DGWG parallel session, March 17th 2010

Impact of Fwd-PID and Bwd-EMC using Semi-Leptonic Breco

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LAPP SuperB Workshop

LABORATOIRE DE L'ACCÉLÉRATEUR LINÉAIRE

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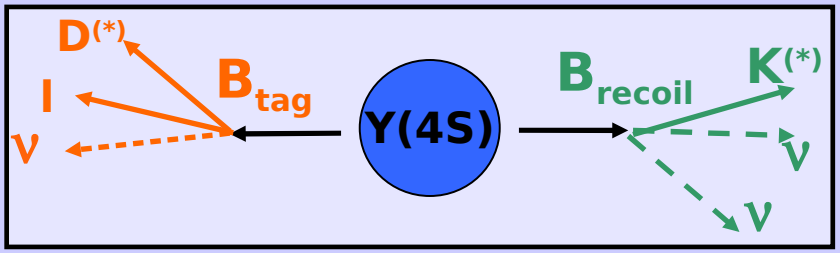
Outline

- **Reminder**
  - Semi-Leptonic technique
  - $B^+ \rightarrow K^+ \nu\nu$ analysis strategy
- **Detector Geometries**
  - Fwd region: TOF or extended DCH
  - Bwd-EMC
- **MC samples ⇒ February 2010 production**
- **Machine Backgrounds issue (Bhabha and radiative Bhabhas)**
- **Some preliminary results**
  - Fwd PID ⇒ Time Of Flight (TOF)
  - Bwd EMC ⇒ Veto device
- **Summary and outlook**

Reminder: SL technique

- Search for $B \to D^{(*)} l \nu$



- Reconstruction steps:
  - Reconstruct $D^{(*)} \to$ hadrons

$D^{*+} \to D^0 \pi^+$

~~$D^{*0} \to D^0 \pi^0$~~

$D^{*0} \to D^0 \gamma$

$D^0 \to K^- \pi^+$

$D^0 \to K^- \pi^+ \pi^0 (\gamma\gamma)$

$D^0 \to K^- \pi^+ \pi^+ \pi^-$

$D^0 \to K^0_S \pi^+ \pi^-$

$D^+ \to K^- \pi^+ \pi^-$

$D^+ \to K^- \pi^+ \pi^- \pi^0$

$D^+ \to K^0_S \pi^+$

$D^+ \to K^0_S \pi^+ \pi^- \pi^+$

$D^+ \to K^0_S \pi^+ \pi^0$

  - Use $D^{(*)}$ and add lepton ($e^{\pm}$,$\mu^{\pm}$) to form a $D^{(*)}l$ candidate

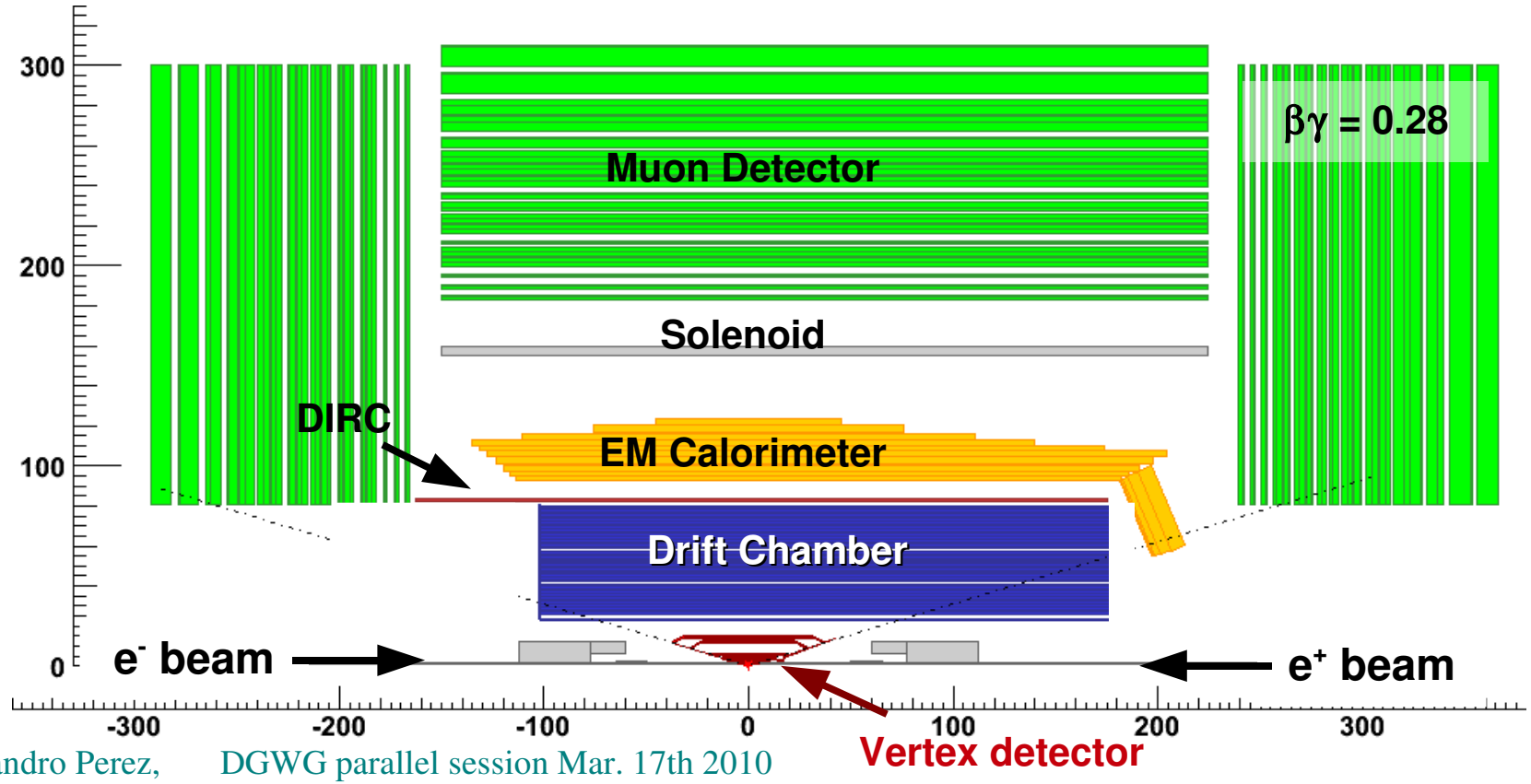
- Sample of 14 decay modes (charged + neutrals)
- Kinematics is unconstrained due to neutrinos 
- Relatively high reconstruction efficiency ~2% 

