Vernier scan Au-Au

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Vernier scan

- Machine luminosity is defined as
- $\mathcal{L}_{machine} = \frac{f_{beam}}{2\pi\sigma_x\sigma_y} N_{bunch} N_b N_y$
- σ_x, σ_y are the effective beam width derived from vernier scan.

- MBD cross section is defined as
- $\sigma_{MBD} = \frac{R_{max}}{\mathcal{L}_{machine}\varepsilon_{vertex}}$

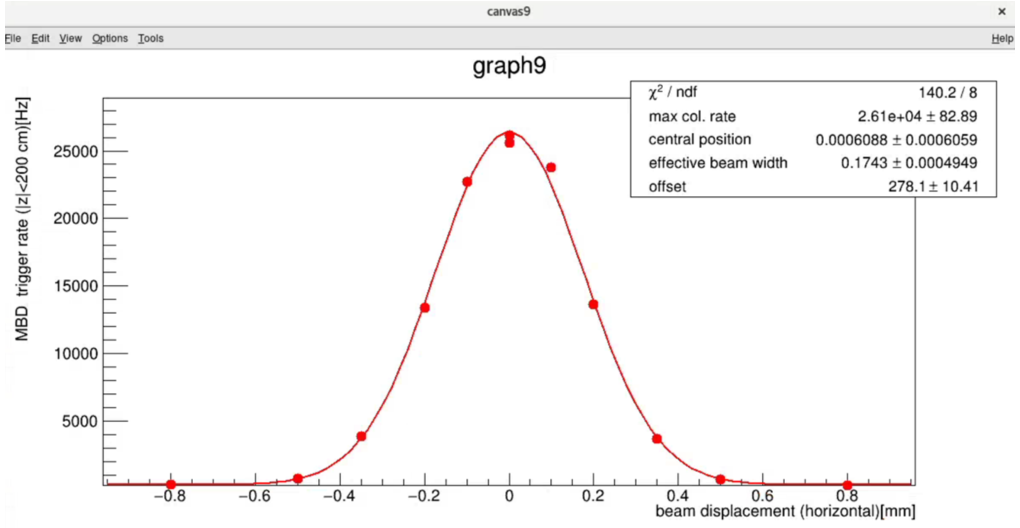
Result of measurement in Au-Au collision

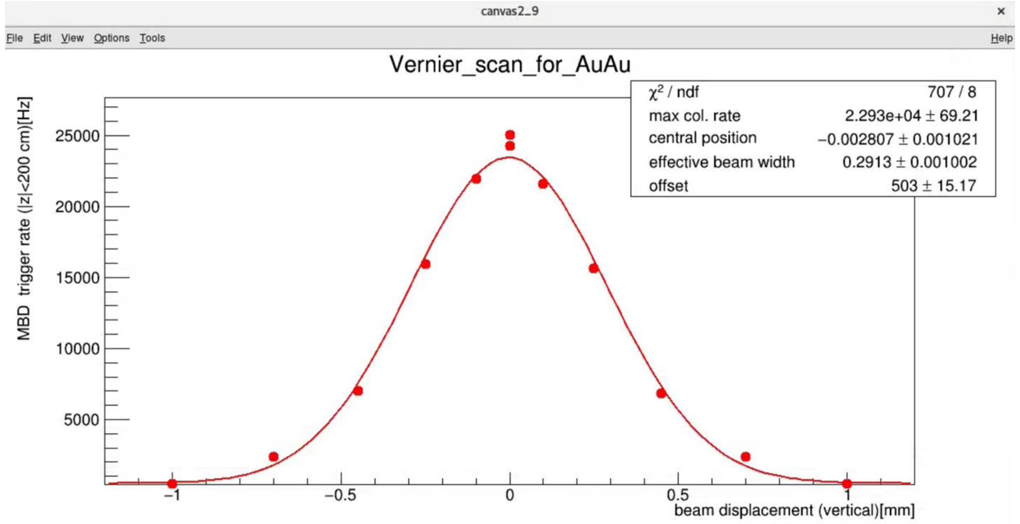
- The machine luminosity is **3.6** $\mathbf{mb^{-1}s^{-1}}$.
- MBD cross section is **7.1 barn.**
- Beam width of each direction is

0.174 mm(horizontal), 0.291 mm(vertical).

- Beam set position is used.
- Corrections which are applied are

z-vertex cut (|**z**|<**200 cm**), DCCT, emittance.





