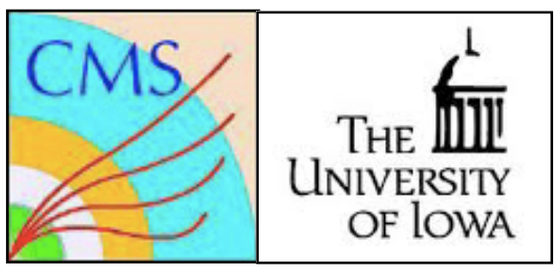
Observation of Structures in the $J/\psi\phi$ Mass Spectrum of Exclusive $B^+ \to J/\psi\phi K^+$ Decays around 4148 and 4317 MeV



Analysis

- We are searching for structures in the J/ψφ mass spectrum from the inclusive $B^+ \rightarrow J/\psi\varphi K^+$ decays produced in $\sqrt{s}$ = 7 TeV proton-proton collisions at Large Hadron Collider

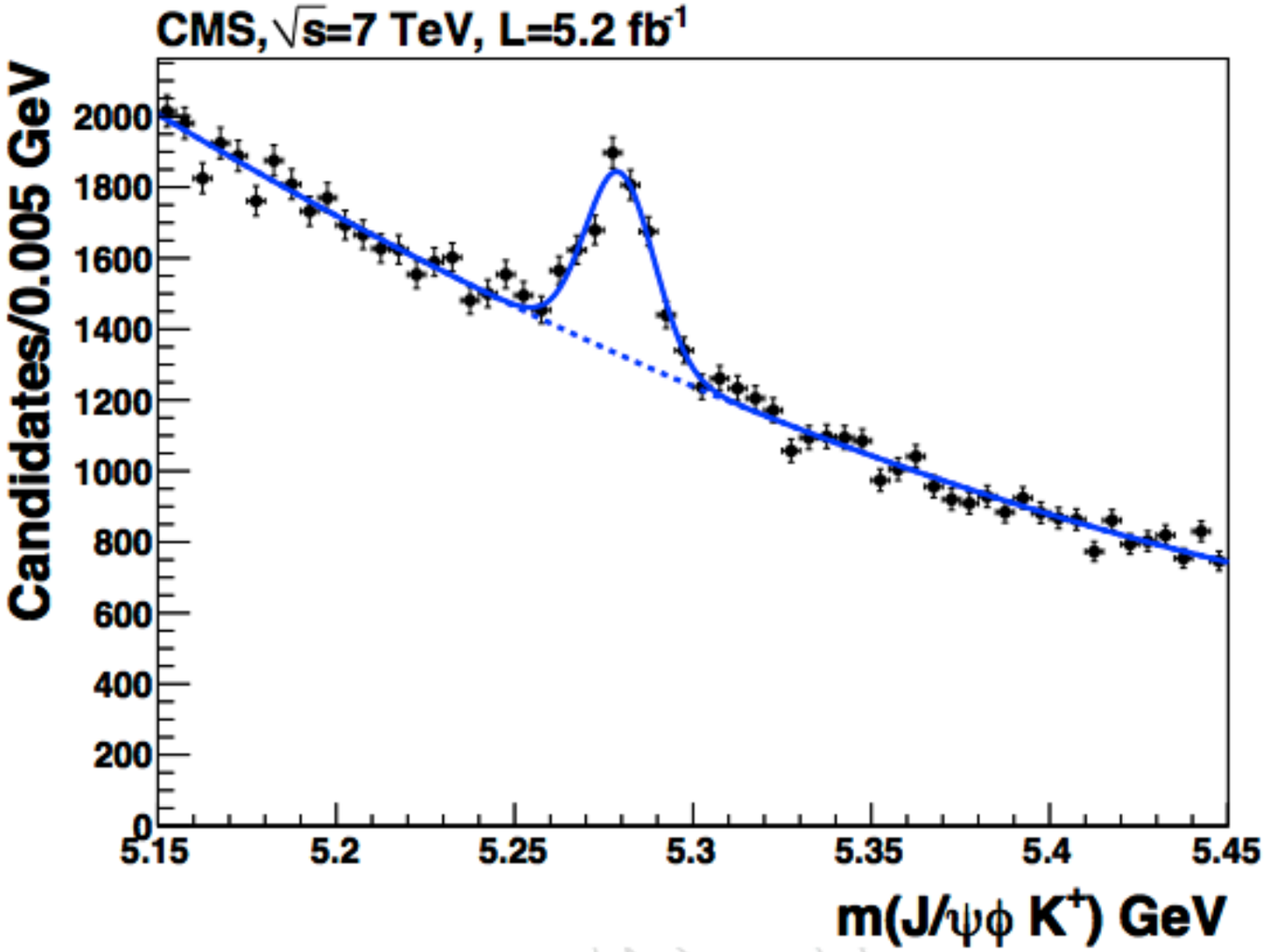
- In 2009 CDF collaboration first reported a narrow structure near the J/ψφ threshold. Recently, the LHCb collaboration reported a result in conflict with CDF measurements. That's why result from an independent experiment is important to clarify the status.

