

# 1 Theory

Useful formula:

$$p = 0.3 \cdot B \cdot V \cdot r \quad (1)$$

## 2 Results

### 2.1 Multiplicity

Of the 64 inelastic scattering events, 11 had two, 35 four, 13 six, and 5 eight outgoing charged particles, giving a total of 280 charged tracks from 64 events, giving an average charged multiplicity of  $m_{\text{chg}} = 4.375$ . This matches our expectations for  $s \approx 47 \text{ GeV}^2$ .<sup>5</sup> From this, the  $\pi^0$  multiplicity is

$$m_0 = \frac{m_{\text{chg}}}{4} = 1.094$$

As at high energies, positive, negative and neutral pions are created in equal numbers,<sup>5,6</sup> we expected the multiplicity to be around  $1.3 \pm 0.3$ .

The other way we calculated the neutral pion multiplicity is to count the detected pair productions. We found 4 such events. The formula then reads

$$m_{\pi^0} = \frac{n_{\text{pp}} \cdot l}{2 \cdot n_{\text{inel}} \cdot ((x_0 \cdot e^{-l/x_0} - 1) + l)} = 0.5026 \pm 0.0003, \quad (2)$$

where the error comes from the uncertainty of the measured length of  $(148.739 \pm 0.085)$  we examined. This result is in disagreement with the first, and the reason is the low pair production count we recorded (quantifying this uncertainty would also give a much larger deviation for the multiplicity)

### 2.2 Neutrino momentum

The pion had an initial radius of  $27.0 \pm 0.9 \text{ cm}$ , this gives a momentum of  $120.1 \pm 3.8 \text{ MeV/c}$ . The track length was measured to be  $79.3 \pm 0.9 \text{ cm}$ . The graph provided gave a corresponding  $128.5 \pm 5.9 \text{ MeV/c}$ . Comparing the two values, we infer that the pion has indeed decayed while at rest in the laboratory frame.

Next, we measured the length of the  $\mu$  track, and found it to be  $0.597 \pm 0.085 \text{ cm}$ . From the graph again, a momentum of  $27.64 \pm 1.26 \text{ MeV/c}$  was read, in fairly good agreement with the theoretical  $29.8 \text{ MeV/c}$  value.<sup>5</sup>

### 2.3 V0

We found two  $V_0$ -candidate events. It is important to note that the angle between the two produced particles in each case was close to  $0^\circ$ , so the possibility of these being pair productions is considerable.

On image 2898 we detected a primary vertex with 2 visible outgoing particles and one distant vertex of two particles with opposite charges (meaning it was a decay process) which is suspected to have come from the primary

vertex. The distance of the two vertices was measured to be  $137 \text{ cm}$ .

#### 2.3.1 The secondary vertex

The neutral particle decayed into two particles with an angle of  $(0 \pm 0.1)^\circ$  between them, this made the association to the primary vertex an easy task. We measured the two radii to be  $(56 \pm 2) \text{ cm}$  for the negative,  $750 \pm 50$  for the positive particle. From Eqn. 1, in a coordinate system with the x-axis along the supposed  $V_0$  path, we get

$$\begin{aligned} p_- &= ((249.2 \pm 8.9) \text{ MeV/c}, \quad (0.22 \pm 0.22) \text{ MeV/c}) \\ p_+ &= ((3337.1 \pm 222.7) \text{ MeV/c}, \quad (-2.92 \pm 2.92) \text{ MeV/c}) \end{aligned}$$

The total  $V_0$  momentum is then

$$|p_0| = (3586.21 \pm 222.89) \text{ MeV/c} \quad (3)$$

#### 2.3.2 A first look at the primary vertex

The primary vertex consists of the incoming proton, and two positively charged particles: particle 1 has a path with radius  $(2000 \pm 200) \text{ cm}$  and angle  $(2 \pm 0.3)^\circ$ , particle 2  $(1700 \pm 100) \text{ cm}$  and  $(4.5 \pm 0.3)^\circ$ . Using the incoming beam as the direction of the x-axis and the positive quarter plane being the top right one, we can write down the momenta:

$$\begin{aligned} p_1 &= ((8893.4 \pm 889.8) \text{ MeV/c}, \quad (310.6 \pm 56.0) \text{ MeV/c}) \\ p_2 &= ((7540.7 \pm 444.2) \text{ MeV/c}, \quad (-593.5 \pm 52.7) \text{ MeV/c}) \\ p_0 &= ((3585.7 \pm 62.6) \text{ MeV/c}, \quad (222.9 \pm 19.2) \text{ MeV/c}) \\ \Sigma p &= ((20019.7 \pm 1019.1) \text{ MeV/c}, \quad (-220.3 \pm 79.3) \text{ MeV/c}) \end{aligned}$$

The momenta of the three particles do not add up to the momentum of the incoming proton ( $23877 \text{ MeV/c}$  in the x-direction), this offers two probable explanations to check first:

- Another neutral particle was created which was not detected, or
- One neutral particle was created that decayed into neutral particles very close to the primary vertex, and one of these decayed, showing up as a secondary vertex.

Of course other options are also possible, but we are hoping to find the event to be one of these two types.

#### 2.3.3 Determining $V_0$

Unfortunately, we cannot conclude much from the secondary vertex, situated  $(138 \pm 1) \text{ cm}$  away from the primary vertex, showing the path of two particles which leave the chamber. We assume that the  $V_0$  particle decayed into two charged particles and nothing else, as the