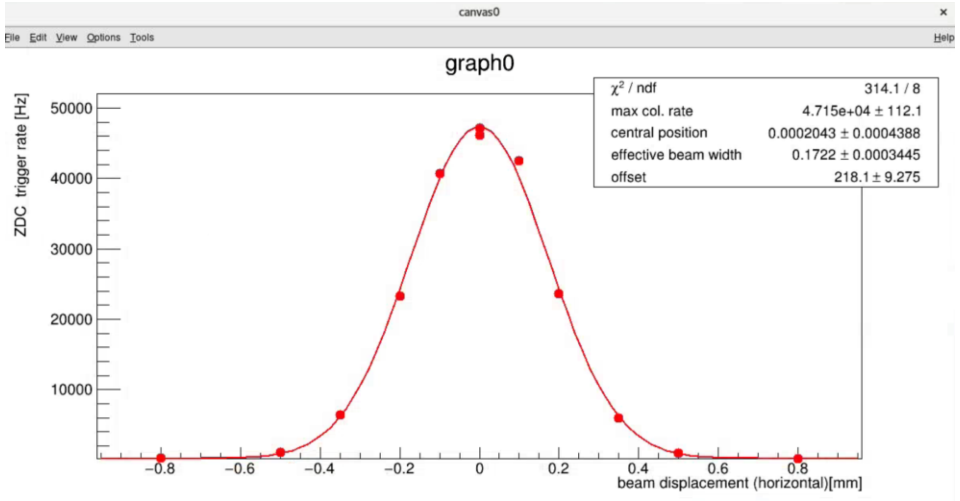
Result of measurement in Au-Au collision

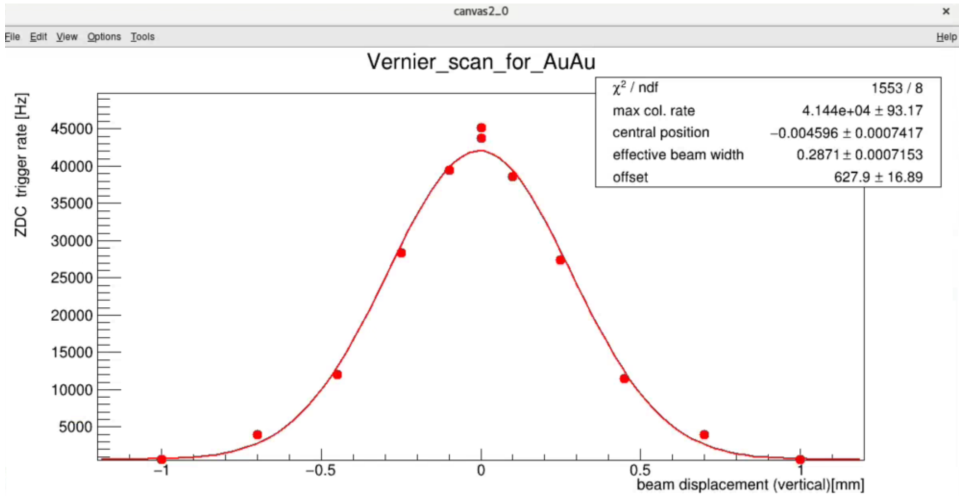
- The machine luminosity is **3.67** $\mathbf{mb^{-1}s^{-1}}$.
- ZDC cross section is **12.8 barn**.
- Beam width of each direction is

0.172 mm(horizontal), 0.287 mm(vertical).

- Beam set position is used.
- Corrections which are applied are

DCCT, emittance.





Comparison with Phenix measurement

- This result 7.1 barn is similar to Phenix result 6.5 barn.
- Phenix's one is applied some other correction, like vertex cut.
- These fit may need double gaussian fit, as Phenix did for ZDC vernier scan.

