# Summary of Activities and Plans ATLAS

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# Physics Analysis at ATLAS

Two areas of interest:

Exotics Group: LQ search (uses expertise from CDF)

- **TeV4LHC Workshop**

**Phys.Rev.D71:057503,2005**

**• Bringing together the Tevatron and LHC experimental groups and the theoretical community to make the best possible use of data and experience from the Tevatron in preparing for the LHC experimental program:**

- **Understanding how to use Tevatron data to improve event modelling**
- **Theoretical understanding of cross sections for the signals and backgrounds at LHC,**
- **Using experience with real problems at the Tevatron**

Top Group: Single Top (born of b-tagging studies in single top sample)

Work started in the framework
of the Rome Physics Workshop (June 2005)
and extended to specific studies aimed at testing analyses strategies
and tools availability over the past years

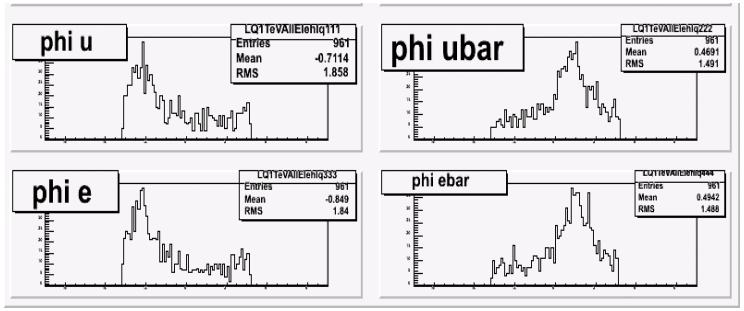
# Leptoquarks in ATLAS

LQ sensitivity will extend at LHC to masses up to 1.5 TeV/$c^2$
Pair production is still the dominant process contributing to the cross section.

In the framework of the Rome workshop, we studied the signal

- -Detection efficiency for 2 set of masses, 0.5 TeV and 1 TeV
- -The samples were suffering from a generation problem, but very preliminary results could be derived.
- -The signal efficiency found is in agreement with previous measurement performed in the framework of the fast ATLAS simulation

Generator Level $\phi$ distribution



# Expected Sensitivity for 100pb$^{-1}$ and 1fb$^{-1}$

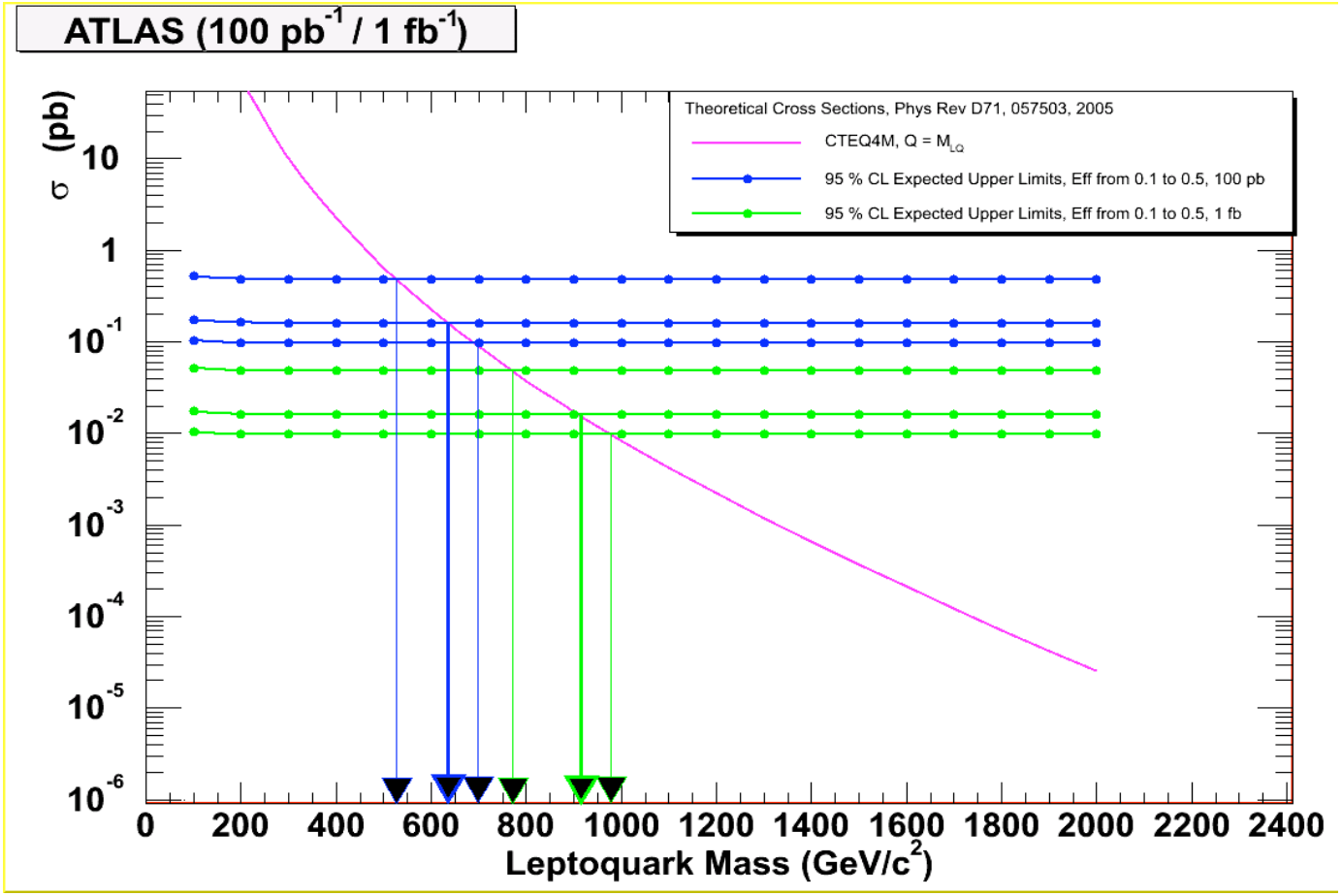
1) the cross section is the NLO recent calculation from M. Spira et al. (Phys.Rev.D71, 057503, 2005) for LQ pair production

2) the signal efficiency is assumed to vary from 0.10 to 0.50 for all masses (going from 100, already excluded, to 2000 GeV/c$^2$)
This would the final efficiency, which will include lepton ID, trigger, kinematical/topological cuts.
a) Remember that, from TeVatron/HERA results, the region of interest with a few pb will be m(LQ) > 300 GeV/c$^2$
b) the number for the signal efficiency from the old study from Mitsou et al. is about 0.60, so I used that as an upper limit.

3) in the calculation of the expected $\sigma_{limit}$ (95% CL) I had to make
some assumptions on the number of observed and expected events. I used a S/B ratio going from 10 to 100 ( again roughly using the numbers quoted in Vienna 2004) and the limit varies of a factor of 2, which effect when crossing the steeply falling theory cross section is negligible.

The "limit" is calculated in the assumption of seeing 0 signal, ie
number of events observed = number of expected background events (and background subtraction if the number of observed evts is not 0). So this is really the best scenario. Of course any (limited) excess will lower the mass limit, but of course at some point it will show the new physics...

# Projected sensitivity




Conclusion

for 100pb$^{-1}$ we could be able to set limits up to 700 GeV/c$^2$
for 1fb$^{-1}$ slightly less than 1TeV.

# Publications (cont'd)

In October 2007 I joined the PDG author list as the author of the LeptoQuark minireview

## The Review of Particle Physics

Physics Letters **B667**, 1 (2008).



