A hadronic search for SuperSymmetry using the α_T kinematic variable.

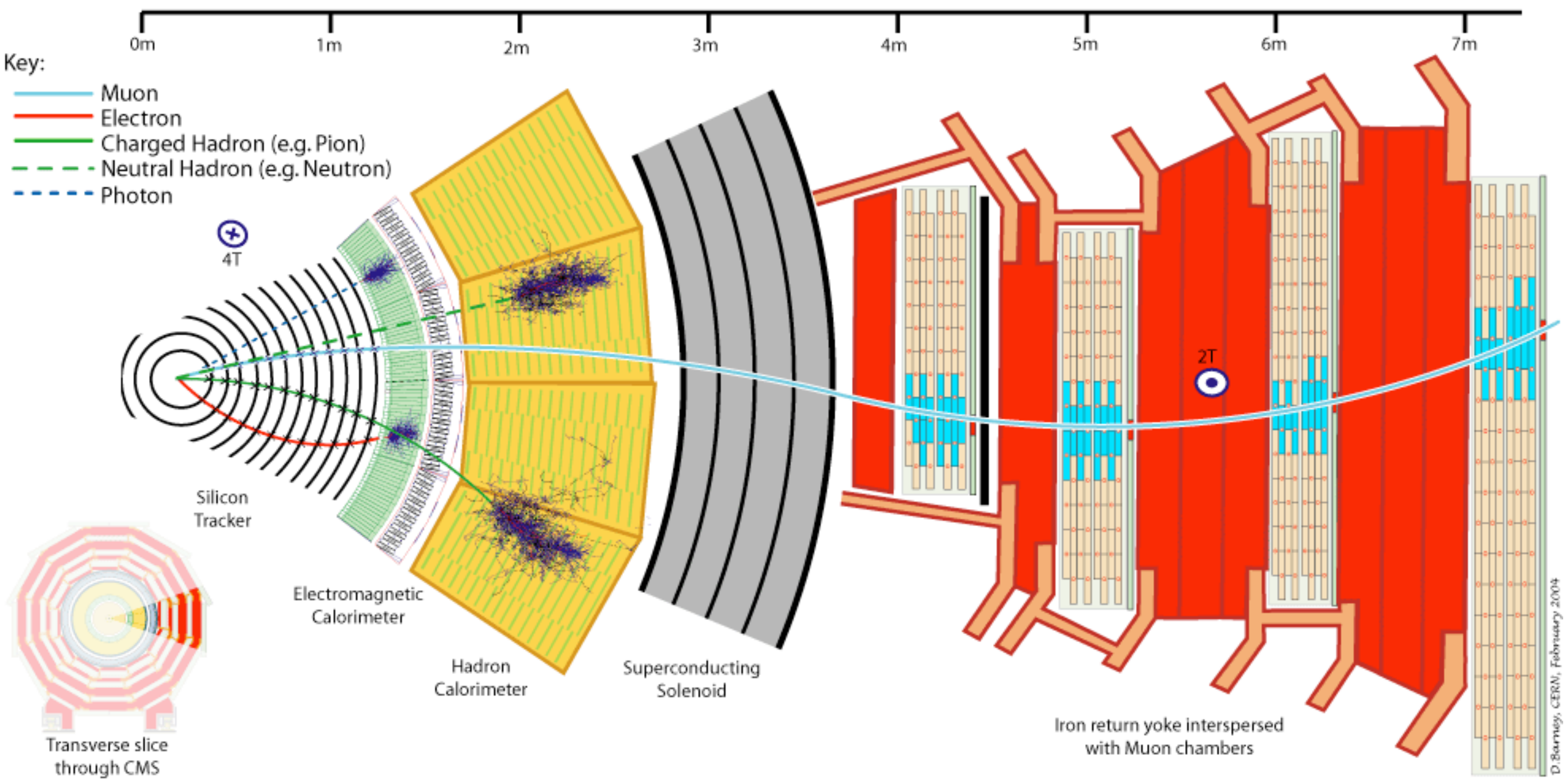
Bryn Mathias

Outline

- The CMS detector.
- What is α_T?
- Outline of the Analysis.
- Background estimation.
- 1/fb Result & Interpretation.
- Plans for the 5/fb analysis.
- Dedicated αT triggers.
- Conclusion

