Dectector Configuration Studies with Knunu SL BReco

Alejandro Pérez,

E. Manoni, F. Renga,

A. Stocchi

LAL – Université Paris XI

SLAC SuperB Workshop

Wednesday Oct. 7th 2009

LABORATOIRE DE L'ACCÉLÉRATEUR LINÉAIRE

Outline

- Reminder:
  - - Theory
  - - Recoil technique
- Semi-Leptonic Breco and $B^+ \to K^+ \nu\nu$, $B \to K^{(*)} \nu\nu$
- Test of different detectors configurations
- Some comments on Backgrounds
- A Extrapolation to SuperB statistics
- Summary and Next steps

Remainder: Theory

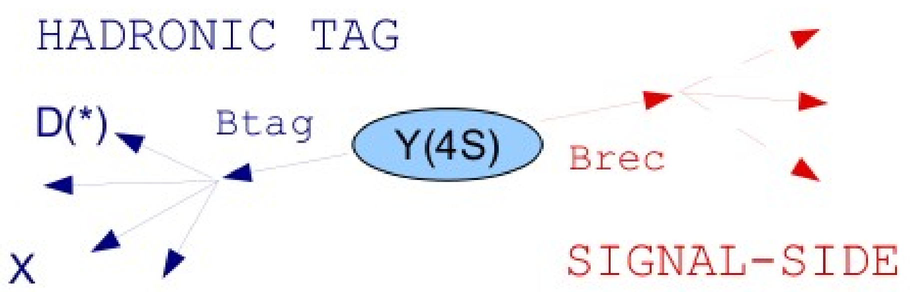
Altmannshofer et al. arXiv:0902.0160

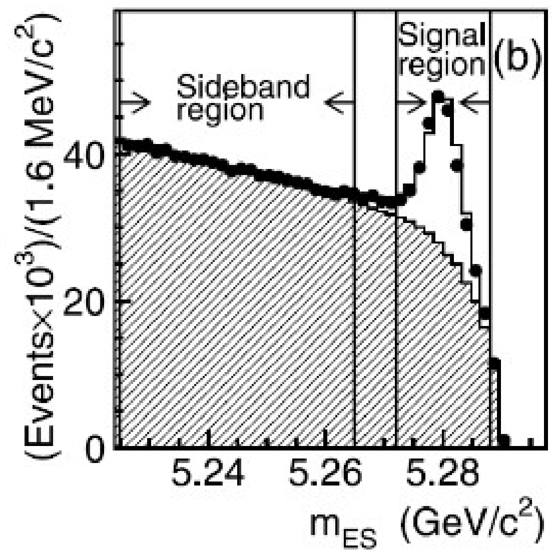
- $BR(B \to K \nu \nu) = (4.5 \pm 0.7) \times 10^{-6}$
- $BR(B \to K^* \nu \nu) = (6.8 \pm 1.0) \times 10^{-6}$
- $B \to K(^*) \nu \nu$ can test several scenarios:
  - Non-standard Z couplings (Buchalla et al. hep-ph/0006136);
  - Light Dark Matter (Bird et al. hep-ph/0401195);
  - Unparticle (Aliev et al. arXiv:0705.4542);
  - Extra-Dimensions (Neubert at LLWI '09);
  - SUSY with R-parity violation (Kim et al. arXiv:0904.0318);
- NP modify the kinematic spectra:
  - K* momentum in the analysis can give model dependence;
  - Angular analysis can be interesting.

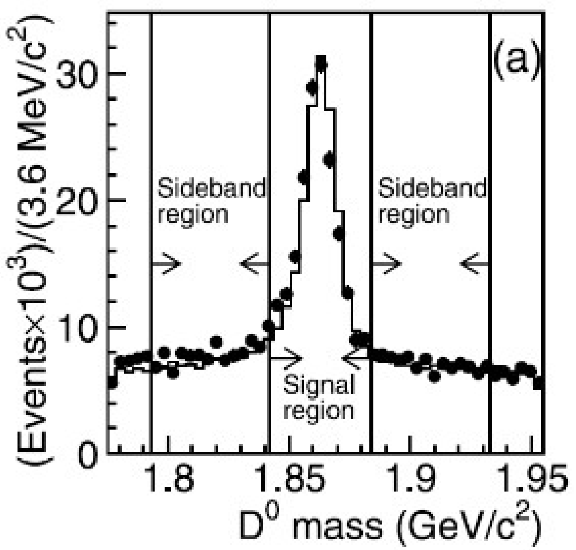
Francesco Renga, Warwick SuperB workshop

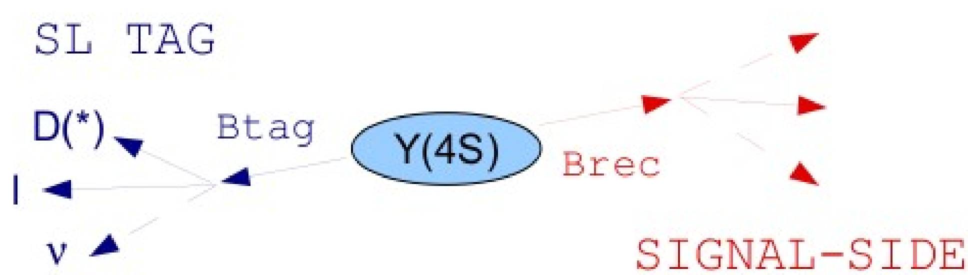
Remainder: Recoil Technique

- Most of the searches for rare B decays performed by exploiting the Recoil Technique:









TAG EFFICIENCY ~ 1%

Francesco Renga, Warwick SuperB workshop

Semi-Leptonic Breco (I)

