Positively charged pions and kaons production in argon-nucleus collisions at 3.2 GeV/n in the BM@N experiment at the Nuclotron

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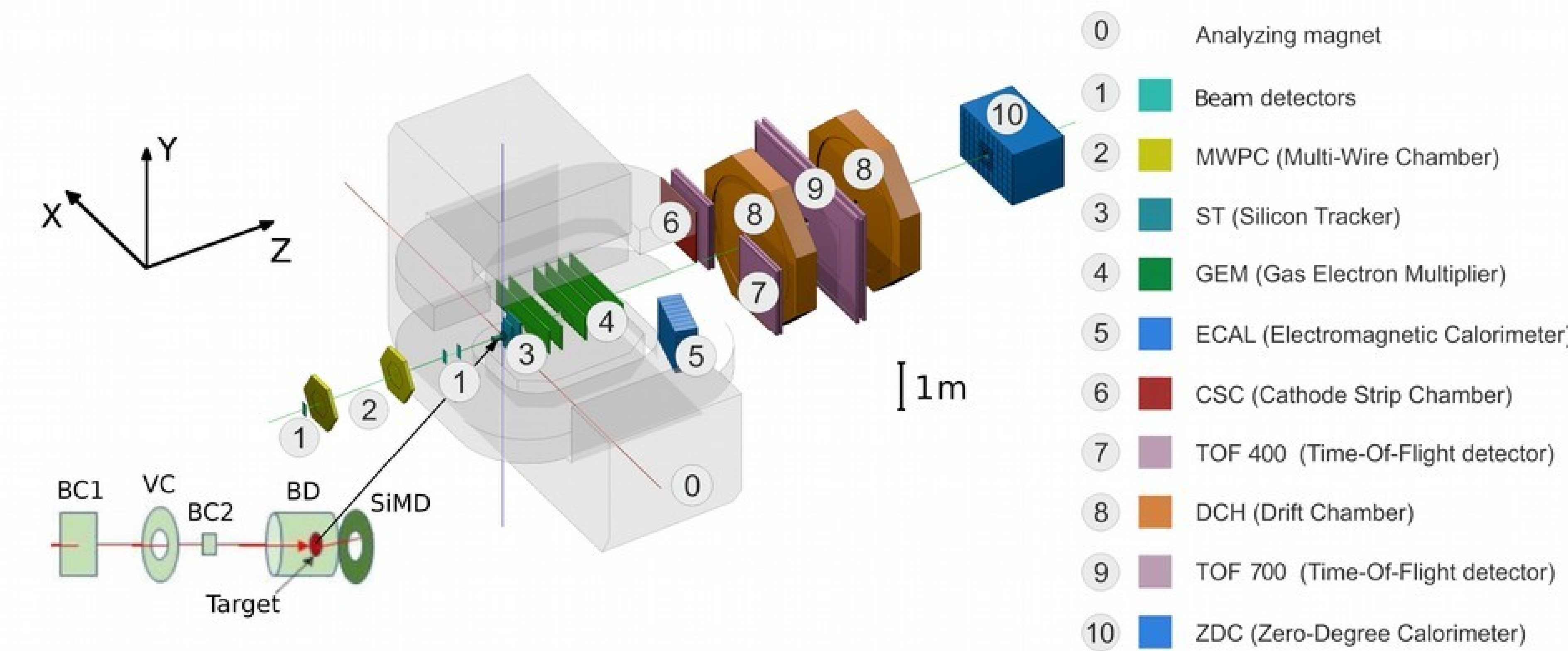
Outline

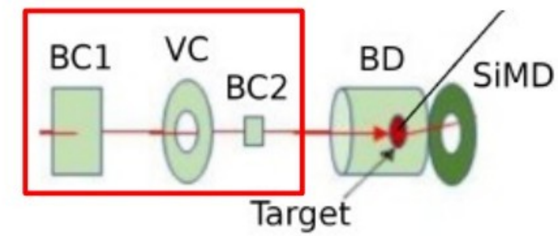
1. Run with argon beam (March 2018)
   - ✓ BM@N detector set-up
2. Data analysis (*Ar+C*, *Ar+Al*, *Ar+Cu*, *Ar+Sn*, *Ar+Pb* at 3.2A GeV)
   - ✓ Selection criteria
   - ✓ Reconstructed signal of π^+ and K^+
   - ✓ Data - MC agreement
   - ✓ π^+ and K^+ reconstruction efficiency
   - ✓ Trigger efficiency
   - ✓ Yields of π^+ and K^+
   - ✓ Systematic uncertainties
   - ✓ p_T and y spectra of π^+ and K^+ and extracted inverse slope parameter
   - ✓ Extrapolation factors and number of participants
3. Summary

BM@N set-up in Ar run



Detectors used in the analysis: Beam detectors (1), Multiplicity Detectors, ST (3), GEM (4), CSC (6), TOF 400 (7), DCH (8), TOF 700 (9).

Event selection criteria



✓ Beam halo, pile-up suppression within the readout time window, number of signals in the start detector: BC1=1, number of signals in the beam counter: BC2=1, number of signals in the veto counter around the beam: Veto=0;

✓ Trigger condition in the multiplicity detectors: number of signals BD≥m, m ∈ [2;4], SiMD≥n, n ∈ [2;4] and combinations of SiMD and BD triggers (run dependent).

Number of triggered events, beam fluxes and integrated luminosities collected for the argon beam of 3.2A GeV (*ToF-400* (*ToF-700*)).

Interactions (target thickness)	**Number of triggers / 10^6**	**Integrated beam flux / 10^7**	**Integrated luminosity / 10^{30} cm^{-2}**
Ar+C (2mm)	11.7 (11.3)	10.9 (8.7)	2.06 (1.97)
Ar+Al (3.33mm)	30.6 (29.2)	15.4 (10.2)	2.30 (2.05)
Ar+Cu (1.67mm)	30.9 (28.7)	15.9 (11.3)	1.79 (1.60)
Ar+Sn (2.57mm)	30.0 (25.9)	15.1 (9.5)	1.11 (0.91)
Ar+Pb (2.5mm)	13.7 (13.7)	7.0 (4.9)	0.50 (0.40)

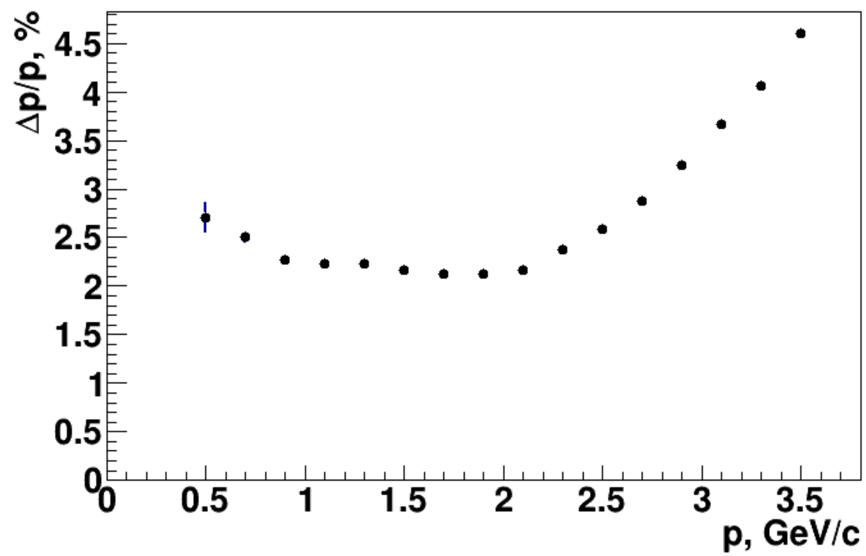
Technical characteristics of the Ar run

- ✓ Beam intensity: few 10^5 ions per spill
- ✓ Spill duration: 2–2.5 s
- ✓ Nuclear length of solid targets: ~3%
- ✓ Analized events: ~16.3M

- ✓ Pseudorapidity range: $1.6 \le \eta \le 4.4$

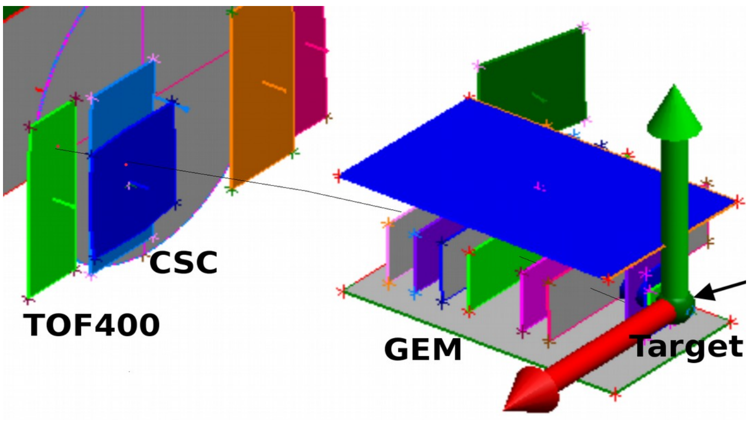
Analysing magnet bending power: ~2.1T·m

- ✓ Resolution of the distance from a track to PV in the X-Y plane: 2.4 mm
- ✓ Time resolutions of the ToF-400 and ToF-700 systems: 84 ps and 115 ps



Relative momentum resolution as a function of the momentum

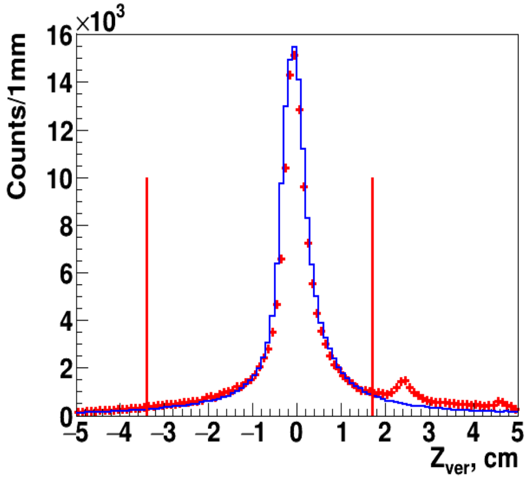
π^+ and K^+ selection criteria

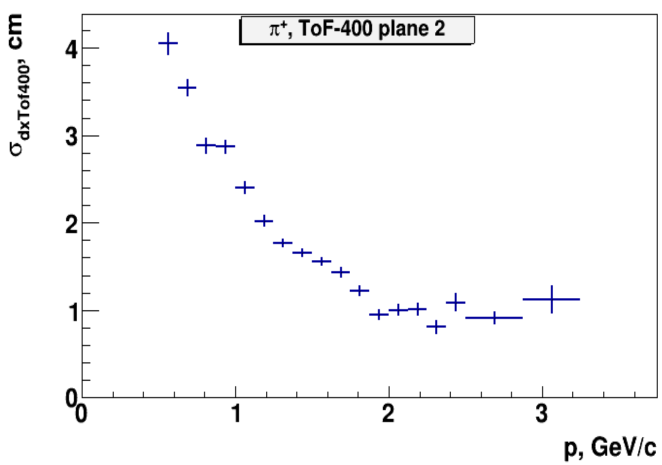


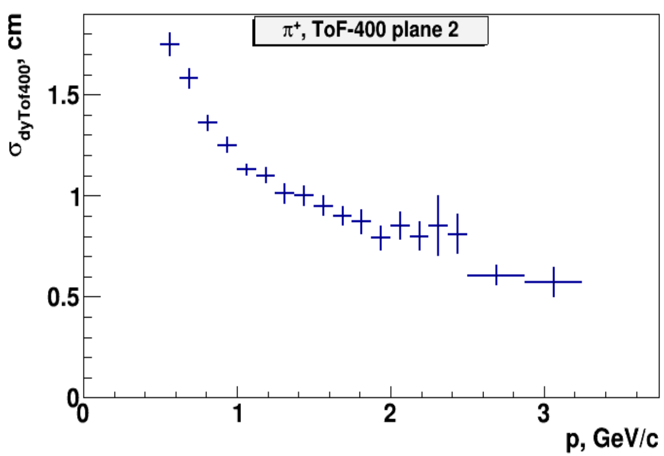
Abbreviation:

