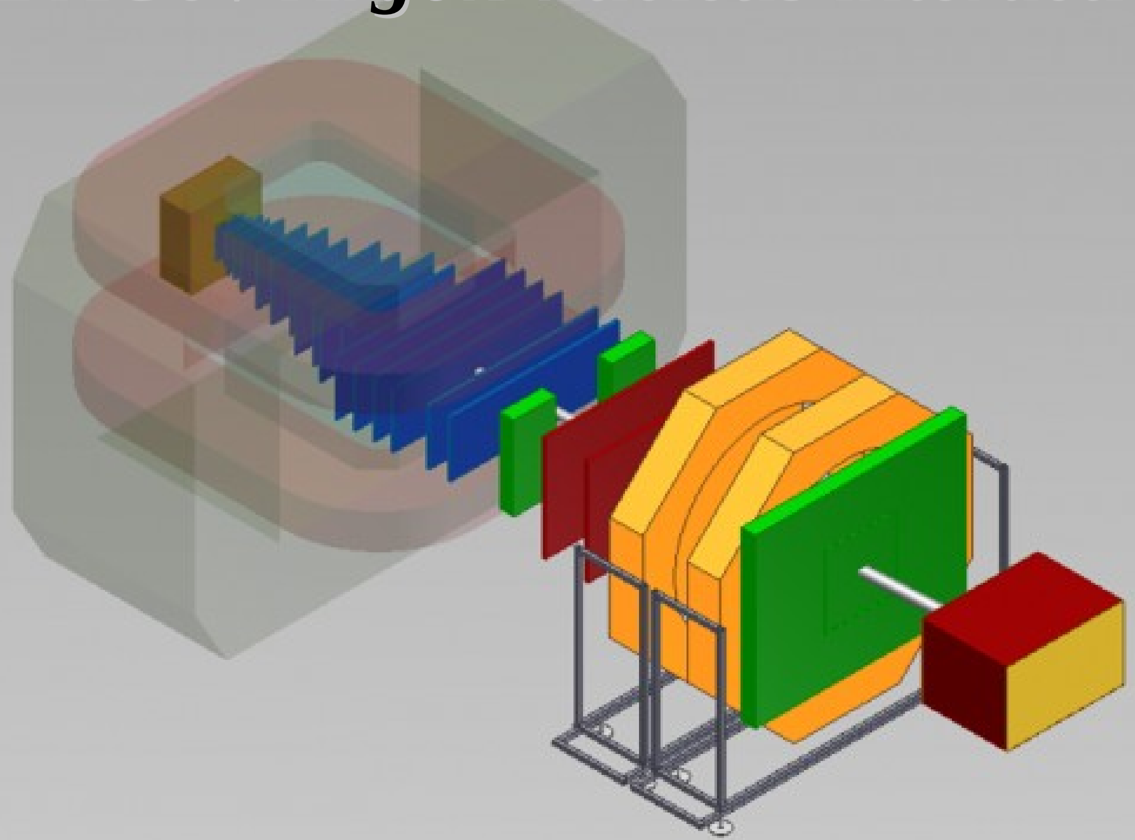
Current Progress in Analysis of p,d,t production in 3.2 AGeV Argon-nucleus interactions



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Results of the analysis were presented at the 10th BM@N Collaboration meeting in May 2023 (L.Kovachev) and at the BM@N Analysis and Software meeting in September 2023 (L.Kovachev, M.Kapishin).
Intermediate steps of the analysis were presented at the previous Collaboration meetings (L.Kovachev, V.Plotnikov).

Related analysis notes:

https://indico.jinr.ru/event/4165/attachments/17543/29918/Note_analAr_pdt3.pdf
https://indico.jinr.ru/event/4165/attachments/17543/29919/Note_centrality_pdt_text.pdf
https://indico.jinr.ru/event/4165/attachments/17543/29920/Flux_lumi_trigger.pdf
https://indico.jinr.ru/event/4165/attachments/17543/29921/lumi.pdf

$<m_t>$-m and dN/dy: dependence on y

$$\frac{d^2N}{dm_t dy} = \frac{dN/dy}{T_{eff}(m+T_{eff})} m_t exp(-\frac{m_t - m}{T_{eff}}) \rightarrow dN/dy \text{ and } <m_t> - m = T_{eff} + T^2_{eff}/(m+T_{eff})$$

perform NA49 analysis (Phys.Rev.C 94 (2016) 4, 044906):
fit $<m_t>$ values for protons and deuterons to extract T and $<\beta>$ values

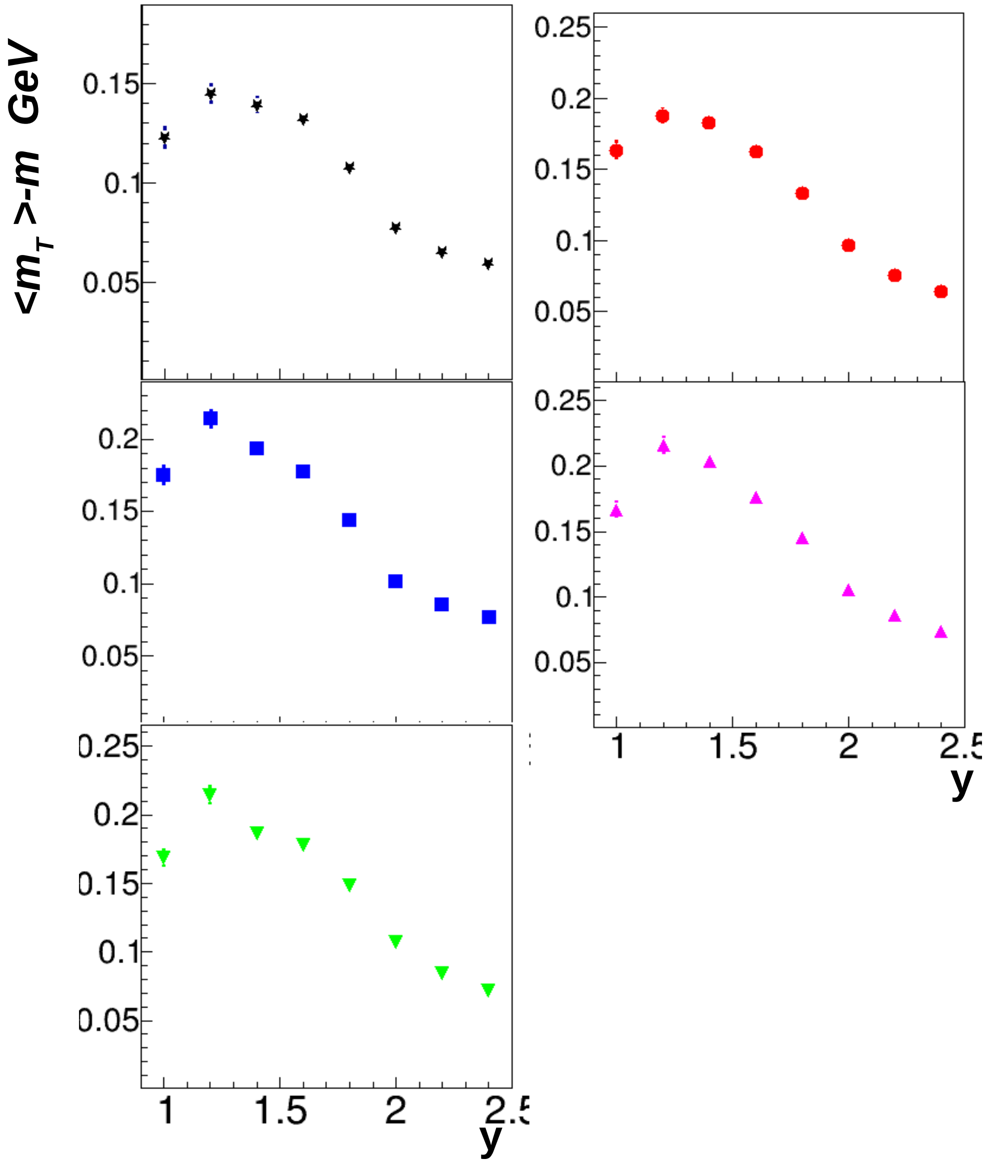
$$\langle m_t \rangle - m = \langle E_t \rangle_{kin} \approx \langle E \rangle_{therm.} + \langle E \rangle_{flow} = \frac{3}{2}T + (\gamma - 1)m$$

$$\gamma = 1/\sqrt{1 - \langle \beta \rangle^2} \qquad T^* = T\sqrt{\frac{1+\langle \beta \rangle}{1-\langle \beta \rangle}}$$