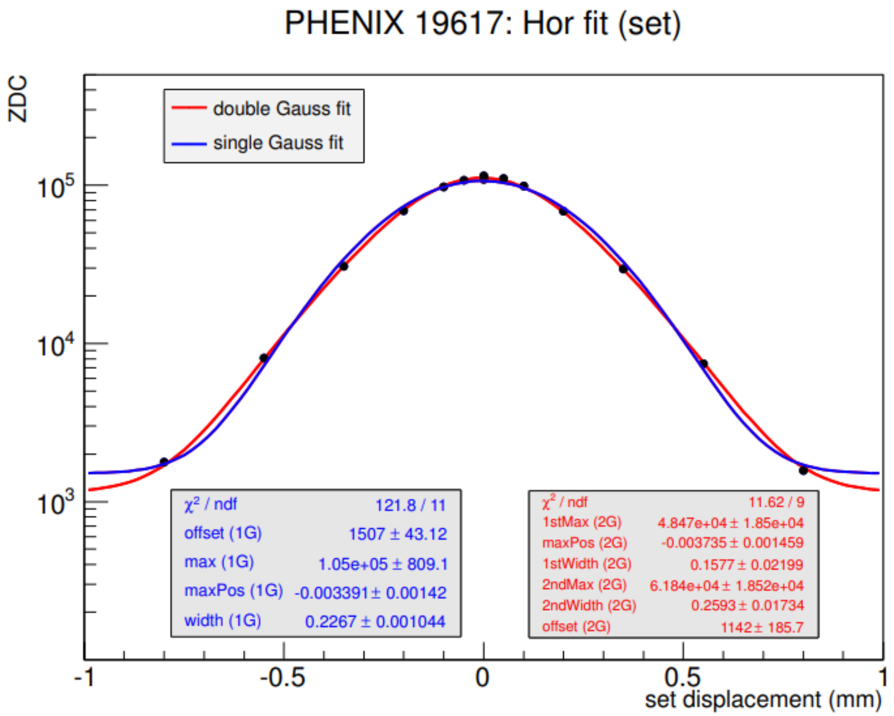
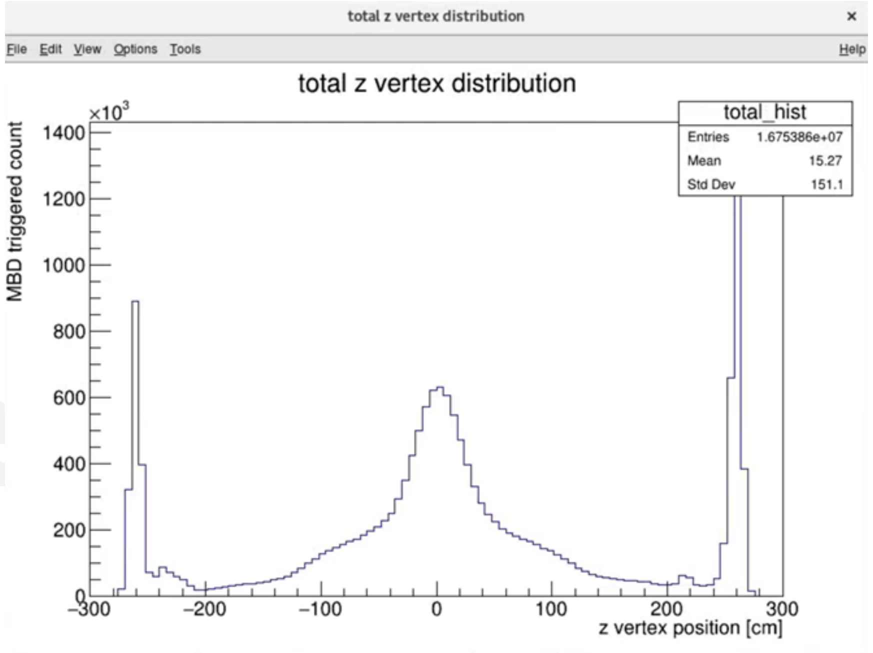


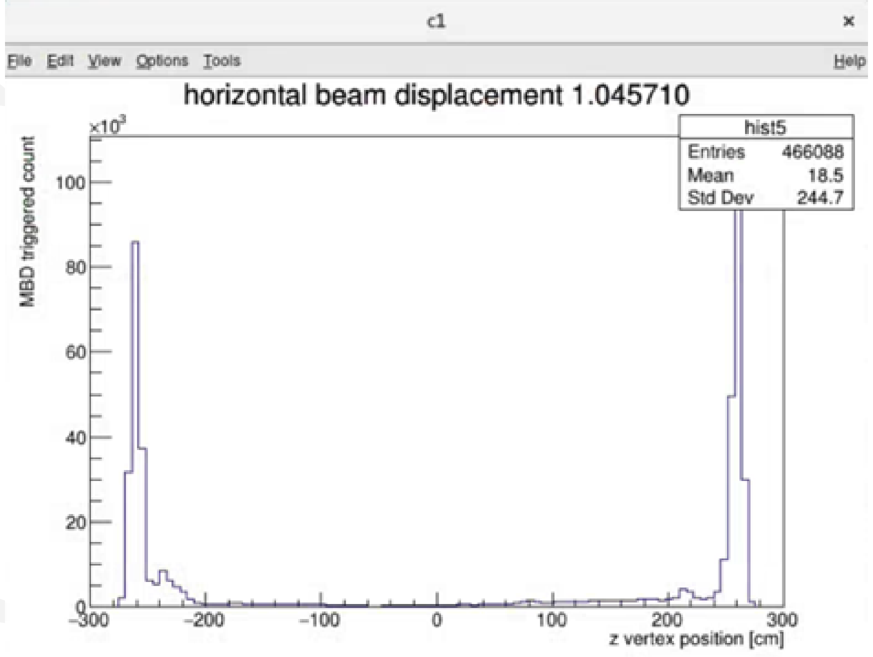
Figure 1: The signal from the PHENIX experiment ZDCs fitted with a 1-Gauss and a 2-Gauss fit function. The 2-Gauss fit function in this case is favored by about a factor 10 in χ^2/ndf. This fill was selected for demonstration purpose only.

