Photons and π^0 ID in release-00-08

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Outline

- Photons and pi0s physics lists in release-00-08
- Performances are evaluated looking at efficiency, purity and resolutions of the photons and pi0s in BB generic events generated in different bkg conditions (BGx0, BGx1and BGx2)
- Dedicated extra clusters and pi0 cleaning against beam background

Photon lists

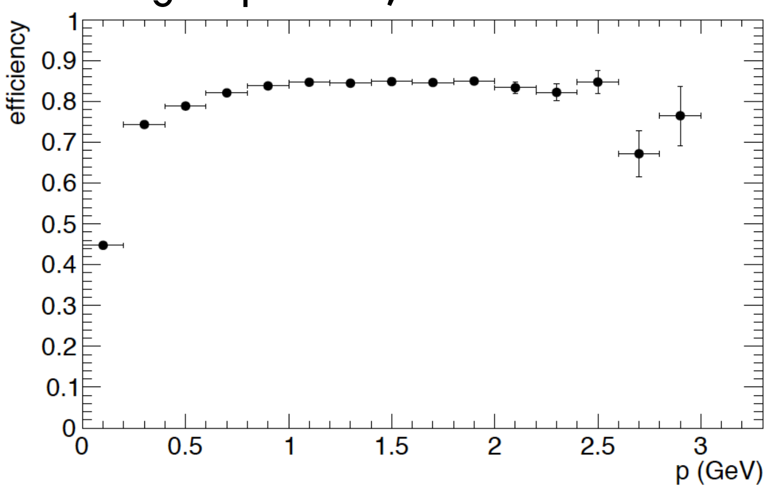
- Definition of physics photon lists with relatively high efficiency and purity based on one-dimensional cuts
  - stdPhotons('all'): all clusters with E>20MeV, |t| < dt99 (99% efficient timing cut for E<50MeV), no matched tracks
  - stdPhotons('loose'): 'all' + no failed waveform fit (for highest energetic crystal in shower) and E1oE9>0.4 below 75MeV, no E1oE9 cut above 75 MeV
  - stdPhotons('tight'): 'loose' + E>50/75MeV (Barrel and FWD / BWD)
  - stdPhotons('pi0'): 'loose' used to build pi0s
  - stdPhotons('pi0highE'): 'pi0' + E > 200 MeV

Usage via `from stdPhotons import *`

Photon efficiency vs momentum and costheta

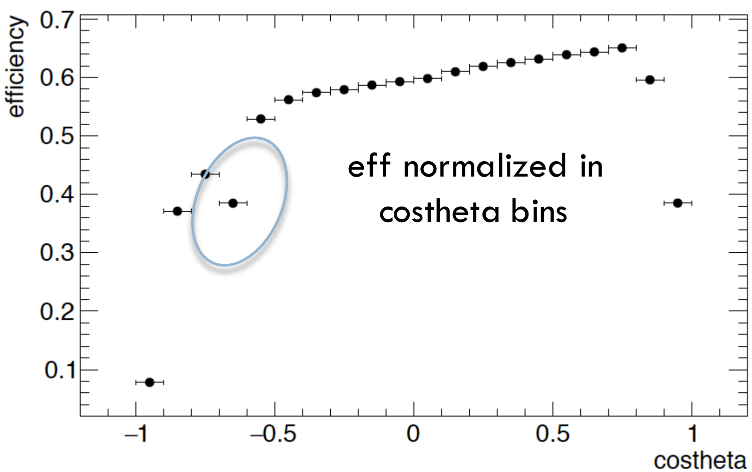
- Efficiency of the various physics lists evaluated taking the ratio between the number of true photons (mc matched) selected by the list and the number of generated photons in the BB sample, in the whole theta range.

“Tight” photons, BGx1



Above 0.5 GeV ε~80%
Inefficiency due to the gaps included in the plot

“Tight” photon, BGx1

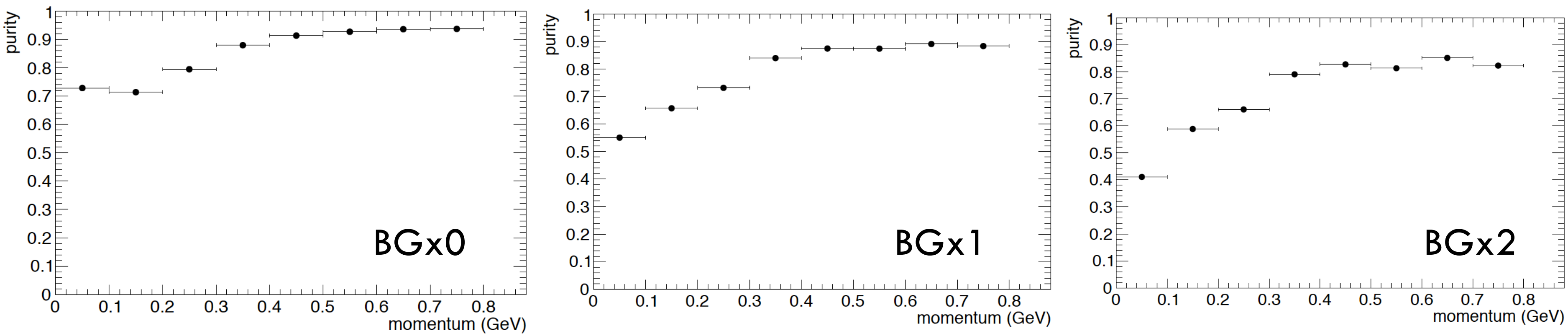


Backward gap: need to optimize reconstruction here

Photons purity vs momentum

- Purity is evaluated as the ratio between the number of true photons (mc matched) selected by the list and the number of total reconstructed photons. Plots shown in the CDC acceptance region 17° < theta < 150°

"Tight" photons



- Purity below 800 MeV looks reasonable, small degradation with increasing background level

Pi0 lists

- Definition of pi0 physics lists:
  - stdPi0('all'): gamma:all
  - stdPi0('veryLoose'): gamma:pi0 with 90 MeV < $m_{\gamma\gamma}$ <165 MeV
  - stdPi0('Loose'): gamma:pi0highE 100 MeV < $m_{\gamma\gamma}$ <165 MeV (E_{γ} > 200 MeV)
  - stdPi0('veryLooseFit') and stdPi0('LooseFit'): stdPi0('veryLoose') and

