Fwd PiD Studies with Semi-Leptonic BReco

Alejandro Pérez
A. Stocchi, L. Burmistrov, N. Arnaud
LAL – Université Paris XI

Tuesday September 15th 2009

Outline

- Semi-Leptonic Breco and $B^+ \rightarrow K^+ \nu\nu$
- Test of different detectors configuration:

  Signal sample

- Some comments about Background

Semi-Leptonic Breco (l)

- Look for $B^+ \rightarrow D^{0(*)} l\nu$ and $B^0 \rightarrow D^{+(*)} l\nu$ ($l = e/\mu$)

- D^0/D^+ reconstructed in 6 decays channels:
  - $D^0 \rightarrow K^-\pi^+, K^-\pi^+\pi^-\pi^+, K^-\pi^+\pi^0, K^0_S\pi^+\pi^-$
  - $D^+ \rightarrow K^-\pi^+\pi^-, K^0_S\pi^+$

- Also look also for D* decays:
  - $D^{*+} \rightarrow D^0\pi^+, D^+\pi^0$ (slow pions)
  - $D^{*0} \rightarrow D^0\pi^0, D^0\gamma$

- Form a $D^{(*)}l$ pair adding a hard lepton

Semi-Leptonic Breco (II)

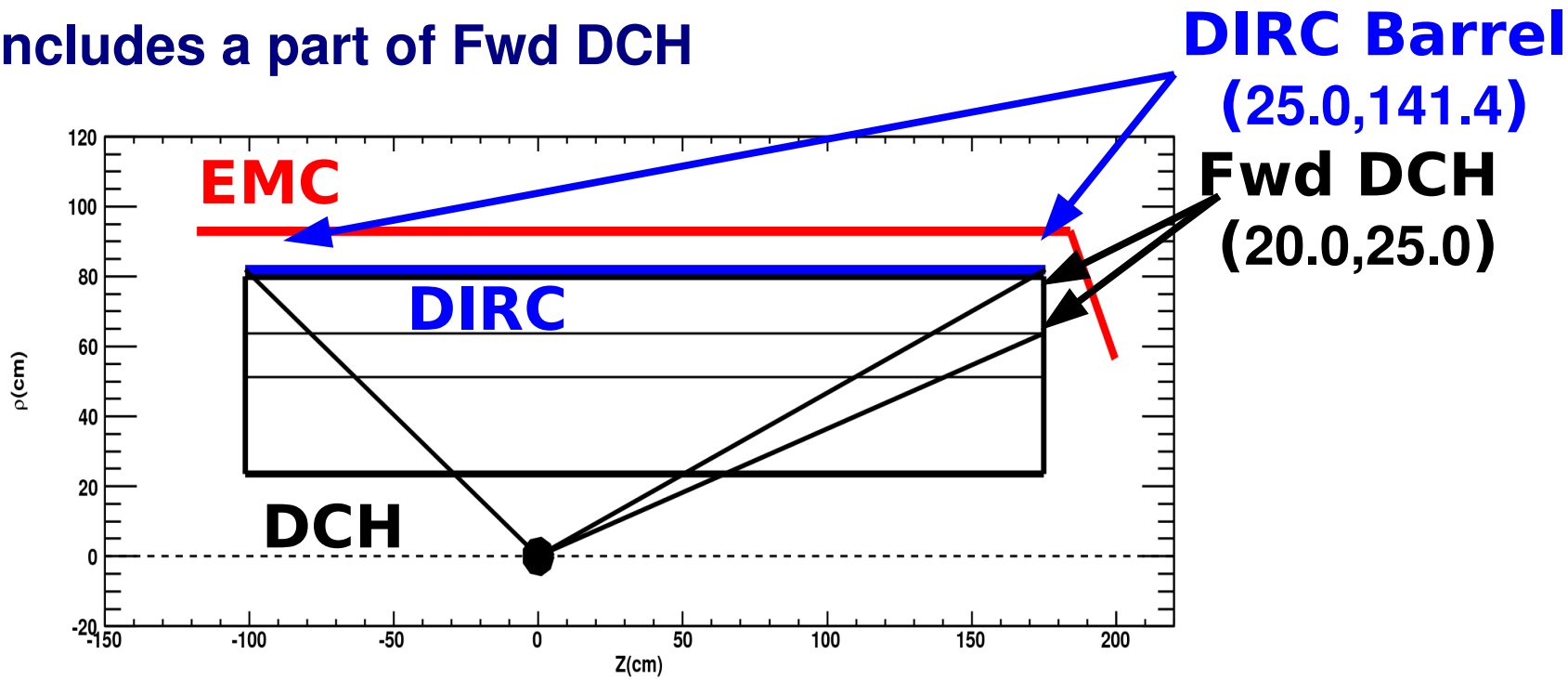
- **PID: use TableBasedXXXSelection selectors (BaBar run6-r24c PiD tables)**

- **Previous BaBar analysis:**
  - **Electron ⇒ ElectronLHTight**
  - **Muon ⇒ MuonNNTight**
  - **Kaon ⇒ All selectors**
  - **Pion ⇒ Not a Kaon/PionLoose**

Scenarios: Detector Configurations

- Tag(Signal)-Side Kaon → All selectors(Tight),
  Tag-Side Pions → Not a Kaon/PionLoose
- Use all four decays channels for D^0 meson
- BaBar Detector ($\beta\gamma$ = 0.56)

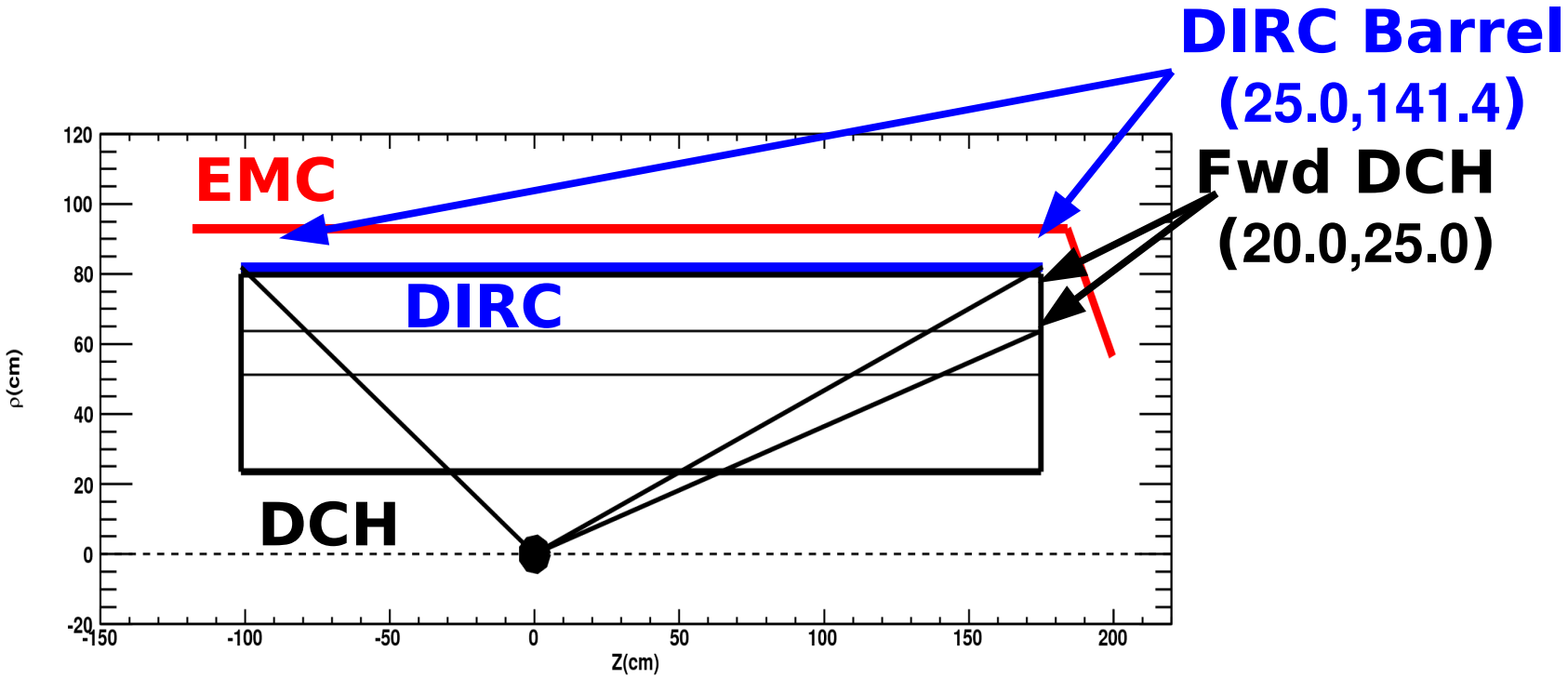
- Identified particles in (20.0,141.4),
  includes a part of Fwd DCH



