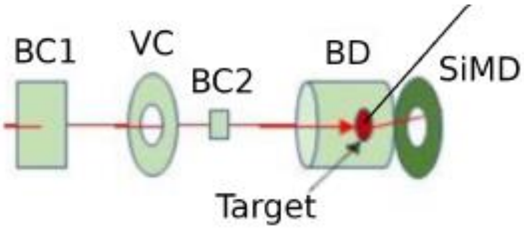
Measurement of the integrated ion flux and calculation of the luminosity.

To count the number of beam ions that passed through the target (beam flux Nb), a logical beam trigger BT = BC1⨂VC⨂BC2 was used. The beam flux for active (not busy) time of DAQ was integrated spill by spill. The probability of two and more ions giving BT signal within 20 ns of BT coincidence time window is within 2% taken as the systematic uncertainty of the beam flux measurement.



Luminosity L was calculated according to the formula:

$L = N_b \cdot N_A \cdot \rho \cdot l / A \cdot Corr$;

where N_b – integrated ion flux through the target, measured by BT trigger, N_A – Avogadro number, $\rho \cdot l$ – target thickness (g/cm^2), A – target atomic weight, Corr – correction factor for the fraction of the beam flux missed the target (see the last paragraph of Lumi.pdf document for Argon beam – Run7: "... Based on this assumption our evaluation of the difference in events population with Y coordinate above Y_C and below accounts 27%. The X-Y distribution of the primary vertices do not exceed the 3σ limits around the target. The systematic uncertainty for this measurement do not exceed 2%.), i.e. Corr = 1 – 0.27/2 = 0.865 ± 0.02.

This value is valid for ToF-400 and ToF-700 data. Transformation coefficients from the beam flux to the luminosity coeff = $N_A \cdot \rho \cdot l / A$ are given in Table 1a for different targets. They are valid for ToF-400 and ToF-700 data.

Table 1a. Number of triggered events, transformation coefficients, beam fluxes and integrated luminosities collected in interactions of the argon beam with different targets (ToF-400 data sample).

Interactions, target thickness	coeff	Integrated beam flux / 10^7	Integrated luminosity / 10^{30} cm^{-2}
Ar+C (2 mm)	0.2256	9.1	2.06
Ar+Al (3.33 mm)	0.2006	11.5	2.30
Ar+Cu (1.67 mm)	0.1411	12.7	1.79
Ar+Sn (2.57 mm)	0.0954	11.6	1.11
Ar+Pb (2.5 mm)	0.0824	6.1	0.50

Table 1b. Number of triggered events, beam fluxes and integrated luminosities collected in interactions of the argon beam with different targets (ToF-700 data sample).

Interactions, target thickness	Integrated beam flux $/ 10^{7}$	Integrated luminosity $/ 10^{30}\ cm^{-2}$
Ar+C (2 mm)	8.7	1.97
Ar+Al (3.33 mm)	10.2	2.05
Ar+Cu (1.67 mm)	11.3	1.60
Ar+Sn (2.57 mm)	9.5	0.91
Ar+Pb (2.5 mm)	4.9	0.40

Estimation of the trigger efficiency

For online selection of events with interactions signals from the BD and SiMD trigger detectors were used. Therefore, the efficiency of BD and SiMD triggers was calculated. BD efficiency was calculated in the runs when SiMD was included in the online trigger and BD was not enabled. Conversely, the efficiency of SiMD was calculated in the runs when BD was included in the online trigger and SiMD was not enabled. In various runs, the conditions for the minimum the number of signals in BD and SiMD changed from 2 to 4. The minimum number of signals in BD and SiMD was set by hardware. The trigger condition for which the efficiency was considered, was applied offline in program, so how the number of signals in BD and SiMD was recorded for each event in experimental data. For example, e_tr(BD>=2) was estimated as

e_tr(BD>=2) = N(BD>=2&&SiMD>=3)/N(SiMD>=3) ,   (1)

where N(SiMD>=3) is the number of events collected with the hardware-set condition SiMD>=3, N(BD>=2&&SiMD>=3) - the number of events collected with the hardware-set condition SiMD>=3, in which the number of registered signals BD>=2. The BD and FD detectors cover different parts of the acceptance of the BM@N setup, that is, they detect different (independent) reaction products. To evaluate the possible distortion of e_tr(BD>=2) due to the selection of events with the initial condition N(SiMD>=3), e_tr(BD>=2) was evaluated in events without conditions N(SiMD>=3), which in a limited number were registered with a beam trigger BT. The difference between the result and the result according to formula (1) was treated as the systematic uncertainty of the trigger efficiency. A similar procedure was applied to determine e_tr(BD>=4), e_tr(FD>=3), e_tr(FD>=4), which were used in the analysis. To determine the efficiency of e_tr(BD>=2,FD>=3), the value was used

e_tr(BD>=2,FD>=3) = e_tr(BD>=2) * e_tr(FD>=3)   (2)

To evaluate the possible correlation effect of triggers BD>=2 and FD>=3, efficiency e_tr(BD>=2,FD>=3) was determined directly on a limited statistics in events registered with BT beam trigger. The difference between the result and the result according to formula (2) was treated as the systematic uncertainty of trigger efficiency. The trigger efficiency e_tr was evaluated as a function of the number of tracks in the primary vertex (nTrPV) and the coordinates of the primary vertex in the event, X (Xpv) and Y (Ypv). The trigger efficiency was applied to data when filling histograms of raw spectra pi+ (K+) in rapidity and transverse momentum. For each pi+ (K+), identified in an event with a primary vertex characterized by nTrPV, Xpv, Ypv, value added to histogram with weight 1/e_tr(nTrPV, Xpv, Ypv).