INSTITUTO DE FÍSICA CORPUSCULAR

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Twin Higgs from Left-Right Symmetry

Study of channel $W_H(1\,TeV/c^2) \rightarrow Tb$

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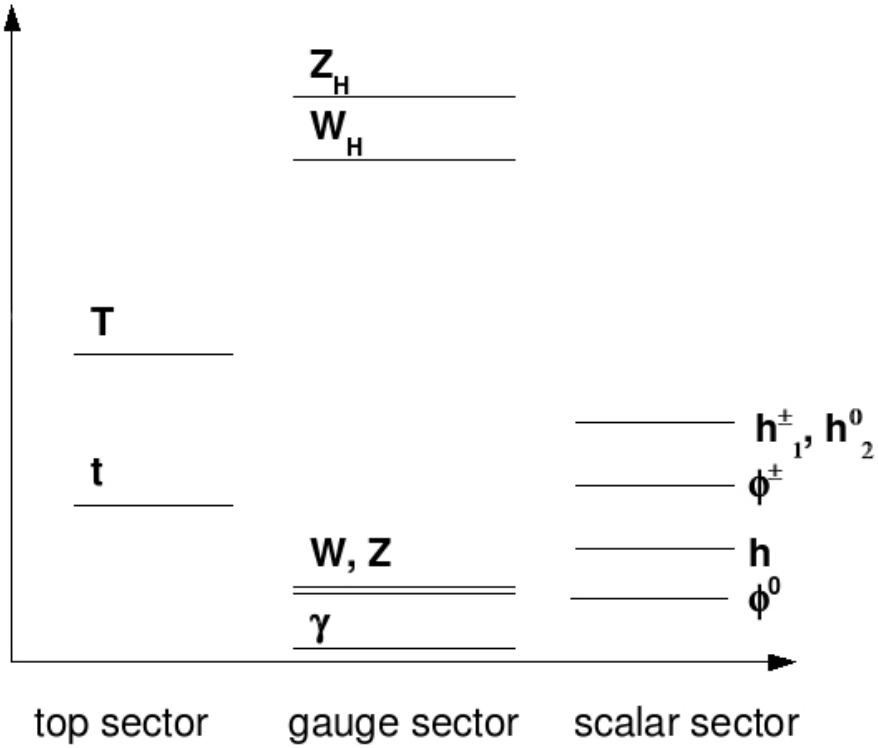
Twin Higgs from Left-Right Symmetry

- The *Left-Right Twin Symmetry* when broken adds new terms to the Lagrangian.
- This eliminates cuadratic divergences (at NLO) from Higgs boson's mass.

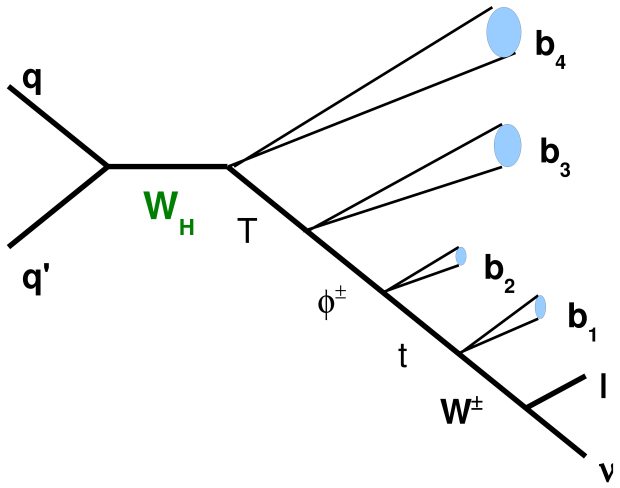


Mass is the only free parameter of the Twin Higgs model. Amongst its predictions, there are $SU(2)_R$ gauge bosons, vector-like quarks and a natural candidate to dark matter (h^0_2)

Z. Chacko, H.S. Goh, R. Harnik, A Twin Higgs model from left-right symmetry, JHEP 0601 (2006) 108, hep-ph/0512088

H.S. Goh, S. Su, Phenomenology of The Left-Right Twin Higgs Model, Phys. Rev. D 75 (2007) 075010

