**Abstract**

Photon veto analysis has been done based on the 2002 pnn1 1/3 samples. In this analysis, we observed the various interesting phenomena which didn't observed and/or were not taken care in '98 analysis. And thanks to that study and knowledgement, we have success in getting more rejection, even though we are in difficult condition from the start point in terms of the acceptance due to the high rate environment and more accidentals.

This is the summary of the PV analysis.

# Contents



# 1 Hardware Changes in PV

Basically, we have following changes compare to E787.

- Newly installed photon veto detectors.

  **Barrel Veto Liner(BVL):** Adding 2.4 radiation length and convering 45 degree hole.

  **Beam line Photon Veto:** DPV, UPV, AD, CO, $\cdots$
  covering the small angle from the beam line and being expected to catch the potential escape photons. These will play an important role especially in pnn2 analysis and might give us more rejection.

- **Mean-timer :** It was afraid that the online PV rejection with conventional analog sum would lose acceptance much under the high rate environment in E949 due to the requirement of wider gate width to store whole pulses from PMTs. But the Meantimer method allows us to reduce the gate width (currently being set to 10ns) which directory corresponds to the dead time also. But we should note that this may bring some changes in the rejection of online PV to some extent.

- *Other related things*

  **High Intensity Kaon Beam :** The beam intensity in E949 is drastically changed. Roughly speaking, it is about XXX times stronger than that of E787, and XXX times more accidentals are expected. This will correspond to the XXX % acceptance loss by a simple estimation.

  **RS Layer-20,21 :** We removed the 2 high-end counters (layer-20, 21) in RS for the sake of BVL installation. Thus, we can not expect anymore that the major part of km2 muons stop in RS, and actually large fraction of km2 muons are observed in the BV/BVL. This fact indicates that we can not use traditional method in acceptance measurement, and have to develop another new method.

# 2 Tuning Samples and Cut Conditions

During in our study, we used the PNN1 skim1,4 as rejection samples and km21 monitor as for acceptance samples. Here, we wrote down the details of our samples and the cuts used for purifing the samples.

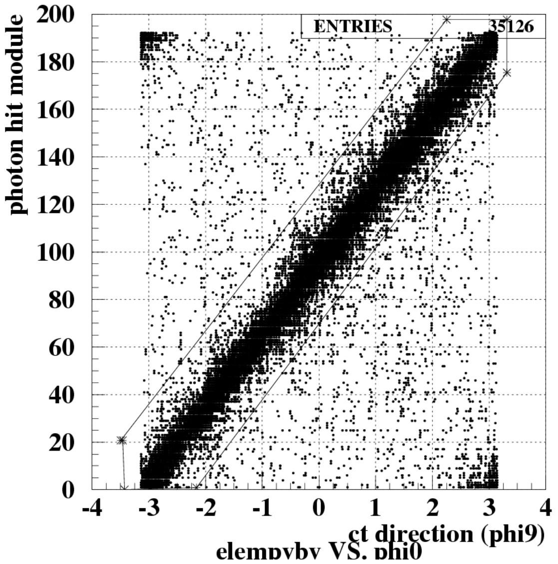
1. **Rejection Samples**
   - PNN1 trigger : *(including online PV cuts, of course.)*
   - PASS1 cuts : *Note that INTIME cut is switched off.*
   - skim(1,4) cuts :
     TGRECON, RSHEX2, PSCUT, TDCUT, TGCUT,
     TGPVCUT *(not included in the latest one.)*
   - Ntskim cuts :
     skim(1).or.skim(4), KPI2BOX, KINCUT01_NOBOX, PSCUT02
2. **Acceptance Samples**
   - Km21 trigger:
   - Ntskim cuts :
     KMU2BOX, KINCUT01_MU, PSCUT02

After the above cuts and with some prescales, we have XXXX rejection samples and XXXXX acceptance samples. All studies were done based on them.

# 3 High Lights

## 3.1 Back-to-Back correlation band

We observed the stong geometrical correlation between charged tack direction and photon direction. This back-to-back correlation is much stronger than we expected at first. *(see figuer-)* Anyway, the point is that if we successfully introduce the geometrical cut, we can kill the




photons much more effectively.

