$B \to K^{(*)} \nu\nu$ analysis (SL tag): Background Studies

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Outline

- **Background studies strategy**
- **Remind on selection:**
  - $B^+ \to K^+ \nu\nu$
  - $B^0 \to K^0 \nu\nu$
  - $B^* \to K^* \nu\nu$
- **Background studies results:**
  - Background dependence on PID
  - Background characterization (main contributing modes)
- **Summary and outlook**

Background studies strategy (I)

- **Wants to produce a list of modes which are the dominant contribution to the BB-background (charge and neutral)**
- **Samples:**
  - Use BB-generic (charged and neutrals) n-tuples from previous BaBar analyses
    - $B^{+/0} \rightarrow K^{+/0} \nu\nu$ (BAD-2132)
    - $B^{+/0} \rightarrow K^{*+/0} \nu\nu$ (BAD-1845)
- **Two step approach (suggested by Matteo):**
  - Study background composition of tag-side reconstruction
  - Then study background composition of signal-side
- **The method:** look at the true information and,
  - study sources of background due to mis-rec and mis-ID
  - study nature and multiplicity of the background B-decay modes
- **From those samples will construct a cocktails of B decays**

Background studies strategy (II)

- **Method to study the background composition:**
  - **Need to define true-B associated with the tag and signal side candidates**
  - **Reminder:**
    - Btag reconstructed in $D^{(*)}lnu$ ($l = e^{+/-}, \mu^{+/-}$)
    - D is reconstructed in final states with a K^+ or K^0_S (e.g. $K^-\pi^+$, $K^0_S\pi^+\pi^-$,...)
  - **Definitions:**
    - **true-Btag:** grand-grand-...-mother of the associated true particle of the K^+/K^0_S and lepton
    - **true-Bsig:** the other true-B in the event
  - **Problem with this definition are SCF events:** events with either
    - a fake K^0_S (combinatoric, 5% of the rec-K^0_S)
    - different associated true-B to the Kaon and lepton
  - **Only characterize the contributing B-modes for the non-SCF events**
  - **The SCF events has very similar B-modes contributions**

Reminder: $B^{(*)} \to K^{(*)} \nu\nu$ Analysis

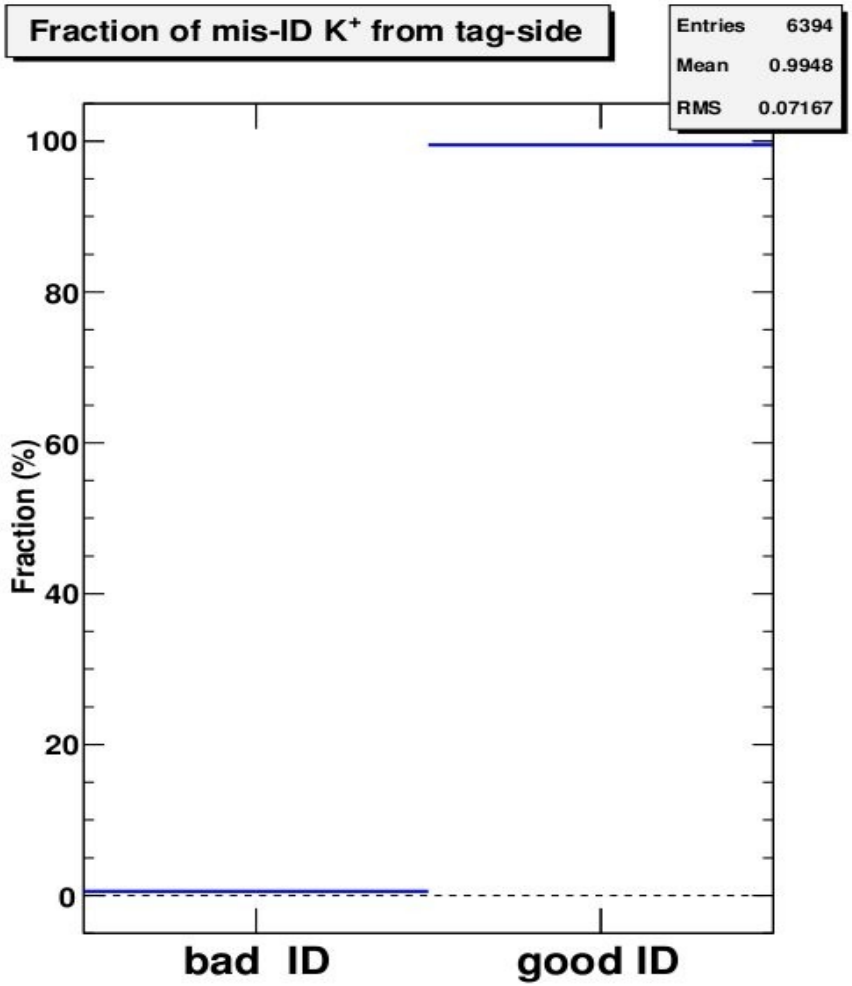
- **Tag-side selection**
  - Look for $D^{(*)}$lnu decays (l = e,μ)
  - D* reconstructed as $D^* \to D\pi$, $D\gamma$
  - D reconstructed as: - $K^-\pi^+$, $K^-\pi^+\pi^-\pi^+$, $K^-\pi^+\pi^0$, $K^0_S\pi^+\pi^-$ (neutral)