Study of channel $W_H(1\,TeV/c^2) \rightarrow Tb$



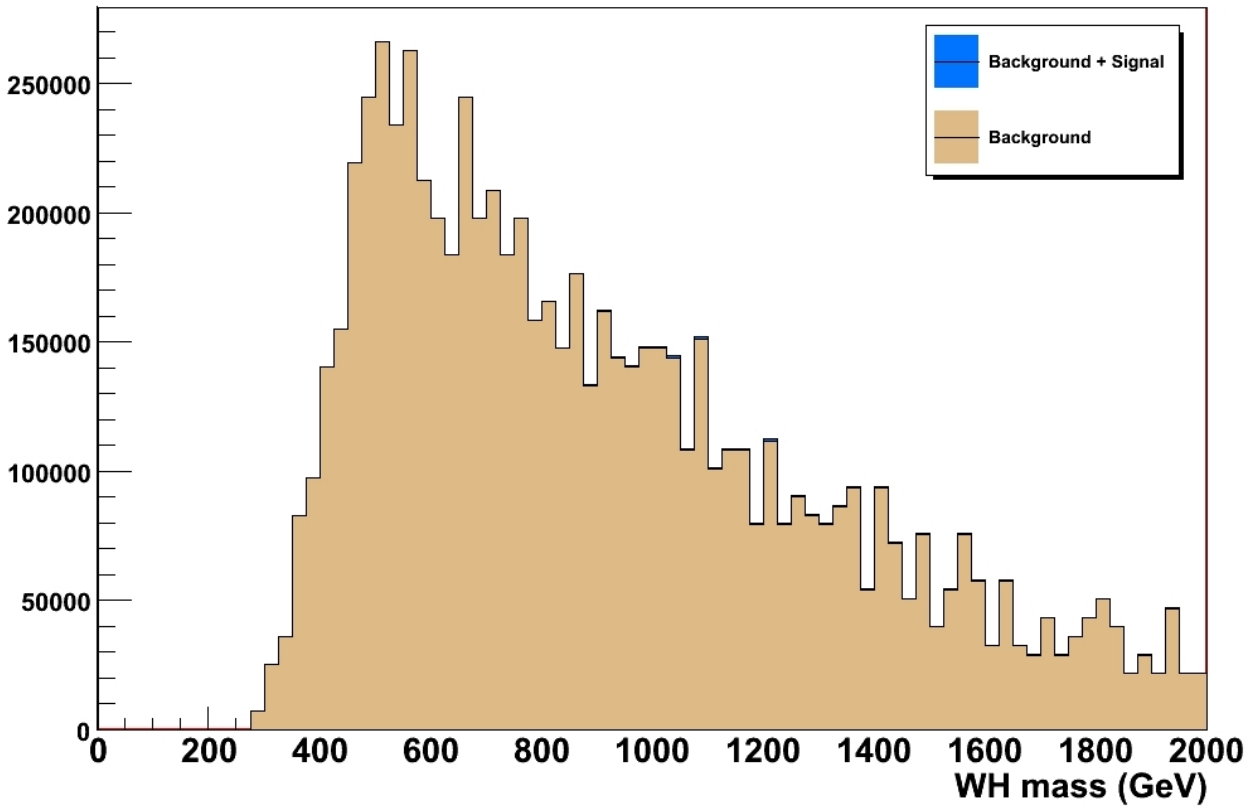
Particle	Mass (GeV)	Decay	BR
W_H	1000	$T_H b$	20%
T_H	500	$\phi^{\pm} b$	80%
$\phi^{\pm}$	200	tb	100%
t	175	$W^{\pm} b$	100%
$W^{\pm}$	80	$l\nu$	21%

- $4b + l + E_T^{Miss}$ does not appear in *Little Higgs*
- Wide energy range b-jets (good test subject for b-tagging)
- Full and Fast simulation comparison
- W_H reconstruction method:
  - $W_H = 4$ biggest jets $+w$
  - Mass template

"New Physics at the LHC: A Les Houches Report. Physics at Tev Colliders 2007" – New Physics Working Group. Gustaaf H. Brooijmans et al. Feb 2008 arXiv:0802.3715 [hep-ph]

$W_H = 4$ biggest jets $+w$

- A sample of 20000 events of $W_H(1\,TeV/c^2) \rightarrow Tb$ was made with Athena v.12.0.6.1
  - Generation with Pythia v.6.4
  - Simulation with GEANT4
- Also 20000 events of background $t\bar{t}$ No Hadronic (Semileptonic + Dileptonic)
  - $p_T > 100 GeV$



Mass Template

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  - Generation with Pythia v.6.4
  - Simulation with GEANT4
  - Reconstruction made including IPatRec info.
- Also 20000 events of background $t\bar{t}$ No Hadronic (Semileptonic + Dileptonic)
  - $p_T > 100 GeV$
  - $\sqrt{s} > 500 GeV$
  - Reconstruction made including IPatRec info.

