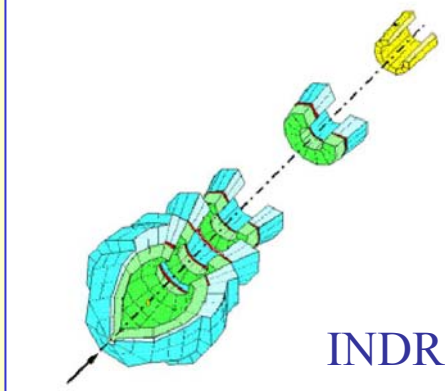
Collective flow
at intermediate energies



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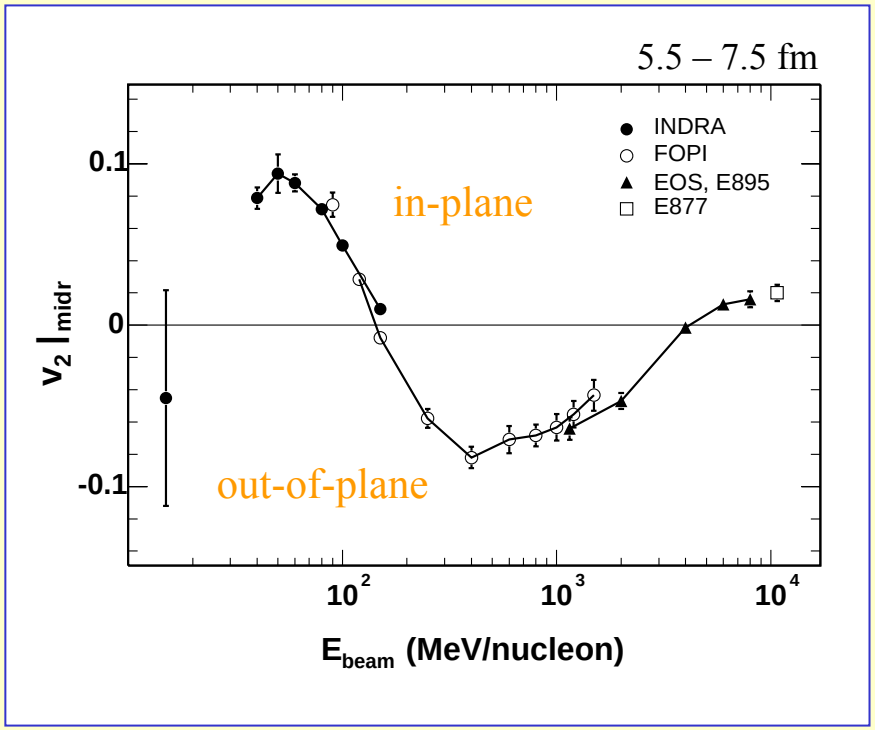
INDRA@GSI: Au+Au @ 40-150, ^{124,129}Xe+^{112,124}Sn @ 100, 150 AMeV

Excitation functions of flow

new technique of correcting:
J. Łukasik and W.T., Proc. IWM2005
A. Andronic et al.,
Eur. Phys. J. A 30, 31 (2006)

