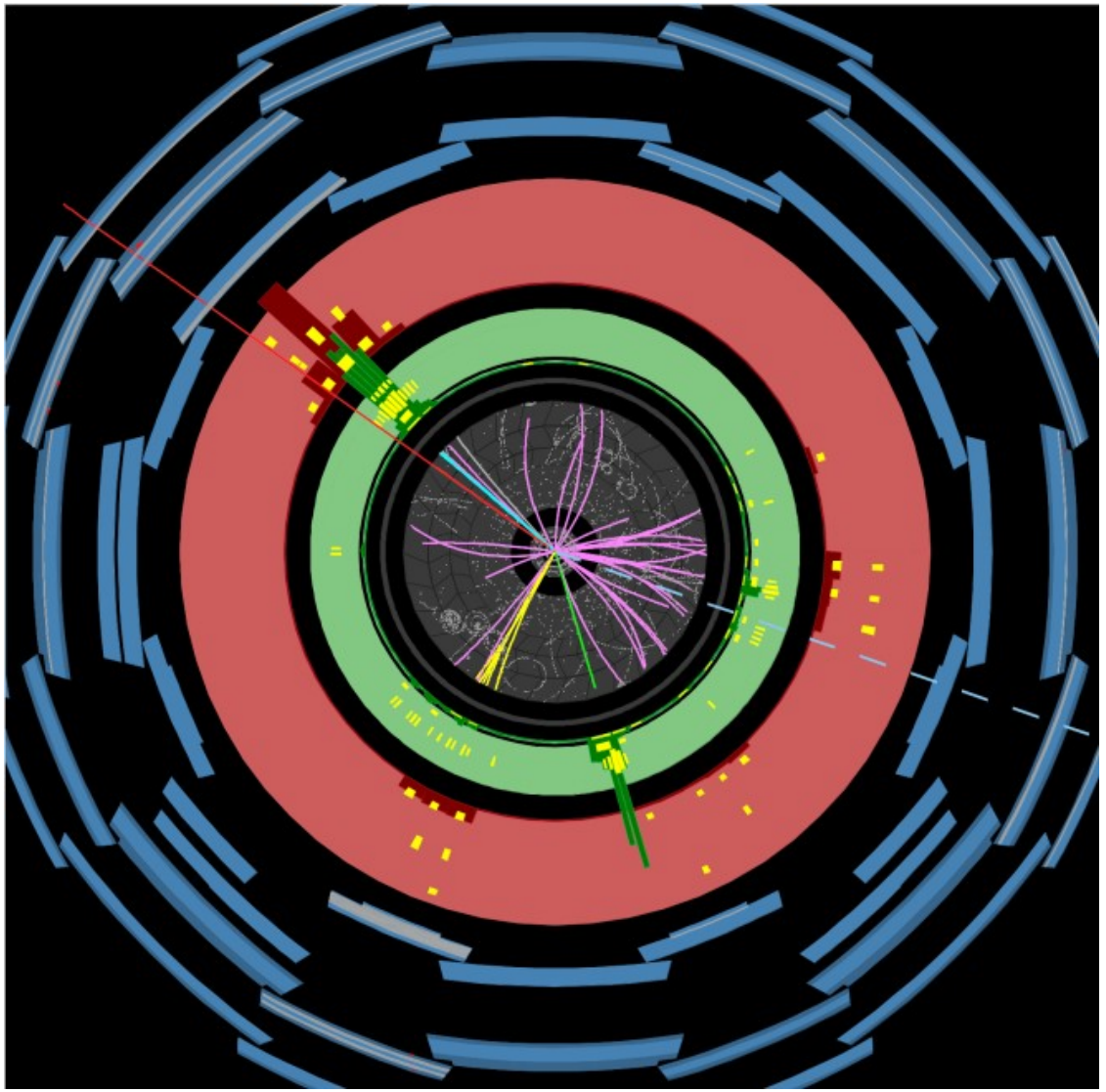
ATLAS Status and New Physics Searches



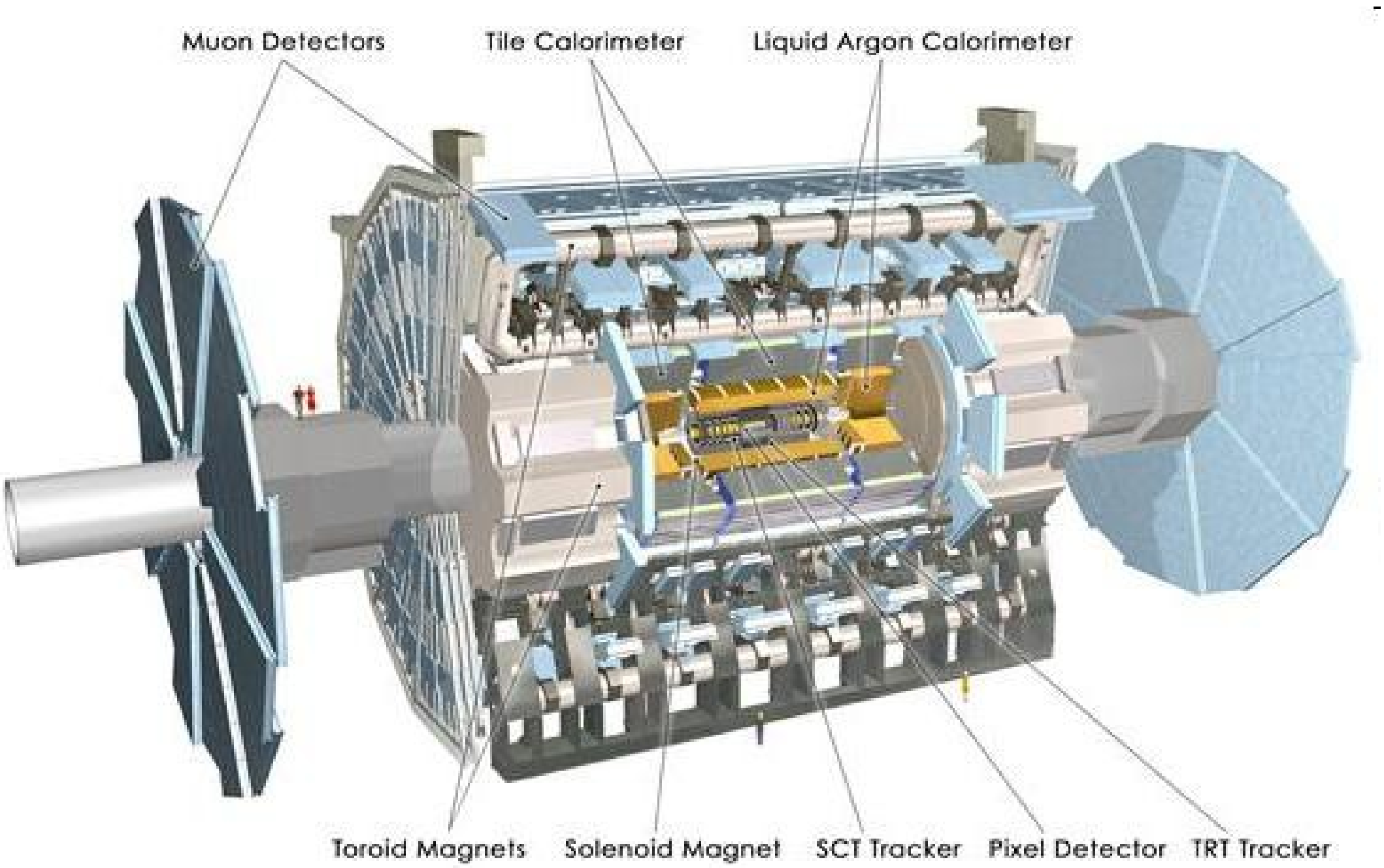
Andy Haas
SLAC

Topologies'10 Workshop
@ SLAC

September 23, 2010

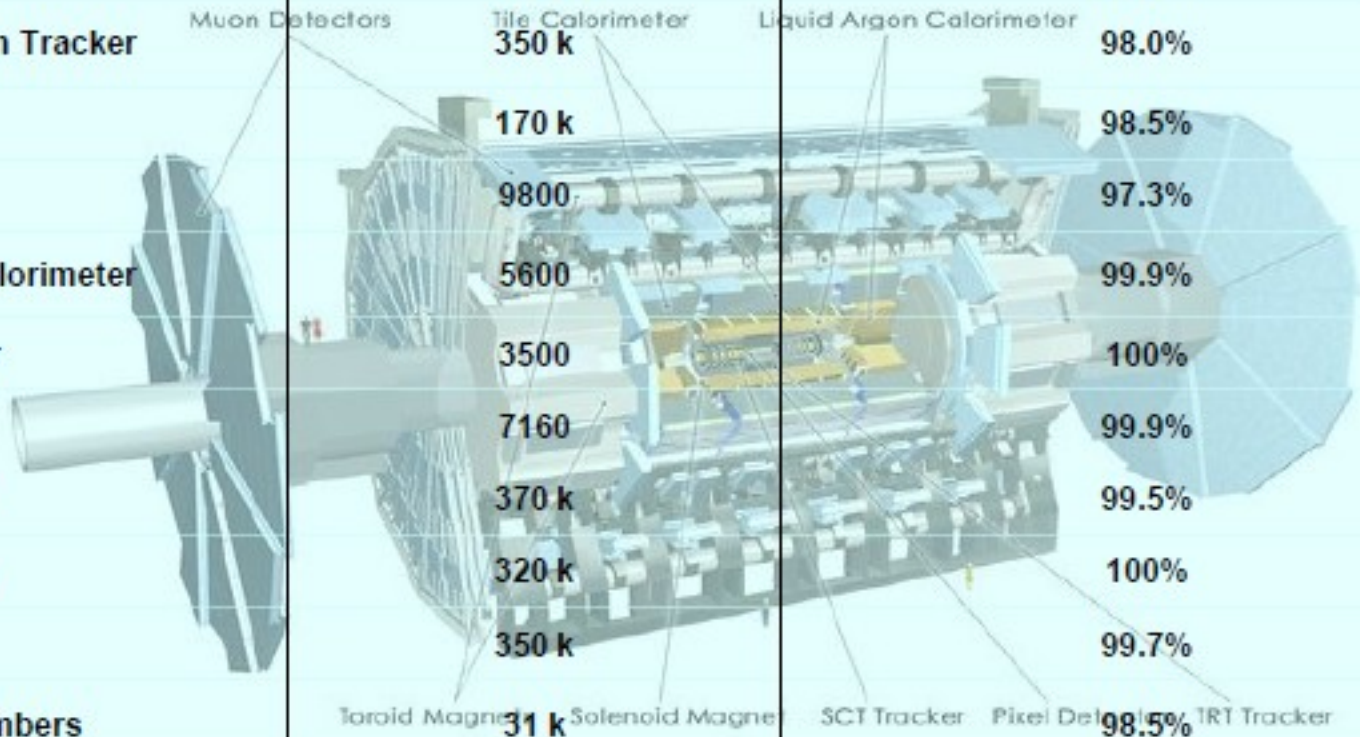
SLAC NATIONAL ACCELERATOR LABORATORY

ATLAS Detector



