Aneta **I**ordanova

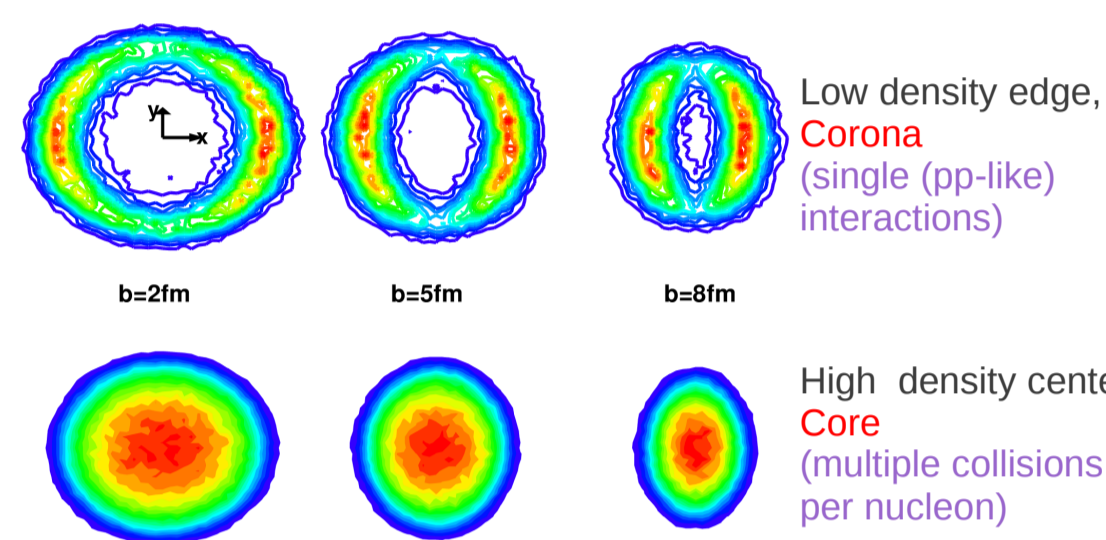UC **R**IVERSIDE — UNIVERSITY OF CALIFORNIA

Forward J/ψ production in Au+Au and Cu+Au collisions at PHENIX

QM 12 QuarkMatter

Initial Geometry and Core/Corona

CuAu collisions
→ unique initial conditions compared to Au+Au (e.g real ψ_3)
→ different corona on Au-side compared to Cu-side
→ Cu can be completely within the Au-nucleus in very central collisions

Nuclear overlap yields wide variety of densities versus centrality (for all species and collisions)

Estimate corona size using a Glauber model – divide according to the number of collisions per nucleon

In Au+Au and Cu+Au collisions:
A significant corona in central collisions exists

b=2fm   b=5fm   b=8fm

Low density edge, Corona (single (pp-like) interactions)

High density center, Core (multiple collisions per nucleon)

Physics motivation

Assume that the J/ψ is formed in a region (corona), free from the hot, dense plasma (Matsui/Satz, 1986)

The large corona asymmetry in Cu+Au may result in asymmetry in the J/ψ production

Also expect that asymmetric corona will result in an asymmetric v_2 (or v_1) amplitude

The existence of such a signal will allow a tag of the Cu-side and Au-side in the collision

