Improvements on identification of τ lepton

Romain MADAR[a]

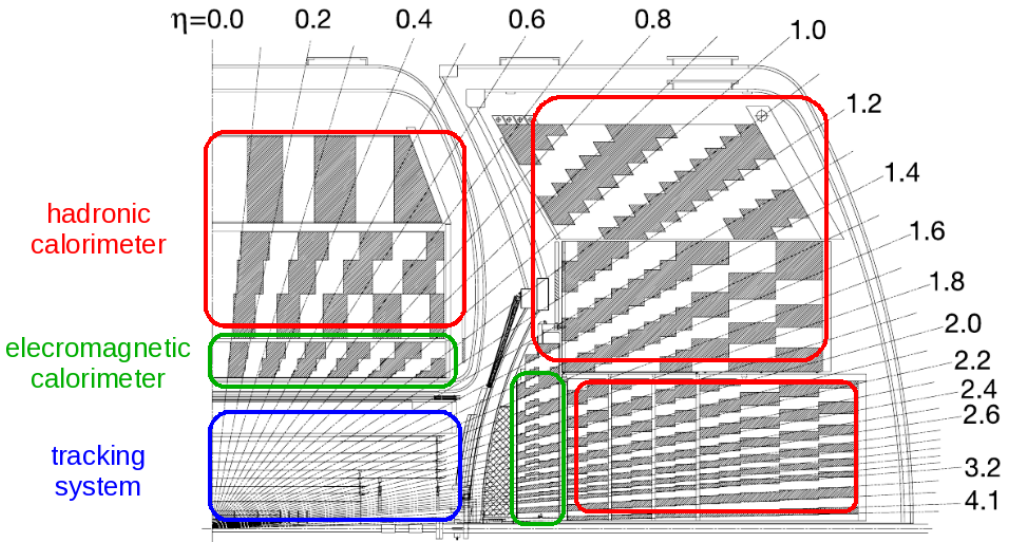
[a] Service de Physique des Particules
CEA Saclay, Irfu/SPP - France

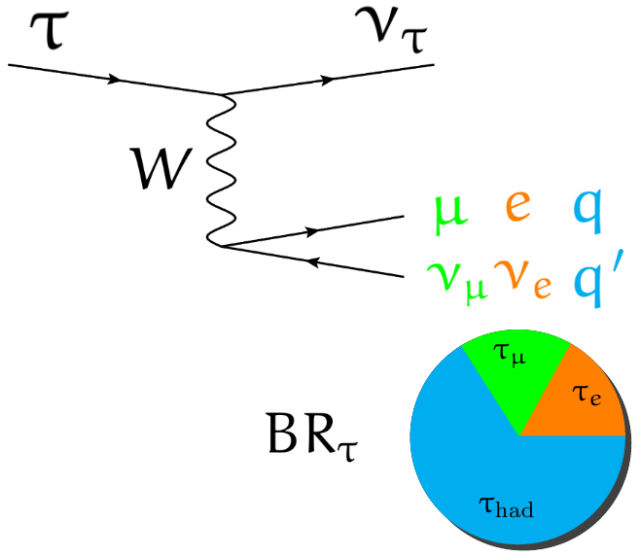
DØ France – 3th of May 2010 –

Overview

The τ lepton and its reconstruction

Physical properties : $m_\tau = 1.78$ GeV, $c\tau_{life} = 87$ μm



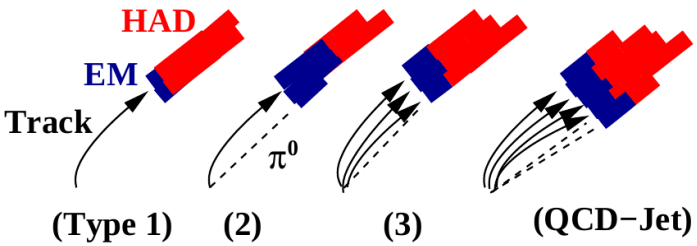


We will focus on **hadronic decay of τ** : τ_{had}

Reconstruction and τ type definition for hadronic decay :

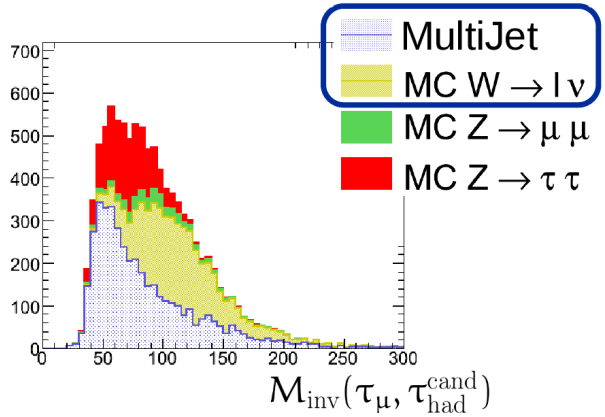
- type 1 ≡ 1 trk, HAD deposit $\sim \tau^\pm \to \pi^\pm \nu_\tau$
- type 2 ≡ 1 trk, EM and HAD deposit $\sim \tau^\pm \to \rho^\pm (\to \pi^0 \pi^\pm) \nu_\tau$
- type 3 ≡ at least 2 trks, HAD deposit $\sim \tau^\pm \to a_1^\pm (\to \pi^\pm \pi^\mp \pi^\pm) \nu_\tau$

Identification of true τ

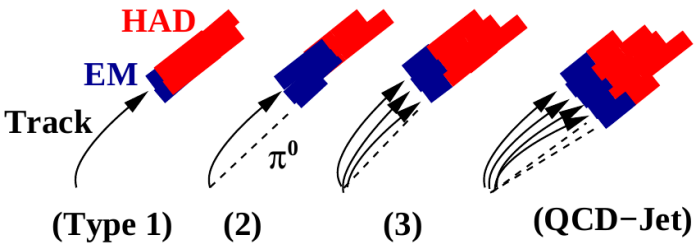


$\tau_{had} \approx$ narrower jet with lower track multiplicties

Jets could have the same experimental signatures as hadronic τ and need to be removed.

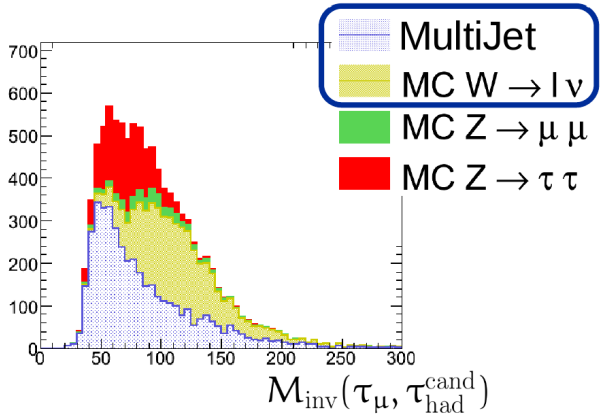


Identification of true τ



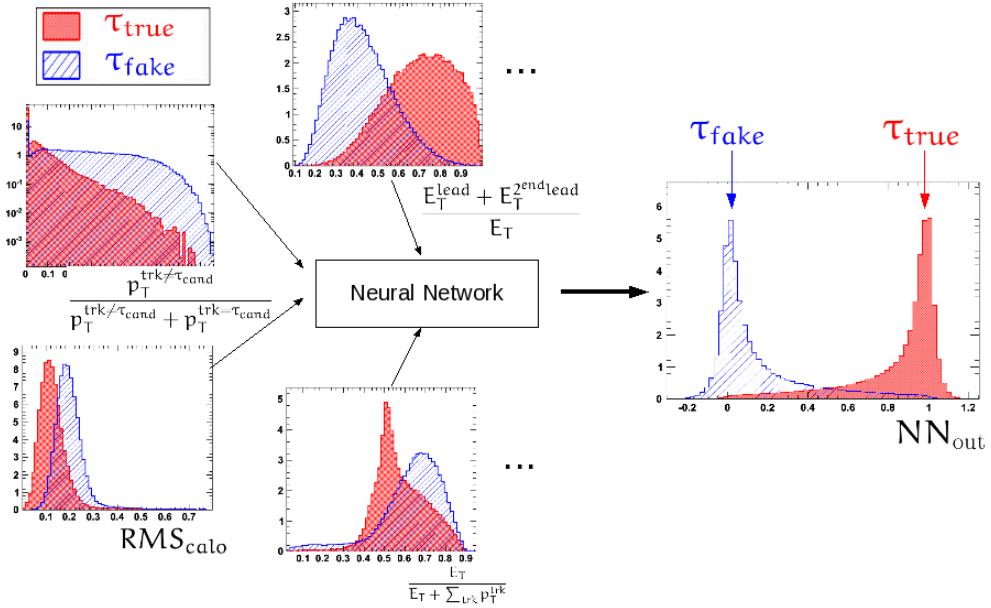
$\tau_{had} \approx$ narrower jet with lower track multiplicties

Jets could have the same experimental signatures as hadronic τ and need to be removed.



