Search for new physics in multi-body final states at high invariant masses

Michael Henke
Kirchhoff-Institute for Physics
University of Heidelberg
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IRTG Fall School

- Motivation
- Data sample
- Search strategy
- Definitions
- Distributions
- Uncertainties
- Limit on cross section
- Summary & Outlook

HGSFP
Heidelberg Graduate School of Fundamental Physics

International Research Training Group
Development and Application of Intelligent Detectors

FSP 101 ATLAS

PHYSICS AT THE TERA SCALE
Helmholtz Alliance

Motivation

- Standard Model leaves open questions
  - e.g. Hierarchy of interaction scales

"We are dealing with a stomach problem, not a mind problem"

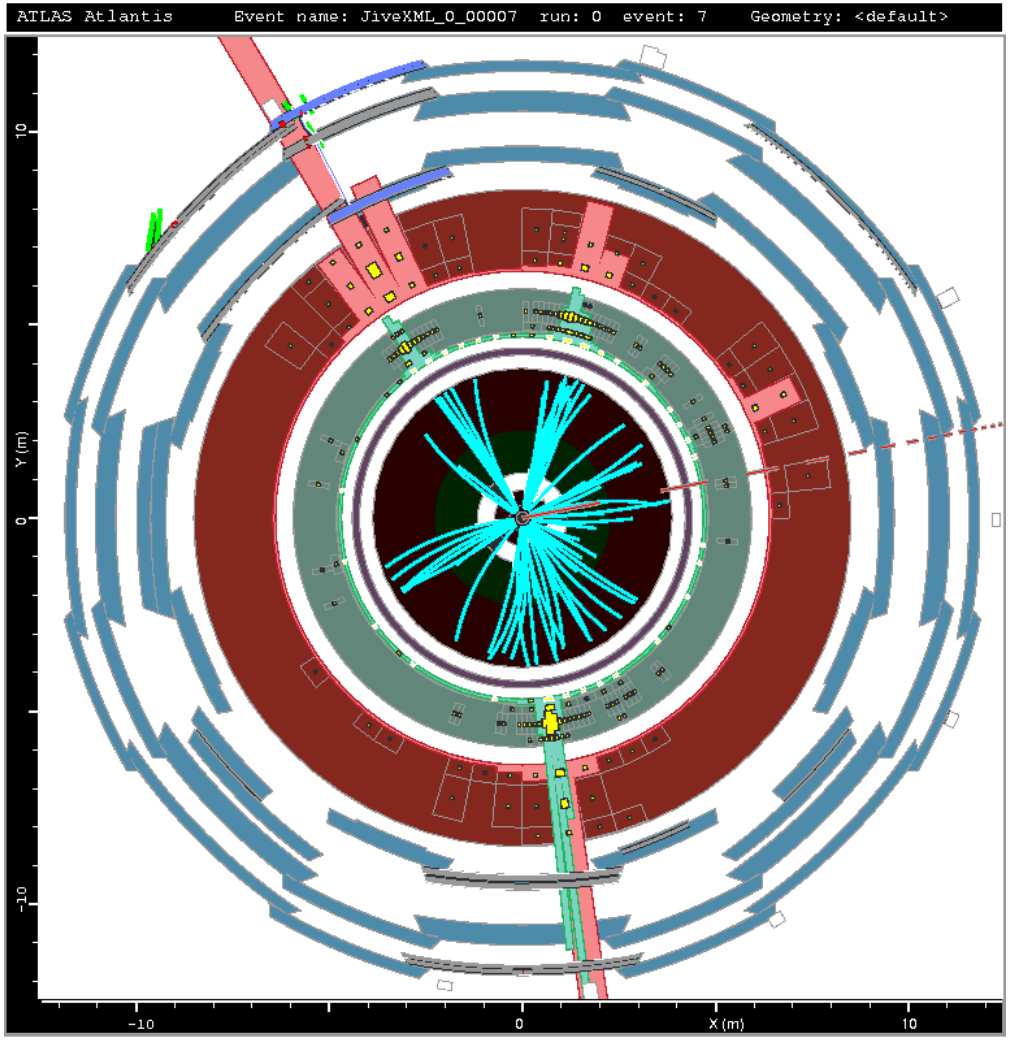
Chris Quigg

$$M_{EW} \sim 10^2\,\mathrm{GeV} \Leftrightarrow M_{Pl} = \sqrt{\frac{\hbar c}{G_N}} \sim 10^{19}\,\mathrm{GeV}$$

- New Physics could answer these questions
  - e.g. low scale gravity, weakly coupled string theory, SUSY
  - Likely to appear in high mass, high p_T states

Signature

- basic inclusive properties
  - high multiplicity
  - high p_T objects
  - high mass



