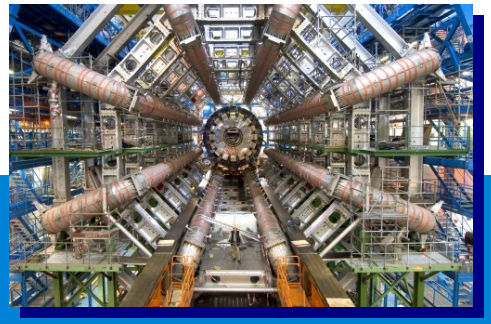
Status of the DESY ATLAS Group

Gerhard Brandt
on behalf of the DESY ATLAS Group

- ATLAS Data Taking
- Rediscovering the Standard Model
  - Soft QCD, W/Z, tau, jets, top
- Preparing for the Future
  - Upgrade



The DESY-ATLAS Group

People

- 8 Senior Staff
- 2 YIG Leaders (+ 1 starting January)
- 16 PostDocs (Fellows)
- 16 PhD Students

Sites

- DESY Hamburg
- DESY Zeuthen

Collaborations

- Uni Hamburg
- Humboldt Uni Berlin
- Terascale Alliance

Activities (Non-Analysis)

Trigger

- Core Software
- Menu Configuration + Trigger DB
- Online Monitoring
- Trigger Analysis Tools
- Offline Rate Studies
- Upgrade Simulation

Software and Computing

- Core Software (Athena)
  - (recently: CutFlowSvc)
- High-Level (ntuple) Analysis Software
  - ROOT-based Frameworks+Tools
  - PROOF
- NAF Support

Monte Carlo

- Generator Integration and Validation
- MC Tuning
- ALPGEN+PYTHIA Matching (*LPCC*)

Hardware Projects

- ALFA Luminosity Detector
- IBL (Insertable *b*-Layer)
- PETAL2014 (R&D for SCT Upgrade)

Managing Positions

- PubComm Deputy
- MC Group Convenorship
- Tau Reconstruction Convenor
- Top D-Convenor
- Computing Boards: GCTF, NUC, D-CRB, ICB

These topics only mentioned where relevant for analysis →

Physics Analysis Programme

Overall strategy of the DESY group:

- Focus on SM **measurements** to help lay foundation for searches for new physics (not covered in this talk)

Will provide Input + experience for...

- Charged-Particle Production (Minimum Bias)
- W/Z Production
  - inclusively ($Z \rightarrow ee$)
  - in association with jets
  - Tau channel
    - $Z \rightarrow \tau\tau$, $W \rightarrow \tau\nu$
- Multijet Production
- Top Pair-Production

Pdf Studies + SUSY (GMSB)
jet + lepton (mSUGRA)

SUSY with tau-leptons

New physics with top

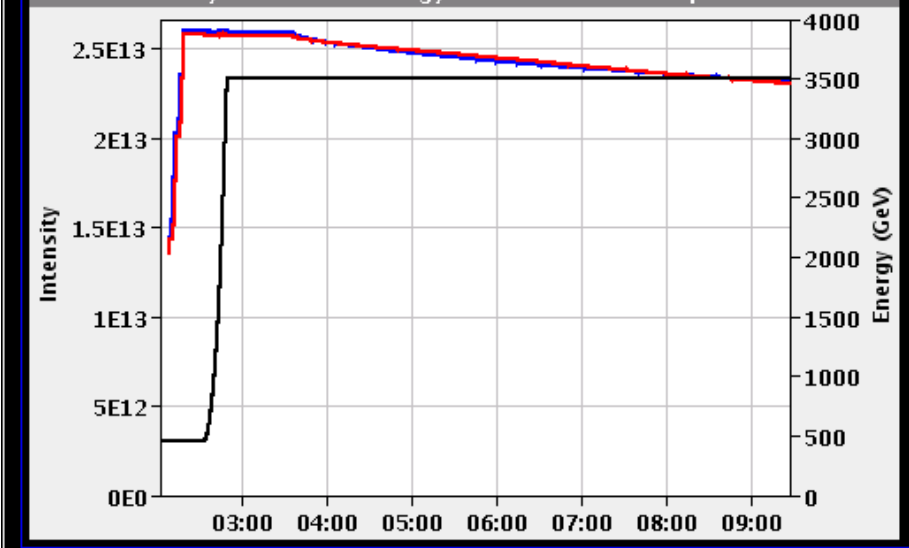
Highlight plots with essential contribution from DESY

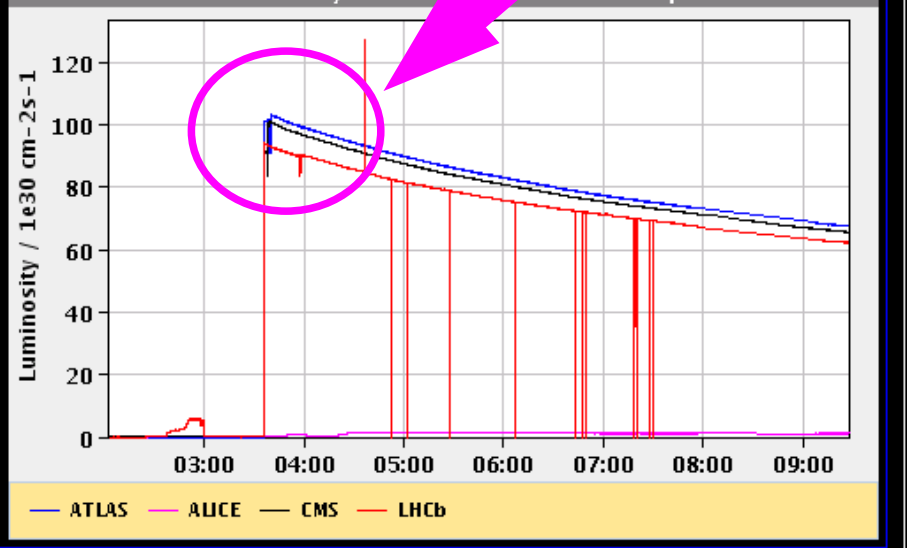
LHC Operation Status This Morning

LHC Page1 | Fill: 1418 | E: 3500 GeV | 14-10-2010 09:27:30

PROTON PHYSICS: STABLE BEAMS

Energy:	3500 GeV	I(B1):	2.50e+13	I(B2):	2.42e+13





Comments 14-10-2010 09:13:11 :

All TOTEM roman pots, H & V in
WE plan to dump at 13:00
Then injection of 312 b and MP test
Then fill for physics (312 bunches/ring)

BIS status and SMP flags	B1	B2
Link Status of Beam Permits	true	true
Global Beam Permit	true	true
Setup Beam	false	false
Beam Presence	true	true
Moveable Devices Allowed In	true	true
Stable Beams	true	true

AFS: 150ns_248b_233_16_233_3x8bpi15inj | PM Status B1: ENABLED | PM Status B2: ENABLED

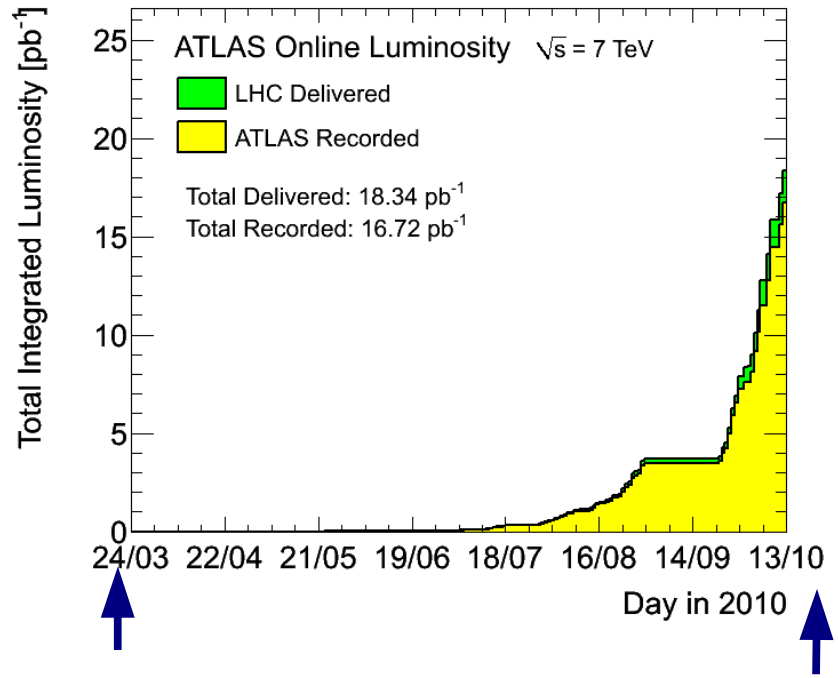
ATLAS Data Taking

- Integrated luminosity 16.7 (+ >1 last night) pb^{-1}

- **Peak luminosity in ATLAS:**
  $\mathcal{L}$ ~ > 10^{32} cm^{-2} s^{-1} at 3:40 am

- Luminosity detectors calibrated with van der Meer scans to **11%**
  (error dominated by beam intensity)

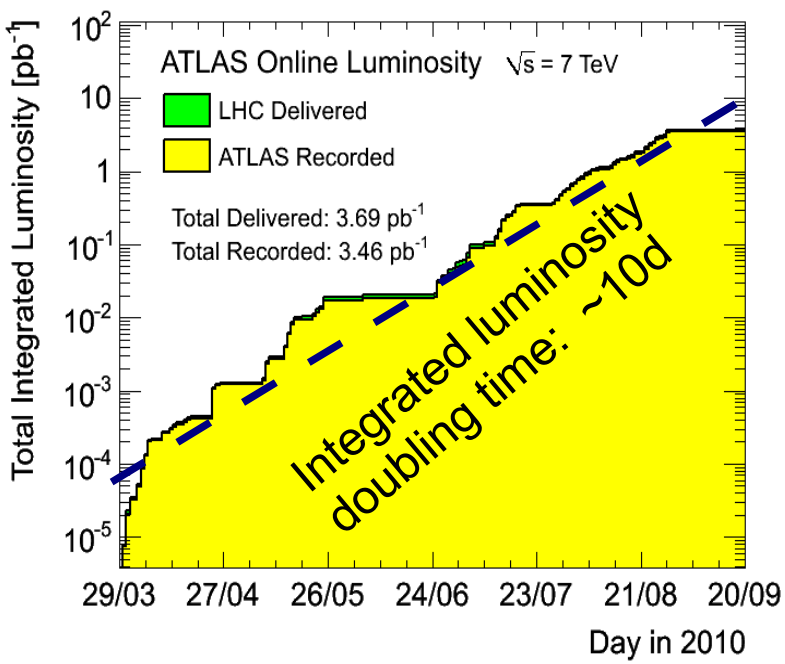
ATLAS-CONF-2010-060



$L \sim 10^{27} cm^{-2}\ s^{-1}$

$L \sim 10^{32} cm^{-2}\ s^{-1}$

3 weeks old plots (LHCC) already historic



Many measurements already constrained by the luminosity uncertainty

Contributions by DESY to improve the precision... →

Luminosity Measurements

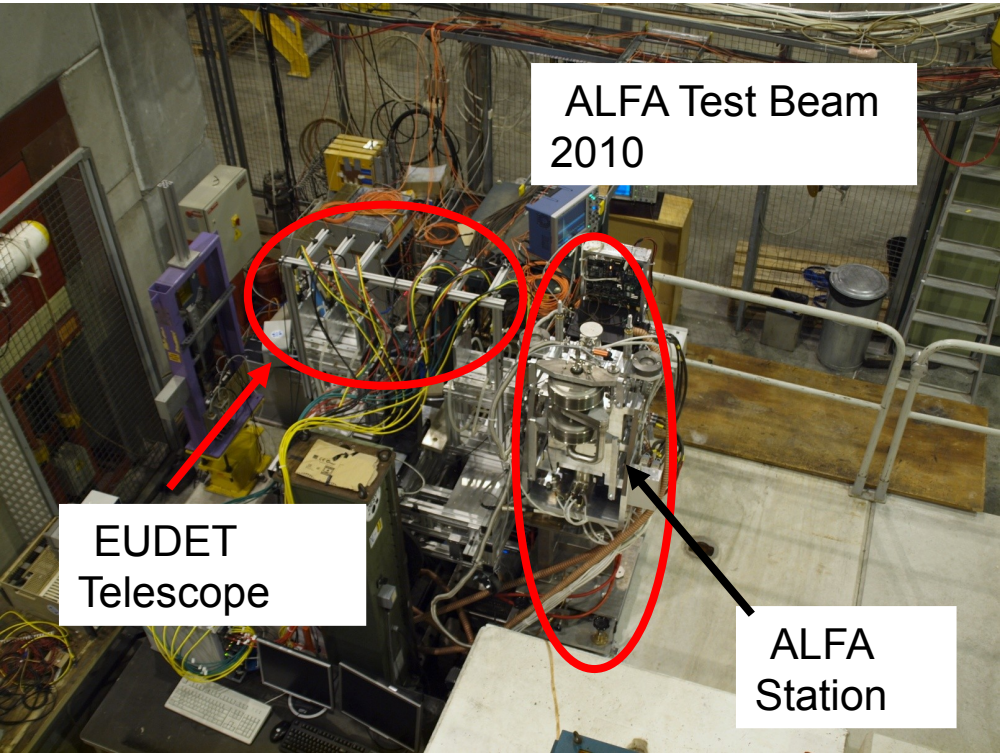
ALFA

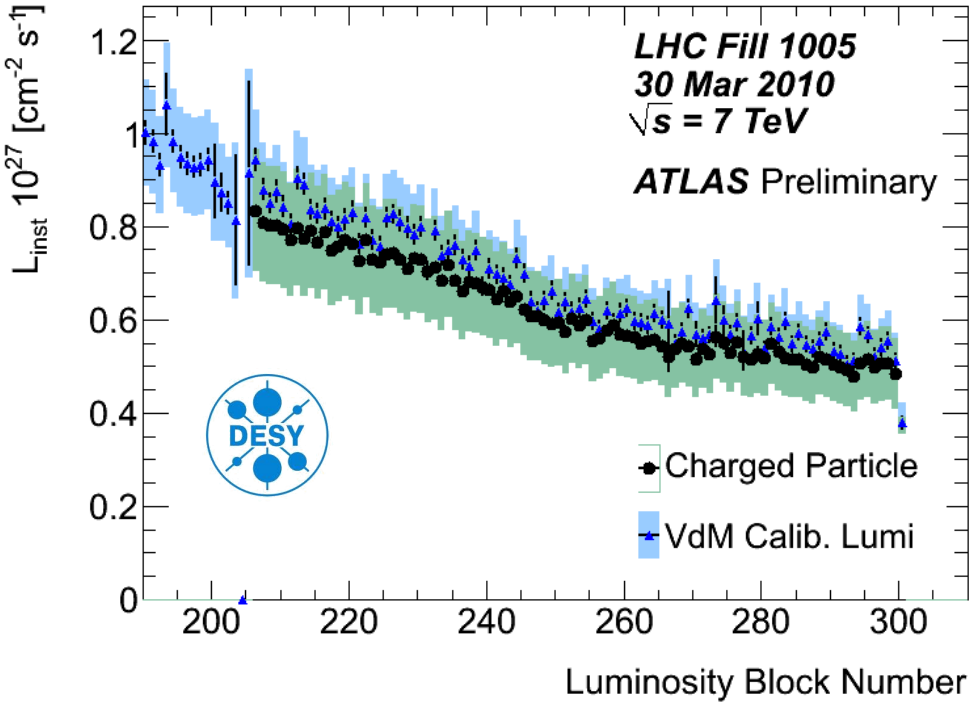
- Absolute luminosity determination with scintillating fibres in Roman Pots
- Will be used to calibrate LUCID

- Testbeam measurement with complete detector on surface successful + stable
- Ready to install during technical stop
- Prospects: 3% lumi precision