Mid-central collisions   Summed over many Glauber events

Cu-side   Au-side
Reaction Plane

Corona only
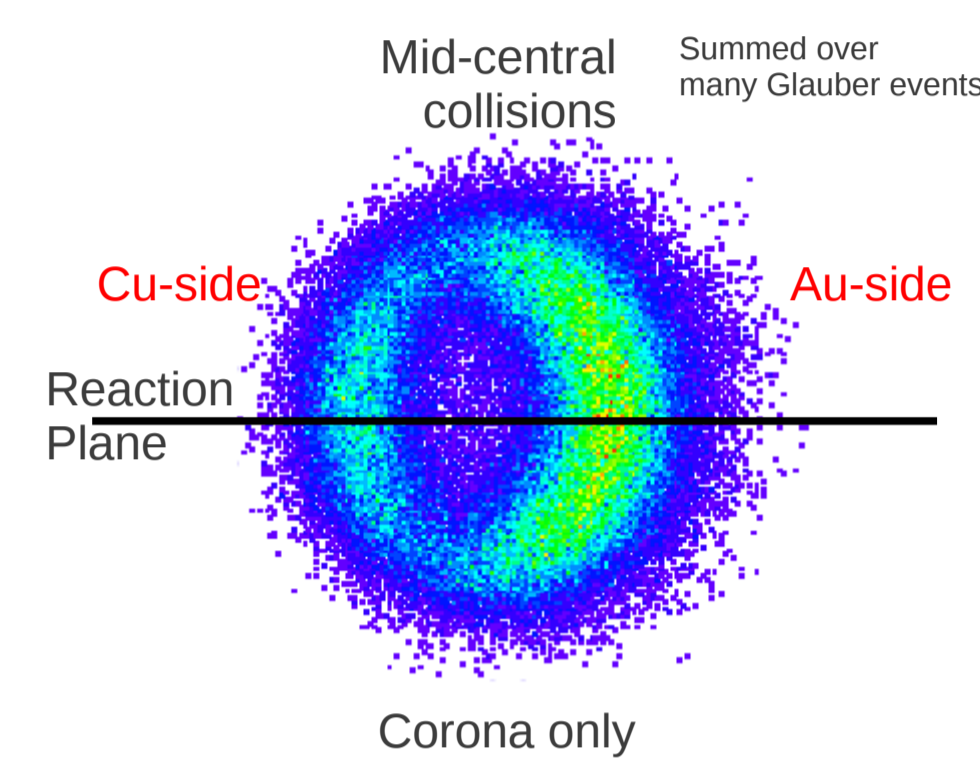
Proposed measurements

Measure J/ψ production independently on
• Cu-side and Au-side (left/right asymmetry)
• Cu-going side and Au-going side along z of the collision (backward/forward rapidity asymmetry)

This measurement may give a direct handle on the relative J/ψ production in the two parts of the corona, in the same event. By varying the centrality we could attempt to measure the corona size

v_2 (v_n) – Anticipated *asymmetric* v_2 (v_n^a) needed not only for tagging of the Au-side, but interesting to measure in itself

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The original approach was aimed to explain the ~25% enhancement in the total charged particle multiplicity in AA collisions compared to pp and e^+e^- collisions

"Leading Hadrons" observed in pp collisions
→ about 50% of the energy of the collision does not contribute to particle production
→ considering this unites pp and e^+e^- collision data
→ Assume that, in AB collisions, this "leading hadron" is fully reabsorbed after a series subsequent collisions – leading to a higher multiplicities.
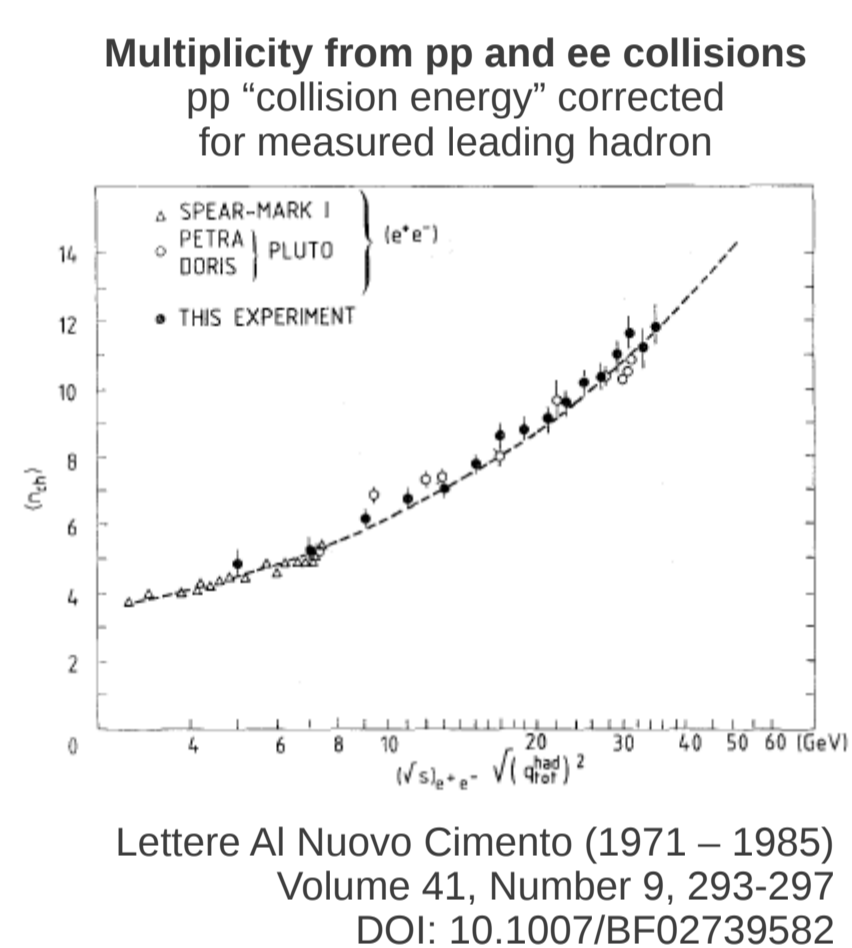
One can connect this to the Glauber Model, by asserting
• "surface" **corona** is a low-density singly-interacting region (allows leading hadrons)
• "central" **core** is dominated by multiply-interacting nucleons (no leading hadrons)

