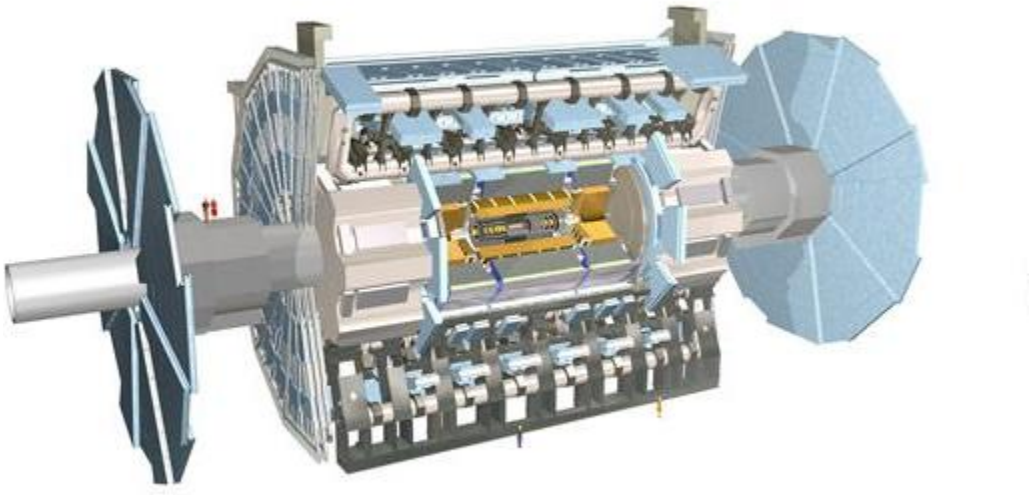
Status of the ATLAS Experiment



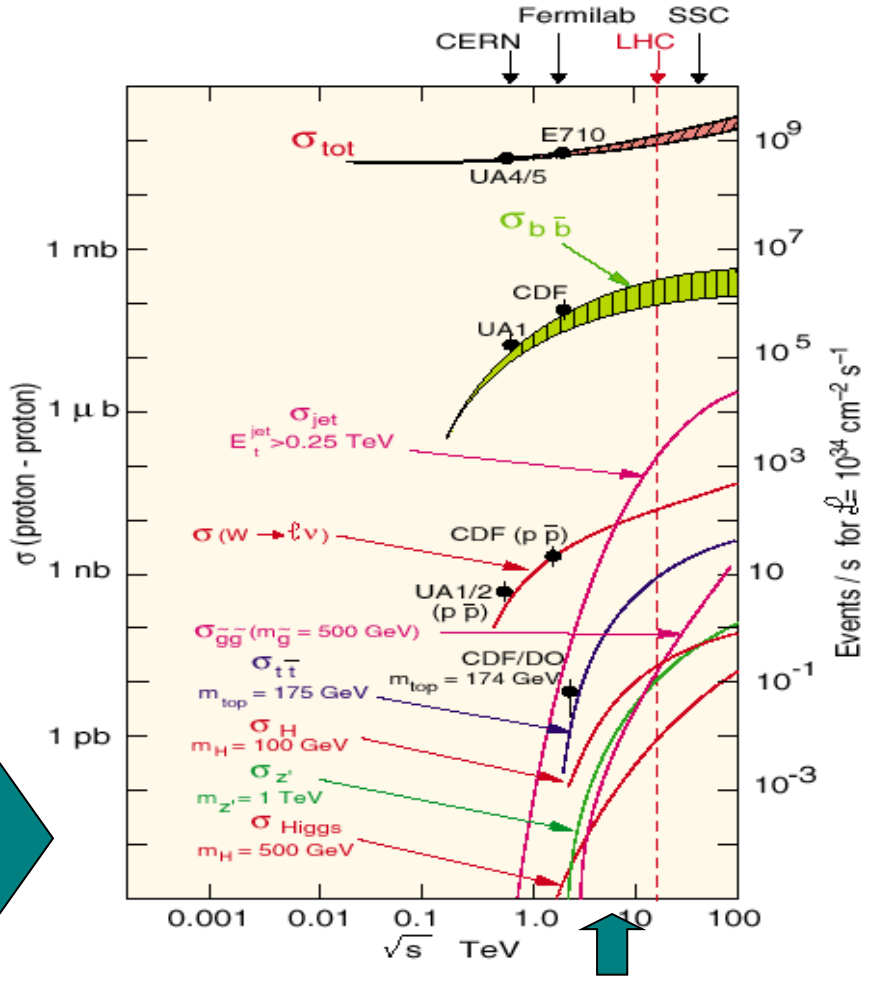
Domizia Orestano
Università Roma Tre & INFN
On behalf of the ATLAS Collaboration
Charged Higgs 2010
Uppsala, 27/9/2010

ATLAS EXPERIMENT
http://atlas.ch

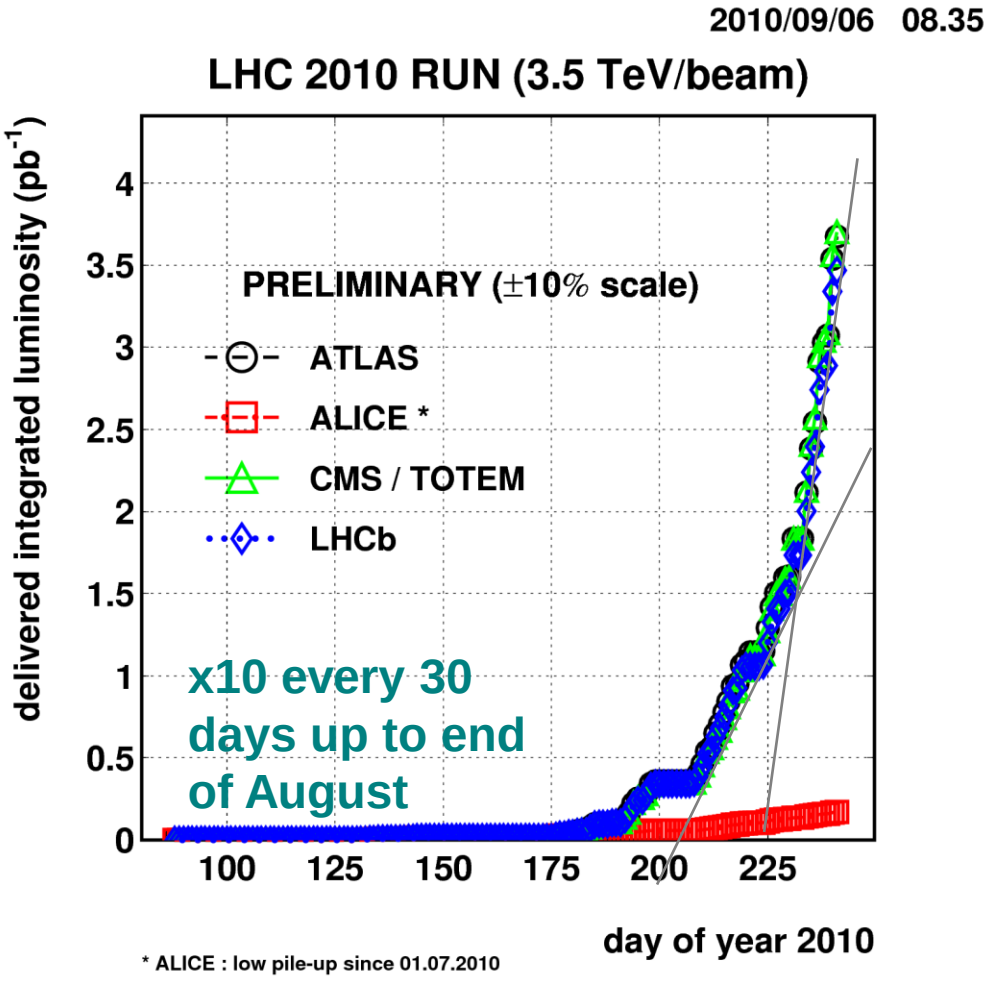
ROMA TRE
UNIVERSITÀ DEGLI STUDI

Outline

- LHC status
- ATLAS detector in data taking
- Understanding physics objects
- A selection of first physics results
- 2010 physics reach

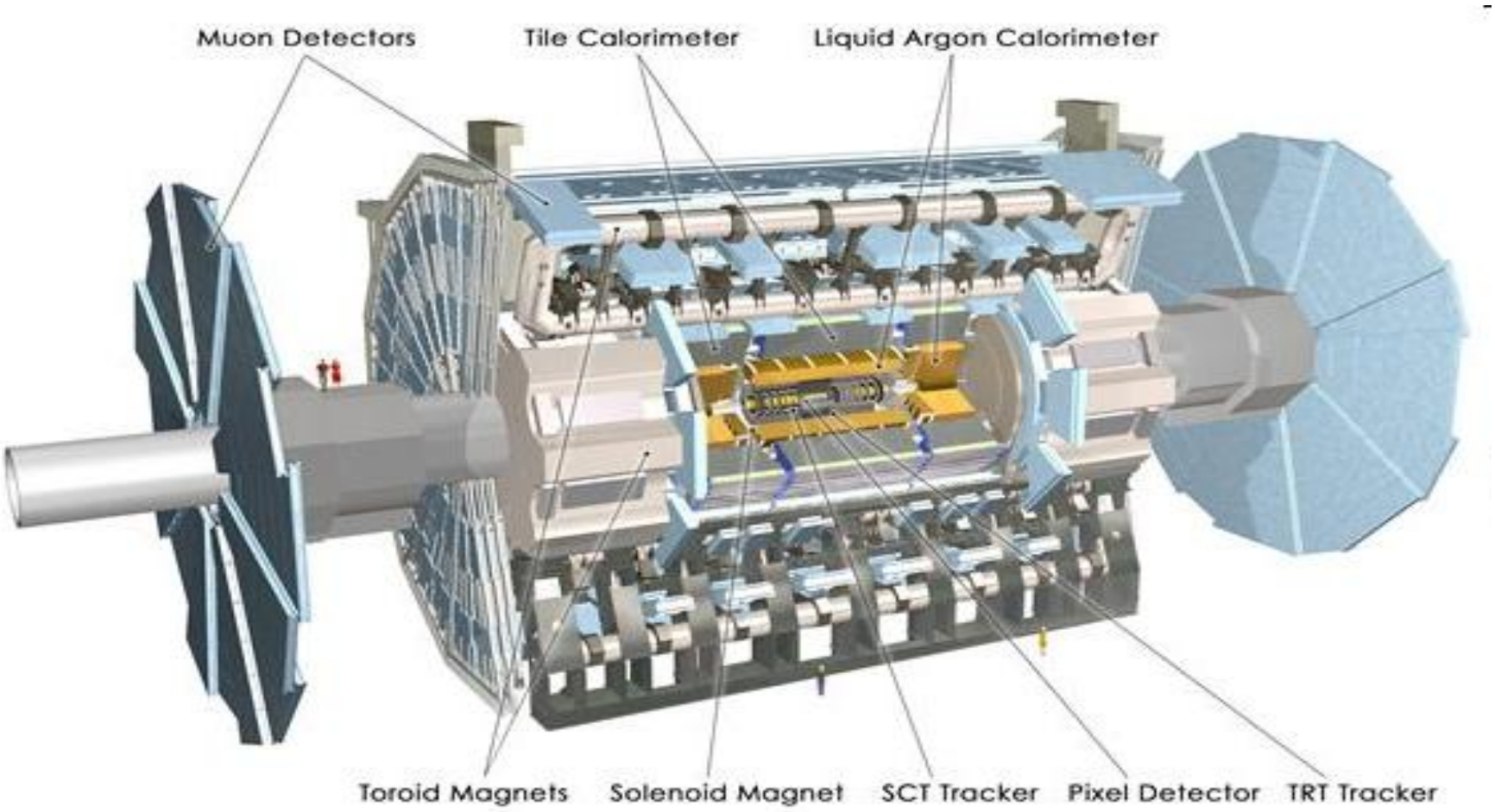


LHC operation

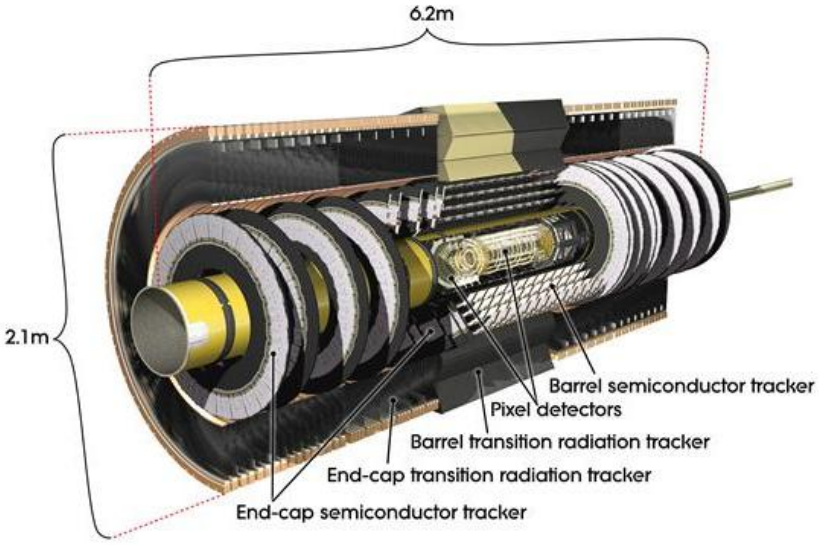


- Just restarted with bunch trains after a technical stop
- Peak instantaneous luminosity (25/9/10 value) $3.6 \times 10^{31} cm^{-2} s^{-1}$
- Plan:
  reach $10^{32} cm^{-2} s^{-1}$ by the end of the year

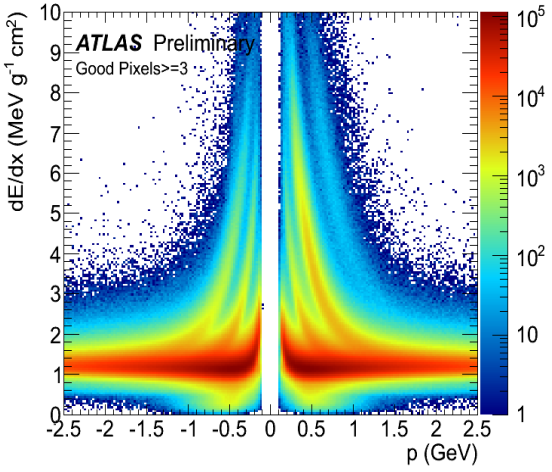
ATLAS DETECTOR



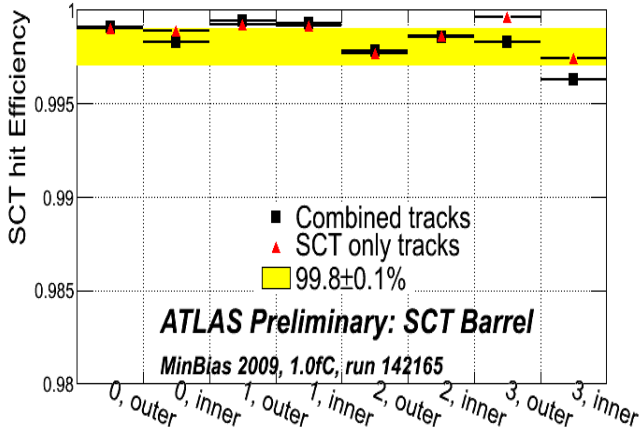
ATLAS INNER DETECTOR



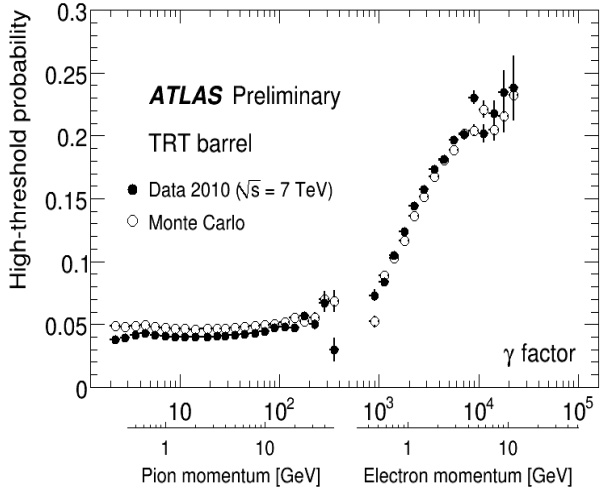
Inner Detector ($|\eta|$<2.5, B=2T):
Si Pixels, Si strips, Transition Radiation detector (straws)
Precise tracking and vertexing, e/π separation
Momentum resolution:
$\sigma/p_T \sim 3.8\times10^{-4}\ p_T\ (GeV) \oplus 0.015$



dE/dx in pixels

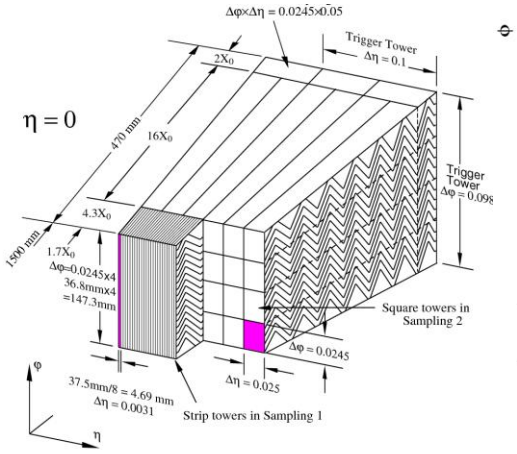


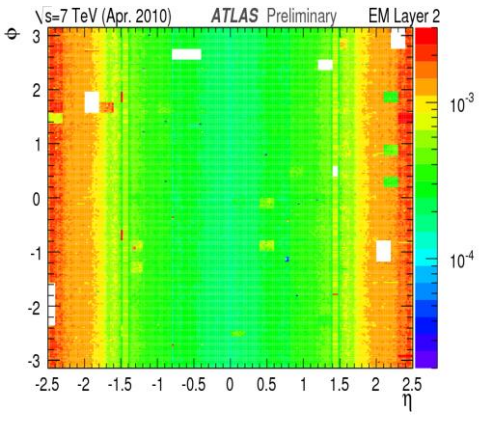
Transition radiation

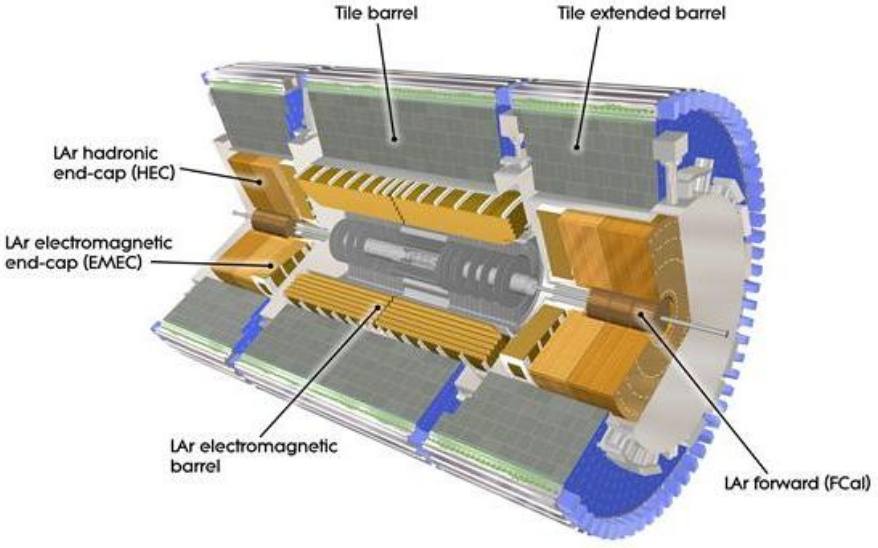


ATLAS CALORIMETERS

EM calorimeter: Pb-LAr Accordion
e/γ trigger, identification and measurement
E-resolution: σ/E ~ 10%/√E[GeV]

