Update on the Jet Cross Section Ratio: $\sigma(pp \rightarrow n\ njets+X\ n \geq 3) / \sigma(pp \rightarrow n\ njets+X\ n \geq 2)$ at 7 TeV

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Outline

- Data
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- Resolutions studies
  - η resolution studies
  - p_T resolution studies
  - H_T resolution studies
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  - R_{32} with Calo-GenJets and antikt7
  - R_{32} Comparison sisCone7-antikt7
- Trigger Studies at 7TeV
- Comparison Summer09@7TeV and 10TeV
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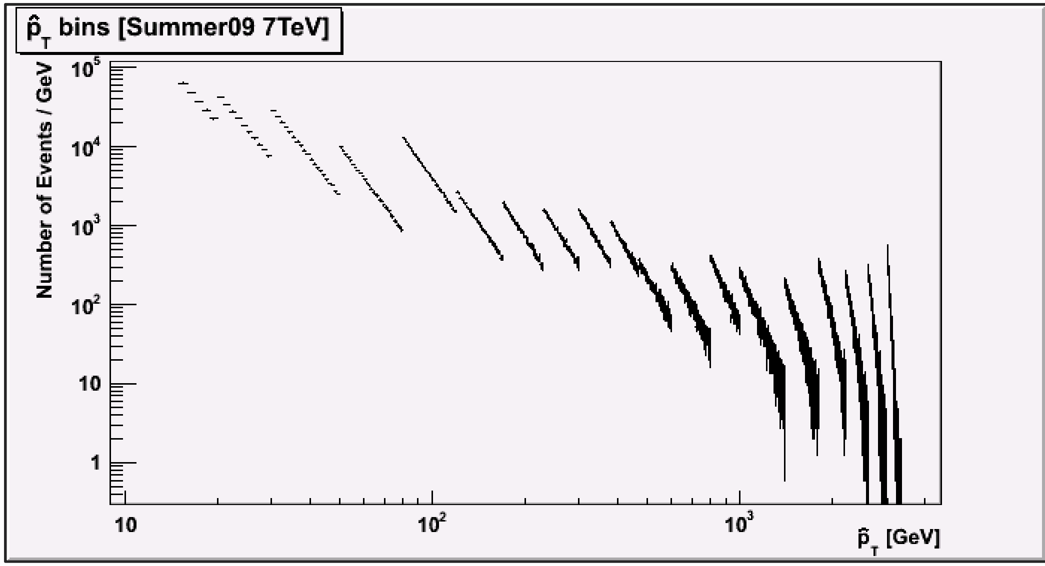
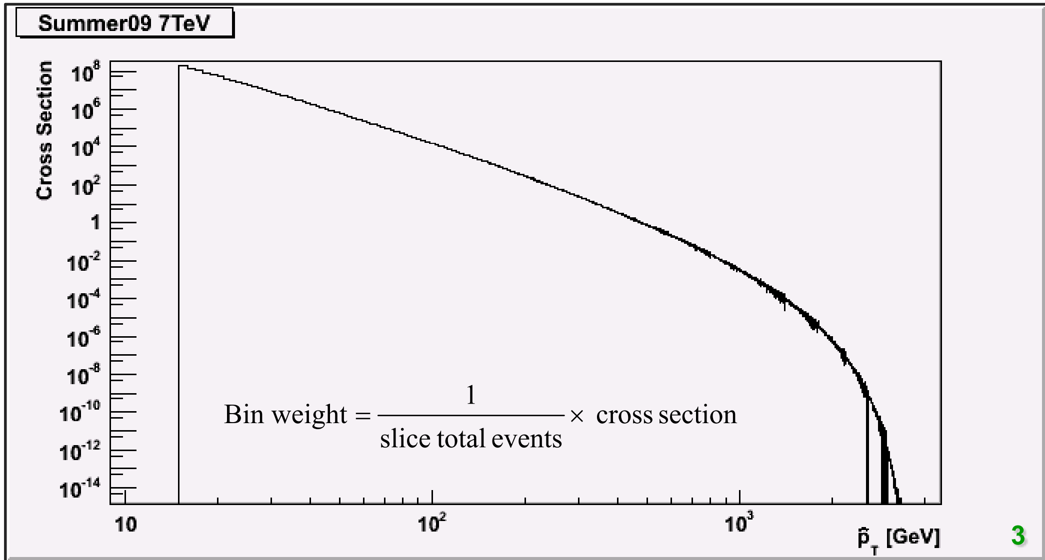
Summer09 QCDDiJet@7TeV

Analysis done using versions:

- CMSSW_3_1_4 for Jet Algo: sisCone7
- CMSSW_3_3_0 for Jet Algo: antikt7
- Jet Energy Corrections: L2L3
- Bin p_THat:0-15 GeV not used

	P_THat bin [GeV]	Number of events	Cross section [pb]	Equivalent Luminosity [pb^{-1}]
1	0-15	200000	4.844e+10	4.13e-06
2	15-20	200000	5.794e+08	3.45e-04
3	20-30	200000	2.361e+08	8.47e-04
4	30-50	200000	5.311e+07	3.77e-03
5	50-80	104821	6.358e+06	1.65e-02
6	80-120	200000	7.849e+05	0.25
7	120-170	56296	1.151e+05	0.50
8	170-230	50240	2.014e+04	2.49
9	230-300	54028	4.094e+03	13.20
10	300-380	61325	9.346e+02	65.62
11	380-470	51472	2.338e+02	220.15
12	470-600	20380	7.021e+01	290.27
13	600-800	22784	1.557e+01	1.46e+3
14	800-1000	33996	1.843e+00	1.85e+4
15	1000-1400	27624	3.318e-01	8.34e+4
16	1400-1800	20575	1.086e-02	1.89e+6
17	1800-2200	36670	3.499e-04	1.05e+8
18	2200-2600	21527	7.549e-06	2.85e+9
19	2600-3000	20792	6.465e-08	3.21e+11
20	3000-3500	23460	6.295e-11	3.73e+14



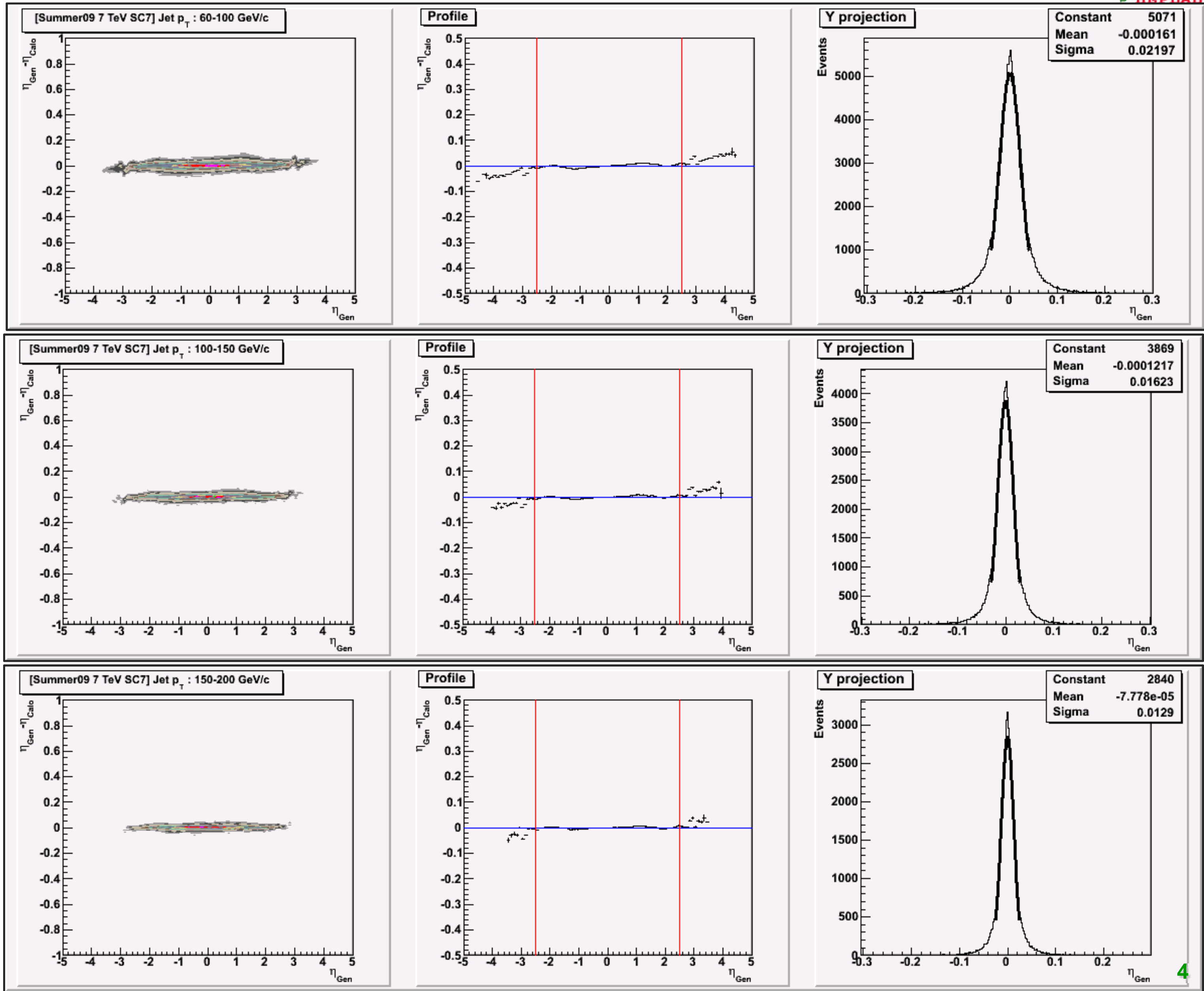


$$\text{Bin weight} = \frac{1}{\text{slice total events}} \times \text{cross section}$$

η resolution studies : Summer09 QCDDiJet@7TeV

- Plot the difference: (GenJet η – CaloJet η) vs (GenJet η)
  - For various bins of GenJet p_T