- ✓ PV – primary vertex

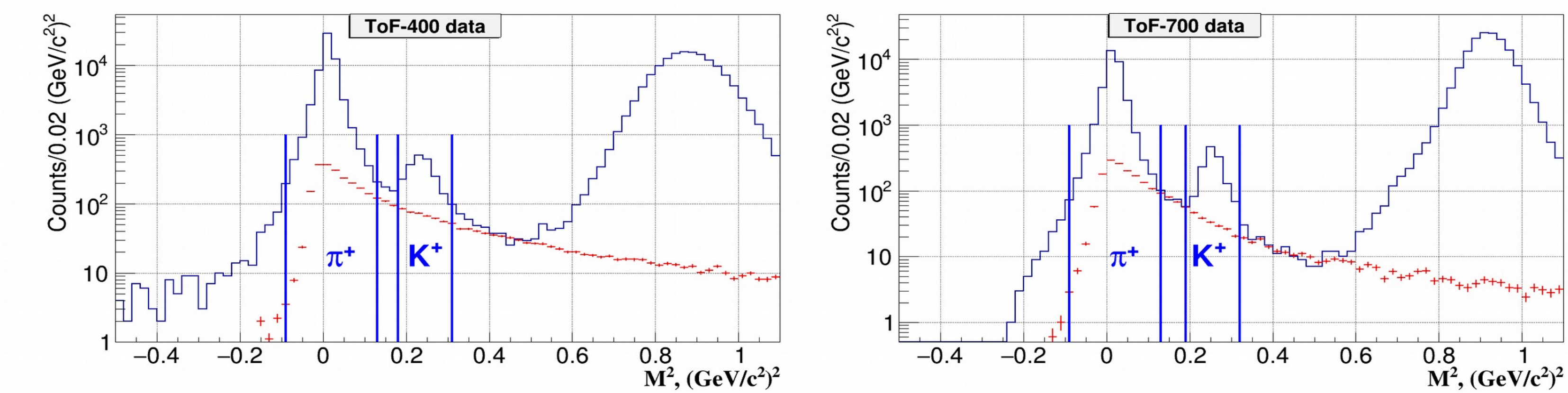
- ✓ Number of hits in 6 GEM per track > 3
- ✓ Number of tracks in the PV > 1
- ✓ Tracks from PV: $-3.4 < Z_{PV} - Z_0 < 1.7$ cm
- ✓ Momentum range of tracks for ToF-400 (ToF-700): $p > 0.5\ (0.7)$ GeV/c
- ✓ Distance from a track to PV in the X-Y plane: $dca < 1$ cm
- ✓ χ^2/NDF for tracks from the PV $< 3.5^2$
- ✓ Distance of extrapolated tracks to *CSC* (*DCH*) and *ToF-400* (*ToF-700*): $|resid_{X,Y}| < 2.5\ \sigma$ of hit-track residual distribution







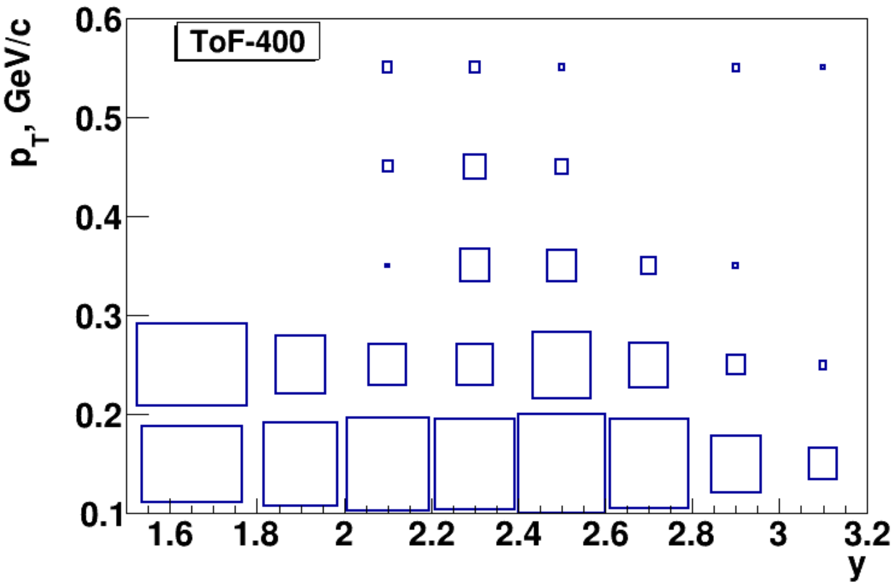
Signal of π^+ and K^+ in $Ar+A$ interaction

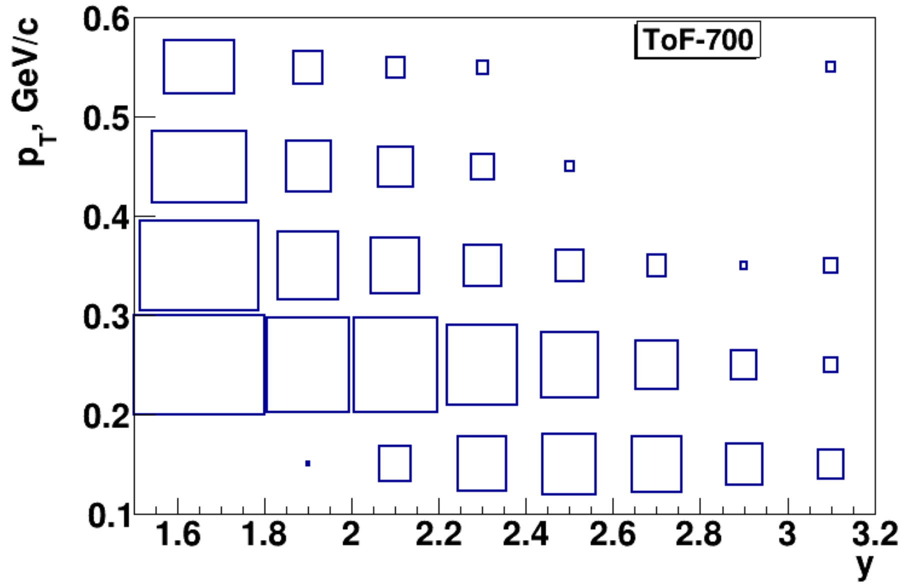


M^2 spectra of positive particles produced in argon-nucleus interactions and measured in the ToF-400 (left) and ToF-700 (right) detectors. Vertical lines show the signal ranges of identified π^+ and K^+ mesons. Red points with the error bars show the the background estimated from "mixed" events.

Reconstructed signals of π^+ and K^+ for *ToF-400* and *ToF-700*.

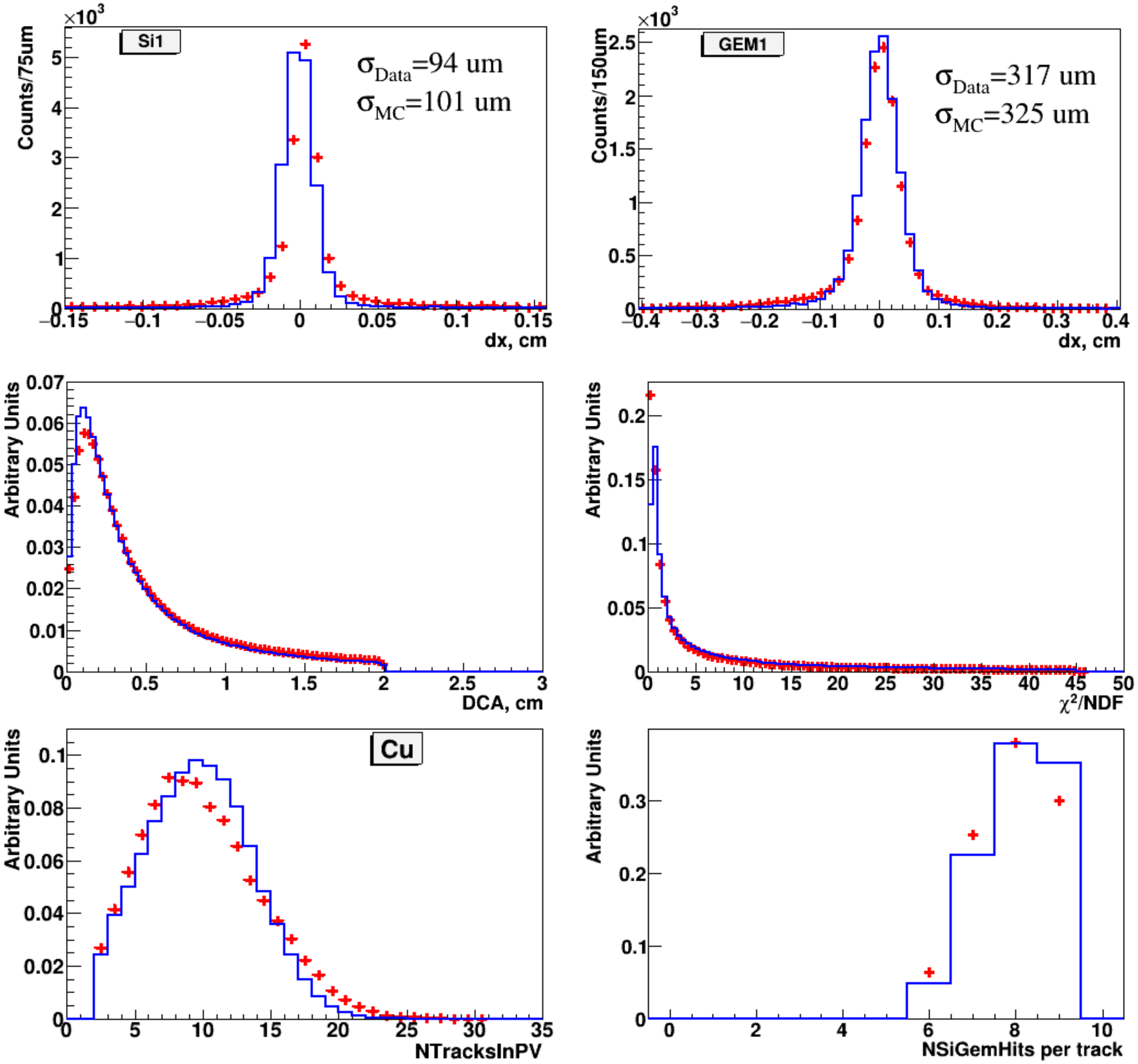
Particle, Detector	**Target**				
	C	***Al***	***Cu***	***Sn***	***Pb***
π^+, *ToF-400*	4020±66	21130±152	28010±175	32060±186	22420±156
π^+, *ToF-700*	1070±34	5640±80	8090±95	9450±104	6830±86
K^+, *ToF-400*	45±10	278±25	538±31	729±36	570±32
K^+, *ToF-700*	31±6	117±16	193±21	346±23	221±20





Distribution of the π^+ signals measured in ToF-400 (left) and ToF-700 (right) in the rapidity and transverse momentum bins in Ar+Sn interactions.

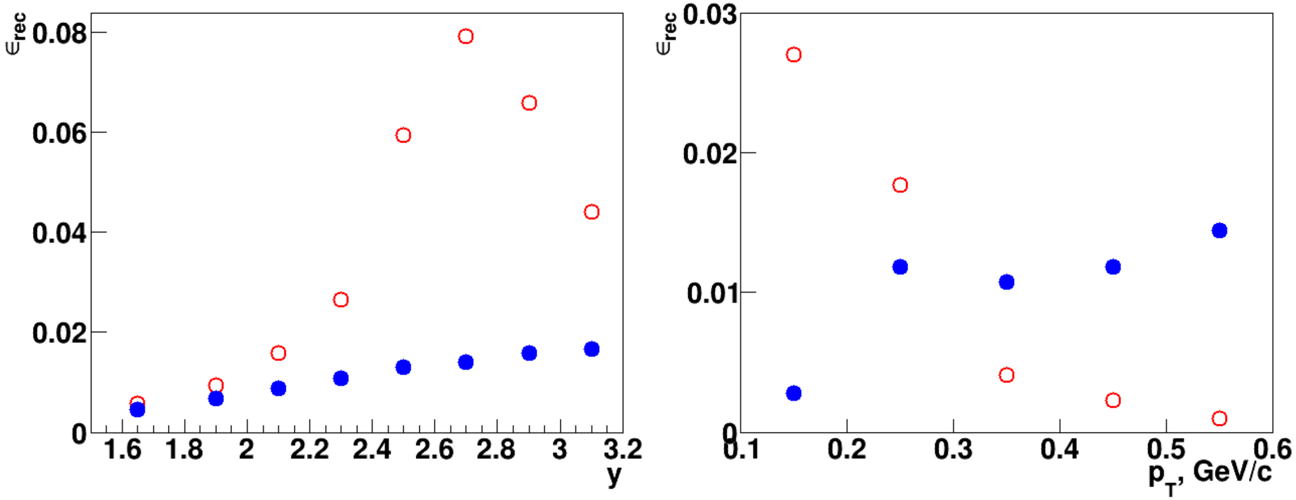
Comparison of experimental data and MC



Residual distributions of hits in the X projection (magnet deflection plane) with respect to reconstructed tracks: (left) - in the first forward silicon plane, (right) - in the first GEM plane. Experimental data are shown as red crosses, and simulated data are shown as blue histograms.

Comparison of the experimental distributions (red crosses) and reconstructed Monte Carlo GEANT distributions of events generated with the DCM-SMM model (blue lines): DCA; χ^2/NDF of reconstructed tracks; number of tracks reconstructed in the primary vertex; number of hits per track reconstructed in 3 forward silicon and 6 GEM detectors.