**Particle Data Group**

C. Amsler,[1] M. Doser,[2] M. Antonelli,[3] D.M. Asner,[4] K.S. Babu,[5] H. Baer,[6] H.R. Band,[7] R.M. Barnett,[8] E. Bergren, J. Beringer,[8] G. Bernardi,[9] W. Bertl,[10] H. Bichsel,[11] O. Biebel,[12] P. Bloch,[2] E. Blucher,[13] S. Blusk,[14] R.N. Cahn,[8] M. Carena,[15,13,16] C. Caso,[17*] A. Ceccucci,[2] D. Chakraborty,[18] M.-C. Chen,[19] R.S. Chivukula,[20] G. Cowan,[21] O. Dahl,[8] G. D'Ambrosio,[22] T. Damour,[23] A. de Gouvêa,[24] T. DeGrand,[25] B. Dobrescu,[15] M. Drees,[26] D.A. Edwards,[27] S. Eidelman,[28] V.D. Elvira,[15] J. Erler,[29] V.V. Ezhela,[30] J.L. Feng,[19] W. Fetscher,[31] B.D. Fields,[32] B. Foster,[33] T.K. Gaisser,[34] L. Garren,[15] H.-J. Gerber,[31] G. Gerbier,[35] T. Gherghetta,[36] G.F. Giudice,[2] M. Goodman,[37] C. Grab,[31] A.V. Gritsan,[38] J.-F. Grivaz,[39] D.E. Groom,[8] M. Grünewald,[40] A. Gurtu,[41,2] T. Gutsche,[42] H.E. Haber,[43] K. Hagiwara,[44] C. Hagmann,[45] K.G. Hayes,[46] J.J. Hernández-Rey,[47†] K. Hikasa,[48] I. Hinchliffe,[8] A. Höcker,[2] J. Huston,[20] P. Igo-Kemenes,[49] J.D. Jackson,[8] K.F. Johnson,[6] T. Junk,[15] D. Karlen,[50] B. Kayser,[15] D. Kirkby,[19] S.R. Klein,[51] I.G. Knowles,[52] C. Kolda,[53] R.V. Kowalewski,[50] P. Kreitz,[54] B. Krusche,[55] Yu.V. Kuyanov,[30] Y. Kwon,[56] O. Lahav,[57] P. Langacker,[58] A. Liddle,[59] Z. Ligeti,[8] C.-J. Lin,[8] T.M. Liss,[60] L. Littenberg,[61] J.C. Liu,[54] K.S. Lugovsky,[30] S.B. Lugovsky,[30] H. Mahlke,[62] M.L. Mangano,[2] T. Mannel,[63] A.V. Manohar,[64] W.J. Marciano,[61] A.D. Martin,[65] A. Masoni,[66] D. Milstead,[67] R. Miquel,[68] K. Mönig,[69] H. Murayama,[70,71,8] K. Nakamura,[44] M. Narain,[72] P. Nason,[73] S. Navas,[74†] P. Nevski,[61] Y. Nir,[75] K.A. Olive,[76] L. Pape,[31] C. Patrignani,[17] J.A. Peacock,[52] A. Piepke,[77] G. Punzi,[78] A. Quadt,[79] S. Raby,[80] G. Raffelt,[81] B.N. Ratcliff,[54] B. Renk,[82] P. Richardson,[65] S. Roesler,[2] S. Rolli,[83] A. Romaniouk,[84] L.J. Rosenberg,[11] J.L. Rosner,[13] C.T. Sachrajda,[85] Y. Sakai,[44] S. Sarkar,[86] F. Sauli,[2] O. Schneider,[87] D. Scott,[88] W.G. Seligman,[89] M.H. Shaevitz,[90] T. Sjöstrand,[91] J.G. Smith,[25] G.F. Smoot,[8] S. Spanier,[54] H. Spieler,[8] A. Stahl,[92] T. Stanev,[34] S.L. Stone,[14] T. Sumiyoshi,[93] M. Tanabashi,[94] J. Terning,[95] M. Titov,[96] N.P. Tkachenko,[30] N.A. Törnqvist,[97] D. Tovey,[98] G.H. Trilling,[8] T.G. Trippe,[8] G. Valencia,[99] K. van Bibber,[45] M.G. Vincter,[4] P. Vogel,[100] D.R. Ward,[101] T. Watari,[102] B.R. Webber,[101] G. Weiglein,[65] J.D. Wells, [103] M. Whalley,[65] A. Wheeler,[54] C.G. Wohl,[8] L. Wolfenstein,[104] J. Womersley,[105] C.L. Woody,[61] R.L. Workman,[106] A. Yamamoto,[44] W.-M. Yao,[8] O.V. Zenin,[30] J. Zhang,[107] R.-Y. Zhu,[108] P.A. Zyla[8]

*Technical Associates:* G. Harper,[8] V.S. Lugovsky,[30] P. Schaffner[8]

# Single Top in ATLAS

First Look at single-top cross-section measurements in Atlas with FullSim AOD's

Arnaud Lucotte

IN2P3/LPSC Grenoble

Thanks To :

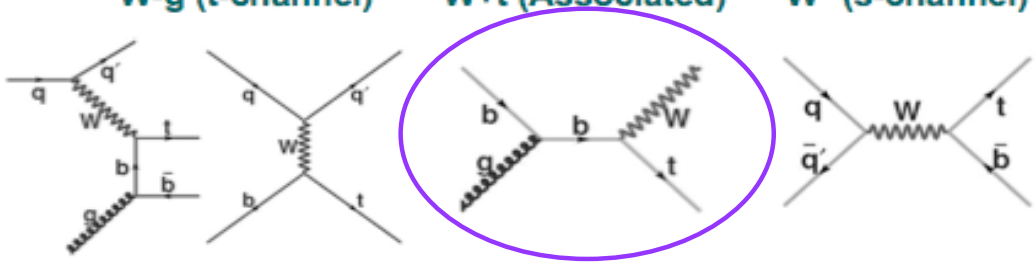
Within the Top Group :
- F. Chevallier (LPSC)
- M. Barisonzi (NiKHEF)
- M. Cobal, M.P. Giordani (Udine)
- S. Rolli (Tufts)
- C. Roda, I. Vivarelli (Pisa)

The Athena/PhysicsAnalysis/ Experts :
- K. Assamagan (BNL)
- S. Binet (Clermont-Ferrand)
- Production team, etc...

## Single-top in the SM

- 3 production mechanisms

W-g (t-channel) W+t (Associated) W* (s-channel)




→ Two of them could be seen at theTeVatron (W*,Wg)

→ All will be measured *precisely* at the LHC

## Motivations

- Properties of the Wtb vertex :
  - Determination of $\sigma(pp \to tX)$, $\Gamma(t \to Wb)$
  - Direct determination of $|V_{tb}|$
  - Top polarization
- Precision measurements → probe to new physics
  - Anomalous couplings, FCNC → t-channel,W+t
  - Extra gauge-bosons W′ (GUT, KK)
  - Extra Higgs boson (2HDM) → s-channel
- Single-top is one of the main background to …

  … Higgs physics with jets…

Selection efficiency

| ε(%) | W+t FullSim | W+t TDR |
|---|---|---|
| Total processed | -- | M. Cobal, Giordani, Rolli, C. Roda |
| N(ele)=1, $p_T$>20 | 49.5 | |
| $p_T$(e)>20, $mE_T$>20 | 44.3 | |
| N(b-jet) = 1, $p_T$>50 | 18,7 | |
| N(jet) = 2, $p_T$>30 | 8.98 | |
| 60 < $m_{jj}$ < 95 | 0.93 | 1.27 |

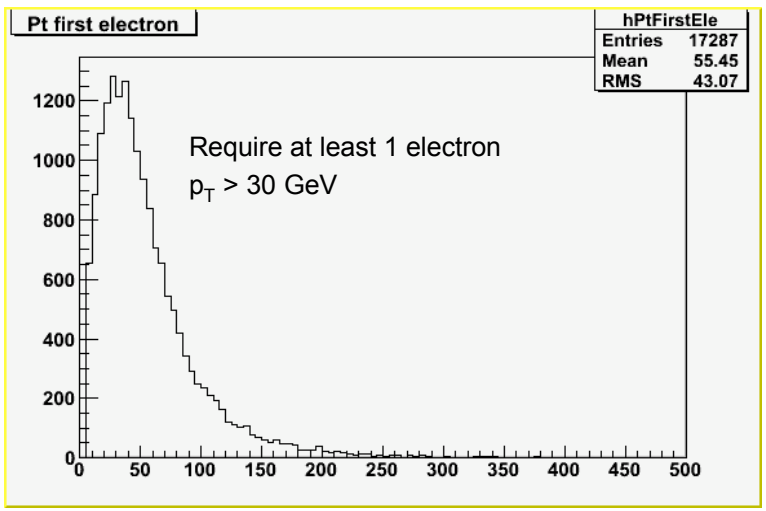
# Initial Studies

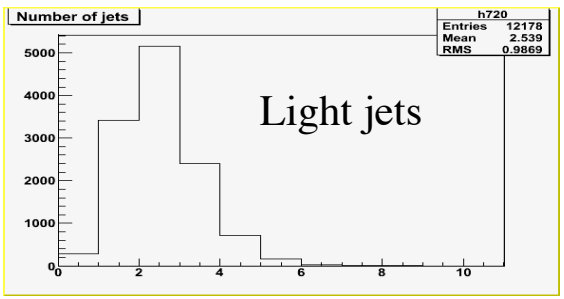
- CBNT and AOD preliminary studies
  - The AOD data format was used for the first time to reproduce the old TDR numbers;
  - Compared to old combined ntuple data
  - Test of the physics analysis objects as well as analysis tools

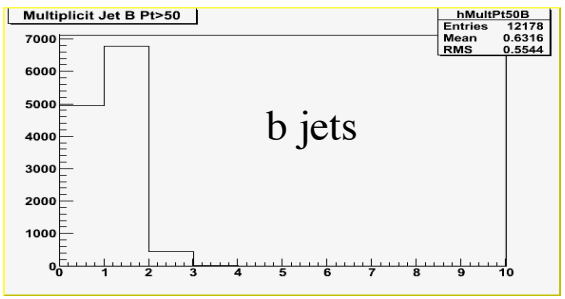
| Description of cuts | Cumulative Selection Efficiency (%) | | |
|---|---|---|---|
| TDR | $Wt$ | $t\bar{t}$ | $Wb\bar{b}$ |
| Pre-selection cuts | 25.5 | 44.4 | 2.49 |
| njets = 3; $p_T > 50$ GeV | 3.41 | 4.40 | 0.05 |
| nb-jet = 1 | 3.32 | 3.24 | 0.037 |
| $m_{tot} < 300$ GeV | 1.43 | 0.71 | 0.008 |
| $65 < m_{jj} < 95$ GeV | 1.27 | 0.41 | 0.003 |
| Events/30 $fb^{-1}$ | 6828 ± 269 | 30408 ± 742 | 58 ± 19 |

