Update on two identical π interferometry analysis in MIPP

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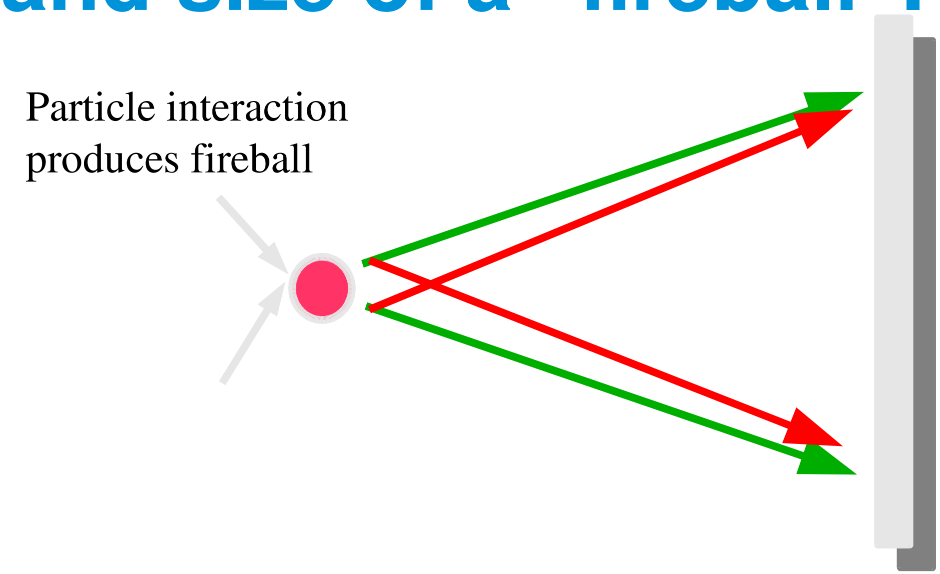
Outline:

- Separating the projectile data.
- Fitting interference peak to source radius
- Gamov correction of charge repulsion

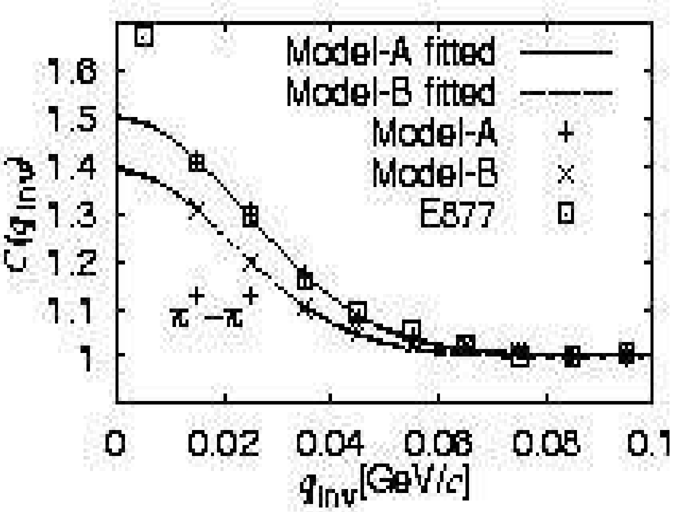
Origin of affect in particle physics:

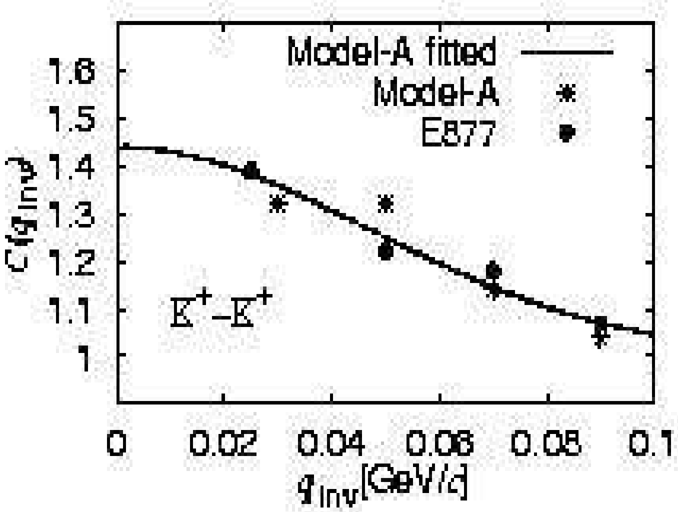
- **It was Goldhaber PRL v3 1959 that first accidentally saw this affect as an angular preference for pions at BNL.**
- **Independently in 1958 the Russian Physicist Landau has proposed using the HBT effect in particle physics interactions to study the lifetime and size of a ”fireball”.**