elliptic flow v_2

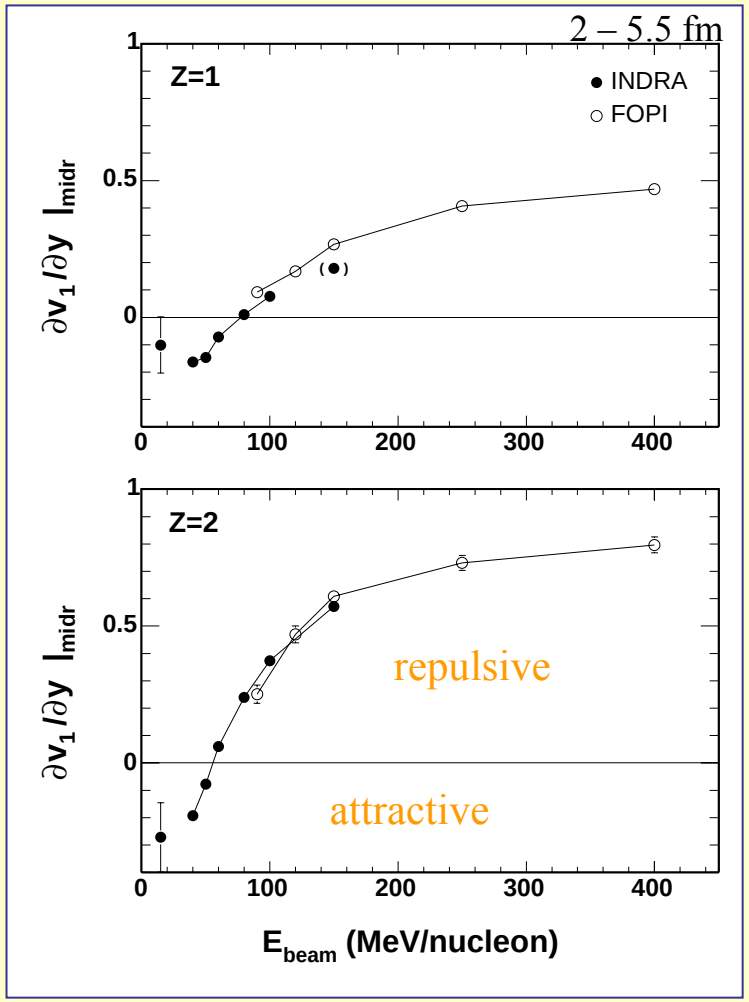


$$v_1 \equiv \langle \cos(\phi - \phi_R) \rangle \quad \text{directed flow}$$

$$v_2 \equiv \langle \cos 2(\phi - \phi_R) \rangle \quad \text{elliptic flow}$$

^{197}Au + ^{197}Au, data from INDRA, FOPI, and AGS experiments

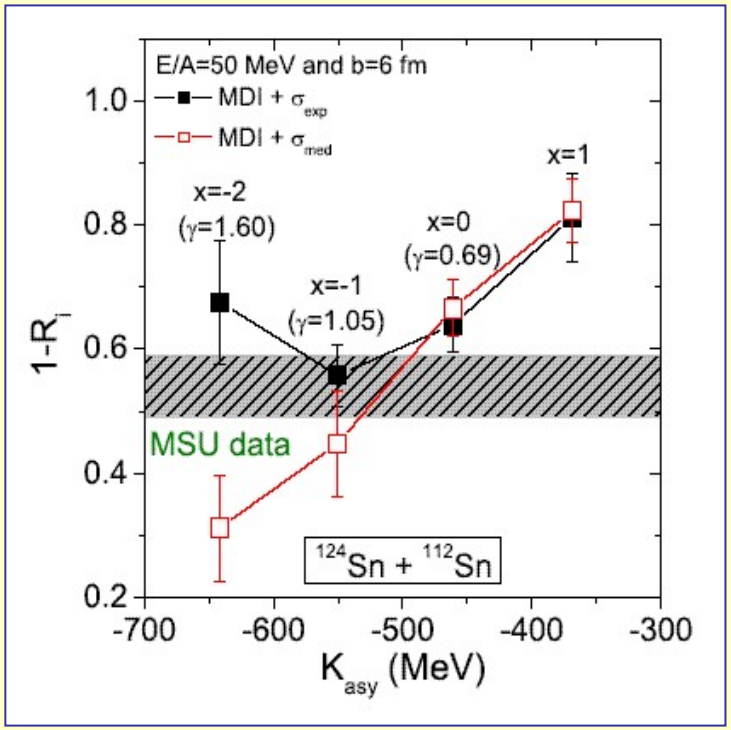
sidewards flow dv_1/dy

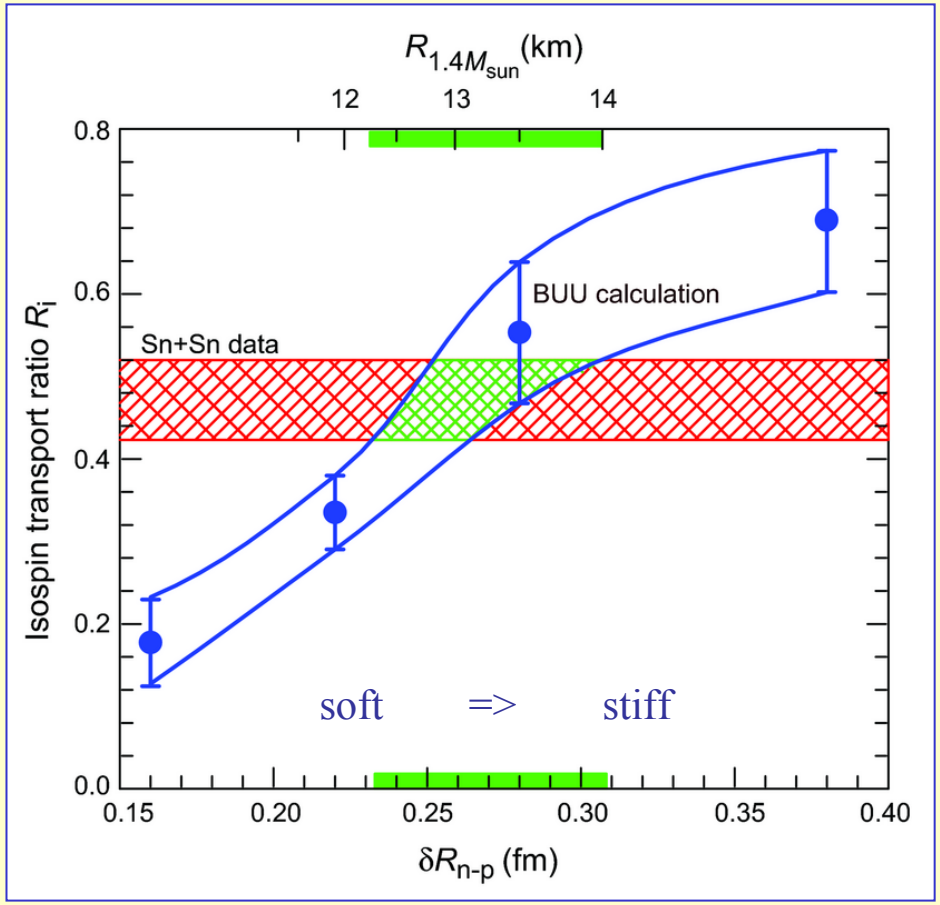


Isospin diffusion

from ISF White Paper (MSU)

stiff <= soft





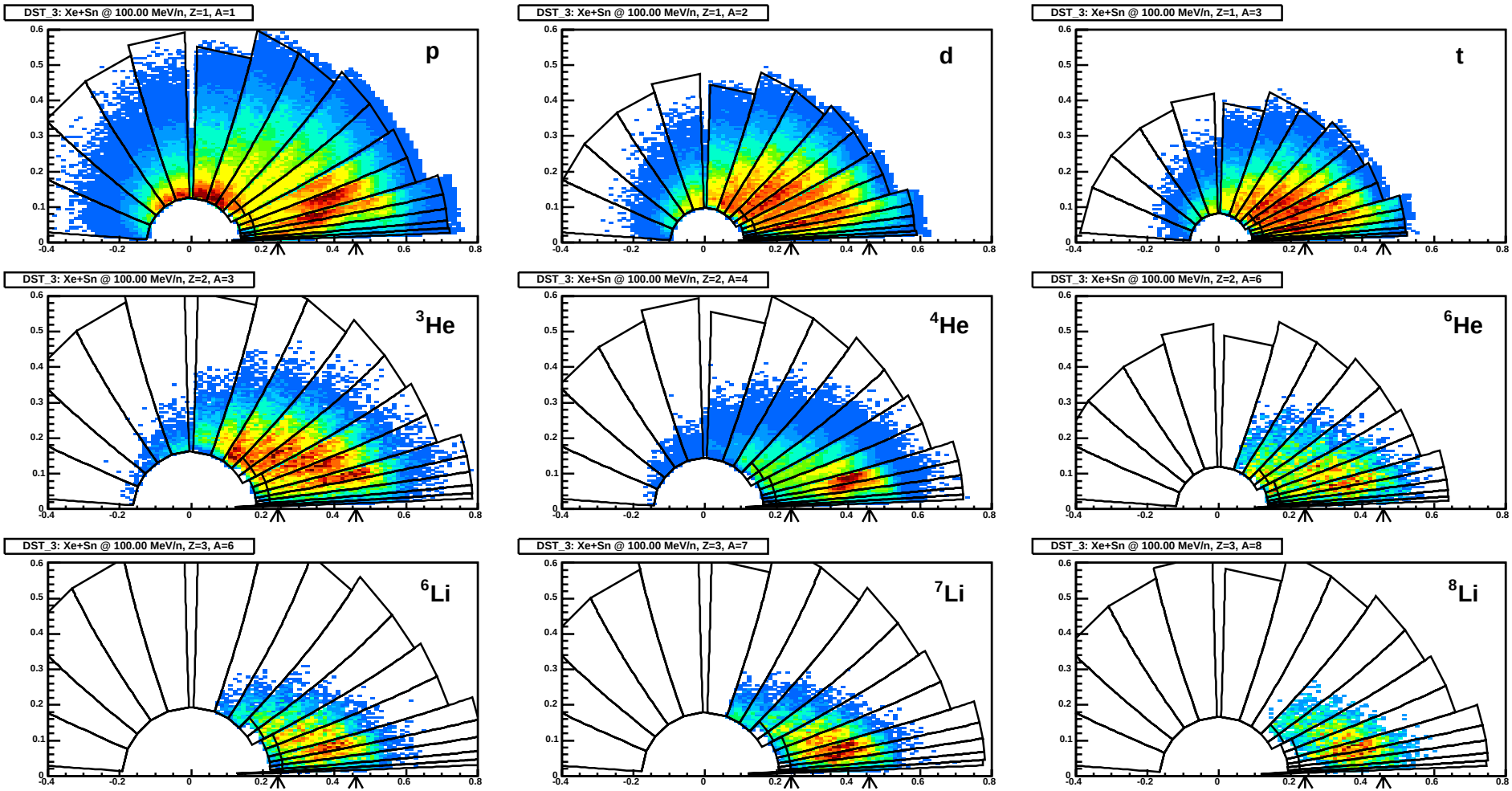
^{112,124}Sn + ^{112,124}Sn isotopic cross bombardment at 50 A MeV

data: Tsang et al., PRL 92, 062701 (2004)

analysis: Chen, Ko, Li, Yong et al., arXiv:0704.2340v1[nucl-th]