# CNBT Studies Summary

40000 Wt generated with TopRex
rome.004530.evgen.wt_ph_ml._0000X.pool.root
X=1,9 ($W^- \rightarrow l^- \upsilon$ $W^+ \rightarrow jj$)
**Standard Atlfast** run on it, relevant parameters:
Electrons: pt > 5 GeV, $|\eta|<2.5$
Jets: Cone 0.4, pT > 5 GeV



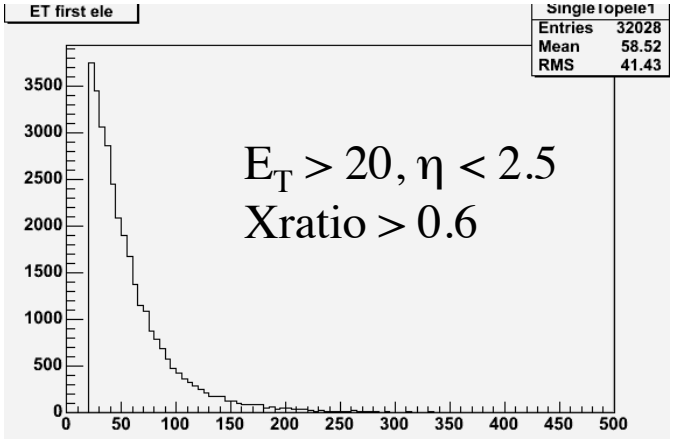




| | |
|---|---|
| All evts | 40000 |
| 1 lepton | 12178 |
| 1 b jets pt 50 | 6788 |
| 2 light jet pt 30 | 2873 (7.1%) |

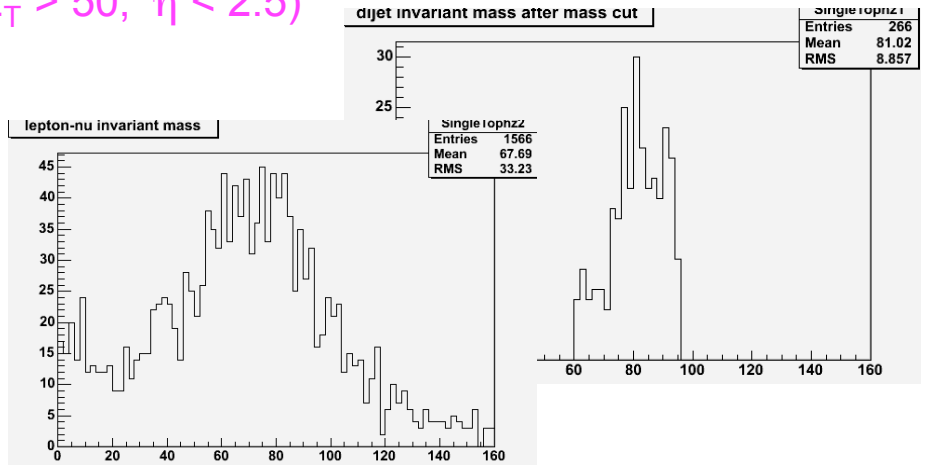
# AOD Studies Summary

- 65020 events from rome.004530.recov10.wt_ph_ml.* and rome.004531.recov10.wt_pl_mh.*
- Objects accessed:
  - ElectronCollection
  - METFinal
  - ConeTowerParticleJets (Cone 07)
  - BJetCollection




32028 evts with 1 one $P_T$ ele (XRatio > 0.6)
28582 evts with MET > 20 GeV
12175 evts with 1 and only 1 b-jet (Lhsig > 0.9, $E_T > 50$, $\eta < 2.5$)
1566 evts with 2 jets (3 total) $E_T > 30$, $\eta < 2.5$

<u>2.4% final acceptance (3% TDR)</u>



# Validation work

To Do List:
-- Ele ID check (IsEM vs Xratio vs Likelihood)
-- **B-tagging Efficiency**: Standard Algorithms vs Combined Likelihood
-- Muons (an entirely different beast..)
-- Study of jet linearity and **energy resolution systematics**
-- Full Comparison with TDR and coherence between atlfast and AOD analysis
-- AOB

# B-Tagging Studies

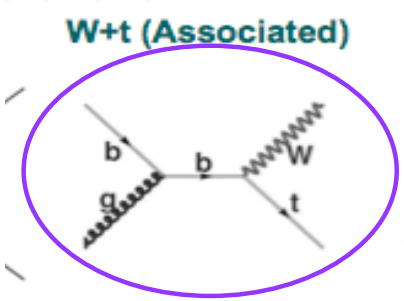
# Summary on b-tagging algs

- Historical » taggers:
  - **IP2D**: transverse impact parameter
  - **IP3D**: 2D+longitudinal
  - **SV1, SV2**: inclusive secondary vertex **SV1+IP3D** (we call it FabSV)
- New taggers:
  - Lifetime2D: transverse impact parameter
  - **lhSig**: secondary vertex + impact parameter (2D&3D)
- Tagging weights:
  - For each taggers discriminative variables are selected (iifetime taggers: impact significances $S=d_0/\sigma(d_0)$) and calibration functions are built:
    - Track weight: likelihood ratio $w_t=P_b(S)/P_u(S)$
  - Jet weight: $W_j= \Sigma \ln w_t^i$
- Generalization of the weight for various taggers, can be combined by summing them up (IP3D + SV1).

# B-tagging performance estimators

- b-jet efficiency $\varepsilon_b$ as function of variable cut:
  - Denominator:
    - jets defined as b using MC truth with $p_T > 50$ GeV/c, $|\eta|<2.5$
  - Numerator:
    - ditto + cut on a tagging weight
- light-jet rejection $R_u = 1 / \varepsilon_u$
  - R=100 means 1% mistag rate
  - light jets: u, d, s, g

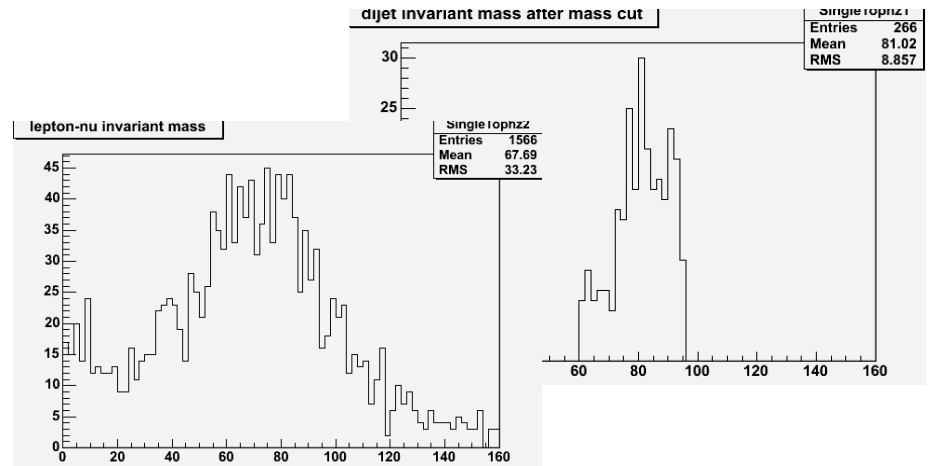
# Wt channel




**Selection of a specific topology**

- Number of high-$p_T$ jets Njet) = 3
- Presence of a high-$p_T$ b-tagged jets
  → Only **one** b-jet in W+t events
- Presence of a W-boson mass peak
  → requires 60 < M(j,j) < 90 GeV/$c^2$

