Angular correlations of identified particles in pp collisions in ALICE

Anna Zaborowska

Supervisors:
M.Sc. Łukasz Graczykowski
M.Sc. Małgorzata Janik
Dr. Adam Kisiel

Warsaw University of Technology

05.12.2012

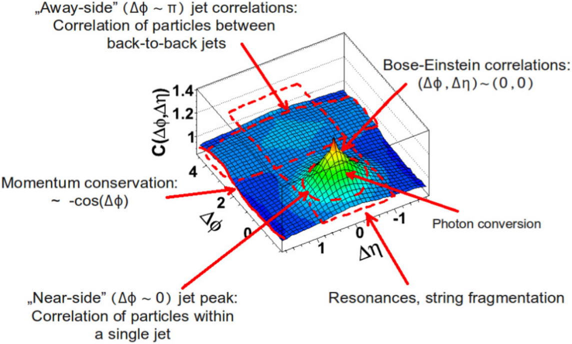
Outline

1. Motivation to study
   - Physics goals
   - Conservation laws
2. Analysis
   - Data sample
   - Construction of correlation function
3. Correlation functions
   - Collision data
   - MC truth data
     - Pythia
     - Phojet
4. Summary

Physics goals

Characterisation of different correlation sources:

- minijets,
- femtoscopic correlations,
- resonances,
- photon conversion,
- **conservation laws**,
- ...



Each source has a different distribution in $\Delta\eta\Delta\varphi$ that contributes to the total correlation function.

Conservation laws

Production of different types of particles is influenced by the **different conservation laws**.

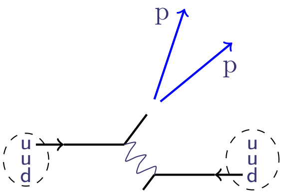
The correlation functions of different particles (with different **quark contents**) need to be analysed.

	conservation law			
particle	momentum	charge	strangeness	baryon number
pions	✓	✓		
kaons	✓	✓	✓	
protons	✓	✓		✓

Conservation laws

Laws conserved globally

In the whole event each of the conservation laws must be obeyed.



- momentum
- charge

  $q = e + e$
- strangeness

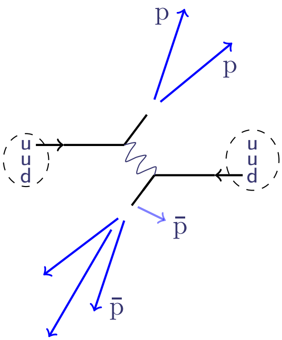
  $S = 0$
- baryon number

  $B = 1 + 1$

Conservation laws

Laws conserved globally

In the whole event each of the conservation laws must be obeyed.



- momentum
- charge

  $q = e + e - e - e = 0$
- strangeness

  $S = 0$
- baryon number

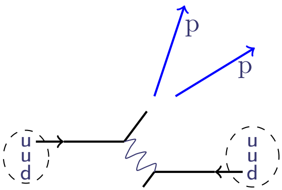
  $B = 1 + 1 - 1 - 1 = 0$

Conservation laws

Laws conserved locally for each fragmentation

If one assumes that the near-side peak is a result of parton fragmentation, than in each minijet there must be charge, strangeness and baryon number conserved.

Momentum of the minijet has to be balanced with the momenta of the particles going in the opposite direction.



- charge

  $q = e + e$
- strangeness

  $S = 0$
- baryon number

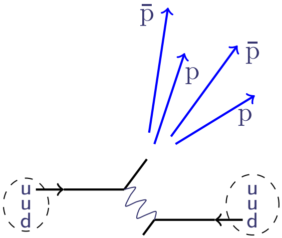
  $B = 1 + 1$

Conservation laws

Laws conserved locally for each fragmentation

If one assumes that the near-side peak is a result of parton fragmentation, than in each minijet there must be charge, strangeness and baryon number conserved.

Momentum of the minijet has to be balanced with the momenta of the particles going in the opposite direction.



- charge

  $q = e + e - e - e = 0$
- strangeness

  $S = 0$
- baryon number

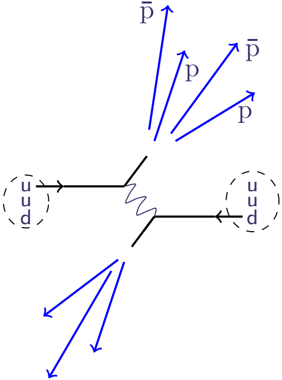
  $B = 1 + 1 - 1 - 1 = 0$

Conservation laws

Laws conserved locally for each fragmentation

If one assumes that the near-side peak is a result of parton fragmentation, than in each minijet there must be charge, strangeness and baryon number conserved.

