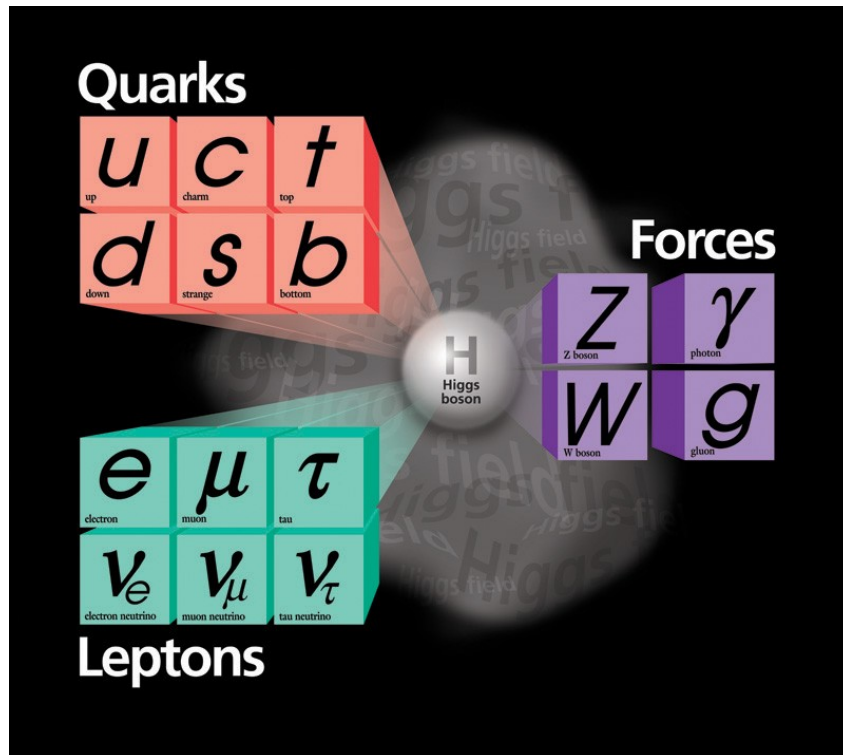


Results from the ATLAS experiment at the LHC after 1 year of data taking



Standard Model of Particle Physics

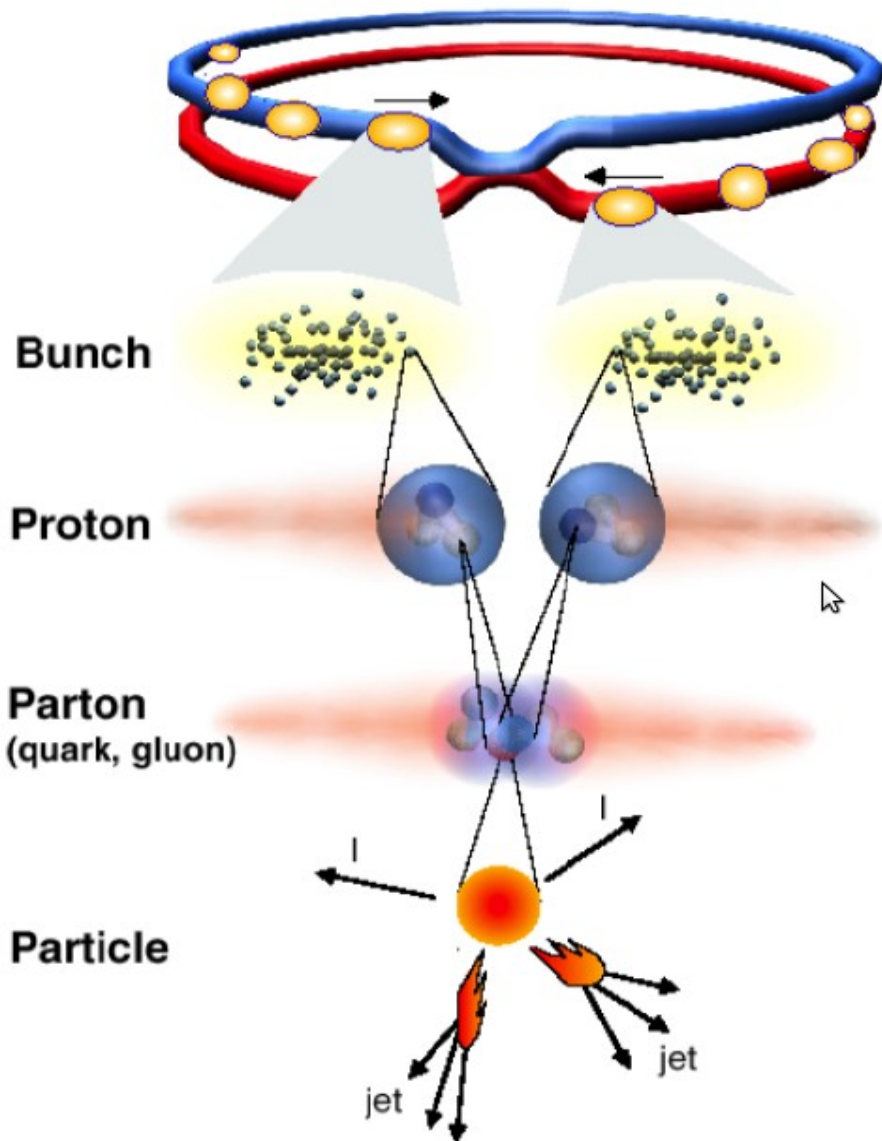


- Building blocks of matter and their interactions - describe well current observations, but missing pieces
- Higher energy: Reproduce conditions of early Universe
- TeV energy scale: Expect breakdown of current calculations unless a new interaction or phenomenon appears
- Many theories, but need data to distinguish between them

The LHC and Experiments



Collisions at the LHC



Proton-Proton-Kollisionen
2835 Teilchenbündel (Bunch)

10^{11} Protonen / Bunch
Kollisionsrate 40 MHz (25 ns)

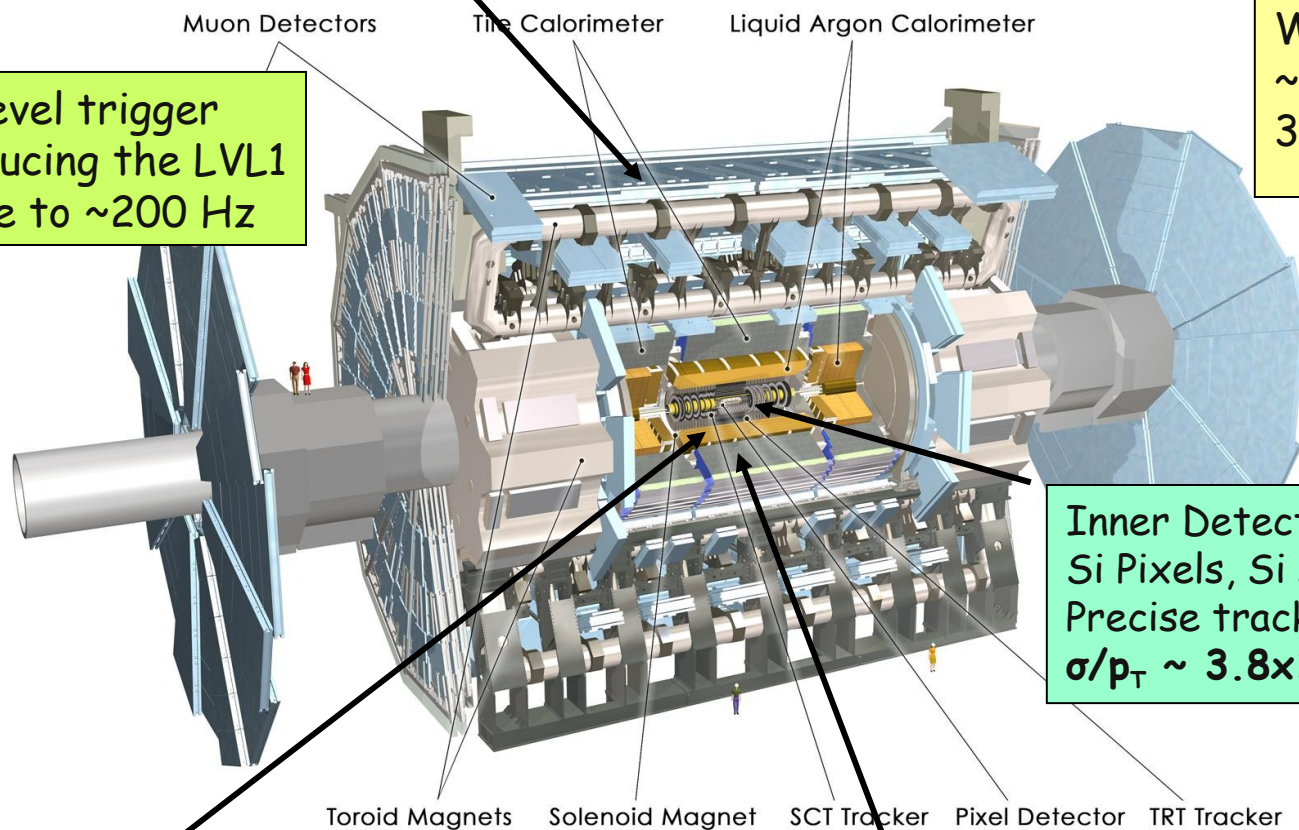
Schwerpunktsenergie 14 TeV
(= 7400 x Ruheenergie der kollidierenden Teilchen)

Schwerpunktsenergie der kollidierenden Quarks und Gluonen bis einige TeV

~25 pp-Kollisionen pro Bunch-Kollision

Interessante Ereignisse: 10^{-9} – 10^{-11} unterdrückt!

Muon Spectrometer ($|\eta| < 2.7$) : air-core toroids with gas-based muon chambers
Muon trigger and measurement with momentum resolution $< 10\%$ up to $E_\mu \sim 1$ TeV



**3-level trigger
reducing the LVL1
rate to ~ 200 Hz**

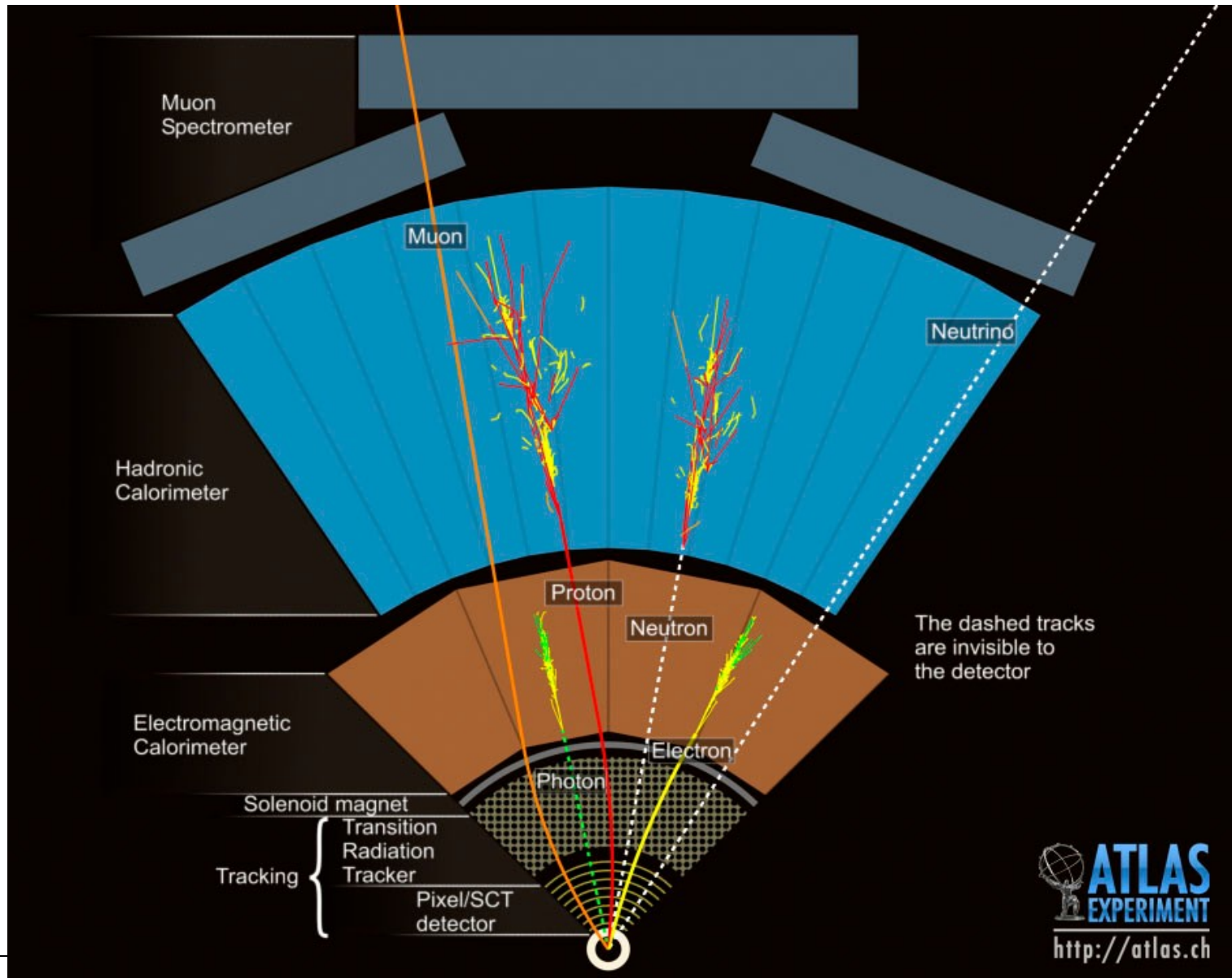
Length : ~ 46 m
 Radius : ~ 12 m
 Weight : ~ 7000 tons
 $\sim 10^8$ electronic channels
 3000 km of cables

Inner Detector ($|\eta| < 2.5$, $B=2$ T):
 Si Pixels, Si strips, TRT
 Precise tracking and vertexing,
 $\sigma/p_T \sim 3.8 \times 10^{-4} p_T (\text{GeV}) \oplus 0.015$

EM calorimeter: Pb-LAr Accordion
 e/ γ trigger, identification and measurement
 E-resolution: $\sigma/E \sim 10\%/\sqrt{E} \oplus 0.007$
granularity : $.025 \times .025 \oplus$ strips

HAD calorimetry ($|\eta| < 3$): segmentation 0.1×0.1
 Fe/scintillator Tiles (central), Cu/W-LAr (fwd)
 E-resolution: $\sigma/E \sim 50\%/\sqrt{E} \oplus 0.03$
 FWD calorimetry: W/LAr $\sigma/E \sim 90\%/\sqrt{E} \oplus 0.07$

Particle Detection

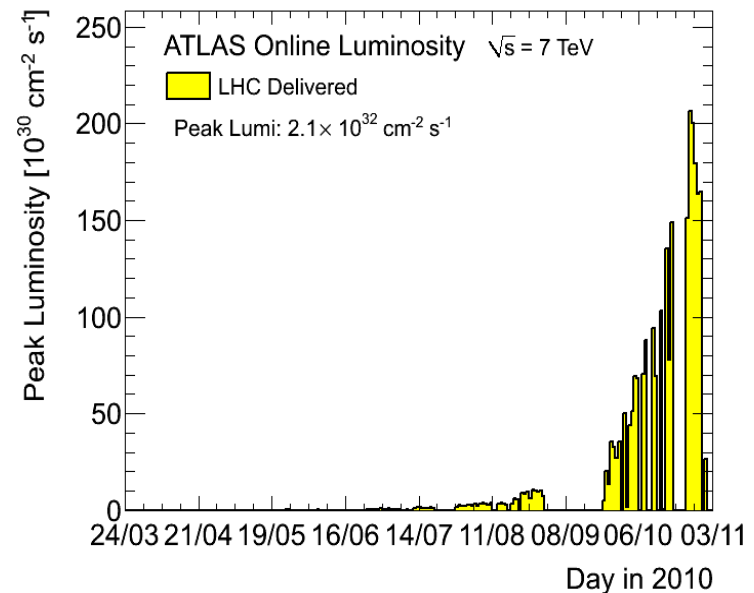
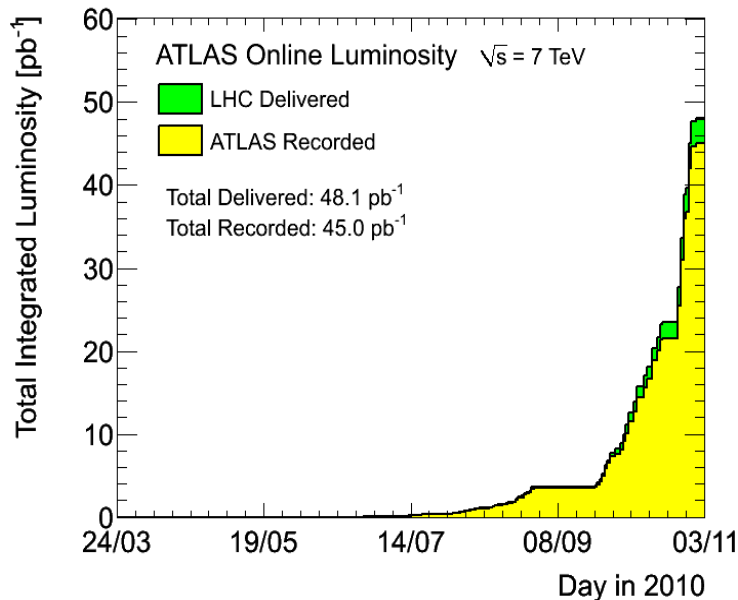


~3000 scientists from 174 Institutions and 38 Countries



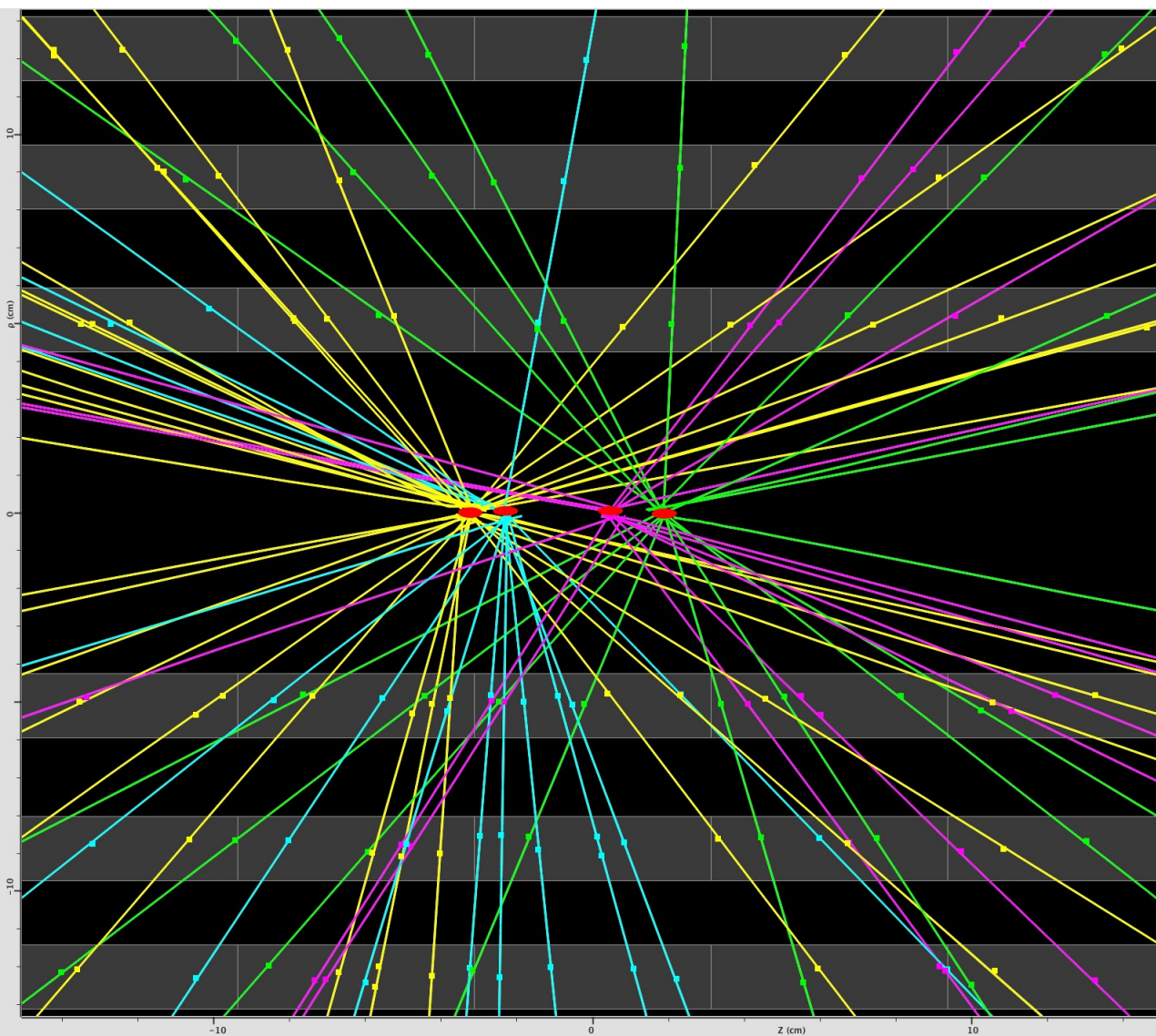
ATLAS status and operations

- Year 2009: pp collisions at $\sqrt{s}=0.9, 2.36$ TeV: $\sim 12\mu\text{b}^{-1}$
- Year 2010: pp collisions at $\sqrt{s}=7$ TeV, $\sim 45\text{pb}^{-1}$ collected by ATLAS



- ~ 97 - 100% of detector elements in operation
- Peak luminosity: $2.07 \times 10^{32} \text{ cm}^{-2} \text{ s}^{-1}$
- Highest mean 3.8 interactions/crossing
- Almost 1 billion pp events recorded $\rightarrow$ 1 PB RAW data

Event with 4 pileup vertices in same pp-collision

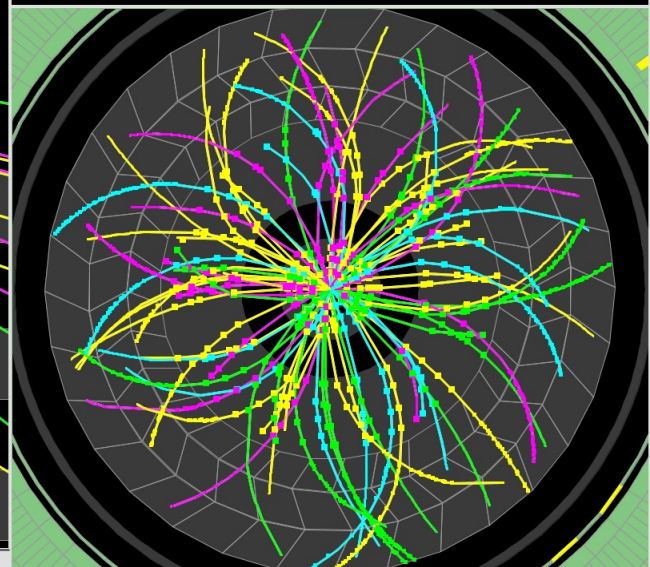


ATLAS
EXPERIMENT

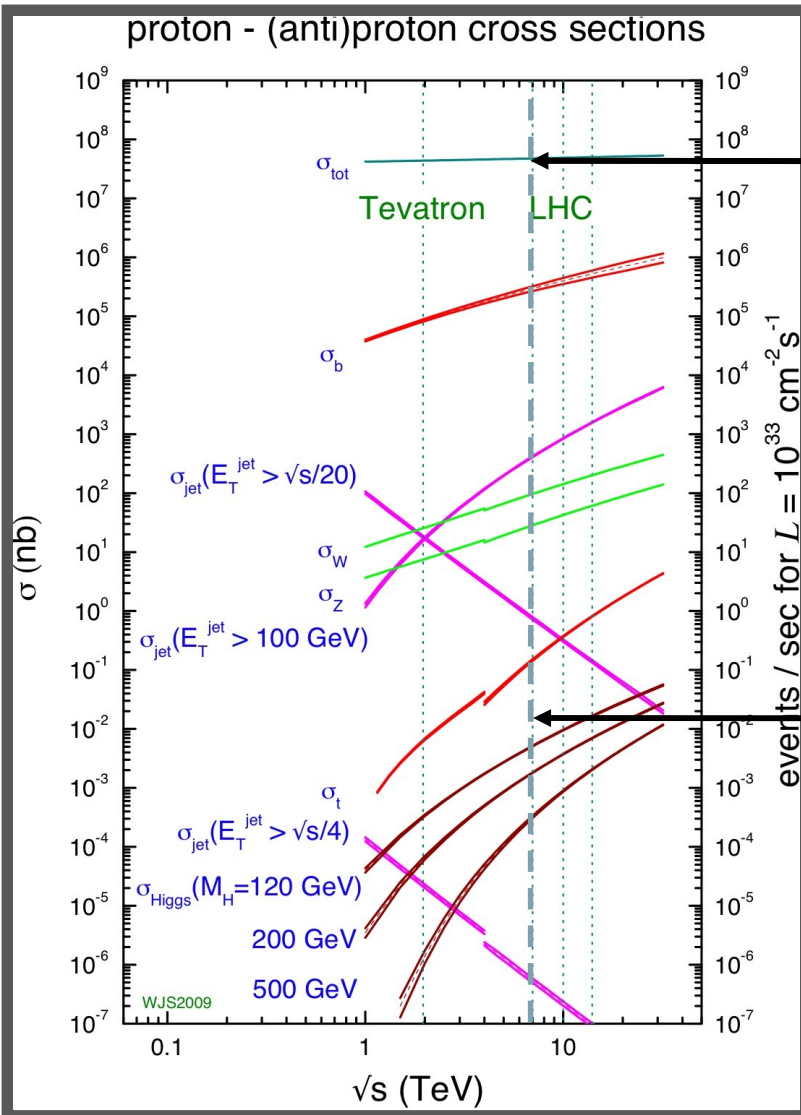
Run Number: 153565, Event Number: 4487360

Date: 2010-04-24 04:18:53 CEST

**Event with 4 Pileup Vertices
in 7 TeV Collisions**



Number of events in 45pb⁻¹



70 billion (10^9) pb $\rightarrow$ **3 trillion (10^{12}) events! ***

* N.B. only a very small fraction saved!

Higgs ($m_H=120$): **17 pb $\rightarrow$ 750 events**

e.g. potentially ~1 Higgs in every 300 billion interactions!

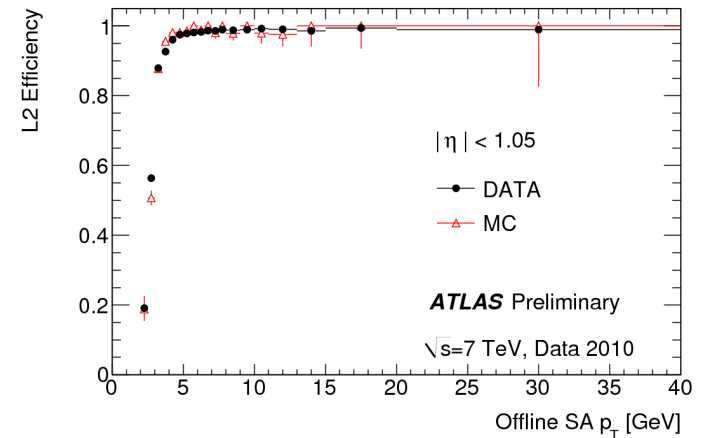
Trigger evolution

Five orders of magnitude increase in luminosity

Gradually commission and then apply higher level trigger (HLT) rejection

Evolution of HLT configuration during the pp run:

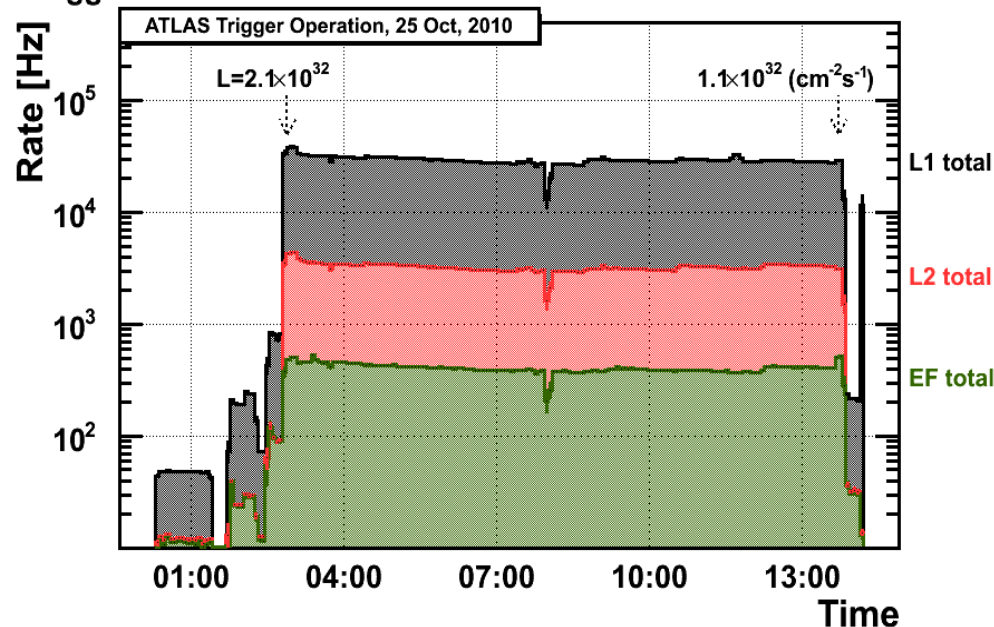
One of many examples: check eff. of L2 4GeV p_T muon selection



Date (2010)	April	May	June	July	August	September	October
Luminosity (cm ² s ⁻¹)	27 10	28 10	29 10	30 10	31 10		32 10
	Level 1 active			HLT Rejection on			
				Increasing HLT Rejection			
HLT Trigger Config	MinBias Records all data, HLT in pass-through	MinBias prescaled, e, γ, μ, jets, MET, τ, in pass-through mode	Single item unprescaled thresholds (GeV)				
menu	InitialBeam_v3, approx. 600 items				Physics Menu approx. 550 items		

Trigger rates in highest luminosity fill

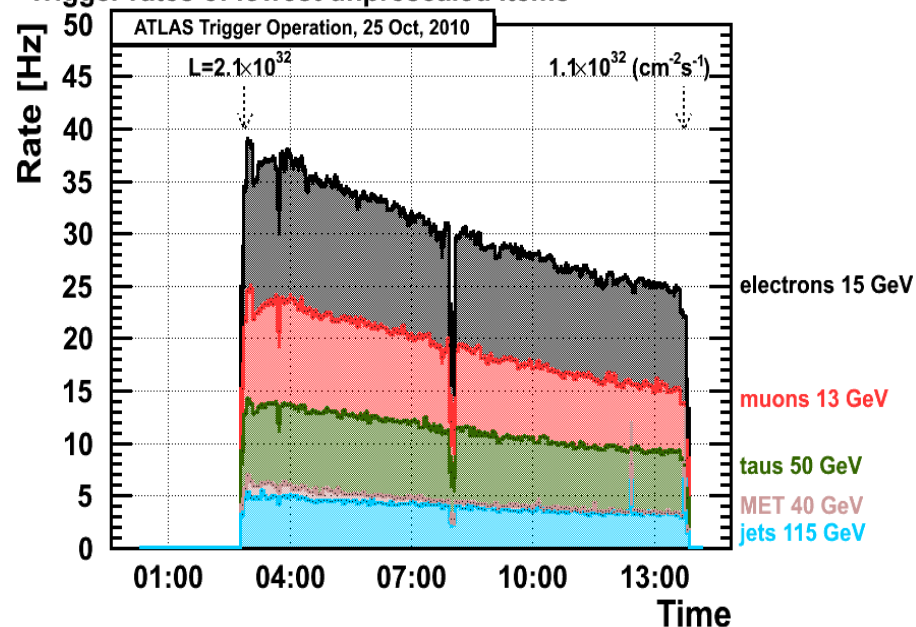
Trigger rates at each level



3 Trigger Levels:

- L1 (Hardware)
- L2
- EF (EventFilter, Software)

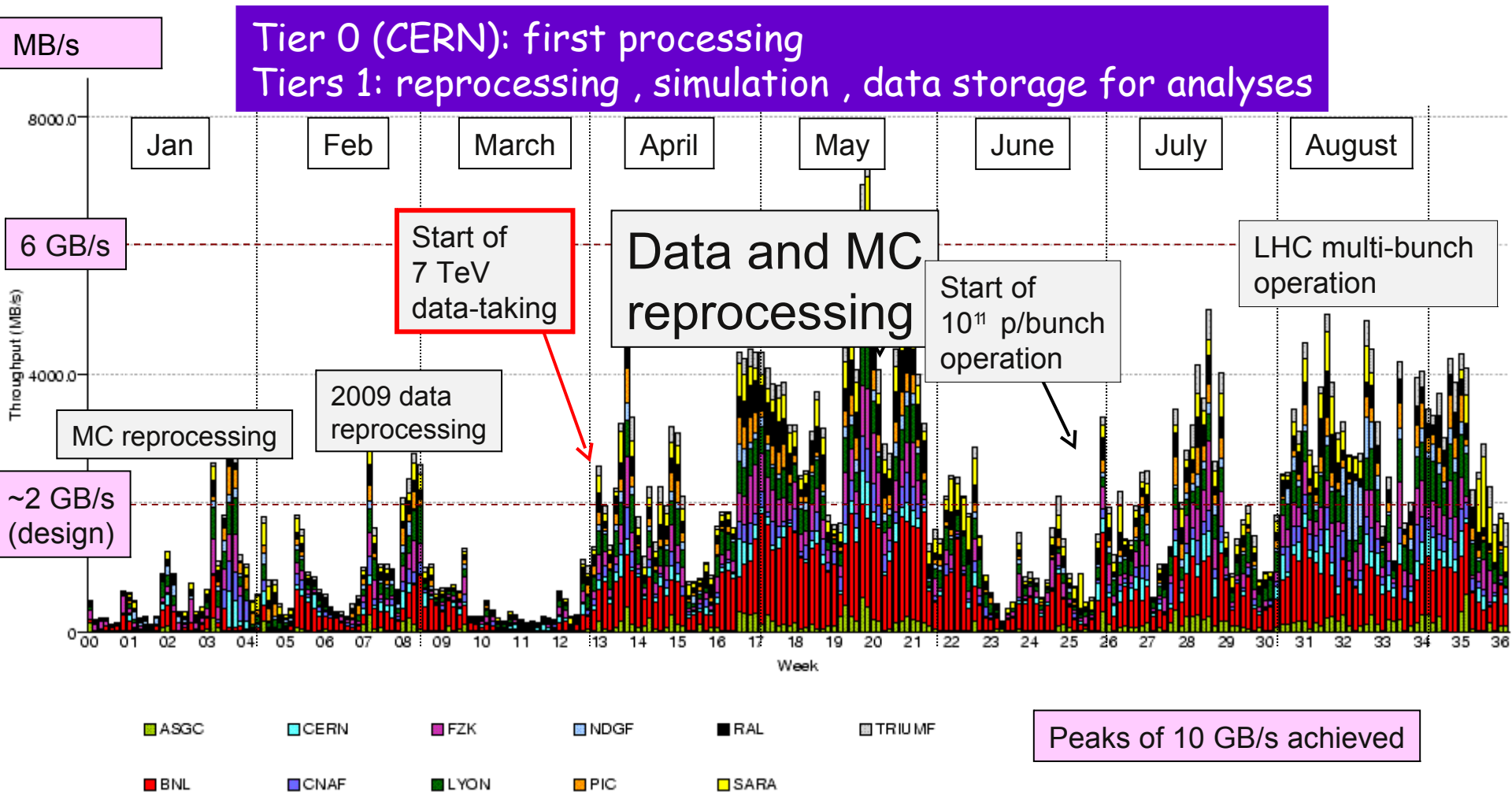
Trigger rates of lowest unprescaled items



