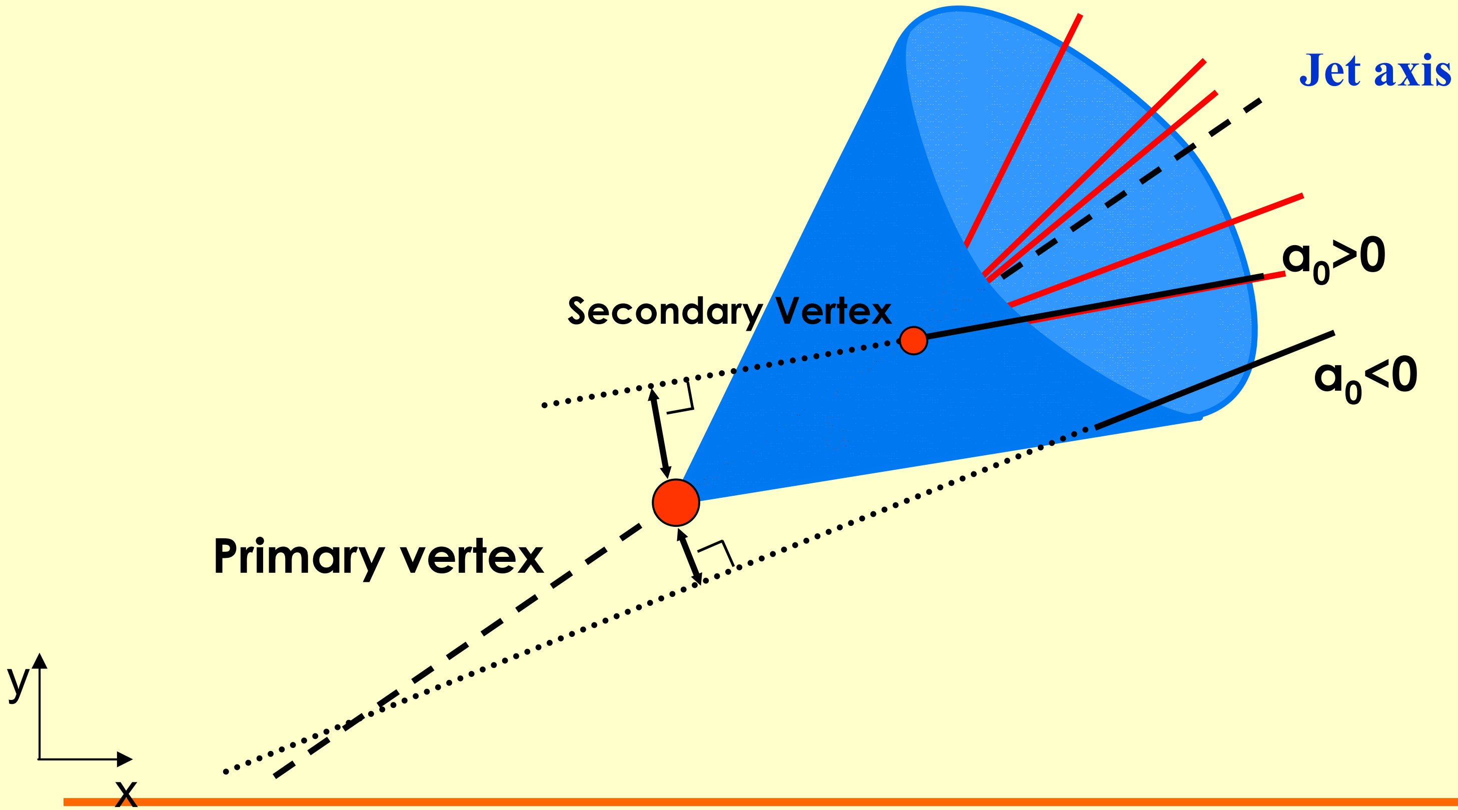
Outline

- **b-tagging methods**
- **b-tagging and high p_T processes**
- **b-tagging performance at LHC**
- **Effects of efficiency and alignment on b-tagging**
- **Initial detector limitation at LHC start-up**
- **Conclusions**