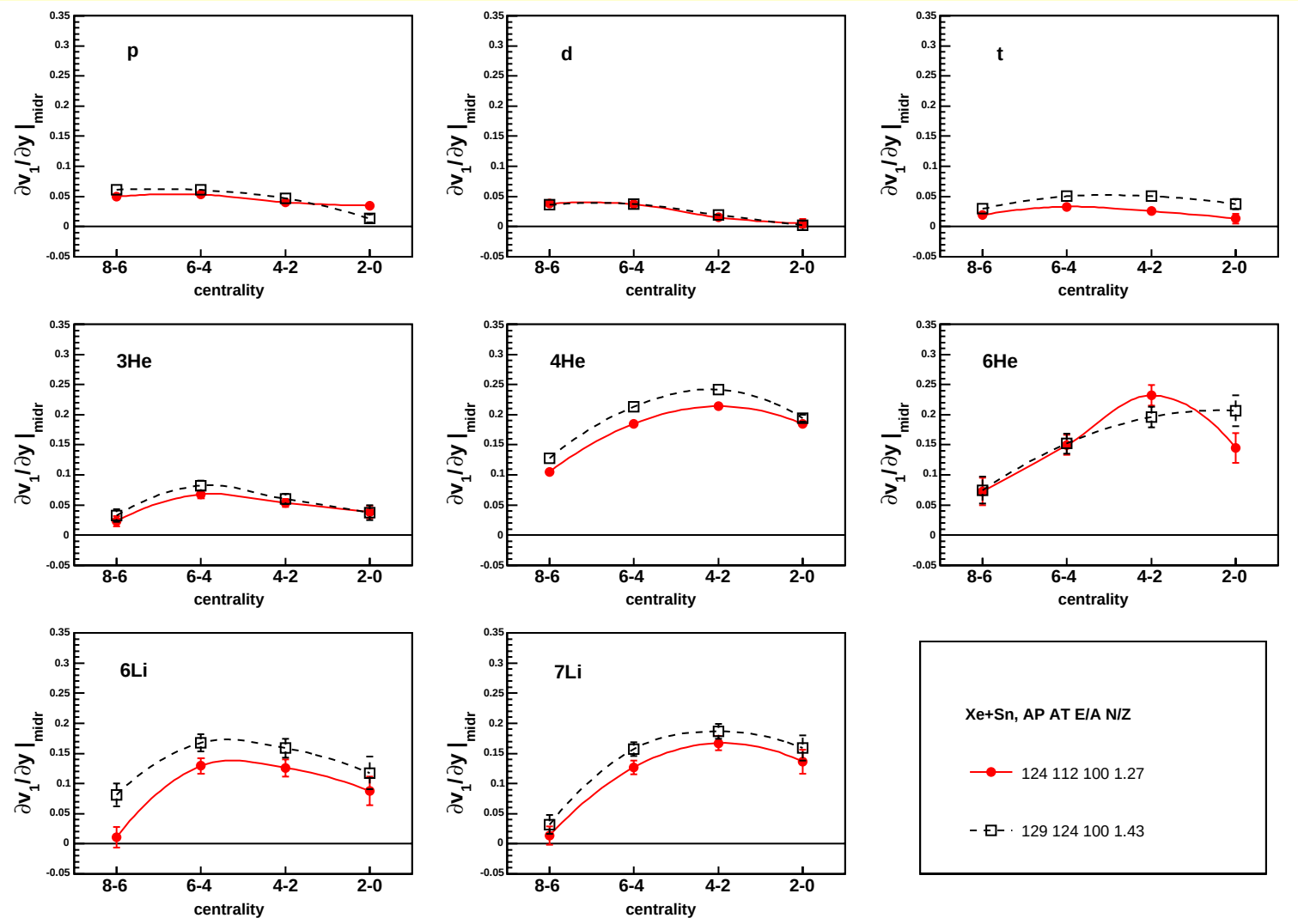
Inclusive cross section distributions

Xe + Sn @ 100 A MeV



thresholds below mid-rapidity for light fragments

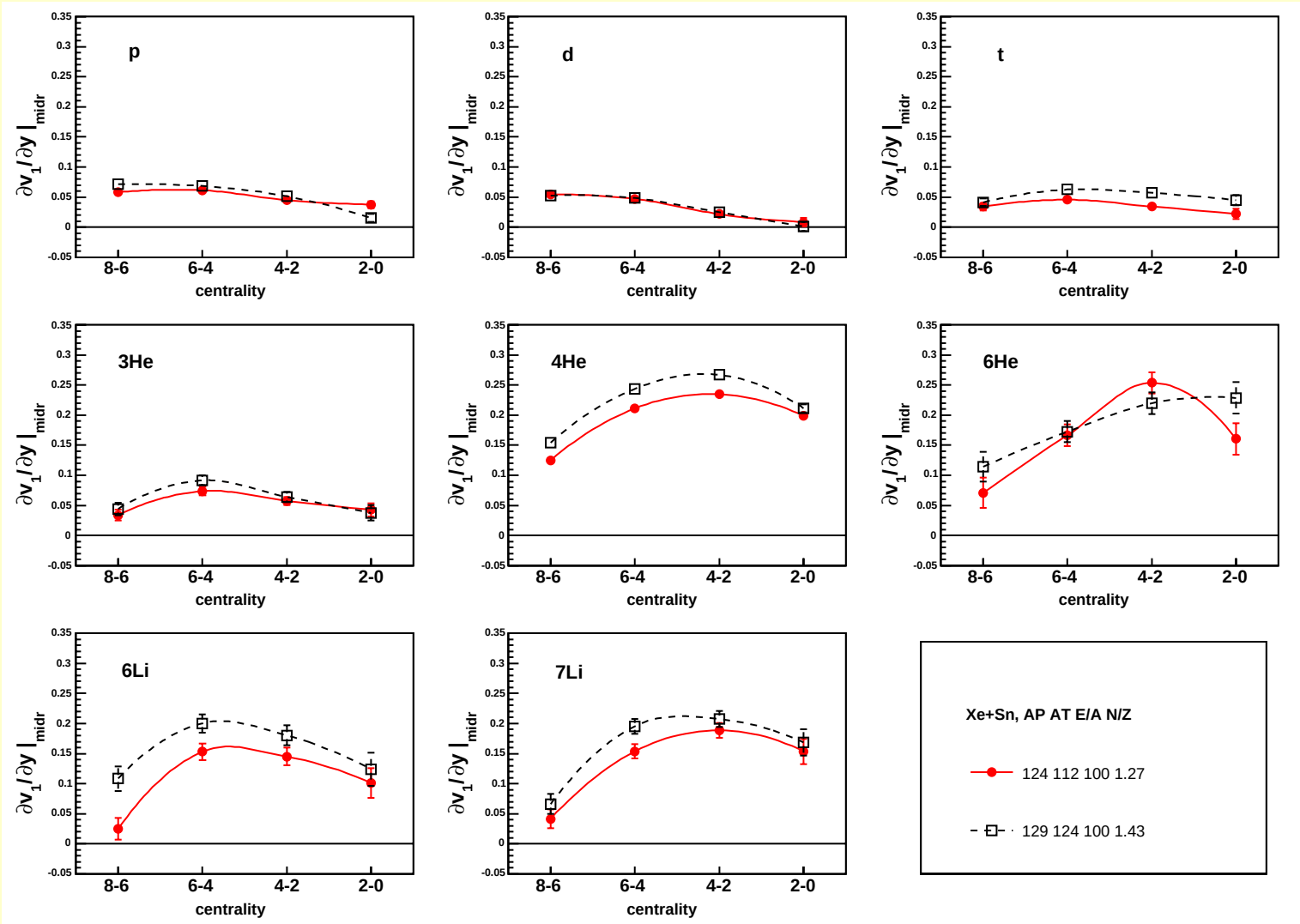
V_1 for extreme N/Z all p_t



□ neutron rich
129+124

● neutron poor (-17 neutrons)
124+112