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

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

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

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

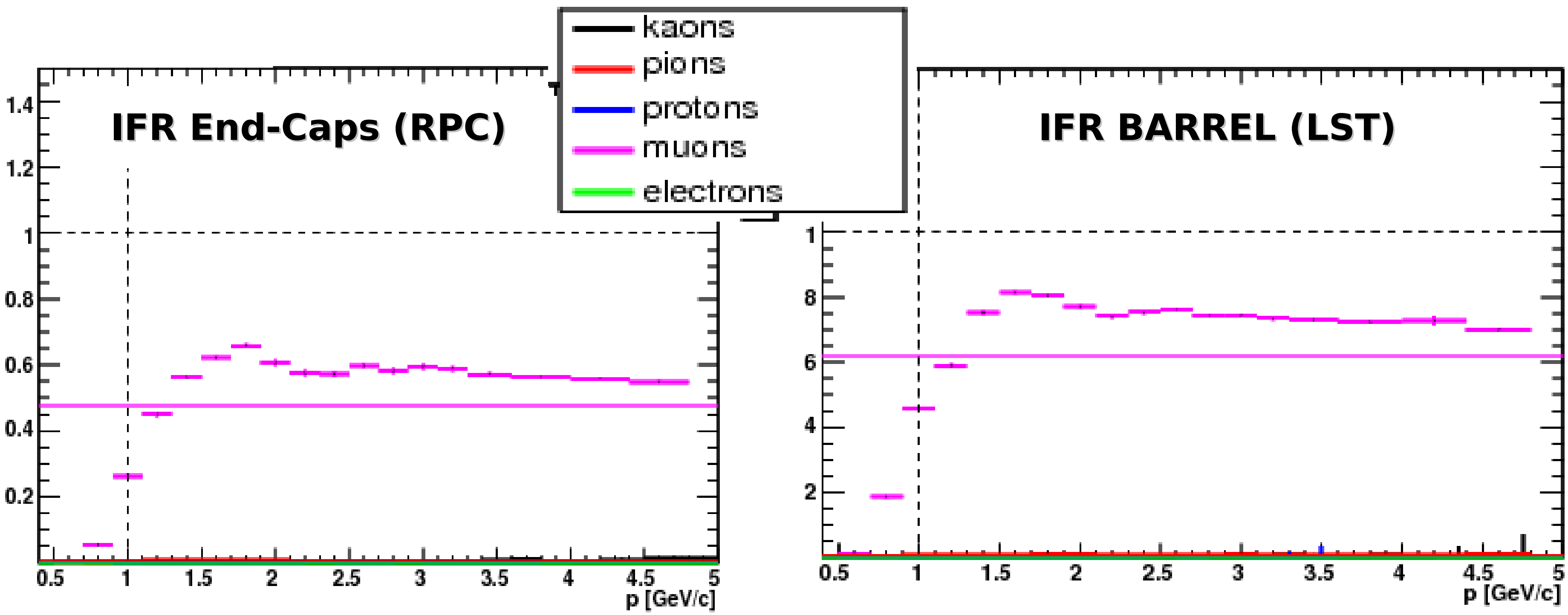
Semi-Leptonic Breco (II)

- PID: still use TableBasedXXXSelection selectors for Kaons, pions and muons (BaBar run6-r24c PiD tables)

Semi-Leptonic Breco (II)

- PID: still use TableBasedXXXSelection selectors for Kaons, pions and muons (BaBar run6-r24c PiD tables)

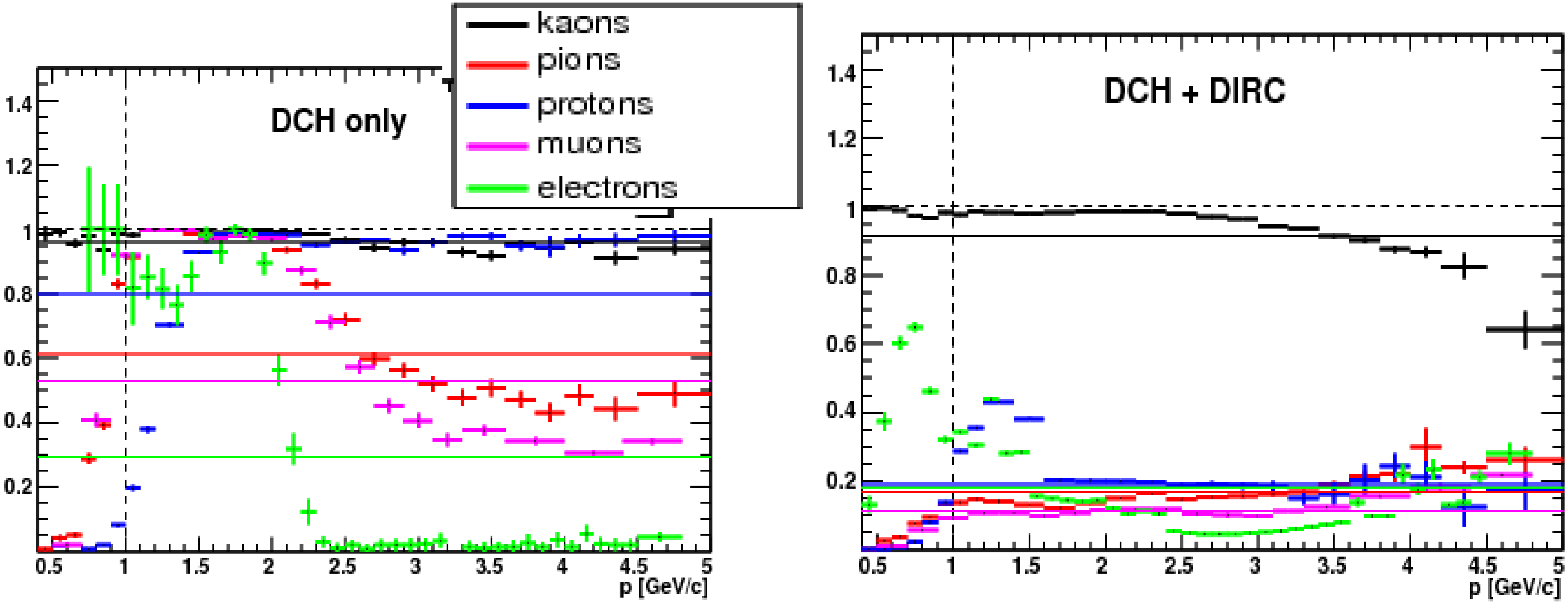
- Muon ⇒ MuonNNTight



Semi-Leptonic Breco (II)

- **PID: still use TableBasedXXXSelection selectors for Kaons, pions and muons (BaBar run6-r24c PiD tables)**

