Standard Model results from ATLAS

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on behalf of the ATLAS collaboration

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Hadron Structure '11
Tatranská Štrba

Why SM ?

- “Re-discovery” of known particles
 - good exercise of analysis with increasing integrated luminosity
- Precise measurement in the standard model
 - check of detector performance
 - validation of the SM prediction in the energy frontier
 - perturbative QCD at NLO
 - background estimation for searches
 - direct/indirect search for beyond SM

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 - dijet / multi-jet production

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 - Electroweak ★
 - inclusive W/Z cross section measurements
 - W/Z + jets
 - diboson production

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 - diboson production
 - Top ★
 - pair production cross section, mass measurement
 - single top quark production

LHC and ATLAS

LHC

- Large Hadron Collider

- The world's largest and highest energy proton-proton (Pb-Pb) collider at CERN (Geneva, Switzerland)
 - circumference: 27 km
 - max. energy: 7+7 TeV (p-p)

- 4+2 experiments

- ATLAS, CMS
 - general purpose
- LHC-B
 - B physics
- ALICE
 - Heavy Ion collision
- LHCf, TOTEM
 - forward particles
 - total cross section

LHC status

- 2010/2011 run
 - $\sqrt{s} : 3.5+3.5 = 7\text{TeV}$
- peak luminosity
 - $2.1 \times 10^{32} / 1.3 \times 10^{33} \text{ cm}^{-2} \text{ s}^{-1}$
- integrated luminosity
 - $45 / \sim 1100 \text{ pb}^{-1}$

✓ reached 1fb^{-1} !!

Parameter	2010	2011	Nominal
Beam energy	3.5 TeV	3.5 TeV	7 TeV
Beam squeeze	3.5 m	<1.5m	0.55 m
Transverse emittance	2-3 $\mu\text{m rad}$	2.5 $\mu\text{m rad}$	3.75 $\mu\text{m rad}$
Protons per bunch	up to 1.2×10^{11}	1.2×10^{11}	1.15×10^{11}
Bunch separation	150 ns	50 ns	25 ns
Number of bunches	368	>1000	2808
max peak luminosity ($\text{cm}^{-2}\text{s}^{-1}$)	2.1×10^{32}	1.3×10^{33}	$>10^{34}$

ATLAS

- A Toroidal LHC ApparatuS

- multipurpose detector designed to cover all the expected physics channels at the TeV energy scale

- Collaboration

- ~ 3000 scientists
 - more than 1000 PhD students
- 174 institutions
- 38 countries

- The ATLAS detector

- weight: ~ 7000 tons
- height: 25m
- length: 45m
- ~ 10^8 channels
 - (90% in the tracker)

Jet production

What are Jets ?

- Collimated bunches of stable hadrons
 - originating from partons (quarks & gluons) after fragmentation/hadronization
- Difficulty in the jet measurement
 - need to understand every stage
 - Prediction by theory
 - parton distribution
 - ✓ quark/gluon
 - hadronization
 - Jet Finding
 - approximate attempts to reverse-engineer the quantum mechanical processes of hadronization
 - Calorimeter response
 - in the EM scale
 - to hadrons

Jet reconstruction

- **Constituent** : input for reconstruction
 - **TopoCluster** : 3D, default
 - 4-2-0 noise suppression using pedestal σ
 - **TopoTower** : 2D
 - w/ noise suppression
 - **(Tower)**
 - w/o noise suppression

- **Anti- k_T algorithm**
 - **infrared-safe** and **Collinear-safe**

- based on the distance measures:

$$d_{ij} = \min(k_{Ti}^{2p}, k_{Tj}^{2p}) \frac{\Delta_{ij}}{R} \quad p = -1 : \text{anti-}k_T$$

$$\Delta_{ij}^2 = (y_i - y_j)^2 + (\phi_i - \phi_j)^2$$

- ✓ between two constituents

$$d_{iB} = k_{Ti}^{2p}$$

- ✓ between any constituents and the beam

- **ATLAS: Anti- k_T TopoCluster jet with $R=0.4, 0.6$**
 - larger size jet study ongoing

arXiv: 0802.1189,
M. Cacciari, G.P. Salam, G. Soyez

1. compute all distances and find the smallest one
- 2-a. if d_{ij} , recombine i and j
- 2-b. if d_{iB} , i is a jet
3. sequentially repeat 1-2