Event Reconstruction

- The $\mu^+\mu^-$ channel is used to reconstruct J/ψ candidates
- The dataset is divided into two parts (A and B) corresponding to different trigger requirements on the p_T of the muons and the J/ψ in different periods of time characterized by the rising luminosity and pile-up.
- The p_T requirement on the J/ψ and muon candidates
  - p_T (J/ψ) > 7 GeV in datasetA
  - p_T (J/ψ) > 7 GeV, p_T (μ^+) > 4 GeV, and p_T (μ^-) > 4 GeV
- The opposite sign muon pairs are required to form a good 3D vertex
  - The J/ψ is required to be displaced from the primary vertex in the transverse plane at least three times its uncertainty.
- Only tracks which pass the CMS quality requirements and corrected for ionization energy loss are used in reconstructing the $B^+ \rightarrow J/\psi\varphi K^+$ candidates.
- B candidates are reconstructed by combining the $\mu^+\mu^-$ candidates with additional three charged tracks with a total charge of +/- 1
  - Tracks are assigned with kaon mass
  - p_T (kaon) > 1.0 GeV
- The K^+K^- pair with lower mass is chosen to be φ candidate
- Reconstructed J/ψ and φ vector meson masses are required to be within a suitable range of their nominal values
  - 2.9967 GeV < m($\mu^+\mu^-$) < 3.1967 GeV
  - 1.008 GeV < m(K^+K^-) < 1.035 GeV

