PHYSICS WITH TAU LEPTONS AT ATLAS

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on behalf of the ATLAS collaboration

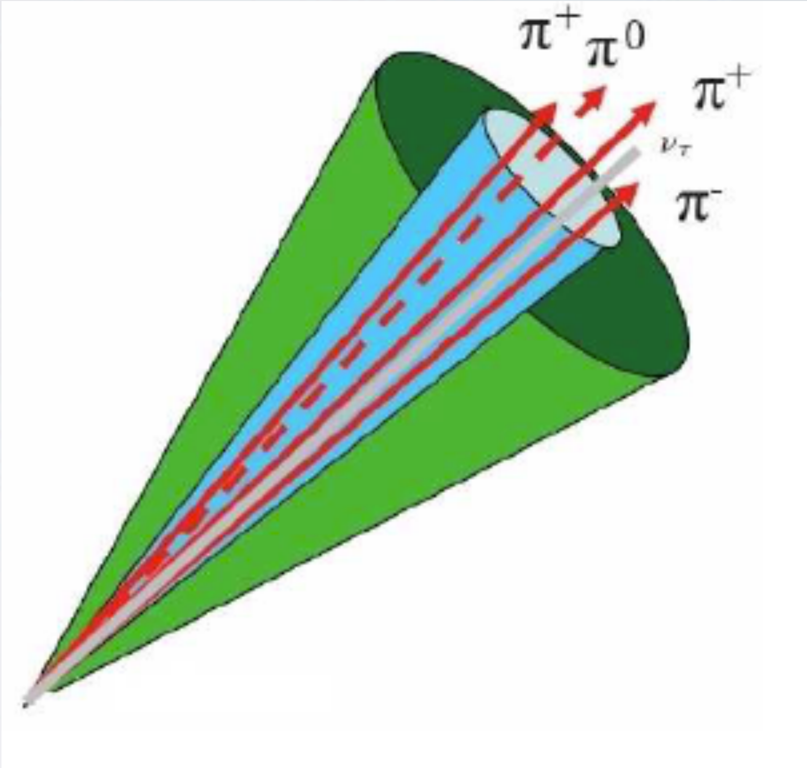
Phenomenology 2012 Symposium
Pittsburgh

Outline

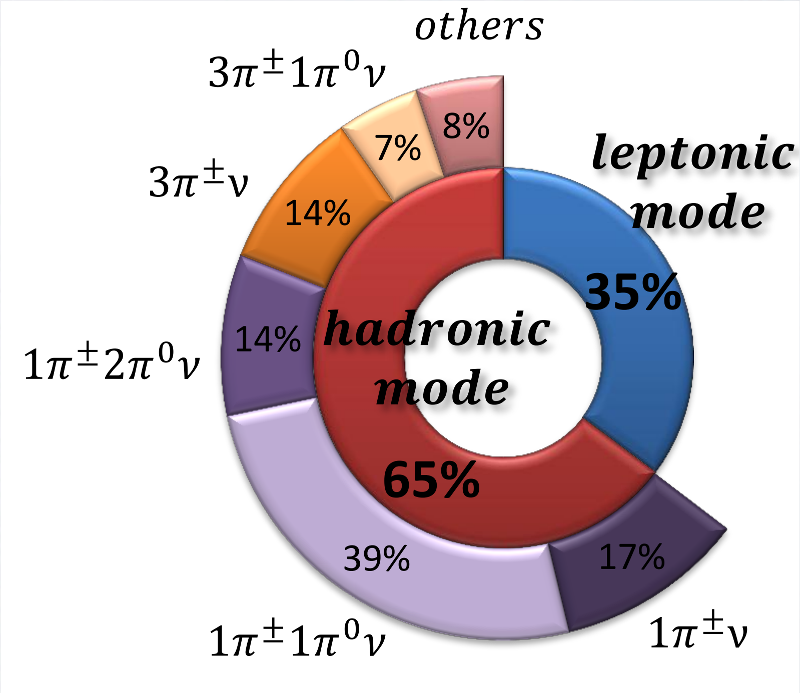
- **Introduction**
  - Tau reconstruction
  - Tau identification
- **Physics with Tau leptons**
  - $W \rightarrow \tau\nu$ polarisation
  - Standard Model Higgs
  - Charged Higgs
  - SUSY

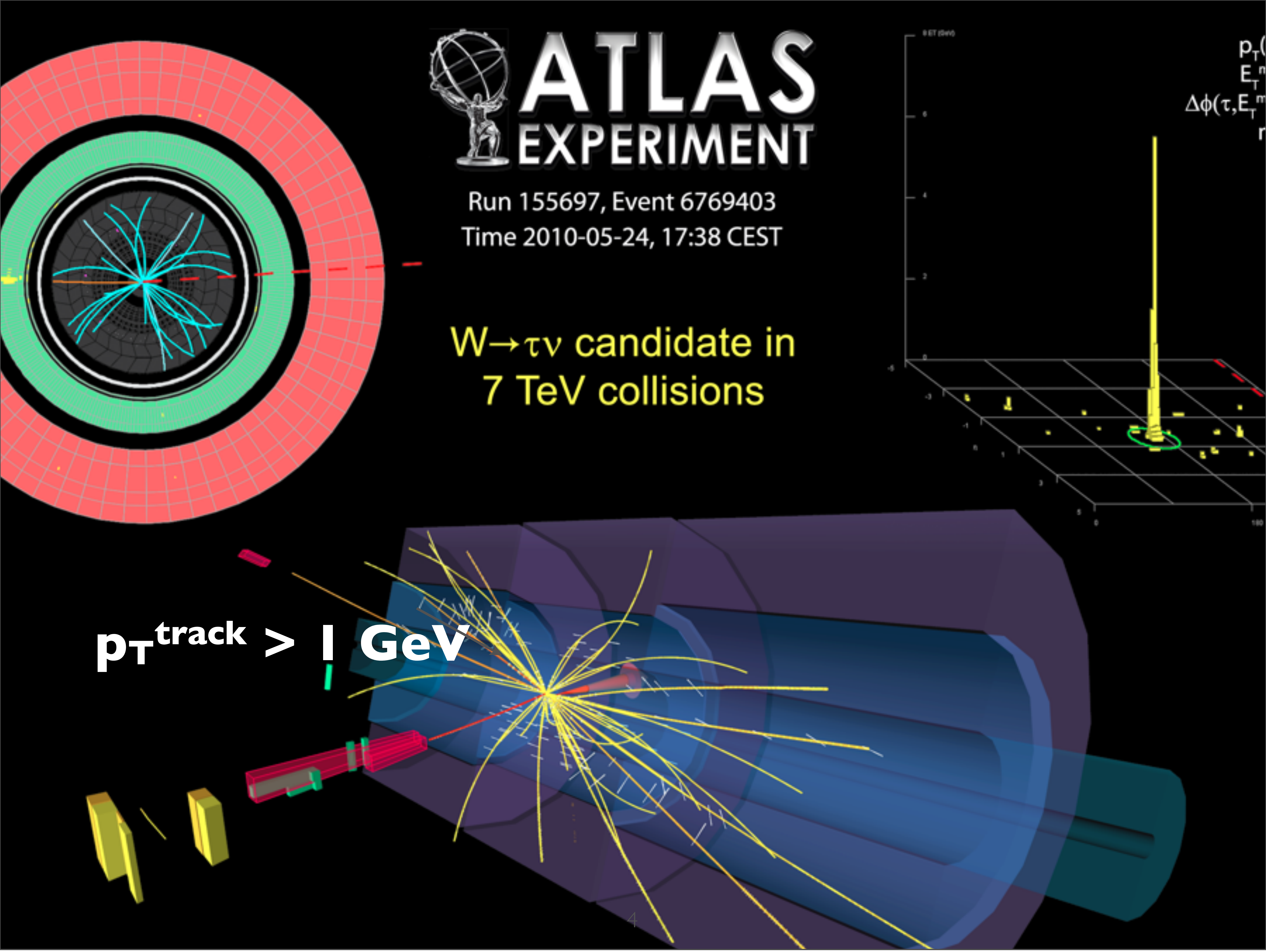
Characteristics of tau decays

- m_τ = 1.777 GeV
- $c\tau$ = 87 μm
- Leptonic decays hard to distinguish from primary electrons and muons
  - Only hadronic decays considered for dedicated reconstruction algorithms
- Mainly one/three charged tracks
- Collimated decay



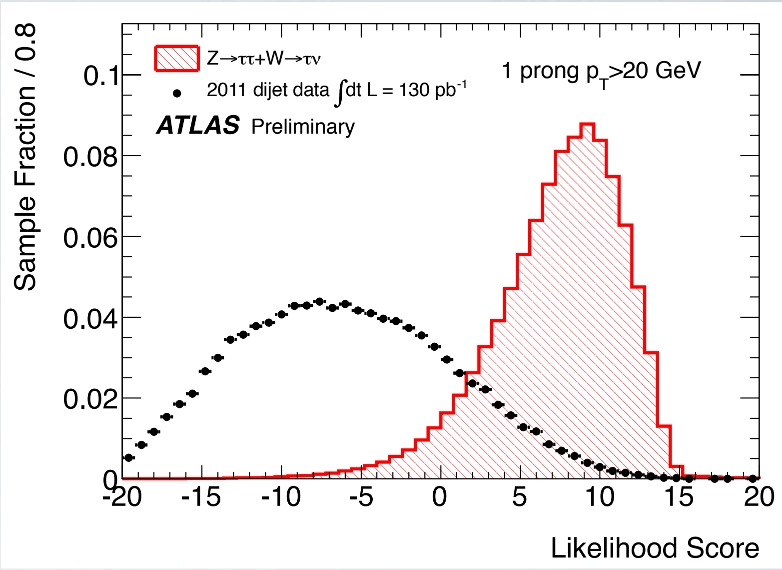
- Reconstruction divided into two steps
- Tau reconstruction
  - Building of tau candidates
  - Starting point: anti-k_t jets (R = 0.4) with p_T > 10 GeV and within $|\eta|$ < 2.5
- Tau identification
  - Aim: selection of real tau decays and rejection of fake sources (jets, e, μ)
  - Dedicated methods for separation against jets, electrons, muons

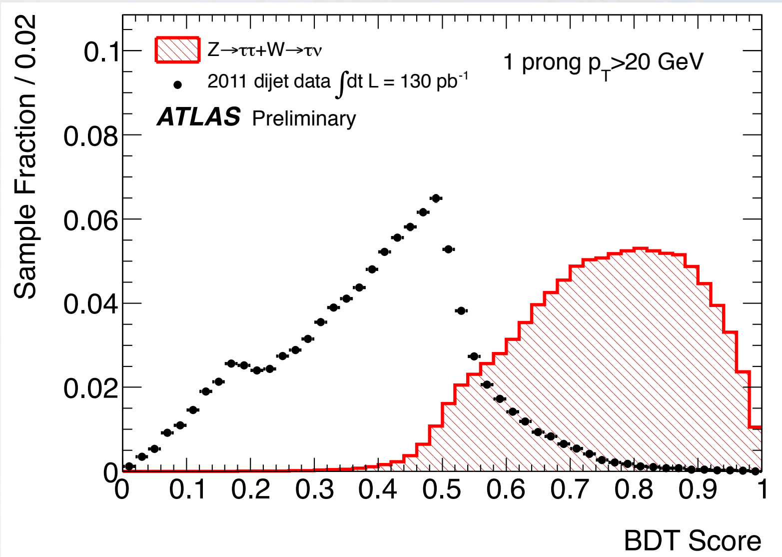


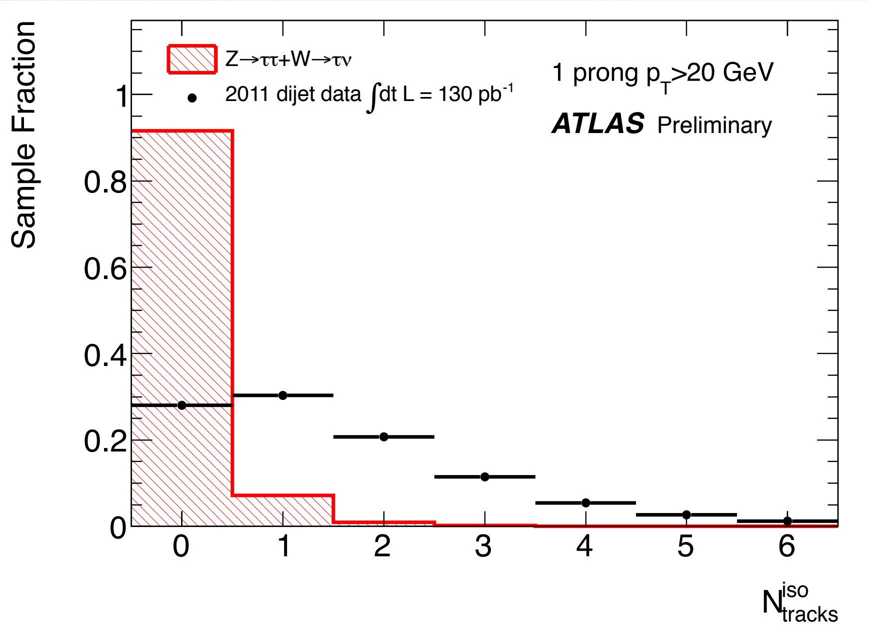

ATLAS
EXPERIMENT
Run 155697, Event 6769403
Time 2010-05-24, 17:38 CEST
W→τν candidate in
7 TeV collisions
p_T^{track} > 1 GeV

Identification of taus

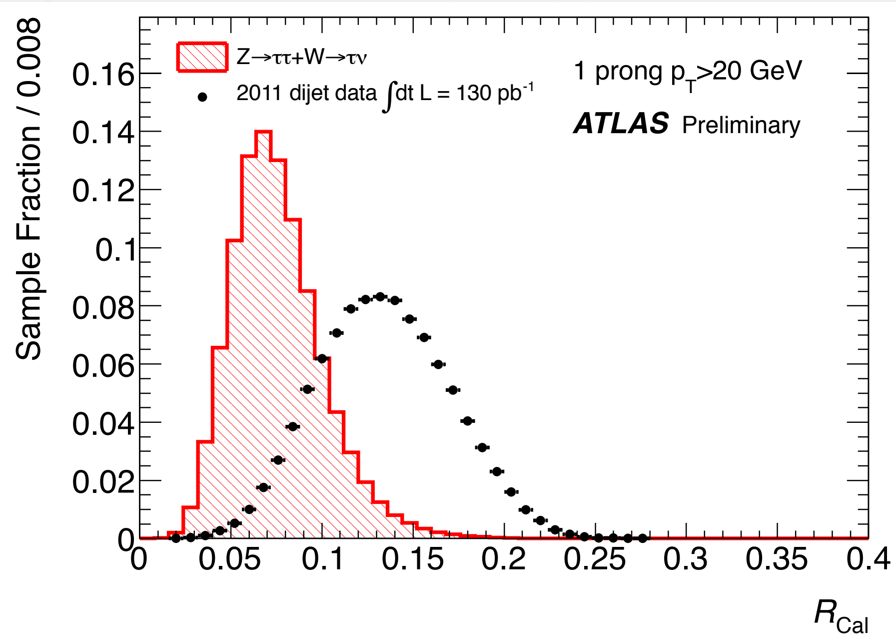
- Using multivariate techniques
- Boosted Decision Trees, Log-Likelihood method
- Tracking and calorimeter information used
- Separately trained for single-/multi-prong tau decays
- Optimized for different working points corresponding to signal efficiencies of about 60%, 45%, 30%







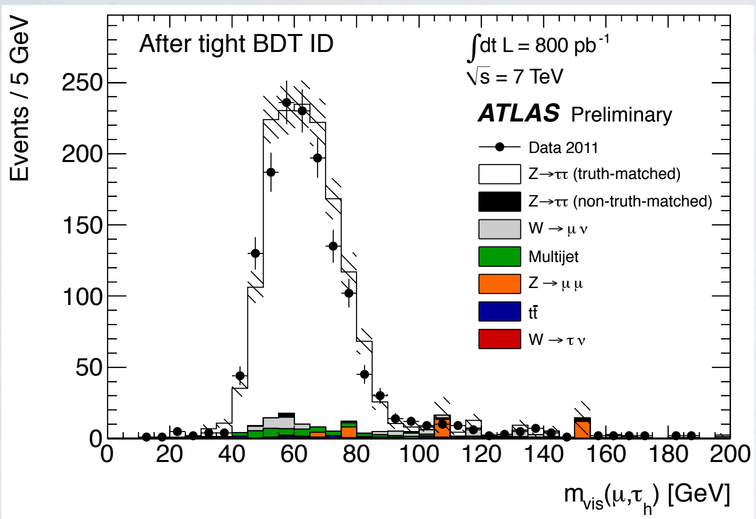
No. of tracks in isolation cone

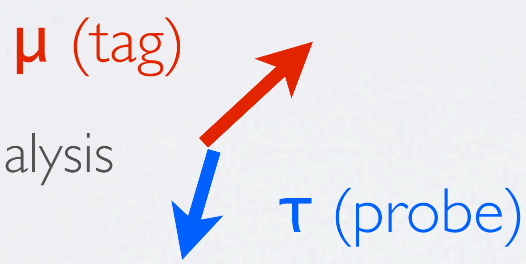


Energy-weighted shower width

Data-driven tau-ID efficiency measurement

Z→ττ

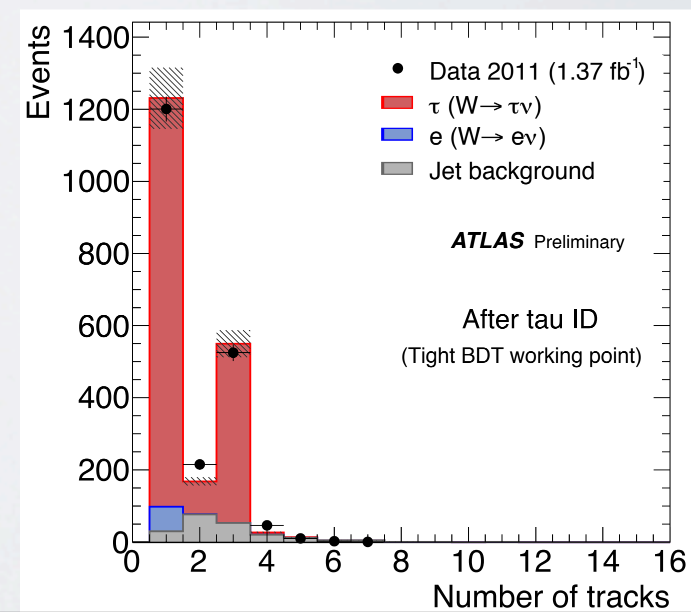




- Follows Z→ττ→lh cross-section analysis
- Apply tag-and-probe method
- Dominant backgrounds: W+jets (taken from MC), multi-jets (estimated from data)
- Efficiency measured at three pre-defined working points
- Uncertainty: 8 - 12 % (improved to 4-5% for 2012 analysis)

W→τυ

- Tag-and-probe method using E_T^{miss}
- Fit track distribution using three templates
  - Real taus (W→τυ from MC)
  - Multi-jets (data in control region)
  - Electron fakes (from MC)
- Single fit to simultaneously measure efficiency of three pre-defined working points
- Uncertainty: 3 - 17 % (improved to 4-5%)



ATLAS-CONF-2011-152

PHYSICS INVOLVING TAU LEPTONS

$W \rightarrow \tau\nu$ polarisation measurement

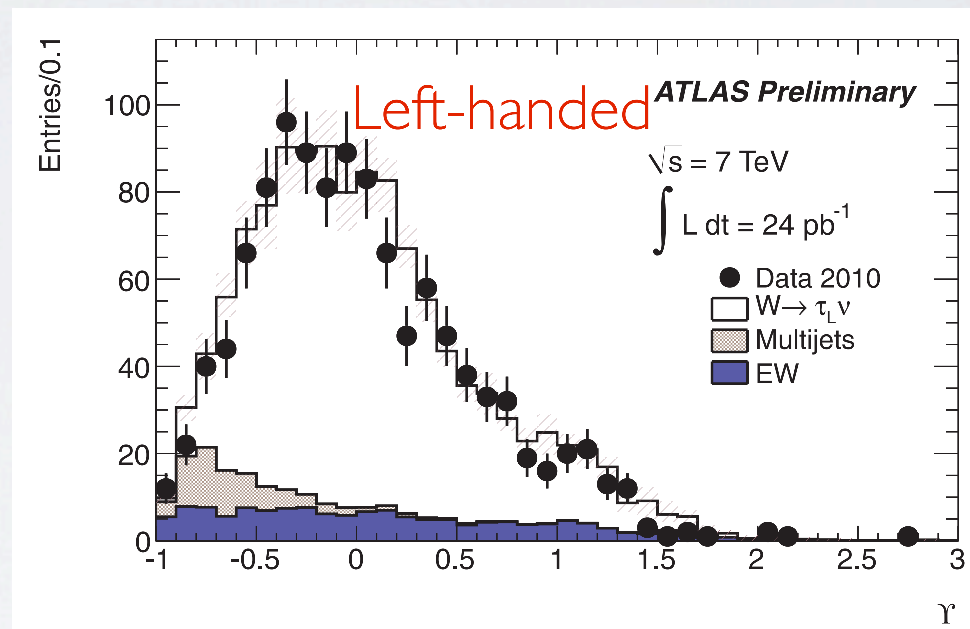
- Performed on 2010 data corresponding to L = 24 pb^{-1}
- First time measured at a hadron collider

Event selection

- 1 single track high p_T tau
- $E_T^{miss} > 30$ GeV
- $|\Delta\phi(\text{jet}, E_T^{miss})| > 0.5$ rad
- $S_T = \frac{E_T^{miss}}{\sigma(E_T^{miss})} \geq 6$

Discriminating variable

$$\frac{E_T^{\pi^-} - E_T^{\pi^0}}{p_T} \approx 2\frac{p_T^{trk}}{p_T} - 1 = \Upsilon$$

