Identified Particle $v_2(p_t,y)$ for 200-GeV AuAu

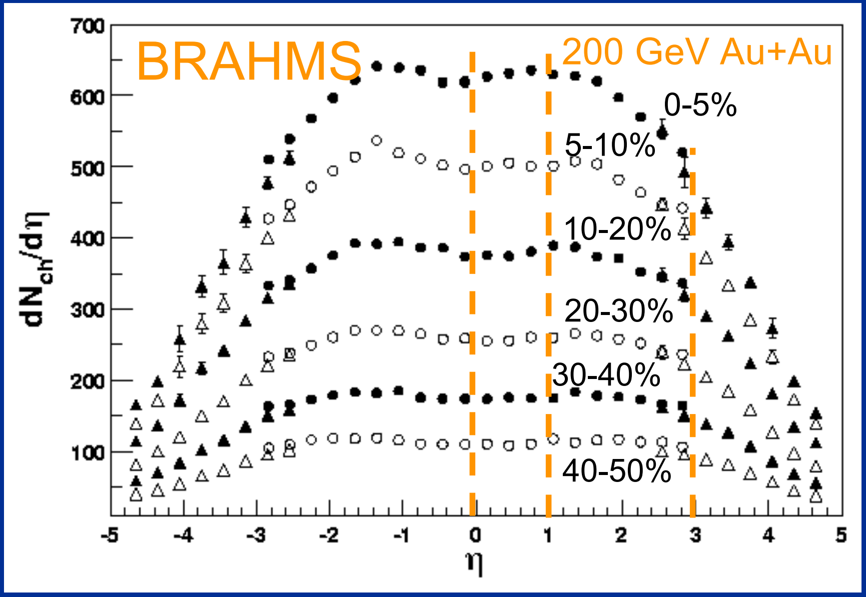
S. J. Sanders, U. Kansas
(for the BRAHMS Collaboration)

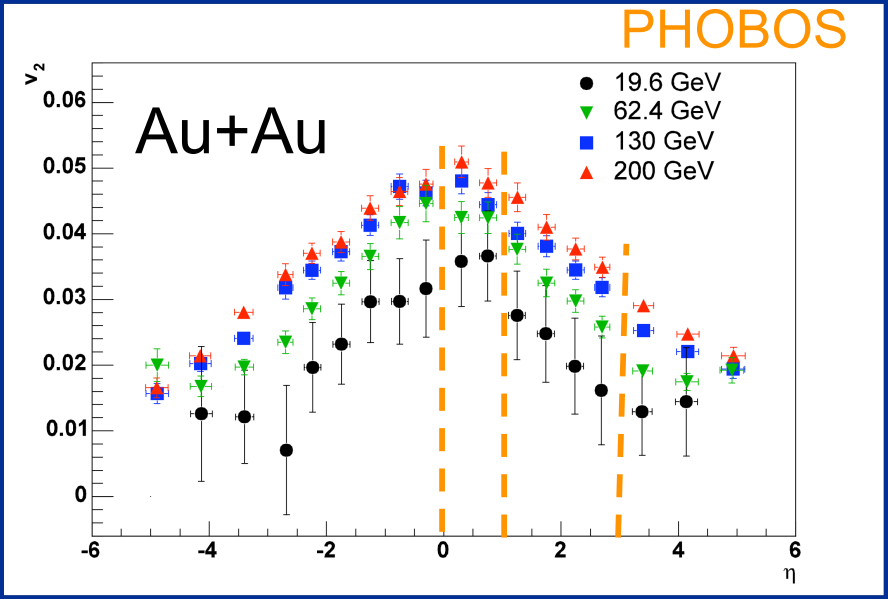
I. C. Arsene[12], I. G. Bearden[7], D. Beavis[1], S. Bekele[12], C. Besliu[10], B. Budick[6],
H. Bøggild[7], C. Chasman[1], C. H. Christensen[7], P. Christiansen[7], H.Dalsgaard[7], R. Debbe[1],
J. J. Gaardhøje[7], K. Hagel[8], H. Ito[1], A. Jipa[10], E.B.Johnson[11], J. I. Jørdre[9],
C. E. Jørgensen[7], R. Karabowicz[5], N. Katrynska[5] ,E. J. Kim[11], T. M. Larsen[7], J. H. Lee[1],
Y. K. Lee[4],S. Lindahl[12], G. Løvhøiden[12], Z. Majka[5], M. J. Murray[11],J. Natowitz[8], C.Nygaard[7]
B. S. Nielsen[8], D. Ouerdane[8], D.Pal[12], F. Rami[3], C. Ristea[8], O. Ristea[11],
D. Röhrich[9], B. H. Samset[12], S. J. Sanders[11], R. A. Scheetz[1], P. Staszel[5],
T. S. Tveter[12], F. Videbæk[1], R. Wada[8], H. Yang[9], Z. Yin[9], I. S. Zgura[2]

1. Brookhaven National Laboratory, Upton, New York, USA
2. Institute of Space Science, Bucharest - Magurele, Romania
3. Institut Pluridisciplinaire Hubert Curien et Université Louis Pasteur, Strasbourg, France
4. Johns Hopkins University, Baltimore, USA
5. M. Smoluchkowski Institute of Physics, Jagiellonian University, Krakow, Poland
6. New York University, New York, USA
7. Niels Bohr Institute, University of Copenhagen, Copenhagen, Denmark
8. Texas A&M University, College Station, Texas, USA
9. University of Bergen, Department of Physics and Technology, Bergen, Norway
10. University of Bucharest, Romania
11. University of Kansas, Lawrence, Kansas, USA
12. University of Oslo, Department of Physics, Oslo, Norway

BRAHMS explores the longitudinal behavior of RHIC reactions…

Some things change…





From η~0 to η~3, $dN_{ch}/d\eta$ drops about 25%…

…and v_2 is reduced about 40%.

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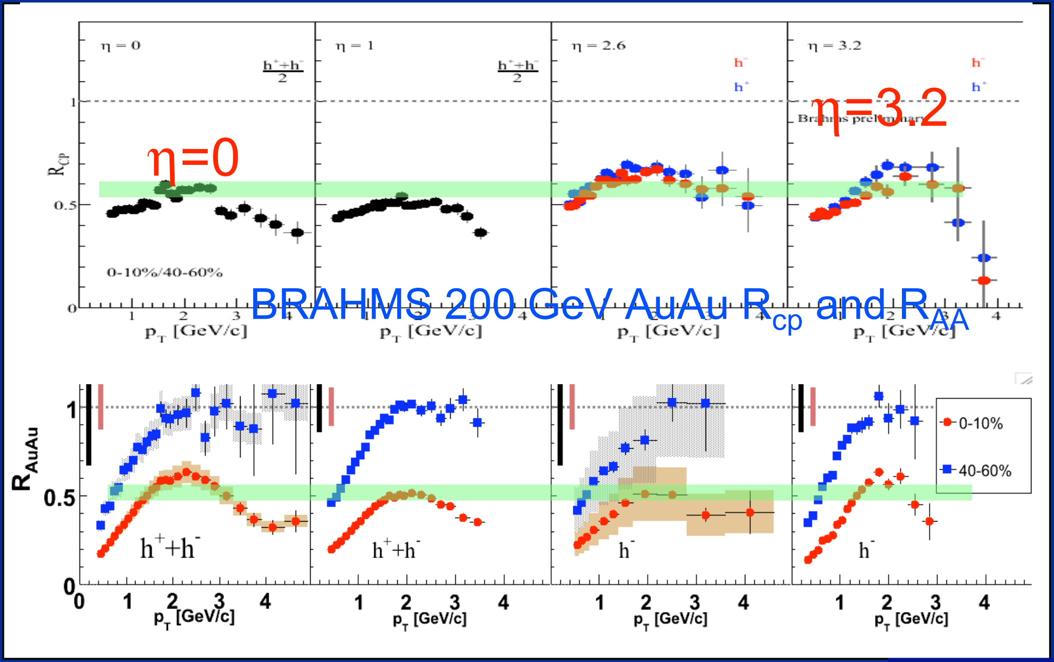
…while other remain remarkably constant.



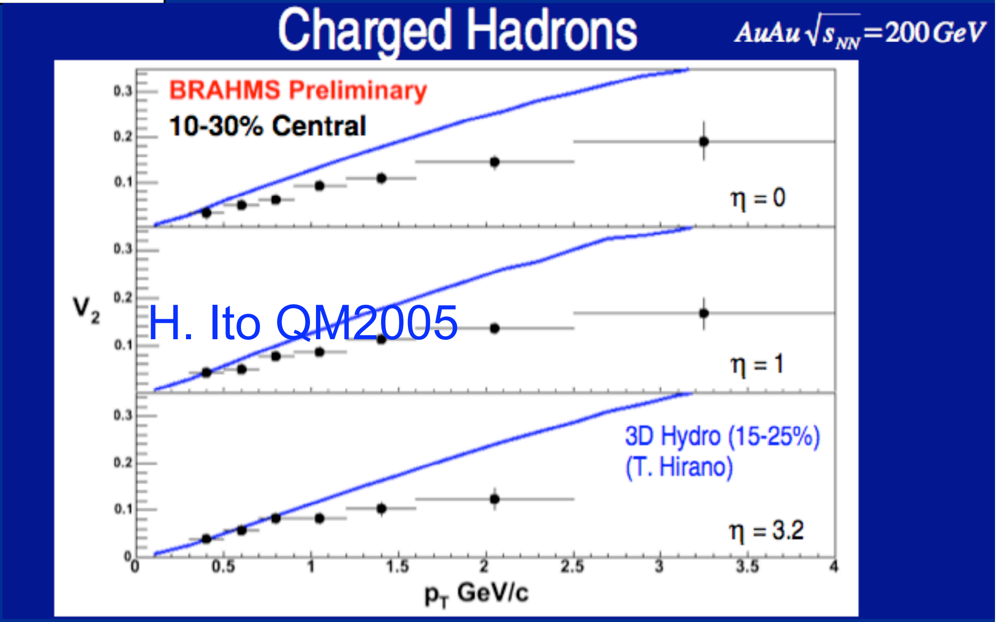
η=0

η=3.2

BRAHMS 200 GeV AuAu R_{cp} and R_{AA}

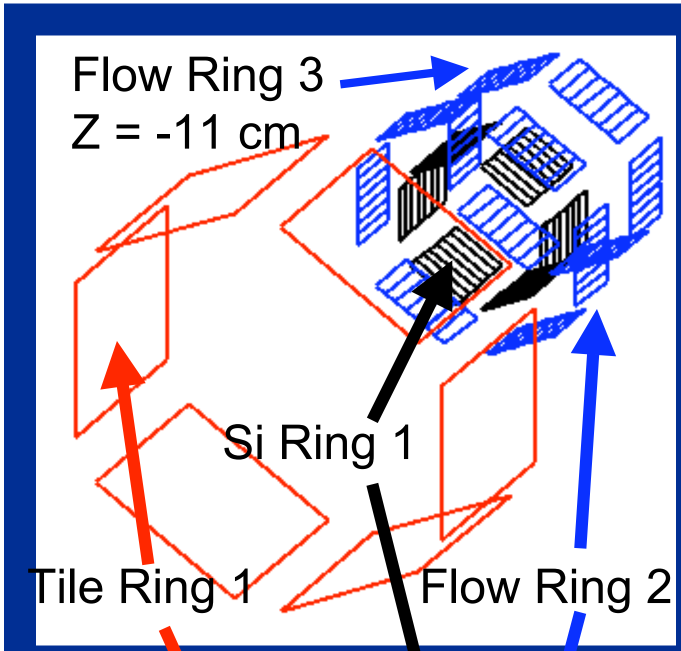
- Is the decrease in particle density compensated by increase in path length through final hadronic medium?
- Are initial state saturation effects competing with partonic energy loss and/or recombination effects?
- **Does partonic matter only dominate near mid-rapidity?**