Luminosity with Tracks

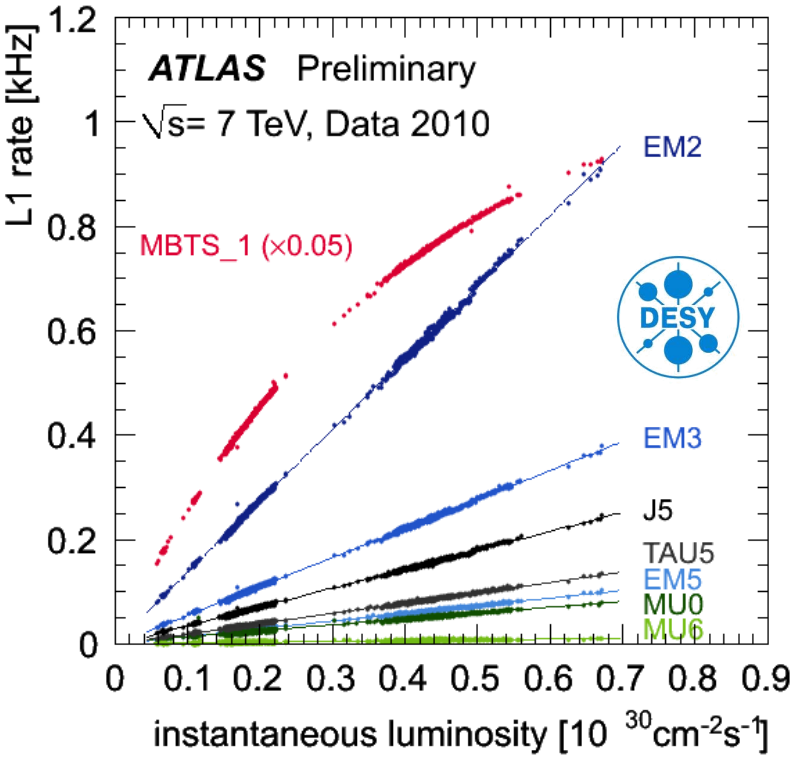
- Measure rate of charged particles
- Convert to luminosity using MC cross section
- Based on minimum bias analysis constrained to $p_T > 0.5$ GeV, $|\eta|<0.8$
- Comparison to other methods and experiments in progress (*LPCC*)



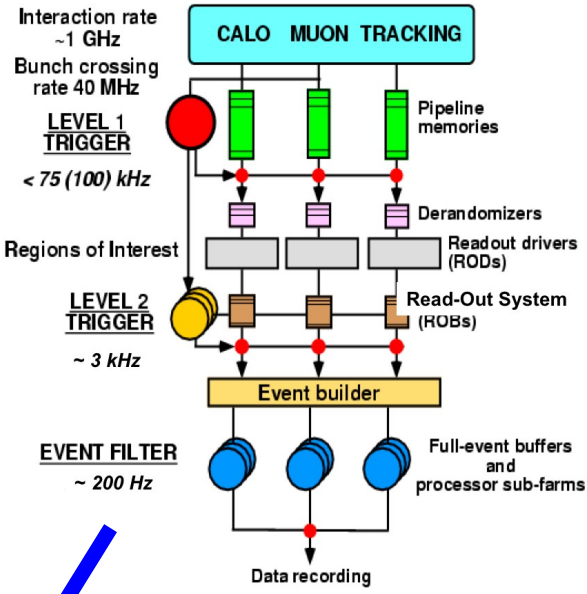


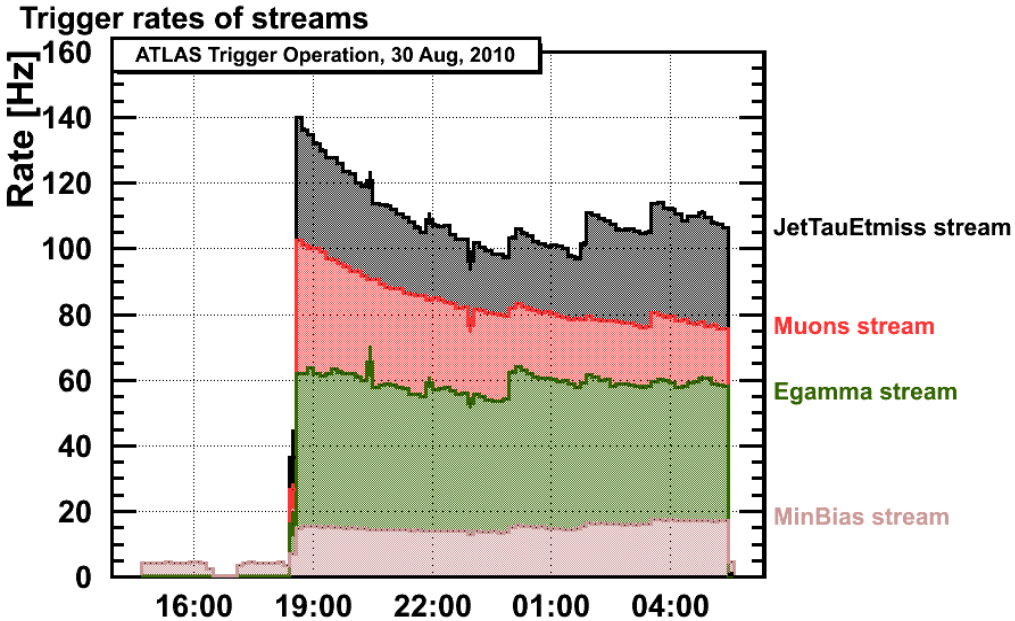
Trigger Status

- 3-Level trigger system fully active now (L1,L2,EF)
- Total Output rate kept at ~300 Hz by carefully balancing prescales in the trigger menu
- Rates increase with lumi - can be precisely predicted
- Designed menu for $\mathcal{L} > 10^{32}$ cm^{-2} s^{-1}



MBTS trigger rates are becoming saturated at high luminosity due to pile-up

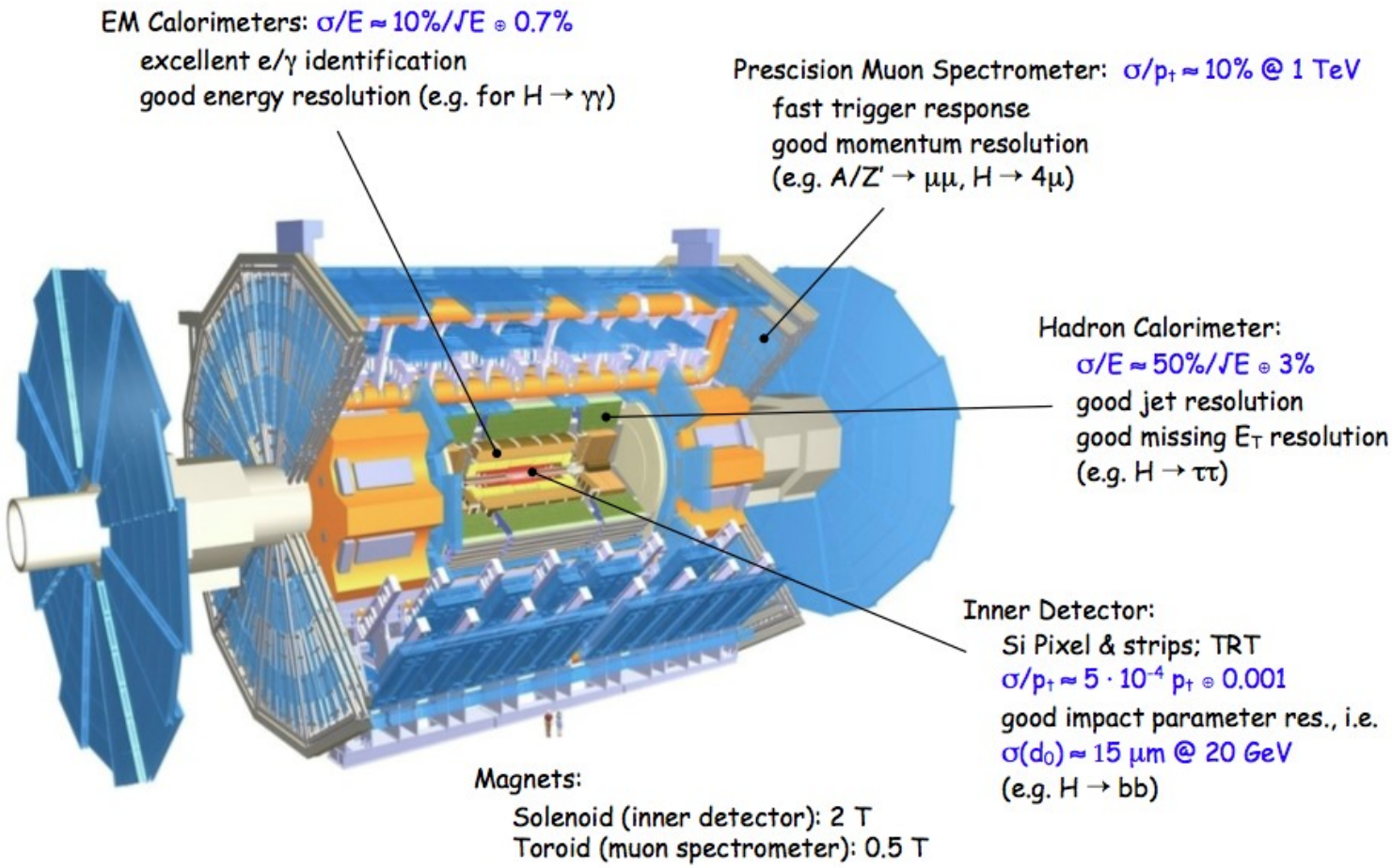




ATLAS Detector Status

Overall data taking efficiency (with full detector on)

~ 94%



Good Quality Data Fraction
~97% *)

Lumi Weighted Detector Uptime

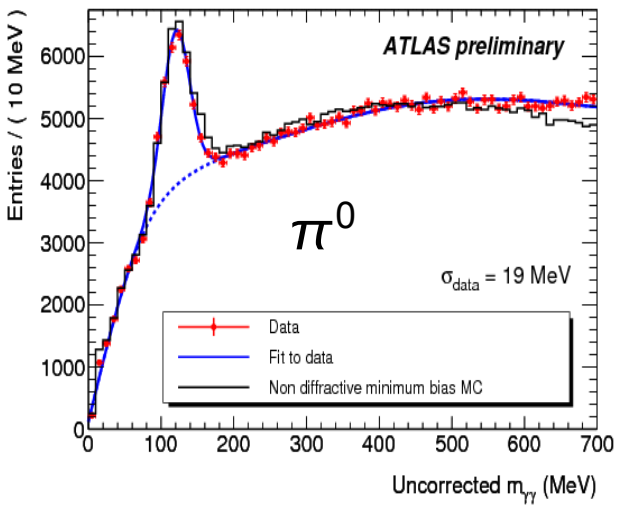
Inner Tracking Detectors			Calorimeters				Muon Detectors			
Pixel	SCT	TRT	LAr EM	LAr HAD	LAr FWD	Tile	MDT	RPC	TGC	CSC
96.7	97.5	100	93.8 *)	98.8	99.0	99.7	98.6	98.5	98.6	98.5

Luminosity weighted relative detector uptime and good quality data delivery during 2010 stable beams at $\sqrt{s}$=7 TeV between March 30th and August 30th (in %)

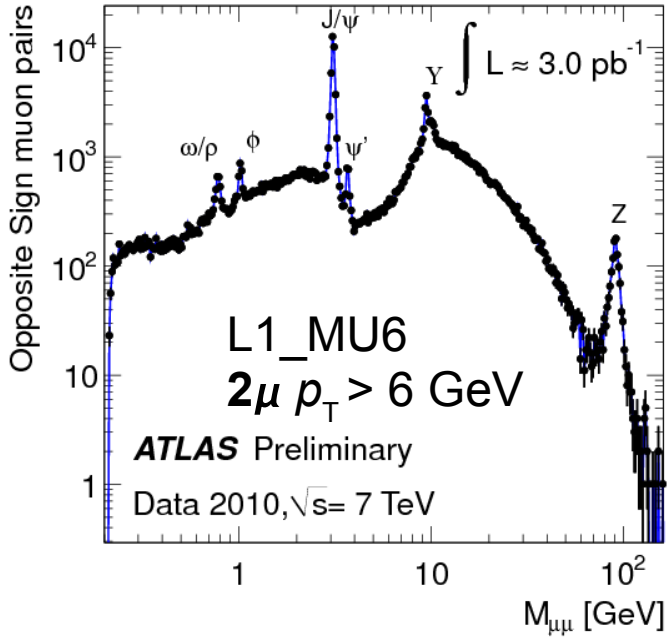
*) 50% can be recovered in Spring2011 reprocessing (noise bursts)

Reconstruction Performance

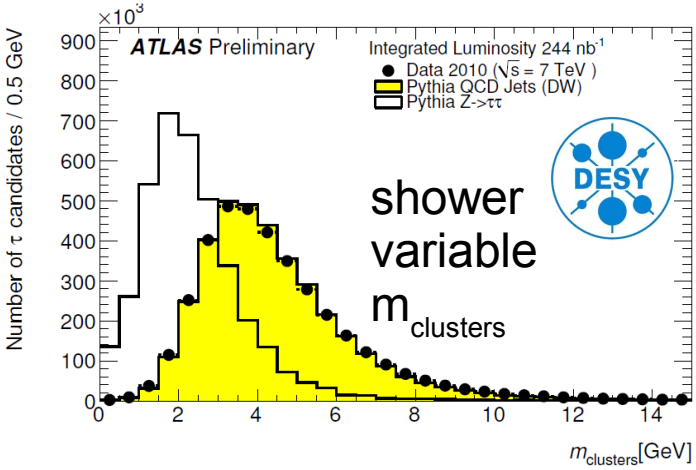
e/γ ID



Muon ID

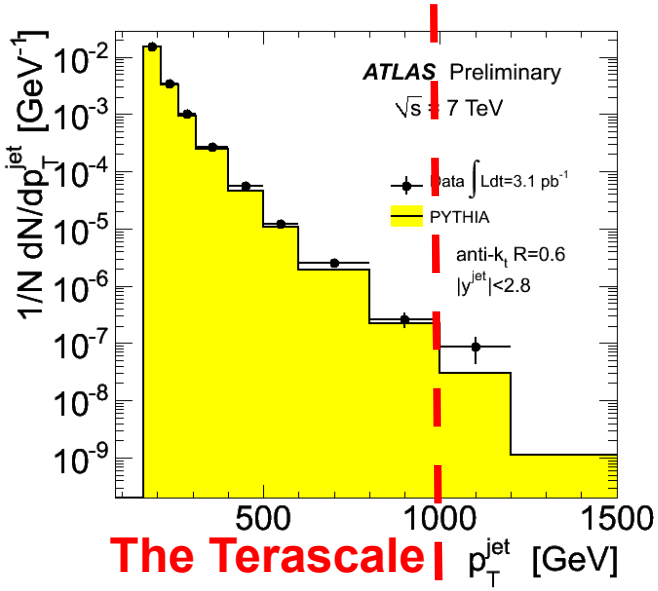


Tau ID



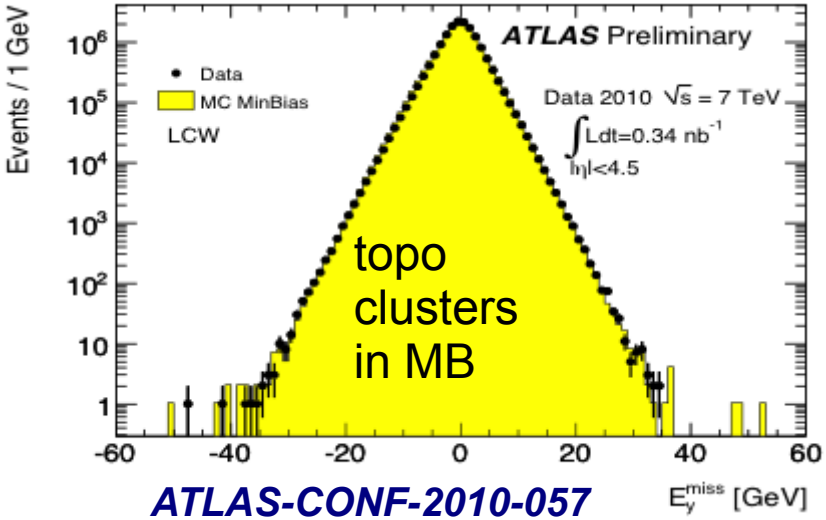
ATLAS-CONF-2010-086

Jets



The Terascale

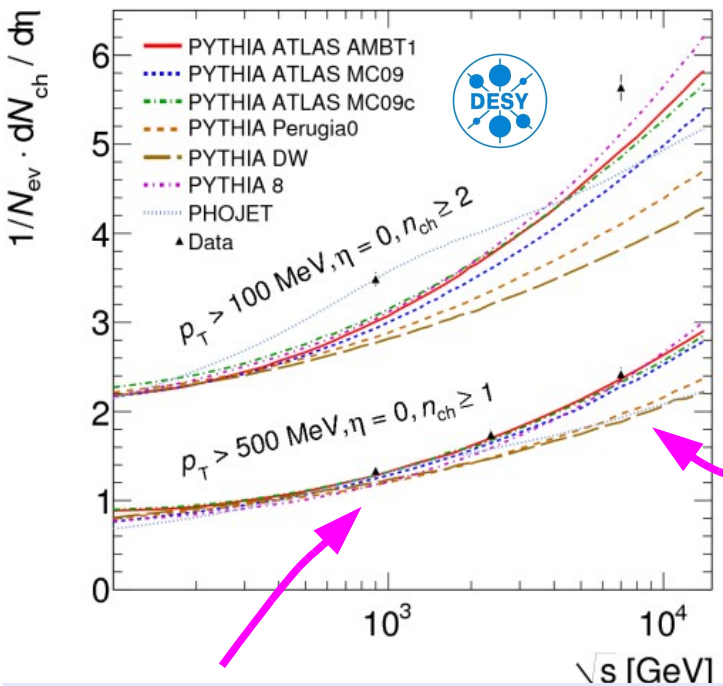
Missing Energy



ATLAS-CONF-2010-057

- Excellent reconstruction performance of physics objects
- Can already look into most high-p_T final states
- Looking at the Terascale today...