Multiplicity from pp and ee collisions
pp "collision energy" corrected for measured leading hadron

- SPEAR-MARK I
- PETRA
- DORIS   PLUTO (e^+e^-)
- THIS EXPERIMENT

Lettere Al Nuovo Cimento (1971 – 1985)
Volume 41, Number 9, 293-297
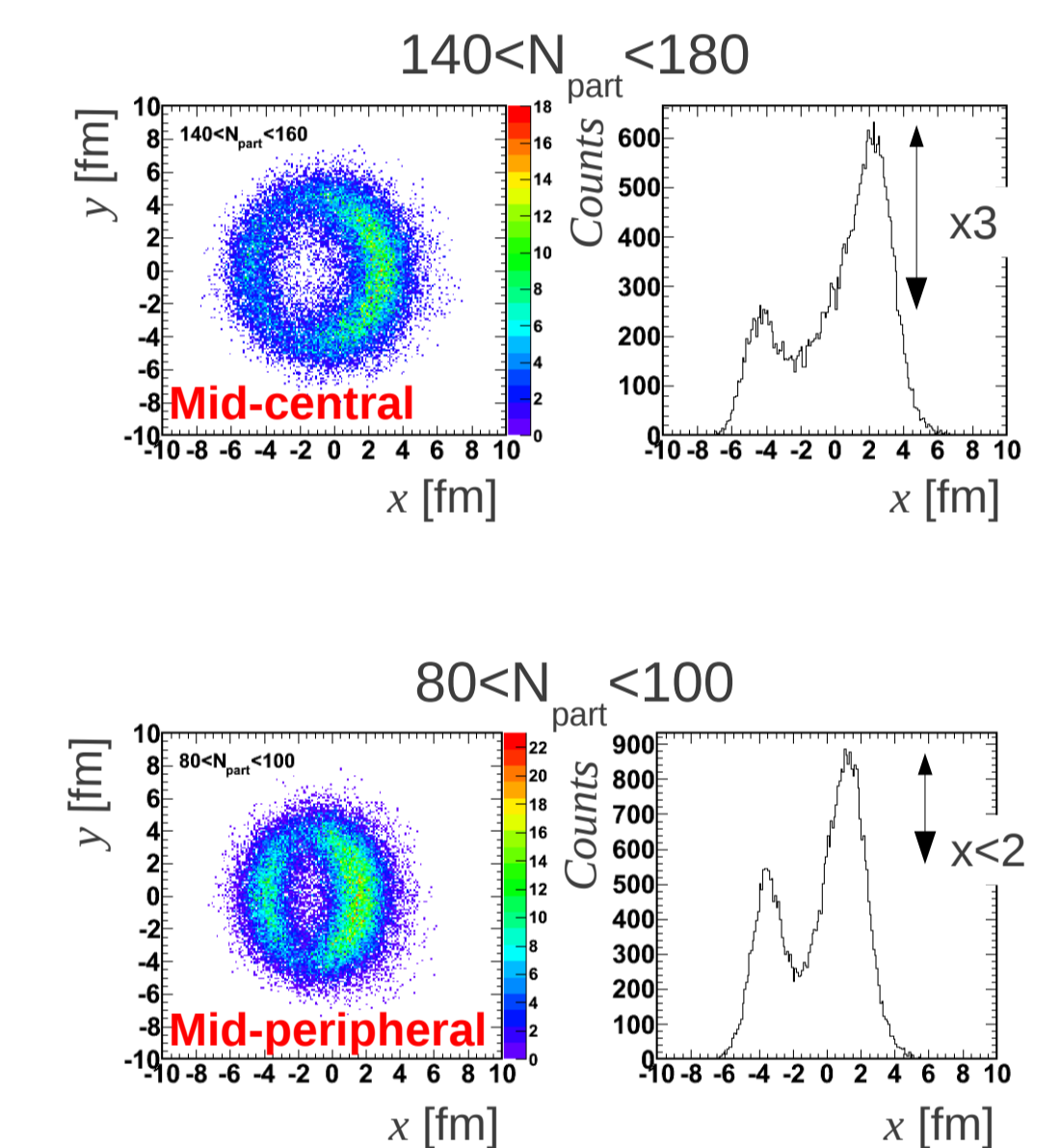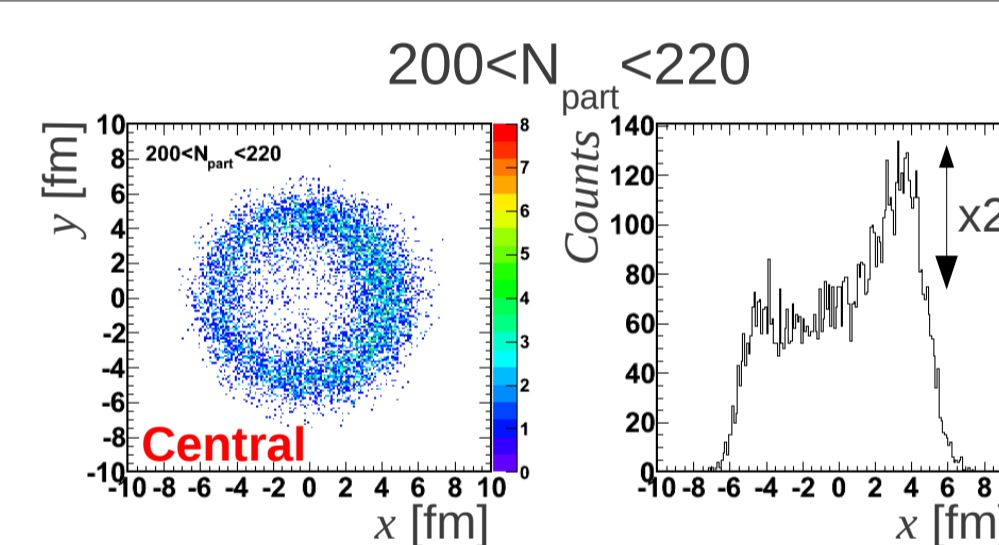DOI: 10.1007/BF02739582

