November 3, 2000

# NOTE to BRAHMS on Beam-Beam Counters. Part II.

by Yury Blyakhman

Purpose of this note is to give an update of the charged multiplicity analysis with beam-beam counters. Only Big tubes are used for the analysis. Reason for that is very high nonlinearity in the Small tube's response.

## Contents

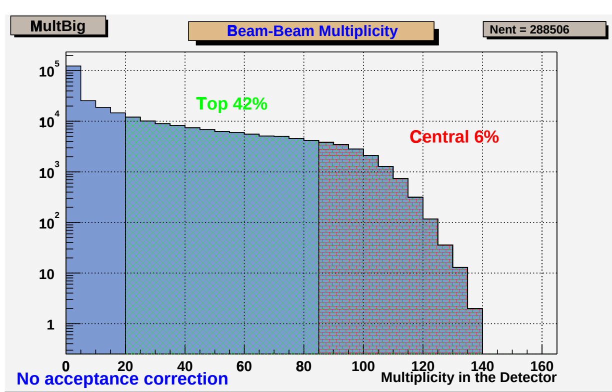


## 1 Centrality determination

So far we still have not agreed on common centrality determination, so Beam-Beam multiplicities are used in this analysis. Big tubes only were used. Multiplicity per event was determined as:

$$Mult_{perTube} = \frac{Adc - Pedestal}{1MIPPulseHight} \qquad \text{and summed over all tubes.}$$

Here's the picture:



## 2 $dN/d\eta$ *vs.* $\eta$ extraction.

Detailed description was given in the first BRAHMS BB Note. Here I'll just give the outline of $dN/d\eta$ and $\eta$ calculation on event-per-event basis:

- Tube's Multiplicity $mult$ and Number of Hits after the acceptance correction $N$ are:

$$mult = \frac{Adc-Pedestal}{1MIPPulseHight}\ , \qquad N = \frac{mult \cdot RingArea}{TubeArea}$$

- Vertex location $Z_o$ is determined by BB. Only events which have $|Z_o \leq 45cm|$ are considered. All Big Tube's pulse heights and 1particle hits in a Small tubes are used for $Time - Zero$ determination. If this method is unaccessible, "Fastest Tubes" method is used. For very peripheral collisions, with no BB data, ZDC vertex location was used. Timing method with slewing corrections was described in detail in the first BB Note.

- Determine $\eta$ and $\Delta\eta$ from the found vertex using well-know formulae:

$$\eta = -log\left(tan(\tfrac{\theta}{2})\right)\ , \qquad \theta = tan^{-1}\left(\frac{R}{d}\right)\ , \qquad \Delta\eta = \eta|_{R=R+r} - \eta|_{R=R-r}\ ,$$

  where $R$ is the distance to the ring of tubes from the beam-pipe;
  $\theta$ – angle between the beam-pipe ($z$-axis) and direction from the vertex onto the tube;
  $d$ – distance from the vertex to the array location along the $z$-axis: $d = 213cm$.

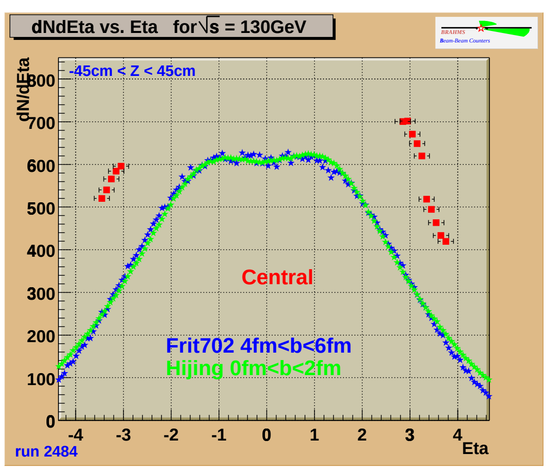
- Thus, for every tube I have $dN/d\eta$ value as $dN/d\eta = N/\Delta\eta$. "*Big Tubes only*" and $|Z_o \leq 45cm|$ restrictions give us the following $\eta$ range:

$$-3.0 \leq \eta \leq -3.5 \qquad \text{and} \qquad 2.8 \leq \eta \leq 3.8$$

  This range is splited in smaller intervals of $\Delta\eta = .1$. Each small interval of $\Delta\eta$ corresponds a histogram which is filled with $dN/d\eta$ values with their $\eta$ falling in this particular interval. That gives me 5 histograms for the Left Array and 10 histograms for the Right Array.

