First results from ATLAS

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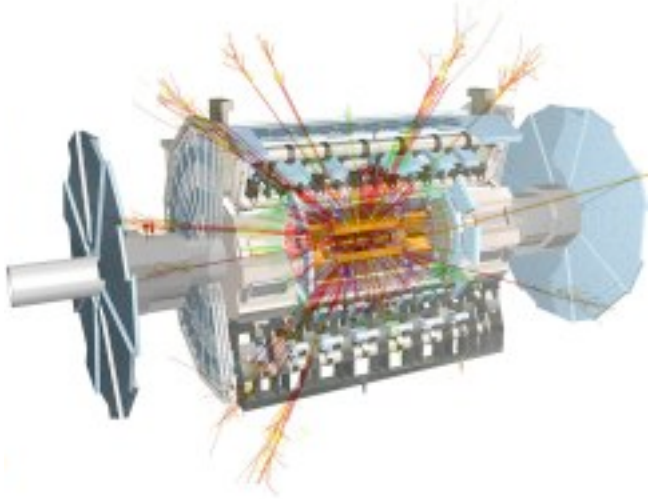
for the Swiss ATLAS groups

CHIPP Workshop on the High-Energy Frontier
1-2 September 2010



ATLAS physics results

Soft QCD

ATLAS-CONF-2010-046	Charged particle multiplicities in pp interactions for track PT > 100 MeV at sqrt(s) = 0.9 and 7 TeV measured with the ATLAS detector at the LHC	20 July 2010
ATLAS-CONF-2010-047	Charged particle multiplicities in pp interactions at sqrt(s) = 2.36 TeV measured with the ATLAS detector at the LHC	16 July 2010
ATLAS-CONF-2010-024	Charged particle multiplicities in pp interactions at sqrt(s) = 7 TeV measured with the ATLAS detector at the LHC	21 April 2010
Publication	Charged-particle multiplicities in pp interactions at sqrt(s) = 900 GeV measured with the ATLAS detector at the LHC	15 March 2010
ATLAS-CONF-2010-031	Charged particle multiplicities in pp interactions at sqrt(s) = 0.9 and 7 TeV in a diffractive limited phase-space measured with the ATLAS detector at the LHC and new PYTHIA6 tune	31 May 2010
ATLAS-CONF-2010-048	Studies of Diffractive Enhanced Minimum Bias Events in ATLAS	20 July 2010
ATLAS-CONF-2010-029	Track-based underlying event measurements in pp collisions at sqrt(s) = 900GeV and 7 TeV with the ATLAS Detector at the LHC	28 May 2010
ATLAS-CONF-2010-081	Track-based underlying event measurements in pp collisions at sqrt{s} = 900 GeV and 7 TeV with the ATLAS Detector at the LHC	19 August 2010
ATLAS-CONF-2010-082	Angular correlations between charged particles from proton-proton collisions at sqrt(s) = 900 GeV and sqrt(s) = 7 TeV measured with ATLAS detector	20 August 2010

Hard QCD

ATLAS-CONF-2010-050	Measurement of jet production in proton-proton collisions at 7 TeV centre-of-mass energy with the ATLAS Detector	16 July 2010
ATLAS-CONF-2010-049	Measurement of differential cross section and fragmentation of jets from tracks in proton-proton collisions at centre-of-mass energy sqrt(s) = 7 TeV with the ATLAS detector	16 July 2010
ATLAS-CONF-2010-083	Azimuthal Decorrelations in Dijet Events at sqrt(s)=7 TeV	20 August 2010
ATLAS-CONF-2010-084	Measurements of multijet production cross sections in proton-proton collisions at 7 TeV center-of-mass energy with the ATLAS Detector	18 August 2010
ATLAS-CONF-2010-085	Measurement of dijet production with a jet veto in pp collisions at sqrt(s) = 7 TeV using the ATLAS detector	20 August 2010
ATLAS-CONF-2010-080	Search for new particles decaying into dijets in proton-proton collisions at sqrt{s} = 7 TeV with the ATLAS detector	23 July 2010
ATLAS-CONF-2010-074	High-pT dijet angular distributions in pp interactions at sqrt(s)=7TeV measured with the ATLAS detector at the LHC	20 July 2010
ATLAS-CONF-2010-077	Evidence for prompt photon production in pp collisions at $\sqrt{s}= 7\TeV$ with the ATLAS detector	21 July 2010

Top

ATLAS-CONF-2010-063	Search for top pair candidate events in ATLAS at sqrt(s)=7 TeV	21 July 2010
ATLAS-CONF-2010-087	Background studies for top-pair production in lepton plus jets final states in sqrt(s)=7 TeV ATLAS data	19 August 2010

b and c Physics

ATLAS-CONF-2010-062	A first measurement of the differential cross section for the J/ψ →μμ resonance and the non-prompt to prompt J/ψ cross section ratio with pp collisions at √s = 7 TeV in ATLAS	21 July 2010
ATLAS-CONF-2010-078	J/psi Performance of the ATLAS Inner Detector	21 July 2010
ATLAS-CONF-2010-034	D^(*) mesons reconstruction in pp collisions at sqrt{s} = 7 TeV	5 June 2010

Electroweak

ATLAS-CONF-2010-051	Measurement of the W -> lnu production cross-section and observation of Z -> ll production in proton-proton collisions at sqrt(s) = 7 TeV with the ATLAS detector	21 July 2010
ATLAS-CONF-2010-076	Measurement of the Z -> ll production cross section in proton-proton collisions at sqrt(s) = 7 TeV with the ATLAS detector	23 July 2010

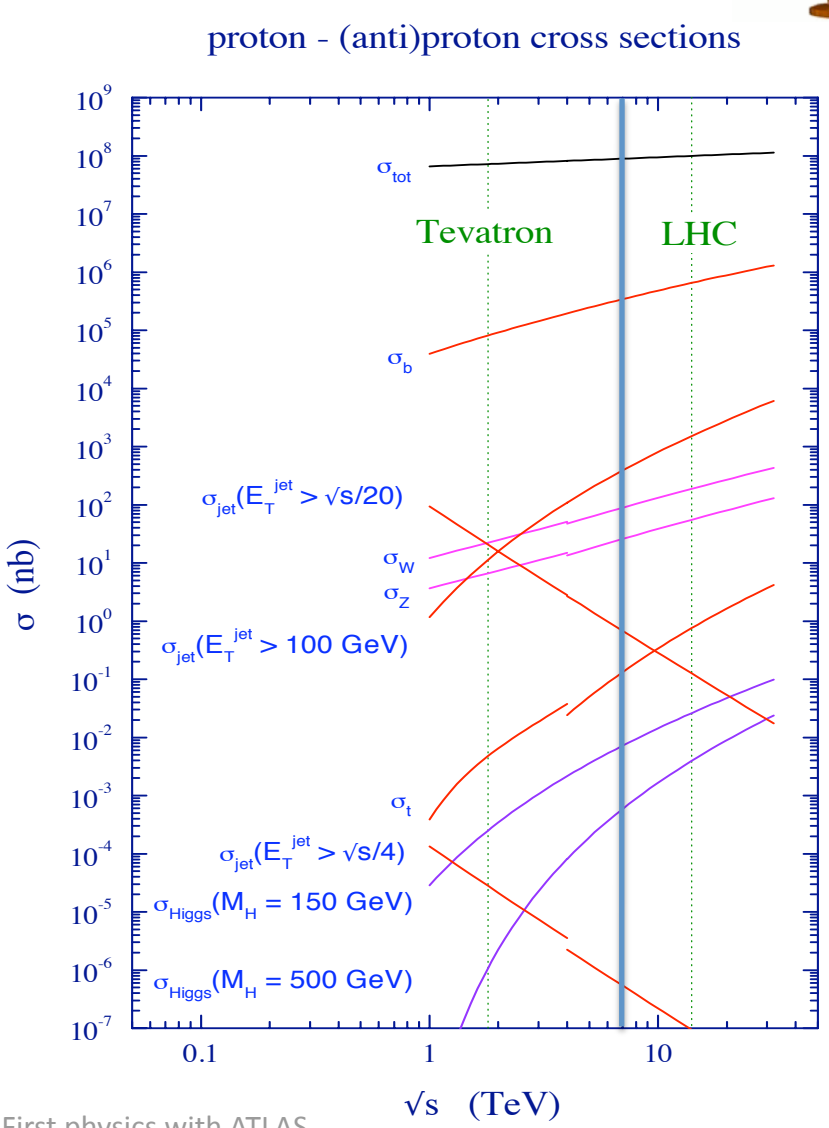
Searches

ATLAS-CONF-2010-080	Search for new particles decaying into dijets in proton-proton collisions at sqrt{s} = 7 TeV with the ATLAS detector	23 July 2010
ATLAS-CONF-2010-074	High-pT dijet angular distributions in pp interactions at sqrt(s)=7TeV measured with the ATLAS detector at the LHC	20 July 2010
ATLAS-CONF-2010-088	Search for new physics in multi-body final states at high invariant masses with ATLAS	20 August 2010
ATLAS-CONF-2010-089	Search for high-mass states with electron plus missing transverse energy using the ATLAS Detector at $\sqrt{s}= 7$~tev	23 August 2010
ATLAS-CONF-2010-065	Early supersymmetry searches in channels with jets and missing transverse momentum with the ATLAS Detector	20 July 2010
ATLAS-CONF-2010-066	Early supersymmetry searches with jets, missing transverse momentum and one or more leptons with the ATLAS Detector	20 July 2010
ATLAS-CONF-2010-079	Early supersymmetry searches in events with missing transverse energy and b-jets with the ATLAS detector	20 August 2010
ATL-PHYS-PUB-2010-010	Prospects for Supersymmetry discovery based on inclusive searches at a 7 TeV centre-of-mass energy with the ATLAS detector	17 July 2010
ATLAS-CONF-2010-071	Background studies to searches for long-lived stopped particles decaying out-of-time with LHC collisions	21 July 2010
ATL-PHYS-PUB-2010-009	ATLAS Sensitivity Prospects for Higgs Boson Production at the LHC Running at 7 TeV	16 July 2010

A selection of SM results is presented here focusing on Swiss interests, activities

The story so far…

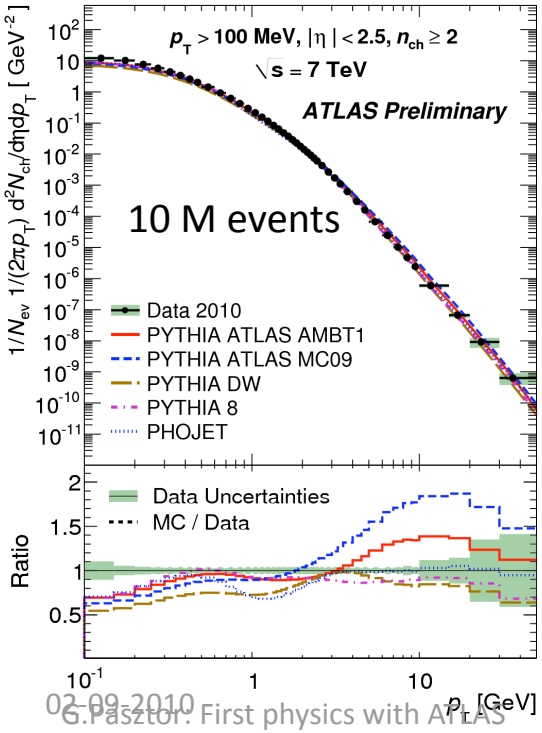
- Charged particle multiplicities (UniGe)
- Rediscovery of mesons and baryons (UniGe: J/ψ)
- High-p_T jets (UniBe)
- Prompt photons (UniGe)
- Prompt leptons from HF decays (UniGe: electrons)
- W/Z boson (UniBe, UniGe)
- Top (UniGe)
- First searches: di-jet resonances, W', SUSY (UniBe, UniGe)
  (→ talk of C. Topfel)