~ 12 discrimating observables

- track isolation,
- calo isolation,
- shower shape,
- trk-cal correlations.



Overview

Improvement strategy

General point of view : Neural Networks output $\eta^{NN}(\vec{X})$ converges to

$$\eta^{true}(\vec{X}) \equiv \frac{\mathcal{S}(\vec{X})}{\mathcal{S}(\vec{X}) + \mathcal{B}(\vec{X})}$$

where $\vec{X} \equiv (x_1, x_2, ..., x_n)$ describes the discriminating variables space.

In the τID context :
A lot of ideas were tested to improve the current identification of τ :

- Include the Central preshower (2 approaches) ✗
- Exploit the long τ life time (using b-tagging tools) ✓

} improve $\eta^{true}(\vec{X})$

- Tune NN parameters (epoch, nodes, statistics) ✓
- Dedicated training for τ of high p_T ✓
- Dedicated training for high luminosity events ✗
- Dedicated training in ICD (for type 1) ✓

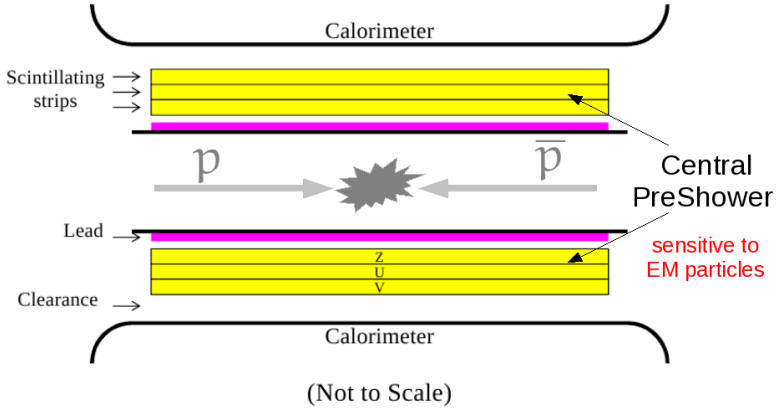
} minimize $|\eta^{NN} - \eta^{true}|$

Overview

Central PreShower (CPS) for type 2

Physical idea. Exploit specific resonance of τ **type** 2 decay : $\tau^{\pm} \rightarrow \rho^{\pm}\nu \rightarrow \pi^{\pm}\pi^{0}\nu$. Use Central PreShower detector with fine segmentation : $\Delta\phi_{\mathrm{CPS}} \simeq 0.1 \times \Delta\phi_{\mathrm{calo}}$

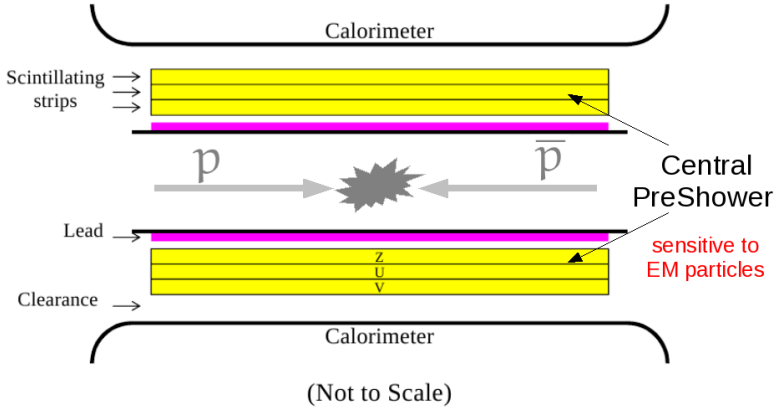
$$\mathrm{CPS}_{\mathrm{cluster}} \approx \pi^{0} \ , \ \mathrm{trk} \approx \pi^{\pm}$$

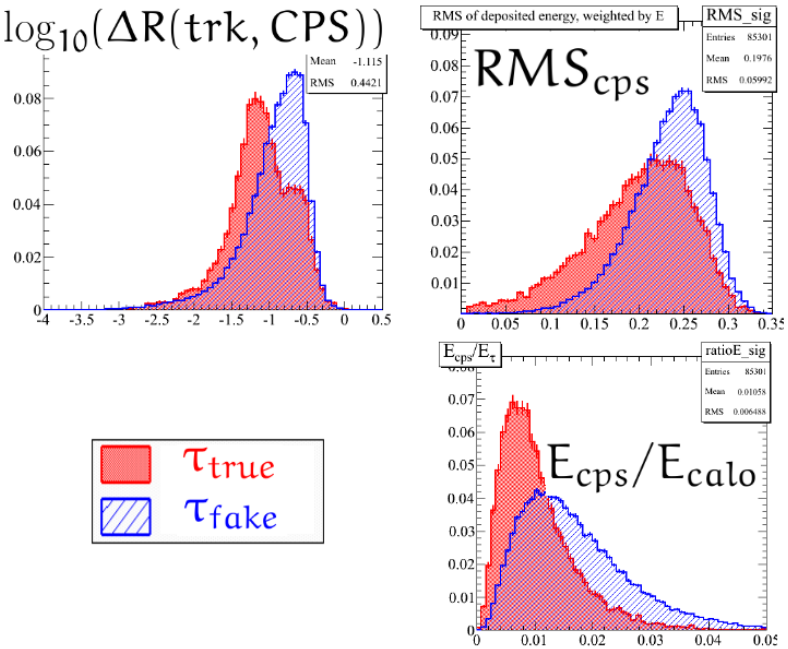


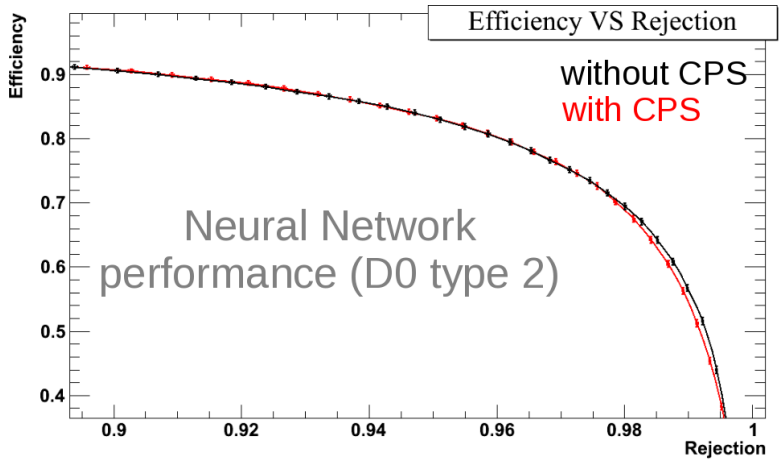
Central PreShower (CPS) for type 2

Physical idea. Exploit specific resonance of τ **type** 2 decay : $\tau^{\pm} \rightarrow \rho^{\pm}\nu \rightarrow \pi^{\pm}\pi^{0}\nu$. Use Central PreShower detector with fine segmentation : $\Delta\phi_{CPS} \simeq 0.1 \times \Delta\phi_{calo}$