Reminder: $B^+ \to K^+ \nu\nu$ Analysis

- **Btag candidate:** K^+ (π^+) from D reconstruction is LHKaonTight (is not LHKaonNotAPion)
- **Bsig candidate:** look in ROE for a K^+ in LHKaonTight list with opposite charged as Btag
- **Do a cut and count analysis** with the following selection cuts:
  - Number of Charged tracks in event < 12
  - Number of Neutrals in event < 15
  - R2 < 0.84
  - $-2.5 < \mathrm{Cos}(\theta_{BDl}) < 1.1$
  - $|M_D(\mathrm{rec}) - M_D(\mathrm{PDG})| < 3\sigma$ (mass resolution)
  - $M_{Dl} > 3.0\ \mathrm{GeV}/c^2$
  - $p^*_D(\mathrm{CM}) > 0.5\ \mathrm{GeV}/c$
  - $p^*_{lep}(\mathrm{CM}) > 1.35\ \mathrm{GeV}/c$
  - $M_{miss} > 1.0\ \mathrm{GeV}/c^2$
  - $p^*_{signalK}(\mathrm{CM}) > 1.25\ \mathrm{GeV}/c$
  - $|\mathrm{Cos}(\theta[K,Dl])(\mathrm{CM})| < 0.8$
  - $E_{extra} < 250\mathrm{MeV}$ (**see later slide**)

Detector Geometries

- Baseline configuration: BaBar with reduced boost ($\beta\gamma = 0.28$)



Detector Geometries

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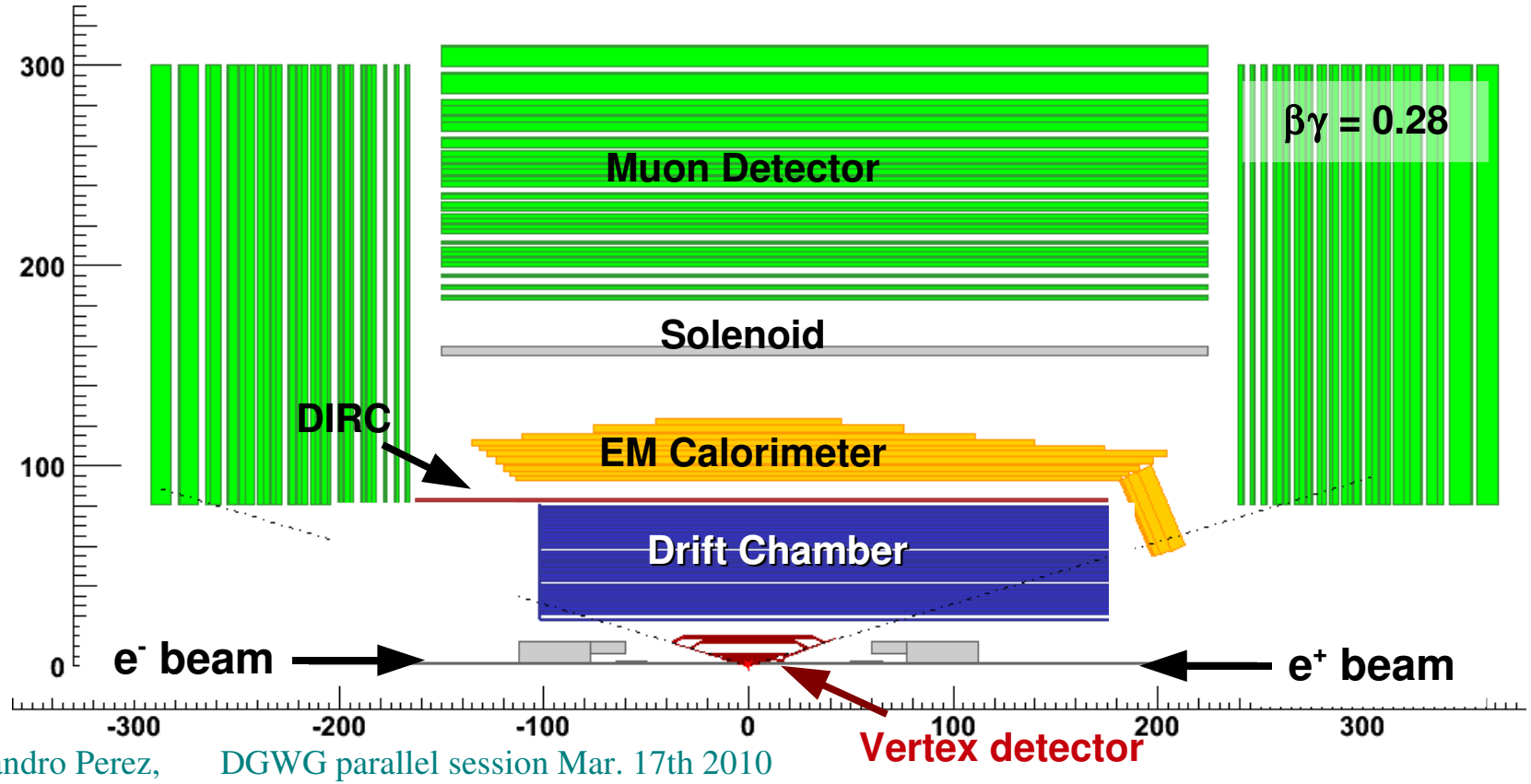
- Generated geometries:



