LUND UNIVERSITY

Discussion on CMS ridge effect
12 October 2010
CERN, Geneva

Some thoughts on the CMS ridge effect

Torbjörn Sjöstrand

Department of Astronomy and Theoretical Physics
Lund University

Apologies:

⋆ do not know the solution ⋆

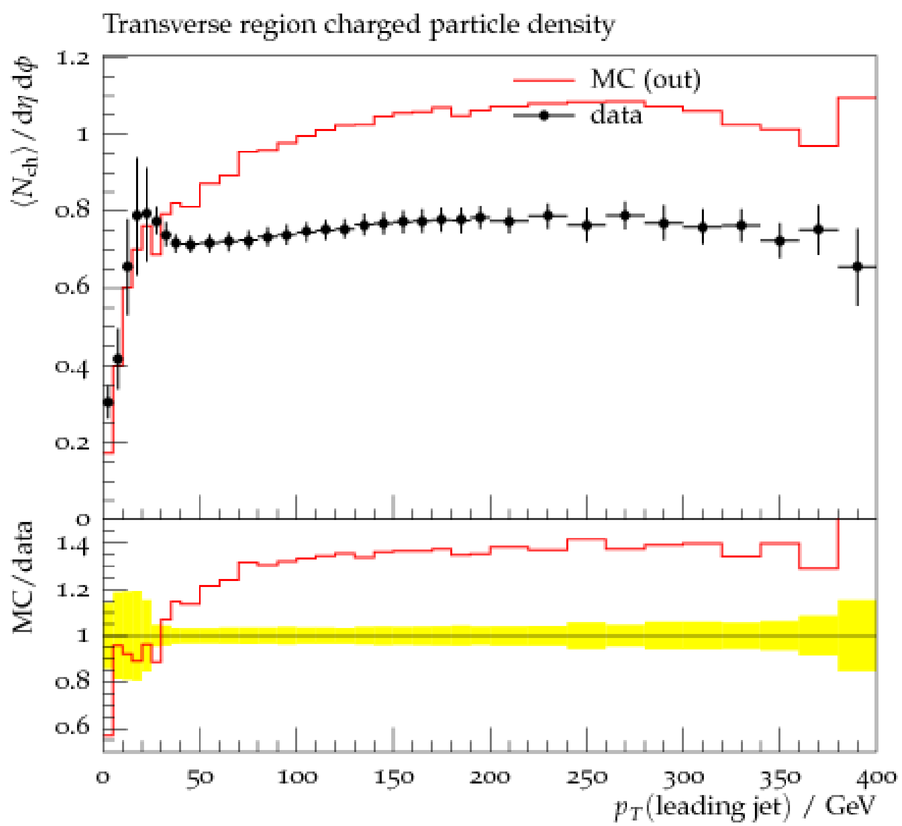
⋆ studies only simple last-minute ⋆

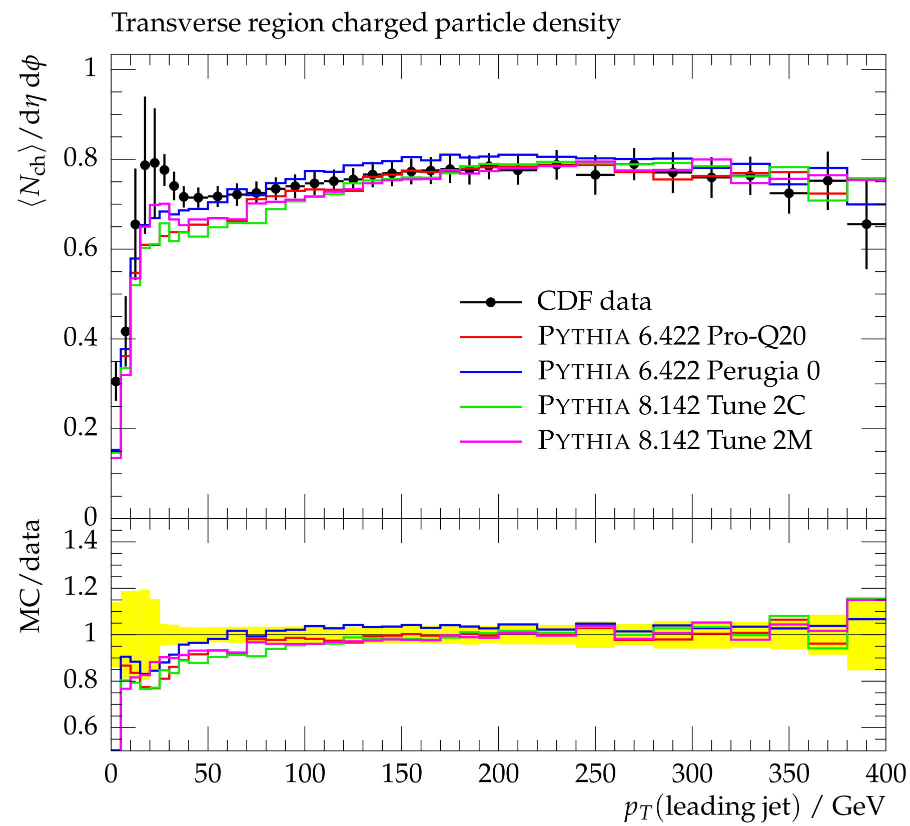
PYTHIA 8 version

For CMS studies PYTHIA 8.135 was used (!? P. Bartalini, private comm.)

No promises that current 8.142 would do any better, but . . . :

- fixed MB/UE conflict (FSR/ISR doublecounting)





- azimuthal angles of ISR slightly more aligned (coherence)

Impact-parameter plane

Impact parameter b crucially important in heavy-ion collisions.

Also needed e.g. for MPI to give a broad enough multiplicity distribution.

This defines a collision plane, and thereby possibly azimuthal anisotropies.

- additional pressure in plane $\Rightarrow$ faster expansion (HI) ?
- orbital angular momentum conservation ?

