Study Of Balance Function In Pb – Pb Collisions as a function of centrality

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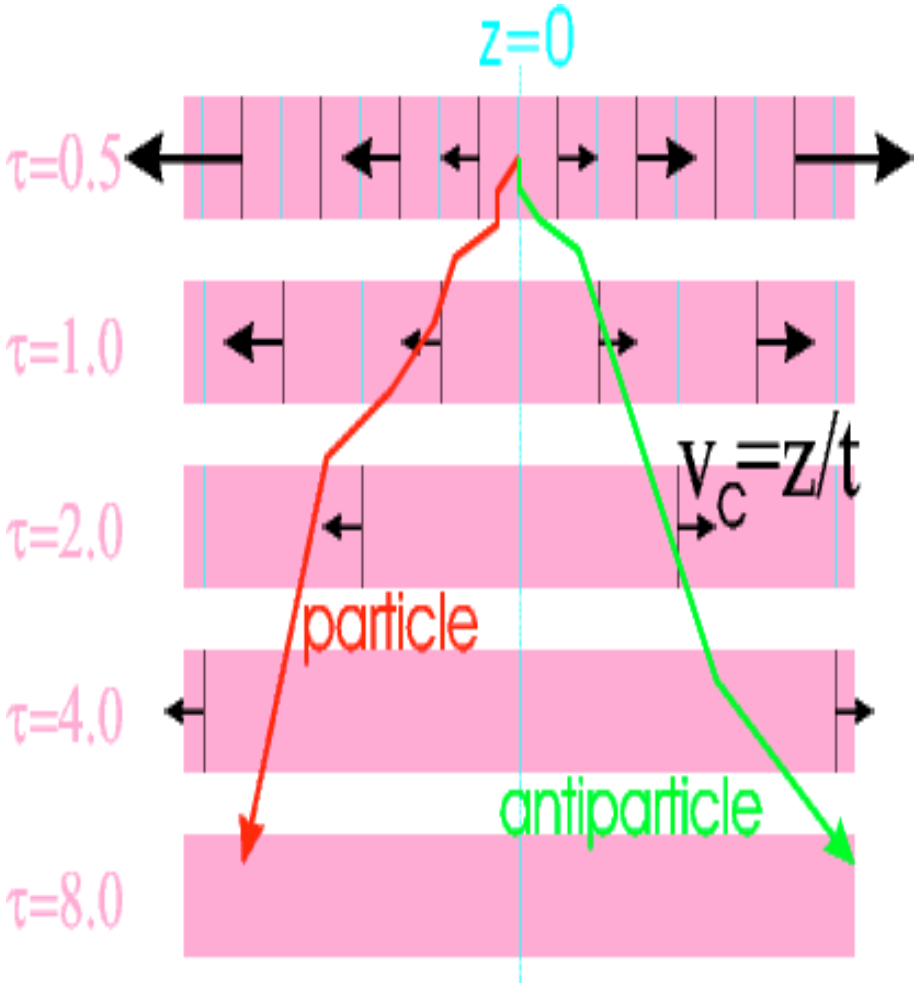
OUTLINE

- Introduction – Toy model
- Analysis of pp@158 GeV
  Stability of results (V_x , V_y , b_x , b_y cuts)
- Analysis of PbPb@158 AGeV
  Stability of results
  Centrality dependence
- Future Plans

MOTIVATION



- Motivated by the idea that hadrons are locally produced in charge – anticharge pairs.
- We can measure separation of balancing charges.
- Early pairs separate due to longitudinal expansion.
- Later pairs are correlated at small Δy.
- Can signal delayed hadronization.

BALANCE FUNCTION DEFINITION

The Balance function is defined as a correlation in y of oppositely charged particles, minus the correlation of same charged particles, normalized to the total number of particles.

$$B(P_2 \mid P_1) = \frac{1}{2}\left(\frac{N(+,P_2 \mid -,P_1) - N(-,P_2 \mid -,P_1)}{N(-,P_1)} + \frac{N(-,P_2 \mid +,P_1) - N(+,P_2 \mid +,P_1)}{N(+,P_1)} \right)$$

where P_2: relative rapidity

P_1: anywhere in the detector

Normalization: $\sum_{P_2} B(P_2 \mid P_1) = 1$

Statistical Errors: $\sigma_{statistical} \propto \frac{1}{\sqrt{N_{EVENTS}}}$

Error in Balance Function: $\partial B = \frac{1}{2}\left(\left(\sqrt{\frac{\sqrt{\Delta_{+-} + \Delta_{++}}}{N_+}} \right)^2 + \left(\sqrt{\frac{\sqrt{\Delta_{-+} + \Delta_{--}}}{N_+}} \right)^2 \right)$

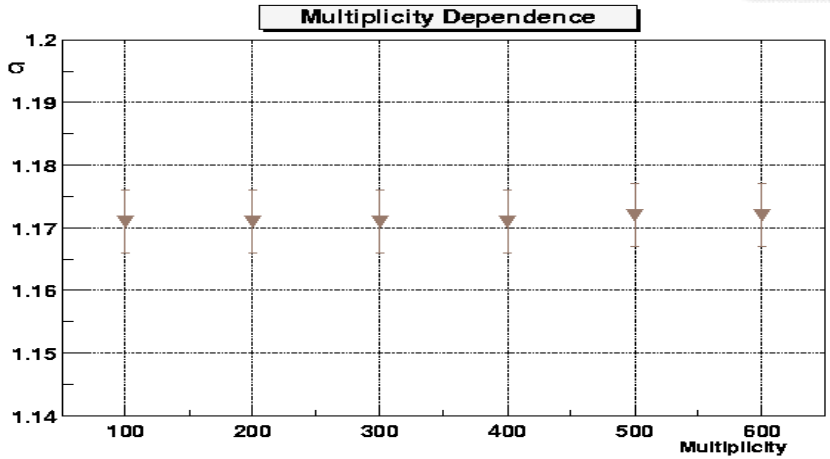
Ref:

- Bass-Danielewicz-Pratt, Phys. – Rev.Lett.85, 2000
- D. Drijard et al, Nucl. Phys. B(155), 1979

