AlphaT analysis of the full 2012 dataset

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(Bristol, Brown, CERN, Imperial, Rochester)

Existing public results with 2012 dataset

- High Priority Analysis for ICHEP 2012
  - PAS-SUS-12-016 based on 3.9/fb @ 8 TeV
- Preliminary result for HCP 2012
  - PAS-SUS-12-028 based on 11.7/fb @ 8 TeV
- HCP result was basis for published result
  - Eur. Phys. J. C 73 (2013) 2568
  - Already >50 citations (plus >30 for two PAS's)
  - Inclusive search yet competitive limits
  - eg, T2(u_L), T2bb, T1bbbb

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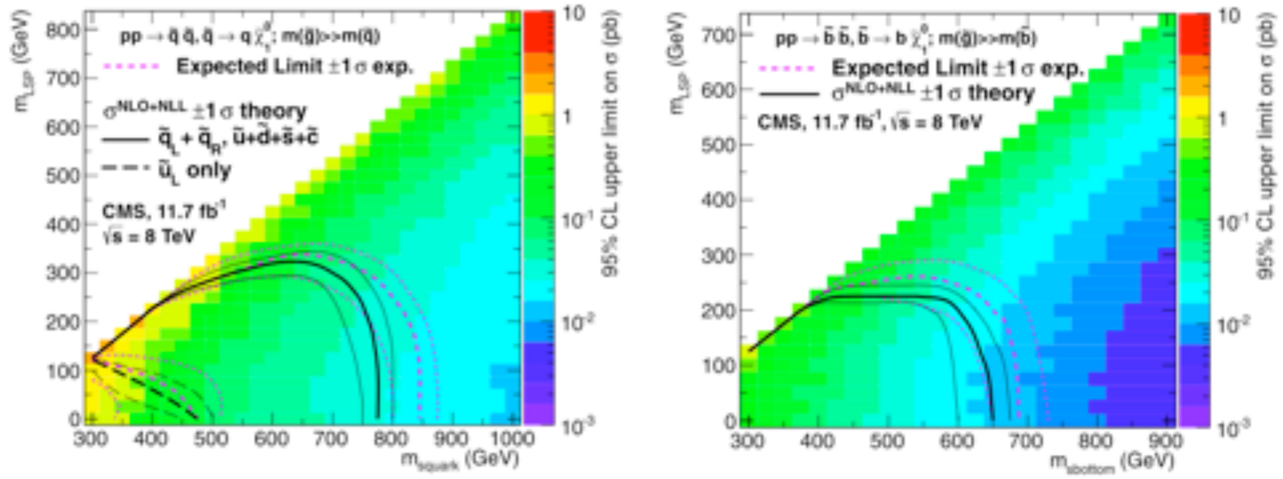
THE EUROPEAN PHYSICAL JOURNAL C

Regular Article - Experimental Physics

Search for supersymmetry in hadronic final states with missing transverse energy using the variables α_T and b-quark multiplicity in pp collisions at $\sqrt{s} = 8$ TeV

The CMS Collaboration*
CERN, Geneva, Switzerland



Motivation and status

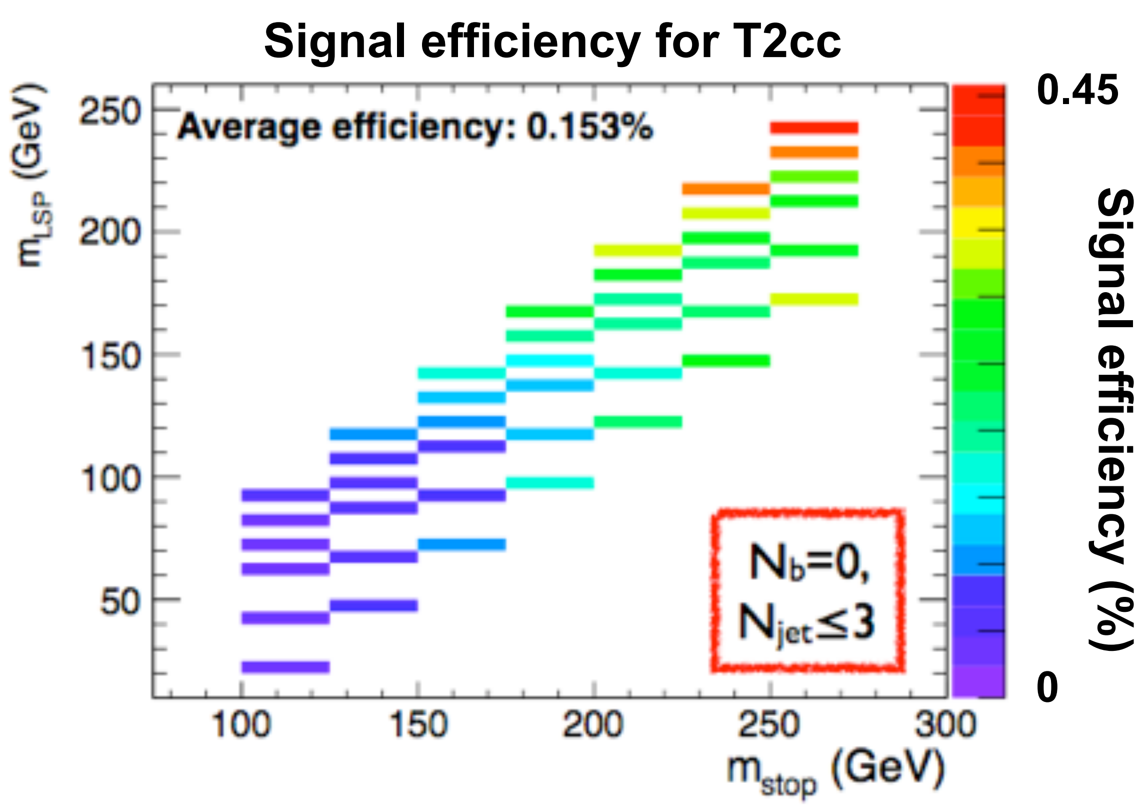
- Motivation
  - Legacy result based on full 2012 dataset
  - We have new data thanks to the parked trigger!
  - Focus on (near) mass-degenerate models (ie, difficult region near the diagonal)
- Status
  - Extended signal region to include **parked data**
  - Updated to **latest recommendations**: 22Jan2012 ReReco, MC samples, GTs, POGs...
  - **Good understanding of control samples**, derived background systematics
  - Developments concerning (improved) background control are ongoing
    - eg, Single Isolated Track Veto and QCD: we will report on these in the next meeting
  - Preparing for signal interpretations (efficiencies and systematics)
  - We are **still blind** w.r.t. the parked data and the last 6.6/fb
- Identical analysis methods w.r.t. approved 11.7/fb result, unless stated otherwise
  - Changes are highlighted in red

Mass-degenerate SUSY

- Models with small mass splittings yield very soft decay products below thresholds
  - Acceptance is only due to recoil against hard jets from initial state radiation
  - Expect sensitivity to low mass region where large XS compensates for low efficiency
- Expect broad excess at low- to mid-HT and lots of MET (≈HT)
  - Parked trigger allows to go lower in HT
- Signal sits in region with large backgrounds (irreducible $Z \rightarrow \nu\nu$ dominates)
  - Focus is to reduce B and σ_B to maximise sensitivity
  - Signal systematics dominated by ISR for small mass splittings

Example yields from SM-only fit and for T2cc with 12/fb

HT (GeV)	275–325	325–375	375–475	475–575	575–675
Fit	6235.0 ± 100.0	2900.0 ± 60.0	1955.0 ± 39.0	558.0 ± 15.0	186.0 ± 11.0
300	42.0 ± 3.0	31.1 ± 2.7	25.4 ± 2.4	10.0 ± 1.5	2.8 ± 0.8
220/195	144.3 ± 13.3	96.1 ± 11.2	78.4 ± 10.2	10.6 ± 3.8	4.0 ± 2.3
220/170	159.8 ± 13.9	62.1 ± 9.0	47.0 ± 7.8	5.2 ± 2.6	2.6 ± 1.8
220/145	189.8 ± 15.1	89.2 ± 10.7	57.5 ± 8.7	23.5 ± 5.5	0.0 ± 0.0
160	255.1 ± 39.8	113.8 ± 27.6	87.9 ± 24.4	20.3 ± 11.7	0.0 ± 0.0



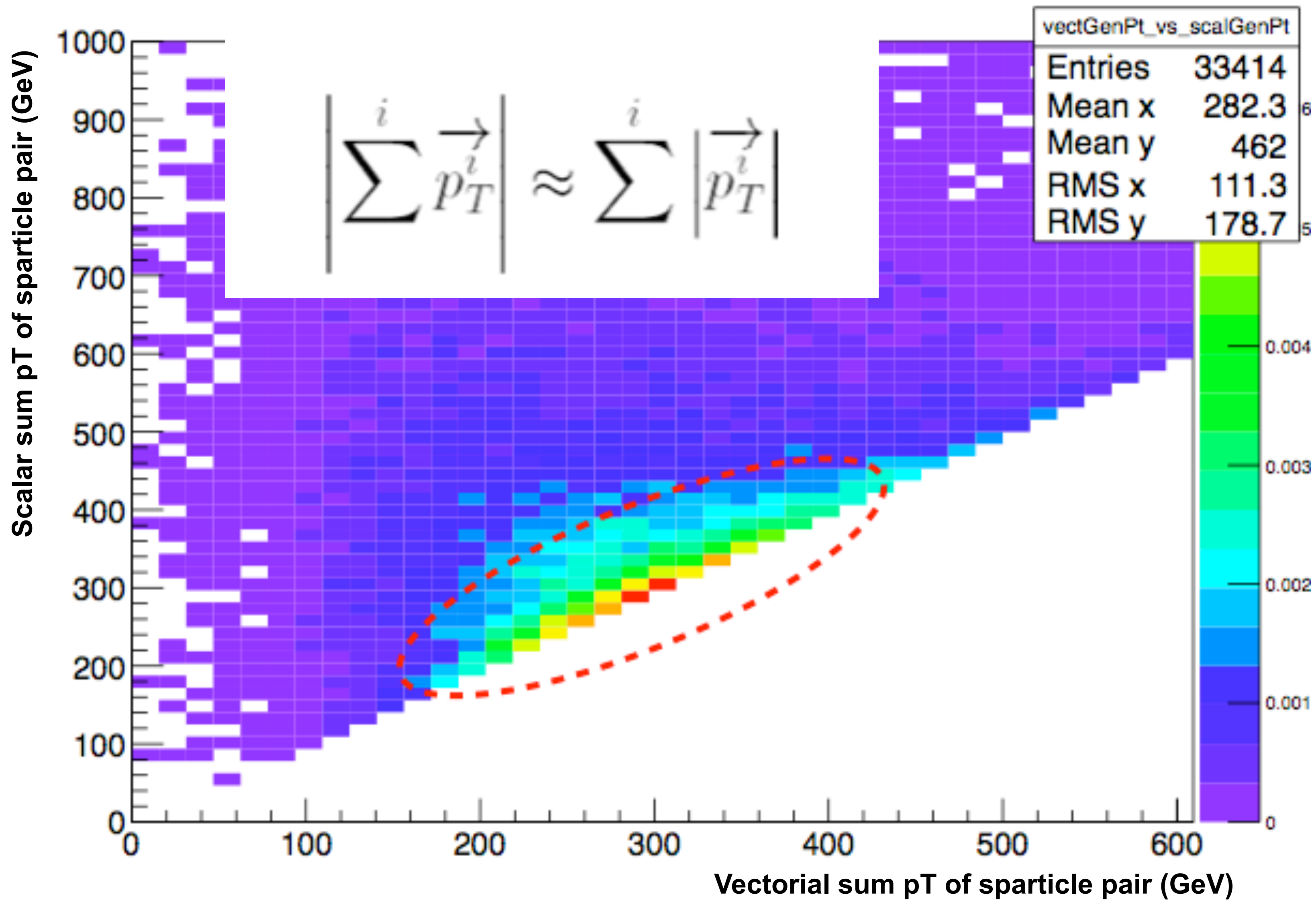
Special topology near the diagonal

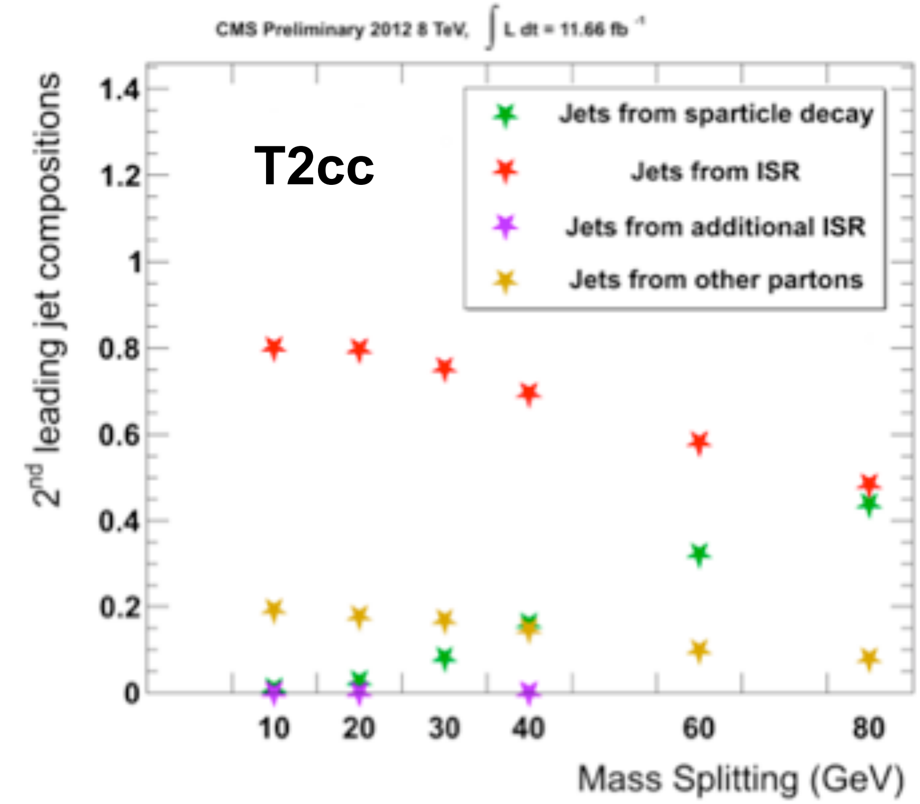
Acceptance mainly due to ISR jets at small Δm