Minimum Bias Measurements

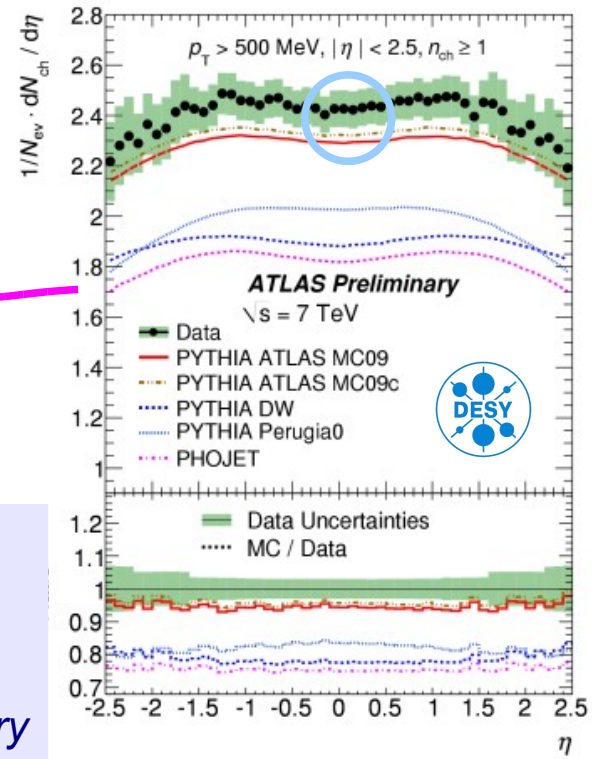


- Added low p_T tracks: p_T >100 MeV, n_{ch}>=2

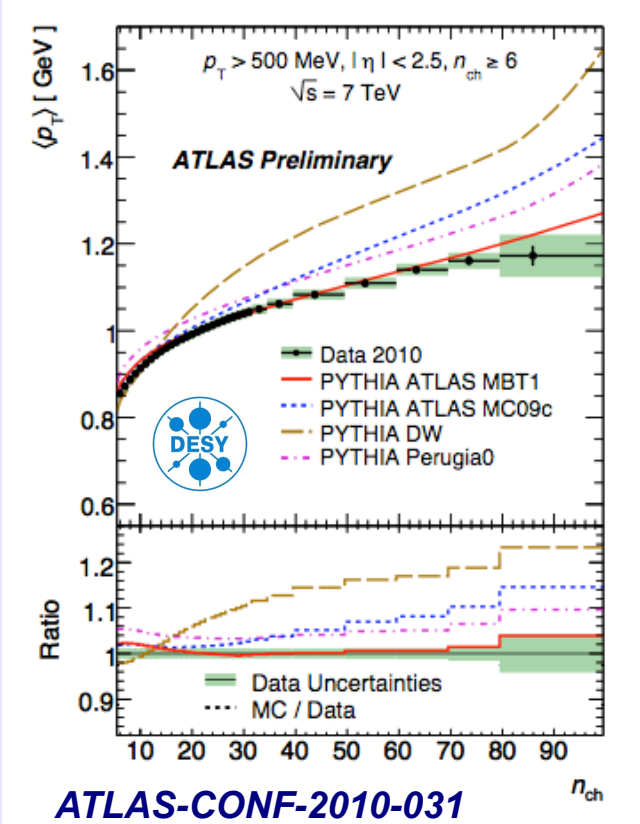
ATLAS-CONF-2010-046

- Added sqrt(s)=7 TeV and 2.36 TeV data

ATLAS-CONF-2010-024 ***ATLAS-CONF-2010-047***



- Used diffraction depleted sample for MC tuning: AMBT1



ATLAS-CONF-2010-031

Topic at last PRC:
First ATLAS paper on minimum bias at sqrt(s)=900GeV

arXiv:1003.3124

Analysis has evolved into small industry

- Minimum Bias analysis also studied technically as large-scale analysis precedence case
  - Need to keep ~ O(TB) of files until late
  - Derived realistic I/O benchmark and site stress test
  - Used to profile NAF and other German Tier-2s

- LHC comparison analysis in common phase space with other experiments (*LPCC*)

Inclusive W/Z Production

Using about 3.2 pb^{-1} ATLAS has collected ~10^4 W's and ~10^3 Z's per channel.

Excellent description of almost background-free samples ~O(2-5%)

($Z \rightarrow \mu\mu$ resolution: muon alignment under study)

DESY Contributions

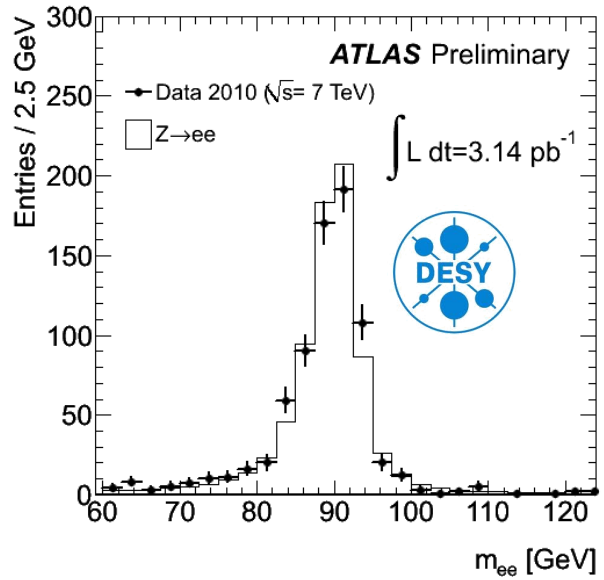
- Result for $Z \rightarrow ee$
- Data quality and stability control

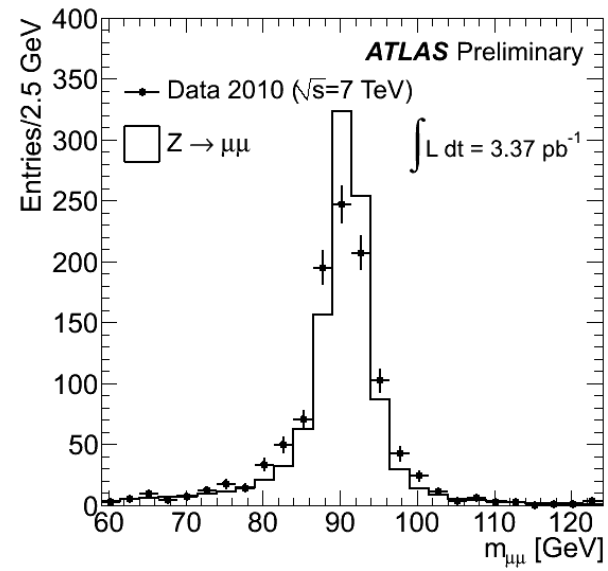
Working on further checks for all channels

Electrons E_T>20GeV

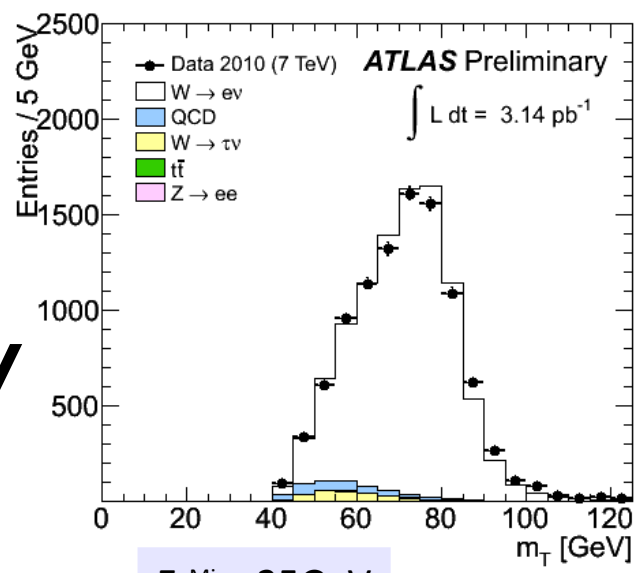
Muons p_T>20GeV

Z

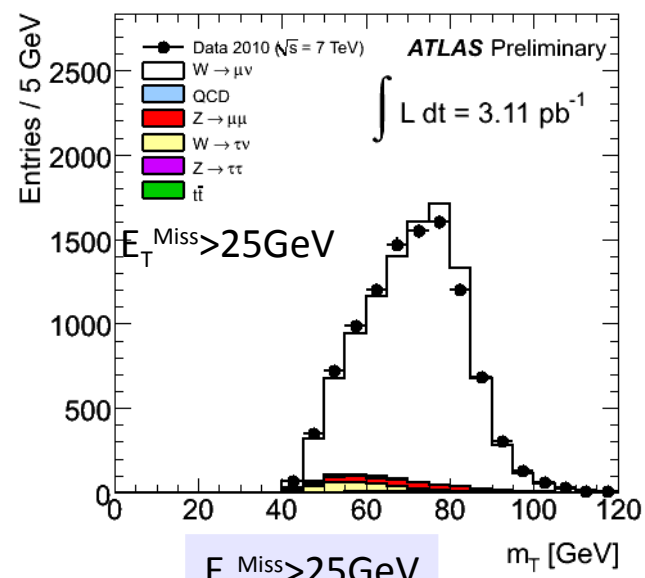




W



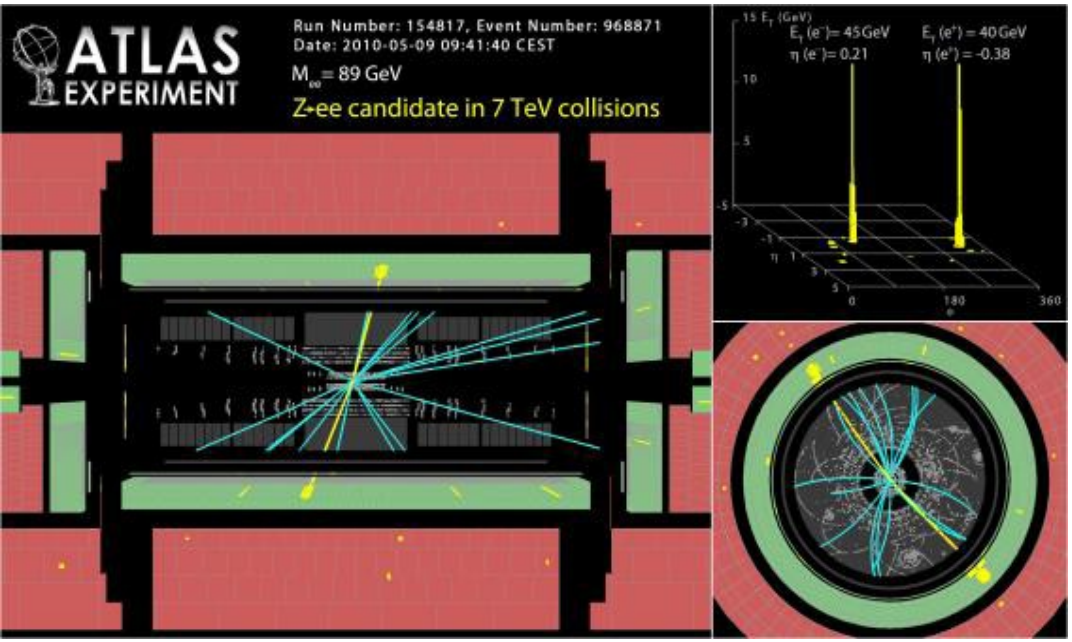
E_T^{Miss}>25GeV



E_T^{Miss}>25GeV

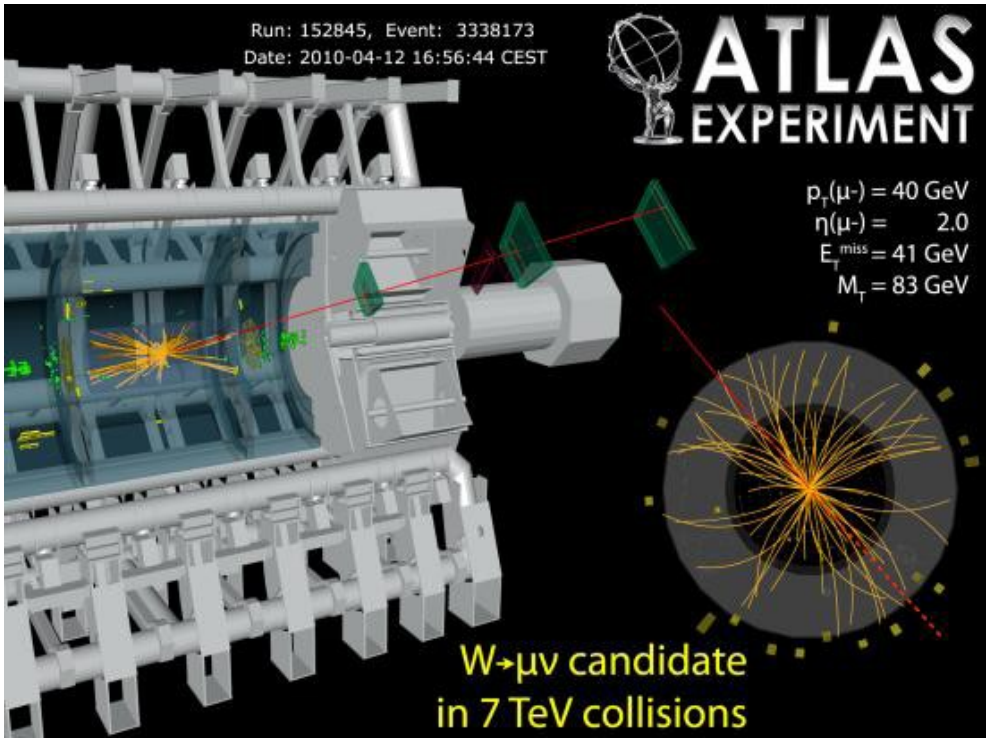
W/Z Candidate Event Examples

$Z \rightarrow ee$



$E_T(e^+)$	= 40 GeV
$\eta(e^+)$	= -0.38
$E_T(e^-)$	= 45 GeV
$\eta(e^-)$	= 0.21
m_{ee}	= 89 GeV