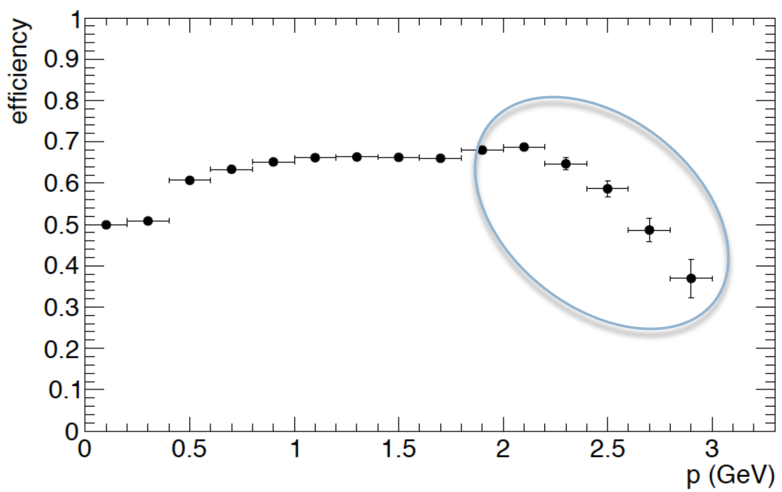
    stdPi0('Loose') with pi0 mass constrained to PDG value (massKFit)

Usage via `from stdPi0s import *`

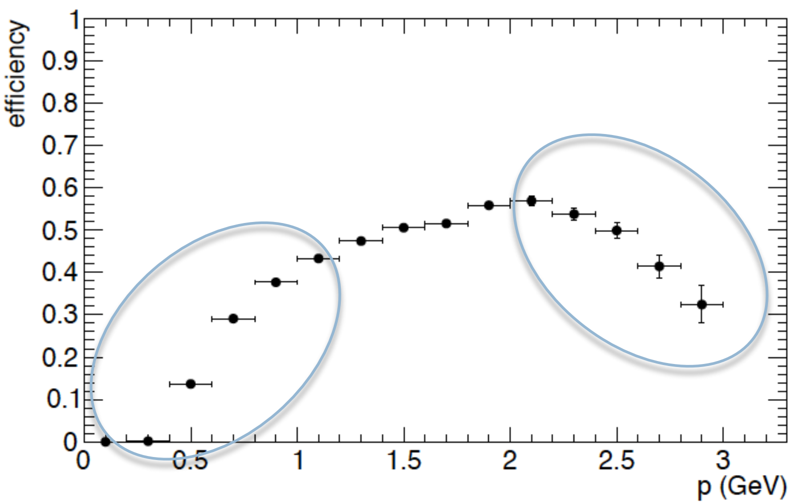
Pi0 efficiency vs momentum

- Pi0 efficiency: same definition as for photons

'VeryLoose' pi0 list, BGx1



'Loose' pi0 list, BGx1

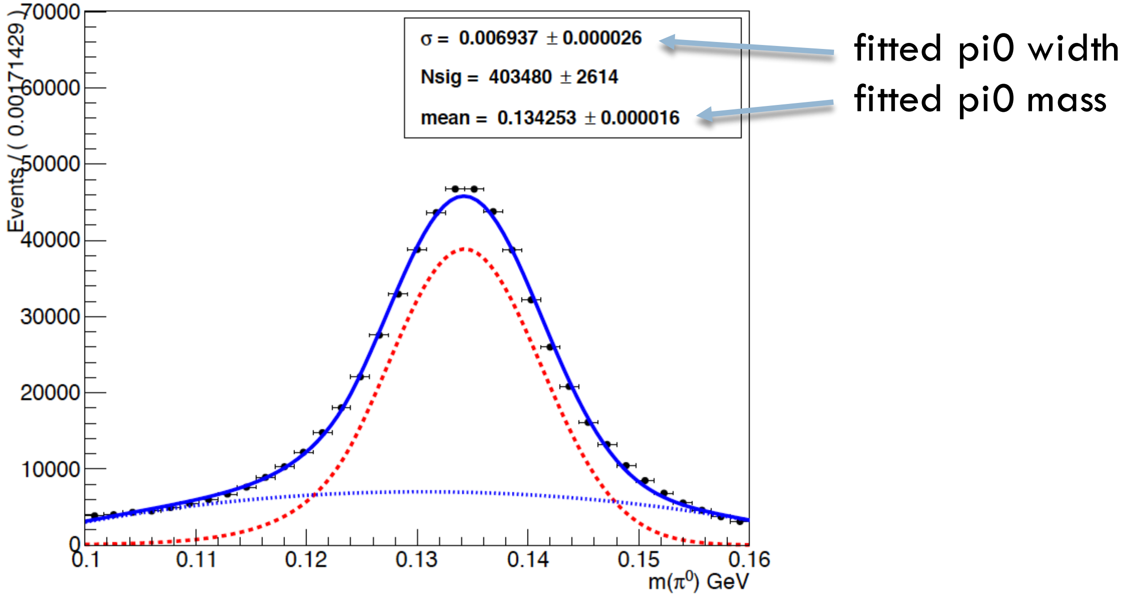


- VeryLoose pi0 list uses the loose photon list
- Loose pi0 list uses the most tight photon selection (gamma:pi0highE) in particular E_{γ}>200 MeV --> low efficiency at small momentum values.
- Efficiency drop at high momentum needs investigation, probably due to the merged photons from pi0 (Savino Longo is working on merged pi0 physics list based on second moments)

Pi0 resolution

Mass fit with Crystal Ball (signal) + 2nd order Chebyshev polynomial (bkg)

pi0 in BB generic events



- In the next slides: pi0 resolution for 'veryloose' and 'loose' pi0 lists, as function of background (bgx0, bgx1, bgx2)

