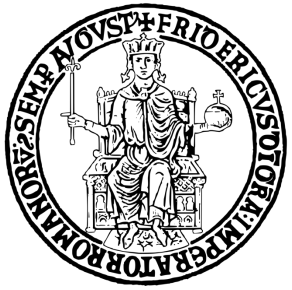
E_{ECL} studies in $B \to \tau\nu$ analysis

Michele Aversano[A],

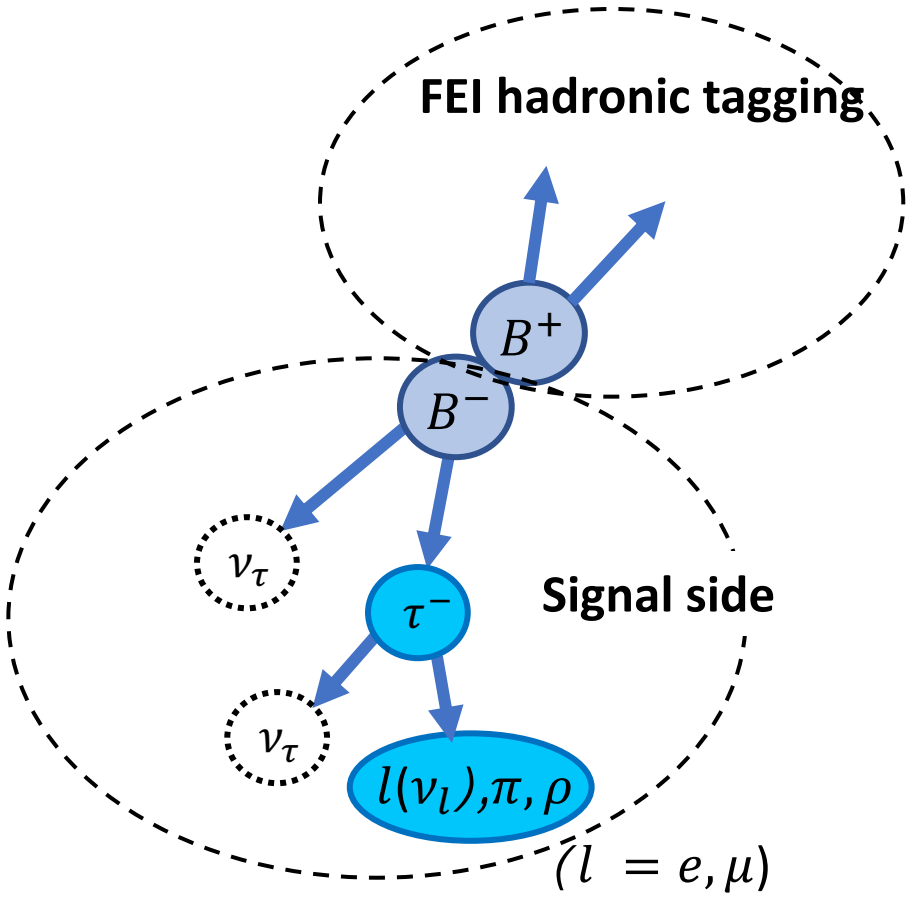
Guglielmo De Nardo[B], Giovanni Gaudino[B,C], Toru Iijima[A,D,E], Mario Merola[B]

Nagoya University[A], INFN Napoli – University of Napoli Federico II[B], INFN Napoli – Scuola Superiore Meridionale[C], Nagoya KMI[D], KEK IPNS[E]



Joint (S)L/EWP mini-workshop
2023/05/30

Search for $B \to \tau\nu$ decay



→ **No Extra Tracks (from IP)**

Signal is searched through τ decays (1-prong):

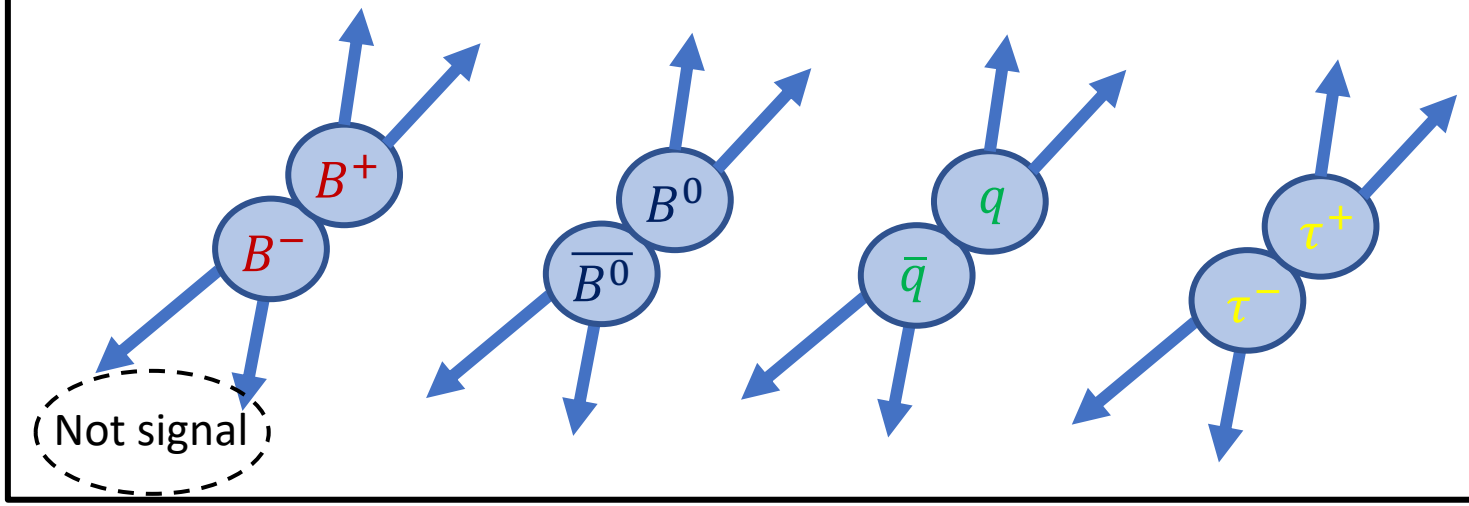
~71% of the τ Brancing Fraction

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

New light-release 2303-iriomote

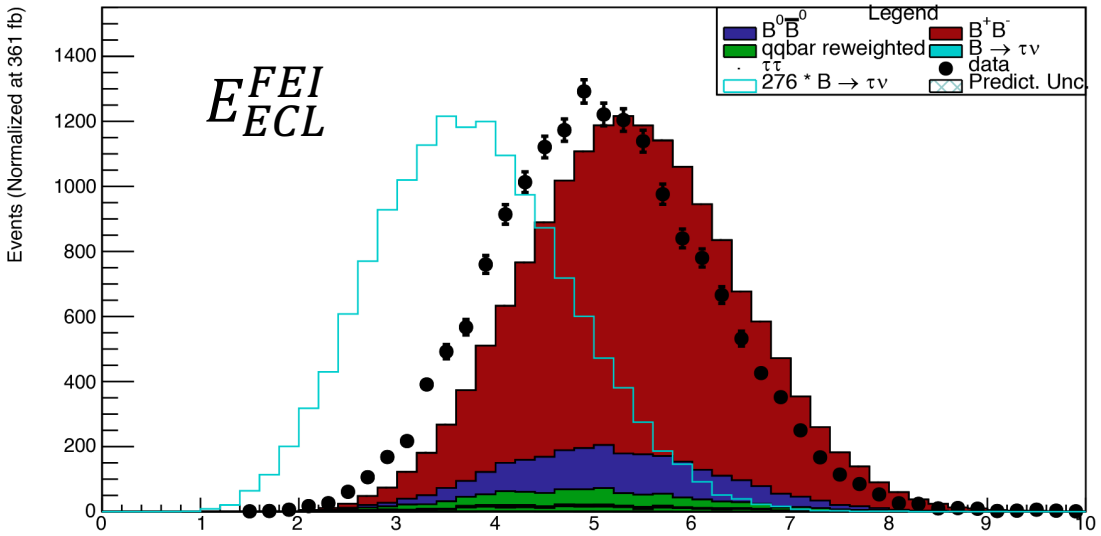
MC 15ri	Data
Signal ~ $40 \cdot 10^6$ events $B^0\overline{B^0}$ 2.8 ab^{-1} B^+B^- 2.6 ab^{-1} $q\bar{q}$ 800 fb^{-1} $\tau^+\tau^-$ 400 fb^{-1}	362 fb^{-1}+ offres 42fb^{-1}

Backgrounds:



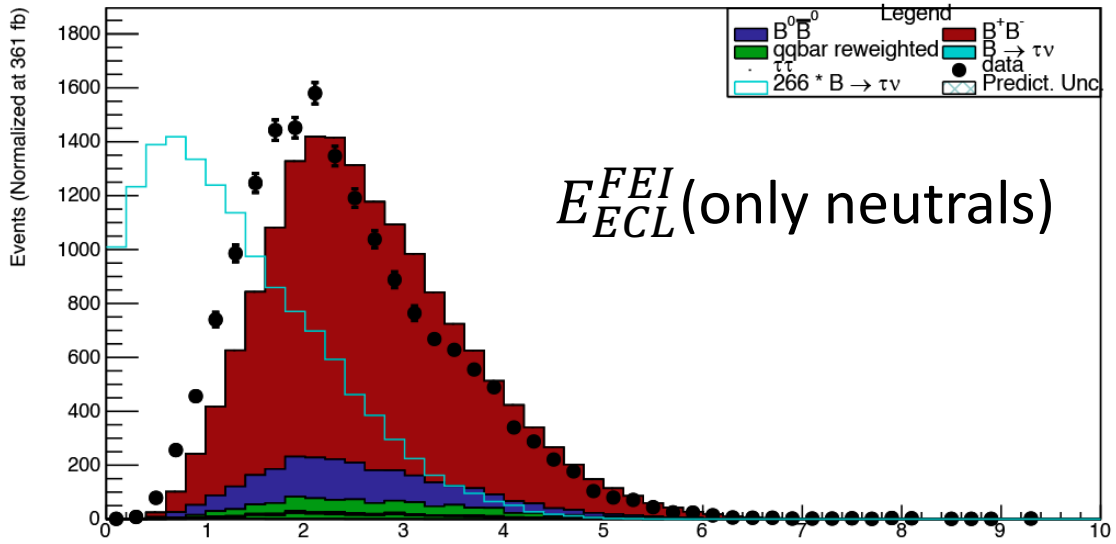
Data/MC extra energy shift

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



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

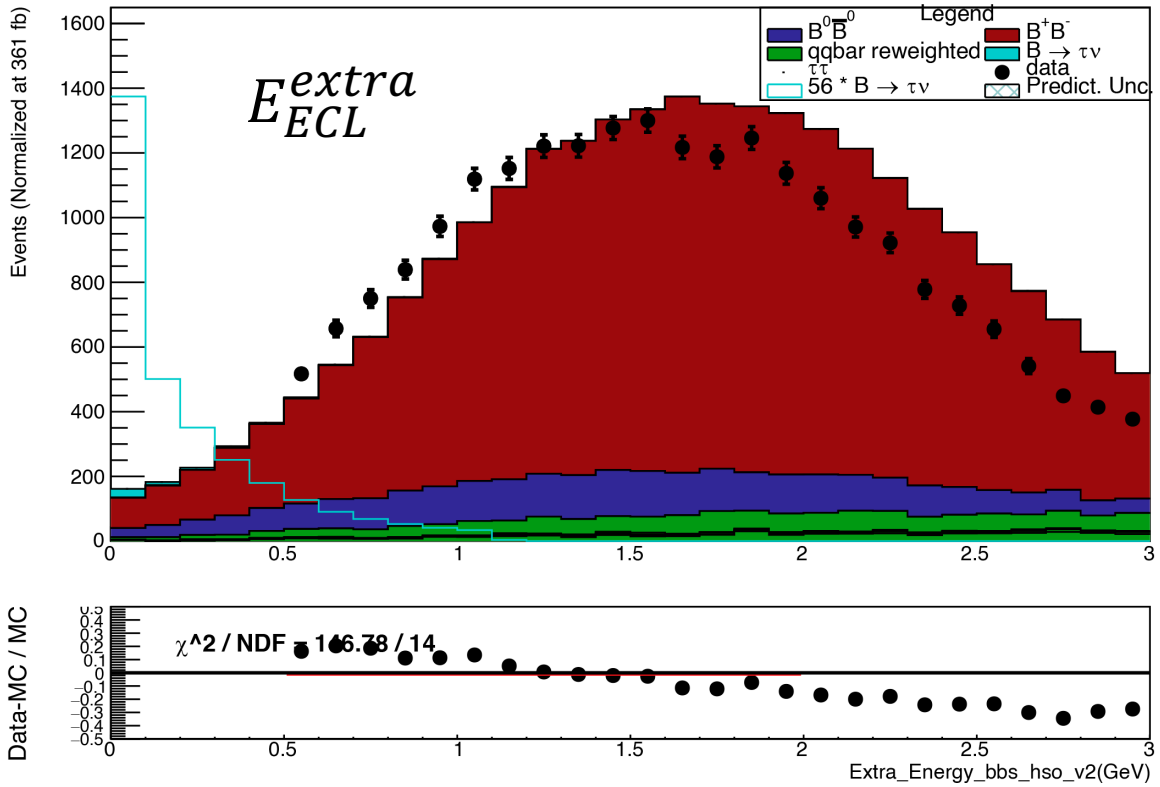
Cut on this variable removed in latest Skims .



Data/MC extra energy shift

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

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



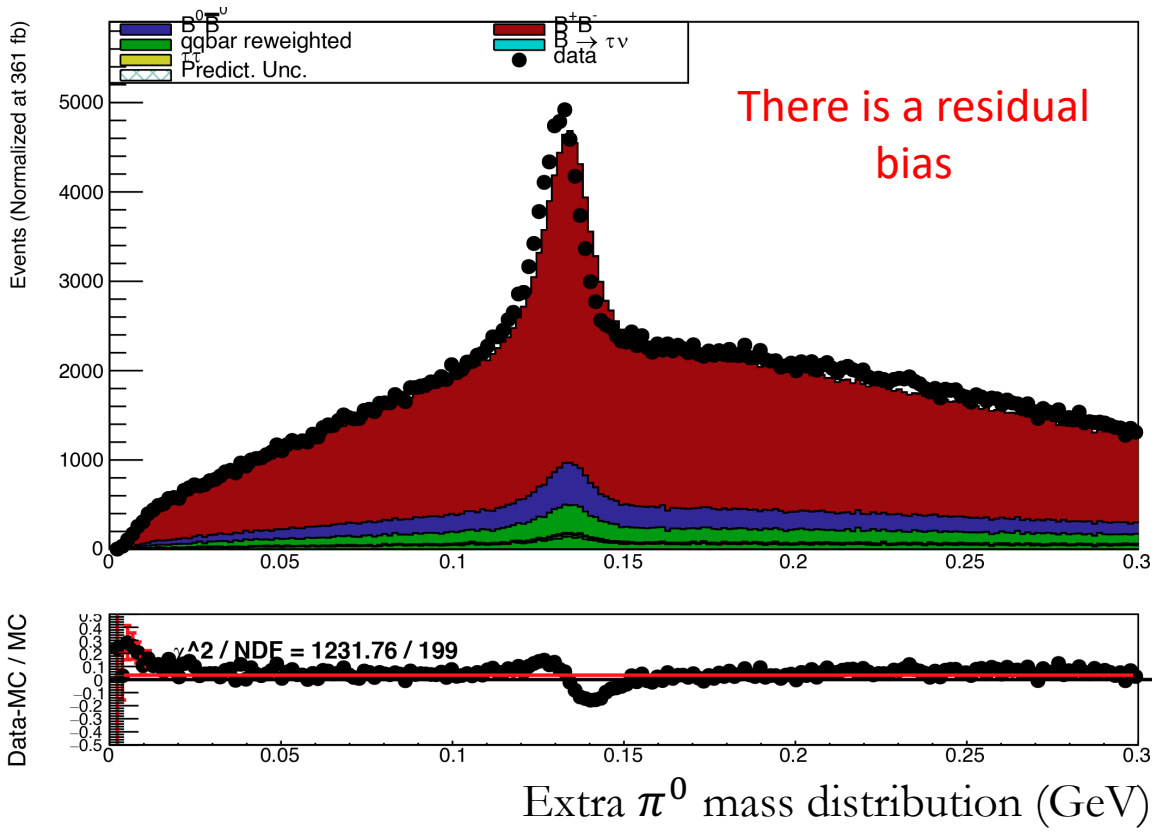
There are several potential causes:

- **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 clustesNHits > 1.5 and beamBackgroundSuppression > 0.5 and fakePhotonSuppression > 0.1)

Extra Clusters Studies

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



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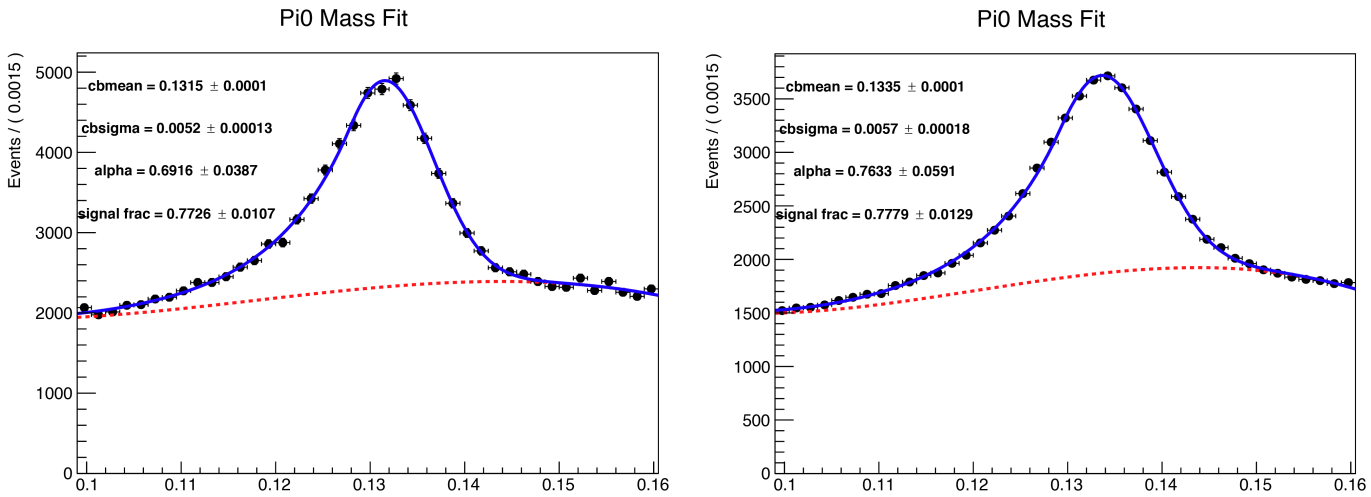

Extra π^0 mass distribution (GeV)