  K.G. Boreskov, A.B. Kaidalov, O.V. Kancheli, Eur.Phys.J.C58 (2008) 445

  P. Van Mechelen, private communication
- other mechanisms ?

Effects automatically spread over whole rapidity range.

But should then disappear at the largest multiplicities,
where impact parameter is close to zero:

n_{ch}	$\langle b \rangle \pm \sigma_b$	n_{event}
0 — 5	1.31 ± 0.36	225273
6 — 10	1.21 ± 0.37	256050
11 — 20	0.96 ± 0.35	254323
21 — 40	0.64 ± 0.29	198726
41 — 70	0.40 ± 0.21	61572
71 — 100	0.28 ± 0.16	3948
101 —	0.22 ± 0.12	108

$p_{\perp \mathrm{hard}}$	$\langle b \rangle \pm \sigma_b$	n_{event}
0 — 5	1.14 ± 0.41	585416
5 — 10	0.83 ± 0.42	338272
10 — 20	0.73 ± 0.41	69539
20 — 40	0.71 ± 0.41	6326
40 —	0.67 ± 0.39	447

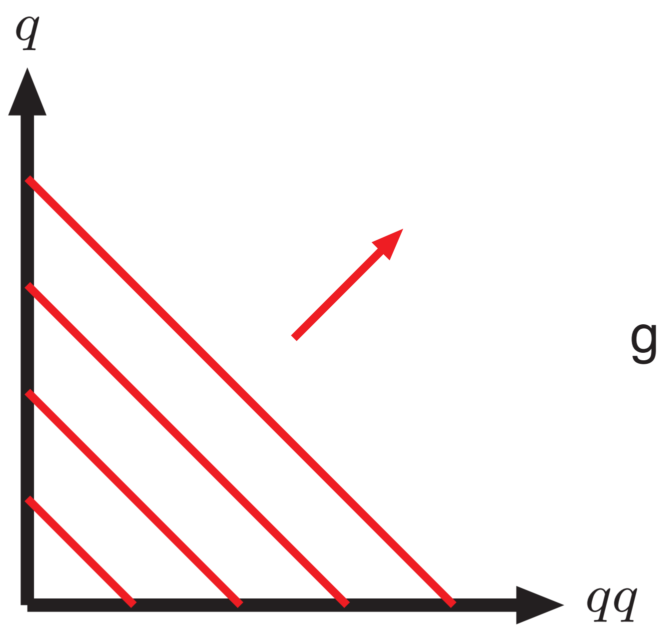
based on 10^6 “minbias” events, with PYTHIA 8.142 Tune 2C,
charged tracks in $|\eta| < 2.4$ and $p_{\perp} > 0.4$ GeV.
Normalization such that $\langle b \rangle \equiv 1$ for all “minbias” events.

