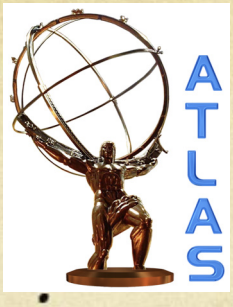

SUSY Searches in Tau Channels at ATLAS

5th Annual Workshop of the Helmholtz Alliance

Bonn, December 2011

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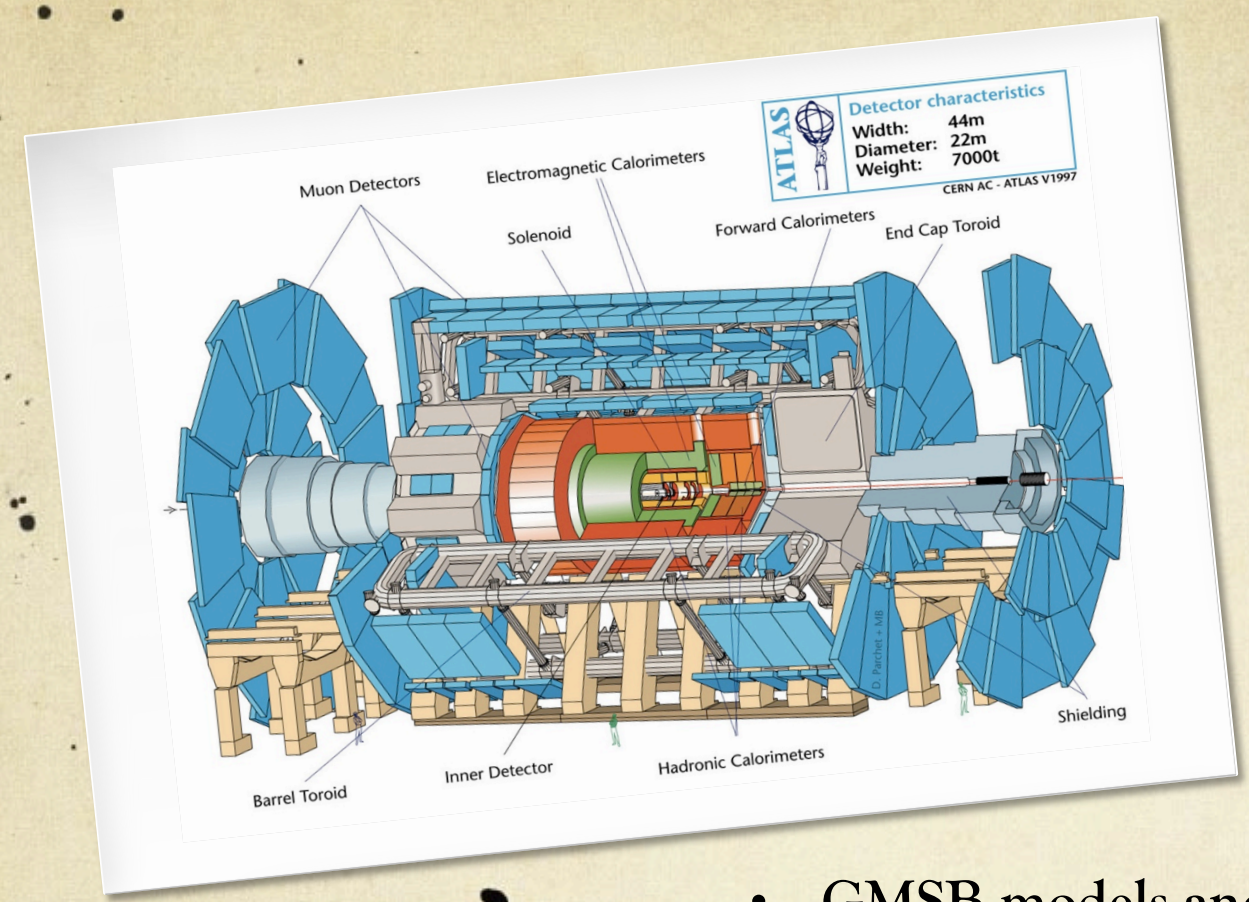
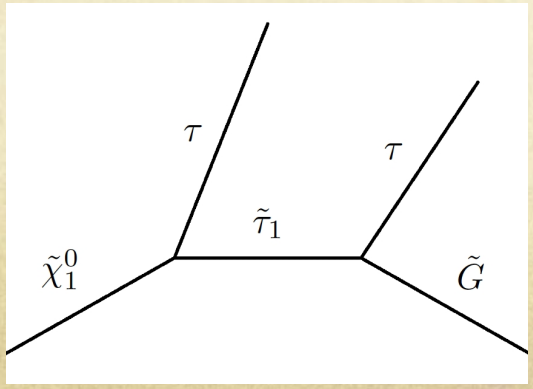


Outline

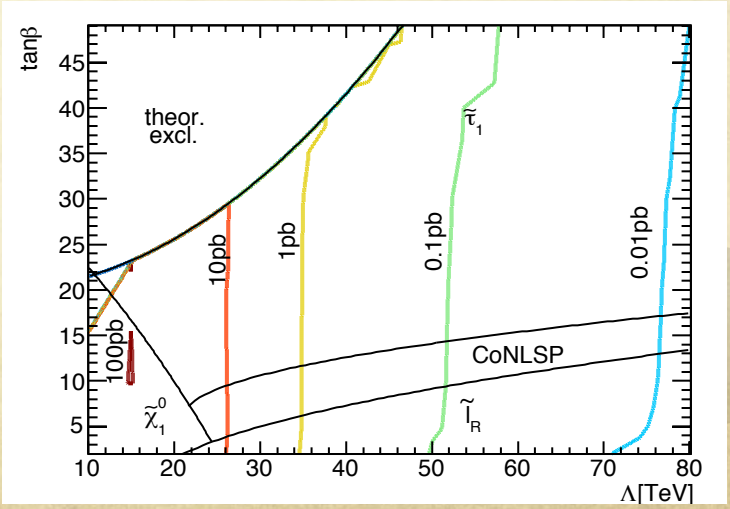
- GMSB models and Tau-Channels
- Object and Event Selection
- Background estimation
  W + top, QCD
- Systematic Uncertainties
- Results