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

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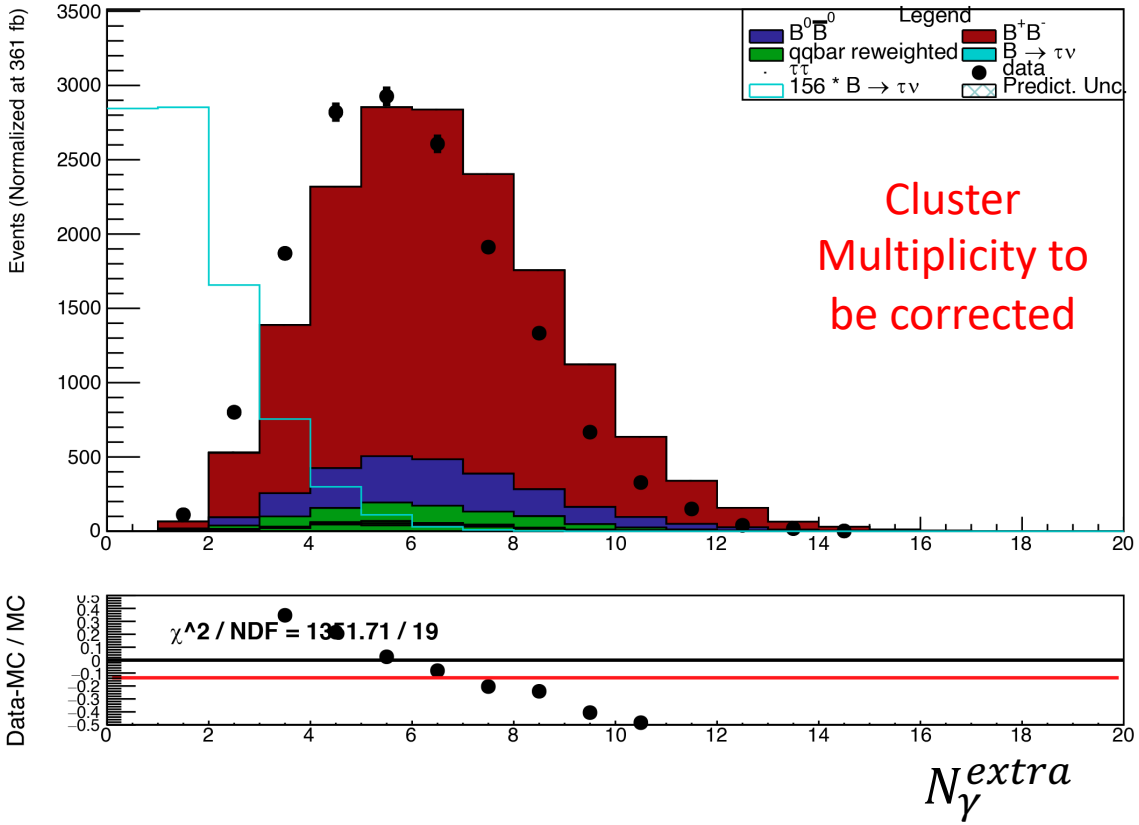

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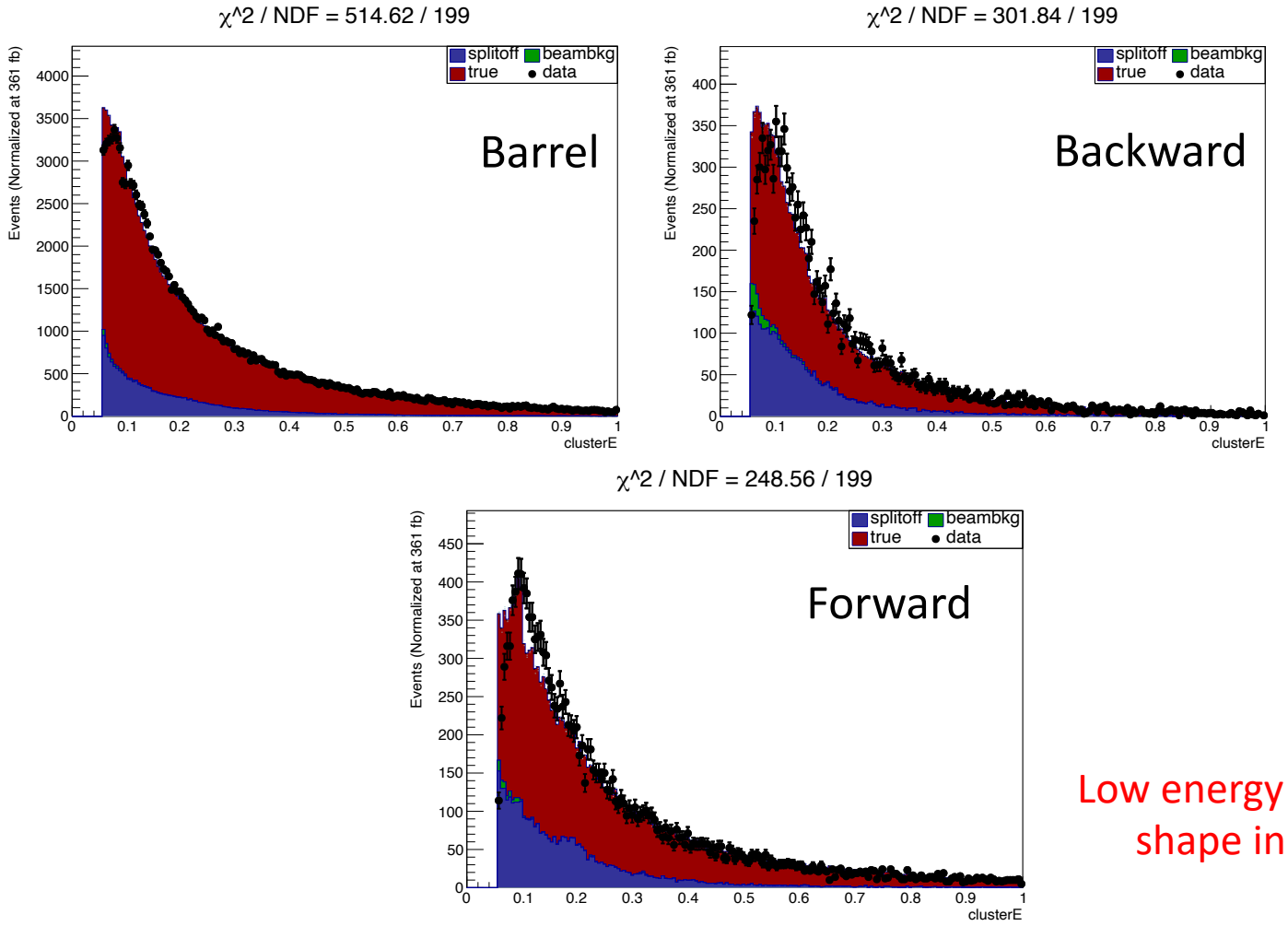
Cluster Energy



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Low energy γ show different shape in the 3 regions

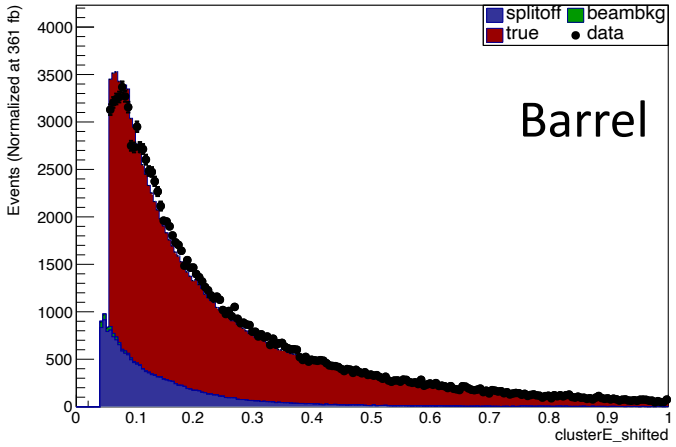
ECL region	Energy threshold (MeV)	
	Old	New
Barrel	55	55
Backward	55	100
Forward	55	80

Extra Clusters Studies

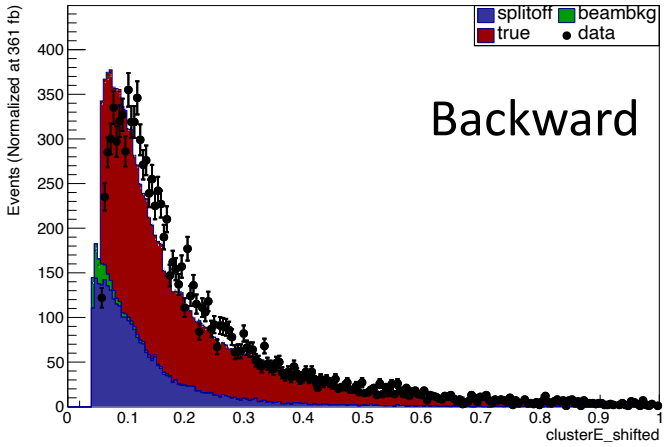
The E_{ECL}^{extra} has not a good agreement between Data and MC.