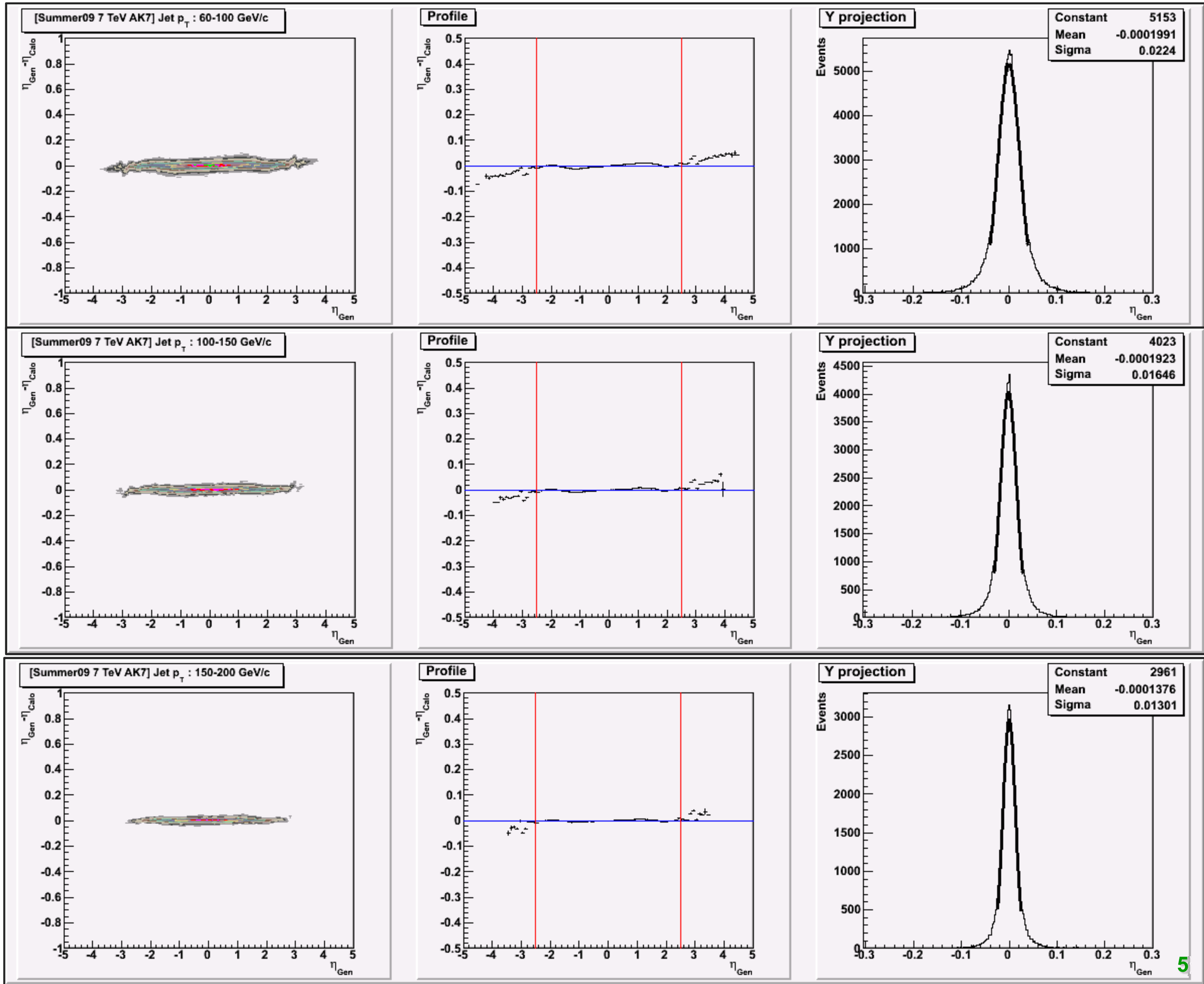
Jet Algorithm: sisCone7



η resolution studies : Summer09 QCDDiJet@7TeV

Jet Algorithm: antikt7

- Same results as with sisCone7
- Reasonable cut on |η|≤2.5

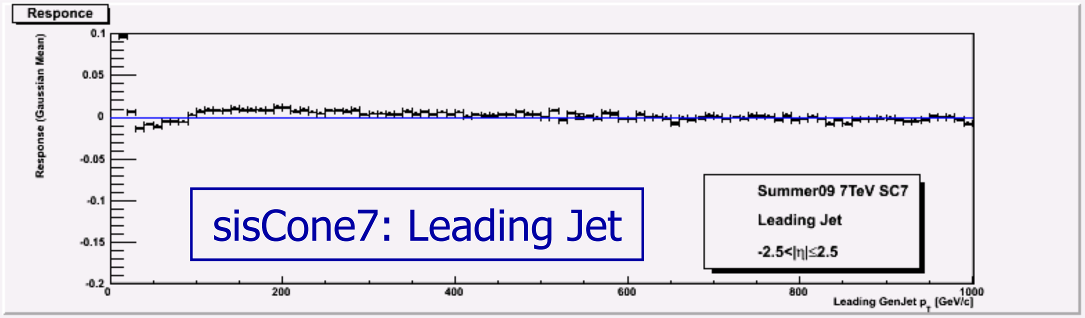


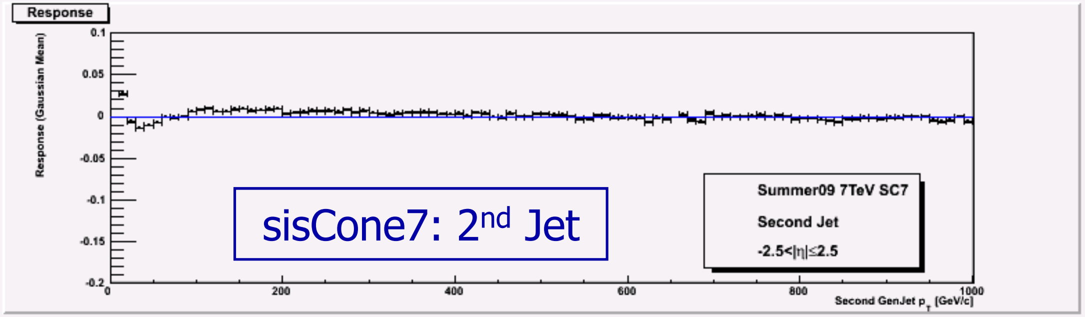
p_T resolution studies: Summer09 QCDDiJet@7TeV

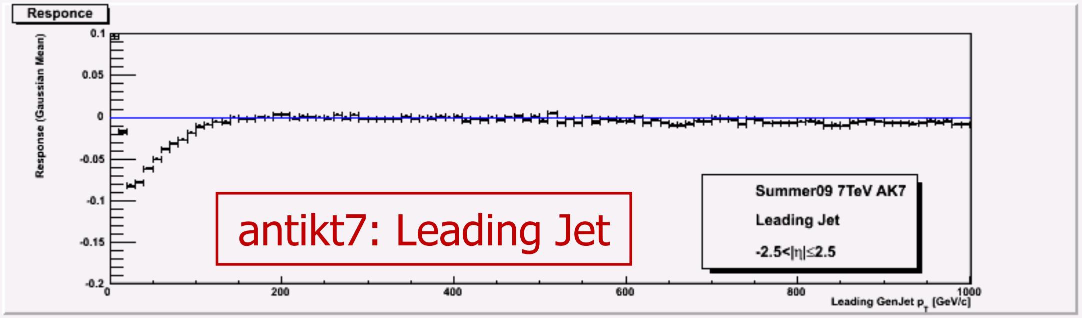
Jet p_T resolution studies at GenJet-CaloJet level:

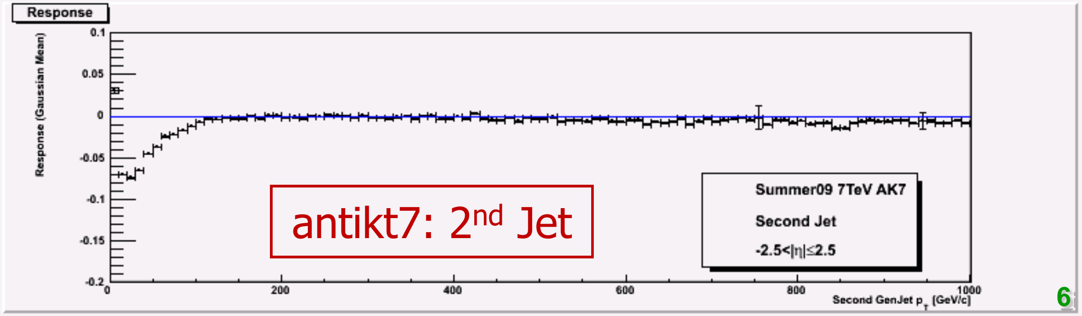
$$p_T \text{ Resolution} = \frac{\text{GenJet } p_T - \text{CaloJet } p_T}{\text{GenJet } p_T}$$

For antikt7 below 100 GeV CaloJet is overestimated by few per cent.







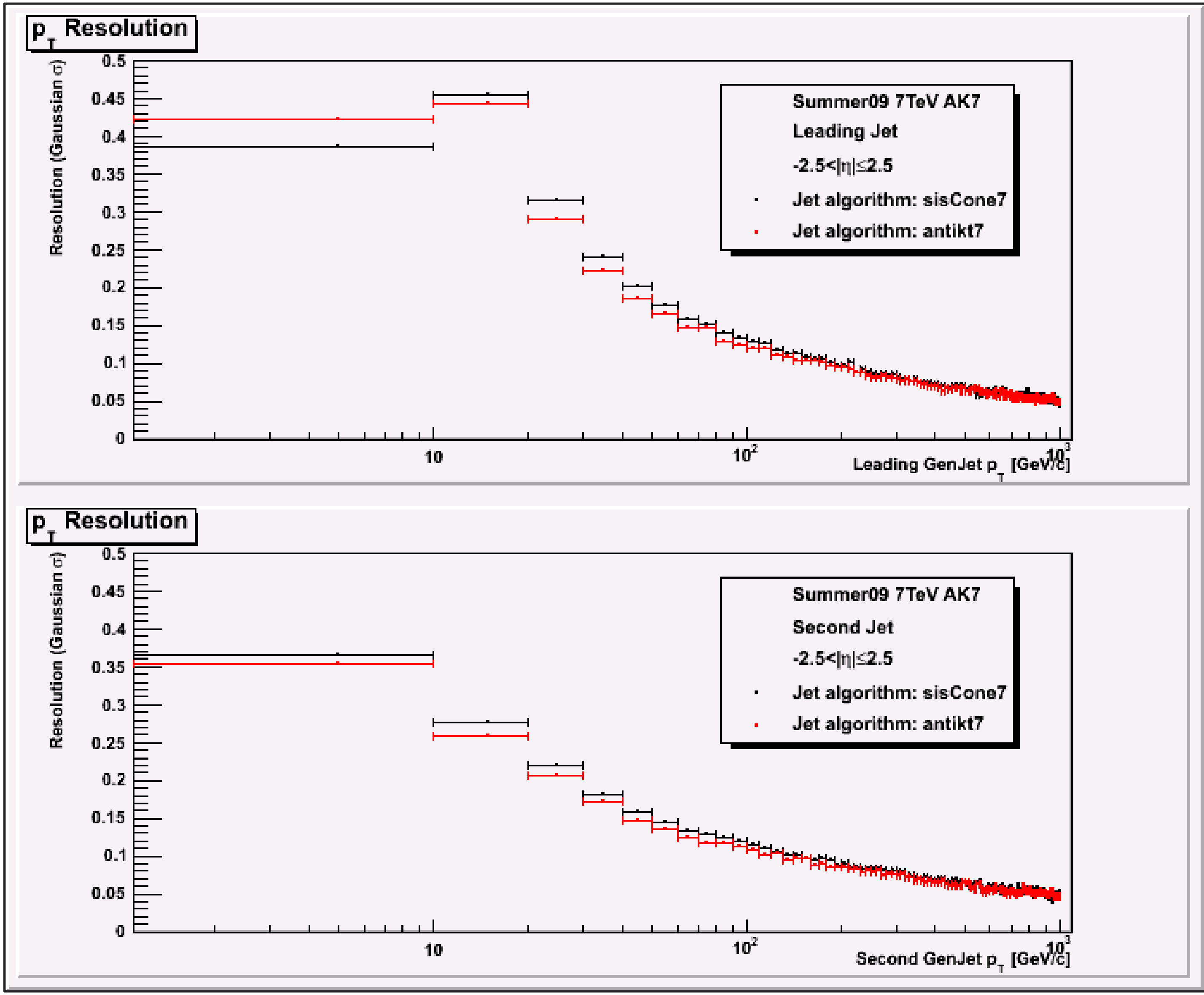


p_T resolution studies: Summer09 QCDDiJet@7TeV

Below ~200 GeV resolution is better for antikt7.