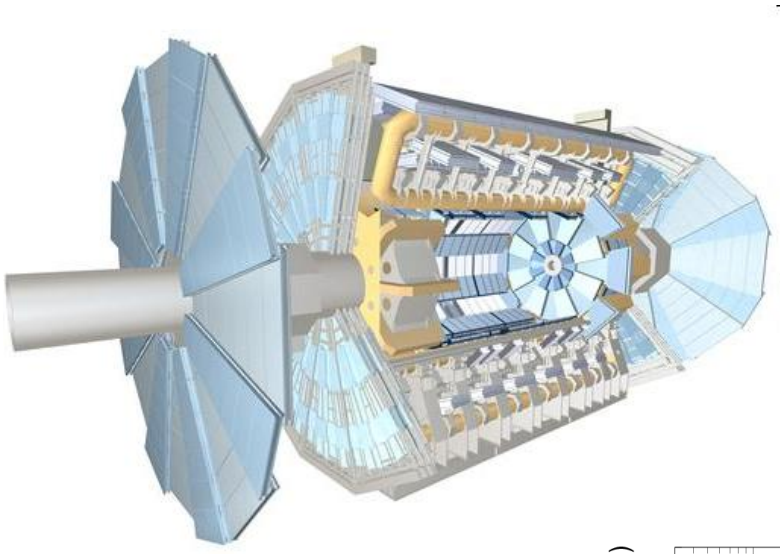






HAD calorimetry (|η|<5): segmentation, hermeticity
Fe/scintillator Tiles (central), Cu/W-LAr (fwd)
Trigger and measurement of jets and missing E_T
E-resolution: σ/E ~ 50%/√E[GeV] ⊕ 0.03

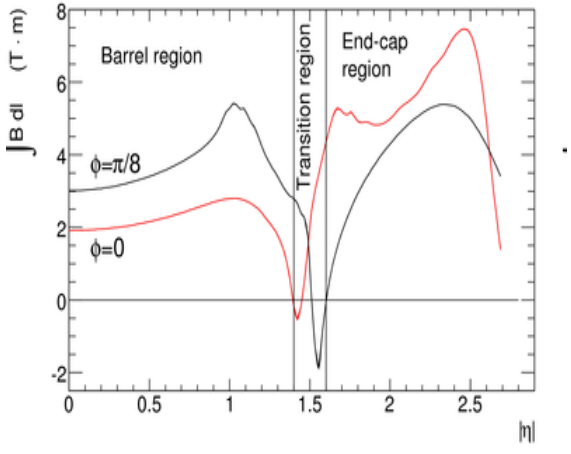
ATLAS MUON SPECTROMETER

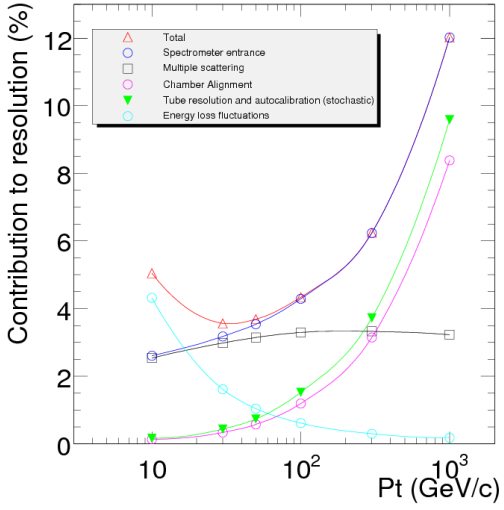


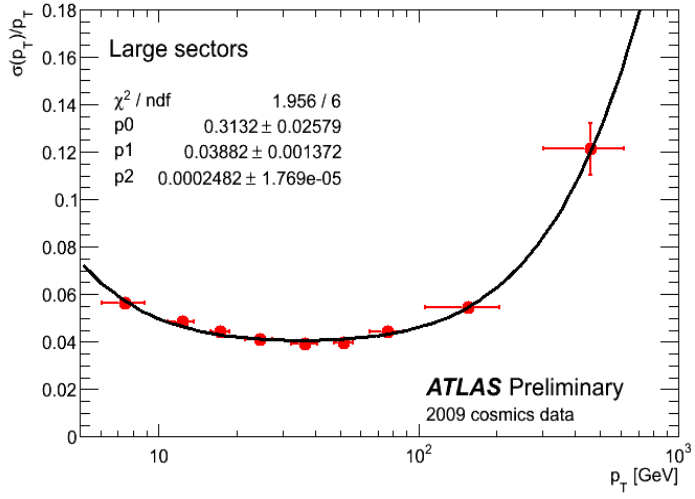
Muon Spectrometer (|η|<2.7) : air-core toroids with gas-based muon chambers

- **Muon Drfit Tubes & Cathode Strip Chambers in the precision coordinate**
- **Resistive plate Chambers & Thin Gap Chambers for trigger and second coordinate**

Muon trigger and measurement with momentum resolution < 10% up to E_{μ}~1TeV

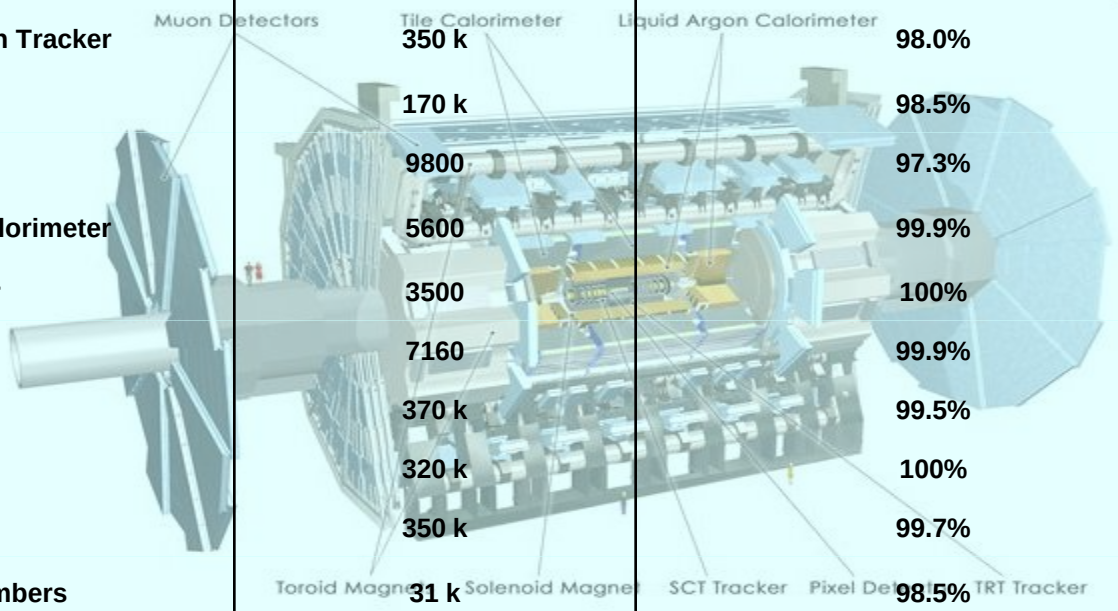




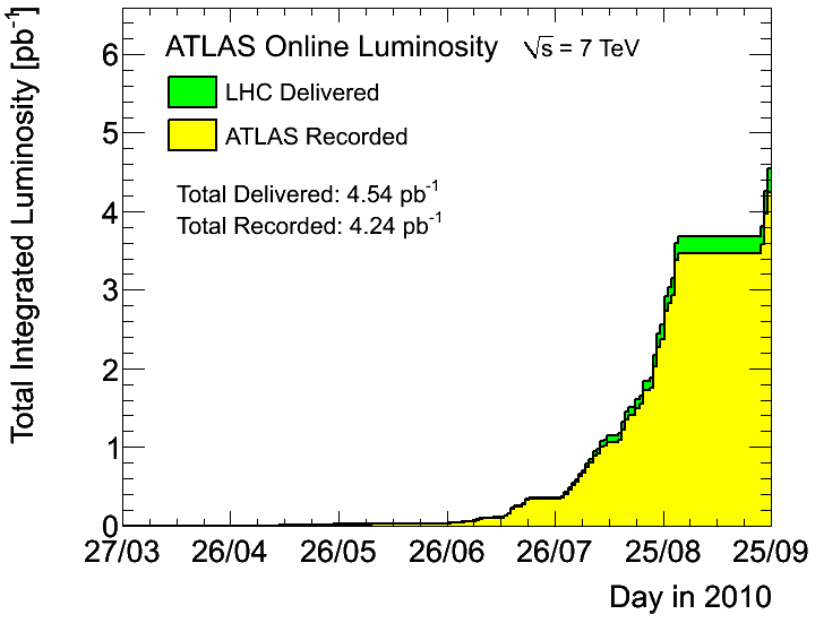


ATLAS DETECTOR STATUS

Subdetector	Number of Channels	Approximate Operational Fraction
Pixels	80 M	97.4%
SCT Silicon Strips	6.3 M	99.2%
TRT Transition Radiation Tracker	350 k	98.0%
LAr EM Calorimeter	170 k	98.5%
Tile calorimeter	9800	97.3%
Hadronic endcap LAr calorimeter	5600	99.9%
Forward LAr calorimeter	3500	100%
LVL1 Calo trigger	7160	99.9%
LVL1 Muon RPC trigger	370 k	99.5%
LVL1 Muon TGC trigger	320 k	100%
MDT Muon Drift Tubes	350 k	99.7%
CSC Cathode Strip Chambers	31 k	98.5%
RPC Barrel Muon Chambers	370 k	97.0%
TGC Endcap Muon Chambers	320 k	98.6%



ATLAS recorded luminosity



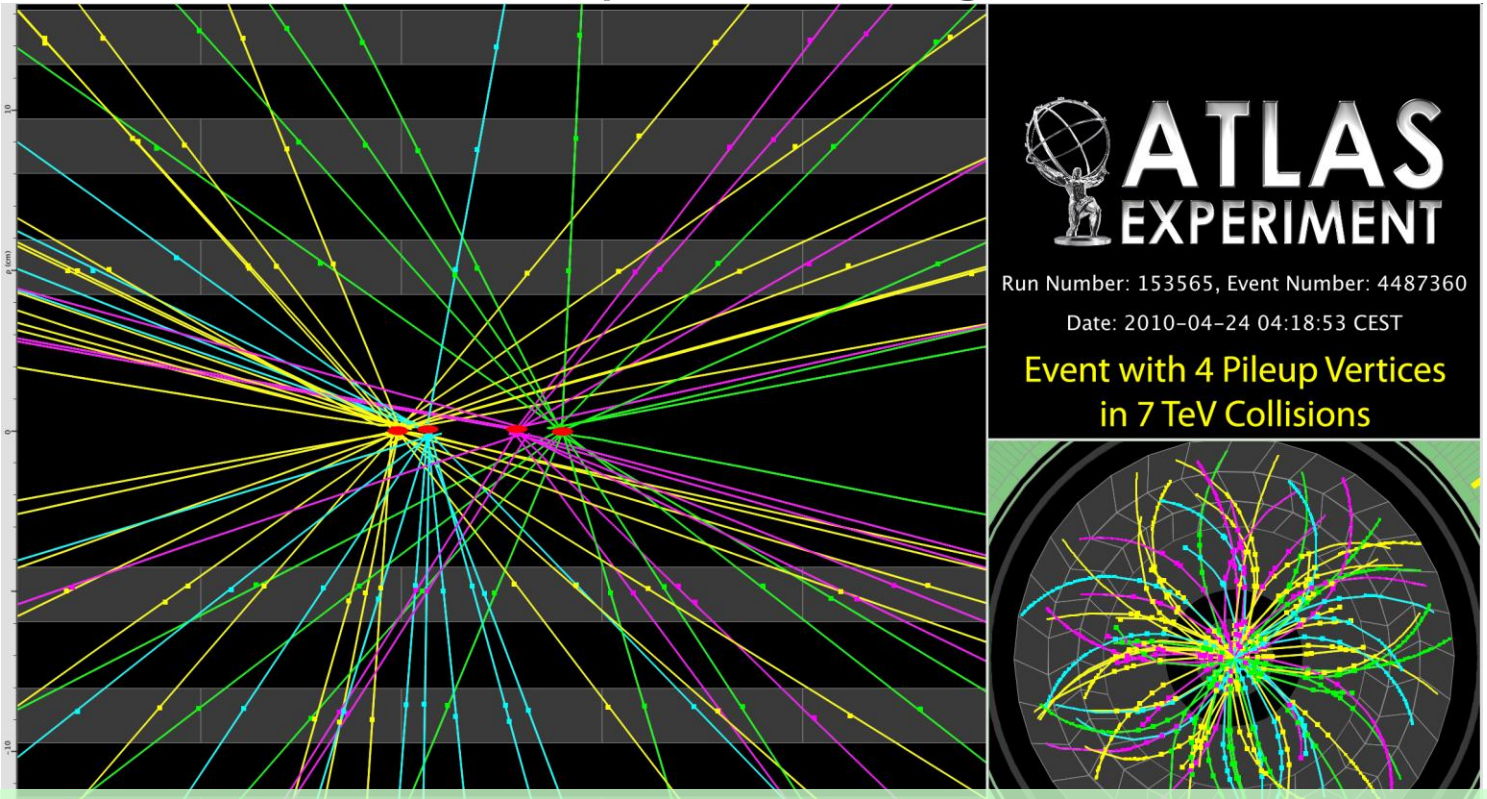
- Luminosity detectors calibrated with Van-der-Meer method
- Systematic uncertainty 11% dominated by knowledge of colliding beam currents

Inner Tracking Detectors			Calorimeters				Muon Detectors			
Pixel	SCT	TRT	LAr EM	LAr HAD	LAr FWD	Tile	MDT	RPC	TGC	CSC
97.7	96.4	100	94.4	98.7	99.3	99.2	98.5	98.3	98.6	98.3

Luminosity weighted relative detector uptime and good quality data delivery during 2010 stable beams at √s=7 TeV between March 30th and August 14th (in %)

Pile-up

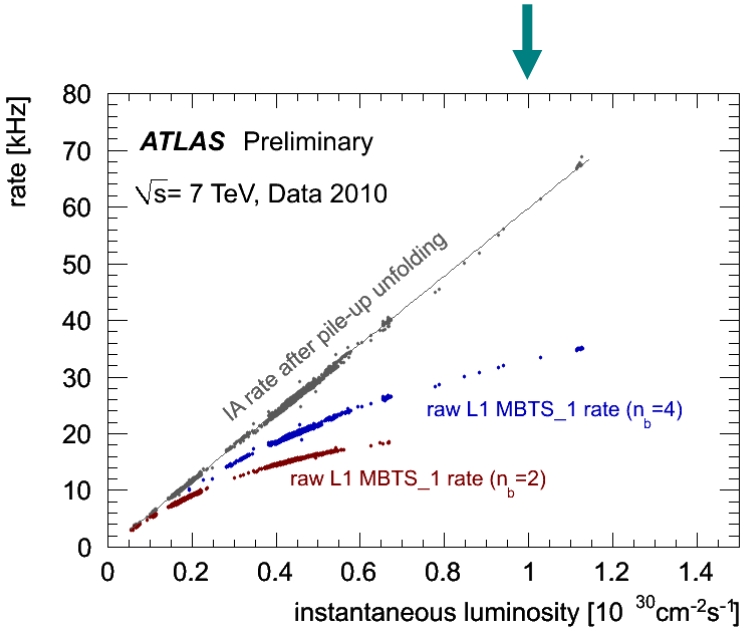
- Currently about 40% of the events have more than 1 interaction per crossing



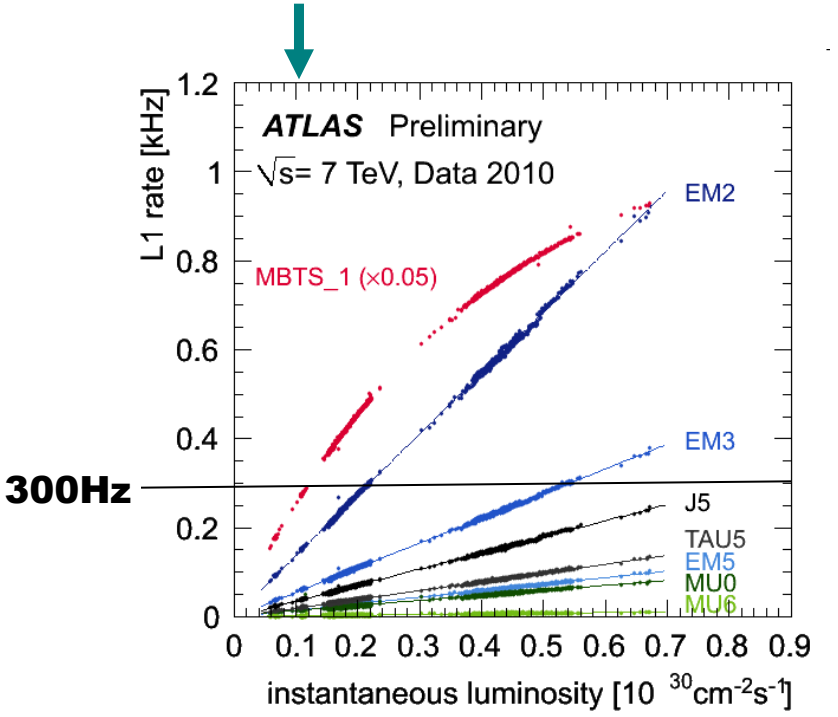
~ 10-45 tracks with p_T >150 MeV per vertex
Vertex z-positions : −3.2, −2.3, 0.5, 1.9 cm (vertex resolution better than ~200 μm)