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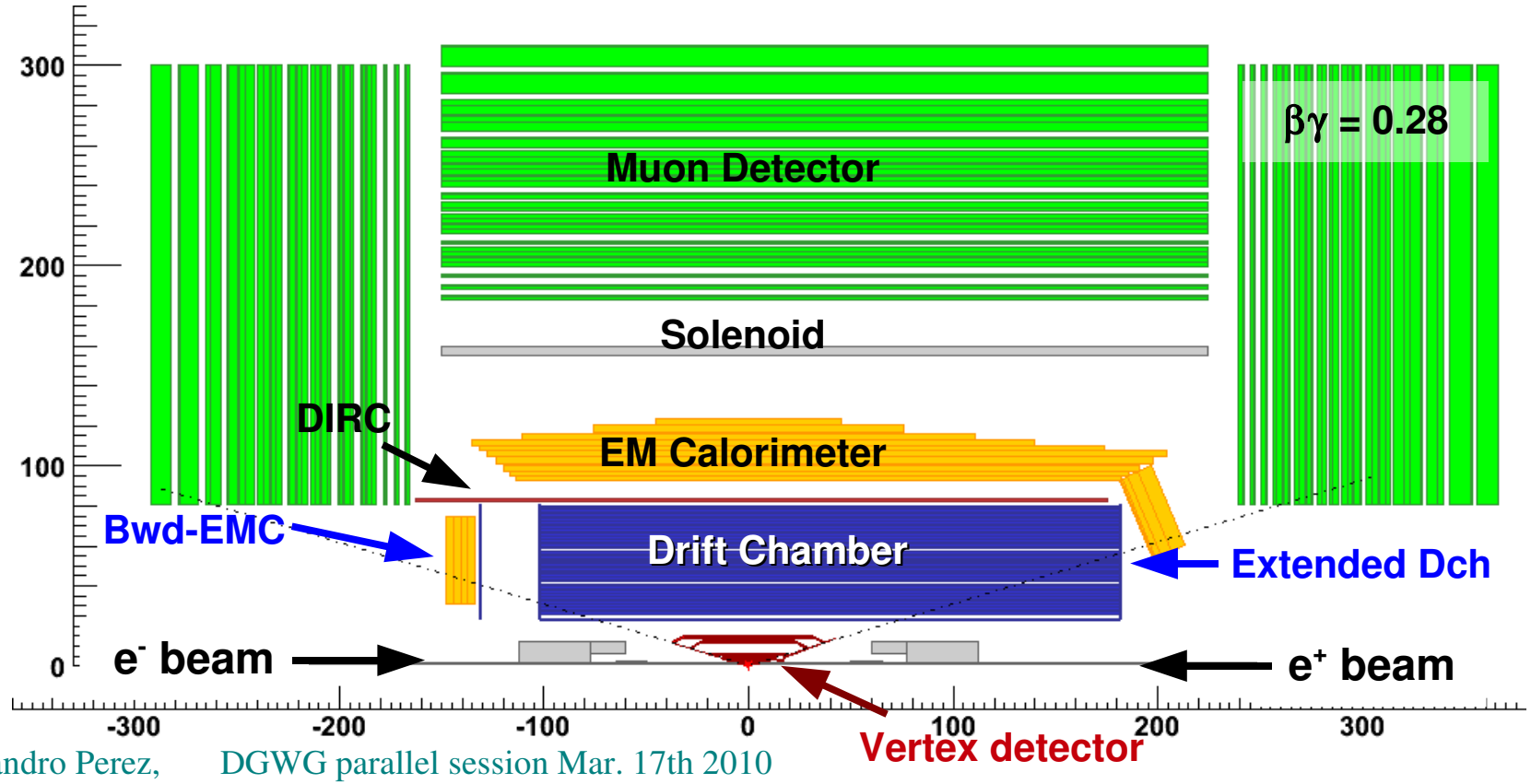
- Generated geometries:
  - Baseline + Bwd-EMC + Extended Dch (**DG_3**)



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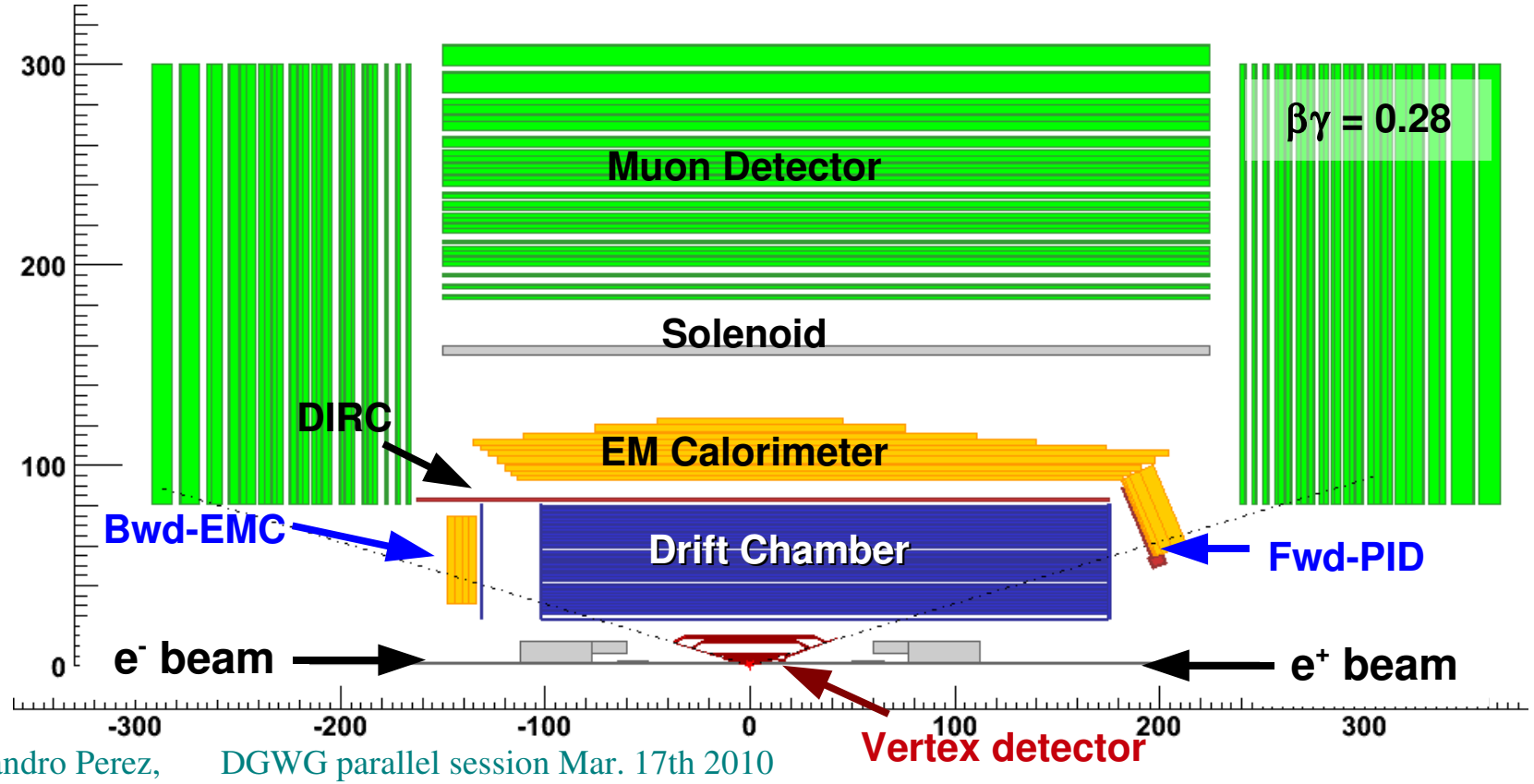
  - Baseline + Bwd-EMC + Fwd-PID (**DG_4**)