Particle	Mass (GeV)	Decay	BR
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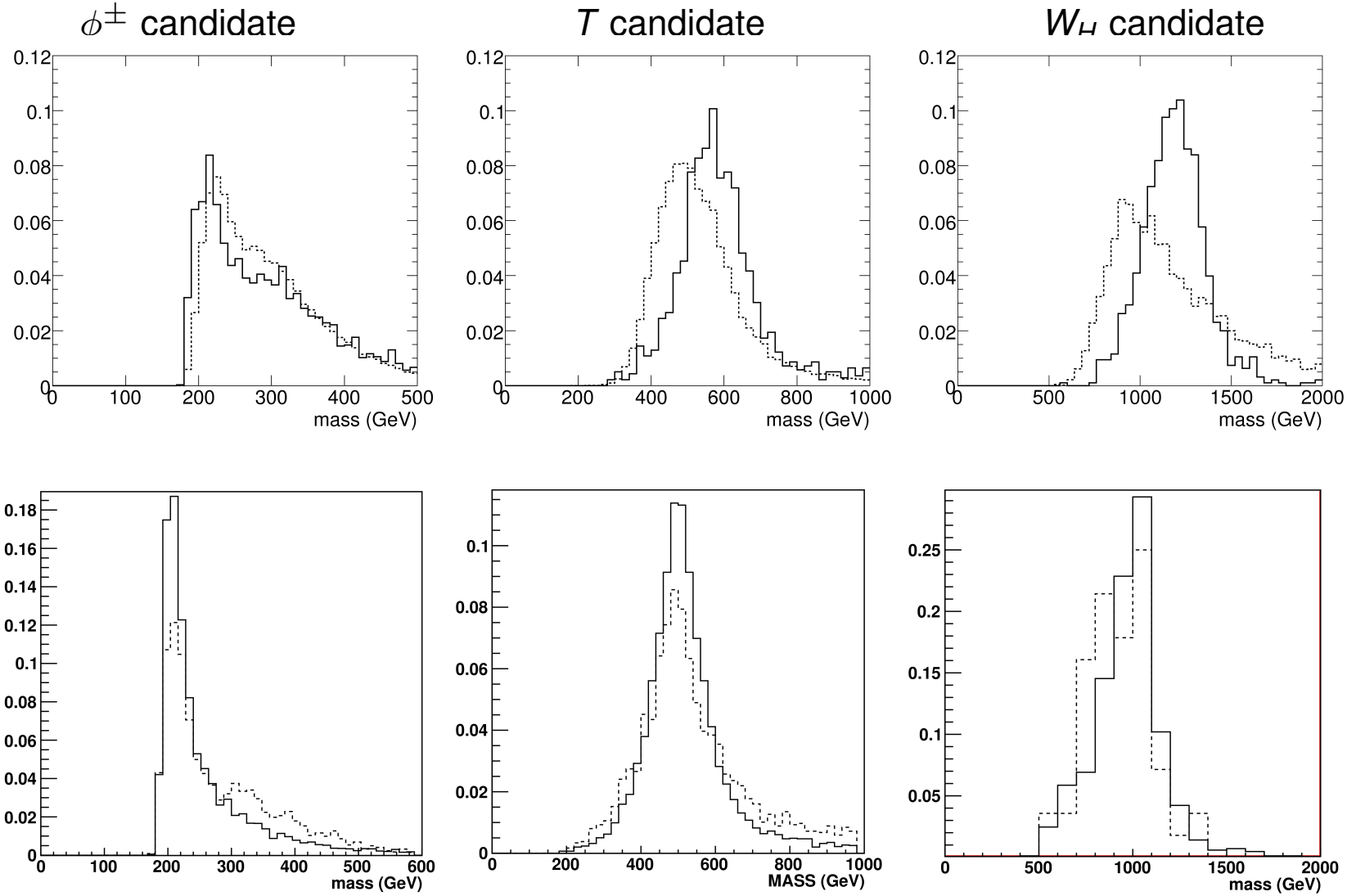
W_H invariant mass reconstruction.