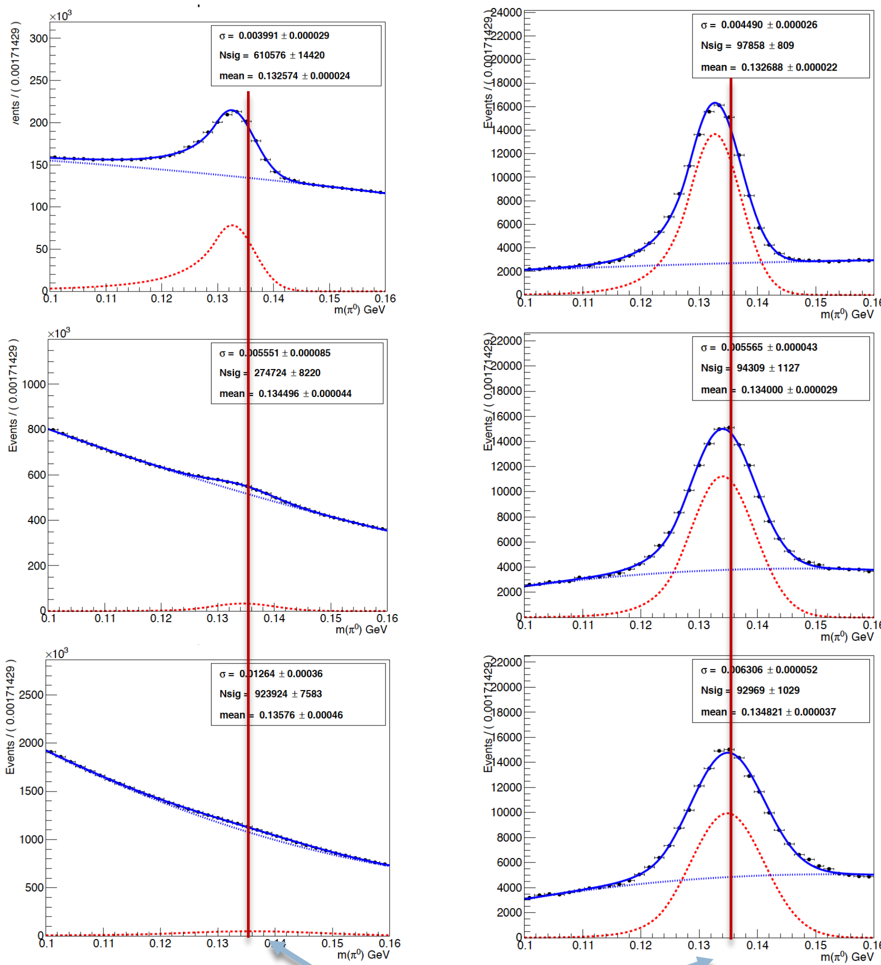
Pi0 resolution as function of background (1)

'VeryLoose' 'Loose'

BGx0

BGx1

BGx2



pdg mass

σ (MeV)	VeryLoose	Loose
BGx0	4.0	4.5
BGx1	5.6	5.6
BGx2	13	6.3

- Reasonable resolution. Sensitive to bkg level, as expected
- Expected small shift in the central mass value towards lower pi0 mass due to photon low energy tails

Photon and pi0s: future plans

- For photons the idea is to provide also a photon likelihood.
- A possibility could be to train a BDT and use its output to define the likelihood
- Also for π^0 lists we may define a BDT $\rightarrow$ w.r.t. simple cuts it has best performance, but sensitive to systematic uncertainties; good for statistics limited analyses exploiting the full reconstruction
- Anyways, since π^0 reconstruction is strongly sensitive to kinematics of the particular final state, we need to perform a detailed study and eventually people might want to optimize their own lists.

Extra clusters cleaning and and pi0 selection optimization on MC8

- The aim of the study is to clean up the π^0 reconstruction and the E_{extra} for physics studies ($B \to \tau\nu$, $B \to K^* \nu\nu$, and others)
- Study was already performed on MC5 and MC6 and can be found: https://confluence.desy.de/display/BI/Physics+Pi0Reco
- The idea is to start from the $B \to \tau\nu$ analysis reconstruction: FEI B-tag reconstruction + 1 track on the signal side (e, μ, π or $\pi\pi^0$)
- Then consider either extra photons (not coming from B-tag or signal π^0) or Y4S photons

Selection strategy

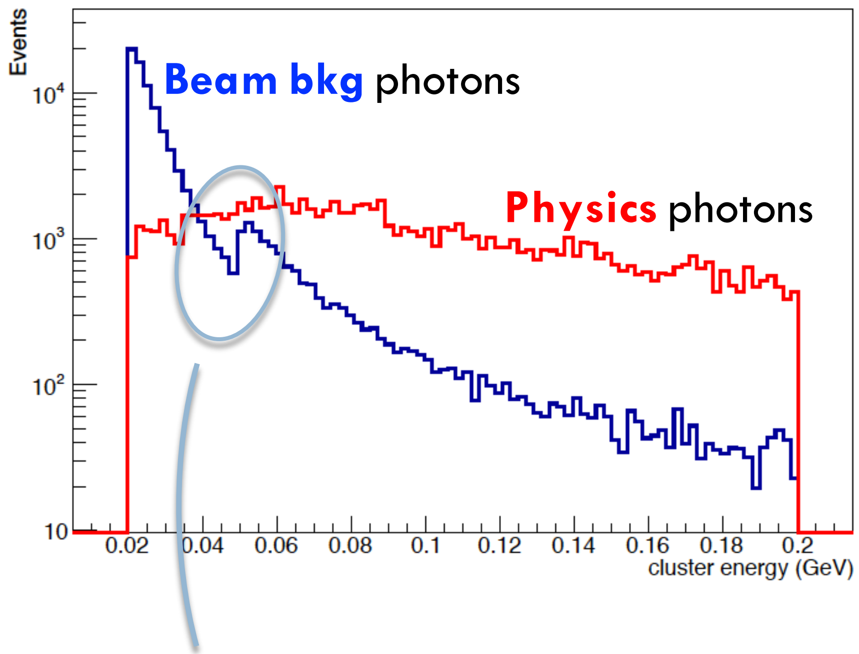
- Consider the "Loose" photon physics list
- Define two photon categories:
  - Beam background photons (photons failing MC matching)
  - Physics photons (photons with correct MC ID)
- Consider the photon energy and cluster timing for the different angular regions (forward, barrel and backward)
- For each variable evaluate at different cut points the efficiency of physics photons vs beam bkg photons (ROC curves)

