ATLAS Littlest Higgs Analysis

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Little Higgs

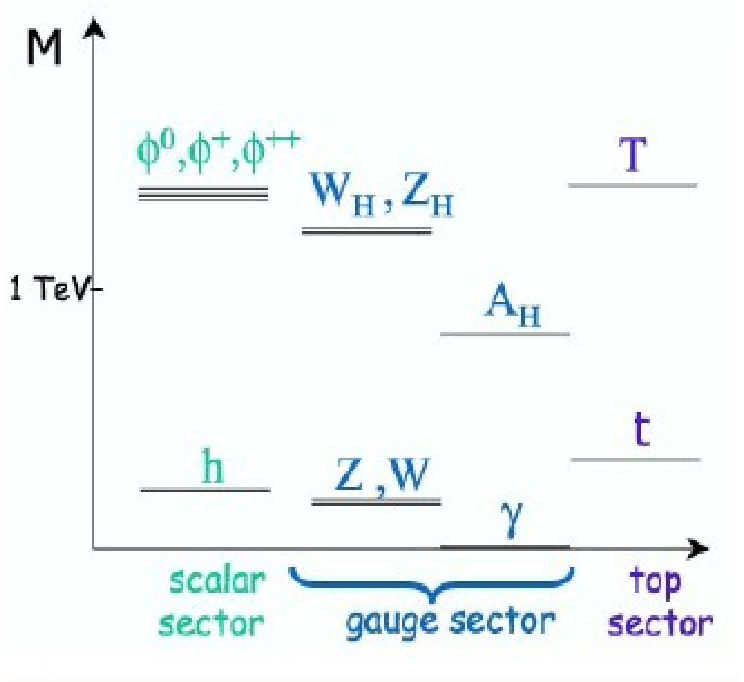
- This model solves hierarchy problem of SM including new particles to cancel radiative corrections:

– T quark with charge 2/3.

– Heavy gauge bosons.

– Scalar particles, including Higgs.

- Only two parameters: mass and angle between W_H and Z_H.
- Littlest Higgs: minimum particles are needed.



This plot shows Littlest Higgs Model with quarks top and T, four gauge bosons and four scalars.

W_H and Z_H are interesting because they have a high cross section.

General description

- Signal Channel (Littlest Higgs): $Z_H \rightarrow t\,\bar{t}$ $m_{Z_H} = 1\,\mathrm{TeV}$
- Irreducible Background : $g\,g \rightarrow t\,\bar{t}$

Es la continuación en Full Simulation del trabajo de Luis March en este canal.

Objetivo: utilizar diferentes métodos para separar la señal del background.

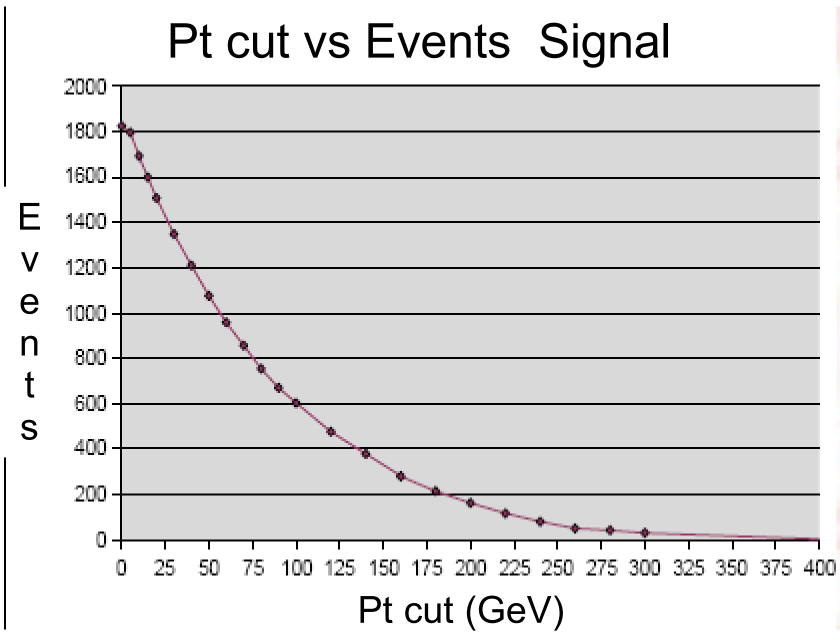
- Estudio 1º: Corte en pT de muones
- Estudio 2º: Diferentes variables para discriminar la señal (Truth)
- Estudio 3º: Reconstrucción del bosón pesado ZH

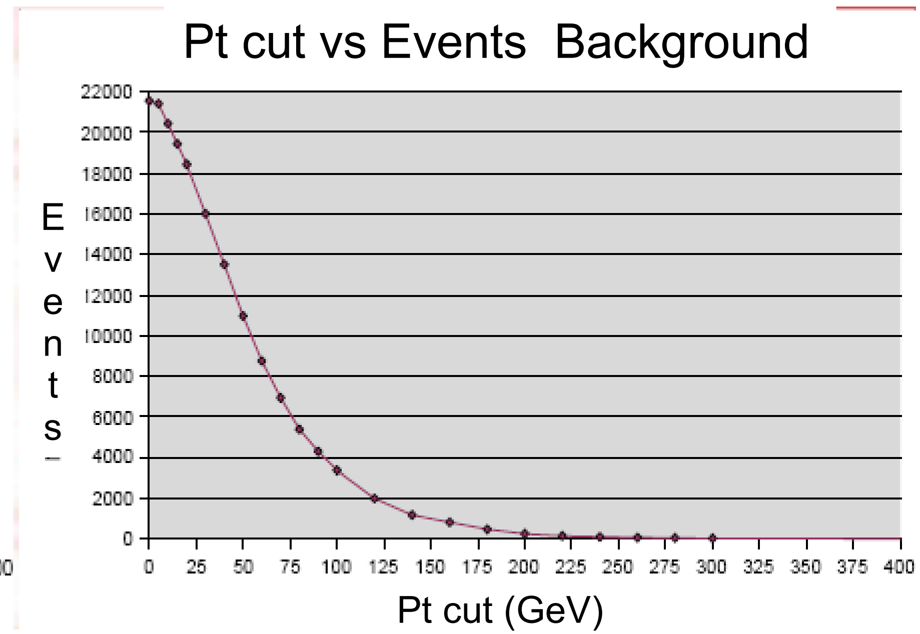
1º Estudio

Corte en pT de muones:

Buscar un corte óptimo del pT de los muones tal que aumente la eficiencia de la señal.