Data and Search Strategy

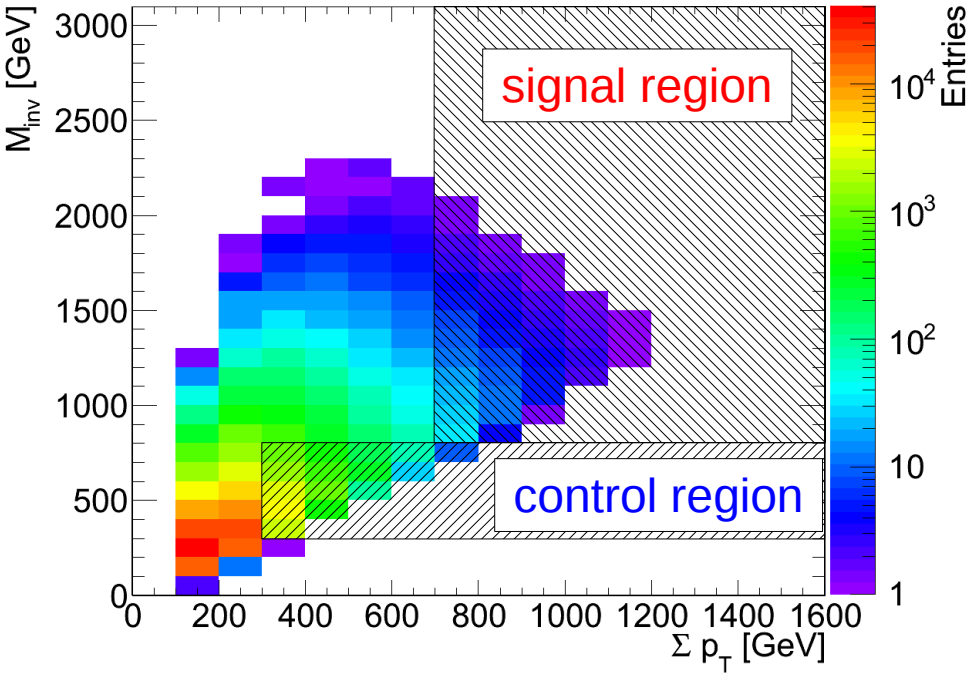
- 0.295 pb^{-1}
- background processes:
  - QCD jet production
    - Alpgen
    - Pythia
    - Herwig/Herwig++
  - (ttbar)
  - (W+jet)
  - (Z+jet)
- search strategy for first data
  - event selection
  - normalization of background MC to data in control region
  - count events in signal region

Definitions

- objects
  - jets, electrons, photons, muons
- Σp_T: p_T sum of all objects
- M_{inv}: invariant mass calculated from all objects (plus E_T^{miss})
- control and signal region
  - control region:
    - $\Sigma p_T > 300$ GeV &&

      $300\ \text{GeV} < M_{inv} < 800\ \text{GeV}$
  - signal region:
    - $\Sigma p_T > 700$ GeV &&

