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NOTE to BRAHMS on Beam-Beam Counters. Part III.

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Abstract

Purpose of this note is to give an update of the charged multiplicity analysis with Beam-Beam counters. New/different method of centrality determination is used. "*Empty Boxes*" method is used on Small Tubes for $dN/d\eta$ extraction. Comparison is made to the numbers extracted from the Big Tubes. Latest $dN/d\eta$ *vs.* η distribution is shown for different centrality cuts.

Contents

1 Centrality determination

Different method of centrality determination is suggested for Beam-Beam analysis. The reason for that is linear dependence of the pseudorapidity coverage range on the range of the considered vertex. Methods using Multiplicity array in any way are bound to the narrow vertex cut of $z_o \leq 20 \div 40cm$ which restricts Beam-Beam coverage to $2.9 \leq |\eta| \leq 3.7$ and that in case of presenting single averaged result for both Beam-Beam arrays[2]

Proposed new/different method is shown on **Fig. 1** and similar to the method of centrality determination, used by PHENIX. This method uses dependence of the `ZdcAdcSum` on the total number of particles hitting Beam-Beam Counters for a particular event. Comparison to the old centrality method is shown on the right part of **Fig. 1** for different centrality cuts: $0\% \div 6\%$, $6\% \div 20\%$ and $20\% \div 50\%$ with a restriction of $|z_o| \leq 30cm$. One can see basic agreement between "*Central*" events, defined by both methods. Method is "Vertex-independent" by construction, since it uses a sum of the signals in the Left and Right Modules. It was checked and confirmed.

Consistency check was conducted. $dN/d\eta$ numbers extracted for $0\% \div 6\%$ central events were found to be $\sim 6\%$ above the numbers for the $0\% \div 9\%$ central events and $\sim 6\%$ above the numbers for the $0\% \div 10\%$ central events. $dN/d\eta$ numbers extracted for $0\% \div 6\%$ central events with $|z_o| \leq 30cm$ were within 2% difference with the same numbers extracted using Multiplicity Centrality method for the same vertex cut.

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[2]See separate discussion of this issue in **Seq. 5**.

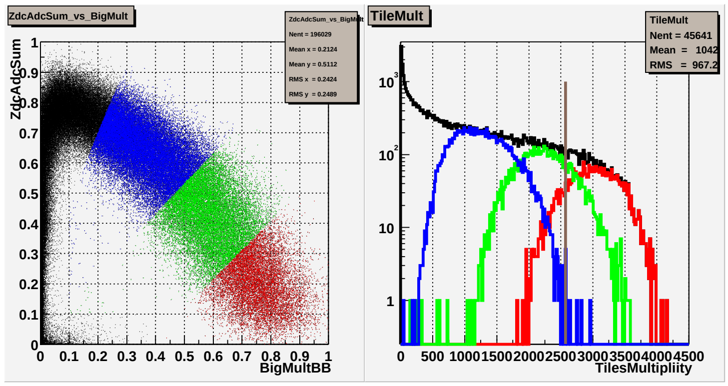

Figure 1: Centrality determination using ZDCs and BBCs.

Conclusion: Even though two centrality definitions are not identical, difference between them is well within a systematic error of our measurements. Thus, we conclude, that we can use this new/different method for Beam-Beam counters.

2 $dN/d\eta$ *vs.* η news.

Detailed description was given in the first two BRAHMS BB Notes. Here I'll just give the outline of changes:

- Right Array tubes were considered as two sets. "*Outer*" and "*Inner*" tubes by their distance to the beam-pipe.
- Mistake was found and corrected in the RA Outer tubes position (Holes were drilled not as specified in the design papers)
- Outlier was found and removed form the Left Array tubes.
- Arrays location in GEANT was completely recalculated; changes submitted and new Background corrections calculated for $|z_o| \leq 150cm$
- Multiplicity array had to be included in GEANT simulation for vertex positions $|z_o| \geq 60cm$ as introducing reasonable background events.
- Additional error analysis was conducted. See **Seq. 3** for details.