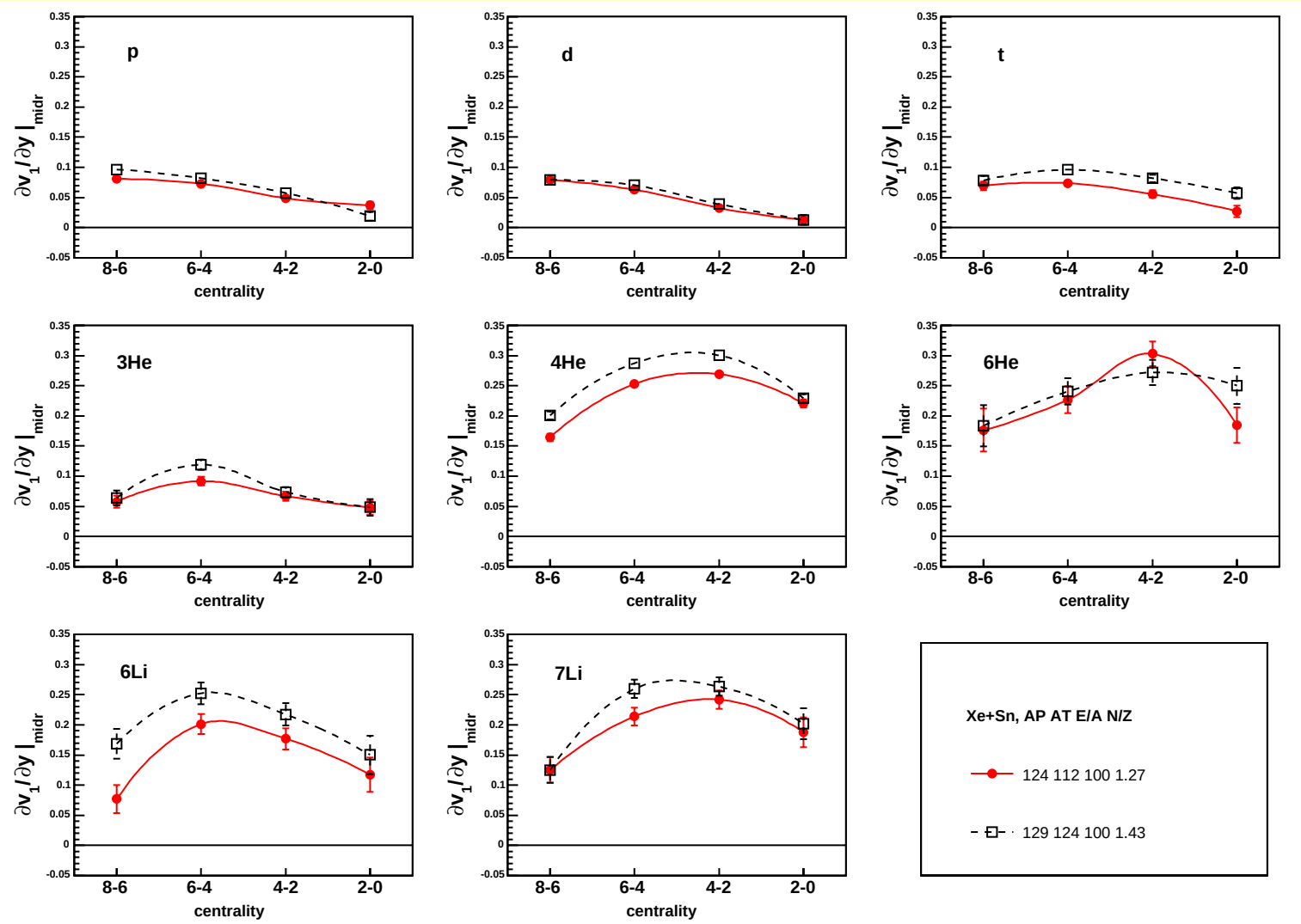
V_1 for extreme N/Z $p_t/m > 0.05$



□ neutron rich 129+124

● neutron poor 124+112 (-17 neutrons)

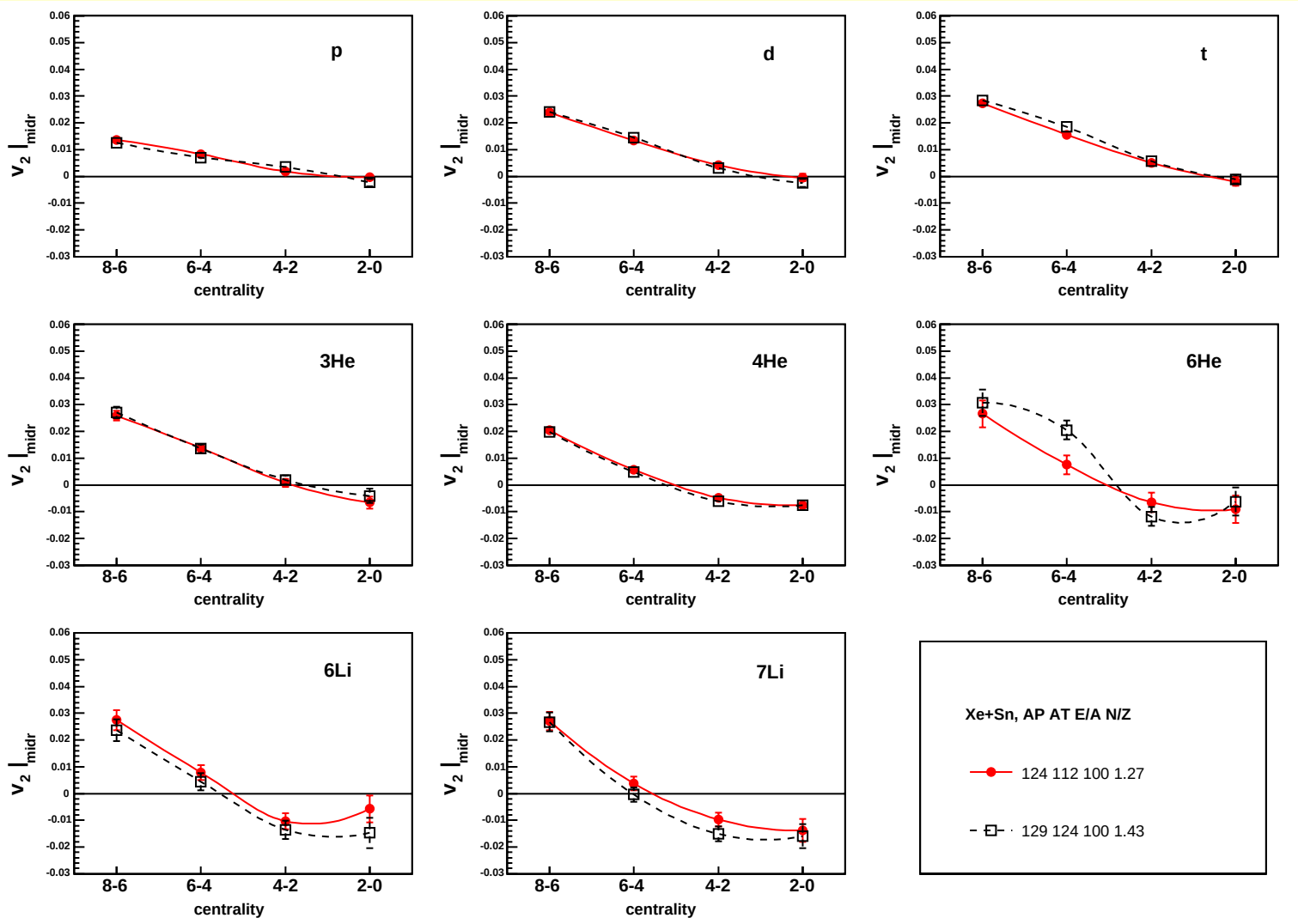
V_1 for extreme N/Z $p_t/m > 0.10$



□ neutron rich 129+124

● neutron poor 124+112 (-17 neutrons)