- $dN/d\eta$ values are extracted form this histograms using $GetMean()$ method.

Here is the graph of raw data. Frit702 and Hijing curves are given for the reference.

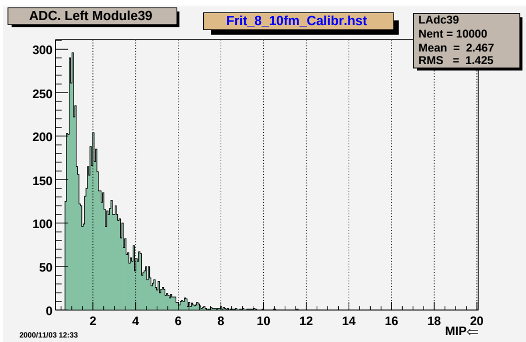


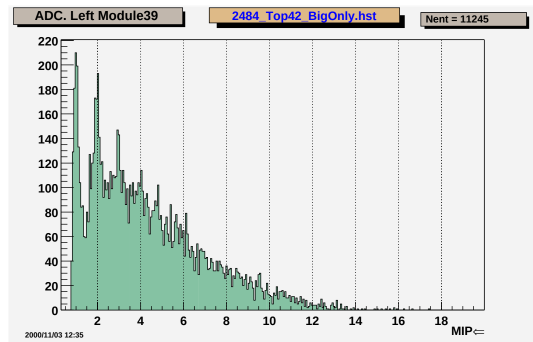
# 3 Background Corrections

Two methods are currently used:

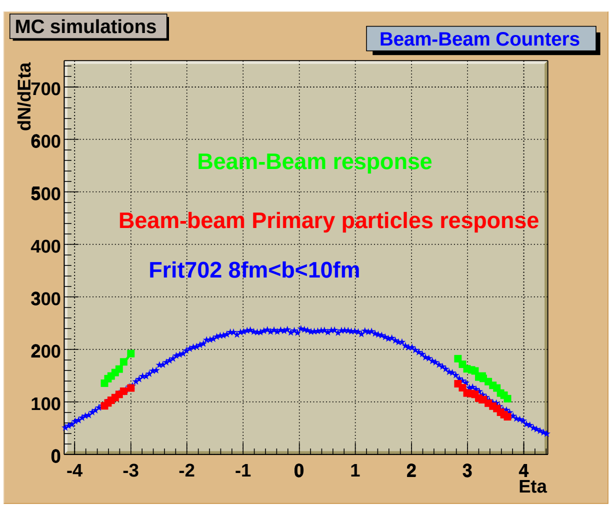
## 3.1 MC Background correction

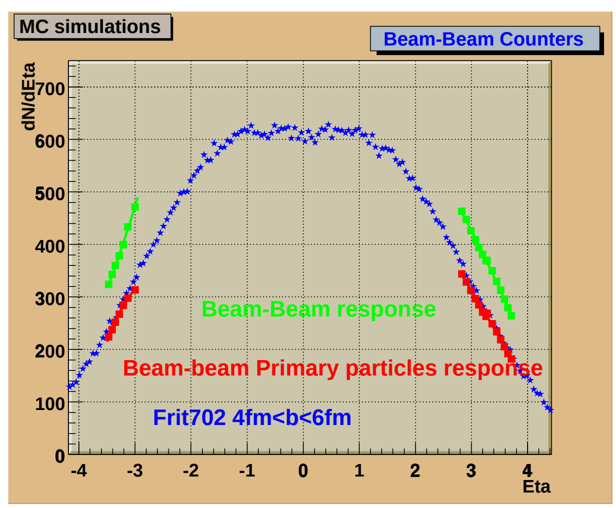
- Frit702 was used with the restriction $8fm \leq b \leq 10fm$ first for the comparison with the real data. Adc spectrum of Big Tube response to this event generator was found resembling the real data spectrum for the events with Top 42% central events (see section 1). Here's the picture with the examples of such spectra:




- A set of MC simulation files was created with variable vertex location to account for the real data vertex distribution. 7 points were taken: $Z_o = 0cm; \pm 15cm; \pm 30cm; \pm 45cm$
- These files were feeded through the same analysis codes as a real data to generate detector's response. Simulations allowed us to clearly ask for the primary events only in order to generate background corrected BB response. It perfectly follows theoretical Frit curve. Here is the picture of the result for different impact parameters:

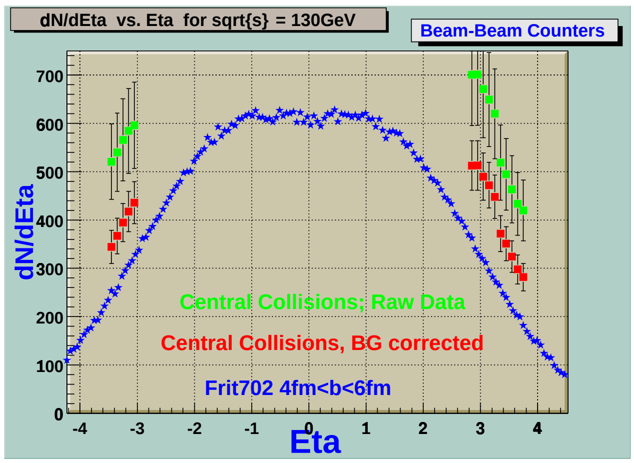



- Fractions $(dN/d\eta)_{FullResponse}/(dN/d\eta)_{PrimaryOnlyResponse}$ for a set of $\eta$ points were taken as a Background Correction Coefficients for the particular $\eta$ region.

- Simple background fitting for the real data with the assumption of a constant background returned almost identical coefficients, which allowed us to use these numbers as a Background Corrections for this particular centrality.

- Fractions taken for the Frit702 with $4fm \leq b \leq 6fm$ (the one, which looks like Hijing and real data) give us same correction factors. This allowed us to use them for real beam-beam central events for background correction. Here's the picture, which was shown at the DNP meeting:



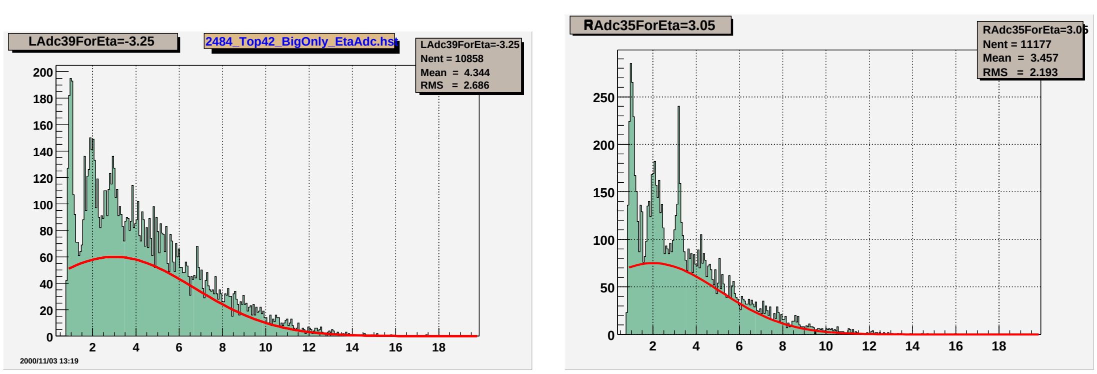

**NOTE:** Frit curve was not shown at the DNP and Error bars will be addressed later in this note.

## 3.2 Manual Background correction

This study is not finished, so I present it's present status.

- Raw data with Top42% multiplicity events were taken and Adc spectra were filled for each tube and for each $\eta$ interval, mentioned earlier. So, for each tube we have 5 Adc spectra for different $\eta$ values.