MC8 production: $B \to \tau\nu$ - BGx1

First look at cluster variables

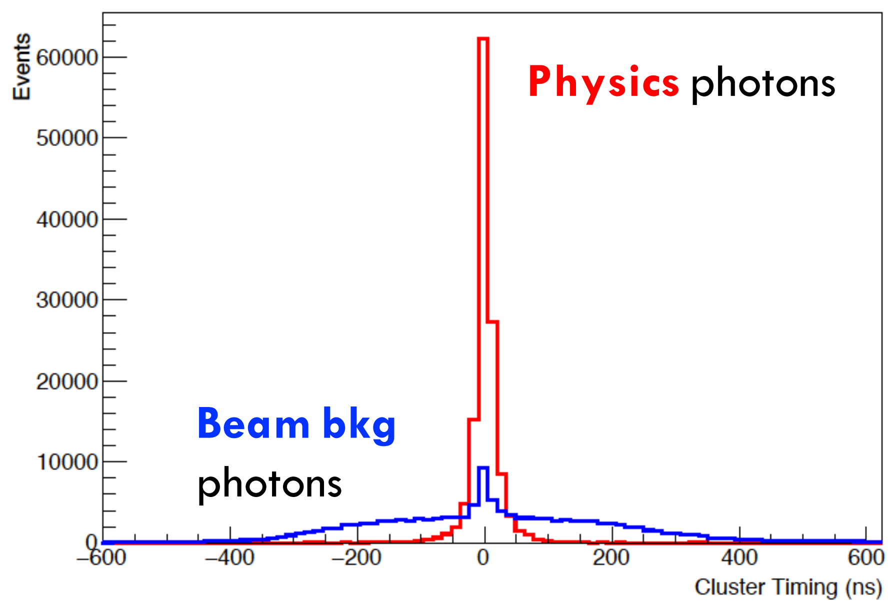
Extra clusters

Cluster energy



Dip due to an implicit cluster timing cut below 50 MeV

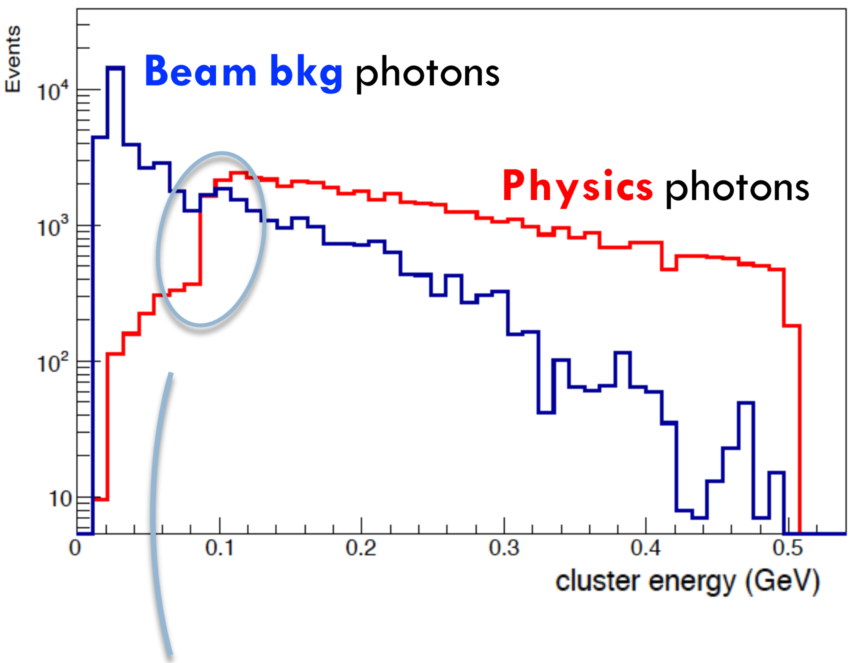
Cluster timing



First look at cluster variables

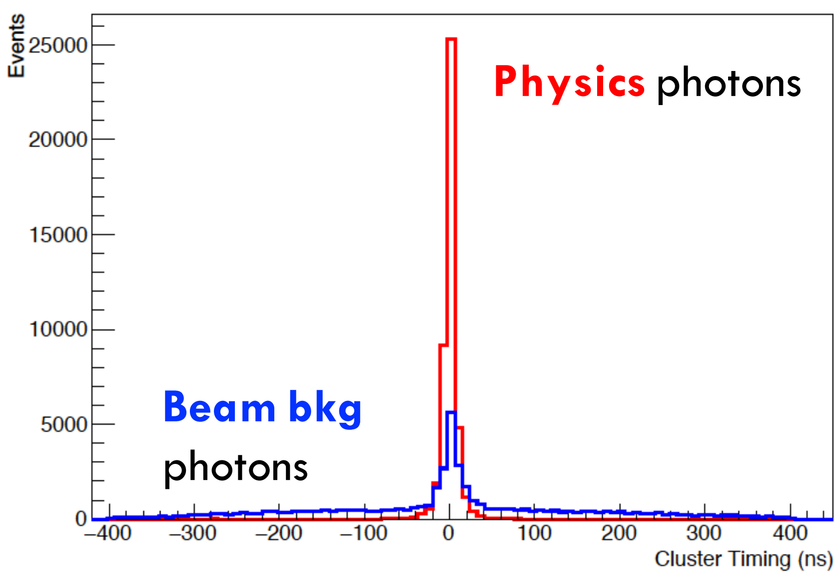
Y4S clusters

Cluster energy



Rise due to the pi0 mass window selection

Cluster timing



Photon cuts: summary

Y4S photons

- `E > 58 MeV, abs(clusterTiming) < 18 ns – forward`
- `E > 62 MeV, abs(clusterTiming) < 21 ns – barrel`
- `E > 40 MeV, abs(clusterTiming) < 38 ns – backward`

Efficiency: 95%

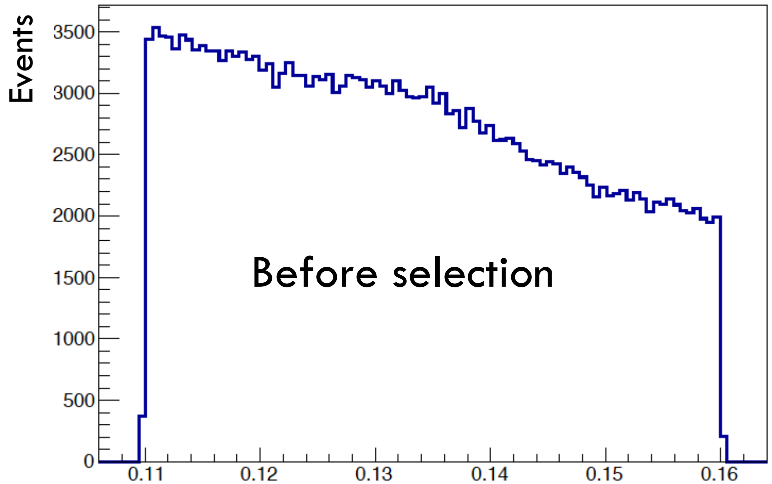
Extra photons

- `E > 62 MeV, abs(clusterTiming) < 18 ns – forward`
- `E > 60 MeV, abs(clusterTiming) < 20 ns – barrel`
- `E > 56 MeV, abs(clusterTiming) < 44 ns – backward`

