First measurement of the W production cross-section and its charge asymmetry with the ATLAS experiment

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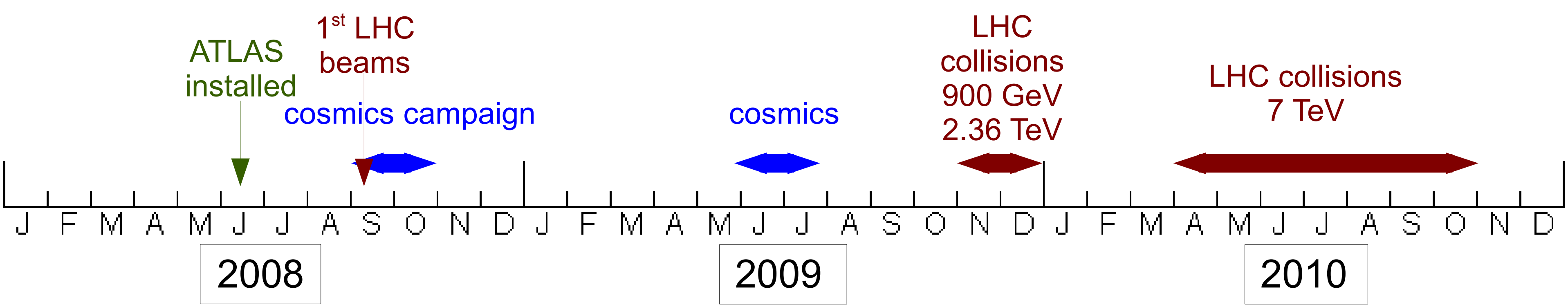
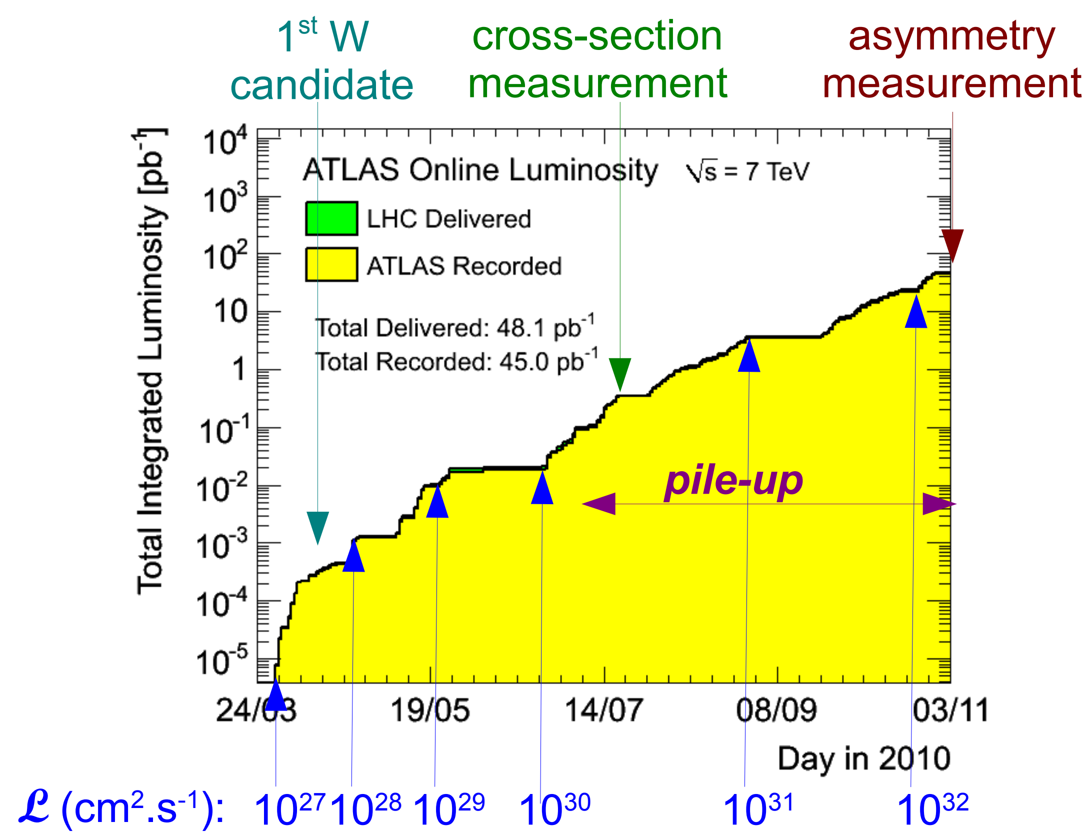
Séminaire des thésards de 3ème année

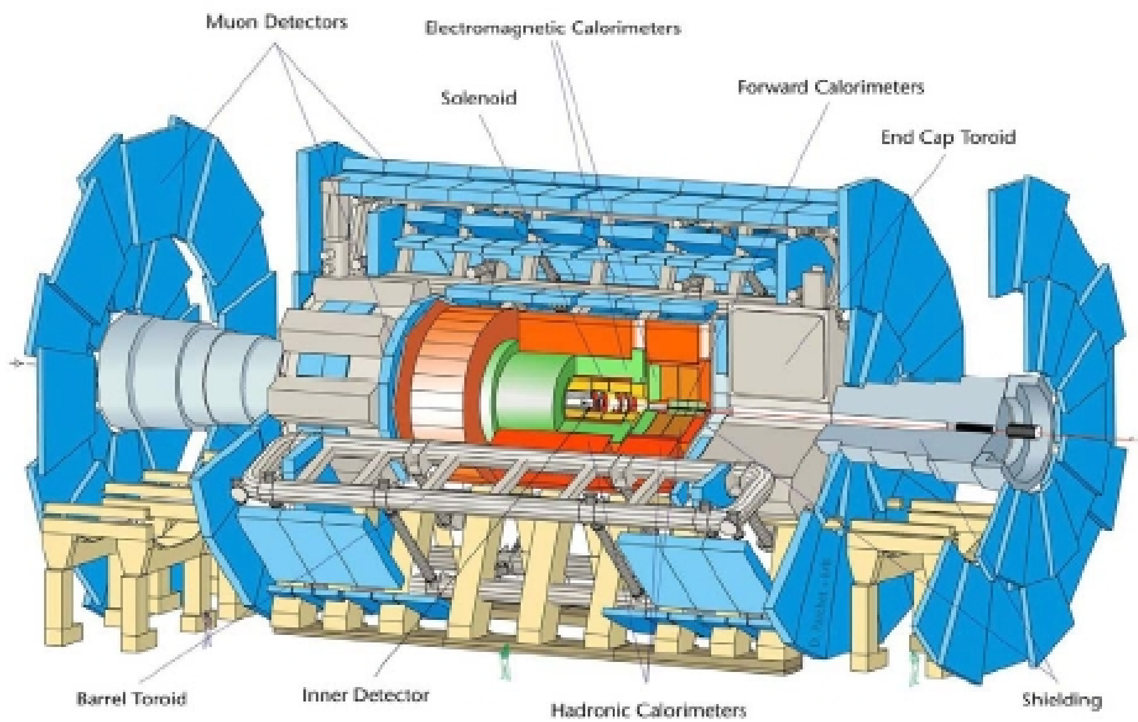
Introduction



- Outline:
  - Commissioning of E_T^{miss} and calorimeters
  - First measurement of σ(W)
  - W charge asymmetry measurement



The ATLAS experiment



	Inner detector, $\|\eta\| < 2.5$		
	Pixel	SCT	TRT
# channels	80 M	6.3 M	350 k
operational	97.3%	99.2%	97.1%

Calorimeter system, $\|\eta\| < 4.9$			
LAr EM	LAr HEC	LAr FCal	Tile
170 k	5,6 k	3,5 k	9,8 k
97.9%	99,9%	100,0%	96.8%

Muon spectrometer, $\|\eta\| < 2.7$			
MDT	CSC	RPC	TGC
350 k	31 k	370 k	320 k
99.5%	98.5%	97.0%	96.8%

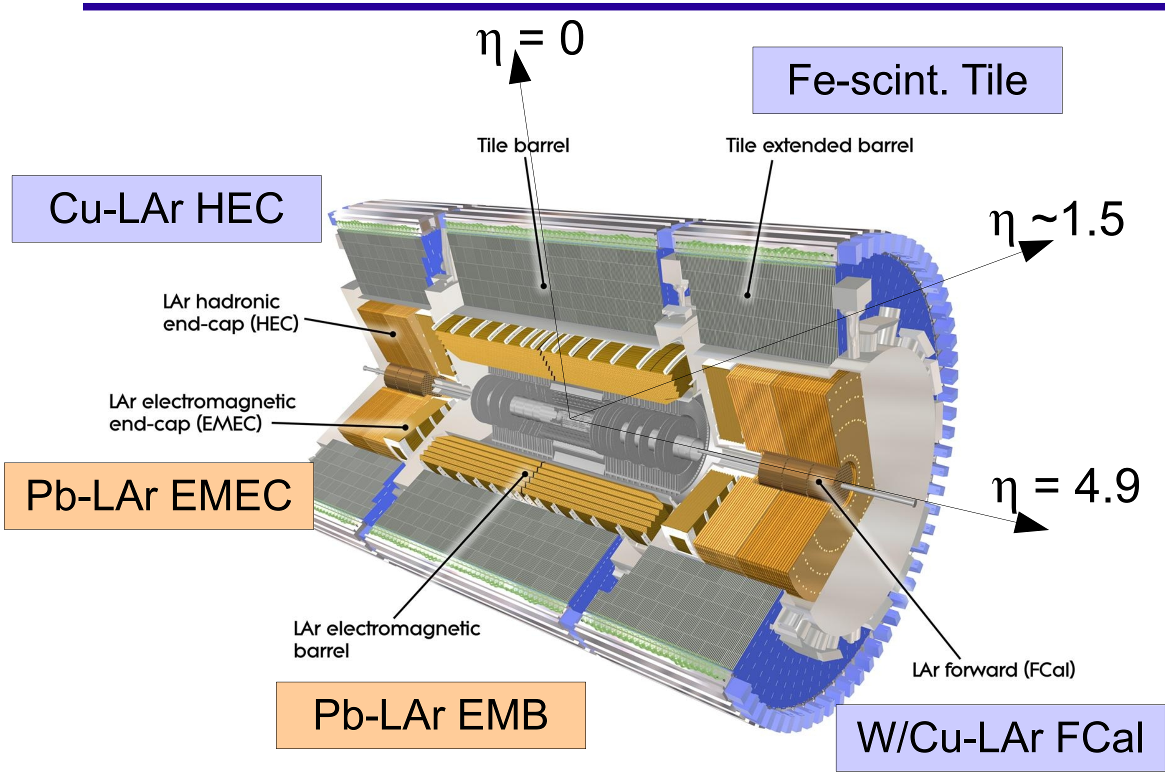
- ♦ Installation finished in June 2008
  - *in situ* commissioning since then
- ♦ Fraction of data available for physics in 2010:

Inner Tracking Detectors			Calorimeters				Muon Detectors			
Pixel	SCT	TRT	LAr EM	LAr HAD	LAr FWD	Tile	MDT	RPC	CSC	TGC
99.1	99.9	100	90.7	96.6	97.8	100	99.9	99.8	96.2	99.8

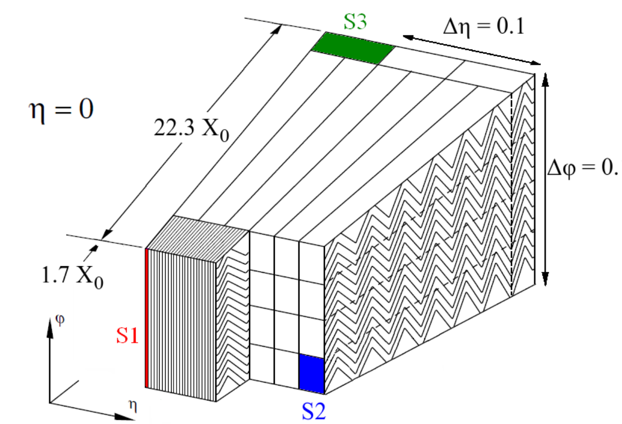
Luminosity weighted relative detector uptime and good quality data delivery during 2010 stable beams in pp collisions at $\sqrt{s}$=7 TeV between March 30th and October 31st (in %). The inefficiencies in the LAr calorimeter will partially be recovered in the future.

➔ Excellent behaviour of all subdetectors

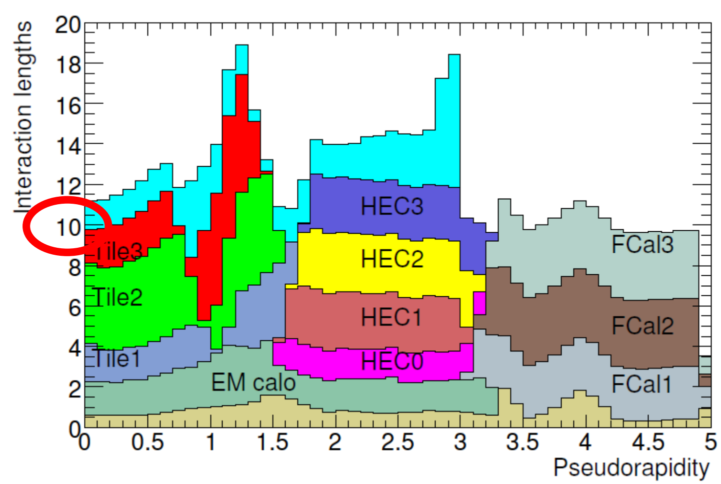
The calorimeter system (1)



- EM calorimeters
  - up-to η = 3.2
  - high granularity (173312 cells)
  - hermetic in φ (accordion)

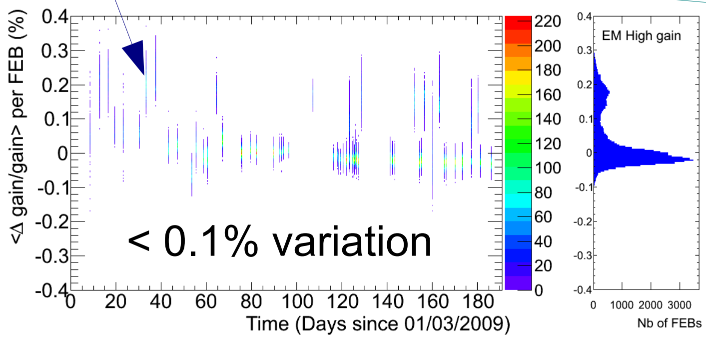


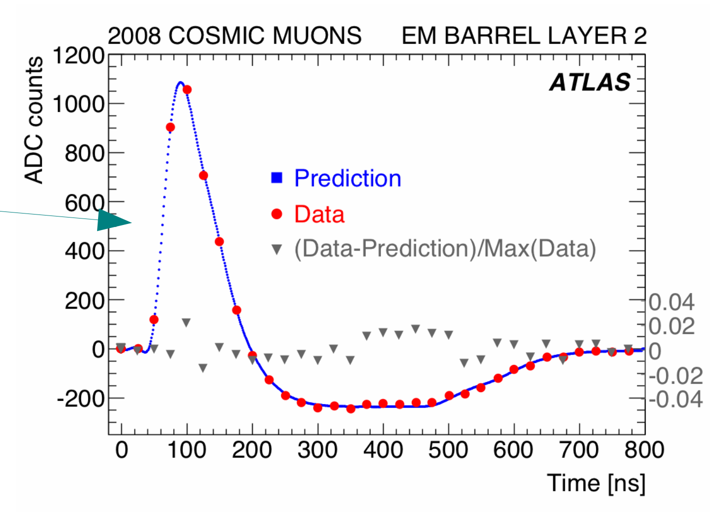
- HAD calorimeters
  - up-to η = 4.9 (~ 0.1°)
  - hermetic in η (λ ~ 10)
  - 14336 cells



The calorimeter system (2)

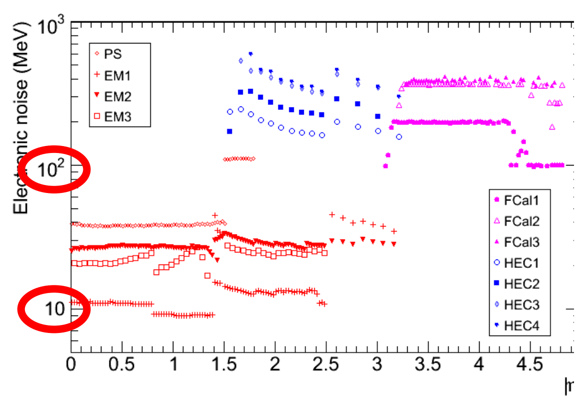
- Cell energy reconstruction checked with test-beams (2000-2005) and cosmics (2008-2009)
  - $E_{cell} \propto G \sum_{i=1}^{5} a_i (s_i - p)$

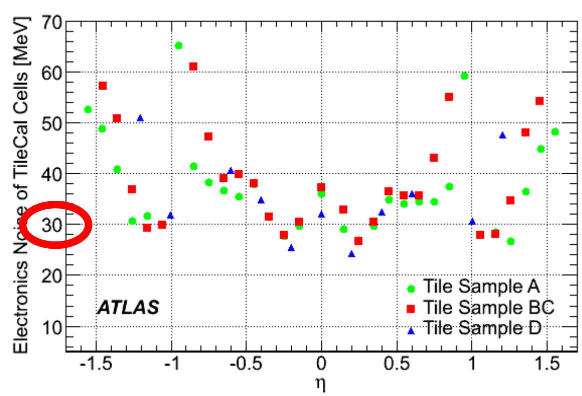




- Noise stable (few %) and under control

LAr





Tile

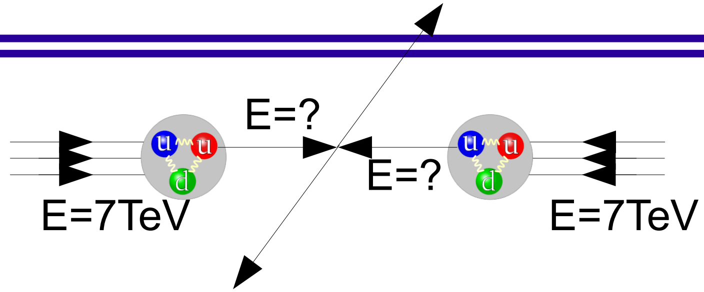
➔ Energy response constantly checked in ~200000 cells

Part I :

E_T^{miss} commissioning

Importance of E_T^{miss}

- **Hadronic** collider
  => conservation of transverse momentum only (E_T^{miss})

