System size dependence of the log-periodic oscillations of transverse momentum spectra

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Statistical description

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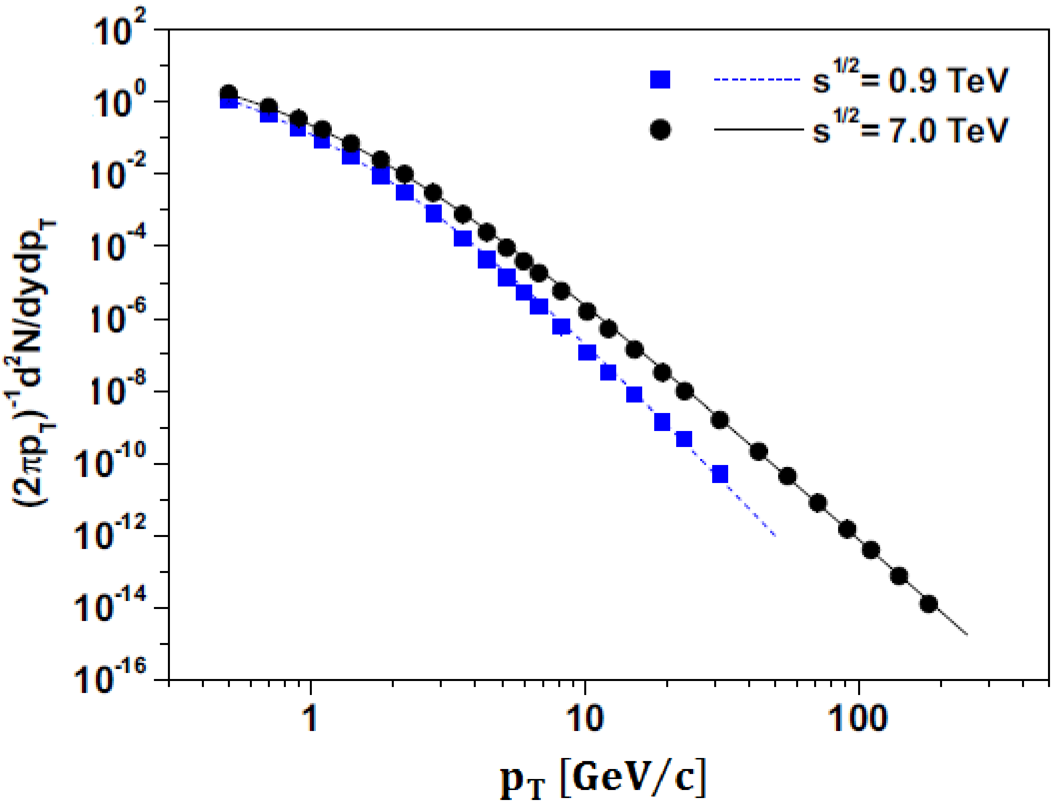
$$f(p_T) = C \cdot \left[1 - (1-q)\frac{p_T}{T}\right]^{\frac{1}{1-q}} \qquad (1)$$

or, in the so called **„QCD inspired" Hagedorn form** (with parameters: m and T)

$$h(p_T) = C \cdot \left(1 + \frac{p_T}{mT}\right)^{-m} \qquad (2)$$

$$m = \frac{1}{q-1}$$

p_T distributions in p+p interactions



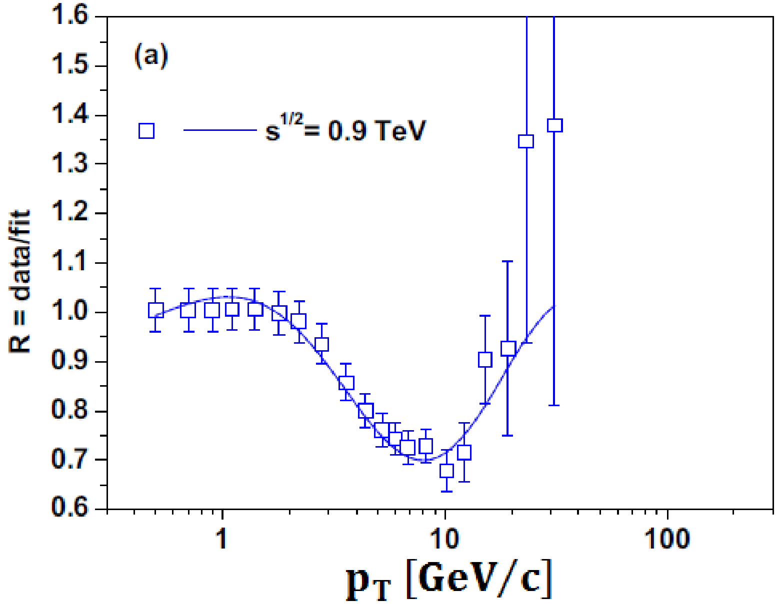
$\sqrt{s}$ [TeV]	T	m
0.9	0.135	8
7.0	0.145	6.7