GMSB Models

- Taus – final state in various SUSY breaking mechanisms
- mSugra: stau - lightest slepton due to RGE
  - can have large left handed component (in contrast to selectron/smuon)
- Gauge Mediated Symmetry Breaking (GMSB) – alternative breaking mechanism
- LSP is very light Gravitino (≪1keV)
- NLSP strongly determines the phenomenology



- Stau NLSP -> multi tau final state
- 6 parameters in simplest approach
- Λ and tanβ - largest influence on mass hierarchy
- Signal grid - other parameters fixed to ensure slepton or stau NLSP
- only very few Standard Model processes have multiple taus and MET in the final state



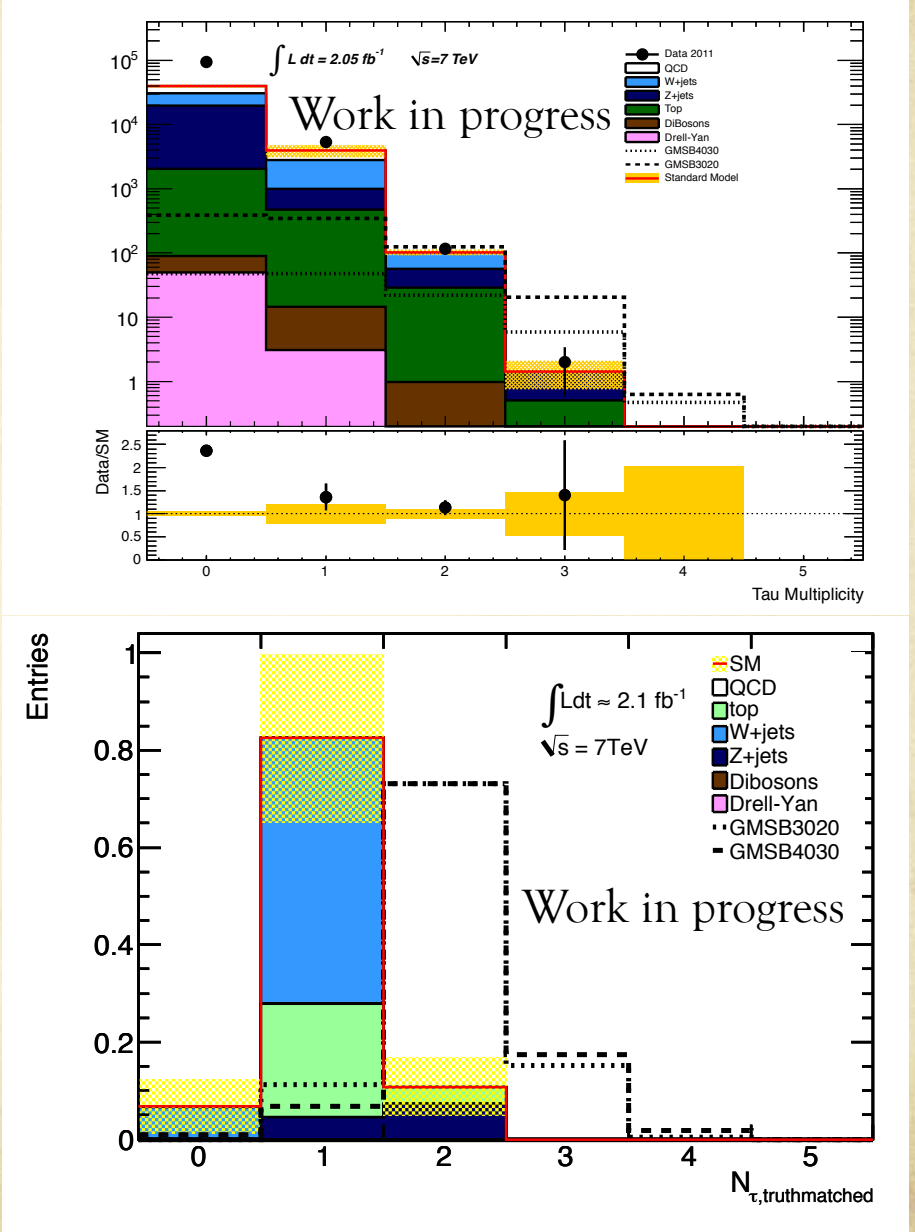
Tau Channels

- 3 Analyses ($2fb^{-1}$)
  - ≥ 1 Tau
  - **≥ 2 Taus**
  - 1 Tau + 1 Muon
- Updates ($5fb^{-1}$) in preparation for Moriond
- Triggers
  - Jet + MET
  - Muon
- Lepton veto for only tau channels for easy combination of channels (to come)

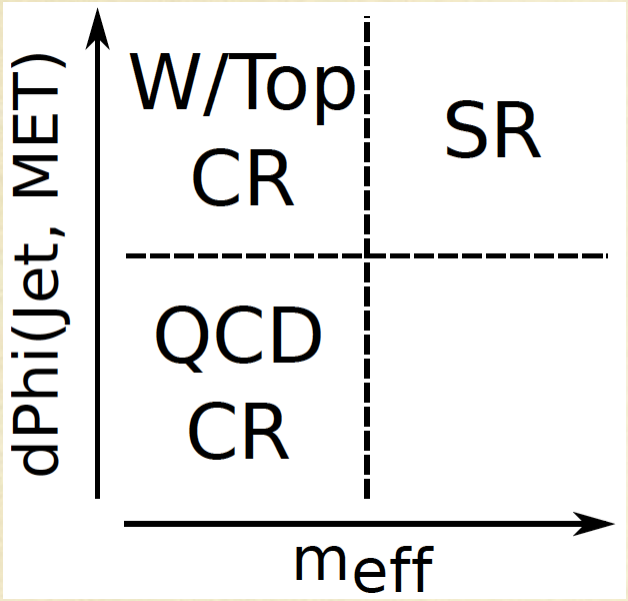
- Tau candidates seeded from calo clusters – hadronically decaying taus
- One or three tracks in $|\eta| < 2.5$ Charge $|q| = 1$
- Discriminant versus jets by BDT output
  - based on 11 input variables
- 3 predefined working points
  - loose, medium, tight
  - 60% - 50% - 30% signal efficiency
  - at 10% - 3% - 0.5% background efficiency