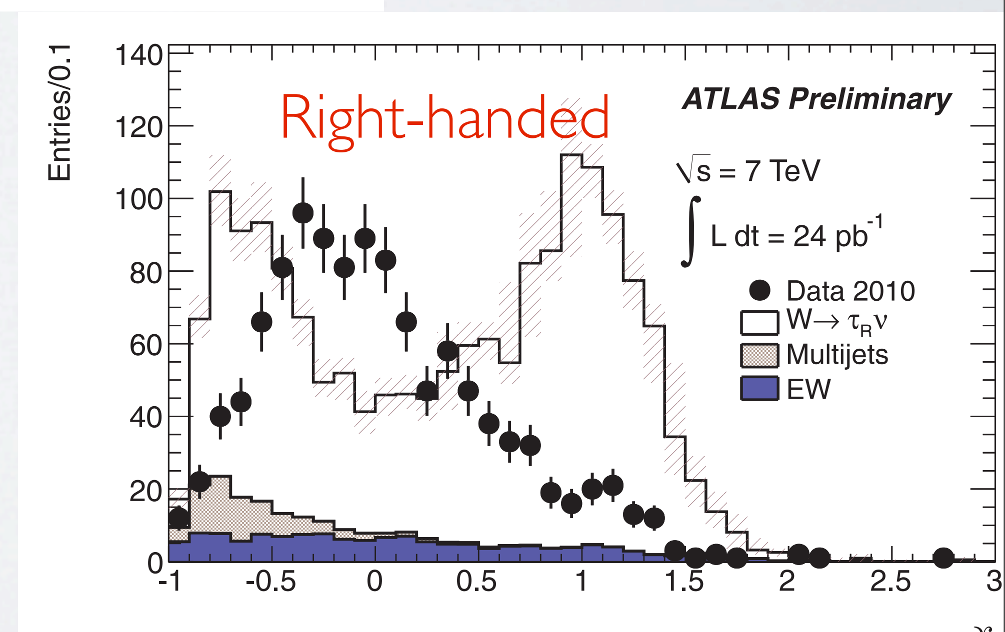


Result

$$P_\tau = \frac{\sigma_R - \sigma_L}{\sigma_R + \sigma_L}$$

- extracted by fitting ϒ

$$P_\tau = -1.06 \pm 0.04\ (stat)\ ^{+0.05}_{-0.07}\ (syst)$$



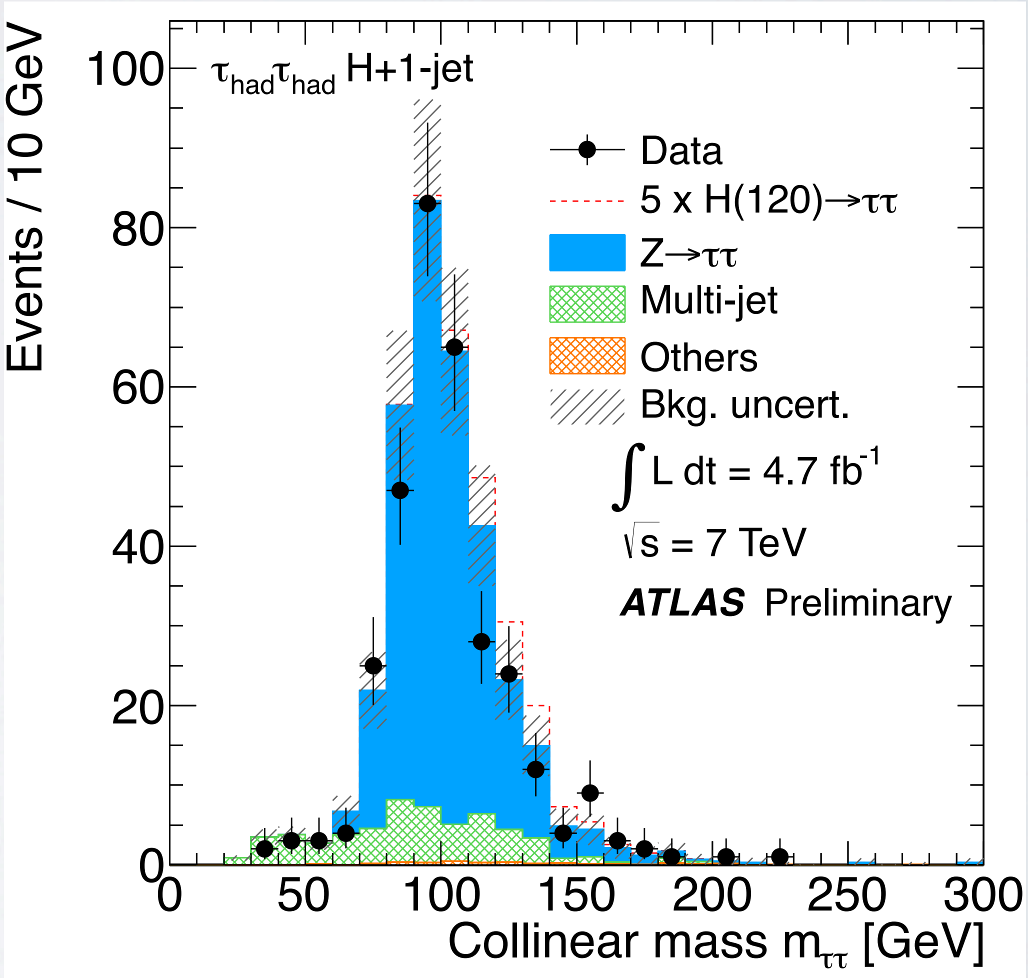
arXiv:1204.6720

STANDARD MODEL HIGGS

Event selection

- Based on full 2011 dataset corresponding to L = 4.7 fb^{-1}
- All tau decay modes ($ll+4\nu$, $l\tau_h+3\nu$, $\tau_h\tau_h+2\nu$) considered
    - Defined in exclusive way
- Sub-channels divided into several categories (0-, 1-, 2-jet VH, 2-jet VBF)
- Example $H\rightarrow\tau_h\tau_h+2\nu$ + 1-jet category
- Exactly 2 isolated high-p_T (35, 25 GeV) tau leptons
- Collinear approximation
- Taus separated by $\Delta R(\tau,\tau) < 2.2$
- Invariant mass of taus and jet, $m_{\tau\tau j} > 225$ GeV

Final discriminating variable



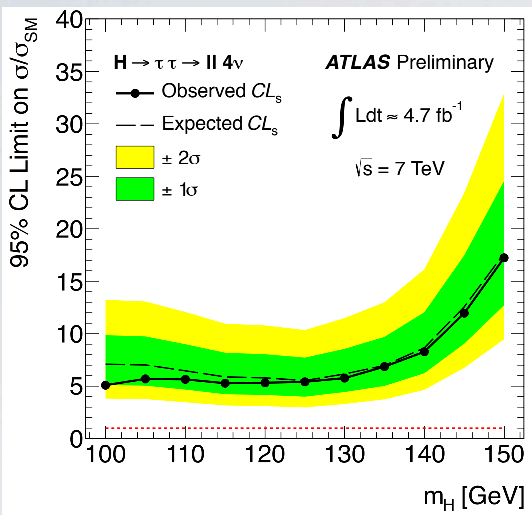
Backgrounds

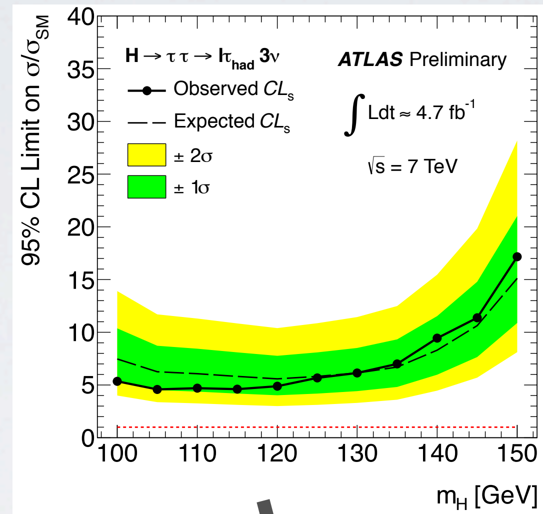
- Dominant backgrounds (multi-jet, $Z\rightarrow\tau\tau$) from data
- Further backgrounds (W+jets, tt, diboson) from MC

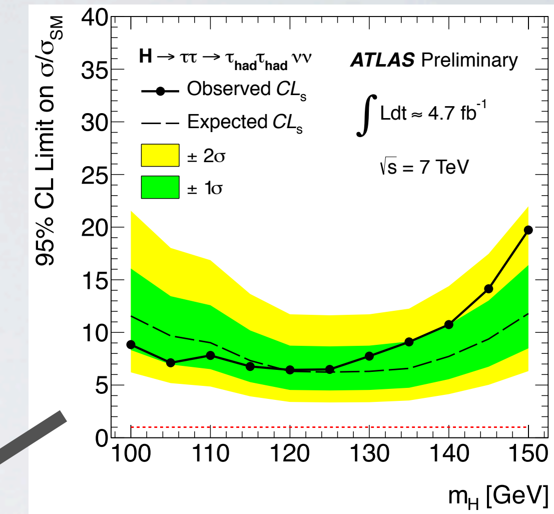
ATLAS-CONF-2012-014

95% CL_s exclusion limit

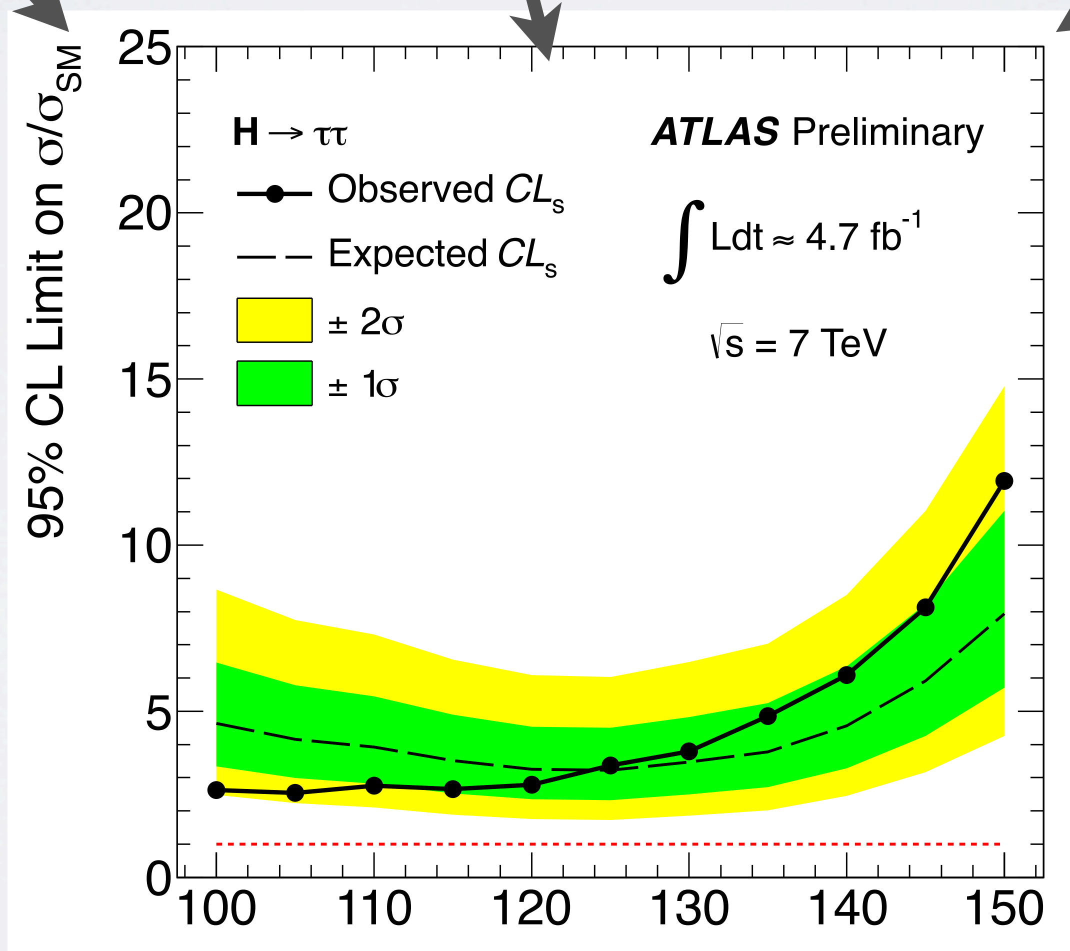
- Combination -







- Use profile likelihood ratio
- Systematics treated as nuisance parameters

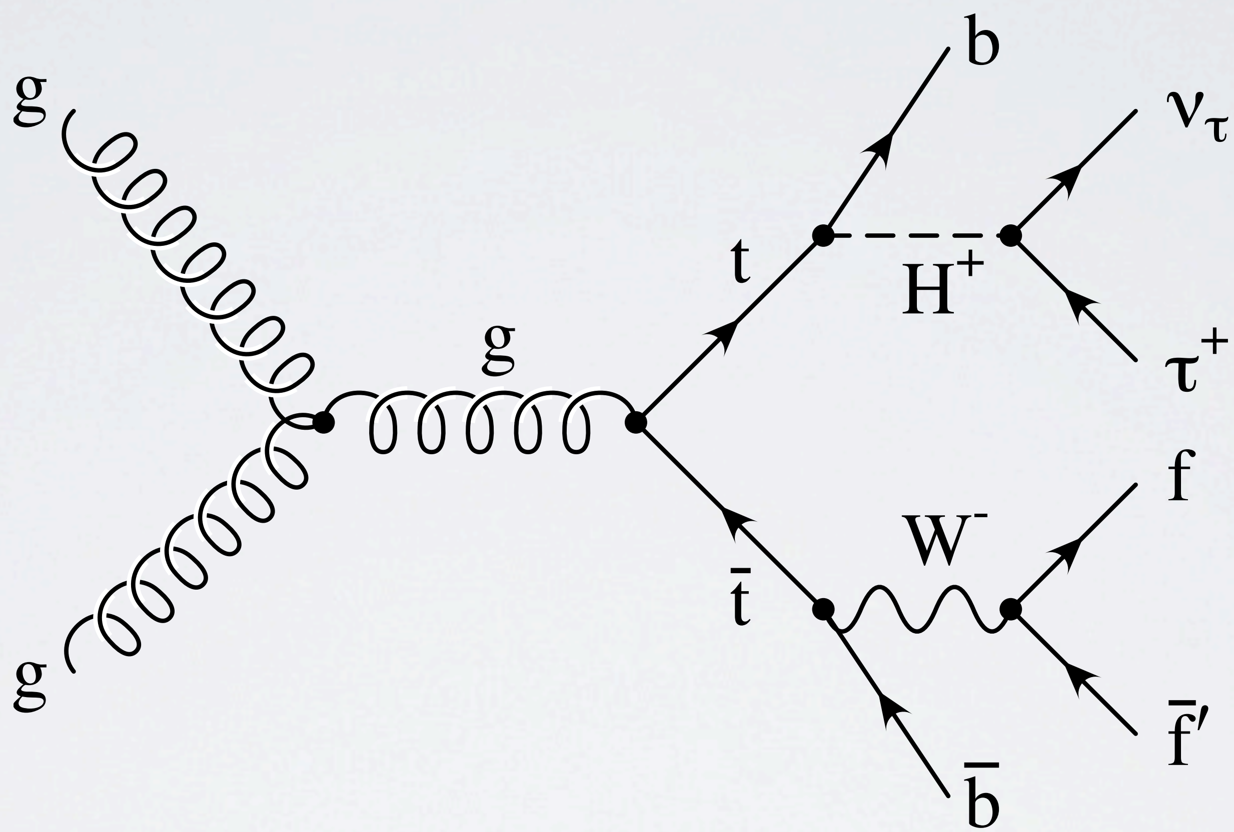


- No significant excess observed in mass range of 100 - 150 GeV

CHARGED HIGGS

lepton + jets

$tt \rightarrow bbWH^{+} \rightarrow bb(qq')(\tau_{l}\upsilon)$



lepton + tau

$tt \rightarrow bbWH^{+} \rightarrow bb(l\upsilon)(\tau_{h}\upsilon)$

tau + jets

$tt \rightarrow bbWH^{+} \rightarrow bb(qq')(\tau_{h}\nu)$

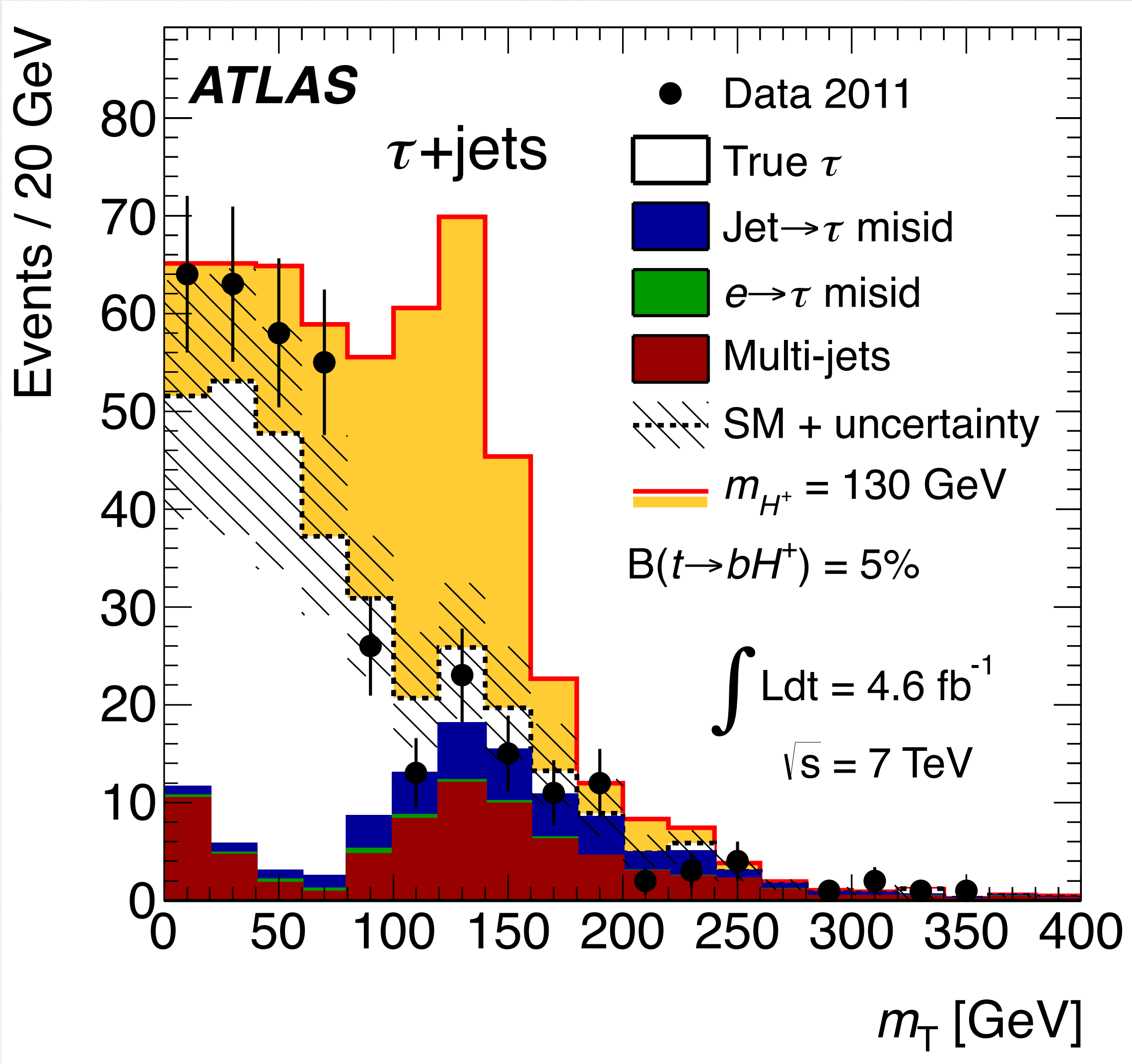
arXiv:1204.2760

Event selection

- Predicted by many non-minimal Higgs models (e.g. 2HDM)
- Observation would be a direct observation of new physics BSM
- Uses full 2011 data set corresponding to L = 4.6 fb^{-1}
- Light $H^{\pm}$ analysis, i.e. analysed mass range from 90 GeV to 160 GeV
- Search performed in tt environment

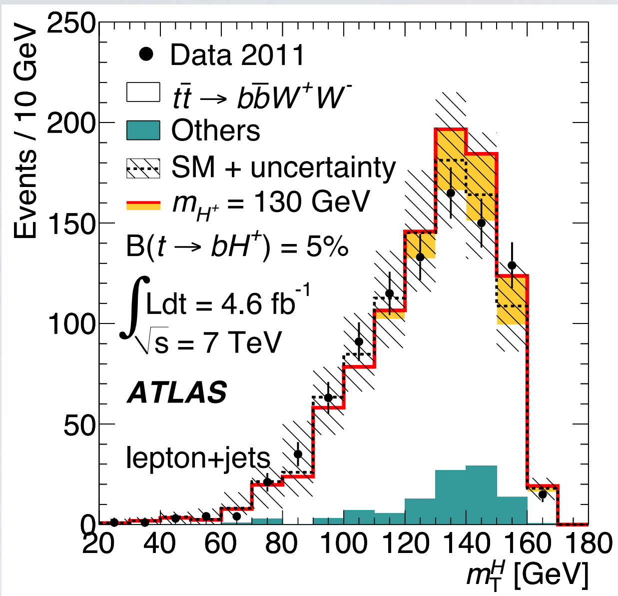
- Example: tt→bbWH^{+}→bb(qq')(τν)
- Tau + E_T^{miss} trigger (29, 35 GeV)
- ≥ 4 jets with p_T > 20 GeV
  - 2 of them b-tagged
- E_T^{miss} > 65 GeV
- MET significance, $\Sigma_T = \frac{E_T^{miss}}{0.5\ \mathrm{GeV}^{1/2} \cdot \sqrt{\sum p_T}} > 13$
- Top quark decay topology