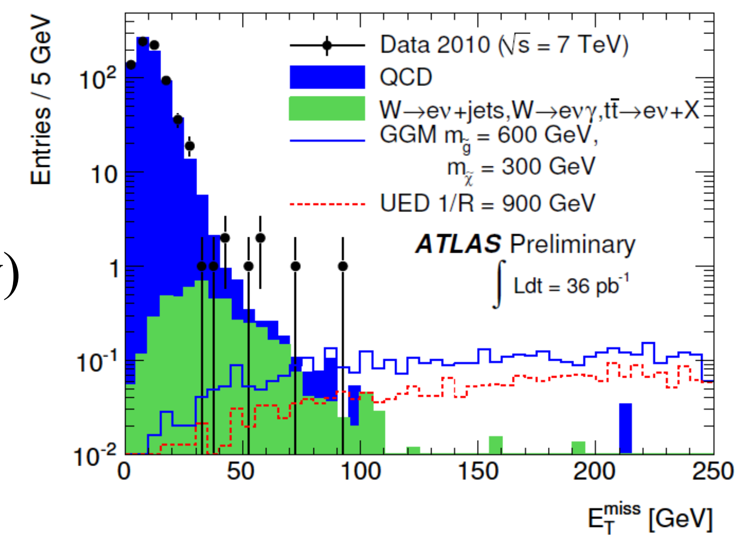


- To reconstruct **standard model candles** with neutrinos in final state ($E_T^{\nu} = E_T^{miss}$) :
  - τ lepton ($\tau \rightarrow$ jet + ν_τ, $\tau \rightarrow$ l + ν_l + ν_τ)
  - W bosons
  - top quark

➔ reconstruction and calibration

- To search for **new physics** with non-interacting particles:
  - SUSY (Higgs boson (H/A ➔ $\tau\tau$), supersymmetry)
  - Heavy jauge bosons (W')
  - Extradimensions (graviton)

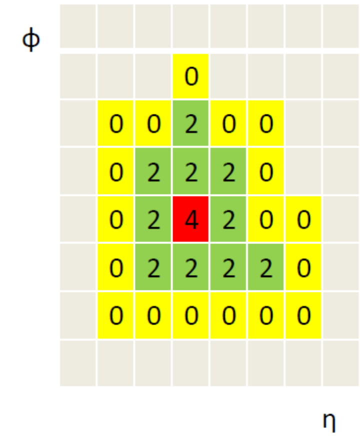
➔ control tails



⇒Missing E_T is a key signature to discover new physics

E_T^{miss} reconstruction

- Variables of E_T^{miss}:
  - scalar sum of transverse energy: $\mathbf{\Sigma E_T}$
  - opposite of vectorial transverse energy sum projected on x, y-axis: $\mathbf{E_{X,Y}^{miss}}$
  - module: $E_T^{miss} = \sqrt{E_X^{miss2} + E_Y^{miss2}} = \mathbf{E_T^{miss,Calorimeter}} + E_T^{miss,DeadMaterial} + E_T^{miss,Muon}$
  - direction: $\boldsymbol{\varphi}^{\mathbf{miss}} = \mathrm{atan}(E_Y^{miss}/E_X^{miss})$

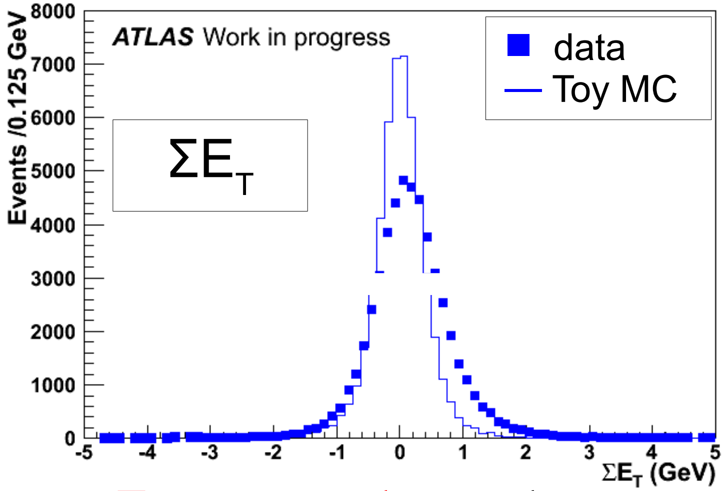


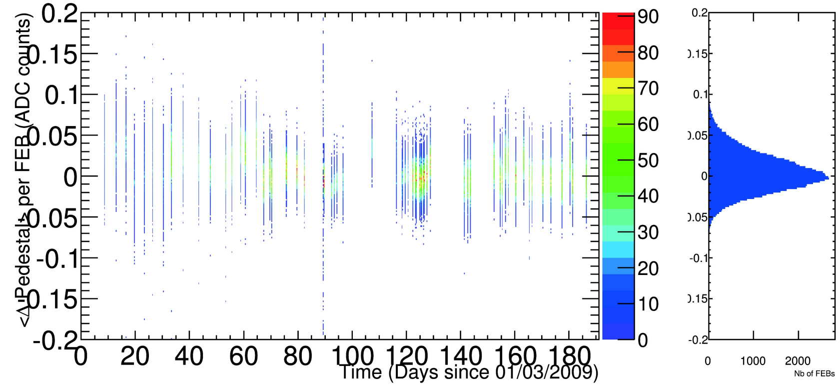
- Calorimeter noise reduction:
  - 3-D topoclusters
  - $|E|>4*\sigma_{noise}$ seed, $|E|>2*\sigma$ neighbours, $|E|>0*\sigma$ boundaries
  - need to tag noisy cells

- Commissioning of E_T^{miss} with 2008/2010 data:
  - Study at **EM scale**
  - Random events: *(600 k events)* — $<E_X^{miss}> = <E_Y^{miss}> = 0, <\Sigma E_T> = 0$
  - Minimum bias events: *(500 k events at 900 GeV 34 M events at 7 TeV)* — $<E_X^{miss}> = <E_Y^{miss}> = 0$, ΣE_T in [0;250] GeV

E_T^{miss} reconstruction in RNDM events

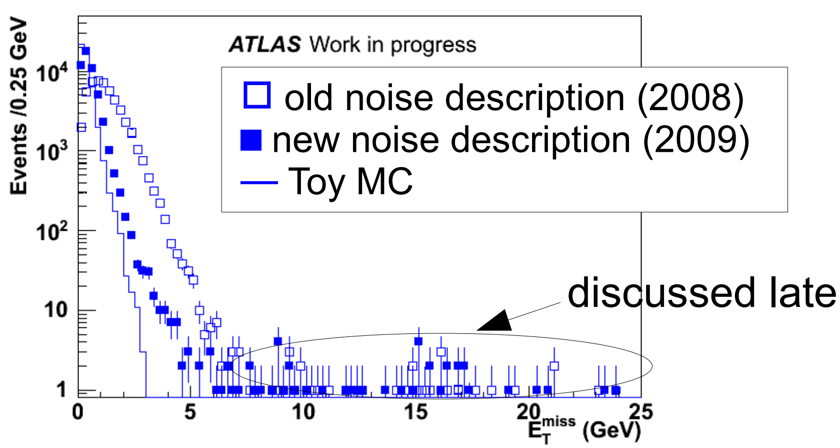
- Use E_T^{miss} to commission the calorimeters
- Cell pedestals understood:





  – ΣE_T centered on 0, because stable pedestals (1 MeV shift /cell ⇒ 1 GeV shift of ΣE_T)

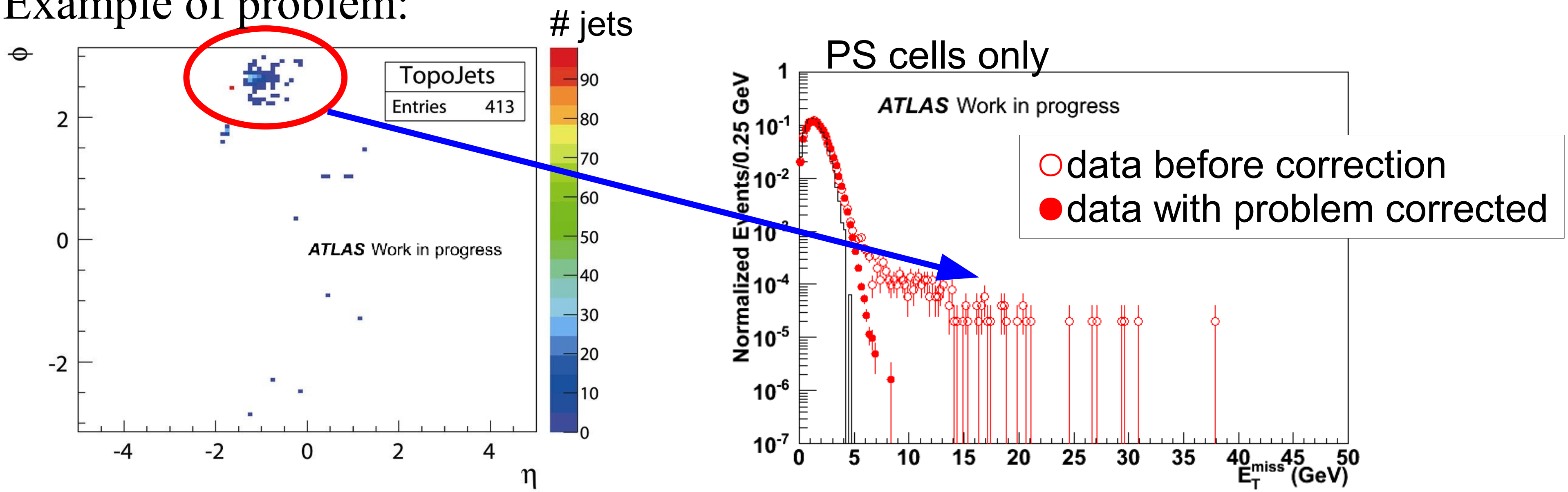
- Noise suppression assume Gaussian and non-coherent noise
  – OK for LAr
  – needed new noise description in Tile



➔ Pedestal and noise under control before LHC start

E_T^{miss} tails in RNDM events

- Setup a procedure to tag the calorimeter problems
- Use jets as a probe: no jet expected in random events
  - reconstructed jets in a narrow cone ($\Delta R = 0.4$)
  - study jet properties : number of cells with 90%, sampling with max energy, EM fraction, timing, etc.
- Example of problem:



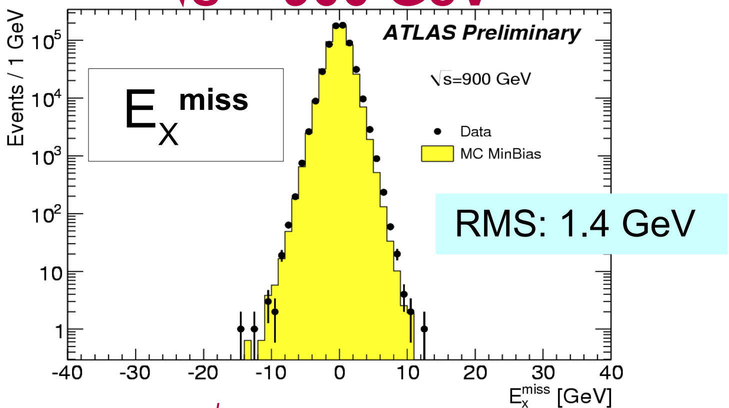
  - jets with max energy in presampler: coherent noise → E_T^{miss} tails
  - related to faulty HV cable in PS, changed during Winter 08 shut-down
  - tails disappeared in 2009

"Testing calorimetric Missing transverse energy and jet reconstruction with random and cosmic data", F. Hubaut, E. Petit, P. Pralavorio, D. Rousseau, D. Varouchas, A. Olariu, *ATLAS internal notes physics ATL-PHYS-INT-2009-045*

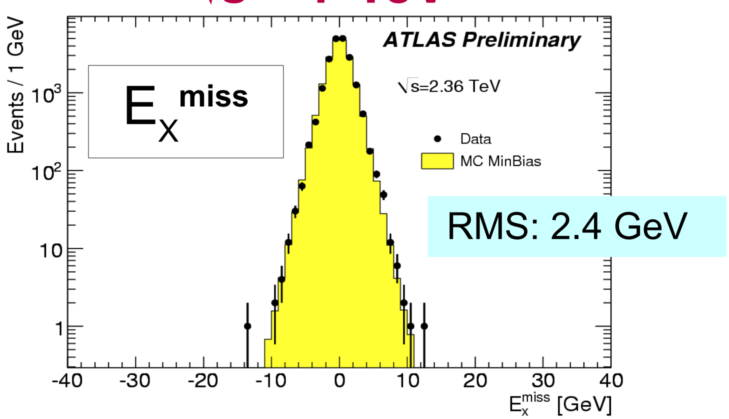
"Readiness of the ATLAS Liquid Argon Calorimeter for LHC collisions", The ATLAS collaboration, *European Physics Journal C, 2010, 10.1140/epjc/s10052-010-1354-y*

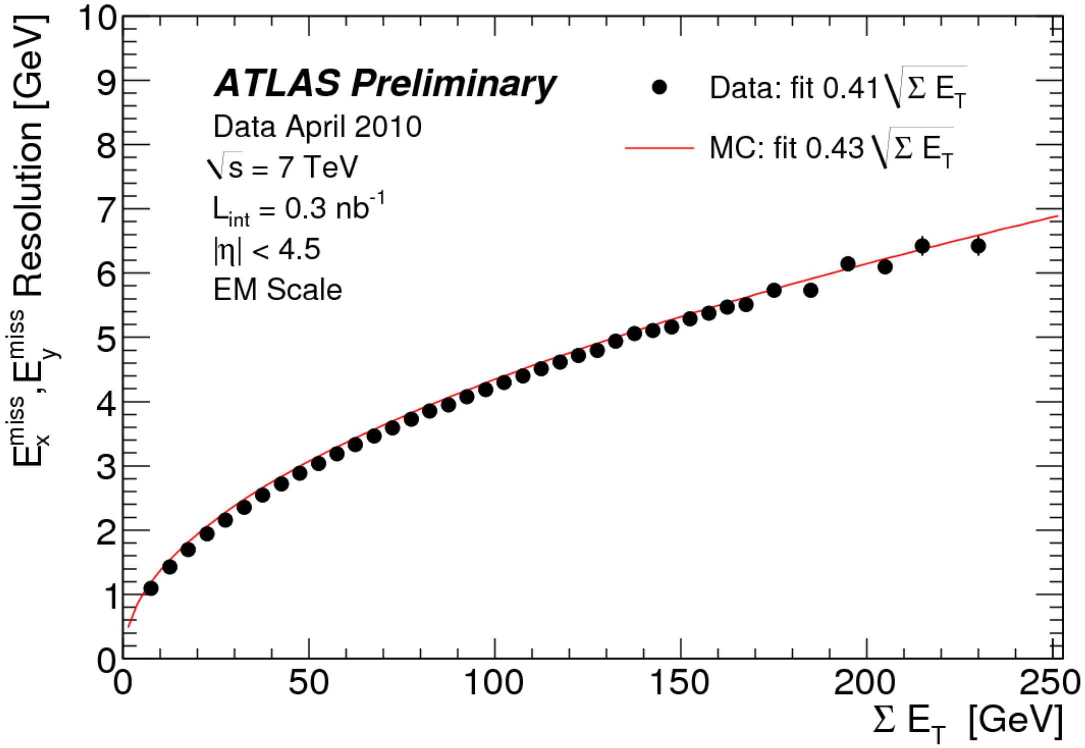
E_T^{miss} performance in MinBias events

$\sqrt{s}$ = 900 GeV



$\sqrt{s}$ = 7 TeV





➔ Very good agreement data/MC

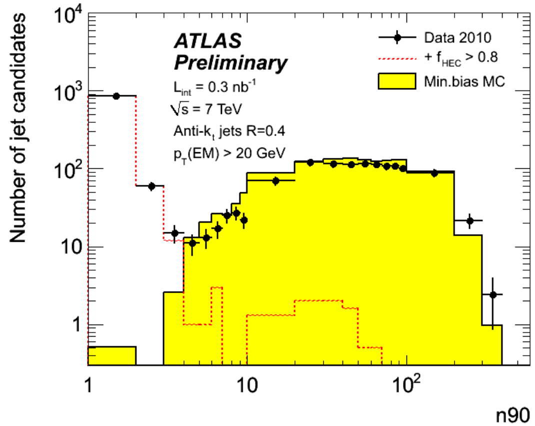
➔ Resolution of $\sigma(E_{X,Y}^{miss}) = 0.41 * \sqrt{\Sigma E_T}$

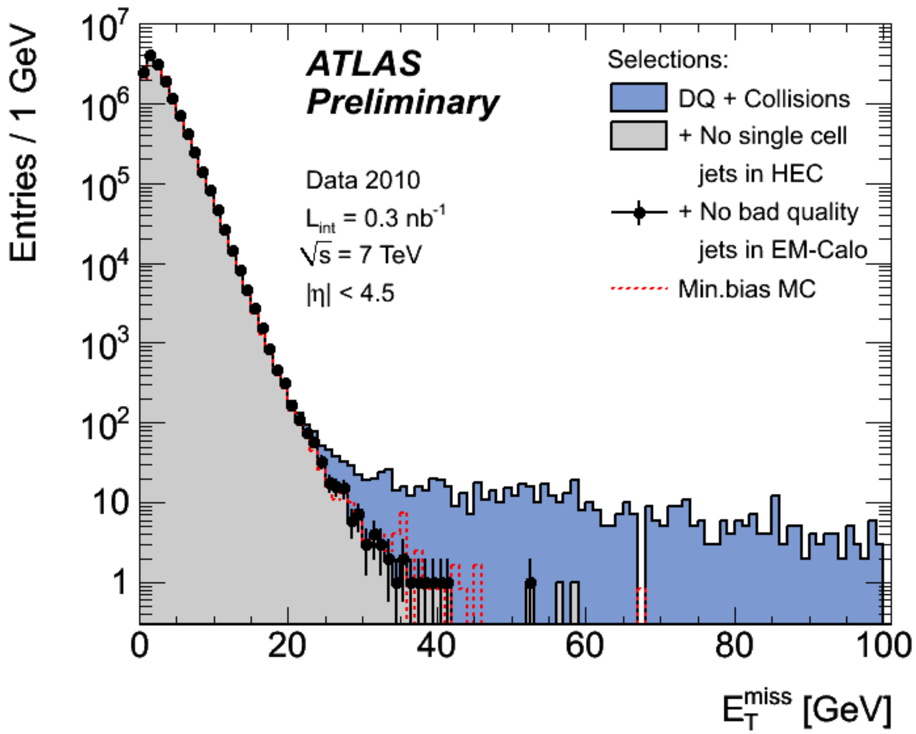
"Performance of the missing transverse energy reconstruction in minimum bias events at $\sqrt{s}$ of 900~GeV and 2.36~TeV with the ATLAS detector", The ATLAS collaboration, *ATLAS conference note ATLAS-CONF-2010-008*