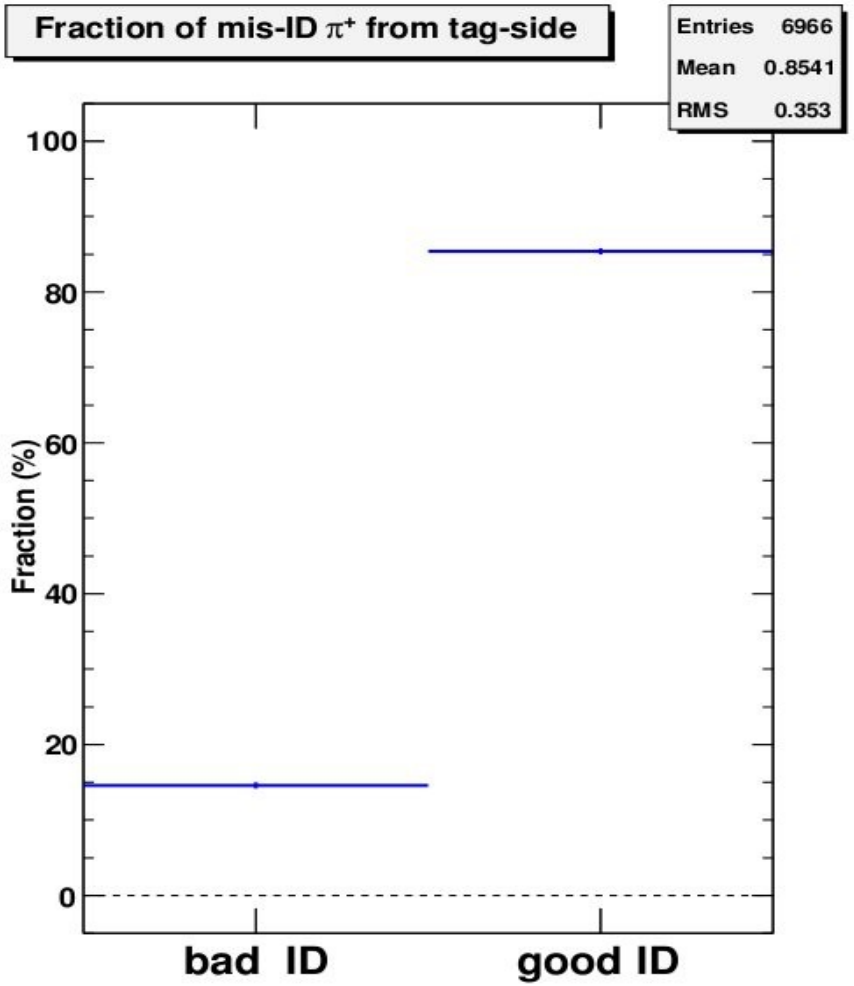
    - $K^-\pi^+\pi^-$, $K^0_S\pi^-$ (charged)
  - K^+ (π^+) from D reconstruction is LHKaonTight (is not LHKaonNotAPion)
- **Signal-side selection**
  - $B \to K\nu\nu$: look for a K^+ (K^0_S) in LHKaonTight (KsTight) list.
  - $B^* \to K^*\nu\nu$: look for a K^{*+} (K^{*0}): - $K^{*+} \to K^0_S(\to\pi^+\pi^-)\pi^+$, $K^0_S(\to\pi^0\pi^0)\pi^+$, $K^+\pi^0$ (charged)

    - $K^{*0} \to K^+\pi^-$ (neutral)
  - For charged mode apply charge correlation (opposite charges for Btag and Bsig)
- **For this background studies only apply relaxed cuts on the main discriminant variables:**
  - CM momenta and mass of the tag-side D, lepton and signal-side K/K*
  - Number of extra tracks in the event
  - No cut on Eextra