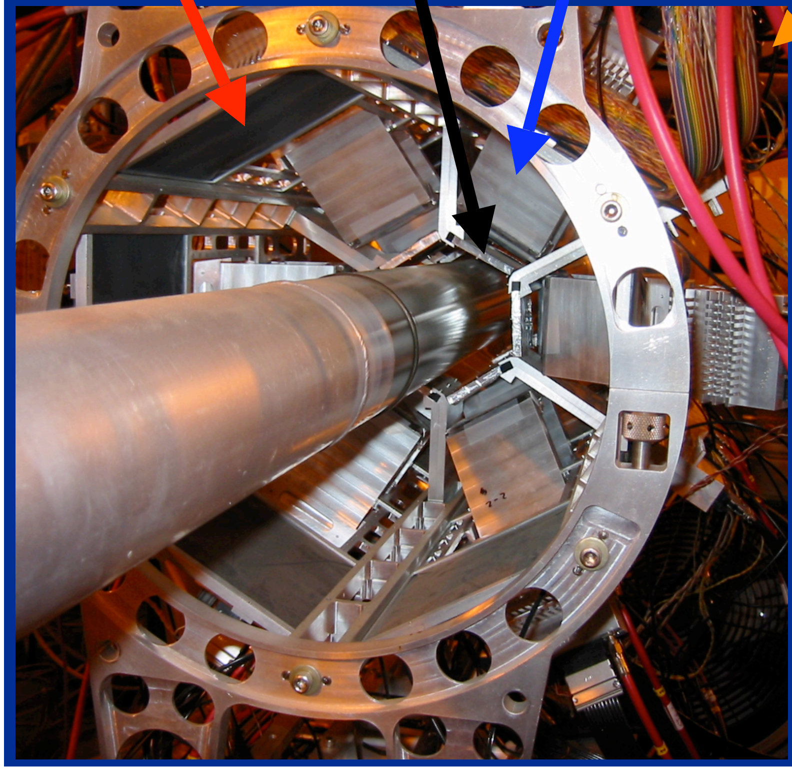
- **How is is possible for the integral v_2 to fall off so rapidly, and yet not see a strong change in the charged hadron $v_2(p_T)$ behavior?**
- **How does identified particle $v_2(p_T)$ change in going to forward angles?**

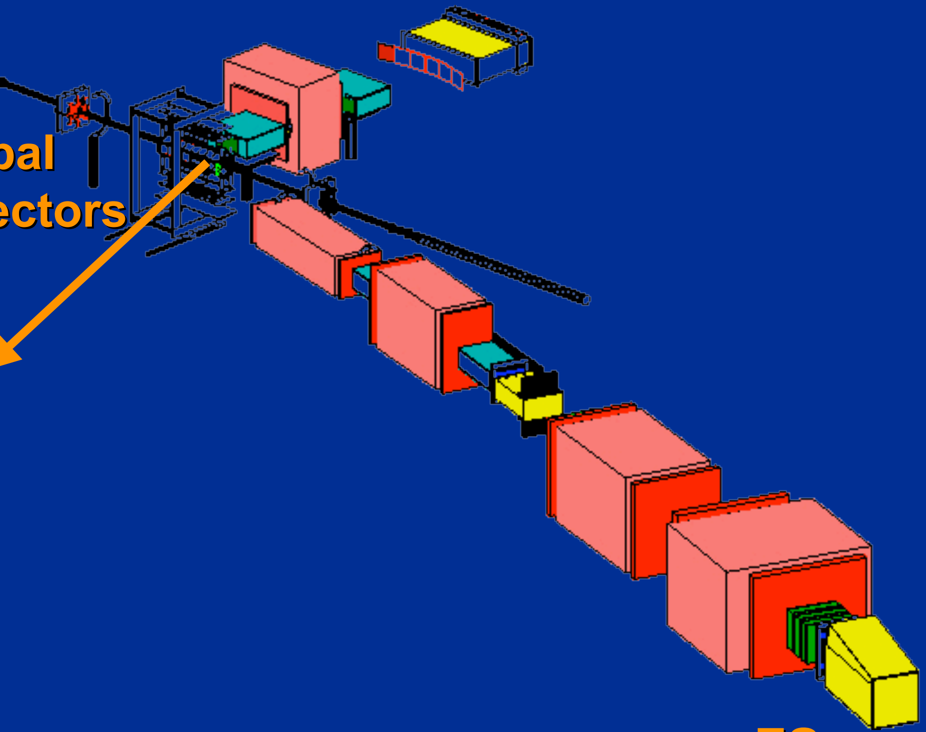


H. Ito QM2005

BRAHMS Experimental Arrangement



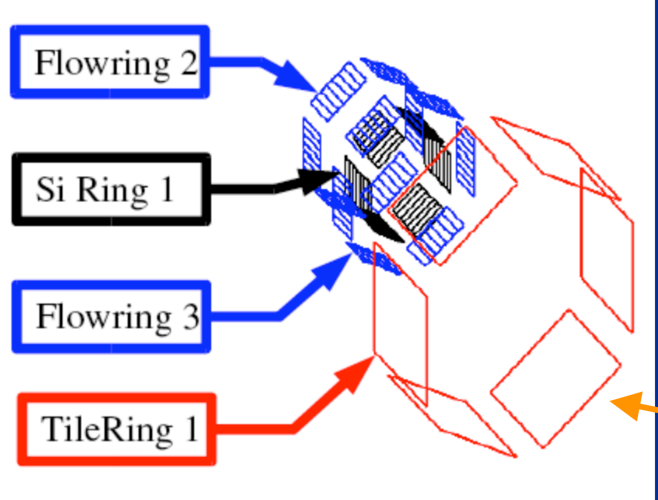




Identified particle v_2 deduced using spectrometer data, with global detectors used to determine reaction plane.

Determining Reaction Plane with Multiple Detector Subsystems

- $$\frac{d^3N}{2\pi p_T dp_T dy d\left(\phi-\Psi_R\right)} = \frac{d^2N}{2\pi p_T dy}\left(1+\sum_n 2v_n\cos\left[n\left(\phi-\Psi_R\right)\right]\right)$$



i^th element around ring

- $$v_n = \left\langle \cos\left(n\left[\phi-\Psi_R\right]\right)\right\rangle$$ **(True v_2 with real reaction plane.)**

- $$\Psi_n = \frac{1}{n}\tan^{-1}\frac{\sum_i w_i\sin\left(n\phi_i\right)-\left\langle\sum w_i\sin\left(n\phi_i\right)\right\rangle_{MB}}{\sum_i w_i\cos\left(n\phi_i\right)-\left\langle\sum w_i\cos\left(n\phi_i\right)\right\rangle_{MB}}$$

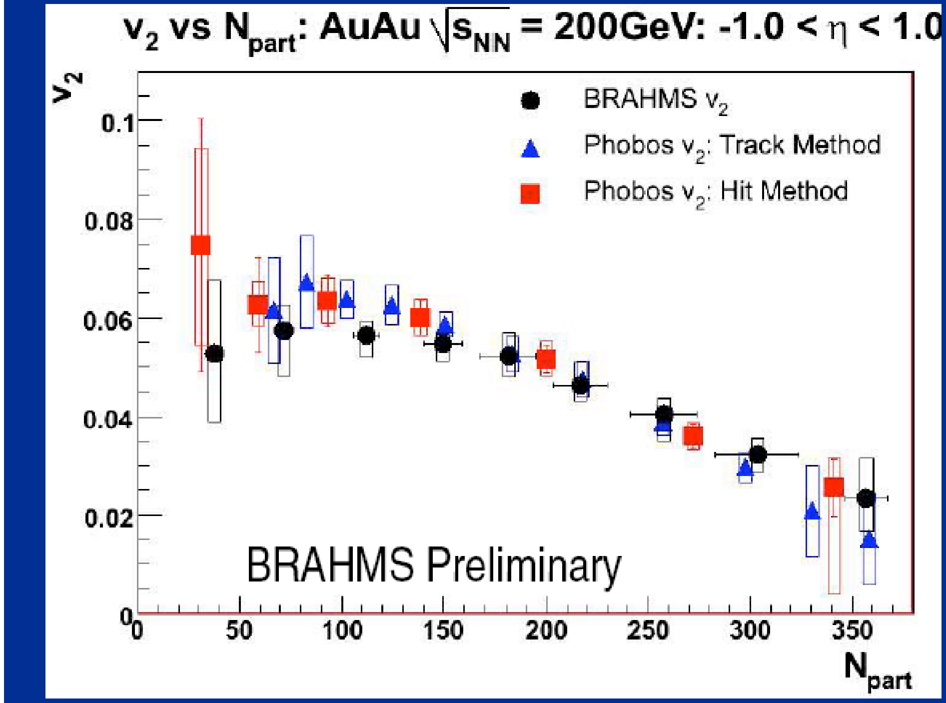
- $$v_n' = \frac{\left\langle\cos\left(n\left[\phi-\Psi_2\right]\right)\right\rangle}{\text{ResCor}}$$ **(Deduced v_2 with experimental reaction plane.)**

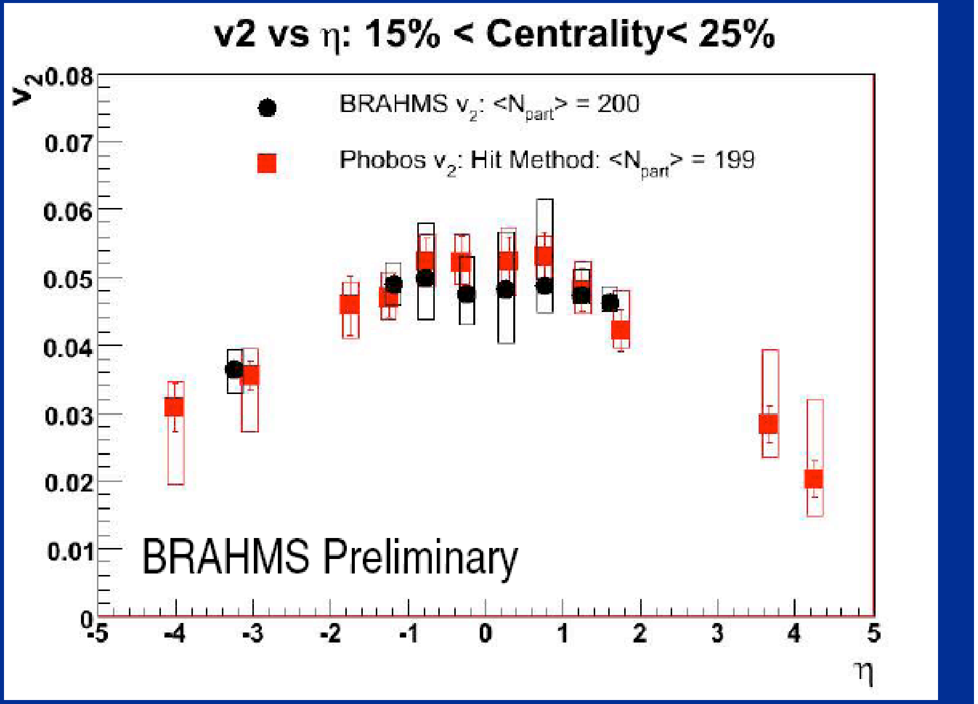
- $$\text{ResCor(Detector A)}=\sqrt{\frac{\left\langle\cos\left(2\left[\Psi_2^A-\Psi_2^B\right]\right)\right\rangle\left\langle\cos\left(2\left[\Psi_2^A-\Psi_2^C\right]\right)\right\rangle}{\left\langle\cos\left(2\left[\Psi_2^B-\Psi_2^C\right]\right)\right\rangle}}$$

Poskanzer & Voloshin PRC 58, 1671 (1998)

Experimental correction factors found in good agreement with Monte Carlo simulations.

