B→τν update

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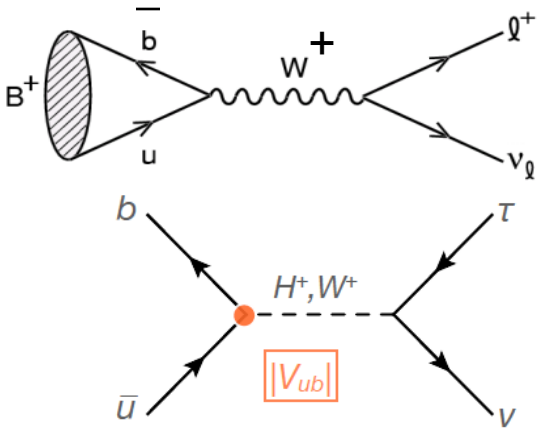
WG1 meeting, 26–Oct-17

- Optimization of extra clusters / photons / pi0 selection using MVA



Selection reminder

B tag side

Hadronic tag using FEI

1) Pre-selection on B-tag kinematics*
2) Cut on FEI output discriminant
3) Pick the highest sigprob B candidate

* Beam-constrained mass: $M_{bc} = \sqrt{E^{*2}_{beam} - p^{*2}_{B}}$

* Energy difference: $\Delta E = E^{*}_{B} - E^{*}_{beam}$

B sig side

$B \to \tau\nu$

- 4 tau modes: $\mu\nu\nu$, $e\nu\nu$, $\pi\nu$, $\pi\,\pi^0\nu$
- PID, ECL cluster cleaning (see next slides)
- $110 < M(\pi^0) < 160$ MeV
- $625 < M(\rho) < 925$ MeV

Require full reconstruction of tag side and only one additional track in the event

Run on MC9 bgx1 production: $B \to \tau\nu$ and B^+B^-

https://confluence.desy.de/display/BI/Data+Production+MC9

Selection (2)

PID selection

- Use the release 09 recommended working points:

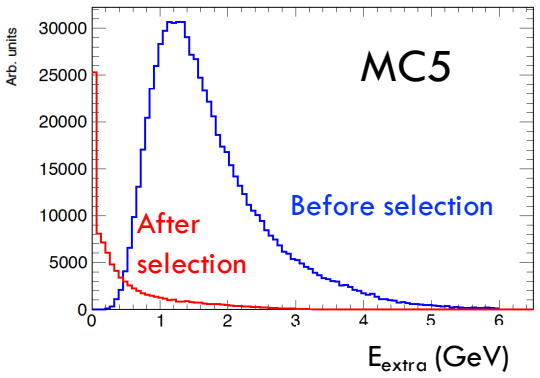
https://confluence.desy.de/display/BI/Physics+StandardParticles

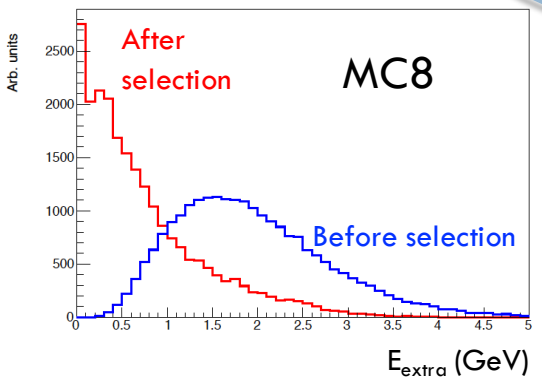
  - electrons: eid > 0.750
  - muons: muid > 0.625 and eid<0.750
  - pions: piid > 0.429 and eid<0.750 and muid<0.625

Photon selection

- Cluster cleaning to reject photons from beam background
- Old selection with rectangular cuts on cluster energy and absolute timing can be found here: https://confluence.desy.de/display/BI/Physics+Pi0Reco
- New MVA classifiers trained for the extra clusters and for the pi0 selection

old selection





this presentation

Extra clusters cleaning

- Define two photon categories:
  - Beam background photons (photons failing MC matching, no MC photon corresponding to the reconstructed one)
  - Physics photons (photons with correct MC ID)

- Consider the following variables: energy, timing, dt99 (time containing 99% of the signal, at ECLCalDigit level), cluster region (bwd, barrel, fwd), lateral energy distribution, E1/E9 and Zernike moments (account for energy distribution in a plane perpendicular to the shower)

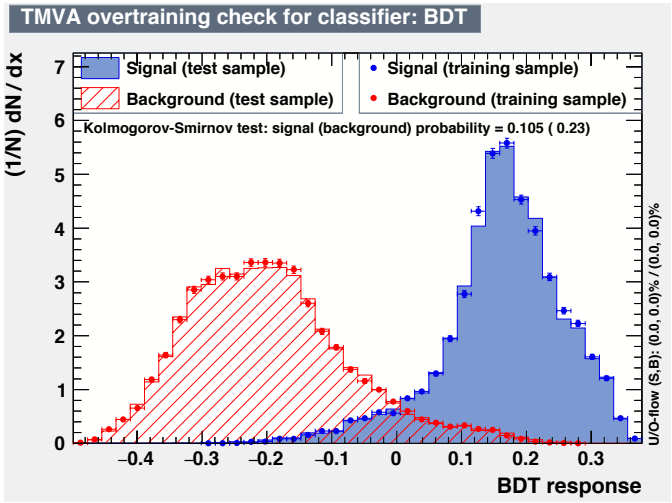
- Train a BDT with $B \rightarrow \tau\nu$ events from MC9 production bgx1 (using TMVA)

