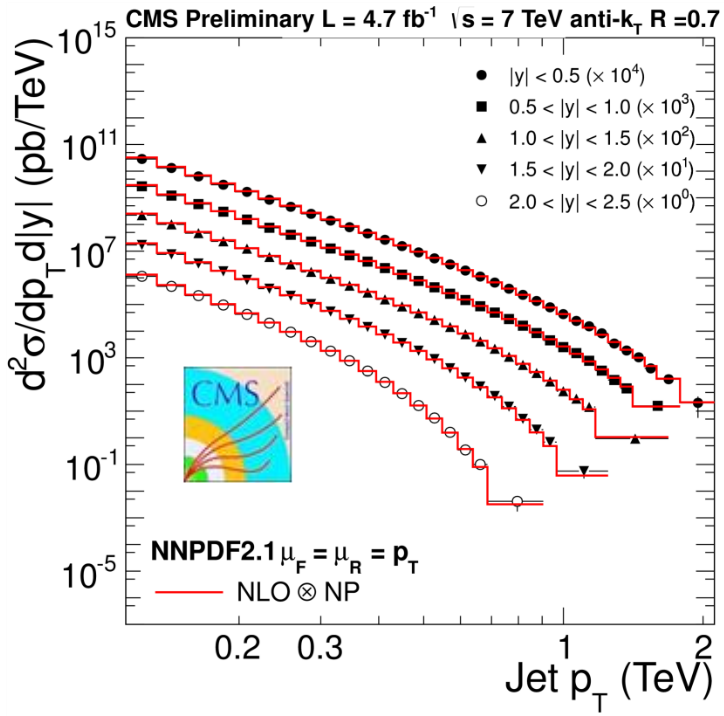
- Probing large momentum $20 < p_T < 1300$ GeV/c
- Rapidity region $|y| < 4.4$
- Agreement with NLO pQCD

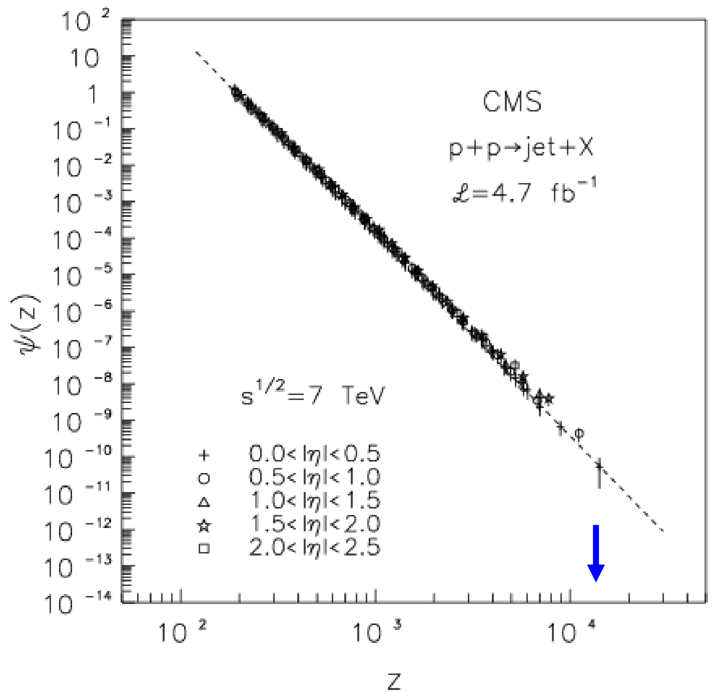
J.Zhang, ATLAS Collaboration
XIX International Workshop on Deep-Inelastic Scattering and Related Subjects
April 11-15, 2011, Newport News, Virginia, USA
ATLAS-CONF-2011-047 (2011)

- Angular independence of Ψ(z)
- Power law, $\Psi(z) \sim z^{-\beta}$, up to $z \approx 10^4$
- Self-similarity of jet production

ATLAS data confirm z-scaling of jet production in pp

Inclusive Jets at CMS & z-Scaling





MT
T.Dedovich
I.Zborovsky
HS&QCD
Gatchina, 2012

Measurements of inclusive jet cross sections:

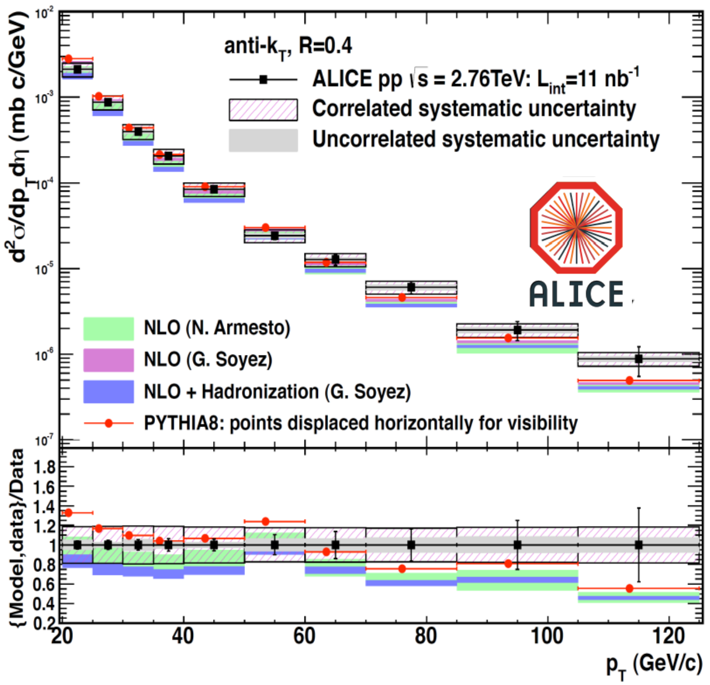
- Probing large momentum $114 < p_T < 2000$ GeV/c
- Rapidity region $|y| < 2.5$
- Agreement with NLO pQCD

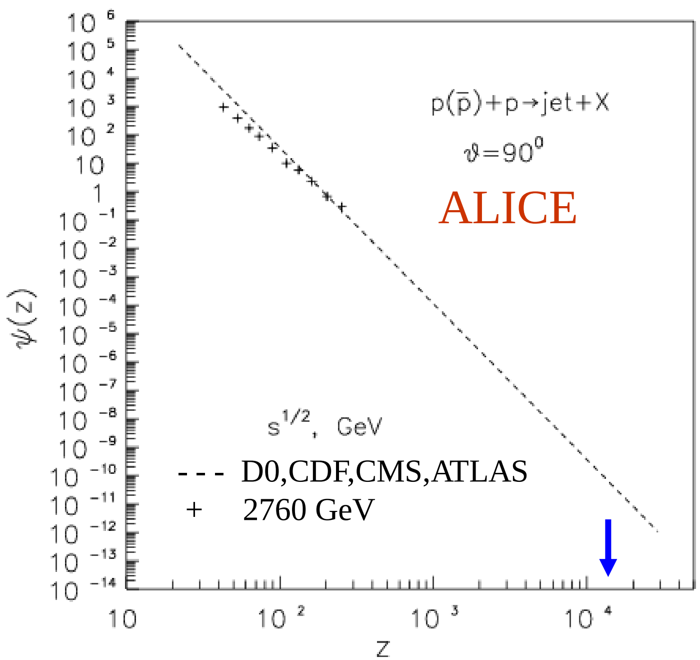
CMS Collaboration,
CMS PAS QCD-11-004
P.Krieger, Physics at LHC,
Vancouver, June 4-9, 2012

- Angular independence of $\Psi(z)$
- Power law, $\Psi(z) \sim z^{-\beta}$, up to $z \approx 1.3 \cdot 10^4$
- Self-similarity of jet production

CMS data confirms
z-scaling of jet production in pp

Inclusive Jets at ALICE & z-Scaling





Measurements of inclusive jet cross sections:

- Probing large momentum $20<p_T< 130$ GeV/c
- Rapidity region $|y| < 3$
- Agreement with NLO pQCD

- Angular independence of $\Psi(z)$
- Power law, $\Psi(z) \sim z^{-\beta}$, up to $z \approx 3\cdot10^3$
- Self-similarity of jet production

ALICE data confirm
z-scaling of jet production in pp

R.Ma, ALICE Collaboration
"Hard Probes 2012" Gagliari, Italy,
May 27- June 1, 2012.