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

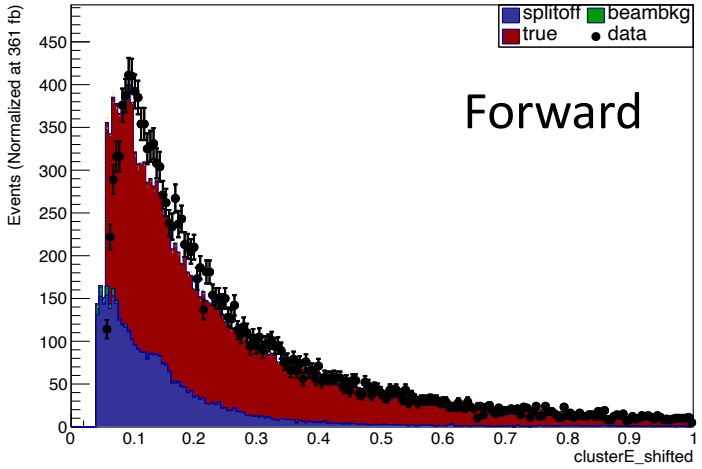
χ^2 / NDF = 538.88 / 199



χ^2 / NDF = 309.48 / 199



χ^2 / NDF = 239.71 / 199



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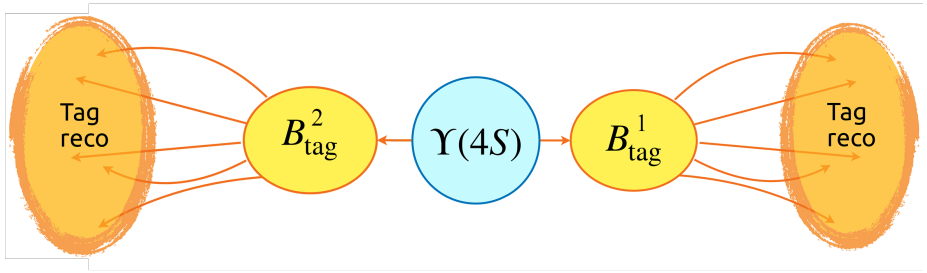
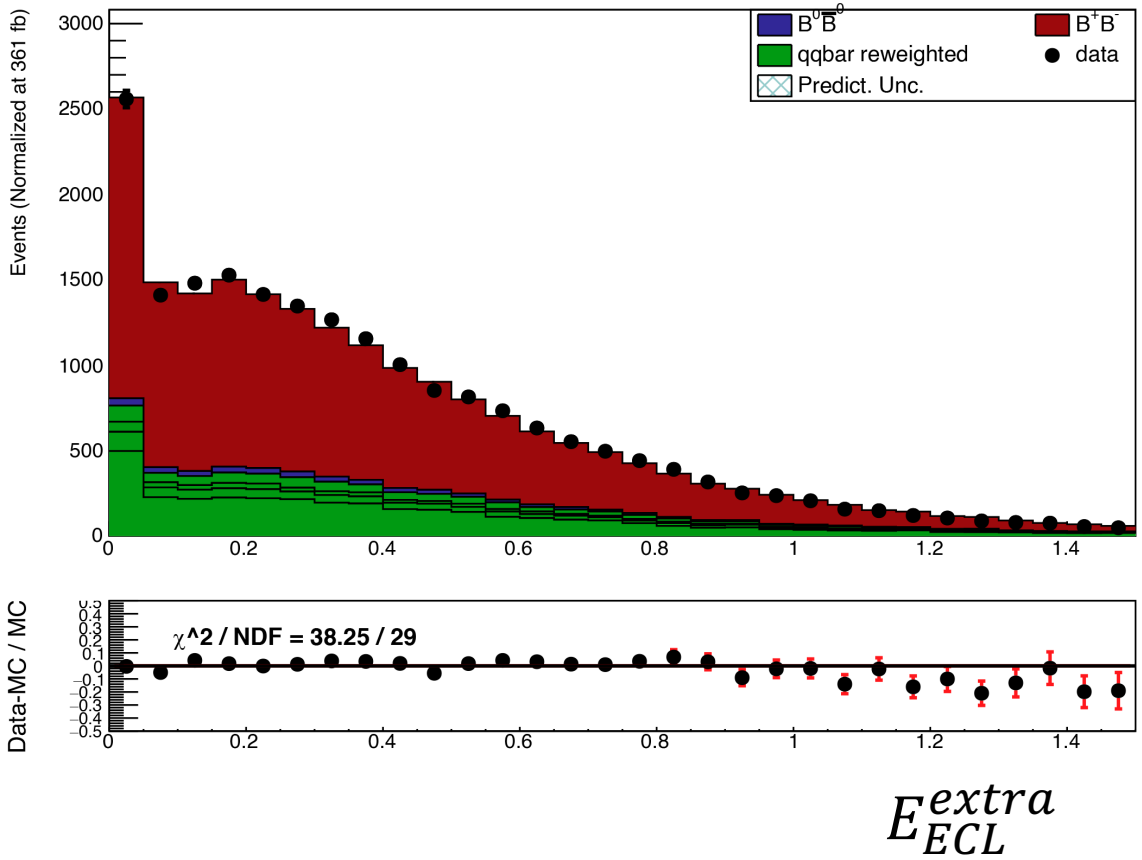
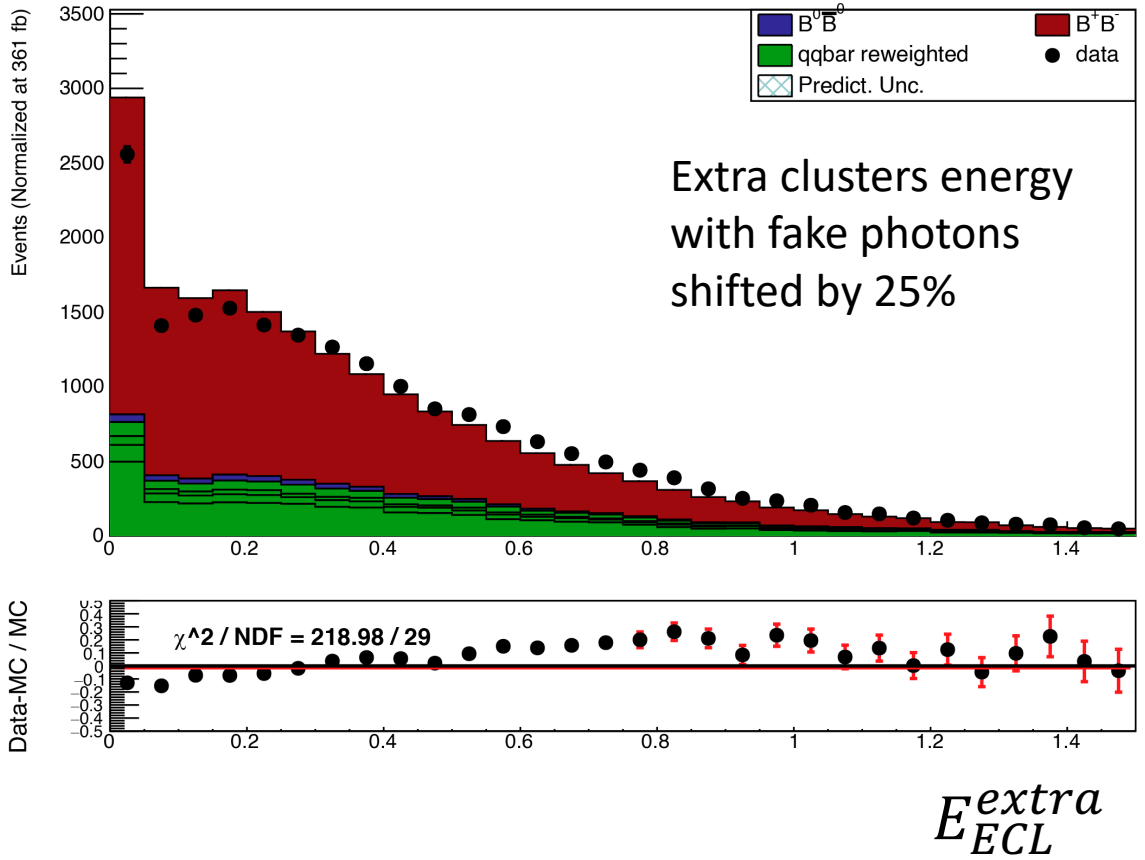
Extra Clusters Studies Control Sample : Double Tag

The double tag sample is enriched in split-off and beam background extra clusters (more Signal like).
Possibility to check data and MC.







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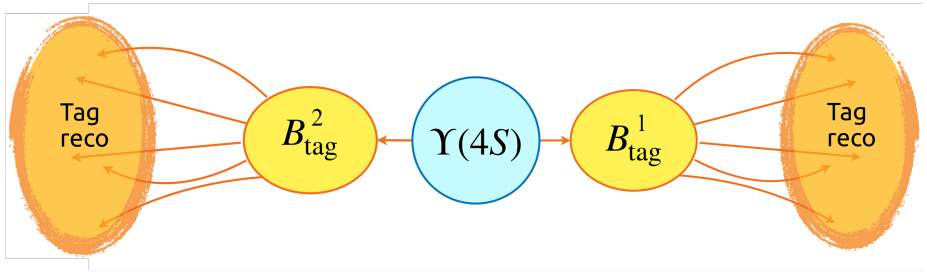