TOY MODEL ANALYSIS

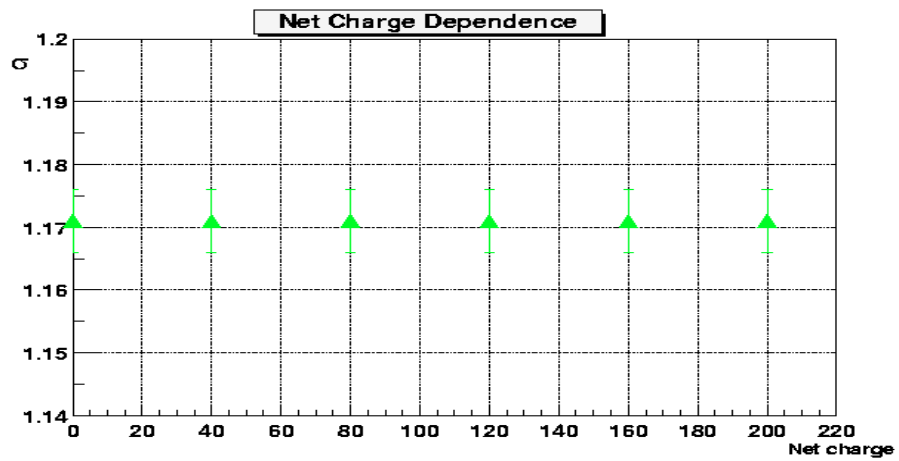
Multiplicity Dependence

- Equal number of positive & negative particles.
- For each run this number is increased , starting from 100 to 600 total particles with a step of 100 (50 pos. & 50 neg.).
- We analyze the whole interval of the input distribution.



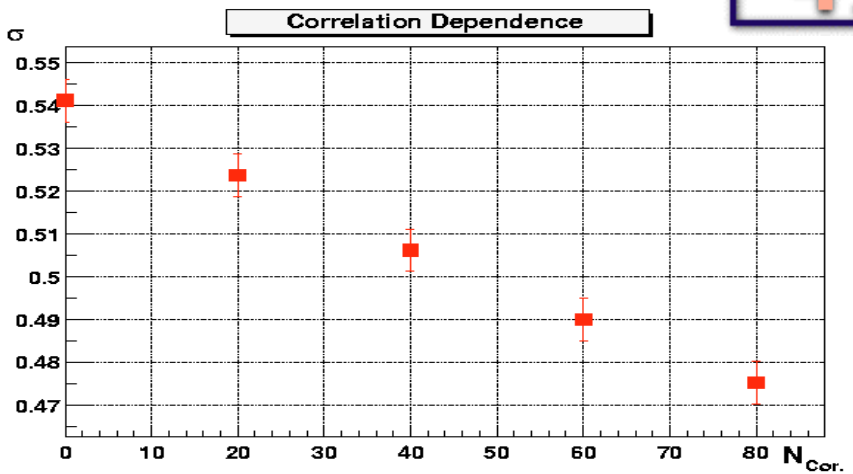
Net charge Dependence

- Fixed number of total particles (400).
- For each run the net charge is increased , starting from 40 to 200.
- The number of positive particles is always bigger than that of the negative particles.
- We analyze the whole interval of the distribution.



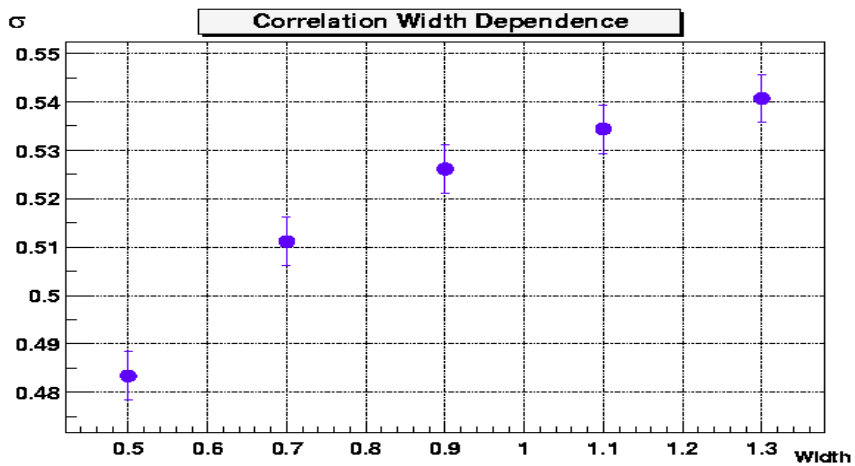
Correlation Dependence

- Fixed number of total particles (400).
- For each run , equal number of positive and negative particles is doped symmetrically around the mean of the input distribution.
- The distributions of the correlated particles are also Gaussians with a much narrower width.
- For each run the number of the correlated particles is increased , starting from 20 to 80.
- We analyze in the interval mean ± 1.2 (symmetrically around the mean).



Correlation Width Dependence

- Fixed number of total particles (400).
- Fixed number of correlated particles (60).
- The distributions of the correlated particles are also Gaussians.
- For each run the width of the distributions of the correlated particles is increased.
- We analyze in the interval mean ± 1.2 (symmetrically around the mean).



DATA SAMPLES ANALYZED

- pp @ 158 GeV – 500k Events
  DST FILE : **std+–160GeV–pp–00R**
  Mixed pp @ 158 GeV – 500k Events

- PbPb @ 158 AGeV – Minimum Bias
  DST FILE : **std+–160GeV–minbias–00M** (200K Events)
  DST FILE : **std--160GeV–minbias–00N** (200K Events)
  DST FILE : **std+-160GeV–minbias–low–int–01J** (200K Events)
  DST FILE : **std--160GeV–central–00O** (100K Events)
  Centrality Dependence – 6 Centrality Bins
- PbPb @ 158 AGeV – Mixed Events – (00M – 00N – 00O DST)