ATLAS trigger

- Interaction rate: 70KHz @ $10^{31}cm^{-2}s^{-1}$
- Recording rate is ~300Hz

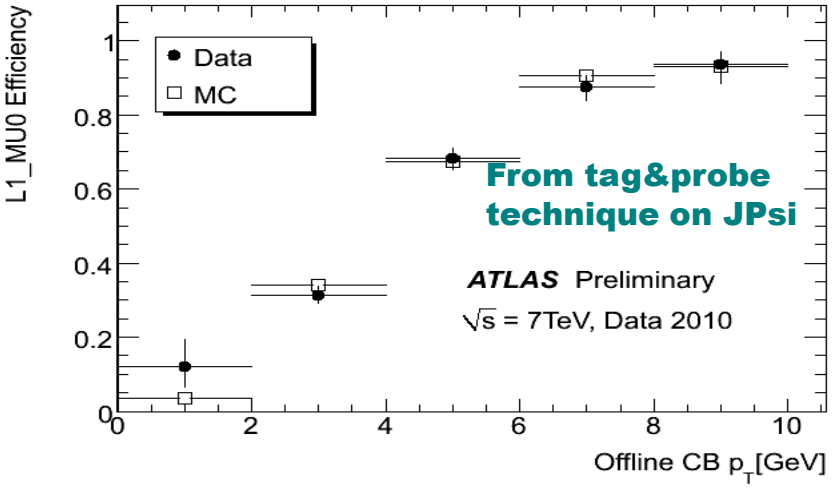


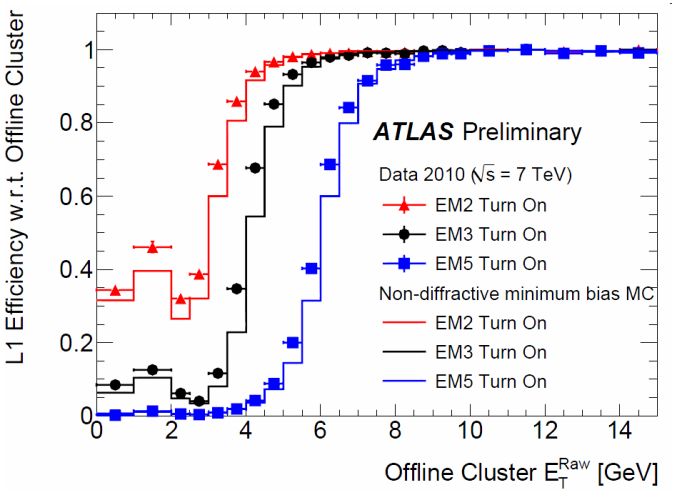
- high level trigger selection in use since $10^{29}cm^{-2}s^{-1}$

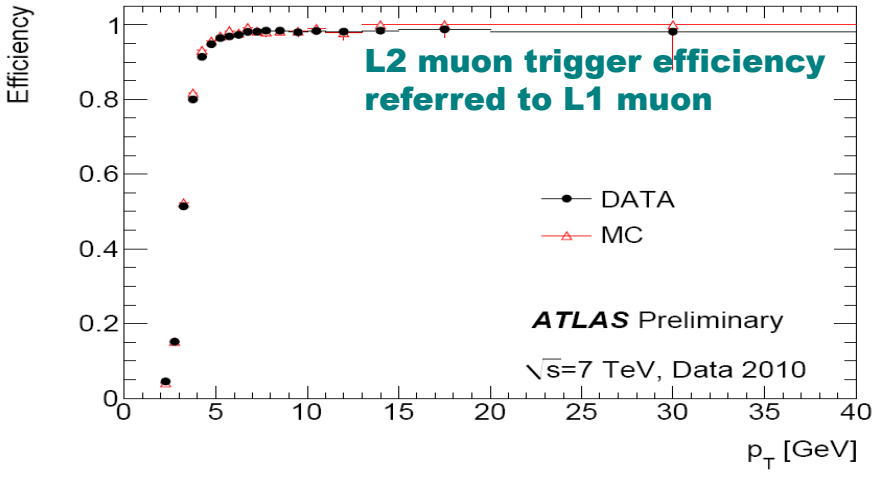


Trigger performance

- Few examples trigger performance studies:
  - absolute efficiency with tag&probe techniques
  - Efficiencies relative to a lower trigger level
  - Efficiencies relative to the reconstructed objects

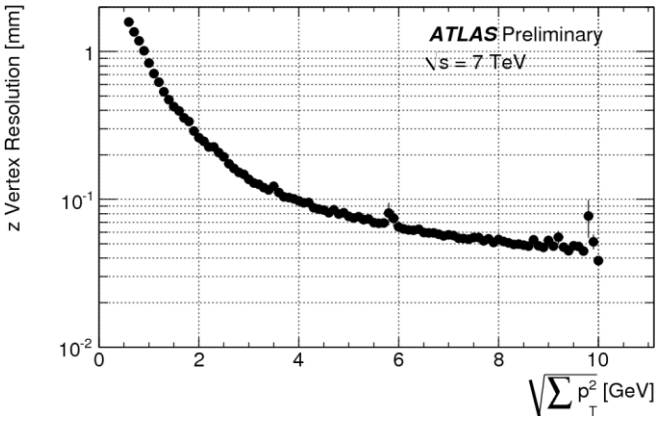




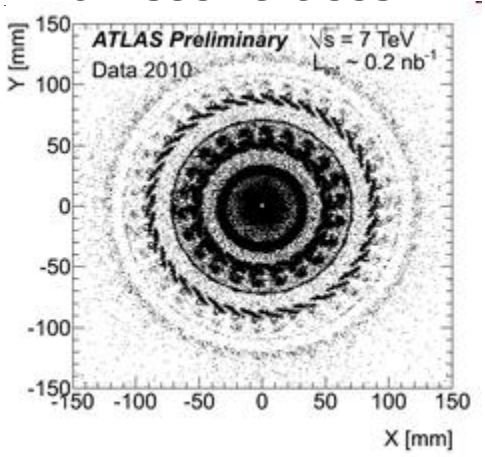


Tracking performance

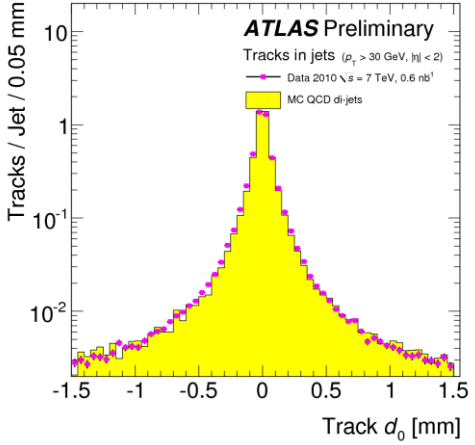
Vertexing



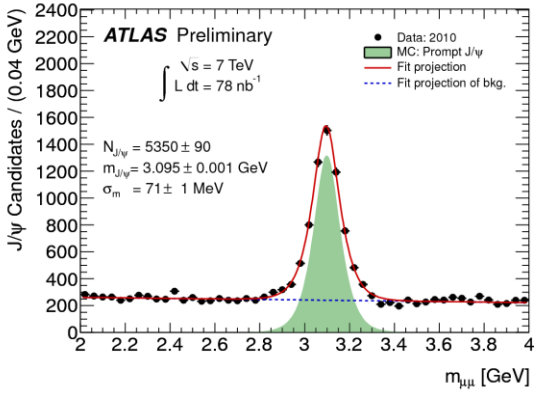
Material mapping
from sec vertices

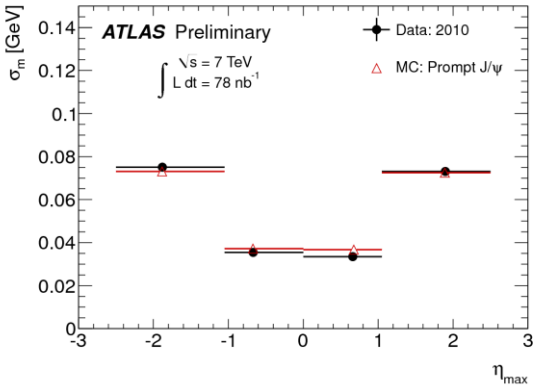


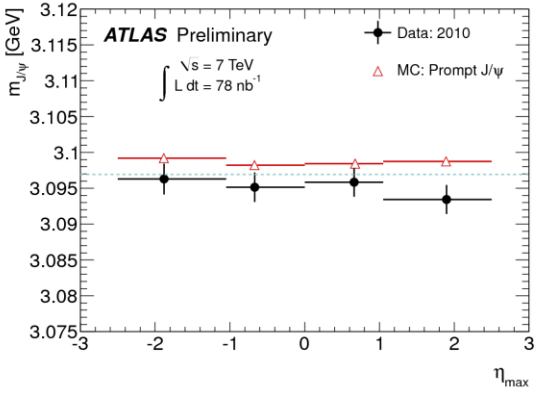
Impact parameter



Momentum resolution and scale using resonances: JPsi example

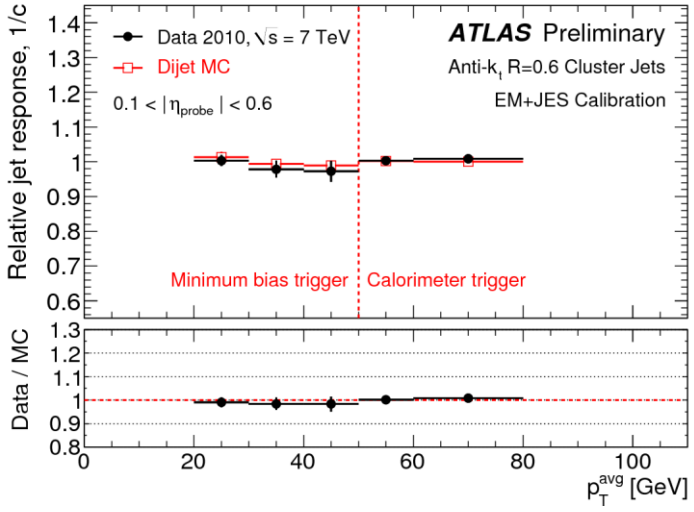




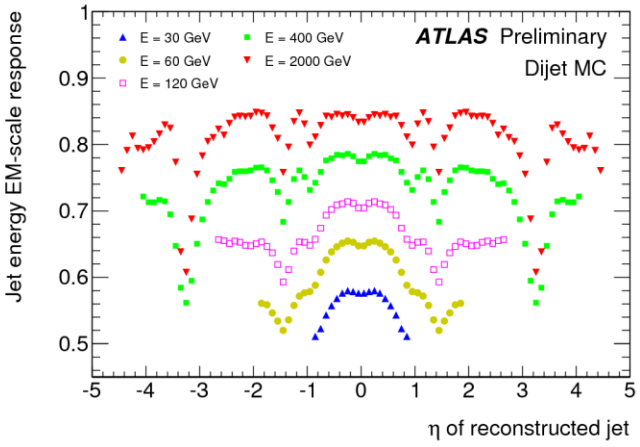


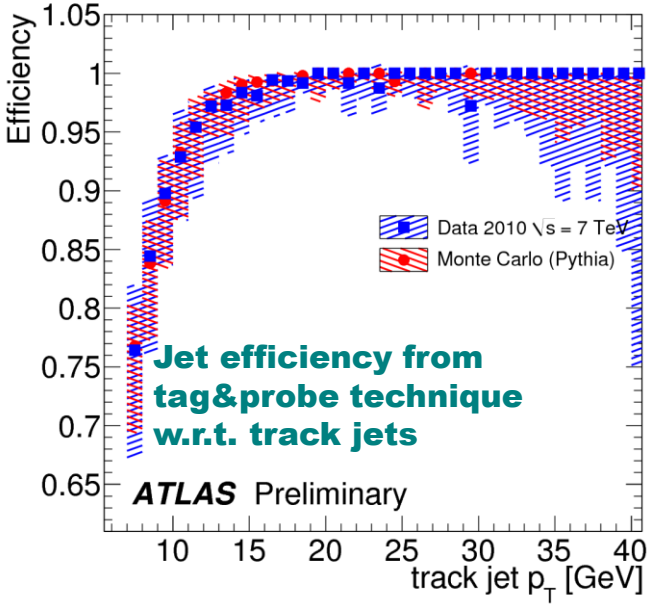
Jets

- Non compensating calorimeter
- MC based corrections are validated on data by comparing, in di-jet events, the probe jet energy to the one of a central jet



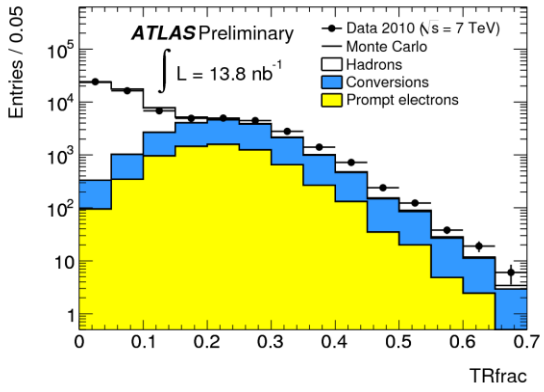
- Di-jets, reconstructed by tracking, are also used to measure calorimetric jets efficiency

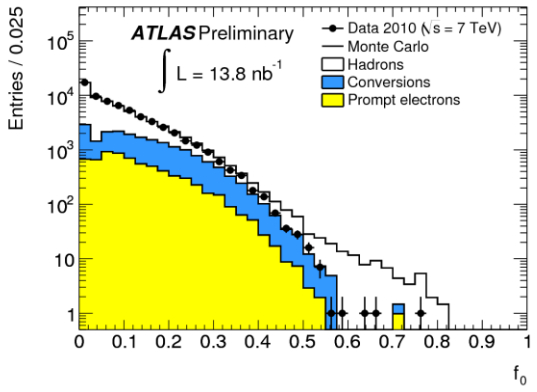


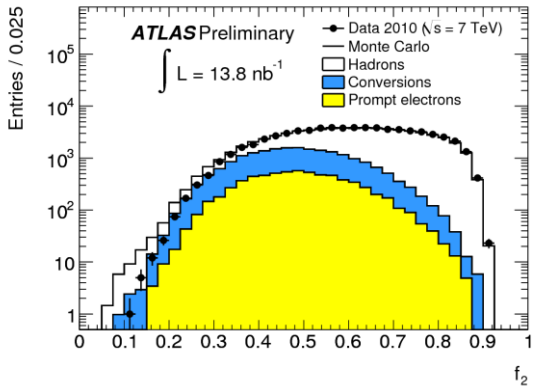


Electrons

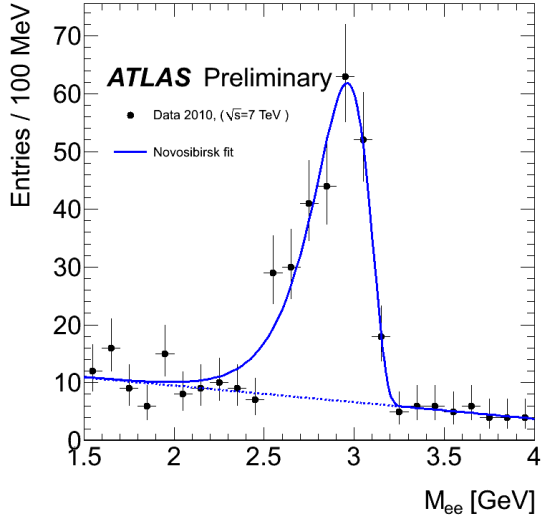
Inclusive electron studies, some TRT and Calo based discriminants