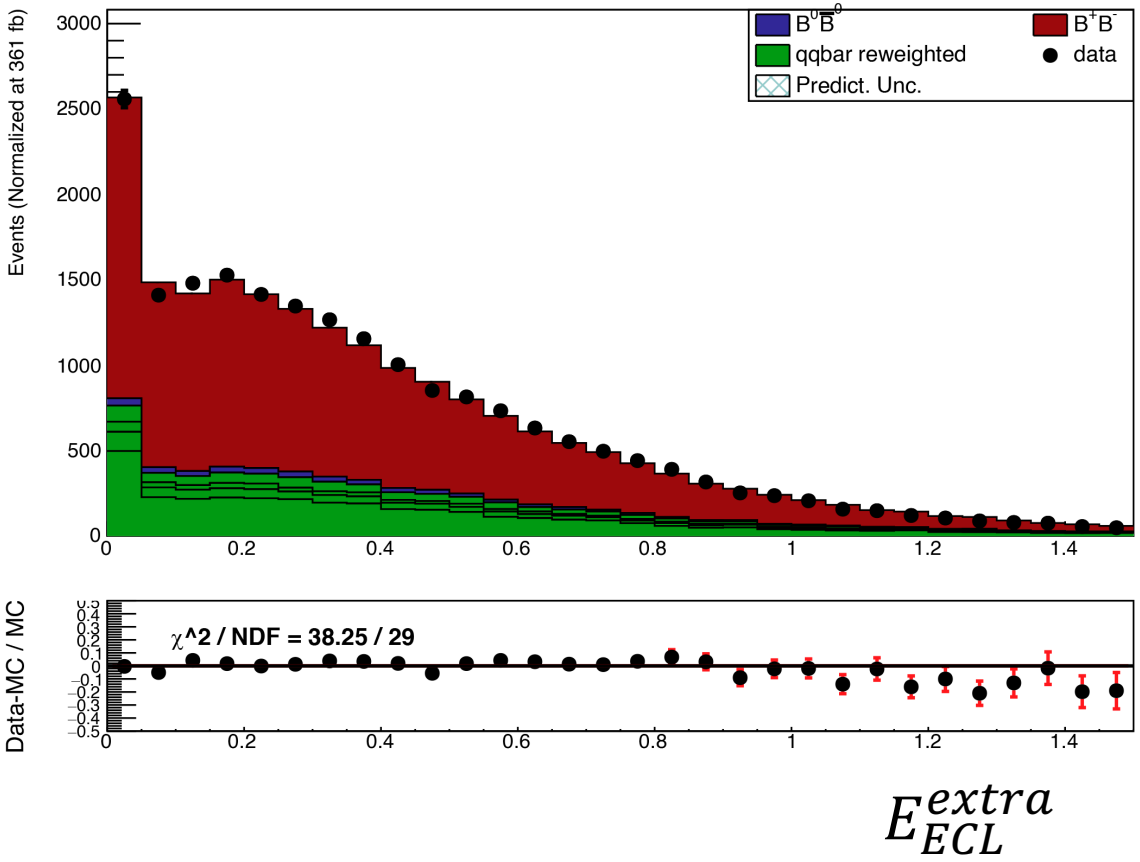

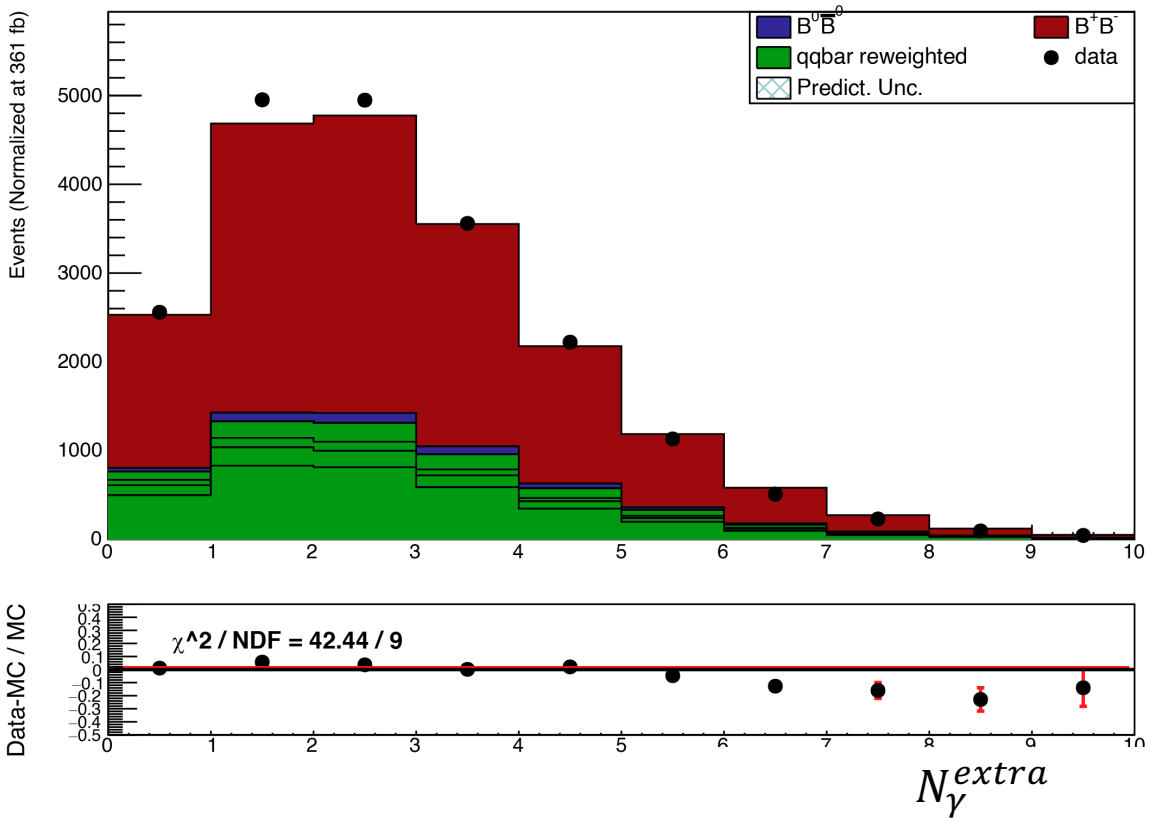

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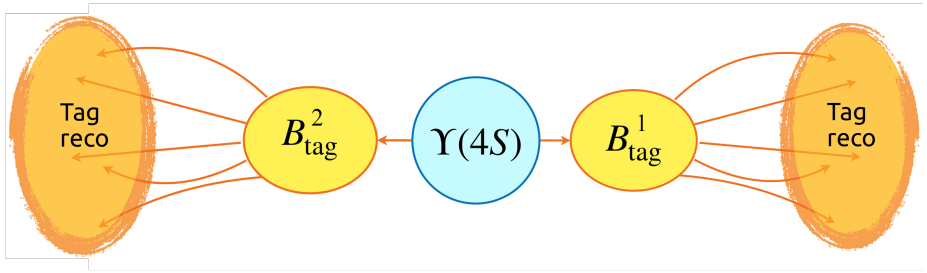
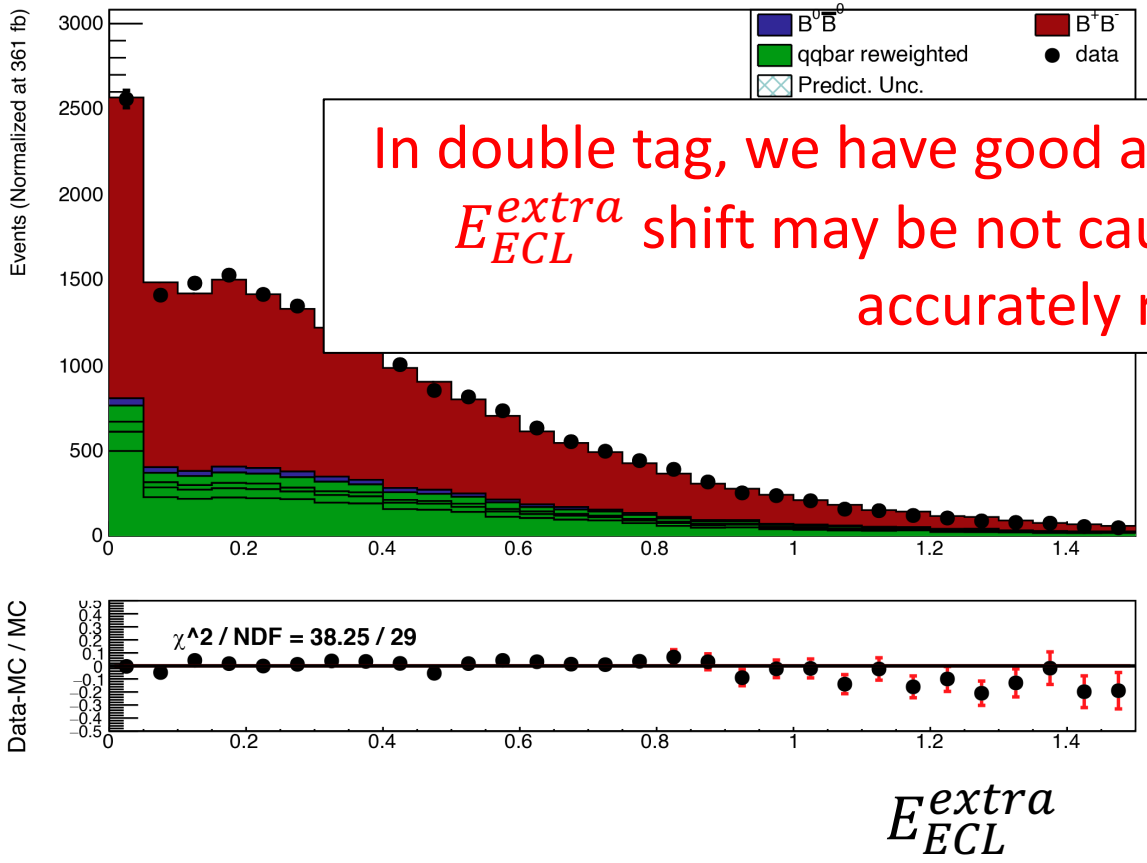
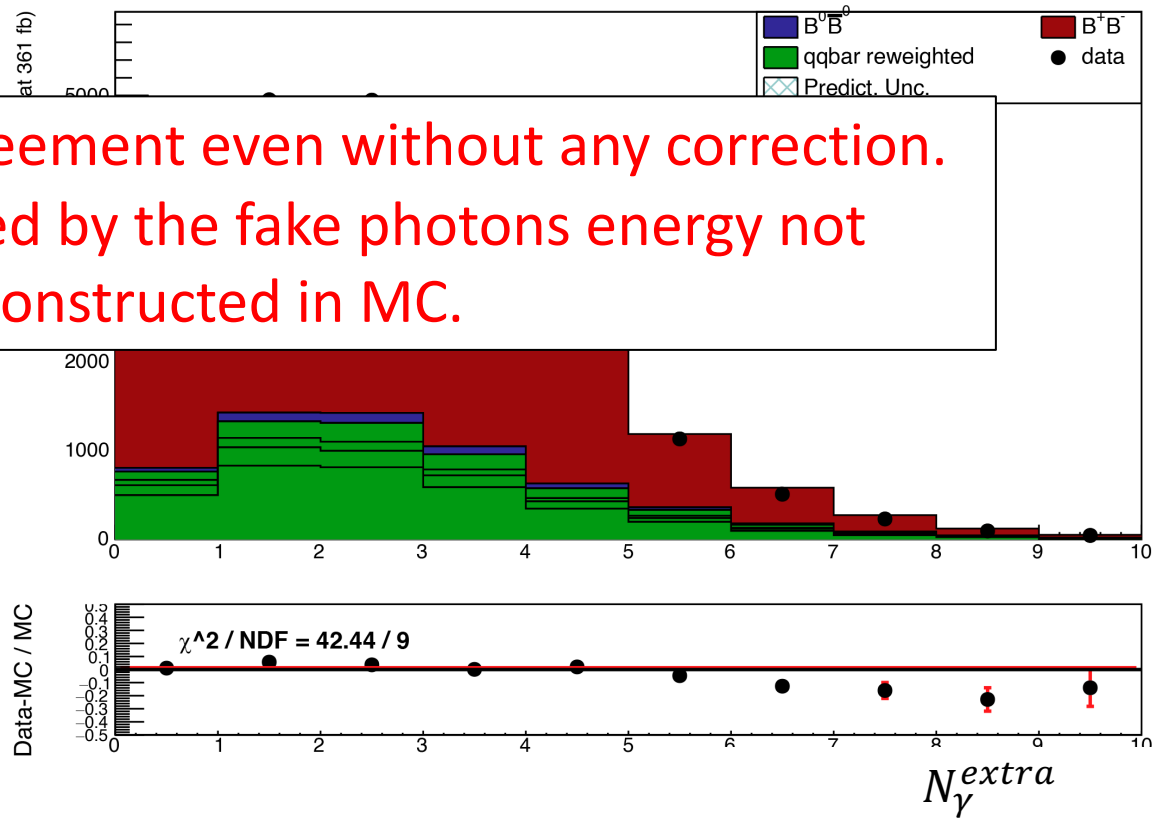


In double tag, we have good agreement even without any correction.
E_{ECL}^{extra} shift may be not caused by the fake photons energy not accurately reconstructed in MC.