Cu-side / Au-side determination method

1. Find reaction-plane ψ_2
2. Orient it along Au side
3. Tag the particle ¾π around the x-axis as from the Au-side, opposite tagged as Cu-side

Note: No asymmetry in Au+Au but could still tag the two nuclei at forward rapidity (where v_1 is large)
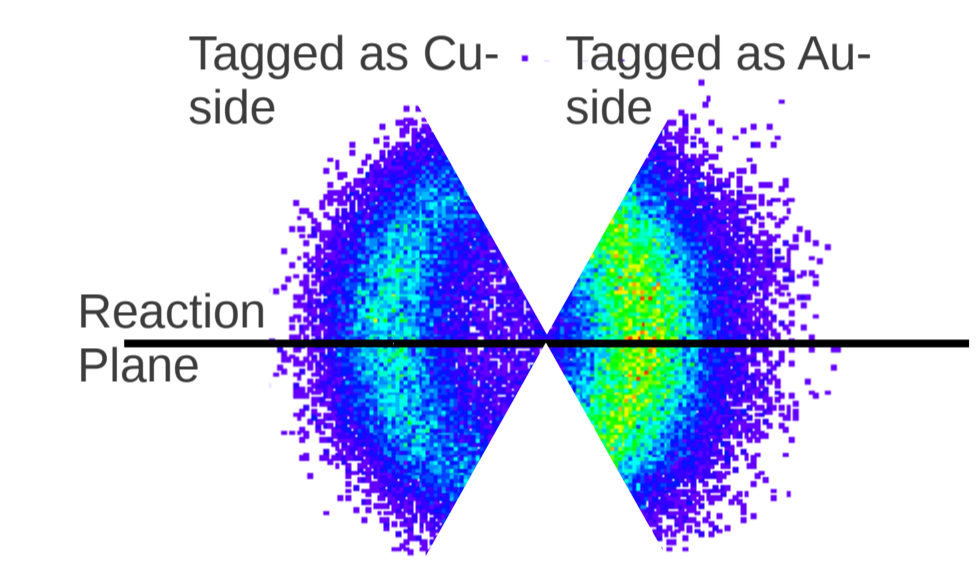
Glauber simulation of Cu+Au corona and number of particles in Au versus Cu tagged side
→ Cu/Au-corona size changes with centrality

Will this difference be apparent in the data?