Around 50 Gev/c p_T resolution ~18%

For our analysis we apply a cut on Jet $p_T \geq 50$ GeV/c



H_T resolution studies: Summer09 QCDDiJet@7TeV

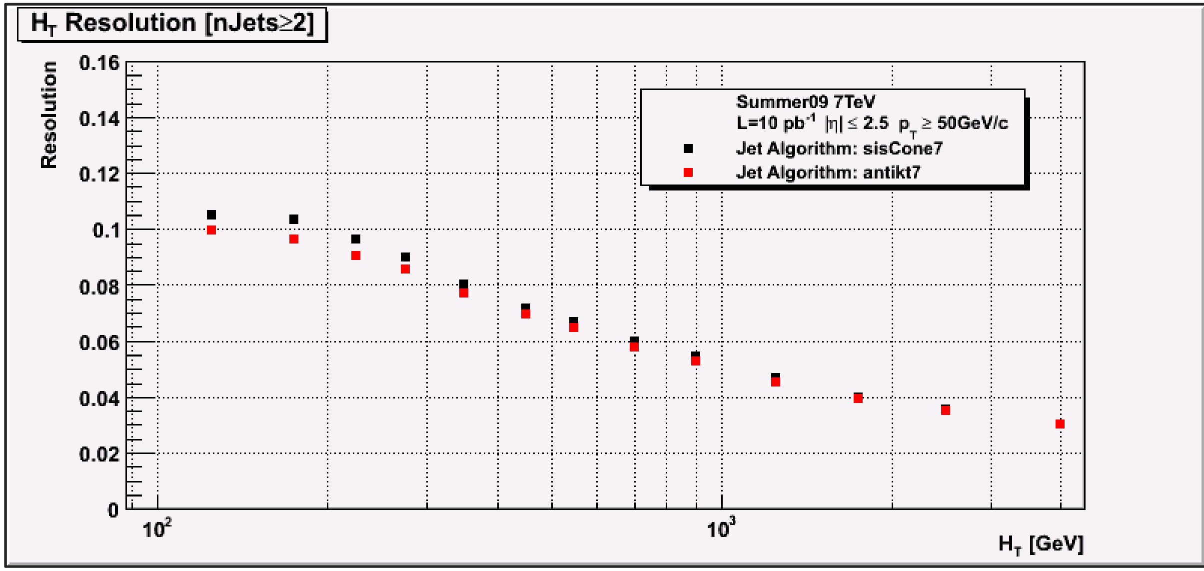
Jet H_T resolution studies at GenJet-CaloJet level:

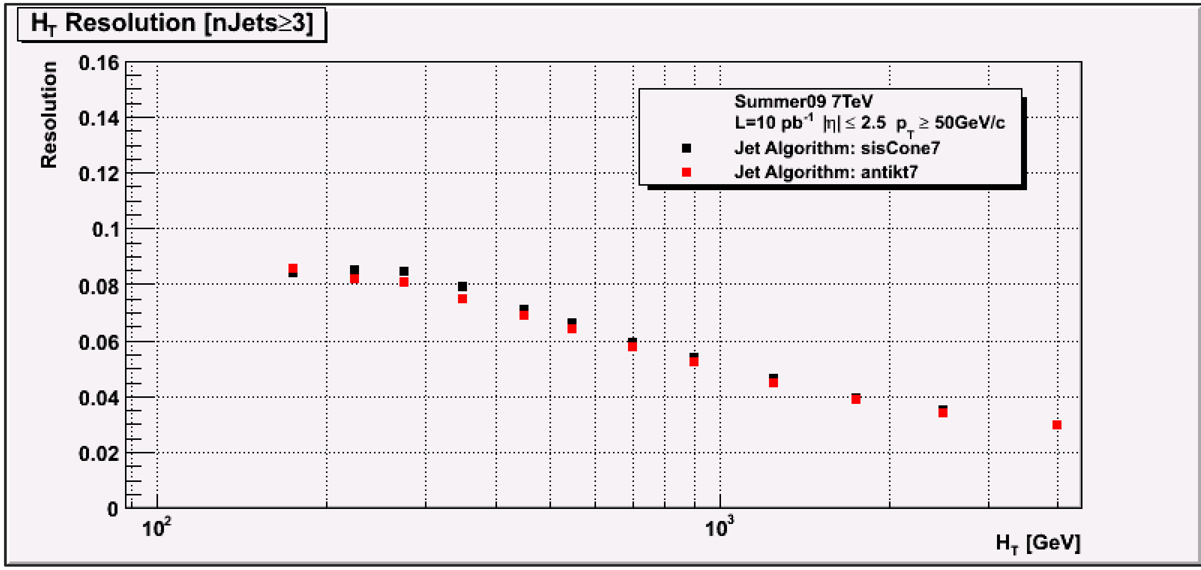
$$H_T\ \text{Resolution} = \frac{\text{GenJet } H_T - \text{CaloJet } H_T}{\text{GenJet } H_T}$$

Important study to define the binning for the ratio R32.

Slightly better resolution for antikt7.

Around 200 Gev H_T resolution ~10%





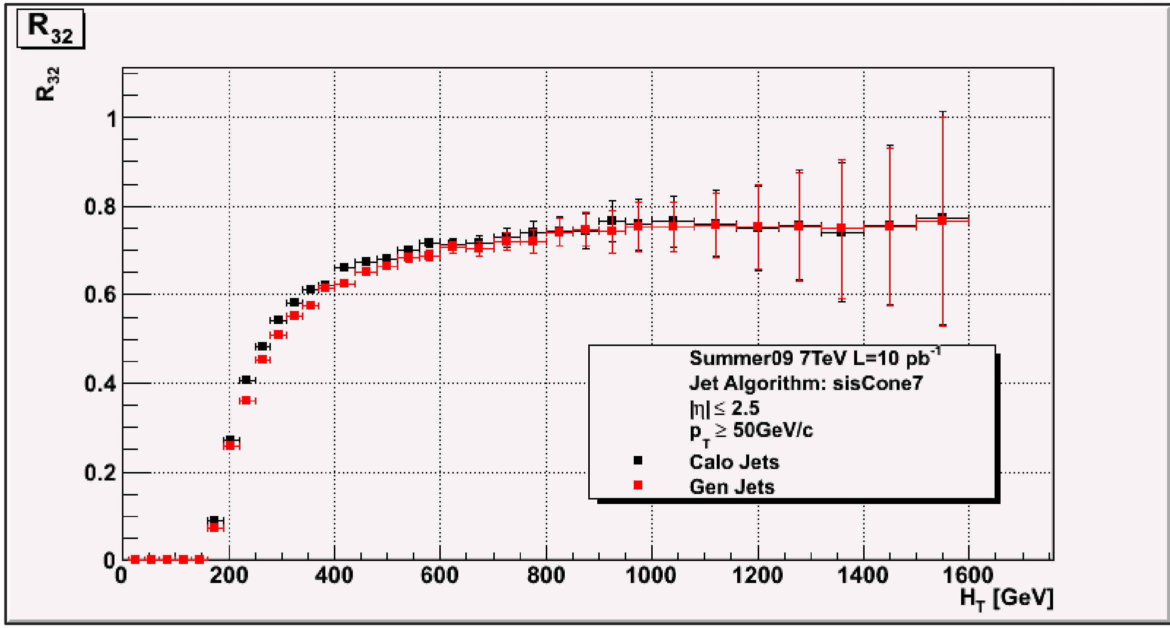
R_{32} : Summer09 QCDDiJet@7TeV

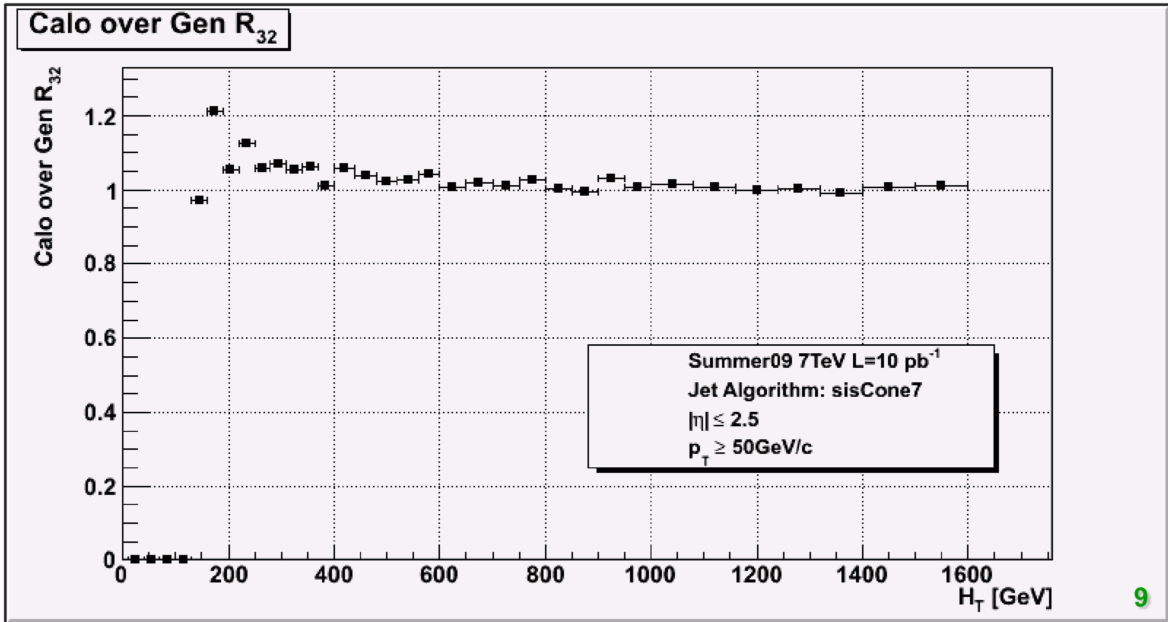
Evaluation of 3Jet/2Jet Ratio vs H_T

$$R_{32} = \frac{\sigma_3}{\sigma_2} = \frac{\sigma(pp \to n \;\; \text{jets} \; + X; \; n \geq 3)}{\sigma(pp \to n \;\; \text{jets} \; + X; \; n \geq 2)}$$

Jet Algorithm
sisCone7

At 7 TeV and with a Luminosity of $10pb^{-1}$ is possible to extend the measurement up to H_T~1200 GeV
(~2 times the scale of Tevatron).



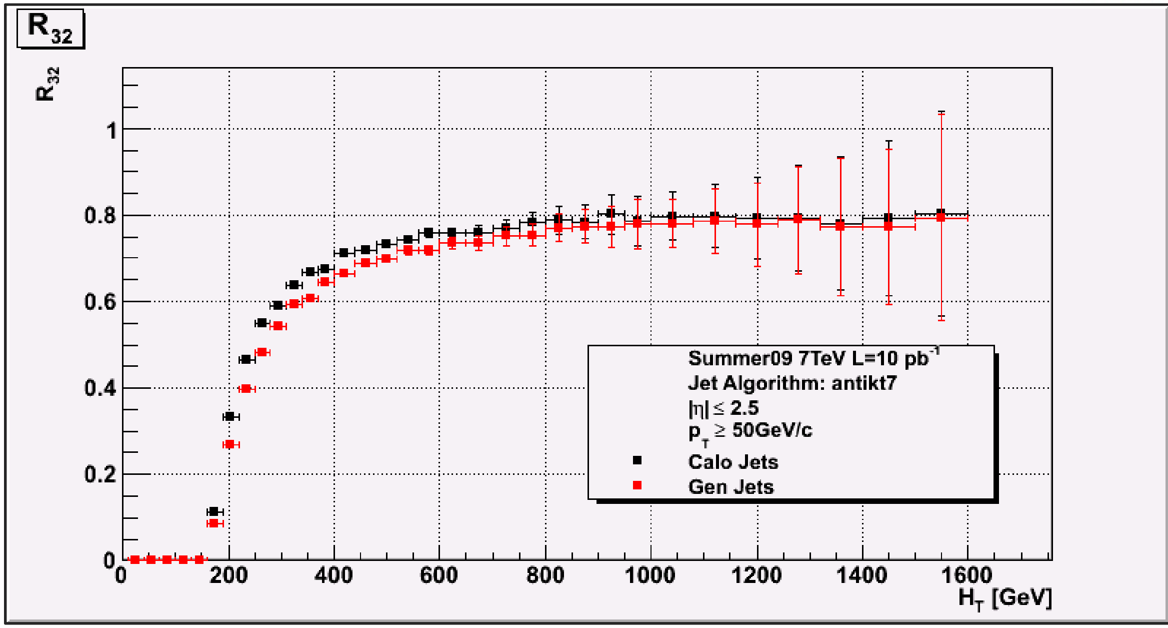


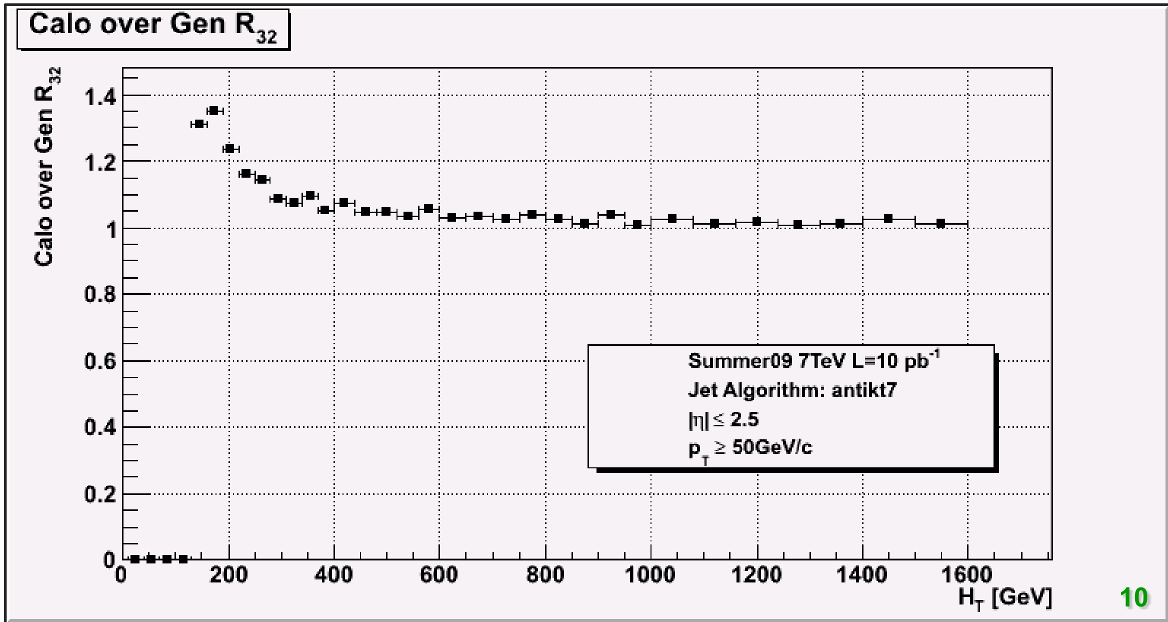
R_{32} : Summer09 QCDDiJet@7TeV

Evaluation of 3Jet/2Jet Ratio vs H_T

$$R_{32} = \frac{\sigma_3}{\sigma_2} = \frac{\sigma(pp \rightarrow n \ \text{jets} + X;\ n \geq 3)}{\sigma(pp \rightarrow n \ \text{jets} + X;\ n \geq 2)}$$