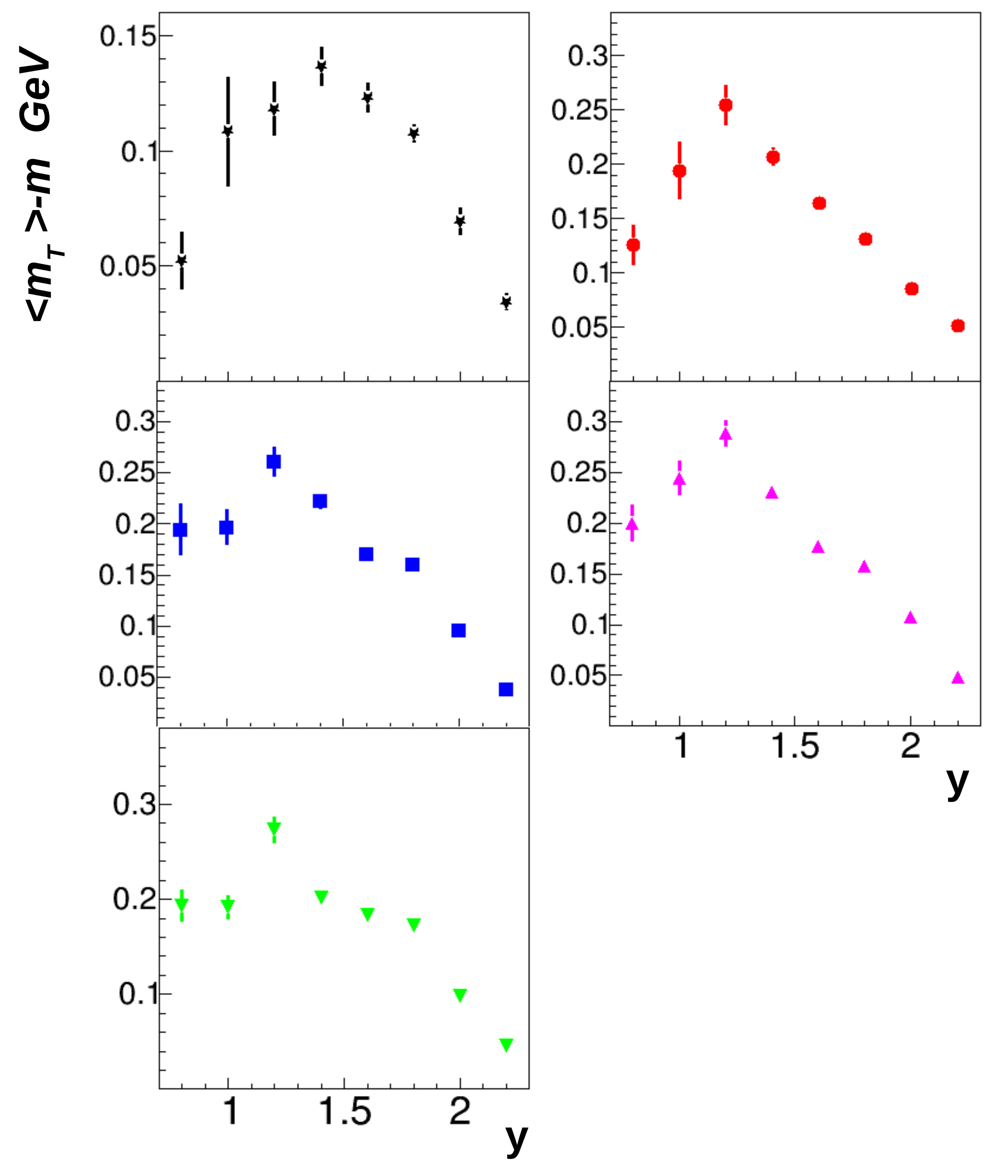
$\langle m_t \rangle - m$ dependence on y centrality 0-40%