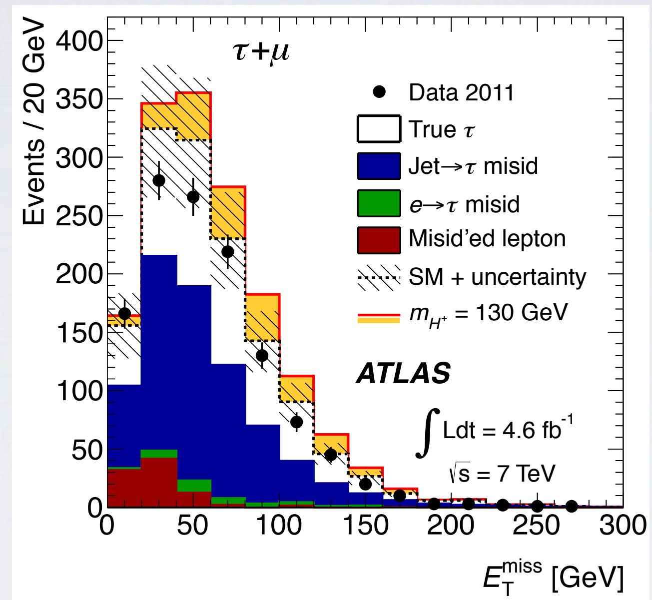
all backgrounds estimated from data

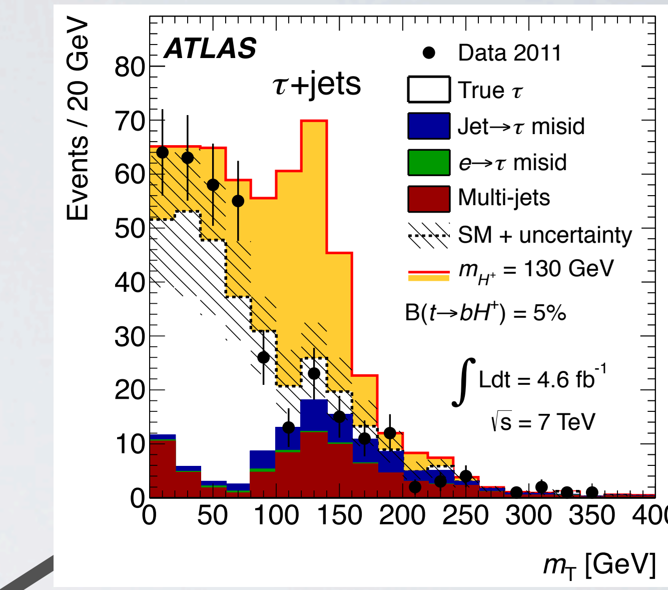


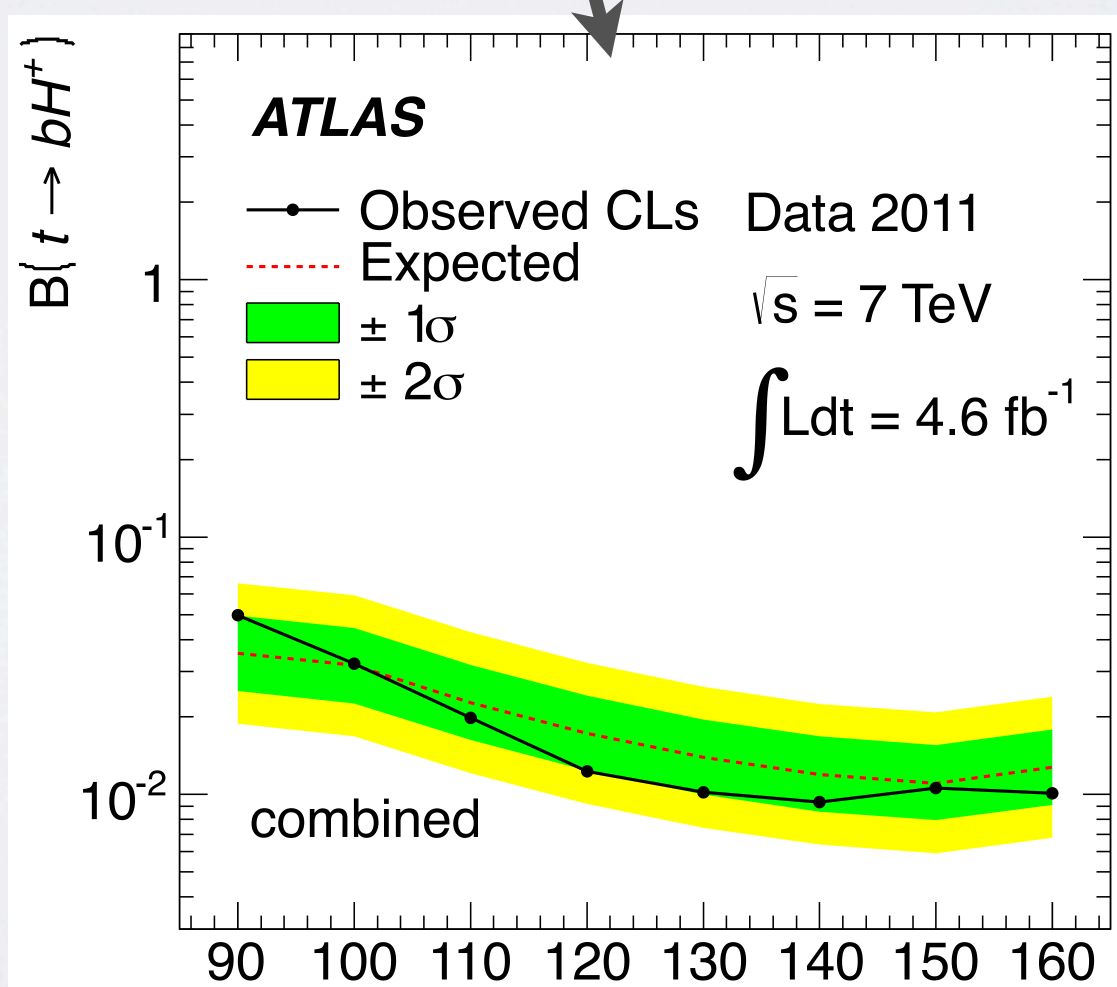
$$m_T = \sqrt{2\, p_T(\ell) \cdot E_T^{miss} \cdot \left(1 - \cos\Delta\phi(\ell, E_T^{miss})\right)}$$

95% CL_s exclusion Limit on BR($t \rightarrow bH^+$)







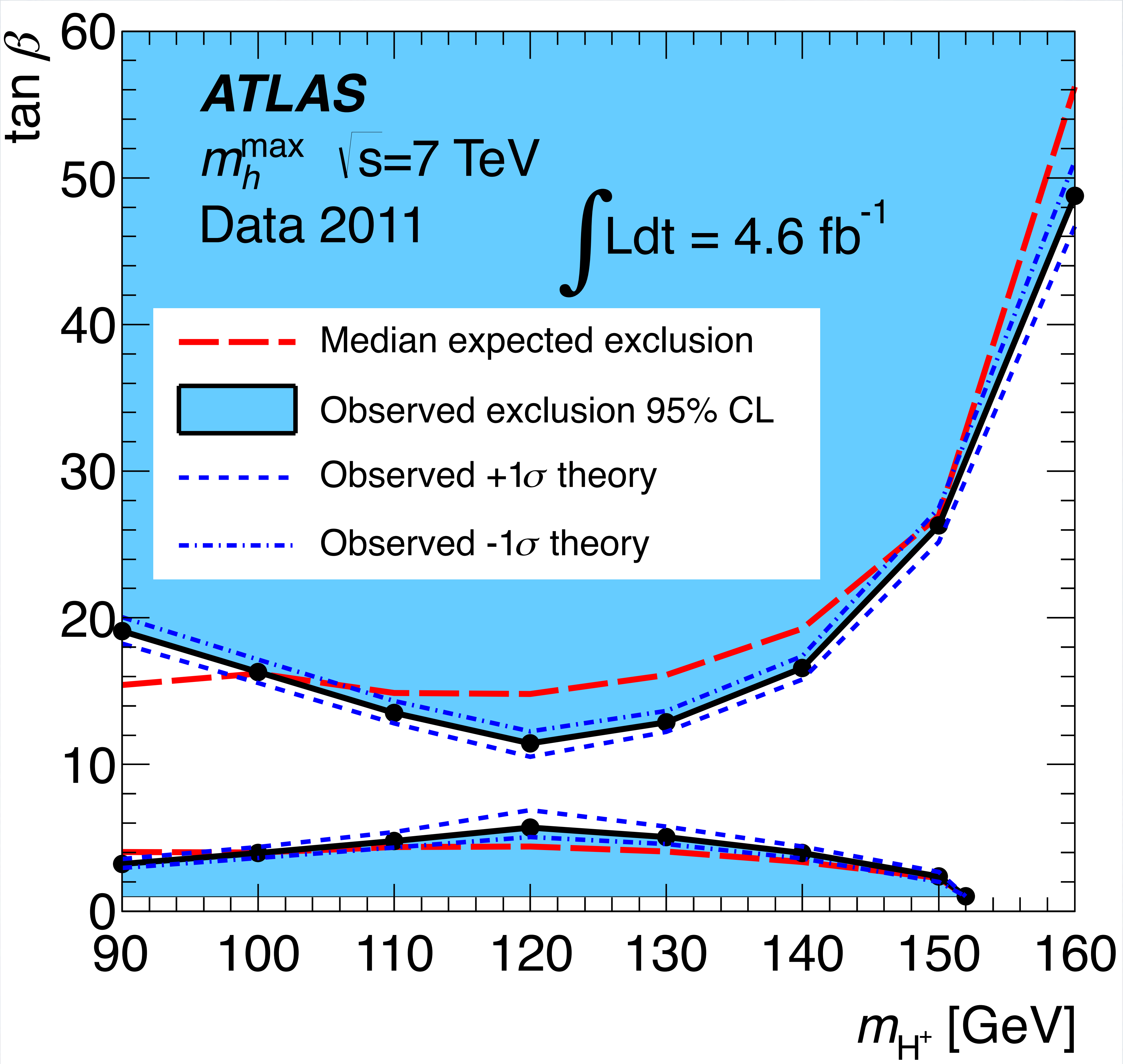


- Use profile likelihood ratio
- Systematics treated as nuisance parameters
- tt normalisation corrected for BR ($t \rightarrow bH^+$)

- No significant deviation from SM prediction observed

➡ Set exclusion limit on BR($t \rightarrow bH+$)

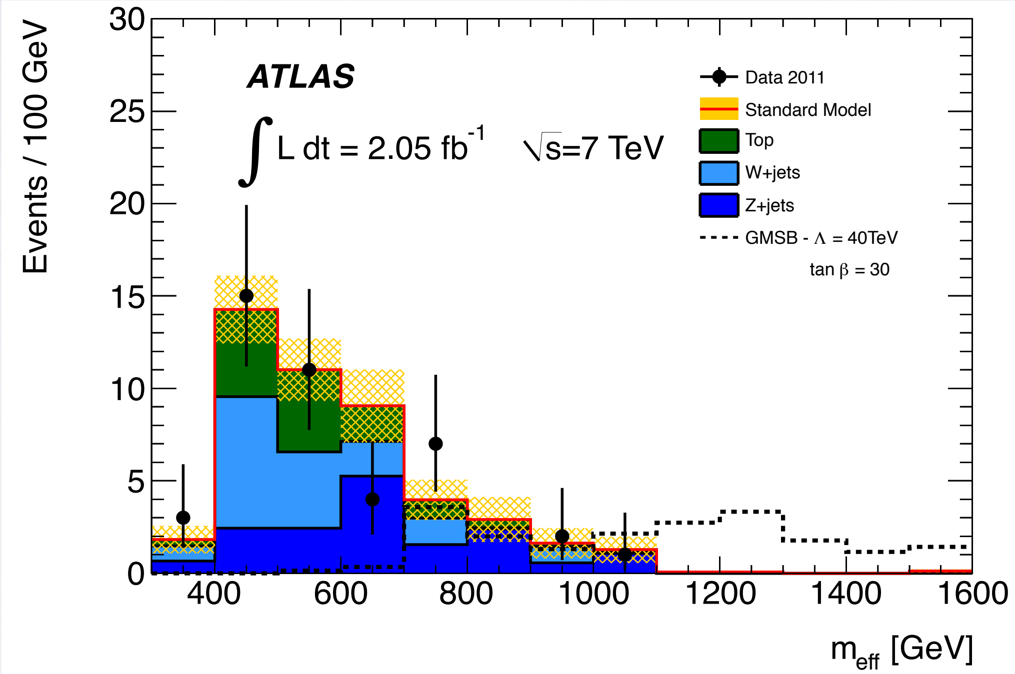
95% CL_s exclusion Limit



SUSY SEARCHES INVOLVING TAU LEPTONS

Event selection

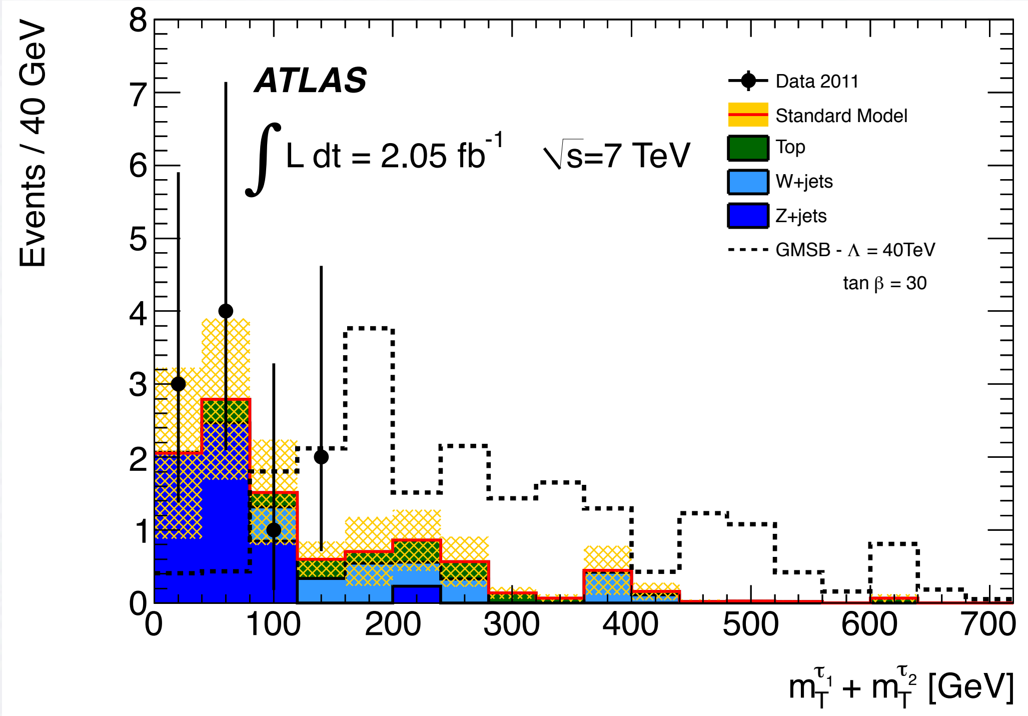
- Use sub-set of 2011 dataset corresponding to $L = 2.0\ fb^{-1}$
- Investigate GMSB scenario
- Search for events with large E_T^{miss}, jets and $\geq 2\tau$ leptons



- Jet + E_T^{miss} trigger $p_T > 75$ GeV, $E_T > 45$ GeV
- Reconstructed jet with $p_T > 130$ GeV
- $E_T^{miss} > 130$ GeV
- ≥ 2 identified τ
- 2^{nd} jet with $p_T > 30$ GeV (→against multi-jets)
- $\Delta\phi(p_T^{miss}, jet_{1,2}) > 0.4$ rad (→against multi-jets)
- $m_{eff} > 700$ GeV
- $m_T^{\tau 1} + m_T^{\tau 2} > 80$ GeV

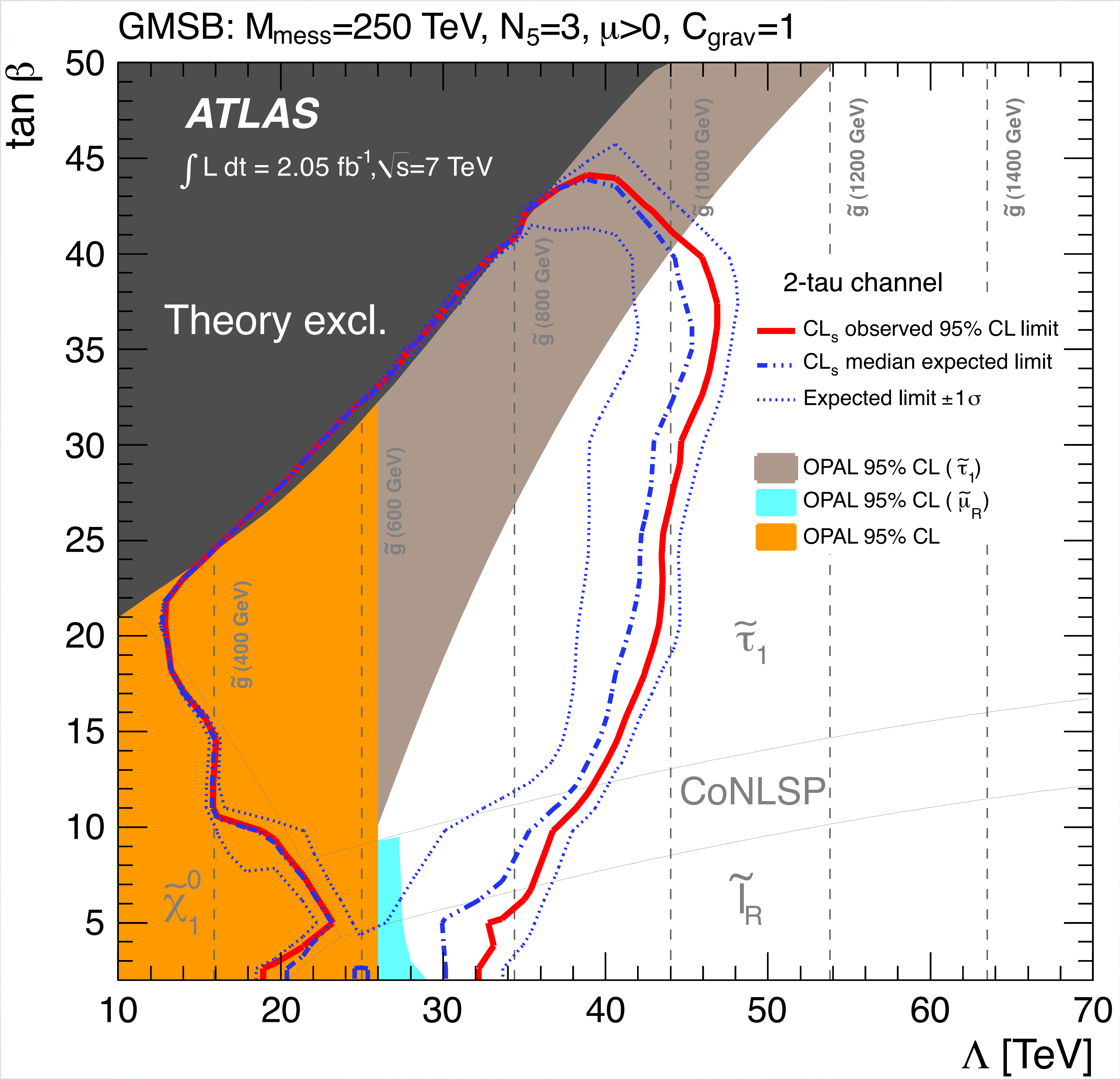
Backgrounds

- W+jets, tt simultaneously estimated in data
- Z+jets taken from MC



arXiv:1203.6580

95% CL$_s$ exclusion Limit



Conclusion

- Well performing tau identification @ ATLAS
- $W \rightarrow \tau\upsilon$ polarisation measurement first time performed at a hadron collider shows very good agreement with theory pred.
- Standard Model $H \rightarrow \tau\tau$ reach combined sensitivity to ~3*σ_{SM}
- Charged Higgs exclude (95% CL) tanβ of 12-26 and between 1 and 2-6 in m_h^{max} scenario
- SUSY searches with taus excludes (95% CL) for Λ<32 GeV independent on tanβ

References

- **ATLAS-CONF-2011-152**

  Performance of the Reconstruction and Identification of Hadronic Tau Decays with ATLAS

  http://cdsweb.cern.ch/record/1398195

- **ATLAS-STDM-2011-46-002**

  Measurement of Tau Polarization in W -> tau,nu Decays with the ATLAS Detector in pp Collisions at sqrt(s) = 7 TeV

  http://cdsweb.cern.ch/record/1428549

- **ATLAS-CONF-2012-014**

  Search for the Standard Model Higgs boson in the H->tau tau decay mode with 4.7 fb^-1 of ATLAS data at sqrt(s)=7TeV

  http://cdsweb.cern.ch/record/1429662

- arXiv:1204.2760

  Search for charged Higgs bosons decaying via H+ -> taunu in top quark pair events using pp collision data at sqrt(s) = 7 TeV with the ATLAS detector

- arXiv:1203.6580

  Search for Events with Large Missing Transverse Momentum, Jets, and at Least Two Tau Leptons in 7 TeV Proton-Proton Collision Data with the ATLAS Detector

References

- arxiv:1204:3852

  Search for supersymmetry with jets, missing transverse momentum and at least one hadronically decaying tau lepton in proton-proton collisions at $\sqrt{7}$ TeV with the ATLAS detector

- **ATLAS-CONF-2012-006**

  Z -> tau tau cross section measurement in proton-proton collisions at 7 TeV with the ATLAS experiment

  http://cdsweb.cern.ch/record/1426991

- ***Phys.Lett. B706 (2012) 276-294***

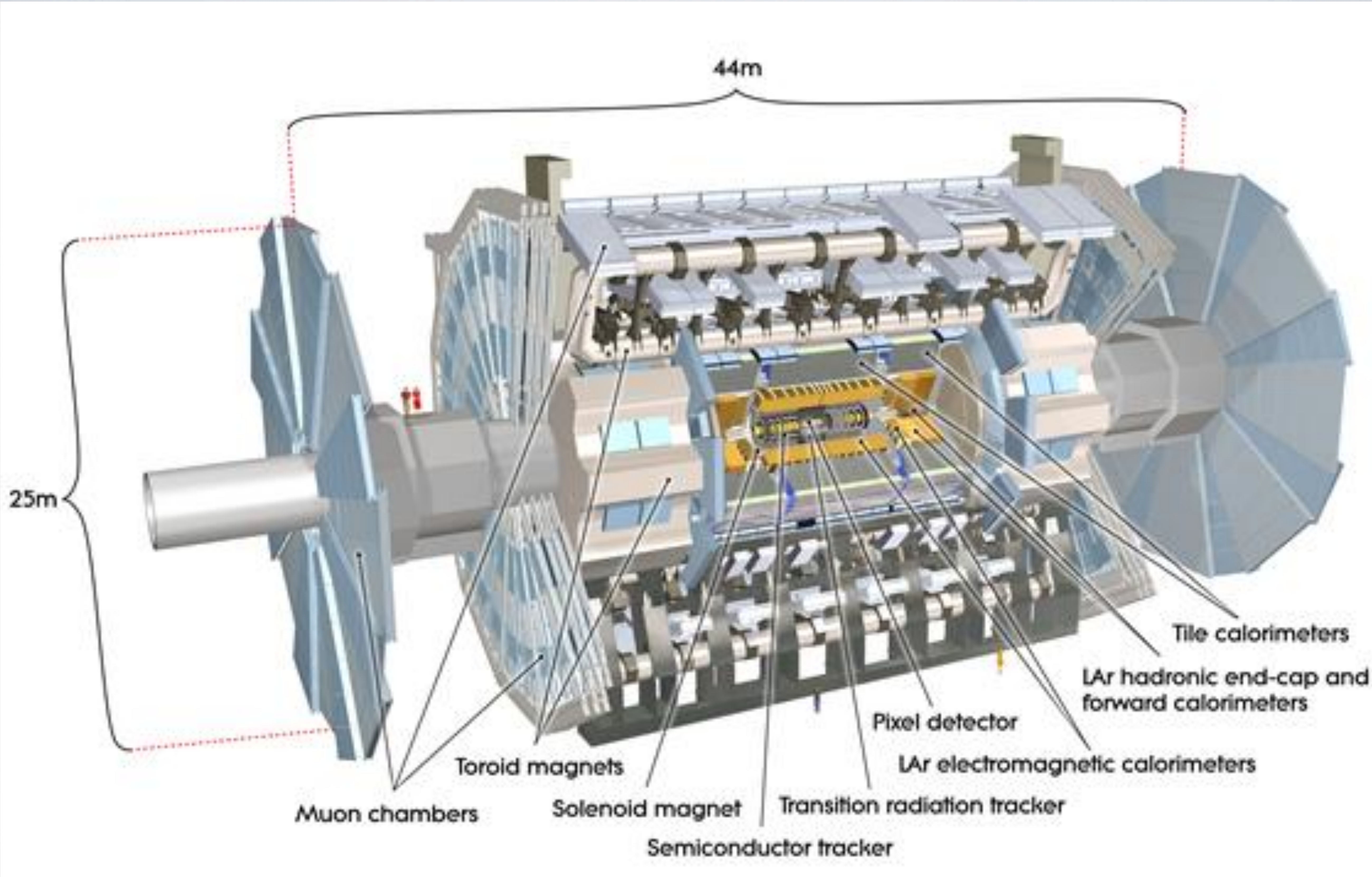
  Measurement of the W->tau Cross Section in pp Collisions at sqrt(s) = 7 TeV with the ATLAS Experiment

