ϕ-meson exclusive production simulation at NICA SPD

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Introduction: ϕ-meson

We are studying exclusive production of phi meson – meson consists of quark-antiquark pair – $s\bar{s}$.

- $m = 1019$ MeV
- $\Gamma = 4$ MeV
- $\phi \to K^+K^-$ The most common decay mode (49%)

Motivation for pp$\to$ppϕ study:

- Probe QCD models at low energy, low Q^2:
  - production via meson exchange [NewJ.Phys.4:68,2002]
  - v.s. pomeron-odderon meson vertex [Phys.Rev. D101, 094012 (2020)].
- search for pentaquarks with hidden strangeness: pp $\to$ p$P_s^+(\to$ p$\phi)$
- reconstructed ϕ signal to use for detector performance studies

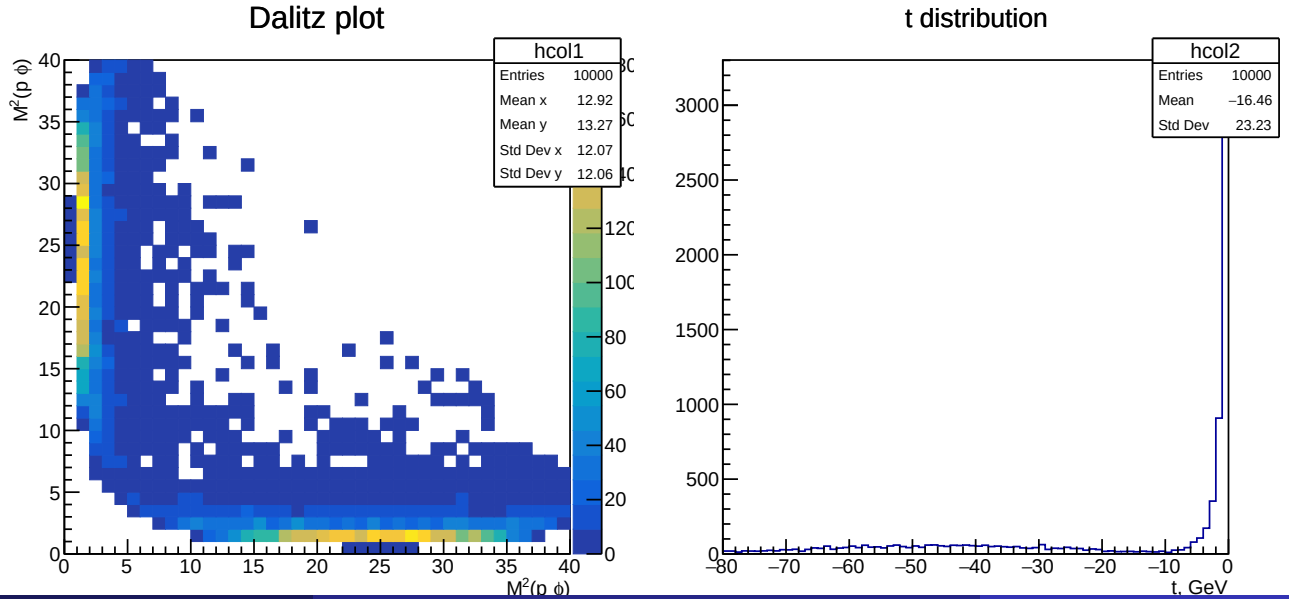
Matrix element

The matrix element we have used is:

$$|M|^2 = \sum_{i=1}^{4} \frac{k}{|p'_f|} F^2(t) D^2(t) \sigma(w) w^2 t =$$

$$= \sum_{i=1}^{4} \frac{\lambda^{1/2}(w^2, m_p^2, m_\pi^2)}{\lambda^{1/2}(w^2, m_p^2, m_\phi^2)} F^2(t) D^2(t) \sigma(w) w^2 t$$

[Sibirtsev, Nucl.Phys.A 604 (1996) 455]