$\langle mt \rangle - m \sim T_{eff}$

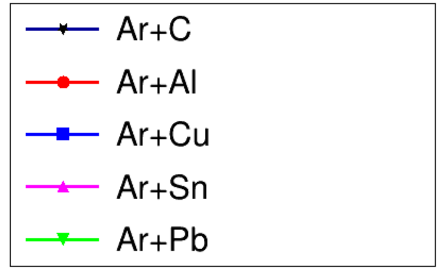
protons



deuterons

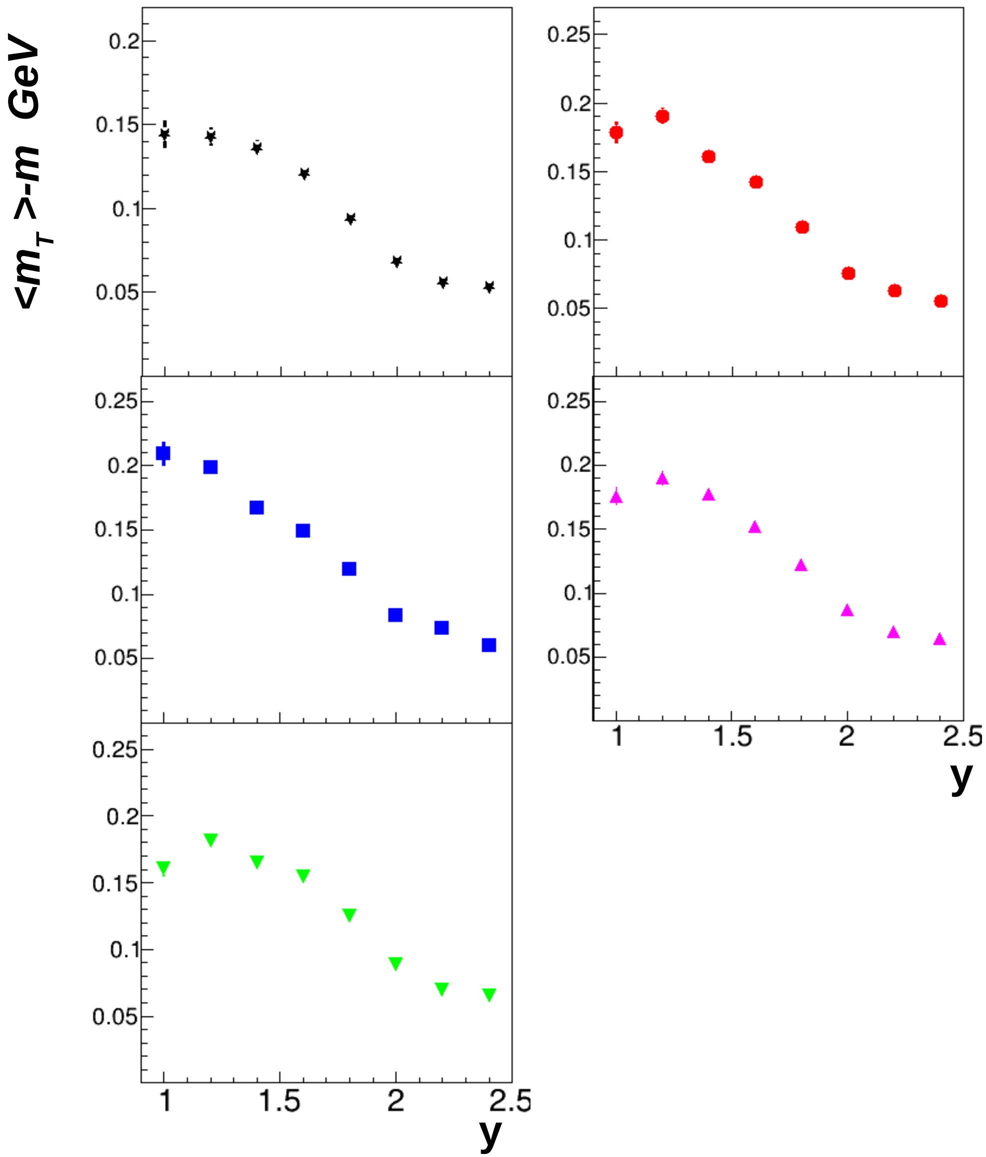


$\langle m_t \rangle$-m dependence on y
centrality 40-100%

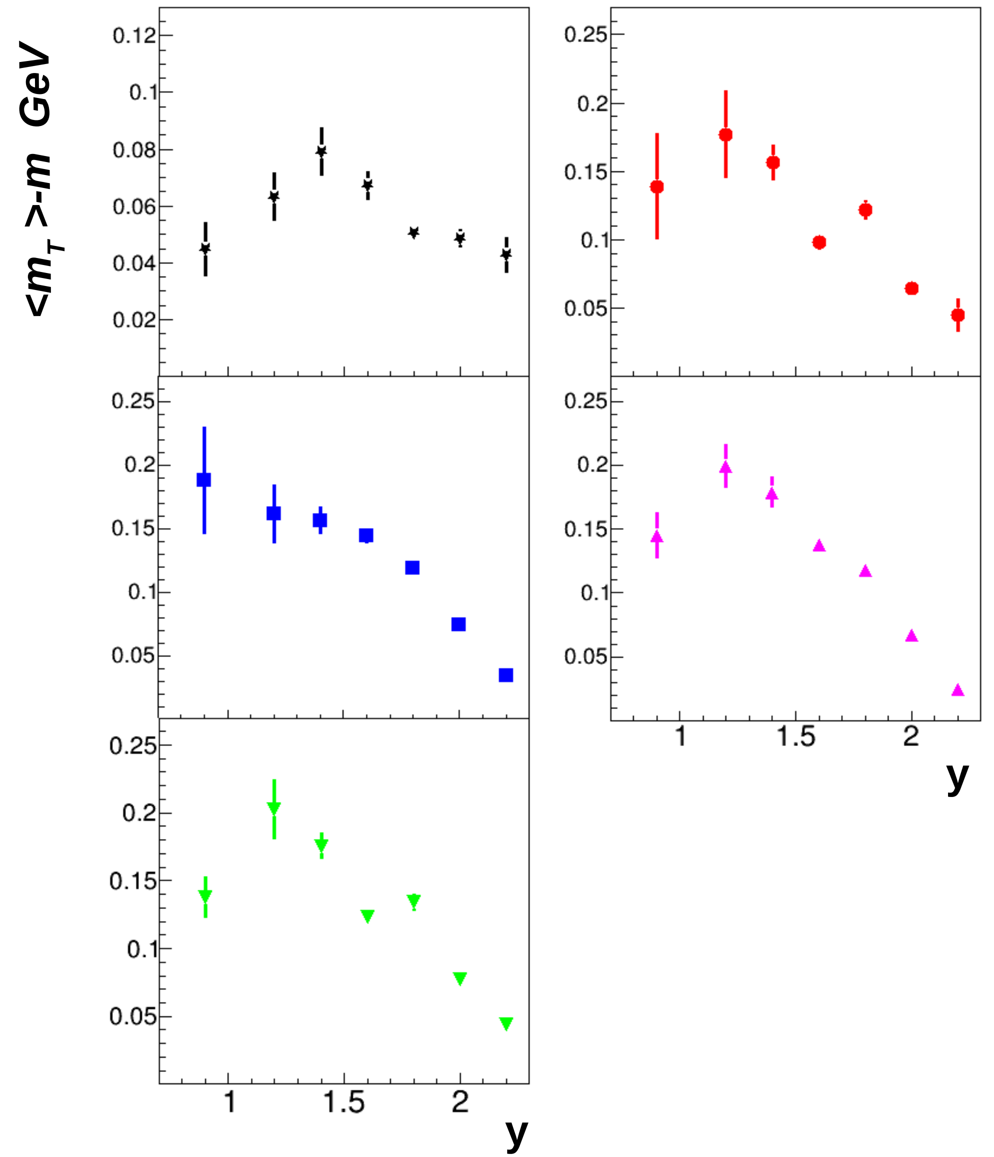


$\langle mt \rangle$-m ~ T_{eff}