Particles detected away from fireball and $q = |p_{1\perp} - p_{2\perp}|$

Momentum Observations:

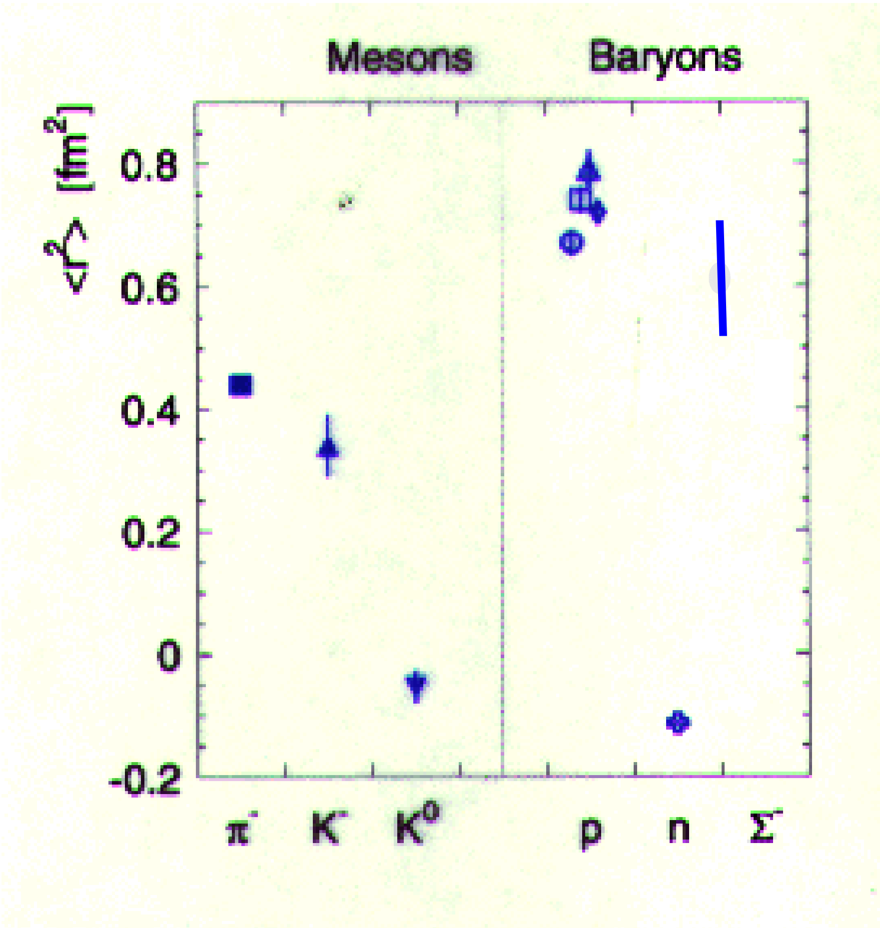




- Take all the π^+ in an event and compute q for each pair.
- Take a single π^+ from one event and compute q between it and all π^+ from another event to get the background.
- Take the bin-by-bin ratio of these two histograms to see the quantum mechanics HBT affect.