$W \rightarrow \mu\nu$



$p_T(\mu-)$	= 40 GeV
$\eta(\mu-)$	= 1.1
E_T^{miss}	= 41 GeV
M_T	= 83 GeV

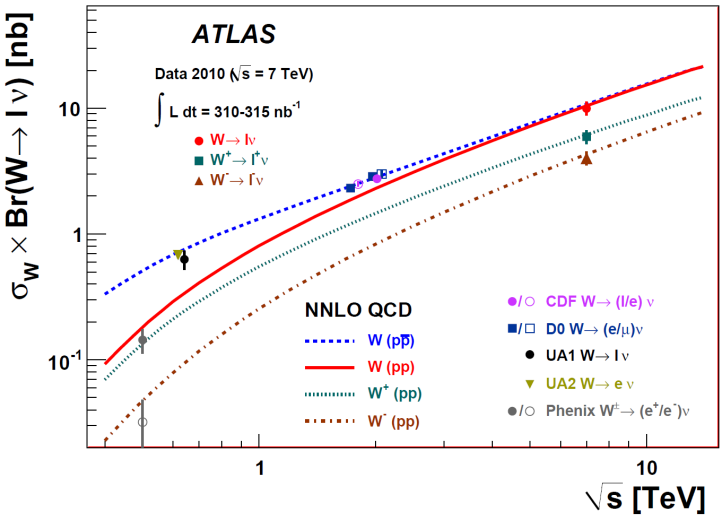
W/Z Inclusive Cross Section Measurement

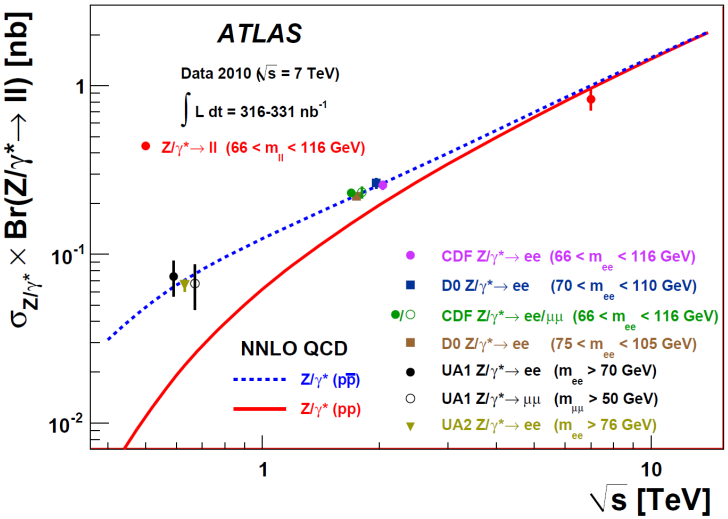
First cross section measurement uses 0.32 pb^{-1} data

arXiv:1010.2130 (11.10.2010)

Not statistically limited, but by lumi error 11%

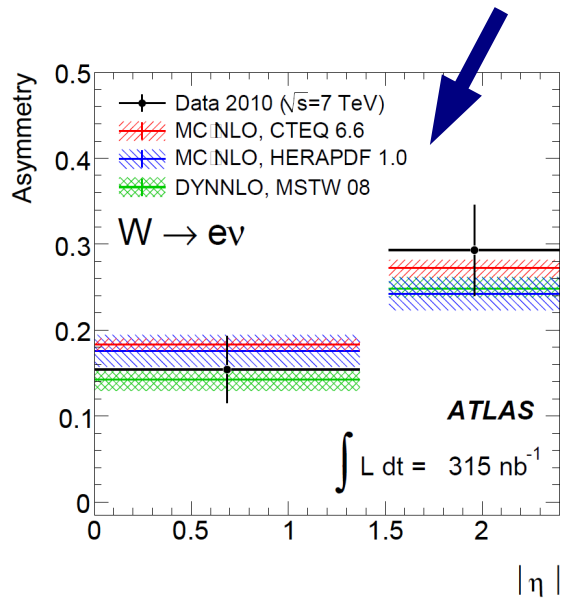
σ ($W \to \nu$ l) = 9.96 ± 0.23 (stat) ± 0.50 (syst) ± 1.10 (lumi) nb
σ ($\gamma^*/Z \to$ ll) = 0.82 ± 0.06 (stat) ± 0.05 (syst) ± 0.09 (lumi) nb

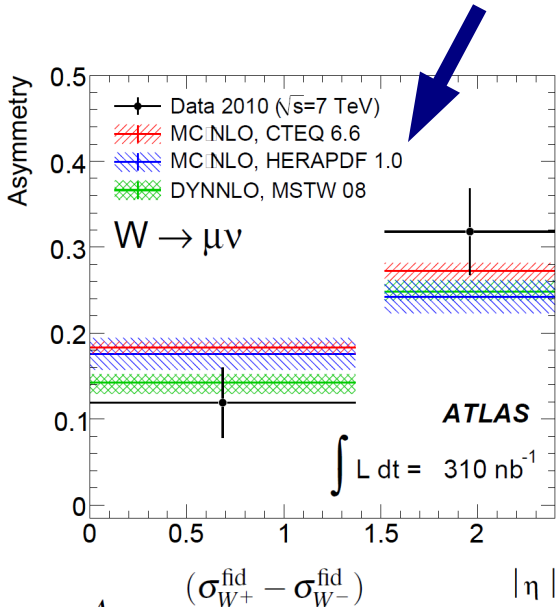




Now starting more differential measurements

- Ratios: W/Z, W^+/W^-
- Asymmetries: A_l, A_{FB}
- Differential cross sections
- Prepare use of data in pdf-fits and vice versa bringing HERA legacy to LHC

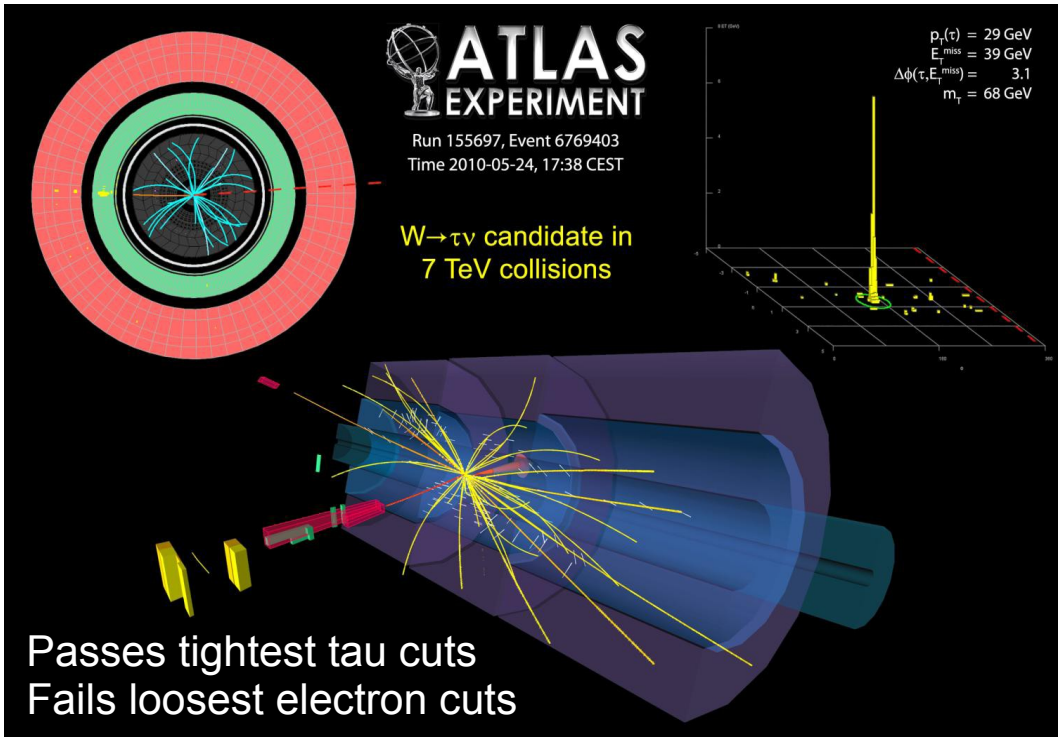


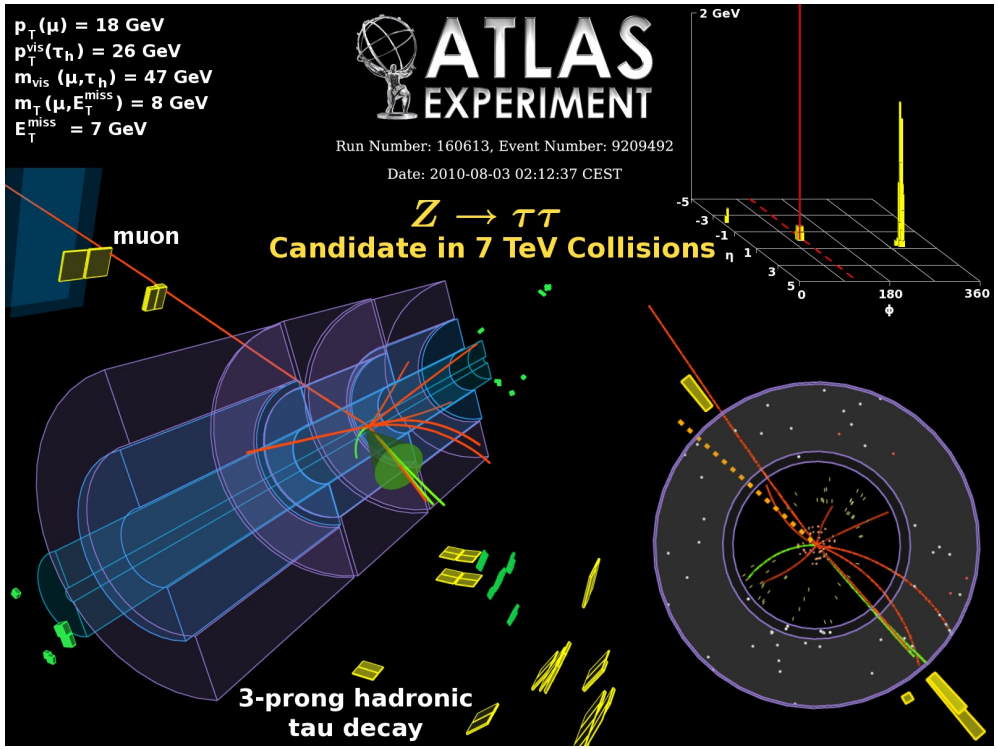


$$A_\ell = \frac{(\sigma^{\rm fid}_{W^+} - \sigma^{\rm fid}_{W^-})}{(\sigma^{\rm fid}_{W^+} + \sigma^{\rm fid}_{W^-})}$$

W/Z with Hadronic Tau Decays

- Tau-channel should compare to e, μ (lepton universality)
- But: enhanced in many BSM models and Higgs
- Several convincing tau candidate events already observed
- Inclusive cross section measurement in progress
  - $Z \rightarrow \tau\tau$, $W \rightarrow \nu\tau$
- Strong involvement from DESY

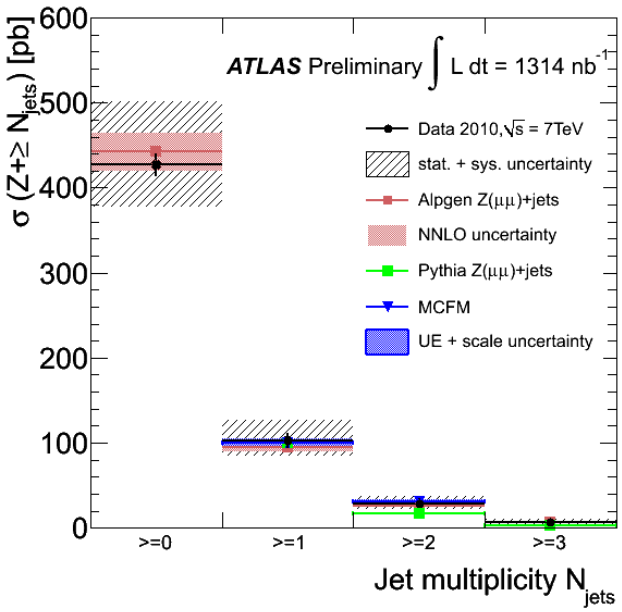




$p_T(\tau)$	= 29 GeV
E_T^{miss}	= 39 GeV
$\Delta\varphi(\tau, E_T^{miss})$	= 3.1
m_T	= 68 GeV

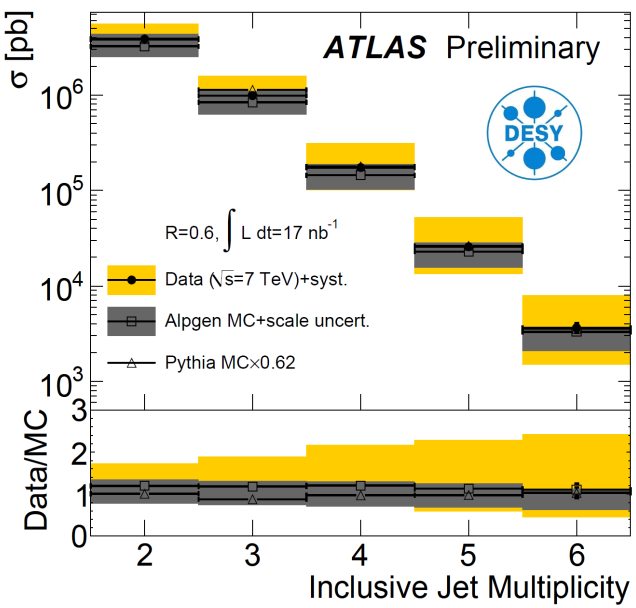
$p_T(\mu)$	= 18 GeV
$p_T^{vis}(\tau_h)$	= 26 GeV
$m_{vis}(\mu, \tau_h)$	= 47 GeV
$m_T(\mu, E_T^{miss})$	= 8 GeV
E_T^{miss}	= 7 GeV

W/Z+Jets and Multijets



W/Z+jets

- Use W/Z selection and look at jets
- Test NLO pQCD Predictions and LO MC's at sqrt(s)=7 GeV
- Sensitive to and background for SM and BSM processes
- Exploit various ratios: dσ(V + ≥Njets) / dσ(V + ≥Njets-1),
  R_{jets} = dσ(W + ≥Njets) / dσ(Z + ≥Njets)
- DESY: Framework and Cross Checks for R_{jets}



Multijets

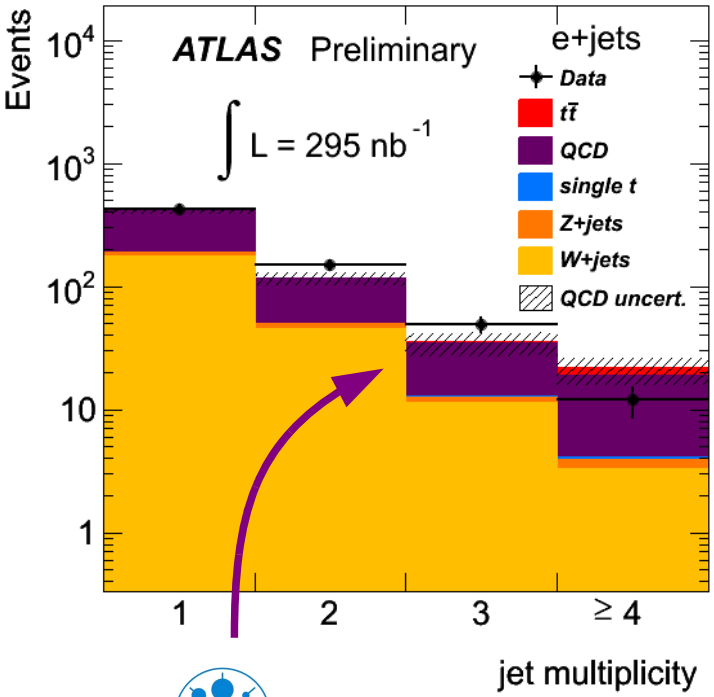
- Measure Multi-Jet Cross Section
- Compare to PYTHIA, ALPGEN
- Measure jet multiplicity ratios and α_s
- Ultimately prepare for ttbar resonance searches