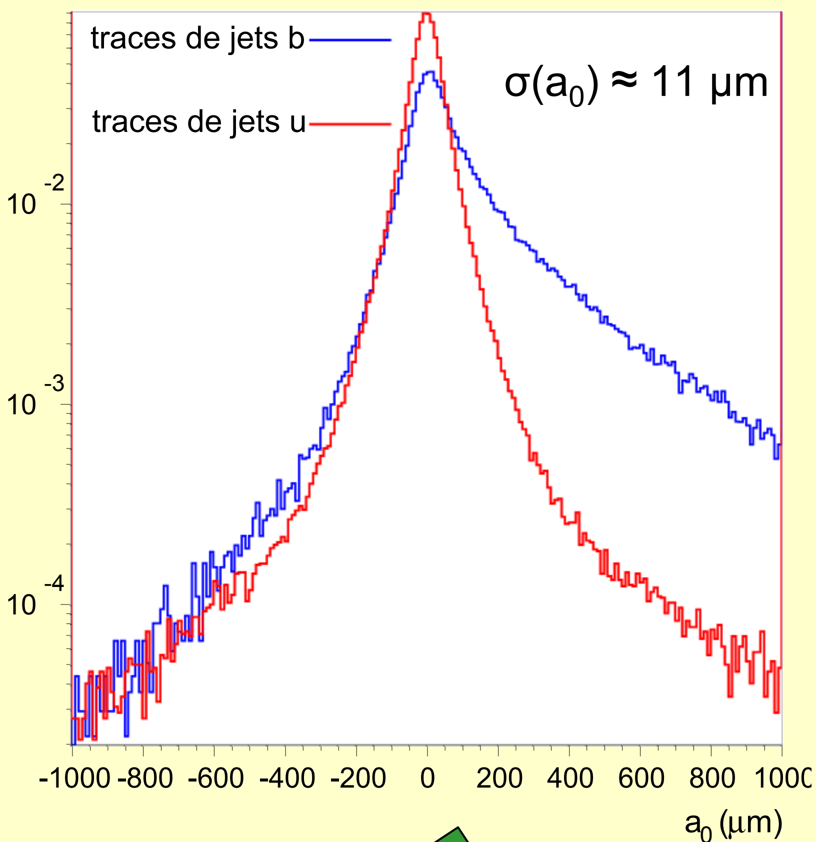
Space b-tagging

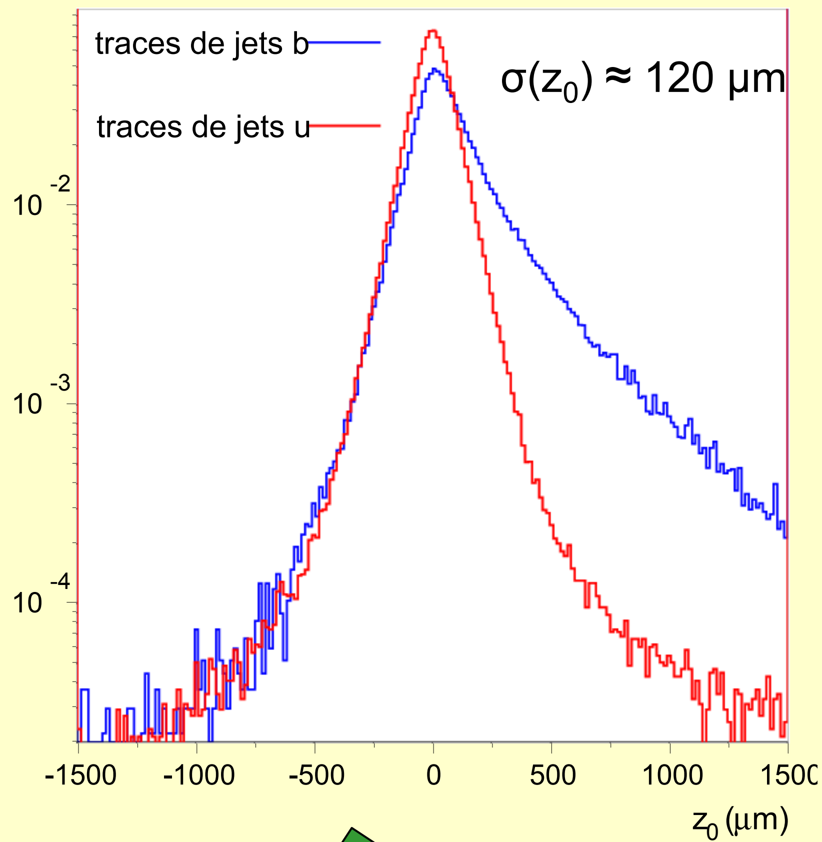
Efficiency of b-jet tagging ε_b

Rejection of light jets (udscg) $R_j = 1./\varepsilon_i$



Impact parameters



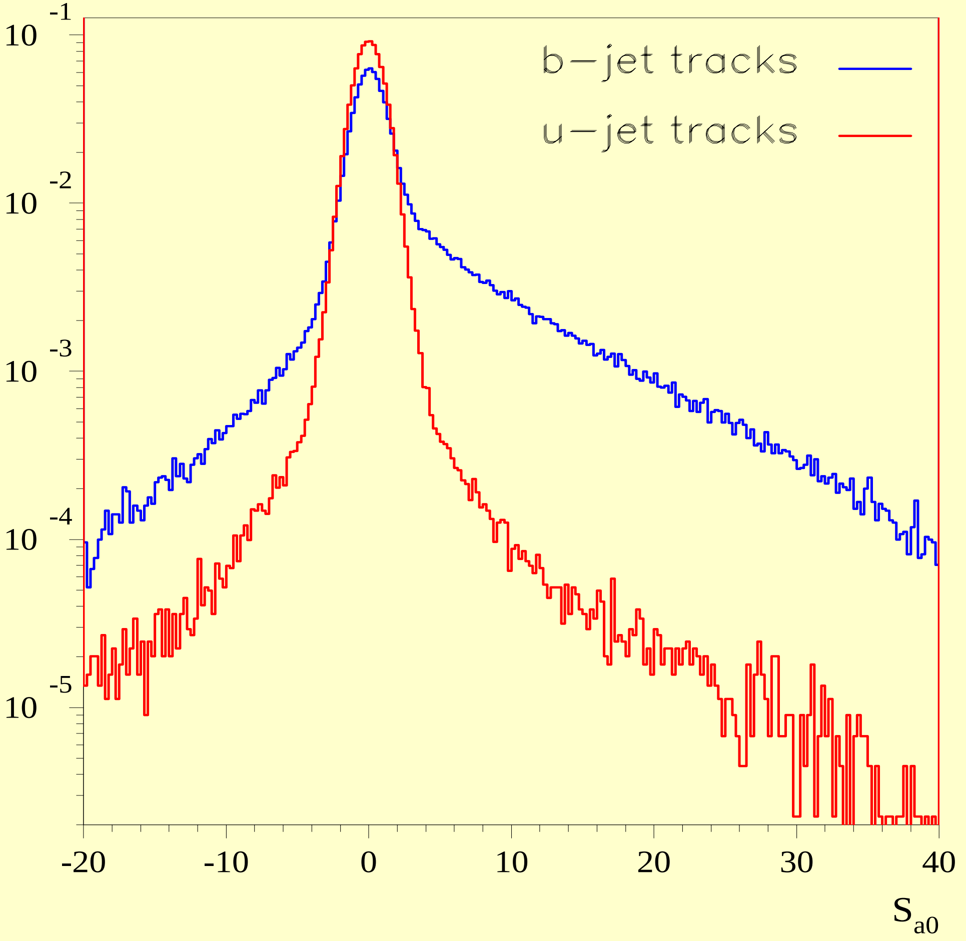


Transverse (2D)

3DMethod

Longitudinal (+1D)

Normalized Impact Parameter



$$S(a_0) = \frac{a_0}{\sigma(a_0)}$$

Smoothed distributions

↓

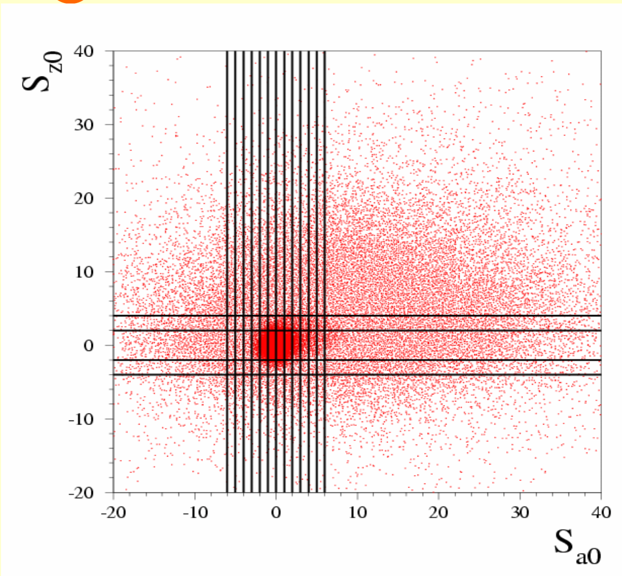
Probability density functions b(S) and u(S)

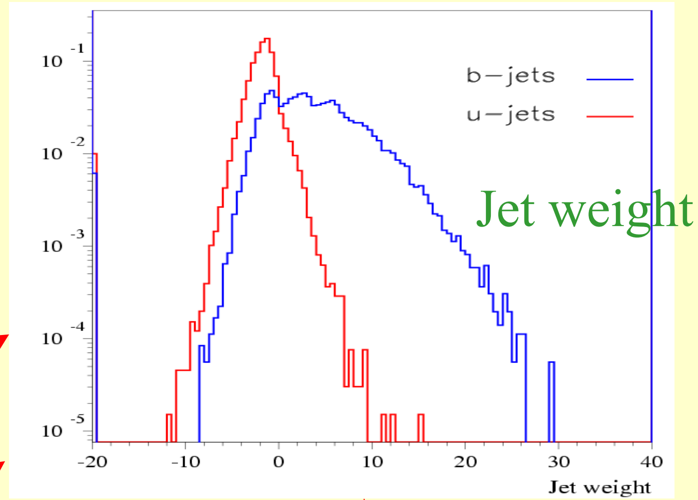
jet weight :

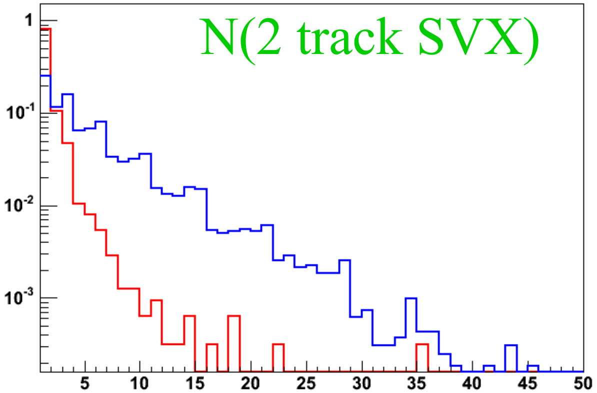
$$W_{jet} = \sum_{tracks} \ln\left(\frac{b(S)}{u(S)}\right)$$

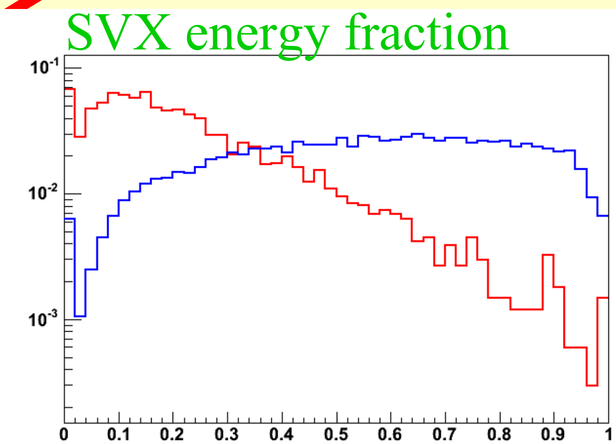
b-tagging and its uses at high p_T (LHC)