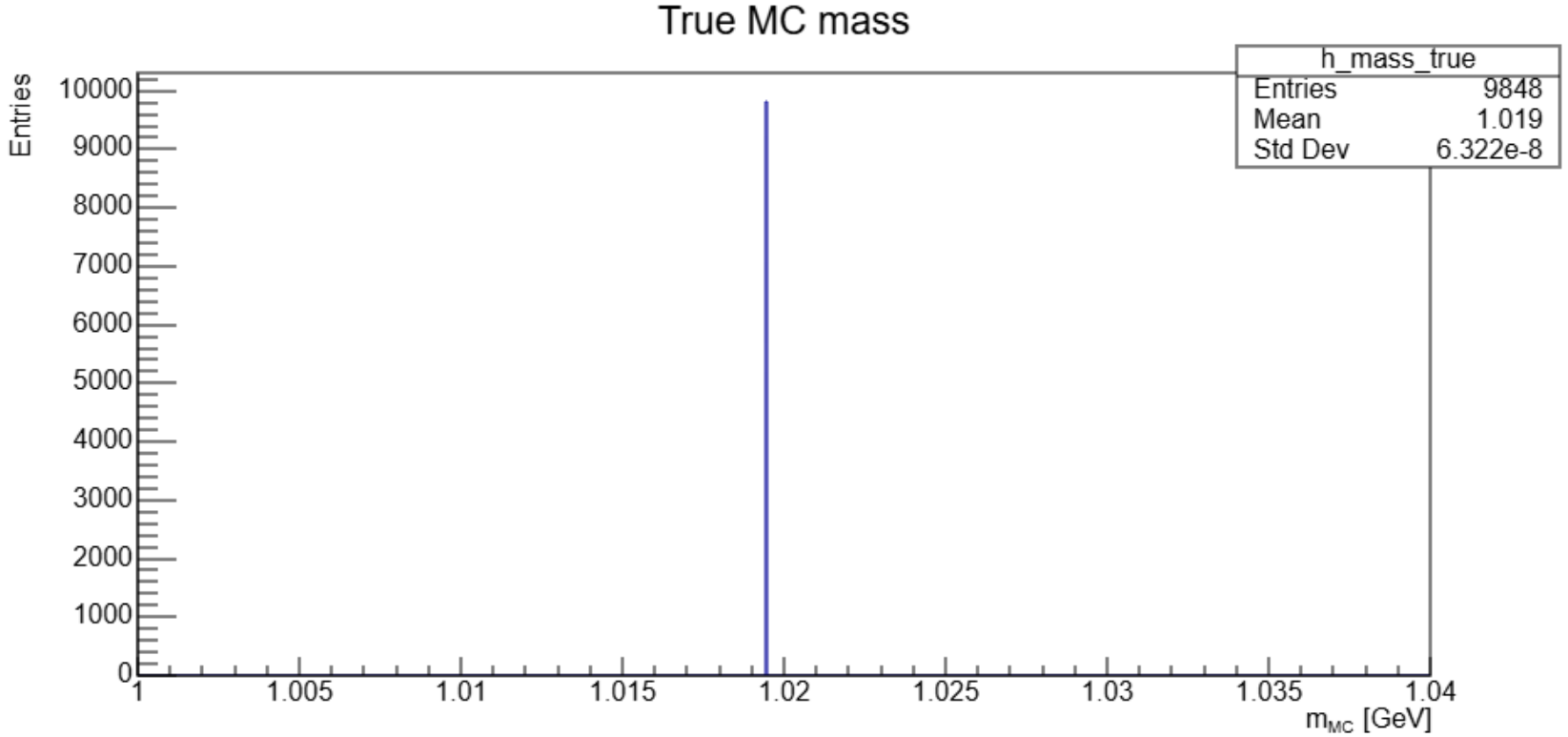
Criteria

To identify the exclusive process it was required:

- only 3 tracks in event: 2 K-mesons and 1 proton
- Particle Identification – Likelihoods method based on the energy losses of particles during ionization of the medium
  - momentum cut for π-mesons: if $p > 0.6 GeV \Rightarrow$ K-meson