Event display

- a dijet event in 2010 with the highest invariant mass

Jet calibration

- Calibration constant : “jet energy scale” (JES)
 - derived from Monte Carlo (MC) truth information
 - (η, p_T) dependent correction factor for $E_{\text{true}}/E_{\text{calo}}^{\text{EM}}$
- EM+JES
 - default calibration
 - well understood uncertainty
- JES uncertainty (for 2010 data)
 - based on single hadron response method
 - MC model dependence
 - extension to forward region
 - η -intercalibration
 - Pile-up
 - energy from other primary vertices

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Jet production measurements

- Results in 2010 data (36-37 pb⁻¹)
 - Inclusive jet cross section
 - Dijet production
 - B-jet production
 - Dijet azimuthal decorrelation
 - Dijet production with a jet veto
 - Multi-jet production (2.43 pb⁻¹)
 - Jet mass and substructure
 - ...

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 - ...
- Skipped results and details
 - <https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/CONFNOTES/>

Inclusive jet cross section

- Event selection
 - at least 1 primary vertex
 - single jet trigger
 - jet quality selection criteria
 - to remove non-collision jets
- Theoretical predictions
 - NLO calculations (NLOJET++ 4.1.2 + Applgrid) with non-perturbative corrections (Pythia, AMBT1)
 - NLO parton shower MC using POWHEG
 - uncertainties in predictions
 - PDF
 - factorisation (hadronization)
 - renormalisation scale
 - α_s
- Unfolding
 - to recover true distribution of jet p_T calculating migration of jets
 - bin-by-bin using MC
- Results in 2010 data (37pb^{-1})
 - e.g.) anti- k_T $R=0.6$
 - $p_T > 20\text{GeV}$, $|y| < 4.4$
 - good agreement over 9 orders of magnitude !!

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Dijet cross section

- Double-differential dijet cross section
 - $p_{T1} > 30 \text{ GeV}, p_{T2} > 20 \text{ GeV}$
 - $|y| < 2.8$
- Systematic uncertainty
 - $\sim 20\%$

Dijet azimuthal decorrelation

- $\Delta\phi$ of leading jets
 - depends on number of partons
 - ✓ sensitive test of QCD predictions
- Uncertainties
 - JES: 2-17%
 - unfolding: 1-19%
 - jet energy and position resolution: 0.5-5%

- Results
 - relatively good agreement with similar size of uncertainties in data and theory

arXiv:1102.2696, published in PRL

Multi-jet production

- **Motivation**

- multi-jet probe higher-order perturbative QCD
- cross section ratios are calculated at NLO and can be used to extract α_s
- understand as a background source to searches

- **Inclusive jet multiplicity**

- JES is the dominant systematic uncertainty
- **Ratio of the n-jet cross section to the (n-1) jet cross section**
 - systematics reduced
 - Alpgen describes better than Pythia

- **Differential cross section vs. H_T**

- scalar sum of the p_T of the selected jets
 - e.g. $(\geq 3 \text{ jets})/(\geq 2 \text{ jets})$
 - Pythia

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Electroweak Bosons

W/Z production measurements

- W/Z production cross section
 - cross section ratios
- Properties
 - W charge asymmetry
 - $Z \rightarrow \tau\tau$ measurement
- Production associated with jets
 - W + jets
 - Z + jets
- Diboson production
 - $W\gamma$ / $Z\gamma$ production
 - WW production
 - WZ production

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W/Z production cross section

- Inclusive cross section measurement
- Event selection
 - $W \rightarrow \ell \nu$
 - $p_T^\ell > 20$ GeV
 - $p_T^\nu > 25$ GeV
 - $m_T > 40$ GeV
 - $Z \rightarrow \ell \ell$
 - $p_T^\ell > 20$ GeV
 - $66 < m_{\ell\ell} < 116$ GeV
 - extended to one forward electron
 - $2.5 < |\eta| < 4.9$
- Background estimation
 - QCD background
 - data-driven methods
 - EW background
 - based on MC predictions

