Single Top Wt channel: b-tagging and Jet Resolution Studies

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Outline

- Single Top at LHC
- Activities for last year Rome workshop
- b-tagging algorithms performance comparisons
- Jet Resolution studies
- Plans for the future

http://www1.fisica.uniud.it/twiki/bin/view/Sandbox/AtlasAnalysisPage

Why Single Top ?

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 } t-channel,Wt
  - FCNC
  - Extra gauge-bosons W' (GUT, KK) } s-channel
  - Extra Higgs boson (2HDM)
- Single-top is one of the main background to …
  … Higgs physics…

M(top) = 175 GeV/c^2	s-channel	t-channel	Associated tW	Combined (s+t)
TeVatron σ_{NLO}	0.88 ± 0.11 pb	1.98 ± 0.25 pb	0.1 pb	
LHC σ_{NLO}	10.6 ± 1.1 pb	247 ± 25 pb	62^{+17}_{-4} pb	
Run II 95% CL — CDF	<3.2 pb	< 3.1pb	NA	< 3.5
Run II 95% CL — D0	< 5 pb	< 4.4 pb	NA	NA

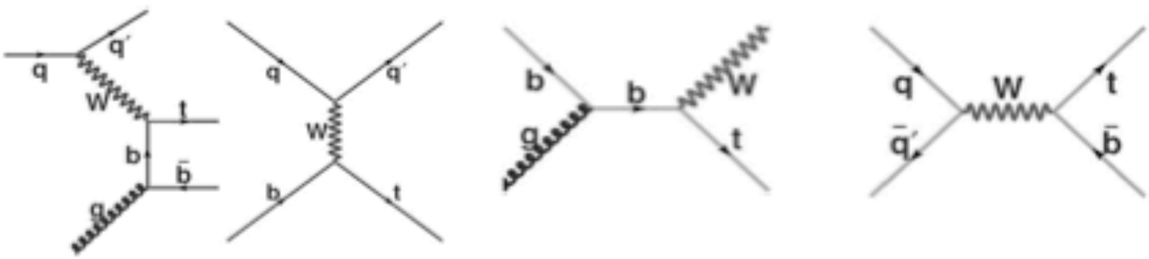
σ_{t+s} = 2.9 pb for m(top) = 175 GeV/c^2

B.W. Harris et al.:Phys.Rev.D66,054024 T.Tait: Phys.Rev.D61,034001
Z.Sullivan Phys.Rev.D70:114012 A.Belyaev,E.Boos: Phys.Rev.D63,034012

Single Top at LHC

- All 3 contributing mechanisms in SM:

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



- Computation at NLO available for W* and W-g :
  - Increase of σ(W*) by ~30 %
  - Affect p_T(jet) distribution, H_T etc…

Channel	σ x BR(pb)
W-g	54.2
W+t	17.8
W*	2.2
ttbar	246
Wbb	66.7
W+jets	3,850

Decay modes:

- W* : W* → t bbar → ($l^+\nu$b) bbar
- Wg: q'g → t q bbar → ($l^+\nu$b) q bbar
- W+t: bg → t W → ($l^+\nu$b) qq'

1 leptons + MET
+ ≥ 2 jets
+ 1(2) b-tags

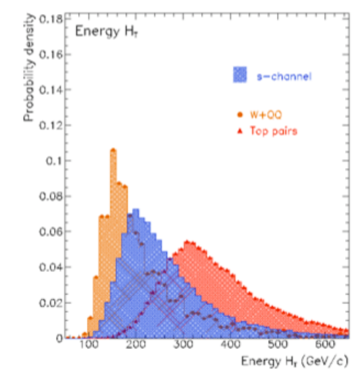
Common selection for all 3 single-top samples :

- 1 High pT Lepton + mET

→ reduce non-W events

- At least two high-p_T jets

→ reduce W+jets events



- Single-top ~22-26%
- ttbar ~ 38%
- WQQ ~ 1.5% , W+njets < 1/1000

Top Physics for Commissioning

- Many detector-level checks (tracking, calorimetry etc)
- Try to see large cross section known physics signals
- But to ultimately get to interesting physics, also need to calibrate many higher level reconstruction concepts such as jet energy scales, b-tagging and missing energy

Algorithms benefiting from early data for calibration include

- B-tagging
  - Identify jets originating from b quarks from their topology
  - Exploit relatively long lifetime of B decays → displaces vertex
- Jet energy scale calibration
  - Relate energy of reconstructed jet to energy of parton
  - Detector and physics calibration (some fraction of parton energy is undetectable to due production of neutrinos, neutral hadrons etc...).
  - Dependent of flavor of initial quark → need to measure separately for b jets

→ Current Activities

Initial Studies

- CBNT and AOD preliminary studies performed for Rome workshop (June 2005):
  - Starting point was to reproduce the TDR numbers;
  - Final goal is to complete the analysis with full simulation, all background sources and new 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

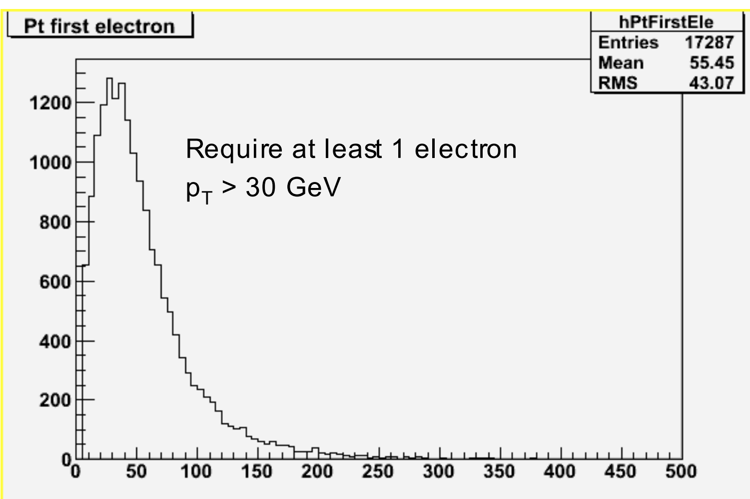
rome.004530.evgen.wt_ph_ml._0000X.pool.root