- Optimize / tune "by eye" the training options in order to get the highest BDT classifier ROC integral with overtraining under control

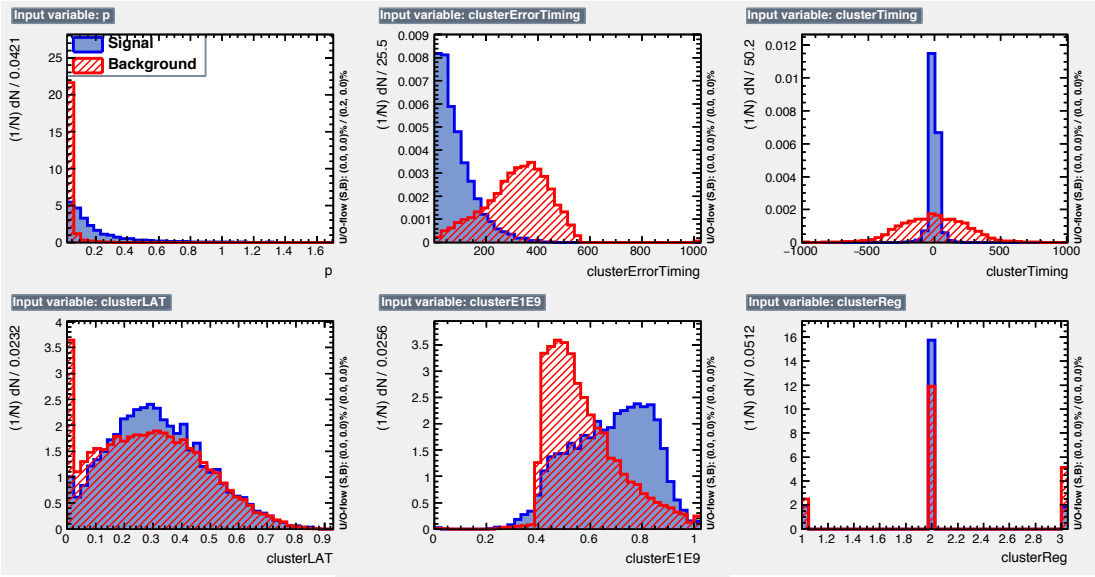
- Remove the less significant variables (checking the ROC integral does not get worse significantly) and re-perform the training

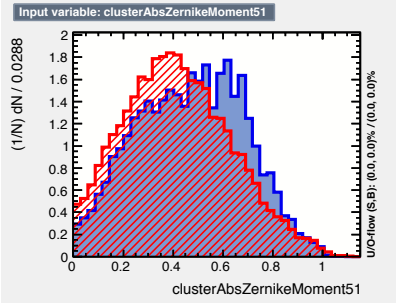
Extra clusters MVA

BDT output classifier for signal (physics photons) and background (photons from beam)