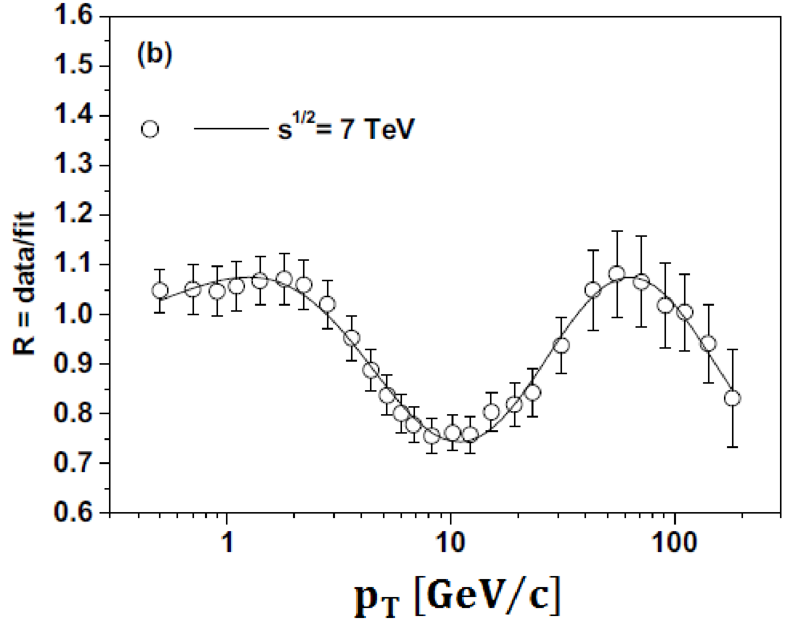
Data from:

V. Khachatryan et al. (CMS Collaboration), JHEP 02 (2010) 041 and JHEP 08 (2011) 086;
Phys. Rev. Lett. 105 (2010) 022002

p_T distributions in p+p interactions

$$R(p_T) = a + b\cos[c \cdot \ln(p_T + d) + f] \qquad (3)$$





data/fit ratio is not flat but shows some kind of clearly visible oscillations

Details in:
G. Wilk and Z. Wlodarczyk, arXiv:1403.3508 [hep-ph]

Scale invariance – digression (I)

If some function O(x) is scale invariant, i.e.:

$$O(\lambda x) = \mu O(x)$$

then it must have a power law behavior:

$$O(x) = C x^{-m} \qquad \text{with} \quad m = -\frac{\ln\mu}{\ln\lambda}$$

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The evolution of the differential $df(p_T)/dp_T$ of a Tsallis distribution $f(p_T)$ with power index *n* performed for finite differences $\delta p_T = \alpha(nT + p_T)$ results in the following scale invariant relation:

$$g[(1+\alpha)x] = (1-\alpha n)g(x) \qquad x = 1 + \frac{p_T}{nT}$$

Scale invariance – digression (II)

In general, one can write $h(p_T) = C \cdot \left(1 + \frac{p_T}{mT}\right)^{-m}$ in the form:

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Since we do not know *a priori* the details of dynamics of processes under consideration (i.e. we do not know the weights w_k), in what follows we use only k = 0 and k = 1 terms:

$$g(p_T) \cong \left(1 + \frac{p_T}{nT}\right)^{-m_0} \left\{w_0 + w_1 \cos\left[\frac{2\pi}{\ln(1+\alpha)} \ln\left(1 + \frac{p_T}{nT}\right)\right]\right\}$$

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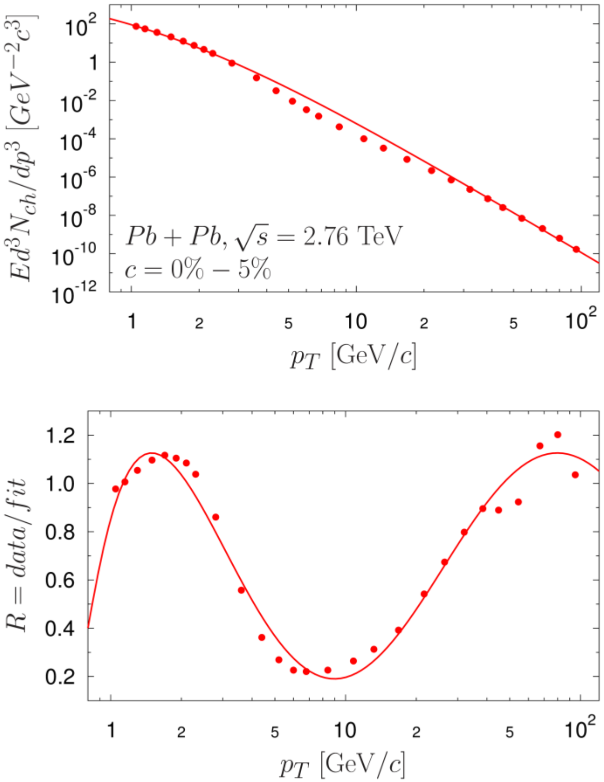
The parameters in general modulating factor $R(p_T) = a + b\cos[c \cdot \ln(\mathrm{p_T} + \mathrm{d}) + \mathrm{f}]$ can be indentified as follows:

$$a = w_0 \qquad c = \frac{2\pi}{\ln(1+\alpha)} \qquad d = nT$$

$$b = w_1 \qquad f = -c \cdot \ln(nT)$$

p_T distributions in Pb+Pb collisions



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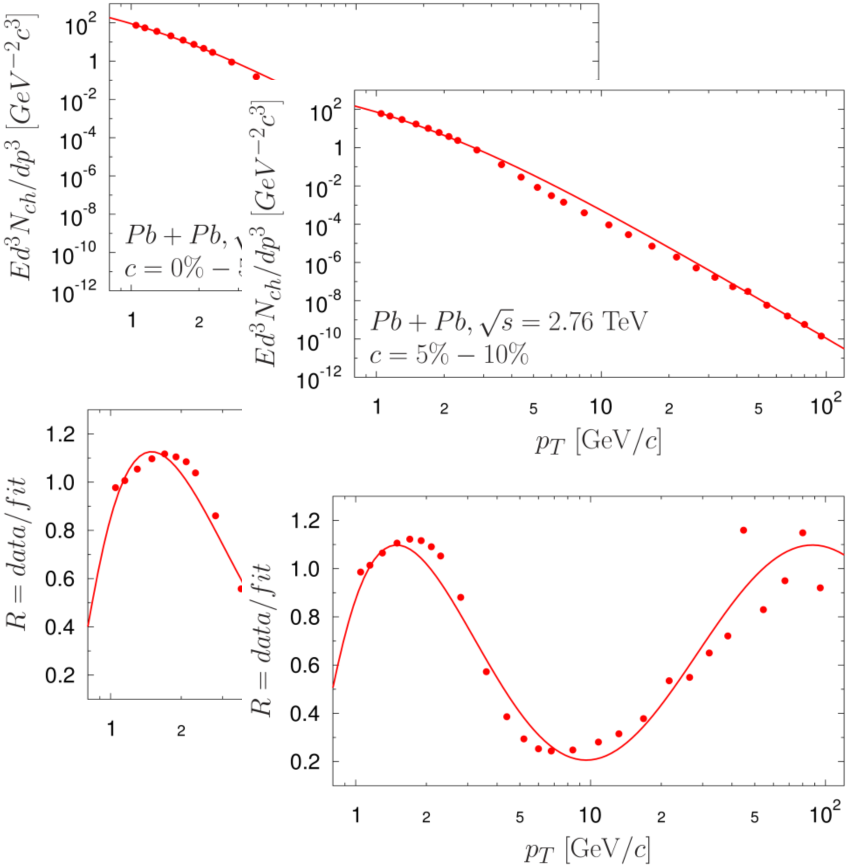

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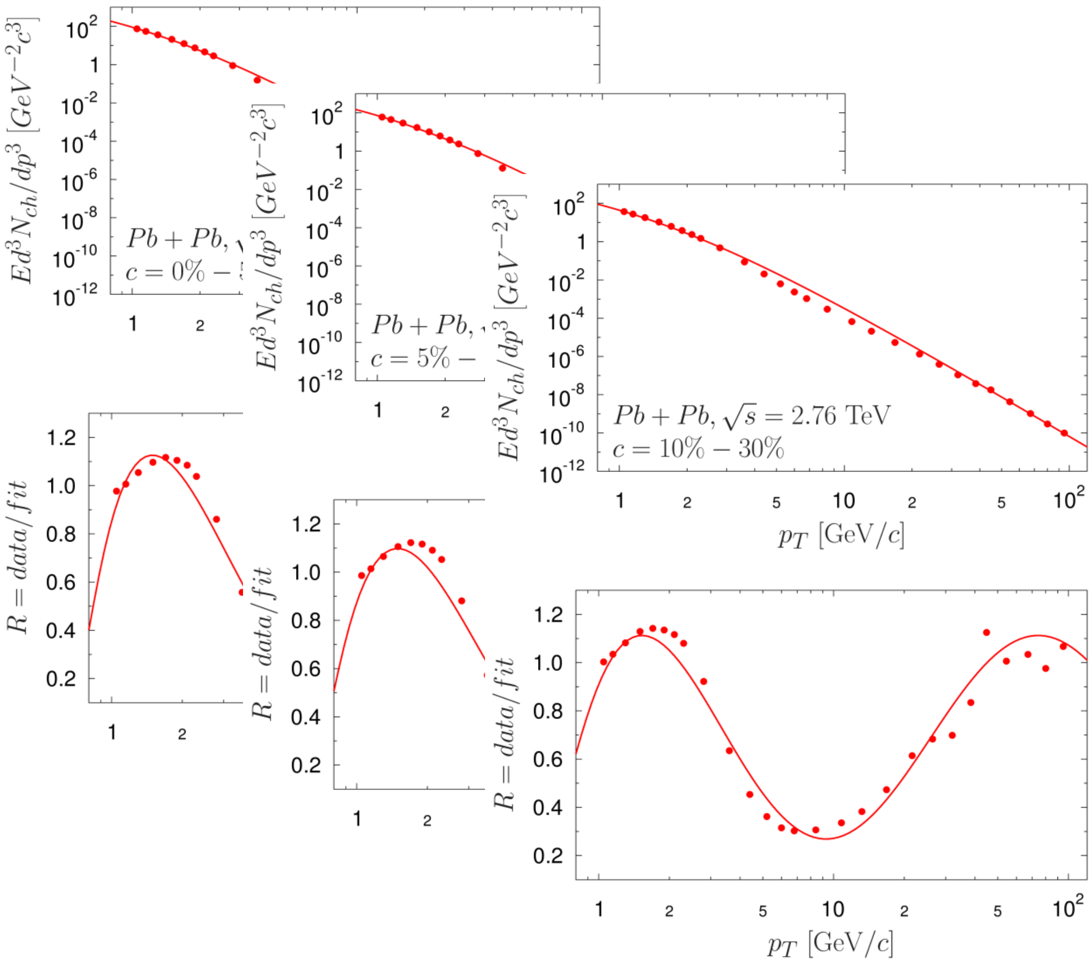