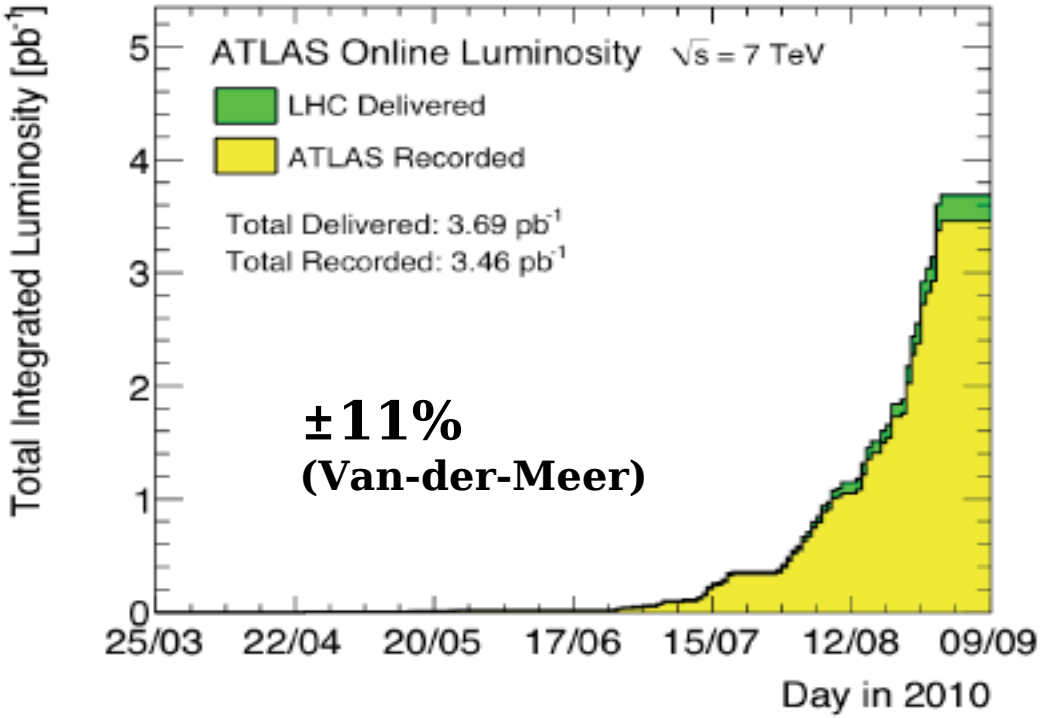
ATLAS Detector

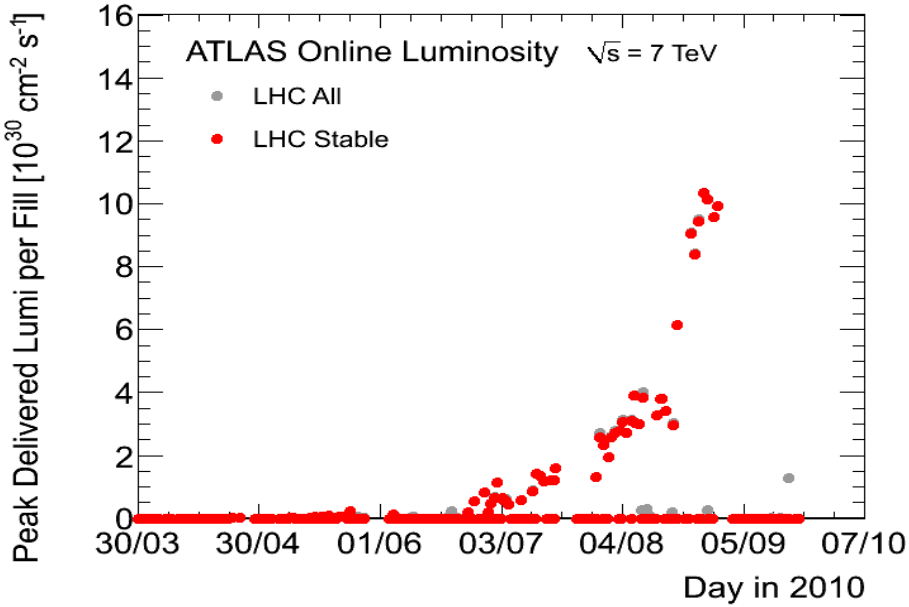
Subdetector	Number of Channels	Approximate Operational Fraction
Pixels	80 M	97.4%
SCT Silicon Strips	6.3 M	99.2%
TRT Transition Radiation Tracker	350 k	98.0%
LAr EM Calorimeter	170 k	98.5%
