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NOTE to BRAHMS on Beam-Beam Counters.

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Purpose of this note is to describe some technical details of the analysis involving Beam-Beam Counters. It consists of the following parts:

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1 Plot $dN/d\eta$ *vs.* η.

1.1 Average for all events. No vertex correction.

1. **Get pedestal Mean Values and RMS's:**
   Fill histograms for every tube with the *adc* values for "synch" trigger only. Use ROOT's functions *GetMean()* and *GetRMS()* to extract numbers $PedMean$ and $PedRMS$.

2. **Get AdcGain0**
   Fill histograms for every tube with the $(adc - PedMean - 2PedRMS)$. Extract location of the First Peak and call it $AdcGain0$.

3. **Get Average multiplicity for the ring of tubes:**
   For every tube fill a histogram with $[(adc - PedMean - 2PedRMS)/AdcGain0]$ for all chosen events. Use ROOT's *GetMean()* function to get average multiplicity per tube: $MultPerTube$. Get average multiplicity per ring:

$$N = \frac{RingArea}{TubeArea} \cdot \frac{1}{NumOfTubesPerRing} \sum MultPerTube \;, \qquad \text{where}$$
$$RingArea = \pi(R+r)^2 - \pi(R-r)^2 \;, \qquad TubeArea = \pi r^2$$

4. **Get η, $\Delta\eta$ and $dN/d\eta$:**

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

where R is the distance to the ring of tubes from the beam-pipe;
θ – 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: $d = 213cm$. $dN/d\eta = N/\Delta\eta$, thus, I have 8 points $\{\eta,\ dN/d\eta\}$ for the Right Array and 5 for the Left Array.

1.2 On event-per-event basis with "vertex correction"

1. and 2. are same as above;

3. **Get Multiplicity and Number of hits in a ring of tubes:**
   For each event for each tube Multiplicity $mult$ and Number of Hits in a ring of tubes N is:

$$mult = \frac{adc}{AdcGain0}\ , \qquad N = \frac{mult \cdot RingArea}{TubeArea}$$

4. **Get vertex location z_o:**
   One can use two different methods in determining Δt_o. See description below. Once this is known for each event, vertex location z_o is determined as:

$$z_o = \frac{c}{2}\Delta t_o$$

5. **Get η, $\Delta\eta$ and $dN/d\eta$ for given η:**
   Same as item 4. in the previous section, only for every event for every tube, and d would be different for different array. Namely: $d_L = 213cm + z_o$ and $d_R = 213cm - z_o$, with $z = 0$ point located at the physical center (right in the middle between the Left and Right Arrays).
   For each event for every tube $dN/d\eta = N/\Delta\eta$.

6. **Get $dN/d\eta$ *vs.* η graph:**
   Collision events are picked by the condition of $|\Delta t_o| < 10nsec$, that gives us the following range in η: $1.80 \leq \eta \leq 4.72$. I split this range in $[(4.7 - 1.8) * 10] = 29$ intervals as: $1.8 \leq \eta_1 \leq 1.9$ and so on. For each interval of η I fill a separate histogram with $dN/d\eta$ values for all η's from this interval, for each event for each tube. So, at the end I have 29 histograms of $dN/d\eta$'s each of which gives me a $dN/d\eta$ value through ROOT's *GetMean()* function and η value as a middle of the η interval for this histogram. Thus, η error bars are fixed and equal to: $\delta\eta = \pm 0.05$.

2 Time-Zero and Vertex determination

1. **Using "Earliest Left" and "Earliest Right" tubes:**

$$\Delta t_o = t_L - t_R - 2.0nsec\ , \qquad t_R = [Min(RTdc) - \Delta RTdc] \cdot 25\frac{psec}{tdc\ channels}\ ,$$

   where $Min(RTdc)$ is the earliest tdc value for all Right Array tubes for each event;
   $\Delta RTdc$ – calibration alignment constant for each tube;
   $25 psec/tdc\ channels$ – tdc conversion constant;
   $2.0nsec$ is the famous correction for centering the vertex distribution.

2. **Using Big Tubes only:**
   Use Right Array as an example. Big Module Numbers are from 31 to 35.

