

Systematic Studies On Track Reconstruction Efficiency At Belle II

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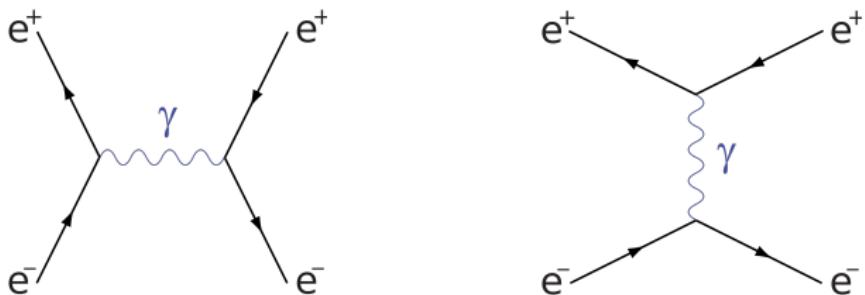
Johannes Gutenberg-Universität Mainz

Outline

- Overview of the Belle II experiment
- Kinematics at Belle II
- Method for calculating the tracking efficiency
- Tracking efficiency
- Comparing the tracking efficiency of different phases
- Conclusion

Motivation

- At an electron-positron collider most events are $e^+e^- \rightarrow e^+e^-$ (these events are called Bhabha events)
- These events can be used to estimate the performance of the tracking detectors
- If the *tag* particle in a Bhabha event is associated with a track than the *probe* particle also should have a track associated
→ a tracking efficiency can be calculated
- Knowing the tracking efficiency is highly important for analysis



Overview Of The Belle II Experiment

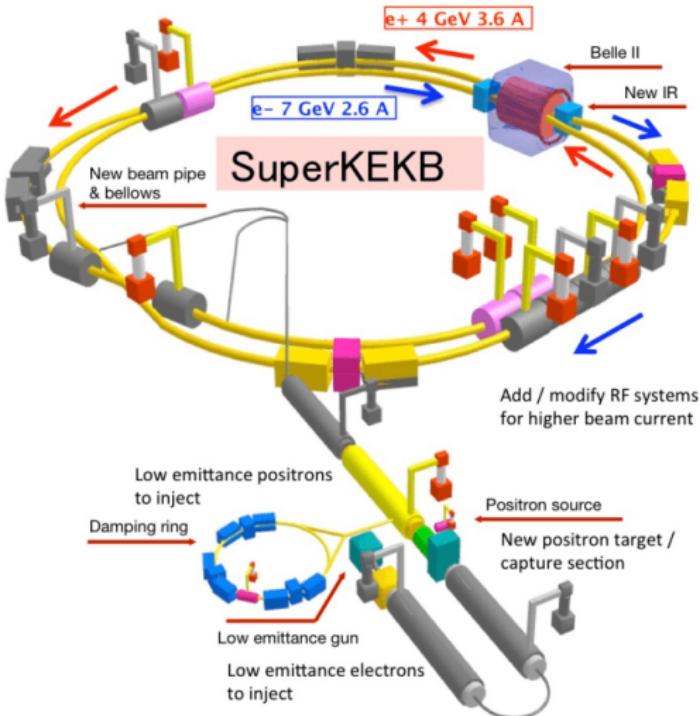
The SuperKEKB e^+e^- Collider And Luminosity Goals

- Located at Tsukuba, Japan



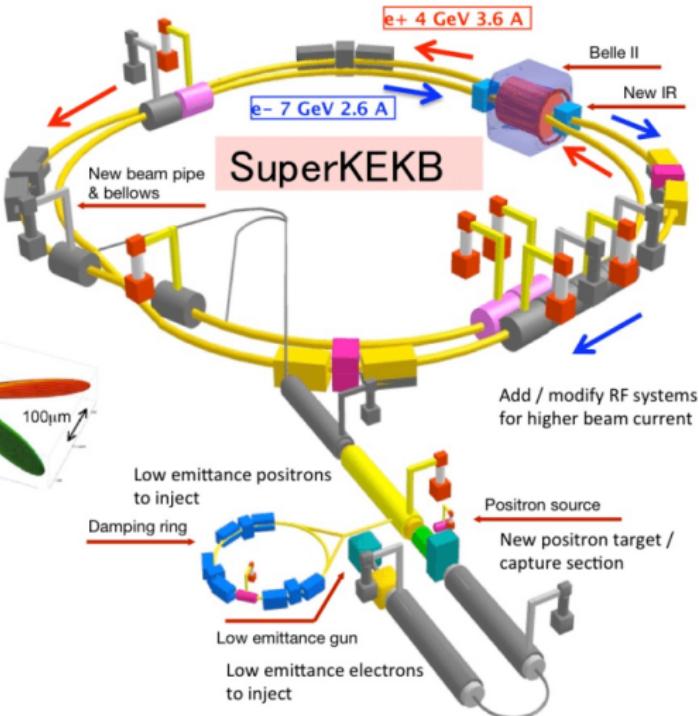
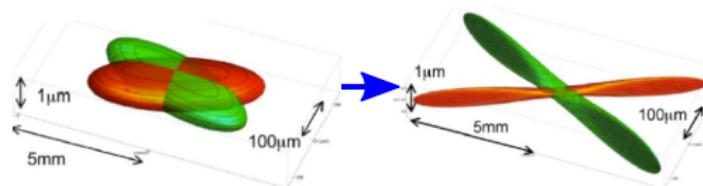
The SuperKEKB e^+e^- Collider And Luminosity Goals

- Located at Tsukuba, Japan
- Asymmetric collider
- Center-of-mass equal to $\Upsilon(4S)$
 $\sim 10.58 \text{ GeV} \rightarrow B\text{-factory}$
- Upgrade of the KEKB collider:
 - Larger beam currents
 - Reduced beam size at interaction region



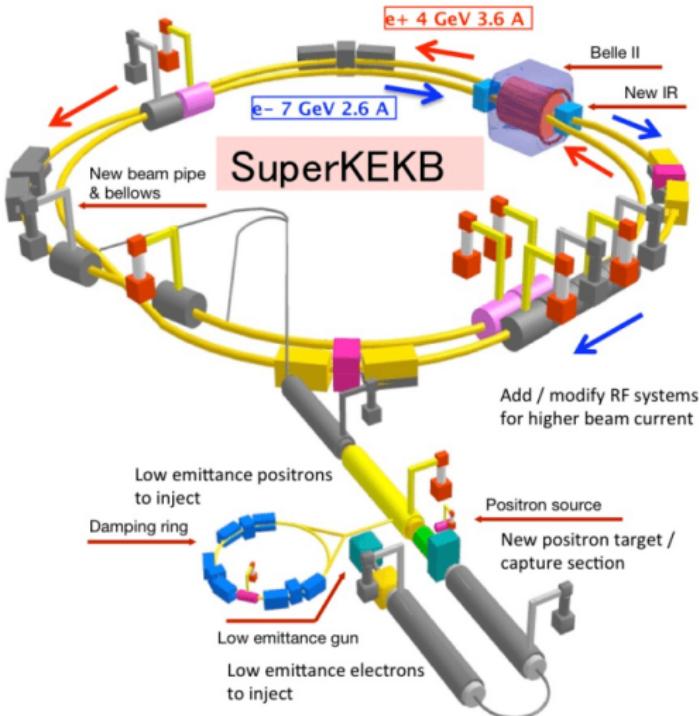
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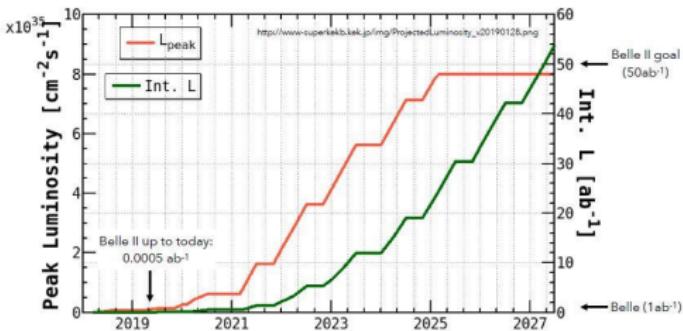
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- \rightarrow Luminosity increase $\times 40$



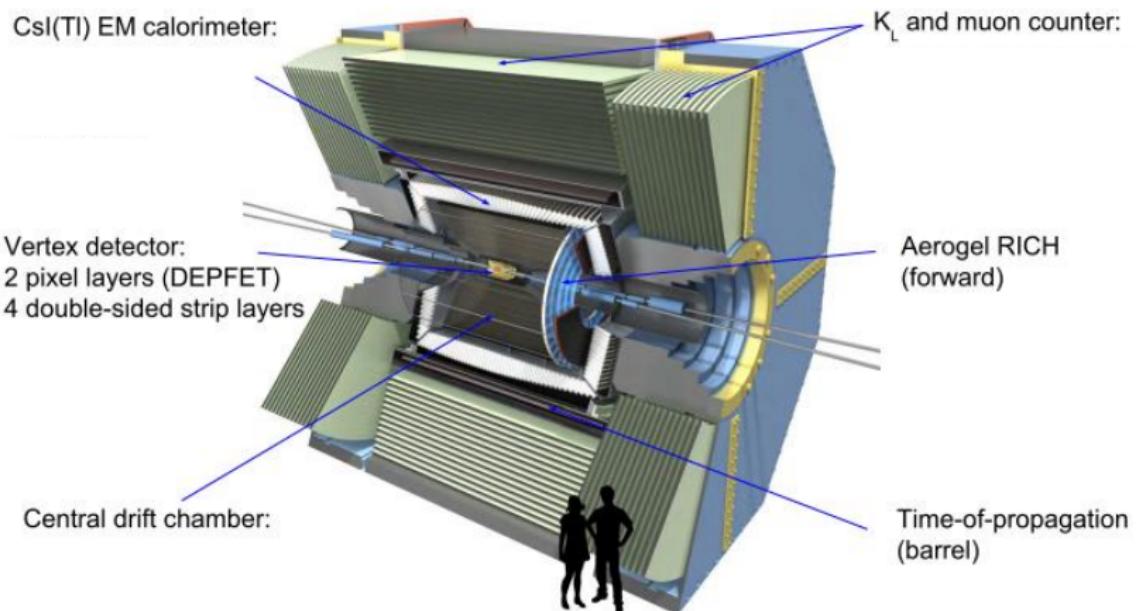
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- Upgrade of the KEKB collider:
 - Larger beam currents
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- \rightarrow Luminosity increase $\times 40$
- Design peak luminosity of $8 \cdot 10^{35} \text{ cm}^{-2}\text{s}^{-1}$
- Desired data sample corresponding to a recorded integrated luminosity of $\sim 50 \text{ ab}^{-1}$ (50x the integrated luminosity of Belle)



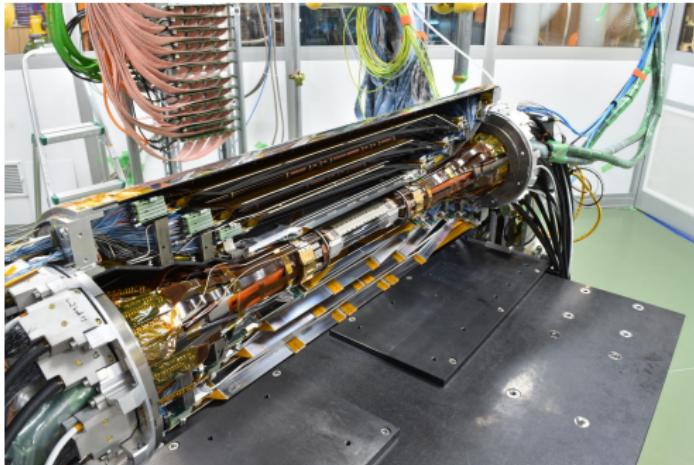
- Phase1: accelerator commissioning and background estimation (completed in 2016)
- Phase2: collision runs and background studies with partially installed detector (completed in 2018)
- Phase3: data taking with the whole detector (started in April 2019)

The Belle II Detector



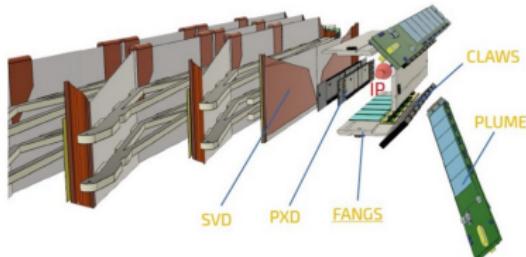
Vertex Detectors (VXD)

- Consist of Pixel Detector (PXD) and Silicon Vertex Detector (SVD)
 - Both detectors consist of multiple ladders in multiple layers (2 PXD with radii of 14 and 22 mm and 4 SVD with radii of 38, 80, 115 and 140 mm)
 - Charged particles create electron-hole pairs, which are separated by an electric field
- particle position can be determined

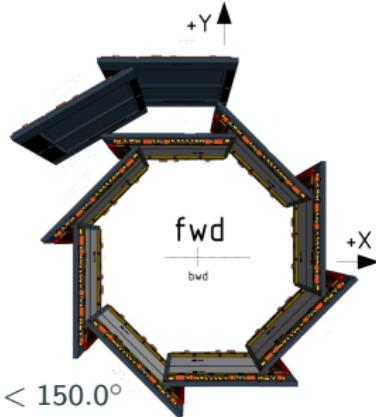


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 - particle position can be determined
- During phase2, only a fraction of the VXD detectors were installed
- During phase3, the complete SVD and half of the PXD are installed

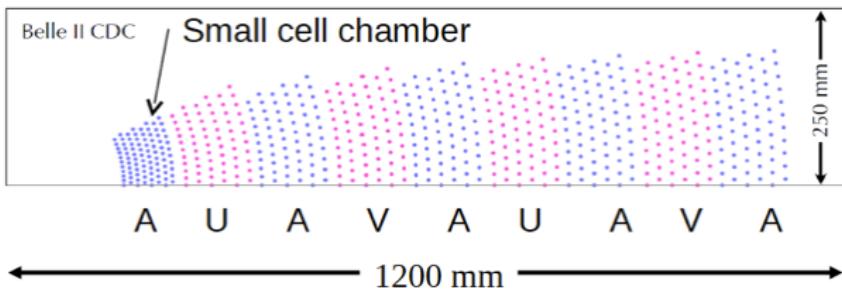
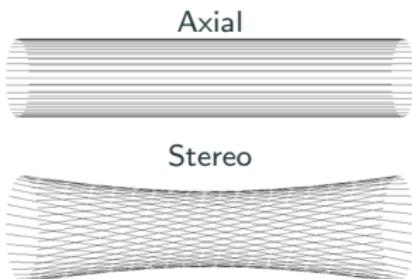


- Acceptance: $17.0^\circ < \theta < 150.0^\circ$

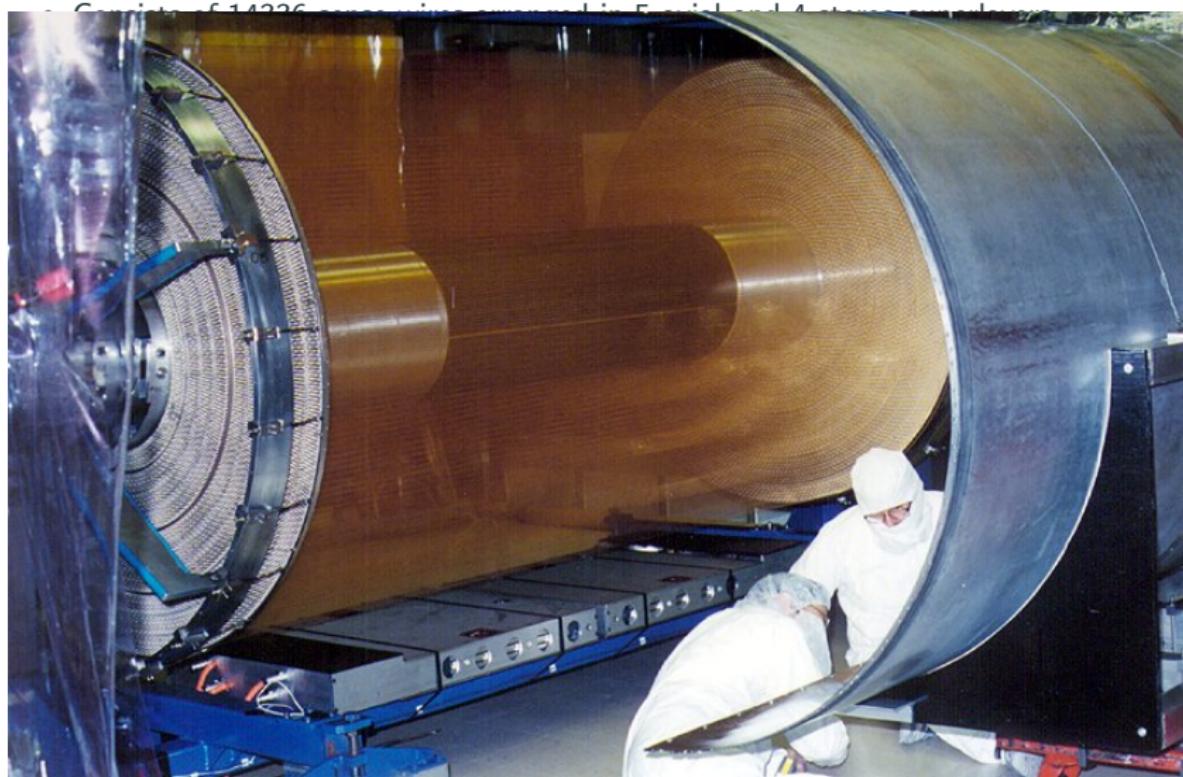


Central Drift Chamber (CDC)

- Consists of 14336 sense wires arranged in 5 axial and 4 stereo superlayers (each superlayer consists of 6 layers; with an exception to the innermost superlayer)
- The CDC is immersed in a 50 % helium and 50 % ethane gas mixture
- Charged particles ionize the gas
The signal is then read out by the sense wires
→ Determination of momenta and tracks of charged particles
- Acceptance: $17.0^\circ < \theta < 150.0^\circ$

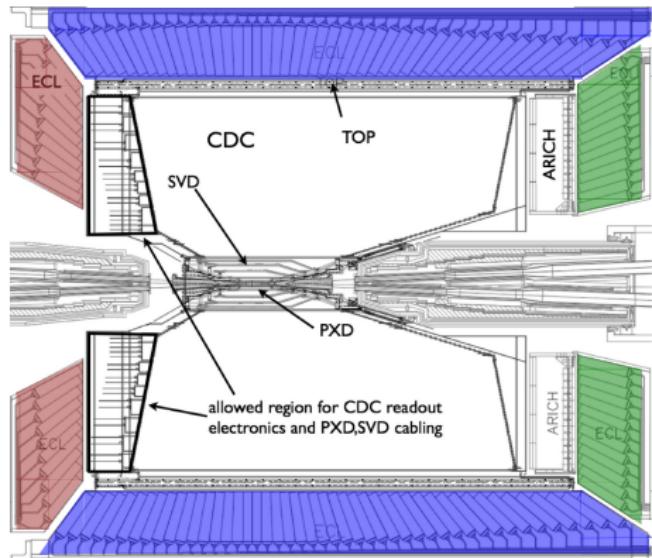


Central Drift Chamber (CDC)



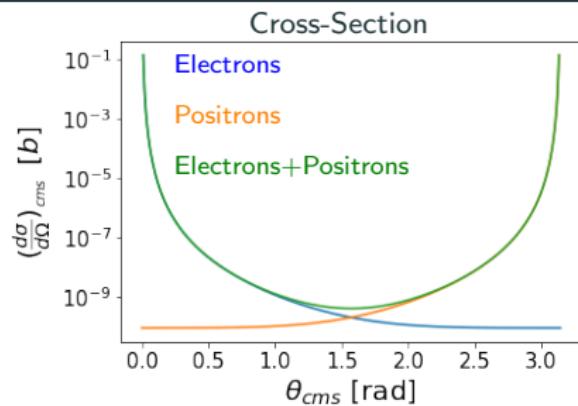
Electromagnetic Calorimeter (ECL)

- Consists of 8936 CsI(Tl) crystals
- Electromagnetically interacting particles are creating electromagnetic shower when they pass through the crystals
These shower spread through multiple crystals
 - The position and the energy of the particles can be determined
- Separation in **barrel**, **forward end-cap** and **backward end-cap**
- There are two $\sim 1^\circ$ wide gaps at transition between the sections
- Acceptance: $12.4^\circ < \theta < 155.1^\circ$

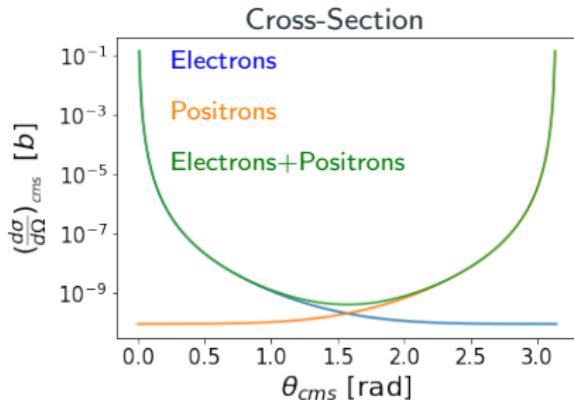


Bhabha Kinematics At Belle II

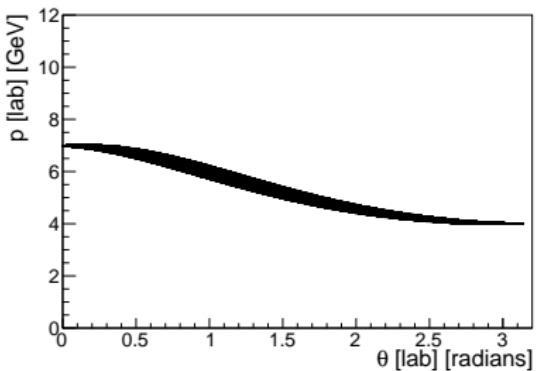
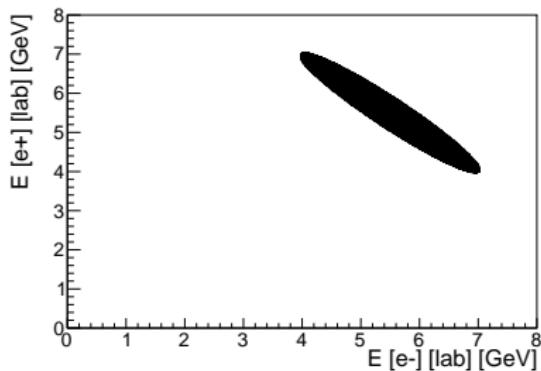
Bhabha Kinematics At Belle II



Bhabha Kinematics At Belle II



- The beams have asymmetric energies
- The beams are hitting each other under an angle of 1.26°
→ Boost the particles from CMS to lab frame



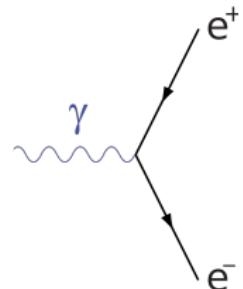
Preparation For Calculating The Tracking Efficiency

Introducing Cuts

Strategy: Reconstruct Bhabha events using only ECL information

$$\text{vpho} \rightarrow \text{ECL-Object(HclE)} + \text{ECL-Object(LclE)}$$

HclE: particle with higher cluster Energy; LclE: particle with lower cluster Energy



Introducing Cuts

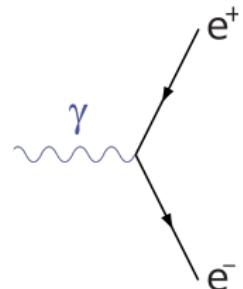
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- The particles have to pass the tracking detectors

$$\rightarrow 17.0^\circ < \theta_{\text{ECL-Object}} < 150.0^\circ$$



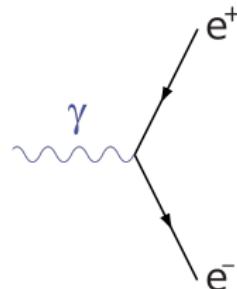
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- The particles have to pass the tracking detectors
 $\rightarrow 17.0^\circ < \theta_{\text{ECL-Object}} < 150.0^\circ$
- $8 \text{ GeV} < M_{vpho} < 12 \text{ GeV}$
- 2 clusters with at least 3.5 GeV per event; One cluster has to have at least 4.5 GeV
- Number of reconstructed tracks per event < 7
- Total energy in the ECL $< 15 \text{ GeV}$
- ECL-Trigger signal is required on data (the trigger simulation does not work reliably on MC)



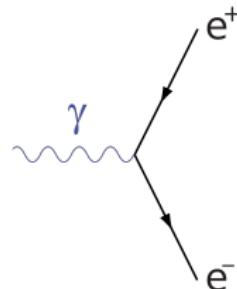
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- Only 1 reconstructed virtual photon candidate survives these cuts in both MC and data



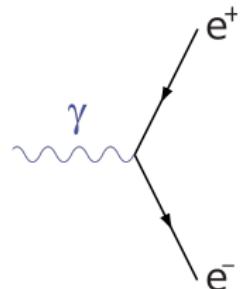
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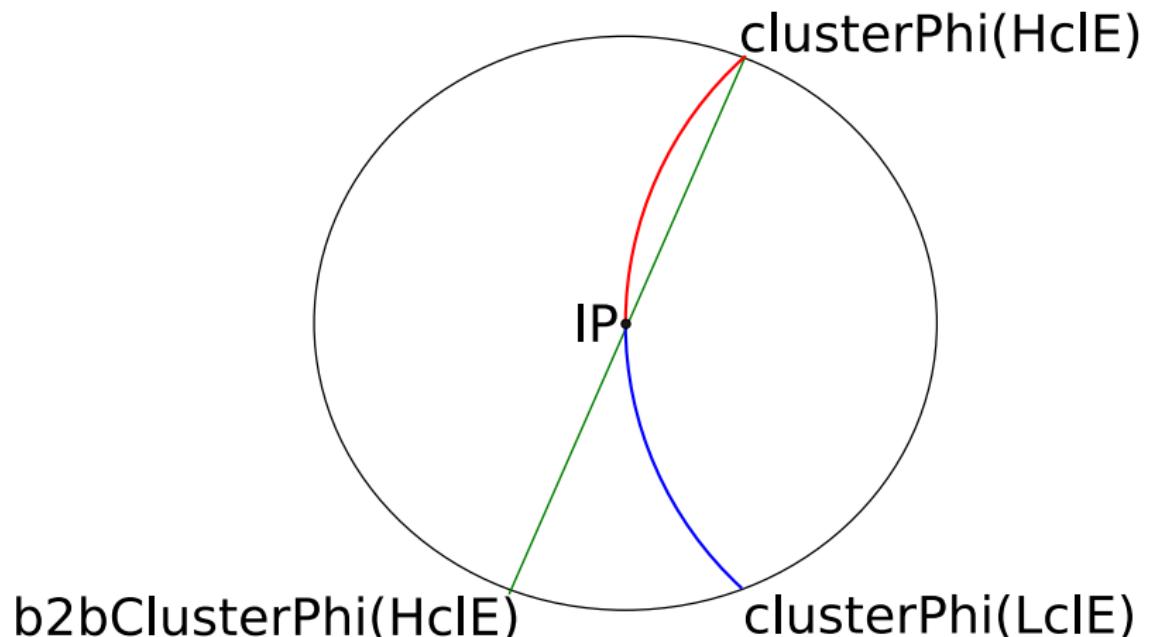
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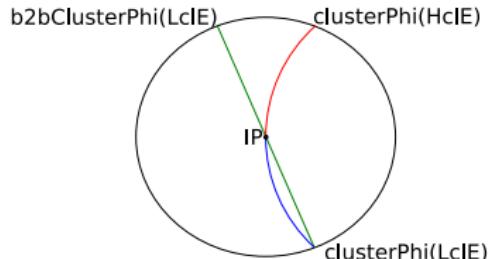
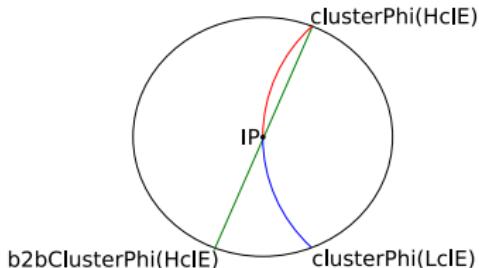
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- 2 clusters with at least 3.5 GeV per event; One cluster has to have at least 4.5 GeV
- Number of reconstructed tracks per event < 7
- Total energy in the ECL $< 15 \text{ GeV}$
- ECL-Trigger signal is required on data (the trigger simulation does not work reliably on MC)
- Only 1 reconstructed virtual photon candidate survives these cuts in both MC and data
- Data also contains $e^+e^- \rightarrow \gamma\gamma$