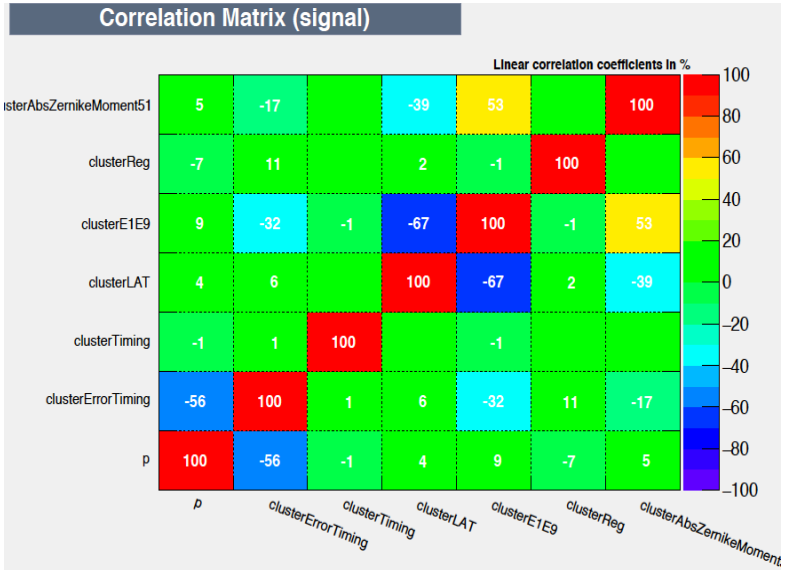
Input variables

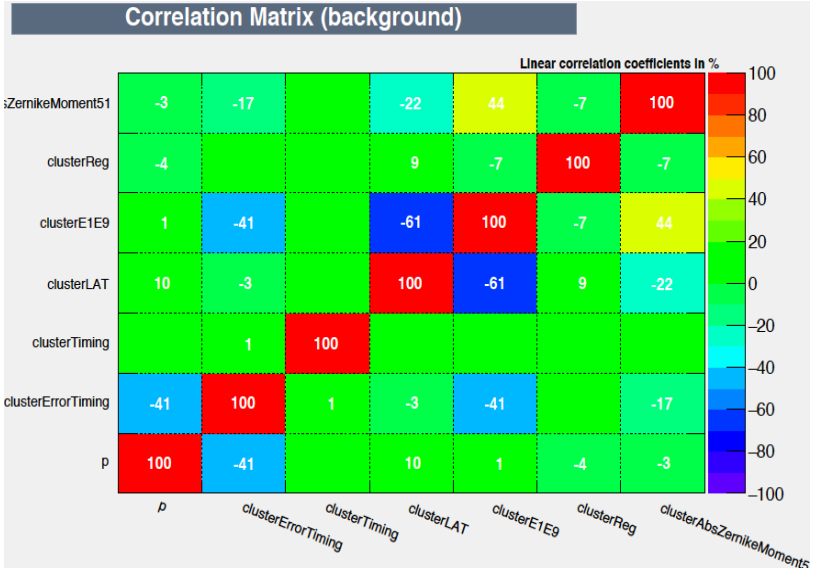




- Ranking: dt99, timing, ZernikeMoment51, Lateral distribution, E1/E9, energy, cluster region

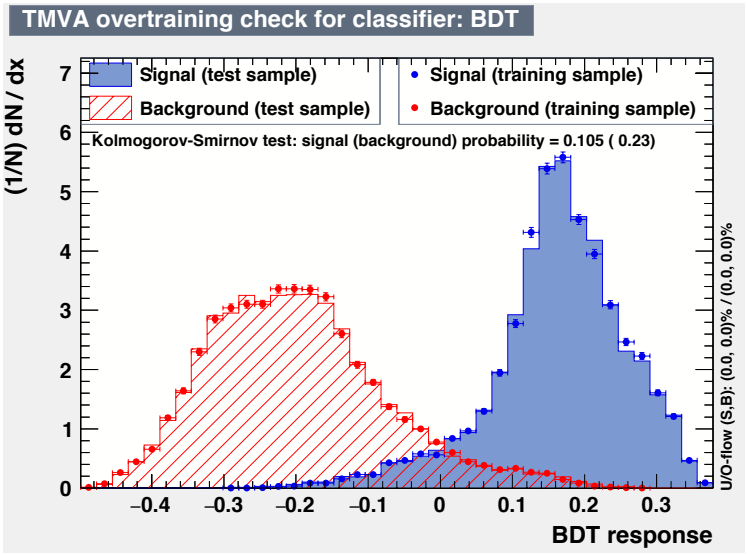
Extra clusters MVA: variables correlation

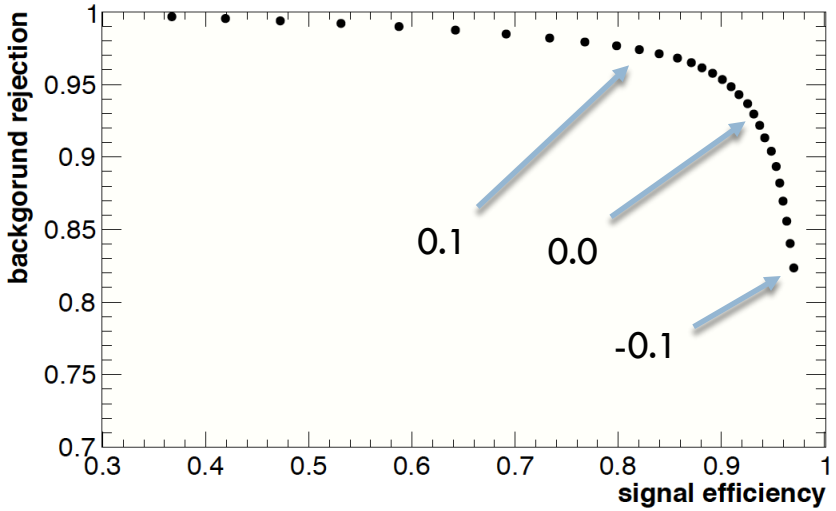




- Shower shape variables slightly correlated (E1/E9, Zernike and LAT)
- Some level of correlation between dt99 and the cluster energy