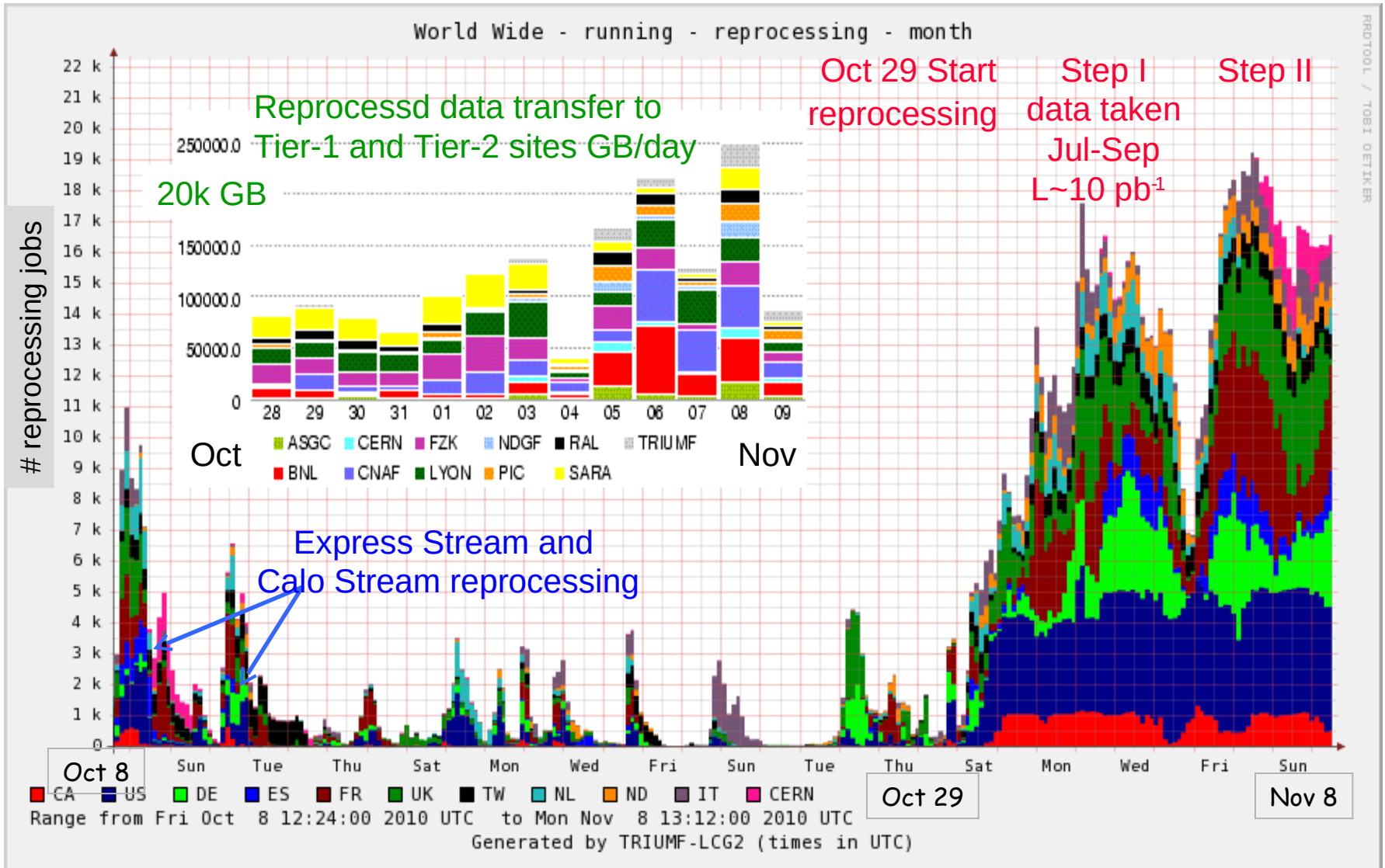
· Rates fall with luminosity

· Rates of Prescales adjusted during fill to keep ~400 Hz constant output rate with decreasing luminosity

ATLAS Worldwide Grid Computing

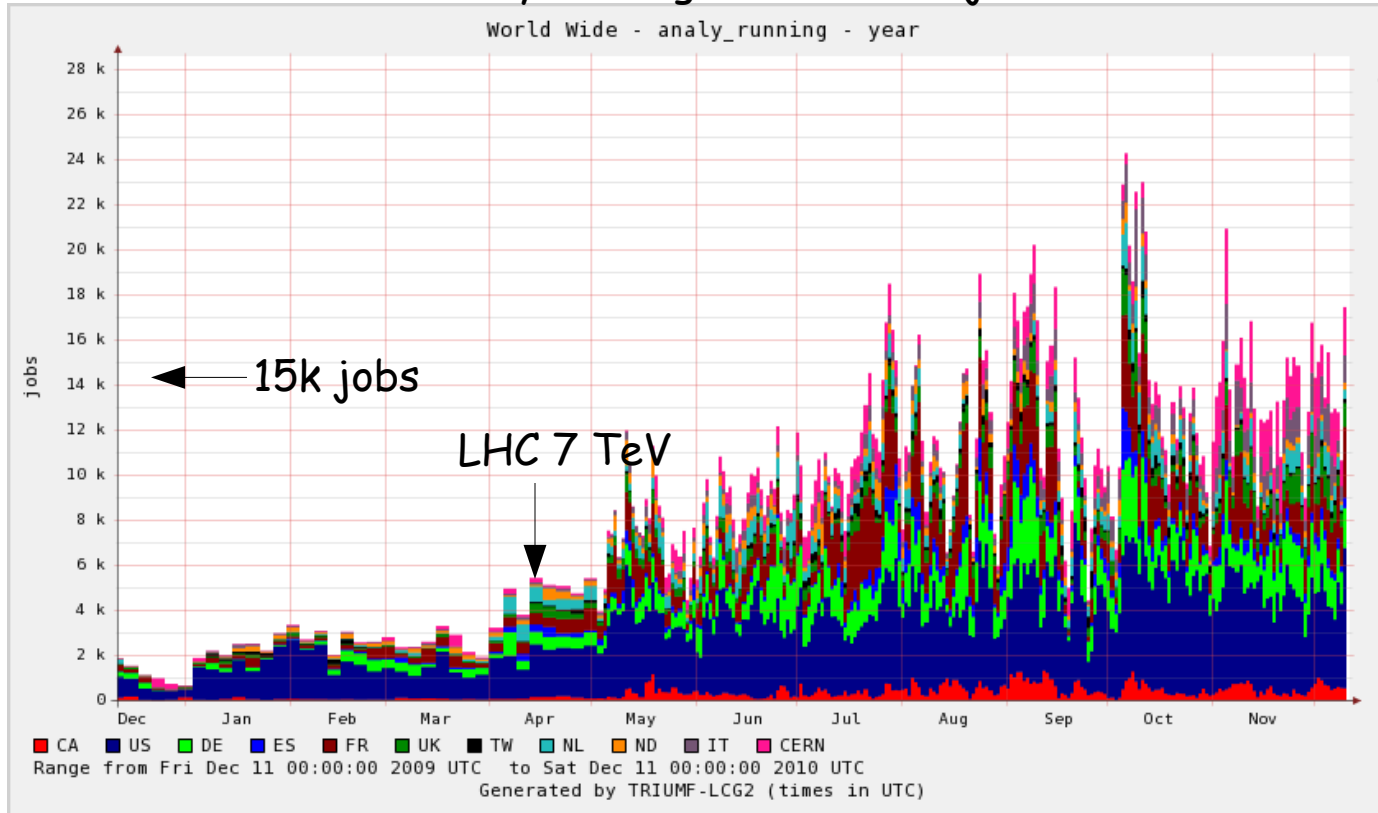


Autumn 2010 Reprocessing



World Wide Distributed Analysis

Number of simultaneously running ATLAS user jobs in 2010:



Compare with:
• 50K daily MC
Production jobs

LMU contributions
in all areas:
• Production
• Data distribution
• User analysis
• Tier1 operations
at FZK
• Tier2 at LRZ-LMU

Grid-based analysis in summer 2010:

>1000 different users, > 15mio analysis jobs processed

Analysis ingredients in a nutshell

Cross section measurement:

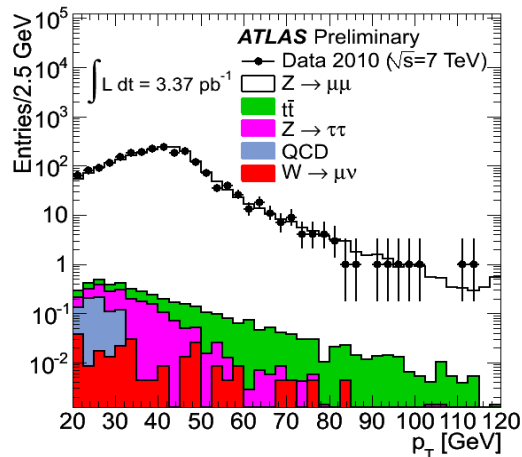
$$\sigma = \frac{N_{\text{Observed}} - N_{\text{BG}}}{\epsilon_{\text{Total}} * L}$$

N_{Observed} : number of observed events

N_{BG} : Number of background events

ϵ_{total} : Overall detection efficiency

L : Luminosity provided by collider



Select interesting events based signal event characteristics:

- e.g. leptons, jets, E_T^{Miss} , angular correlations etc.

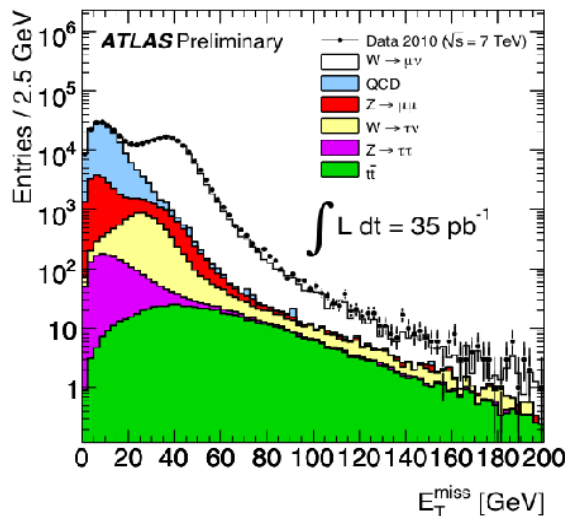
Example: $Z \rightarrow \mu\mu$:

- 2 isolated μ -tracks, back-to-back, low E_T^{Miss} , high transverse momentum, low jet activity

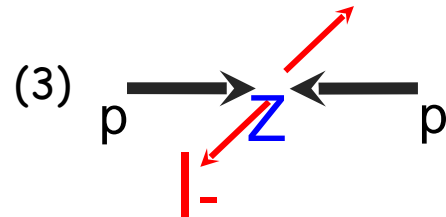
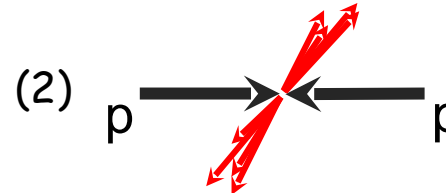
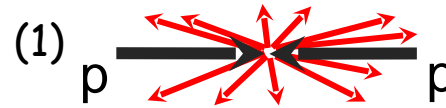
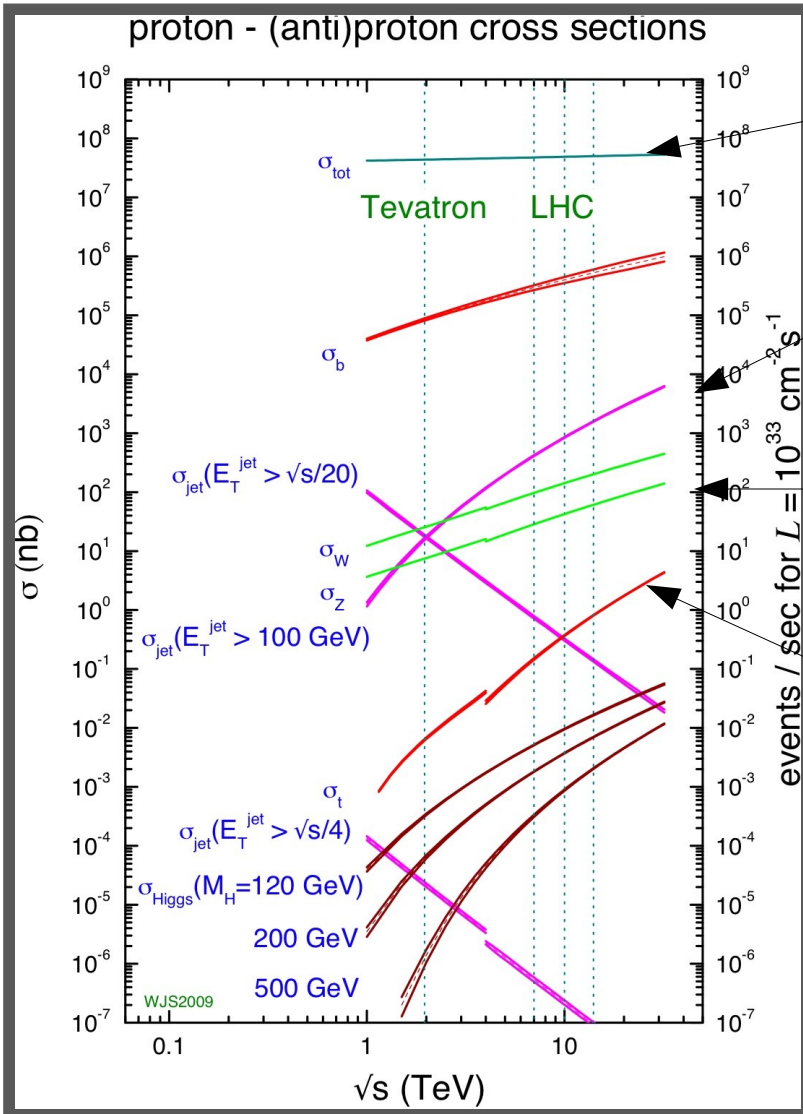
Determine N_{BG} or Signal prediction from Monte Carlo or data driven methods

ϵ_{total} : Combination of Efficiencies:

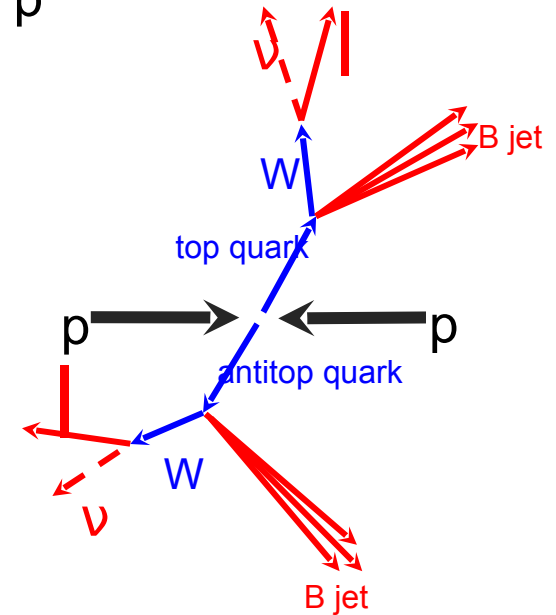
- Trigger, Reconstruction, Acceptance, Cuts etc.



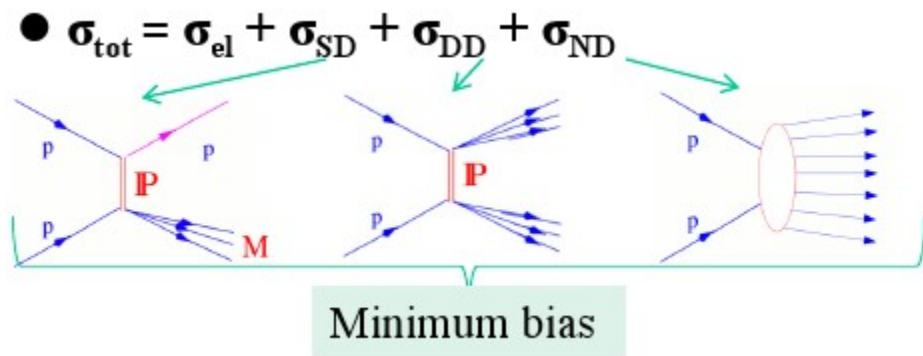
Different Analysis



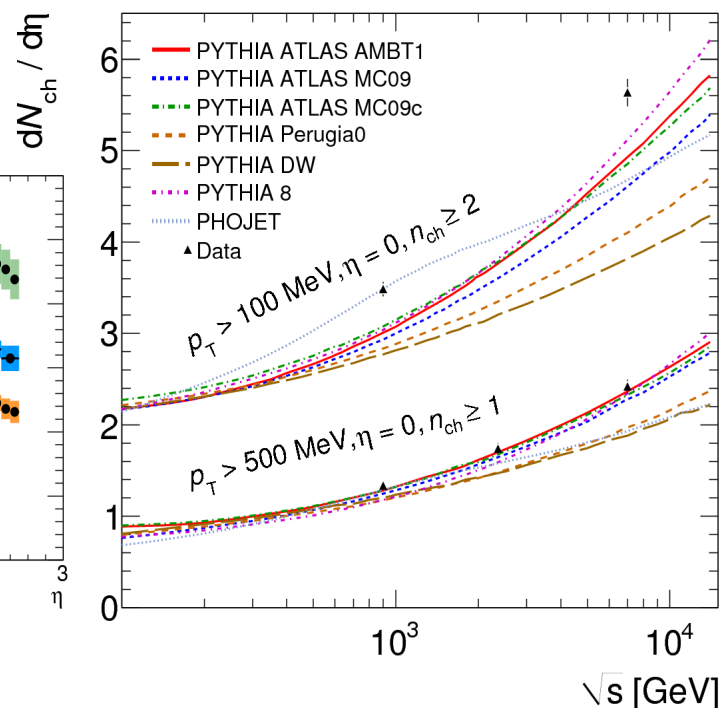
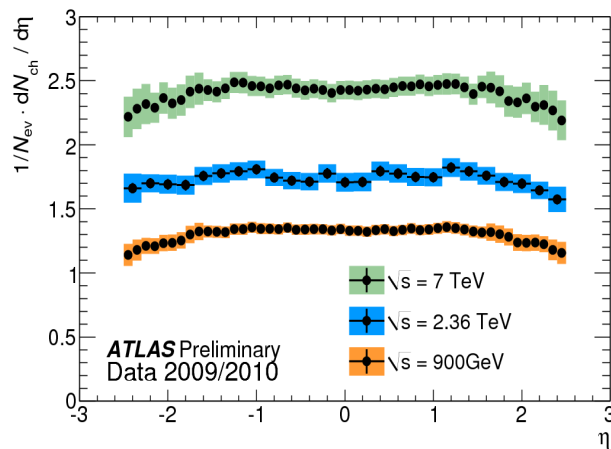
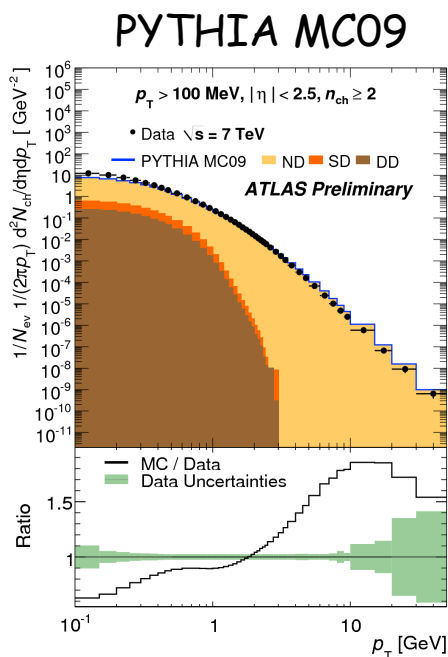
(4)



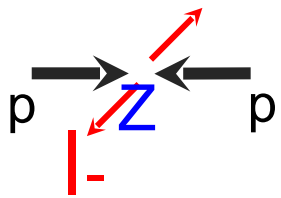
1st measurements with pp - Minimum Bias



Charged particle multiplicity
Measured down to $p_{\text{Track}} > 100 \text{ MeV}$



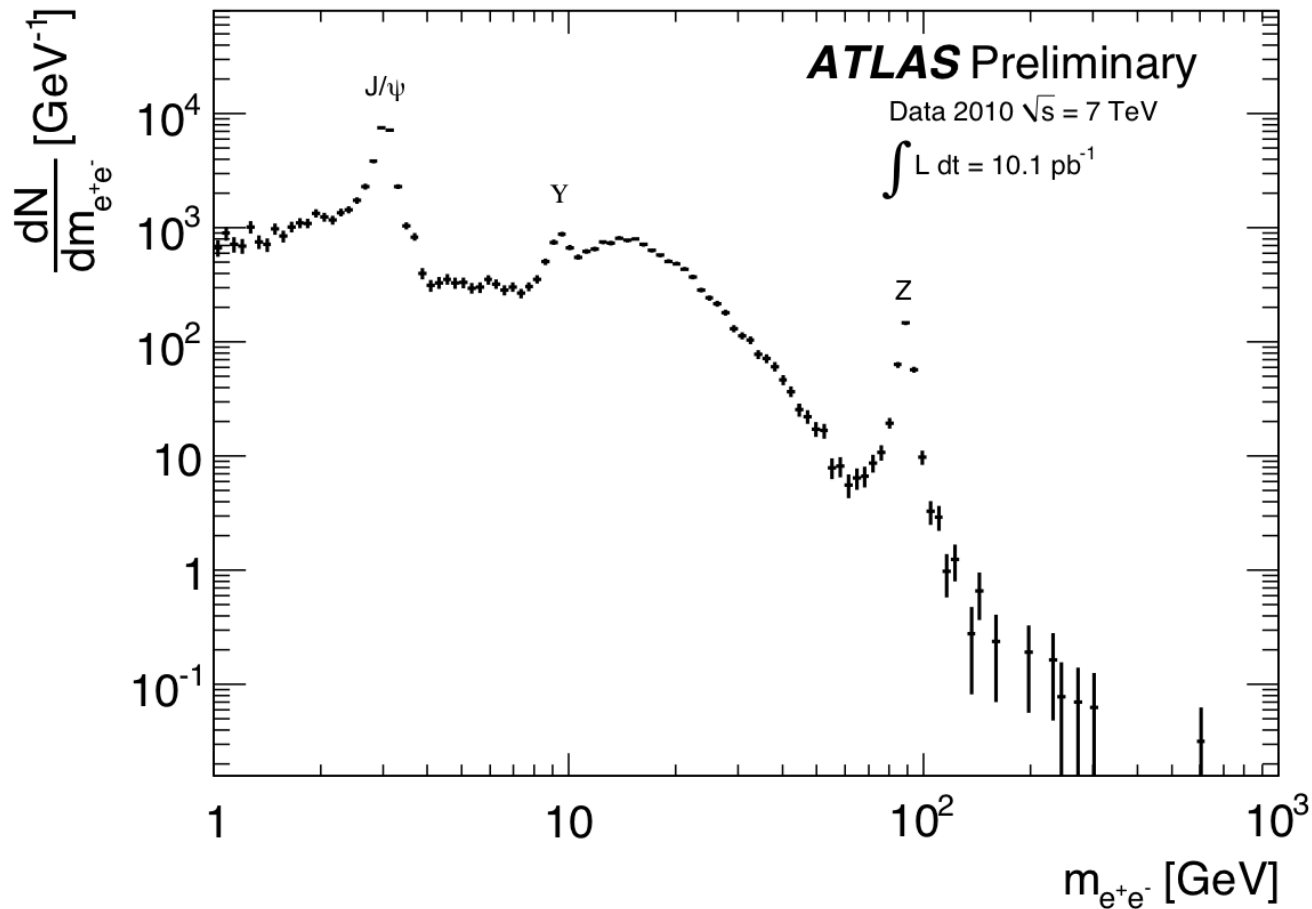
Multiplicity higher in data compared to pre-LHC tunes, and even to post LHC-tunes for $p_{\text{Track}} > 100 \text{ MeV}$, i.e. better tune and diffractive models necessary



Di-electron invariant mass

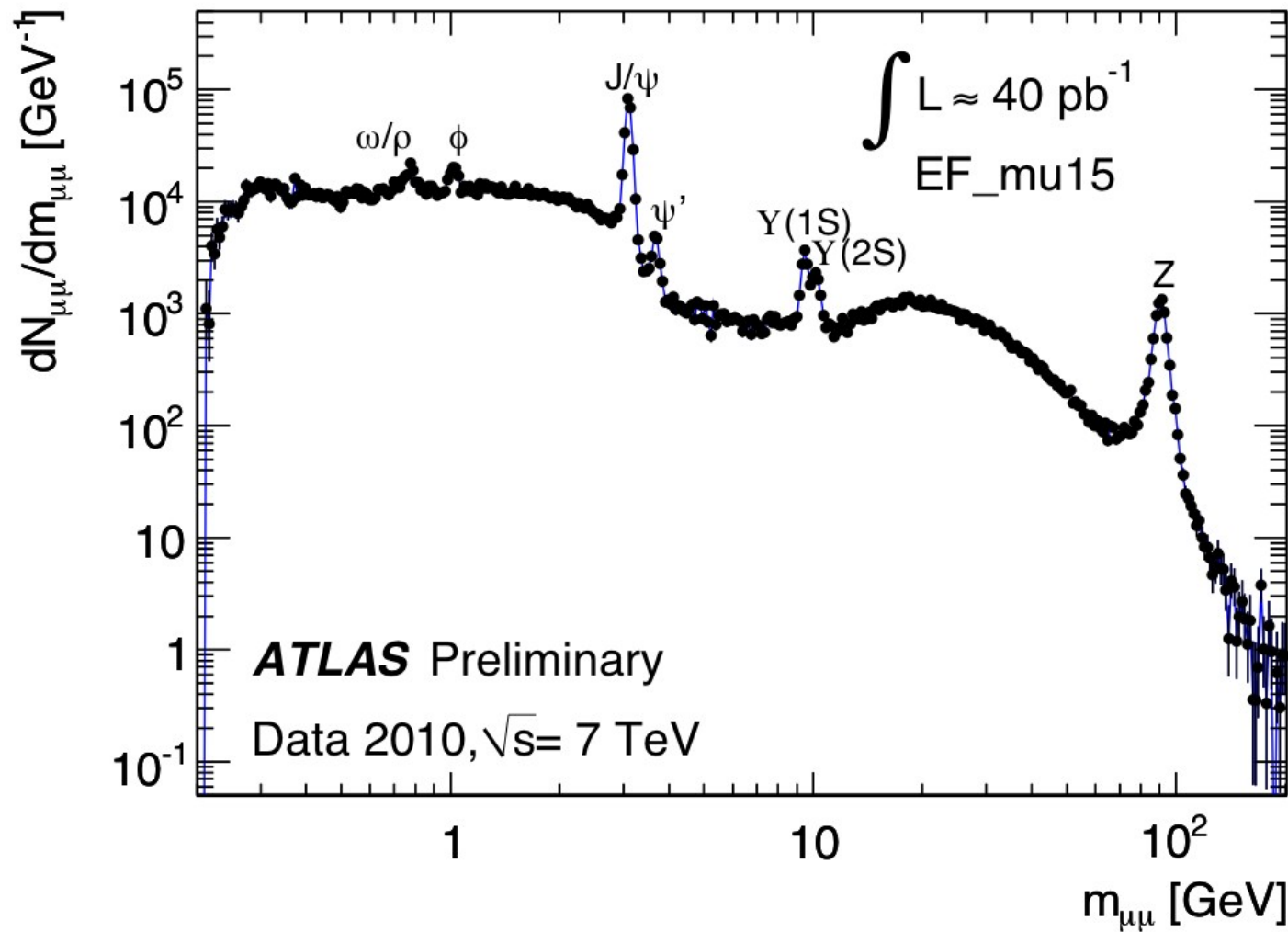
Data with 5 GeV E_T di-electron trigger (prescaled in later data)

Trigger selection produces shoulder around 15 GeV



Di-muon invariant mass

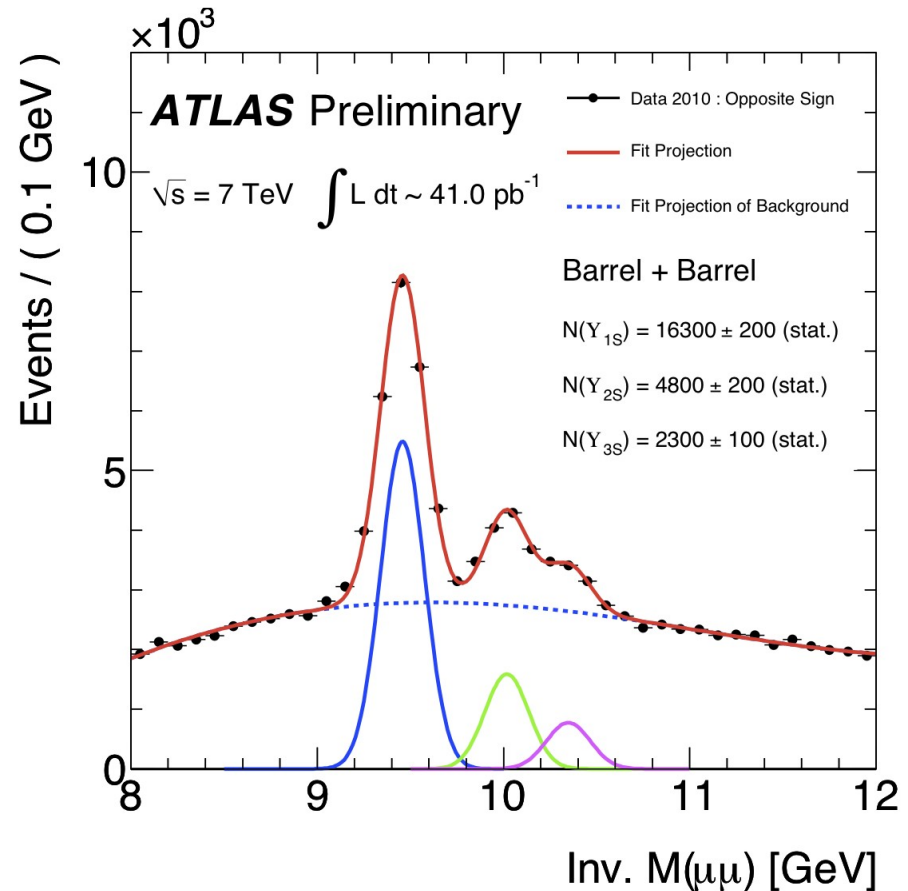
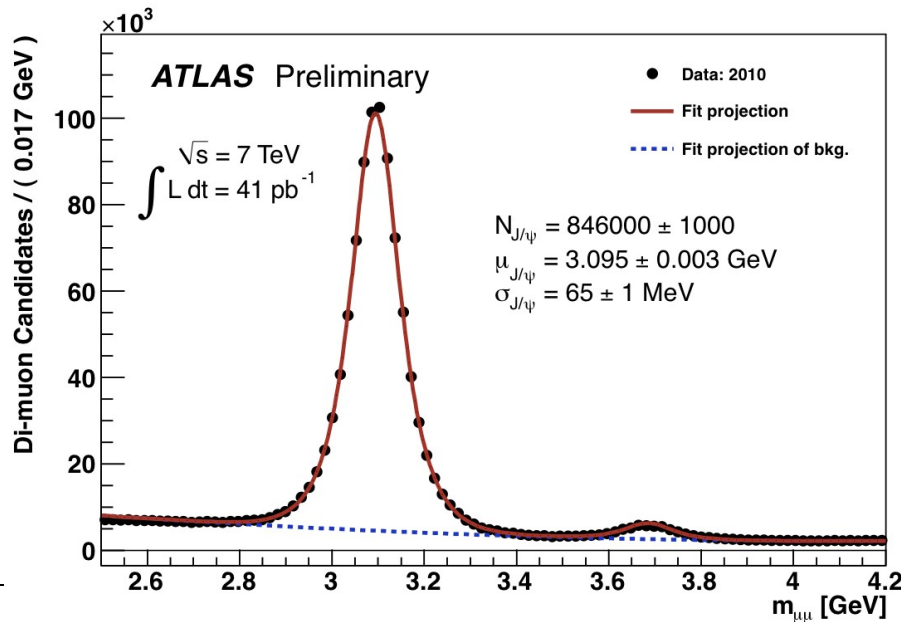
Leading muon, $p_T > 15$ GeV, second muon, $p_T > 2.5$ GeV



$J/\psi, \psi(2S)$ and $\Upsilon \rightarrow \mu\mu$

Use a selection of looser triggers
Oppositely charged muons with
 $p_T(\mu_1\mu_2) > (2.5, 4) \text{ GeV}$

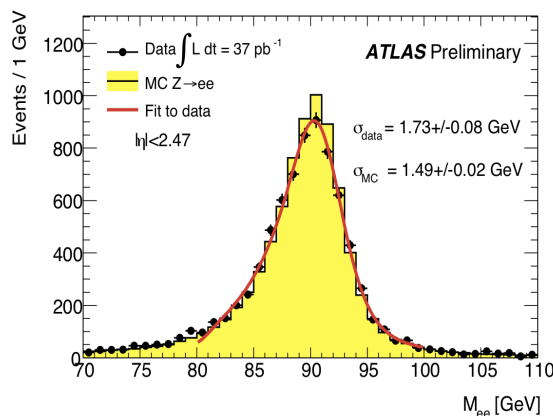
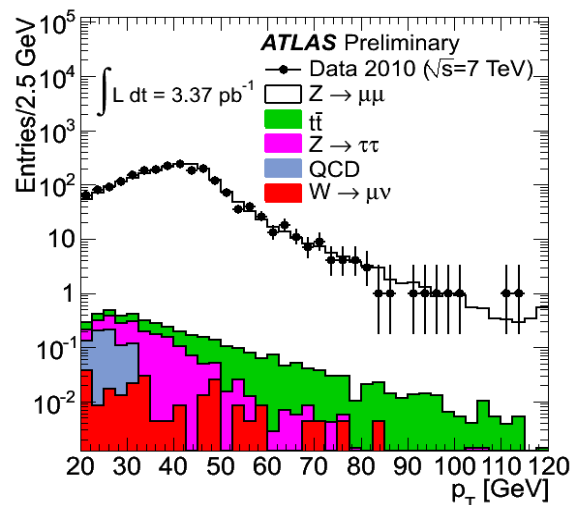
For J/ψ & $\psi(2S)$ fit tracks
to a common vertex and
recalculate mass.