Problem to solve

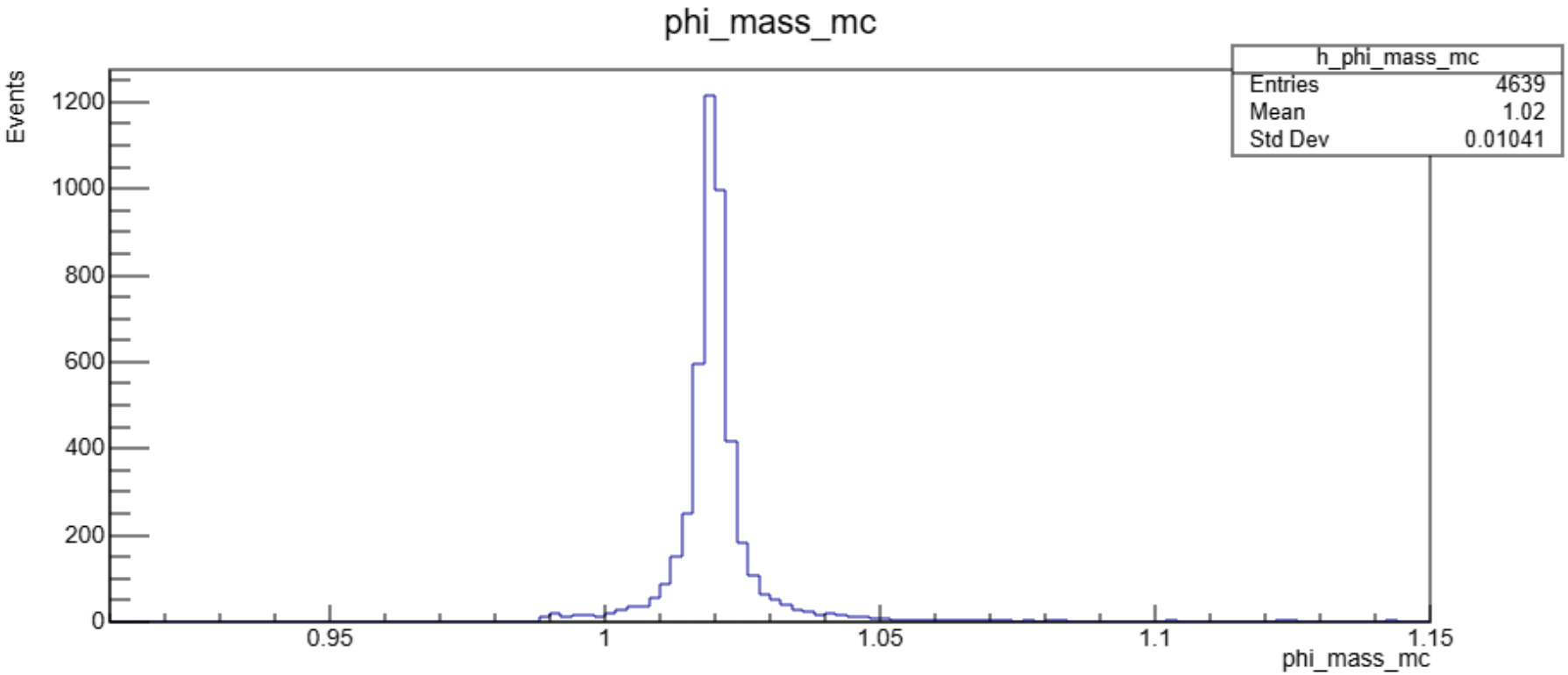
There were suspicions that in previous version of code phi-meson had not its own width. The test allowed us to verify it and indeed its invariant mass was the constant value. And because of it we could observe only detector resolution in invariant mass distribution.