$$CPS_{cluster} \approx \pi^{0} \ , \ trk \approx \pi^{\pm}$$

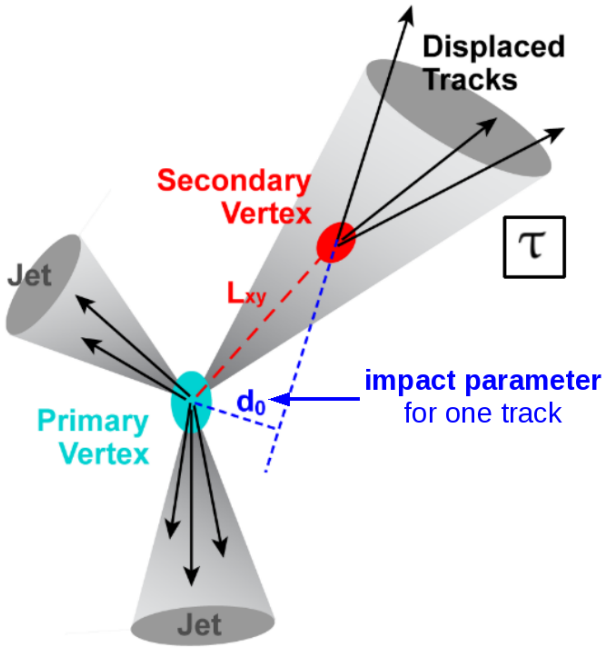






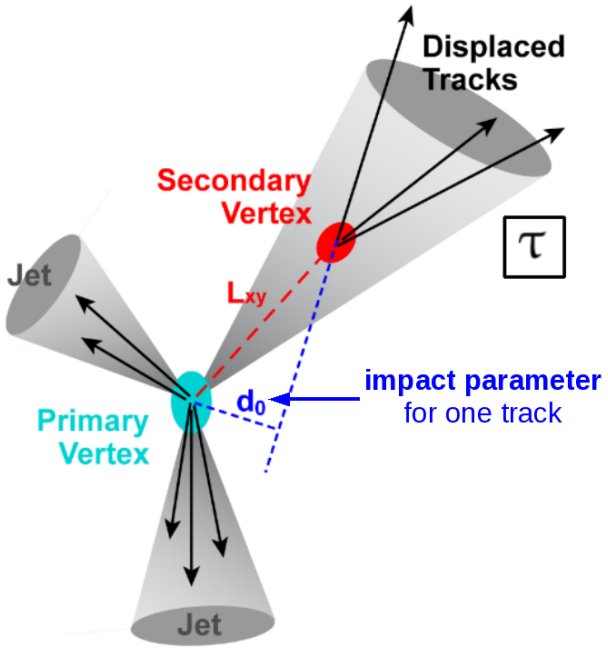
No significant improvement

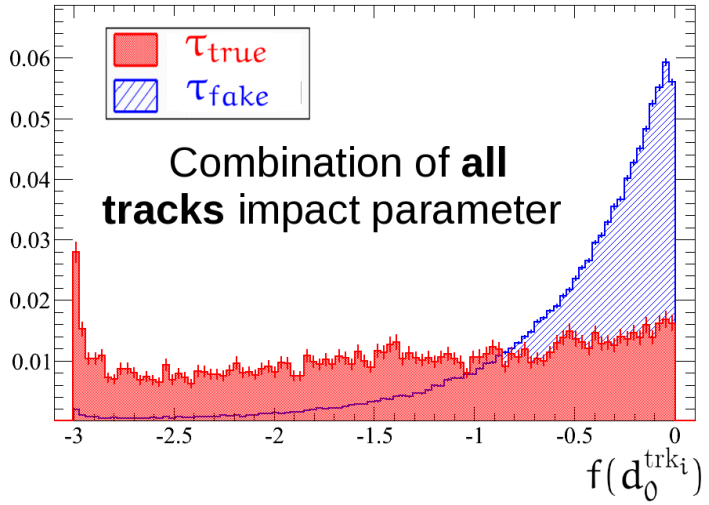
τ is a long lived particle



Use impact parameter to remove jets faking τ more efficiently.
(large $c\tau_{life} \Rightarrow$ large d_0)

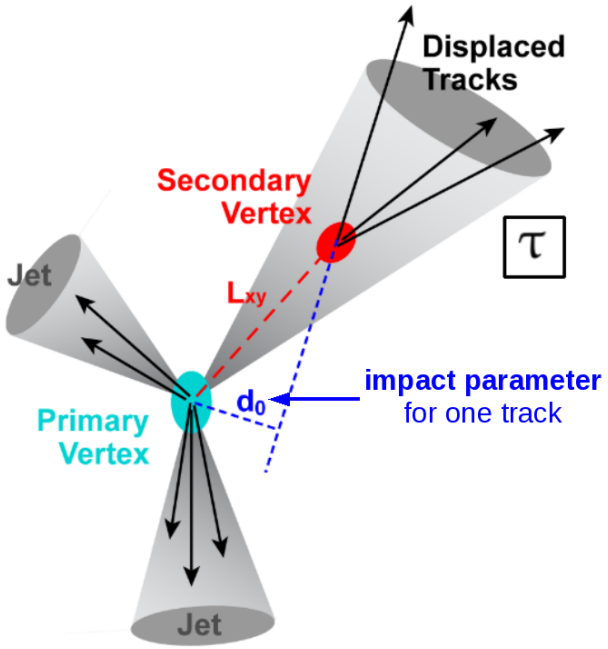
τ is a long lived particle



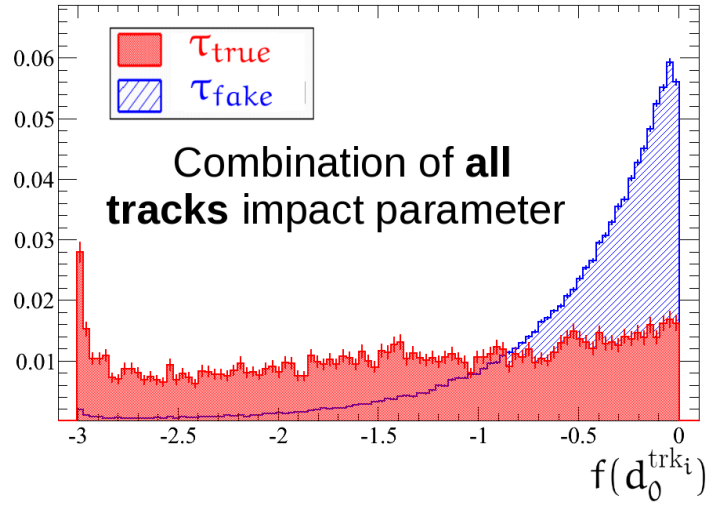


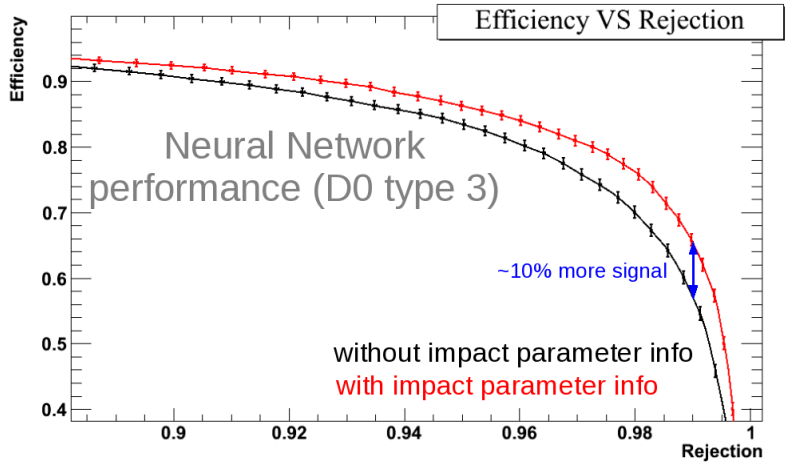
Use impact parameter to remove jets faking τ more efficiently.
(large $c\tau_{life} \Rightarrow$ large d_0)

τ is a long lived particle



Use impact parameter to remove jets faking τ more efficiently.
(large $c\tau_{life} \Rightarrow$ large d_0)



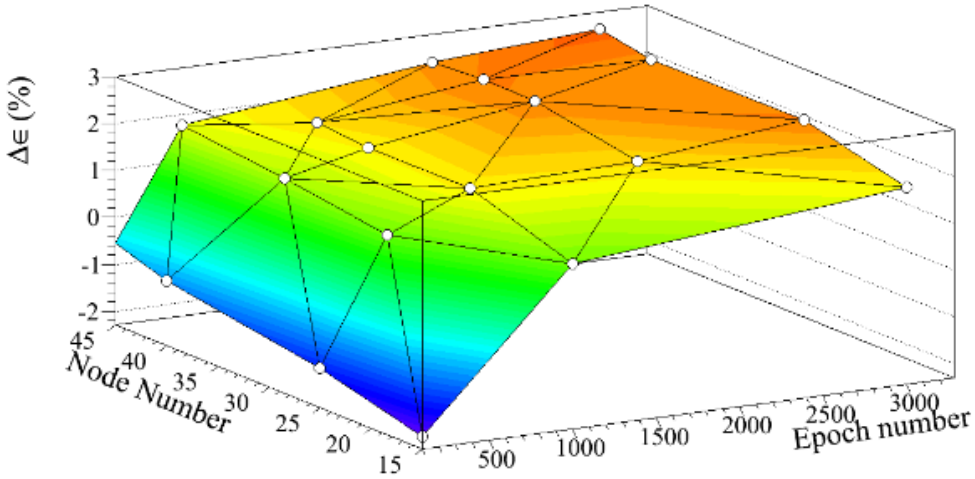


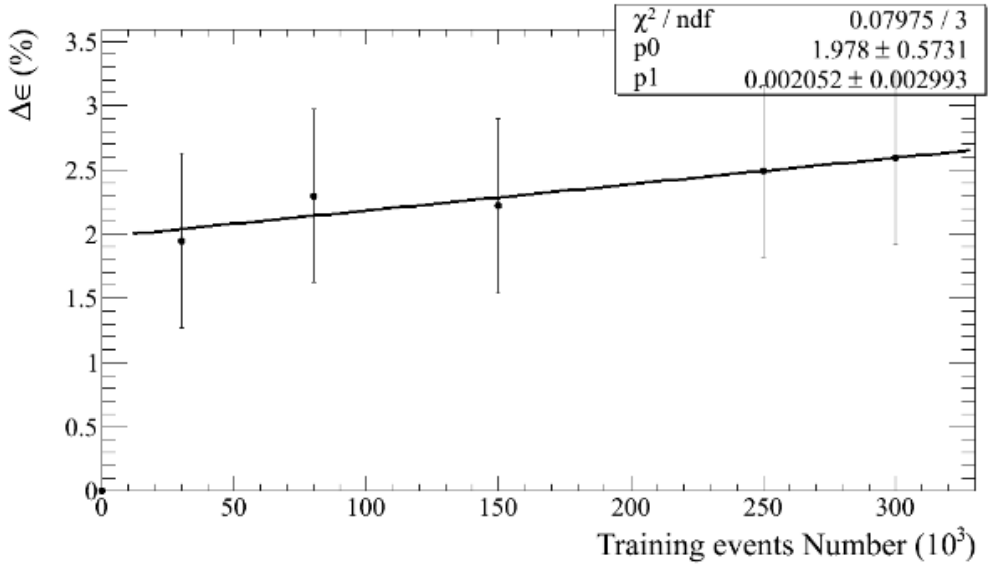
Clear improvement in performance !