The J/ψϕK+ Mass Distribution

The J/ψφK+ mass distribution after event selections



	Mass	Width	Yield
Data	5.2796 ± 0.0006	9.7 ± 0.7 MeV	2478 ± 162

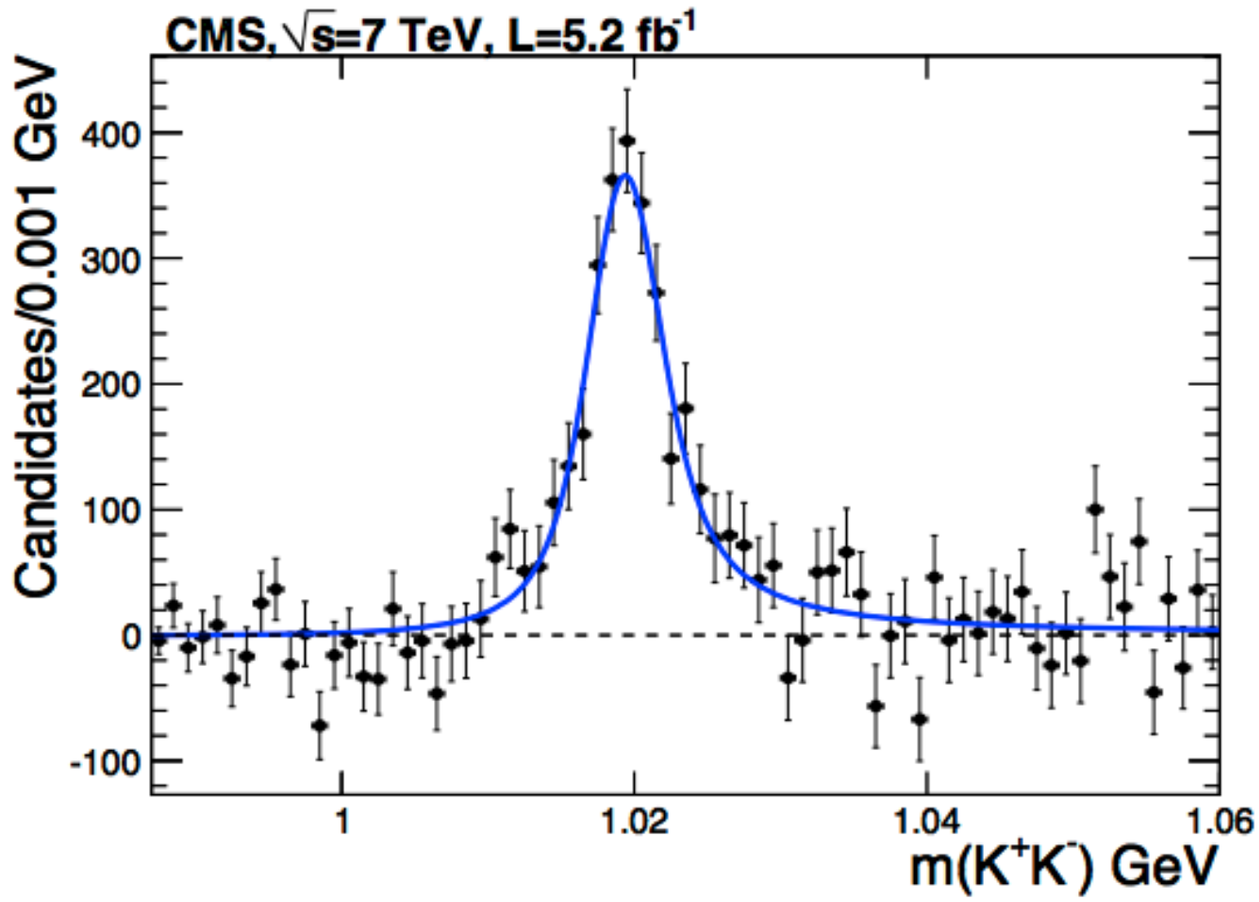
Mass is consistent with PDG value and the width is consistent with the value which is obtained from MC.

This is the largest exclusive $B^+ \rightarrow J/\psi K^+ K^- K^+$ sample to date in the world.

Signal PDF: A Gaussian signal
Background PDF: A second order Chbyshev polynomialText

The ϕ Signal

The B^+ sideband subtracted mass distribution of K^+K^- candidates.
The $J/\psi\varphi K+$ mass is within 3σ of the B+



