Systematic Studies On Track Reconstruction Efficiency At Belle II

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Outline

- Overview on the Belle II experiment
- Bhabha kinematics at Belle II
- Preparation for calculating the tracking efficiency
- Phase3 tracking efficiency
- Comparing the phase2 with phase3 tracking efficiency
- Conclusion

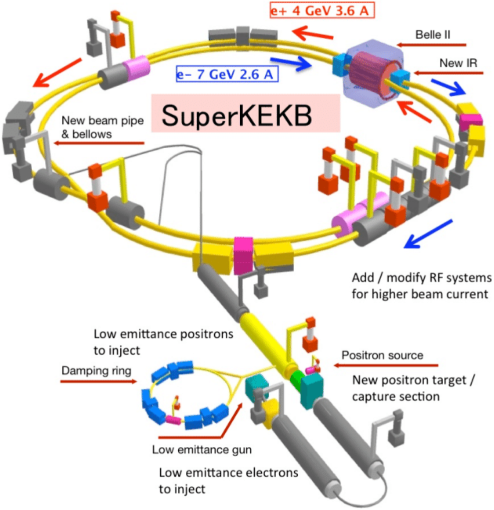
Motivation

- At an electron-positron accelerator most outgoing particles are again electrons and positrons (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 has a track than the *probe* particle also should have a track associated
  $\rightarrow$ a tracking efficiency can be calculated

Overview Of The Belle II Experiment

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

- Asymmetric *B*-factory
- Center-of-mass close to $\Upsilon(4S) \sim 10.58\,\mathrm{GeV}$
- Upgrade of the KEKB collider:
  - Larger beam currents
  - Reduced beam size



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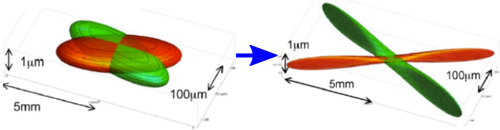

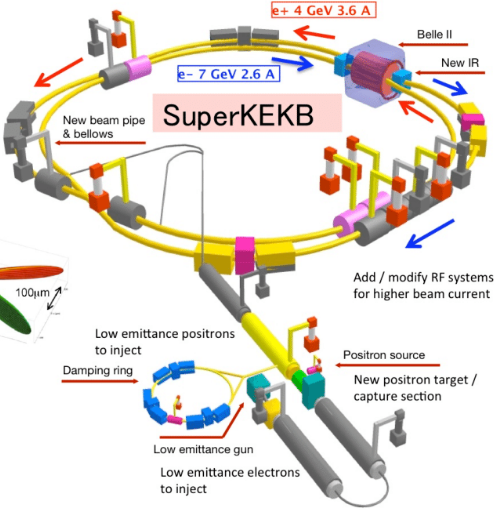

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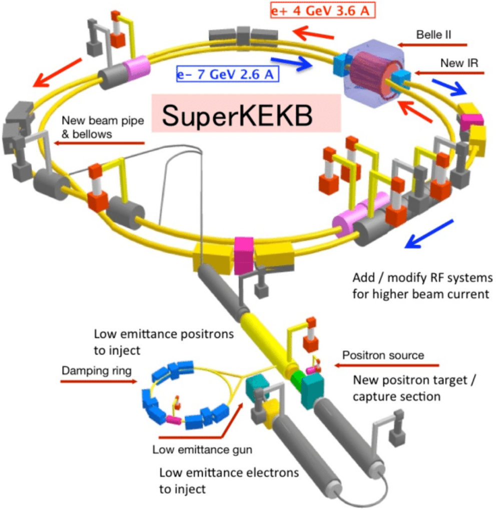
- $\rightarrow$ Luminosity increase x40



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

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- Upgrade of the KEKB collider:
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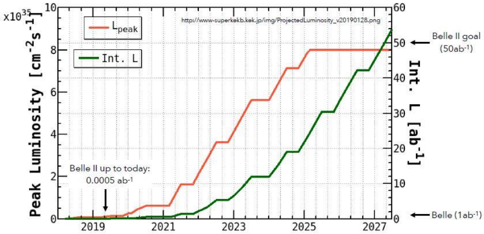
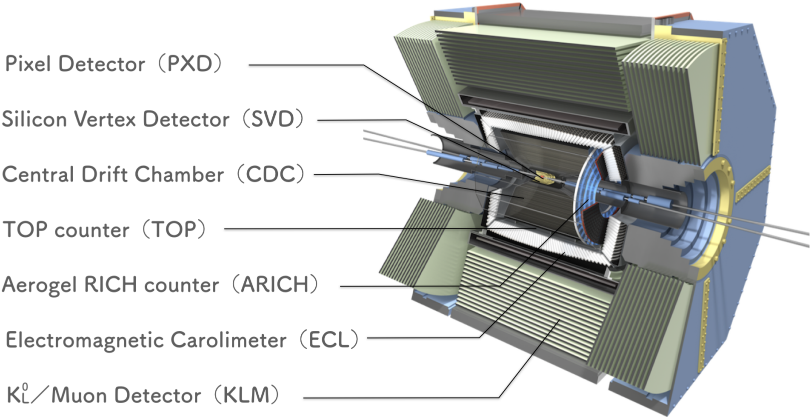
- $\rightarrow$ Luminosity increase x40
- Designed peak luminosity of $8 \cdot 10^{35}\,\mathrm{cm}^{-2}\mathrm{s}^{-1}$
- Planned data sample corresponding to a recorded integrated luminosity of $\sim 50\,\mathrm{ab}^{-1}$



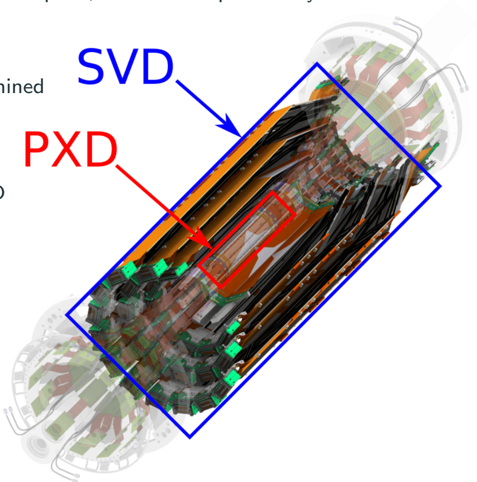
- Phase1: accelerator commissioning and background estimation (completed in 2016)
- Phase2: collision runs and background studies with partially installed detector (completed in 2018)
- Phase3: data taking with the whole detector (started in April 2019)


Pixel Detector（PXD）
Silicon Vertex Detector（SVD）
Central Drift Chamber（CDC）
TOP counter（TOP）
Aerogel RICH counter（ARICH）
Electromagnetic Carolimeter（ECL）
K_L^0／Muon Detector（KLM）

Vertex Detectors

Vertex Detectors (VXD):

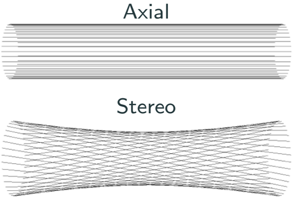
- Consist of Pixel Detector (PXD) and Silicon Vertex Detector (SVD)
- Both detectors consist of multiple ladders of strip detectors
- Charged particles create electron-hole pairs, which are separated by an electric field
  The signal is then read out
  $\rightarrow$ particle position can be determined
- During phase2, only a fraction of the VXD detectors were installed
- During phase3, the complete SVD and roughly half of the PXD are installed
- Acceptance: $17.0^{\circ} < \theta < 150.0^{\circ}$

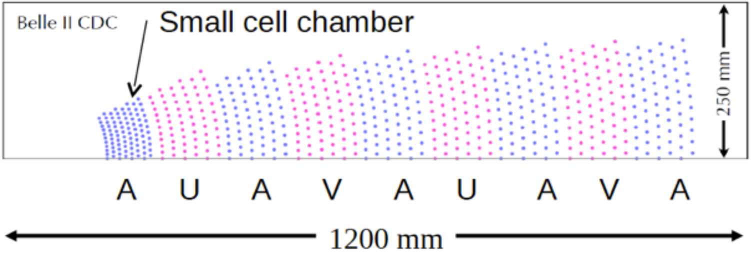


Central Drift Chamber:

- 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)
- Charged particles ionize the gas
  The signal is then read out by the sense wires

  $\rightarrow$ Determination of momenta and tracks of charged particles
- Acceptance: $17.0^\circ < \theta < 150.0^\circ$





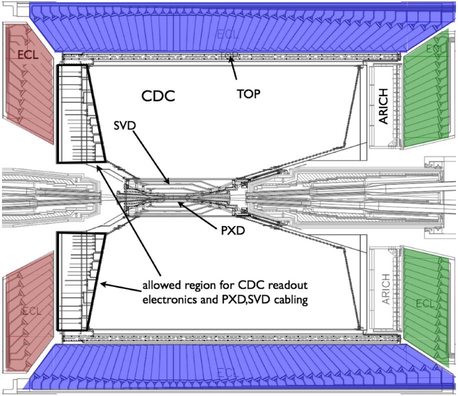
Electromagnetic Calorimeter

Electromagnetic Calorimeter:

- Consists of 8936 CsI(Tl) crystals
- Electromagnetically interacting particles are creating electromagnetic cascades when they pass through the crystals

  $\rightarrow$ clusters are created

  $\rightarrow$ 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

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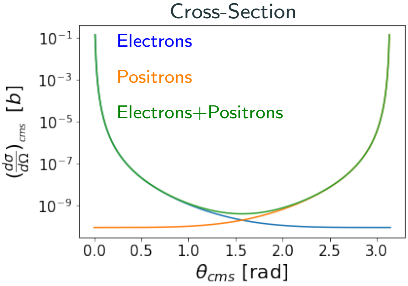
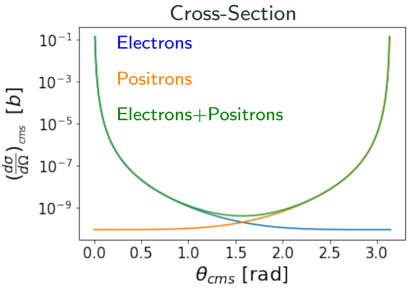
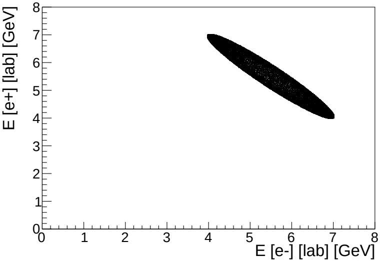
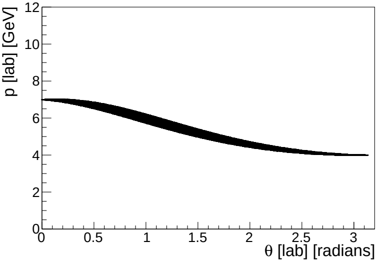


Bhabha Kinematics At Belle II



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





Preparation For Calculating The Tracking Efficiency

Introducing Cuts

Goal: 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

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Goal: Reconstruct Bhabha events using only ECL information

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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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- $8\,\mathrm{GeV} < \mathrm{M_{vpho}} < 12\,\mathrm{GeV}$
- 2 clusters with at least $3.5\,\mathrm{GeV}$ per event; One cluster has to have at least $4.5\,\mathrm{GeV}$
- Number of reconstructed tracks per event < 7
- Total energy in the ECL $< 15\,\mathrm{GeV}$

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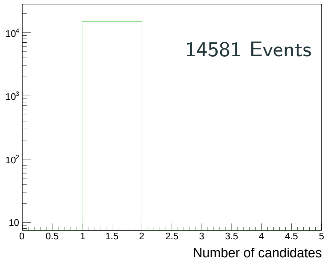
Single phase2 MC10 Bhabha file



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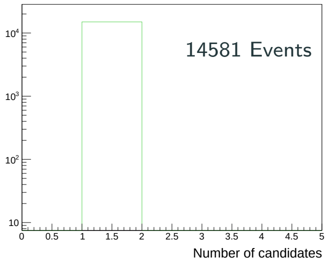
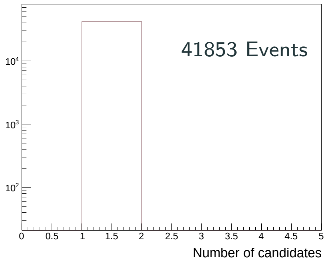


Single phase2 data file



Introducing Cuts

Goal: Reconstruct Bhabha events using only ECL information

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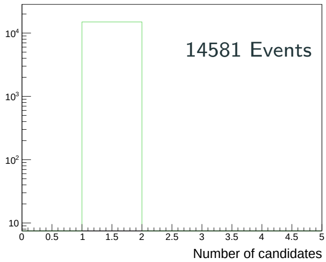
- The particles have to pass the tracking detectors
  $\rightarrow 17.0° < \theta_{\text{ECL-Object}} < 150.0°$
- $8\,\mathrm{GeV} < \mathrm{M}_{\text{vpho}} < 12\,\mathrm{GeV}$
- 2 clusters with at least 3.5 GeV per event; One cluster has to have at least 4.5 GeV
- Number of reconstru
- Total energy in the E

Also contains $\mathrm{ee} \rightarrow \gamma\gamma$ events

Single phase2 MC10 Bhabha file



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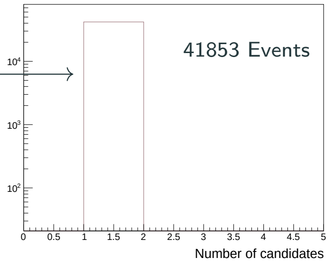
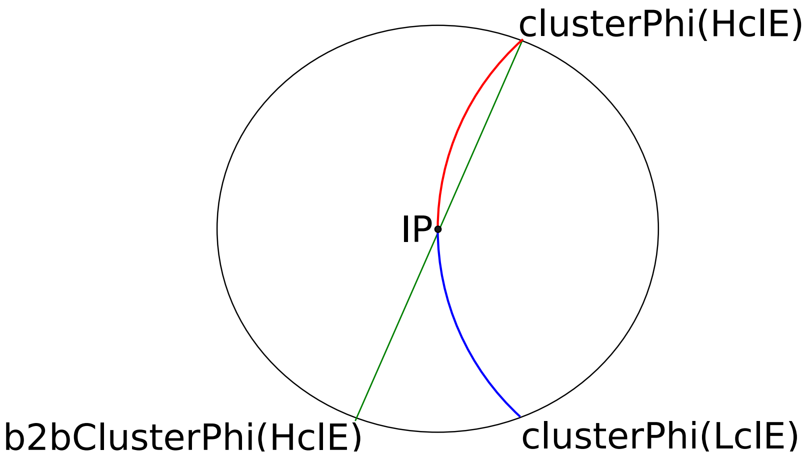
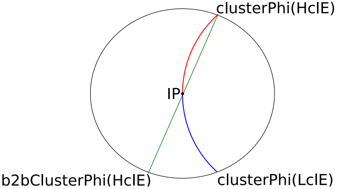
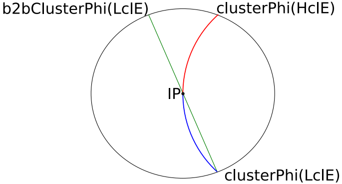
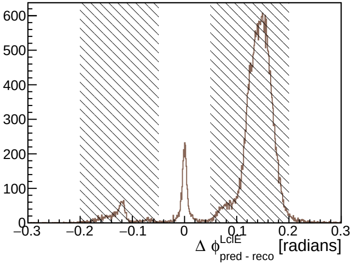


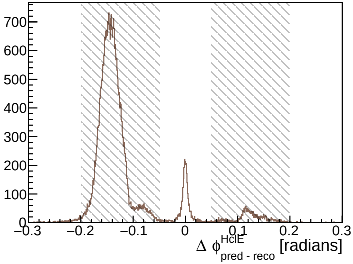

clusterPhi(HclE)
IP
b2bClusterPhi(HclE)
clusterPhi(LclE)

