LABORATOIRE DE L'ACCÉLÉRATEUR LINÉAIRE

# Top analysis using the semileptonic decay channel

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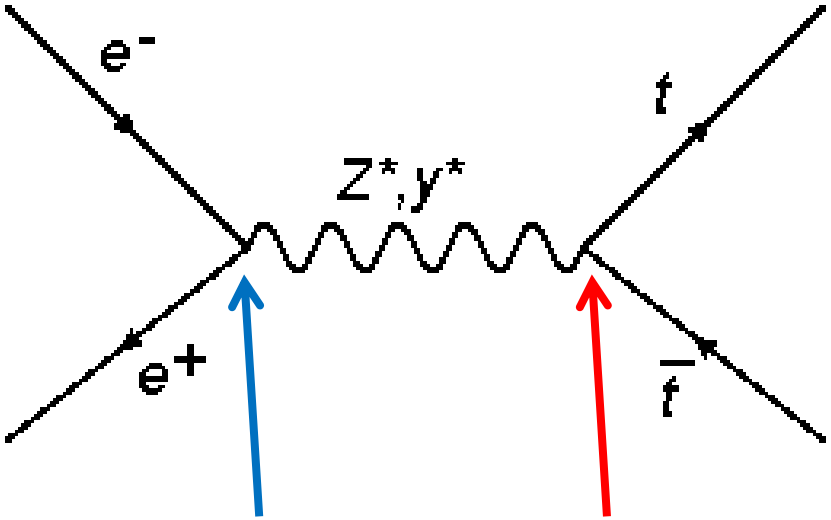
# Introduction




Use different ($e^-$,$e^+$) polarisations : (+,-) (-,+)

Probe R/L Ztt couplings (~ V/A)

Semileptonic decay

$t_1 \rightarrow bW^{\pm} \rightarrow b(l^{\pm}\nu)$
$t_2 \rightarrow bW \rightarrow b(qq)$

($l = e,\mu$)

- $l^{\pm}$ gives $t_{1,2}$ charge signs (charge mis-id. < 1‰)
- aim to reconstruct $t_2$ (hadronic top)

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The semileptonic channel as a detector benchmark :

- Lepton id. + tracking
- B-tagging in a 4 jets environment
- Jet energy resolution for W and t reconstruction

} Intensive use of PFA

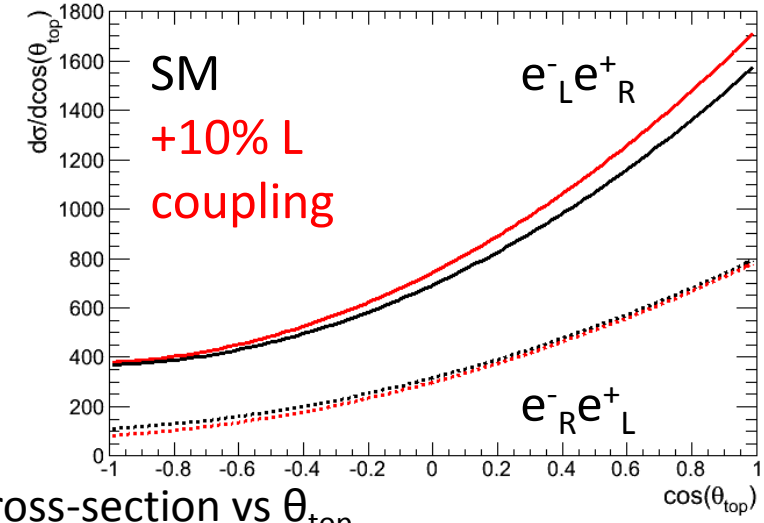
# Observables

- Observables of interest : σ(tt), $A_{LR}$, $A_{FB}$(top/lepton)

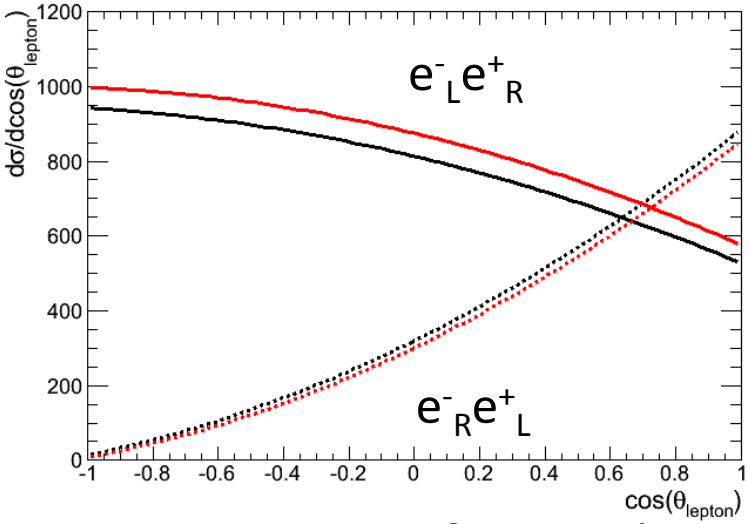
$$A_{LR} = \frac{N_{top}(e^-_L) - N_{top}(e^-_R)}{N_{top}(e^-_L) + N_{top}(e^-_R)}$$ (e⁻ polar. flip)