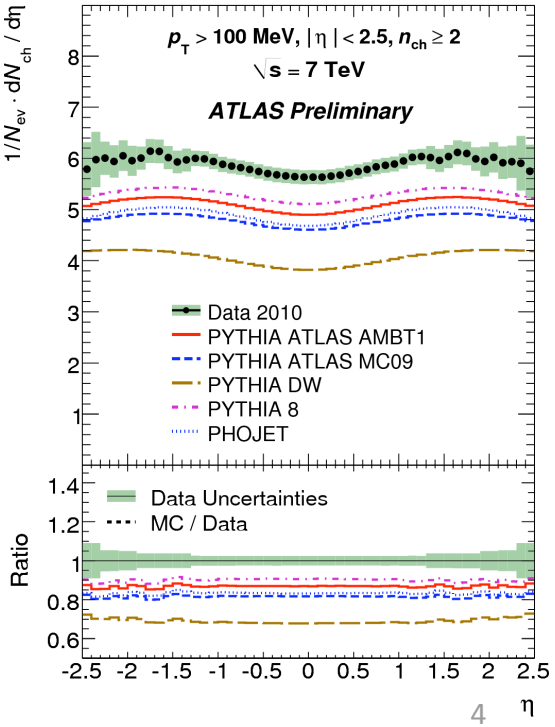
Charged-particle multiplicity distributions

- Very first physics results at LHC (0.9, 2.36 and 7 TeV)
- Test basic underlying physics of pp interactions
- Tune MC models to describe low p_T processes (→new ATLAS tune: AMBT1)
- Measured in well-defined kinematic regions (eg. $n_{ch} \geq 2$, $p_T > 100$ MeV, $|\eta| < 2.5$)
- Single arm minimum bias trigger
- No subtraction of SD/DD components
- Distributions corrected back to hadron level
- Minimally model-dependent
- High-precision (≲3% experimental error)
- Paper in preparation containing 3 different phase-space regions to allow the tuning of the different components

$1/(2\pi p_T)\, d^2N_{ch}/d\eta dp_T$

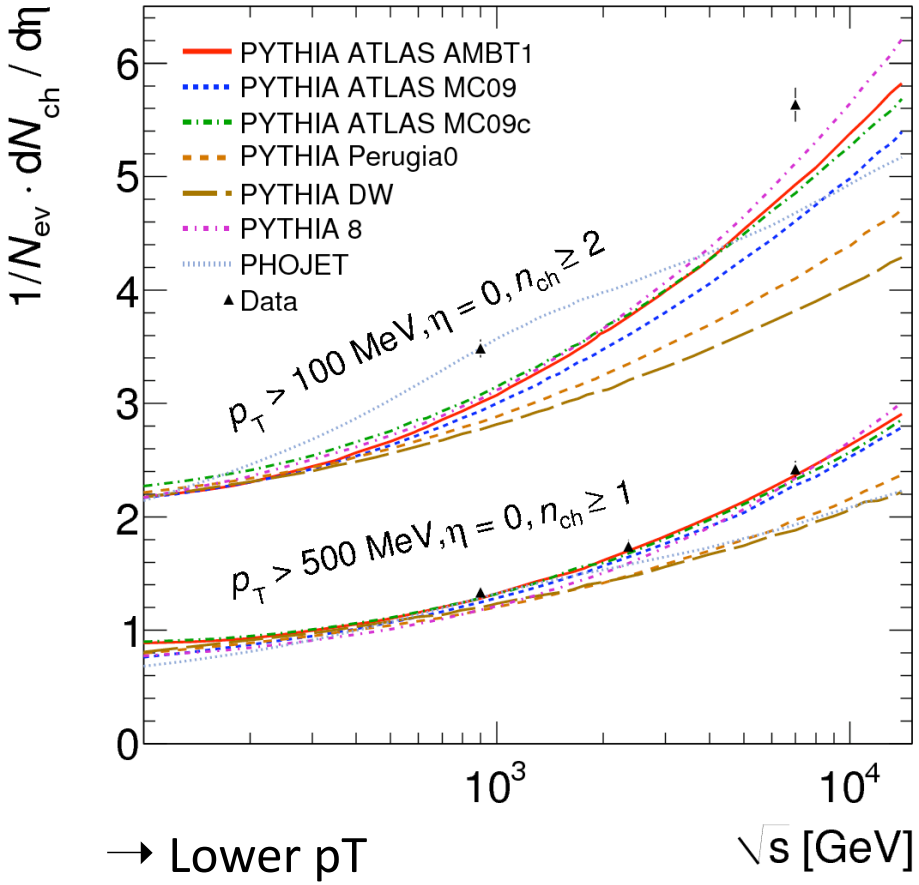


$dN_{ch}/d\eta$



Charged-particle multiplicity distributions

$dN_{ch}/d\eta$ ($\eta \approx 0$)

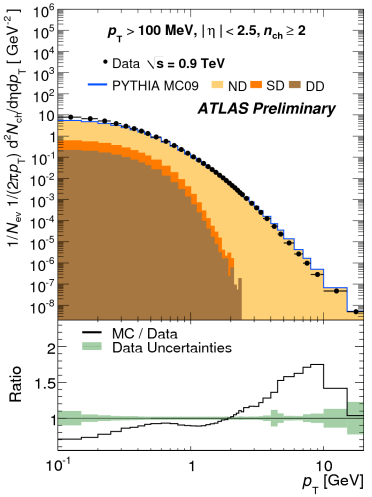


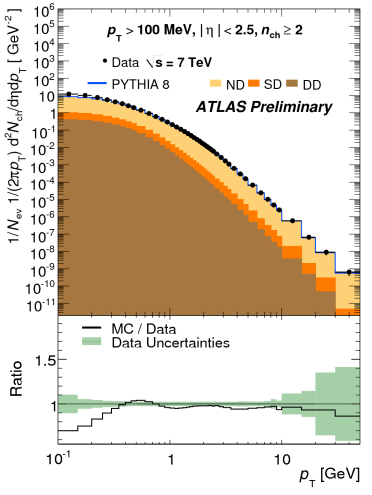
→ Lower pT

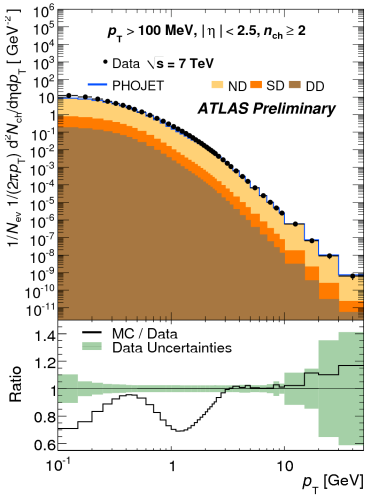
→ Larger diffractive component

→ Worse description by MC models

$1/(2\pi p_T)\, d^2N_{ch}/d\eta dp_T$







Comparison of ND/SD/DD contributions of different MC models

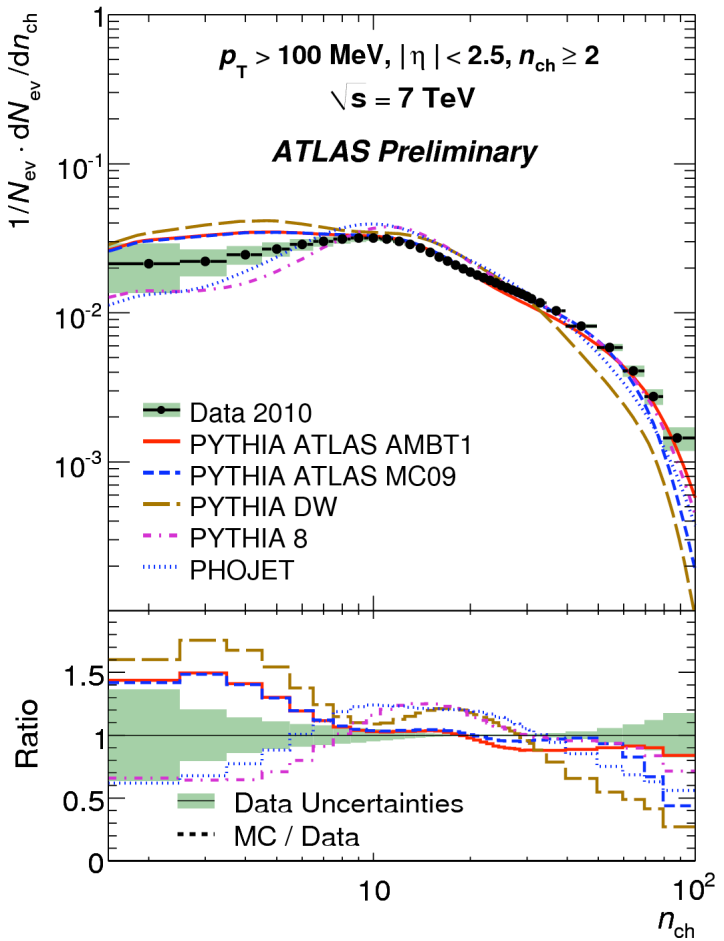
Charged-particle multiplicity distributions

Areas of Uni Geneva contributions:

- Coordination (first and second ATLAS publication)
- Correction strategy
- Minbias trigger
- Data quality
- Beam backgrounds, pile-up
- Validating common D3PDs
- Alignment weak mode study
- Validating new tracking configuration

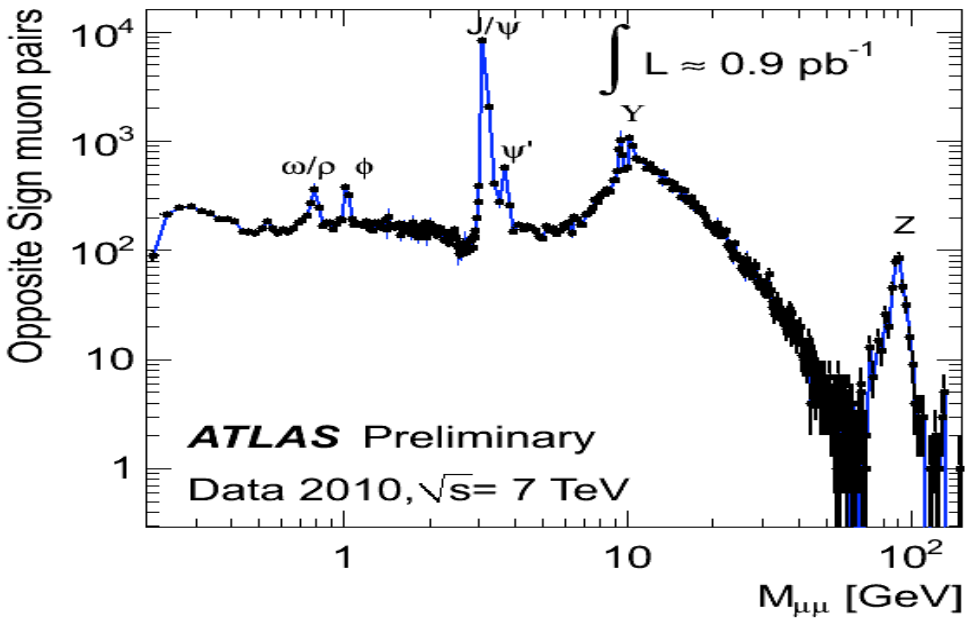
Now main focus on publication,
better understanding of systematics

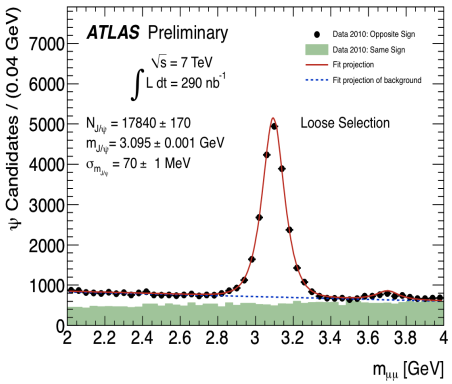
dN_{ev}/dn_{ch}



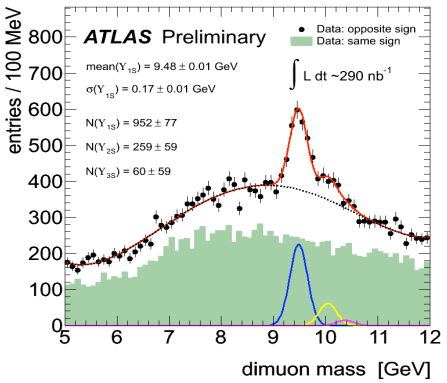
Low-mass dimuon signatures

- Di-lepton signatures are important standard candles to calibrate our detectors and to measure its performance
- Charmonium production mechanisms at hadron colliders are not well understood. These processes give good testing ground for a variety of QCD calculations.