Bhabha Event Selection

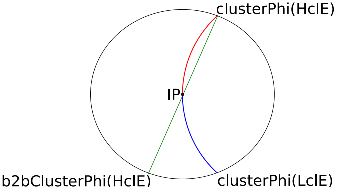


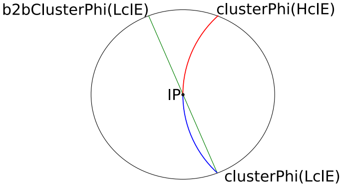


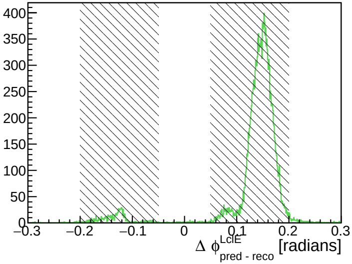


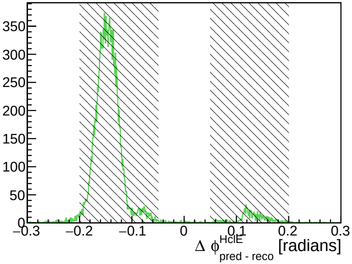


Bhabha Event Selection









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

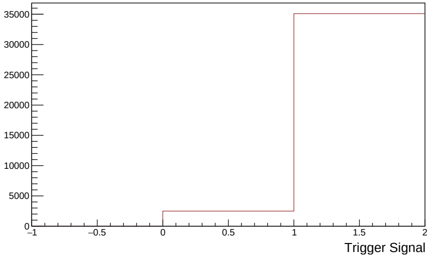
Otherwise there could be a bias

$\rightarrow$ 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
- $160^\circ < \sum \theta_{cms} < 200^\circ$
- $140^\circ < \Delta\phi_{cms} < 220^\circ$

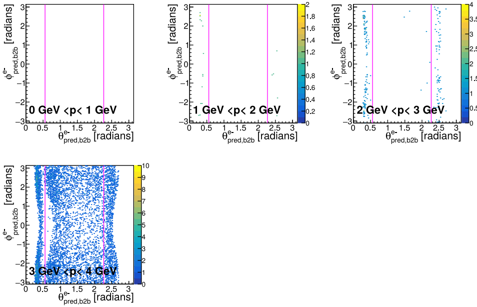
The trigger cut will not be applied to MC since the trigger simulation does not work reliably on MC



Dividing The ECL In Areas Of Interest

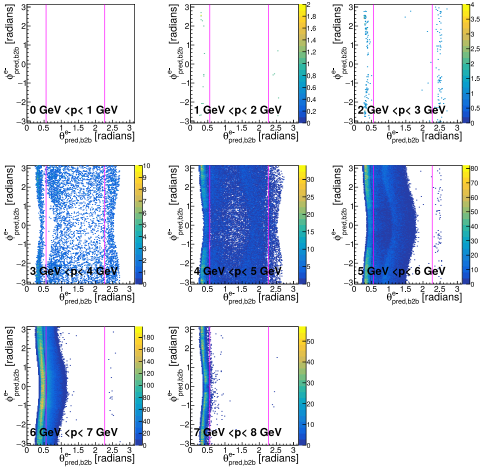
As function of azimuthal angle $\phi_{\mathrm{pred,b2b}}$

	$\mathrm{p(e^-)}$
Forward End-Cap	
Barrel	
Backward End-Cap	



As function of azimuthal angle $\phi_{\text{pred,b2b}}$

	$\mathrm{p(e^-)}$
Forward End-Cap	$4\,\mathrm{GeV} - 8\,\mathrm{GeV}$
Barrel	$4\,\mathrm{GeV} - 7\,\mathrm{GeV}$
Backward End-Cap	/



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As function of azimuthal angle $\phi_{\text{pred,b2b}}$

	$\text{p}(\mathrm{e}^-)$
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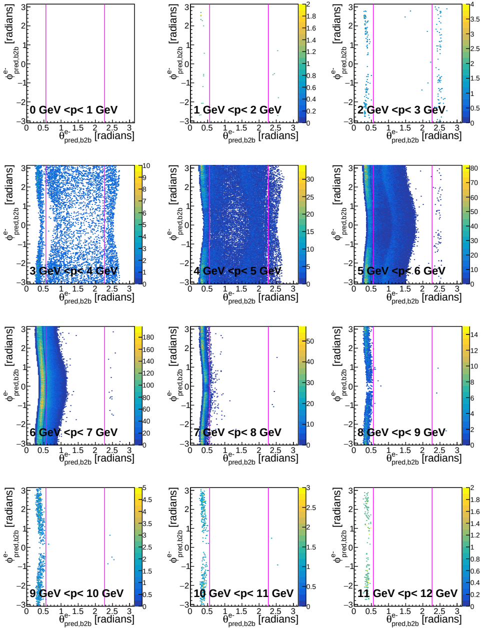
Barrel	$4\,\text{GeV} - 7\,\text{GeV}$
Backward End-Cap	/



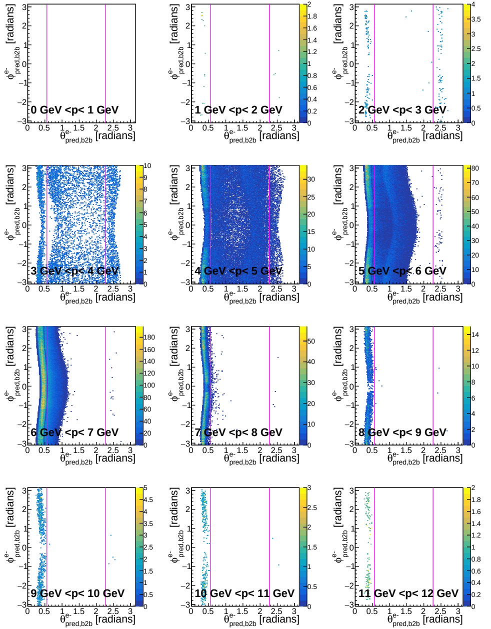
Dividing The ECL In Areas Of Interest

As function of azimuthal angle $\phi_{\text{pred,b2b}}$

	$p(e^-)$
Forward End-Cap	$4\,\text{GeV} - 8\,\text{GeV}$
Barrel	$4\,\text{GeV} - 7\,\text{GeV}$
Backward End-Cap	/

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

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



Dividing The ECL In Areas Of Interest

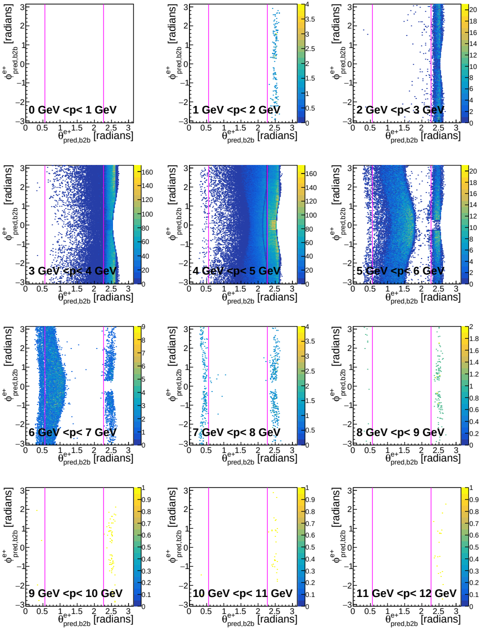
As function of azimuthal angle $\phi_{\text{pred,b2b}}$

	p(e^-)
Forward End-Cap	$4\,\text{GeV} - 8\,\text{GeV}$
Barrel	$4\,\text{GeV} - 7\,\text{GeV}$
Backward End-Cap	/

	p(e^+)
Forward End-Cap	/
Barrel	$3\,\text{GeV} - 7\,\text{GeV}$
Backward End-Cap	$2\,\text{GeV} - 6\,\text{GeV}$

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

	p
e^-	$4\,\text{GeV} - 9\,\text{GeV}$
e^+	$2\,\text{GeV} - 7\,\text{GeV}$



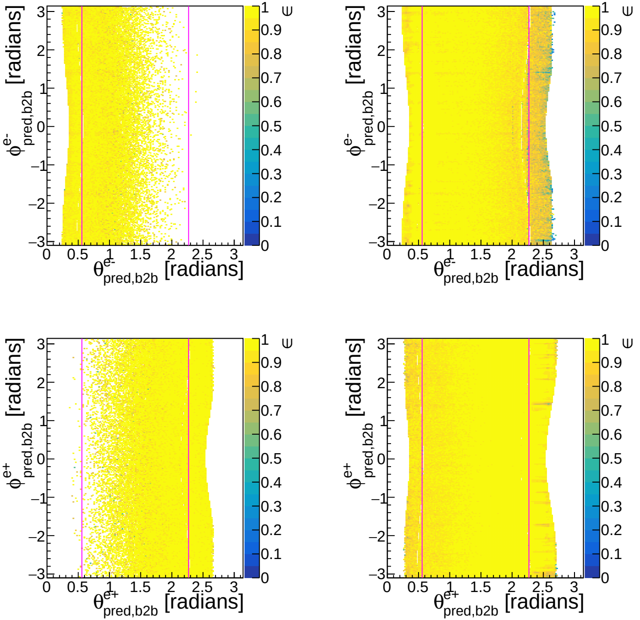
Phase3 Tracking Efficiencies

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

MC | Data

e^-

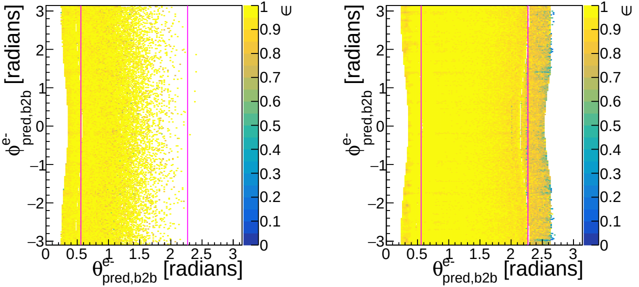
e^+



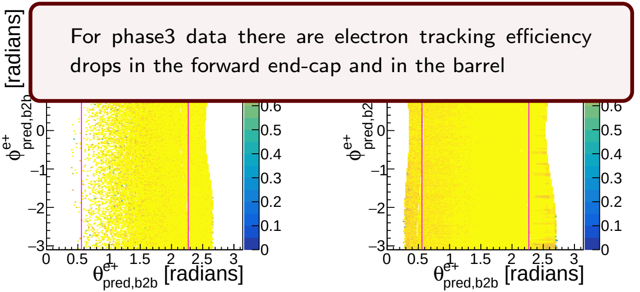
Phase3 Tracking Efficiencies As Function Of $\theta_{\mathbf{pred,b2b}} - \phi_{\mathbf{pred,b2b}}$

MC Data

e^-



e^+

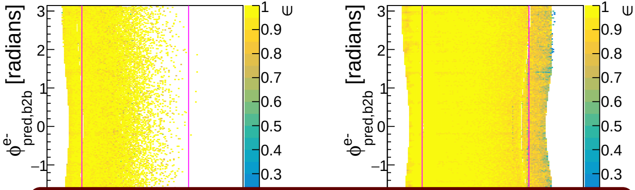


For phase3 data there are electron tracking efficiency drops in the forward end-cap and in the barrel

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

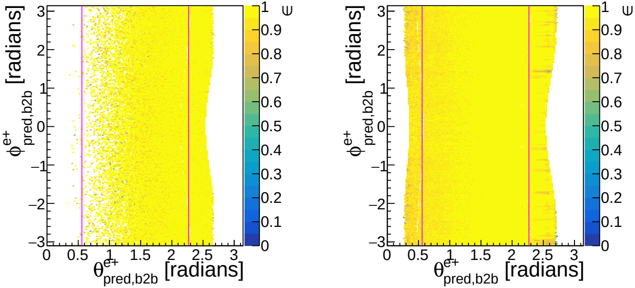
MC | Data

e^-



The same kind of drops are also visible in the positron tracking efficiency in the backward end-cap

e^+

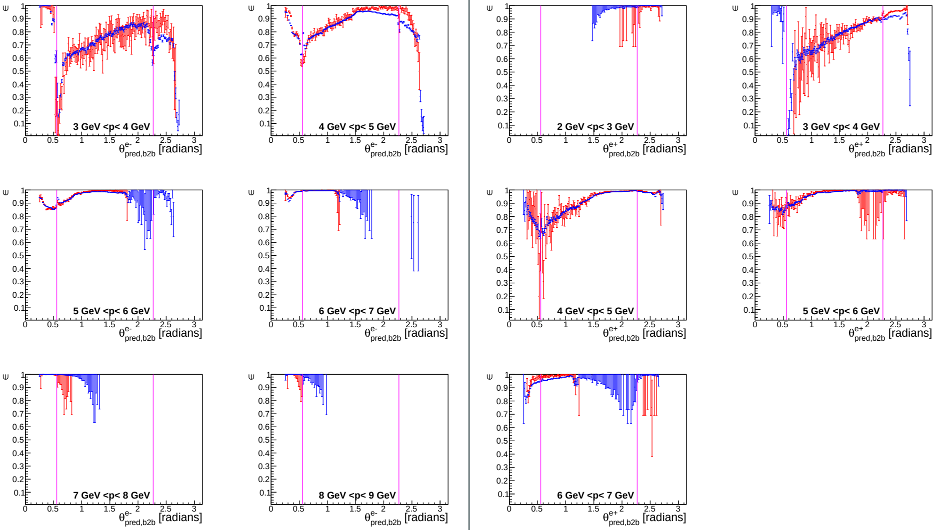


Phase3 Tracking Efficiencies As Function Of $\theta_{\mathrm{pred,b2b}}$

Phase3 MC10

Phase3 Data

e^- e^+

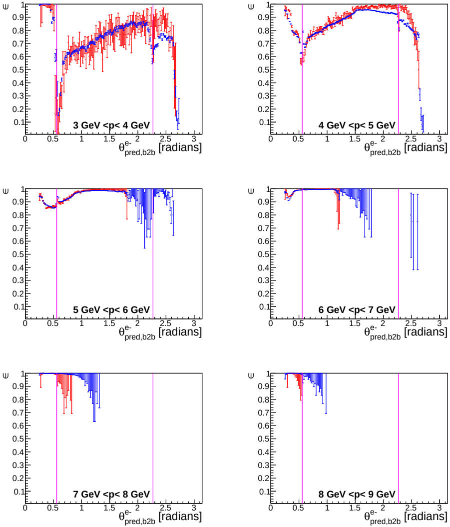


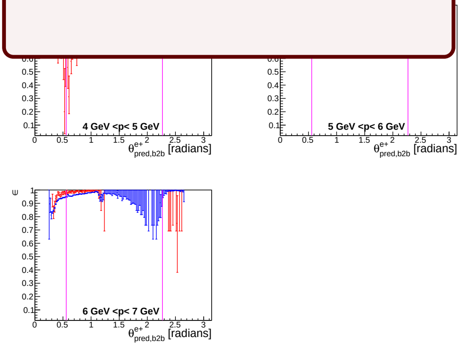
Phase3 Tracking Efficiencies As Function Of $\theta_{\mathrm{pred,b2b}}$

Phase3 MC10

Phase3 Data

e^-





Electron Tracking Efficiency:

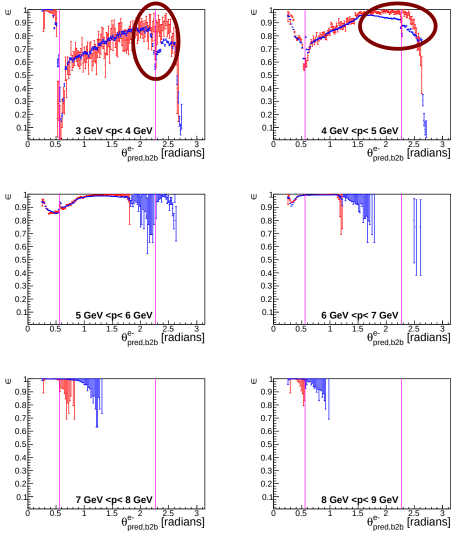
- Phase3 MC and phase3 data are very close to each other (an exception occurs for momenta between $3\,\mathrm{GeV}$ and $5\,\mathrm{GeV}$)

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

Phase3 MC10

Phase3 Data

e^-



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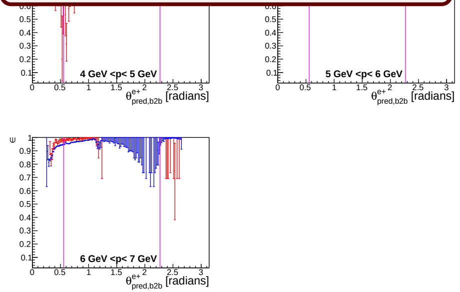

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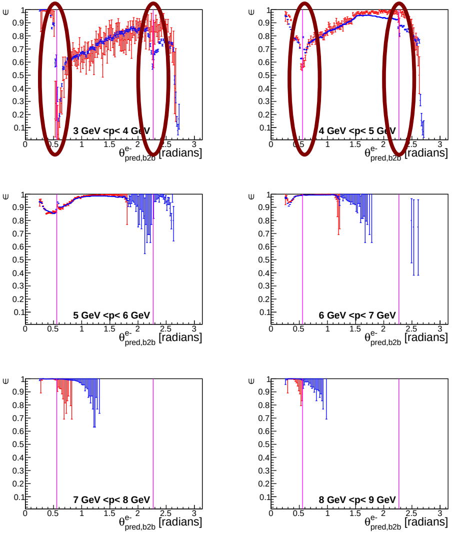
Phase3 MC10