Tile calorimeter	9800	97.3%
Hadronic endcap LAr calorimeter	5600	99.9%
Forward LAr calorimeter	3500	100%
LVL1 Calo 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 7 TeV Data

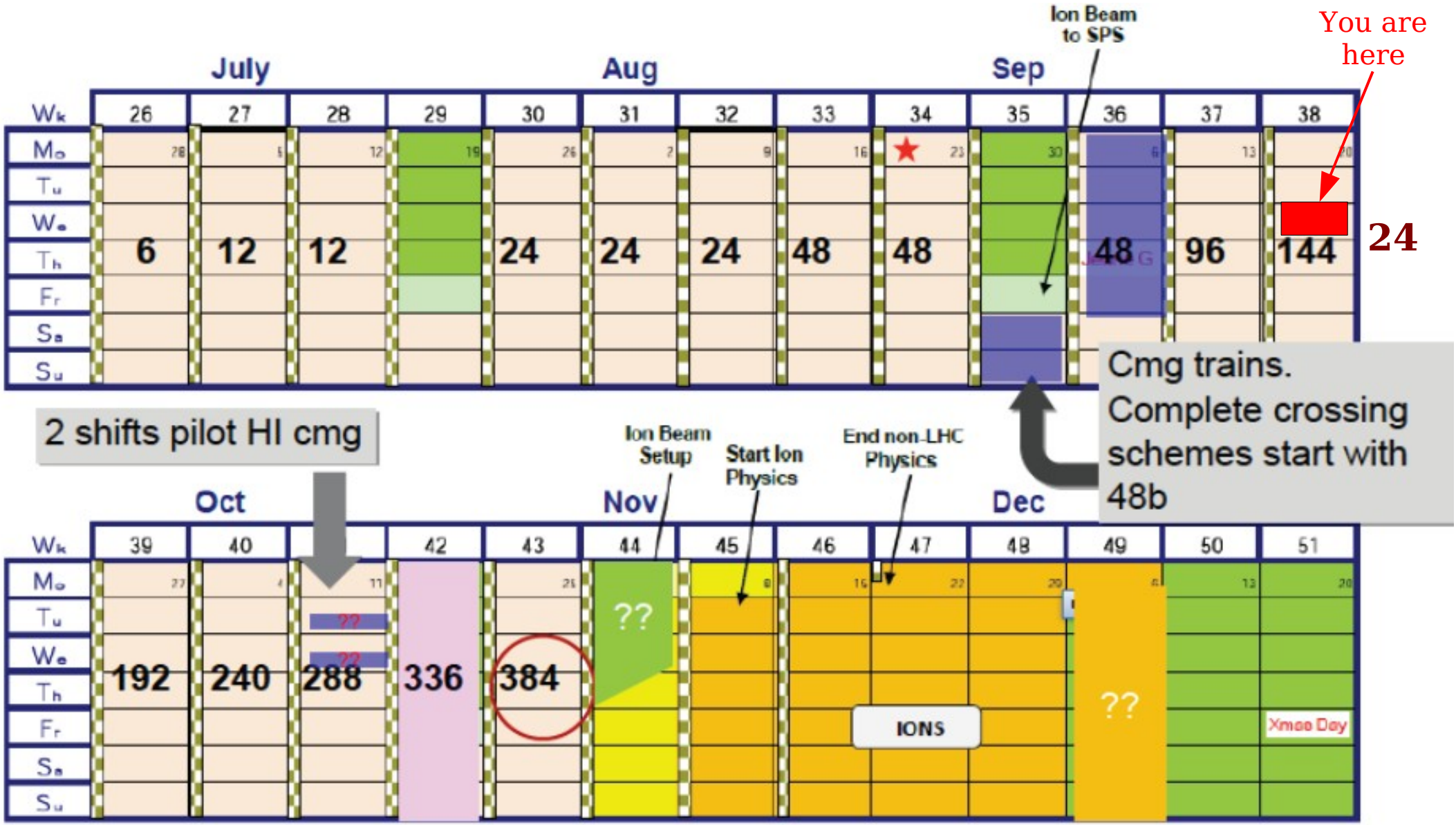
- Several pb^{-1} recorded
  - 100's of tops
  - 1000's of Z's
  - 10000's of W's
- ATLAS average data taking efficiency already ~90%
  - Comparable to D0/CDF
- Peak inst. lumi ~10/μb/s
  - $x10^7$ s/y = 100/pb/y
- Trying to get to ~100/μb/s by the end of the year (end of October)
  - 1/fb/y (basic plan for 2011)
  - "Just" increase N bunches



