Pion Correlation Predictions from *pp* collisions at the LHC from a Rescattering Model and Comparisons with Data

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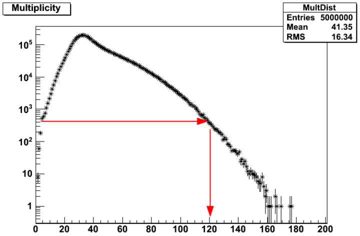
Initialize the Model

1. Set rescattering parameters.
   1. Proton radius $= 0.85\ fm$
   2. Hadronization time $= 0.3\ \frac{fm}{c}$
   3. Average time between scatterings $= 0.7\ \frac{fm}{c}$
   4. Determine impact parameter scale
2. Build *pp* collision event
3. Find initial positions in the center of mass frame

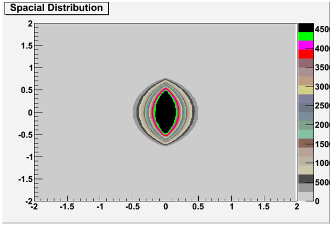


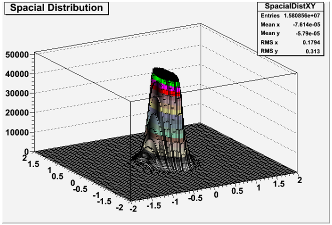
Impact Parameter

$$b = 2r_p \frac{N_{max} - N}{N_{max} - N_{min}}$$

Initialize the Model

1. Set rescattering parameters.
2. Build *pp* collision event
   1. Use Pythia 8.1 to simulate a *pp* collision
   2. Read through event and take earliest occurring rescatterable particles... (π, K, n, Λ, ρ, ω, η, Δ)
   3. Generate 2D overlap region, based on the event's initial multiplicity, for use as the hadrons' initial *xy* positions
   4. Randomly rotate reaction plane
3. Find initial positions in the center of mass frame



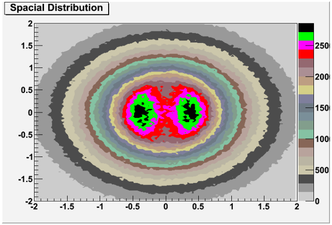


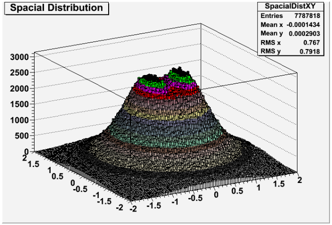
Initialize the Model

1. Set rescattering parameters.
2. Build *pp* collision event
3. Find initial positions in the center of mass frame
    1. Move particles relativistically to their initial hadronization positions in the lab frame

$$x_H = x_0 + \tau \frac{p_x}{m_0}$$
$$y_H = y_0 + \tau \frac{p_y}{m_0}$$
$$z_H = \tau \frac{p_z}{m_0}$$

    2. Convert τ_{Hadron} from proper time to lab frame for all particles





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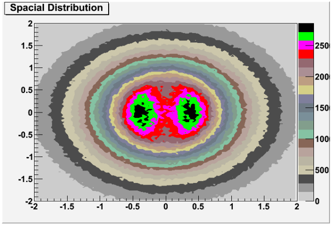
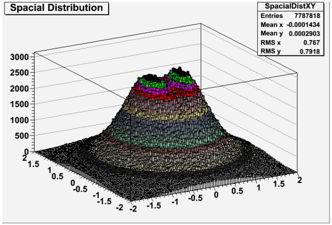
$$t_H = \tau \frac{E}{m_0}$$





Model Procedure

1. Cycle over all particles in increments of $t = 0.1 \ \frac{fm}{c}$ and check if they have...
   - hadronized. If yes then check to see if they have...
   - decayed since the last check. If so, then...
   - decay them and enter their daughters into the particle array
2. Scan each particle against all others and determine if each pair is close enough to scatter and if either partner has been scattered too recently.
3. If a pair can be scattered, determine if the collision will be inelastic. Then randomly generate a scattering angle in the pair's CMS frame. Update each particle's (or new daughter's) momentum
4. Once scattering is done, move each particle relativistically to its position for the next time step
5. Repeat until freezeout and record each particle's final state momentum and the coordinates of it's last collision