Reconstruction efficiency of π^+



Reconstruction efficiency of π^+ detected in ToF-400 (open red circles) and ToF-700 (full blue circles), calculated as a product of the geometrical acceptance, detector efficiency and efficiency of kinematic and spatial cuts in bins of the rapidity y in the laboratory frame (left) and in bins of p_T (right). The results are shown for π^+ mesons produced in Ar+Sn interactions.

$$\varepsilon_{rec}(y,p_T) = N_{rec}(y,p_T)/N_{gen}(y,p_T),$$

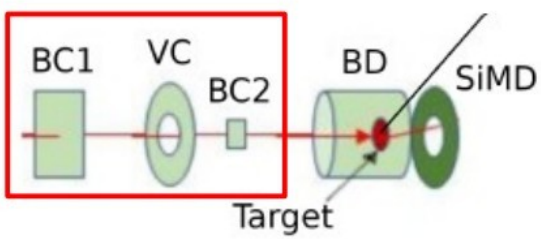
where N_{rec} – number of reconstructed π^+ (K^+), N_{gen} – number of generated π^+ (K^+). The π^+ and K^+ reconstruction efficiency is evaluated in intervals of the rapidity y and transverse momentum p_T. It takes into account the geometrical acceptance, the detector efficiency, the efficiency of kinematic, spatial cuts and the losses of π^+ and K^+ due to decays on flight.

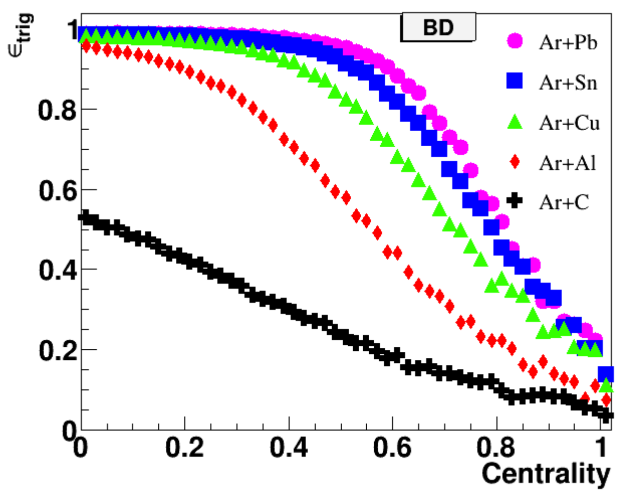
Trigger efficiency

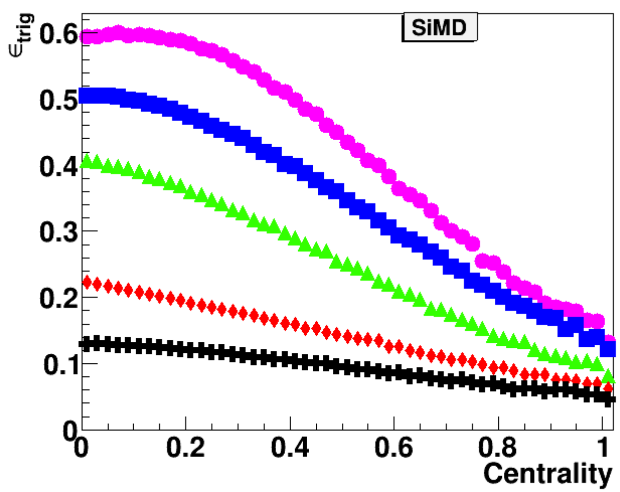
The efficiency to get a trigger signal based on multiplicities of fired channels in the BD (SiMD) detectors ε_{trig} was calculated for events with reconstructed π^+ and K^+ mesons using experimental event samples recorded with an independent trigger based on the SiMD (BD) detectors:

$$\varepsilon_{trig}(BD \geq m) = N(BD \geq m, SiMD \geq n)/N(SiMD \geq n),$$

where m and n are the minimum number of fired channels in BD and SiMD varied in the range from 2 to 4. The dependences of the trigger efficiency on the track multiplicity in the primary event vertex and the X/Y vertex position were taken into account. The efficiency for the combined BD and SiMD triggers was calculated as a product of the BD and SiMD trigger efficiencies. The systematic uncertainties combine the differences in the π^+, K^+ signals obtained by using $<\varepsilon_{trig}>$ instead of $\varepsilon_{trig}(N_{tr}, X_{PV}, Y_{PV})$ and the differences with $\varepsilon_{trig}(BT)$.







Results

The differential cross sections $d^2\sigma_{\pi,K}(y, p_T)/dydp_T$ and yields $d^2N_{\pi,K}(y, p_T)/dydp_T$ of π^+ and K^+ meson production in Ar+C, Al, Cu, Sn, Pb interactions are calculated in bins of (y, p_T) according to the formulae:

$$\mathbf{d^2\sigma_{\pi,K}(y,p_T) / dydp_T = \Sigma\left(d^2n_{\pi,K}(y,p_T,N_{tr}) / \varepsilon_{trig}(N_{tr})dydp_T\right) \cdot 1/ (\varepsilon_{rec}(y,p_T) \cdot L)}$$

$$\mathbf{d^2N_{\pi,K}(y,p_T) / dydp_T = d^2\sigma_{\pi,K}(y,p_T) / dydp_T / \sigma_{inel}}$$

where L is the luminosity,

$n_{\pi,K}$ – the number of reconstructed π^+ and K^+ mesons in intervals dy and dp_T,

ε_{rec} – the efficiency of the π + and K + meson reconstruction,

ε_{trig} – the trigger efficiency,

σ_{inel} – the cross section for minimum bias inelastic *Ar+A* interactions.

The cross sections for inelastic *Ar+C, Al, Cu, Sn, Pb* interactions are taken from the predictions of the DCM-SMM model which are consistent with the results calculated by the formula:

$\boldsymbol{\sigma_{inel} = \pi R_0^2 (A_P^{1/3} + A_T^{1/3})^2}$, where R_0 = 1.2 fm is an effective nucleon radius, A_P and A_T are atomic numbers of the beam and target nucleus.

Interaction	***Ar+C***	***Ar+Al***	***Ar+Cu***	***Ar+Sn***	***Ar+Pb***
σ_{inel}, mb	1470±50	1860±50	2480±50	3140±50	3970±50

Systematic uncertainties

The systematic uncertainty of the π^+ and K^+ meson yields and ε_{rec} in every p_T and y bin is calculated as a root square of quadratic sum of uncertainties coming from the following sources:

Sys1: systematic uncertainty of the central tracking detector efficiency.

Sys2: systematic uncertainty of the matching of central tracks to the CSC (DCH) hits and ToF-400 (ToF-700) hits.

Sys3: systematic errors of the reconstruction efficiency due to the remaining difference in the X/Y primary vertex distribution in the simulation relative to the experimental data.

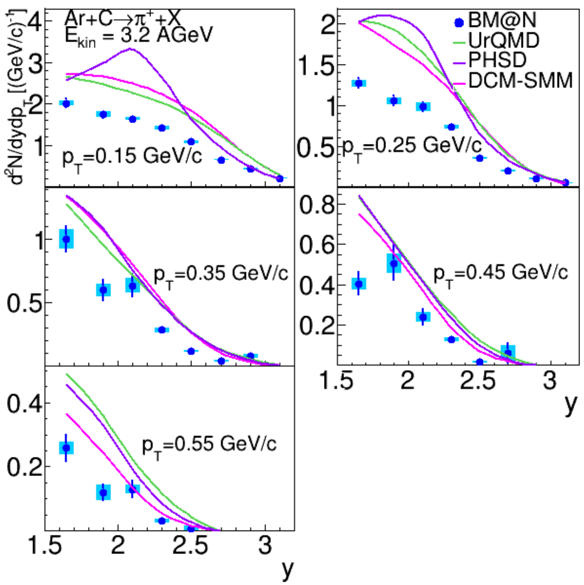
Sys4: systematic errors of the background subtraction under the π^+ and K^+ signals in the mass squared spectra of identified particles.

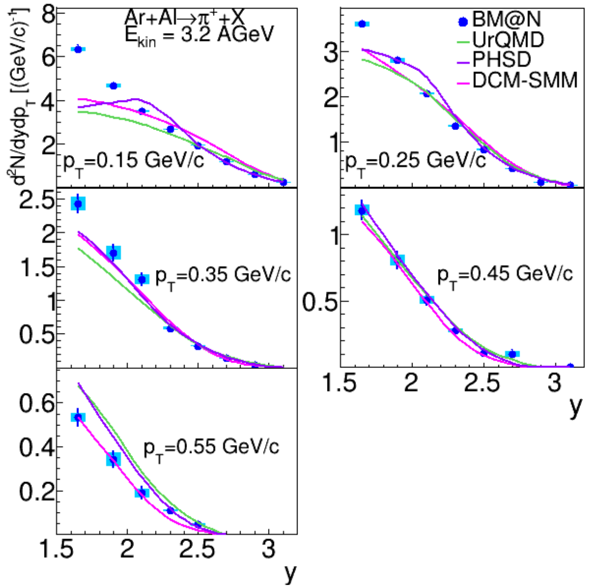
Mean systematic uncertainties in y, p_T bins of the π^+ and K^+ mesons.

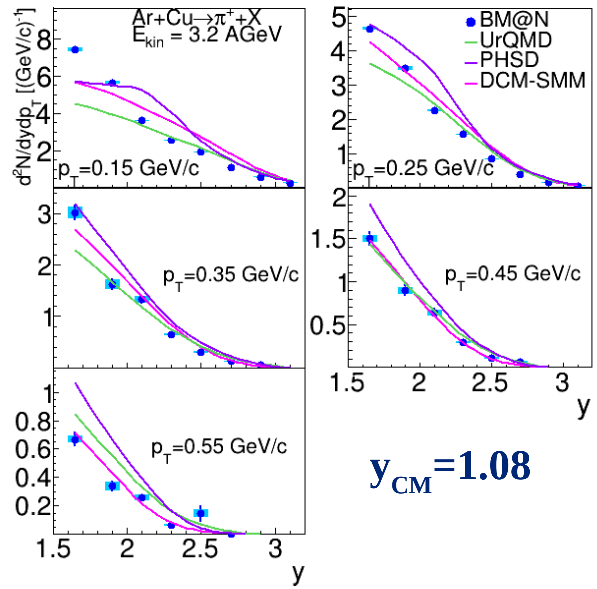
Target / Systematics	π^+					Target / Systematics	K^+				
	***C*,** sys%	***Al*,** sys%	***Cu*,** sys%	***Sn*,** sys%	***Pb*,** sys%		***C*,** sys%	***Al*,** sys%	***Cu*,** sys%	***Sn*,** sys%	***Pb*,** sys%
Total	17	14	14	13	13	Total	40	27	17	16	17

The π^+ and K^+ meson yield normalization uncertainties are calculated for the whole measured (y, p_T) range as a quadratic sum of the statistical uncertainty of the trigger efficiency, uncertainties of the tracking detector efficiency, efficiency of the track matching to the CSC (DCH) outer detectors and to ToF-400 (ToF-700), uncertainties of the luminosity and inelastic nucleus-nucleus cross section.