Error, $\Delta A = \sqrt{\frac{1 - A^2_{FB(LR)}}{N_{total}}}$

$$A_{FB} = \frac{N_{top}(\cos\theta > 0) - N_{top}(\cos\theta < 0)}{N_{top}(\cos\theta > 0) + N_{top}(\cos\theta < 0)}$$ (flip direction)




Cross-section vs $\theta_{top}$




Cross-section vs $\theta_{lepton}$

Also needs ≈ 0.1% precision on polarisation

# Strategy

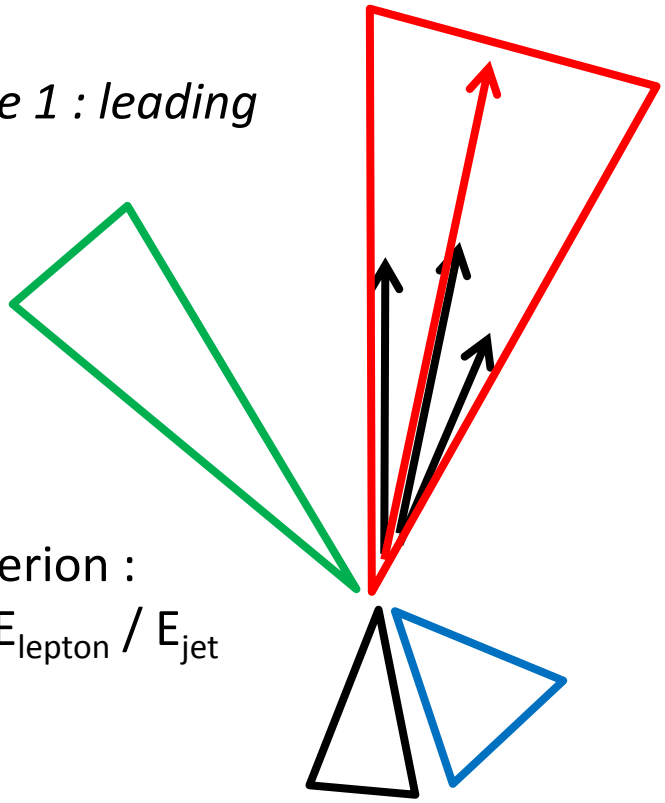
$tt \rightarrow b(l\nu)b(qq')$

1. Reconstruct the event (Pandora, …)
2. Find 1 lepton
3. Substract this lepton, force jet clustering $N_{jets} = 4$
4. B tagging → select 2 highest b-tagged jets
5. 2 least b-tagged jets = W
6. Pairing : $(b_1+W)$ or $(b_2+W) = t$ (lepton gives charge)
7. Identify top event (cuts)

# Finding the lepton

- Force 4 jets topology → lepton embedded in a jet
- The lepton from W decay must be « leading » or « isolated »
  - Kills pions faking muons (always inside a jet)
  - Kills leptonic b decays (neither leading, nor isolated)