Note: having one hard interaction does not bias as much as having a high charged multiplicity. You would need several hard ones to compete.

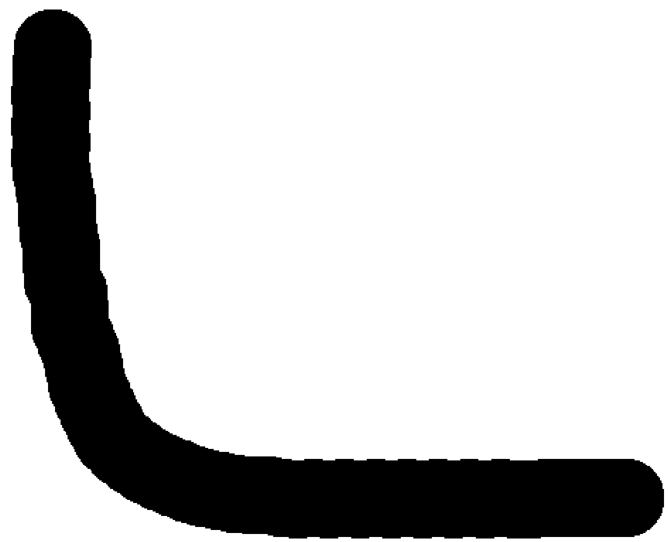
Way around (?): incoming proton state has elongated parton distribution
(C. Flensburg, G. Gustafson, L. Lönnblad)

String/dipole effect

String fragmentation along boosted axis in space-time
gives hadrons along hyperbolic region in momentum space.



gives



Excellent way to obtain effect in $p_\perp$ range 1 – 3 GeV:
- higher-$p_\perp$ hadrons mainly along hard jet axis
- lower-$p_\perp$ hadrons mainly symmetric around beam jet axis

. . . but effect should die out like $\exp(-\Delta y)$ away from jet axis,
so unlike CMS observation

Radiation off colour dipole stretched between high-$p_\perp$ parton and beam follows same pattern as string (same colour flow!), but

- DGLAP evolution of ISR roughly rapidity-ordered
  $\Rightarrow$ increasing decorrelation in Δy
- have compared with 3-jet ME's that PYTHIA 8.142 should have about right correlations (in the first shower emission)

Possible project: look for ridge effect in 4-parton (5-parton) ME's

Possible way out: BFKL dynamics?

For now: no valid idea how ridge came about

Suggestions for experimental analyses

1) Use a (mini)jet trigger.
Then look for a ridge in LOW-multiplicity events.

Reason: assume it is a dipole(+string) effect, after all.
If so, it is set by the colour flow of the hardest interaction;
further MPI will only dilute the primary effect by random noise.
High-multiplicity trigger has only been indirect way to pick jet events.

Then better select events with pair of jets, but few further MPI,
and study azimuthal distribution of particles w.r.t. jet plane
as you move further away in η from the two jets.

Further: colour flow different between events;
sometimes only dipoles stretched from high-$p_\perp$ to one beam,
so ridge only on one side of the jets, unlike geometrical picture.
Thus: look for ridge event-by-event.