$p_t(\mu)$ cut vs Events

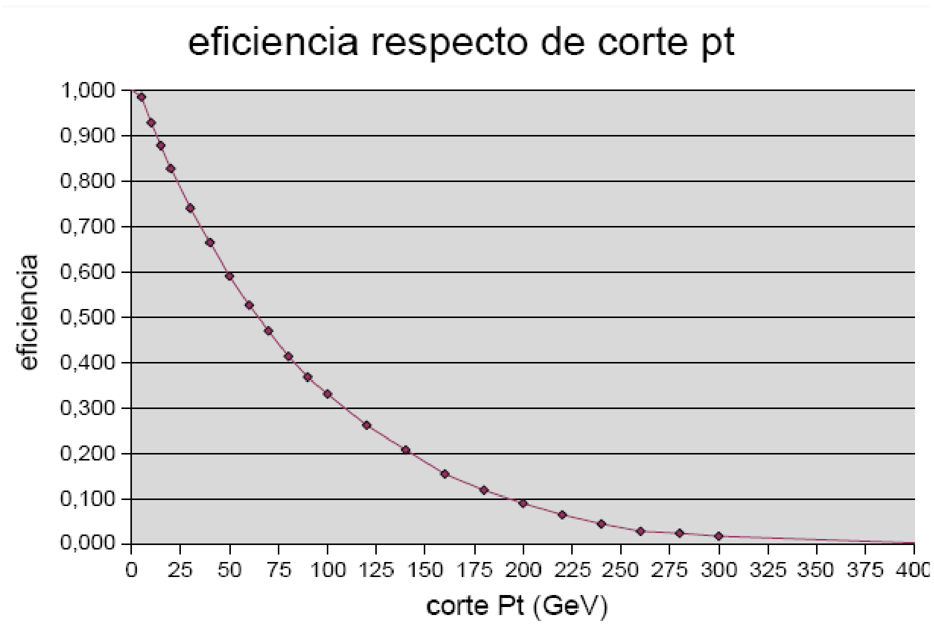


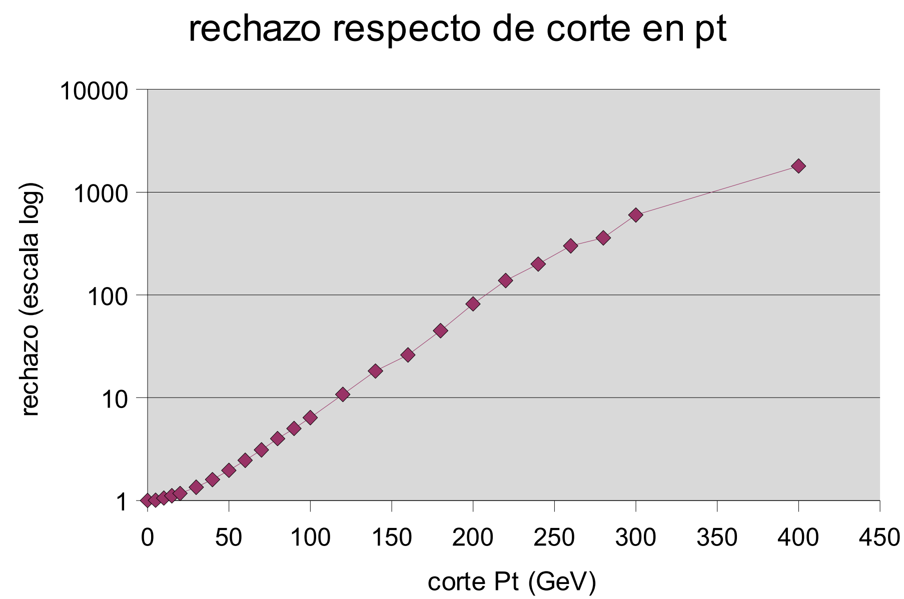


Athena Release: 10.0.1
Container: MuonCollection
Pt(μ) cuts: 0-400 GeVs

Signal Dataset: Generated by Luis March
Background Dataset: rome.004100.recov10.T1_McAtNLO_top.AOD.pool.root