Extra clusters MVA: ROC curve





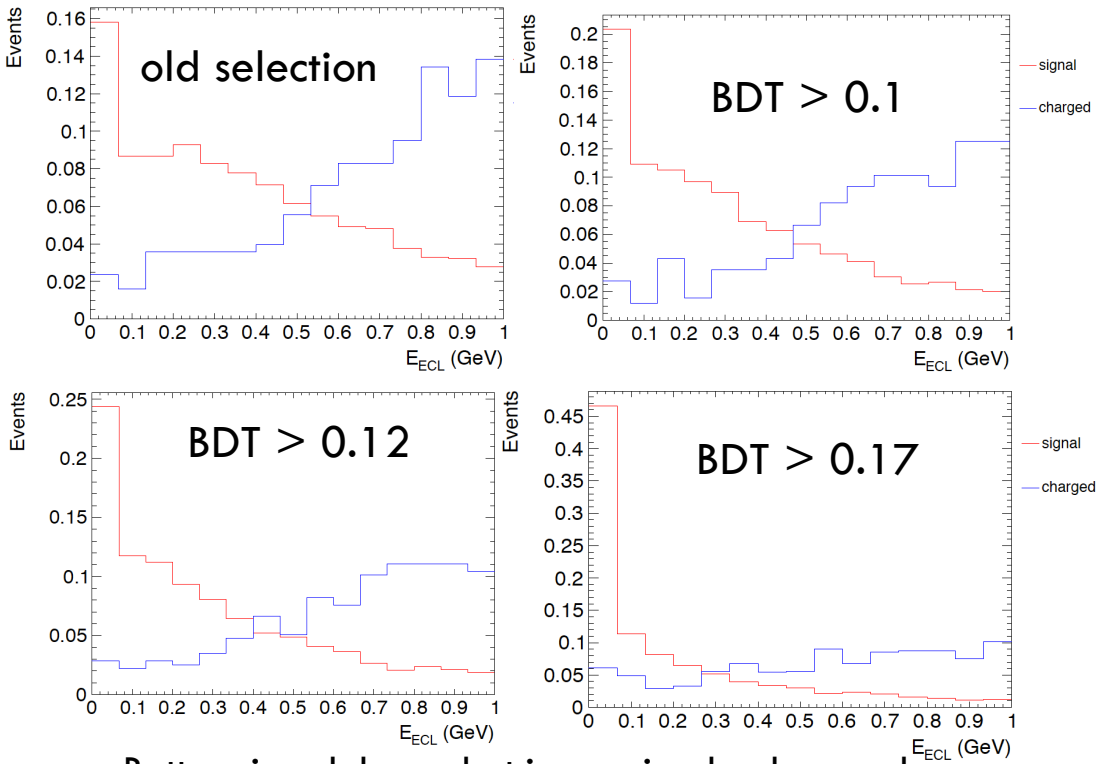
Scan BDT from -0.1 to 0.2 with step of 0.01

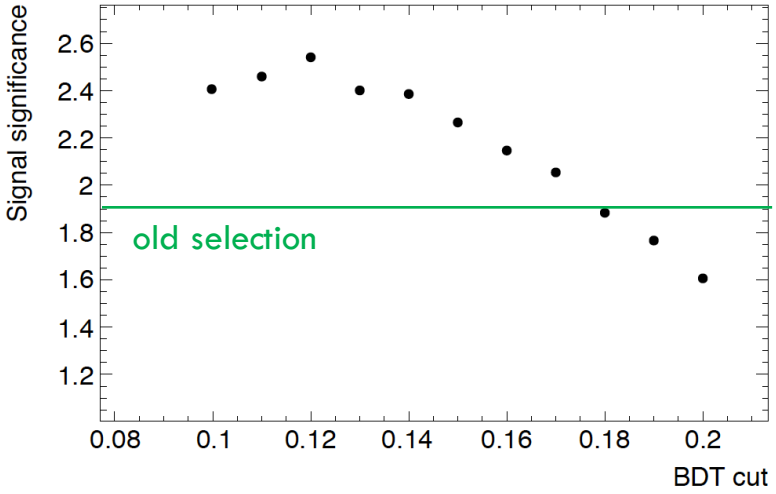
- Signal efficiency: N true photons after BDT cut / Ntot true photons
- Background efficiency: N bkg photons after BDT cut / Ntot bkg photons
- Background rejection = 1 - Background efficiency

- The choice of the optimal BDT cut should take in consideration also the BB background

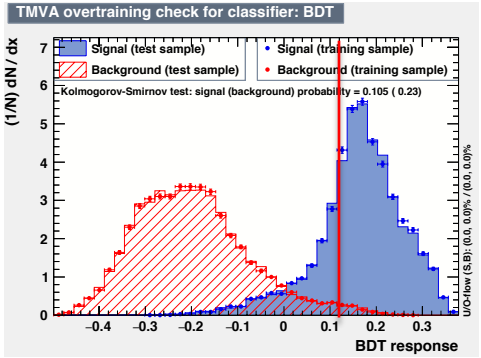
Extra clusters MVA: performance on Extra distribution

- Eextra distribution for tau nu signal and B^+B^- background with $M_{bc} > 5.27$ GeV





Significance evaluated as S/sqrt(S+B) in Eextra < 0.2 GeV, where S is tau nu and B is B^+B^-. Normalized to 1 ab^{-1}



Better signal shape but increasing background yield in signal region (Eextra < 0.2 GeV)

MVA for pi0 selection

- Same strategy used for extra clusters cleaning

- Consider the following variables: energy, timing, dt99 (time containing 99% of the signal, at ECLCalDigit level), cluster region (bwd, barrel, fwd), cluster phi, lateral energy distribution, E1/E9, minimun distance between cluster and tracks, and Zernike moments (account for energy distribution in a plane perpendicular to the shower)