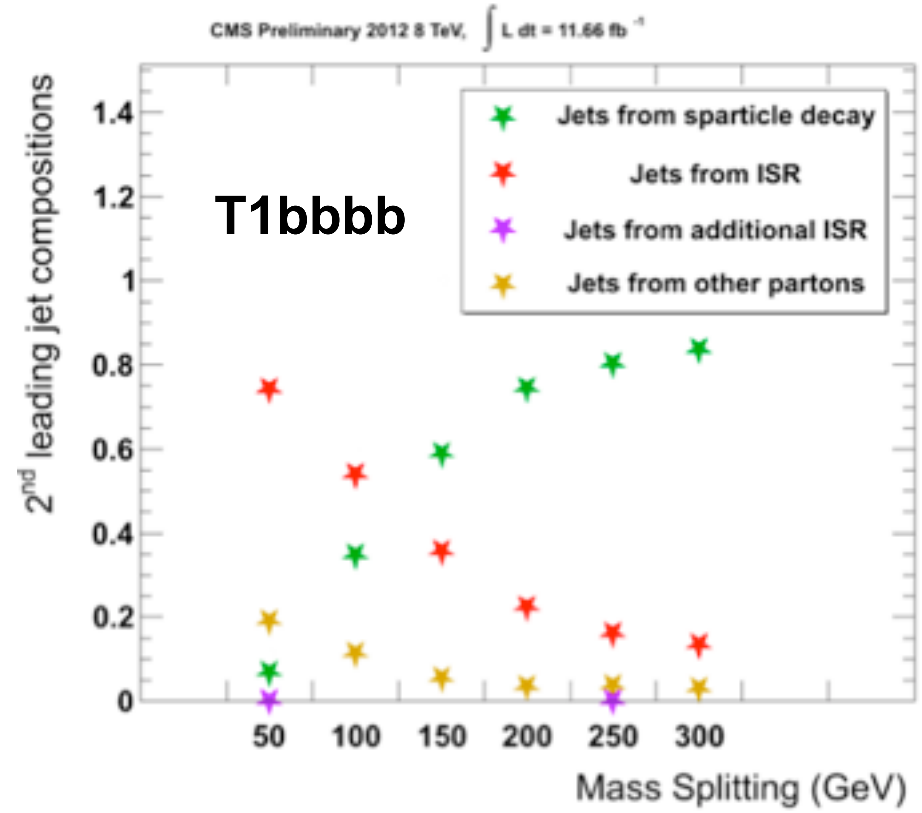
Special topology near diagonal:

two leading jets (nearly) collinear in φ balancing MET

MHT → HT as Δm → 0







Search strategy

- Hadronic jets + MET signature: veto events with isolated muons, electrons, photons
- Reduce QCD to a negligible level via the AlphaT variable
  - Discriminates b/w genuine MET and fake MET from jet mismeasurements
- Dominant backgrounds: irreducible $Z \rightarrow \nu\nu$ and "lost leptons" or $\tau \rightarrow$had from $(t \rightarrow) W \rightarrow \ell\nu$
- Estimate remaining SM backgrounds with data control samples and transfer factors
  - Multiple data control samples, SM-enriched, kinematically similar, binned identically to SR
- Confront data against background predictions (simultaneously) over:
  - Broad range in HT: up to 11 bins from 200 to >1075 GeV
  - Multiple b-tag multiplicity bins: N_b = 0, 1, 2, 3, ≥4
  - Two bins in jet multiplicity: $2 \leq N_{jet} \leq 3$, $N_{jet} \geq 4$
- Aim: robust, inclusive search that provides sensitivity to:
  - squark and gluon pair-production
  - both large and small mass splittings
  - third-generation sparticle production and decay
- Strategy is unchanged w.r.t. HCP result

Datasets and MC

- Using 22Jan2013 ReReco (JSON covers 190456-208686)
- HTMHTParked dataset for signal candidate events (18.3/fb certified + ntuplised)
- Datasets for control samples:
  - HTMHT, JetHT, SingleMu, SinglePhoton, SinglePhotonParked (all ~19/fb)
- Currently still blind w.r.t. parked data and last 6.6/fb (paper with 11.7/fb)
- Monte Carlo samples
  - SM samples: FullSim, Summer12, PU S10
  - Madgraph: W, Z, DY, GJets, VV
  - Powheg: tt, t
  - Signal samples now all Madgraph (details later)

Dataset	Luminosity (fb^{-1})
/HTMHTParked/Run2012B-22Jan2013-v1/AOD	
/HTMHTParked/Run2012C-22Jan2013-v1/AOD	
/HTMHTParked/Run2012D-22Jan2013-v1/AOD	18.33
/HT/Run2012A-22Jan2013-v1/AOD	
/JetHT/Run2012B-22Jan2013-v1/AOD	
/JetHT/Run2012C-22Jan2013-v1/AOD	
/JetHT/Run2012D-22Jan2013-v1/AOD	18.33
/SingleMu/Run2012A-22Jan2013-v1/AOD	
/SingleMu/Run2012B-22Jan2013-v1/AOD	
/SingleMu/Run2012C-22Jan2013-v1/AOD	
/SingleMu/Run2012D-22Jan2013-v1/AOD	19.15
/Photon/Run2012A-22Jan2013-v1/AOD	
/SinglePhoton/Run2012B-22Jan2013-v1/AOD	
/SinglePhoton/Run2012C-22Jan2013-v1/AOD	
/SinglePhotonParked/Run2012D-22Jan2013-v1/AOD	19.18

List of MC samples

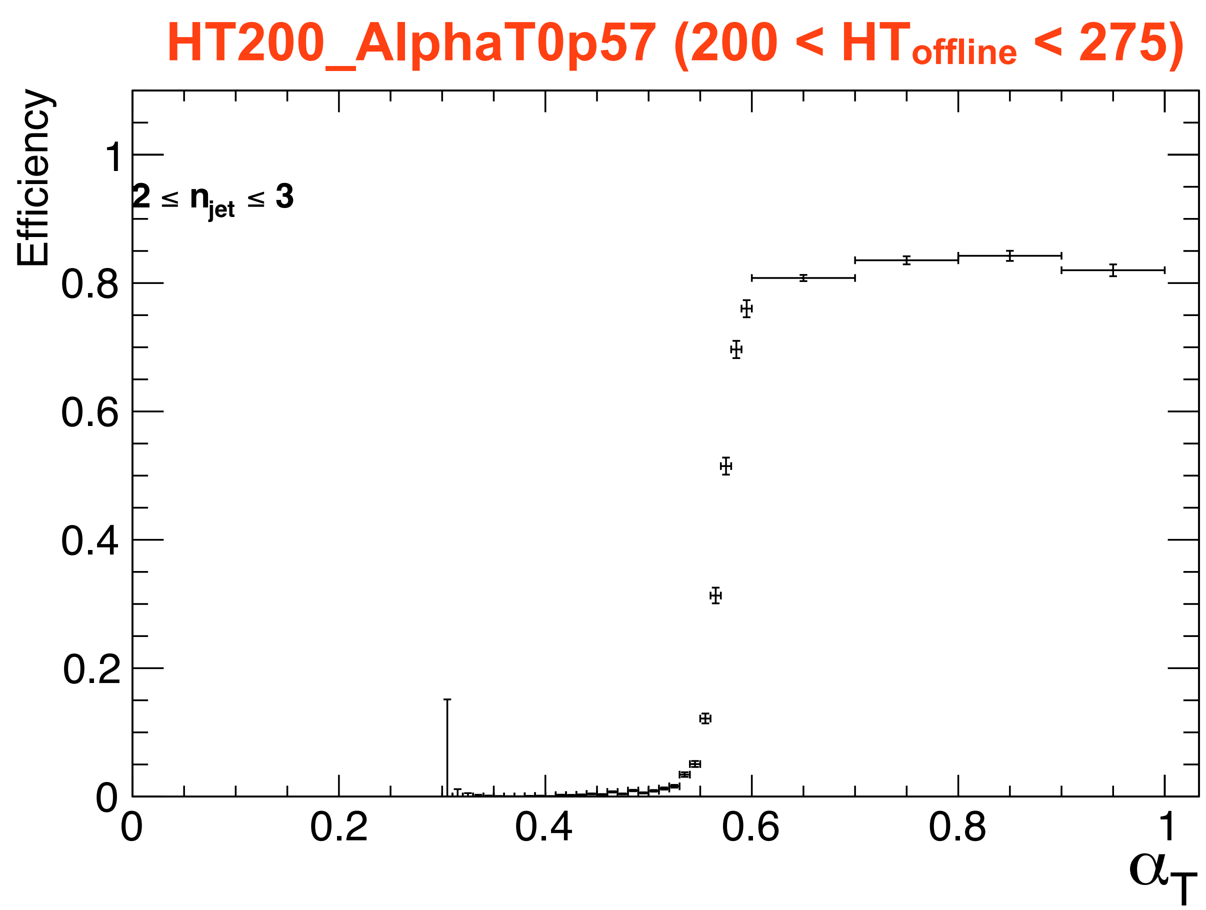
Sample	N_{event}	XS @ (N)NLO (pb)	Luminosity (fb^{-1})
/WJetsToLNu_TuneZ2Star_8TeV-madgraph-tarball/Summer12_DR53X-PU_S10_START53_V7A-v1/AODSIM	57661905	37509.0	1.5
/WJetsToLNu_HT-150To200_8TeV-madgraph/Summer12_DR53X-PU_S10_START53_V7C-v1/AODSIM	21414209	253.8	84.4
/WJetsToLNu_HT-200To250_8TeV-madgraph/Summer12_DR53X-PU_S10_START53_V7C-v1/AODSIM	9895771	116.5	84.9
/WJetsToLNu_HT-250To300_8TeV-madgraph_v2/Summer12_DR53X-PU_S10_START53_V7A-v1/AODSIM	4924990	57.6	85.5
/WJetsToLNu_HT-300To400_8TeV-madgraph_v2/Summer12_DR53X-PU_S10_START53_V7A-v1/AODSIM	5141023	48.4	106.2
/WJetsToLNu_HT-400ToInf_8TeV-madgraph_v2/Summer12_DR53X-PU_S10_START53_V7A-v1/AODSIM	4923847	30.8	159.9
/ZJetsToNuNu_50_HT_100_TuneZ2Star_8TeV_madgraph(_ext)/Summer12_DR53X-PU_S10_START53_V7A-v1/AODSIM	23743998	452.8	52.4
/ZJetsToNuNu_100_HT_200_TuneZ2Star_8TeV_madgraph(_ext)/Summer12_DR53X-PU_S10_START53_V7A-v1/AODSIM	9876059	190.4	51.9
/ZJetsToNuNu_200_HT_400_TuneZ2Star_8TeV_madgraph(_ext)/Summer12_DR53X-PU_S10_START53_V7A-v1/AODSIM	9649619	45.1	214.0
/ZJetsToNuNu_400_HT_inf_TuneZ2Star_8TeV_madgraph(_ext)/Summer12_DR53X-PU_S10_START53_V7A-v1/AODSIM	5079710	6.26	811.5
/TT_CT10_TuneZ2star_8TeV-powheg-tauola/Summer12_DR53X-PU_S10_START53_V7A-v1(v2)/AODSIM	27094723	234.0	115.8
/TTZJets_8TeV-madgraph_v2/Summer12_DR53X-PU_S10_START53_V7A-v1/AODSIM	210160	0.172	1221.9
/T_t-channel_TuneZ2star_8TeV-powheg-tauola/Summer12_DR53X-PU_S10_START53_V7A-v1/AODSIM	3710227	56.4	65.8
/Tbar_t-channel_TuneZ2star_8TeV-powheg-tauola/Summer12_DR53X-PU_S10_START53_V7A-v1/AODSIM	1935072	30.7	63.0
/T_s-channel_TuneZ2star_8TeV-powheg-tauola/Summer12_DR53X-PU_S10_START53_V7A-v1/AODSIM	243961	3.79	64.4
/Tbar_s-channel_TuneZ2star_8TeV-powheg-tauola/Summer12_DR53X-PU_S10_START53_V7A-v1/AODSIM	139974	1.76	79.5
/T_tW-channel-DR_TuneZ2star_8TeV-powheg-tauola/Summer12_DR53X-PU_S10_START53_V7A-v1/AODSIM	497658	11.1	44.8
/Tbar_tW-channel-DR_TuneZ2star_8TeV-powheg-tauola/Summer12_DR53X-PU_S10_START53_V7A-v1/AODSIM	493460	11.1	44.5
/DYJetsToLL_M-10To50filter_8TeV-madgraph/Summer12_DR53X-PU_S10_START53_V7A-v1/AODSIM	7116223	13124.1	0.5
/DYJetsToLL_M-50_TuneZ2Star_8TeV-madgraph-tarball/Summer12_DR53X-PU_S10_START53_V7A-v1/AODSIM	30171503	3503.7	8.6
/DYJetsToLL_HT-200To400_TuneZ2Star_8TeV-madgraph(_ext)/Summer12_DR53X-PU_S10_START53_V7A-v1/AODSIM	6892777	24.3	283.7
/DYJetsToLL_HT-400ToInf_TuneZ2Star_8TeV-madgraph/Summer12_DR53X-PU_S10_START53_V7A-v1/AODSIM	2695789	3.36	802.3
/GJets_HT-200To400_8TeV-madgraph/Summer12_DR53X-PU_S10_START53_V7A-v1/AODSIM	57891147	1140.8	50.7
/GJets_HT-400ToInf_8TeV-madgraph/Summer12_DR53X-PU_S10_START53_V7A-v1/AODSIM	9459562	124.7	75.9
/WW_TuneZ2star_8TeV_pythia6_tauola/Summer12_DR53X-PU_S10_START53_V7A-v1/AODSIM	9888431	57.1	173.2
/WZ_TuneZ2star_8TeV_pythia6_tauola/Summer12_DR53X-PU_S10_START53_V7A-v1/AODSIM	9841248	12.6	781.1
/ZZ_TuneZ2star_8TeV_pythia6_tauola/Summer12_DR53X-PU_S10_START53_V7A-v1/AODSIM	9751908	8.26	1180.6
/QCD_Pt-50to80_TuneZ2star_8TeV_pythia6/Summer12_DR53X-PU_S10_START53_V7A-v2	5950860	8148778 (LO)	0.001
/QCD_Pt-80to120_TuneZ2star_8TeV_pythia6/Summer12_DR53X-PU_S10_START53_V7A-v3	5962864	1033680 (LO)	0.006
/QCD_Pt-120to170_TuneZ2star_8TeV_pythia6/Summer12_DR53X-PU_S10_START53_V7A-v3	5985732	156293 (LO)	0.038
/QCD_Pt-170to300_TuneZ2star_8TeV_pythia6/Summer12_DR53X-PU_S10_START53_V7A-v1(v2)	20155180	34138 (LO)	0.590
/QCD_Pt-300to470_TuneZ2star_8TeV_pythia6/Summer12_DR53X-PU_S10_START53_V7A-v1(v2,v3)	23588100	1759.5 (LO)	13.4
/QCD_Pt-470to600_TuneZ2star_8TeV_pythia6/Summer12_DR53X-PU_S10_START53_V7A-v2	3978848	113.9 (LO)	34.9
/QCD_Pt-600to800_TuneZ2star_8TeV_pythia6/Summer12_DR53X-PU_S10_START53_V7A-v2	3964864	27.0 (LO)	146.8
/QCD_Pt-800to1000_TuneZ2star_8TeV_pythia6/Summer12_DR53X-PU_S10_START53_V7A-v2	3854563	3.55 (LO)	1085.8
/QCD_Pt-1000to1400_TuneZ2star_8TeV_pythia6/Summer12_DR53X-PU_S10_START53_V7A-v1	1964088	0.738 (LO)	2661.4
/QCD_Pt-1400to1800_TuneZ2star_8TeV_pythia6/Summer12_DR53X-PU_S10_START53_V7A-v1	1988062	0.0335 (LO)	59345.1
/QCD_Pt-1800_TuneZ2star_8TeV_pythia6/Summer12_DR53X-PU_S10_START53_V7A-v1	977586	0.00183 (LO)	534200