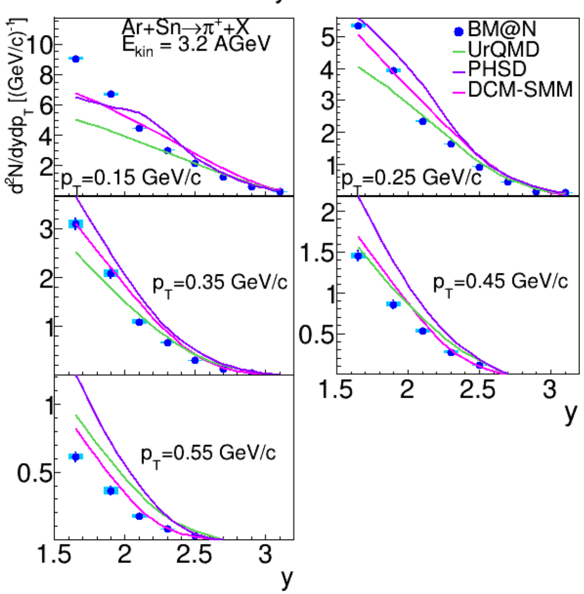
y spectra of π^+ mesons

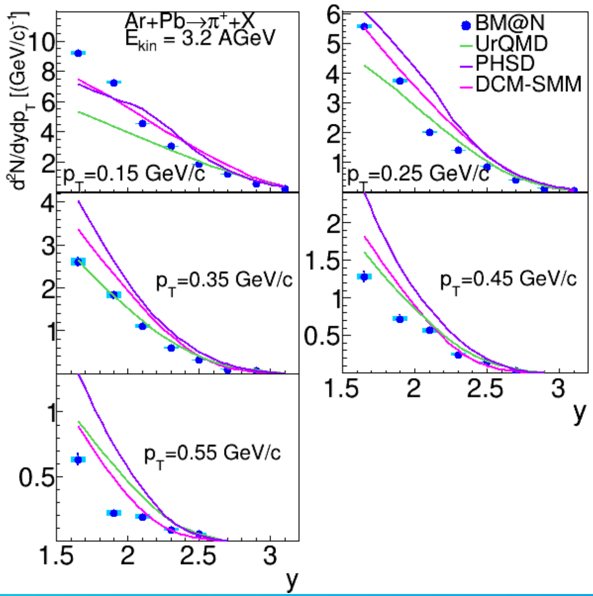






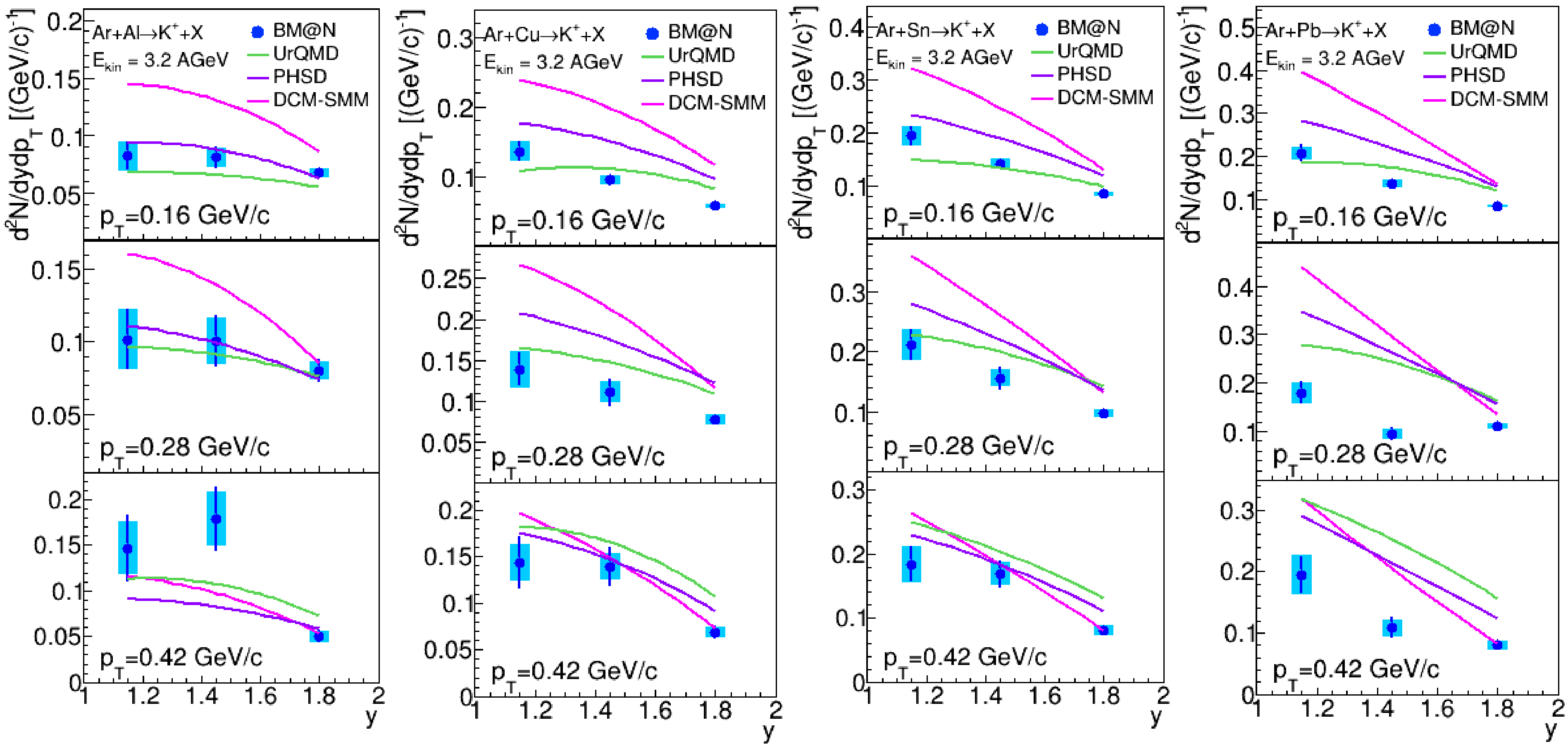
y_{CM}=1.08





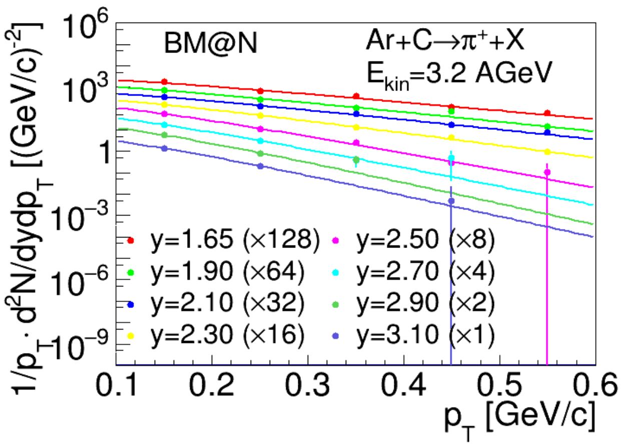
Rapidity spectra (y) of π^+ mesons produced in Ar+C, Al, Cu, Sn, Pb interactions at the argon beam energy of 3.2 AGeV. The results are given for bins of π^+ meson transverse momentum. The error bars represent the statistical errors, the boxes show the systematic errors. The predictions of the DCM-SMM, UrQMD and PHSD models are shown as rose, green and magenta lines.

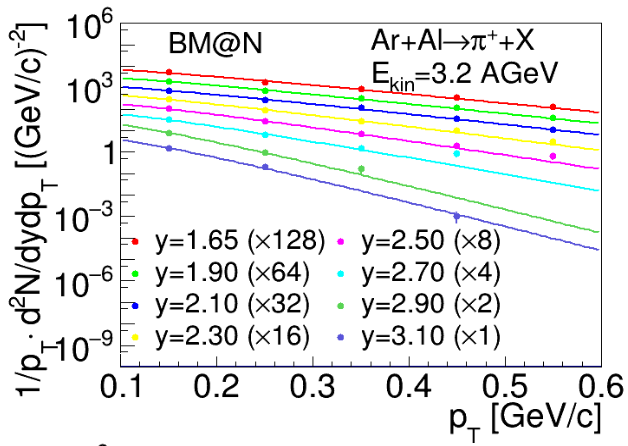
y spectra of K^+ mesons

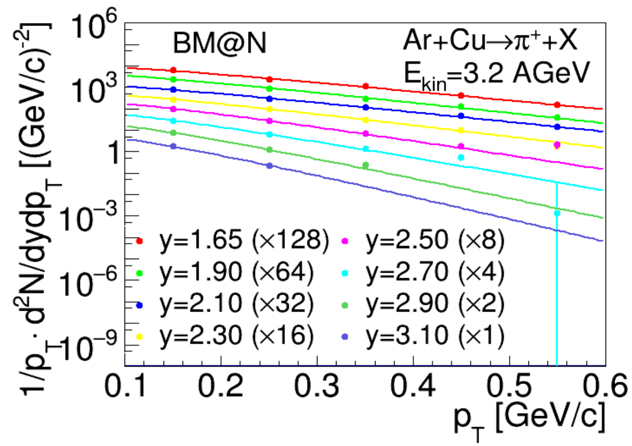


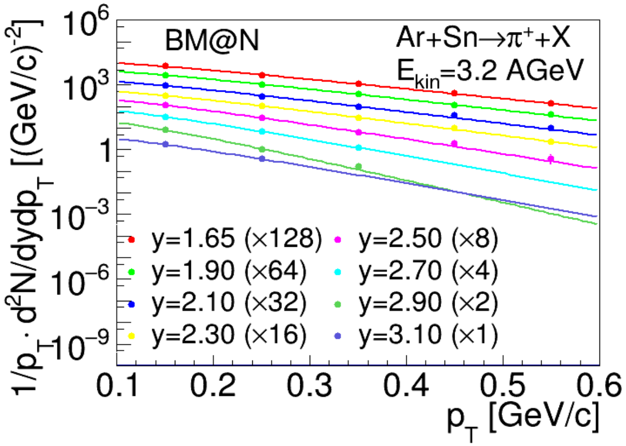
Rapidity spectra (y) of K^+ mesons produced in Ar+Al, Cu, Sn, Pb interactions at the argon beam energy of 3.2 AGeV. The results are given for bins of K^+ meson transverse momentum. The error bars represent the statistical errors, the boxes show the systematic errors. The predictions of the DCM-SMM, UrQMD and PHSD models are shown as rose, green and magenta lines.

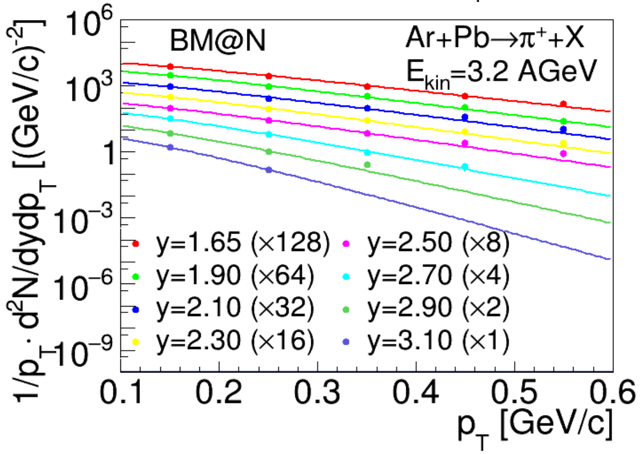
Invariant p_T spectra of π^+ mesons









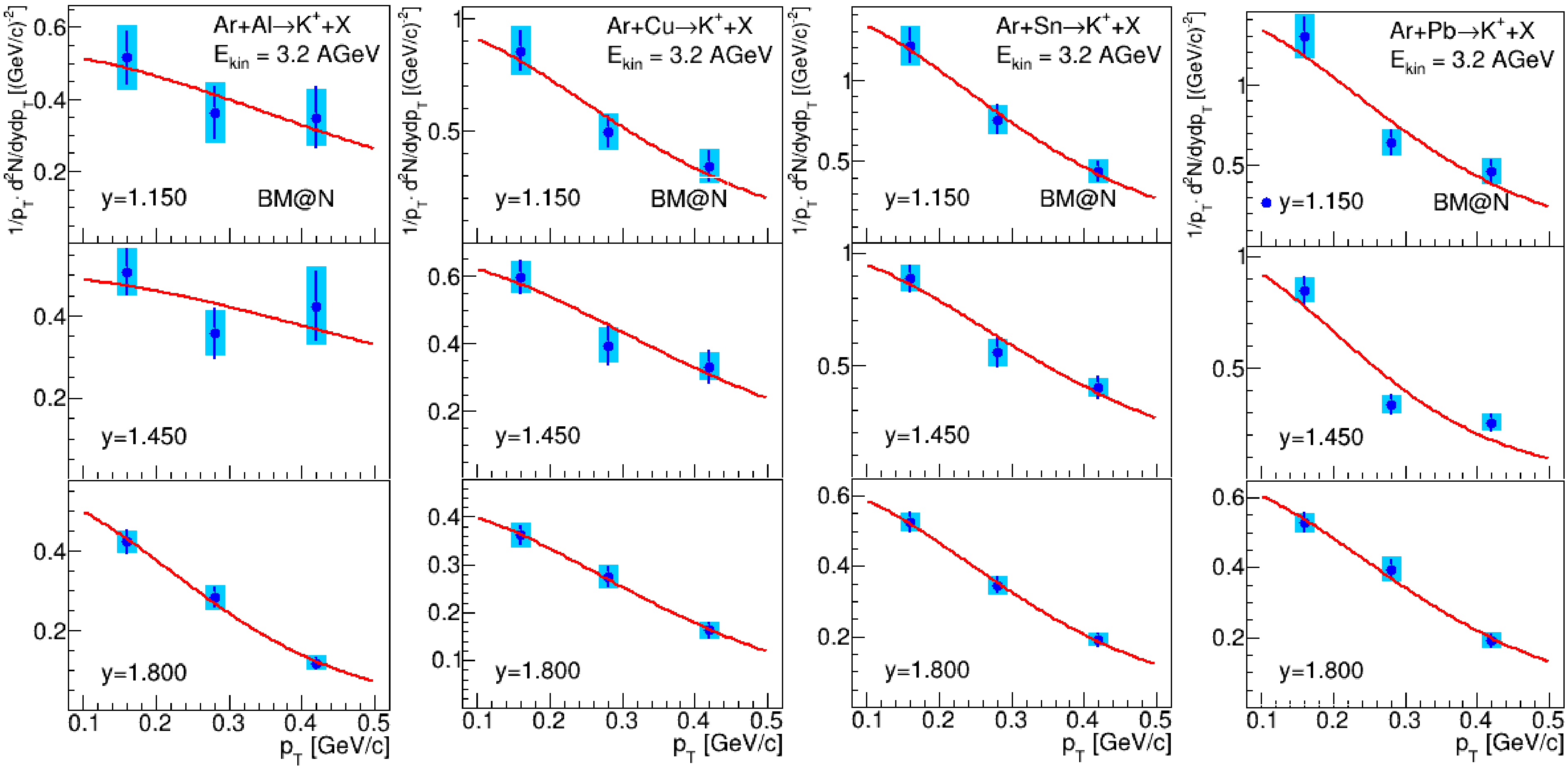


Invariant transverse momentum spectra (p_T) of π^+ mesons produced in Ar+C, Al, Cu, Sn, Pb interactions at the argon beam energy of 3.2 AGeV. The results are given for bins of π^+ meson rapidity. Results of the fit are shown as curves.