Efficiency & Rejection

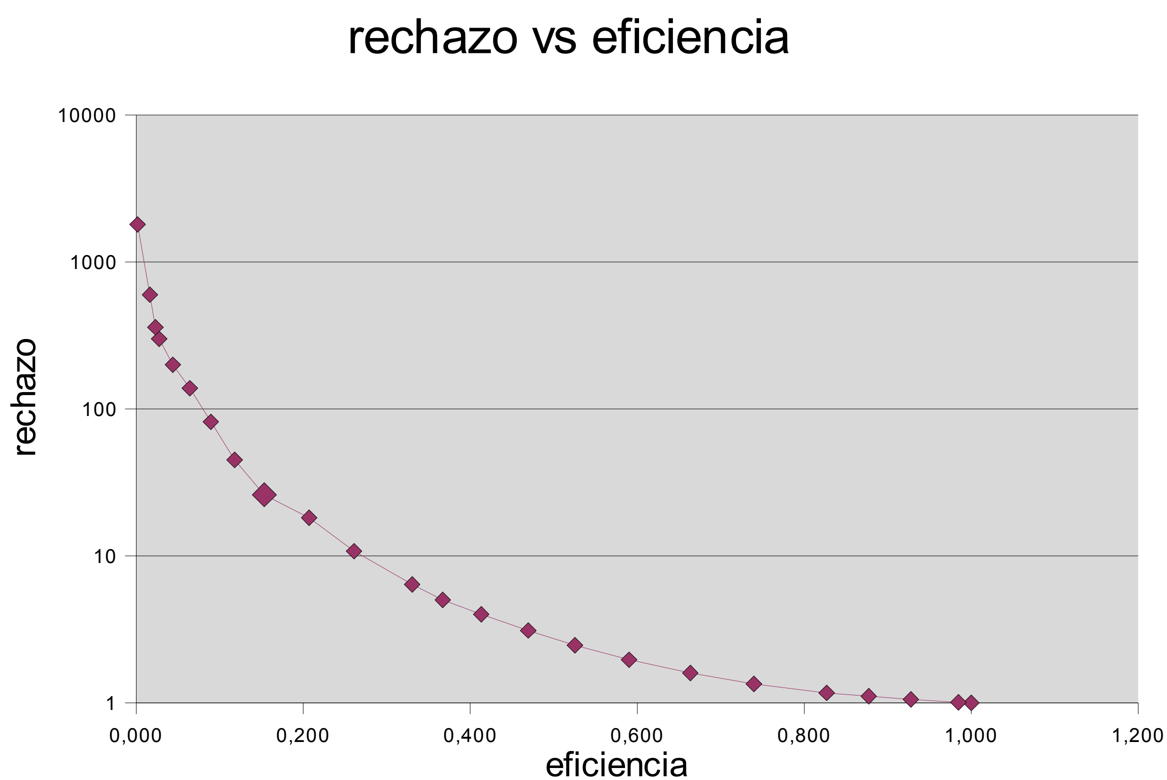




$$\epsilon = \frac{n^o\ Signal\ \mu\ identified}{n^o\ Signal\ \mu\ identified + n^o\ Background\ \mu\ identified}$$

$$R = \frac{n^o\ Background\ \mu\ not\ identified + n^o\ Background\ \mu\ identified}{n^o\ Background\ \mu\ identified}$$

Rejection vs Efficiency



Not special improvement is obtained with pt cut

2º Estudio

Diferentes variables para discriminar la señal del fondo (en Truth).

Discriminate Signal between Background

- Angle between top and topbar. $$\cos\theta = \frac{\vec{p}(t)\cdot\vec{p}(\bar{t})}{|\vec{p}(t)||\vec{p}(\bar{t})|}$$
- Subtractions of momentums $|\vec{p}(t)| - |\vec{p}(\bar{t})|$ $\quad p_t(t) - p_t(\bar{t})$
- Relations with leptons (e and μ) $$\cos\theta_{lep} = \frac{\vec{p}(t)\cdot\vec{p}(l)}{|\vec{p}(t)||\vec{p}(l)|}$$

$$|\vec{p}(t)| \; vs \; p_t(l)$$

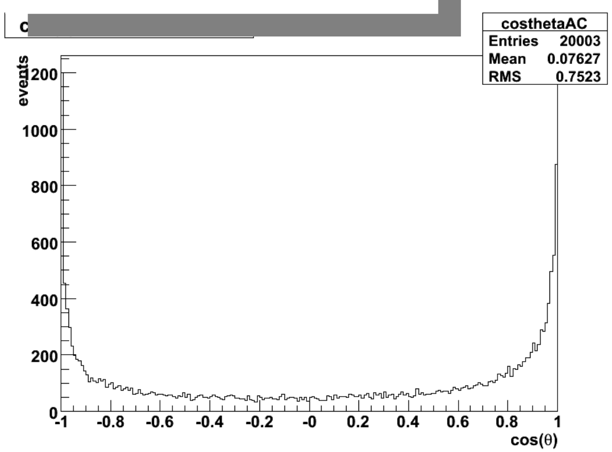
Description

- Different sources (Angle top topbar):
  - Dataset : trig1_misal1_mc12.005200.T1_McAtNlo_Jimmy.recon.AOD.v12000601_tid005997
  - Generated without cuts.
  - Generated with cuts: $\sqrt{s} > 500\,GeV \quad p_t > 100\,GeV$

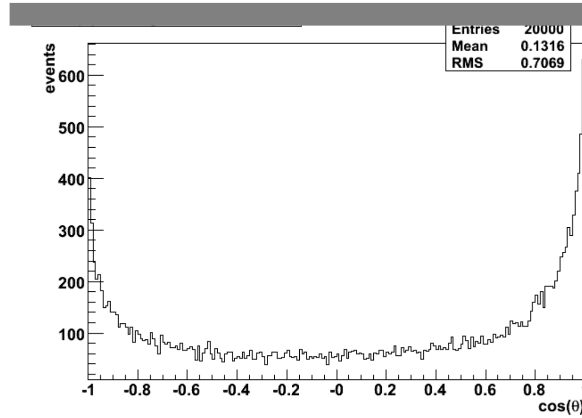
    (Background for the rest of points).
- Analysis with athena 12.0.6 Package: UserAnalysis-00-09-10
- AODs generated with Pythia 6.4.
- Only container: TruthParticleContainer.