Overview

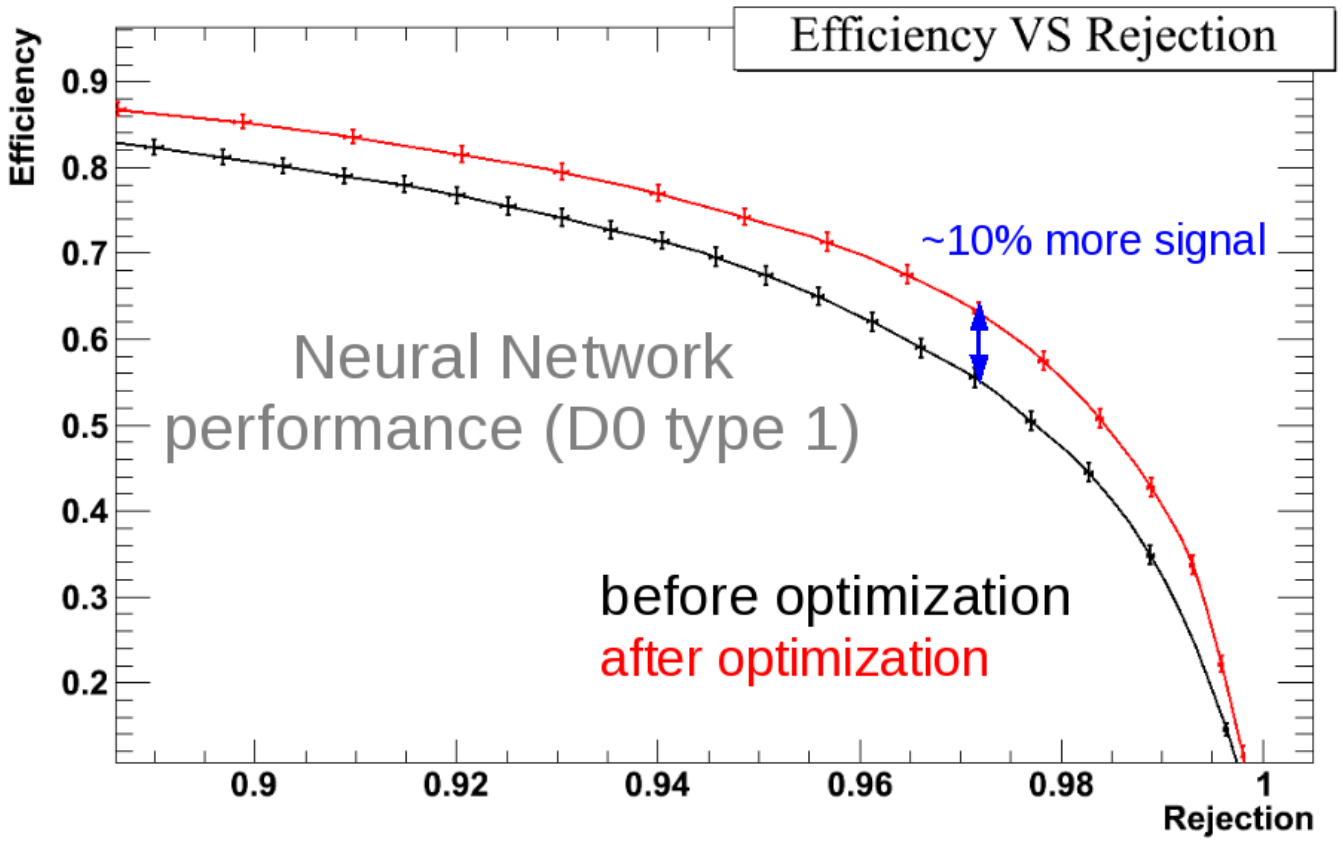
Fine tuning of NN parameters

$$\Delta\epsilon \equiv \epsilon_{\text{new}} - \epsilon_{\text{off}} \text{ at } 97.0\% \text{ rejection}$$