Imperial College London

The CMS detector



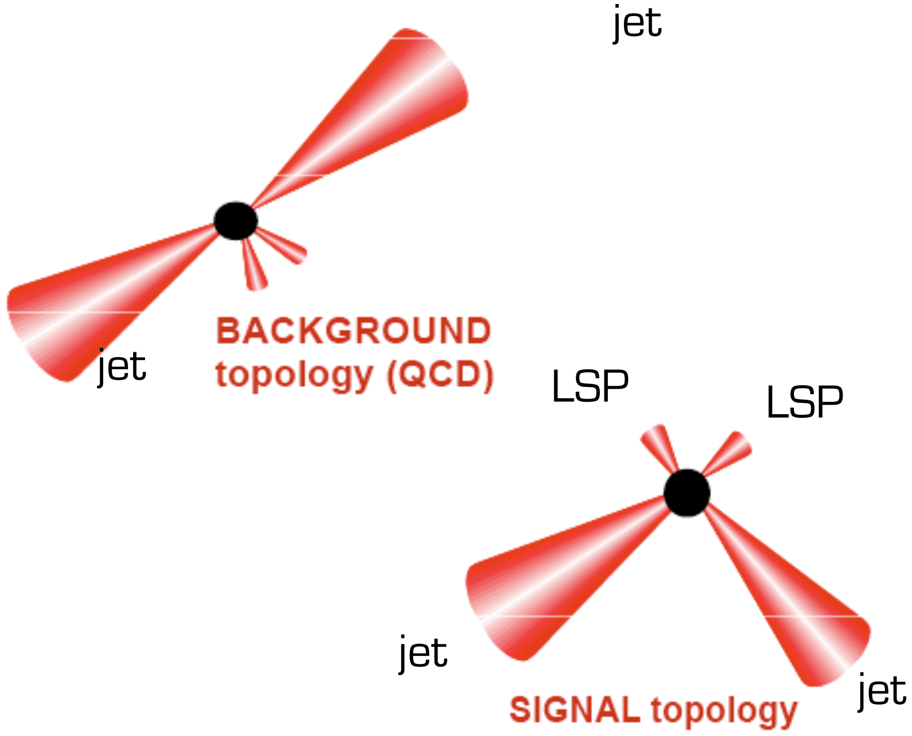
Key Features

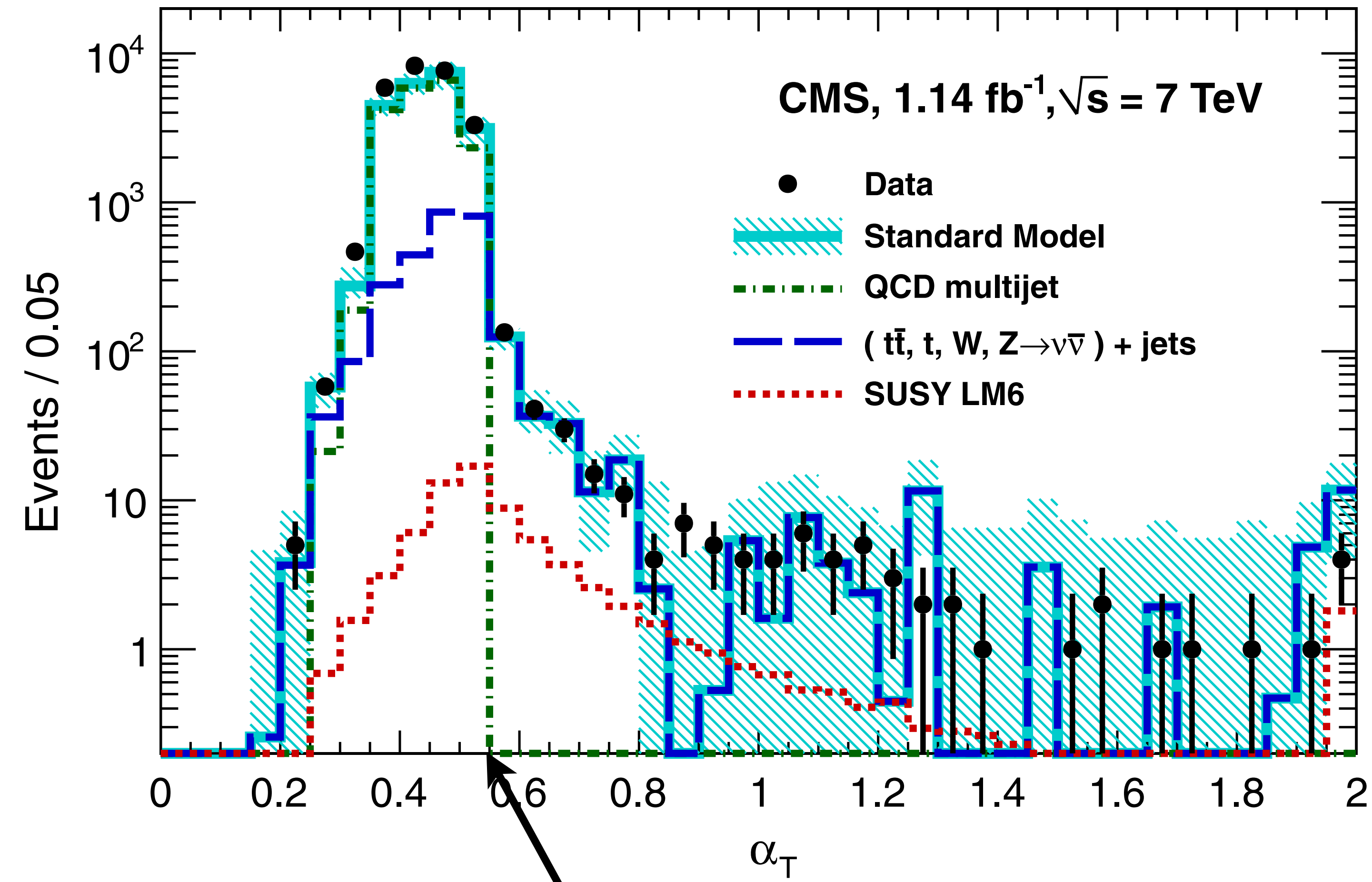
- Fine grain Silicon Tracker
- Lead Tungstate ECal
- Brass HCal
- 4T magnetic field
- Precision muon system

The α_T analysis primarily uses the calorimeters. The tracking and muon systems are used in the background estimation.

What is αT?

α_T was inspired by L.Randal and D.Tucker-Smith (10.1103/PhysRevLett.101.221803) and expanded to multi-jet transverse topologies by CMS