Results

	$\sigma_{W(\pm)}^{\text{tot}} \cdot \text{BR}(W \rightarrow \ell \nu)$ [nb]
W^+	$6.257 \pm 0.017(\text{sta}) \pm 0.152(\text{sys}) \pm 0.213(\text{lum}) \pm 0.188(\text{acc})$
W^-	$4.149 \pm 0.014(\text{sta}) \pm 0.102(\text{sys}) \pm 0.141(\text{lum}) \pm 0.124(\text{acc})$
W	$10.391 \pm 0.022(\text{sta}) \pm 0.238(\text{sys}) \pm 0.353(\text{lum}) \pm 0.312(\text{acc})$
	$\sigma_{Z/\gamma^*}^{\text{tot}} \cdot \text{BR}(Z/\gamma^* \rightarrow \ell\ell)$ [nb], $66 < m_{\ell\ell} < 116$ GeV
Z/γ^*	$0.945 \pm 0.006(\text{sta}) \pm 0.011(\text{sys}) \pm 0.032(\text{lum}) \pm 0.038(\text{acc})$

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W/Z cross section ratios

- Systematic uncertainties

- luminosity: 3.4 %
- acceptance corrections: 3-4%
- E_T^{miss} requirement: 2%
- electron ID: 1-2%

- Results

- good agreement with theoretical prediction in NNLO QCD

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W + jets

- Motivation of W(Z) + jets measurements
 - very powerful tool to test pQCD
 - important background for Higgs/SUSY searches
- Signal selection
 - leptons: similar to inclusive measurement
 - jet definition
 - anti- k_T with $R=0.4$
 - $|y_{\text{jet}}| < 2.8$
 - $p_T > 20$ GeV
 - lepton/jet overlap removal
 - $\Delta R < 0.5$
 - pile-up jets are rejected by jet-vertex-fraction (JVF):
 - $\Sigma p_T(\text{tracks})$ from other primary vertices
- Main backgrounds
 - QCD
 - top : electron channel
- Dominating systematic
 - JES : 10-20 %
- Results
 - very good agreement between data and pQCD predictions

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$W\gamma / Z\gamma$ production

arXiv: 1106.1592, submitted to JHEP

Characteristics

- sensitive to $WW\gamma$
 - triple gauge boson coupling (TGC) vertex
- γ from ISR+ $WW\gamma$ survive at high- p_T cut
- cross section can not be well defined without fragmentation photon contribution

Signal selection

- similar selection to one in inclusive W/Z analysis
- tight quality isolated photon
 - $|\eta| < 2.5$, $dR(e/\mu, \gamma) > 0.7$, $p_T > 15\text{ GeV}$

Main backgrounds

- W/Z + jets, where one jet is mis-identified as a γ

Result in 2010 data

- good agreement between data and SM prediction

WW production

Signal selection

- $p_T(\text{lepton}) > 20 \text{ GeV}$
- E_T^{miss}
 - $> 40 \text{ GeV}$ ee/ $\mu\mu$
 - $> 20 \text{ GeV}$ e μ
- Veto $|m_{ll} - m_Z| < 10 \text{ GeV}$
- Veto jets with $p_T(\text{jet}) > 20 \text{ GeV}$ in $|\eta| < 3$

Backgrounds

- Drell-Yan + fake E_T^{miss}
- other dibosons
- W+jets with a jet faking a lepton
- tt-bar with two lost b-jets

Results in 2010 data

- statistically dominated
 - 8 events observed
 - expectation
 - ✓ 6.85 signal
 - ✓ 1.68 BG
- p-value
 - $1.72 \pm 0.37 \pm 0.45 : 3\sigma$
- $\sigma_{WW} = 41^{+20}_{-16}(\text{stat.}) \pm 5(\text{syst.}) \pm 1(\text{lumi.}) \text{ pb}$
 - prediction: $44 \pm 3(\text{syst.}) \text{ pb}$

arXiv: 1104.5225, submitted to PRL

WZ production

- **Signal selection**

- at least 3 leptons, Z candidate two leptons with
 - $|M_{ll} - M_Z| < 10 \text{ GeV}$
- $E_T^{\text{miss}} > 25 \text{ GeV}$
- W transverse mass $M_T(l_3, E_T) > 20 \text{ GeV}$

