# Lumi evaluation for Run-6/7.

Luminosity evaluation method based on X-Y beam profile distribution at target position. Since in Run-6/Run-7 there were no beam telescope the beam particle was not seen thus the only information about beam profile would be the distribution of the beam particle interactions with the target material. The reconstructed primary vertices are considered as a signature of these interactions

Vertex reconstruction done with the full combinatorial approach. The data set was limited with the events of at least 3 reconstructed tracks and maximum 10 tracks. The upper limit was chosen to speed up the reconstruction procedure. The track multiplicity at primary vertex was limited within the range of 3 to 10 tracks.

The primary vertices distributions in X-Y plane and in Z coordinate are shown in Fig. 1,2. A clear interactions are seen in the target surrounding material and in the spectrometer detectors.

The interactions in the target support form a big circle in X-Y. The fit of this structure by the circle reveal the diameter of $6.56+/-0.01cm$ (Fig. 1,right). We suppose than the center of the target coincides with the fit result.

The X-Y of the primary vertices distribution transformed to polar $\rho - \phi$ coordinate system is show in Fig. 3 The sharp peak at R= 6.56cm was fit by Gaussian function with $\sigma_\rho = 0.22 \pm 0.01$. This value is the resolution of the method along the radial direction.

The double peak distribution for the interaction in the spectrometer detectors is shown in Fig. 2. Each peak corresponds to the beam interactions with individual planes of the detector. The fit of the distribution by the double Gaussian function resulting with the resolution in Z-direction $\sigma_Z = 0.48 \pm 0.02cm$. We accepted the conservative evaluation $\sigma_Z = 0.48 \pm 0.02cm$ as a resolution in Z coordinate.

## Carbon beam - Run-6

In Run-6 the shape of the beam profile is very symmetric in each run, but the position of the beam fluctuates from run to run. The X-Y beam profile was cut at its different height by the plane with the aim to keep 98%, 85%, and 75% of the counts above the plane. The plane-beam profile crossing line was fit by the ellipse. In Fig. 4 the corresponding ellipses are shown for the individual run (left) or for all runs (right). The selected areas do not exceed the $3\sigma$ limits around the target. The systematic uncertainty for this measurement do not exceed 2% if X-Y and Z of the vertex position do not exceed $3\sigma$ deviation limits in $\rho$ and Z relative to the target position.

## Argon beam - Run-7

In Run-7 the beam was shifted in Y-direction and also touched the trigger detector (forward Si detector). In data set collected with the trigger condition based on BD detector (Fig. 5,left ) a clear cut by the edge of the target is visible.

In data set collected with the trigger condition based on Si detector (Fig. 5,right ) a narrow band in X-Y plane is present. The events within this band were recorded with higher efficiency relative the rest part of the beam spot .

The fit of the symmetric part of the beam profile (Fig. 5,left ) within a small blue circle by the paraboloid shows the position of the maximum at $(X_C = 0.19, Y_C = 2.58)$. The distribution was rotated around the target center till the big axe of the ellipsoid became parallel to Y-axe, $Y_C'$ represent the rotated $Y_C$. We consider that the part of the beam profile below $Y_C'$ represent the beam profile above $Y_C'$ which was deteriorated by the edge of the target due to shifted beam position. 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 $3\sigma$ limits around the target (Fig. 6.The systematic uncertainty for this measurement do not exceed 2%.

# Image collection

It was found convenient to put all images in a separate section.