Event selection – ditau channel

- Event cleaning
- Trigger plateau cuts (MET > 130 GeV, 1.Jet pT > 130 GeV)
- 2.Jet pT > 30 GeV
- Lepton veto
- 1. loose Tau, pT > 20 GeV
- 2. loose Tau, pT > 15 GeV
- $\Delta\phi$(1./2.Jet; MET) > 0.4
- meff > 700 GeV
- mT (1.Tau;MET) + mT (2.Tau;MET) > 80 GeV
- other channels use similar selections

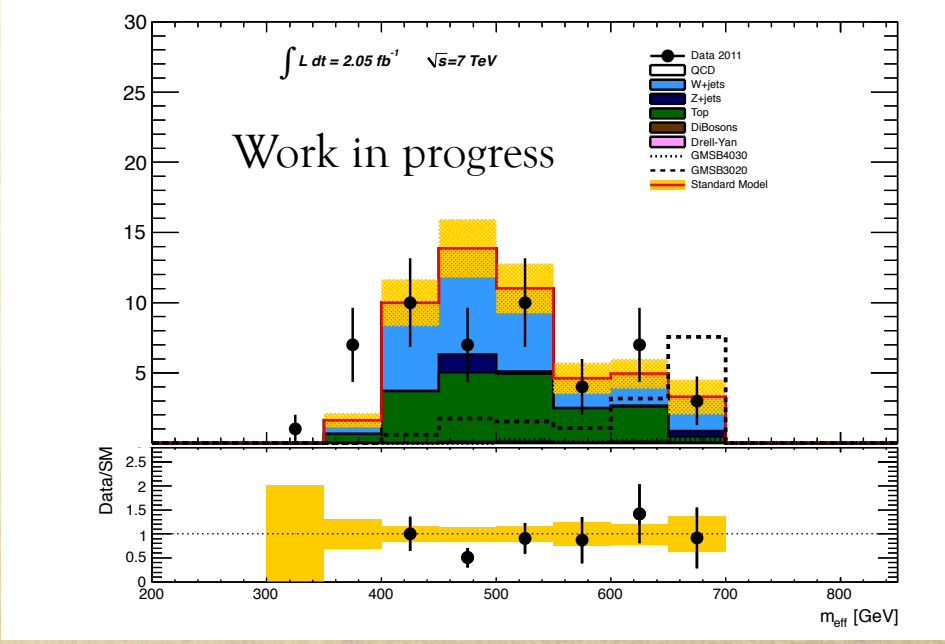


Background estimation – W + top



- W/top CR: inverting meff cut
- QCD CR: additionally inverting $\Delta\phi$ cut
- General technique: Obtain scale factors from control region and apply in signal region
- MC - overestimating tau fakes

- Subtract remaining non-W/Top contribution from data, scale W and Top MC to data
- Obtained scale factor: 0.553±0.093
- Agrees well with H->ττ search (0.57, ATLAS-CONF-2011-132)
- separating regions suffers from low statistics



Background estimation - QCD

- Invert meff and $\Delta\phi$ cuts
- MET/meff < 0.4
- Split the QCD CR into three regions
  - 0tau, 1tau, ≥2taus
  - one-tau uses ABCD instead
- From 0 tau sideband calculate QCD scale factor w_0 = 1.03±0.13:

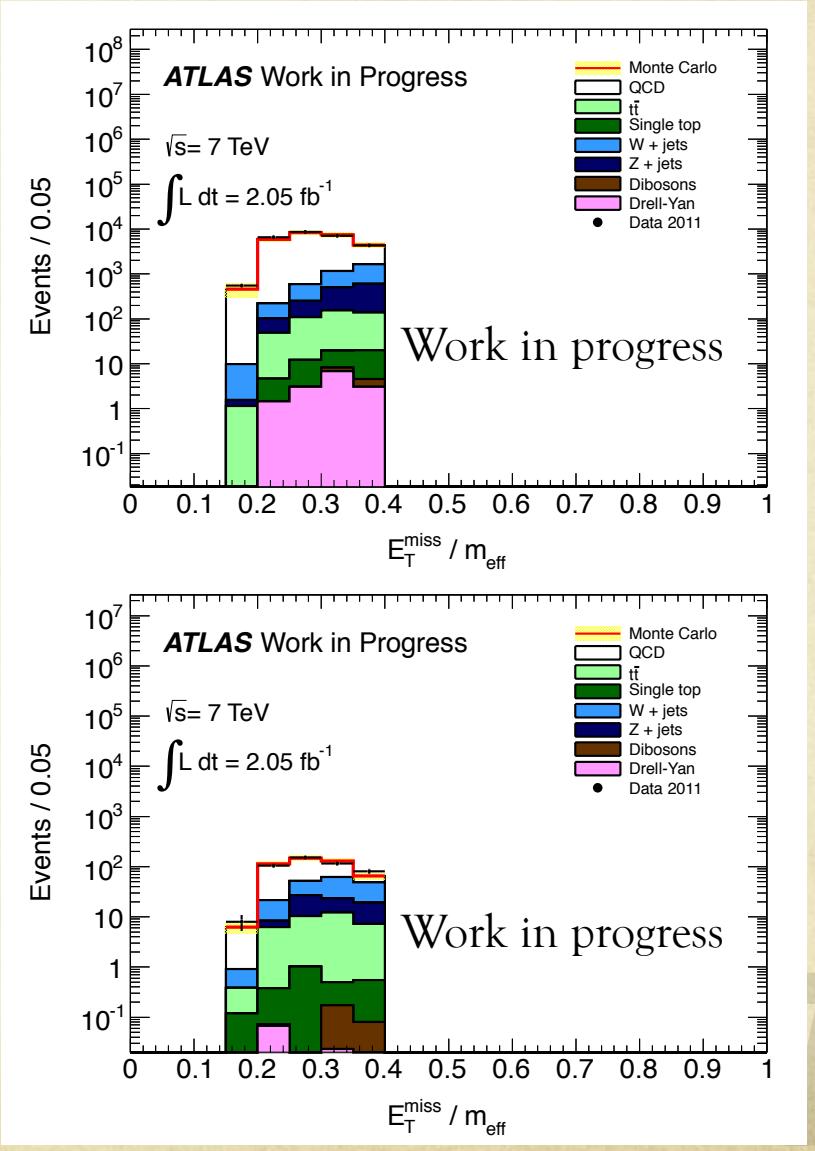
$$w_0 = \frac{N_{0\tau}^{data} - N_{0\tau}^{nonQCD}}{N_{0\tau}^{QCD}}$$