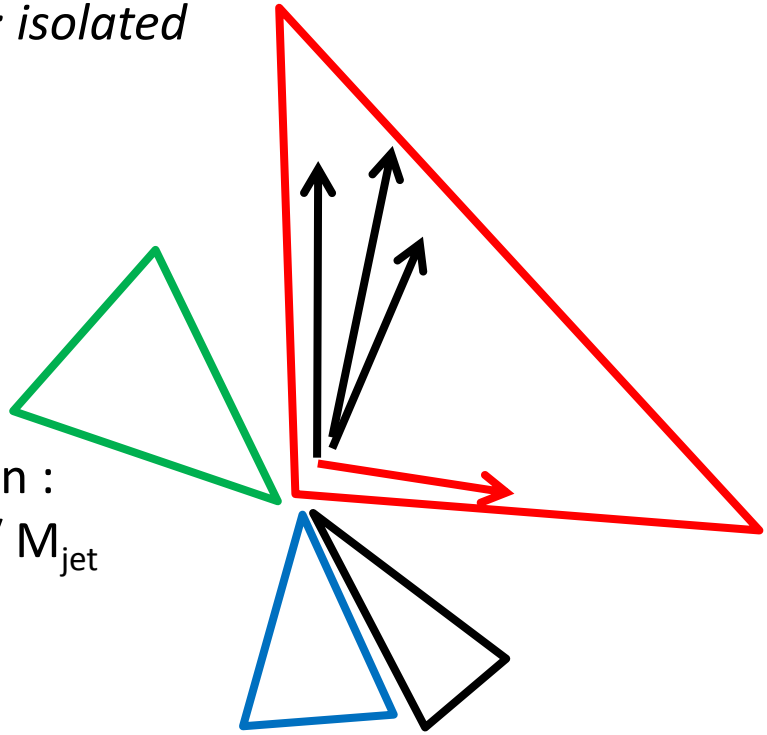
*Case 1 : leading*



Criterion :

$z = E_{lepton} / E_{jet}$

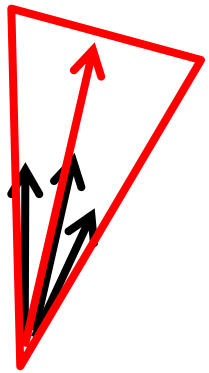
*Case 2 : isolated*



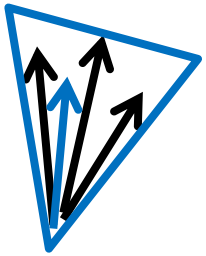
Criterion :