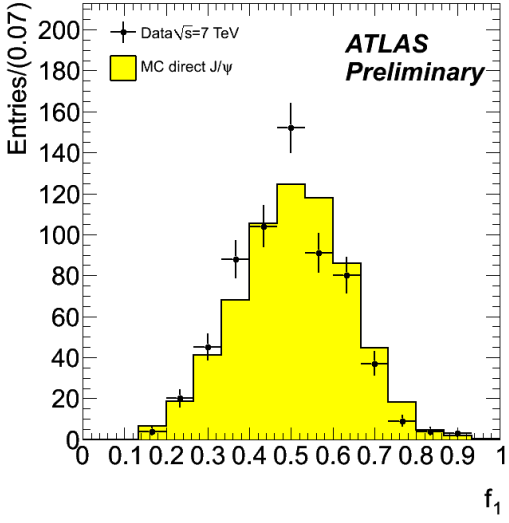


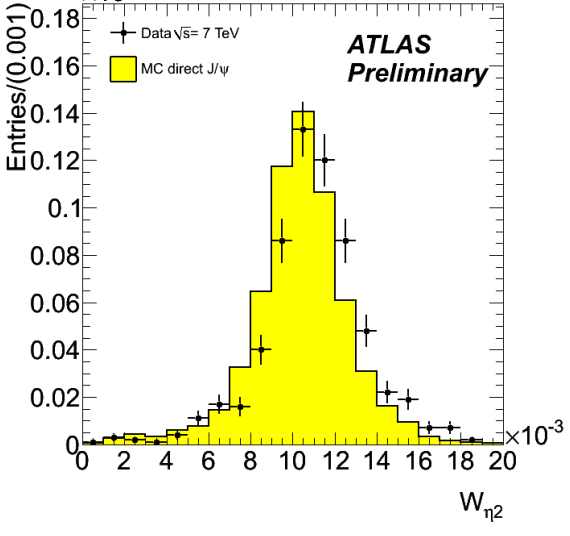




Selected electrons from JPsi: distributions for Calo based discriminants

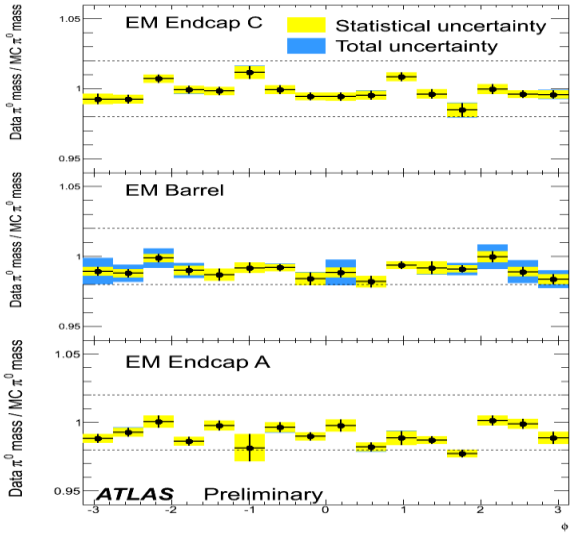


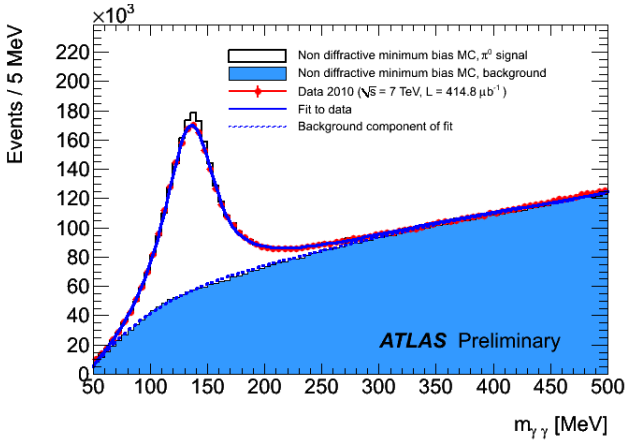


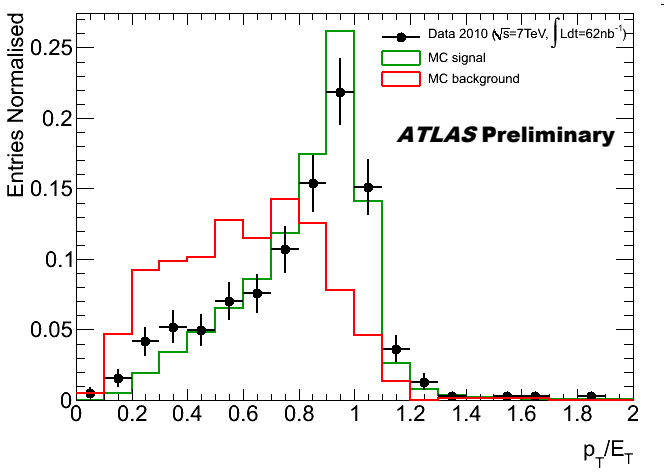


Photons

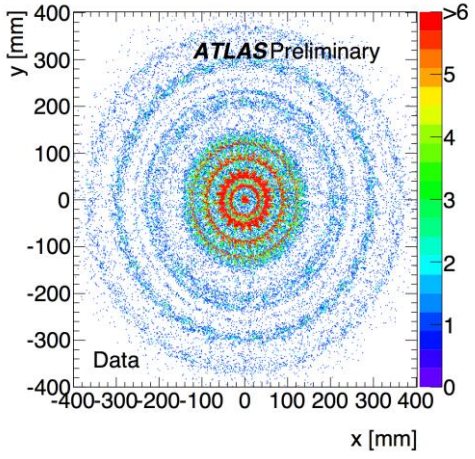
Energy scale from π^0 mass



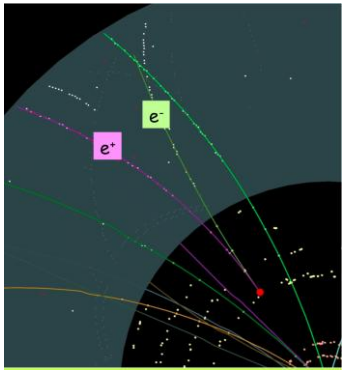




Material mapping from conversion point

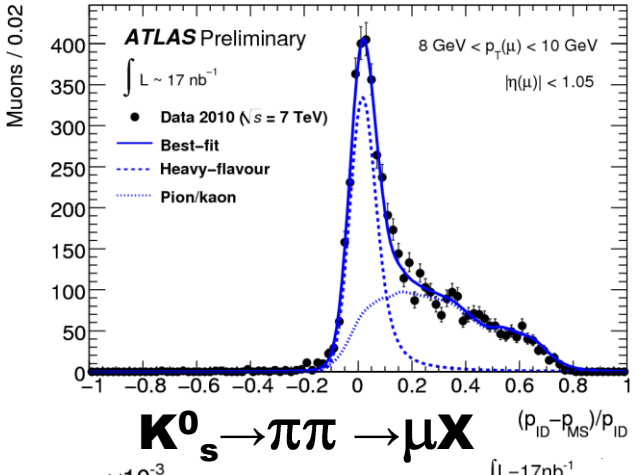


Converted photon candidates

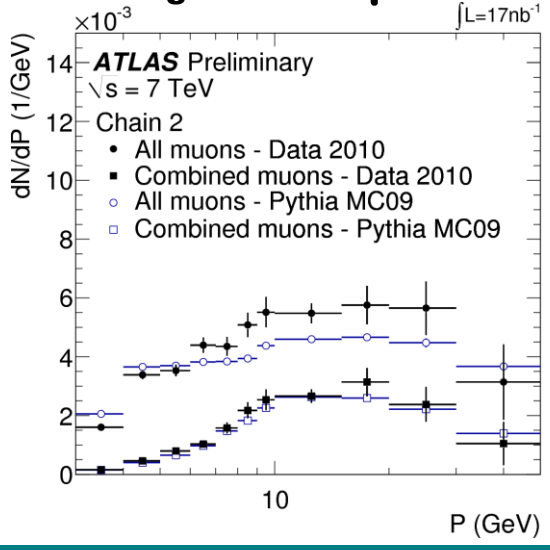


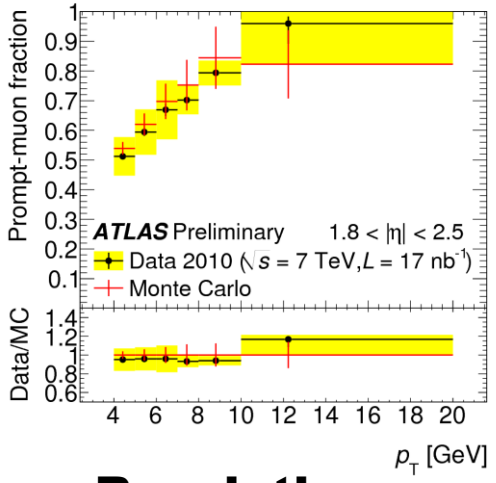
Muon performance

Inclusive muon studies: discriminants, composition

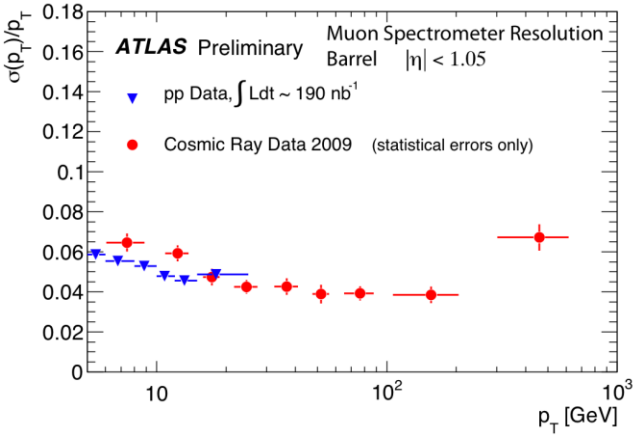


$K^0_s \rightarrow \pi\pi \rightarrow \mu X$



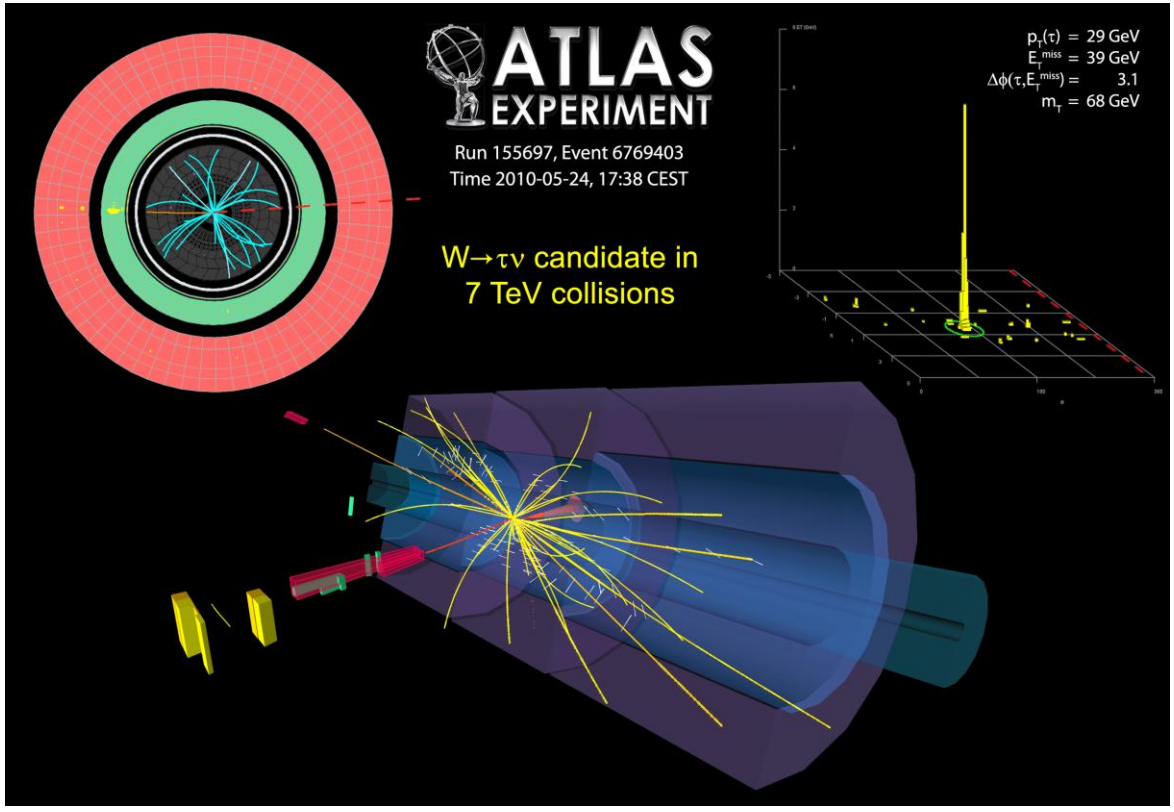


Resolution



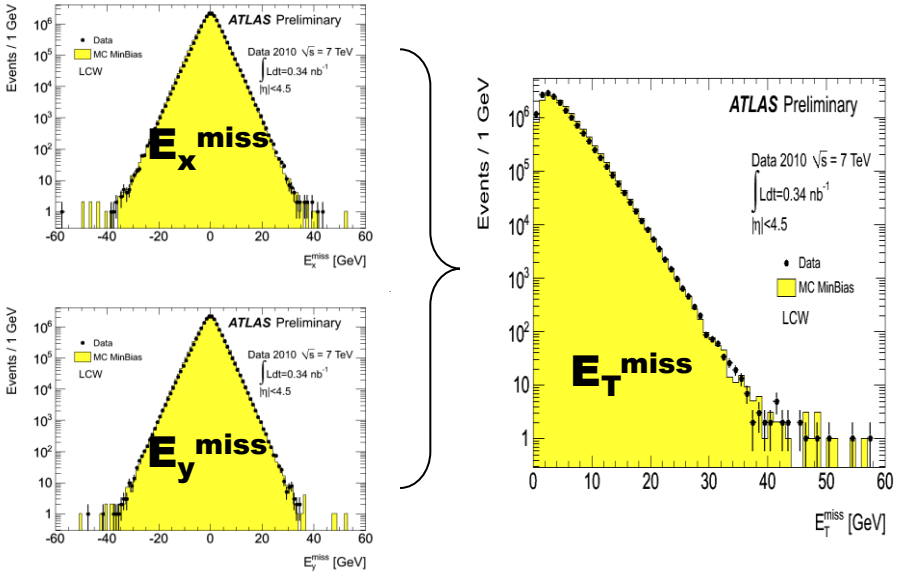
τ identification

- This topic will be extensively discussed by Yann Coadou in his talk on Wednesday

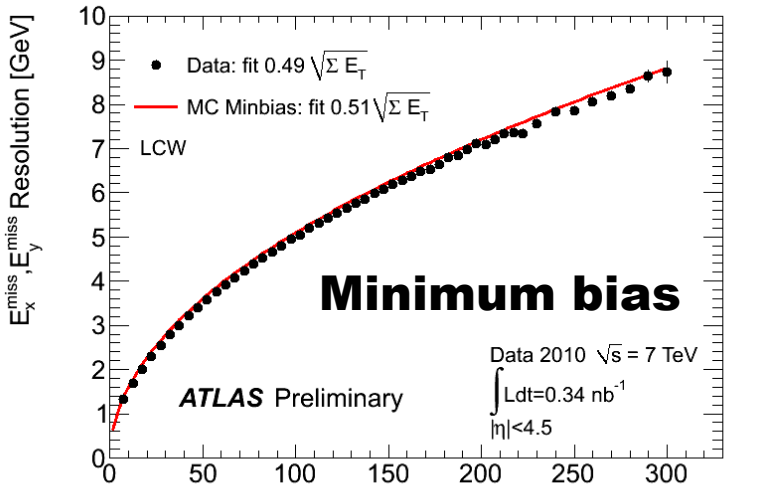


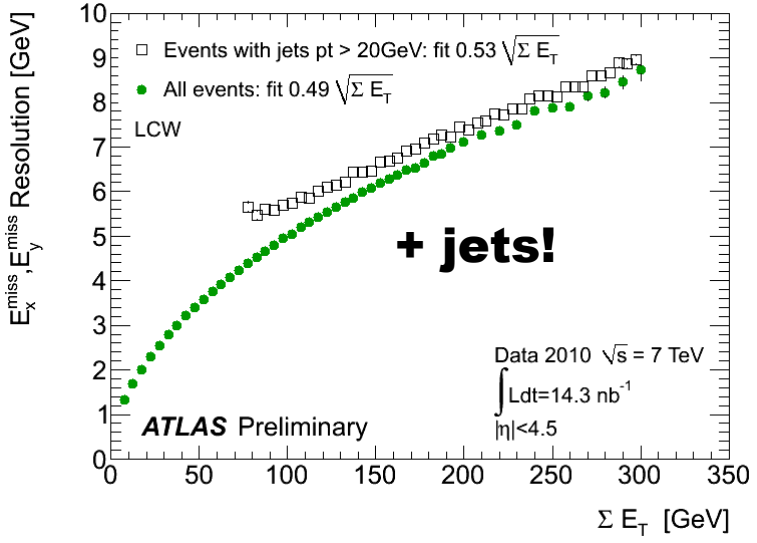
Missing E_T

- A complex object!
- Relative energy scales need careful intercalibration

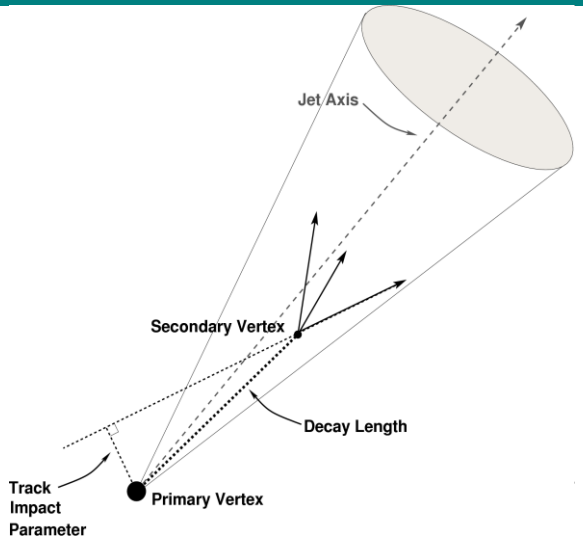


Detector hermeticity in minimum bias events

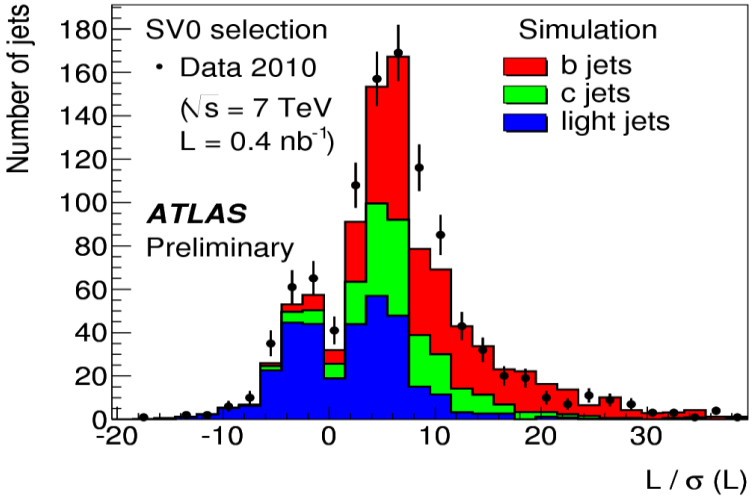


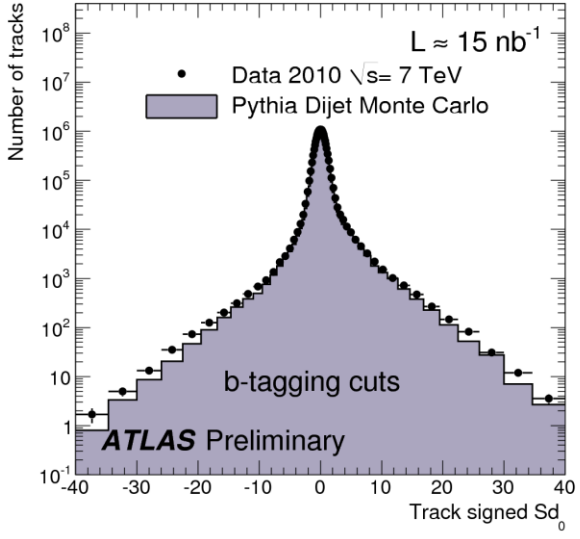


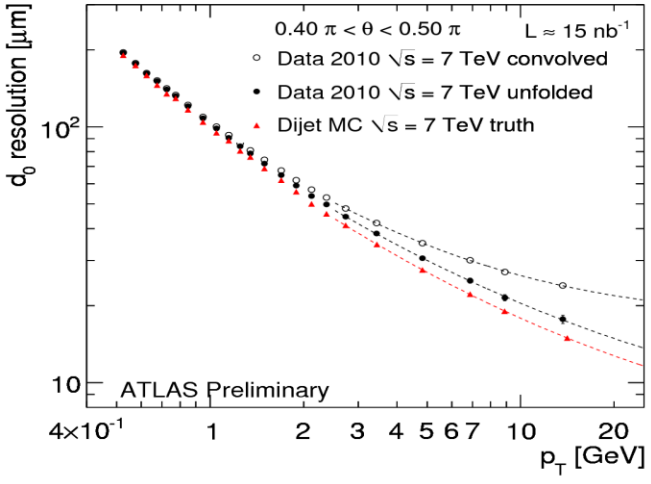
B-tagging



- SVO algorithm: looks at the signed distance between secondary and primary vertex