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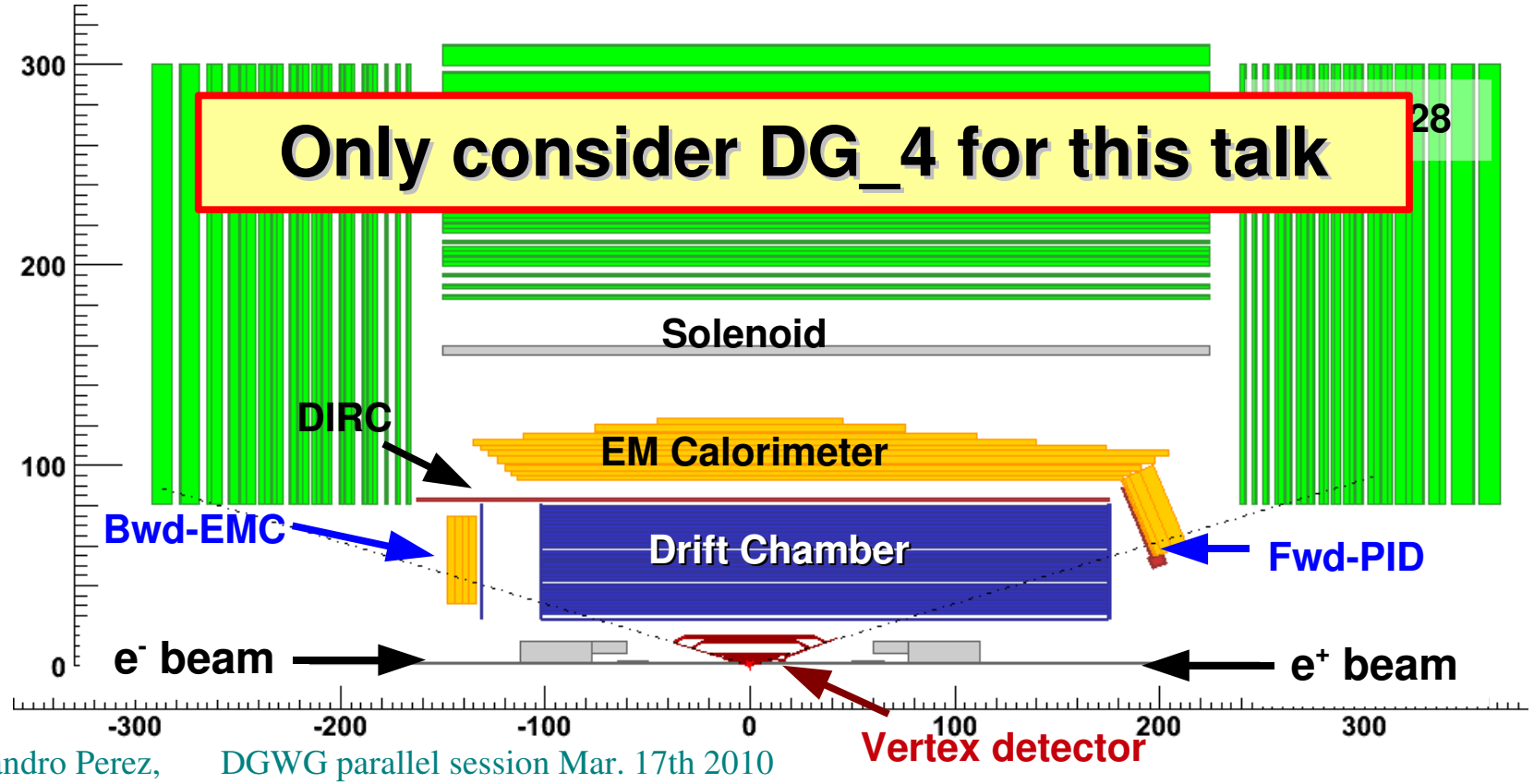
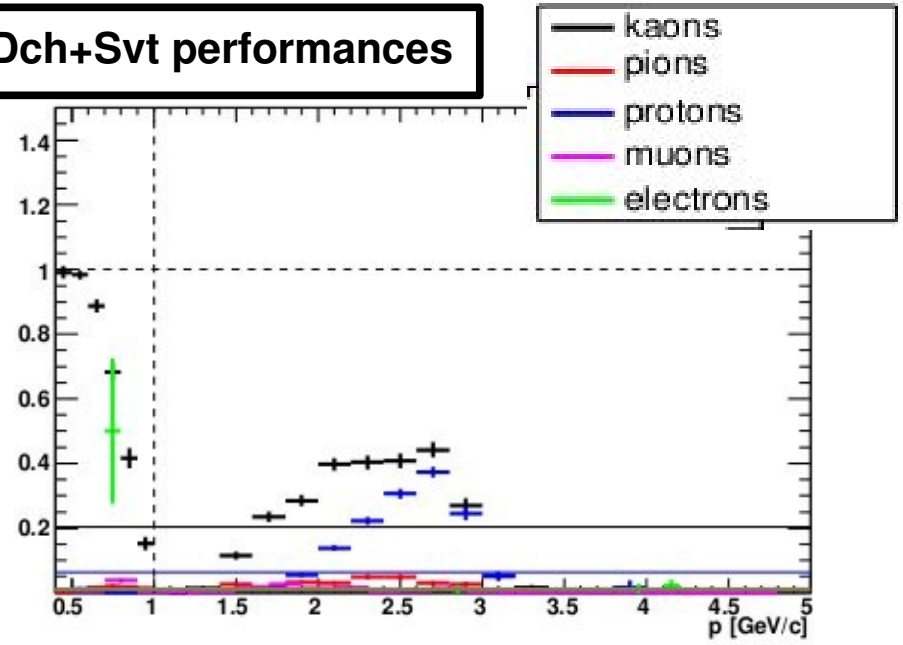


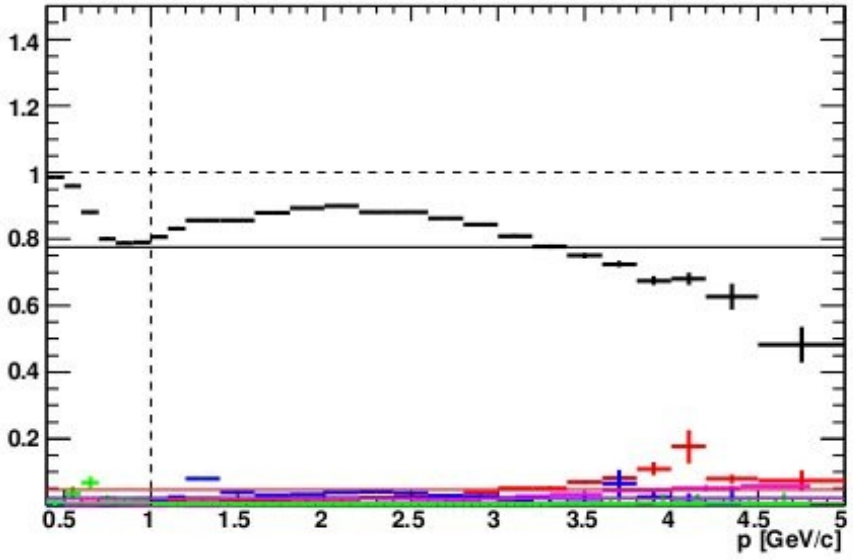
Fwd-PID impact studies: strategy

- All MC samples have been generated with flat efficiencies and mis-IDs for all charged Kaons and pions candidates used to reconstruct Btag and Bsig
- Table-based selectors used to test different performances of PID in the forward (coverage from 20° to 25°)
  - Dch+Svt
  - Dch+Svt+Fwf-PID device. Two strategies: DIR-like or fTOF

