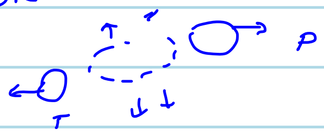
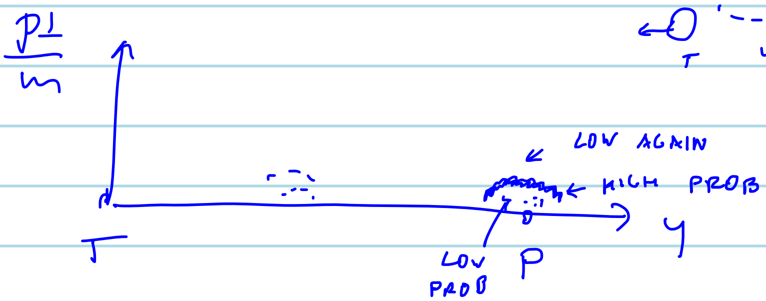
CORRELATIONS

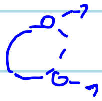
SINGLE-PARTICLE OBSERVABLES

SO-FAR – SINGLE-PTCLE DISTRIBUTIONS
YIELDS

? MUTUAL INFLUENCE OF EMITTED PTCLES ON EACH OTHER







COULOM BOOST

CENTRAL SOURCE CAN CONTAMINATE COULOMB HOLE

CORRELATION FUNCTION

$$C(\vec{v}_1, \vec{v}_2) = \frac{P_2(\vec{v}_1, \vec{v}_2)}{P_1(\vec{v}_1) \cdot P(\vec{v}_2)}$$

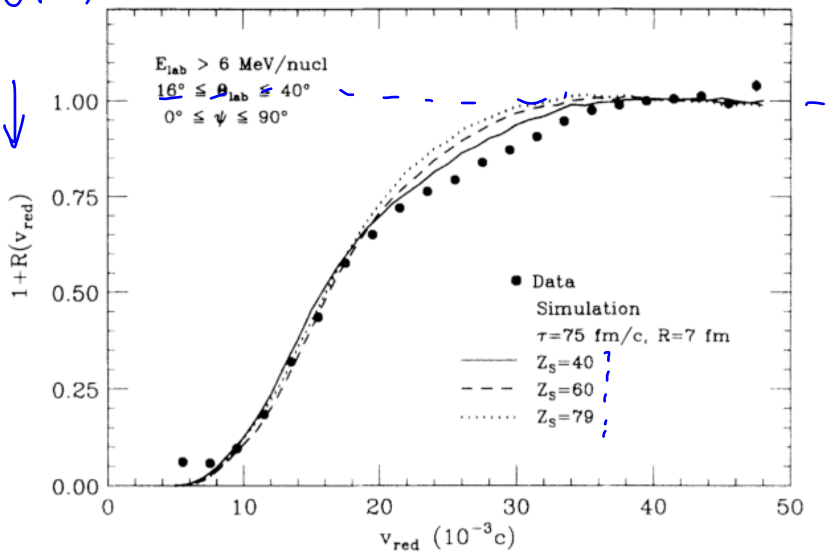
IF EMISSION UNCORRELATED $P_2(\vec{v}_1, \vec{v}_2) = P_1(v_1) \cdot P_2(v_2)$

$C(v_1, \vec{v}_2) = 1$

$C \to 1$ WHEN $|\vec{v}_1 - \vec{v}_2|$ LARGE

V. OFTEN DEVIATIONS FROM 1 OCCUR WHEN $|\vec{v}_1 - \vec{v}_2| \to 0$

$c(v_{rel})$



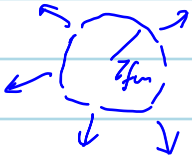
GLASMACHER

Ar + Au

AT 50 MeV/nucl

$4 \leq Z_{IMF} \leq 9$

INTERMEDIATE MASS FRAGMENTS



ISOTROPIC EMISSION

$e^{-t/\tau}$

$$P(\vec{v}_1\ \vec{v}_2) = \int d^3 r_1^s\, d^3 r_2^s\, d^3 v_1^s\, d^3 v_2^s$$

$$\mathcal{P}_{source}(r_1^s\ r_2^s\ v_1^s\ v_2^s)$$

$$\underbrace{\mathrm{Transf}\,(r_1^s\, r_2^s\ v_1^s\ v_2^s \rightarrow \qquad \bar{v}_1\ v_2)}_{\text{CLASSICAL EQ OF MOTION}}$$

