

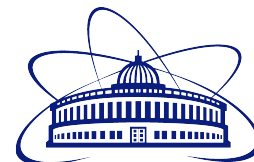
Directed flow v_1 of deuterons in Xe+CsI collisions at 3.8A GeV

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Anisotropic flow

Spatial asymmetry of the initial state matter transforms into momentum anisotropy of the produced particles

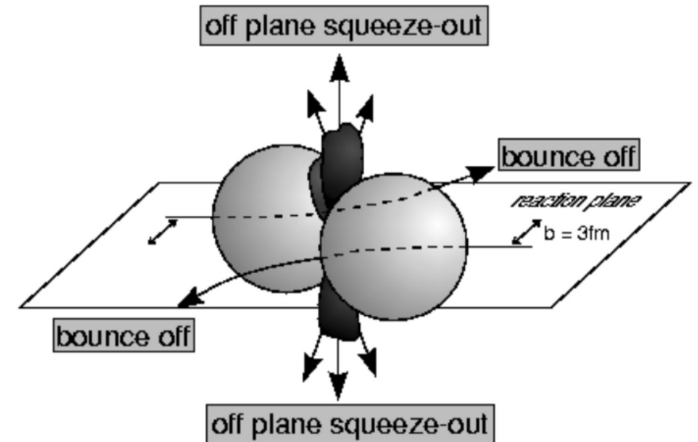
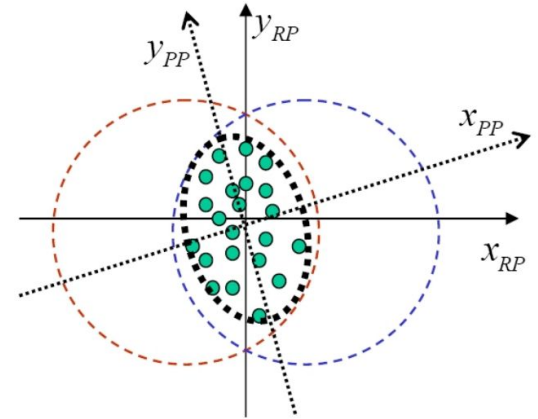
$$E \frac{d^3N}{d^3p} = \frac{1}{2\pi} \frac{d^2N}{p_t dp_t dy} \left(1 + \sum_{n=1}^{\infty} 2v_n \cos(n(\phi - \Psi_r)) \right)$$

$$v_n = \langle \cos(n(\phi - \Psi_r)) \rangle$$

Coefficients v_n quantify anisotropic transverse flow of particles

Anisotropic flow is sensitive to:

- Time of the interaction between overlap region and spectators
- Compressibility of the created matter



Event and track selection criteria

Event selection criteria:

Physical runs

Central collision trigger CCT2

at least 2 tracks in vertex

$Vtx_R < 1$ cm

$Vtx_Z < 0.1$ cm

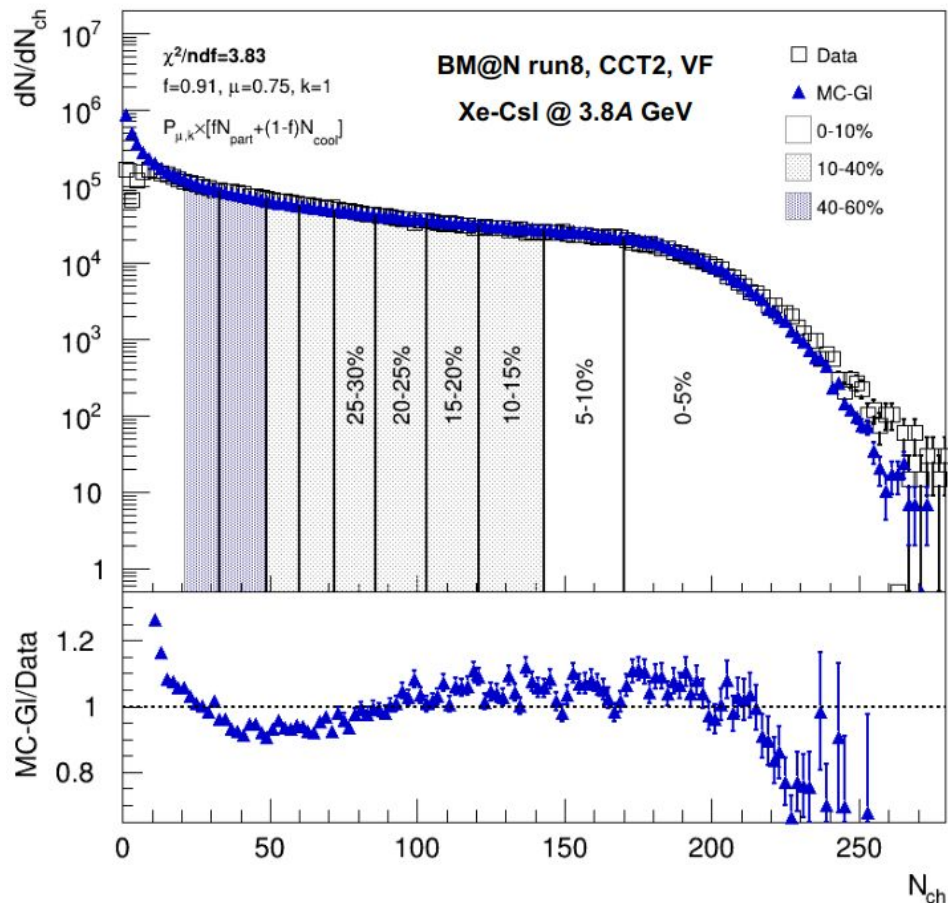
Track selection criteria:

Outside the FHCAL acceptance

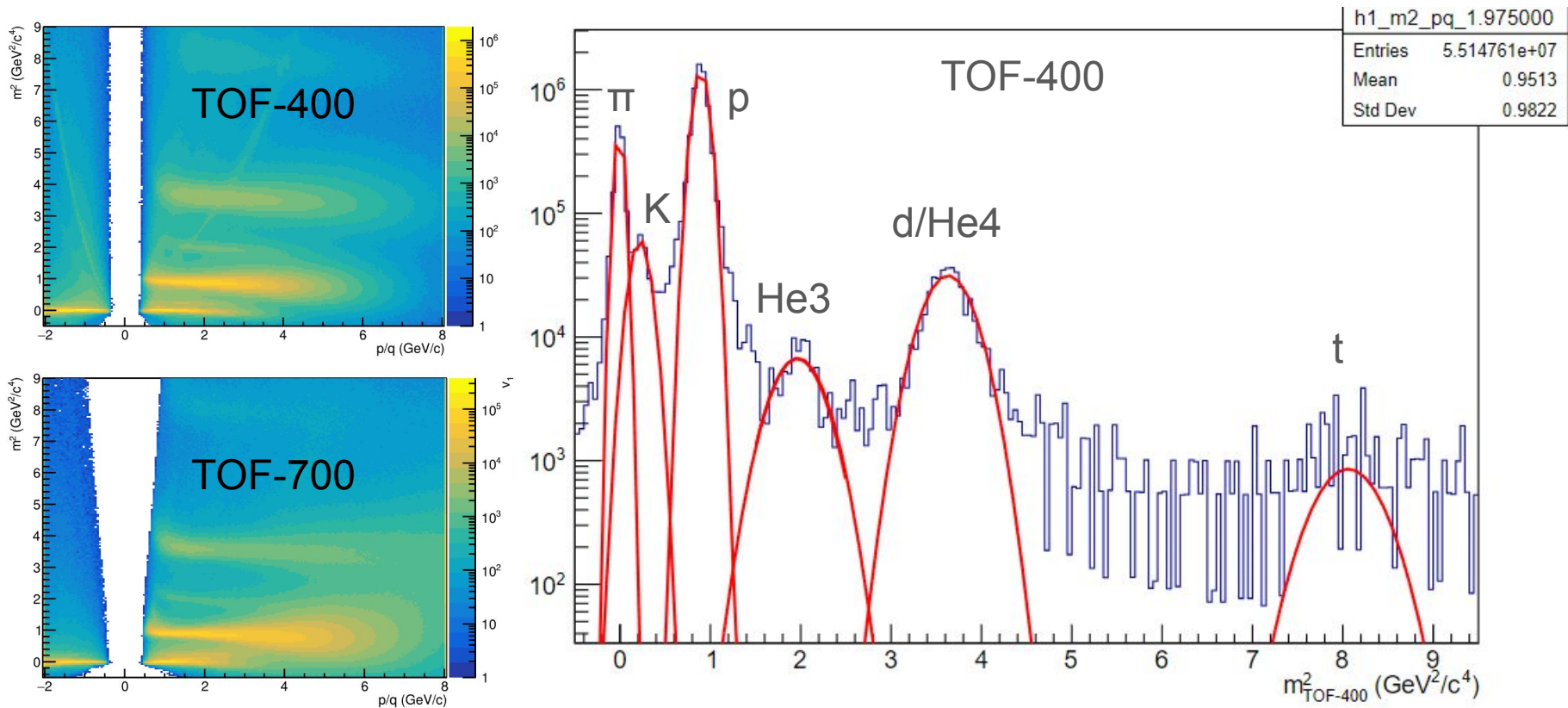
$N_{hits} > 5$

$\chi^2 < 5$

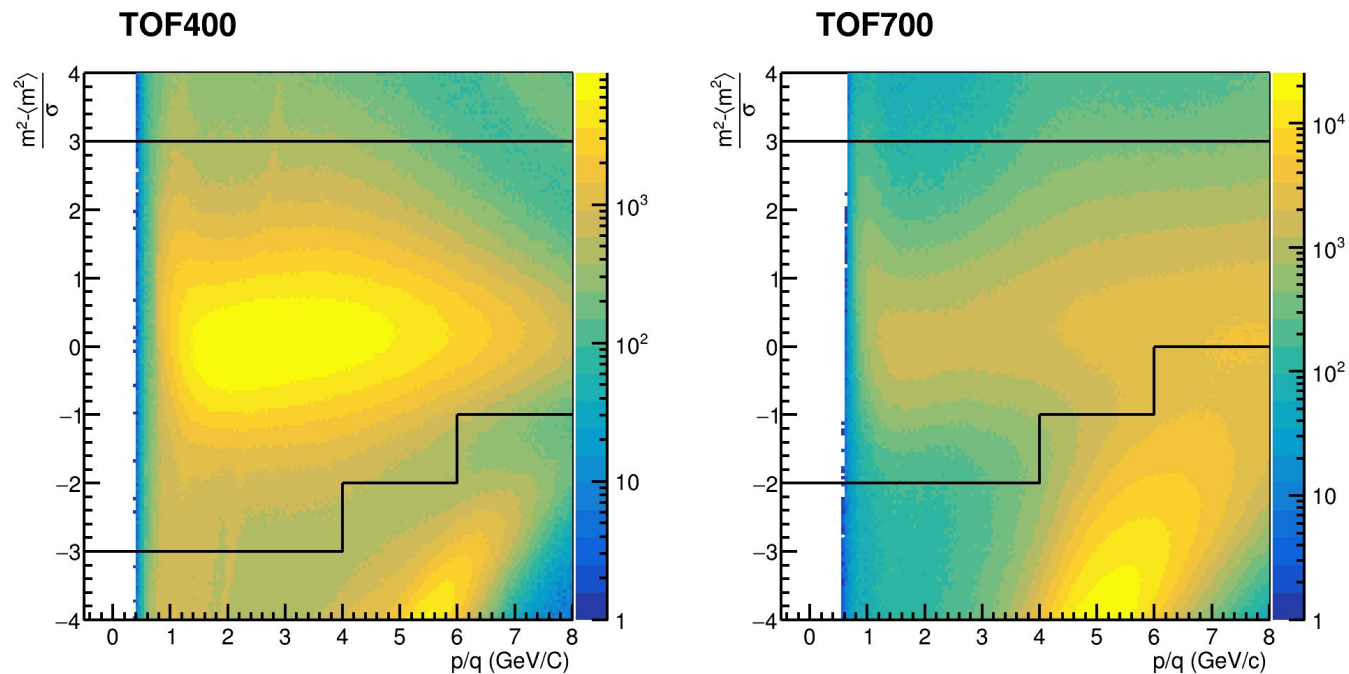
DCA < 5 cm



Particle Identification



Deuteron identification criteria

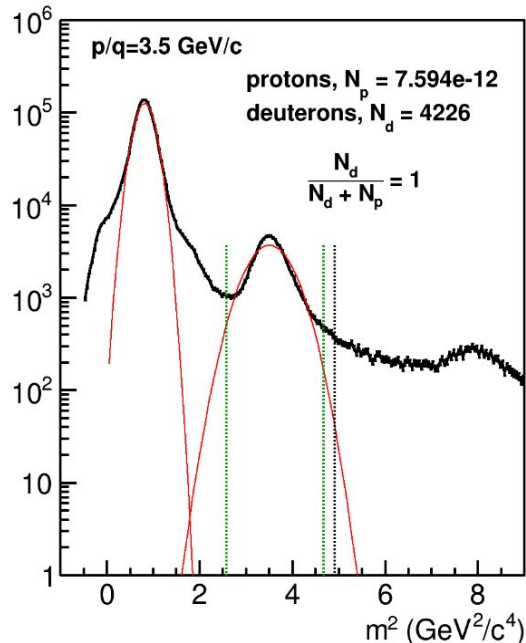


N- σ distributions for deuteron candidates
Solid lines represent the selection criteria for different p/q ranges.

m^2 -distribution in narrow p/q ranges

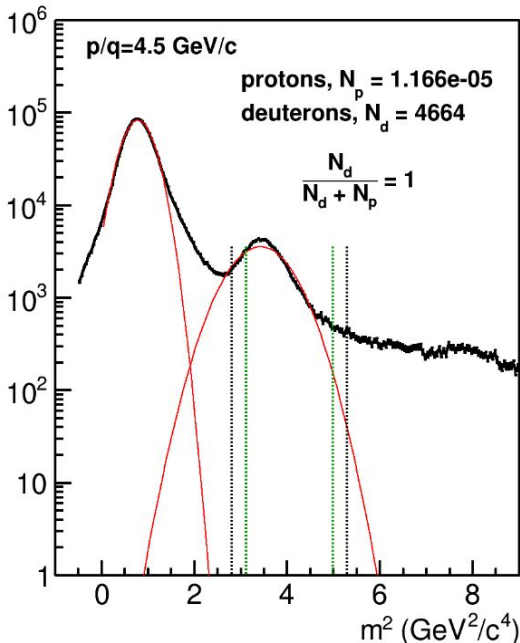
$$-2\sigma < m^2 - \langle m^2 \rangle < 3\sigma$$

$$-2\sigma < m^2 - \langle m^2 \rangle < 2.5$$



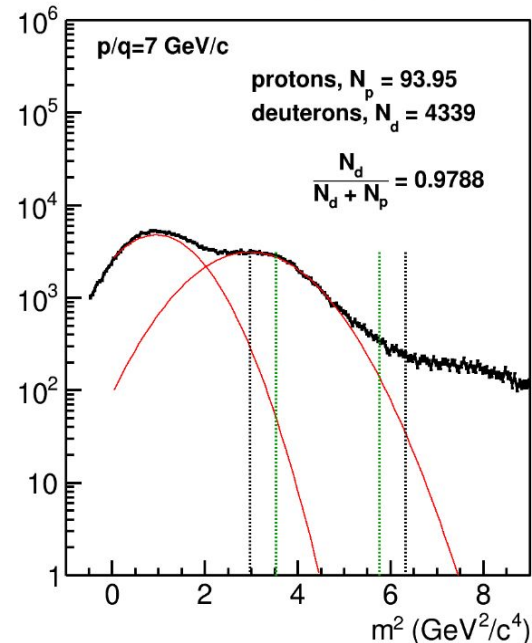
$$-\sigma < m^2 - \langle m^2 \rangle < 3\sigma$$

$$-0.5\sigma < m^2 - \langle m^2 \rangle < 2.5$$



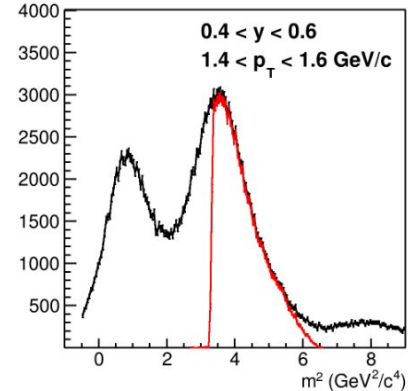
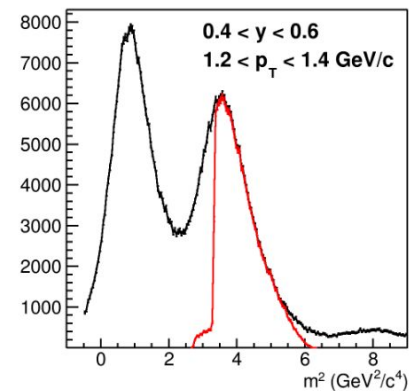
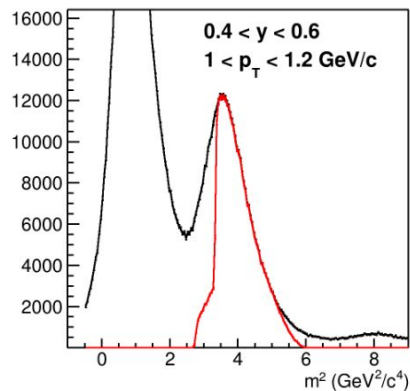
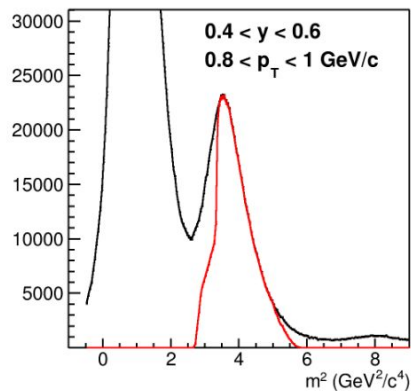
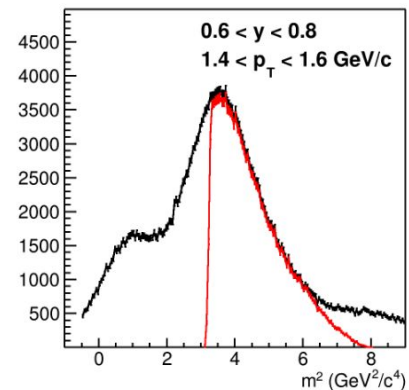
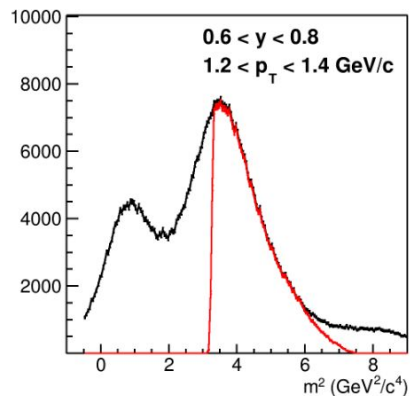
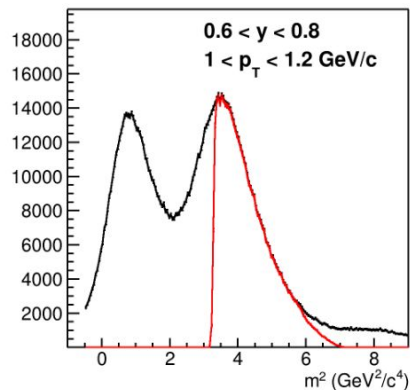
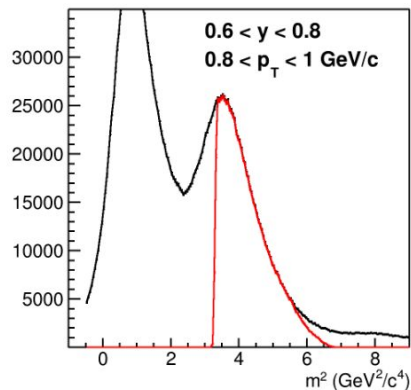
$$0 < m^2 - \langle m^2 \rangle < 3\sigma$$

