Energy and Isospin Dependence of Elliptic Flow - An Alternative Analysis of the LAND-FOPI Data

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Outline :

- Description of the experimental setup
- Available statistics
- Data analysis (n/H)
  - pt integrated v2
  - differential squeeze-out v2(pt)
  - squeeze-out ratio
- Consistency checks, evaluation of systematic errors
- Conclusions and Prospects

Relevant variables

- Normalised transverse momentum

$$pt0 = p_{\perp,part}/p_{proj}$$

- Rapidity

$$y = 0.5 ln(\frac{1+\beta_z}{1-\beta_z})$$

- Normalised rapidity

$$y0 = y_{part}/y_{proj}$$

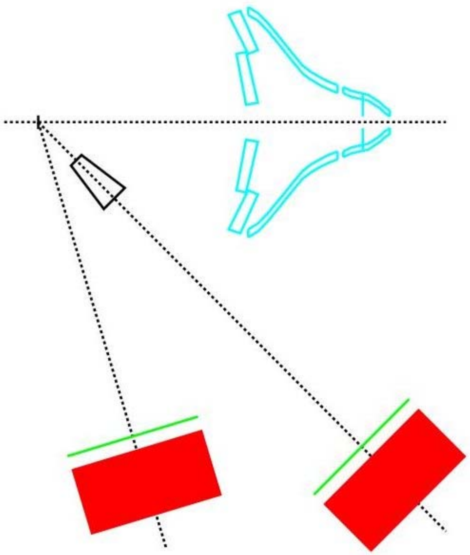
- Q - vector

$$\vec{Q} = \sum_{\nu} w_{\nu} \vec{p}_t(\nu)$$

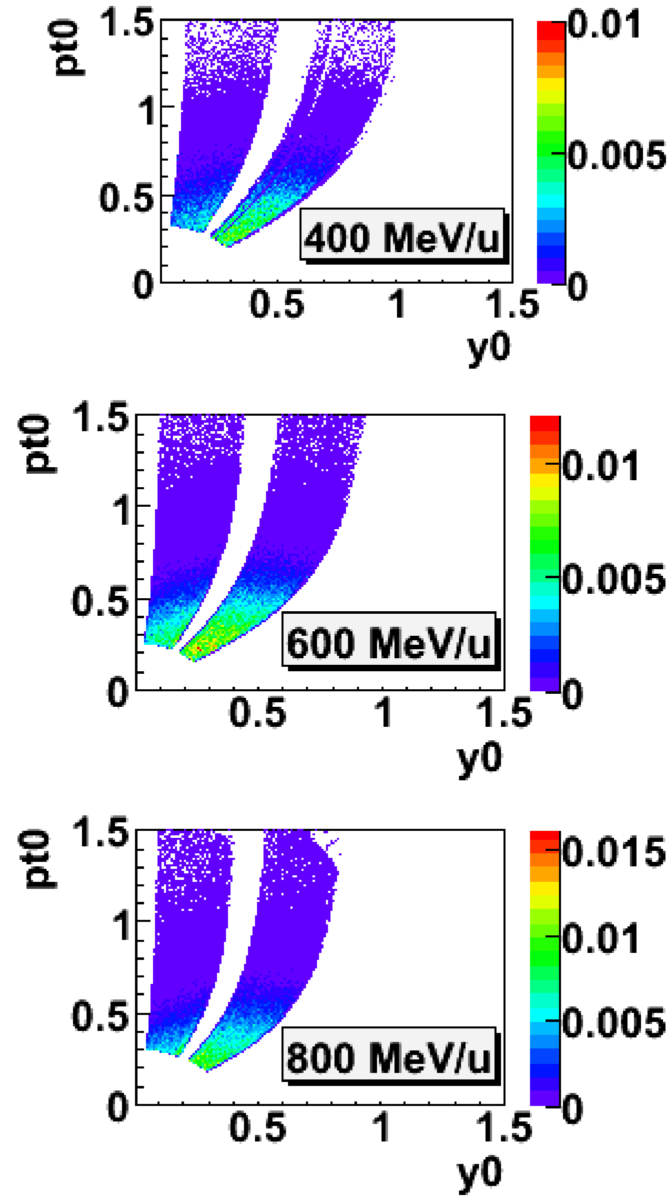
$$w_{\nu} = 1 \quad y > y_{cm}, \quad w_{\nu} = -1 \quad y < y_{cm}$$

p_{proj}/MeVc^{-1}	Y_{proj}	E/MeV
432	0.896	400
529	1.0815	600
610	1.2313	800

Description of the experimental setup



LAND:
- Velocity vectors of neutrons and light charged particles
- Mass determination from total deposited energy



PLAWA:
- Charge from ΔE-TOF
- Reaction plane determination from total transverse momentum of charged particles