- DESY: DQ control, GRL, MJ trigger,
  NLOjet++ prediction, unfolding,
  pile-up treatment, UE modeling

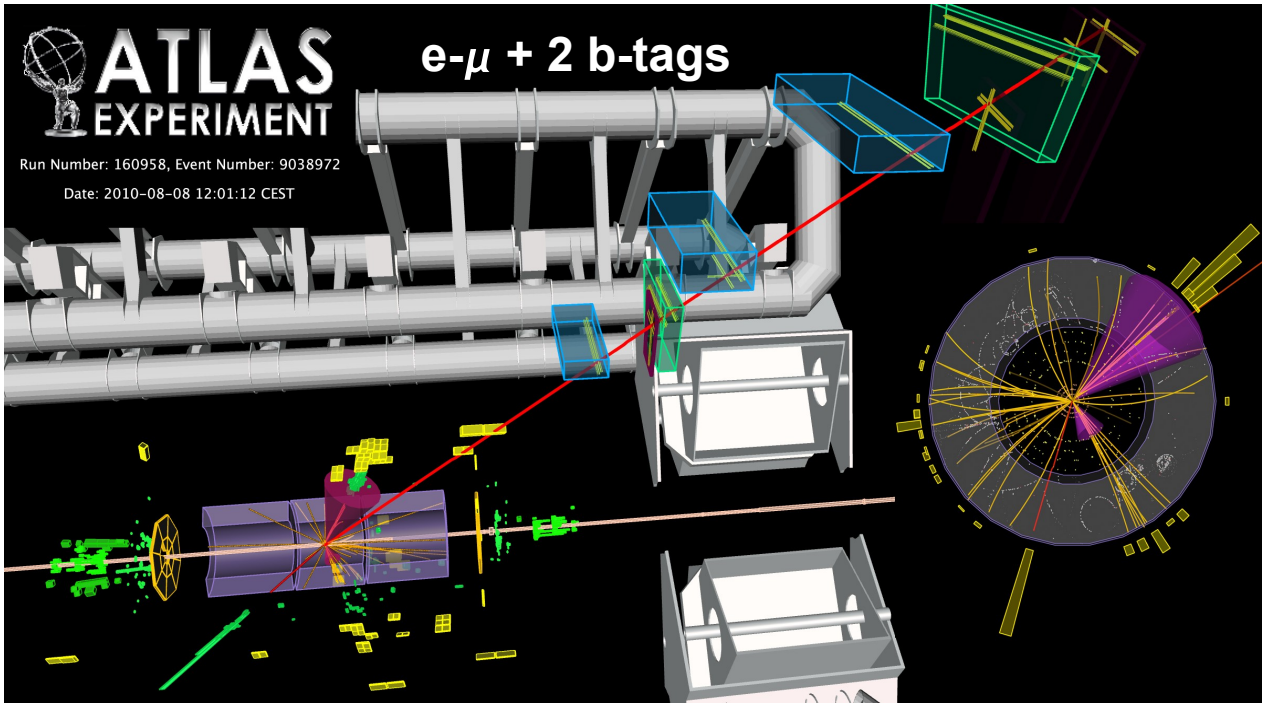
ATLAS-CONF-2010-084

Top "Rediscovery"

- Early focus is on (di)lepton+jets channels
- Several Candidates observed already in 280 nb^{-1}
  ATLAS-CONF-2010-063
- Cross Section Measurement in progress...



Platinum-Plated Top Candiate

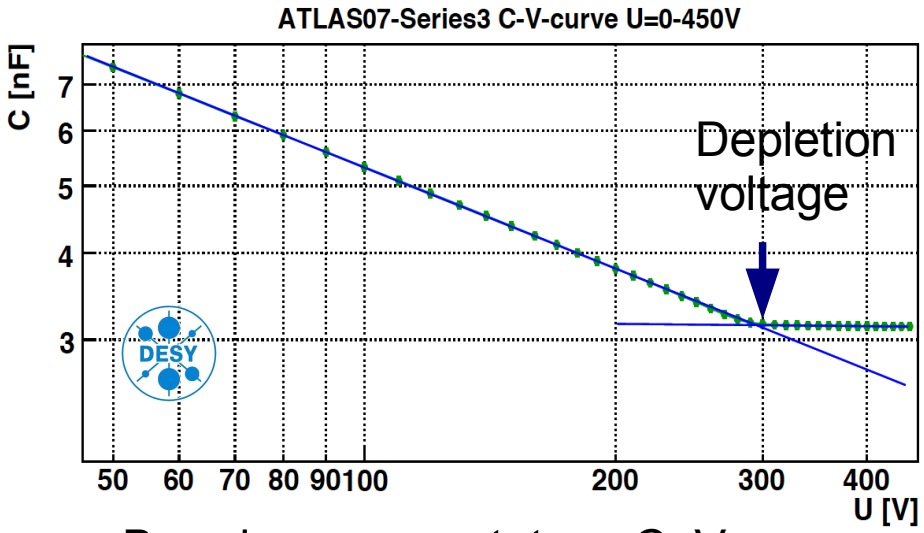


DESY:
- Lepton ID and trigger efficiencies
- QCD background from anti-electron fitting method
- File Preparation
- Signal MC production: MC@NLO mass samples
  POWHEG samples
- Expected ttbar cross section calculations

Upgrade Activities

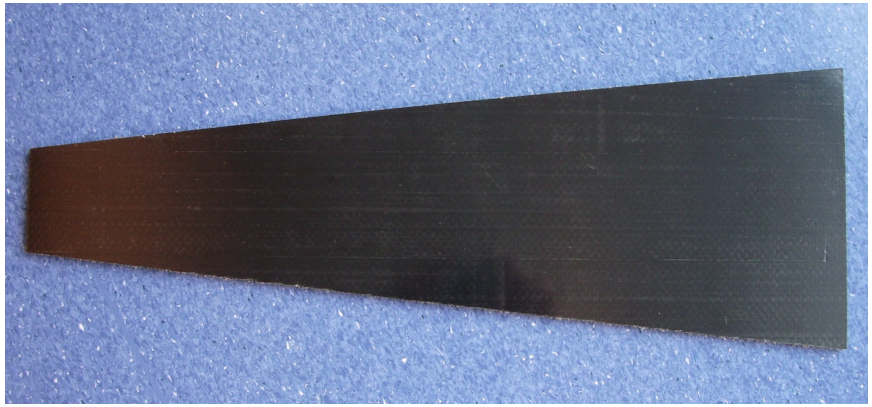
Exploit synergies within DESY
- Common document with CMS on projects, investments, cost, personnel in progress

Pixel IBL
- Test beam activities continuing (EUDET telescope useful tool)



- Barrel sensor prototype C–V curve

Petal2014 project for the ATLAS strip end cap
- Approved and work started
- Module production preparation
  First prototype barrel sensors tested in-house
- Petal mechanical design
- DAQ system for module test
- MC Simulation
- Team constantly growing:
  engineers, postdocs and students joined recently



PETAL2014 Support Structure Prototype 0 build at DESY

Summary

- DESY-ATLAS strongly contributes to many areas in ATLAS
  - Many contributions to core and analysis software
  - Physics analysis programme with focus on SM studies
    - Minimum Bias, W/Z (+jets), multijets, tau leptons, ttbar
  - Many results with significant DESY-contributions already published/approved
    - A lot more in the pipeline ...
  - Transition to searches once SM is understood
    - SUSY, ttbar Resoncances
- Increasing contribution to hardware development (ALFA, IBL, PETAL2014)

BACKUP

References 1 (Minimum Bias)

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
ATLAS-CONF-2010-047	Charged particle multiplicities in pp interactions at sqrt(s) = 2.36 TeV measured with the ATLAS detector at the LHC
ATLAS-CONF-2010-024	Charged particle multiplicities in pp interactions at sqrt(s) = 7 TeV measured with the ATLAS detector at the LHC
arXiv:0911.5430	Charged-particle multiplicities in pp interactions at sqrt(s) = 900 GeV measured with the ATLAS detector at the LHC
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

References 2

CERN-PH-EP-2010-037, arXiv:1010.2130 [hep-ex] 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.

ATLAS-CONF-2010-060 Luminosity Determination Using the ATLAS Detector

ATLAS-CONF-2010-086 Tau Reconstruction and Identification Performance in ATLAS

ATLAS-CONF-2010-057 Performance of the Missing Transverse Energy Reconstruction and Calibration in Proton-Proton Collisions at a Center-of-Mass Energy of $\sqrt{s}=7$ TeV with the ATLAS Detector

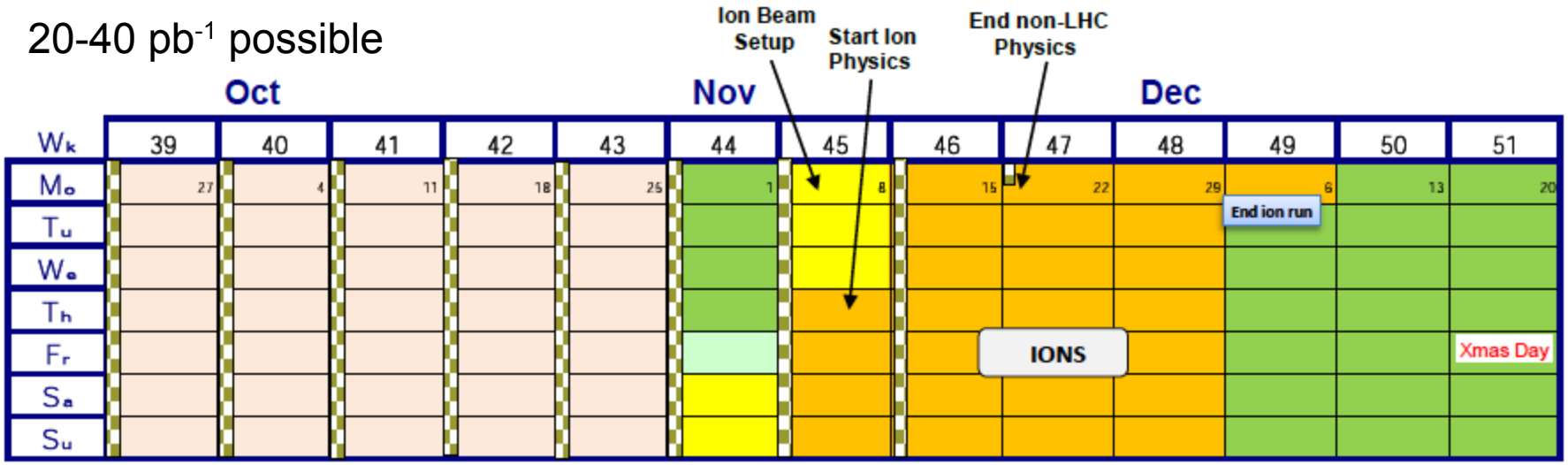
ATLAS-CONF-2010-063 Search for top pair candidate events in ATLAS at sqrt(s)=7 TeV

ATLAS-CONF-2010-087 Background studies for top-pair production in lepton plus jets final states in sqrt(s)=7 TeV ATLAS data

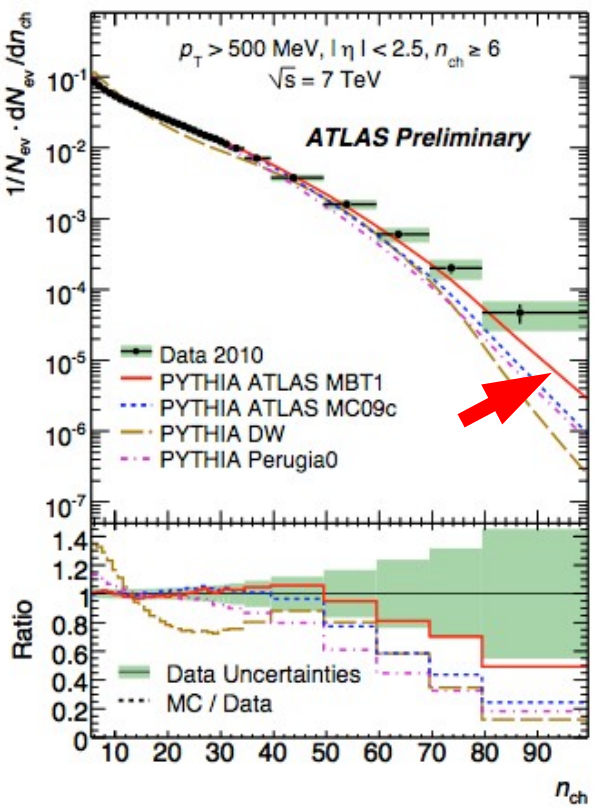
ATLAS-CONF-2010-084 Measurements of multijet production cross sections in proton-proton collisions at 7 TeV center-of-mass energy with the ATLAS Detector

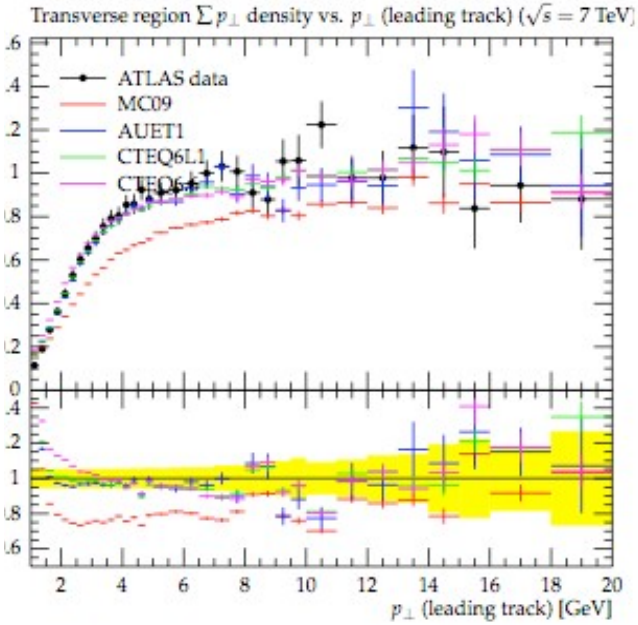
LHC Running

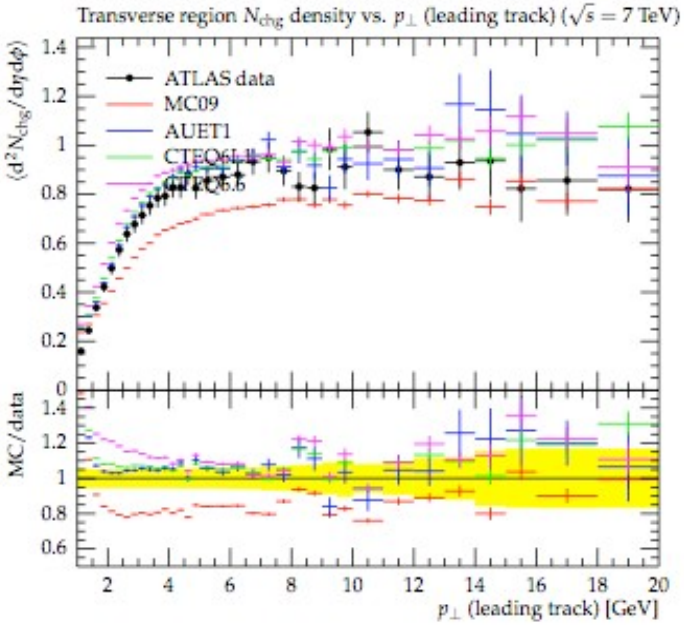
20-40 pb^{-1} possible



Monte Carlo and Minimum Bias



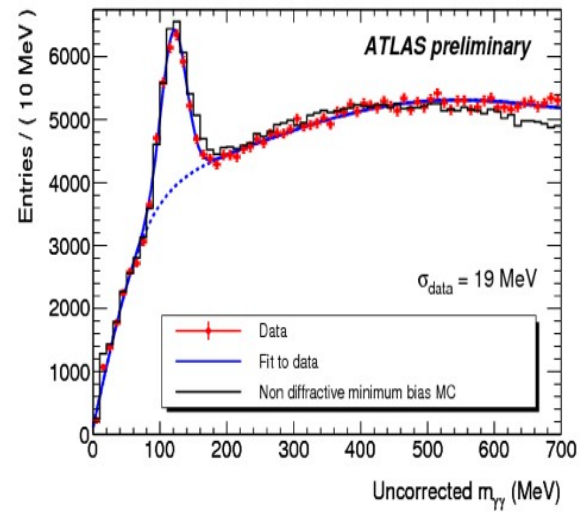


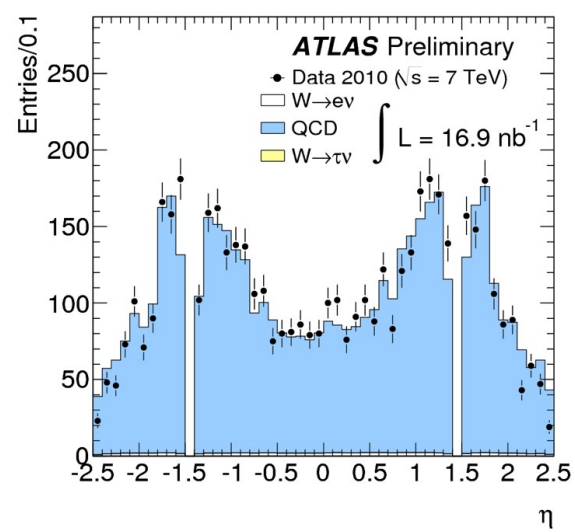


- Diffraction depleted sample n_{ch}>=6 allows to study well understood non-diffractive xsection
  - **ATLAS MBT1 tune** to minimum bias data from ATLAS and Tevatron
    - Adjustment of free MPI and color reconnection model parameters
  - **ATLAS UET1 tune** to underlying event data from ATLAS and Tevatron
    - Improve description of plateau region
- Done using PROFESSOR tool (HUB), tunes used in MC10 production
- Future goal: *One tune to describe them all ...*