Allowed Inelastic Collisions and Decays

Resonances and their Decay Modes:

- $\pi + \pi \longrightarrow \rho \longrightarrow \pi + \pi$
- $\pi + \pi \longrightarrow \eta \longrightarrow \pi + \pi$
- $\pi + \pi \longrightarrow \eta' \longrightarrow \pi + \pi + \pi$
- $\pi + \pi \longrightarrow \omega \longrightarrow \pi + \pi + \pi$
- $\pi + \pi \longrightarrow \phi \longrightarrow K + K$
- $K + K \longrightarrow \phi \longrightarrow K + K$
- $\pi + n \longrightarrow \Delta \longrightarrow \pi + n$
- $\pi + K \longrightarrow K^{\star} \longrightarrow \pi + K$

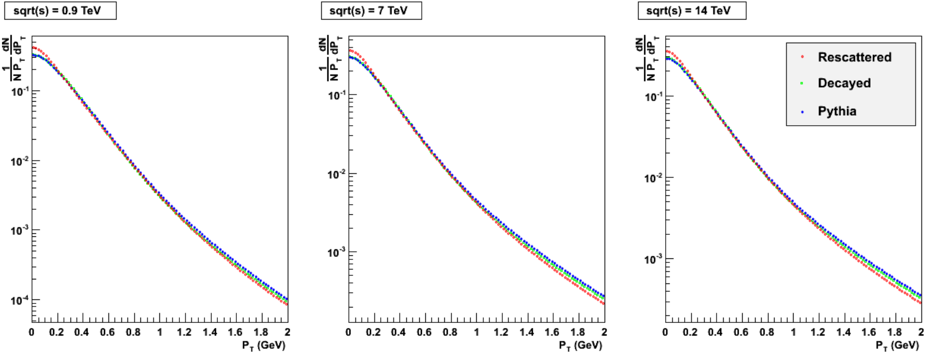
- $\Lambda \longrightarrow \pi + n$

Inelastic Collisions:

- $n + n \longrightarrow n + \Delta$
- $\pi + n \longrightarrow \pi + \Delta$
- $\pi + n \longleftrightarrow K + \Lambda$
- $K + n \longleftrightarrow \pi + \Lambda$

Kinematic Observables

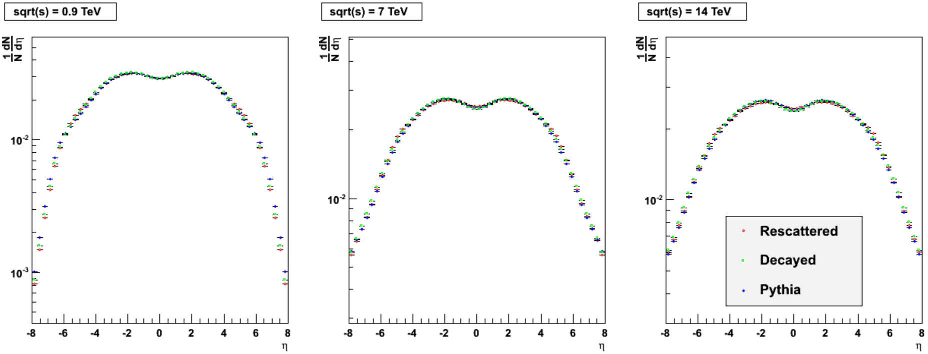
P_T Distribution:



Rescattering model accurately reproduces final state Pythia P_T and η distributions.

Kinematic Observables

η Distribution:



Rescattering model accurately reproduces final state Pythia P_T and η distributions.