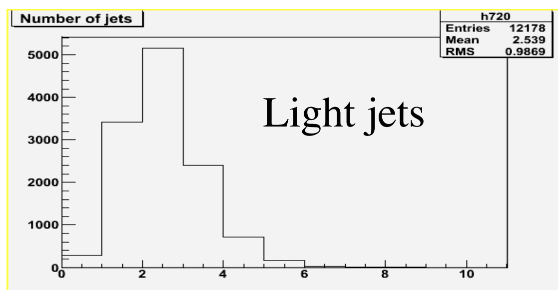
X=1,9 $(W^- \rightarrow l^- \upsilon \; W^+ \rightarrow jj)$

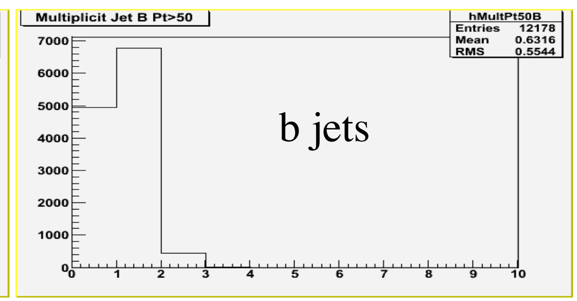
Standard Atlfast run on it, relevant parameters:

Electrons: pt > 5 GeV, $|\eta|<2.5$

Jets: Cone 0.4, pT > 5 GeV



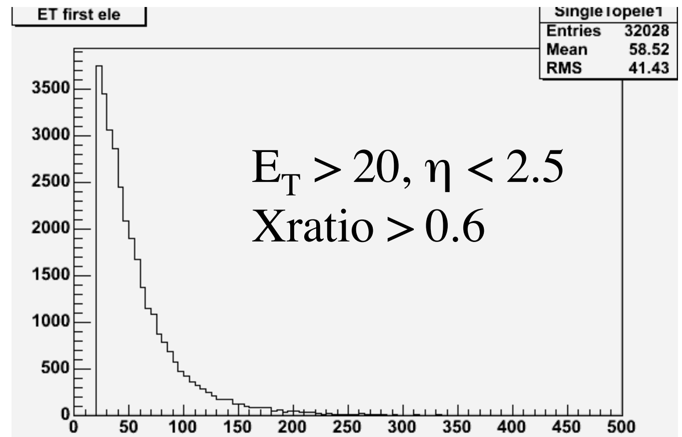




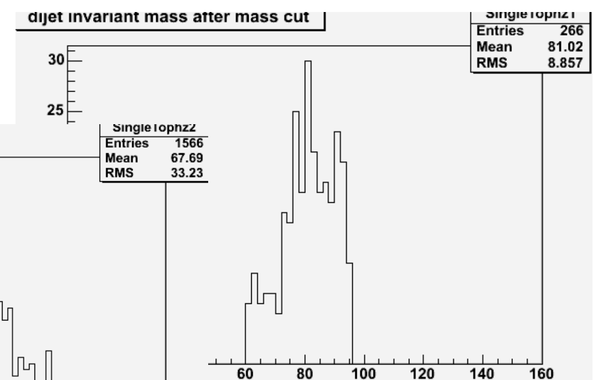
All evts	40000
1 lepton	12178
1 b jets pt 50	6788
2 light jet pt 30	2873 (7.1%)

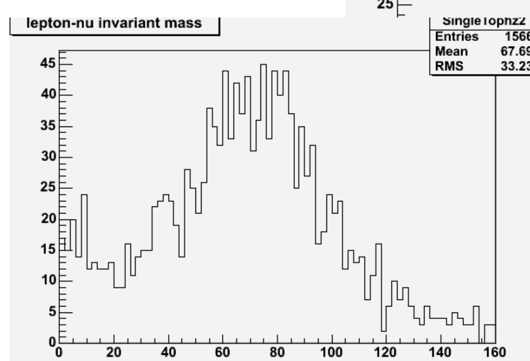
AOD Studies Summary

- 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) $E_T > 30$, $\eta < 2.5$





2.4% final acceptance (3% TDR)

Goals

<u>VALIDATION</u>:
- We want to arrive to a systematic comparison of CBNT and AOD for fast and full simulation using the Wt channel

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

<u>PHYSICS</u>

-- Benchmark the channel and identify the analysis strategy
-- Understand possible sensitivity to new physics

B-Tagging Studies

Sample

- 65020 events from rome.004530.recov10.wt_ph_ml.* and rome.004531.recov10.wt_pl_mh.* (cone 0.7 studies)
- 20000 events from rome.004531.recov10.wt_pl_mh.* (cone 0.4 studies)
- Objects accessed:
  - ConeTowerParticleJets (Cone 07)
  - BJetCollection (btagging was run only for cone 0.7 jets)
  - Cone04TowerParticleJets (Cone 0.4)
  - BJetCollection - Btagging was rerun following the instructions at: https://uimon.cern.ch/twiki/bin/view/Atlas/BTagging#Running_the_b_Tagging

Outlook

- Preliminary look at b-tagging efficiency and light jet rejection
  - Sept 2005, cone 0.7, no TruthInfo accessed
  - Dec 2006, cone 0.7, accessing TruthInfo
  - March 2006, cone 0.4 reprocessed
- Using as reference the talks of:
  - L. Vacavant, Rome Workshop
  - J.B. deVivie, May 2005 b-tagging group
  - L.Vacavant, Feb 2006, pg15
- In Rome preliminary results, LHSig was used to select b-jets