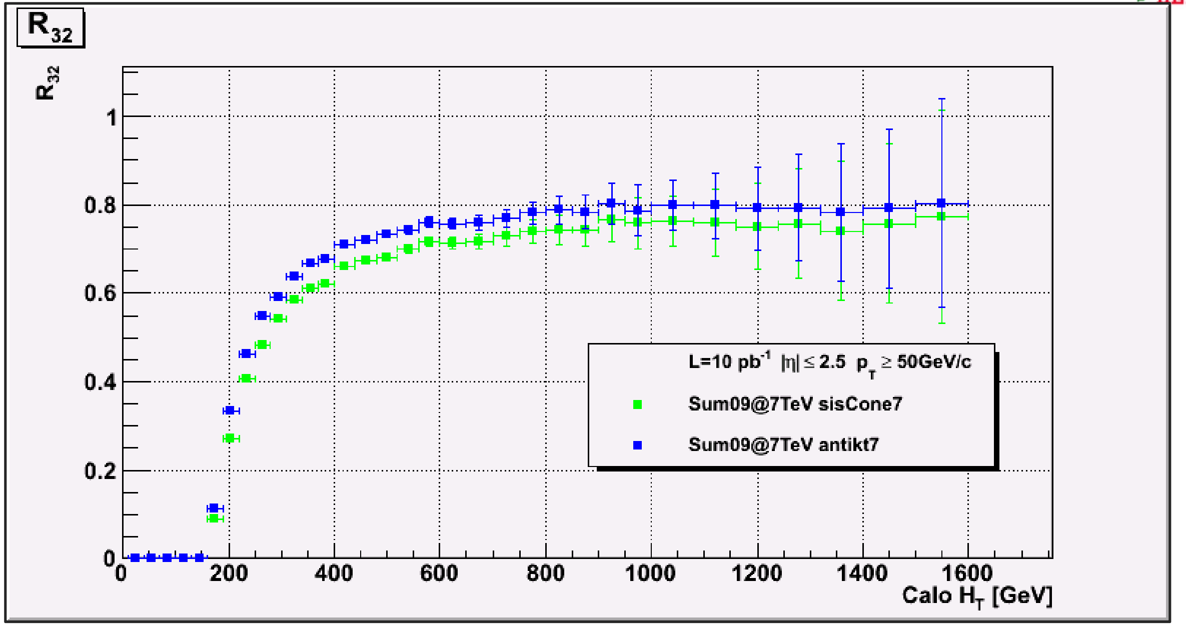
Jet Algorithm
antikt7

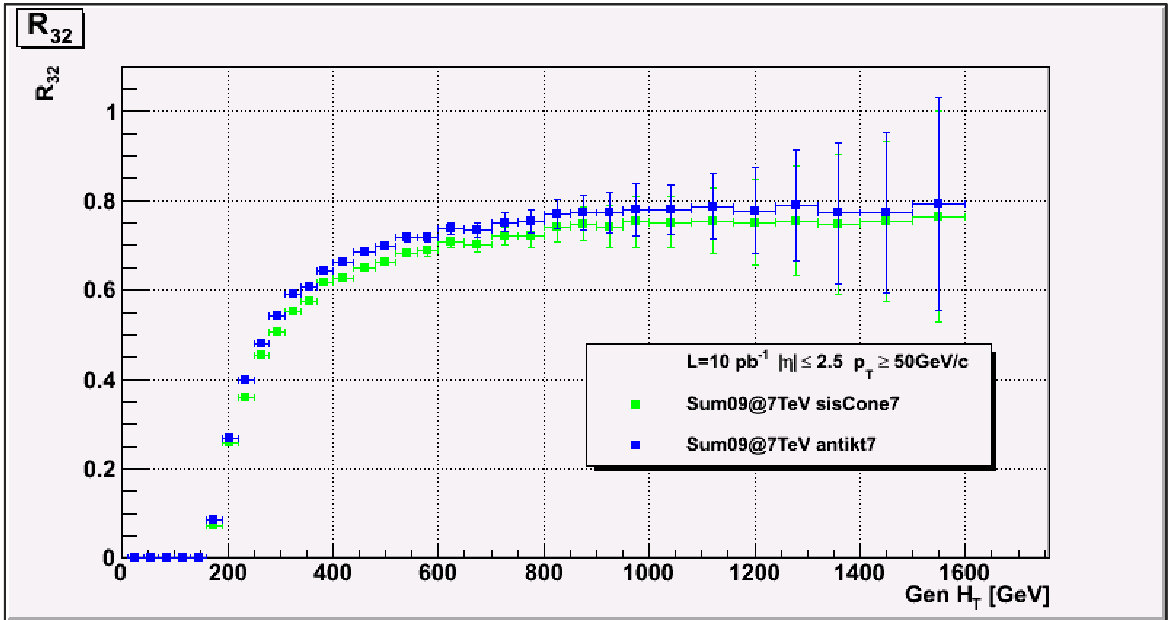




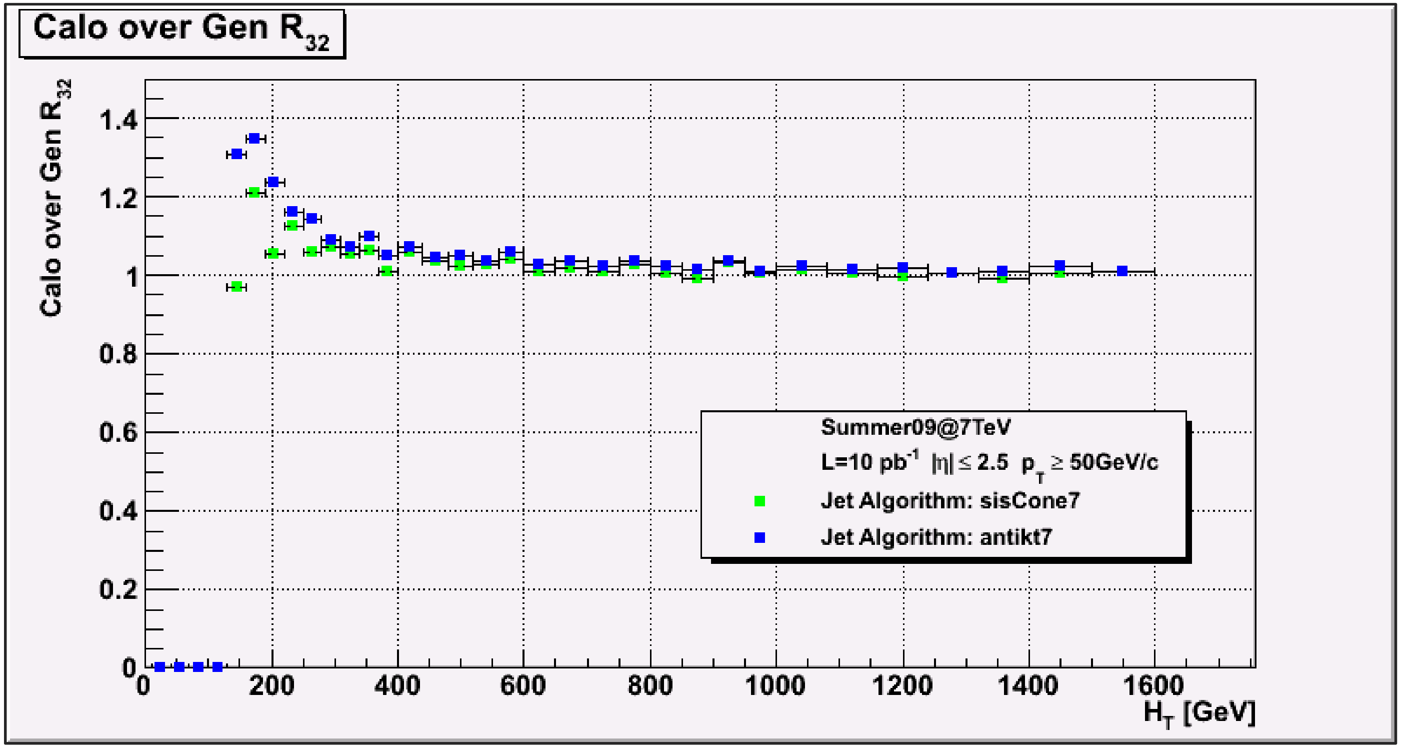
R_{32} Comparison: sisCone7- antikt7

Ratio R_{32} using antikt7 is constantly above.





R_{32} Calo over Gen Comparison: sisCone7- antikt7



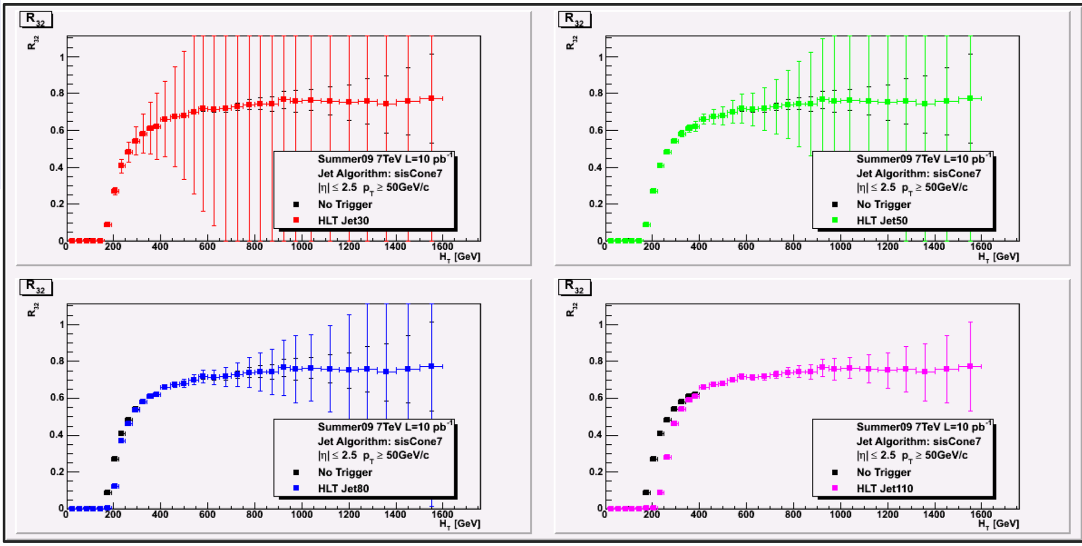
Observe larger smearing effects for antikt7.