$$1/p_T \cdot d^2N/dp_T dy = C \cdot exp(-(m_T - m_{\pi,K})/T_0)$$

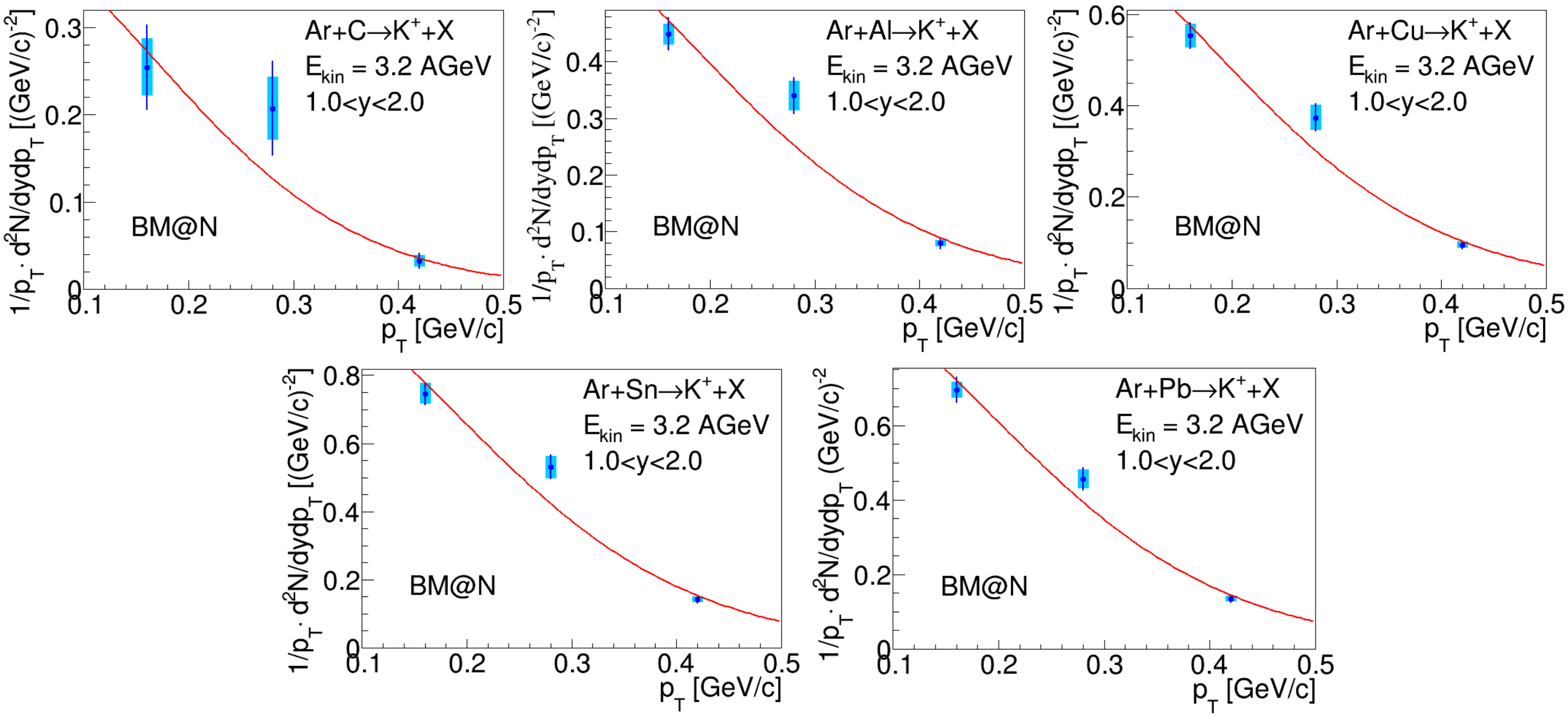
where $m_T = \sqrt{(m_{\pi,K}^2 + p_T^2)}$ is the transverse mass, C – normalization (free parameter), T_0 – inverse slope (free parameter), dy is the width of the measured y bin, dp_T is the width of the measured p_T bin.

Invariant p_T spectra of K^+ mesons



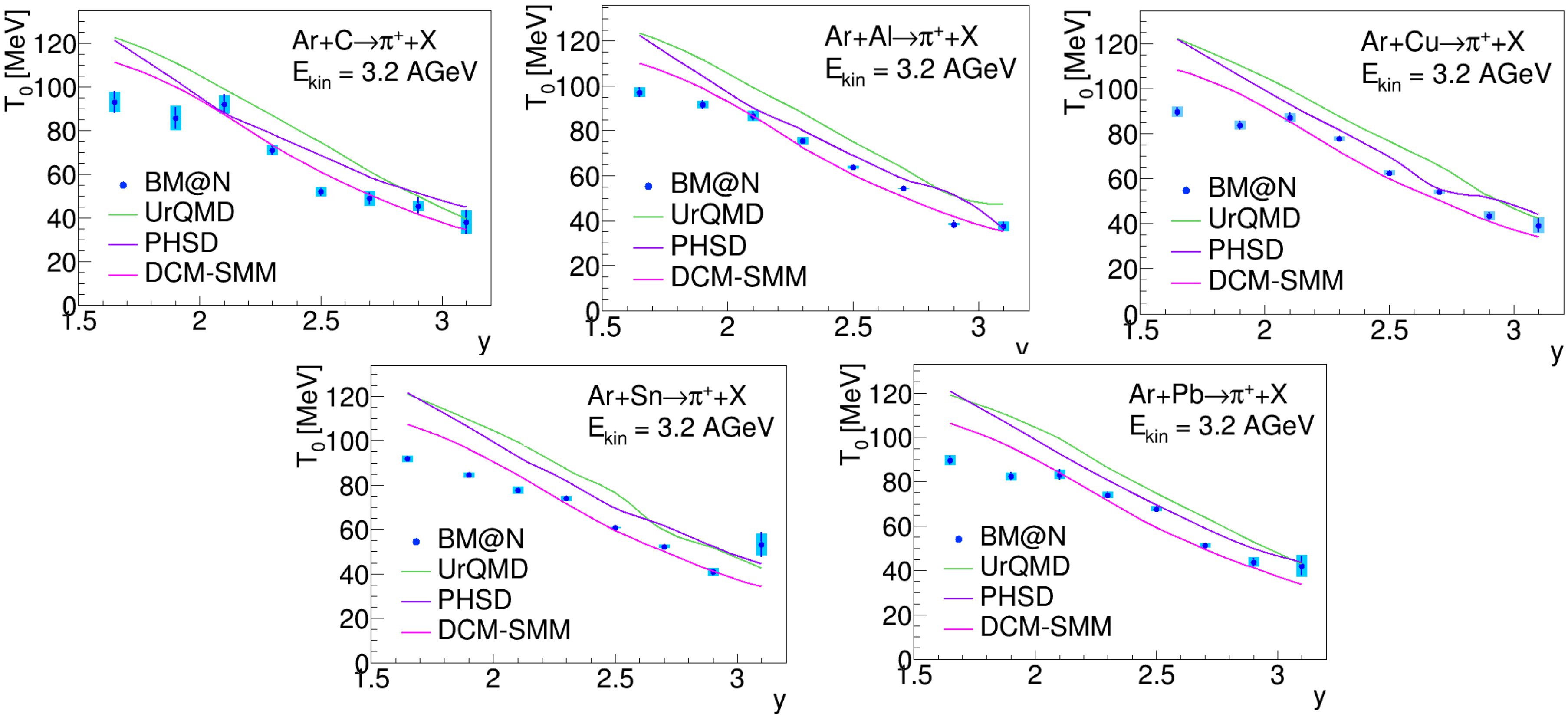
Invariant transverse momentum spectra (p_T) of K^+ mesons produced in Ar+Al, Cu, Sn, Pb interactions at the argon beam energy of 3.2 AGeV. The results are given for three bins of K^+ meson rapidity. The error bars represent the statistical errors, the boxes show the systematic errors. Results of the fit are shown as red curves.

Invariant p_T spectra of K^+ mesons



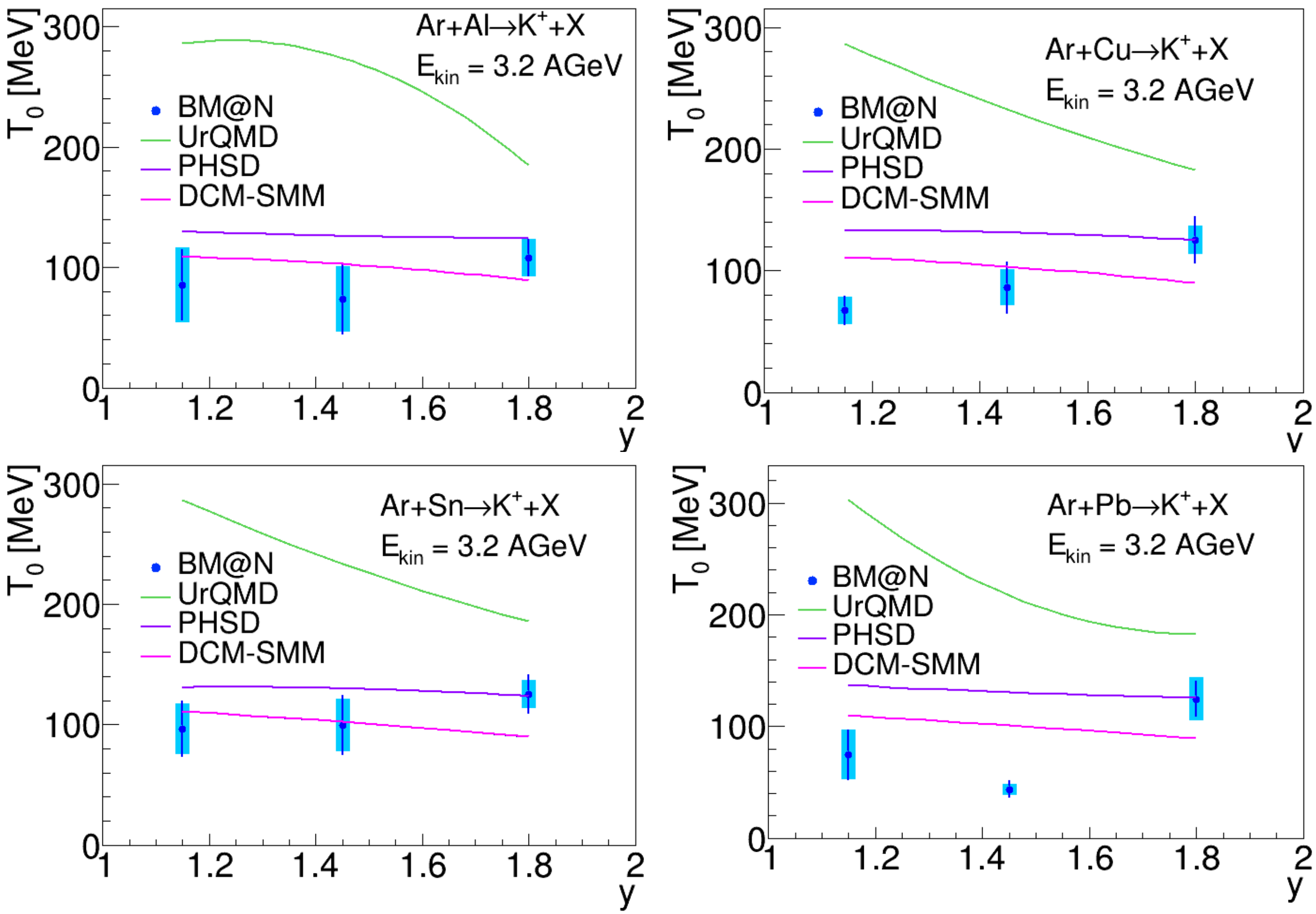
Reconstructed invariant transverse momentum p_T spectra of K^+ in the measured rapidity range in minimum bias Ar+C, Ar+Al, Ar+Cu, Ar+Sn, Ar+Pb interactions at 3.2 AGeV argon beam energy (symbols). Results of the fit are shown as red curves.