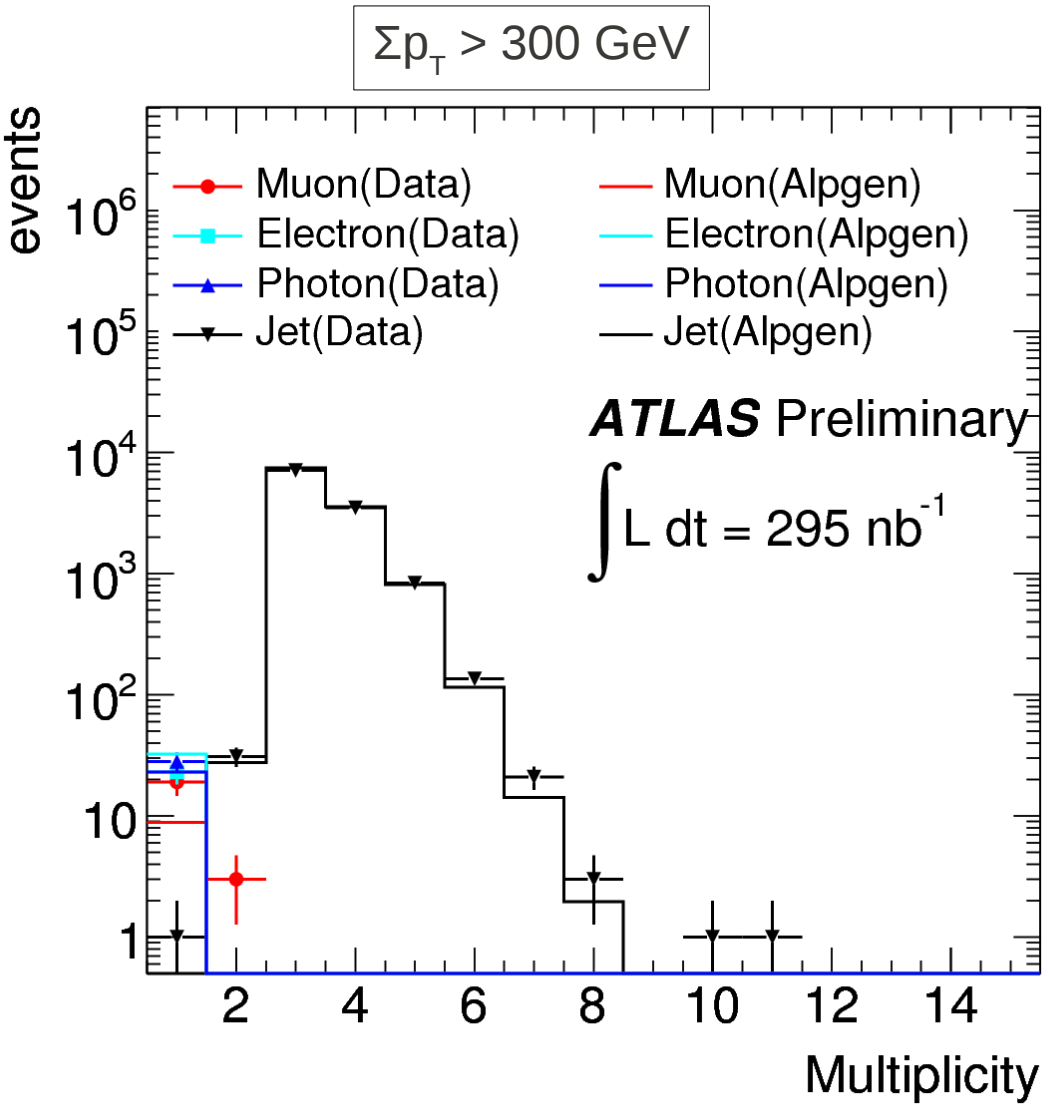
      $M_{inv} > 800$ GeV



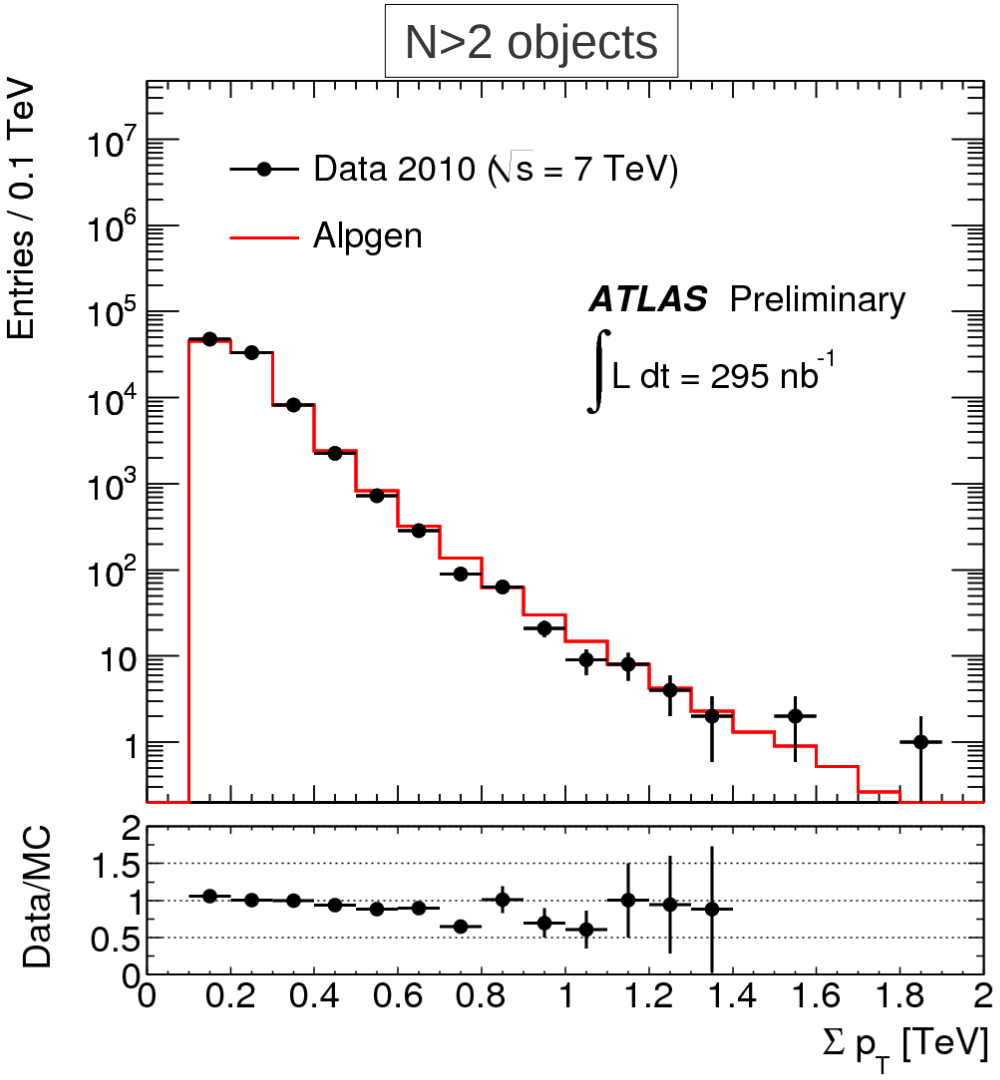
Selection

- before object selection:
  - L1_J15 trigger
  - vertex requirement
- object selection
- after object selection:
  - N>2 objects