$$0.5\sigma < m^2 - \langle m^2 \rangle < 2.5$$



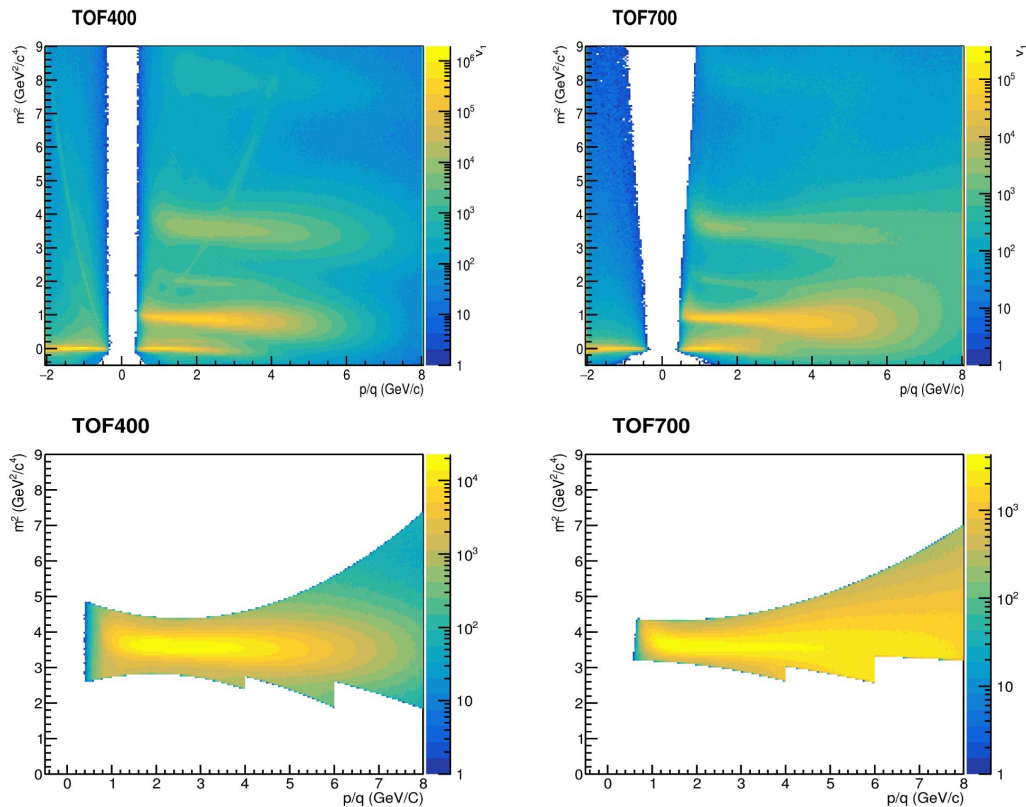
m^2 particle distribution for p/q corresponding to different ($m^2 - \langle m^2 \rangle$) selection criteria in the TOF700

m^2 -distribution in p_T - y windows



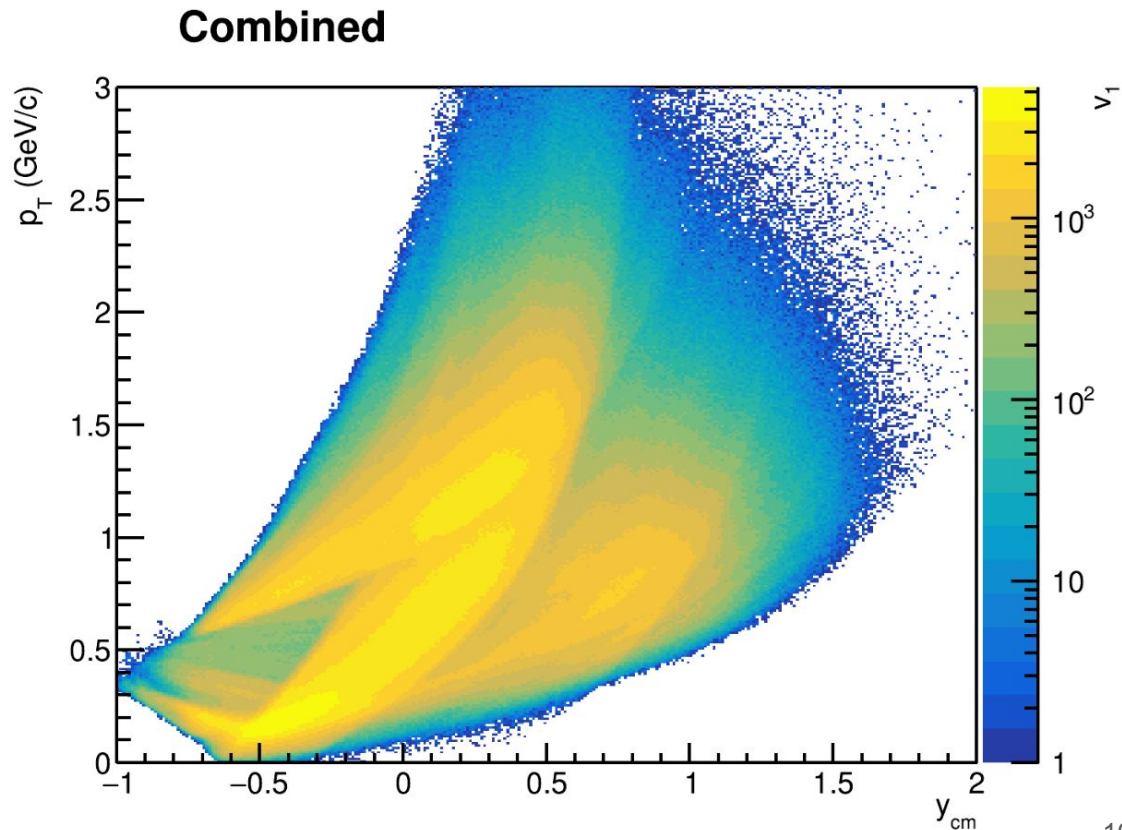
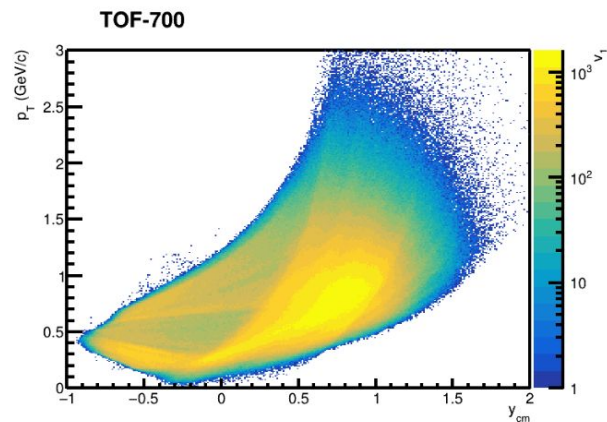
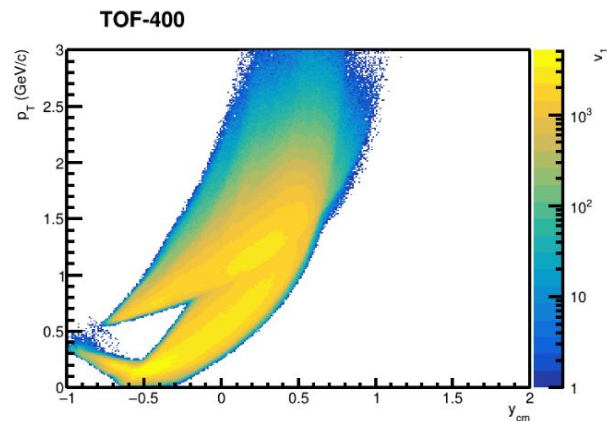
m^2 particle distribution in p_T and y bins in the TOF700

Particle Identification



m^2 versus p/q distribution of the selected deuteron candidates

Deuteron p_T - y acceptance



Flow vectors

A unit $u_{n,k}$ vector is defined in the transverse plane for each particle k

$$u_{n,k} = e^{in\phi_k}$$

Event flow vector Q_n - an estimate of the reaction plane

$$Q_n = \frac{\sum_{k=1}^M w_k u_{n,k}}{\sum_{k=1}^M w_k} = |Q_n| e^{in\Psi_n^E}$$

Ψ_n^E - n -th harmonic event plane angle,

M - multiplicity of particles in the group.

Resolution

Scalar product method

$$v_1 = \frac{\langle u_1 Q_1^{F1} \rangle}{R_1^{F1}}$$

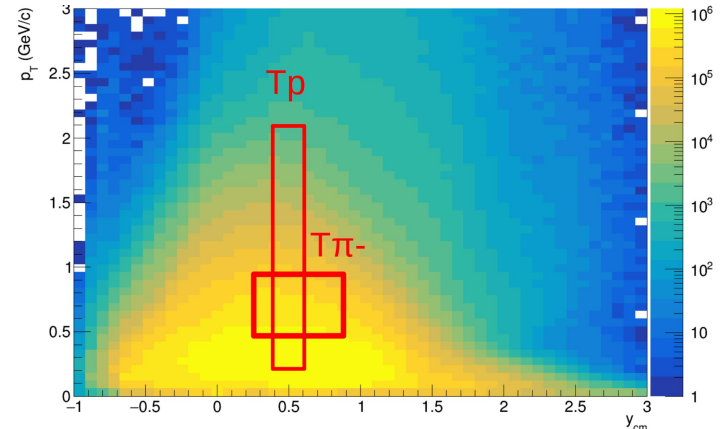
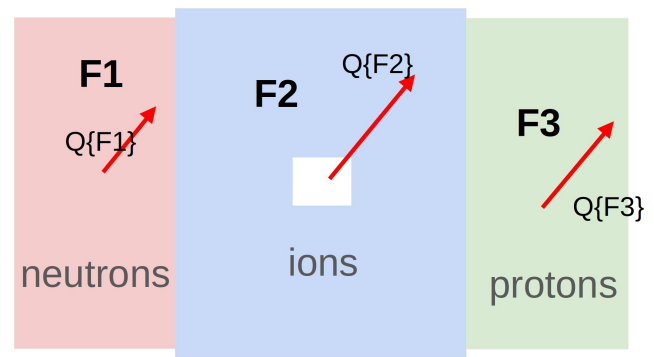
The resolution correction factor R_n

$$R_1^{F1} = \langle \cos(\Psi_1^{F1} - \Psi_1^{RP}) \rangle$$

Using three groups of particles and the pairwise correlations of Q_n , R_n reads

$$R_1^{F2(F1,F3)} = \frac{\sqrt{\langle Q_1^{F2} Q_1^{F1} \rangle \langle Q_1^{F2} Q_1^{F3} \rangle}}{\sqrt{\langle Q_1^{F1} Q_1^{F3} \rangle}}$$