About 60k $\Upsilon(1S, 2S, 3S)$ candidates
over full acceptance

Z-Production cross section

2 oppositely charged leptons (ee or $\mu\mu$) with $p_T^1 > 20$ GeV

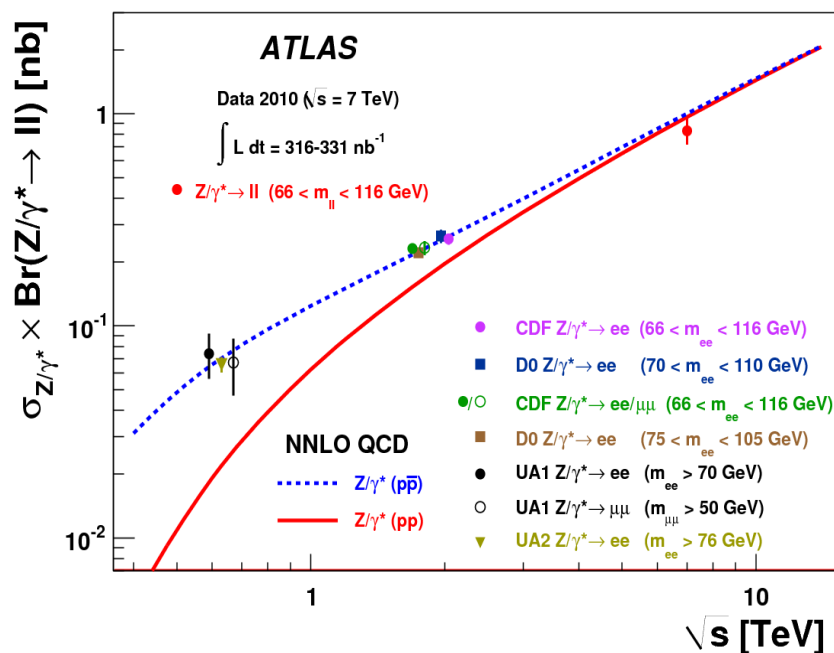


Total Z-Production cross section ($L \sim 320 \text{ nb}^{-1}$)

• Acceptance: $46.5 \pm 1.5\%$

• Reconstruction eff.: $64.5 \pm 14\%$ (e), $79.7 \pm 7\%$ (μ)

$$\sigma_{Z/\gamma^*}^{\text{tot}} \cdot \text{BR}(Z/\gamma^* \rightarrow \ell\ell) = 0.82 \pm 0.06(\text{stat}) \pm 0.05(\text{syst}) \pm 0.09(\text{lumi}) \text{ nb} \\ (66 < m_{\ell\ell} < 116 \text{ GeV})$$



Z: $\sim 9\text{k ee}$ and $14\text{k } \mu\mu$ in $\sim 40\text{pb}^{-1}$

Luminosity (11%) is dominant syst. source
 $\rightarrow \sigma(W)/\sigma(Z)$: cancellation

W-Production cross section

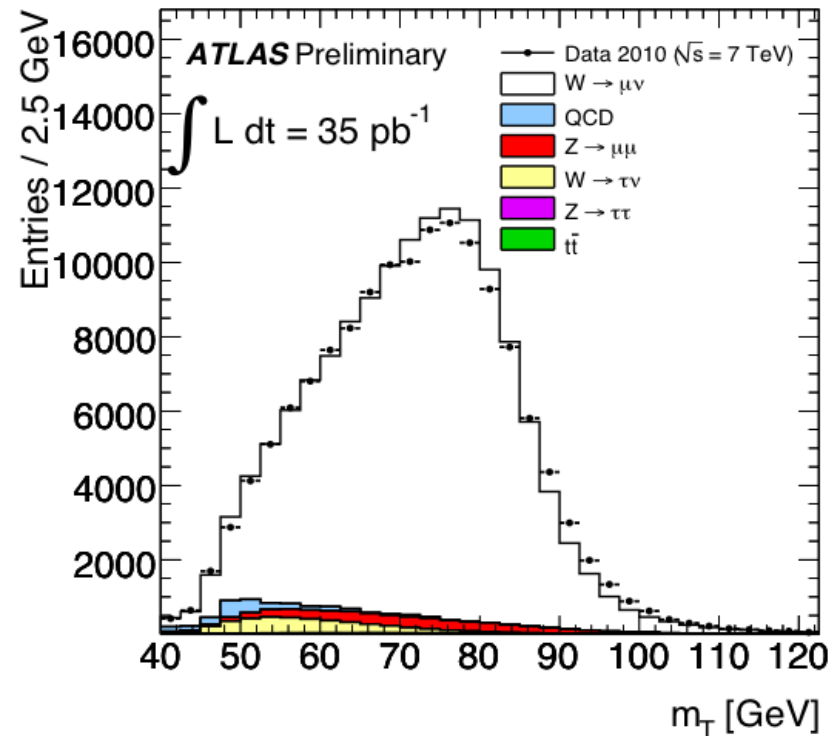
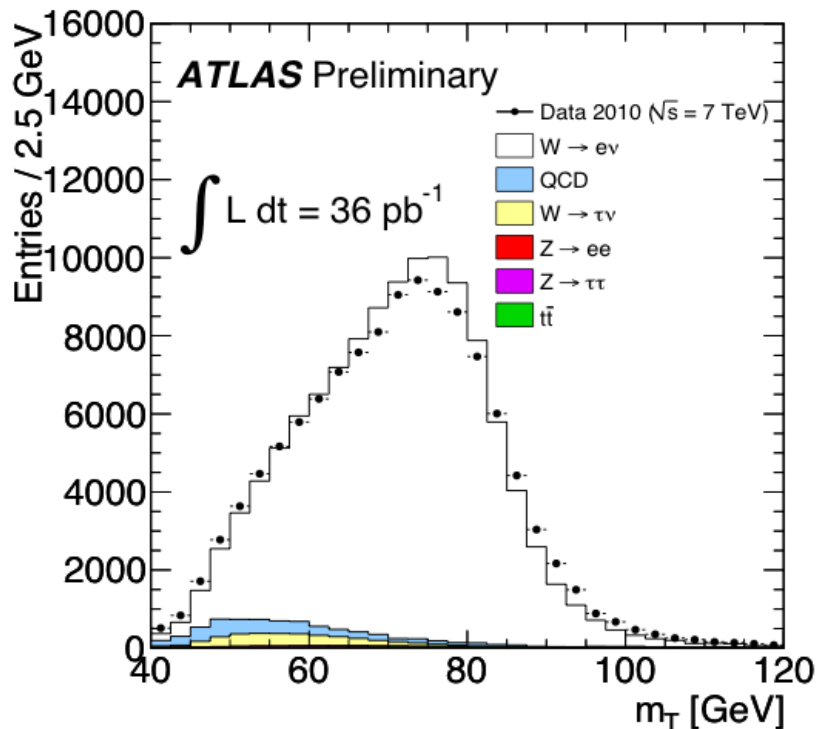
Event selection:

- $p_T(\text{Lepton}) > 20 \text{ GeV}$
- Isolation (μ only): $\Sigma p_T(\text{ID})/p_T(\mu) < 0.2$
- $E_T^{\text{miss}} > 25 \text{ GeV}$
- $m_T > 40 \text{ GeV}$

Transverse Mass:

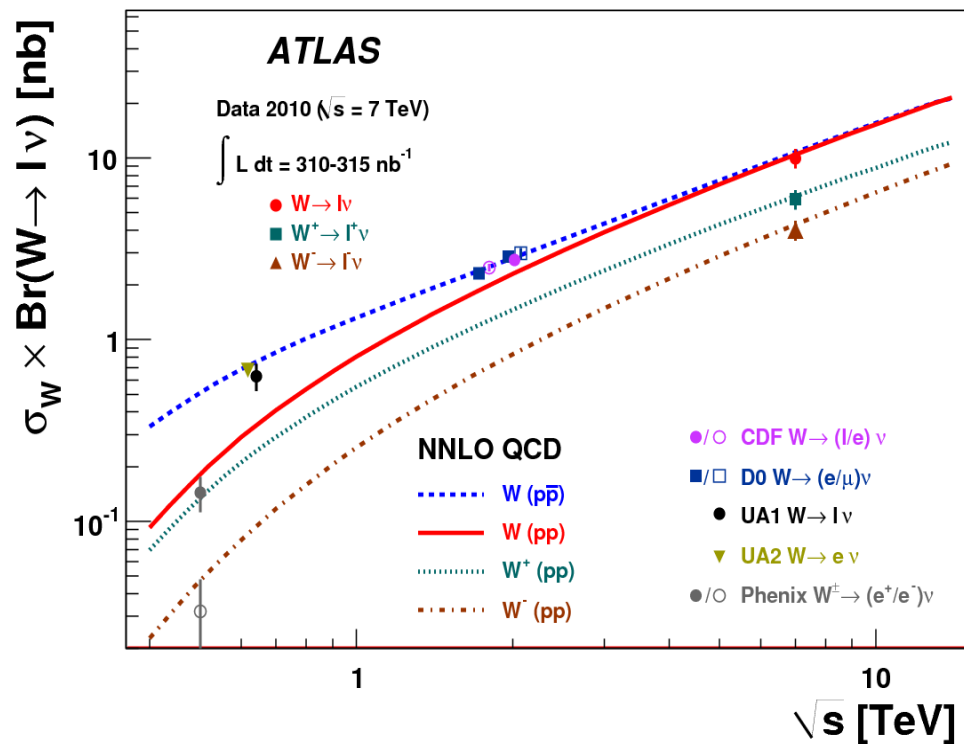
$$m_T = \sqrt{2 p_T^l p_T^\nu (1 - \cos(\phi^l - \phi^\nu))}$$

119k e and 135k μ candidates in $\sim 40 \text{ pb}^{-1}$



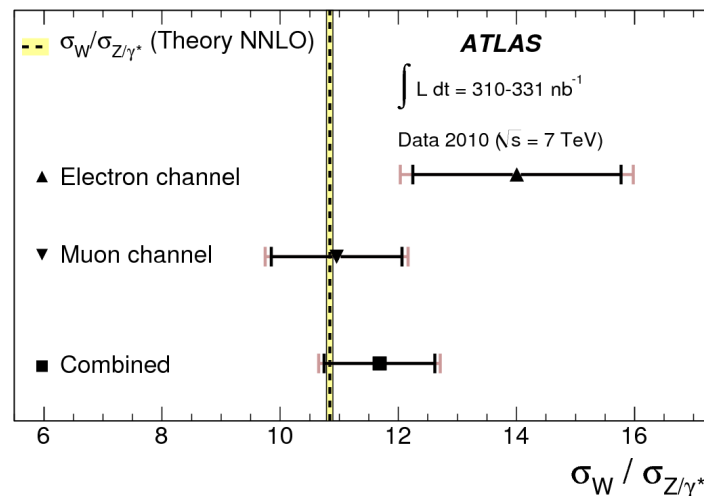
W/Z-Production cross section

Total W-Production cross section ($\mathcal{L} \sim 320 \text{ nb}^{-1}$)



$$\sigma_W^{\text{tot}} \cdot \text{BR}(W \rightarrow \ell \nu) = 9.96 \pm 0.23(\text{stat}) \pm 0.50(\text{syst}) \pm 1.10(\text{lumi}) \text{ nb}$$

Ratio of W to Z cross sections:
 $\sigma(W)/\sigma(Z/\gamma^*)$



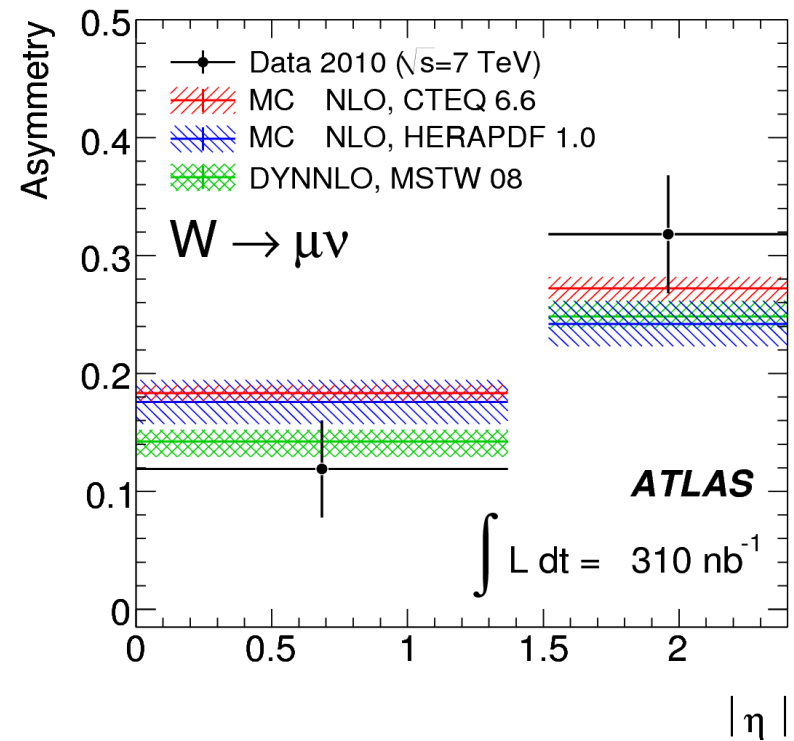
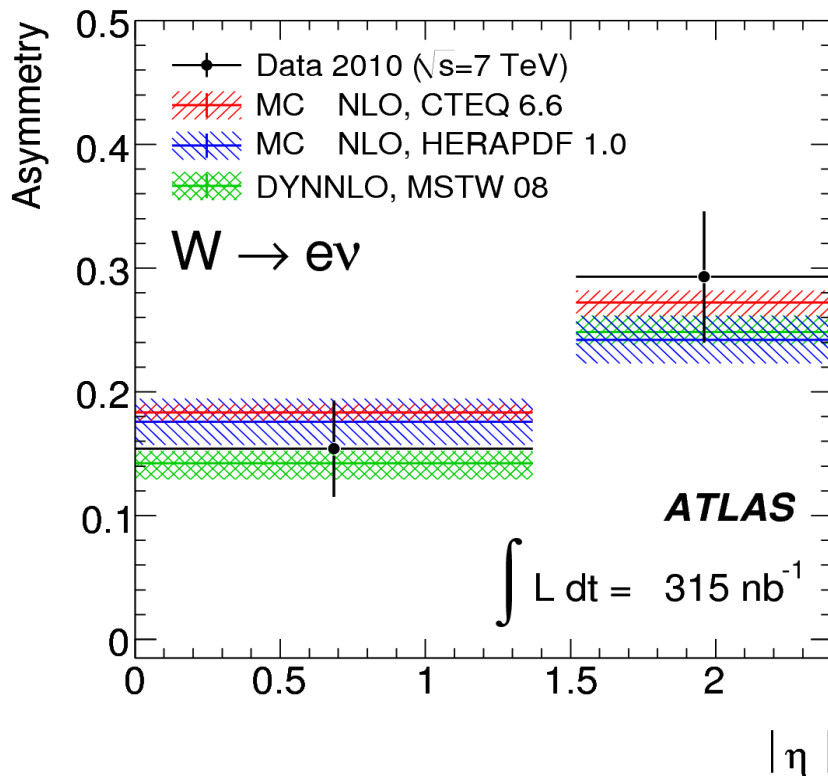
• In the cross section ratio both exp/theory uncertainties partially cancel:

Exp: luminosity, Theory: PDF

Measured cross sections are in agreement with theor. predictions based on NNLO QCD

W⁺/W⁻ charge asymmetry

$$A = \frac{\sigma_{W^+} - \sigma_{W^-}}{\sigma_{W^+} + \sigma_{W^-}} \approx \frac{u_V - d_V}{u_V + d_V + \bar{u} + \bar{d}} \quad \text{Sensitive to valence quark PDFs}$$



Data demonstrates the expected charge asymmetry

$W \rightarrow \tau \nu$ observation

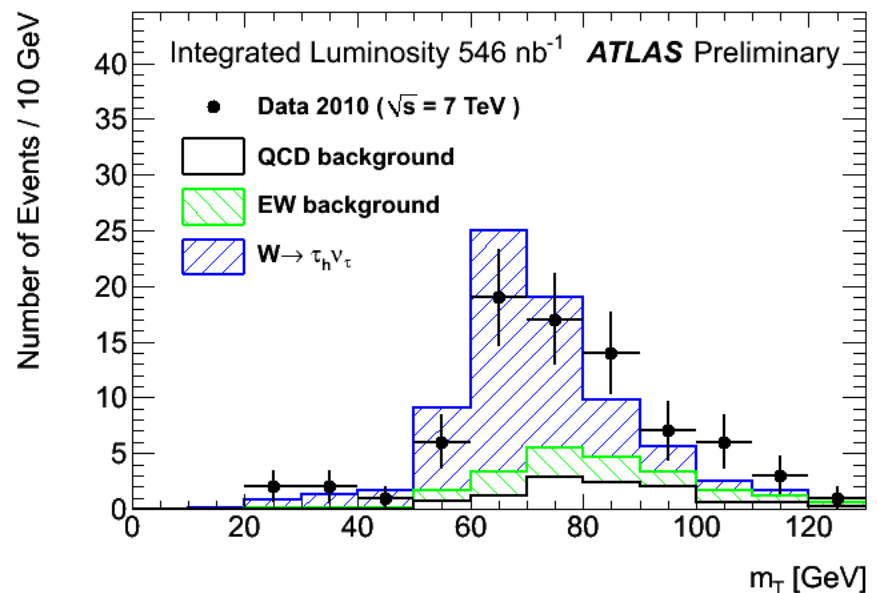
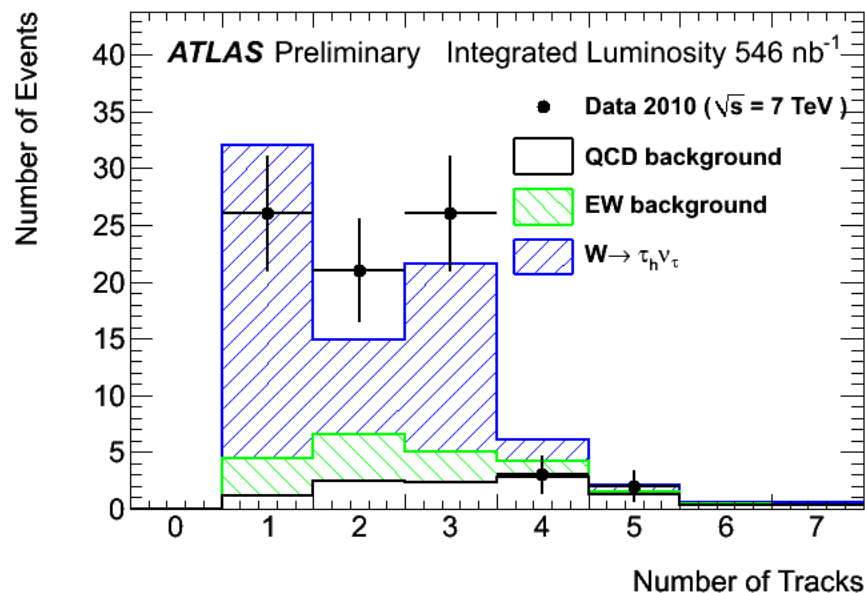
Observation of $W \rightarrow \tau \nu$ based on 550 nb^{-1} also available.

78 events with hadronic τ decay candidates. Backgrounds:

$11.1 \pm 2.3 \pm 3.2$ from QCD

$11.8 \pm 0.4 \pm 3.7$ from other W/Z decays

Event properties consistent with expectation



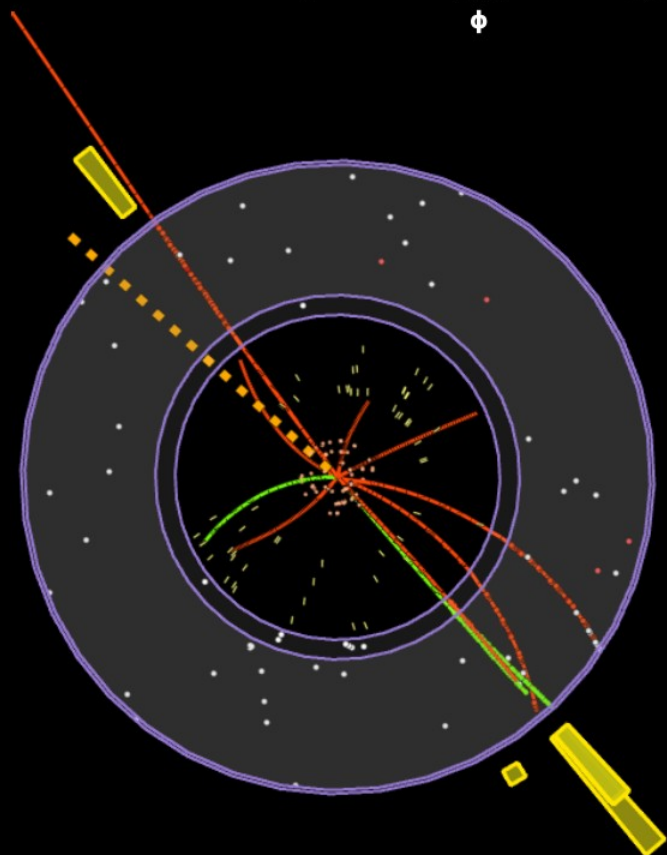
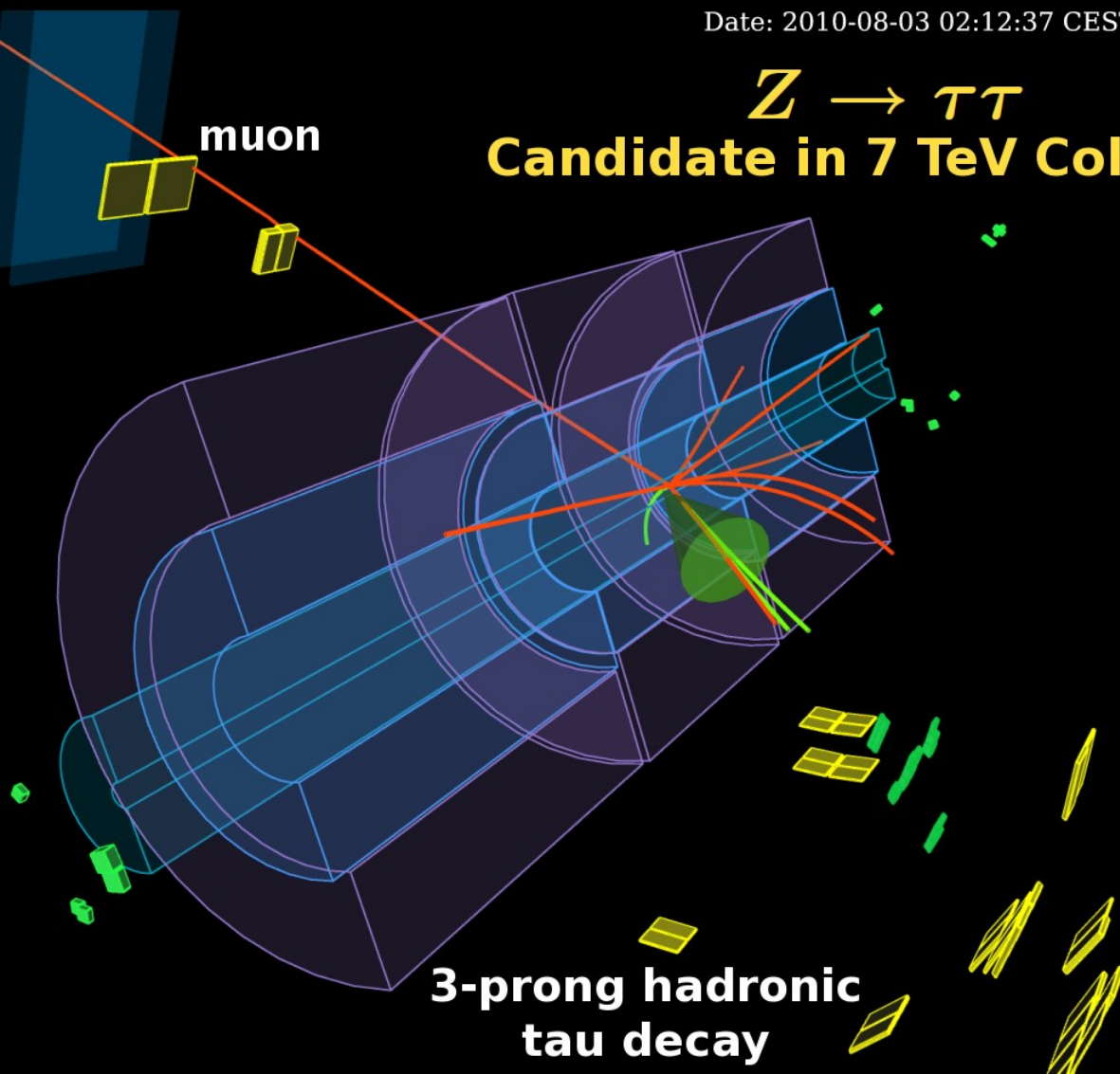
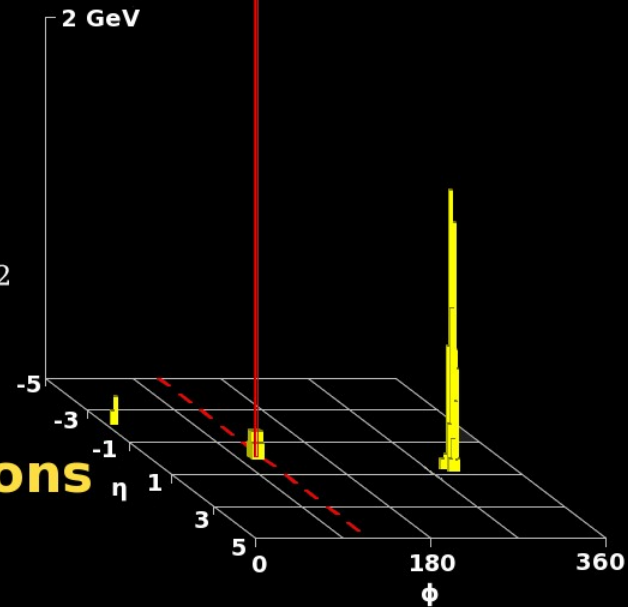
$$\begin{aligned}
 p_T(\mu) &= 18 \text{ GeV} \\
 p_T^{\text{vis}}(\tau_h) &= 26 \text{ GeV} \\
 m_{\text{vis}}(\mu, \tau_h) &= 47 \text{ GeV} \\
 m_T(\mu, E_T^{\text{miss}}) &= 8 \text{ GeV} \\
 E_T^{\text{miss}} &= 7 \text{ GeV}
 \end{aligned}$$

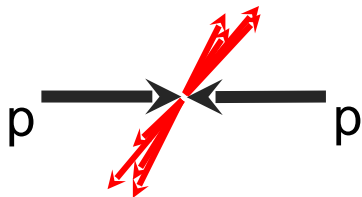


Run Number: 160613, Event Number: 9209492

Date: 2010-08-03 02:12:37 CEST

$Z \rightarrow \tau\tau$ Candidate in 7 TeV Collisions





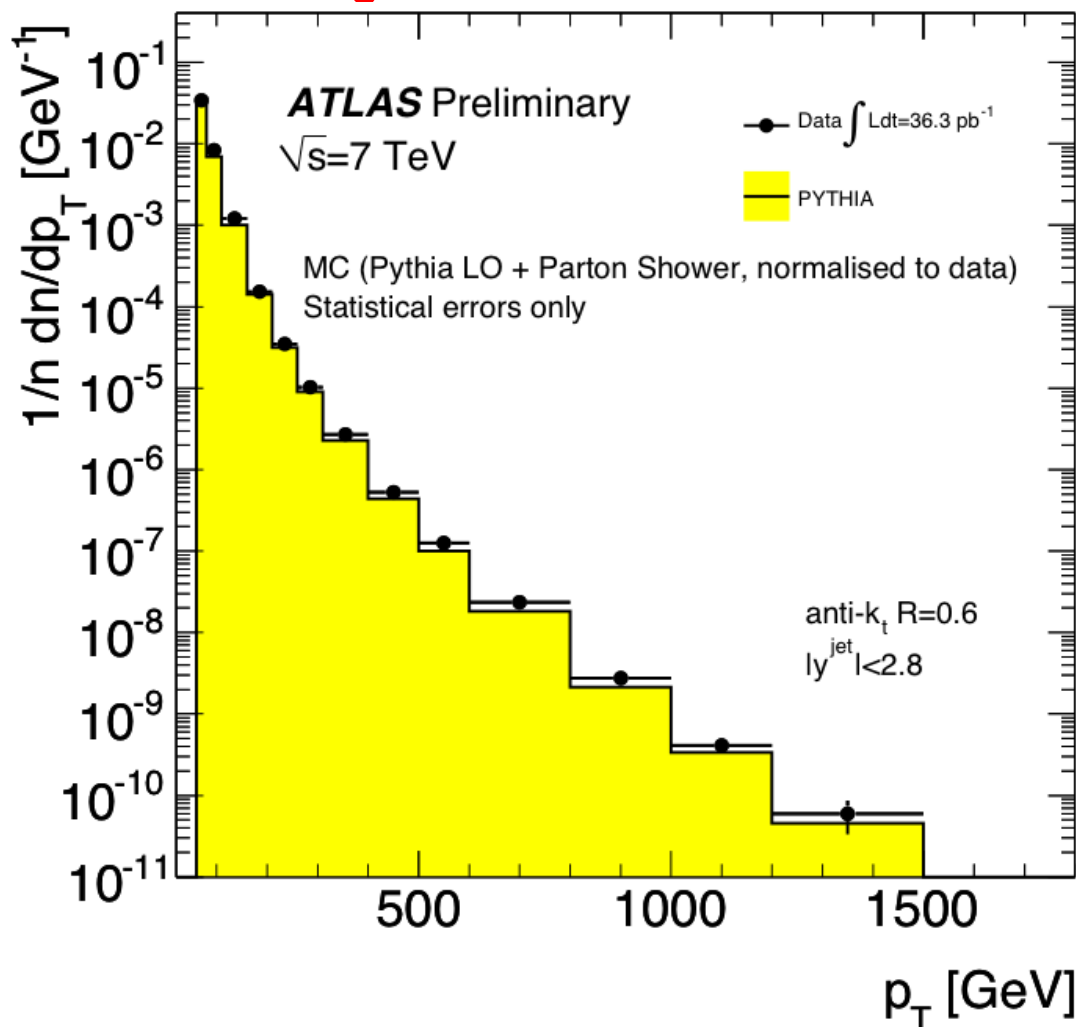
Combine a range
of triggers to cover
the full p_T spectrum

In all cases, jets
corrected to
hadronic scale
(JES uncertainty 7%)

Jet $p_T > 60 \text{ GeV}$

Highest p_T jet 1.3 TeV

Inclusive jets

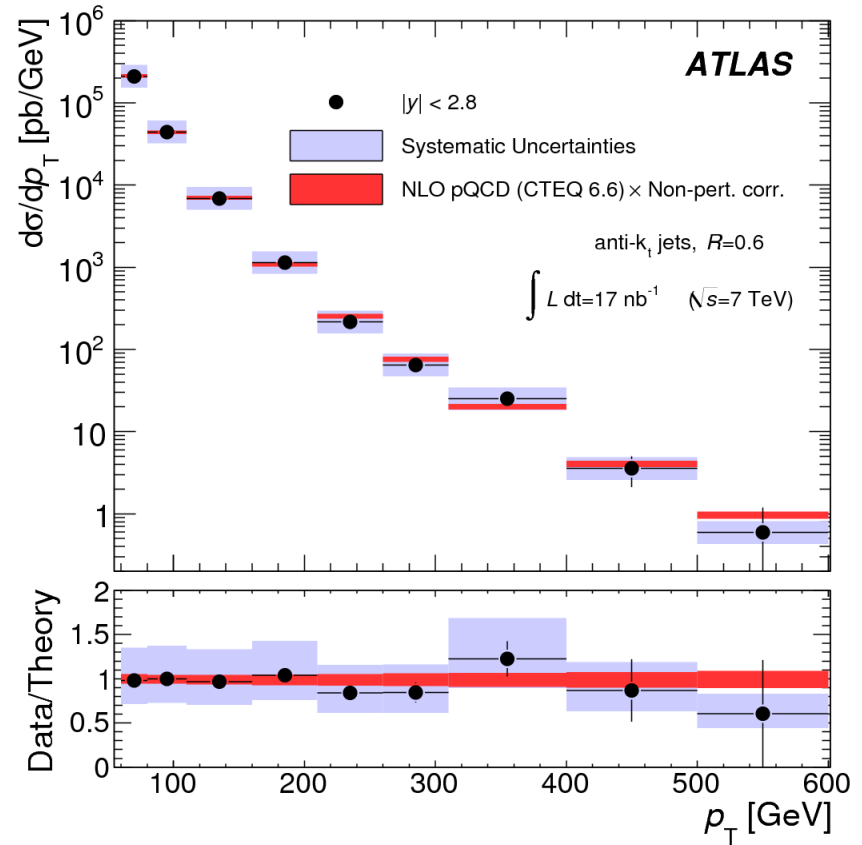


Shape comparison with MC PYTHIA (LO + parton shower)