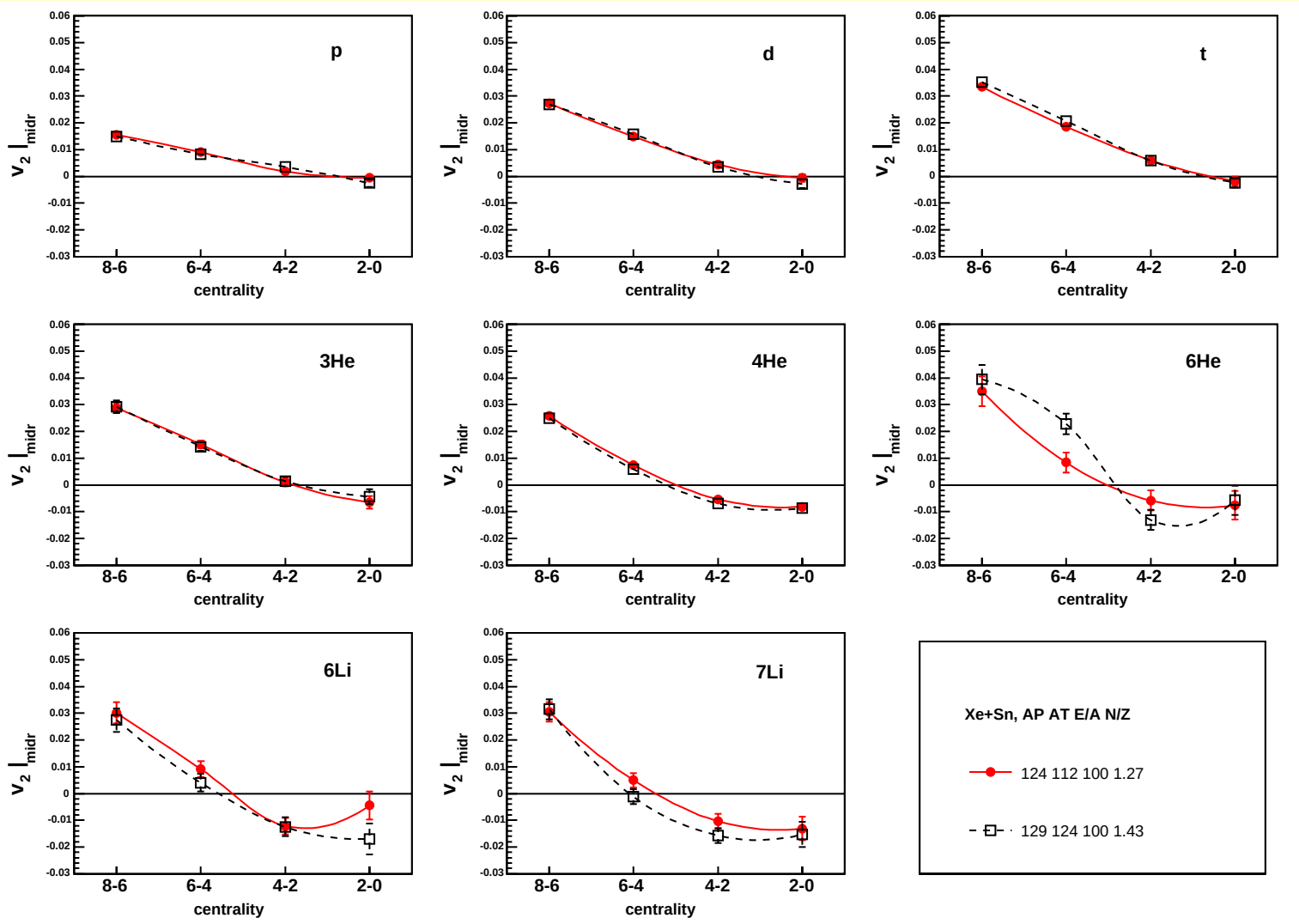
v_2 for extreme N/Z all p_t



□ neutron rich
129+124

● neutron poor (-17 neutrons)
124+112

v_2 for extreme N/Z $p_t/m > 0.05$

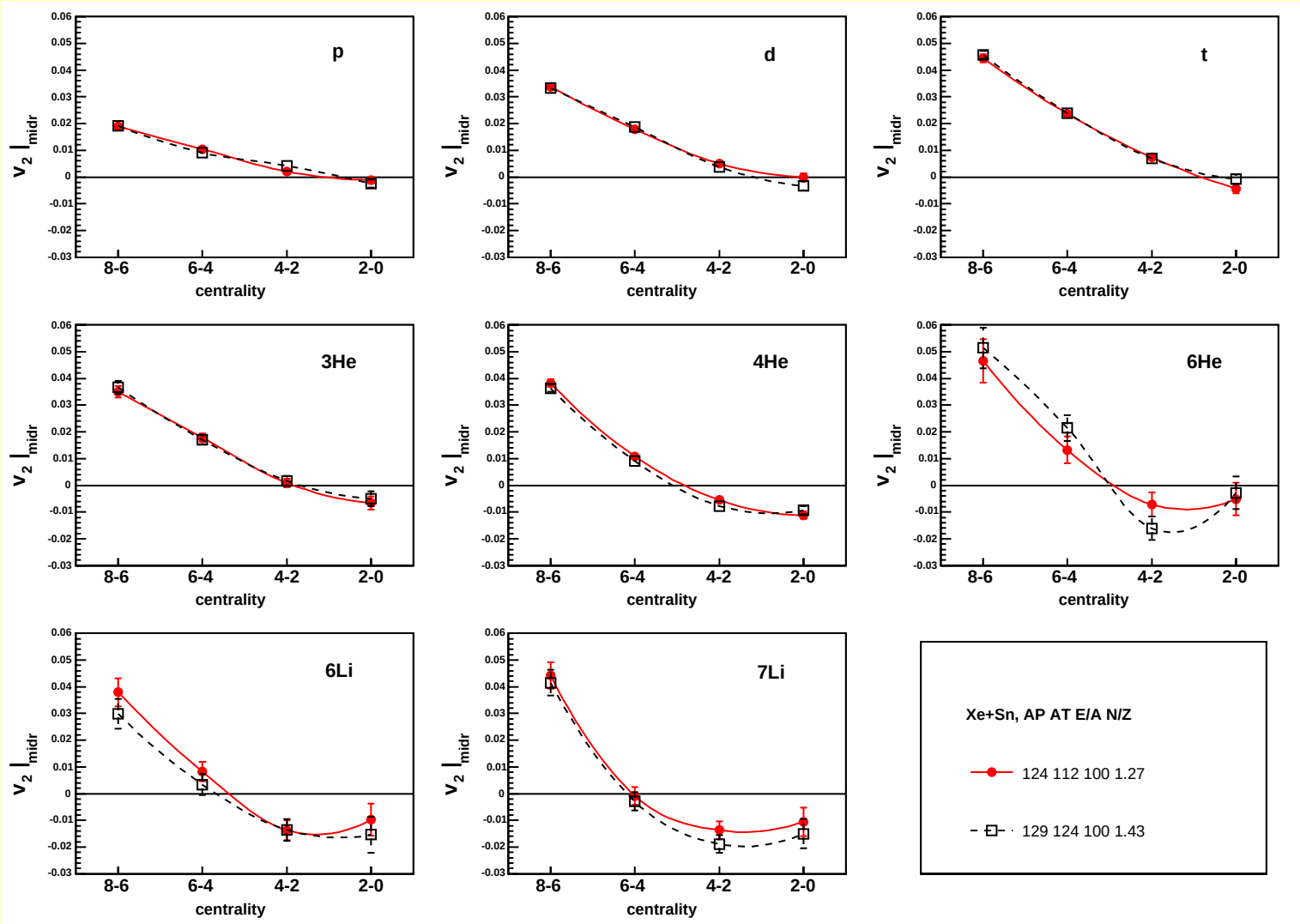


□ neutron rich
129+124

● neutron poor
124+112

(-17 neutrons)