LAND 1: θlab=45°±8°

PLAWA: 1°≤θlab≤30°

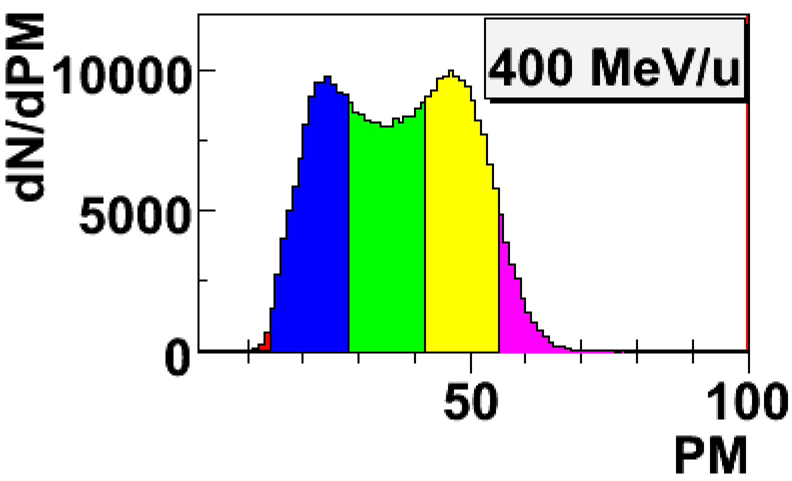
LAND 2: θlab=73°±12°

Statistics overview

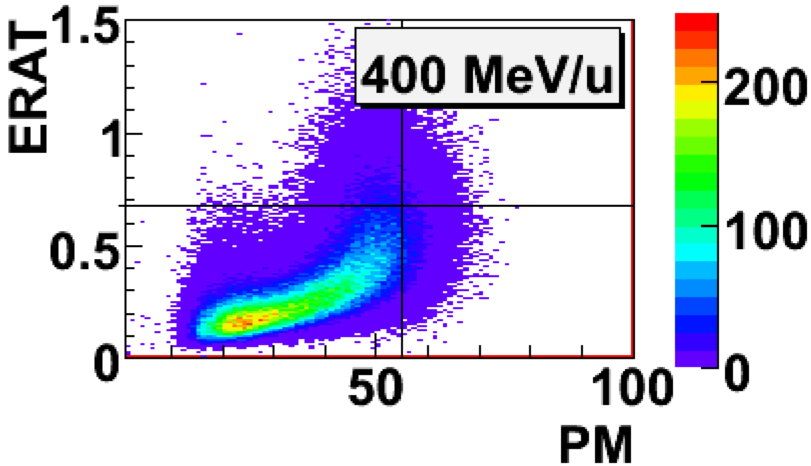
(× 10^5)

Energy		total evt.	evt. cut	particles	part. cut	n	H
400 MeV/u	no shadow bar	18.0	30 %	12.3	6.6	2.8	2.9
	shadow bar 1	2.4	26 %	0.9	0.32	0.01	0.004
	shadow bar 2	4.7	23 %	1.2	0.14	0.1	0.03
600 MeV/u	no shadow bar	23.4	40 %	28.3	18.9	8.6	8.8
	shadow bar 1	8.7	40%	7.5	0.3	0.18	0.06
	shadow bar 2	8.0	43 %	5.8	1.2	0.8	0.36
800 MeV/u	no shadow bar	13.7	38 %	17.2	9.7	4.8	4.0
	shadow bar 1	5.0	38 %	4.6	0.12	0.08	0.03
	shadow bar 2	7.4	41 %	5.6	0.98	0.62	0.3

Details of analysis procedure



- 5 PLAWA multiplicity and 5 ERAT bins



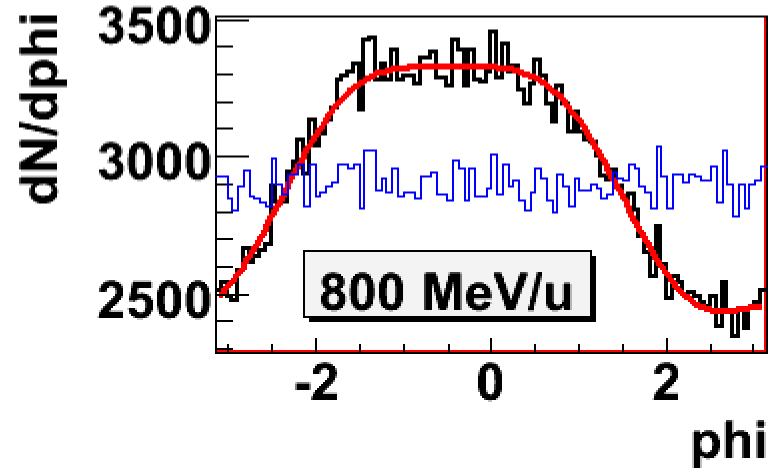
- ERAT 5: Identical cross section for last bin of both observables