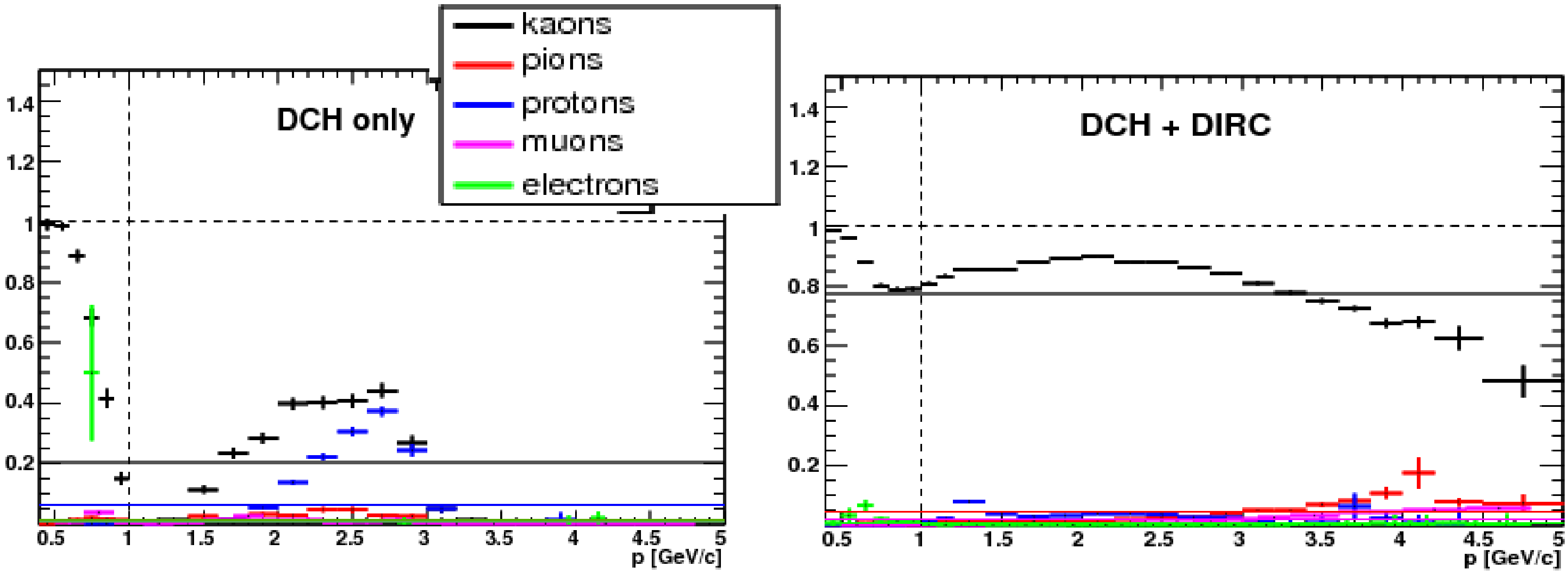
- Kaon ⇒ KaonNotPion



Semi-Leptonic Breco (II)

- **PID: still use TableBasedXXXSelection selectors for Kaons, pions and muons (BaBar run6-r24c PiD tables)**

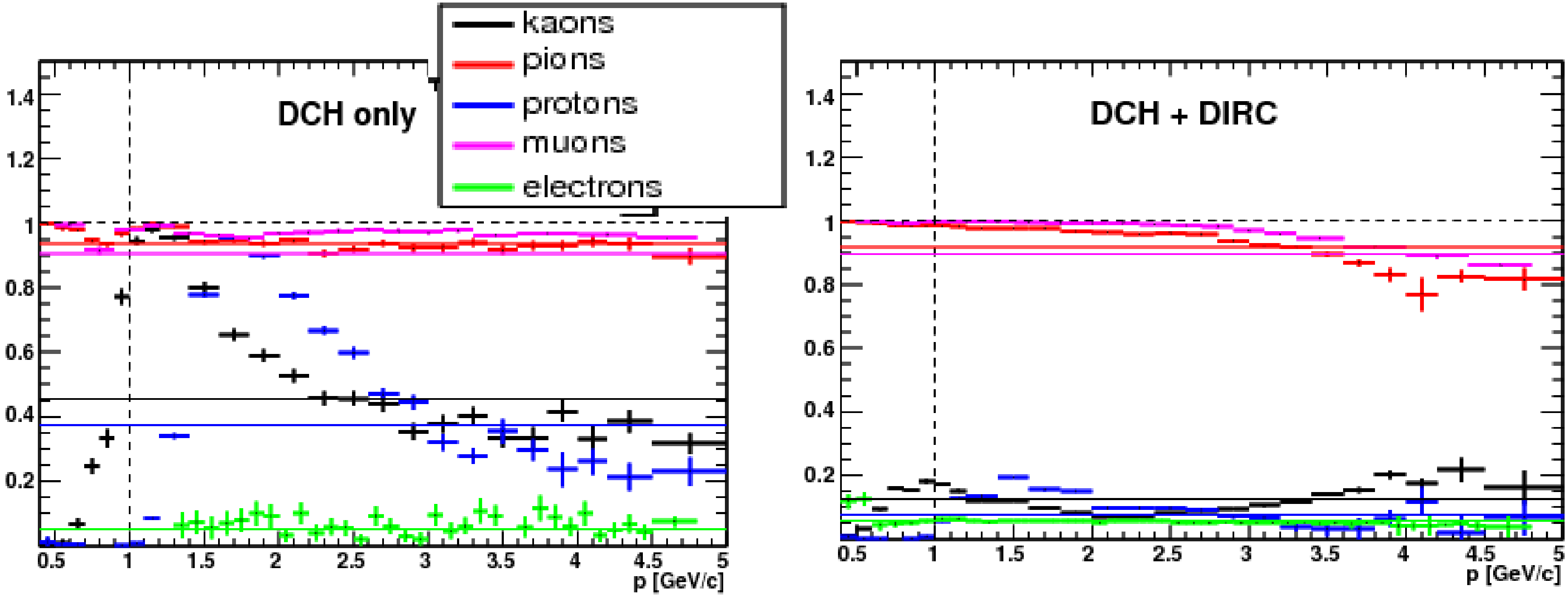
- Kaon ⇒ KaonTight



Semi-Leptonic Breco (II)

- **PID: still use TableBasedXXXSelection selectors for Kaons, pions and muons (BaBar run6-r24c PiD tables)**

- Pion ⇒ Pion Not a Kaon (test PionLoose)