The unique issues in Au-Au collision

- Run 54733 has a lot of background noise of charged particles.
- There're peaks in z=±250 cm (~10% of hit in head-on).
- It remained even with a big beam displacement.
- They're should be removed when calculating beam width.

- This background makes it difficult to estimate the effect of accidental coincidence and pileup effect.
- That will increase error at the end.

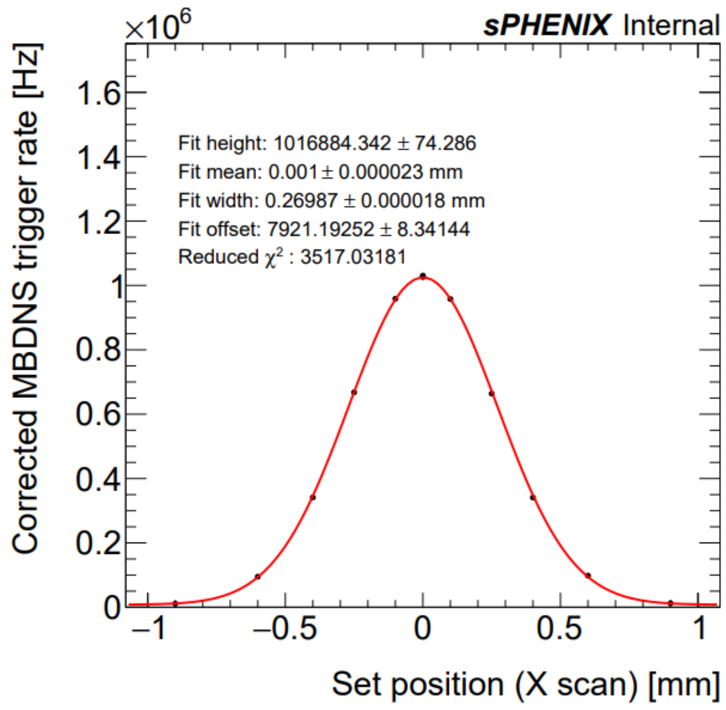


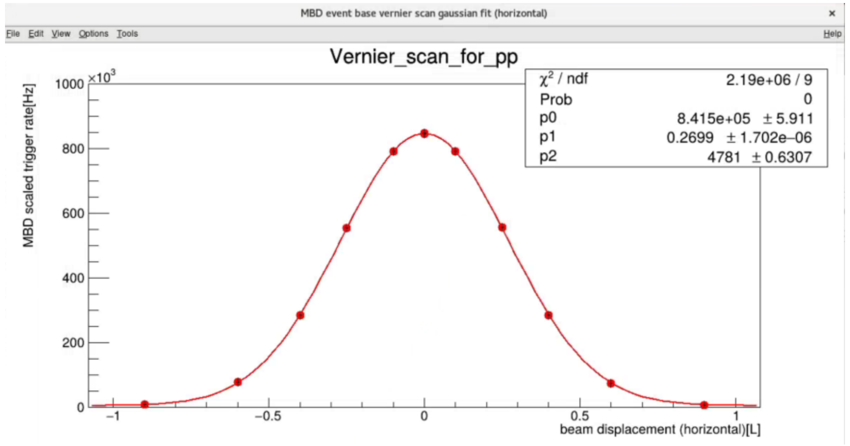


Scale up from event base data

- Since z vertex cut is mandatory, scale up from event is needed.
- The consistency of event base and raw scaler was checked with p-p data.