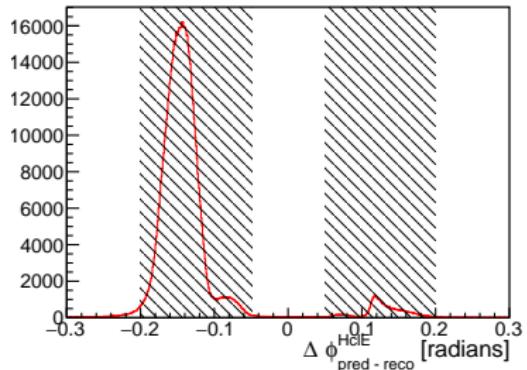
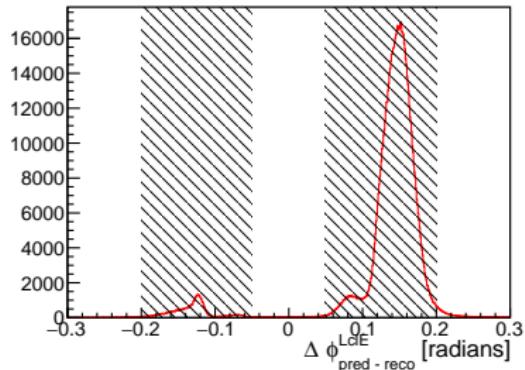


Bhabha Event Selection



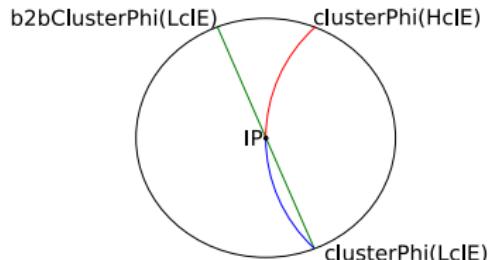
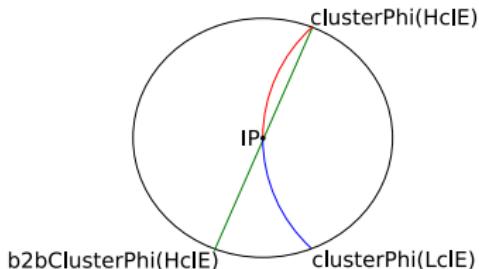
$$\Delta\phi_{\text{pred-reco}} = \phi_{\text{pred,b2bcl}} - \phi_{\text{Cluster}}$$

Only events with $0.05 < |\Delta\phi_{\text{pred-reco}}| < 0.2$ are taken into account



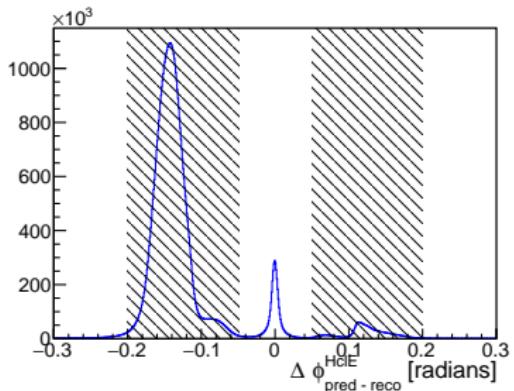
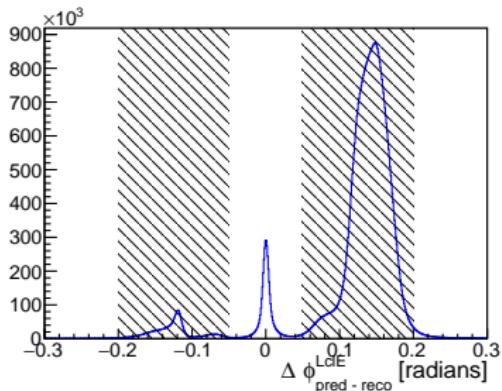
Phase3 MC: 852093 events survive

Bhabha Event Selection



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Only events with $0.05 < |\Delta\phi_{\text{pred-reco}}| < 0.2$ are taken into account



Phase3 MC: 852093 events survive

Phase3 Data: $5.3 \cdot 10^7$ events survive (after trigger cut)

Selection Of Momentum With Enough Statistics

As function of azimuthal angle

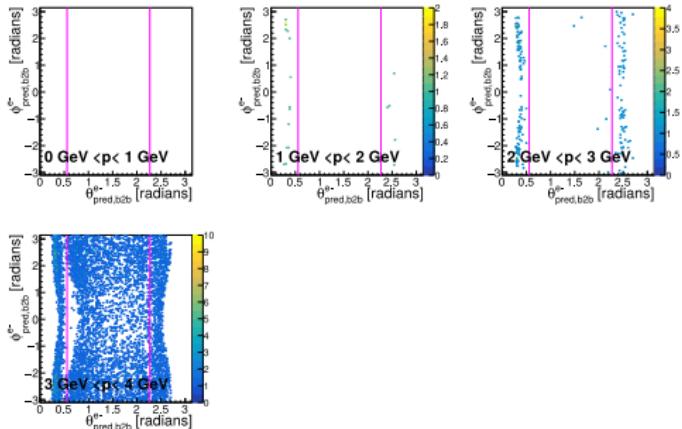
$$\phi_{\text{pred},\text{b2b}}$$

$$p(e^-)$$

Forward End-Cap

Barrel

Backward End-Cap



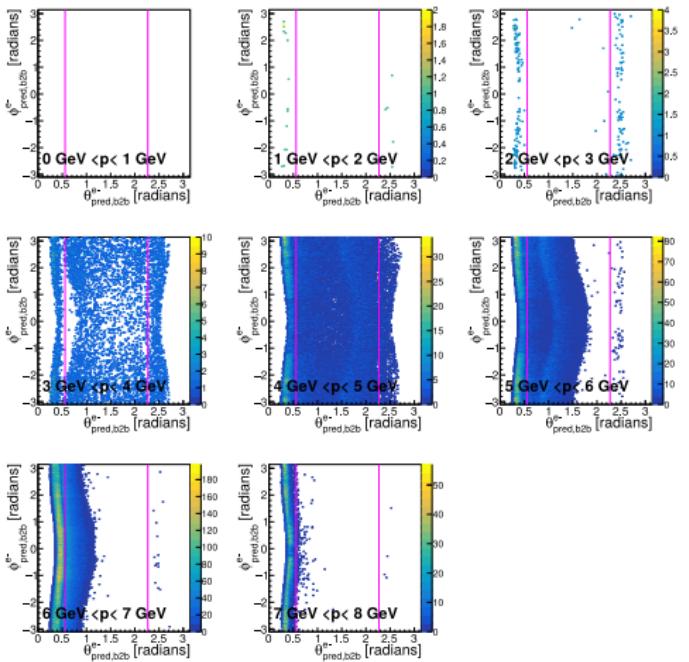
Selection Of Momentum With Enough Statistics

As function of azimuthal angle

$\phi_{\text{pred},\text{b2b}}$

$p(e^-)$

Forward End-Cap	4 GeV – 8 GeV
Barrel	4 GeV – 7 GeV
Backward End-Cap	/

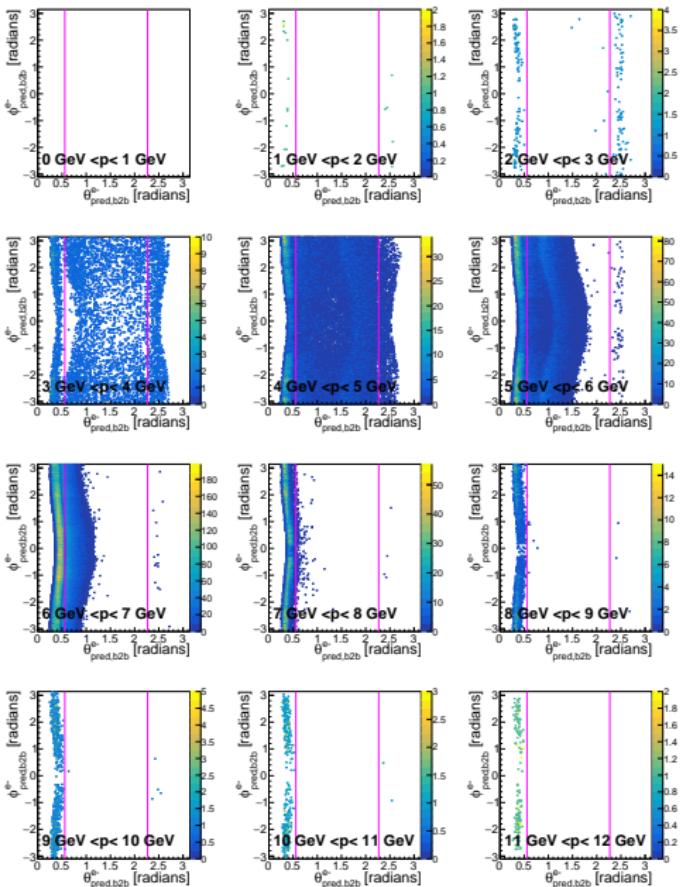


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Forward End-Cap	4 GeV – 8 GeV
Barrel	4 GeV – 7 GeV
Backward End-Cap	/

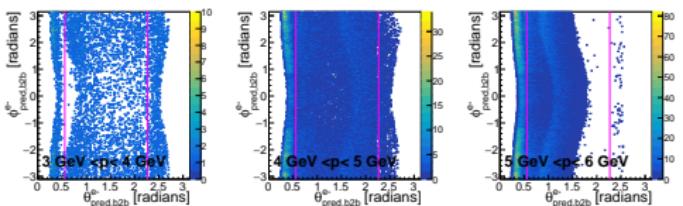
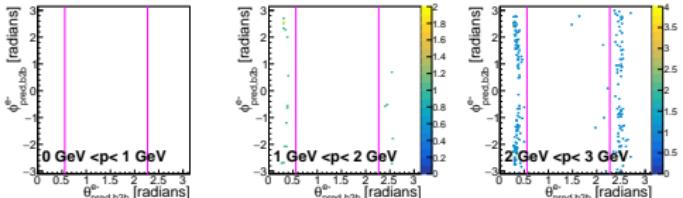


Selection Of Momentum With Enough Statistics

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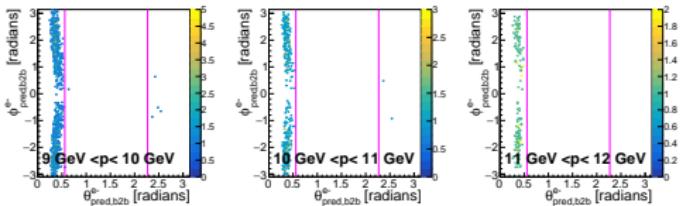
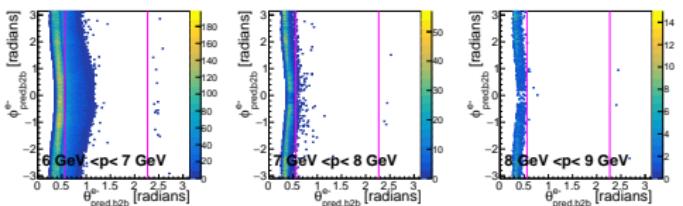
$\phi_{\text{pred},\text{b2b}}$

Forward End-Cap	4 GeV – 8 GeV
Barrel	4 GeV – 7 GeV
Backward End-Cap	/



As function of polar angle $\theta_{\text{pred},\text{b2b}}$

p^- $4 \text{ GeV} - 9 \text{ GeV}$



Selection Of Momentum With Enough Statistics

As function of azimuthal angle

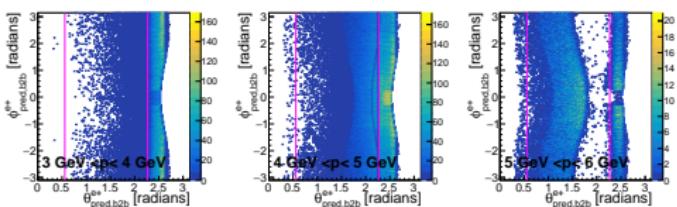
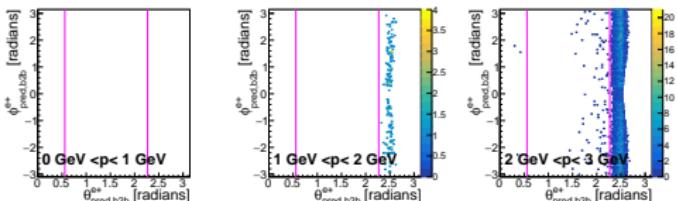
$$\phi_{\text{pred},\text{b2b}}$$

$$p(e^-)$$

Forward End-Cap	4 GeV – 8 GeV
Barrel	4 GeV – 7 GeV
Backward End-Cap	/

$$p(e^+)$$

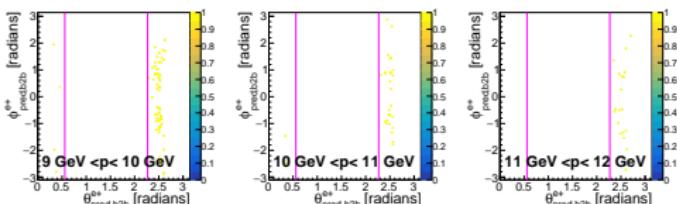
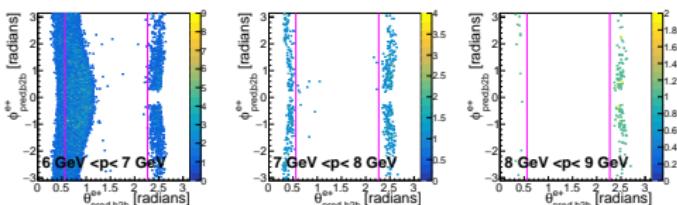
Forward End-Cap	/
Barrel	3 GeV – 7 GeV
Backward End-Cap	2 GeV – 6 GeV



As function of polar angle $\theta_{\text{pred},\text{b2b}}$

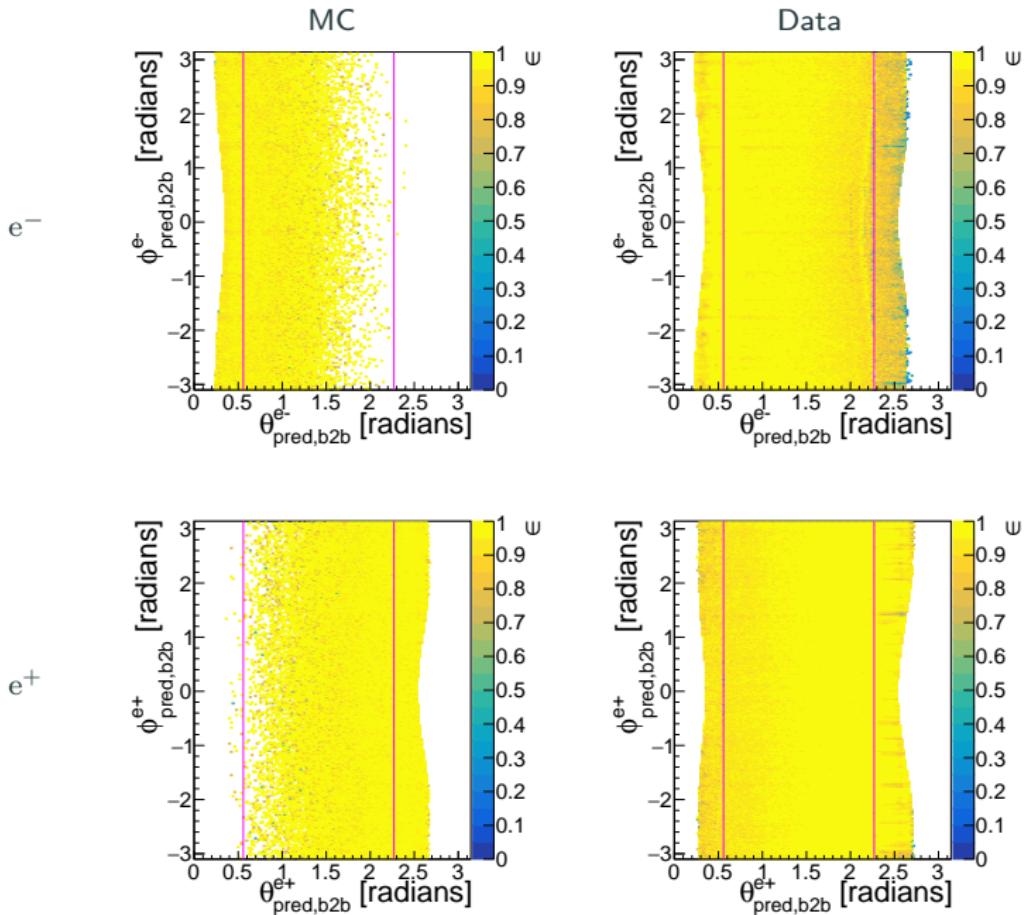
$$p$$

$$\begin{aligned} e^- & 4 \text{ GeV} - 9 \text{ GeV} \\ e^+ & 2 \text{ GeV} - 7 \text{ GeV} \end{aligned}$$

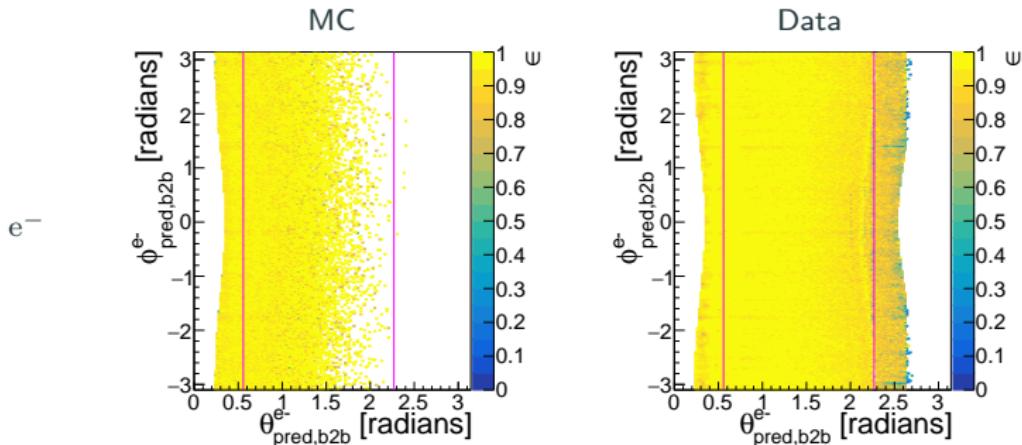


Phase3 Tracking Efficiencies

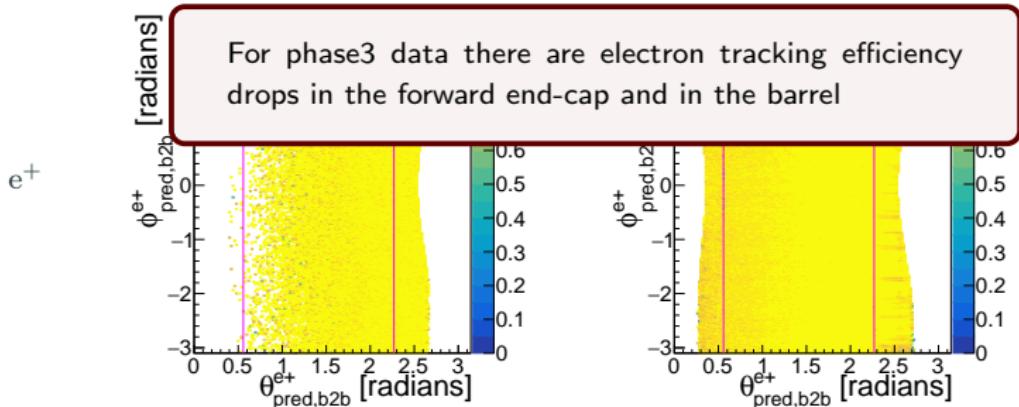
Phase3 Tracking Efficiencies As Function Of $\theta_{\text{pred,b2b}} - \phi_{\text{pred,b2b}}$



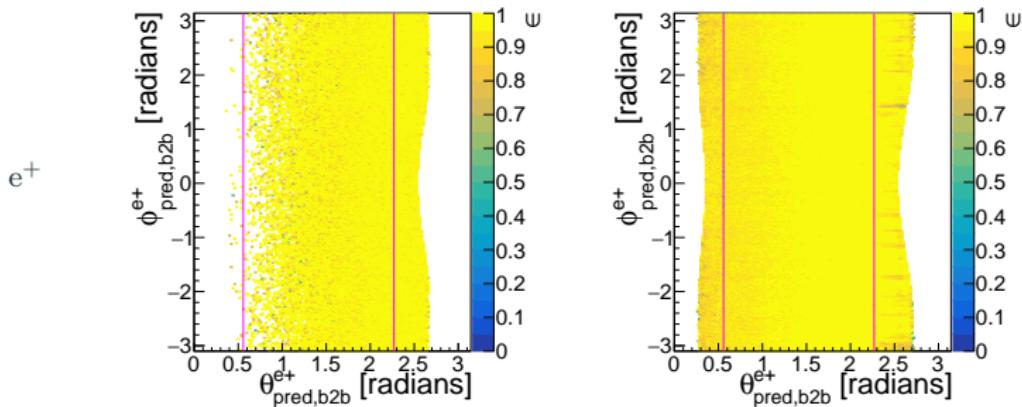
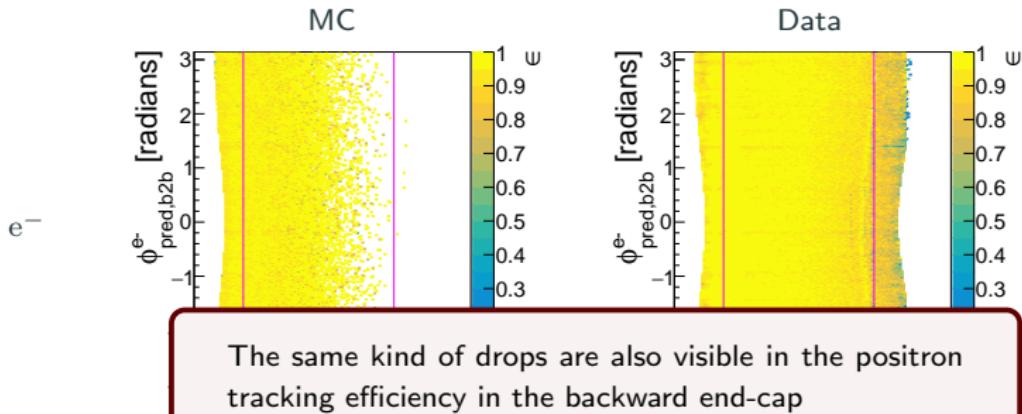
Phase3 Tracking Efficiencies As Function Of $\theta_{\text{pred,b2b}} - \phi_{\text{pred,b2b}}$



For phase3 data there are electron tracking efficiency drops in the forward end-cap and in the barrel



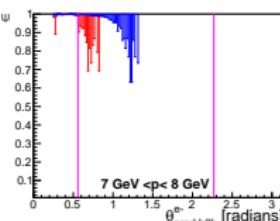
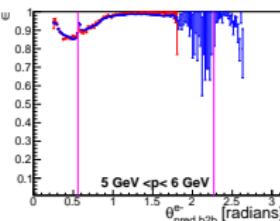
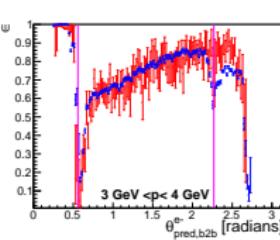
Phase3 Tracking Efficiencies As Function Of $\theta_{\text{pred,b2b}} - \phi_{\text{pred,b2b}}$



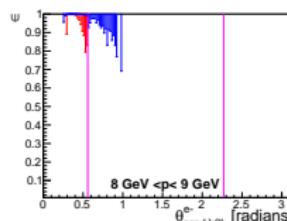
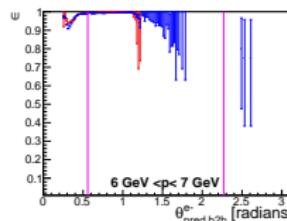
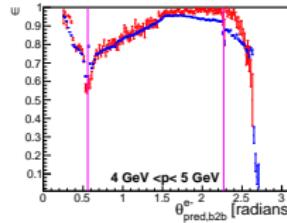
Phase3 Tracking Efficiencies As Function Of $\theta_{\text{pred,b2b}}$

Phase3 MC10

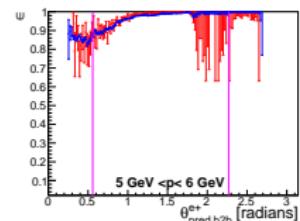
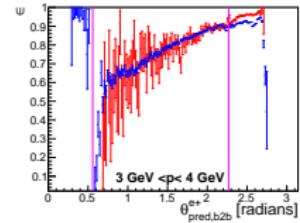
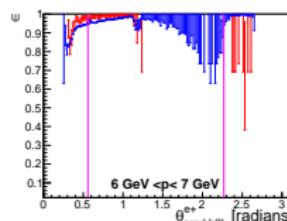
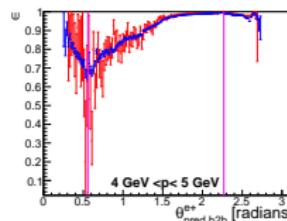
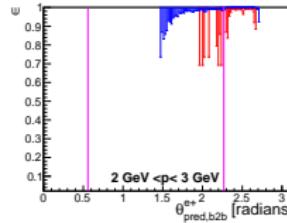
Phase3 Data



e⁻



e⁺

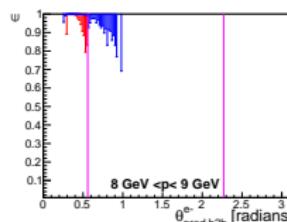
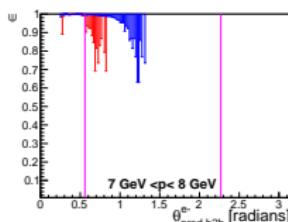
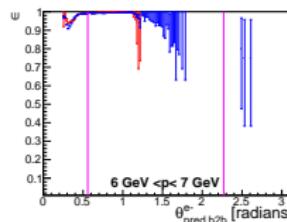
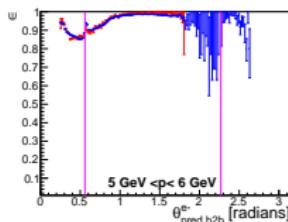
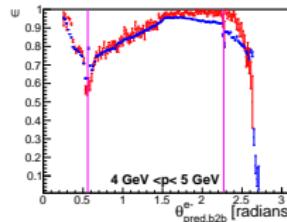
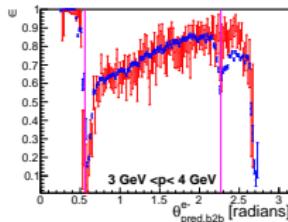


Phase3 Tracking Efficiencies As Function Of $\theta_{\text{pred,b2b}}$

Phase3 MC10

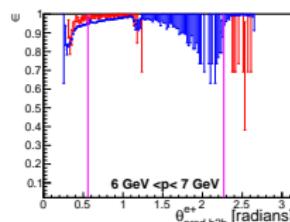
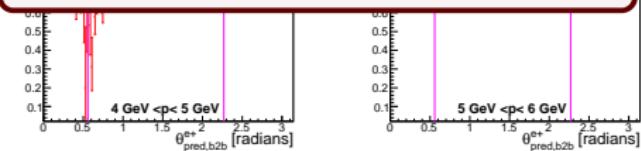
Phase3 Data

e^-



Electron Tracking Efficiency:

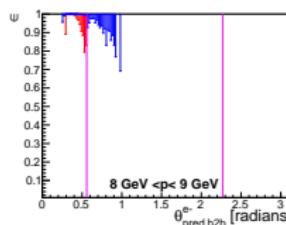
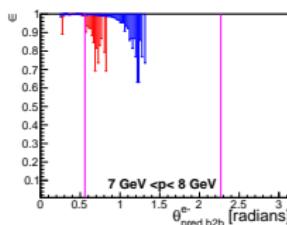
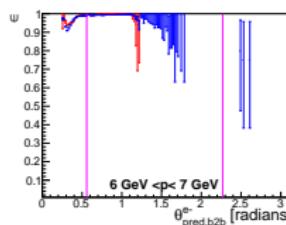
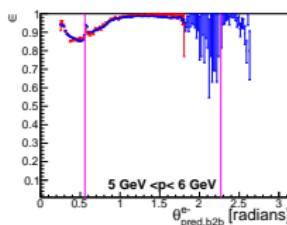
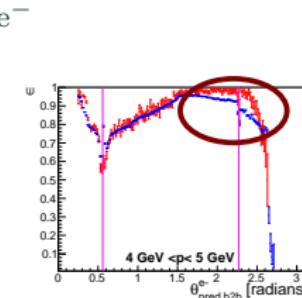
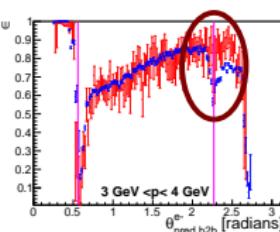
- Phase3 MC and phase3 data are very close to each other (an exception occurs for momenta between 3 GeV and 5 GeV)