Triggers for signal and control regions

- Hadronic signal region:
  - HT200_AlphaT0p57: 200 < HT < 275 GeV ← New parked trigger
  - HT250_AlphaT0p55: 275 < HT < 325 GeV
  - HT300_AlphaT0p53: 325 < HT < 375 GeV
  - HT350_AlphaT0p52: 375 < HT < 475 GeV
  - HT400_AlphaT0p51: HT > 475 GeV
  - All signal triggers are in the HTMHTParked dataset (18.6/fb)
- Hadronic control region (multijet background):
  - HT200, HT250, HT300, HT350, HT400, ... HT750
  - Low-threshold triggers are heavily prescaled
- Muon and dimuon control samples (W, tt, $Z \rightarrow \nu\nu$ backgrounds):
  - IsoMu24_eta2p1: unprescaled throughout 2012
- Photon control sample ($Z \rightarrow \nu\nu$ background):
  - HLT_Photon150: unprescaled throughout 2012
  - (Investigating the use of HLT_Photon90 in the SinglePhotonParked dataset)

Signal trigger efficiencies

- Efficiencies measured in data using IsoMu24_eta2p1 as the reference trigger
  - Event selection: require 1 isolated muon, $p_T > 30$ GeV, $|\eta| < 2.1$, $\Delta R(\mu,\text{jet}) > 0.3$
  - Apply usual offline jet requirements, ignore muons, calculate HT, MHT, AlphaT, etc
- L1 seed is the main source of inefficiency at low HT
  - HT200_AlphaT0p57 seeded by L1_DoubleJetC64
  - All other AlphaT triggers also seeded by L1_HTT175



Trigger	H_T (Gev)	α_T	Efficiency (%)	
			$2 \leq n_{\text{jet}} \leq 3$	$n_{\text{jet}} \geq 4$
HLT_HT200_AlphaT0p57_v*	200–275	> 0.60	81.6 ± 0.4	66.5 ± 3.3
HLT_HT250_AlphaT0p55_v*	275–325	> 0.55	90.1 ± 0.4	66.6 ± 1.3
HLT_HT300_AlphaT0p53_v*	325–375	> 0.55	98.8 ± 0.2	97.1 ± 0.8
HLT_HT350_AlphaT0p52_v*	375–475	> 0.55	99.4 ± 0.2	98.8 ± 0.6
HLT_HT400_AlphaT0p51_v*	> 475	> 0.55	100.0 ± 0.2	100.0 ± 0.5

Control trigger efficiencies

- HT triggers used by the QCD background estimation only
- HT trigger efficiencies measured in data using reference triggers
  - Low-threshold HT triggers are heavily prescaled → small event yields
  - Now use two reference triggers to minimise statistical uncertainties
    - HLT_IsoMu24_eta2p1: require 1 isolated muon and ignore
    - HLT_Physics (Minimum Bias): apply hadronic pre-selection
  - Combine efficiency measurements
    - Expect efficiency to be independent of ref. triggers
    - Statistical uncertainty dominates (5-100%)
- L1 is the main source of inefficiency at low HT
  - HT200 seeded by L1_DoubleJetC64
  - All other HT triggers also seeded by L1_HTT175
- Photon150: >98% for p_T > 165 GeV
- IsoMu24_eta2p1: 88% 1μ (μ POG), >95% μμ

Trigger	H_T (GeV)	Efficiency (%)	
		$2 \leq n_{jet} \leq 3$	$n_{jet} \geq 4$
HLT_HT200_v*	200–275	66.3 ± 10.8	81.7 ± 81.7
HLT_HT250_v*	275–325	79.3 ± 15.9	50.2 ± 29.1
HLT_HT300_v*	325–375	106.9 ± 19.0	117.3 ± 48.0
HLT_HT350_v*	375–475	106.7 ± 15.0	67.7 ± 27.8
HLT_HT450_v*	475–575	104.1 ± 12.8	96.2 ± 20.6
HLT_HT550_v*	575–675	83.9 ± 11.7	107.0 ± 19.8
HLT_HT650_v*	675–775	105.7 ± 13.8	99.5 ± 18.2
HLT_HT750_v*	775–875	96.9 ± 5.2	95.0 ± 7.0
HLT_HT750_v*	875–975	100.0 ± 7.2	100.0 ± 10.5
HLT_HT750_v*	975–1075	100.0 ± 9.6	100.0 ± 13.5
HLT_HT750_v*	> 1075	100.0 ± 13.5	100.0 ± 19.4

Event selection

- Physics objects satisfy recommendations of the POGs
  - Use CaloJets with AK5 and L1FastJet, L2, L3, L2L3Residual corrections(fully supported by JetMET POG)
- Pre-selection (common to signal and control regions)
  - Event cleaning
  - Jet p_T > 50 GeV
  - $N_{jet} \geq 2$
  - 2^{nd} most energetic jet p_T > 100 GeV
  - HT > 200 GeV
- Hadronic signal region: preselection plus:
  - Veto events with isolated muons and electrons (photons) with pT > 10 (25) GeV
  - AlphaT > 0.55 for HT > 275 GeV
  - AlphaT > 0.60 for 200 < HT < 275 GeV (trigger efficient, QCD free)
  - POG-recommended MET filters
  - MHT/MET < 1.25 (removes events with jets below threshold contributing to MHT)
  - "Dead ECAL": veto event if ΔR(jet,dead cell/EB-EE boundary) < 0.3 and $\Delta\varphi^*_{min} < 0.5$

Signal region bins

- Eight (N_{jet},N_b) event categories and 70 bins
- New HT bins: 200-275, 975-1075, >1075 (latter two bins for N_{jet} = 2-3, N_b = 0 only)
- AlphaT > 0.55 (0.60) for HT > 275 GeV (200 < HT < 275 GeV)

Njet	Nb	HT 200	275	325	375	475	575	675	775	875	975	1075
2-3	0											
2-3	1											
2-3	2											
≥4	0											
≥4	1											
≥4	2											
≥4	3											
≥4	≥4											