### Resolution of the method

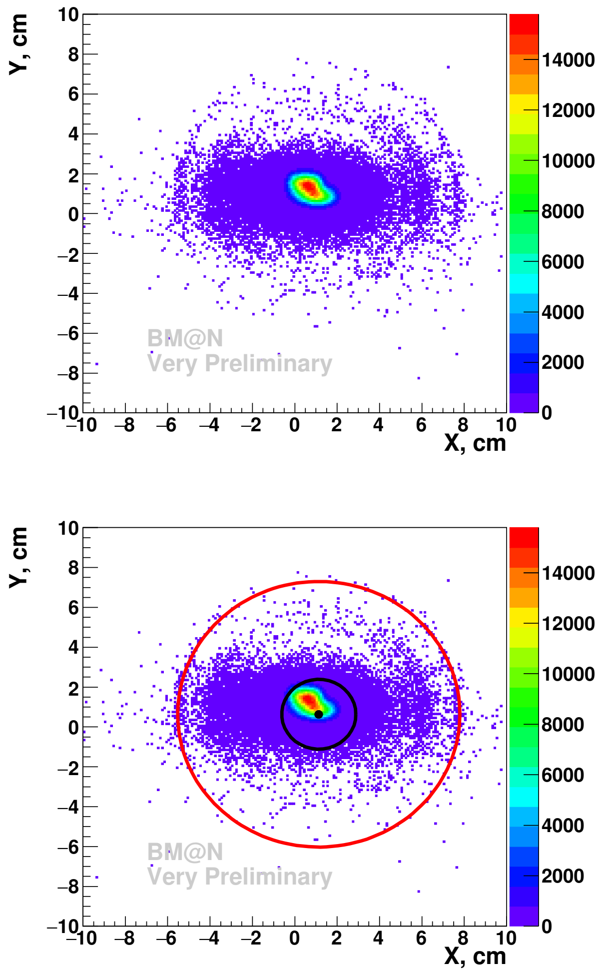



Figure 1: X-Y of the primary vertices at target position: Left - raw distribution, Right - result of the fit of the raw distribution. Red circle - the target support, black circle - the target geometrical size.

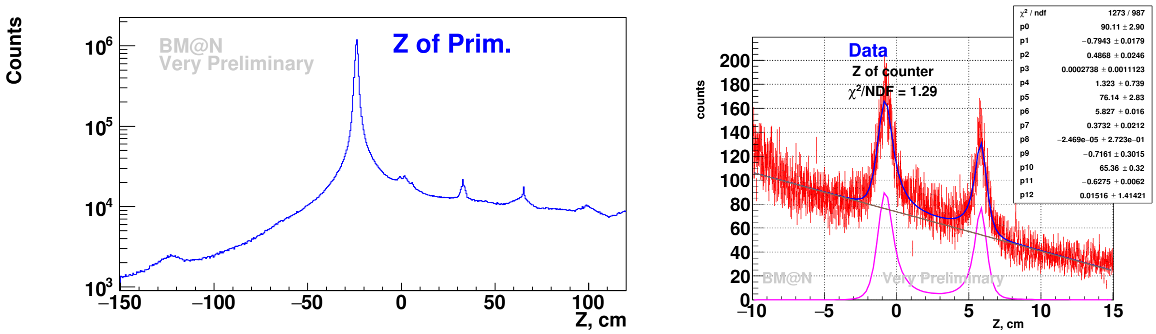



Figure 2: Z of the primary vertices distribution. Left - wide scale; Right - double peak at Z=5cm. Each peak fit with the Gaussian function. The resolution is: the first peak $= \sigma - 0.48 \pm 0.02 cm$ , the second peak $= \sigma - 0.37 \pm 0.02 cm$ .

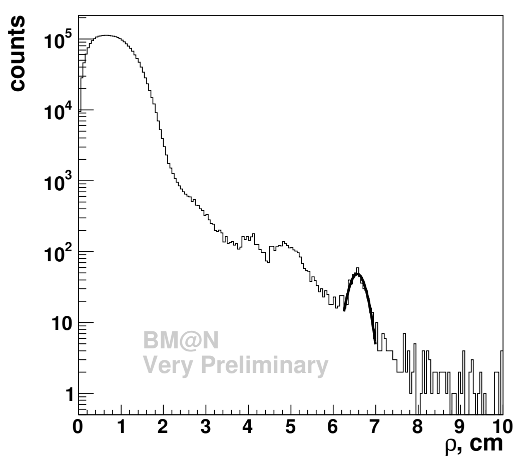
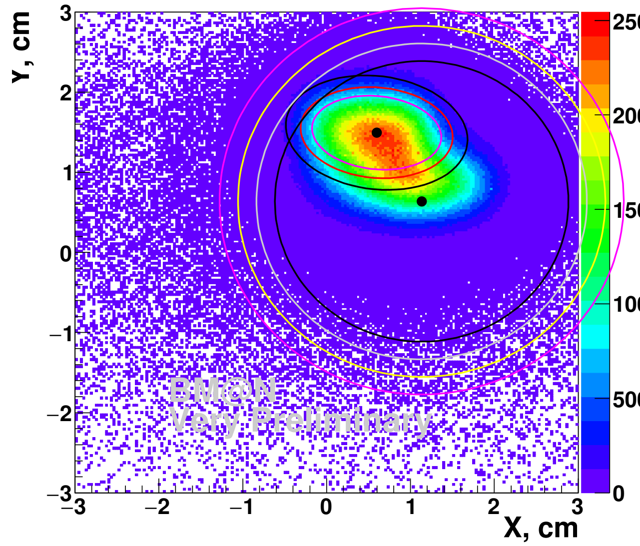