? ONLY INFLUENCE OF 2 FRAGMENTS

TRANSF ACCOUNTED FOR BY SCHROEDINGER EQ. IF ONLY IMPACT OF ONE FRAGMENT OR ANOTHER THEN 2-BODY SCHR. EQ. BUT EFFECTIVELY 1-BODY

IF $\mathcal{P}_{emison}(v_1^s\ v_2^s) \simeq \mathcal{P}_{emis}(V)$

$$V \simeq v_1^s \simeq v_2^s$$

$$P(\vec{v}_1, \vec{v}_2) = \int d^3 r_1^s \int d^3 r_2^s \; P_{emsou}(r_1^s, r_2^s, V) \; |\psi_{\vec{v}_1 - \vec{v}_2}(\vec{r}_1^{\,s} - \vec{r}_2^{\,s})|^2$$

DATA

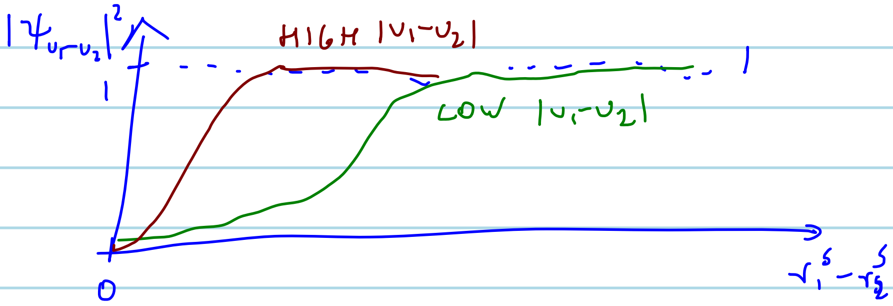
INFO ON SPATIAL EXTENT OF REACTION

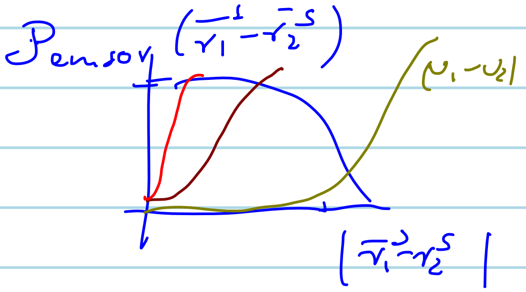
YOU KNOW HOW TO CALCULATE

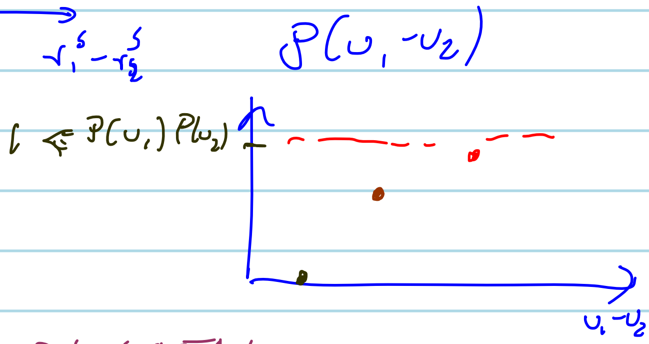
SCATTERING WAVE FUNCTION

AT LARGE $|\vec{v}_1 - \vec{v}_2|$ $\quad |\psi|^2 \simeq 1$