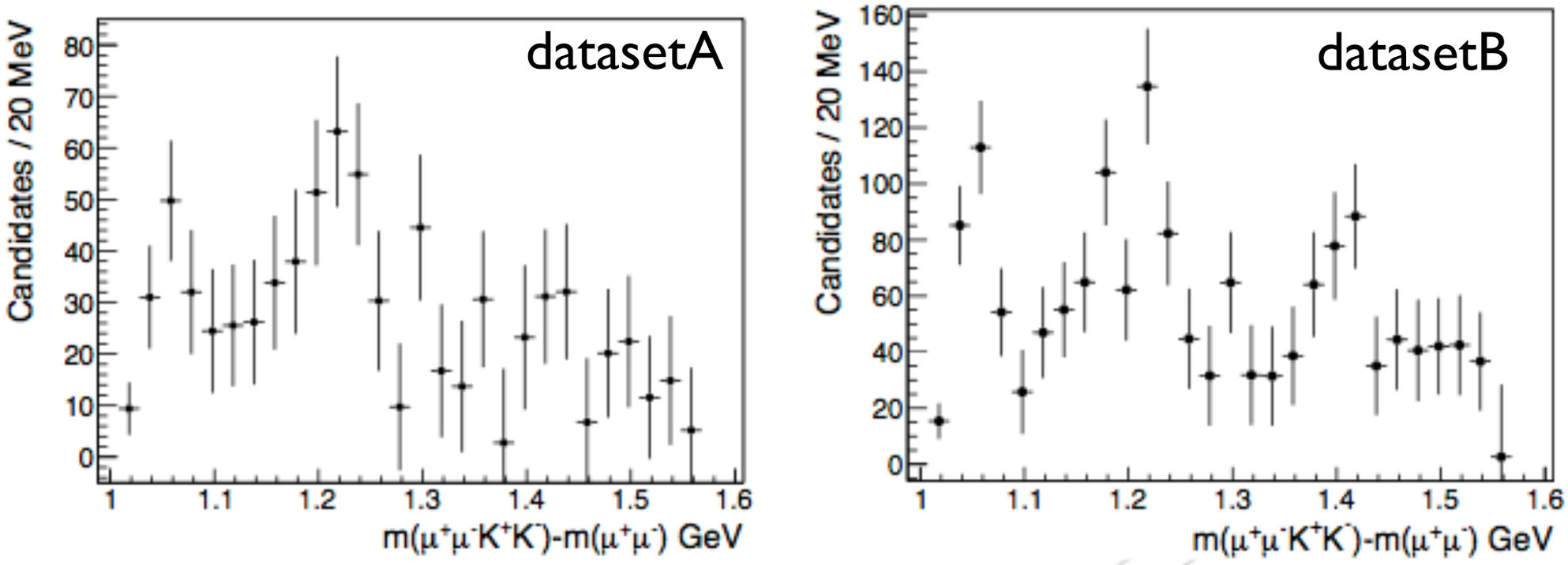
Distribution is fitted with a P-wave relativistic Breit-Weigner function convoluted with a Gaussian resolution function.

PDG Value: Mass = 1019.455 ± 0.020 MeV/c^2, Width = 4.26 ± 0.04 MeV/c^2					
Fit Range	χ^2	d.o.f	p(χ^2)	Mass	Width
1.008 - 1.035 GeV	19.99	27 - 3 = 24	70%	1019.4 ± 0.1 MeV/c^2	4.89 ± 0.44 MeV/c^2
0.987 - 1.060 GeV	78.31	73 - 3 = 70	23%	1019.4 ± 0.1 MeV/c^2	4.68 ± 0.41 MeV/c^2

The Δm Spectrum

For historical reasons (CDF and LHCb), we use the variable Δm which is defined as $m(\mu^+\mu^-K^+K^-) - m(\mu^+\mu^-)$ and use it to investigate the possible structures.