FAST SIM

FULL SIM



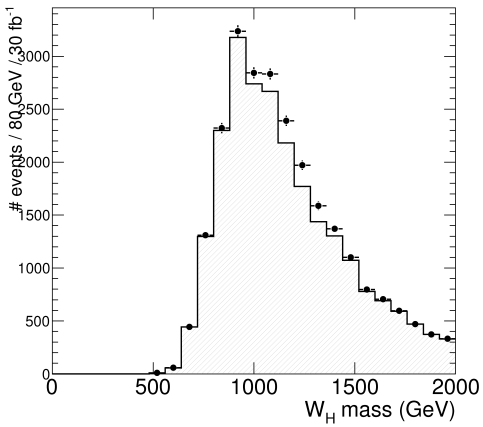
Mass distributions for different steps of the reconstruction of the decay chain for signal events (full line) and the dominant $t\bar{t}$ background (dashed histogram) both for Atlfast (up) and Full simulation (down)

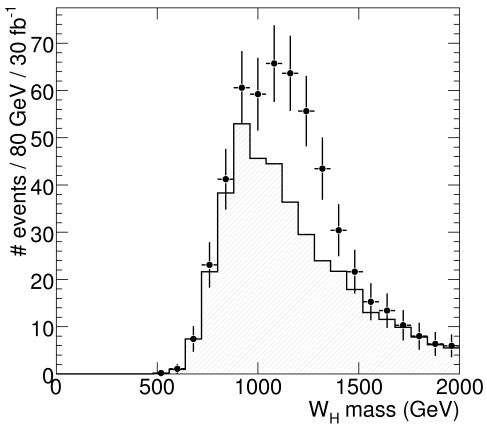
B-tagging effect on W_H invariant mass reconstruction.

Before b-tagging

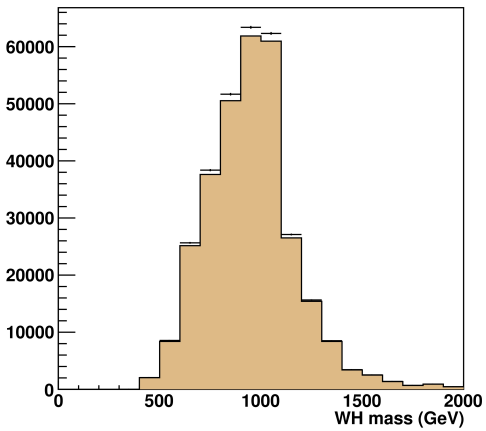
After b-tagging

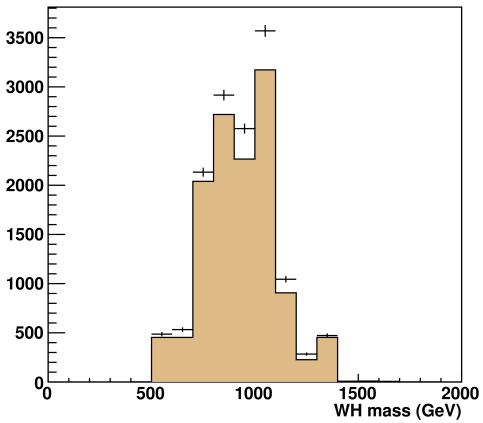
FAST SIM





FULL SIM





	Atlfast		Full	
selection	no b-tag	b-tag	no b-tag	b-tag
signal	1058	138	4414	917
$t\bar{t}$	23500	392	193537	7251
$S/\sqrt{B}$	6.9	7.0	10.0	10.8
S/B	0.05	0.4	0.02	0.13