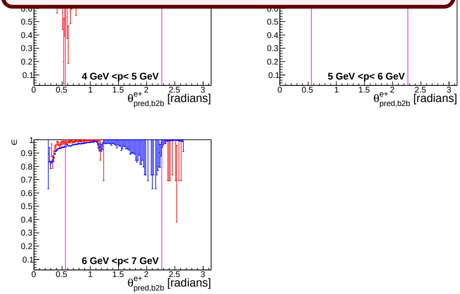
Phase3 Data

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

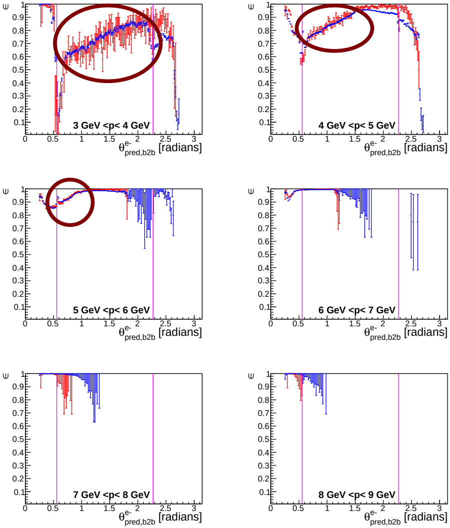


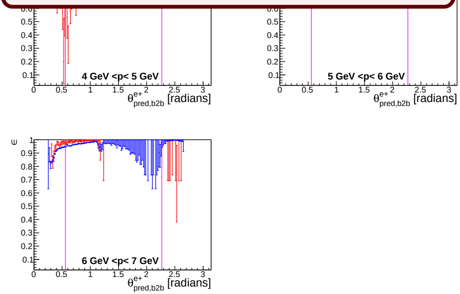
Phase3 Tracking Efficiencies As Function Of $\theta_{\mathbf{pred,b2b}}$

Phase3 MC10

Phase3 Data

e^{-}





Electron Tracking Efficiency:

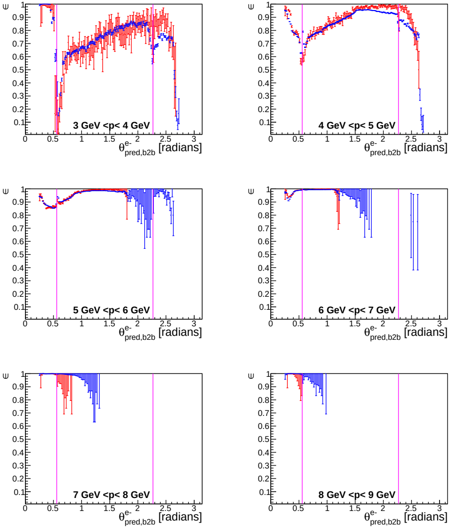
- Phase3 MC and phase3 data are very close to each other (an exception occurs for momenta between $3\,\mathrm{GeV}$ and $5\,\mathrm{GeV}$)
- Efficiency drops at transition between barrel and end-caps
- There is a slope in the barrel

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

Phase3 MC10

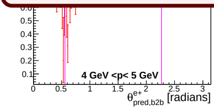
Phase3 Data

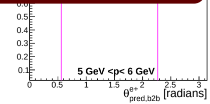
e^-

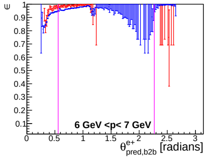


Electron Tracking Efficiency:

- 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

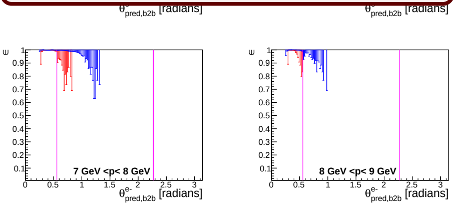


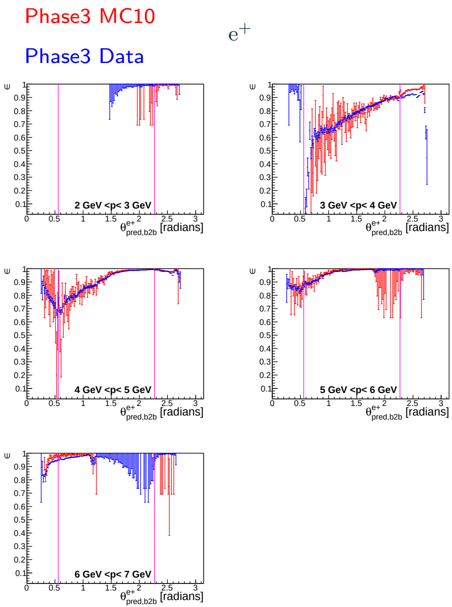




Positron Tracking Efficiency:

- 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 $2\,\mathrm{GeV}$ and $4\,\mathrm{GeV}$ and between $6\,\mathrm{GeV}$ and $7\,\mathrm{GeV}$)

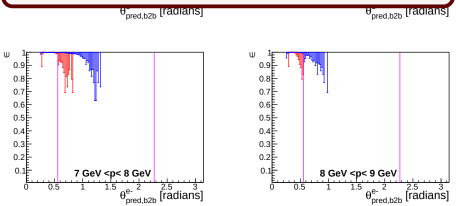




Phase3 Tracking Efficiencies As Function Of $\theta_{\mathrm{pred,b2b}}$

Positron Tracking Efficiency:

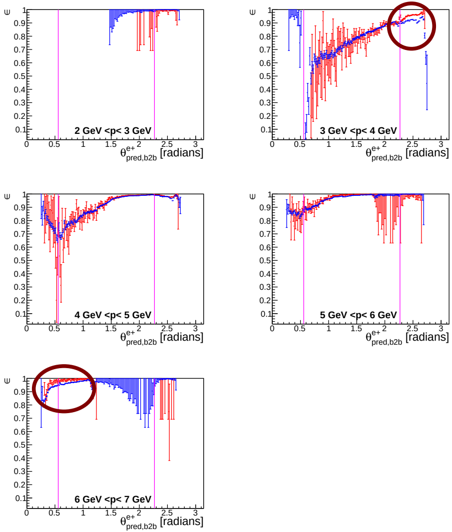
- The tracking efficiency pf phase3 MC and phase3 data are close to each other (an exception occurs in the backward end-cap for momenta between $2\,\mathrm{GeV}$ and $4\,\mathrm{GeV}$ and between $6\,\mathrm{GeV}$ and $7\,\mathrm{GeV}$)



Phase3 MC10

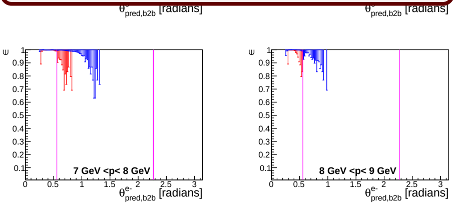
Phase3 Data

e^{+}



Positron Tracking Efficiency:

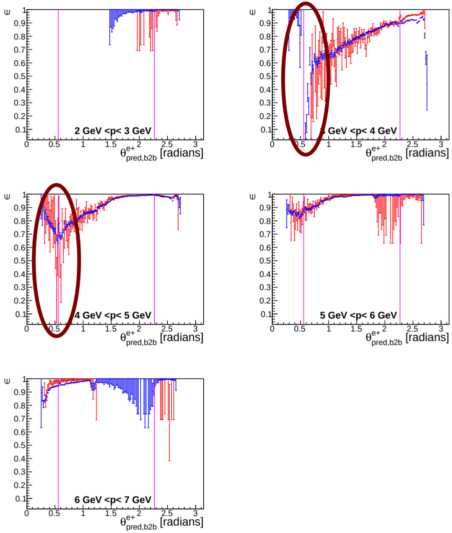
- The tracking efficiency pf phase3 MC and phase3 data are close to each other (an exception occurs in the backward end-cap for momenta between $2\,\mathrm{GeV}$ and $4\,\mathrm{GeV}$ and between $6\,\mathrm{GeV}$ and $7\,\mathrm{GeV}$)
- Efficiency drops at transition between barrel and end-caps



Phase3 MC10

Phase3 Data

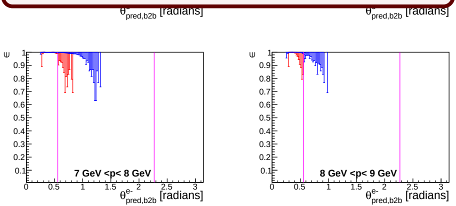
e^+



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

Positron Tracking Efficiency:

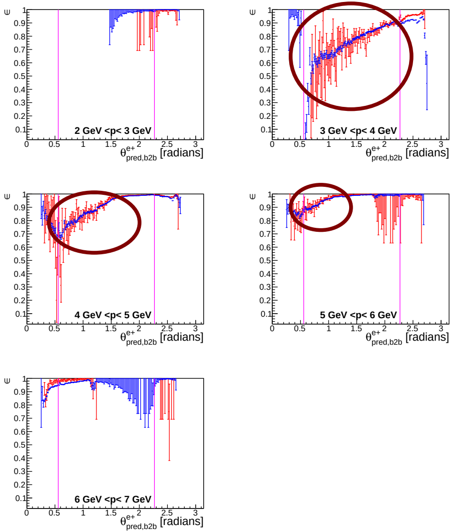
- The tracking efficiency pf phase3 MC and phase3 data are close to each other (an exception occurs in the backward end-cap for momenta between $2\,\mathrm{GeV}$ and $4\,\mathrm{GeV}$ and between $6\,\mathrm{GeV}$ and $7\,\mathrm{GeV}$)
- Efficiency drops at transition between barrel and end-caps
- There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



Phase3 MC10

Phase3 Data

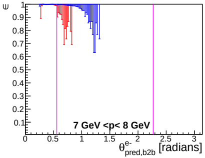
e^+

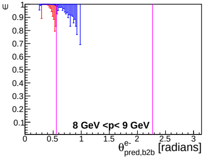


Phase3 Tracking Efficiencies As Function Of $\theta_{\mathrm{pred,b2b}}$

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 $2\,\mathrm{GeV}$ and $4\,\mathrm{GeV}$ and between $6\,\mathrm{GeV}$ and $7\,\mathrm{GeV}$)
- Efficiency drops at transition between barrel and end-caps
- There is a slope in the barrel

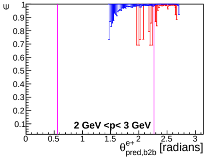


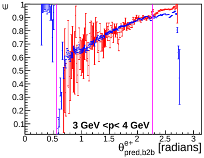


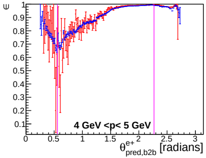
Phase3 MC10

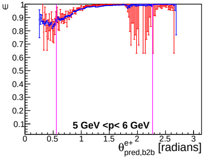
Phase3 Data

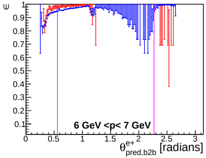
e^+









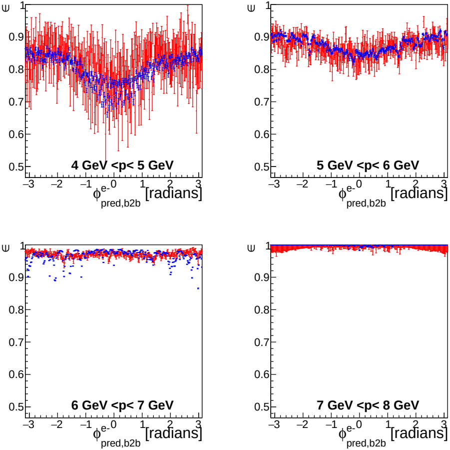


Phase3 Tracking Efficiencies As Function Of $\phi_{\mathbf{pred,b2b}}$; Forward End-Cap

Phase3 MC10

Phase3 Data

e^-



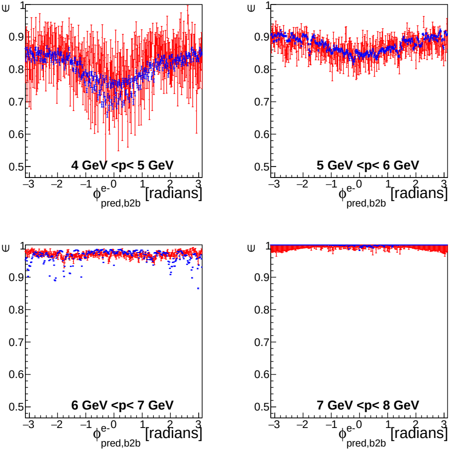
e^+

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

Phase3 MC10

Phase3 Data

e^{-}



Electron Tracking Efficiency:

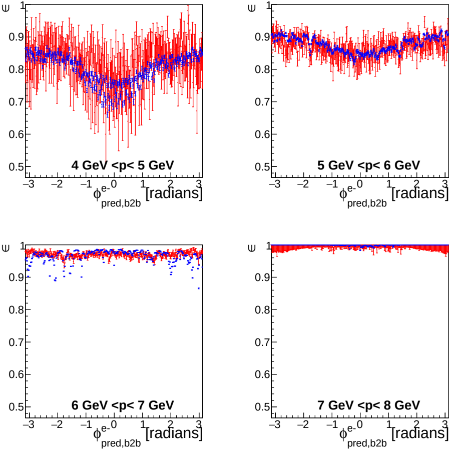
- Highest tracking efficiency for momenta between 7 GeV and 8 GeV

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

Phase3 MC10

Phase3 Data

e^-



Electron Tracking Efficiency:

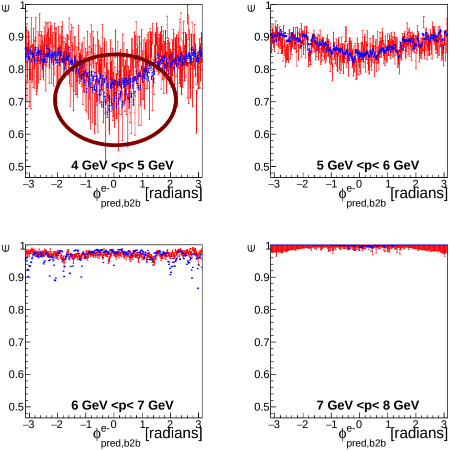
- Highest tracking efficiency for momenta between 7 GeV and 8 GeV
- Minimum at $\phi_{\mathrm{pred,b2b}} \approx 0$ for momenta between 4 GeV and 6 GeV

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

Phase3 MC10

Phase3 Data

e^-



Electron Tracking Efficiency:

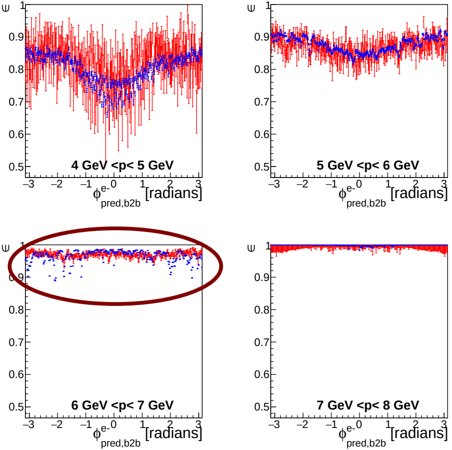
- Highest tracking efficiency for momenta between 7 GeV and 8 GeV
- Minimum at $\phi_{\mathrm{pred,b2b}} \approx 0$ for momenta between 4 GeV and 6 GeV
- Weird *ribbon* structure in the phase3 data tracking efficiency at $\phi_{\mathrm{pred,b2b}} \approx 0$ for momenta between 4 GeV and 5 GeV

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

Phase3 MC10

Phase3 Data

e^-



Electron Tracking Efficiency:

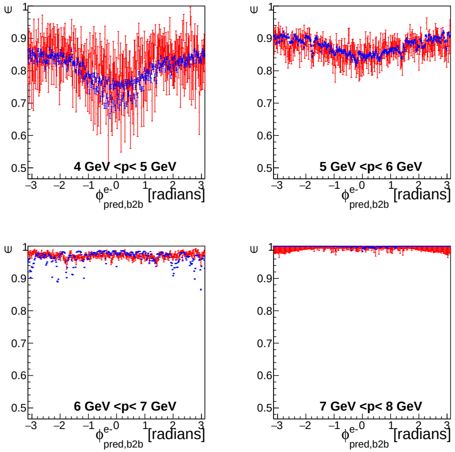
- Highest tracking efficiency for momenta between 7 GeV and 8 GeV
- Minimum at $\phi_{\mathrm{pred,b2b}} \approx 0$ for momenta between 4 GeV and 6 GeV
- Weird *ribbon* structure in the phase3 data tracking efficiency at $\phi_{\mathrm{pred,b2b}} \approx 0$ for momenta between 4 GeV and 5 GeV
- Weird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