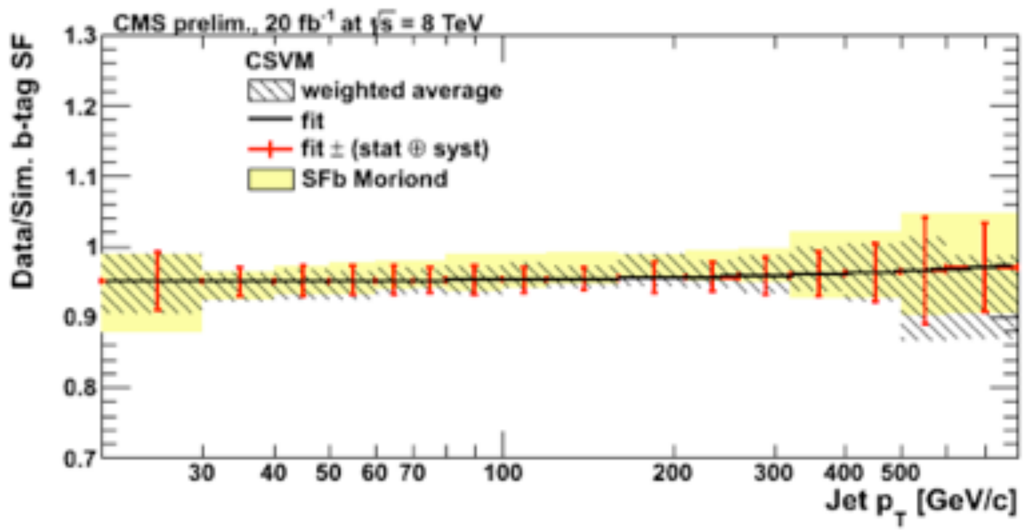
Event selection for control regions

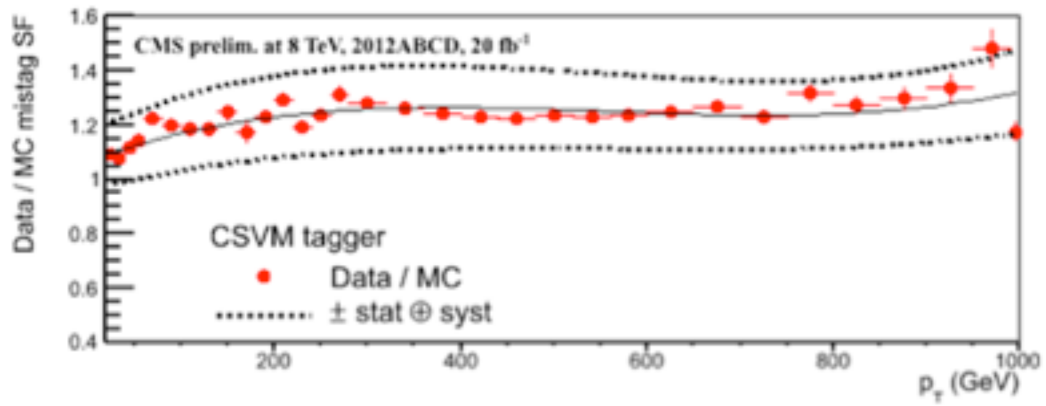
- **Pre-selection, plus:**
- Hadronic control sample (QCD background):
  - Veto events with isolated muons and electrons (photons) with pT > 10 (25) GeV
- μ + jets selection (tW, tt, t backgrounds)
  - Single isolated muon (TightID), $p_T > 30$ GeV, $|\eta| < 2.1$, $\Delta R(\mu, jet_i) > 0.5$
  - $M_T > 30$ GeV, $|m_{\mu\mu} - m_Z| > 25$ GeV (if 2nd $\mu^{loose,non\text{-}iso}$ found), MHT/MET < 1.25
- μμ + jets selection ($Z \rightarrow \nu\nu$ background)
  - Two muons (TightID), ≥1 isolated, $p_T > 10$ GeV, lead $p_T > 30$ GeV, $|\eta| < 2.1$, $\Delta R(\mu_i, jet_j) > 0.5$
  - $|m_{\mu\mu} - m_Z| < 25$ GeV, MHT/MET < 1.25
- γ+jets selection ($Z \rightarrow \nu\nu$ background)
  - Single isolated photon (TightID), $p_T > 165$ GeV, $|\eta| < 1.44$
  - MHT/MET < 1.25, AlphaT > 0.55
- No alphaT requirement for muon samples
  - Higher yields improves statistical precision of background estimates
  - Reduced S/B from signal contamination
  - Systematic covered by dedicated closure test (see later)

Recommended corrections applied to MC

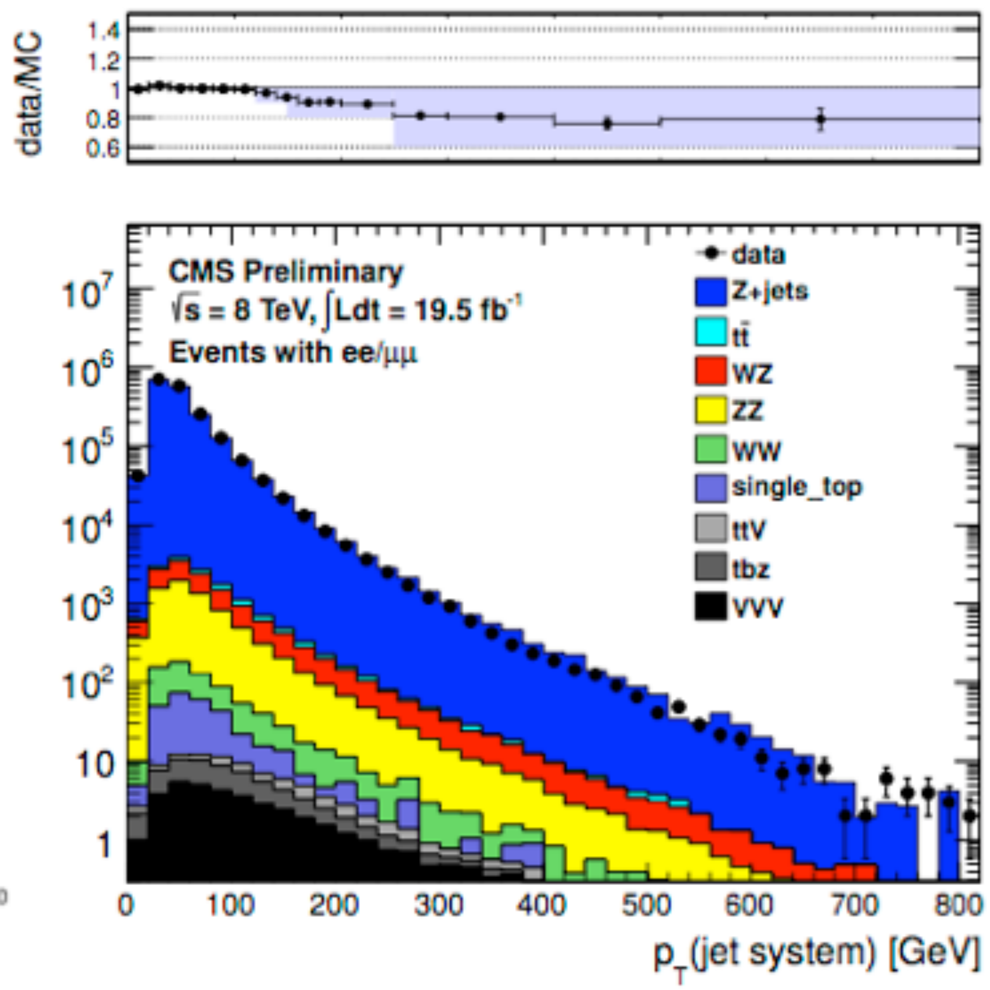
- PU interactions in MC corrected to data following recipe from the PPD group
- b-tag scale factors (b,c,light) applied, as recommended by the BTV POG
  - Using scale factors w.r.t. 22Jan2013 ReReco
- "ISR corrections" applied to main backgrounds (W, Z, tt) according to AN2013-059
  - Dominick Olivito *et al*, "Hadronic Recoil Studies of Heavy Boosted Systems"

SF_b and SF_{light} for CSVM

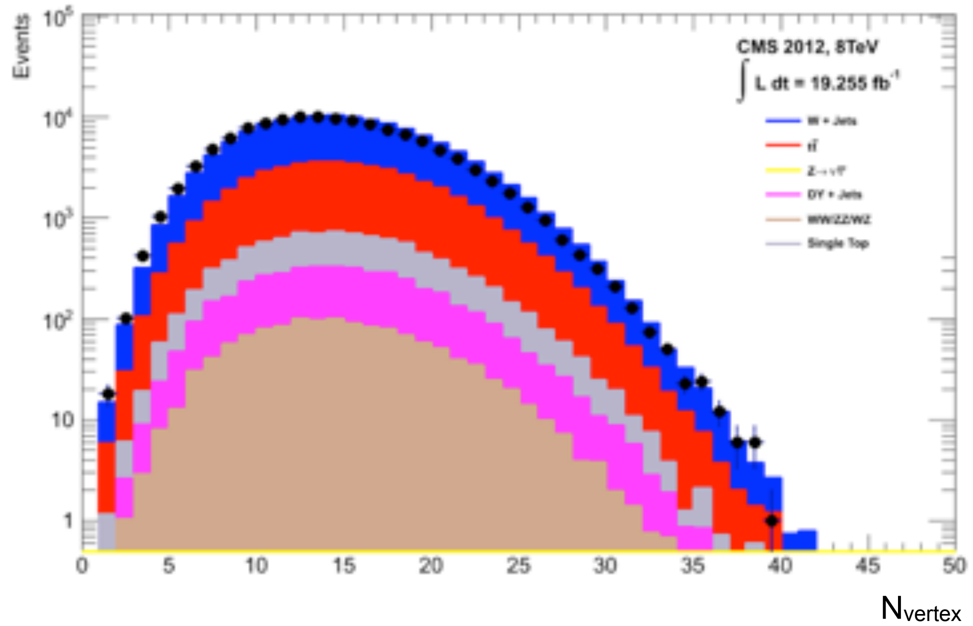




ISR corrections



N_{vertex} distribution



Precision MC yields at high b-tag multiplicities

- Sensitivity to models with third-generation squarks is driven by high N_b multiplicities
  - Rare events $N_b \geq 3$ + MET: eg, tt + 1 mis-tag, tt + gluon→bb, ...
  - Important to reduce statistical uncertainties in MC yields
- Hence, we employ the “formula method” to obtain precise MC yields at high Nb
  - Rely on precise knowledge of reco-level b-tag efficiencies and mis-tag probabilities (per HT bin)...
  - ...and number of reco-level jets matched to truth-level flavour information (per HT bin)
  - Method significantly improves statistical precision for Nb ≥ 3 (negligible for low N_b)
- The CSVM tagger/working point is used in this analysis
- Recommended b-tag scale factors (plus their uncertainties) applied throughout
- Method validated with MC closure tests and in data control samples (AN-12-407)

$$N(n_\mathrm{b}) = \sum_{n_\mathrm{jet}} \sum_{n_\mathrm{b}} \left(N(n_\mathrm{b}^\mathrm{gen}, n_\mathrm{c}^\mathrm{gen}, n_\mathrm{q}^\mathrm{gen}) \times P_\mathrm{b} \times P_\mathrm{c} \times P_\mathrm{q} \right)$$

$$P_\mathrm{b} \equiv P(n_\mathrm{b}^\mathrm{tag}; n_\mathrm{b}^\mathrm{gen}, \epsilon)$$

$$n_\mathrm{jet} = n_\mathrm{b}^\mathrm{gen} + n_\mathrm{c}^\mathrm{gen} + n_\mathrm{q}^\mathrm{gen} \qquad P_\mathrm{c} \equiv P(n_\mathrm{c}^\mathrm{tag}; n_\mathrm{c}^\mathrm{gen}, f_\mathrm{c})$$

$$n_\mathrm{b} = n_\mathrm{b}^\mathrm{tag} + n_\mathrm{c}^\mathrm{tag} + n_\mathrm{q}^\mathrm{tag} \qquad P_\mathrm{q} \equiv P(n_\mathrm{q}^\mathrm{tag}; n_\mathrm{q}^\mathrm{gen}, f_\mathrm{q})$$

Estimation of non-multijet backgrounds

- Dominant SM backgrounds
  - $Z \to \nu\nu$ + jets is "irreducible" → γ+jets / μμ+jets control samples
  - (t→)W→$\ell\nu$ when e/μ is "lost" or τ→had → μ+jets control sample
  - Residual contributions from t, VV, DY...
- Method relies on data control regions and "transfer factors" (ratios from MC)
  - Extrapolate from data yields in CR to background predictions in SR using transfer factors
  - "Formula method" used to obtain precision MC yields at high b-tag multiplicities
  - MC yields are corrected with various recommended scale factors: PU, ISR, b-tag SF...
- N_{MC}^{signal} and $N_{MC}^{control}$ are strongly correlated, because data control samples:
  - are binned identically to the SR
  - are kinematically similar (jet systems) to the SR
  - have the same SM processes and very similar admixtures found in the SR
- Transfer factors largely insensitive to accuracy of MC modelling, as biases largely cancel

$$\boxed{N_{\rm pred}^{\rm signal}(H_{\rm T}, n_{\rm jet}, n_{\rm b}) = \frac{N_{\rm MC}^{\rm signal}(H_{\rm T}, n_{\rm jet}, n_{\rm b})}{N_{\rm MC}^{\rm control}(H_{\rm T}, n_{\rm jet}, n_{\rm b})} \times N_{\rm obs}^{\rm control}(H_{\rm T}, n_{\rm jet}, n_{\rm b})}$$