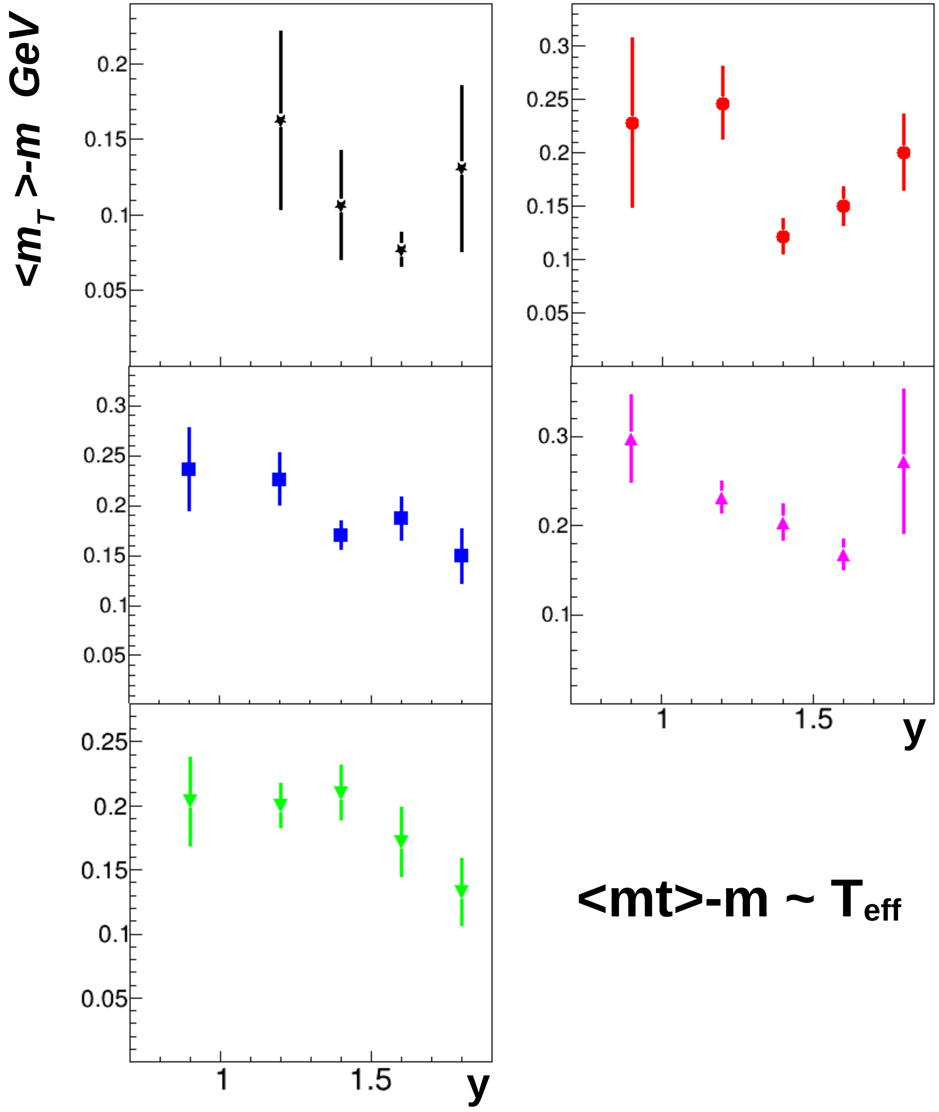
protons



deuterons

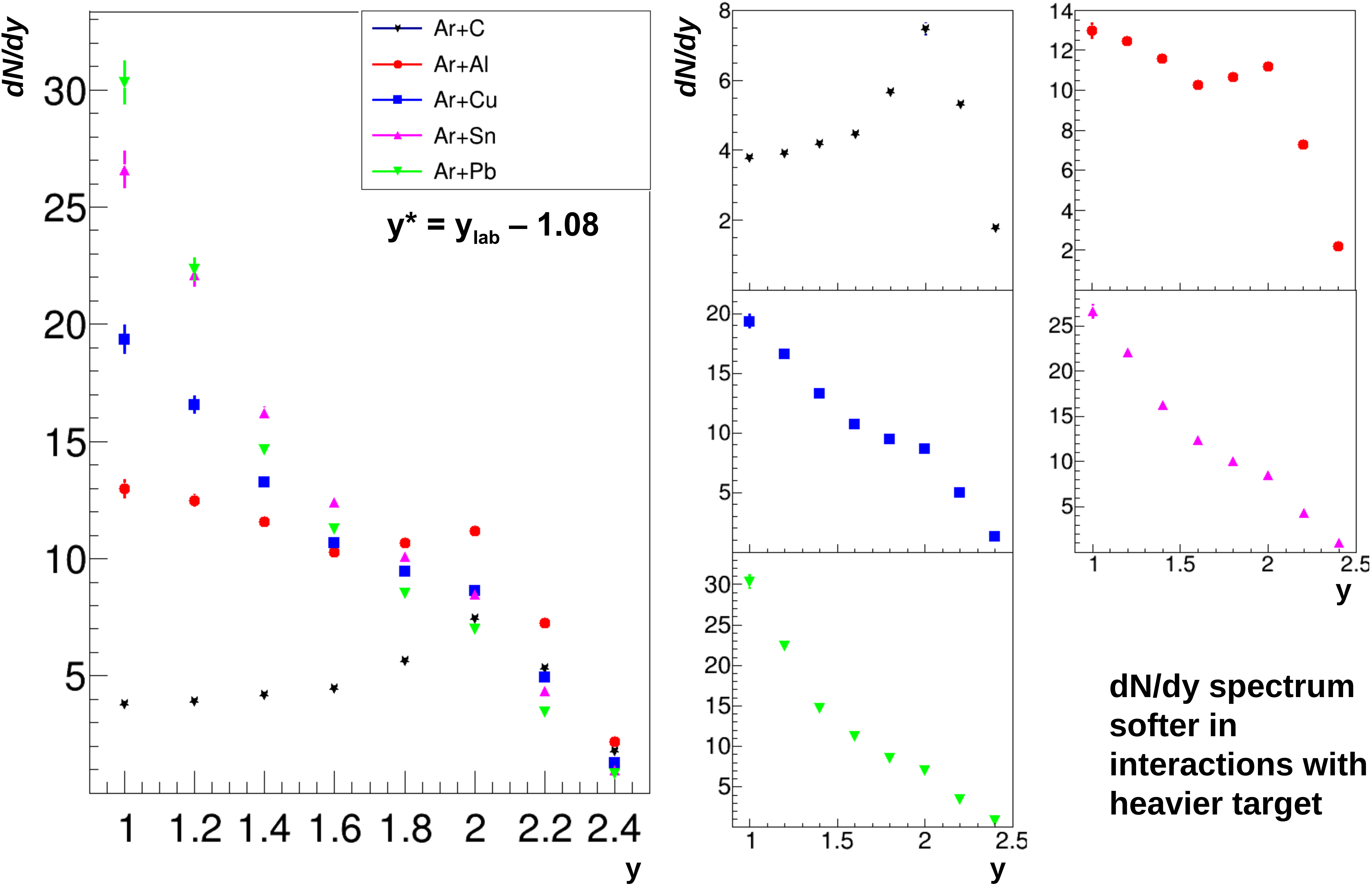


$<m_t>$-m dependence on y
for tritons, all targets, centrality 0-40%



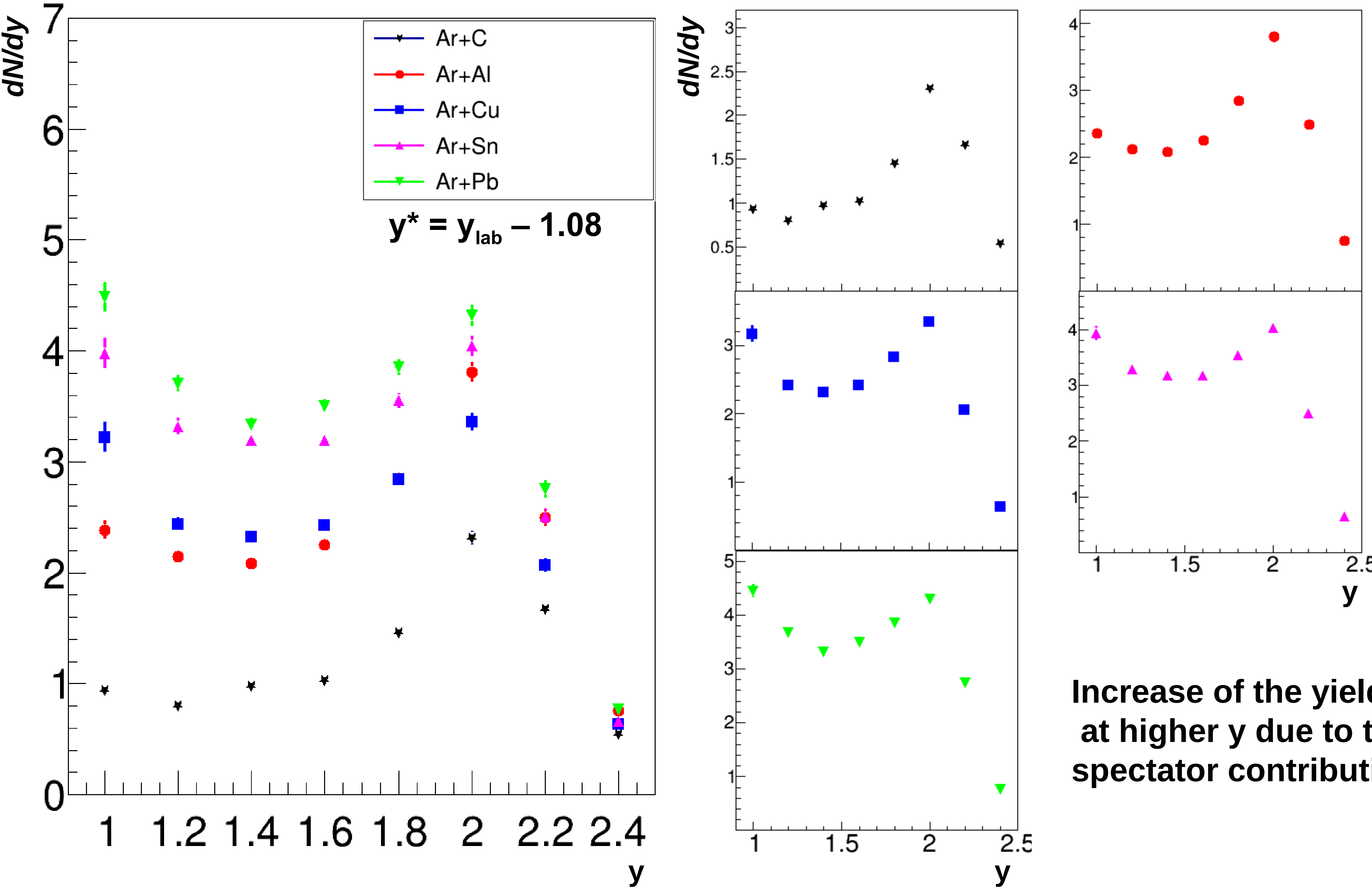
<mt>-m ~ T_{eff}

dN/dy dependence on y for protons, centrality 0-40%