v_2 for extreme N/Z $p_t/m > 0.10$



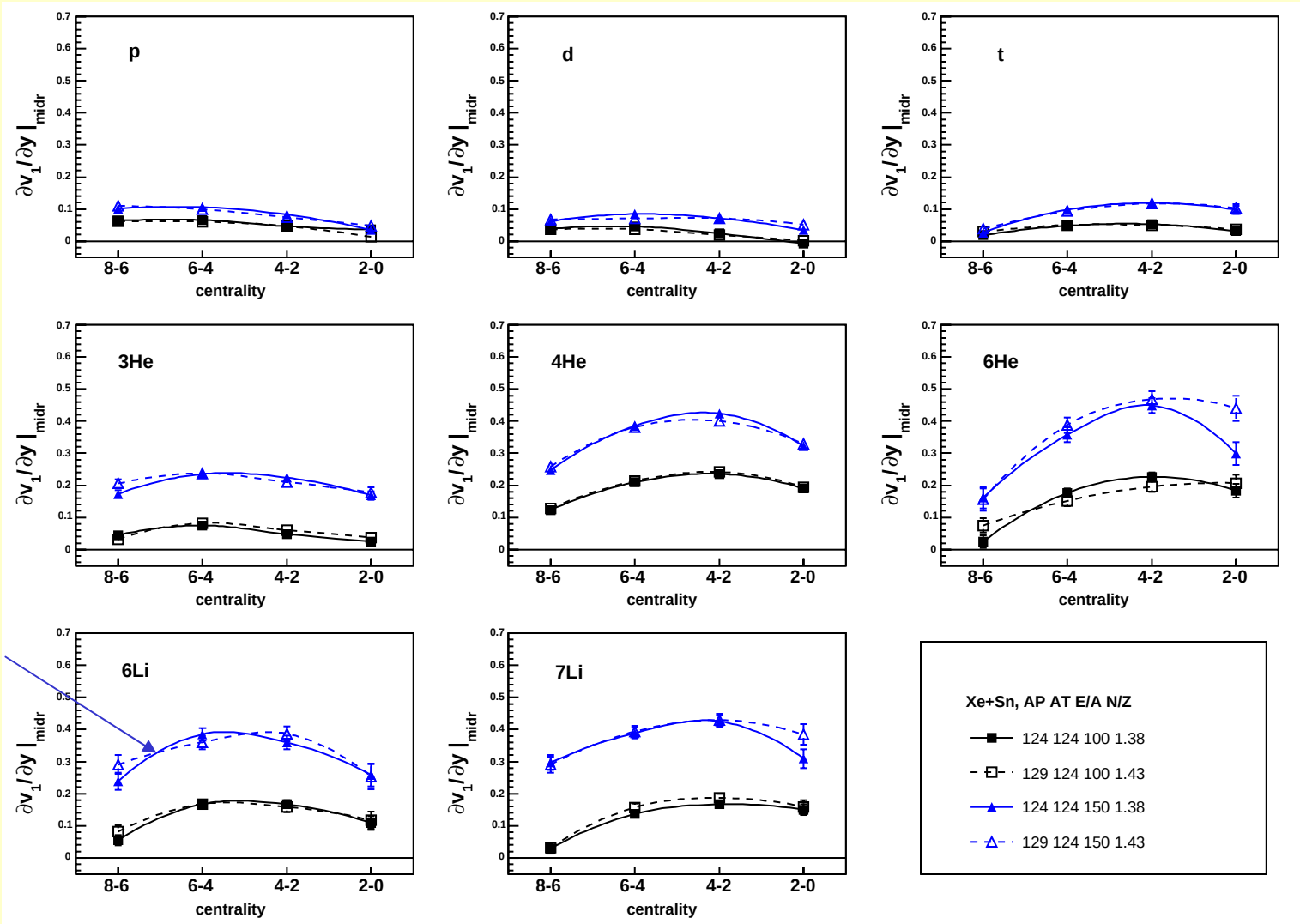
□ neutron rich
129+124

● neutron poor
124+112

(-17 neutrons)