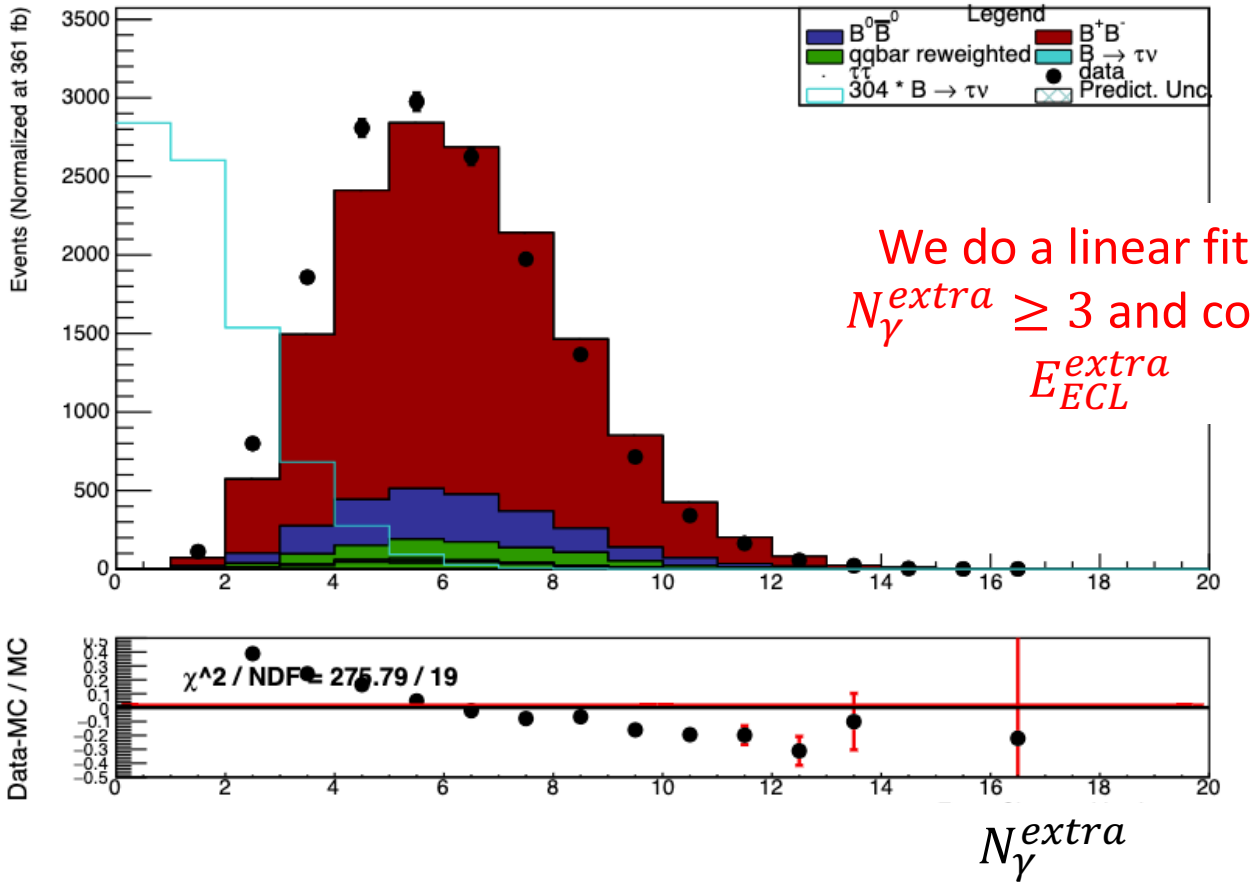
Extra Clusters Studies

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

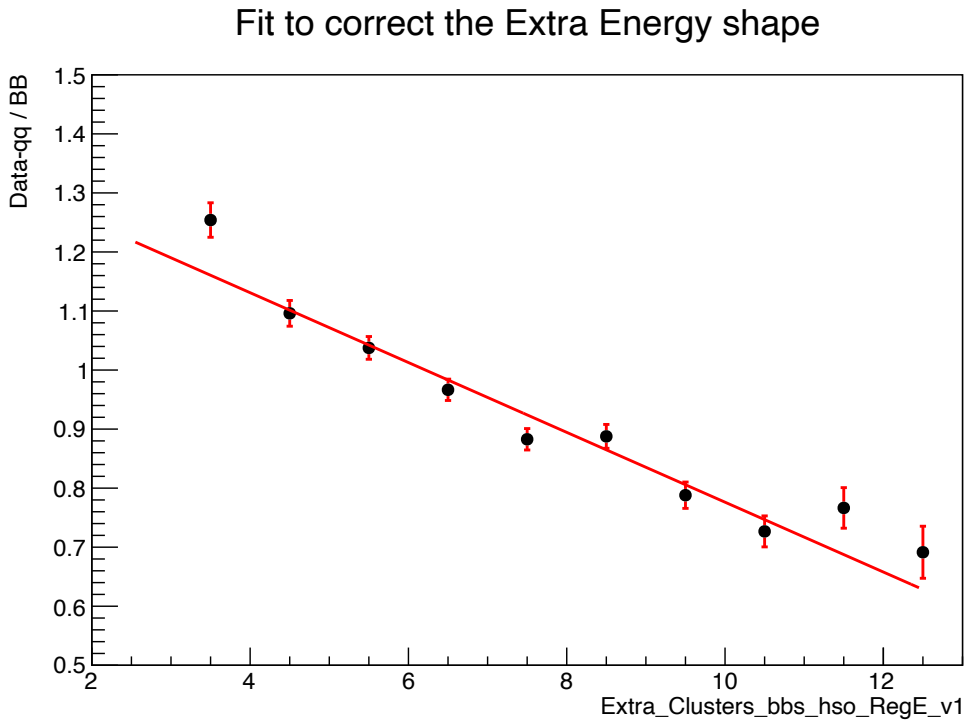
Electron:

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

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



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



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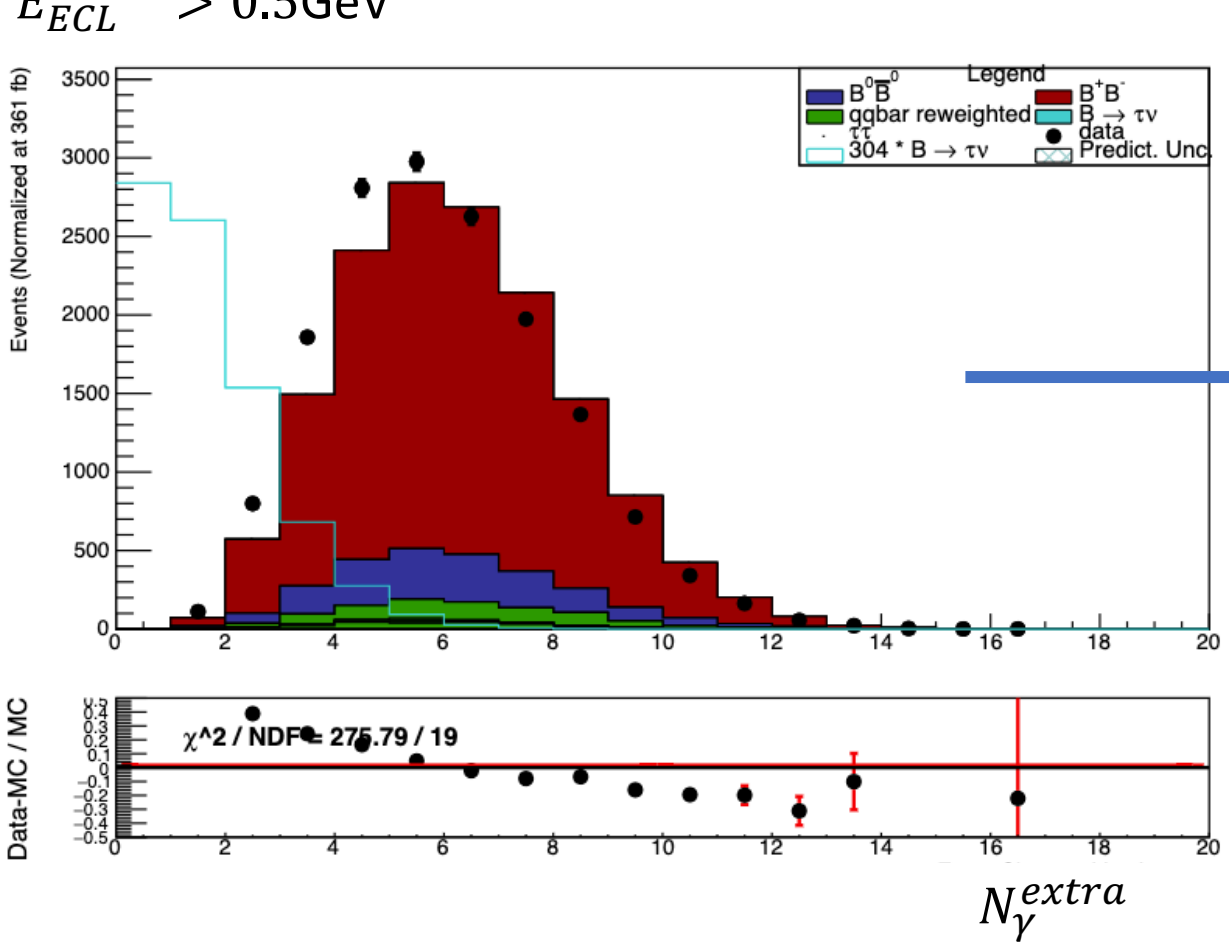
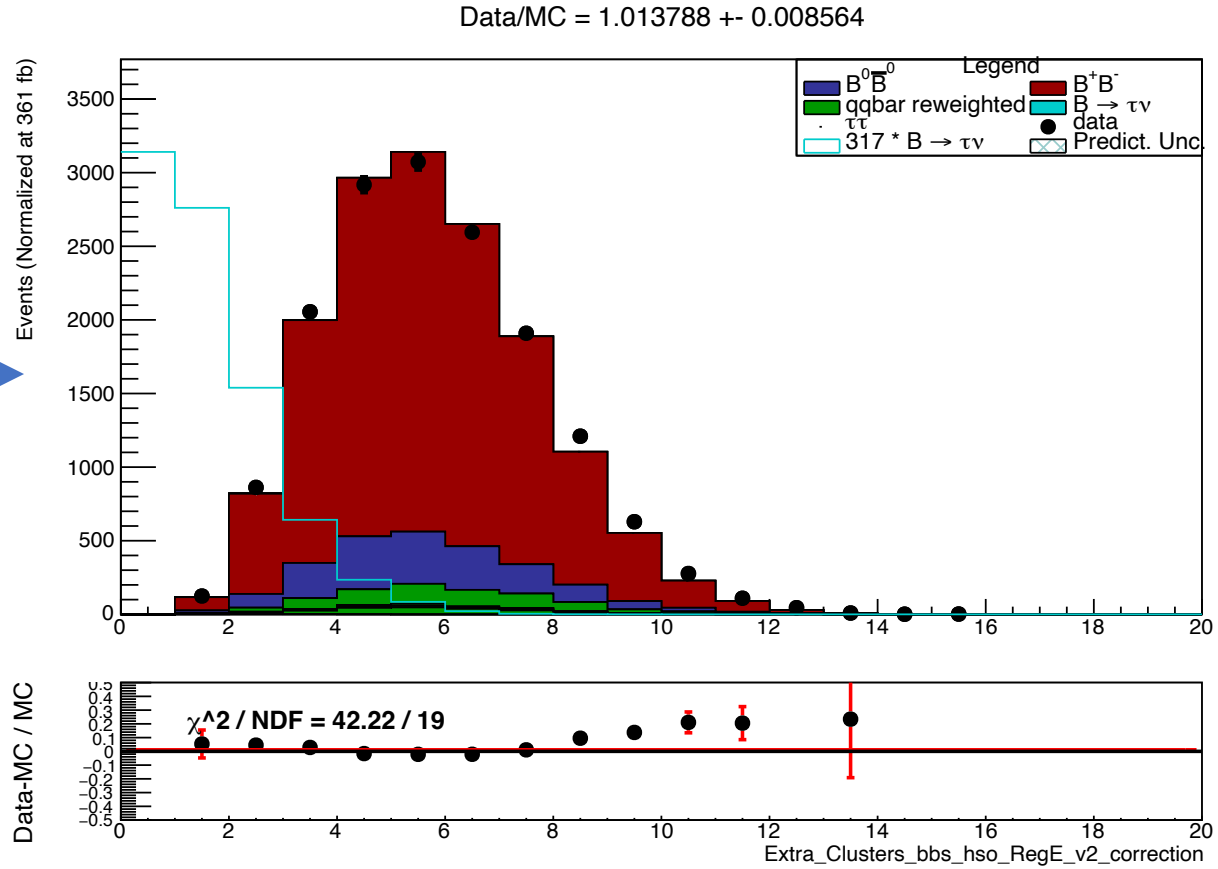