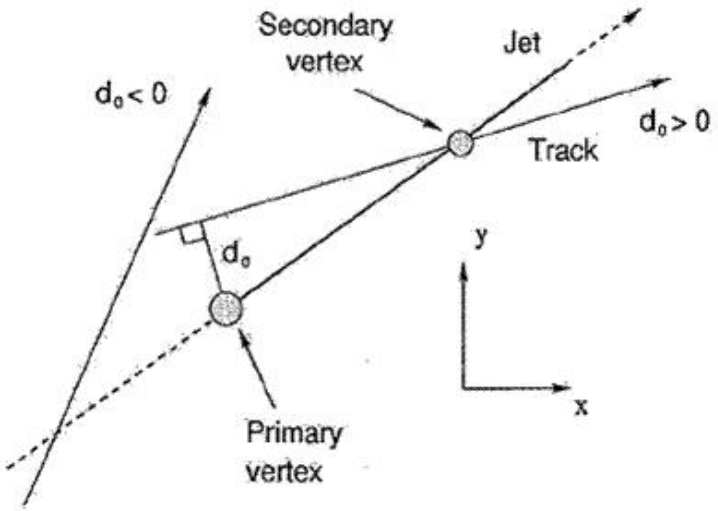
Even though both kinematic reconstruction and btagging work worse in FULL than in FAST we still get statistic significance for $W_H(1\,TeV)$

Reconstructed mass distribution of W_H candidates (data points). The contribution of the $t\bar{t}$ and W + *jets* backgrounds is indicated by the colored region. Results shown both for Atlfast (up) and Full simulation (down)

B-tagging

IP3D and SV1

Both based on b's lifetime $c\tau = 450\mu m$

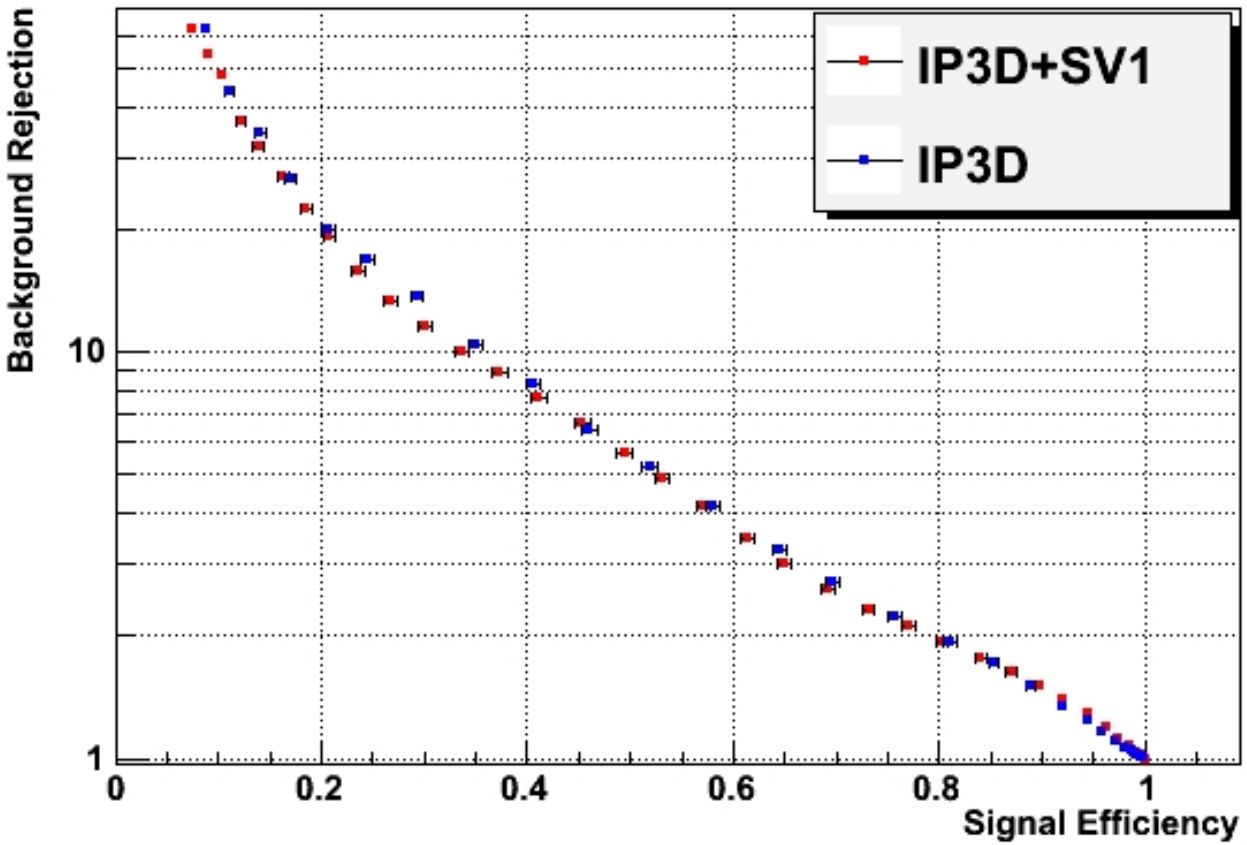


- Impact Parameter in 3D
  - Look at the impact parameter of tracks associated to the jet.
  - IP defined as the closest distance between the primary vertex and the track helix in the transverse plane (d_0) or in the longitudinal direction (z_0)