- From 1tau sideband calculate fake rate f = 0.45±0.33:

$$f = \frac{w_1}{w_0} = \frac{N_{1\tau}^{data} - N_{1\tau}^{nonQCD}}{w_0 \cdot N_{1\tau}^{QCD}}$$

- Can be used for calculation of fake rate in signal region 0.20±0.30:

$$w_2 = w_0 \cdot f^2$$



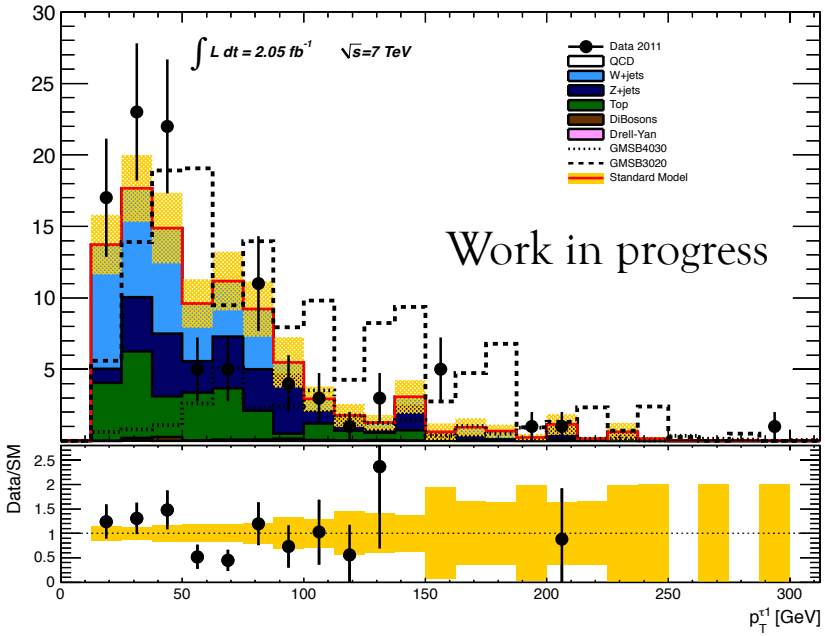
Systematic Uncertainties

- Systematics studied for this analysis:
  - Jet energy scale
  - Jet energy resolution
  - Tau energy scale
  - Tau identification uncertainty
  - Tau fake uncertainty
  - Pileup
  - Luminosity
- Systematic dominated by jet systematics
- Uncertainties on W and Top drive total uncertainty
- Values compatible with those found in the one tau analysis

Systematic	QCD	Diboson	Z+jets	W / Top	All
Scaling	150.0%	0.0%	0.0%	7.9%	6.3%
JER	208.2%	0.1%	-6.2%	-13.5%	-11.7%
JES down	0.0%	-5.0%	-12.6%	-20.8%	-18.8%
JESup	0.0%	15.0%	23.3%	-17.0%	-8.5%
Pileup	29.4%	7.6%	2.2%	3.8%	4.2%
TauID	0.0%	7.2%	7.1%	0.3%	1.7%
TauFake	19.7%	3.3%	3.6%	-1.4%	-0.4%
TES down	0.0%	0.0%	-27.3%	8.7%	1.6%
TES up	3.5%	4.6%	19.2%	2.4%	5.7%
Luminosity	3.7%	3.7%	3.7%	0.0%	0.8%
Total	211.2%	16.9%	42.6%	29.3%	22.3%

Work in progress

“Results”