- From raw (Cheng Wei): $\sigma_x = 0.2698\,mm$
- From scaled : $\sigma_x = 0.2699\,mm$





Corrections

- Applied

Background cut with z vertex

DCCT

Emittance

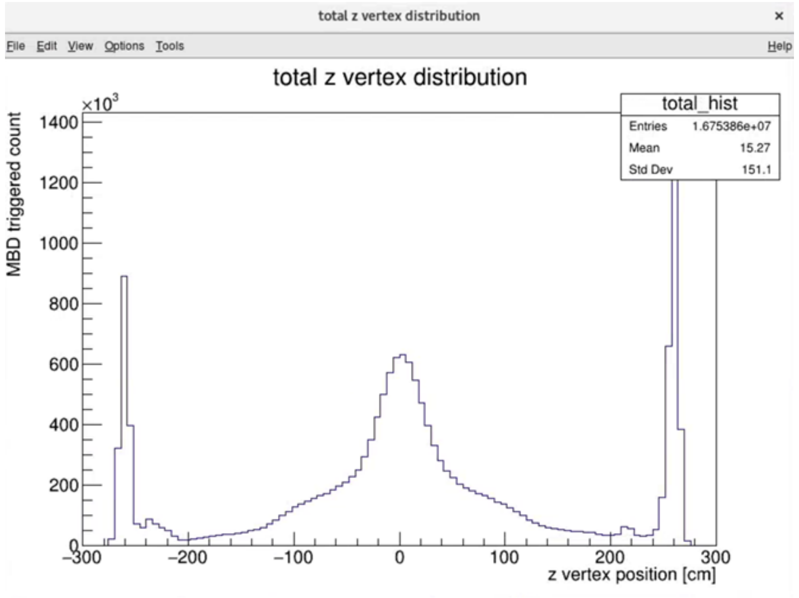
- Not applied

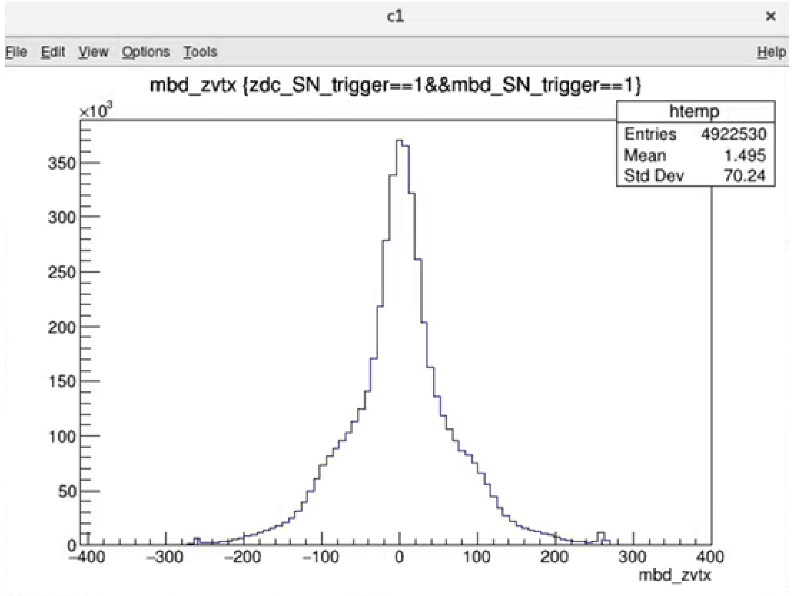
Multiple collision/Accidental coincidence

Correction of z vertex detection efficiency with ZDC

Corrections: Background cut

- There are z vertex peaks around |z|=250 cm.
- That doesn't show up when we take coincidence with ZDCN&S, that means they are charged particles.