Angle between top and topbar

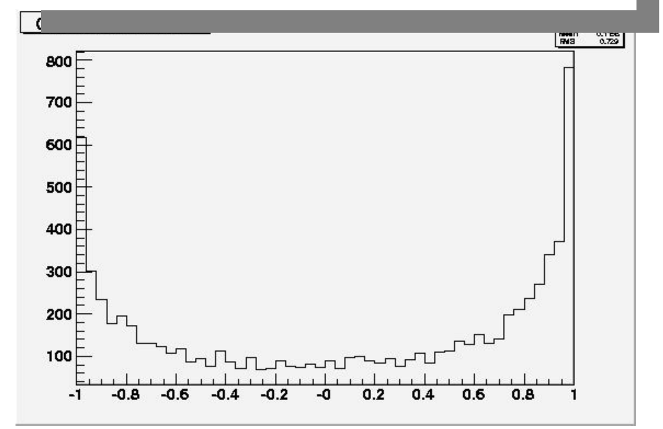
Cosθ Dataset 5200



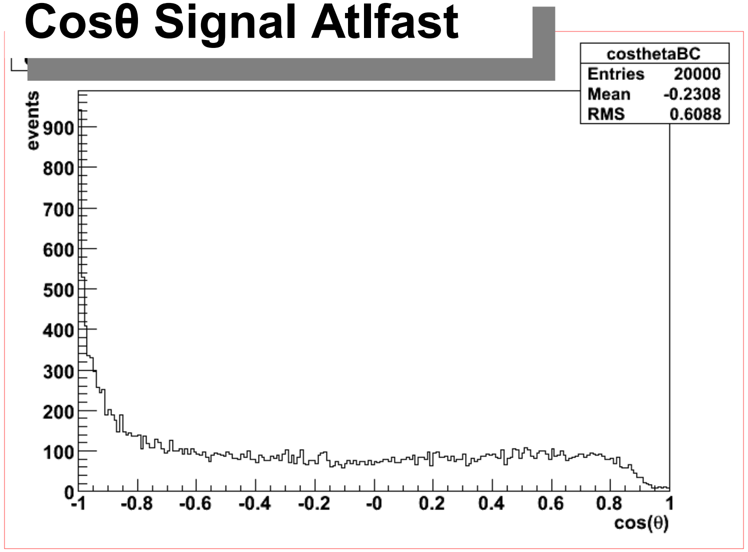
Cosθ Background No Cuts



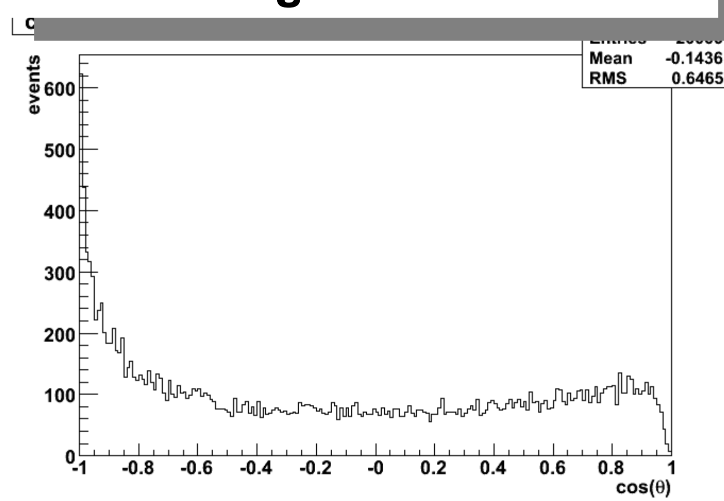
Susana Cabrera Dataset 5200



Cosθ Signal Atlfast



Cosθ Background With Cuts

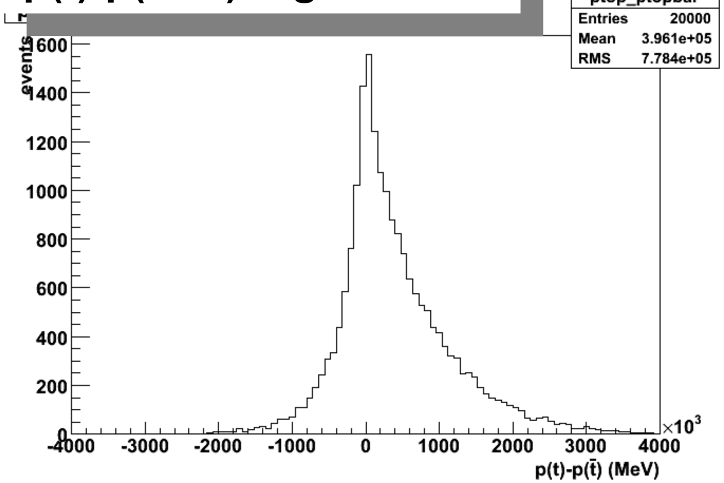


We note a peak next to cosθ=1 with Dataset 5200 and Generated Background without cuts.

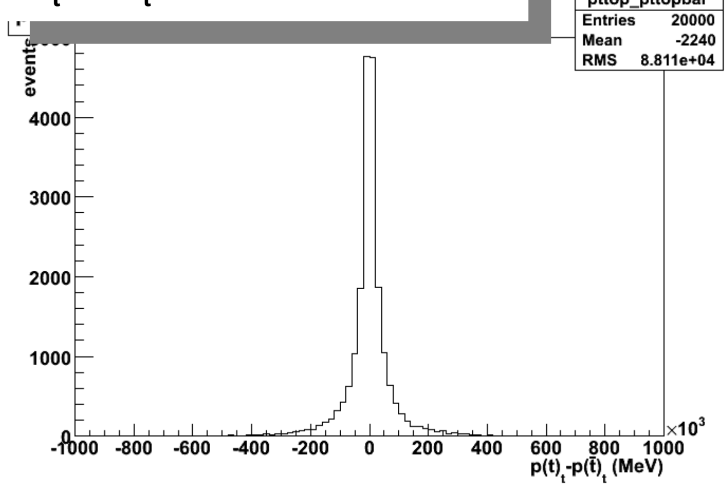
However, this peak disappeared with the correct Background. We could not discriminate Signal between Background.

Subtractions of momentums

p(t)-p(tbar) Signal

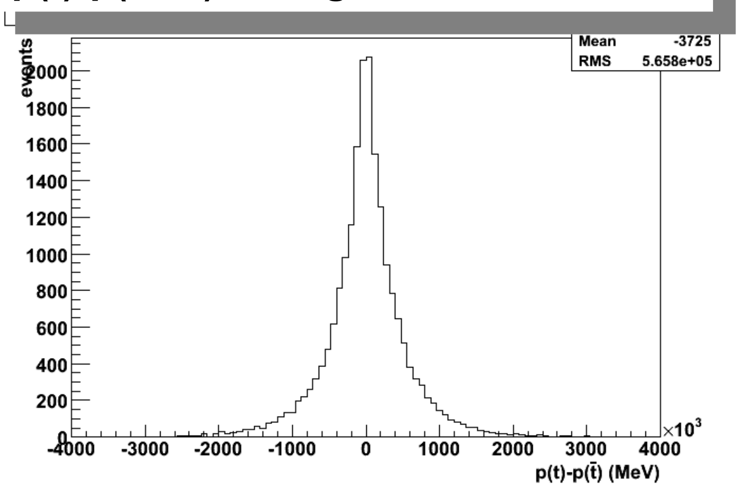


p_t(t)-p_t(tbar) Signal

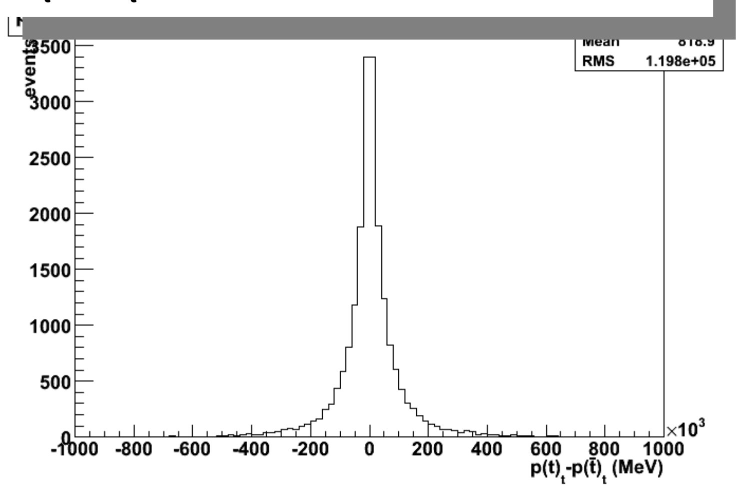


The component p_z of top (or antitop) could be not reliable in this simulation, therefore we may use p_t.