Phase3 Tracking Efficiencies As Function Of $\theta_{\text{pred,b2b}}$

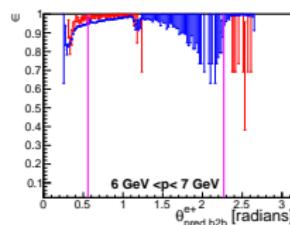
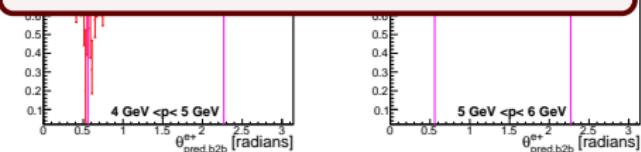
Phase3 MC10

Phase3 Data



Electron Tracking Efficiency:

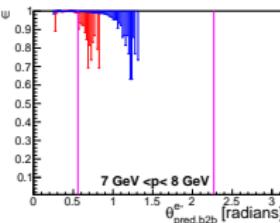
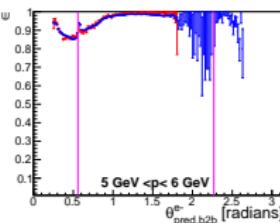
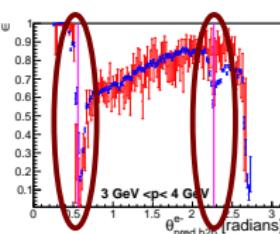
- Phase3 MC and phase3 data are very close to each other (an exception occurs for momenta between 3 GeV and 5 GeV)



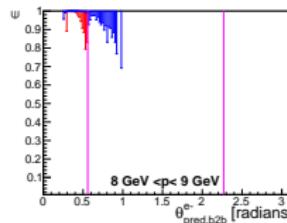
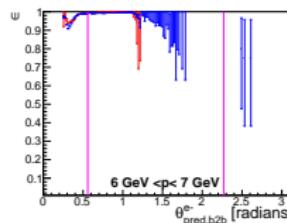
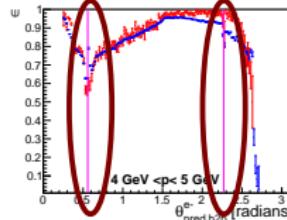
Phase3 Tracking Efficiencies As Function Of $\theta_{\text{pred,b2b}}$

Phase3 MC10

Phase3 Data

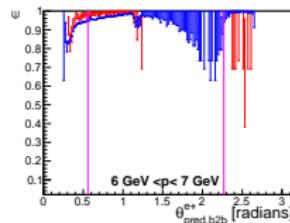
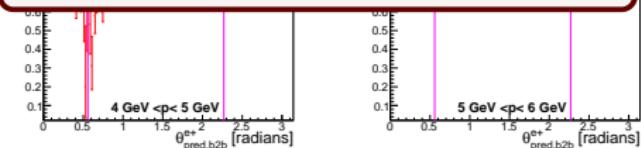


e^-



Electron Tracking Efficiency:

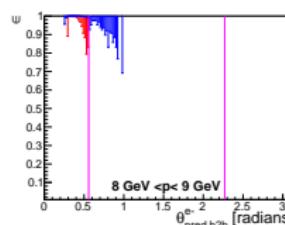
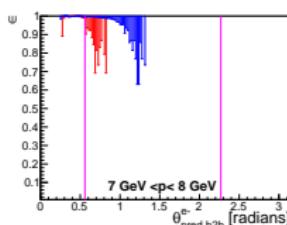
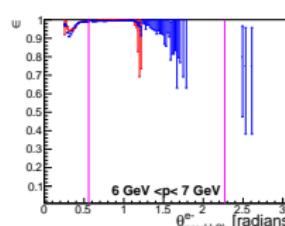
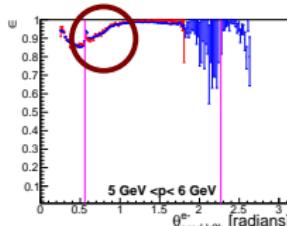
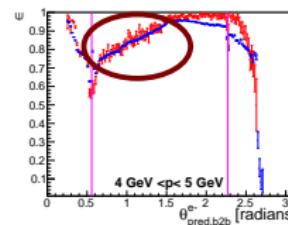
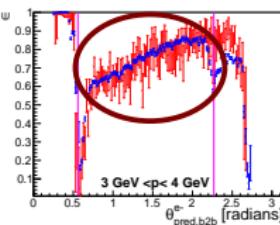
- Phase3 MC and phase3 data are very close to each other (an exception occurs for momenta between 3 GeV and 5 GeV)
- Efficiency drops at transition between barrel and end-caps



Phase3 Tracking Efficiencies As Function Of $\theta_{\text{pred,b2b}}$

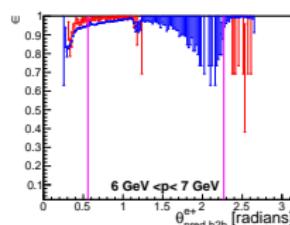
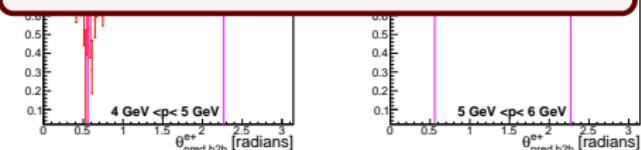
Phase3 MC10

Phase3 Data



Electron Tracking Efficiency:

- Phase3 MC and phase3 data are very close to each other (an exception occurs for momenta between 3 GeV and 5 GeV)
- Efficiency drops at transition between barrel and end-caps
- There is a slope in the barrel

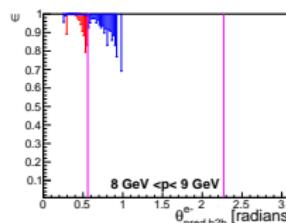
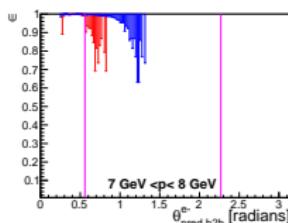
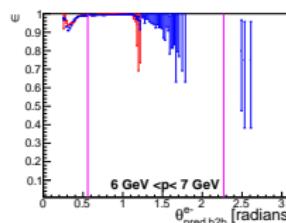
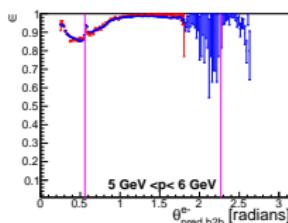
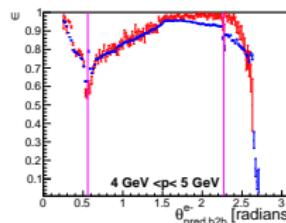
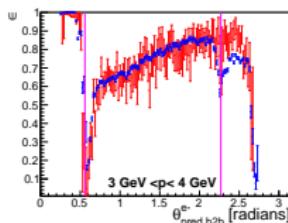


Phase3 Tracking Efficiencies As Function Of $\theta_{\text{pred,b2b}}$

Phase3 MC10

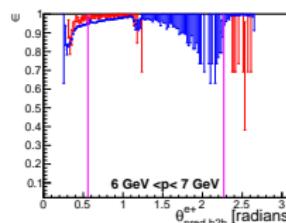
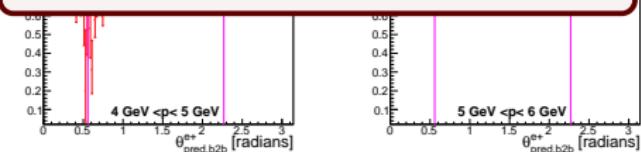
Phase3 Data

e⁻



Electron Tracking Efficiency:

- Phase3 MC and phase3 data are very close to each other (an exception occurs for momenta between 3 GeV and 5 GeV)
- Efficiency drops at transition between barrel and end-caps
- There is a slope in the barrel



Phase3 Tracking Efficiencies As Function Of $\theta_{\text{pred,b2b}}$

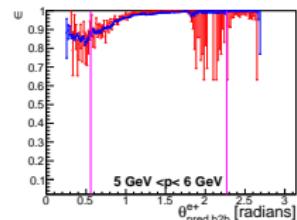
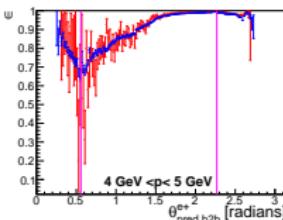
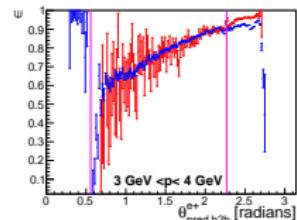
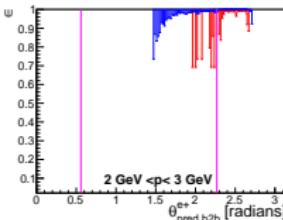
Positron Tracking Efficiency:

- The tracking efficiency pf phase3 MC and phase3 data are close to each other (an exception occurs in the backward end-cap for momenta between 2 GeV and 4 GeV and between 6 GeV and 7 GeV)

Phase3 MC10

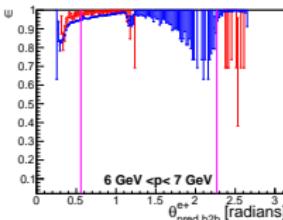
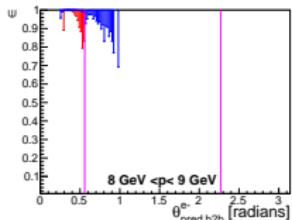
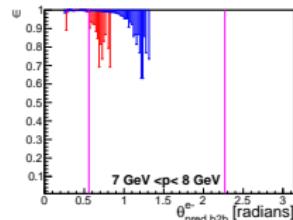
Phase3 Data

e⁺



$\theta_{\text{pred,b2b}}$ [radians]

$\theta_{\text{pred,b2b}}$ [radians]



Phase3 Tracking Efficiencies As Function Of $\theta_{\text{pred,b2b}}$

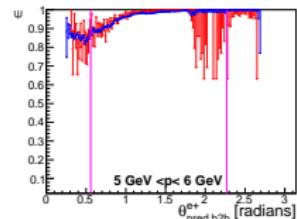
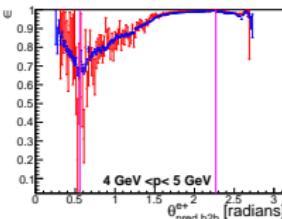
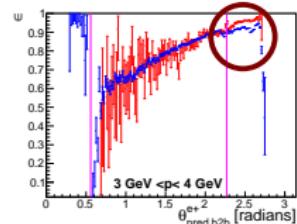
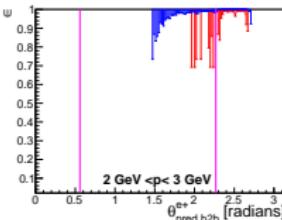
Positron Tracking Efficiency:

- The tracking efficiency pf phase3 MC and phase3 data are close to each other (an exception occurs in the backward end-cap for momenta between 2 GeV and 4 GeV and between 6 GeV and 7 GeV)

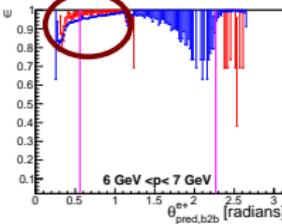
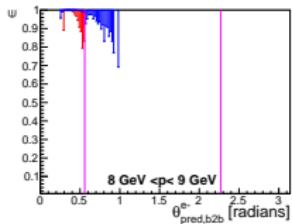
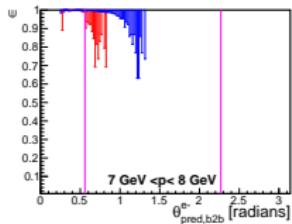
Phase3 MC10

Phase3 Data

e⁺



$\theta_{\text{pred,b2b}}$ [radians] $\theta_{\text{pred,b2b}}$ [radians]



Phase3 Tracking Efficiencies As Function Of $\theta_{\text{pred,b2b}}$

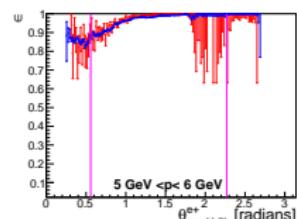
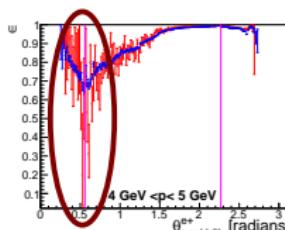
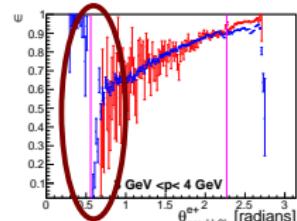
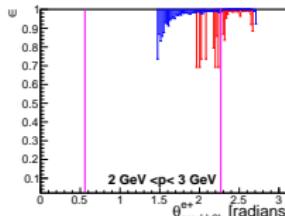
Positron Tracking Efficiency:

- The tracking efficiency pf phase3 MC and phase3 data are close to each other (an exception occurs in the backward end-cap for momenta between 2 GeV and 4 GeV and between 6 GeV and 7 GeV)
- Efficiency drops at transition between barrel and end-caps

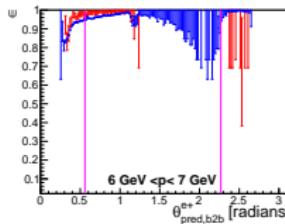
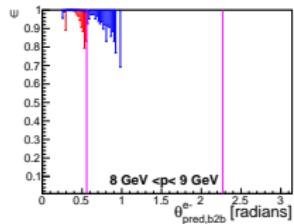
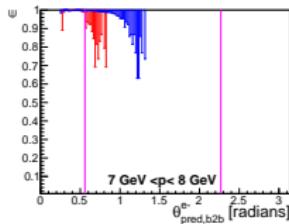
Phase3 MC10

Phase3 Data

e⁺



θ_{pred,b2b} [radians] θ_{pred,b2b} [radians]



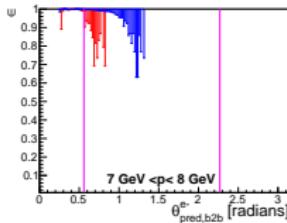
Phase3 Tracking Efficiencies As Function Of $\theta_{\text{pred,b2b}}$

Positron Tracking Efficiency:

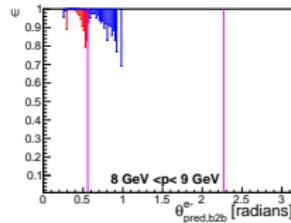
- The tracking efficiency pf phase3 MC and phase3 data are close to each other (an exception occurs in the backward end-cap for momenta between 2 GeV and 4 GeV and between 6 GeV and 7 GeV)
- Efficiency drops at transition between barrel and end-caps
- There is a slope in the barrel

$\theta_{\text{pred,b2b}}$ [radians]

$\theta_{\text{pred,b2b}}$ [radians]



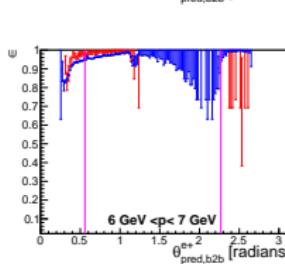
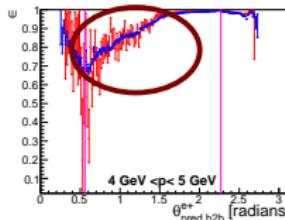
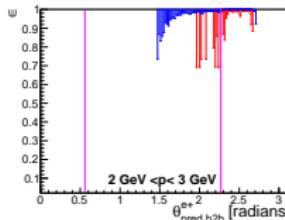
7 GeV < p < 8 GeV



8 GeV < p < 9 GeV

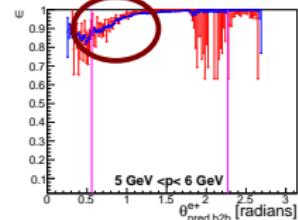
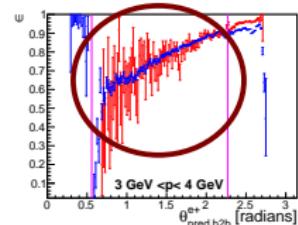
Phase3 MC10

Phase3 Data



6 GeV < p < 7 GeV

e⁺



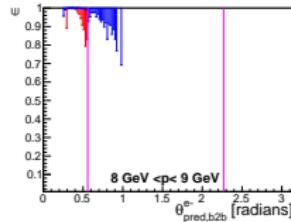
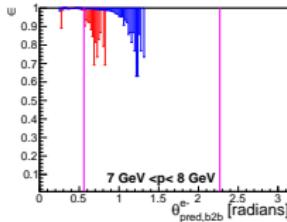
Phase3 Tracking Efficiencies As Function Of $\theta_{\text{pred,b2b}}$

Positron Tracking Efficiency:

- The tracking efficiency pf phase3 MC and phase3 data are close to each other (an exception occurs in the backward end-cap for momenta between 2 GeV and 4 GeV and between 6 GeV and 7 GeV)
- Efficiency drops at transition between barrel and end-caps
- There is a slope in the barrel

$\theta_{\text{pred,b2b}}$ [radians]

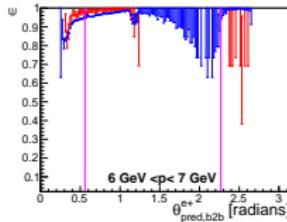
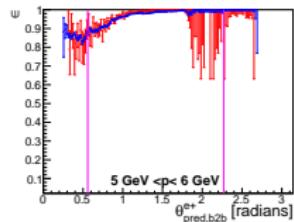
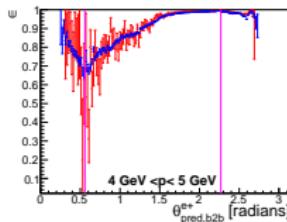
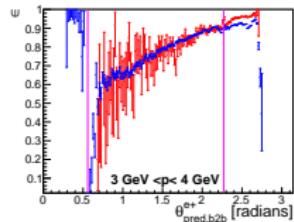
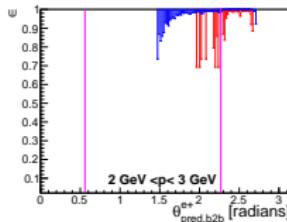
$\theta_{\text{pred,b2b}}$ [radians]



Phase3 MC10

Phase3 Data

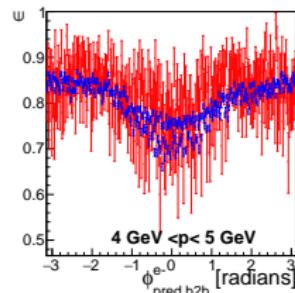
e⁺



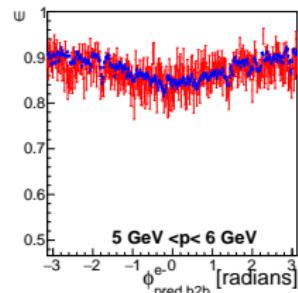
Phase3 Tracking Efficiencies As Function Of $\phi_{\text{pred,b2b}}$; Forward End-Cap

Phase3 MC10

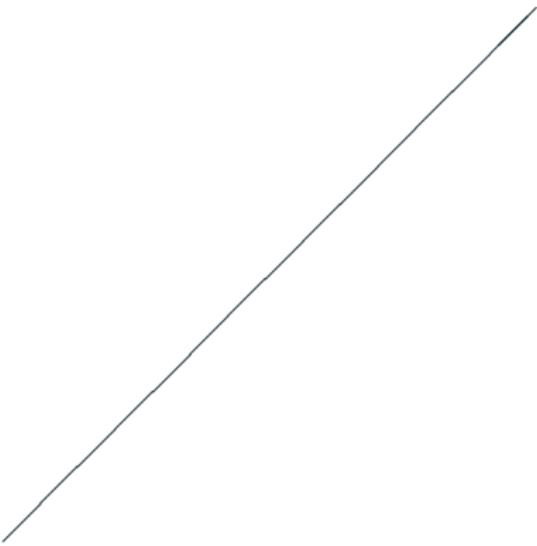
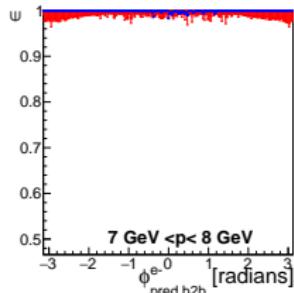
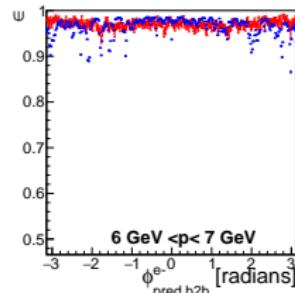
Phase3 Data



e^-



e^+

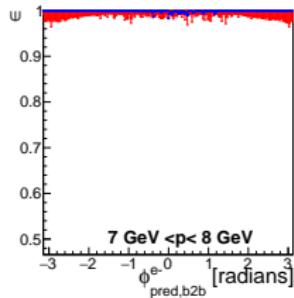
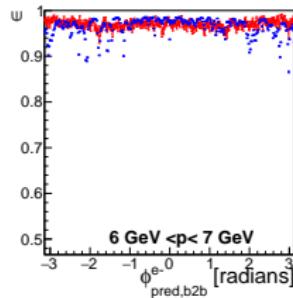
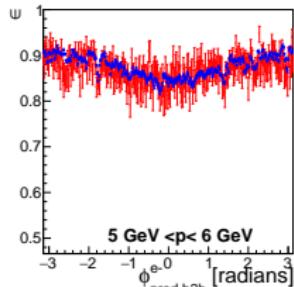
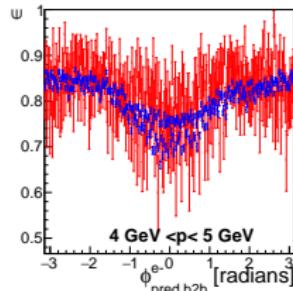


Phase3 Tracking Efficiencies As Function Of $\phi_{\text{pred,b2b}}$; Forward End-Cap

Phase3 MC10

Phase3 Data

e⁻



Electron Tracking Efficiency:

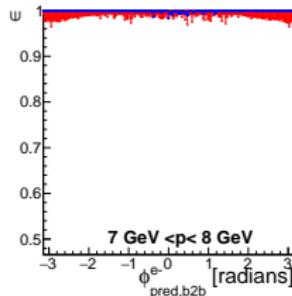
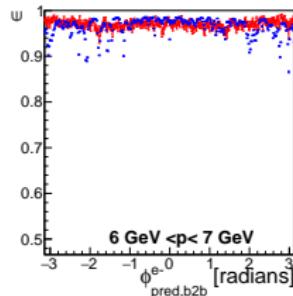
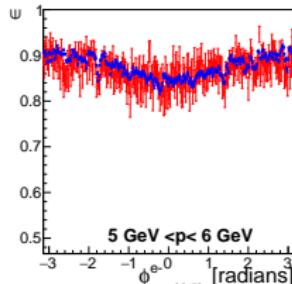
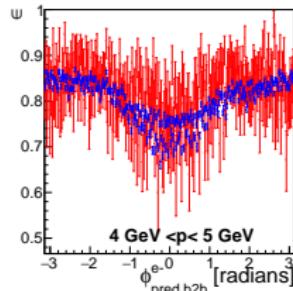
- Highest tracking efficiency for momenta between 7 GeV and 8 GeV

Phase3 Tracking Efficiencies As Function Of $\phi_{\text{pred,b2b}}$; Forward End-Cap

Phase3 MC10

Phase3 Data

e⁻



Electron Tracking Efficiency:

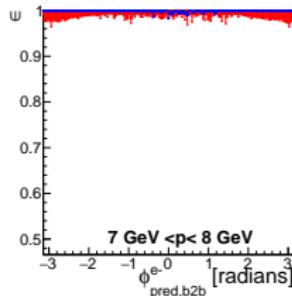
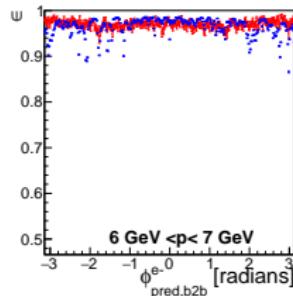
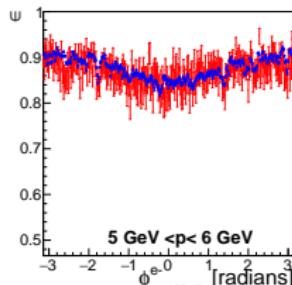
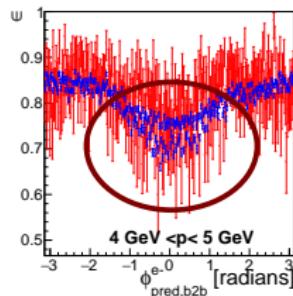
- Highest tracking efficiency for momenta between 7 GeV and 8 GeV
- Minimum at $\phi_{\text{pred,b2b}} \approx 0$ for momenta between 4 GeV and 6 GeV

Phase3 Tracking Efficiencies As Function Of $\phi_{\text{pred,b2b}}$; Forward End-Cap

Phase3 MC10

Phase3 Data

e⁻



Electron Tracking Efficiency:

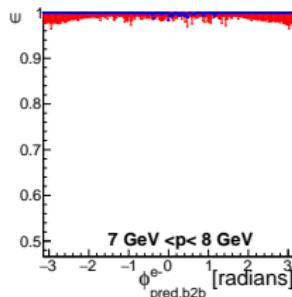
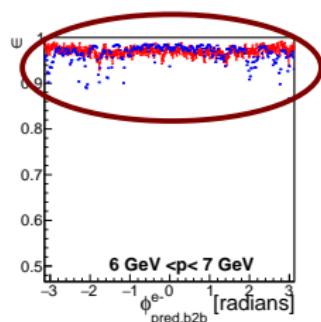
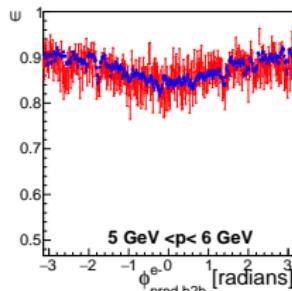
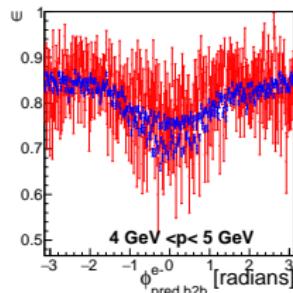
- Highest tracking efficiency for momenta between 7 GeV and 8 GeV
- Minimum at $\phi_{\text{pred,b2b}} \approx 0$ for momenta between 4 GeV and 6 GeV
- Weird *ribbon* structure in the phase3 data tracking efficiency at $\phi_{\text{pred,b2b}} \approx 0$ for momenta between 4 GeV and 5 GeV

Phase3 Tracking Efficiencies As Function Of $\phi_{\text{pred,b2b}}$; Forward End-Cap

Phase3 MC10

e⁻

Phase3 Data



Electron Tracking Efficiency:

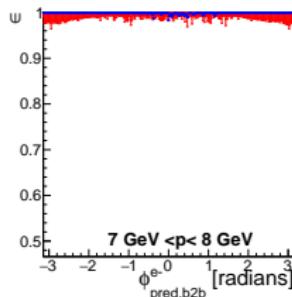
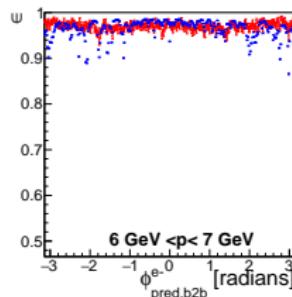
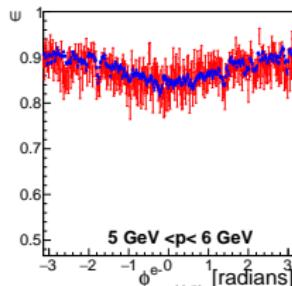
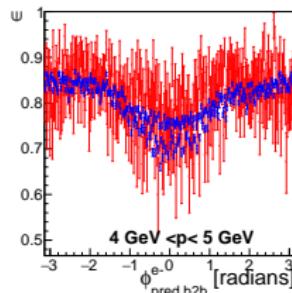
- Highest tracking efficiency for momenta between 7 GeV and 8 GeV
- Minimum at $\phi_{\text{pred,b2b}} \approx 0$ for momenta between 4 GeV and 6 GeV
- Weird *ribbon* structure in the phase3 data tracking efficiency at $\phi_{\text{pred,b2b}} \approx 0$ for momenta between 4 GeV and 5 GeV
- Weird efficiency drops in phase3 data for momenta between 6 GeV and 7 GeV