- Impact parameter significance: input to more sophisticated algorithms

First physics results

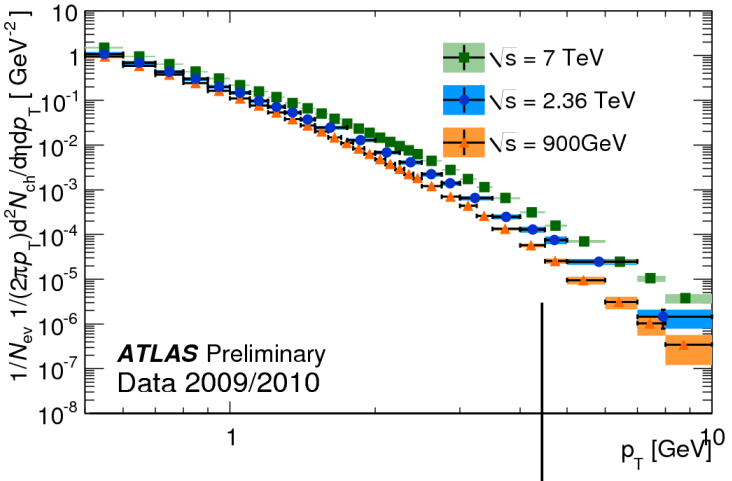
- ✓ Charged-particles multiplicities
- • Underlying event
- ✓ Jet production
- ✓ Low mass resonances:
  - JPsi differential cross-section and fraction from B
  - Upsilon observation in $\mu\mu$
- ✓ $W \rightarrow \ell \nu$ cross-section – see also Fabien Tarrade's talk on Wednesday
- ✓ $Z \rightarrow \ell\ell$ cross-section
- • Top observation – see Martin Flechl's talk on Wednesday
- ✓ Direct photon production

Searches for

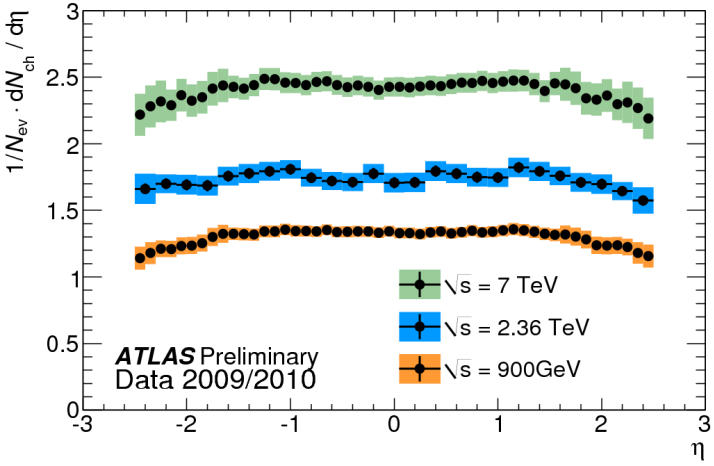
- ✓ New Particles in Two-Jet Final States
- ✓ W' (lepton+missing E_T)
- • Multi-body high mass final states
- • Deviations with respect to QCD angular distributions
- ✓ SUSY

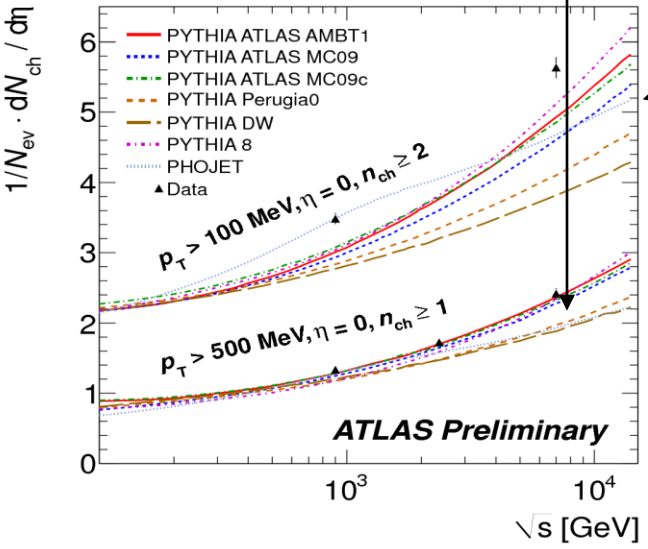
- *Not covered in this talk*

Charged particles multiplicities & spectra



p_T > 500 MeV
|η| <2.5
Events with ≥ 1 charged particle

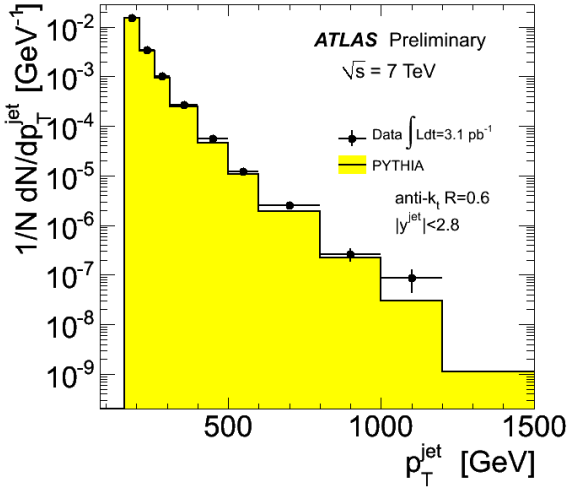


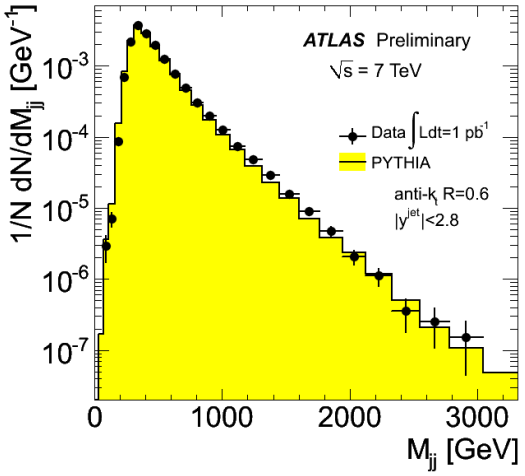


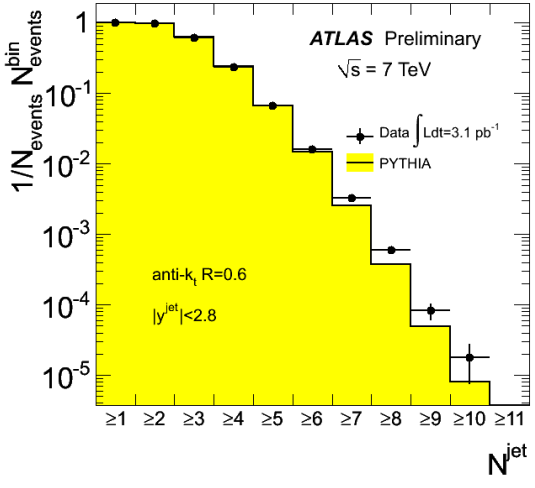
≥ 2 charged particles with p_T > 100 MeV, |η| <2.5

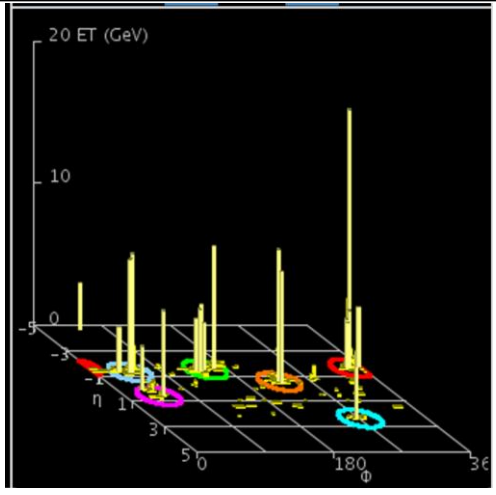
No subtraction for single/double diffractive components
❑ Distributions corrected back to hadron level
→ High-precision *minimally* model-dependent measurements
→ Provide strong constraints on MC models

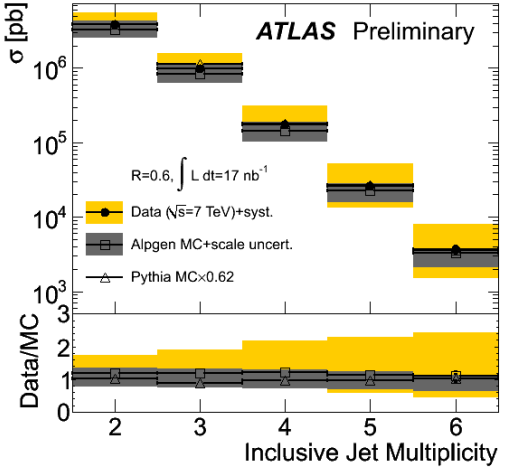
QCD: inclusive Jet distributions



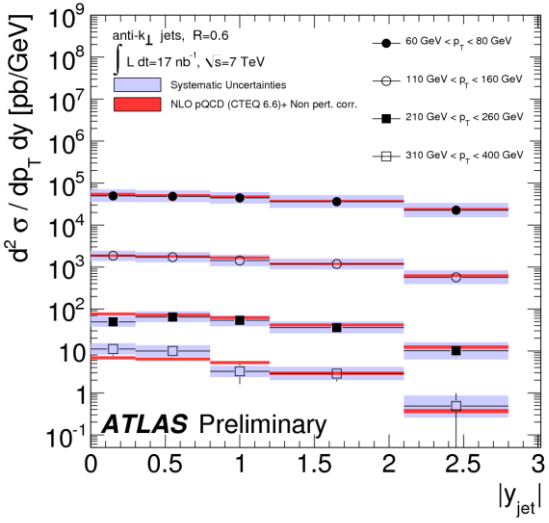


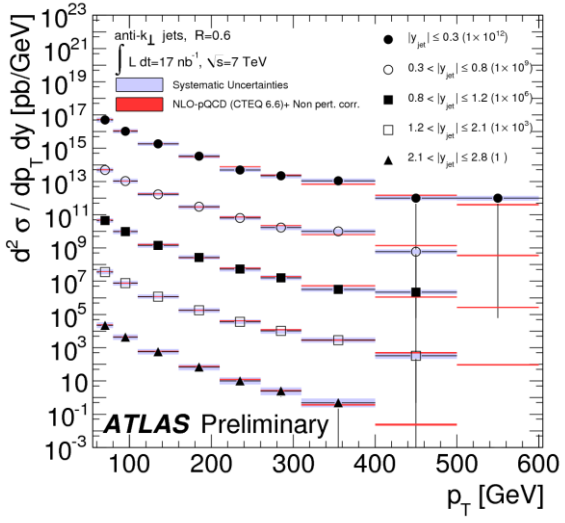


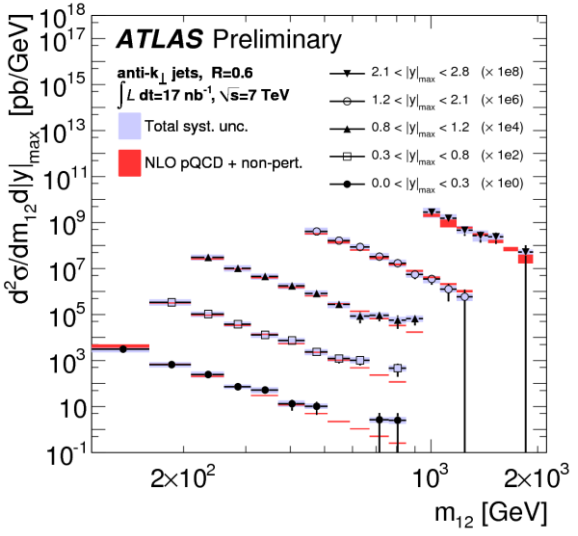




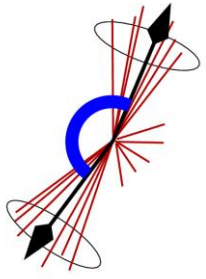
QCD cross-sections



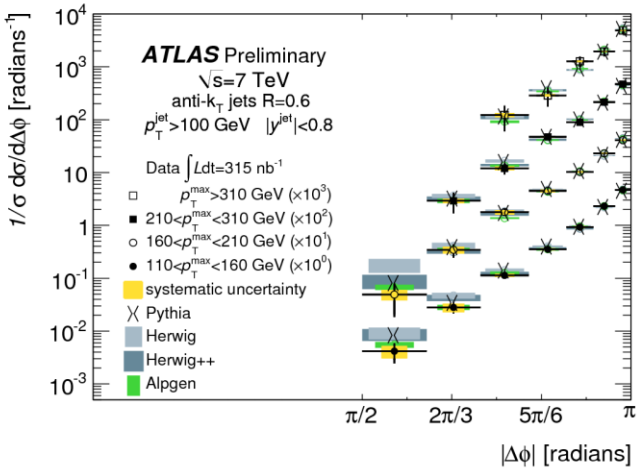




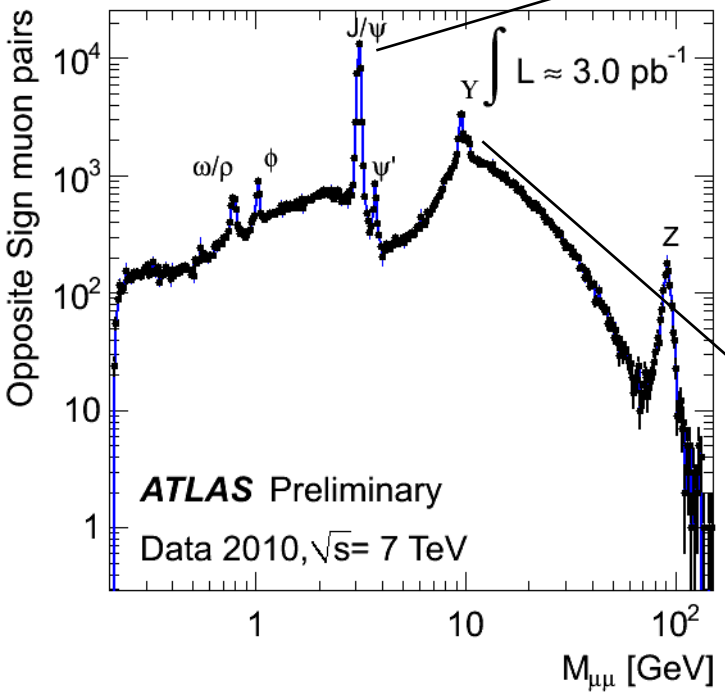
Double differential cross-sections in very good agreement with NLO predictions

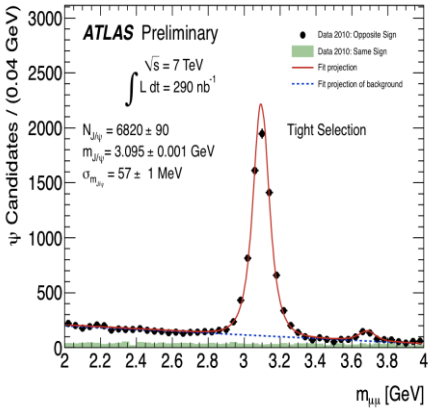


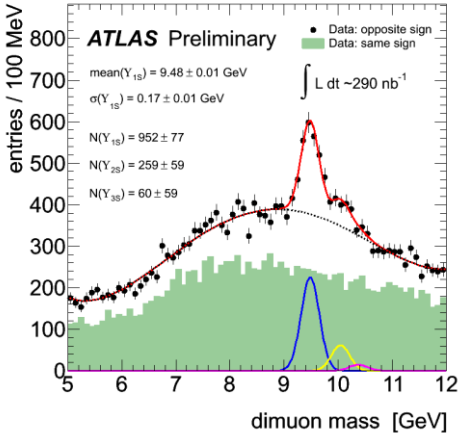
Soft radiation probed by di-jets angular decorrelation