Object Multiplicity

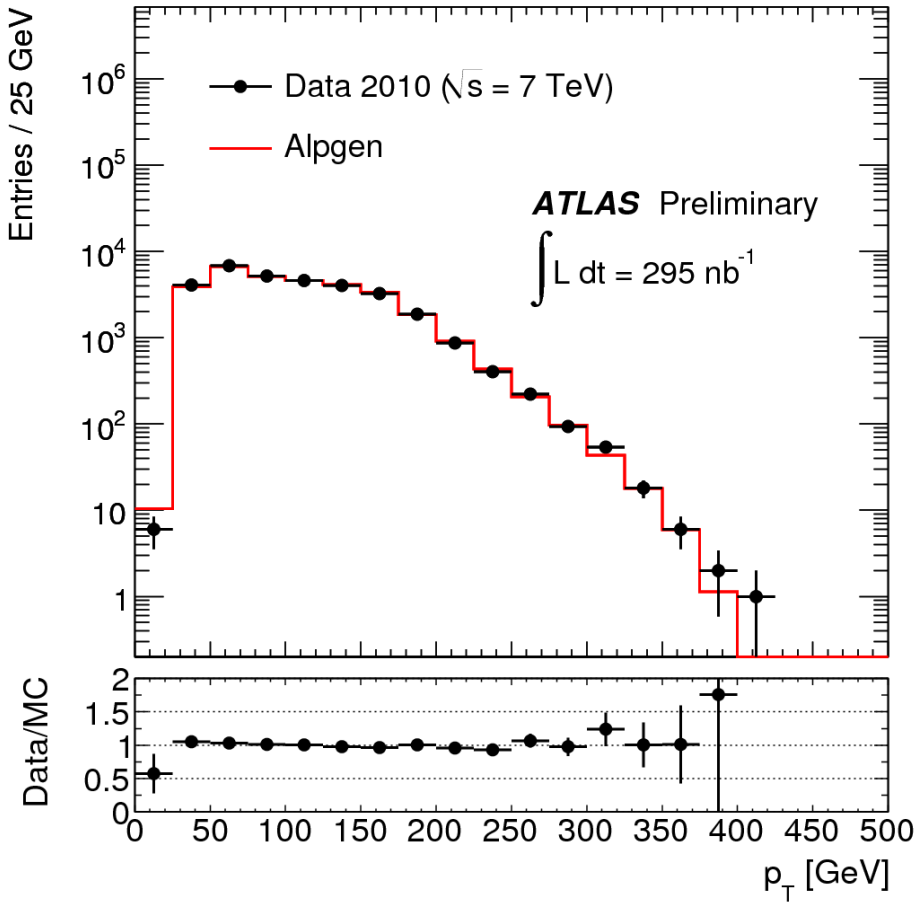


Σp_T Distribution

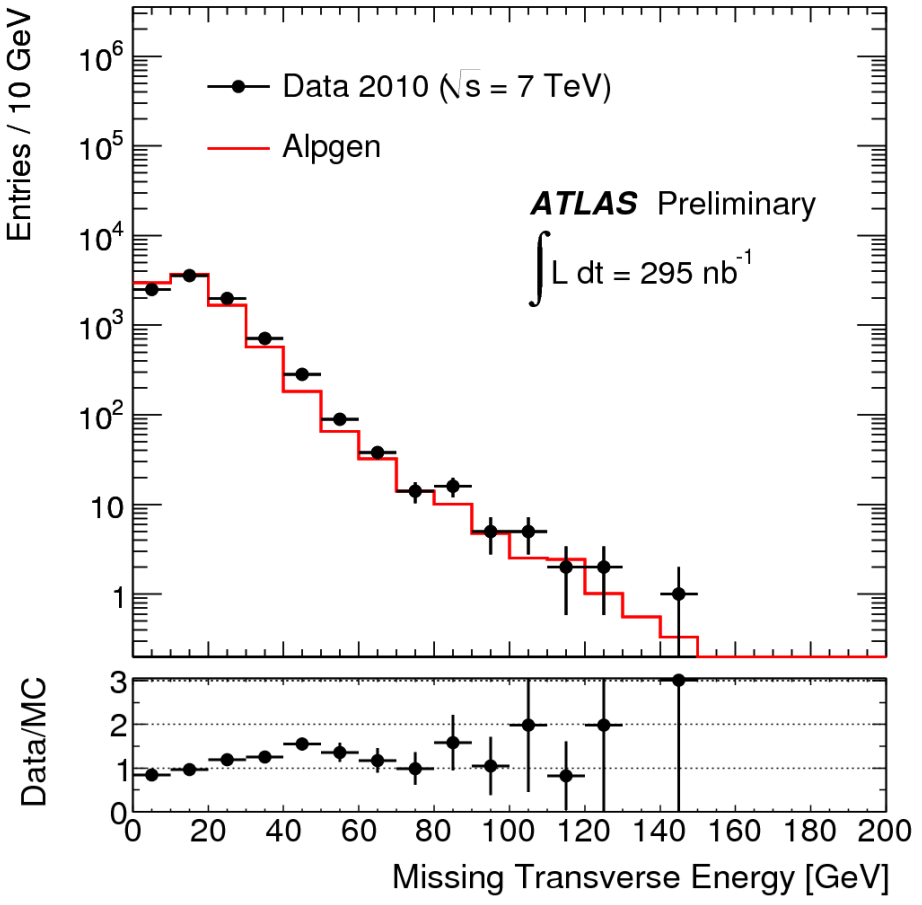


Object p_T & E_T^{miss}

control region

