So the topic of my talk today is about the stability test of Compass data from 2008.

There are three main goals about this data analysis of stability test. First, I want to find the abnormal runs which have very different variable values compared to others. Second, after identifying these bad runs, I want to check how they go wrong and what kind of strange symptoms they have individually. Last, I want to figure out why I have these bad runs, what is the probable cause and whether I should select these data out.

All the data for this test came from the COMPASS and this picture shows the layout of detectors inside. COMPASS is a fixed target scattering experiment and the target, which is liquid hydrogen, is located between the first solenoid magnet and RPD, recoiled proton detector. On the left of the target, we have the incoming particle beam going through multiple triggers, such as scintillating fibre and RPD. In our case, the incoming particle beam is pion beam which is generated by the nuclear reaction between the protons and beryllium. On the right of target, we have two sets of tracking detectors and calorimeters. The one on the front is used for measuring tracks or energy of outgoing particles with large scattering angle. And the one behind is used for small scattering angles. All these detectors only start to read out the signals when the triggers are triggered by the pion beam.

The data coming from those detectors are stored first with different run number. And for each run number, it has also different spill number. One spill represents the one period of bunching and debunching of pion beam, which, therefore, contains large amount of events. By using PHAST analysis framework, we then can extract specific information about each individual event, such as the number of particles or momentum of outgoing particles, etc.

The data-sets we used of the COMPASS is from three weeks in 2008. And they are already preselected by the following conditions: first events are only selected if we find a primary vertex inside. Second, the position of the primary vertex must be very close to the target. And this range is between -2 meters and 1.6 meters. Third, for each event, it must have one or three charged tracks coming out of the primary vertex. And for the last, the sum of all charged tracks must be equal to -1. With all these 4 conditions applied, the data after the selection cut are very likely to be the process of one pion be scattered into three charged pions. And of course, multiple photons can be also emitted at the same time.

So let us have a first look of how many events we still have after the selection for each spill of each run. The first impression we can get from this 2 dimensional histogram is that all the events seem to be pretty low for the whole scale. With a closer look we could find that there is a single spill on one run which have much larger event counts than others. If we check this run further, it can be seen that the time of that specific spill is around 2 times longer than the normal one, which could be due to the malfunction of the triggers.

After selecting this run out and redraw the event distribution of the whole process. The X axis of this two dimensional histogram shows the run number of each run and y axis shows the spill number of the run. As we can see, the maximum value of spill number cannot be larger than 200. Also there are the runs that don’t have any events at all. And there are some runs who have less spill number. Therefore, the total event number is very different for each run. Event number is first parameter that can be used to show the stability of run. However, it could have no effect at all when one try to calculate the resonance energy or its corresponding distribution.

So, for the next, we need to check the variation of those parameters which actually can affect the results we need. The most obvious one is the invariant mass of three pions. Also, we can check the photon energy as well. Once we have the three pions and photons, the total invariant mass can be calculated. Since we want to see what might go wrong for the scattering, we also checked the recoiled proton and its angular distribution. At last, we also extract FWHM width from the invariant mass distribution.

This 2 dimensional histogram shows the distribution of invariant mass of three pions for all runs. The x axis is.. and y axis is the value of invariant mass. As can be easily seen that the position of maximal value is almost the same for each run. If we take the y projection at a normal run number, we can see the structure of three pions invariant mass in detail. It has two peaks located at 1.32 GeV and 1.67 GeV. To see if there is any significant variation, we extract the position of maximal value and the half width from each run.

In this graph, the blue point is the position corresponding to maximal value. And the the error bar corresponds to the position of half width. It can be easily seen that there is one run which stray away from the normal. It can also be seen better if we check it in the two dimensional histogram.

For the next, we also checked the energy of photons recorded by the calorimeters. As can be seen in this histogram, most of photons have low energy. This is because in the detectors, photons could not only come from the interaction between pion and proton, but also from the background. And these background photons usually have low energy. Different from the charged particles, photons leave no track and therefore no vertex position could be known for each photon. To distinguish the photons created by scattering and the photons from the background, the only thing we can do is set a energy cut: for photons measured by ECAL1, the energy cut is at 1 GeV and for ECAL2, it is at 4GeV. The effect of the energy cut can be shown in this histogram. Before the cut, there are significant amount of events who have more than 10 photons. After the cut is applied and photons from background is removed, most of the events only have less than 6 photons.

Knowing the energy and momentum of photons and 3 pions, we can, thus, get the total invariant mass for each run as is shown in this 2-dimensional histogram. Again, if we do the y projection along a one run number, we can see the invariant mass distribution in detail. It has same two peaks in case of three pions invariant mass at 1.3 GeV and 1.6 GeV. But if we do the y projection at some run number, such as 70650, the situation can be very different. We have a distribution that has a very large half width.

Therefore, I checked the half width of every run, which is shown in this graph. We can see that there are few runs which have pretty large values of half width, which corresponds to wide range of distribution of invariant mass. But on the other hand, we also discover that some runs have slightly smaller value of half width.

Our first guess for this abnormal phenomenon is about the scattering process. This can be checked directly by the recoiled protons. We checked the angular distribution of recoiled proton for the abnormal run and compare it with a normal run. In the graph, the x axis is the theta, which is the angle between the direction of recoiled proton and z direction. It is easy to see that for the abnormal run, it has a larger width at 23% of maximal value.

If we compare this width at 23% of maximal value of angular distribution of recoiled proton and the half width of total invariant mass, an correlation could be found, which is shown in this graph. For the most of time, the significant increase of the half width of invariant mass is synchronized by the significant increase of width in recoiled proton. But what about those half width slightly smaller than the normal?

We also compared the half width of invariant mass with photon number. In this graph, the blue points are still the value of half width and the red points are the percentage of photon number from ECAL1, which is equal to the photon number of ECAL1 over the total photon number. Thus we can see that the decreases of half width are synchronized with the increase of ECAL1 percentage. If we look into the photon number of ECAL2, the increase of ECAL1 percentage is actually due to the decrease of ECAL2 photon number.