E_T^{miss} tails in MinBias events

- Extension of method developed with random events: bad jets with p_T(EMscale) > 10 GeV, to get rid of:
  - HEC noise bursts: $f_{HEC} > 0.8$ and $n90 \leq 5$ → 0.65%
  - EM calo coherent noise: $f_{EM} > 0.95$ and $|f_{quality}| > 0.8$ → 0.01%
  - cosmics: $|t_{jet}| > 50$ ns → 0.11%

fraction of events in data :





- ➔ Good agreement data/MC
- ➔ Almost no impact on physics
- ➔ No high E_T^{miss} tails
  - promising for physics with real E_T^{miss}

"Performance of the missing transverse energy reconstruction in proton-protons collisions at $\sqrt{s}$ of 7 TeV with the ATLAS detector", The ATLAS collaboration, *ATLAS conference note ATLAS-CONF-2010-039*

"Performance of ET miss reconstruction in first ATLAS data" , E. Petit, ***Phenomenology 2010 Symposium*** *(Pheno10), May 2010 (Madison, Wisconsin)*

Part II :
W physics with 2010 data

W cross-section

- First physics measurement in ATLAS
  - 315 nb^{-1} = 4 months after LHC start at $\sqrt{s} = 7$ TeV

- Need to compute systematics for electron and E_T^{miss}, etc
  - pioneer methods now used for other physics analysis

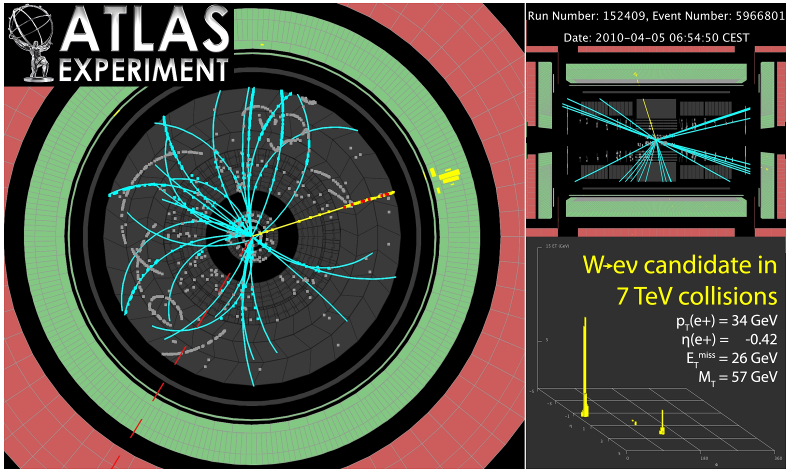
- Focus on $W \to e\nu$ channel
  - already precise theoretical predictions

	σ.BR (nb)	
$W \to e\nu$	10.46 ± 0.52	NNLO
di-jet (p_T > 15 GeV)	$1.2.10^6$	LO
$W \to \tau\nu \to e\nu\nu\nu$	3.68 ± 0.18	NNLO
$t\bar{t}$	0.16 ± 0.01	NLO + NNL
$Z \to ee$ (m_{ee} > 60 GeV)	0.99 ± 0.05	NNLO
$Z \to \tau\tau$ ($m_{\tau\tau}$ > 60 GeV)	0.99 ± 0.05	NNLO

W → eν selection (1)

➔ General strategy: reduce background to very low level

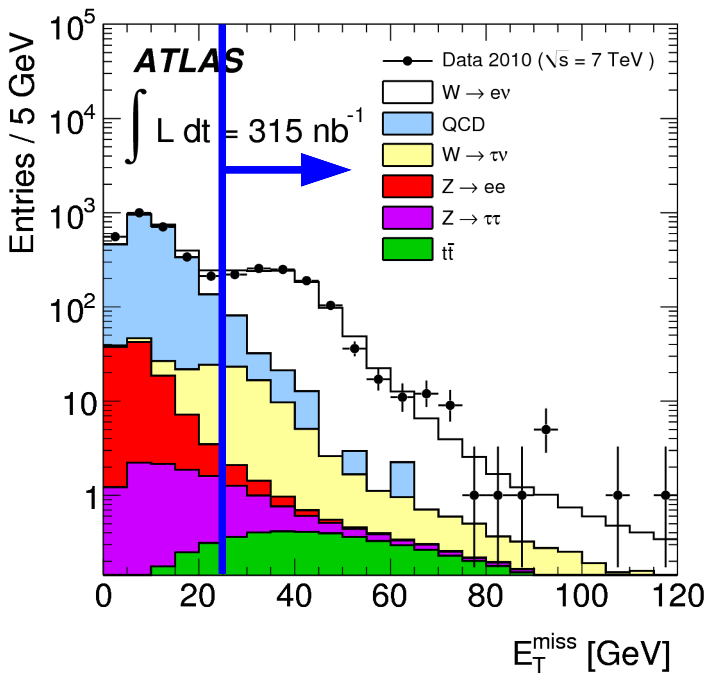
- ♦ Trigger
  - level 1, energy deposit in EM calo > 14 GeV → 6.5 M events

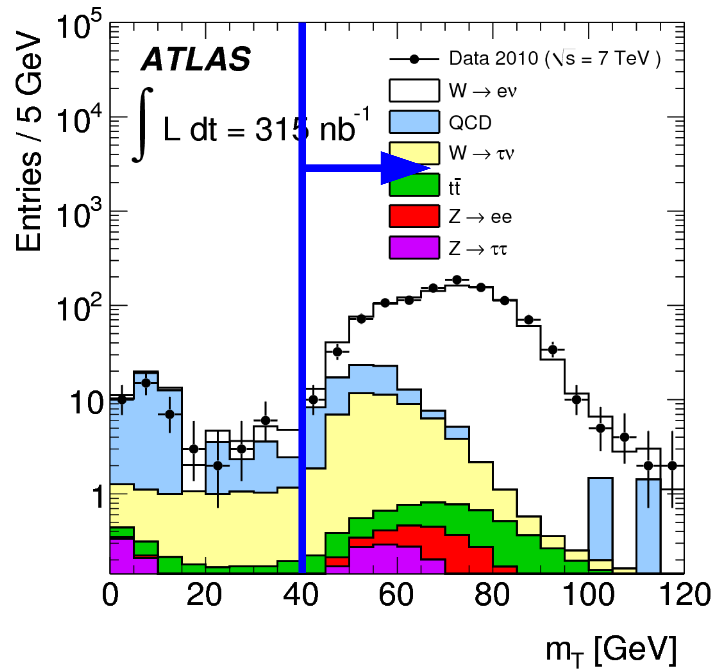


- ♦ Primary vertex with at least 3 tracks
- ♦ Remove events with bad jet
- ♦ Select high p_T electron
  - |η| < 2.47, not in crack, E_T > 20 GeV, tight identification → 4003 events
- ♦ Remove problematic regions of the calorimeter
  - ~2% of dead read-out cells

W → eν selection (2)

- $E_T^{miss} > 25$ GeV → 1116 events





- $m_T > 40$ GeV

$$m_T = \sqrt{2 E_T^e E_T^{miss} (1 - \cos(\Delta\varphi))}$$

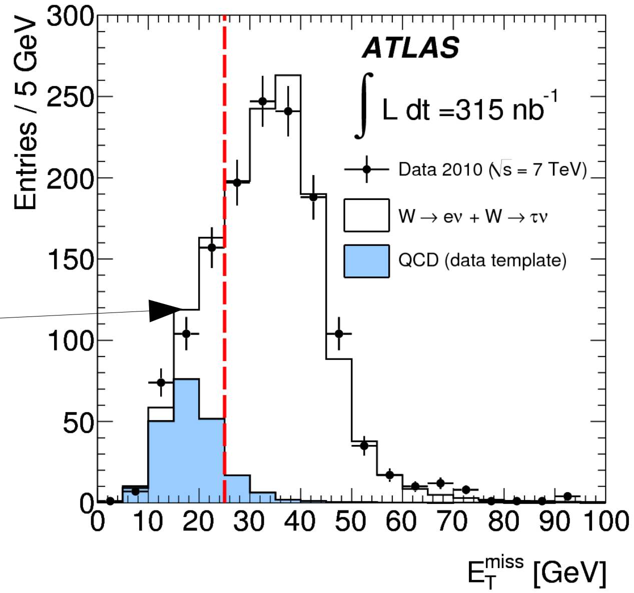
➔ Good agreement data-MC

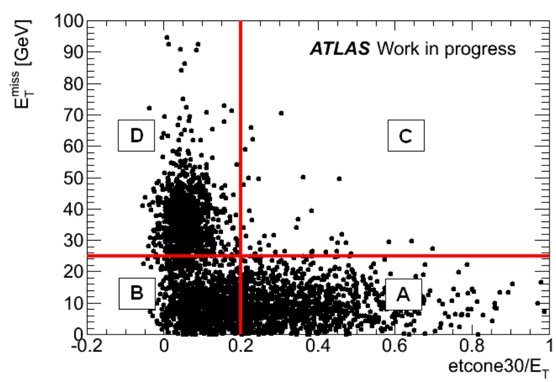
➔ 1069 W → eν candidates

➔ S/B ~ 20

Background event estimation

- EW ($W \to \tau\nu$, $Z \to \ell\ell$ (ℓ=e,τ)) and $t\bar{t}$ from MC
- QCD from data-driven method
  - binned maximum likelihood fit on E_T^{miss}
    - signal shape from MC
    - QCD shape from reversed cuts on data
    - robust method still used
  - tried ABCD method (used for muon channel)
    - but not possible to find 2 uncorrelated variables





Background (EW + $t\bar{t}$)	Background (QCD)	N^{sig}
33.5 ± 0.2 ± 3.0	28 ± 3 ± 10	1008 ± 33 ± 11

X ± stat ± syst

$$N_D^{QCD} = \frac{N_B^{data} * N_C^{data}}{N_A^{data}}$$

➔ error on cross-section: $\delta\sigma/\sigma = 1\%$

Cross-section calculation

- Total inclusive cross-section: $$\sigma_W^{tot} . BR(W \rightarrow l\nu) = \frac{N_W^{obs} - N_W^{bkg}}{\epsilon_W . L_{int}}$$
- L: total integrated luminosity ($\delta L/L = 11\%$)
- N^{bkg}: number of background signal events
- $\varepsilon_W = A_W * C_W$: efficiencies
  - A_W: truth level acceptance = 46.2%, $\delta A_W/A_W = 3\%$ (PDFs, renormalisation, ...)
  - C_W: detector reconstruction efficiency = 65.9%

➔ Challenge: background estimation and systematics from detector reconstruction efficiencies

Detector reconstruction efficiencies

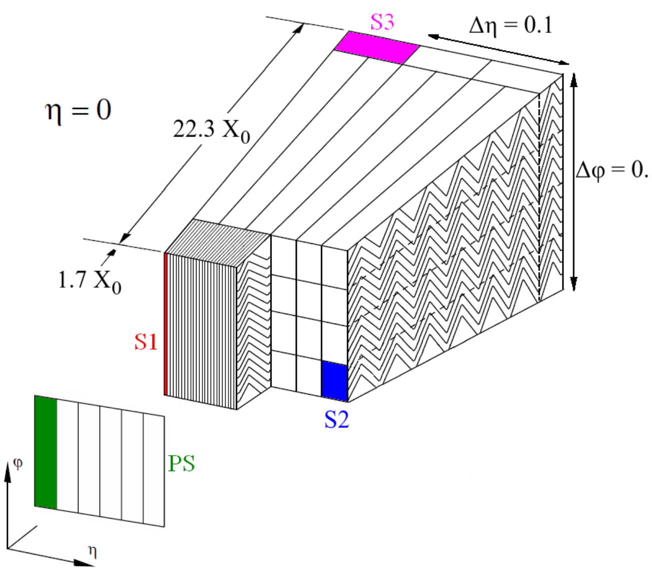
- $C_W = \varepsilon_{event}.\varepsilon_{trig}.\alpha_{reco}.\varepsilon_{lep}$
  - ε_{event}: event selection efficiencies (primary vertex, …)
  - ε_{trig}: trigger efficiency
  - α_{reco}: detector resolution (electron p_T scale, E_T^{miss})
  - ε_{lep}: electron reconstruction and identification efficiency
- Systematics on C_W :

Parameter	$\delta C_W / C_W (\%)$
Trigger efficiency	<0.2
Material effects, reconstruction and identification	5.6
Energy scale and resolution	3.3
E_T^{miss} scale and resolution	2.0
Problematic regions in the calorimeter	1.4
Pile-up	0.5
Charge misidentification	0.5

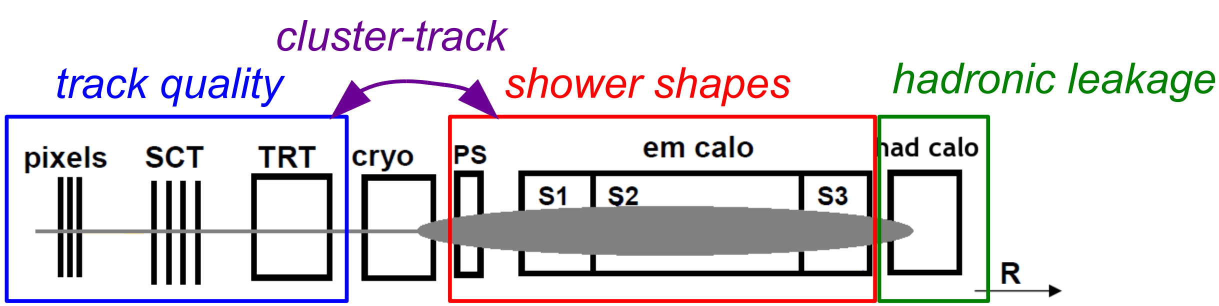
- Conservative estimate in this first step: 7%

Electron reconstruction and identification (1)

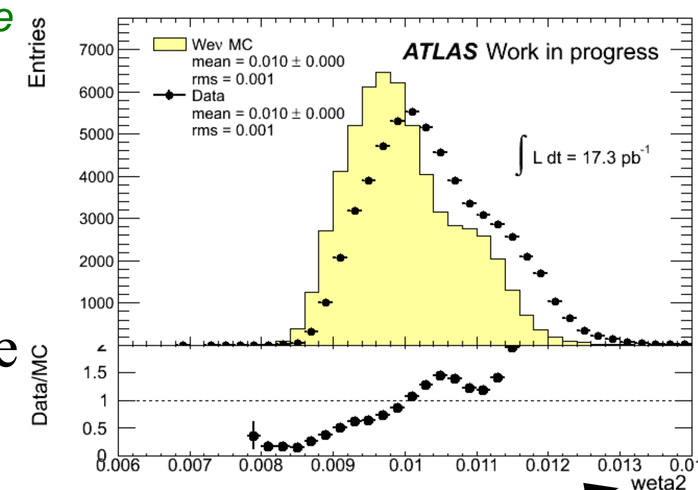
- Electron = seed cluster + matching track
- Cluster reconstruction
  - $\Delta\eta \times \Delta\varphi = 0.075\mathrm{x}0.175$ = 3x7 cells, in barrel
  - $\Delta\eta \times \Delta\varphi = 0.125\mathrm{x}0.125$ = 5x5 cells, in endcap
  - $E_{cluster} \approx E_{PS} + E_{S1} + E_{S2} + E_{S3}$



- Identification: calorimeter and tracker information



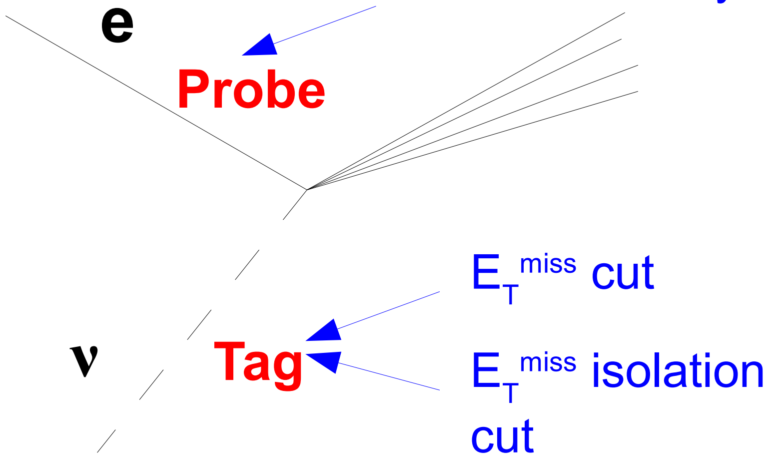
  - lateral shower shapes not understood at the time
- Sensitive to material before calorimeter



lateral width of the shower

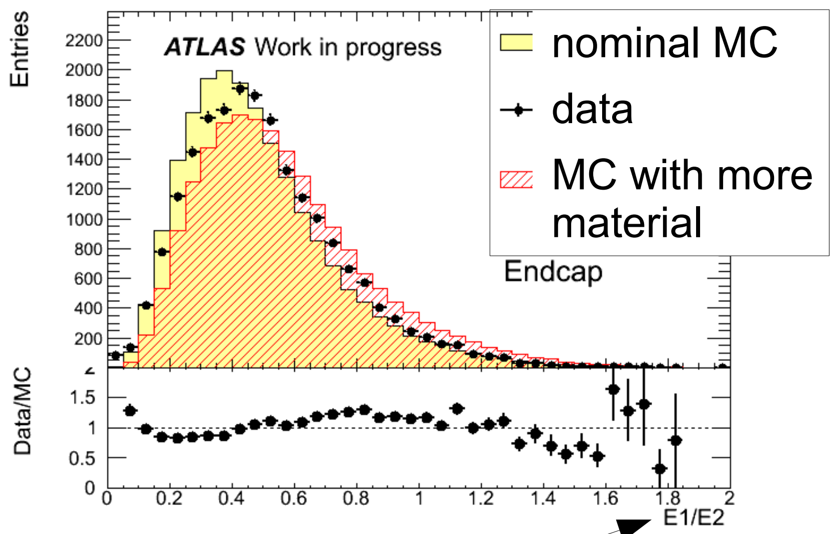
Electron reconstruction and identification (2)

- Electron identification
  - identification efficiencies from data with Wenu tag-and-probe
  - $\epsilon = \frac{N(\text{probes passing identification cuts})}{N(\text{all probes})}$
  - 4.7% uncertainty



- Material before the calorimeter:
  - known with 0.1 X_0 precision (0.01 needed)
  - compare efficiencies for $W \rightarrow e\nu$ MCs with additional material
  - 3% uncertainty