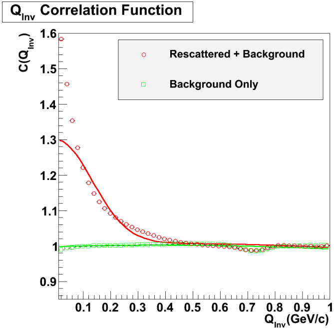
Fitting Function and Cuts

Track Cuts:

- $P_T \rightarrow 0.100 - 1.000 \ GeV$
- $\eta \rightarrow -0.800 - 0.800$

Pair Cuts:

- $k_T \rightarrow 0.100 - 1.000 \ GeV$



Guassian Fit:

$$C_2(q) = B(q)\, N[1 + \lambda e^{-R^2 q^2}]$$

where the background function is

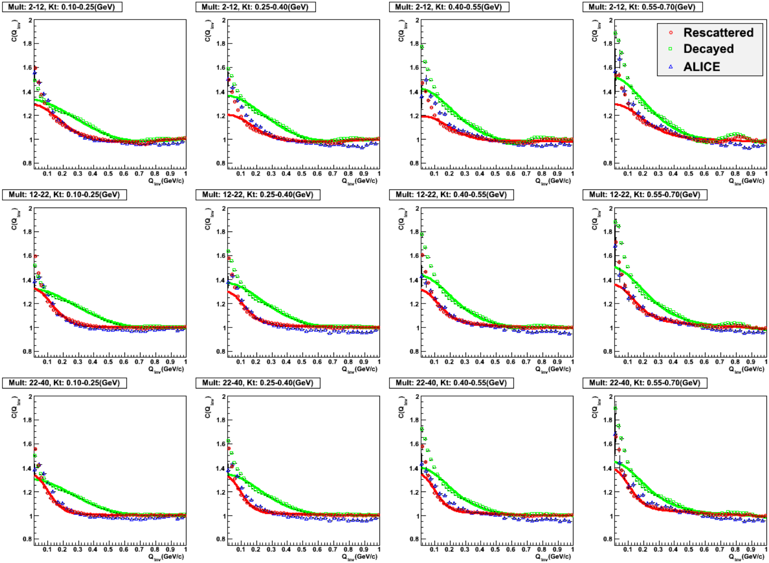
$$B(q) = b_0 + b_1 q + b_2 q^2$$

Bose-Einstein Weights:

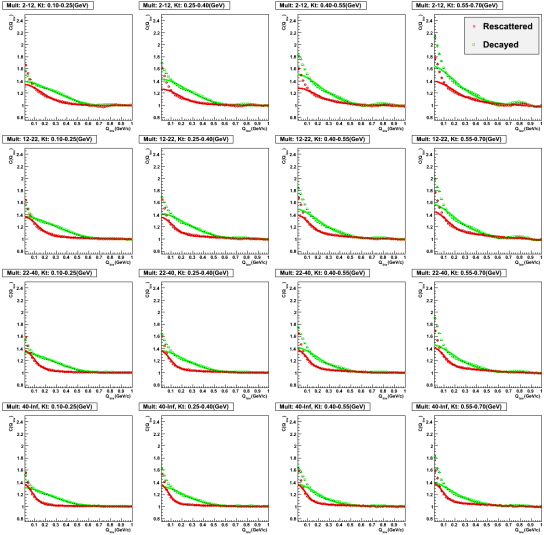
Real pairs weighted by

$$W = 1 + \cos(q \cdot \triangle r)$$

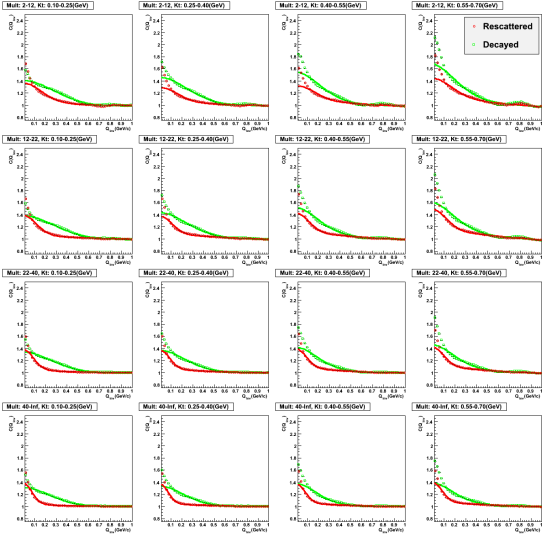
HBT Correlation Functions at sqrt(s) = 0.9 TeV