Momentum of the minijet has to be balanced with the momenta of the particles going in the opposite direction.



- charge

  $q = e + e - e - e = 0$
- strangeness

  $S = 0$
- baryon number

  $B = 1 + 1 - 1 - 1 = 0$

Data sample

Data used in analysis come from **pp** collisions at centre of mass collision energy $\sqrt{s} = \mathbf{7\ TeV}$ registered by ALICE in **2010**.

About **165 million** minimum bias events have been analysed.

Particles were reconstructed and identified using the Inner Tracking System (ITS), the Time Projection Chamber (TPC) and the Time-Of-Flight detector (TOF).

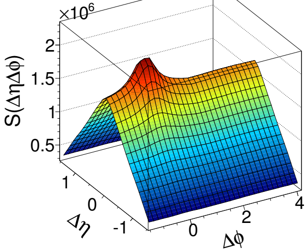
The analysis was performed on particles:

- located within $\left(0.018 + 0.035 p_{\mathrm{T}}^{-1.01}\right)$ cm in the transverse plane and 2.0 cm in the beam direction with respect to the primary vertex,
- within the pseudorapidity range $|\ \boldsymbol{\eta}\ | < \mathbf{1}$,
- with the transverse momenta higher than:
  - $p_{\mathrm{T}} > 100\ ^{\mathrm{MeV}}/_{c}$ for pions,
  - $p_{\mathrm{T}} > 300\ ^{\mathrm{MeV}}/_{c}$ for kaons,
  - $p_{\mathrm{T}} > 500\ ^{\mathrm{MeV}}/_{c}$ for protons.

Construction of correlation function

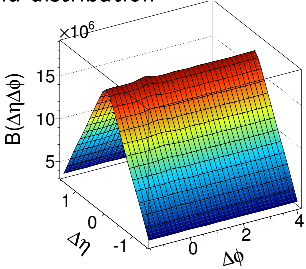
Signal distribution

$$S\left(\Delta\eta,\Delta\varphi\right)=\frac{\mathrm{d}^2 N^{\mathrm{signal}}}{\mathrm{d}\Delta\eta\mathrm{d}\Delta\varphi}$$

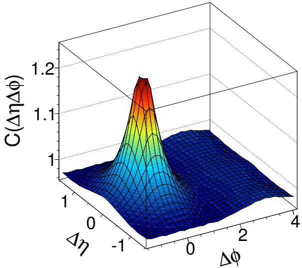


Background distribution

$$B\left(\Delta\eta,\Delta\varphi\right)=\frac{\mathrm{d}^2 N^{\mathrm{mixed}}}{\mathrm{d}\Delta\eta\mathrm{d}\Delta\varphi}$$



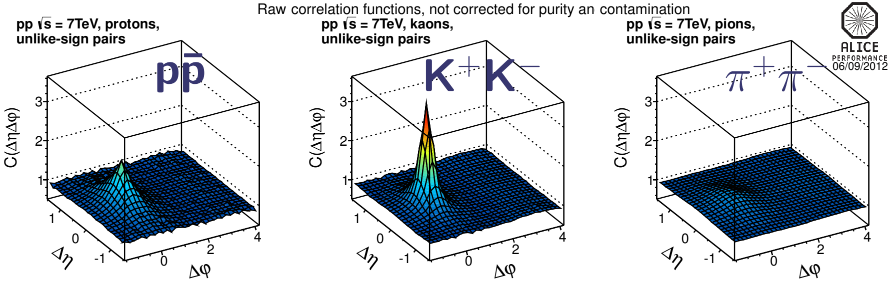
Ratio



$$C\left(\Delta\eta,\Delta\varphi\right)=$$

$$=\frac{N^{\mathrm{mixed}}_{\mathrm{pairs}}}{N^{\mathrm{signal}}_{\mathrm{pairs}}}\frac{S(\Delta\eta,\Delta\varphi)}{B(\Delta\eta,\Delta\varphi)}$$

Unlike-sign pairs

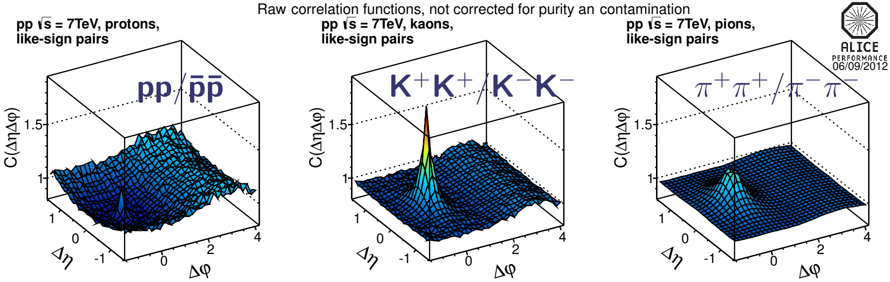


While creating unlike-sign particles **the least energetically expensive** is always to produce **the particle-antiparticle pair**. Such pairs produce **the strong near-side peak** in the identified correlations.