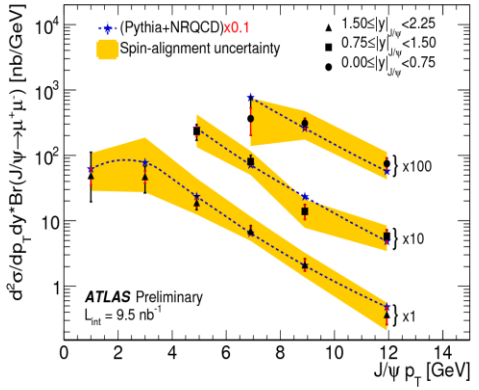


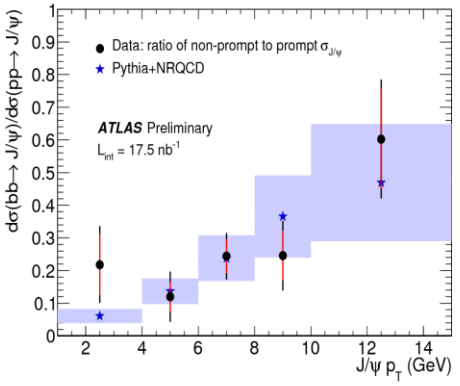
Dimuons


Opposite Sign muon pairs
J/ψ
ω/ρ
ϕ
ψ'
Υ
Z
∫ L ≈ 3.0 pb-1
ATLAS Preliminary
Data 2010, √s= 7 TeV
Mμμ [GeV]


ATLAS Preliminary
√s = 7 TeV
∫ L dt = 290 nb-1
Tight Selection
ψ Candidates / (0.04 GeV)
mμμ [GeV]

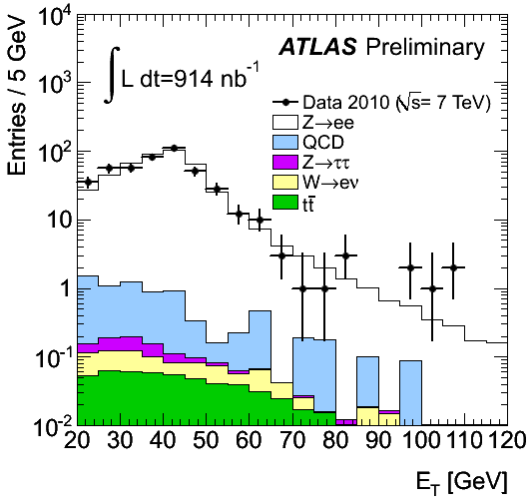

ATLAS Preliminary
Data: opposite sign
Data: same sign
∫ L dt ~290 nb-1
entries / 100 MeV
dimuon mass [GeV]

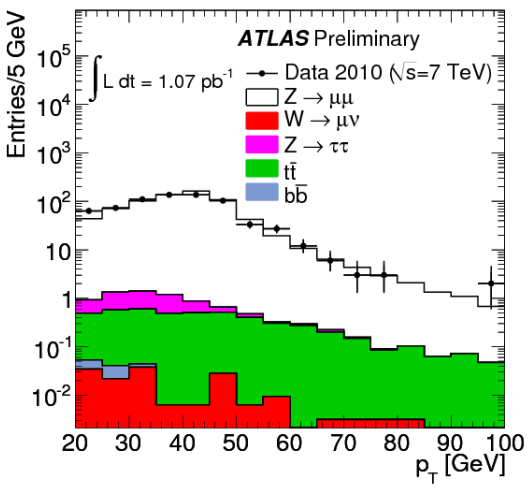

(Pythia+NRQCD)x0.1
Spin-alignment uncertainty
ATLAS Preliminary
Lint = 9.5 nb-1
x100
x10
x1
J/ψ pT [GeV]

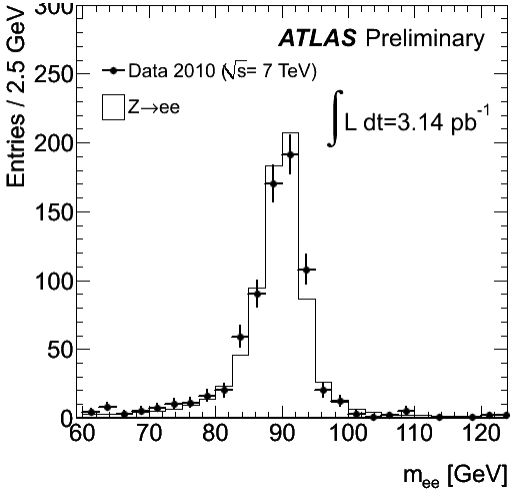

Data: ratio of non-prompt to prompt σJ/ψ
Pythia+NRQCD
ATLAS Preliminary
Lint = 17.5 nb-1
J/ψ pT (GeV)

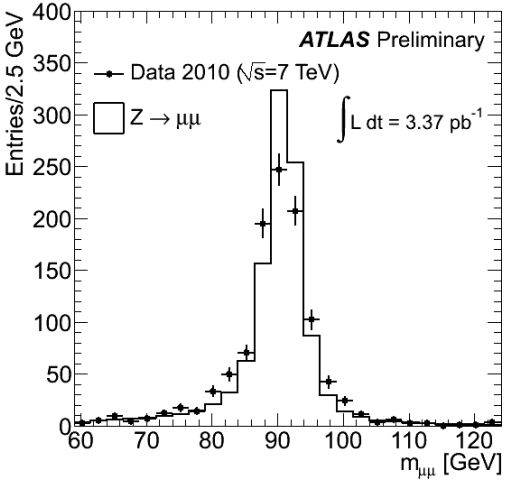
$Z \to \ell\ell$

	Electron channel	Muon channel
Trigger	**L1EM10**	**L1MU6**
Lepton ID	**Medium**	**Combined**
Isolation	**NO**	**Track based**
p_T or E_T cut [GeV]	**20**	**20**
Addtional cuts		**To reduce cosmics and in-flight decays**
Acceptance x efficiency	**~ 30%**	**~ 40%**
S/B	**~ 100**	**~ 100**

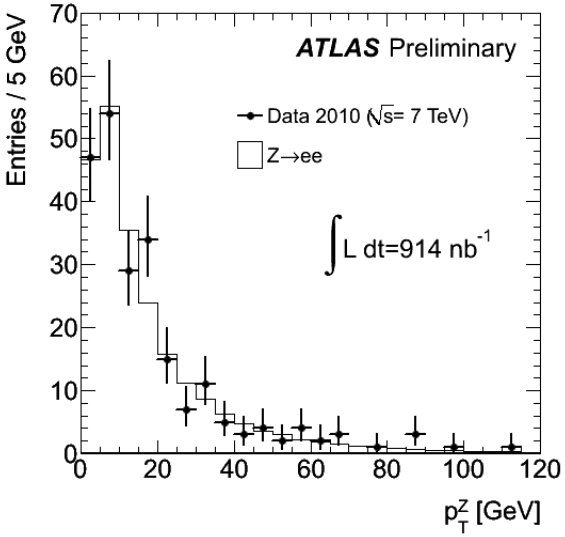


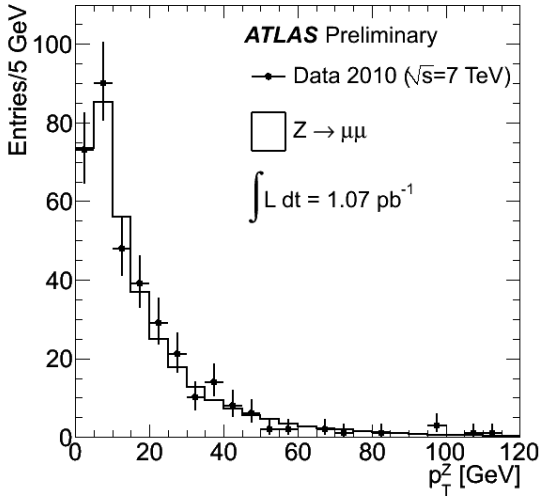






Z production

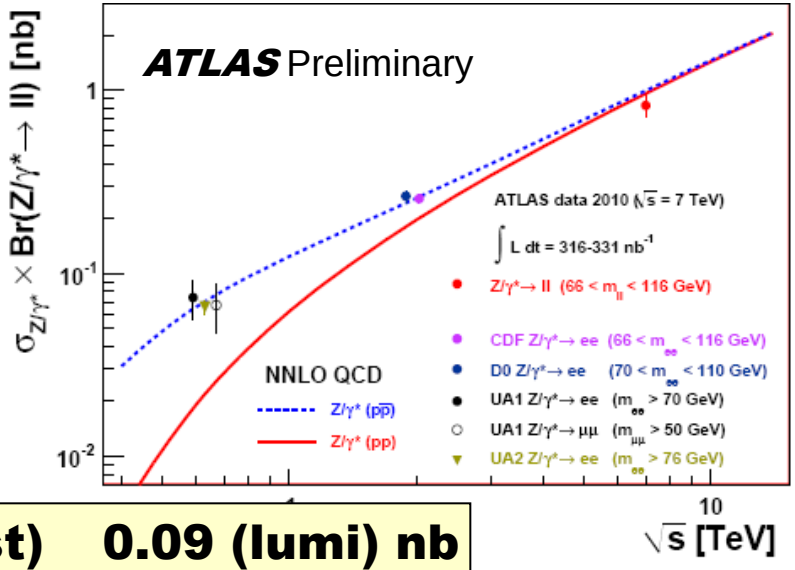




Mass window:
66 < *mℓ ℓ* < 116 GeV

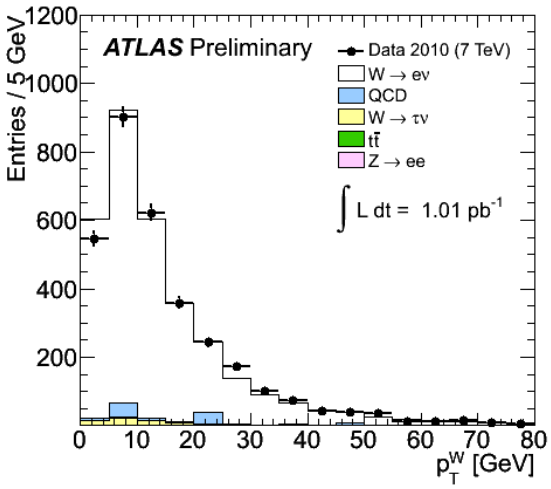
Cross-section:

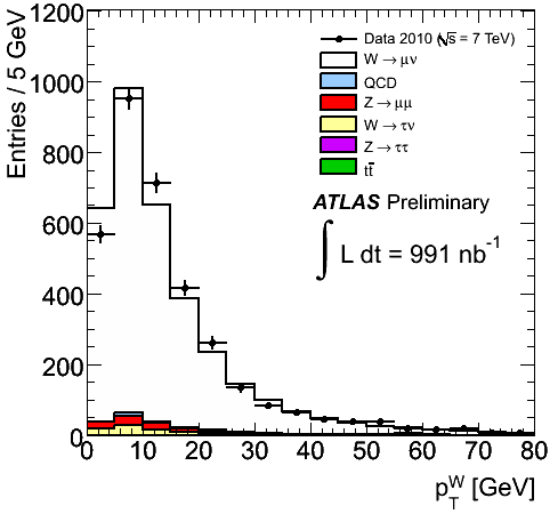
- Based on ~320 nb^{-1} (179 candidates in both cannels)
- Dominant experimental uncertainty from lepton reconstruction and identification



σ (γ*/Z→ ll) = 0.83 0.06 (stat) 0.04 (syst) 0.09 (lumi) nb

W production

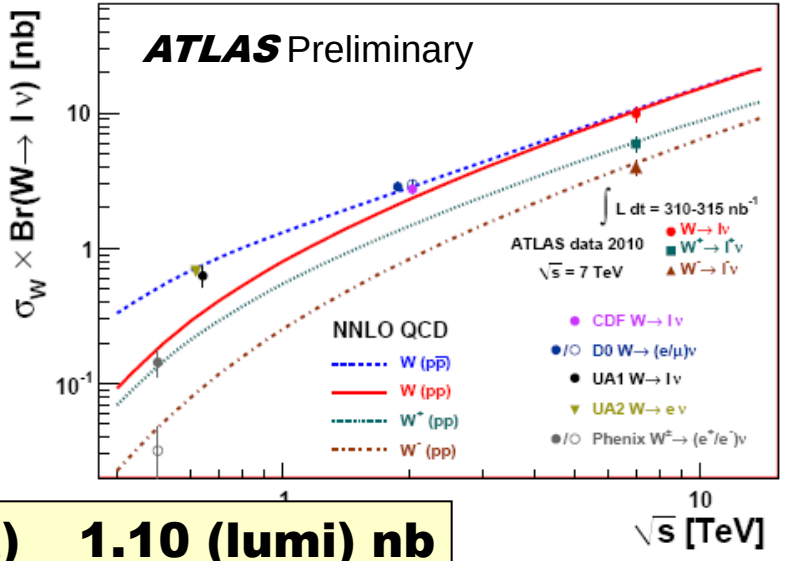




E_TMiss > 25 GeV and m_T > 40 GeV

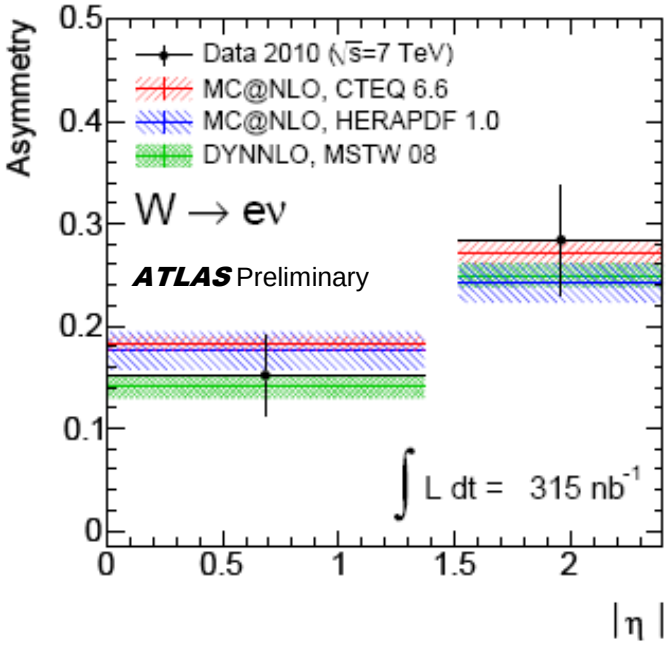
Cross-section:

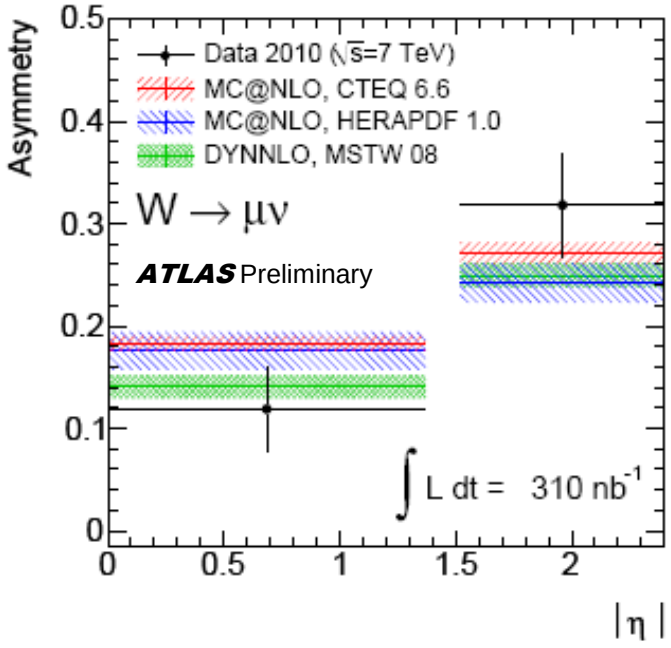
- Based on ~310 nb^{-1} (2250 candidates in both cannels)
- Dominant experimental uncertainty from lepton reconstruction and identification



σ (W→ ln) = 9.96 0.23 (stat) 0.50 (syst) 1.10 (lumi) nb

W asymmetry



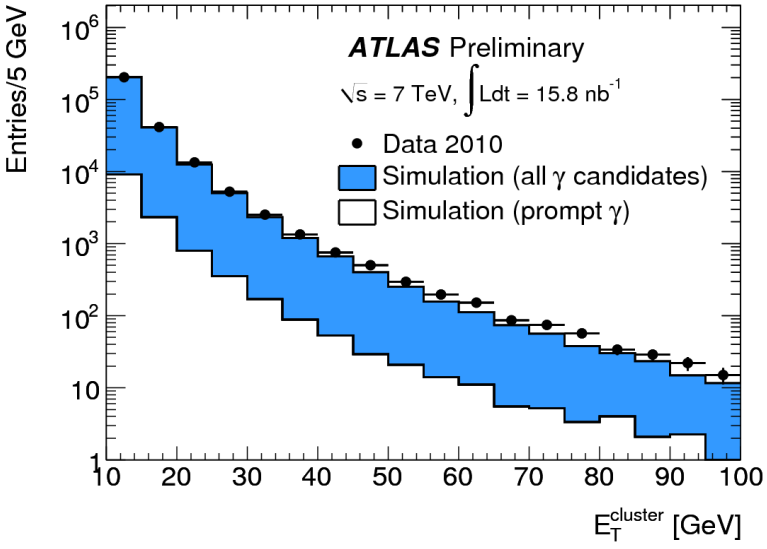


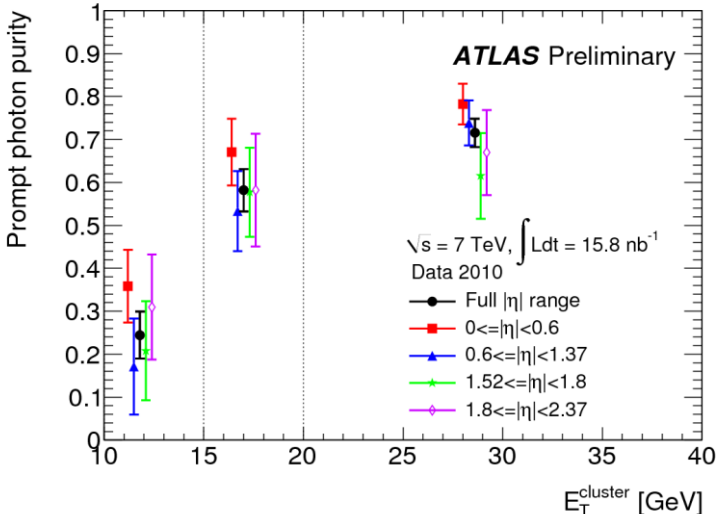
$$A = \frac{\sigma\,(W \to \ell^{+}\nu) - \sigma\,(W \to \ell^{-}\nu)}{\sigma\,(W \to \ell^{+}\nu) + \sigma\,(W \to \ell^{-}\nu)} \neq 0$$