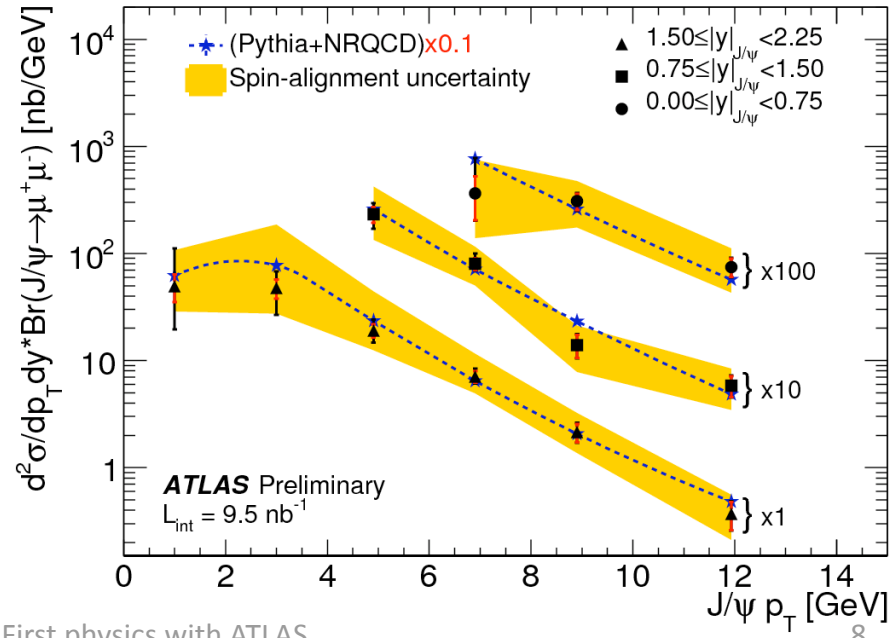
J/ψ ψ'



$\Upsilon_{1,2,3}$

J/ψ→μμ differential cross-section

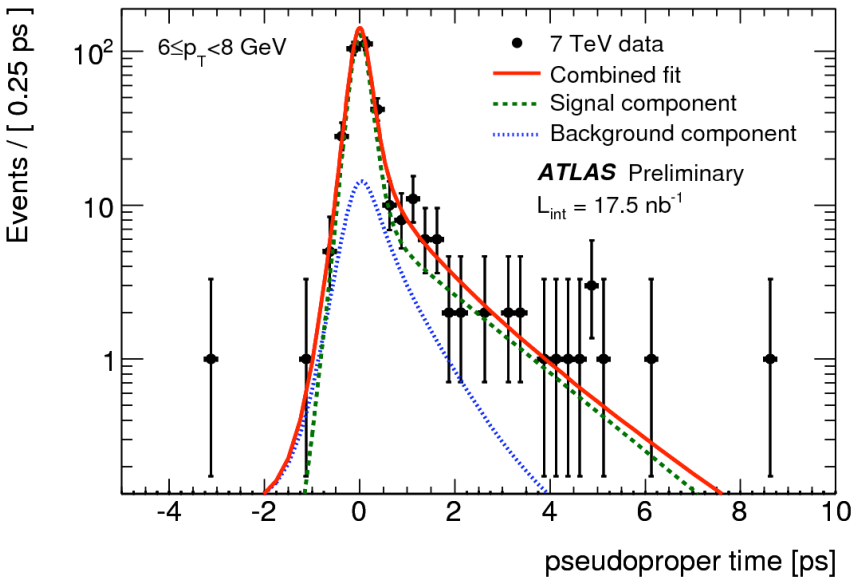
- L1 minbias trigger scanned for Muon Spectrometer track at EF
- Muons formed by an Inner Detector track and a MS track/segment
- Opposite-charge muon pairs fitted to common vertex
- Unbinned event-by-event maximum likelihood fit in bins of p_T and rapidity
- To account for acceptance, reconstruction and trigger efficiencies, events weighted by $w=1/[A(p_T,y,\lambda_i)\cdot\epsilon_\mu(\mathbf{p_1})\cdot\epsilon_\mu(\mathbf{p_2})\cdot\epsilon_{trig}(\mathbf{p_1},\mathbf{p_2})]$
- Cross-section agrees in shape with Pythia NRQCD prediction but not in magnitude
- Dominant error: acceptance due to unknown spin alignment
- Experimental errors also important (especially at low p_T):
  - Data statistics (~600 J/ψ events)
  - Reconstruction and trigger efficiencies
  - Binning for acceptance, efficiency corrections



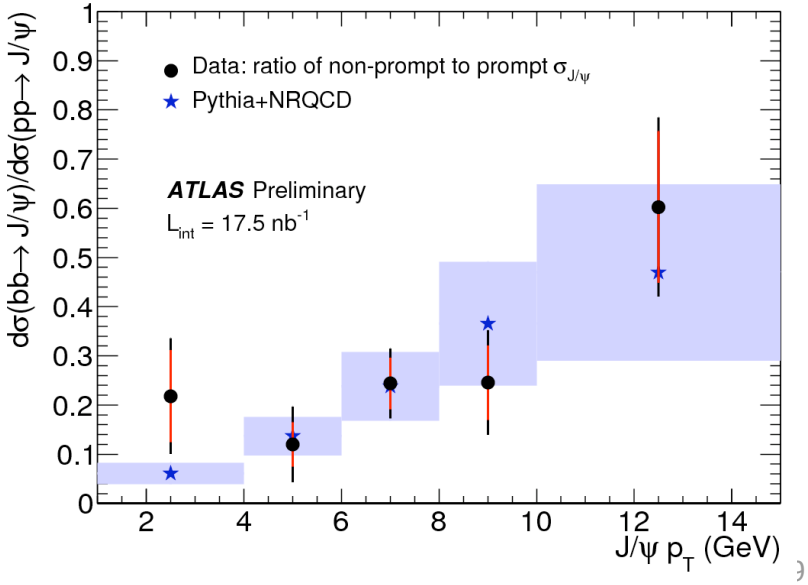
Non-prompt to prompt J/ψ production cross-section ratio

- Same efficiencies and acceptances for muons coming from prompt and non-prompt (B-hadron) sources
- Add events from lowest threshold L1 muon trigger
- Simultaneous fit of dimuon mass and J/ψ pseudoproper time in p_T bins
- Signal pdf: δ function (prompt) + exponential (non-prompt), convolved with a Gaussian resolution function

$\tau = L_{xy} \cdot m_{\mu\mu}/p_{T,\mu\mu}$

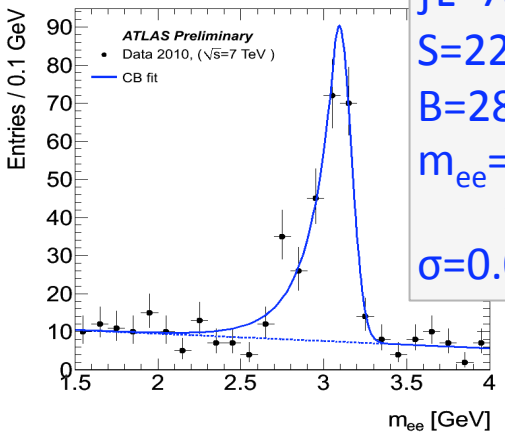


$R = \sigma(b\bar{b} \rightarrow J/\psi)/\sigma(pp \rightarrow J/\psi)_{prompt}$



J/ψ→ee cross-section measurement

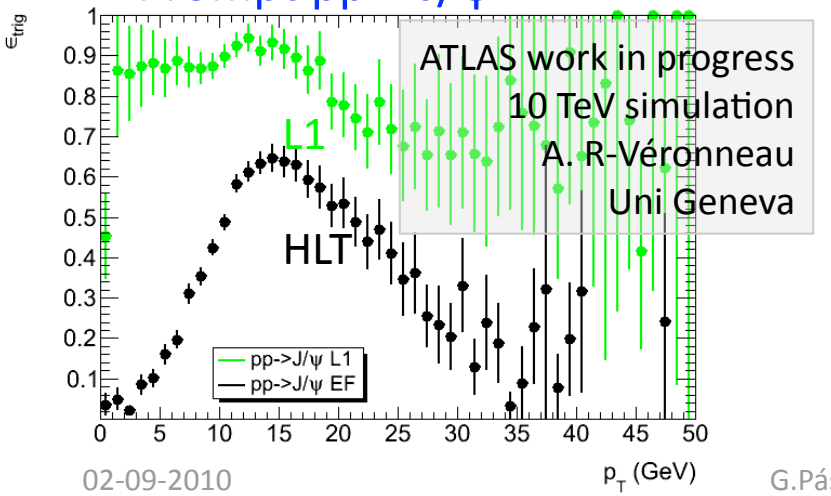
- After bremsstrahlung aware track refitting, good J/ψ mass resolution
- High Level Trigger and offline electron ID relies on calorimeter shower shapes, which are different for electrons from prompt and non-prompt production (due to nearby hadrons in B→J/ψX→eeX)
- Important systematics on efficiencies
- Optimized J/ψ trigger is on the way



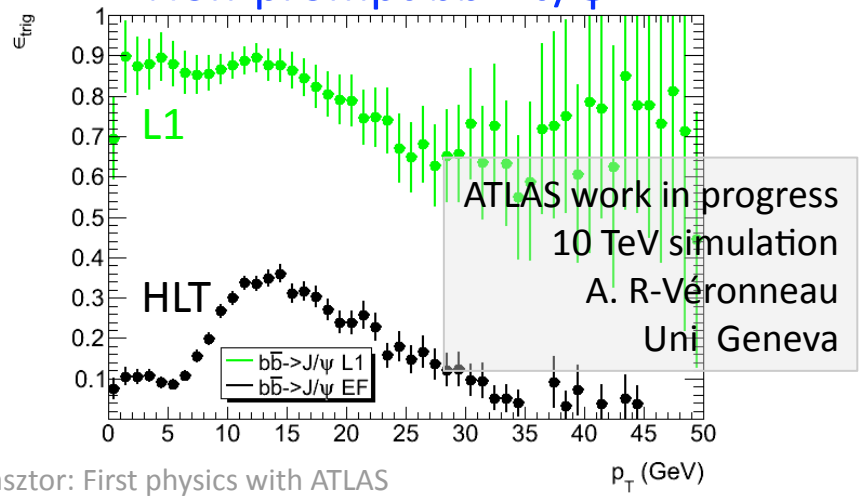
∫L=78 nb^{-1}
S=222±11 events
B=28±2 events
m_{ee}=3.09 ±0.01 GeV
σ=0.07±0.01 GeV