1 b-jet
2 light jets

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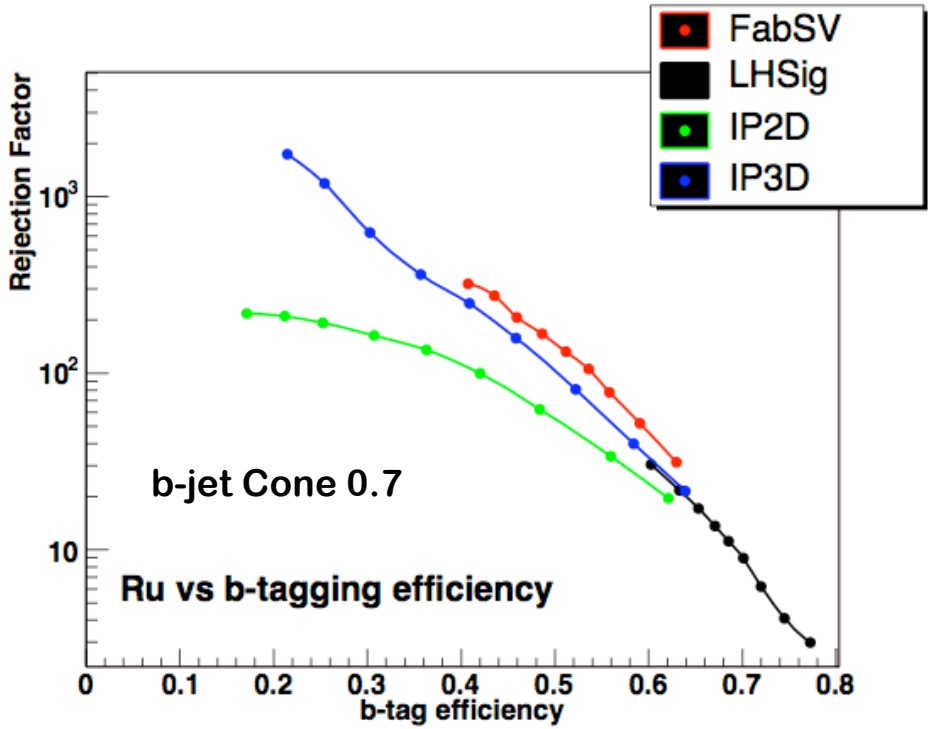
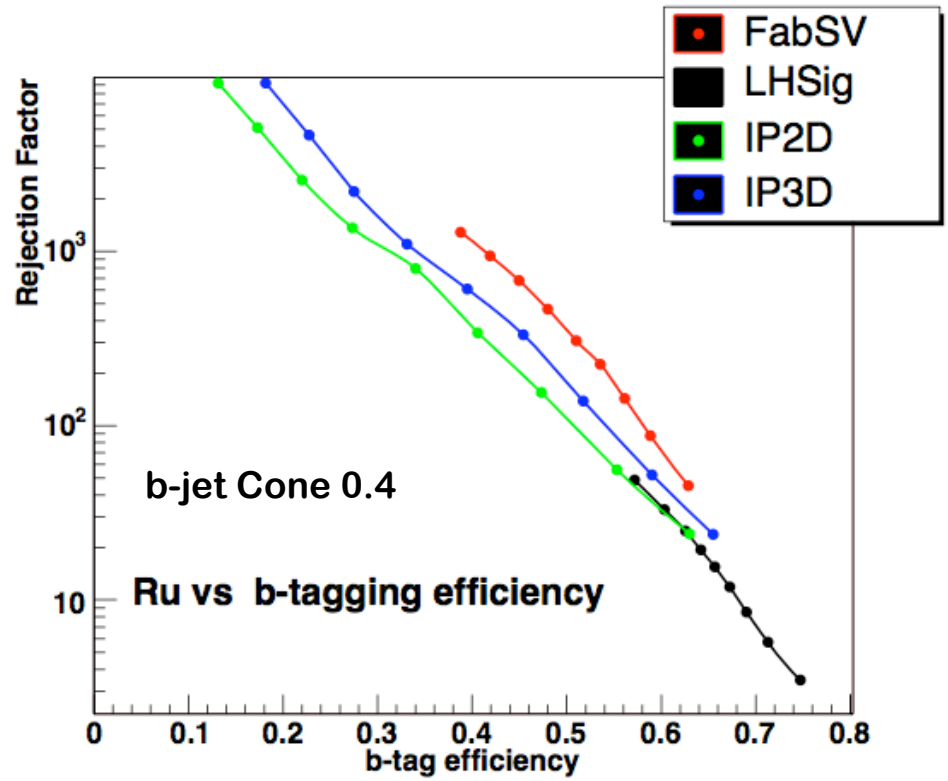
1566 evts with 2 jets (3 total) $E_T$ > 30, $\eta$ < 2.5

2.4% final acceptance (3% TDR)

# Rejections


FabSV
LHSig
IP2D
IP3D
Rejection Factor
$10^3$
$10^2$
10
b-jet Cone 0.7
Ru vs b-tagging efficiency
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
b-tag efficiency


FabSV
LHSig
IP2D
IP3D
Rejection Factor
$10^3$
$10^2$
10
b-jet Cone 0.4
Ru vs b-tagging efficiency
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
b-tag efficiency

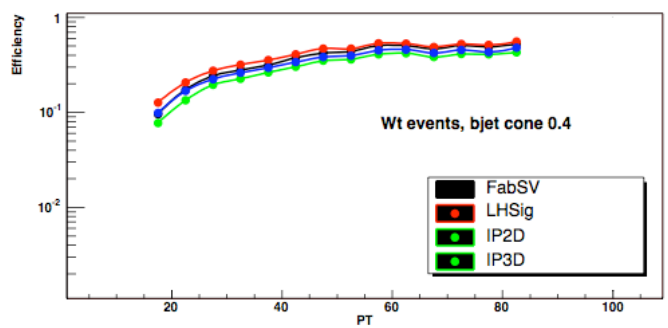
# Wt: Efficiencies ($P_T$ and $\eta$)

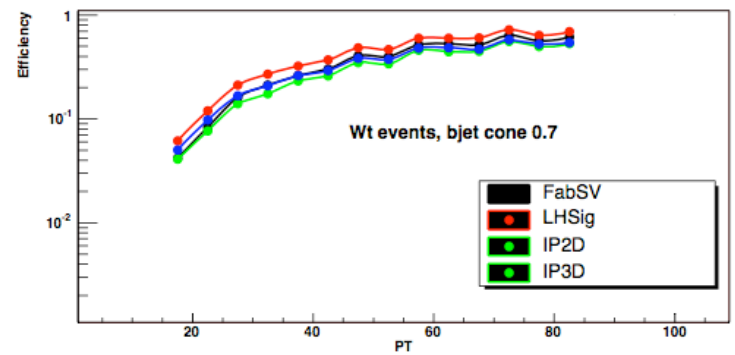
Efficiencies are calculated in the following way:

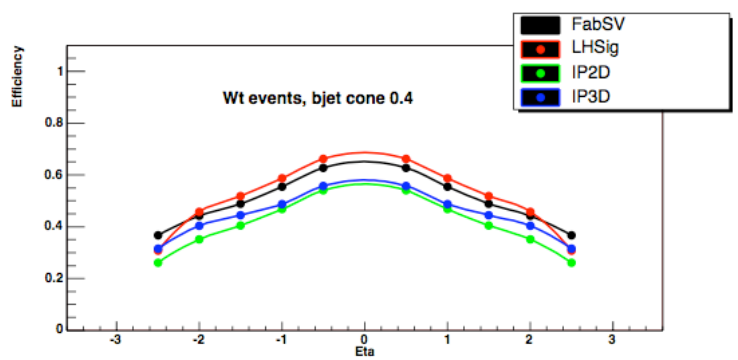
<u>Denominator</u>: number of b-partons with $P_T$ and $\eta$ in given interval;

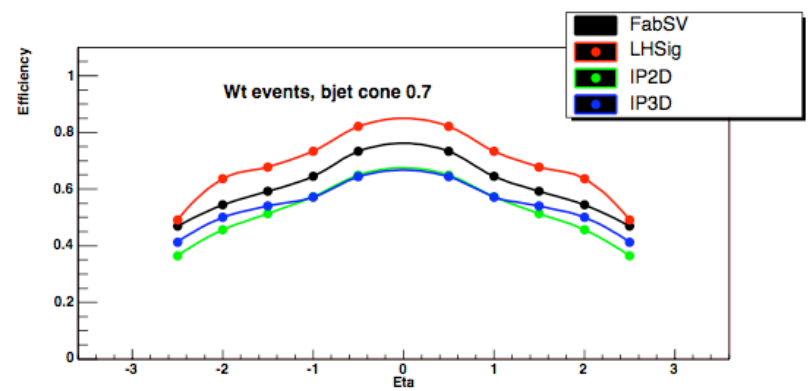
weight/likelihood cut fixed

<u>Numerator</u>: bjets matched with the b-parton (parton level info) with $P_T$ and $\eta$ in given interval and cut on weight/LHSig.