Figure 3: The primary vertices distribution in polar coordinate system. The sharp peak at 6.56cm fit with the Gaussian function.

**Run-6 images**



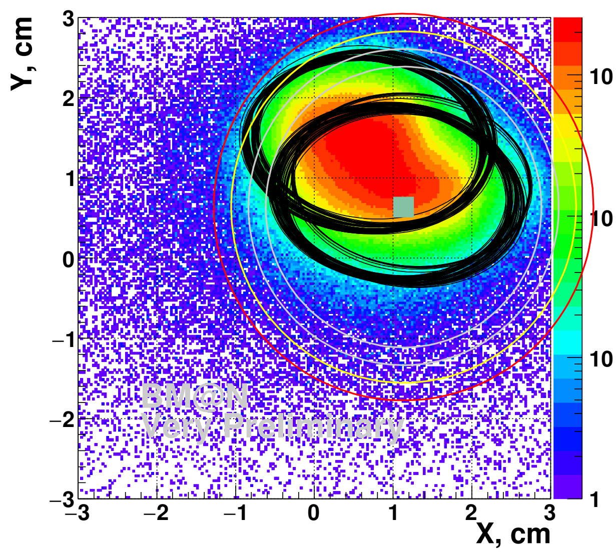




Figure 4: Ellipses : Black - 98%, Red - 85%, Blue - 75% of Vertices inside the ellipse
Target : Gray - $+1\sigma$, Yellow - $+2\sigma$, Magenta- $+3\sigma$ : Top - individual run, Bottom - all runs in RUN-6.

**Run-7 images**

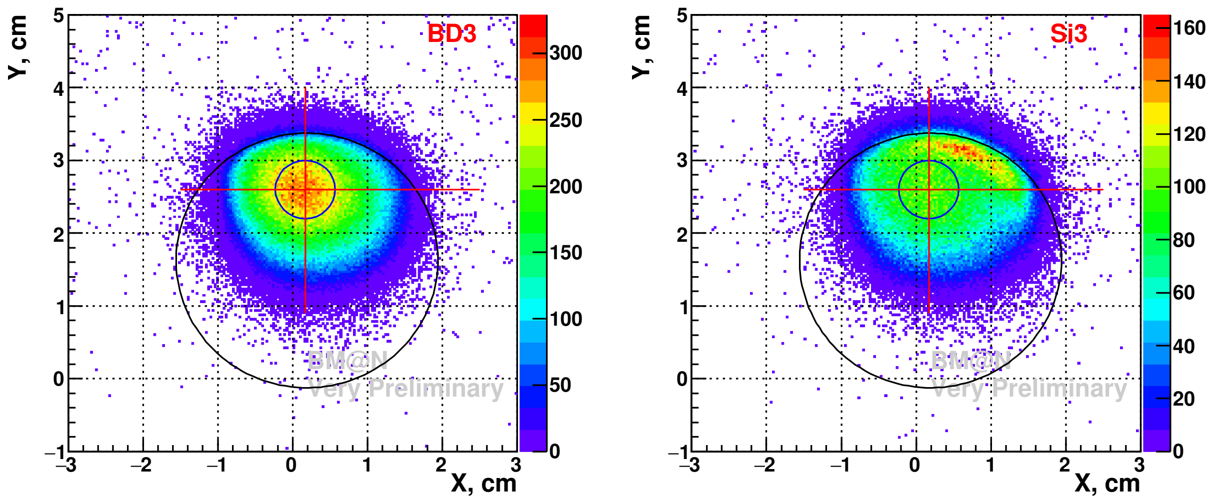



Figure 5: Run-7, X-Y of the primary vertices for different trigger conditions. Left: $BD \geq 3$, Right: $Si \geq 3$