Dielectron trigger efficiencies wrt reconstruction (E^{thr}_T=5 GeV)

Prompt pp→J/ψ



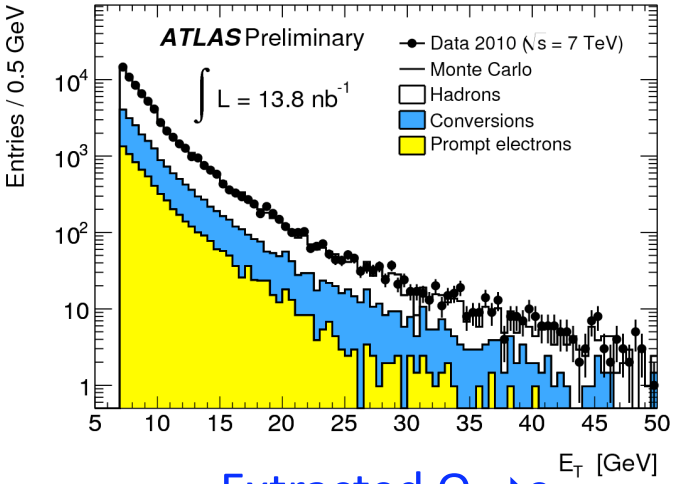
Non-prompt bb→J/ψ



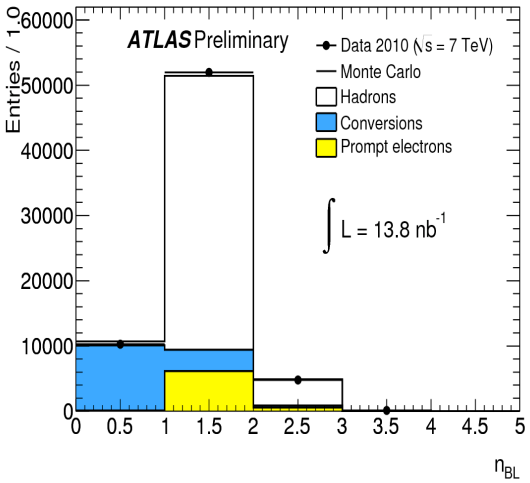
Inclusive electron spectrum

- Measure charm and beauty production
- Need to reject background electrons dominantly from photon conversion and control the rate of hadronic fakes
- Extract Q→e component with matrix method using pixel and TRT information

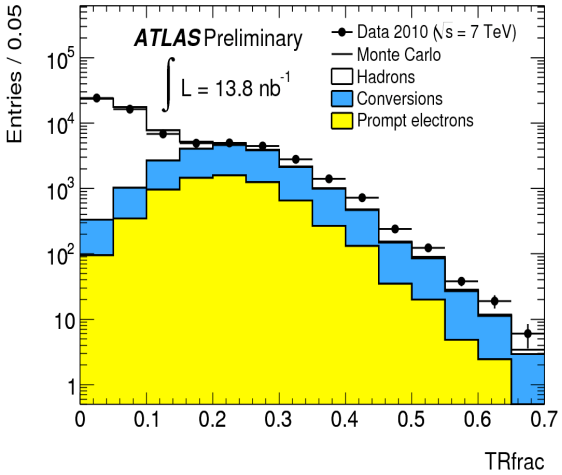
Electron E_T (medium ID)



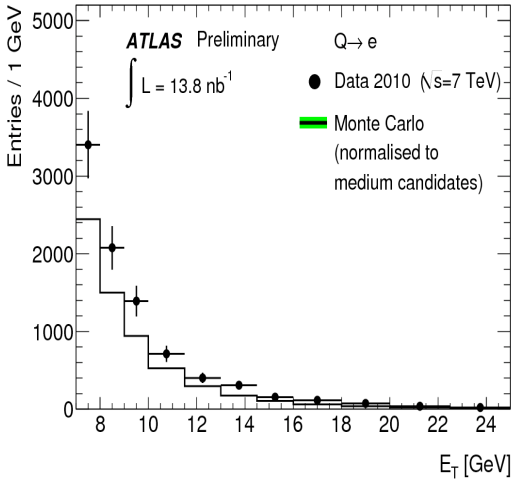
Hit count in first pixel layer



Fraction of TRT high threshold hits



Extracted Q→e electron E_T spectrum

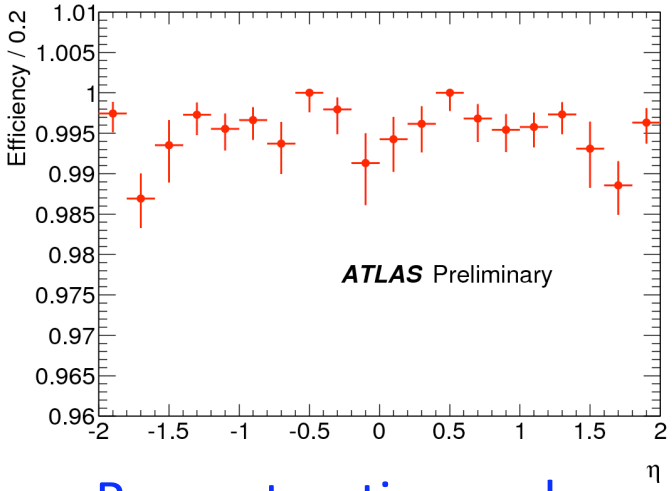


Towards a HF cross-section measurement

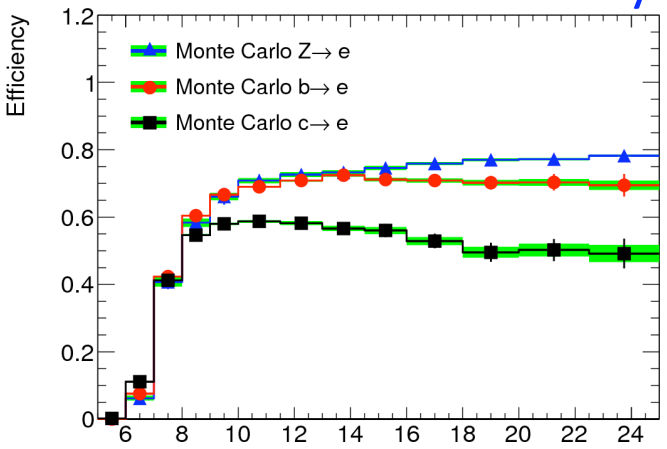
Major Uni Geneva contribution:

- Coordination
- Selection optimization
- Signal separation with LH method, bias studies
- b/c separation
- Trigger and offline efficiencies and related systematics
- Unfolding, cross-section derivation
- Theory uncertainties

Trigger efficiency

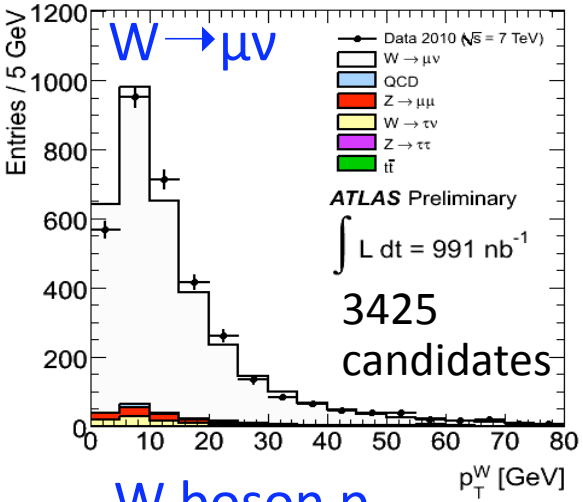


Reconstruction and identification efficiency

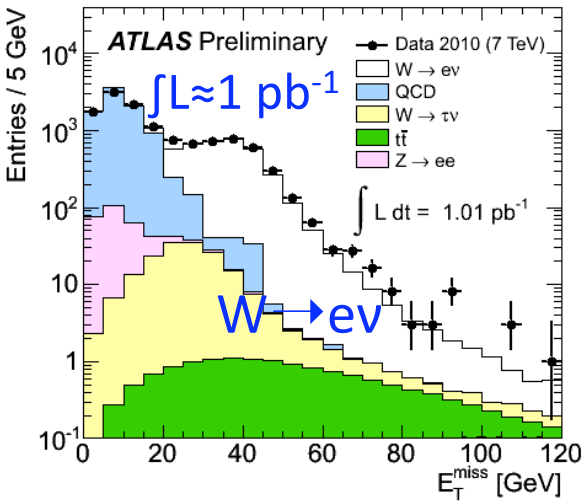


W boson selection

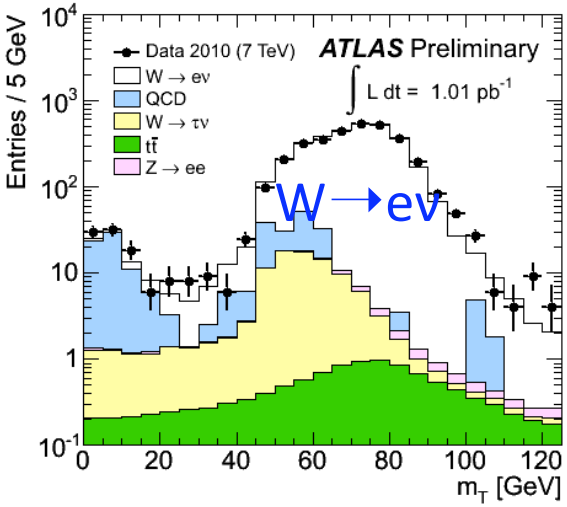
- W/Z measurements test QCD and constrain PDFs (low parton momentum fractions at high energy scale)
- Typical selection:
  - High p_T (>20 GeV), isolated lepton in detector acceptance ($|\eta| \lesssim 2.5$)
  - Large missing E_T(>25 GeV) and transverse mass M_T(>40 GeV)