Inclusive Jet cross section

- ❑ Measured jets corrected to particle-truth level (incl μ and ν) using parton- shower MC (Pythia, Herwig):
- ❑ Results compared to NLO QCD prediction after corrections for hadronization and underlying event
- ❑ Theoretical uncertainty: $\sim 20\%$ (up to 40% at large $|y_j|$) from variation of PDF, α_s , scale (μ_R , μ_F)
- ❑ Experimental uncertainty: $\sim 30\text{-}40\%$ dominated by Jet E-scale (known to $\sim 7\%$,)
- ❑ Luminosity uncertainty(11%) not included

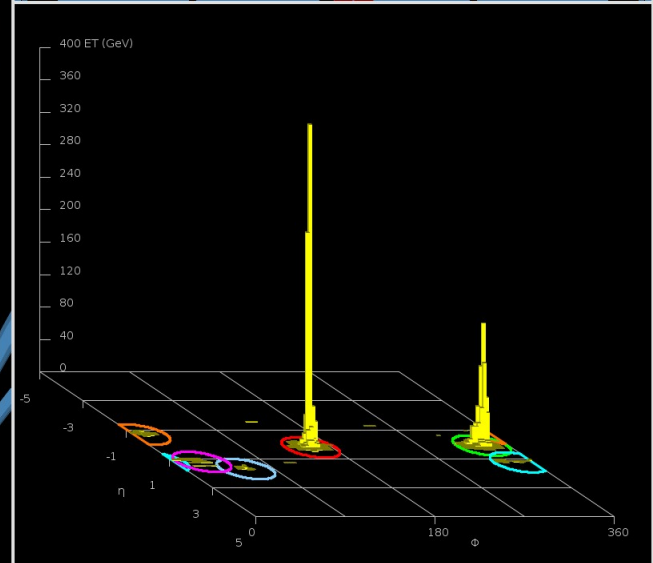
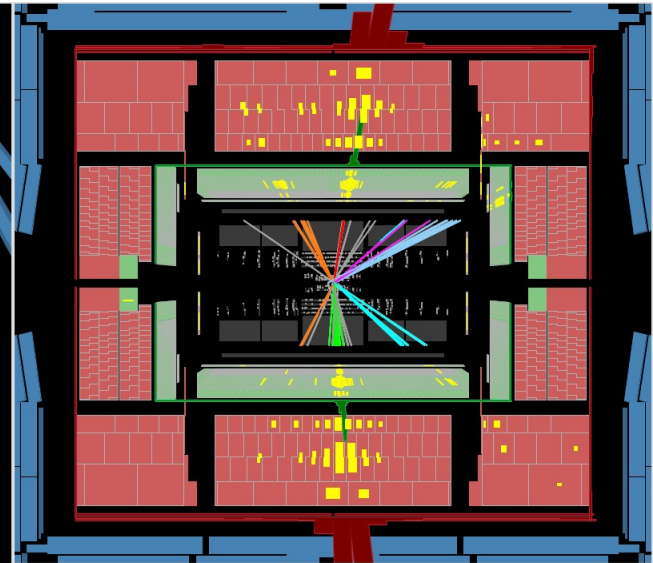
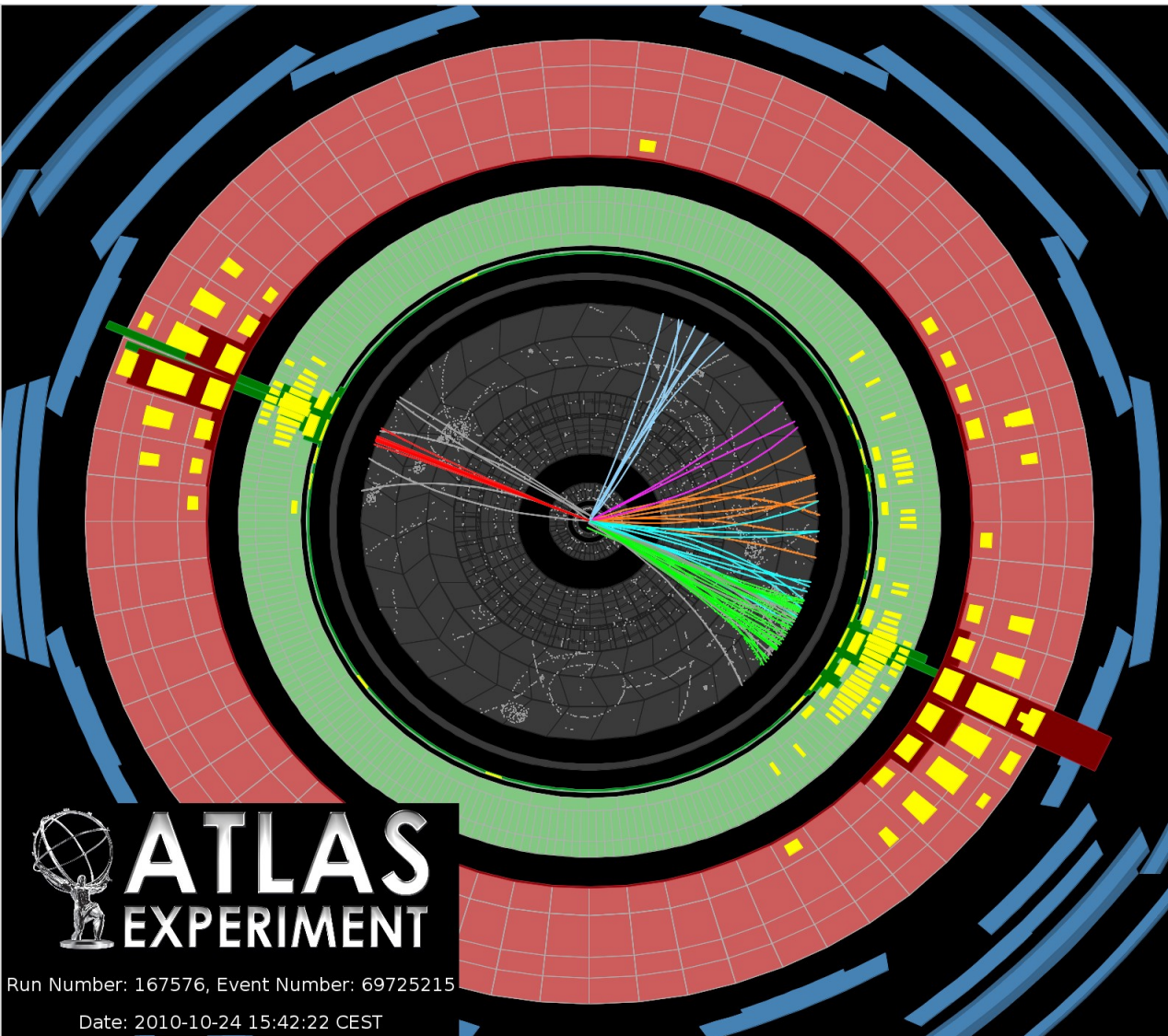
All Jets from events with at least
One Jet $p_{T^j} > 60 \text{ GeV}$, $|y^j| < 2.8$



Good agreement data-NLO QCD over 5 orders of magnitude

Highest p_T jet event

$p_{T \text{ jet1}}=1.3 \text{ TeV}$ (also
 $p_{T \text{ jet2}}=1.2 \text{ TeV}$, $m_{jj}=2.6 \text{ TeV}$)



Dijets and multi jets

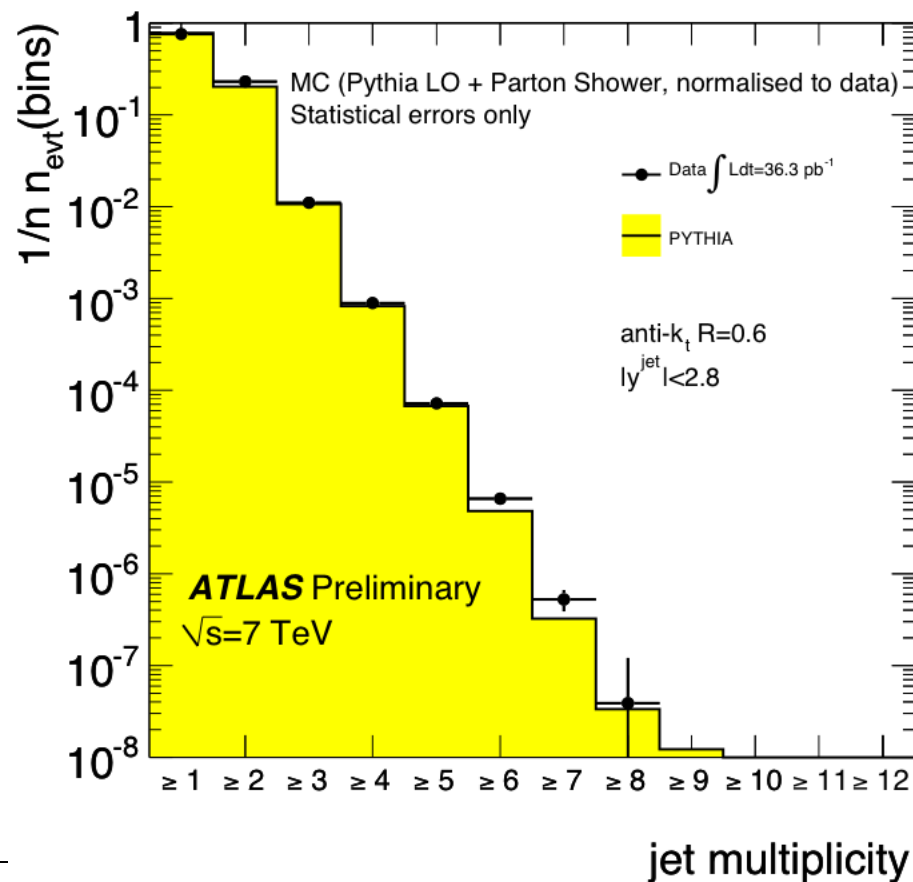
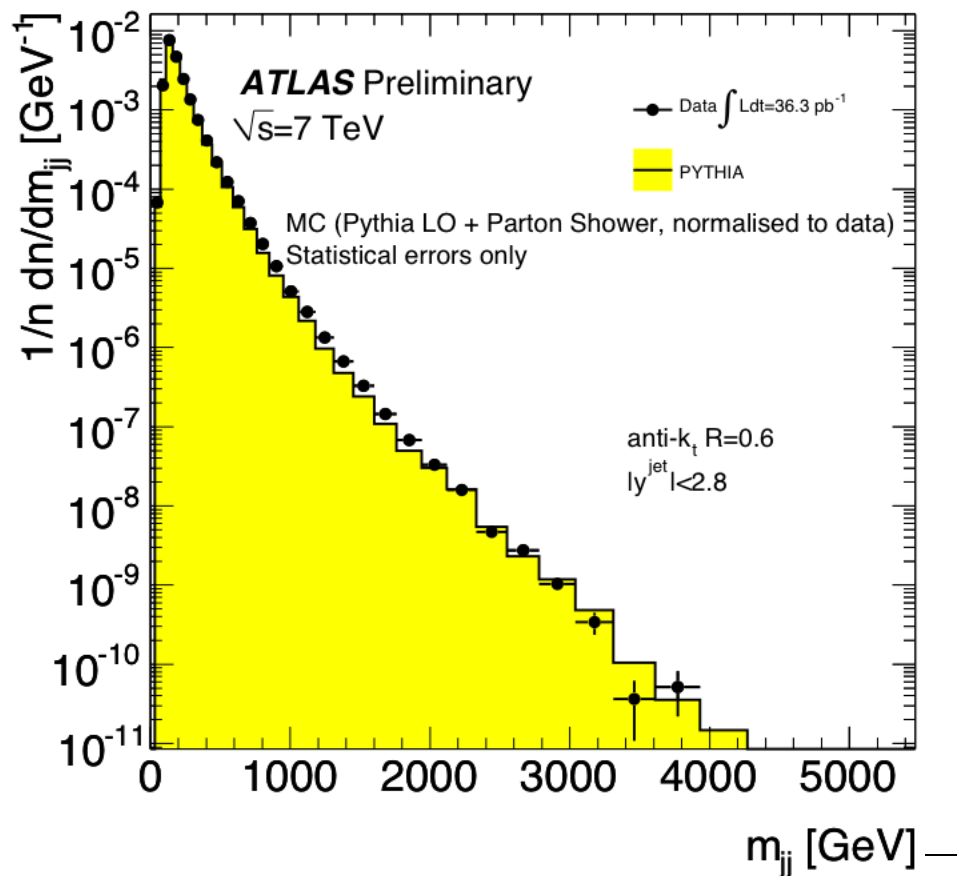
Leading jet $p_T > 60$ GeV,

Subleading $p_T > 30$ GeV

Highest dijet mass 3.7 TeV

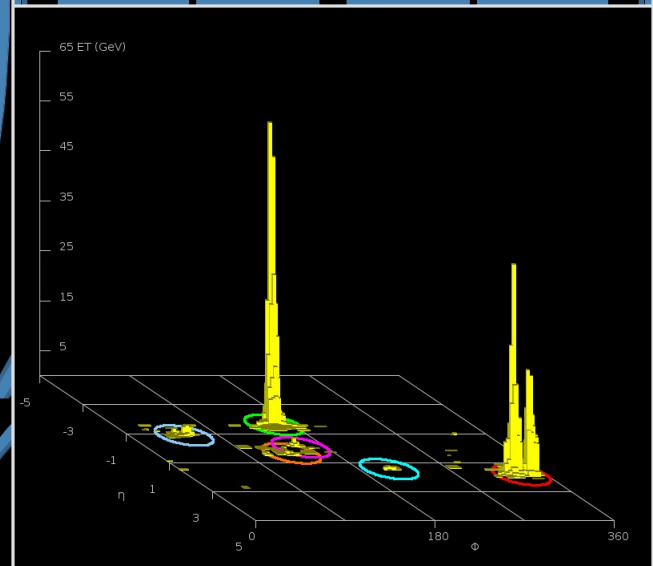
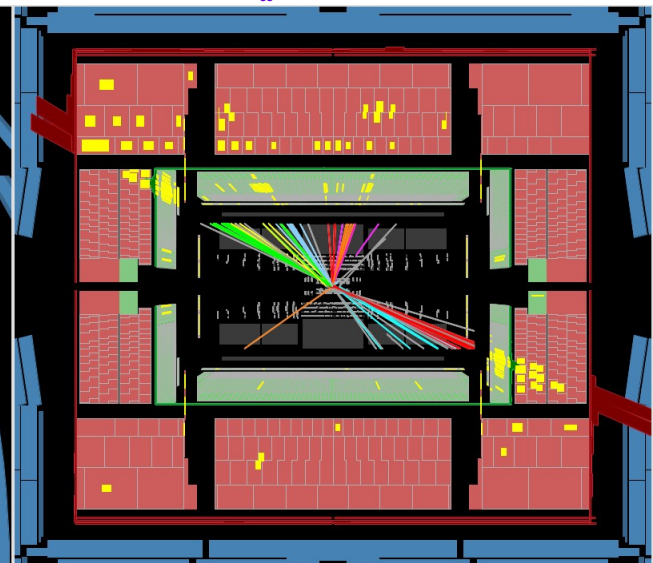
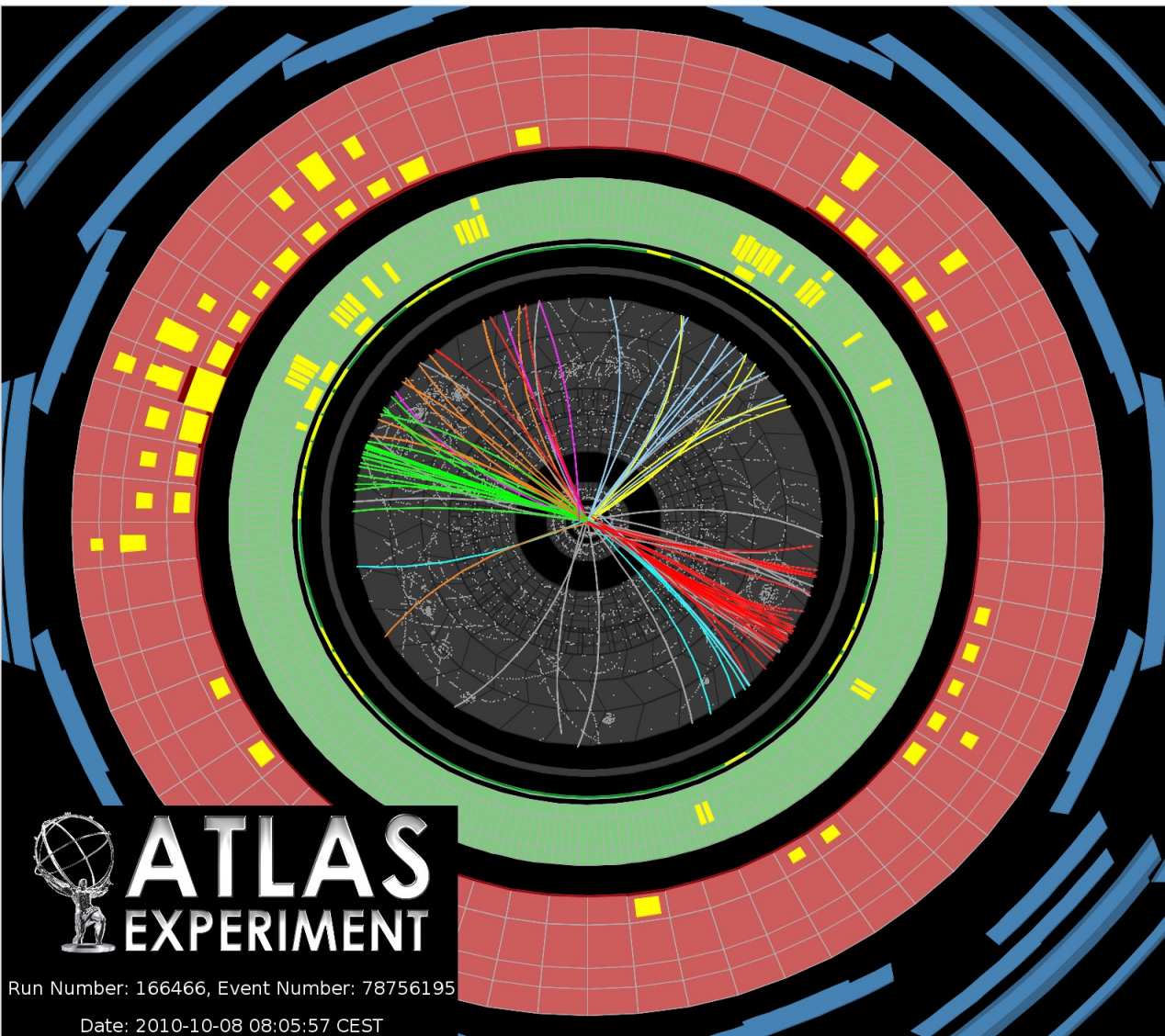
Count jets with $p_T > 60$ GeV

One event with 8 jets



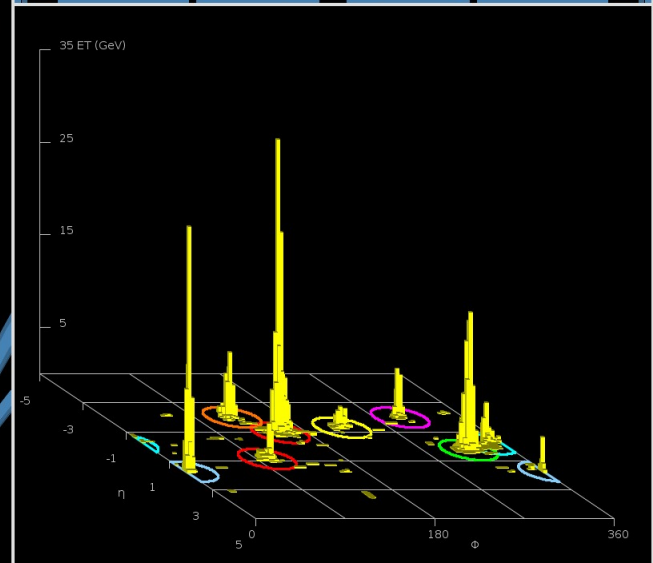
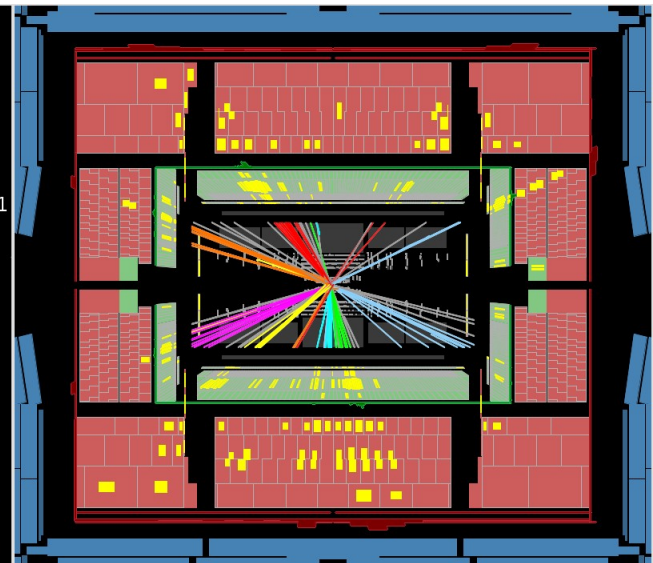
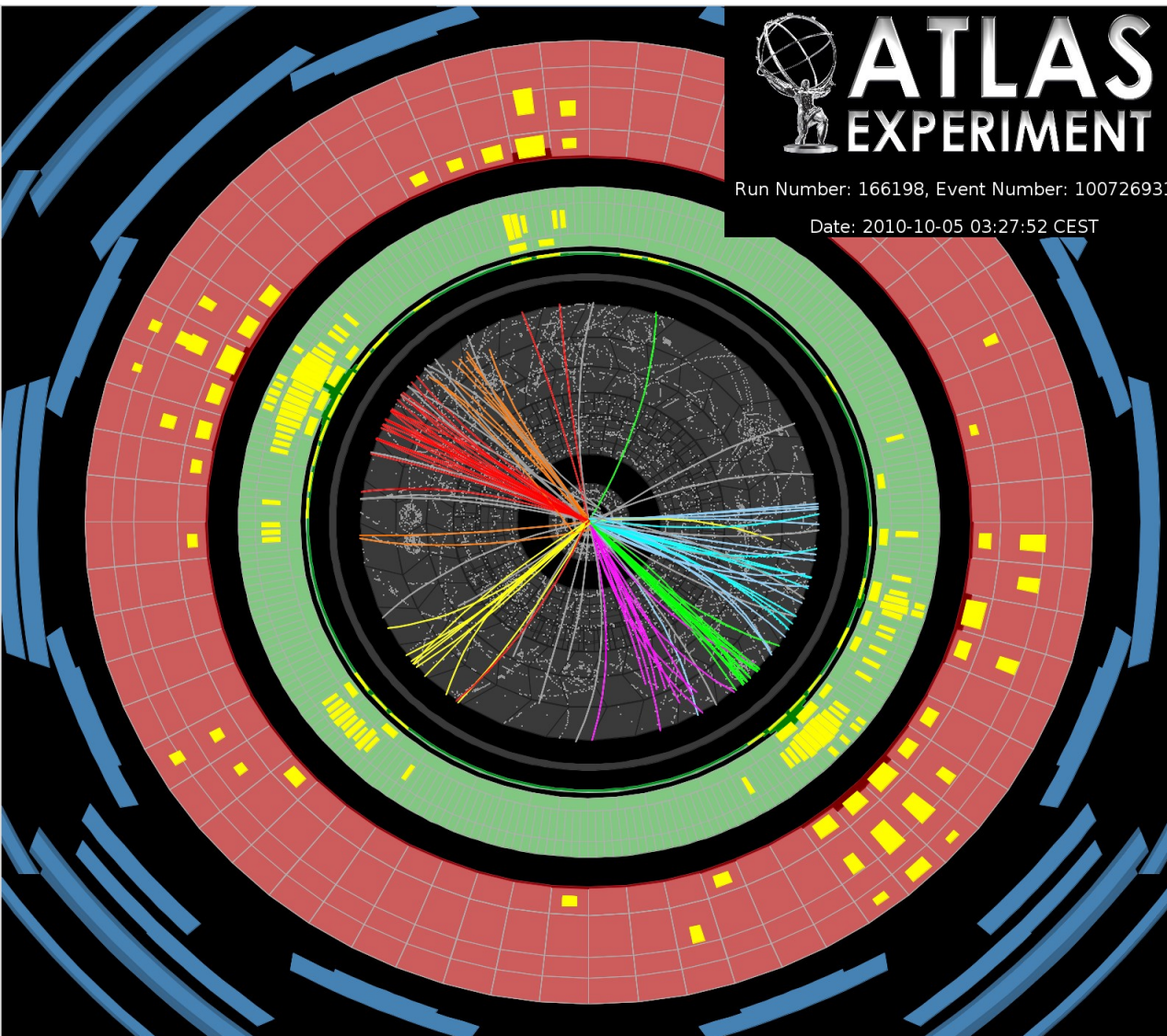
Highest mass di-jet

$p_{\text{T jet1}}=670 \text{ GeV}$,
 $p_{\text{T jet2}}=610 \text{ GeV}$, $m_{\text{jj}}=3.7 \text{ TeV}$

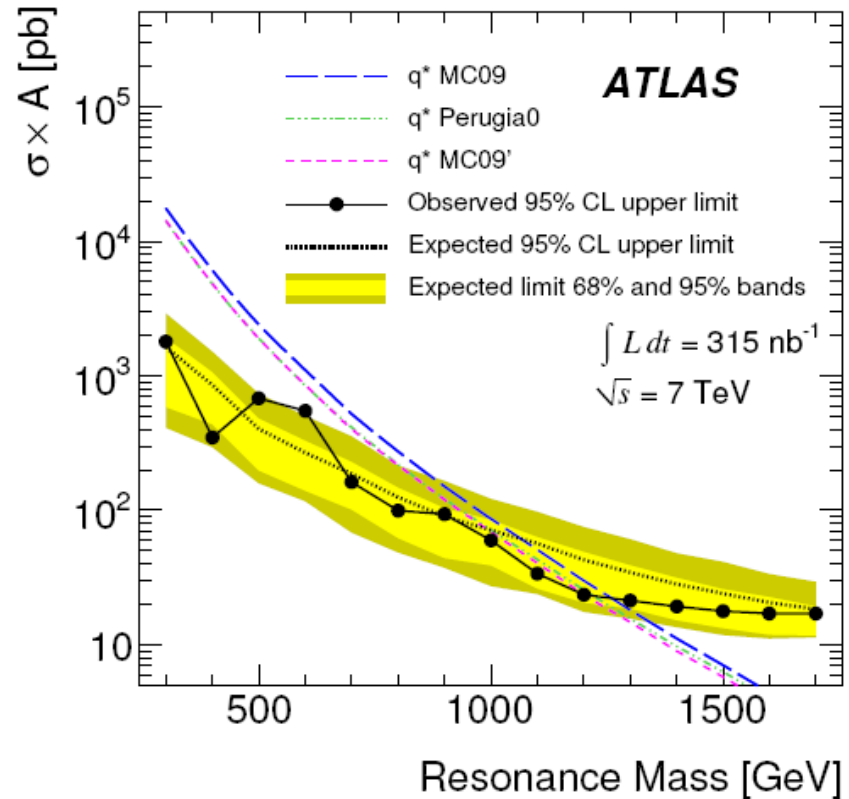
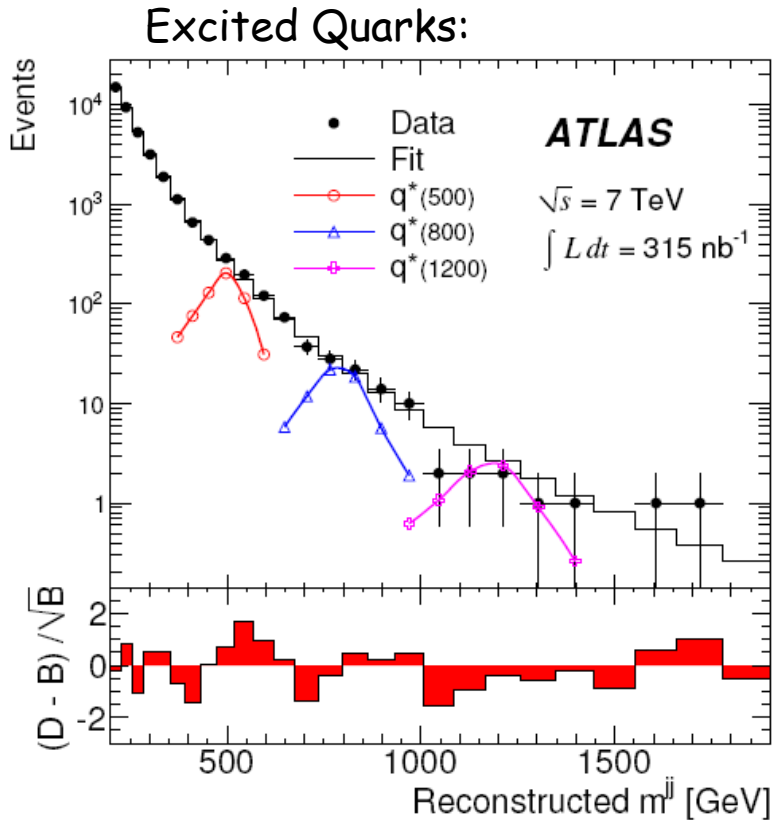


8-jet event

8 jets with $p_T > 60$ GeV



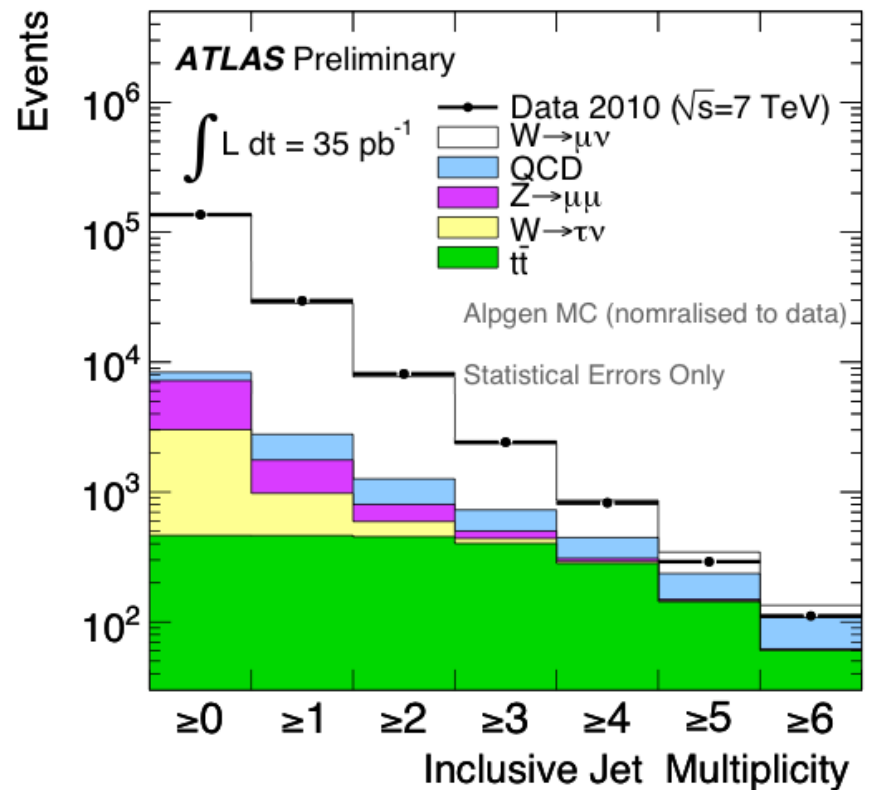
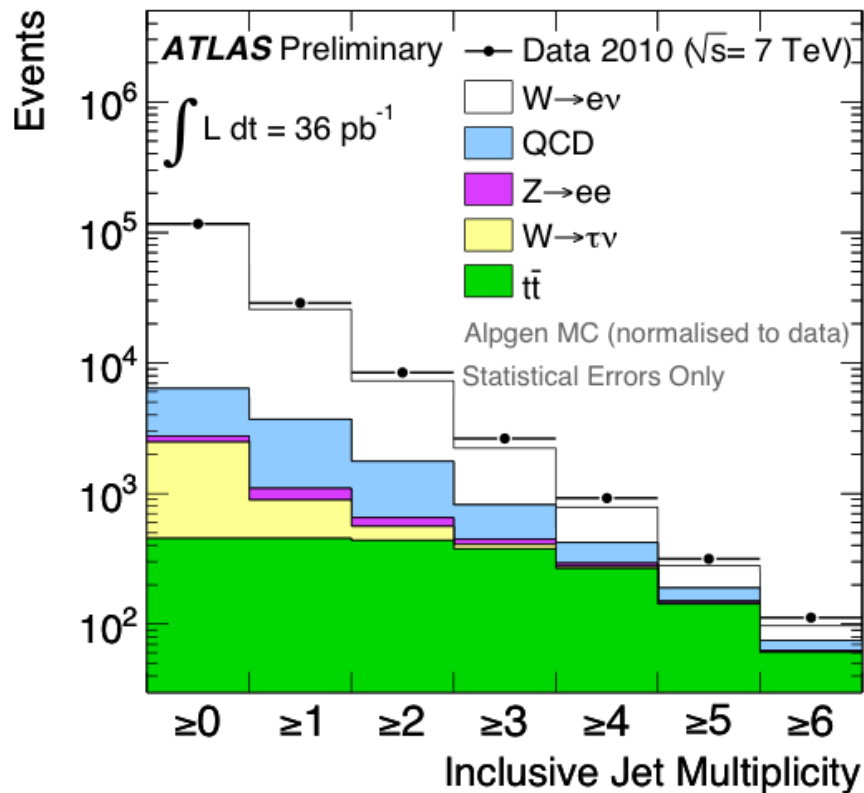
Resonance search in Di-jets