- Secondary Vertex Reconstruction
  - Reconstruct the secondary vertex associated to the jet.
    - ★ Search all track pairs with $\chi^2 < 3.5$ with impact parameter significance > 2.
    - ★ Fit track pairs into a common geometrical vertex.
    - ★ Remove tracks with χ^2 is unacceptably large.
  - The probability to find a secondary vertex in a b-jet is high, and the same probability for u-jet is low.

B-tagging

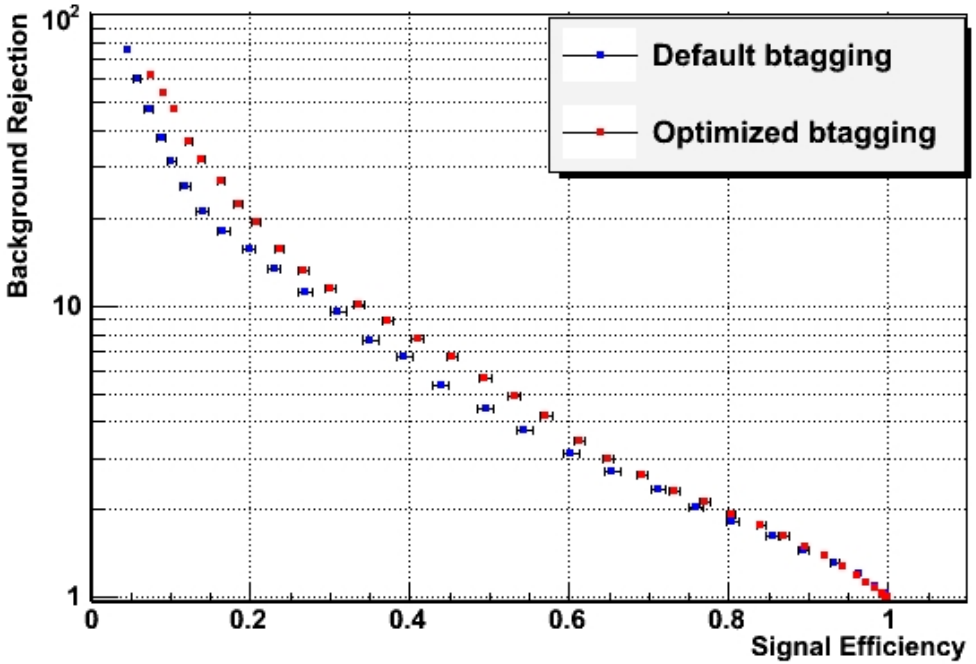
- Combination of IP3D and SV1 used.
- Paremeters of both algorithms have been optimized for a wider energy range jets.
- Although SV1 was found to have negligible efect.



This plot shows signal efficiency (4 b-jets) versus background rejection (2 b-jets) both for IP3D and IP3D+SV1.

B-tagging

- Sarted with b-tagging algorithms optimized for high p_T jets shown in the following plot as "defalut"
- $W_H \longrightarrow Tb$ has a wider energy range b-jets so we had to change algorithms' parameters in order to improve background rejection.