- **Main background sources**

- 3 hard leptons mainly from ZZ events
- 2 hard leptons (Z, WW, top) + a 3rd one coming from a jet faking a lepton
 - heavy quark decay, decay in flight
- 1 hard lepton and 2 leptons from fake or heavy flavor decay

- **Results with 205 pb⁻¹ in 2011 data**

- $\sigma_{WZ}^{\text{tot}} = 18^{+7}_{-6} \text{ (stat.)} \pm 3 \text{ (syst.)} \pm 1 \text{ (lumi.) pb}$
 - prediction: $16.9^{+1.2}_{-0.8} \text{ (syst.) pb}$

✓ good agreement with the SM expectation

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Summary of W/Z production

- ATLAS W and Z results with the 2010 dataset (31-35 pb⁻¹)

- **Conclusions**

- ▶ important tests of pQCD, constraints for PDFs
 - ▶ W and Z bosons have been observed using electron, muon and tau channels
 - ▶ demonstrated good performance and understanding of the detector
 - ▶ results show good agreement with SM expectations

- 2011 data

- ▶ dramatically improves statistics, and allows precision measurements
 - ▶ W/Z already measured in 2011 data

Top quark

Top events

- Top decay in the SM
 - $\text{Br}(t \rightarrow Wb) \approx 100\%$
- Challenging signature
 - multiple leptons & jets
 - missing E_T
- $(t \bar{t})$ decay signatures characterized by W decays
 - all-Hadronic
 - $\text{Br} \sim 45\%$
 - large QCD background
 - no significance yet
 - lepton + jets
 - $\text{Br} \sim 30\%$
 - moderate backgrounds
 - dilepton
 - $\text{Br} \sim 5\%$
 - very clean
- Dominant backgrounds for leptonic channels
 - $W/Z + \text{jets}$
 - QCD jets
- Signal
 - event selection
 - high- p_T leptons, ≥ 3 jets, E_T^{miss} , transverse mass
 - multi-region fit : $(e, \mu) + n\text{jets}$

Top results

- Top pair production
 - single lepton
 - dilepton
 - summary of cross section measurements
- Top quark mass measurement
- W polarization in top decays
- Single top production

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Top pair production

- **single lepton + jets**
 - **analysis 1: without b-tagging**
 - fit of projective likelihood based on uncorrelated variables
 - lepton η , lepton charge, ...
 - **analysis 2: with “continuous” b-tagging**
 - profile likelihood fit extracts 16 parameters including $\sigma_{t\bar{t}}$
- **Results in 2010 data**
 - **without b-tagging**
 - $\sigma_{t\bar{t}} = 171 \pm 17(\text{stat})^{+20}_{-17}(\text{syst}) \pm 6(\text{lumi}) \text{ pb}$
 - **with b-tagging**
 - $\sigma_{t\bar{t}} = 186 \pm 10(\text{stat})^{+21}_{-20}(\text{syst}) \pm 6(\text{lumi}) \text{ pb}$
- **Uncertainty**
 - **JES dominated: 13-15 %**
 - improvements expected in 2011

ATLAS-CONF-2011-023

ATLAS-CONF-2011-035

Top cross section

- Combined result in 2010 data
 - lepton + jets and dilepton analyses on the level of likelihood functions

► $\sigma_{t\bar{t}} = 180 \pm 9(\text{stat.}) \pm 15(\text{syst.}) \pm 6(\text{lumi.}) \text{ pb}$

ATLAS-CONF-2011-040

Top quark mass measurement

- **Direct measurement**
 - **top mass: key parameter in SM**
 - high precision from Tevatron (0.6%)
- **2010 data (35pb⁻¹)**
 - **template-based analyses**
 - Lepton + jets selection
 - 1D “stabilized mass”: $R_{32} = m_t^{\text{reco}}/m_W^{\text{reco}}$
 - 1D kinematic fit
 - 2D: mass vs. Jet energy scale factor (JSF)
- **Result (e/μ combined)**
 - $m_t = 169.3 \pm 4.0(\text{stat.}) \pm 4.9(\text{syst.}) \text{ GeV}$
 - 3.7% total uncertainty
 - ✓ cf.) Tevatron $172 \pm 0.9 \pm 1.3 \text{ GeV}$