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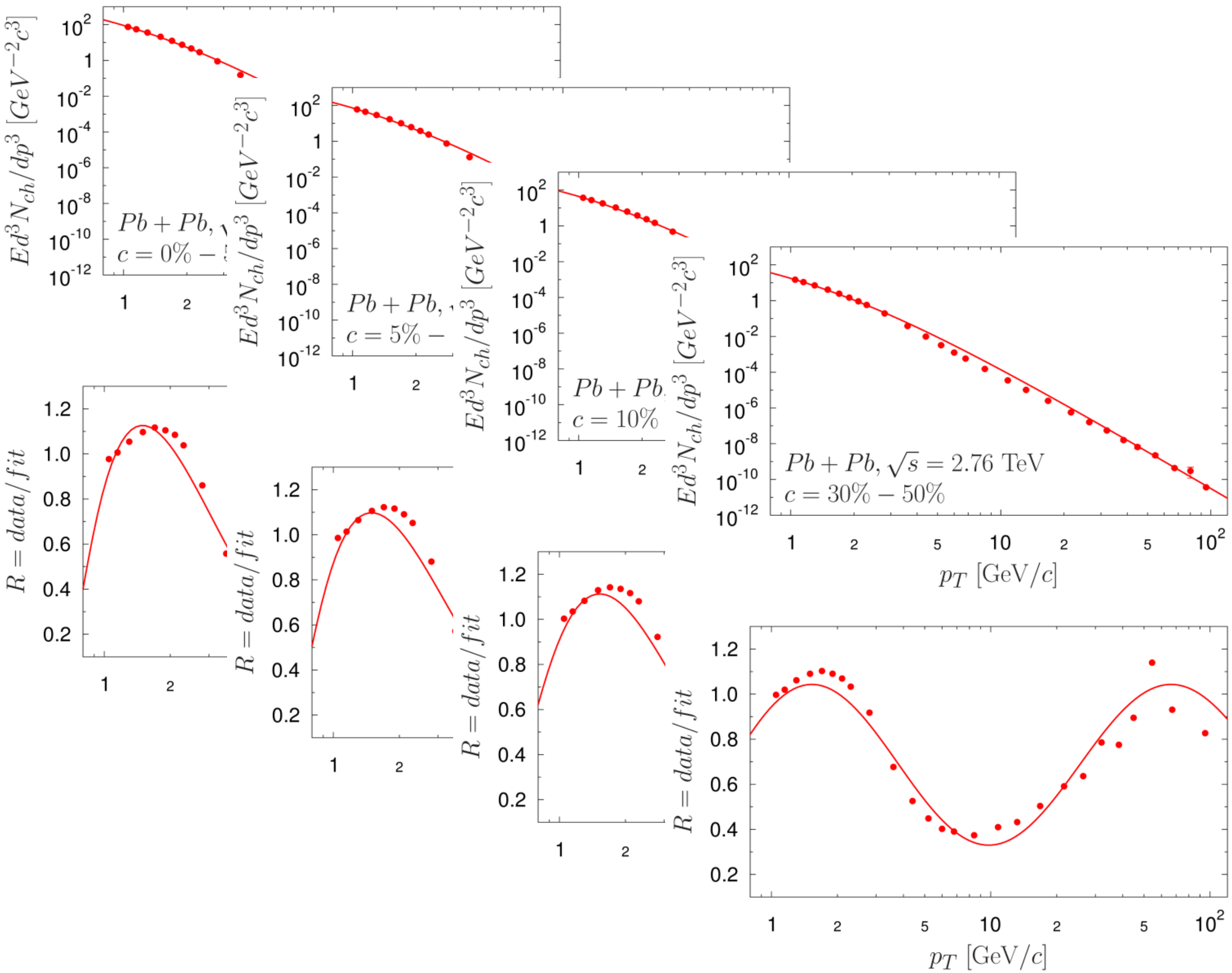

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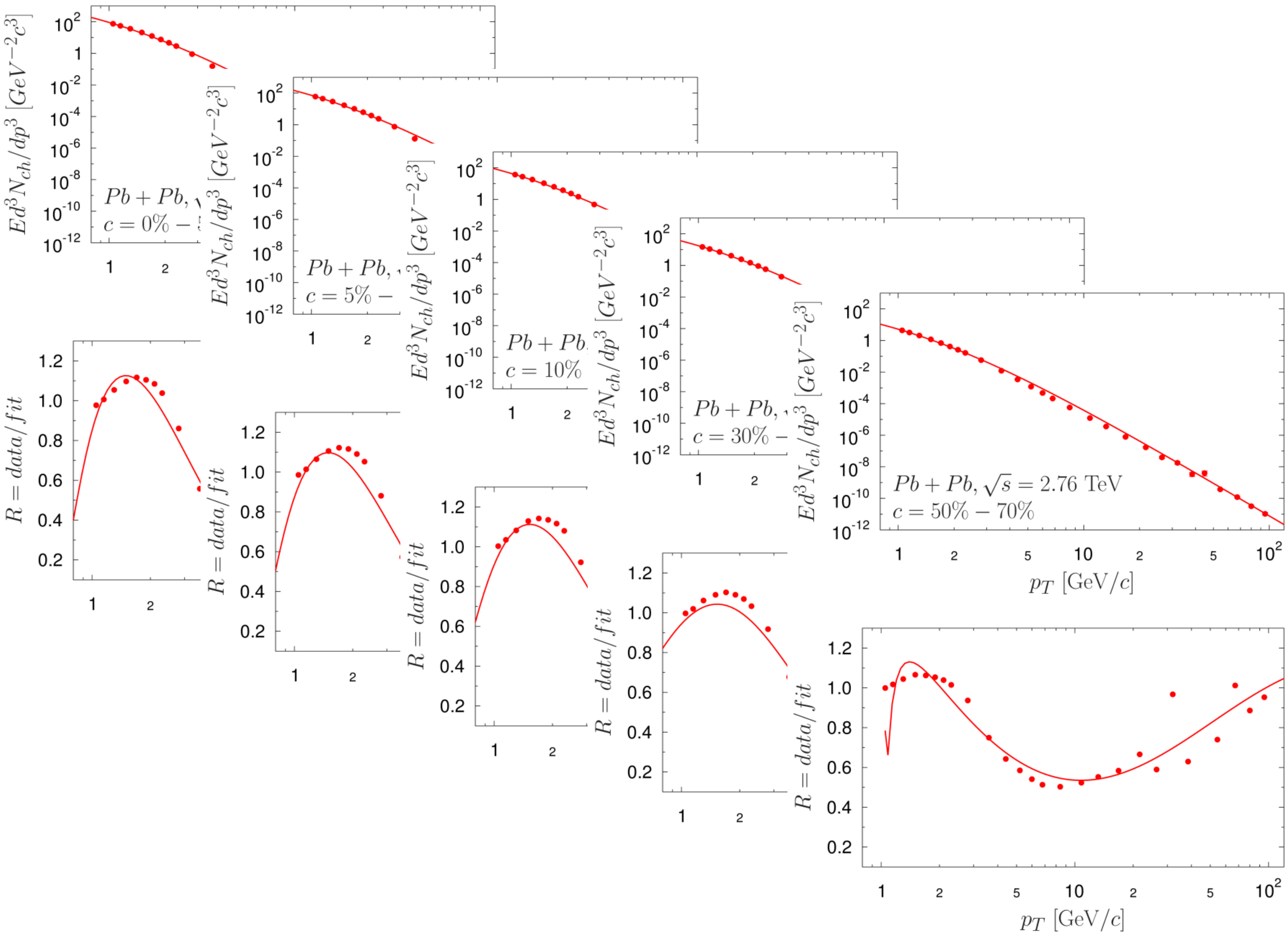