Tagged as Cu-side   Tagged as Au-side
Reaction Plane

$140<N_{part}<180$ x3   Mid-central

$200<N_{part}<220$ x2   Central

$80<N_{part}<100$ x<2   Mid-peripheral

Au-side tagging feasibility studies

To test whether it is feasible to make this measurement, HIJING was modified to produce particles which mimics flow.
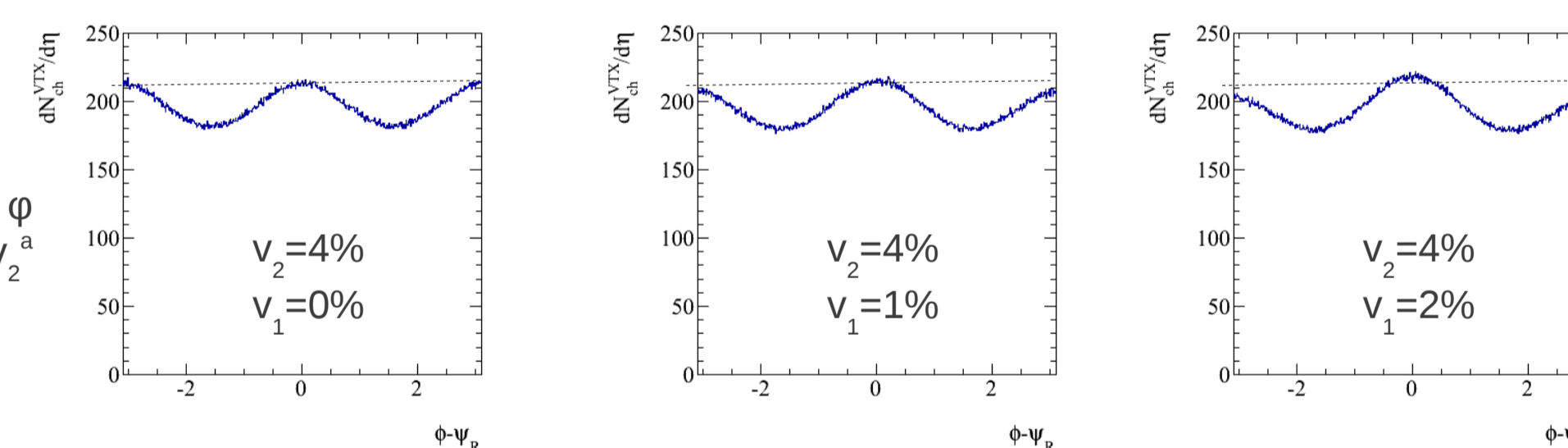The procedure:
1. Simulate HIJING Cu+Au events
2. Rearrange final particle φ distributions to mimic v_1 and v_2
→ No model distinction between v_1 and v_2
3. Change the input v_1 to produce different levels of v_2^a
4. Use measured v_2 values for Cu+Cu system
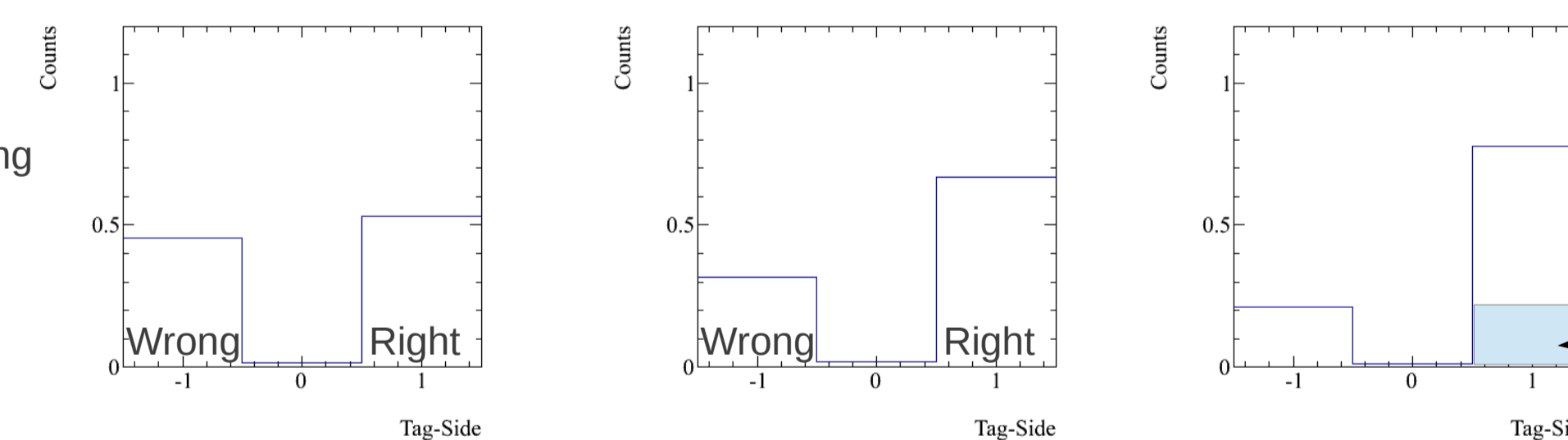→ 3-5% was measured (centrality dependent)