Inclusive Jets at CMS @ DØ & z-Scaling

DØ Collaboration
B.Abbott et al., Phys.Rev.Lett. 82, 2451 (1999)
B.Abbott et al., Phys.Rev. D64, 032003 (2001)
D.Elvira, Ph.D Thesis Univsodad de Buenos Aires, Argentina (1995).
V.M.Abazov et al., Phys.Lett. B525, 211 (2002)
V.M.Abazov et al., Phys.Rev.Lett. 101, 062001 (2008)

CMS Collaboration,
Phys.Rev.Lett.107,132001,2011
CMS PAS QCD-11-004
P.Krieger, Physics at LHC,
Vancouver, June 4-9, 2012

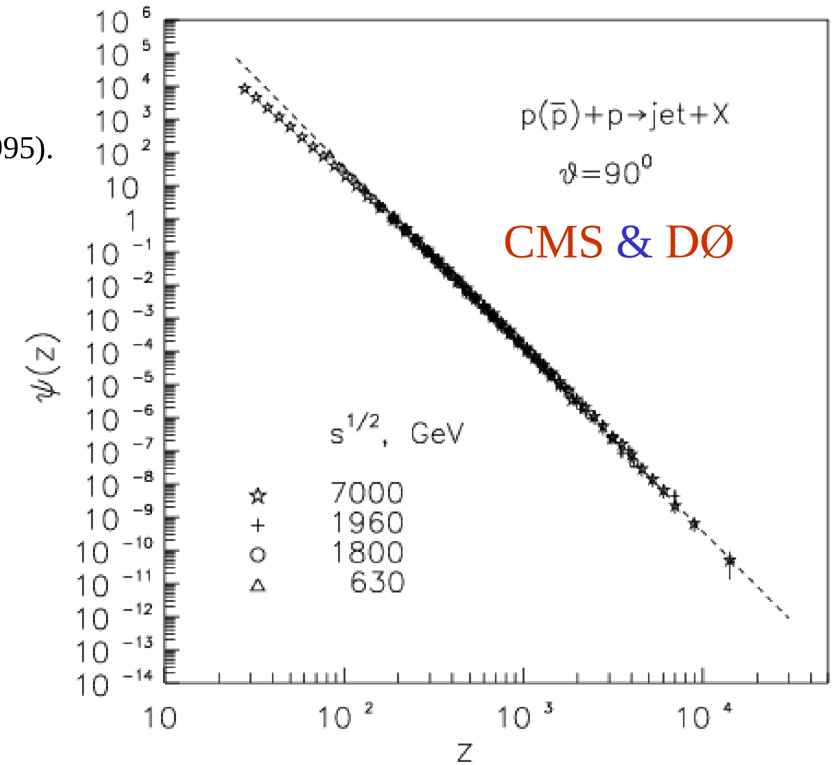
M.T. & T. Dedovich
Int. J. Mod. Phys.
A15 (2000) 3495

M.T. & T.Dedovich
Phys.At. Nucl. 68, 404 (2005)

M.T. & I.Zborovsky
Phys.Part.Nucl.Lett. 3, 312 (2006)

M.T. & I.Zborovsky
High-pT Physics at LHC 09
February 4-7, 2009
Prague, Czech Republic
PoS (High-p_T physics09) 046

M.T. & T.Dedovich, I.Zborovsky
Preprint JINR E2-2012-19
Int.J.Mod.Phys.A27 (2012) 1250115



- Energy independence of Ψ(z)
- Universality of Ψ(z) in pp & $p\bar{p}$
- Power law of Ψ(z) for z >10^2

CMS & DØ data confirm z-scaling of jet production

Inclusive Jets at CMS @ CDF & z-Scaling

CDF Collaboration
F.Abe et al., Phys.Rev.Lett. 77, 438 (1996).
T.Affolder et al., Phys.Rev. D 64, 032001(2001)
A.Abulencia et al., Phys.Rev.Lett. 96, 122001(2006)
A.Abulencia et al., Phys.Rev. D74, 071103 (2006)
A.Abulencia et al., Phys.Rev. D75, 092006 (2007)
T.Aaltonen et al.,Phys.Rev. D78 ,052006 (2008)

CMS Collaboration,
Phys.Rev.Lett.107,132001,2011
CMS PAS QCD-11-004
P.Krieger, Physics at LHC,
Vancouver, June 4-9, 2012