Current knowledge of radius:

- **MIPP has the ability to measure three projectile onto a fundamental target of Liquid Hydrogen**
- **Of most interest is improving charged Kaon point.**

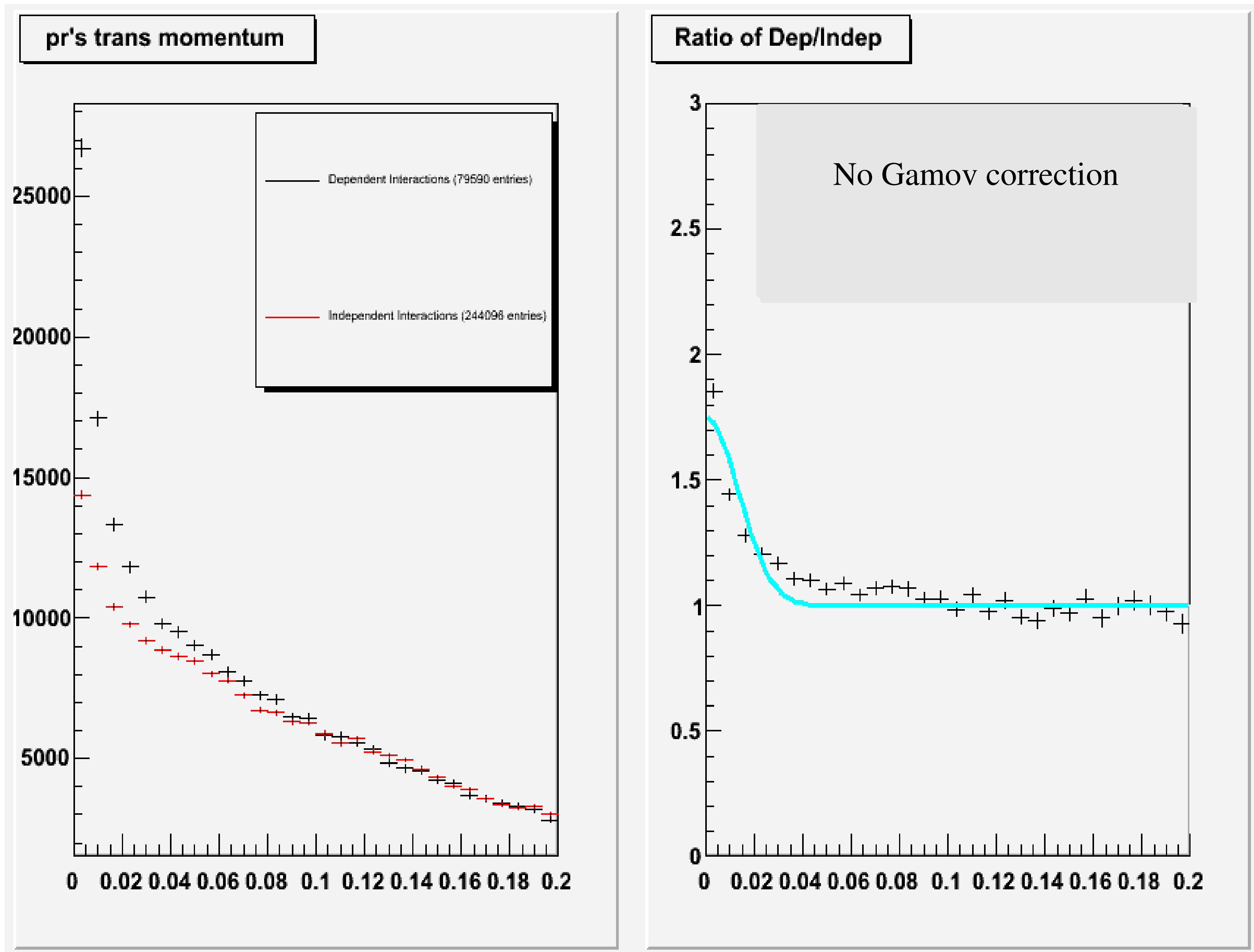


Status of Analysis

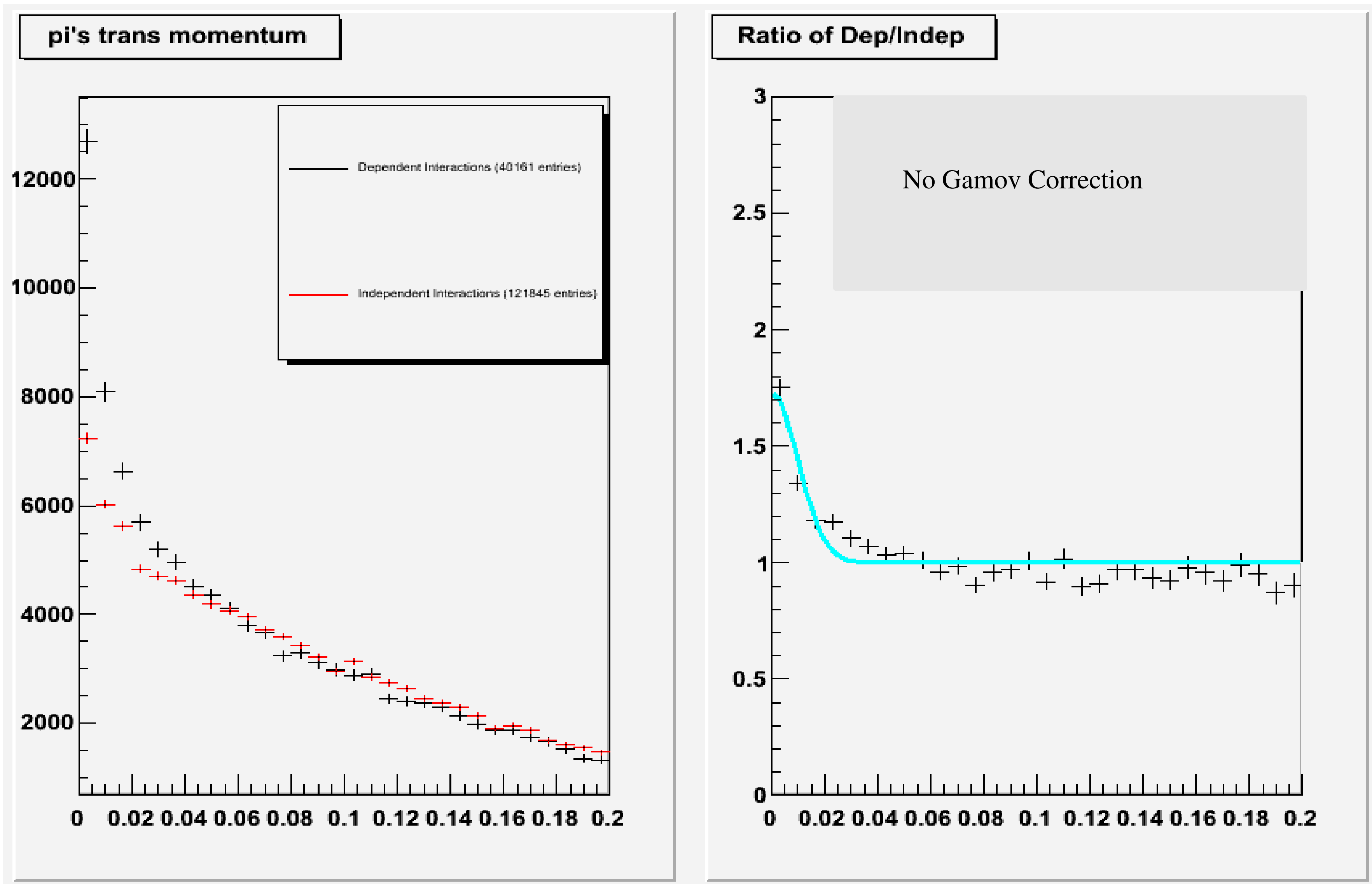
- So far our analysis has the charged particle in the TPC reconstructed for momentum and transverse momentum. Using only particles with p<1GeV/c.
- It also has the projectile particle identified with the Beam Ckov.
- The analysis has both the in time $q_{\perp}$ and the background from out of time particles. They are normalized in the tail between 0.5 and 1.0 GeV/c. We see the interference peak.

- We do not yet have:
  - Vertex cuts for particles coming only from the primary interaction.
  - TPC does not have charged pions tagged, so there is some dilution.
- Data shown is from 6 runs, all positive beam on Liquid Hydrogen target:
  - 13112, 13582, 13598, 13600, 13780 and 13808
  - This is 235,000 raw events.
  - Yields for useful events in plots shown inside box.