Evaluate the tagging efficiency:
1. Tag the Au side using v_2^a
2. Wrong tag/random benefit due to fluctuations
→ Dilutes the measurement (but exactly measurable)
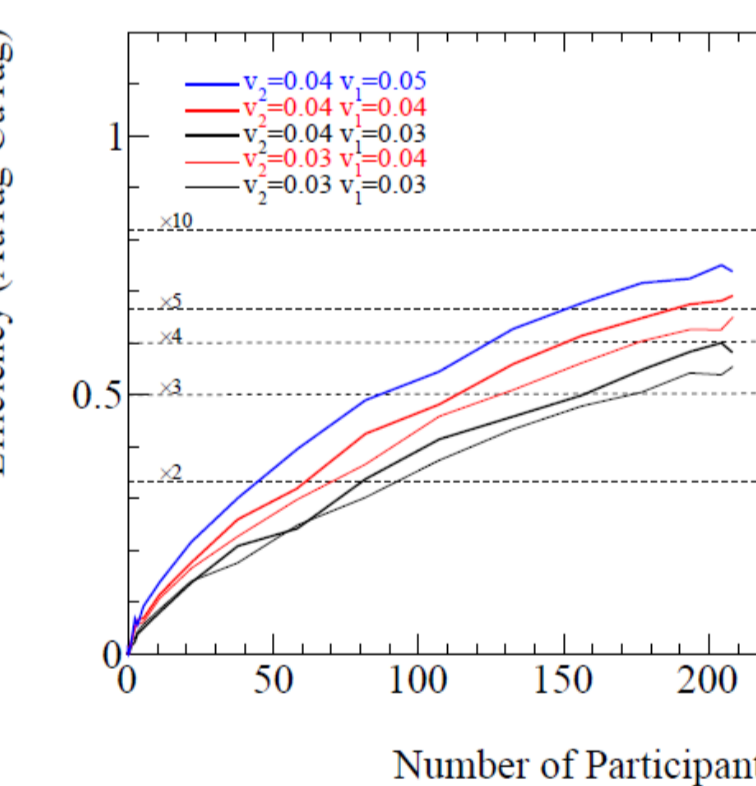3. Find the tagging efficiency