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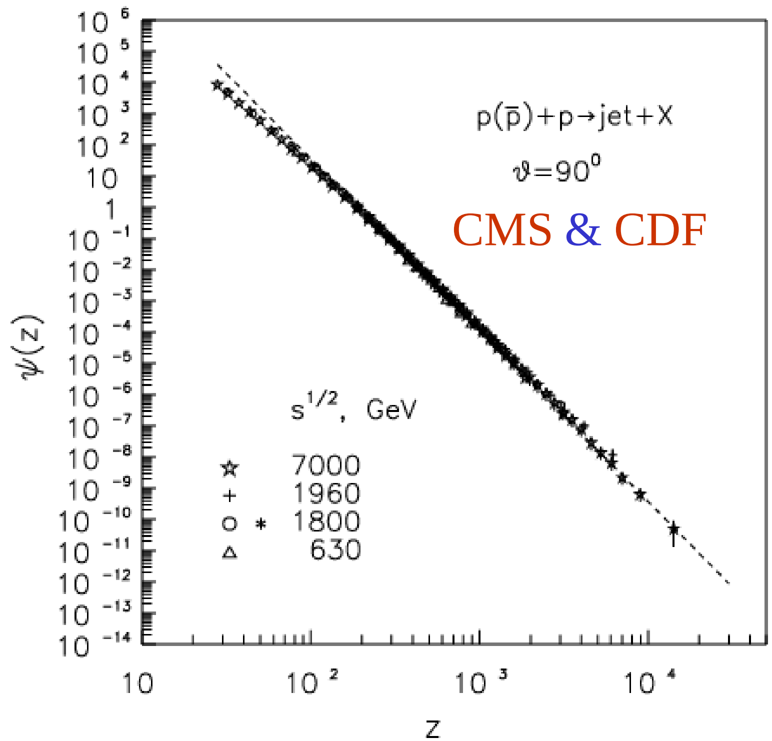


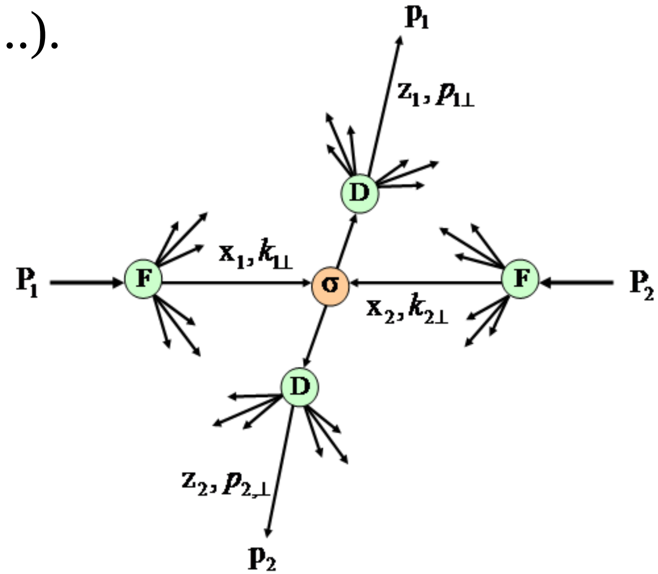
- Energy independence of Ψ(z)
- Universality of Ψ(z) in pp &$p\bar{p}$
- Power law of Ψ(z) for z >10^2

CMS & CDF data confirm z-scaling of jet production

QCD test of z-scaling

- QCD is basic theory for calculations of hadron interactions in terms of quarks and gluons.
- Perturbative expansion is under control (LO, NLO, ...).
- Non-perturbative effects – PDFs, FFs, μ_R, μ_F, μ_H, are partially under control.
- Correct extrapolation in low and high (x, p_T) range is restricted by available data (e^+e^-, DIS, SIDIS,…).
- Additional constraints on PDFs and FFs are needed to confirm their universality (gluons, flavor, …).
- Soft regime (multiple interactions, …).

Hadron interaction at a constituent level



$$F_h^q(x_1, k_{1\perp}, \mu_F)$$
$$\sigma_{qq}(x_1, x_2, k_{1\perp}, k_{2\perp}, \mu_R)$$
$$D_q^h(z_1, p_{1\perp}, \mu_H)$$

- A lot of data are analyzed in framework of z–presentation.
- New confirmations from Tevatron and LHC are obtained.
- Can NLO QCD describe z-scaling in soft and hard regime ?
- …..