MC predicts no QCD past a cut of 0.55

$$\alpha_T = \frac{H_T - \Delta H_T}{2\sqrt{H_T^2 - \not{H}_T^2}}$$

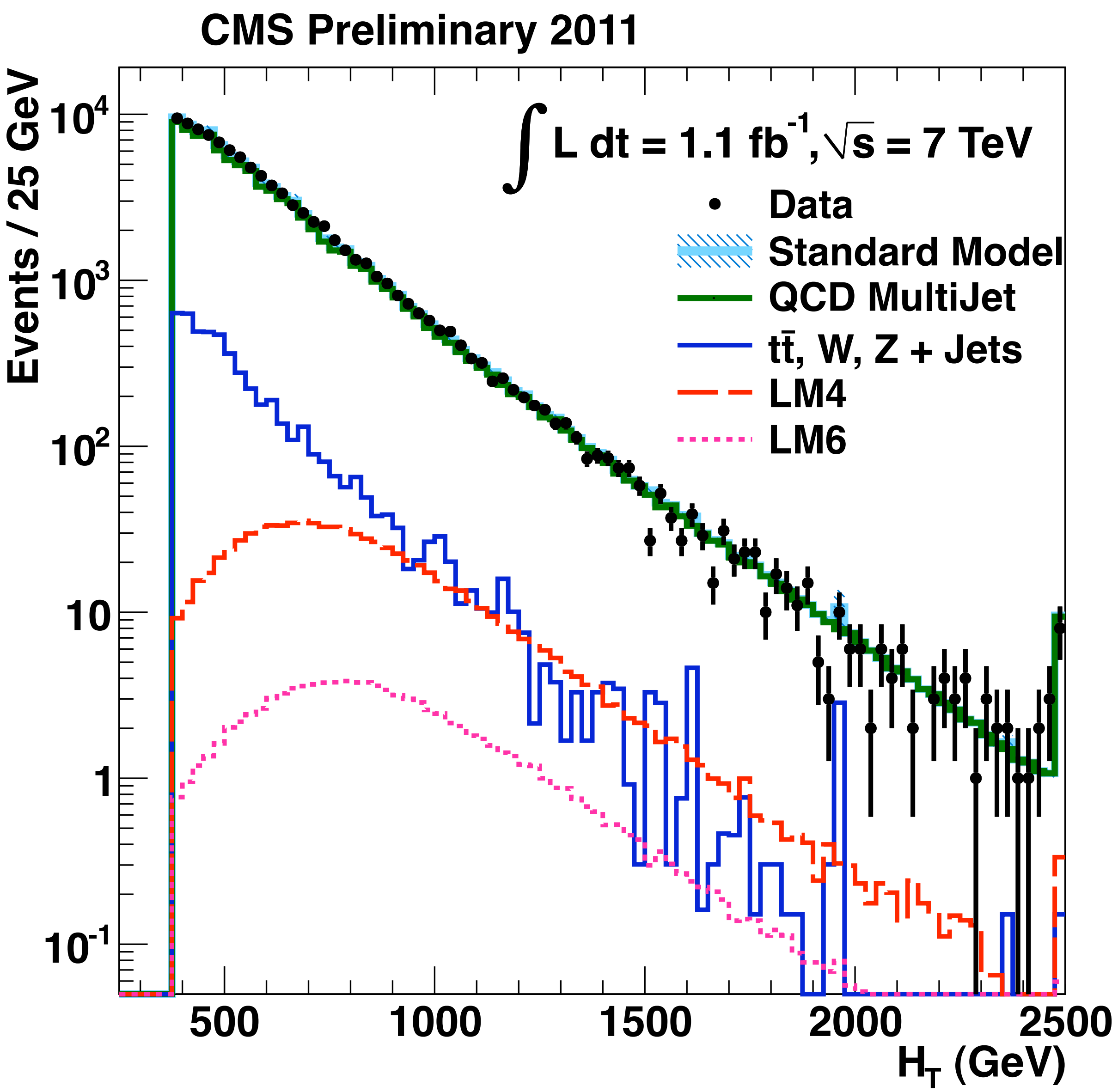
where $H_T = \sum_{jets} E_T$ and $\not{H}_T = |\sum_{jets} \vec{P}_T|$

The analysis

- Updated from the 35/pb analysis, which was a cut and count experiment, using the same background estimation procedure.
- Robust, QCD free. Which makes it ideal for early running conditions.
- Now use a shape analysis in HT.
- Uses a total of 1.1/fb of data.

Cut Flow

- 'good' collision vertex
- HT > 275 GeV
- Two or more jets, reconstructed with AK5 algorithm with pT > 50GeV and |η| < 3.
- Leading Jet with in |η| < 2.5
- Sub leading Jet with pT > 100GeV
- Veto events with isolated leptons(photons) with pT > 10(25) GeV
- Detector failure cleaning cuts

