DRAGON TECHNICAL DOCUMENT

GEANT GAS TARGET PROFILE

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This document describes the proposed implementation of a gas target density profile in the DRAGON GEANT simulation based on results obtained in D.A. Hutcheon's report of June 3, 2002 entitled 'The Gas Target Density Profile' (http://dragon.triumf.ca/docs/profile.ps).

The model

The gas target model is a Fermi function within the gas box having its maximum within the trapezoidal gas cell and falling off rapidly at the cell apertures to reach a baseline pressure within the rest of the box. The baseline pressure is some ratio of the central pressure:

$$P_{base} = f \times P_{cent}$$

The parameter f has been measured as 0.056 for a gas target pressure of 8.08 Torr (hydrogen) downstream of the gas target using the 6mm and 8mm apertures.

The Fermi function may in reality not be symmetric about the origin, leading to different baseline pressures at the upstream and downstream sides of the cell. In this work we will make the assumption that it is symmetric. We also make the assumption that the half-height point of the Fermi function exponential fall-off is located at the physical centre of the cell aperture, which will become a useful assumption later.

In the stepped collimator tube connected to the gas box, it is assumed the flow follows the 'Knutsen (Knudsen?) flow equation' for a cylindrical pipe:

$$q = 380\mathrm{d}^4 \frac{(P_1^2 - P_2^2)}{2\mathrm{L}} + 46.1\mathrm{d}^3 f(d \cdot \bar{P}) \frac{(P_1 - P_2)}{L}$$

where *P1* and *P2* are the pressure at either end, *d* is the tube diameter, *L* is the tube length, and *f* (approximately equal to 0.8) is a slow varying function of the average pressure.

Approximating the model for GEANT

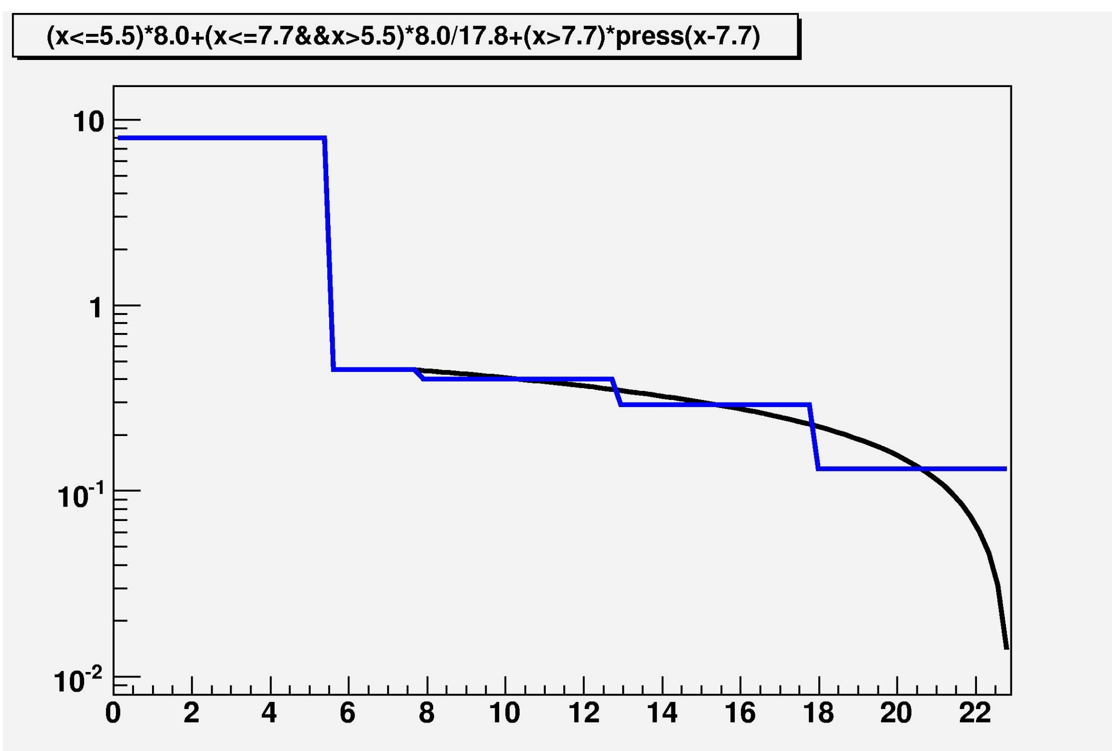
In order to adapt the model for GEANT I made the assumptions regarding the Fermi function noted above. This meant that in terms of calculating the effective gas target length, the Fermi function was equivalent to having a step function at the entrance and exit apertures of the gas cell, since for the Fermi function, the symmetric nature of the exponential fall-off about its half-height point means that the deficit in pressure on one side would be canceled out by the excess on the other side. Thus we approximate the pressure distribution by a constant pressure inside the cell stepping down to the baseline pressure at the entrance and exit apertures (z=+/- 5.5 cm).

It was then assumed that the stepped collimator tubes were of constant diameter (i.e, not stepped) in order to be able to calculate the flow for a given set of boundary conditions. Assuming baseline pressure at the tube entrance, and a pressure 1/500th of that value at the tube exit, and using a diameter of 0.892cm (the diameter of the narrowest section of the collimator tube) and length of 15.24cm we calculate a flow q = 2.36466 (in whatever units this equation gives).

It is then possible to rearrange the equation to give the pressure at an arbitrary point z, along its length, using the baseline pressure and the flow rate just derived. Integrating the function over the length of the gas box and collimator(s) gives rise to an effective length of 12.3cm, as measured.

To simulate better the pressure drop-off we then divide the collimator into its three 5.08cm long sections. In GEANT, these are separate volumes and we must define a constant material density for them. The calculations discussed here were made for 8 Torr central pressure. Integrating the pressure function over each section gives areas of 2.04287, 1.48253 and 0.67183 Torr cm for the closest to the farthest section from the gas cell respectively. Dividing these areas by the length of each section gives the average pressure in each, and now in terms of effective length we have the equivalent to the analytical function.

The following figure shows the pressure distribution as a function of distance from the gas cell centre, showing the plateau at 8 Torr and the step down to 8*0.056=0.448 Torr baseline pressure in the gas box. The black curve shows the quadratic function of pressure dependence within the collimator tubes, while the blue line shows the approximated function for constant pressures in each section (note log scale).



The ratio of pressure to central pressure along these separate sections are as follows:

Central region: 1
Box region: 0.056
First collimator: 0.050
Second collimator: 0.036
Third collimator: 0.016

Although conditions will be different for various combinations of central pressure, entrance and exit apertures, and pumping tubes, I propose to fix these ratios in GEANT so that the relative shape of this distribution will be maintained for any given simulation at a given pressure. It should be noted that this is a more sophisticated treatment than we have at the moment in the simulation.

The volumes outwith the sections described here will be considered vacuum.

-Chris