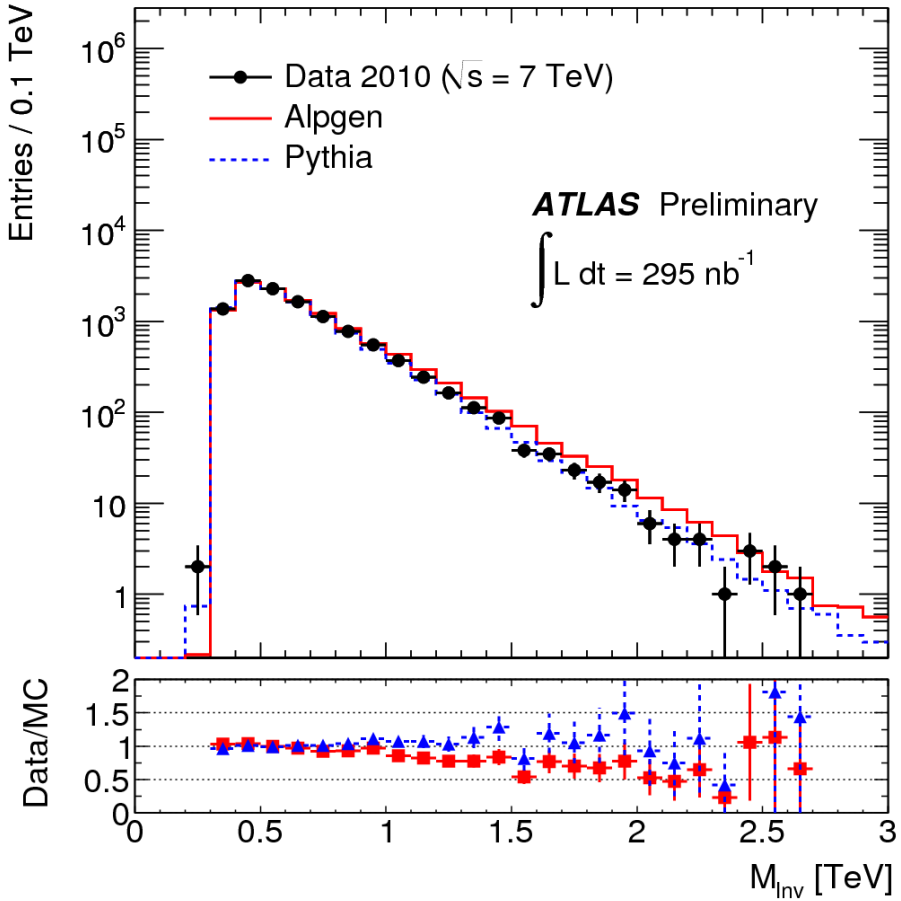


control region

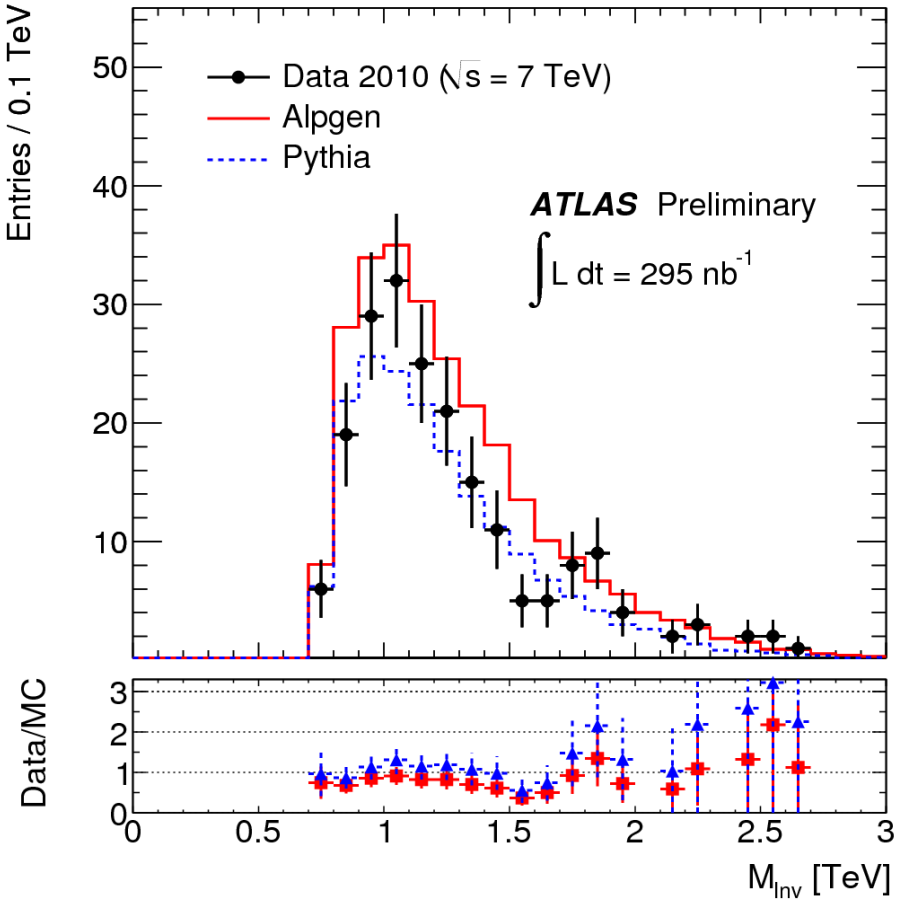


Invariant Mass

Σp_T > 300 GeV



Σp_T > 700 GeV



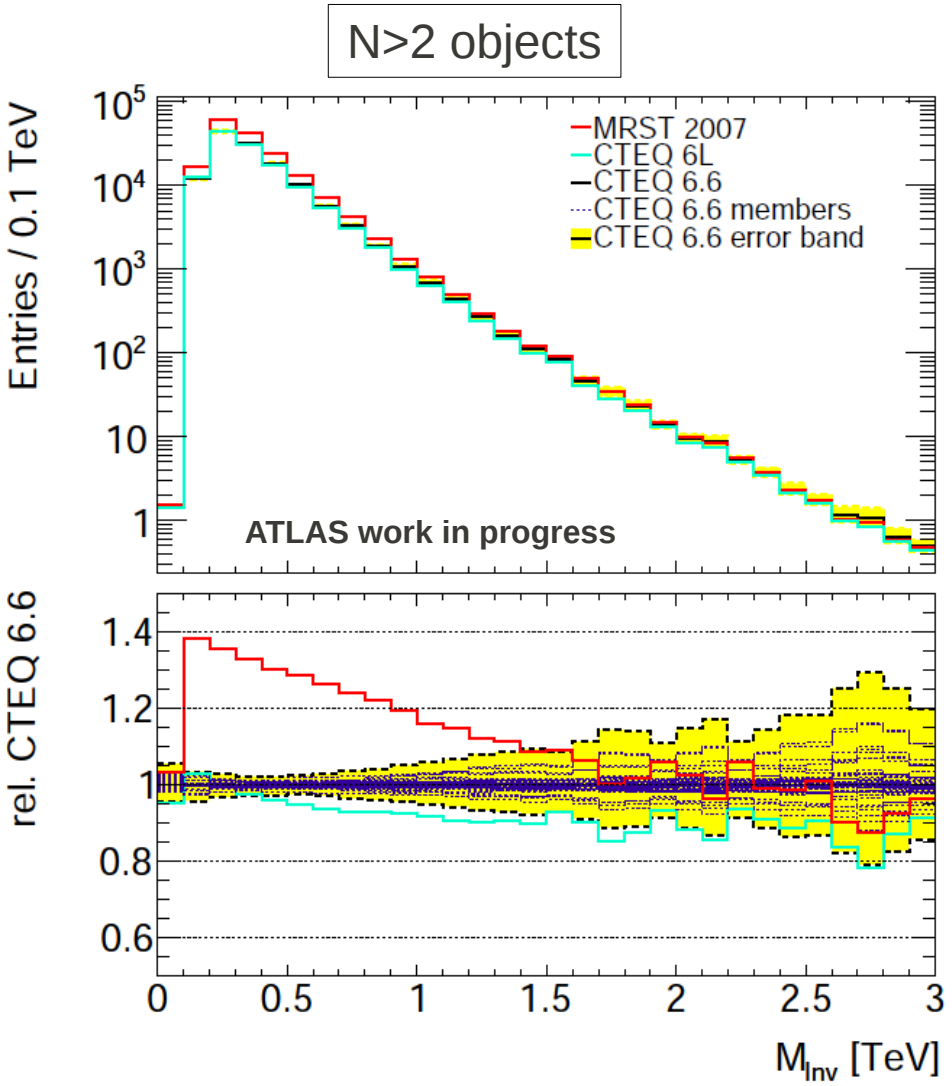
Uncertainties

Quantity	Uncertainty
background (QCD)	26%
PDF (choice)	12%
PDF (error set)	+6.8% -5.7%
JES	11%
control region	10%
other background	+0.6%
JER	0.6%
JES (MET)	0.5%
including e,γ,μ	0.2%