E.G. COULOMB REPULSION



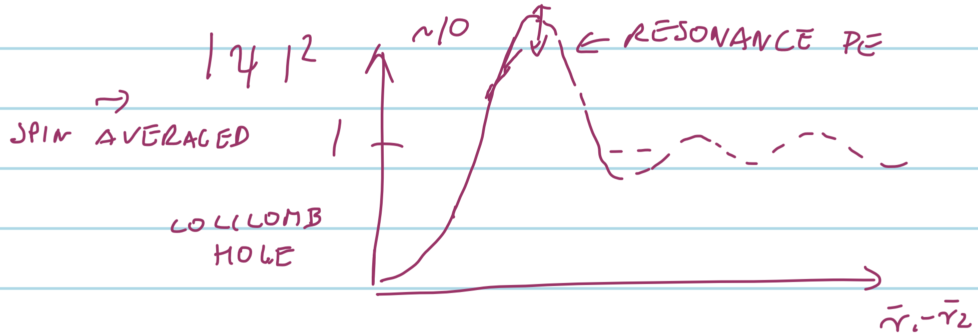


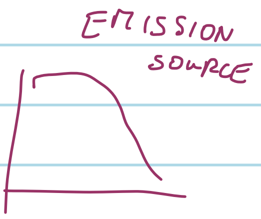


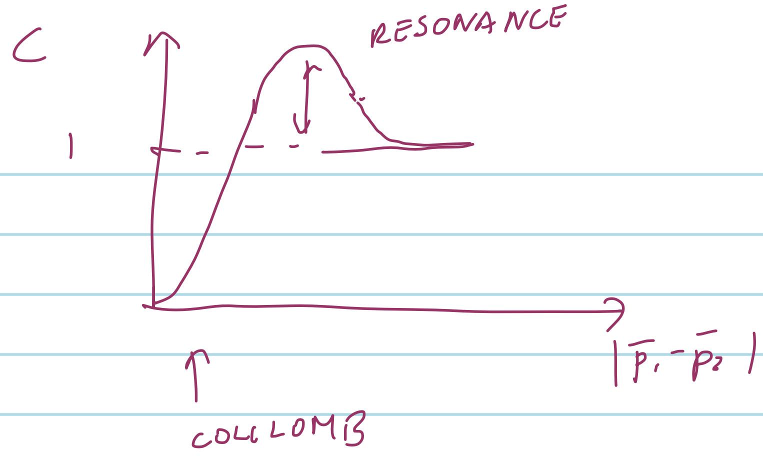
GAIN IN TRANSITION FROM CLASSICAL TO QUANTAL DESCRIPTION: ABILITY TO ACCOUNT PROPERLY FOR STRONG INTERACTIONS, RESONANCE PHENOMENA ETC

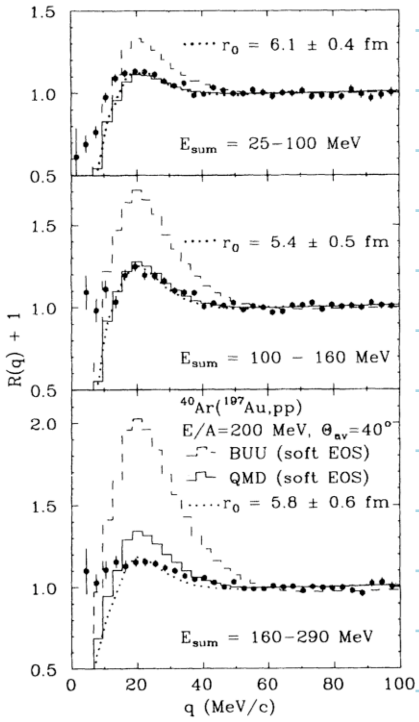
? CORRELATIONS OF PROTONS WITH EACH OTHER:

- COULOMB REPULSION
- STRONG ATTRACTION W/ RESONANCE
- INTERFERENCE









KUNDE

Ar + Au   200 MeV/nucl

POINTS DATA

$$P_{em}(r_1^s) \propto \exp\left(-\frac{r_1^{s\,2}}{r_0^2}\right)$$

GAUSSIAN EMISSION

SHAPE FOR EACH PROTON

SPACE

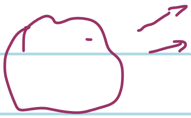
↑ ANALYSIS MISSES BACKGROUND!