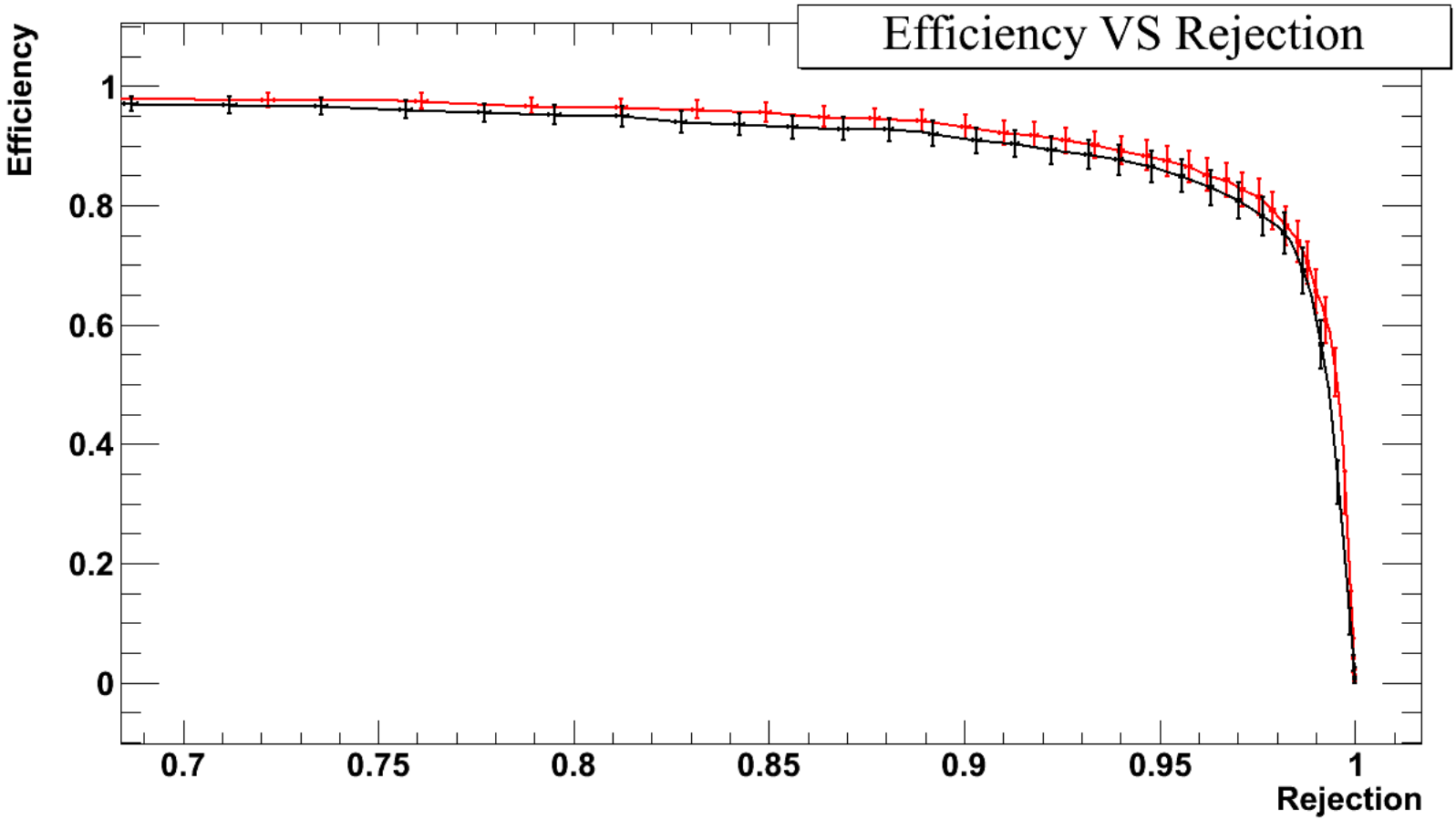
Fine tuning of NN parameters



Overview

Tested on $45 < p_T < 150$ sample, type 2

training on $10 < p_T < 150$ sample, training on $45 < p_T < 150$ sample

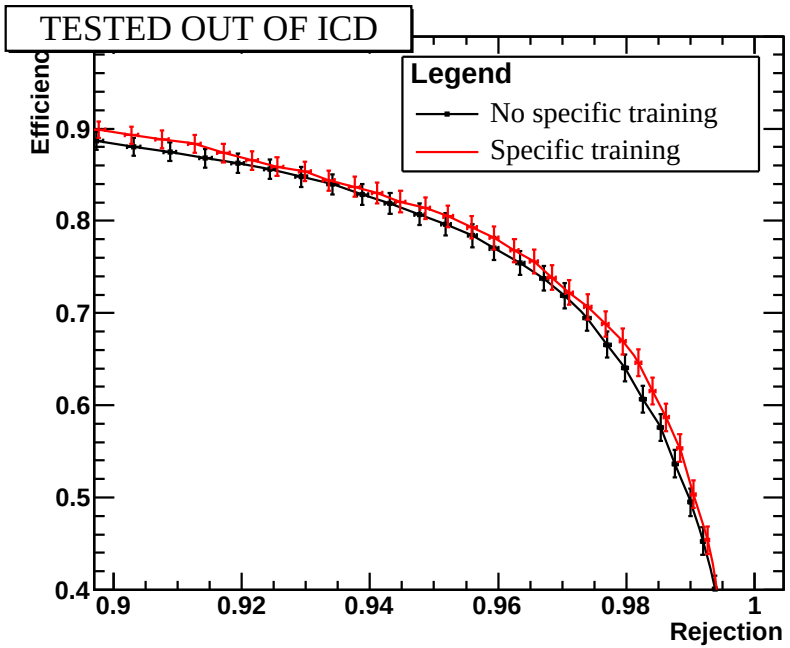


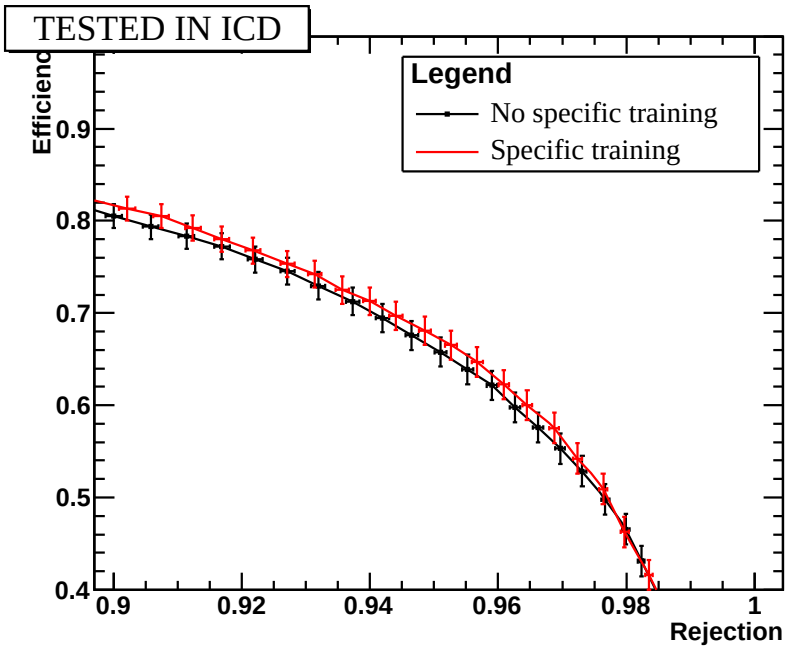
Overview

Effect of dedicted training in ICD (type 1)

In ICD :

no EM cluster ⇒ physical type 2 are reconstructed as type 1

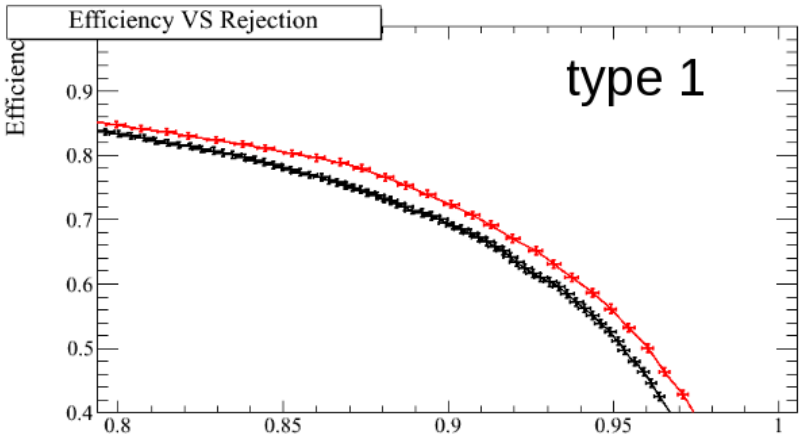


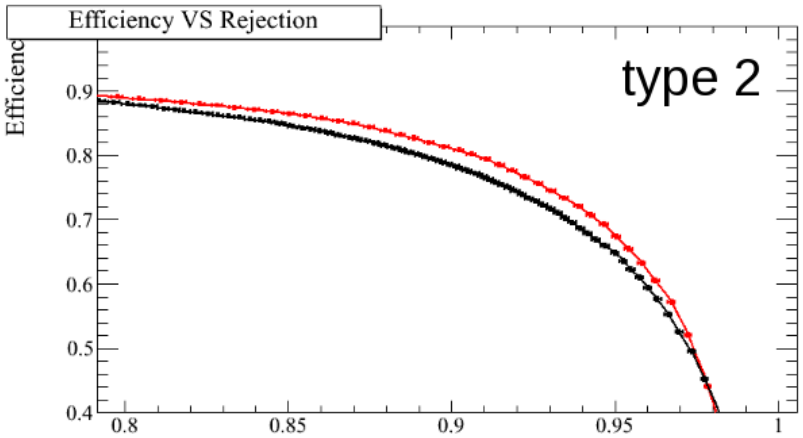


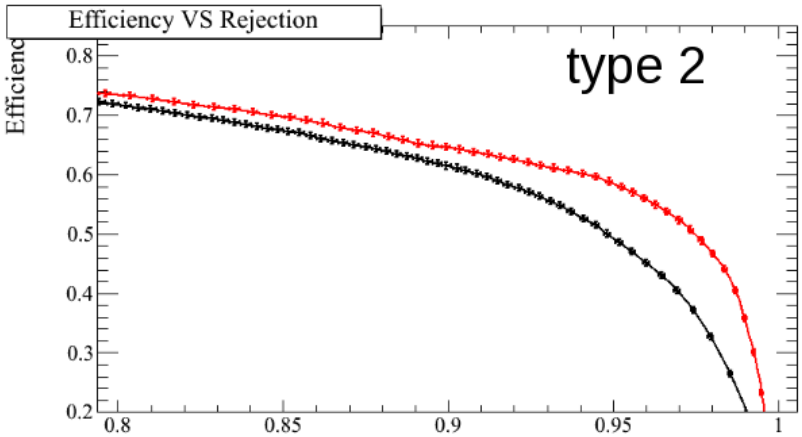
Overview

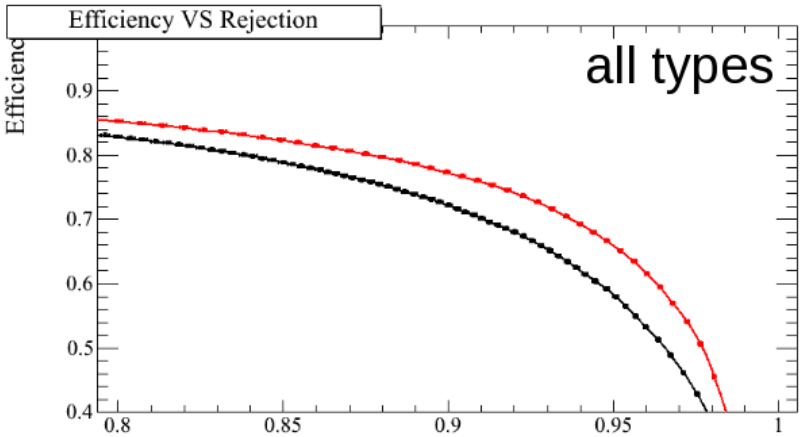
Test in data

Background estimation : from an isolated muon (OS/SS method used in $\phi \rightarrow \tau\tau$ analysis)