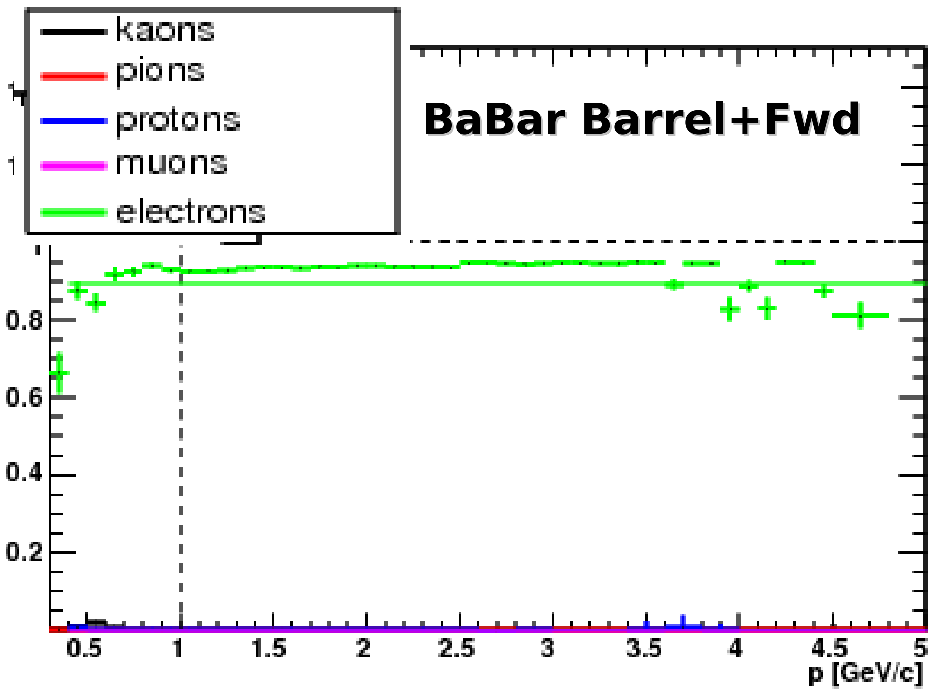


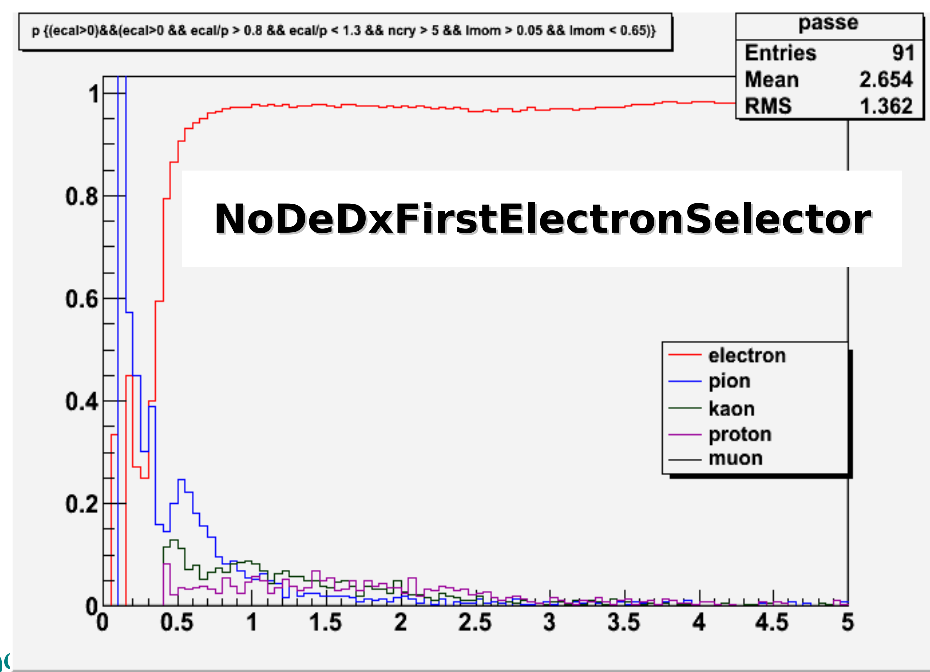
Semi-Leptonic Breco (II)

- PID: still use TableBasedXXXSelection selectors for Kaons, pions and muons (BaBar run6-r24c PiD tables)

- Electron ⇒ NoDeDxFirstElectronSelector

- Uses Mainly E/p
- Only tuned for Barrel Emc





Semi-Leptonic Breco (II)

- PID: still use TableBasedXXXSelection selectors for Kaons, pions and muons (BaBar run6-r24c PiD tables)

Need to switch to Real selectors. See Leonid's Talk

Semi-Leptonic Breco (III)

- **Additional cuts on tag-side ($B^+ \to K^+ \nu\nu$):**
  - 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)
  - $|p^*_D|$ > 0.5GeV/c
  - Dl vertex Prob > 0.04
  - m_{Dl} > 3GeV/c^2
  - $|p^*_l|$ > 1.35GeV/c (**assures selection of Semi-Lep. decays**)

Semi-Leptonic Breco (III)

- **Additional cuts on tag-side ($B \to K^{(*)}\nu\nu$):**
  - signal-side effic. ~10 smaller wrt $K^+\nu\nu$
  - More relaxed cuts ⇒ ~ tag-side effic. twice $K^+\nu\nu$

  - |Net charge| < 2
  - -2.0 < cos(B,Dl) < 1.1
  - Usual cuts in m_{D0} (|mass – PDG| < 3*sigma)
  - Dl vertex Prob > 0.04
  - $|p^*_l|$ > 0.8GeV/c

Signal Side

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

- |cos(K,Dl)| < 0.8
- $|p^*_K| > 1.25$GeV/c
- $E_{extra} < 250$ MeV/c²

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

- Usual K* mass cuts
- For $K^{*+} \to K^0_S \pi^+$, usual mass(K^0_S) cuts
- $E_{extra} < 1.2$ GeV/c²

- Flavour correlation (**$K^+ \leftrightarrow K^-(D^0)$ in tag side**)
- Signal K inside PID system (**Include Fwd DcH/PiD**)