Inverse slope parameter T_0 of π^+ mesons



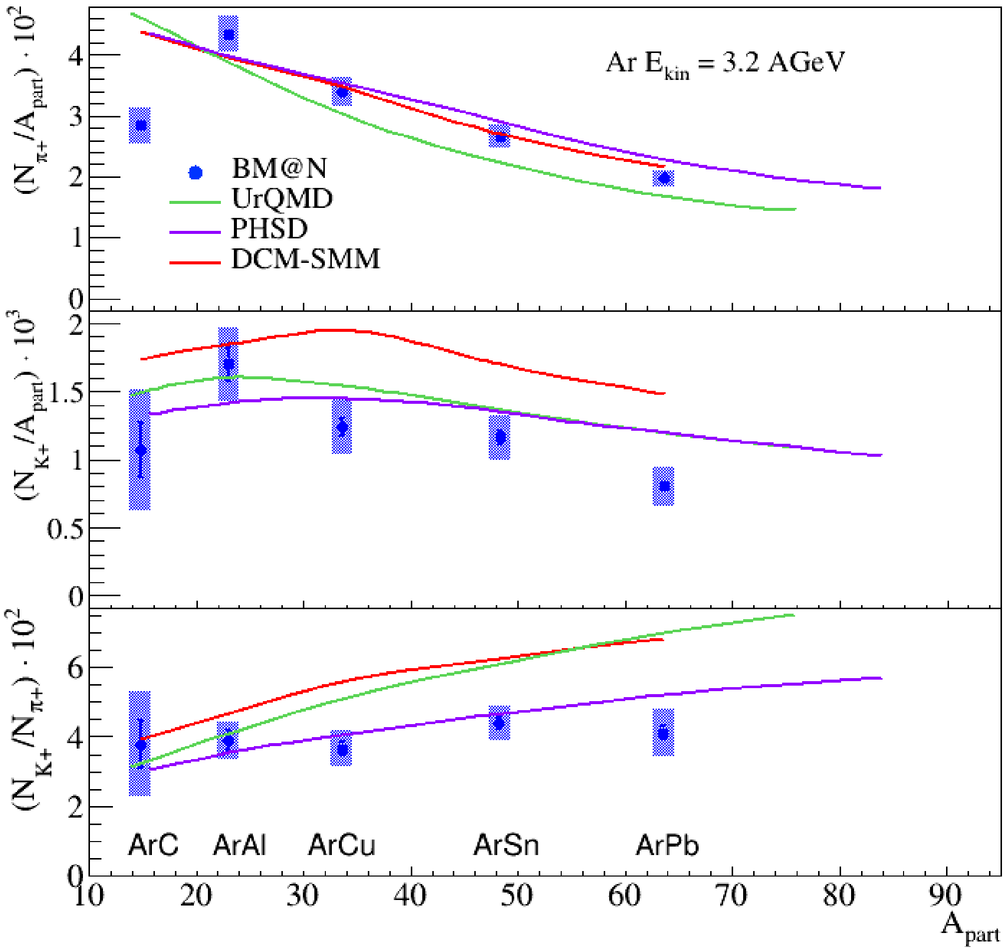
Rapidity y dependence of the inverse slope T_0 extracted from the fits of the π^+ p_T spectra in Ar+C, Al, Cu, Sn, Pb interactions. The error bars represent the statistical errors, the boxes show the systematic errors. The predictions of the DCM-SMM, UrQMD and PHSD models are shown as rose, green and magenta lines.

Inverse slope parameter T_0 of K^+ mesons



Rapidity *y* dependence of the inverse slope T_0 extracted from the fits of the K^+ p_T spectra in Ar+Al, Cu, Sn, Pb interactions. The error bars represent the statistical errors, the boxes show the systematic errors. The predictions of the DCM-SMM, UrQMD and PHSD models are shown as rose, green and magenta lines.

$N_{\pi+}/A_{part}$, N_{K+}/A_{part}, $N_{K+}/N_{\pi+}$



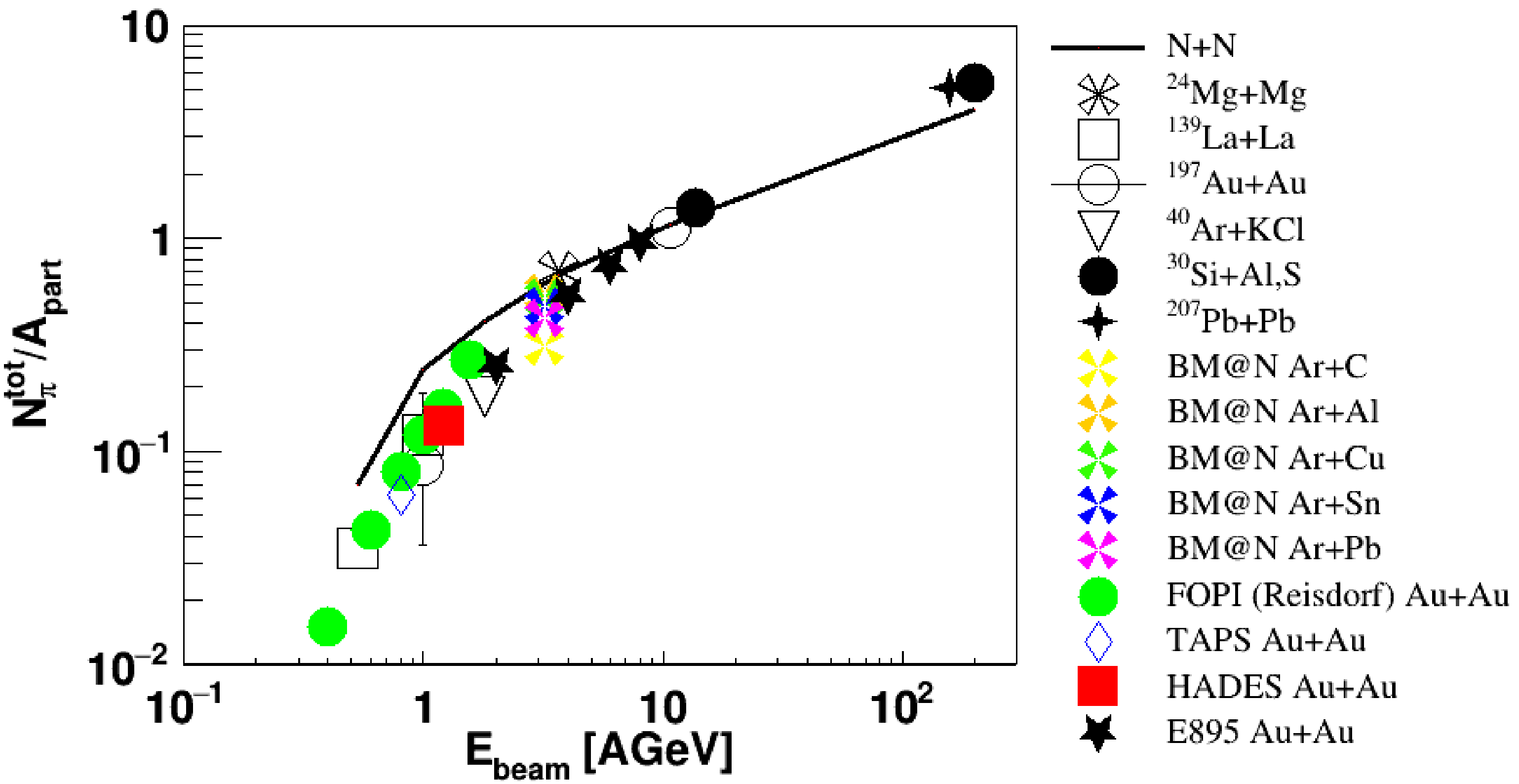
Ratios of the π^+ (top) and K^+ (middle) multiplicities to the number of nucleons-participants and ratios of the K^+ to π^+ multiplicities (bottom) in the measured kinematical range in Ar+C, Al, Cu, Sn, Pb interactions. The error bars represent the statistical errors, the blue boxes show the systematic errors. The BM@N results are compared with predictions of the DCM-SMM, UrQMD and PHSD models for argon-nucleus interactions shown as red, green and magenta lines.

Extrapolation factors and A_{part}

1) Extrapolation factors for π^+ and K^+ meson multiplicities from the measured range to the full kinematical range. The factors are averaged over predictions of the DCM-SMM, PHSD, UrQMD models. The errors are maximum difference between the model factors from their averaged value.
2) Number of nucleons-participants from predictions of the DCM-SMM model.

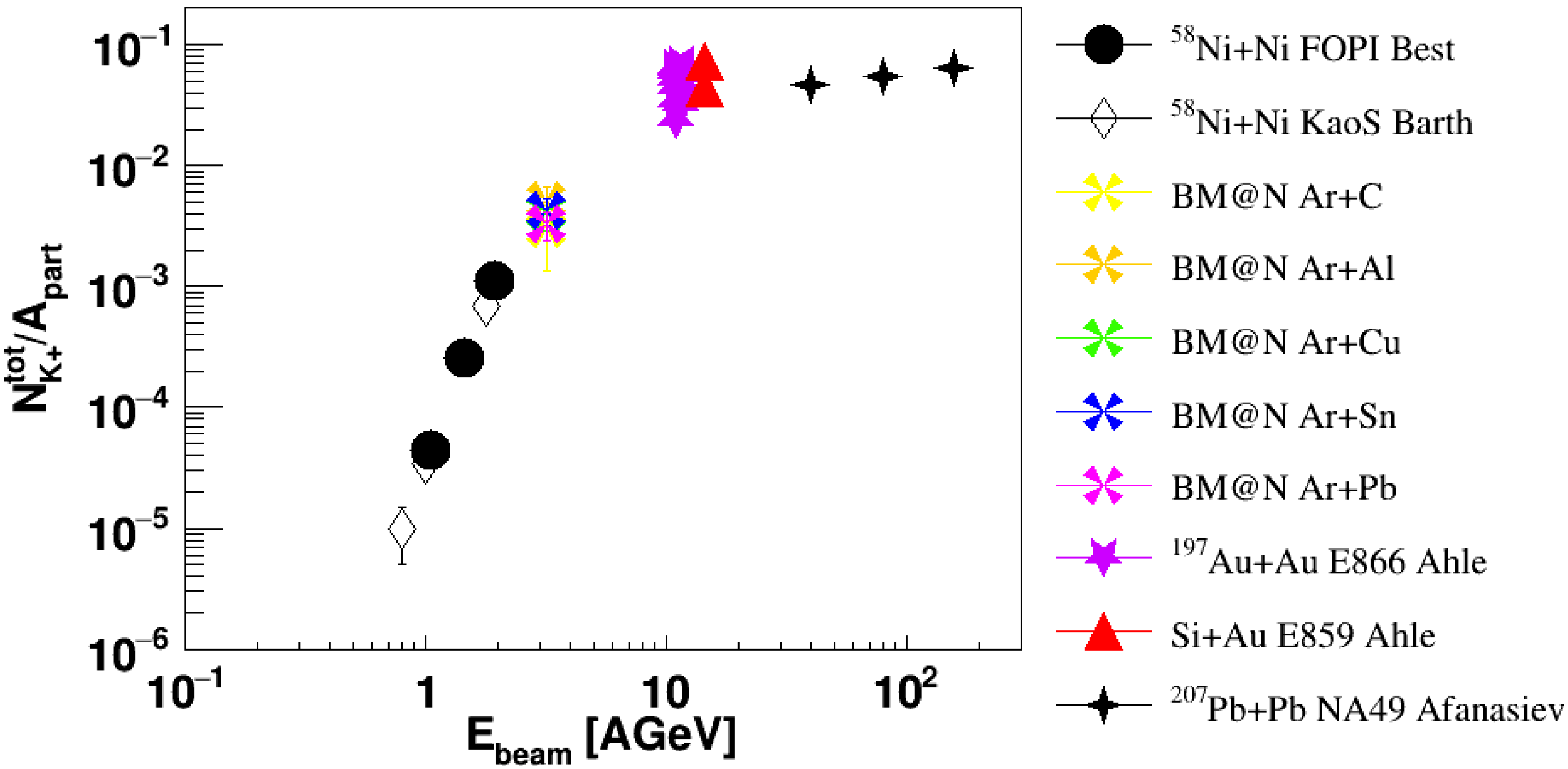
3.2 AGeV	***C***	***Al***	***Cu***	***Sn***	***Pb***
Extrap. factor for π^+	3.25 ± 0.18	3.73 ± 0.13	4.45 ± 0.07	5.12 ± 0.26	5.91 ± 0.55
Extrap. factor for K^+	2.81 ± 0.66	3.02 ± 0.67	3.34 ± 0.65	3.7 ± 0.58	4.1 ± 0.43
A_{part}, DCM-SMM	14.8	23.0	33.6	48.3	63.6

N_π^{tot}/A_{part}



Pion multiplicity N_π^{tot} per the mean number of nucleons-participants A_{part} shown as a function of the beam kinetic energy E_{beam}. The BM@N results are compared with the world measurements.

N_{K+}^{tot}/A_{part}



K^+ multiplicity per the mean number of nucleons-participants A_{part} shown as a function of the beam kinetic energy E_{beam}. The BM@N results are compared with the world measurements.

The π^+ and K^+ yields and inverse slopes

Yields of K^+, π^+ production and effective inverse slopes of invariant m_T spectra measured in interactions of light and medium nucleus. For T_{eff}, the transverse momentum for BM@N in measured range.