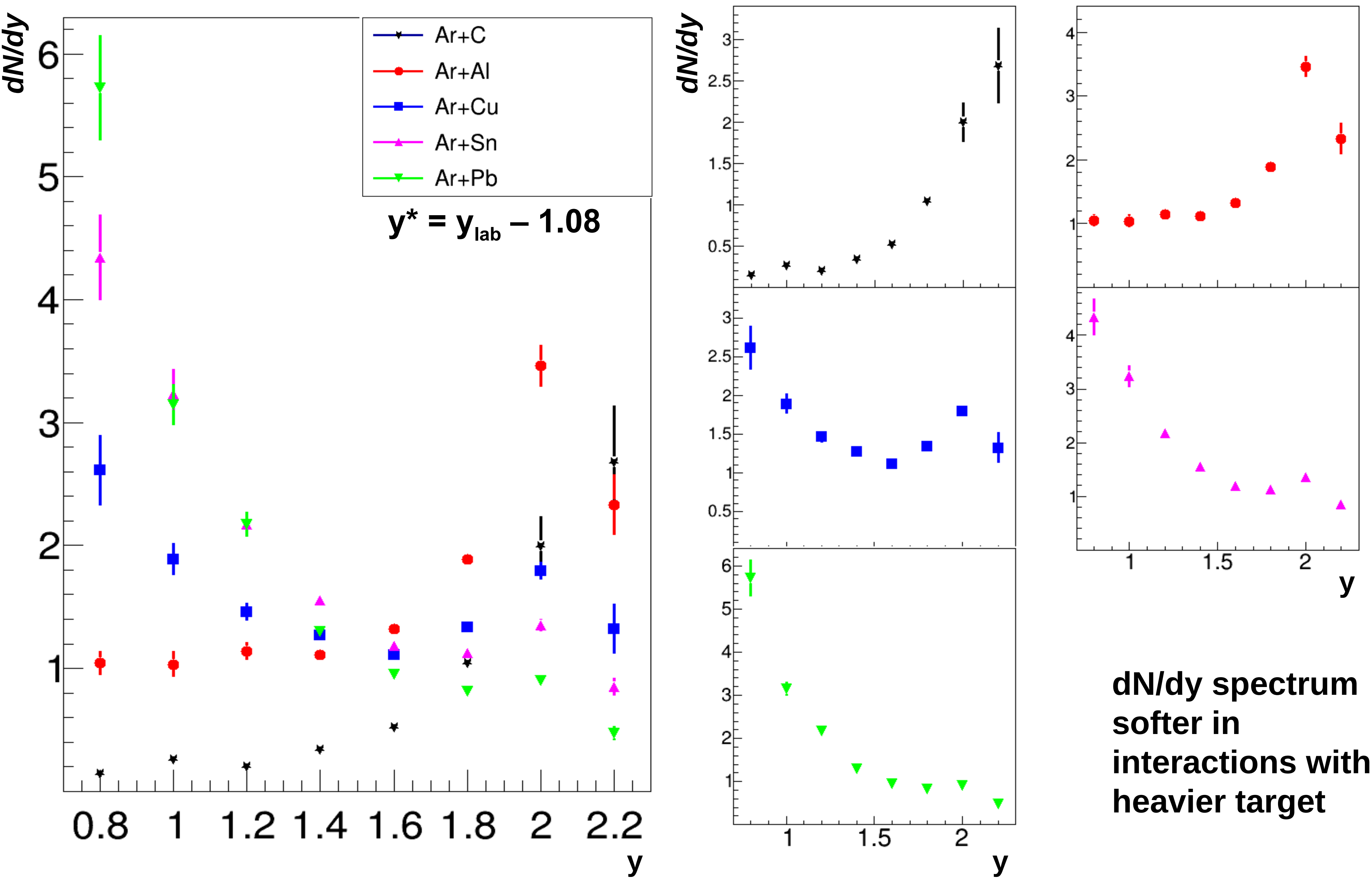
dN/dy spectrum softer in interactions with heavier target

dN/dy dependence on y for protons, centrality 40-100%



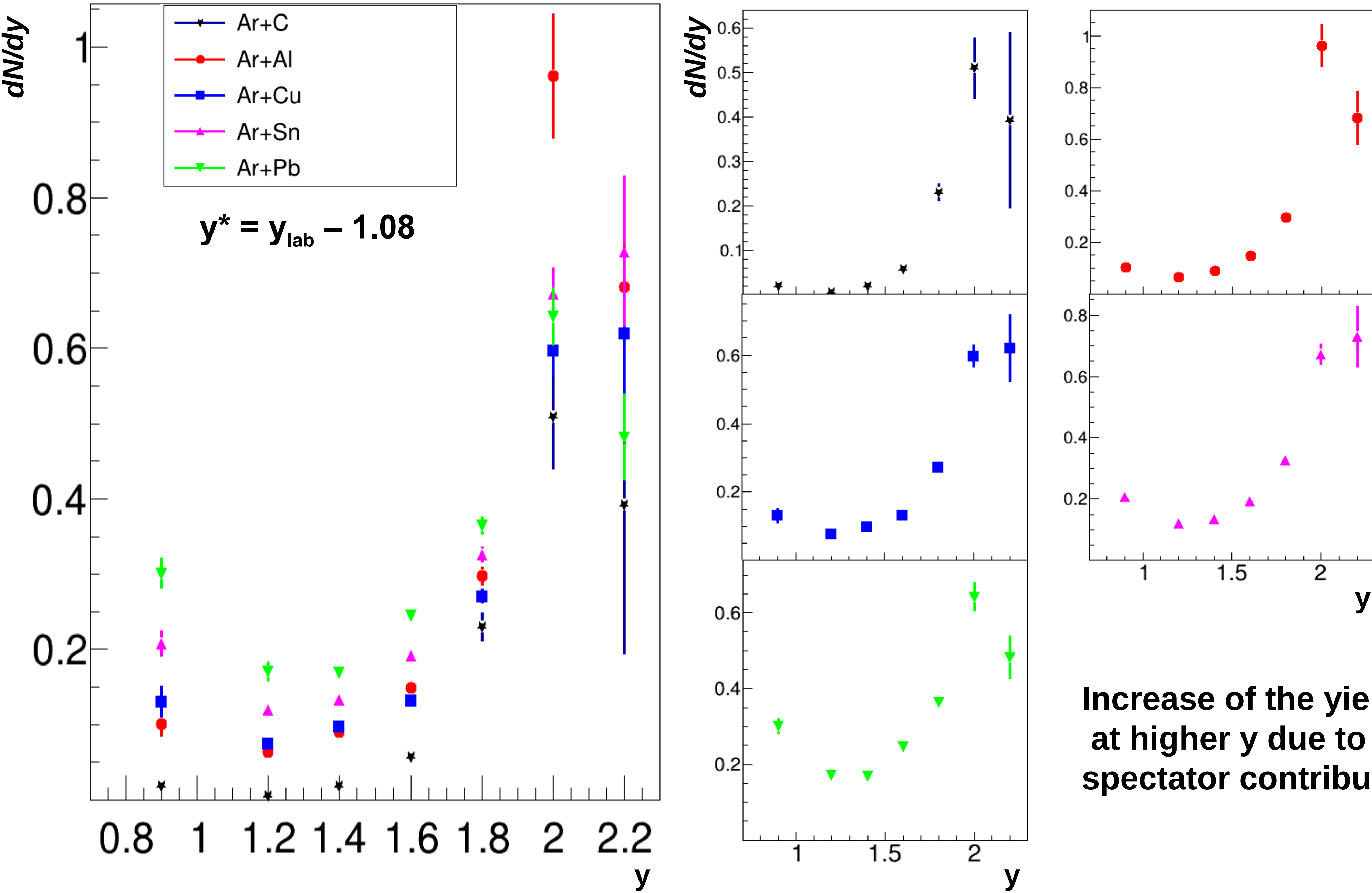
Increase of the yields at higher y due to the spectator contribution