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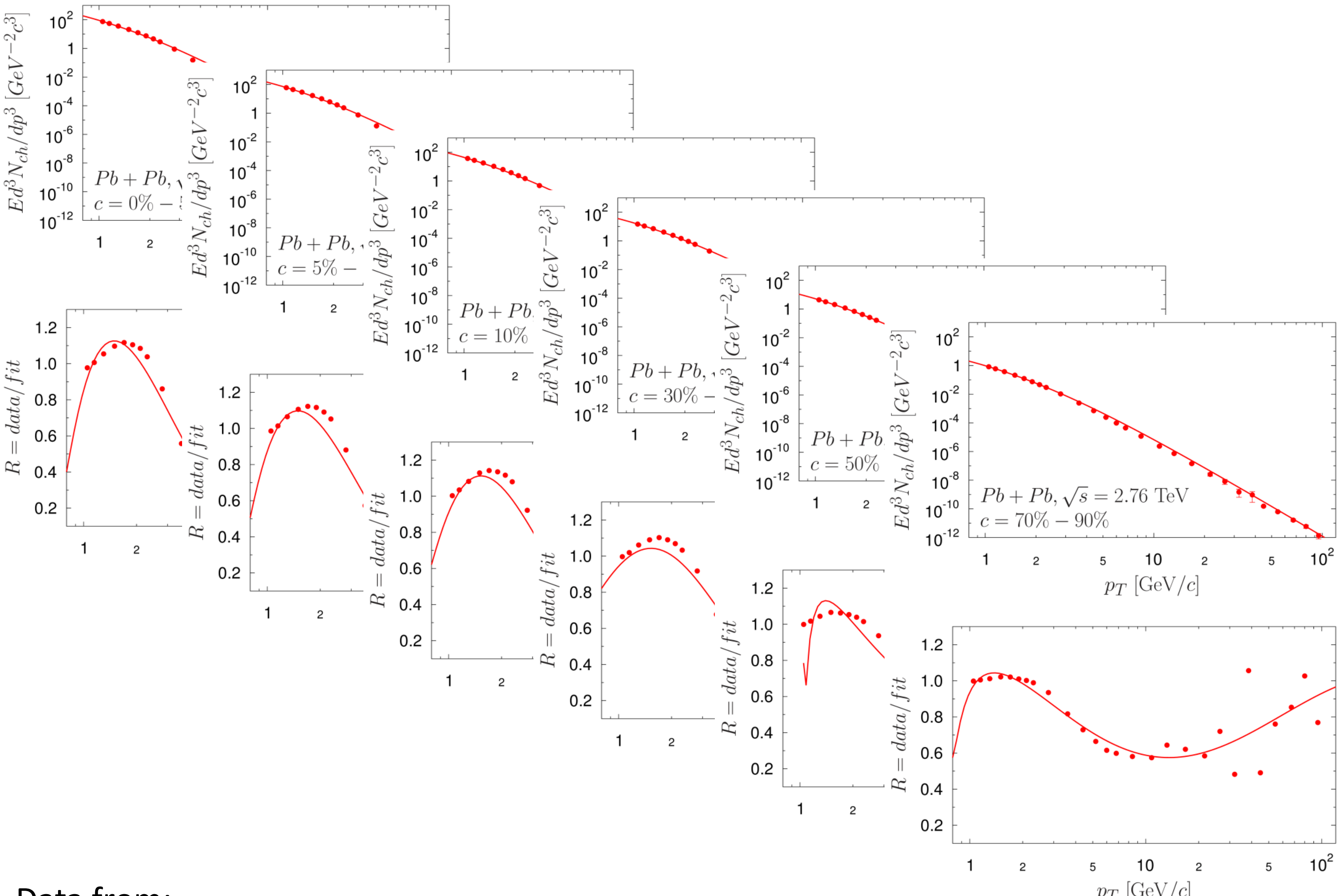

Data from:

S. Chatrchyan et al. (CMS Collaboration), EPJ C72 (2012) 1945

Parameters – centrality dependence

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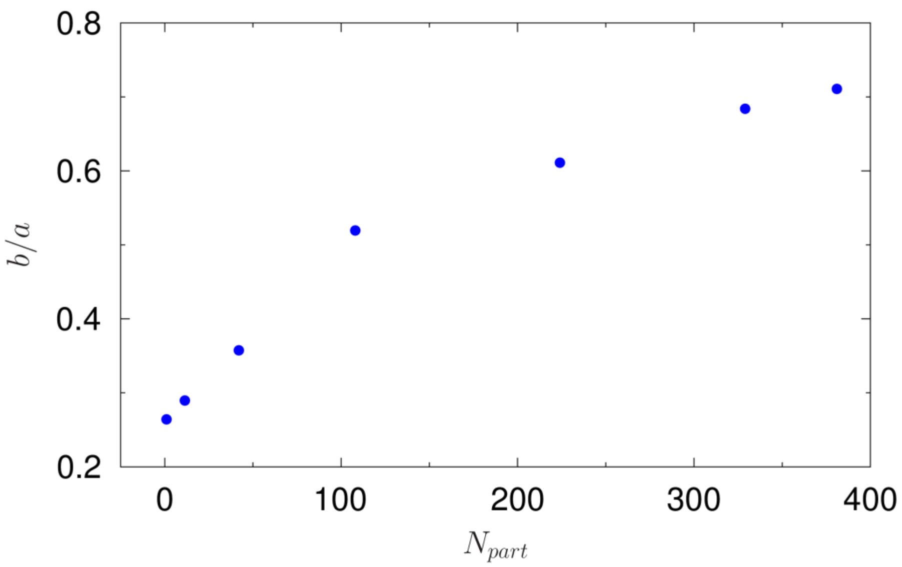

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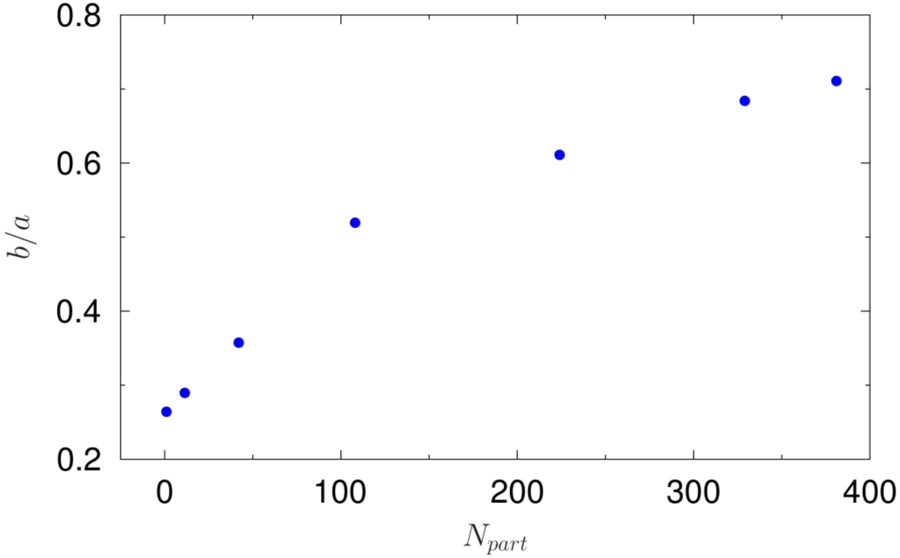