$x_T = p_T / M_{jet}$

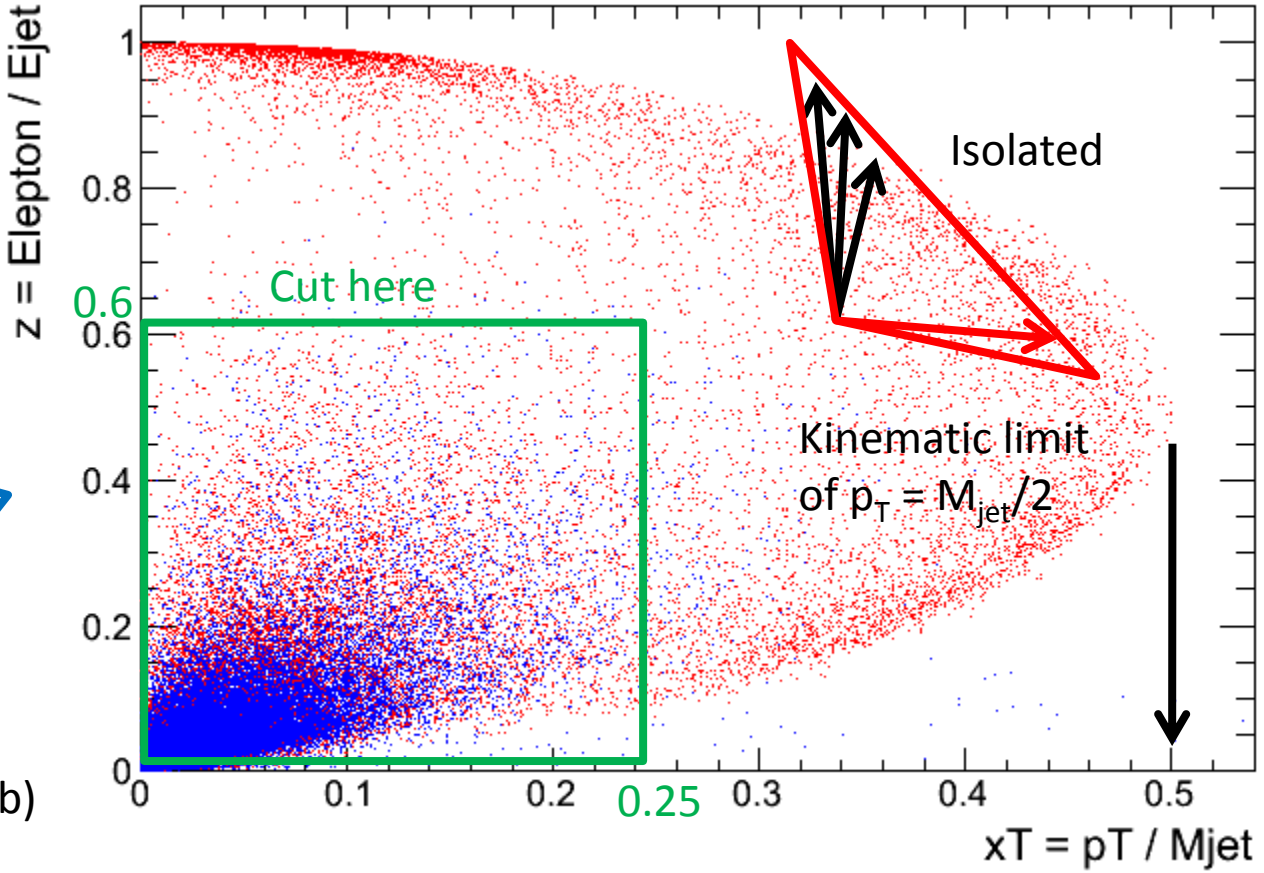
# Isolation cuts



Leading



Not isolated
(lepton from b)

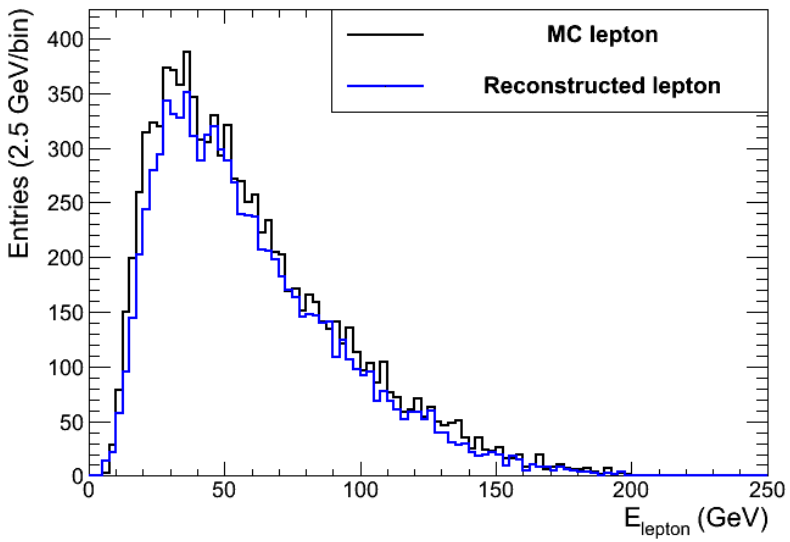



Red = leptons in semileptonic top events

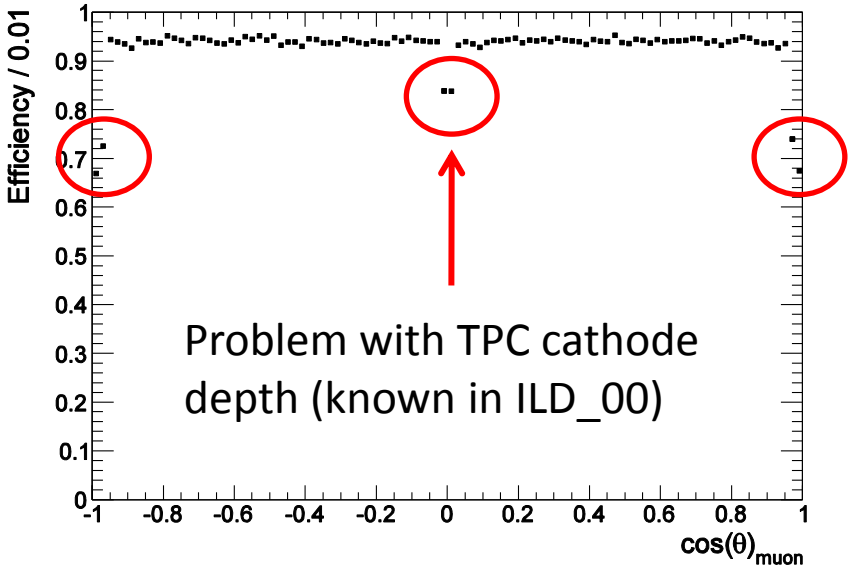
Blue = leptons in full hadronic top events = leptons from b

| Semileptonic tt | Fraction of events with Nlep = 1 | Contamination (fraction of bad leptons) |
|---|---|---|
| muons | 87.5 % | 0.3 % |
| electrons | 85.7 % | 0.4 % |