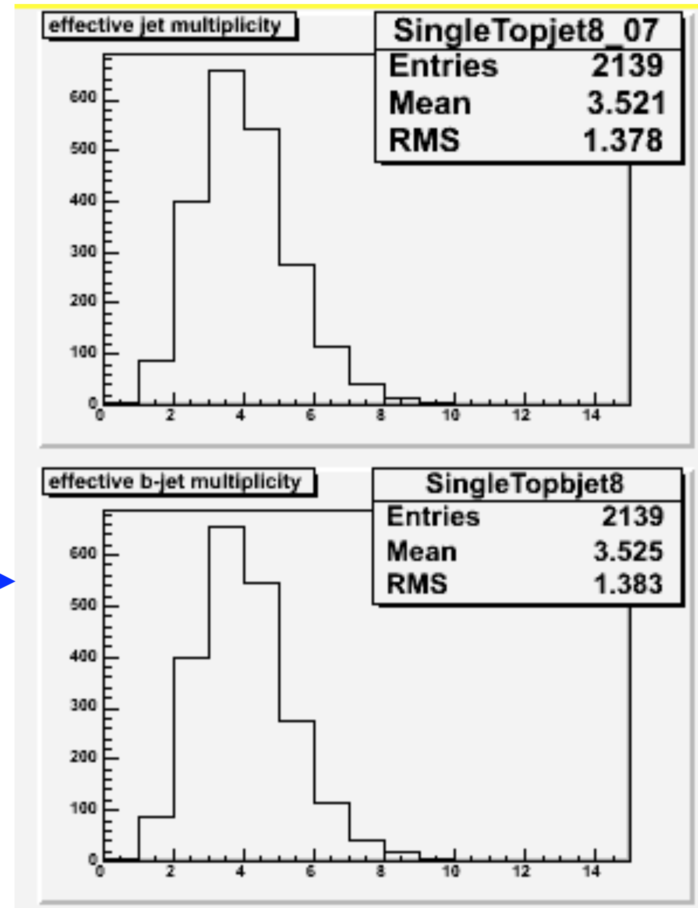
Release 10.0.1

Summary on b-tagging algorithms

- Historical » taggers: L. Vacavant, Rome workshop
  - **IP2D**: transverse impact parameter
  - **IP3D**: 2D+longitudinal
  - **SV1, SV2**: inclusive secondary vertex **SV1+IP3D** (called SV1 in CBNT)
- New taggers:
  - Lifetime2D: transverse impact parameter
  - **lhSig**: secondary vertex + impact parameter (2D&3D)
- Tagging weight:
  - IP2D: based on impact parameter significances $S=d_0/\sigma(d_0)$
  - 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 other taggers, can be combined by summing them up.

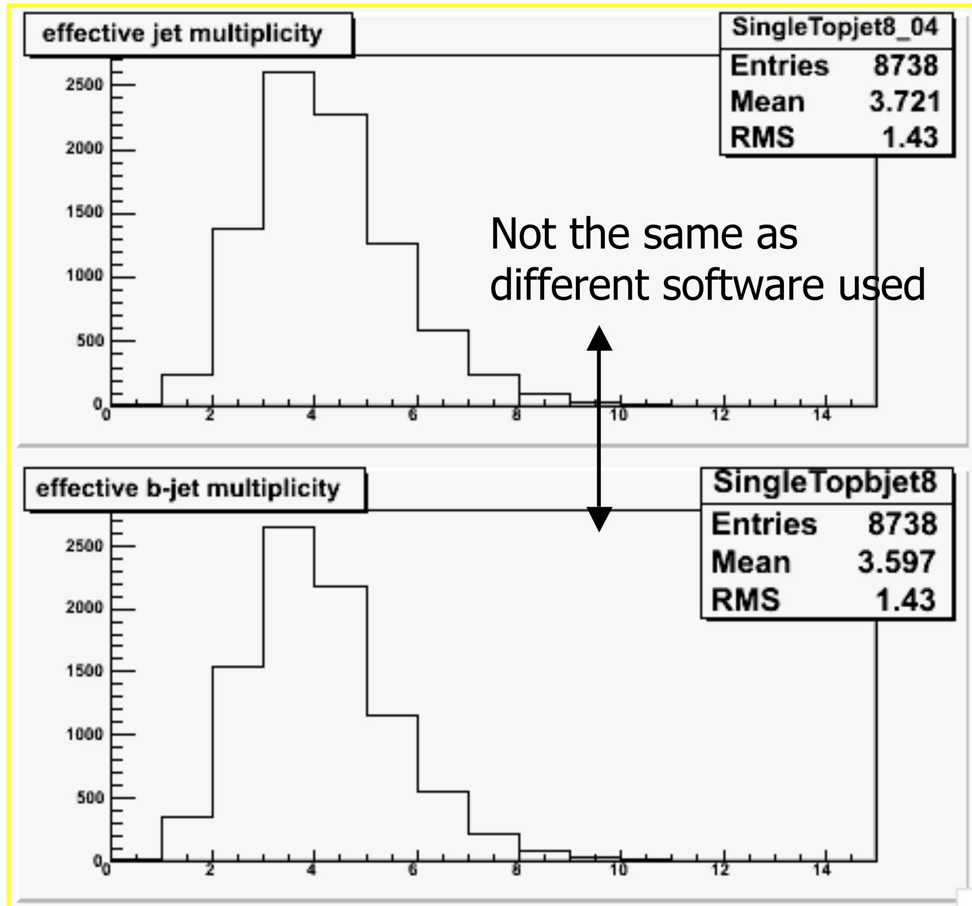
BTagCollection

Btag collection, in Rome samples,
 includes only cone07 Jets,
tagged or untagged
(same multiplicity as the
ConeTowerCollection)