Modified HIJING φ distribution to mimic v_2^a

$v_2=4\%$ $v_1=0\%$ $v_2=4\%$ $v_1=1\%$ $v_2=4\%$ $v_1=2\%$

Result of tagging

Wrong   Right   (repeated)   Random Benefit

Excess over random benefit >x2 desired for effective tagging

Lowest centrality for measurement depends on strength of v_2^a

Number of Participants

Tagging the Au side: v_2^a vs v_1
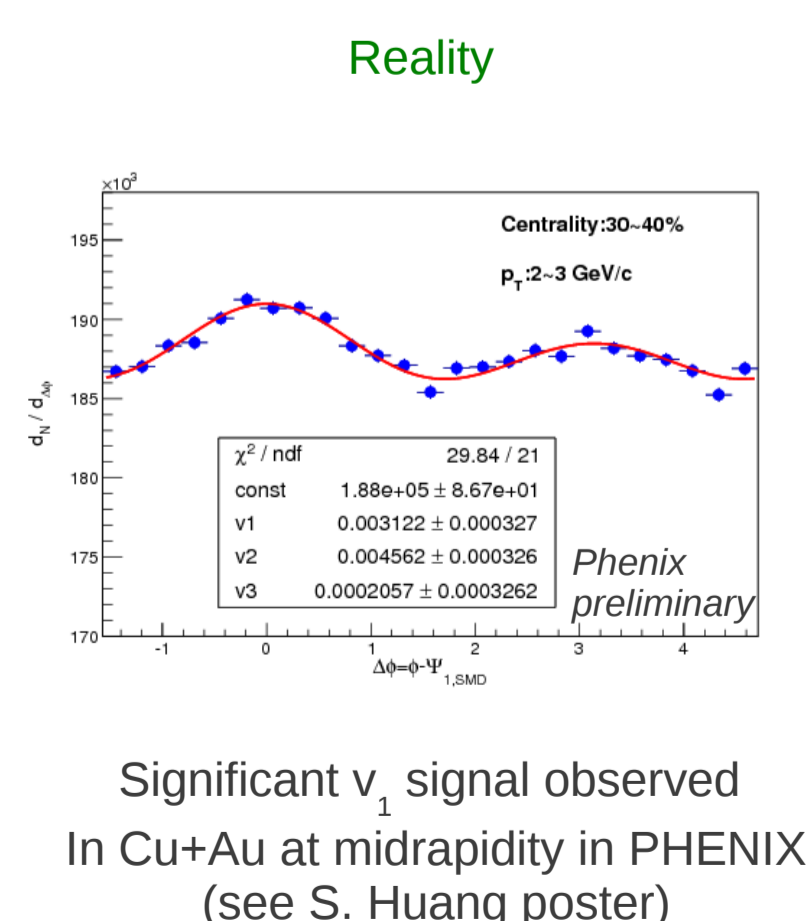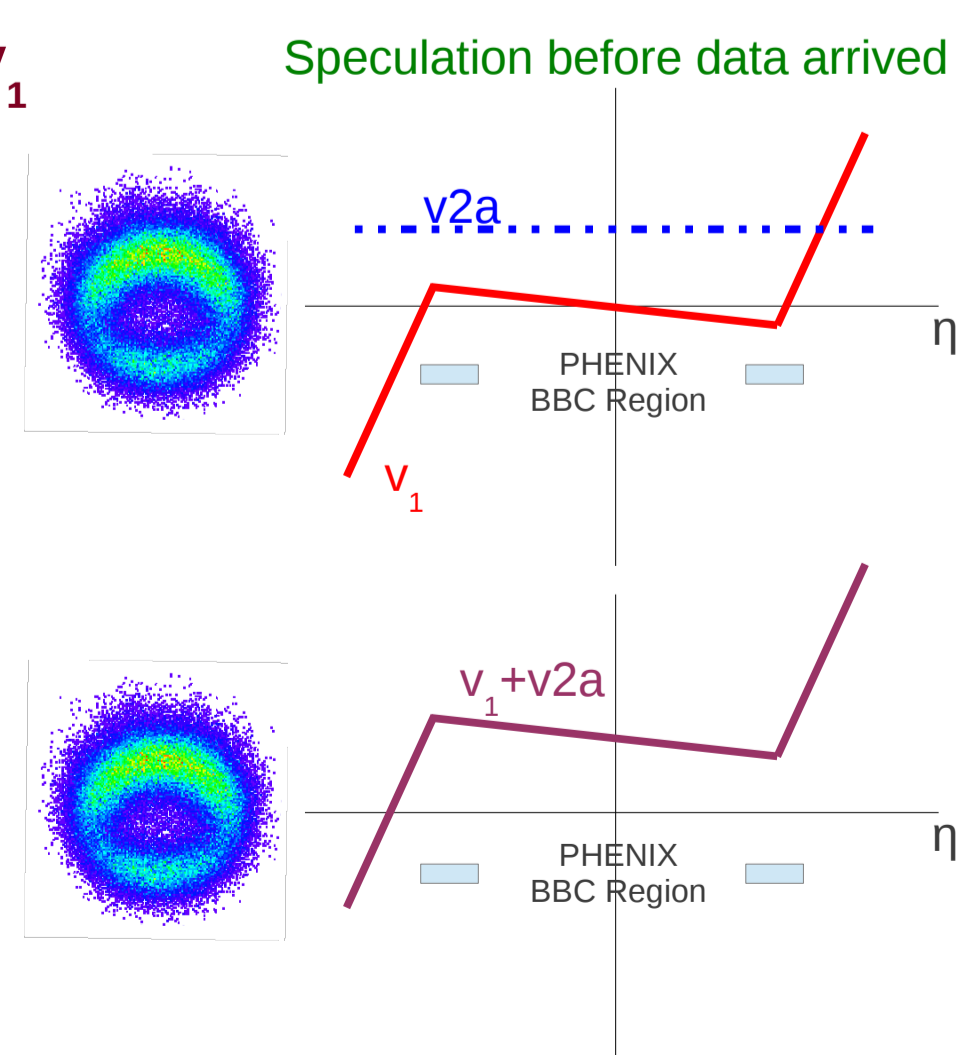
Do we need both v_1 and v_2^a?

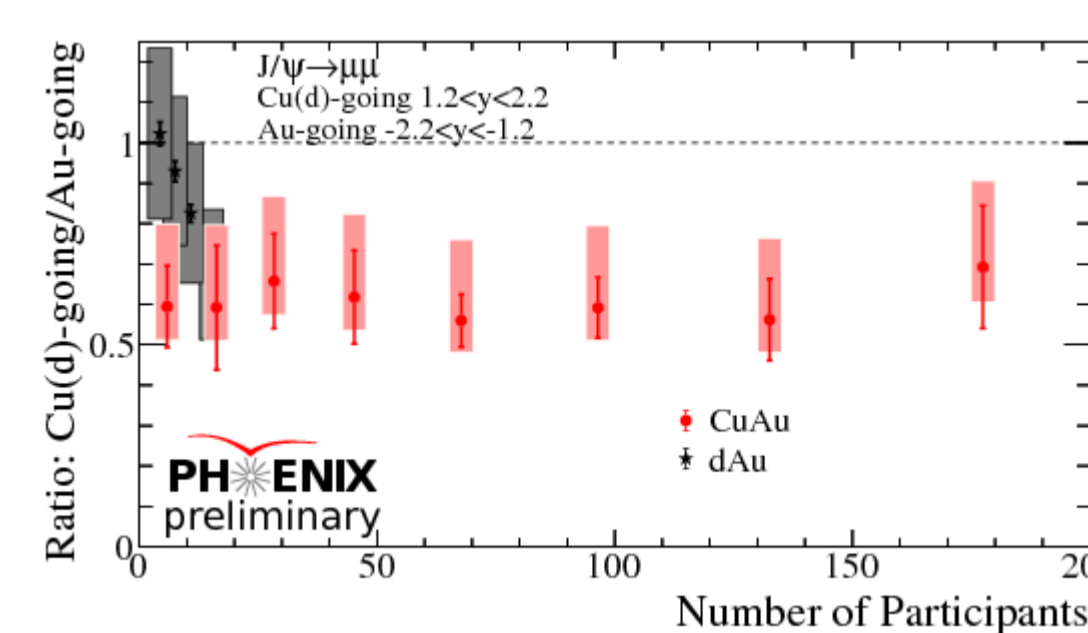What is the origin of v_1?
Bounce off?
Same as v_2^a? (possibly not)