Some results: dependence on PID

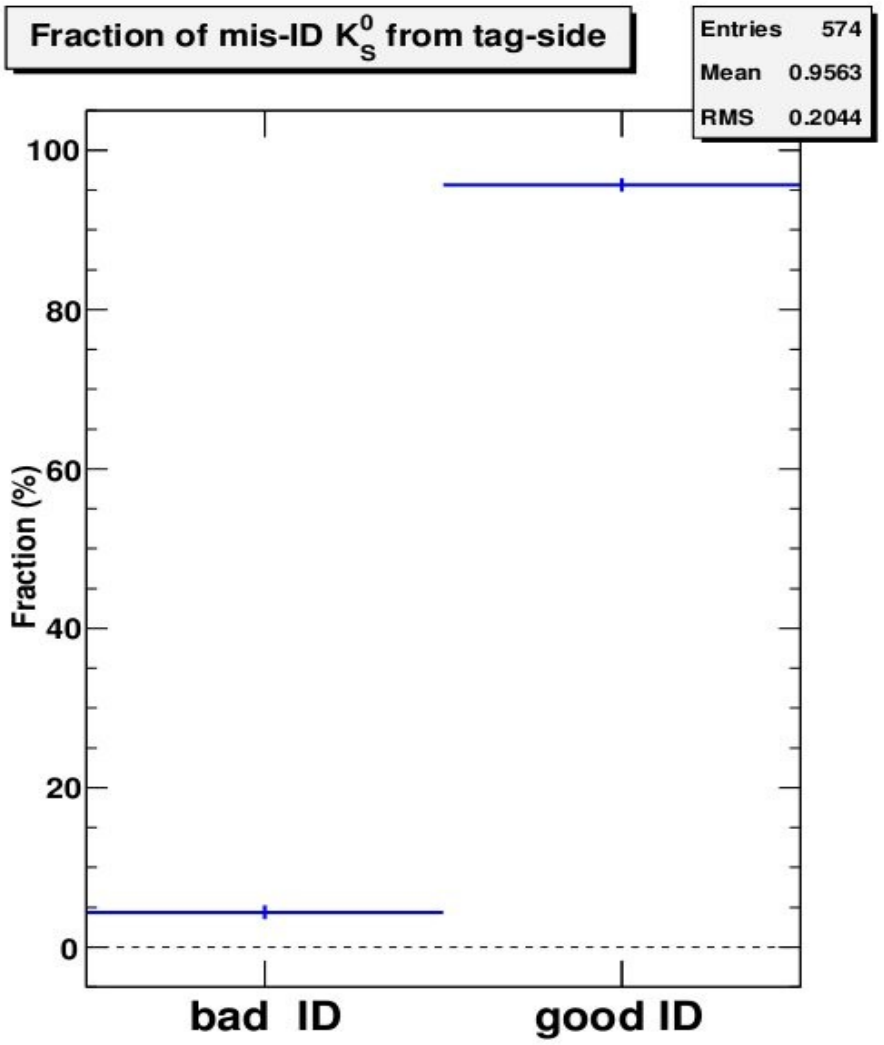
Tag-Side

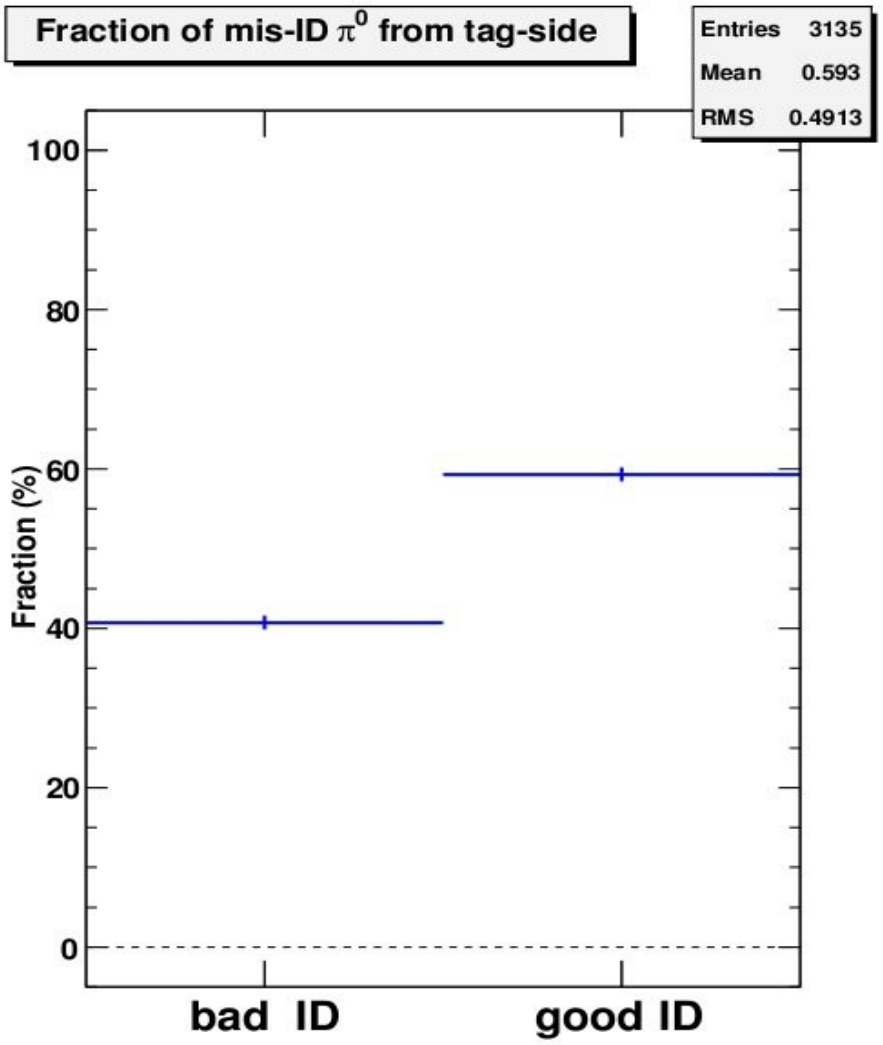




Some results: dependence on PID

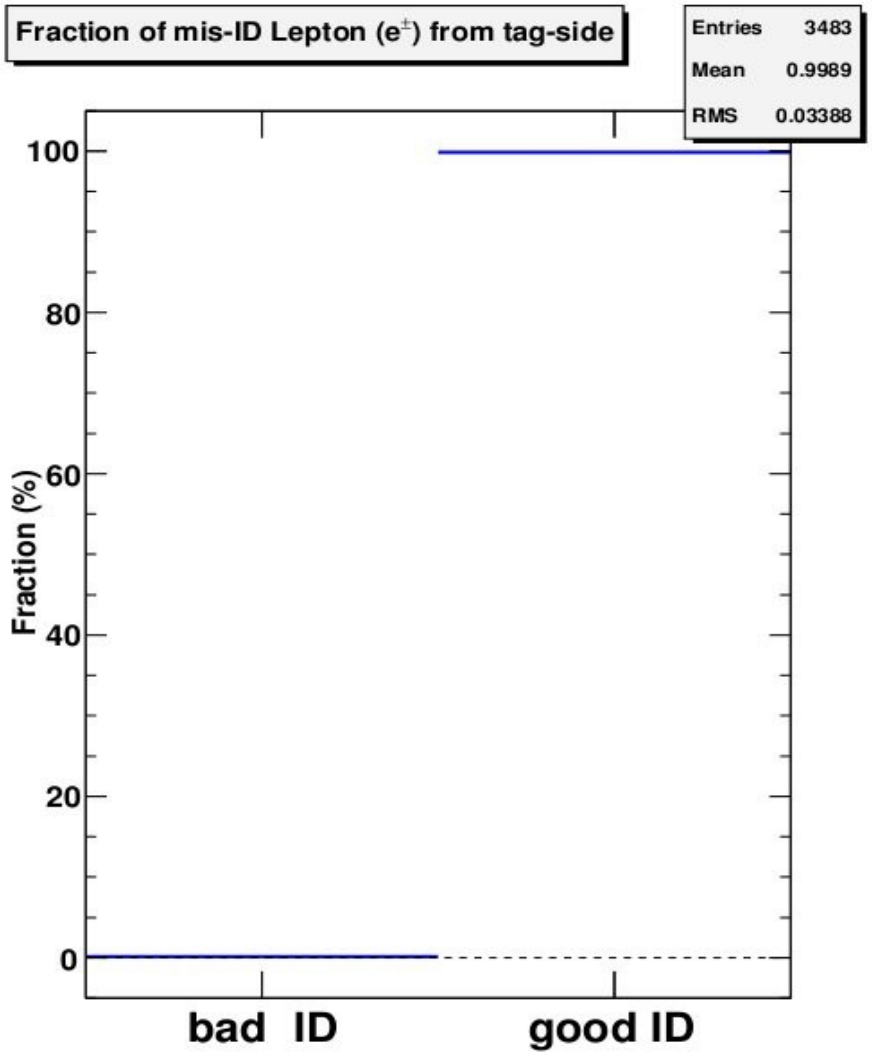
Tag-Side

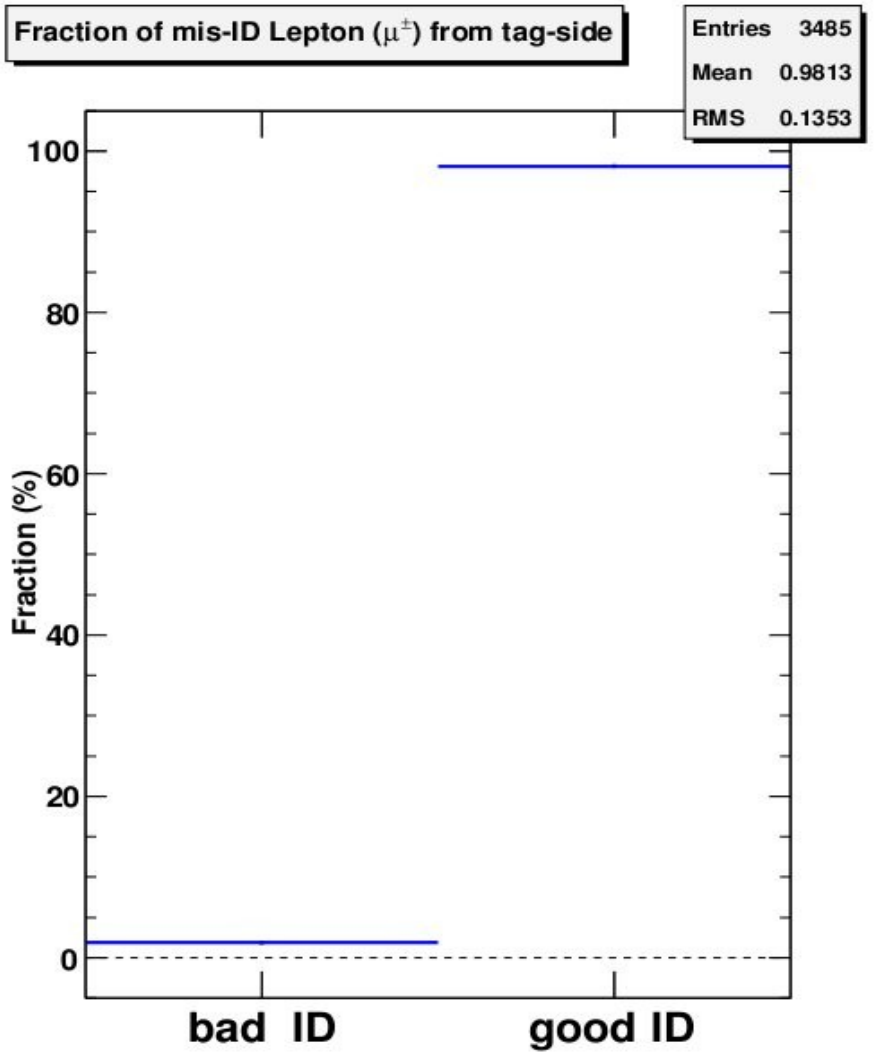




Some results: dependence on PID

Tag-Side

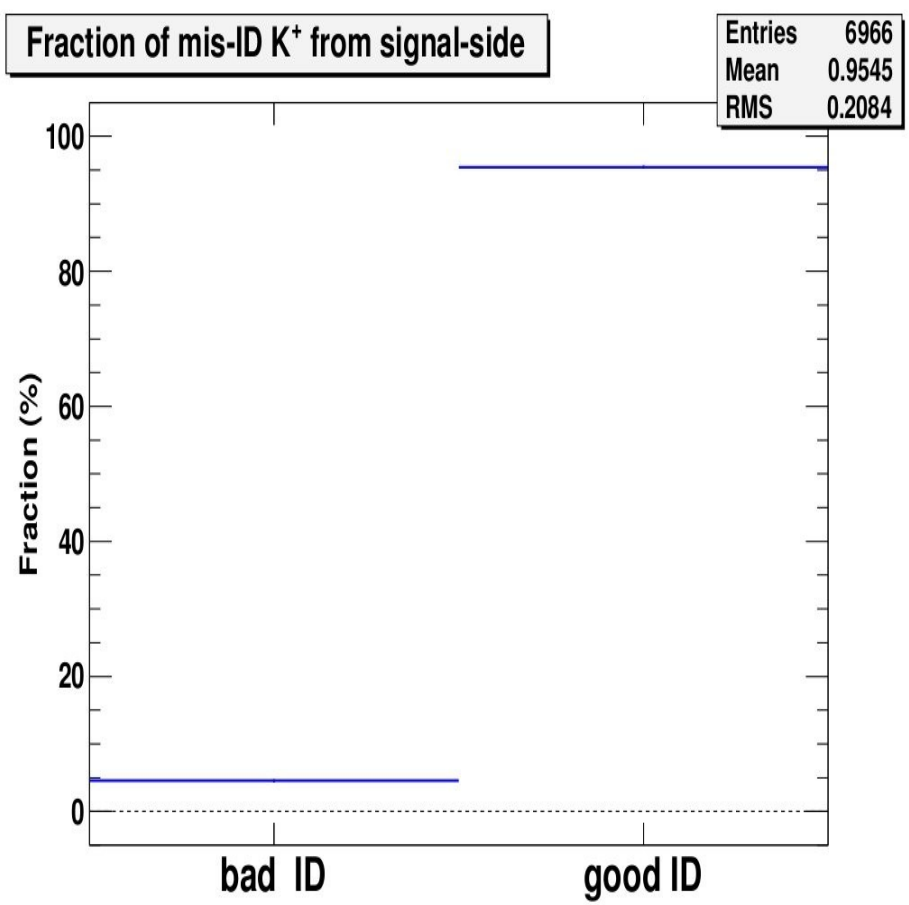




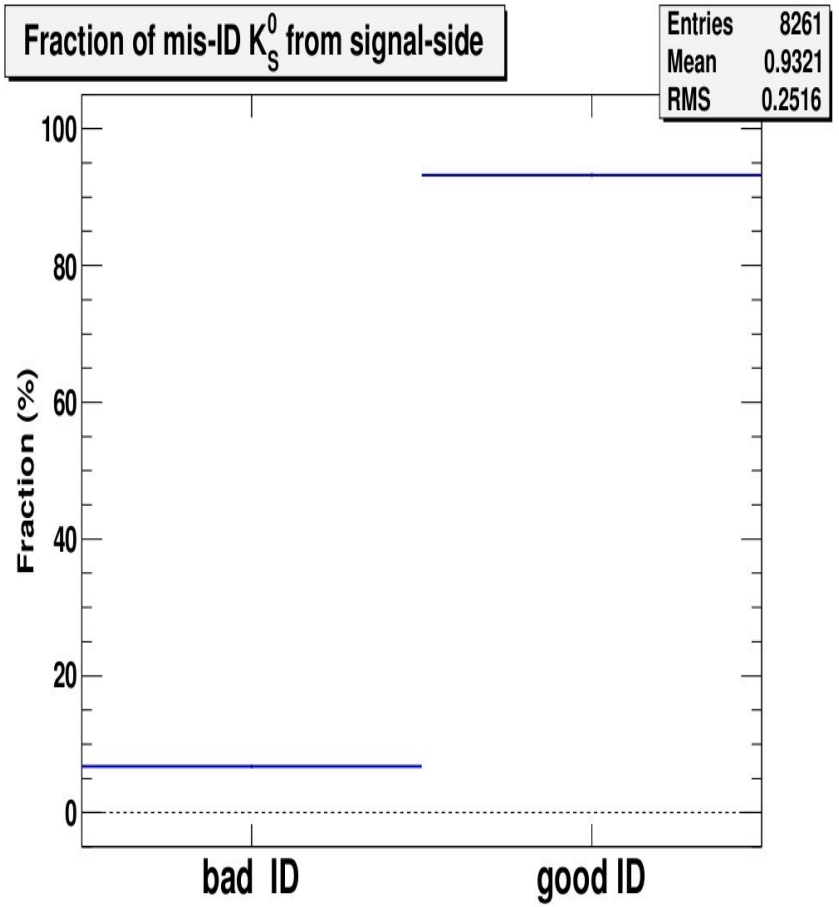
Some results: dependence on PID

Signal-Side

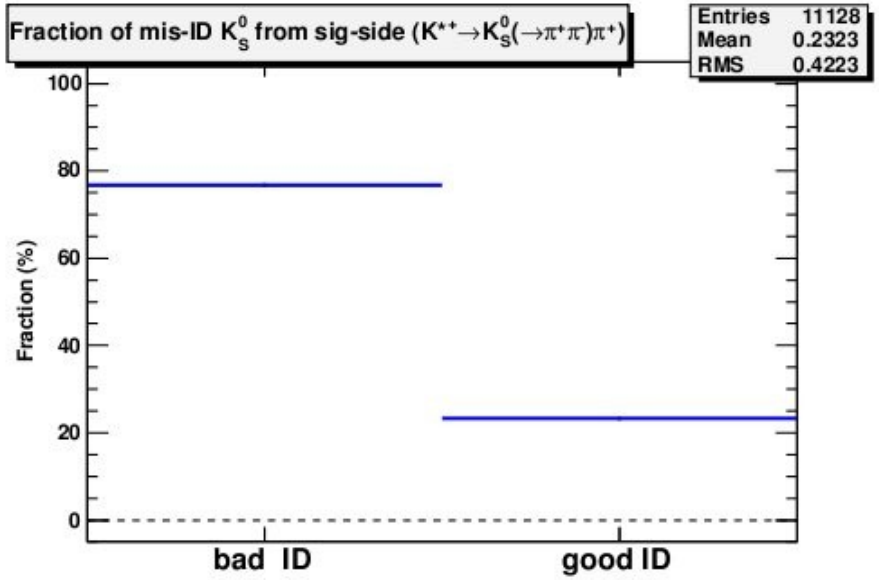
$B^+ \to K^+ \nu\nu$

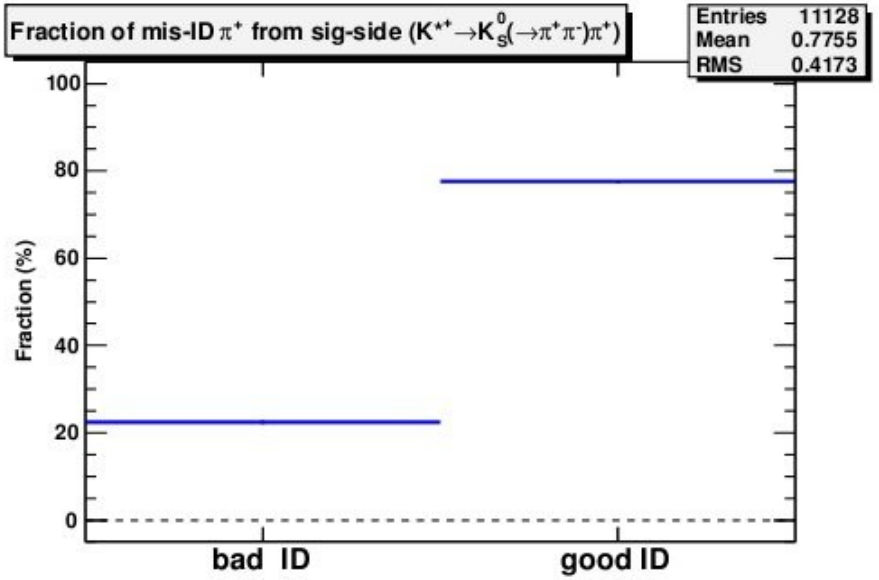


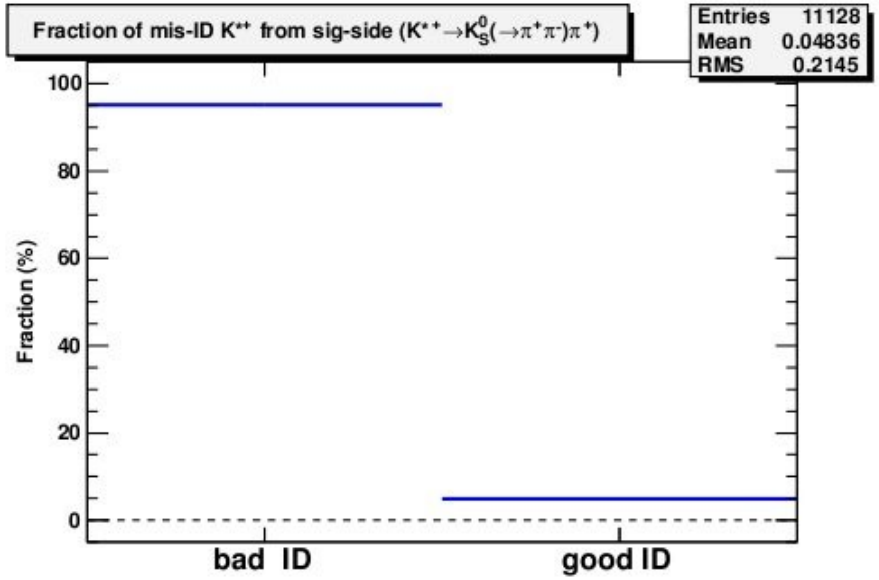
$B^0 \to K^0_S \nu\nu$



Some results: dependence on PID





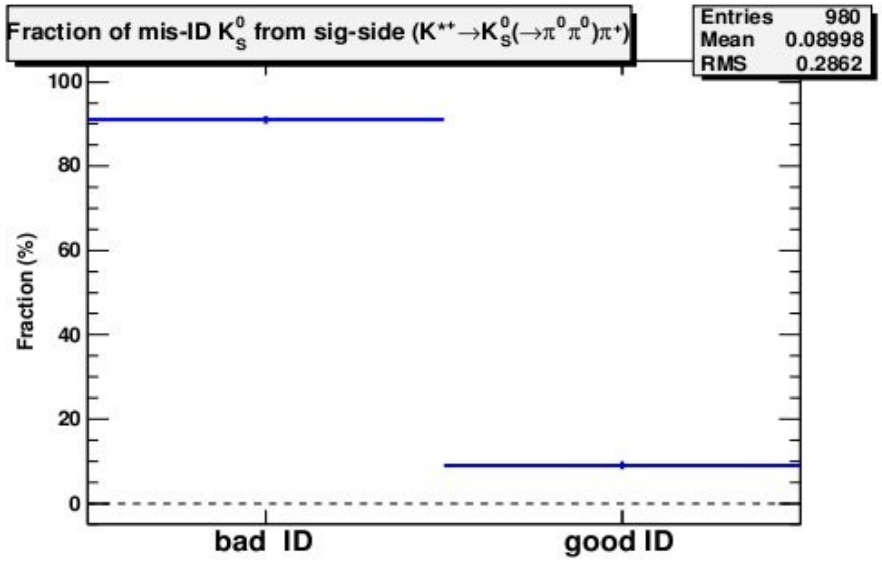


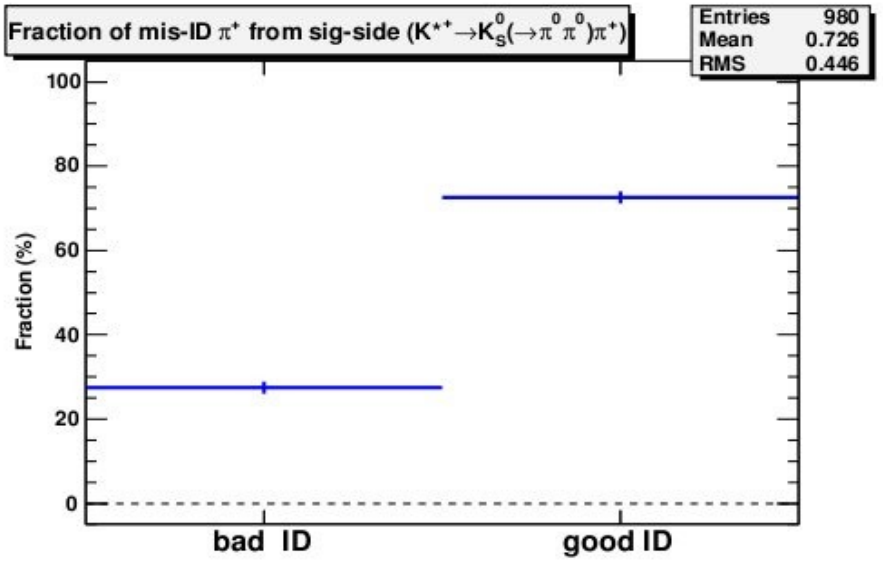
Signal-Side

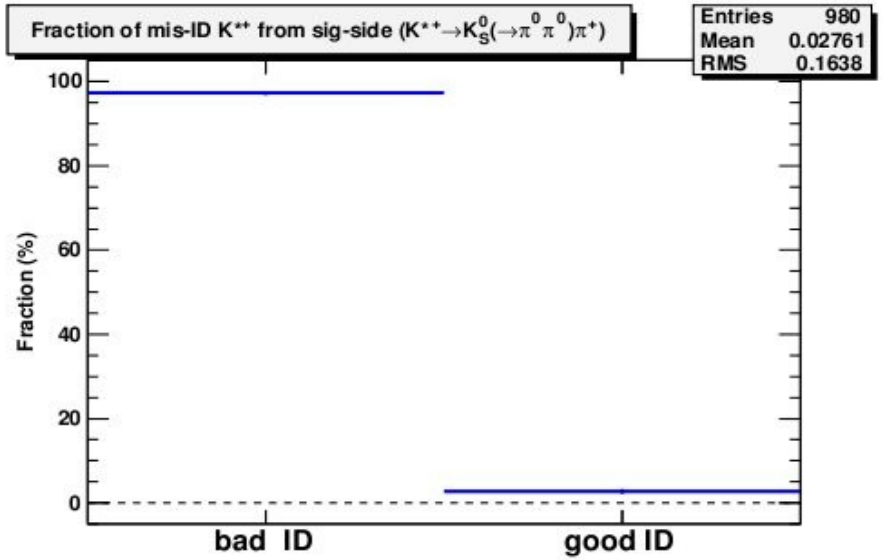
$B^+ \to K^{*+} \nu\nu$

$K^{*+} \to K^0_S(\pi^+\pi^-)\pi^+$

Some results: dependence on PID





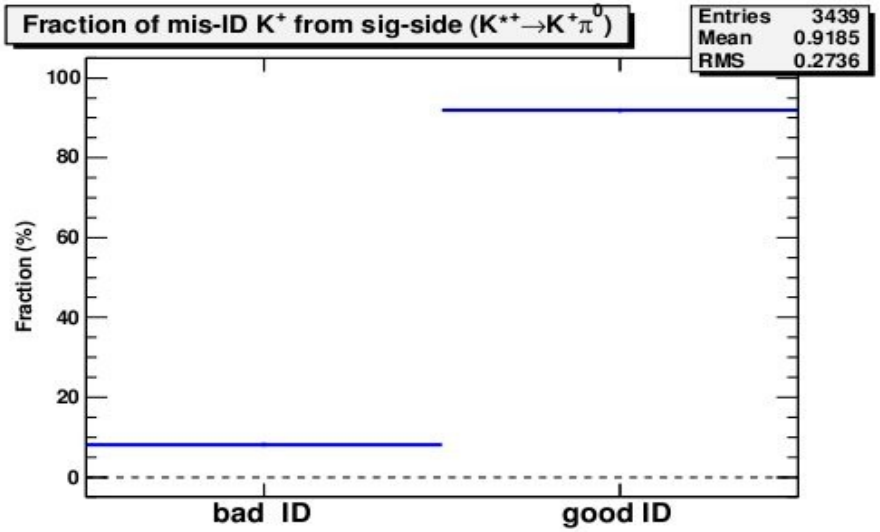


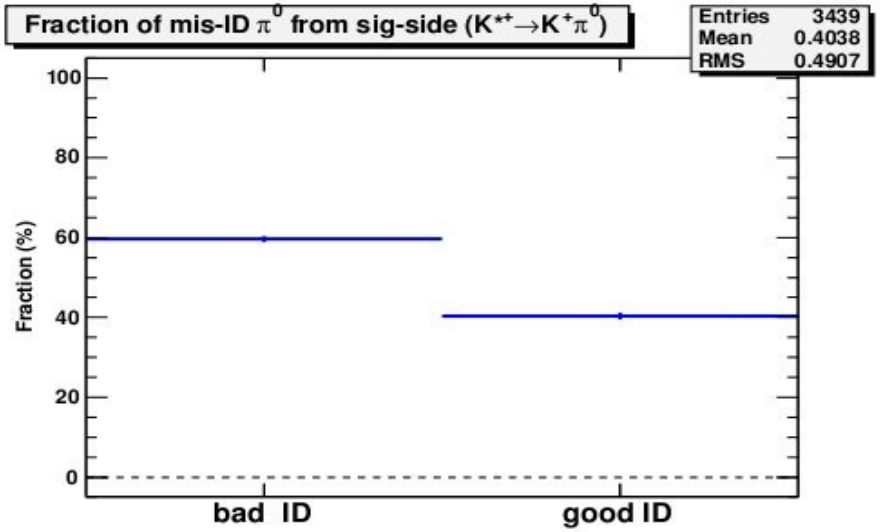
Signal-Side

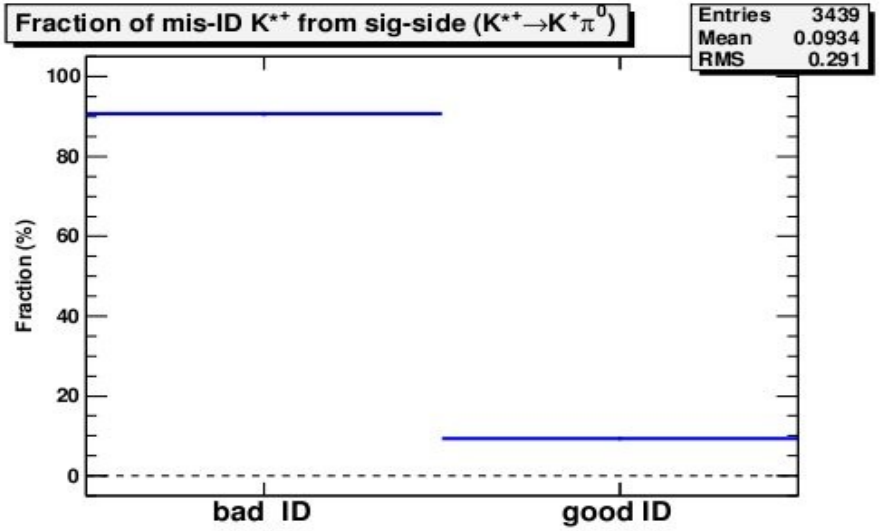
$B^+ \to K^{*+} \nu\nu$

$K^{*+} \to K^0_S(\pi^0\pi^0)\pi^+$