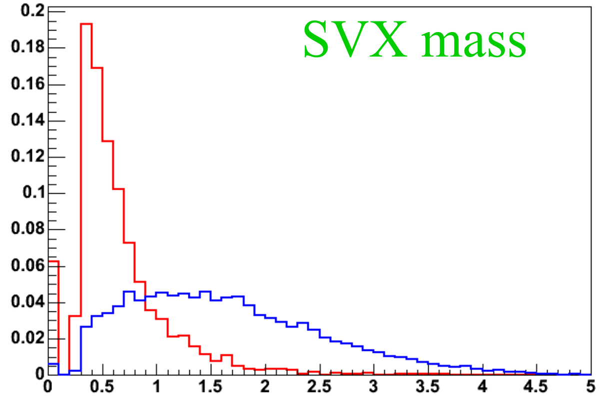
Space and vertex b-tagging







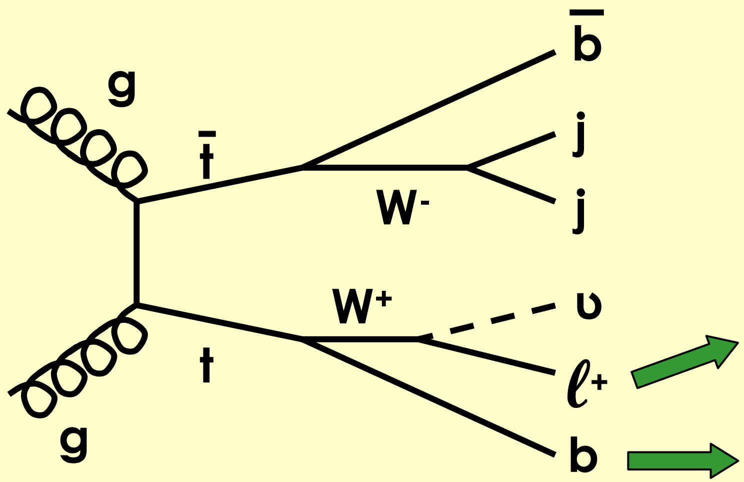




Studies of top physics with t-> bW

- top mass
- top cross-section
- top polarization

σ_{incl}=833 pb
Rate ~ $2.5x10^6$ evts /year



* : ℓ = e ou μ

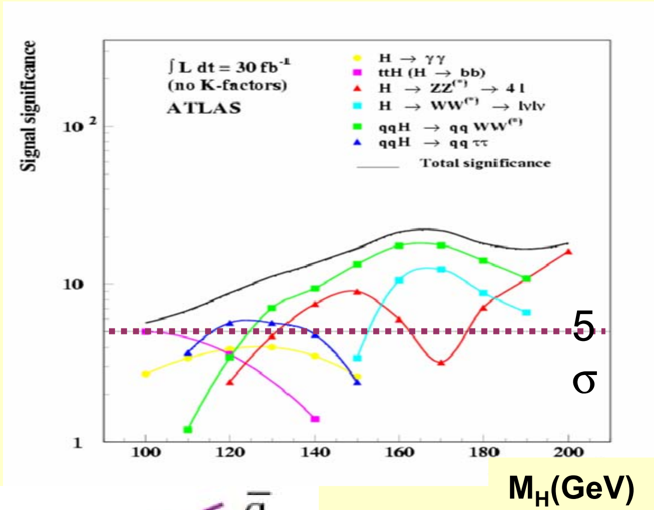
sélect this jet

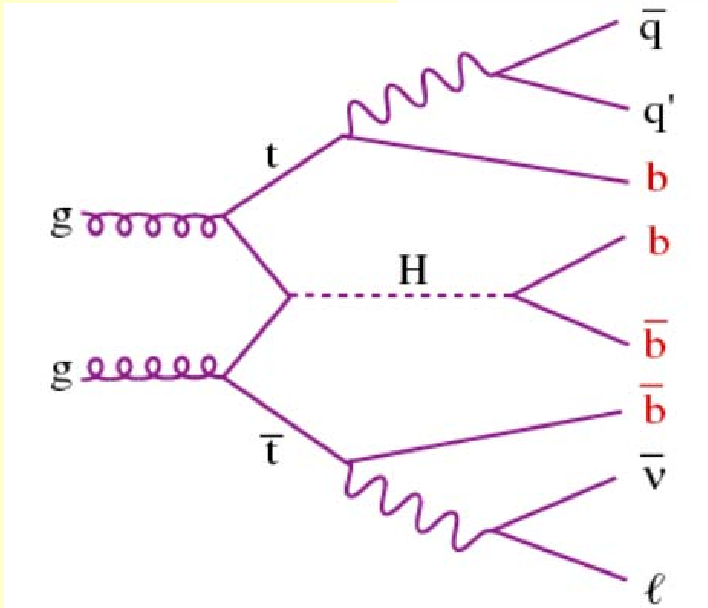
Calibration of b-tagging with tt events

b-tagging for SM Higgs

b-tagging role in:

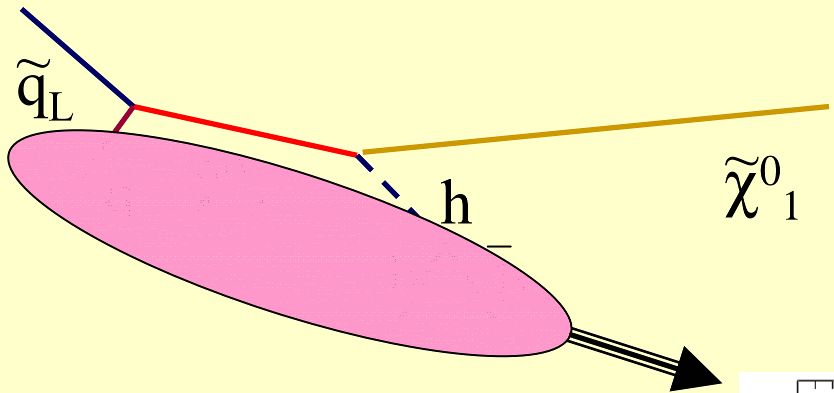
- **Discovery channel**
  - **ttH with H-> bb**
- **Supplementary channels**
  - **WH with H-> bb**
  - **ttH with H-> WW***
- **Background channels**
  - **ttjj**
  - **ttbb**

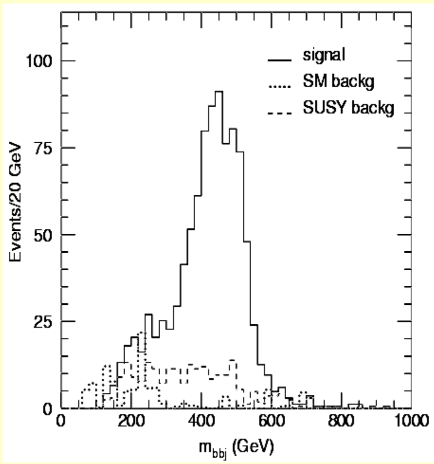




b-tagging in SUSY

- **S-quark - Two b-jets in the final state with h**



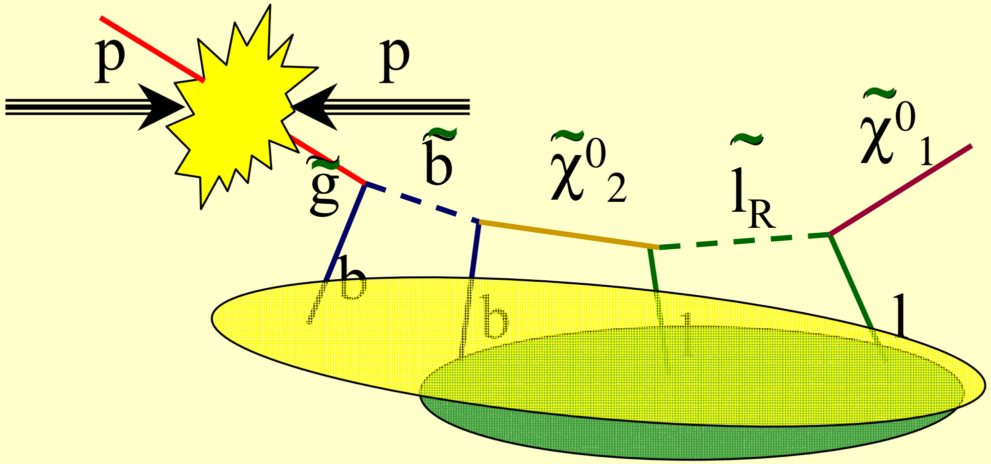


bbq edge
1% error
(100 fb^{-1})

ATLAS

b-tagging for Sbottom/Gluino Mass

- require b-tagged jet in addition to dileptons.
- sensitivity to sbottom and gluino masses.



b-tagging for SUSY Higgs

- Charged Higgs $H^{\pm}$ with $H^{\pm} \rightarrow tb$ or $H^{\pm} \rightarrow cb$ or $H^{\pm} \rightarrow bbW$
- Charged Higgs $tH^{\pm}$ with $H^{\pm} \rightarrow tb$
- Cascade Neutral Higgs $H \rightarrow h\, h \rightarrow b\, b\, b\, b$ (trigger …)
- Cascade Neutral Higgs $H \rightarrow h\, h \rightarrow b\, b\, \tau\, \tau$
- Cascade Neutral Higgs $H \rightarrow h\, h \rightarrow b\, b\, \gamma\, \gamma$
- Associated Higgs bbA/H with $H \rightarrow \tau\, \tau$
- Associated Higgs bbA/H with $H \rightarrow bb$ (trigger …)
- Cascade Neutral Higgs $A \rightarrow Z\, h$ with $Z \rightarrow \mu\, \mu$ and $h \rightarrow b\, b$
- Associated Higgs Wh with $h \rightarrow bb$
- Associated Higgs tth with $h \rightarrow bb$

SUSY – b-tagging Eldorado

Final state ttH+ttjj -> ttlν4j2b (6 jets)

ATLFAST jets, 3 layers pixel detector, no pileup, ΔR(jet-jet)=0.7

ε_b=50% R_u=320 ε_b=60% R_u=160

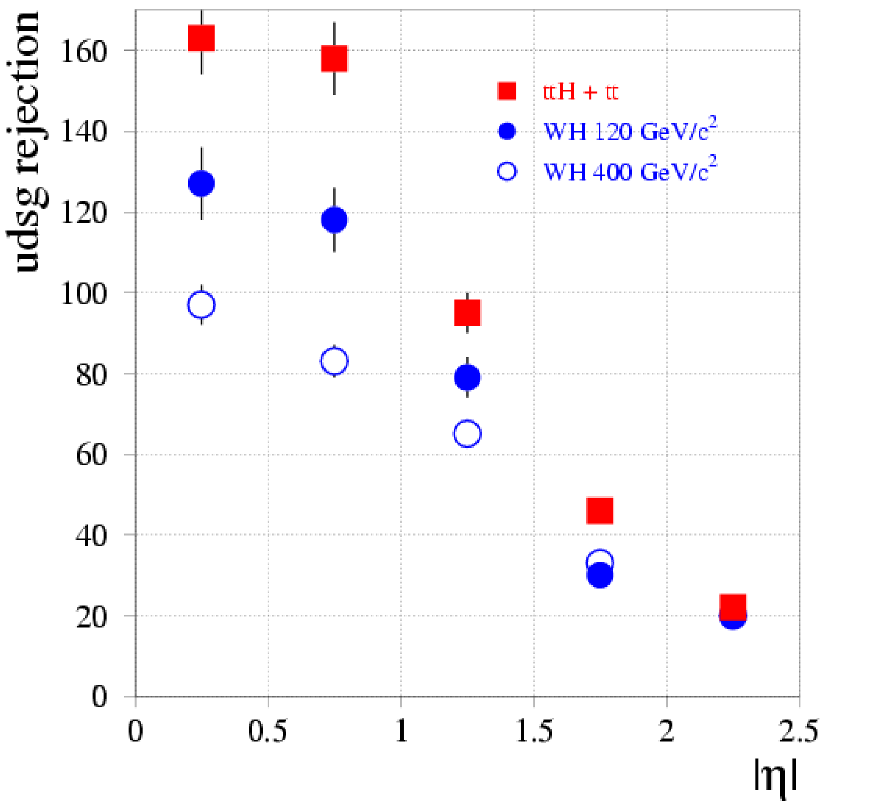
+ no b-quark in a cone ΔR=0.6 around light quark jet