pp @ 158 GeV

SELECTION CRITERIA

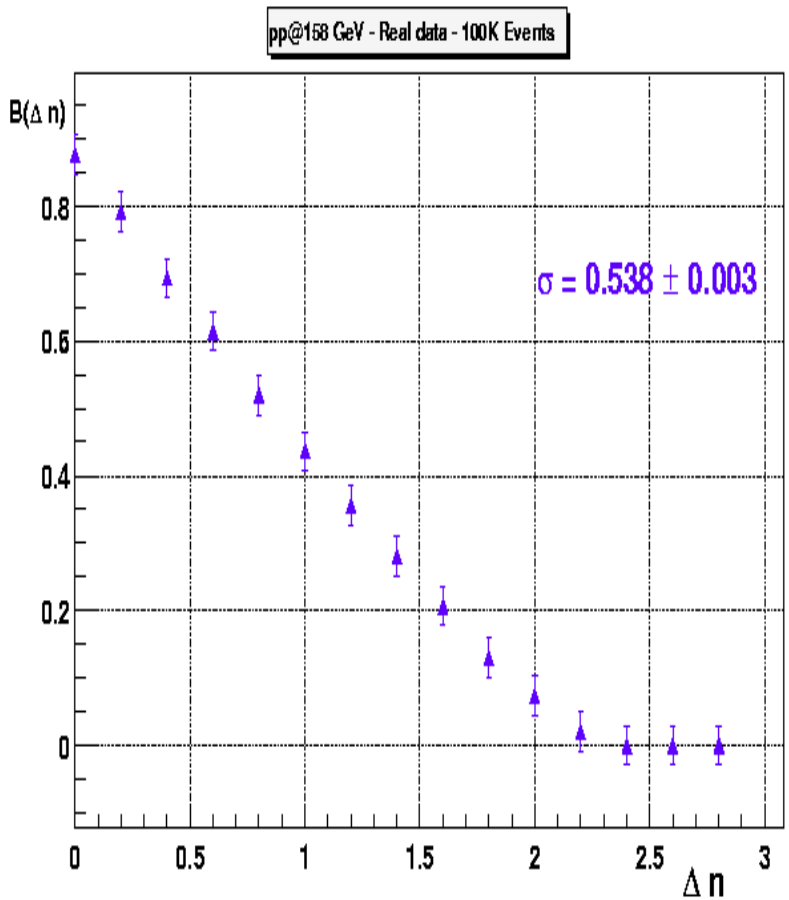
- **Event Level Cuts:**

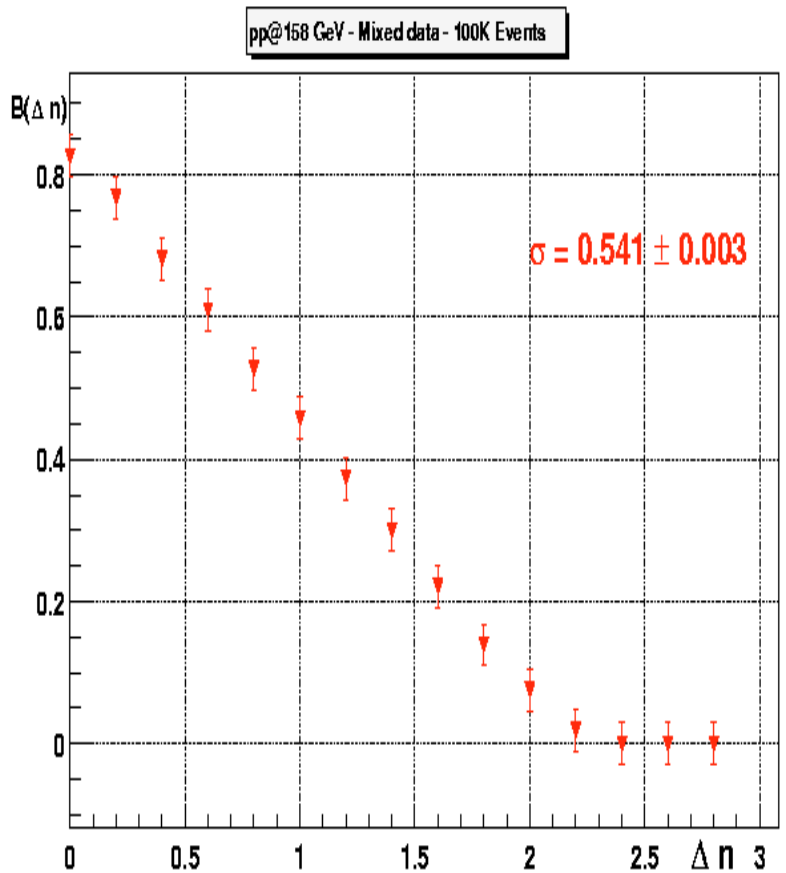
  $-0.5 < V_x < 0.5$
  $-0.5 < V_y < 0.5$
  $-583.0 < V_z < -579.0$
  Number of tracks > 2
  Track Ratio > 0.3
  At least one positive and one negative track per event.

- **Track Level Cuts:**

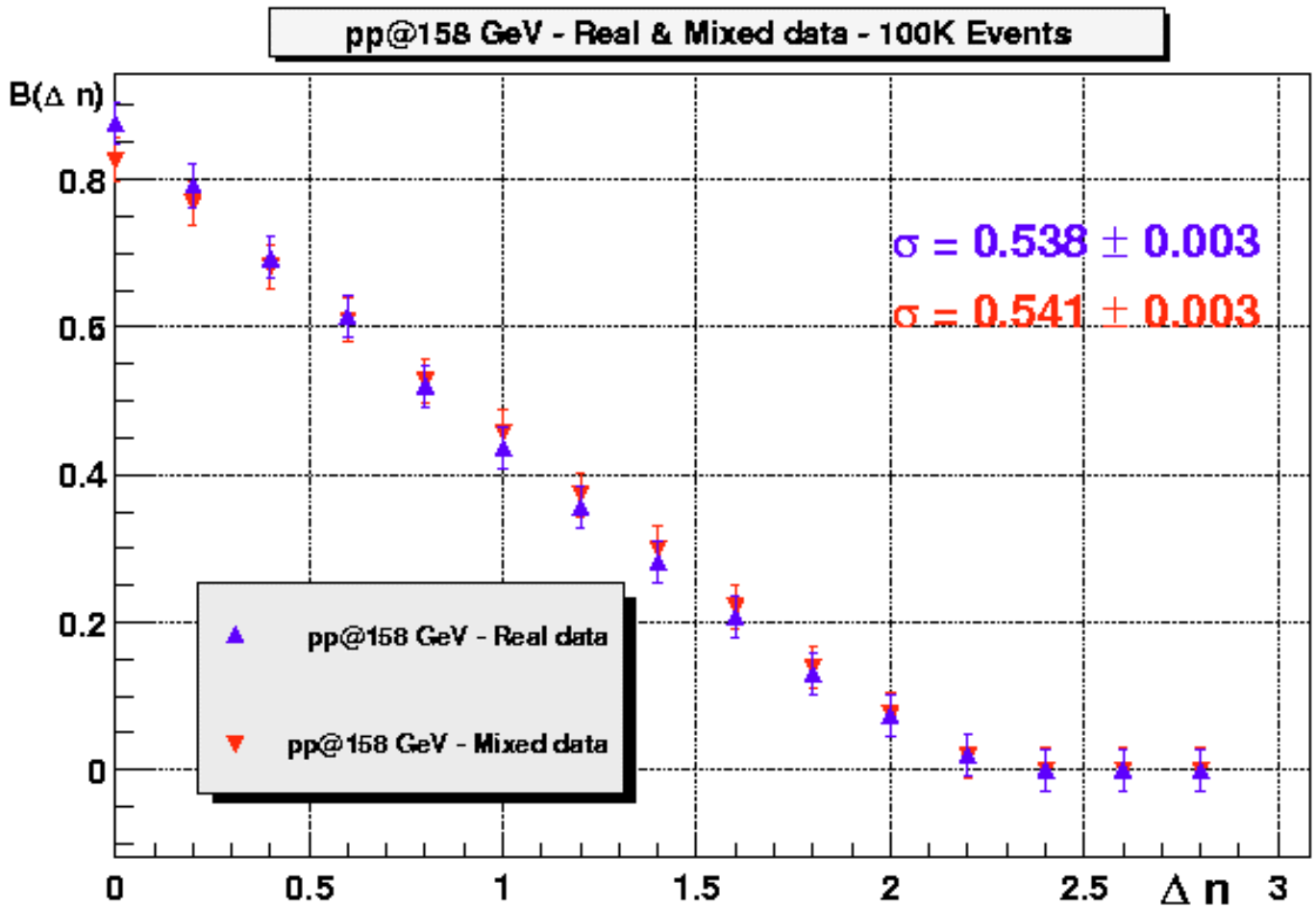
  $-1.0 < b_x < 1.0$
  $-1.0 < b_y < 1.0$
  $0.005 < P_t < 1.5$