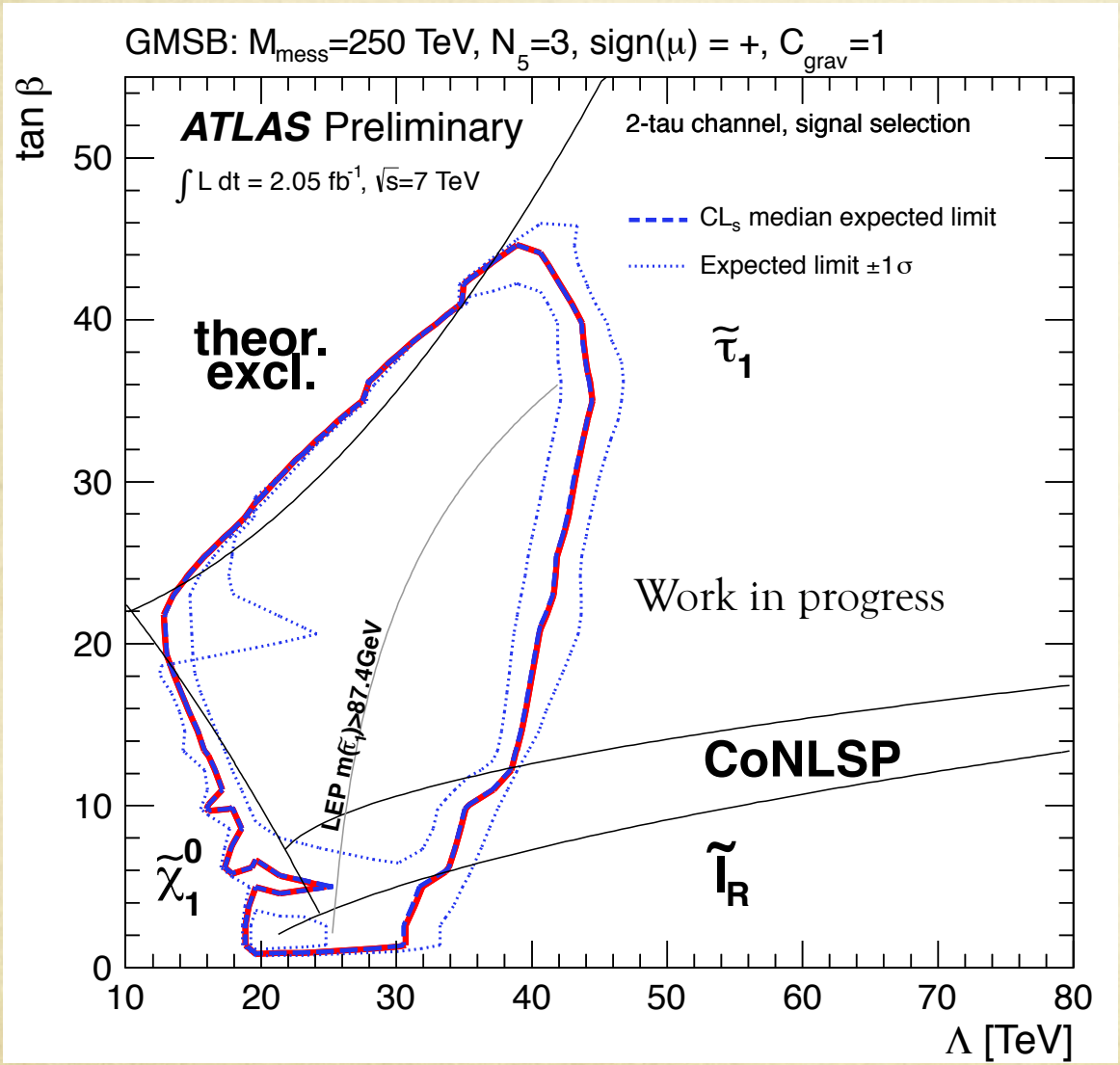


- Leading tau pt after 2 tau requirement (scaling obtained in CR applied, yellow bands statistical error only)

Work in progress	All MC	Data	GMSB3020	GMSB4030
Preselection	$4.56 \cdot 10^9 \pm 3.91 \cdot 10^6$	$2.59 \cdot 10^7$	4059 ± 75	695 ± 13
$E_T^{miss} > 130$ GeV	$2.59 \cdot 10^5 \pm 5.96 \cdot 10^3$	509075	2573 ± 51	462 ± 12
$p_T^{jet1} > 130$ GeV	$1.74 \cdot 10^5 \pm 4.34 \cdot 10^3$	440356	2442 ± 45	407 ± 10
$p_T^{jet1} > 30$ GeV	$1.17 \cdot 10^5 \pm 4.28 \cdot 10^3$	116530	2411 ± 45	400 ± 9
Lepton Veto	95381 ± 4257	98964	876 ± 26	124 ± 6
$N_\tau \geq 1, p_T^{\tau 1} > 20$ GeV	4012 ± 169	3646	445 ± 19	72 ± 6
$N_\tau \geq 2, p_T^{\tau 1} > 15$ GeV	95 ± 10	102	144 ± 10	28 ± 4
$\Delta\phi(E_T^{miss}, \text{jet}) > 0.4$	85 ± 9	79	130 ± 10	25 ± 3
$m_{eff} > 700$ GeV	14 ± 2	[redacted]	111 ± 9	24 ± 3
$m_T^{\tau 1} + m_T^{\tau 2} > 80$ GeV	$7.23 \pm 1.56 \pm 1.61$		$100 \pm 8 \pm 17$	$23 \pm 3 \pm 4$

011

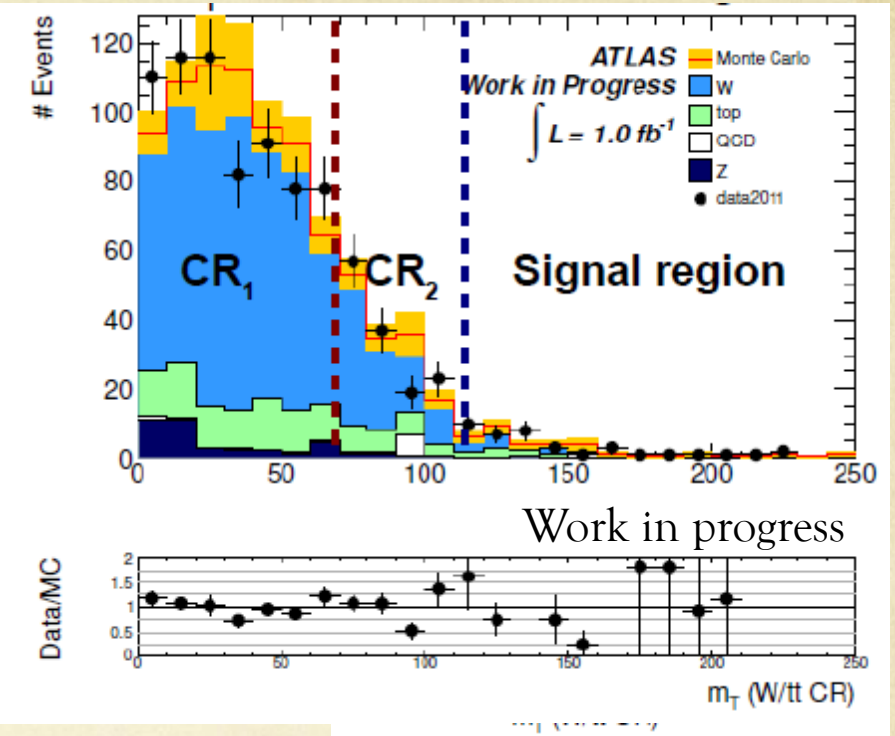
“Results”