- ***Phys.Lett. B705 (2011) 174-192***

  Search for neutral MSSM Higgs boson decaying to tau^+tau^- pairs in proton-proton collisions at √s = 7 TeV with the ATLAS experiment

BACKUP

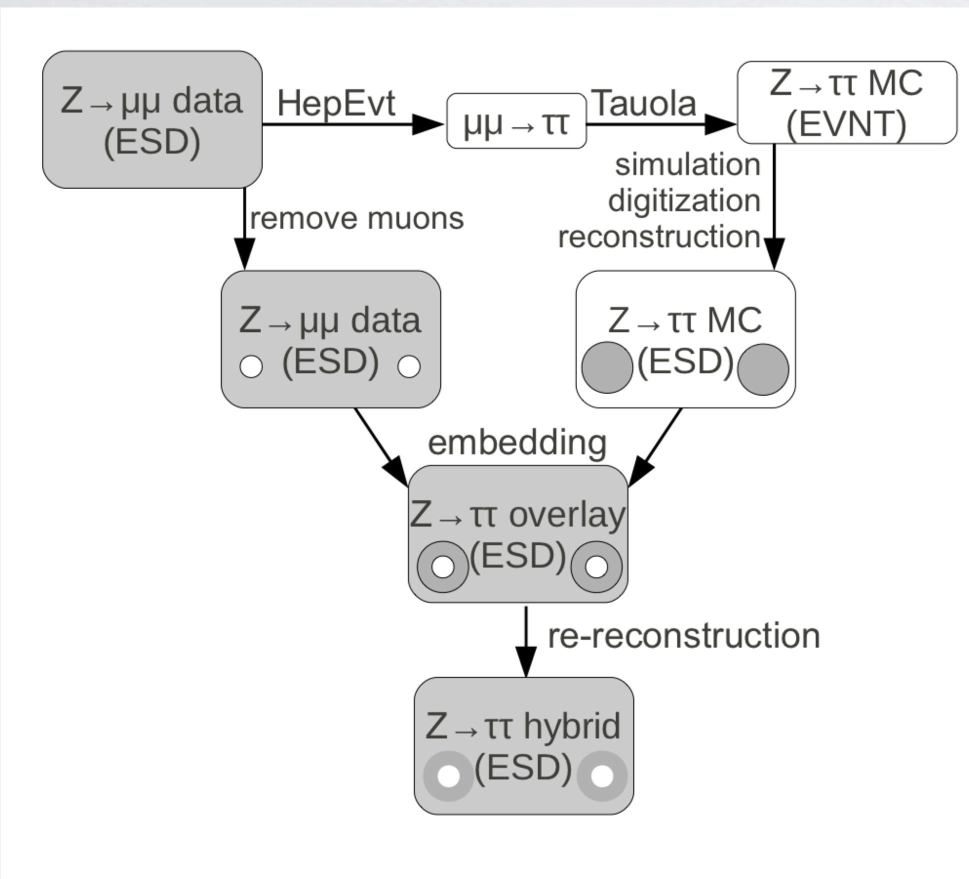
ATLAS detector

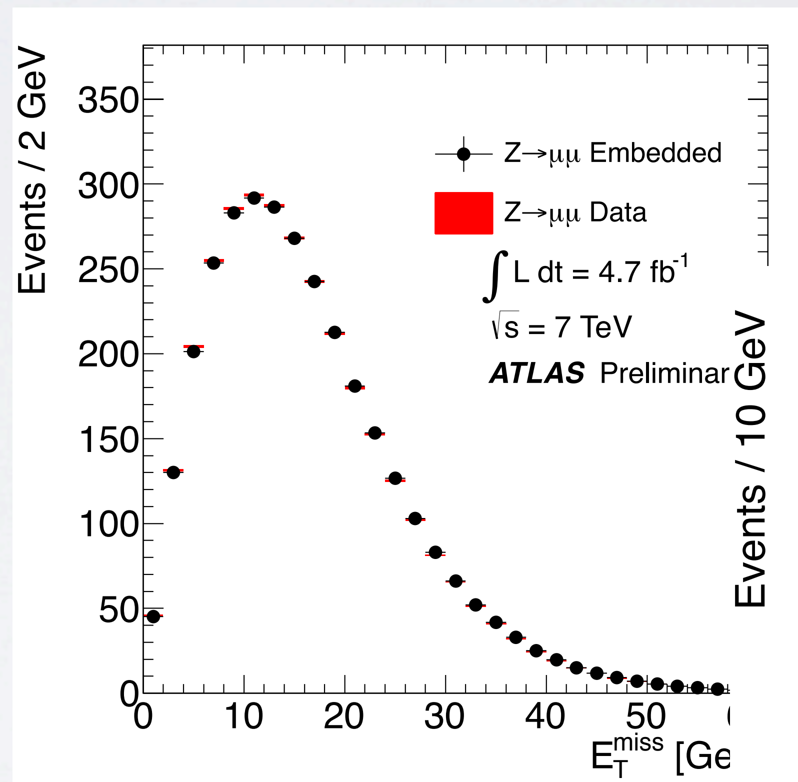


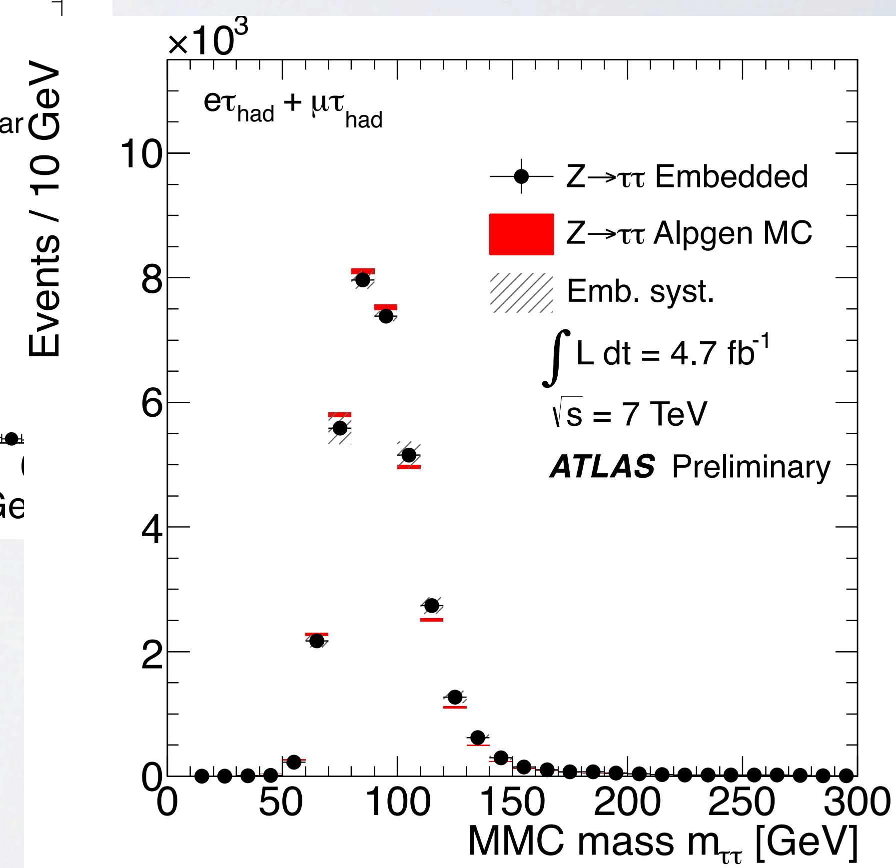
Sunday, May 6, 2012

EMBEDDING TECHNIQUE

- select pure Z→μμ events in data
- replace muons by simulated tau decays using TAUOLA

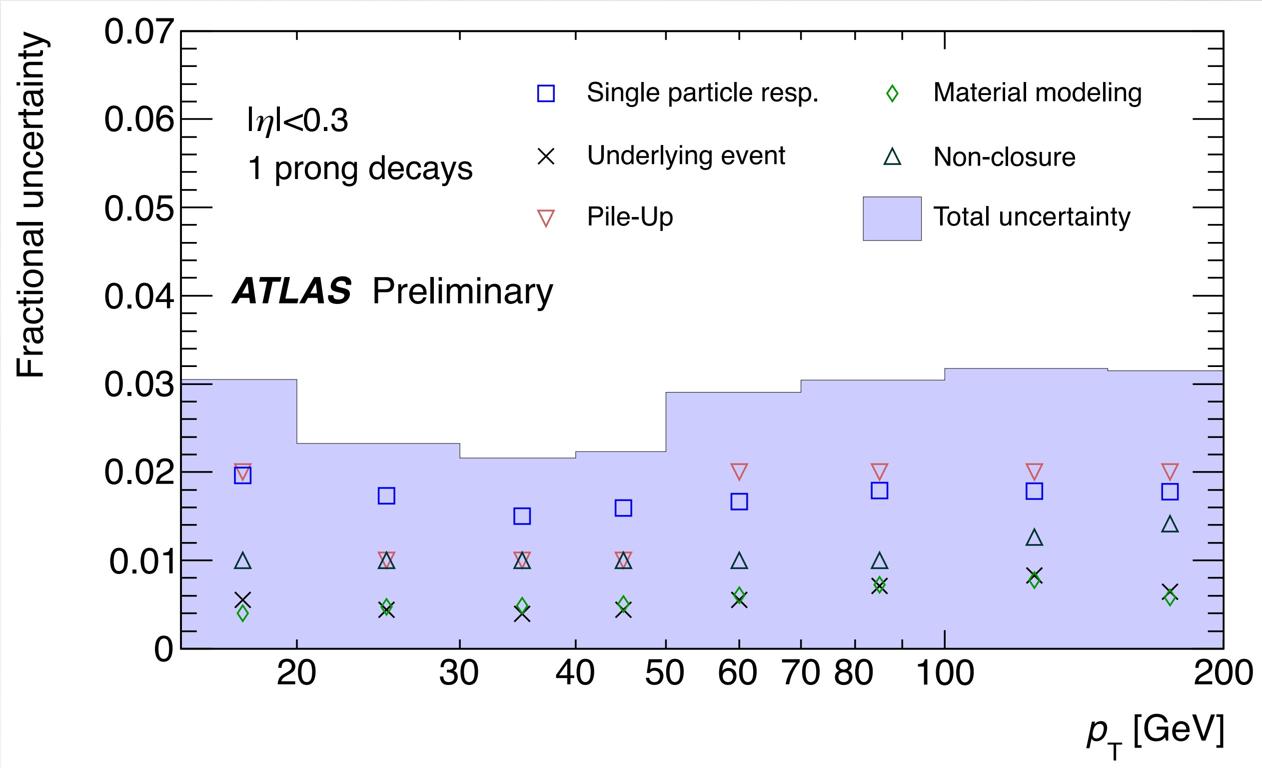


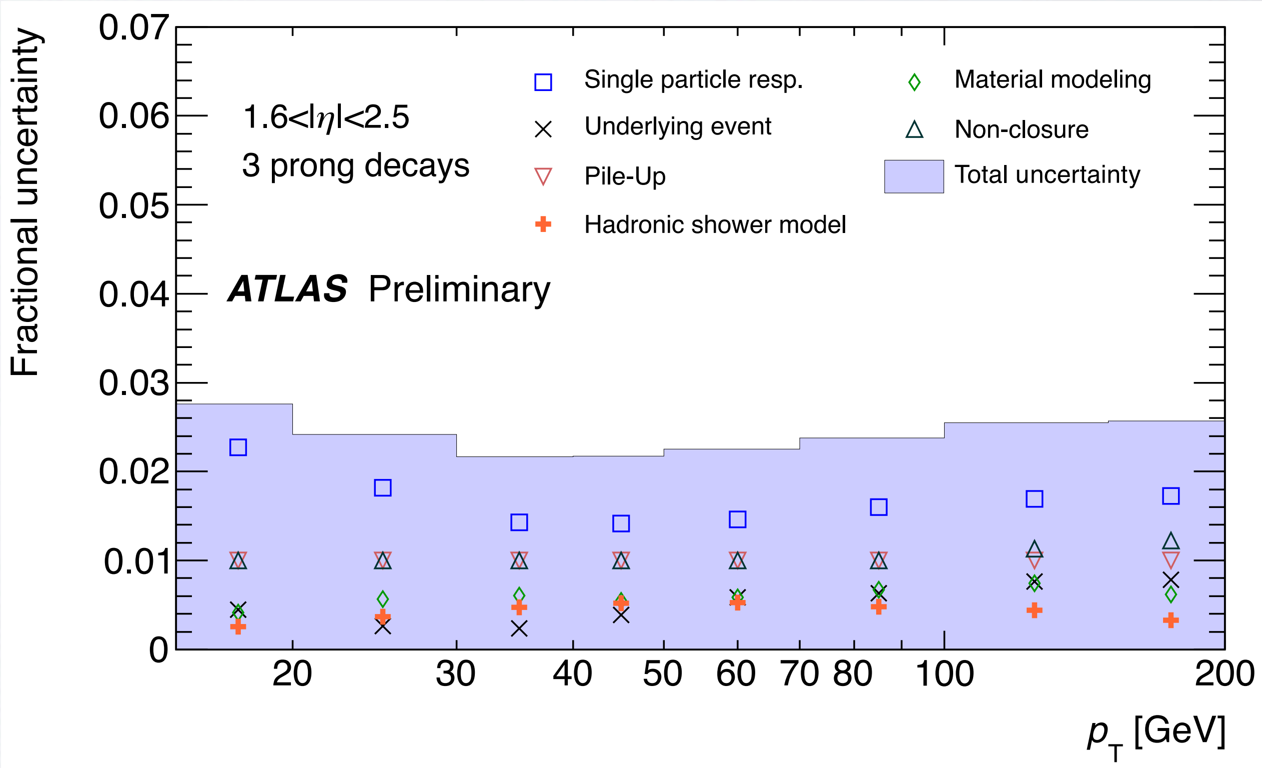




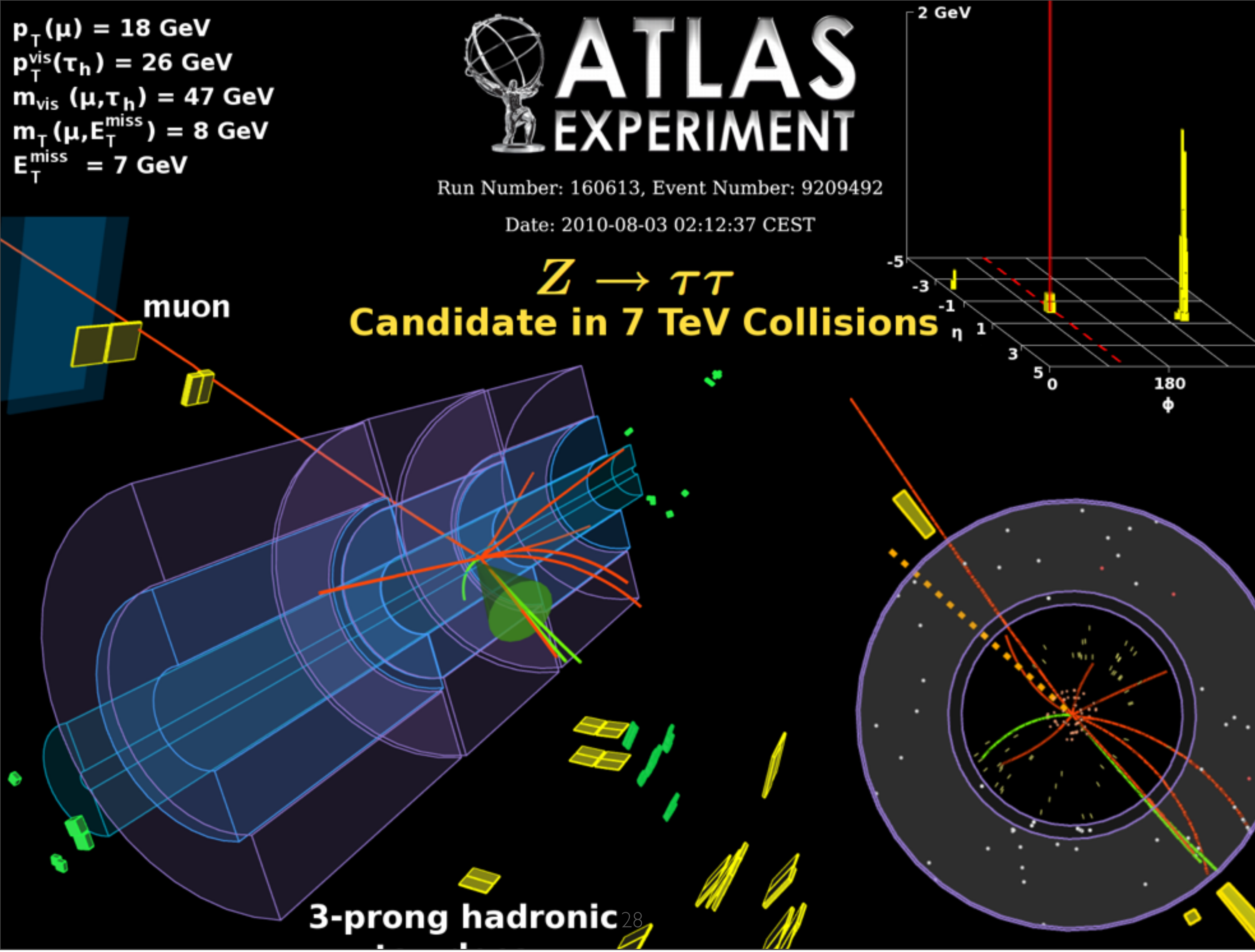
TAU ENERGY SCALE

- in-situ E/p measurement for p < 20GeV
- test beam measurements for p > 20 GeV





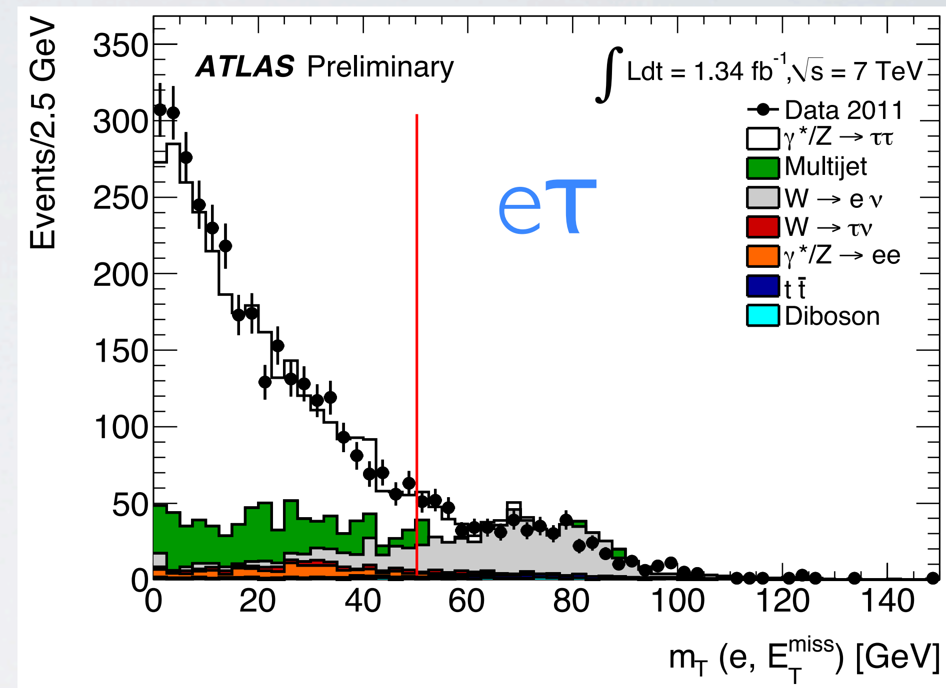
PHYSICS INVOLVING TAU LEPTONS

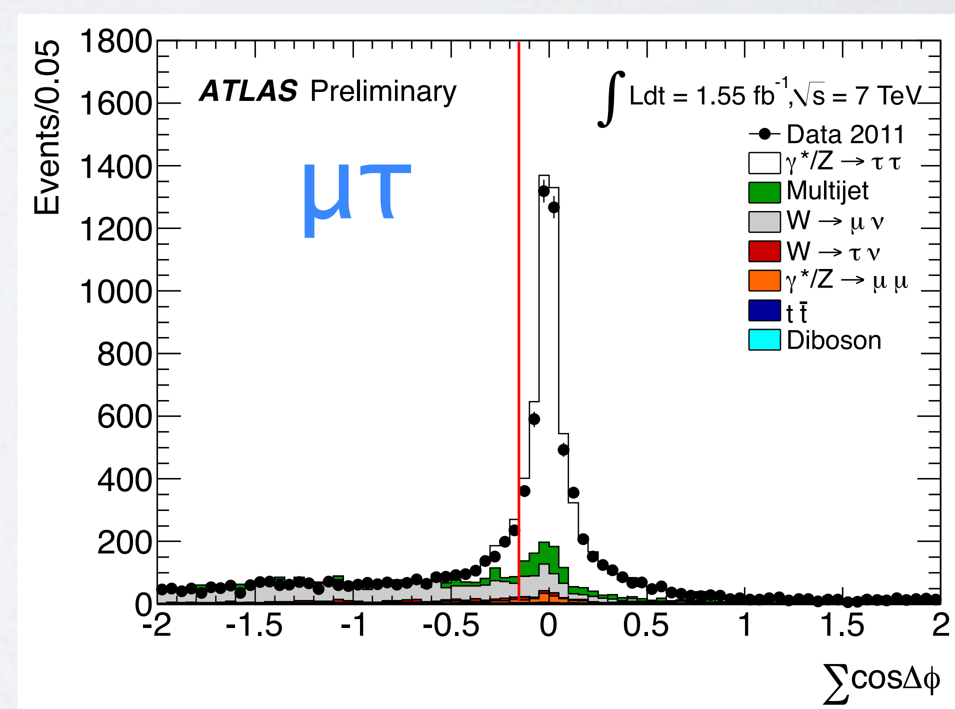

$p_T(\mu)$ = 18 GeV
$p_T^{vis}(\tau_h)$ = 26 GeV
m_{vis} (μ, τ_h) = 47 GeV
$m_T(\mu, E_T^{miss})$ = 8 GeV
E_T^{miss} = 7 GeV
ATLAS EXPERIMENT
Run Number: 160613, Event Number: 9209492
Date: 2010-08-03 02:12:37 CEST
$Z \rightarrow \tau\tau$
Candidate in 7 TeV Collisions
muon
3-prong hadronic
2 GeV
η
φ
-5
-3
-1
1
3
5
0
180