Electron Reconstruction Performance

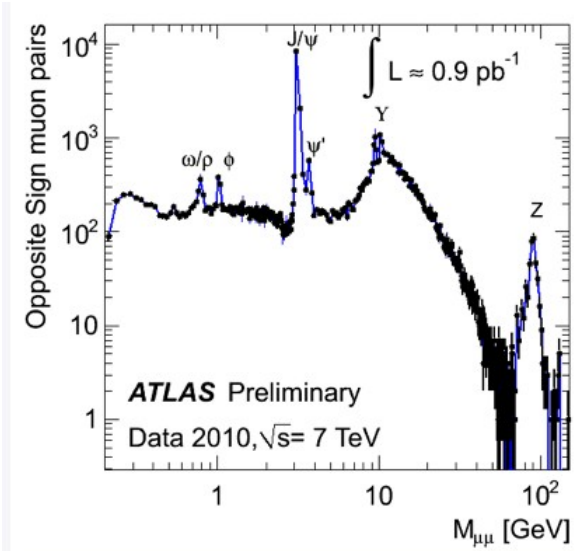
- Electron reconstruction via seed cluster of energy of E_T > 2.5 GeV in the 2nd layer of the electromagnetic calorimeter
  - Require matched ID-track
  - cluster sizes of $\Delta\eta \times \Delta\varphi = 0.075 \times 0.175$ in the barrel calorimeter and 0.125×0.125 in the end-cap for final electron candidates
- Three reference sets of require- ments (“loose”, ”medium”, and “tight”) provide progressively stronger jet rejection
- Efficiencies
  - Medium: 94.3% (4.2% rel. unc., data-driven)
  - Tight: 74.9% (5.2% rel. unc., data-driven)
- Energy Scale: known better to 1%

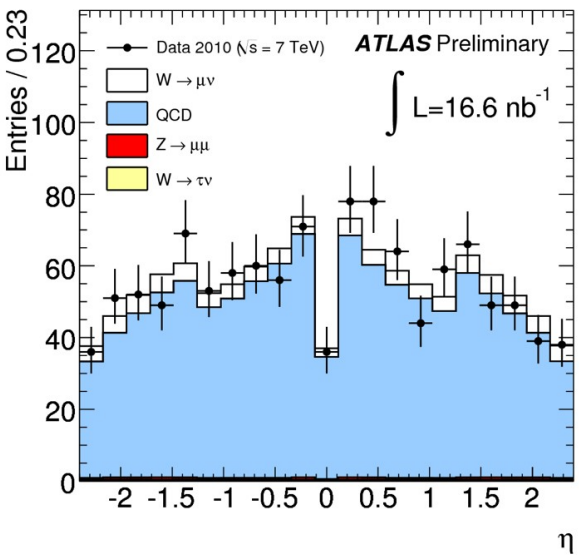




Muon Reconstruction Performance

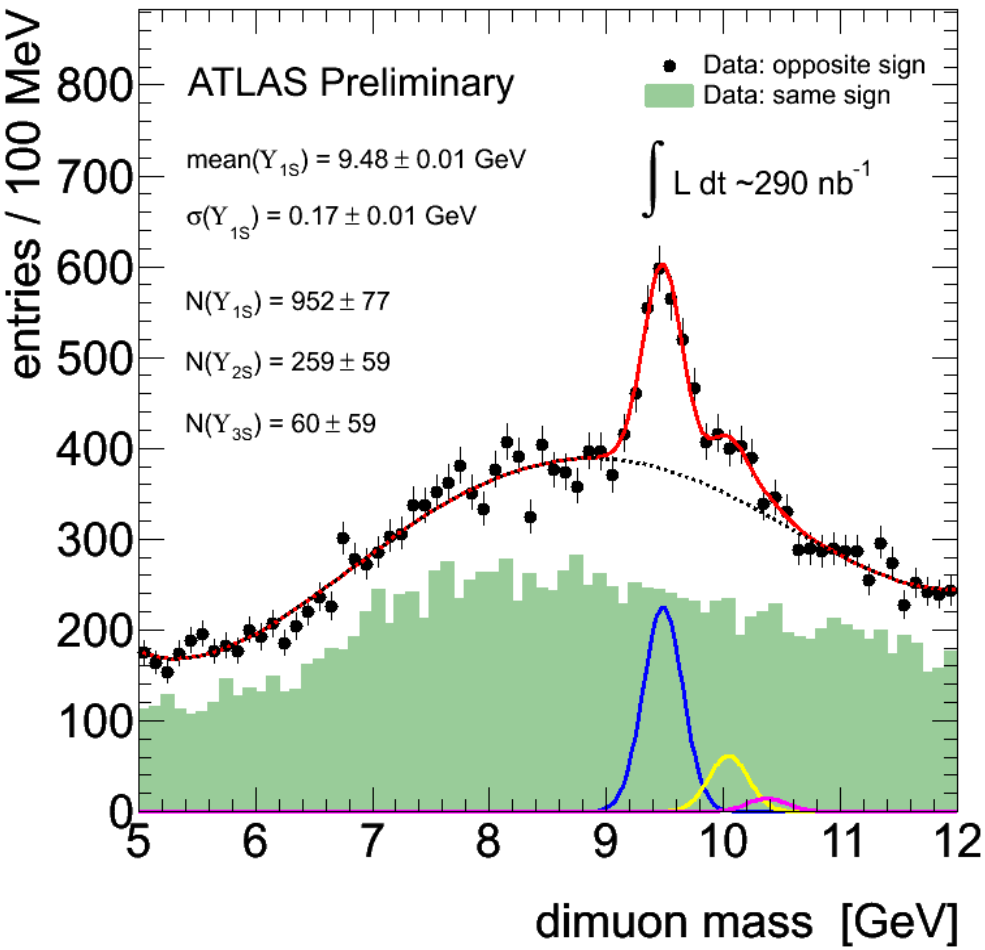
- Stand-alone muon reconstruction based entirely on muon-spectrometer information
  - Independent from inner detector
- Combined muon reconstruction: associates a stand-alone muon spectrometer track to an inner- detector track
  - Combines measurement of two independent detectors
  - reduction of uncertainties
- Combined Muon Reconstruction Efficiency
  - ID-Reconstruction Efficiency: > 99%
  - Muon Reconstruction Efficiency:
    - 92.4% (2.5% rel. unc., data-driven)
- Momentum Scale and Resolution
  - Scale: known to better than 1%
  - Resolution: known better than 5%



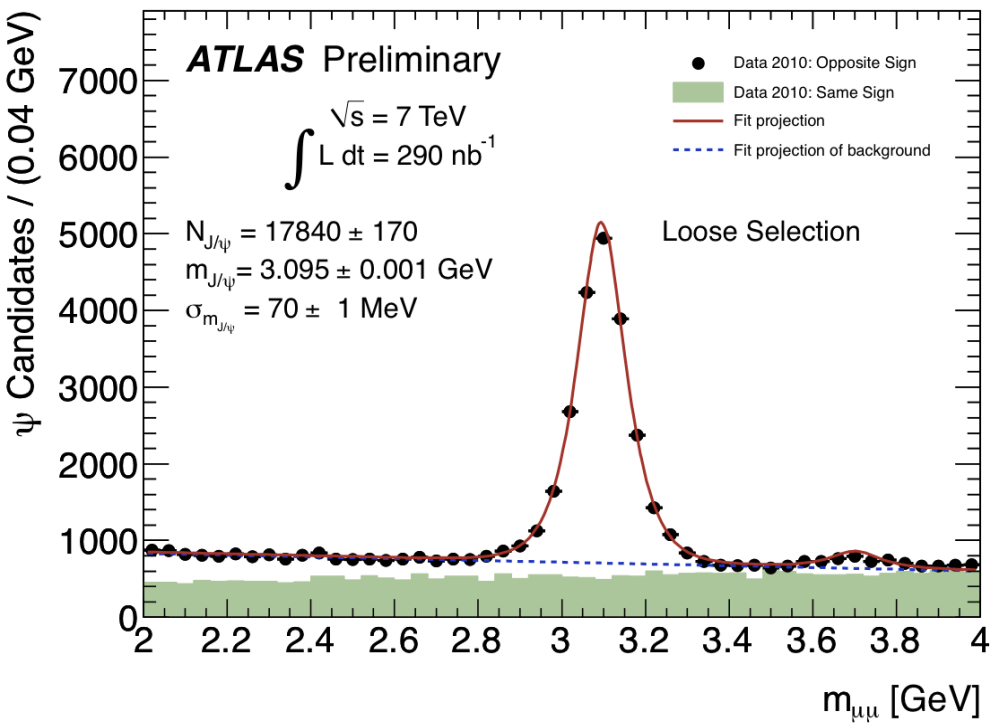


Resonances and Muon Resolution

Y



J/Psi

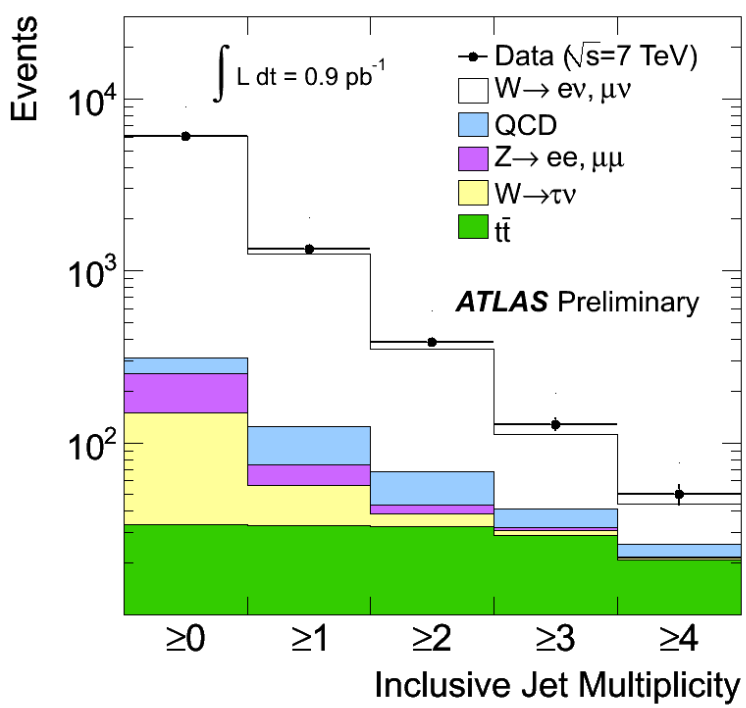


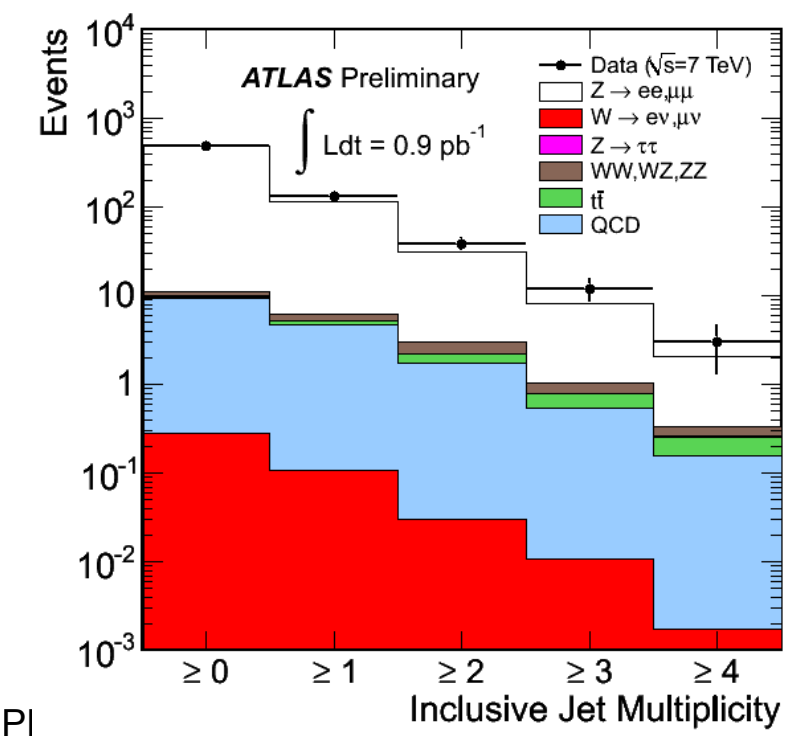
W/Z+jets Cross sections

- Goal of W/Z+jets analysis: test perturbative QCD Predictions
  - Test of NLO pQCD calculation and LO MC's in a new (LHC) phase space.
- Also an important background for SM
- Sensitive to and background for beyond SM processes

- Measurements follows inclusive W/Z analysis taking into account present jets
  - Jet algorithm anti-k_T R=0.4 $|\eta|<2.8$ $p_T>20$ GeV

- Exploit ratios to partially cancel systematic uncertainties and luminosity
  - dσ(V + ≥Njets) / dσ(V + ≥Njets-1)
  - dσ(W + ≥Njets) / dσ(Z + ≥Njets)