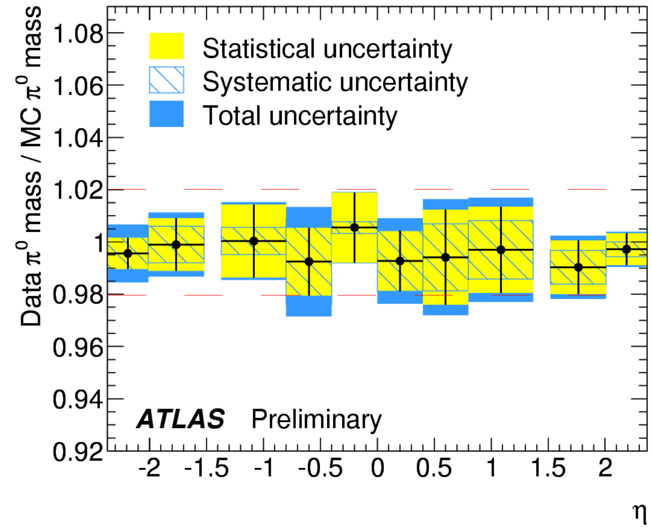
➔ 5.6% uncertainty on $\frac{\delta C_W}{C_W}$



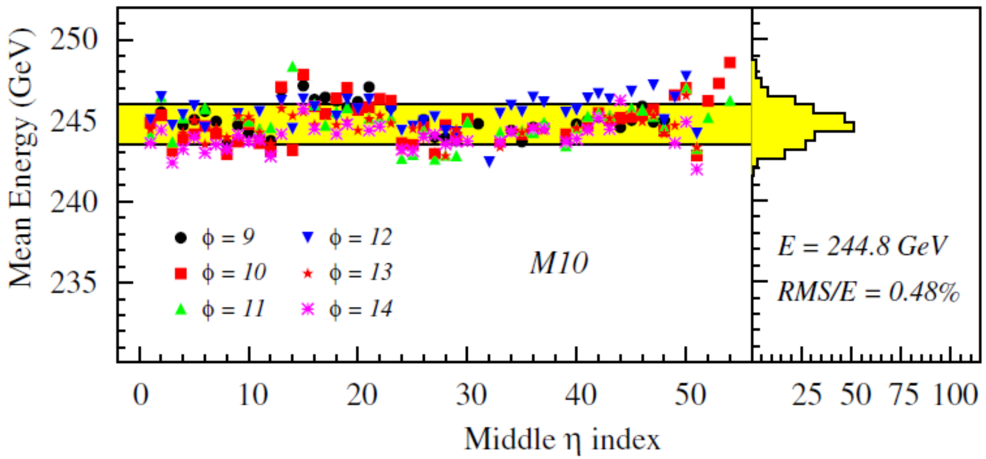
sensitive to material before the calorimeter

Electron energy scale

- ♦ Electron energy scale checked with π^0
  - – data/MC agreement within 2% over η



- ♦ In agreement with test-beams results



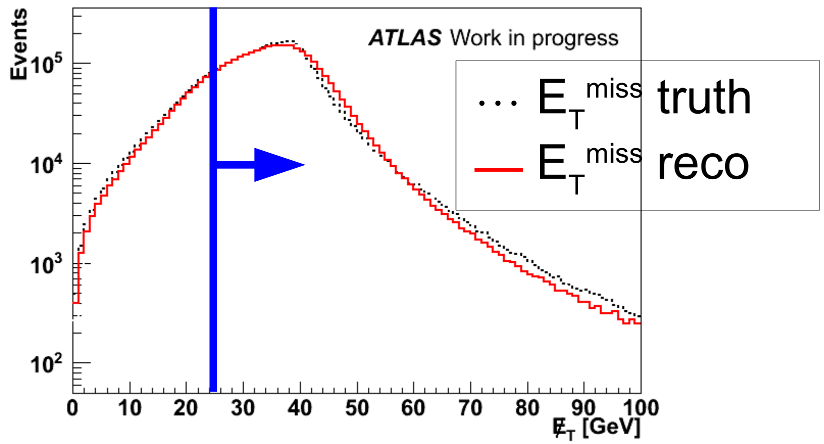
➔ conservatively 3% uncertainty on energy scale

- ♦ Affects reconstruction, identification, E_T^{miss} cut
  - – change the electron energy and E_T^{miss} by ±3%

➔ 3.3% uncertainty on $\frac{\delta C_W}{C_W}$

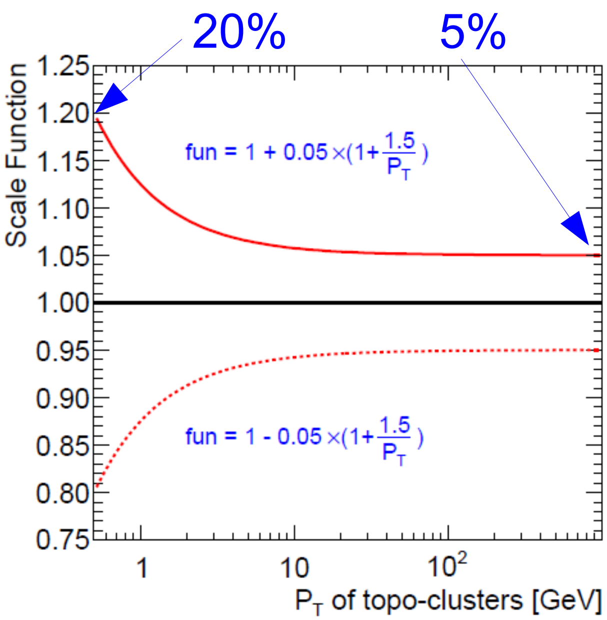
(main) systematics from E_T^{miss}

- E_T^{miss} response
  - difference cutting at truth level and reco level
  - eff. cut = 81% truth, 82% reco
  - uncertainty of 1%



- Hadronic calibration
  - uncertainty from charged hadron E/p studies
  - change in E_T^{miss} cut when topocluster energy multiplied by $1 \pm a.(1+b/p_T)$, with a = 5% and b = 1.5

  $\Rightarrow$ uncertainty of 1.5%



➔ Total systematic E_T^{miss} uncertainty: 2.0%

➔ method used in all SM/E_T^{miss} analysis

Cross-section results (1)

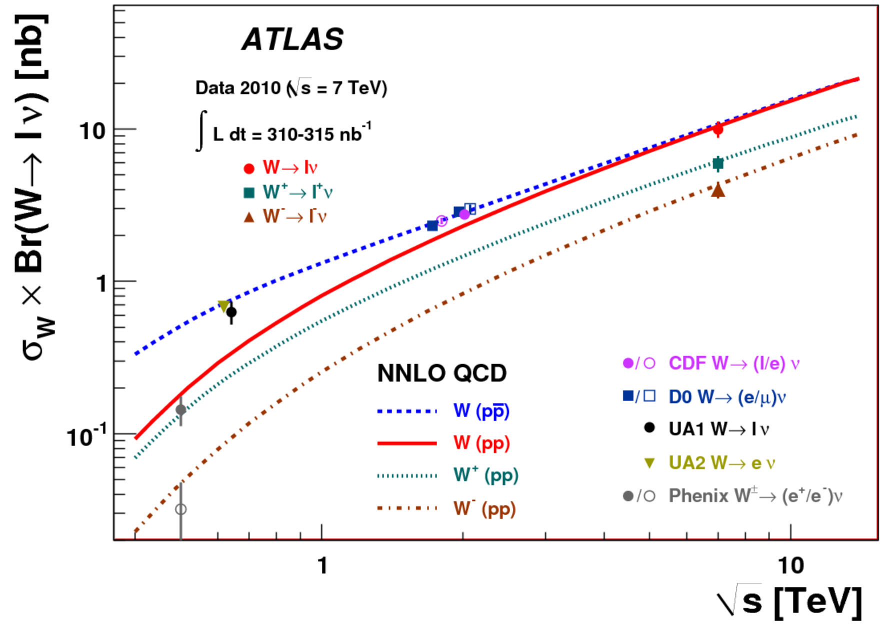
σ.BR(W → eν) = 10.51 ± 0.34 (stat) ± 0.81 (syst) ± 1.16 (lumi) nb

- Muon channel
  - same method used
- Background:
  - ~same amount of QCD bkgd
  - more EW bkgd (Z → μμ)
- main systematic errors:
  - reconstruction and isolation: 2.7% (no material effect)
  - energy scale and resolution: 2.3%
  - trigger: 1.9%
  - total: 4%

σ.BR(W → μν) = 9.58 ± 0.30 (stat) ± 0.50 (syst) ± 1.05 (lumi) nb

- Combinaison of results:

σ.BR(W → ℓν) = 9.96 ± 0.23 (stat) ± 0.50 (syst) ± 1.10 (lumi) nb

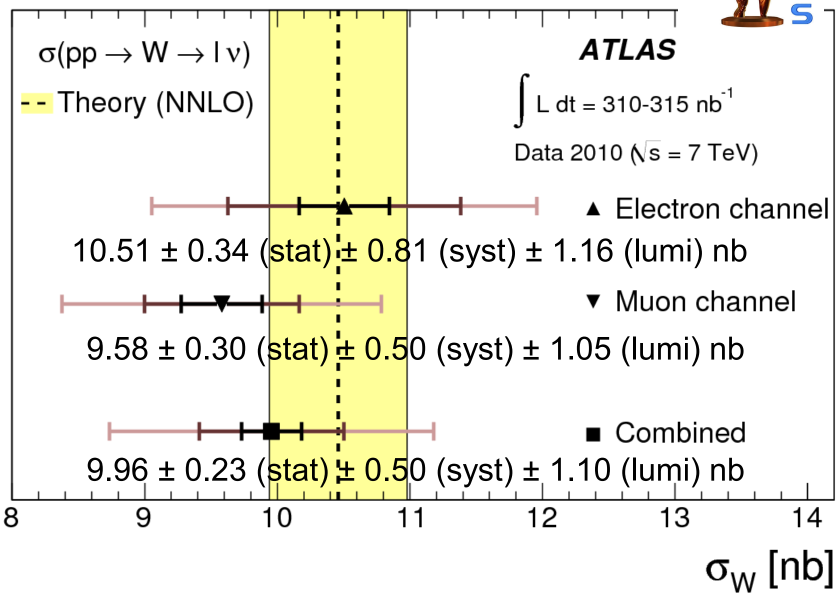


➔ compatible with prediction (10.46 ± 0.52) nb

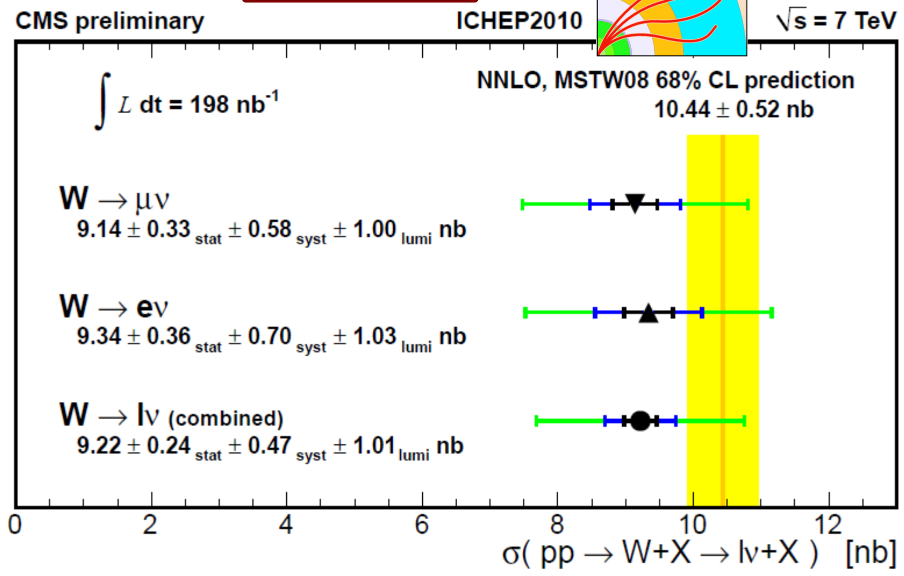
➔ First (published) physics ATLAS measurement

Cross-section results (2)

ATLAS



CMS



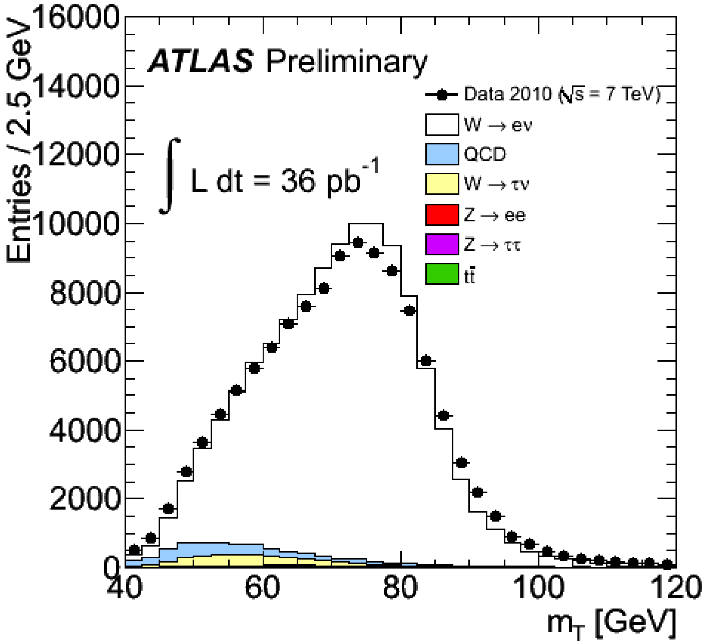
- ♦ Signal extracted from maximum likelihood fit to E_T^{miss} or m_T

➔ central value of combined results below prediction for both experiments

“**Measurement of the W -> lnu and Z/gamma* -> ll production cross sections in proton-proton collisions at sqrt(s) = 7 TeV with the ATLAS detector**”, The ATLAS Collaboration, *Journal of High Energy Physics Volume 2010, Number 12, 1-65*

Cross-section results (3)

- Measurement with all 2010 data (36 pb^{-1})
- Improvement of systematic errors
  - electron reconstruction and identification: Wenu and Zee tag-and-probe: 5.6% → 1.9%
  - energy scale and resolution: Zee tag-and-probe: $\Delta C_W/C_W$: 3.3% → 0.5%
  - E_T^{miss}: still 2%
  - total syst error : 7% → 2.8%
  - luminosity error: 11% → 3.4%



$\sigma.BR(W \to e\nu) = 10.551 \pm 0.032(stat) \pm 0.300(syst) \pm 0.359(lumi) \pm 0.316(th)$ nb

$\sigma.BR(W \to \mu\nu) = 10.322 \pm 0.030(stat) \pm 0.249(syst) \pm 0.377(lumi) \pm 0.310(th)$ nb

$\sigma.BR(W \to l\nu) = 10.391 \pm 0.022(stat) \pm 0.238(syst) \pm 0.353(lumi) \pm 0.312(th)$ nb

➔ not dominated by detector effects anymore

W charge asymmetry (1)

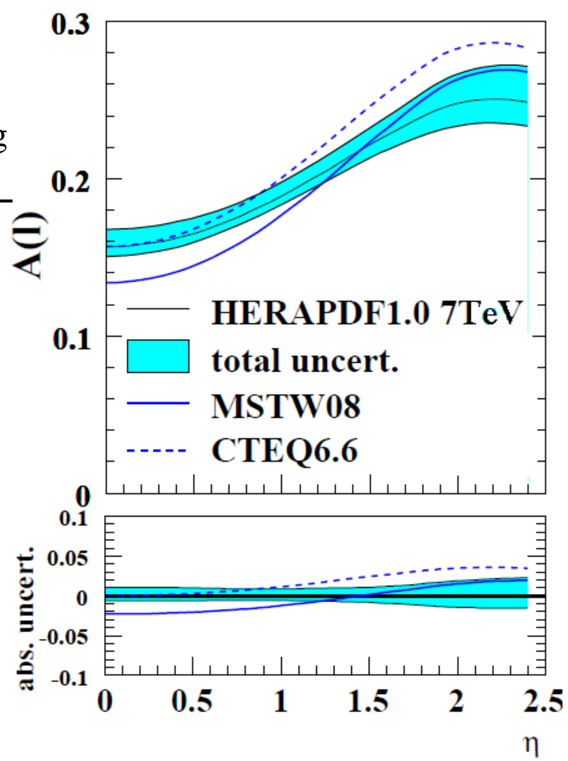
PDF: probability to find a quark with a fraction x of the proton momentum

- PDFs extracted from fits of processes sensitive to them

$$\sigma^{NNLO}_{W^+\to l\nu} = 6.16\,\mathrm{nb}^{-1}$$
$$\sigma^{NNLO}_{W^-\to l\nu} = 4.30\,\mathrm{nb}^{-1}$$

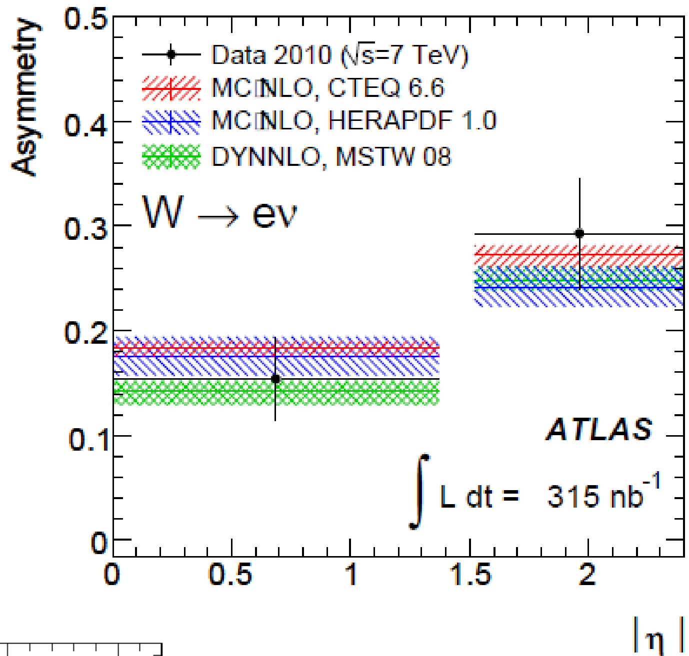
$\hookrightarrow A^{NNLO} \sim 0.18$

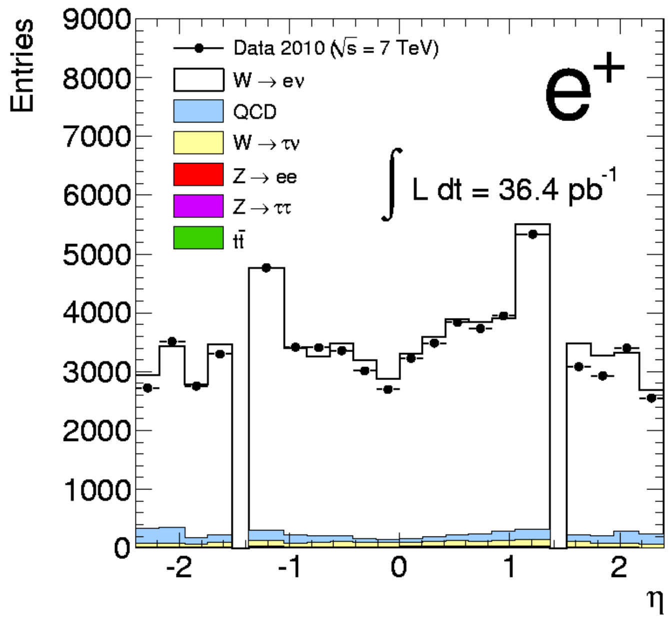
- $u\bar{d} \to W^+$ and $d\bar{u} \to W^-$
  - more u than d $\Rightarrow$ more W^+ than W^-
  - W^+ larger boost along beam-axis than W^-
- charge asymmetry: $A_l = \dfrac{\sigma^{fid}_{W^+} - \sigma^{fid}_{W^-}}{\sigma^{fid}_{W^+} + \sigma^{fid}_{W^-}}$ with $\sigma^{fid}_{W} = \dfrac{N_l^{obs} - N_l^{bkg}}{\not{L}.C_W}$
  - x values not accessible with other experiments
  - Tevatron results already used
  - could discriminate between PDFs