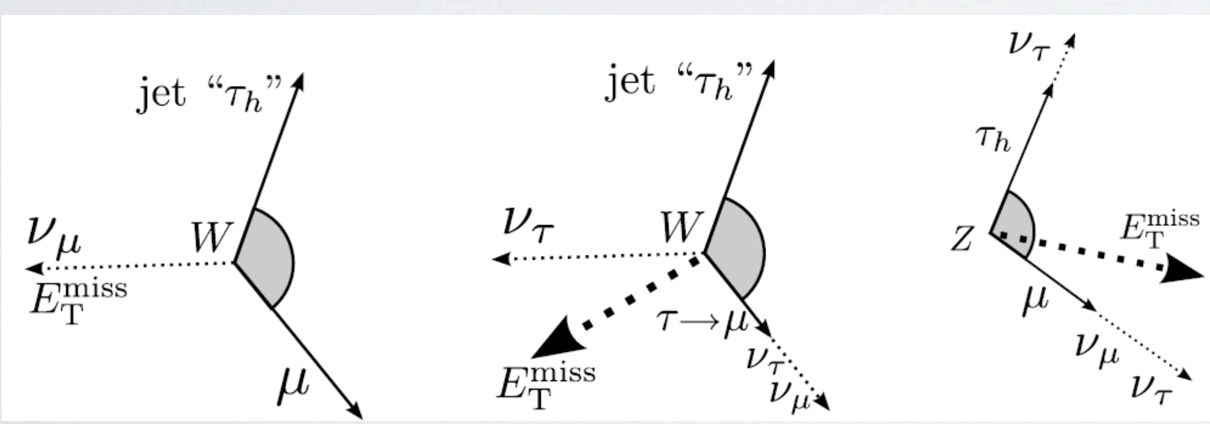
Event selection

- performed on 2011 data corresponding to L = 1.34 fb^{-1} - 1.55 fb^{-1}
- combination of 3 final states: eμ, $e\tau_{had}$, $\mu\tau_{had}$

- single lepton trigger (e, μ)
- μ (e) p_T > 15 (10) GeV
- opposite high p_T lepton-tau pair
- transverse mass, $m_T = \sqrt{2\, p_T(\ell) \cdot E_T^{miss} \cdot \left(1 - \cos\Delta\phi(\ell, E_T^{miss})\right)} < 50$ GeV
- Σ cos(Δφ) > -0.15 (against W+jets)
- visible mass: 35 GeV < m_{vis} < 75 GeV







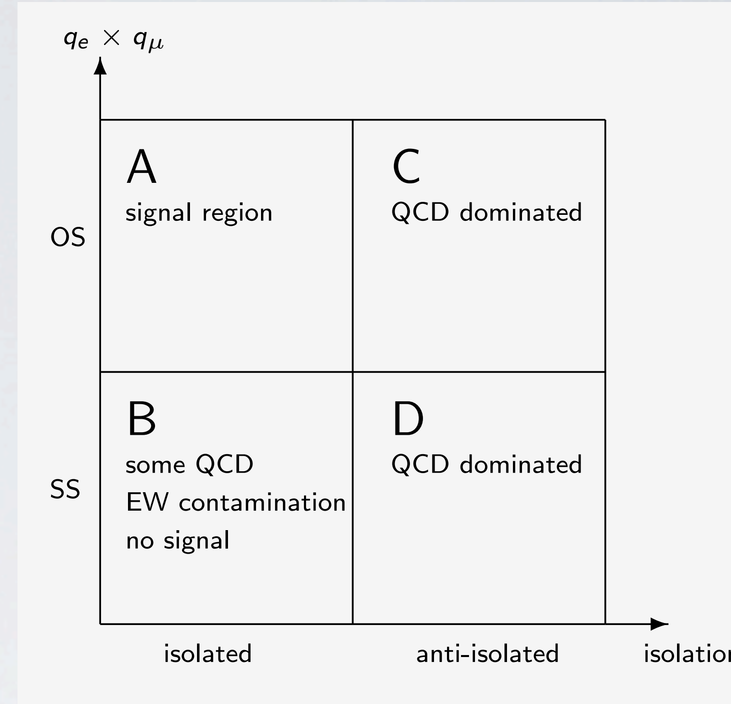
$$\sum \cos\Delta\phi = \cos\left(\phi(\ell) - \phi(E_T^{miss})\right) + \cos\left(\phi(\tau_h) - \phi(E_T^{miss})\right)$$

ATLAS-CONF-2012-006

Background estimation

QCD multijets

- low Monte-Carlo (MC) statistics
- estimated by data-driven matrix method
- correction for electro-weak (EW) backgrounds using MC



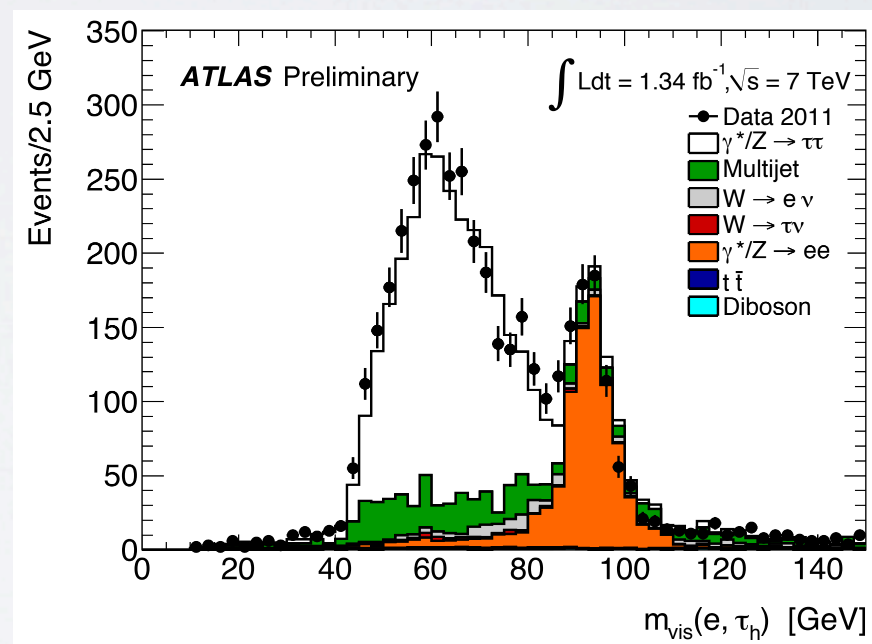
Electroweak backgrounds

- lepton fakes:
  - Z→ee, Z→μμ tag-and-probe method

μ (tag)

τ (probe)

- jet fakes:
  - Z enriched control region



further backgrounds

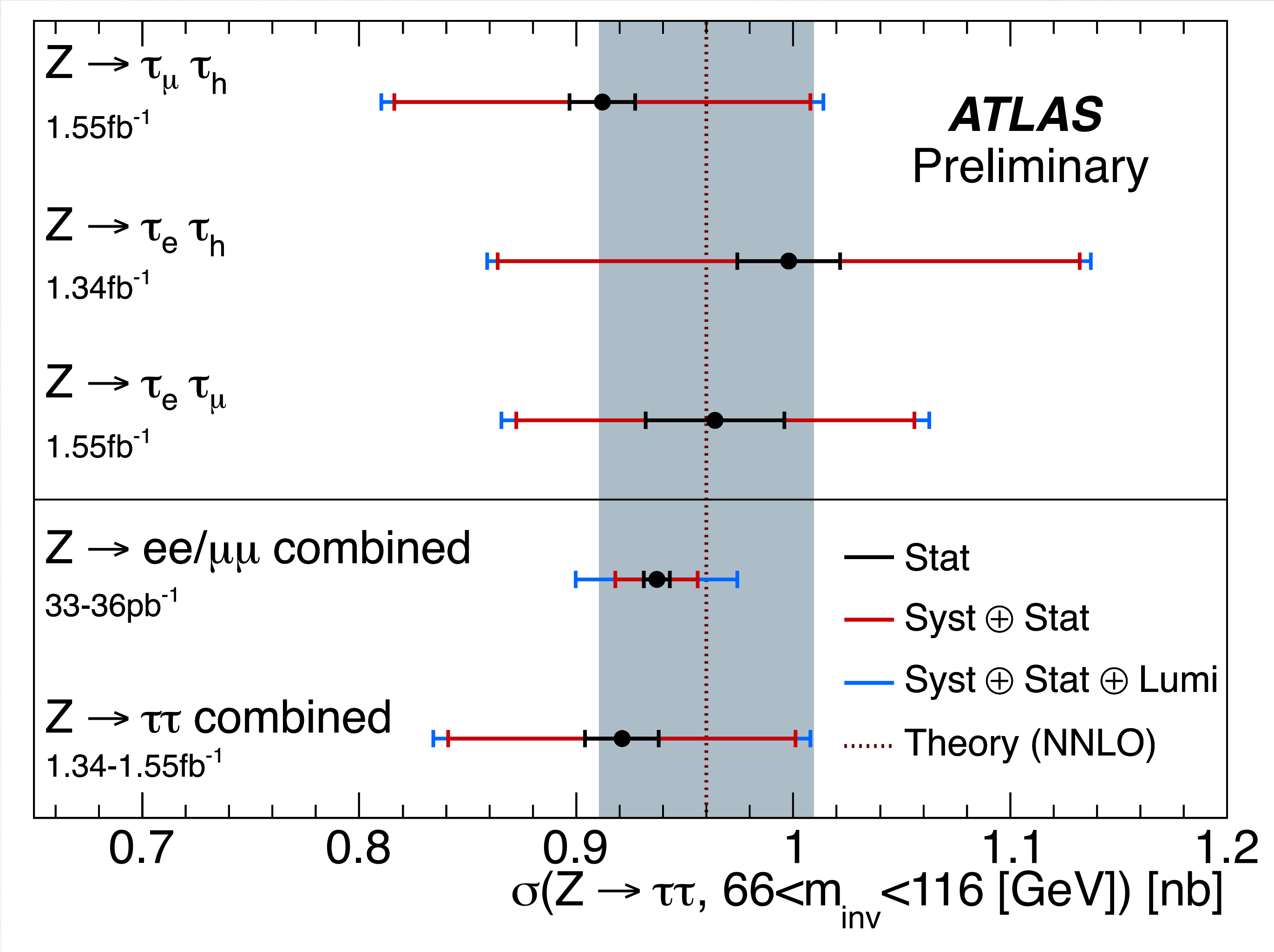
- normalisation from **W** enriched control region, shape from MC
- tt, di-boson estimated using MC

Results

$$\sigma(Z \rightarrow \tau\tau) \times \mathrm{B} = \frac{N_{\mathrm{obs}} - N_{\mathrm{bkg}}}{A_Z \cdot C_Z \cdot \mathcal{L}}$$

σ = 0.92 ± 0.02(stat) ± 0.08(syst) ± 0.03(lumi) nb

- measured separately in each channel
- combined result obtained by BLUE (Best Linear Unbiased Estimate) method
- shows very good agreement with NNLO prediction
  - $\sigma_{\mathrm{NNLO}} = 0.96 \pm 0.05$ nb*



* K. Melnikov and F. Petriello, *Electroweak gauge boson production at hadron colliders through $O(\alpha(s)^2)$*, Phys. Rev. **D74** (2006) 114017.

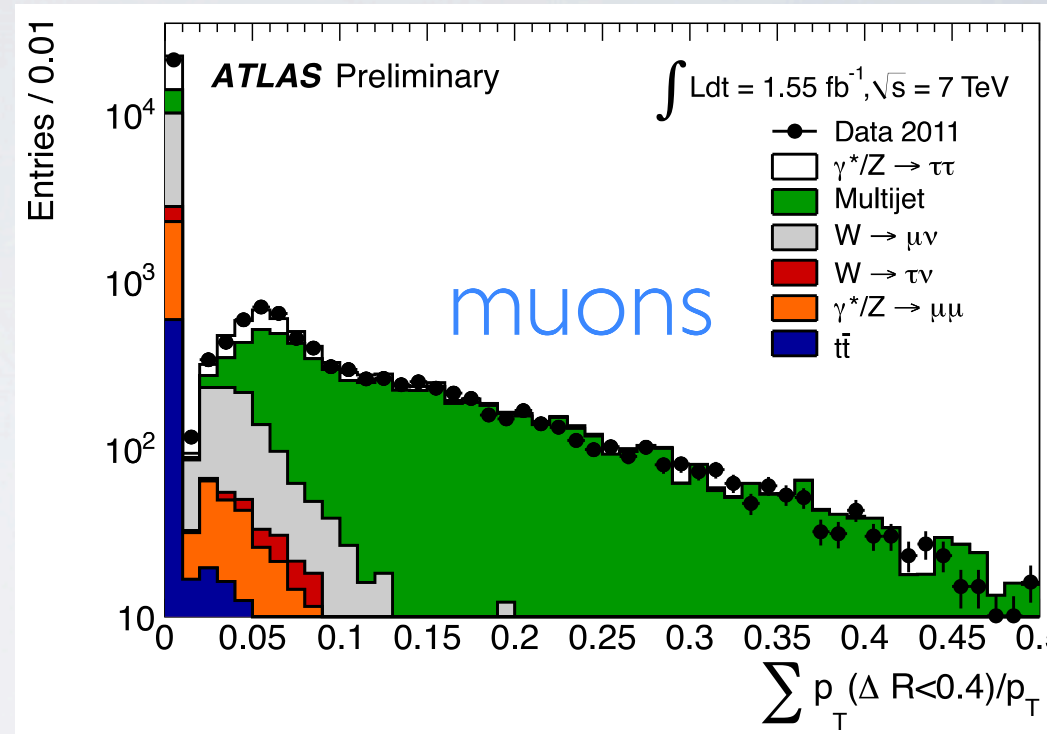
R. Gavin, Y. Li, F. Petriello et al., *FEWZ 2.0: A code for hadronic Z production at next-to-next-to-leading order*, arXiv:1011.3540 [hep-ph].

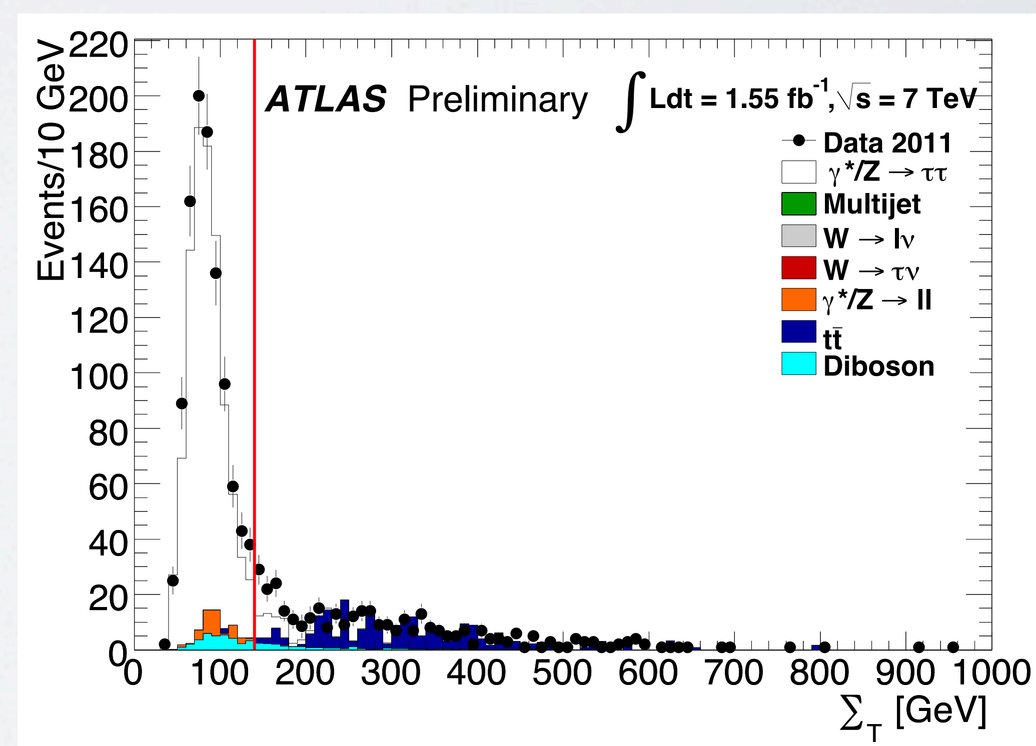
S. Catani, L. Cieri, G. Ferrera, D. de Florian, and M. Grazzini, *Vector boson production at hadron colliders: a fully exclusive QCD calculation at NNLO*, Phys. Rev. Lett. **103** (2009) 082001.

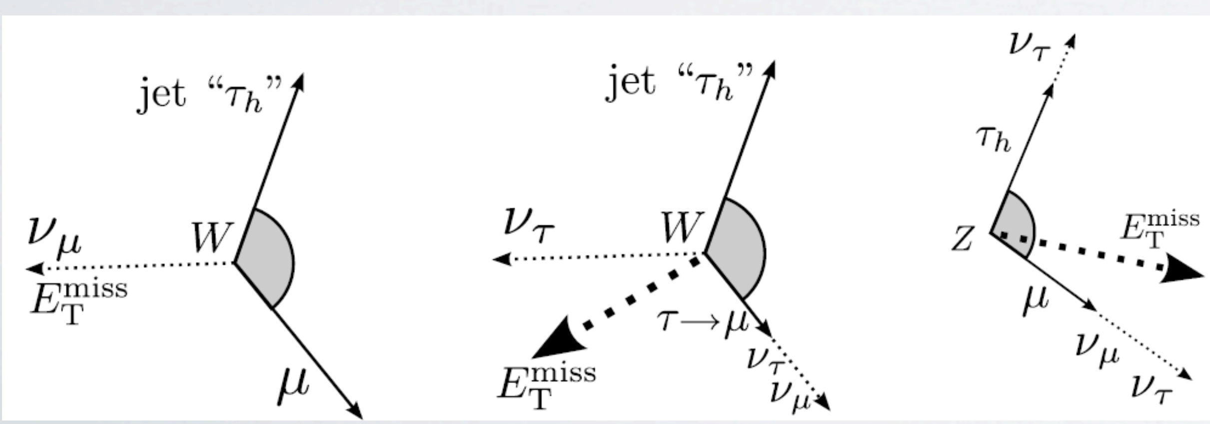
Z→ττ→eμ cross-section measurement

Event selection

- at least 1 primary vertex with more than 3 tracks
- single lepton trigger (e, μ, τ)
- μ (e) p_T > 15 (10) GeV
- exactly 1 light isolated lepton
- $Q_l * Q_\tau = -1$
- Σ cos(Δφ) > -0.15 (against W, tt background)
- Σ_T < 140 GeV $\qquad \Sigma_T = E_T(e) + E_T(\mu) + E_T(jets) + E_T^{miss}$
- visible mass: 35 GeV < m_{vis} < 75 GeV







$$\sum \cos \Delta\phi = \cos\left(\phi(\ell) - \phi(E_T^{miss})\right) + \cos\left(\phi(\tau_h) - \phi(E_T^{miss})\right)$$

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SYSTEMATICS

- trigger efficiency
- efficiency of lepton reconstruction, identification, isolation
- hadronic tau identification efficiency and misidentification rate
- energy scale
- background estimation
    - QCD multi-jets: $R_{OS/SS}$
    - Z/W: statistical error on normalisation factor
    - acceptance systematics
    - proton PDF (use different PDF sets)
    - modeling of W/Z production (use MC@NLO interfaced to HERWIG)

Final State	Fiducial cross section $\sigma^{fid}(Z \to \tau\tau) \times B(\tau \to ...)$
$\tau_\mu\tau_h$	20.0 ± 0.3(stat) ± 2.0(syst) ± 0.7(lumi) pb
$\tau_e\tau_h$	15.9 ± 0.4(stat) ± 2.0(syst) ± 0.6(lumi) pb
$\tau_e\tau_\mu$	4.7 ± 0.2(stat) ± 0.4(syst) ± 0.2(lumi) pb
Final State	**Total cross section $\sigma(Z \to \tau\tau, m_{\text{inv}}[66 - 116\ \text{GeV}])$**
$\tau_\mu\tau_h$	0.91 ± 0.01(stat) ± 0.09(syst) ± 0.03(lumi) nb
$\tau_e\tau_h$	1.00 ± 0.02(stat) ± 0.13(syst) ± 0.04(lumi) nb
$\tau_e\tau_\mu$	0.96 ± 0.03(stat) ± 0.09(syst) ± 0.04(lumi) nb

STANDARD MODEL HIGGS

SM H→ττ

Common object selection

Electrons

- $E_T^{cluster}$> 16 GeV
- 0 < |η| < 1.37 or
- 1.52 < |η| < 2.47
- medium (tight)identification for eμ (eτ)

Muons

- inner detector track has to match muon spectrometer track
- p_T > 10 GeV(eμ, μμ);
- p_T > 15 GeV (μτ)
- |η| < 2.4
- long. IP < 10 mm
- quality criteria

Taus

- E_T^{vis} > 20 GeV
  - < |η| < 1.37 or
  - 1.52 < |η| < 2.47
- CUTS loose ID
- 1 or 3 charged tracks
- |Q| = 1