Here is the final graph of $dN/d\eta$ *vs.* η for individual sets of tubes for $0\% \div 6\%$ central events. Hijing curve is given for the reference.

3 Errors

Most of the analysis can be found in BRAHMS BB Note I. Here I'll give an update and a final result

3.1 Systematic errors

- Extraction of $dN/d\eta$ without averaging over all tubes, but for the individual tube, gives approximate $\delta(dN/d\eta) \simeq 4.8\%$ from the comparison.
- Thickness of the Al part of the beam-pipe was pushed to it's maximum possible value from specs. This introduced $\delta(dN/d\eta) \simeq 2.0\%$
- δ-rays were introduced in GEANT and presumed to be generated in the Al part of the beam-pipe. This introduced $\delta(dN/d\eta) \simeq 1.0\%$

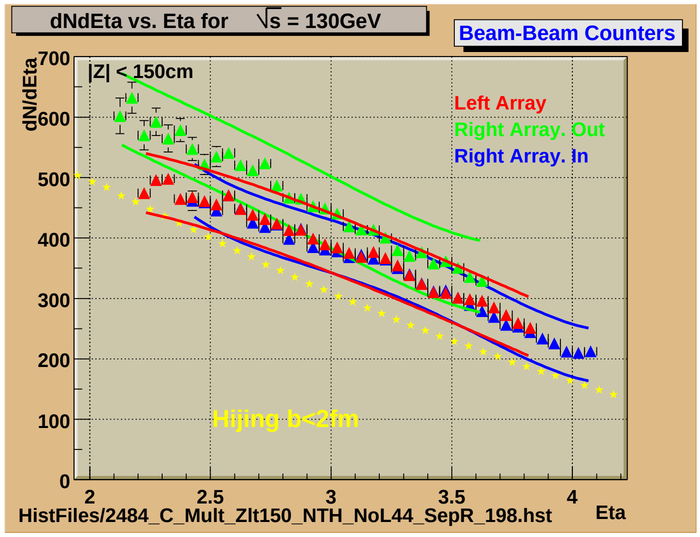

Figure 2: Charged particles multiplicity for different sets of Big Tubes.

- Better slewing corrections were found for the Beam-Beam Counters, which decreased vertex resolution down to $19mm$ and decreased error associated with that.

Conclusion: Total systematic error was evaluated to be 12.7%.

3.2 Statistical Error

Statistical error is confirmed to be less than 1%.

4 "*Empty Boxes*" analysis

This analysis was long time ago proposed by Chellis and was successfully used and demonstrated by the PHOBOS collaboration. It is based on using the number of "*no hits*" in the particular phototube. A set of Small Tubes located very far away from the beam-pipe was used for this purpose. Particles hits distribution is assumed to be Poisson, as

$$P(n) = \frac{\lambda^n e^{-\lambda}}{n!},$$

where n is number of incoming particles and λ is a mean of a distribution, or average number of MIPs in our case. Thus knowing the number of entries for $n = 0$ and assuming even distribution,one can extract λ. Even distribution was achieved by considering narrow vertex cuts. **Fig. 4** shows actual ADC spectrum for one of the Small Tubes with obvious saturation and big number of "*no hits*" and reconstructed Poisson distribution.

Regular analysis was repeated for the extracted average number of MIPs to create $dN/d\eta$ distribution. 5 different sets of Small Tubes were used. As one can easily see on **Fig. 4**, results are in good agreement with **Fig. 2**

Conclusion: I don't think, that we can use this distributions directly, but they do serve as a good confirmation of the final charged particles multiplicity result in **Seq. 5**.