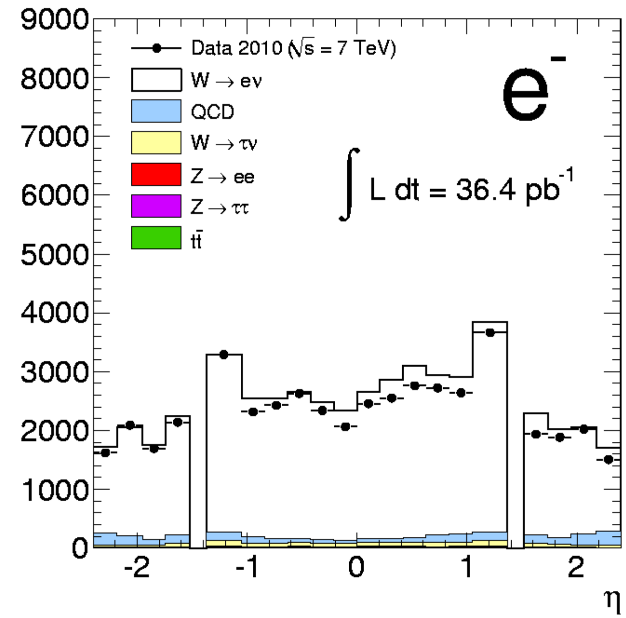


W charge asymmetry (2)

- Same event selection as cross-section measurement
- Feasibility of measurement with 315 nb^{-1}
  - $A_e = 0.21 \pm 0.03$ (stat) ± 0.01 (syst) $\rightarrow 7\sigma$ from 0
  - still dominated by stat error
- Measurement with 2010 data (36 pb^{-1})
  - 10 bins in $|\eta|$



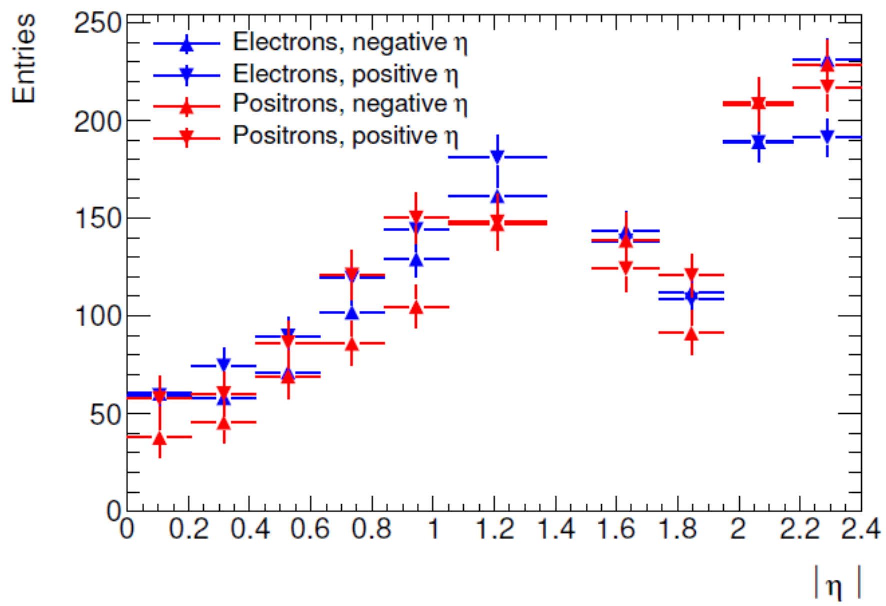




Background

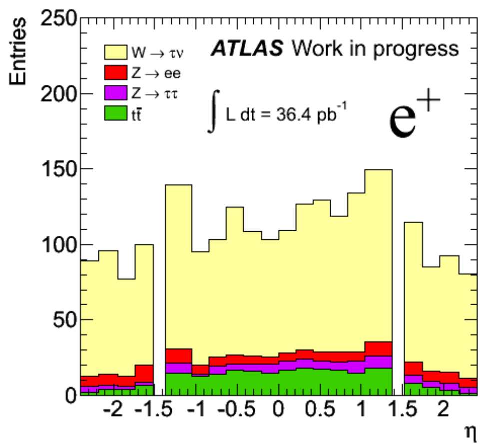
- QCD from data-driven method
  - binned maximum likelihood fit on E_T^{miss}
  - statistical errors from fit: 5-10%
  - systematic errors: 10-30%

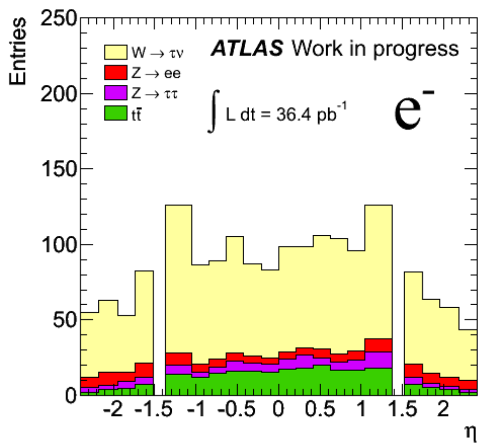
➔ $\Delta A/A \sim 1$ %



- EW ($W \rightarrow \tau\nu$, $Z \rightarrow \ell\ell$ (ℓ=e,τ)) and $t\bar{t}$ from MC
  - 14 % error (luminosity, PDFs, cross-sections)

➔ $\Delta A/A \sim 0.1$-0.3 %



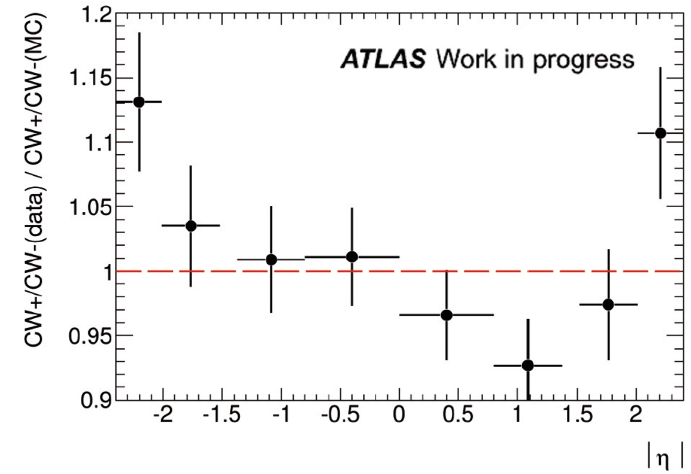


Detector efficiencies

- Electron identification: compare data and MC efficiencies for e+ and e-
  - error on asymmetry = deviation of $(Cw_{data}^{+}/Cw_{MC}^{+})/(Cw_{data}^{-}/Cw_{MC}^{-})$ from 1

➔ $\Delta A/A \sim$ 6-20 %

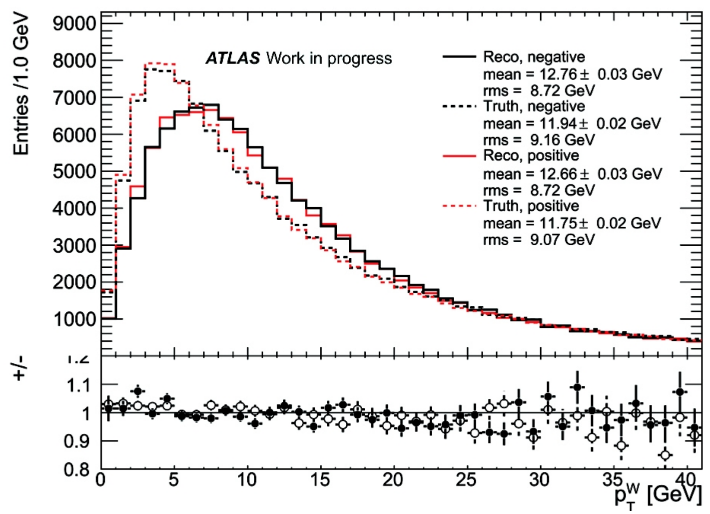
  - closer to 1 with better inner-detector alignment
  - still under study



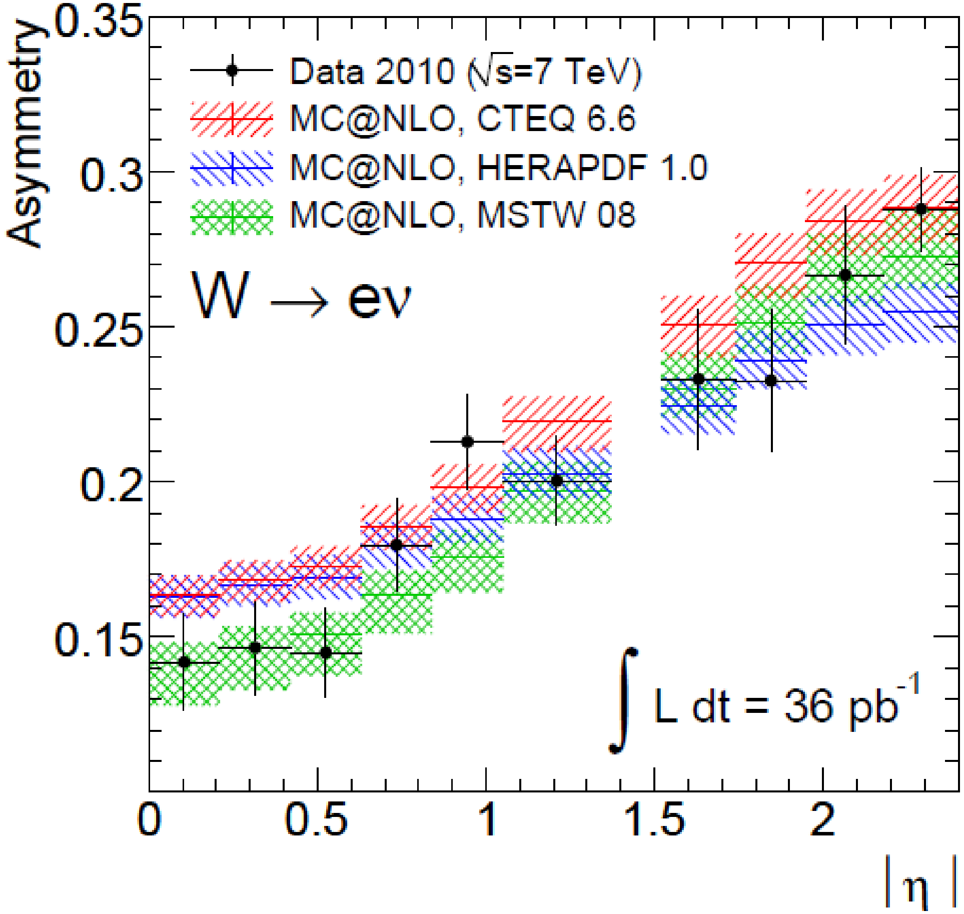
- Electron energy scale

➔ $\Delta A/A \sim$ 1.5-2.5 %

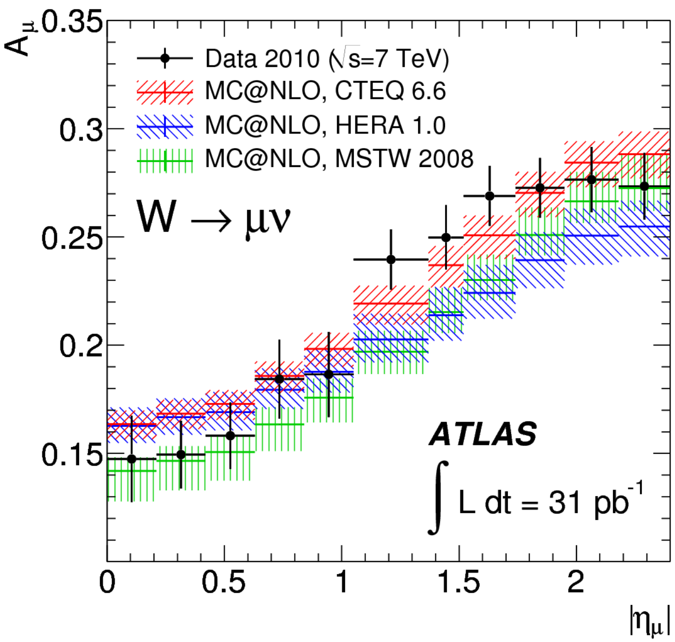
- E_T^{miss} :
  - no visible difference between W+ and W-
  - neglected here



Results (1)



- ATLAS results in muon channel
  - same method, same binning
  - main systematics: trigger, muon reconstruction
    ⇒ total syst: 3-10%

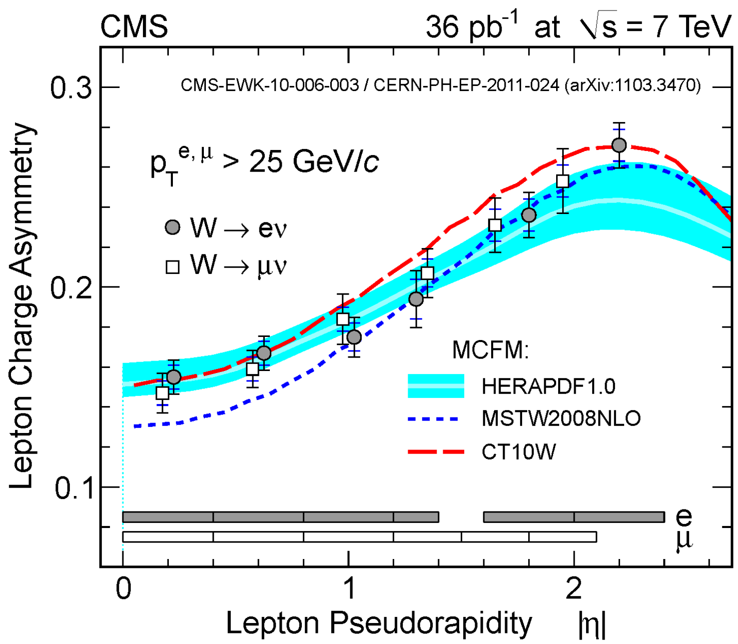


➔ predictions at NLO with CTEQ6.6, HERAPDF1.0, MSTW2008
  - kinematic selection cuts at truth level

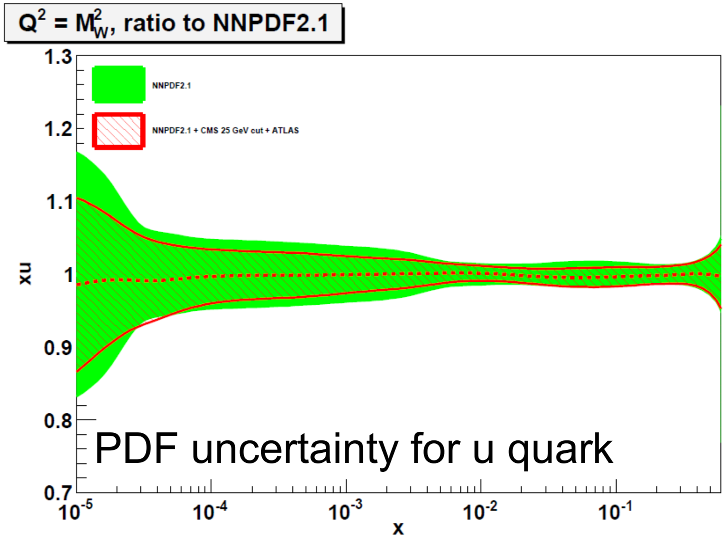
➔ Currently compatible with all the predictions

Results (2)

- CMS results
  - 6 bins, in |η|, 2 bins in p_T
  - simpler calculation: $A_l = \frac{N^+ - N^-}{N^+ + N^-}$
  - main systematics: identification, energy scale, charge mis-identification $\Rightarrow$ total syst: 4-5%



➔ Improvement of PDF uncertainties with ATLAS and CMS asymmetry data:



Conclusion

- 3 years of a very exciting period...
- … from calorimeter final installation...