Dch+Svt performances



DIRC-like performances in Fwd region



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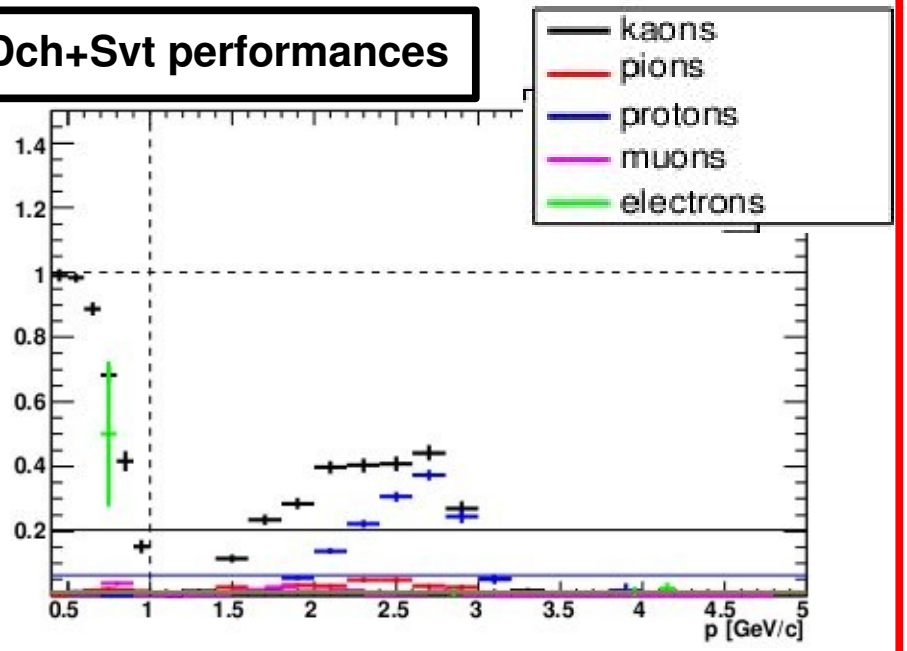
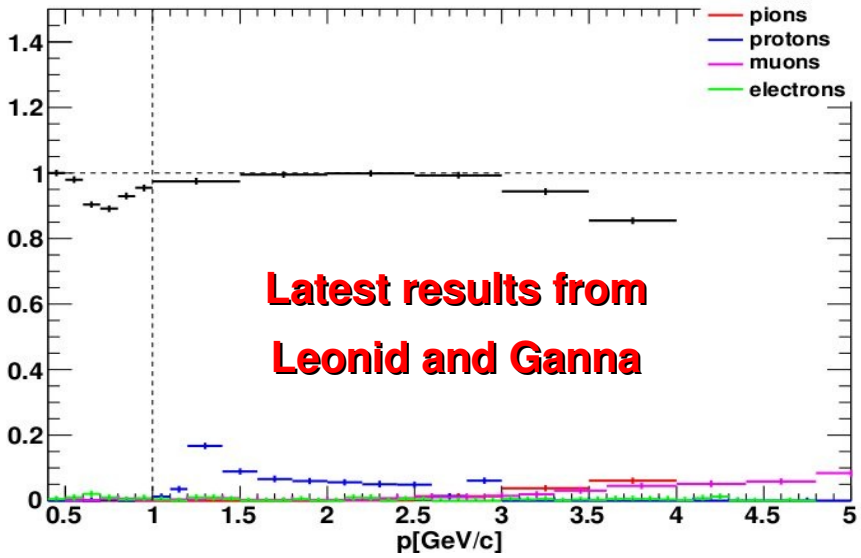


More realistic TOF performances



Fwd-EMC impact studies: Veto device (I)

- **Quite difficult to reconstruct π^0s with photons from Bwd-EMC**

  (see Chih-hsiang talk at Frascati SuperB workshop, Dec 2009)
- **Previously:**
  - Bwd-EMC used as an extension of Barrel-Fwd-EMC
    $\Rightarrow$ used neutrals from Bwd-EMC to reconstruct B_{tag} and B_{sig} candidates.
  - Results: - Increase in signal efficiencies (added badly reconstructed π^0s)
    - Background efficiencies increased accordingly
- **Decided to use Bwd-EMC as a veto device**
  - B_{tag} and B_{sig} candidates reconstructed without neutrals from Bwd-EMC
  - Two types of E_{extra} variables:
    - E_{extra}(Barrel-Fwd) = Σ(extra neutrals on Barrel-Fwd EMC)
    - E_{extra}(Bwd) = Σ(extra neutrals on Bwd EMC)
  - Can used E_{extra}(Bwd) to cut on and E_{extra}(Barrel-Fwd) to perform a fit
  - Currently E_{extra}(Barrel-Fwd) use photons with $E(\gamma)_{min} > 30$MeV
  - Need to define a $E(\gamma)_{min}$ cut (currently 30MeV) for Bwd-EMC photons (depend on machine background), as well as a cut on E_{extra}(Bwd) (analysis dependent)

Fwd-EMC impact studies: Veto device (II)

- **Use Bwd-EMC as a veto has several advantages:**
- Can generate all geometries always including Bwd-EMC
- Can decide to use/not to use E_{extra}(Bwd) ⇒ **can study Bwd-EMC impact with same sample!**
- Above statement is not completely true ...but almost
  - Muon selectors should be modified due material (Bwd-EMC) before Bwd-IFR. Currently not an issue ⇒ muon selector implement as TableBasedSelector
  - E/p cut based electron selector currently includes information from Bwd-EMC.
    - It is only optimized for Barrel-Fwd
    - Need to run a different optimization for the Bwd
    - Currently exclude electrons reconstructed in Bwd-EMC
- **Vetoing by cutting on E_{extra}(Bwd)**
  - Need to understand machine backgrounds
  - Veto is expected to be analysis dependent
    ⇒ different charged and neutral multiplicities in signal side
  - Plan: define a cut which maximized significance.