Integral v_2 Results

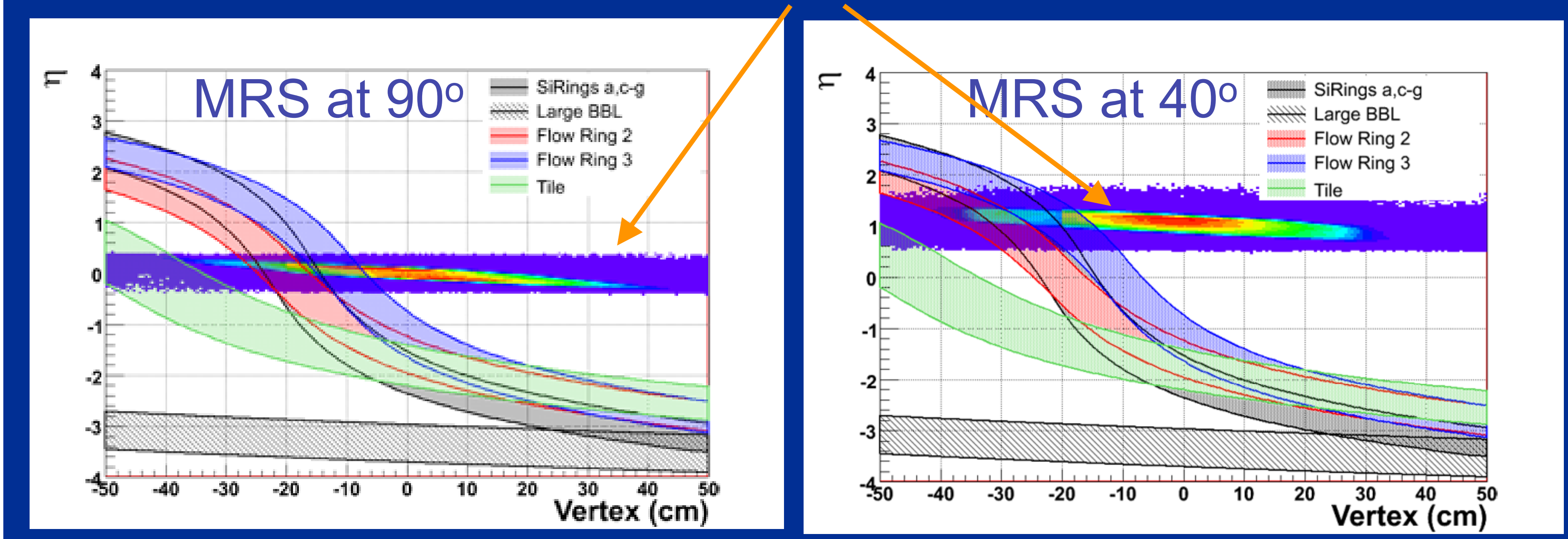




PHOBOS: PRC 72, 051901(R) (2005)

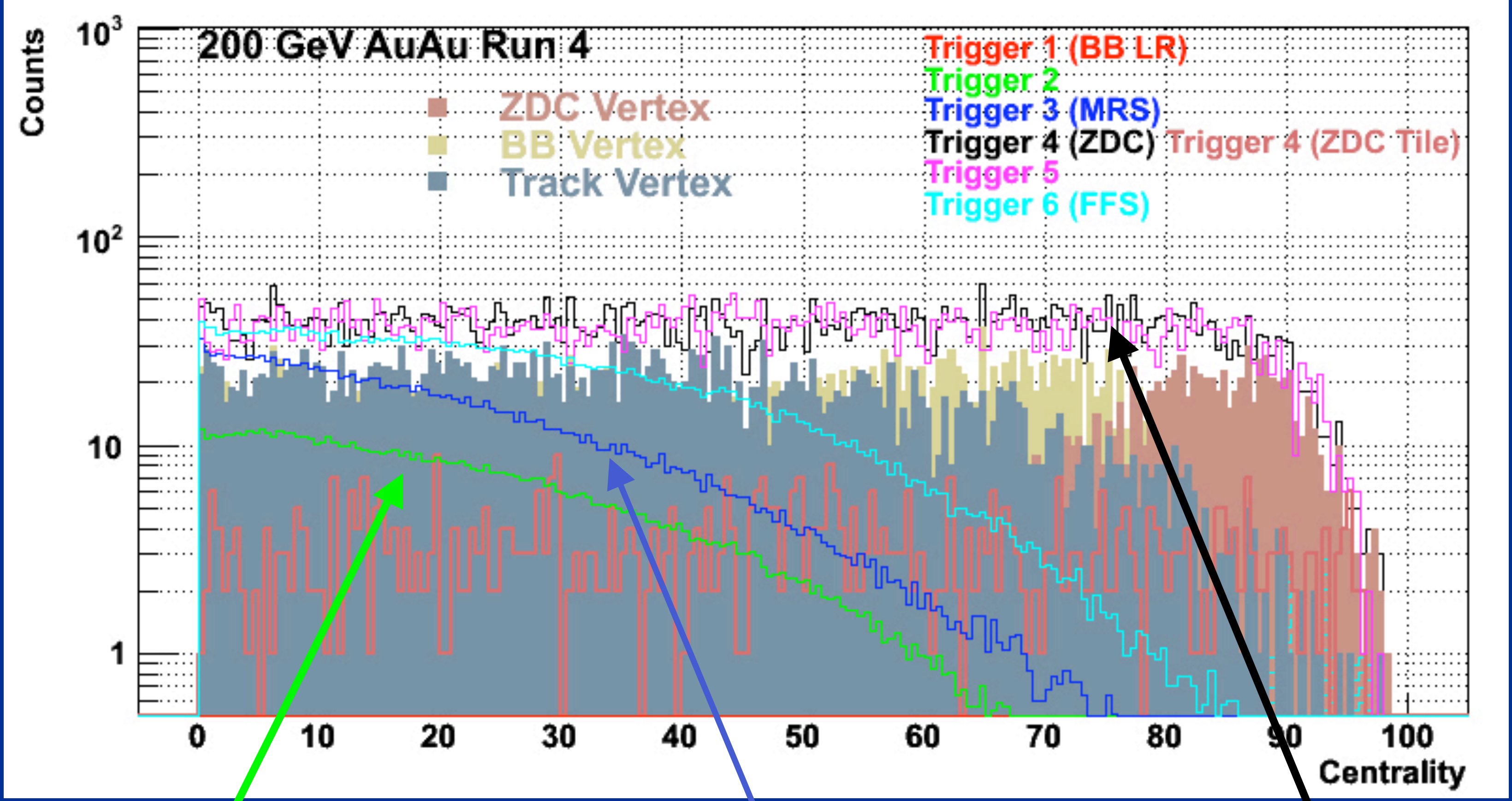
Avoiding auto correlations when analyzing spectrometer data…

MRS Events



A restricted vertex range is used in the analysis to avoid auto correlations: z>-10 cm at 90° and z>-20 cm at 40° and 4°.

Trigger Centrality Dependence…



Forward Spectrometer Trigger
$\langle\text{centrality}\rangle_{10\text{-}50\%} = 25.8\%$

Mid-rapidity Spectrometer Trigger
$\langle\text{centrality}\rangle_{10\text{-}50\%} = 24.7\%$

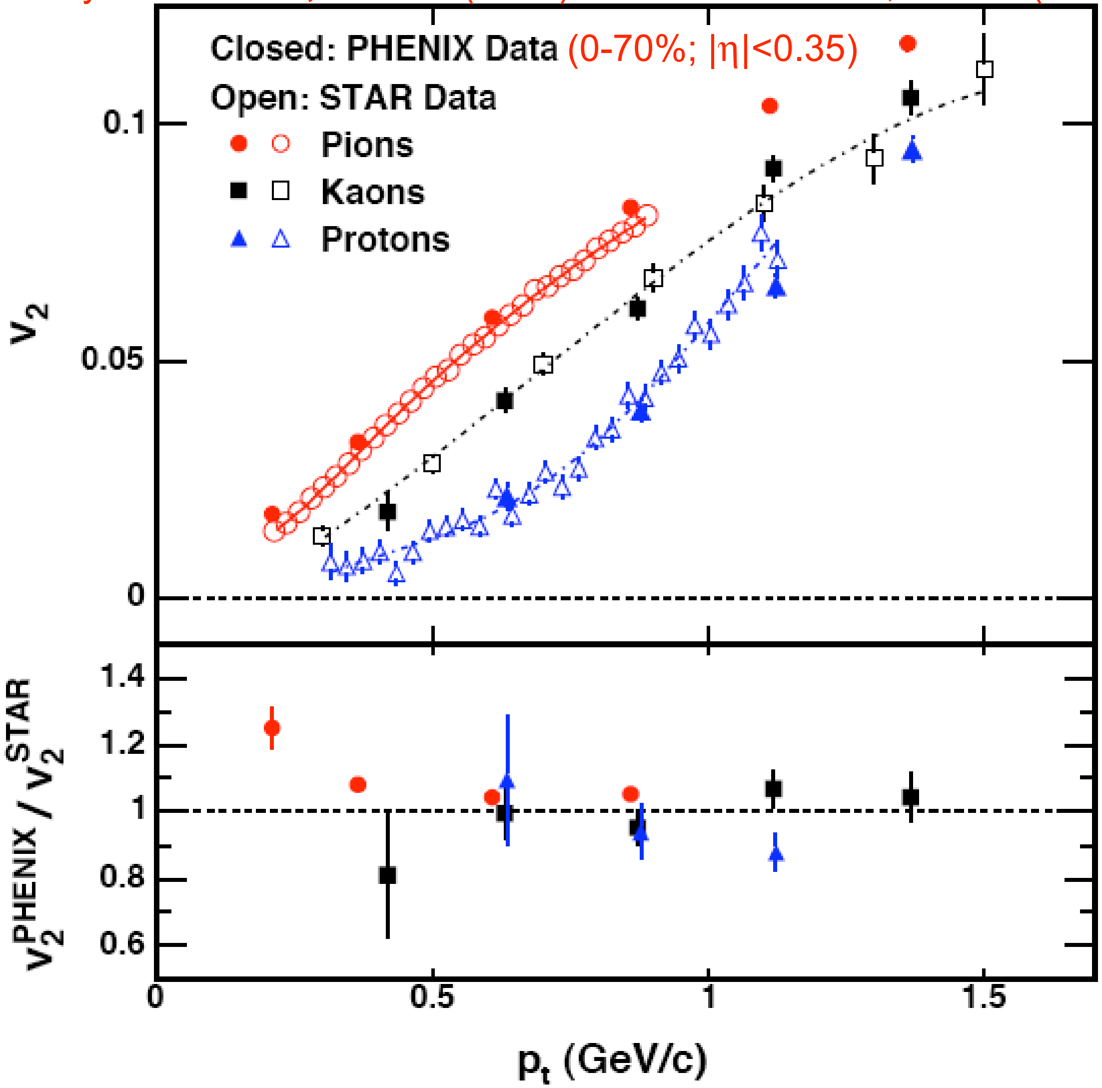
Minimum bias Trigger

$\langle b\rangle_{\text{Hijing}}(25\%) \approx 7.8$ fm

$N_{\text{part}}(25\%) \approx 162$

Precision measurements at mid-rapidity (STAR and PHENIX)