$$ERAT = \frac{\sum_{part.} E_{\perp}}{\sum_{part.} E_{\parallel}}$$

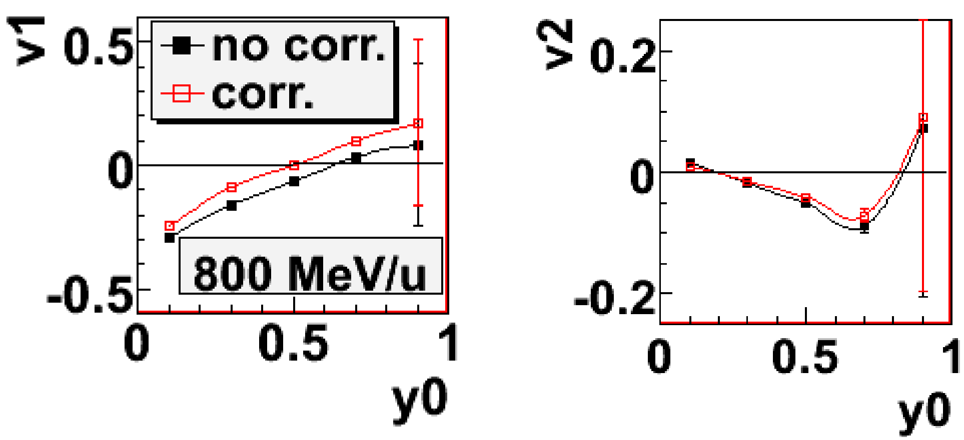
$$F(\Delta\phi) = N(1 + 2(v1cos(\Delta\phi) + v2cos(2\Delta\phi)))$$

Details of analysis procedure

- Correction on detector acceptance and efficiency included
- Substraction of normalised shadow bar run data

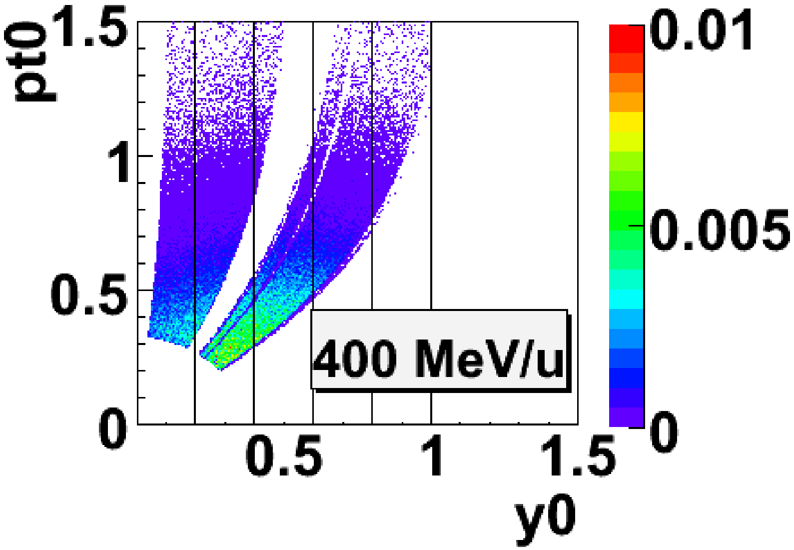


- Correction of anisotropic asymuthal distribution of reaction plane after applied trigger cuts
- Corrected weights calculated for each shadow/ non shadow bar run data

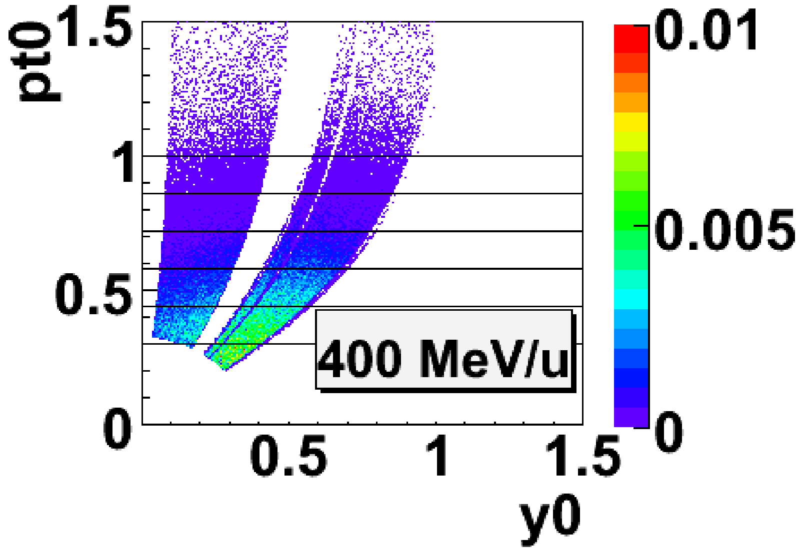


Details of analysis

pt integrated flow:



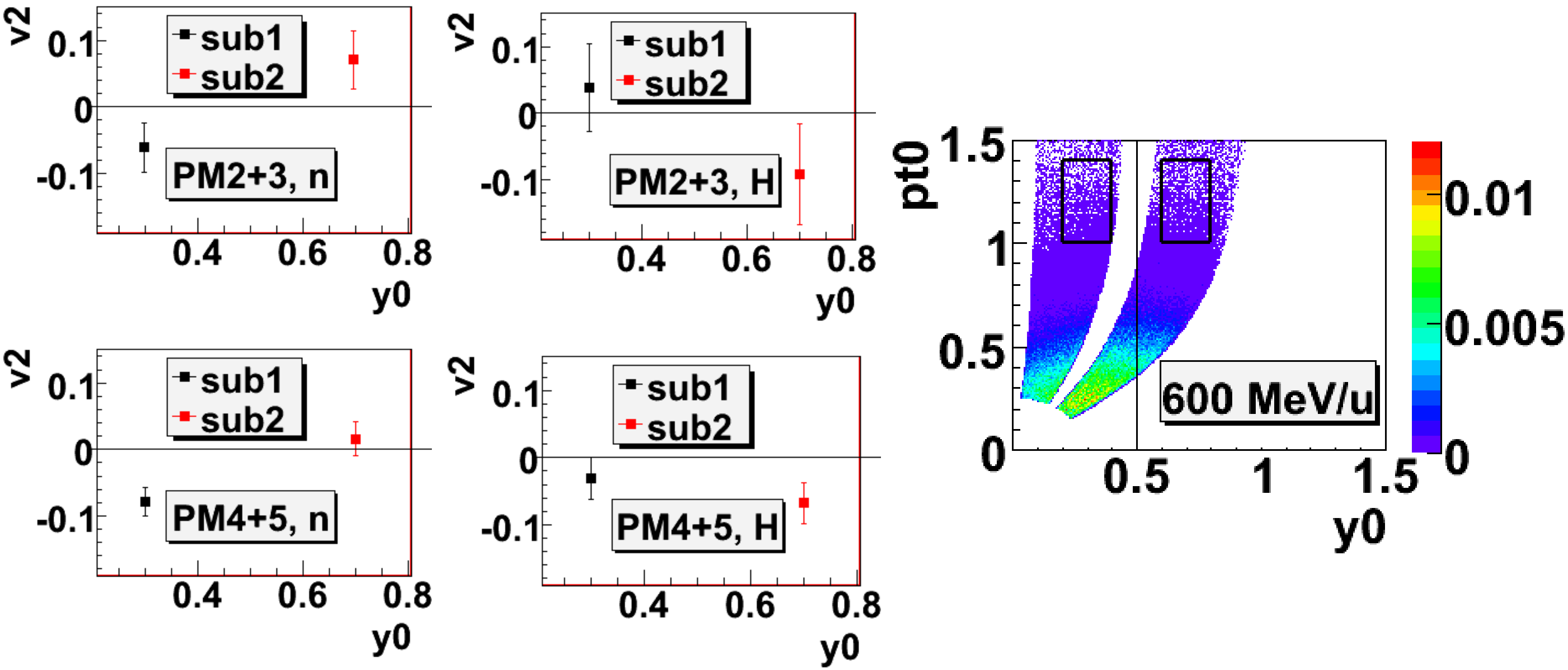
differential flow:



- 5 equidistant bins in normalised rapidity and transverse momentum

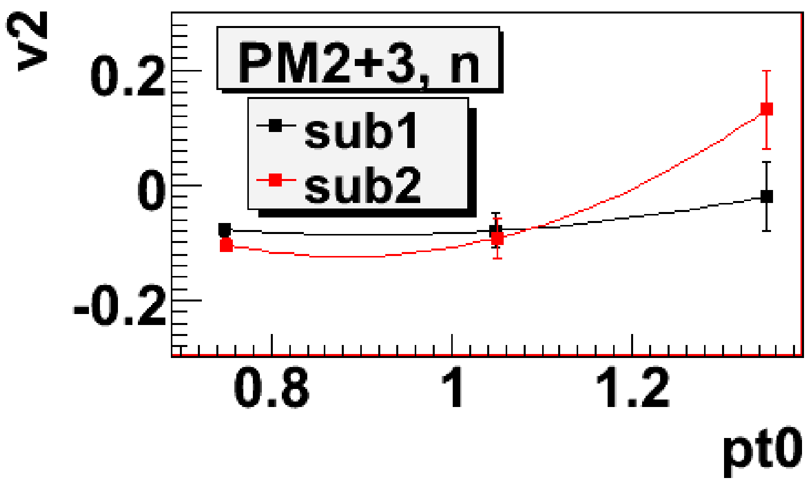
Consistency checks

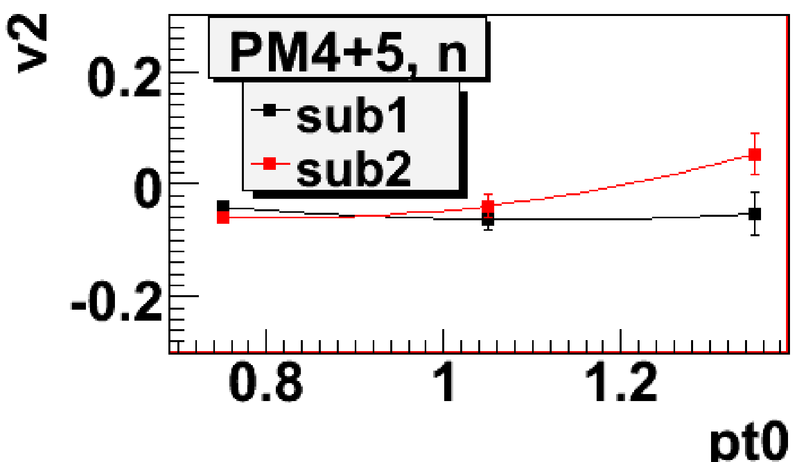
600 MeV/u

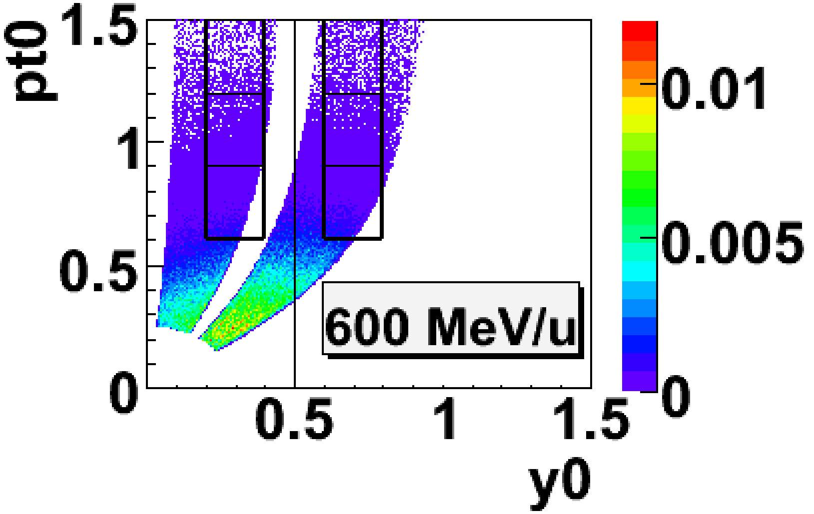


- The symmetry in v2 observable was checked for two symmetric windows in detector acceptance, for y0 and pt0-dependence (in the next slide!)