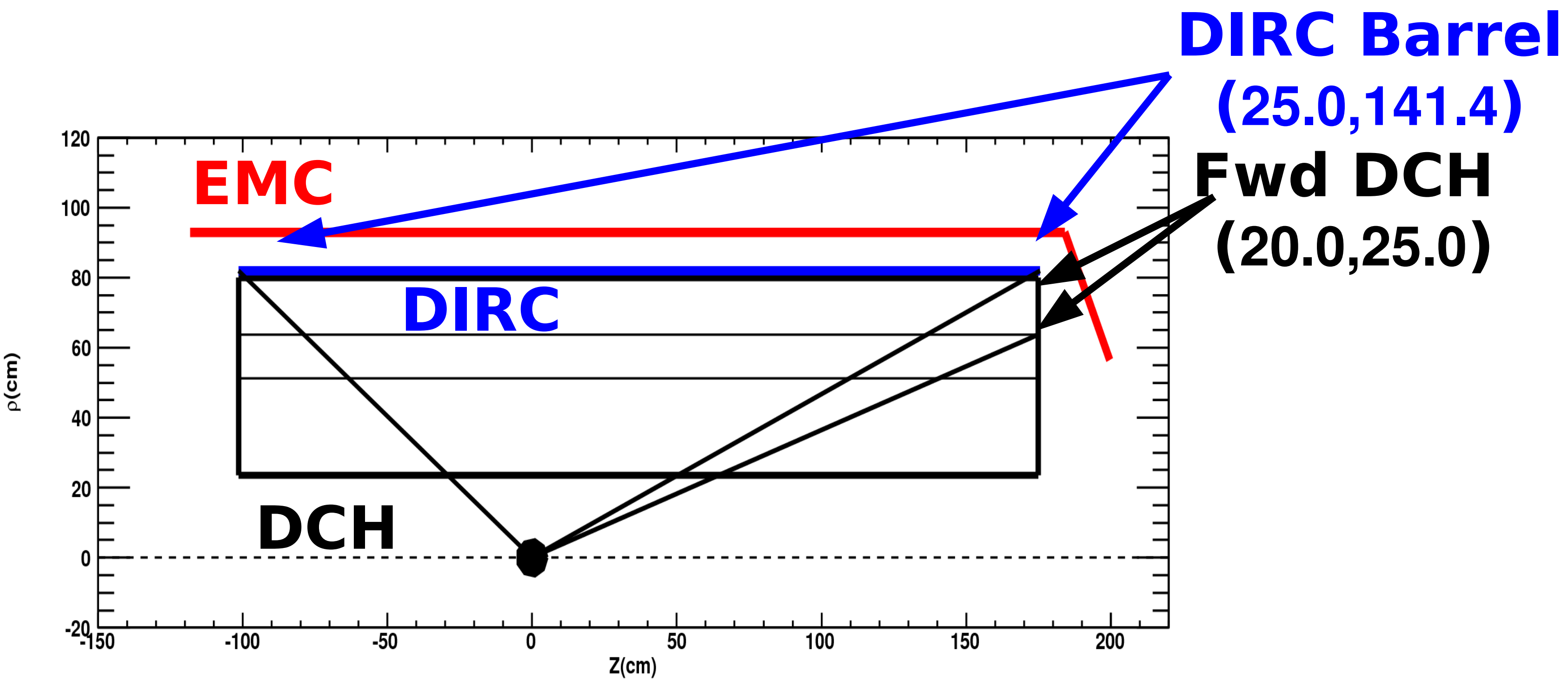
Scenarios: Detector Configurations

- **Test addition of FwdPiD and BwdEmc to SuperB baseline**

Scenarios: Detector Configurations

- Test addition of FwdPiD and BwdEmc to SuperB baseline
- BaBar ($\beta\gamma$ = 0.56)

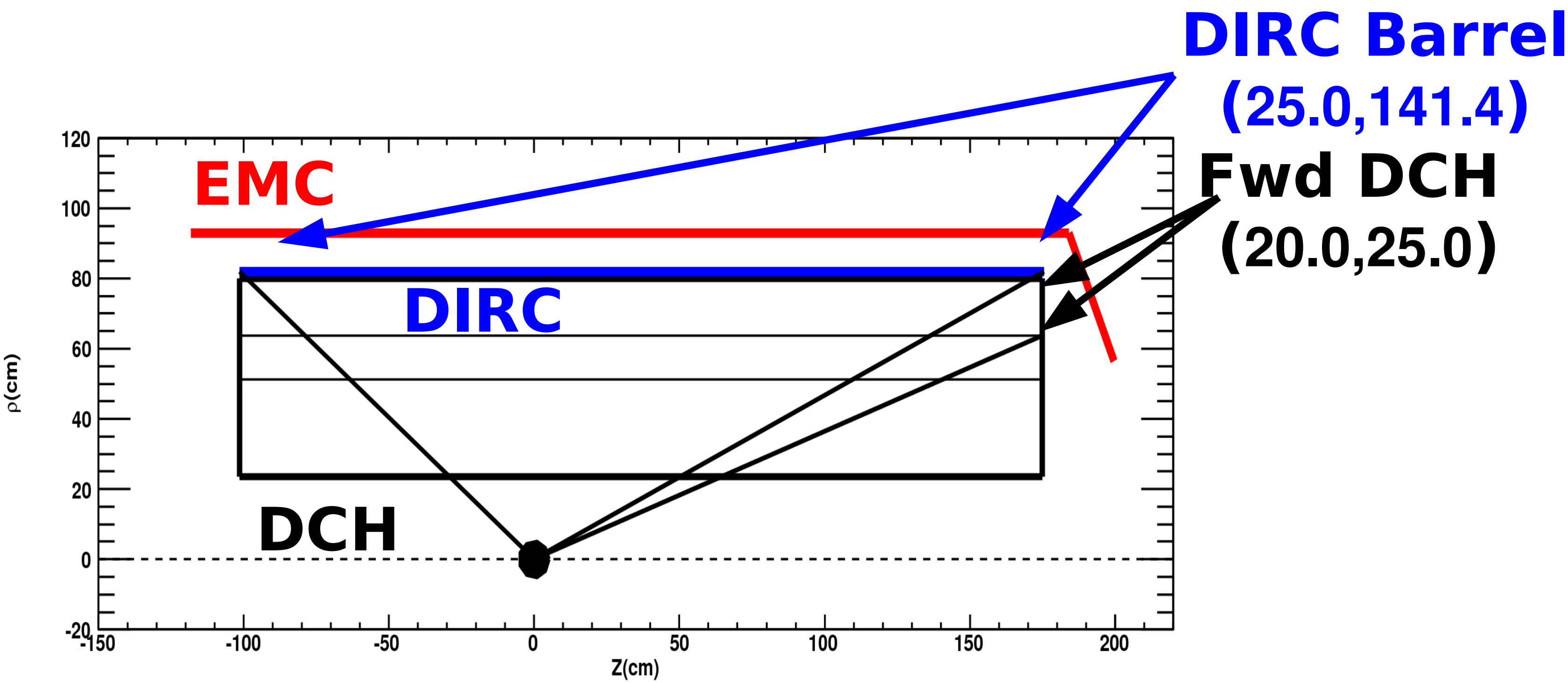
  - PID in (20.0,141.4) (includes Fwd DCH)