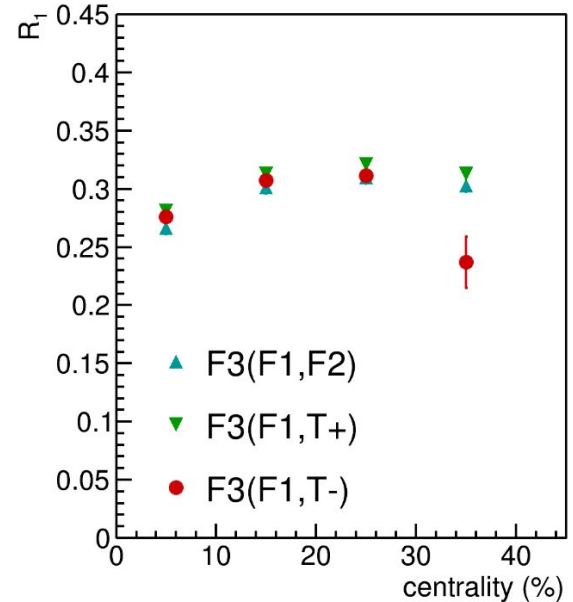
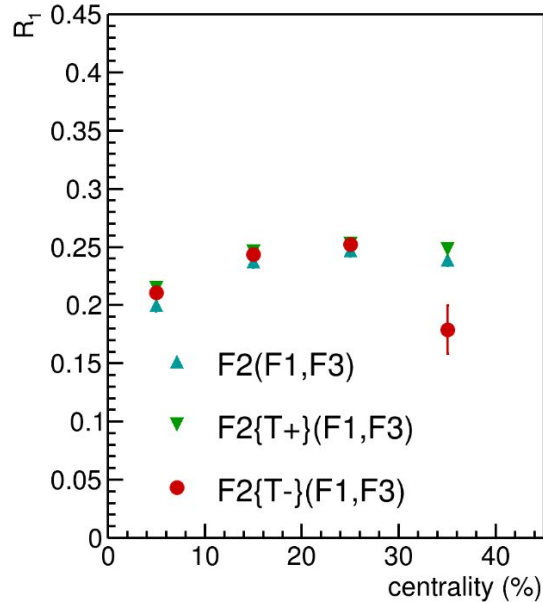
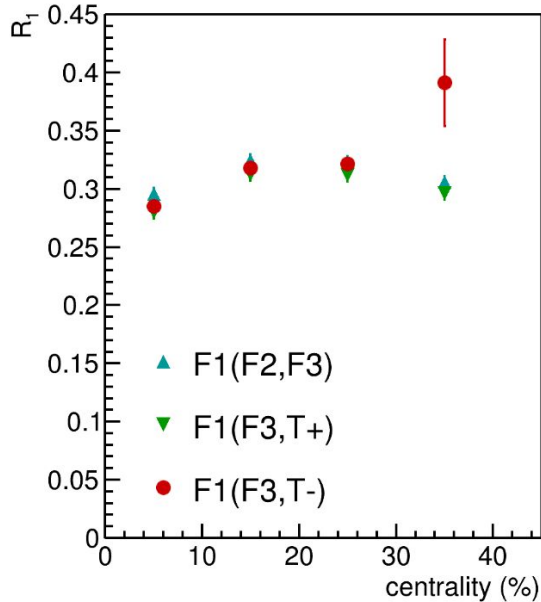
$$R_1^{F2\{Tp\}(F1,F3)} = \langle Q_1^{F2} Q_1^{Tp} \rangle \frac{\sqrt{\langle Q_1^{F1} Q_1^{F3} \rangle}}{\sqrt{\langle Q_1^{Tp} Q_1^{F1} \rangle \langle Q_1^{Tp} Q_1^{F3} \rangle}}$$



T-: all negatively charged particles with:
 $1.5 < \eta < 4$
 $p_T > 0.2$ GeV/c

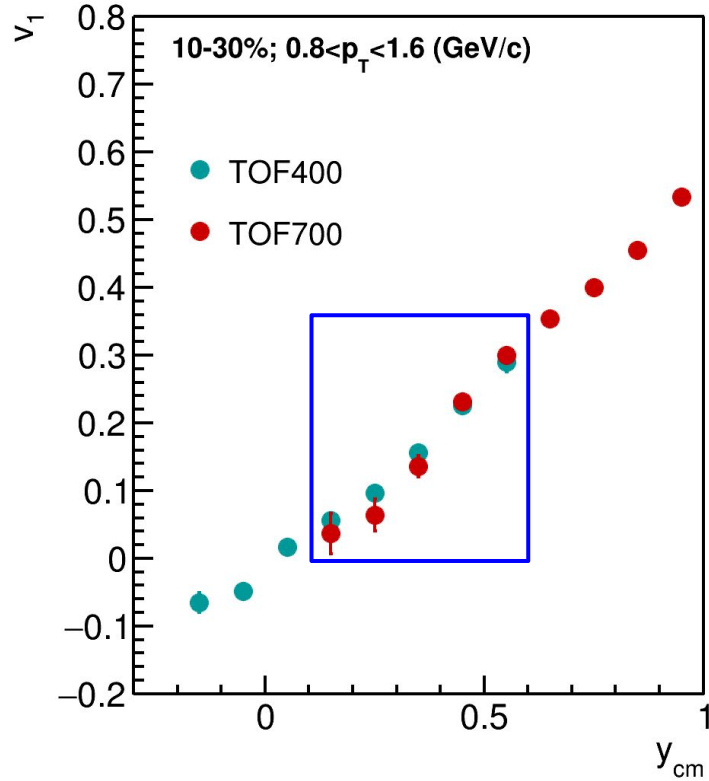
T+: all positively charged particles with:
 $2.0 < \eta < 3$
 $p_T > 0.2$ GeV/c

Symmetry plane resolution as a function of centrality

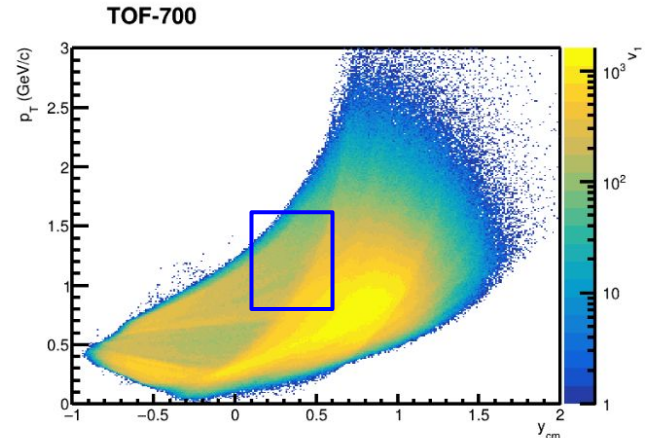
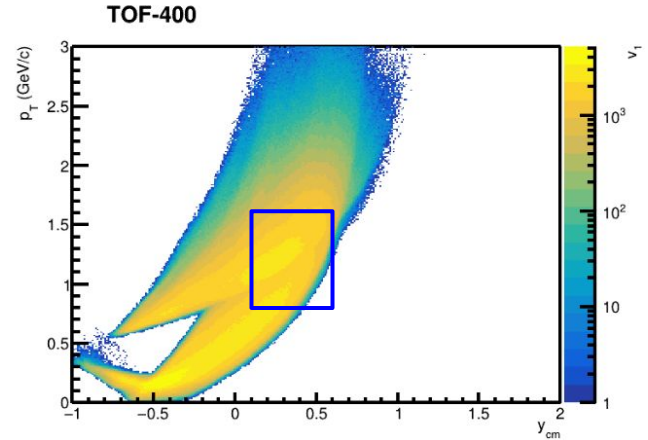


Different estimations of R_1 are in reasonable agreement for all three symmetry planes.

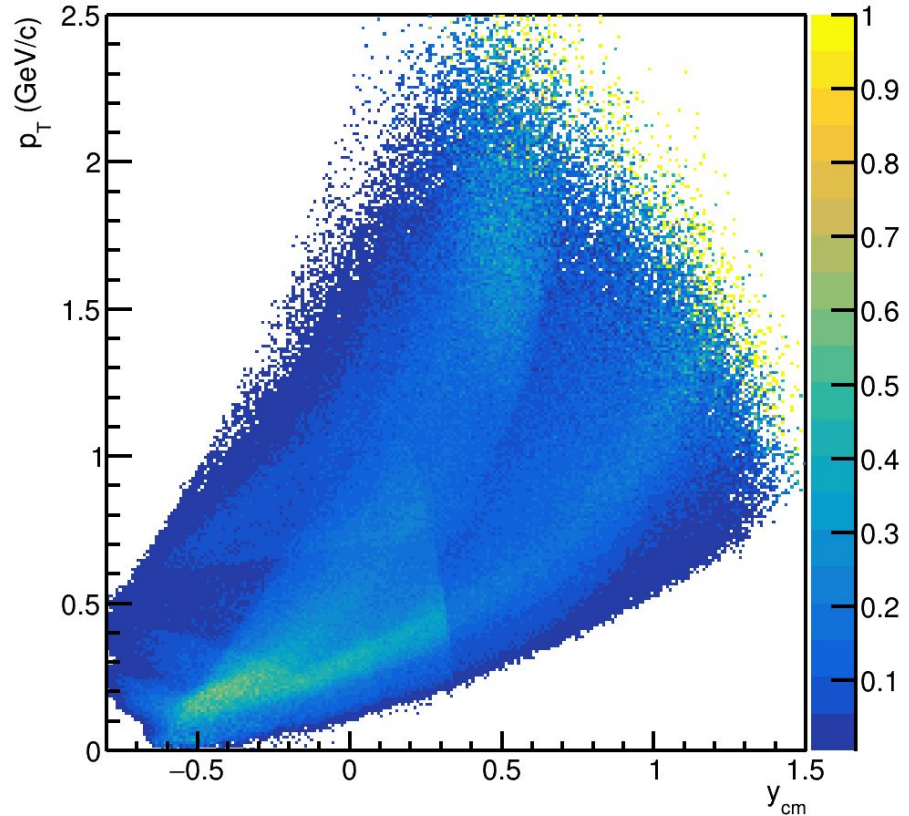
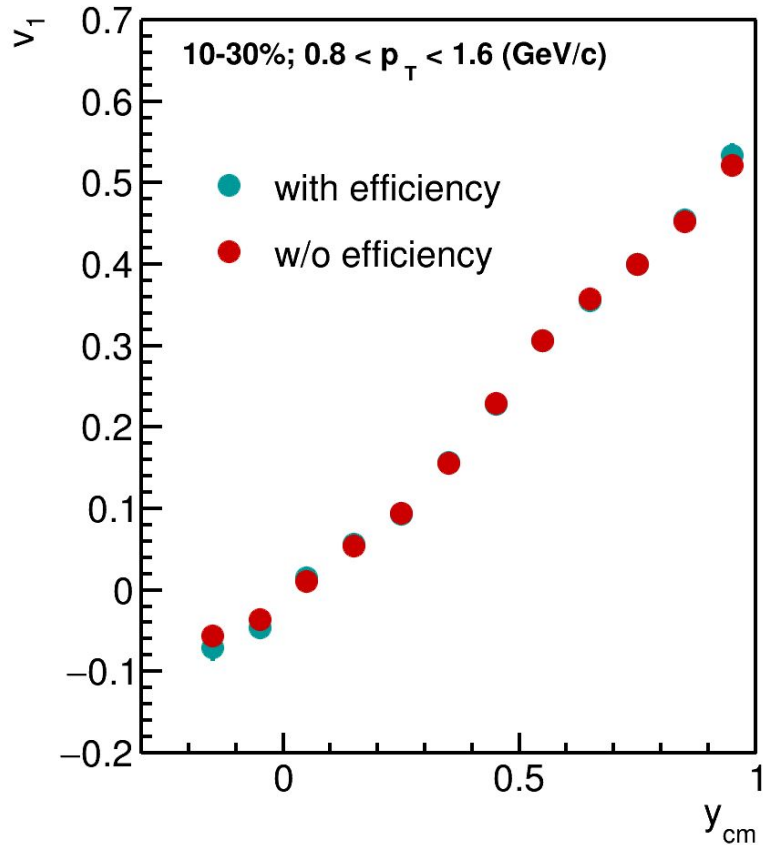
v_1 for deuterons from the TOF400 and TOF700