Scenarios: Detector Configurations

- Tag(Signal)-Side Kaon → All selectors(Tight),
  Tag-Side Pions → Not a Kaon/PionLoose
- Use all four decays channels for D^0 meson
- SuperB base line ($\beta\gamma$ = 0.28)

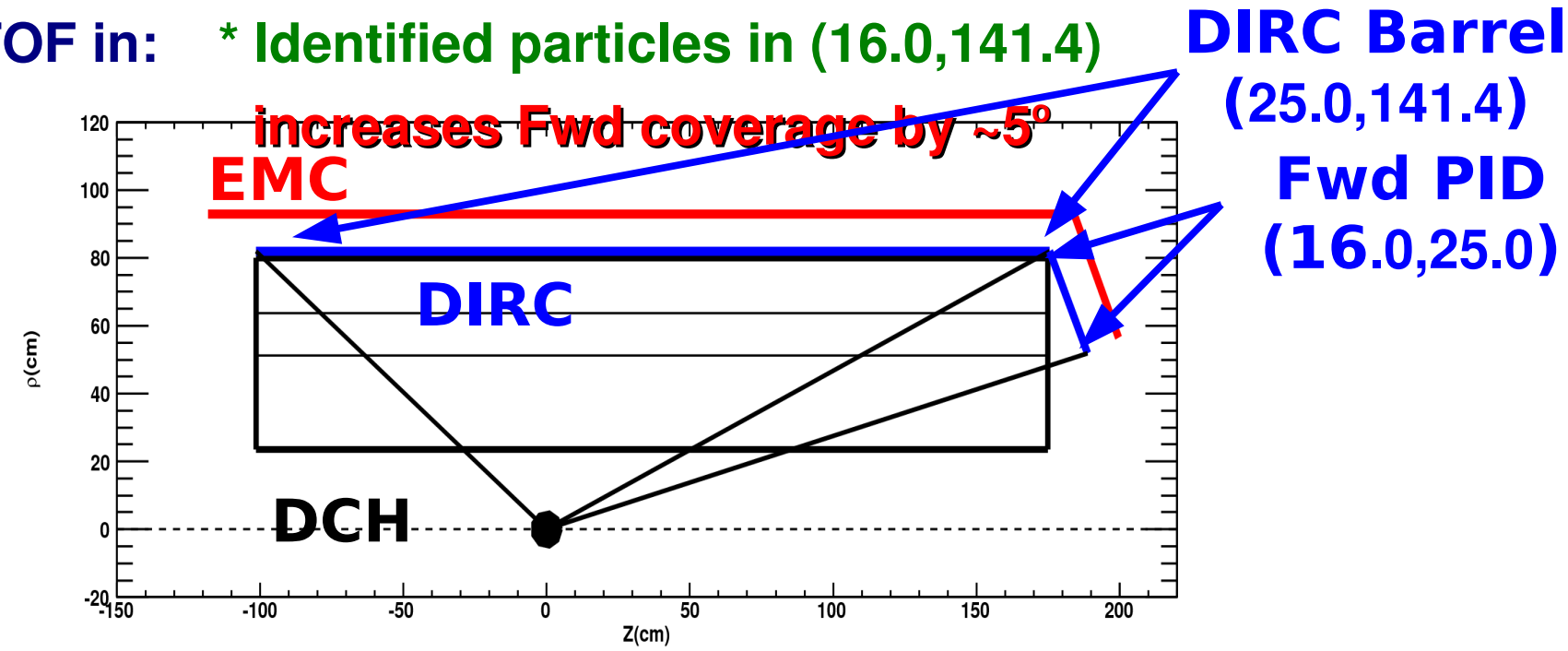
- TOF out: * Identified particles in (20.0,141.4)



Scenarios: Detector Configurations

- Tag(Signal)-Side Kaon → All selectors(Tight),
  Tag-Side Pions → Not a Kaon/PionLoose
- Use all four decays channels for D^0 meson
- SuperB base line ($\beta\gamma$ = 0.28)

- TOF out: * Identified particles in (20.0,141.4)
- TOF in: * Identified particles in (16.0,141.4)
  increases Fwd coverage by ~5°



Scenarios: Detector Configurations

- Tag(Signal)-Side Kaon → All selectors(Tight),
  Tag-Side Pions → Not a Kaon/PionLoose
- Use all four decays channels for D^0 meson
- BaBar Detector ($\beta\gamma$ = 0.56)

  - Signal-Side Kaon in (20.0,141.4),
    includes a part of Fwd DCH

- SuperB base line ($\beta\gamma$ = 0.28)

  - TOF out: * Identified particles in (20.0,141.4)
  - TOF in: * Identified particles in (16.0,141.4),
    increases Fwd coverage by ~5°

Signal Sample

- **Signal sample ($B^+ \to K^+ \nu\nu / B^- \to$ generic): 8M events**

- **Try to quantify the improvements on Tagging and signal efficiencies**

Signal Sample: selection efficiency

Tagging efficiency: Kaon Tight; Pion Not a Pions

	BaBar	SuperB	
D^0 Dec. Channel	DIRC+FwdDch	DIRC+FwdDch	DIRC+FwdPiD
$K^-\pi^+$	0.1104%	+11.1%	+5.9%
$K^-\pi^+\pi^-\pi^+$	0.1054%	+4.0%	+10.4%
$K^-\pi^+\pi^0$	0.2618%	+9.7%	+6.2%
$K^0_s\pi^+\pi^-$	0.0287%	+6.6%	+4.6%
Average	0.5063%	+8.6%	+7.0%

Signal efficiency: Kaon Tight

	BaBar	SuperB	
D^0 Dec. Channel	DIRC+FwdDch	DIRC+FwdDch	DIRC+FwdPiD
--------	26.9%	2.8%	1.8%

Some Comments about Bkg

- **Semi-Leptonic BReco analyses:**

  $K^+\nu\nu$:

  - Most of the background (95%) comes from Had/SL decays with particles lost due to acceptance, and decays with KL.

  - Not very dependent on PiD.