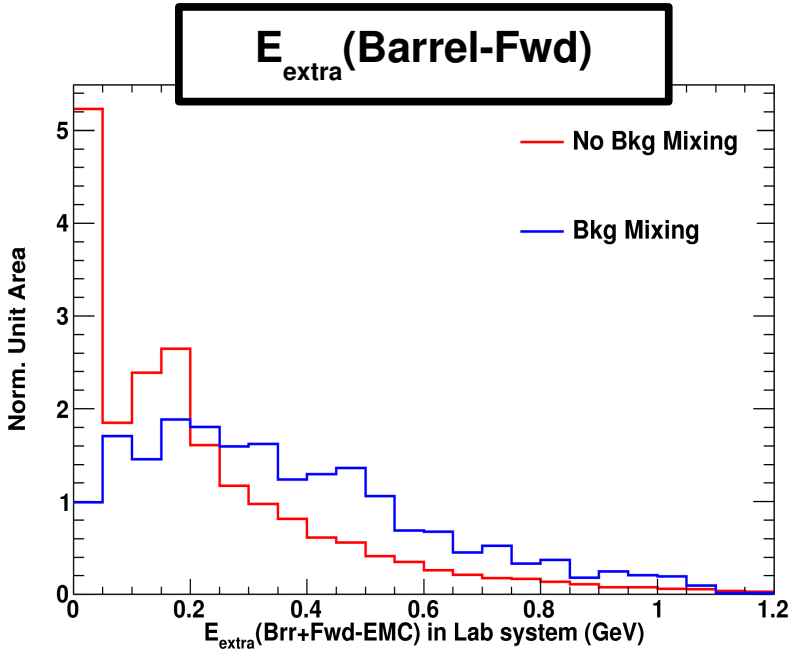
MC Samples: February 2010 Production

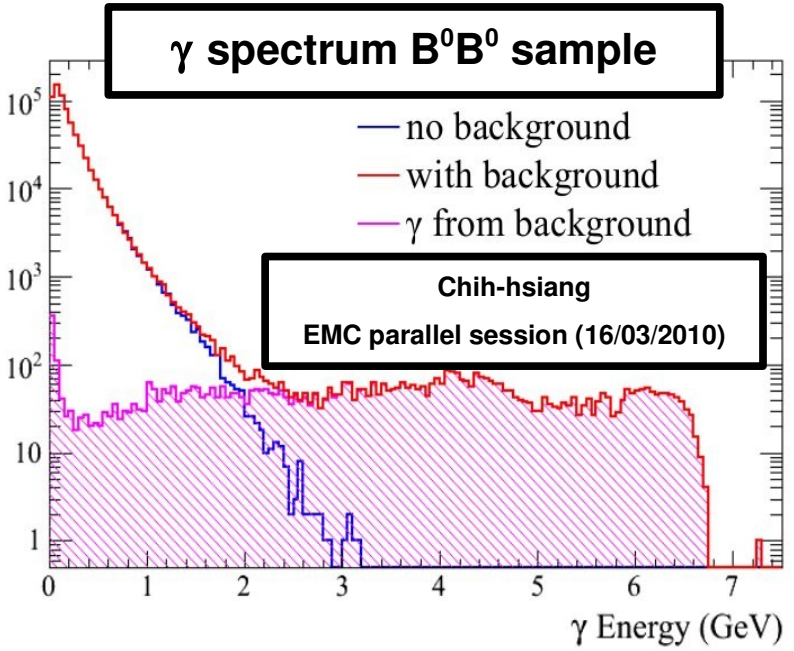
- **Signal samples:** $B^+ \to K^+ \nu\nu$ (DG_4)
  - 1M events Bkg Mixing (BhaBha, Rad-Bhahba)
  - 10M events without Bkg Mixing
- **Background Samples (DG_4):**
  - B+B- generic:
    - 4.9M Bkg Mixing
    - 104.25M without Bkg Mixing
  - B0B0 generic:
    - 6.2M Bkg Mixing
    - 101.25M without Bkg Mixing
  - cc:
    - 6.6M Bkg Mixing
    - 102.90M without Bkg Mixing
  - uds:
    - 10.08M Bkg Mixing
    - 525.20M without Bkg Mixing

- **Too low statistics of Background samples with Bkg mixing**
- **Possible use of background samples without bkg mixing (see next slides)**

Bkg mixing (Bhabha/Rad-Bhabha) issue

- **BaBar: negligible effect due to relatively low event rate**
- **SuperB: significant amount of high energy background γs from Bhabhas/Rad-Bhabhas**
  ⇒ Bkg mixing samples spoiled
  - Significantly reduced signal efficiency due to number of neutrals cut (<15)
  - E_{extra}(Brr-Fwd) distribution modified
  - Similar effects seen by other analysis using Breco ($B \to K^{(*)}\nu\nu$ and $B \to \tau\nu$ Had-Breco)
- **Need to re-produce n-tuples with Bkg mixing removing number of neutrals cut**
- **Need separate Bkg component ⇒ study discrimination against bkg gammas**





Use of MC samples without bkg Mixing

- **Bkg gammas affects signal and background samples in same way**
  - Higher combinatorics for π^0 and $D^{*0} \rightarrow D^0\gamma$ reconstruction
  - E_{extra}(Brr-Fwd) distribution distorted (shifted to high values)
  - Need re-optimize E_{extra}(Brr-Fwd) cut

- **Ansatz:** can study impact of Fwd-PID and Bwd-EMC using MC samples without bkg mixing $\Rightarrow$ can at least set upper limit of gains