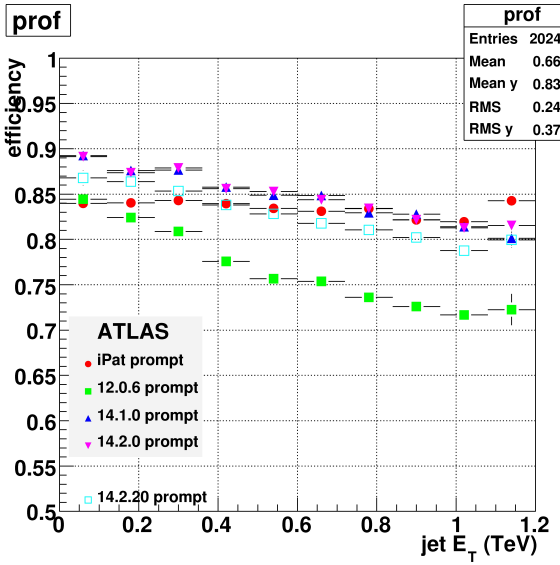


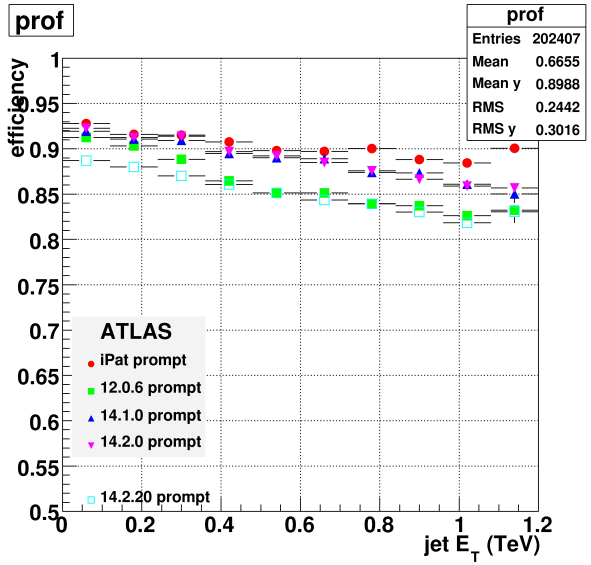
- Sum weights of the four jets used on W_H reconstruction.
- Use events with sum $>$ 34 (20% signal efficiency and 95% background rejection)

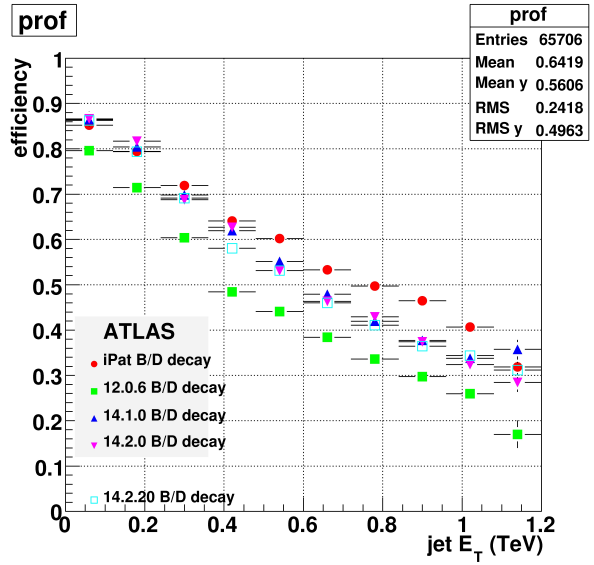
More on high p_T b-tagging:
CSC book: the ATLAS collaboration, Expected Performance of the ATLAS Experiment - Detector, Trigger and Physics, arXiv:0901.0512

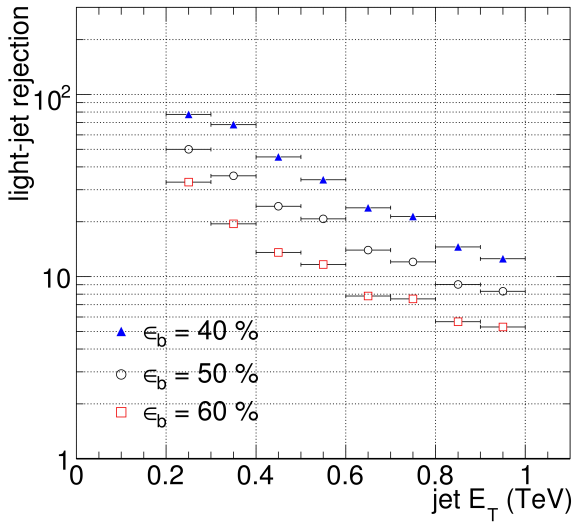
B-tagging

Track reconstruction for pions in high p_T jets









top/left B Quality selection

top/middle Raw

top/right B decay

bottom b-u rejection

Key points and future steps.

To Do

- 12.0.6 is out of date. Move to 14.2.25
- Use MC@NLO instead of Pythia and study heavier W_H (2 TeV)
- Improve high p_T btagging using tracking on new versions of Athena.

Key Points

- Undestand better the excess of background we find compared with FAST study.
- How to improve our signal-background separation?