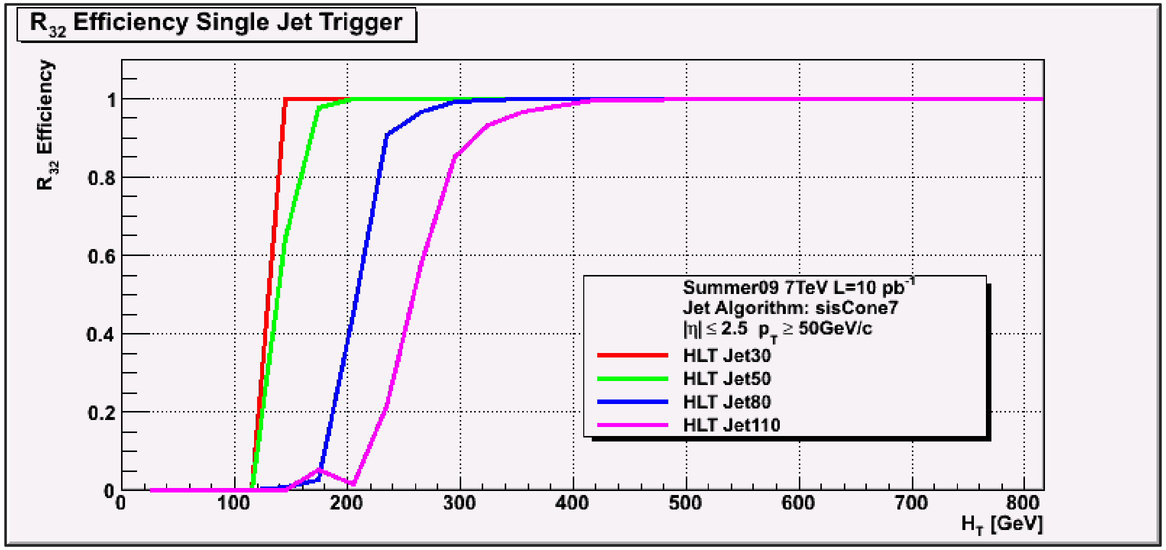
Summer09@7TeV Trigger study: HLT Single Jet

Study of Single Jet HLTs.

- Plot R_{32} after applying the HLTs
- Evaluate trigger efficiency for ratio R_{32}

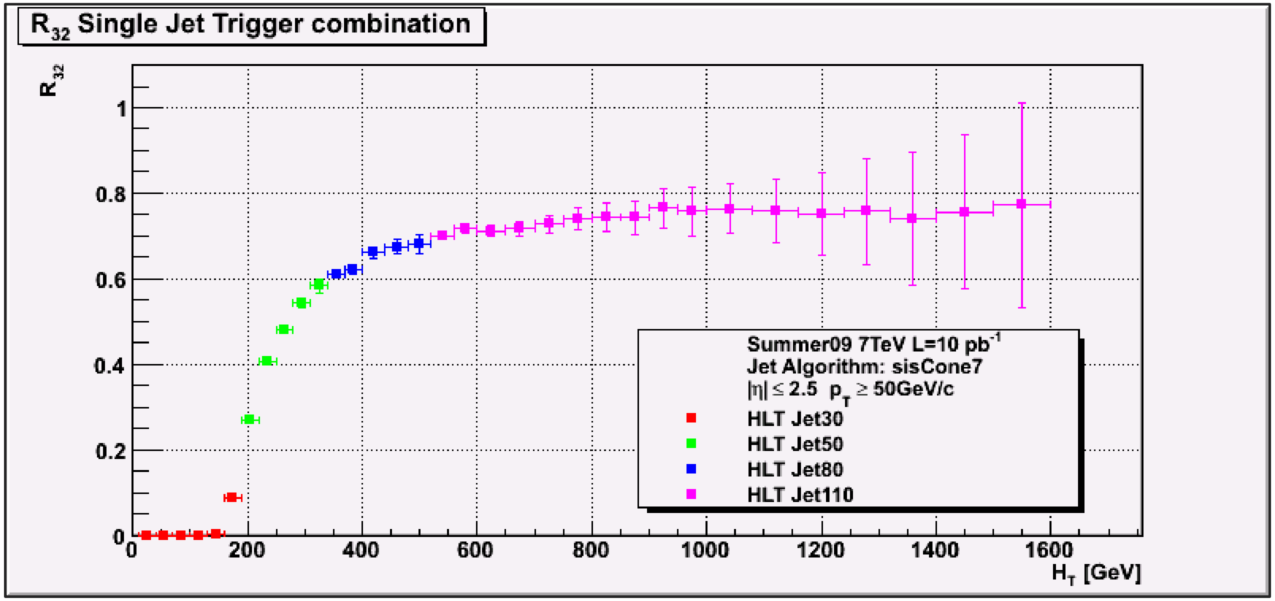
Path name	L1 Trigger	Prescale (L1xHLT)
HLT Jet30	L1_SingleJet15	500x5
HLT Jet50	L1_SingleJet30	50x1
HLT Jet80	L1_SingleJet50	5x2
HLT Jet110	L1_SingleJet70	1





Trigger Path name	Threshold (100% efficient)
HLT Jet30	150
HLT Jet50	200
HLT Jet80	350
HLT Jet110	500

Trigger study: Single Jet Triggers



Combine Single Jet HLTs for data collection :

- HLT Jet30 (prescale 500x5)
- HLT Jet50 (prescale 50x1)
- HLT Jet80 (prescale 5x2)
- HLT Jet110 (prescale 1)

HLT Jet30 covers the first bin of the ratio.

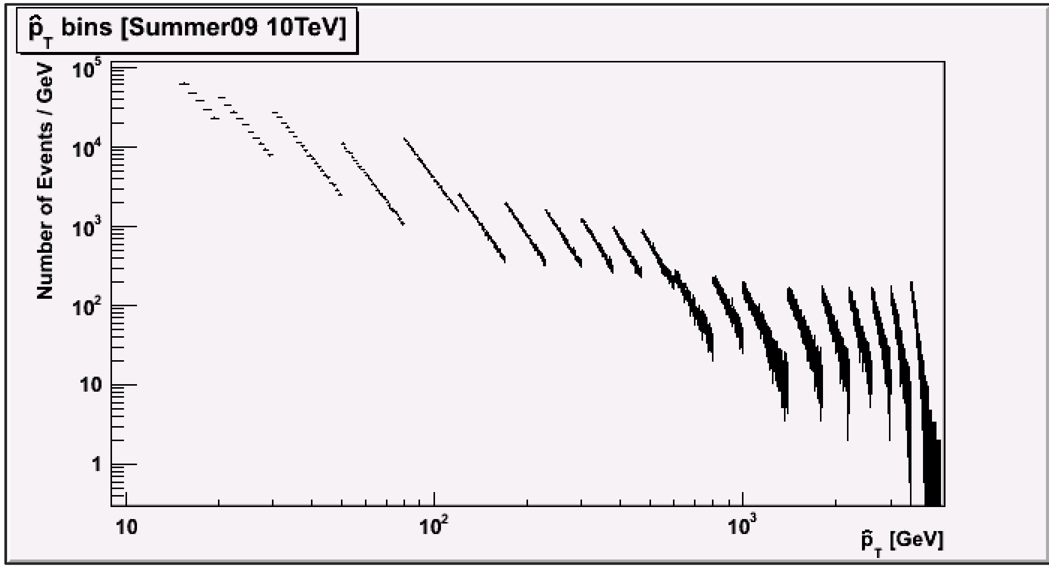
Practically the measurement can be done using trigger combination HLT Jet50, 80 and 110

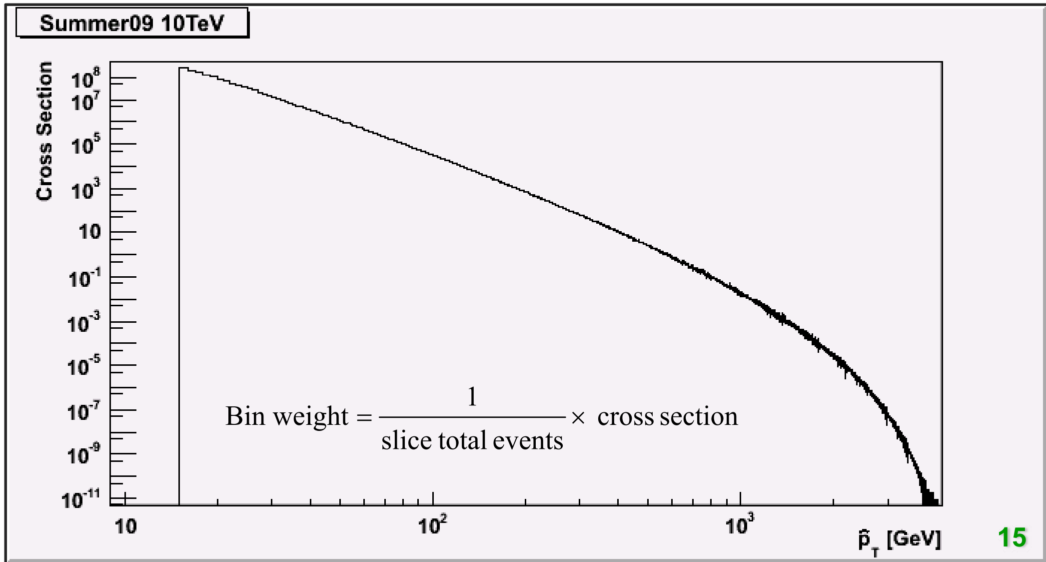
Summer09 QCDDiJet@10TeV

Analysis done using version:

- CMSSW_3_1_4 for Jet Algo: sisCone7
- Jet Energy Corrections: L2L3
- Bin p_THat:0-15 GeV not used

	P_THat bin [GeV]	Number of events	Cross section [pb]	Equivalent Luminosity [pb^{-1}]
1	0-15	200000	51562800000	3.88E-06
2	15-20	200000	949441000	2.11E-04
3	20-30	200000	400982000	4.99E-04
4	30-50	200000	94702500	2.11E-03
5	50-80	119642	12195900	9.81E-03
6	80-120	200000	1617240	1.24E-01
7	120-170	54568	255987	0.21
8	170-230	54100	48325	1.12
9	230-300	54028	10623.2	4.79
10	300-380	50886	2634.94	19.31
11	380-470	45886	722.099	63.55
12	470-600	55905	240.983	231.99
13	600-800	21424	62.4923	342.83
14	800-1000	21028	9.42062	2.23E03
15	1000-1400	21784	2.34357	9.30E03
16	1400-1800	21810	0.156855	1.39E05
17	1800-2200	21730	0.013811	1.57E06
18	2200-2600	22013	0.00129608	1.70E07
19	2600-3000	22046	0.00011404	1.93E08
20	3000-3500	20908	0.0000084318	2.48E09
21	3500-inf	21060	0.00000018146	1.16E11





$$\text{Bin weight} = \frac{1}{\text{slice total events}} \times \text{ cross section}$$