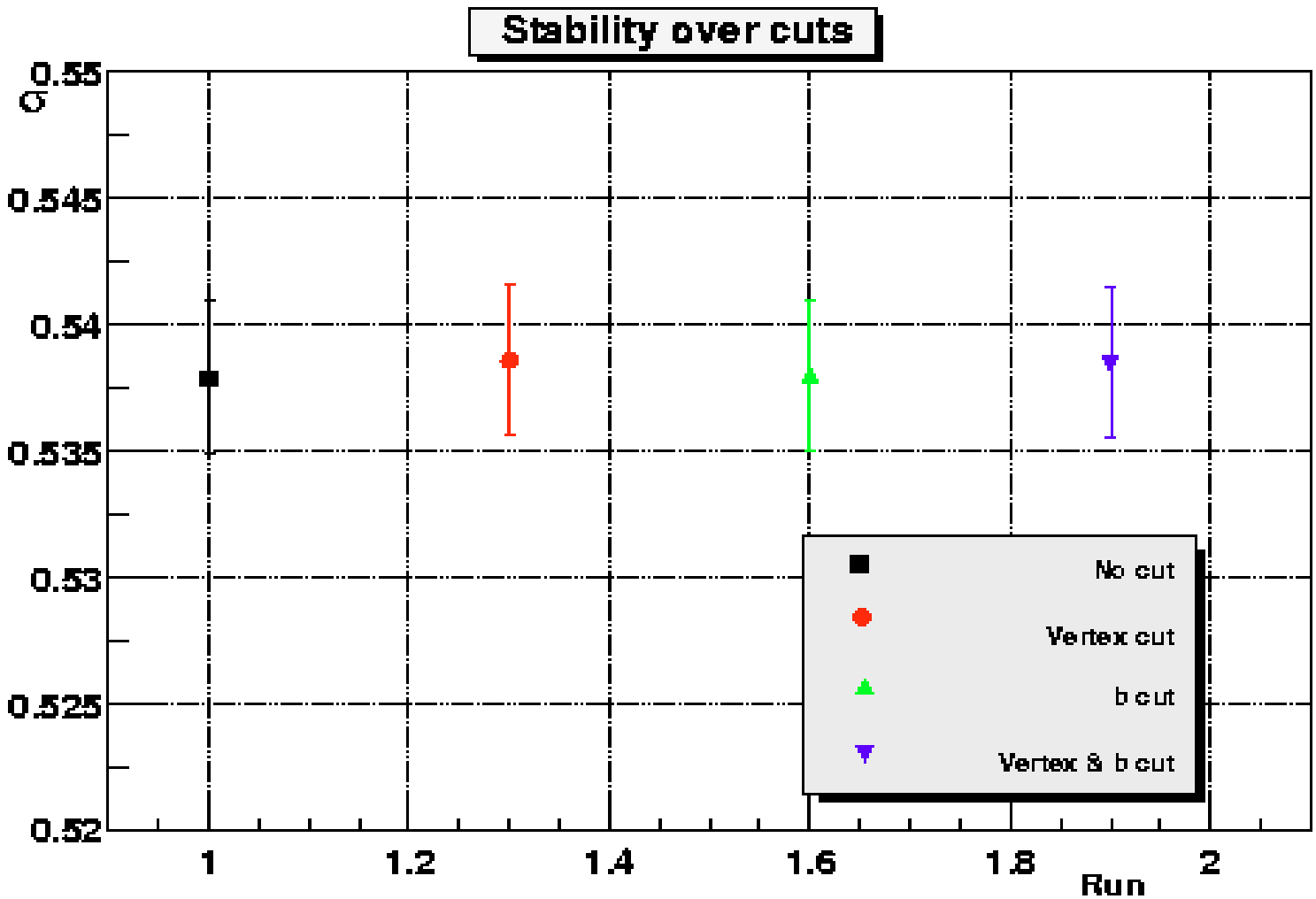
Balance function for pp@158 GeV real and mixed data





Comparison of the two previous balance functions




Stability over cuts
σ
0.55
0.545
0.54
0.535
0.53
0.525
0.52
1
1.2
1.4
1.6
1.8
2
Run
No cut
Vertex cut
b cut
Vertex & b cut

PbPb @ 158 AGeV

PbPb@158 AGeV – 00N – 01J – 00O

SELECTION CRITERIA

Event level :

$-0.1 < Vx < 0.1$
$-0.1 < Vy < 0.1$
$-579.3 < Vz < -578.5$
$-580.8 < Vz < -580.0$(**01J**)

Number of tracks > 50
Track Ratio > 0.3

Track level :