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Single top production

ATLAS-CONF-2011-088

- **t-channel production analysis**
 - **156 pb⁻¹** of 2011 ATLAS data
 - Lepton + jets final state
 - Cut-based and Neural network analysis

- **Cross section**
 - **cut based:**
 - $\sigma_t = 97^{+56}_{-30}$ pb
 - **NN based:**
 - $\sigma_t = 76^{+41}_{-21}$ pb
 - ✓ σ_t (SM) = 66 pb

- **observed (expected) significance**
 - **cut based**
 - 6.2 (5.7) σ
 - **NN based**
 - 6.3 (4.5) σ

Candidate Events

Candidate Events

Summary

- LHC

- working extremely well
- delivered more than 1 fb^{-1} in 2011

- ATLAS

- taking very good quality data
- data analysis is proceeding at very high speed

- Standard model results presented by ATLAS

- high- p_T jets
 - probe QCD to a new energy regime and larger rapidities
- electro weak bosons
 - important tests of pQCD
- top quark
 - cross section
 - mass and properties
- The overall standard prediction with pQCD shows good agreement with $\sqrt{s} = 7 \text{ TeV}$ data
 - results with 200 pb^{-1} shown

- We will have more precise SM measurements in 2011/2012 with $2 - 10 \text{ fb}^{-1}$ of integrated luminosity!!

Backup slides

Luminosity calibration

- Total 5 Van der Meer scans (I-V) in 2010
 - Previous error on luminosity calibration from the first three scans: $\sim 11\%$
 - Dominated by uncertainty on bunch current (10%)
- Understanding the beam current in the scan IV,V
 - transformers (BCTs) and improve measurement

Scan Number	I	II–III	IV–V
Fill Number	1059	1089	1386
DCCT baseline offset	3.9%	1.9%	0.1%
DCCT scale variation	2.7%	2.7%	2.7%
Bunch-to-bunch fraction	2.9%	2.9%	1.0%
Total	5.6%	4.4%	2.9%

- Result
 - $\sigma_{\text{vis}} = 41.75 \pm 1.30 \text{ mb}$
 - Total uncertainty: **3.2%**
 - significant improvement

ATLAS-CONF-2011-012

Uncertainty Source	$\delta\mathcal{L}/\mathcal{L}$
Statistical	0.1%
Bunch charge product	2.9%
Beam centering	$< 0.1\%$
Emittance growth and other non-reproducibility	0.3%
Beam position jitter	0.2%
Length scale calibration	0.3%
Absolute ID length scale	0.3%
Fit model	0.2%
Transverse correlations	0.9%
μ dependence	0.5%
Long-term consistency	0.5%
Total	3.2%

Inner Detector

- **Purpose**
 - to measure charged tracks trajectories in a 2 Tesla SC solenoidal B-field
- **3 sub-detectors: (Resolution)**
 - Pixel: 10/115 μm in $R\Phi/z$
 - Silicon strip(SCT): 17/580 μm in $R\Phi/z$
 - Transition Radiation Tracker (TRT): 130 μm in $R\Phi$
- **Coverage**
 - $|\eta| < 2.5$ (2.0 for TRT)
with 3 Pixel measurements, 8 SCT and ~ 30 TRT
- **Design**
 - $\epsilon_{\text{track}} > 90\%$ (π) and 99% (μ)
 - $\sigma_{p_T}/p_T = 0.05\% p_T \oplus 1\%$
 - $\sigma(\text{ip}) = 10\mu\text{m}$ at high momentum

Inner Detector

Envelopes		
Pixel	-----	45.5<R<242mm Z <3092mm
SCT barrel	-----	255<R<549mm Z <805mm
SCT end-cap	-----	251<R<610mm 810< Z <2797mm
TRT barrel	-----	554<R<1082mm Z <780mm
TRT end-cap	-----	617<R<1106mm 827< Z <2744mm