- Fit smooth function (assume Bgrd only)
 - Syst. Errors: JES, background fitting, luminosity taken into account
 - Requirement on $p_T(j_1) > 150 \text{ GeV}$ to match the evolving trigger.
 - $0.30 < m_{q^*} < 1.26 \text{ (1.20) TeV @ 95\% C.L. Exclusion with MRST2007(CTEQ6L1) PDF}$
- First ATLAS limit to extent previously existing limit

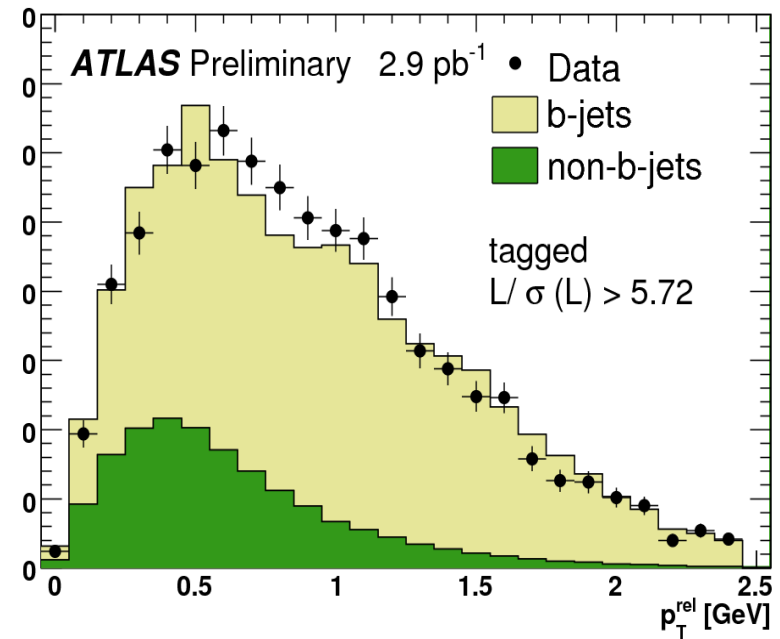
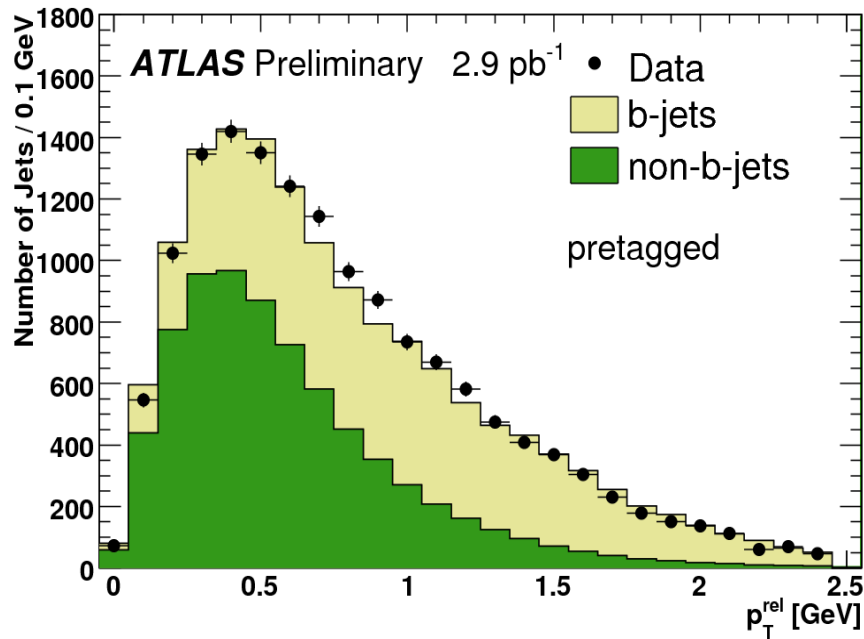
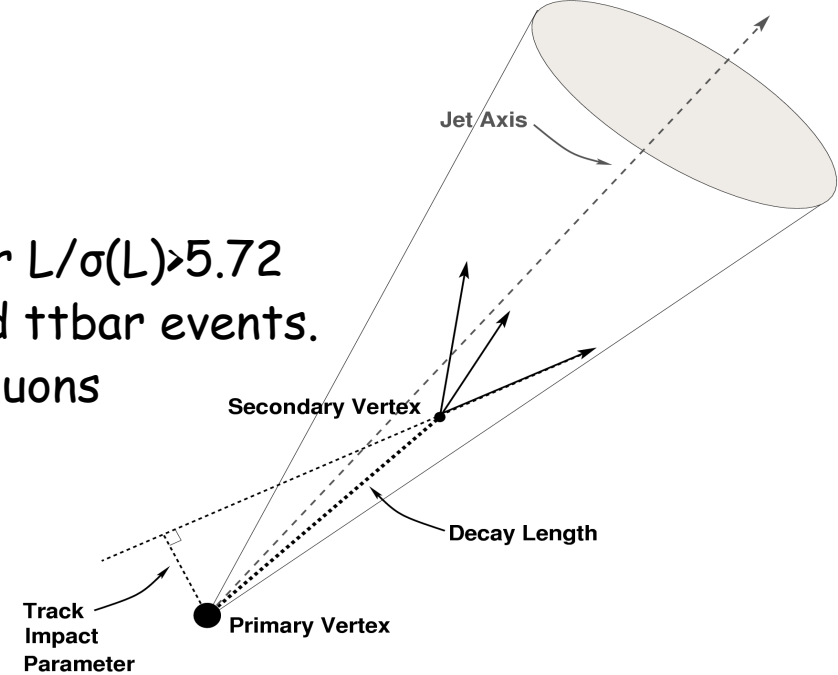
W plus jets

Distribution of number of jets in selected W events.
Stat errors only, with ALPGEN MC normalised to data



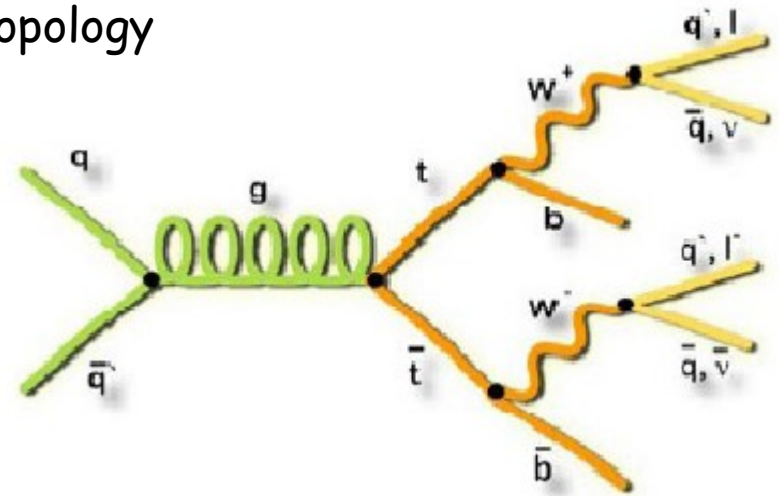
b-tagging efficiency

- Calibrate SV0 (secondary vertex) tagger $L/\sigma(L) > 5.72$
 - 50% tag efficiency point in simulated $t\bar{t}$ events.
- Tag rates from template fit to p_T^{rel} of muons
 - Evaluate data/MC scale factors.



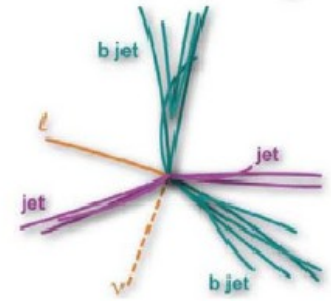
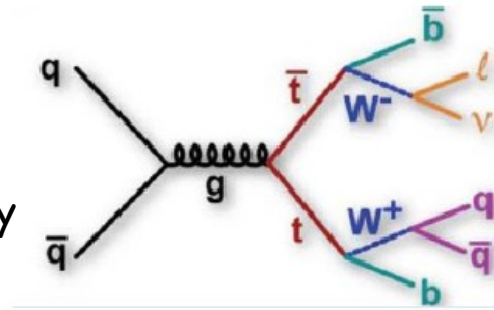
Measurement of top cross section

- Complete set of ingredients to investigate production of $t\bar{t}$, which is the next step in verifying the SM at the LHC:
 - $e, \mu, E_T^{\text{miss}}, \text{jets}, b\text{-tag}$
- Assume all tops decay to Wb : event topology then depends on the two W decays.
- Of interest:
 - lepton (e or μ)
 $E_T^{\text{miss}}, jjbb$ (37.9%)
 - dilepton ($ee, \mu\mu$ or $e\mu$)
 E_T^{miss}, bb (6.46%)
- Data-driven methods to control QCD and W +jets backgrounds
- Counting experiment, with simultaneous likelihood fit to all channels to derive the combined cross section.



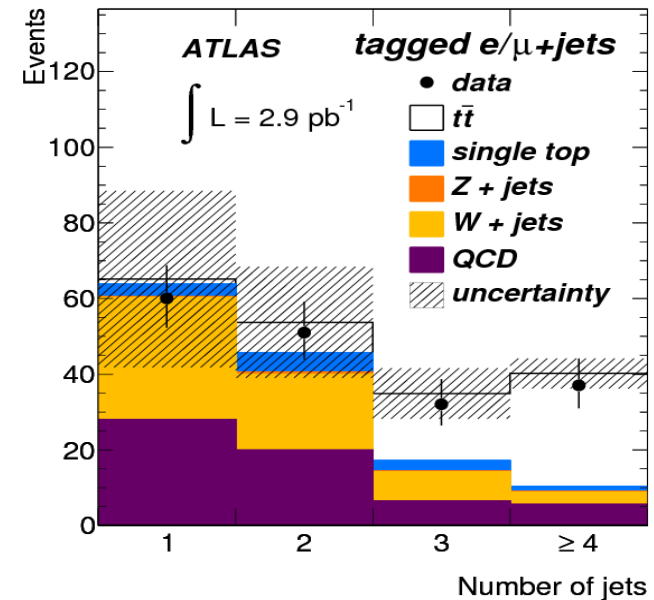
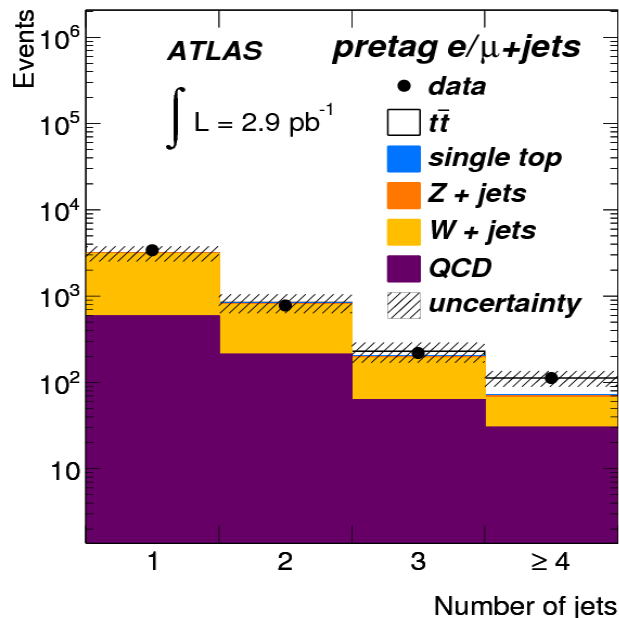
Top Quarks in Lepton+Jets Mode

- BR=33%: 'Golden' channel
- 1 isolated e or μ , $p_T^1 > 20 \text{ GeV}$, $|\eta^1| < 2.5$
- ≥ 4 jet with $p_T^{\text{Jet}} > 25 \text{ GeV}$, $|\eta^{\text{Jet}}| < 2.5$
- ≥ 1 b-tagged jet $\rightarrow$ 50% b-tag efficiency
- $E_T^{\text{Miss}} > 20 \text{ GeV}$, $E_T^{\text{miss}} + m_T(W) > 60 \text{ GeV}$



$\rightarrow 37 \text{ events in } 2.9 \text{ pb}^{-1}$
 $12.2 \pm 3.9 \text{ events Background}$

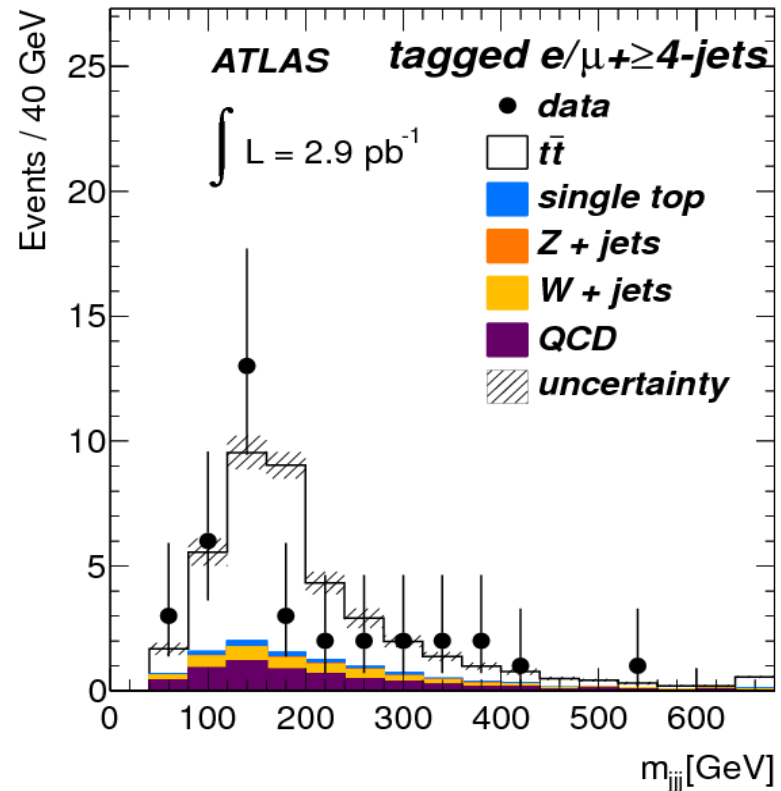
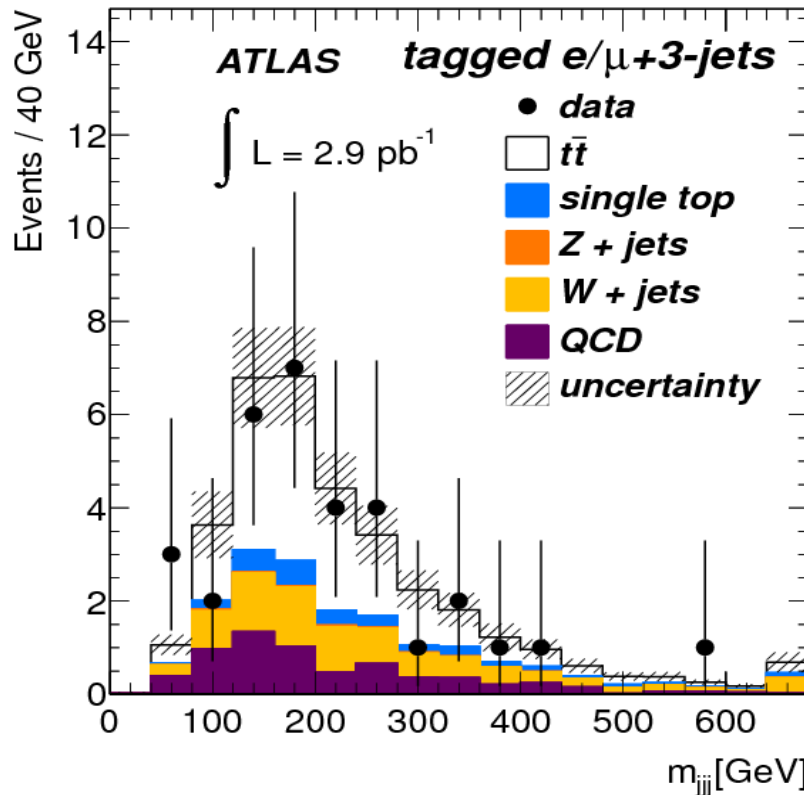
Signal: 4 or more jets, and at least 1 b-tag



Top Quarks in Lepton+Jets Mode

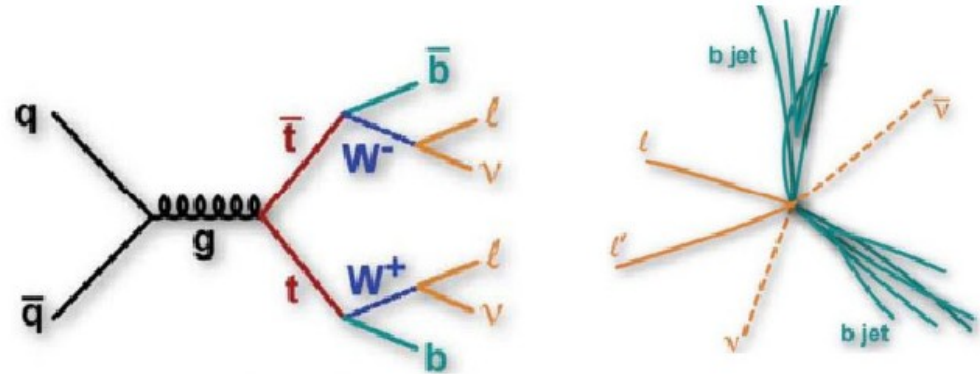
3-jet mass:

- Invariant mass of the highest p_T 3-jet combination for tagged 3 and 4 jet events used in cross-check analyses. Agrees with top hypothesis.

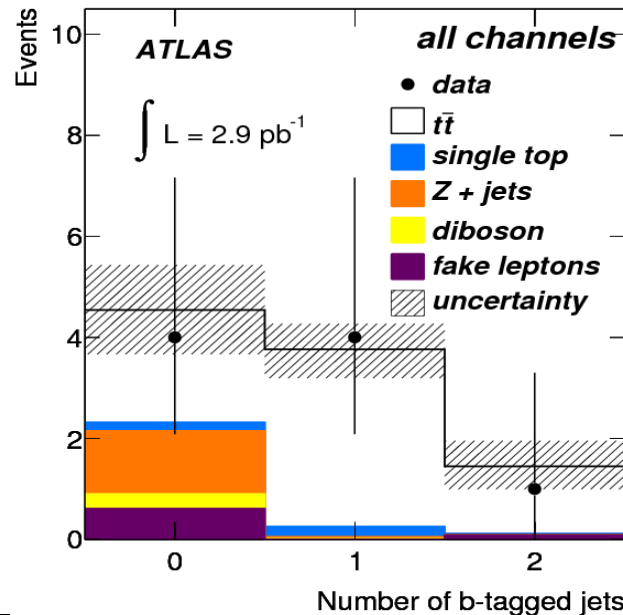
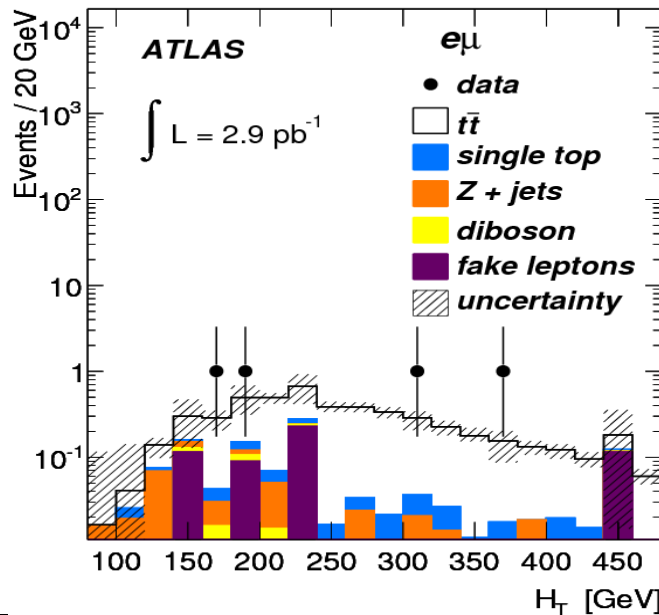


Top Quarks in Di-Lepton mode

- BR=6%: 'High purity' channel
- 2 isolated opposite charged e or μ :
ee, e μ , $\mu\mu$, $p_T > 20$ GeV
- ≥ 2 Jets with $p_T^{\text{Jet}} > 20$ GeV, $|\eta^{\text{Jet}}| < 2.5$
- $E_T^{\text{Miss}} > 40(30)$ GeV for ee ($\mu\mu$)
- $H_T = \sum p_T^l + \sum p_T^{\text{Jet}} > 150$ GeV for e μ
- $|M_{ll} - M_Z| > 5$ (10) GeV for ee ($\mu\mu$)



$\rightarrow 9$ events in 2.9pb^{-1}
 2.6 ± 0.6 events Background

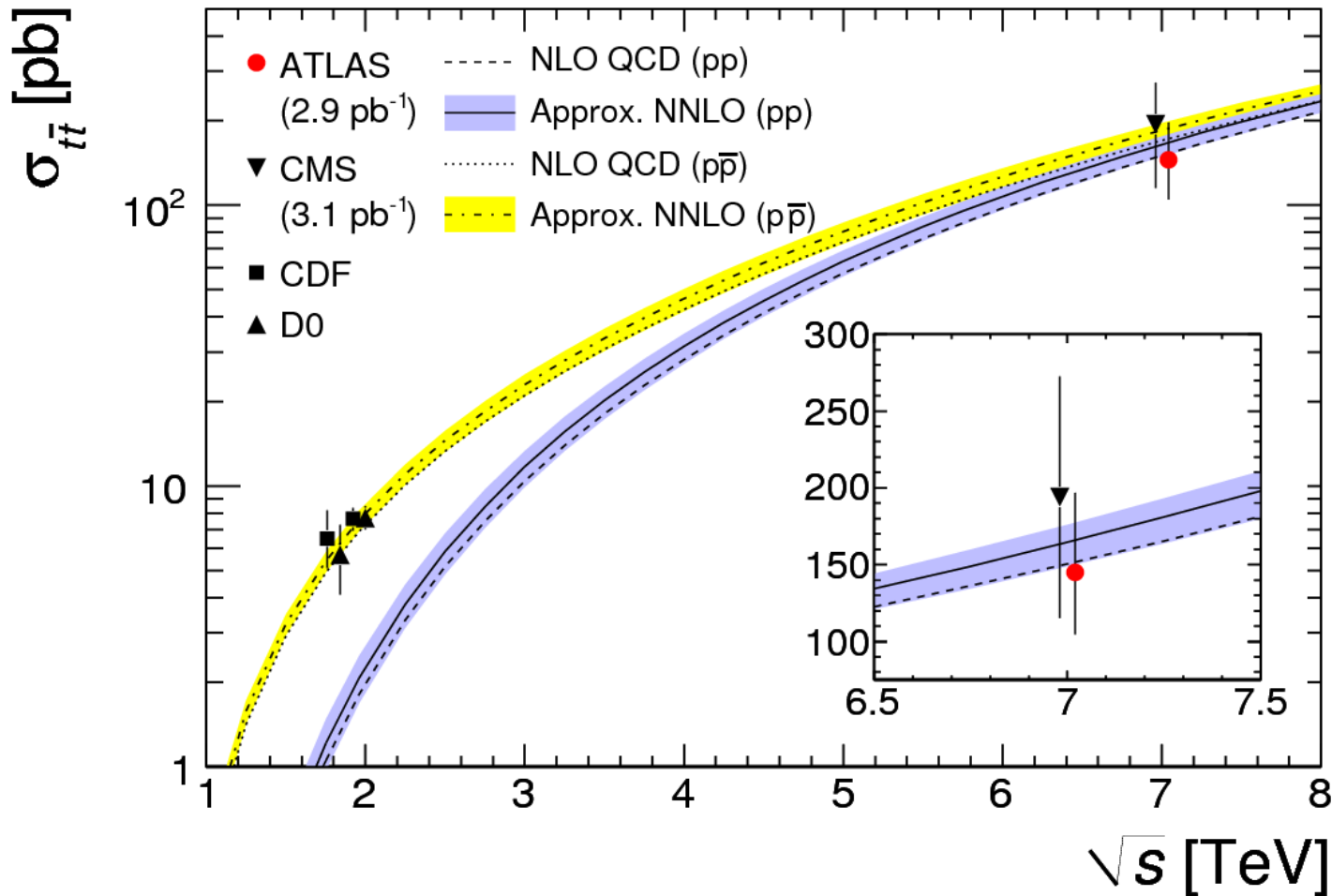


No b-tagging
 used, but good
 cross check

Top Quark cross section

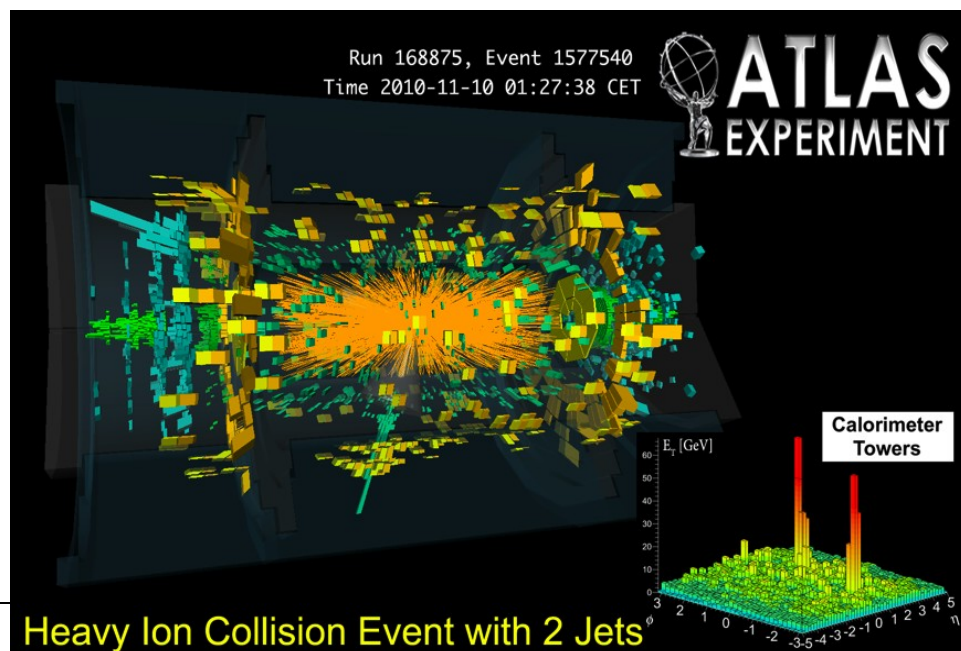
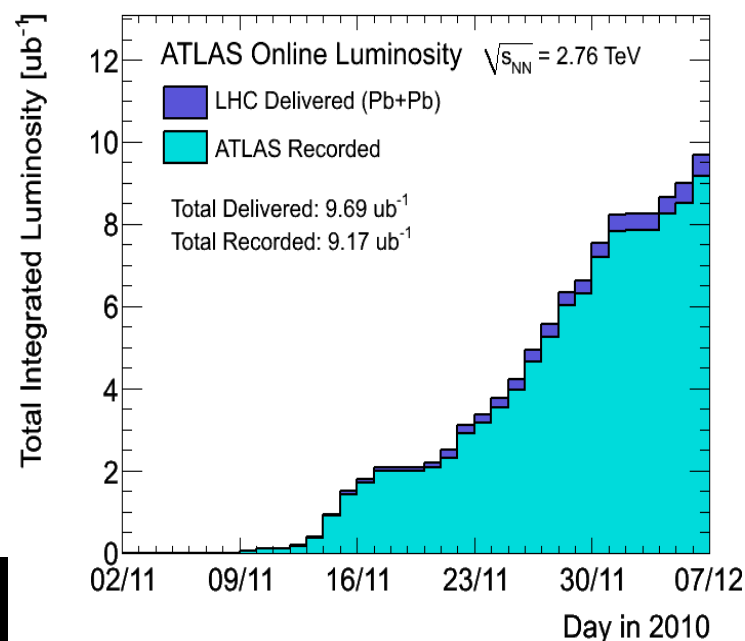
Combining all channels, $\sigma_{t\bar{t}} = 145 \pm 31^{+42}_{-27}$ pb

Significance of $\sim 4.8\sigma$ w.r.t. background only hypothesis.

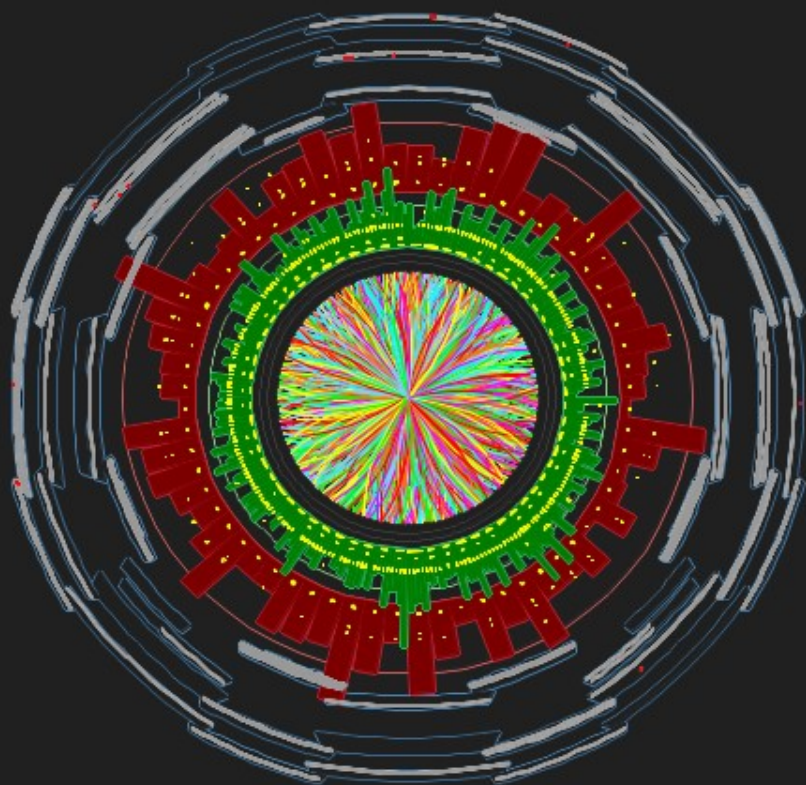


Heavy Ion Data Taking & Luminosity

- LHC Heavy Ion (Pb-Pb) running started on Nov 4, ended on Dec 6.
- $\sqrt{s_{NN}} = 2.76$ TeV, 14 x higher in energy compared to RHIC at BNL
- First observation of HI events on Nov 7, jet events shortly after
- Total recorded Lumi = $9.17 \mu\text{b}^{-1}$ (95% efficient!)
- Peak luminosity = $3 \times 10^{25} \text{ cm}^{-2} \text{ s}^{-1}$
- First physics results submitted for publication in PRL on Nov 25, accepted on Nov 26.