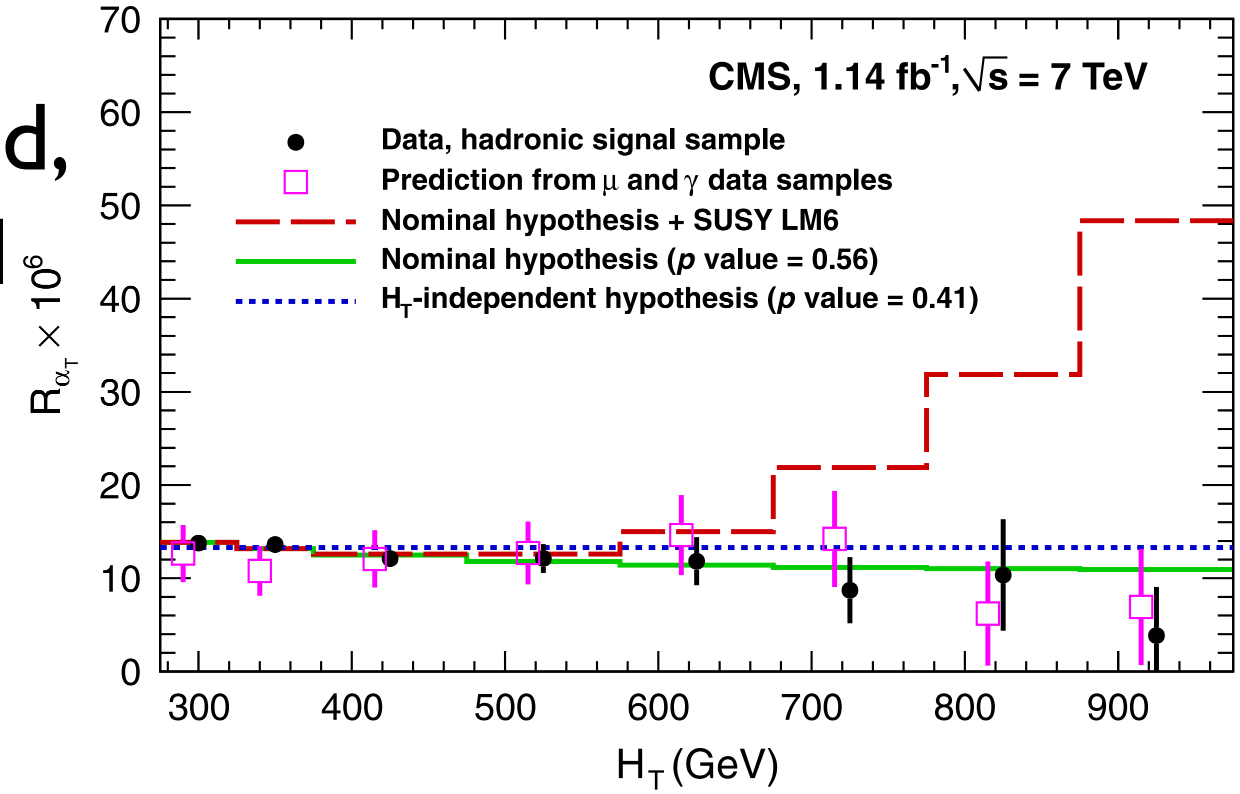


Background estimation

- Backgrounds are electro-weak processes with real MET, top, Z->nu nu + Jets, etc.
- Use visible decay modes to predict irreducible electro-weak background, we don’t rely on monte-carlo yields for background prediction.
- Predict total background from properties of HT/α_T distribution.

Background estimation 1) Total background estimation

- Use lower HT control regions to predict the total background in the signal region.
- Adjust the jet Pt thresholds to keep the event kinematics the same.
- Define $\mathrm{R}_{\alpha_T} = \mathrm{N}(\alpha_T > \mathrm{x})/\mathrm{N}(\alpha_T < \mathrm{x})$
- For QCD Rat is expected to fall with increasing HT.
- For EWK flat behaviour is expected, this is checked with the W/Υ control samples.
- Final selection is QCD free.



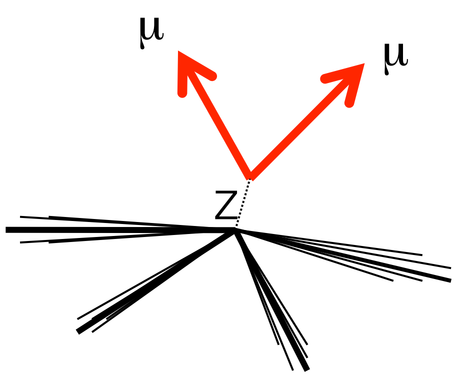
Background Estimation
2) W + jets and ttbar background

Use the same object definitions as for the ttbar cross section measurement.

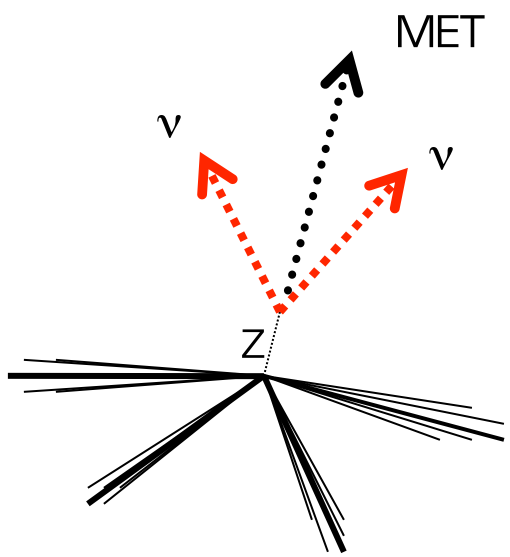
- Use the same selection as for signal, with the requirement of a high Pt muon and calculate α_T excluding the muon.
- Extra selection requirement of Transverse mass > 30GeV to remove QCD.
- Use MC efficiencies and acceptances for the muon sample.

Absolute numbers are not used, we take the ratio between the hadronic and muon selections to predict the w+jets & ttbar backgrounds

Background Estimation 3) Z->nu nu + Jets



Use visible decay modes to predict incurable background

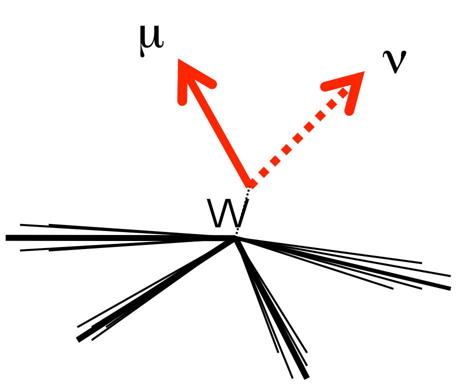


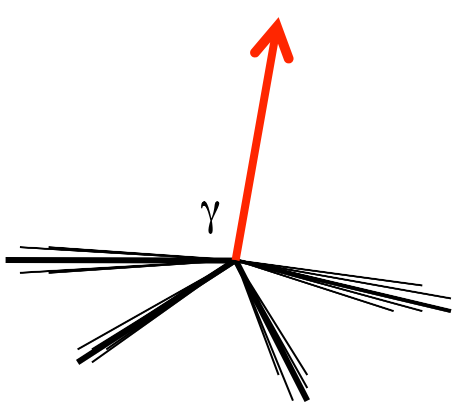
Z → ll + jets

Strength: very clean

Weakness: low statistics

Use ϒ + Jet events, select pure events with ϒ with Pt > 100GeV. Use MC to scale ϒ ➪ Z - Largest systematic.





W → lν + jets

Strength: larger statistics

Weakness: background from SM and SUSY

ϒ + jets

Strength: large statistics and clean at high E_T

Weakness: background at low E_T, theoretical errors

Background estimation 4)

Perform a simultaneous fit to the different background predictions to give a total background estimate.