The **strength of the correlation** depends on the energetic price of the **alternative solution**. The larger the difference in prices between basic and alternative solutions, the stronger the correlation.

- for **pions** the alternative solution is just another opposite-charge particle;
- for **protons** that is another antibaryon (charged, or neutral plus additional charged particle);
- for **kaons**, which carry the strange quark, the alternative solution would be at least a lambda together with another baryon;

Like-sign pairs



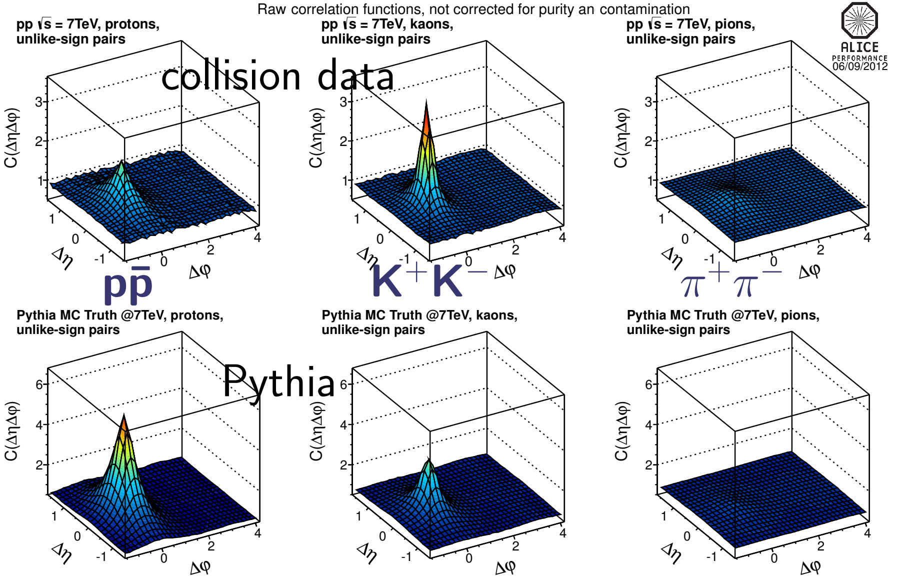
For like-sign particles **producing two identical particles is not the cheapest energetically** like for particle – antiparticle case.

Masses of the particles play a significant role:

- for **pions** and **kaons**: the prominent near-side peak in the correlation function (due to the minijets, femtoscopic correlations, resonances)
- for **protons**: a large dip near the $(\Delta\eta, \Delta\varphi) = (0, 0)$ is present (producing two heavy identical particles going in roughly the same direction and another two baryons (or antybarions) which are also heavy particles is an expensive solution).

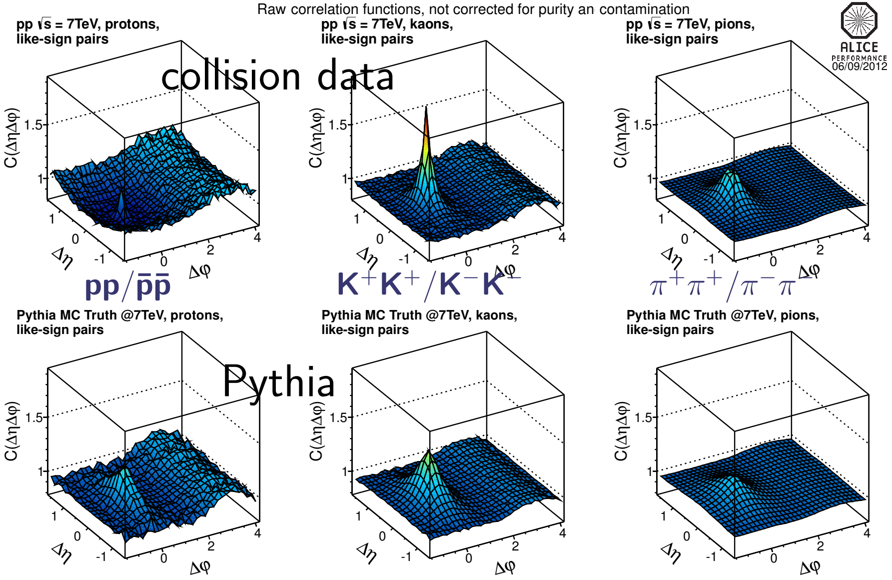
Unlike-sign pairs

Pythia does not reproduce the shape of the correlation function for identified particles.