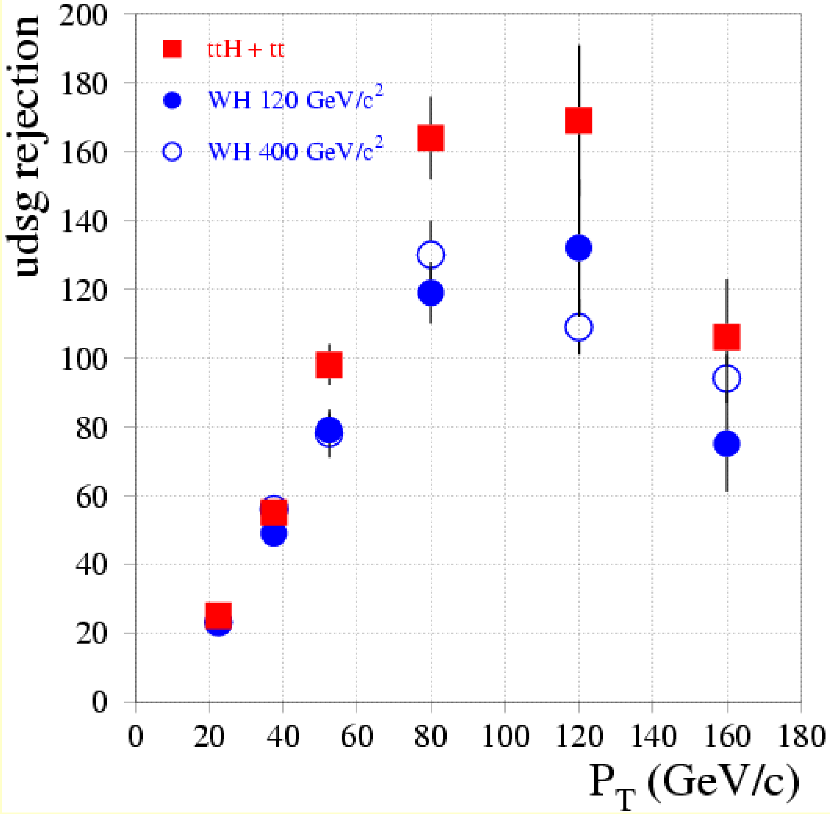
ε_b=50% R_u=2500 ε_b=60% R_u=680

b-tagging performance is limited by physics:
gluon splitting and occasional coincidence between light jet and b-quark directions.

b-tagging and its uses at high p_T (LHC)

Dependence on η and p_T

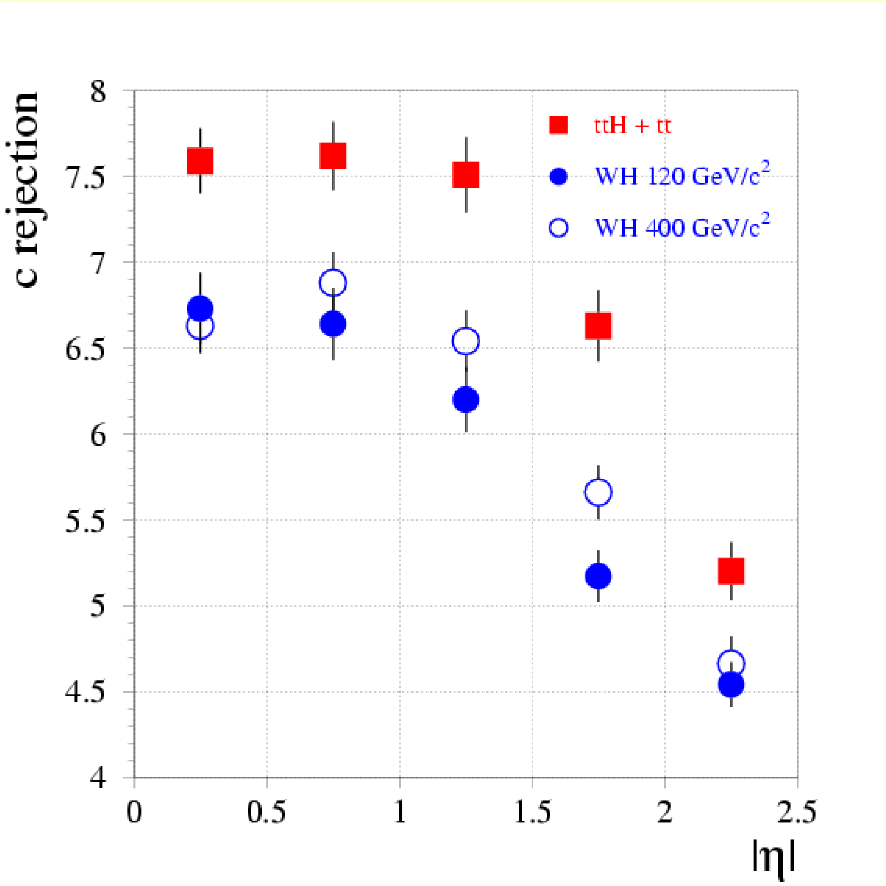


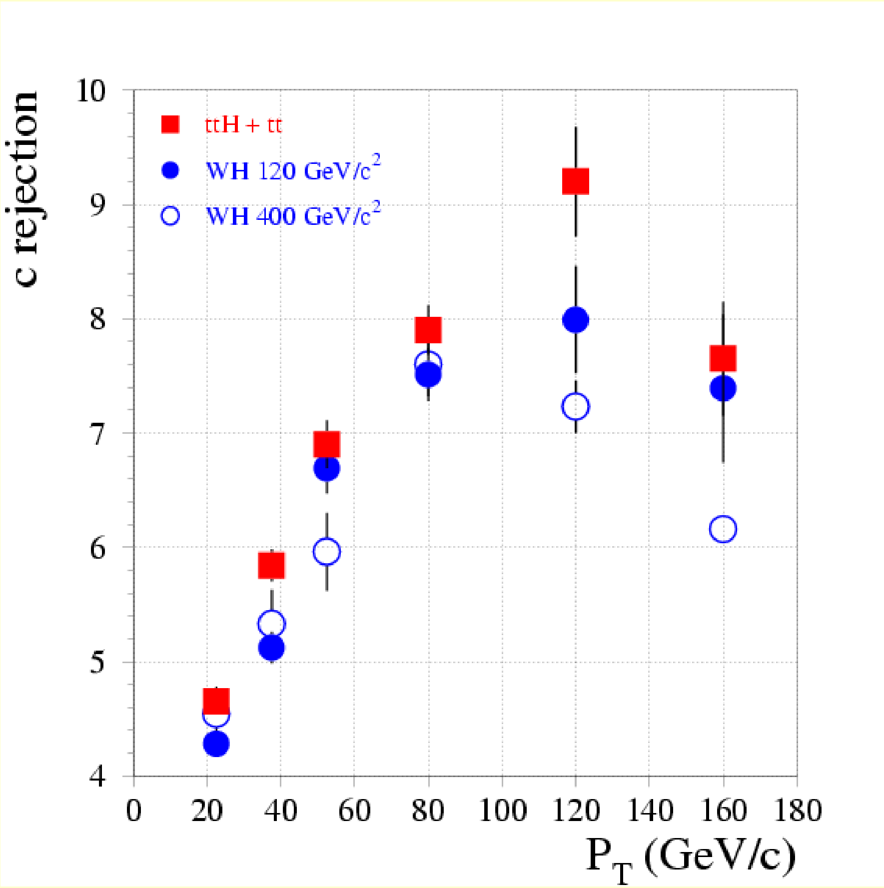


ε_b=60 %, perfect detector, 3D-method, Isolated light jets in ttH,tt

b-tagging and its uses at high p_T (LHC)

c-rejection dependence on η and p_T





3D-method

Prospective of b-tagging

- leptons in jets
- K^0 and Λ^0 impact parameters
- track quality classification
- multiple secondary vertices
- η and p_T dependences of pdf
- hope to reach ε_b=70 % with R_u=100

