Beam Commissioning of K1.8BR Beamline at J-PARC Hadron Hall

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Abstract. K1.8BR beamline at J-PARC Hadron Hall is brand-new beamline. Beam-tuning and secondary particles yield study about Kaon and p-bar have done to know the performance of K1.8BR beamline. We measured momentum dependence of the yields of K\(^+\), K\(^-\), p-bar and it is compared with the calculation based on empirical Sanford-Wang’s formulae.

1. Introduction

K1.8BR beamline at J-PARC Hadron Hall is brand-new beamline, whose available beam momentum range is until 1.1GeV/c for experiments with low momentum secondary Kaon beam. So it is needed to study the performance and do beam-tuning. Particle identification has been done by online’s trigger and offline’s TOF. We have studied secondary particle yields, Kaon and other particles ratio, dependence of production target, beamline acceptance and momentum bite, beam profile at experimental target, and so on.

2. Beam tuning technique and result

2.1. J-PARC Hadron Hall
A schematic description of J-PARC Hadron Hall is given by figure 1. 30GeV primary proton beam from the synchrotron bumps production target named T1. On T1, Ni or Pt are chosen as the target and the secondary particles are created. They are branched off KL, K1.8, and K1.8BR beamline. Separation of particles can be done by the electrostatic separator (ES1) [1], magnets (CM1,CM2), and vertical mass slit (MS1). In order to carry out experiments with low momentum K\(^+\), K\(^-\) on the momentum range up to 1.1GeV/c, the total beam line length of K1.8BR from T1 to the final focus point, FF is designed to be as short as 30m.

2.2. Beam tuning setup and particle identification
The particle identification has done beam momentum range at 0.7~0.9GeV/c. Figure 2 show the beam tuning setup. TOF between BHD and T0 make possible particle separation as offline, and the flight length is 7.7m. About cherenkov counters, gas (GC), lucite1 (LC1) and lucite2
Figure 1. A schematic view of J-PARC Hadron Hall. The feature is having a long length (6m) electrostatic separator, ES1.

Figure 2. A schematic view of the setup for beamtuning at K1.8BR.

Table 1. The working table of cherenkov counters for particle’s species, and the working range for particles velocity. The mark of y and n mean occurrence or no of the cherenkov radiation in the counter, respectively.

| counter | working range(β) | e | π | K | p |
|---------|------------------|---|---|---|---|
| GC      | 0.997 ~          | y | n | n | n |
| LC1     | 0.67 ~ 0.905     | n | n | y | n |
| LC2     | ~ 0.905          | y | y | n | n |

(LC2) are installed. They depend on secondary particles velocity like table1. Using this relation, triggers for particle identification are made, and online’s scaler count made be reliable one with offline’s TOF. Particle yields has been studied for the triggers.

2.3. CM-scan and kick angle dependence

Using ES1, CM1,2, and MS1, particle separation has done, namely CM-scan. Secondary particles are bended for the CM1’s magnet field, separated for the ES1’s electric field, and then bended again for the CM2’s magnet field. CM-scan means to change current value of CM1,2 step by step, and search for the maximum yield of each particles. Kick angle for CM1 and ES1 are defined by

\[ y = eEl/pc\beta \]  

where \( e \) is elementary electric charge, \( E \) is electric field of ES1, \( l \) is length of ES1, 6m, \( p \) is secondary particle momentum, and \( c\beta \) is secondary particle velocity. Figure 3 show the kick angle dependence of secondary particles yield about K⁺, K⁻ and p-bar. The dependence is caused strongly by particle’s loss for cutting out on the edge of CM1,2 and ES1, and so on.

Figure 3. The kick angle dependence normalized by SEC about K⁺, K⁻, p-bar. SEC means Secondary Emission Chamber, 1 count\~ 2.5 \times 10⁹/spill.
3. Secondary particles yield

3.1. Momentum and target dependence
After setting the optimum CM’s current value, particle’s yields are studied about momentum and kind of production target, Ni and Pt. Figure 4 show the result. About the particle’s yield, they increase with momentum from 0.7 to 0.9GeV/c and Pt is better than Ni. Especially K⁺,K⁻ yield about division of Pt/Ni are bigger than division of beam loss ratio, so Pt is superior to Ni about their yield. The superiority is ratchet down following the inflight cross section is ratchet up. So the division yield’s superiority of Pt/Ni about K⁺,K⁻,p-bar ratchet down. Furthermore about the purity of K, Pt is superior to Ni, too.

3.2. Comparison between Sanford-Wang formula and measurement
The results of comparison between Sanford-Wang (S.W.) formula [2] and measurement are given figure 5. They don’t compare the value but the shape of momentum dependence because normalized at 0.7GeV/c. S.W. formula predicts momentum dependence of secondary particle yields and means two models, one is calculation for S.W., the other is calculation for S.W.+kinematic reflection in the production target. For calculations, kick angle dependence and decay factor through beamline are taken into account. Measured yields are different from both calculations, because these calculations are well matched over 1.0GeV/c region, not such low momentum region.

![Figure 4](image1.png)

![Figure 5](image2.png)

**Figure 4.** The momentum and target dependence of K⁺,K⁻,p-bar yield. Particle’s yields are normalized by 1.0×10^{12}proton. Pt/Ni means division of particles yield about each target. Beam loss occur in the production target, and the ratio is that Pt is 50%, Ni is 30%. red dotted line show the division of beam loss ratio.
4. Conclusion
K1.8BR beamline has been successfully tuned for Kaon thanks for triggers, TOF separation, and CM-scan. The secondary particles yield has been measured for the momentum range of 0.7~0.9GeV/c and Pt target is superior to Ni target in both of yield and purity for Kaon. Furthermore momentum dependence of Kaon and p-bar yield are different from Sanford-Wang formula. The simulated K^-’s yield about Ni target on 0.75GeV/c is $5.8 \times 10^5$K^-/spill, and measured one is $5.1 \times 10^5$K^-/spill. So the beam quality is satisfied the design value, well. Low momentum Kaon experiment will be done successfully at K1.8BR.

5. References
[1] M. Ieiri et al. Nucl. Instr. and Meth. in Phys. Res. B 266 (2008) 4205-4208
[2] J.R. Sanford and C.L. Wang, BNL 11279 (1967)