Some results: dependence on PID





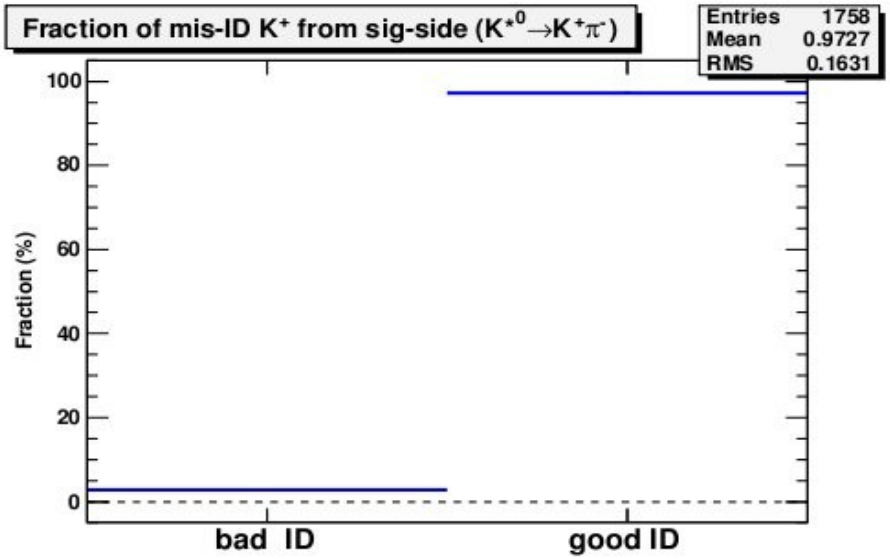


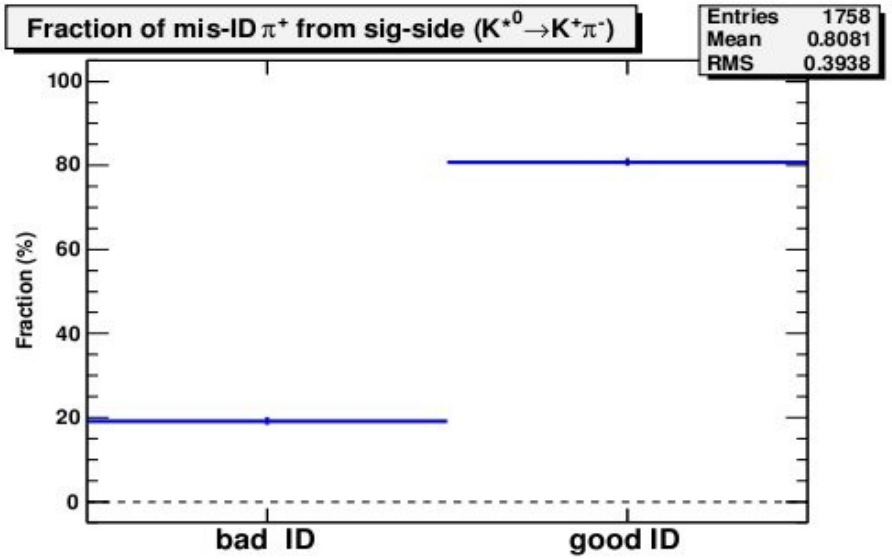
Signal-Side

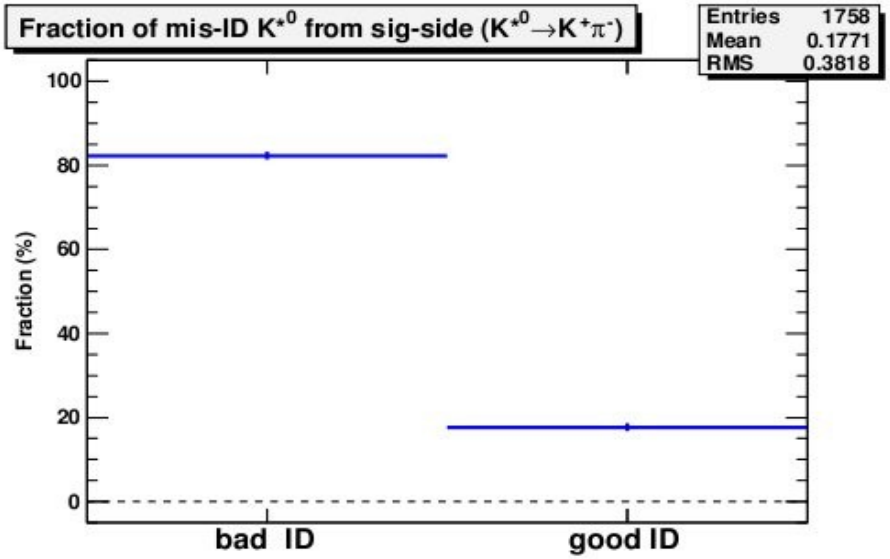
$B^+ \rightarrow K^{*+} \nu\nu$

$K^{*+} \rightarrow K^+ \pi^0$

Some results: dependence on PID







Signal-Side

$B^0 \to K^{*0} \nu\nu$

$K^{*0} \to K^+ \pi^-$

Some results: contributing modes (SCF)

- **Fraction of SCF events:**
  - $B^+ \to K^+ \nu\nu$: ~11% (32%) of the BB-generic charged (neutral) sample
  - $B^0 \to K^0_S \nu\nu$: ~15% (17%) of the BB-generic charged (neutral) sample
  - $B \to K^* \nu\nu$: ~10% (22%) of the BB-generic charged (neutral) sample

- **The results quoted in the next slides for the background composition on the tag and signal sides correspond to the non-SCF events**

- **I also Looked very quickly to SCF events and they seem to have the same mode composition as non-SCF ones**

Some results: contributing modes (Btag)

- **B-decay modes composition on the Tag-side:**
  - Most of the modes found (96-98% in all samples) are semi-leptonic decays B→Dlnu:
    - D is either a D, D*, or a higher D state (e.g. D'_1,D^*_0,D^*_2,...)
    - the lepton l is either e (50%), μ (48%), τ (2%)
    - Dlnu modes correspond to ~25% (23%) of the total B^+ (B^0) BR
  - The rest of the B-decay modes are
    - semi-leptonic non-Dlnu decays (0.1-0.5% in all samples)
    - Hadronic decays (2-3% in all samples)

- **A detailed summary of the results for the different modes can be found at http://www.slac.stanford.edu/~aperez/SuperB/Bkg_characterization/**

Some results: contributing modes (Bsig)

- **B-decay modes composition on the signal-side:**
  - **A significant amount of the modes found (30-50%) are semi-leptonic decays B→Dlnu, with similar composition as those found on the tag-side**
    - $B^+ \to K^+ \nu\nu$: ~44.6% (46.3%) of the charged (neutral) BB-generic sample
    - $B^0 \to K^0_S \nu\nu$: ~52.9% (57.4%) of the charged (neutral) BB-generic sample
    - $B^* \to K^* \nu\nu$: ~38.4% (34.2%) of the charged (neutral) BB-generic sample
- **A detailed summary of the results for the different modes can be found at http://www.slac.stanford.edu/~aperez/SuperB/Bkg_characterization/**

Some results: contributing modes (Bsig)

- **B-decay modes composition on the signal-side:**
  - **Hadronic decays:** similar contributions are found for all signal modes
    - Most are 2- and 3-body B-decays, mainly with a D (D*, $D^{(*)}_s$, D'_1, D_1, D^*_0, D^*_2) and/or a K^+/K^0_S in the final state

Mode	Sample	frac. 2-body	frac. 3-body
$B^+ \to K^+ \nu\nu$	B+B- generic	34.8	13.2
$B^+ \to K^+ \nu\nu$	B0B0 generic	23.9	21.9
$B^0 \to K^0 \nu\nu$	B+B- generic	23.2	13.8
$B^0 \to K^0 \nu\nu$	B0B0 generic	20.5	14.4
$B^* \to K^* \nu\nu$	B+B- generic	27.5	16.8
$B^* \to K^* \nu\nu$	B0B0 generic	20.5	23.8

    - Higher multiplicity are similar to the ones above but with extra π^0s in the final state
- **A detailed summary of the results for the different modes can be found at http://www.slac.stanford.edu/~aperez/SuperB/Bkg_characterization/**

Some results: contributing modes

- **Accomplished goals:**
  - Both tag and signal sides have been characterized