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

Phase3 MC10

Phase3 Data

e^-



Electron Tracking Efficiency:

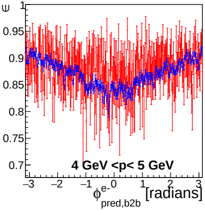
- Highest tracking efficiency for momenta between 7 GeV and 8 GeV
- Minimum at $\phi_{\mathrm{pred,b2b}} \approx 0$ for momenta between 4 GeV and 6 GeV
- Weird *ribbon* structure in the phase3 data tracking efficiency at $\phi_{\mathrm{pred,b2b}} \approx 0$ for momenta between 4 GeV and 5 GeV
- Weird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

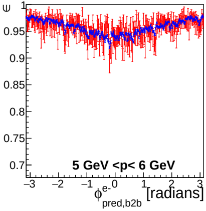
Phase3 Tracking Efficiencies As Function Of $\phi_{\mathbf{pred,b2b}}$; Barrel

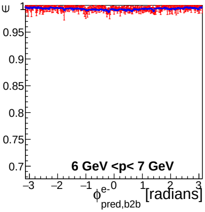
Phase3 MC10

Phase3 Data

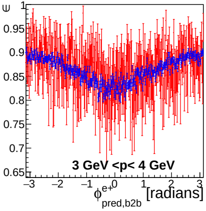
e^-

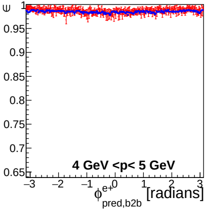


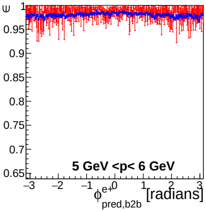


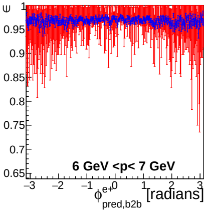


e^+







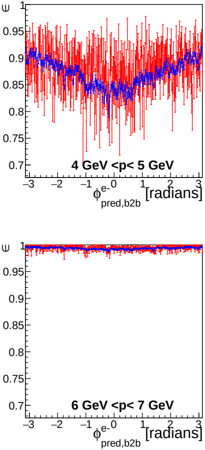


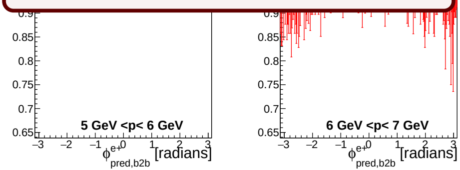
Phase3 Tracking Efficiencies As Function Of $\phi_{\mathbf{pred,b2b}}$; Barrel

Phase3 MC10

Phase3 Data

e^{-}





Electron Tracking Efficiency:

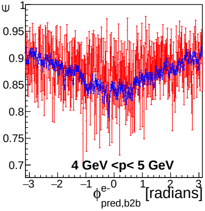
- Highest tracking efficiency for momenta between 6 GeV and 7 GeV
- Lowest tracking efficiency for momenta between 4 GeV and 5 GeV

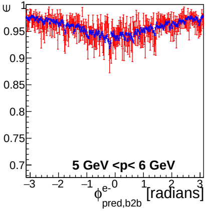
Phase3 Tracking Efficiencies As Function Of $\phi_{\mathrm{pred,b2b}}$; Barrel

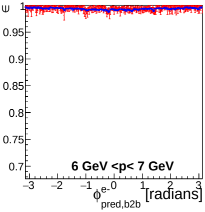
Phase3 MC10

Phase3 Data

e^-

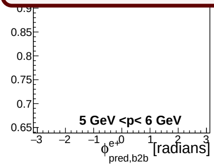


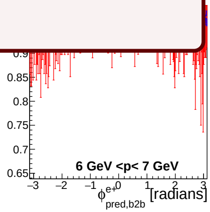




Electron Tracking Efficiency:

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

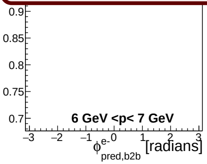




Phase3 Tracking Efficiencies As Function Of $\phi_{\mathbf{pred,b2b}}$; Barrel

Positron Tracking Efficiency:

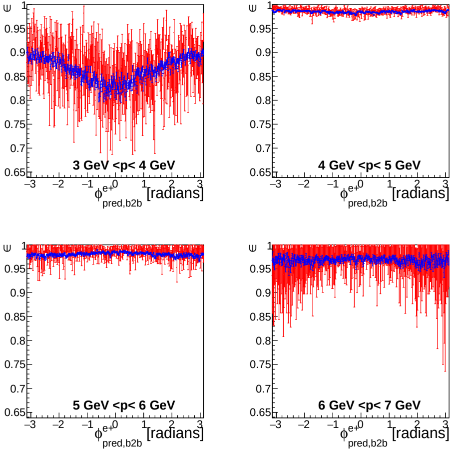
- Highest tracking efficiency for momenta between 4 GeV and 6 GeV
- Lowest tracking efficiency for momenta between 3 GeV and 4 GeV



Phase3 MC10

Phase3 Data

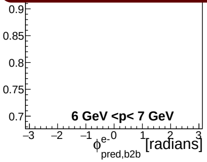
e^+



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

Positron Tracking Efficiency:

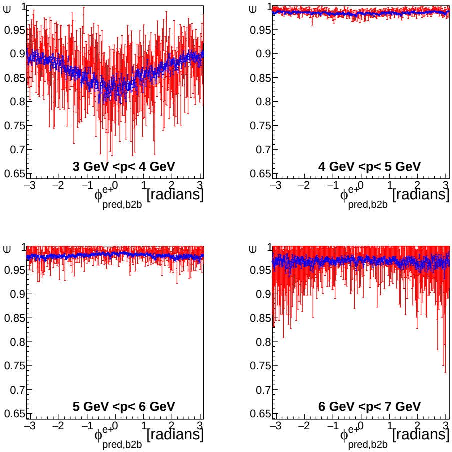
- Highest tracking efficiency for momenta between $4\,\mathrm{GeV}$ and $6\,\mathrm{GeV}$
- Lowest tracking efficiency for momenta between $3\,\mathrm{GeV}$ and $4\,\mathrm{GeV}$
- Minimum at $\phi_{\mathrm{pred,b2b}} \approx 0$ for momenta between $3\,\mathrm{GeV}$ and $4\,\mathrm{GeV}$



Phase3 MC10

Phase3 Data

e^{+}



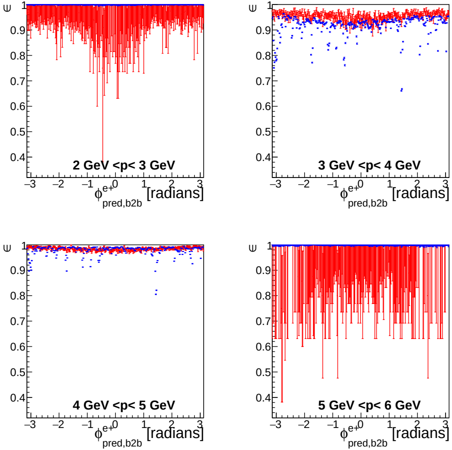
Phase3 Tracking Efficiencies As Function Of $\phi_{\mathbf{pred,b2b}}$; Backward End-Cap

Phase3 MC10

Phase3 Data

e^-

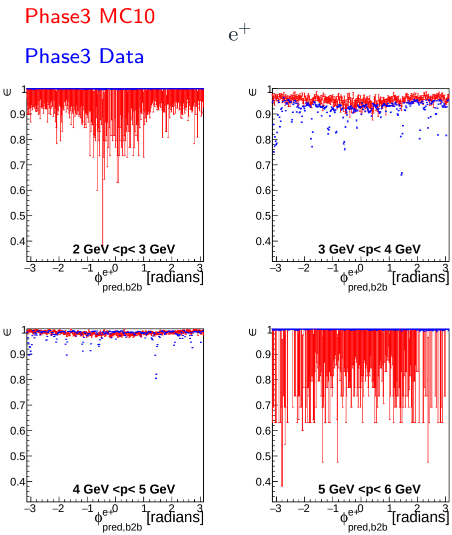
e^+



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

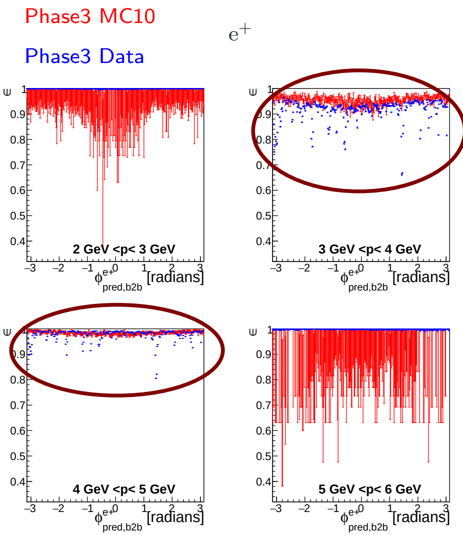
Positron Tracking Efficiency:

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



Positron Tracking Efficiency:

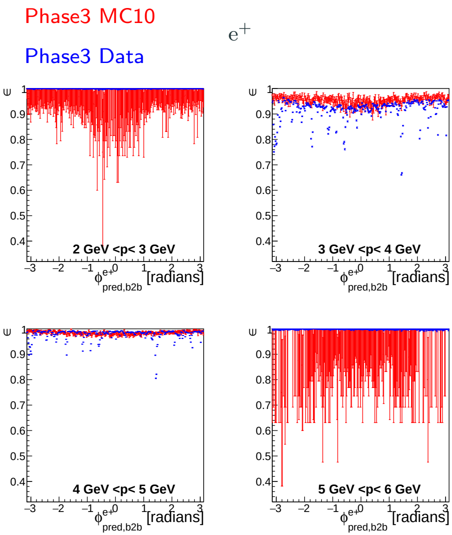
- The highest phase3 data tracking efficiency occurs for momenta between 2 GeV and 3 GeV and 5 GeV and 6 GeV
- Weird efficiency drops in the phase3 data tracking efficiency for momenta between 3 GeV and 5 GeV



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



Comparing The Tracking Efficiency Of Phase2 Data with Phase3 Data

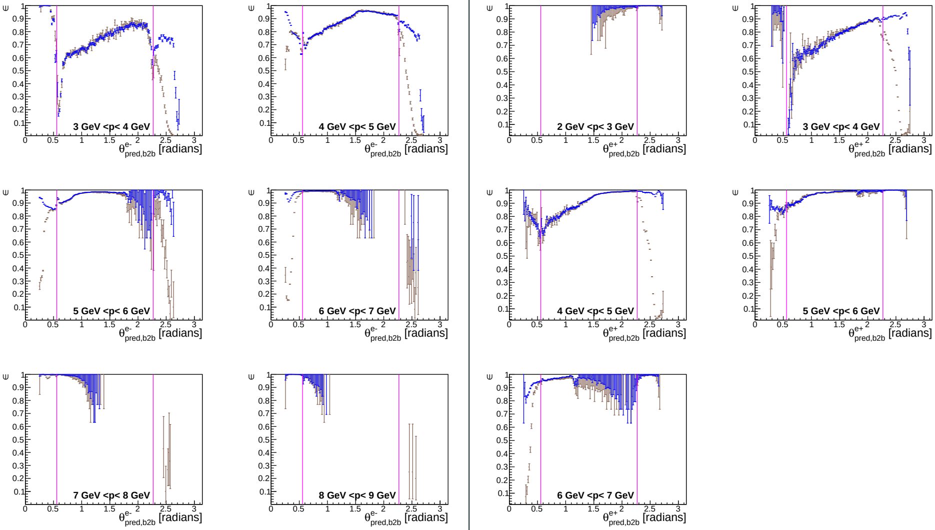
Tracking Efficiencies As Function Of $\theta_{\mathrm{pred,b2b}}$

Phase2 Data

Phase3 Data

e^-

e^+

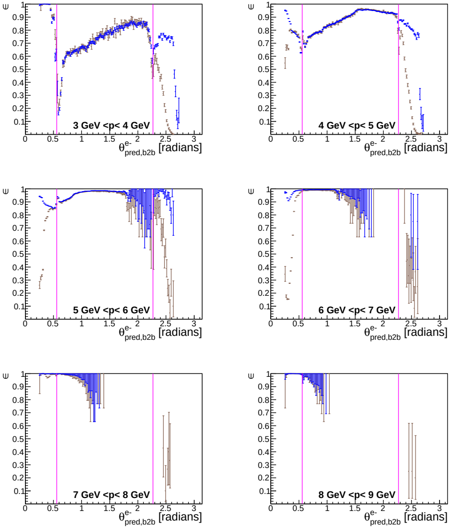


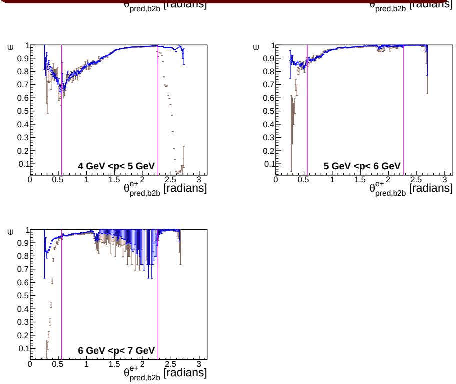
Tracking Efficiencies As Function Of $\theta_{\mathrm{pred,b2b}}$

Phase2 Data

Phase3 Data

e^-





Electron Tracking Efficiency:

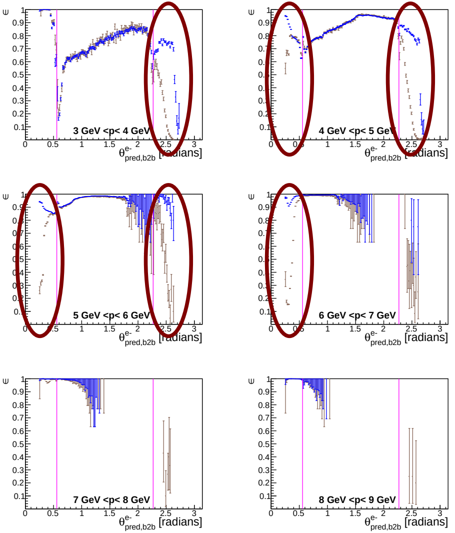
- Drastic improvement in the end-caps

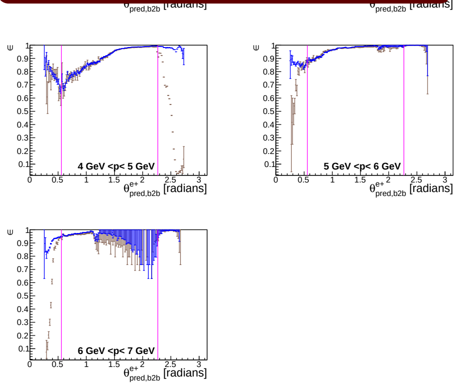
Tracking Efficiencies As Function Of $\theta_{\mathrm{pred,b2b}}$

Phase2 Data

Phase3 Data

e^-





Electron Tracking Efficiency:

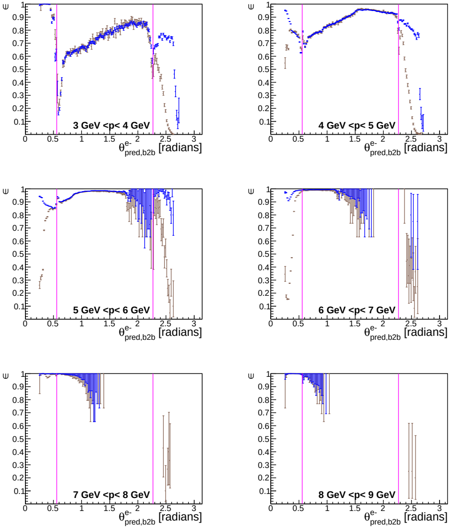
- Drastic improvement in the end-caps

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

Phase2 Data

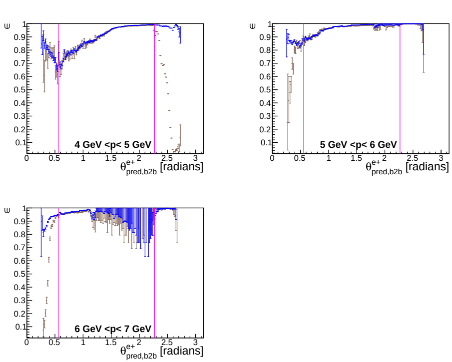
Phase3 Data

e^-



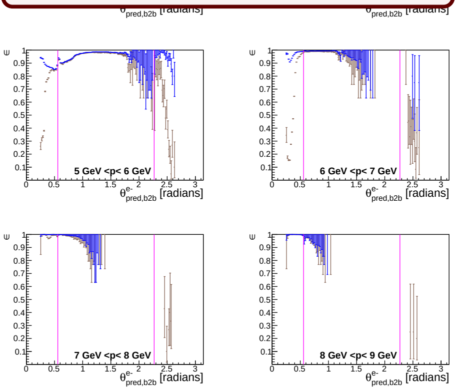
Electron Tracking Efficiency:

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



Positron Tracking Efficiency:

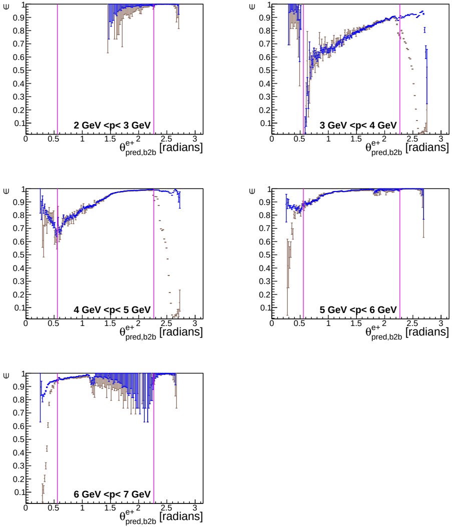
- Drastic improvement in the end-caps



Phase2 Data

Phase3 Data

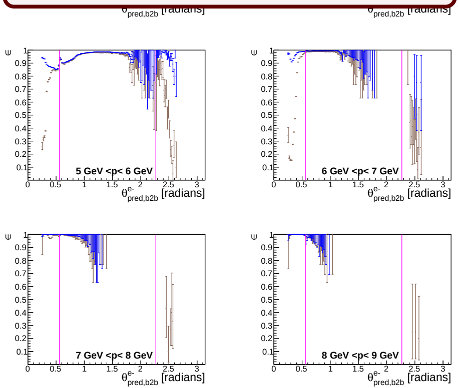
e^+



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

Positron Tracking Efficiency:

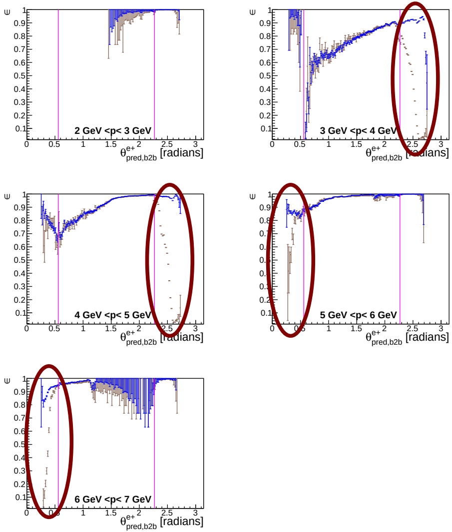
- Drastic improvement in the end-caps



Phase2 Data

Phase3 Data

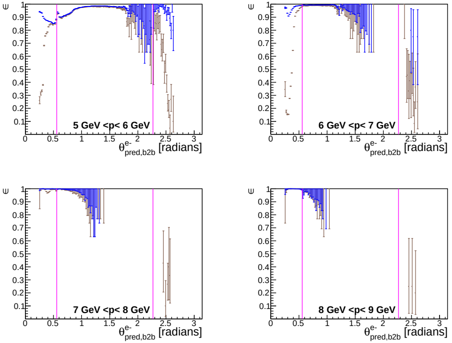
e^+



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

Positron Tracking Efficiency:

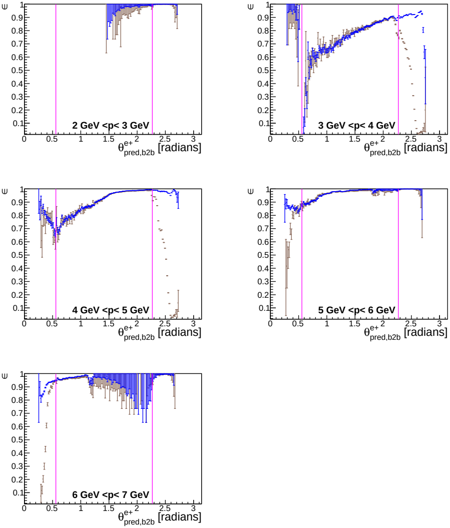
- Drastic improvement in the end-caps
- Tracking efficiency in the barrel stayed more or less the same



Phase2 Data

Phase3 Data

e^{+}



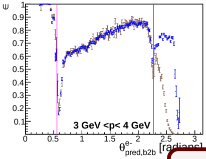
Tracking Efficiencies As Function Of $\theta_{\mathrm{pred,b2b}}$

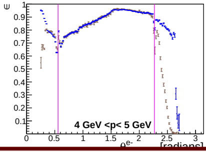
e^-

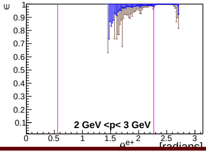
Phase2 Data

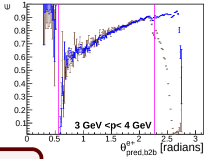
Phase3 Data

e^+

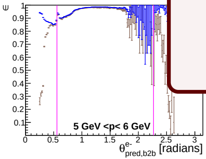


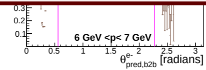


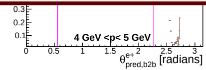


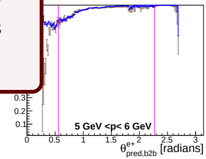


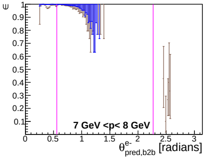
We will only compare the tracking efficiencies for electrons in the forward end-cap and the tracking efficiencies for positrons in the backward end-cap

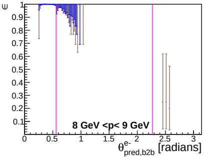


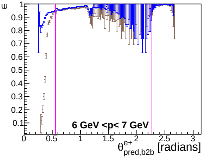










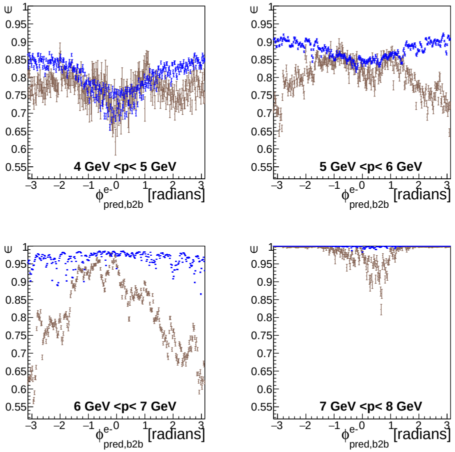


Tracking Efficiencies As Function Of $\phi_{\mathrm{pred,b2b}}$; Forward End-Cap

Phase2 Data

Phase3 Data

e^-



Electron Tracking Efficiency:

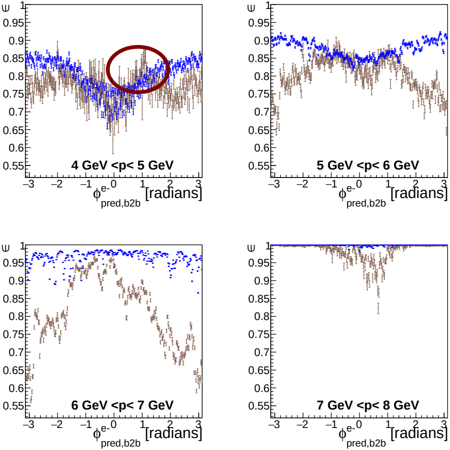
- The tracking efficiency improved over almost all $\phi_{\mathrm{pred,b2b}}$ (exception occurs for $\phi_{\mathrm{pred,b2b}} \approx 1$ for momenta between $4\,\mathrm{GeV}$ and $5\,\mathrm{GeV}$)

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

Phase2 Data

Phase3 Data

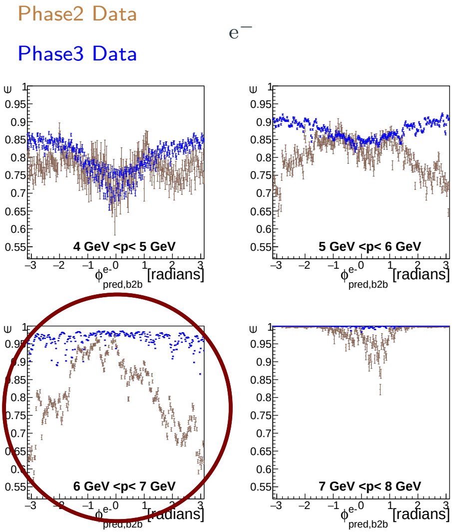
e^-



Electron Tracking Efficiency:

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

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



Electron Tracking Efficiency:

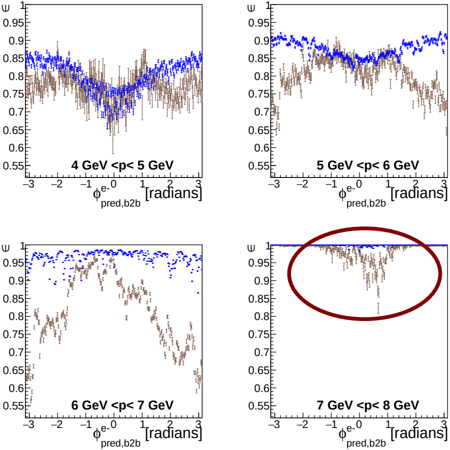
- The tracking efficiency improved over almost all $\phi_{\text{pred,b2b}}$ (exception occurs for $\phi_{\text{pred,b2b}} \approx 1$ for momenta between $4\,\text{GeV}$ and $5\,\text{GeV}$)
- The tracking efficiency improved drastically for momenta between $6\,\text{GeV}$ and $7\,\text{GeV}$

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

Phase2 Data

Phase3 Data

e^-



Electron Tracking Efficiency:

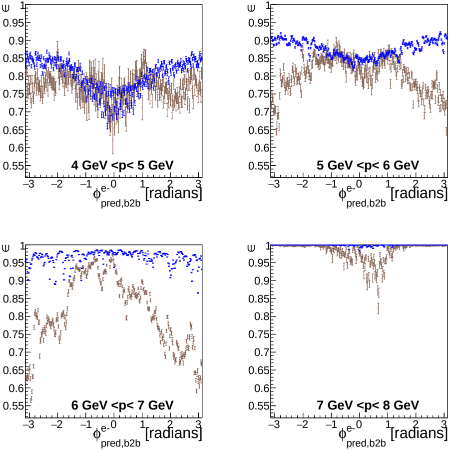
- The tracking efficiency improved over almost all $\phi_{\mathrm{pred,b2b}}$ (exception occurs for $\phi_{\mathrm{pred,b2b}} \approx 1$ for momenta between $4\,\mathrm{GeV}$ and $5\,\mathrm{GeV}$)
- The tracking efficiency improved drastically for momenta between $6\,\mathrm{GeV}$ and $7\,\mathrm{GeV}$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

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

Phase2 Data

Phase3 Data

e^-



Electron Tracking Efficiency:

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

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

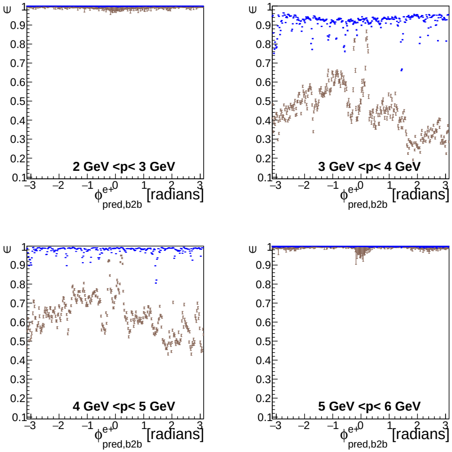
Positron Tracking Efficiency:

- The tracking efficiencies for momenta between $2\,\mathrm{GeV}$ and $3\,\mathrm{GeV}$ and between $5\,\mathrm{GeV}$ and $6\,\mathrm{GeV}$ look very similar

Phase2 Data

Phase3 Data

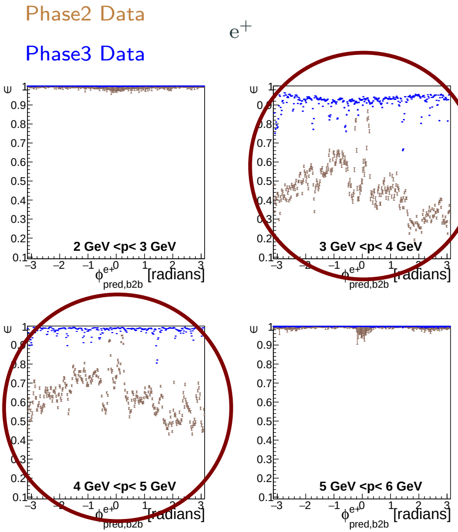
e^+



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

Positron Tracking Efficiency:

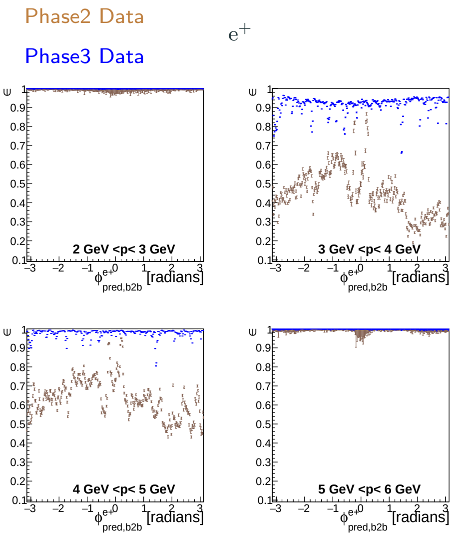
- The tracking efficiencies for momenta between $2\,\mathrm{GeV}$ and $3\,\mathrm{GeV}$ and between $5\,\mathrm{GeV}$ and $6\,\mathrm{GeV}$ look very similar
- The tracking efficiency for momenta between $3\,\mathrm{GeV}$ and $5\,\mathrm{GeV}$ improved drastically



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

Positron Tracking Efficiency:

- The tracking efficiencies for momenta between $2\,\mathrm{GeV}$ and $3\,\mathrm{GeV}$ and between $5\,\mathrm{GeV}$ and $6\,\mathrm{GeV}$ look very similar
- The tracking efficiency for momenta between $3\,\mathrm{GeV}$ and $5\,\mathrm{GeV}$ improved drastically