EASY CASE OF CORRELATION

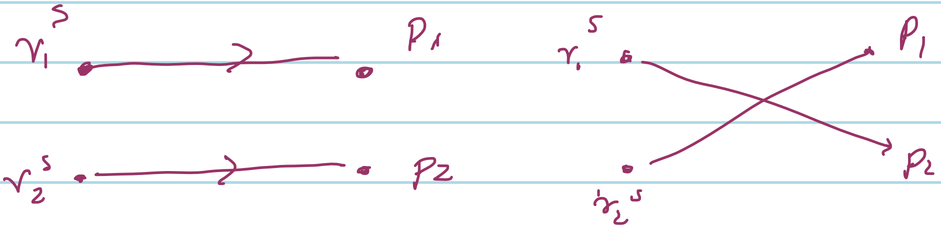
INTERFERENCE IN π EMISSION

π IDENTICAL PIONS

P_{em} s



π IDENTITY INTERFERENCE



$$|\psi_{\bar p_1 p_2}(\bar r_1^s, r_2^s)|^2 = \left|\frac{1}{\sqrt{2}}\left(e^{i\bar p_1 \bar r_1^s} e^{i\bar p_2 \bar r_2^s} + e^{i\bar p_2 \bar r_1^s} e^{i\bar p_1 \bar r_2^s}\right)\right|^2$$

$$= \frac{1}{2}\Big(1+1+ e^{i\bar p_1 \bar r_1^s} e^{i\bar p_2 \bar r_2^s} e^{-i\bar p_2 \bar r_1^s} e^{-i\bar p_1 \bar r_2^s}$$

$$+ e^{i\bar p_2 \bar r_1^s} e^{i\bar p_1 \bar r_2^s} e^{-i\bar p_1 \bar r_1^s} e^{-i\bar p_2 \bar r_2^s}\Big)$$

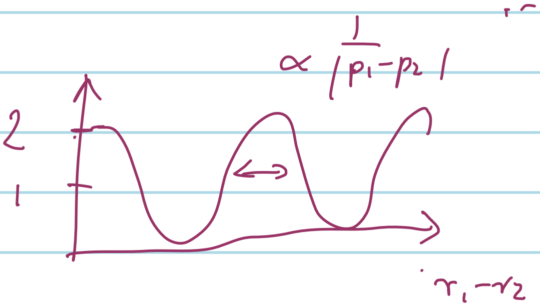
$$= \frac{1}{2}\left(2 + e^{i\bar p_1(\bar r_1^s - \bar r_2^s) - i\bar p_2(\bar r_1^s - \bar r_2^s)} + e^{i p_2(r_1 - r_2) - i p_1(r_1 - r_2)}\right)$$

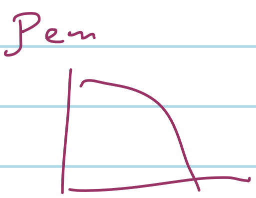
$$= \frac{1}{2}\left(2 + e^{i(\bar p_1 - \bar p_2)(\bar r_1 - \bar r_2)} + e^{-i(\bar p_1 - \bar p_2)(\bar r_1 - \bar r_2)}\right)$$

$$= 1 + 2\cos\left((\bar p_1 - \bar p_2)(\bar r_1 - \bar r_2)\right)$$

$$P(p_1, p_2) = \int d^3 r_1\, d^3 r_2\, \rho_{cm}(\bar r_1\, \bar r_2)$$

$$\left(1 + \cos\left((\bar p_1 - \bar p_2)(\bar r_1 - \bar r_2)\right)\right)$$





$$d^3 r_1\, d^3 r_2 = d^3(r_1 - r_2)\, d^3\left(\frac{r_1 + r_2}{2}\right)$$

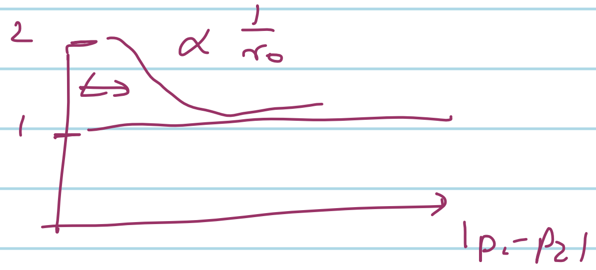
$$P(p_1, p_2) = \int d^3(r_1 - r_2)\, P_{em}(\bar{r}_1 - \bar{r})$$
$$\left(1 + \cos\left((\bar{p}_1 - \bar{p}_2)(\bar{r} - \bar{r}_2)\right)\right)$$