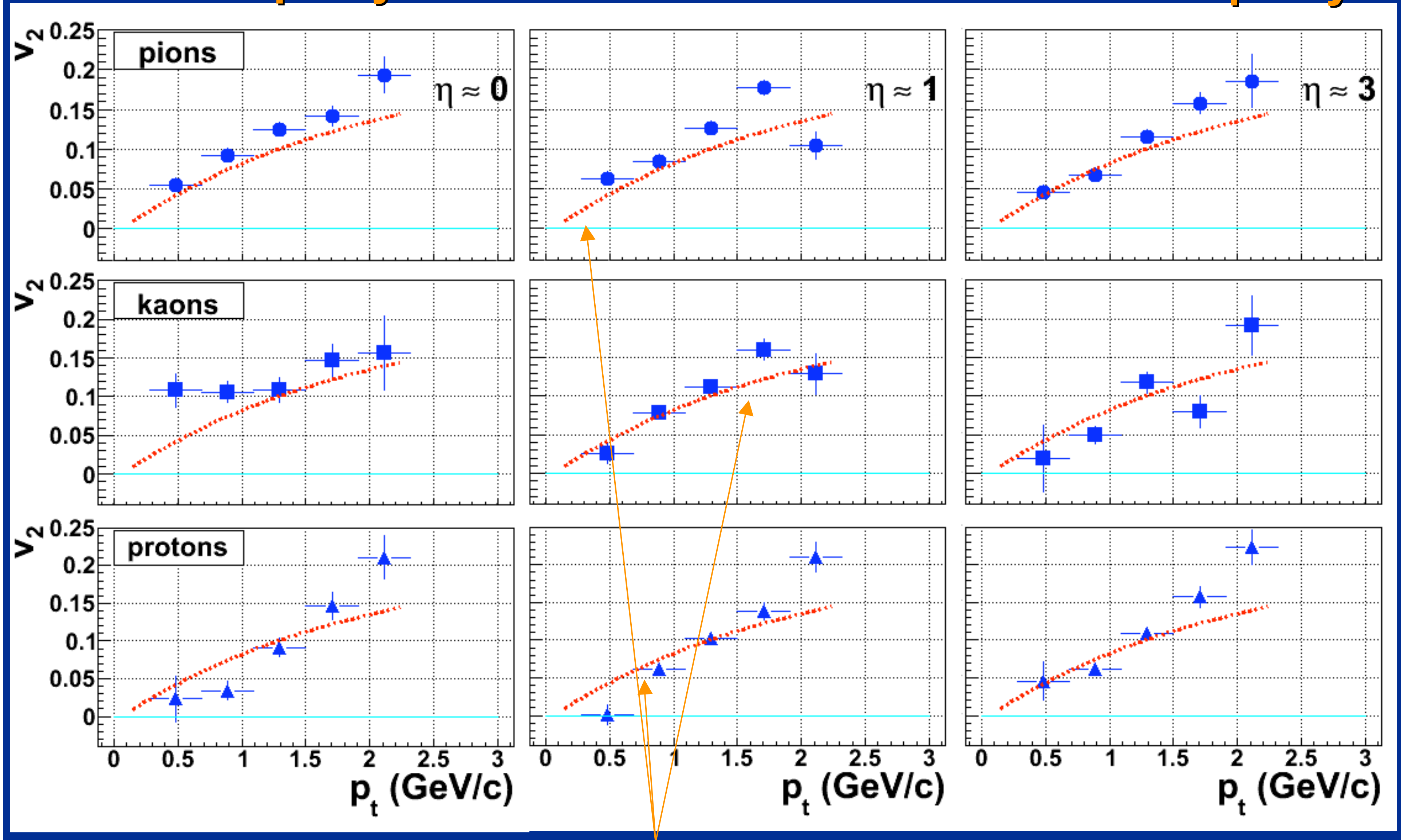
STAR: Phys. Rev. C **72,** 014904 (2005) / PHENIX: PRL 91, 182301(2003)



Protons and kaons show delayed onset of v_2 rise (consistent with hydrodynamic models)

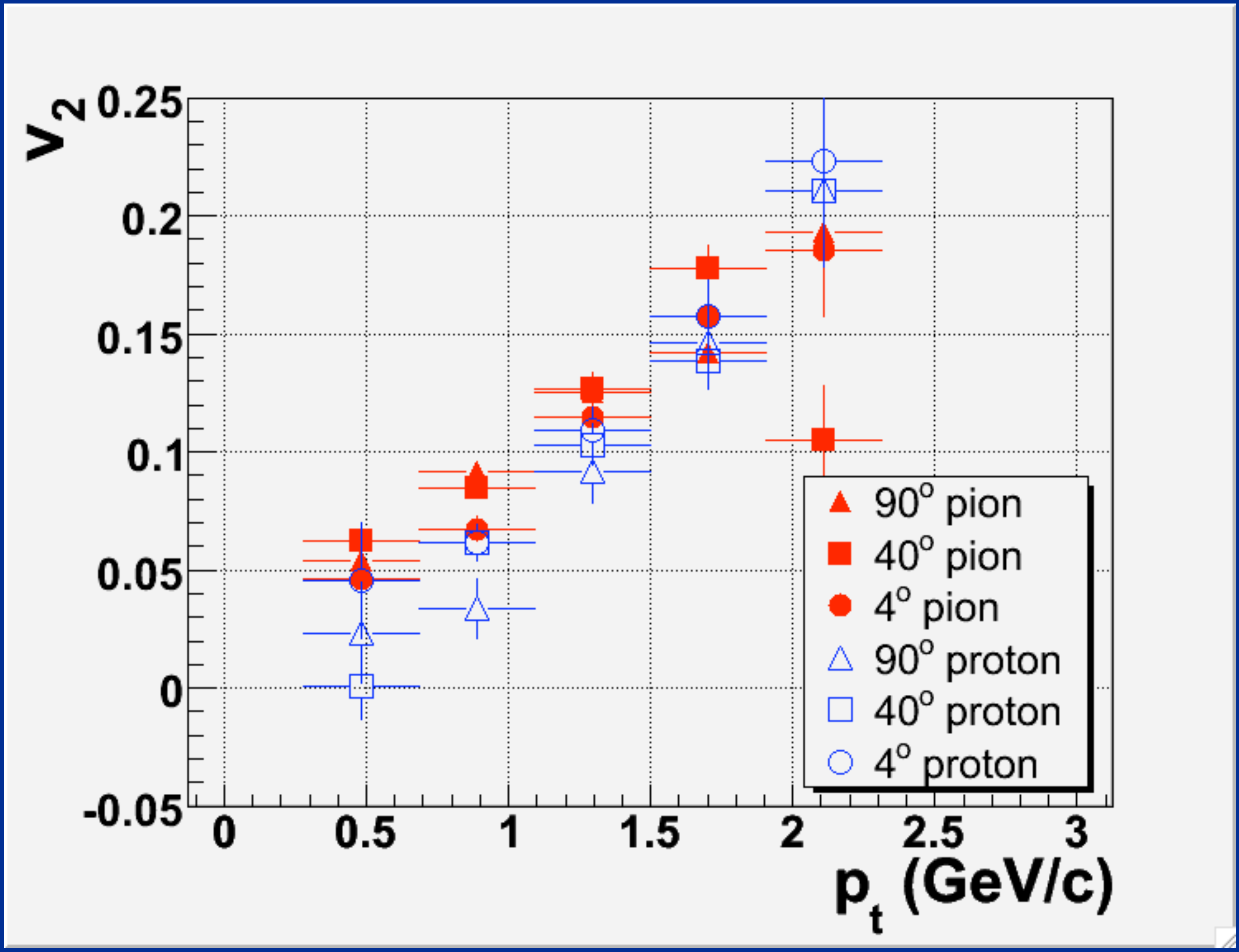
BRAHMS $v_2(p_t)$ (10-50% central) Results