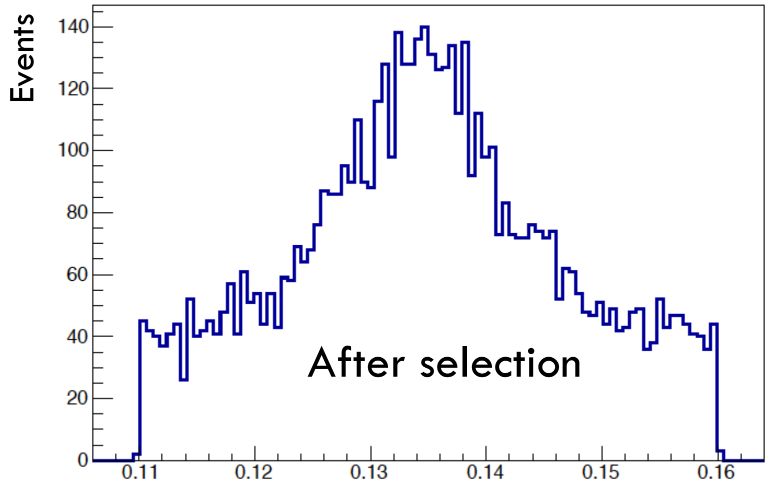
Efficiency: 70%

Y4S photons cleaning: π^0 mass

Signal MC: $B \rightarrow \tau\nu$ – BGx1



π^0 mass (GeV)

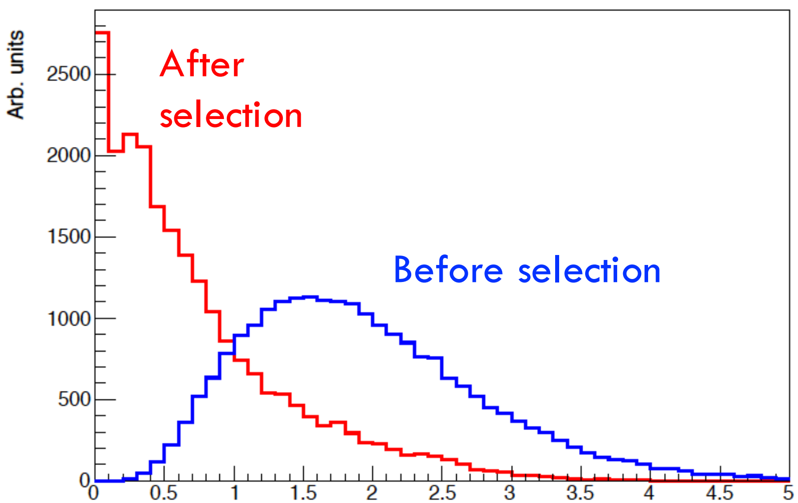


π^0 mass (GeV)

- π^0 reconstruction efficiency: ~75%
- Reject ~98% photon pairs from beam bkg
- With a simple gaussian fit around the peak we measure a mean of 134 MeV and a width of 8 MeV → resolution ~6%

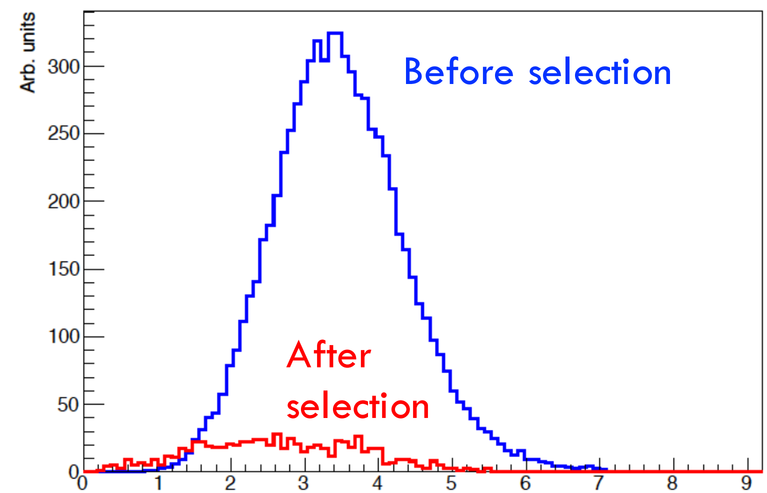
Extra photons cleaning: E_{extra} distribution

signal $B \to \tau\nu$ – BGx1



E_{extra} (GeV)

B^+B^- bkg – BGx1



E_{extra} (GeV)

- After cluster cleaning the E_{extra} distribution for signal peaks at zero as expected

N.B. no cut on M_{bc} and $|\Delta E|$

Extra cluster cleaning and pi0 selection: conclusions

- The study performed on MC8 with software release-08 profits from the improved ECL reconstruction, but it is affected by the higher level of background with respect to the older campaigns

- The photons and pi0s physics list can be used as starting point, then an optimization is needed for the specific analysis mode considered

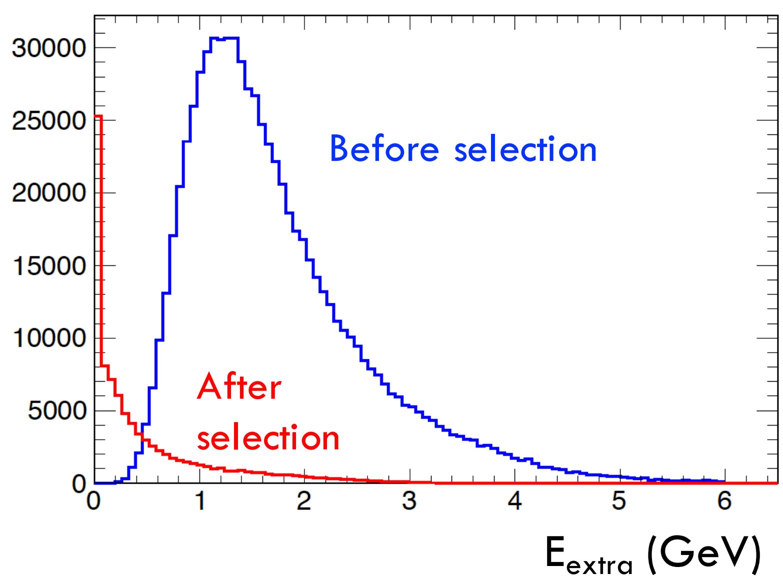
- Selection based on cluster energy and timing with respect to the bunch crossing: ~OK for pi0, needs to be improved for the extra energy