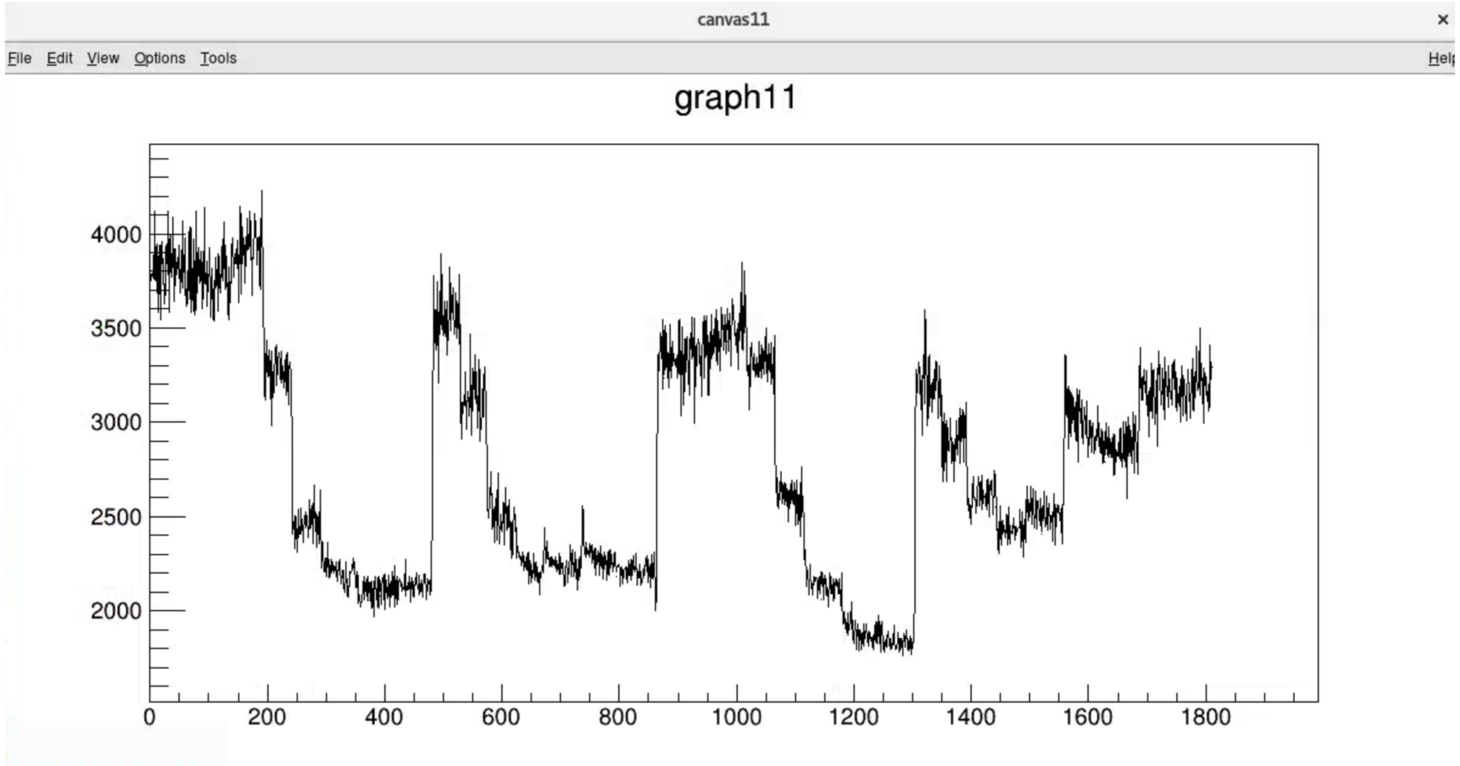




Corrections: Background cut

- This background is still there during a big beam displacement.
- The rate is ~4000 Hz (head on) to ~2000 Hz (biggest displacement)

- I cut the event which |z|> 200 cm.



Corrections: DCCT

- DCCT measure the number of particles N in each ring.
- This correction is calculated as $\frac{N_{\mathbf{yellow,ref}}}{N_{\mathbf{yellow}}}\frac{N_{\mathbf{blue,ref}}}{N_{\mathbf{blue}}}$.

Horizontal	
Step	corr. factor
1	1
2	1.00128246
3	1.002562318
4	1.003857152
5	1.00541094
6	1.007941984
7	1.010583913
8	1.012033314
9	1.013567496
10	1.015397191
11	1.017836241
12	1.022350399

Vertical	
Step	corr. factor
1	1.028015253
2	1.029384549
3	1.030732208
4	1.031980103
5	1.033207602
6	1.035030605
7	1.036890505
8	1.038312022
9	1.039981934
10	1.042046948
11	1.045122516
12	1.053191747

Corrections: Emittance

- The emittance σ increases especially after beam injection.
- This measurement was done soon after injection, so it is needed to apply the emittance correction.
- From CAD, this correction is described as $\sqrt{\frac{\sigma}{\sigma_{\mathbf{ref}}}}$
- where $\sigma = \sigma_{\mathrm{B,x}} \times \sigma_{\mathrm{B},y} \times \sigma_{\mathrm{Y,x}} \times \sigma_{\mathrm{Y},y}$.

Horizontal	
Step	corr. factor
1	1
2	1.002828644
3	1.003474516
4	1.004659761
5	1.00723511
6	1.011241424
7	1.00986279
8	1.010237106
9	1.012156062
10	1.01640327
11	1.017394959
12	1.017685588

Vertical	
Step	corr. factor
1	1.02194775
2	1.018129227
3	1.024882154
4	1.027266898
5	1.027629126
6	1.030937535
7	1.031076761
8	1.032376737
9	1.033096225
10	1.033411152
11	1.035492194
12	1.031330708

Multiple collision/Accidental coincidence

- These are not applied to the result by now.