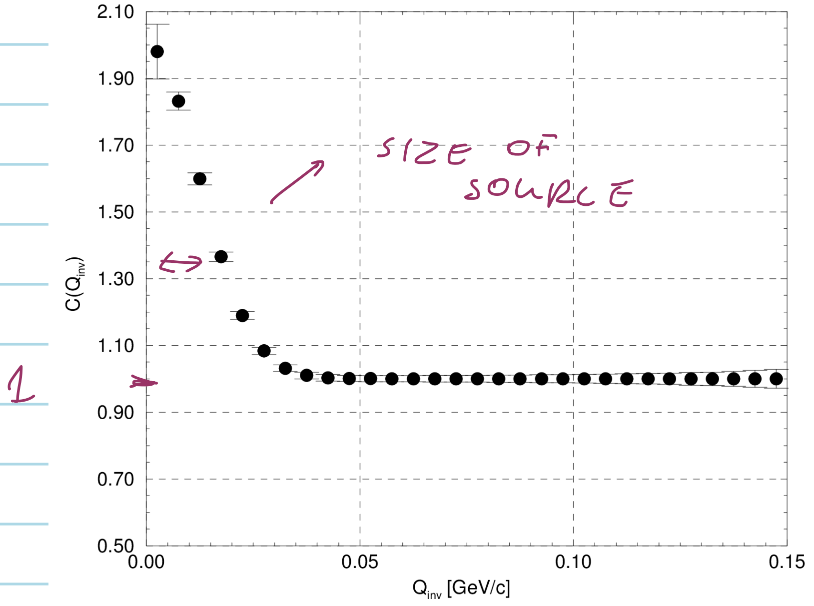
$$P_{em}(\bar{r}_1) \propto \exp\left(-\frac{\bar{r}_1^{\,2}}{r_0^{\,2}}\right)$$

$$\int d^3\left(\frac{r_1 + r_2}{2}\right) P_{em}(\bar{r}_1)\, P_{em}(\bar{r}_2) \propto \exp\left(-\frac{(\bar{r}_1 - r_2)^2}{2 r_0^{\,2}}\right)$$

$$P(p_1, p_2) \propto \int d^3(r_1 - r_2)\, \exp\left(-\frac{(r_1 - r_2)^2}{2 r_0^{\,2}}\right)\left(1 + \cos\left((p_1 - \bar{p}_2)(\bar{r}_1 - \bar{r}_2)\right)\right)$$

$$P(p_1, p_2) \propto 1 + \exp\left(-\frac{(p_1 - p_2)^2\, r_0^{\,2}}{2}\right)$$





MORE COMPACT SOURCES YIELD STRONGER CORRELATIONS AT SMALL RELATIVE VELOCITIES

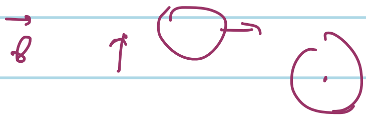
→ WAY TO DETERMINE SIZE OF THE EMISSION ZONE

AZIMUTHAL OR REACTION-PLANE CORRELATIONS

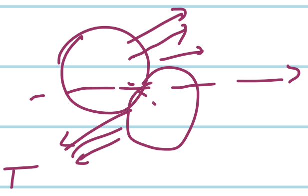
$p_\perp$ $\quad$ y

REACTION PLANE

B



$\vec{b}$ HAS AZIMUTHAL DIRECTION



$$\vec{Q}^{\perp} = \sum_{y_\nu > y_{cm}} \vec{p}_\perp^{\,\nu} - \sum_{y_\nu < y_{cm}} \vec{p}_\perp^{\,\nu}$$

? LOOK FOR ORIENTATION OF REACTION PLANE ?

