Statistical Modelling of the Multiplicity Distribution

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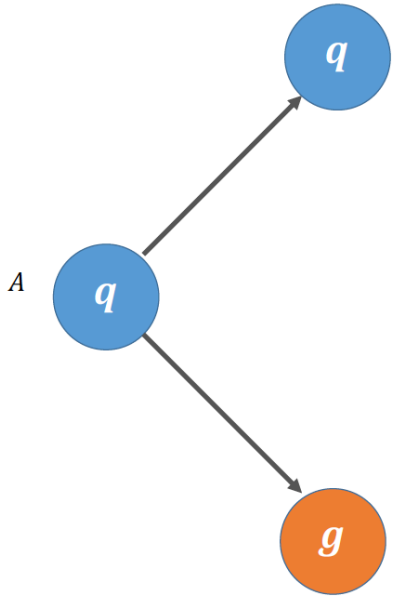
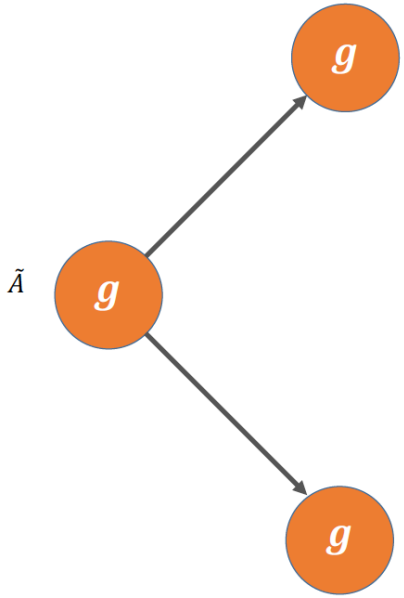
Branching processes



A: rate of gluon bremsstrahlung



A: rate of gluon splitting

Models

Generalised Multiplicities Distribution (GMD):

$$P_{GMD}(n;p,k,k') = \frac{\Gamma(n+k)}{\Gamma(n-k'+1)\,\Gamma(k'+k)}(1-p)^{n-k'}(p)^{k'+k}$$

n: multiplicity
k: number of initial quarks
k': number of initial gluons
$p = \mathrm{e}^{-At}$, where t: QCD evolution parameter

Mean:

$$\bar{n} = \frac{k'+k}{p} - k$$

$k' \to 0 \Rightarrow$GMD $\to$ NBD

[chan, chew, Z. Phys. C 55 (1992) 503]
[Wang, Leong, Ng, Dewanto, Chan, Oh, Proceedings of the Conference in Honour of the 90th Birthday of Freeman Dyson (2014), 400]

Models

Sum over event-by-event initial gluon number fluctuations:

$$P_{WGMD}(n; x_1, ..., x_r, p, k) = \sum_{k'=0}^{n} P(k'; x_1, ..., x_r) \times P_{GMD}(n; p, k, k')$$

Mean:

$$\overline{n} = \sum_{n=0}^{\infty} n P_{WGMD}(n; x_1, ..., x_r, p, k)$$

$$= \frac{\langle k' \rangle + k}{p} - k$$

Same form as GMD with $k' \rightarrow \langle k' \rangle$

Models

Assume gluon source with Poissonian: $P(k';x_1,\dots,x_r) \to P\left(k';\overline{k'}\right) = \frac{\overline{k'}^{k'}\exp\left(-\overline{k'}\right)}{k'!}$

$$P_{PGMD}(n) = \Gamma(n+k)\sum_{k'=0}^{n}\frac{\overline{k'}^{k'}\exp\left(-\overline{k'}\right)}{k'!\Gamma(n-k'+1)\Gamma(k'+k)}(1-p)^{n-k'}p^{k'+k}$$