- Current equations that correct pileup effect and accidental coincidence premise no background.
- It seems impossible to subtract triggers which were from background, especially in MBD N trigger and MBD S trigger individually.

Multiple collision

- It may be still possible to give the upper limit of pileup effect.
- Assuming that all MBD N and S trigger were fired by true collision, we get the maximum range of multiple collision correction.

- $R_{corr.} = \frac{\sum_{i=1}^{\infty} i\,P(i)}{\sum_{i=1}^{\infty} P(i)}$, where $P(i) = \frac{\mu^k}{i!} e^{-\mu}$, $\mu = \frac{N_{mbdN\&S}}{N_{clock}}$

- The maximum correction would increase the collision rate **~1% (head-on).**

Accidental coincidence

- High MBD N and MBD S rate relative to MBD NS will provide a lot of accidental coincidence that should be removed.
- From the z-vertex distribution with displacement 1 mm, there seems few events that have |z|<200 cm that caused by background.

- $k_S = \frac{N_S - N_{NS}}{N_{NS}} \sim 0.3$ in pp run. (consistence with Phenix result)
- $k_S = \frac{N_S - N_{NS}}{N_{NS}} \sim 3.5$ in AuAu run. (Almost same value as ZDC in pp)

Accidental coincidence

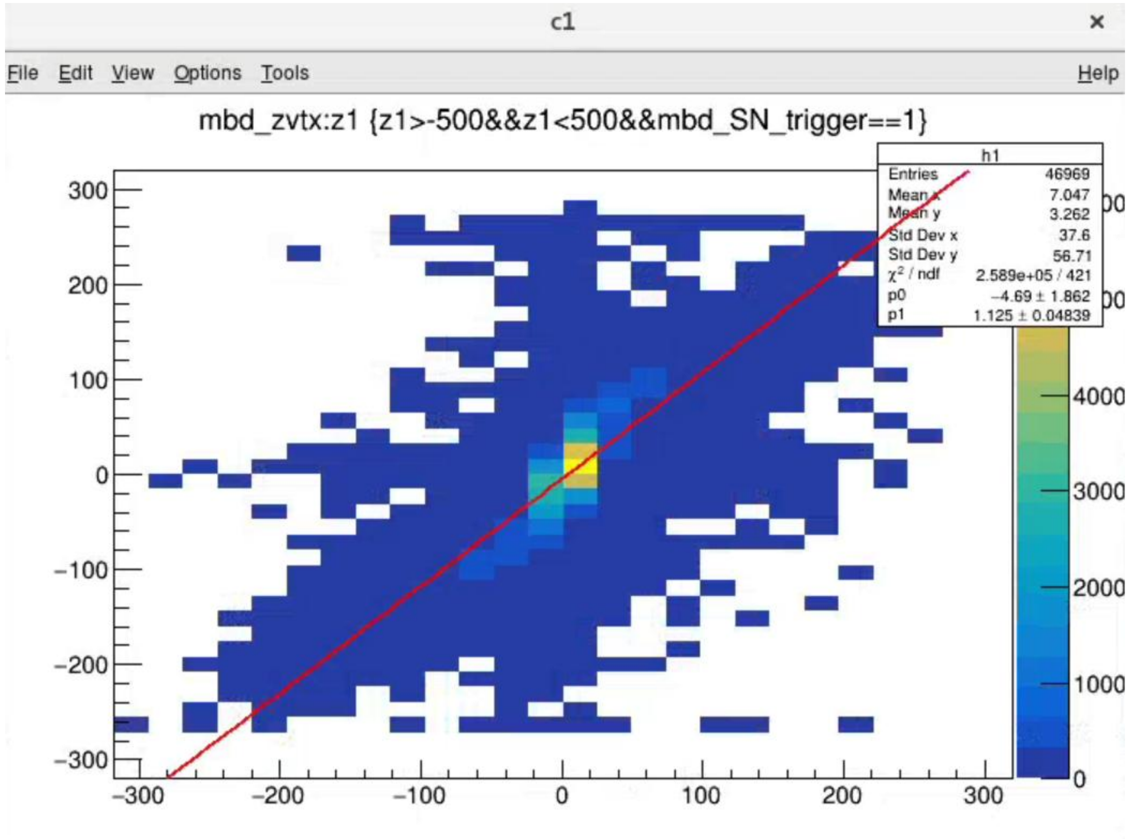
- From the z-vertex distribution with displacement 1 mm, there seems few events that have $|z|<200$ cm that caused by background.
- I'm still thinking how to get the upper limit of accidental coincidence.

