Target Performance – $[^{11}\text{C}]\text{CO}_2$ and $[^{11}\text{C}]\text{CH}_4$ Production

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Introduction
A systematic investigation on $\text{N}_2$ (0.1 % $\text{O}_2$) and $\text{N}_2$ (5 % $\text{H}_2$) target performances is presented in terms of saturation yields as function of target body temperature and irradiation current.

Materials and methods
Identical aluminium target bodies were used for both $[^{11}\text{C}]\text{CO}_2$ and $[^{11}\text{C}]\text{CH}_4$ productions. The conical chambers measured 11.2 x 90.0 x 19.4 mm (front I.D. x length x back I.D.) and 16.9 cm$^3$. The inlet foil was supported by a metallic grid having a transparency of ~ 70 %. In all irradiations the chambers were loaded at 20 °C to 35 bar pressure and irradiated for 20 minutes. Variable parameters were the target body temperature (10, 40, 70 °C), regulated with a cooling fluid circuit and a heat exchanger, and the irradiation current (10, 20, 30, 40 µA). For the data points $n = 2$. The proton beam was generated with a fixed energy (17 MeV) negative ion cyclotron (CC 18/9, D.V. Efremov Scientific Research Institute of Electrophysical Apparatus, St. Petersburg, Russia).

The irradiation product was directed to a hot cell via a capillary and valve arrangement and a mass flow controller. The main $^{11}\text{C}$-species was first separated from the target gas using a selective trap: Porapak N column in Ar(Liq) for the $[^{11}\text{C}]\text{CH}_4$ and an Ascarite column at room temperature for the $[^{11}\text{C}]\text{CO}_2$. The traps were placed in a dose calibrator and the irradiated gas that passed a trap was collected as gas. The collected volume was readable from the gas trap and an aliquot could be taken for radioactivity measurement.

The $^{11}\text{C}$ main product yield was thus measured on-line with the dose calibrator containing the first trap. The content of $^{11}\text{C}$ and $^{13}\text{N}$ in the second trap was determined by iterating the decay curve fitting to the radioactivity values at early and late time points. Yields for the $^{11}\text{C}$ main product and $^{11}\text{C}$ and $^{13}\text{N}$ by-products were calculated as saturation activities ($A_{\text{sat}}$ [GBq/microA]).

![Figure 1. Pressure versus irradiation current at different target body temperatures](image-url)
Results
The pressure increase as function of beam current was similar for both targets (figure 1). A slight difference was observed at higher currents.

The main component yield is practically constant for the $[^{11}\text{C}]\text{CO}_2$ (figure 2, pane A) across the range of varied target body temperature and irradiation current. The $[^{11}\text{C}]\text{CH}_4$ yield (figure 2, pane B) is directly proportional to the temperature and inversely proportional to the current.

$[^{11}\text{C}]\text{CO}$ generation in the N$_2$ (0.1 % O$_2$) target is low and inversely proportional to temperature and constant across the investigated current range. $[^{11}\text{C}]$by-product generation is negligible in the N$_2$ (5 % H$_2$) target.

$^{13}\text{N}$ generation is constant across the range of current and temperature using either N$_2$ (0.1 % O$_2$) or N$_2$ (5 % H$_2$) target gases. However, $^{13}\text{N}$ production is slightly lower for the N$_2$ (5 % H$_2$) target.

Figure 2. Yield of the main component as a function of irradiation current at 10 – 70 °C.

Conclusions
Production of $[^{11}\text{C}]\text{CO}_2$ is practically independent of the irradiation current and the target body temperature, whereas $[^{11}\text{C}]\text{CH}_4$ production was found to be strongly dependent on the current and target body temperature.

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References