Interacting nucleus / Beam kinetic energy / Experiment	**T_{eff} at $y^* =$ 0 (World), $y^* \approx 0.5$ (π^+, BM@N), y^* *in meas. range* (K^+, *BM@N*)**
Ar+KCl, 1.76 AGeV, HADES	$82.4 \pm 0.1^{+9.1}_{-4.6}$ (π^-, $A_{part} = 38.5$) $89 \pm 1 \pm 2$ (K^+, $A_{part} = 38.5$)
Ni+Ni, 1.93 AGeV, FOPI	110.9 ± 1.0 (K^+, $A_{part} = 75$)
Ni+Ni, 1.93 AGeV, KaoS	97 ± 7 (K^+, $A_{part} \sim 5$) 107 ± 10 (K^+, $A_{part} \sim 100$)
Ar+Cu, 3.2 AGeV, BM@N	90 ± 2 (π^+, $A_{part} = 33.6$) 81 ± 5 (K^+, $A_{part} = 33.6$)
Ar+Sn, 3.2 AGeV, BM@N	92 ± 2 (π^+, $A_{part} = 48.3$) 81 ± 5 (K^+, $A_{part} = 48.3$)

Summary

1. First physics results of the BM@N experiment are presented on the π^+ and K^+ meson yields and their ratios in argon-nucleus interactions at the beam kinetic energy of 3.2 AGeV.
2. The results are compared with the models of nucleus-nucleus interactions and with the results of other experiments.
3. Paper published in JHEP.

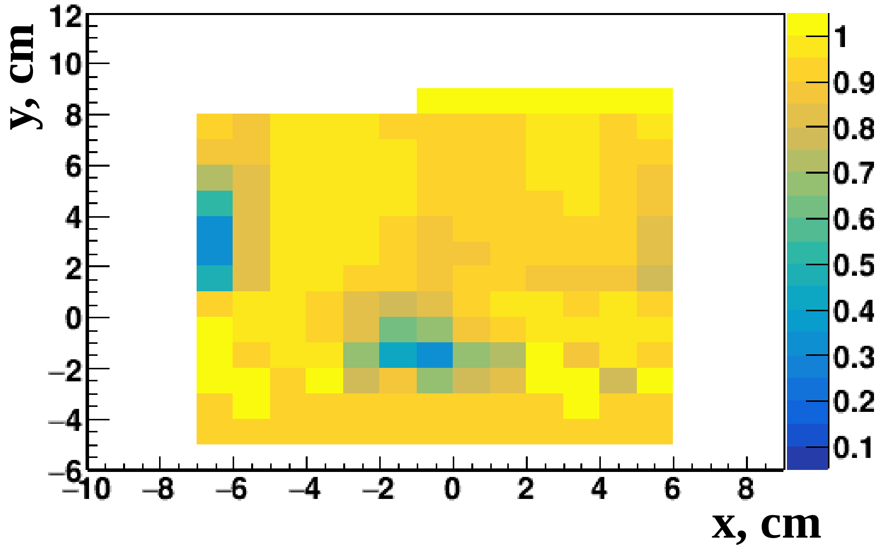
   https://link.springer.com/article/10.1007/JHEP07(2023)174

Thank you for attention!

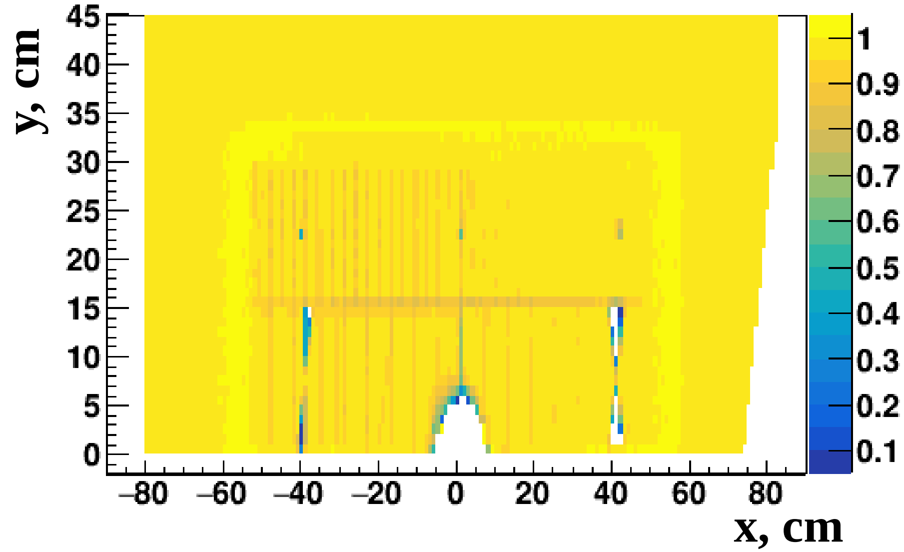
Backup

Efficiency distributions in Si/GEMs

Si-2



GEM-3



Two-dimentional efficiency distributions in Si and GEM stations measured with experimental tracks and implemented into Monte Carlo simulation

Trigger efficiency for BD

Mean BD trigger efficiency evaluated for events with reconstructed π^+/K^+ in interactions of the argon beam with the whole set of C, Al, Cu, Sn, Pb targets.

Trigger / Target **π^+ mesons**	***C***	***Al***	***Cu***	***Sn***	***Pb***
ε_{trig} (BD>=2)	0.80±0.03	0.96±0.01	0.98±0.01	0.99±0.01	0.99±0.01
ε_{trig} (BD>=3)	0.66±0.02	0.92±0.01	0.97±0.01	0.98±0.01	0.99±0.01
ε_{trig} (BD>=4)	0.48±0.02	0.88±0.01	0.95±0.01	0.97±0.01	0.98±0.01

Trigger / Target **K^+ mesons**	***C***	***Al***	***Cu***	***Sn***	***Pb***
ε_{trig} (BD>=2)	0.67±0.15	0.97±0.02	0.98±0.01	0.99±0.01	0.99±0.01
ε_{trig} (BD>=3)	0.67±0.15	0.96±0.02	0.97±0.01	0.99±0.01	0.99±0.01
ε_{trig} (BD>=4)	0.67±0.15	0.94±0.02	0.95±0.02	0.99±0.01	0.98±0.01

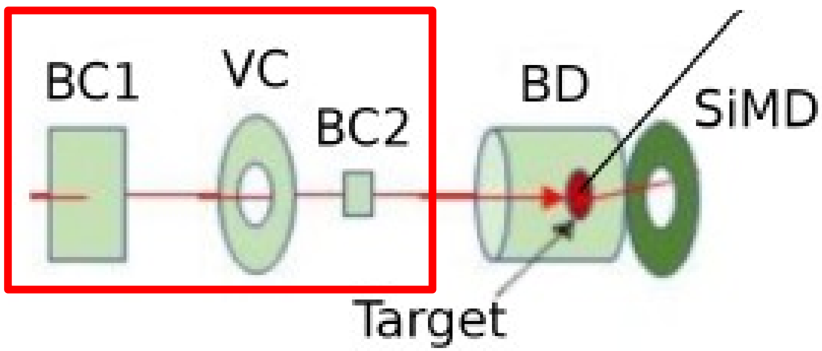
Trigger efficiency for SiMD

Mean SiMD trigger efficiency evaluated for events with reconstructed π^+ and K^+ in interactions of the argon beam with the whole set of C, Al, Cu, Sn, Pb targets.

Trigger / Target π^+ mesons	***C***	***Al***	***Cu***	***Sn***	***Pb***
ε_{trig} (SiMD>=2)	0.28±0.01	0.40±0.01	0.56±0.01	0.65±0.01	0.72±0.01
ε_{trig} (SiMD>=3)	0.14±0.01	0.22±0.01	0.37±0.01	0.49±0.01	0.58±0.01
ε_{trig} (SiMD>=4)	0.08±0.01	0.11±0.01	0.23±0.01	0.34±0.01	0.46±0.01

Trigger / Target K^+ mesons	***C***	***Al***	***Cu***	***Sn***	***Pb***
ε_{trig} (SiMD>=2)	0.30±0.06	0.40±0.03	0.64±0.03	0.74±0.03	0.82±0.03
ε_{trig} (SiMD>=3)	0.17±0.04	0.23±0.02	0.45±0.03	0.61±0.03	0.73±0.03
ε_{trig} (SiMD>=4)	0.08±0.03	0.12±0.02	0.35±0.03	0.44±0.03	0.58±0.03

Luminosity and fluxes



$$\boxed{L = N_b \cdot N_A \cdot \rho \cdot l / A \cdot corr = N_b \cdot coeff}$$

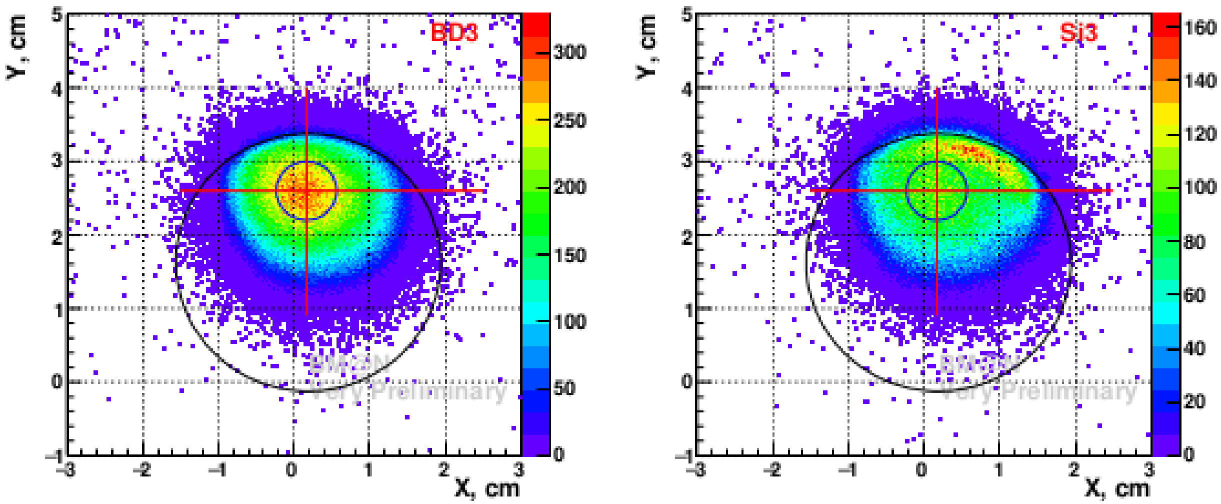
- ✓ N_b – integrated ion flux through the target
- ✓ N_A – Avogadro number
- ✓ $\rho \cdot l$ – target thickness (g/cm^2)
- ✓ A – target atomic weight
- ✓ corr = 0.865±0.02 – correction (see below)
- ✓ coeff – transformation coefficient

✓ To count the beam flux (N_b) we use BT

BT = BC1∧VC∧BC2

- ✓ Beam halo, pile-up suppression within the readout time window, number of signals in the start detector: BC1=1, number of signals in the beam counter: BC2=1, number of signals in the veto counter around the beam: VC=0;
- ✓ Beam flux for active (not busy) time of DAQ was integrated spill by spill for each target (C, Al, Cu, Sn, Pb)

Luminosity



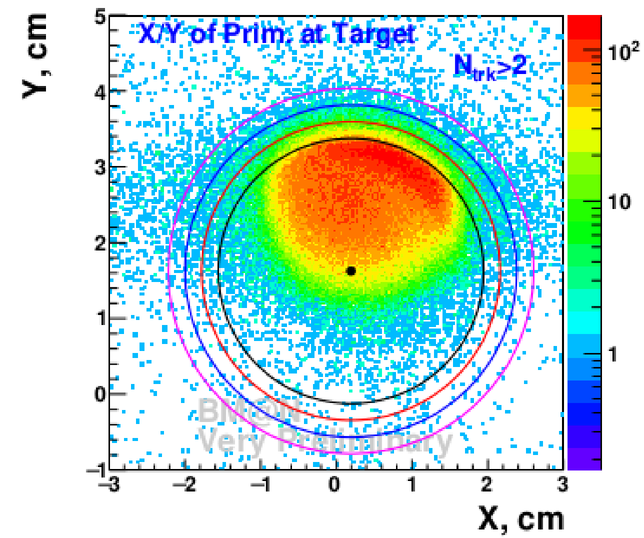


Fig.5 (lumi.pdf). Run-7, X-Y of the primary vertices for different trigger conditions. Left: $BD \geq 3$, Right, $SiMD \geq 3$.

Fig.6 (lumi.pdf). Run-7, X-Y of the primary vertices within 3−σlimits around the target.

- ✓ 13.5% of the beam is missed the target by the edge of the target due to shifted beam position.
- ✓ The systematic uncertainty for this measurement do not exceed 2%.
- ✓ The events collected with the Si-trigger near the upper edge of the target were recorded with higher efficiency relative the rest of the beam spot.