➔ Calorimeter system and E_T^{miss} *in situ* commissioning in 2008-2009

  - well understood and under control

- … to the first collisions and physics measurements in 2009-2010

➔ First W-boson production cross-section with 315 nb^{-1}

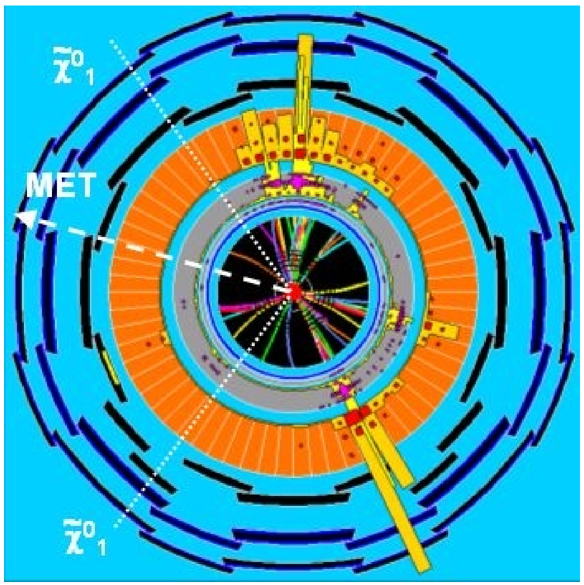
  - implementation of systematics for electrons and E_T^{miss}
  - in good agreement with expectations

➔ Charge asymmetry measurement with 36 pb^{-1}

  - not sensitive to PDFs yet
  - but can already improve their uncertainties

Back-up slides

Importance of missing E_T



Transverse cut-away view of the ATLAS detector :
decay of supersymetric particles

- **Hadronic** collider
  => conservation of transverse momentum only (E_T^{miss})

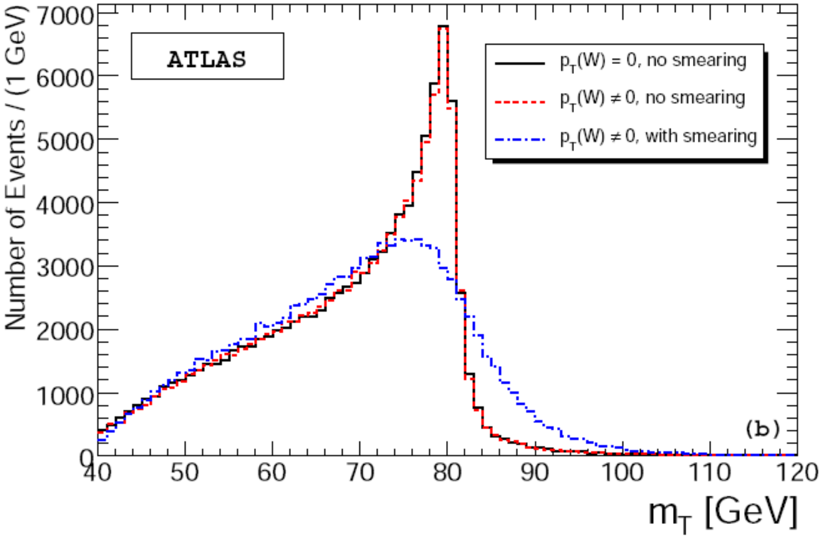
- To reconstruct **standard model candles** with neutrinos in final state ($E_T^{\nu} = E_T^{miss}$) :
  - τ lepton ($\tau \rightarrow jet + \nu_\tau$, $\tau \rightarrow l + \nu_l + \nu_\tau$)
  - Z, W bosons
  - top quark

- To search for **new physics** with non-interacting particles:
  - SUSY (Higgs boson ($H/A \rightarrow \tau\tau$), supersymmetric particles)
  - Heavy jauge bosons (W')
  - Extradimensions (graviton)

$\Rightarrow$ Missing E_T is a key signature to discover new physics

Low E_T^{miss} events

- Reconstruction of tranverse masses :
  - $W \to e\,\nu$ ($E_T^{miss} > 20$ GeV)
  - $t \to Wb$
- Reconstruction of masses :
  - $Z \to \tau\tau$ ($E_T^{miss} > 20$ GeV)
  - $H \to \tau\tau$ ($E_T^{miss} > 40$ GeV)
  - $A \to \tau\tau$ ($E_T^{miss} > 20$ GeV)



Transverse mass of W :
$M_T^2 = 2E_T^e E_T^{miss}(1-\cos(\varphi_\nu-\varphi_e))$
with (red line) and without (blue line) the effects of finite detector resolution (ie smearing)

$\Rightarrow$ Understand the detector performances :
  - Resolution
  - Linearity
  - Energy scale

High E_T^{miss} events

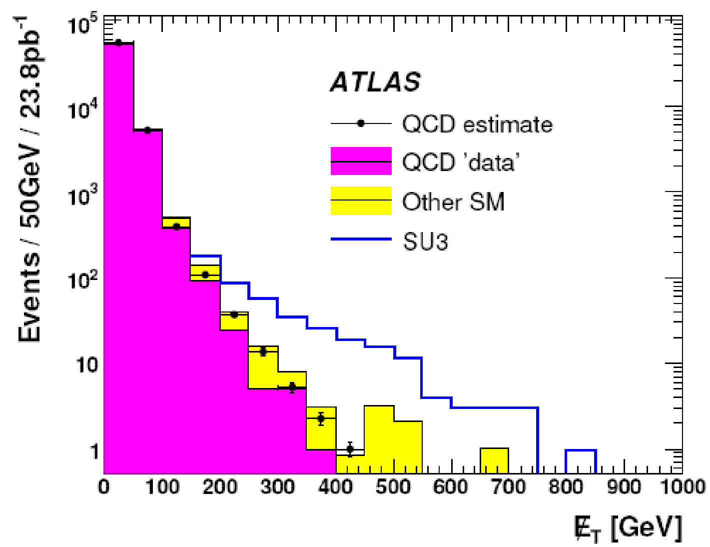
- Particles with high E_T^{miss} :
  - $H^+ \rightarrow \tau^+ \nu$
  - $H \rightarrow \chi_1^0 \chi_1^0$
  - $A \rightarrow \chi_2^0 \chi_2^0$ ($\chi_2^0 \rightarrow \chi_1^0 l^+ l^-$)
  - G_{KK} (graviton)
  - $W' \rightarrow e\, \nu$ ($E_T^{miss} > 50$ GeV)

SUSY : $E_T^{miss} > 100$ GeV (first three processes)

extradimensions : $E_T^{miss} > 1$ TeV (G_{KK})

- Understand E_T^{miss} tails :

$\Rightarrow$control the instrumental problems that can fake E_T^{miss}



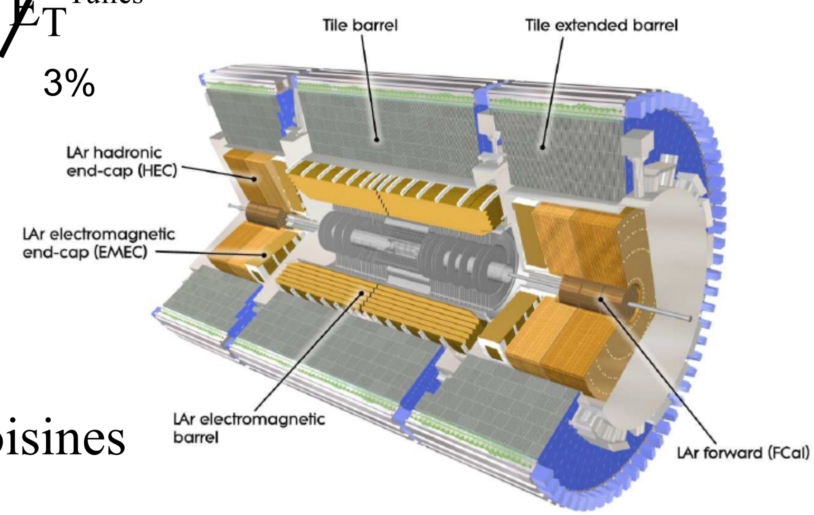
E_T^{miss} distribution of background processes and SUSY signal for 0-lepton mode with an integrated luminosity of 23.8pb^{-1}.

Le terme E_T^{miss} calorimétrique

- La mesure de $E_T^{miss,Calo}$ repose sur 187648 cellules (10 fois plus que DØ/CDF)

$$\not\!E_T^{Calorimètre} = \not\!E_T^{EM,tonneau} + \not\!E_T^{EM,bouchon} + \not\!E_T^{HEC} + \not\!E_T^{FCal} + \not\!E_T^{Tuiles}$$

Ncellules :	100%	58%	34%	3%	2%	3%
		92%				



1) Supprimer le bruit

- Cellules telles que $|E|>2*\sigma_{bruit}$
- TopoClusters : graines $|E| > 4*\sigma_{bruit}$, cellules voisines $|E| > 2*\sigma_{bruit}$, cellules frontière $|E| > 0*\sigma_{bruit}$

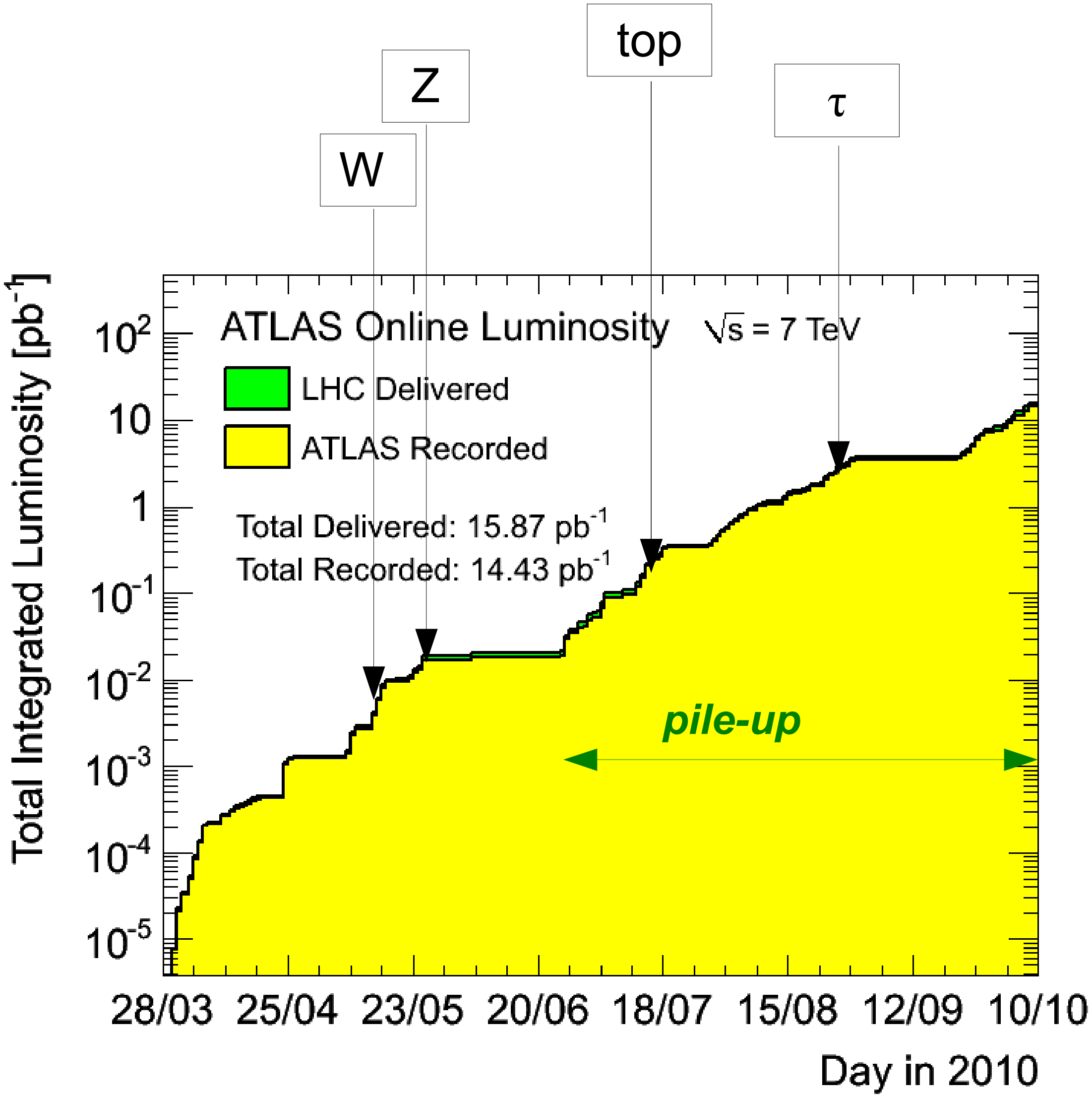
2) Identifier et traiter les cellules à problèmes

3) Non compensation des calorimètres ⇒ calibrer les cellules différemment pour les gerbes électromagnétiques et hadroniques

➔ Les points 1 et 2 peuvent être étudiés avec les événements cosmiques

First months of LHC running at 7 TeV

- SM discovery:
  - electron: 1897
  - muon: 1936
  - tau: 1975
  - quarks: 1968-1994
  - ν_e: 1956
  - ν_μ: ~1950
  - ν_τ: 2000
  - Higgs: 2012 ?



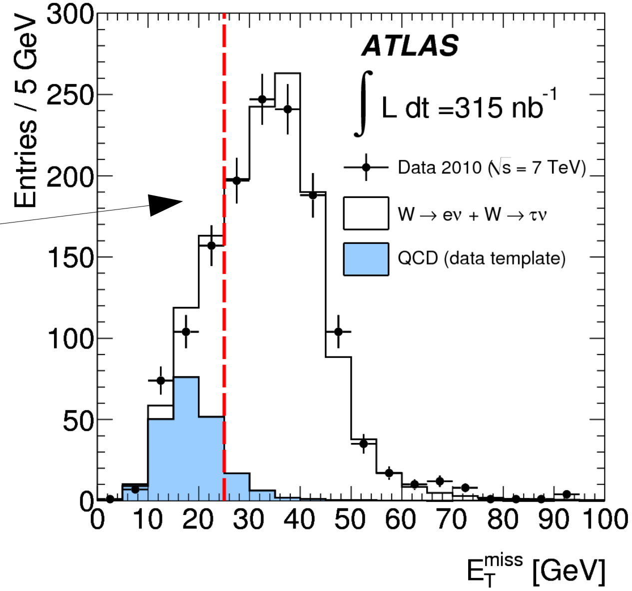
Number of signal events

Electron

Muon

- $N^{sig} = N^{observed} - N^{background}$
- EW ($Z \rightarrow \ell\ell$ (ℓ=e,μ,τ), $W \rightarrow \tau\nu$) and $t\bar{t}$ from MC
- QCD from data-driven method
  - binned maximum likelihood fit on E_T^{miss}
    - signal shape from MC
    - QCD shape from reversed cuts on data
  - matrix method

$$\begin{cases} N_{loose} = N_{nonQCD} + N_{QCD} \\ N_{iso} = \varepsilon^{iso}_{nonQCD}.N_{nonQCD} + \varepsilon^{iso}_{QCD}.N_{QCD} \end{cases}$$



	Observed candidates	Background (EW + $t\bar{t}$)	Background (QCD)	N^{sig}
e	1069	33.5 ± 0.2 ± 3.0	28 ± 3 ± 10	1008 ± 33 ± 11
μ	1181	77.6 ± 0.3 ± 5.4	23 ± 5 ± 9	1081 ± 34 ± 11

X ± stat ± syst

➔ Dominated by stat. error

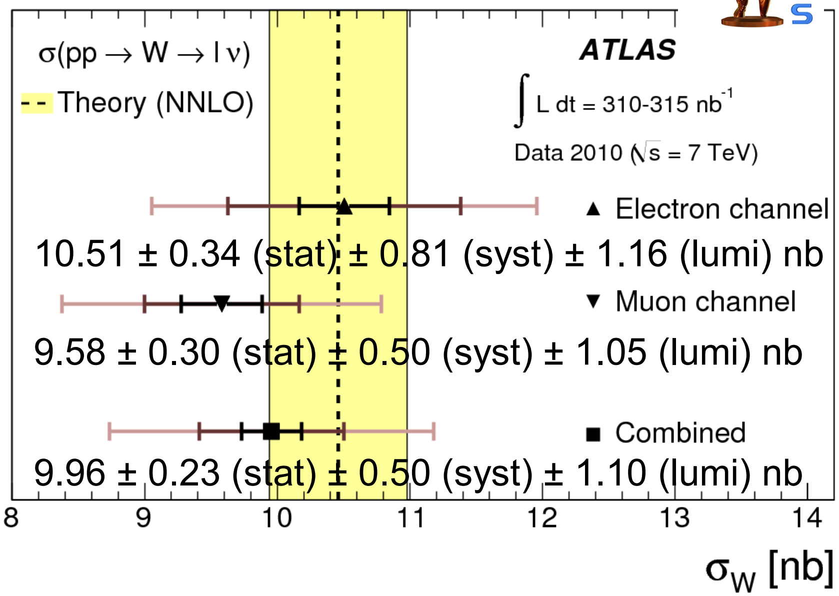
C_W factors

- $C_W = \varepsilon_{event}.\alpha_{reco}.\varepsilon_{lep}.\varepsilon_{trig}$
  - ε_{event}: event selection efficiencies (primary vertex, …)
  - ε_{trig}: trigger efficiency
  - α_{reco}: detector resolution (electron p_T scale, E_T^{miss})
  - ε_{lep}: reconstruction and identification efficiency
- Systematics on C_W (example for electron channel):

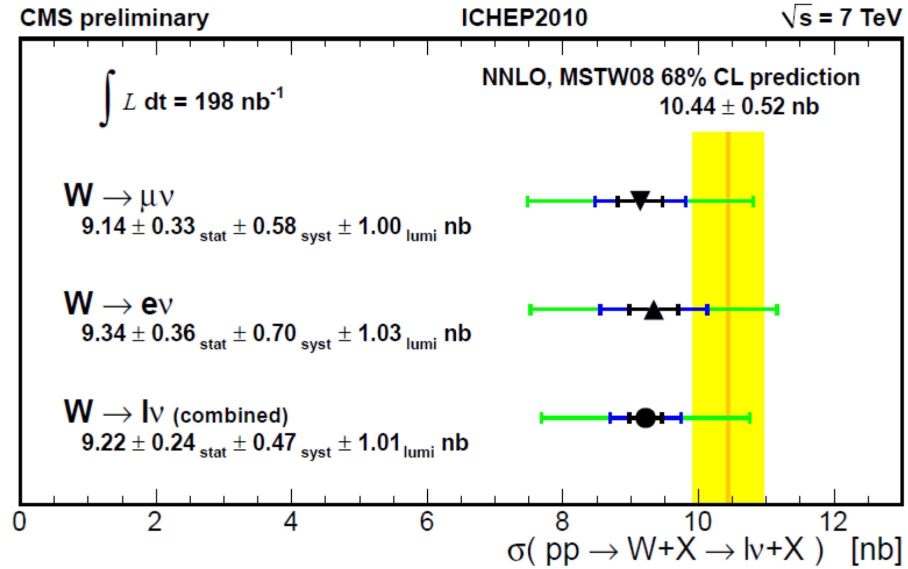
Parameter	$\delta C_W / C_W (\%)$
Trigger efficiency	<0.2
Material effects, reconstruction and identification	5.6
Energy scale and resolution	3.3
E_T^{miss} scale and resolution	2.0
Problematic regions in the calorimeter	1.4
Pile-up	0.5
Charge misidentification	0.5
FSR modelling	0.3
Theoretical uncertainty (PDFs)	0.3
Total uncertainty	7.0

Cross-section results (2)