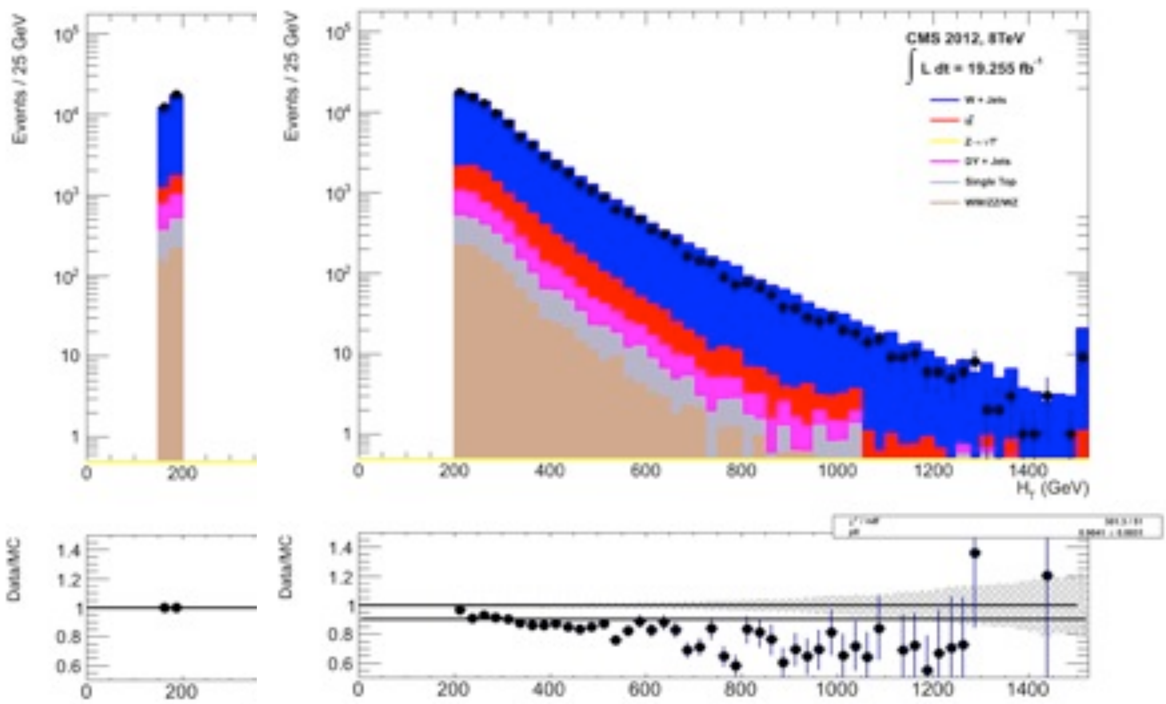
MC sample normalisation

- Use 150 < HT < 200 GeV sideband in data to correct MC normalisation
  - As done for HCP analysis and paper
- Process-dependent corrections derived with (N_{jet},N_b) categories rich in W, tt, Z(μμ)
  - Corrections to cross sections are *O*(10%)
- Transfer factors are robust against biases such as these
  - eg, variations in XS by ±20% yields %-level variations in TF (shown with HCP analysis)
- However, our method to derive background systematic uncertainties is sensitive
  - Irrelevant for our analysis, so should not be propagated through to our systematics
  - HT sideband corrections remove this normalisation problem from closure tests (and systematics)

Selections for main backgrounds

Process	W	Z(μμ)	tt
Sample	μ+jets	μμ+jets	μ+jets
N_{jet}	2-3	2-3	≥4
N_b	0	0	≥1
Purity	~90%	~90%	~90%

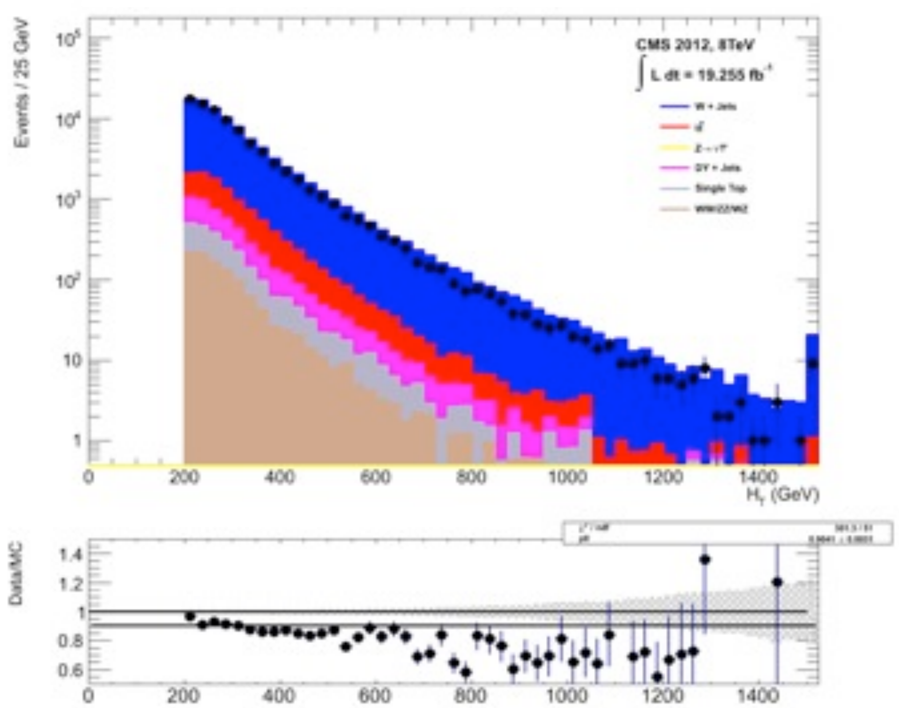
HT distribution for W-enriched sample (μ + jets, 2 ≤ N_{jet} ≤ 3, N_b = 0)



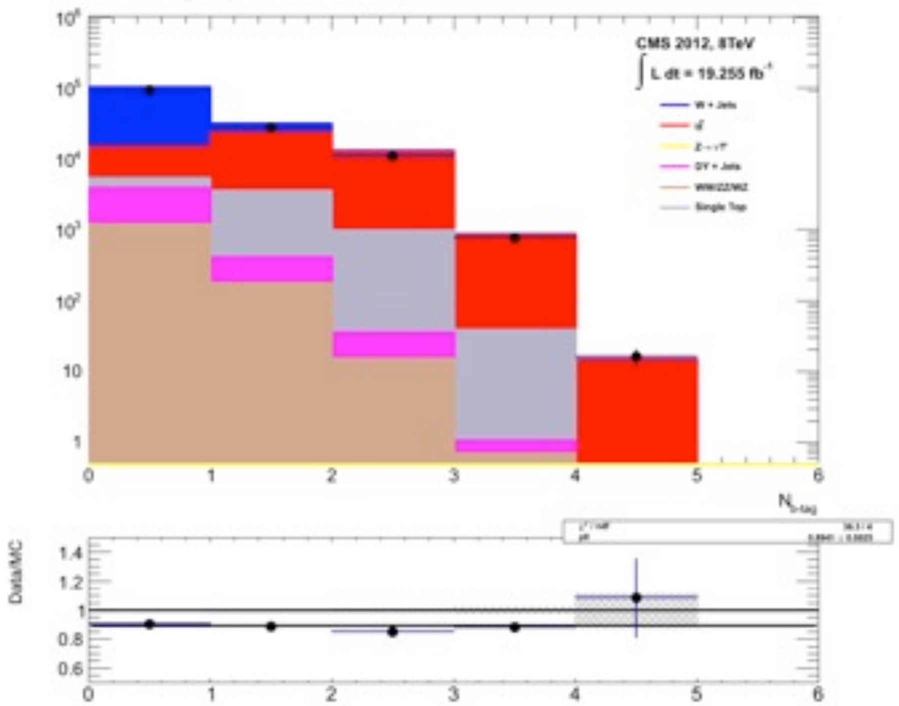
Example distributions for control regions

- Corrections are applied to MC: PU, ISR, trigger, b-tag SF, MC normalisation

HT for μ + jets, 2 ≤ N_{jet} ≤ 3, N_b = 0



Njet for μ + jets, inclusive N_{jet},N_b selection

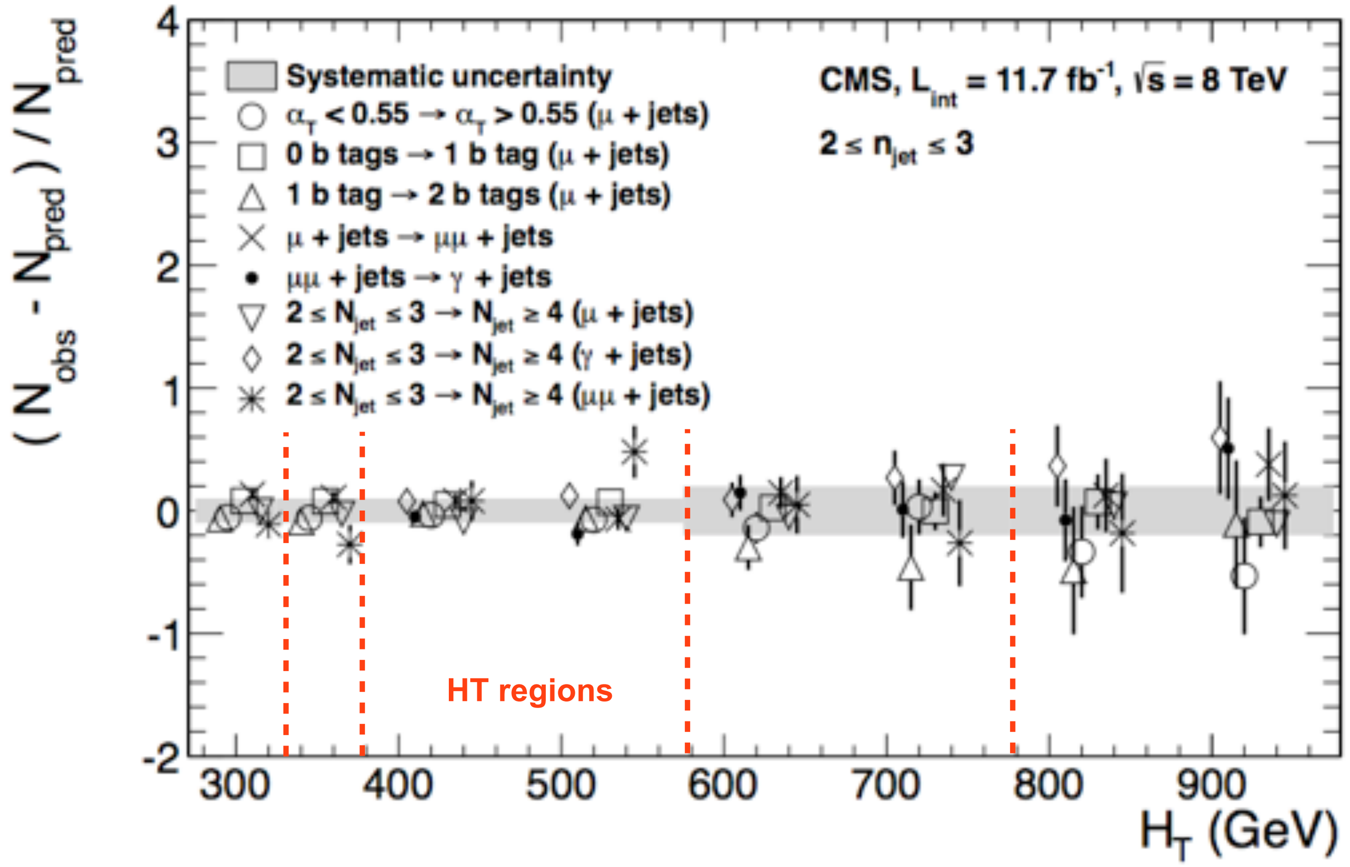


PLOTS

Closure tests

- Probe MC modelling of variables and identify process-dependent biases
  - General principle: use one control sample to predict yields in another control sample
  - Probe systematically all major ingredients in transfer factors against data
  - A large ensemble of tests (»100) used to identify N_{jet} and HT-dependent biases

- Used to derive **N_{jet}**- and **HT**-dependent systematics in transfer factors
  - Conservative: some tests are "ambitious", ie, not done in analysis (W→tt, 1b→2b, γ→μμ)
  - Conservative: define *uncorrelated* systematics for each HT bin or small regions