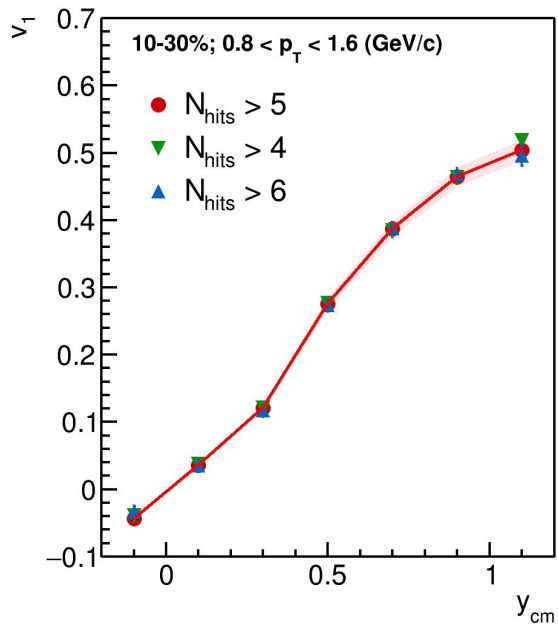
v_1 for deuterons identified separately with TOF400 and TOF700 are in a good agreement



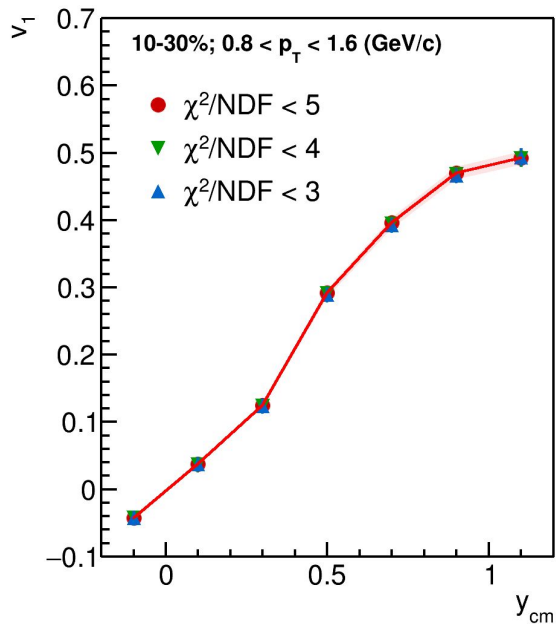
v_1 : effect of applying efficiency correction



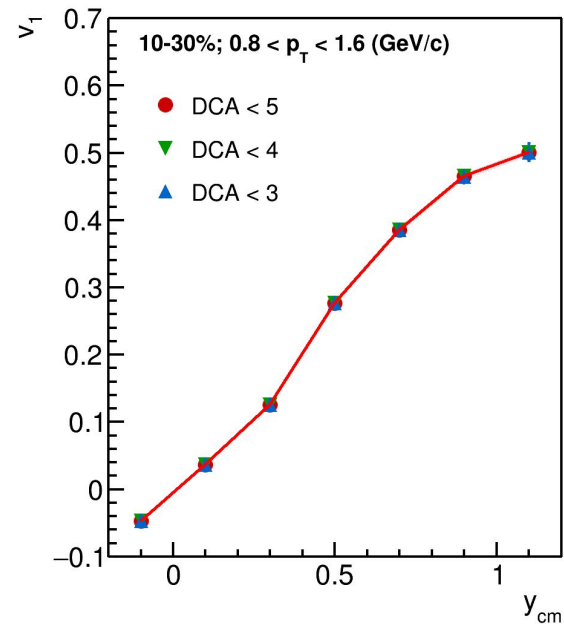
Systematics due to tracking and secondary particles



systematics is below 3%

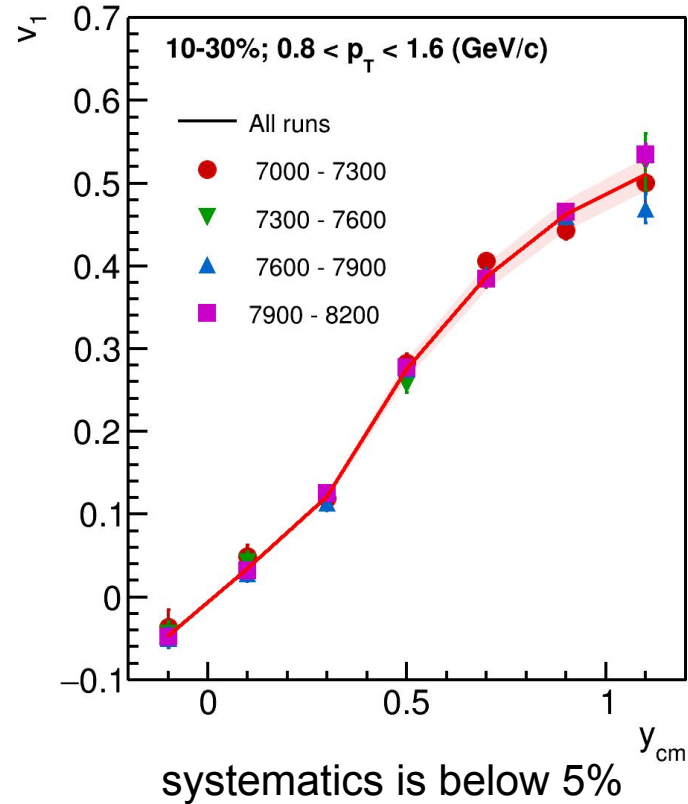


systematics is below 2%

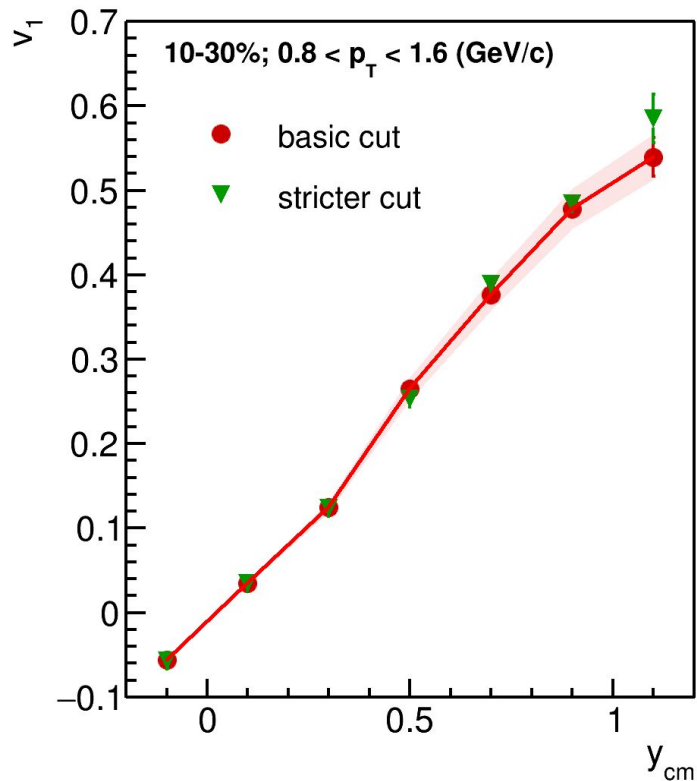


systematics is below 1%

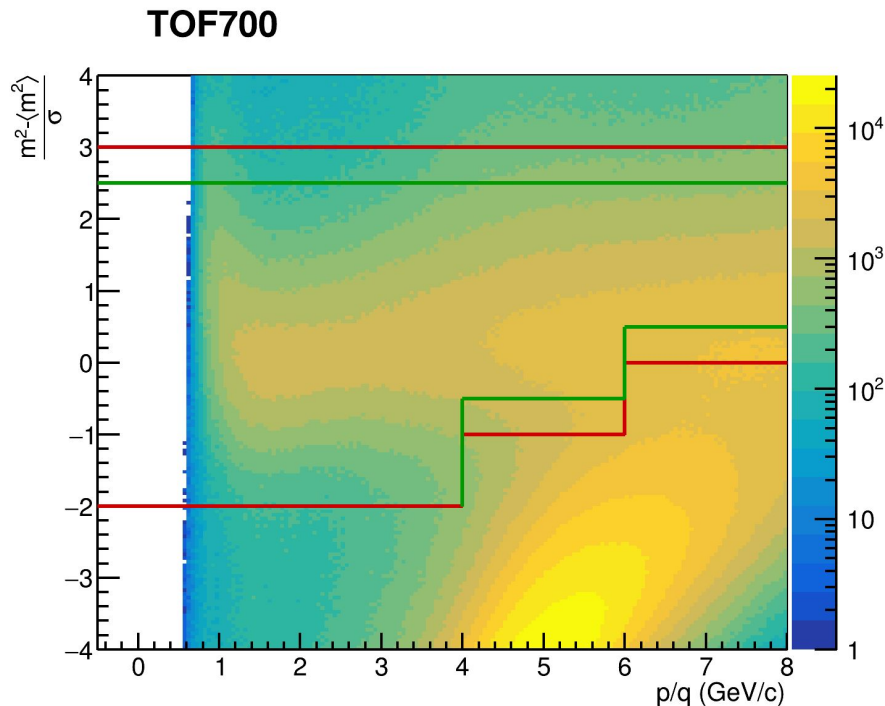
Systematics due to run-by-run variations



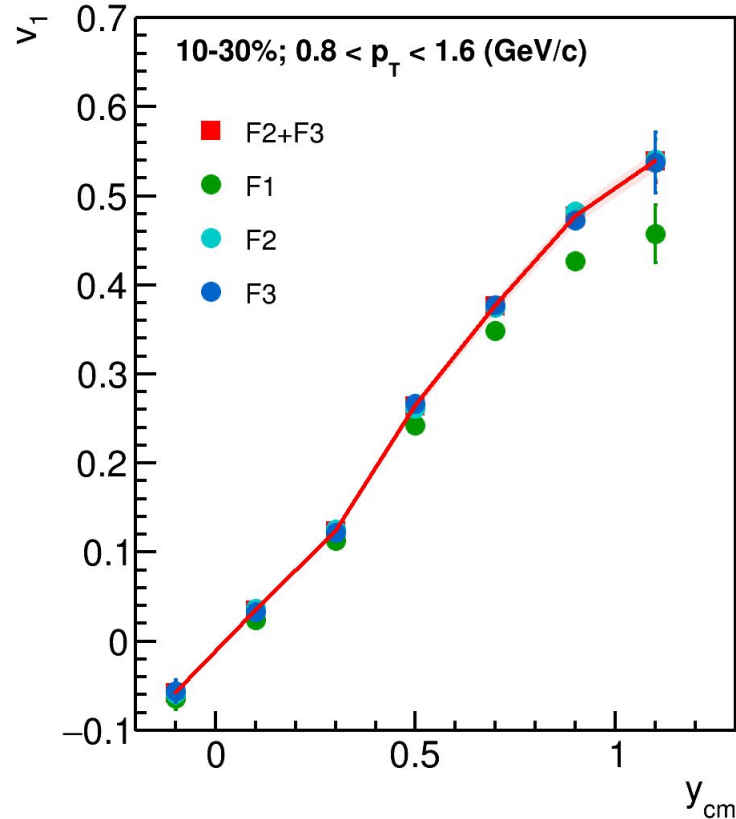
Systematics due to contamination from other particle species



systematics is below 5%



Systematics due to symmetry plane estimation (non-flow)