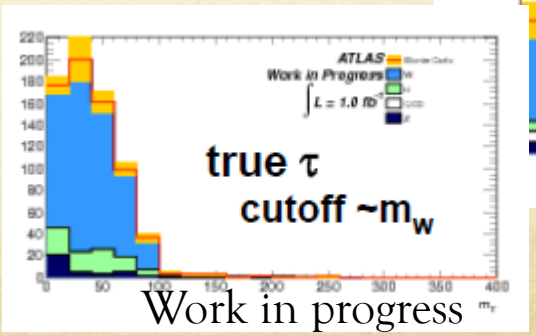
- Full results will appear in future publications
- **Expected** limit is shown
- If observed events = SM MC background expectation
  - limit would exceed LEP limit

One-tau channel

- Similar selection as the 2-tau channel
- SR:
  - meff > 600 GeV
  - MET/meff > 0.25
  - mT (1.Tau;MET) > 110 GeV
- CR for W/top by inverting mT and meff cuts
- mT cut effective at isolating true tau contribution:
  - mT < 70GeV
    - 91% pure real tau from MC
  - 70 < mT < 110 GeV or mT > 110 GeV && meff < 600 GeV
    - 50/50 split real/fake tau in MC (same as SR)



Work in progress



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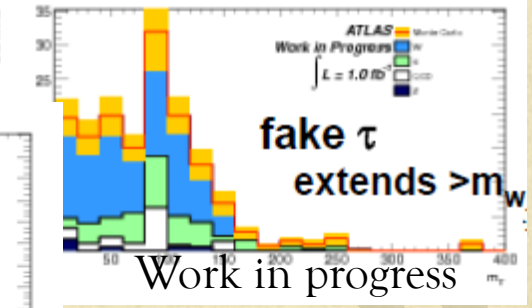
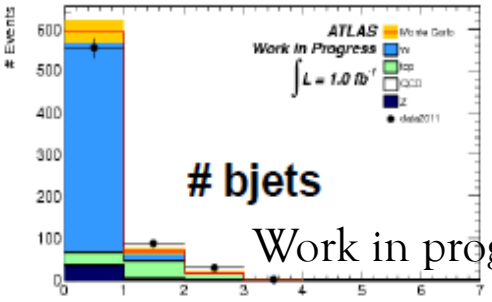


Work in progress

Slides by M. Janus

W+top separation in CR1



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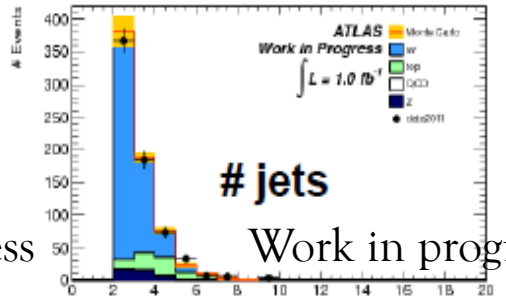

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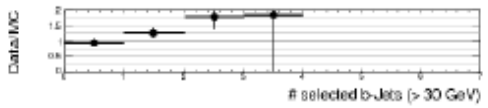

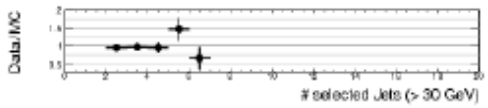

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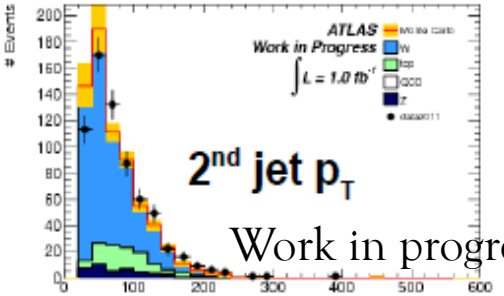

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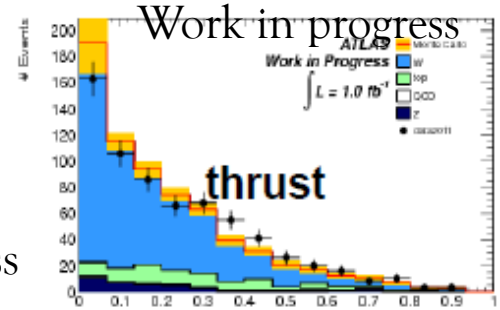

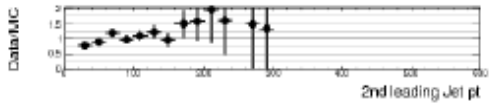

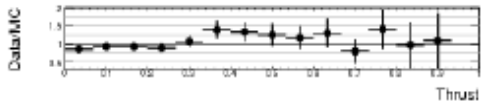

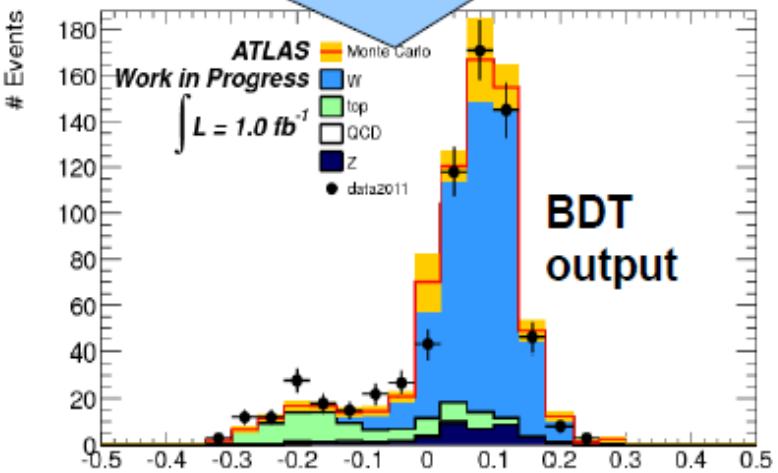

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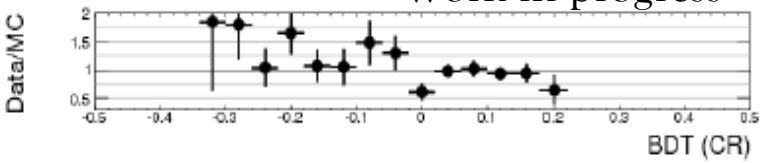