  $K^*\nu\nu$:

  - ~9% of background comes from K $\leftrightarrow$ π miss-ID

  - Expect significant improvement with better PiD

- **Had BReco analyses (K(*)νν) can benefit significantly with an improved PiD system**
- **Due to low B-background efficiencies (~10^{-5} – 10^{-6}), need around $1ab^{-1}$ of B-generic samples.**

Summary

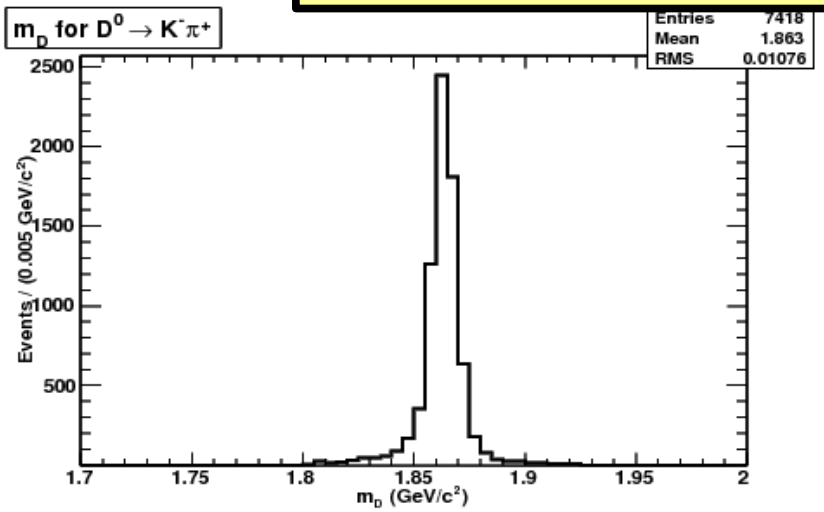
- $K^+\nu\nu$ (SL) Signal sample:
  - Tagging efficiencies: increases from ~6% to ~10% depending on charged particles multiplicities (average ~7%)
  - Signal efficiencies: only one track, gain of ~3%
  - Need to do same studies for $K^*\nu\nu$ (SL) and $K^*\nu\nu$ (HD).
- Background studies:
  - $K^+\nu\nu$ (SL): bkg marginally dependent on PID
  - $K^*\nu\nu$ (SL): expect significant improvement on bkg rejection with better PID system
  - $K(^*)\nu\nu$ (HD): expect as well improvements with better PID
- Next steps for SLAC workshop:
  - Need to switch from table-based to real PiD selectors
  - Implementation of BReco analyses in PacProduction → almost finish
  - Quantify improvements with the different Detec. Configs. → see Elisa's talk
  - Complete study including all MC samples → need ~1ab^{-1}

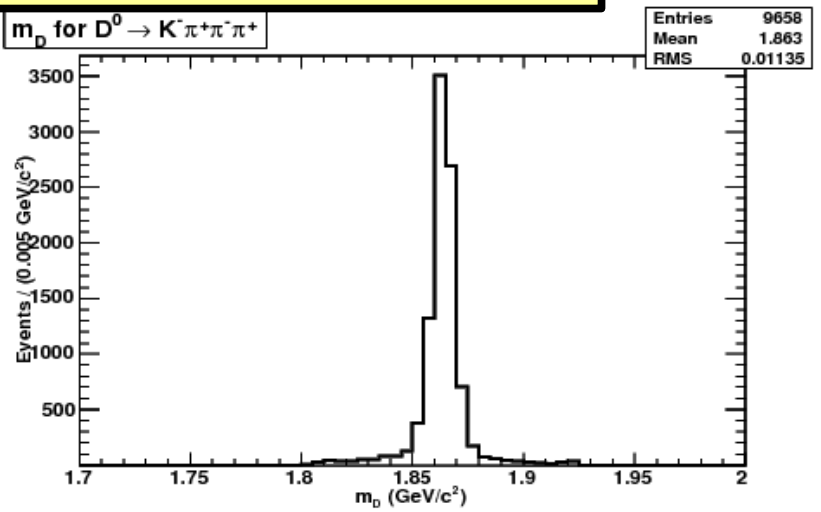
Backup

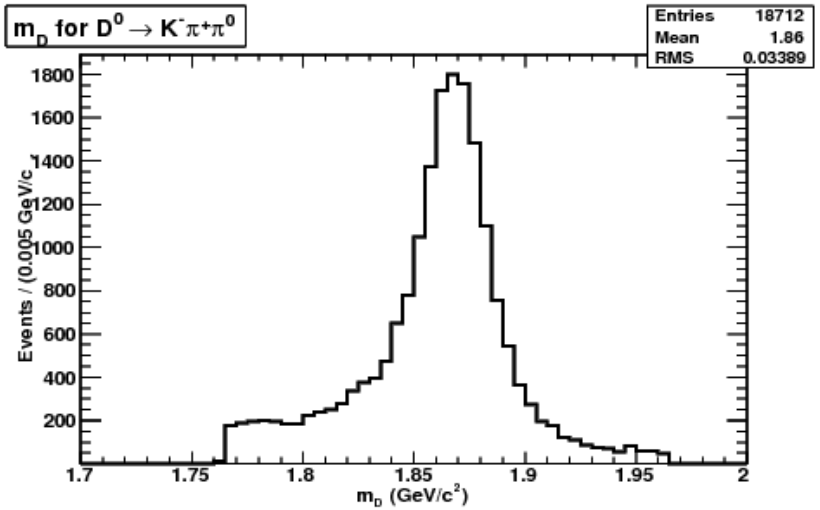
Signal Sample

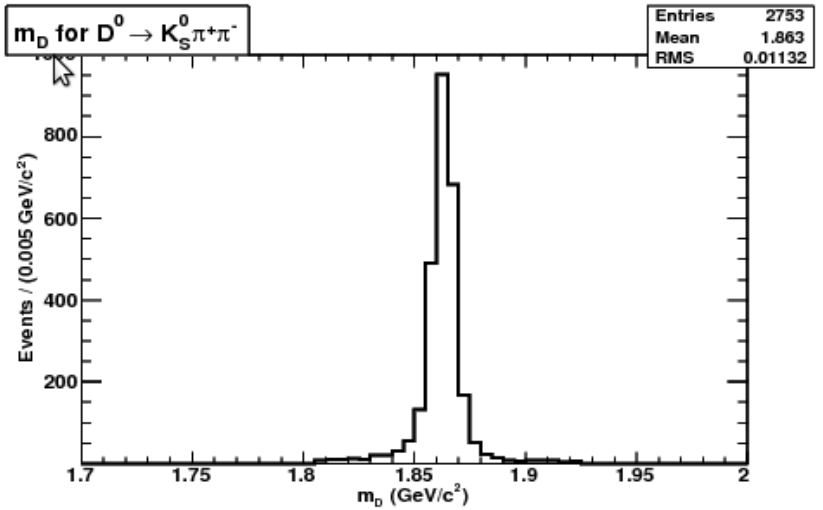
- Signal sample ($B^+ \to K^+ \nu\nu / B^- \to$ generic): 8M events