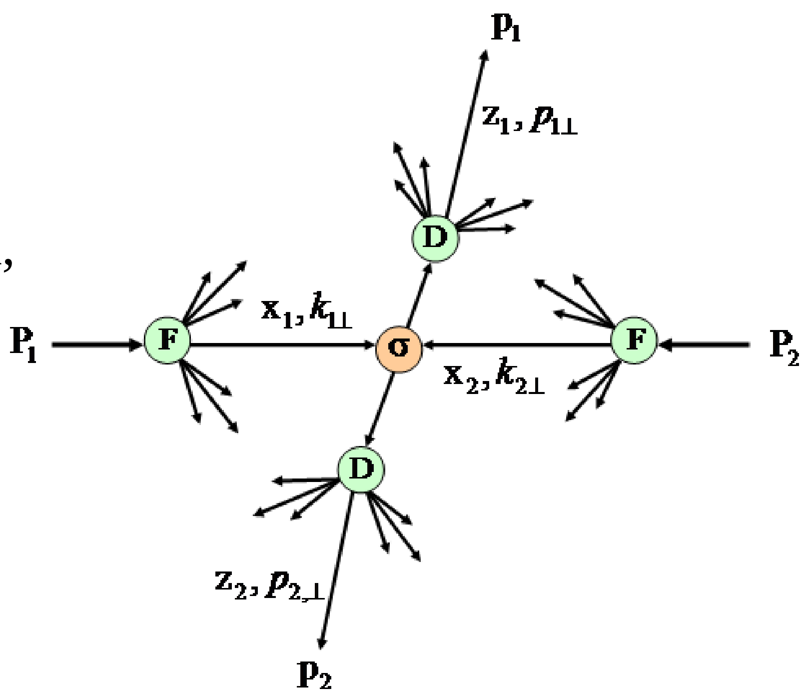
NLO QCD ingredients

- NLO QCD jet production code
  S.D.Ellis, Z.Kunszt, D.Soper
  PRD40,2188(1989); PRL69,1496(1992); PRD46,192 (1992)

- Parton Distribution Functions
  CTEQ6M – J.Pumplin, D.R.Stump, J.Huston, H.L.Lai, P.Nadolski, W.K.Tang
  JHEP 0207 (2002) 012
  MRST01 – A.D.Martin, R.G.Roberts, W.J.Stirling, R.S.Thorne
  Eur. Phys. J. C23 (2002) 73

- Scales $\mu = c \cdot p_T$, c = 1/2, 1, 2
  – Renormalization μ_R
  – Factorization μ_F
  – Hadronization μ_H