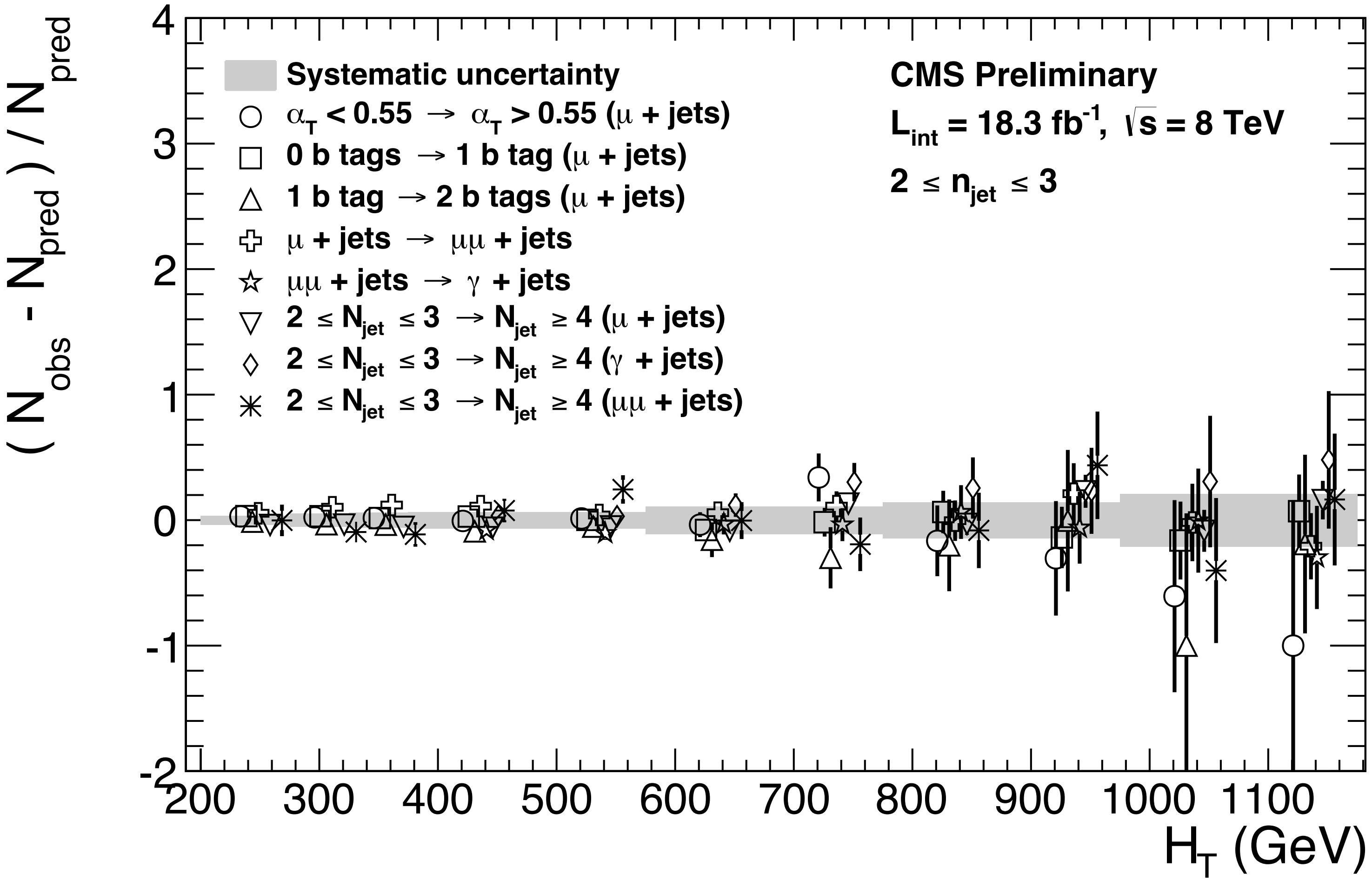
Modelling of AlphaT distribution
Admixture of W+jets and tt
b-tagging performance
Use W+jets or tt to predict Z+jets
Consistency b/w γ+jets and μμ+jets
Modelling of N_{jet} distributions

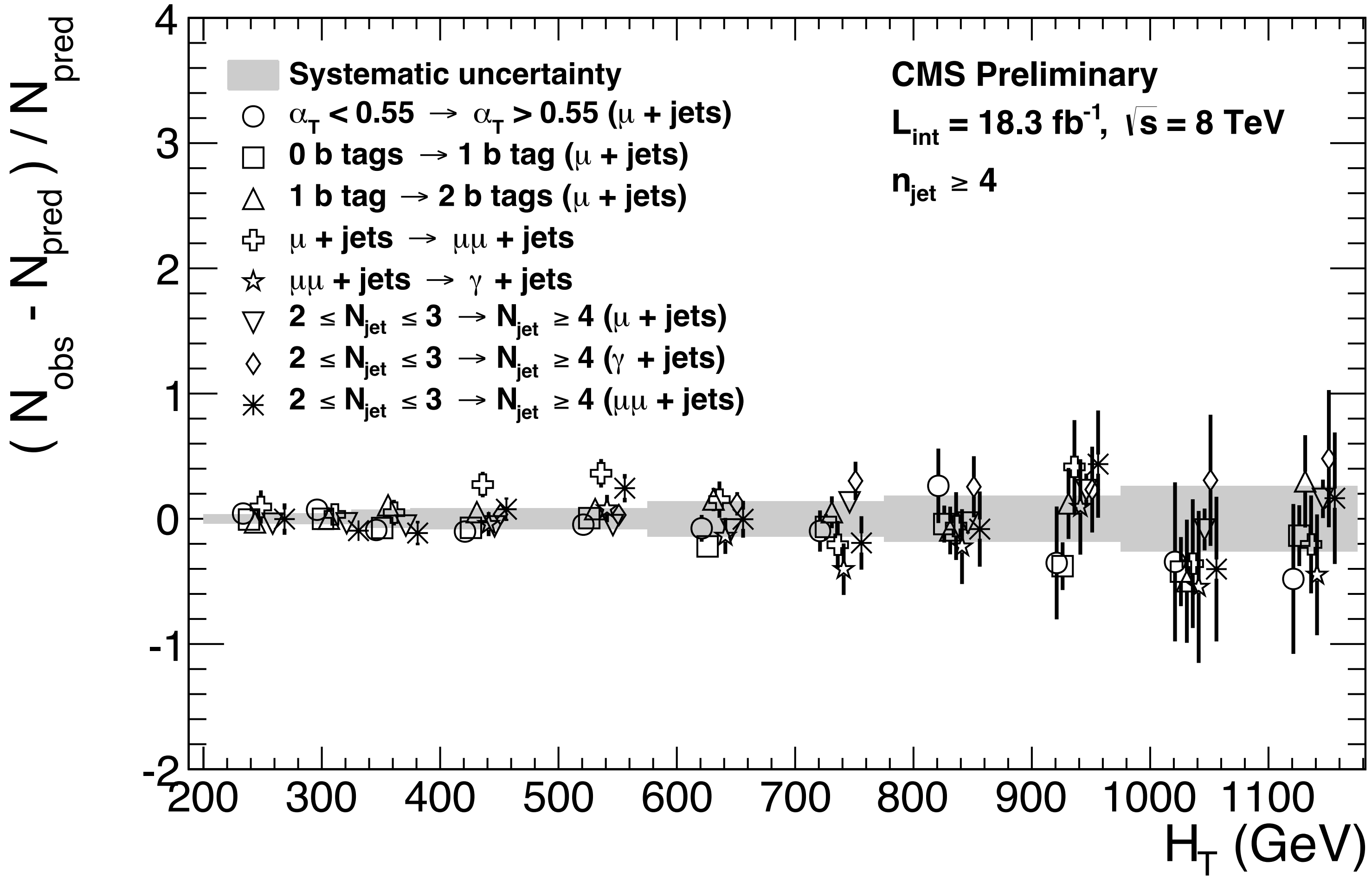
Background systematic uncertainties

- Systematics determined from weighted variance of closure tests within HT region
- Uncertainties from b-tagging are at %-level (we propagate $\sigma_{SF}{}^{b}$, $\sigma_{SF}{}^{c}$, $\sigma_{SF}{}^{light}$)

Value of $\sqrt{(\mu^2+\sigma^2)}$ per HT region (%)

N_{jet}	200-275	275-325	325-375	375-575	575-775	775-975	>975
2-3	4.2	5.4	6.1	6.6	11.0	15.0	21.1
≥ 4	4.2	4.3	8.4	8.6	14.3	18.5	27.0