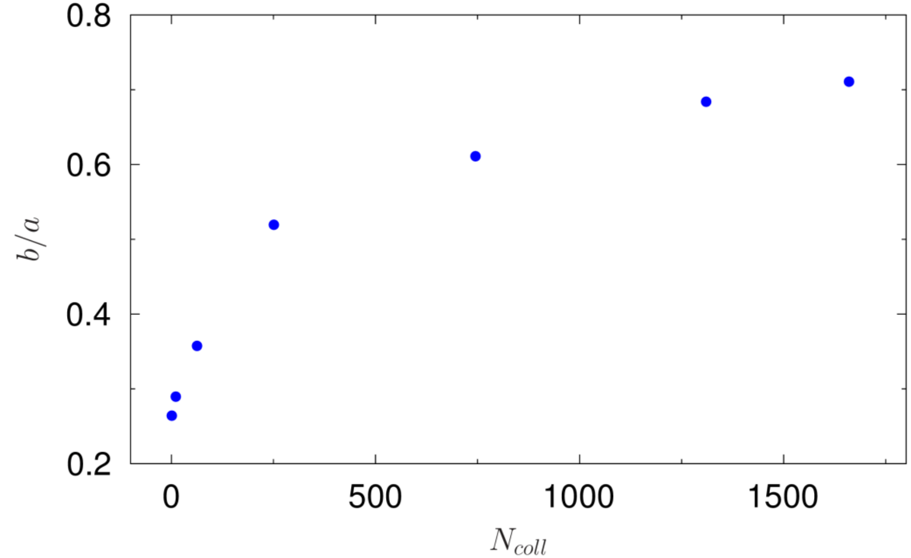

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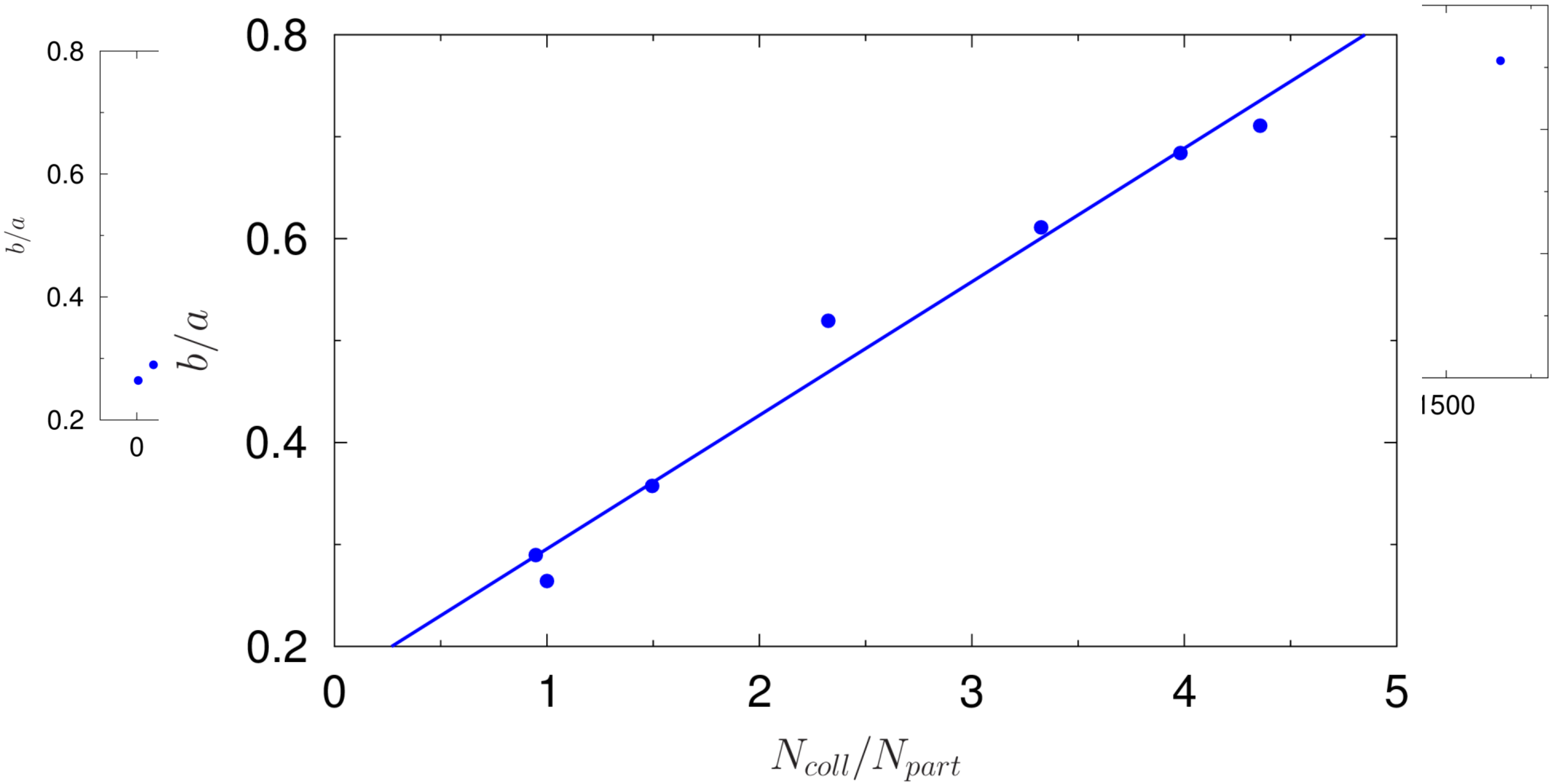
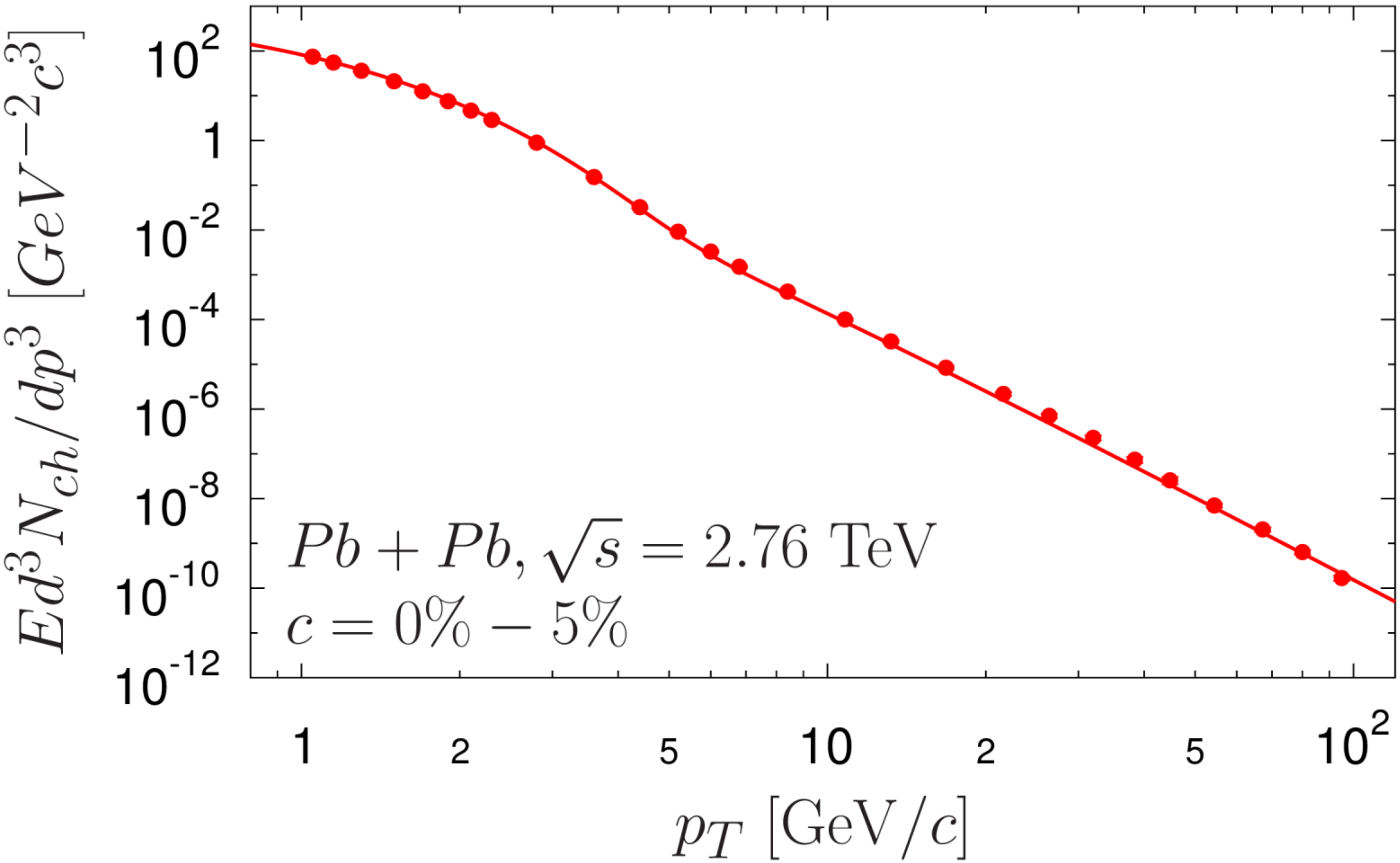