   - Fill 4 histograms with $(RTdc[31] - RTdc[i])$ with the following condition:
     $(RAdc[31] - PedMean[31] - 2PedRMS[31]) > (RAdcGain0[31] - 200)$ &&
     $(RAdc[i] - PedMean[i] - 2PedRMS[i]) > (RAdcGain0[i] - 200)$,
     where 200 is an average value for the 1st peak RMS in the ADC-filled histogram.
   - Do a slewing correction as:

$$\left(RTdc[31] - \frac{k}{\sqrt{(RAdc[31] - PedMean[31] - 2PedRMS[31])}}\right) - \left(RTdc[i] - \frac{k}{\sqrt{(RAdc[i] - PedMean[i] - 2PedRMS[i])}}\right)$$

for the adc conditions, mentioned above. Get Slewing Constant k.

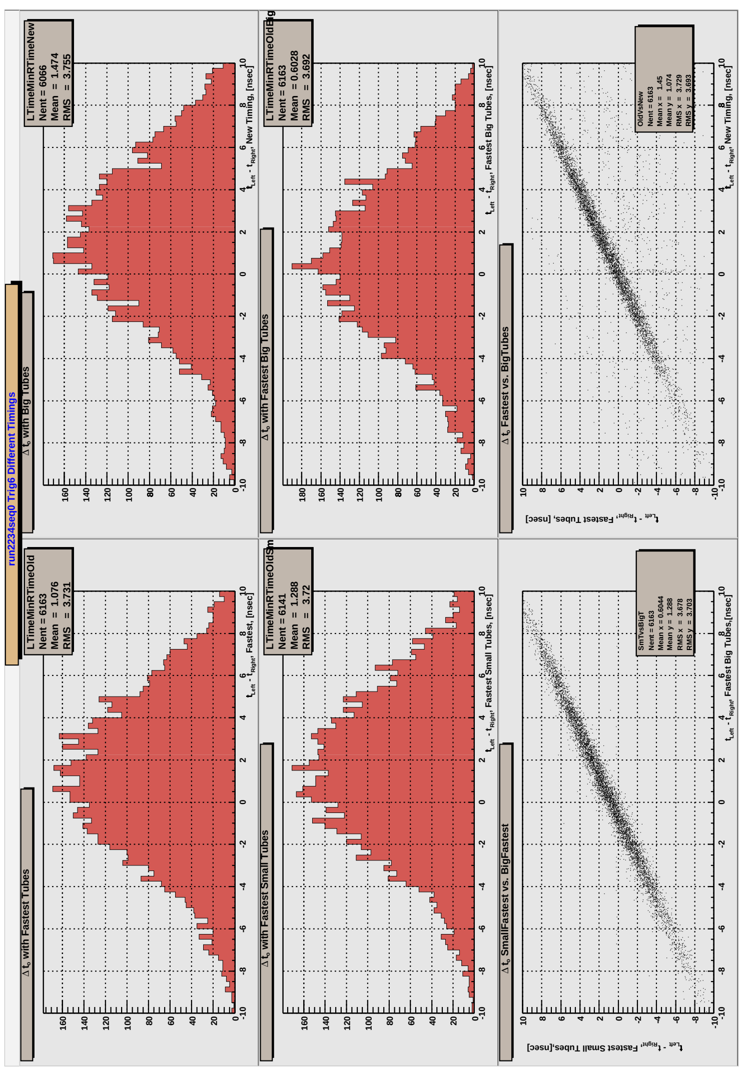
- Align them all to have mean value at 0 and obtain Aligning Constant $\Delta Tdc[i]$
- Get Δt_o as:

$$\Delta t_o = t_L - t_R - 2.0nsec \ ,$$

$$t_R = \frac{1}{NumOfBigTubes} \sum \left(RTdc[i] - \frac{k}{\sqrt{(RAdc[i] - PedMean[i] - 2PedRMS[i])}} - \Delta Tdc[i]\right)$$