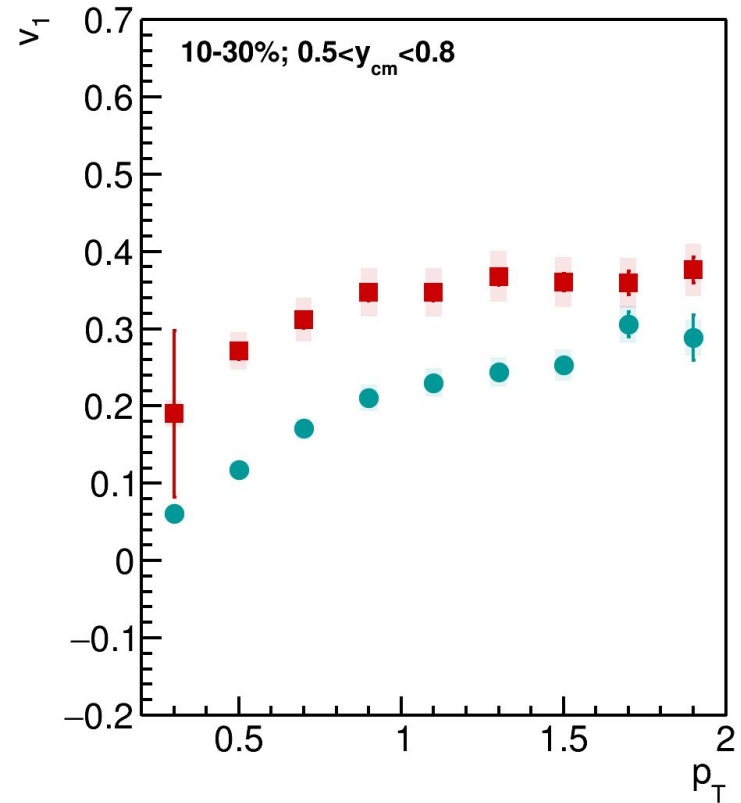
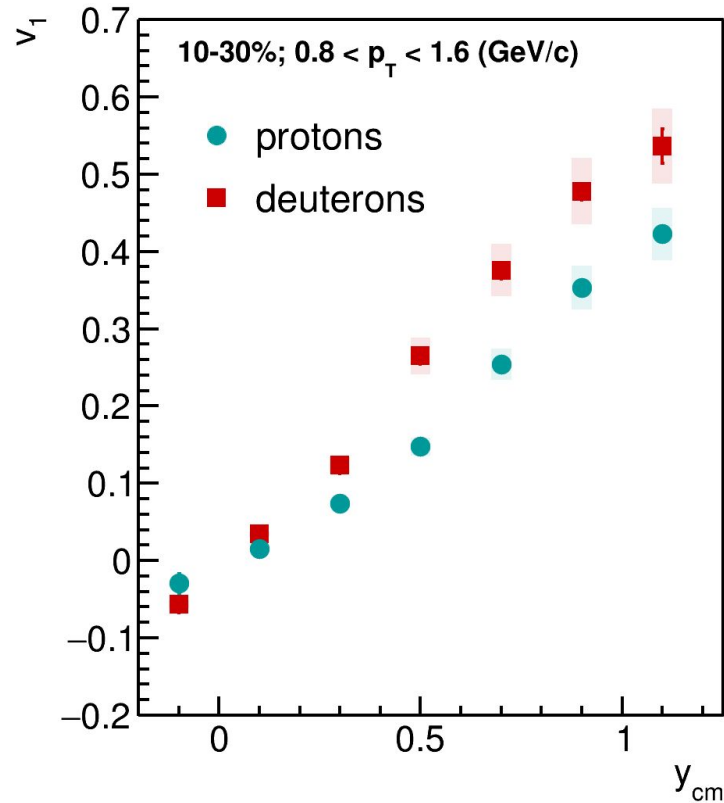


The systematics for combined (F2+F3) planes is below 2%

Total systematics estimation

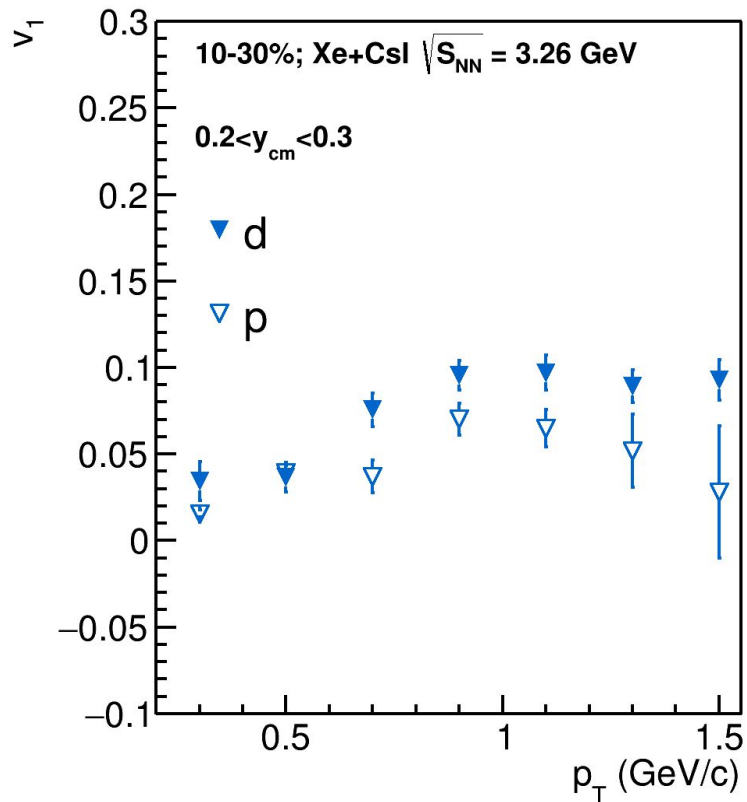
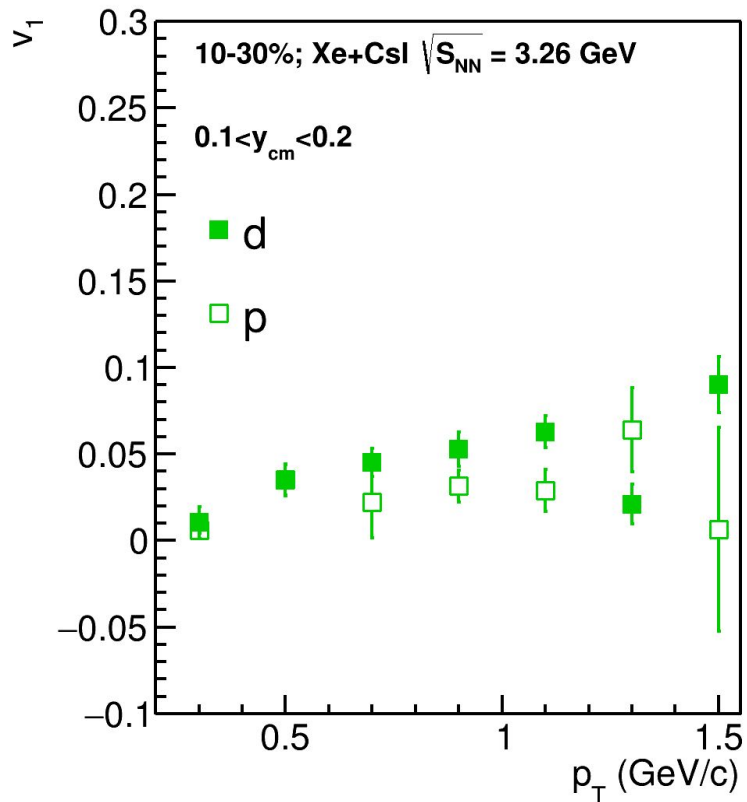
N_{hits}	Chi2/N DF	DCA	Vtx	runId	centrality	non-flow	Identification	total
3%	2%	1%	3%	4%	5%	2%	5%	9%

v_1 of protons and deuterons as a function of y and p_T

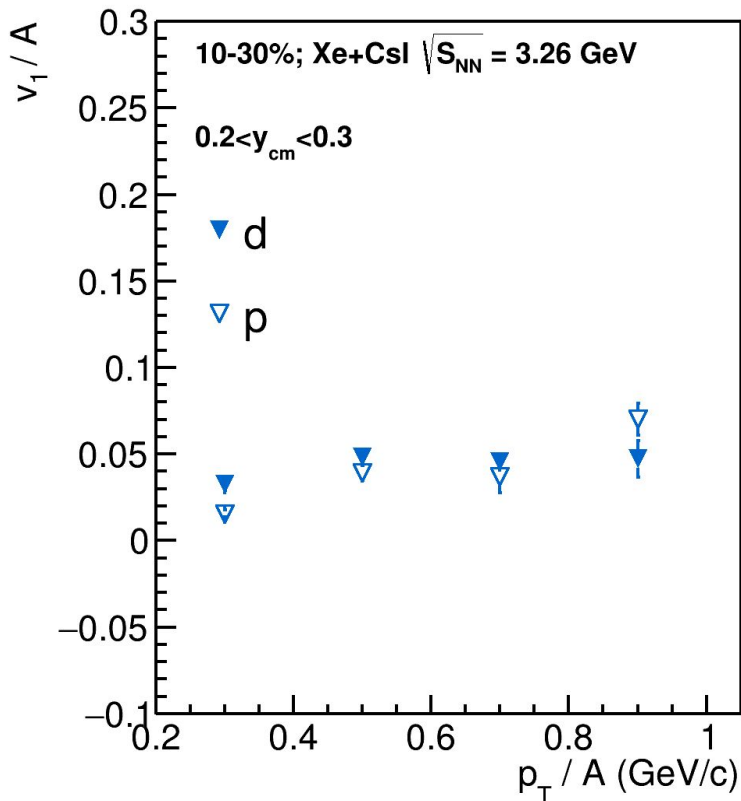
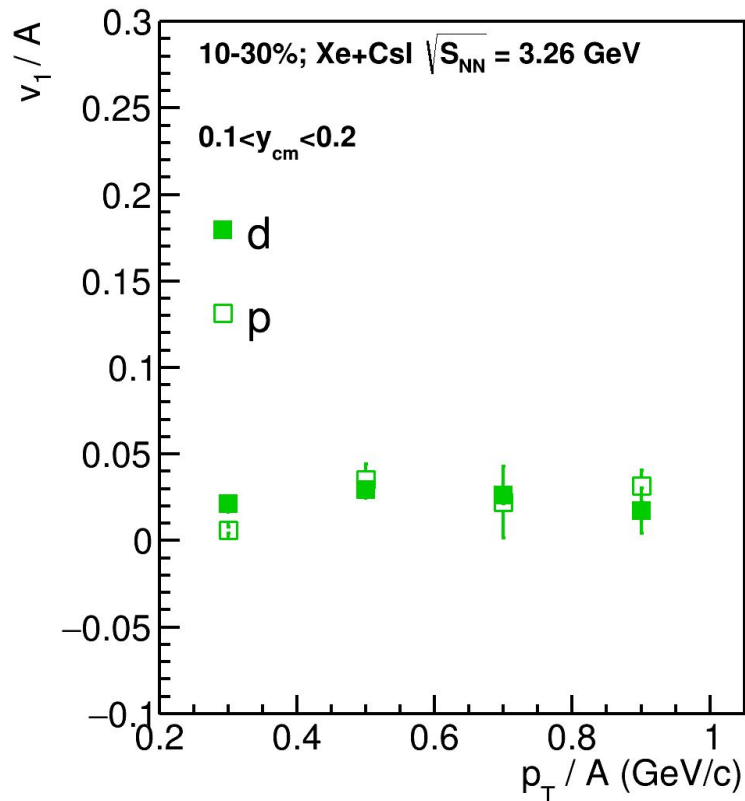


v_1 of deuterons is larger than v_1 of protons as expected.