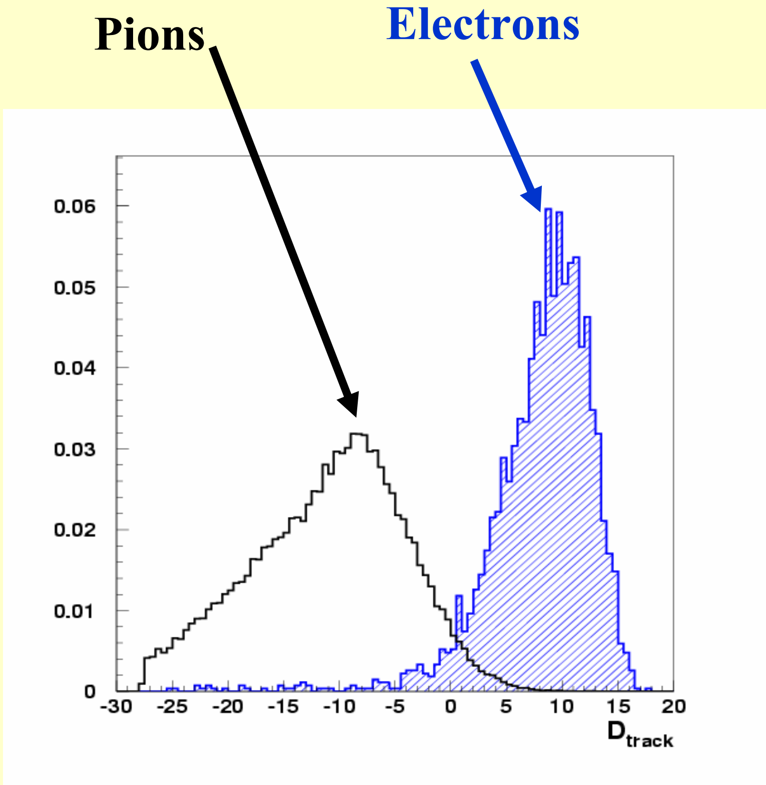
Soft electron b-tagging

- b-jet tagging based on B->D->eX

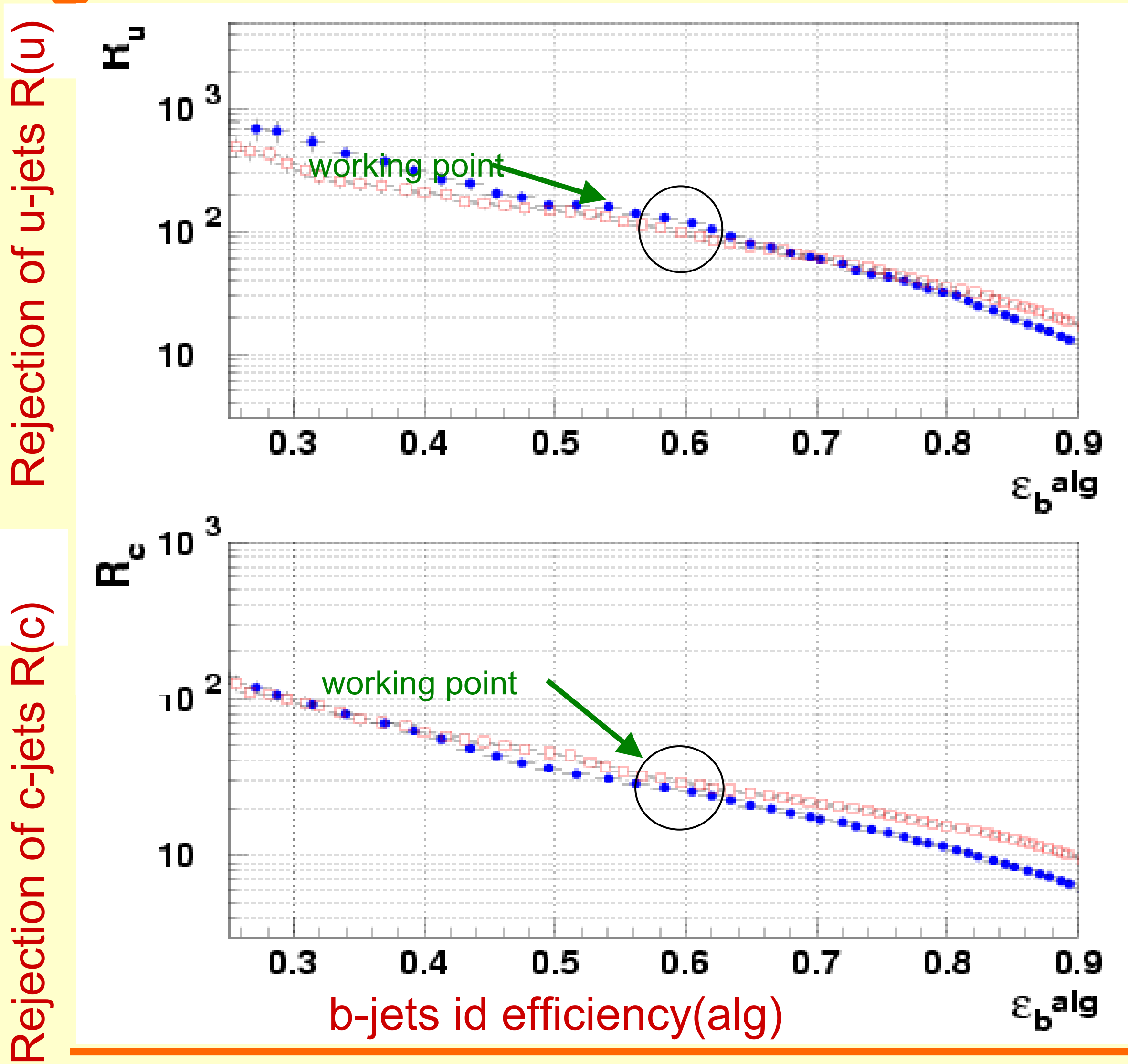
- choose the track with biggest electron-id weight inside the jet

- declare as b-jets if the weight is above the threshold

- Efficiency for b-jets with electrons (~10 % branching ratio) of p_T > 2 GeV/c



Rejection with electron b-tagging



- **Rejection of jets for 60% of algorithm efficiency**
- **Ru = 98 ± 8**
- **Rc = 29 ± 2**

With conversion package:

- **Ru = 110 ± 8**
- **Rc = 29 ± 2**

Commissioning Detector Scenario

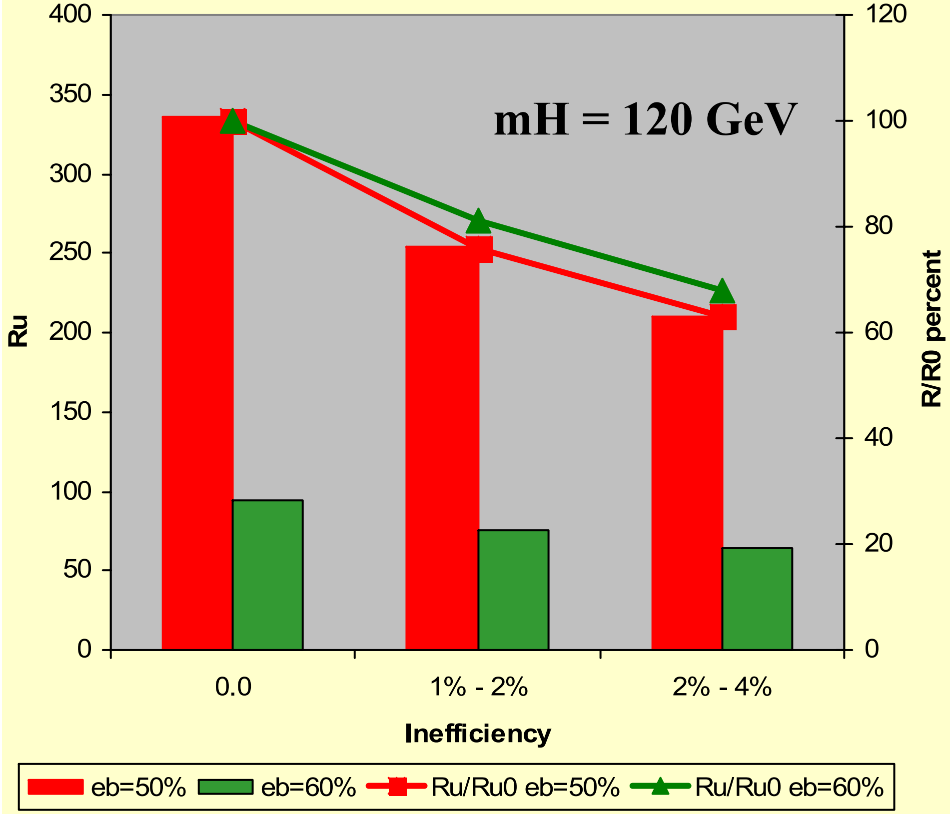
Initial ATLAS in DC1 layout (2 barrel pixels, 2 pixel disks, no TRT C-wheels)