Impact parameters

Mean impact parameters of min. bias *Ar+C, Ar+Al, Ar+Cu, Ar+Sn, Ar+Pb* interactions with π^+.

MC	*b*, fm (*Ar+C*)	*b*, fm (*Ar+Al*)	*b*, fm (*Ar+Cu*)	*b*, fm (*Ar+Sn*)	*b*, fm (*Ar+Pb*)
Events with gen. π^+	4.18	4.79	5.59	6.29	7.04
Events with gen. π^+ in the measured range of BM@N	3.75	4.29	5.03	5.70	6.43
Events with rec. π^+	3.51	3.91	4.61	5.29	6.13

Mean impact parameters of min. bias *Ar+C, Ar+Al, Ar+Cu, Ar+Sn, Ar+Pb* interactions with K^+.

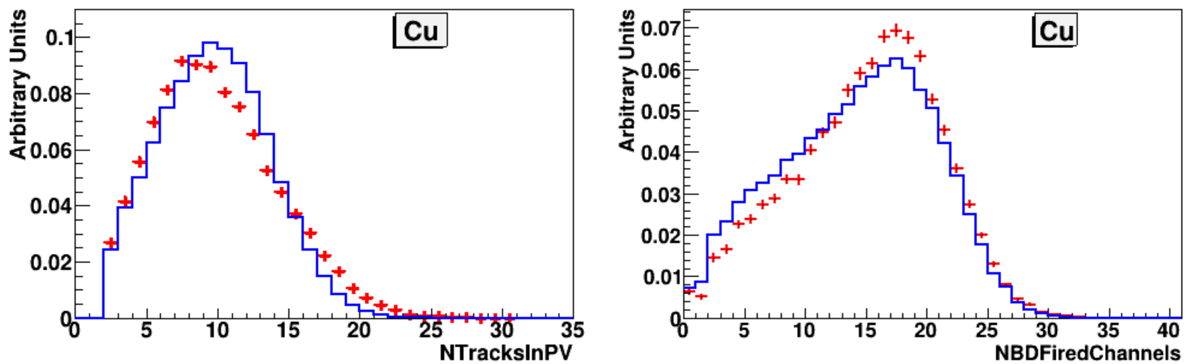
MC	*b*, fm (*Ar+C*)	*b*, fm (*Ar+Al*)	*b*, fm (*Ar+Cu*)	*b*, fm (*Ar+Sn*)	*b*, fm (*Ar+Pb*)
Events with gen. K^+	3.24	3.50	3.98	4.50	5.12
Events with gen. K^+ in the measured range of BM@N	3.17	3.42	3.90	4.44	5.13
Events with rec. K^+	3.25	3.55	4.13	4.72	5.46

π^+ and K^+ meson multiplicities

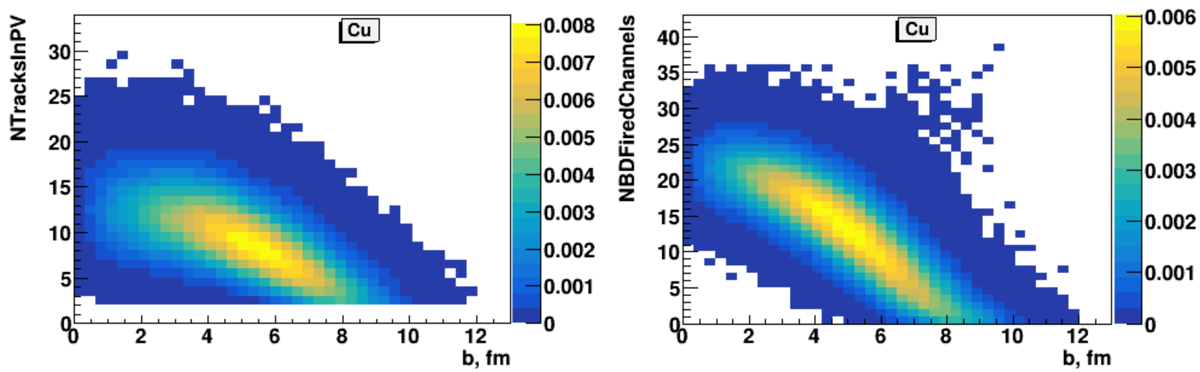
π^+ and K^+ meson multiplicities measured in Ar+C, Al, Cu, Sn, Pb interactions at the argon beam energy of 3.2 AGeV. The first error given is statistical, the second error is systematic. The third error given for the full π^+ and K^+ multiplicities is the model uncertainty.

3.2 AGeV Ar beam	*C*	*Al*	*Cu*	*Sn*	*Pb*
Measured π^+ multiplicity $N_{\pi+}$	0.42 ± 0.008± 0.045	1.00 ± 0.01± 0.07	1.14 ± 0.01± 0.08	1.28 ± 0.01± 0.09	1.25 ± 0.01± 0.08
Measured K^+ multiplicity $N_{K+}/10^{-2}$	1.59 ± 0.29± 0.65	3.90 ± 0.28± 0.61	4.17 ± 0.21± 0.66	5.60 ± 0.22± 0.75	5.10 ± 0.22± 0.92
Full π^+ multiplicity $N_{\pi+}^{tot}$	1.365 ± 0.026± 0.146 ± 0.08	3.73 ± 0.04± 0.26 ± 0.13	5.07 ± 0.04± 0.36 ± 0.08	6.55 ± 0.05± 0.46 ± 0.33	7.39 ± 0.06± 0.47 ± 0.69
Full K^+ multiplicity $N_{K+}^{tot}/10^{-2}$	4.47 ± 0.81± 1.83 ± 1.05	11.8 ± 0.9± 1.8 ± 2.6	13.9 ± 0.7± 2.2 ± 2.7	20.7 ± 0.8± 2.8 ± 3.3	20.9 ± 0.9± 3.8 ± 2.2
$N_{K+}/N_{\pi+}/10^{-2}$ Measured range	3.79 ± 0.69± 1.52	3.90 ± 0.28± 0.55	3.66 ± 0.19± 0.53	4.39 ± 0.18± 0.51	4.11 ± 0.18± 0.68
$N_{K+}^{tot}/N_{\pi+}^{tot}/10^{-2}$, Full kin. range	3.27 ± 0.6± 1.38 ± 0.79	3.16 ± 0.23± 0.54 ± 0.71	2.75 ± 0.14± 0.48 ± 0.54	3.16 ± 0.13± 0.48 ± 0.52	2.83 ± 0.12± 0.54 ± 0.39
K+ inverse slope T_0, MeV measured range	67 ± 12 ± 12	80 ± 7 ± 5	81 ± 5 ± 5	81 ± 5 ± 4	78 ± 5 ± 4

Comparison of experimental data and MC

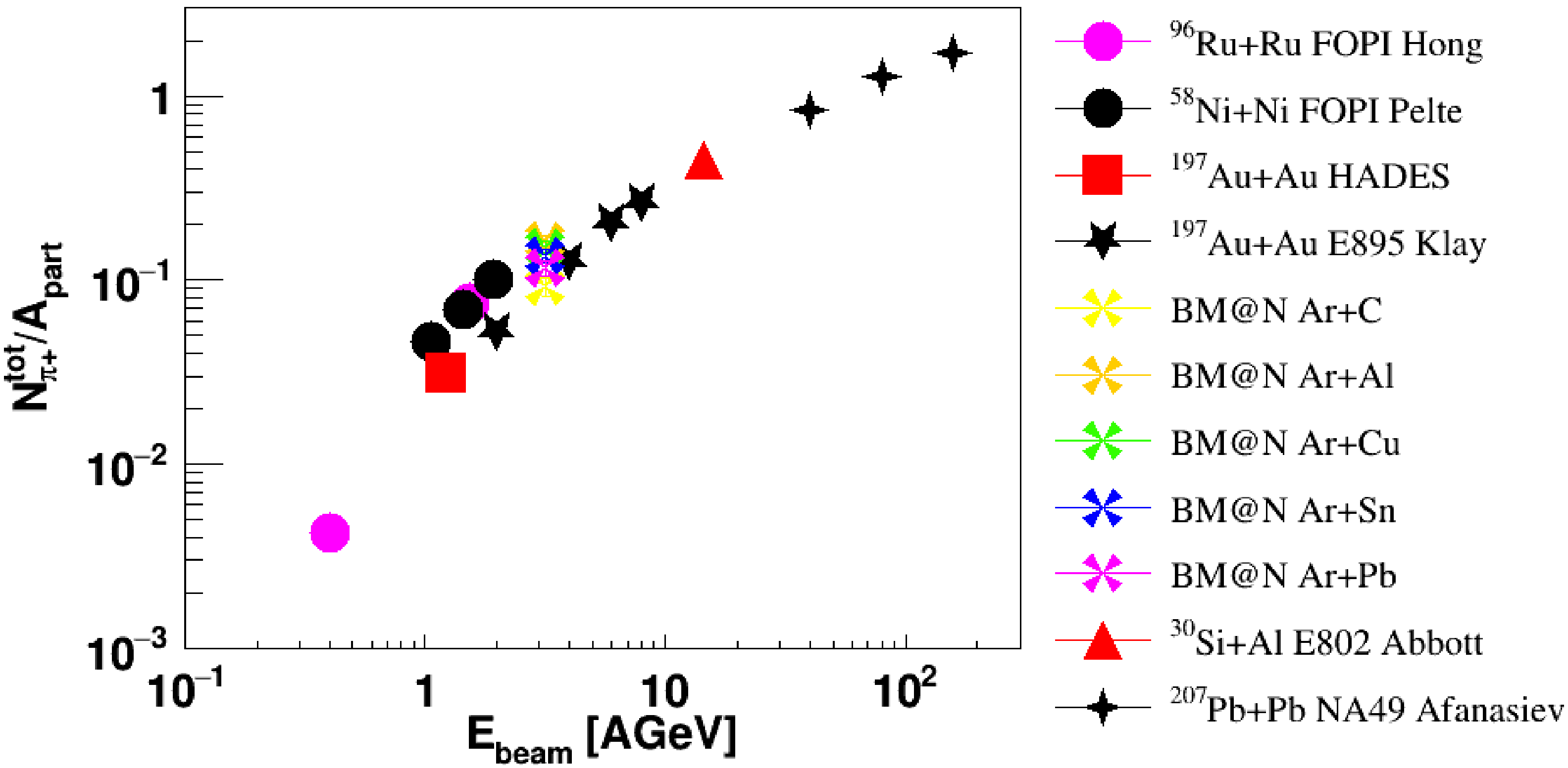


Comparison of the experimental distributions (red crosses) and reconstructed Monte Carlo GEANT distributions of events generated with the DCM-SMM model (blue lines): number of tracks reconstructed in the primary vertex (left); number of fired BD channels (right).



Correlation obtained from the DCM-SMM model of the number of tracks in the primary vertex (left) and the number of fired channels in the BD (right) with impact parameter.

$N_{\pi+}{}^{tot}/A_{part}$



π^{+} multiplicity per the mean number of nucleons-participants A_{part} shown as a function of the beam kinetic energy E_{beam}. The BM@N results are compared with the world measurements.

The π^+ and K^+ yields and inverse slopes

Yields of K^+, π^+ production and effective inverse slopes of invariant m_T spectra measured in interactions of light and medium nucleus. For T_{eff}, the transverse momentum for BM@N in measured range.

Interacting nucleus / Beam kinetic energy / Experiment	**π^+, K^+ yields**	**K^+ / π^+ yield ratio, $\cdot 10^{-2}$**	**T_{eff} at $y^* =$ 0 (World), $y^* \approx 0.5$ (π^+, BM@N), *y^* in meas. range* (K^+, *BM@N*)**
Ar+KCl, 1.76 AgeV, HADES	3.9±0.1±0.1 (π^-, A_{part}= 38.5) (2.8±0.2)$\cdot 10^{-2}$ (K^+)		82.4±0.1$^{+9.1}_{-4.6}$ (π^-) 89±1±2 (K^+)
Ni+Ni, 1.93 AGeV, FOPI	3.6$\cdot 10^{-2}$ (K^+, A_{part} = 46.5) 8.25$\cdot 10^{-2}$(K^+, A_{part} = 75)	(7.59±0.49)$\cdot 10^{-3}$ (A_{part} = 46.5)	110.9±1.0 (K^+, A_{part} = 75)
Ni+Ni, 1.93 AGeV, KaoS	3$\cdot 10^{-2}$ (K^+)		97±7 (K^+, A_{part} ~ 5) 107±10 (K^+, A_{part} ~ 100)
Ar+Cu, 3.2 AGeV, BM@N	5.1±0.4 (π^+, A_{part} = 33.6) (13.9±2.2)$\cdot 10^{-2}$ (K^+)	(27.5±4.8)$\cdot 10^{-3}$	90±2 (π^+) 81±5 (K^+)
Ar+Sn, 3.2 AGeV, BM@N	6.6±0.5 (π^+, A_{part} = 48.3) (20.7±2.8)$\cdot 10^{-2}$ (K^+)	(31.6±4.8)$\cdot 10^{-3}$	92±2 (π^+) 81±5 (K^+)