Mid-rapidity → **Forward rapidity**



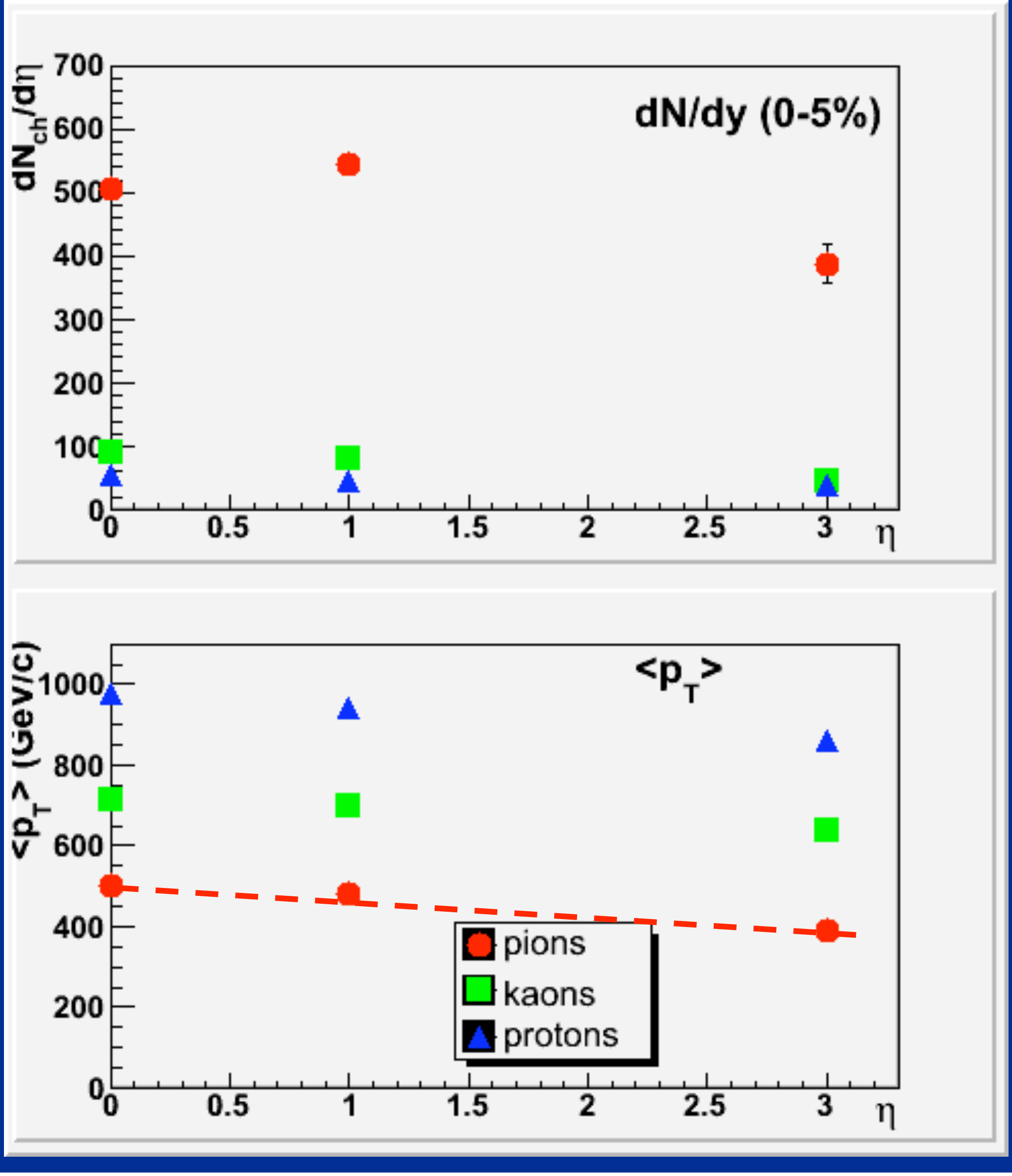
STAR 0-50% Charged Hadrons (Phys. Rev. C **72,** 014904 (2005))

Comparison of 4°, 40° and 90° settings.



No appreciable change observed above 1 GeV/c.

How do we understand the integral v_2 behavior? What else changes in going to forward rapidities?



Pions responsible for ~82% of yield: they most likely drive the integral v_2 behavior.

BRAHMS Spectrum Analysis

BRAHMS PRELIMINARY

		dN/dy	**$<p_t>$**
90^o	π+	248+/-5	517 MeV/c
	π-	258+/-5	488
	K+	47+/-1	718
	K-	42+/-1	714
	p	33+/-1	945
	pbar	20+/-1	1001
	Sum	**648**	

BRAHMS $dN_{ch}/d\eta$ (η=0)=625+/-55

		dN/dy	**$<p_t>$**
40^o	π+	276+/-3	481 MeV/c
	π-	268+/-4	478
	K+	45+/-1	682
	K-	37+/-1	711
	p	28+/-1	937
	pbar	19+/-1	944
	Sum	**673**	

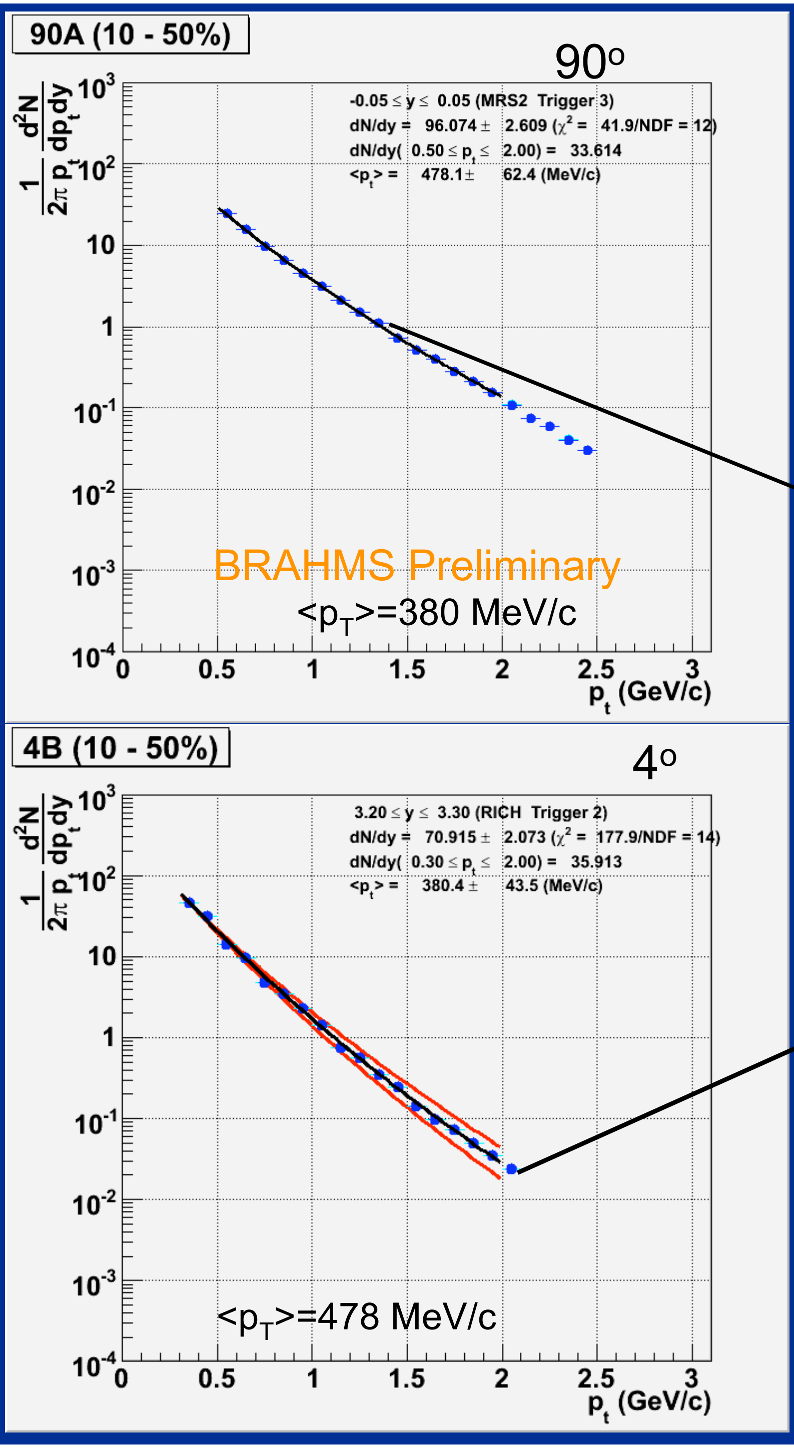
BRAHMS $dN_{ch}/d\eta$ (η=1)=635+/-55

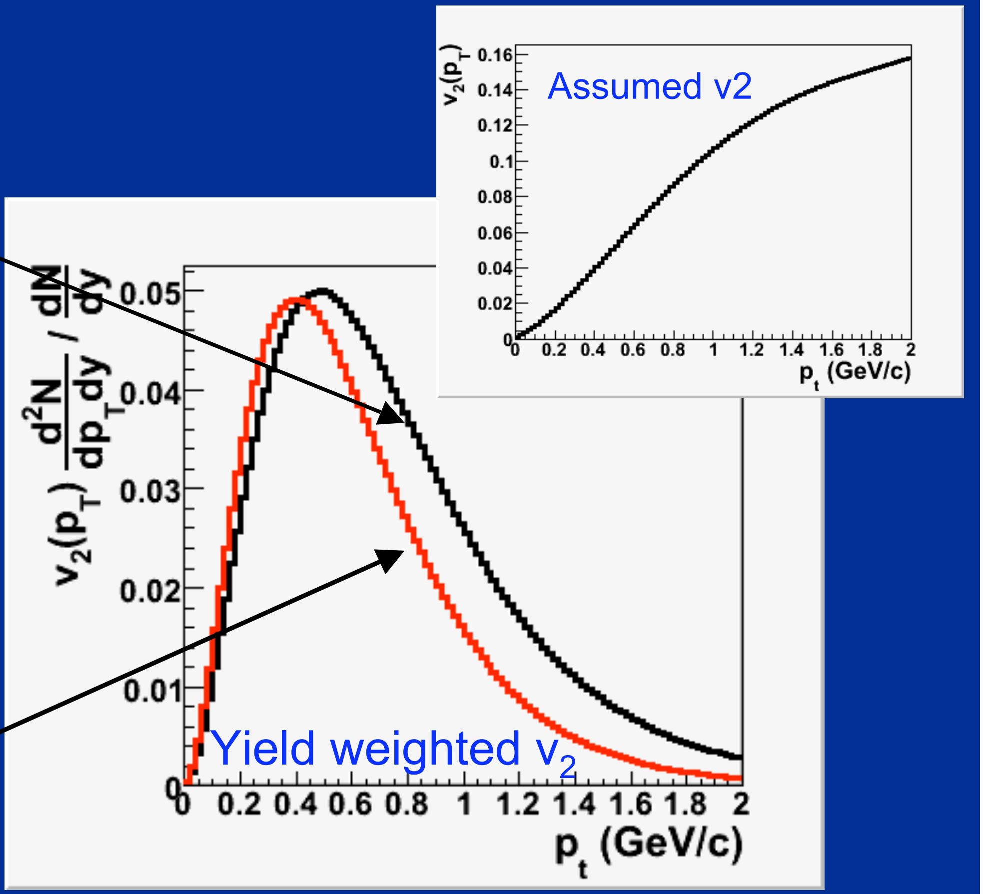
		dN/dy	**$<p_t>$**
4^o	π+	186+/-17	390 MeV/c
	π-	202+/-19	384
	K+	16+/-1	661
	K-	28+/-1	625
	p	32+/-1	862
	pbar	7+/-1	855
	Sum	**471**	

BRAHMS $dN_{ch}/d\eta$ (η=3)=470+/-44

Toy model:

- All π+
- No y dependence of $v_2(p_T)$



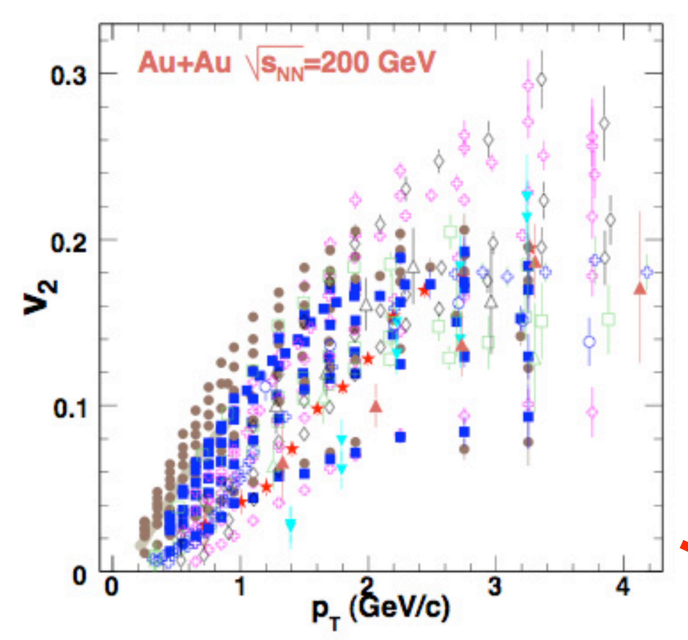


Integral v_2(90°) = 0.046

Integral v_2(4°) = 0.036±3

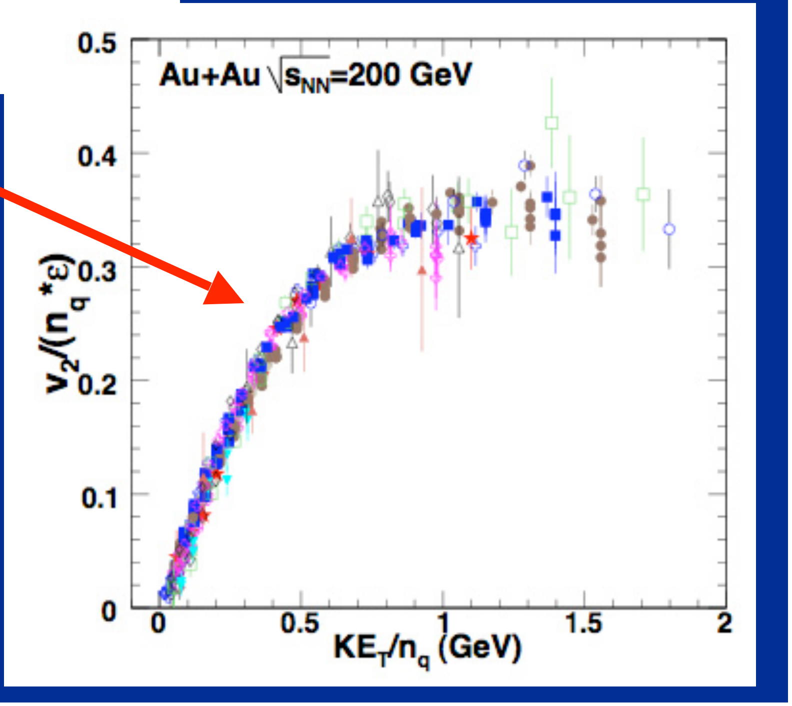
22±6% decrease

Universal Scaling for Perfect Hydrodynamics (mid-rapidity)

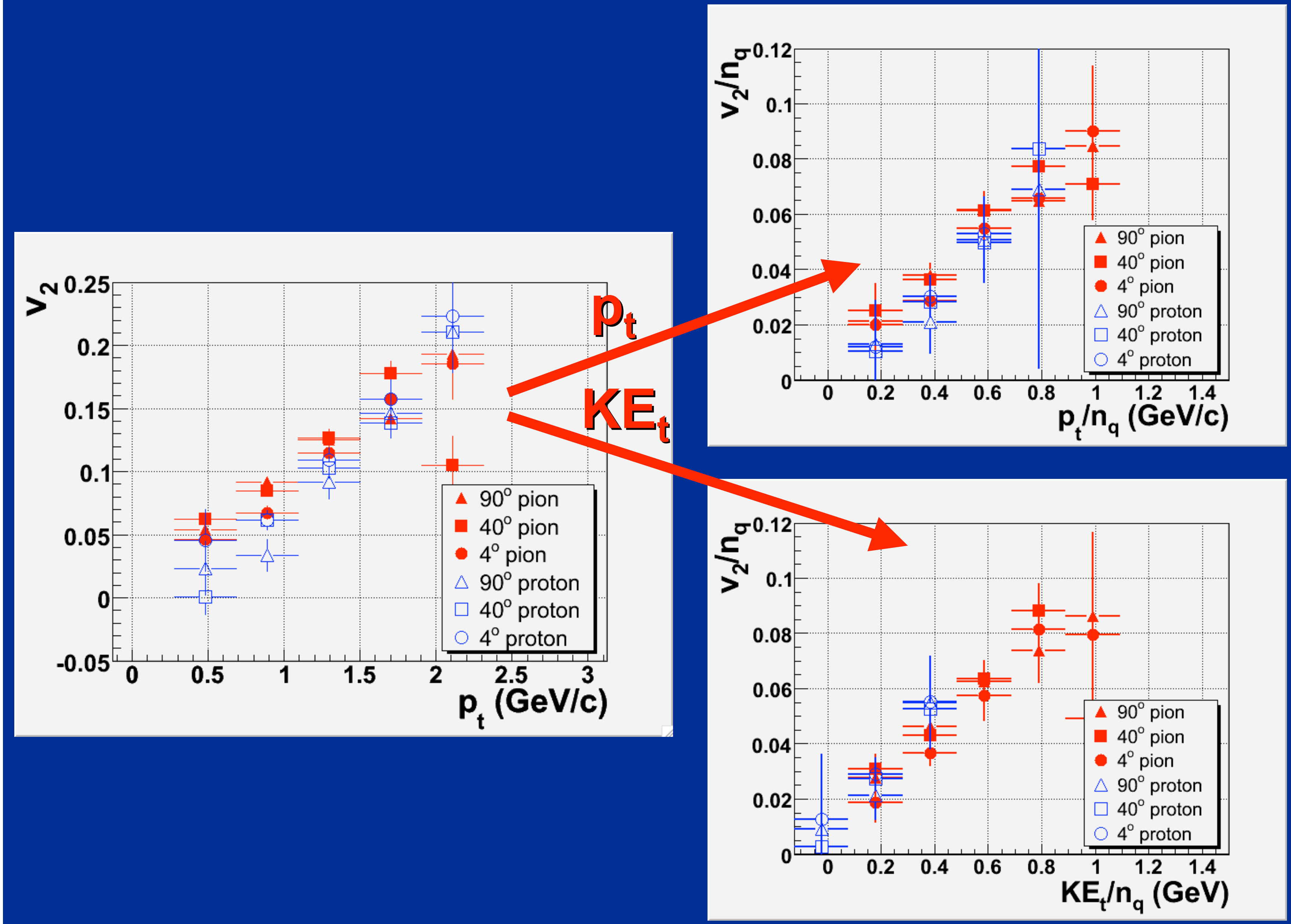


R.A. Lacey and A. Taranenko, nucl-ex/0610029

Scaling expected for ideal hydro



Valance Quark Scaling



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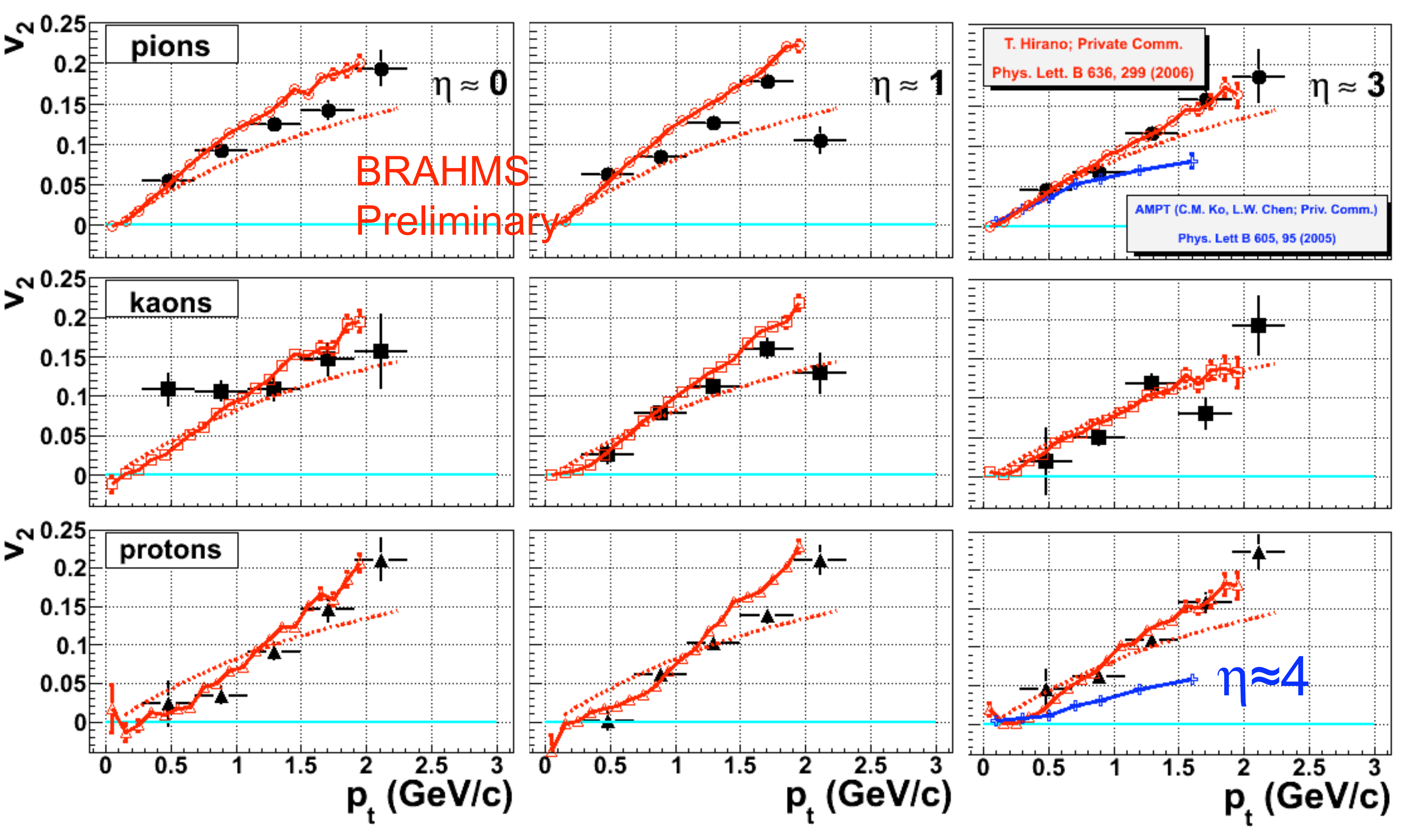
Comparison to models…



AMPT provides reasonable description with “string melting” near mid rapidity (|η|<3).
Lie-Wen Chen, Vincenzo Greco, Che Ming Ko, Peter F. Kolb Phys. Lett. B, 605(2005)95; private communication.