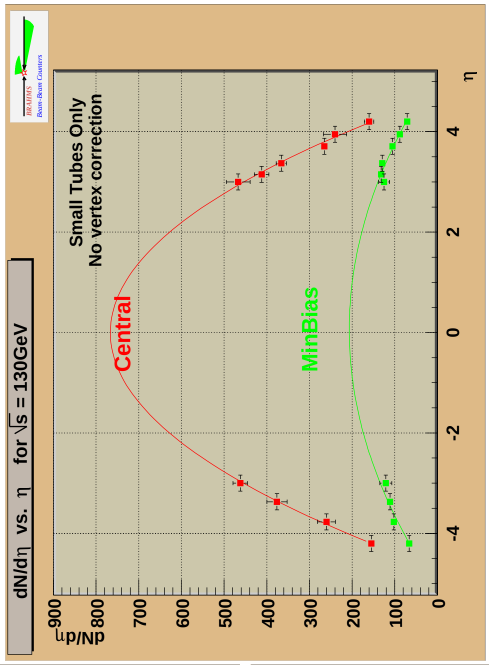
for all Big Tubes, satisfying adc condition above.

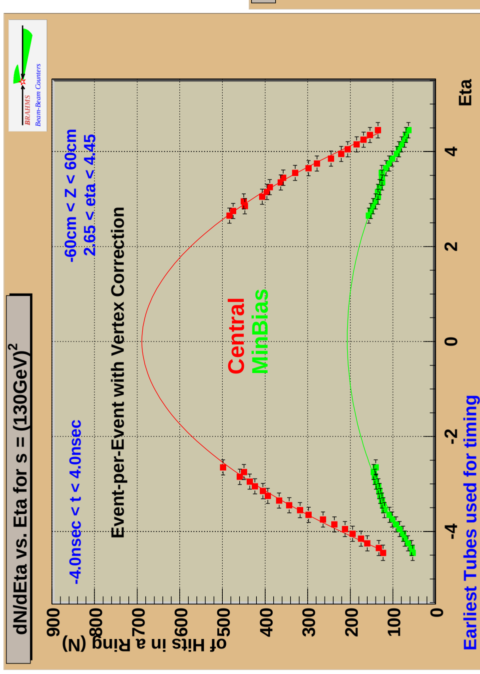
3. **Comparison:**
Figure 1 shows all possible comparisons for these two methods, illustrating, that they are almost identical in bulk, but only second one could be used on event-per-event basis.

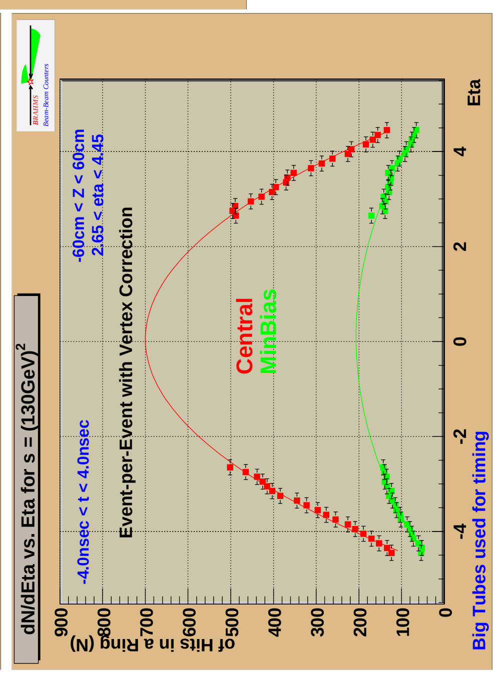


3 Comparison of $dN/d\eta$ graphs for different timings.

Pictures below shows 3 graphs of $dN/d\eta$ $vs.$ η for three different conditions:







4 BB Vertex dependent response.

Adc spectra were analyzed for small and big tubes in both arrays for three vertex locations:

- $\Delta t_o = -5.0 \pm 0.5 nsec$

- $\Delta t_o = 0.0 \pm 0.5 nsec$
- $\Delta t_o = 5.0 \pm 0.5 nsec$

On the picture below raws represent different vertex locations and columns are for LeftSmall, LeftBig, RightSmall and RightBig tubes respectively. One particle's peaks were fitted with Gauss and it shows, that *Mean* and *RMS* values for these modules stay the same for different vertex locations.