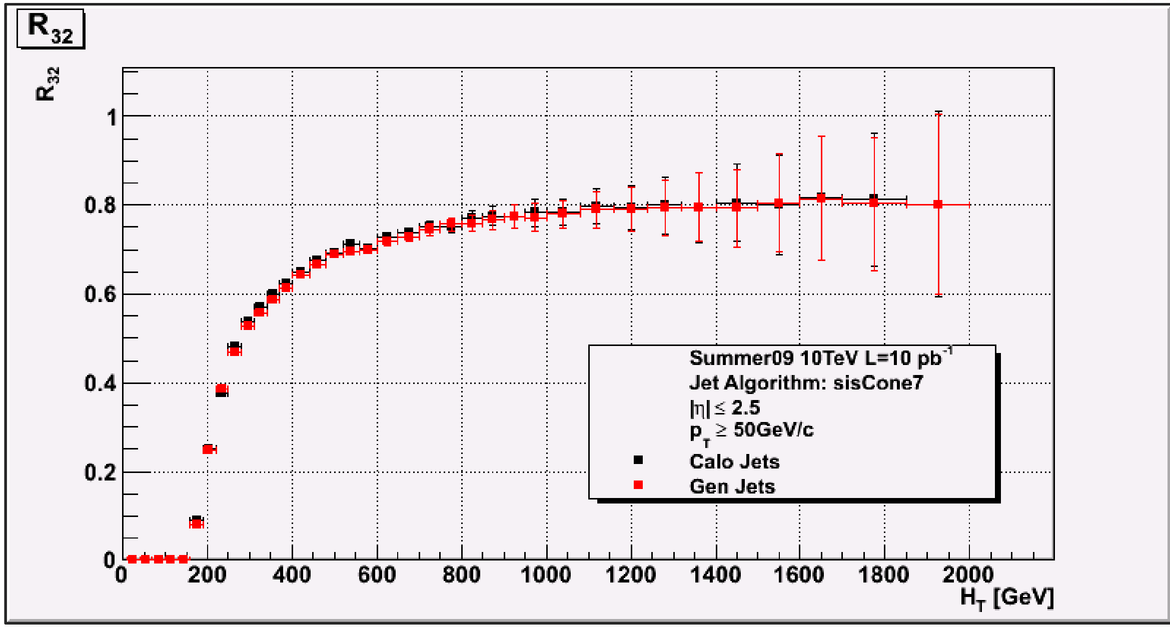
R_{32} : Summer09 QCDDiJet@10TeV

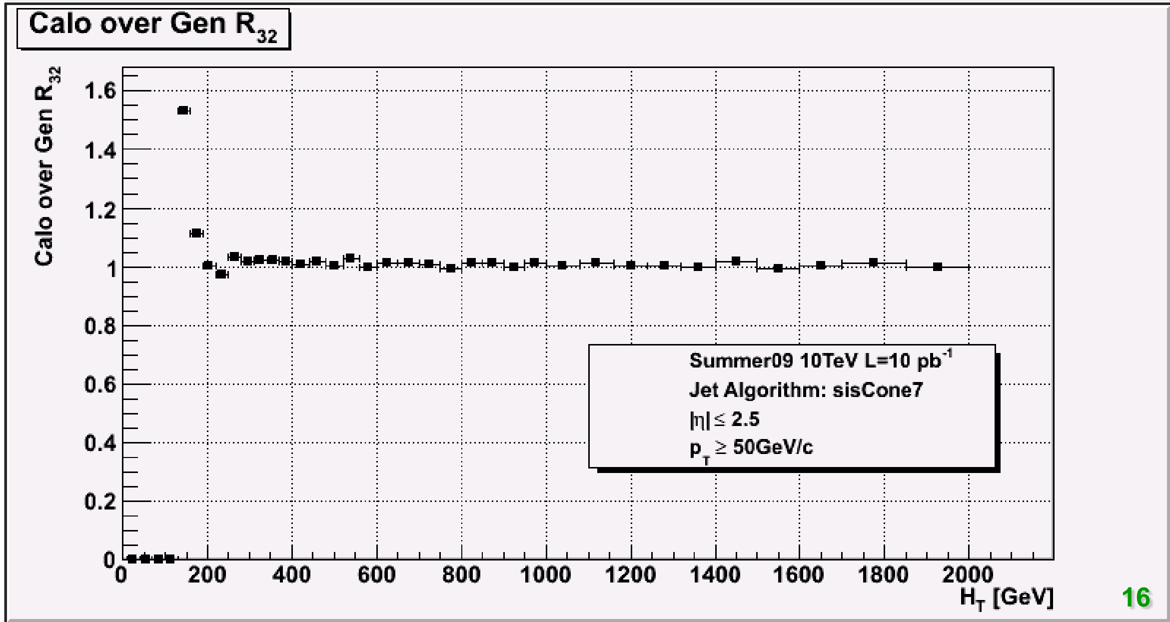
Evaluation of 3Jet/2Jet Ratio vs H_T

$$R_{32} = \frac{\sigma_3}{\sigma_2} = \frac{\sigma(pp \to n\ \text{jets}\ + X;\ n \ge 3)}{\sigma(pp \to n\ \text{jets}\ + X;\ n \ge 2)}$$

Jet Algorithm
sisCone7

At 10 TeV and with a Luminosity of $10pb^{-1}$ is possible to extend the measurement up to H_T~1600 GeV (~3 times the scale of Tevatron).





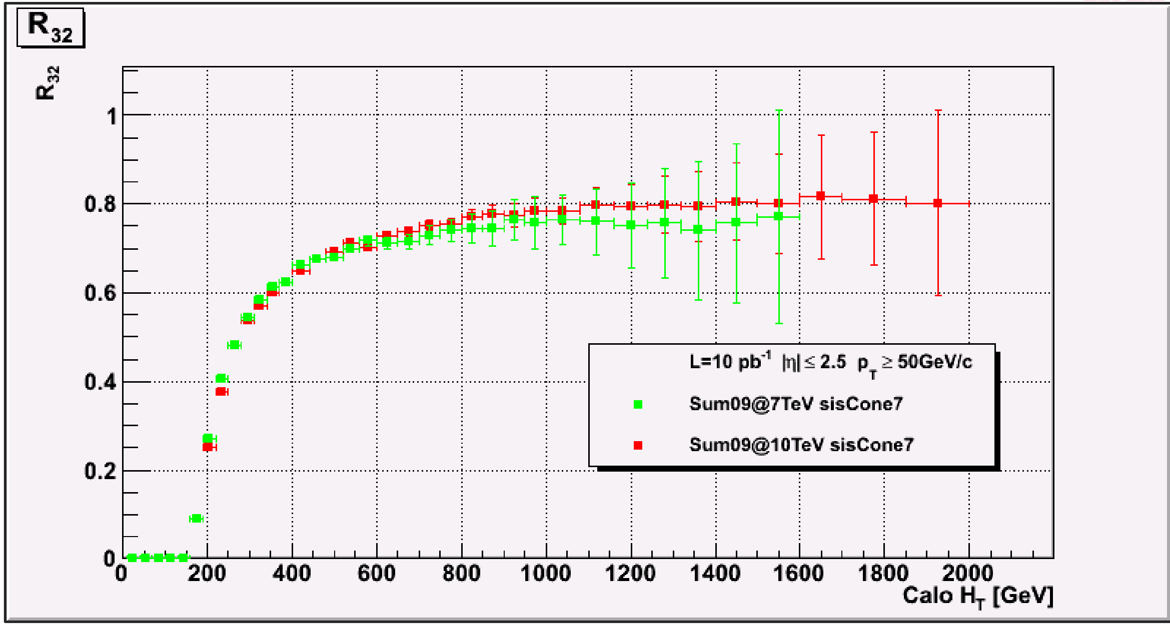
R_{32} : Summer09 QCDDiJet@7-10TeV

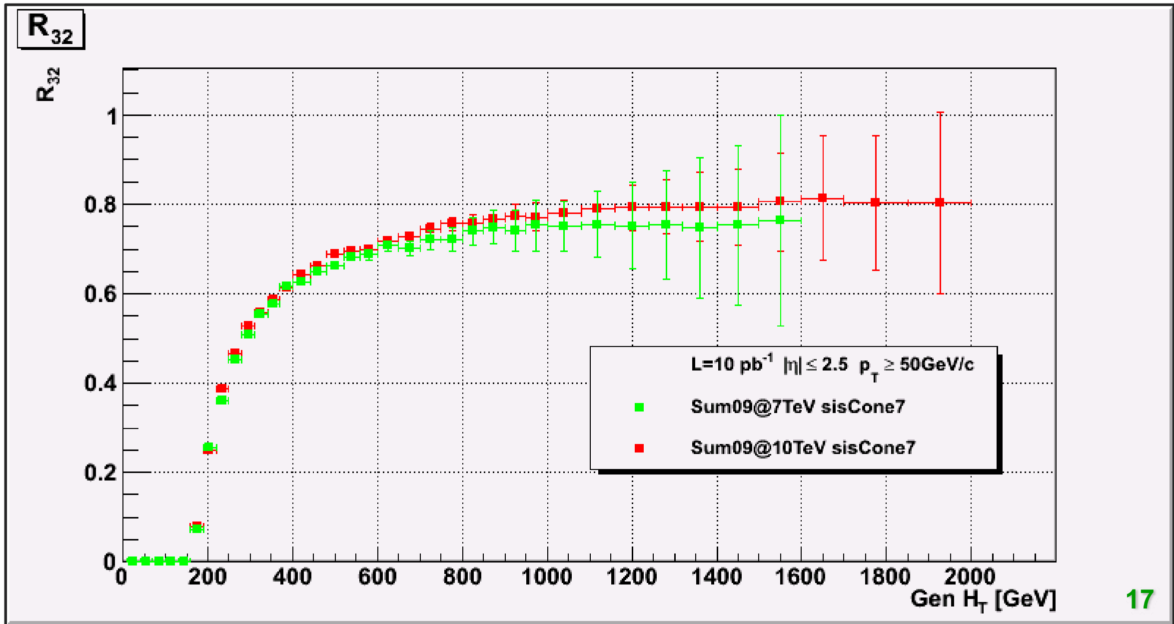
At 7 TeV R_{32} is slightly smaller when comparing with 10 TeV

With a Luminosity of $10pb^{-1}$ is possible to extend the measurement :

@7TeV: H_T~1200 GeV
(~2 times the scale of Tevatron)

@10TeV: H_T~1600 GeV
(~3 times the scale of Tevatron)





Summary

- Summer09 at 7TeV were analyzed
  - Jet Algorithms: sisCone7 and antikt7
  - Jet Energy Corrections: L2L3

- p_T resolution studies shows:
  - For antikt7 below 100 GeV CaloJet is overestimated by few per cent.
  - Below ~200 GeV resolution is better for antikt7.

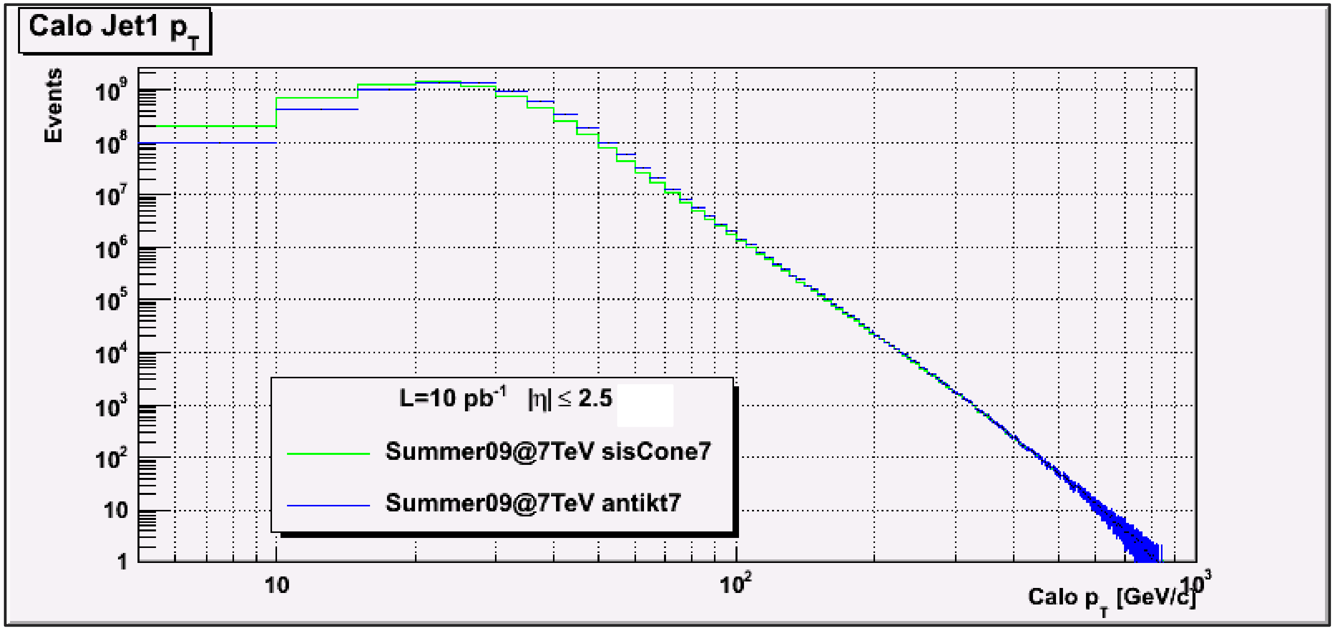
- Concerning R_{32}:
  - At 7 TeV and with a Luminosity of $10pb^{-1}$ is possible to extend the measurement of the ratio up to H_T~1200 GeV (~2 times the scale of Tevatron).
  - Ratio R_{32} using antikt7 is constantly higher (Calo and Gen level).