SuperB+FwdPiD, Kaon Loose





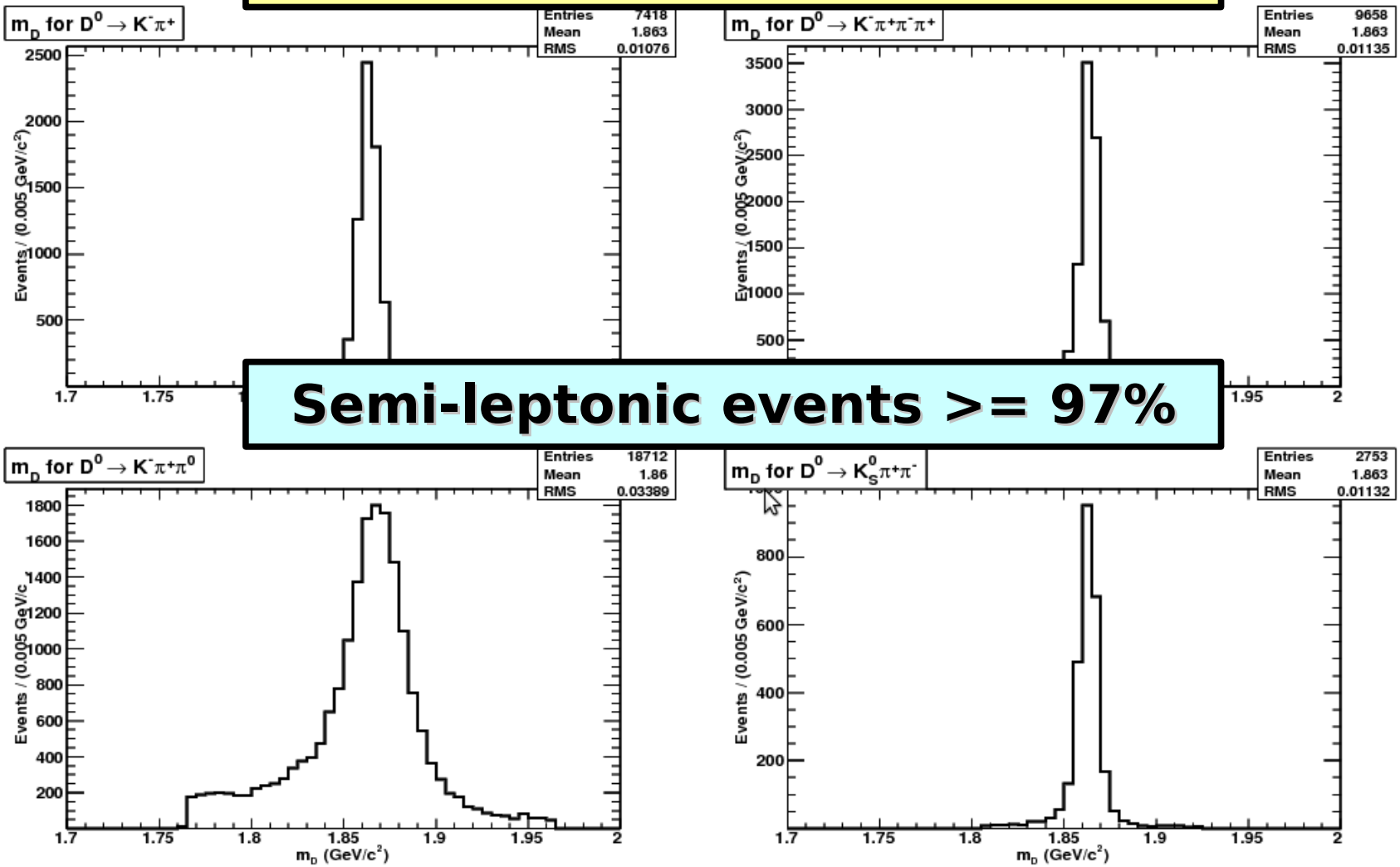




Signal Sample

- Signal sample ($B^+ \to K^+ \nu\nu / B^- \to$ generic): 8M events

SuperB+FwdPiD, Kaon Loose



Semi-leptonic events >= 97%

Semi-Leptonic Breco (III)

- **Additional cuts:**

  - $M_{miss} > 1.0\ GeV/c^2$
  - $|Net\ charge| < 2$
  - $-2.5 < \cos(B,Dl) < 1.1$
  - Usual cuts in m_{D0} ($|mass - PDG| < 3*sigma$)
  - $|p^*_D| > 0.5 GeV/c$
  - Dl vertex Prob > 0.04
  - $m_{Dl} > 3GeV/c^2$
  - $|p^*_l| > 1.35GeV/c$ (**assures selection of Semi-Lep. decays**)

Signal Side

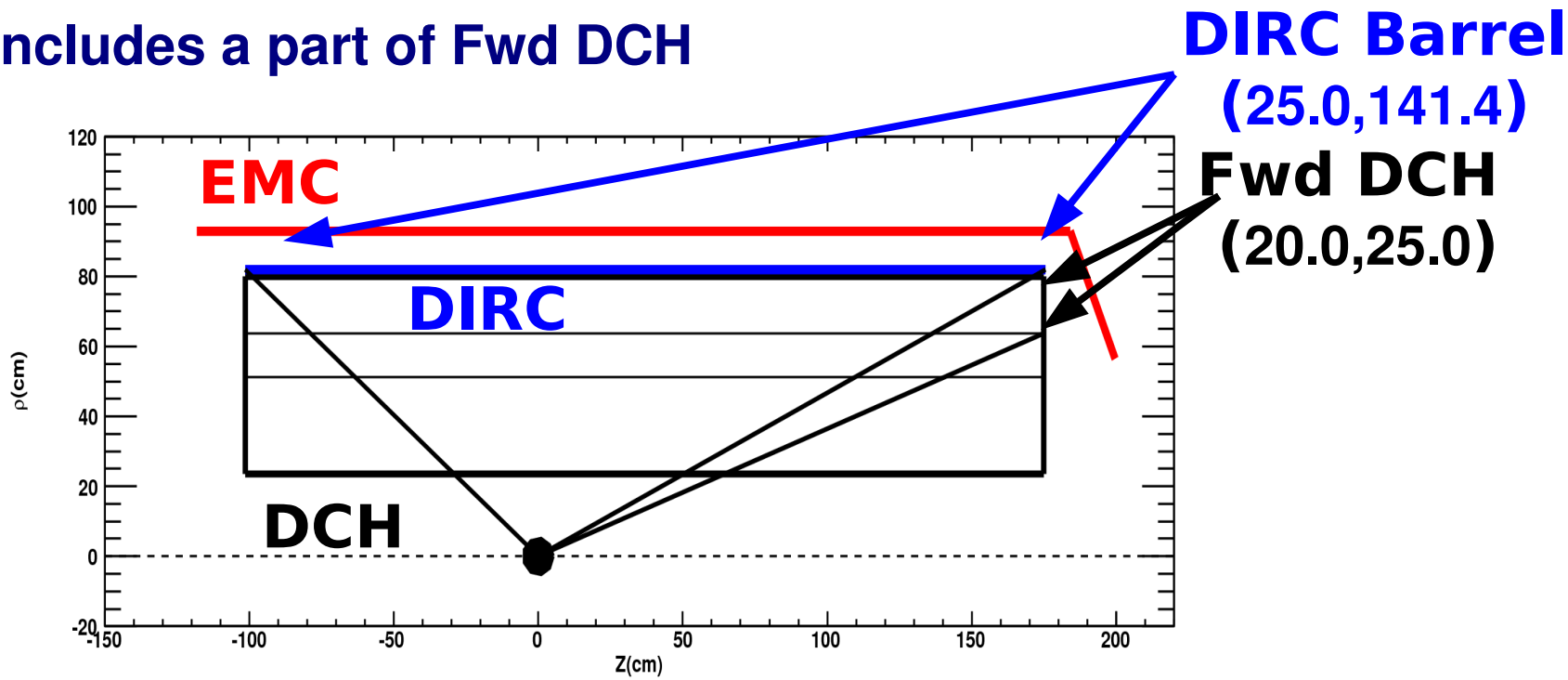
- **Signal side:**

- $|\cos(K,Dl)| < 0.8$
- $|p^*_K| > 1.25 GeV/c$
- $E_{extra} < 250\ MeV/c^2$
- Flavour correlation ($K^+ \leftrightarrow K^-(D^0)$ in tag side)
- Signal K inside PID system (we include Fwd DcH/PiD)