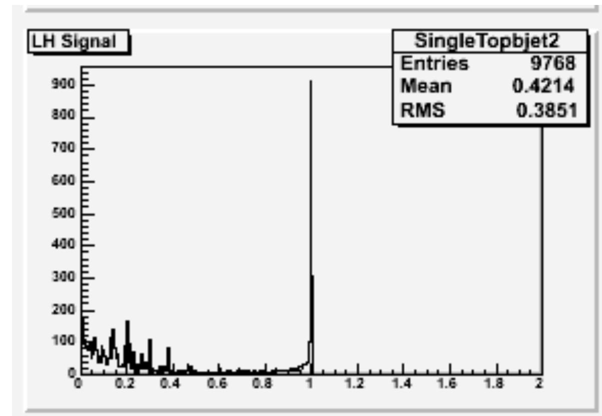
Cone 0.4

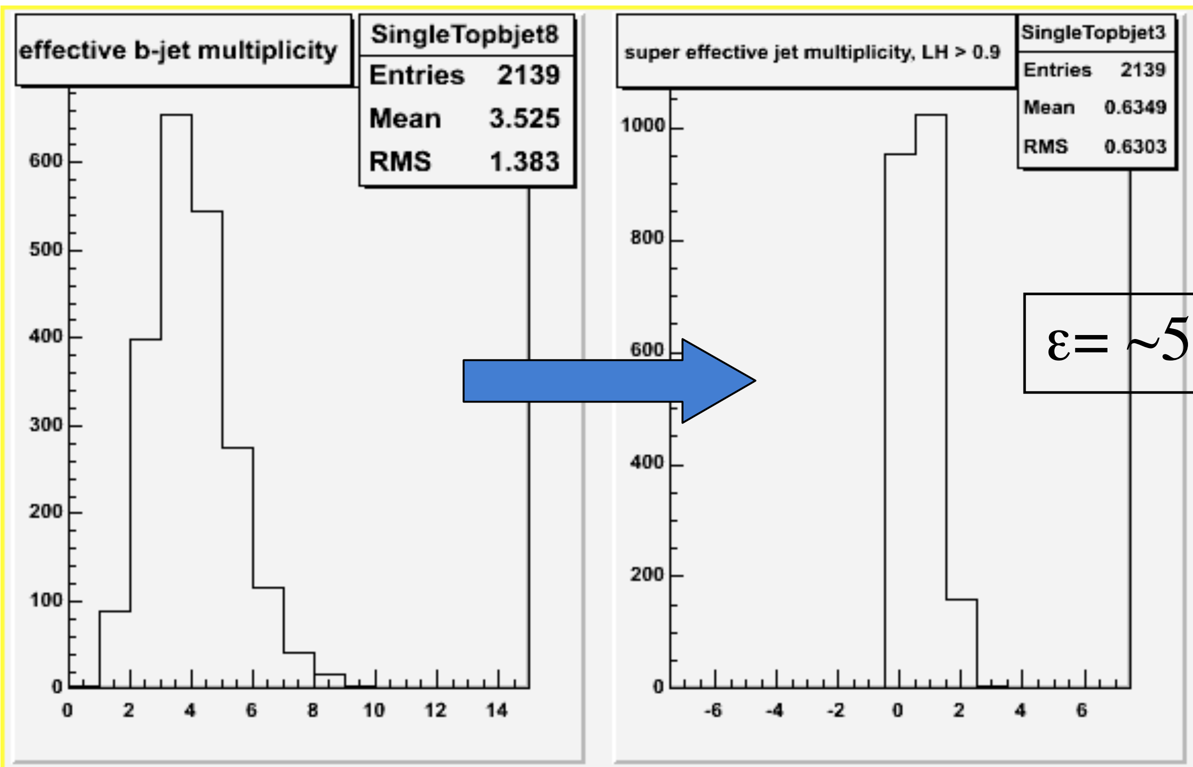
We reprocessed the data as from the recipe on the btagging page
and got the multiplicities for cone 0.4 jets.



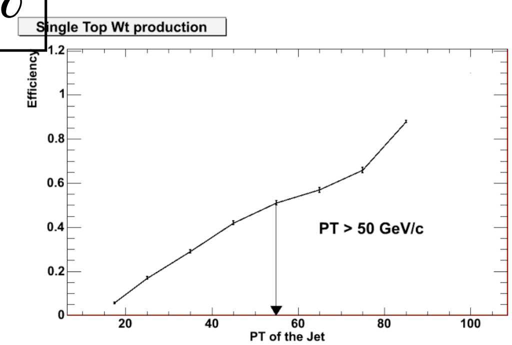
Rome selection (0.7)

- In the BTagCollection a jet was selected if:
  - $E_T > 50$ GeV, $\eta < 2.5$
  - LHSig > 0.9



