net-proton moments compared to "IRV" cumulant arithmetic

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net-proton paper GPC discussion

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Backstory in recent bulkcorr presentations:

`http://wjllope.rice.edu/fluct/protected/moments_20130417.pps`
`http://wjllope.rice.edu/fluct/protected/moments_20130626.pps`

"Sampled singles" breaks the intra-event correlations "numerically/stochastically"
The stability of the sampled singles results *vs.* the TRandom3 seed is greatly improved by "oversampling," with the only expense being CPU time.

This sampled singles approach breaks any existing intra-event correlations between Np and Npbar by construction.
…Excellent reproduction of the experimentally measured net-p moments products.

There is however an approach to calculate the moments products that also assumes the absence of intra-event correlations that requires no sampling.

This approach is based on the additive properties of cumulants.

Introduction

We are interested in measuring Sσ and Kσ2 for net-protons here.
These quantities are related to the cumulants, C_k, as follows.

$S\sigma = C_3/C_2$ and $K\sigma^2 = C_4/C_2$ (C_1=mean, C_2=variance)

where C_k is a "cumulant."

A feature of cumulants is their additivity for pairs of independent random variables.
i.e. given independent random variables u and v, then

$$C_k(u+v) = C_k(u) + C_k(v)$$

But here, we are interested in Sσ and $K\sigma^2$ for **net-p**, *i.e.* "u-v" with u=Np and v=Npbar

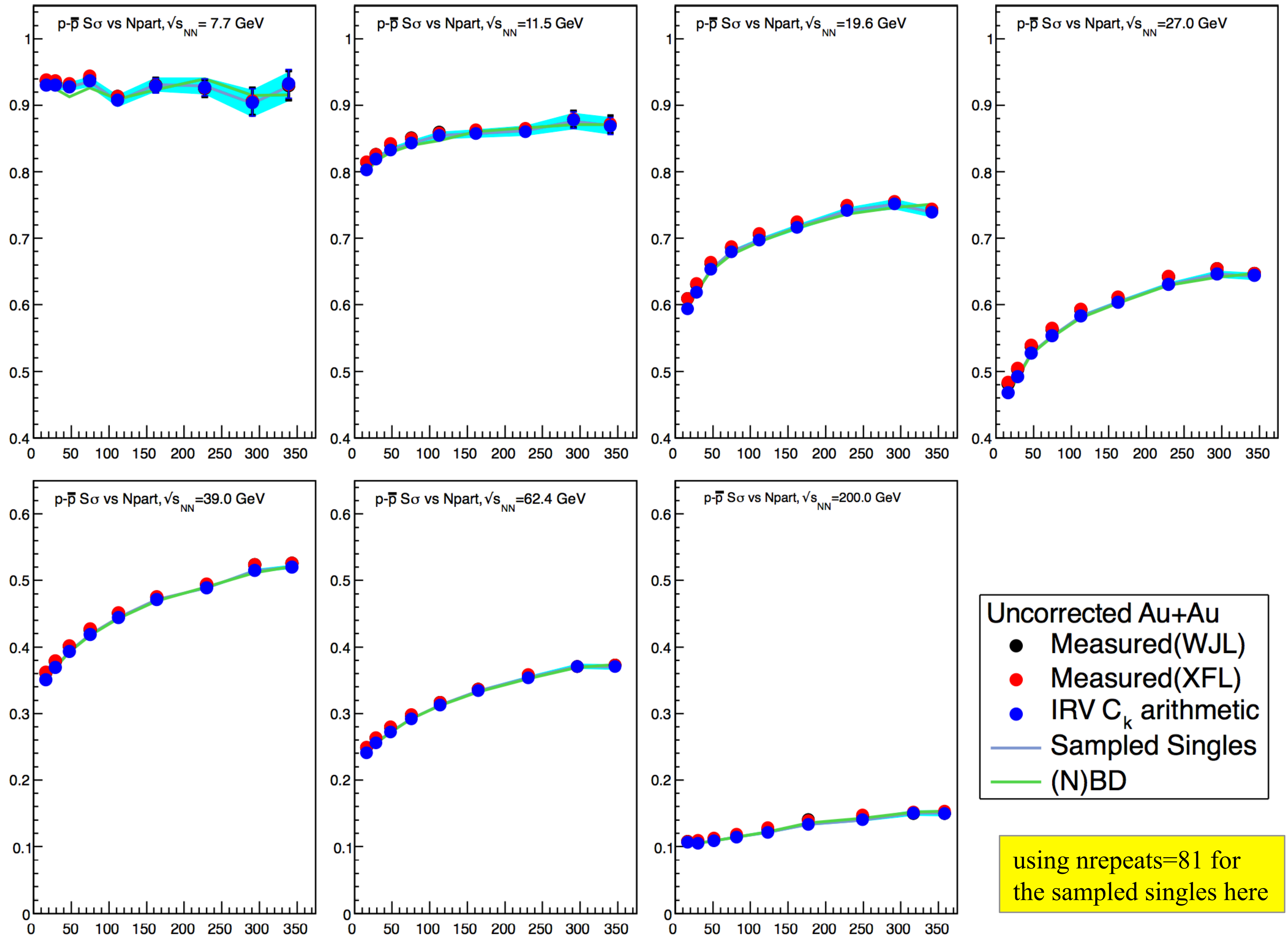
In this case, $C_k(u-v) = C_k(u) + (-1)^k \times C_k(v)$
This relation will only hold if u (Np) and v (Npbar) are random and independent variables.