## 3.2 BV/BVL/RD early TDC hit

We found out that the skim1 samples make a significant excess in the early TDC region (say -50ns ∼-10ns) by compared with the acceptance sample. *( see the figure-1 )* And, by looking into them closer, it was turned out that they have similar energy distribution to the events in prompt, and, this is rather strinking, they certainly make a band structure in their hit geometry. We assume they are the TDC screw-up events due to the early hit accidentals. Our conclusion is tha these are enough singal-like and should be vetoed. We extended the TDC unpacking range to -50 ns (previously it was -20ns. ) and introduced the new cut category to kill them effectively. We possibly get more rejection by this cuts.

## 3.3 Another timing peak in BVL

BVL has 2 timing peaks in its timing distribution. The one is standing at $\sim$ 0ns, so called prompt peak and almost all hits belongs to this. But the other one is standing at -3∼-2.5ns, and the important point is that this peak doesn't come from the particular run nor the particular modules. Thus, they are assumed as a real physics process.

From the further study, we knew that the 2nd peak has 2 interesting characteristics.

1. Higher Energy : They have a tendency to have higher energy (see figure-)

2. Smaller Time Difference : If we calculate the time difference in each end, all hits in the 2nd peak are localized around 0ns. (see figure-)

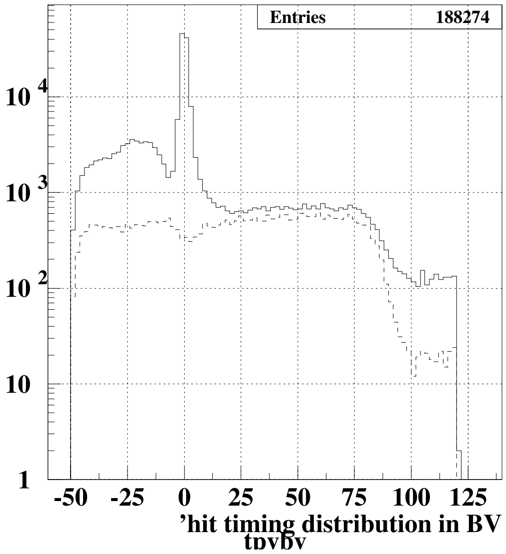



Figure 1: Hit timing distribution in BV
solid line: PNN1 skim1,4 (rejection sample)
dashed line : Km21 monitor (acceptance sample)
The same things are observed in BVL and RS also.

Here, we make an assumption to describe the 2nd peak which is satisfying the above 2 phenomena.

**Model :** ***2 photons from $\pi^0$ hit the same BVL rod simultaneously.*** (figure-)

Anyway, the point is that this 2nd peak events are not vetoed by the standard PV cuts because BVL veto width is not so wide to include the 2nd peak. But if we veto them, $\sim 3\%$ additional rejection are expected.

### 3.4 Dima's new TD/TDC array

Dima wrote down the TDC complement codes, which can fill the missing TDC information masked by the early accidentals with using the TD information. This can save the events in the RS single-end hit category before and put them into the both-end category which is more reliable.

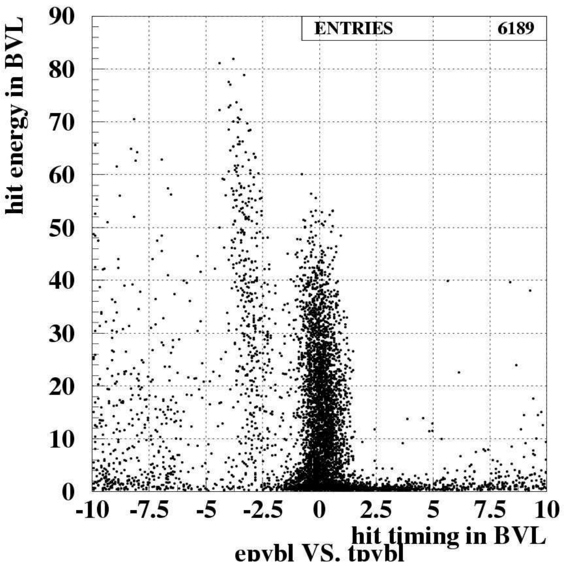
# 4 Acceptance

## 4.1 Online PV Acceptance

As mentioned before, we are in difficulty for measuring the online PV acceptance due to the fact that lots of KM2 muons reach the BV/BVL and fire the online trigger bits. In the '02 pnn1 analysis, we developed **Blankout Method** and **Layer 18 Method**. We will give you more detail below.