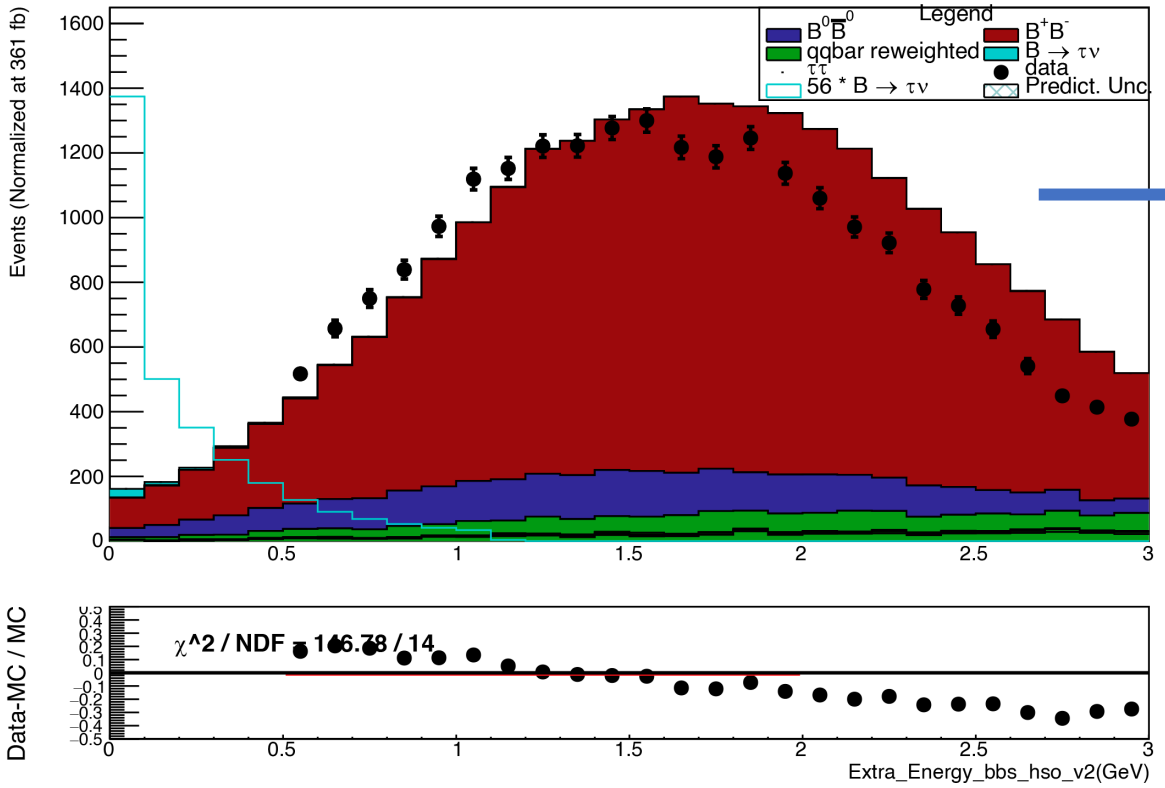


Extra Clusters Studies

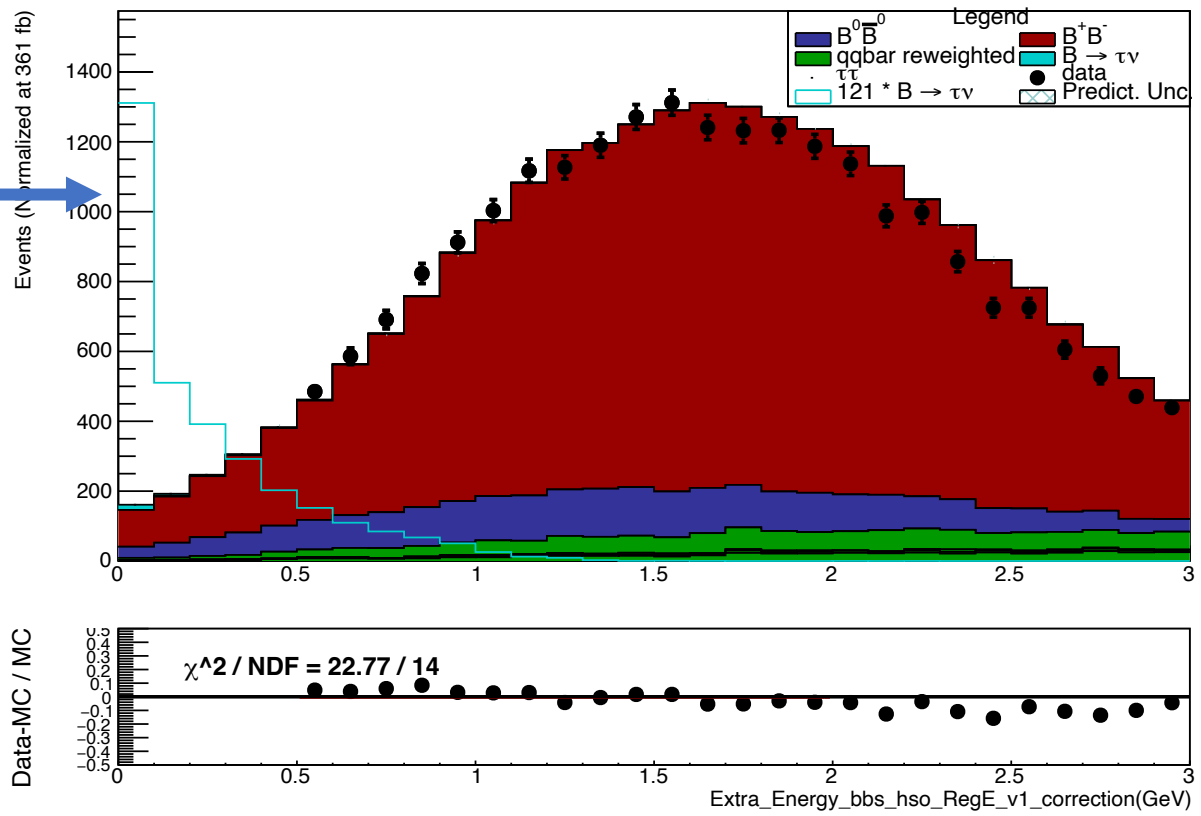
The E_{ECL}^{extra} agreement between Data and MC improve correcting just for the multiplicity.

