HELIX STRING FRAGMENTATION AND CHARGED PARTICLE CORRELATIONS WITH ATLAS

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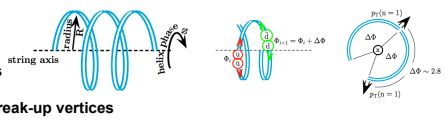
Phenomenology

QCD confinement modeled by 3D string
Vortex translated into helical chain of gluons



Requirement of causal cross-talk between break-up vertices reveals a quantization scheme : hadrons correspond to string pieces carrying multiple of ΔΦ (~2.8 rad) of helix phase.

Quantization proceeds in $m_t = n\,\kappa R\,\Delta\Phi$ rather than mass alone.
Non-trivial quantized correlations in the transverse plane (w.r.t. string axis). Sparsely populated QCD vacuum ?

More information to be found in : JHEP09(1998)014, Phys.Rev.D89(2014)015002

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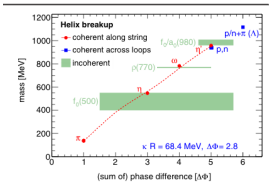


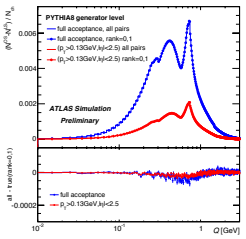
Experimental toolbox

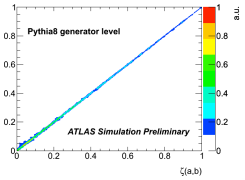
$\Delta(Q) = (N^{+-} - N^{++,--}) / N_{ch}$ [1]

extracts information from colour-adjacent hadrons

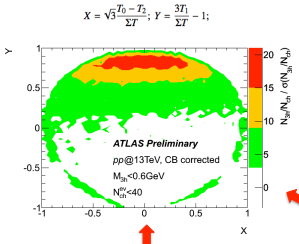
and for those:
$\zeta(a,b) = |p_a| / |p_b|$, $|p_a| < |p_b|$

correlates with fragmentation function

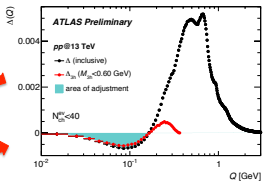


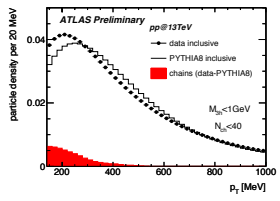


Anomalous production of like-sign pions predicted by the model & found in the data : source extracted (charge-ordered triplets constructed around each particle using mass minimization , M_{3h} <~ 0.6 GeV)



$$\Delta_{3h}(Q) = \frac{1}{N_{ch}} \sum_{i=1}^{N_{ch}} w_i \begin{cases} +\frac{1}{2}\,\delta(Q - Q_i^{+-\,min}) \\ +\frac{1}{2}\,\delta(Q - Q_i^{+-\,max}) \\ -1\,\delta(Q - Q_i^{++,--}) \end{cases}$$



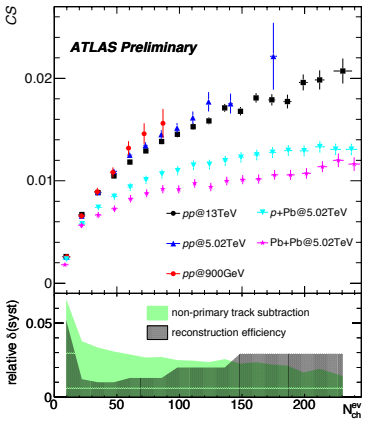


Signature of quantized fragmentation in 1-,2-,3-particle distributions

Model independent measurement

[1]

Model independent quantification of the anomalous production of close like-sign hadron pairs

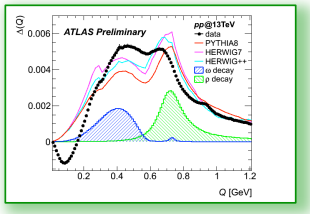


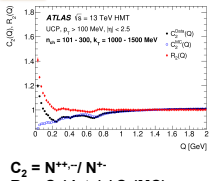
CS is the integral over the negative part of Δ(Q)

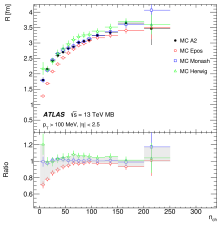
[1]

Quantized fragmentation absorbs data traditionally attributed to Bose-Einstein interference : links them to correlations between colour-adjacent hadrons (pure hadronization effect)

[2]

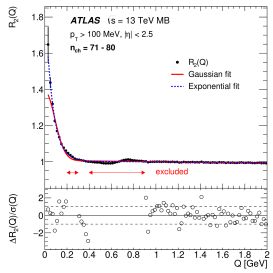


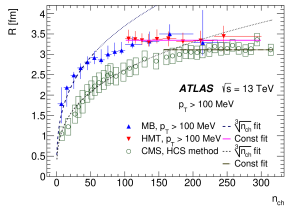




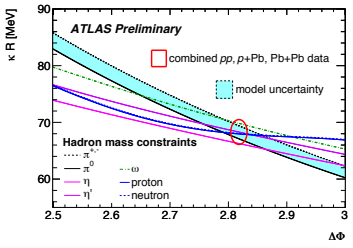
$C_2 = N^{++,--}/ N^{+-}$
$R_2 = C_2(data) / C_2(MC)$

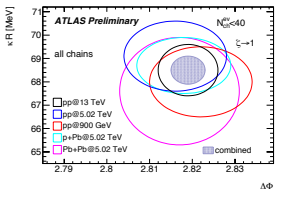
Correlation function is model dependent & there are no models which describe the data sufficiently well





[1]





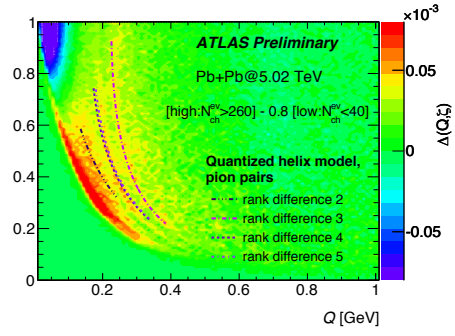
κ stands for string tension

- **model overconstrained : more observables than parameters**
- **very good agreement between pp, p+Pb, Pb+Pb data**

Measurement of model parameters using correlations between hadrons

BONUS : Signature of long pion chains observed in peripheral Pb+Pb collisions

Predictions published in 2017
Data collected in 2018



[1]

[1] *Study of ordered hadron chains in proton-proton,proton-lead and lead-lead collisions with ATLAS detector, ATLAS-CONF-2022-055*
[2] *Two-particle Bose-Einstein correlations in pp collisions at √s=13TeV with the ATLAS detector, Eur.Phys.J.C82(2022)608*

ATLAS EXPERIMENT