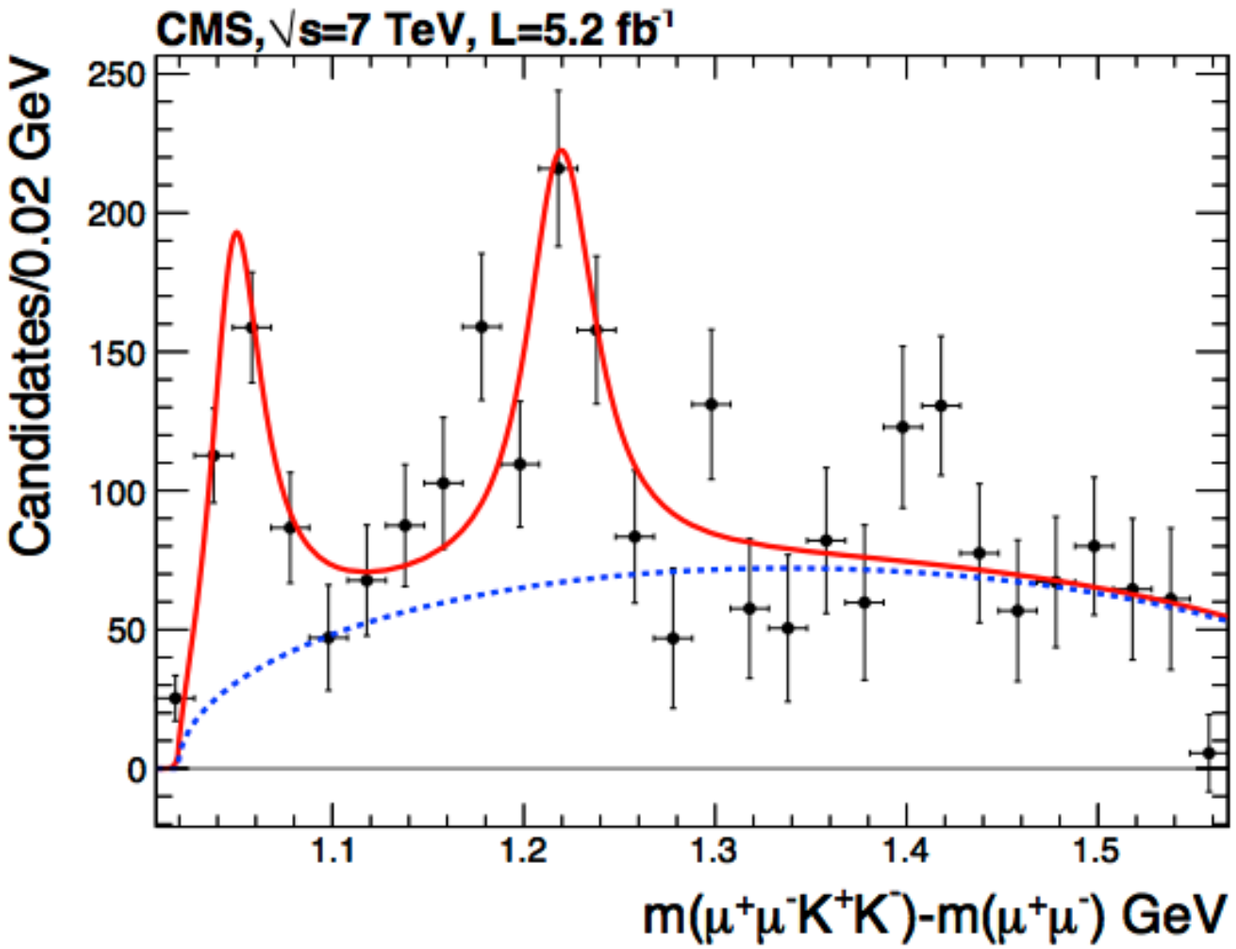
Δm spectra in the defined B mass window for dataset A and dataset B



Δm spectrum above 1.568 GeV is excluded to remove the combinatorial background expected from misidentified $B_s^0 \to \psi(2S)\varphi \to J/\psi\pi^+\pi^-\varphi$ decays

Results

The relative efficiency corrected Δm from the exclusive $B^+ \rightarrow J/\psi\varphi K^+$ signal



We modeled the observed structured by S-wave relativistic Breit-Wigner functions convoluted with a Gaussian resolution function whose rms are fixed to values obtained from simulation.

Three body phase space is used to describe the background.

The Δm mass, width and the signal yield from the two signal hypotheses fit

	Mass (MeV)	Width (MeV)	Signal Yield
First Peak	1051.5 ± 2.0	32.3 ± 9.68	355 ± 46
Second Peak	1220.0 ± 3.0	40.1 ± 11.1	445 ± 83

Including the systematics and adding the J/Ψ mass into the Δm spectrum, the masses and the widths of the two structures

- First Peak
  - mass: $4148.2 \pm 2.0(\text{stat}) \pm 5.2(\text{sys})$ MeV
  - width: $32.3 \pm 9.7(\text{stat}) \pm 20.1(\text{sys})$ MeV
- Second Peak
  - mass: $4316.7 \pm 3.0(\text{stat}) \pm 10.0(\text{sys})$ MeV
  - width: $40.1 \pm 11.1(\text{stat}) \pm 20.0(\text{sys})$ MeV

The fit results from the null, one signal and two signal hypotheses

	χ^2	dof	$\Delta(\chi^2)$	$p(\chi^2,3)$	Significance
Null	147.1	27			
One Peak	88.4	24	58.7	$5.6\ x10^{-13}$	$7.1\ \sigma$
Two Peaks	50.3	21	38.1	$1.4\ x10^{-8}$	$5.5\ \sigma$