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 *random* efficiency drops 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

```
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)

reconstructDecay('vpho:gamma -> gamma:all', '', path=mypath)
reconstructDecay('vpho:elec -> e+:all', '', path=mypath)

copyLists(outputListName = 'vpho:ECLObjectUnranked', inputListNames=['vpho:elec', 'vpho:gamma'], path=mypath)

rankByHighest('vpho:ECLObjectUnranked', 'daughter(0,clusterE)', path=mypath)
cutAndCopyList('vpho:ECLObject', 'vpho:ECLObjectUnranked', '', path=mypath)

reconstructDecay('vpho:bhabha -> vpho:ECLObject vpho:ECLObject', '', path=mypath)

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:

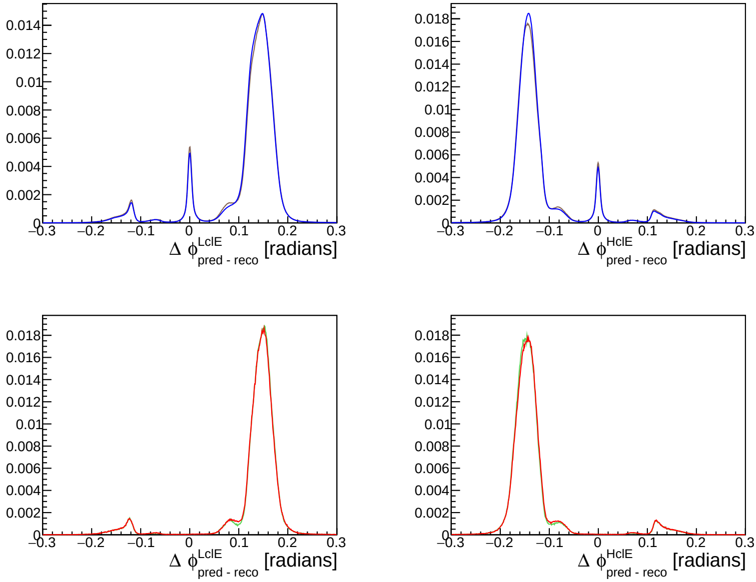
- /belle/MC/release-01-00-02/DB00000294/MC10/ prod00004668/s00/e1002/4S/r00000/3600520000/mdst/sub00

Phase3 data:

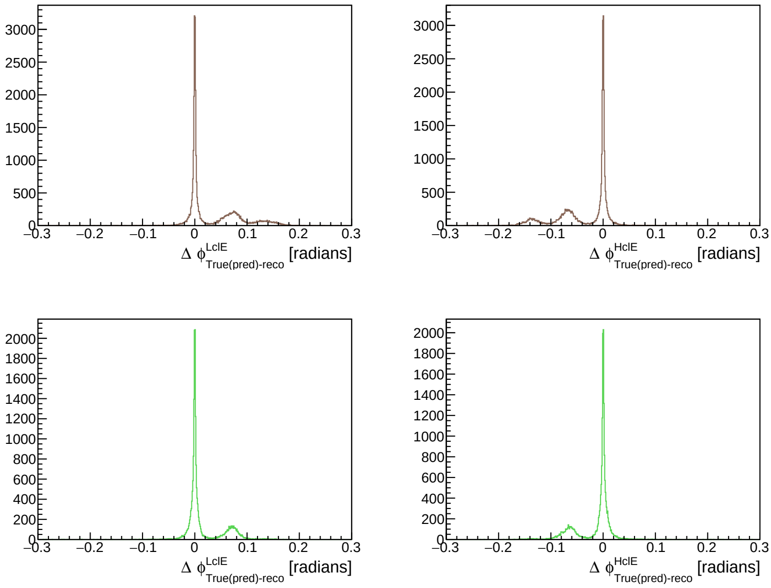
- Exp7: /group/belle2/dataprod/Data/release-03-02-02/DB00000654/proc9/e0007/4S/r0*/all/mdst/sub00/*.root
- Exp8: /group/belle2/dataprod/Data/release-03-02-02/DB00000654/proc9/e0008/4S/r0*/all/mdst/sub00/*.root
- proc9

Phase3 MC:

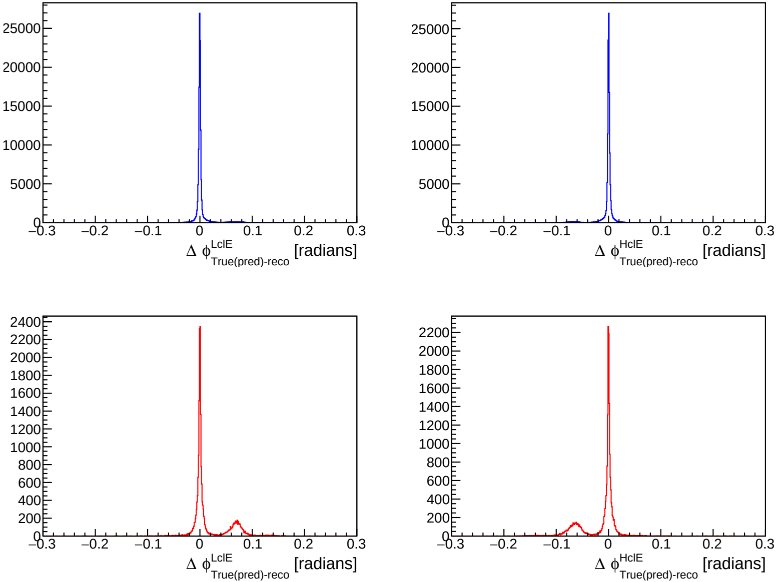
- /belle/MC/release-01-00-02/DB00000294/MC10/ prod00004664/s00/e0000/4S/r00000/3600520000/mdst/sub00



0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
−0.3 −0.2 −0.1 0 0.1 0.2 0.3
Δ φ LclE pred - reco [radians]
0.018
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
−0.3 −0.2 −0.1 0 0.1 0.2 0.3
Δ φ HclE pred - reco [radians]
0.018
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
−0.3 −0.2 −0.1 0 0.1 0.2 0.3
Δ φ LclE pred - reco [radians]
0.018
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
−0.3 −0.2 −0.1 0 0.1 0.2 0.3
Δ φ HclE pred - reco [radians]



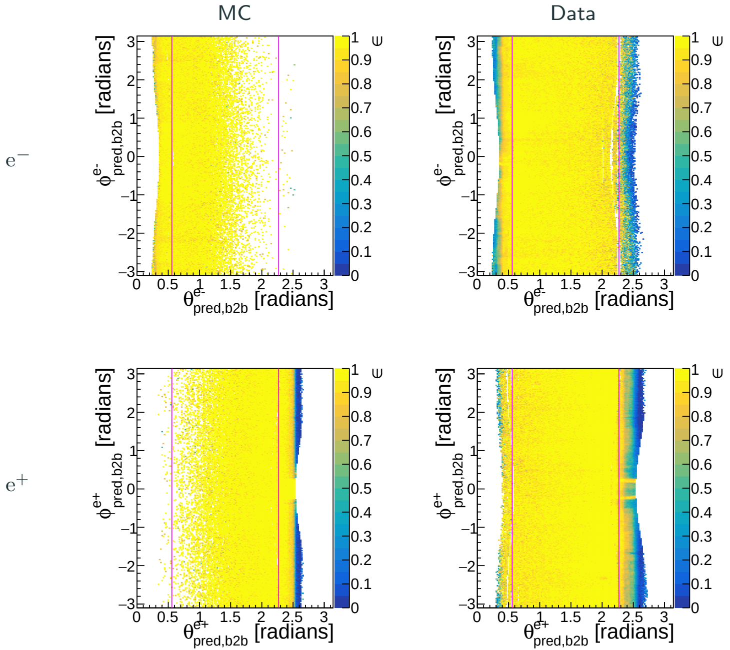
3000
2500
2000
1500
1000
500
0
−0.3 −0.2 −0.1 0 0.1 0.2 0.3
Δ φ^LclE True(pred)-reco [radians]
Δ φ^HclE True(pred)-reco [radians]
2000
1800
1600
1400
1200
1000
800
600
400
200
0
Δ φ^LclE True(pred)-reco [radians]
Δ φ^HclE True(pred)-reco [radians]



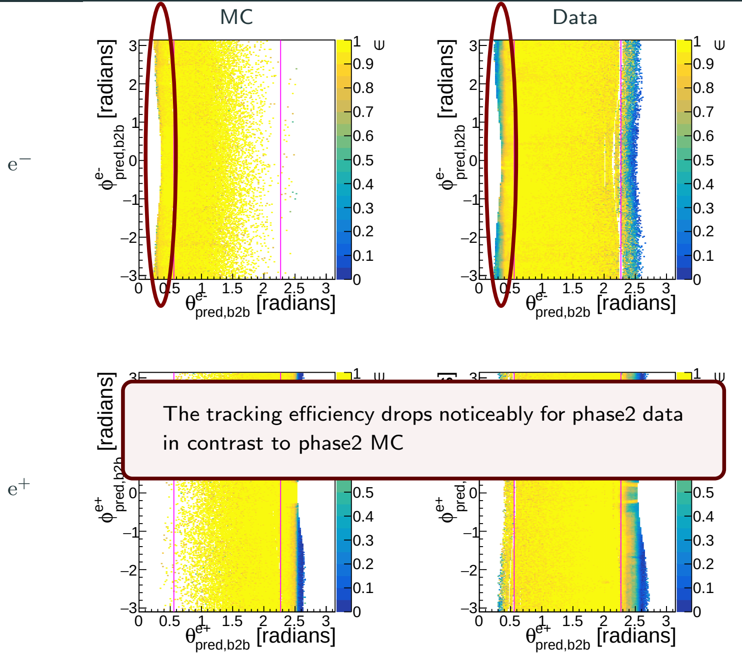
25000
20000
15000
10000
5000
0
−0.3
−0.2
−0.1
0
0.1
0.2
0.3
$\Delta\ \phi^{LclE}_{True(pred)-reco}$ [radians]
$\Delta\ \phi^{HclE}_{True(pred)-reco}$ [radians]
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200

Phase2 Tracking Efficiencies

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

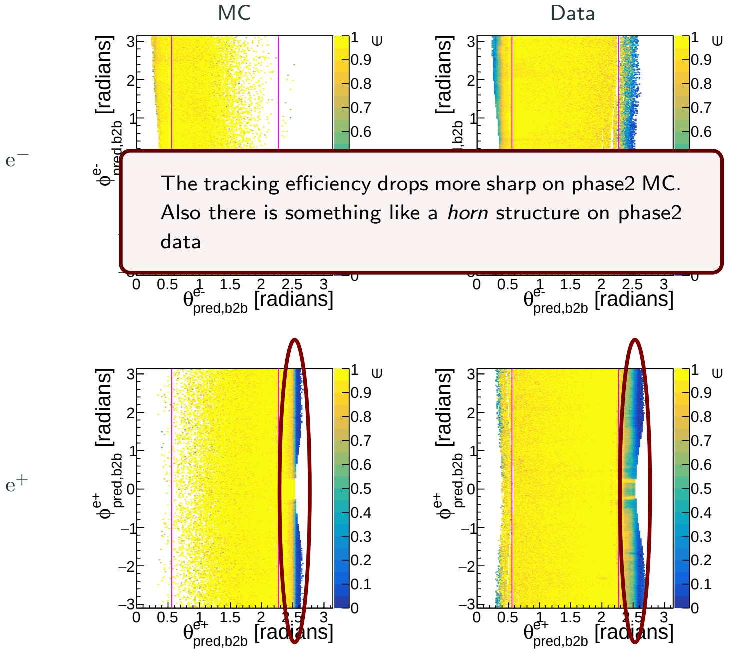


Phase2 Tracking Efficiencies As Function Of $\theta_{\mathbf{pred,b2b}} - \phi_{\mathbf{pred,b2b}}$



The tracking efficiency drops noticeably for phase2 data in contrast to phase2 MC

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

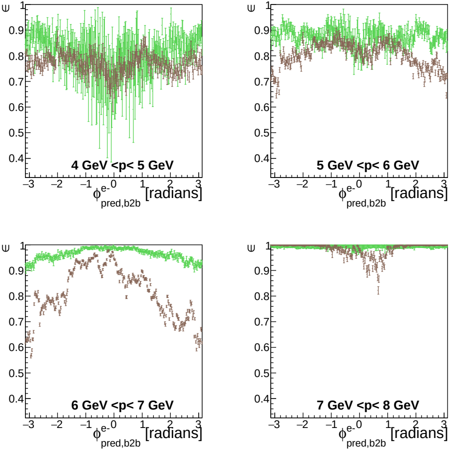


Phase2 Tracking Efficiencies As Function Of $\phi_{\mathbf{pred,b2b}}$; Forward End-Cap

Phase2 MC10

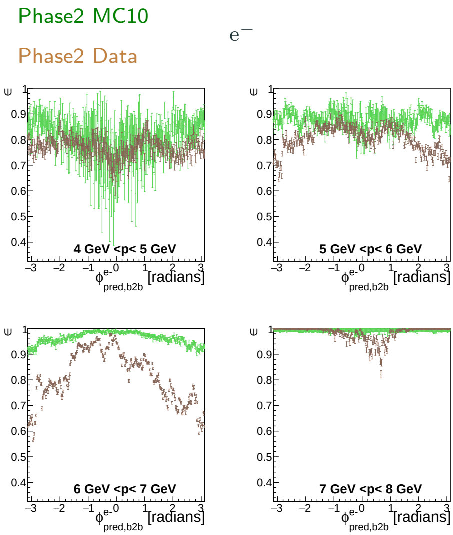
Phase2 Data

e^-



e^+

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



Electron Tracking Efficiency:

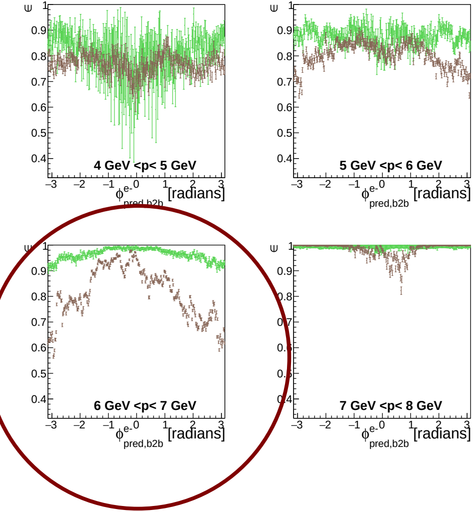
- Phase2 MC has almost always a higher tracking efficiency compared to phase2 data
- For most momenta the biggest difference between phase2 MC and phase2 data occurs for $|\phi_{\mathrm{pred,b2b}}| \gtrsim 2$

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

Phase2 MC10

Phase2 Data

e^-



Electron Tracking Efficiency:

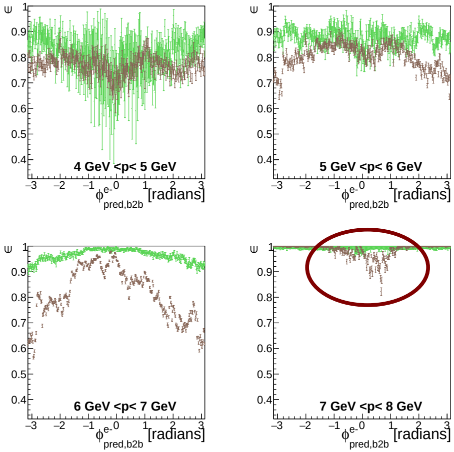
- Phase2 MC has almost always a higher tracking efficiency compared to phase2 data
- For most momenta the biggest difference between phase2 MC and phase2 data occurs for $|\phi_{\mathrm{pred,b2b}}| \gtrsim 2$
- There is no similarity in the structure for momenta between $6\,\mathrm{GeV}$ and $7\,\mathrm{GeV}$

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

Phase2 MC10

Phase2 Data

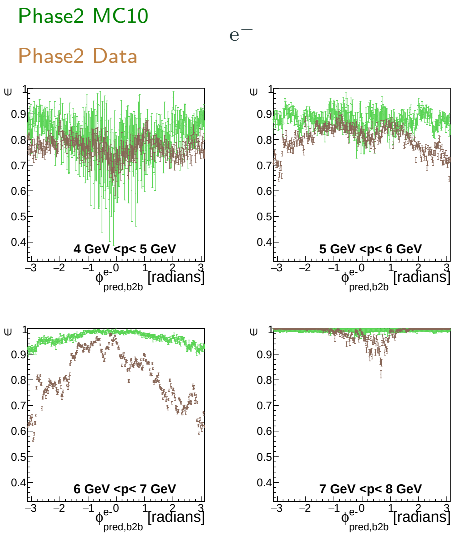
e^-



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 $|\phi_{\mathrm{pred,b2b}}| \gtrsim 2$
- There is no similarity in the structure for momenta between $6\,\mathrm{GeV}$ and $7\,\mathrm{GeV}$
- Highest tracking efficiency occurs for momenta between $7\,\mathrm{GeV}$ and $8\,\mathrm{GeV}$. But there is also an efficiency drop at $\phi_{\mathrm{pred,b2b}} \gtrsim 0$

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



Electron Tracking Efficiency:

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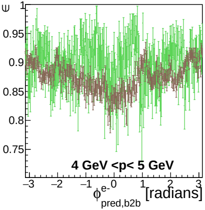
- Highest tracking efficiency occurs for momenta between $7\,\mathrm{GeV}$ and $8\,\mathrm{GeV}$. But there is also an efficiency drop at $\phi_{\mathrm{pred,b2b}} \gtrsim 0$

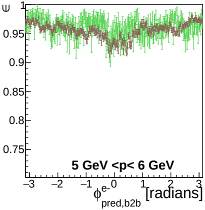
Phase2 Tracking Efficiencies As Function Of $\phi_{\mathrm{pred,b2b}}$; Barrel

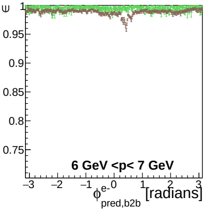
Phase2 MC10

Phase2 Data

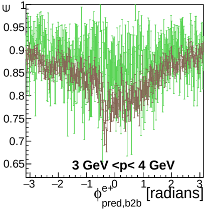
e^-

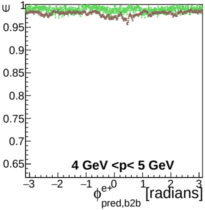


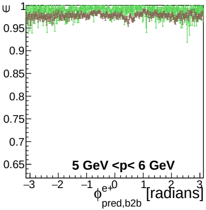


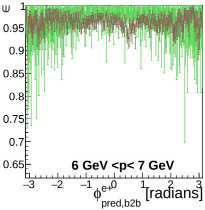