Scenarios: Detector Configurations

- Tag(Signal)-Side Kaon → All selectors(Tight),
  Tag-Side Pions → Not a Kaon/PionLoose
- Use all four decays channels for D^0 meson
- BaBar Detector ($\beta\gamma$ = 0.56)

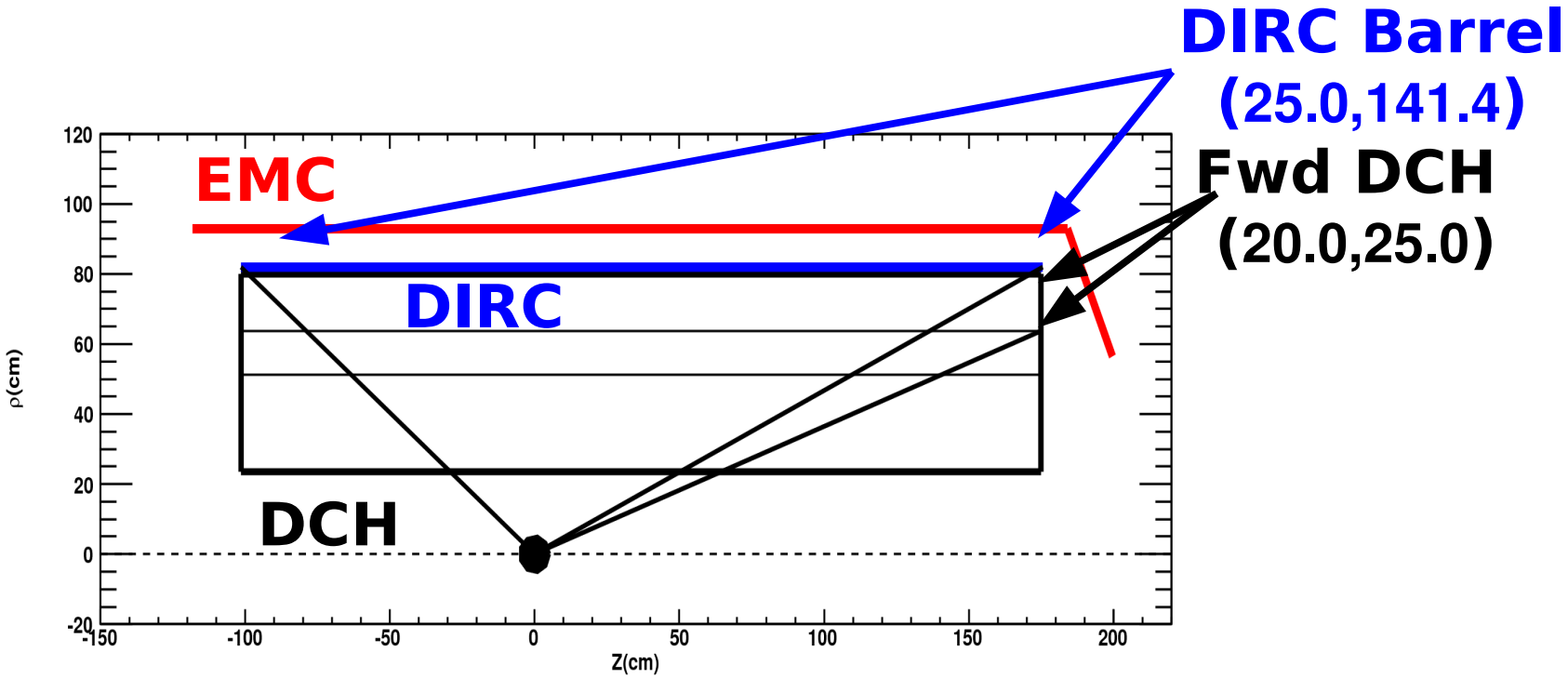
- Identified particles in (20.0,141.4),
  includes a part of Fwd DCH



Scenarios: Detector Configurations

- Tag(Signal)-Side Kaon → All selectors(Tight),
  Tag-Side Pions → Not a Kaon/PionLoose
- Use all four decays channels for D^0 meson
- SuperB base line ($\beta\gamma$ = 0.28)

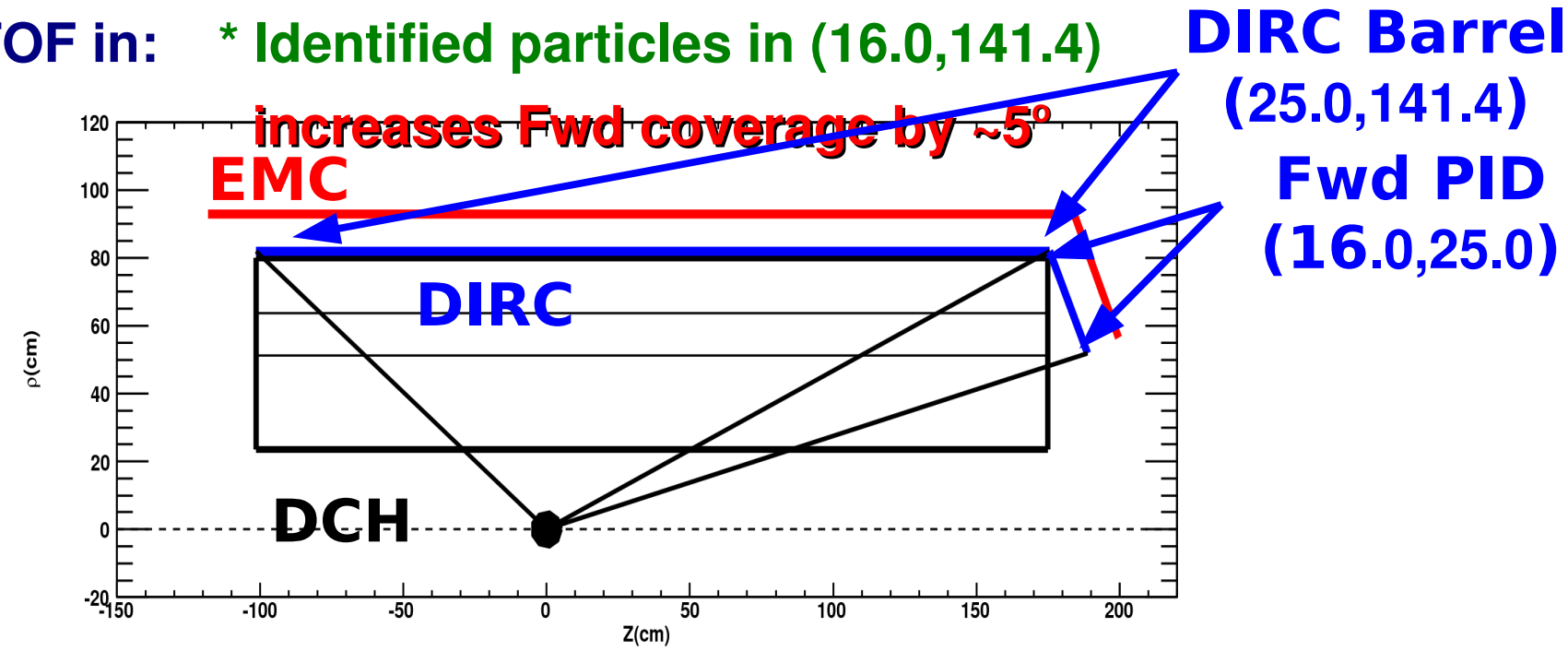
- TOF out: * Identified particles in (20.0,141.4)