So, here I'll calculate Sσ and $K\sigma^2$ using the values of $C_k(u-v)$ via $C_k(u)$ and $C_k(v)$

Tests the importance of intra-event correlations of Np and Npbar that requires no stochastic sampling. The information used here comes only from the singles distributions.

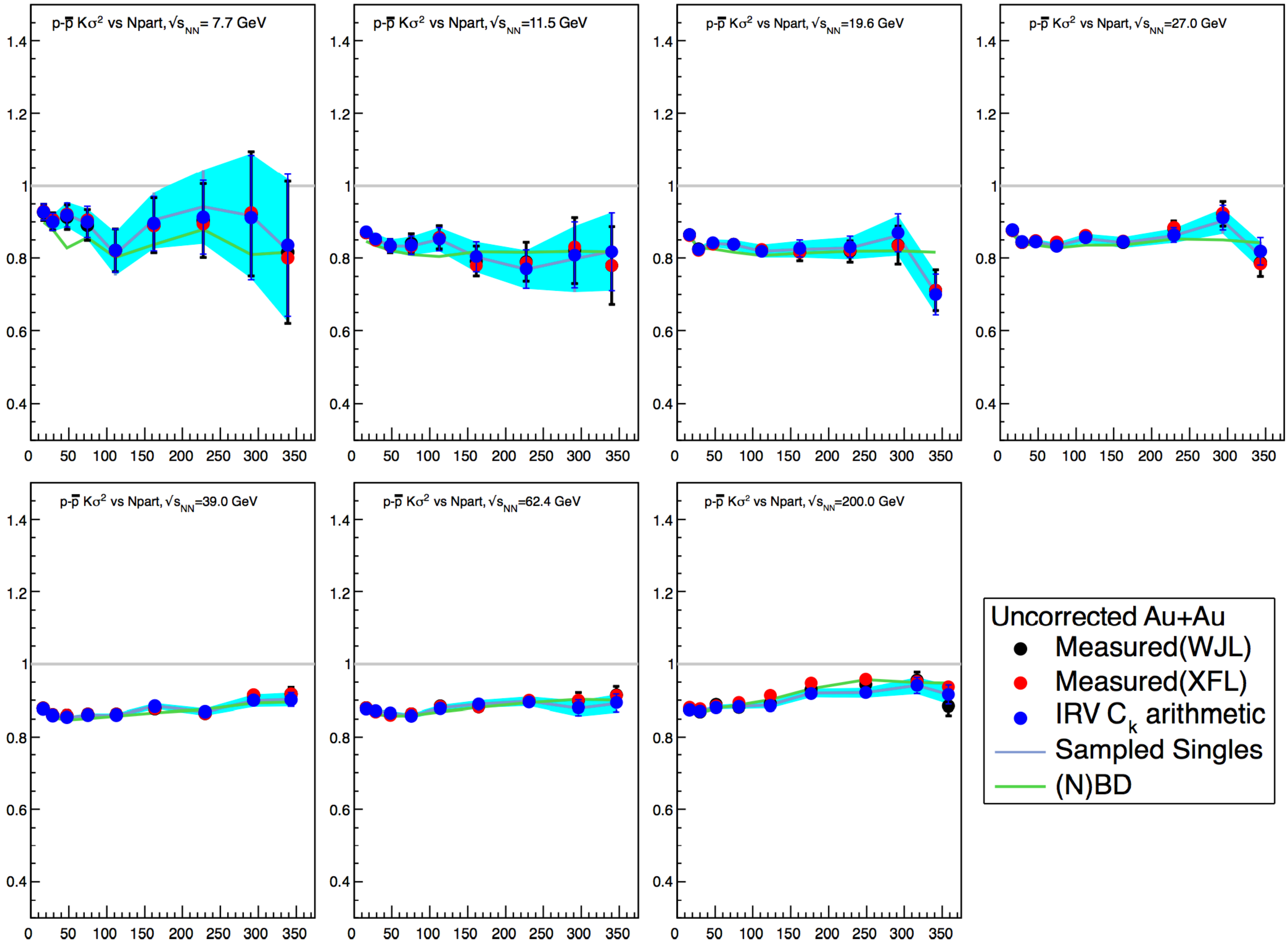
How does this approach compare to the sampled singles approach? and to the data?