2) Long-range correlations in (pseudo)rapidity, e.g. like UA5:

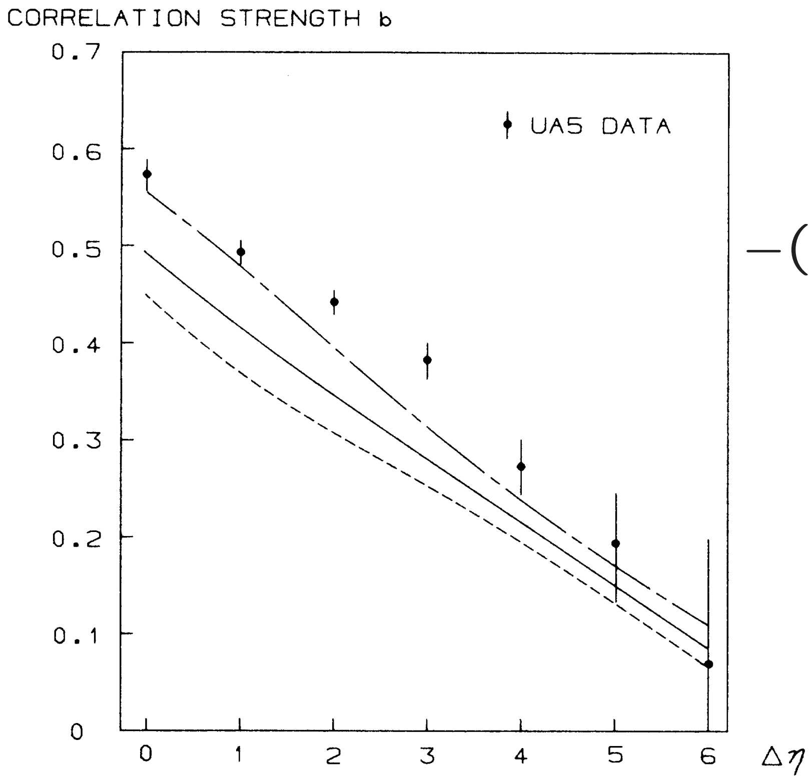
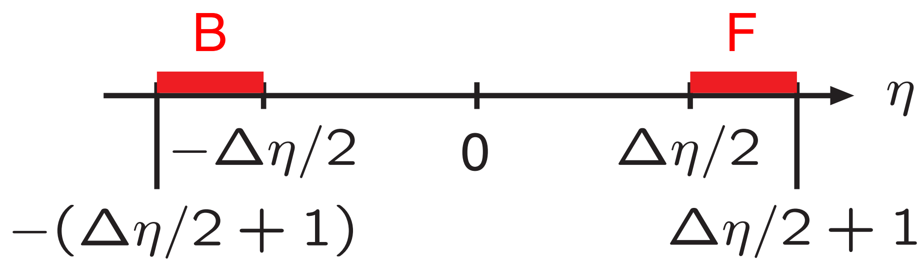


FIG. 6. Forward-backward multiplicity correlation at 540 GeV, UA5 results (Ref. 33) vs impact-parameter-independent multiple-interaction model; the latter with notation as in Fig. 5.