# Lepton distributions




Energy distribution of true (MC) lepton and reconstructed lepton



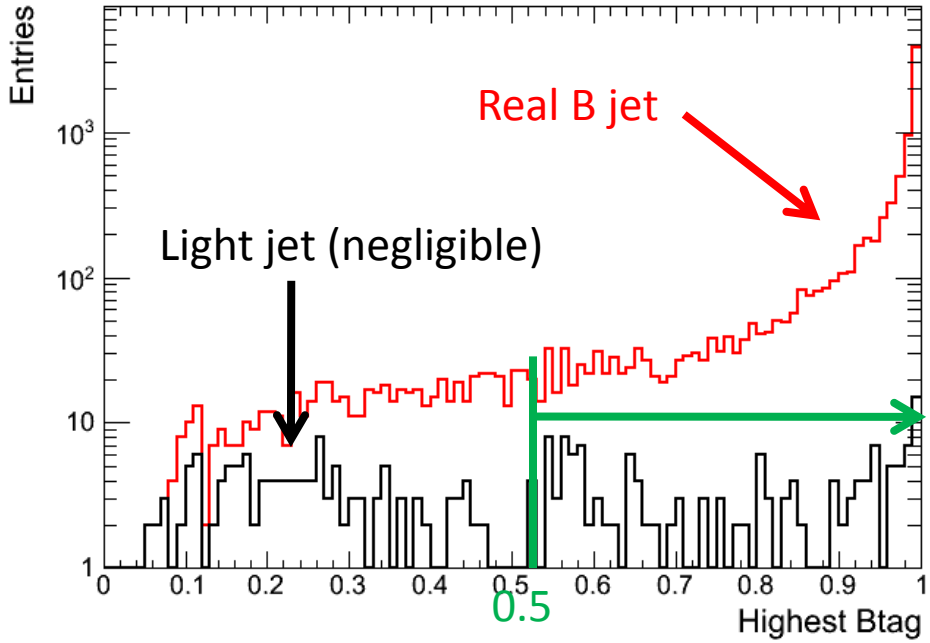

Lepton angular efficiency

- Efficiency worse for low energy leptons due to isolation cuts
- Angular efficiency worse in the center (TPC cathode) and in very forward regions

Then, remove lepton, re-do jet clustering $N_{jets}$ = 4 & b-tagging

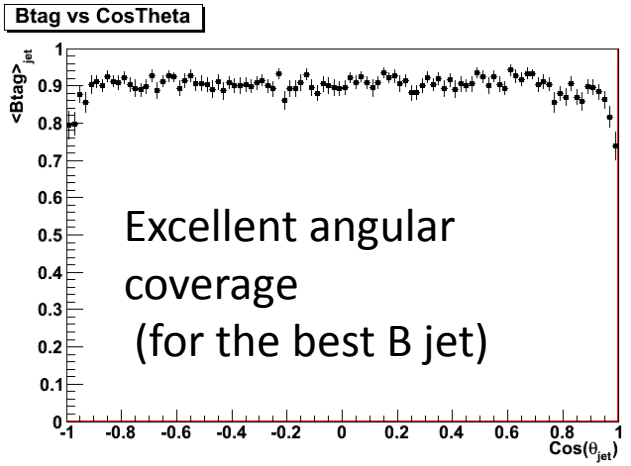
# B tagging

- 2nd most important feature for semileptonic top : ability to tag b jets
- Only one b is required (b come in pairs)
- Once the lepton is substracted, redo 4 jets clustering