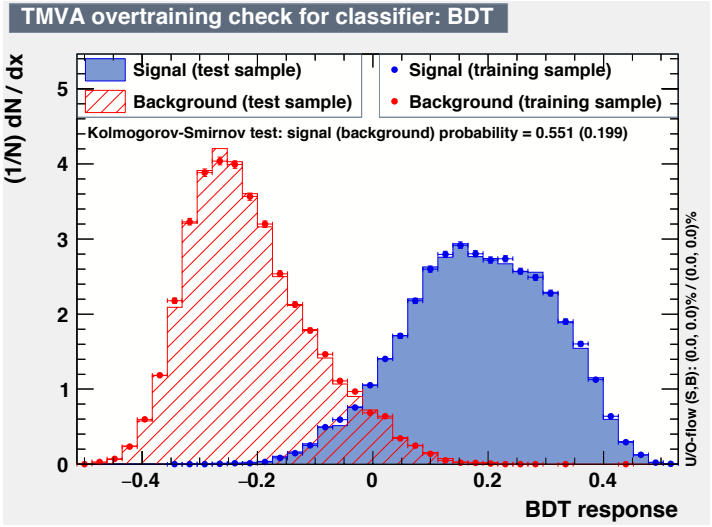
- Train a BDT with B $\rightarrow \tau\nu$ events from MC9 production bgx1 (using TMVA)

- Test the performances of the MVA looking at pi0 peak and width

N.B. To keep this study general I'll consider all the pi0s in generic B and B $\rightarrow \tau\nu$.

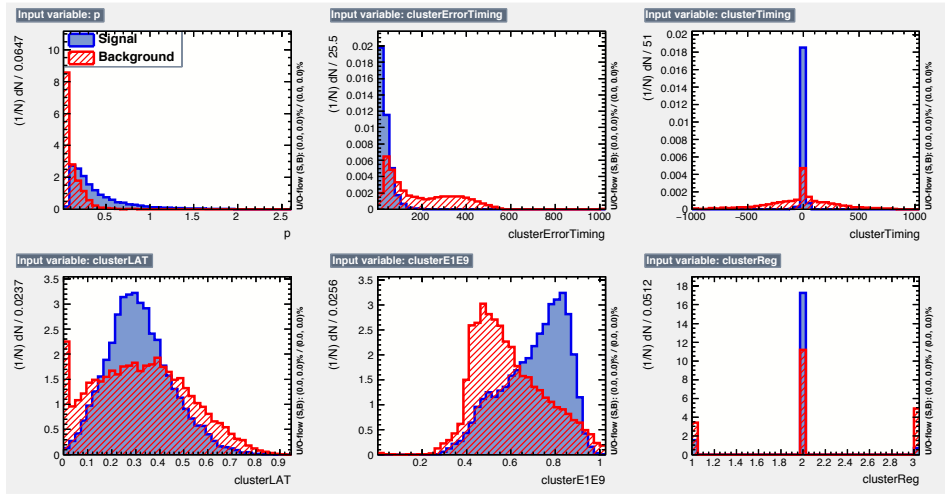
MVA for pi0 selection

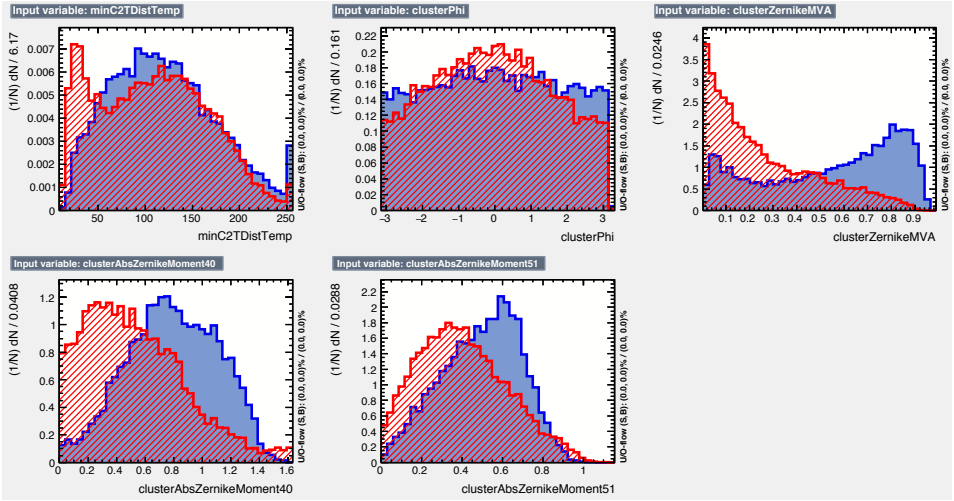
BDT output classifier for signal (physics photons) and background (photons from beam)



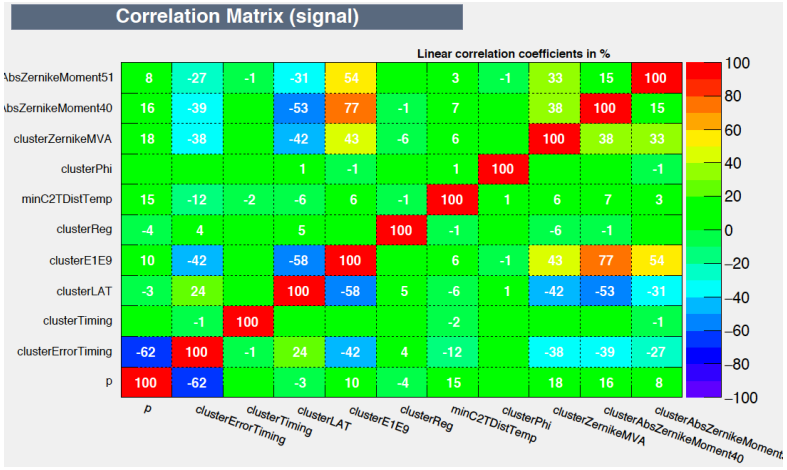
- Ranking: timing, dt99, ZernikeMomentMVA, cluster phi, minDistC2T, Lateral distribution, ZernikeMoment40, ZernikeMoment51, E1/E9, energy, cluster region