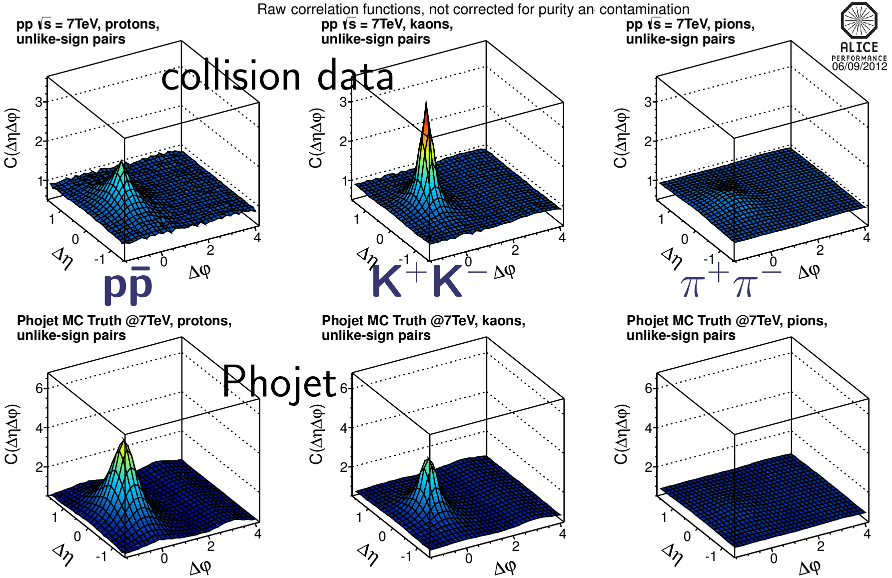
Like-sign pairs

Pythia does not reproduce the shape
of the correlation function for identified particles.



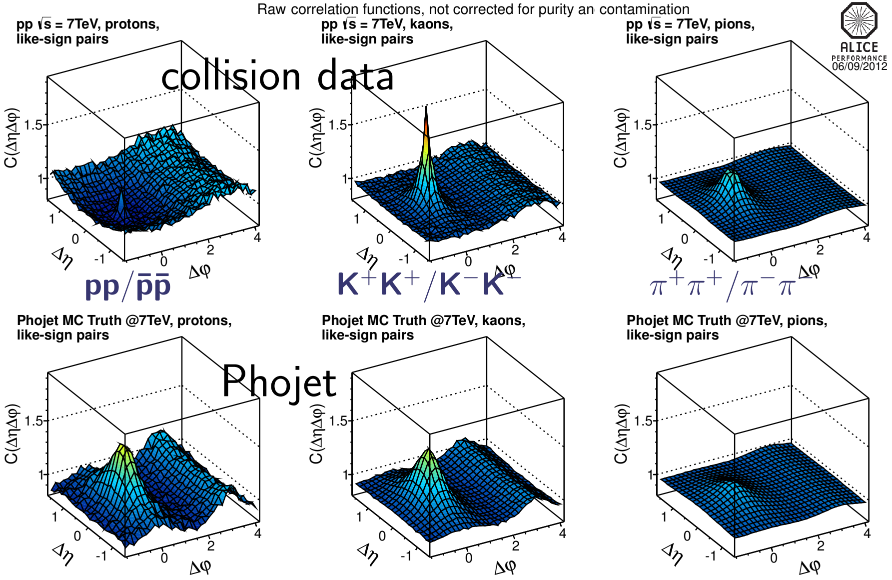
Unlike-sign pairs

Phojet does not reproduce the shape of the correlation function for identified particles.



Like-sign pairs

Phojet does not reproduce the shape
of the correlation function for identified particles.



Summary

Conservation laws play a significant role in determination of the shape of correlation functions.

- unlike-sign pairs of particles: correlation is the strongest for kaons, lower for protons, and the weakest for pions;
- like-sign pairs of particles: negative correlation near $(\Delta\eta, \Delta\varphi) = (0, 0)$ for protons;

Monte Carlo models do not reproduce the shape of the correlation functions for identified particles. Suggests that local quantum number conservation processes may not be modelled correctly.

Fitting procedure needs to be performed to quantitatively describe different features of the correlation functions.