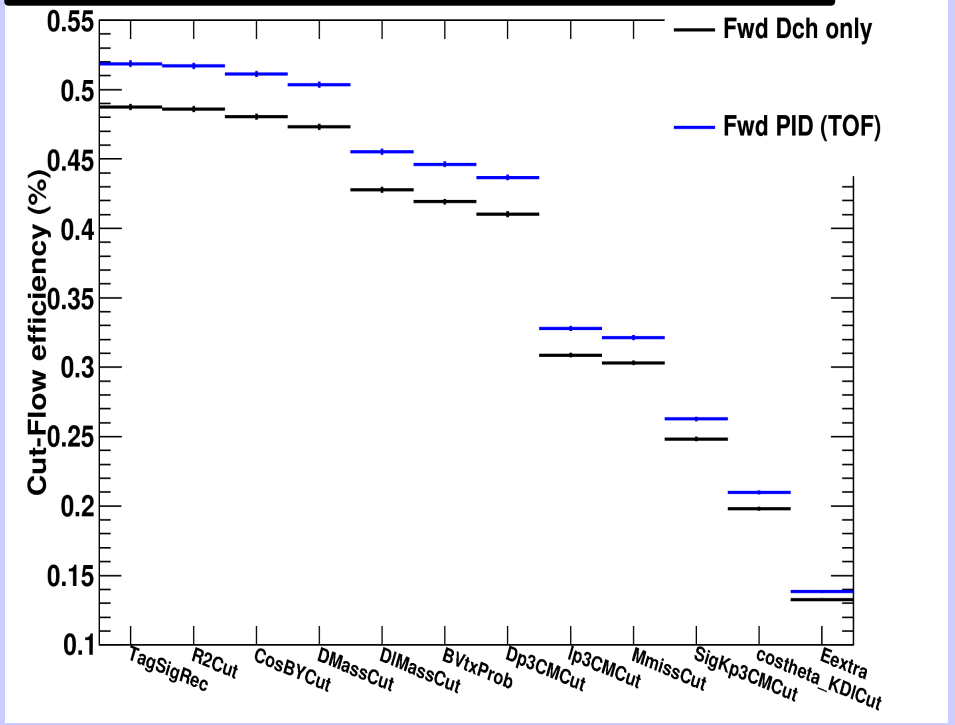
- **Fwd-PID device:**
  - Only affects the reconstruction and selection of Btag and Bsig candidates
  - Do not affect main selection cuts (based on kinematics)

- **Bwd-PID device:**
  - Gammas from Bhabha/Rad-Bhabas bkg mainly distributed in the fwd-region
  - Expects negligible distortion of E_{extra}(Bwd) distribution

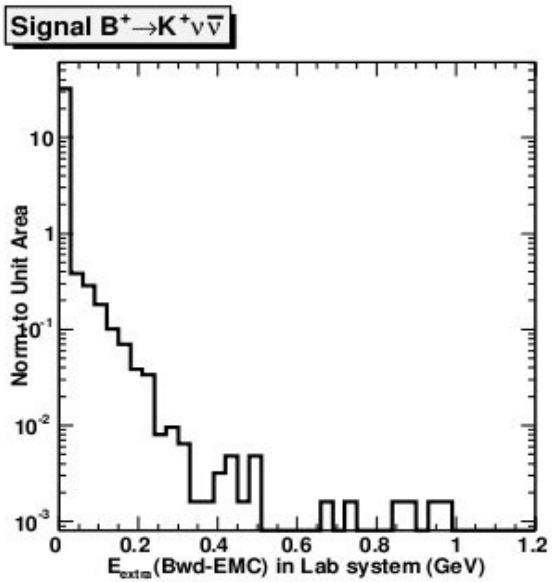
Preliminary Results: Fwd-PID

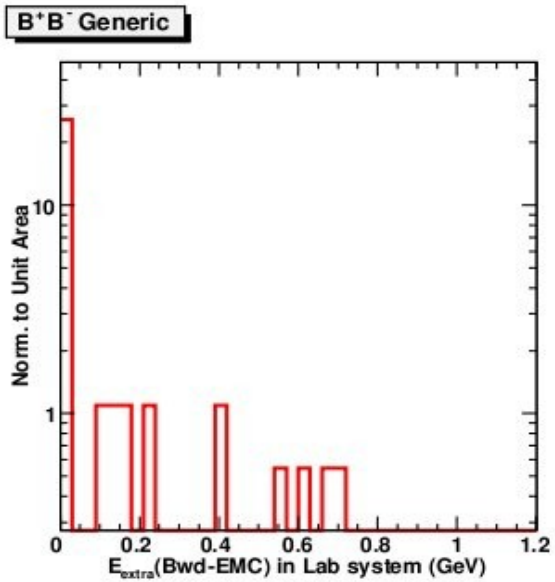
- **Compare Fwd-Dch with Fwd-PID (TOF performances from Leonid and Ganna)**
- **Caveat: low statistics for background samples**
- **Relative gains:**
  - 6.4% Signal
  - 4.8% B^+B^- generic
  - 3.3% B^0B^0 generic
  - 6.2% ccbar
  - 6.1% uds
- **Main background components not due K/π mis-ID**
- **Efficiency increase for all samples due to K^+ efficiency increase**
- **Background components get lower gains than signal sample**

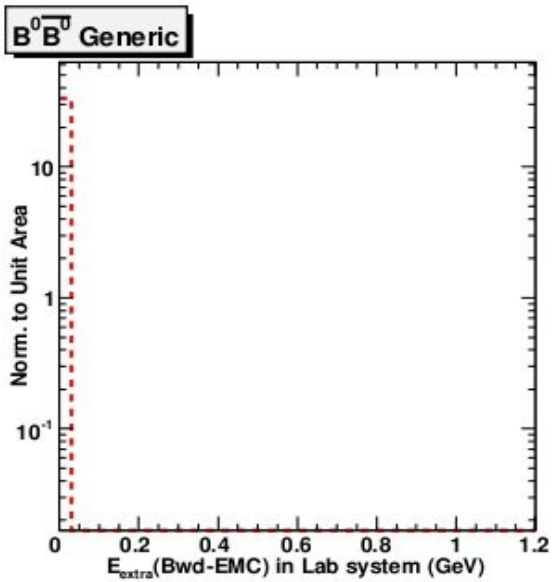
Cut-flow efficiency for signal sample

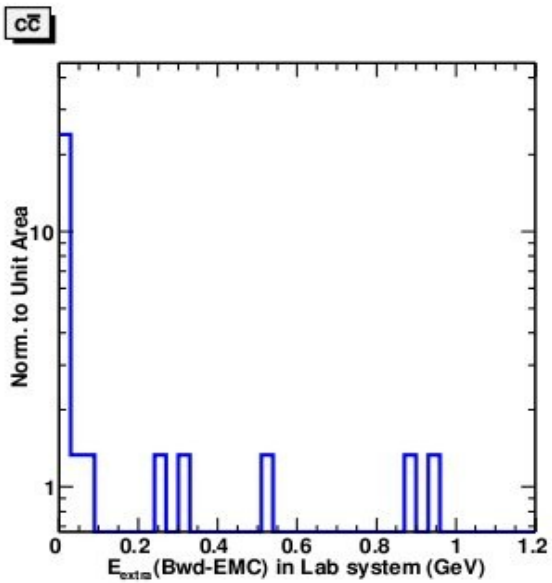


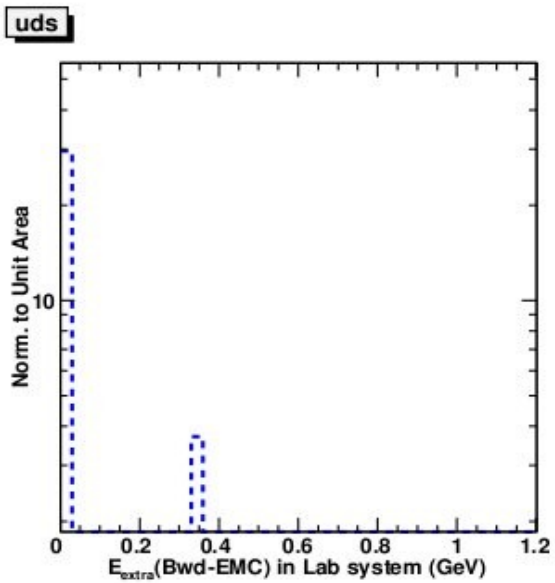
Preliminary Results: Bwd-EMC (I)