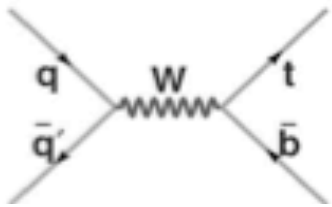


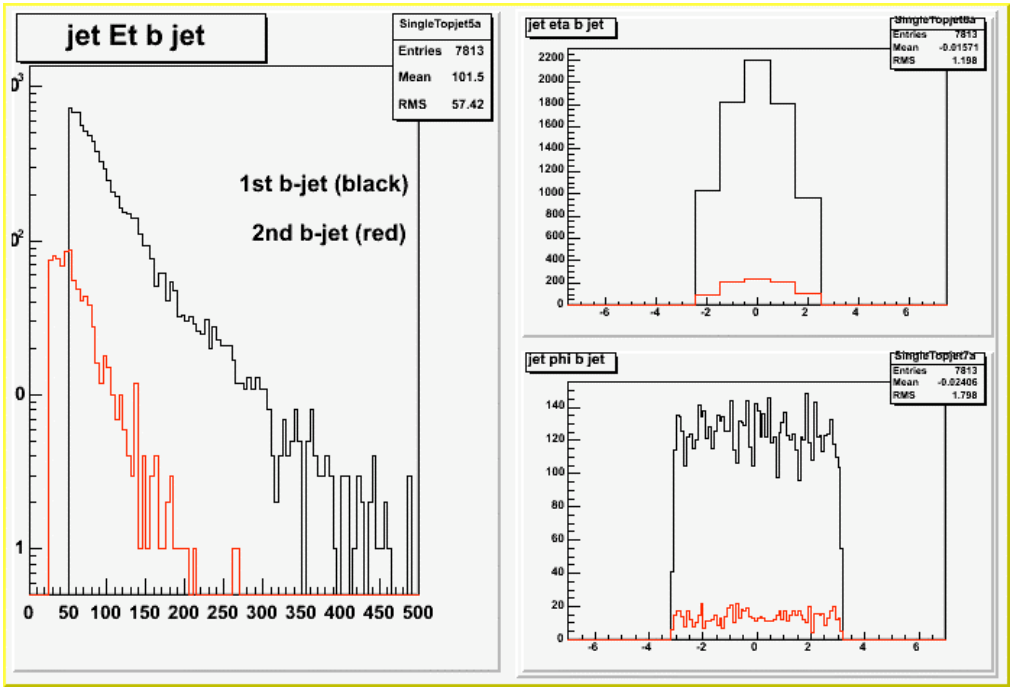
# s-channel




**Selection criteria**

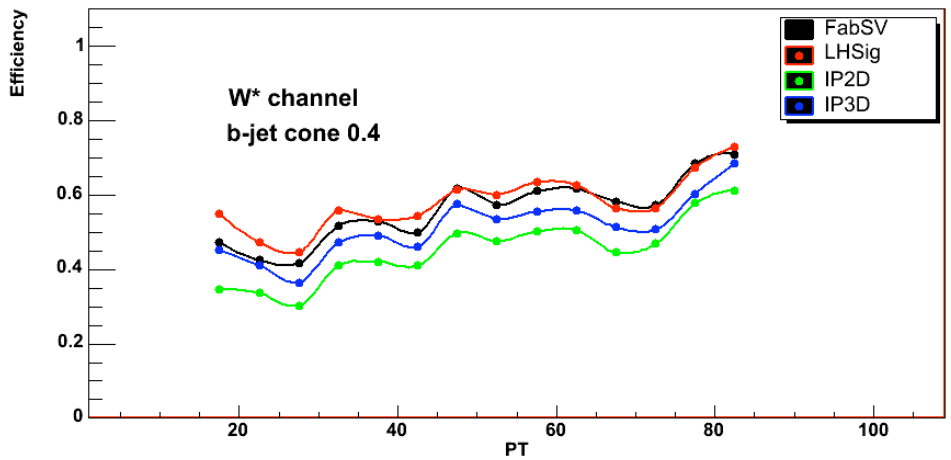
- Number of jets : N(jet) = 2
- Presence of two high $p_T$ jets
- Presence of two central, high-$p_T$ b-tagged jets
- Reconstruct $M_{lvb}$ within $m_{top} \pm 25$ GeV/$c^2$
- Window in $H_T$

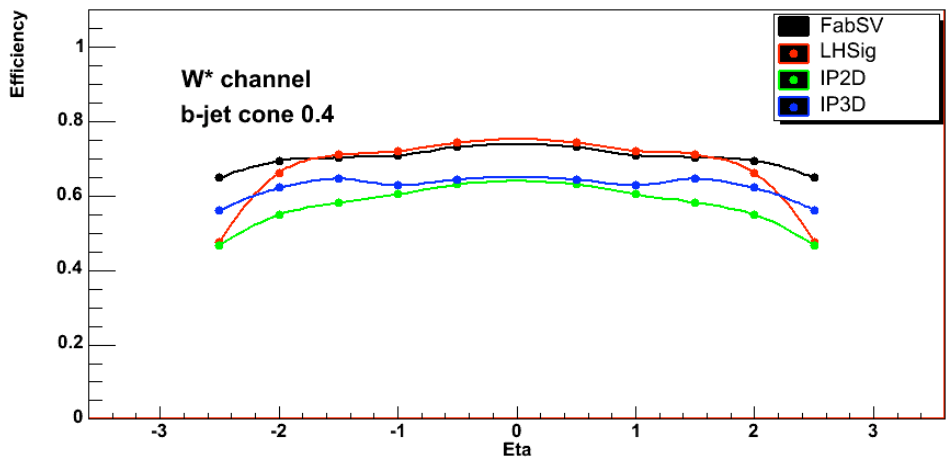
2 bjets only

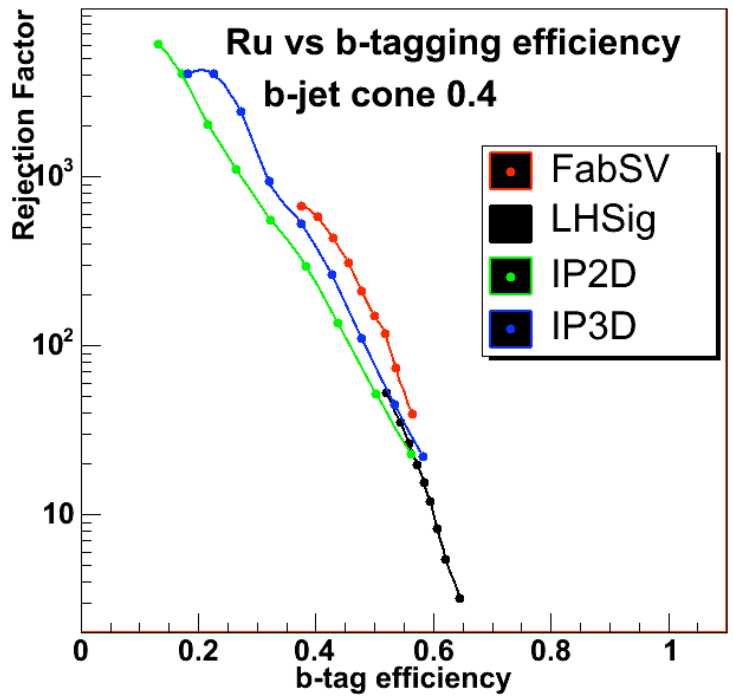



| | |
|---|---|
| One high pt ele (Et > 20) | 40% |
| + one b-jet > 50 | 38% |
| +one ele + 2 jets (1 tagged) | 19% |
| +one more b-jet > 25 | 4% |