p(t)-p(tbar) Background with cuts

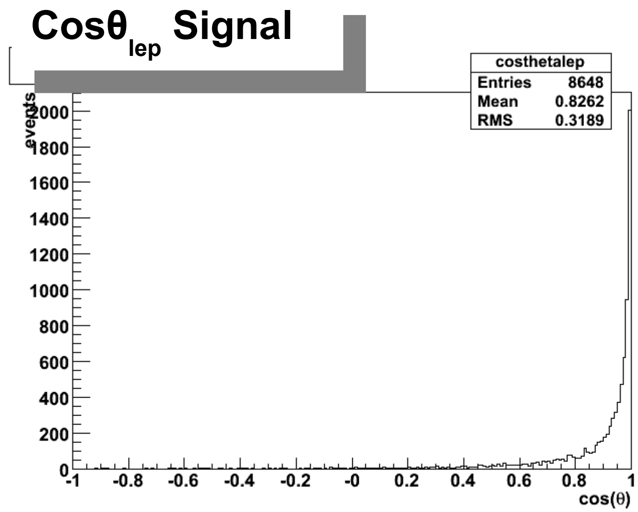


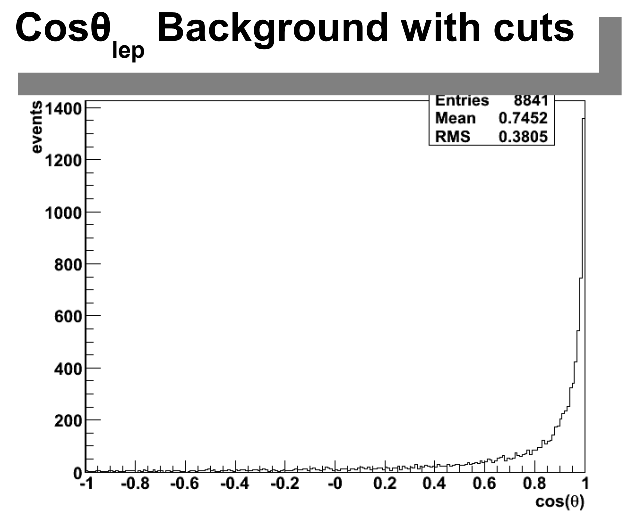
p_t(t)-p_t(tbar) Background with cuts

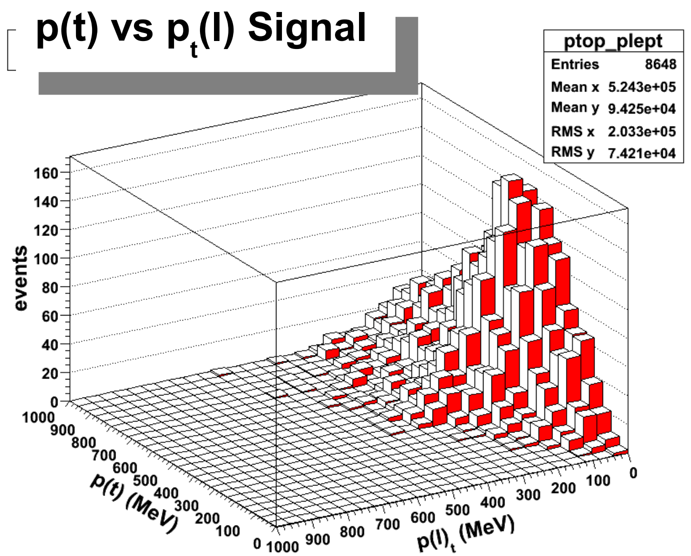


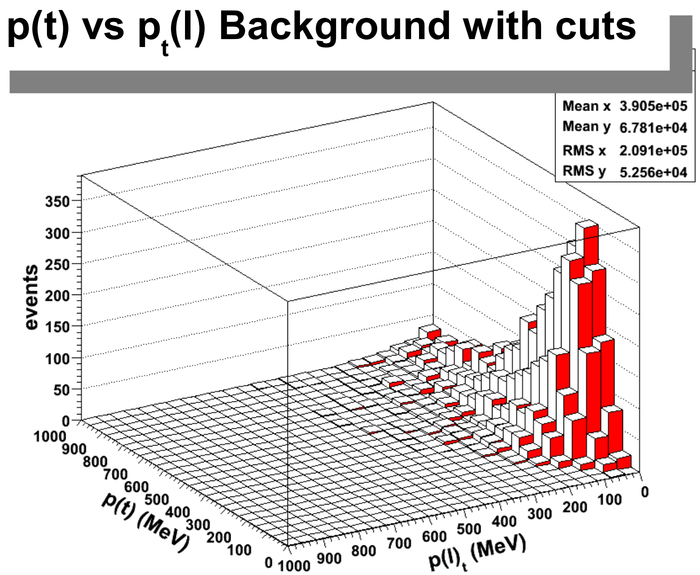
Although differences are seen in sigma of Signal and Background. We need to normalize to same luminosity.

Relations with leptons









We observe a poor discrimination between Signal and Background.