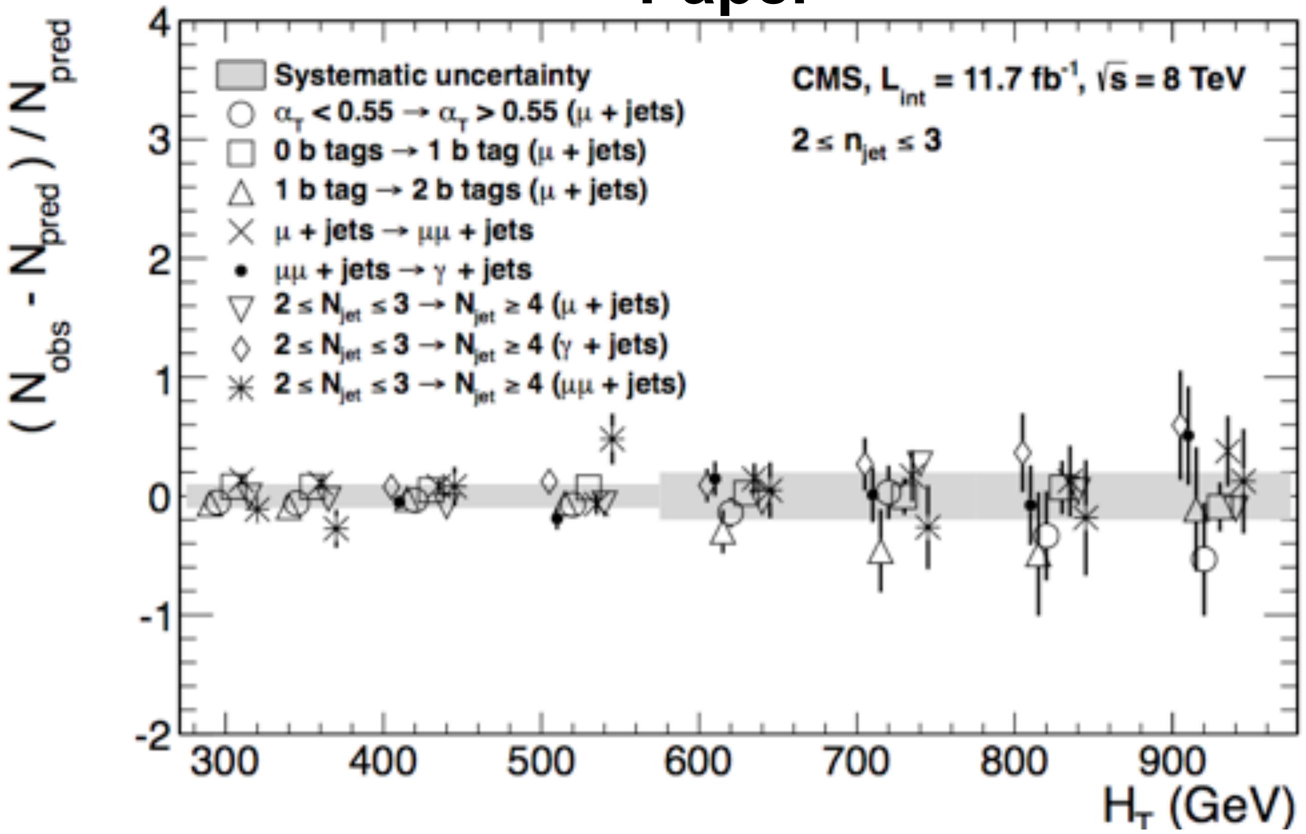


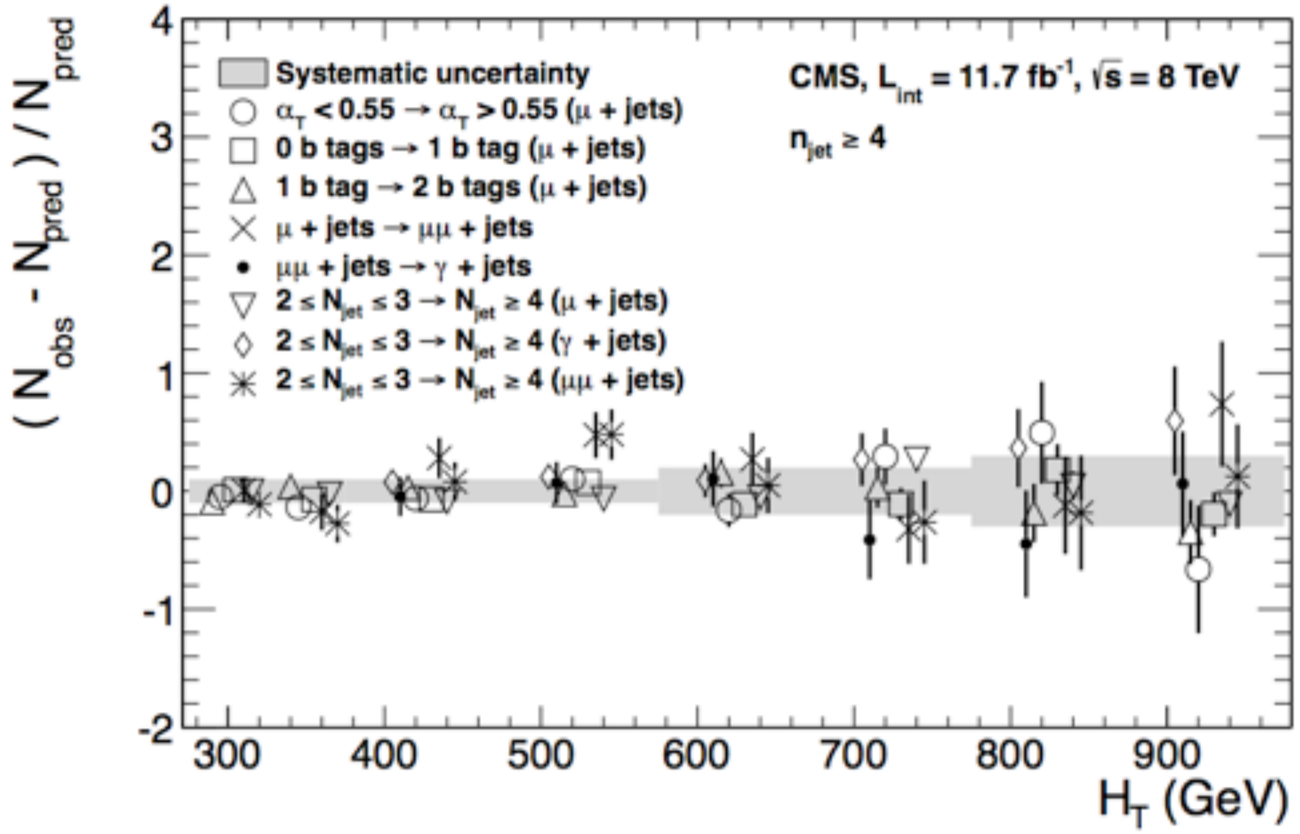


Systematics w.r.t. 11.7/fb paper

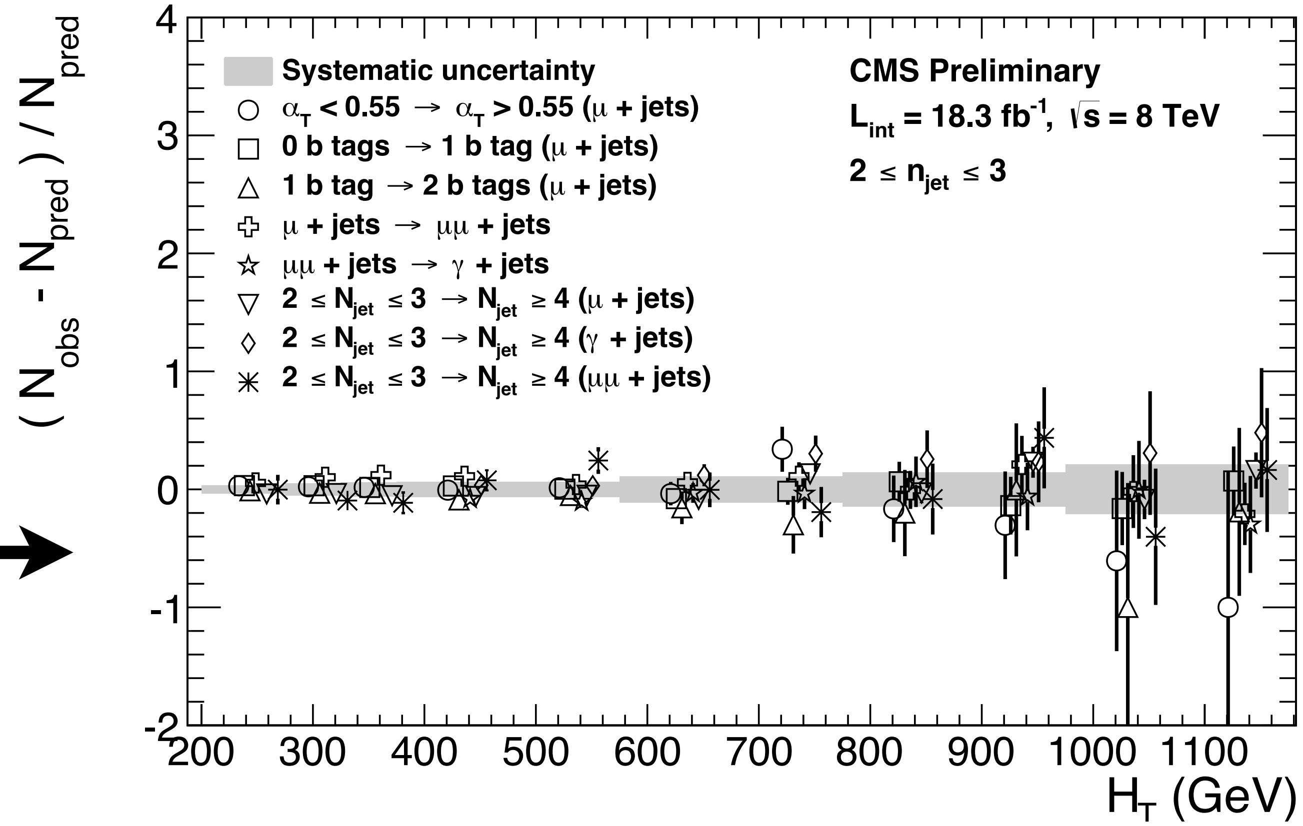
- Systematic uncertainties reduce as luminosity increases (**syst. is stat. limited**)

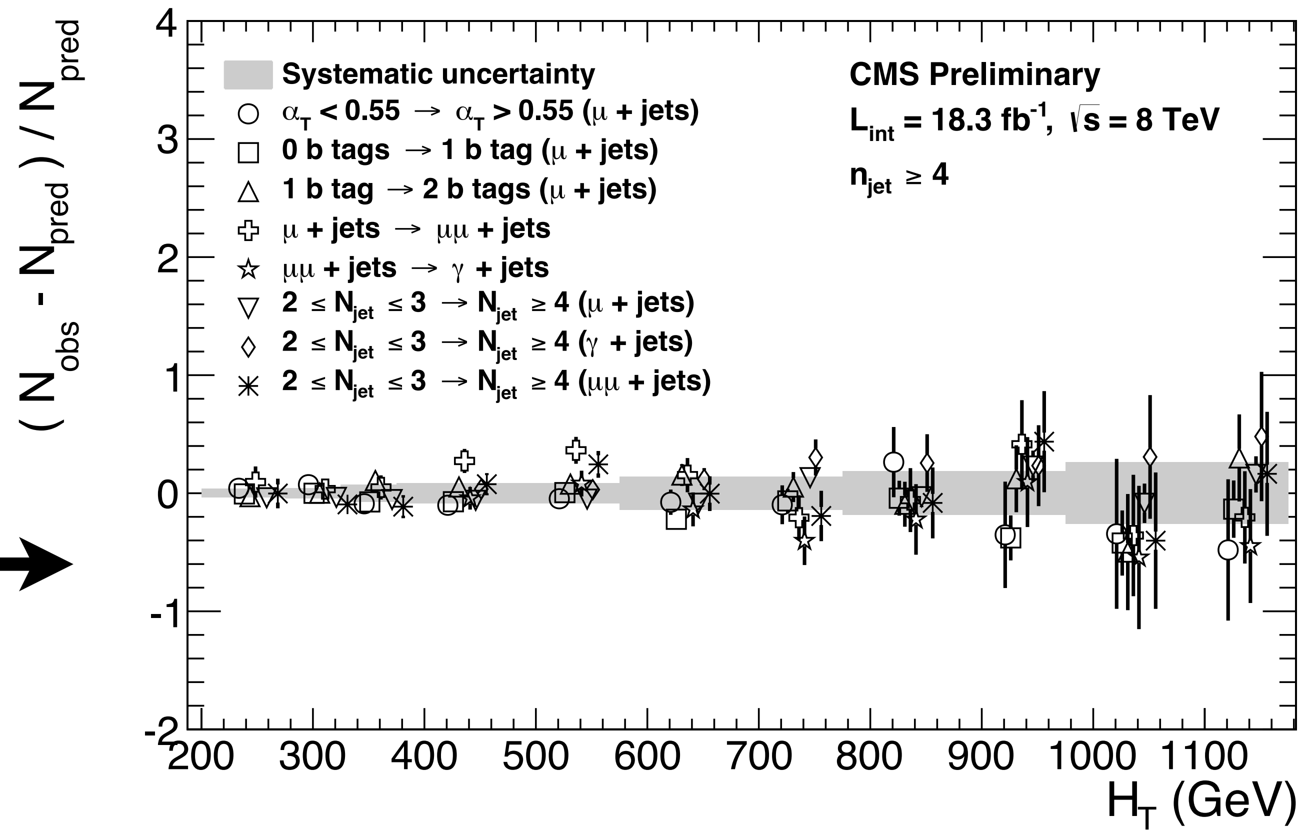
Paper





Now

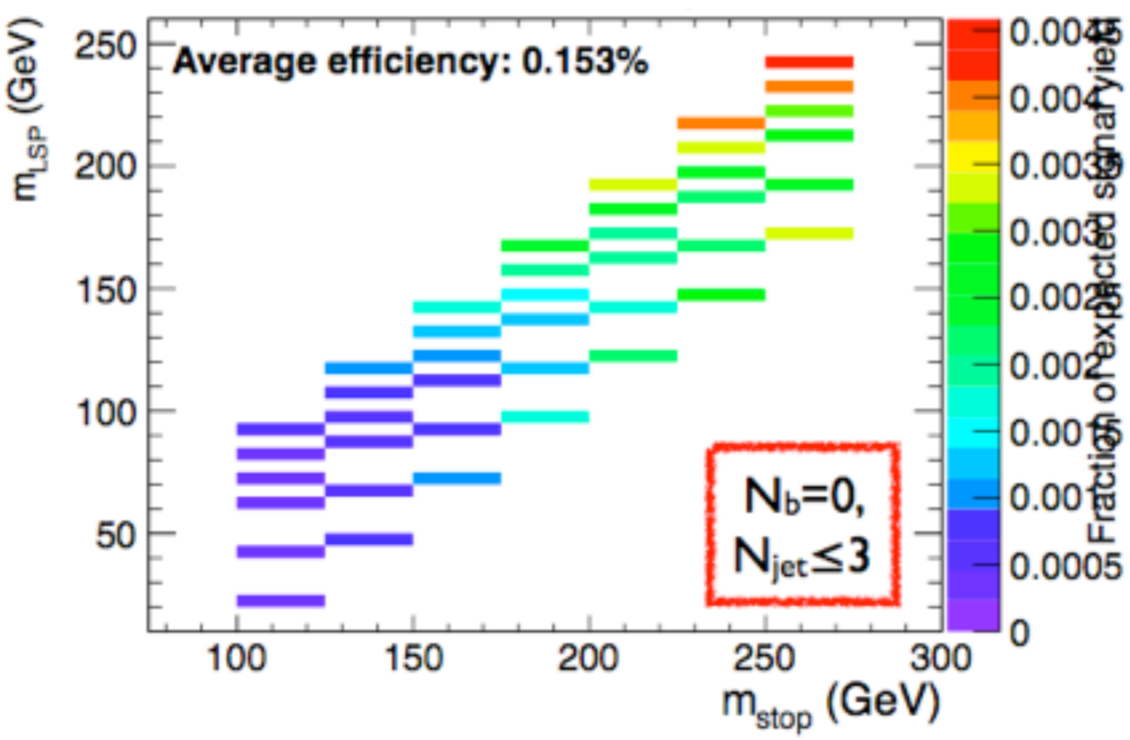




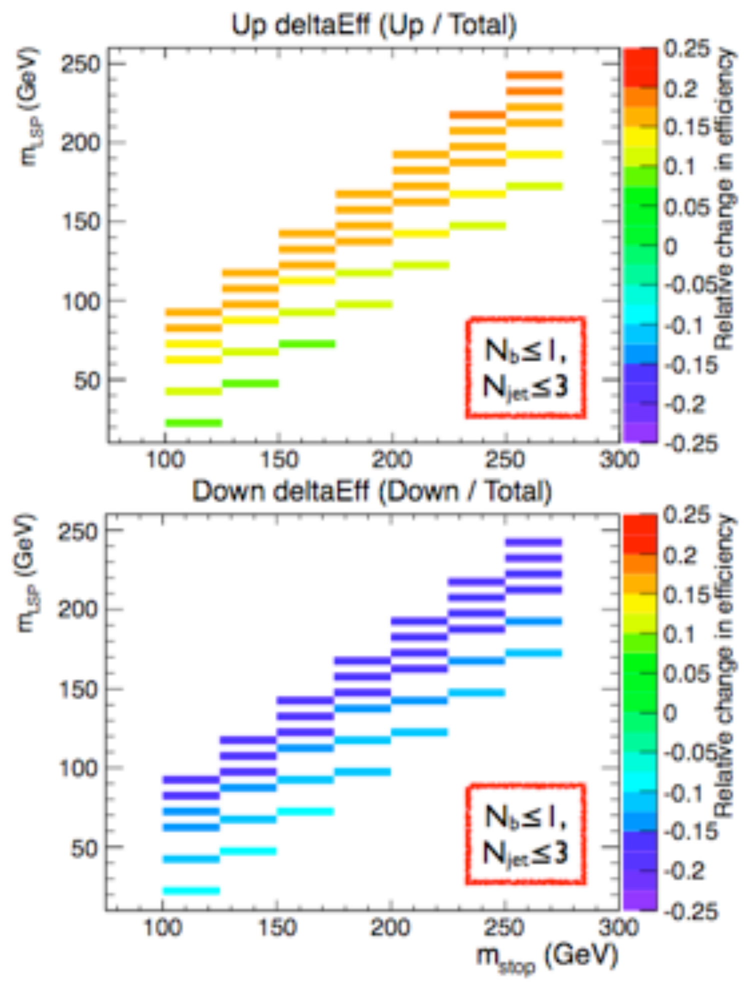
Signal models

- We plan to consider several models
  - T2cc, T2tt, T2bW (x=0.25), T2bb, T2(uL+8fold), T1tttt, T5tttt, T1t1t, ...
  - Ntuples exist, all Madgraph samples, FastSim, CMSSW_5_2_9
- Preparing for interpretations: studies underway for signal efficiencies and systematics
- Preliminary T2cc systematics: ISR (~20%), PDF (2-8%), JES (~4%), total ~25%