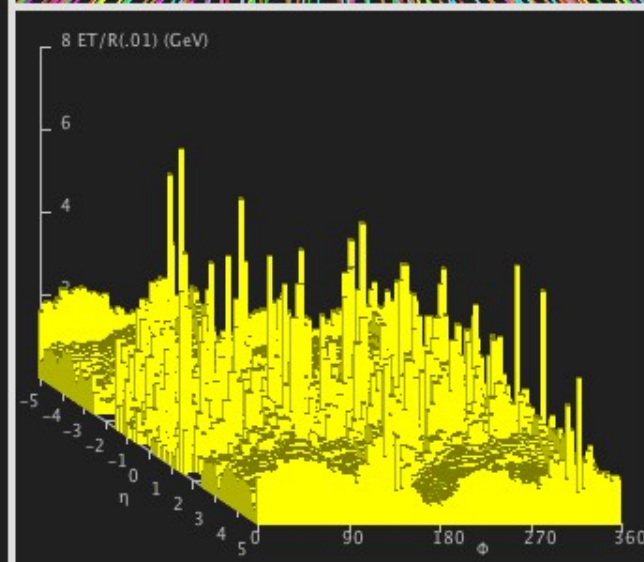
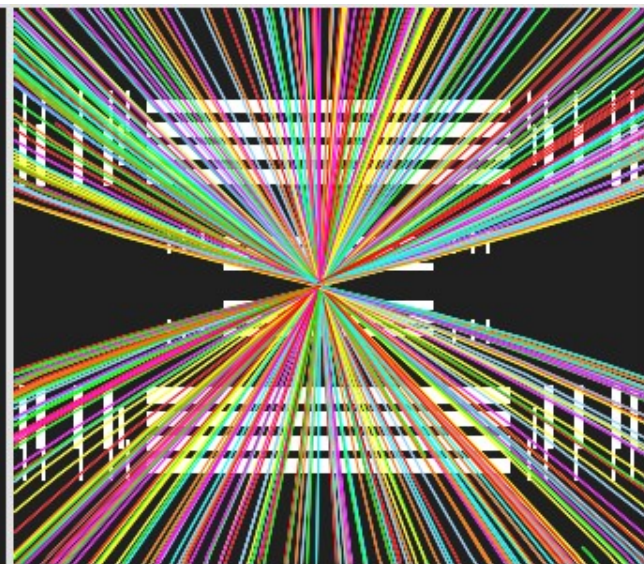
One of the first Pb-Pb events



 **ATLAS**
EXPERIMENT

Run Number: 168665, Event Number: 57983

Date: 2010-11-08 11:29:31 CET

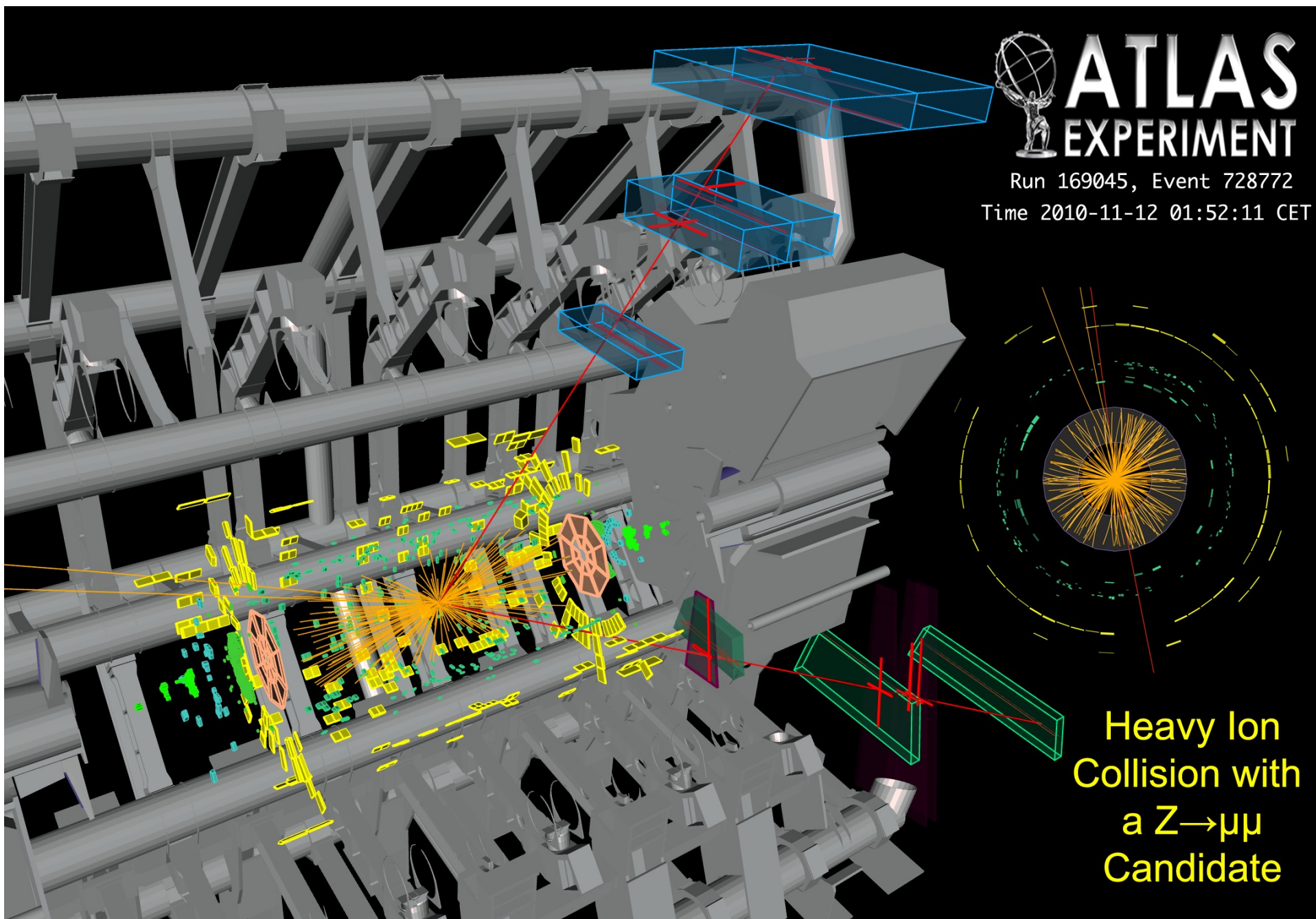




ATLAS EXPERIMENT

Run 169045, Event 728772

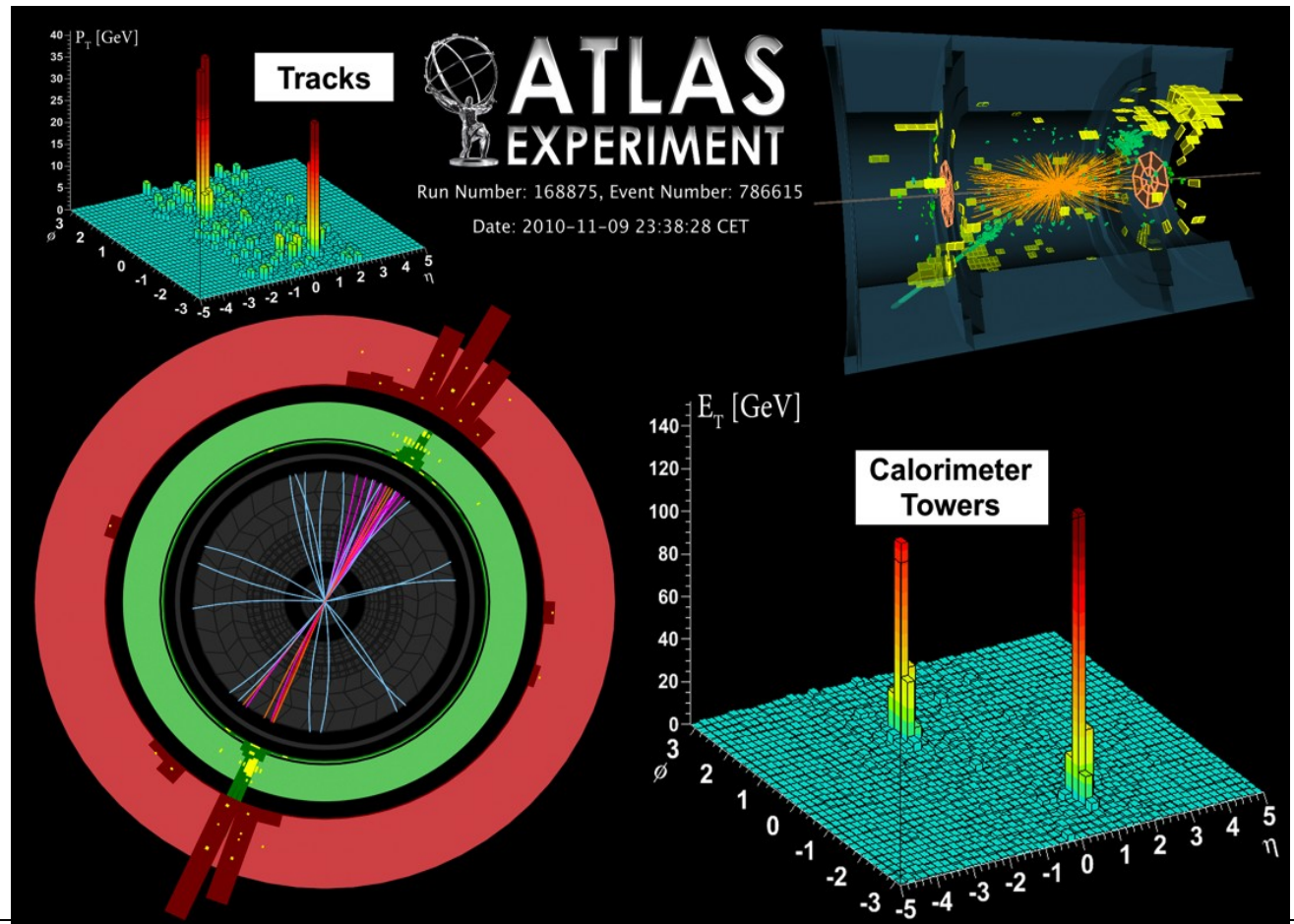
Time 2010-11-12 01:52:11 CET



Di-Jets events in Heavy Ions

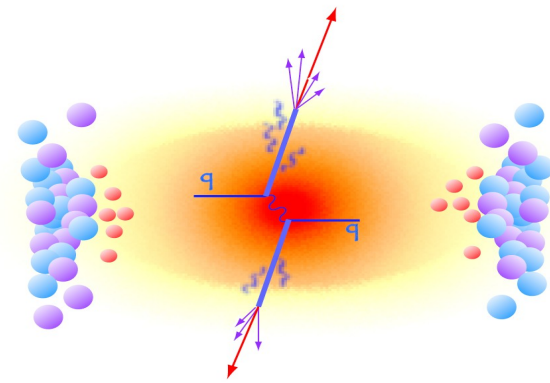
- Use jets reconstructed with $R=0.4$ anti-kt clustering jet algorithm (cone-like but infrared and collinear safe)
- Background subtracted on per-layer, per η -ring(0.1), event-by-event

Symmetric di-jet event



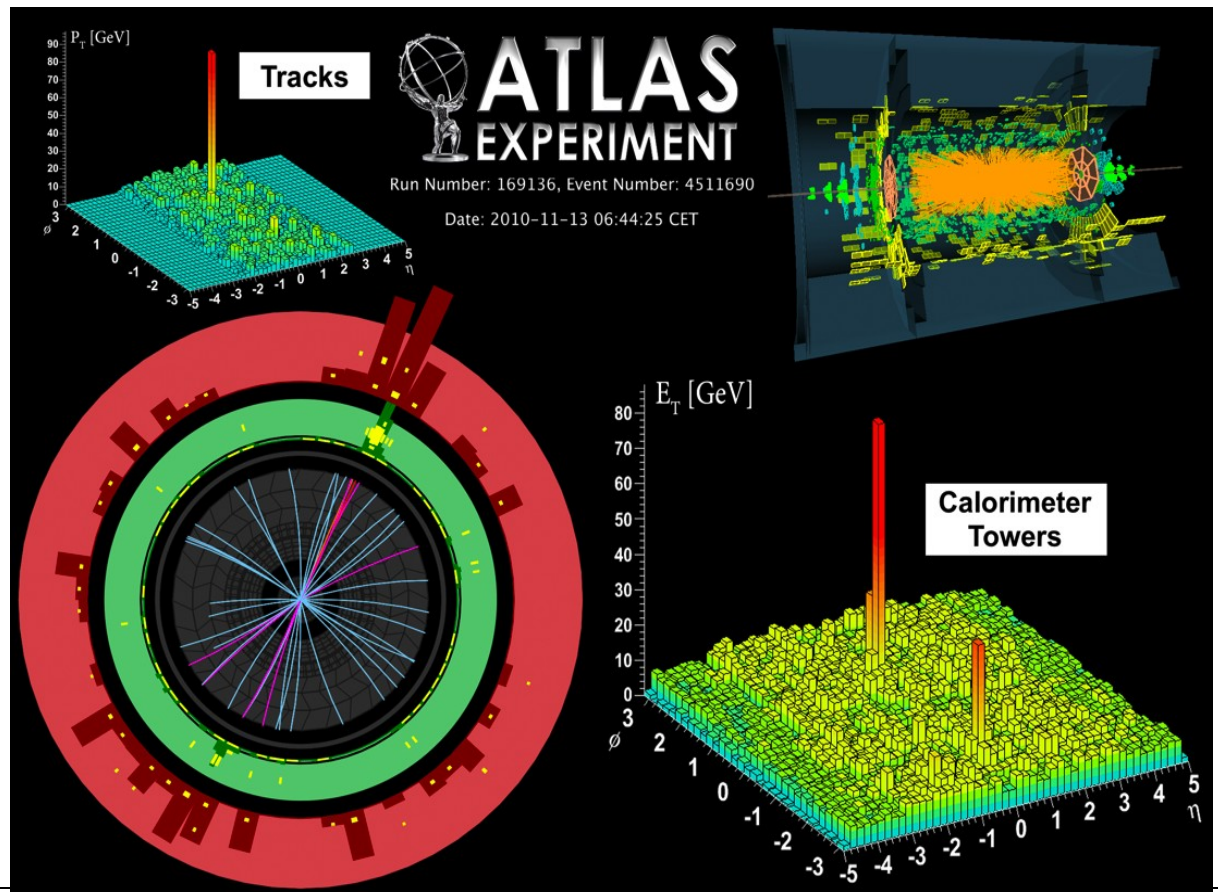
Asymmetric di-jet events

- Jet quenching is expected in central HI collision
RHIC observed quenching in two particle correlation
- Study the physics responsible for jet quenching
How parton shower develops in the dense medium

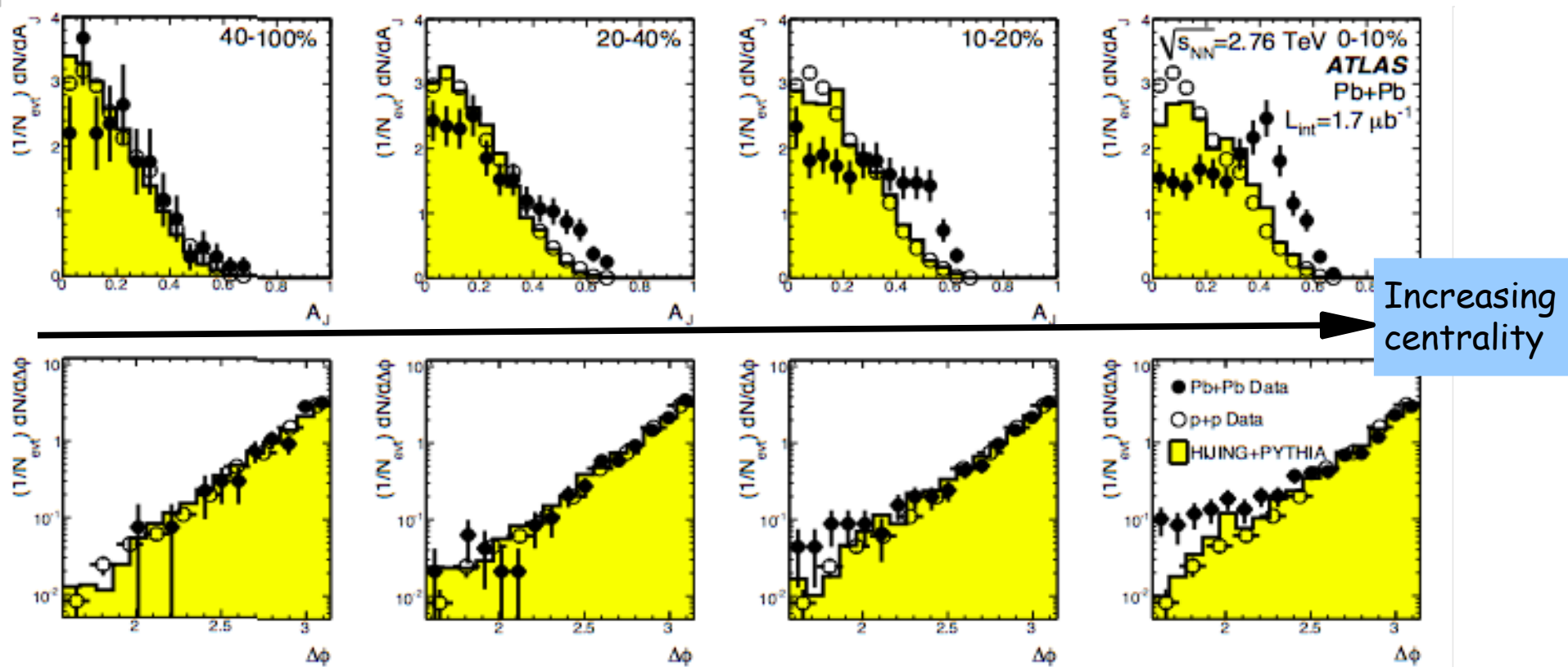


Select events with leading jet, $E_T > 100 \text{ GeV}$, $|\eta| < 2.8$
 Sub-leading: highest E_T -jet in opposite hemisphere
 $\Delta\phi > \pi/2$ with $E_T > 25 \text{ GeV}$, $|\eta| < 2.8$
 5% of selected jets have no sub-leading jet
 Di-jet Asymmetry:

$$A \equiv \frac{E_{T1} - E_{T2}}{E_{T2} + E_{T1}}$$



Di-jet Asymmetry- Full centrality range

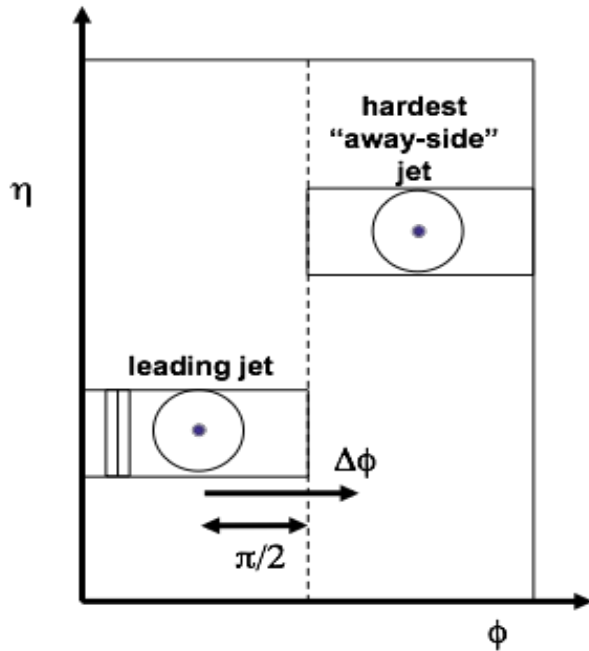


For more central collisions:

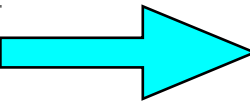
- Increased fraction of jets with large asymmetry
- For all centralities, $\Delta\phi$ strongly peaks at π

- First observation of large dijet asymmetries in Pb+Pb collisions
- Not observed in p-p collisions or peripheral collisions

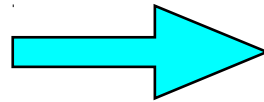
Cross check example: Energy, p_T flow analysis



Calorimeter
 E_T , offset
subtracted

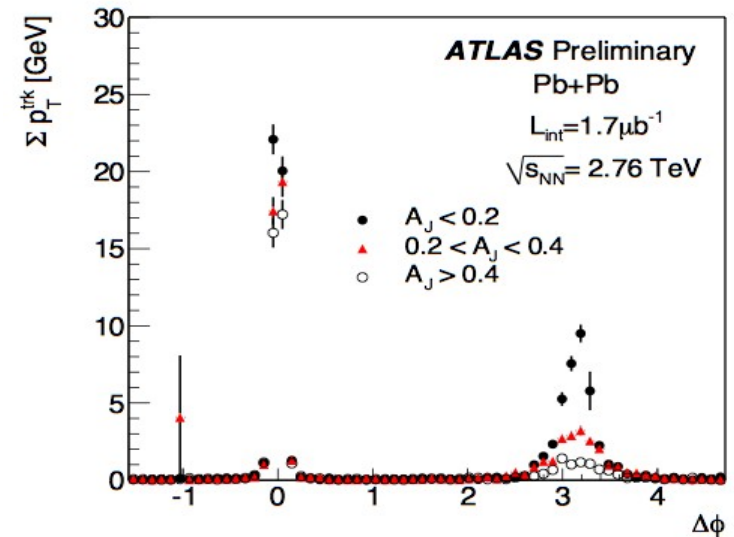
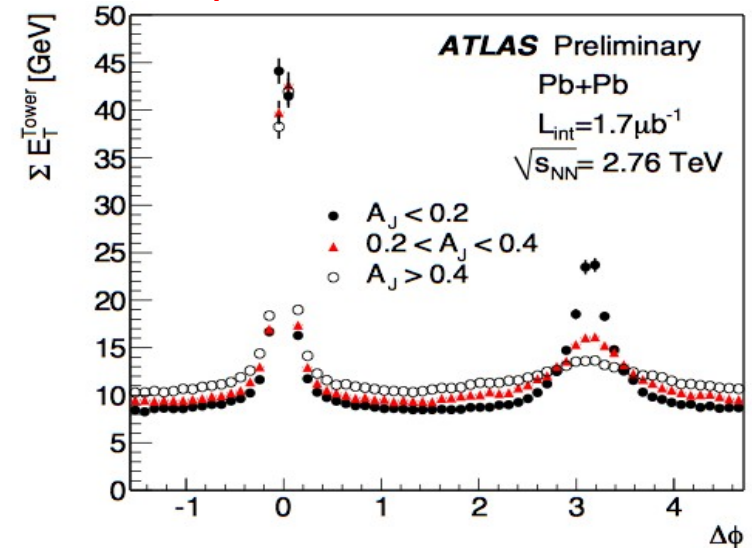


Tracks,
 $p_T > 4$ GeV

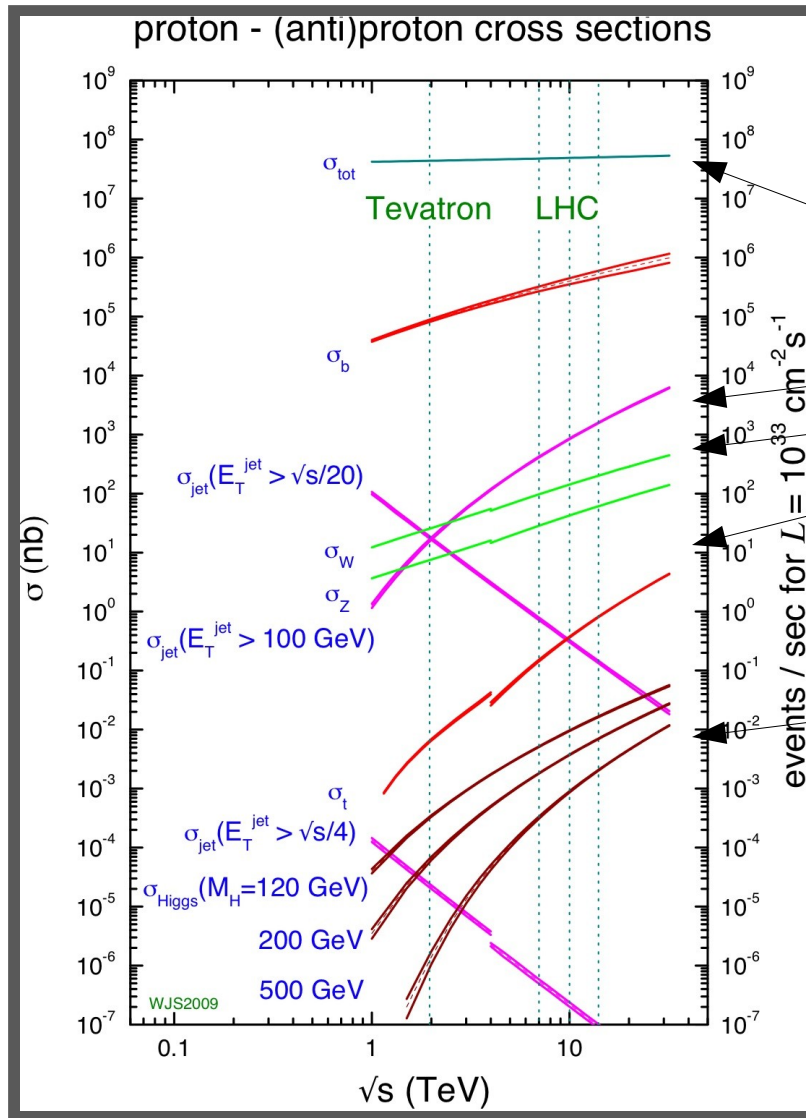


- Independent check without jet algorithm and no subtraction

Asymmetry seen in calorimeter data
And also in tracks



Prospects of pp results



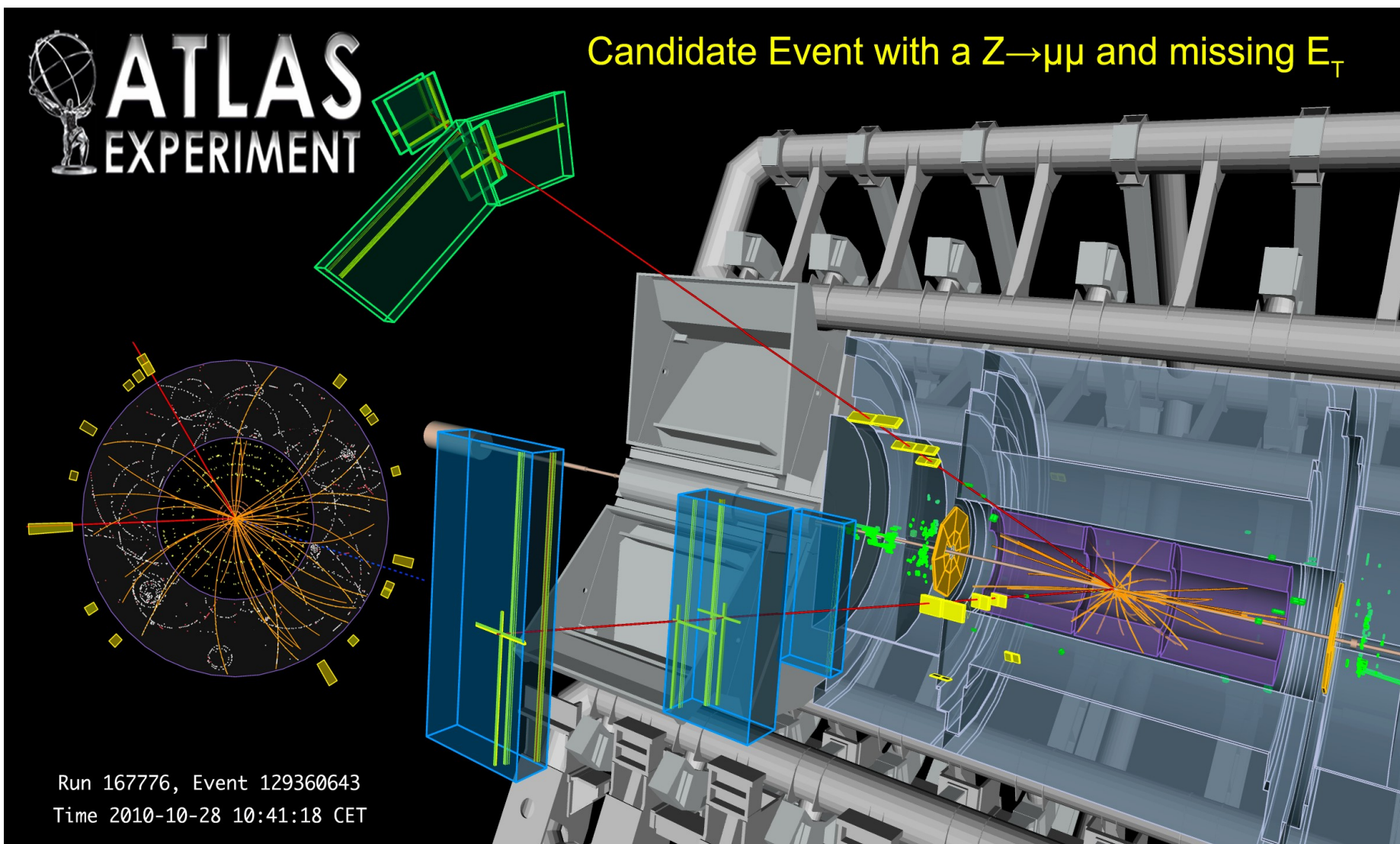
Discussed:

- Inclusive
- Jets
- W/Z Bosons
- Top

Next Year(s):

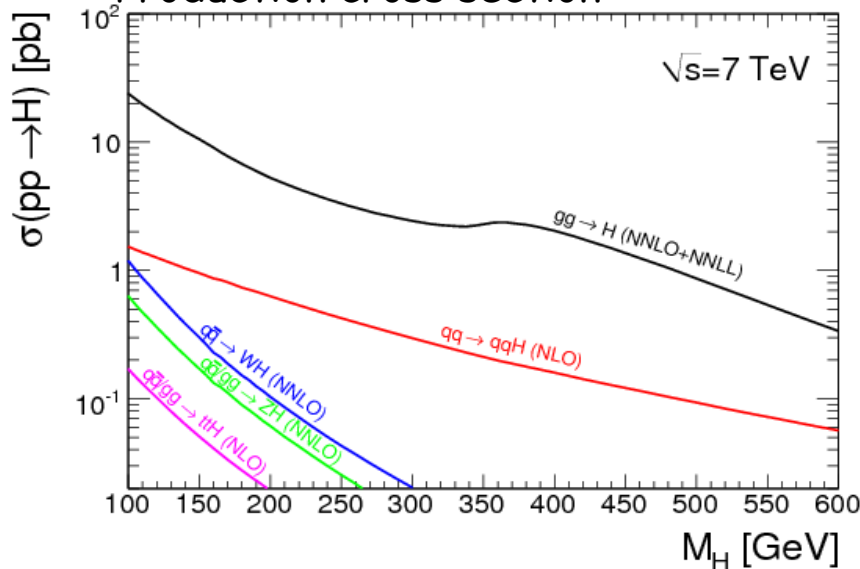
- Di-Bosons: WW, WZ, ZZ, ...
- Higgs ?
- SUSY ?

Candidate $ZZ \rightarrow \mu\mu\nu\nu$

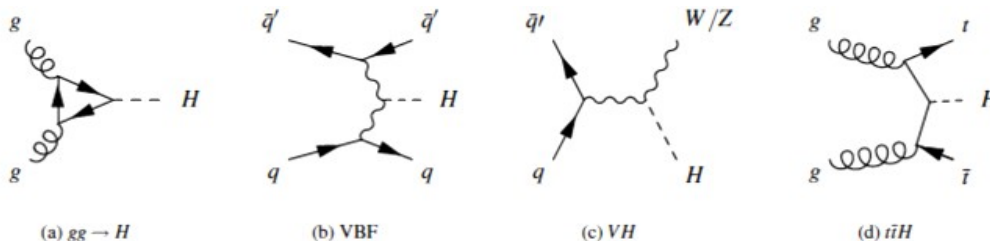
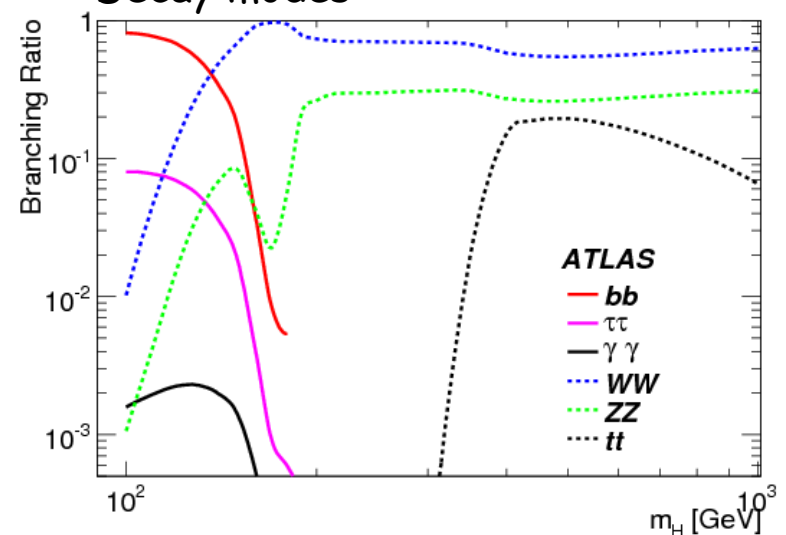


Higgs Production and Decay

Production cross section:



Decay modes:



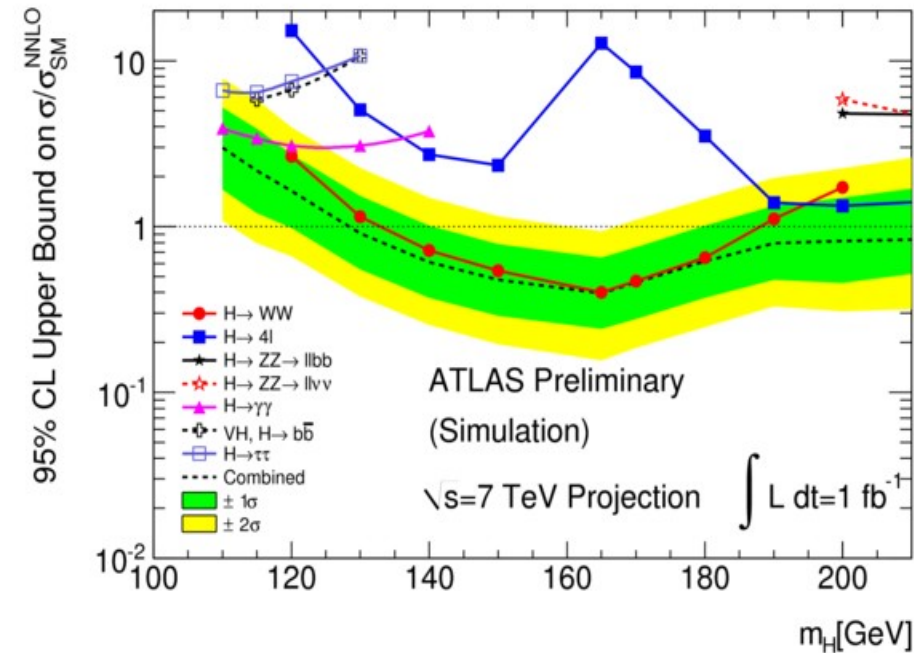
At low masses:

- dominant bb decay, enormous QCD background
- $H \rightarrow \tau\tau$ via Vector Boson Fusion
- $H \rightarrow \gamma\gamma$ has low BR, but excellent γ /jet separation and γ resolution