3º Estudio

Reconstrucción del bosón pesado ZH

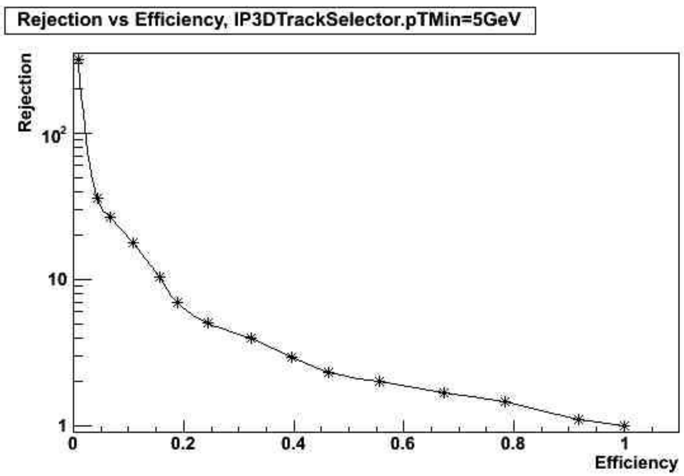
Mejorar la eficiencia con btagging de alto pT y observar cómo afecta a la reconstrucción.

B tagging de alto pT

- A raíz de un estudio de B tagging de Miguel Villaplana, aplicamos el mismo concepto a este caso.
- Inconveniente: mismo número de bjets (2) tanto en señal como en fondo.

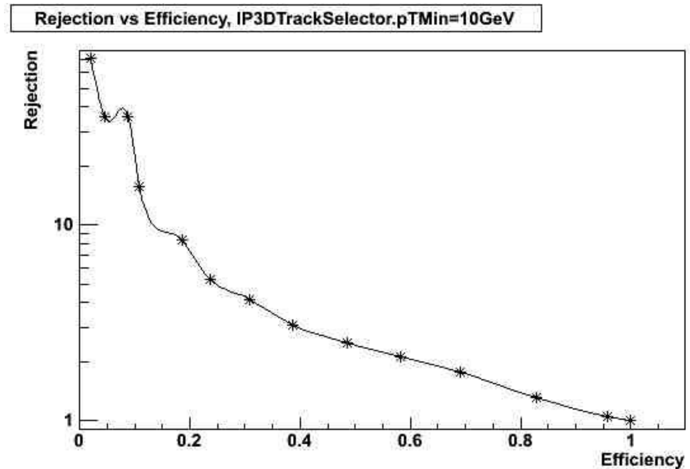
Reconstrucción: B tagging

5 GeV (sin modificar)



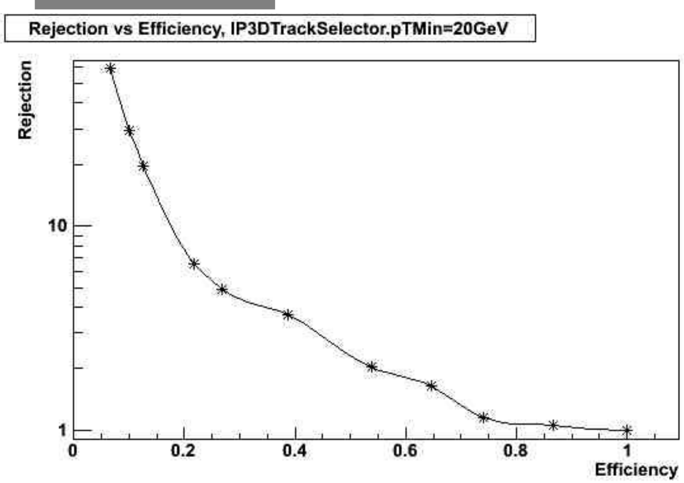
Para x= 0.187668 y= 7

10 GeV



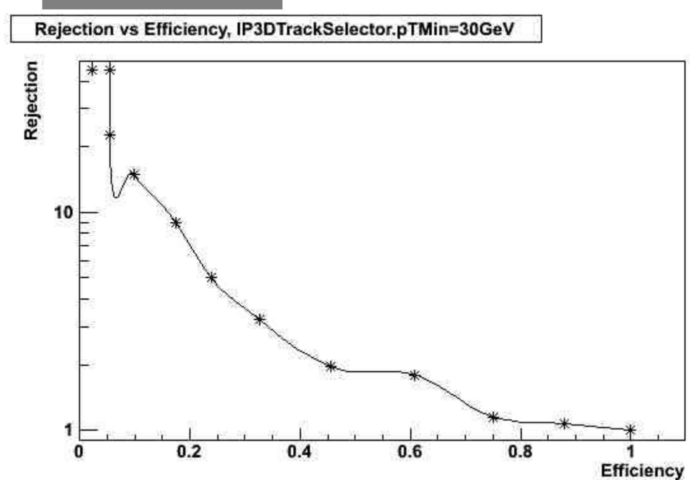
Para x= 0.185567 y= 8.35294

20 GeV



Para x= 0.218487 y= 6.55556

30 GeV



Para x= 0.173913 y= 9

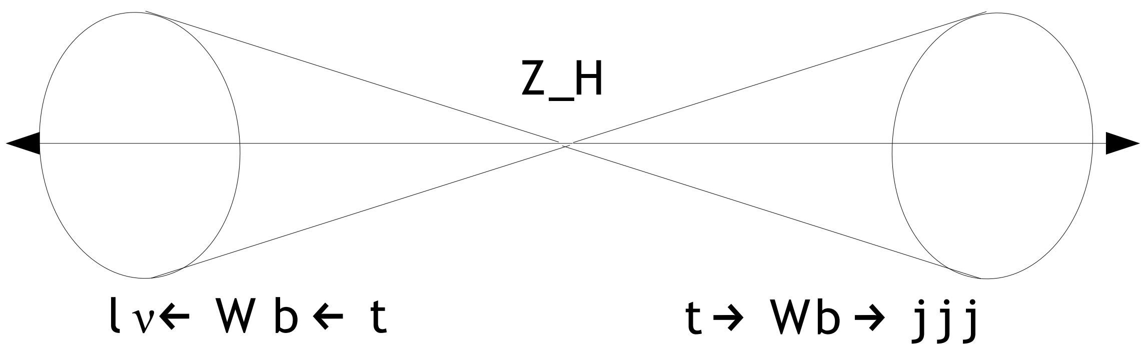
Aumentar Rechazo a una eficiencia fija de aproximadamente 0.20 de la suma de los 'weights' de los 2 bjets utilizados en la reconstrucción de los tops.

Cambiar valor de parámetros del btagging: Variando IP3DTrackSelector. pTMin

Para corte en 40 GeV se pierde estadística.