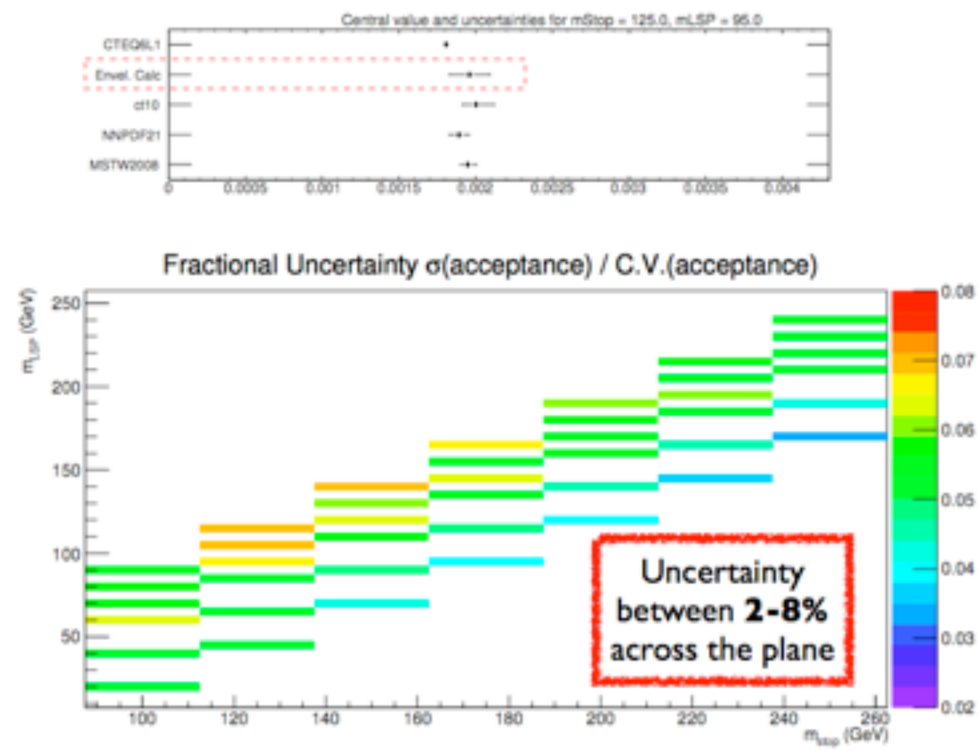
Signal efficiency



ISR uncertainties from AN-13-059

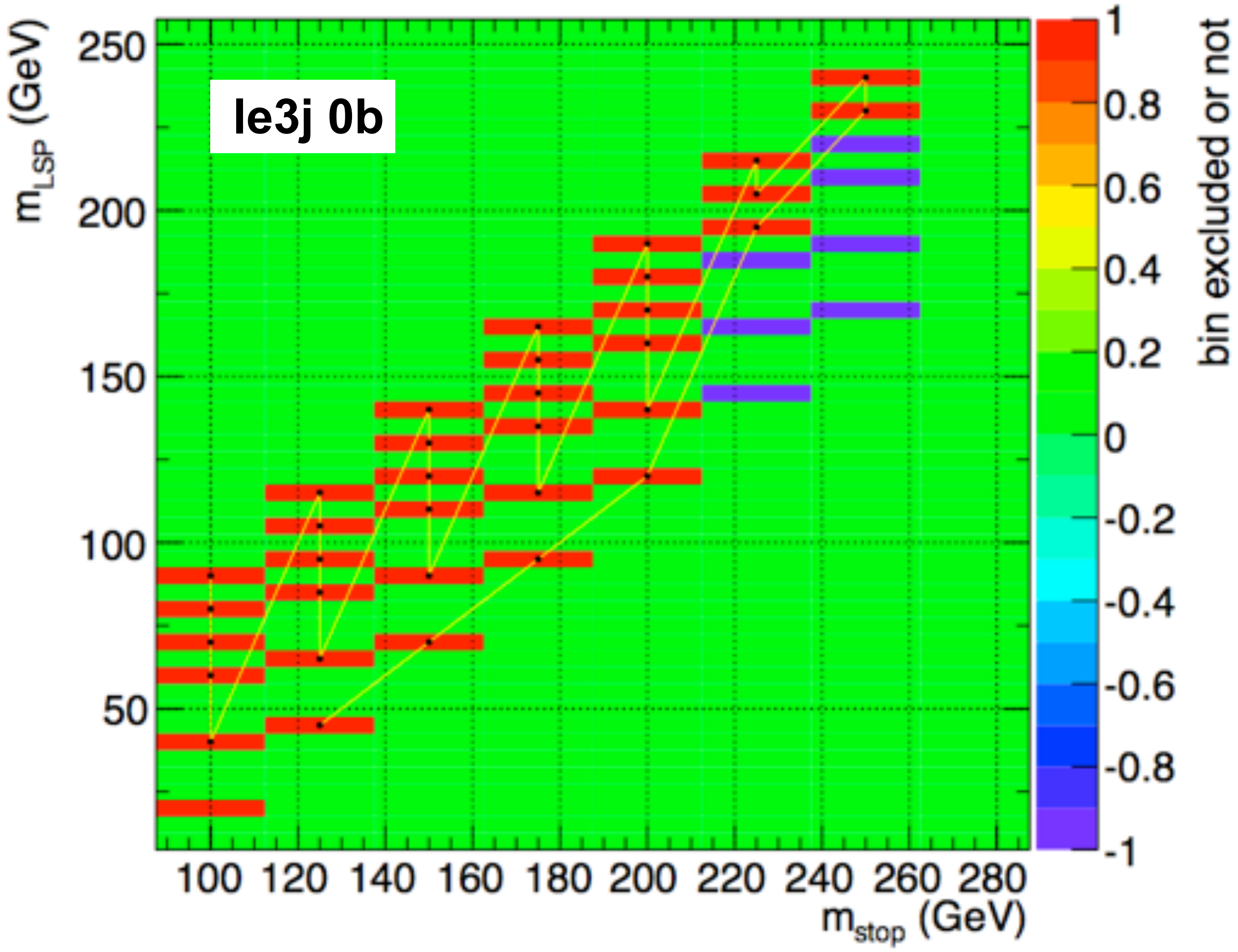


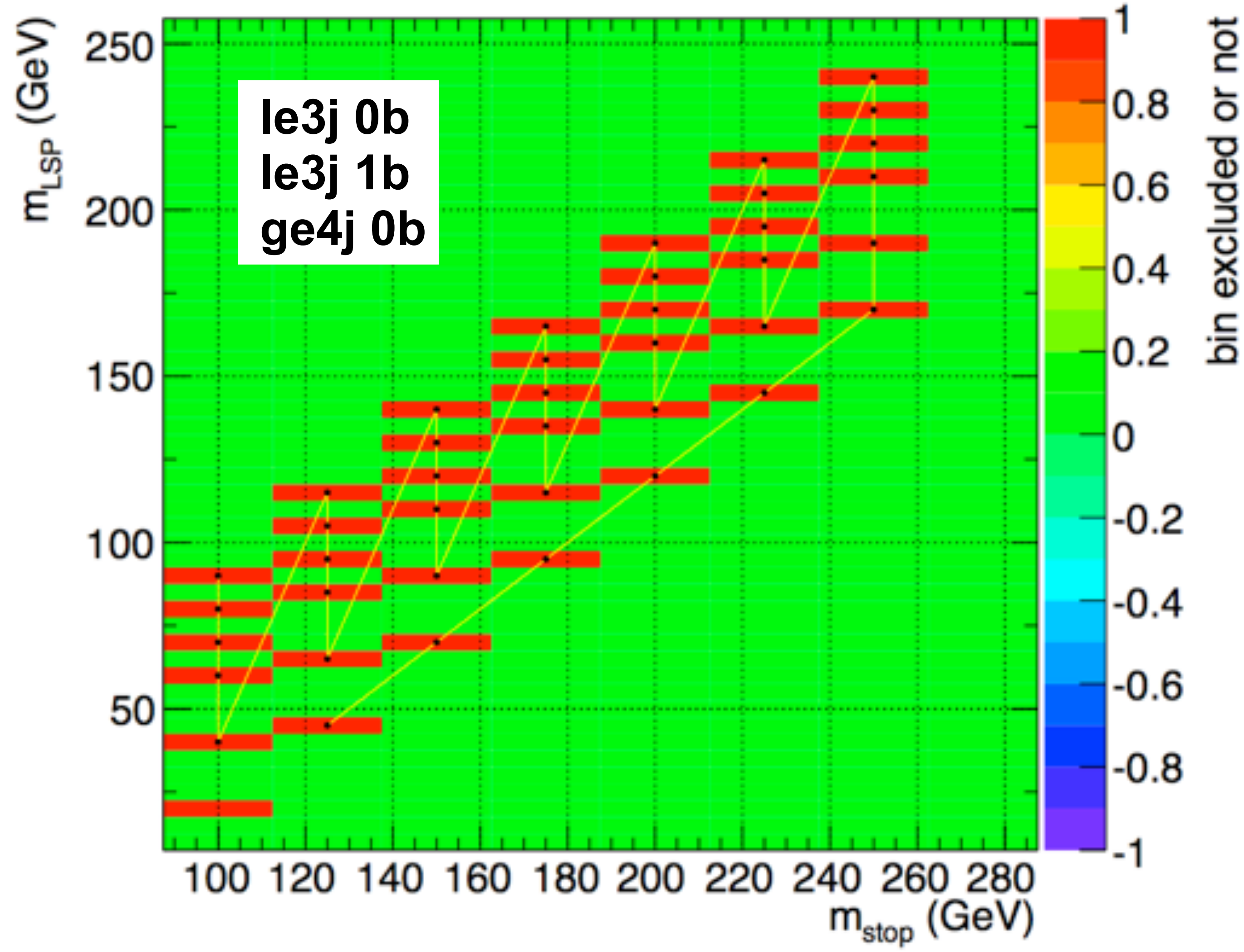
PDF expal. uncertainties (PDF4LHC recipe)

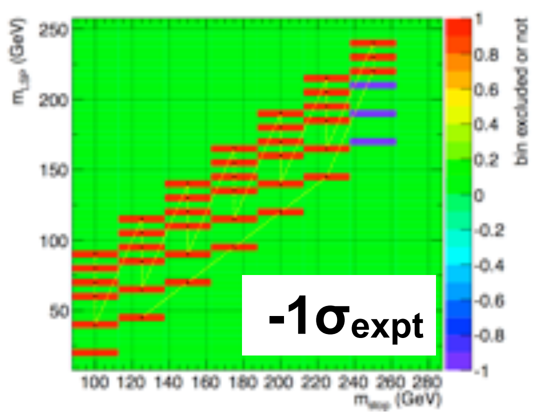


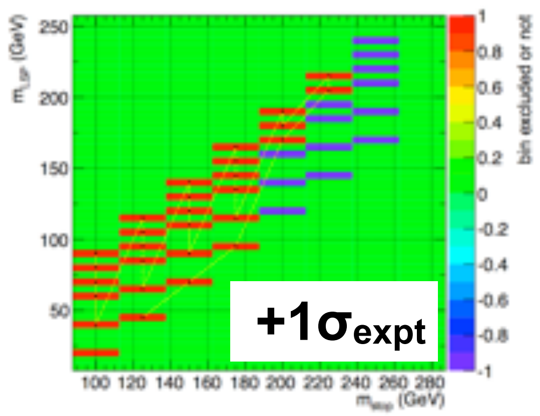
T2cc expected limit

- **Very preliminary expected limits!**
- Many caveats! (Trigger efficiencies, systematics, QCD, no SITV...)









Based on prelim studies, we should consider extending the scan...

Summary

- Primary focus is on (near) mass-degenerate models, in particular T2cc
- We have added parked data, updated to 22Jan2012 ReReco, latest MC samples...
- Control samples and systematics look to be well understood
- Update at next meeting: details on SITV, QCD, limits
- Preliminary expected limits look encouraging: further scrutiny required
- We believe we can progress quickly and move to pre-approval / unblinding soon

Final motivating slide?

- NB: remember our caveats...