  - A list of the main contributing modes (those with at least 5 events) can be found in the web: http://www.slac.stanford.edu/~aperez/SuperB/Bkg_characterization/
  - Most of tag-side modes are Dlnu decays (~25% of the total B BR)
  - On the signal-side around half of the modes are Dlnu decays (25% of total B BR), and the other half 2-Body/3-Body hadronic decays (~15-20% of total B BR)
  - The list of modes on tag- and signal-sides represents around ~25%x(25+15)% = 10% of the total B-B decays modes

    ⇒ can improve BB-background production time by a factor of ~8-10!
- **Some Issues:**
  - Some modes found in the BB-generic samples (3-body decays and higher) are not in the list of generic B-decays, e.g:
    - $B^+ \to D^0 \rho^+ \pi^0$, $D^0 K^+ K^0$, $\Delta^+ n D^0$, ...; $B^0 \to D^- \omega \pi^+$, $D^- K^+ K^0$, $\Delta^0 n D^0$, ...
  - Are those a non-resonant decay modeled in EvtGen, or products with material interaction?
  - Only need to solve this issue to build the cocktails of BB modes to be produced as a representative sample of BB-background

Summary and outlook

- **Mis ID backgrounds:**
  - Most of Kaons, pions, Ks and leptons used to construct the tag- and signal- side candidates are not fake

  ⇒ Main background contribution is combinatorics
- **Background composition results:**
  - There is a significant amount of SCF between the signal and tag side (10-30%). These events have essentially the same composition of non-SCF events
  - Almost all the tag-side candidates (~96-98%) are Dlnu decays (25% of total B BR)
  - On the signal side:
    - Around 30-50% of modes found are Dlnu decays
    - The rest are 2-body/3-body hadronic decays with a D and/or Kaon in the final state
    - Those modes represent around 40-50% of the total B BR
  - Can built a cocktail that represent around 10% of the total B-B decays

    ⇒ can gain a factor of 8-10 in time of the BB-background production
- **Next steps:**
  - To solve the issue of modes found in BB-generic samples and not listed in the generic B decays file
  - Build the cocktails for the B-background production

Backup