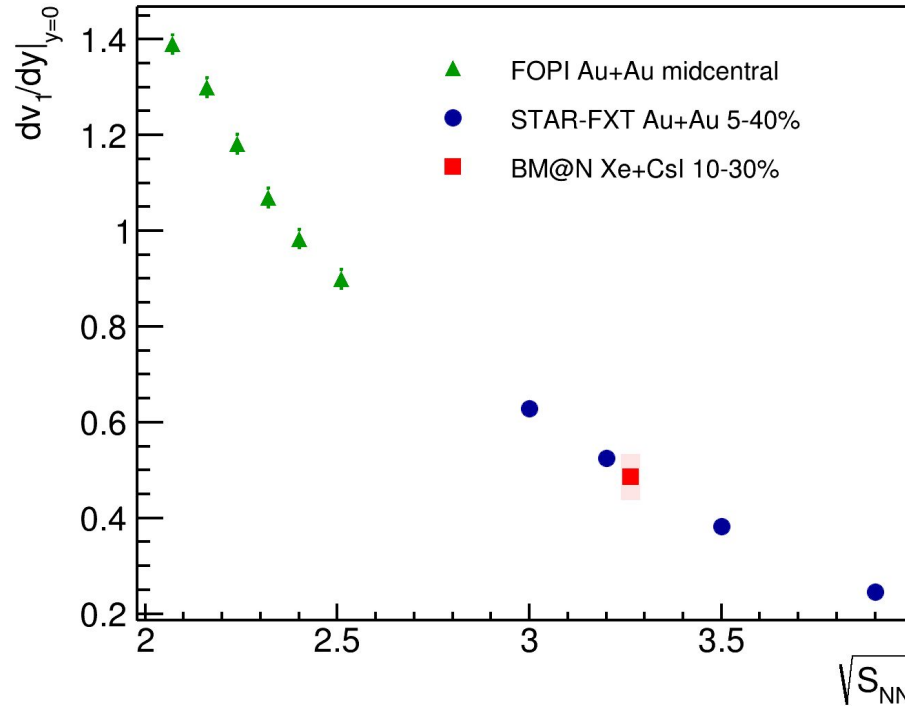
v_1 of protons and deuterons as a function of p_T



Scaled v_1 of protons and deuterons as a function of scaled p_T/A



The slope of v_1 of deuterons at midrapidity as a function of collision energy



Directed flow slope of deuterons at midrapidity dv_1/dy is found to be in a good agreement with existing world data.

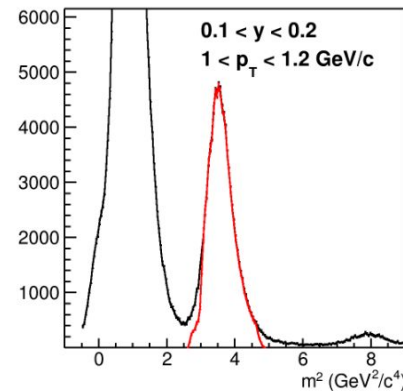
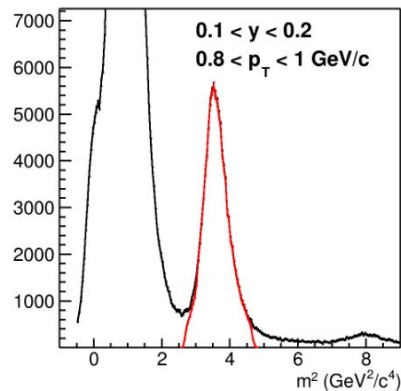
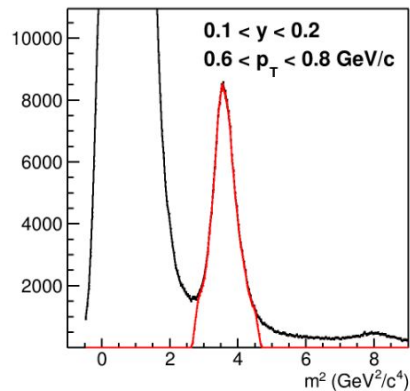
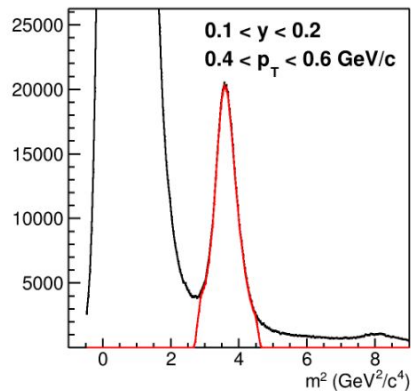
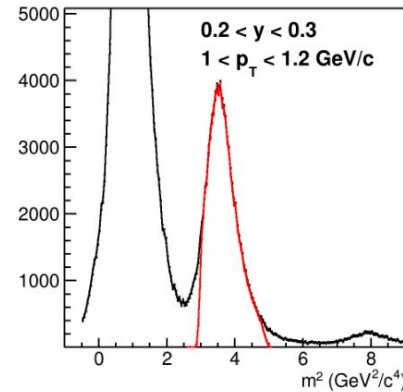
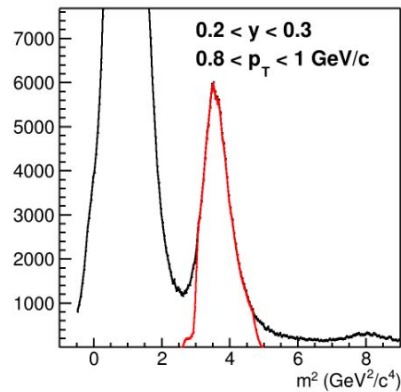
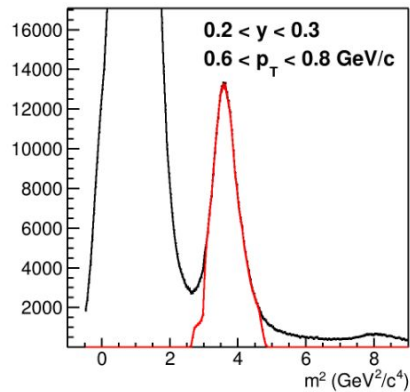
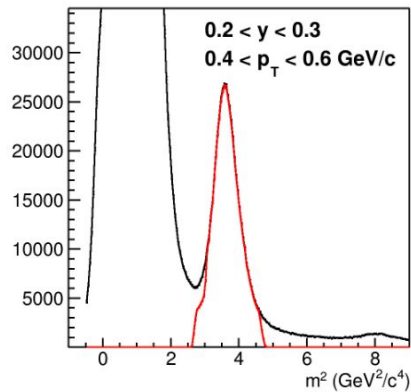
The slope of v_1 of deuterons at midrapidity $dv_1/dy_{cm}|_{y_{cm}=0}$ as a function of collision energy.

Summary

- v_1 of deuterons was measured differentially as a function of transverse momentum, rapidity and centrality
- The systematic uncertainty due to track quality, secondaries contamination, contamination from different particle species and run-by-run variations were estimated. The total systematic uncertainty was found to be below 9%
- The directed flow v_1 of protons and deuterons was studied for mass-number scaling. v_1 for protons and deuterons follow the scaling
- The directed flow slope at midrapidity $dv_1/dy|_{y=0}$ was extracted. Value for $dv_1/dy|_{y=0}$ is found to be in agreement with the world data

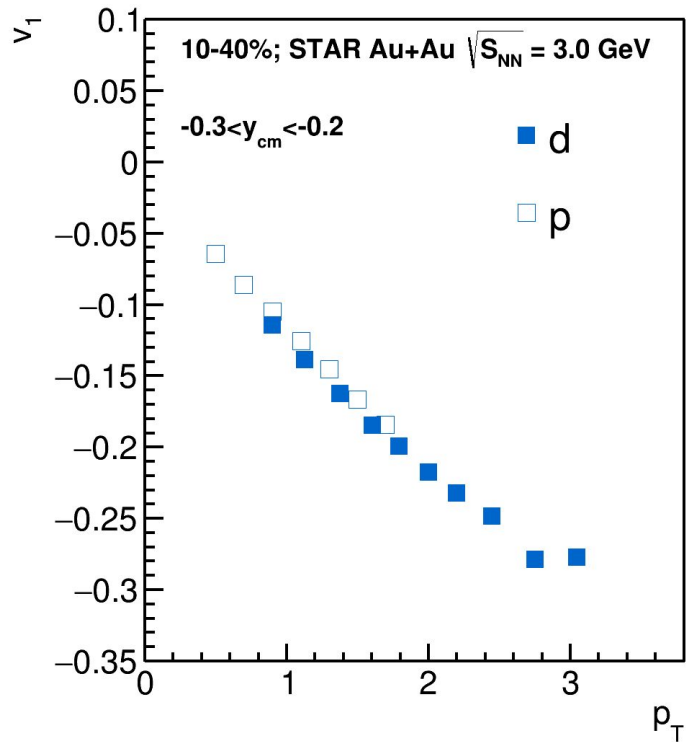
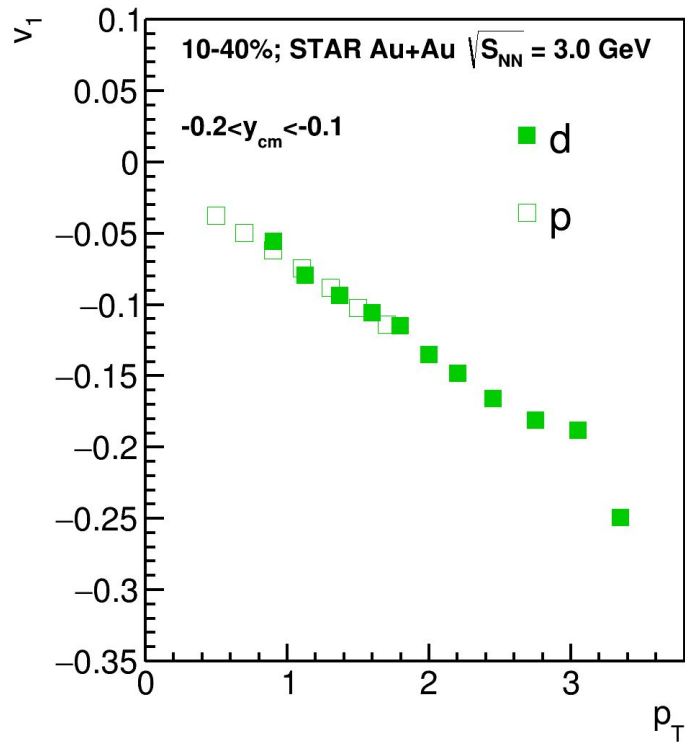
Backup