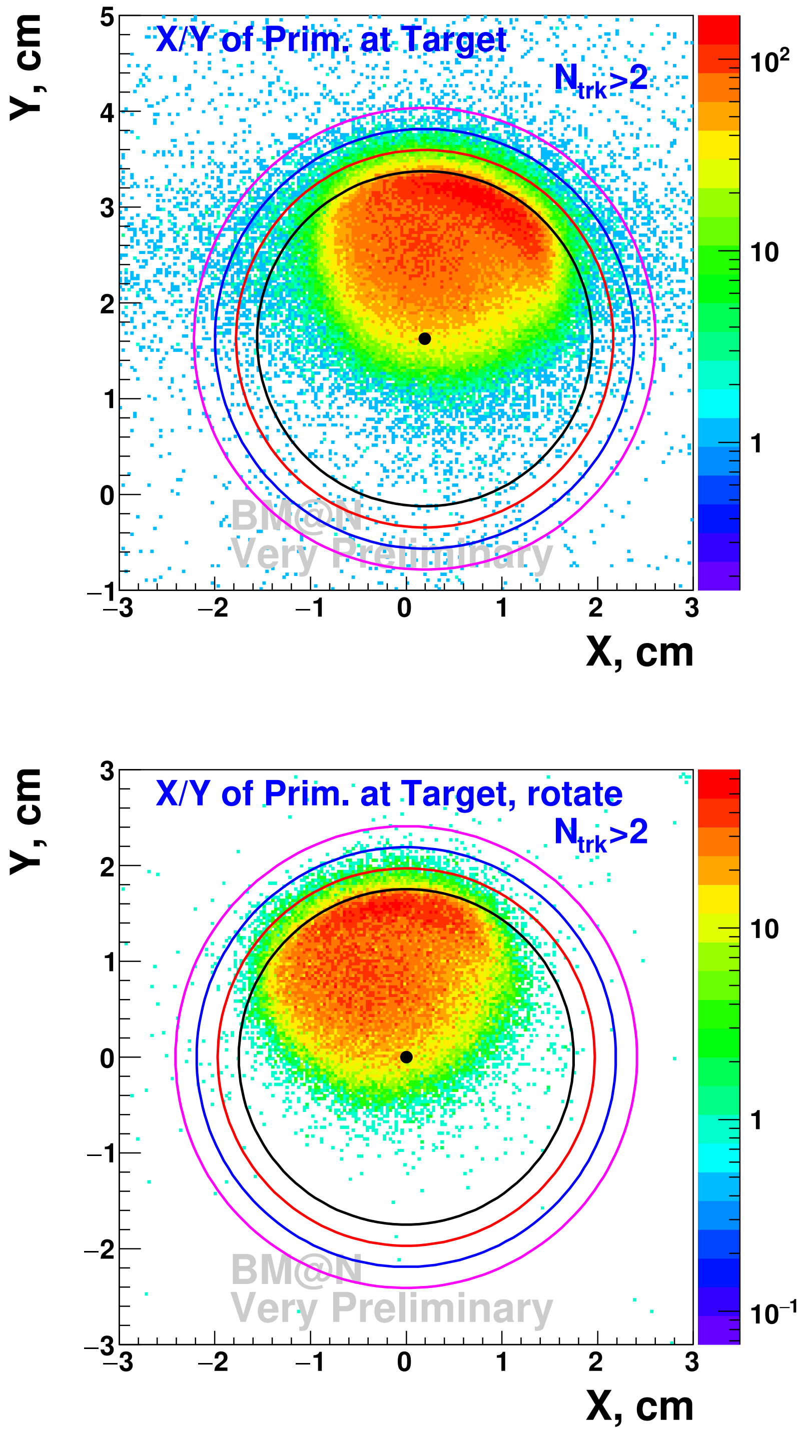



Figure 6: Run-7, X-Y of the primary vertices within $3-\sigma$ limits around the target. Top - original distribution, Bottom - distribution rotated around the target center.