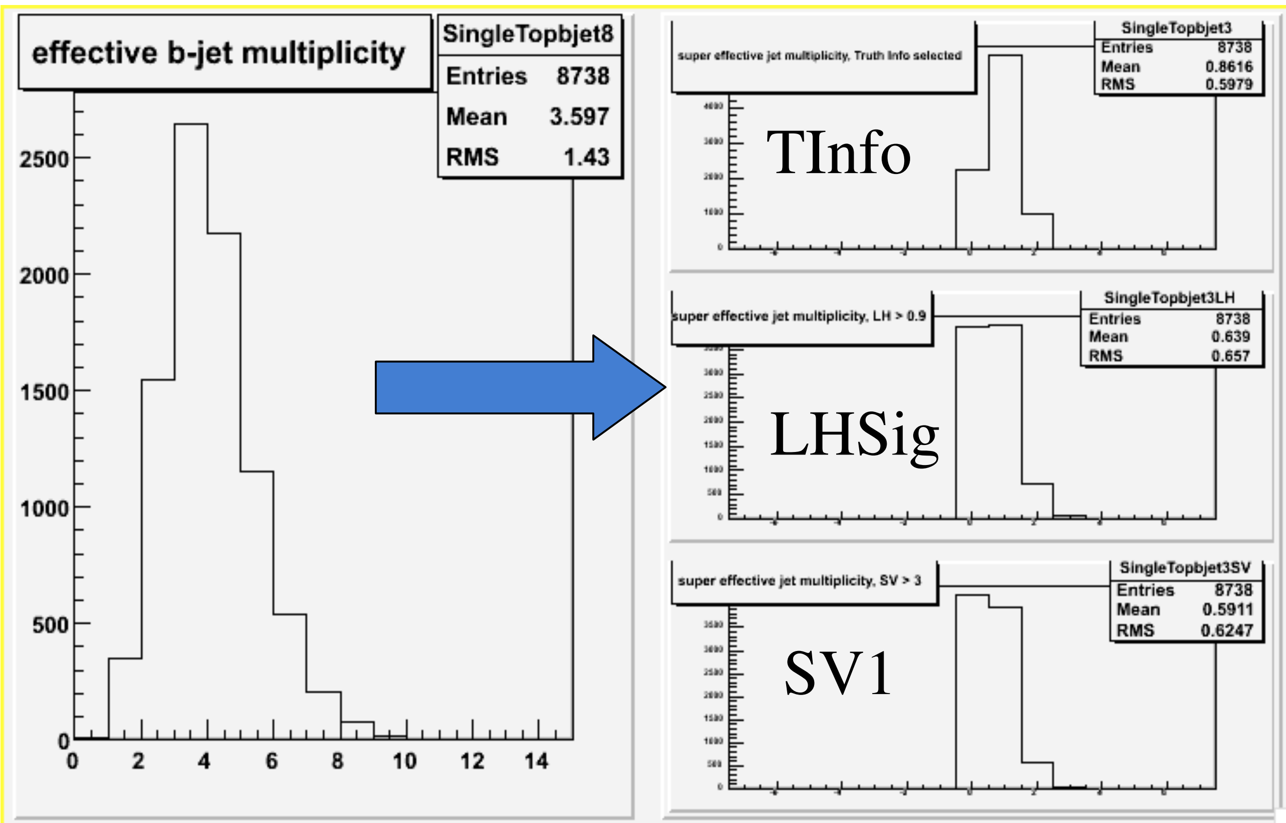


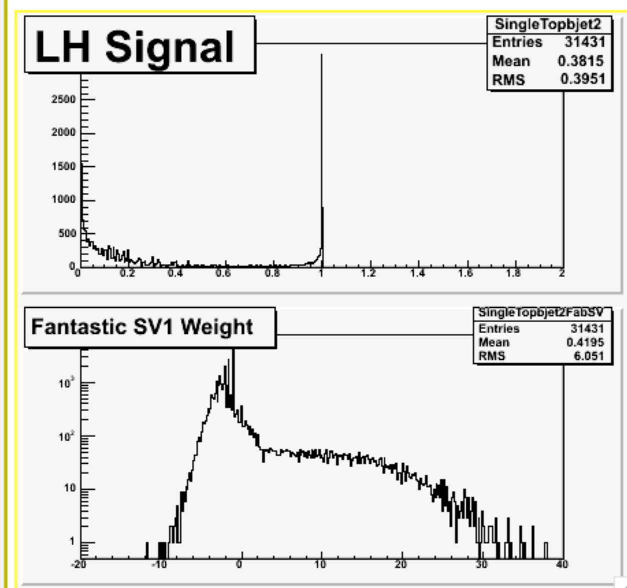
$\varepsilon = \sim 50\%$



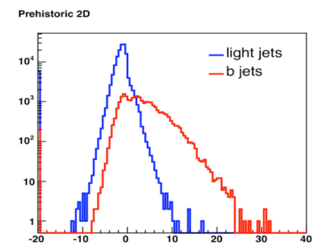
B-jet selection (0.4)

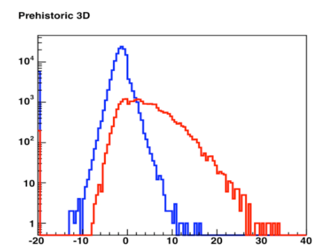
From the Btag collection jets were selected using TruthInfo, LHSig (>0.9) and SV1 (> 3)





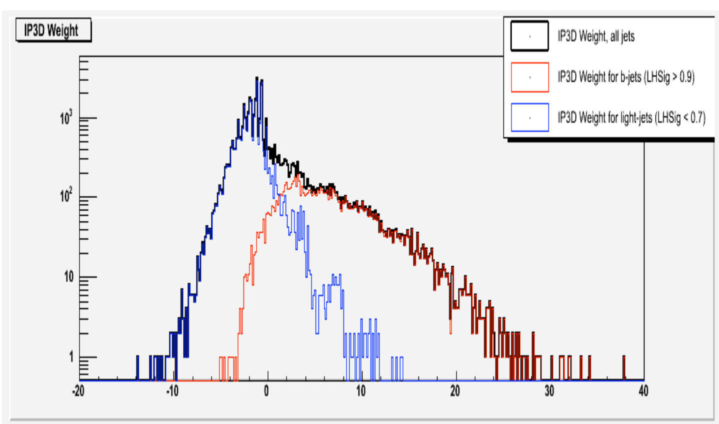
Btag Info

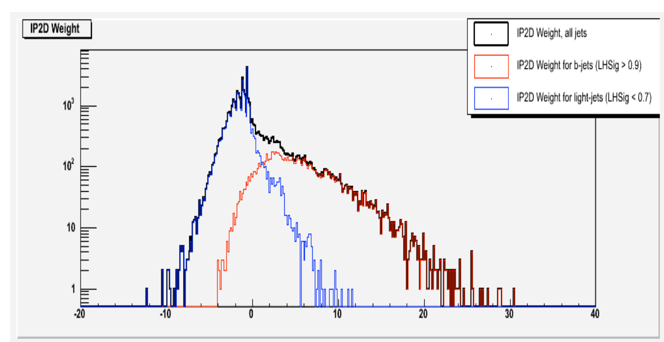




- Suggestion to use SV1, IP2D and IP3D
- Weights accessed from AOD:
  - m_bjetwSV1[j] = (*newBJets)[j]->weightForTag(); (SV1+IP3D)
  - m_bjetwSV1[j] = (*newBJets)[j]->weightForTag("SV1");
  - m_bjetwIP2D[j] = (*newBJets)[j]->weightForTag("IP2D");
  - m_bjetwIP3D[j] = (*newBJets)[j]->weightForTag("IP3D");
- Various web pages/instructions suggest a cut at

  <u>Weight > 3.0 to select b-jets</u>
- We tested various value of the cut , from 1 to 9 and compared with lhSig.