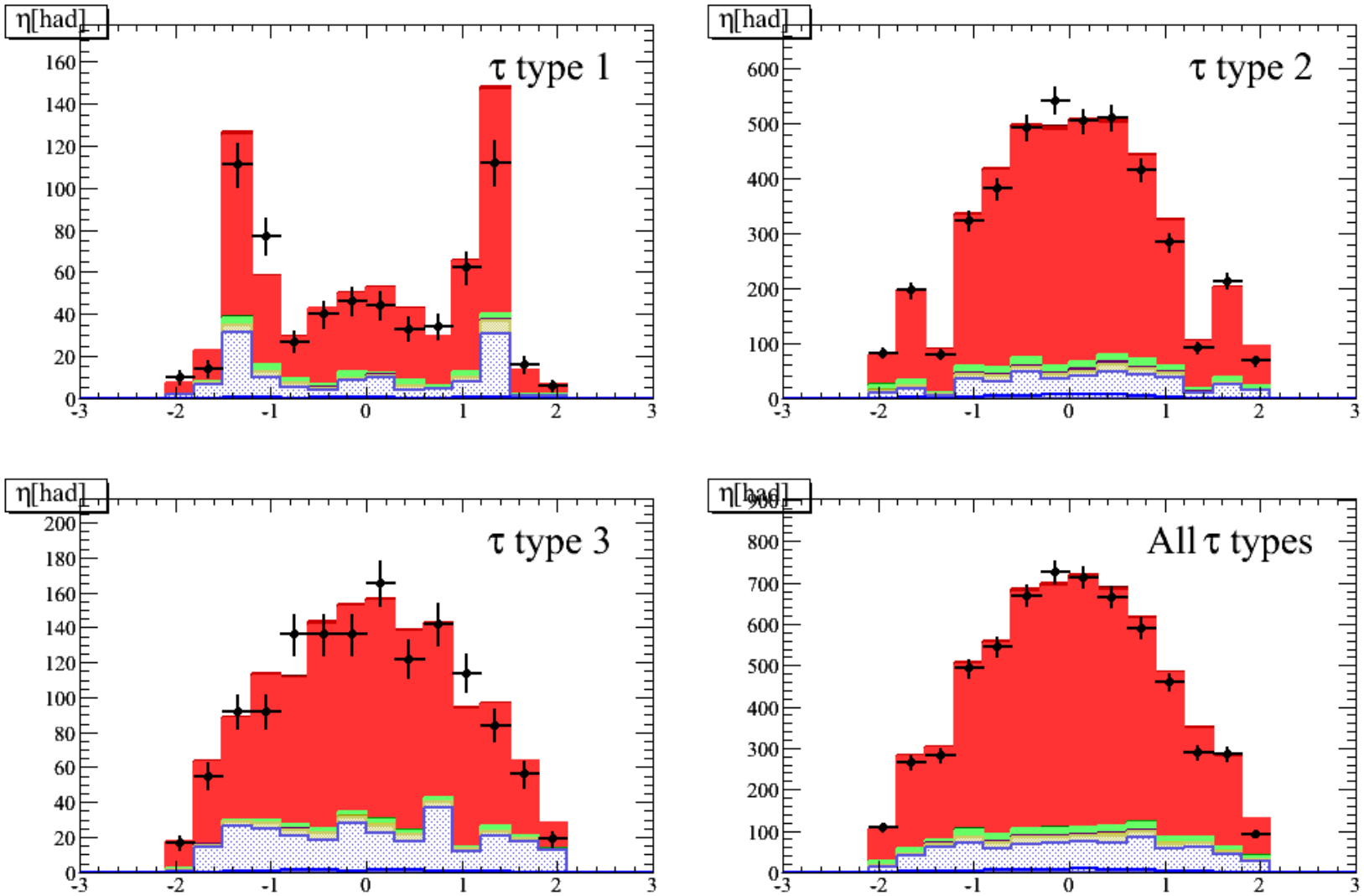




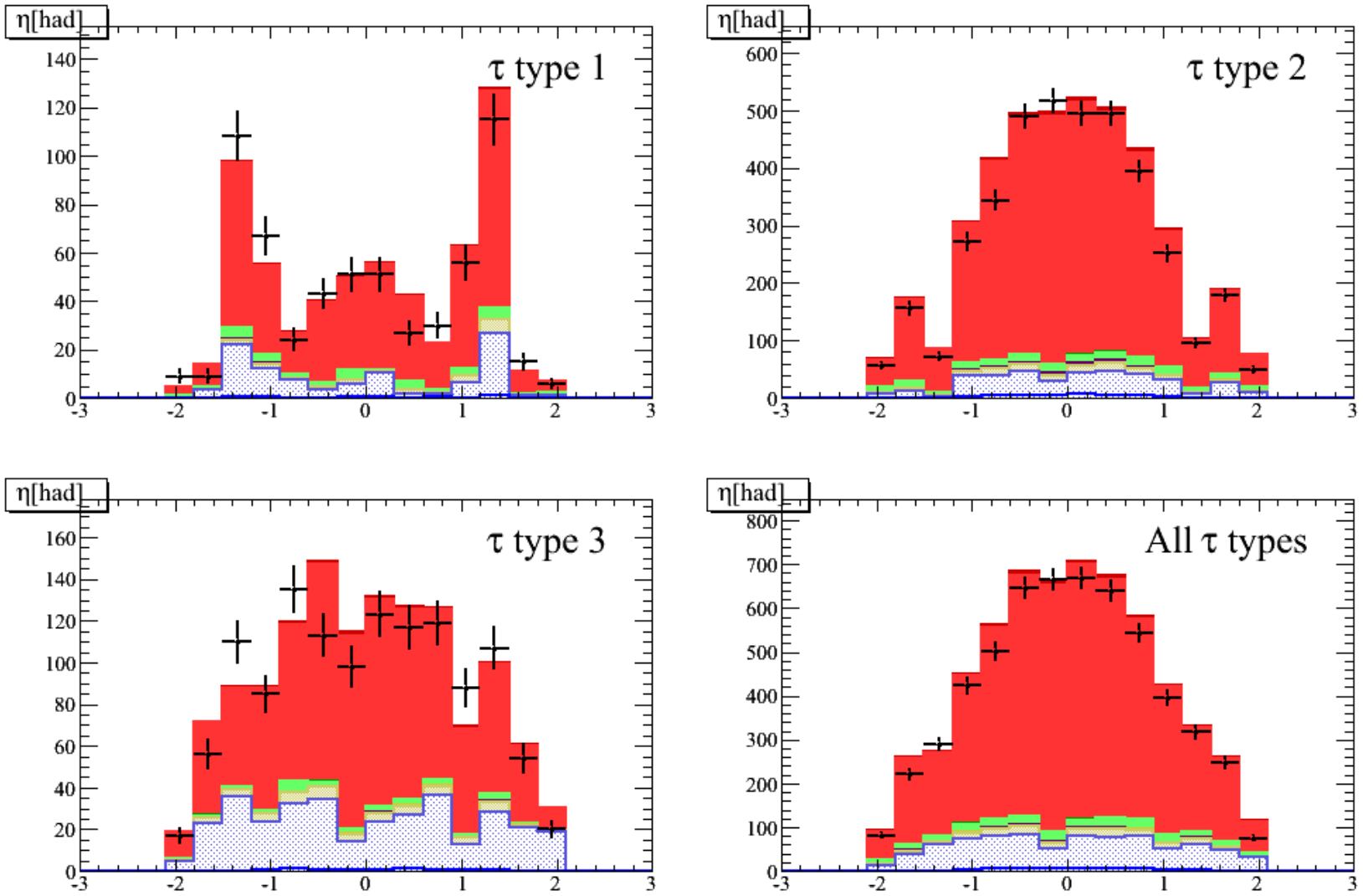


New NN, Old NN

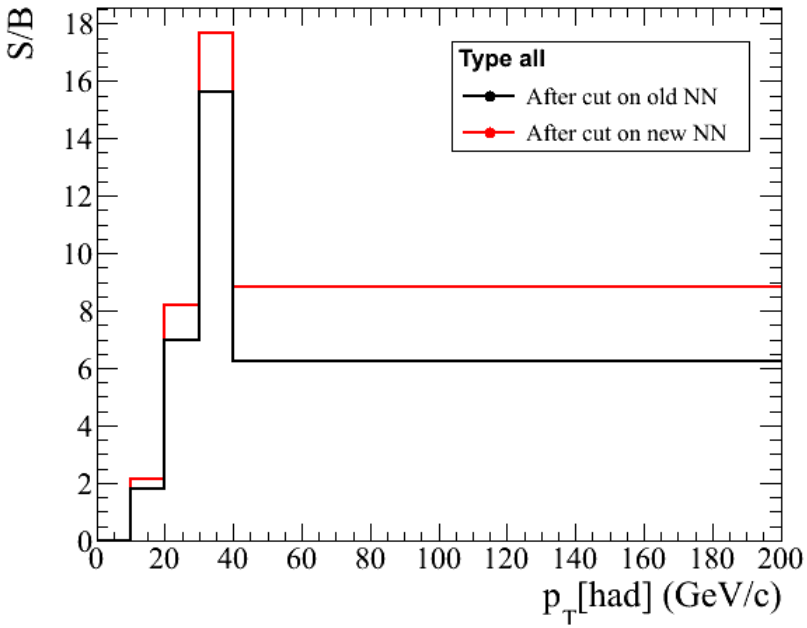
$\eta_d(\tau)$ distribution after cut on New NN

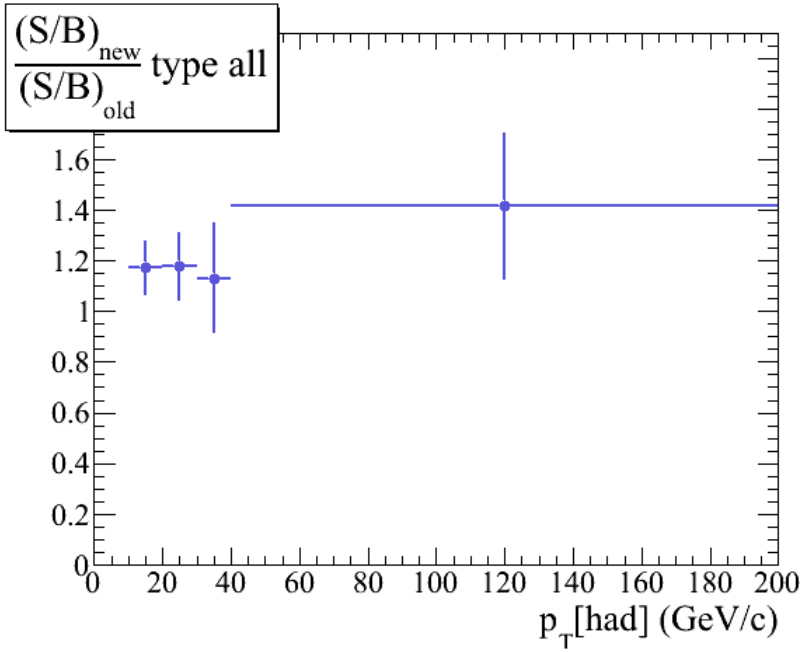


$\eta_d(\tau)$ distribution after cut on Old NN



S/B VS p_T for all type





Comments :

Important improvement at high p_T, but really good improvement also at low p_T !