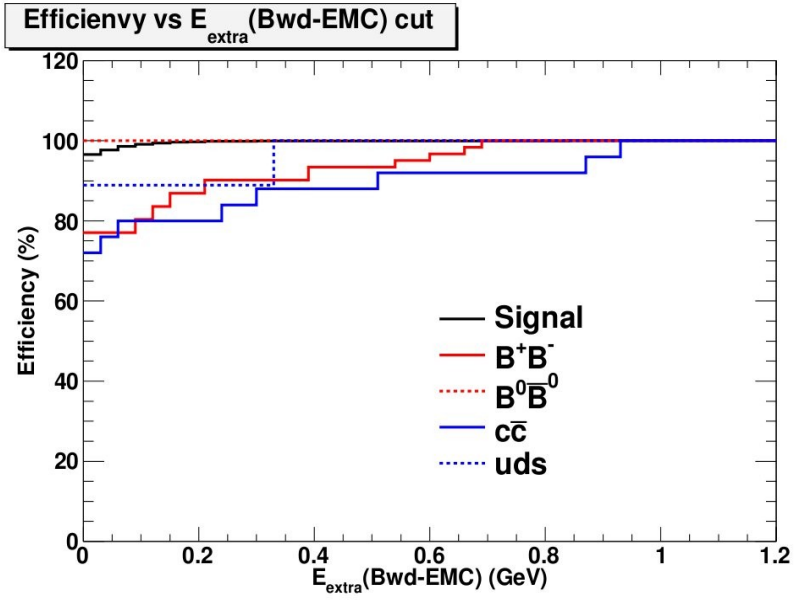


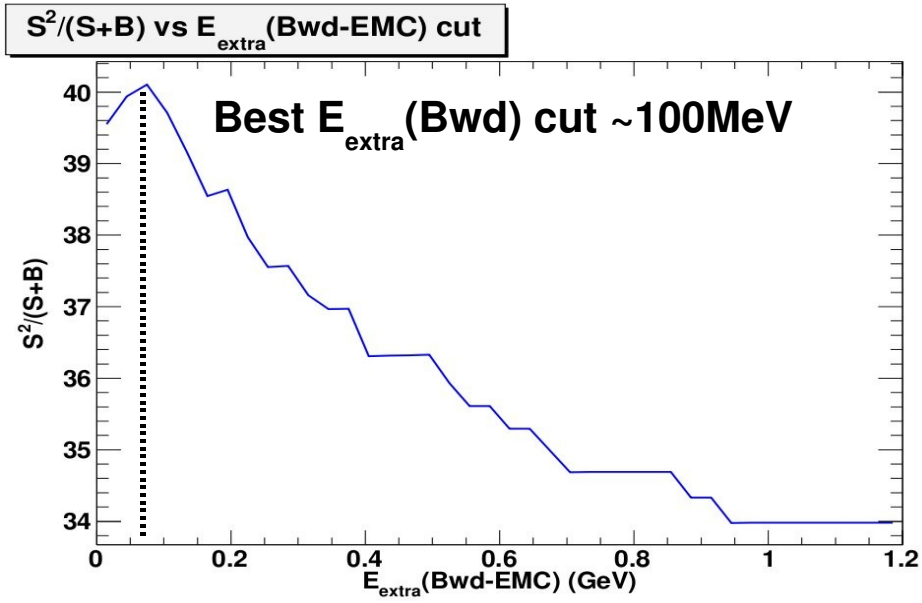


- E_{extra}(Bwd) distribution for all samples
- Low statistics for background samples

Preliminary Results: Bwd-EMC (II)

- **Study efficiency vs E_{extra}(Bwd) cut for all samples (signal and backgrounds)**
- **Optimize cut to maximize $S^2/(S+B) \Rightarrow E_{extra}$(Bwd) cut at ~100MeV**
- **Efficiencies after E_{extra}(Bwd) cut:**
  - ~99% Signal
  - ~80% B^+B^- generic
  - ~99% B^0B^0 generic (almost no events)
  - ~80% ccbar
  - ~90% uds





Summary

- **February 2010 production:**
  - Several background samples with/without bkg mixing (Bhabhas/Rad-Bhabhas)
  - Tree geometries: DG_BaBar, DG_3, DG_4
  - Low background statistics to study impact of Bwd-EMC and/or Fwd-EMC
- **Bkg Mixing issue:**
  - Significant number of high-energy gammas
  - Distorted E_{extra}(Brr-Fwd) distribution (shifted to high values)
- **Preliminary Results: Fwd-PID (no Bkg mixing)**
  - Main backgrounds do not depend of K/π mis-ID
    $\Rightarrow$ global gain in efficiency for all samples (~6.0%)
- **Preliminary Results: Bwd-EMC (no Bkg mixing)**
  - Use discriminant variable E_{extra}(Bwd) (Bwd-EMC as a veto device)
  - Obtain significant reduction on main backgrounds (~20% for B^+B^- and ccbar)
  - Negligible reduction on signal (~1.0%)

Next steps

- **Re-produce n-tuples (including Bkg mixing) removing cut on max. number of neutrals**
- **Study separate sample of bkg gammas (Bhabha/Rad-Bhabhas)**
  - Effects on Btag and Bsig candidates reconstruction: π^0 and $D^{*0} \rightarrow D^0 \gamma$
  - High-energy bkg gammas component on E_{extra}(Brr-Fwd) and E_{extra}(Bwd)
- **Will need high statistics background samples (including bkg mixing)**
  - Estimate 1ab^{-1} (~1000M events) for B^+B^-, B^0B^0, ccbar and uds samples
  - Can perform Fwd-PID and/or Bwd-EMC studies with DG_4
  - Need to coordinate for next production
- **Perform similar studies for other modes**
  - $B^0 \rightarrow K^0_S \nu\nu$, $B^+ \rightarrow K^{*+} \nu\nu$, $B^0 \rightarrow K^{*0} \nu\nu$, $B^+ \rightarrow \tau^+ \nu$
  - Angular analysis for $B \rightarrow K^* \nu\nu$

Backup