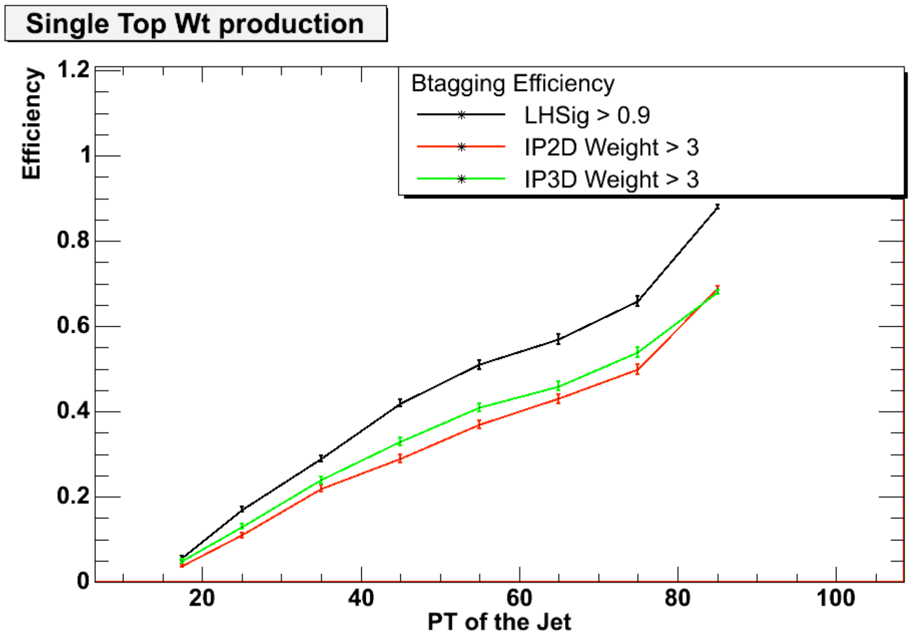
B-tag efficiencies

Efficiencies are calculated in the following way:
Denominator: number of jets matched with the b-parton, with $P_T > 50$ GeV, $\eta < 2.5$
Numerator: ditto with cut on weight/likelihood

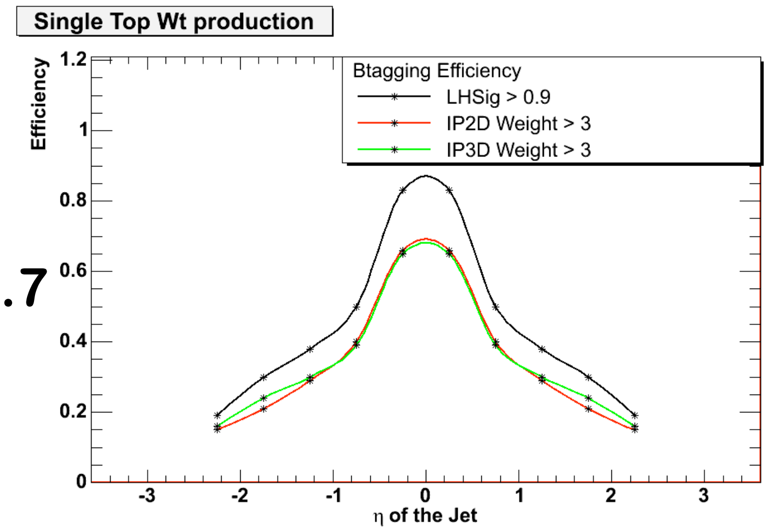
IP2D Cut	Eff Ip2D	SV1 Cut	Eff SV1	LHSig cut	Eff LHsig
1	0.60 0.63	1	0.63 0.63	0.1	0.80 0.75
2	0.54 0.55	2	0.59 0.59	0.2	0.76 0.72
3	0.49 0.48	3	0.55 0.57	0.3	0.72 0.69
4	0.43 0.41	4	0.53 0.54	0.4	0.70 0.67
5	0.38 0.35	5	0.51 0.51	0.5	0.68 0.66
6	0.33 0.28	6	0.48 0.48	0.6	0.67 0.65
7	0.29 0.21	7	0.46 0.46	0.7	0.65 0.63
8	0.25 0.18	8	0.43 0.43	0.8	0.63 0.61
9	0.21 0.14	9	0.41 0.40	0.9	0.60 0.57

Cone 0.7
Cone 0.4

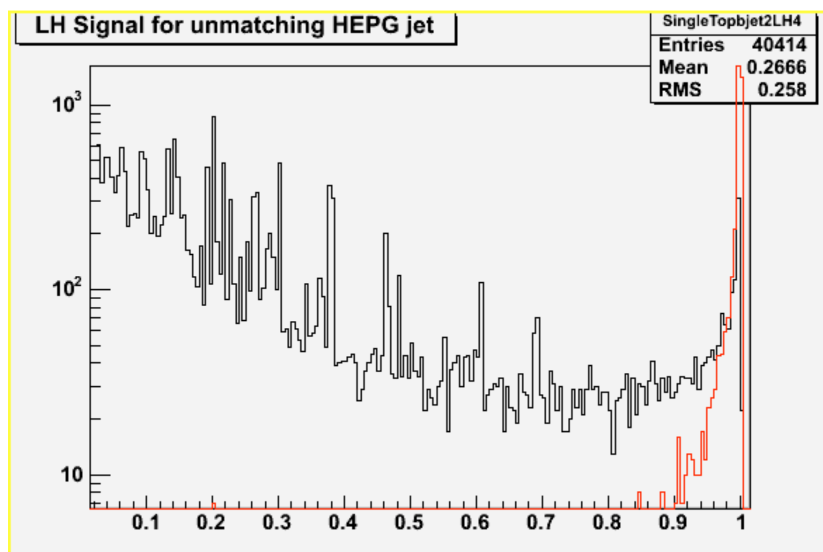
B-tag efficiencies



Cone 0.7



Taggers cross-check



LHSig distribution:

IP2D > 3.0 (red)

IP2D < 1.0 (black)

Light Jet rejection

In order to select a light jet needs to access the parton level information of the light jets (TruthInfo).
This was not done originally (Truth Info missing from our ntuples) and we used an alternative selection using LHSig as the discriminator for b-jets and light jets.

We updated the results using TruthInfo in December (cone 0.7) and in March we presented the results for jets of cone 0.4

b-tagging performance estimators

- b-jet efficiency ε_b:
  - Denominator:
    - jets defined as b using MC truth with (raw) p_T>15 GeV/c, $|\eta|$<2.5
    - NB: jets with no “good” tracks for b-tagging **are** included
    - NB: iso. electrons are not present in the JetTag collection (.)
  - 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

Light Weight rejection

	R_u (ε_b = 50%)	R_u (ε_b = 60%)
IP2D	166 (125) (158 -109)	25 (50) (55-57)
LHSig	NA (172-NA)	33 (33) (66-NA)
SV1	333 (100) (505-325)	100 (33) (184-156)

Wt (S.R)

Wt cone 0.7

WH sample (L.V.)

ttbar sample (L.V.)