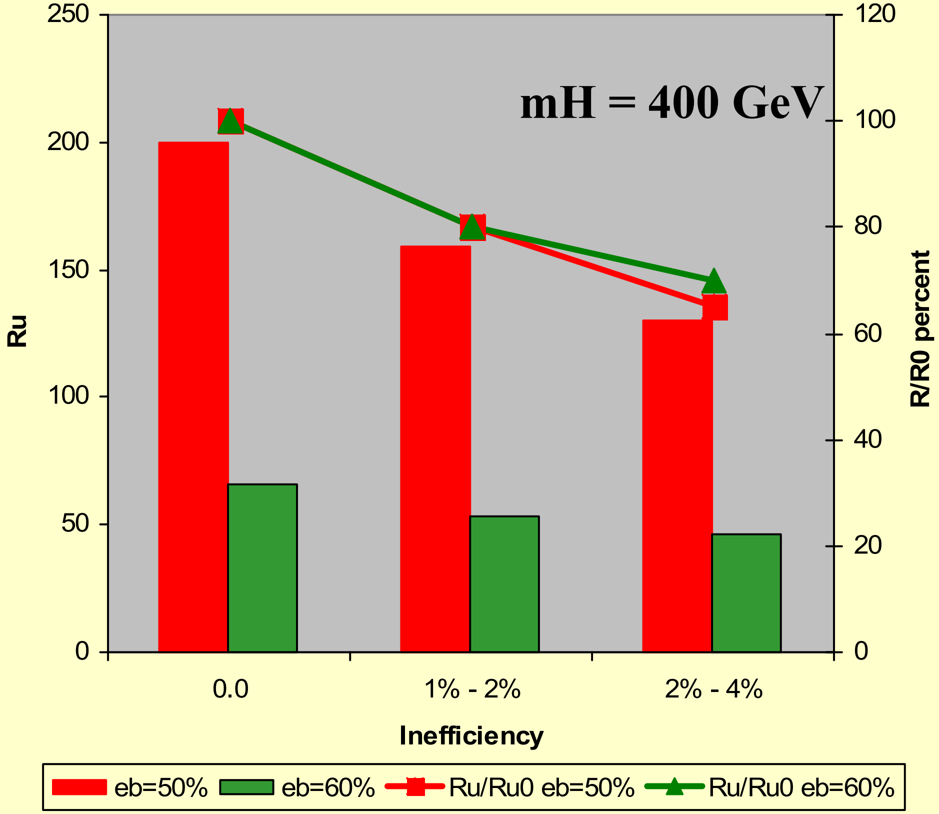
- **default inefficiency from the start-up 3% pixels, 2% chips, 1% modules**
- **b-layer inefficiency 1% chips, 0.5% modules**
- **but systematic error big, 2/4 % inefficiencies to be considered**
- **Pixel-SCT alignment after 3 months $\sigma_{R\varphi}$=20 μm , σ_z=60 μm**
- **Pixel-SCT alignment after 6 months $\sigma_{R\varphi}$=10 μm , σ_z=30 μm**
- **Pixel-SCT alignment after 9 months $\sigma_{R\varphi}$= 5 μm , σ_z=15 μm**
- **Direct simulations needed to prove the feasibility of this scenario**

Influence of inefficiencies with WH

WH events, no pile-up, 2 pixel layers, 3D method

- WH → μν bb - effect
- H → uu - used as "background"





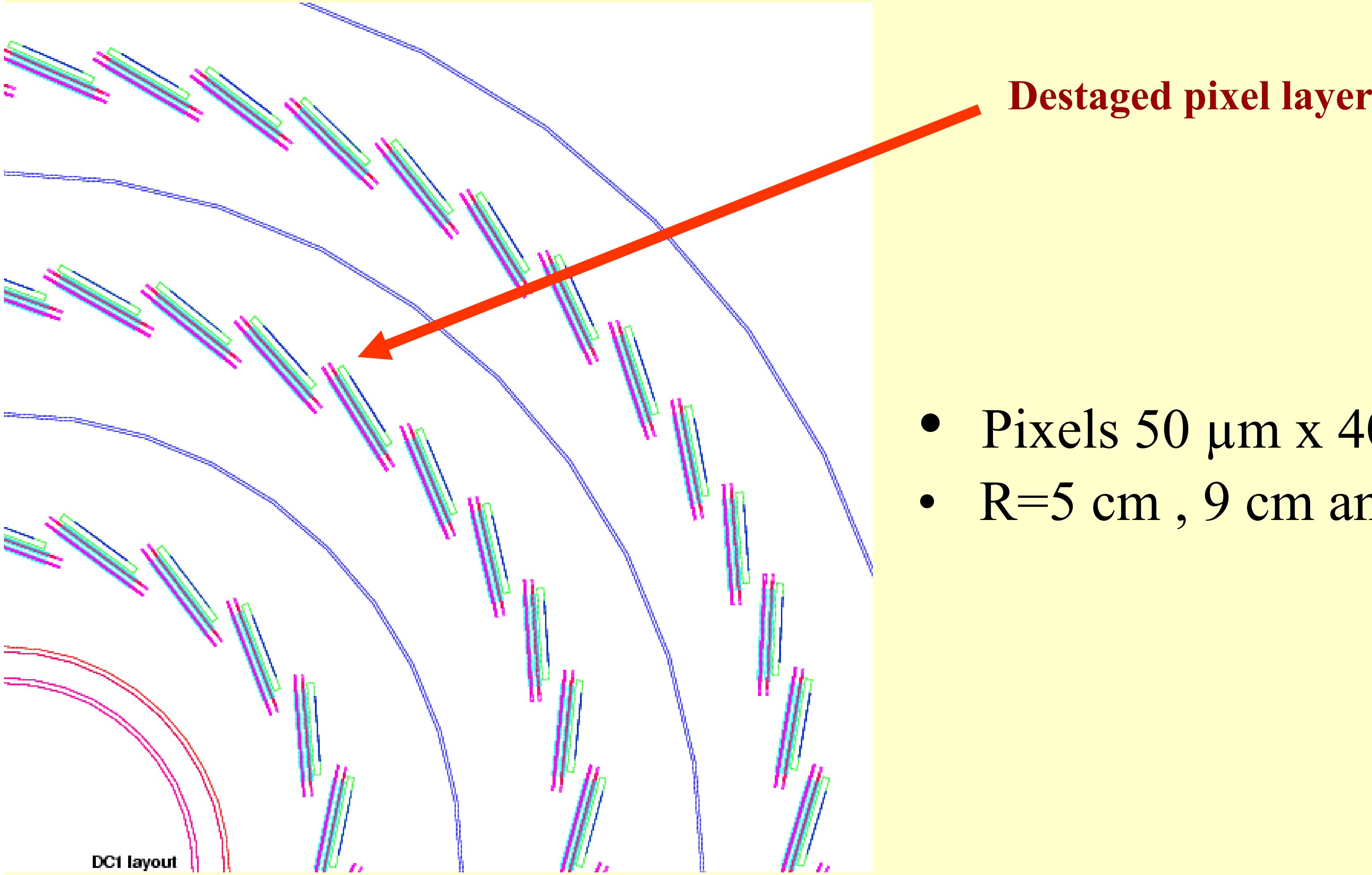
Influence of alignment with ttH

- ttH+tt events, mH=120 GeV
- Low luminosity pile-up L=2 10 ^{33} cm^{2} s^{-1}
- Initial layout, 400 μm b-layer z-pitch
- 3D b-tagging method
- Inefficiency module/chips b-layer 0.5%/1.0%, others 1%/2%
- Specification of pixel alignment $\sigma_{R\varphi}$=5 μm σ_z=10 μm
- Specification of silicon strips tracker alignment $\sigma_{R\varphi}$=12 μm σ_z=50 μm

Influence of alignment with ttH(120)/ttjj

Period	Precision		R_u	R/R_0
3 months	$\sigma_{R\varphi}$=20 μm σ_z=60μm	ε_b=50%	175 ±4	0.67
		ε_b=60%	57 ±1	0.71
6 months	$\sigma_{R\varphi}$=10 μm σ_z=30 μm	ε_b=50%	237 ±7	0.91
		ε_b=60%	74 ±1	0.92
9 months	$\sigma_{R\varphi}$=5 μm σ_z=15 μm	ε_b=50%	259 ±8	0.99
		ε_b=60%	79 ±1	0.97
ideal	$\sigma_{R\varphi}$=0 μm σ_z=0 μm	ε_b=50%	262 ±8	1.
		ε_b=60%	81 ±1	1.

