



MERIT Calculation Sheet

Oak Ridge National Laboratory

CALCULATION Nozzle Offsets

SHEET 1 OF 1

DRAWING NO

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Problem is to calculate the vertical offset of the nozzle given a Z starting position relative to the center of the magnet so that the jet path intersects the beam and magnet axes simultaneously.

From the equations for projectile motion we have

$$x = v_0 \cos \theta \cdot t$$

$$y = v_0 \sin \theta \cdot t - \frac{1}{2} g t^2$$

$$y = f(x) = x \tan \theta - \frac{g}{2v_0^2 \cos^2 \theta} x^2$$

$$\frac{dy}{dx} = \tan \theta - \frac{g}{v_0^2 \cos^2 \theta} x$$

With regards to these equations, coordinate system is at the center of the jet starting position. All angular references are with respect to the ground (relative to the beam for our experiment).

An approximation is made that for small angles, $\cos^2 \theta \sim 1$, so we can determine a starting angle which will provide a desired slope at a specified distance.

$$x := 45\text{cm} \quad dydx := -0.033 \quad v_0 := 2000 \frac{\text{cm}}{\text{s}}$$

$$\theta := \text{atan} \left(dydx + \frac{g}{v_0^2} \cdot x \right) \quad \theta = -0.022$$

Now calculate the vertical drop of the jet after traveling 45cm horizontally.

$$y := \tan(\theta) \cdot x - \frac{g}{2 \cdot v_0^2 \cdot \cos(\theta)^2} \cdot x^2 \quad y = -1.237 \text{ cm}$$

The jet falls 1.24 cm over the distance, so the starting position of the nozzle should compensate for this fall. So for a horizontal starting position of Z=-45cm, the center of the nozzle should be 1.24cm above the beam and have a starting angle of -22mrad relative to the beam. Note this calculation does not include deflections caused by MHD effects.