dN/dy dependence on y
for deuterons, centrality 0-40%



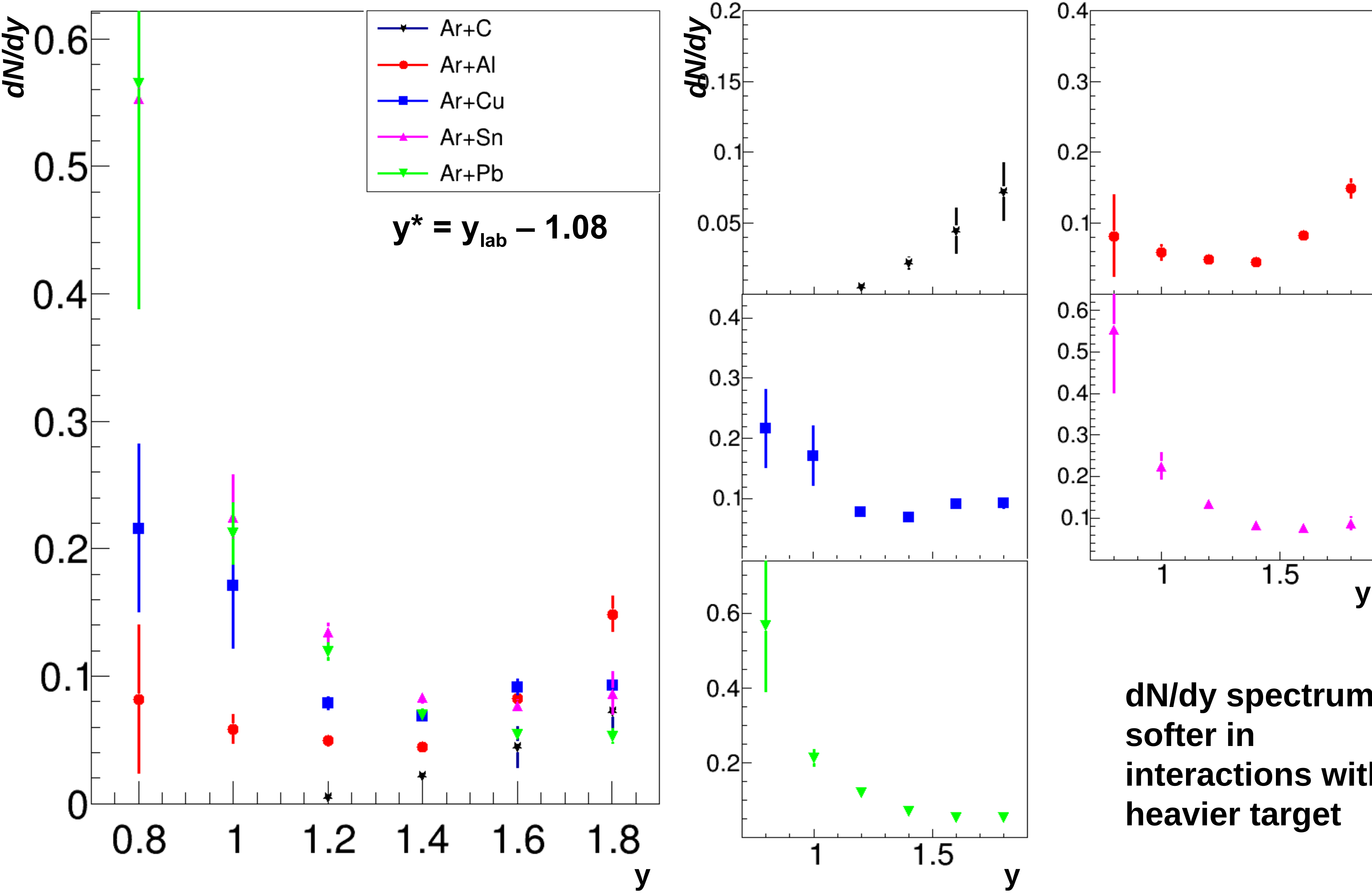
dN/dy spectrum softer in interactions with heavier target

dN/dy dependence on y for deuterons, centrality 40-100%



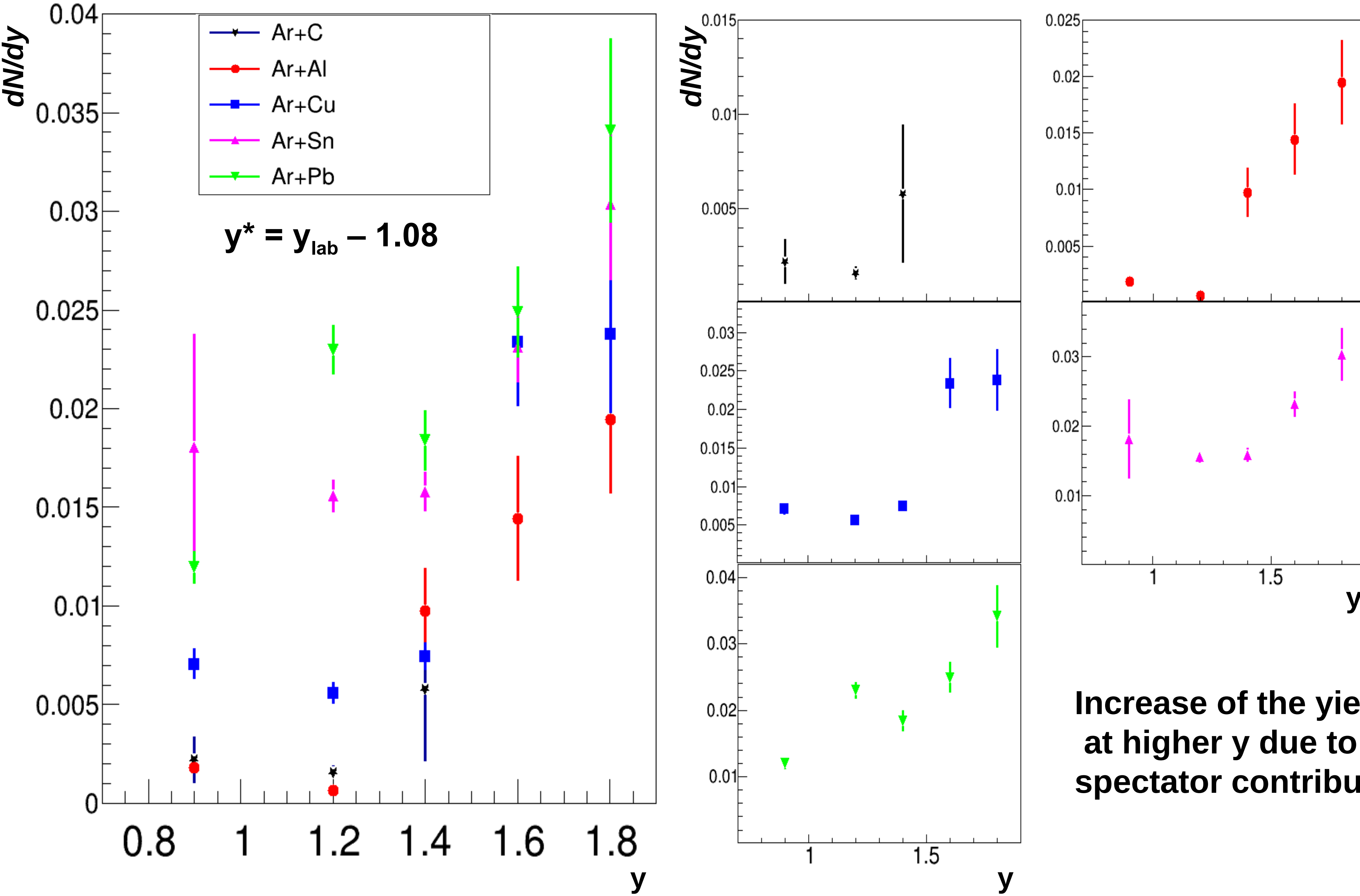
Increase of the yields at higher y due to the spectator contribution