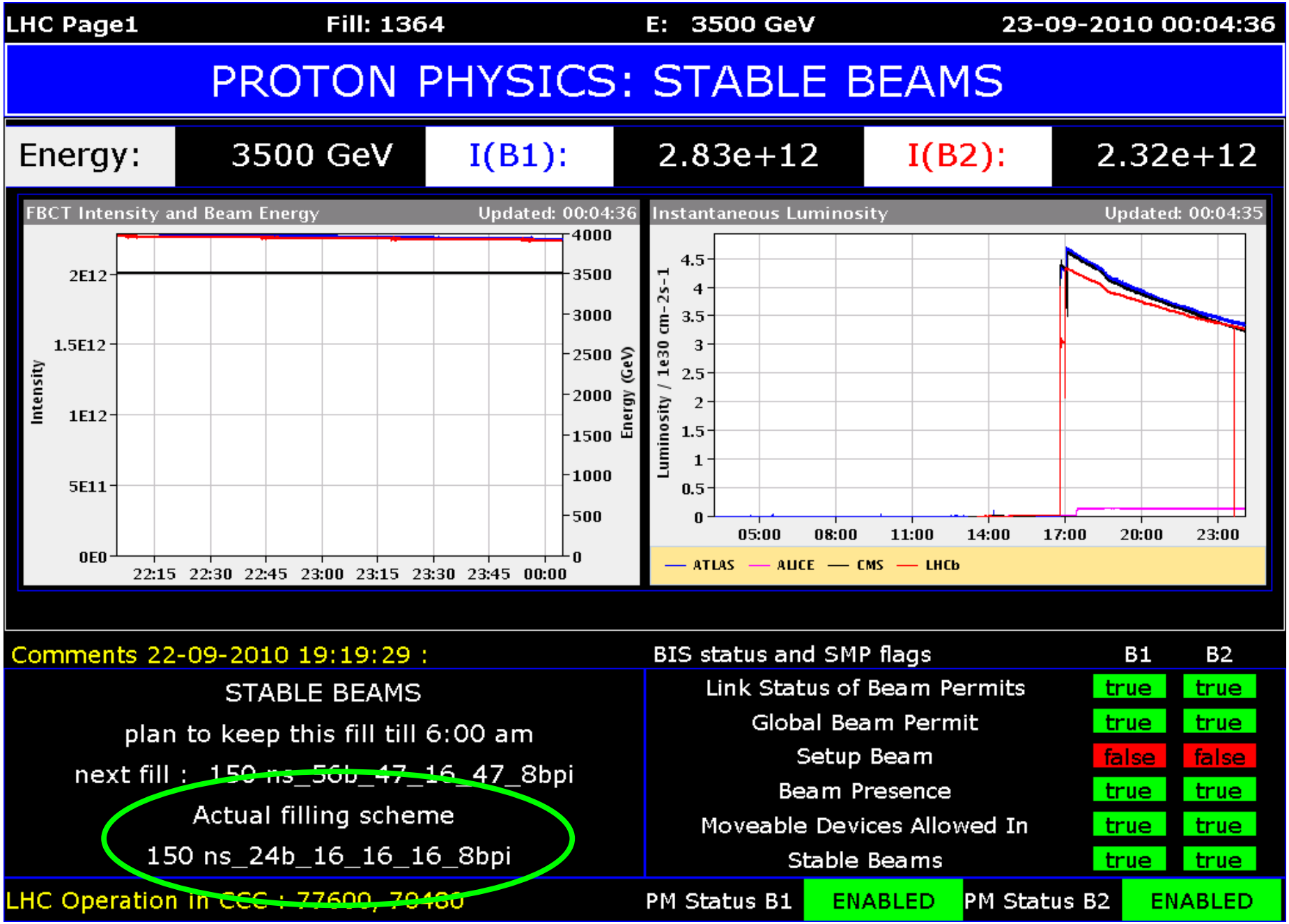


Near-term LHC plans

- Starting ~now, extra 48 bunches / week, until end of October

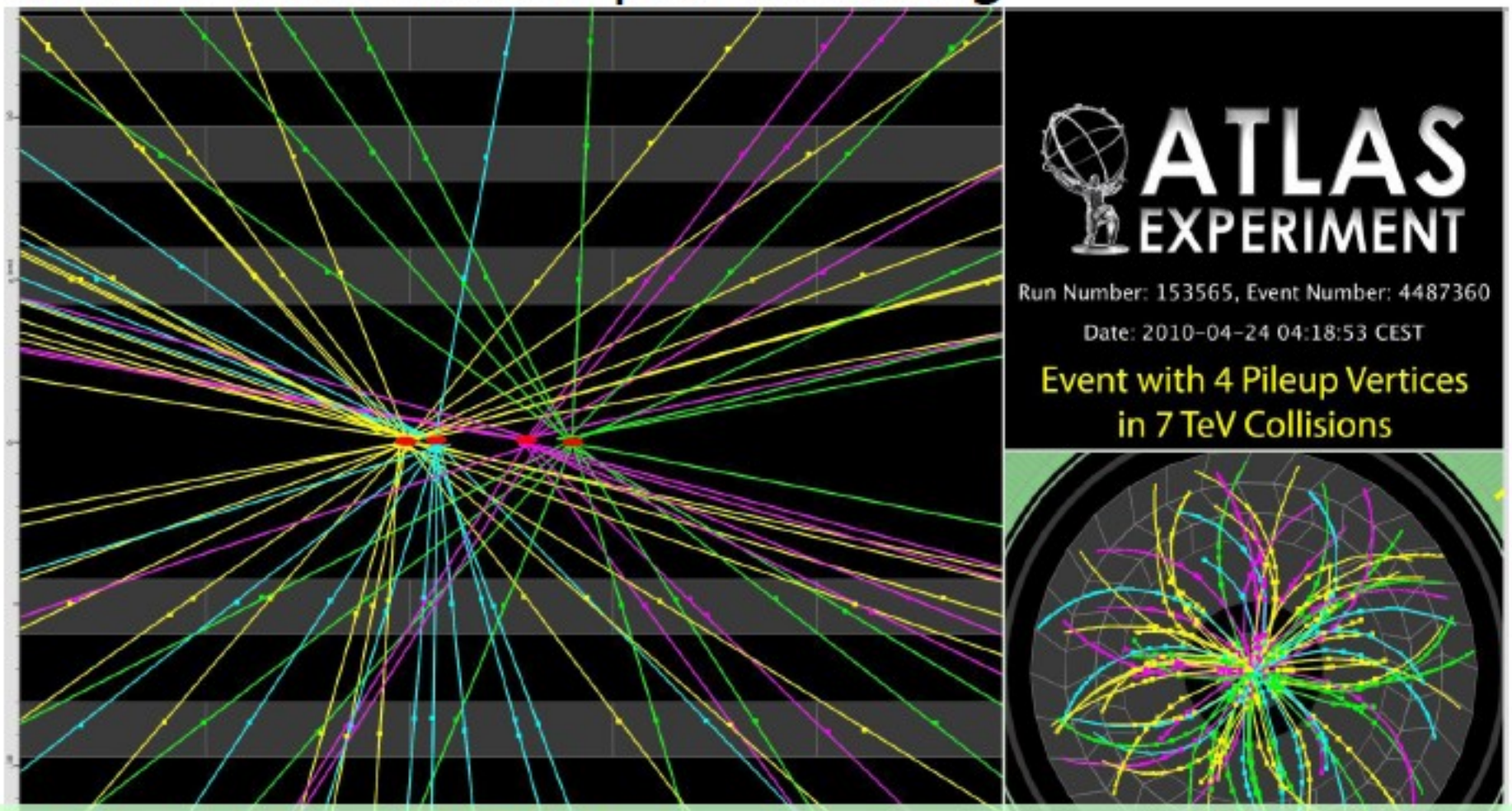


Yesterday – colliding bunch trains!