Reconstrucción ZH

Señal semileptónica



$$dr = \sqrt{(\Delta \eta)^2 + (\Delta \phi)^2}$$

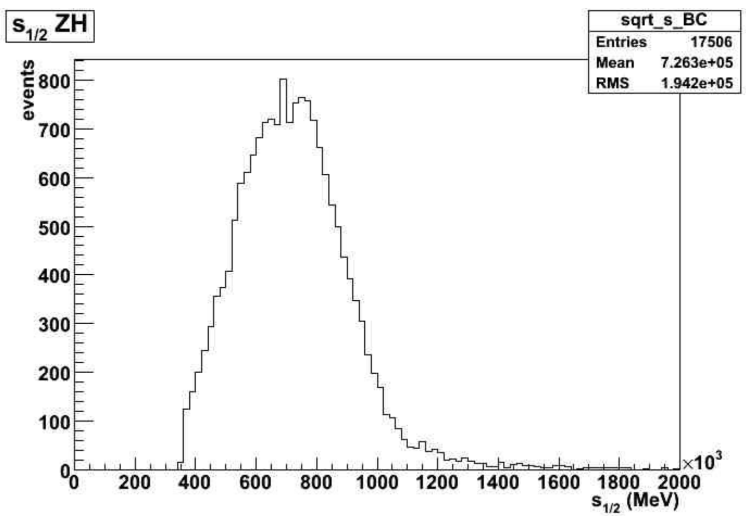
bjet respecto leptón

$$\textit{bjet1}\ 0.05 < dr < 2$$
$$\textit{bjet2}\ dr > 2$$

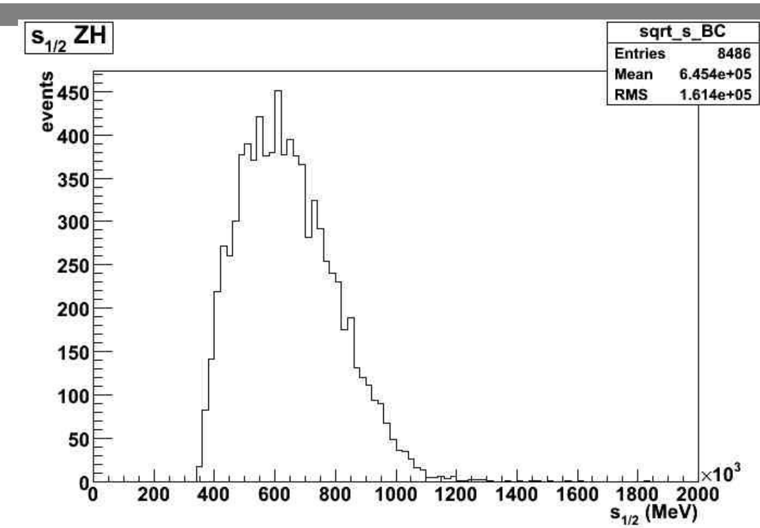
Resonancia del ZH de la señal y el background para 4 casos:
Caso 1:sin utilizar el btagging,
Caso 2: btagging de Luis March utilizó con la release 10.0.1,
Casos 3 y 4: cortes en 'weight' en 0 y en 3, donde IP3DTrackSelector.pTMin= 30 GeV

Reconstrucción ZH (Signal)

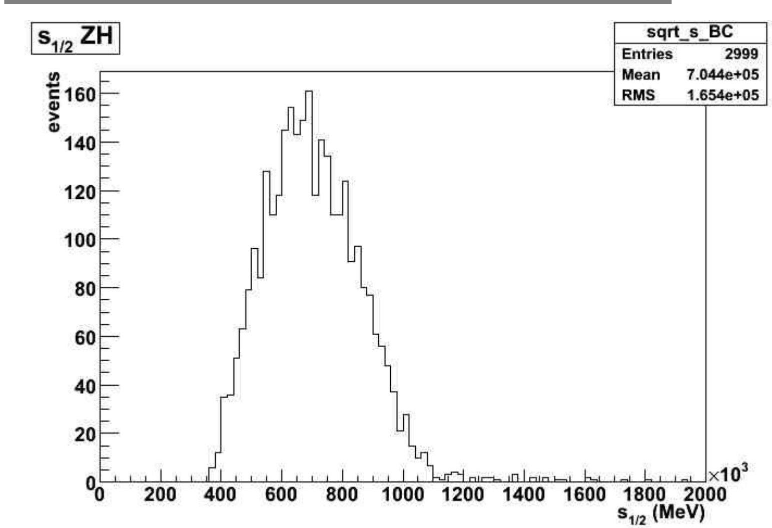
Caso 1: Sin btagging



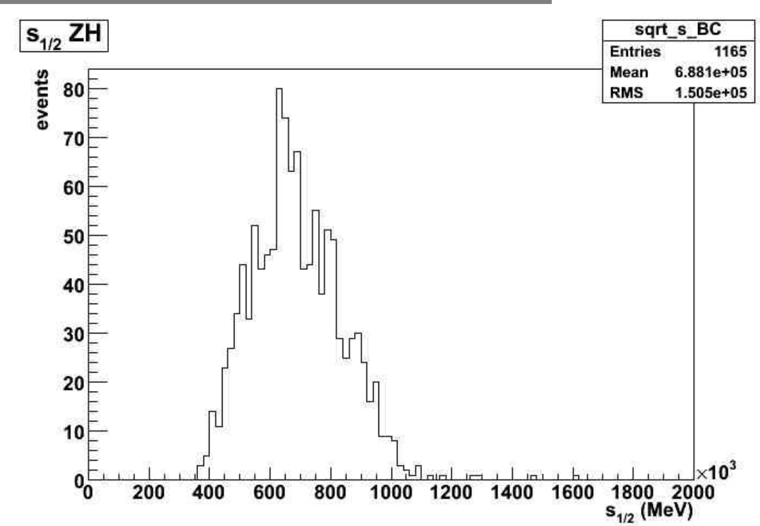
Caso 2: Btagging utilizado por Luis es: que los bjets cumplan 'pdgId=5 y lhSig>=0'



Caso 3: Btagging utilizado: 'bjet1_weigh+bjet2_weightt>0'