Efficiency-uncorrected net-p Sσ vs centrality by $\sqrt{s_{NN}}$

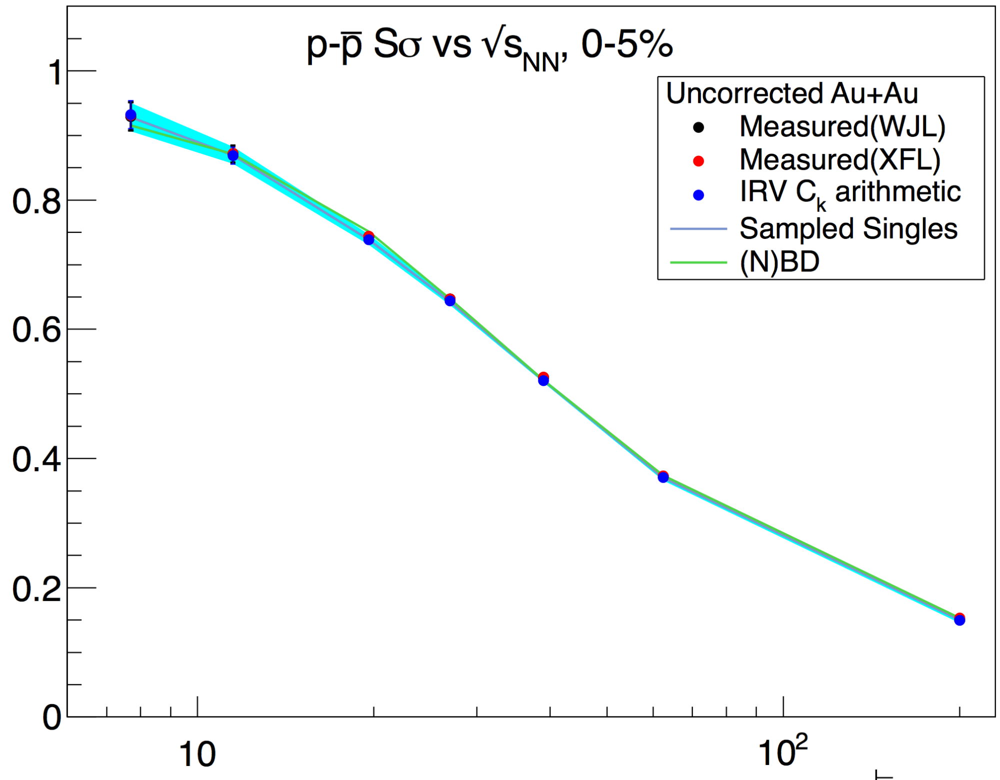


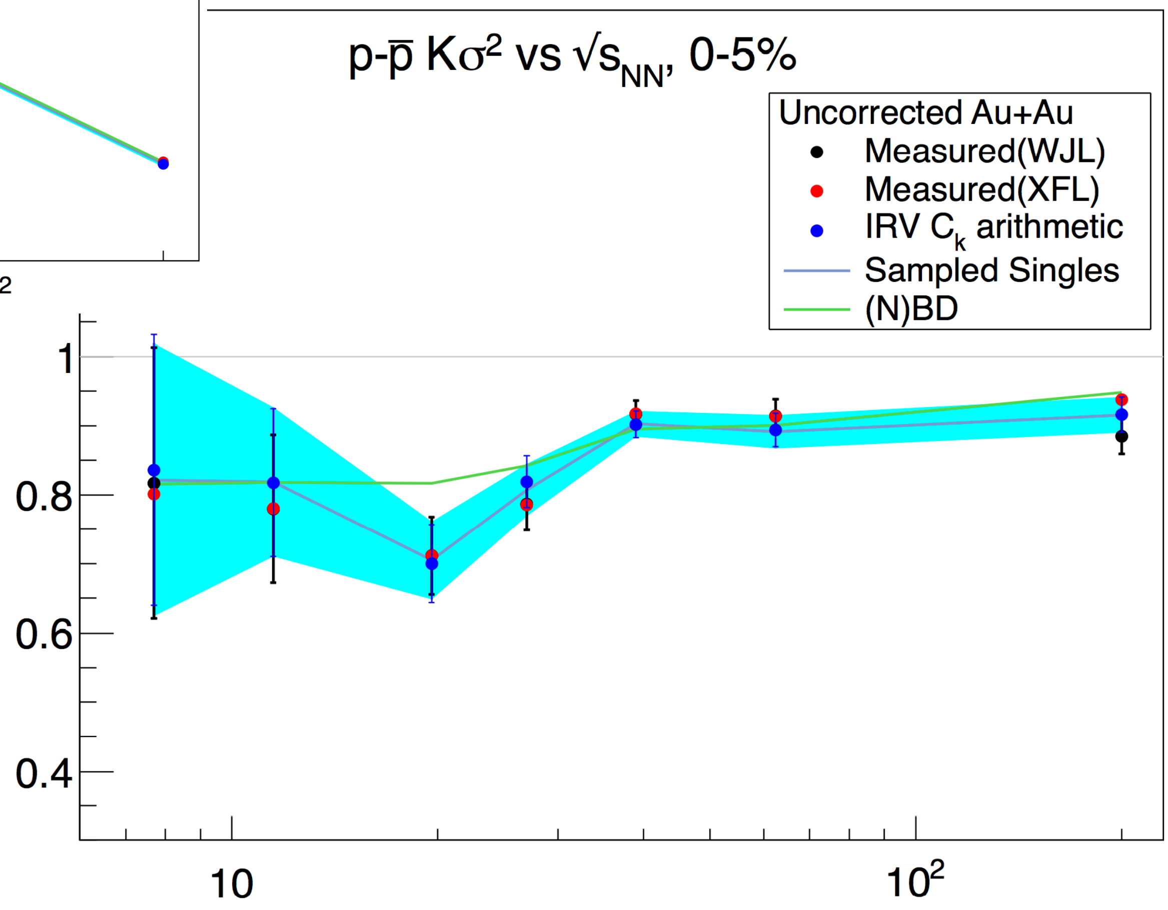
using nrepeats=81 for the sampled singles here

Efficiency-uncorrected net-p $K\sigma_2$ vs centrality by $\sqrt{s_{NN}}$



Efficiency-uncorrected net-p Sσ and Kσ² vs $\sqrt{s_{NN}}$ for 0-5% centrality





Summary

Sampled singles approach reproduces the experimental data points when "oversampled" to remove the stochastic dependence on the random number seed used when running the code.

One can also calculate the values of $S\sigma$ and $K\sigma^2$ assuming Np and Npbar are random and uncorrelated and using the additivity properties of the (single particle) cumulants.

This comparison was done here.

The "IRV" (independent random variable) cumulant arithmetic reproduces the
- (oversampled) sampled singles results, which is stochastic.
- the experimental values.

This should

lend confidence to the sampled singles approach

and

underscore the unimportance of intra-event correlations to the measured moments as no sampling was used here – just the cumulants of Np and Npbar