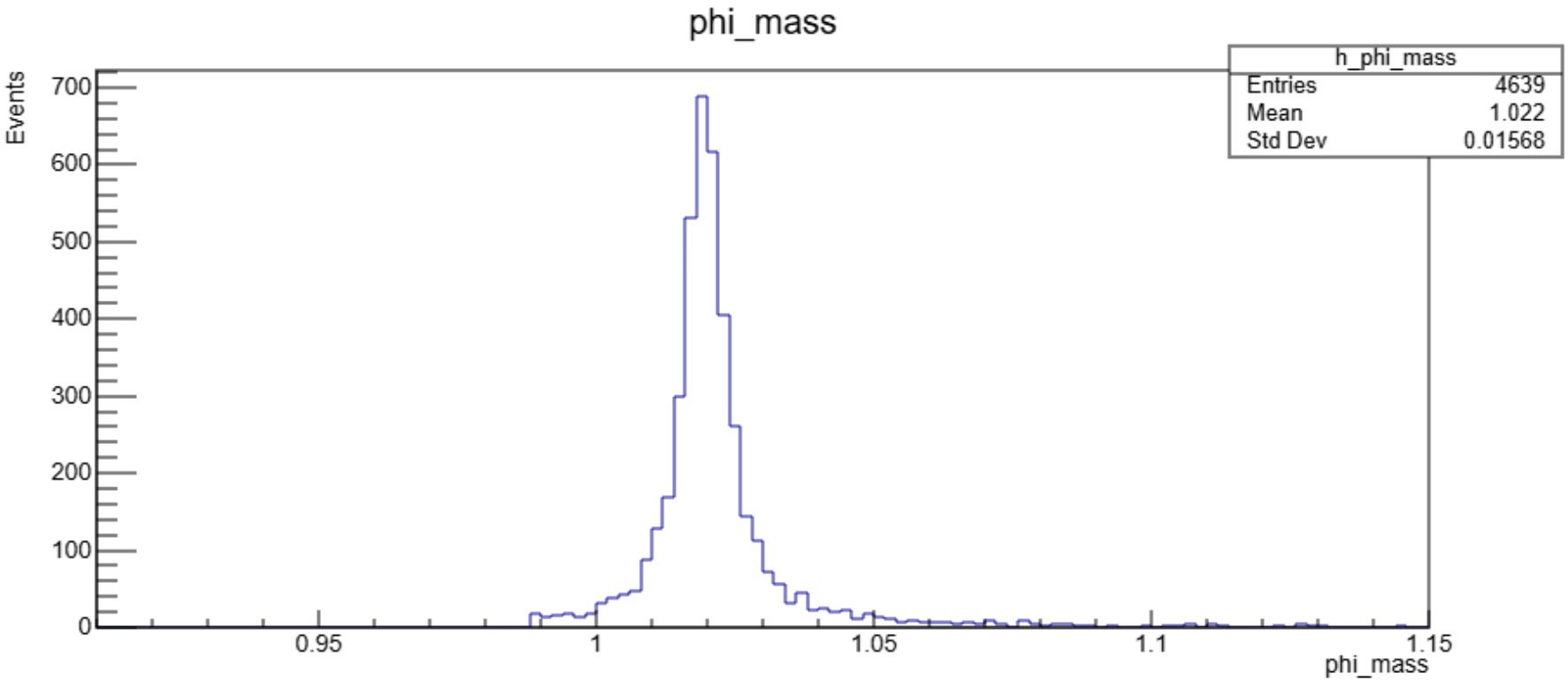
The relativistic Breit-Wigner distribution

```
1  double m_gen;
2  do {
3      m_gen = rnd.BreitWigner(m_phi, w_phi);
4  } while ((m_gen <= 0.910 || m_gen > fEnergy - 2*m_p);
5
6  fMasses[fPhiIndex] = m_gen;
7
8  fGenPhaseSpace.SetDecay(Ptot, fMasses.size(), fMasses.data()
       );
9  weight = fGenPhaseSpace.Generate();
10
11 for (int i=0; i<fPDGs.size(); i++) {
12     v = fGenPhaseSpace.GetDecay(i);
13     MomArray[i].SetPxPyPzE(v->Px(), v->Py(), v->Pz(), v->E()
       );
14 }
15
16 weight = weight * MatrixElement2(init_p1, init_p2,
17                                  MomArray[0], MomArray[1],
       MomArray[2]);
```

The relativistic Breit-Wigner distribution



The relativistic Breit-Wigner distribution



Tasks for the future

We are planning to

- fit signal with two Voigt-functions
- take the background into account
- make the same calculations for ρ-meson

Thank you for attention!