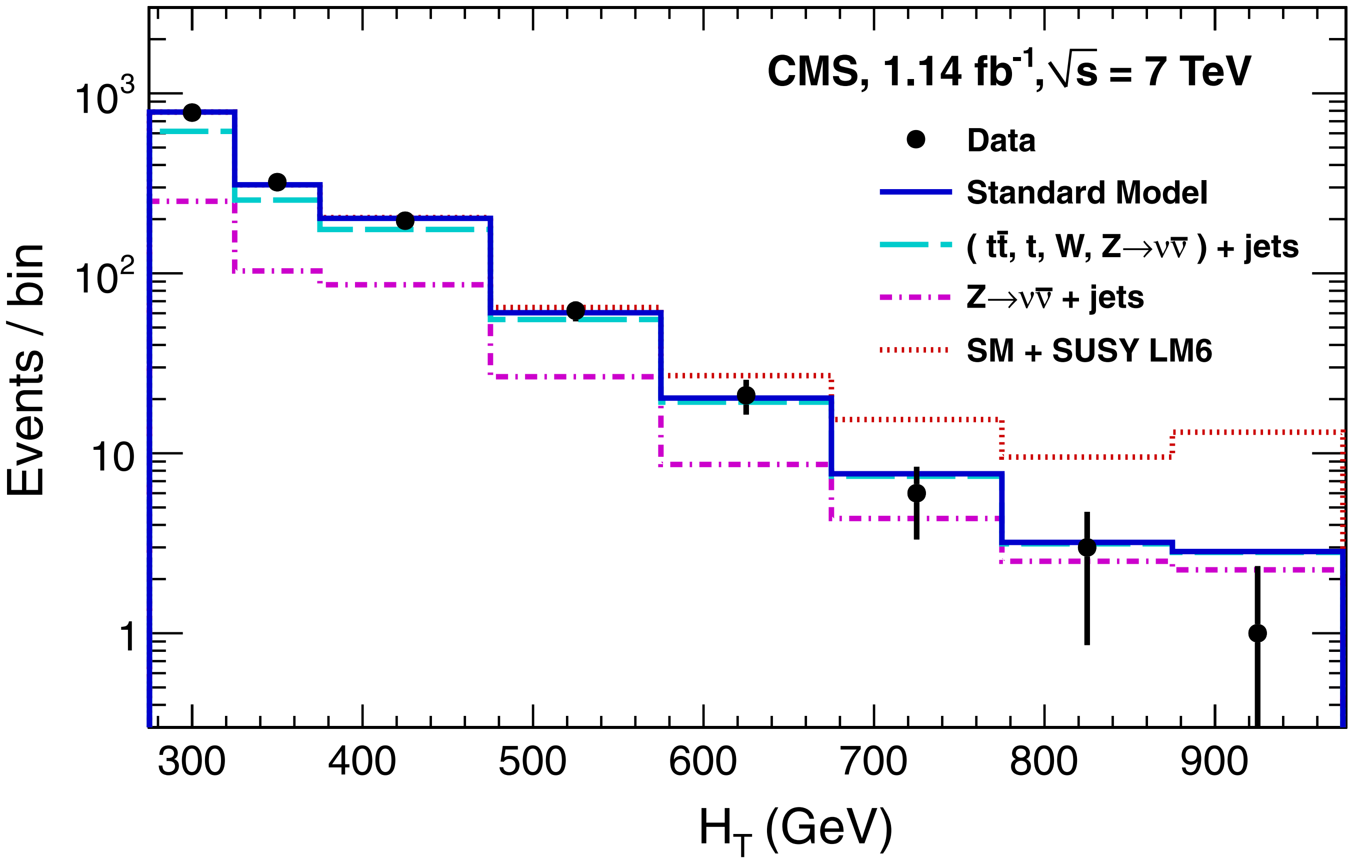
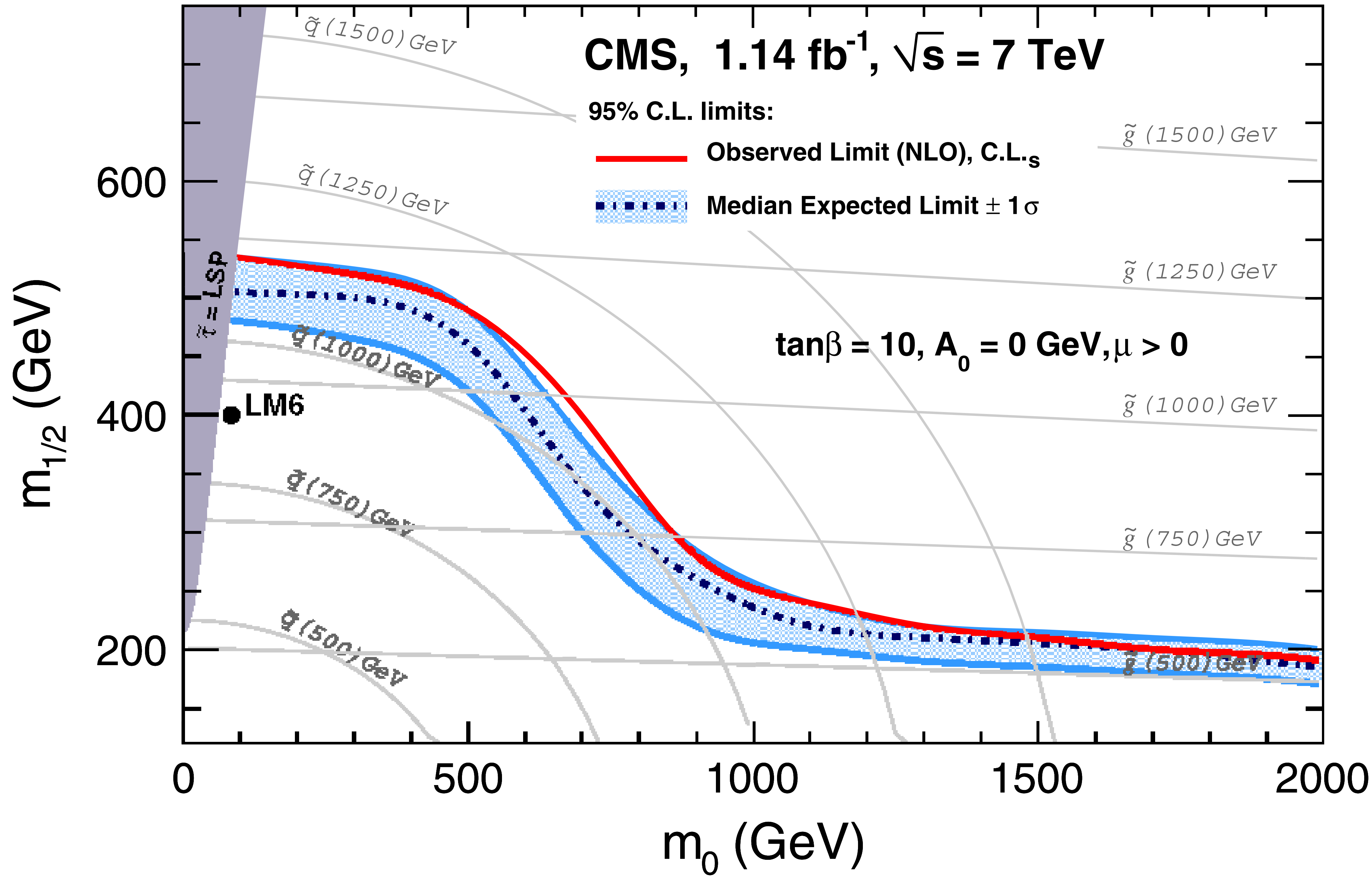