Jets

- E_T > 20 GeV
- |η| < 4.5
- anti-kT jets (R = 0.4)
- jet cleaning

overlap resolved in order: μ, e, τ, jet

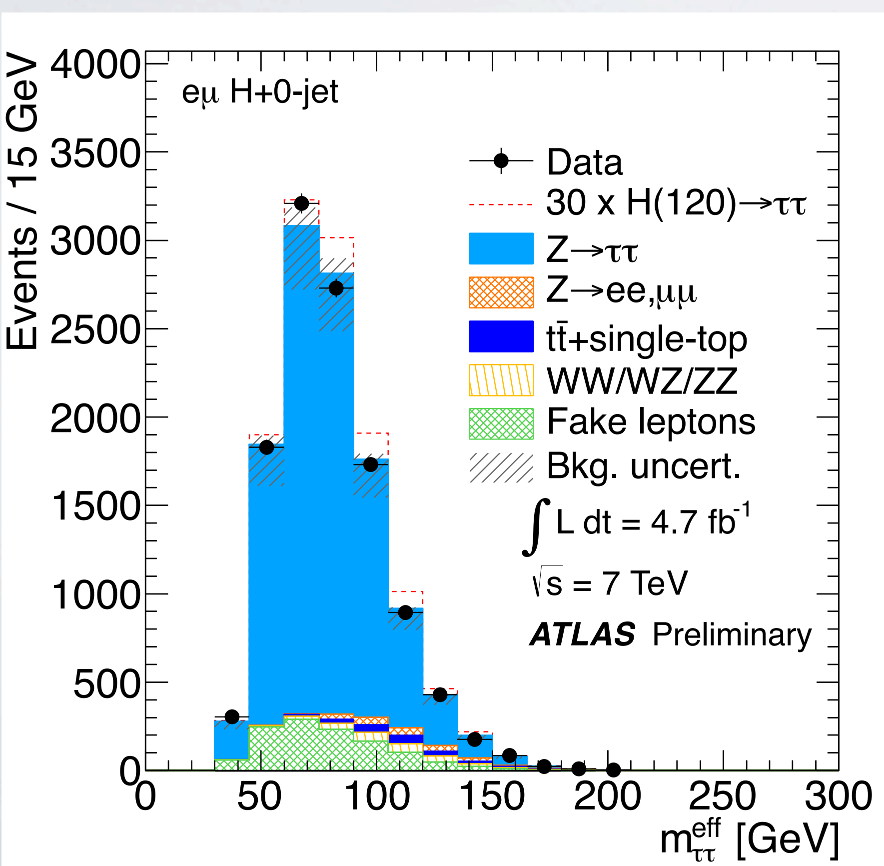
SM $H \to \tau\tau \to ll + 4\nu$

- **four categories defined:**
  - **H + 2-jet VBF**
  - **H + 2-jet VH**
  - **H + 1-jet**
  - **H + 0-jet**

- 2-jets with $E_T > 40$ (25) GeV
- separated jets, $\Delta\eta_{jj} > 3$ (VBF), $\Delta\eta_{jj} < 2$ (VH)
- invariant dijet mass $m_{jj} > 350$ GeV (VBF), 50 GeV $< m_{jj} < 350$ GeV (VH)
- third jet ($E_T > 25$ GeV, $|\eta| < 2.4$) veto

- only events failing 2-jet cuts
- invariant jet + di-tau mass $m_{\tau\tau j} > 225$ GeV

- all events failing 1-/2-jet category
- uses effective mass, $m_{\tau\tau}^{eff}$ due to poor resolution



Common event selection

- single-/di-lepton trigger
- leading jet $E_T > 40$ GeV
- $E_T^{miss} > 20$ (40) GeV (ee, $\mu\mu$)
- $Q_l * Q_l = -1$
- $\Delta\phi(l,l) > 2.5$ rad
- b-jet ($E_T > 25$ GeV) veto (against tt)
- leptonic transverse energy, $H_T^{lep} < 120$ GeV
- collinear approximation, $0 < x_1, x_2 < 1$
- invariant mass of taus and jet,

30 GeV $< m_{ll} < 100$ (75) GeV (ee, $\mu\mu$)

SM H→ττ→lτ + 3υ

- **seven categories defined:**
- depending on jet properties and E_T^{miss}
  - **H + 2-jet VBF**
  - **H + 1-jet**
  - **H + 0-jet**

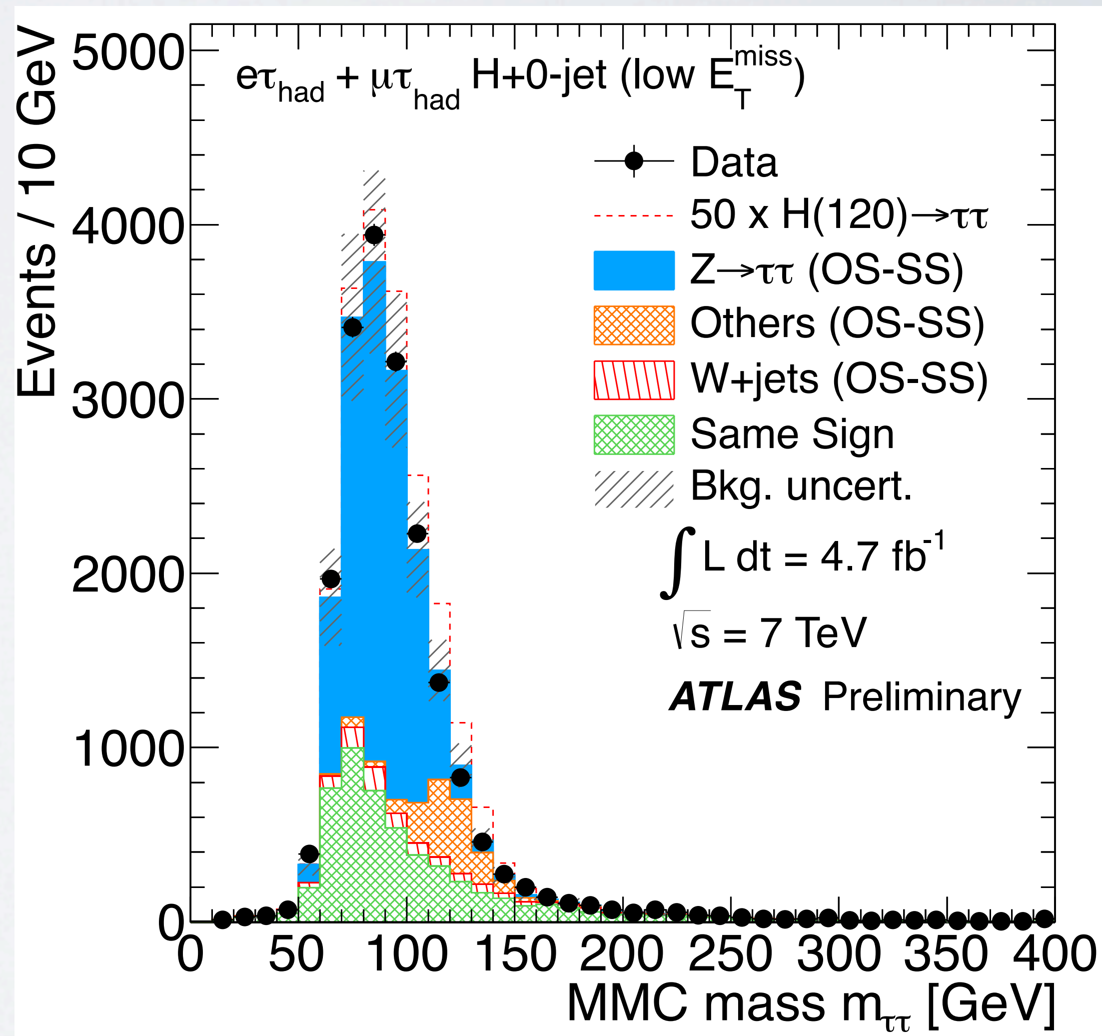
- ≥2-jets with E_T > 25 GeV
- E_T^{miss} > 20 GeV
- separated jets, $\Delta\eta_{jj} > 3$
- invariant dijet mass m_{jj} > 300 GeV
- tau, lepton in η range between jets
- includes eτ and μτ final states due to limited statistics

- E_T^{miss} > 20 GeV
- ≥ 1-jets with E_T > 25 GeV failing VBF selection
- eτ and μτ final states considered exclusively

- no jet with E_T > 25 GeV
- eτ and μτ final states considered exclusively
- separated in E_T^{miss} > 20 GeV and E_T^{miss} ≤ 20 GeV

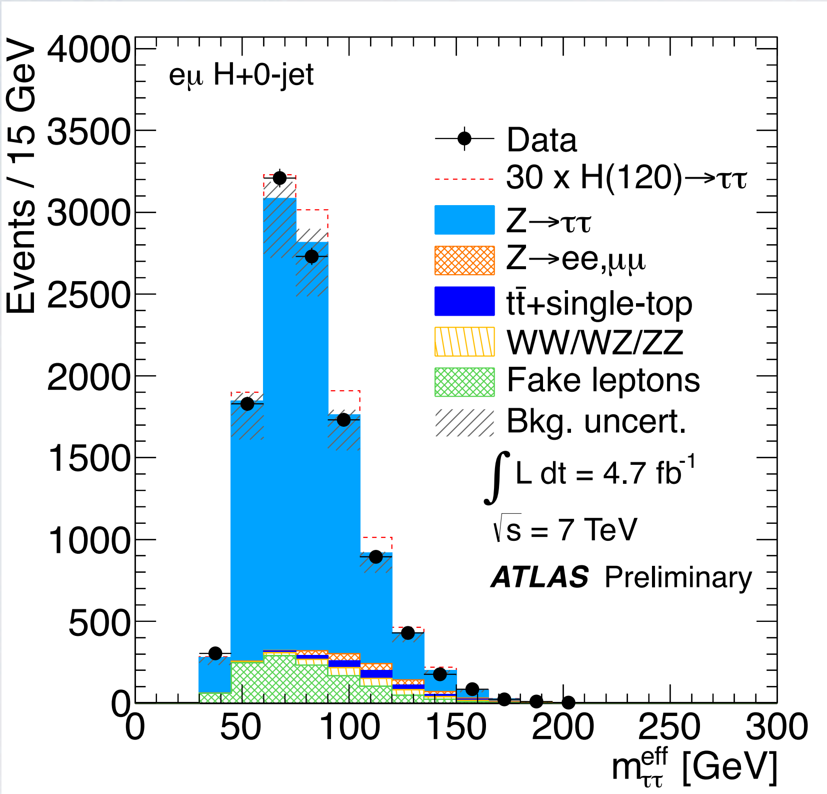
Common event selection

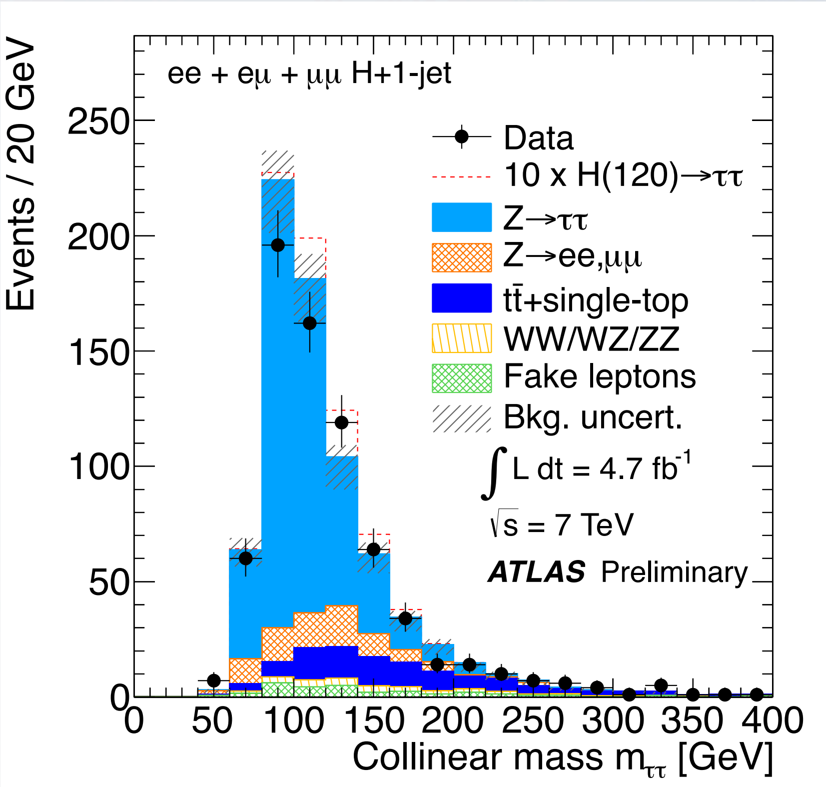
- single-lepton trigger
- leading jet E_T > 40 GeV
- one light lepton with E_T > 25 GeV (e), pT > 20 GeV (μ)
- $Q_l * Q_\tau = -1$
- transverse mass, m_T ≤ 30 GeV (against tt)