- difference between Pythia and Alpgen

total systematic uncertainty: 33%

PDF Uncertainty



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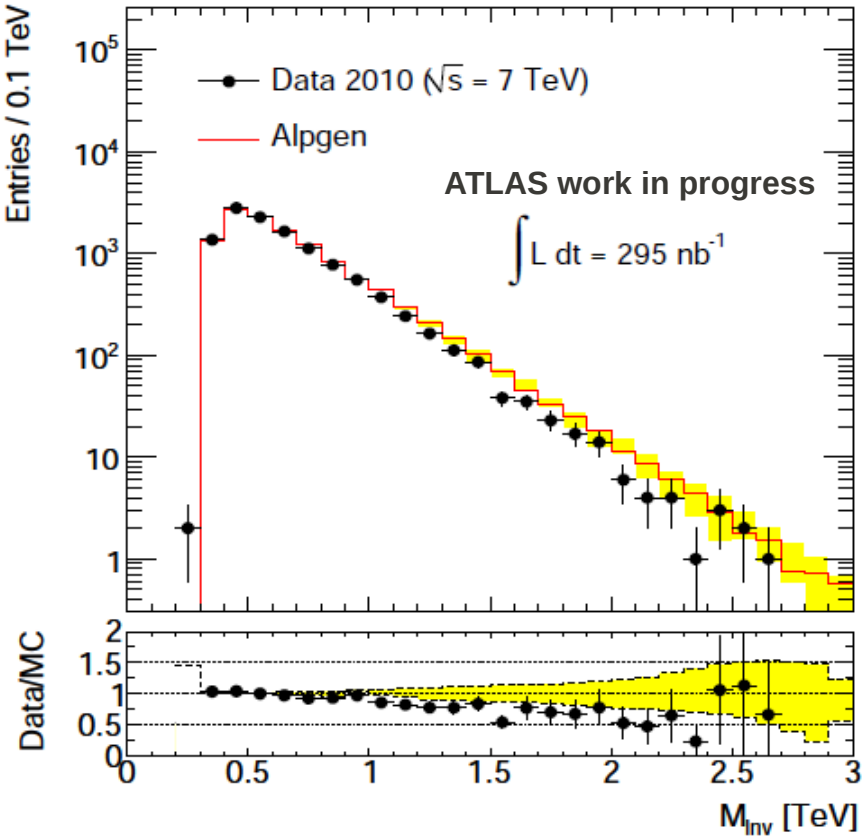

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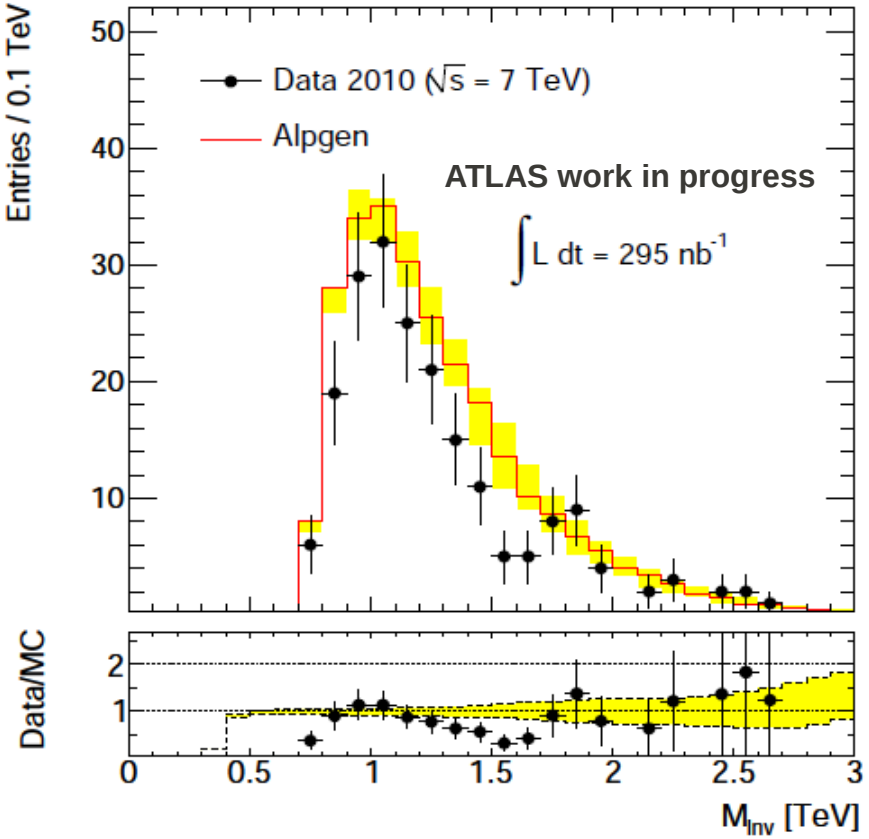

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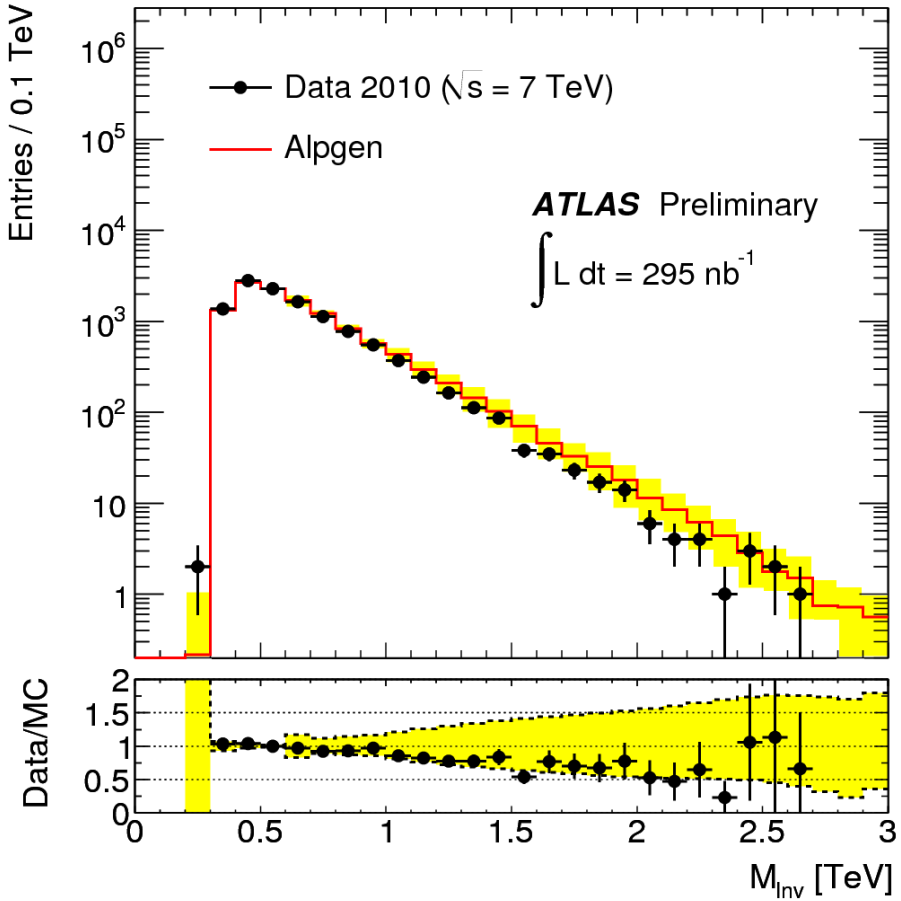
- difference between Pythia and Alpgen
- CTEQ6L1, MRST2007, CTEQ6.6
- jet energy scale
- choice of control region
- ttbar, W+jet, Z+jet
- jet energy resolution
- electron, photon, muon efficiency