Hadron interaction at a constituent level



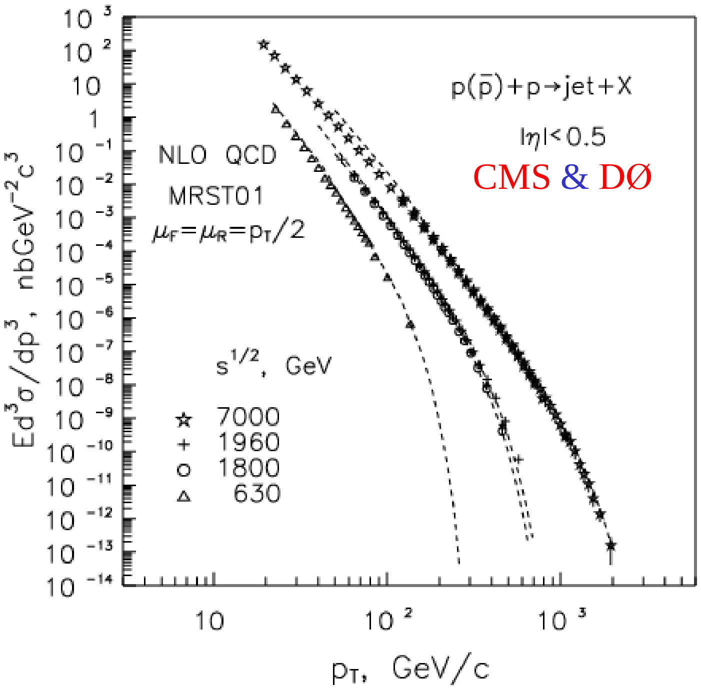
$F_h^q(x_1, \mu_F)$

$\sigma_{qq}(x_1, x_2, k_{1\perp}, k_{2\perp}, \mu_R)$

$D_q^h(z_1, \mu_H)$

Jet NLO QCD spectra in pp and p$\bar{p}$ & PDFs

MRST01 & EKS

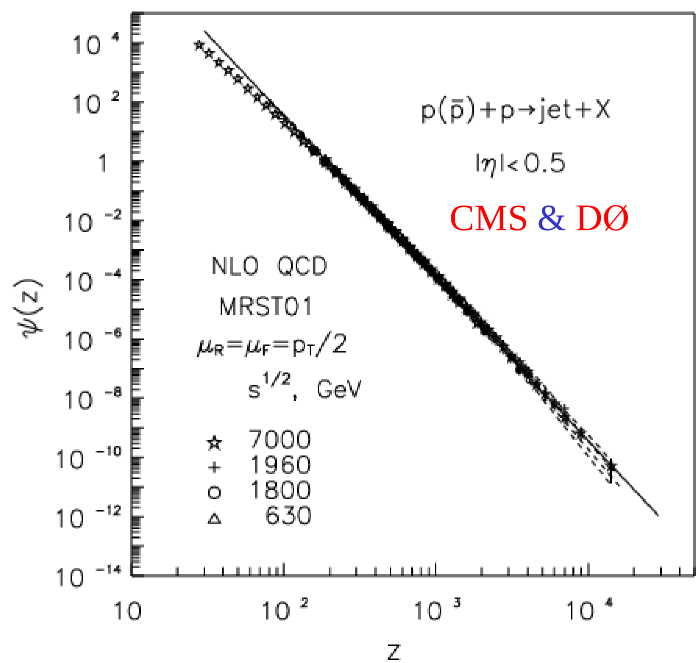


LHC

Tevatron

RHIC

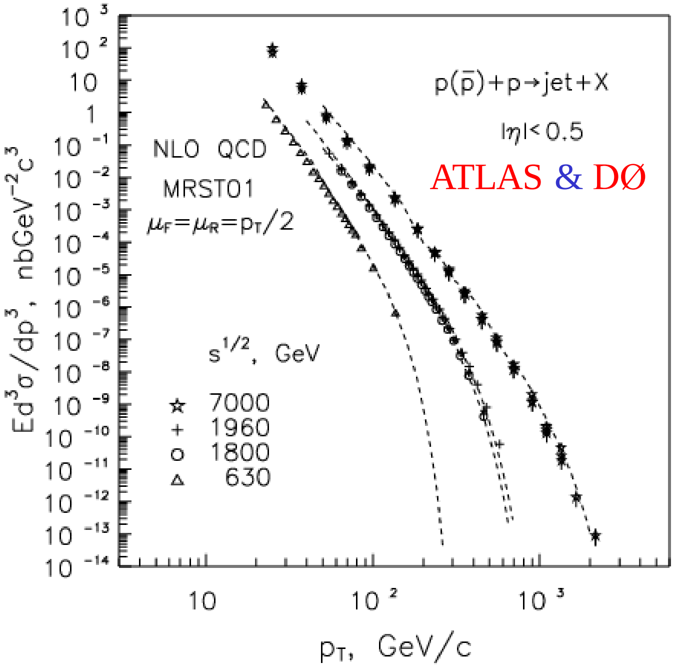
$s^{1/2}$=630-14000 GeV, |η|<0.5, R=0.7



- Strong dependence of spectra on energy $s^{1/2}$ at high p_T .
- Sensitivity to PDFs (MRST) & μ_R, μ_F, μ_H scales.
- NLO QCD calc. results are in agreement with available data.
- Different extrapolation of spectra predicted by NLO QCD and z-scaling for high transverse momenta.

Jet NLO QCD spectra in pp and $\bar{p}p$ & PDFs

MRST01 & EKS



LHC

↑

Tevatron

↑

RHIC

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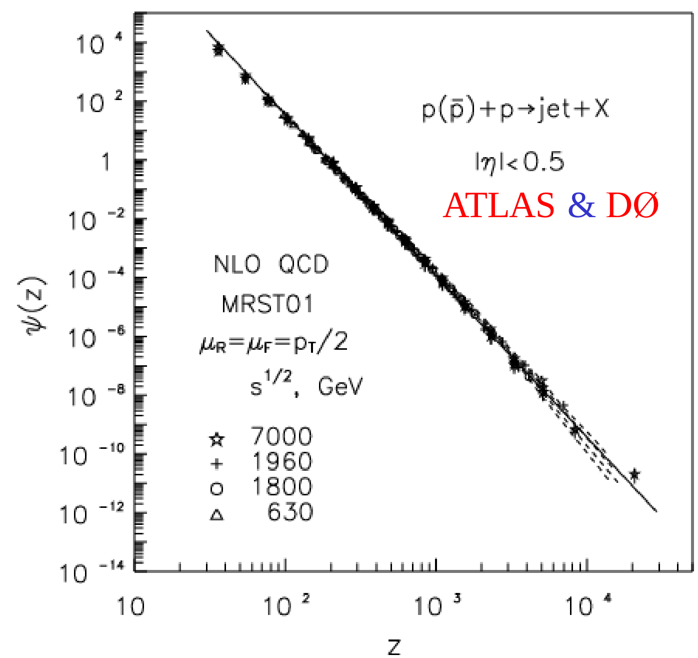