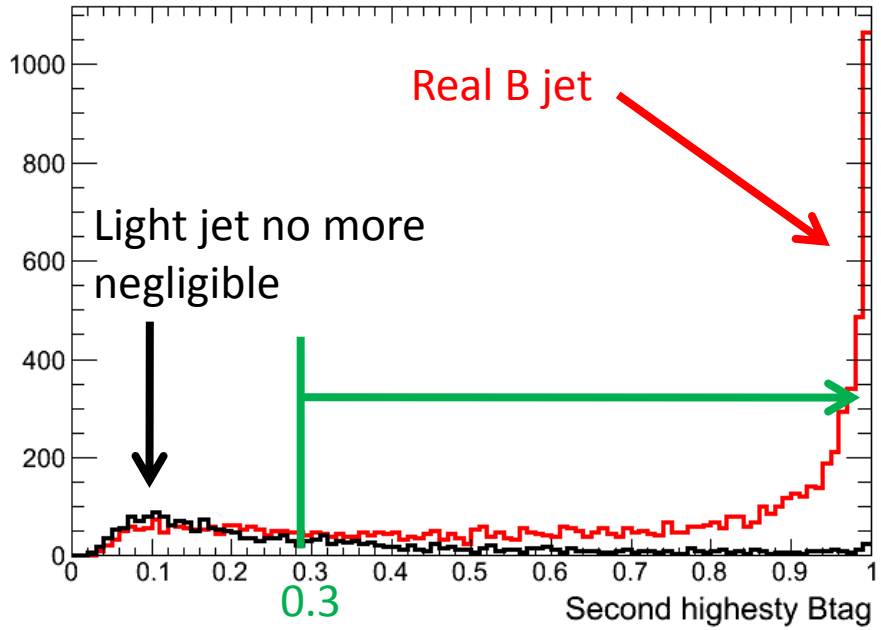

Highest btag in the 4 jets

Btag > 0.5 :
Purity = 98%
Efficiency = 91%



# Second highest Btag

- Second highest Btag is not mandatory (1 b jet is enough)
- Performances are worse in semileptonic top events

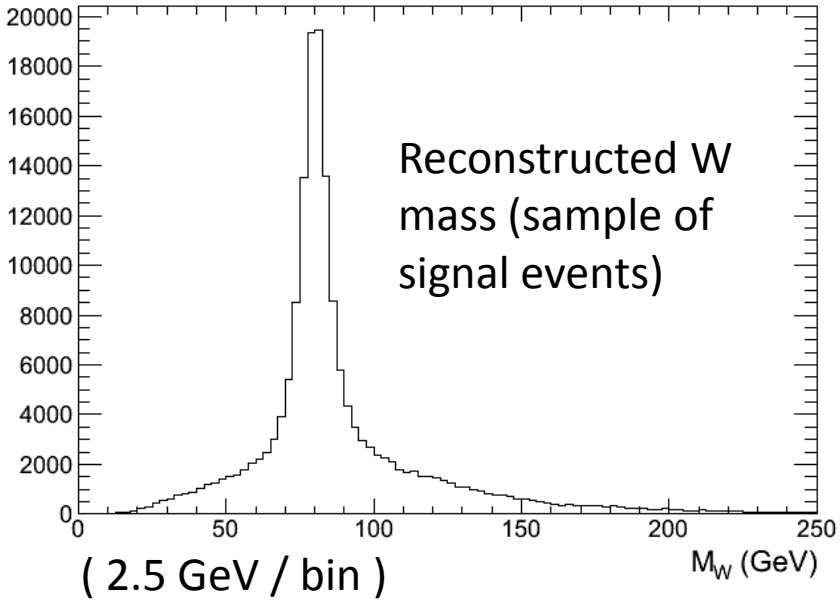


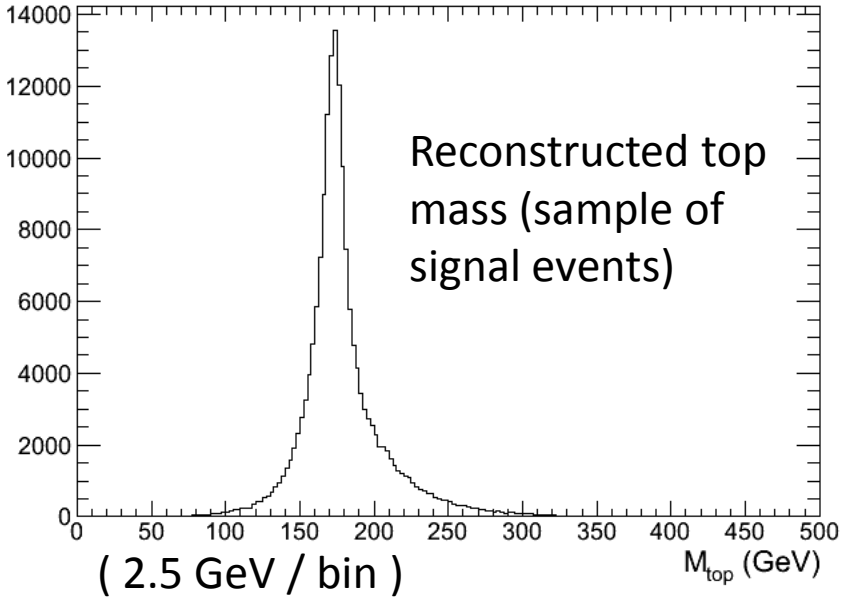

Btag > 0.3
Efficiency = 63 %
Impurities = 10 %

# Paring b and W

- We use the constraints on the top energy and mass : $E_{top}$ = 250 GeV, $M_{top}$ = 174 GeV

- Minimise $d_{1,2} = \left(E(b_{1,2}W) - 250\right)^2 + \left(M(b_{1,2}W) - 174\right)^2$