$-0.5 < bx < 0.5$
$-0.3 < by < 0.3$
$0.005 < Pt < 1.5$

PbPb@158 AGeV – 00M

SELECTION CRITERIA

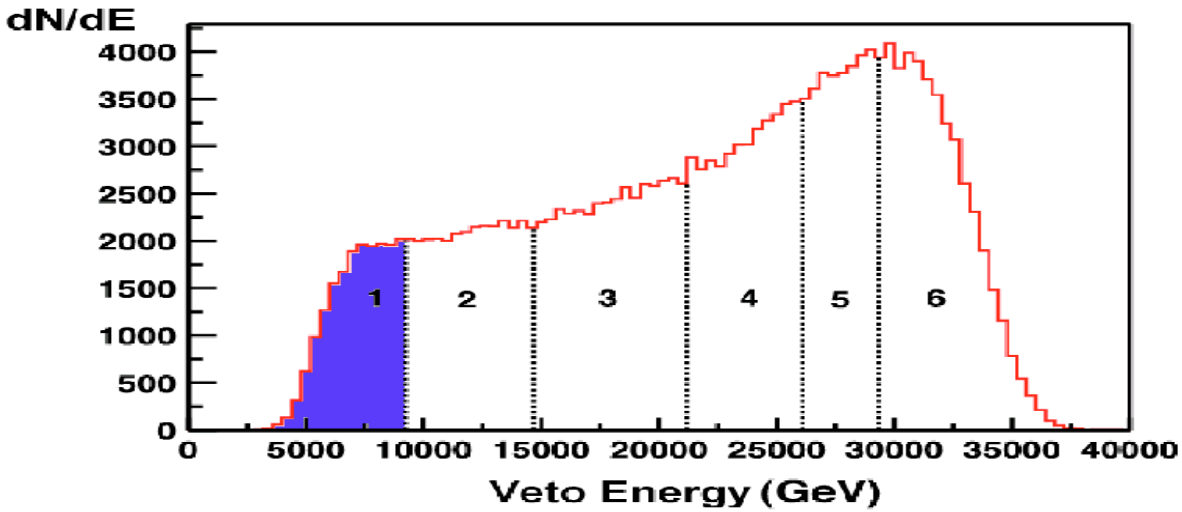
Event level :

$-0.12 < Vx < -0.02$
$0.0 < Vy < 0.1$
$-579.3 < Vz < -578.5$

Number of tracks > 50
Track Ratio > 0.3

Track level :

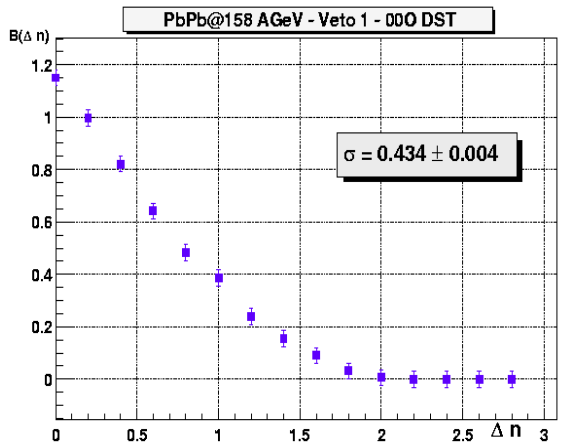
$-0.5 < bx < 0.5$
$-0.3 < by < 0.3$
$0.005 < Pt < 1.5$

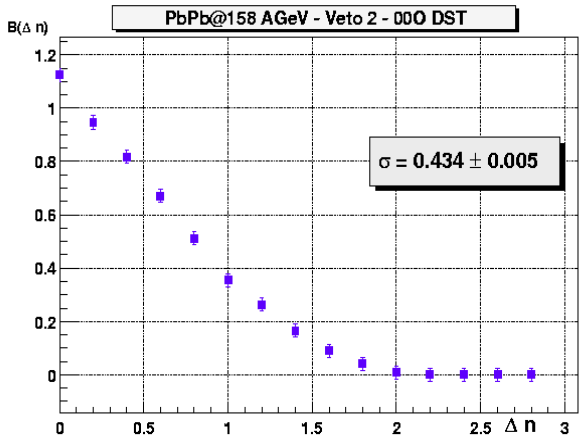


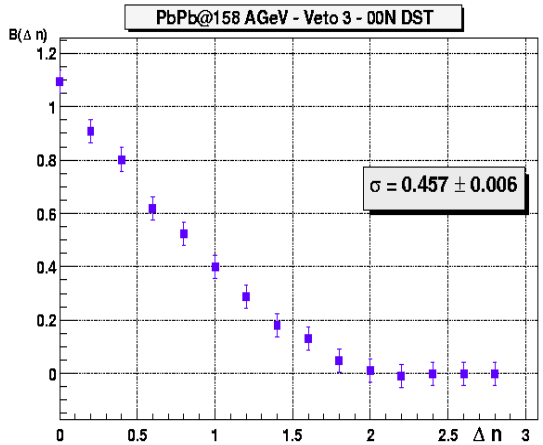
Bin	E_0 Range (Gev)	N_{spec}	N_{part}
1	0 – 9250	43	373
2	9250 – 14670	97	319
3	14670 – 21190	164	252
4	21190 – 26080	228	188
5	26080 – 29340	275	141
6	29340 – 40000	328	88