dN/dy dependence on y for tritons, centrality 0-40%



dN/dy spectrum softer in interactions with heavier target

dN/dy dependence on y for tritons, centrality 40-100%



Increase of the yields at higher y due to the spectator contribution

Coalescence factors B_2 and B_3

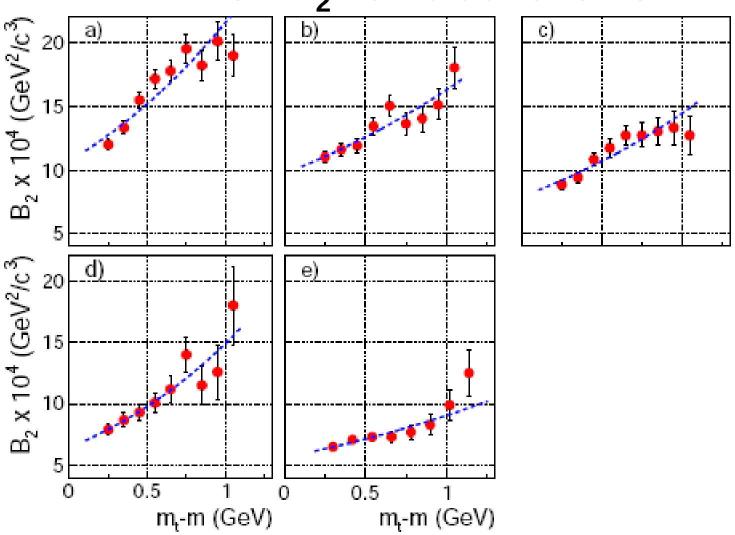
$$E_A \frac{d^3N_A}{dp_A^3} = B_A\left(E_p \frac{d^3N_p}{dp_p^3}\right)^Z \left(E_n \frac{d^3N_n}{dp_n^3}\right)^{A-Z}$$
$$\approx B_A\left(E_p \frac{d^3N_p}{dp_p^3}\right)^A ,$$

$$\rightarrow B_A = d^2N_A/2\pi p_T dp_T(A)dy \;/\; [d^2N_p/2\pi p_T dp_T(p)dy)]^A , \; A=2(d),\ 3(t)$$

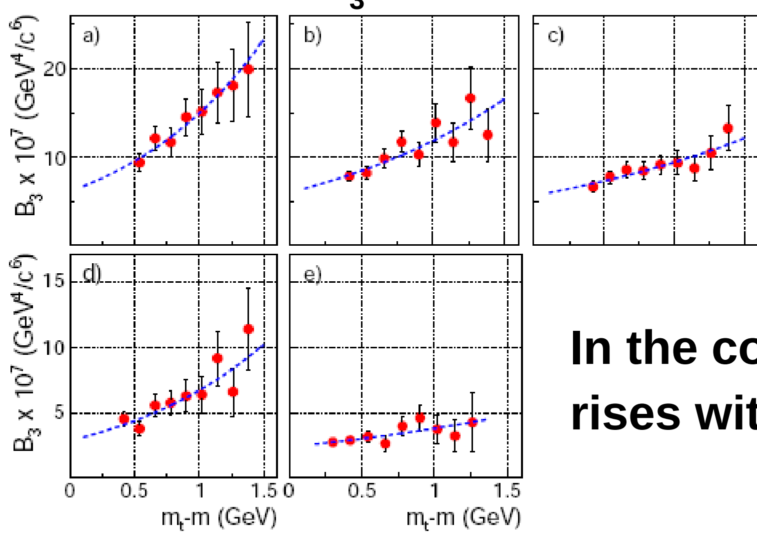
where E_A: Energy of the nucleus A and (d^3N_A/dp^3_A): differential yield of nucleus A with respect to its 3-momentum P_A
B_A is the coalescence parameter that characterizes the probability of nucleons to form nucleus A.

Coalescence parameter B_A depends on the nucleus mass number A, collision system, centrality, energy, and transverse momentum