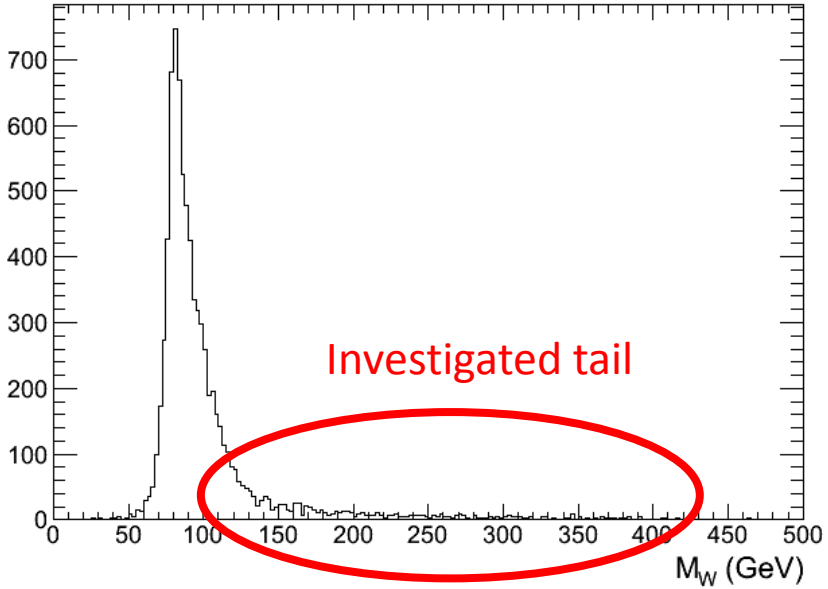


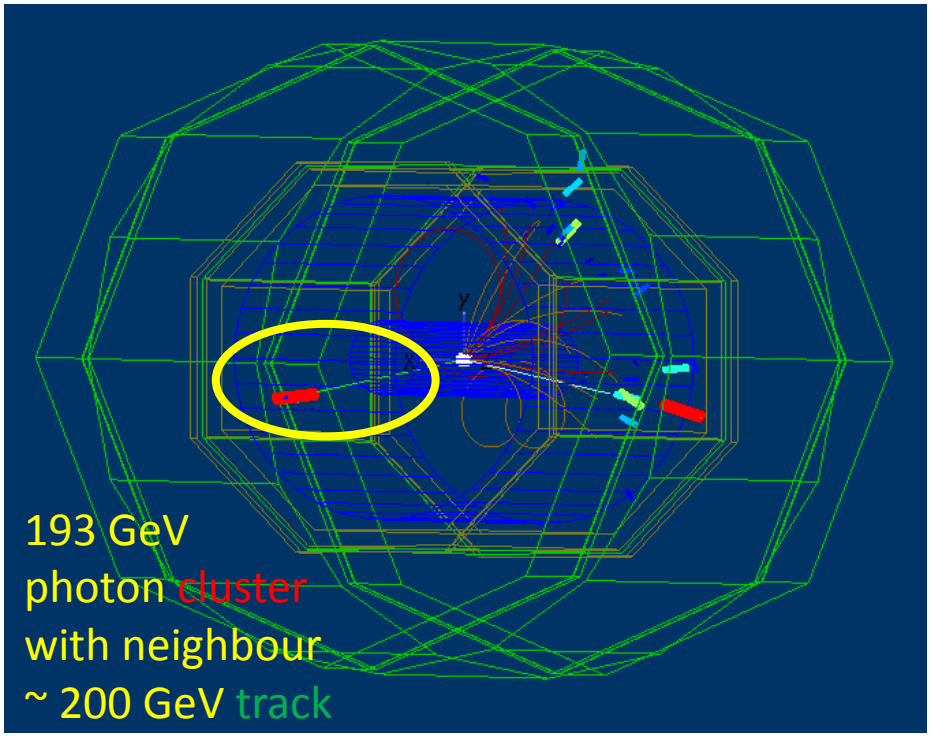




Some problems occured during background checks (WW)