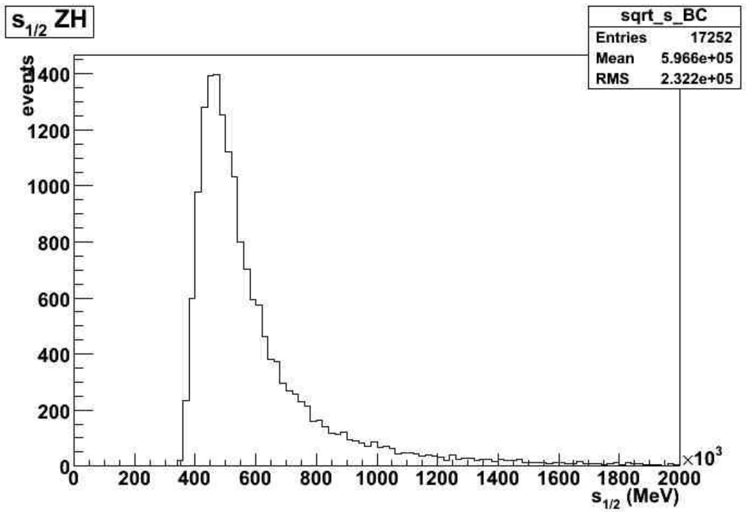


Caso 4: Btagging utilizado: bjet1_weight+bjet2_weight>3'

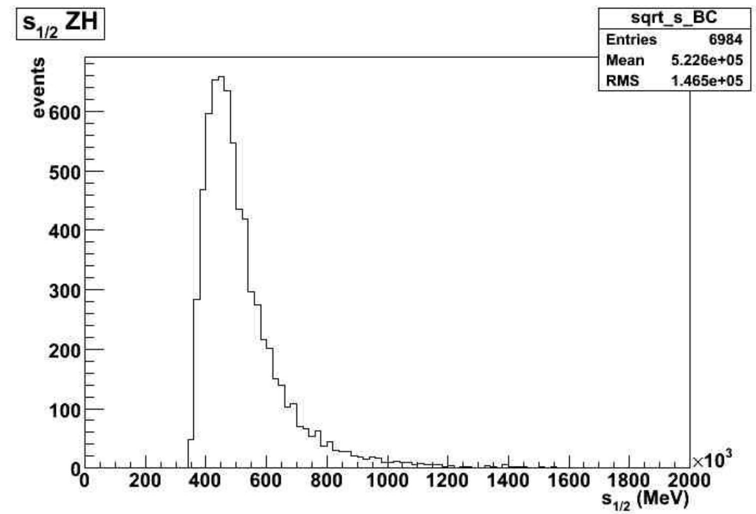


Reconstruccion ZH (Background)

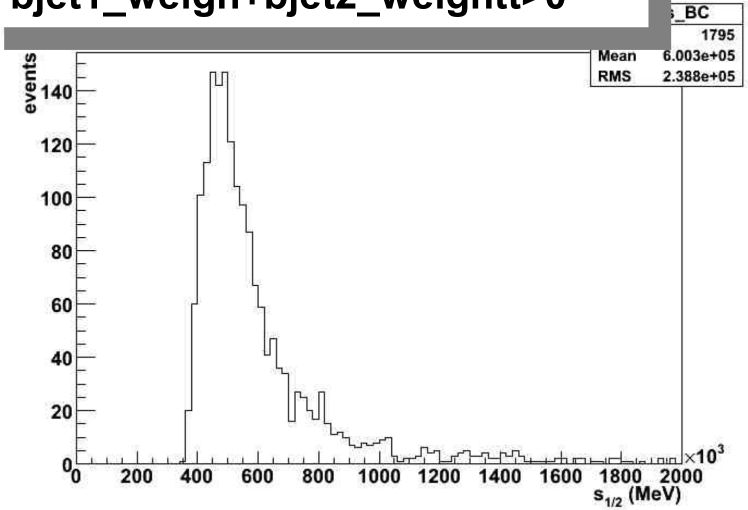
Caso 1: Sin btagging



Caso 2: Btagging utilizado por Luis es: que los bjets cumplan 'pdgId=5 y lhSig>=0'



Caso 3: Btagging utilizado: 'bjet1_weigh+bjet2_weightt>0'



Caso 4: Btagging utilizado: bjet1_weight+bjet2_weight>3'

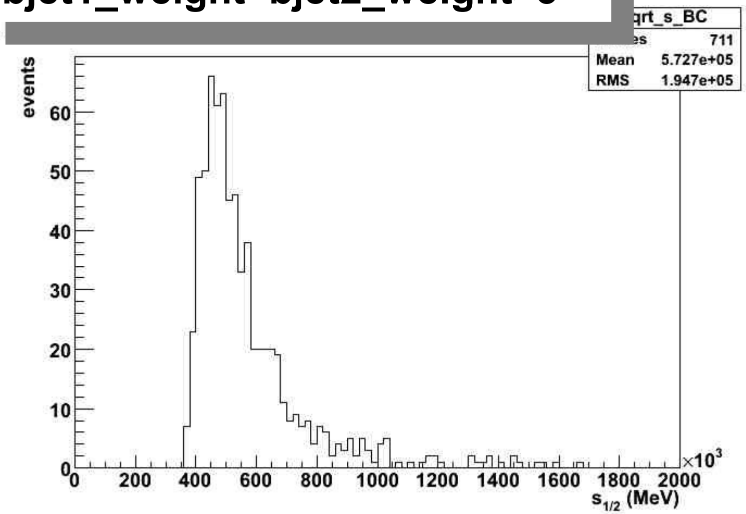


Tabla reconstrucción

Case	Events Signal	Events Background	Peak Signal (GeV)	Sigma Signal (GeV)
1	17506	17252	713	168
2	8486	6984	641	160
3	2999	1795	695	154
4	1165	711	681	148

El máximo no se corresponde con la masa del Z_H (1 TeV)

La resonancia es cada vez más estrecha pero perdemos estadística

Conclusiones y pasos siguientes

- Rechazo sigue bajo:
  - Cambiar otros parametros de IP3D.
  - Mejorar reconstruccion ZH → corte en σ
- Resonancia ZH no es de 1 TeV:
  - Falta parametrizar.
- Pasar a athena 14:
  - Buscar datasets de Signal y Background.
  - Si no existieran → simularlos.
- Hechos los pasos anteriores:
  - Significancia y Comparar con TruthParticle.