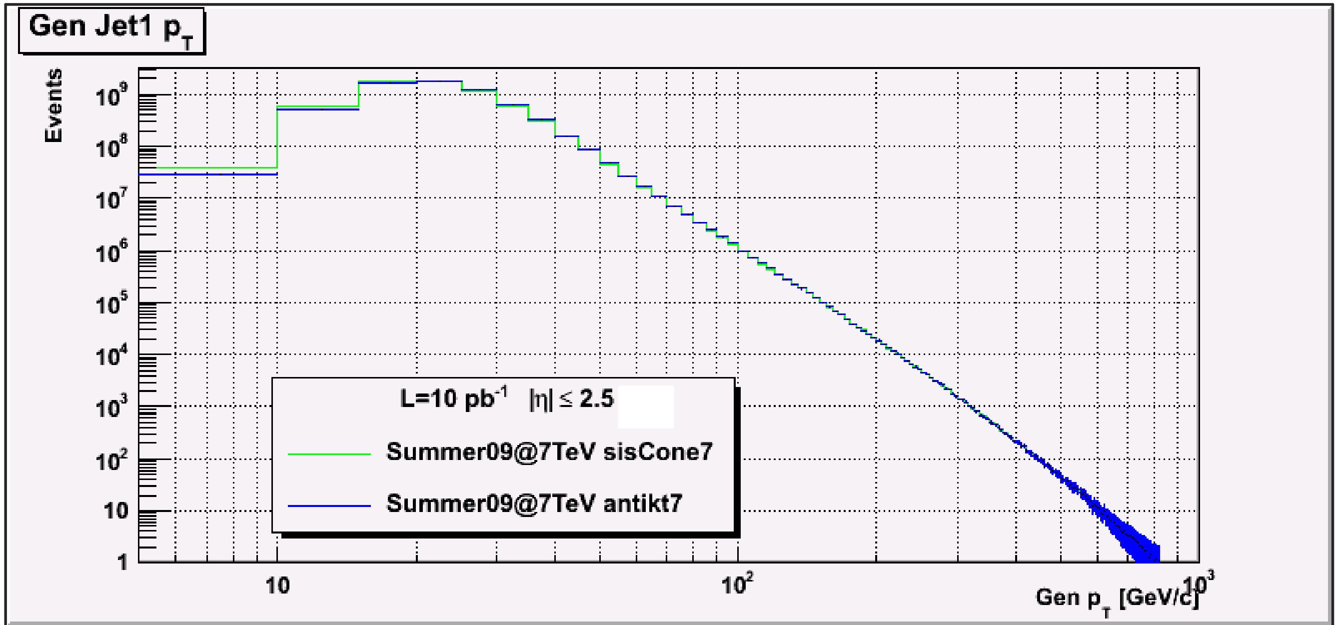
- Trigger studies shows that practically the measurement at 7TeV can be done using a combination of HLT Single Jet 50, 80 and 110.

- We note that we also performed studies to evaluate systematic uncertainties of 2 jet, 3jet cross sections and of measured R_{32} by varying JES by 10%
  - Our study shows strong uncertainty cancellation for R_{32} (uncertainty of R_{32} is less than 5%)
  - Same results as at 10 TeV

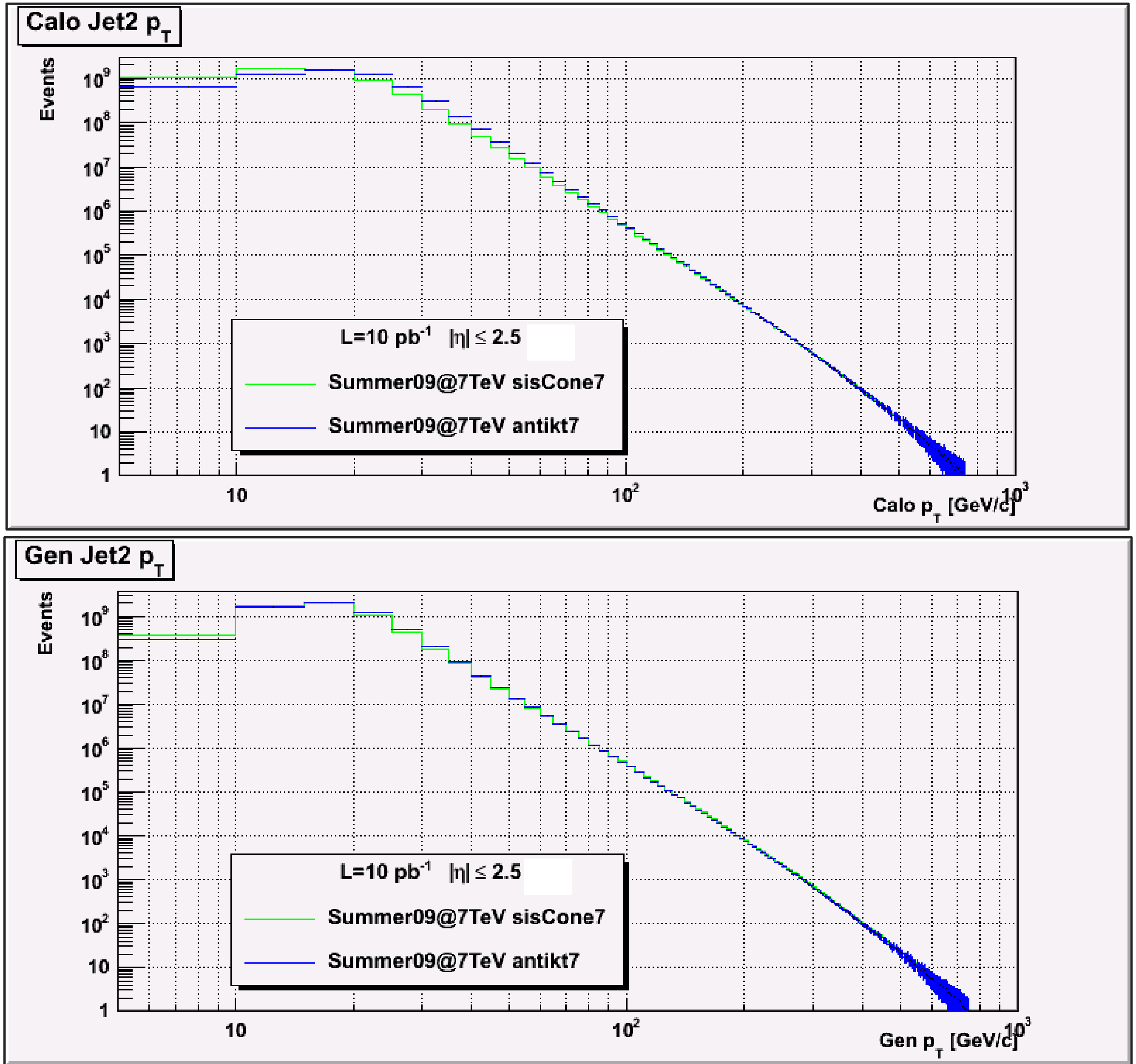
Spare

Comparison sisCone7 – antikt7: Leading Jet p_T (7TeV)

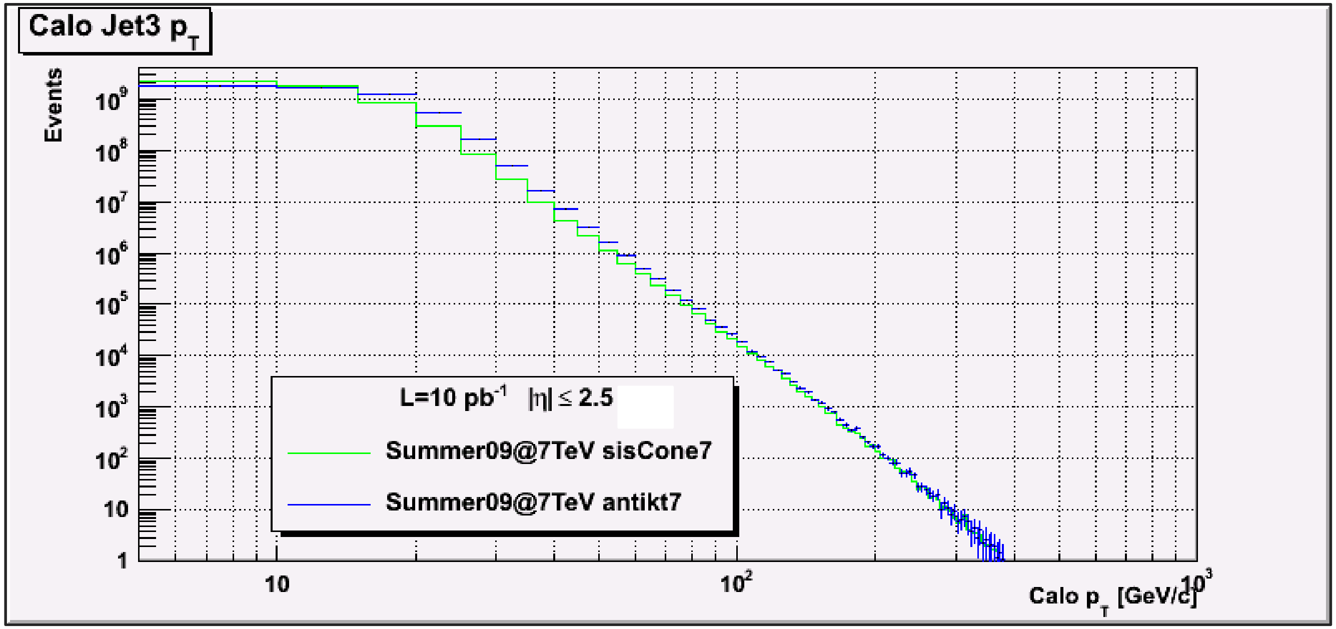


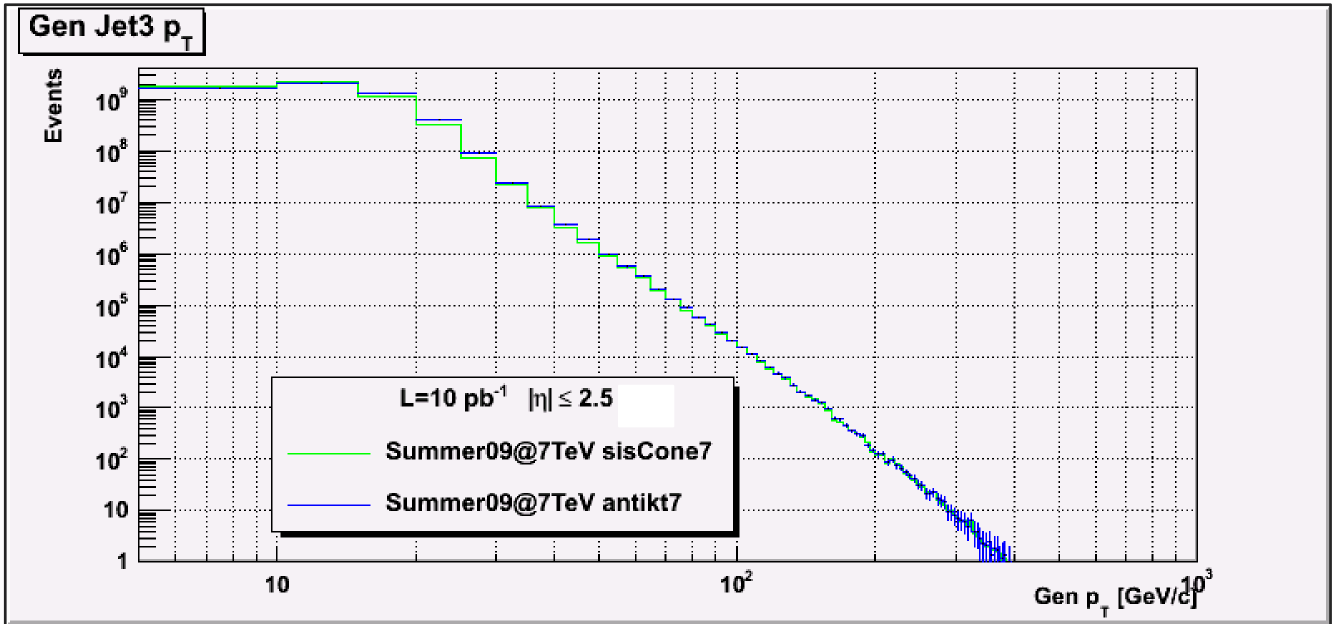


Comparison sisCone7 – antikt7: Second Jet p_T (7TeV)