Slides by M. Janus

W+top separation in CR2

- medium m_T and high m_T/low m_{Eff} regions:
  - Subtract off expected true τ contribution
  - Take ratio of data/MC remaining as fake τ scale factor:

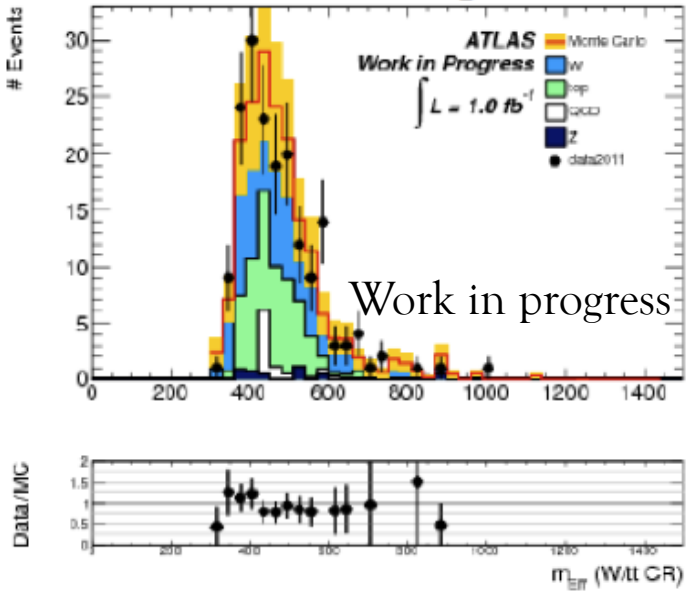
	true τ	fake τ	total
W	63.8 ± 7.8	47.4 ± 6.1	111.2 ± 9.9
top	27.4 ± 9.6	33.3 ± 11.6	60.7 ± 15.1
Z	3.1 ± 1.2	0.97 ± 0.64	4.0 ± 1.3
QCD	0 ± 0	8.8 ± 5.5	8.8 ± 5.5
total	94.3 ± 12.4	90.5 ± 14.2	184.8 ± 18.9
data	Work in progress		177

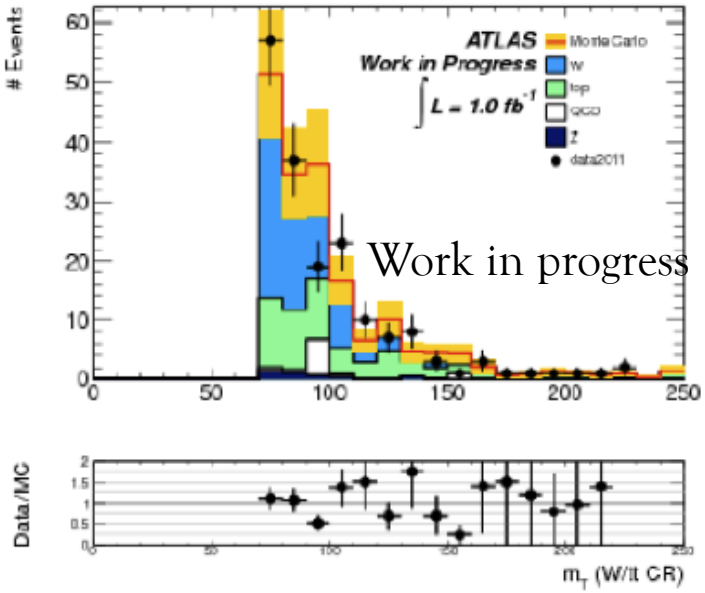
$$f_{\text{fake}} = \frac{N^{\text{CR}_2} - \hat{N}^{\text{CR}_2}_{\text{true}}}{\hat{N}^{\text{CR}_2}_{\text{fake}}} = \frac{177 - (94.3 \pm 12.4)}{(90.5 \pm 14.2)} = 0.91 \pm 0.21$$