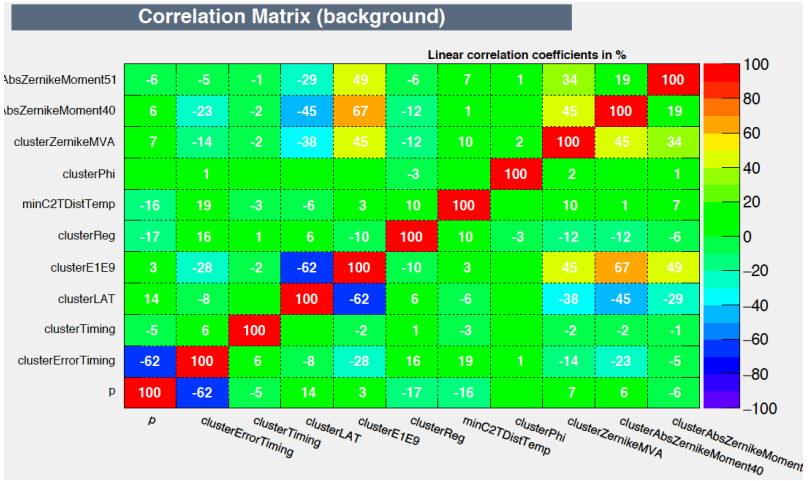
Input variables





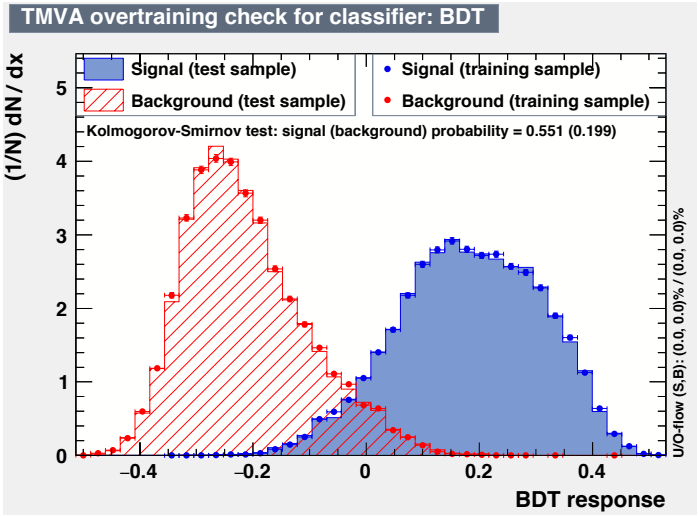
Pi0 MVA: variables correlation





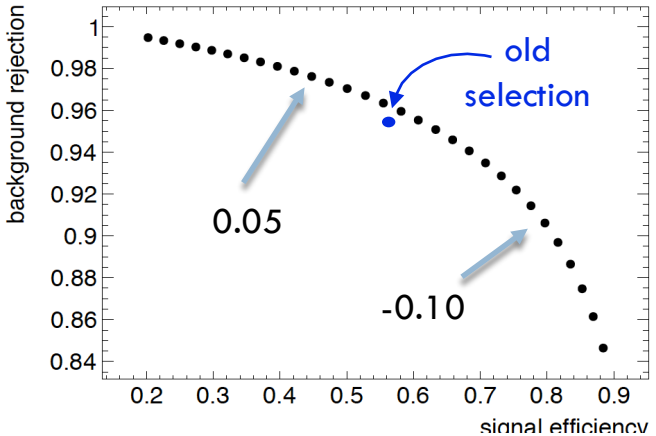
- Shower shape variables slightly correlated (E1/E9, Zernike and LAT)
- Some level of correlation between dt99 and the cluster energy

Pi0 MVA: performances



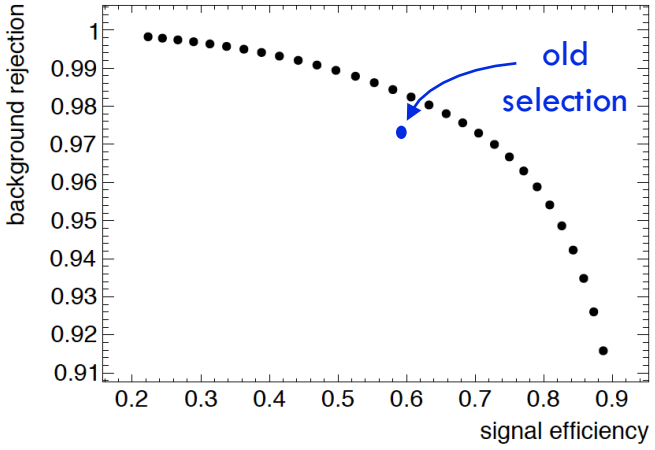
Perform a scan of the BDT from -0.15 to 0.15 with step of 0.01, and plot the signal efficiency vs background rejection