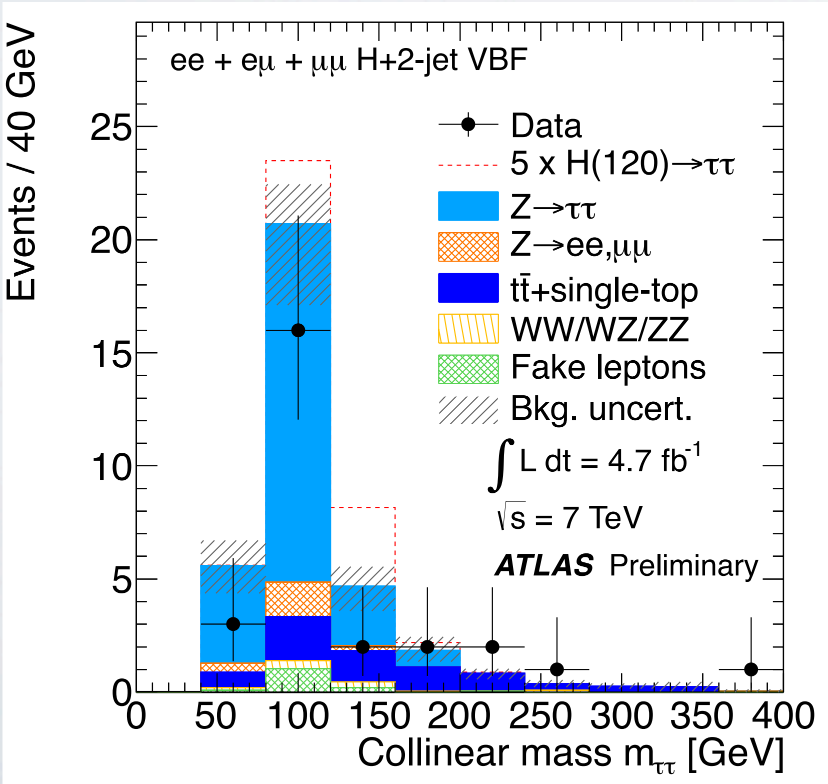


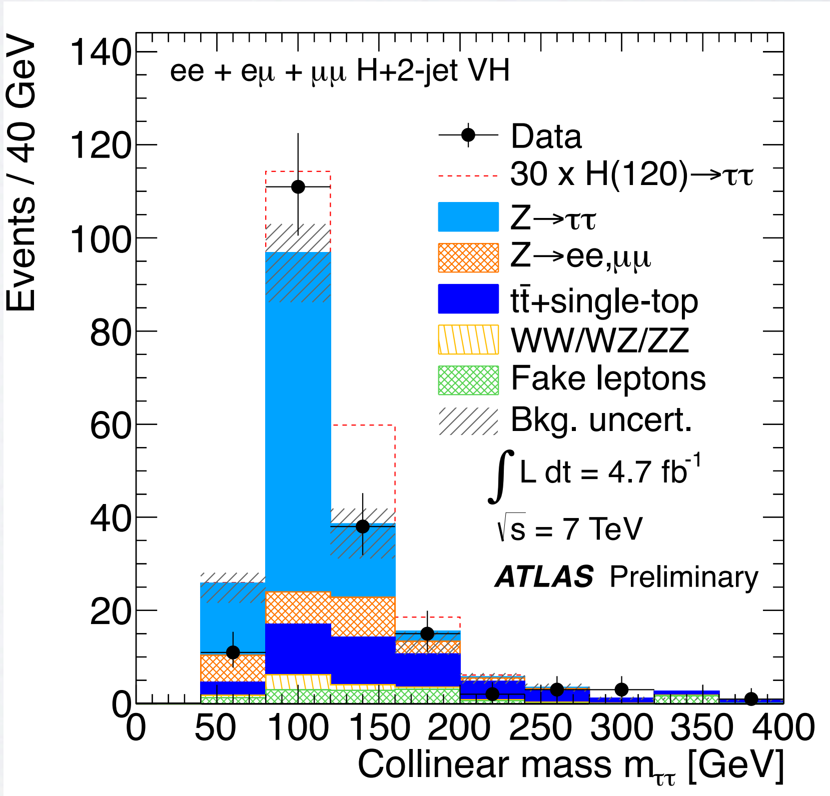
SM $H \to \tau\tau \to ll (l = e, \mu)$

Final mass distributions



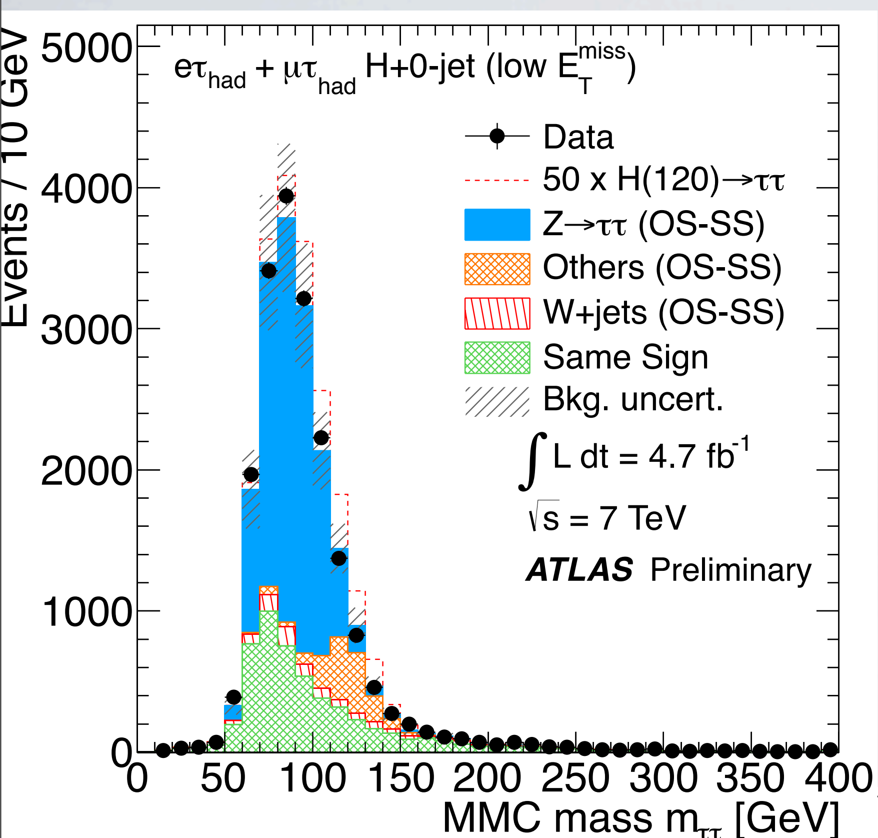


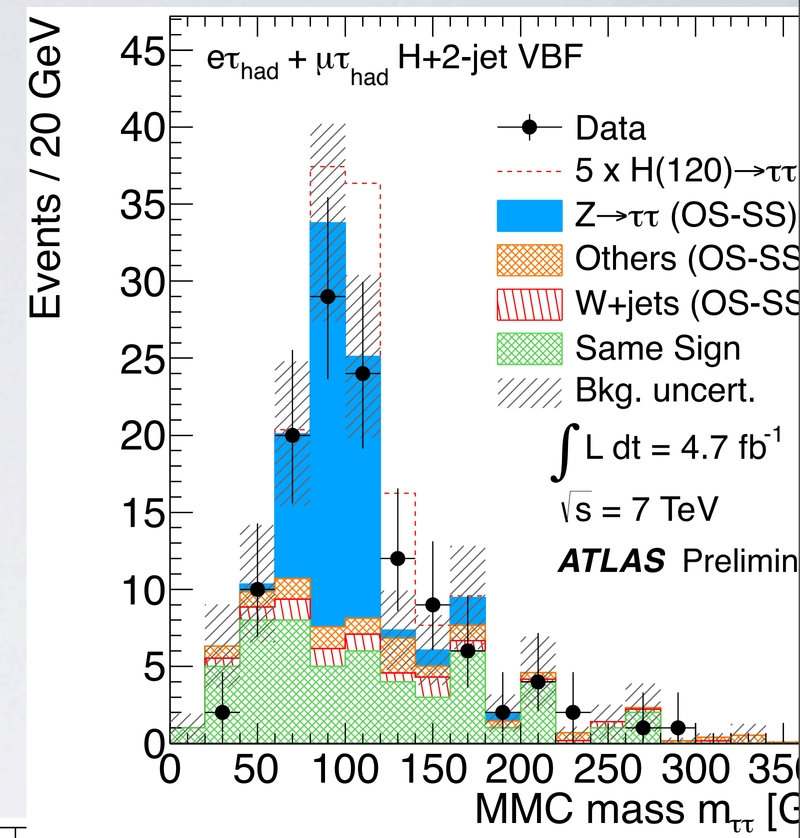


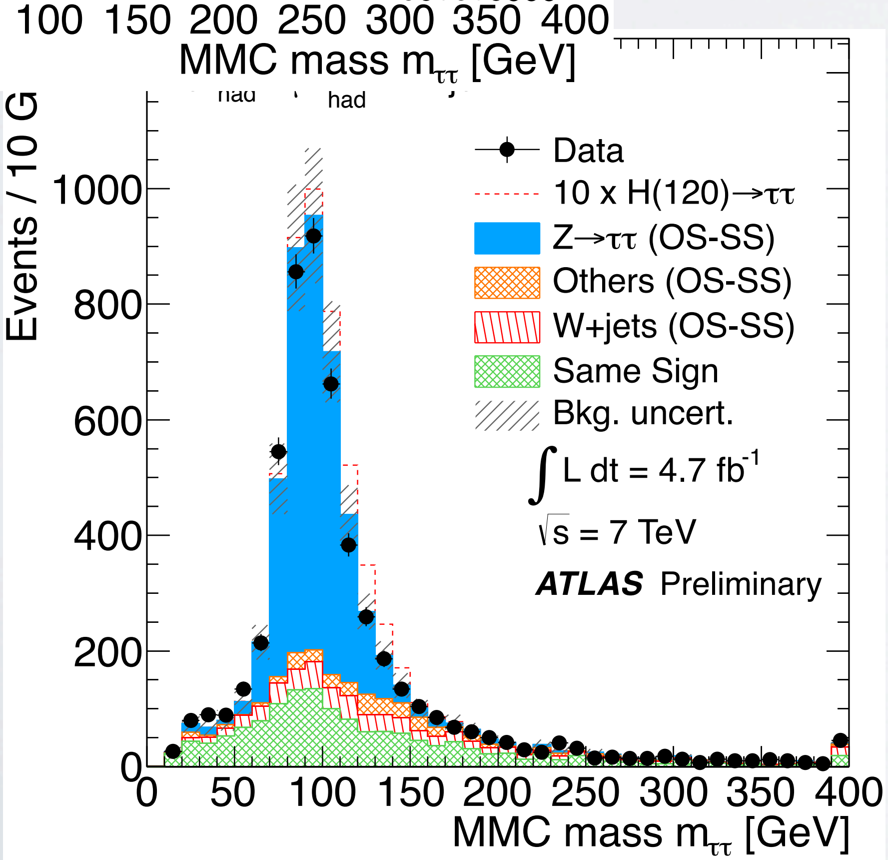


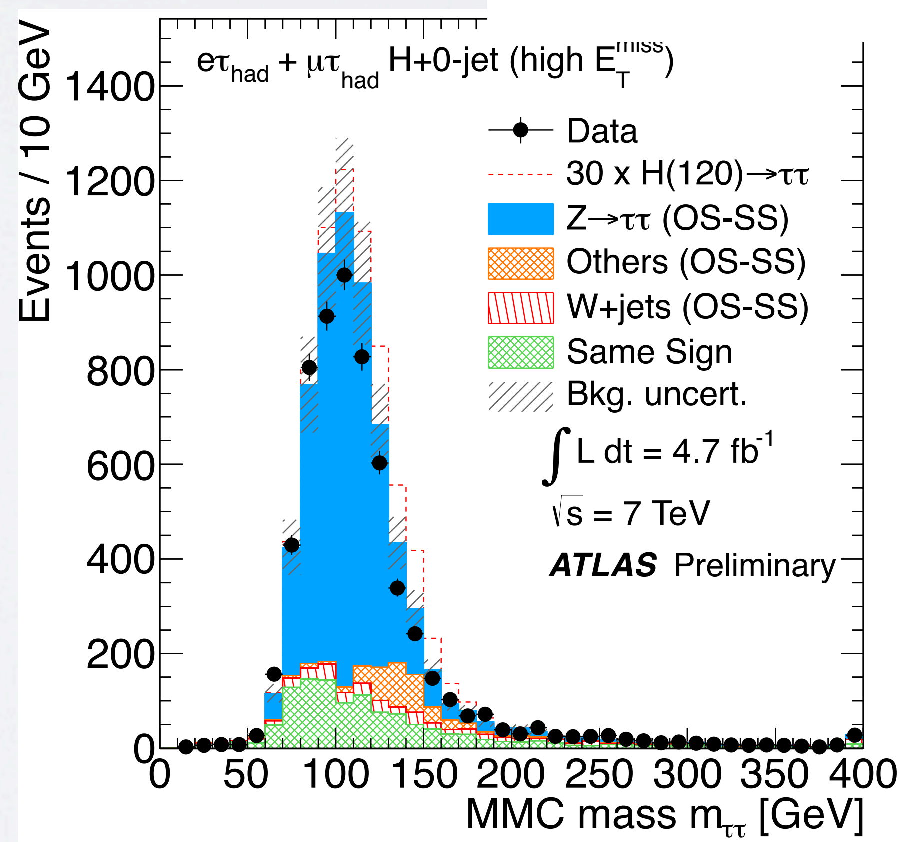
SM $H \rightarrow \tau\tau \rightarrow l\tau_h (l = e, \mu)$

Final mass distributions









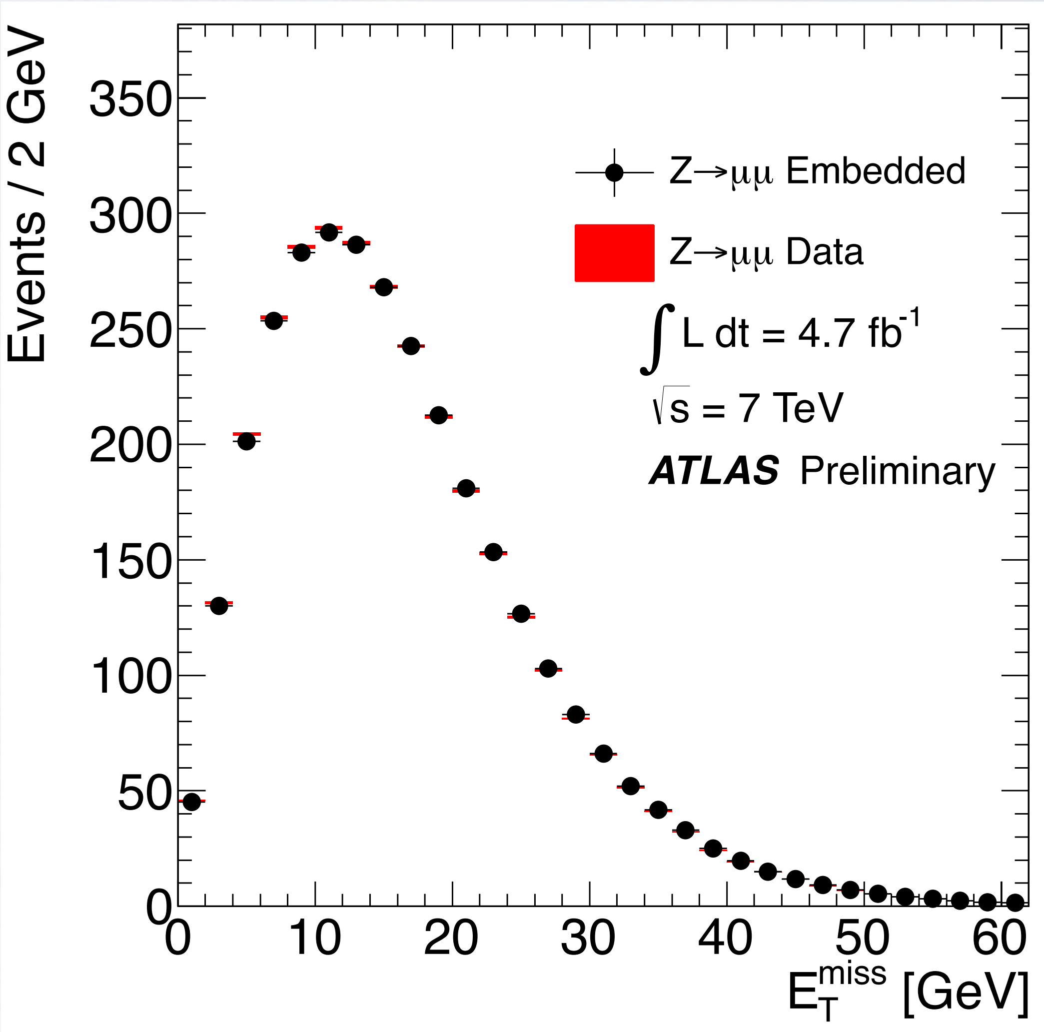
BACKGROUND ESTIMATION

- main background (multi-jet, Z→ττ) estimated by data-driven methods
- normalisation and shape extracted from data
- further backgrounds (diboson, tt) estimated from MC

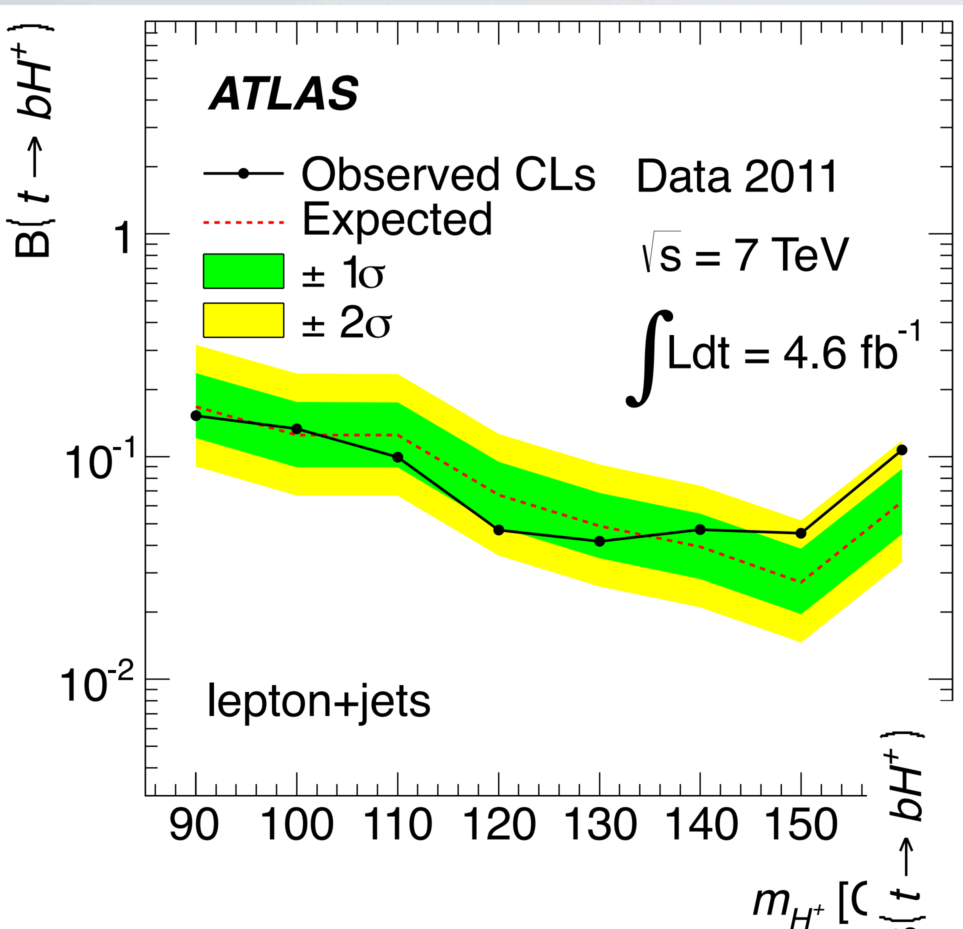
- embedding technique Z→ττ to model shape
- fitting track multiplicity (in ΔR < 0.6) of taus simultaneously
- multi-jet template from same sign control region
- Z→ττ template from MC
- fit result used to normalise embedded sample
- multi-jet estimation by 2-dimensional fit in signal region

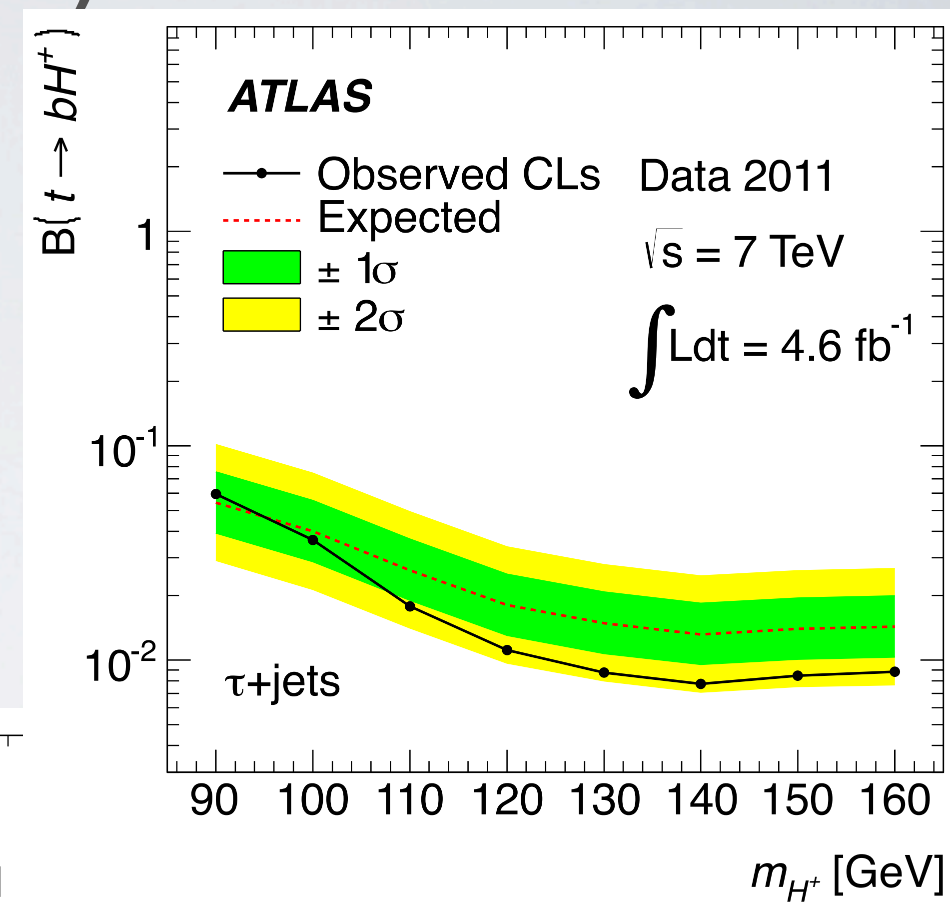
Systematics

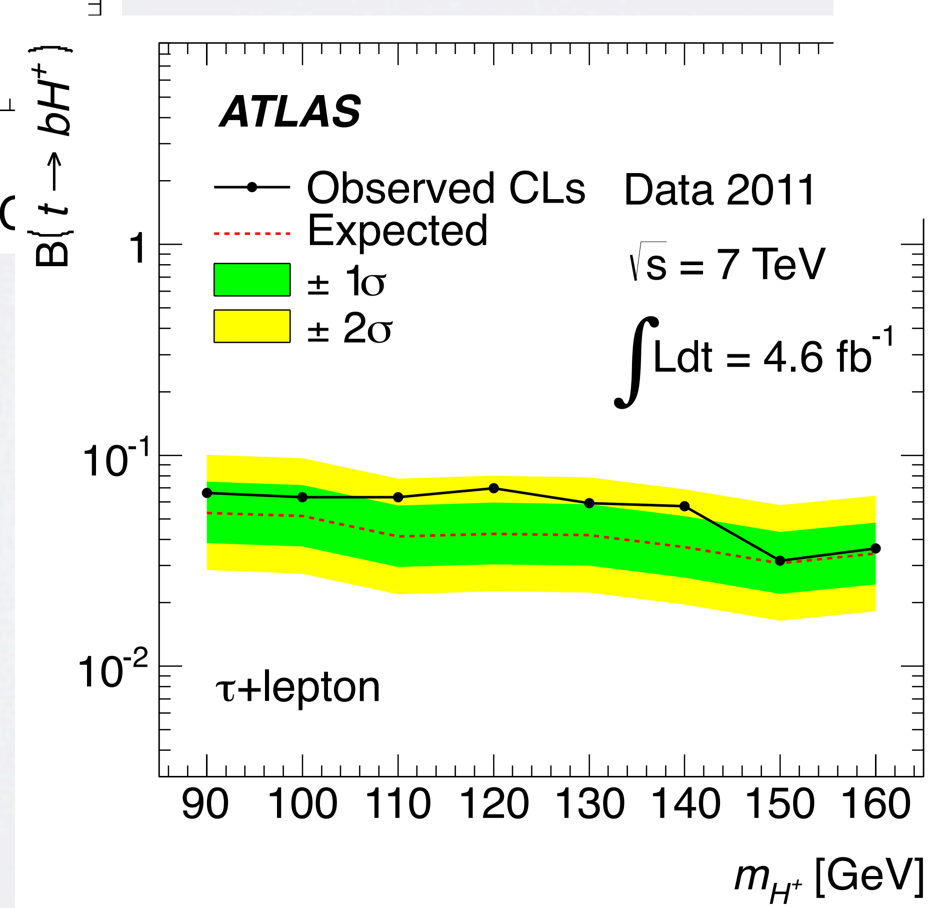
- vary multi-jet template by requiring additional light lepton (enhancing W+jets)
- Z→ττ : 11.6 %
- multi-jet: 22 %



95% CL$_s$ exclusion Limit on BR($t \rightarrow bH^+$)