# Reconstruction of WW semileptonic backgroud

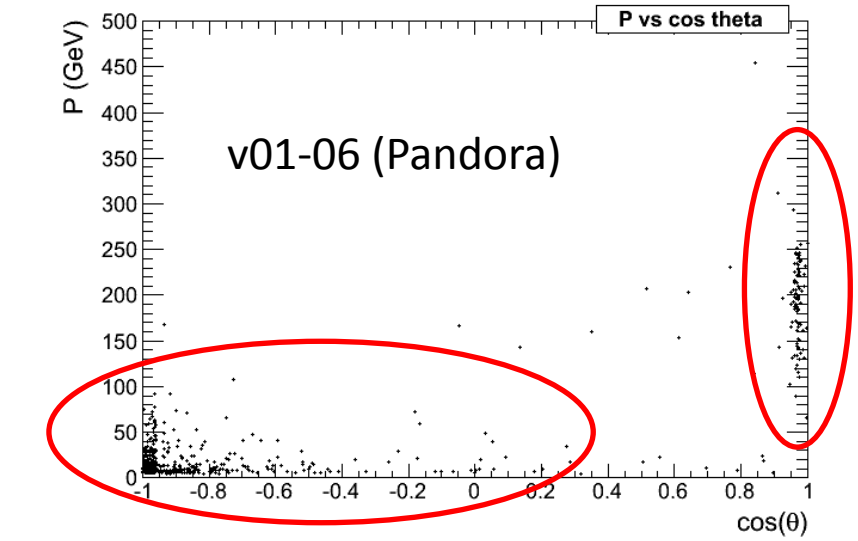
- After lepton selection, problems with reconstructed W mass (large tail)
- Problem occurs with tracks not associated to clusters

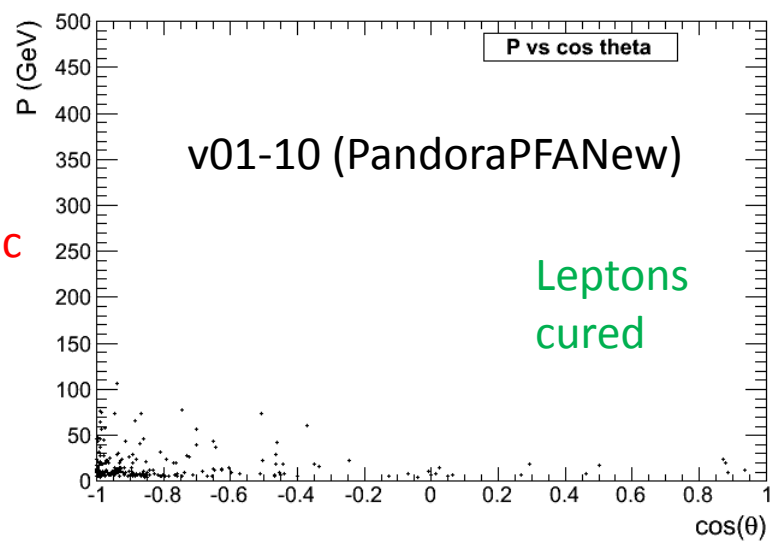



Event display of a csev event : one track is not associated to its cluster while momenta and positions are very close.

# Case of non-associated tracks




~500 entries (old) – ~200 entries (new) for 1000 evts

- In the LOIs : v01-06 → improved in v01-10 but they still exist (even with a cut on $\Delta P/P^2$)
- Reconstruction needed be re-done (started last month, with v01-10)

# New problems in new reconstruction

- LOI simulated files used
- Reconstruction using ilcsoft v01-10
- Some files (1k out of ~20k) systematically fail (exception thrown): ecal calo hits with bad positions, e.g. *positionVector x: 1.29475e+19 y: 7.04853e+34 z: 2475.35 length: inf*
- Communication with John Marshall : no more problem in v01-11 but does it affect the physics ?

# Results obtained

- Cut based analysis :
  - 1 lepton + 1 b jet are required
  - added cut on thrust and « hadronic » mass/energy
  - and cut on $m_W$-$m_{top}$
- Efficiency : 75 %
- Contamination : 5 % (non final : 1 % expected)
- Using MVA method (BDT)
  - can reach 86% efficiency, < 1% contamination

- Precisions achievable (all preliminary) :
  - $\Delta\sigma/\sigma \approx 0.2$ % - $\Delta A_{LR} \approx 0.2$ % - $\Delta A_{FB} \approx 0.5$ %
  - $(\Delta g/g)_{ZtLtL} \approx 0.2$ % - $(\Delta g/g)_{ZtRtR} \approx 0.2$ % , using $A_{FB}$(lep)

# Conclusions and perspectives

- Top measurements at the ILC require
  - Tracking with full coverage
  - B tagging and jet reconstruction (particle flow)
  - Improvements are being done in these fields !

- Efficiency > 75 % - purity > 95 %
  - Leads to permil precisions on observables and derived Ztt couplings

- Still to do :
  - Add other backgrounds (ZZ, …)
  - Systematics on $A_{FB}$ measure
  - /!\ Some problems in the LOI samples are still present

Thank you for your attention