Pileup

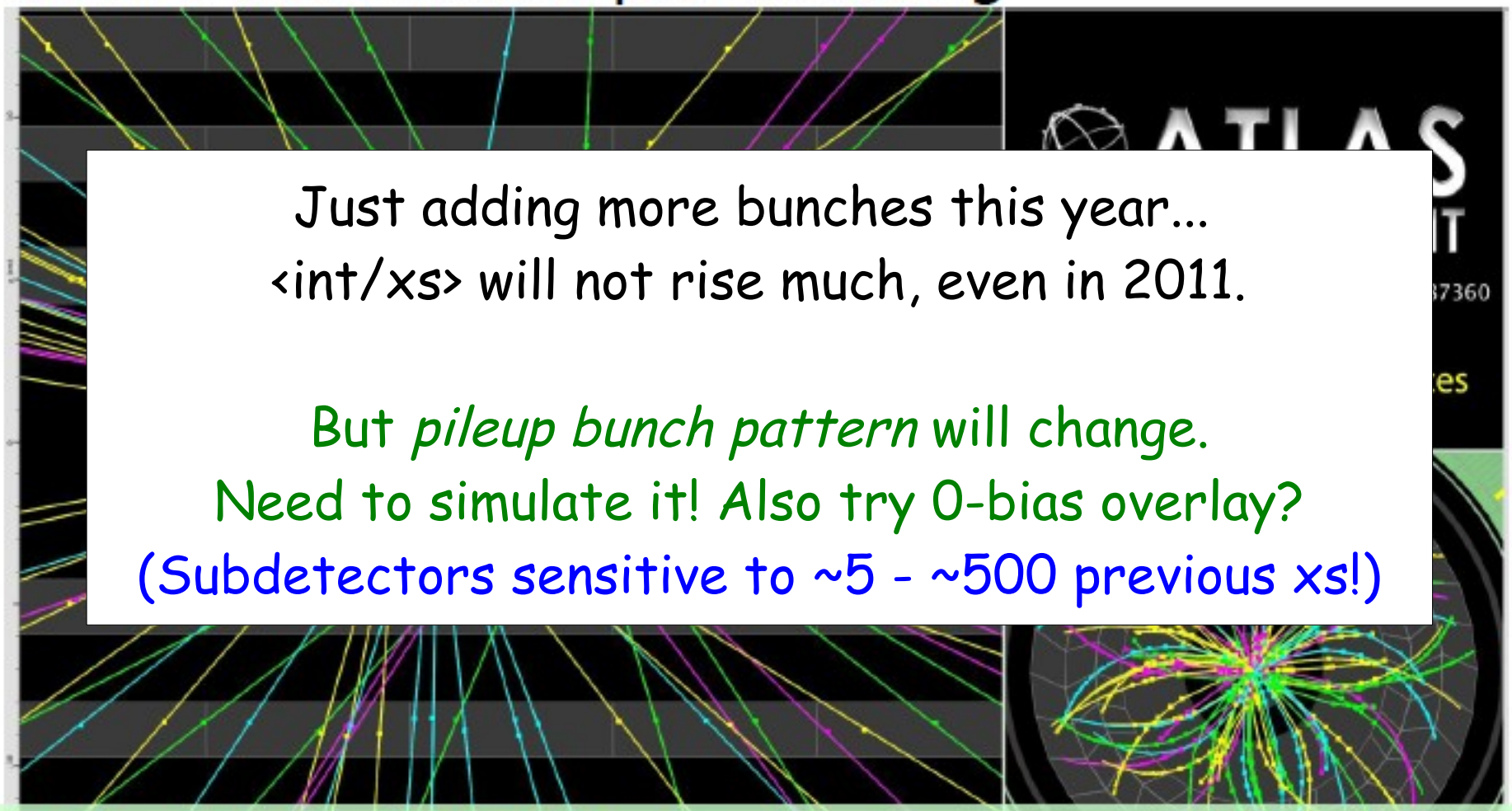
- Currently about 40% of the events have more than 1 interaction per crossing



~ 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)

Pileup

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



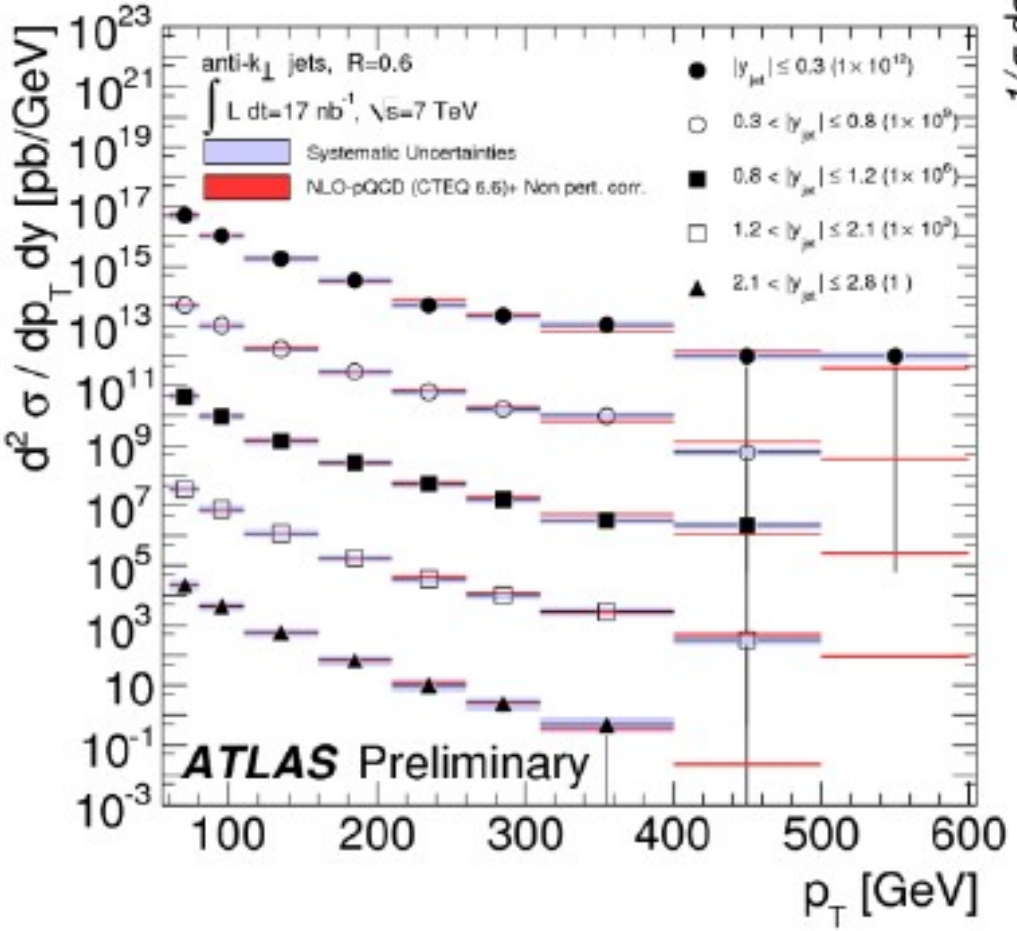
Just adding more bunches this year...
<int/xs> will not rise much, even in 2011.