Scenarios: Detector Configurations

- Tag(Signal)-Side Kaon → All selectors(Tight),
  Tag-Side Pions → Not a Kaon/PionLoose
- Use all four decays channels for D^0 meson
- SuperB base line ($\beta\gamma$ = 0.28)

- TOF out: * Identified particles in (20.0,141.4)
- TOF in: * Identified particles in (16.0,141.4)
  increases Fwd coverage by ~5°



Scenarios: Detector Configurations

- Tag(Signal)-Side Kaon → All selectors(Tight),
  Tag-Side Pions → Not a Kaon/PionLoose
- Use all four decays channels for D^0 meson
- BaBar Detector ($\beta\gamma$ = 0.56)

  - Signal-Side Kaon in (20.0,141.4),
    includes a part of Fwd DCH

- SuperB base line ($\beta\gamma$ = 0.28)

  - TOF out: * Identified particles in (20.0,141.4)
  - TOF in: * Identified particles in (16.0,141.4),
    increases Fwd coverage by ~5°

Signal Sample

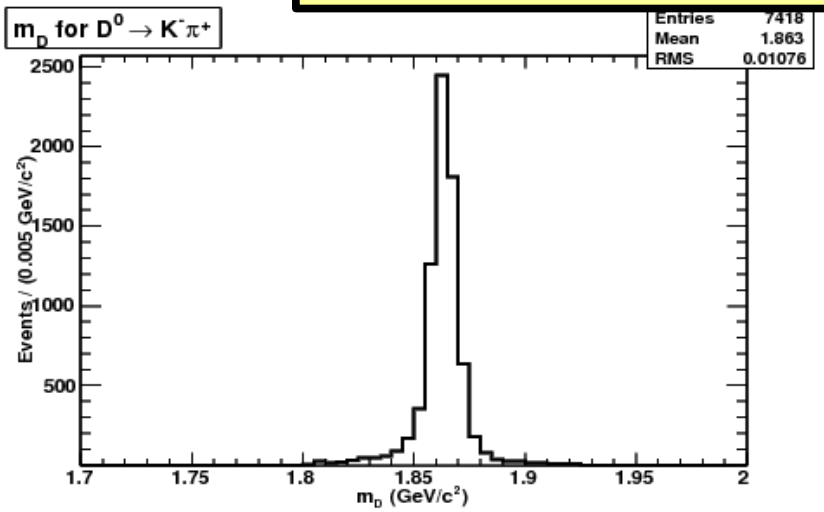
- **Signal sample ($B^+ \to K^+ \nu\nu / B^- \to$ generic): 8M events**

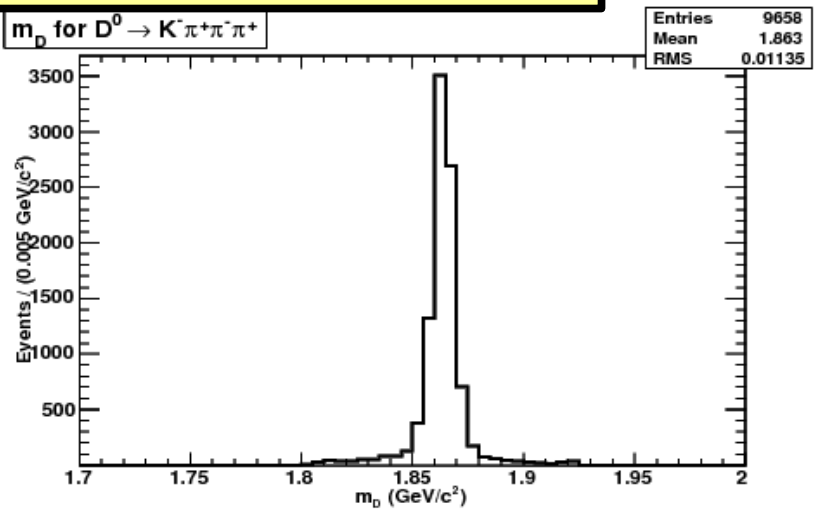
- **Try to quantify the improvements on Tagging and signal efficiencies**

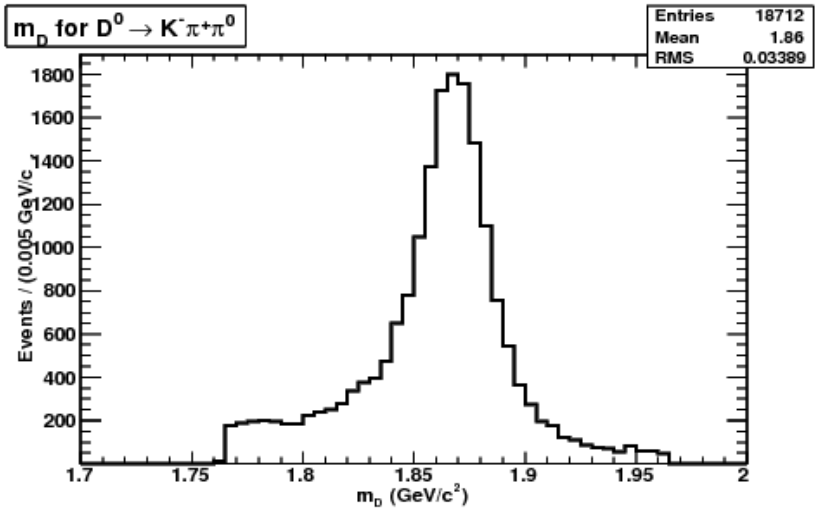
Signal Sample

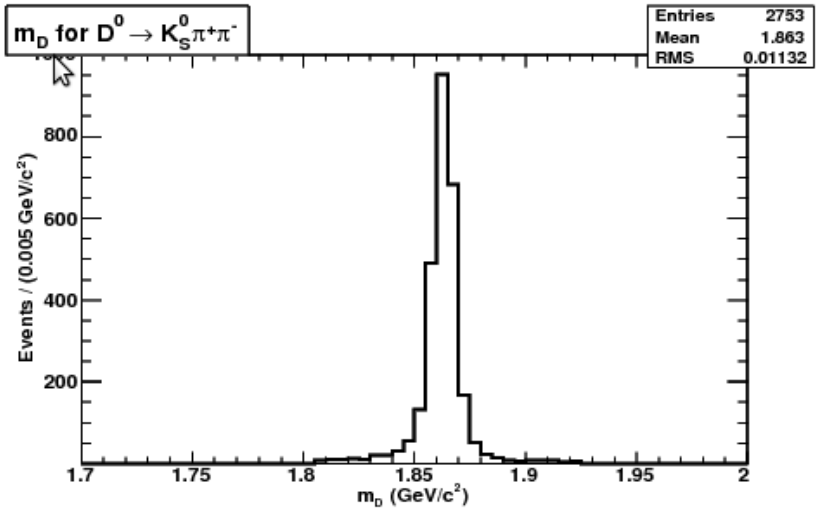
- Signal sample ($B^+ \to K^+ \nu\nu / B^- \to$ generic): 8M events