Possible that v_2^a may cancel v_1 on one side and enhance it on the other

What if v_2^a =0?
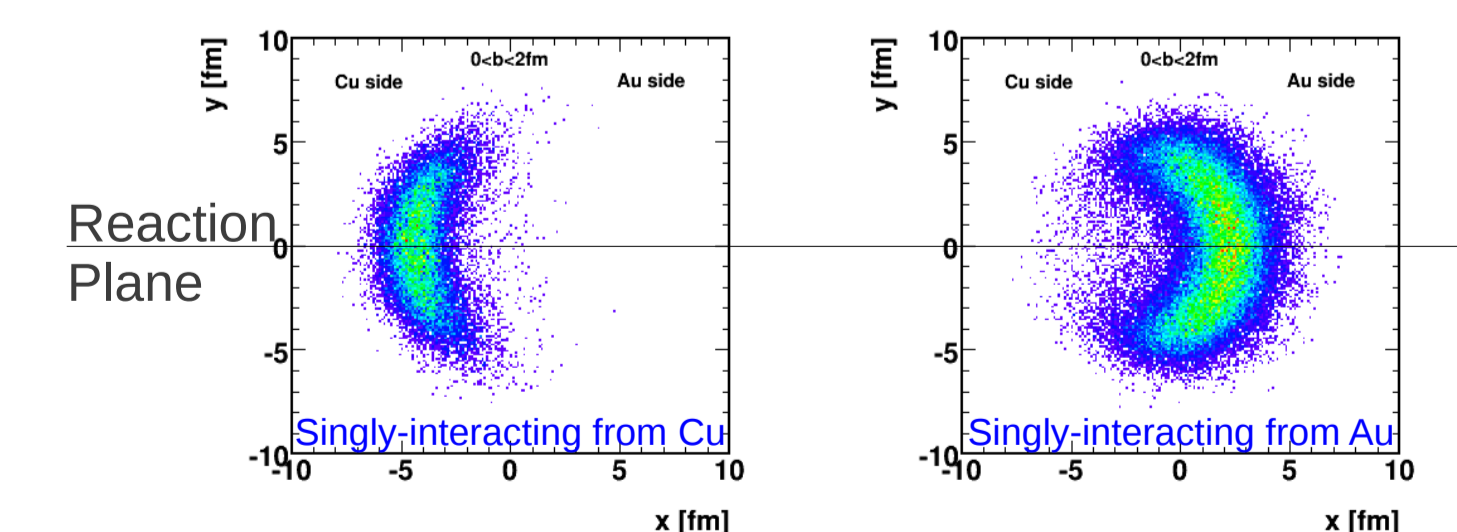Tag on v_1 in BBC region or with ZDC SMD

Speculation before data arrived

v2a
PHENIX BBC Region
v_1

v_1+v2a
PHENIX BBC Region

Reality

Centrality:30–40%
p_t:2–3 GeV/c

χ²/ndf   29.84/21
const   1.88e+05±8.67e+01
v1   0.003122±0.000327
v2   0.004562±0.000326
v3   0.0002057±0.0003262

Phenix preliminary

Significant v_1 signal observed
In Cu+Au at midrapidity in PHENIX
(see S. Huang poster)

J/ψ measurement and outlook

Ratio: Cu(d)-going/Au-going

J/ψ→μμ
Cu(d)-going 1.2<y<2.2
Au-going -2.2<y<-1.2

CuAu
dAu

PH ENIX preliminary

Number of Participants

First J/ψ measurement from Cu+Au collisions shows a significant forward/backward difference

We want to investigate the origin of this with the detailed tagging

Cu side   0<b<2fm   Au side

Reaction Plane

Singly-interacting from Cu   Singly-interacting from Au

Within the corona have p(n)+A collisions
• Au-side : p(n)+Cu
• Cu-side : p(n)+Au

We are currently working toward measuring the forward/backward J/ψ ratios using Au-side/Cu-side tagging scheme