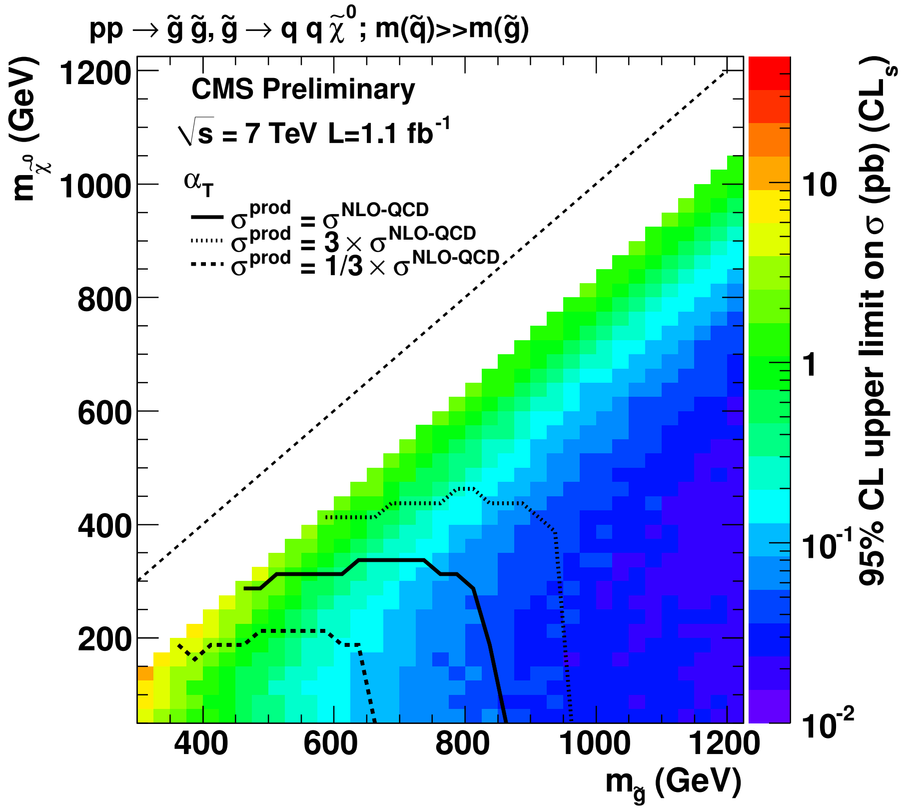
TABLE I. Comparison of the measured yields in the different H_T bins for the hadronic, μ + jets and γ + jets samples with the SM expectations and combined statistical and systematic uncertainties given by the simultaneous fit.

H_T bin (GeV)	275–325	325–375	375–475	475–575	575–675	675–775	775–875	>875
SM hadronic	787^{+32}_{-22}	310^{+8}_{-12}	202^{+9}_{-9}	$60.4^{+4.2}_{-3.0}$	$20.3^{+1.8}_{-1.1}$	$7.7^{+0.8}_{-0.5}$	$3.2^{+0.4}_{-0.2}$	$2.8^{+0.4}_{-0.2}$
Data hadronic	782	321	196	62	21	6	3	1
SM μ + jets	367^{+15}_{-15}	182^{+8}_{-9}	113^{+8}_{-7}	$36.5^{+3.8}_{-3.3}$	$13.4^{+2.2}_{-1.8}$	$4.0^{+1.4}_{-1.2}$	$0.8^{+0.9}_{-0.1}$	$0.7^{+0.9}_{-0.1}$
Data μ + jets	389	156	113	39	17	5	0	0
SM γ + jets	834^{+28}_{-30}	325^{+17}_{-17}	210^{+12}_{-12}	$64.7^{+6.9}_{-7.0}$	$21.1^{+3.9}_{-4.3}$	$10.5^{+2.5}_{-2.6}$	$6.1^{+0.9}_{-1.7}$	$5.5^{+0.9}_{-1.6}$
Data γ + jets	849	307	210	67	24	12	4	4