V_1 100 and 150 A MeV same N/Z

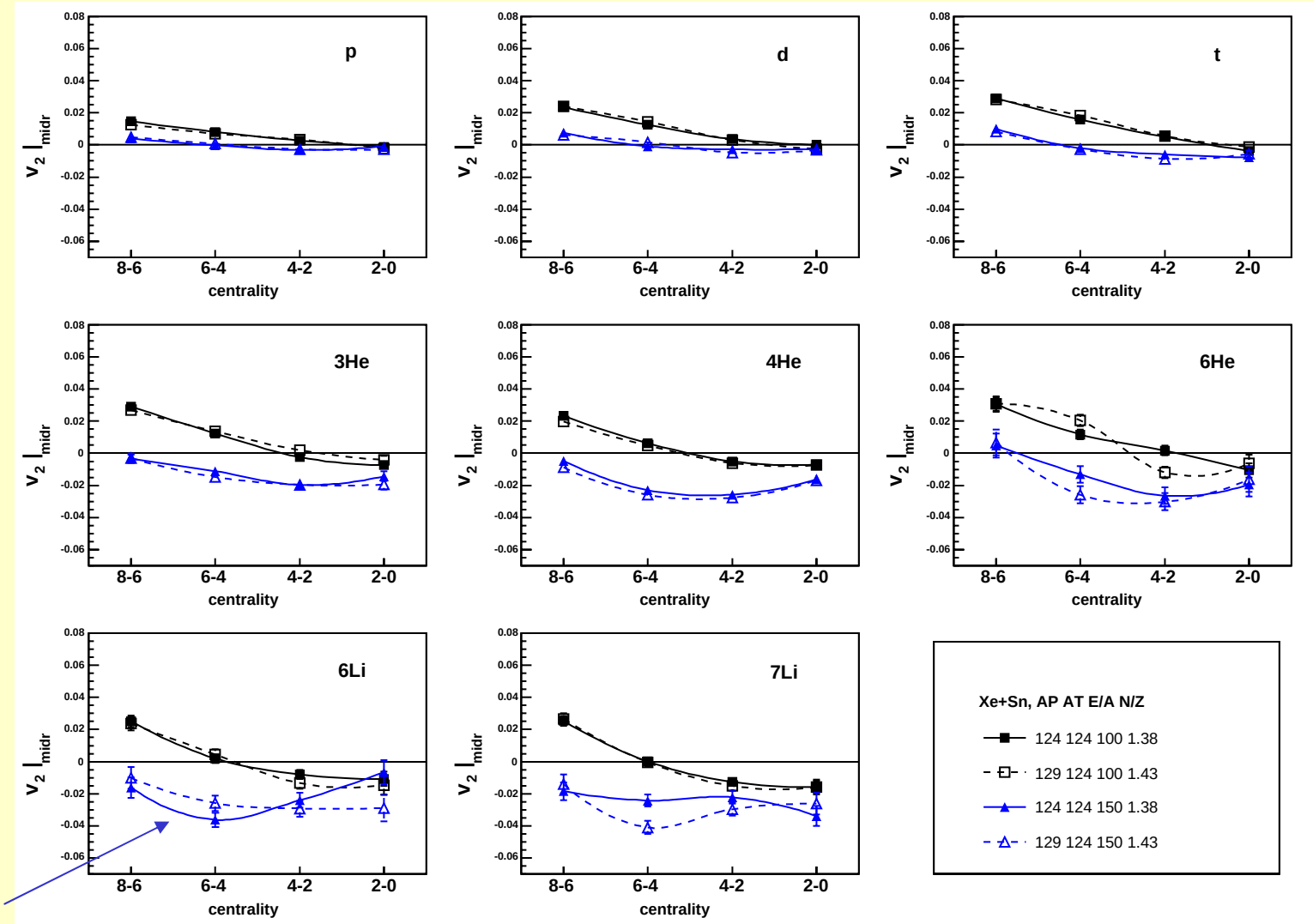
150 AMeV



□ Δ neutron rich 129+124

■ ▲ neutron poor (-5 neutrons) 124+124

V_2 100 and 150 A MeV same N/Z

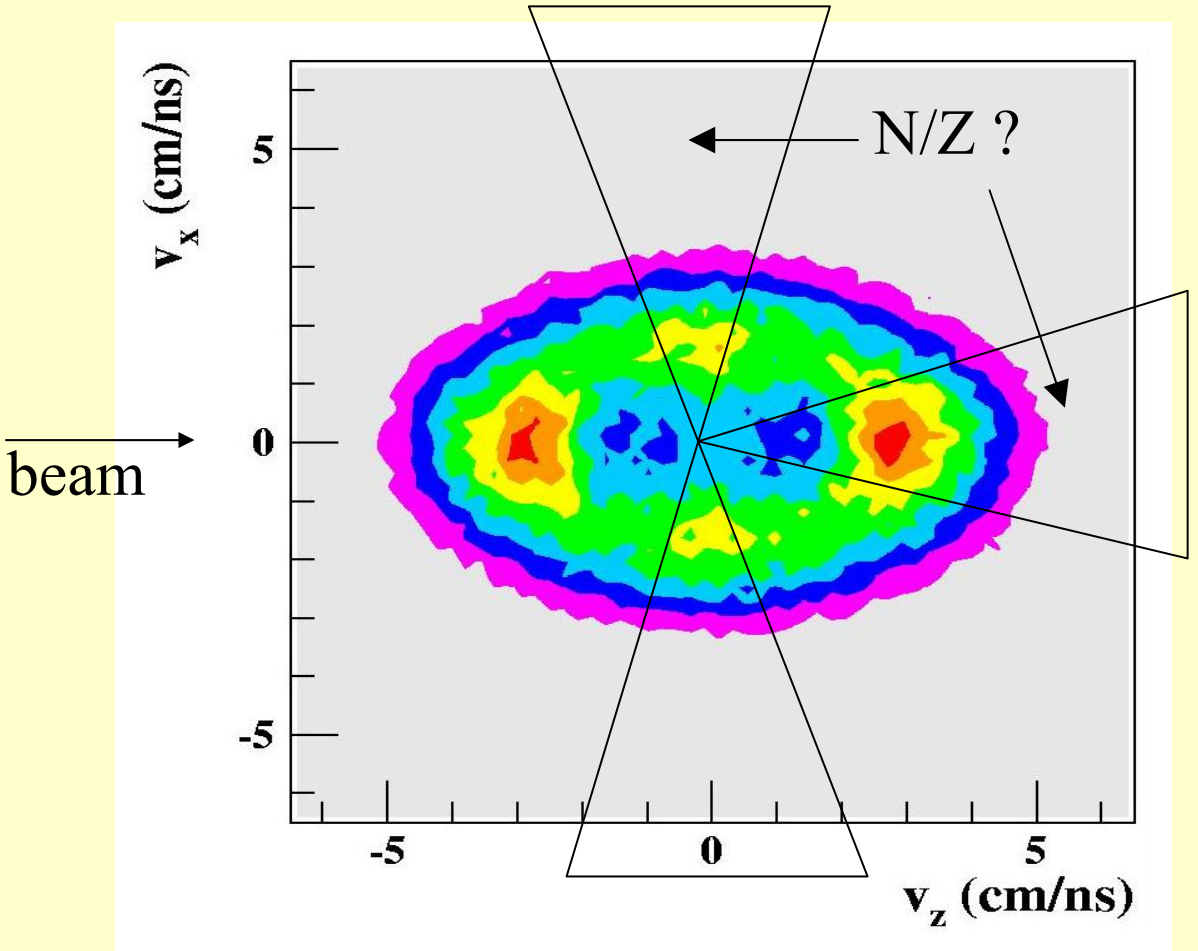


150 AMeV

□ Δ neutron rich 129+124

■ ▲ neutron poor (-5 neutrons) 124+124

Isospin tracer analysis



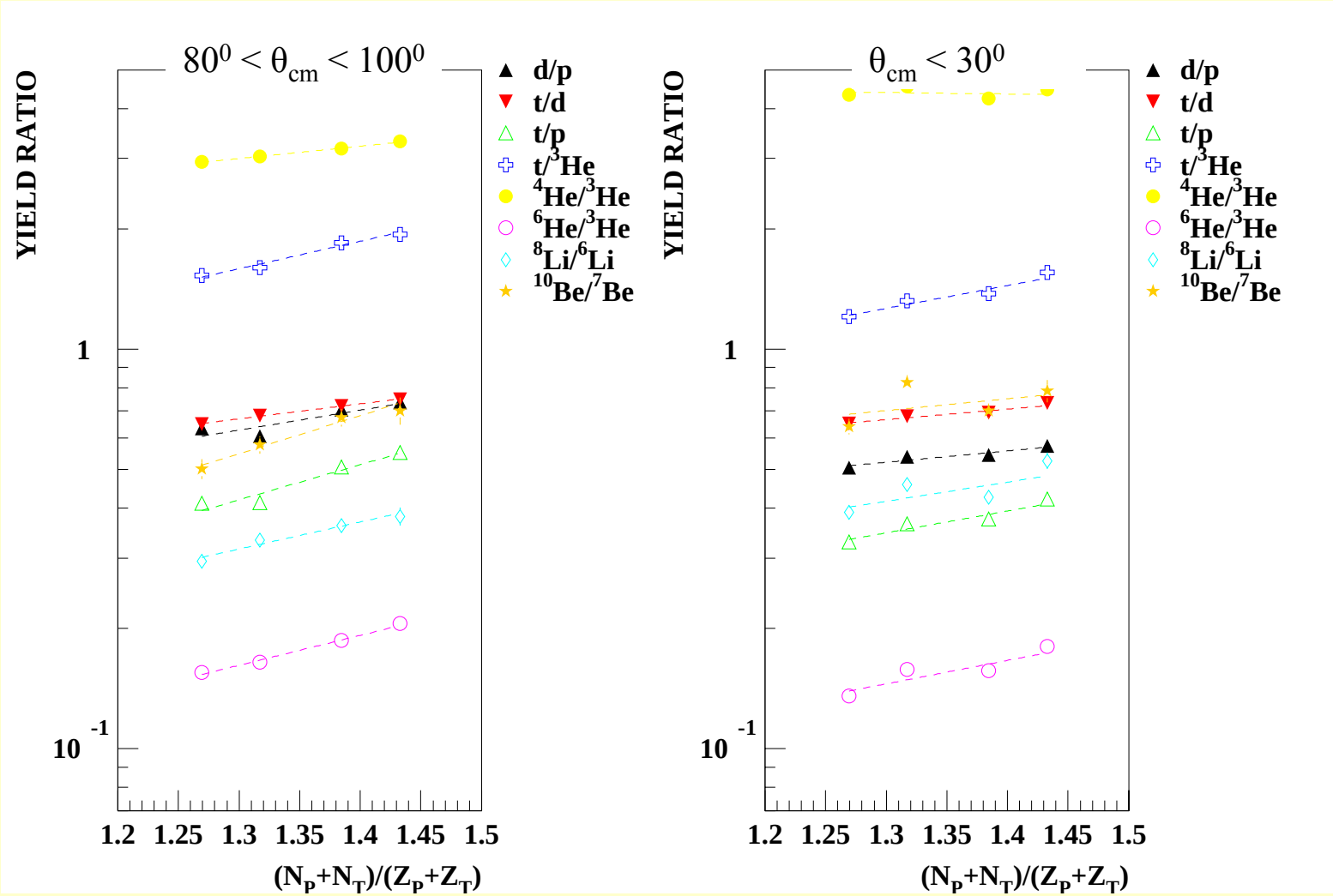
^{124,129}Xe + ^{112,124}Sn isotopic cross bombardment at 100 AMeV

Idea: use sideways N/Z ratios for calibration
use forward ratios to determine isospin transparency (diffusion)