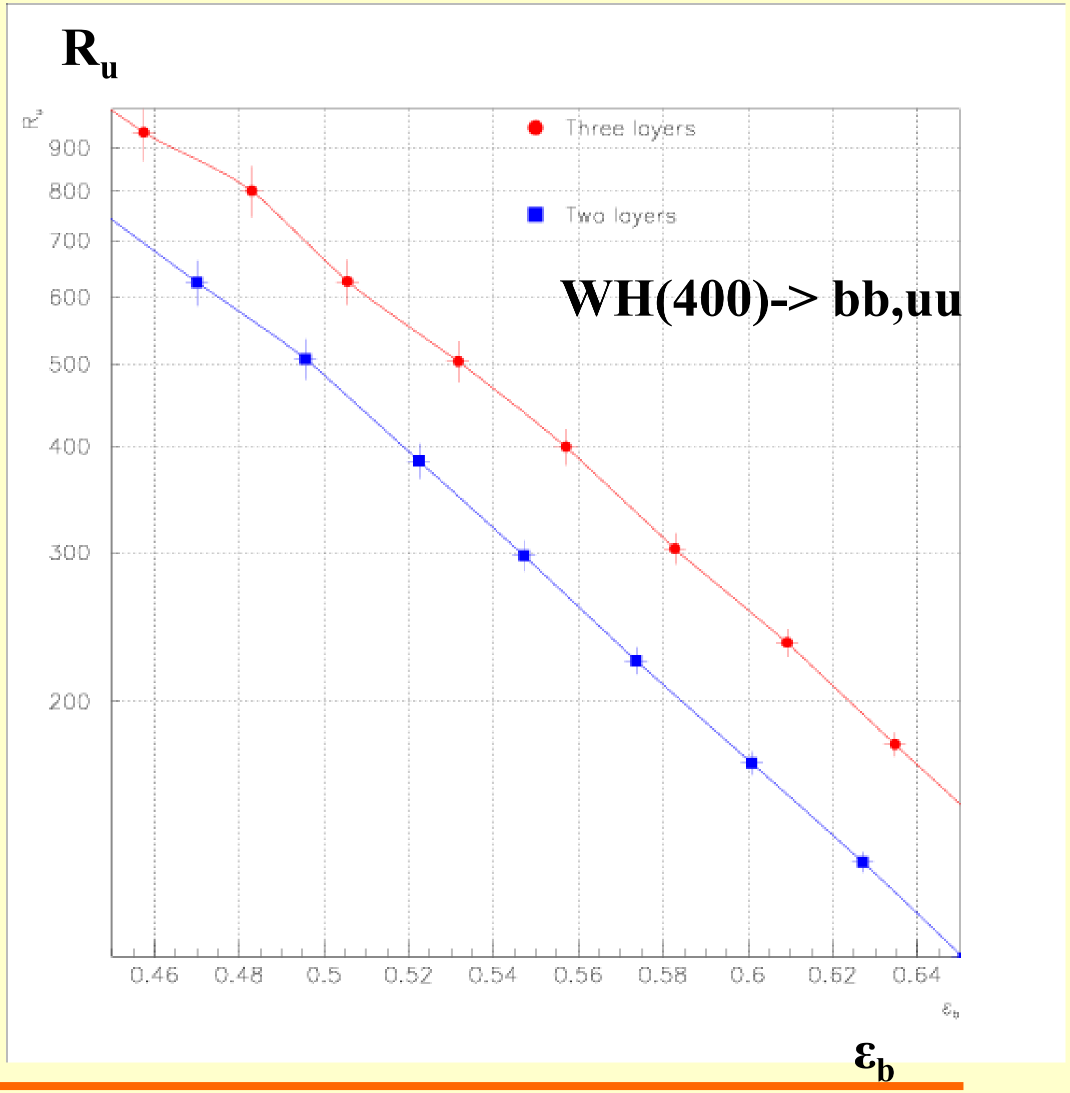
Pixels ATLAS



- Pixels 50 μm x 400 μm
- R=5 cm , 9 cm and 12 cm

ATLAS without one pixel layer

- default inefficiency 3 % pixels, 2 % chips, 1 % modules
- b-layer 1 % chips, 0.5% modules
- 400 µm b-layer z-pitch
- Reconstructed primary vertex
- low luminosity pile-up
- DC1 datasets:
- WH(120,400)-> bb,uu
- ttH-> bb - signal
- ttjj -> b l ν b jjjj -background



Two versus three pixel layers summary

Light jet rejection R_{udsg} for 60% b-jet tagging efficiency

Process	2 -layers	3 -layers	$R_{3/2}$
WH(120) SV	131 ± 3	164 ± 6	1.25
WH(400) SV	170 ± 5	257 ± 10	1.51
ttH(120)/ttjj 3D	81 ± 1	119 ± 2	1.47

Two versus three pixel layers summary

Light jet rejection R_{udsg} for 60% b-jet tagging efficiency, $\Delta R_{jj} > 0.8$, $\Delta R_{jbquark} > 0.8$, calibration for Initial layout

Process	2 –layers, Initial	3 -layers	$R_{3/2}$
ttH(120)/ttjj 3D	135 ± 4	220 ± 8	1.63
ttH(120)/ttjj SV1	418 ± 22	686 ± 46	1.64
ttH(120)/ttjj SV2	392 ± 20	659 ± 43	1.68

Conclusions

- b-tagging is essential to reach new physics at LHC
- Excellent b-tagging performance in ideal LHC detectors
- "Devil" is in the performance of the real detector
- Realistic studies show acceptable performance R_u~150 at ε_b=60 %
- Low luminosity pile-up degrade by 2-5%
- High luminosity pile-up give 10-20% degradation if lepton can not be used for selection of primary vertex

Conclusions

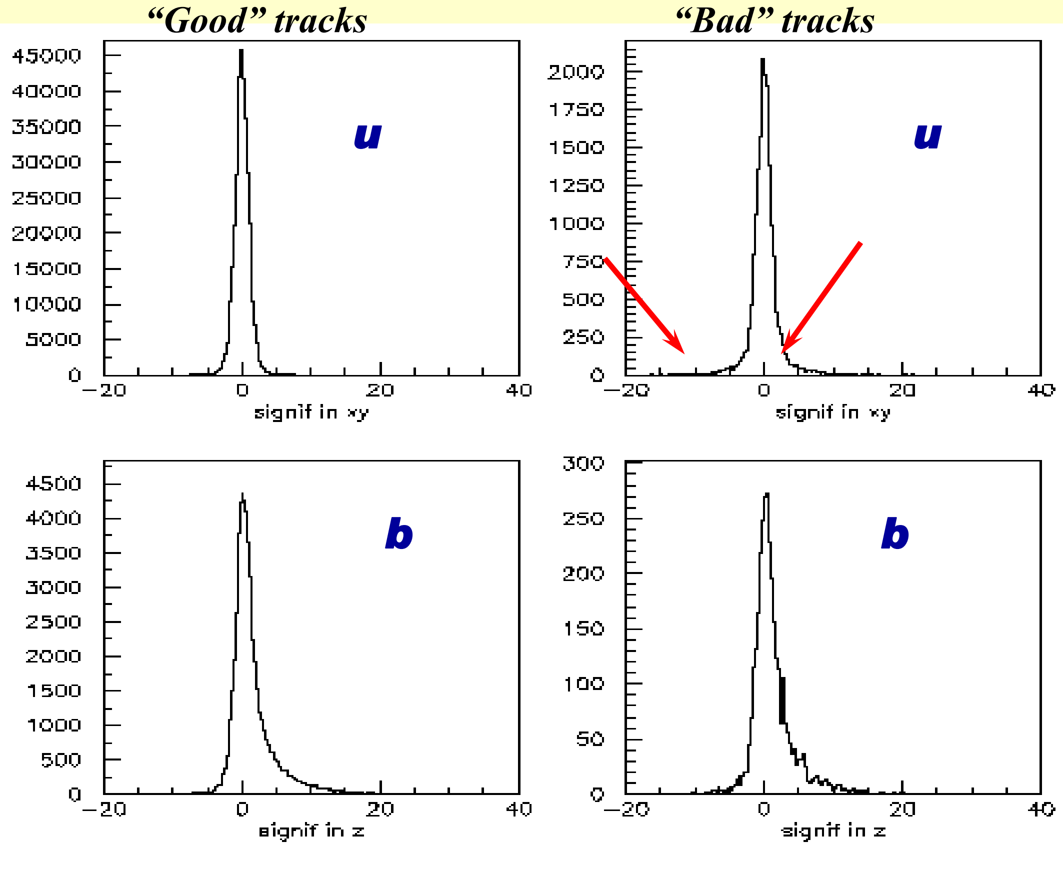
- Loss of (15 ± 15)% due to inefficiencies
- Loss of 30 % b-tagging for 20 μm alignment
- Almost final b-tagging for 5 μm alignment
- Extra pixel layer give the gain of ~1.5 in b-tagging

Additional material

Bad tracks

Bad tracks if one of conditions:

- **one shared hit in b-layer**
- **one shared hit in pixels**
- **two shared hits in SCT**
- **one ambiguous hit in b-layer**



Influence of bad tracks on ttH/ttjj events

ttH/ttjj events, mH=120 GeV, with pile-up, 2 pixel layers Initial layout, b-layer 400 µm,

inefficiencies modules/chips 1-2 % , b-layer inef. 0.5-1.0 %

b- from ttH, u- from ttjj, ATLFAST jets, reconstructed vertex , SV1 method

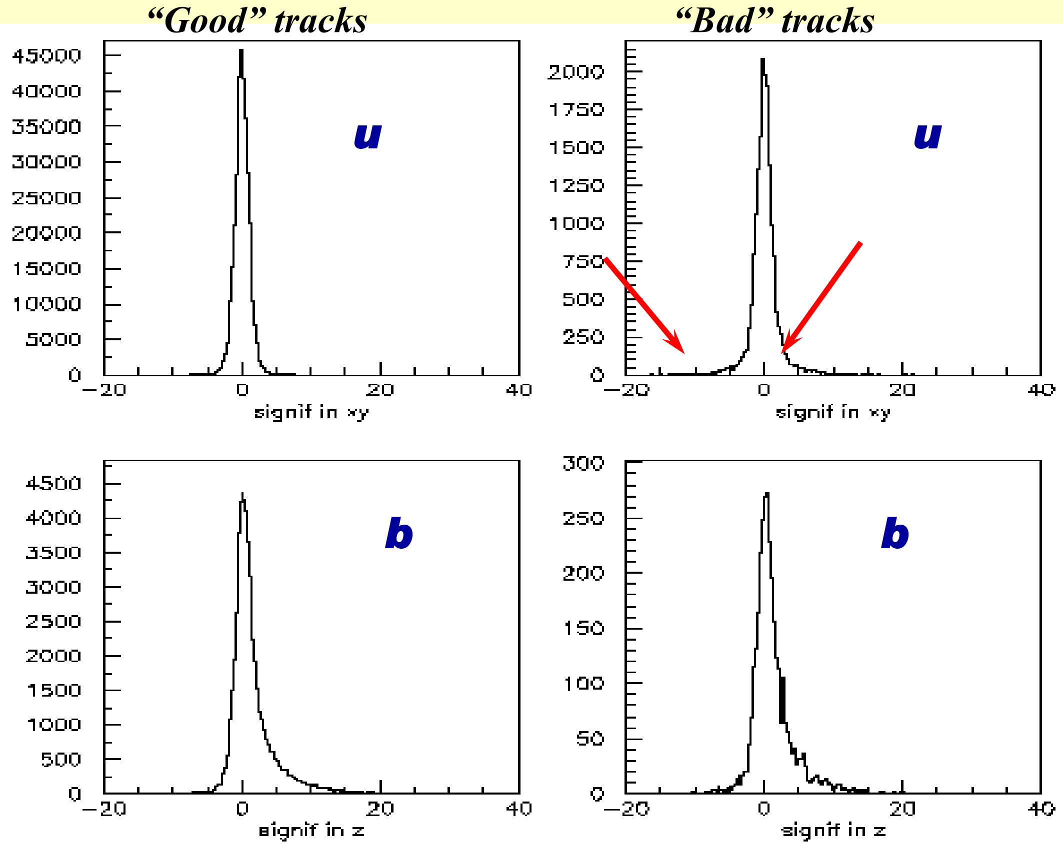
$\Delta R_{jj} > 0.8$, $\Delta R_{jbquark} > 0.8$