ID performance

- **Tracking**
 - good data/MC agreement in each detector
- **e/ π separation**
 - clearly achieved in TRT
- **primary vertex**
 - $\sigma_{x,y} \approx 30 \mu\text{m}$ with beam spot constraint
 - $\sigma_z \approx 50 \mu\text{m}$
 - Good separation within interaction region ($\sim 28\text{mm}$ in the longitudinal plane)
- **B-tagging**
 - Hadrons containing b-quarks travel a few mm before decaying
 - secondary vertices:
 - tracks with large impact parameter vs primary vertex
 - Main tool for top event selection and many Higgs/SUSY searches

track distribution

Calorimeters

- Purpose

- Energy measurement! (and if there is unbalance, i.e. E_T miss)

- Liquid Argon Calorimeter (LAr):

- Pb + LAr ionization
- coverage: $|\eta| < 4.9$
 - EM precise measurement in barrel
 - jet measurement in endcap
 - total energy measurement in the forward
- resolution
 - $\sigma_E/E = 10\%/\sqrt{E} \oplus 0.7\%$

- Tile Calorimeter (Tile):

- Fe absorber + plastic scintillator tiles
- coverage: $|\eta| < 1.7$
 - barrel + endcap
- resolution
 - $\sigma_E/E = 50\%/\sqrt{E} \oplus 3\%$
- Precise measurement of Jet energy
 - goal: JES uncertainty $\sim 1\%$

Calorimeters

Calo performance

• e/γ

- Purely electromagnetic clusters with right shape
 - π_0 , Z^0 mass
- Presence (absence) of pointing tracks

• Jet

- calibrated with MC and single charged π
 - $\sigma \sim 4\text{-}5\%$ achieved

• MET

- resolution dependence on ΣE_T
 - good data/MC agreement
 - ✓ understanding of dead material in the detector

Muon Spectrometers

- Immersed in a toroidal magnetic field (3x8 SC toroids) in air
 - $\int B dl \sim 8 \text{ Tm}$
- Precision detectors
 - Barrel
 - MDT (Monitored Drift Tubes)
 - Endcap
 - CDC (Cathode Drift Chambers)
- Trigger chambers
 - Barrel
 - RPC (Resistive Plate Ch.)
 - Endcap
 - TGC (Thin-Gap Ch.)
- coverage: $|\eta| < 2.7$

Muon Spectrometers

Combined muon performance

- Di-muon resonance
 - All known resonances found again
 - detector calibration resolution understood very well

Trigger

- **Online event selection**

- **Level-1 : Hardware**

- ▶ mainly muon spectrometers and calorimeters
 - ▶ coarse granularity
 - ▶ e/ γ , μ , π , τ , jet candidate selection
 - Define regions of interest (ROIs)

- **Level-2 : Software**

- ▶ Seeded by level-1 ROIs, full granularity
 - ▶ Inner Detector – Calo track matching

- **Event Filter: Software**

- ▶ Offline-like algorithms for physics signatures
 - ▶ Refine LV2 decision
 - ▶ Full event building

- **Rate (2010 / nominal(design))**

- Bunch crossing: 1 MHz / 40 MHz
 - Level-1: 20 kHz / 75 kHz
 - Level-2: 3.5 kHz / 1 kHz
 - EF: 300 Hz / 100 Hz

- **Challenges**

- Coping very well with rapidly increasing luminosity by adjusting pre-scales/menus
 - need to be optimize sharing of the bandwidth for physics
 - final event rate by EF will be **doubled** in 2011, skimming the data size

ATLAS detector performance

- Very stable performance despite dramatic increase in luminosity
- Fraction of operational channels
 - 90-100% depending by sub-detector
- 75-85% of delivered luminosity used for analysis with first-pass processing
 - improving in reprocessing

InnerDetector			Calorimeters				MuonSpectrometer			
Pixel	SCT	TRT	LAr EM	LAr HAD	LAr FWD	Tile	MDT	CSC	RPC	TGC
99.0	99.9	100	90.7	96.6	97.8	94.3	99.9	96.2	99.8	99.8

- ▶ Luminosity weighted relative percentage of good quality data delivery by the various ATLAS subsystems during LHC fills with stable beams in pp collisions at $\sqrt{s}=7$ TeV, and after switching the tracking detectors on.

