$E_{ECL}$ studies in $B \rightarrow \tau\nu$ analysis

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Joint (S)L/EWP mini-workshop
2023/05/30
Search for $B \rightarrow \tau \nu$ decay

Signal is searched through $\tau$ decays (1-prong):

- $\tau \rightarrow e\nu_e\nu_\tau$
- $\tau \rightarrow \mu\nu_\mu\nu_\tau$
- $\tau \rightarrow \pi\nu_\tau$
- $\tau \rightarrow \rho\nu_\tau$ with $\rho \rightarrow \pi^\pm\pi^0$

~71% of the $\tau$ Branching Fraction

FEI hadronic tagging

No Extra Tracks (from IP)

$B^+$

$B^-$

$\tau^-$

$\nu_\tau$

$\nu_\tau$

$l(\nu_l),\pi,\rho$

$l = e, \mu$

Backgrounds:

MC 15ri

Data

<table>
<thead>
<tr>
<th>Signal</th>
<th>MC 15ri</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>$B^0\overline{B^0}$</td>
<td>2.8 ab$^{-1}$</td>
<td>362 fb$^{-1}$+ offres 42 fb$^{-1}$</td>
</tr>
<tr>
<td>$B^+B^-$</td>
<td>2.6 ab$^{-1}$</td>
<td></td>
</tr>
<tr>
<td>$q\overline{q}$</td>
<td>800 fb$^{-1}$</td>
<td></td>
</tr>
<tr>
<td>$\tau^+\tau^-$</td>
<td>400 fb$^{-1}$</td>
<td></td>
</tr>
</tbody>
</table>

New light-release 2303-iriomote
Data/MC extra energy shift

The energy distribution in the calorimeter exhibits different behavior between the Data and MC.

This variable describes the total energy in the ECL in data and MC after the FEI selection without any clean-up.

Cut on this variable removed in latest Skims.

$E_{ECL}^{FEI}$

$E_{ECL}^{FEI}$ (only neutrals)
The $E_{ECL}^{\text{extra}}$ has not a good agreement between Data and MC.

Electron, cut: sigProb > 0.01 and Mbc > 5.27 GeV

There are several potential causes:

- Residual energy bias between Data and MC.
- Photon reconstruction efficiency differ between Data and MC.
- Low energy photons not well-represented in the different ECL regions.

(ROE mask: E > 55 MeV and clusterNhits > 1.5 and beamBackgroundSuppression > 0.5 and fakePhotonSuppression > 0.1)
Extra Clusters Studies

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- **Residual energy bias between Data and MC.**
- Photon reconstruction efficiency differs between Data and MC.
- Low energy photons not well-represented in the different ECL regions.

Clusters in data have a residual energy shift equal to 1.52%
Extra Clusters Studies

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<th>Energy threshold (MeV)</th>
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<td>Barrel</td>
<td>55</td>
</tr>
<tr>
<td>Backward</td>
<td>55</td>
</tr>
<tr>
<td>Forward</td>
<td>55</td>
</tr>
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</table>

Low energy $\gamma$ show different shape in the 3 regions
Extra Clusters Studies

The $E_{ECL}^{extra}$ has not a good agreement between Data and MC.

Cluster Energy with 25% shift on fake photon as B-Knuunu HadTag

There are several potential causes:

• Residual energy bias between Data and MC.

• Photon reconstruction efficiency differ between Data and MC.

• Low energy photons not well-represented in the different ECL regions.

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</tr>
<tr>
<td>Backward</td>
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Low energy $\gamma$ show different shape in the 3 regions
The double tag sample is enriched in split-off and beam background extra clusters (more Signal like). Possibility to check data and MC.
Extra Clusters Studies Control Sample : Double Tag

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In double tag, we have good agreement even without any correction. $E_{ECL}^{extra}$ shift may be not caused by the fake photons energy not accurately reconstructed in MC.
Extra Clusters Studies

The $E_{ECL}^{\text{extra}}$ has not a good agreement between Data and MC.

Electron:

$E_{ECL}^{\text{extra}} > 0.5\text{GeV}$

→ Instead of the cluster energy, we try to correct only the multiplicity.

We do a linear fit for $N_{\gamma}^{\text{extra}} \geq 3$ and correct $E_{ECL}^{\text{extra}}$.
Extra Clusters Studies

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Extra Clusters Studies

The $E_{ECL}^{\text{extra}}$ agreement between Data and MC improve correcting just for the multiplicity.

Electron:

Bereofe

After

Data-MC / MC

$\chi^2 / \text{NDF} = 16.78 / 14$

$\chi^2 / \text{NDF} = 22.77 / 14$

2023/05/30 Michele Aversano
The $E_{ECL}^{\text{extra}}$ agreement between Data and MC improve correcting just for the multiplicity.

$\tau \rightarrow e\nu\nu$

$\tau \rightarrow \mu\nu\nu$

$\tau \rightarrow \pi\nu$

$\tau \rightarrow \rho\nu$
Extra Clusters Studies: $M_{bc}$ sideband

The $E_{ECL}^{extra}$ agreement between Data and MC improve correcting just for the multiplicity also in $M_{bc}$ sideband.

$M_{bc} < 5.27$ GeV

Same correction of the $E_{ECL}^{extra}$ sideband
Summary and Plans

• We are working on MC corrections for $E_{ECL}^{extra}$ pdfs:
  o Double tag checks (signal like - enriched in split-off and beam background)
    o Agreement better even without any correction. Corrections would be much smaller.
  o Correcting the clusters multiplicity → good data-MC agreement.
    o May the discrepancy come from Physics (background composition) ?
  o Did also some checks in $M_{bc}$ sideband with the same correction of the $E_{ECL}^{extra}$ sideband.

Backup
# Analysis Workflow

- Reconstruction + PID correction **(DONE)**

<table>
<thead>
<tr>
<th>Particles</th>
<th>Selections</th>
</tr>
</thead>
<tbody>
<tr>
<td>good track</td>
<td>( dr &lt; 0.5 \text{ cm},</td>
</tr>
<tr>
<td>( e^+ )</td>
<td>good track, ( \mathcal{P}_e &gt; 0.9 )</td>
</tr>
<tr>
<td>( \mu^+ )</td>
<td>good track, ( \mathcal{P}_\mu &gt; 0.9 )</td>
</tr>
<tr>
<td>( \pi^+ )</td>
<td>good track, ( \mathcal{P}_\pi &gt; 0.6 )</td>
</tr>
<tr>
<td>( \pi^0 )</td>
<td>eff40May2020</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ROE tracks((=0))</th>
<th>( dr &lt; 0.5 \text{ and } abs(dz) &lt; 2 ) and ( \text{thetaInCDCAcceptance} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>ROE ( \gamma )</td>
<td>( E &gt; 0.055 \text{ GeV} \text{ and } \text{clusterNHits} &gt; 1.5 )</td>
</tr>
<tr>
<td>ROE ( \gamma )</td>
<td>Hadronic Split off cut</td>
</tr>
<tr>
<td>ROE ( \gamma )</td>
<td>Beam Background cut</td>
</tr>
</tbody>
</table>

**Possible definitions of \( E_{ECL} \)**

- Beam background 1: \( t < 200 \text{ ns and } \sigma_t/t < 2 \)
- Beam background 2: \( \text{beamBackgroundSuppression} > 0.5 \)
- Hadronic Splitoff 1: \( \text{minC2TDist} > 25 \text{ cm} \)
- Hadronic Splitoff 2: \( \text{hadronicSplitOffSuppression} > 0.1 \)

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fakePhotonSuppression from light-2303-iriomote