Hirano et al. start with Glauber initial conditions and follow through hadronic dissipation stage. **Tetsufumi Hirano, Ulrich Heinz, Dmitri Kharzeev, Roy Lacey, Yasushi Nara Phys. Lett. 636 (2006) 299.**

Summary

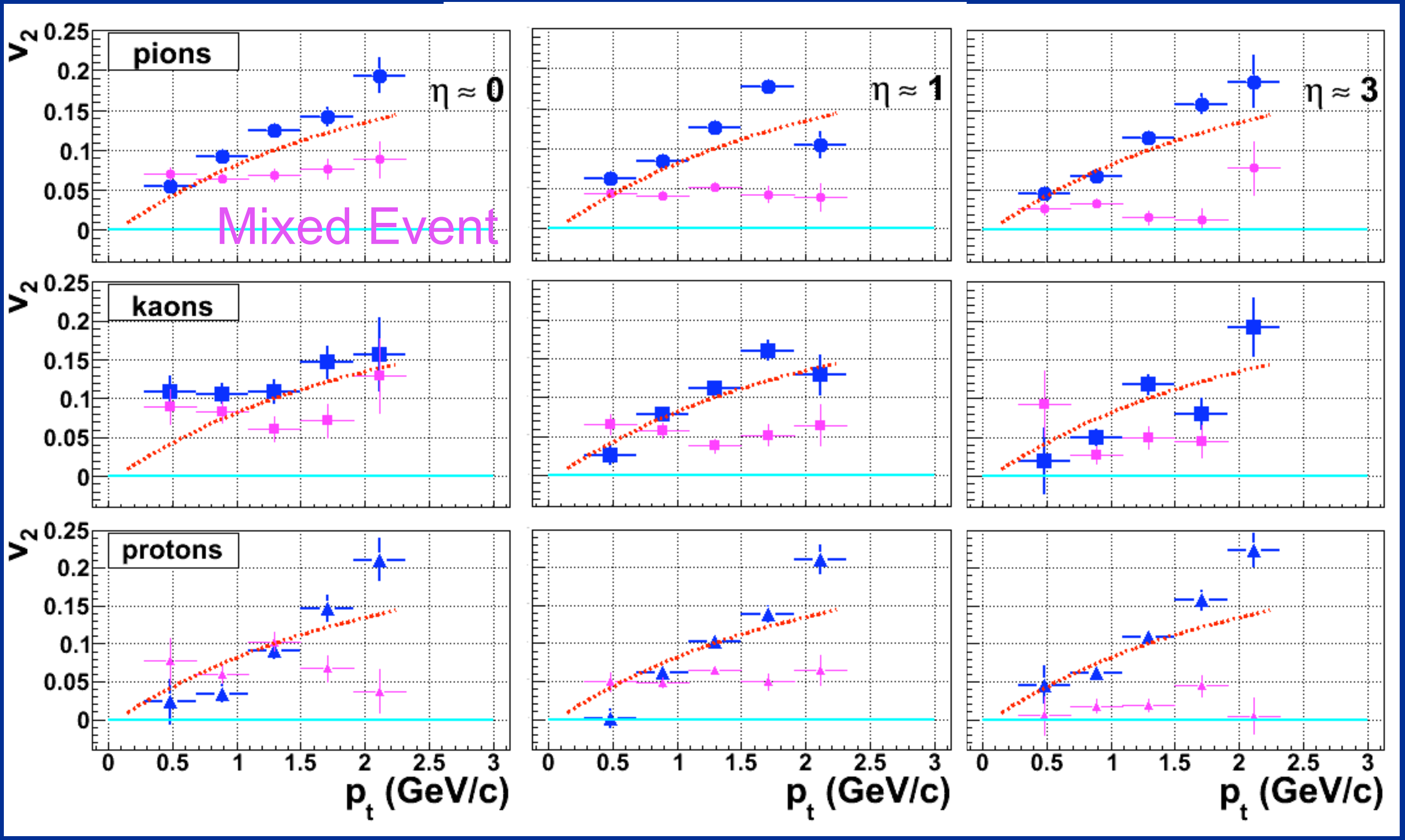
- $v_2(p_T)$ for identified pions, kaons and protons remains relatively constant from y=0 to y=3.

- A significant fraction of the falloff observed for the integral v_2 can be attributed to the y-dependence of $\langle p_T \rangle$.

- Current model calculations with initial hydro followed by hadronic dissipation do good job in describing experimental $v_2(p_t)$ observations.

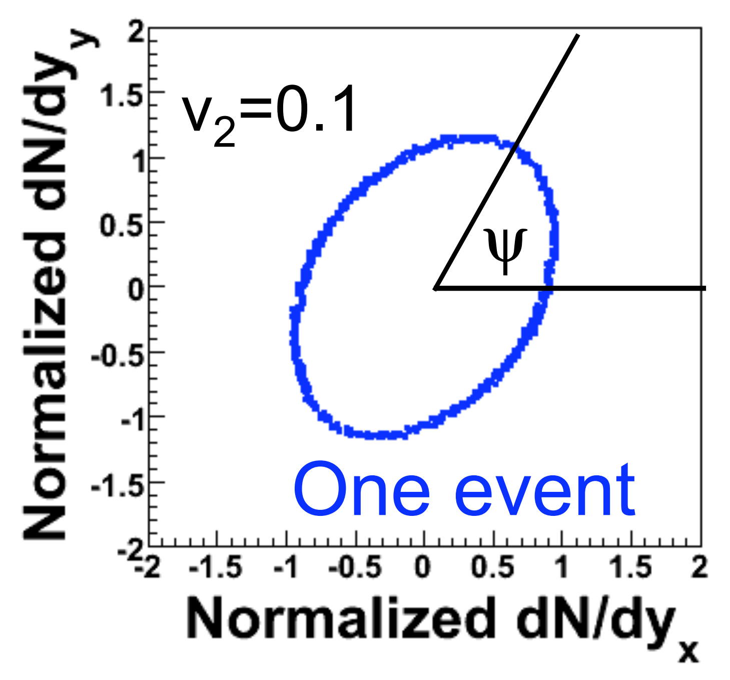
Mixed-Event Analysis

Here the v_2 values for an event are calculated based on the reaction-plane angle found for the previous event satisfying the same vertex and centrality conditions. Since the small acceptance spectrometer triggers bias the selected reaction plane distributions, the mixed events reflect the underlying integral v_2 behavior.

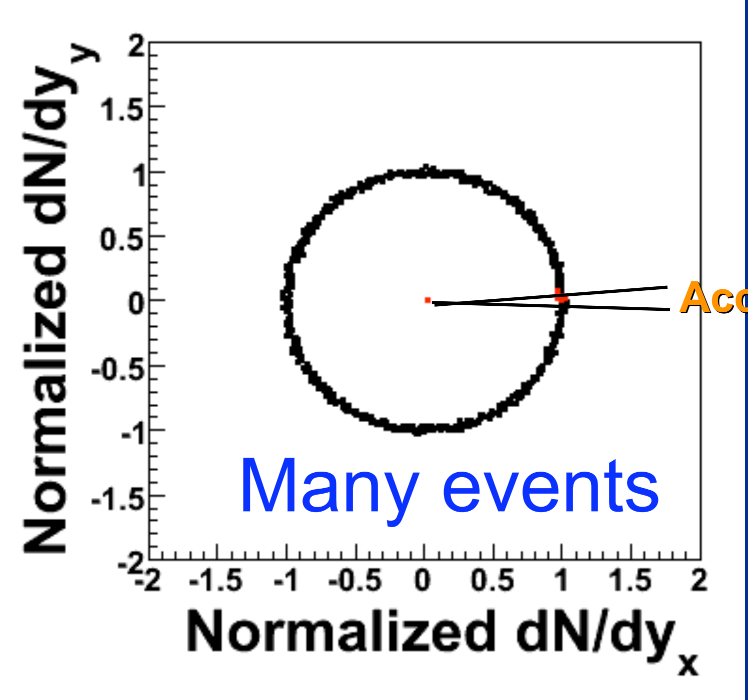


What to expect of mixed event analysis with limited acceptance trigger–A Monte-Carlo investigation…

Start with v_2 distribution wrt impact parameter plane:



Randomly distribute impact-parameter plane angle ψ and select particles within an assumed 4° spectrometer acceptance (~MRS):



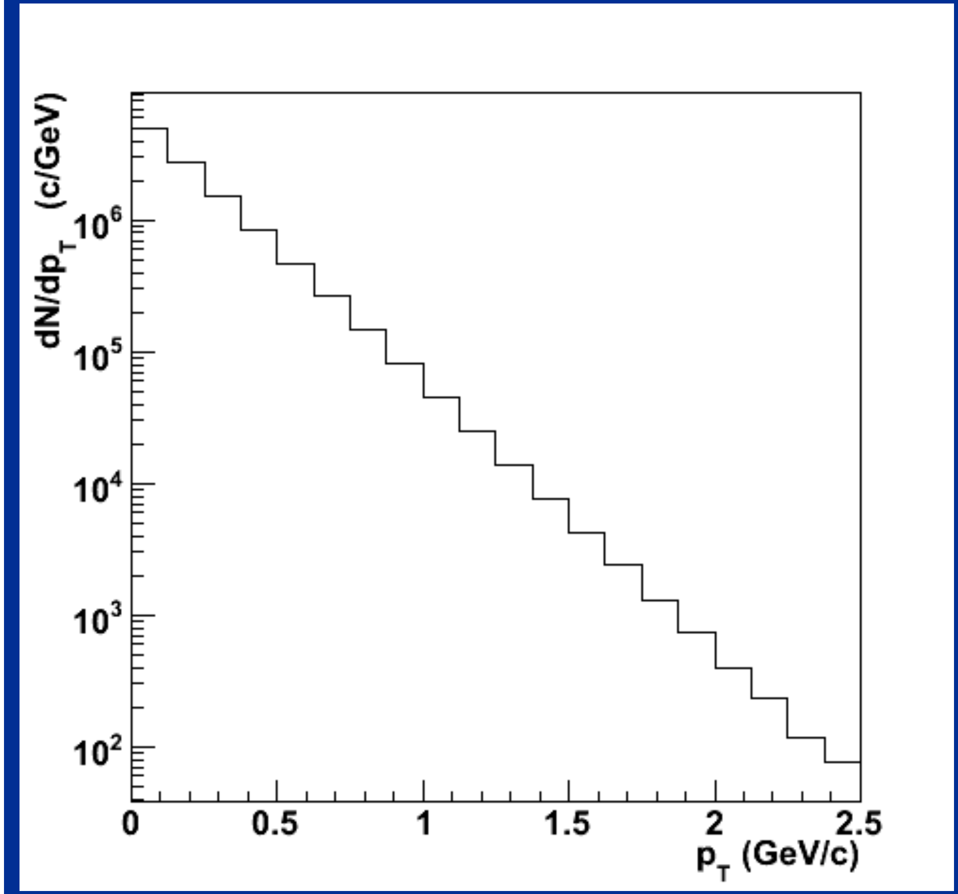
The small acceptance spectrometer trigger preferentially selects events with ψ = 0 or π since they are the most common.