Data

sideward

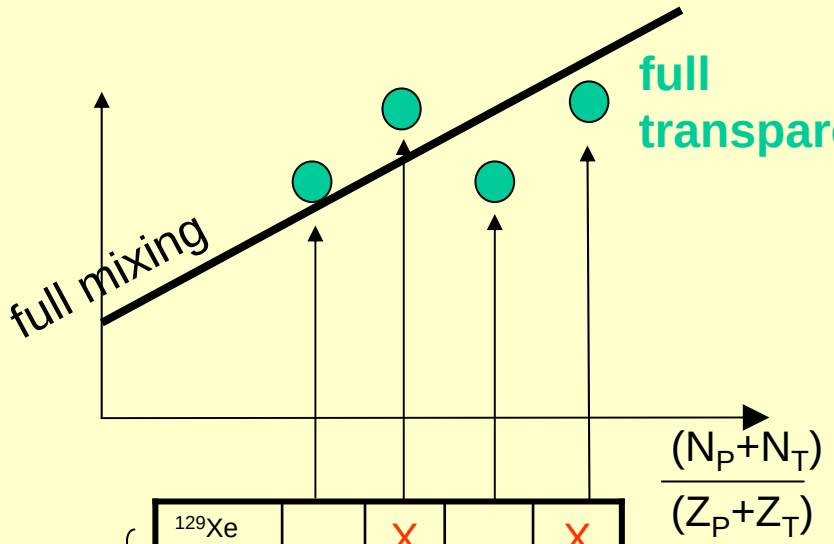
forward

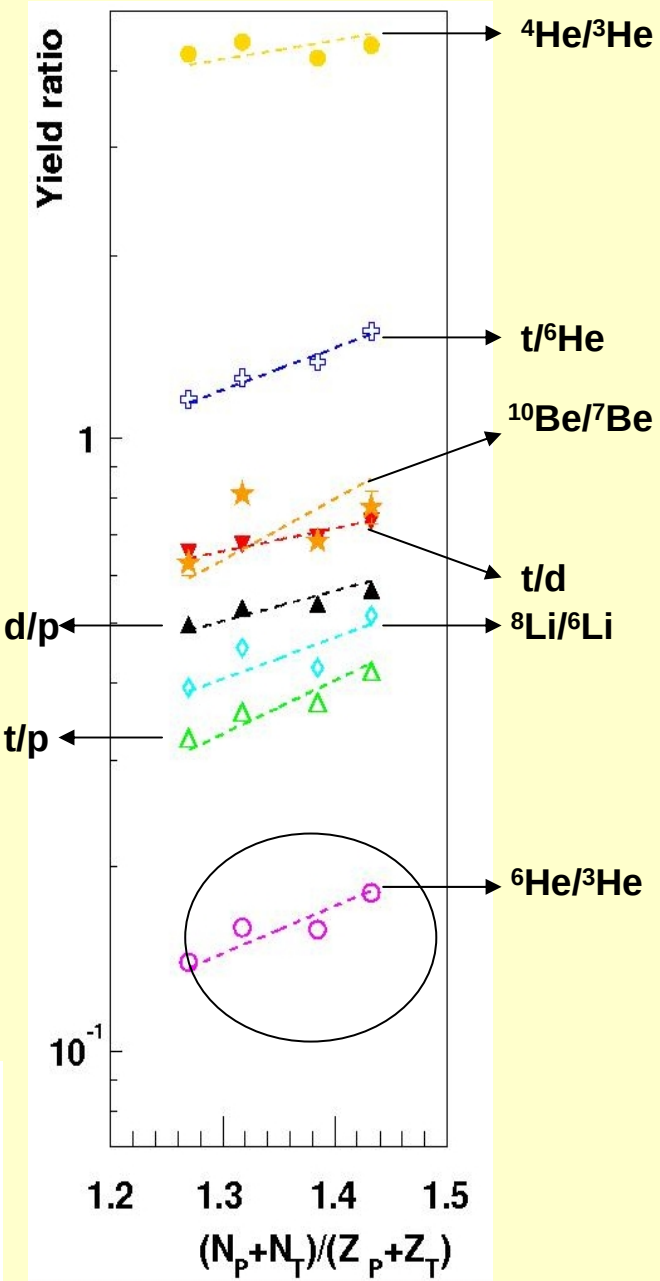


Arnaud Le Fèvre et al.

Transparency

forward data





	d/p	t/d	t/p	$t/^3He$
$\tau(\%)$	34 ± 2	26 ± 2	30 ± 2	22 ± 2
	$^4He/^3He$	$^6He/^3He$	$^8Li/^6Li$	$^{10}Be/^7Be$
$\tau(\%)$	124 ± 4	46 ± 6	64 ± 10	92 ± 10

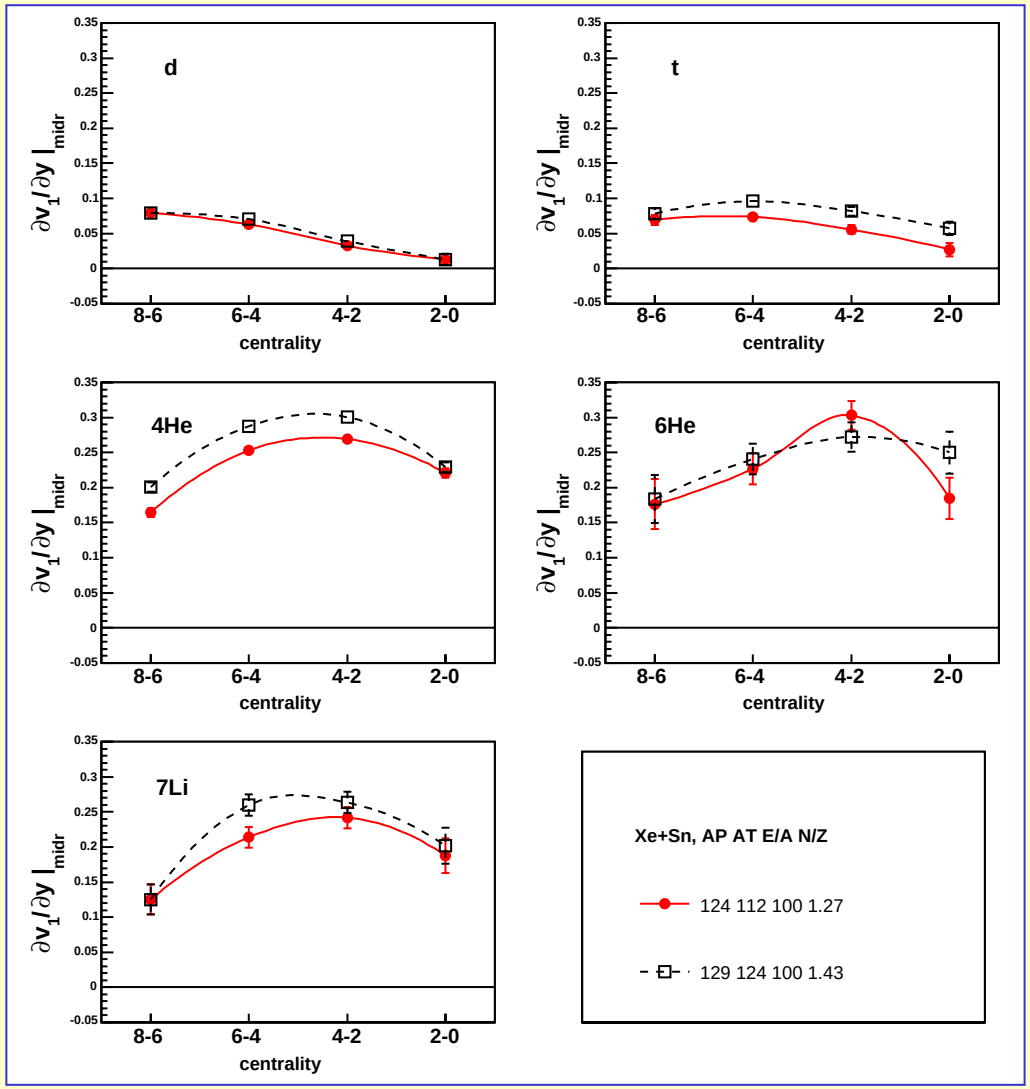
Conclusion

1. high accuracy of flow data due to elaborate corrections

2. very small isotopic effects visible for light isotopes

3. p_t and energy dependence as expected

4. further constraints for symmetry energy from isotopic flow and diffusion to be expected



v_1 at 100 AMeV $p_t/m > 0.10$

Acknowledgment

for references see, e.g.,
J. Łukasik et al.,
PLB 608, 223 (2005)
A. Andronic et al.,
Eur. Phys. J. A 30, 31 (2006)

work by Jerzy Łukasik
Arnaud Le Fèvre
fruitful collaboration
with Anton Andronic
Willi Reisdorf