Study of semileptonic decays of B_s mesons

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Poster ID

Motivation

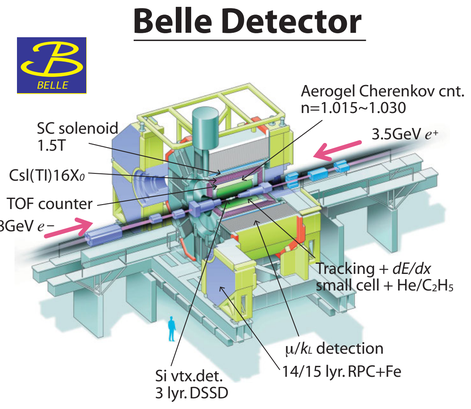
The Cabibbo-Kobayashi-Maskawa matrix elements are fundamental parameters of the Standard Model of particle physics. [1] More precise measurements would crucially help the search for new physics in rare decays, which requires accurate SM predictions.

In particular, V_{cb} represents a long-standing puzzle in flavor physics:

- Direct information on can be obtained from inclusive and exclusive semileptonic bottom mesons decays to charm hadrons
- The two values are approximately three standard deviations apart [2]
- $|\boldsymbol{V_{cb}^{incl}}| = (\boldsymbol{42.19 \pm 0.78}) \times \boldsymbol{10^{-3}}$ and $|\boldsymbol{V_{cb}^{excl}}| = (\boldsymbol{39.25 \pm 0.56}) \times \boldsymbol{10^{-3}}$
- Most recent measured values on exclusive semileptonic $\boldsymbol{B_s^0}$ decays [3] are $(\boldsymbol{41.4 \pm 0.6 \pm 0.9 \pm 1.2}) \times \boldsymbol{10^{-3}}$ and $(\boldsymbol{42.3 \pm 0.8 \pm 0.9 \pm 1.2}) \times \boldsymbol{10^{-3}}$

Data

Belle Detector



The total $b\bar{b}$ production cross-section in the e^+e^- collision at the $E_{cm} = 10.86$ GeV is measured to be $\sigma_{b\bar{b}}^{\Upsilon(5S)} = 0.340 \pm 0.016\ nb$. A fraction of kinematically allowed $B_s^{0(*)}\bar{B}_s^{0(*)}$ pairs $f_s = (22.0^{+2.0}_{-2.1})\%$ with a relative percentages of $f_{B_s^{0*}\bar{B}_s^{0*}} = (87.0 \pm 1.7)\%$ and $f_{B_s^{0*}\bar{B}_s^{0}} = (7.3 \pm 1.4)\%$

Reconstruction and event selection

Process: $e^+e^- \to B_s^{0*(sig)}\bar{B}_s^{0*(tag)}$, $B_s^{0*} \to B_s^0\gamma$
$B_s^{0(sig)} \to X_c\ell\nu_\ell$, $B_s^{0(tag)} \to hadrons$

Event selection for charged tracks:

- $|dr| < 1$ $|dz| < 2$
- $PID(K) = \frac{\mathcal{L}(K)}{\mathcal{L}(K)+\mathcal{L}(\pi)} > 0.6$, where $\mathcal{L}$ – likelihood function
- $PID(\pi) = 1 - PID(K) > 0.4$
- For leptons in laboratory frame $p_e > 0.6$ GeV $\quad p_\mu > 0.9$ GeV

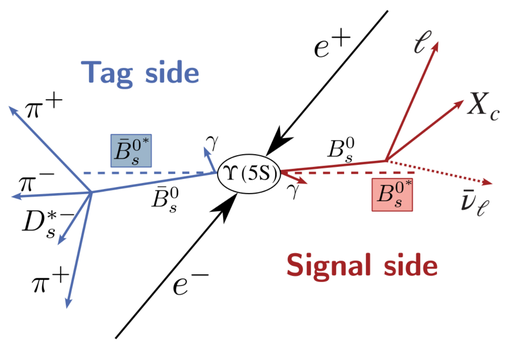
Reconstruction of photons:

- $E > 50\,\mathrm{MeV}$; barrel $(32° < \theta < 130°)$
- $E > 100\,\mathrm{MeV}$; forward endcap $(12° < \theta < 32°)$
- $E > 150\,\mathrm{MeV}$; backward endcap $(130° < \theta < 157°)$

Analysis of $B_s^{0(*)}\bar{B}_s^{0(*)}$ kinematics

Parameter to observe signal — $m^2_{miss} = (P_{sig} - P_{X_c} - P_\ell) \approx m^2_\nu = 0\ \mathrm{GeV}^2$. Because of the undetected neutrino loss it is impossible to measure P_{sig}: $m^2_{miss} \approx M^2_{B_s^0} + M^2_{X_c\ell} - E_{cm}E_{X_c\ell}$.

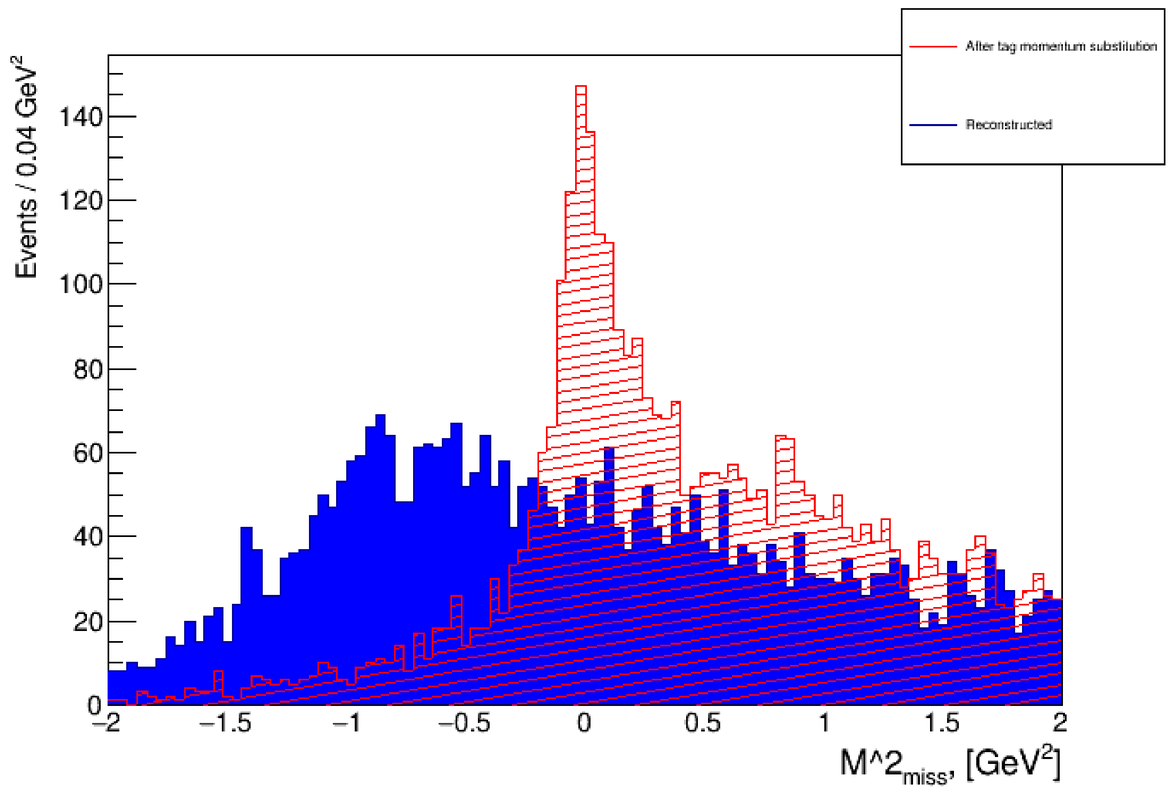
- $B_s^{0*}\bar{B}_s^{0*}$ in CM frame are born back-to-back, after emmiting soft photon $p_{B_s^0}$ changes direction
- Angle between $p_{B_s^0}$ pair lays beetween 100 and 200 mrad
- In $\Upsilon(5S) \to B_s^{0(*)}\bar{B}_s^{0(*)}$ momentum of B_s^0 is less than in $\Upsilon(5S) \to B_s^0\bar{B}_s^0$
- According to MC $E_{B_s^0} = 5.386$ GeV – energy of strange bottom meson in $B_s^{0*} \to B_s^0\gamma$