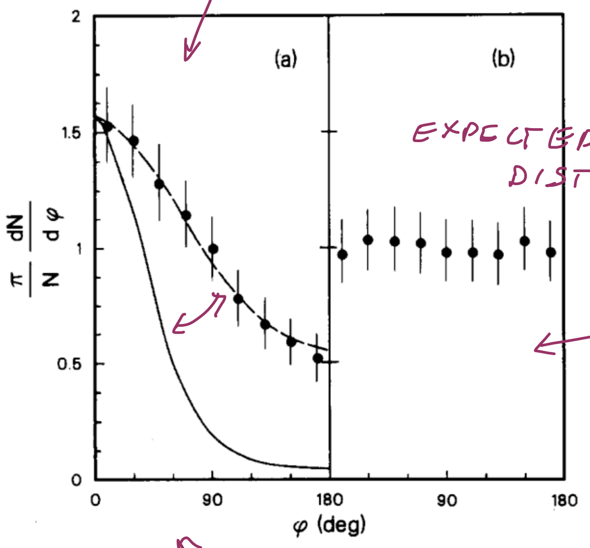
ANY SIGNIFICANCE TO $\vec{Q}^{\perp}$

MANY PTCLES

TAKE EVENT & SPLIT INTO 2: I & II

$\vec{Q}_I^{\perp}$ $\quad$ $\vec{Q}_{II}^{\perp}$

POINTS DATA



EXPECTED NARROWING DISTRIBUTION OF $\vec{Q}$ RELATIVE TO REACTION

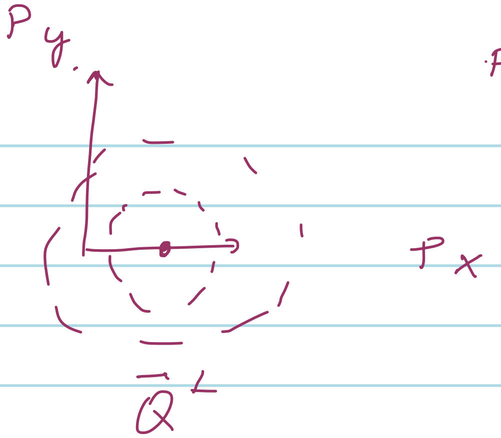
Ar + KCl SEMICENTRAL EVENTS

1.8 GeV/nucl

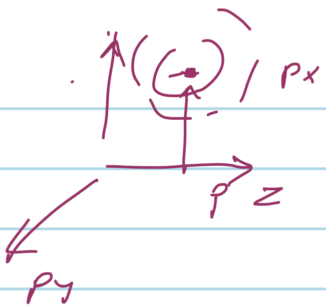
FROM EVENT MIXING

$$\vec{Q} = \vec{Q}_I + \vec{Q}_{II}$$

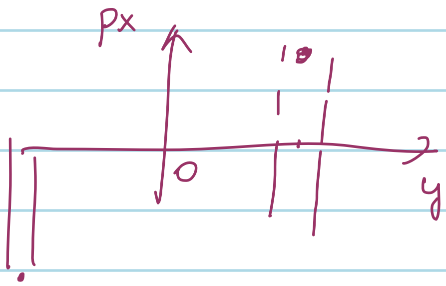
$\vec{Q}_I$ $\vec{Q}_{II}$ DISTRIBUTION IN RELATIVE AZIMUTHAL ANGLE



FORWARD y



? ESTIMATES DIRECTION OF REACTION PLANE



$$\langle p^x(y)\rangle = \vec p^\perp \cdot \frac{\vec Q^\perp}{|\vec Q^\perp|}$$

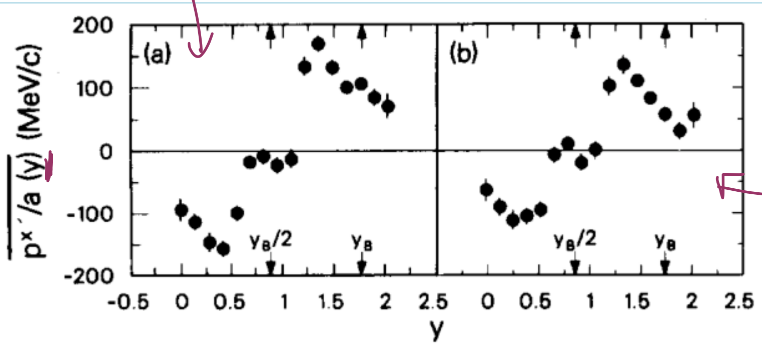
$=$

$$\langle p^x(y)\rangle = \vec p^\perp \frac{\vec Q^\perp}{|Q|}$$

Ar + KCl

1.8 GeV/nucl

DATA



MIXED EVENTS

$w_\nu = \pm 1$

AUTOCORRELATION!

$$\left\langle \vec p_\mu^\perp \cdot \frac{\sum_\nu w_\nu \vec p_\nu^\perp}{|\sum_\nu w_\nu \vec p_\nu^\perp|} \right\rangle$$