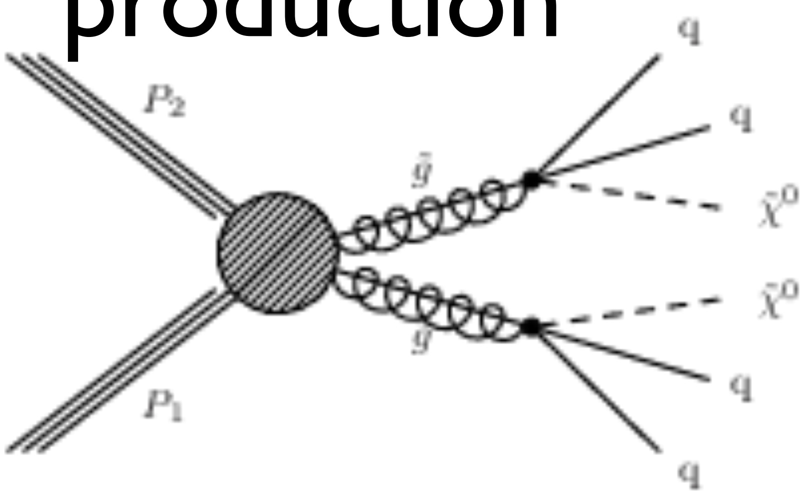
Interpretation I CMSSM

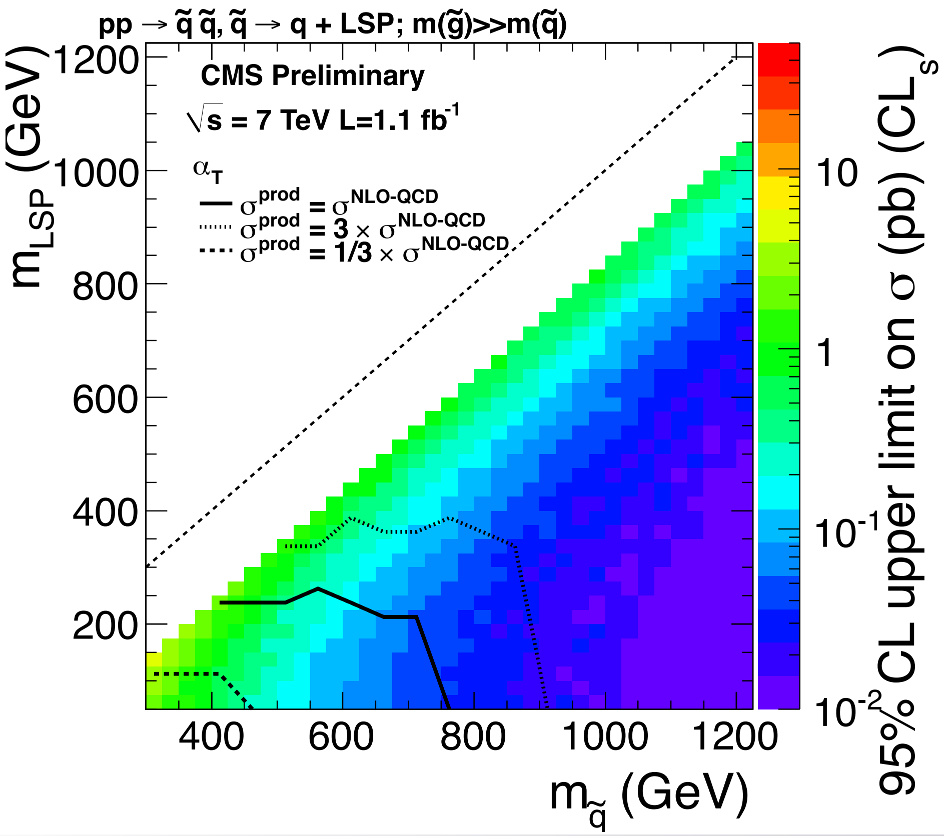


Interpretation 2) Simplified Models

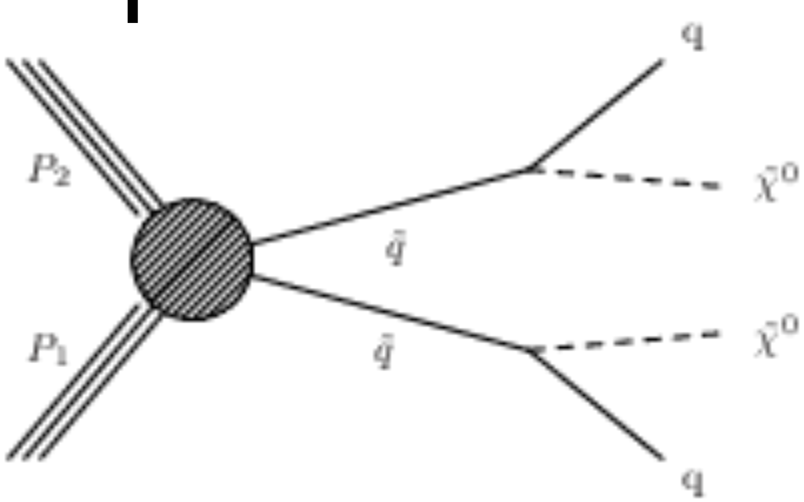


Gluino-Gluino production





Squark-Squark production

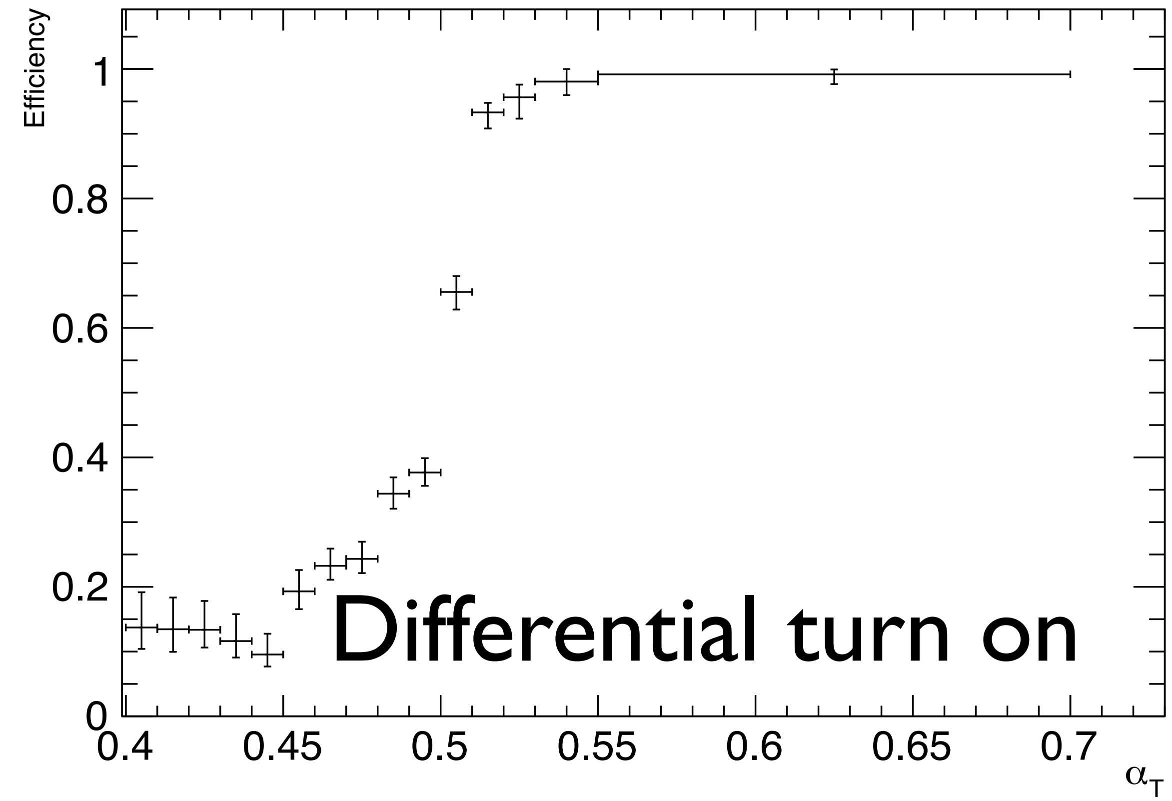


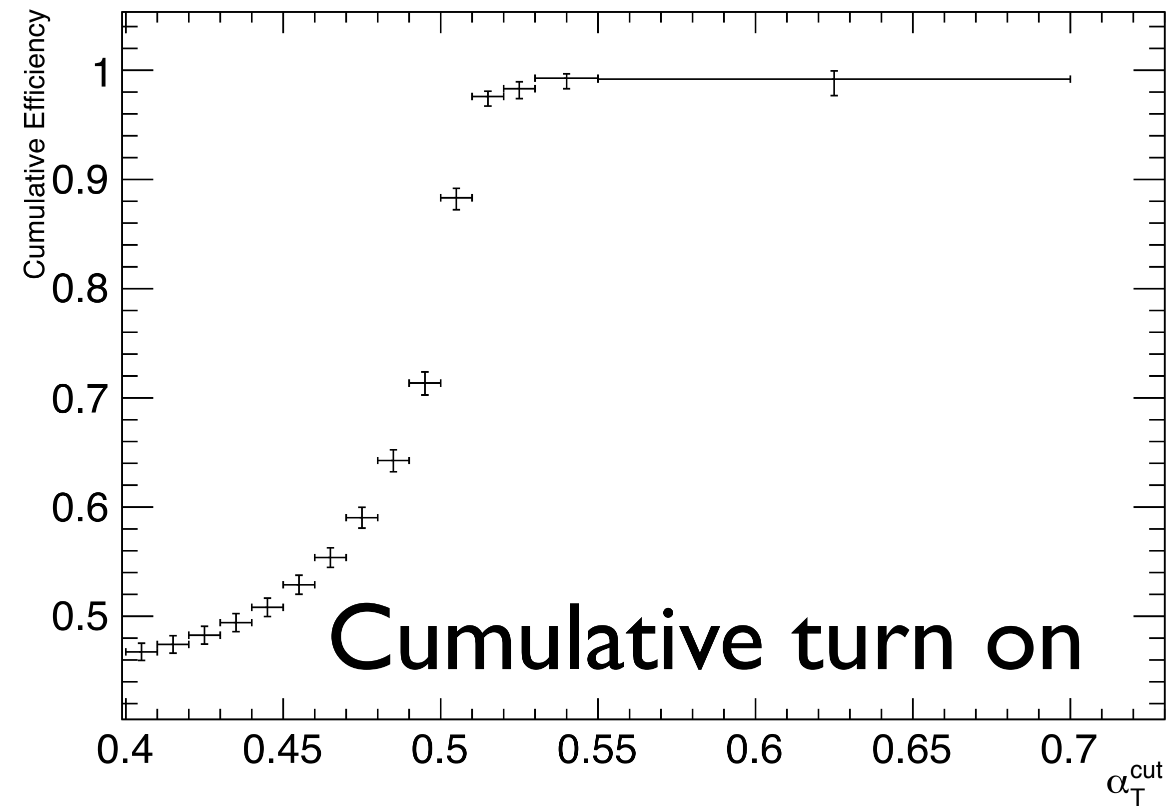
Future work

- **Use α_T specific triggers** to enable us to stay at low HT in the high lumi running.
- Use exclusive B-Tag bins, improve sensitivity to light stops/sbottoms.
- Analyse the full 5/fb of 7TeV data.

α_T Triggers - an example

- Calculate αT iteratively, add each Jet in the event above some threshold. Calculate HT and α_T, if both are above the required thresholds then we accept the event.
- This means that we are not effected by jet thresholds, so we can change the jet thresholds in the offline analysis bins.
- Triggers turn on ~0.02 in α_T after the trigger threshold





Conclusions

- Presented an updated α_T analysis with 1/fb of integrated luminosity.
- Have designed and tested a suite of triggers for the 5/fb analysis.
- Looked at ways of enhancing the analysis given our current findings.
- Plan to release the new analysis in the coming months