e^+







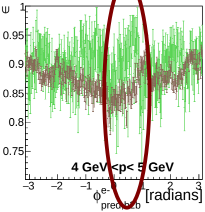


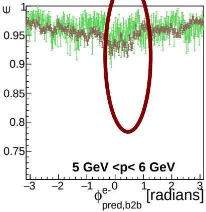
Phase2 Tracking Efficiencies As Function Of $\phi_{\mathrm{pred,b2b}}$; Barrel

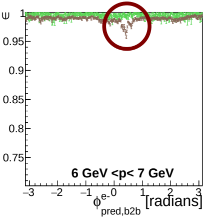
Phase2 MC10

Phase2 Data

e^{-}

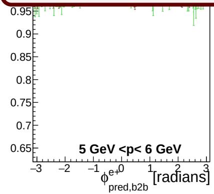


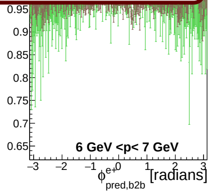




Electron Tracking Efficiency:

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



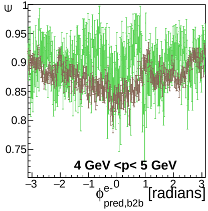


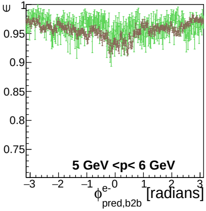
Phase2 Tracking Efficiencies As Function Of $\phi_{\mathrm{pred,b2b}}$; Barrel

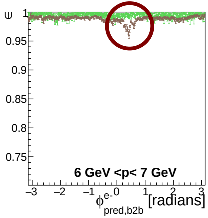
Phase2 MC10

Phase2 Data

e^{-}

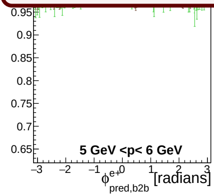


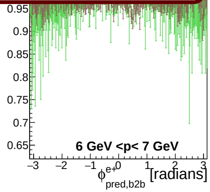




Electron Tracking Efficiency:

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



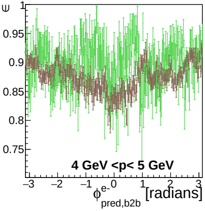


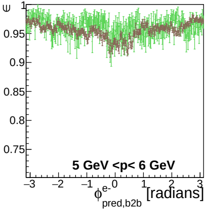
Phase2 Tracking Efficiencies As Function Of $\phi_{\mathrm{pred,b2b}}$; Barrel

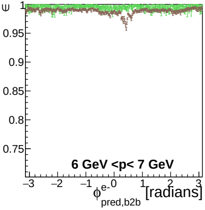
Phase2 MC10

Phase2 Data

e^-

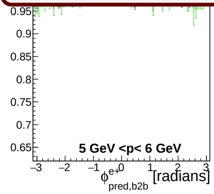


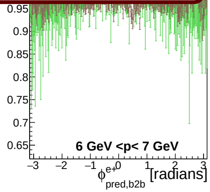




Electron Tracking Efficiency:

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



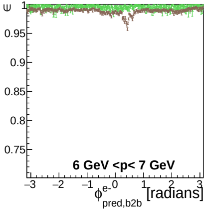


Phase2 Tracking Efficiencies As Function Of $\phi_{\mathrm{pred,b2b}}$; Barrel

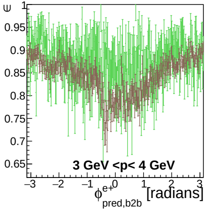
Phase2 MC10

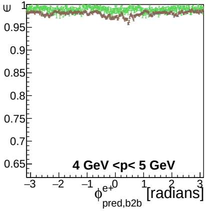
Positron Tracking Efficiency:

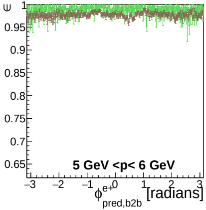
- The highest tracking efficiency occurs for momenta between $4\,\mathrm{GeV}$ and $5\,\mathrm{GeV}$
- The lowest tracking efficiency occurs for momenta between $3\,\mathrm{GeV}$ and $4\,\mathrm{GeV}$ with a minima at $\phi_{\mathrm{pred,b2b}} \approx 0$

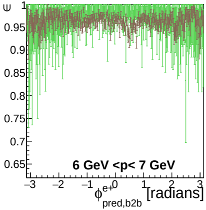


e^{+}









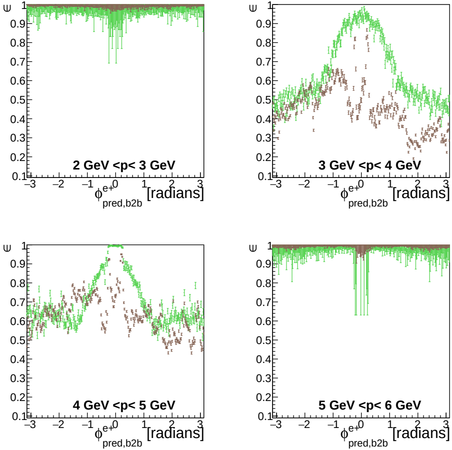
Phase2 Tracking Efficiencies As Function Of $\phi_{\mathbf{pred,b2b}}$; Backward End-Cap

Phase2 MC10

Phase2 Data

e^-

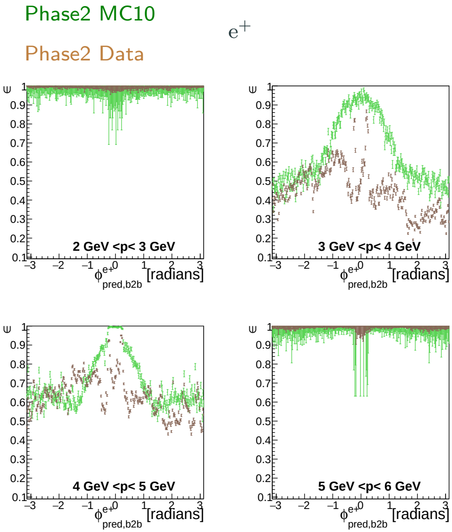
e^+



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

Positron Tracking Efficiency:

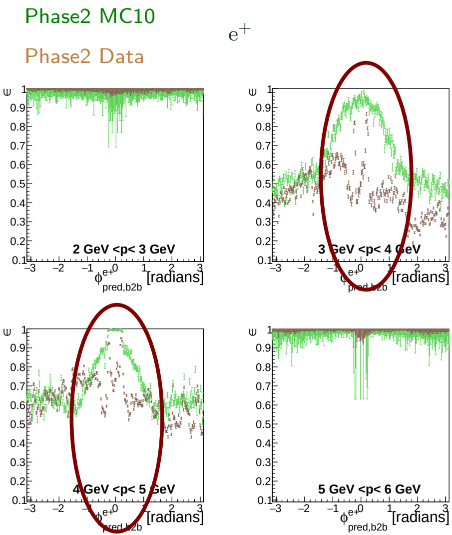
- The highest tracking efficiency occurs for momenta between $2\,\mathrm{GeV}$ and $3\,\mathrm{GeV}$ and $5\,\mathrm{GeV}$ and $6\,\mathrm{GeV}$



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

Positron Tracking Efficiency:

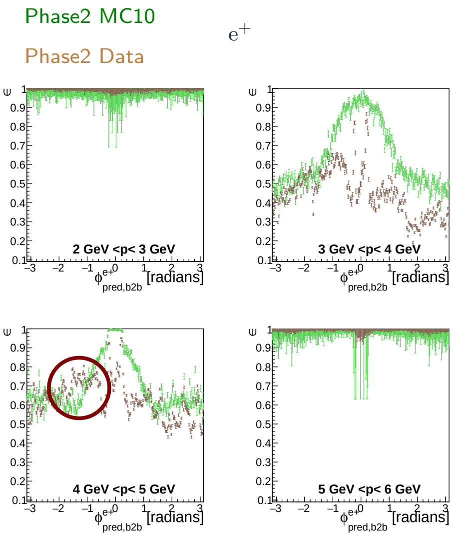
- The highest tracking efficiency occurs for momenta between $2\,\mathrm{GeV}$ and $3\,\mathrm{GeV}$ and $5\,\mathrm{GeV}$ and $6\,\mathrm{GeV}$
- Weird *horn* structure we saw earlier
- Phase2 MC tracking efficiency peaks at $\phi_{\mathrm{pred,b2b}} \approx 0$



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

Positron Tracking Efficiency:

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

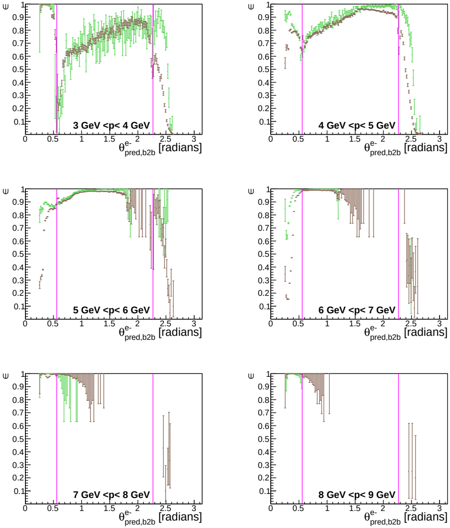


Phase2 Tracking Efficiencies As Function Of $\theta_{\mathbf{pred,b2b}}$

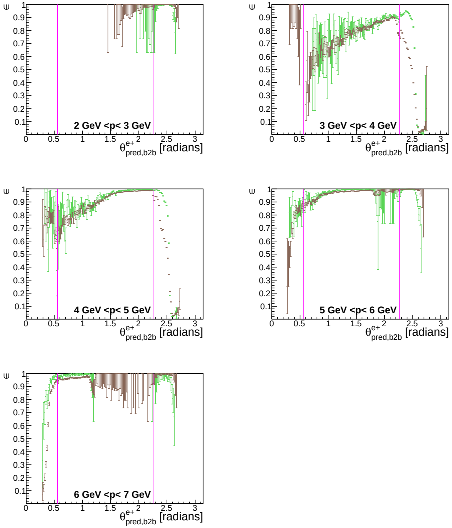
Phase2 MC10

Phase2 Data

e^{-}



e^{+}

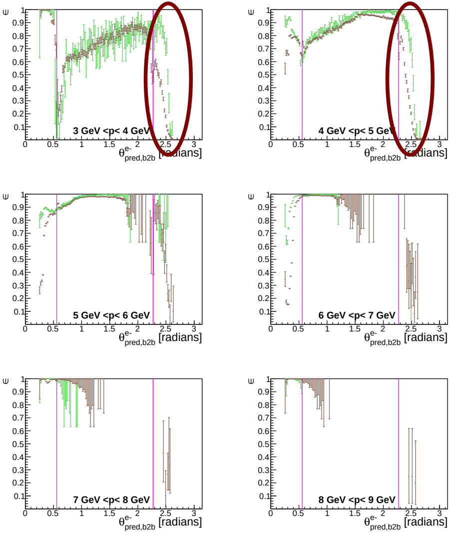


Phase2 Tracking Efficiencies As Function Of $\theta_{\mathbf{pred,b2b}}$

Phase2 MC10

Phase2 Data

e^{-}



Electron Tracking Efficiency:

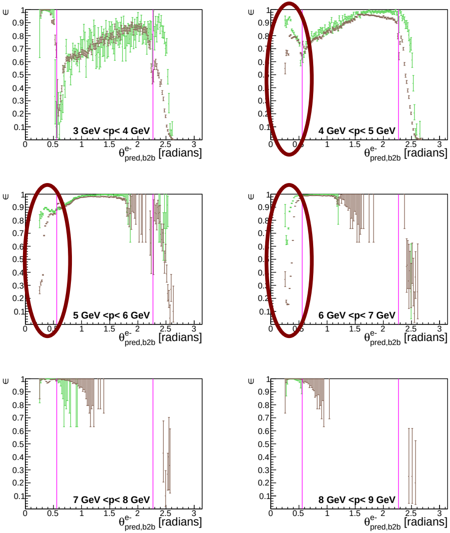
- For momenta between $3\,\mathrm{GeV}$ and $5\,\mathrm{GeV}$ the tracking efficiency in the backward end-cap is worse for phase2 data compared to phase2 MC

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

Phase2 MC10

Phase2 Data

e^-



Electron Tracking Efficiency:

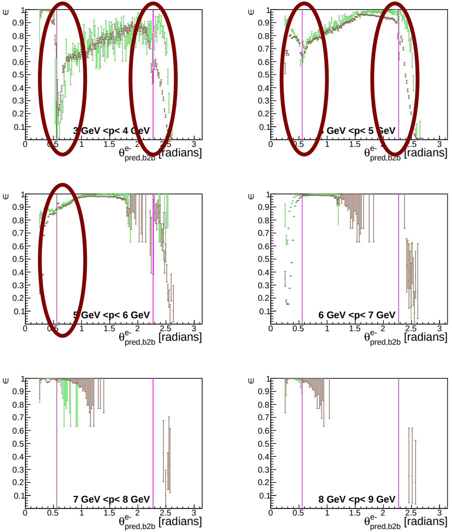
- For momenta between 3 GeV and 5 GeV the tracking efficiency in the backward end-cap is worse for phase2 data compared to phase2 MC
- For momenta between 4 GeV and 6 GeV the tracking efficiency in the forward end-cap is worse for phase2 data compared to phase2 MC

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

Phase2 MC10

Phase2 Data

e^{-}



Electron Tracking Efficiency:

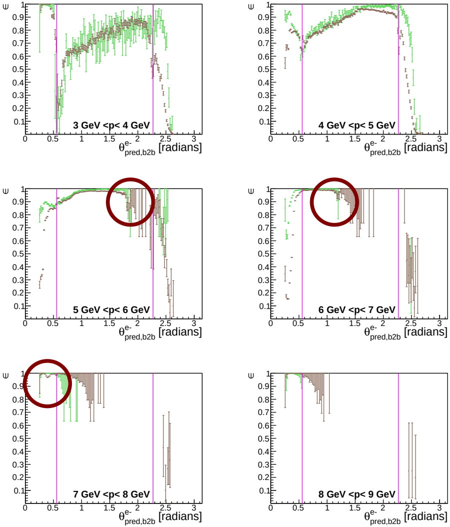
- For momenta between 3 GeV and 5 GeV the tracking efficiency in the backward end-cap is worse for phase2 data compared to phase2 MC
- For momenta between 4 GeV and 6 GeV the tracking efficiency in the forward end-cap is worse for phase2 data compared to phase2 MC
- Drops in efficiency at transition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

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

Phase2 MC10

Phase2 Data

e^-



Electron Tracking Efficiency:

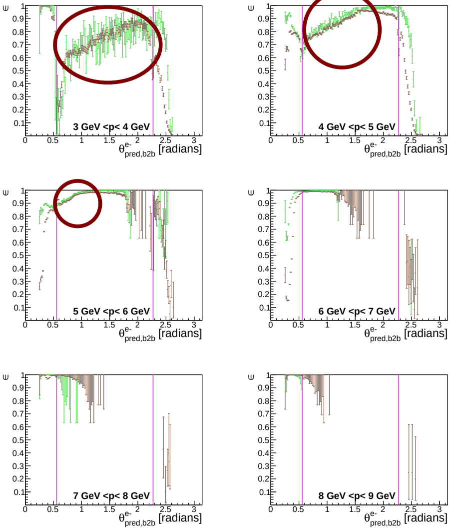
- For momenta between $3\,\mathrm{GeV}$ and $5\,\mathrm{GeV}$ the tracking efficiency in the backward end-cap is worse for phase2 data compared to phase2 MC
- For momenta between $4\,\mathrm{GeV}$ and $6\,\mathrm{GeV}$ the tracking efficiency in the forward end-cap is worse for phase2 data compared to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