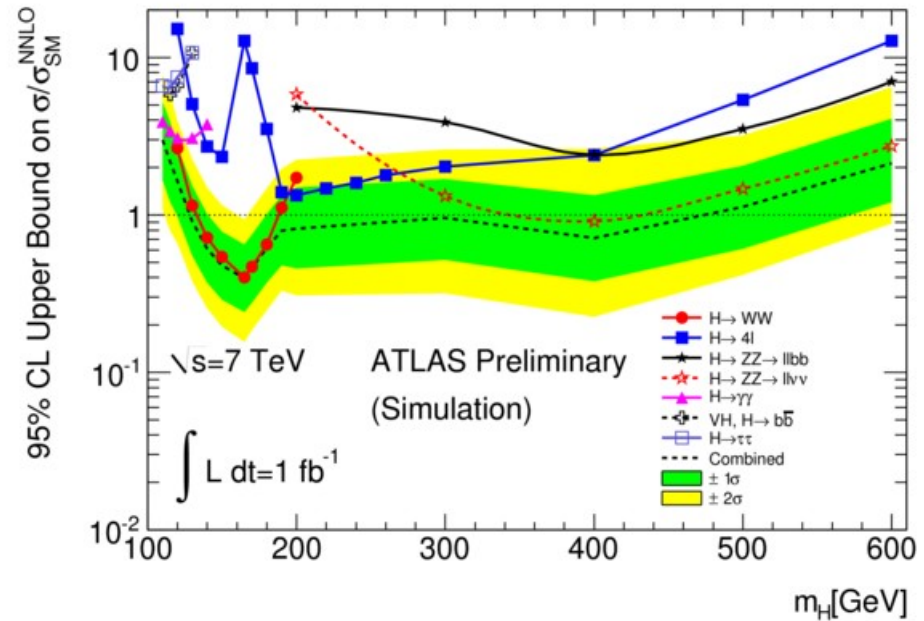
At higher masses

- $H \rightarrow WW$
- $H \rightarrow ZZ \rightarrow 4$ lepton final states

Higgs sensitivity, 7 TeV, 1 fb⁻¹



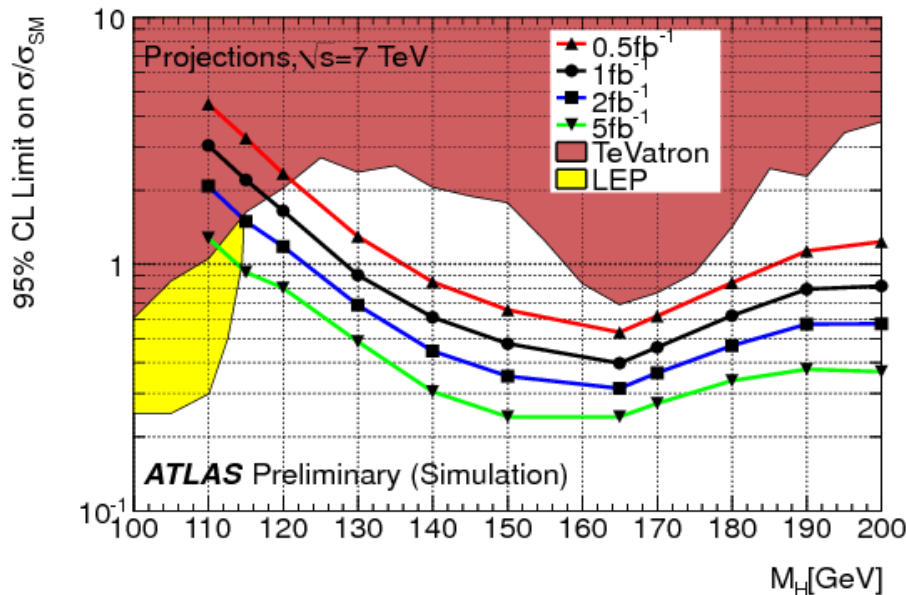
$\tau\tau$, $b\bar{b}$ and $\gamma\gamma$ channels all contribute in low mass region



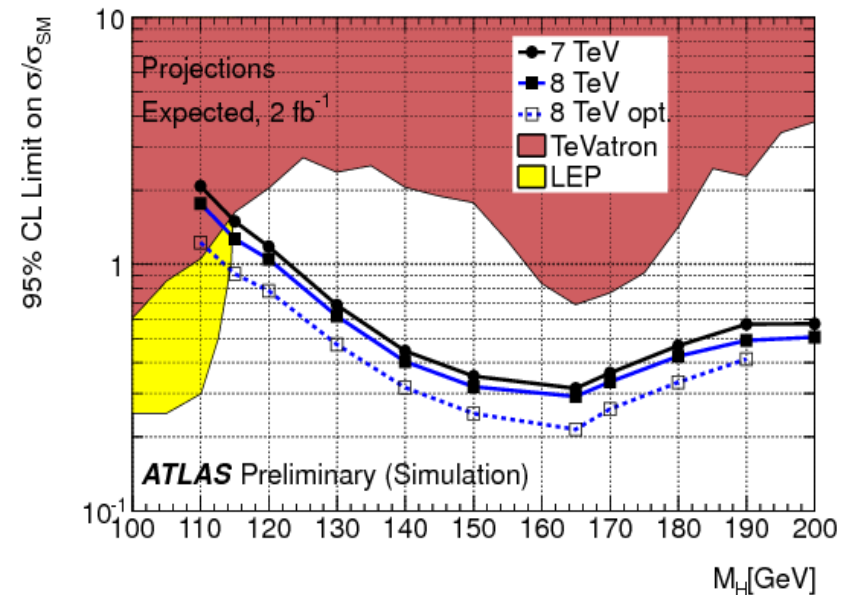
129-460 GeV has >50% chance of exclusion

Higgs sensitivity

Effect of increasing luminosity



Increasing the beam energy



- 1 fb^{-1} at 7 TeV gives: **129 to 460 GeV 95%CL limit**
- 2 fb^{-1} at 7 TeV gives: **Nearly 131 to 430 GeV 3σ**
- 2 fb^{-1} at 8 TeV plus optimization: **114 to $>> 500 \text{ GeV}$ 95%CL limit**
- 5 fb^{-1} enough to close gap with LEP at 7 TeV: **Expected 3σ observation from 123 to 550 GeV**

Summary & Outlook

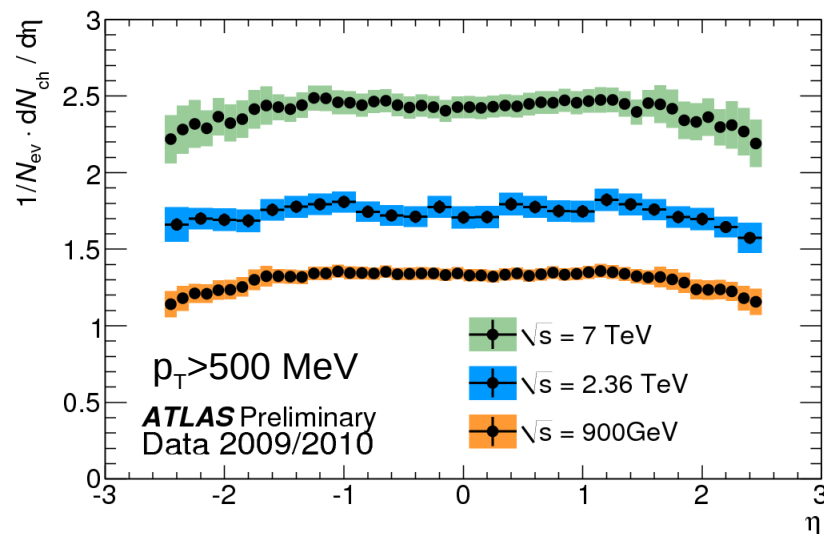
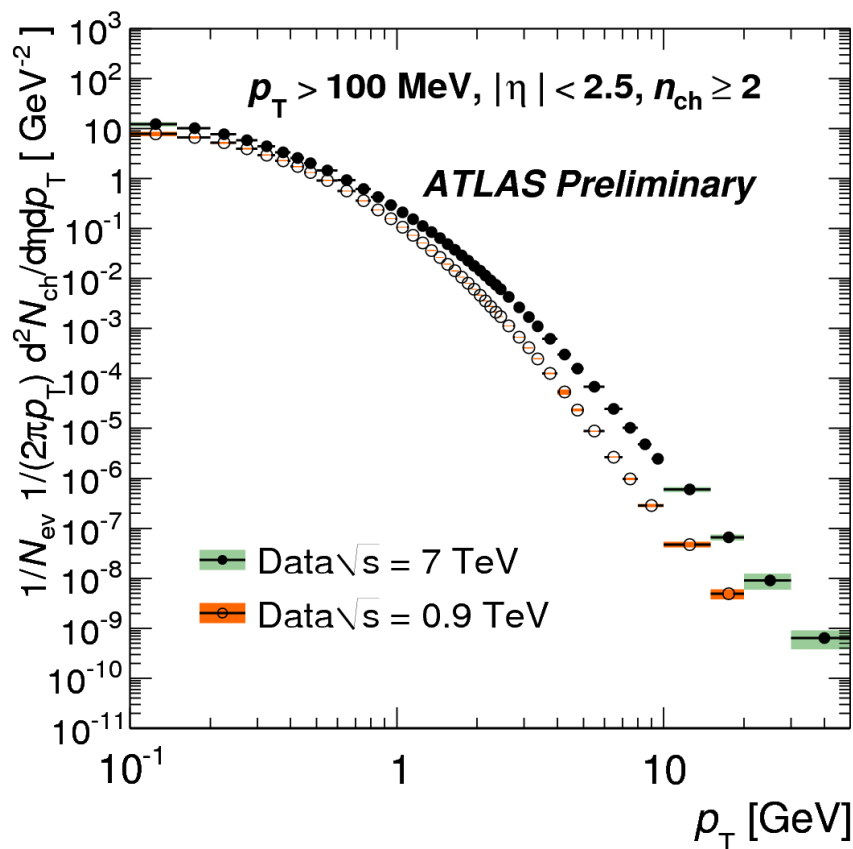
- Successful first year of LHC operation
 - _ Exploring the energy frontier in both pp and heavy ion collisions
- Excellent ATLAS detector operations
 - _ data taking → data processing → distribution → analysis
- Remarkable detector performance demonstrated by the data
 - _ Many years of testbeam, detector modeling give rise to impressive agreement between data and expectation.
- First physics measurements of jet, W, Z, top-pair, and observations of τ leptons
 - _ Searches for new physics at TeV scale have begun
 - _ Many new results to come in the winter conferences
- 1st Heavy Ion run has started a new era of heavy ion physics
 - _ Dijet asymmetry indicates jet quenching
- Very exciting physics ahead next year
 - _ Sensitive to SM Higgs, search for new physics beyond SM.
- Mid Term Plan:
 - _ $L=1\text{fb}^{-1}$ at $\sqrt{s}=7\text{TeV}$ by end of 2011 - possible extension or increase of $\sqrt{s}$ to be discussed end of January
- Long Term Plan:
 - _ So far: ~1 year shutdown 2012 and collect $L=10\text{fb}^{-1}$ at $\sqrt{s}=14\text{TeV}$ by end of 2014



<https://twiki.cern.ch/twiki/bin/view/AtlasPublic>

Backup

First measurements with pp



Number of charged particles
as a function of p_T and η

Plus studies of underlying
event, new MC tune...

Charged-particle multiplicities in pp interactions at $\sqrt{s} = 900 \text{ GeV}$
measured with the ATLAS detector at the LHC. Phys Lett B 688, 1, 21
Additional results with 2.36 and 7 TeV data

$B \rightarrow J/\Psi(\mu\mu)K$

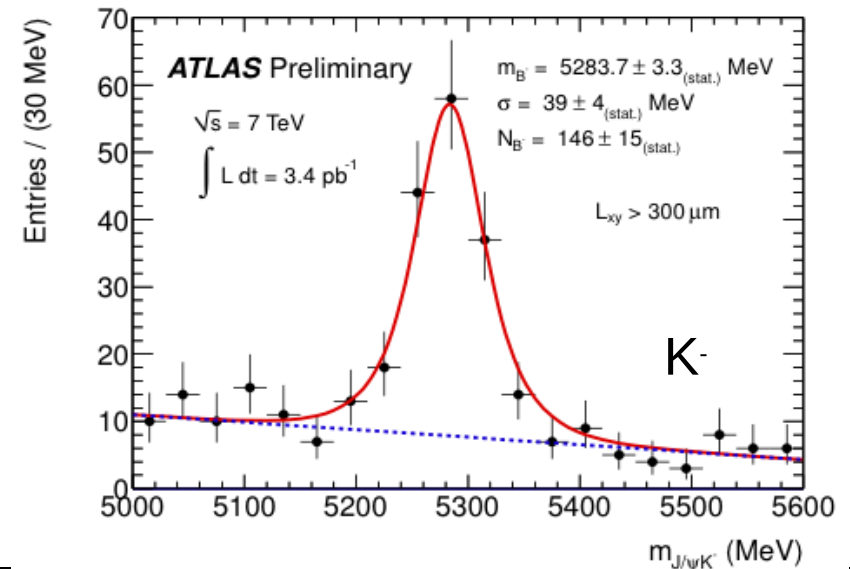
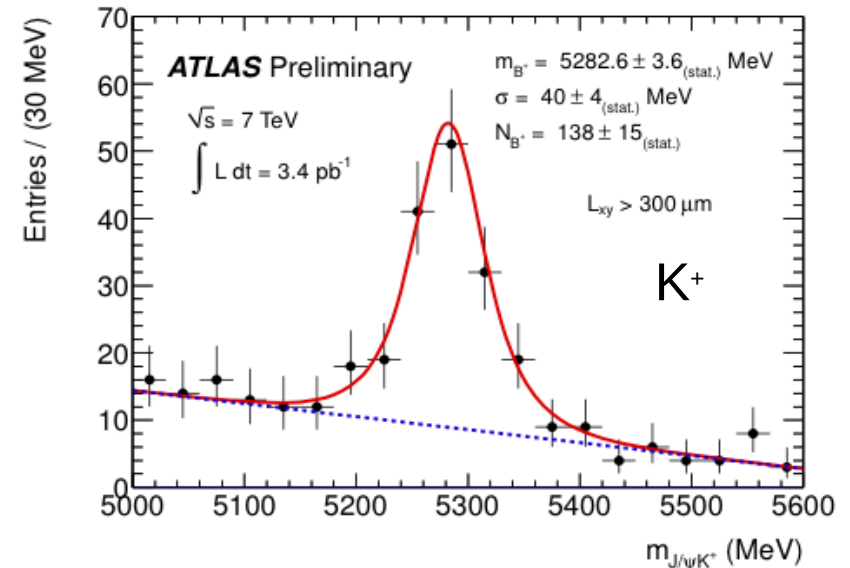
Signal for $B^{\pm} \rightarrow J/\psi(\mu\mu)K^{\pm}$

Require transverse decay
length $> 300 \mu\text{m}$

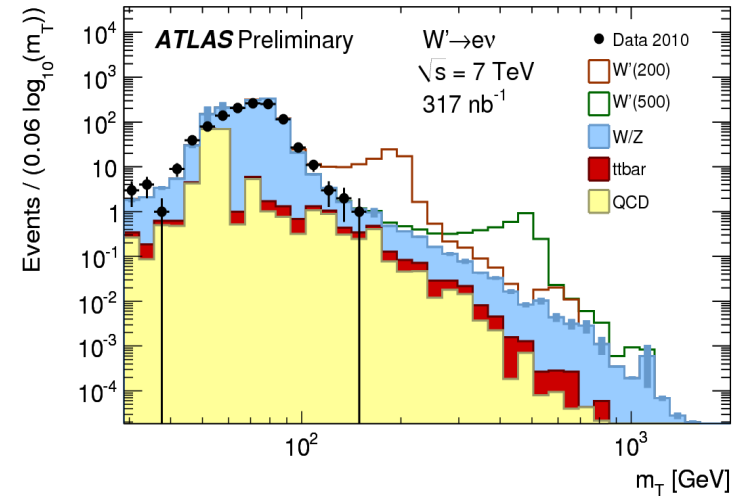
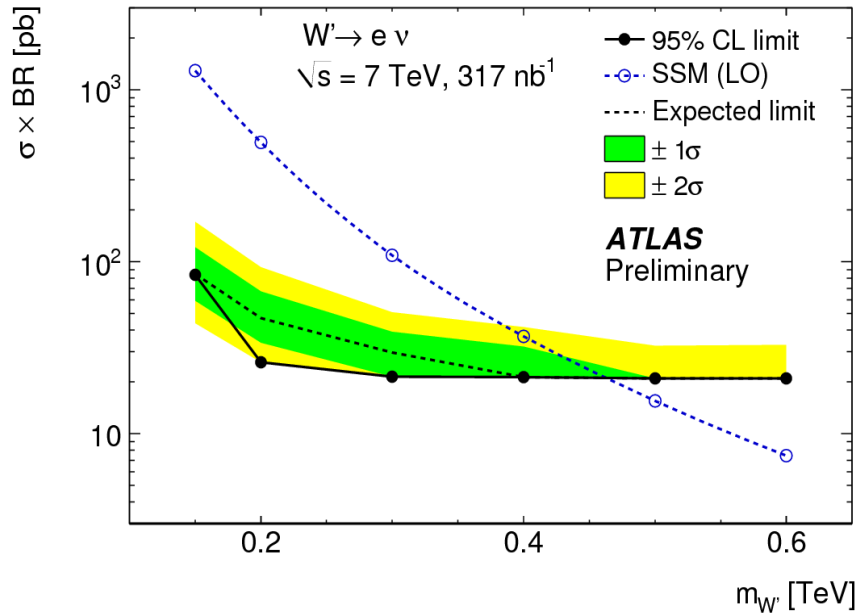
Unbinned likelihood fit to
signal (with event-by-event
mass uncertainty) and
linear background

Combining K^+ and K^-

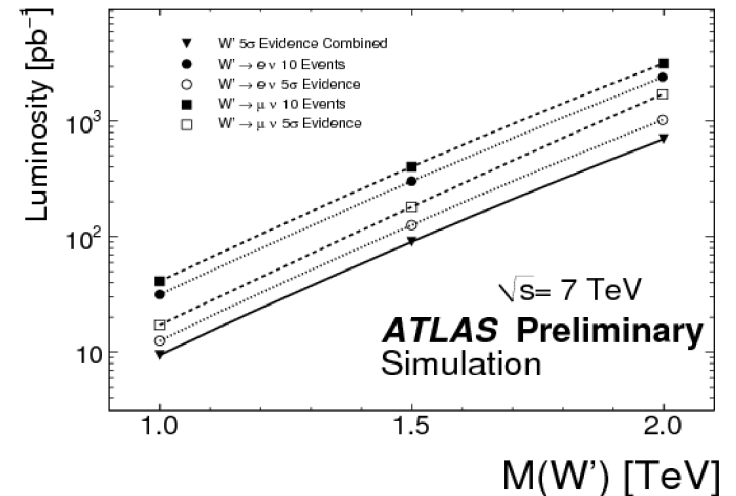
283 ± 22 signal events,
fitted mass 5283 ± 2.5 MeV



W' search

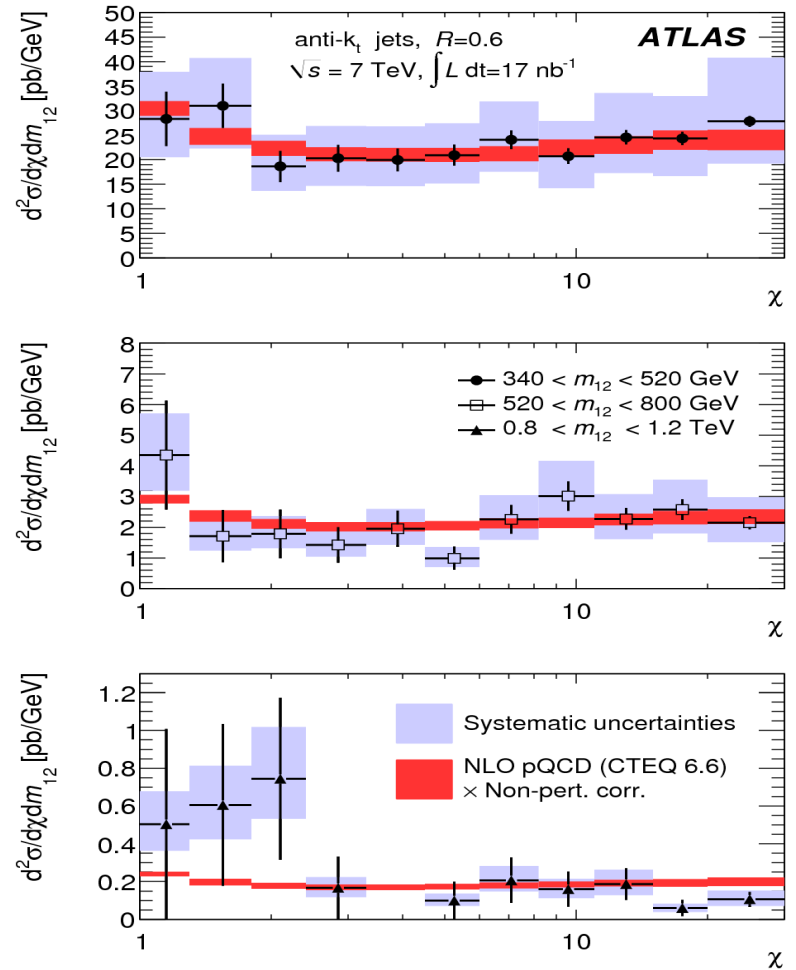
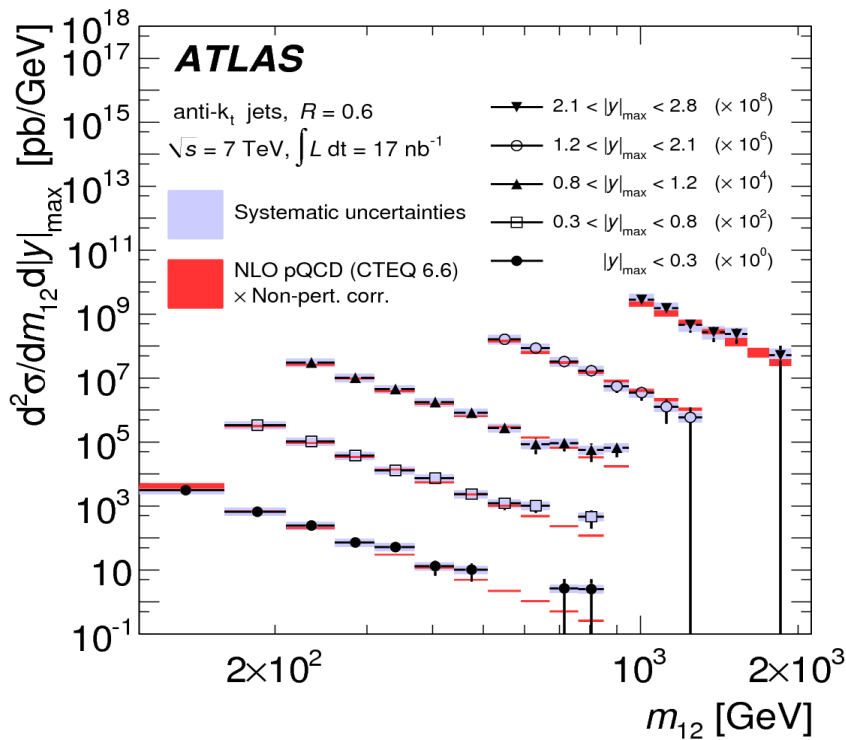


- $m_{W'} > 465 \text{ GeV}$ (with 317 nb^{-1})
 c.f. Current limit: $m_{W'} > 1.0 \text{ TeV}$
- 5σ observation prospect:
 $M_{W'} > 1 (2) \text{ TeV} \rightarrow \sim 10 \text{ pb}^{-1} (\sim 1 \text{ fb}^{-1})$



Inclusive Jet Cross Section

Anti k_T , $R=0.6$ (or 0.4) with $L=17\text{nb}^{-1}$,
 $p_T(\text{Jet}) > 60\text{ GeV}$, $|y_{\text{Jet}}| < 2.8$



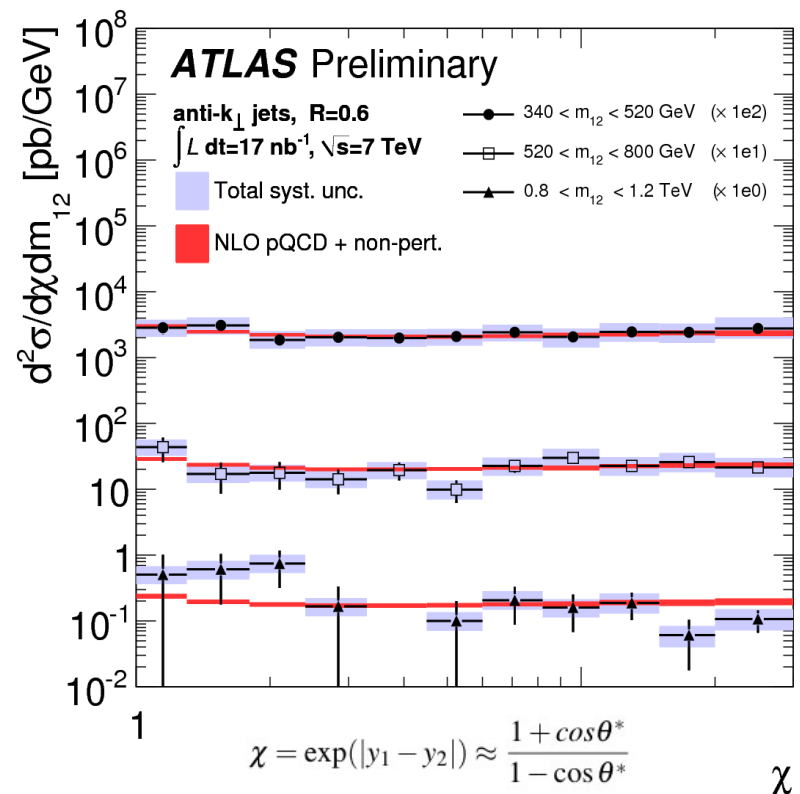
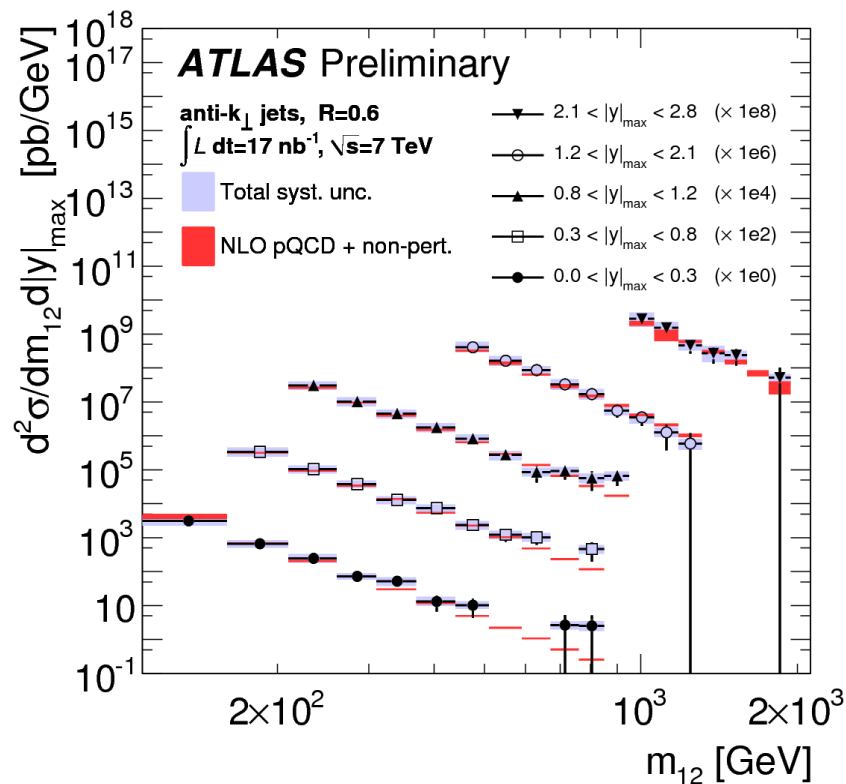
- Data is consistent with NLO pQCD predictions with non-perturbative corrections
- Leading log (LL) parton shower (PS) MCs provide reasonable description (with proper normalization factor)

Di-Jets

M_{JJ} and angular distribution: $\chi = e^{|y_{jet1} - y_{jet2}|} = \frac{1 + \cos \theta^*}{1 - \cos \theta^*}$

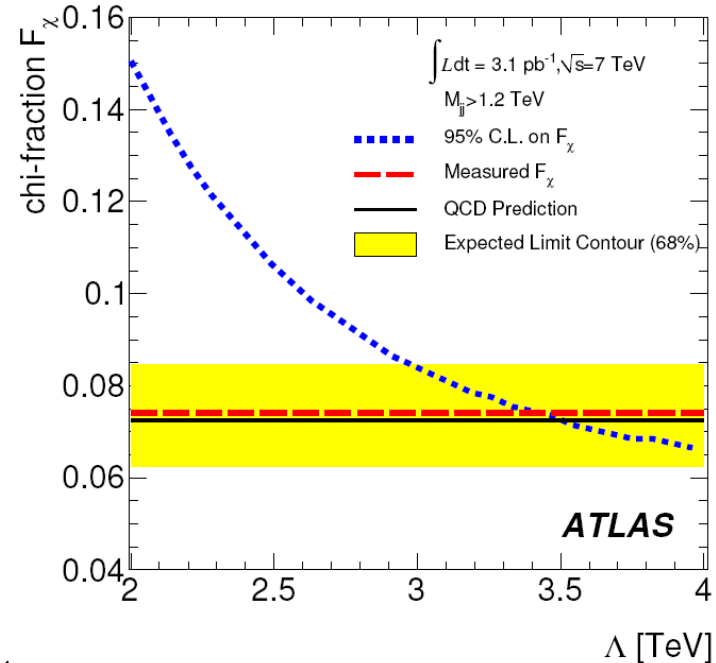
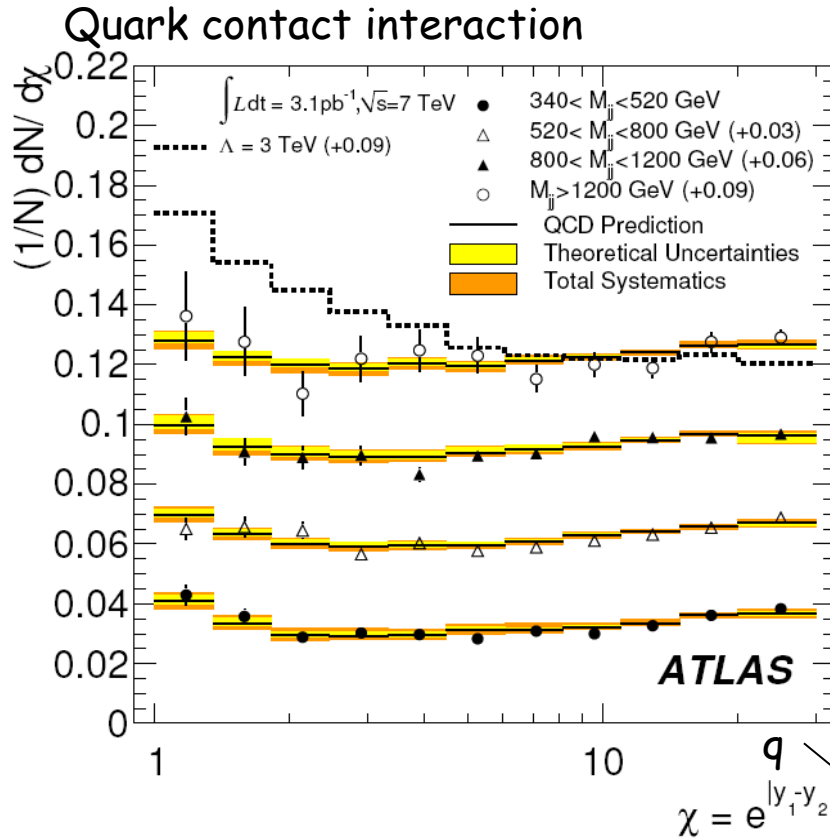
Θ^* corresponds to scattering angle for 2 $\rightarrow$ 2 parton scattering or in di-jet CMS Rutherford (gluon ex.) scattering implies $dN/d\chi$ is flat

$p_{T,jet(2)} > 60(30) \text{ GeV}, |y_{jet}| < 2.8 \text{ (} L=17\text{nb}^{-1}\text{)}$



Data is consistent with NLO pQCD prediction with non-perturbative corrections

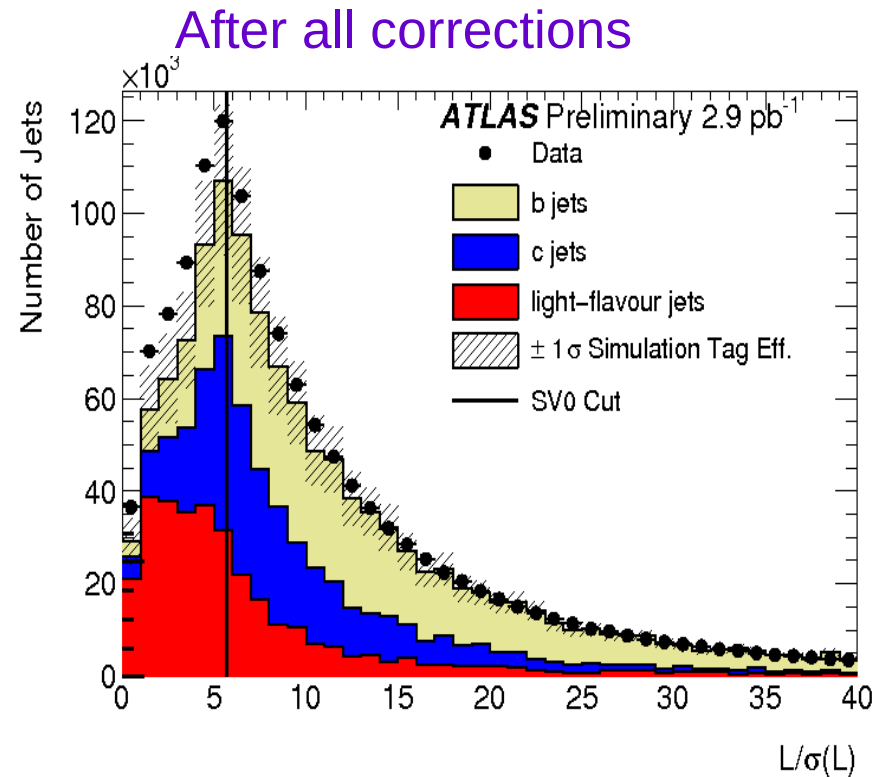
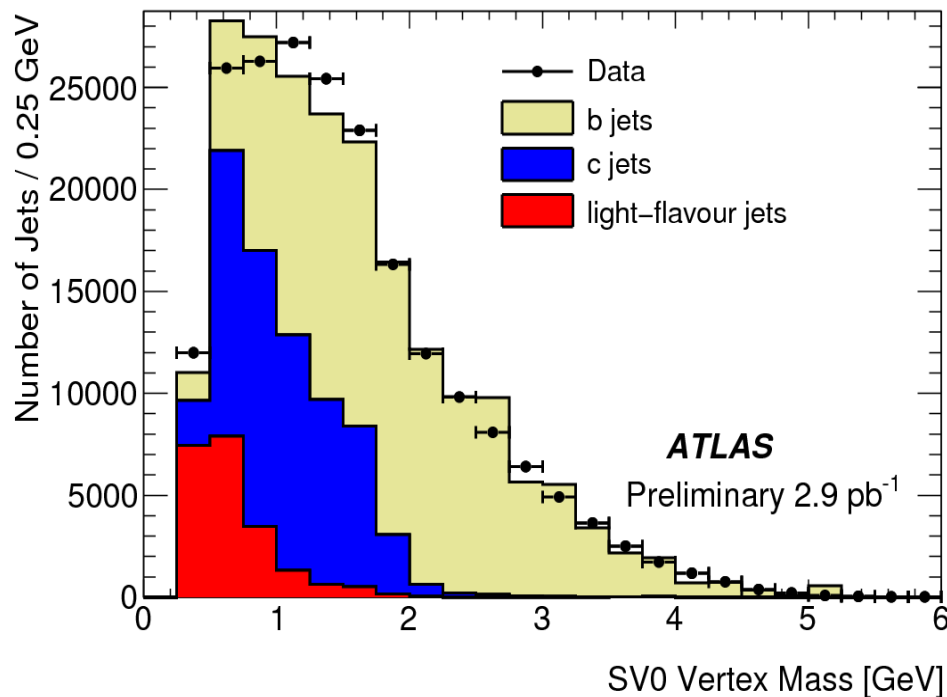
Non-resonance search in Di-jet events