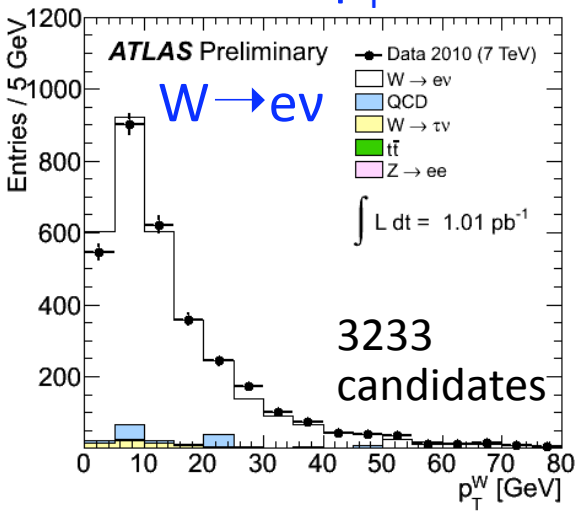
Missing E_T



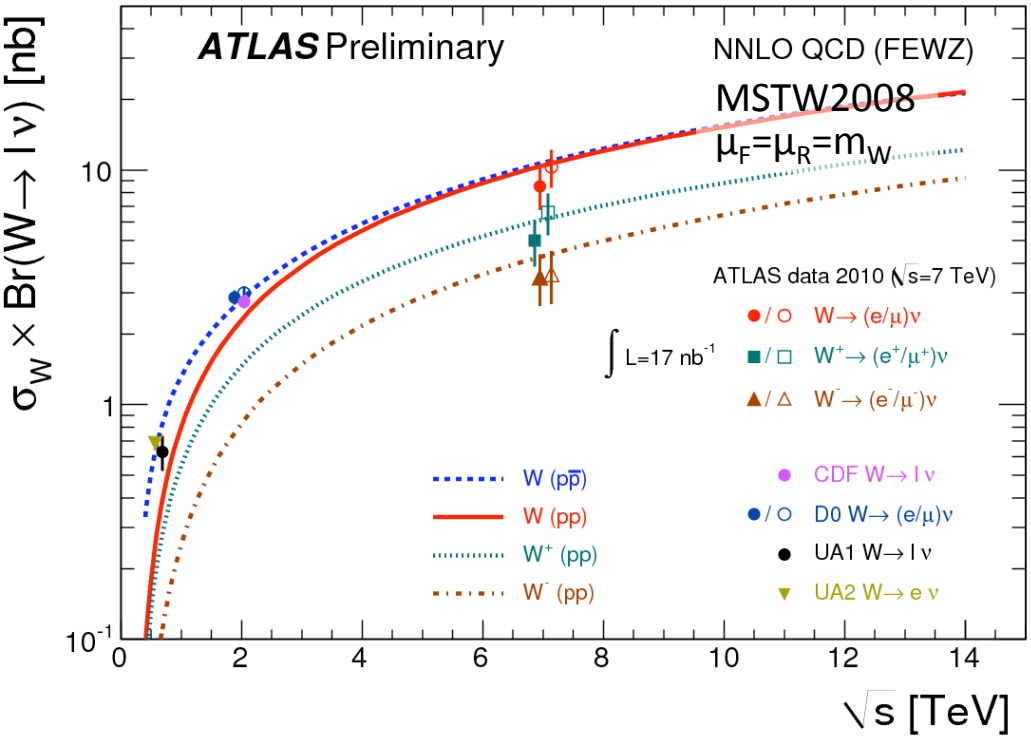
Transverse mass



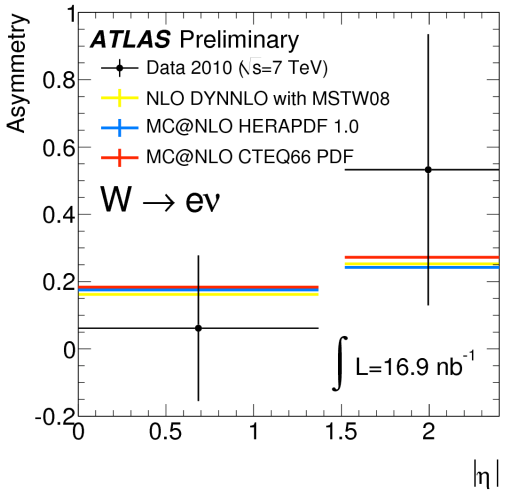
W boson p_T

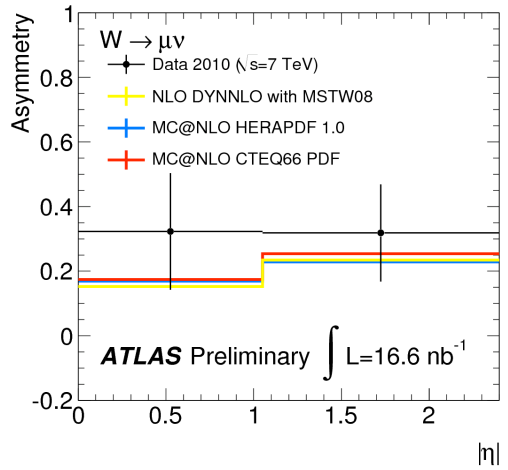


W cross-section and charge asymmetry



$$A = \frac{\sigma^{\ell^+} - \sigma^{\ell^-}}{\sigma^{\ell^+} + \sigma^{\ell^-}}$$





Based on ∫L=17 nb^{-1} and 46 eν + 72 μν candidates:

σ_{W+}= 5.7 ± 0.7(stat) ± 0.4 (syst) ± 0.6 (lumi) nb

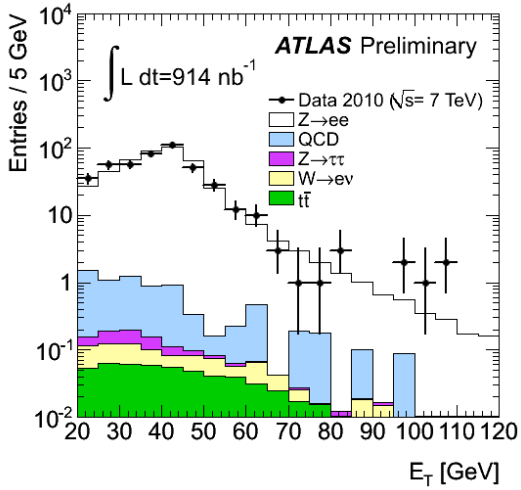
σ_{W-}= 3.5 ± 0.5(stat) ± 0.2 (syst) ± 0.4 (lumi) nb

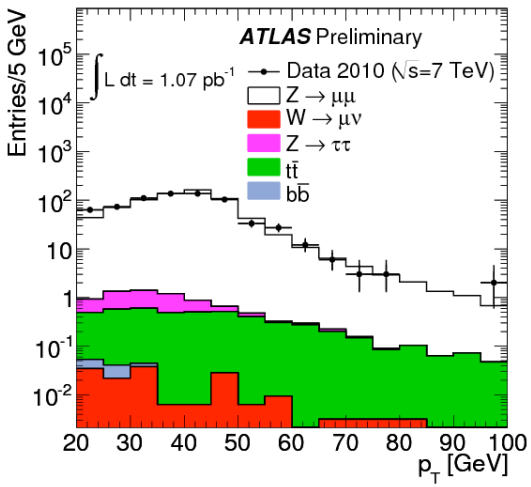
σ_{tot}= 9.3 ± 0.9(stat) ± 0.6 (syst) ± 1.0 (lumi) nb

σ_{theory}= 10.46 ± 0.42 nb

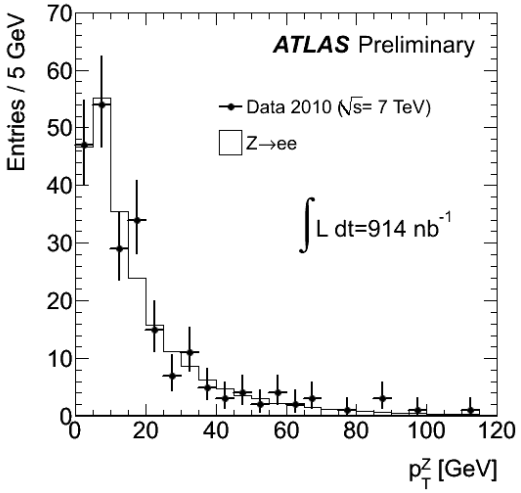
Z cross-section: selected candidates

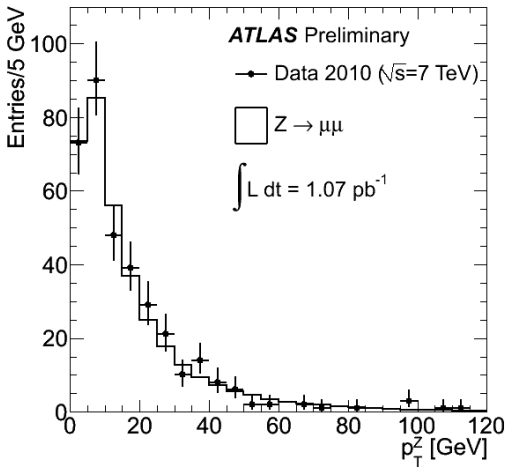
Lepton p_T



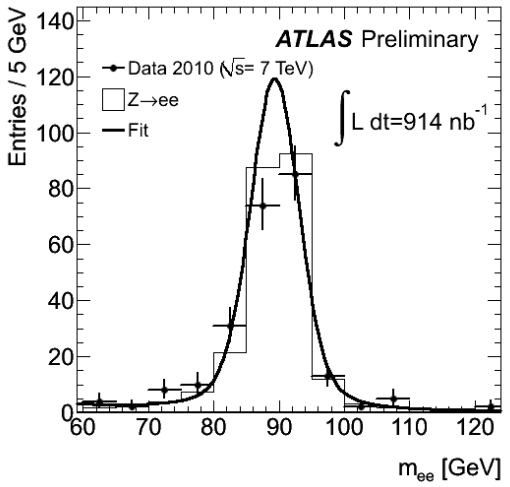


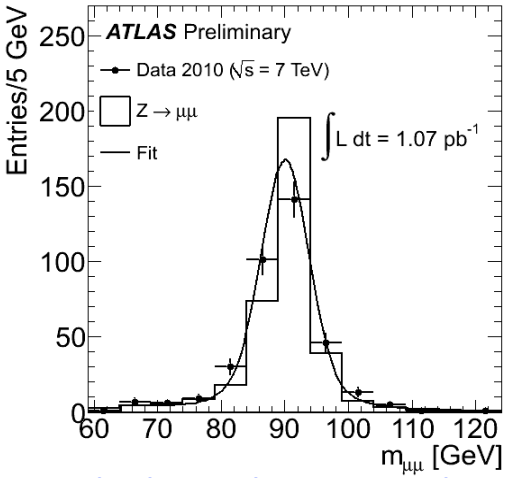
Z boson p_T





Dilepton mass



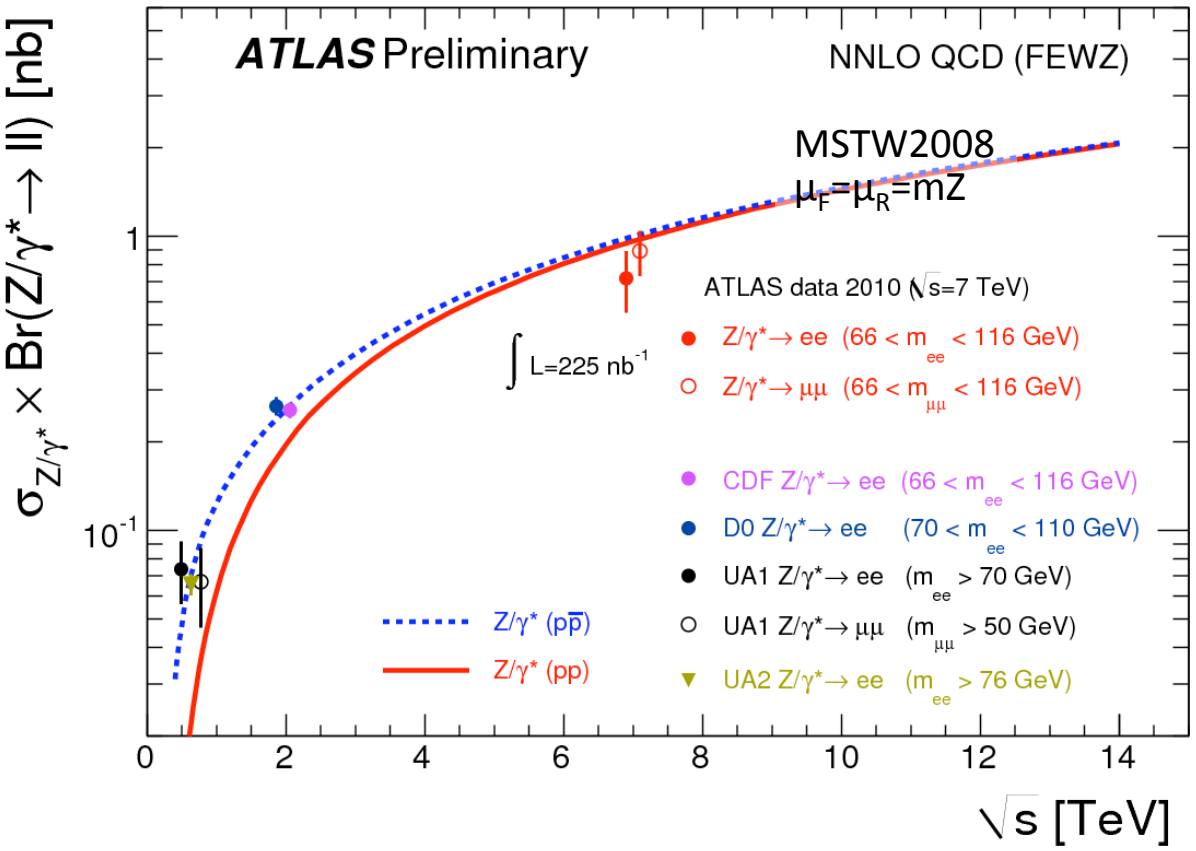


Z→ee
230 cand.
M=90.8±0.3 (91.3) GeV
σ=3.3±0.3 (1.5) GeV

Z→μμ
354 cand.
M=90.9±0.3 (91.6) GeV
σ=3.2±0.3 (1.8) GeV

Fit: theoretical lineshape including photon and Z contribution convolved with Gaussian resolution function