- For reference, the accidental coincidence correction that assumes that all trigger ware fired by collision event would reduce the collision rate **~5% (head-on)**.

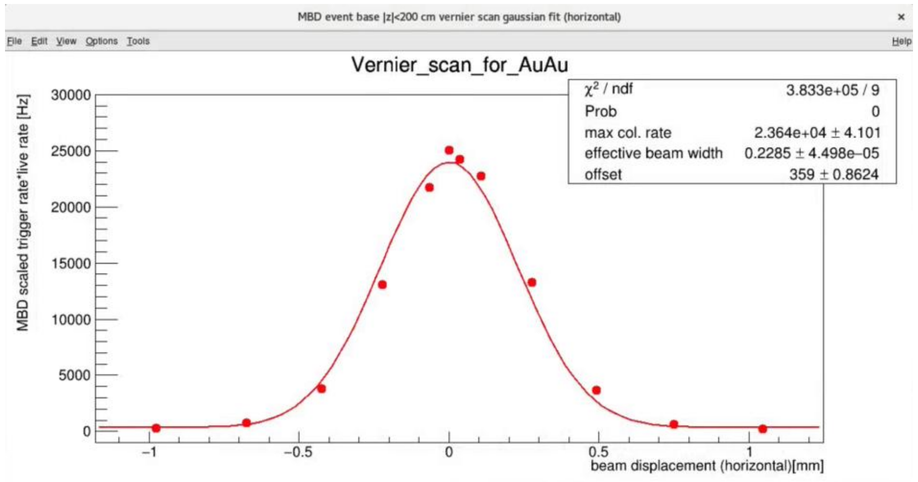
ZDC z-vertex reconstruction

- I tried ZDC z-vertex reconstruction with landau fit. (Same as pp)
- Maybe by the poor time resolution, the fit affected by the initial value.
- And somehow ZDC z vertex distribution is more centered compared to MBD’s one.

- That seems useless.

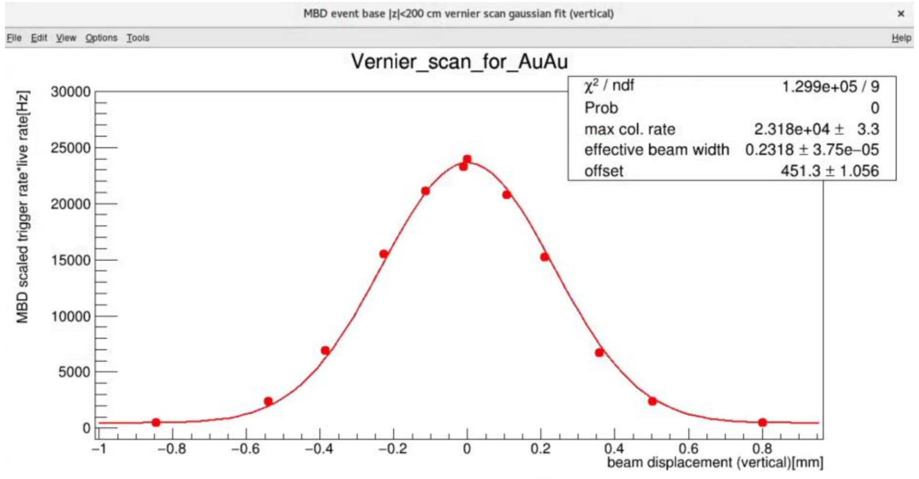


Set position vs Beam Position Monitor (BPM)



	Luminosity [mb-1s-1]	MBD cross section [b]	Beam width [mm](hor.)	Beam width [mm](ver.)
Set position	3.6	7.1	0.17	0.29
BPM	3.4	7.6	0.23	0.23

- Set position is used for pp run since BPM was unreliable for proton beam which had low current.
- That should be more reliable with Au beam.
- But there's a big difference in the beam width using set position or BPM in this measurement.



Summary

- If we take Au-Au vernier scan again, that must be done around the beam dump.
- Background of charged particles increases the error.
- ZDC vertex reconstruction seems not good.
- But the current result is not far away from previous Phenix result.

- Especially for vertical fit, it may be needed to use double gaussian fit.
- There are huge gap between set position and BPM.