SuperB+FwdPiD, Kaon Loose





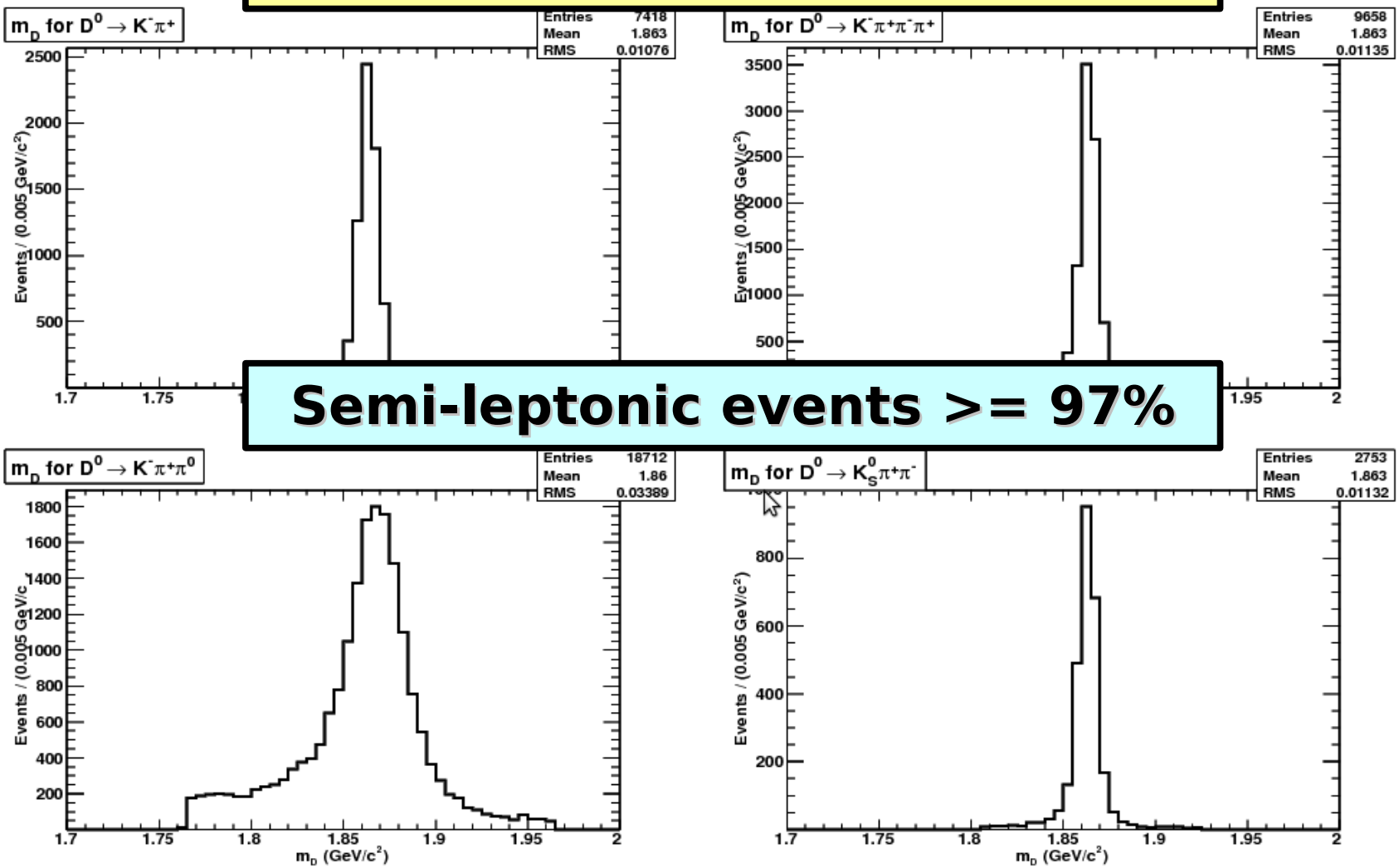




Signal Sample

- Signal sample ($B^+ \to K^+ \nu\nu / B^- \to$ generic): 8M events

SuperB+FwdPiD, Kaon Loose



Semi-leptonic events >= 97%

Signal Sample: selection efficiency

Tagging efficiency

	BaBar	SuperB	
D^0 Dec. Channel	DIRC+FwdDch	DIRC+FwdDch	DIRC+FwdPiD
$K^-\pi^+$			
$K^-\pi^+\pi^-\pi^+$			
$K^-\pi^+\pi^0$			
$K^0_S\pi^+\pi^-$			
Average			

Signal efficiency

	BaBar	SuperB	
D^0 Dec. Channel	DIRC+FwdDch	DIRC+FwdDch	DIRC+FwdPiD

Some Comments about Bkg

- **Semi-Leptonic BReco analyses:**

  $K^+\nu\nu$:

  - Most of the background (95%) comes from Had/SL decays with particles lost due to acceptance, and decays with KL.

  - Not very dependent on PiD.

  $K^*\nu\nu$:

  - ~9% of background comes from $K \leftrightarrow \pi$ miss-ID

  - Expect significant improvement with better PiD

- **Had BReco analyses (K(*)νν) can benefit significantly with an improved PiD system**
- **Due to low B-background efficiencies (~10^{-5} – 10^{-6}), need around $1ab^{-1}$ of B-generic samples.**

Signal Sample: selection efficiency

Tagging efficiency

	BaBar	SuperB	
D^0 Dec. Channel	DIRC+FwdDch	DIRC+FwdDch	DIRC+FwdPiD
$K^-\pi^+$	0.001256	0.001378	0.001484
$K^-\pi^+\pi^-\pi^+$	0.001681	0.001764	0.001932
$K^-\pi^+\pi^0$	0.003307	0.003527	0.003742
$K^0_S\pi^+\pi^-$	0.000463	0.000514	0.000551

Signal efficiency

	BaBar	SuperB	
D^0 Dec. Channel	DIRC+FwdDch	DIRC+FwdDch	DIRC+FwdPiD
$K^-\pi^+$	0.236	0.250	0.256
$K^-\pi^+\pi^-\pi^+$	0.184	0.193	0.198
$K^-\pi^+\pi^0$	0.246	0.259	0.266
$K^0_S\pi^+\pi^-$	0.220	0.243	0.248

Other MC samples

- Background studies: need B-generic, ccbar, uds MC samples
- $K^+\nu\nu$ very rare mode, need huge amount of statistics:
  - B^0/B^0bar generic → effic = ~1.6×10^{-8}
  - B^+/B^- generic → effic = ~1.4×10^{-7}
  - ccbar → effic = ~8.4×10^{-9}
  - uds → effic < 10^{-8}

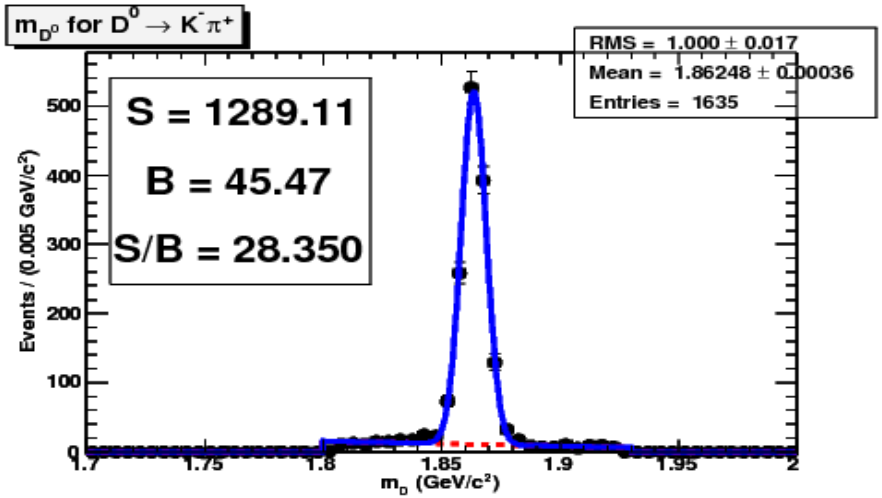
Need to generate ~$1ab^{-1}$!!