Z cross-section



Based on $\int L=225\ nb^{-1}$ and 46 ee + 79 μμ candidates ($66<m_{ll}<116$ GeV):

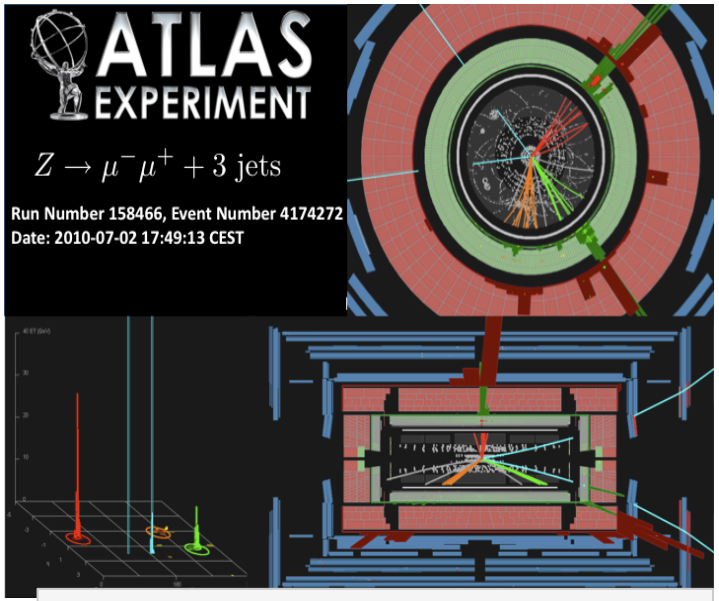
σ_{tot}= 0.83 ± 0.07(stat) ±0.06 (syst) ± 0.09 (lumi)

σ_{theory}= 0.946 ± 0.039 nb

W/Z + jets

Jet selection:
anti-k_T with R=0.4
p_T>20 GeV, |η|<2.8

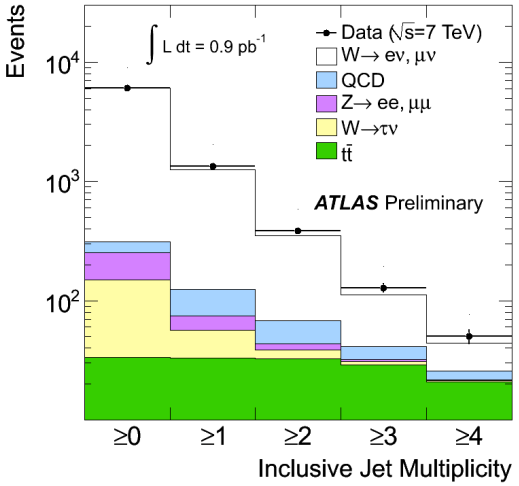
Z→μμ + 3 jets

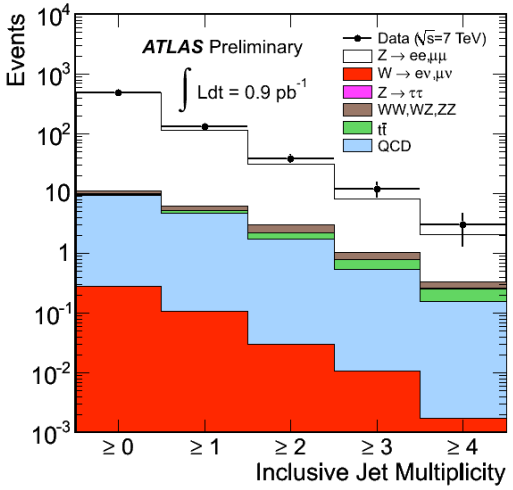


$p_{T,\mu 1}$=96 GeV
$p_{T,\mu 2}$=68 GeV
$M_{\mu\mu}$=79 GeV
$p_{T,\mu\mu}$=144 GeV

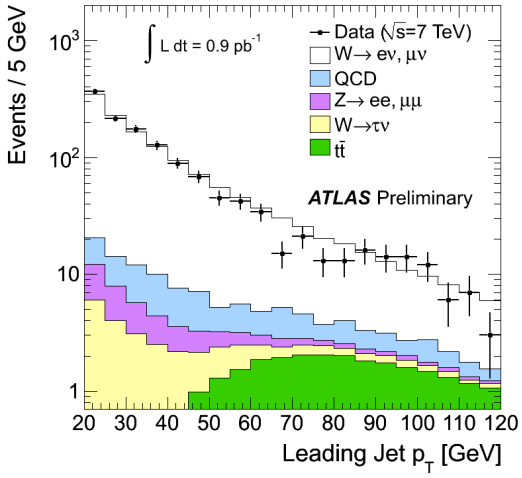
$p_{T,j1}$=168 GeV
$p_{T,j2}$=105 GeV
$p_{T,j3}$=45 GeV

Jet multiplicity

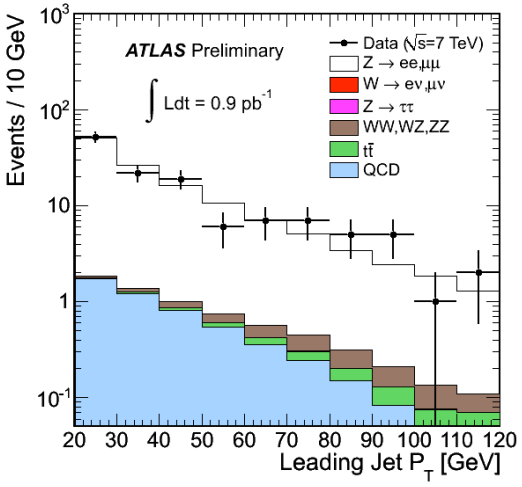




Leading jet p_T



W



Z

From inclusive W/Z measurements to R_{jets}

Both groups are involved in the electron channels

Uni Geneva:

- Efficiencies for inclusive W and R_{jets} selections
- Efficiency systematics
- QCD background determination
- Cross-section calculation for inclusive W measurement
- After completing the first ATLAS W paper on the inclusive cross-section,

concentrate on $R_{\text{jets}} = \dfrac{\sigma(W + n \text{ jets})}{\sigma(Z + n \text{ jets})}$

Uni Bern: $R_{W,n \text{ jets}} = \dfrac{\sigma(W + (n+1) \text{ jets})}{\sigma(W + n \text{ jets})}$ measurement

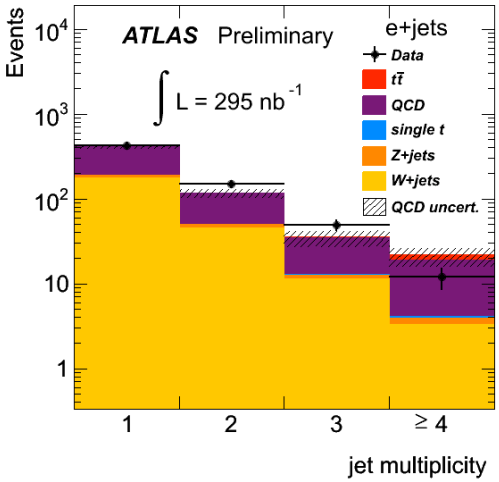
- Jet energy scale, missing E_T systematics
- Generator comparisons
- Unfolding

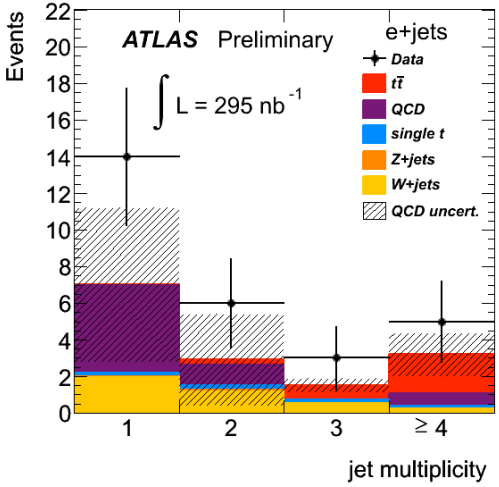
Top background studies: lepton + jets selection

Selection:

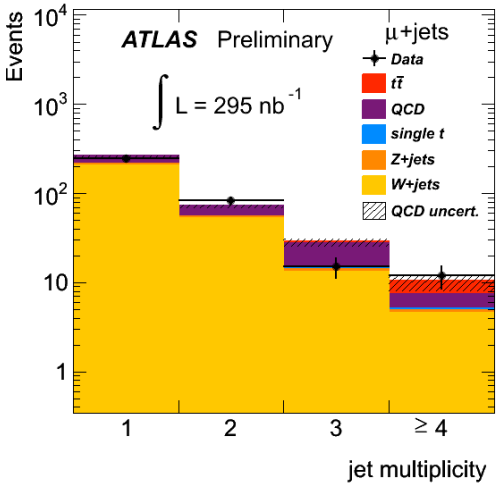
- =1 identified lepton, matched to trigger, p_T>20 GeV, isolated
- ≥4 jets, anti-k_T with R=0.4 @ EM+JES scale, p_T>20 GeV
- ≥1 b-tag (SV0 @ 50% eff.)
- E_T^{miss}>20 GeV

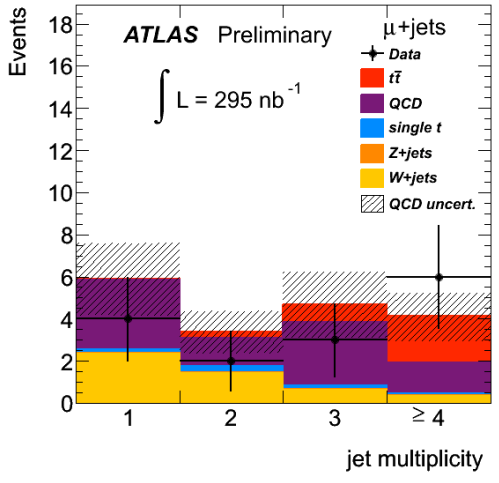
Electron channel





Muon channel





≥1 jet (p_T>20 GeV)

≥1 jet (p_T>20 GeV)

