Detection of Φ(1020) meson by the decay $\Phi \rightarrow K^+K^-$

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Abstract: *This work is carried out at CERN Geneva in 2004 in the Summer Student Program. It is based on numerical simulation of detection of Φ meson by the $\Phi \rightarrow K^+K^-$ decay channel. We processed around 2500 events and according to results obtained, we can expect detection of Φ meson when ALICE will be operational.*

1 Introduction

ALICE (A Large Ion Collider Experiment) is dedicated heavy ion detector. It will study the collisions nuclei-nuclei with a centre of mass energy of 5.5 TeV per nucleon. At this range of energy, the formation of new phase of matter, the quark-gluon plasma, is expected. One possible signal for the quark-gluon plasma formed in heavy ion collisions at high energy is the production of strange particles such as the *Φ* meson. The *Φ* meson particle is an unstable particle, its existence can only be detected by its decay products such as K^+K^-, $K^0_LK^0_S$, $\mu^+\mu^-$,...[1].

2 Detection of phi meson

In our study we use the channel decay $\Phi \rightarrow K^+K^-$ to detect formation of *Φ* meson. This channel is chosen because of its high branching ratio (49.1%)[2] and kaons are easy to detect. We search for 2 tracks with opposite charge coming from the primary vertex. Then we use the particle identification (PID) to select only candidates with high probability to be kaons. Afterwards we calculate the effective mass of the track pair and histogram it. The *Φ* meson signal should be seen as a peak in the effective mass distribution. Since *Φ* meson produced very seldom, it will be difficult to see the signal.

Therefore to make it more visible we could find some cuts on the parameters which characterize kaons coming from φ meson. These parameters are: p^2_t, cosθ, cosθ^*, φ, and φ^*.

p_t is the projection of the incidental particles momentum in a plan perpendicular to the trajectory. θ is the angle measured from the direction of the incidental particles and φ is the azimuth angle measured around this direction. The 2 angles are measured in a laboratory frame. θ^* and φ^* represent the same angles but in the rest frame.

3 Analysis

Since LHC, therefore ALICE, is not operational yet, we analyse the simulated data from the physics data challenge 2004. We have around 2500 central events (*i.e* impact parameter between 0 and 5fm).

The development of the analysis is:

• We process all events and for each event we select kaons according to the method referred in previous paragraph: use of PID to select particles with high probability to be kaons.

• For each event we combine each K^+ with K^- of the same event and we obtain data which contain the signal of Φ meson with the background.

• For each event we combine each K^+ with K^- of another event and we obtain the background (the combinatorial background): this is the mixed-event technique [3, 4].

• Afterward we subtract the combinatorial background to the same events combinations and we obtain a peak which is the signature of the phi meson in the effective mass distribution.

• The peak obtained is fitted by a Breit-Wigner function and we find the characteristics of the φ meson such as its mass and its width.

Note that for the combination of K^+ with K^- to have the combinatorial background we choose 2 events which have the quasi equal impact parameter in order to have a more realistic values for the background. To realize it, we choose 2 events which have the same or quasi-equal multiplicity.

4 Cuts on parameters

Cuts are methods used to track the particle to be identify. Indeed, each type of particles produced in a collision has its own characteristics: its ejection angles (θ, φ), its transverse momentum (p_t) (thus its transverse momentum squared p^2_t). In the other hand, parameters recorded in a collision are not only those of particles on which one is interested but also those of other particles.