Overview

Conclusions & outlooks

Results for the τ identifications : ~ 10% of improvements

- Include the Central preshower (2 approaches) ✗
- Exploit the long τ life time (using b-tagging tools) ✓
- Tune NN parameters (epoch, nodes, statistics) ✓
- Dedicated training for τ of high p_T ✓
- Dedicated training for high luminosity events ✗
- Dedicated training in ICD (for type 1) ✓

Pratical comments :

- Available at `cafe` level : some changes in the τ processor/config file described in calgo and conveners meetings)
- DØ note already started

BACKUP SLIDES

E_τ calibration : "E/p correction"

Known effect

The calorimeter response is slightly different in the simulation and in data.
$\tau_{\text{measured}} \equiv \{\gamma, \pi^{\pm}\}$ energy **needs a relative correction**.

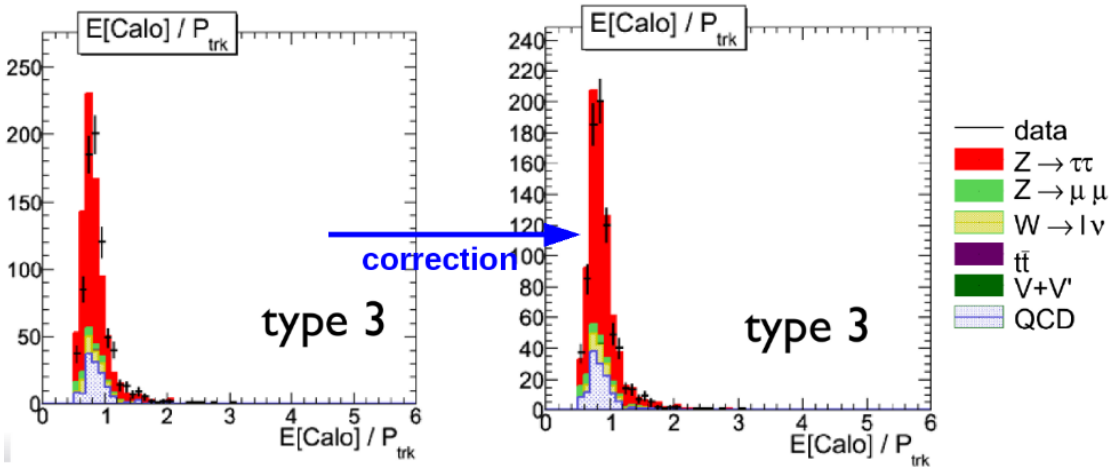
Correction method

Use the track energy as reference to correct simulation event by event :

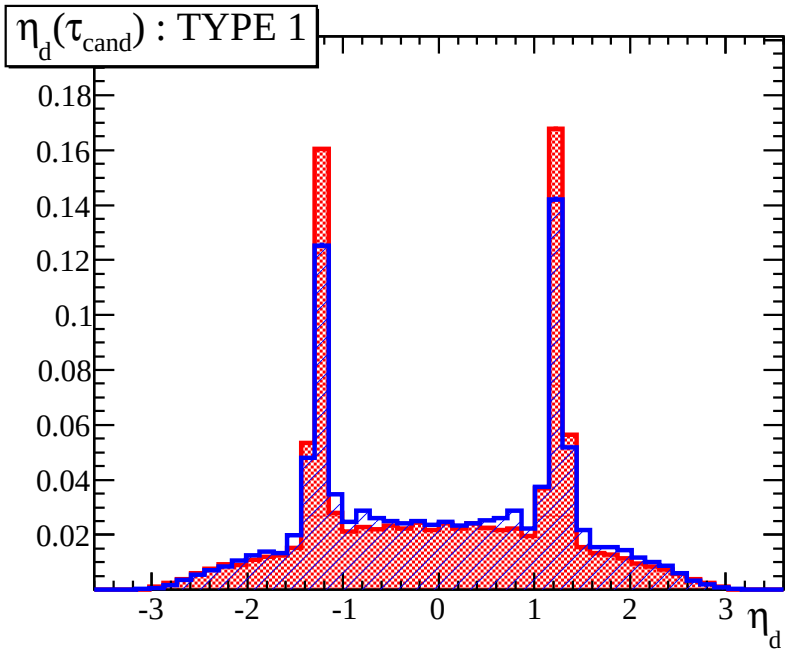
$$\left(\frac{E}{p}\right)_{\text{MCcorr}} = \left(\frac{E}{p}\right)_{\text{MC}} \times \frac{\langle E/p \rangle_{\text{data}[Z\to\tau\tau]}}{\langle E/p \rangle_{\text{MC}}}$$

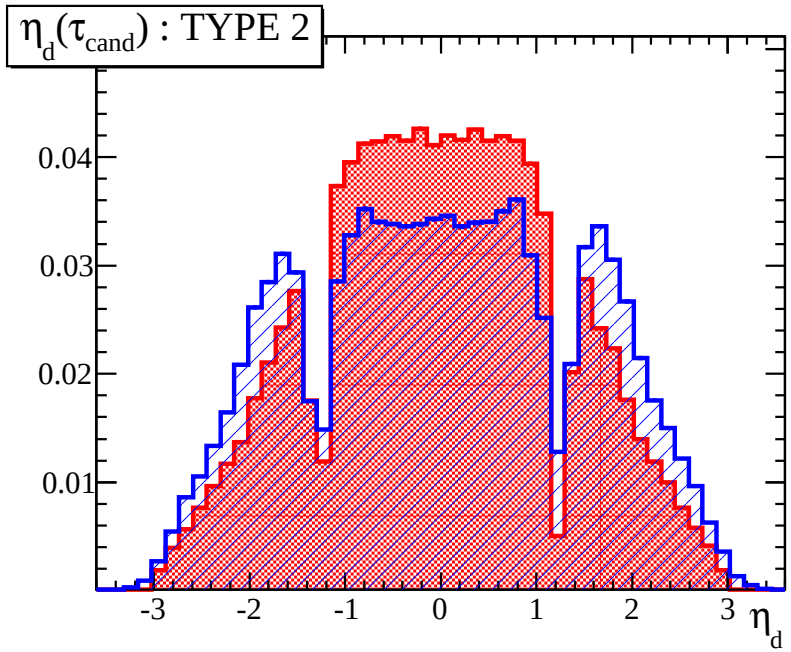
with

- $E/p \equiv E^{\text{calo}}/p^{\text{trk}}$
- $\langle E/p \rangle \equiv$ average value.