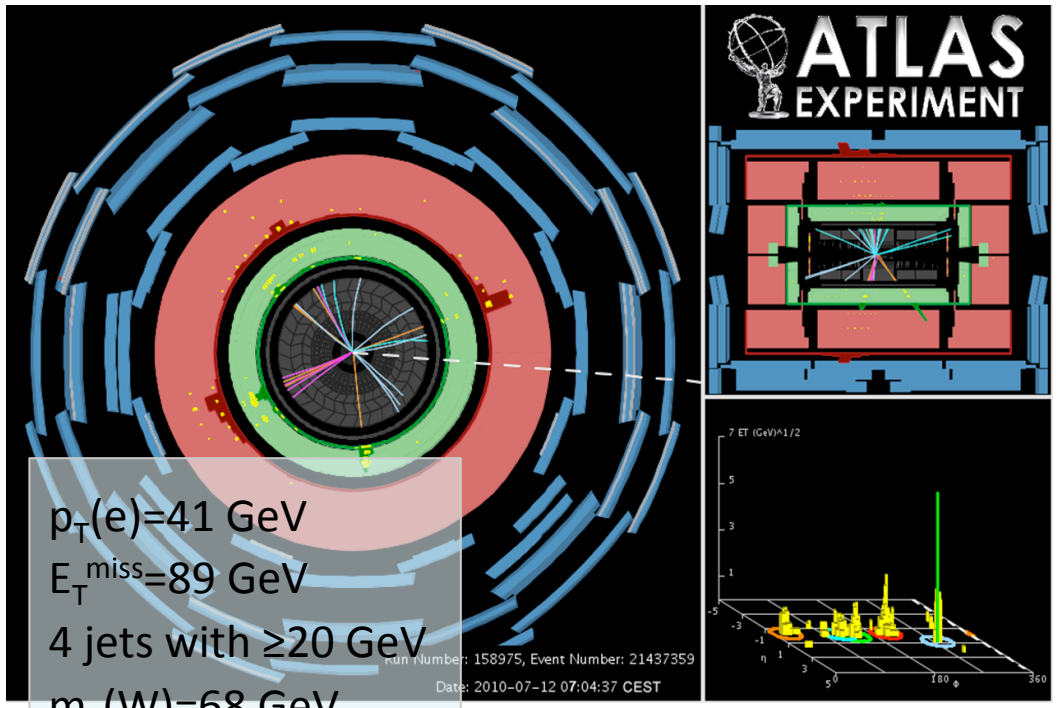
≥1 b-jet

QCD data-driven estimate from matrix method (stat errors only)

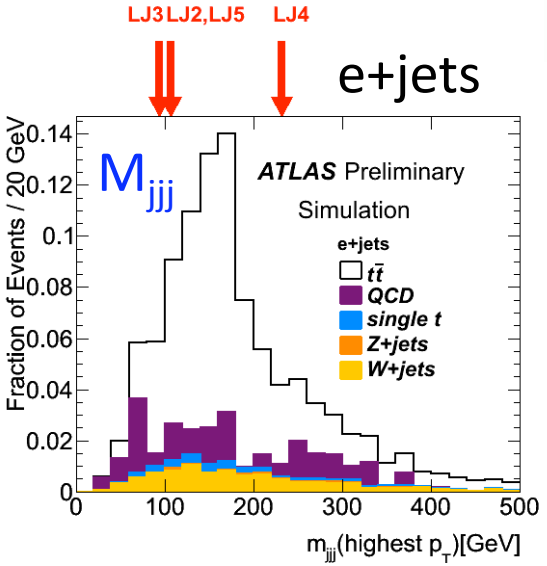
First top candidates

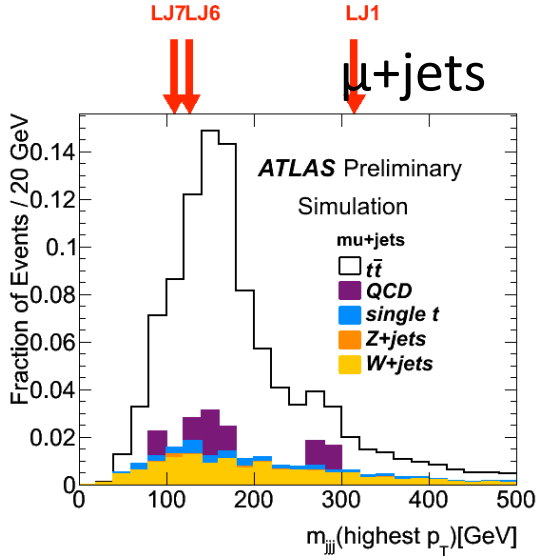
9 candidates in 295 nb^{-1}

- 7 l+jets (4 e, 3 μ)
- 2 di-lepton (ee, eμ)



$p_T(e)$=41 GeV
E_T^{miss}=89 GeV
4 jets with ≥20 GeV
$m_T(W)$=68 GeV
M_{jjj}=106 GeV

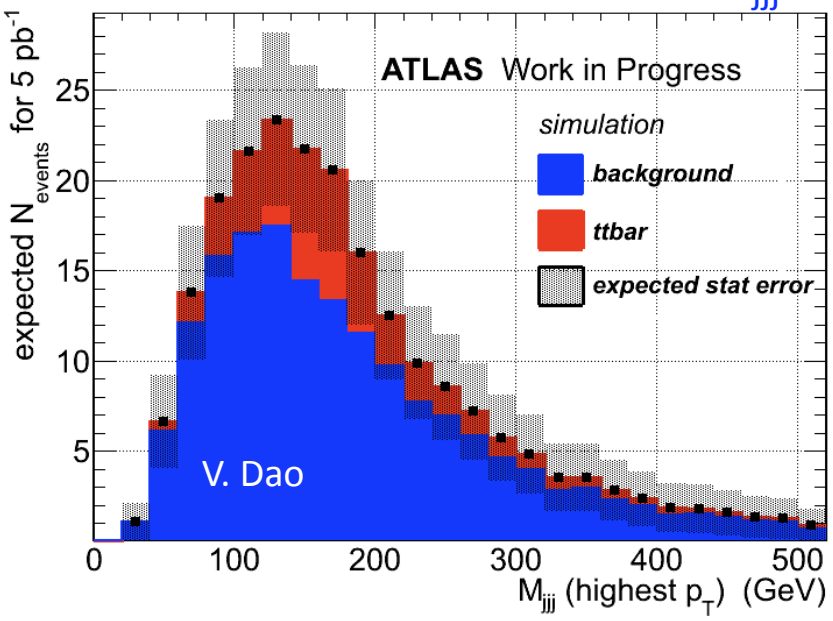




Towards a top cross-section measurement

- Soft QCD group of Uni Geneva moving to top physics
- Main contribution so far: definition and implementation of a common ntuple to be directly produced at Tier-1 (now moving forward the testing stage)
- Concentrate on lepton+jets final state, in particular on kinematic fitting (signal extraction without b-tagging)

Three-jet invariant mass: M_{jjj}

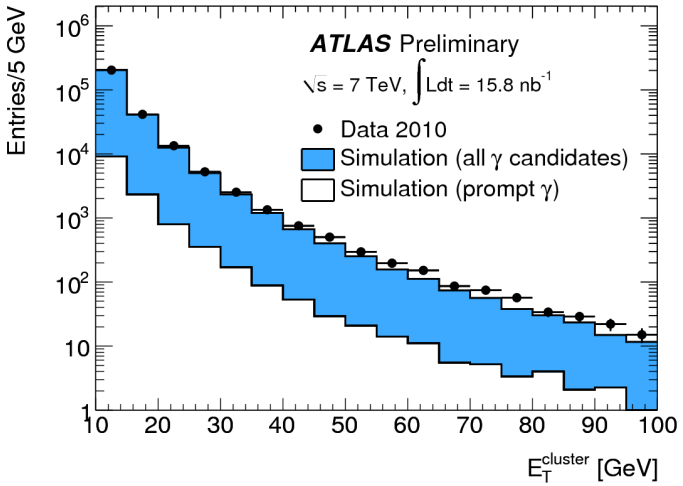


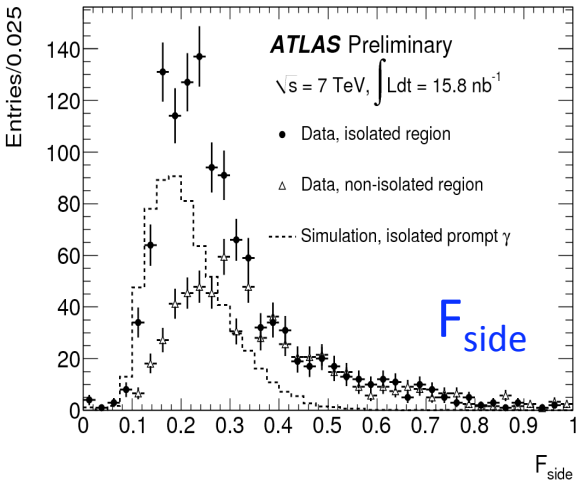
$N_{jets} \geq 4$ ($p_T > 20$ GeV)
No b-tagging requirement

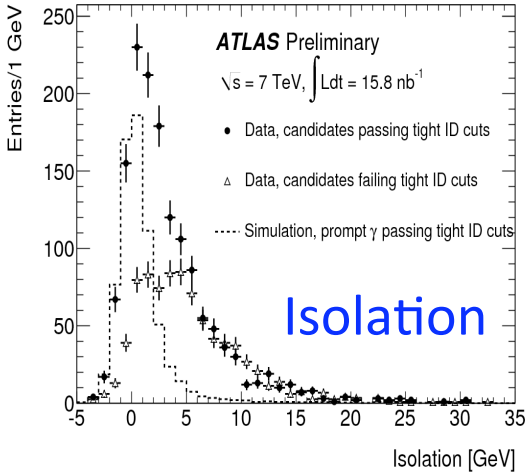
Prompt photons

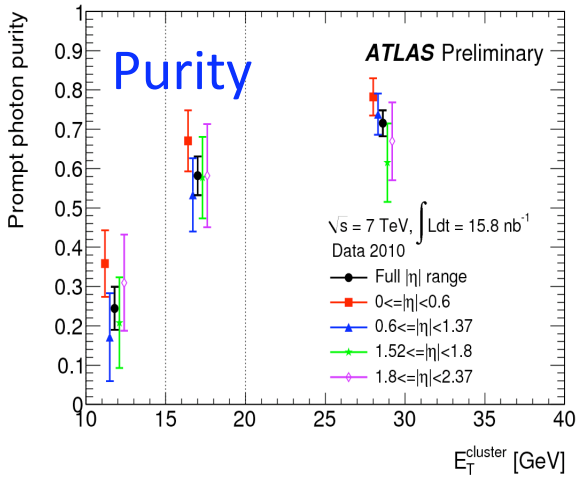
- Test perturbative QCD predictions
- Constrain parton structure functions
- Searches for Higgs, SUSY, BSM signatures
- Prompt photons:
  - hard scattering,
  - QED radiation off quarks,
  - quark/gluon fragmentation
- Suppress background photons from hadron decays (π^0, η…) by isolation requirements
- Extract signal with 2D sideband subtraction