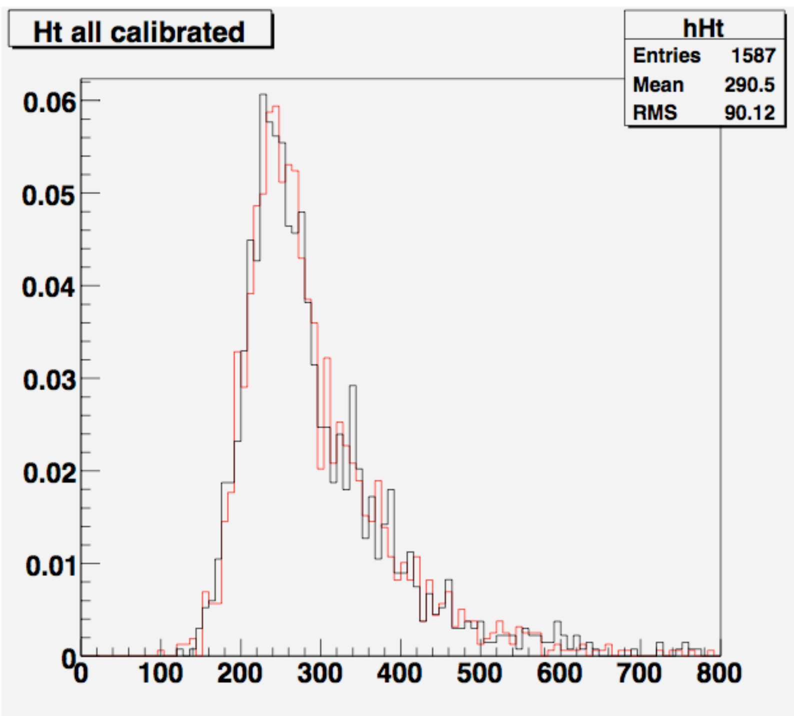
Conclusions on b-tagging

- B-Tag studies on Wt samples:
  - Preliminary tests on various b-tag algorithms, as out of the box on Rome samples for single top were performed
  - Reprocessing of data to obtain cone 0.4 bjets was done;
  - Generally good agreement with previous studies (L.V.)
  - LHSig has slightly higher efficiency to select b-jets (LHSig > 0.9) in Wt data but has a very poor rejection factor.
  - SV1 has slightly lower efficiency, but much higher rejection factor.
  - More studies will be done.
  - More testing woth DC3 data.
  - Planning on a presentation at the btag group sometime in the future
  - Preliminary note in preparation

Jet Resolution

Jet Resolution Studies (atlfast)

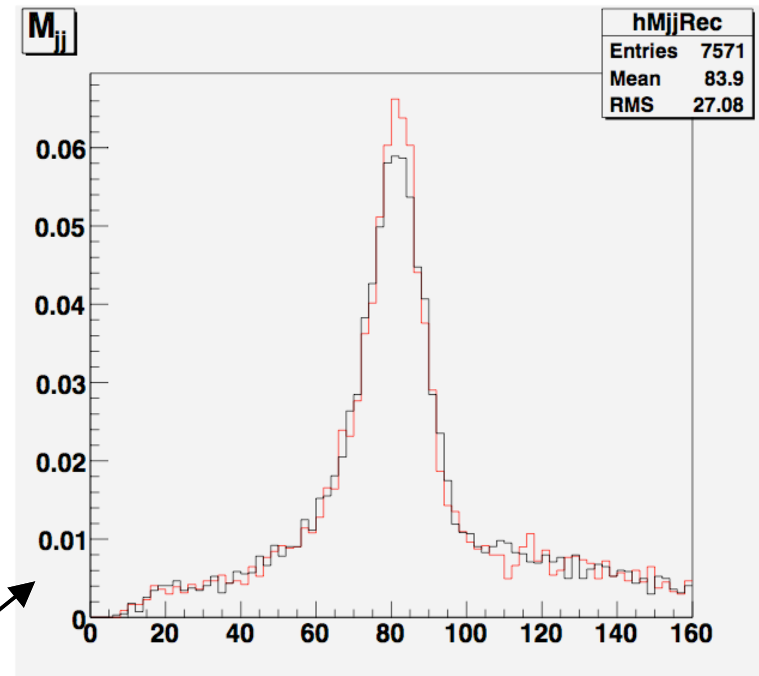
H_T distribution obtained when switching on and off the energy smearing due to the calorimeter resolution (*DoSmearing* flag)



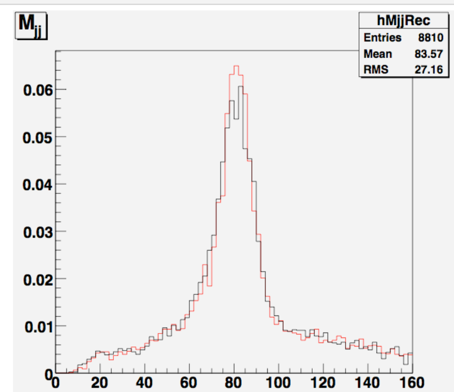
Ht distribution with standard selection cuts with (black) and without smearing (red) for 0.7 cone size on full available statistics of Wt events.