- To do: use of shower shape variables, check the impact of background on the Eextra (compare BGx0, x1, x2) and in the end optimize selection in order to get the best tau nu vs BB separation

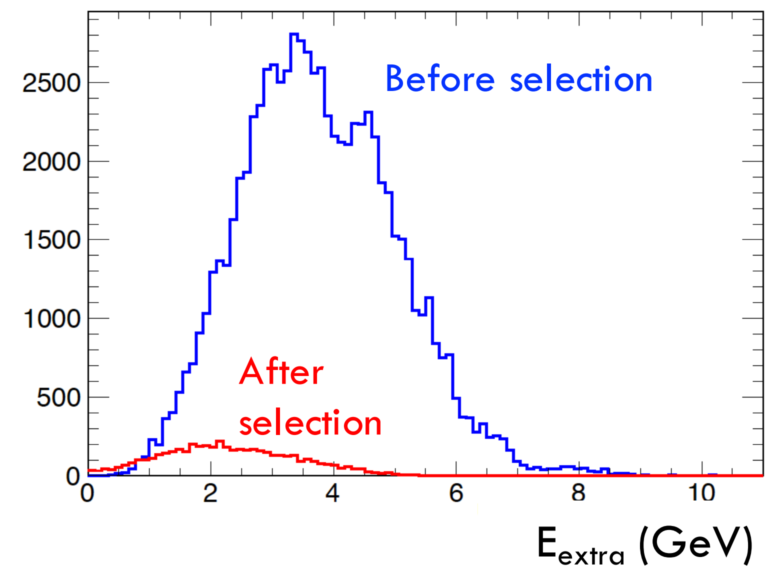
Backup

Extra photons cleaning: E_{extra} distribution MC5

signal $B \to \tau\nu$ – BGx1



B^+B^- bkg – BGx1

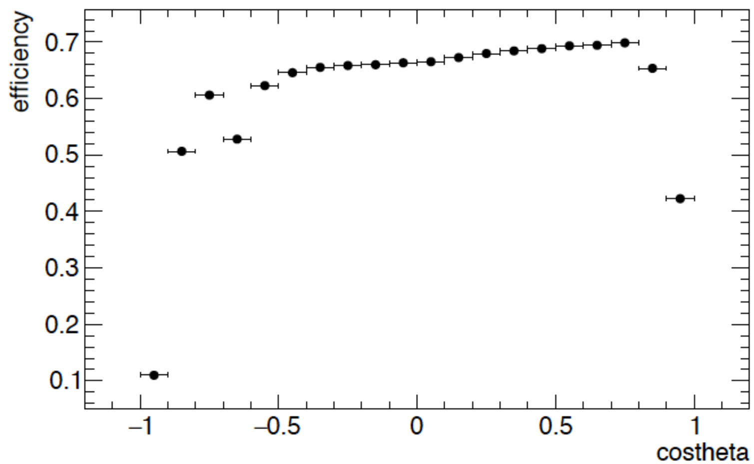


- After cluster cleaning the E_{extra} distribution for signal peaks at zero as expected