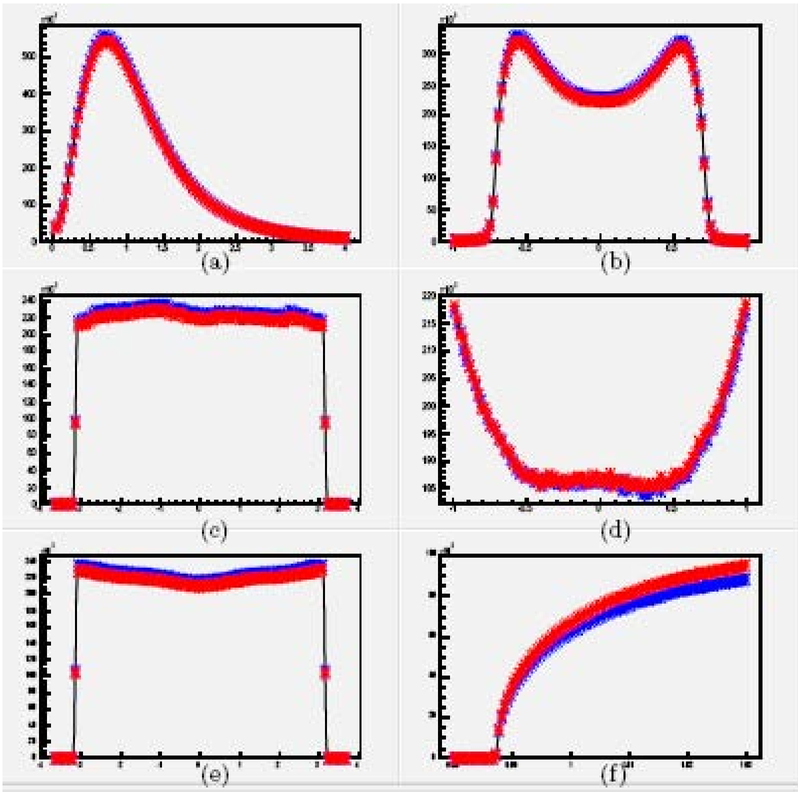

Fig. 1. Distribution of parameters. In red are from same events and in blue from mixed-events. (a) p^2_t distribution in GeV 2/c^2 (b) cosθ distribution (c) φ distribution (d) cosθ distribution (e) φ* distribution (f) effective mass distribution in GeV/c^2*

Then it is necessary to compare shapes of curves obtained in mixed-events and in same events. One eliminates parts where contributions of combinatorial background are too important compared to that of the same events.

Figure 1 gives us the shapes of different parameters. Shape of effective mass spectra of kaons is also shown.

5 Results

According to the figure 1(f), we note that *Φ* meson signal is not visible in the curve. It is necessary to eliminate background by the technique we mentioned above. We made the subtraction of the combinatorial background into the same events in the effective mass spectra. The subtraction is made after normalisation of mixed-events invariant mass into the same events invariant mass in a region far above the peak of resonance of *Φ* meson.

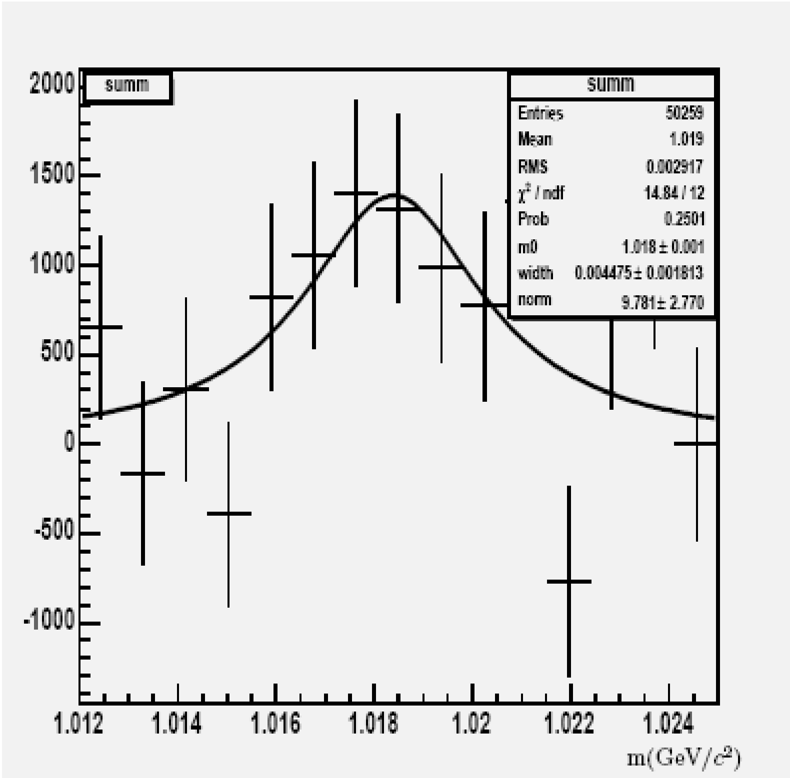

Fig 2. Invariant mass distribution of Φ meson

Then we fitted signal obtained after substraction by a Breit-Wigner function and the results are shown in figure2. Values of parameters are:

mass: $m0$= 1.018±0.001 GeV/c^2

width: Γ=0.004475±0.001813 GeV/c^2

norm: N=9.781±2.770

6 Conclusion

Figure 2 shows us that there are important fluctuations and fit was possible only in the vicinity of the peak of resonance. This may be due to the fact that there are not enough events to analyze (2500 events). The *Φ* meson being a rare particle, it is obvious that the little of data which we used made the identification if the particle rather difficult.

Nevertheless this study shows the possibility to produce *Φ* meson and we can expect detection of *Φ* meson when the LHC therefore ALICE will be operational. The parameters values (mass and width), characteristics of *Φ* meson, obtained by fit are consistent with the values given in literature [2].

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8 References

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