- Angular distributions sensitive to s -channel vs. t -channel (QCD) production of dijets.
- χ is almost flat for QCD. s -channel exchange peaks at low χ .
- Syst. Error: JES (dominant), PDF, NLO scales...
- $\Lambda > 3.4 \text{ TeV}$ @95% CL exclusion → New best limit ($\Lambda > 2.8\text{-}2.96 \text{ TeV}$)

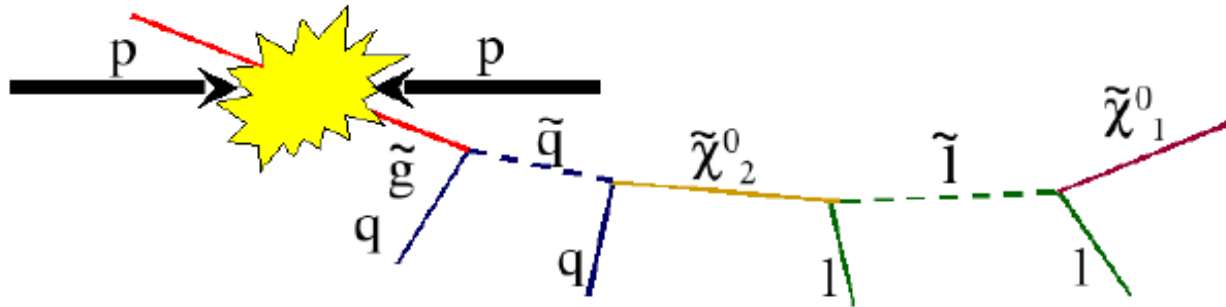
b-tagging mis-tag

- Mis-tag rate from vertex mass fit or rate of signed decay length significance $L/\sigma(L) < -5.72$
 - Mis-tag rate ranges from 0.2 to 1%, as p_T increases



SUSY Searches

if SUSY, LHC produces copiously strongly interacting sparticles (gluinos, squarks)



SUSY signatures:

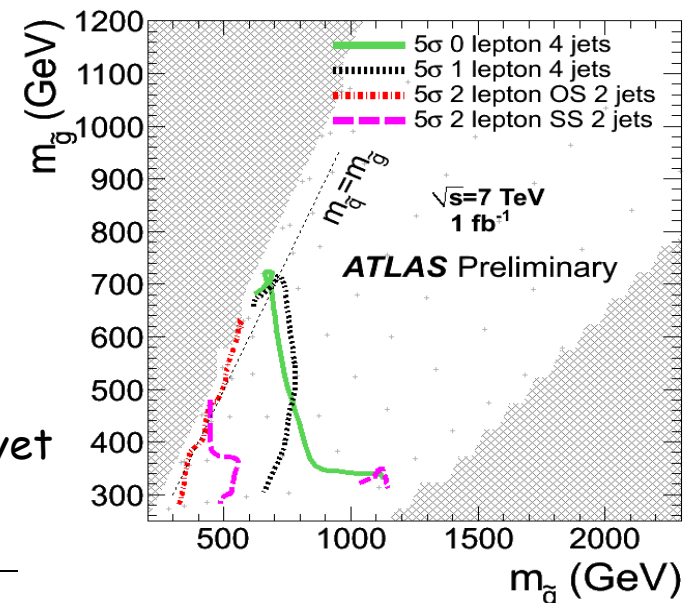
- high p_T jets
- high p_T leptons
- high E_T^{Miss} (from LSP)
- enrichment with τ , b, t (depending on model parameters)

Example Search channels

- jets + E_T^{Miss} + n leptons
- b-jets + E_T^{Miss}

Conclusions:

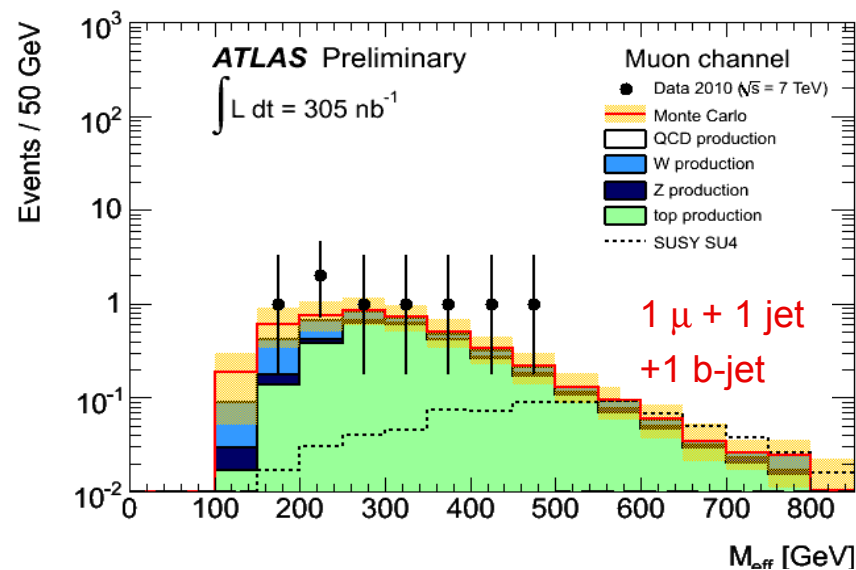
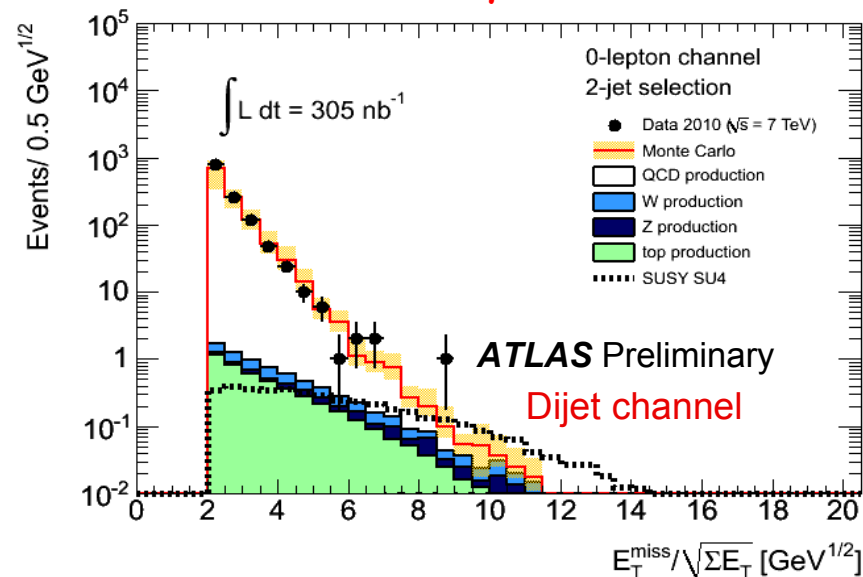
- data compatible with SM expectations
 - within the models investigated no signal expected yet
- ⇒ SM background well under control



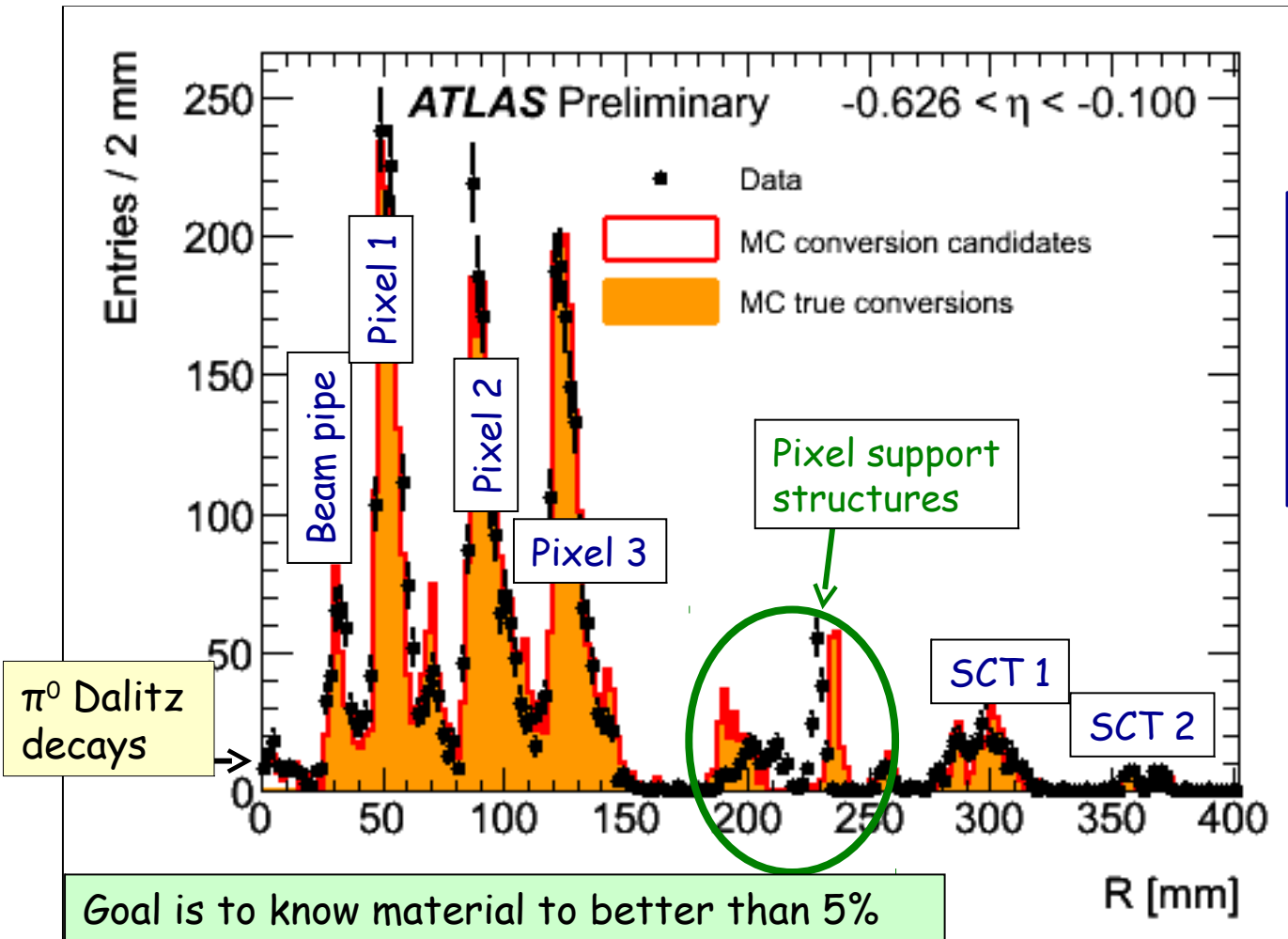
SUSY Search in b-jets and E_T^{Miss}

- Secondary vertex b-tagging algorithm:
 - Decay length significance: $L/s > 6$
 - $\epsilon_{b\text{-tagging}} \sim 50\%$
 - Rejection $> 98\%$ (light), $> 80\%$ (charm)
- Event selection (305 nb^{-1}):
 - Di-jet channel:
 $"\geq 2\text{-j } (70, 30)", \text{ at least one b-jet}$
 - lepton+jets channel
 One isolated muon
 $> 2\text{-jets } (30, 30) \text{ at least one b-jet}$
 - $E_{T^{\text{miss}}} / \sqrt{\sum E_T} > 2 \sqrt{\text{GeV}}$

- Clean ET miss measurement essential
- Data are consistent with background (8 evts seen, 4.7 expected in muon channel)
- With one lepton, top BKG dominates
- Can extend Tevatron sensitivity (gluino 390 GeV) with $\sim 5 \text{ pb}^{-1}$



Mapping the Inner Detector material with $\gamma \rightarrow e^+e^-$ conversions and hadron interaction

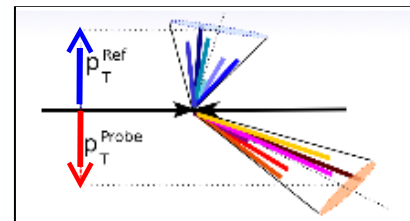
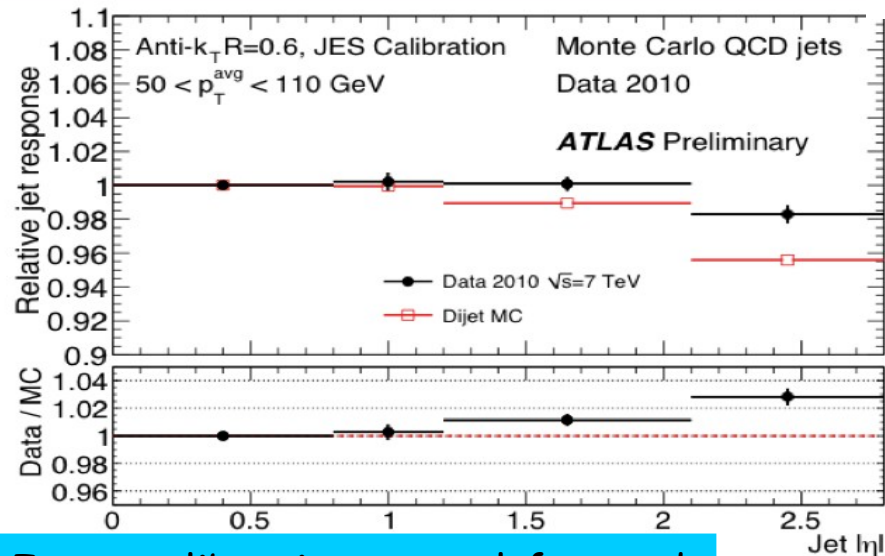
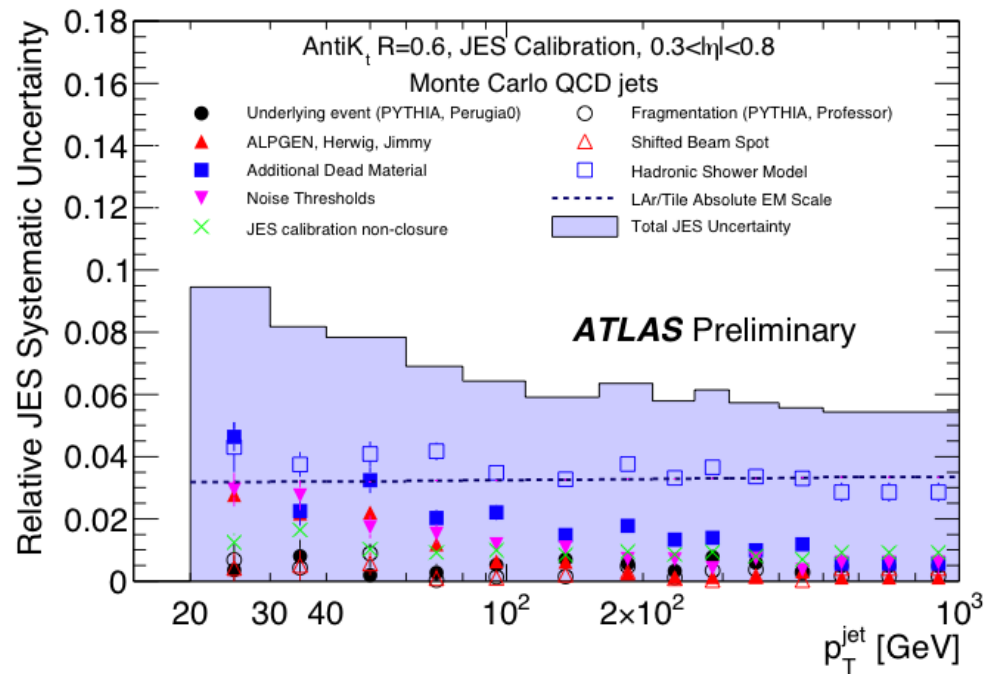


Reconstructed conversion point in the radial direction of $\gamma \rightarrow e^+e^-$ from minimum bias events (sensitive to X_0)

Goal is to know material to better than 5%
(e.g. for W-mass measurement)
Present understanding: at the level of $\sim 10\%$

Jet Energy Scale

- Jet reconstructed from "topological clusters"
- Jet momenta corrected for
 - calorimeter non-compensation
 - dead material, etc.
 using η/p_T -dependent calibration factors derived from MC (tuned with "combined testbeam" data)
- Result checked with single particles / Min bias



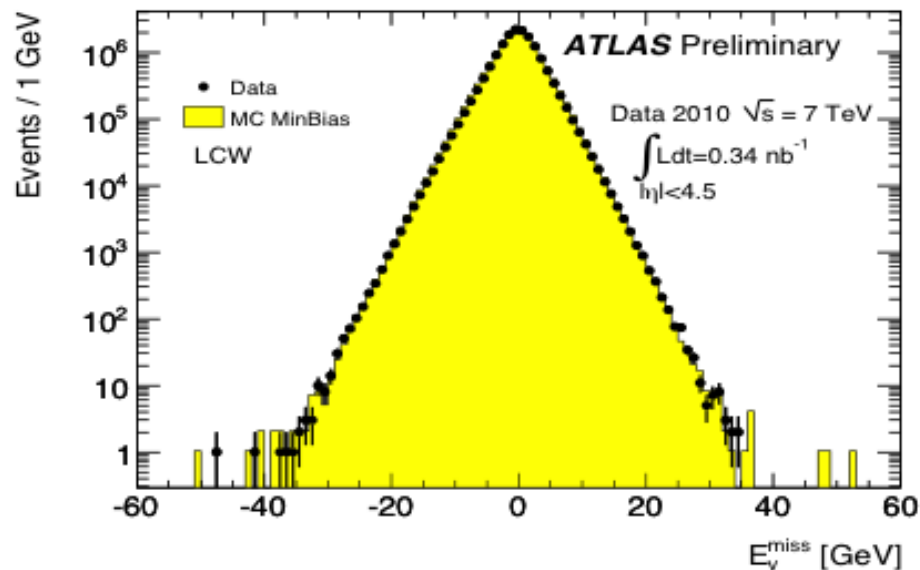
Today JES
known to : ~ 7%

Ultimate goal: ~1%

Inter-calibration central-forward
checked using jet p_T -balance

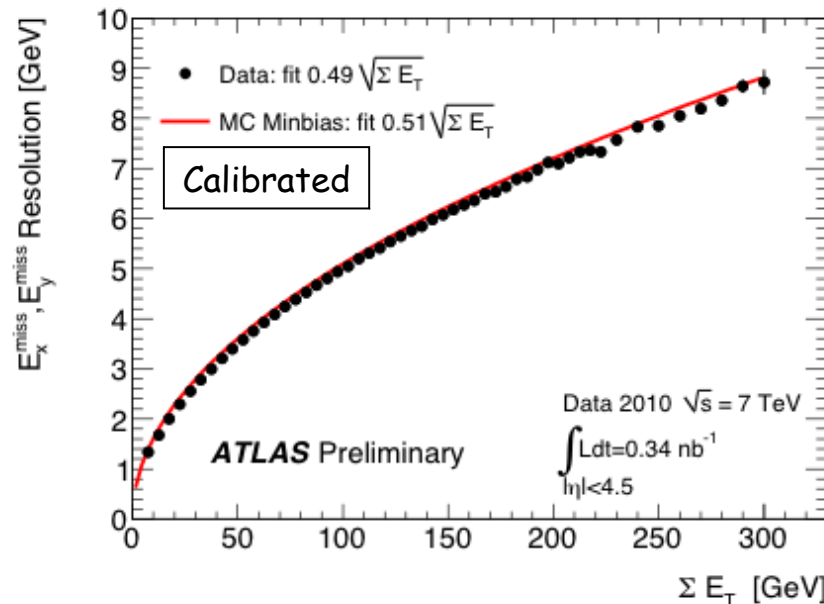
Missing transverse energy in the calorimeters

Calibrated E_T^{miss} from minimum-bias events (component on vertical axis)

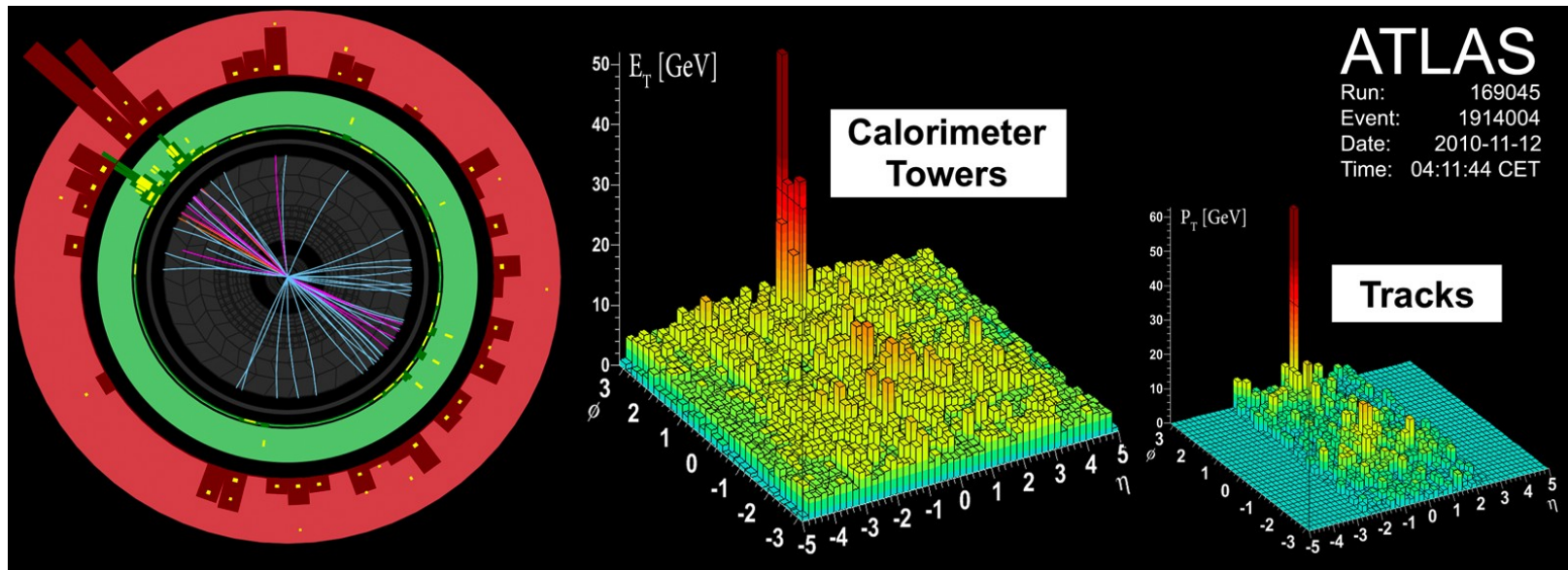


Measured over $\sim$ full calorimeter coverage (360° in ϕ , $|\eta| < 4.5$, $\sim 200k$ cells)

Sensitive to calorimeter performance (noise, coherent noise, dead cells, mis-calibrations, cracks, etc.), and cosmics and beam-related backgrounds ("Event cleaning")



Observation of a Centrality-Dependent Dijet Asymmetry in Pb-Pb Collisions

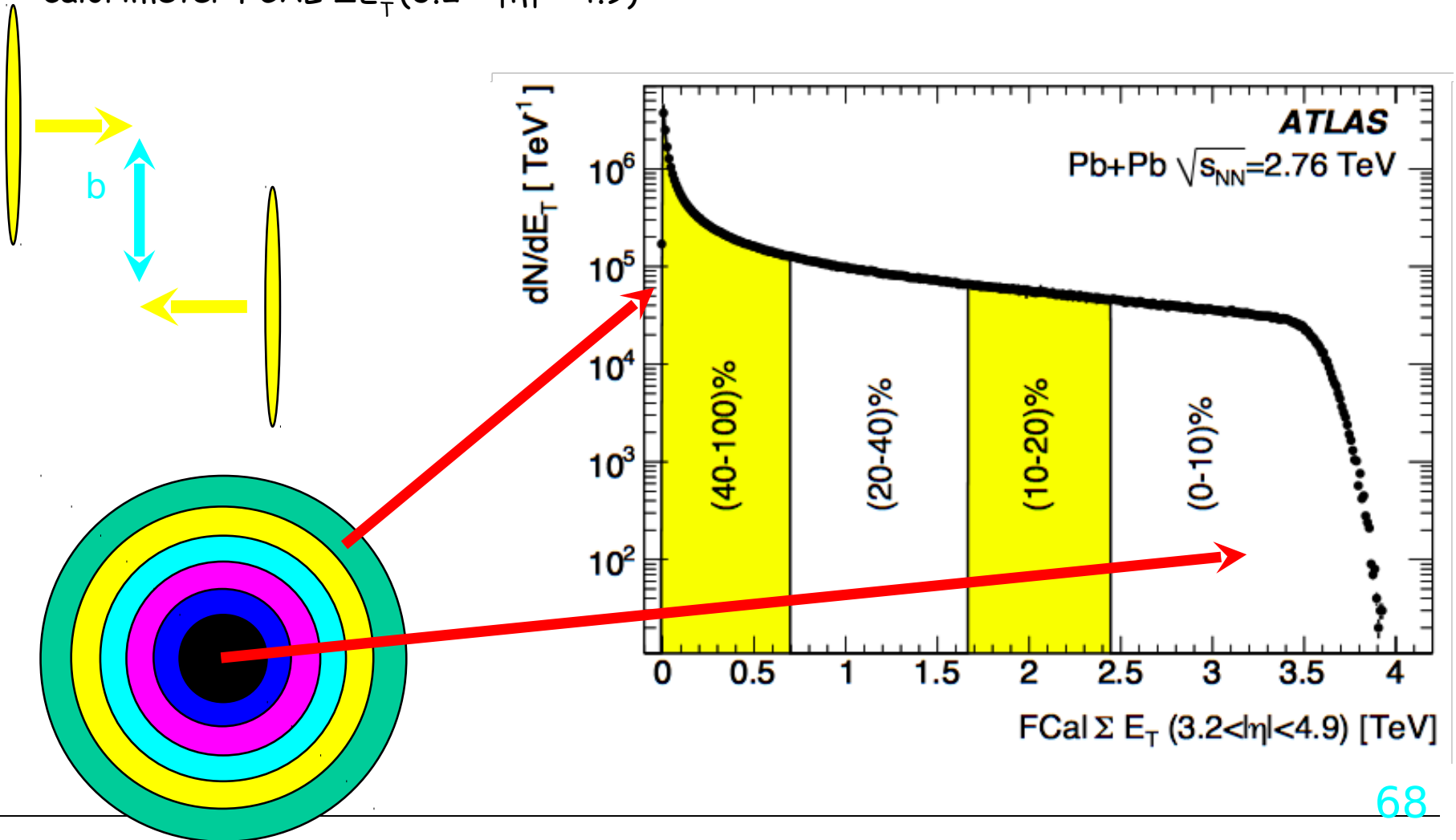


Jet quenching:

How do parton showers in hot medium (quark gluon plasma) differ from those in vacuum ?

Minimum-bias, centrality

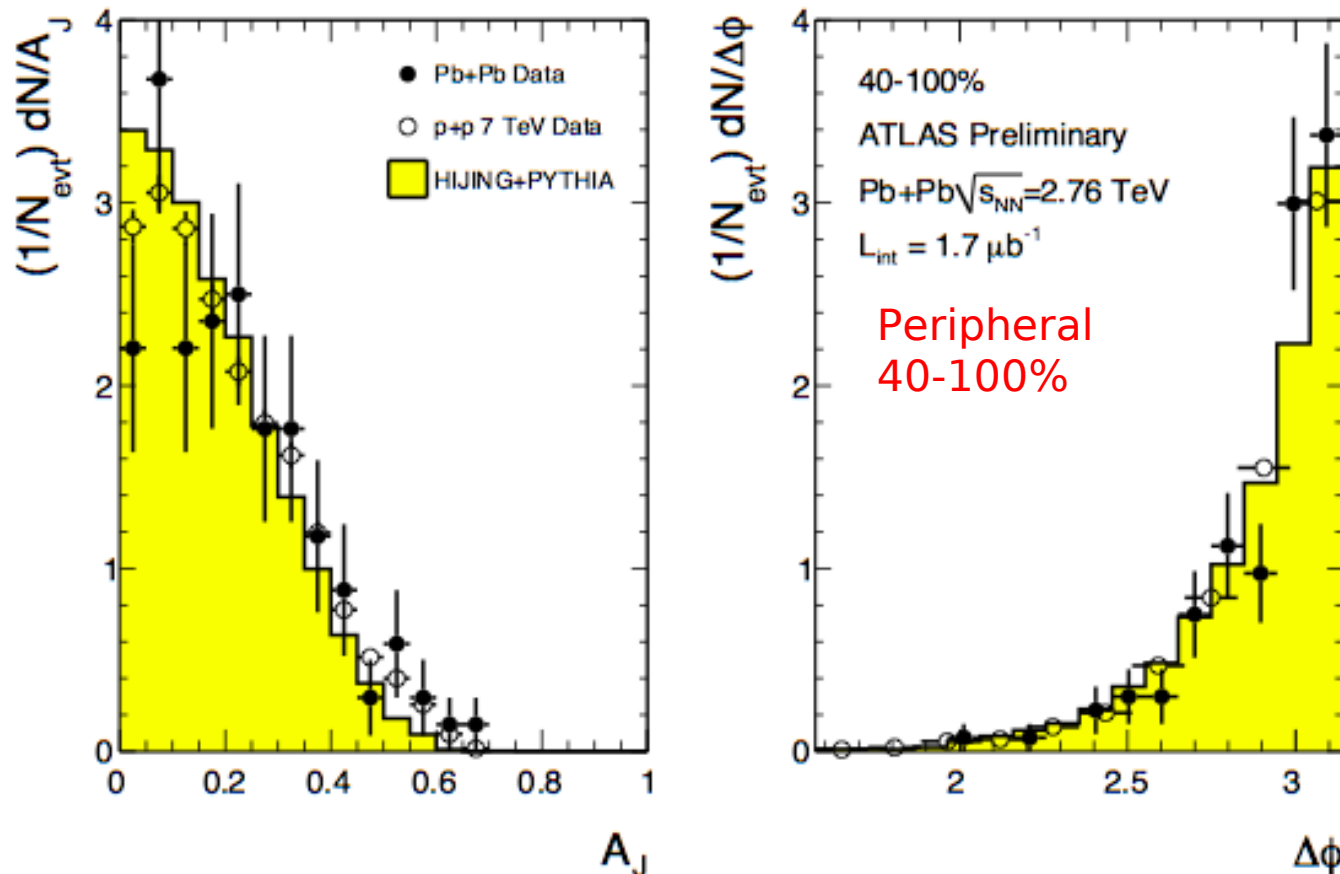
- Triggers: minimum-bias trigger scintillators, ZDC
- Characterize centrality by percentiles of total cross-section using forward calorimeter FCal ΣE_T ($3.2 < |\eta| < 4.9$)



Dijet analysis

- Use jets reconstructed with $R=0.4$ anti-kt clustering jet algorithm (cone-like but infrared and collinear safe)
 - _ Calibrated using energy density cell weighting
- Select events with leading jet, $E_T > 100 \text{ GeV}$, $|\eta| < 2.8$
- Sub-leading: highest E_T -jet in opposite hemisphere $\Delta\phi > \pi/2$ with $E_T > 25 \text{ GeV}$, $|\eta| < 2.8$
 - _ 5% of selected jets have no sub-leading jet
- Introduce new variable to quantify di-jet imbalance:
 - _ Asymmetry:
$$A \equiv \frac{E_{T1} - E_{T2}}{E_{T2} + E_{T1}}$$
- Robust Variable
 - _ Residual subtraction errors cancel in numerator
 - _ Absolute jet energy scale errors cancel in ratio

Dijets: comparison to pp, HIJING+PYTHIA



Pb+Pb di-jet asymmetry (A_J), acoplanarity ($\Delta\phi$)
 Compare to pp data and PYTHIA dijet events embedded in HIJING
 No HIJING quenching, Data agrees with pp, MC in peripheral PbPb

Di-Jet Asymmetry - Cross checks

- Carried out a number of cross checks to test for detector or analysis source of asymmetry - partial list:
- Problems in calorimeter
- Background subtraction
- Different jet sizes
- Jet shape
- Energy loss to muons
- Missing E_T
- Many more

Higgs sensitivity

- Study Higgs sensitivity at 7 (8, 9) TeV
 - Conservative, cut-based analyses
 - Robust systematic error estimates
- Recently added new channels to earlier 7 TeV study
 - Full simulations at 7 TeV for some analyses, and cross section rescaling for others
 - 8 and 9 TeV sensitivity from rescaling
- Also benefit from updated cross section calculations with most complete available higher-order corrections which also give increased sensitivity
- ref. ATL-PHYS-PUB-2010-015