Consistency checks

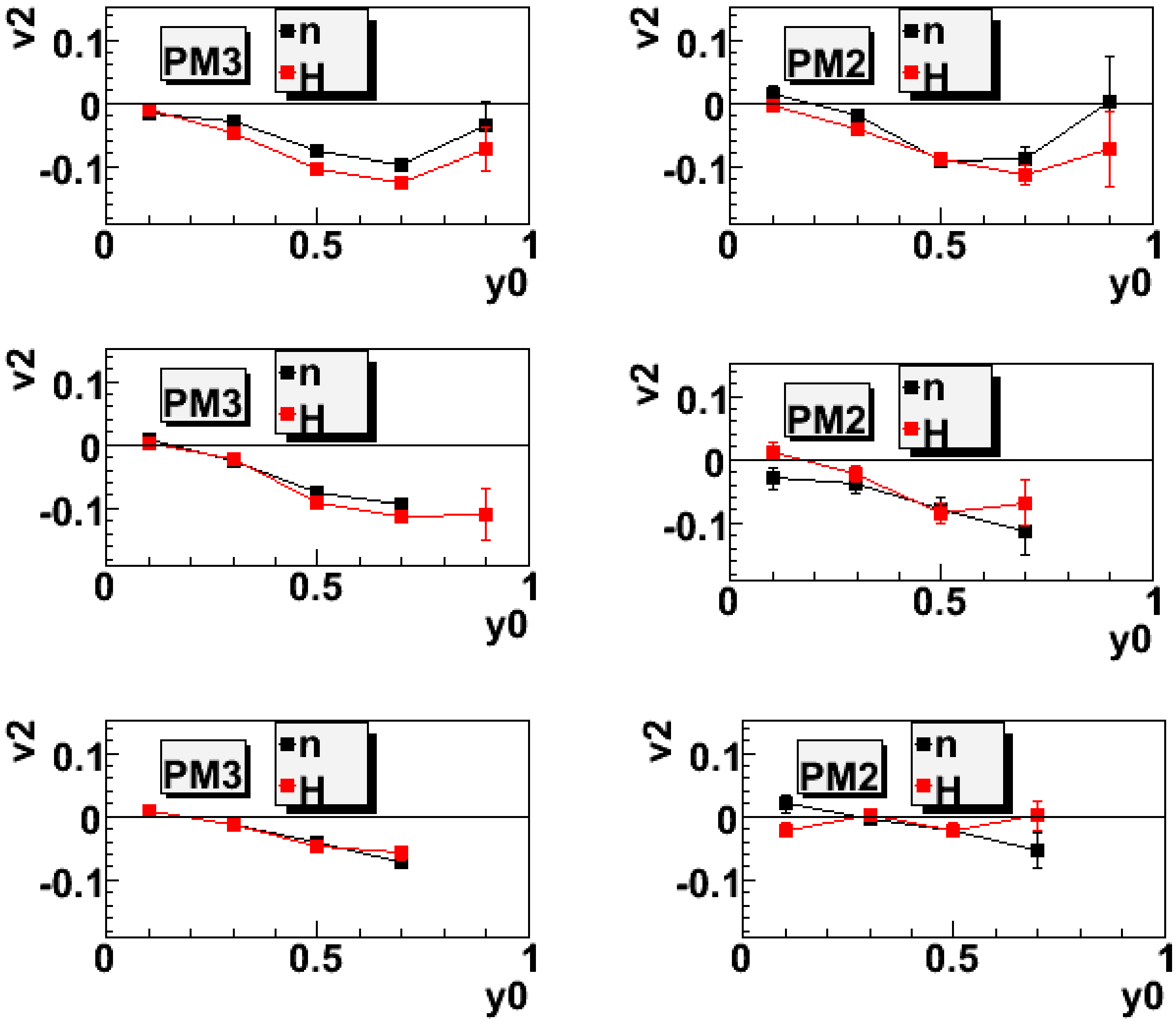






E = 600 MeV/u

pt integrated v2: a comparison between n and H

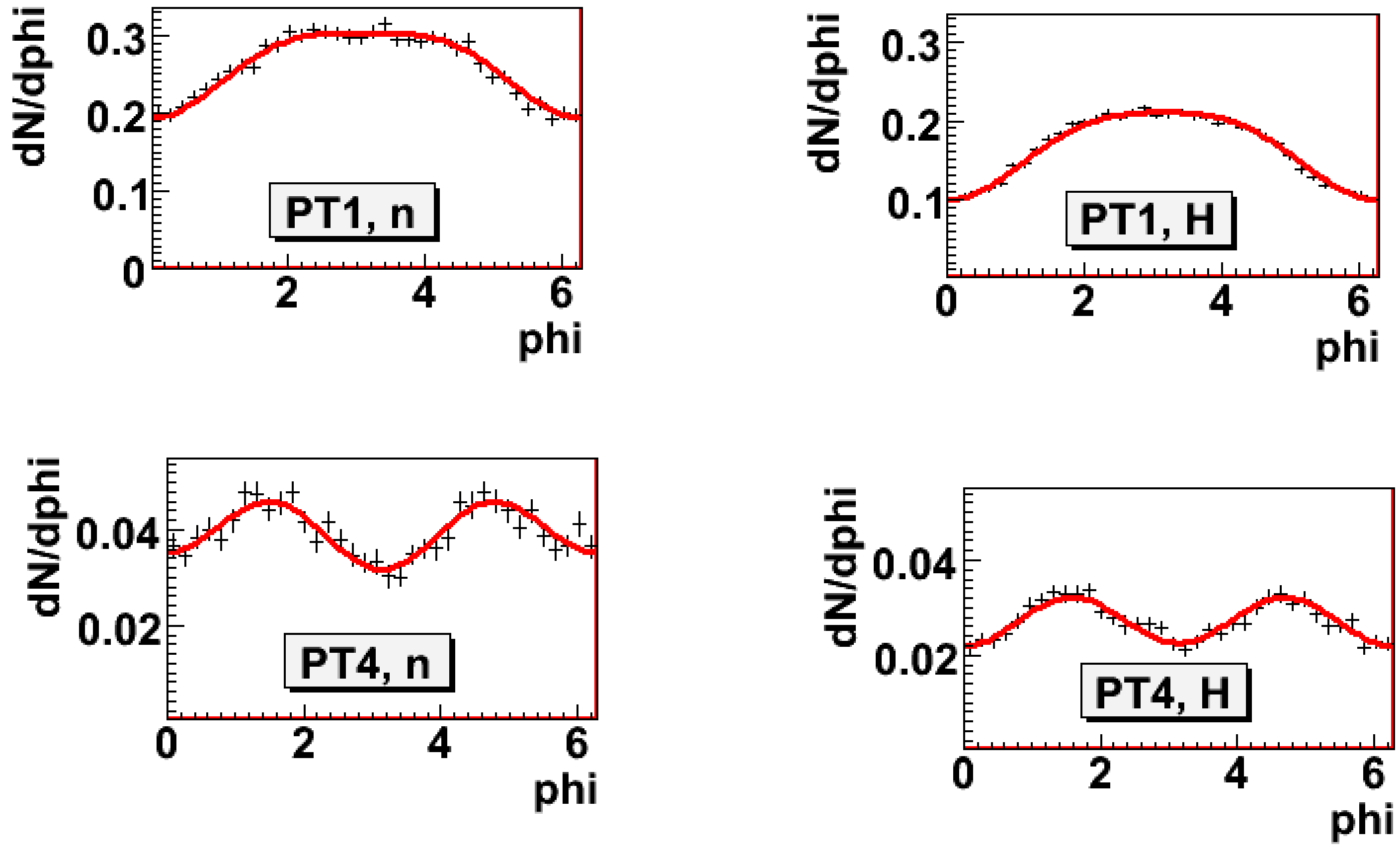


400 MeV/u

600 MeV/u

800 MeV/u

Azimuthal distributions for PT bins



E = 400 MeV/u, central events (PM3+PM4+PM5)

$$F(\Delta\phi) = N(1 + 2(v1cos(\Delta\phi) + v2cos(2\Delta\phi)))$$

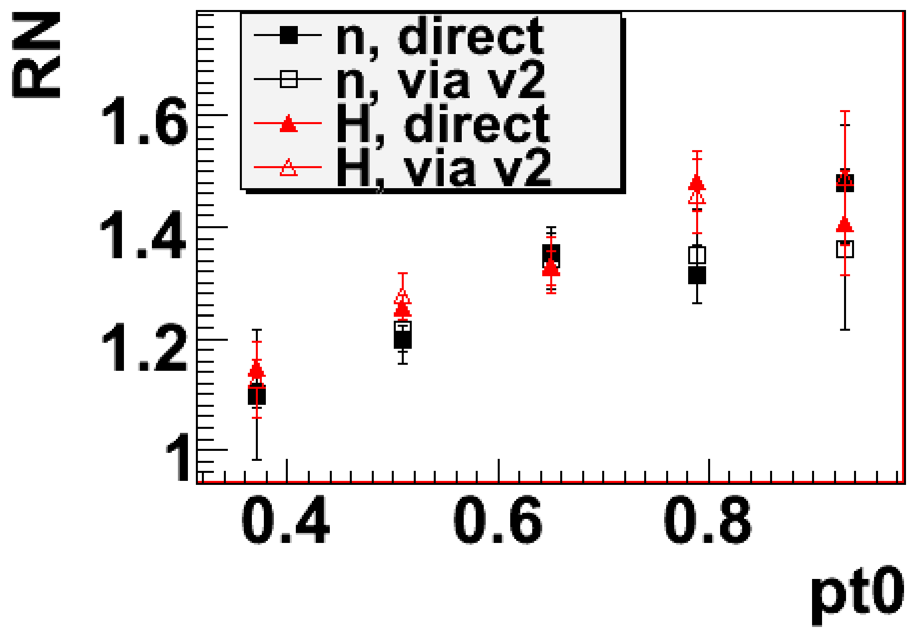
Squeeze-out ratio definition

Two alternative definitions of squeeze-out ratio

$$R_N = \frac{N(90^o) + N(270^o)}{N(0^o) + N(180^o)} \qquad\qquad R_N = \frac{1 - 2v_2}{1 + 2v_2}$$

- Squeeze-out ratio observable chosen because it exibits stable trend in pt0-dependence
- Number of particles corresponding to the particular angle integrated within the finite range
- The integration range was varied to test the stability of result