Two component fit

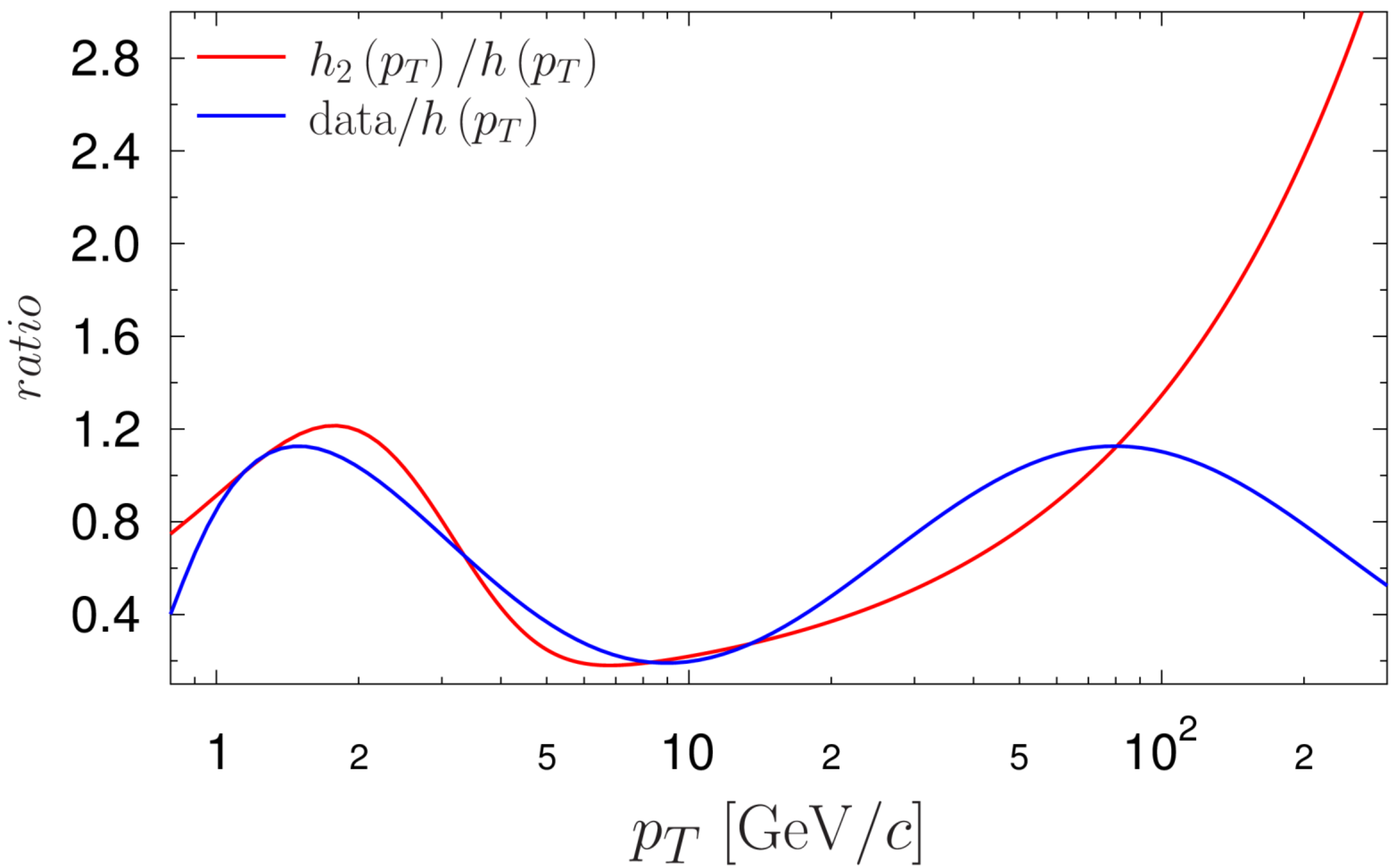
$$h_2(p_T) = C_1 \cdot \left(1 + \frac{p_T}{m_1 T_1}\right)^{-m_1} + C_2 \cdot \left(1 + \frac{p_T}{m_2 T_2}\right)^{-m_2}$$



Details in:

T.S. Biro, G.G. Barnafoldi, P. Van and K. Urmossy, arXiv:1404.1256 [hep-ph]

Ratios



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In the case of Pb+Pb collisions the amplitude of this oscillations increases linearly as a function of N_{coll} / N_{par}, and for the most central collisions we observe a spectacular oscillations.

Additional slides