Scenarios: Detector Configurations

- **Test addition of FwdPiD and BwdEmc to SuperB baseline**
- **SuperB baseline (DG0) ($\beta\gamma$ = 0.28)**

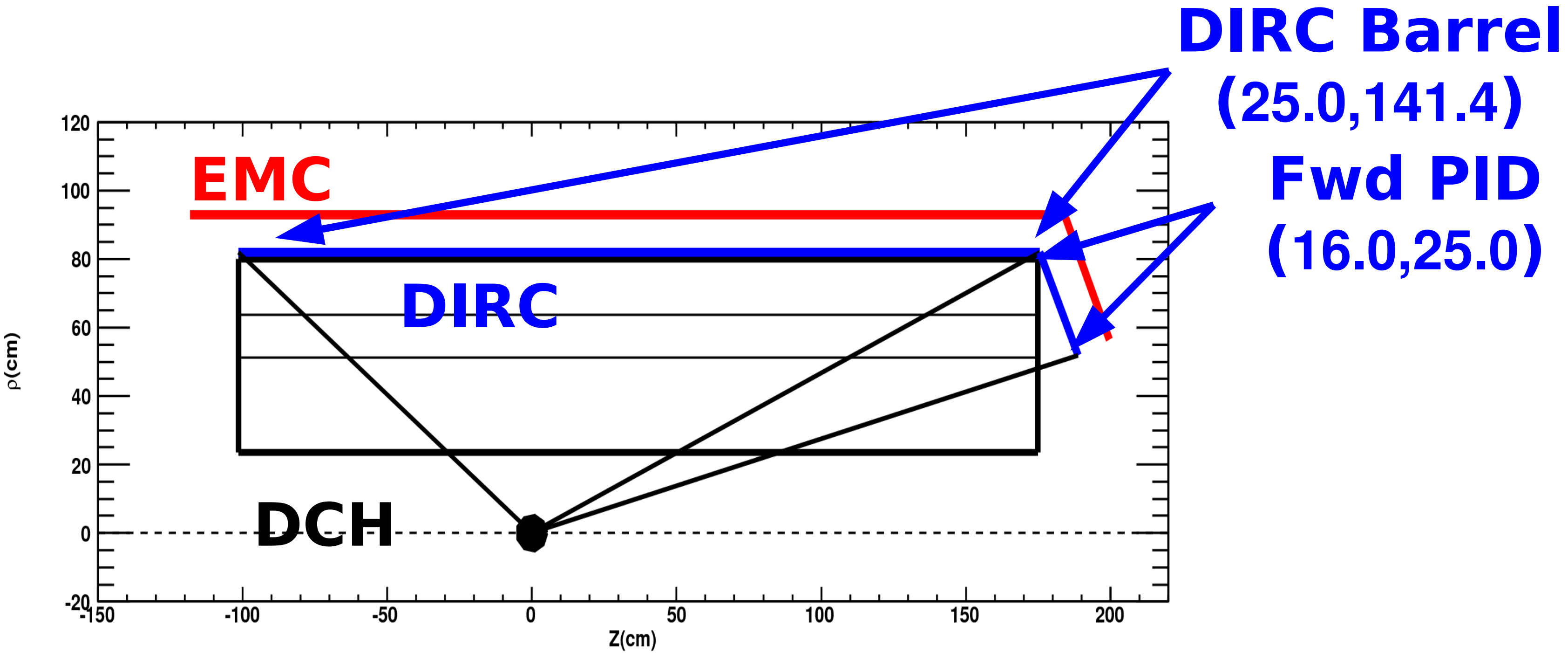
- PID in (20.0,141.4) (includes Fwd DCH)



Scenarios: Detector Configurations

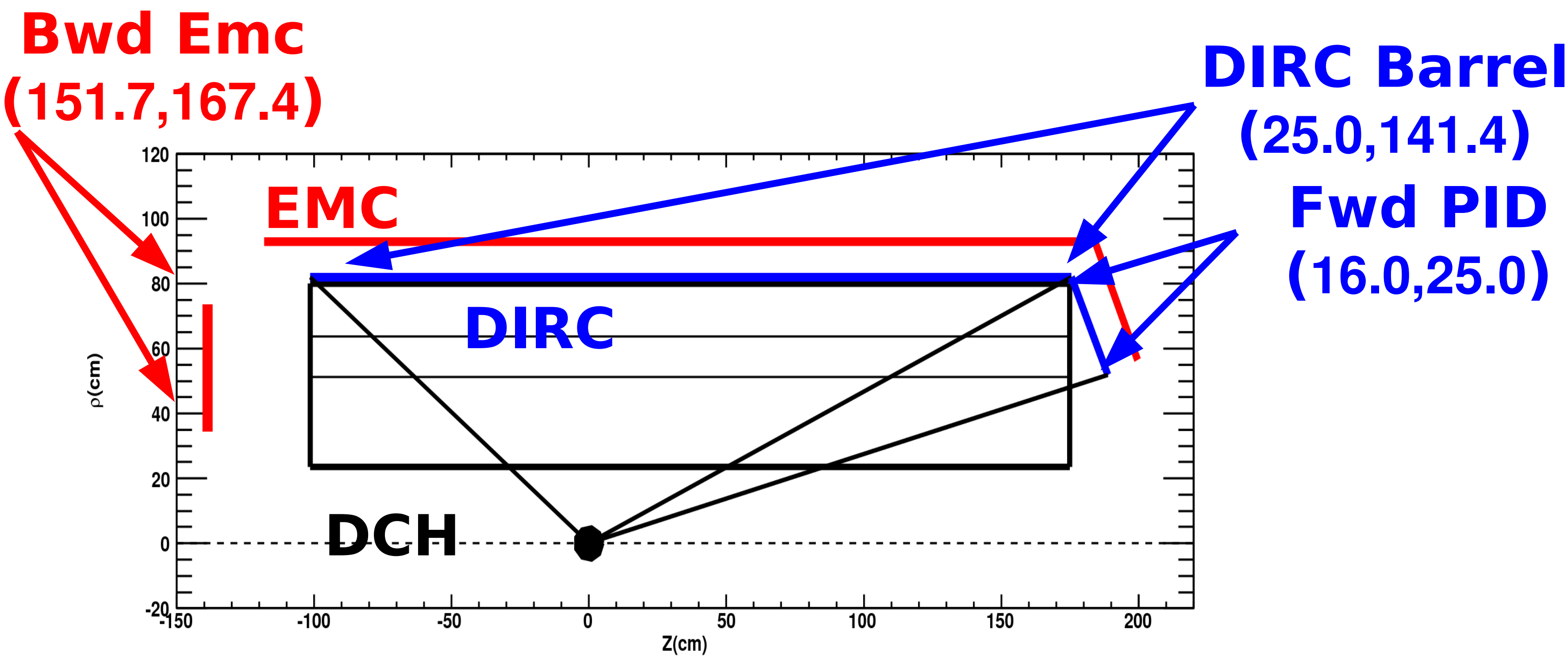
- Test addition of FwdPiD and BwdEmc to SuperB baseline
- SuperB baseline + FwdPiD (DGX) ($\beta\gamma$ = 0.28)