total systematic uncertainty: 33%

Invariant Mass

Σp_T > 300 GeV



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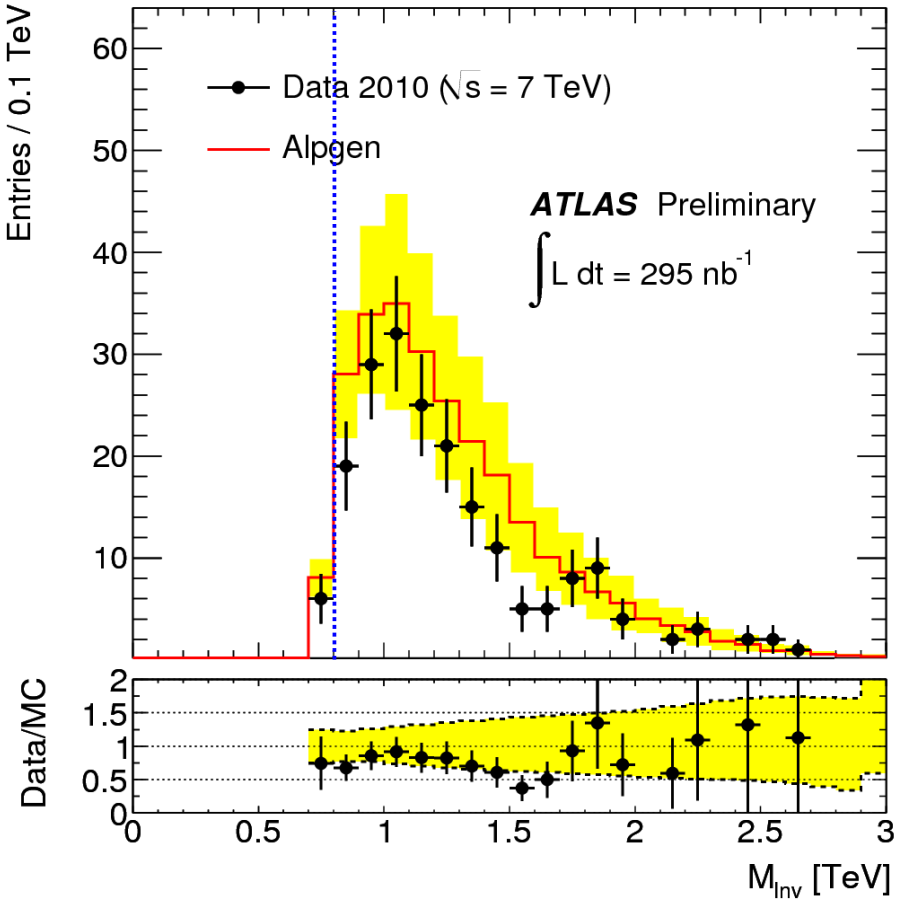

Results

- 0.295 pb^{-1} (±11%) integrated luminosity
- 193 events in signal region
- 254 ±18 ±84 events predicted from background MC
- upper limit on cross section x acceptance
  - 0.34 nb (95% C.L.)
- no well established signal physics model
  - use black hole event generator for illustrative limit
  - acceptance 58±2% (no systematics)
  - limit on cross section 0.6 nb
  - black disc cross section up to O(100) nb

Outlook

- no significant limit improvement with more data
- change of strategy
  - background estimation
  - more signal dependent signatures
    - electroweak object requirement
    - higher multiplicity
    - higher masses

Conclusion

- first search for multi object final states at high invariant masses
- inclusive search strategy
- detailed study of uncertainties
- 0.34 nb (95% C.L.) limit on cross section × acceptance
- important for low scale gravity and weakly coupled string theory
- ATLAS CONF note published (ATLAS-CONF-2010-088)
  - paper in work
- more signal dependent searches with more data