Electron:

Berofe



After



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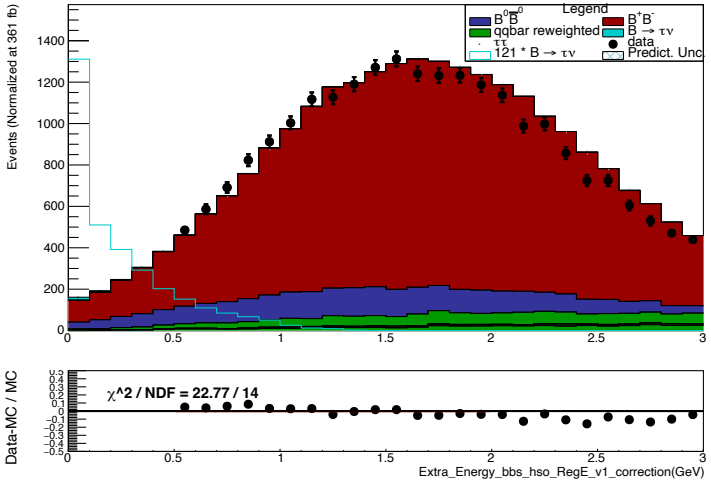
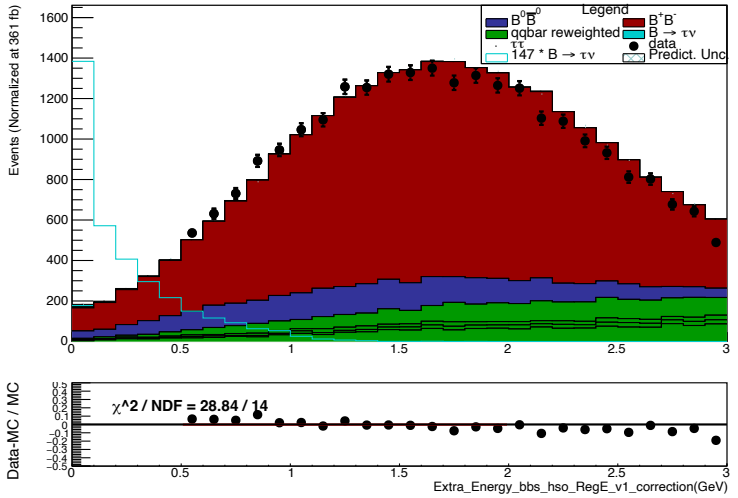
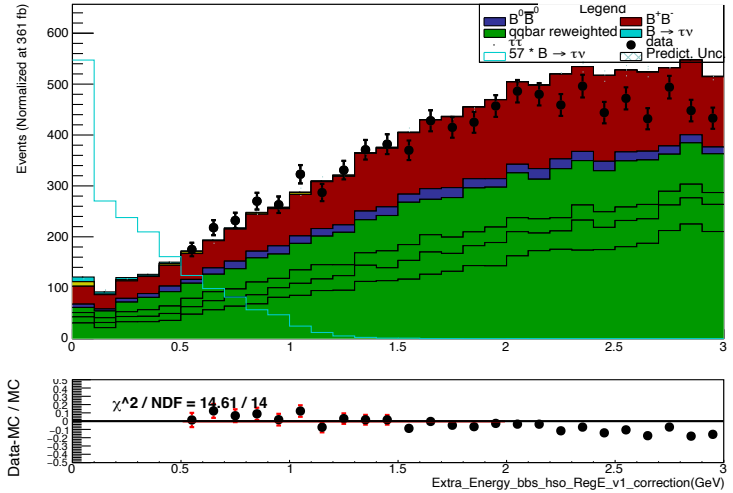


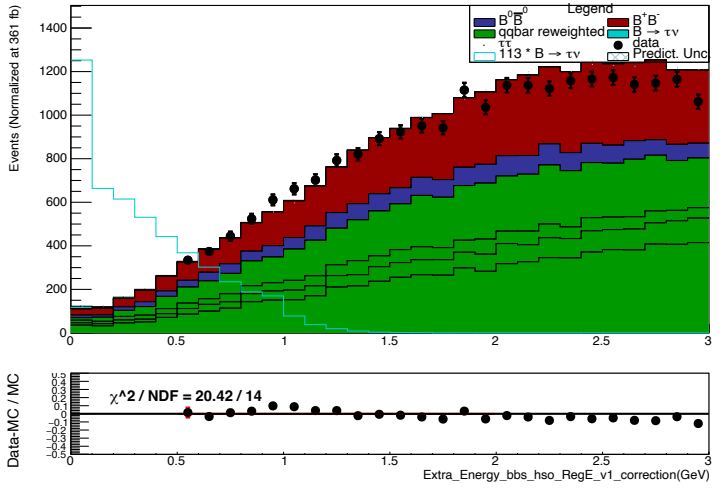
$\tau \rightarrow e\nu\nu$



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



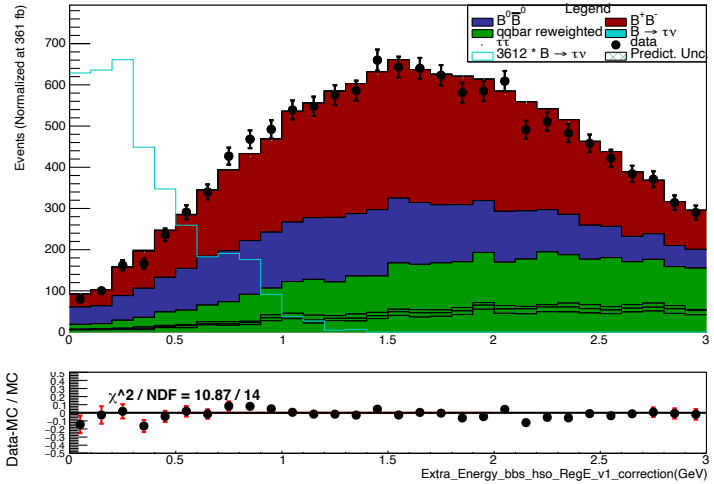
$\tau \rightarrow \pi\nu$



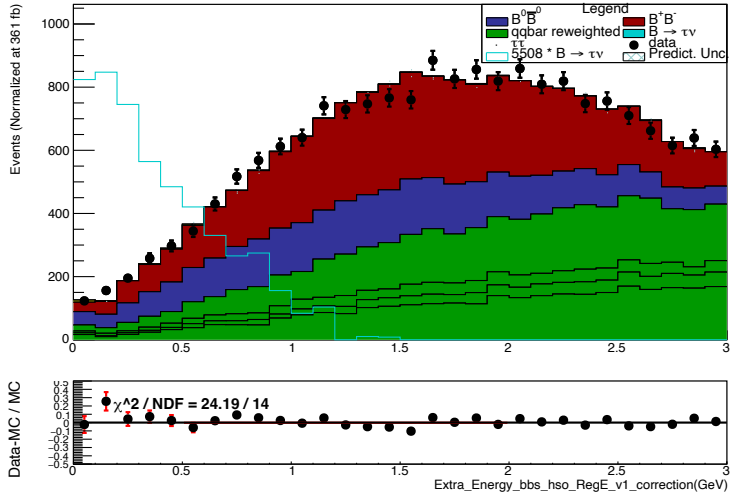
$\tau \rightarrow \rho\nu$

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.



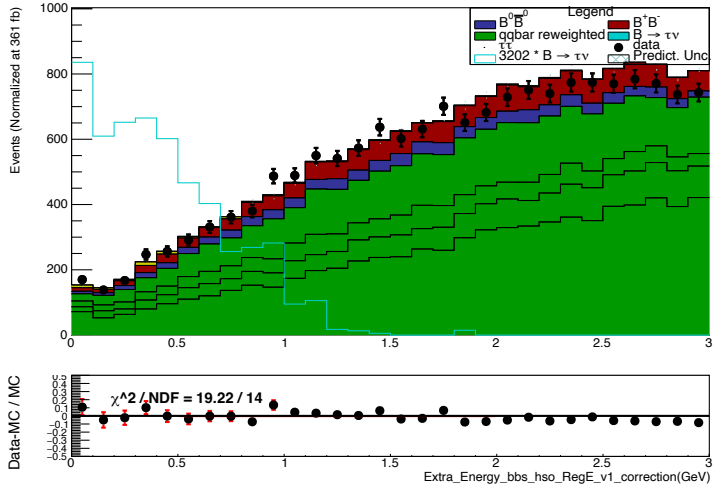
$\tau \to e\nu\nu$



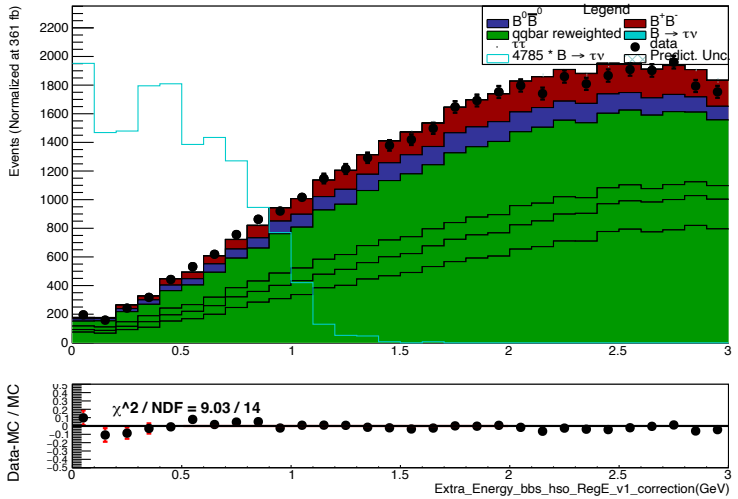
$\tau \to \mu\nu\nu$

$M_{bc} < 5.27\ GeV$

Same correction of the E_{ECL}^{extra} sideband



$\tau \to \pi\nu$



$\tau \to \rho\nu$

Summary and Plans

- We are working on MC corrections for E_{ECL}^{extra} pdfs:
  - Double tag checks (signal like - enriched in split-off and beam background)
    - Agreement better even without any correction. Corrections would be much smaller.
  - Correcting the clusters multiplicity → good data-MC agreement.
    - May the discrepancy come from Physics (background composition) ?
  - Did also some checks in M_{bc} sideband with the same correction of the E_{ECL}^{extra} sideband.
- Our Belle II note: BELLE2-NOTE-PH-2022-025.

Backup

Analysis Workflow

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

Particles	Selections
good track	$dr < 0.5\,\text{cm}$, $\lvert dz\rvert < 2\,\text{cm}$, $p > 0.5\,\text{GeV}$, $nCDCHits > 20$, $E < 5.5\,\text{GeV}$
e^+	good track, $\mathcal{P}_e > 0.9$
μ^+	good track, $\mathcal{P}_\mu > 0.9$
π^+	good track, $\mathcal{P}_\pi > 0.6$
π^0	eff40May2020
ROE tracks(=0)	$dr < 0.5$ and $abs(dz) < 2$ and `thetaInCDCAcceptance`
ROE γ	$E > 0.055\,\text{GeV}$ and $clusterNHits > 1.5$
ROE γ	Hadronic Split off cut
ROE γ	Beam Background cut
Possible definitions of E_{ECL}	
Beam background 1	$t < 200\,\text{ns}$ and $\sigma_t/t < 2$
Beam background 2	`beamBackgroundSuppression` > 0.5
Hadronic Splitoff 1	`minC2TDist` $> 25\,\text{cm}$
Hadronic Splitoff 2	`hadronicSplitOffSuppression` > 0.1

fakePhotonSuppression
from light-2303-iriomote