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

Phase2 MC10

Phase2 Data

e^{-}



Electron Tracking Efficiency:

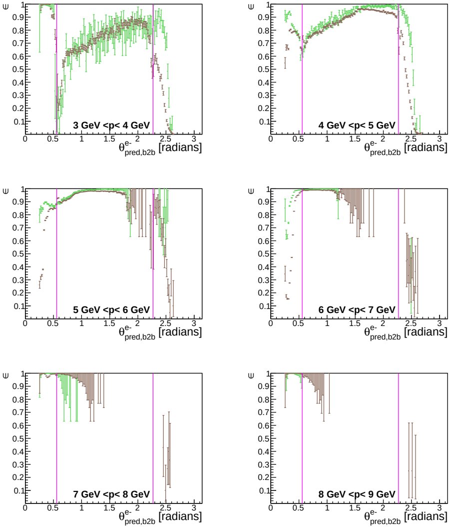
- For momenta between $3\,\mathrm{GeV}$ and $5\,\mathrm{GeV}$ the tracking efficiency in the backward end-cap is worse for phase2 data compared to phase2 MC
- For momenta between $4\,\mathrm{GeV}$ and $6\,\mathrm{GeV}$ the tracking efficiency in the forward end-cap is worse for phase2 data compared to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

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

Phase2 MC10

Phase2 Data

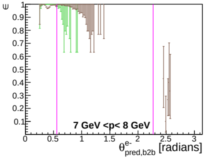
e^{-}

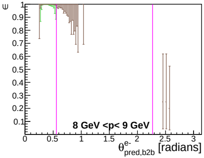


Electron Tracking Efficiency:

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

Positron Tracking Efficiency:

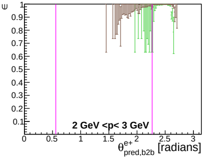


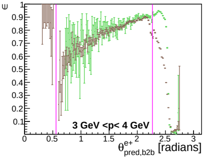


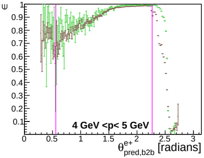
Phase2 MC10

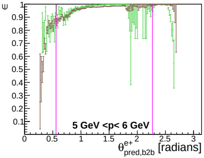
Phase2 Data

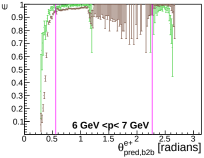
e^+







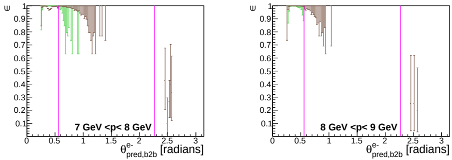




Phase2 Tracking Efficiencies As Function Of $\theta_{\mathbf{pred,b2b}}$

Positron Tracking Efficiency:

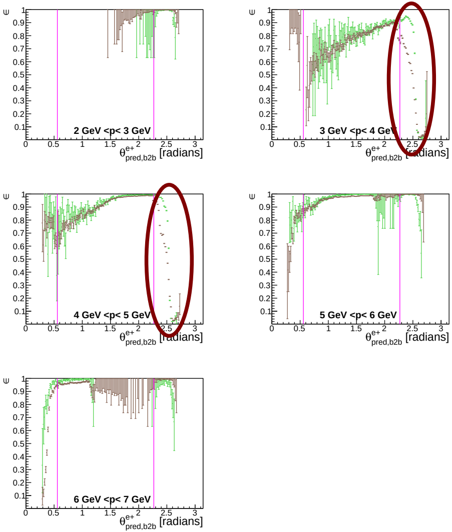
- For momenta between $3\,\mathrm{GeV}$ and $5\,\mathrm{GeV}$ the phase2 data tracking efficiency is lower compared to phase2 MC in the backward end-cap



Phase2 MC10

Phase2 Data

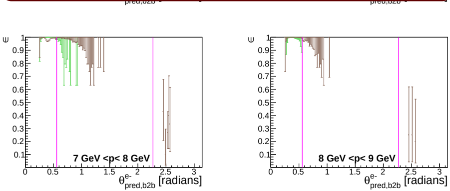
e^+



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

Positron Tracking Efficiency:

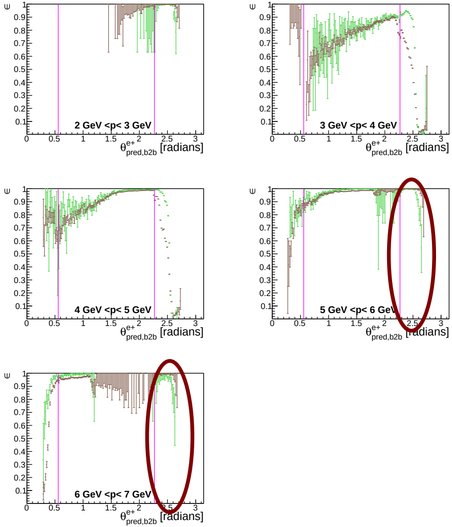
- For momenta between 3 GeV and 5 GeV the phase2 data tracking efficiency is lower compared to phase2 MC in the backward end-cap
- For momenta between 5 GeV and 7 GeV it is vice versa



Phase2 MC10

Phase2 Data

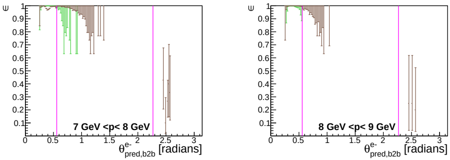
e^{+}

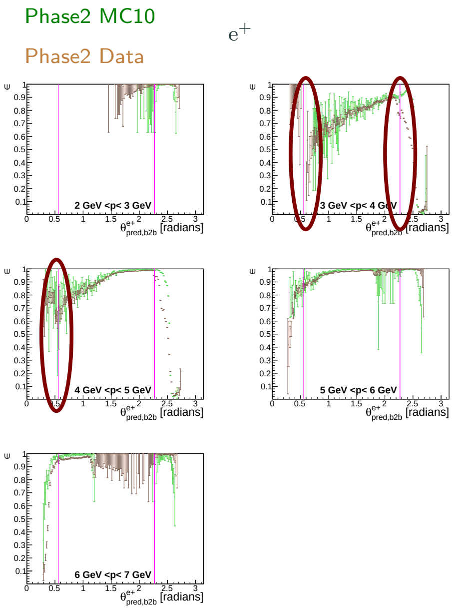


Phase2 Tracking Efficiencies As Function Of $\theta_{\mathrm{pred,b2b}}$

Positron Tracking Efficiency:

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

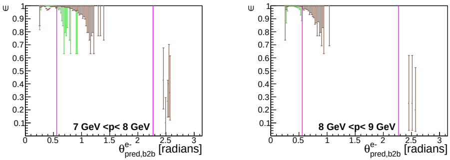




Phase2 Tracking Efficiencies As Function Of $\theta_{\mathbf{pred,b2b}}$

Positron Tracking Efficiency:

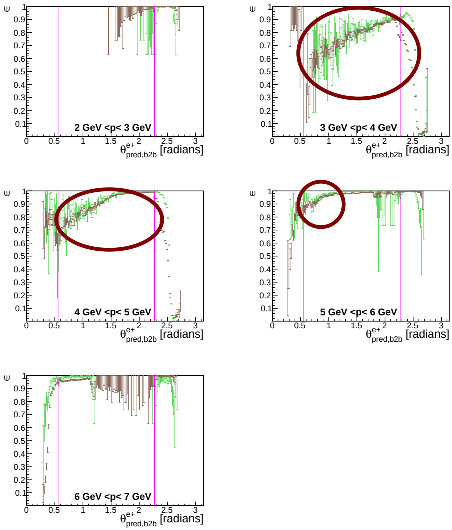
- For momenta between $3\,\mathrm{GeV}$ and $5\,\mathrm{GeV}$ the phase2 data tracking efficiency is lower compared to phase2 MC in the backward end-cap
- For momenta between $5\,\mathrm{GeV}$ and $7\,\mathrm{GeV}$ it is vice versa
- Efficiency drop at transition between barrel and end-caps
- There is a slope in the barrel again



Phase2 MC10

Phase2 Data

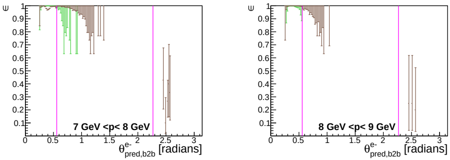
e^+



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

Positron Tracking Efficiency:

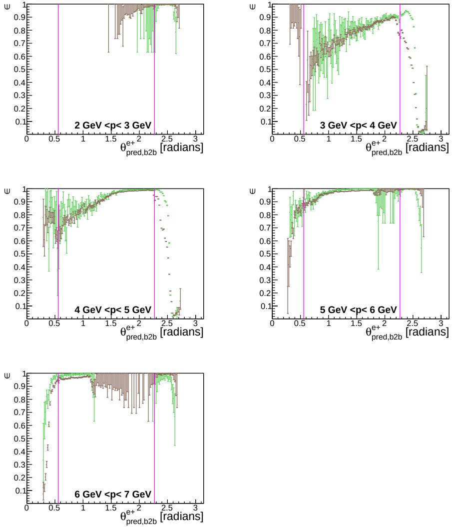
- For momenta between $3\,\mathrm{GeV}$ and $5\,\mathrm{GeV}$ the phase2 data tracking efficiency is lower compared to phase2 MC in the backward end-cap
- For momenta between $5\,\mathrm{GeV}$ and $7\,\mathrm{GeV}$ it is vice versa
- Efficiency drop at transition between barrel and end-caps
- There is a slope in the barrel again



Phase2 MC10

Phase2 Data

e^+



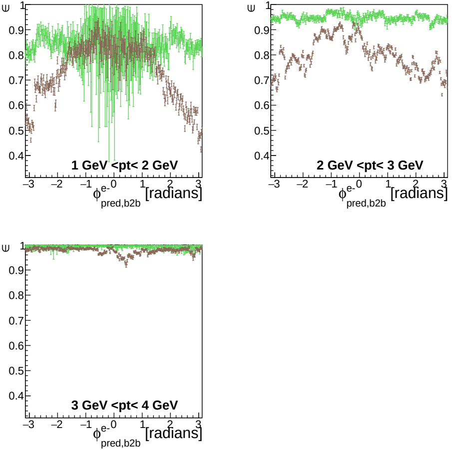
Transverse Momentum

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

Phase2 MC10

Phase2 Data

e^-



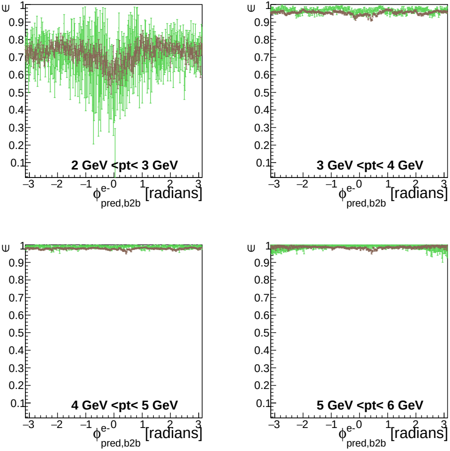
e^+

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

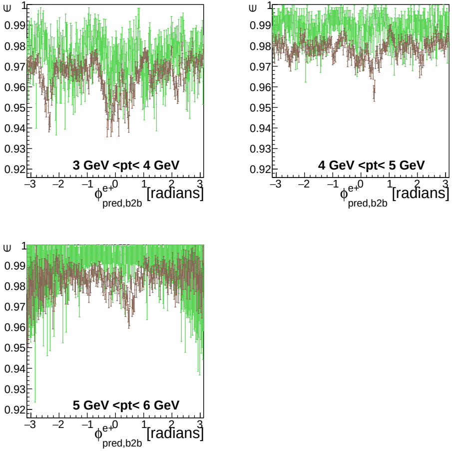
Phase2 MC10

Phase2 Data

e^-



e^+



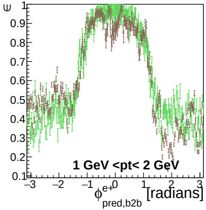
Phase2 pt Tracking Efficiencies As Function Of $\phi_{\mathbf{pred,b2b}}$; Backward End-Cap

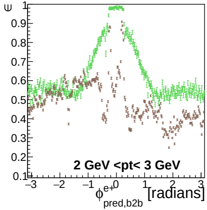
Phase2 MC10

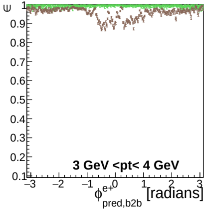
Phase2 Data

e^{-}

e^{+}





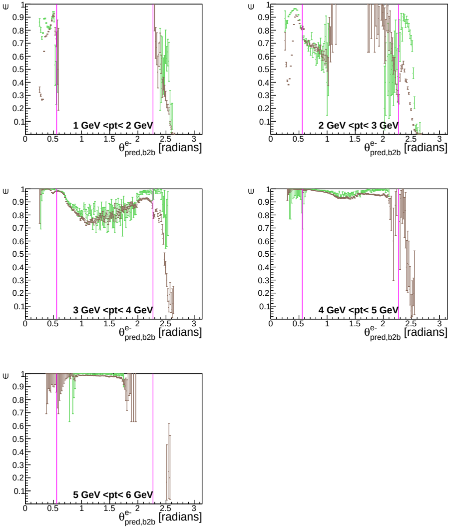


Phase2 pt Tracking Efficiencies As Function Of $\theta_{\mathbf{pred,b2b}}$

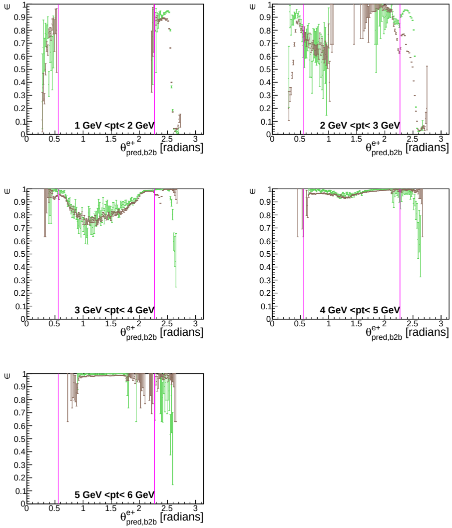
Phase2 MC10

Phase2 Data

e^-



e^+

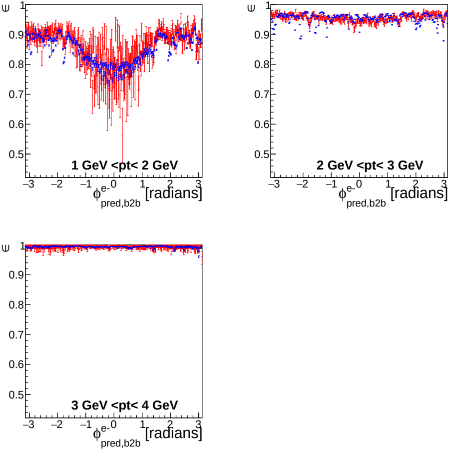


Phase3 pt Tracking Efficiencies As Function Of $\phi_{\mathbf{pred,b2b}}$; Forward End-Cap

Phase3 MC10

Phase3 Data

e^-



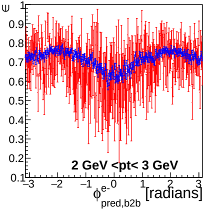
e^+

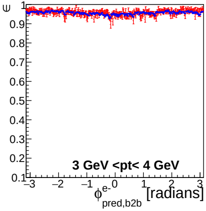
Phase3 pt Tracking Efficiencies As Function Of $\phi_{\mathbf{pred,b2b}}$; Barrel

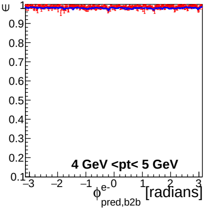
Phase3 MC10

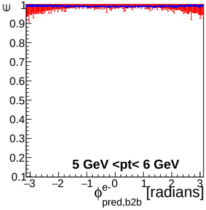
Phase3 Data

e^-

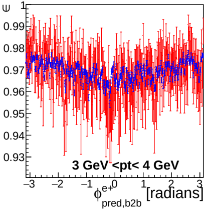


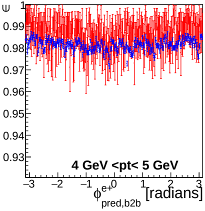


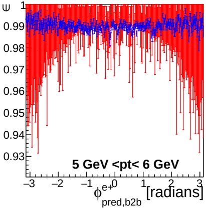




e^+







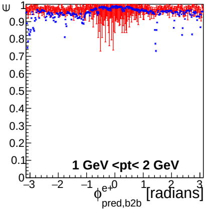
Phase3 pt Tracking Efficiencies As Function Of $\phi_{\mathbf{pred,b2b}}$; Backward End-Cap

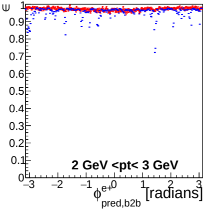
Phase3 MC10

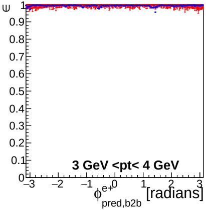
Phase3 Data

e^{-}

e^{+}





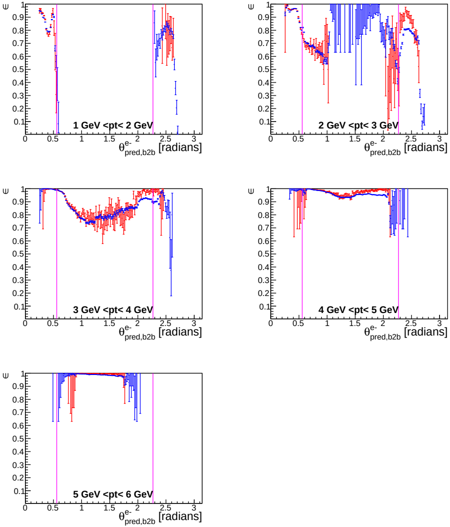


Phase3 pt Tracking Efficiencies As Function Of $\theta_{\mathrm{pred,b2b}}$

Phase3 MC10

Phase3 Data

e^-



e^+