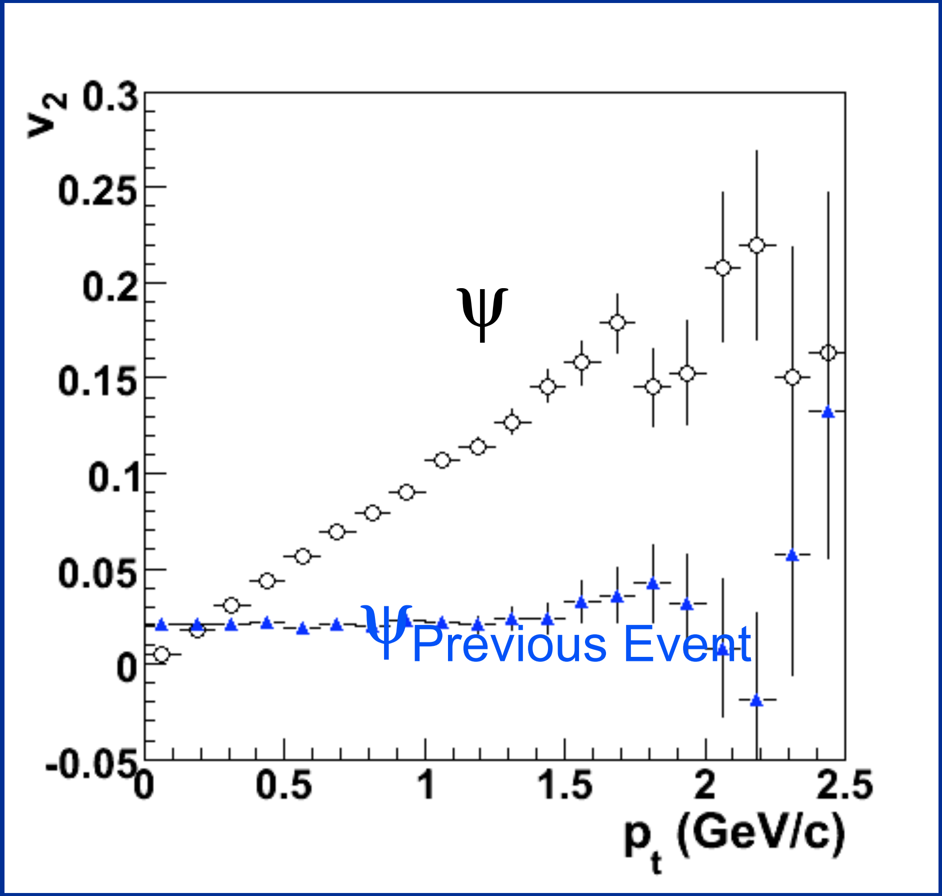
Assume:

- $dN/dp_t \propto Exp(-pt/2.13)$
- $v_2(p_t) = 0.1*p_t$
- v_2(integral)= 0.021

Calculate:

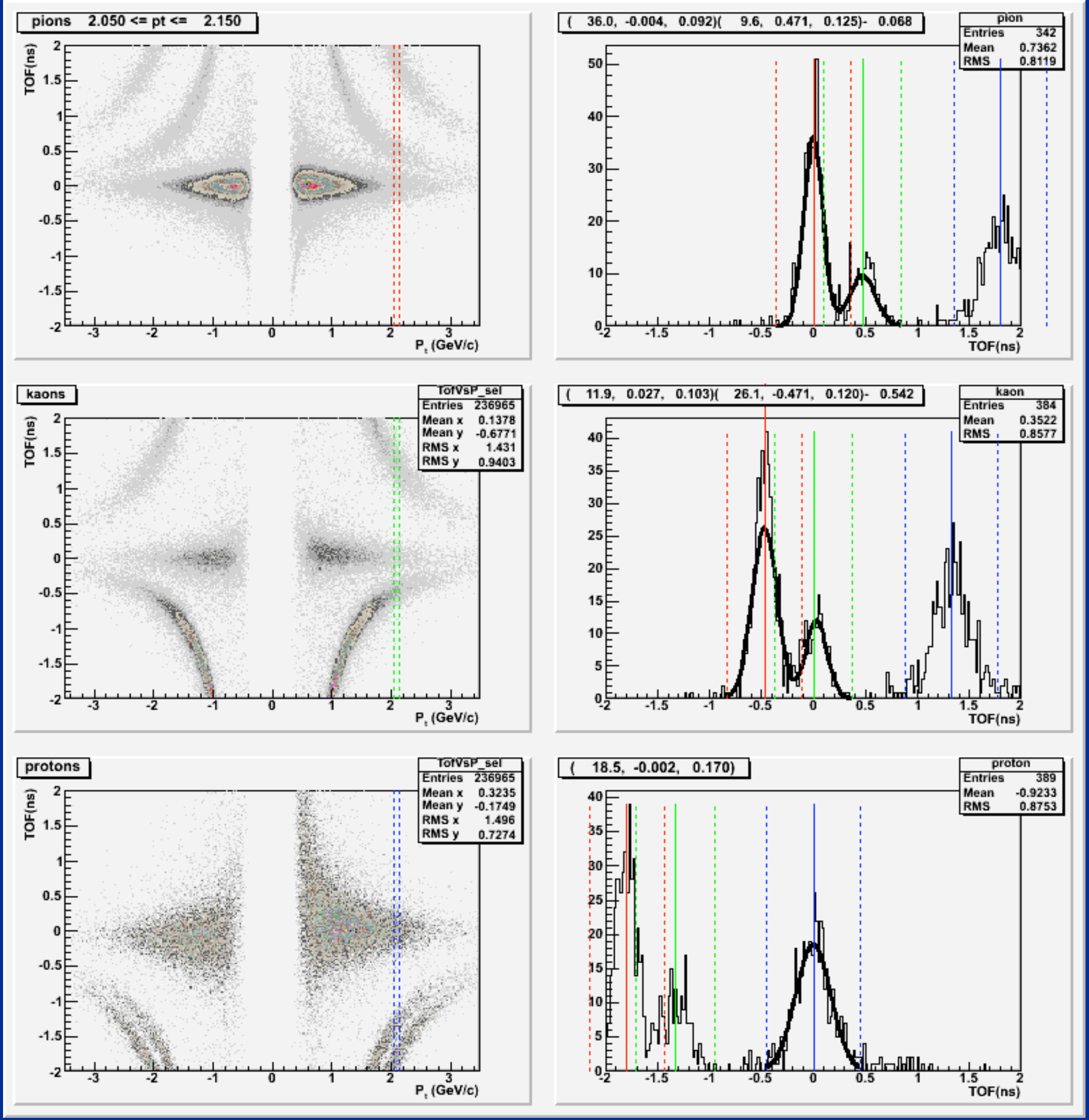
- $v_2=<\cos(2(\phi-\Psi))>$
- $v_2=<\cos(2(\phi-\Psi_{\text{Previous Event}}))>$





v_2(Previous Event) ≈ v_2(integral)

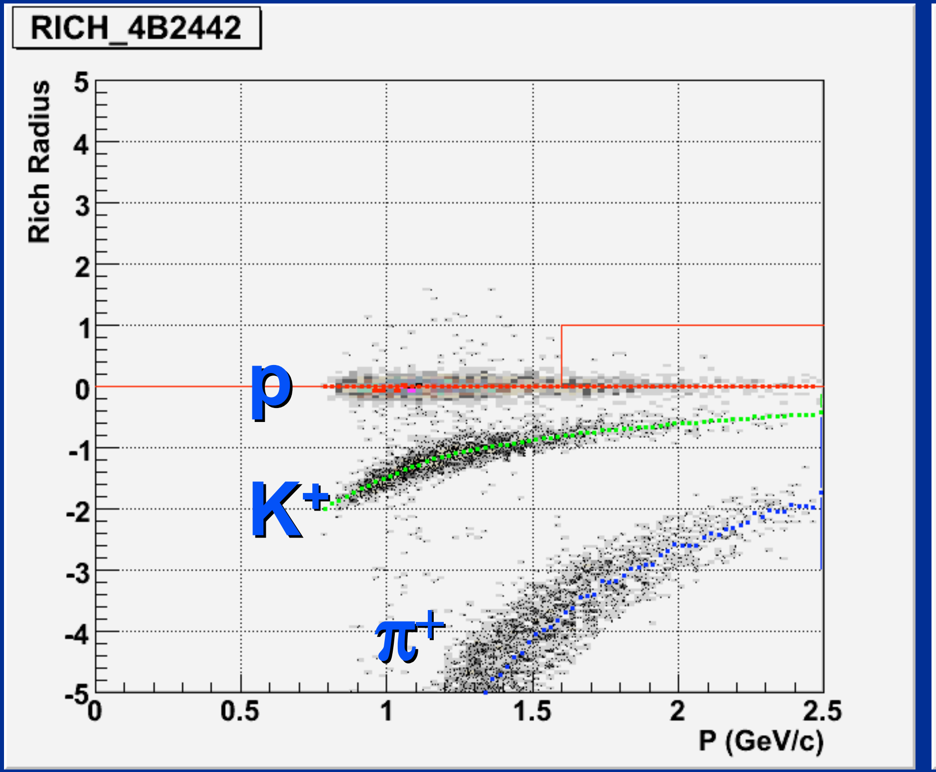
MRS PID



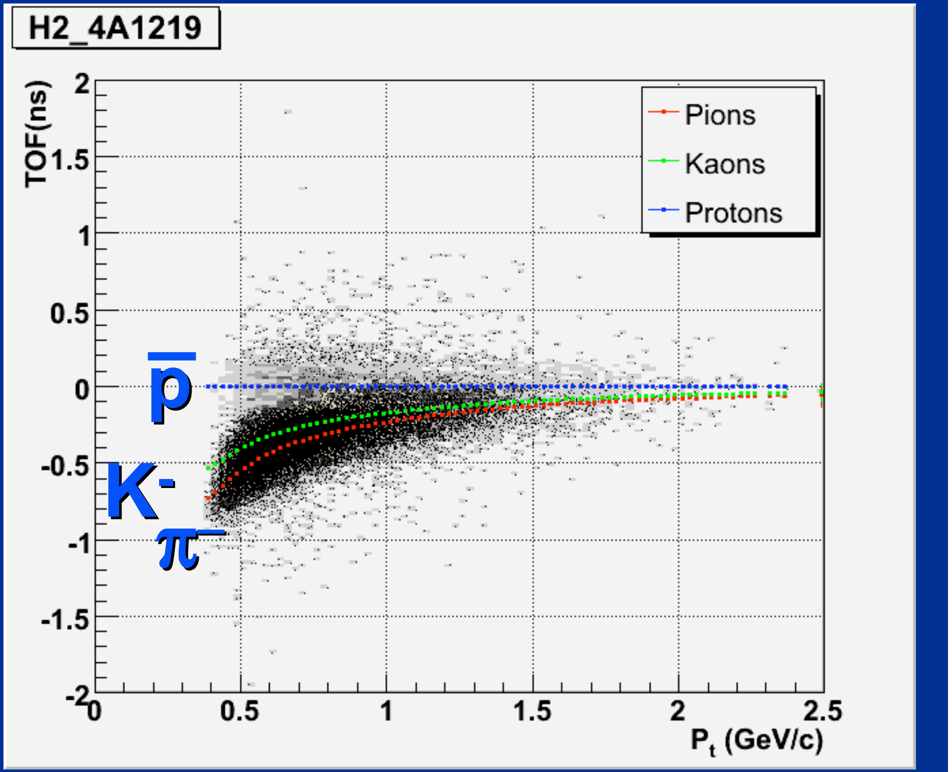
Dashed lines indicate 3σ limits

FS PID (π, K, high-p_T p)

FS (RICH Analysis for π and K)



FS (TOF/RICH Analysis for p)



Acceptance Maps