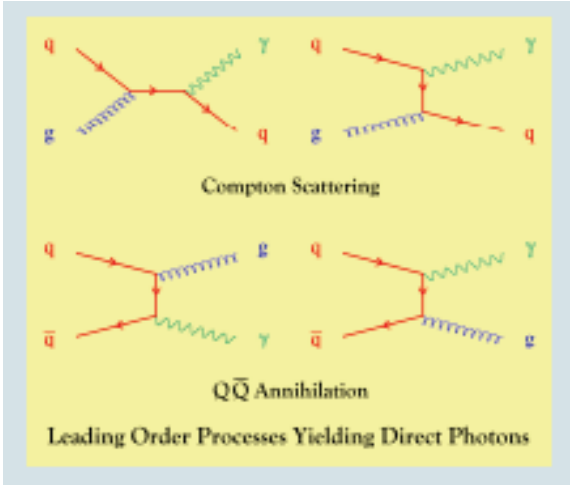
W+ and W- are produced at different rates and with different rapidities

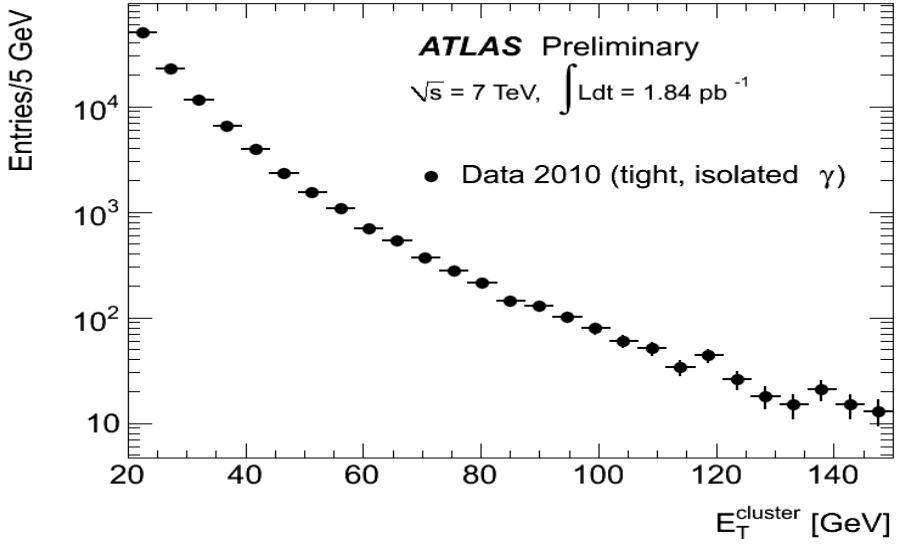
ATLAS measurement (300 nb^{-1}):
A = 0.200 0.022 (stat) 0.006 (syst)
NNLO theory prediction: A=0.2

Direct photons

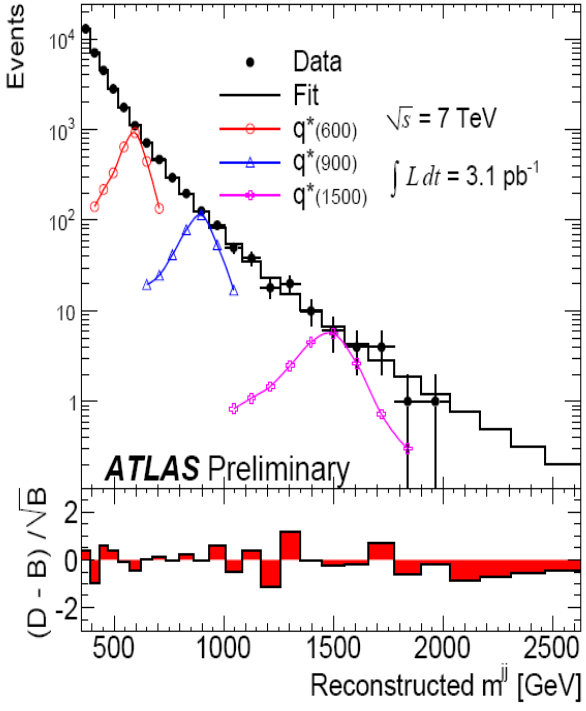




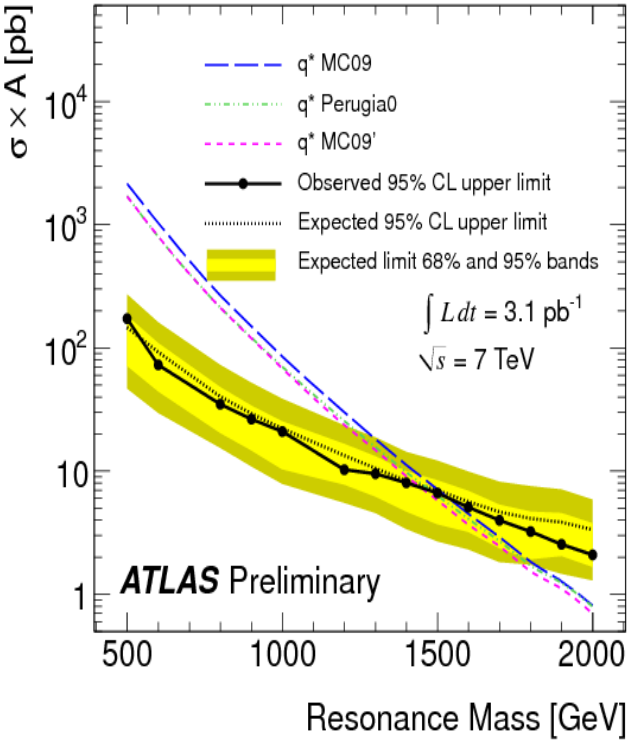




Searches:Dijet resonances

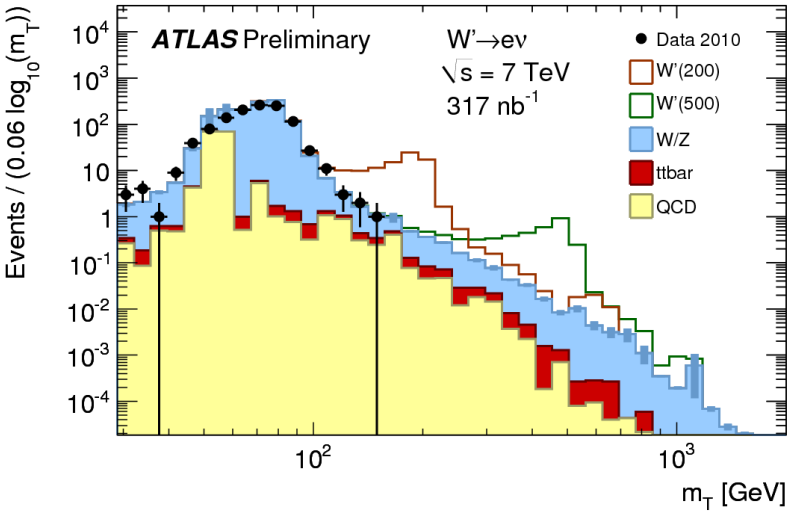


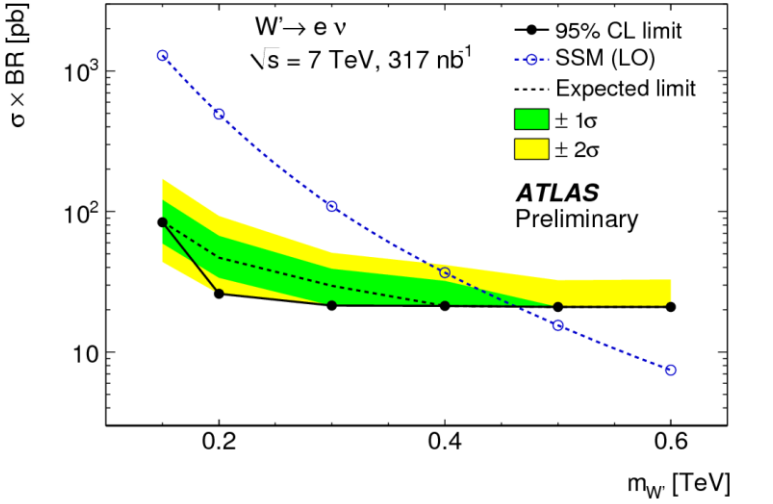
- Data is consistent with QDC
- With 315 nb^{-1} exclusion at 95% CL :
  - 0.4TeV<mq*<1.26TeV, ATLAS default MC settings with MRST2007 LO
  - 0.4TeV<mq*<1.20TeV, MC09' setting with CTEQ6L1
- First ATLAS search result that surpassed world's best limit
- Paper accepted by PRL [arXiv:1008.2461]



Analysis updated to 3.1 pb^{-1}:
the observed limit moves from 1.26 TeV to 1.53 TeV.

Searches: lepton+missing E_T

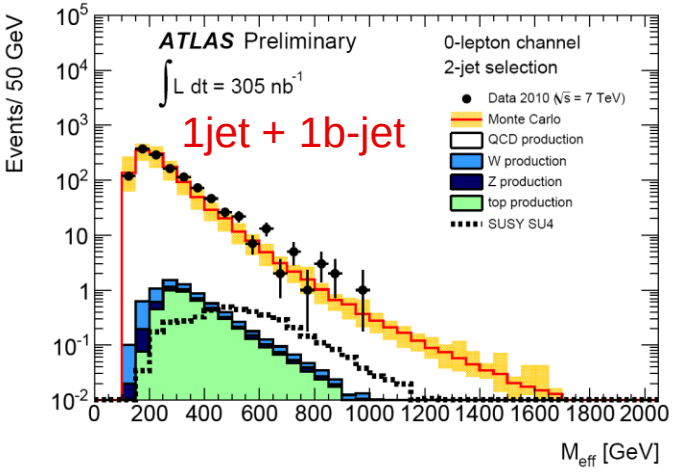


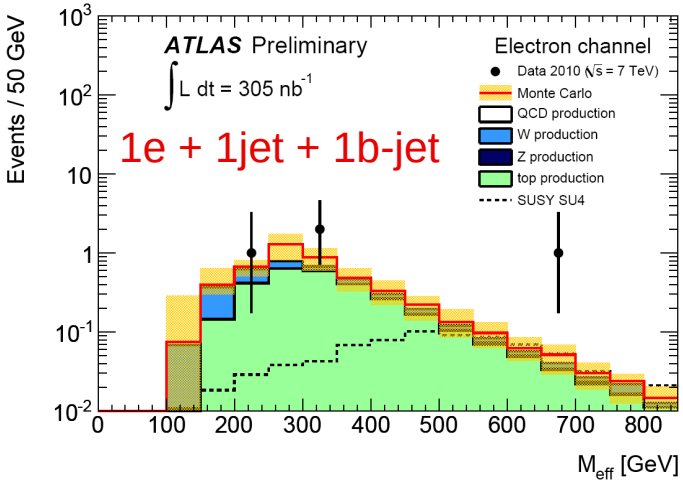


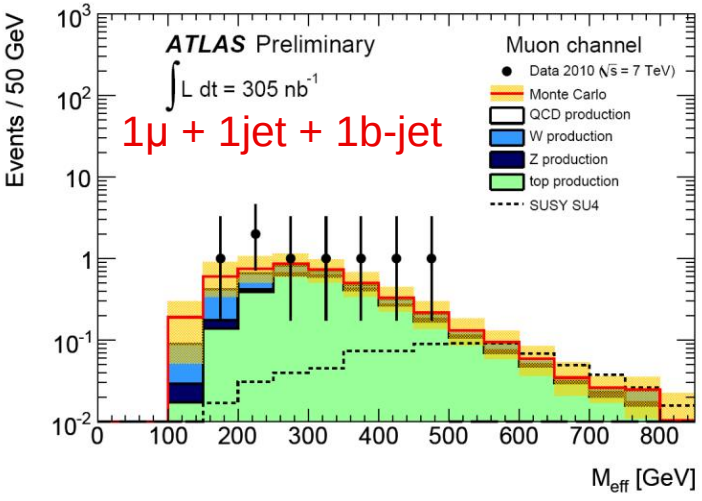
- electron + MET.
- Data is Consistent with SM predictions.
- Current limit that can be set (electrons) 465GeV for SSM W'.
- Current results support estimations from previous MC sensitivity studies.

SUSY searches

- current LHC dataset: no sensitivity to unexplored regions yet
- SUSY analyses rather background studies at this stage
- Many inclusive channels under investigation
- Examples: b-jets+missing E_T

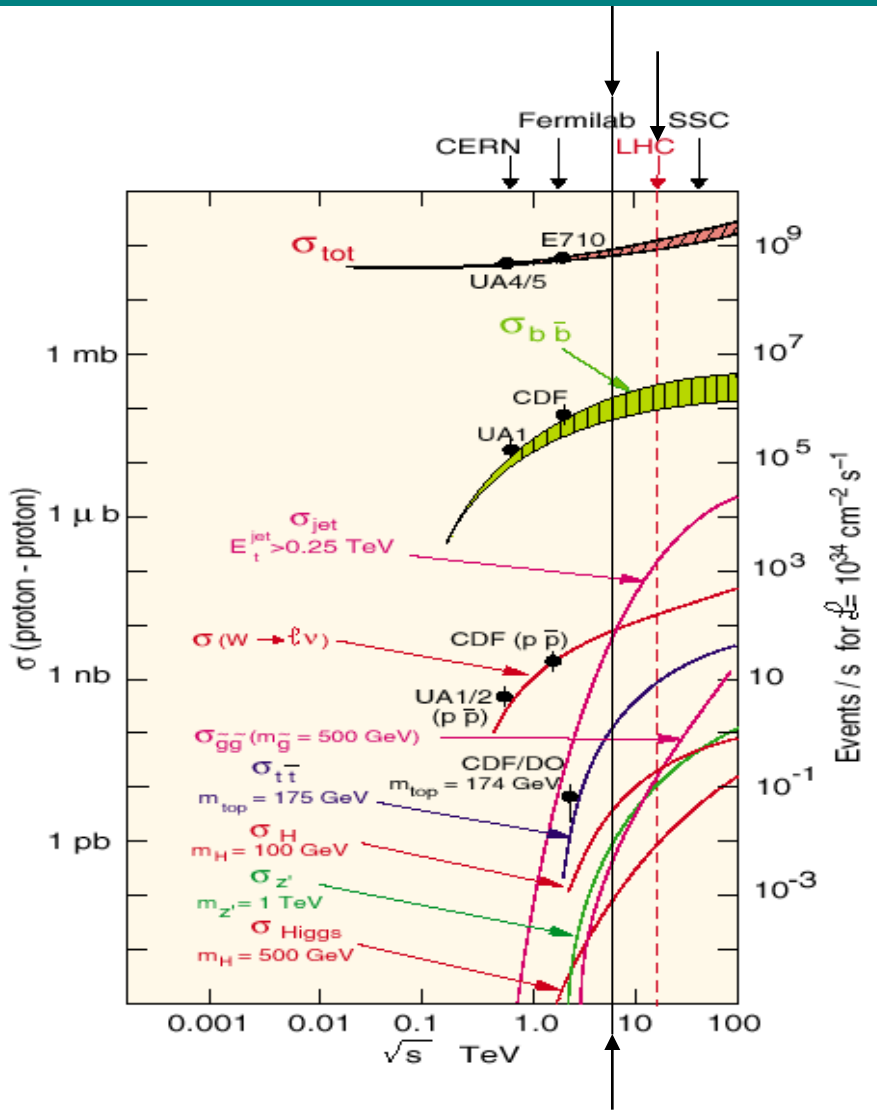






Conclusions

- LHC operation at 7 TeV is proceeding smoothly
- More than 4 pb^{-1} have been integrated in ATLAS since March 30



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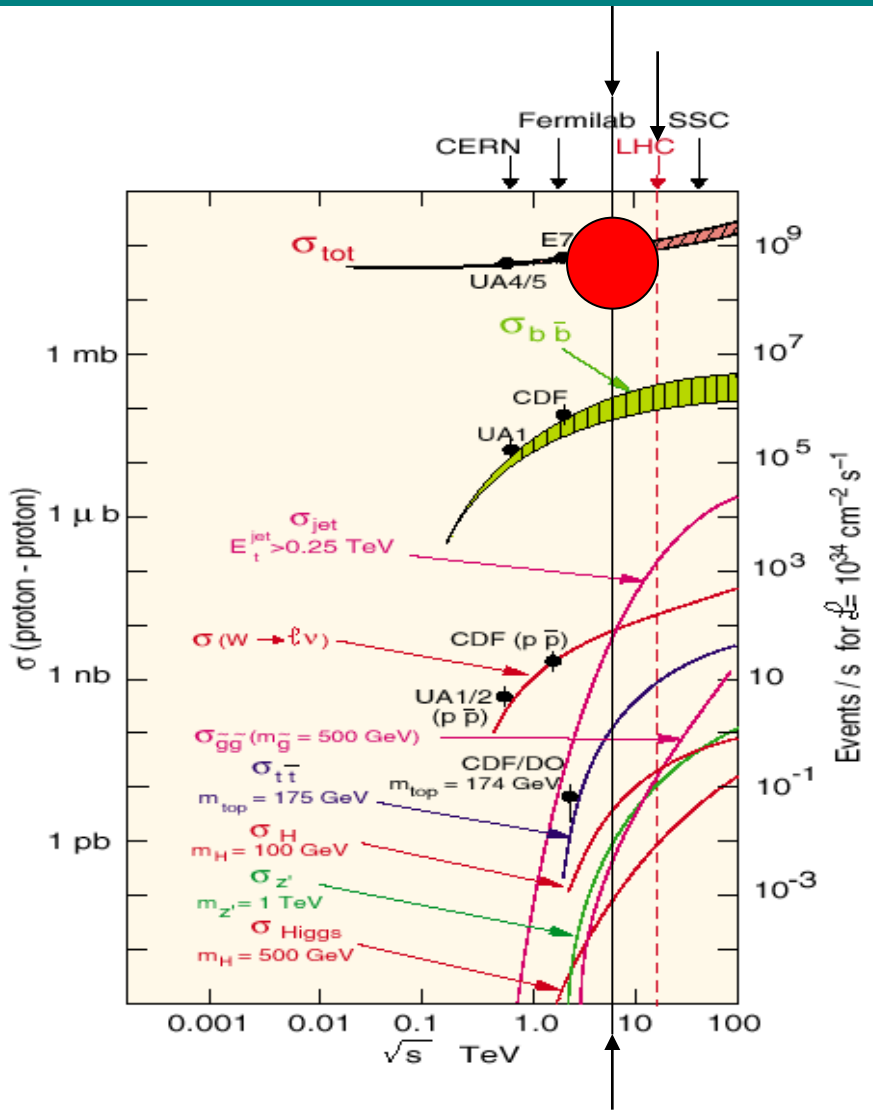
- ATLAS results cover
  - Minimum bias