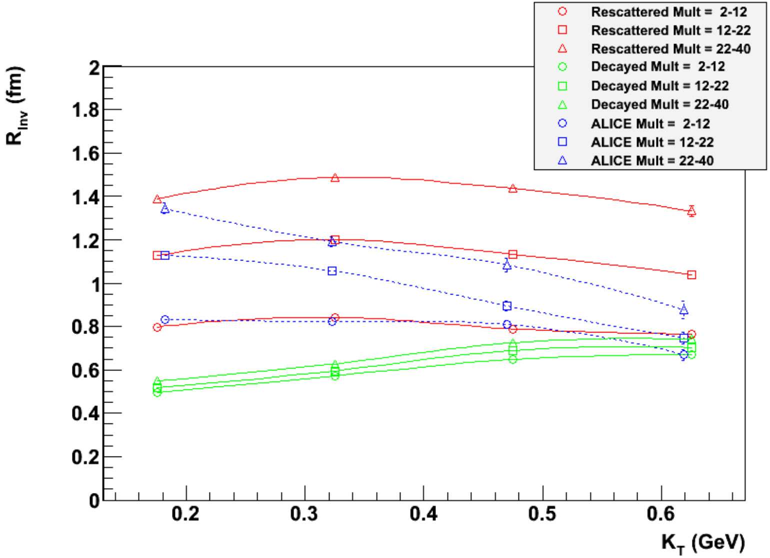
HBT Radii at sqrt(s) = 7 TeV



HBT Radii at sqrt(s) = 14 TeV

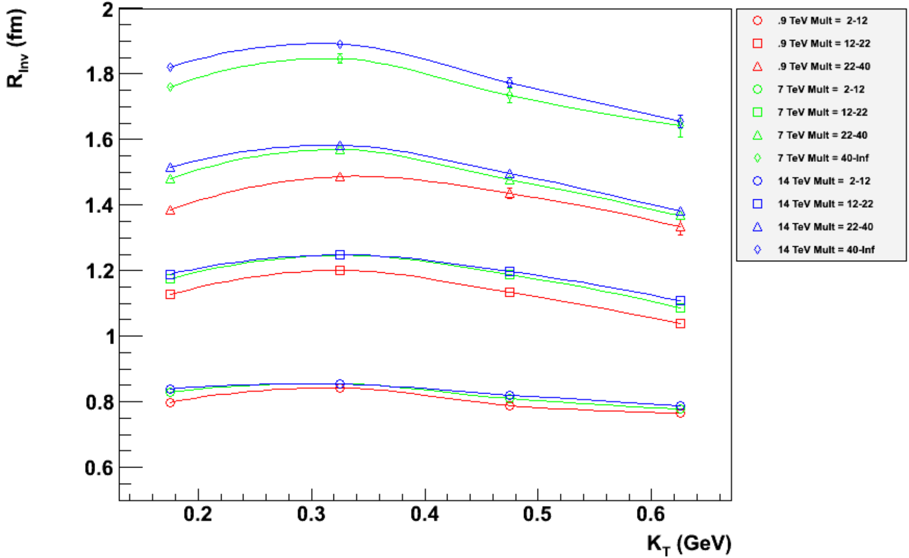


HBT Radii at sqrt(s) = 0.9 TeV

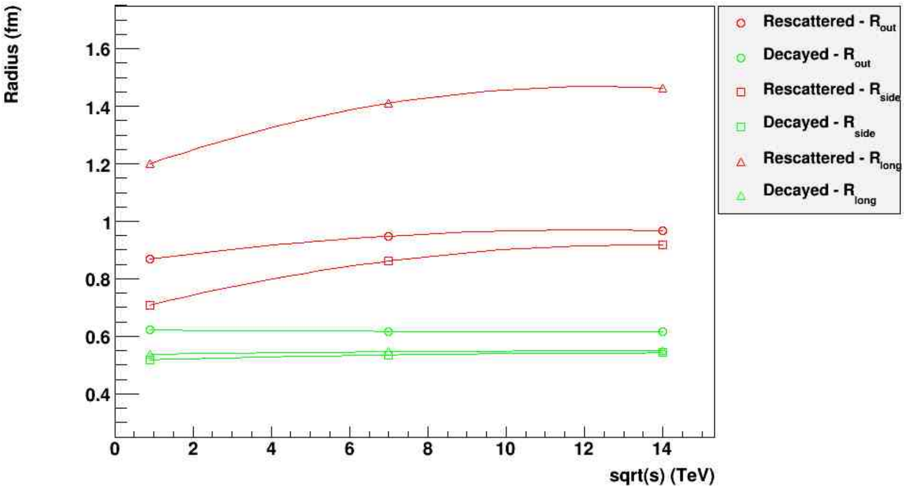


ALICE data taken from **arXiv:1007.0516v1 [hep-ex]**

HBT Radii at sqrt(s) = 0.9, 7, and 14 TeV



3D HBT Radii at sqrt(s) = 0.9, 7, and 14 TeV



Summary

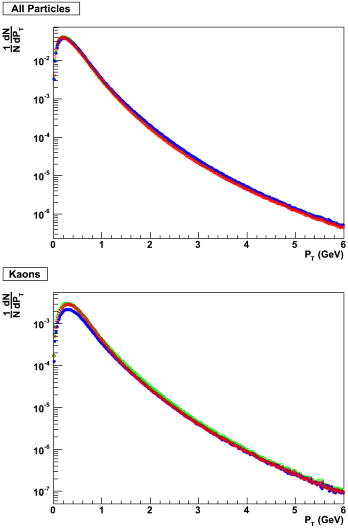
- Hadron rescattering has relatively little effect on initial state P_T and η distributions