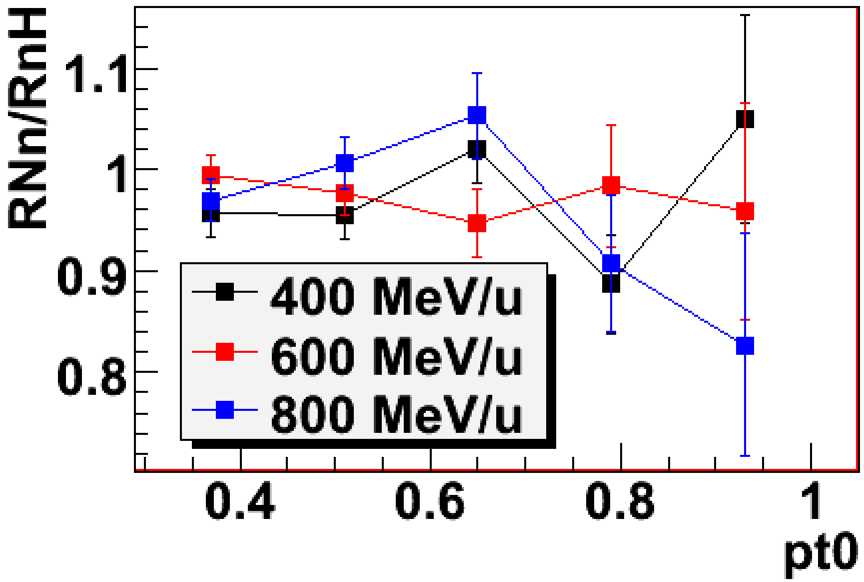
Comparison between the two methods



- Integration range chosen to be ±10 ° for 400 and 600 MeV/u, and ± 6.7 ° for 800 MeV/u, yielding the best agreement between two methods

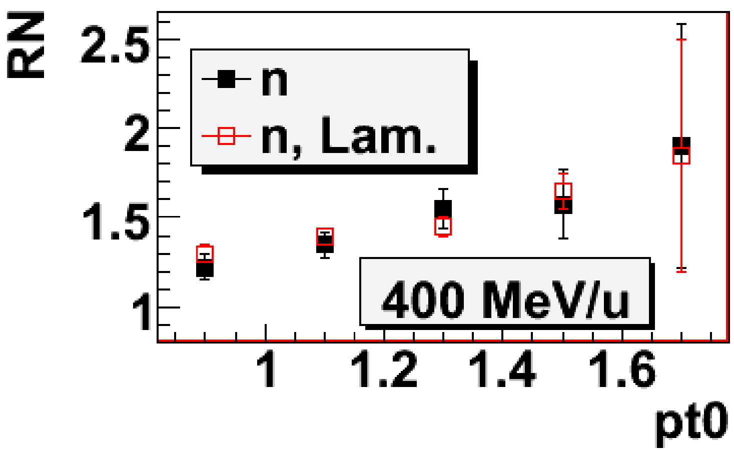
- A comparison between two methods of obtaining R_N shows satisfactorly agreement. The results are shown for 400 MeV/u

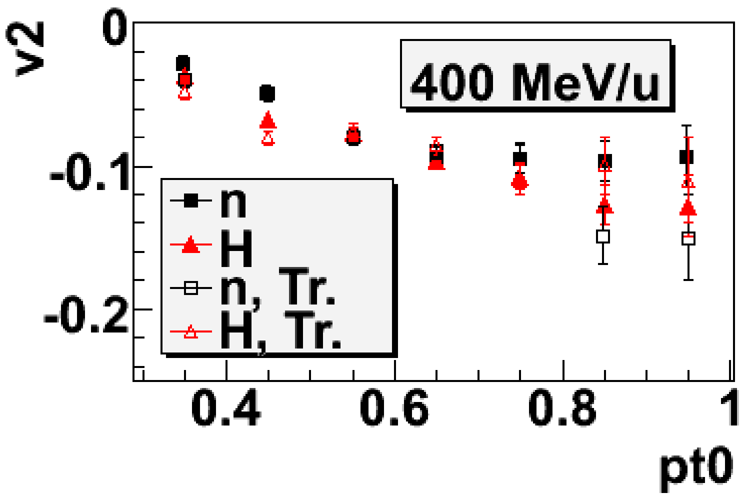
Energy and isospin dependence of differential squeeze-out ratio



- Ratio of squeeze-out ratios is more stable with change of an integration range than the squeeze-out ratio itself
- High energy data more stable with the change of integration range

Comparison to the previous analyses





- A comparison to D.Lambrecht paper Z. Phys. A 350 (1994) on momentum dependence shows satisfactorly agreement

- The results of W.Trautmann analysis arXiv: 0907.2822 confirmed (at 400 MeV/u)

Conclusions

- Present analysis comfirms previous results on differential elliptic flow
- A shift in v1-y0 dependence becomes smaller after applied correction on reaction plane asymuth distribution
- The squeeze-out ratio could show isospin sensitivity of elliptic flow

Future prospects

- UrQMD simulations on squeeze out ratio depencies as function of beam energy
- Extension of present analysis to protons
- Detailed calculation of reaction plane resolution

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Thank you for your attention!