# s-channel

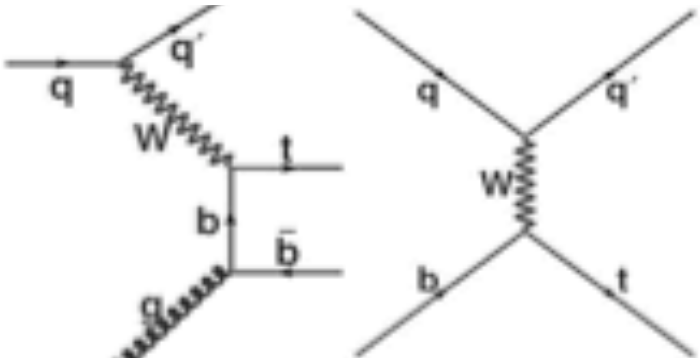


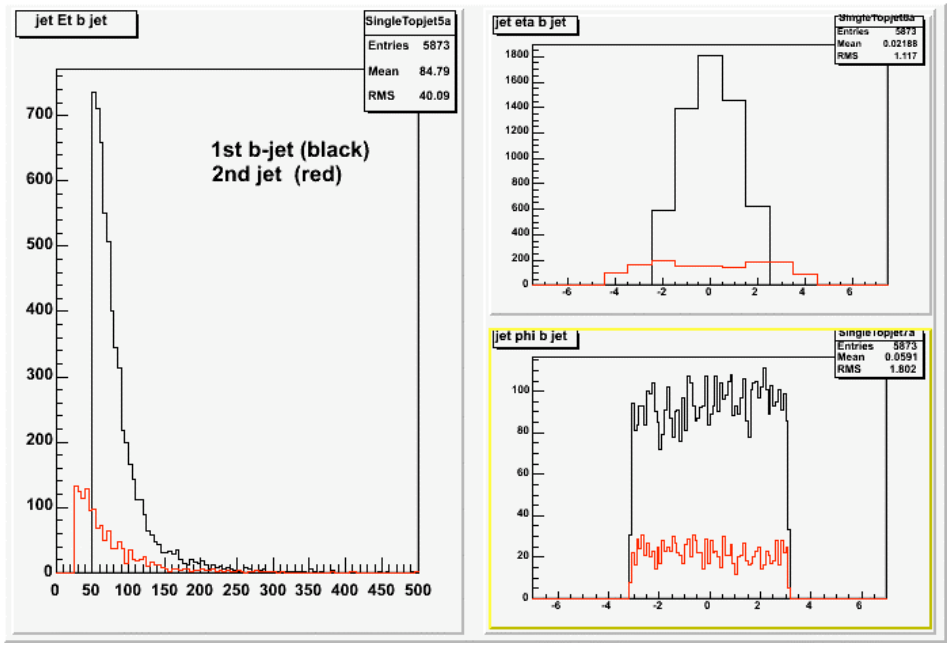




Highets $E_T$ bjet used for Studies - small statistics

# Wg channel



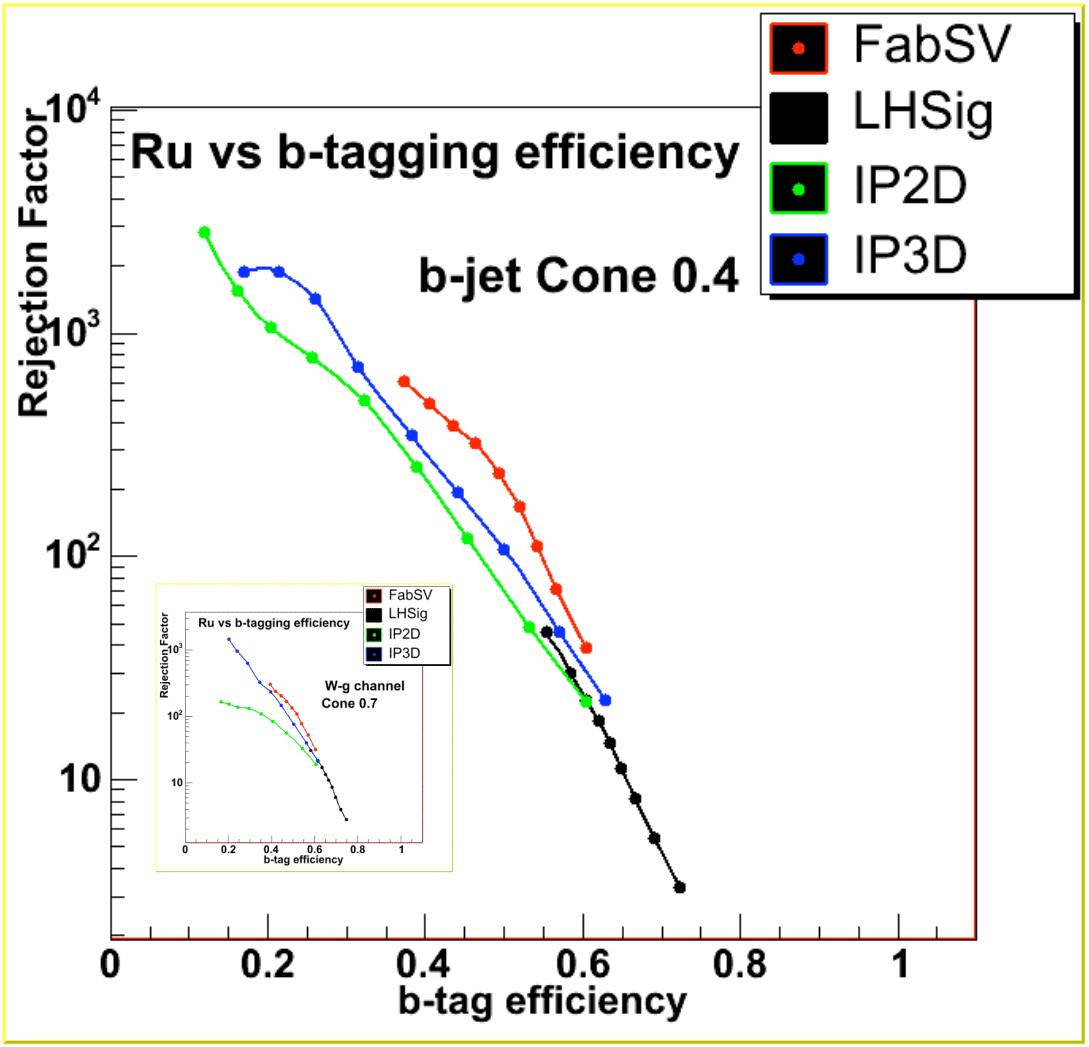




**Selection criteria**

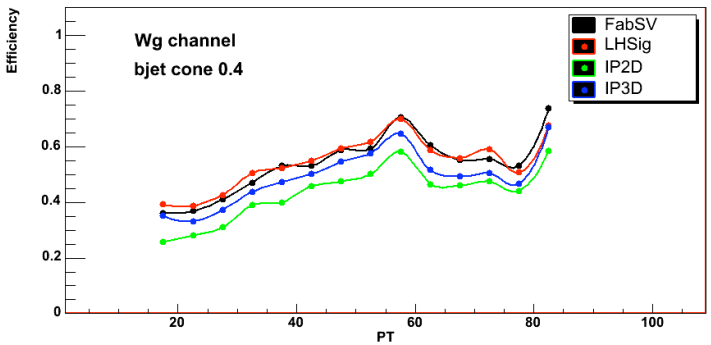
- Number of jets : N(jet) = 2
- Presence of a high-$p_T$ b-tagged jets ($p_T$>40GeV/c)
  Wg evts have 1 b-jet escaping the acceptance
  → requires **only** 1 b-tagged jet
- Presence of a high-$p_T$ forward jet
  → 1 jet with $|\eta|>2.5$ and $p_T \geq 50$GeV/c
- Reconstruct $M_{l\nu b}$ within ±25 GeV/$c^2$
- Window in $H_T$

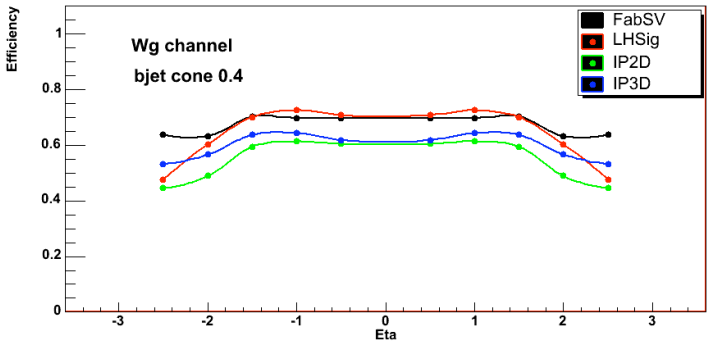
| | |
|---|---|
| One high pt ele | 41% |
| + one b-jet > 50 | 28% |
| + 1 more jet > 30 | 6.7% |

# Wg channel




Highets $E_T$ bjet used for Studies - small statistics

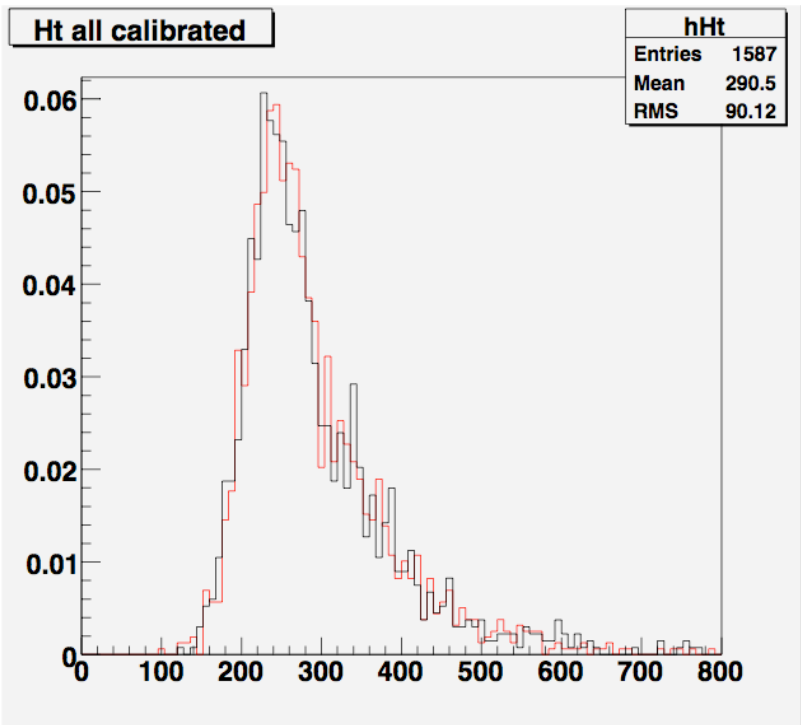


# Jet Resolution

# Jet Resolution Studies (atlfast)

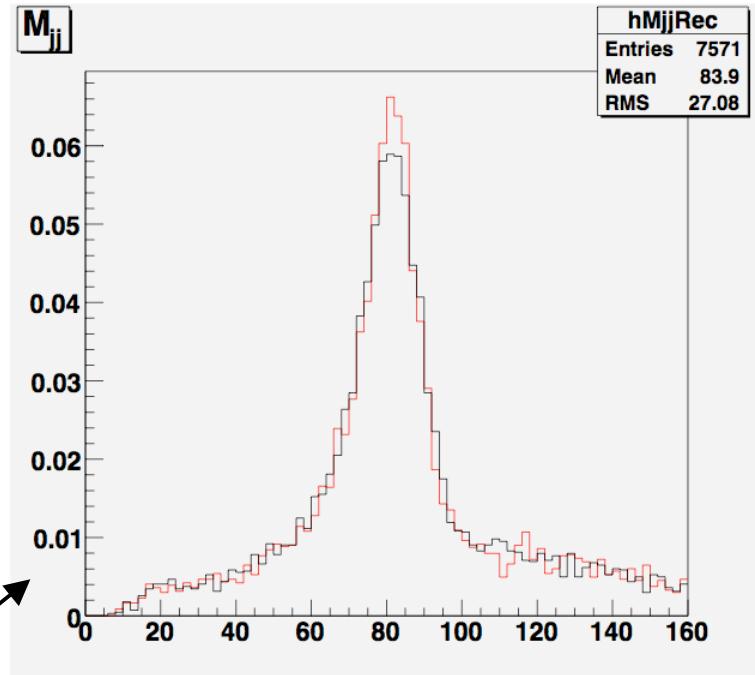
$H_T$ distribution obtained when switching on and off the energy smearing due to the calorimeter resolution (*DoSmearing* flag)



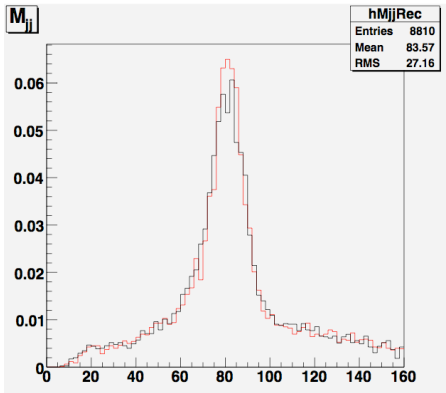

Ht distribution with standard selection cuts with (black) and without smearing (red) for 0.7 cone size on full available statistics of Wt events.