- Rescattering contributes to larger HBT radii with increasing multiplicity, but does not explain observed k_T dependence
- Effect of hadron rescattering on HBT radii is largely independent of initial center of mass energy at LHC energies

Ongoing Work

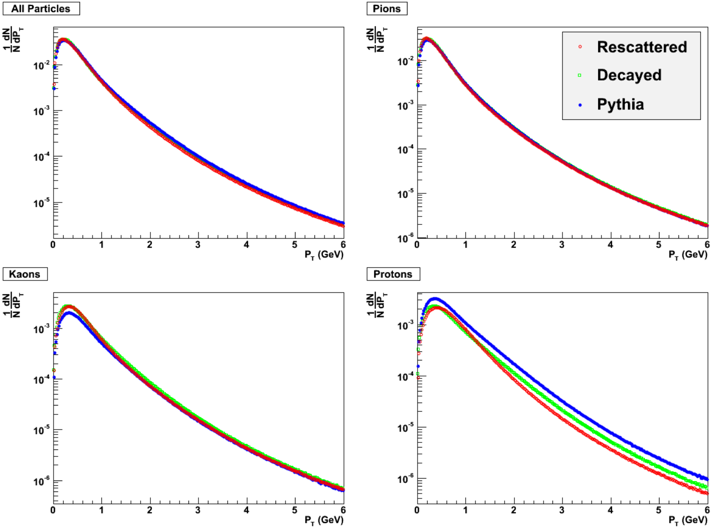
- Analysis of m_T dependence of 1D pion correlations
- Multiplicity, k_T, and m_T dependence of 3D pion correlations
- Investigation of exponential fits

Thank You

P_T Spectra at sqrt(s) = 0.9 TeV



P_T Spectra at sqrt(s) = 7 TeV



P_T Spectra at sqrt(s) = 14 TeV