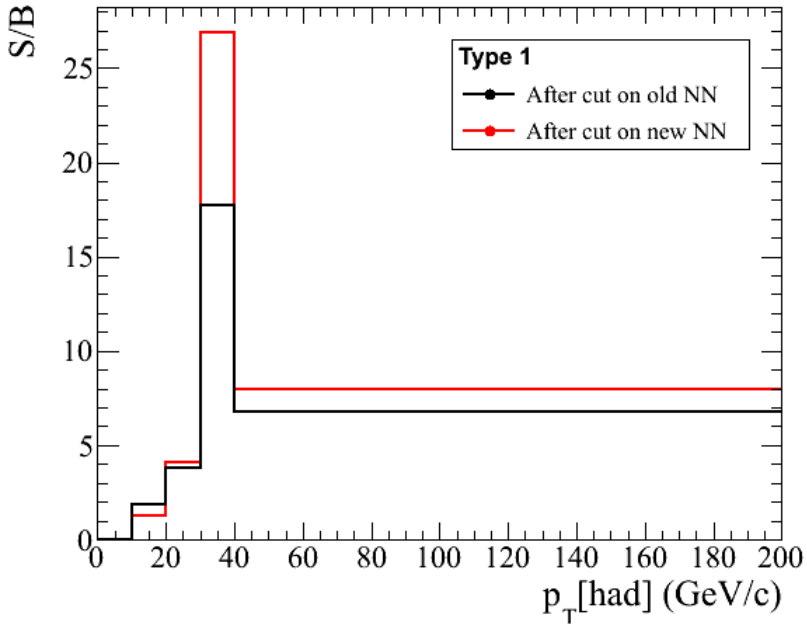


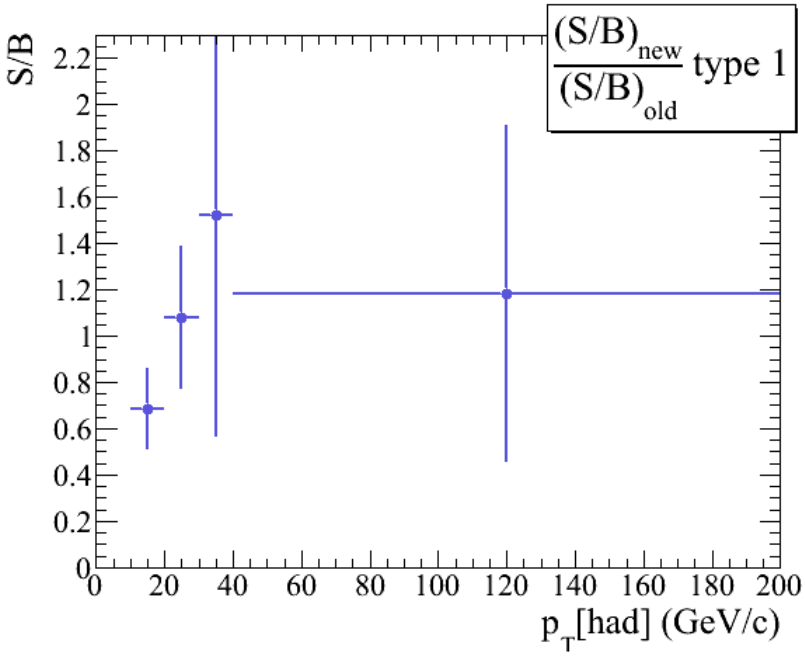
Why a dedicated training for type 1 ?



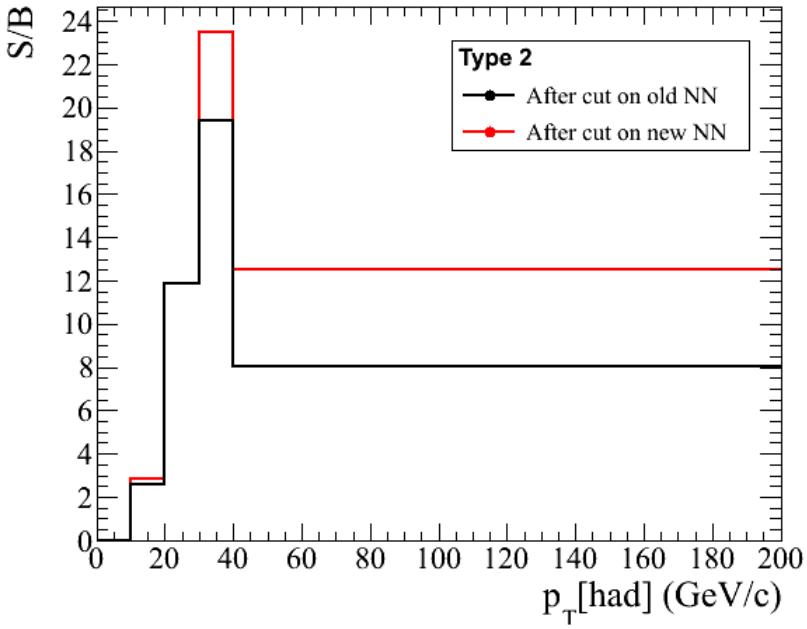


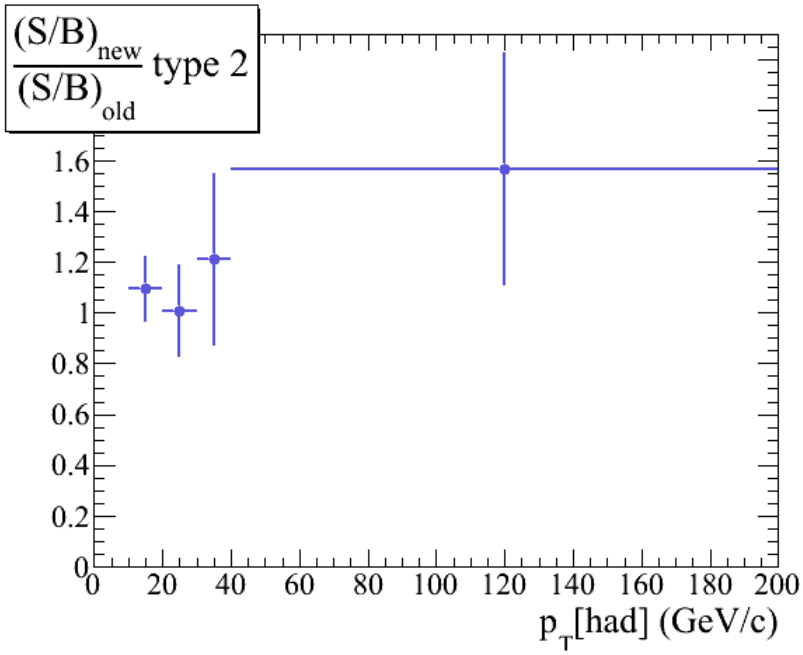
S/B VS p_T type 1



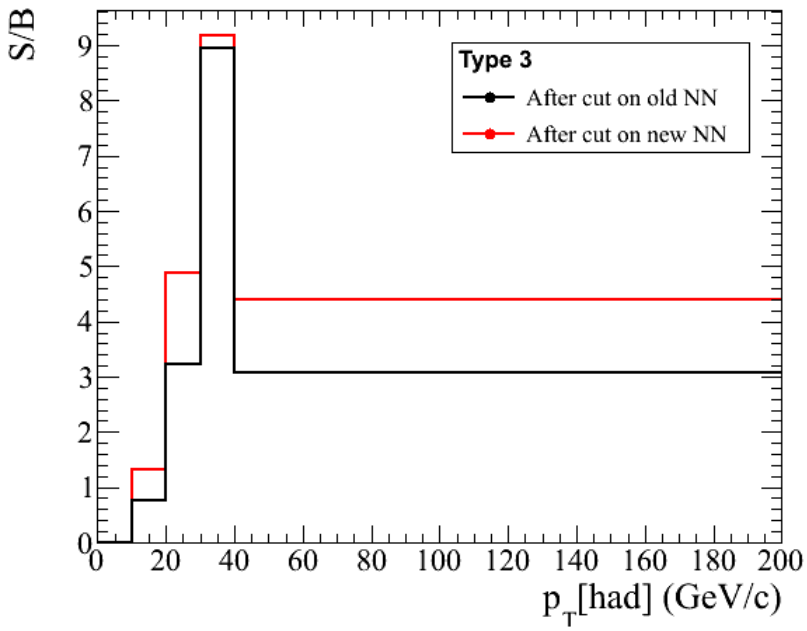


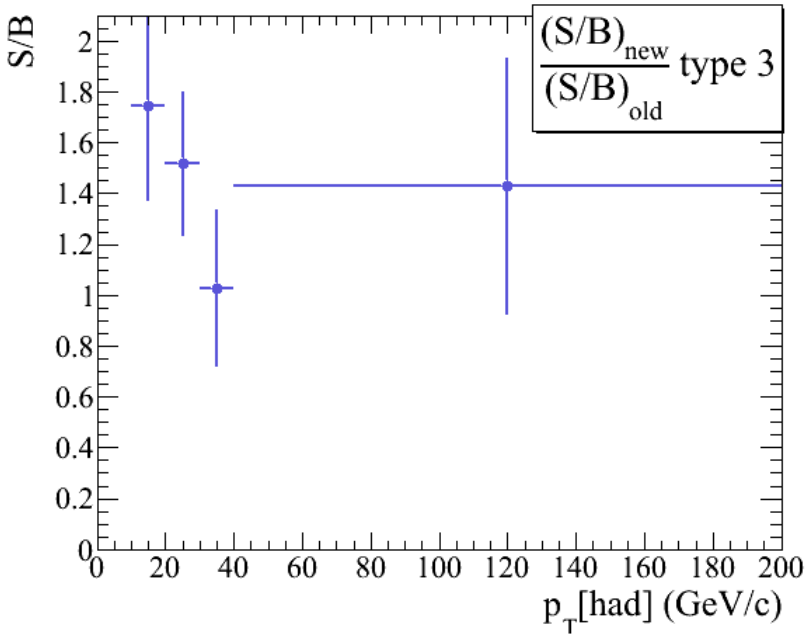
S/B VS p_T type 2





S/B VS p_T type 3





MSSM charged Higgs

Charged higgs bosons via $t\bar{t}$ events