Magnet splices and beam energy

- Missing continuity in the copper stabilizer and contact with the superconducting (SC) cable effectively reduces safe current level
 - In case of quench the cable locally acts like a “fuse” and burns out
 - Value of safe current depends on additional resistance of worst splice
 - Not all splices measured so far: it is then considered unsafe to run at more than 3.5 TeV
- Direct measurement method to be deployed by 2011 winter stop
 - “Thermal Amplifier”: measure of thermal runaway of a bad joint under a pulse of high current (order 3000A)
 - According to the results of the measurement campaign we may decide to increase beam energy in 2012

Jet Vertex Fraction

- Associate jets to **primary vertices** using **tracks** and obtain a jet-selection criterion and **jet-by-jet** energy correction
- Tracks are selected with standard quality criteria and required to be matched to a vertex
 - not required to be unique (2 mm window)
- JVF measures the fraction of charged particle transverse momentum in each jet originating in each identified primary vertex in the event.

$$JVF(\text{jet}_i, \text{vtx}_j) = \frac{\sum_k p_T(\text{trk}_k^{\text{jet}_i}, \text{vtx}_j)}{\sum_n \sum_l p_T(\text{trk}_l^{\text{jet}_i}, \text{vtx}_n)}$$

B-tagging

- Algorithms

- SV0

- lifetime tagger
 - reconstruct secondary vertex
 - cut on decay length significance

- JetProb

- lifetime tagger
 - compare impact parameter significance to resolution function
 - gives probability track originates from primary vertex
 - all tracks in a jet combined, giving P of no long-lived particles

ATLAS-CONF-2011-089

Complementary results

Inclusive jet cross section

- Double-differential cross section

- systematic uncertainty

- JES
 - unfolding
 - luminosity
 - total: ~20%

- Result in 2010 data (37pb⁻¹)

- relatively good agreement in central region
 - larger discrepancy in forward region

ATLAS-CONF-2011-047

B-jet production

- **Selection**
 - $p_T > 20 \text{ GeV}$, $|y| < 2.1$
 - secondary vertex b-tagging
- **Uncertainties**
 - JES + b-jet energy scale: 35-40%
 - b-tagging efficiency: 10-20%
- **Result in 3 pb^{-1} (full dataset in preparation)**
 - predictions in agreement with data, but slightly softer
 - Pythia (LO*)
 - POWHEG (NLO)

ATLAS-CONF-2011-056

Dijet production with a jet veto

- Events with no additional jets in rapidity interval spanned by dijet system
 - ✓ gap fraction
 - test pQCD radiation in dijet system for large Δy , high p_T
 - test wide angle soft gluon radiation (BFKL dynamics)
 - jet vetos in vector boson fusion analyses (Higgs+2 jets)
- Event selection
 - exactly 1 primary vertex
 - dijet system from 2 leading jets
 - $\bar{p}_T > 50 \text{ GeV}$, $|y| < 4.5$
 - ✓ $\bar{p}_T = (p_T^1 + p_T^2)/2$
- Systematic uncertainties
 - absolute and relative JES between jets
- Comparisons with several generators
 - Pythia 6 gives good description
 - HERWIG++ and ALPGEN overestimate gap radiation

ATLAS-CONF-2011-038

Jet mass and substructure

- Mass and substructure in **large jets** ($R=1.0$ and 1.2 are studied)
 - To identify **boosted objects** which can decay hadronically inside the jet
 - electroweak objects, Higgs
 - top
 - To define **splitting scale**
 - $\sqrt{d_{12}} = \min(p_{T_a}, p_{T_b}) \times \delta R_{a,b}$
- **Systematics**
 - JES and jet energy resolution (JER) for larger size jets
 - unfolding
- **Result for jets with $R=1.0$ (35pb^{-1} in 2010)**
 - good agreement between data and MC

ATLAS-CONF-2011-069

W charge asymmetry

- Definition of lepton charge asymmetry from W bosons

$$A_\mu = \frac{d\sigma_{W_{\mu^+}}/d\eta_\mu - d\sigma_{W_{\mu^-}}/d\eta_\mu}{d\sigma_{W_{\mu^+}}/d\eta_\mu + d\sigma_{W_{\mu^-}}/d\eta_\mu}$$