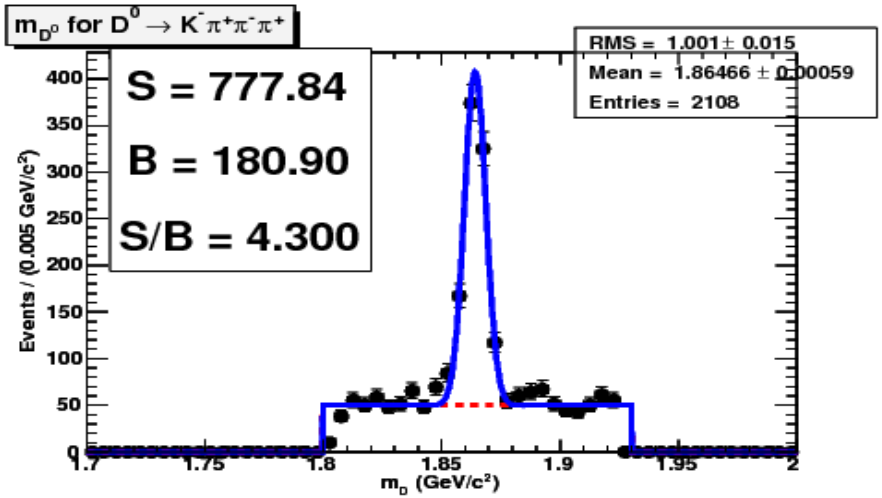
- Tag-side study with B^+/B^- generic sample: 1.6M events
  - Tag Kaon → KaonTight, Tag-Pions → PionLoose
  - Study detector configs. (with/without TOF) with SuperB beams
  - Fit for the peaking component on the D0 mass
  - Try to quantify gain in:
    - * Peaking yield
    - * peaking/non-peaking ratio

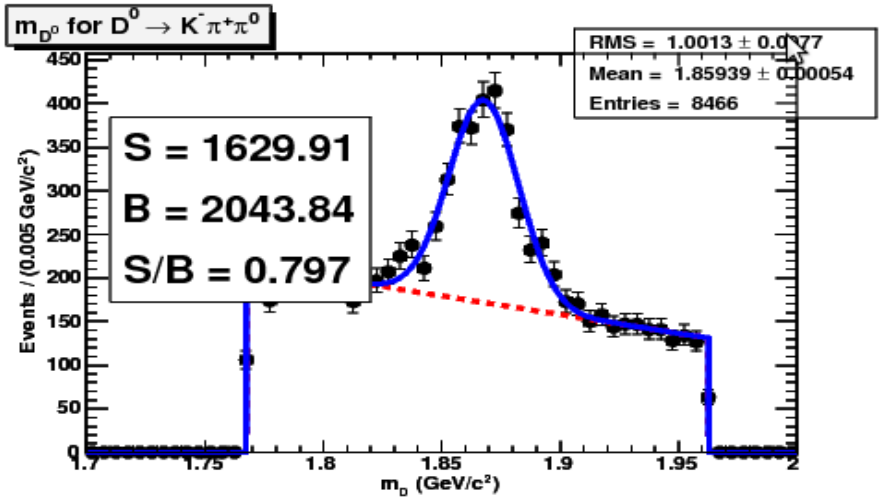
B^+/B^- Sample

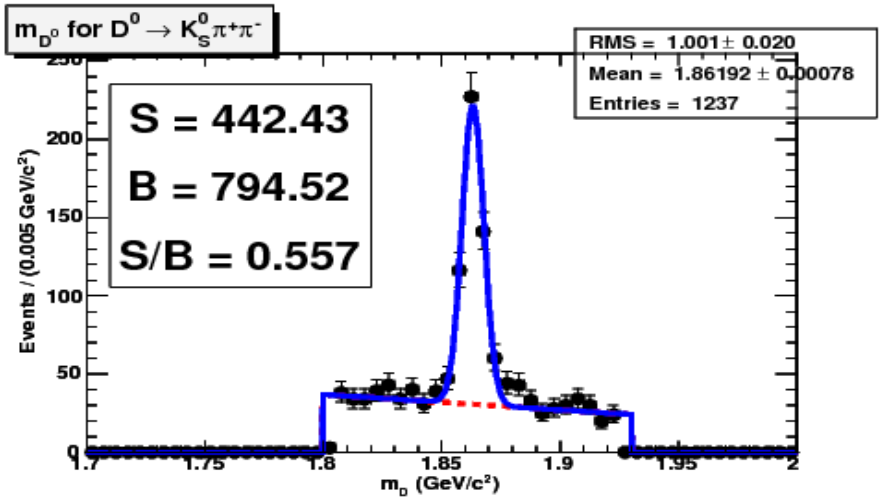
- B^+/B^- generic: 1.6M events

SuperB+NoFwdPiD: KaonTight, PionLoose









Al

B^+/B^- Sample

- B^+/B^- generic: 1.6M events

Increase in peaking yield and peaking/non-peaking ratio

	SuperB	
D^0 Dec. Channel	peaking yield	peaking/non-peaking
$K^-\pi^+$	+4.6%	~0.94
$K^-\pi^+\pi^-\pi^+$	+9.6%	~0.98
$K^-\pi^+\pi^0$	+6.0%	~1.0
$K^0_S\pi^+\pi^-$	+2.7%	~0.96

- **Increase in peaking yields in agreement with signal sample studies**
- **peaking/non-peaking ratio stays constant**
- **Need to study the peaking/non-peaking B-bkg composition**
- **Need to remade studies with more statistics**

Cross Check: BaBar $B^+ \to K^+ \nu\nu$

- Try to reproduce previous Semi-Lep. Babar anaylis (BAD293, 2004)
- Same Tag(Signal)-Side reconstruction/selection
- Not include $D^0 \to K^0_S \pi^+ \pi^-$ channel
- Signal(Tag)-side Kaon from KaonTight(NotPion)
- Identified particles inside DIRC coverage (25.0º,141.9º)

Efficiency	BaBar FullSim	BaBar FastSim (v03)	BaBar FastSim (v09)
Tag-Side	0.00530	0.00543	0.00593
Signal-Side	0.217	0.210	0.229

- **Agreement with BaBar FullSim within 2.5% using FastSim-v03**
- **FastSim-v09 gives higher efficiencies (~10%)**
- **See higher increases with K*nunu (Fracesco Renga Analysis)**

Signal Sample: selection efficiency

Tagging efficiency

	BaBar	SuperB	
D^0 Dec. Channel	DIRC+FwdDch	DIRC+FwdDch	DIRC+FwdPiD
$K^-\pi^+$	0.001256	+9.7%	+7.6%
$K^-\pi^+\pi^-\pi^+$	0.001681	+4.9%	+9.6%
$K^-\pi^+\pi^0$	0.003307	+6.7%	+6.1%
$K^0_S\pi^+\pi^-$	0.000463	+11.0%	+7.2%

Signal efficiency

	BaBar	SuperB	
D^0 Dec. Channel	DIRC+FwdDch	DIRC+FwdDch	DIRC+FwdPiD
$K^-\pi^+$	0.236	+5.9%	+2.4%
$K^-\pi^+\pi^-\pi^+$	0.184	+4.8%	+2.5%
$K^-\pi^+\pi^0$	0.246	+5.3%	+2.7%
$K^0_S\pi^+\pi^-$	0.220	+5.6%	+2.2%

B^+/B^- Sample

- B^+/B^- generic: 1.6M events

SuperB+FwdPiD: KaonTight, PionLoose