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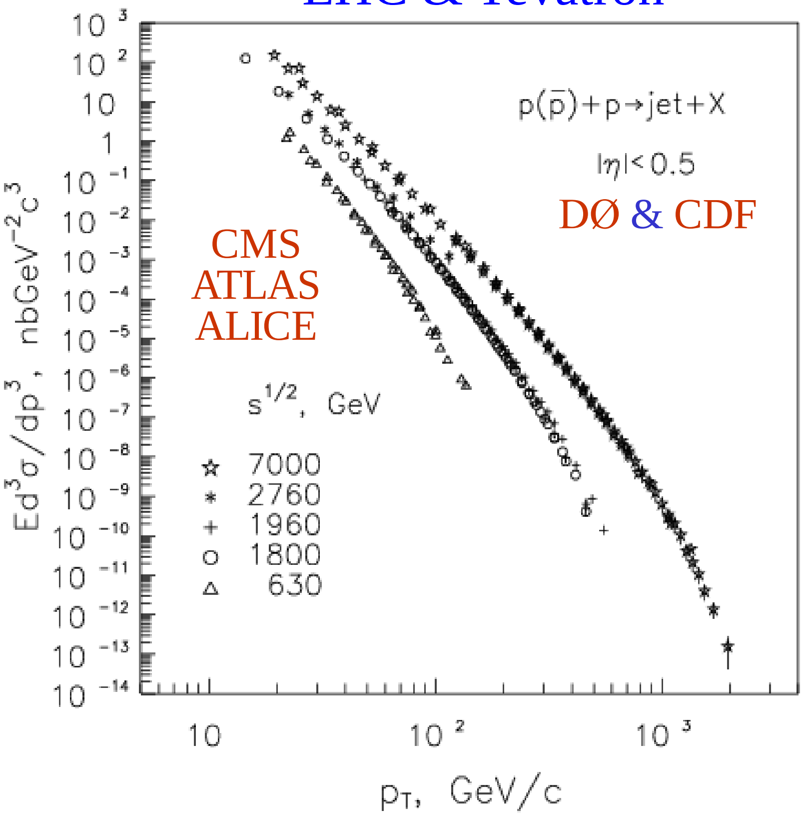
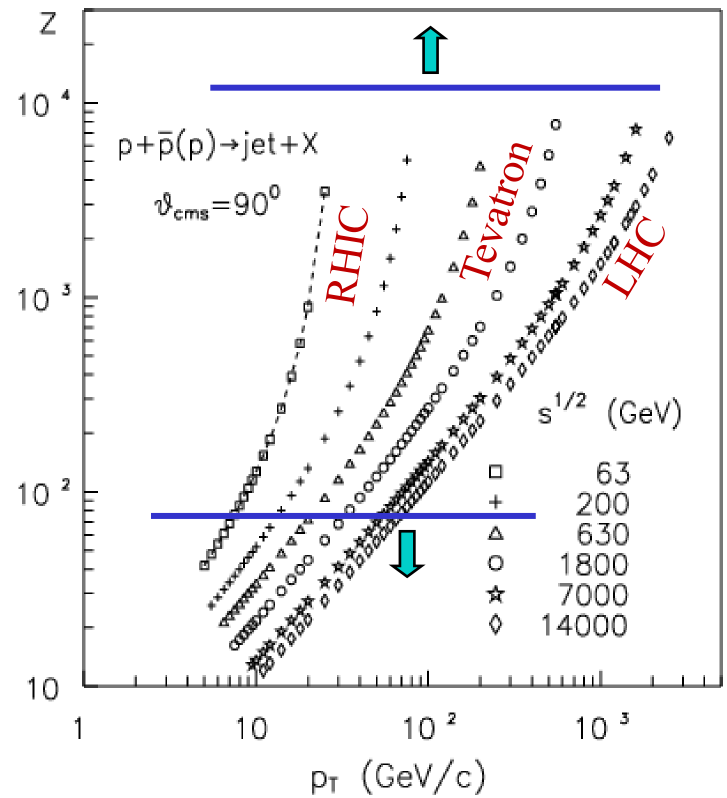
z-p_T plot