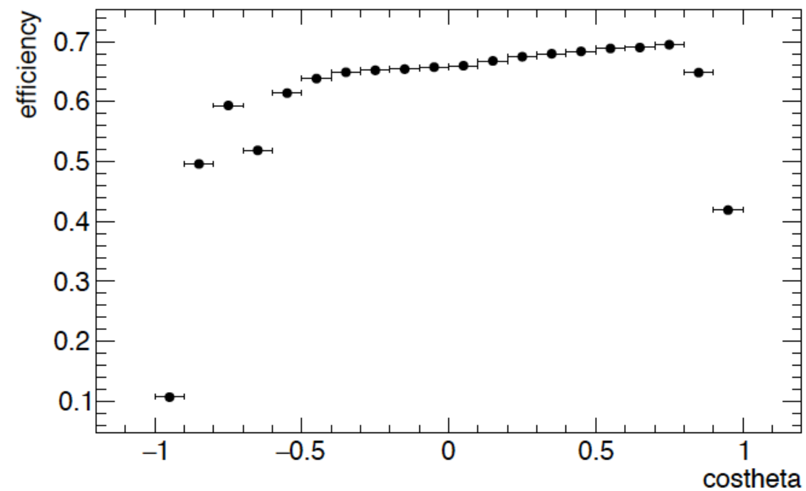
N.B. no cut on M_{bc} and $|\Delta E|$

Photon lists efficiency vs costheta

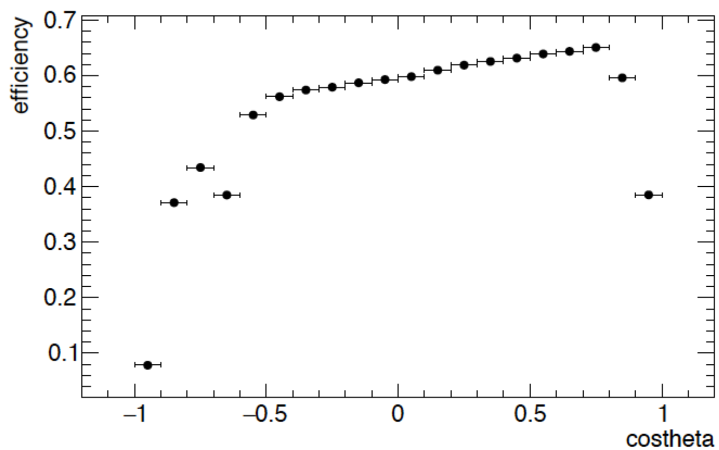
All photon list



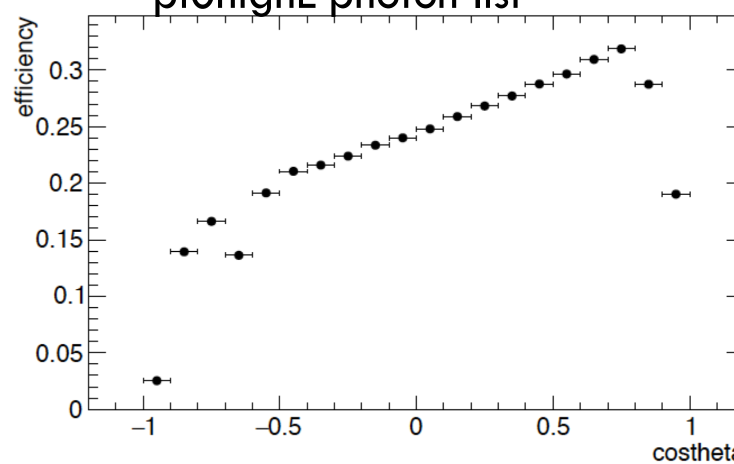
Loose photon list



Tight photon list

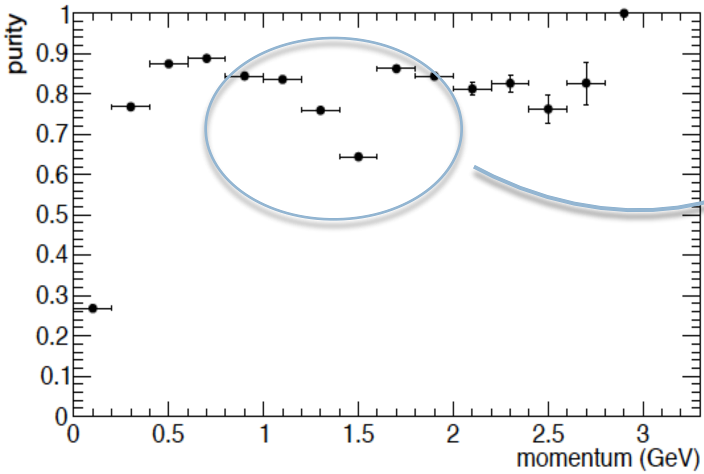


pi0highE photon list

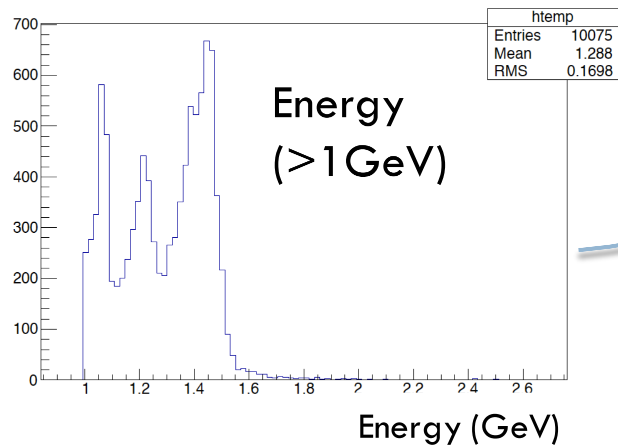


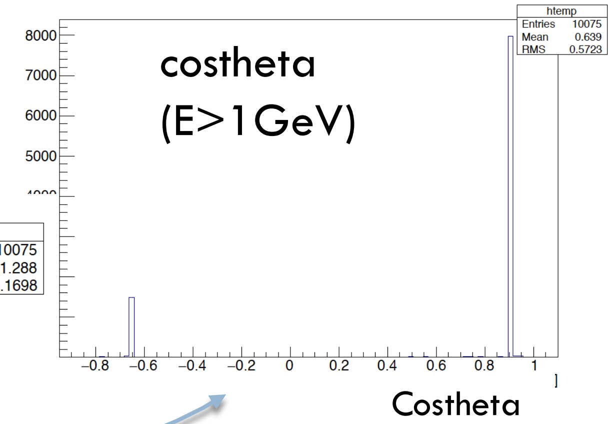
Photons purity vs momentum (2)

- Purity above 800 MeV



Due to clusters not matched to anything (mcflag==0)

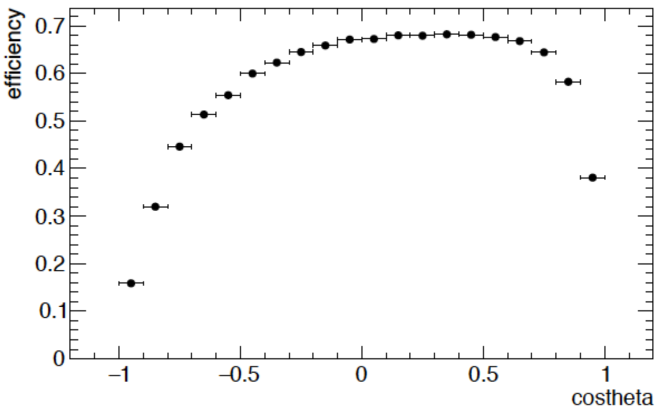




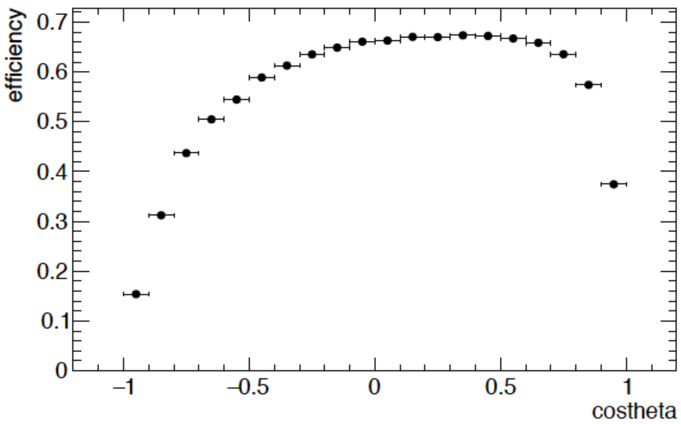
- Entries in the photon list not matched to anything present a peaky energy distribution and are concentrated at theta ~25 degrees
- Issue might be related to the track matching: need to investigate