- PID in (16.0,141.4) (increase Fwd coverage by ~5°)



Scenarios: Detector Configurations

- Test addition of FwdPiD and BwdEmc to SuperB baseline
- SuperB baseline + FwdPiD + BwdEmc (DG4) ($\beta\gamma$ = 0.28)
  - PID in (16.0,141.4) (increase Fwd coverage by ~5°)
  - Bwd Emc in (16.0,141.4) (increase Bwd coverage by ~16°)



$B \to K\nu\nu$ (SL) Signal Sample

- **Signal sample ($B^+ \to K^+\nu\nu / B^- \to$ generic): ~5M events**
- **Signal sample ($B^{+/0} \to K^{*(+/0)}\nu\nu / B^{-/0} \to$ generic): ~5M events**

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

$B^+ \to K^+ \nu\nu$ (SL): efficiency

- Tag-Side: Kaon (Tight), Pion (Loose)
- Sig-Side: Kaon (Tight)

Tagging efficiency(%)

D^0 Channel	BaBar	DG0	DGX(TOF)	DG4
$K^-\pi^+$	0.132 ± 0.001	0.143 ± 0.002	0.149 ± 0.002	0.153 ± 0.002
$K^-\pi^+\pi^-\pi^+$	0.100 ± 0.001	0.105 ± 0.001	0.114 ± 0.002	0.114 ± 0.002
$K^-\pi^+\pi^0$	0.275 ± 0.002	0.295 ± 0.003	0.312 ± 0.003	0.322 ± 0.003
Average	0.539 ± 0.003	0.577 ± 0.004	0.610 ± 0.004	0.624 ± 0.004

Signal efficiency (%)

D^0 Channel	BaBar	DG0	DGX(TOF)	DG4
------------	0.144 ± 0.001	0.163 ± 0.002	0.175 ± 0.002	0.182 ± 0.002

$B^+ \to K^+ \nu\nu$ (SL): efficiency

- Tag-Side: Kaon (Tight), Pion (Loose)
- Sig-Side: Kaon (Tight)

Tagging efficiency(%) Relative Gains

D^0 Channel	BaBar	DG0	DGX(TOF)	DG4
$K^-\pi^+$	0.132 ± 0.001	8.6%	4.3%	6.9%
$K^-\pi^+\pi^-\pi^+$	0.100 ± 0.001	4.7%	8.7%	8.7%
$K^-\pi^+\pi^0$	0.275 ± 0.002	7.4%	5.9%	9.2%
Average	0.539 ± 0.003	7.0%	5.7%	8.2%

Signal efficiency (%) Relative Gains

D^0 Channel	BaBar	DG0	DGX(TOF)	DG4
------------	0.144 ± 0.001	13.0%	7.0%	11.0%

$B^+ \to K^{*+}\nu\nu$ (SL): efficiency

- Tag-Side: Kaon (Tight), Pion (Loose)
- Sig-Side: Kaon (Tight), Pion (Loose)

Tagging efficiency(%)

D^0 Channel	BaBar	DG0	DGX(TOF)	DG4
$K^-\pi^+$	0.222 ± 0.002	0.242 ± 0.003	0.254 ± 0.003	0.256 ± 0.002
$K^-\pi^+\pi^-\pi^+$	0.161 ± 0.001	0.174 ± 0.002	0.185 ± 0.002	0.185 ± 0.002
$K^-\pi^+\pi^0$	0.591 ± 0.004	0.650 ± 0.004	0.672 ± 0.004	0.697 ± 0.004
Average	1.067 ± 0.005	1.160 ± 0.005	1.208 ± 0.006	0.123 ± 0.006

Signal efficiency (%)

D^0 Channel	BaBar	DG0	DGX(TOF)	DG4
------------	0.075 ± 0.002	0.078 ± 0.002	0.082 ± 0.002	0.084 ± 0.002

$B^+ \to K^{*+}\nu\nu$ (SL): efficiency

- Tag-Side: Kaon (Tight), Pion (Loose)
- Sig-Side: Kaon (Tight), Pion (Loose)

Tagging efficiency(%) Relative gain

D^0 Channel	BaBar	DG0	DGX(TOF)	DG4
$K^-\pi^+$	0.222 ± 0.002	8.6%	4.7%	5.4%
$K^-\pi^+\pi^-\pi^+$	0.161 ± 0.001	7.5%	6.5%	5.7%
$K^-\pi^+\pi^0$	0.591 ± 0.004	10.0%	3.4%	7.2%
Average	1.067 ± 0.005	8.7%	4.0%	6.1%

Signal efficiency (%) Relative gain

D^0 Channel	BaBar	DG0	DGX(TOF)	DG4
------------	0.075 ± 0.002	----------------Too low statistics----------------------		

$B^0 \to K^{*0}\nu\nu$ (SL): efficiency

- Tag-Side: Kaon (Tight), Pion (Tight)
- Sig-Side: Kaon (Tight), Pion (Tight)

Tagging efficiency(%)

D^+ Channel	BaBar	DG0	DGX(TOF)	DG4
$K^-\pi^+\pi^-$	0.180 ± 0.002	0.192 ± 0.002	0.204 ± 0.002	0.204 ± 0.002
$Ks\pi^+$	0.053 ± 0.001	0.057 ± 0.002	0.057 ± 0.002	0.057 ± 0.002
Average	0.234 ± 0.003	0.250 ± 0.003	0.261 ± 0.003	0.261 ± 0.003

Signal efficiency (%)