Phase3 Tracking Efficiencies As Function Of $\phi_{\text{pred,b2b}}$; Forward End-Cap

Phase3 MC10

e⁻

Phase3 Data



Electron Tracking Efficiency:

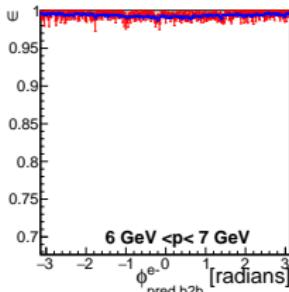
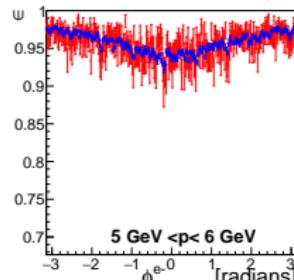
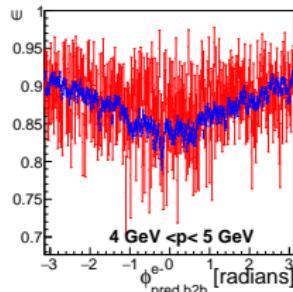
- Highest tracking efficiency for momenta between 7 GeV and 8 GeV
- Minimum at $\phi_{\text{pred,b2b}} \approx 0$ for momenta between 4 GeV and 6 GeV
- Weird *ribbon* structure in the phase3 data tracking efficiency at $\phi_{\text{pred,b2b}} \approx 0$ for momenta between 4 GeV and 5 GeV
- Weird efficiency drops in phase3 data for momenta between 6 GeV and 7 GeV

Phase3 Tracking Efficiencies As Function Of $\phi_{\text{pred,b2b}}$; Barrel

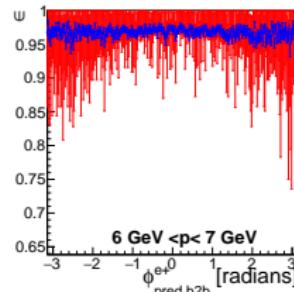
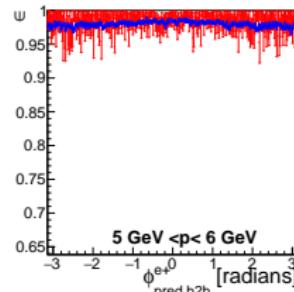
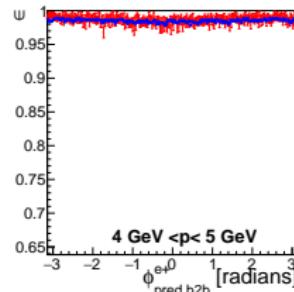
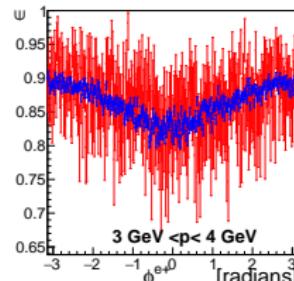
Phase3 MC10

Phase3 Data

e^-



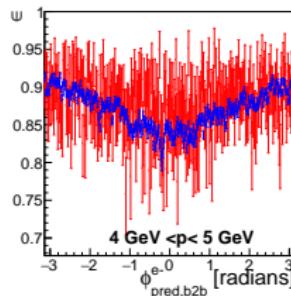
e^+



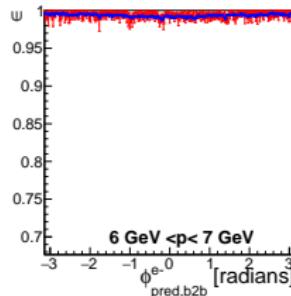
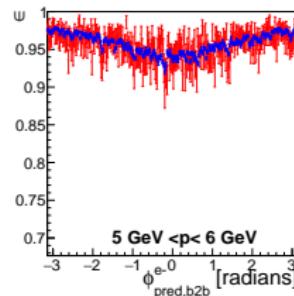
Phase3 Tracking Efficiencies As Function Of $\phi_{\text{pred,b2b}}$; Barrel

Phase3 MC10

Phase3 Data

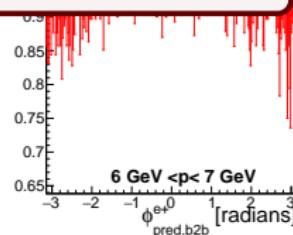
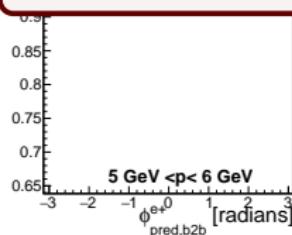


e^-



Electron Tracking Efficiency:

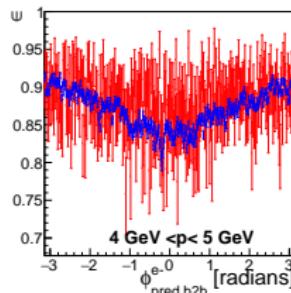
- Highest tracking efficiency for momenta between 6 GeV and 7 GeV
- Lowest tracking efficiency for momenta between 4 GeV and 5 GeV



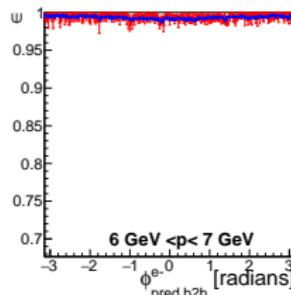
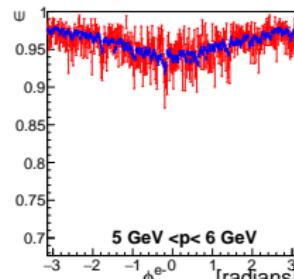
Phase3 Tracking Efficiencies As Function Of $\phi_{\text{pred,b2b}}$; Barrel

Phase3 MC10

Phase3 Data

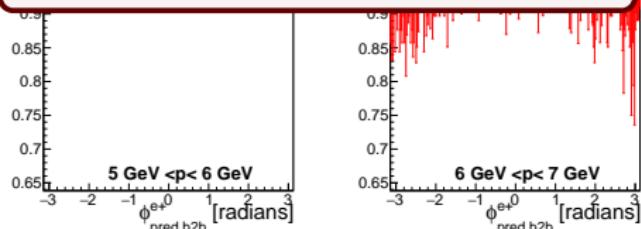


e^-



Electron Tracking Efficiency:

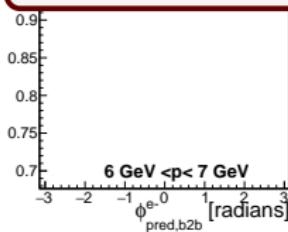
- Highest tracking efficiency for momenta between 6 GeV and 7 GeV
- Lowest tracking efficiency for momenta between 4 GeV and 5 GeV
- Minimum at $\phi_{\text{pred,b2b}} \approx 0$ for momenta between 4 GeV and 6 GeV



Phase3 Tracking Efficiencies As Function Of $\phi_{\text{pred,b2b}}$; Barrel

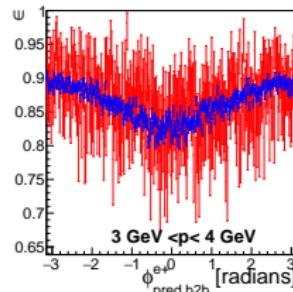
Positron Tracking Efficiency:

- Highest tracking efficiency for momenta between 4 GeV and 6 GeV
- Lowest tracking efficiency for momenta between 3 GeV and 4 GeV

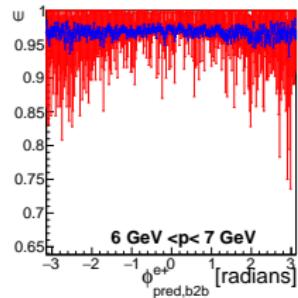
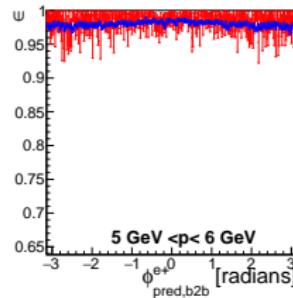
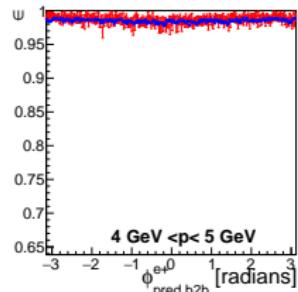


Phase3 MC10

Phase3 Data



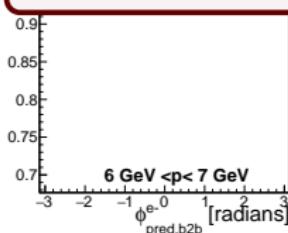
e^+



Phase3 Tracking Efficiencies As Function Of $\phi_{\text{pred,b2b}}$; Barrel

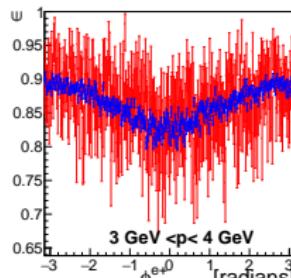
Positron Tracking Efficiency:

- Highest tracking efficiency for momenta between 4 GeV and 6 GeV
- Lowest tracking efficiency for momenta between 3 GeV and 4 GeV
- Minimum at $\phi_{\text{pred,b2b}} \approx 0$ for momenta between 3 GeV and 4 GeV

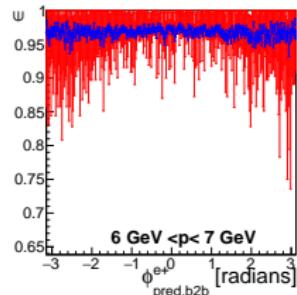
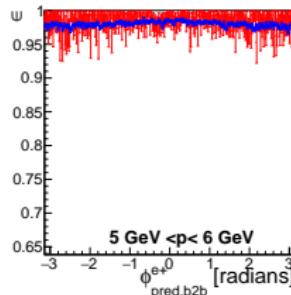
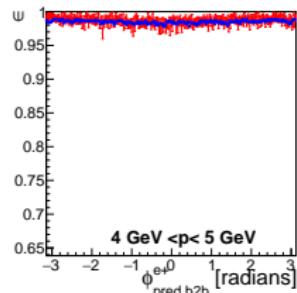


Phase3 MC10

Phase3 Data



e⁺

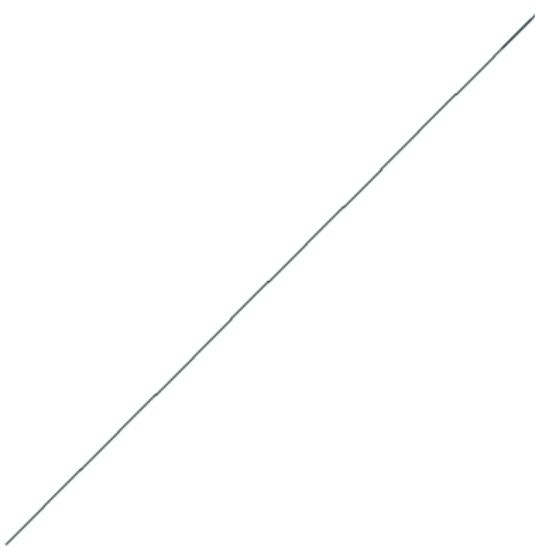


Phase3 Tracking Efficiencies As Function Of $\phi_{\text{pred,b2b}}$; Backward End-Cap

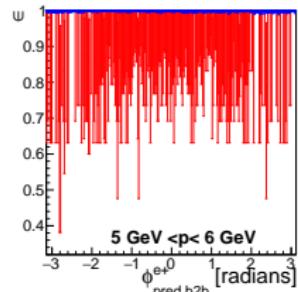
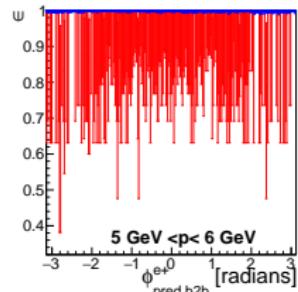
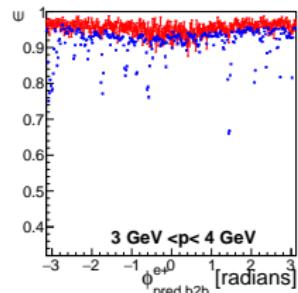
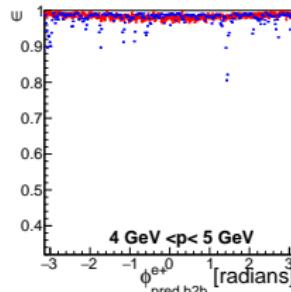
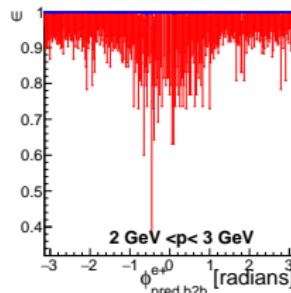
Phase3 MC10

Phase3 Data

e^-



e^+



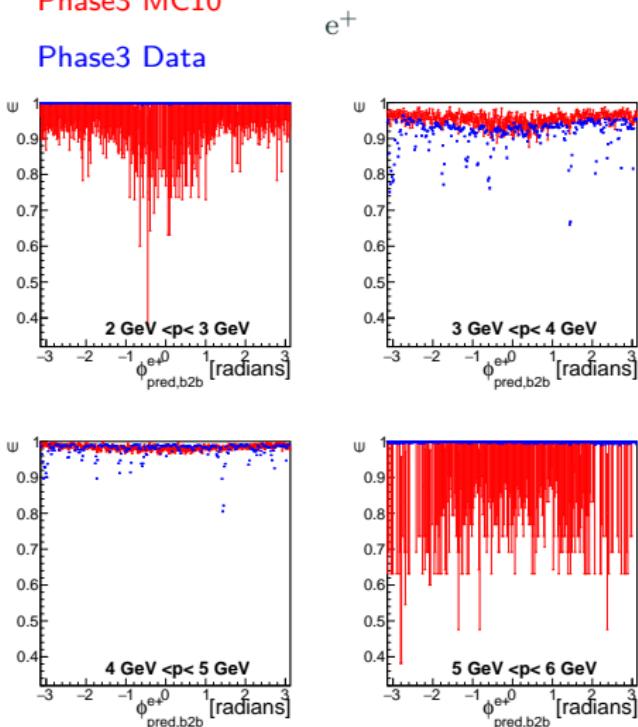
Phase3 Tracking Efficiencies As Function Of $\phi_{\text{pred,b2b}}$; Backward End-Cap

Positron Tracking Efficiency:

- The highest phase3 data tracking efficiency occurs for momenta between 2 GeV and 3 GeV and 5 GeV and 6 GeV

Phase3 MC10

Phase3 Data



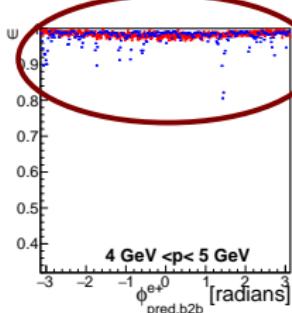
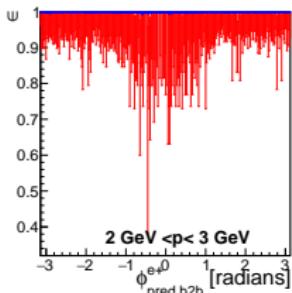
Phase3 Tracking Efficiencies As Function Of $\phi_{\text{pred,b2b}}$; Backward End-Cap

Positron Tracking Efficiency:

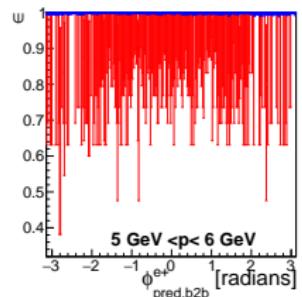
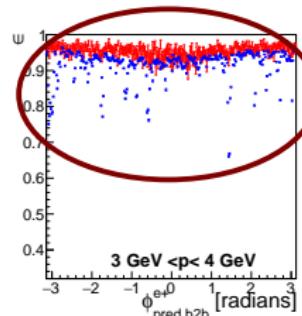
- The highest phase3 data tracking efficiency occurs for momenta between 2 GeV and 3 GeV and 5 GeV and 6 GeV
- Weird efficiency drops in the phase3 data tracking efficiency for momenta between 3 GeV and 5 GeV

Phase3 MC10

Phase3 Data



e^+



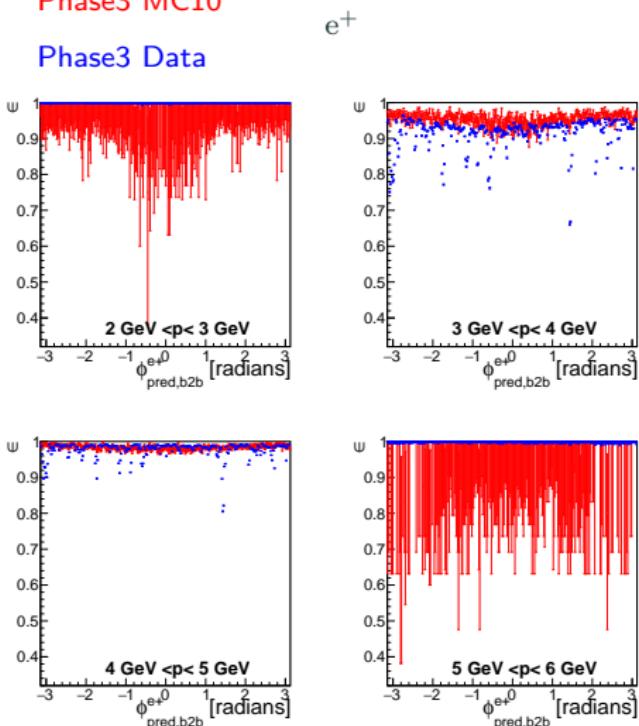
Phase3 Tracking Efficiencies As Function Of $\phi_{\text{pred,b2b}}$; Backward End-Cap

Positron Tracking Efficiency:

- The highest phase3 data tracking efficiency occurs for momenta between 2 GeV and 3 GeV and 5 GeV and 6 GeV
- Weird efficiency drops in the phase3 data tracking efficiency for momenta between 3 GeV and 5 GeV

Phase3 MC10

Phase3 Data



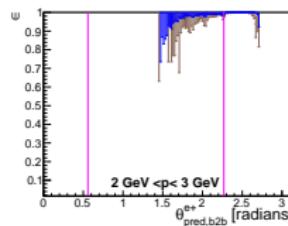
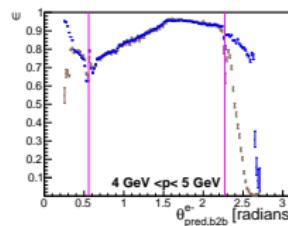
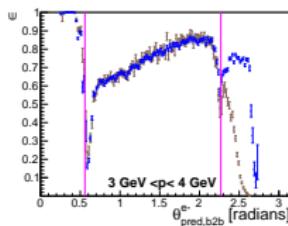
Comparing The Tracking Efficiency Of Phase2 Data with Phase3 Data

Tracking Efficiencies As Function Of $\theta_{\text{pred,b2b}}$

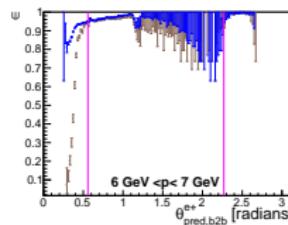
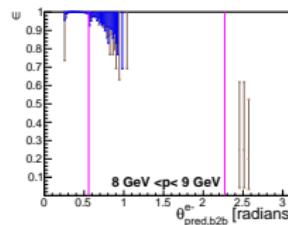
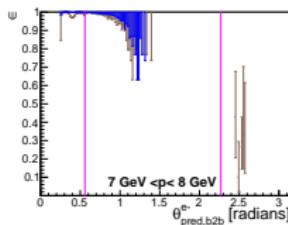
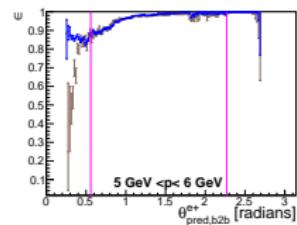
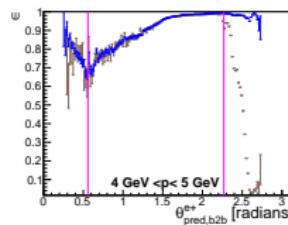
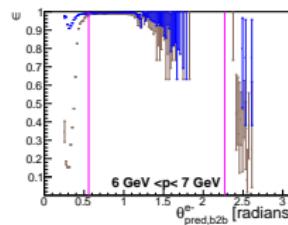
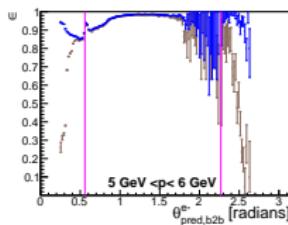
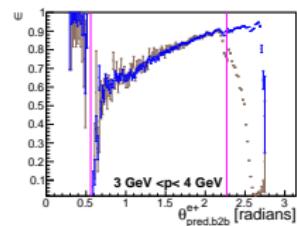
Phase2 Data

e^-

Phase3 Data



e^+

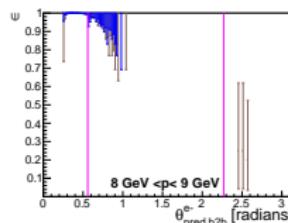
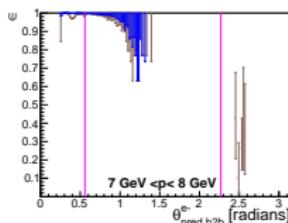
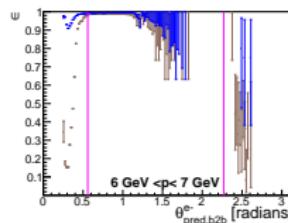
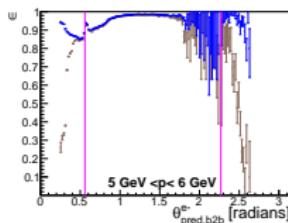
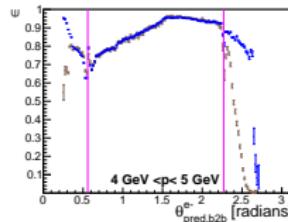
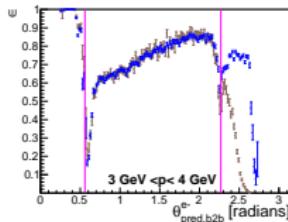


Tracking Efficiencies As Function Of $\theta_{\text{pred,b2b}}$

Phase2 Data

e^-

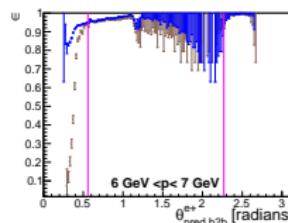
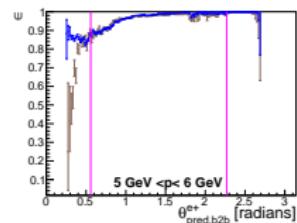
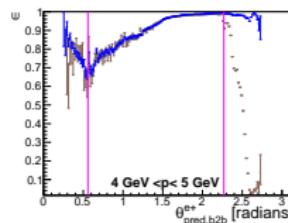
Phase3 Data



Electron Tracking Efficiency:

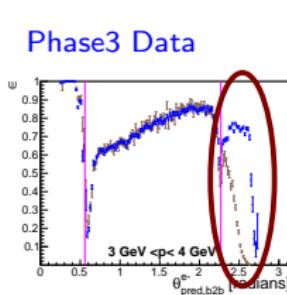
- Drastic improvement in the end-caps

$\theta_{\text{pred,b2b}}$ [radians] $\theta_{\text{pred,b2b}}$ [radians]

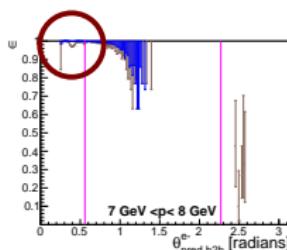
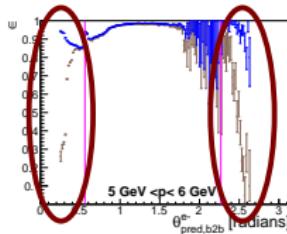
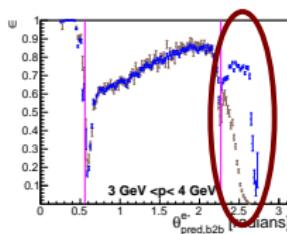


Tracking Efficiencies As Function Of $\theta_{\text{pred,b2b}}$

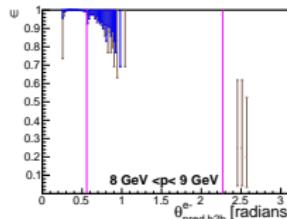
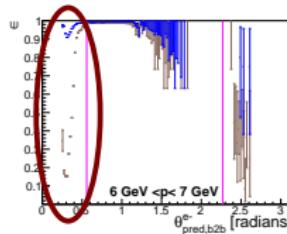
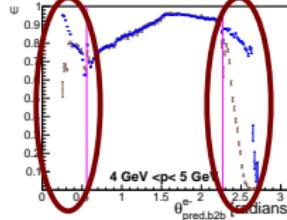
Phase2 Data



Phase3 Data



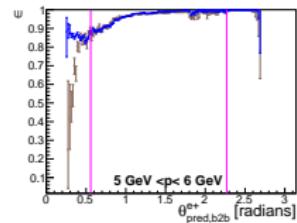
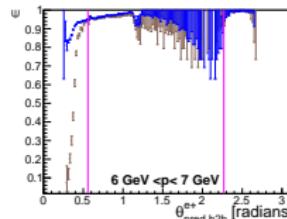
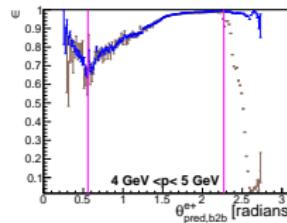
e^-



Electron Tracking Efficiency:

- Drastic improvement in the end-caps

$\theta_{\text{pred,b2b}}$ [radians] $\theta_{\text{pred,b2b}}$ [radians]

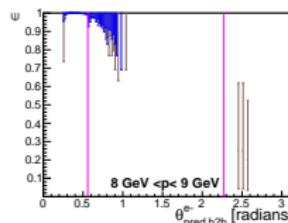
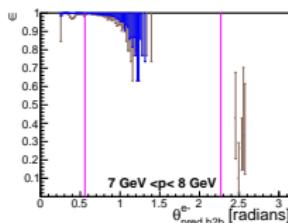
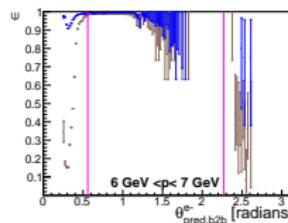
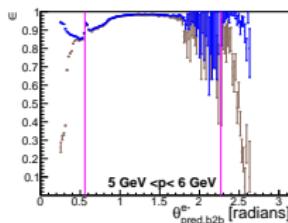
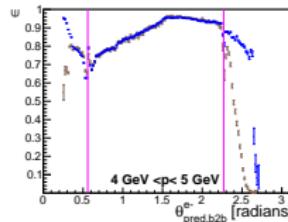
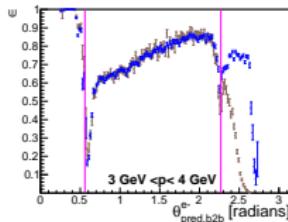


Tracking Efficiencies As Function Of $\theta_{\text{pred,b2b}}$

Phase2 Data

e^-

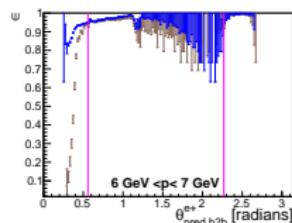
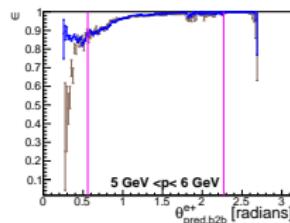
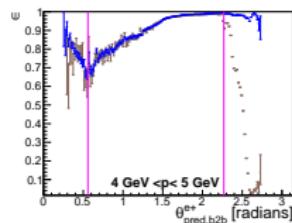
Phase3 Data



Electron Tracking Efficiency:

- Drastic improvement in the end-caps
- Tracking efficiency in the barrel stayed more or less the same

$\theta_{\text{pred,b2b}}$ [radians]