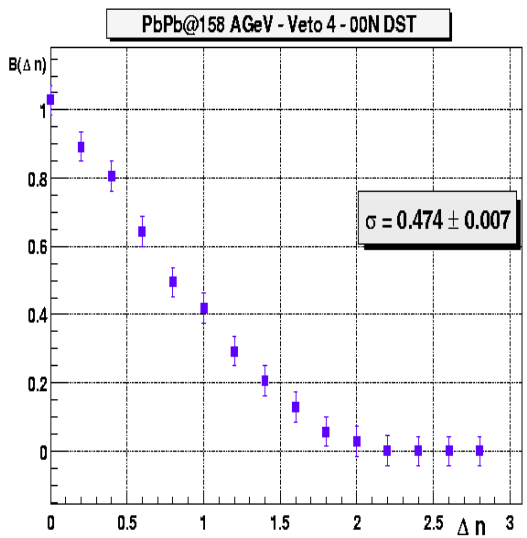
Ref:
- **Glenn Cooper Thesis**

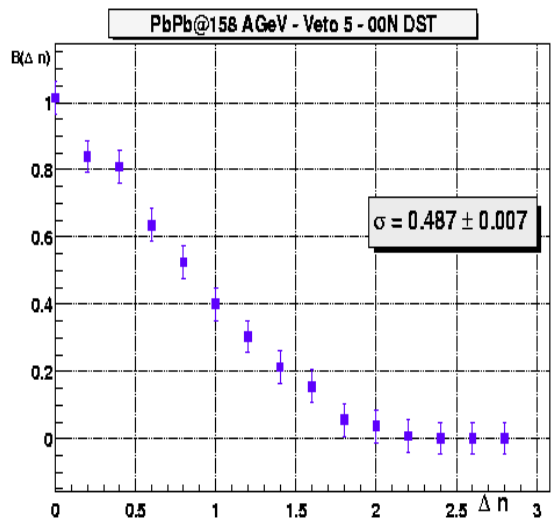
Balance functions for all veto bins

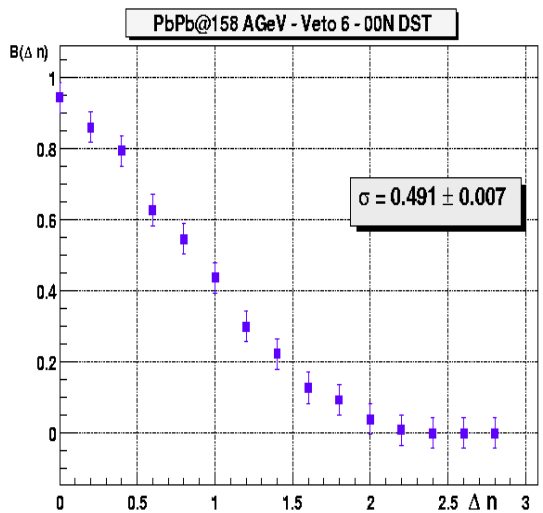




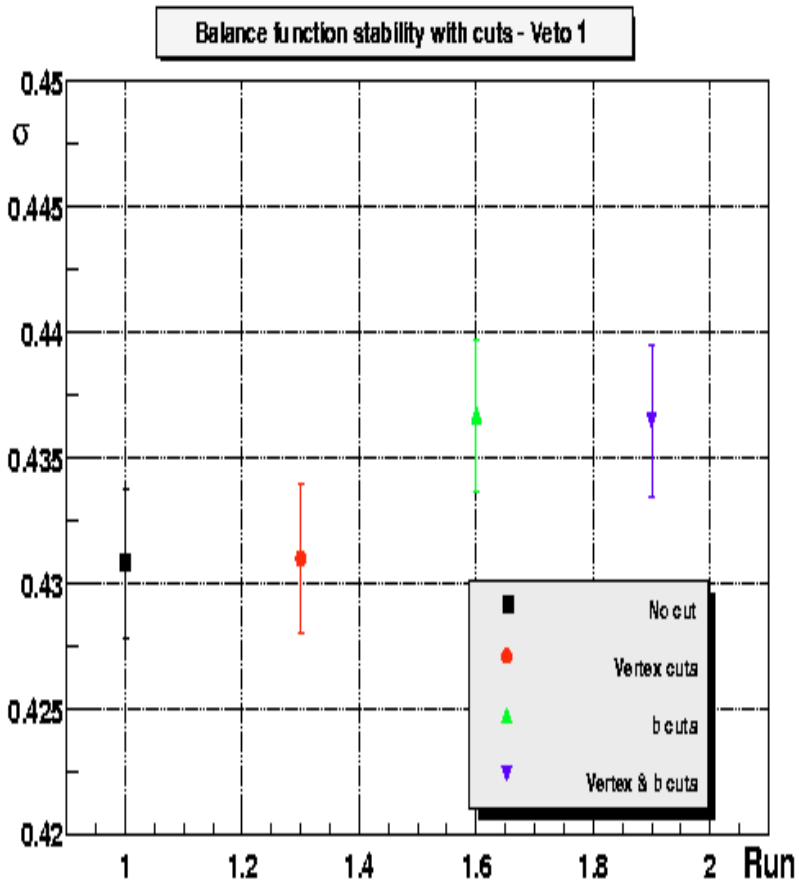


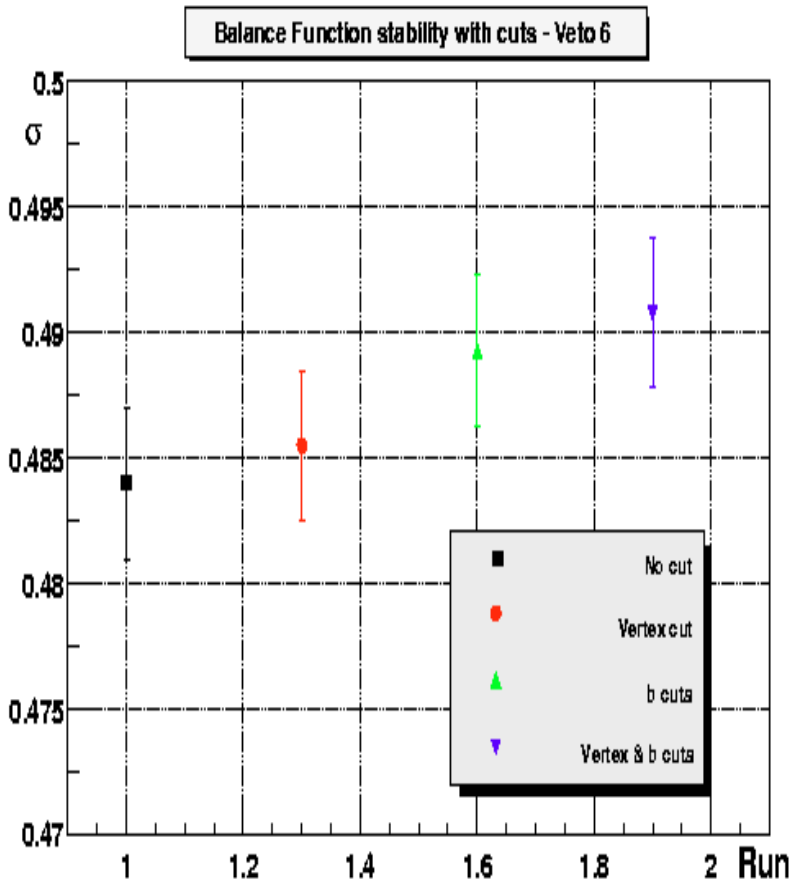