Pi0 lists efficiency vs momentum and costheta

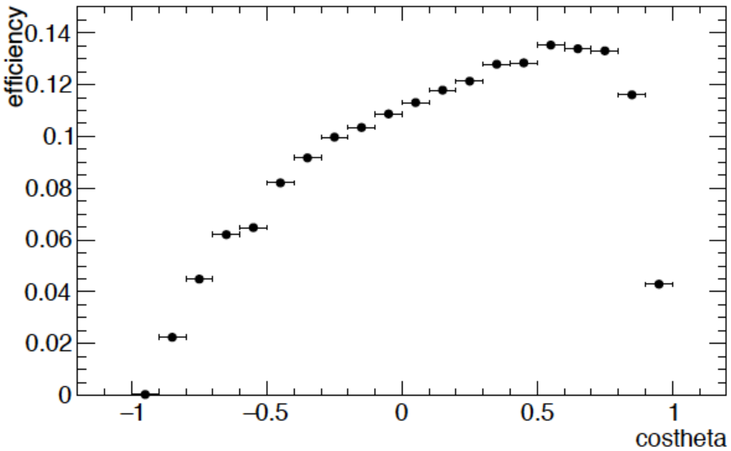
All pi0 list , BGx1



Very Loose pi0 list, BGx1



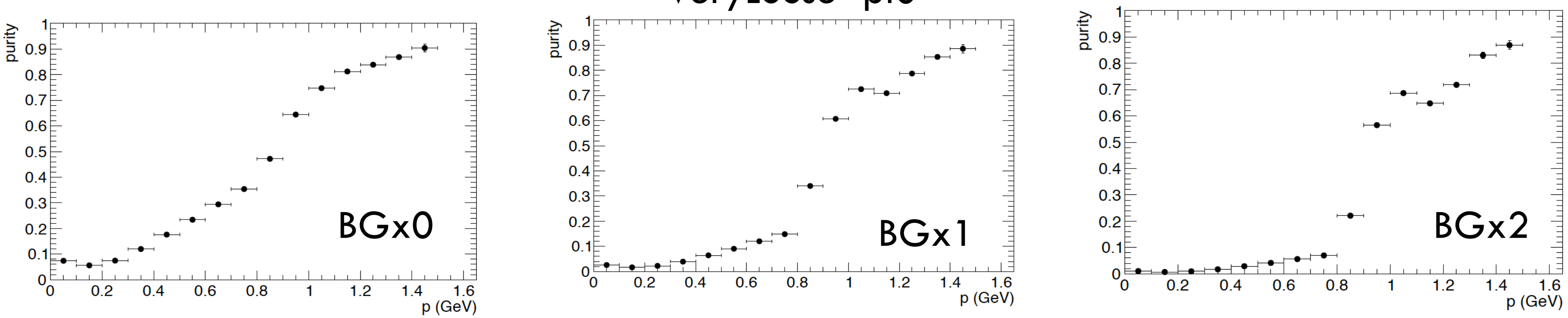
Loose pi0 list, BGx1



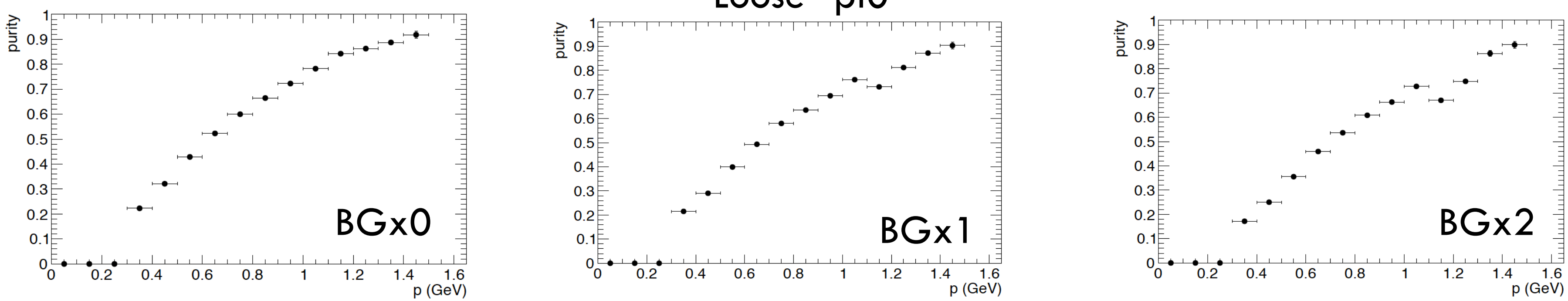
Pi0 purity vs momentum

- Purity defined as for photons. The two photons are restricted to the CDC acceptance region 17° < theta < 150° and with E < 800 MeV.

"VeryLoose" pi0



"Loose" pi0



- Better performances of the 'loose' list, degradation with increasing background level

ECL: new mdst format

	Type	Packing	Range	Size
isTrack	bool	lin	flag	1
status	int	lin	-	16
connectedRegionId	int	lin	-	16
hypothesisId	int	lin	-	16
covarianceMatrix	6*Double32_t	lin	0…25% (E) 0…25 mrad	6*8 = 48
deltaL	Double32_t	lin	-250..250	10
minTrkDistance	Double32_t	lin	0..250	10
absZernike40	Double32_t	lin	0..1.7	10
absZernike51	Double32_t	lin	0..1.2	10
zernikeMVA	Double32_t	lin	0..1	10
E1oE9	Double32_t	lin	0..1	10
E9oE21	Double32_t	lin	0..1	10
secondMoment	Double32_t	lin	0..100	10
LAT	Double32_t	lin	0..1	10
numberOfCrystals	Double32_t	lin	0..200 (~0.1 steps)	10
time	Double32_t	lin	-1000..1000 ns	12
deltaTime99	Double32_t	lin	0..1000 ns	12
theta	Double32_t	lin	0..Pi	16
phi	Double32_t	lin	-Pi..Pi	16
r	Double32_t	lin	75…300 cm	16
energy	Double32_t	log (i.e. log(E))	0.007…20 GeV (ln: -5, 3)	18
energyRaw	Double32_t	log (i.e. log(E))	0.007…20 GeV (ln: -5, 3)	18
energyHighestCrystal	Double32_t	log (i.e. log(E))	0.007…20 GeV (ln: -5, 3)	18

Systematics

Systematics / real data

- We can use control samples to compare shower shape variables and timing distributions in MC and data.
- Muon pairs / random triggers to study background clusters.
- Hadronic split offs are not so easy.
- But how to put this all together? If cutting on the likelihood in MC gives an efficiency ε, what is the systematic error on ε? Requires much thought.

Chris Hearty