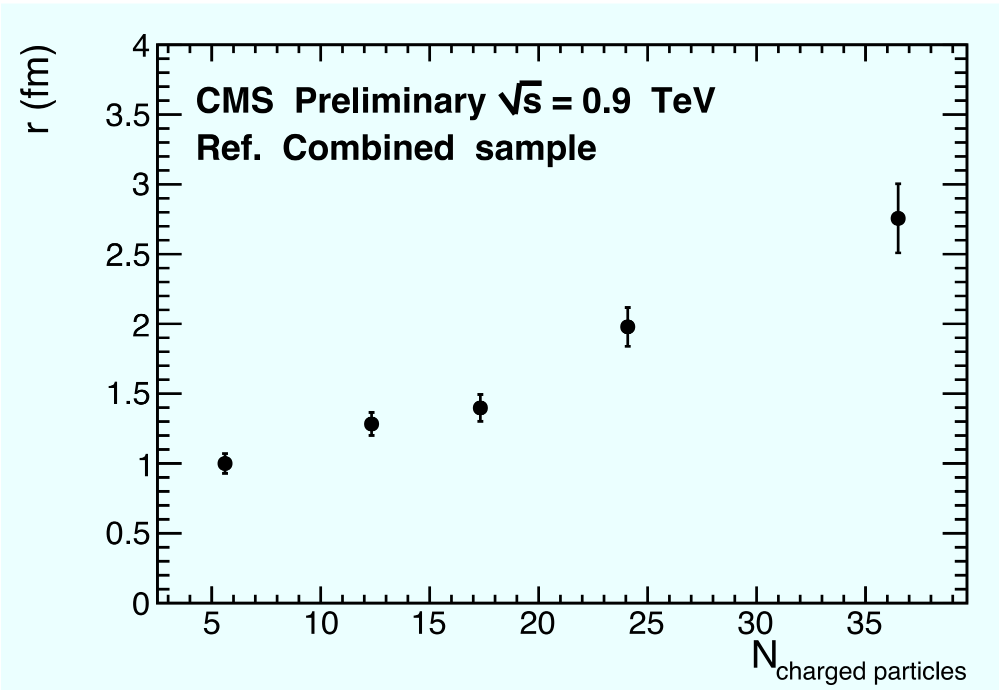


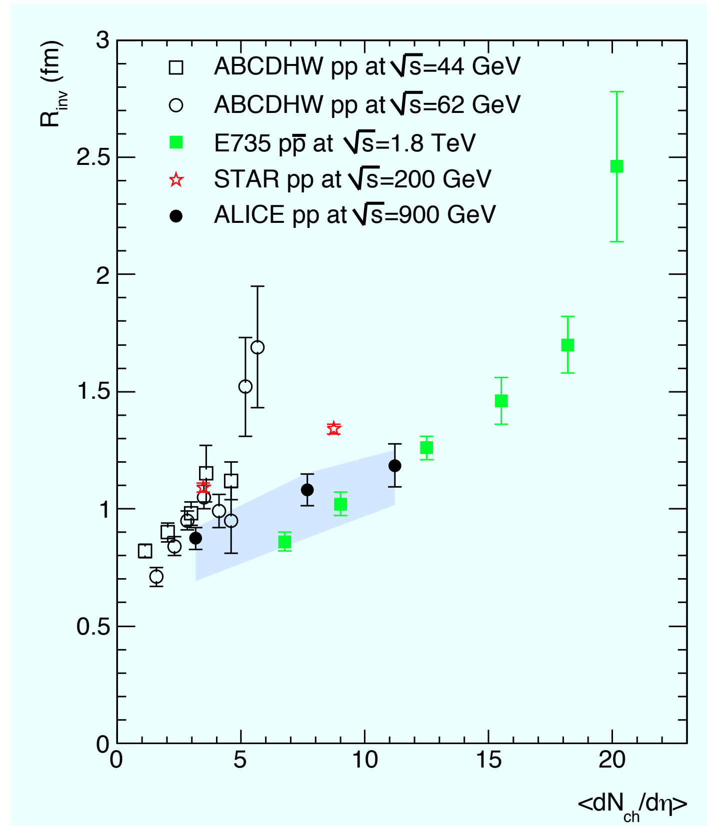
correlation coefficient between two sliding windows

$$b = \frac{\langle n_F n_B \rangle - \langle n_F \rangle^2}{\langle n_F^2 \rangle - \langle n_F \rangle^2}$$

Could also be applied to energy flow, restricted φ slices, high-n_F region, . . . , to explore correlations in general

3) Correlate with Bose-Einstein studies.





Increasing radius with increasing multiplicity indicates
dense fragmentation region (many strings on top of each other),
thus dense hadron gas with large radius of last scattering.
Ridge should correlate with asymmetric BE source in transverse plane.