ATLAS



CMS



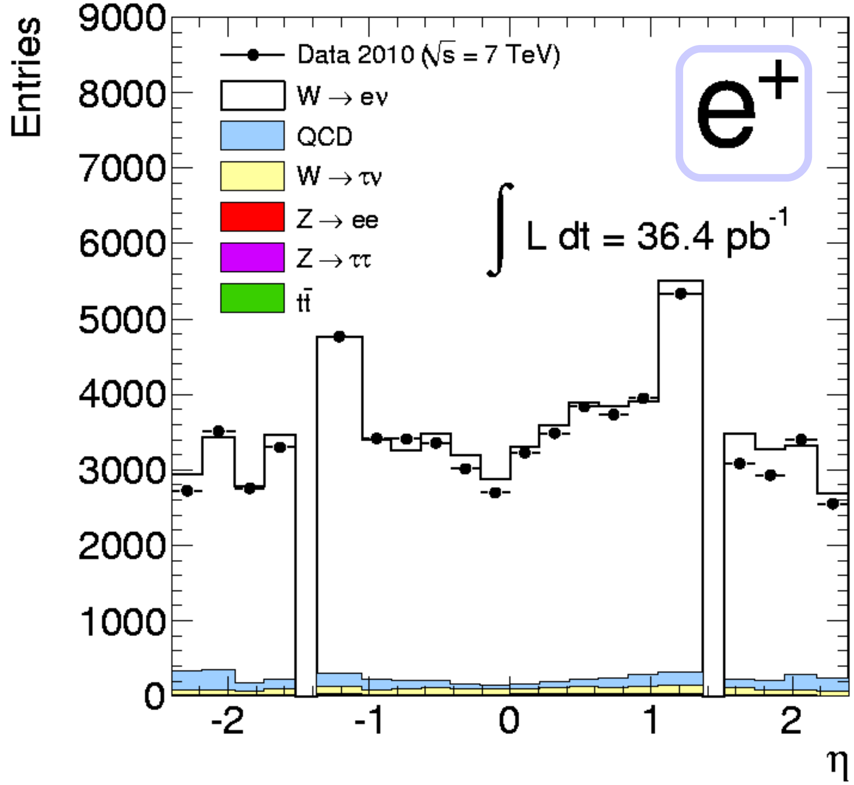
- Signal extracted from unbinned maximum likelihood fit to E_T^{miss} or m_T

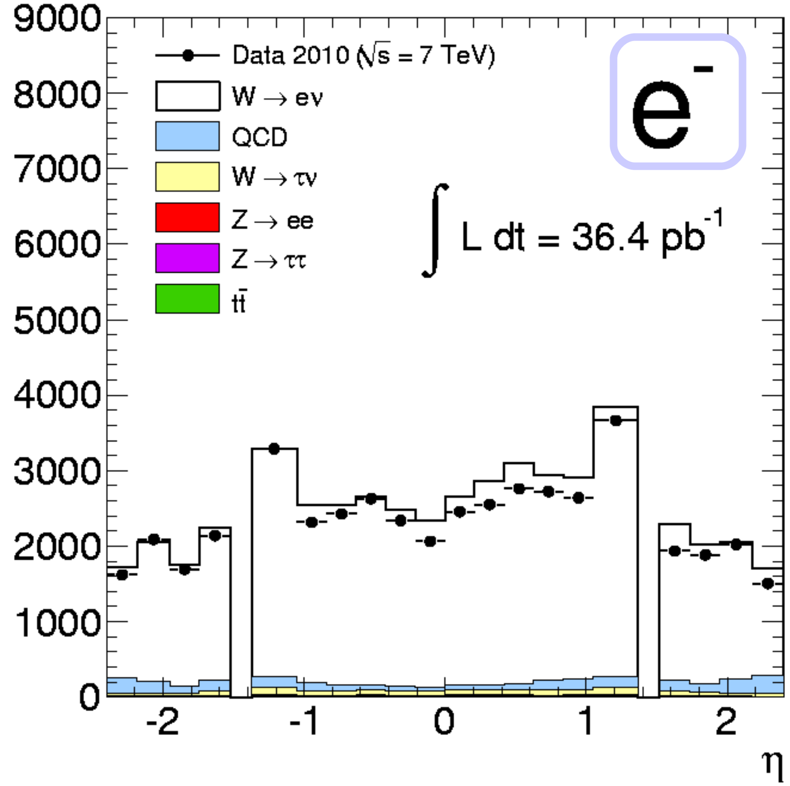
➔ central value of combined results below prediction for both experiments

Electron

Muon

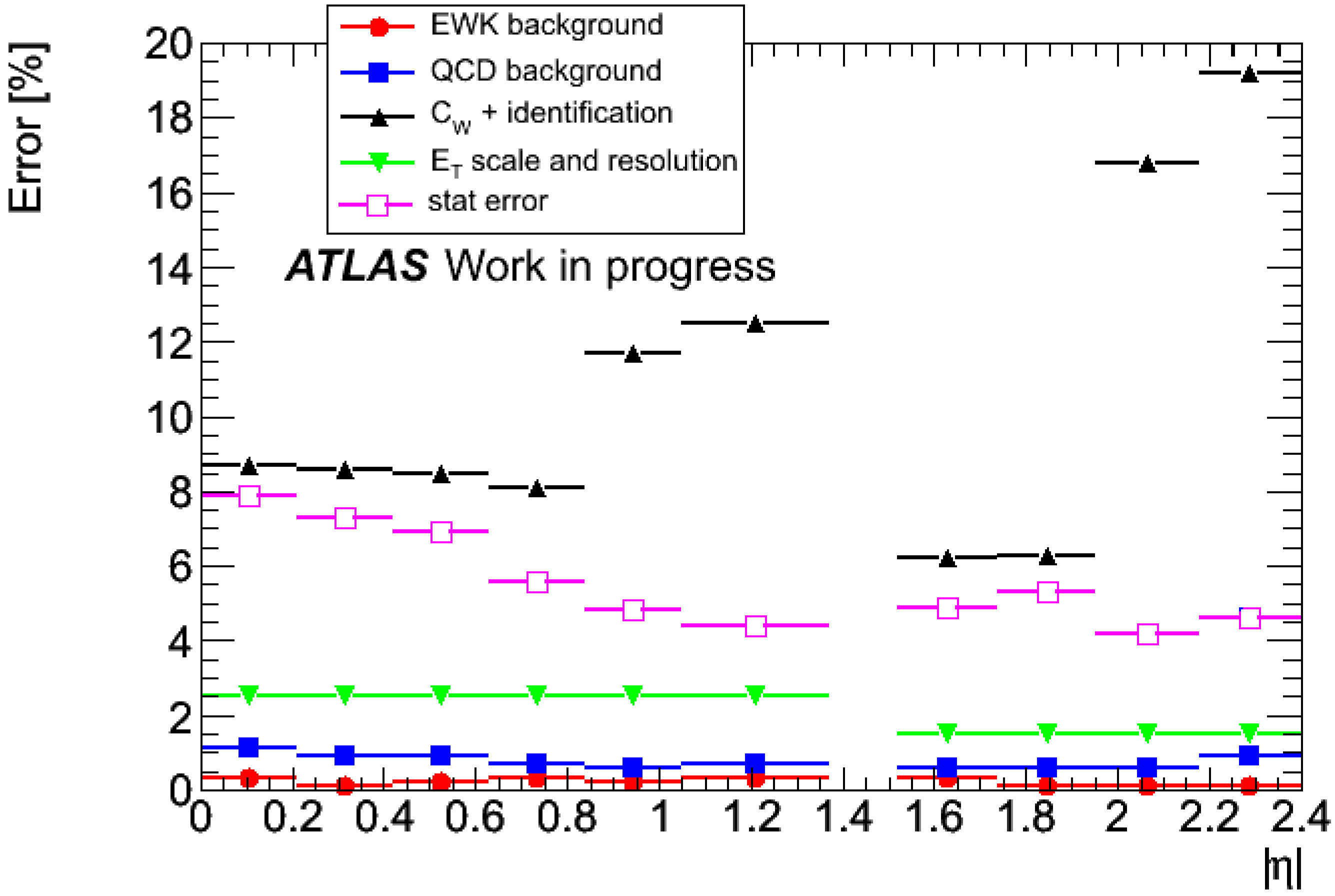
η distributions



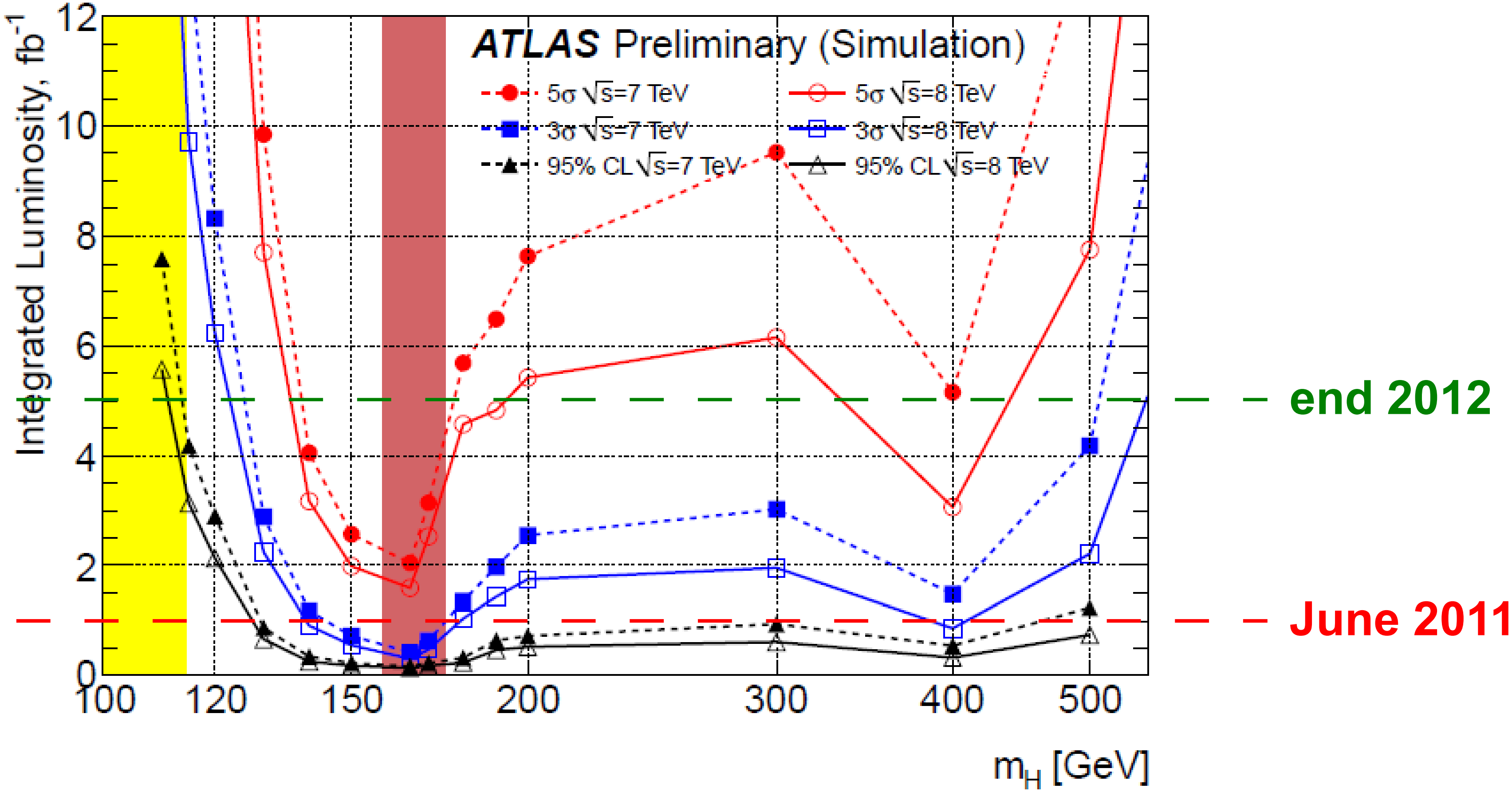


➔ Good agreement data/MC

Asymmetry systematic errors



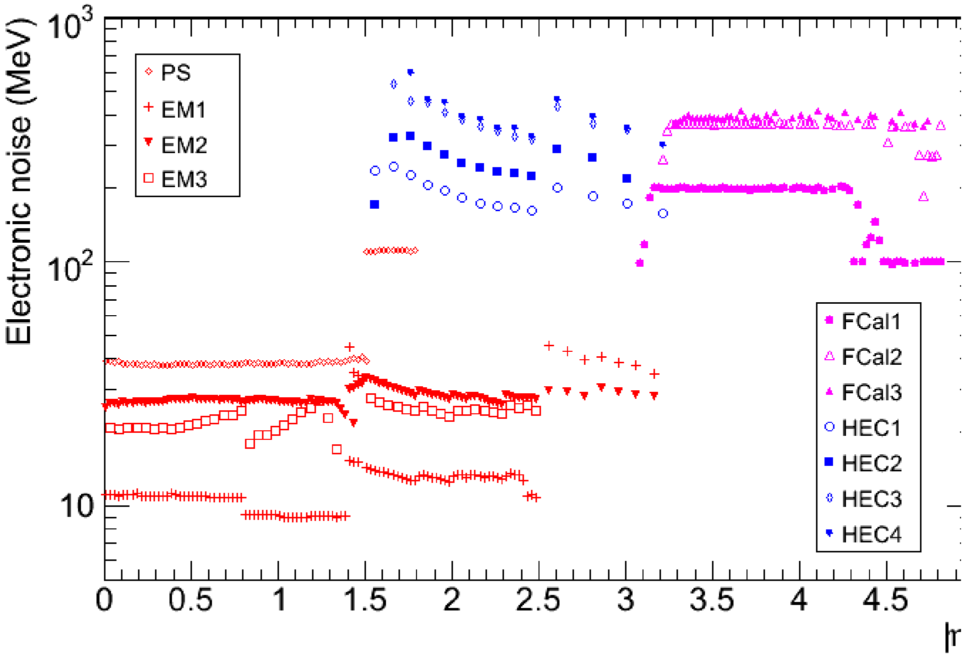
Higgs sensitivity with ATLAS



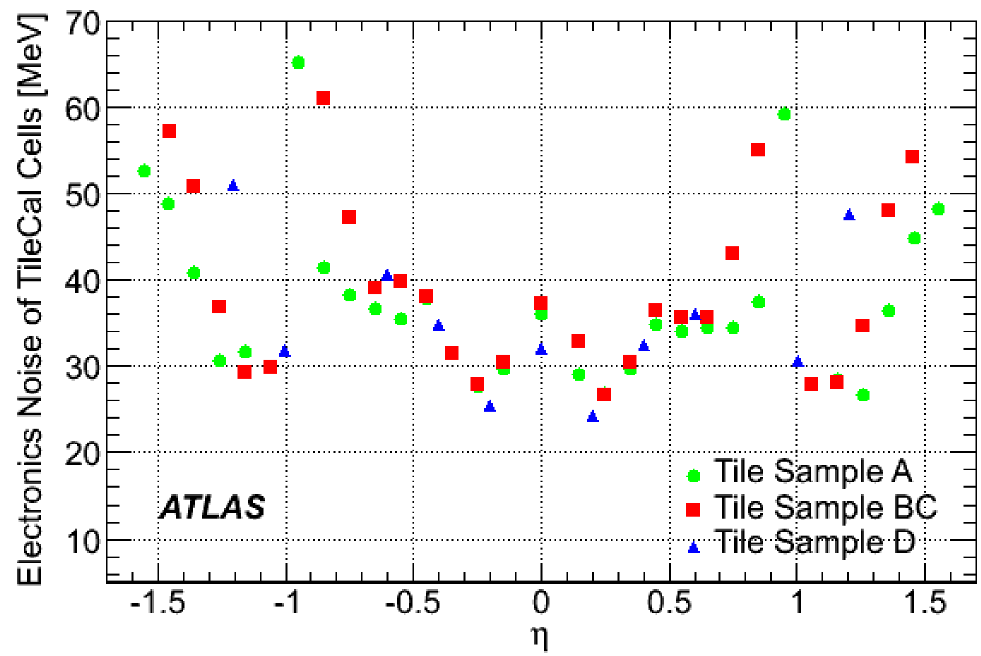
- 95% exclusion with 1 fb^{-1}: 130-460 GeV
- 3σ discovery with 5 fb^{-1}: 120-500 GeV

Electronic noise

LAr

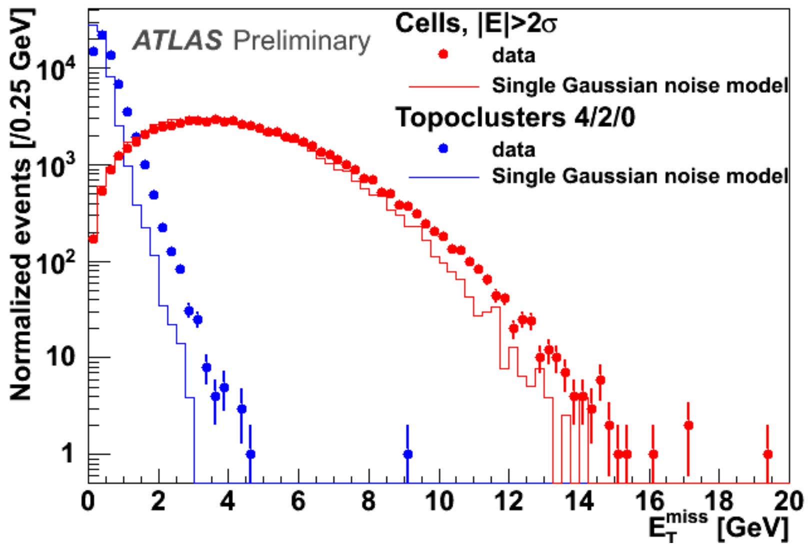


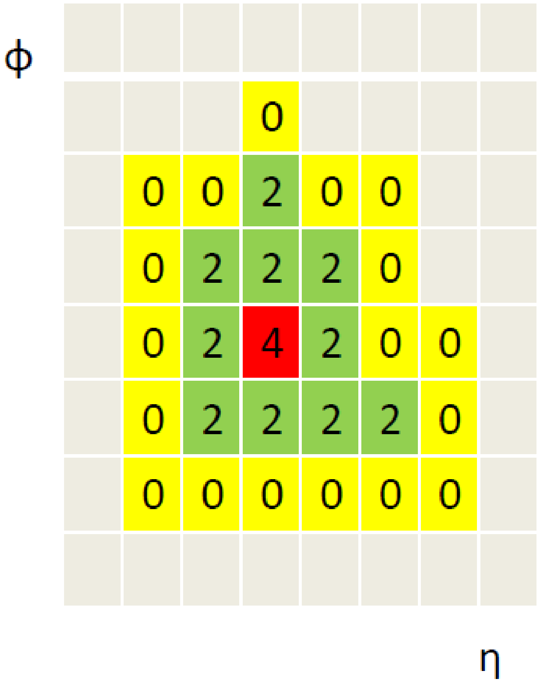
Tile



Topological clustering

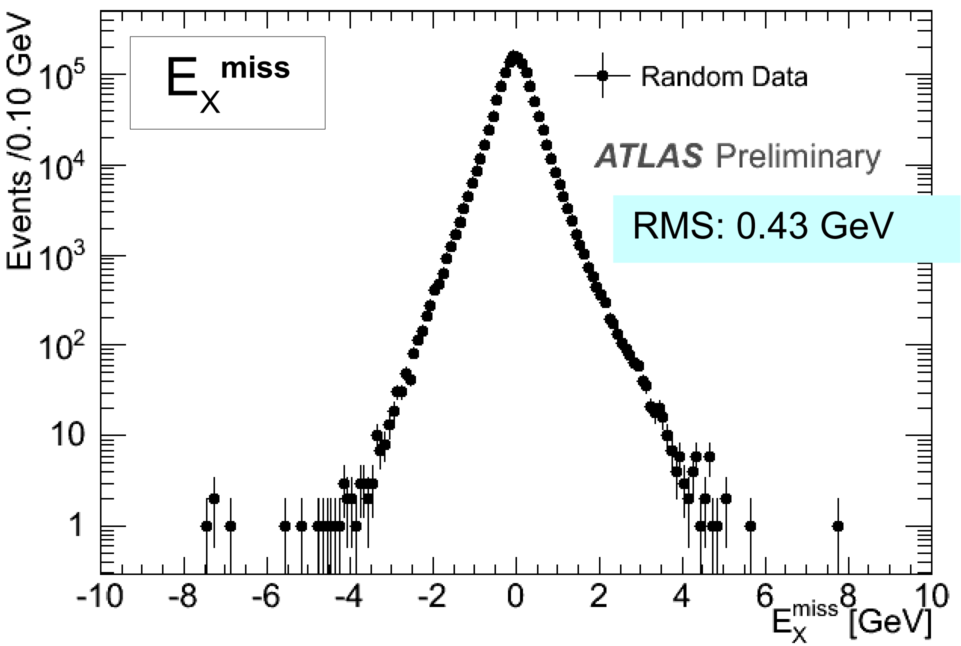
- Input to Calorimeter-E_T^{miss} reconstruction: 4/2/0 topoclusters
- 3-dimensional group of calorimeter cells:
  - seed cells with $|E_{cell}| > 4*\sigma_{noise}$
  - iteratively add neighbours with $|E_{cell}| > 2*\sigma_{noise}$
  - add perimeter cells with $|E_{cell}| > 0*\sigma_{noise}$