B^+B^- events



S-eff / B-rej = 56.5% - 95.8%

B –> τν events



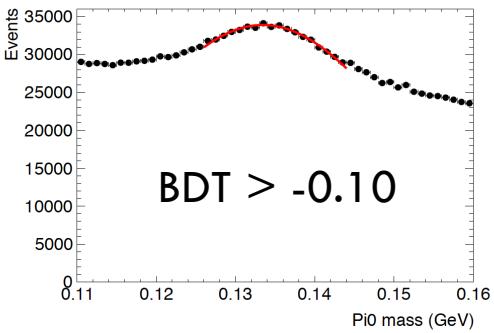
S-eff / B-rej = 59.5% - 97.4%

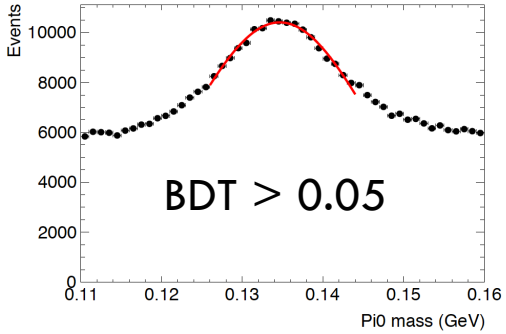
At same signal efficiency level, we have ε_{bkg}=1.6% with respect to 2.6% of old selection –> 60% more bkg rejected

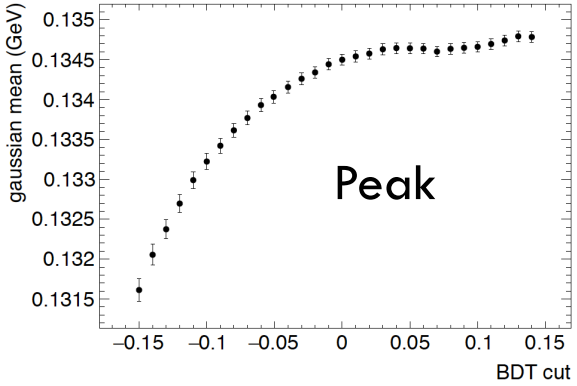
Pi0 MVA: pi0 in B^+B^-

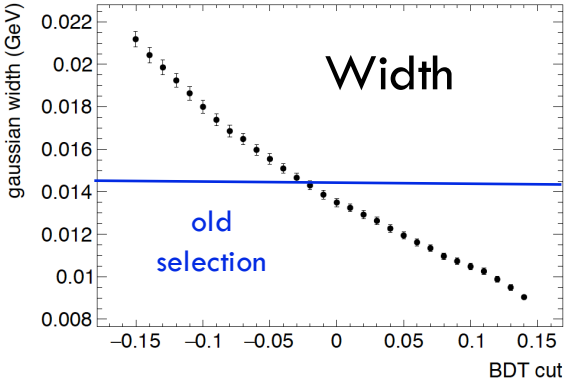
- Simple gaussian fit to the pi0 invariant mass in the range 125-145 MeV, varying the BDT cut

- Example fits



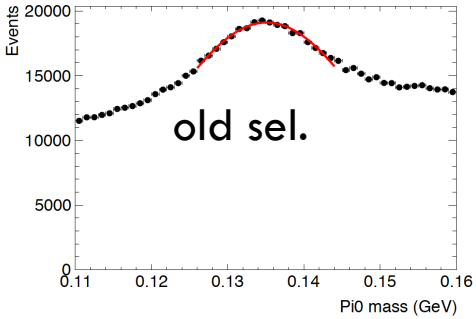






- Tighter the BDT cut, narrower the pi0 width

- Comparison with old selection



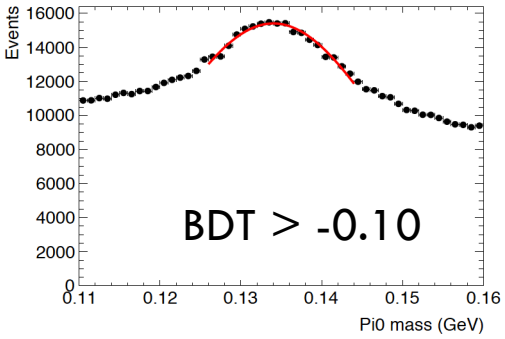
mean: 135.09 +/- 0.07 MeV

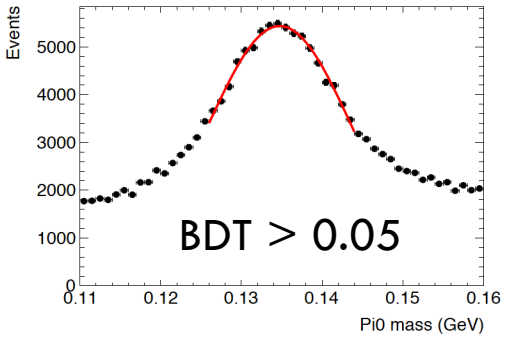
width: 14.2 +/- 0.2 MeV

Pi0 MVA: pi0 in B → τν sample

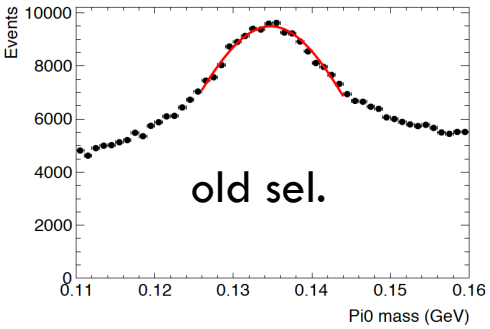
- Simple gaussian fit to the pi0 invariant mass in the range 125-145 MeV