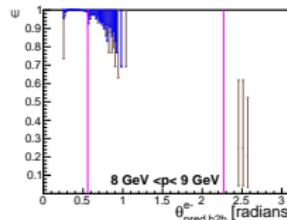
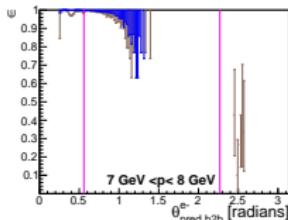
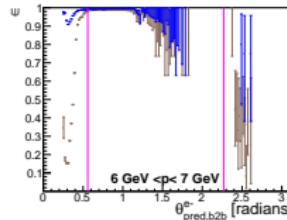
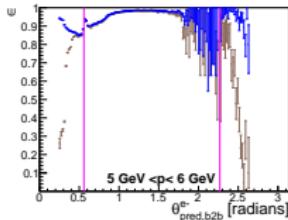


Tracking Efficiencies As Function Of $\theta_{\text{pred,b2b}}$

Positron Tracking Efficiency:

- Drastic improvement in the end-caps

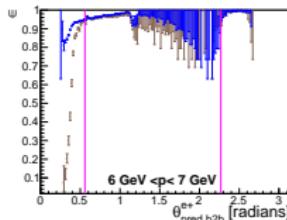
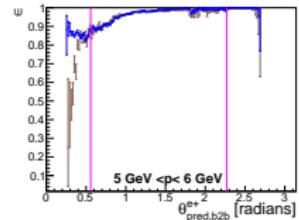
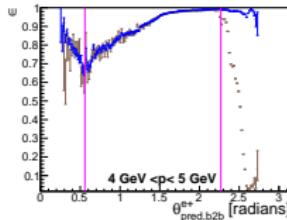
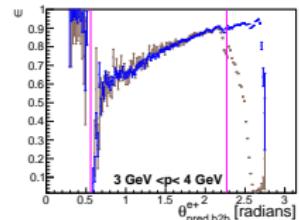
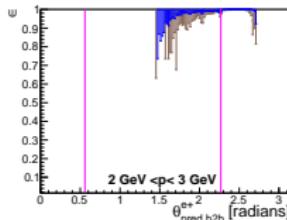
$\theta_{\text{pred,b2b}}$ [radians]



Phase2 Data

Phase3 Data

e⁺

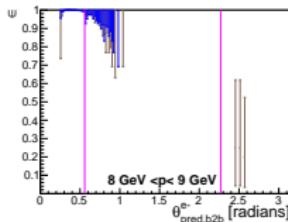
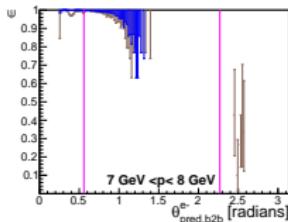
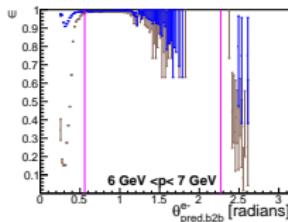
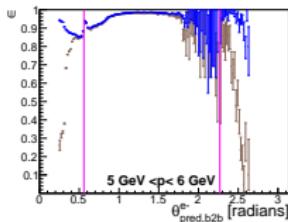


Tracking Efficiencies As Function Of $\theta_{\text{pred,b2b}}$

Positron Tracking Efficiency:

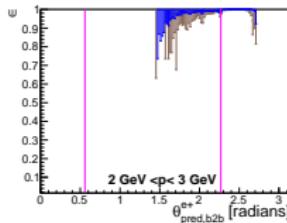
- Drastic improvement in the end-caps

ψ vs $\theta_{\text{pred,b2b}}$ [radians]

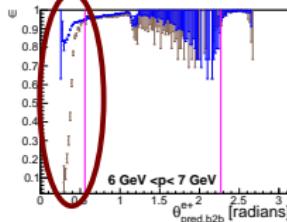
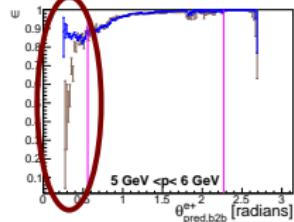
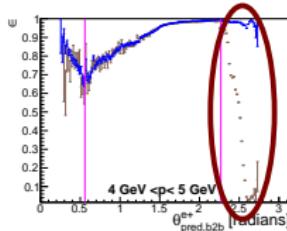
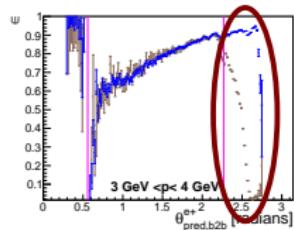


Phase2 Data

Phase3 Data



e^+

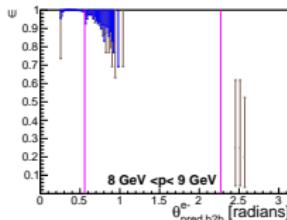
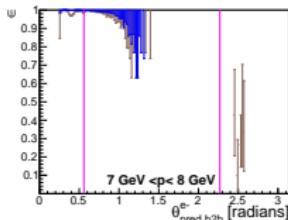
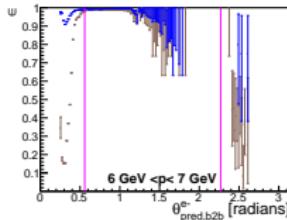
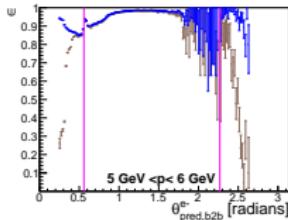


Tracking Efficiencies As Function Of $\theta_{\text{pred,b2b}}$

Positron Tracking Efficiency:

- Drastic improvement in the end-caps
- Tracking efficiency in the barrel stayed more or less the same

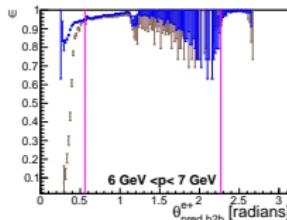
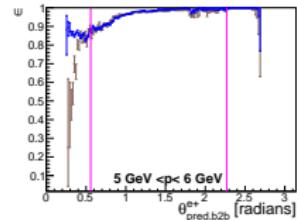
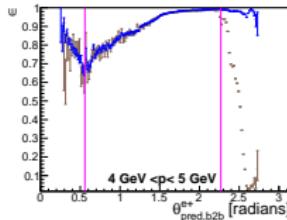
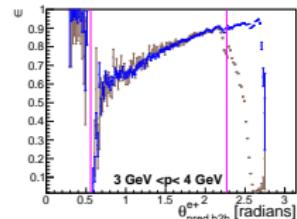
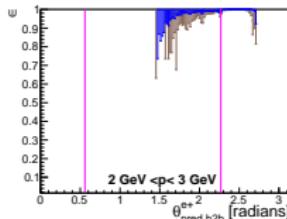
$\theta_{\text{pred,b2b}}$ [radians]



Phase2 Data

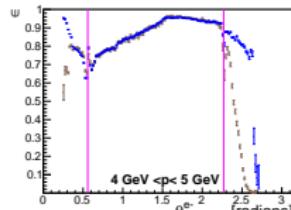
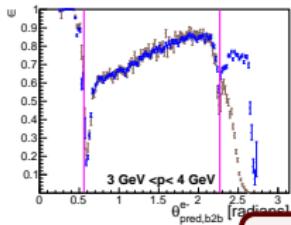
Phase3 Data

e⁺



Tracking Efficiencies As Function Of $\theta_{\text{pred,b2b}}$

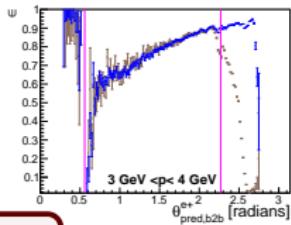
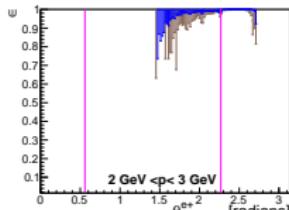
e^-



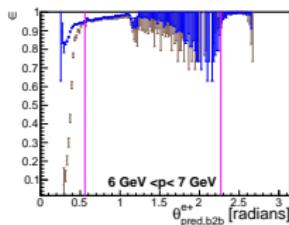
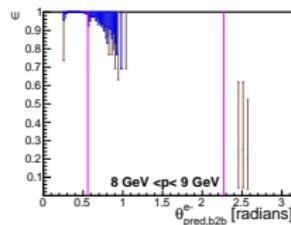
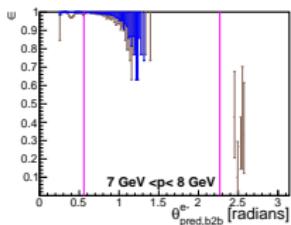
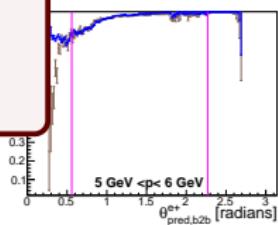
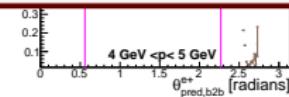
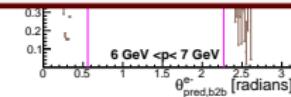
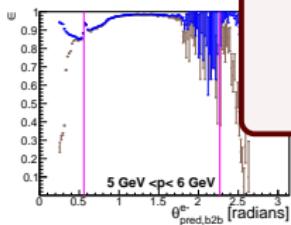
Phase2 Data

Phase3 Data

e^+

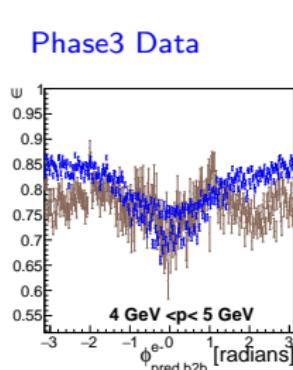


We will only compare the tracking efficiencies for electrons in the forward end-cap and the tracking efficiencies for positrons in the backward end-cap

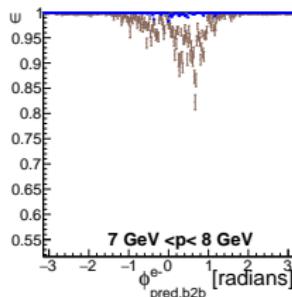
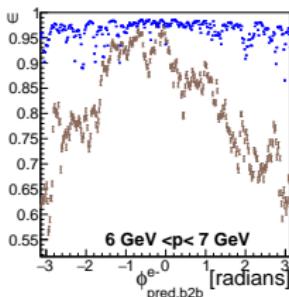
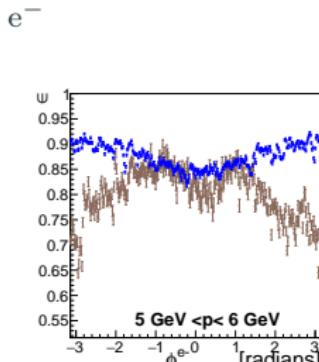


Tracking Efficiencies As Function Of $\phi_{\text{pred,b2b}}$; Forward End-Cap

Phase2 Data



Phase3 Data



e^-

Electron Tracking Efficiency:

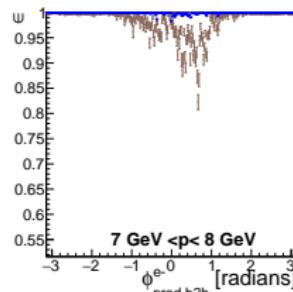
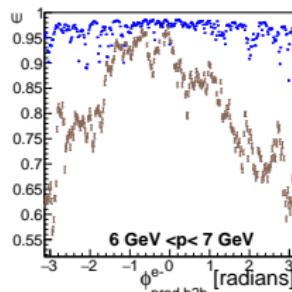
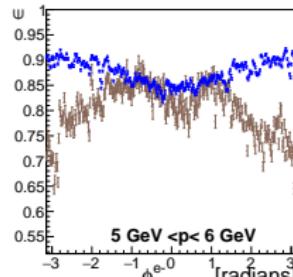
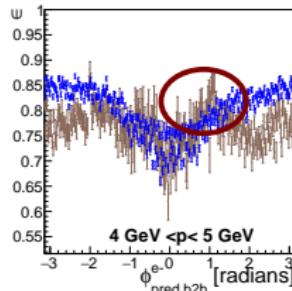
- The tracking efficiency improved over almost all $\phi_{\text{pred,b2b}}$ (exception occurs for $\phi_{\text{pred,b2b}} \approx 1$ for momenta between 4 GeV and 5 GeV)

Tracking Efficiencies As Function Of $\phi_{\text{pred,b2b}}$; Forward End-Cap

Phase2 Data

e⁻

Phase3 Data

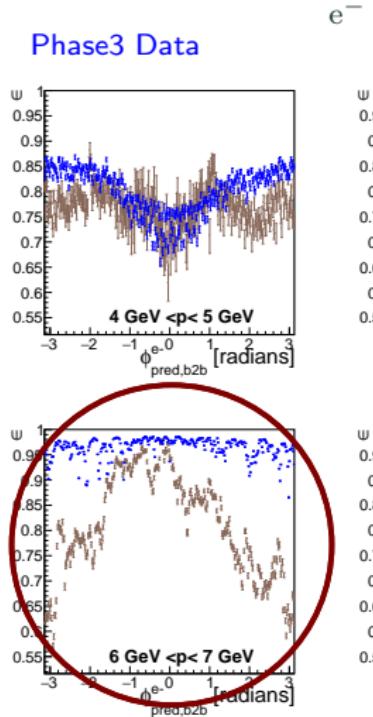


Electron Tracking Efficiency:

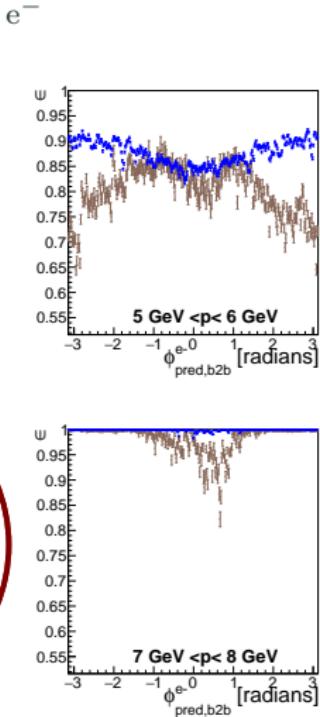
- The tracking efficiency improved over almost all $\phi_{\text{pred,b2b}}$ (exception occurs for $\phi_{\text{pred,b2b}} \approx 1$ for momenta between 4 GeV and 5 GeV)

Tracking Efficiencies As Function Of $\phi_{\text{pred,b2b}}$; Forward End-Cap

Phase2 Data



Phase3 Data



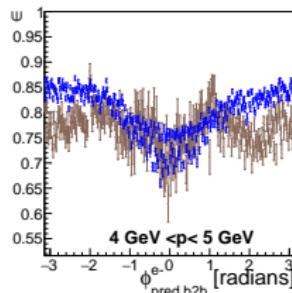
Electron Tracking Efficiency:

- The tracking efficiency improved over almost all $\phi_{\text{pred,b2b}}$ (exception occurs for $\phi_{\text{pred,b2b}} \approx 1$ for momenta between 4 GeV and 5 GeV)
- The tracking efficiency improved drastically for momenta between 6 GeV and 7 GeV

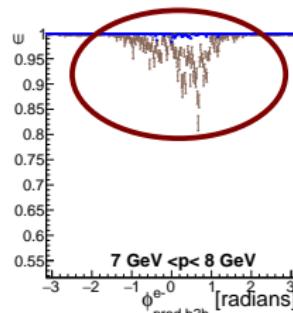
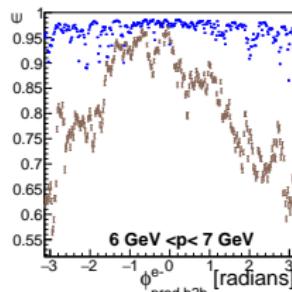
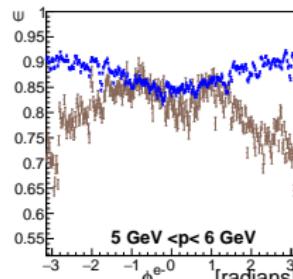
Tracking Efficiencies As Function Of $\phi_{\text{pred,b2b}}$; Forward End-Cap

Phase2 Data

Phase3 Data



e^-

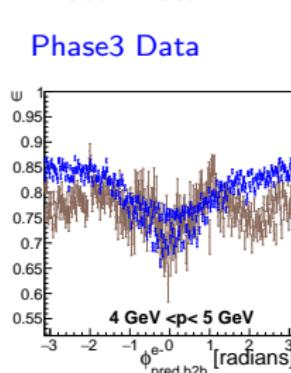


Electron Tracking Efficiency:

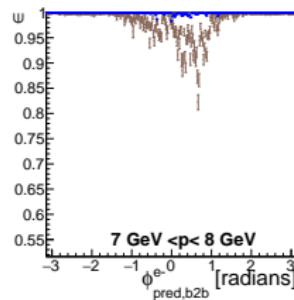
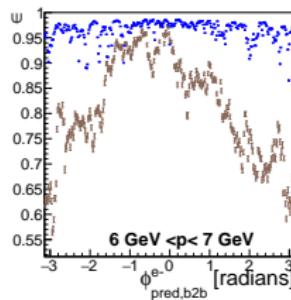
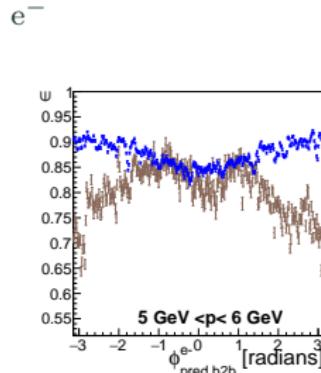
- The tracking efficiency improved over almost all $\phi_{\text{pred,b2b}}$ (exception occurs for $\phi_{\text{pred,b2b}} \approx 1$ for momenta between 4 GeV and 5 GeV)
- The tracking efficiency improved drastically for momenta between 6 GeV and 7 GeV
- No efficiency drops for momenta between 7 GeV and 8 GeV in the phase3 data tracking efficiency

Tracking Efficiencies As Function Of $\phi_{\text{pred,b2b}}$; Forward End-Cap

Phase2 Data



Phase3 Data



Electron Tracking Efficiency:

- The tracking efficiency improved over almost all $\phi_{\text{pred,b2b}}$ (exception occurs for $\phi_{\text{pred,b2b}} \approx 1$ for momenta between 4 GeV and 5 GeV)
- The tracking efficiency improved drastically for momenta between 6 GeV and 7 GeV
- No efficiency drops for momenta between 7 GeV and 8 GeV in the phase3 data tracking efficiency

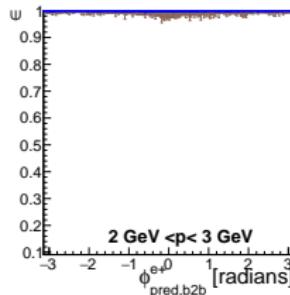
Tracking Efficiencies As Function Of $\phi_{\text{pred,b2b}}$; Backward End-Cap

Positron Tracking Efficiency:

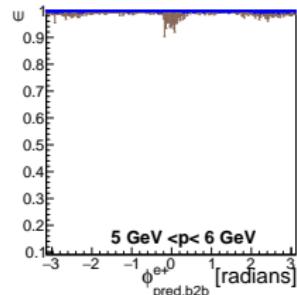
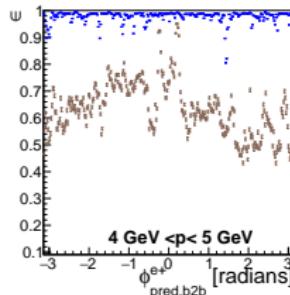
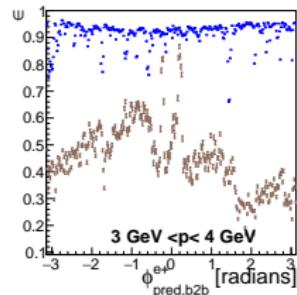
- The tracking efficiencies for momenta between 2 GeV and 3 GeV and between 5 GeV and 6 GeV look very similar

Phase2 Data

Phase3 Data



e^+



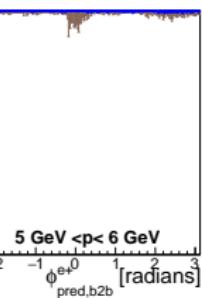
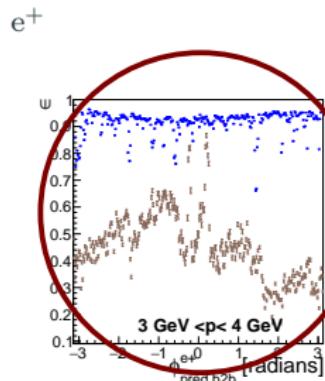
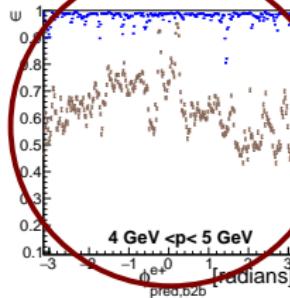
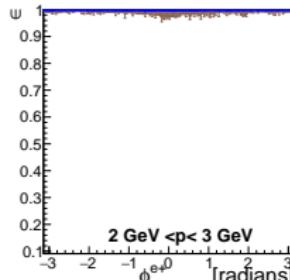
Tracking Efficiencies As Function Of $\phi_{\text{pred,b2b}}$; Backward End-Cap

Positron Tracking Efficiency:

- The tracking efficiencies for momenta between 2 GeV and 3 GeV and between 5 GeV and 6 GeV look very similar
- The tracking efficiency for momenta between 3 GeV and 5 GeV improved drastically

Phase2 Data

Phase3 Data



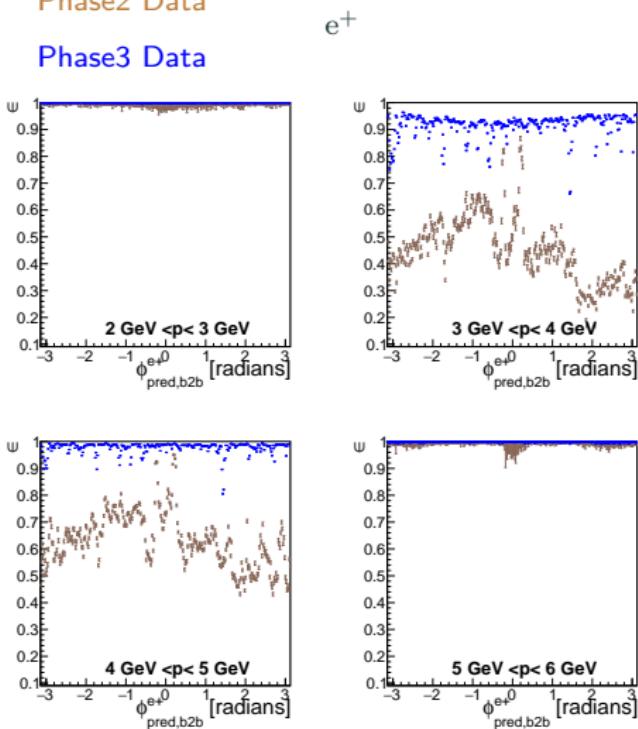
Tracking Efficiencies As Function Of $\phi_{\text{pred,b2b}}$; Backward End-Cap

Positron Tracking Efficiency:

- The tracking efficiencies for momenta between 2 GeV and 3 GeV and between 5 GeV and 6 GeV look very similar
- The tracking efficiency for momenta between 3 GeV and 5 GeV improved drastically

Phase2 Data

Phase3 Data



Conclusion

Conclusion

- It is possible to select Bhabha events using only information coming from the ECL
- The phase3 MC tracking efficiency is very close to the phase3 data tracking efficiency
- On phase3 data *unexpected* low efficiency structures appear for some momenta in the end-caps
- Drastic improvement in the tracking efficiency in the end-caps for phase3 compared to phase2

Appendix

Code

```
1 fillParticleList('gamma:all', 'clusterE > 0.01 and 0.296706 < theta < 2.61799', path  
    ↪ =mypath)  
fillParticleList('e+:all', 'clusterE > 0.01 and 0.296706 < theta < 2.61799', path=  
    ↪ mypath)  
3  
reconstructDecay('vpho:gamma -> gamma:all', '', path=mypath)  
5 reconstructDecay('vpho:elec -> e+:all', '', path=mypath)  
7 copyLists(outputListName = 'vpho:ECLObjectUnranked', inputListNames=['vpho:elec  
    ↪ ', 'vpho:gamma'], path=mypath)  
9 rankByHighest('vpho:ECLObjectUnranked', 'daughter(0,clusterE)', path=mypath)  
cutAndCopyList('vpho:ECLObject', 'vpho:ECLObjectUnranked', '', path=mypath)  
11 reconstructDecay('vpho:bhabha -> vpho:ECLObject vpho:ECLObject', '', path=  
    ↪ mypath)  
13 variablesToNtuple('vpho:bhabha', variables, treename = 'vpho_bhabha', filename =  
    ↪ output.root, path=mypath)
```

More Events

Phase2 data:

- /ghi/fs01/belle2/bdata//Data/release-03-00-03/
DB00000528/proc00000008/e0003/4S/r0*/all/mdst/sub00/*.root
- proc9

Phase2 MC:

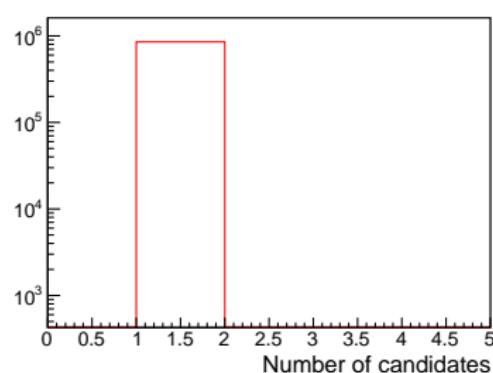
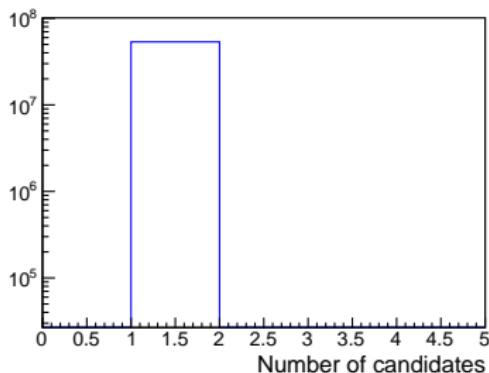
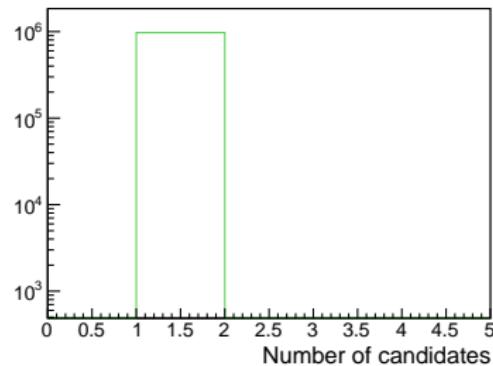
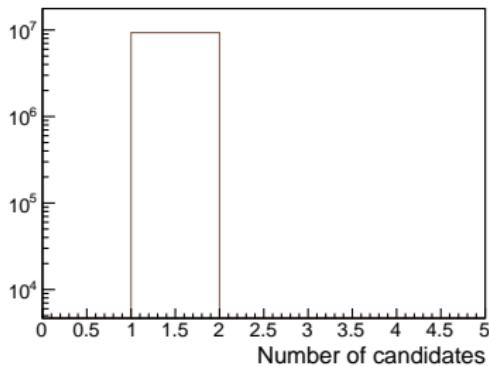
- /belle/MC/release-01-00-02/DB00000294/MC10/
prod00004668/s00/e1002/4S/r00000/3600520000/mdst/sub00