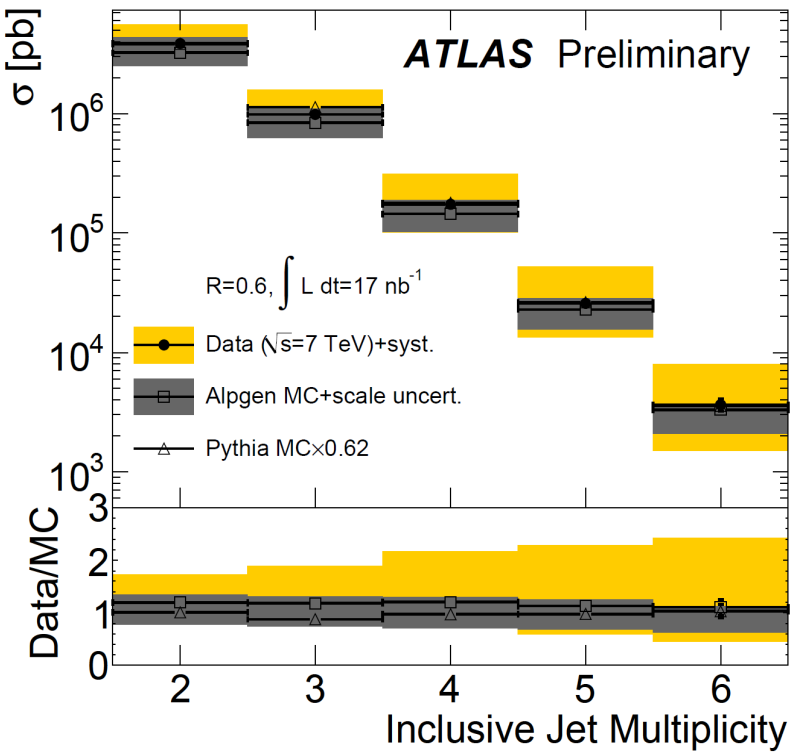




Multi-Jet Cross Section

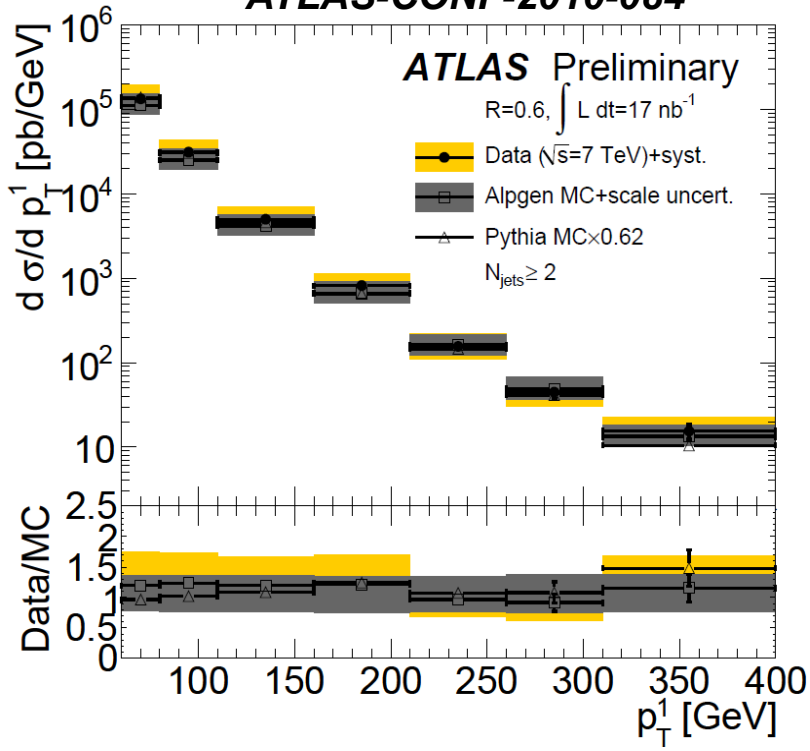
- Measure Multi-Jet Cross Section
- Compare to PYTHIA, ALPGEN
- Measure jet multiplicity ratios and α_s

$P_T^{(lead)} > 30\ (60)$ GeV, $|y| < 2.8$



- Data described by theory within errors
- ALPGEN + PS works best
- PYTHA shape ok, needs scaling x0.62

ATLAS-CONF-2010-084



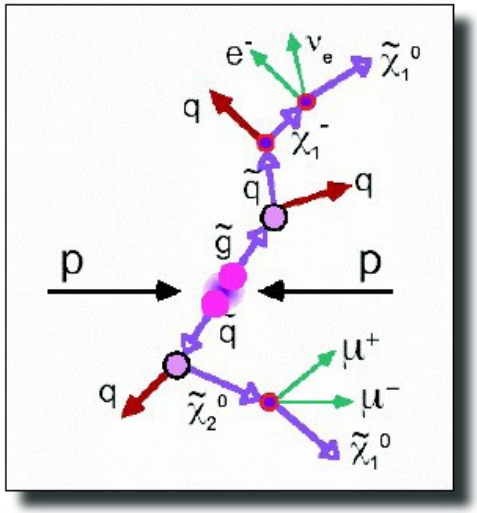
DESY Contributions

- Note co-editing
- Data quality control (event counting, GRL).
- Trigger efficiency for multi-jets
  - From MBTS_1 to L1_J5 to L1_TExx.
- Looking at
  - NLOJet++ parton-level prediction.
  - Unfolding (PYTHIA).
  - Pile-up treatment.
  - UE modelling (PYTHIA).

SUSY Searches

- Inclusive SUSY searches ($\tilde{q}/\tilde{g} \rightarrow j$, $X^{0,}X^{n} \rightarrow l$, LSP $\rightarrow$ MET)
  - Results possible from > 20 pb^{-1} (2010 data)
    - Earliest candidates are searches in lepton+jets+MET (surpass Tevatron limits in direct comparison)
    - jets+MET search (0-lepton) has the best reach if we can understand the bkg at the O(100%) level
    - **Have to build on foundation laid by ATLAS measurements of multijets, W/Z(+jets) and top**

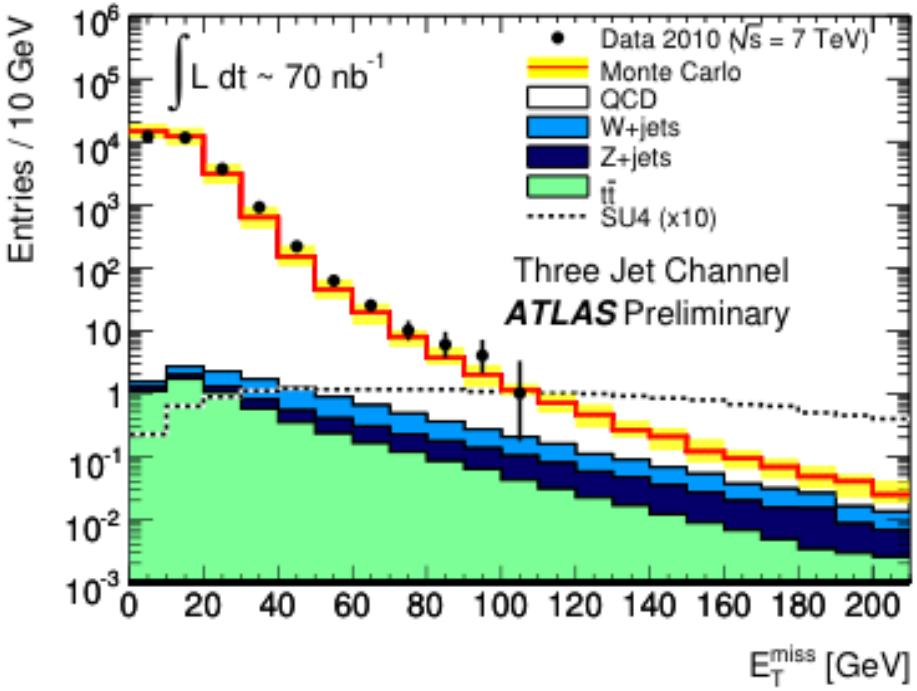
… SM backgrounds all covered in our group



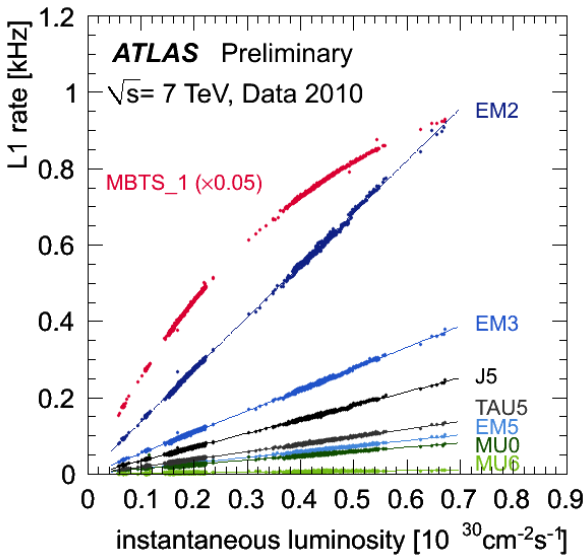
- Most final states need 100 pb^{-1} - 1 fb^{-1} to become sensitive / competitive

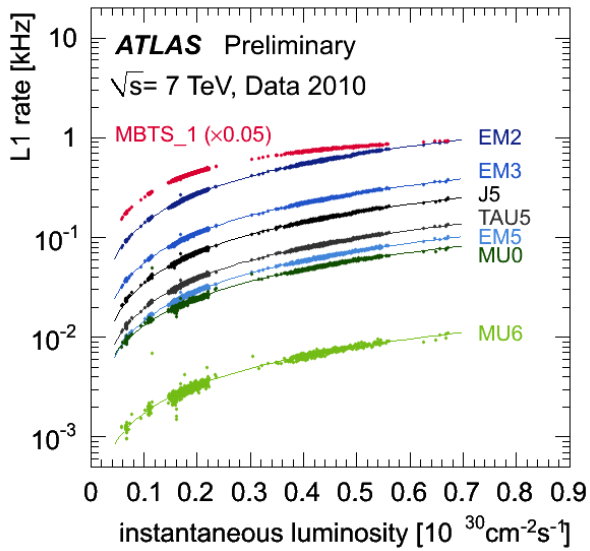
Topics covered by our group:

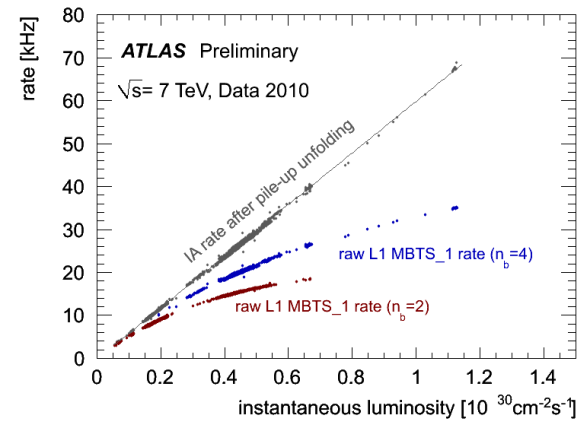
- Search for SUSY
  - with dileptons and MET (mSUGRA)
  - with tau final states (high tanβ)
  - with photon final states (GMSB)
  - Gaugino-mediated with non-universal Higgs masses



Trigger Rates



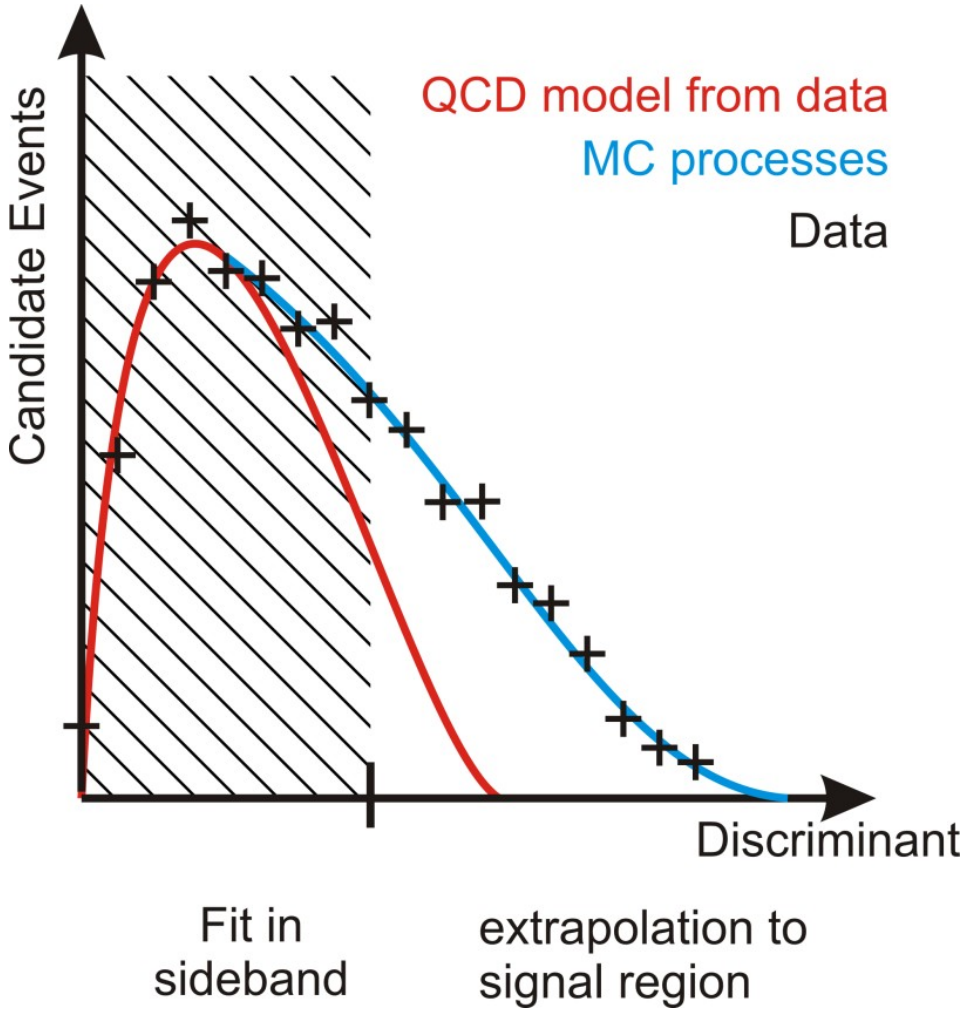




Unprescaled L1 rates as a function of the instantaneous luminosity for electromagnetic triggers (ET thresholds of 2 GeV, 3 GeV and 5 GeV), muon triggers (no pT threshold and pT threshold of 6 GeV), a tau trigger (ET threshold of 5 GeV), a jet trigger (ET threshold of 5 GeV) and a trigger requiring a single hit in one of the minimum bias trigger scintillators mounted on each side of the experiment (MBTS_1). The MBTS_1 rate is scaled down by a factor of 20. Each dot represents a measurement in a time interval of about two minutes taken in runs with two colliding bunches (nb=2) in June 2010. While the electromagnetic, muon, tau and jet trigger rates show a nicely linear behavior, the MBTS rate saturates as it approaches two times the LHC revolution frequency (nb*fLHC~22 kHz) due to pile-up.

Unprescaled L1 rates (red, blue) as a function of the instantaneous luminosity for a trigger requiring a single hit in one of the minimum bias trigger scintillators mounted on each side of the experiment (MBTS_1). Each dot represents a measurement in a time interval of about two minutes in runs taken in June and July 2010 with two (nb=2, red), respectively four (nb=4, blue) colliding bunches. The measurement of the inst. luminosity is already corrected for pile-up effects. As expected, the MBTS rates saturate due to pile-up as they approach two times, respectively four times the LHC revolution frequency, i.e. at nb*fLHC~22 kHz and nb*fLHC~44 kHz. In addition, the rate of interactions (IA, grey) after unfolding the pile-up contribution is shown featuring a nicely linear behavior. This demonstrates the stability of the MBTS trigger with respect to the luminosity detector LUCID.