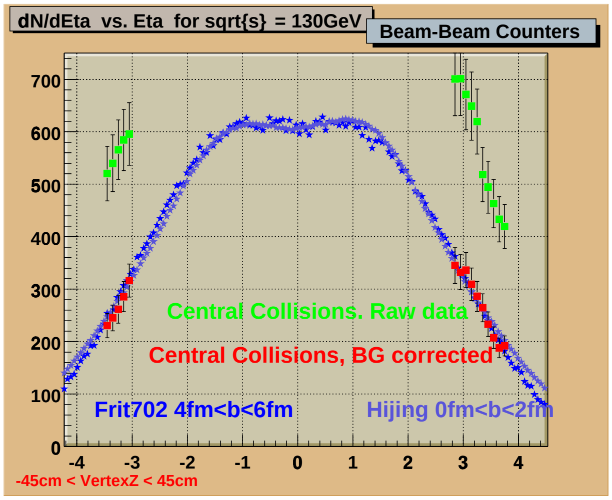
- Gaussian background was manually fitted on them. Here is an example of such a fit:

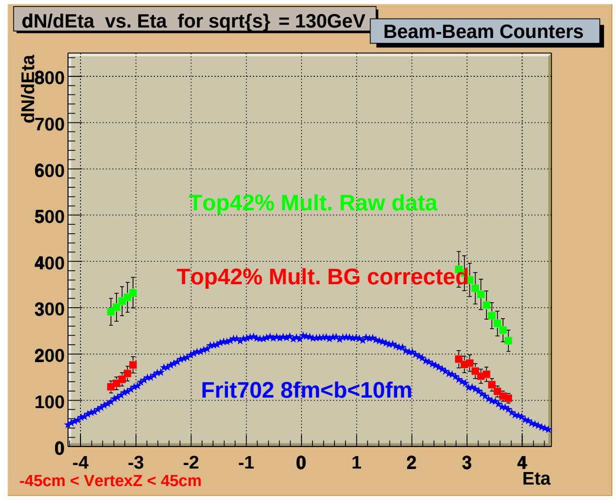



- Background correction factors were extracted from these fits and averaged for all tubes in a ring for the particular $\eta$ value.

- Equality of the correction constants for Frit702 simulations with different impact parameter suggests, that we can use correction factors, extracted above for Top42 multiplicity events and apply them for Central events.

- That exactly what was done. Here how it looks like for Central and Top42% events:




A lot of issues are open here. One of them is planned to be checked ASAP. Namely: MC simulations for the Beam-Beam response. Code has to be checked very carefully in order to make sure that all background sources are accounted for. As for the second method, it is extremely inaccurate, since is done by the eye-fit, but, I think, is empirically correct and gives nice results! :-)))

# 4 Errors

## 4.1 Systematic errors

- Calculating $dN/d\eta$ for small $\eta$ intervals gives error $\Delta\eta = .1 \Rightarrow \delta\eta \simeq 3\%$

- Distribution of the vertex, found by Beam-Beam minus vertex found by the TPC's gives $\sigma_{Z_o} \simeq 4cm$. MC simulations with the vertex position distributeb by Gaus with $\sigma = 2 \cdot 4cm$ returned less than 2% diferense in $dN/d\eta$ results.

- Extraction of $dN/d\eta$ without averaging over all tubes, but for the individual tube, gives approximate $\delta(dN/d\eta) \simeq 10\%$ from the comparison.

- Background correction method is very inaccurate and should correspond to the error of at least 15% (the reason for this number is the upper limit for the results to be trustworthy at all. We don't have a result if it's error is bigger than 20%).

## 4.2 Statistical Error

For run 2484 I compared $dN/d\eta$ values extracted for 3 different bunches of sequences: $seq000 \div seq030$, $seq031 \div seq060$ and $seq061 \div seq085$ with results obtained from the whole run 2484. That gives a statistical error of 3.1%.

## 5 Conclusion

All of the above is just an update of the Beam-Beam analysis status and does not give a final result. As you can see charged multiplicity analysis for Beam-Beam counters is still work-in-progress and as of today, November 3, 2000 I cannot describe $dN/d\eta$ *vs.* $\eta$ distribution better than with 15% error value.

Another thing, which we're doing these days, is improving the Beam-Beam time0 determination, but that is completely different story...