#### 4.1.1 Blankout Method

This is a kind of masking method that any hits in the [*sec*-8:*sec*+4] BV/BVL sector ( where *sec* is the charged track stopping sector. ) are ignored, and using the remaining unmasked 36




(= 48-12) sectors, acceptance loss in the masked 12 sectors is estimated.

### 4.1.2 Layer 18 Method

This method still causes a lot of discussion but, anyway, we intentionally select the large dip-angle Km2 events, it means, muon can have a longer range in RS and have much more possibility to stop in the RS. Strictly speaking, we choose the events which don't have any activity not only in BV/BVL but also in layer 19 and the muons seem to stop successfully in the RS layer 18 (or inner layer ?). But as we know, large dip angle events tend to have funny behavior. Thus we maynot believe what this method is saying. ( ... but it will be a kind of good indication.)

### 4.1.3 Online Acceptance Measurement with 2 Different Methods

Here is the summary of acceptance measurements in both method.

| | "Blank-out" Method | "Layer 18" Method |
|---|---|---|
| HEX | 235541/251930=0.935 | 20523/21990=0.933 |
| BV | - | 20220/20523=0.985 |
| EC | 232587/235541=0.987 | 19974/20220=0.988 |
| BL | - | 19528/19974=0.978 |
| Online TOTAL | 0.923 | 0.888 |

## 4.2 Offline PV Acceptance

Basically total acceptance is set to 80% to keep blance between other studies such as kinematics, TD and beam studies. And if we follow the value, offline PV acceptance should be around 86.5%.

Once the PV optimization starts, we will do some trial to get more rejection, however, this offline set point is always kept.

| | "Blank-out" Method | "Layer 18" Method |
|---|---|---|
| Online TOTAL | 0.923 | 0.888 |
| Offline | 192694/219993=0.865 | 15253/17432=0.875 |
| Total | 0.80 | 0.78 |

# 5 Rejection

## 5.1 Online PV Rejection

Online rejection is measured. Detail will be discussed later, thus, here I just summarize the results.

| Trigger Bit | Rejection | Used Samples |
|---|---|---|
| HEX | $2.981 \pm 0.043$ | kp21 monitor |
| HEX after | $1.11 \pm 0.006$ | kp21 monitor |
| BV*BVL*EC | $1981 \pm 309$ | kp22 monitor |
| Online TOTAL | $6550 \pm 1025$ | |

## 5.2 Offline PV Rejection

### 5.2.1 Optimization

### 5.2.2 Results

| Subsystem | Time Offset | Time Window | Energy Threshold | Band | Rejection |
|---|---|---|---|---|---|
| BV (on-band) | -7.85 | 18.20 | 0.20 | 1.5 | |
| BV (off-band) | 2.25 | 4.10 | 0.70 | - | |
| BL (on-band) | 0.25 | 5.60 | 0.30 | 1.2 | |
| BL (off-band) | 0.75 | 1.80 | 0.20 | - | |
| EC | 0.25 | 2.15 | 1.20 | - | |
| RD (on-band) | -0.10 | 2.75 | 1.10 | 1.4 | |
| RD (off-band) | -1.00 | 2.10 | 1.10 | - | |
| TG | 0.00 | 2.20 | 10.00 | - | |
| IC | -0.05 | 2.15 | 0.50 | - | |
| VC | -1.85 | 3.00 | 1.50 | - | |
| CO | 2.95 | 1.55 | 0.70 | - | |
| CM | -2.10 | 1.90 | 3.10 | - | |
| EC (ring-1) | 0.30 | 2.15 | 0.70 | - | |
| BV SAST | -9.50 | 9.50 | 4.80 | - | |
| RD SAST | -0.10 | 0.50 | 15.80 | - | |
| RD SABT | 2.50 | 1.50 | 2.40 | - | |
| RD NABT | 0.75 | 2.00 | 0.40 | - | |
| RD BAST | 2.40 | 0.10 | 4.70 | - | |
| BV SABT | 2.50 | 3.00 | 2.40 | - | |
| BV NABT | -1.50 | 0.00 | 6.00 | - | |
| BV BAST | -5.60 | 11.00 | 7.30 | - | |
| EC (2nd pulse) | -1.80 | 1.20 | 19.20 | - | |
| BL BAST | 2.20 | 0.60 | 14.20 | - | |
| Total | | | | | $175.75 \pm 7.35$ |