- Example fits

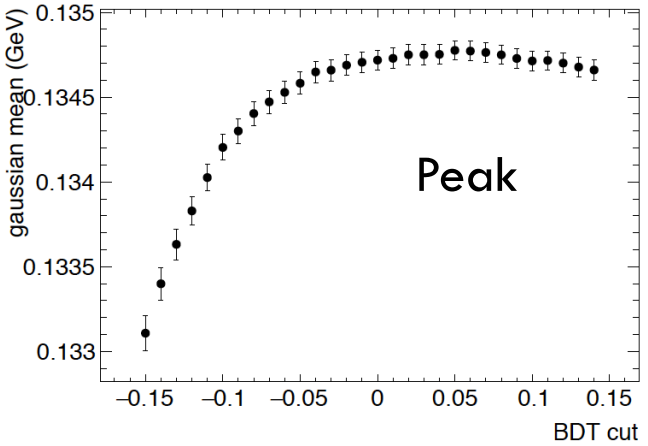


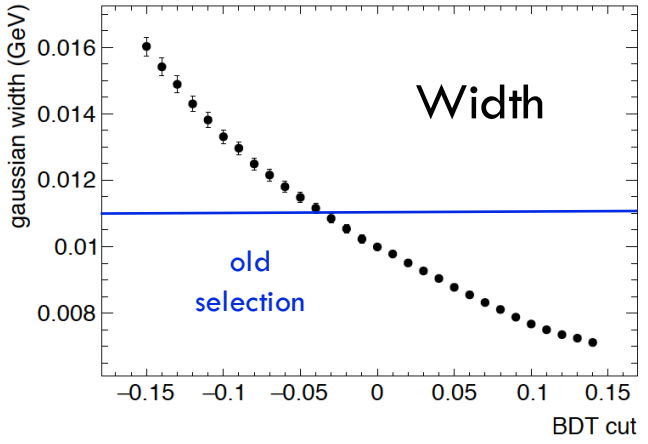


- Comparison with old selection



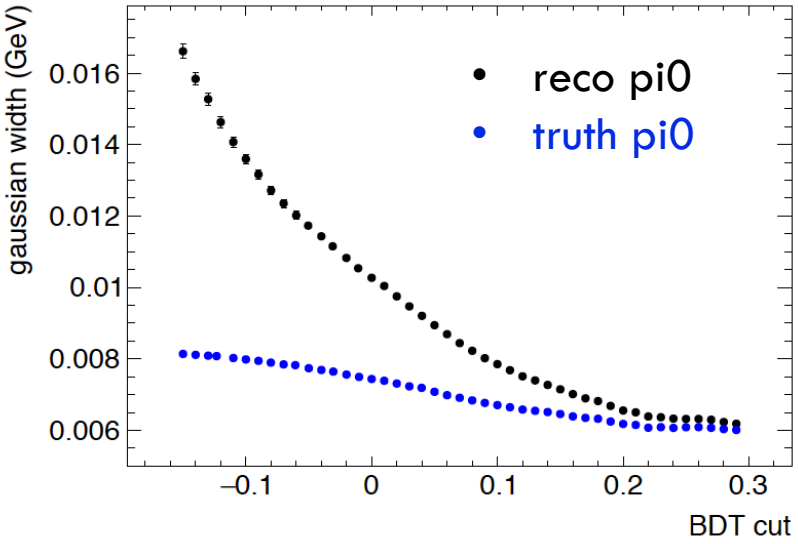
mean: 134.76 +/- 0.07 MeV
width: 11.46 +/- 0.16 MeV





Pi0 MVA: fit consistency check

- We should expect the pi0 fitted width converges at a certain point
- Fit to true pi0s (MC matched), to check the stability of the fit



The pi0 resolution reduction with BDT cut might be overestimated and affected by a bias due to the fit conditions (pure gaussian fit, restricted fit range)

- Next step: fit to pi0s in BGx0 condition (MC9 jobs still in waiting status since a couple of days…)

Summary / plan

- MVA selection for extra clusters and pi0s
  - Improvement of signal / BB separation in Eextra
  - Improvement of pi0 resolution and background rejection

- To do list:
  - Run over the other bkgs (neutral B and continuum, jobs waiting since 19th Oct !?) and re-perform the signal extraction as done in B2TiP to precisely evaluate the impact of MVA
  - Possibly optimize the BDT (variables, training)
  - KL veto (peaking background)
  - Signal extraction: 2D fit with Eextra and missing mass

Backup