NA49: B_2 for deuterons



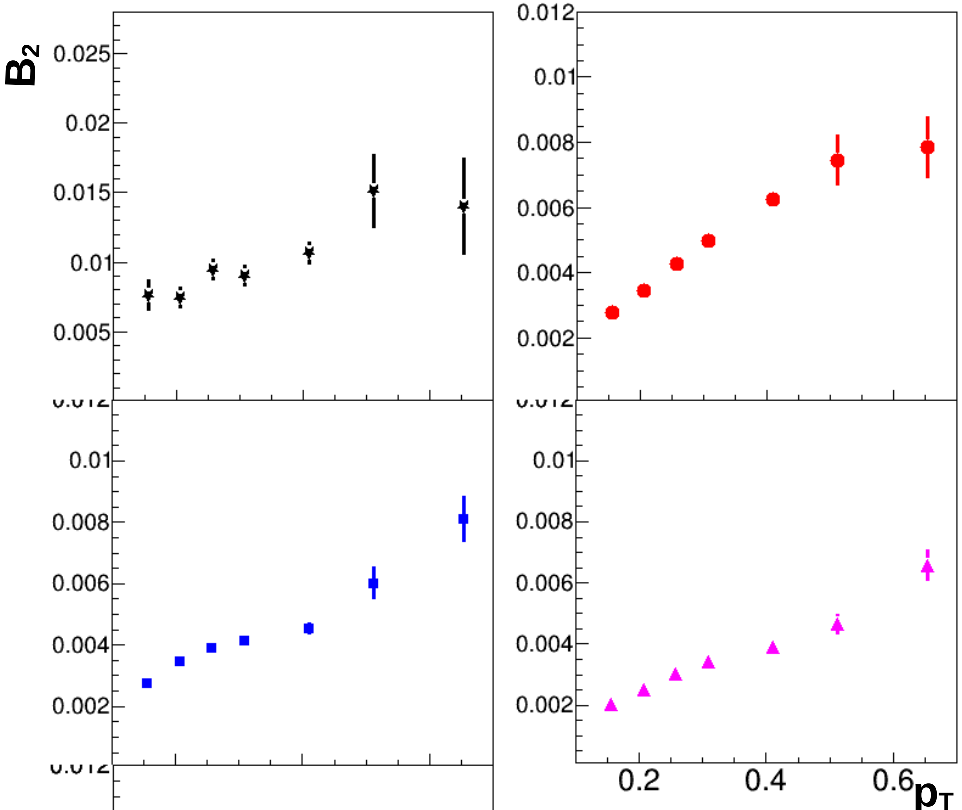
NA49: B_3 for tritons

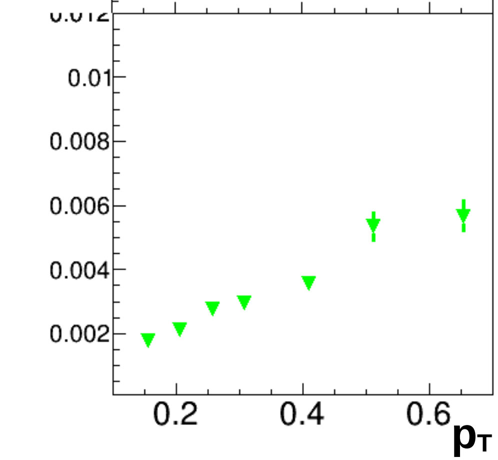


In the coalescence model B_A rises with p_T

B_2 and B_3 factors

B_2: deutrons to protons

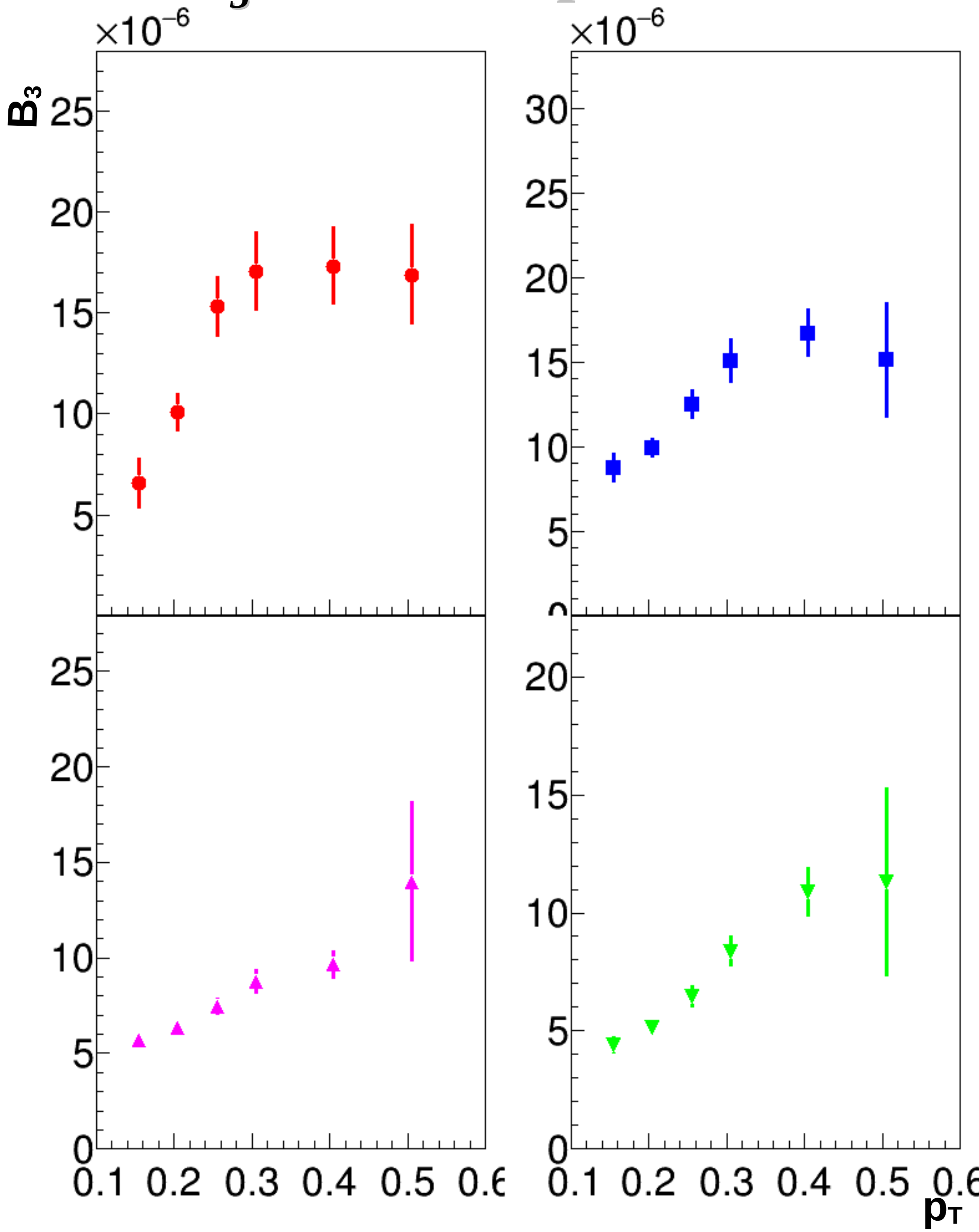




B_2 and B_3 rise with $p_T(A)/A$

$0.9 < y_{lab} < 1.7$
$(-0.18 < y^* < 0.62)$

B_3: tritons to protons



Reaction	Ar+C	Ar+Al	Ar+Cu	Ar+Sn	Ar+Pb
$N_p \cdot N_t / N^2_d$	0.55 ± 0.10	0.62 ± 0.12	0.69 ± 0.11	0.60 ± 0.06	0.59±0.06
$\langle m_t \rangle - m_p$	137 ± 2	172 ± 3	188 ± 3	189 ± 3	187 ± 3
$\langle m_t \rangle - m_d$	144 ± 12	196 ± 8	211 ± 5	222 ± 6	212 ± 5
T, MeV	76 ± 12	78 ± 7	87 ± 6	79 ± 5	85 ± 5
$\langle \beta \rangle$	0.12±0.08	0.22±0.03	0.22±0.03	0.26±0.03	0.23±0.03

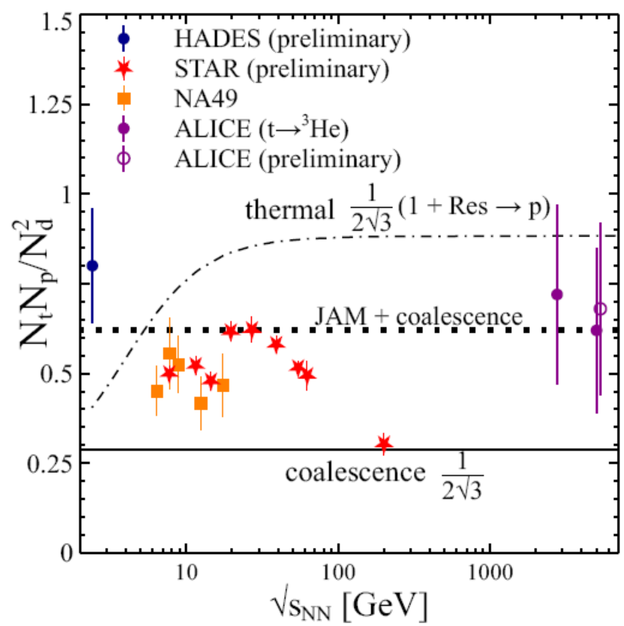
$0.9 < y_{lab} < 1.7$ $(-0.18 < y^* < 0.62)$

T and $\langle \beta \rangle$ from $\langle m_t \rangle$ for protons and deuterons: as in NA-49 analysis

$$\langle m_t \rangle - m = \langle E_t \rangle_{kin} \approx \langle E \rangle_{therm.} + \langle E \rangle_{flow} = \frac{3}{2} T + (\gamma - 1) m$$

$$\gamma = 1/\sqrt{1 - \langle \beta \rangle^2} \qquad T^* = T \sqrt{\frac{1 + \langle \beta \rangle}{1 - \langle \beta \rangle}}$$

$$\frac{N_t N_p}{N_d^2} = \frac{1}{2\sqrt{3}} \frac{1 + 2C_{np} + \Delta\rho_n}{(1 + C_{np})^2}$$



Summary

- **Results of the p,d,t analysis and possible physics messages are presented**

- **Measured coalescence factors B2 for deuterons and B3 for tritons rise with the transverse momentum, as predicted by the coalescence model**

- **Analysis of m_T spectra of protons and deuterons gives temperature T~80 MeV and <β> ~ 0.22-0.26 for Ar + Al-Pb; compared with HADES Au+Au at $\sqrt{s}$=2.4 GeV: T = 66±8 MeV and <β> = 0.34±0.02 (heavier nuclei)**

- **$N_p \cdot N_t / N^2_d$ ~ 0.6 for Ar + Al-Pb; compare with STAR and HADES results for Au+Au**

- **Compare mt and dN/dy spectra with DCM-SMM and PHMD models**

- **Plan to show results at seminars in JINR as preliminary**

Thank you for your attention !