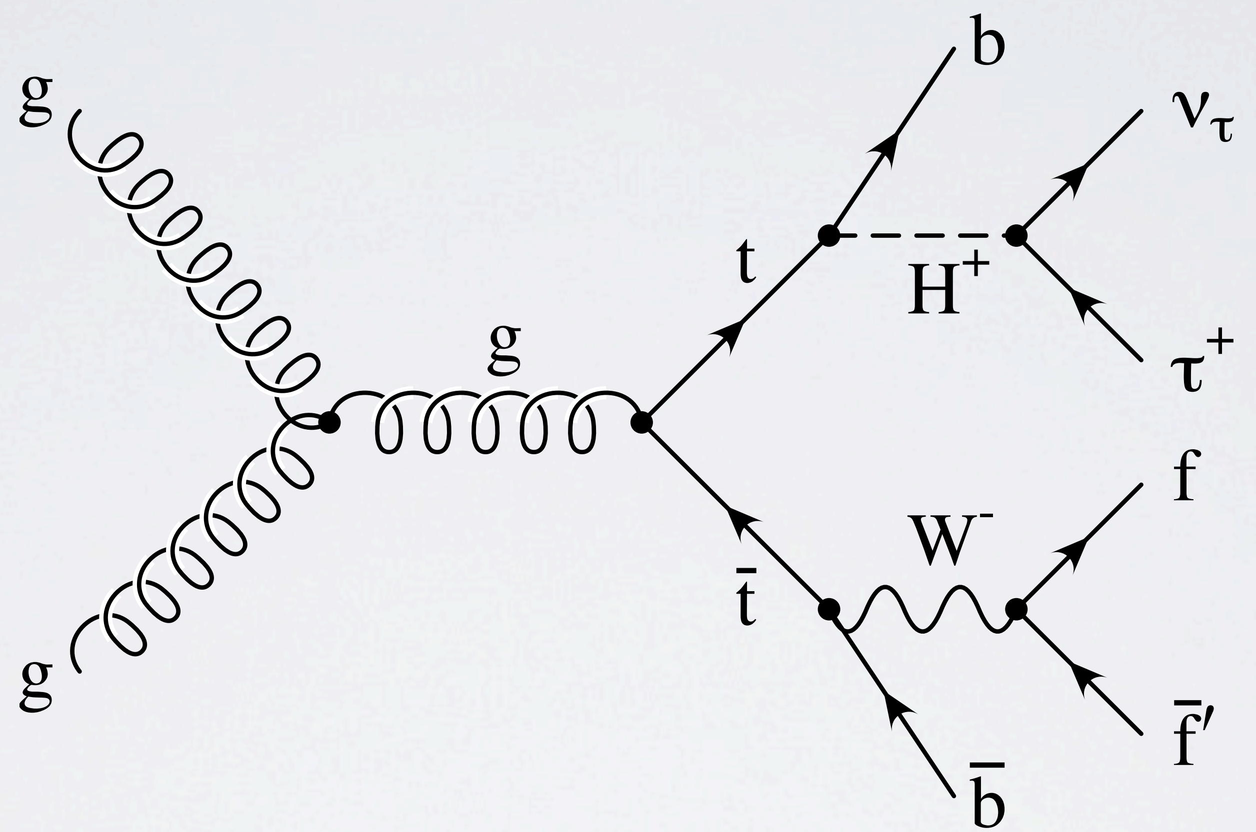




CHARGED HIGGS

lepton + jets

$t\bar{t} \rightarrow b\bar{b}WH^{+} \rightarrow b\bar{b}(qq')(l\nu)$



lepton + tau

$t\bar{t} \rightarrow b\bar{b}WH^{+} \rightarrow b\bar{b}(l\nu)(\tau\nu)$

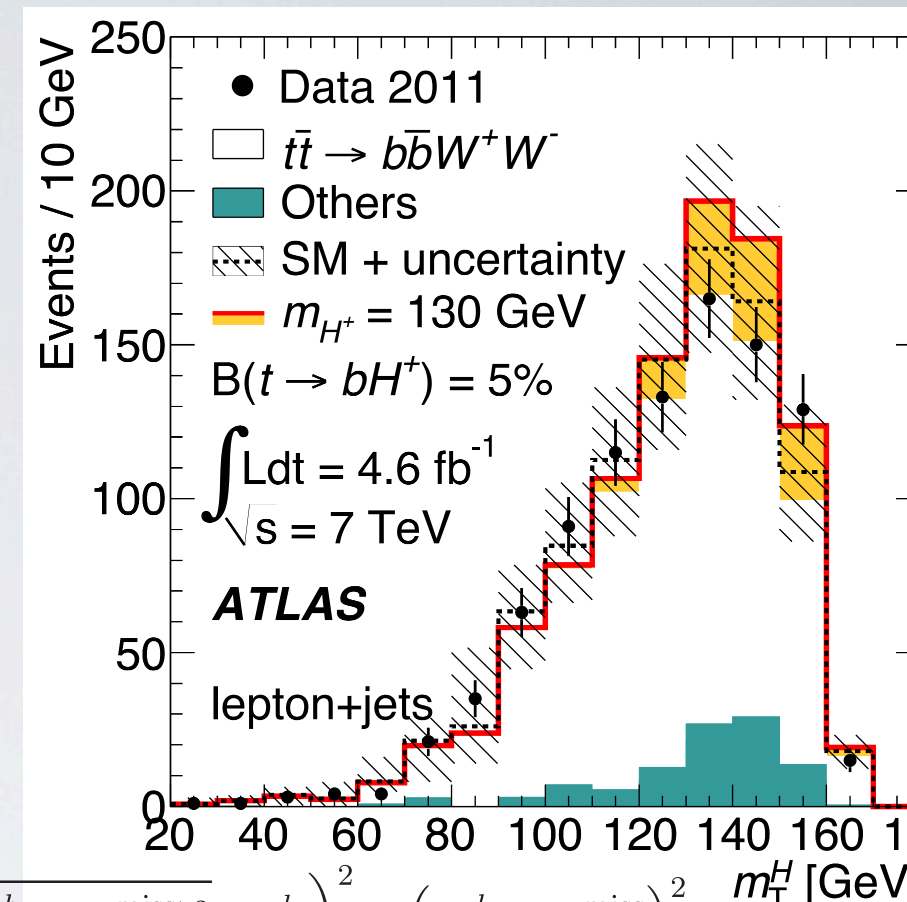
tau + jets

$t\bar{t} \rightarrow b\bar{b}WH^{+} \rightarrow b\bar{b}(qq')(\tau\nu)$

$t\bar{t} \to b\bar{b}WH^+ \to b\bar{b}(qq')(l\nu)$

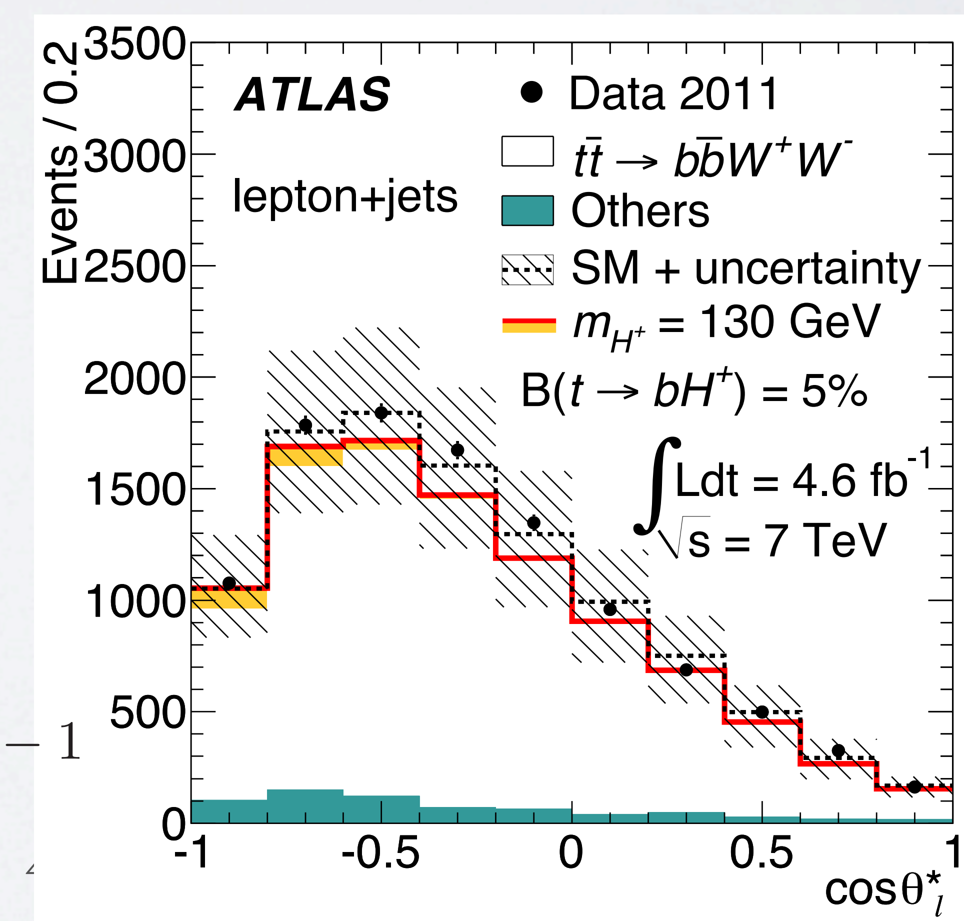
Event selection

- single lepton trigger
- exactly one lepton with $p_T > 25$ (20) GeV e (μ)
- ≥ 4 jets with $p_T > 20$ GeV
    - 2 of them b-tagged
- $E_T^{miss} > 40$ GeV
    - $E_T^{miss} * |\sin \Delta\phi(l, E_T^{miss})| > 20$ GeV (if $\Delta\phi(l, E_T^{miss}) < \pi/6$)
- MET significance, $\Sigma_T > 13$
- $\cos \theta_l^* < -0.6$
- $m_T^W < 60$ GeV
- top quark decay topology
    - $\chi^2 < 5$



$$(m_T^H)^2 = \left(\sqrt{m_{top}^2 + (\vec{p_T}^l + \vec{p_T}^b + \vec{p_T}^{miss})^2} - p_T^b\right)^2 - \left(\vec{p_T}^l + \vec{p_T}^{miss}\right)^2$$

$$\chi^2 = \frac{(m_{jjb} - m_{top})^2}{\sigma_{top}^2} + \frac{(m_{jj} - m_W)^2}{\sigma_W^2}$$

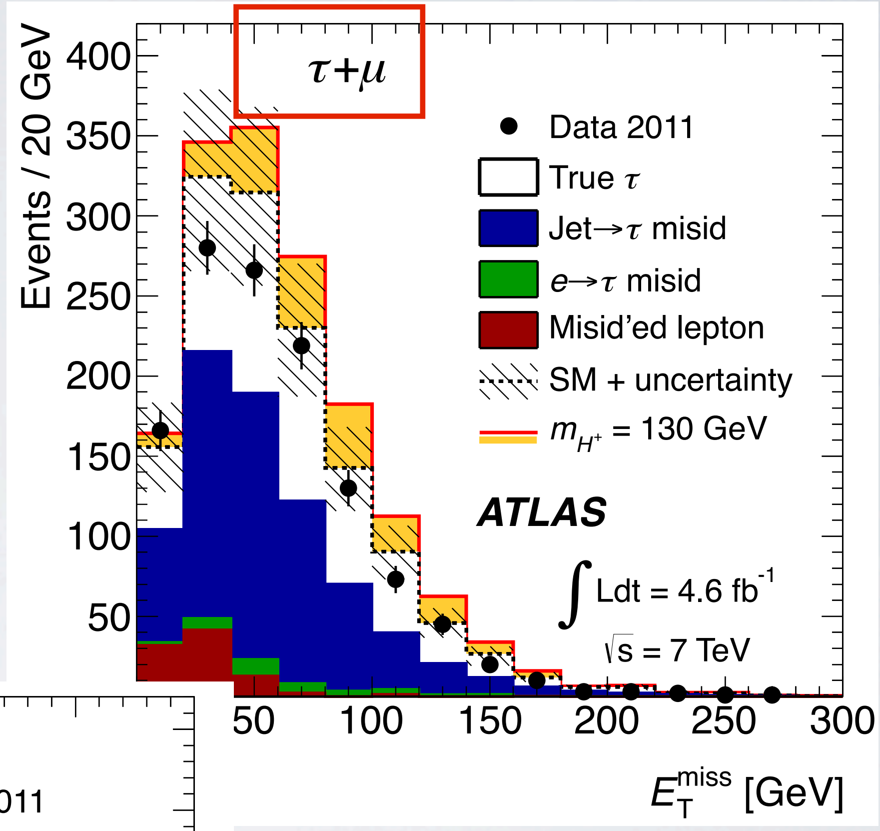


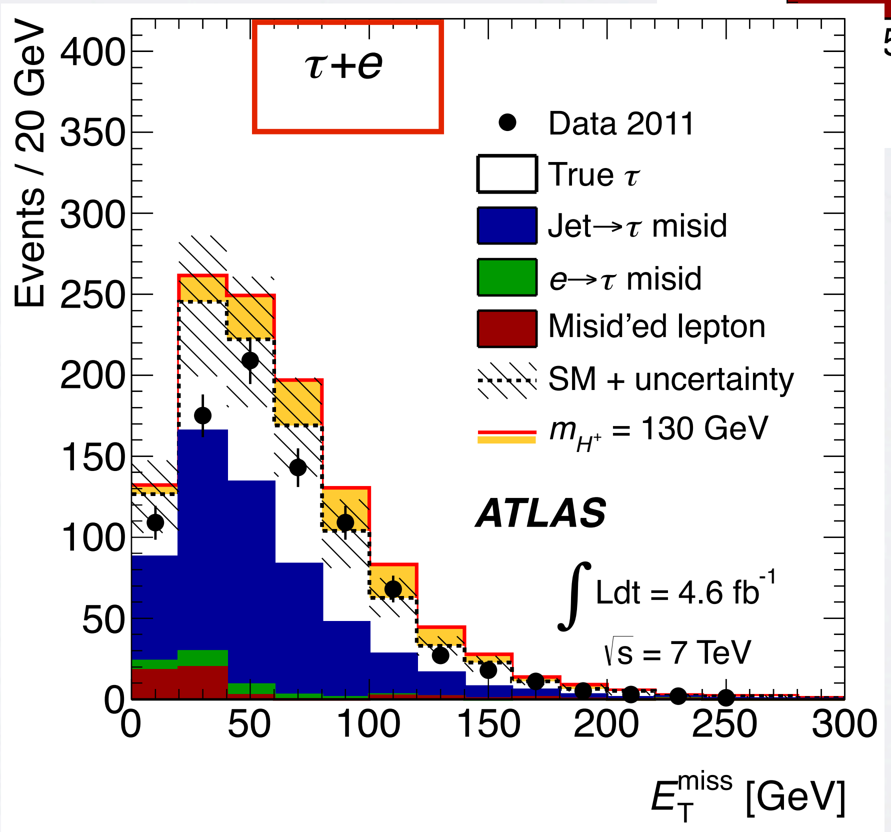
$$\cos \theta_l^* = \frac{2m_{bl}^2}{m_{top}^2 - m_W^2} - 1 \simeq \frac{4\, p^b \cdot p^l}{m_{top}^2 - m_W^2} - 1$$

$t\bar{t} \to bbWH^+ \to bb(l\upsilon)(\tau\upsilon)$

Event selection

- single lepton trigger
- exactly one lepton with $p_T > 25$ (20) GeV e (μ)
- exactly one identified τ with $p_T > 20$ GeV
- $Q_\tau * Q_l = -1$
- ≥ 2 jets with $p_T > 20$ GeV
    - ≥ 1 of them b-tagged
- Σp_T (tracks associated to primary vertex) > 100 GeV



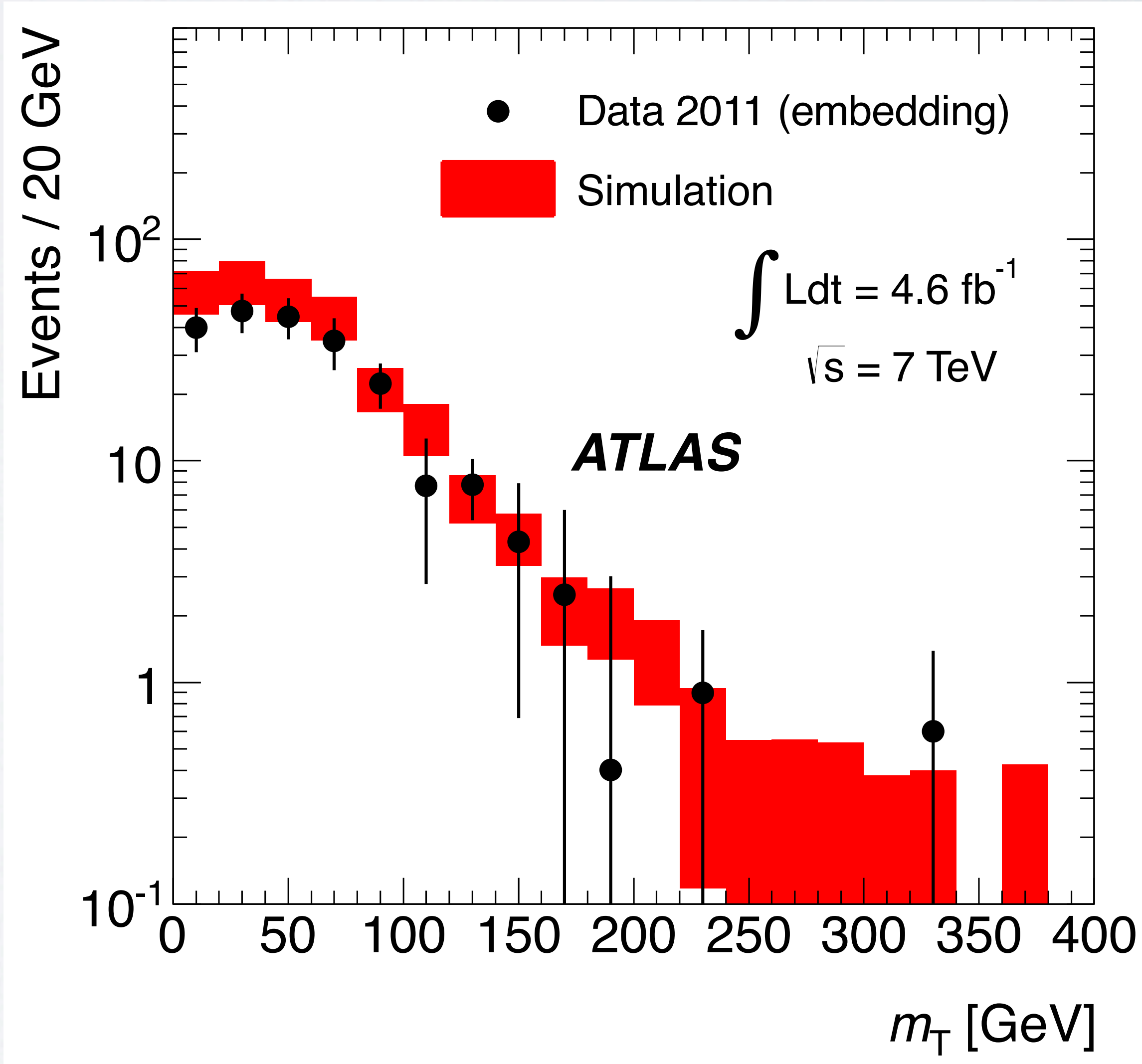


BACKGROUND ESTIMATION

- all backgrounds estimated from data
- example: real tau decays
- apply embedding technique
- control sample of tt-like μ+jets events
- replaced by simulated τ decays
- shape taken from embedded sample

normalisation

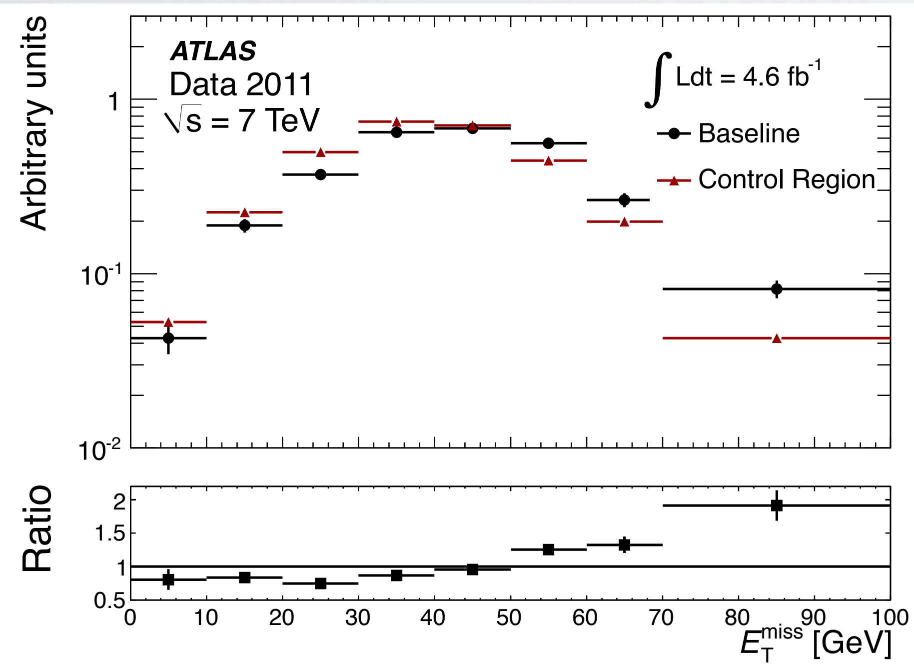
$$N_\tau = N_{\text{embedded}} \cdot (1 - c_{\tau\to\mu}) \frac{\epsilon^{\tau + E_{\text{T}}^{\text{miss}} - \text{trigger}}}{\epsilon^{\mu - \text{ID,trigger}}} \cdot \mathcal{B}(\tau \to \text{hadrons} + \nu)$$



BACKGROUND ESTIMATION

multi-jet

- fit of E_T^{miss} shape
- CR defined by modified τ-ID and b-tag requirement
  - τ's passing loose ID but fail tight; no b-jet
  - m_{jjb} cut removed
  - contamination by other backgrounds < 1% (subtracted from MC)
- differences in shape between SR and CR treated as systematics



electron/jet fakes

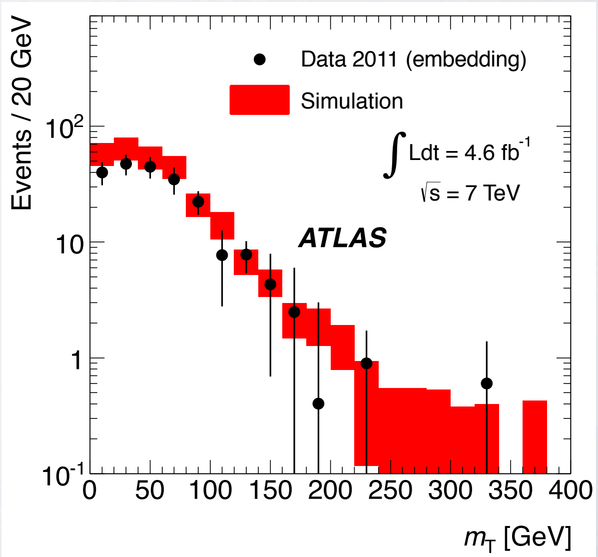
- tt, W+jets, single top quark production → 0.2%
- CR defined by Z→ee selection (electron fakes)
- CR defined by W+jets selection (jet fakes)
  - main difference: b-jet fake probability
  - ➡ take quark-gluon ratio obtained by simulation as sytematics
- fake factors applied to simulated tt, single-top, W/Z/γ* +jets events

real taus

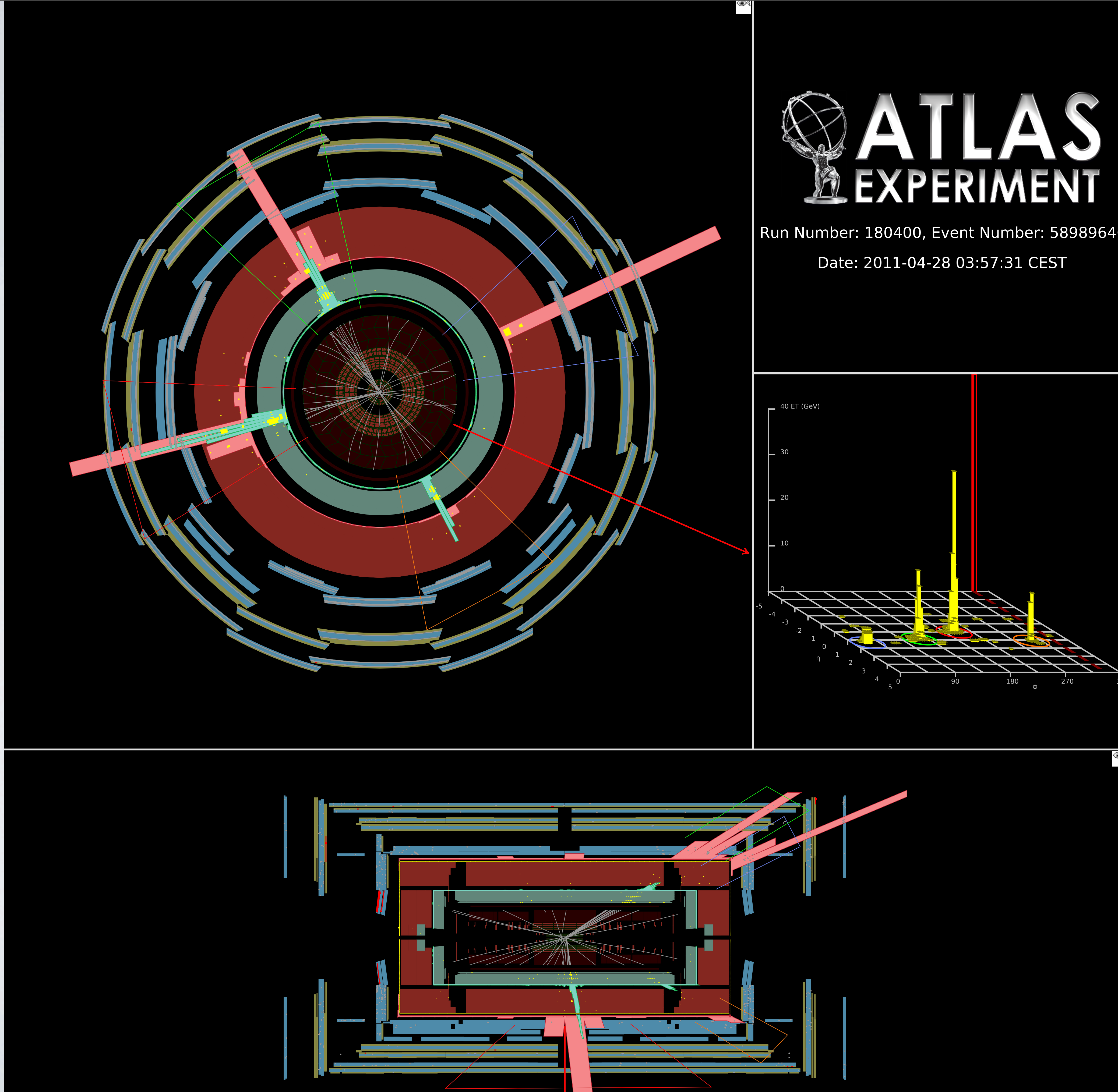
- embedding technique
- control sample of tt-like μ+jets events
- replaced by simulated τ decays
- control sample
  - single μ trigger
  - exactly one isolated μ with p_T > 25 GeV
  - no isolated electron with E_T > 20 GeV
  - ≥ 4 jets with p_T > 20 GeV (≥1 of them b-tagged)
  - E_T^{miss} > 35 GeV

normalisation

$$N_\tau = N_{\mathrm{embedded}} \cdot (1 - c_{\tau\to\mu}) \frac{\epsilon^{\tau+E_T^{\mathrm{miss}}-\mathrm{trigger}}}{\epsilon^{\mu-\mathrm{ID,trigger}}} \cdot \mathcal{B}(\tau \to \mathrm{hadrons} + \nu)$$



SUSY SEARCHES INVOLVING TAU LEPTONS


ATLAS
EXPERIMENT
Run Number: 180400, Event Number: 58989646
Date: 2011-04-28 03:57:31 CEST
40 ET (GeV)
30
20
10
0
η
Φ
0
90
180
270
360

Model Parameters

- Messenger mass: M_{mess} = 250 TeV
- no. of SU(5) messengers: N_5 = 3
- $\mu > 0$
- scale factor for gravitino mass: C_{grav} = 1