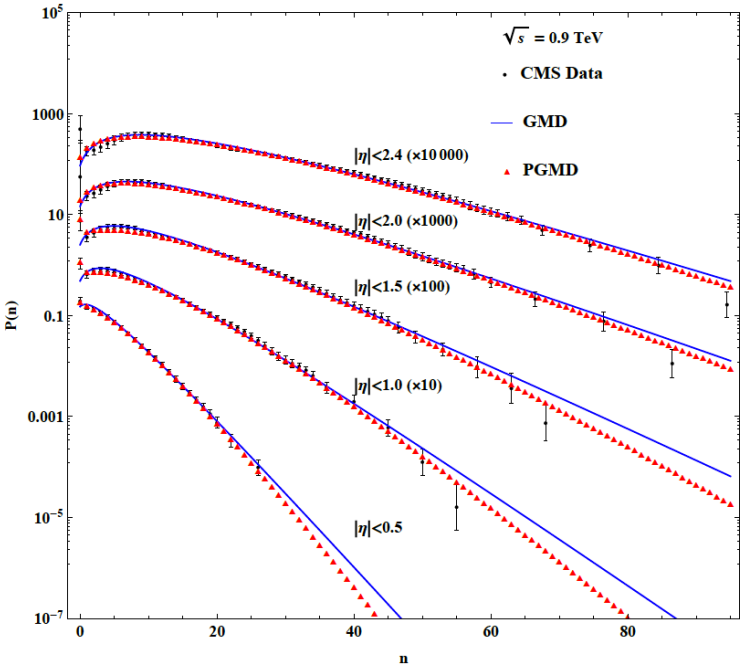
Mean:

$$\bar{n} = \frac{\overline{k'}+k}{p} - k$$

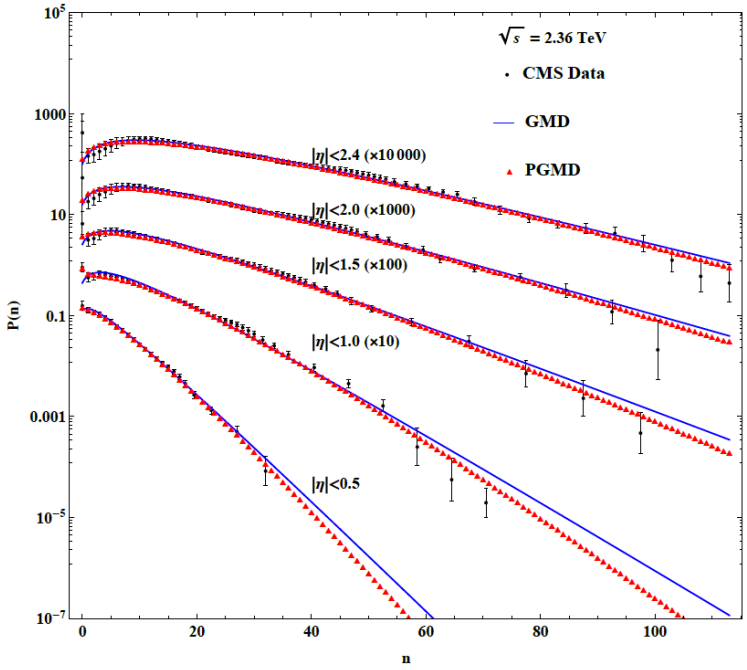
Results

CMS charged-particle multiplicity distribution data:

0.9 TeV

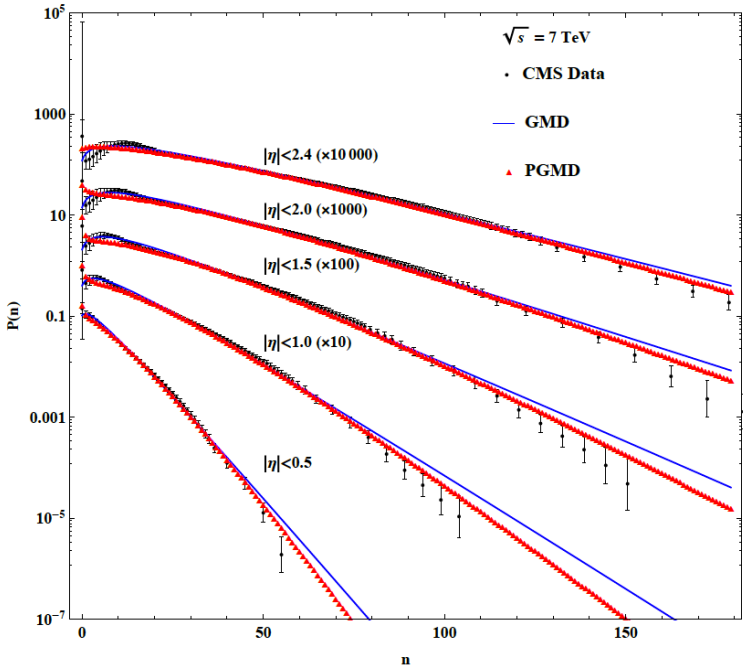


2.36 TeV



Results

7 TeV



13 TeV prediction