E_T spectrum after preselection





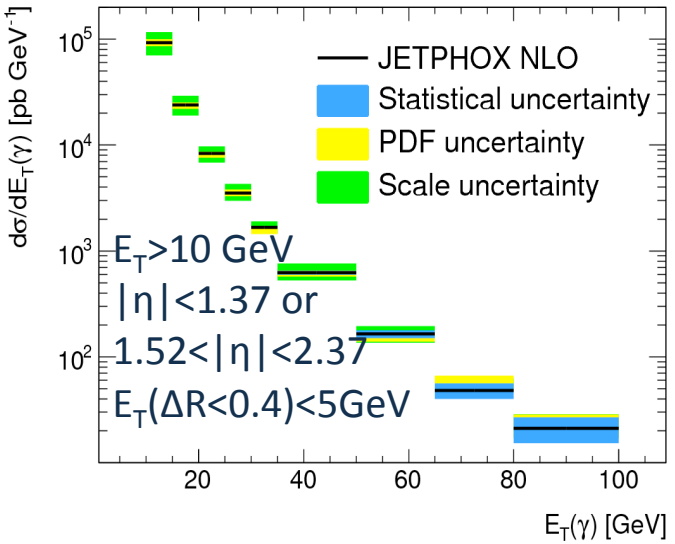




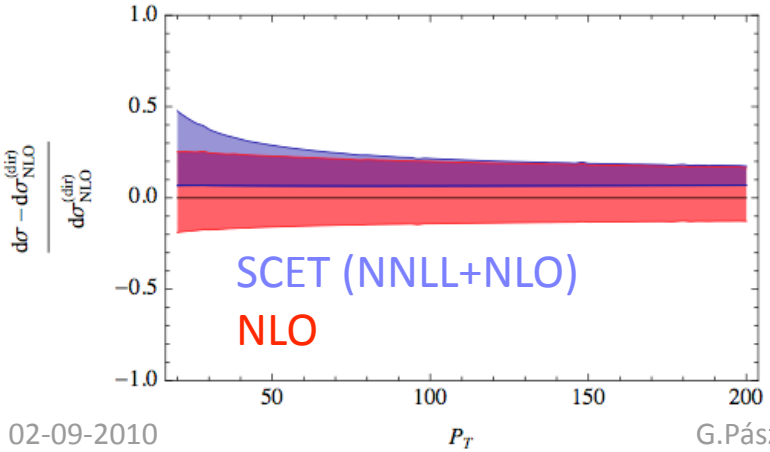
Prompt photon cross-section

- Dominant theoretical error: scale uncertainty
- Using Soft Collinear Effective Theory (SCET), the scale uncertainty can be reduced on the direct component of the cross section (T. Becher (Bern), M. Schwartz, JHEP02(2010)040)
- To be able to compare SCET NNLL results to ATLAS data, the direct component of SCET must be combined with the fragmentation component from JetPhox (NLO).

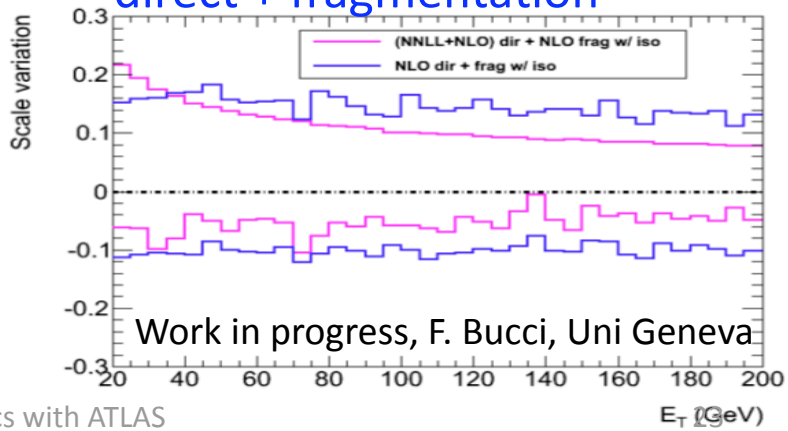
NLO cross-section prediction



Scale uncertainty on direct component

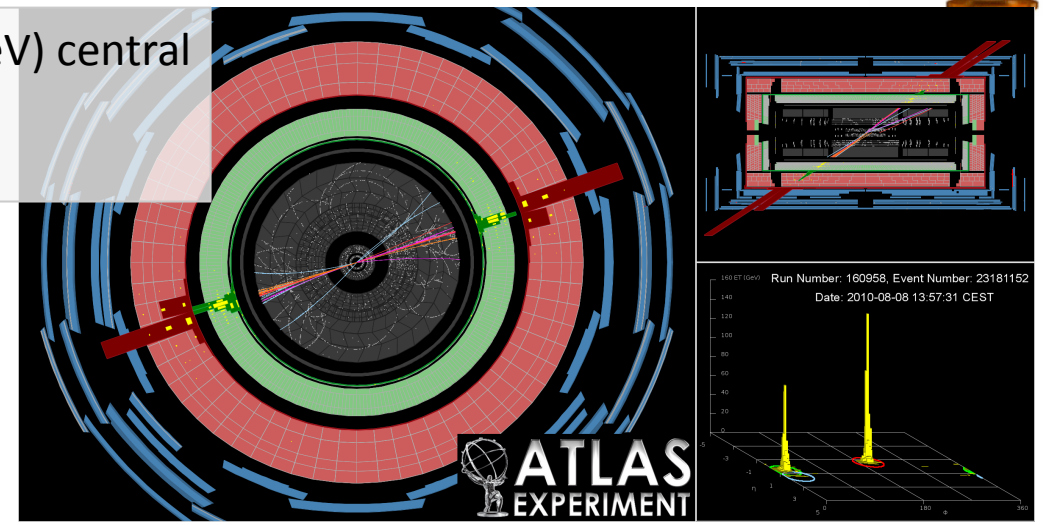


Preliminary combination of direct + fragmentation



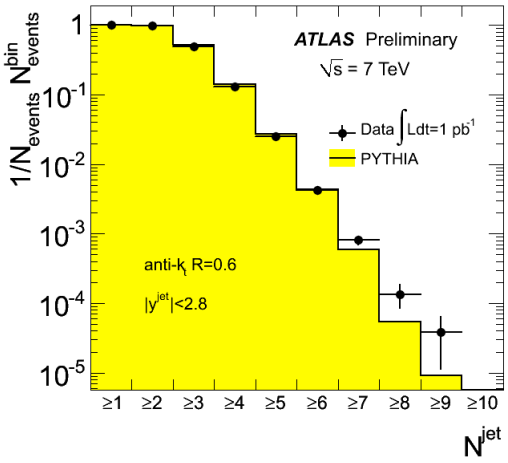
High-p_T jet production

Highest-mass (1.9 TeV) central dijet event so far: $p_{T,jet}$=890, 760 GeV

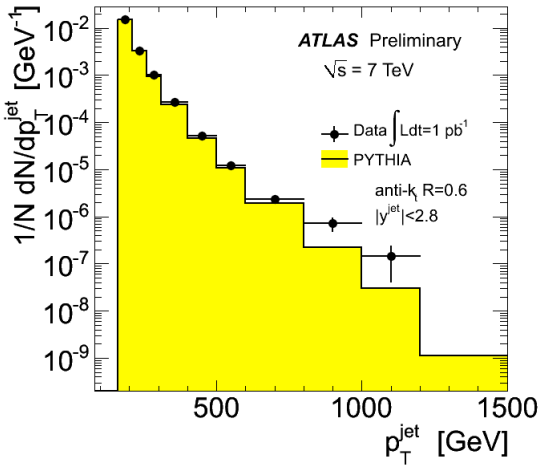


- Jets: anti-k_T with R=0.6
- Leading jet p_T>160 GeV
- Other jets p_T>40 GeV

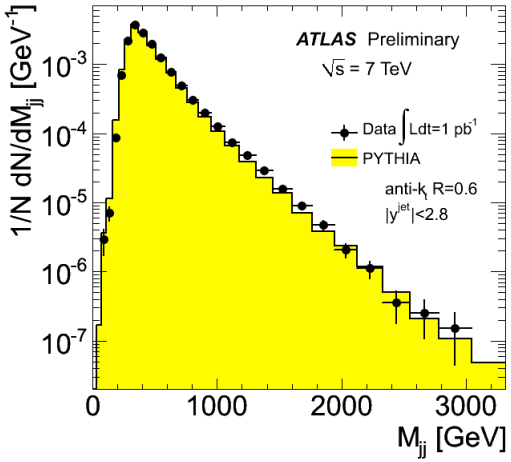
Jet multiplicity



Jet p_T

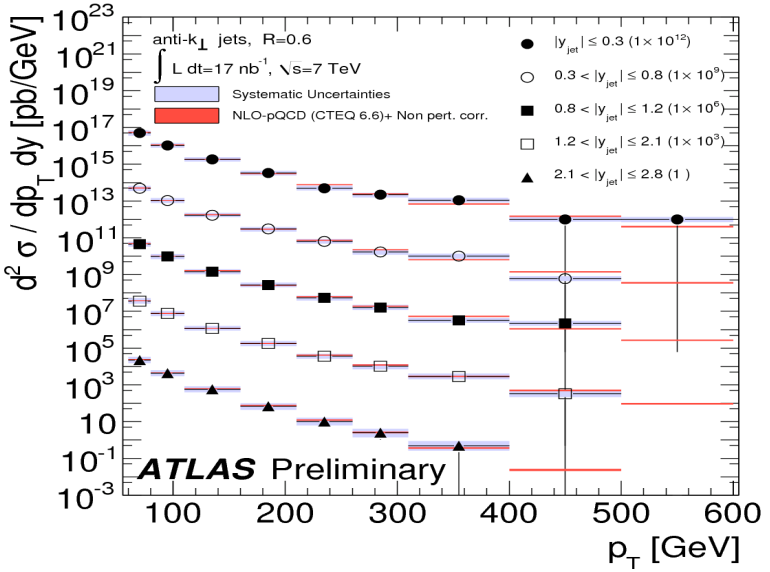


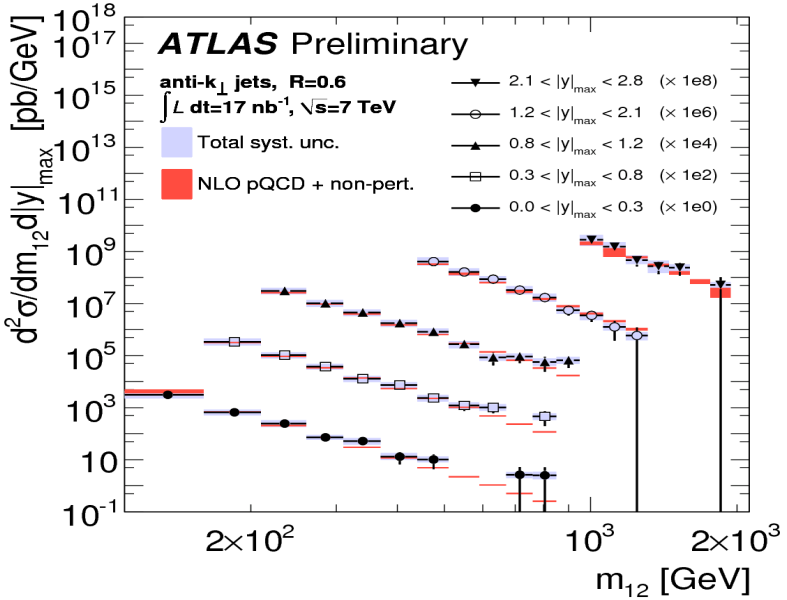
Dijet mass



Jet production cross-sections

- Measured jets corrected to particle level using parton shower MC (Pythia, Herwig)
- NLO QCD prediction corrected for hadronization and underlying event
- Theory uncertainty (PDF, α_s, scales μ_R, μ_F): ~20%, up to 40% at large y
- Experimental uncertainty (dominated by jet energy scale, known to 7%): ~30-40%
- Luminosity uncertainty (11%) not included
- Data and theory are consistent in all rapidity regions over wide range of jet p_T and dijet mass → look for new physics in jet final states





Summary

- The understanding of our detector is well advanced at this initial stage
- First physics results include
  - Cross-section measurements of J/ψ, W, Z, jets…
  - Observation of prompt photons, leptons from heavy flavour decays, top quark candidates…
  - Searches for dijet resonances, W', SUSY …
- Swiss groups provide important contributions to first ATLAS results
- Now focus on publication of these results and the analysis of the full recorded data set
- 2010 was a very exciting year so far… we are looking forward to even more excitement: more and more precise measurements, and hopefully discoveries