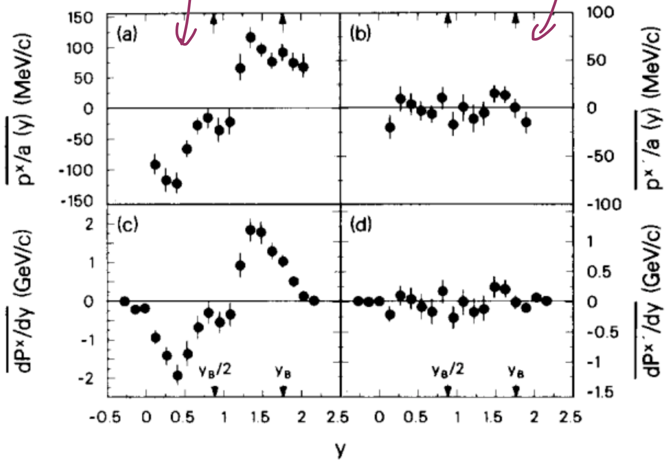
$$= \left\langle \vec p_\mu^\perp \cdot \frac{w_\mu \vec p_\mu^\perp}{|\sum w_\nu \vec p_\nu^\perp|} \right\rangle + \overbrace{\left\langle \vec p_\mu^\perp \frac{\sum_{\nu\neq\mu} w_\nu \vec p_\nu^\perp}{|\sum w_\nu \vec p_\nu^\perp|} \right\rangle}^{\approx 0}$$

$$= w_\mu \left\langle \frac{p_\mu^{\perp 2}}{|\sum w_\nu p_\nu^\perp|} \right\rangle^{>0} = \text{SOMETHING POSITIVE} \cdot w_\mu$$

$$\vec Q_\mu^{\perp\prime} = \sum_{\nu\neq\mu} w_\nu \vec p_\nu^\perp \qquad w_\nu = \pm 1 \text{ DEPENDING ON } y_\nu$$

DATA

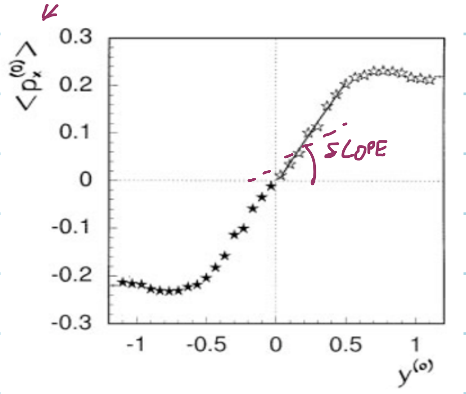
MIXED EVENTS



$\vec{Q} \perp$

DOES NOT POINT EXACTLY ALONG THE REACTION PLANE REDUCING ON AVERAGE THE MAGNITUDE OF $\overline{p^x}$

UNITS OF BEAM MOMENTUM



UNITS OF BEAM RAPIDITY

FOPI

Au + Au

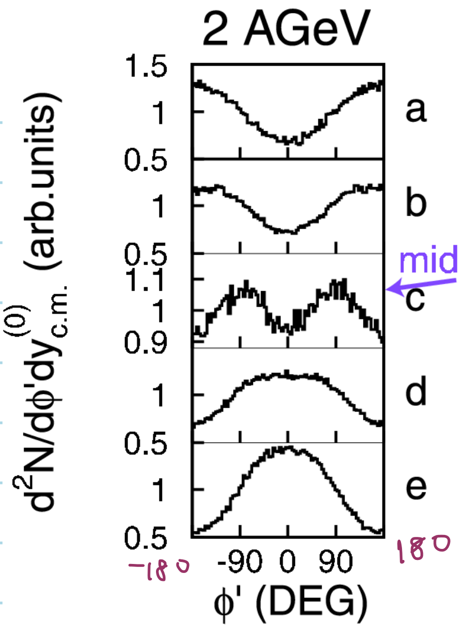
$F = \frac{d\langle p^x \rangle}{dy}$

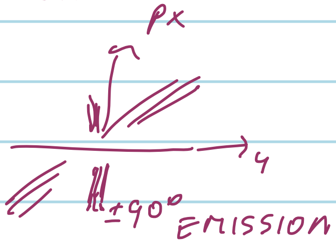
SLOPE

$v_n(p_L)$

$v_1 < 0$

← TARGET RAPIDITY REGION





$v_2 < 0$

$v_1 > 0$

← PROJECTILE RAP REGION

$$\langle \cos n\phi \rangle = v_n$$