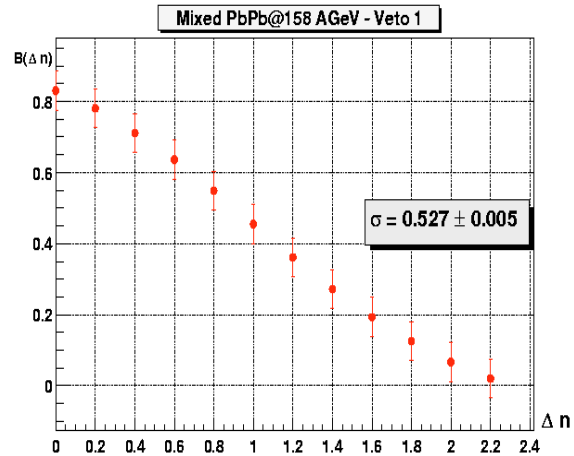


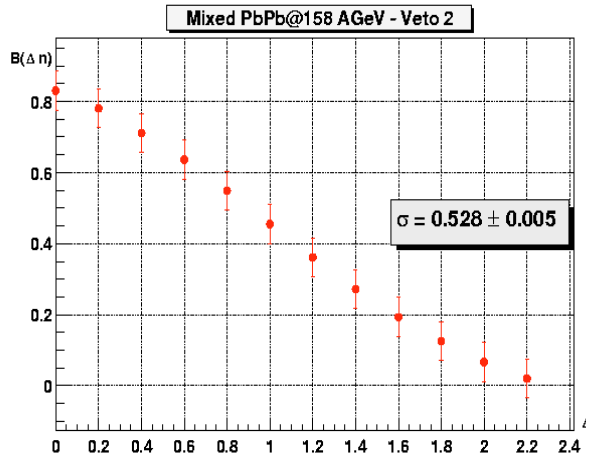
STABILITY OF WIDTH OVER CUTS

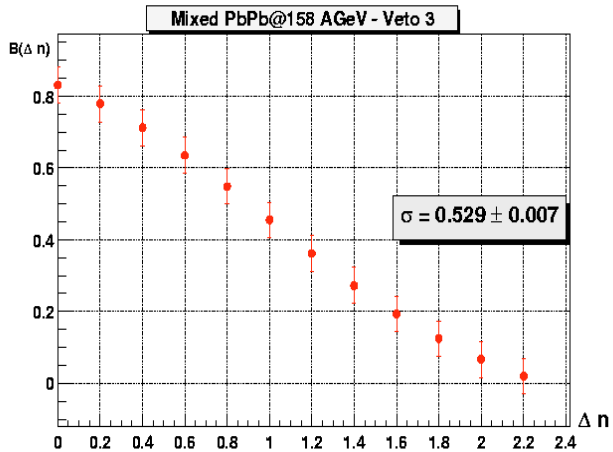


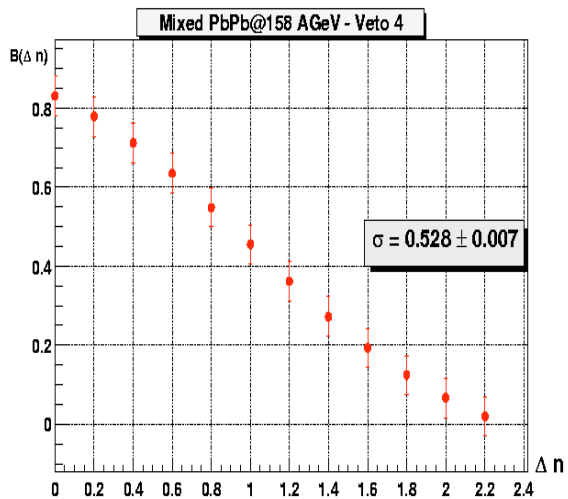


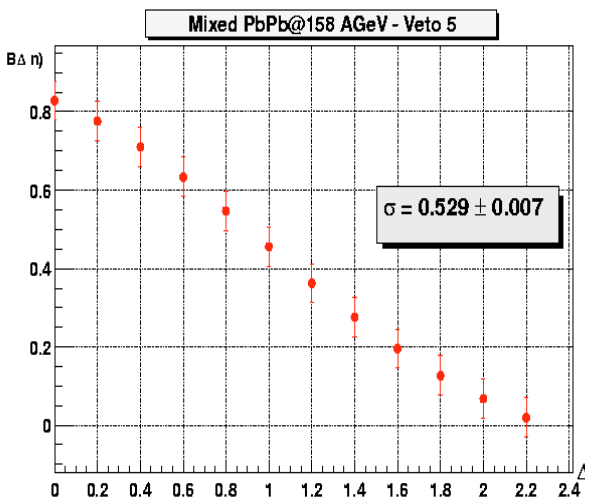
Balance functions for all veto bins – Mixed data