LHC & Tevatron





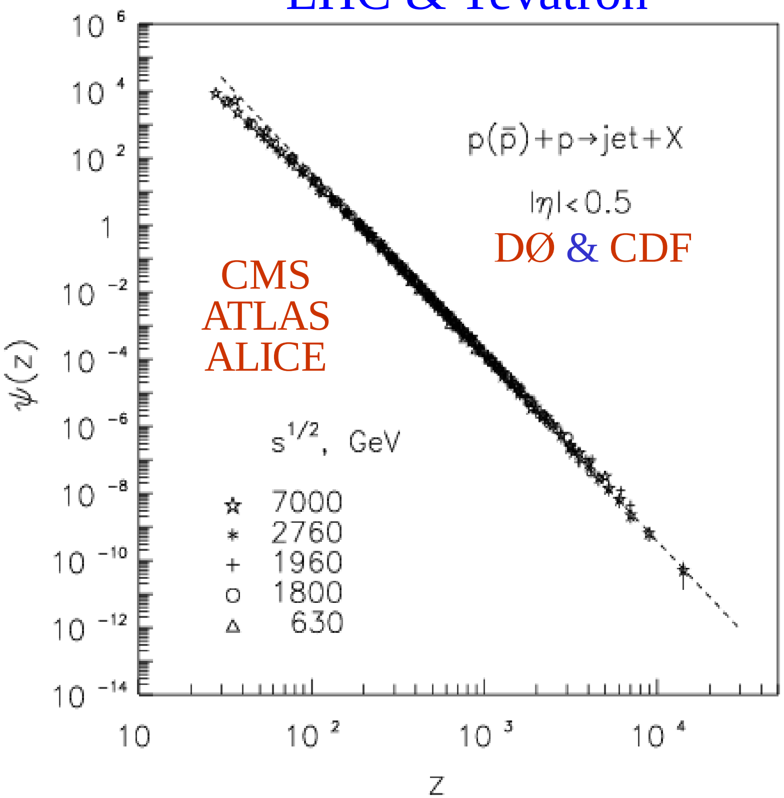
Structural phenomena (constituent substructure, momentum space structure,…)

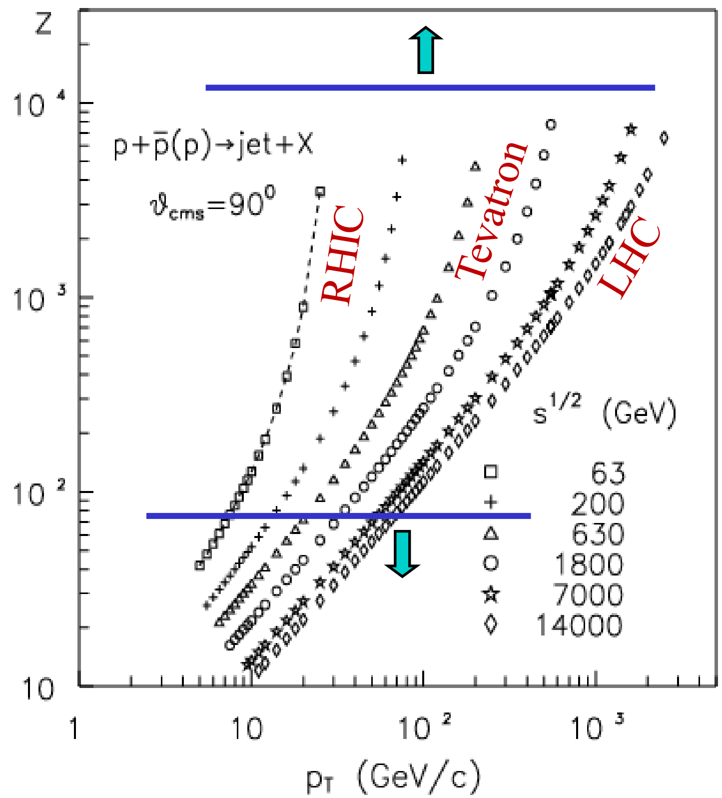
Collective phenomena (multiple jet production, phase transitions,…)

Kinematical regions are of more preferable for searching for new hard and soft physics in jet production at RHIC, Tevatron and LHC.

z-p_T plot

LHC & Tevatron





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Conclusions

- New LHC data on jet production in pp collisions obtained by CMS, ATLAS and ALICE Collaborations were analyzed in the z-scaling approach.
- Results of analysis were compared with Tevatron data.
- New confirmations of z-scaling properties (the energy and angular independences, the power law) were obtained.
- z-Scaling of jet production at high energies manifests self-similarity, locality and fractality of hadron interactions at a constituent level.
- QCD test of z-scaling was performed: z-scaling gives restriction on the asymptotic behavior of jet spectra in high-p_T region.
- New TeV-energy region is available for search for new physics phenomena in jet production at LHC.

Thanks for your attention !