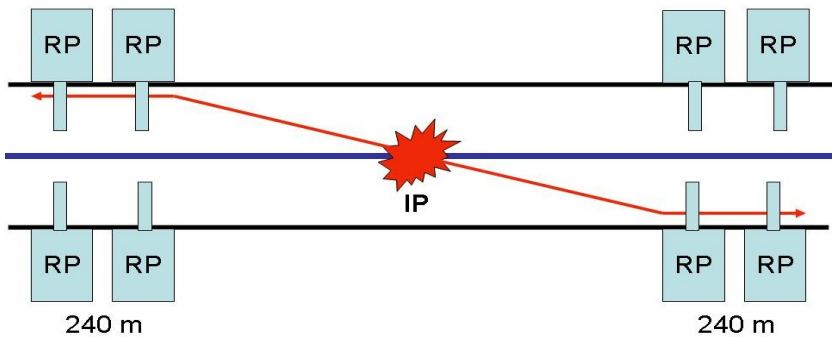
Top: QCD Bkg Anti-electron Method

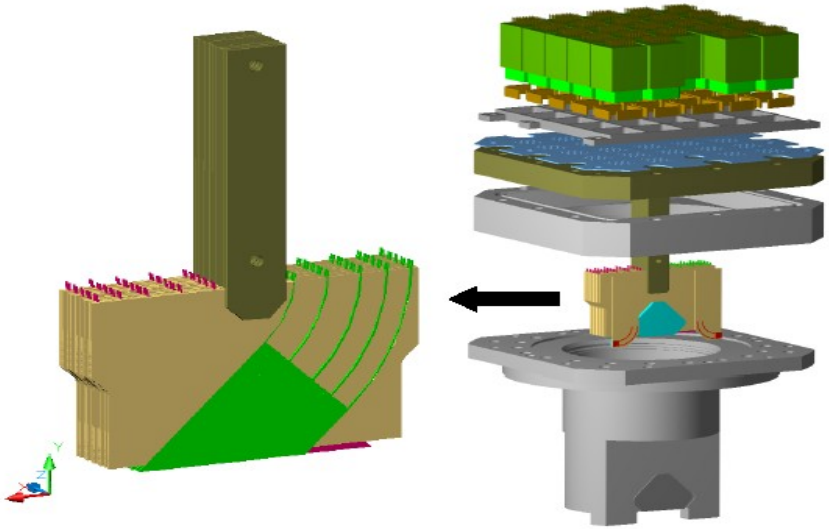


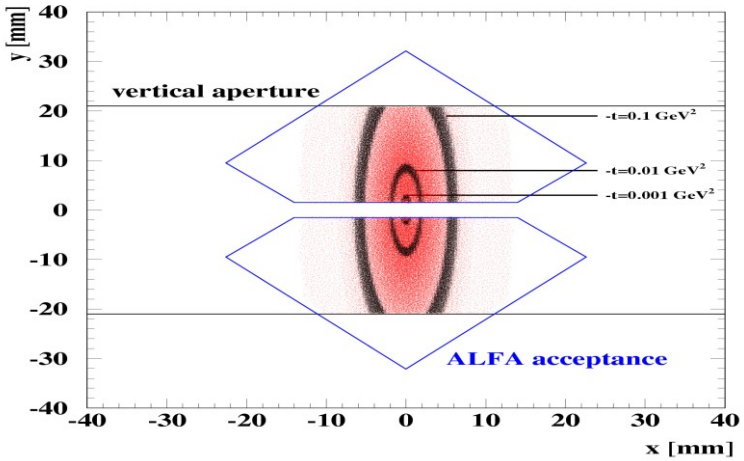
ALFA in one Slide

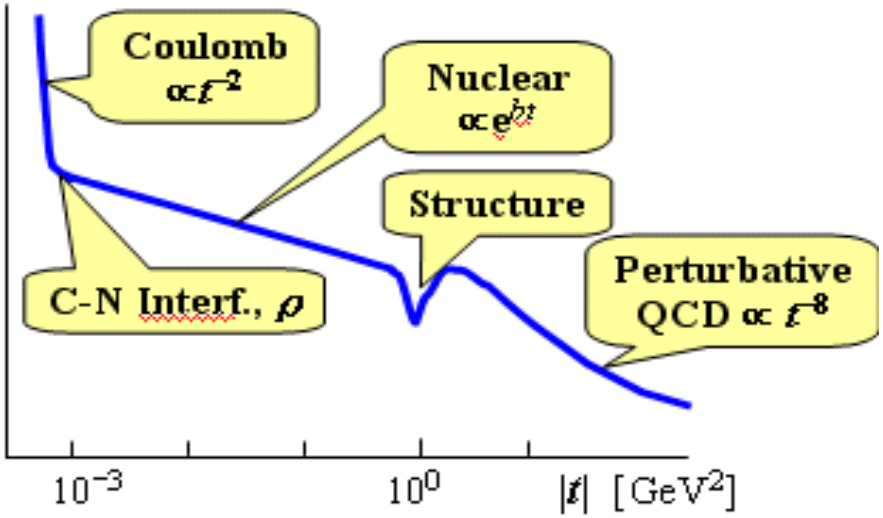
Absolute **L**uminosity **F**or **A**TLAS, to calibrate the LUCID detector

ready to install in next technical stop





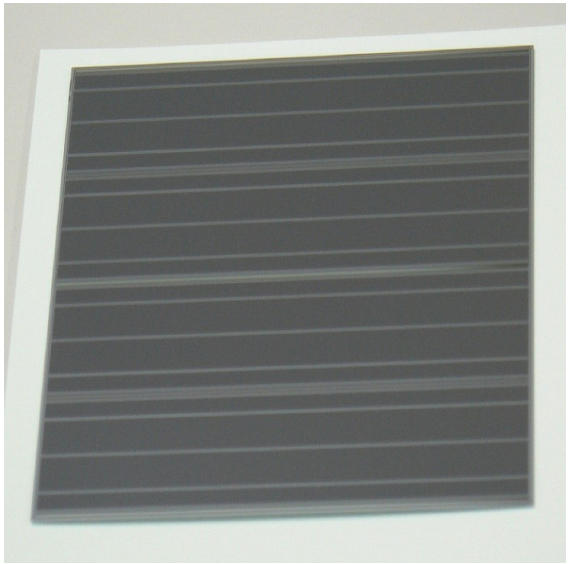




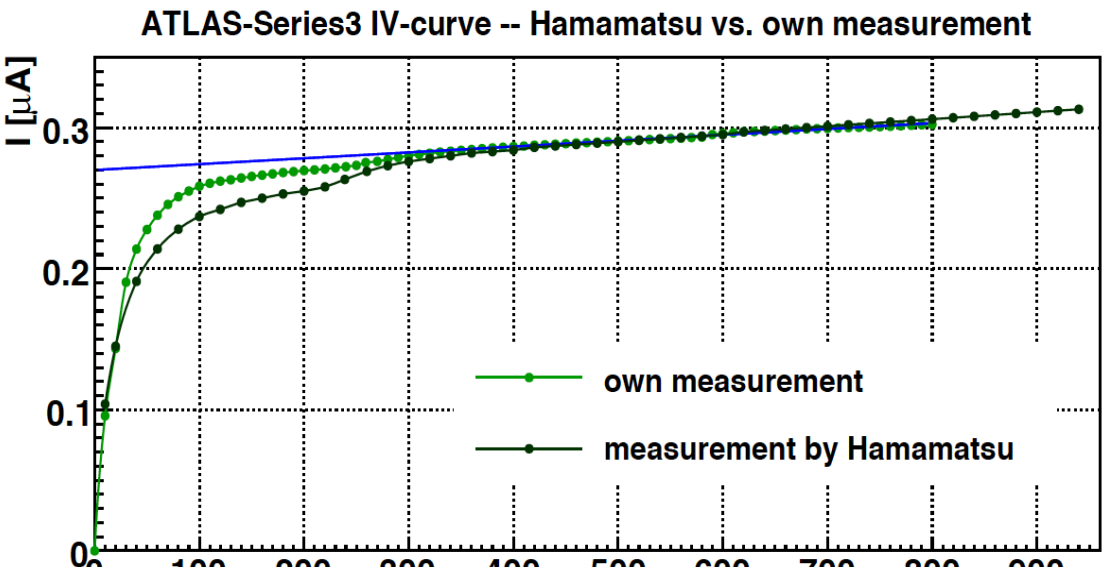
move 1.5 mm to beam → measure interference region → σ_{tot}, b, ρ, L ± 3%

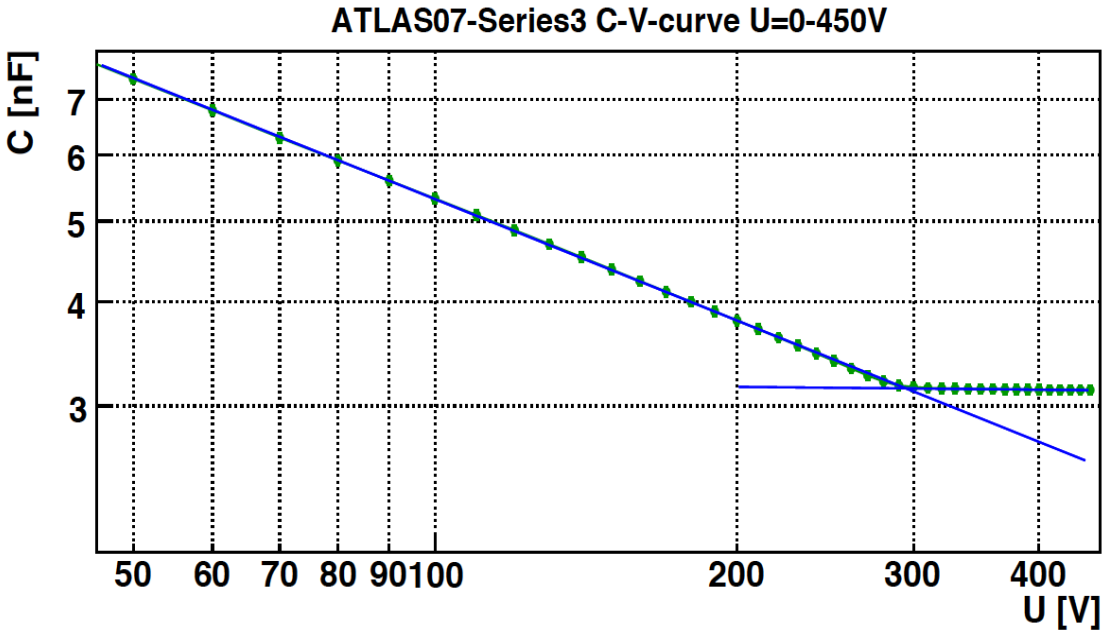
ATLAS Barrel Sensor

- Based on experiences with STAVE09 modules -> knowledge transfer to end cap sensor design.
- First sensor delivered to Zeuthen and detailed tests started.
- Will take advantage of new probe station.
- Preparation for module production started



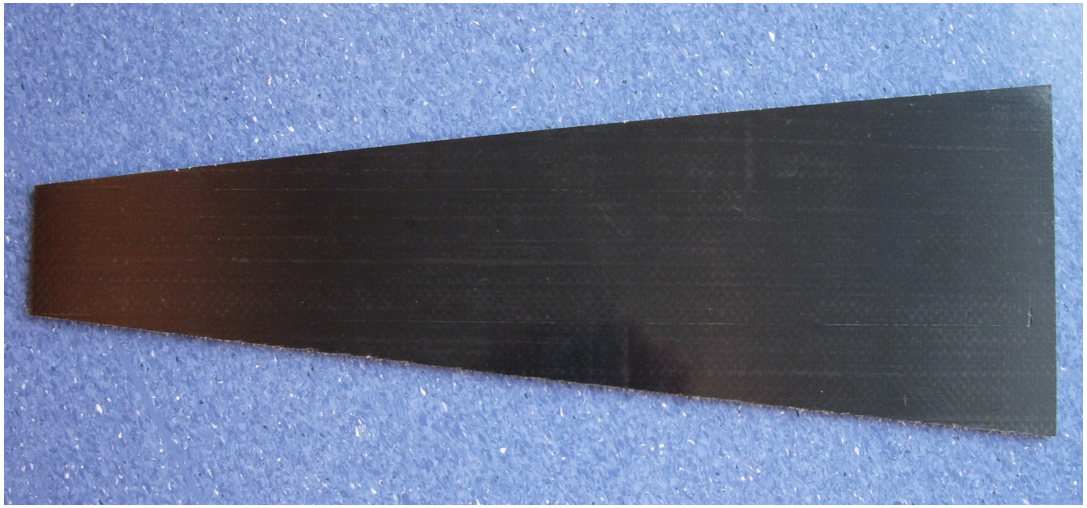
Barrel sensor for STAVE09



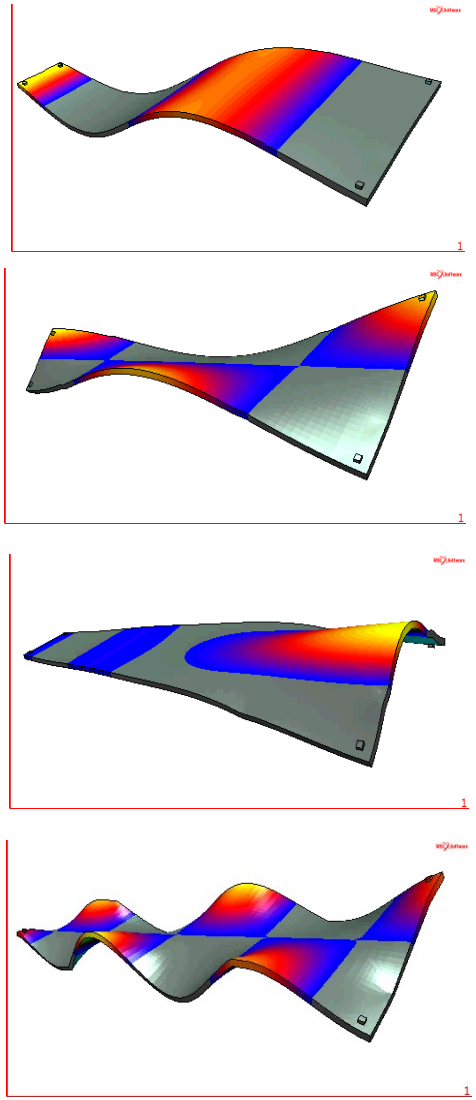


Petal Mechanics

- Close collaboration with NIKHEF and Valencia to find optimal design of petal.
- Measurements and finite element analysis of mechanical properties started.
- Prototype 0 was recently build at DESY.



Prototype 0 build at DESY

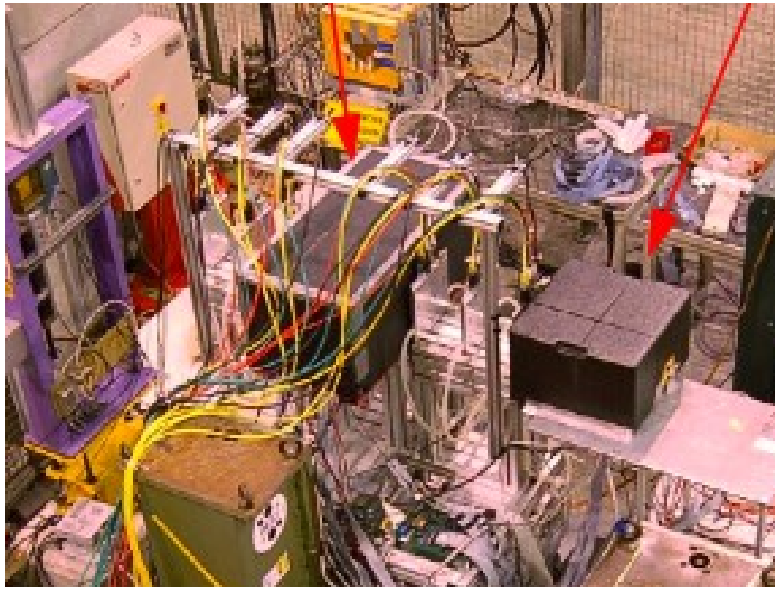


FE simulations at NIKHEF

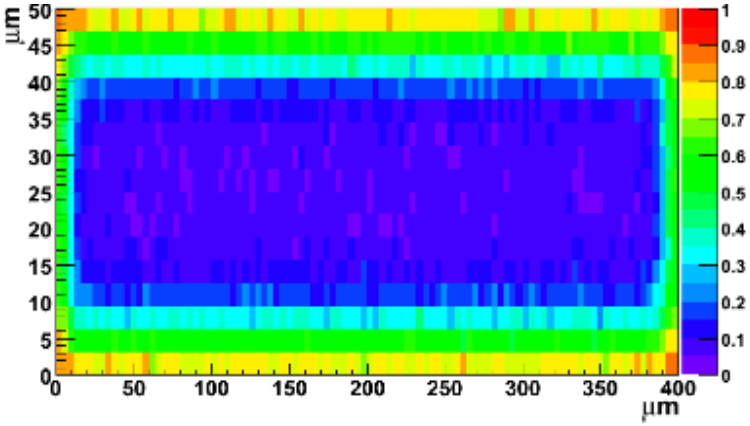
ATLAS IBL Test Beam

ATLAS-Pixel (PPS for IBL)

4 DUTs 4 DUTs



Charge sharing probability versus position



- Three different sensor technologies are under investigation for the ATLAS Insertable B-Layer (upgrade ~2016)
- All three collaborations used the EUDET telescope for independent test beams this summer
- Combined test beam planned for end of October
- DESY team improved test beam analysis chain and enabled ATLAS Pixel analysis in common EUDET software framework