Comparison sisCone7 – antikt7: 3rd Jet p_T (7TeV)





JES Systematics : Ratio R_{32}

Ratio R_{32}

$$R_{32} = \frac{\dfrac{d^2\sigma_3}{dH_T d\eta}}{\dfrac{d^2\sigma_2}{dH_T d\eta}} = \frac{\dfrac{C_{Smear3}}{\cancel{L}\cdot\varepsilon_3}\cdot\dfrac{N^{Calo}(n\ Jets\geq 3)}{\Delta H_T\cdot\Delta\eta}}{\dfrac{C_{Smear2}}{\cancel{L}\cdot\varepsilon_2}\cdot\dfrac{N^{Calo}(n\ Jets\geq 2)}{\Delta H_T\cdot\Delta\eta}} = \underset{\textbf{measurement}}{\boxed{\frac{\dfrac{N^{Calo}(n\ Jets\geq 3)}{\Delta H_T\cdot\Delta\eta}}{\dfrac{N^{Calo}(n\ Jets\geq 2)}{\Delta H_T\cdot\Delta\eta}}}}\cdot\underset{\Updownarrow \atop \textbf{A}}{\boxed{\frac{C_{Smear3}}{\varepsilon_3}}}\cdot\underset{\Updownarrow \atop \textbf{B}}{\boxed{\frac{\varepsilon_2}{C_{Smear2}}}}$$

$$A = \frac{N^{Gen}(n\ \ jets\geq 3)}{N^{CaloPass}(n\ \ jets\geq 3)}\times\frac{N^{CaloPass}(n\ \ jets\geq 3)}{N^{Calo}(n\ \ jets\geq 3)}$$

$$B = \frac{N^{Calo}(n\ \ jets\geq 2)}{N^{CaloPass}(n\ \ jets\geq 2)}\times\frac{N^{CaloPass}(n\ \ jets\geq 2)}{N^{Gen}(n\ \ jets\geq 2)}$$

$1/\varepsilon_3$ (1/efficiency)
nJets≥3

C_{Smear3}
Smearing correction
nJets≥3

$1/C_{Smear2}$
Smearing correction
nJets≥2

ε_2 (efficiency)
nJets≥2

With

$N^{Gen}(n\ \ jets\geq 2{,}3)$: Number of Gen events in bin i of H_T

$N^{Calo}(n\ \ jets\geq 2{,}3)$: Number of reconstructed Calo events in bin i of H_T

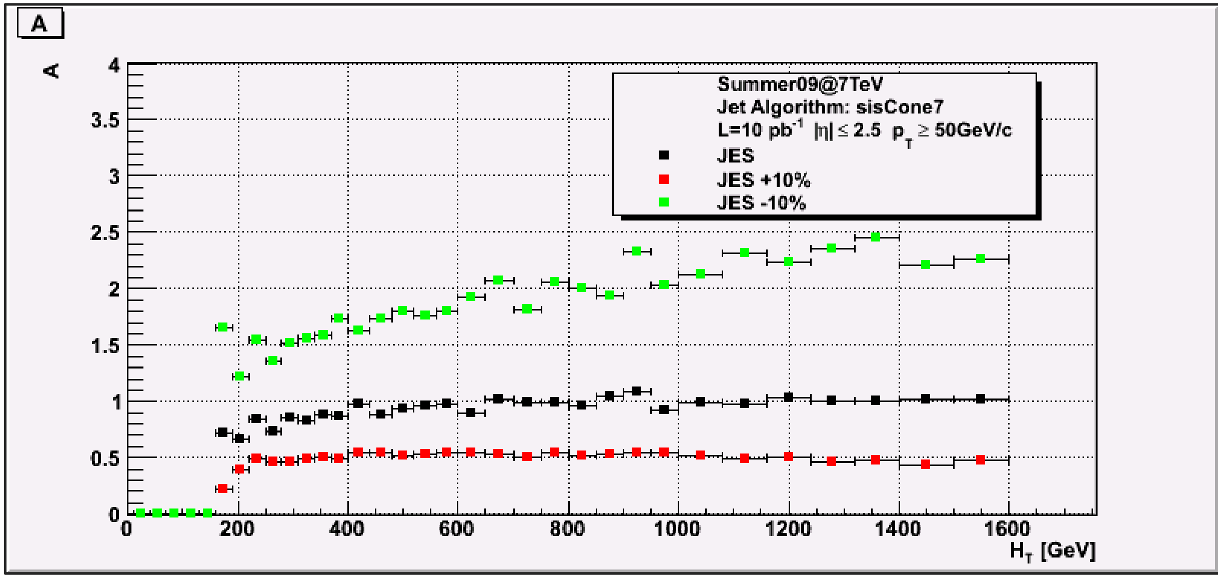
$N^{CaloPass}(n\ \ jets\geq 2{,}3)$: For Gen events of bin i of H_T all reconstructed Calo events survived cuts and appear to any bin

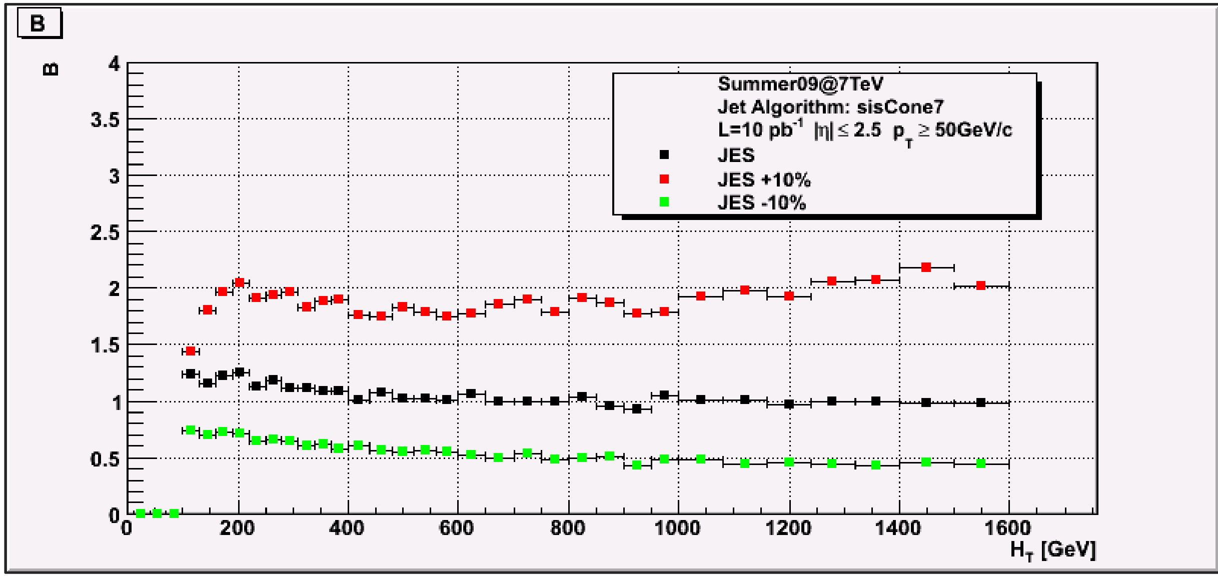
JES Systematics : A and B

$$A = \frac{N^{Gen}(n\ \ jets \geq 3)}{N^{CaloPass}(n\ \ jets \geq 3)} \times \frac{N^{CaloPass}(n\ \ jets \geq 3)}{N^{Calo}(n\ \ jets \geq 3)}$$

Smearing effects dominate

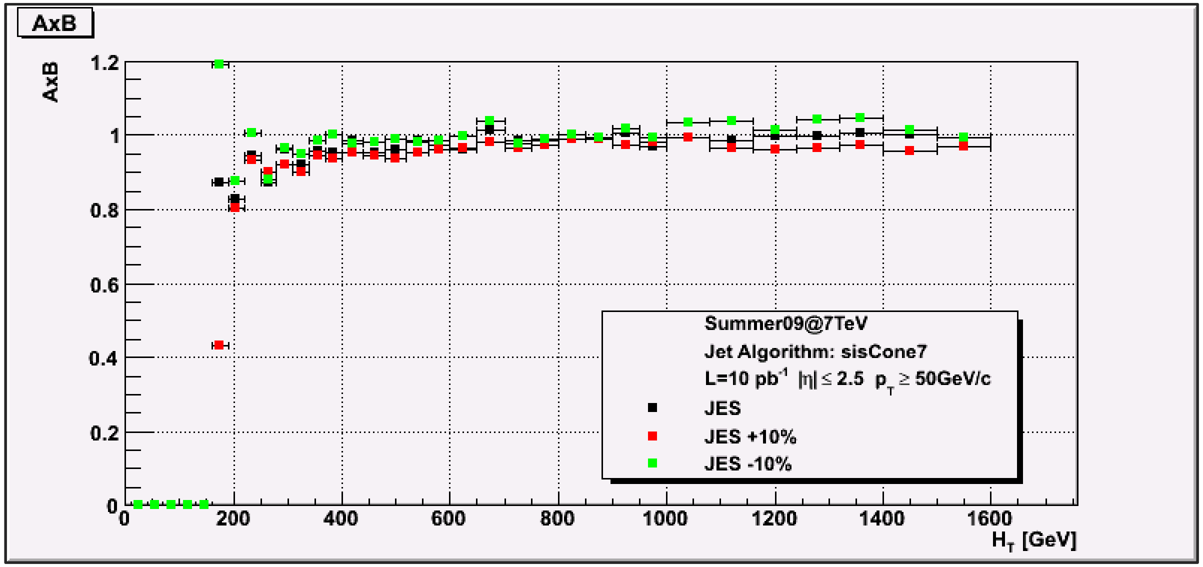
$$B = \frac{N^{Calo}(n\ \ jets \geq 2)}{N^{CaloPass}(n\ \ jets \geq 2)} \times \frac{N^{CaloPass}(n\ \ jets \geq 2)}{N^{Gen}(n\ \ jets \geq 2)}$$

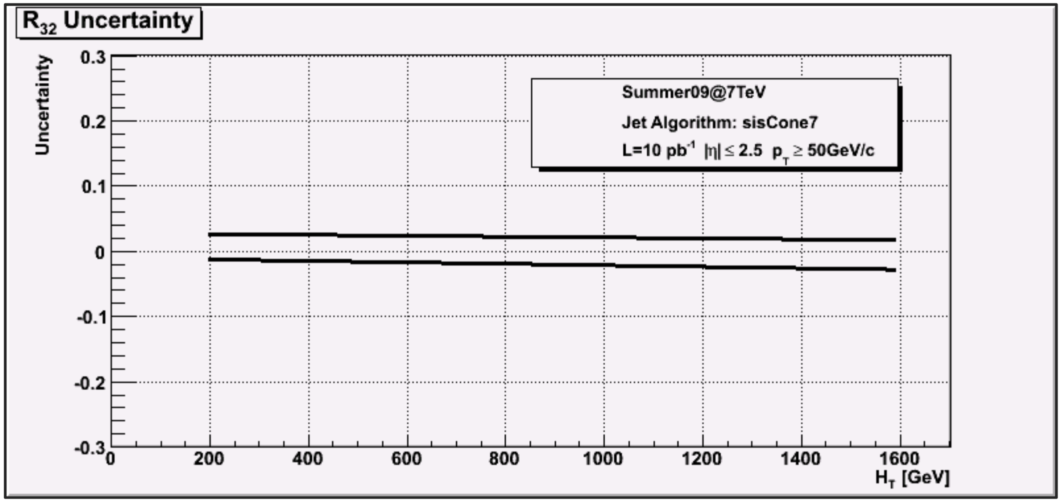




JES Systematics : AxB

$$\left(A=\frac{N^{Gen}(n\ \ jets\geq 3)}{N^{CaloPass}(n\ \ jets\geq 3)}\times\frac{N^{CaloPass}(n\ \ jets\geq 3)}{N^{Calo}(n\ \ jets\geq 3)}\right)\times\left(B=\frac{N^{Calo}(n\ \ jets\geq 2)}{N^{CaloPass}(n\ \ jets\geq 2)}\times\frac{N^{CaloPass}(n\ \ jets\geq 2)}{N^{Gen}(n\ \ jets\geq 2)}\right)$$





We observe a strong uncertainty cancellation (uncertainty less than 5%)