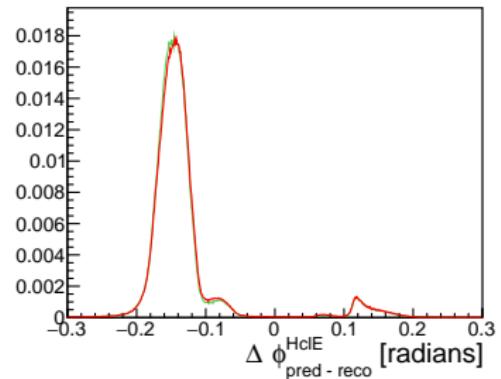
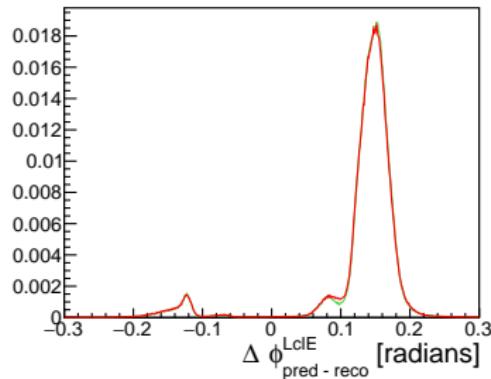
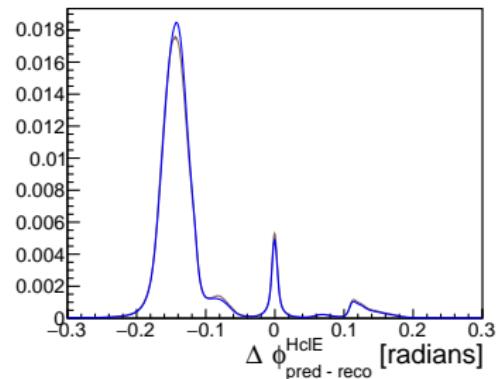
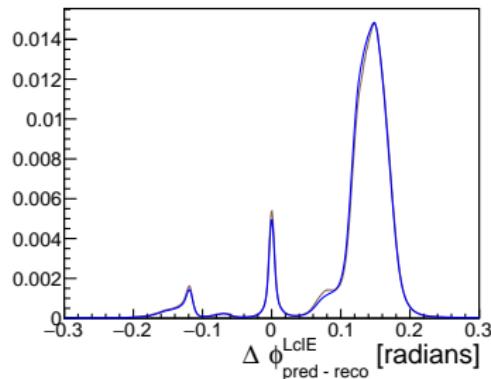
Phase3 data:

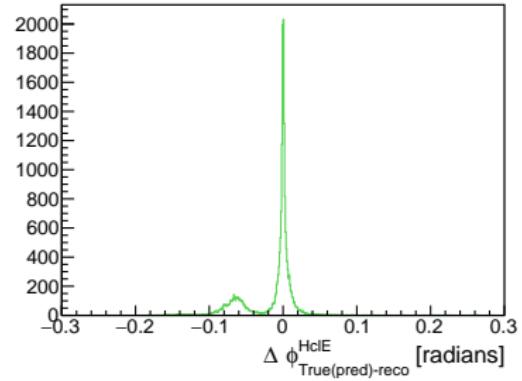
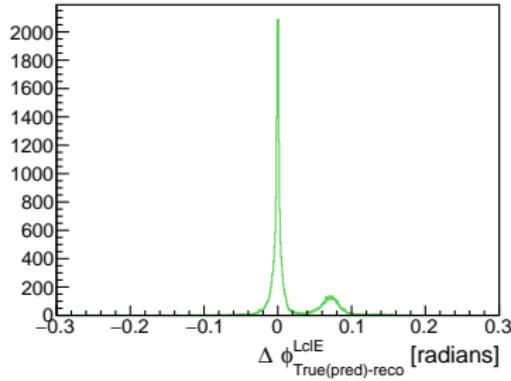
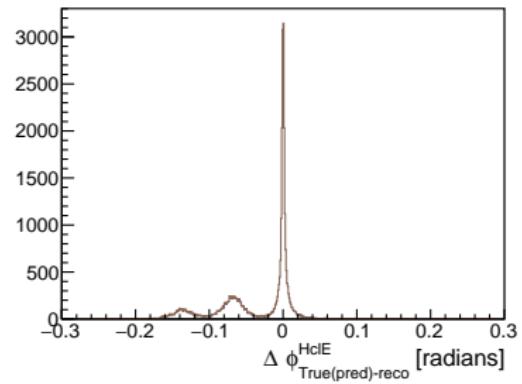
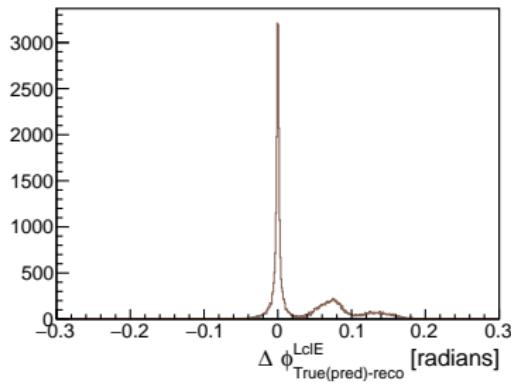
- Exp7: /group/belle2/dataprod/Data/release-03-02-
02/DB00000654/proc9/e0007/4S/r0*/all/mdst/sub00/*.root
- Exp8: /group/belle2/dataprod/Data/release-03-02-
02/DB00000654/proc9/e0008/4S/r0*/all/mdst/sub00/*.root
- proc9

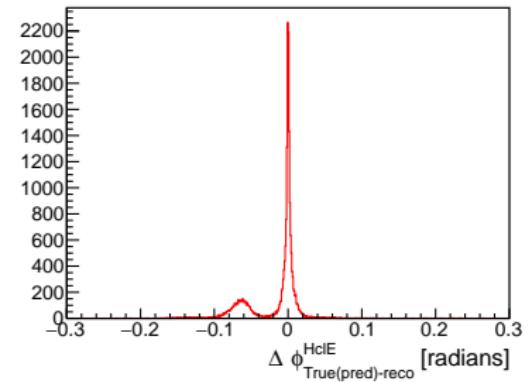
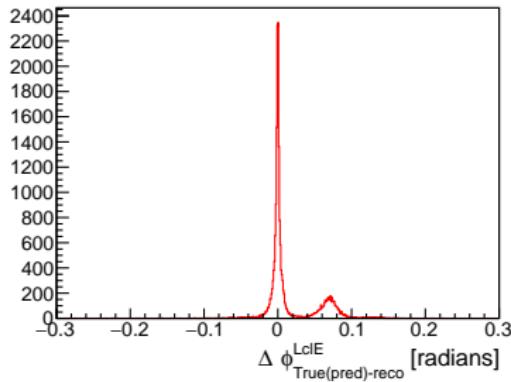
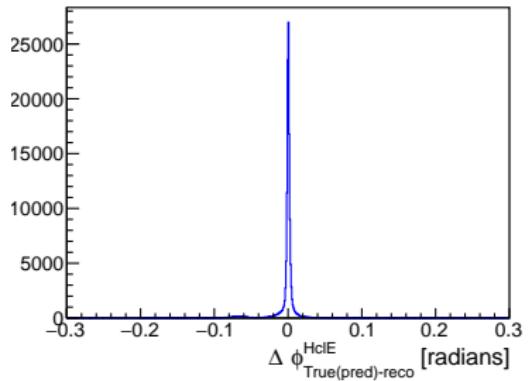
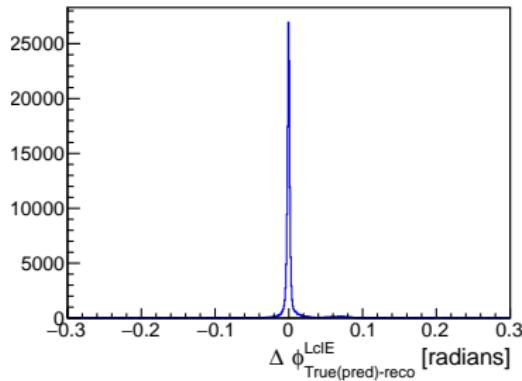
Phase3 MC:

- /belle/MC/release-01-00-02/DB00000294/MC10/
prod00004664/s00/e0000/4S/r00000/3600520000/mdst/sub00









Trigger

We need to be sure that a trigger signal is coming from the ECL

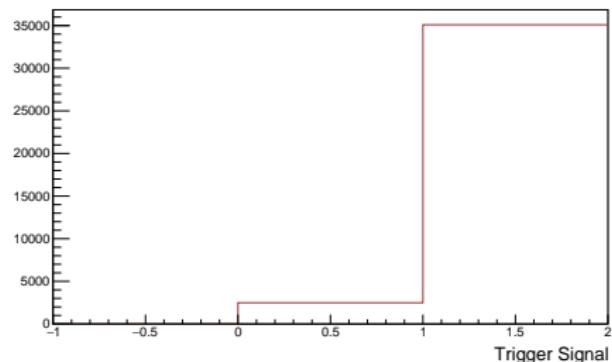
Otherwise there could be a bias

→ The bhabha trigger bit is used

This trigger requires several conditions:

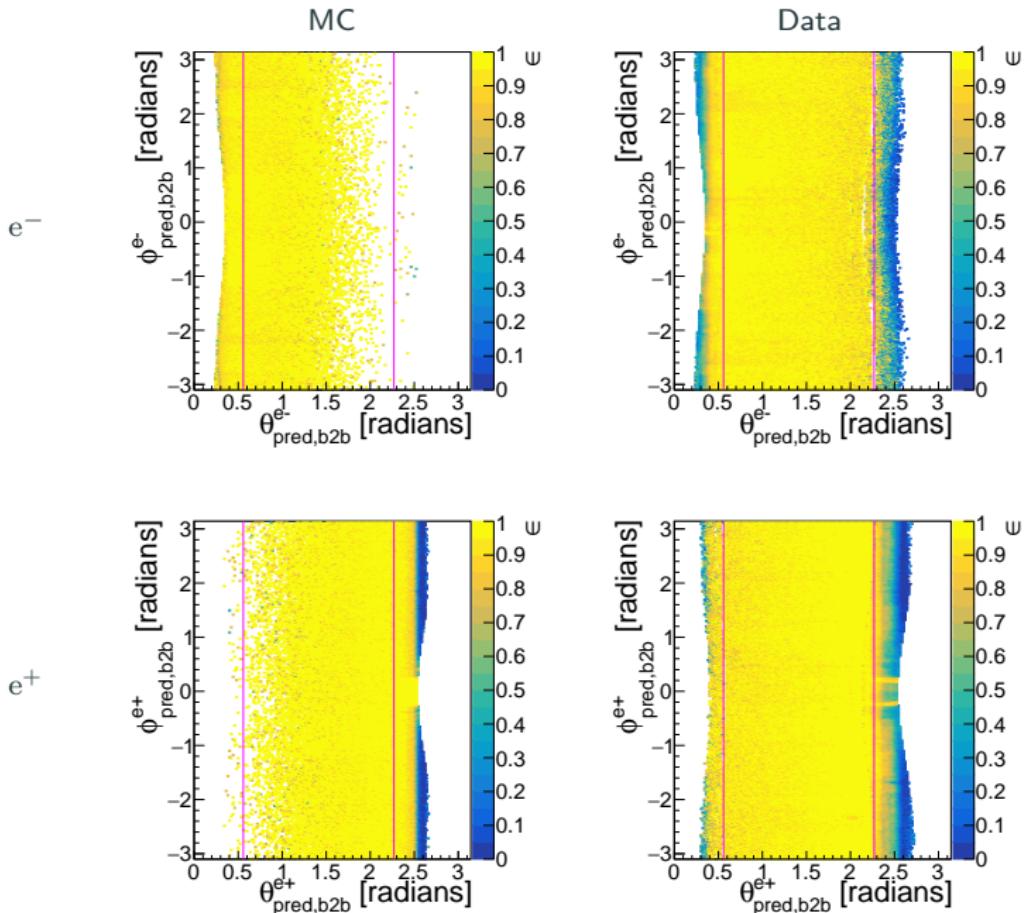
- Trigger signal coming from the ECL
- Both reconstructed particles have to have a cluster energy of at least 2.5 GeV each and one has to have at least 4 GeV
- $160^\circ < \sum \theta_{cms} < 200^\circ$
- $140^\circ < \Delta\phi_{cms} < 220^\circ$

The trigger cut will not be applied to MC since the trigger simulation does not work reliably on MC

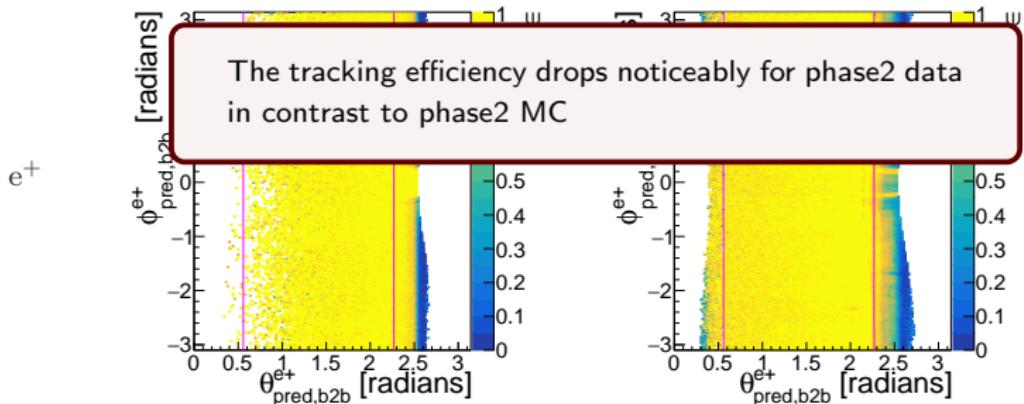
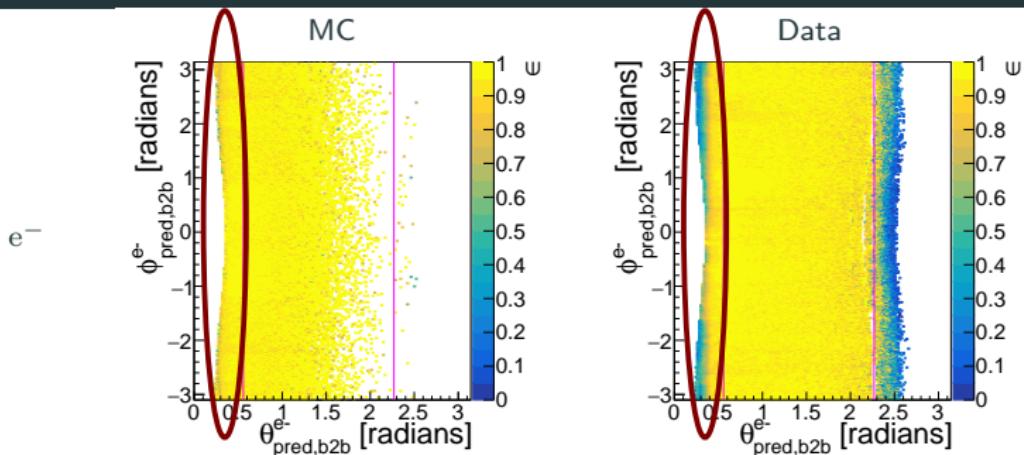


Phase2 Tracking Efficiencies

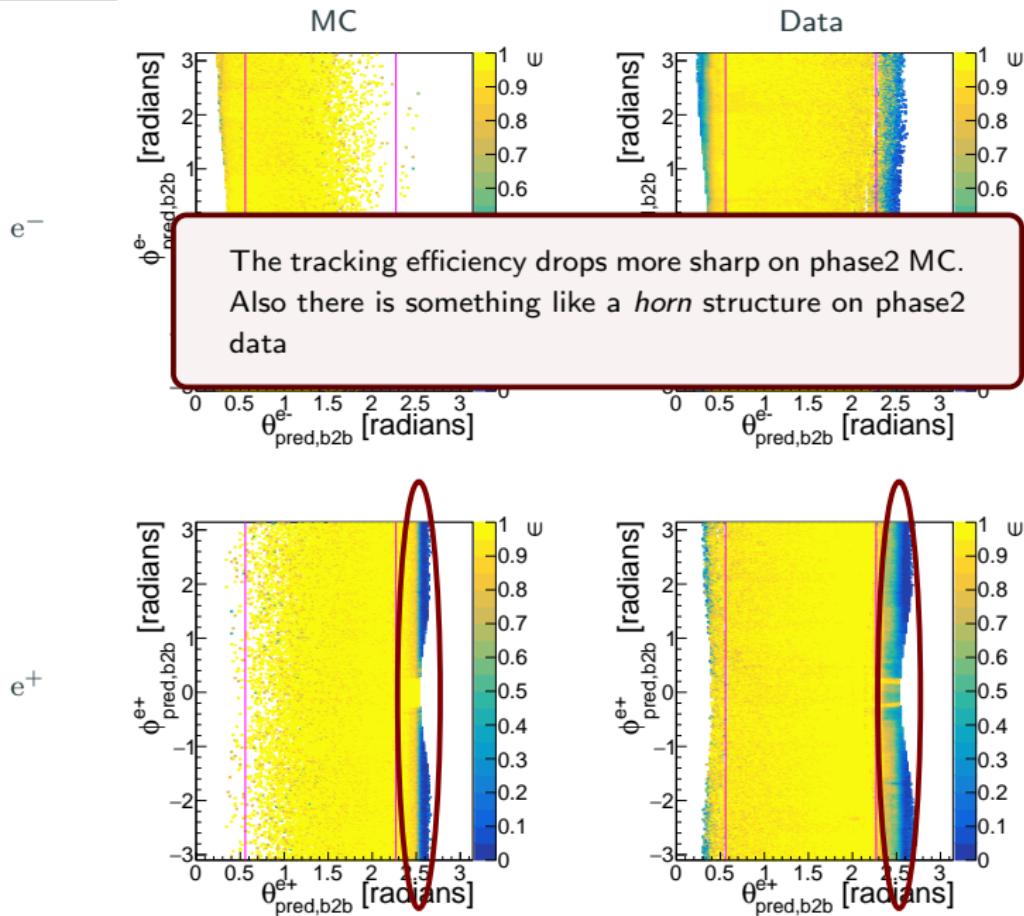
Phase2 Tracking Efficiencies As Function Of $\theta_{\text{pred,b2b}} - \phi_{\text{pred,b2b}}$



Phase2 Tracking Efficiencies As Function Of $\theta_{\text{pred,b2b}} - \phi_{\text{pred,b2b}}$



Phase2 Tracking Efficiencies As Function Of $\theta_{\text{pred,b2b}} - \phi_{\text{pred,b2b}}$

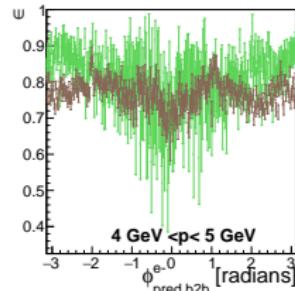


Phase2 Tracking Efficiencies As Function Of $\phi_{\text{pred,b2b}}$; Forward End-Cap

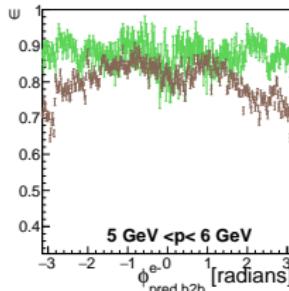
Phase2 MC10

Phase2 Data

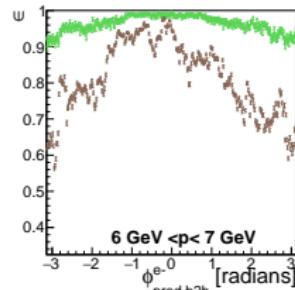
e⁻



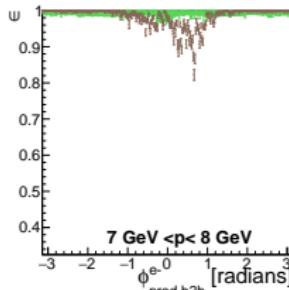
$4 \text{ GeV} < p < 5 \text{ GeV}$



$5 \text{ GeV} < p < 6 \text{ GeV}$

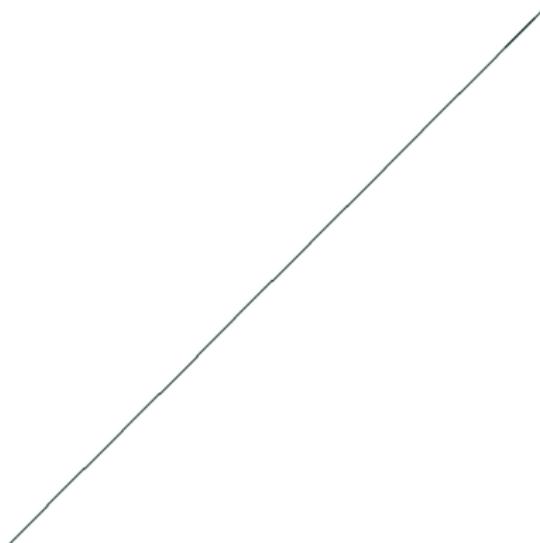


$6 \text{ GeV} < p < 7 \text{ GeV}$



$7 \text{ GeV} < p < 8 \text{ GeV}$

e⁺

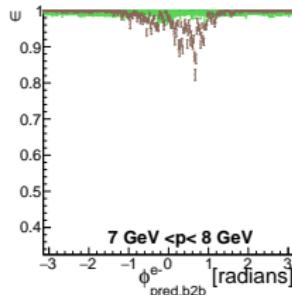
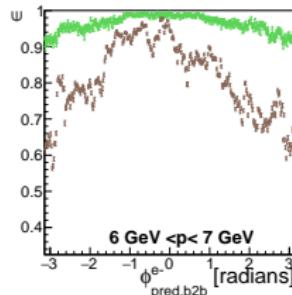
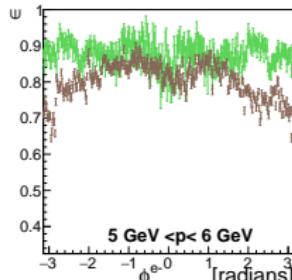
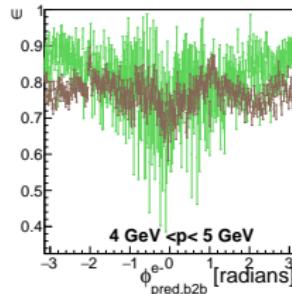


Phase2 Tracking Efficiencies As Function Of $\phi_{\text{pred,b2b}}$; Forward End-Cap

Phase2 MC10

Phase2 Data

e⁻



Electron Tracking Efficiency:

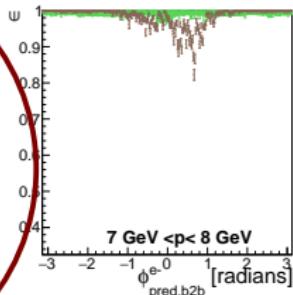
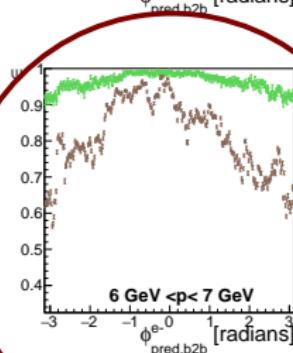
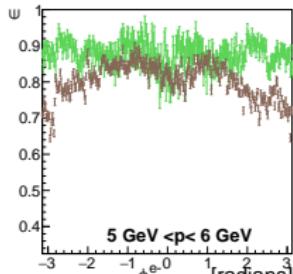
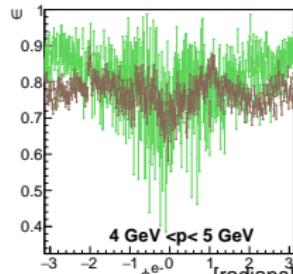
- Phase2 MC has almost always a higher tracking efficiency compared to phase2 data
- For most momenta the biggest difference between phase2 MC and phase2 data occurs for $|\phi_{\text{pred,b2b}}| \gtrsim 2$

Phase2 Tracking Efficiencies As Function Of $\phi_{\text{pred,b2b}}$; Forward End-Cap

Phase2 MC10

Phase2 Data

e⁻



Electron Tracking Efficiency:

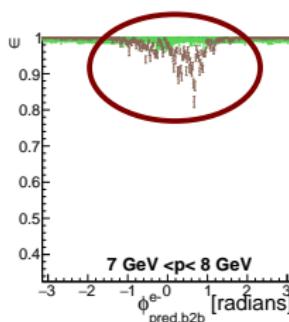
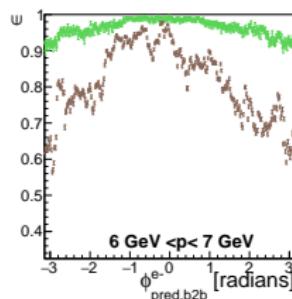
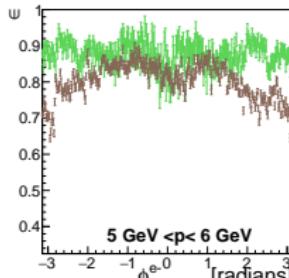
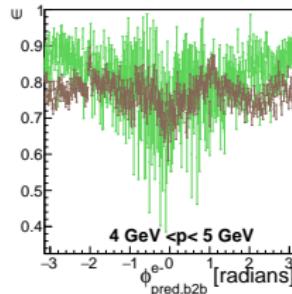
- Phase2 MC has almost always a higher tracking efficiency compared to phase2 data
- For most momenta the biggest difference between phase2 MC and phase2 data occurs for $|\phi_{\text{pred,b2b}}| \gtrsim 2$
- There is no similarity in the structure for momenta between 6 GeV and 7 GeV

Phase2 Tracking Efficiencies As Function Of $\phi_{\text{pred,b2b}}$; Forward End-Cap

Phase2 MC10

Phase2 Data

e⁻



Electron Tracking Efficiency:

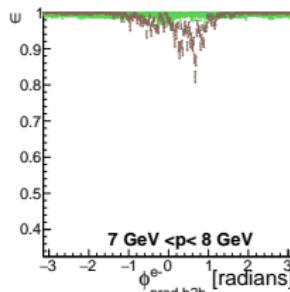
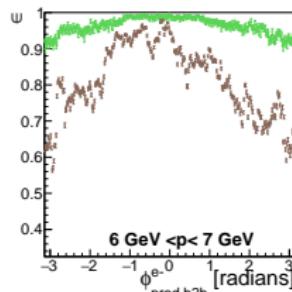
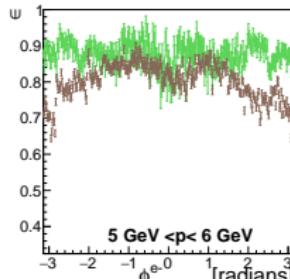
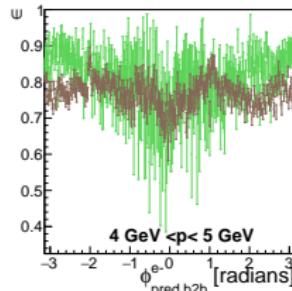
- Phase2 MC has almost always a higher tracking efficiency compared to phase2 data
- For most momenta the biggest difference between phase2 MC and phase2 data occurs for $|\phi_{\text{pred,b2b}}| \gtrsim 2$
- There is no similarity in the structure for momenta between 6 GeV and 7 GeV
- Highest tracking efficiency occurs for momenta between 7 GeV and 8 GeV. But there is also an efficiency drop at $\phi_{\text{pred,b2b}} \gtrsim 0$

Phase2 Tracking Efficiencies As Function Of $\phi_{\text{pred,b2b}}$; Forward End-Cap

Phase2 MC10

Phase2 Data

e⁻



Electron Tracking Efficiency:

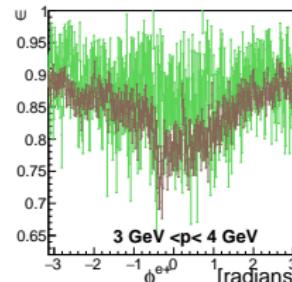
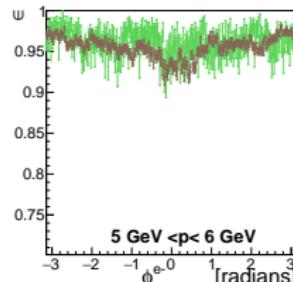
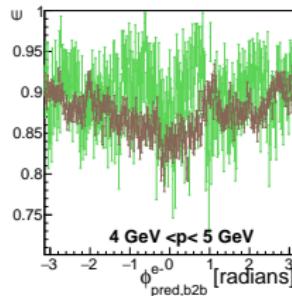
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- For most momenta the biggest difference between phase2 MC and phase2 data occurs for $|\phi_{\text{pred,b2b}}| \gtrsim 2$
- There is no similarity in the structure for momenta between 6 GeV and 7 GeV
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Phase2 Tracking Efficiencies As Function Of $\phi_{\text{pred,b2b}}$; Barrel