# Jet Resolution Studies (atlfast)

The width of the distribution seems dominated by the smearing due the jet reconstruction algorithm as it also seems from looking at the effect of the smearing on of on the jet jet invariant mass.




Here are the plots for the jet jet reconstructed mass for 0.7 and 0.4 cone size.



# Conclusions on Single Top

**ATL-COM-PHYS-2006-036**

- B-Tag studies on single top samples:
  - Preliminary tests on various b-tag algorithms, as out of the box on Rome samples for single top were performed
  - Generally good agreement with previous studies (L.V.)
  - LHSig seems the most powerful flag to use to select b-jets (LHSig > 0.9) in Wt data but it is necessary to control the light jet rejection rate
- Calorimeter Smearing Studies:
  - No visible effects, major effect coming from jet algorithms
- Other Activities:
  - CSC note on Single Top: co-editor (2007)

# Conclusions on ATLAS work

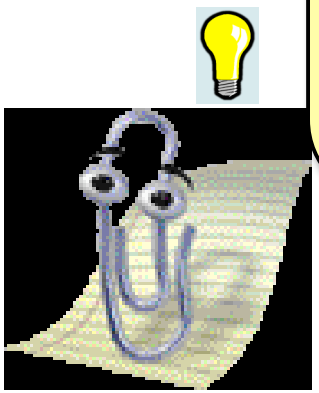
The analysis framework is well developed in ATLAS
- Tools are well advanced and (relatively) easy to use

The analysis ability is still very much in its infancy:
- many people with LEP experience
- TeVatron people contributing actively

The collaboration is certainly oversubscribed….
Many groups doing the same analysis
Limited access to resources
- MC production
- data access

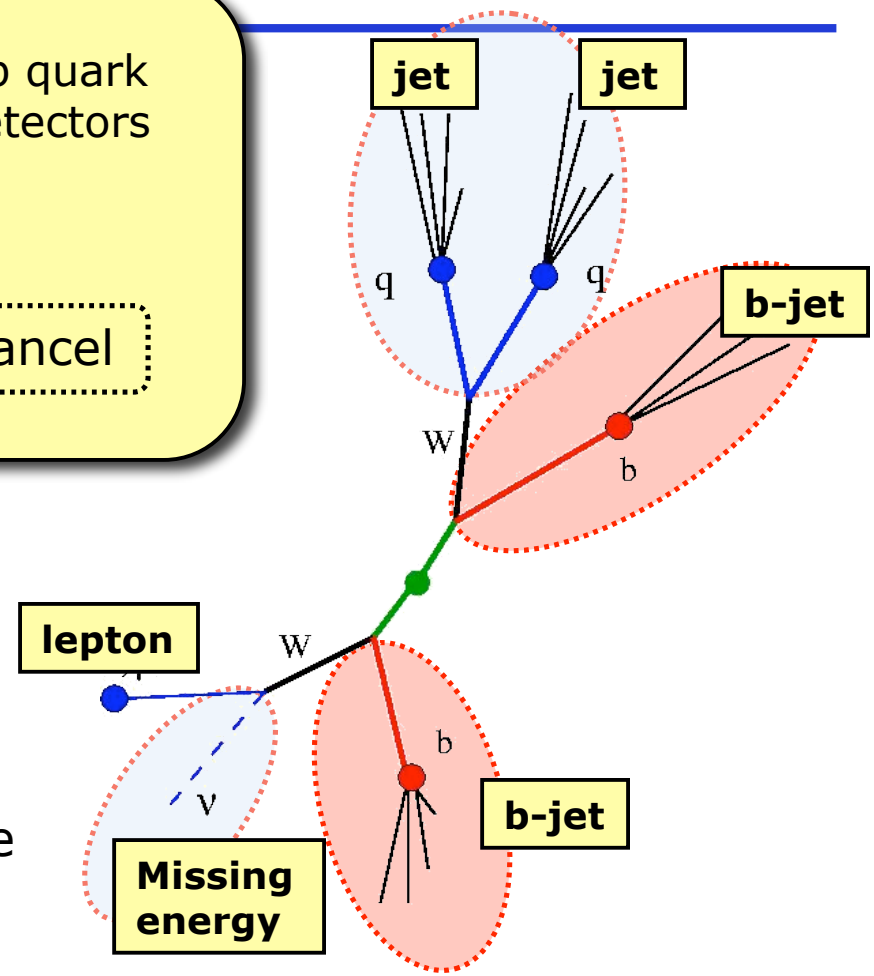
We will keep different option open:
- exotics: LQ
- top: calibration/commisioning tool
- Strong presence in tracking developments (Sharka)

# Top quark pair production as calibration tool



You can use production of top quark pairs to help calibrate LHC detectors in complex event-topologies

Yes No Cancel




→ A candle for complex topologies:

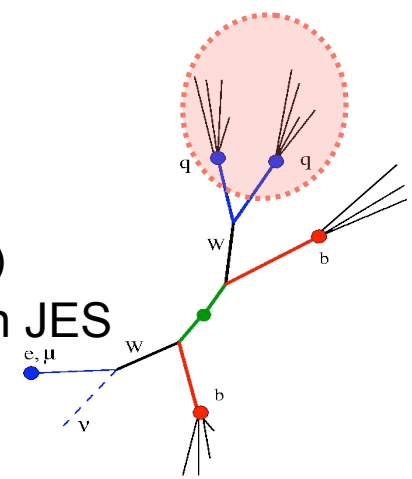
- Calibrate light jet energy scale
- Calibrate missing $E_T$
- Obtain enriched b-jet sample
- Leptons and trigger

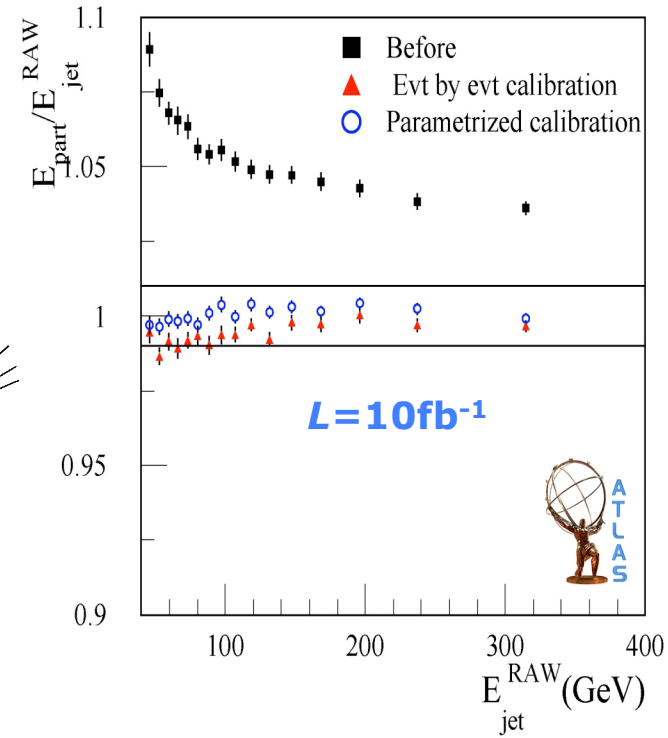
*Note candles: 2 W-bosons*
*2 top quarks*

# Calibrating jet energy scale

One of the most relevant systematic effects on $M_t$

- jet energy: measurement of parton energy
- 1% uncertainty on absolute JES induces $\delta M_t$~1GeV/$c^2$
- sizeable effects also from
  - b-jet energy scale
  - QCD radiation, underlying event, cone algorithm
- at start-up, 5÷10% uncertainty
  - test-beam data
- <u>in-situ correction with Z/γ+jet</u>
  - $p_T$(jet) correction
  - residual mass shift (2% on $M_t$)
- $M_{jj}$=$M_W$ additional constraint on JES
- clean W→jj sample needed
  - 80% purity within tt→lν+jets