Conclusions

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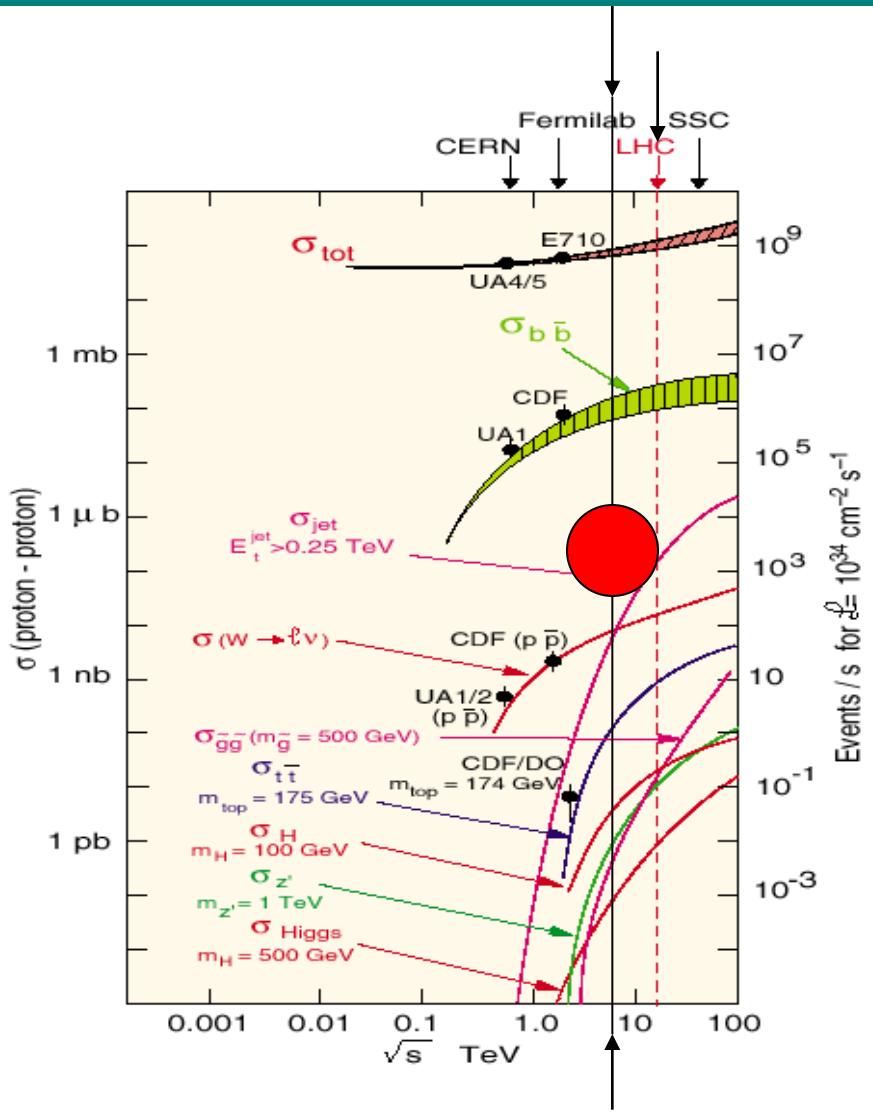

Conclusions

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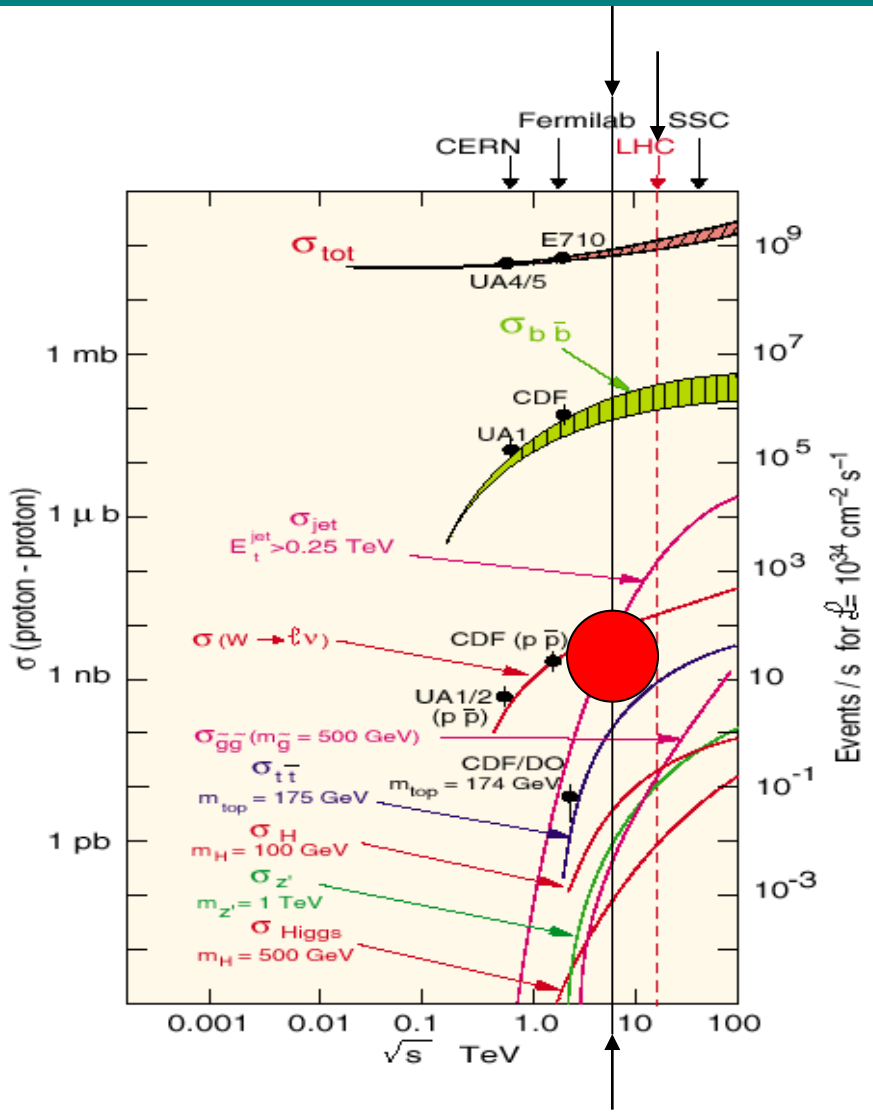
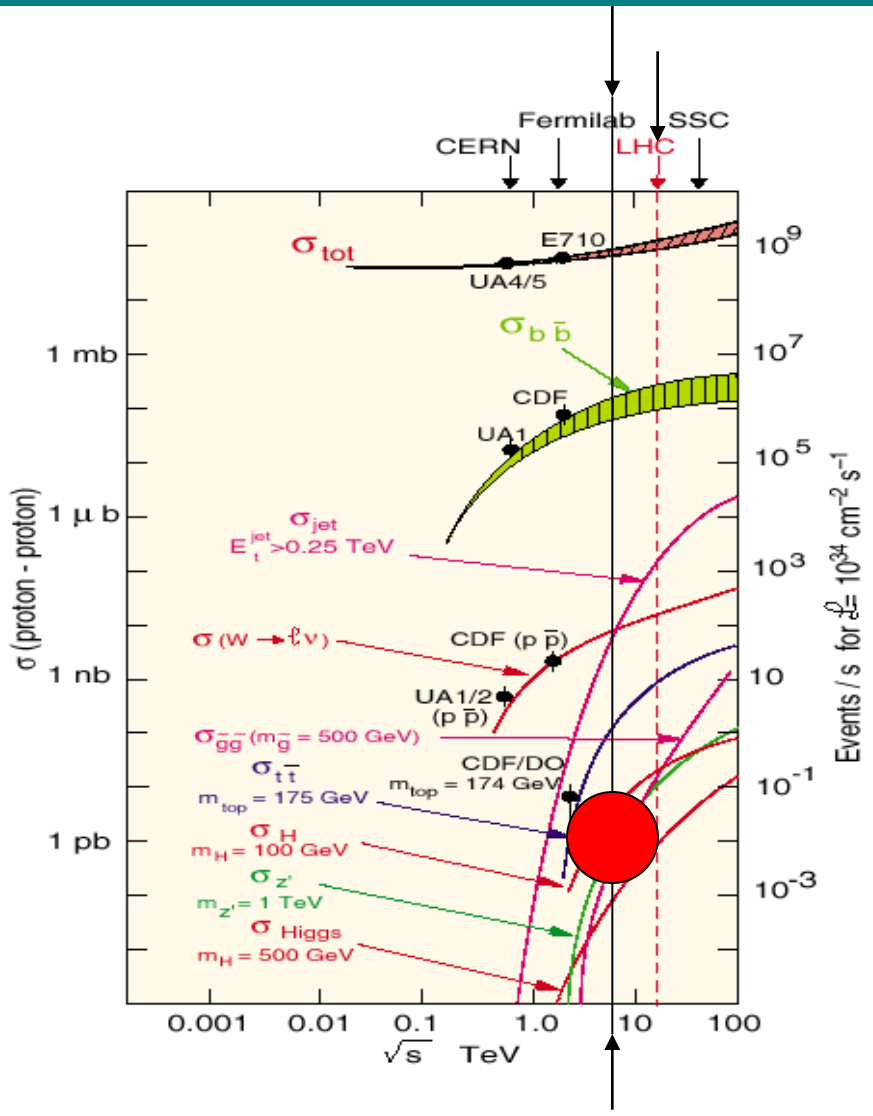
  - Jet production
  - EW bosons



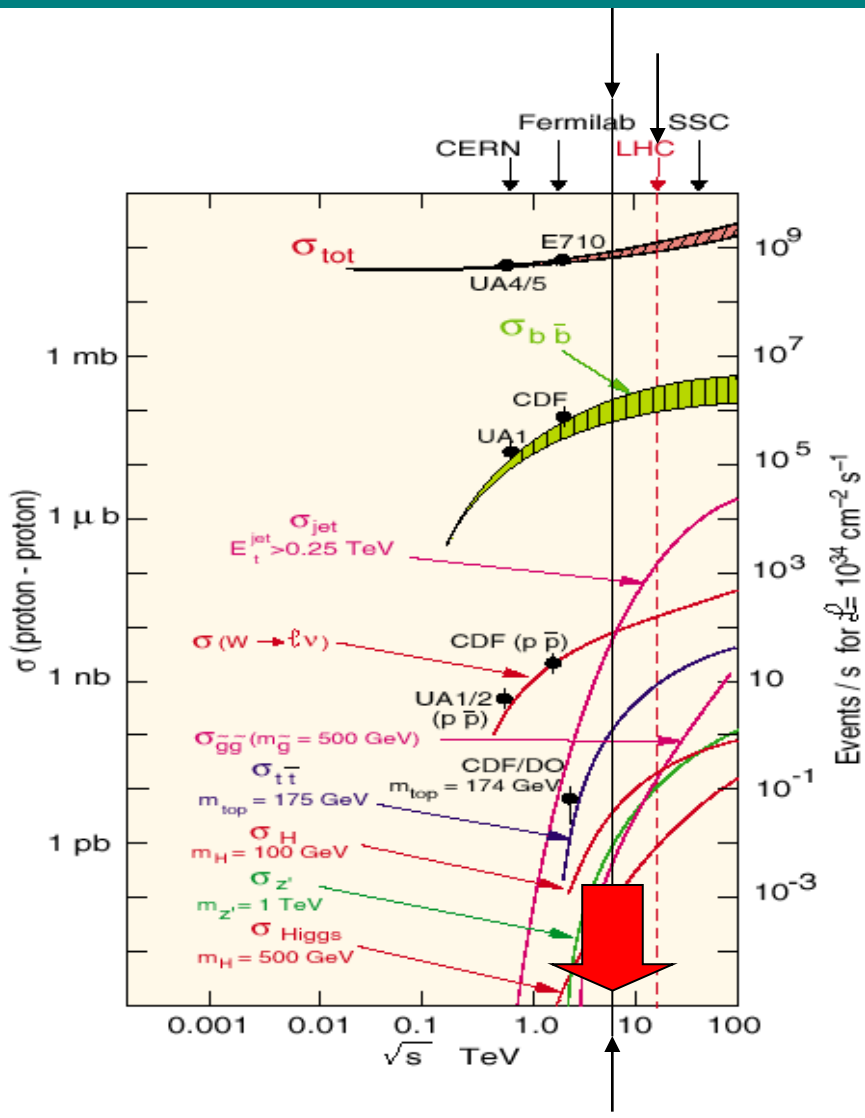
Conclusions

- LHC operation at 7 TeV is proceeding smoothly
- More than 4 pb^{-1} have been integrated in ATLAS since March 30
- ATLAS results cover
  - Minimum bias
  - Jet production
  - EW bosons
  - Top observation



Conclusions

- LHC operation at 7 TeV is proceeding smoothly
- More than 4 pb^{-1} have been integrated in ATLAS since March 30
- ATLAS first results cover
  - Minimum bias
  - Jet production
  - EW bosons
  - Top observation
- Expect many more to come in next months!



References

- Publications:
  - Charged-particle multiplicities in pp interactions at sqrt(s) = 900 GeV measured with the ATLAS detector at the LHC Phys Lett B **688**, Issue 1, 21-42, CERN-PH-EP/2010-004 (15 March 2010)
  - Performance of the ATLAS Detector using First Collision Data Spires record accepted by JHEP (submitted 28 May 2010)
  - Search for New Particles in Two-Jet Final States in 7 TeV Proton-Proton Collisions with the ATLAS Detector at the LHC Spires record accepted by PRL (submitted 14 Aug 2010)

- ATLAS results page:

https://twiki.cern.ch/twiki/bin/view/Atlas/AtlasResults

- Conference notes:

http://cdsweb.cern.ch/collection/ATLAS%20Conference%20Notes?ln=en

Conference notes on physics results:

ATLAS-CONF-2010-077 *Evidence for prompt photon production in pp collisions at* √s=7 TeV *with the ATLAS detector*

ATLAS-CONF-2010-073 Observation of inclusive electrons in the ATLAS experiment at √s=7 TeV

- **Soft QCD**

ATLAS-CONF-2010-024 Charged-particle Multiplicities in pp Interactions at √s=7 TeV Measured with the ATLAS Detector at LHC

ATLAS-CONF-2010-029 Track-based Underlying Event Measurements in pp Collisions at √s=0.9 TeV and 7 TeV with the ATLAS Detector at LHC

ATLAS-CONF-2010-031 Charged-particle Multiplicities in pp Interactions at √s=0.9 TeV and 7 TeV in a Diffractive-limited Phase Space Measured with the ATLAS detector at LHC and a New PYTHIA6 Tune

ATLAS-CONF-2010-046 Charged particle multiplicities in pp interactions for track PT > 100 MeV at √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 √s=2.36 TeV measured with the ATLAS detector at the LHC

ATLAS-CONF-2010-048 Studies of Diffractive Enhanced Minimum Bias Events in ATLAS

ATLAS-CONF-2010-081 Track-based underlying event measurements in pp collisions at √s= 900 GeV and 7 TeV with the ATLAS Detector at the LHC

ATLAS-CONF-2010-082 Angular correlations between charged particles from proton-proton collisions at sqrt(s) = 900 GeV and sqrt(s) = 7 TeV measured with ATLAS detector

Conference notes on physics results:

- **Jet Physics**

ATLAS-CONF-2010-043 Observation of Energetic Jets in pp Collisions at √s=7 TeV using the ATLAS Experiment at the LHC

ATLAS-CONF-2010-049 Measurement of differential cross section and fragmentation of jets from tracks in proton-proton collisions at centre-of-mass energy √s=7 TeV with the ATLAS detector

ATLAS-CONF-2010-050 Measurement of jet production in proton-proton collisions at 7 TeV centre-of-mass energy with the ATLAS Detector

ATLAS-CONF-2010-083 Azimuthal Decorrelations in Dijet Events at sqrt(s)=7 TeV

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

ATLAS-CONF-2010-085 Measurement of dijet production with a jet veto in pp collisions at sqrt(s) = 7 TeV using the ATLAS detector

- **W/Z Signatures**

ATLAS-CONF-2010-044 Observation of W → *l* ν and Z → *ll* Production in proton-proton Collisions at √s=7 TeV with the ATLAS Detector

ATLAS-CONF-2010-051 Measurement of the W → *l* ν production cross-section and observation of Z → *ll* production in proton-proton collisions at √s=7 TeV with the ATLAS detector

ATLAS-CONF-2010-076 Measurement of the Z → *ll* production cross section in proton-proton collisions at √s=7 TeV with the ATLAS detector

Conference notes on physics results:

- **B Physics**

ATLAS-CONF-2010-045 First observation of the J/psi->mumu resonance

ATLAS-CONF-2010-062 Measurement of the J/psi->mumu differential cross section and fraction from B-decays

- **SUSY**

ATLAS-CONF-2010-065 Early supersymmetry searches in channels with jets and missing transverse momentum with the ATLAS detector

ATLAS-CONF-2010-066 Early SUSY searches in events with one or more isolated leptons, jets and missing transverse energy

ATLAS-CONF-2010-071 Background studies to searches for long-lived stopped particles decaying out-of-time with LHC collisions

ATLAS-CONF-2010-079 Early supersymmetry searches in events with missing transverse energy and b-jets with the ATLAS detector

- **Exotics**

ATLAS-CONF-2010-074 High-pT dijet angular distributions in pp interactions at $\sqrt{s}$=7 TeV

ATLAS-CONF-2010-080 Search for new particles decaying into dijets in proton-proton collisions at $\sqrt{s}$=7 TeV

ATLAS-CONF-2010-088 Search for new physics in multi-body final states at high invariant masses with ATLAS

ATLAS-CONF-2010-089 Search for high-mass states with electron plus missing transverse energy using the ATLAS Detector at $\sqrt{s}$=7 TeV