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

- <u>B-Tag studies on Wt samples</u>:
  - 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
- <u>Calorimeter Smearing Studies</u>:
  - No visible effects, major effect coming from jet algorithms
- <u>Future Activities</u>:
  - DC3 samples almost ready, background estimates and complete analysis

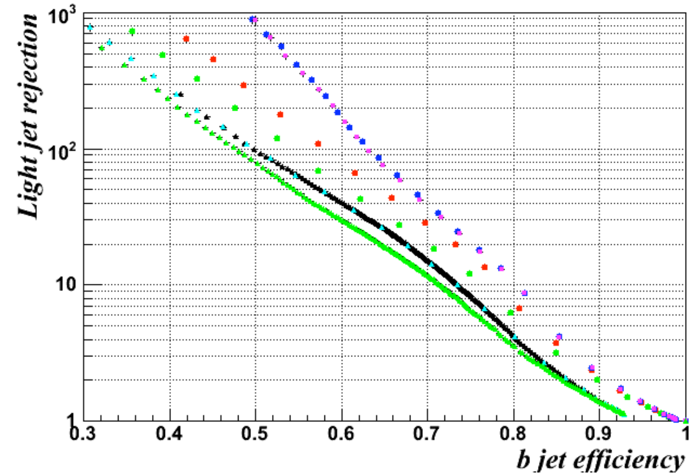
Backup - comparison with yesterday numbers

Performance (WH) 10.5.0

- WH sample
  - (m_H=120 GeV)
  - release 10.5.0

Light quark rejection rates

@ ε_b = 50 (60) %



J.-B. de Vivie, *V.Kostyukhin*
A. Rozanov, L Vacavant

	IP2D	IP3D	SV1+IP3D	SV2+IP3D	lhSig (à la 10.5.0)
Rome Conditions	130 (50)	208 (72)	672 (155)	708 (153)	100 (41)

109 (57)   325 (156)

Performance ($t\bar{t}$) 10.0.1

- $t\bar{t}$ samples
  - Release 10.0.1

	R_u(e=50%)	R_u(e=60%)
IP2D	140 (158)	50 (55)
SV1+IP3D	400 (505)	160 (184)

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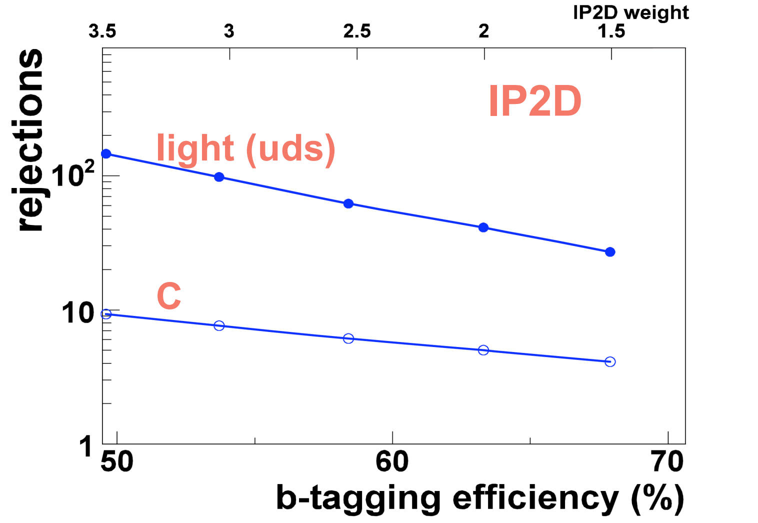

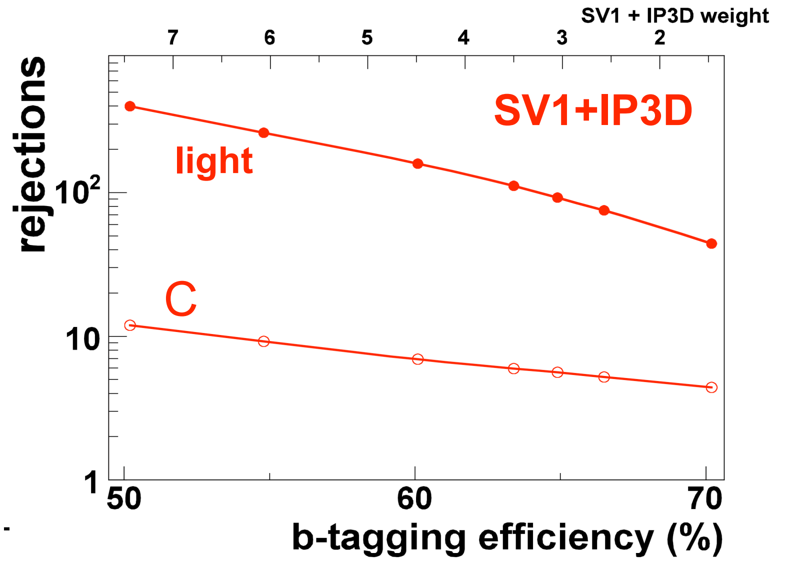

Performance ($t\bar{t}$) 11.0.41

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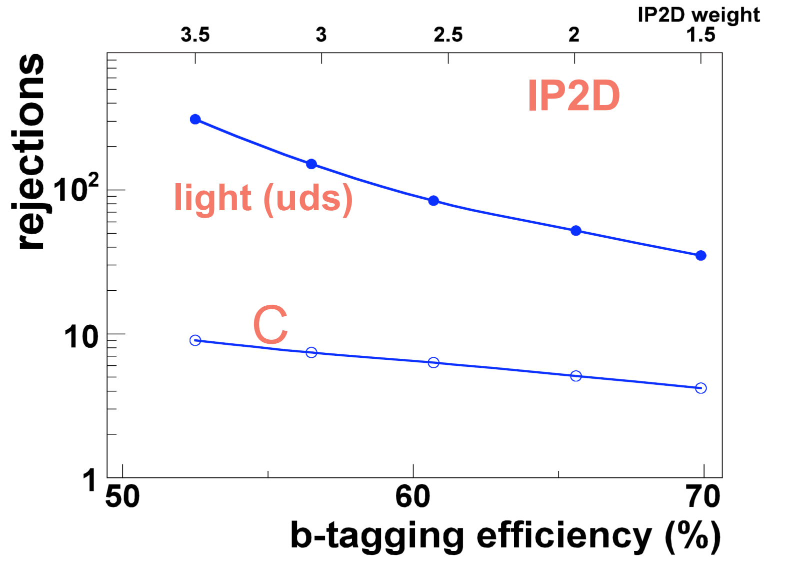
- $t\bar{t}$ samples
  - Release 11.0.41
  - Rejection improved by
    - 20% for R**c** and
    - 50% for R**uds** at ε=60%



	e=50%	e=60%
R_c	10 / 13	6 / 8
R_{uds}	500 / 680	90 / 230