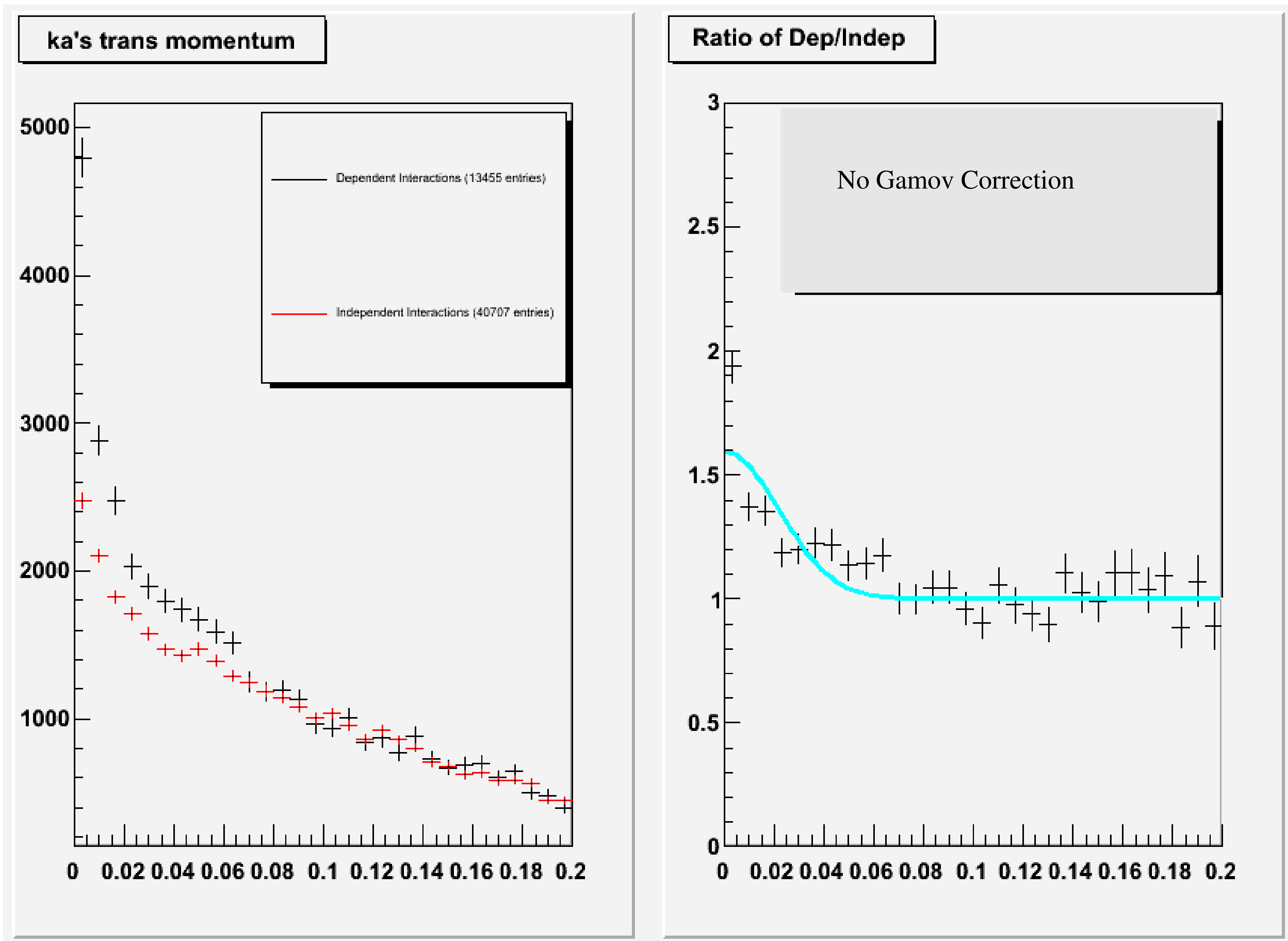
proton interaction data:



pion interaction data:



Kaon interaction data:



First results:

- From these 3 sets of plots we can already see that:
  - The proton interference peak goes out to 80 MeV/c
  - The pion interference peak is not as pronounced going out to 40 MeV/c, similar to other pion data show on slide 3.
  - The Kaon interference peak, our lowest statistics but already greater than the only other measurement from NA22 can be seen to go out to 60 MeV/c.