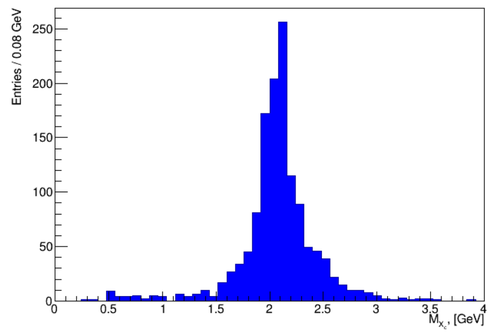
Formalism: we will denote $X_c\ell$ as ROE (rest of event) - all particles that doesn't take part into $B_s^{0(tag)}$ reconstruction .

Signal Monte Carlo analysis

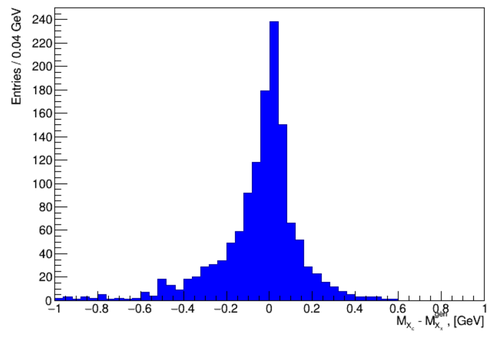
The MC events are generated using EvtGen followed by GEANT.
For analysis 100000 events of $B_s^{0*}\bar{B}_s^{0*}$ were studied as relative percentage of that configuration is much higher than others and lower momentums than in $B_s^0\bar{B}_s^0$ pair leads to higher resolution.
For signal reconstruction approximate formula $m^2_{miss} = (5.386 - E_{ROE})^2 - -(-p_{B_s^{tag}} - p_{ROE})^2$ is used.
Extra cuts: $|charge(ROE)| = 0$ and $p_\ell > 1GeV$ in CM frame



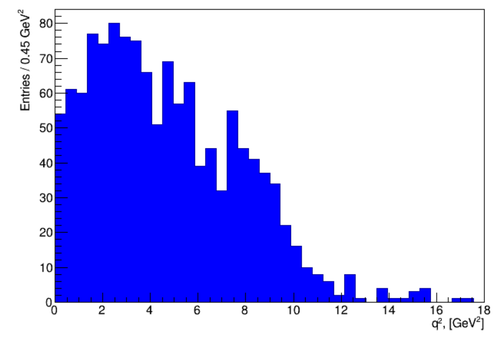
With signal selection $m^2_{miss} < 0.2\mathrm{GeV}^2$, several evaluations were made



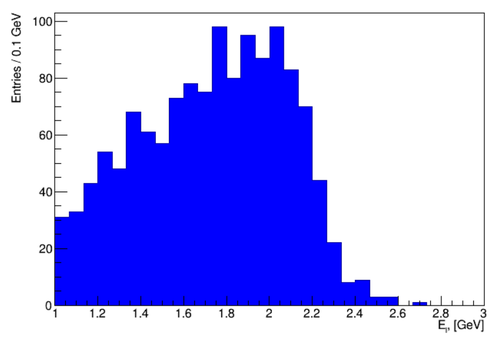
First estimation of hadronic mass spectrum



Difference between observed and generated mass of hadron



Measurment of $q^2 = (P_{sig} - P_{X_c})^2$ – four-momentum transfer squared



Lepton energy in the CM rest frame

Conclusion and discussion

- A method to optimize the recovery of of the lost neutrino's kinematics was presented. Obtained first estimations of spectral moments – moments of the charged lepton energy, the hadronic mass and the hadronic energy spectra.
- Using optimized classificator on $\Upsilon(5S)$ Belle data with 11014 ± 452 B_s^0-candidates a new measurments can be observed. Results of data analysis can be used in further studies of extraction of $|V_{cb}|$ using methods described in [4,5]

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MORE INFORMATION

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