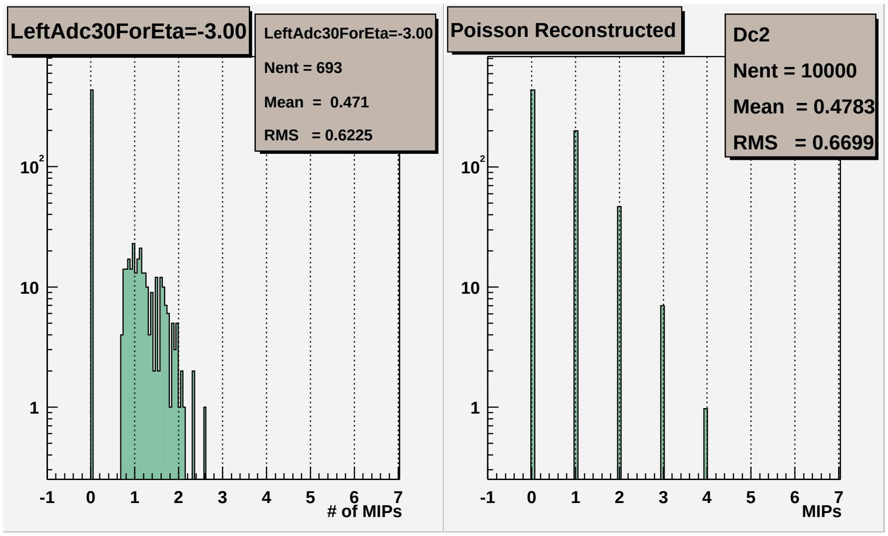

Figure 3: Actual ADC spectrum *vs.* Poisson distribution. Small Tube.

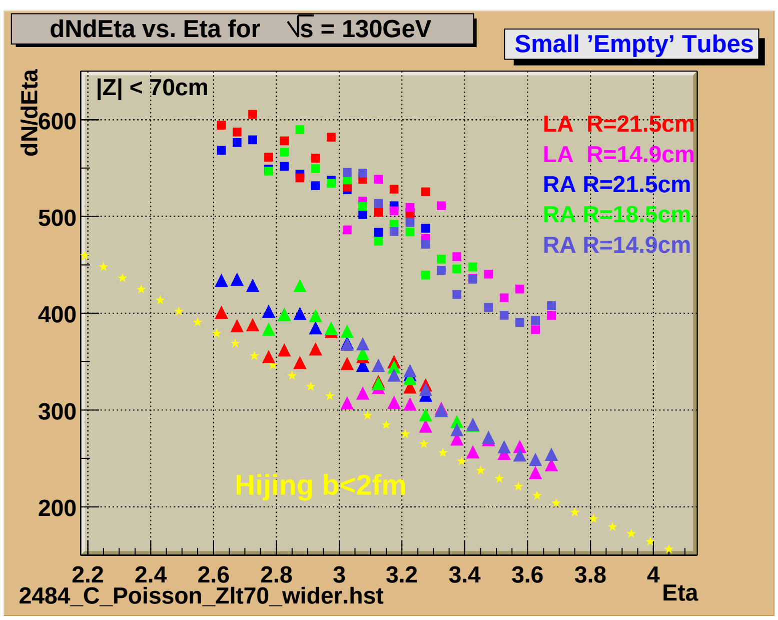

Figure 4: Charged particles multiplicity extracted through the "*Empty Boxes*" analysis. Small Tubes.

5 Final Result

Here I will present two different approaches to presenting the final result. it is for the collaboration to decide which one is to be picked.

5.1 Total weighted average

Here I take three different distributions, extracted for three different sets of Big Tubes and arrive at the final result by calculating the weighted average. Each set of tubes is assigned a weight by the number of tubes it represents. Result is shown on **Fig. 5.1** zoomed for Central events and actual view for three centrality cuts.