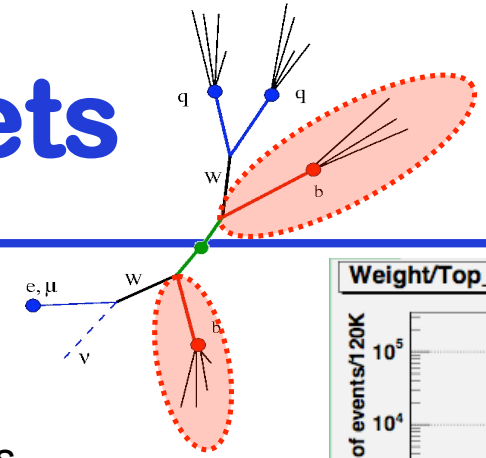


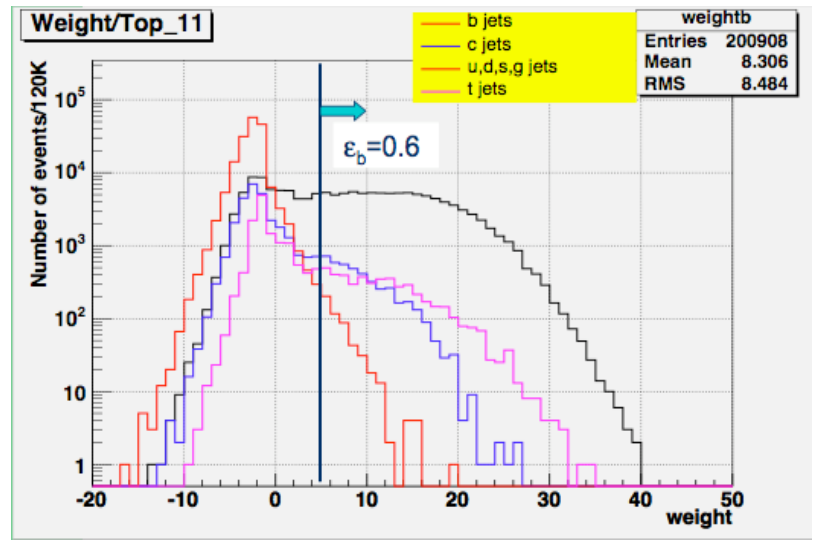

- goal: 2÷3% uncertainty in 1 year (target 1%)
- Alternative method: $P_T$ balance in Z/γ + jet events

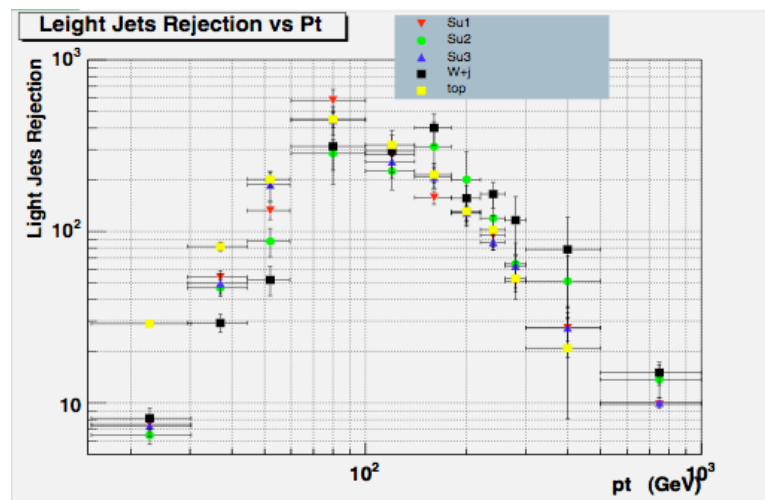
**full simulation**
**tt MC@NLO**

# Calibrating b-jets




- b-tagging techniques rely on
  - impact parameter of decay tracks
  - primary/secondary vertex separation
  - soft leptons
    - targeting b and c semileptonic decays
- Typical performances
  - efficiency ~60% on $p_T$>40GeV/*c* jets
  - light flavour rejection $1/\varepsilon_u$~200
- Jets from b-quarks need specific corrections
  - semileptonic decays of heavy-flavoured quark
    - neutrino induces a large shift on the jet energy
    - effect enhanced if lepton is muon (MIP)
    - jet direction affected as well as jet energy



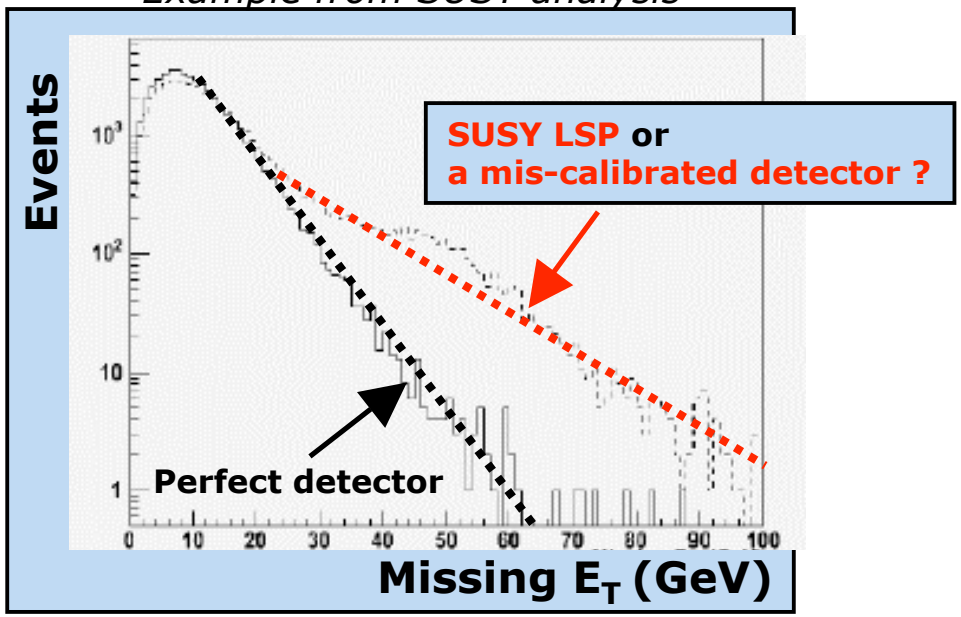



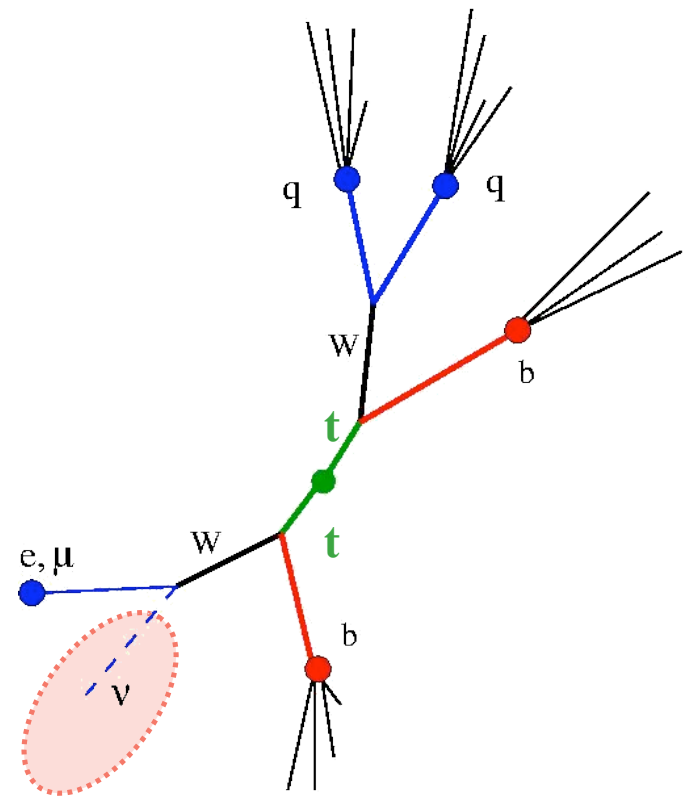
# Calibrating the missing energy

- $P_\mu$(neutrino) constrained from kinematics: $M_W$
  → known amount of missing energy per event

- Calibration of missing energy **vital** for **all** (R-parity conserving) SUSY and most exotics!

*Example from SUSY analysis*




Range: $50 < P_T < 200$ GeV

# Talks and Presentations

- Simona Rolli, I.F.A.E., Pavia April 2006
  - Recent Results on Searches for BSM Physics at the TeVatron
  - Single Top at Hadron Colliders

- Simona Rolli, ATLAS Workshop on SM Physics, Argonne April 2006
  - Single Top Wt Channel Studies

- Simona Rolli, Third North American ATLAS Physics Workshop, Boston July 2006
  - Btagging Perfomance Studies

- Simona Rolli, PASCOS 06, Ohio State University, September 2006
  - Top Physics at LHC

# Talks and Presentations

- Simona Rolli, Tufts University Colloquium, March 2007
  - Collider Physics

- Simona Rolli, CTEQ Workshop on Early Physics at the LHC, Lake Gull, Michigan, May 2007.
  - Top Physics at ATLAS

- Simona Rolli, CDF Collaboration Meeting, Paris, June 2007
  - PerfIDia

# Talks and Presentations

- Simona Rolli, Pheno 2008, UW Madison, April 2008
  - Searches for New Physics at the TeVatron, plenary talk

- Simona Rolli, BNL Forum, November 2008
  - Recent Results from the TeVatron, plenary talk