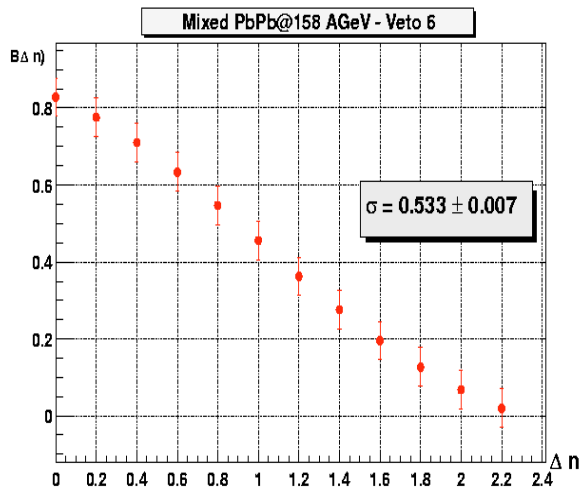


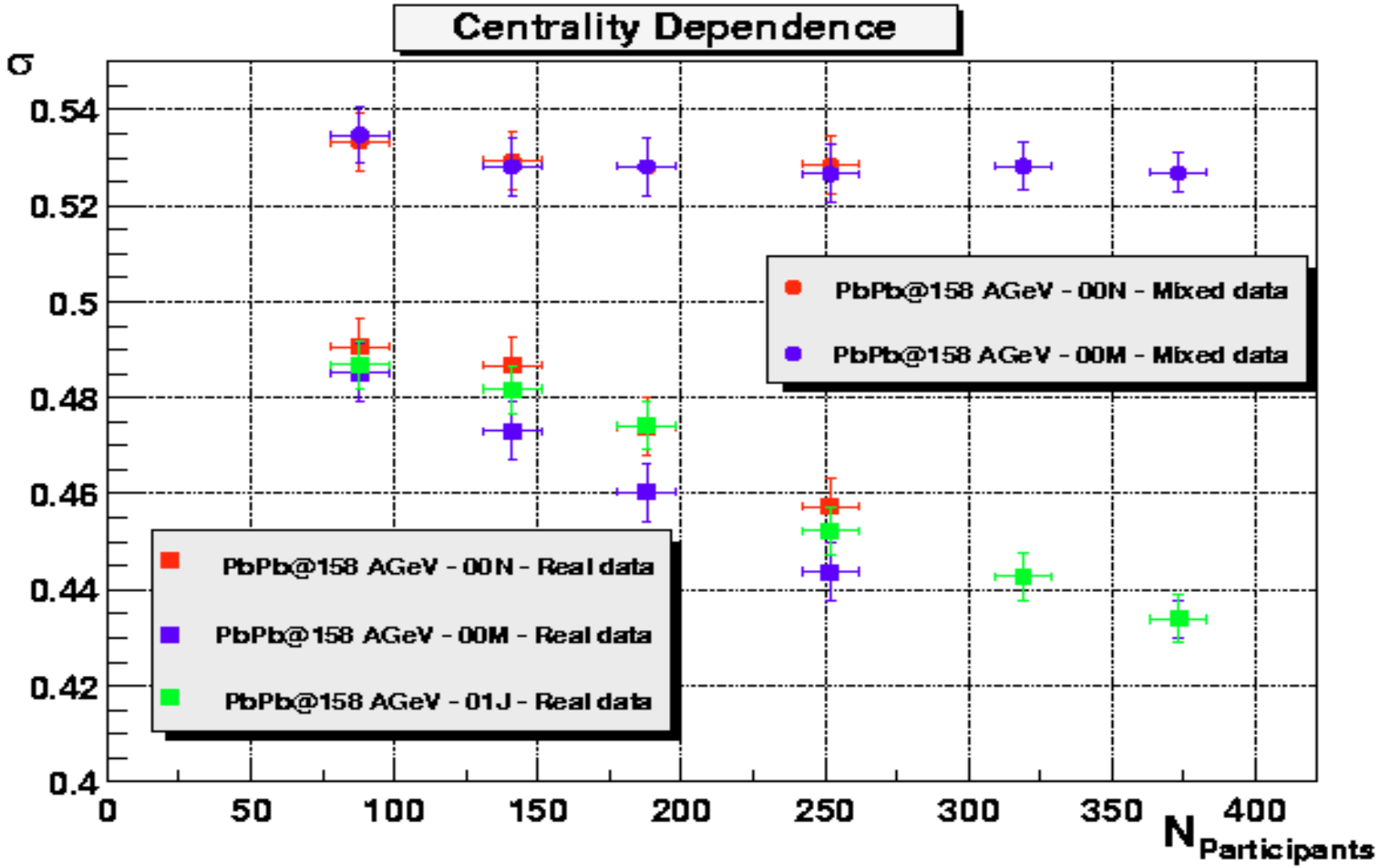


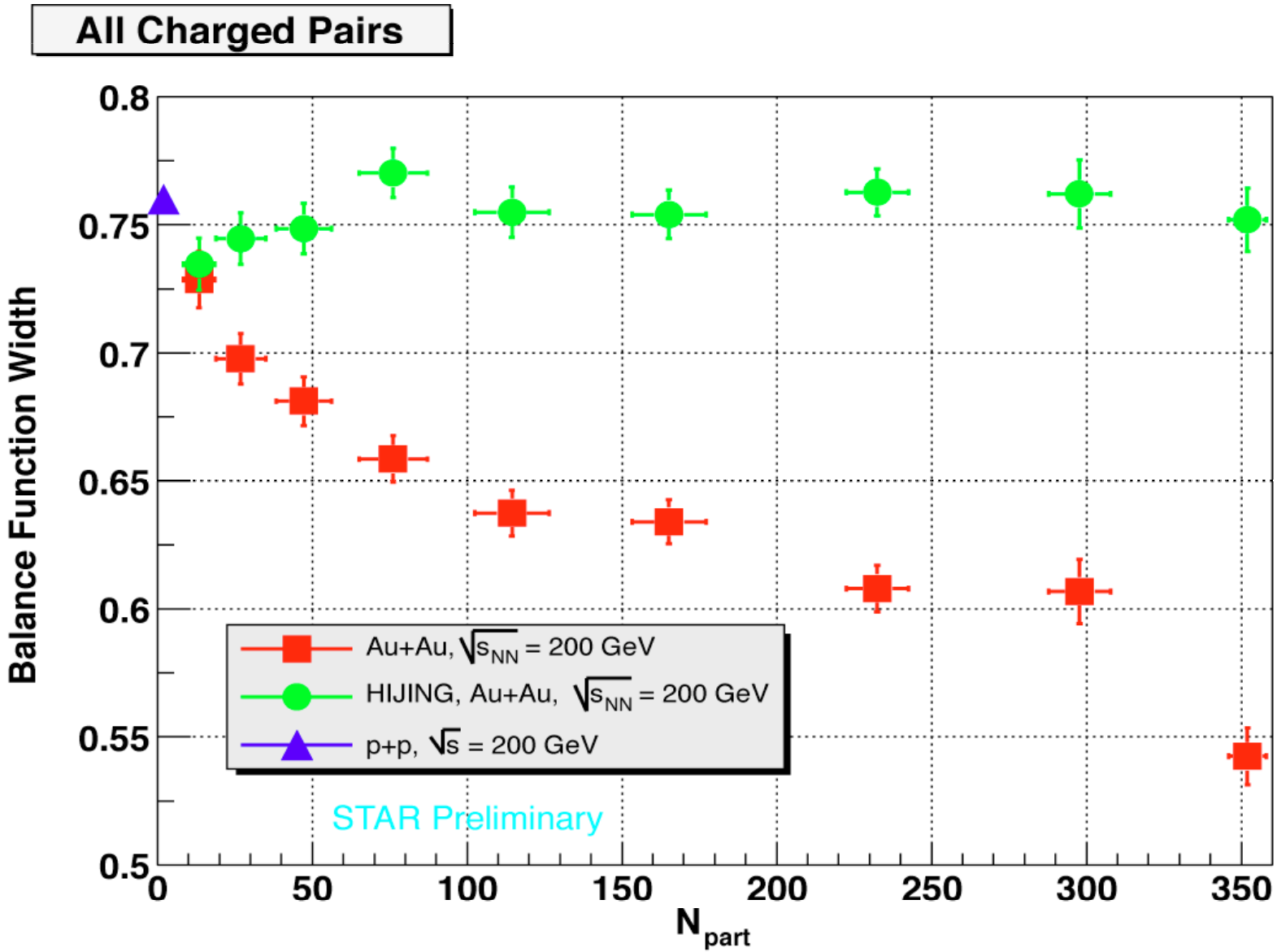









Centrality Dependence
σ
0.54
0.52
0.5
0.48
0.46
0.44
0.42
0.4
0
50
100
150
200
250
300
350
400
N Participants
PbPb@158 AGeV - 00N - Mixed data
PbPb@158 AGeV - 00M - Mixed data
PbPb@158 AGeV - 00N - Real data
PbPb@158 AGeV - 00M - Real data
PbPb@158 AGeV - 01J - Real data


All Charged Pairs
Balance Function Width
0.8
0.75
0.7
0.65
0.6
0.55
0.5
0
50
100
150
200
250
300
350
N part
Au+Au, √sNN = 200 GeV
HIJING, Au+Au, √sNN = 200 GeV
p+p, √s = 200 GeV
STAR Preliminary

FUTURE PLANS

- Centrality dependence – Need for MC data for PbPb @ 158 AGeV in different centralities.
- Study of Balance Function's dependence on dynamical variables (P_T).
- Energy dependence – Analyze PbPb data for different energies .
- System dependence – Study of Balance Function for different systems (CC – SiSi).