Particle Identification

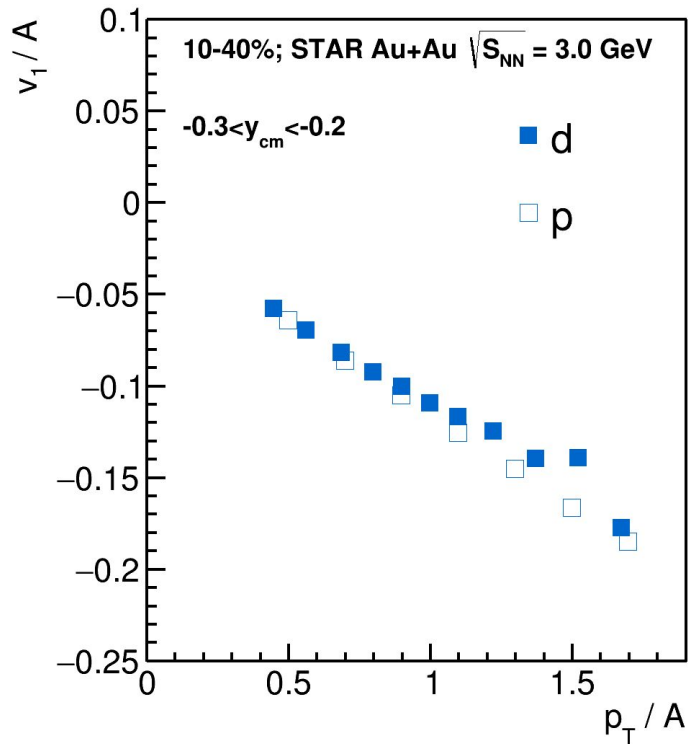
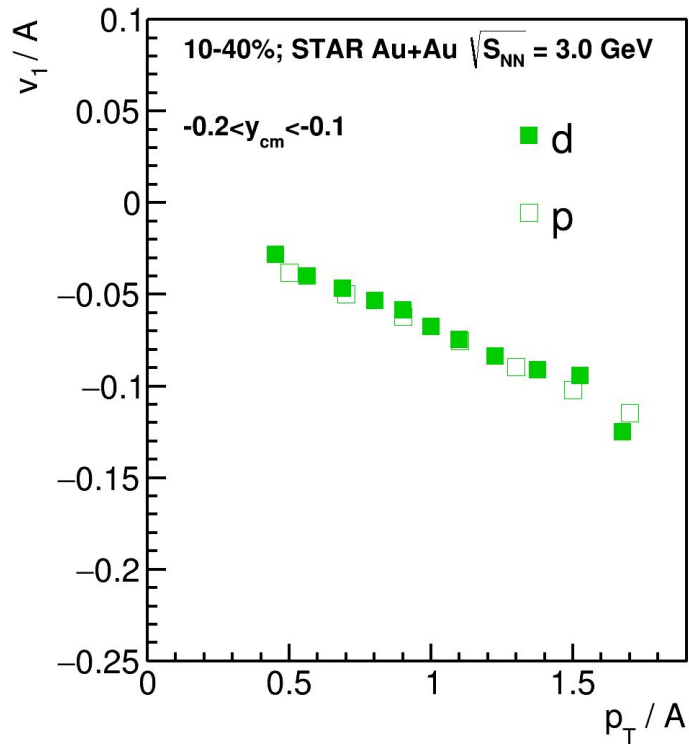


m^2 particle distribution in p_T and y bins in the TOF700

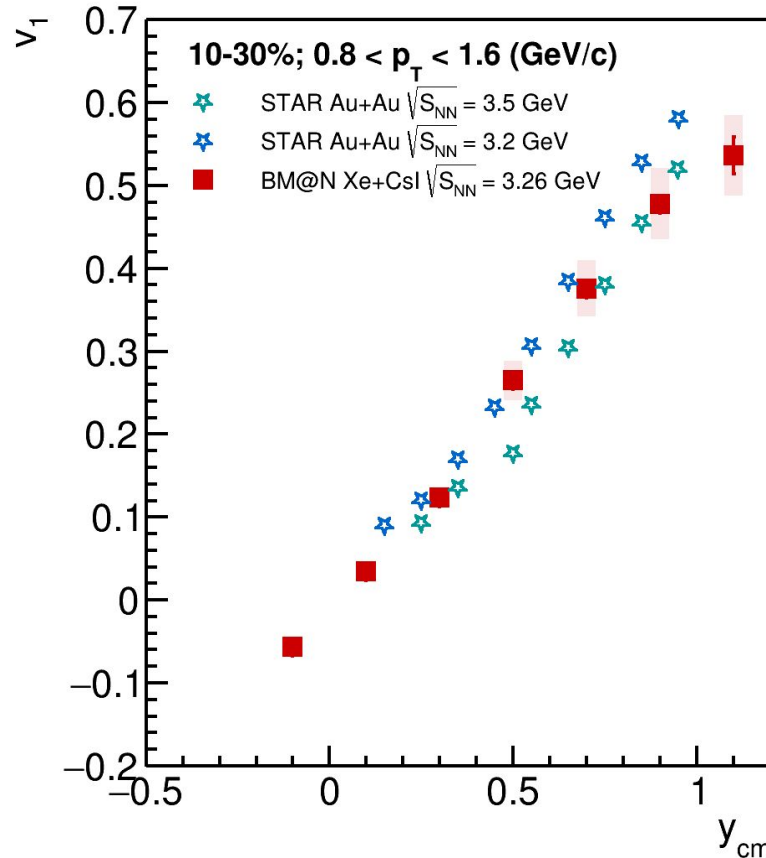
STAR data: v_1 of protons and deuterons as a function of p_T



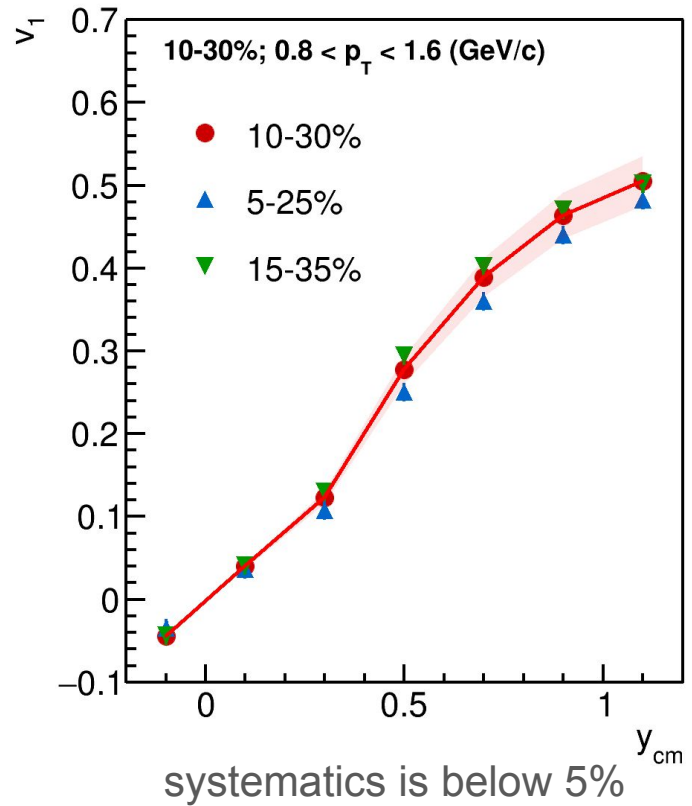
STAR data: scaled v_1/A of protons and deuterons as a function of scaled p_T/A



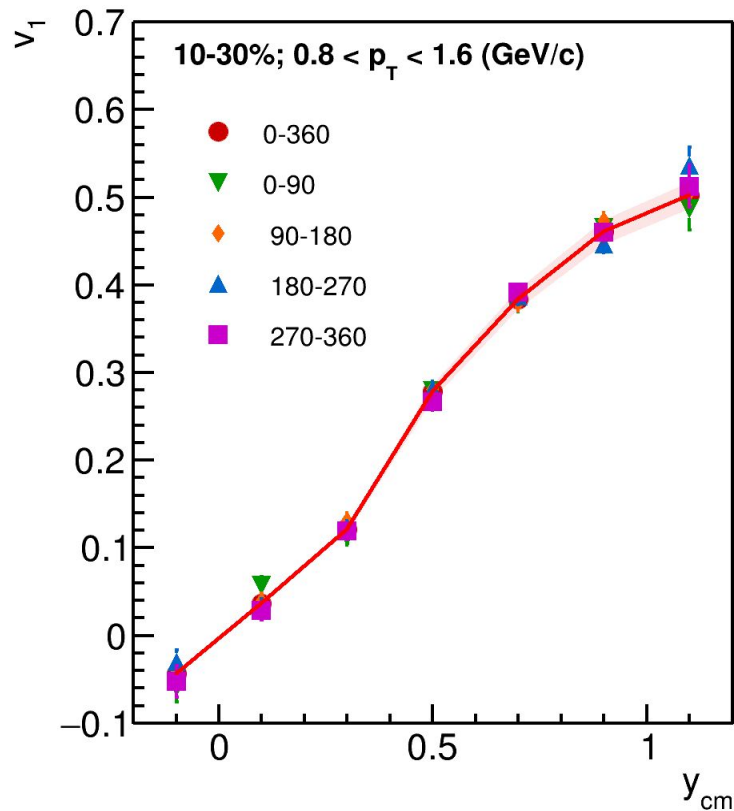
v_1 of protons and deuterons as a function of y and p_T



centrality 10-30% - for the BM@N data
centrality 5-40% - for STAR



Systematics due to vertex position



systematics is below 3%