D^+ Channel	BaBar	DG0	DGX(TOF)	DG4
-----------	0.042 ± 0.001	0.042 ± 0.001	0.044 ± 0.001	0.044 ± 0.001

$B^0 \to K^{*0}\nu\nu$ (SL): efficiency

- Tag-Side: Kaon (Tight), Pion (Tight)
- Sig-Side: Kaon (Tight), Pion (Tight)

Tagging efficiency(%) Relative Gains

D^+ Channel	BaBar	DG0	DGX(TOF)	DG4
$K^-\pi^+\pi^-$	0.180 ± 0.002	7.4%	5.6%	5.6%
$Ks\pi^+$	0.053 ± 0.001	----------	----------	----------
Average	0.234 ± 0.003	7.4%	5.6%	5.6%

Signal efficiency (%) Relative Gains

D^+ Channel	BaBar	DG0	DGX(TOF)	DG4
-----------	0.042 ± 0.001	---------Too low statistics---------		

Bkgs in $B \to K^* \nu\nu$ (SL)

- $K^+\nu\nu$:

  - 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 a relatively significant improvement with better PiD

- Expect significantly improvement with BwdEmc (higher coverage)
- Due to low B-background efficiencies (~10^{-5} – 10^{6}), need around $1ab^{-1}$ of B-generic samples.
- Missed September Test Production ($200ab^{-1}$).

Some extrapolations for $B \to K^* \nu\nu$ (SL)

- $K^+\nu\nu$(SL):

  BR($B^+ \to K^{+(*)}\nu\nu$) = 4.0x10^{-6} (SM value)

  - Ns = 6.4/ab^{-1} (0.164%)
  - Nb = 84/ab^{-1}

  (F. Renga talk SuperB VI)

- Re-scale Ns and Nb for different Lumis
- Detector Configurations: re-scale Ns and Nb for different efficiency gains obtained with FastSim

  (Use signal gains of $K^+\nu\nu$)
- Assume S/B stays constant with Lumi
- Plot the significance sqrt(Ns+Nb)/Ns as a function of Lumi
- Warning: Not include systematic extrapolation

Some extrapolations for B→K*νν (SL)

- Charged mode (5σ (stat) significance):

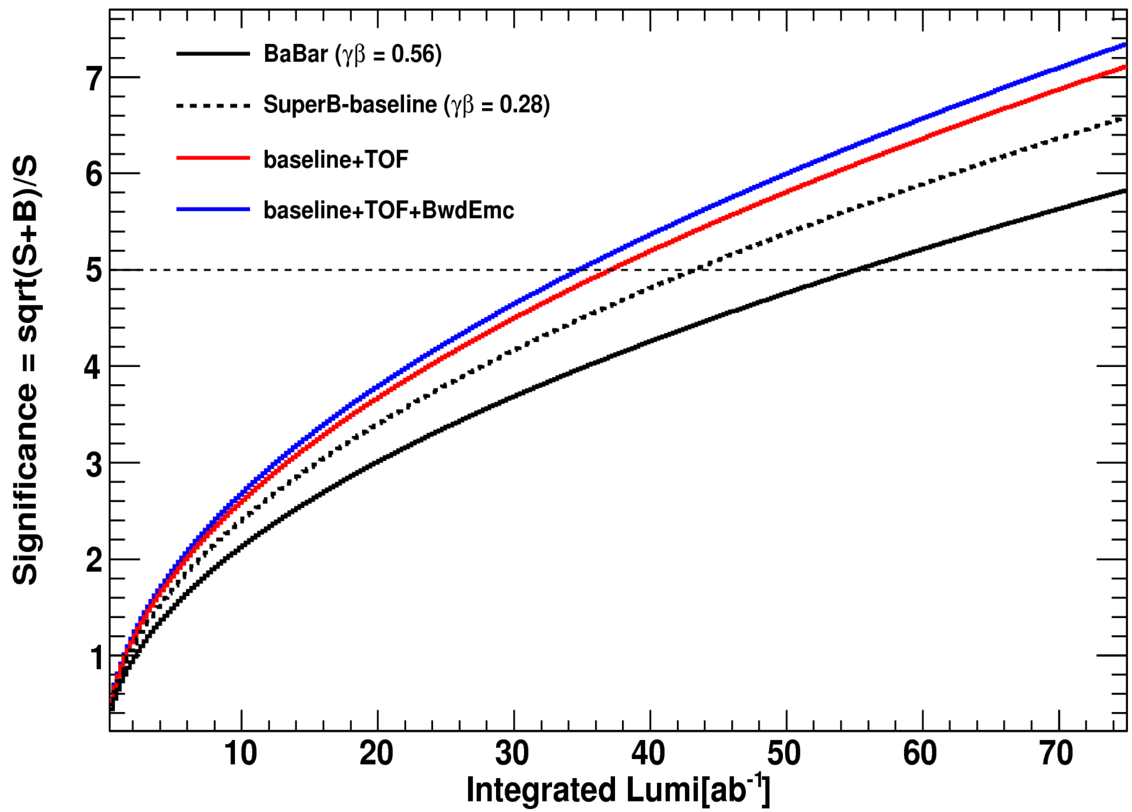
- BaBar: ~55ab^{-1}

- SuperB-base line: ~43ab^{-1}

- +TOF: ~37ab^{-1}

- +TOF+BwdEmc: ~34ab^{-1}

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



Summary

- $K^{(*)}\nu\nu$ (SL) Signal samples (efficiencies):

  Tagging: increases from: TOF: ~4% to ~9% , (TOF+Bwd Emc): ~6% to ~9%, depending on charged/neutral multiplicities (average ~6% (TOF), ~8% (Bwd Emc))

  Total signal ($K^+\nu\nu$): ~7% TOF, ~10% Bwd-Emc

  Need to redo studies with more statistics for signal-side $K^*\nu\nu$
- Backgrounds:

  - marginally dependent on PID
  - expect significant improvement adding Bwd-Emc
- Extrapolation:

  - With detector improvements (TOF+BwdEmc) expect to have same 5σ (stat) significance as BaBar with half of statistics

  (warning, not including systematic error scale).

Summary

- **Next steps:**

- Need to switch from table-based to real PiD selectors

- Implement PacSemiLepRecoilUser in PacProduction → almost finish

- Quantify improvements with the different Detec. Configs.

→ see Elisa's talk for HaD BReco

- Complete study including all MC samples → need ~1ab^{-1}

Backup

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)**