to SR

$$\hat{N}^{m_{\text{eff}}>600\ \text{GeV}}_{\text{fake}} = 8.0 \pm 2.4$$

CR_2 after true and fake τ scaling





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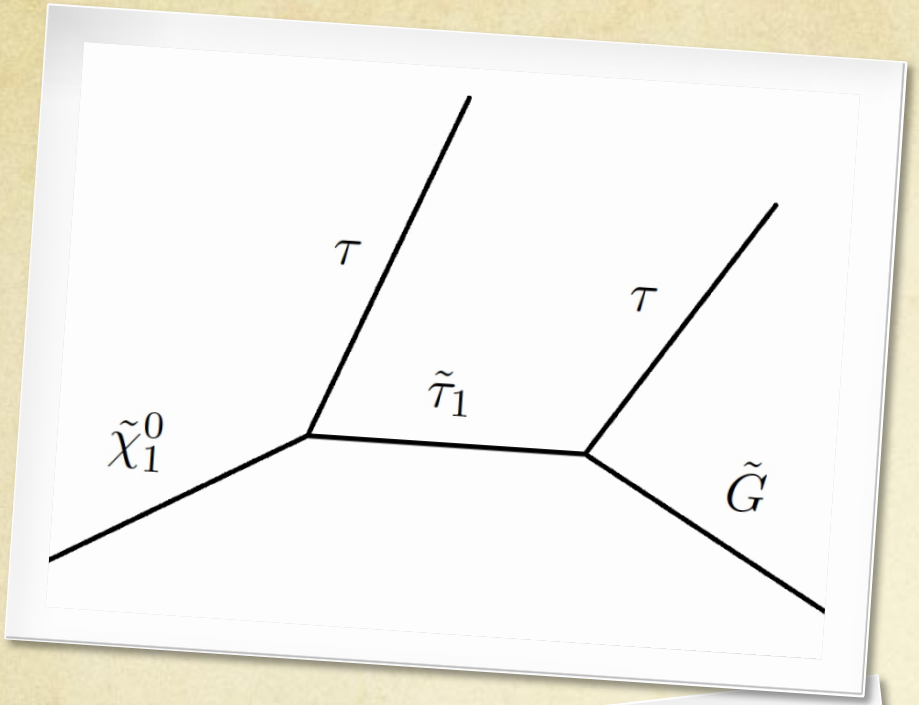
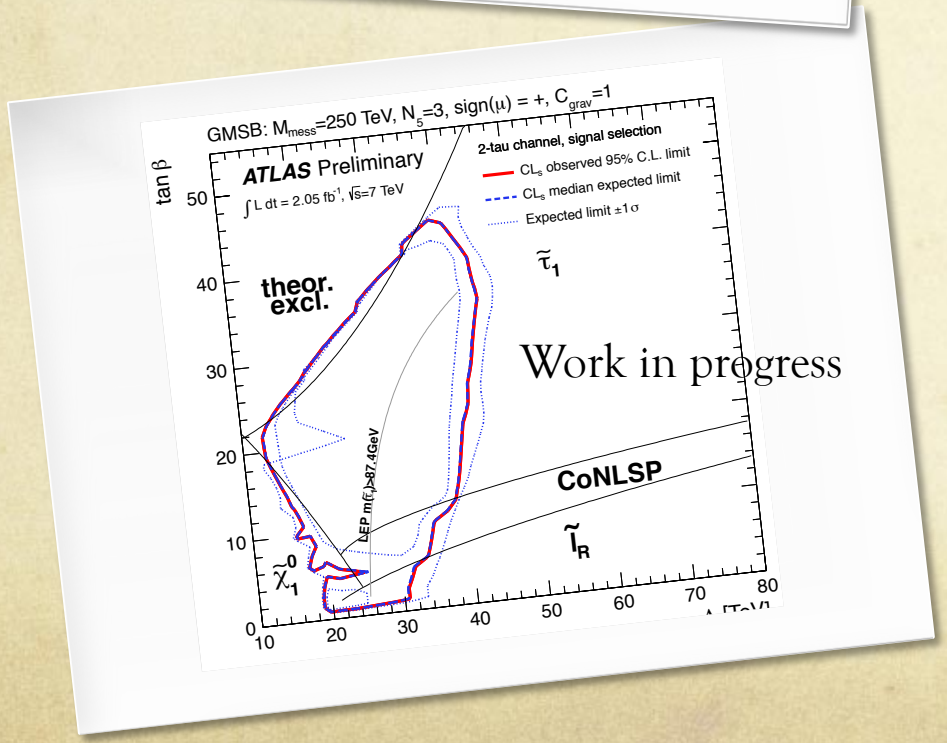




Conclusion

- 3 channels to exploit Tau final states looking for SUSY
- SR and CR well defined and well understood
- individual publications are in the making – all 3 channals have started the official ATLAS review process
- will show full results
- include comparison of 1-tau vs 2-tau

Thank you

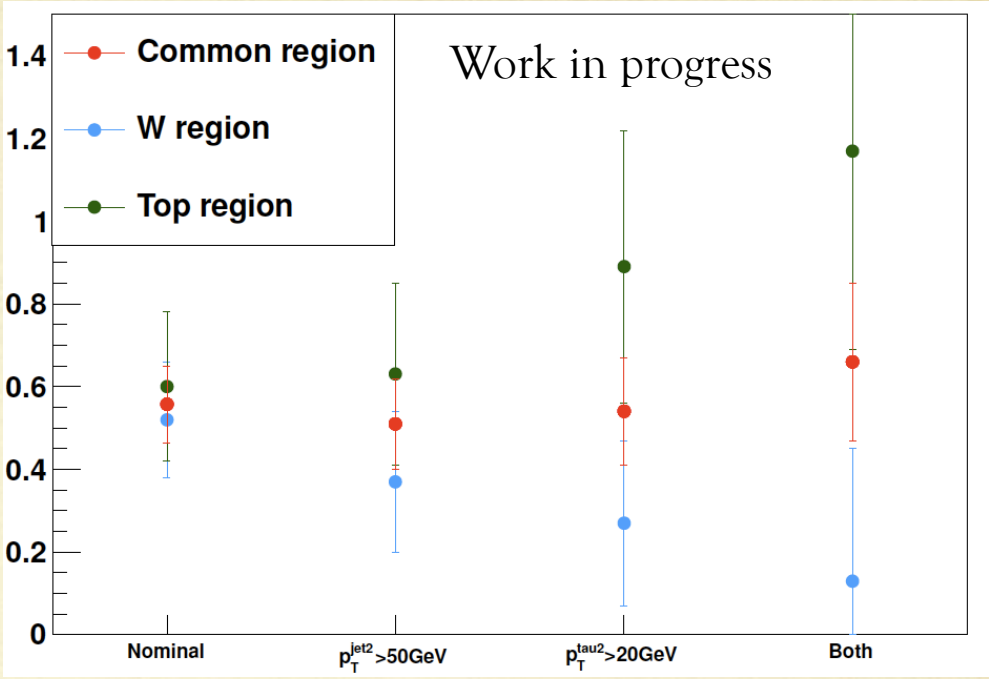
for your attention!

Questions?

Backup

Background estimation – W + top

- Crosscheck: Tighter object selection cuts
- Common scale factor
- remains stable
- Separate factors diverge
- Errors blow up
- Still agreement within uncertainties



Conclusion:

- Take common scaling factor
- Take difference between common and separated scalings (8%) as systematic uncertainty
- Not enough statistics to separate control region

Systematic Uncertainties

- W+jets and Top
  - Most important background
  - Evaluated by recomputing the full scaling for all varied samples
  - . . . taking into account variations on the other channels by doing this
  - Uncertainties on scale factor due to limited MC and data statistic in CR added to statistic uncertainty
  - Additional 8% systematic uncertainty assumed on scale factor (difference between common/separate scaling)
- Signal
  - Selection uncertainties from MC
  - pdf, scale and α_S uncertainties from prospino
- Dibosons
  - Systematics computed purely from MC
- QCD
  - Systematics computed from Monte Carlo as well
  - Took 150% uncertainty on the scale factor as additional
  - systematic uncertainty
- Z+jets
  - Suffers from low MC statistics
  - Evaluated TES while omitting the meff cut
  - Evaluated JER and JES omitting the mT cut