	No bad tracks	With bad tracks	$R_{with/no}$
R_u ε_b=50%	1635 ± 169	1693 ± 178	1.04
ε_b=60%	386 ± 19	418 ± 22	1.08
ε_b=70%	75 ± 2	79 ± 2	1.05

Bad tracks

Bad tracks if one of conditions:

- **one shared hit in b-layer**
- **one shared hit in pixels**
- **two shared hits in SCT**
- **one ambiguous hit in b-layer**



Influence of bad tracks on ttH/ttjj events

ttH/ttjj events, mH=120 GeV, with pile-up, 2 pixel layers Initial layout, b-layer 400 µm,

inefficiencies modules/chips 1-2 % , b-layer inef. 0.5-1.0 %

b- from ttH, u- from ttjj, ATLFAST jets, reconstructed vertex , SV1 method

$\Delta R_{jj} > 0.8$, $\Delta R_{jbquark} > 0.8$

	No bad tracks	With bad tracks	$R_{with/no}$
R_u ε_b=50%	1635 ± 169	1693 ± 178	1.04
ε_b=60%	386 ± 19	418 ± 22	1.08
ε_b=70%	75 ± 2	79 ± 2	1.05

Data sample of ttH/ttjj events for C-wheels

ttH/ttjj events, mH=120 GeV, with pile-up, 2 pixel layers Initial layout, b-layer 400 µm,

inefficiencies modules/chips 1-2 % , b-layer inef. 0.5-1.0 %

b- from ttH, u- from ttjj, ATLFAST jets, reconstructed vertex ,

$\Delta R_{jj} > 0.8$, $\Delta R_{jbquark} > 0.8$, eta > 1.8

3D-method for c-Wheels and 2nd pixel disk

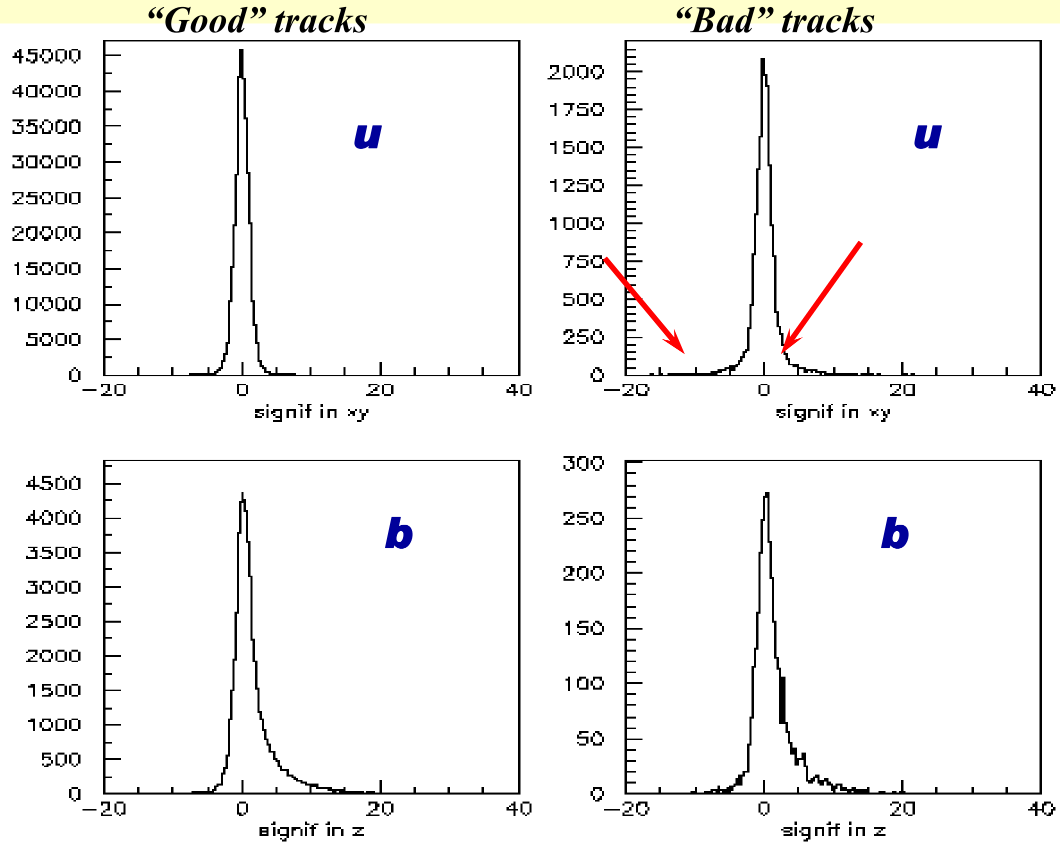
3D method

	No TRT C-wheels No pixel disk-2	With TRT C-wheels	$R_{with/no}$
R_u ε_b=50%	86 ± 4	101 ± 6	1.17
ε_b=60%	30 ± 1	38 ± 1	1.28
ε_b=70%	11 ± 0.2	6 ± 0.1	0.59

Bad tracks

Bad tracks if one of conditions:

- **one shared hit in b-layer**
- **one shared hit in pixels**
- **two shared hits in SCT**
- **one ambiguous hit in b-layer**



Influence of bad tracks on ttH/ttjj events

ttH/ttjj events, mH=120 GeV, with pile-up, 2 pixel layers Initial layout, b-layer 400 μm,

inefficiencies modules/chips 1-2 % , b-layer inef. 0.5-1.0 %

b- from ttH, u- from ttjj, ATLFAST jets, reconstructed vertex , SV1 method

$\Delta R_{jj} > 0.8$, $\Delta R_{jbquark} > 0.8$

	No bad tracks	With bad tracks	$R_{with/no}$
R_u ε_b=50%	1635 ± 169	1693 ± 178	1.04
ε_b=60%	386 ± 19	418 ± 22	1.08
ε_b=70%	75 ± 2	79 ± 2	1.05

Data sample of ttH/ttjj events for C-wheels

ttH/ttjj events, mH=120 GeV, with pile-up, 2 pixel layers Initial layout, b-layer 400 µm,

inefficiencies modules/chips 1-2 % , b-layer inef. 0.5-1.0 %

b- from ttH, u- from ttjj, ATLFAST jets, reconstructed vertex ,

$\Delta R_{jj} > 0.8$, $\Delta R_{jbquark} > 0.8$, eta > 1.8

3D-method for c-Wheels and 2nd pixel disk

3D method

	No TRT C-wheels No pixel disk-2	With TRT C-wheels	$R_{with/no}$
R_u ε_b=50%	86 ± 4	101 ± 6	1.17
ε_b=60%	30 ± 1	38 ± 1	1.28
ε_b=70%	11 ± 0.2	6 ± 0.1	0.59

SV2 method for C-wheels and 2nd pixel disk

SV2 method

	No TRT C-wheels, no pixel disk-2	With TRT C-wheels	$R_{with/no}$
R_u ε_b=50%	223 ± 18	262 ± 23	1.17
ε_b=60%	52 ± 2	69 ± 3	1.32
ε_b=70%	13 ± 0.3	21± 0.5	1.56

Influence of inefficiencies with WH (120)

WH events, mH=120 GeV, no pile-up, 2 pixel layers, 3D method

Module/chip 1-ε	0.	1%/2%	2%/4%
R_u ε_b=50%	336 ± 14	254 ± 9	210 ± 7
ε_b=60%	94 ± 2	76 ± 1	64 ± 1
R/R_0 ε_b=50%	1.	0.76	0.63
ε_b=60%	1.	0.81	0.68

Influence of inefficiencies with WH(400)

WH events, mH=400 GeV, no pile-up, 2 pixel layers, 3D method

Module/chip 1-ε	0.	1%/2%	2%/4%
R_u ε_b=50%	200 ± 7	159 ± 5	130 ± 4
ε_b=60%	66 ± 1	53 ± 1	46 ± 1
R/R_0 ε_b=50%	1.	0.80	0.65
ε_b=60%	1.	0.80	0.70

Influence of inefficiencies with ttH(120)

ttH +tt events, mH=120 GeV, low lumi pile-up, Initial, 400 µm b-layer, 3D method

Module/chip 1-ε	0.	b-layer 0.5%/1%	all 1%/2%
		others 1%/2%	
R_u ε_b=50%	346 ± 12	278 ± 9	261 ± 8
ε_b=60%	97 ± 2	84 ± 1	79 ± 1
R /R_0 ε_b=50%	1.	0.80	0.75
ε_b=60%	1.	0.87	0.81