- dominant production process
 - $u\bar{d}(\bar{u}d) \rightarrow W^\pm$
 - if more valence u-quark in the proton
 - ✓ W^+ is favored over W^-
- Signal selection
 - $p_{T\mu} > 20 \text{ GeV}$
 - asymmetry as a function of η
- Dominating systematic uncertainties
 - reconstruction efficiency
 - muon trigger efficiency
 - theoretical modeling

arXiv: 1103.2929, accepted by PLB

$$Z \rightarrow \tau\tau$$

- Measured using four channels

- $Z \rightarrow \tau_\mu \tau_h$
- $Z \rightarrow \tau_e \tau_h$
- $Z \rightarrow \tau_e \tau_\mu$
- $Z \rightarrow \tau_\mu \tau_\mu$

- Main backgrounds

- $Z \rightarrow ll$
- multi-jet events

- Results

- τ reconstruction is performing well
- important step towards $H \rightarrow \tau\tau$
- combined result
 - $\sigma_Z * \text{Br}(Z \rightarrow \tau\tau)$
 $= 0.97 \pm 0.07(\text{stat.}) \pm 0.07(\text{syst.}) \pm 0.03(\text{lumi.}) \text{ nb}$
 - prediction: $0.96 \pm 0.05 \text{ nb}$
 - ✓ good agreement with SM expectations

ATLAS-CONF-2011-045 + approved plots

Z + jets

• Signal selection

- leptons, m_{ll} : similar to inclusive measurement
- jet definition
 - ▶ anti- k_T with $R=0.4$
 - ▶ $|\eta_{jet}| < 2.8$
 - ▶ $p_T > 30$ GeV
 - ▶ lepton/jet overlap removal
 - $\Delta R < 0.5$
 - ▶ pile-up jets are rejected by JVF

• Background

- dijet background for $Z \rightarrow ee$ is estimated from data
 - ▶ orthogonal control sample containing two loose electrons
 - used to determine the BG shape
 - ▶ fit the shape for each jet multiplicity separately

• Dominant systematics

- JES

• Results

- data described well with NLO qQCD

W polarization in top decays

- Probe V-A structure of Wtb vertex

- SM expectation for polarization fractions

- ▶ left-handed $F_L \approx 0.3$
- ▶ longitudinal $F_0 \approx 0.7$
- ▶ right-handed $F_R \approx 0$

- observable “ $\cos\theta^*$ ”

- ▶ decay angle of charged lepton w.r.t. top boost direction in W rest frame

- Two analysis techniques

- fit left-handed, longitudinal, right-handed templates to measured $\cos\theta^*$
- extract asymmetries (e.g. A^{FB}) from $\cos\theta^*$
 - ▶ correct back to parton level

- Results

- $F_0 = 0.59 \pm 0.12$
- $F_L = 0.41 \pm 0.12$
 - ▶ F_R fixed to 0

- Interpretation

- limits on anomalous couplings g_L, g_R

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Top pair production

Dilepton

- two cut-based analyses
 - without and with b-tag
- 2 high- p_T leptons ($ee/\mu\mu/e\mu$), ≥ 2 jets
- $ee/\mu\mu$ + jets: large missing E_T and $Z \rightarrow \ell\ell$ veto
- $e\mu$ + jets: large H_T (sum of jet and lepton p_T)
- major backgrounds
 - $Z/\gamma^* + \text{jets}$, “fake” leptons
 - (MC-assisted) data-driven estimates

Results

- combination of all dilepton channels
 - profile likelihood
- no b-tagging
 - $\sigma_{t\bar{t}} = 173 \pm 22(\text{stat.})^{+18}_{-16}(\text{syst.})^{+7}_{-6}(\text{lumi.}) \text{ pb}$
- b-tagging
 - $\sigma_{t\bar{t}} = 171 \pm 22(\text{stat.})^{+21}_{-16}(\text{syst.})^{+7}_{-6}(\text{lumi.}) \text{ pb}$

Dominant uncertainties

- JES : 5%
- parton shower model: -5%/+5%
- fake leptons : -4%/+3%

Simultaneous measurement of b-tagging efficiency

- fit to number of b-tags
 - consistent results

no b-tag: max. transverse mass

b-tag: H_T

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