Charge repulsion Correction:

- Before the MIPP interference peak can be fitted to determine the interaction radius it has to be corrected for charge repulsion due to identical charge.
  - Classical Gamow correction
  - Scaled Gamow correction (Sinyukov fit)
  - Full Coulomb scaled correction

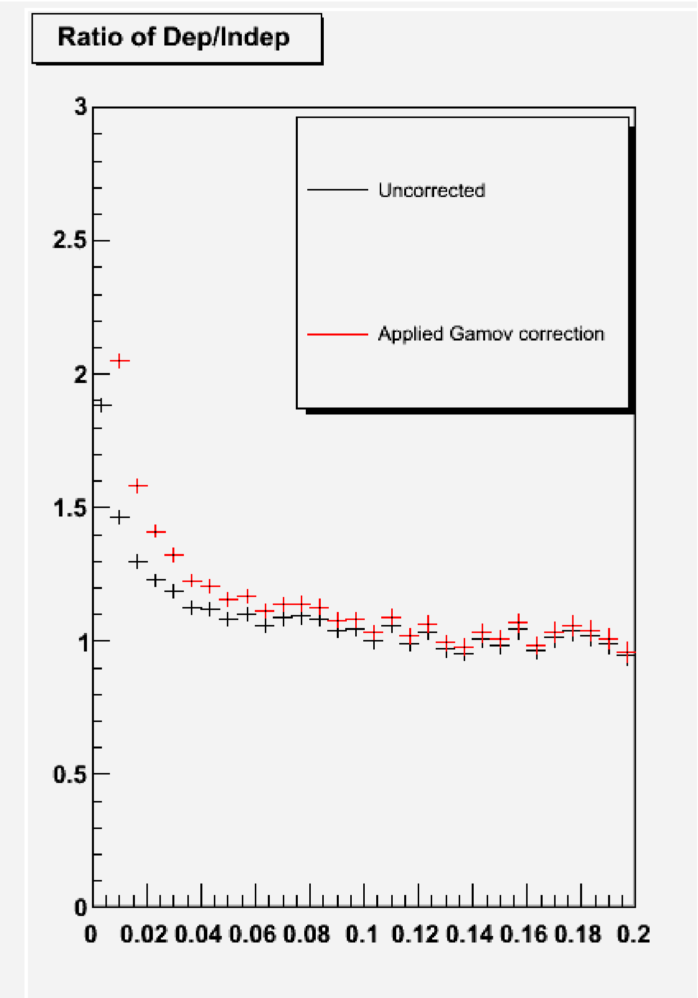
Classical Gamov Correction:

- We have implemented the classical Gamov correction, bin-by-bin in the interference ratio histogram:

$$R_{gamov} = R\, exp(2\pi m_{\pi}\, a/q_{i\text{-}center} - 1)/2\pi m_{\pi}\, a/q_{i\text{-}center}$$

where $a=1/137.038$ and $m_{\pi}=0.139567$ GeV/c^2

MIPP data Gamov corrected:



Black is Ratio uncorrected for charge.

Red is the Classical Gamov charge repulsion correction.

The wiggles on the tail are rarely seen, but are physically expected due to the interference effect.

Fitting for the source radius:

- There are many forms of the source radius to fit to:
  - $1+\lambda \exp(-q_{\perp}^{2} R^2/ \hbar^2 c^2)$
  - $1+\lambda \exp(-q_{\perp} R/ \hbar c)$

  Where λ is the coherency and R is the radius.

- NOT ready yet to quote any numbers but we have the software in place to fit these interference peaks to various forms.

Conclusion:

- We are making progress and see differences between Kaon, pion and proton data.
- This analysis is getting high statistics from the ongoing pass3 production run.
- Simple Gamov correction is in place bin-by-bin.
- Before we can believe the radius fit we need to:
  - develop primary interaction vertex cuts by projecting incoming particle with beam chambers and matching to an observed vertex in the TPC, plus limiting the distance of closest approach (doca) of TPC track back to this vertex.
  - Particle ID in TPC to use only pions.