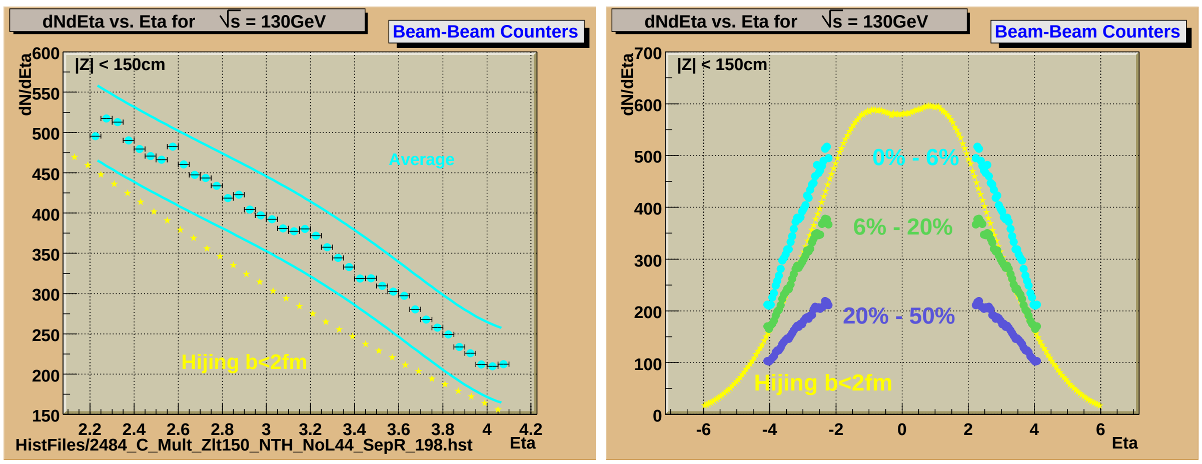

Figure 5: Charged particles multiplicity. Total Weighted Average. Big Tubes. Three centrality cuts.

5.2 Actual measurements

Second approach is about presenting measurements independently for different arrays. Right Array tubes still are averaged with the appropriate weight, while Left Array is shown as is. See **Fig. 5.2**

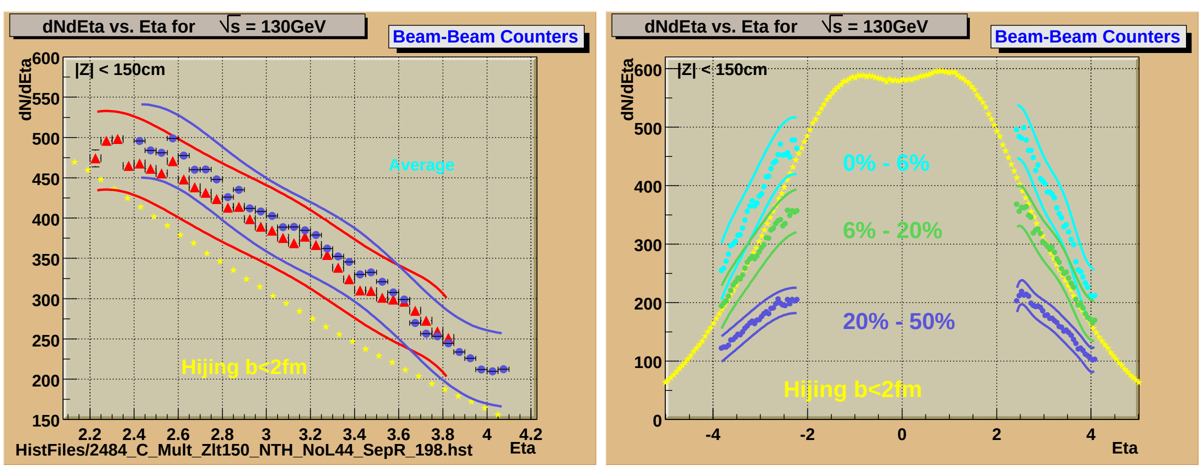

Figure 6: Charged particles multiplicity. Actual Measurements. Big Tubes. Three centrality cuts.

6 Conclusion

Final result for charged particles multiplicity is presented as extracted from the Beam-Beam Counters performance and analysis. Systematic error of 12.7% is assigned to our measurements. Results are in very good agreement with PHOBOS measurements presented at QM'2001. Final decision has to be made on the presentation policy. Either we present a total averaged result, mirror-imaged on both sides of pseudorapidity, or we present our actual measurements with Left and Right Array results in small disagreement with each other, but well within a claimed systematic error. As for my personal opinion, I like "actual measurements" approach, since it shows results extracted from two independent arrays of counters.