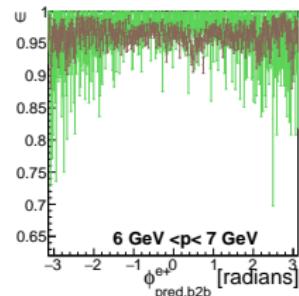
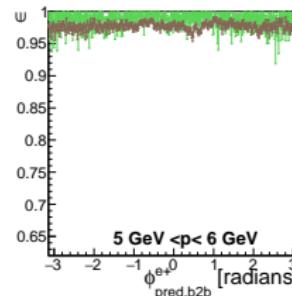
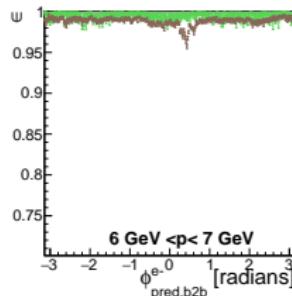
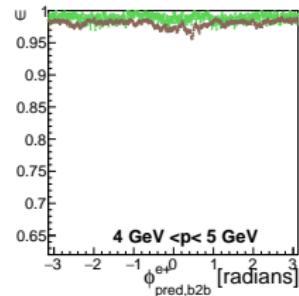
Phase2 MC10

e⁻

Phase2 Data



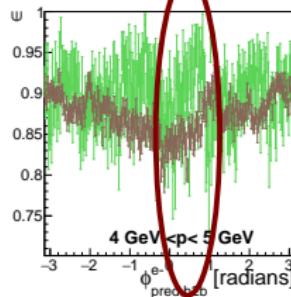
e⁺



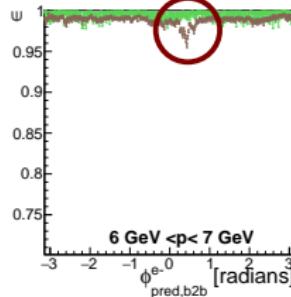
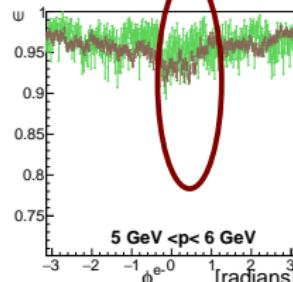
Phase2 Tracking Efficiencies As Function Of $\phi_{\text{pred,b2b}}$; Barrel

Phase2 MC10

Phase2 Data

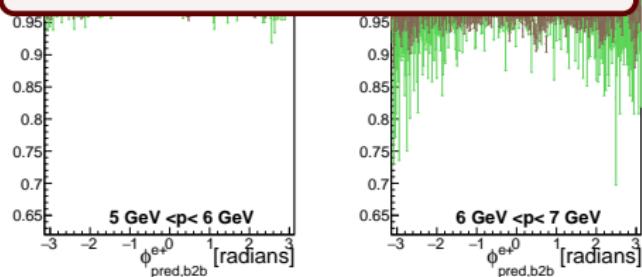


e^-



Electron Tracking Efficiency:

- The highest tracking efficiency occurs for momenta between 6 GeV and 7 GeV
- There is a slope at $\phi_{\text{pred,b2b}} \gtrsim 0$ for phase2 MC and phase2 data

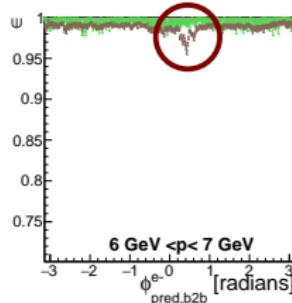
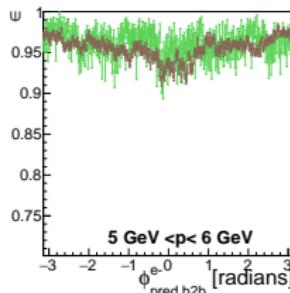
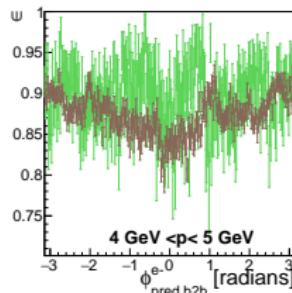


Phase2 Tracking Efficiencies As Function Of $\phi_{\text{pred,b2b}}$; Barrel

Phase2 MC10

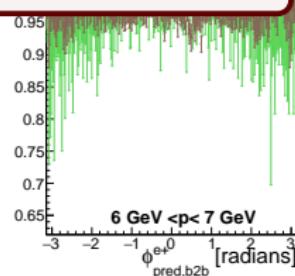
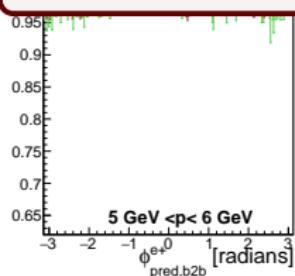
e⁻

Phase2 Data



Electron Tracking Efficiency:

- The highest tracking efficiency occurs for momenta between 6 GeV and 7 GeV
- There is a slope at $\phi_{\text{pred,b2b}} \gtrsim 0$ for phase2 MC and phase2 data
- This kind of drop we also saw in the forward end-cap for momenta between 7 GeV and 8 GeV

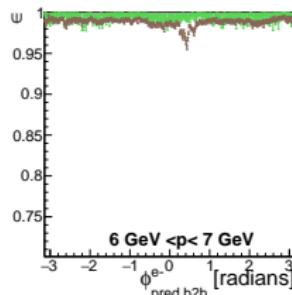
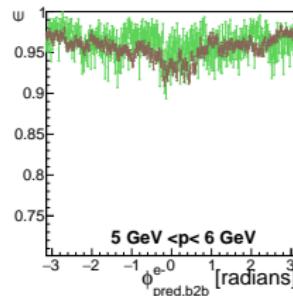
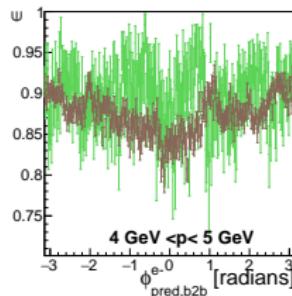


Phase2 Tracking Efficiencies As Function Of $\phi_{\text{pred,b2b}}$; Barrel

Phase2 MC10

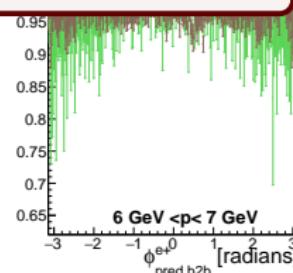
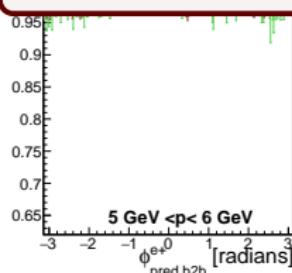
e⁻

Phase2 Data



Electron Tracking Efficiency:

- The highest tracking efficiency occurs for momenta between 6 GeV and 7 GeV
- There is a slope at $\phi_{\text{pred,b2b}} \gtrsim 0$ for phase2 MC and phase2 data
- This kind of drop we also saw in the forward end-cap for momenta between 7 GeV and 8 GeV

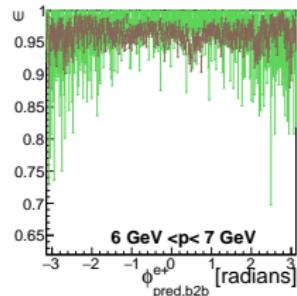
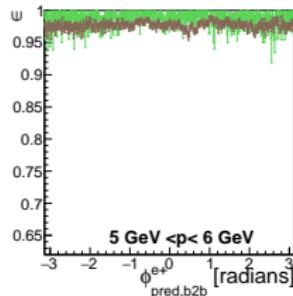
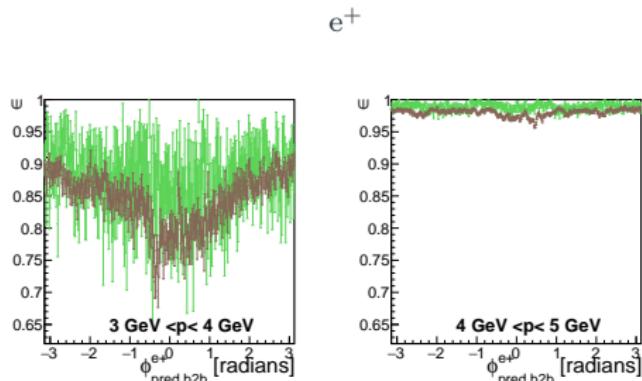
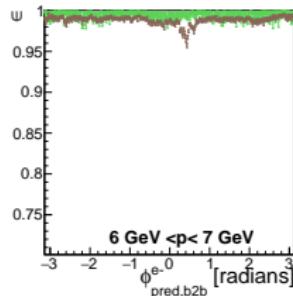


Phase2 Tracking Efficiencies As Function Of $\phi_{\text{pred,b2b}}$; Barrel

Phase2 MC10

Positron Tracking Efficiency:

- The highest tracking efficiency occurs for momenta between 4 GeV and 5 GeV
- The lowest tracking efficiency occurs for momenta between 3 GeV and 4 GeV with a minima at $\phi_{\text{pred,b2b}} \approx 0$

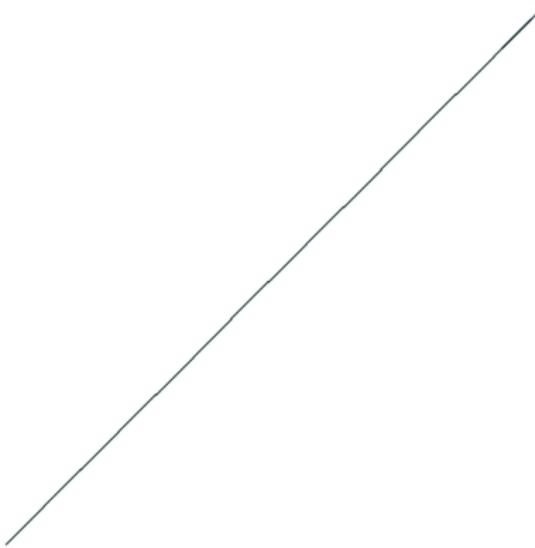


Phase2 Tracking Efficiencies As Function Of $\phi_{\text{pred,b2b}}$; Backward End-Cap

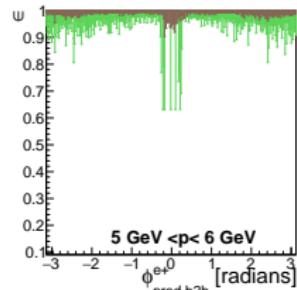
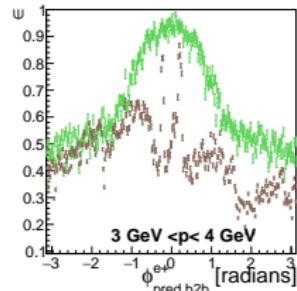
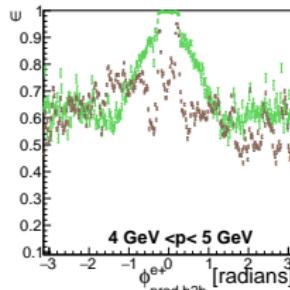
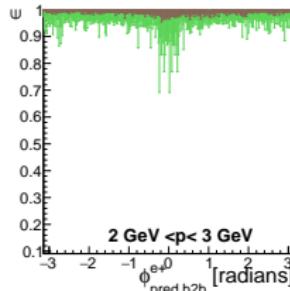
Phase2 MC10

Phase2 Data

e^-



e^+



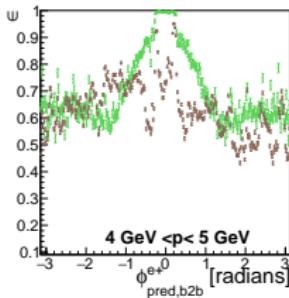
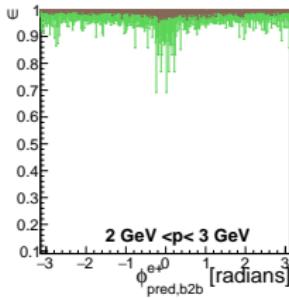
Phase2 Tracking Efficiencies As Function Of $\phi_{\text{pred,b2b}}$; Backward End-Cap

Positron Tracking Efficiency:

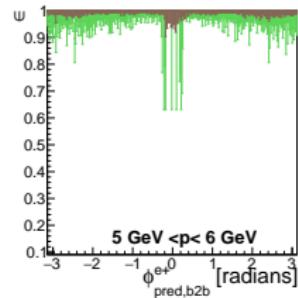
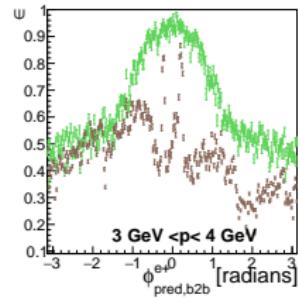
- The highest tracking efficiency occurs for momenta between 2 GeV and 3 GeV and 5 GeV and 6 GeV

Phase2 MC10

Phase2 Data



e^+



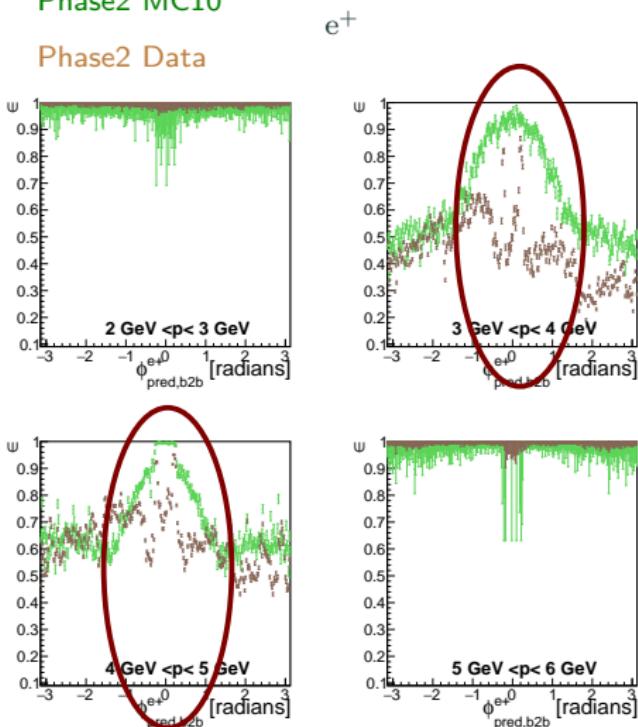
Phase2 Tracking Efficiencies As Function Of $\phi_{\text{pred,b2b}}$; Backward End-Cap

Positron Tracking Efficiency:

- The highest tracking efficiency occurs for momenta between 2 GeV and 3 GeV and 5 GeV and 6 GeV
- Weird *horn* structure we saw earlier
- Phase2 MC tracking efficiency peaks at $\phi_{\text{pred,b2b}} \approx 0$

Phase2 MC10

Phase2 Data



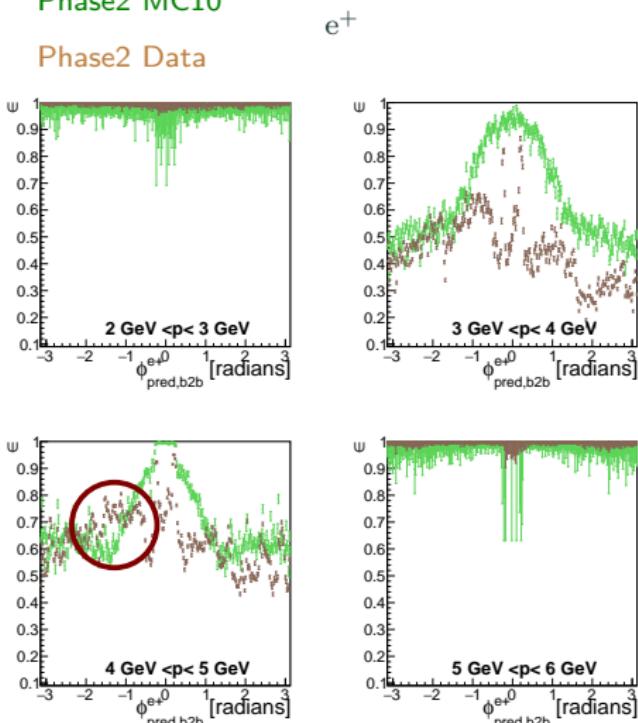
Phase2 Tracking Efficiencies As Function Of $\phi_{\text{pred,b2b}}$; Backward End-Cap

Positron Tracking Efficiency:

- The highest tracking efficiency occurs for momenta between 2 GeV and 3 GeV and 5 GeV and 6 GeV
- Weird *horn* structure we saw earlier
- Phase2 MC tracking efficiency peaks at $\phi_{\text{pred,b2b}} \approx 0$
- For momenta between 4 GeV and 5 GeV phase2 data appears to have a higher tracking efficiency compared to phase2 MC at $\phi_{\text{pred,b2b}} \approx -1$

Phase2 MC10

Phase2 Data

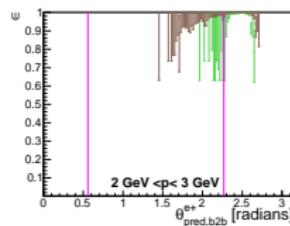
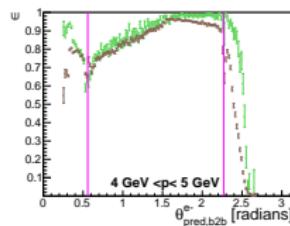
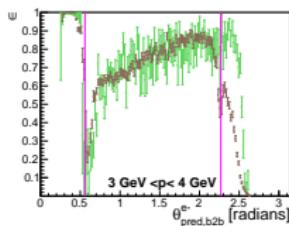


Phase2 Tracking Efficiencies As Function Of $\theta_{\text{pred,b2b}}$

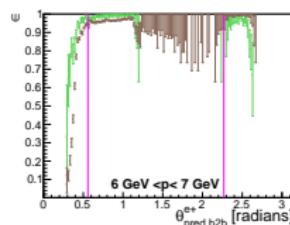
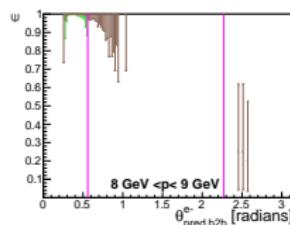
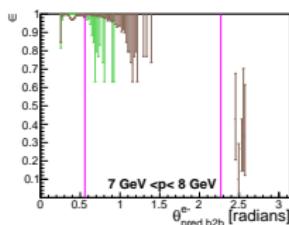
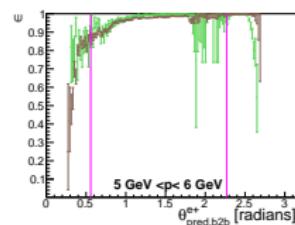
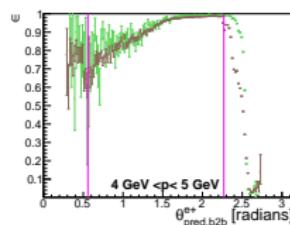
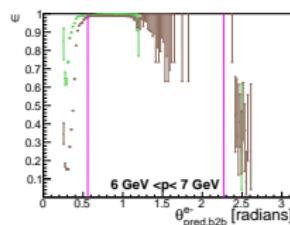
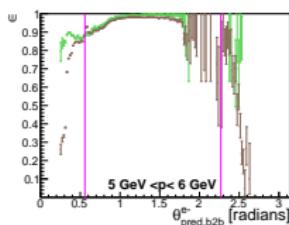
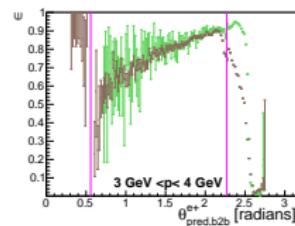
Phase2 MC10

e^-

Phase2 Data



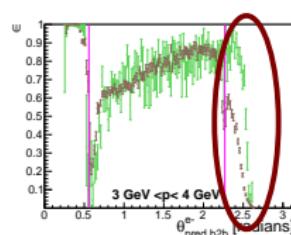
e^+



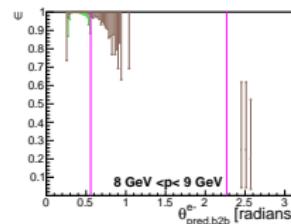
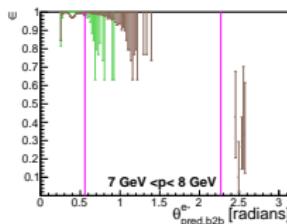
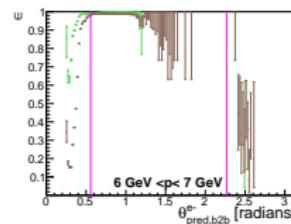
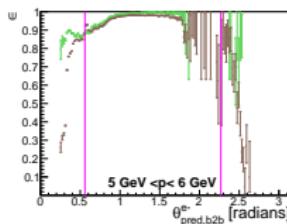
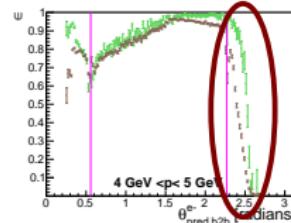
Phase2 Tracking Efficiencies As Function Of $\theta_{\text{pred,b2b}}$

Phase2 MC10

Phase2 Data



e^-



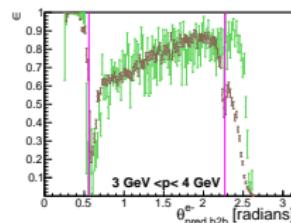
Electron Tracking Efficiency:

- For momenta between 3 GeV and 5 GeV the tracking efficiency in the backward end-cap is worse for phase2 data compared to phase2 MC

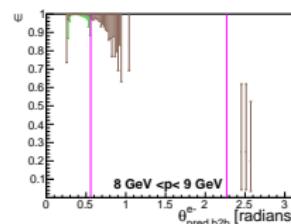
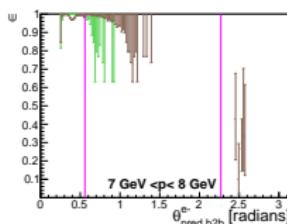
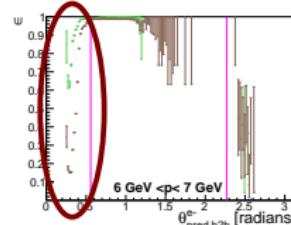
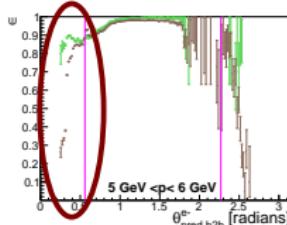
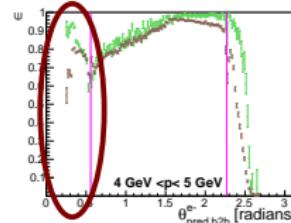
Phase2 Tracking Efficiencies As Function Of $\theta_{\text{pred,b2b}}$

Phase2 MC10

Phase2 Data



e^-



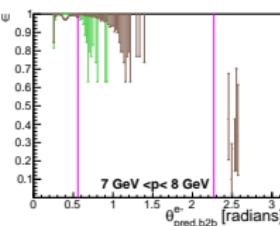
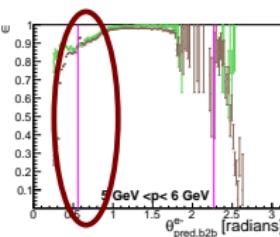
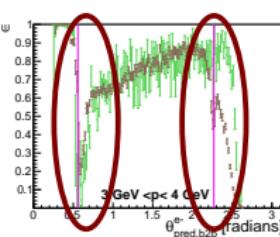
Electron Tracking Efficiency:

- For momenta between 3 GeV and 5 GeV the tracking efficiency in the backward end-cap is worse for phase2 data compared to phase2 MC
- For momenta between 4 GeV and 6 GeV the tracking efficiency in the forward end-cap is worse for phase2 data compared to phase2 MC

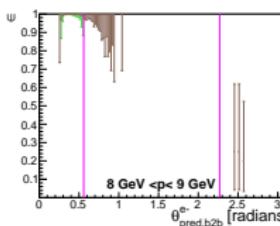
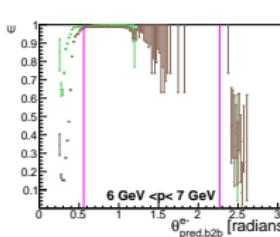
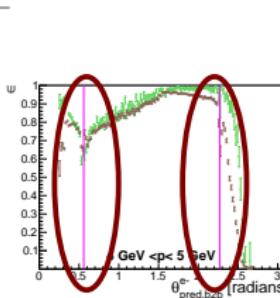
Phase2 Tracking Efficiencies As Function Of $\theta_{\text{pred,b2b}}$

Phase2 MC10

Phase2 Data



e^-



Electron Tracking Efficiency:

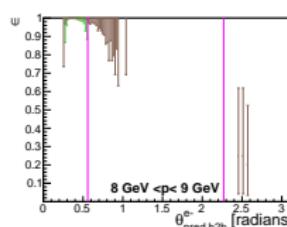
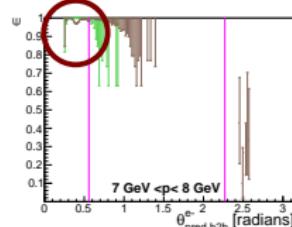
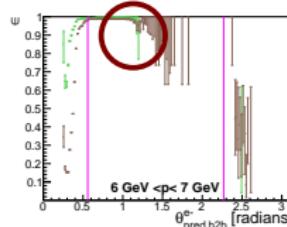
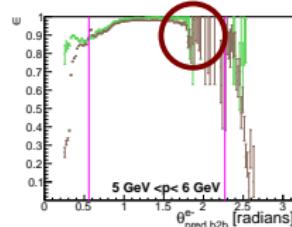
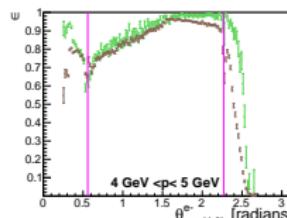
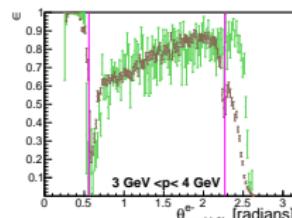
- For momenta between 3 GeV and 5 GeV the tracking efficiency in the backward end-cap is worse for phase2 data compared to phase2 MC
- For momenta between 4 GeV and 6 GeV the tracking efficiency in the forward end-cap is worse for phase2 data compared to phase2 MC
- Drops in efficiency at transition between barrel and end-caps

Phase2 Tracking Efficiencies As Function Of $\theta_{\text{pred,b2b}}$

Phase2 MC10

Phase2 Data

e⁻



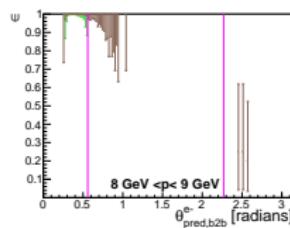
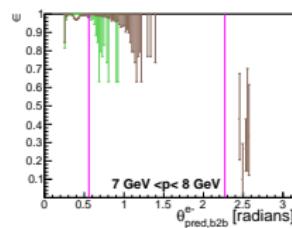
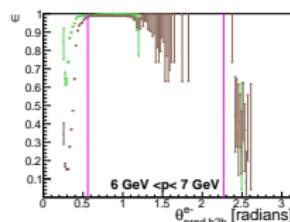
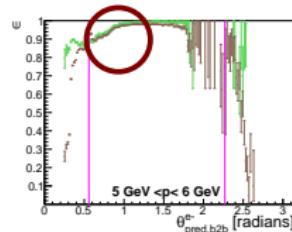
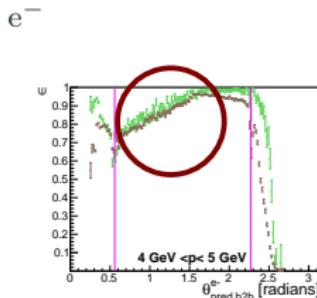
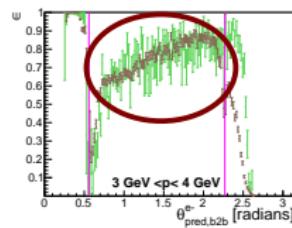
Electron Tracking Efficiency:

- For momenta between 3 GeV and 5 GeV the tracking efficiency in the backward end-cap is worse for phase2 data compared to phase2 MC
- For momenta between 4 GeV and 6 GeV the tracking efficiency in the forward end-cap is worse for phase2 data compared to phase2 MC
- Drops in efficiency at transition between barrel and end-caps
- A efficiency drop appears to propagate for momenta between 5 GeV and 7 GeV for phase2 data

Phase2 Tracking Efficiencies As Function Of $\theta_{\text{pred,b2b}}$

Phase2 MC10

Phase2 Data



Electron Tracking Efficiency:

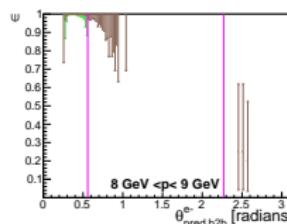
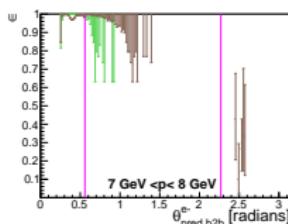
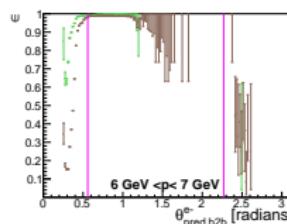
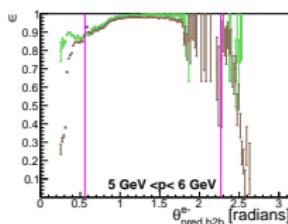
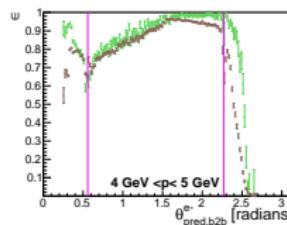
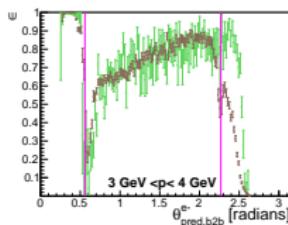
- For momenta between 3 GeV and 5 GeV the tracking efficiency in the backward end-cap is worse for phase2 data compared to phase2 MC
- For momenta between 4 GeV and 6 GeV the tracking efficiency in the forward end-cap is worse for phase2 data compared to phase2 MC
- Drops in efficiency at transition between barrel and end-caps
- A efficiency drop appears to propagate for momenta between 5 GeV and 7 GeV for phase2 data
- There is a slope in the barrel

Phase2 Tracking Efficiencies As Function Of $\theta_{\text{pred,b2b}}$

Phase2 MC10

Phase2 Data

e⁻



Electron Tracking Efficiency:

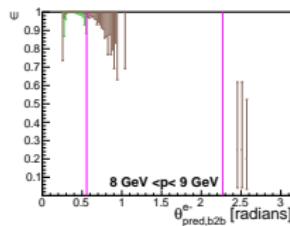
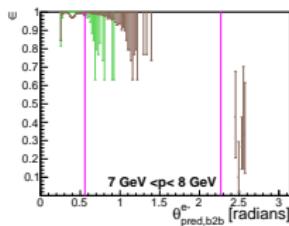
Phase2 Tracking Efficiencies As Function Of $\theta_{\text{pred,b2b}}$

Positron Tracking Efficiency:

Phase2 MC10

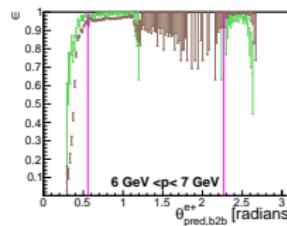
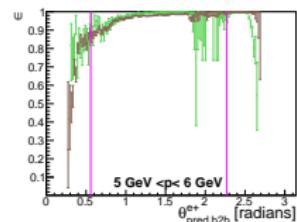
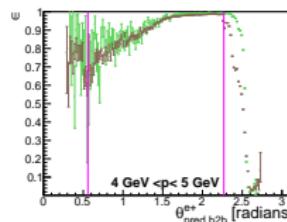
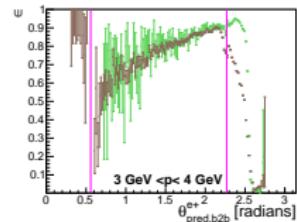
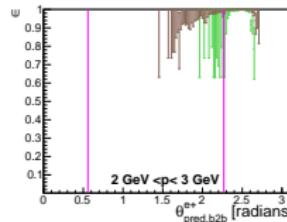
Phase2 Data

e⁺



Phase2 MC10

Phase2 Data



Phase2 Tracking Efficiencies As Function Of $\theta_{\text{pred,b2b}}$

Positron Tracking Efficiency:

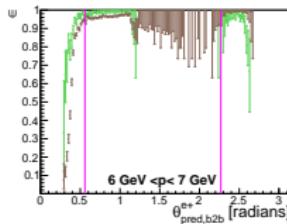
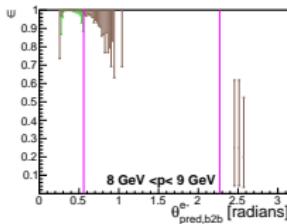
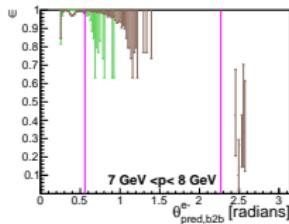
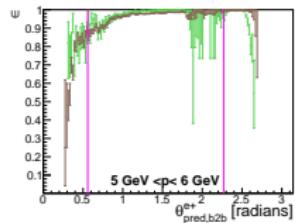
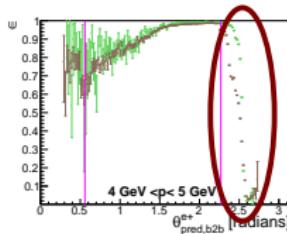
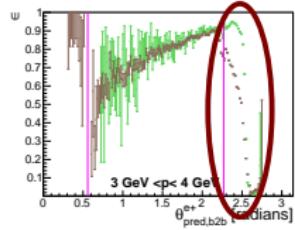
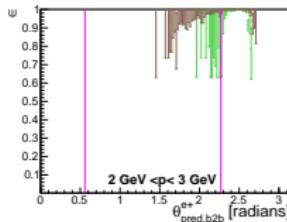
- For momenta between 3 GeV and 5 GeV the phase2 data tracking efficiency is lower compared to phase2 MC in the backward end-cap

Phase2 MC10 Phase2 Data

Phase2 MC10

Phase2 Data

e⁺



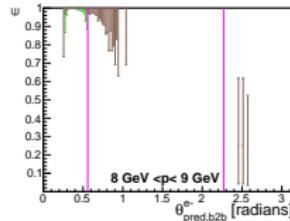
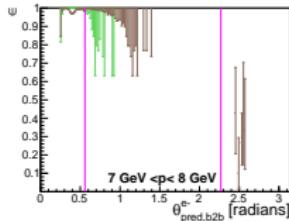
Phase2 Tracking Efficiencies As Function Of $\theta_{\text{pred,b2b}}$

Positron Tracking Efficiency:

- For momenta between 3 GeV and 5 GeV the phase2 data tracking efficiency is lower compared to phase2 MC in the backward end-cap
- For momenta between 5 GeV and 7 GeV it is vice versa

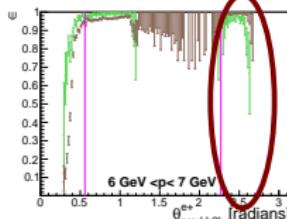
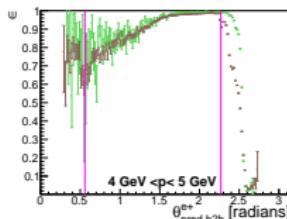
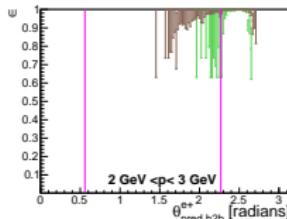
phase2MC10

phase2Data

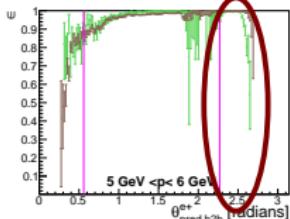
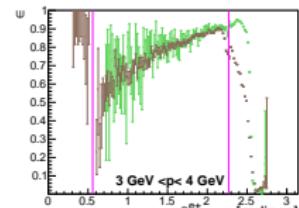


Phase2 MC10

Phase2 Data



e⁺



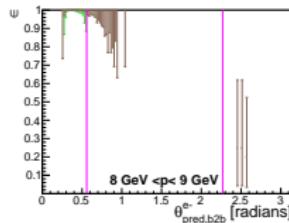
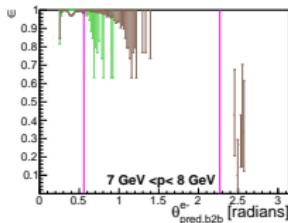
Phase2 Tracking Efficiencies As Function Of $\theta_{\text{pred,b2b}}$

Positron Tracking Efficiency:

- For momenta between 3 GeV and 5 GeV the phase2 data tracking efficiency is lower compared to phase2 MC in the backward end-cap
- For momenta between 5 GeV and 7 GeV it is vice versa
- Efficiency drop at transition between barrel and end-caps

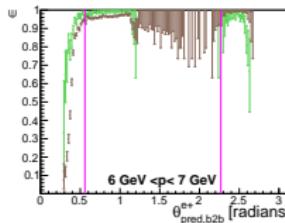
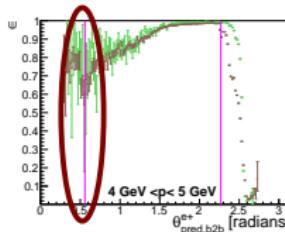
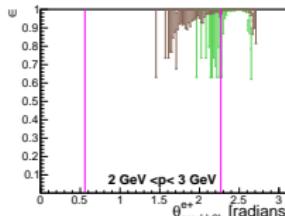
phase2MC

phase2Data

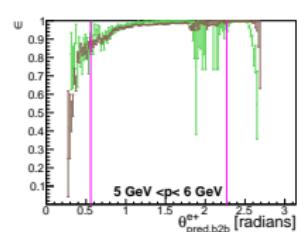
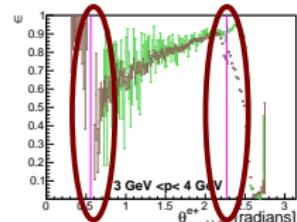


Phase2 MC10

Phase2 Data



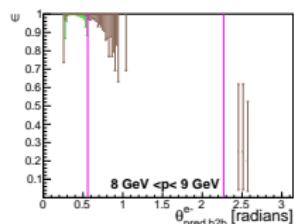
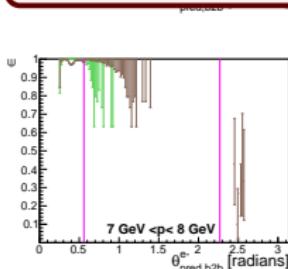
e⁺



Phase2 Tracking Efficiencies As Function Of $\theta_{\text{pred,b2b}}$

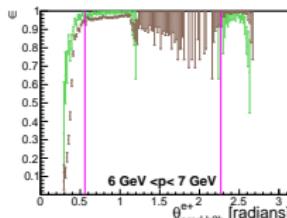
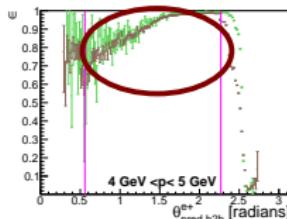
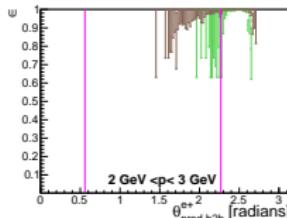
Positron Tracking Efficiency:

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- For momenta between 5 GeV and 7 GeV it is vice versa
- Efficiency drop at transition between barrel and end-caps
- There is a slope in the barrel again

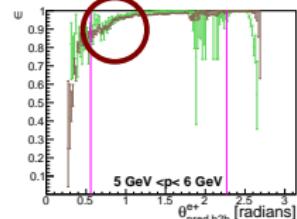
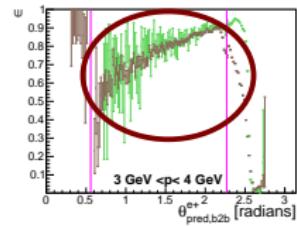


Phase2 MC10

Phase2 Data



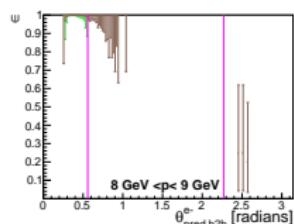
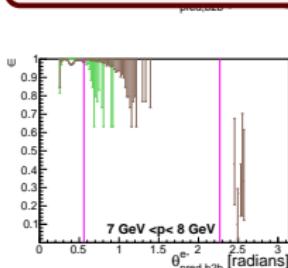
e⁺



Phase2 Tracking Efficiencies As Function Of $\theta_{\text{pred,b2b}}$

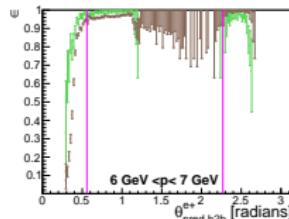
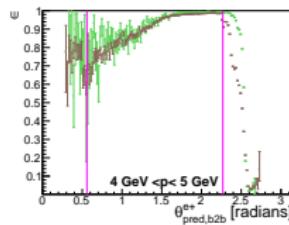
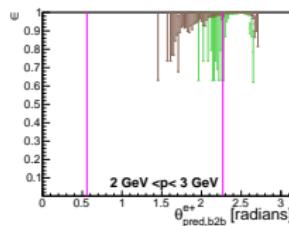
Positron Tracking Efficiency:

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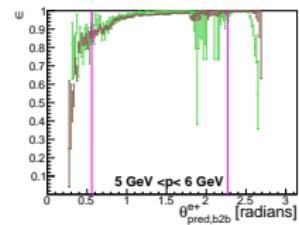
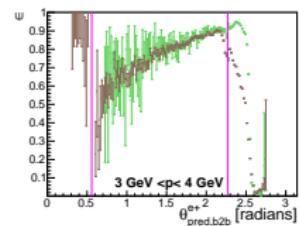


Phase2 MC10

Phase2 Data



e⁺



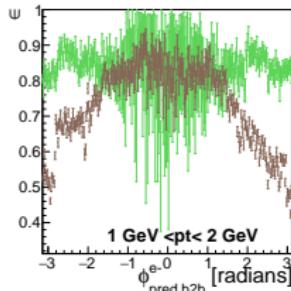
Transverse Momentum

Phase2 pt Tracking Efficiencies As Function Of $\phi_{\text{pred,b2b}}$; Forward End-Cap

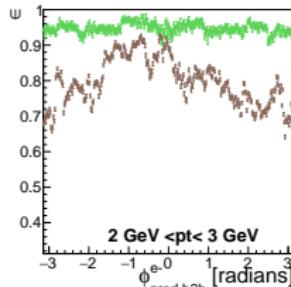
Phase2 MC10

Phase2 Data

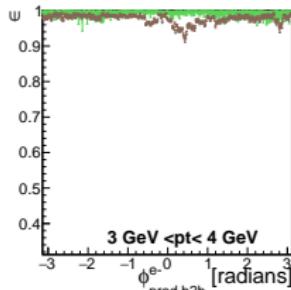
e^-



$1 \text{ GeV} < p_t < 2 \text{ GeV}$

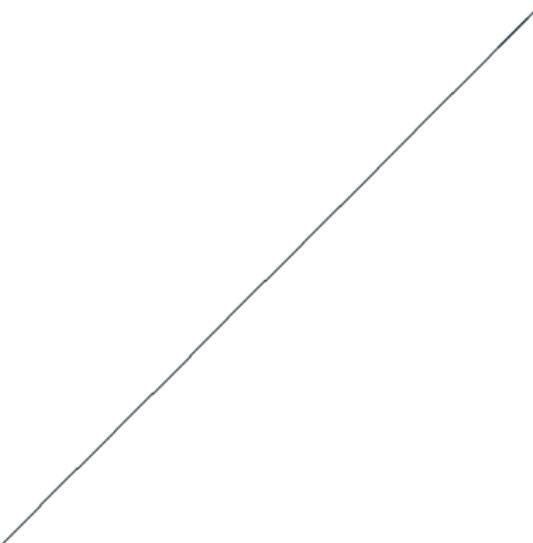


$2 \text{ GeV} < p_t < 3 \text{ GeV}$



$3 \text{ GeV} < p_t < 4 \text{ GeV}$

e^+

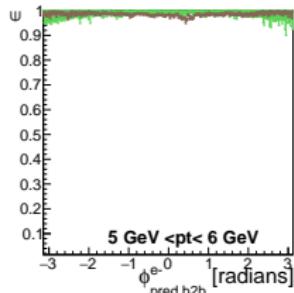
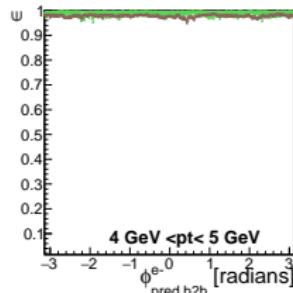
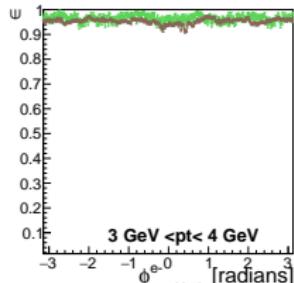
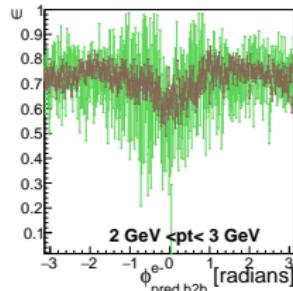


Phase2 pt Tracking Efficiencies As Function Of $\phi_{\text{pred,b2b}}$; Barrel

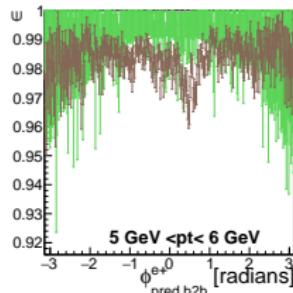
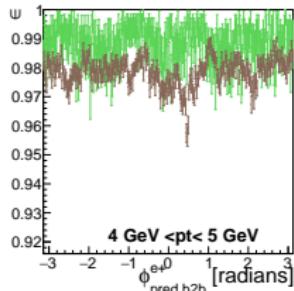
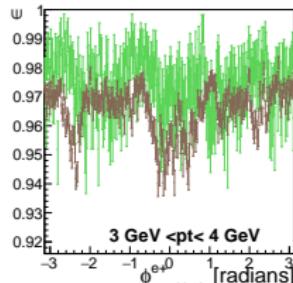
Phase2 MC10

e⁻

Phase2 Data



e⁺

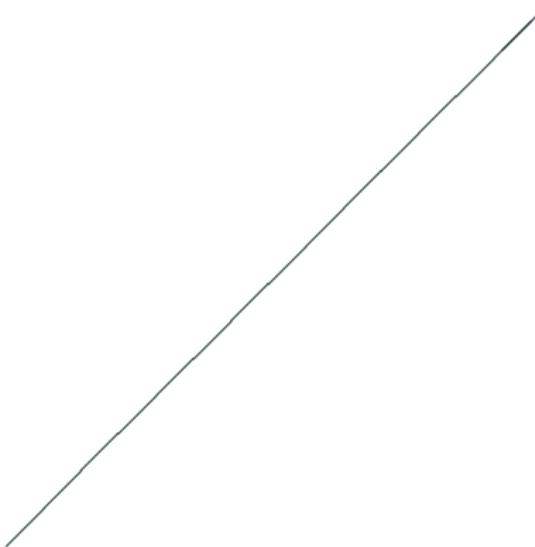


Phase2 pt Tracking Efficiencies As Function Of $\phi_{\text{pred,b2b}}$; Backward End-Cap

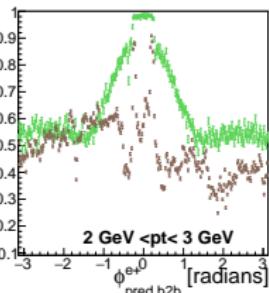
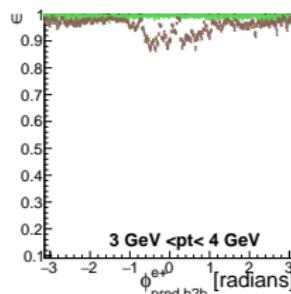
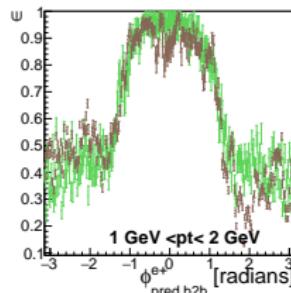
Phase2 MC10

e^-

Phase2 Data



e^+

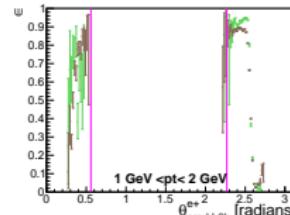
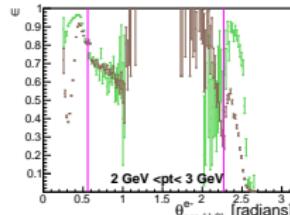
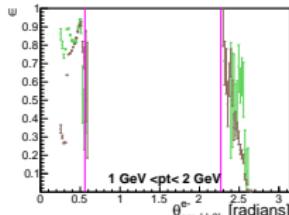


Phase2 pt Tracking Efficiencies As Function Of $\theta_{\text{pred,b2b}}$

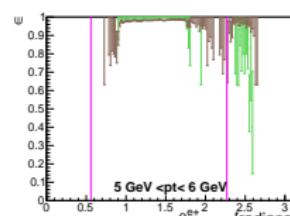
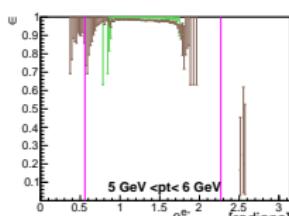
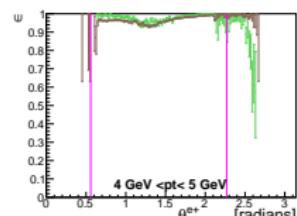
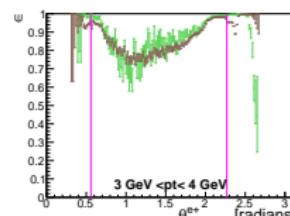
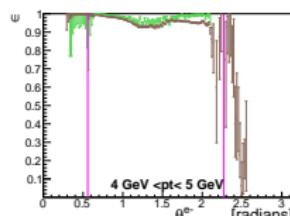
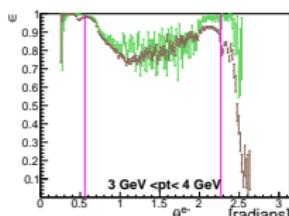
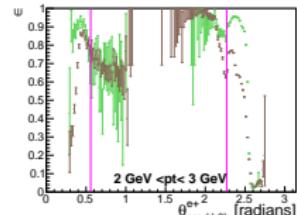
Phase2 MC10

e^-

Phase2 Data



e^+

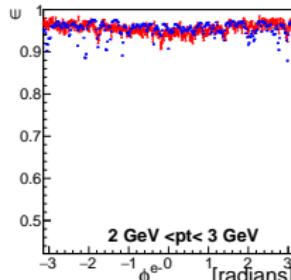
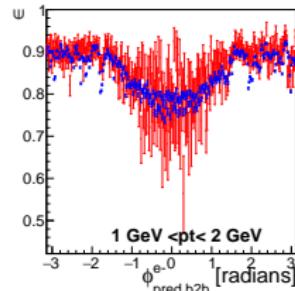


Phase3 pt Tracking Efficiencies As Function Of $\phi_{\text{pred,b2b}}$; Forward End-Cap

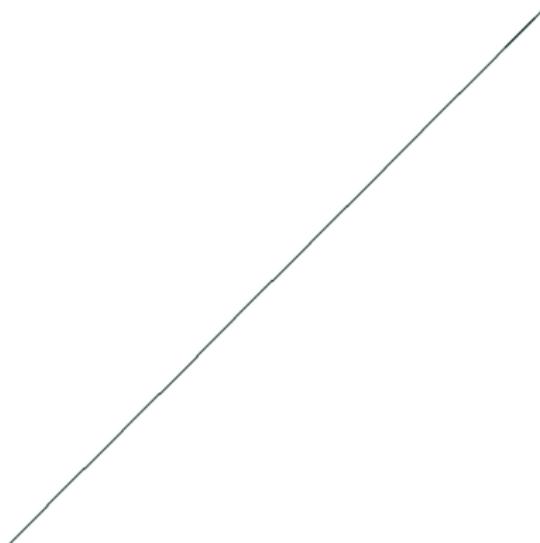
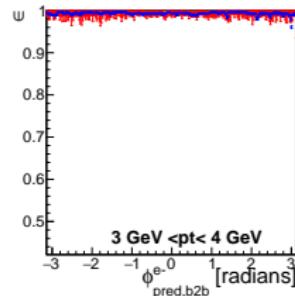
Phase3 MC10

Phase3 Data

e⁻



e⁺

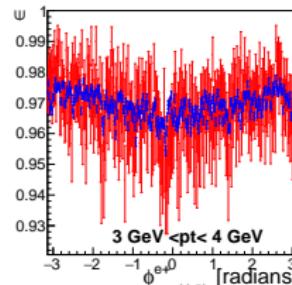
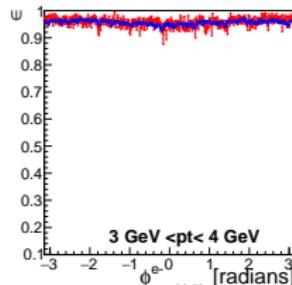
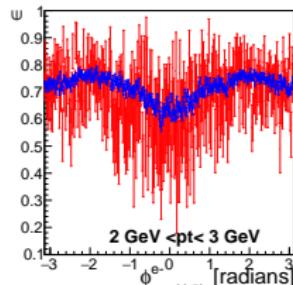


Phase3 pt Tracking Efficiencies As Function Of $\phi_{\text{pred,b2b}}$; Barrel

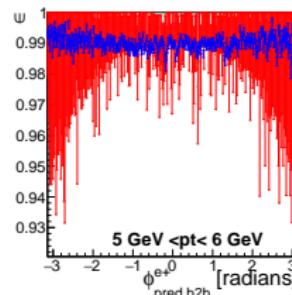
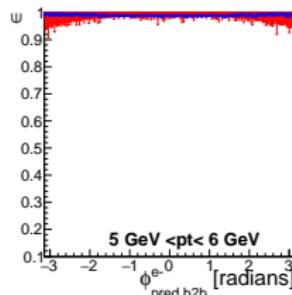
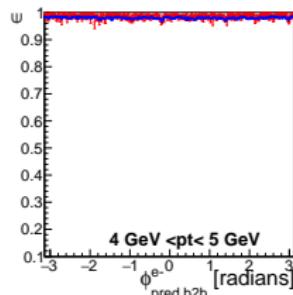
Phase3 MC10

e⁻

Phase3 Data



e⁺

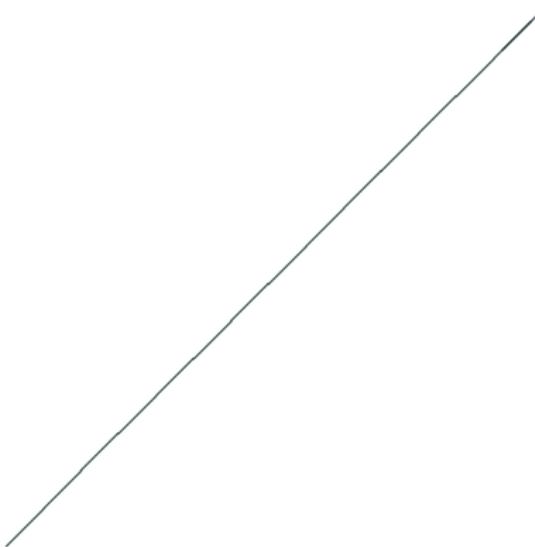


Phase3 pt Tracking Efficiencies As Function Of $\phi_{\text{pred,b2b}}$; Backward End-Cap

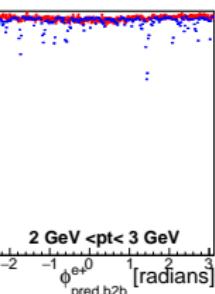
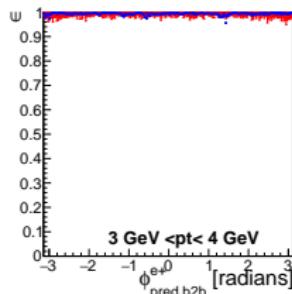
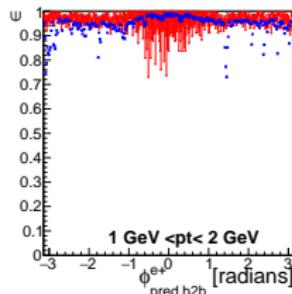
Phase3 MC10

e^-

Phase3 Data



e^+

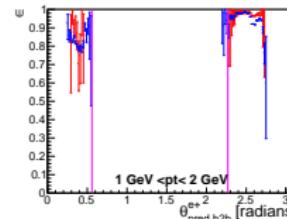
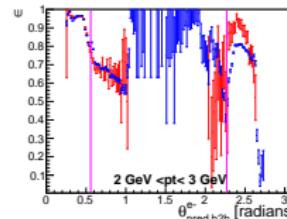
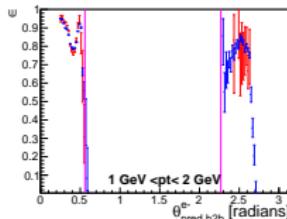


Phase3 pt Tracking Efficiencies As Function Of $\theta_{\text{pred,b2b}}$

Phase3 MC10

e⁻

Phase3 Data



e⁺