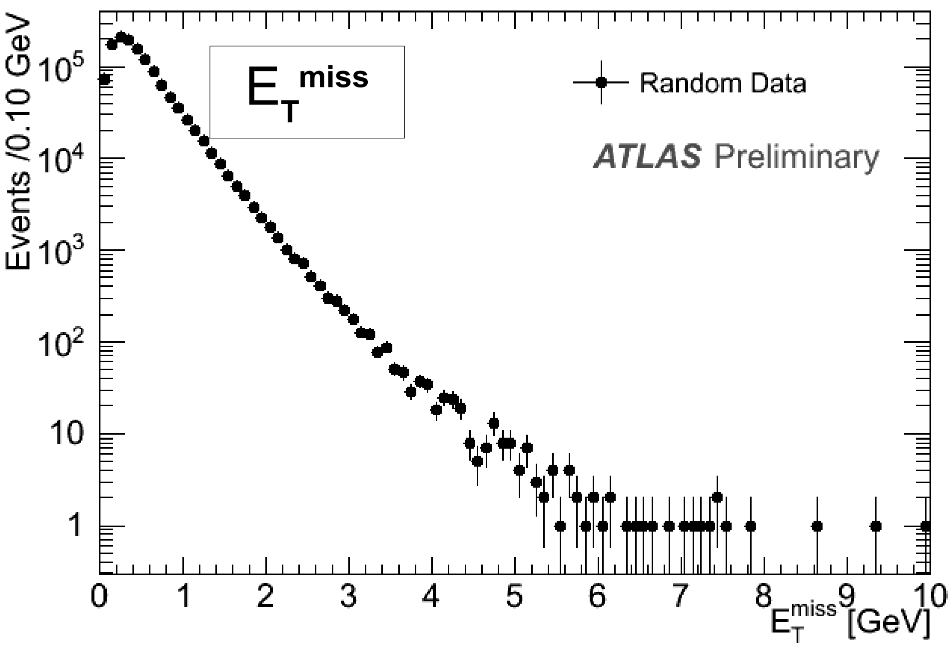




Randomly triggered events

- No energy deposit





➔ Centred on 0

➔ No tails > 10 GeV

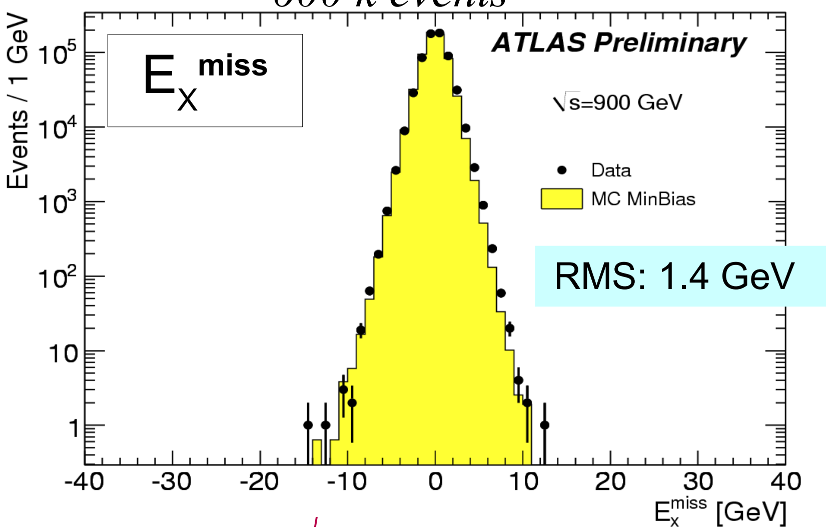
➔ Thanks to noise rejection, no contribution to resolution for physics

Calorimeter-based E_T^{miss} (1)

- Energy deposits in the calorimeters

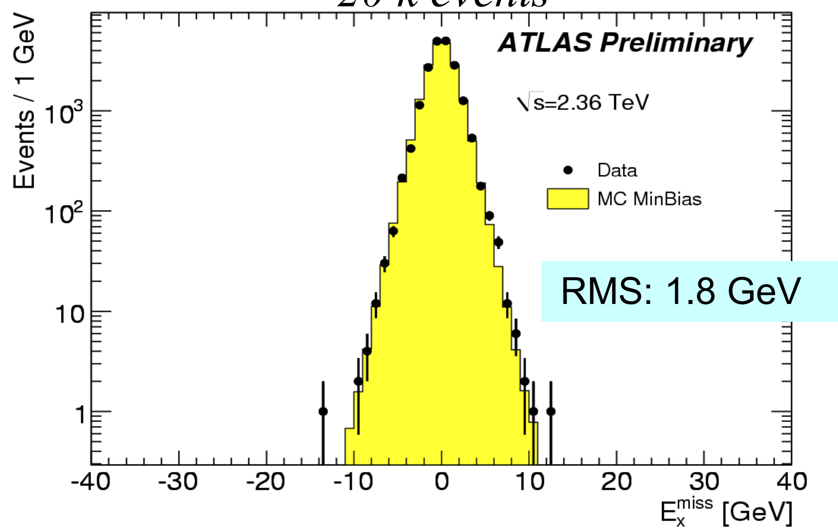
√s = 900 GeV

~600 k events



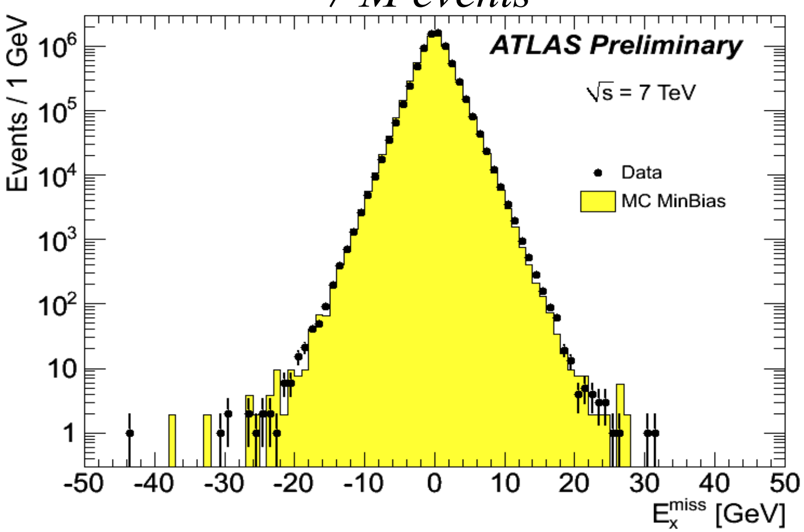
√s = 2.36 TeV

~20 k events



√s = 7 TeV

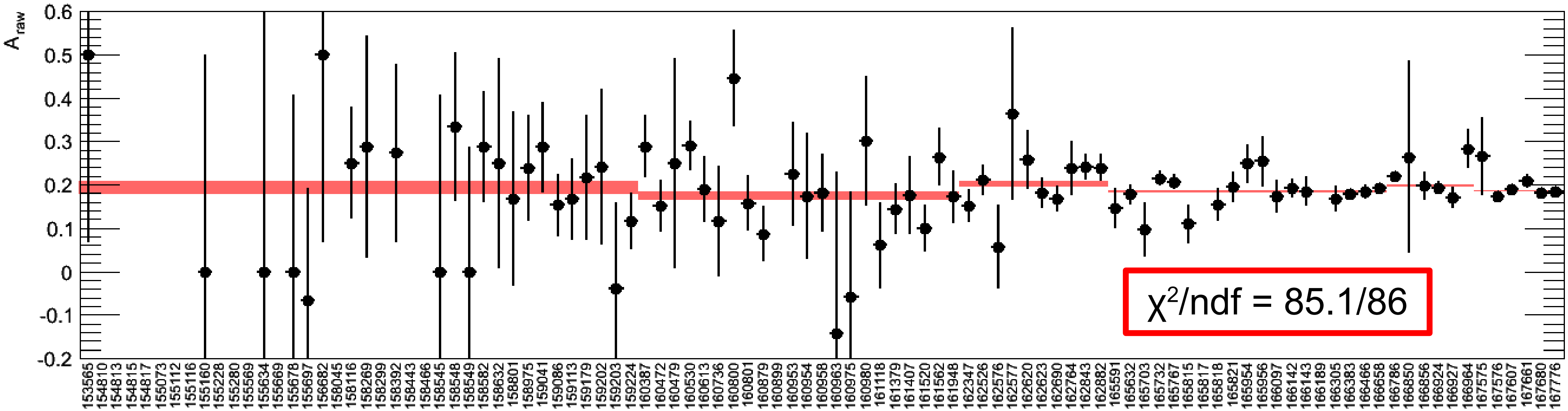
~7 M events



➔Good agreement data/MC

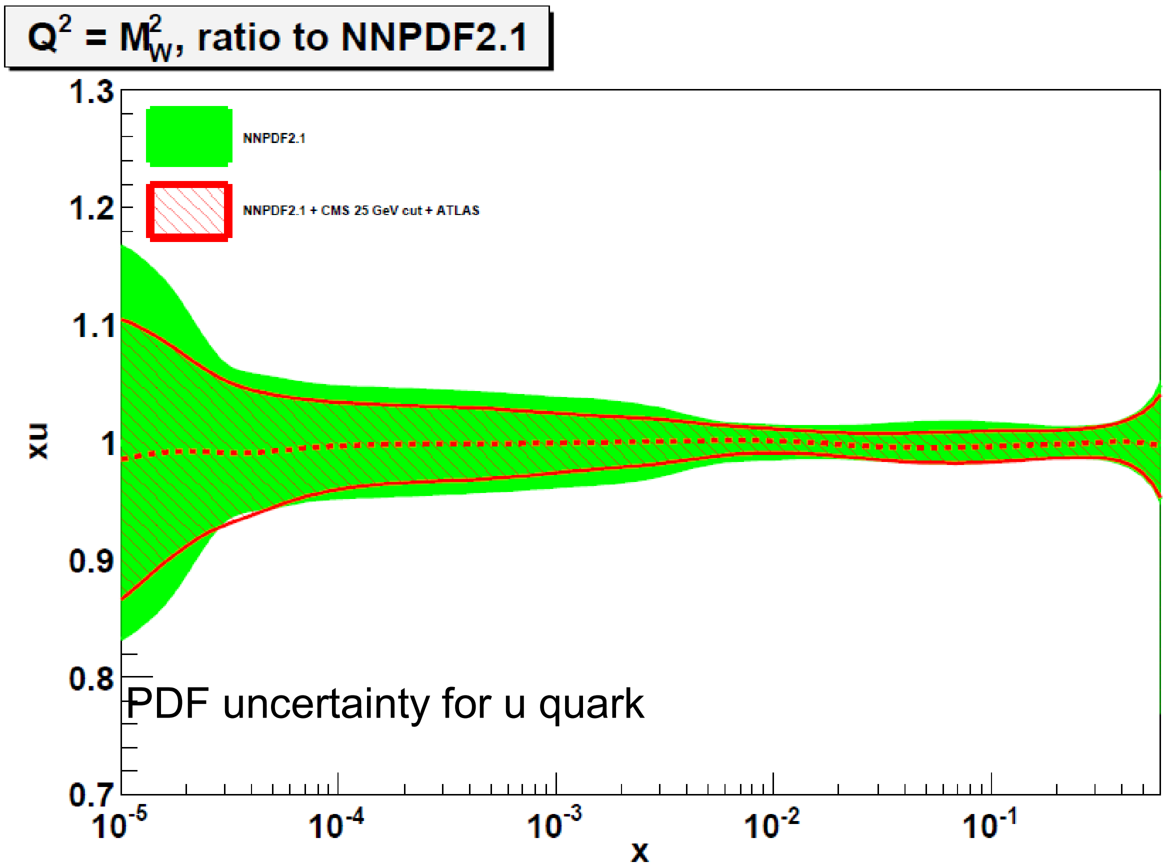
Stability of the selection

- Raw asymmetry $(N^+-N^-)/(N^++N^-)$ for each run



➔ Good stability of the selection with time

Asymmetry results (3)



➔ Results:

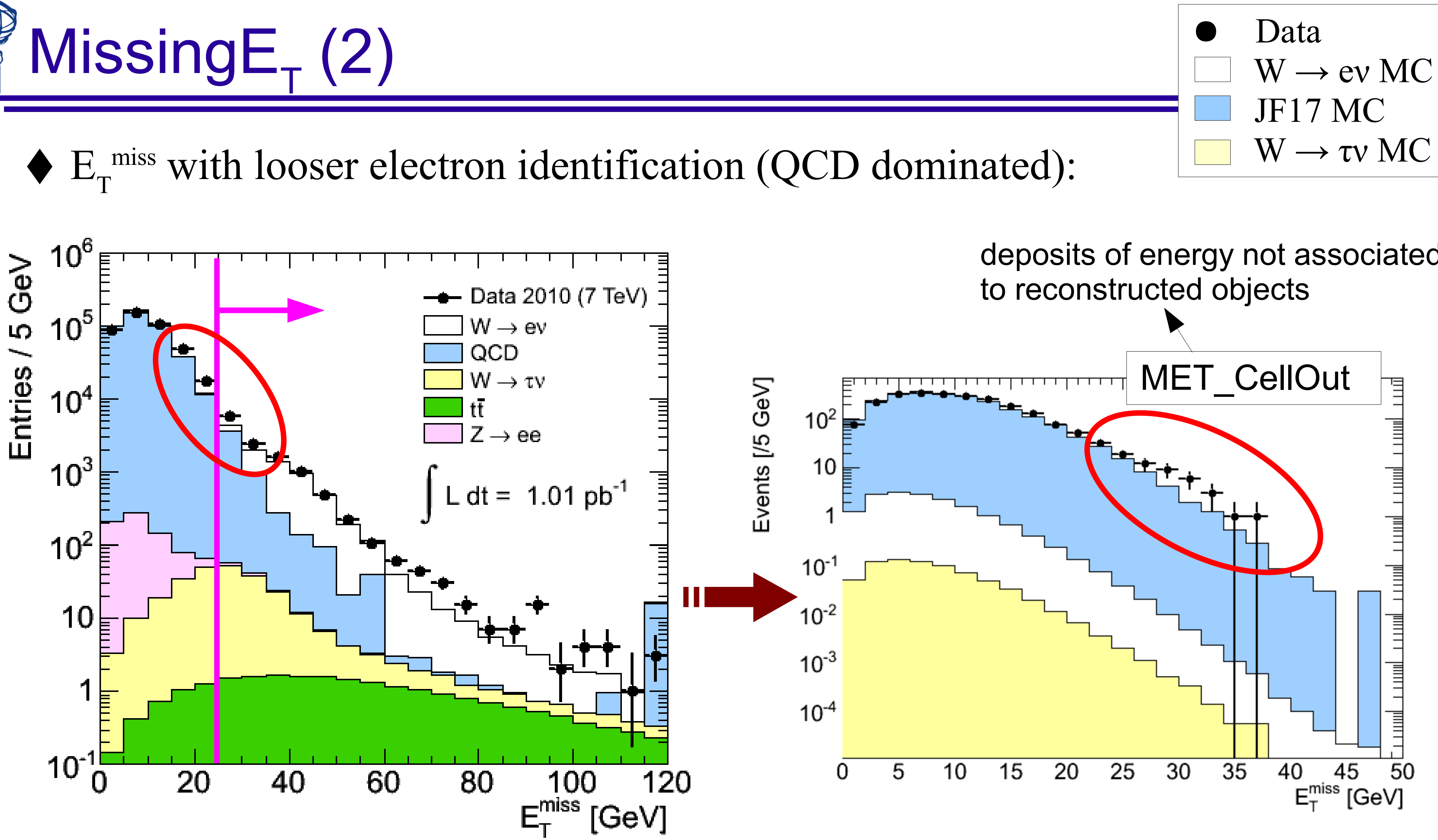
- not possible to discriminate PDFs yet
- implementation of ATLAS and CMS results in PDFs computation

“**Measurement of the W -> lnu and Z/gamma* -> ll production cross sections in proton-proton collisions at sqrt(s) = 7 TeV with the ATLAS detector**”, The ATLAS Collaboration, *Journal of High Energy Physics Volume 2010, Number 12, 1-65*

“**Measurement of W->lnu charge asymmetry in proton-proton collisions at sqrt(s)=7TeV with the ATLAS detector**”, A. Belloni et al, *ATLAS internal note ATL-COM-PHYS-2010-701*

MissingE$_T$ (2)

♦ E_T^{miss} with looser electron identification (QCD dominated):



➔ Efficiency of E_T^{miss} cut (25 GeV): ε(data)/ε(MC) = 1.25±0.04

➔ Discrepancy from soft physics in jet events (mainly in the forward region)

➔ Need data-driven estimate of QCD background