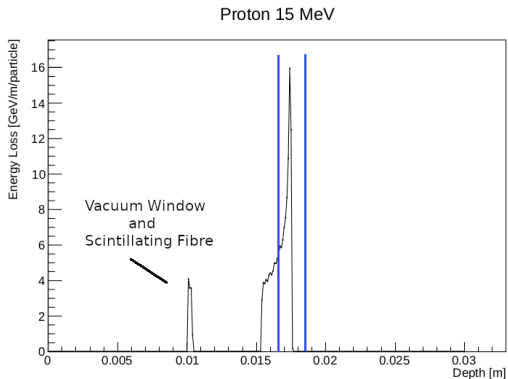


# Dose Rates

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Energy in chamber (blue) = 33.7 GeV (for  $10^4$  particles)

Scaling up to  $10^9 \Rightarrow 33.7 \times 10^5 \text{ GeV}$  ( $5.4 \times 10^{-4} \text{ J}$ )

### Dose

$$\begin{aligned}\text{Dose [Gy]} &= \frac{\text{Energy Deposited [J]}}{\text{Material Density [kg/m}^3\text{]} \times \text{Material Volume [m}^3\text{]}} \\ &= \frac{5.4 \times 10^{-4}}{1000 \times (\pi \times (0.00265)^2 \times 0.002)} = \mathbf{12.23 \text{ Gy}}\end{aligned}$$

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### Instantaneous dose:

$$\begin{aligned}\text{Instantaneous Dose Rate [Gy/s]} &= \frac{\text{Dose [Gy]}}{\text{Bunch Length [s]}} \\ &= \frac{12.23}{(2 \times 10^{-9})} = \mathbf{6.12 \times 10^9 \text{ Gy/s}}\end{aligned}$$

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### Average dose:

$$\begin{aligned}\text{Average Dose Rate [Gy/s]} &= \text{Dose [Gy]} \times \text{Repetition Rate [Hz]} \\ &= 12.23 \times 10 = \mathbf{122.3 \text{ Gy/s}}\end{aligned}$$

## Table Summary

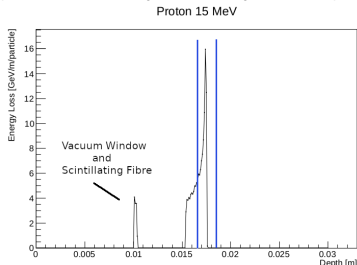
	12 MeV	15 MeV	127.4 MeV	c33.4 MeV/u
Scaled Energy [J]	$2.98 \times 10^{-4}$	$5.4 \times 10^{-4}$	$6.93 \times 10^{-4}$	$4.34 \times 10^{-2}$
Dose per pulse [Gy]	6.75	12.23	15.7	327.6
Instantaneous dose rate [Gy/s]	$3.37 \times 10^9$	$6.12 \times 10^9$	$7.85 \times 10^9$	$1.64 \times 10^{11}$
Average dose rate [Gy/s]	67.5	122.3	157	3276

Table: Summary table.

In table, proton energies are scaled to  $10^9$  particles and carbon scaled to  $\frac{10^9}{3}$

# 15 MeV and 127 MeV Comparison

(Different setups – 10k particles)



Energy in chamber (blue) = 33.7 GeV

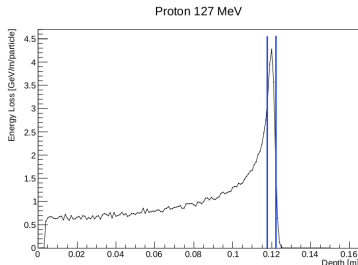
**Consistency Check:**

Integral outside blue = 95.2058 GeV

Integral within blue = 54.7972 GeV

Sum = 150.003 GeV

Initial Beam =  $0.015 \times 10^4$  GeV  
= 150 GeV



Energy in chamber (blue) = 43.3 GeV

**Consistency Check:**

Integral outside blue = 1186.78 GeV

Integral within blue = 83.0 GeV

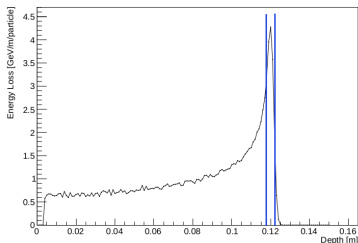
Sum = 1269.78 GeV

Initial Beam =  $0.127 \times 10^4$  GeV  
= 1270 GeV

# 127 MeV and Carbon 33.4 MeV/u Comparison

(Different setups – 10k particles)

Proton 127 MeV



Energy in chamber (blue) = 43.3 GeV

## Consistency Check:

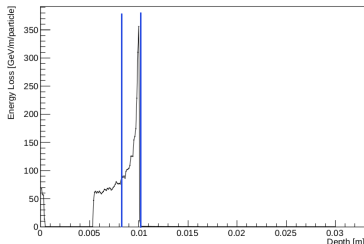
Integral outside blue = 1186.78 GeV

Integral within blue = 83.0 GeV

Sum = 1269.78 GeV

Initial Beam =  $0.127 \times 10^4$  GeV  
= 1270 GeV

Carbon 33.4 MeV/u



Energy in chamber (blue) = 2706 GeV

## Consistency Check:

Integral outside blue = 2105.3 GeV

Integral within blue = 2707.99 GeV

Sum = 4813.29 GeV

Initial Beam =  $(0.0334 \times 12) \times 10^4$  GeV  
= 4008 GeV