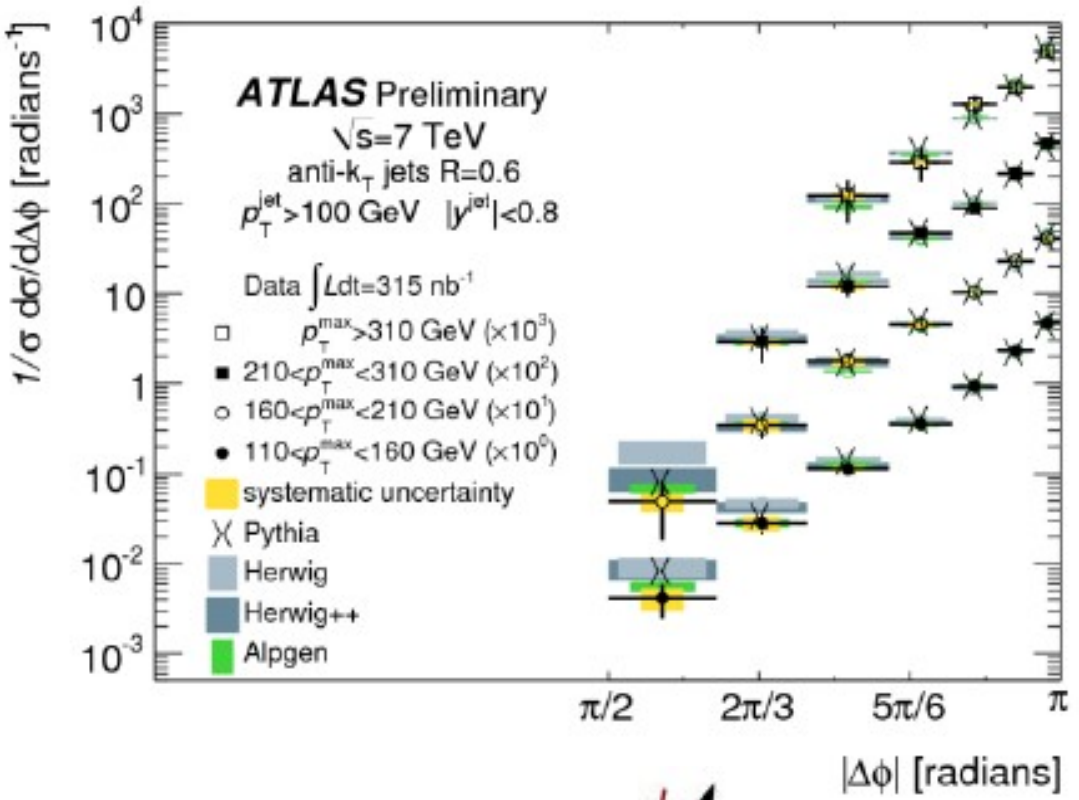
But *pileup bunch pattern* will change.
Need to simulate it! Also try 0-bias overlay?
(Subdetectors sensitive to ~5 - ~500 previous xs!)

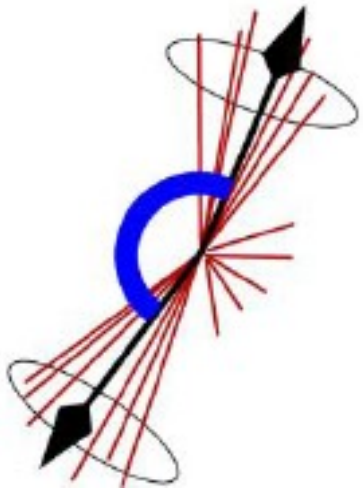
~ 10-45 tracks with p_T >150 MeV per vertex
Vertex z-positions : −3.2, −2.3, 0.5, 1.9 cm (vertex resolution better than ~200 μm)

QCD

- Comparisons of jets to NLO
- Good agreement already

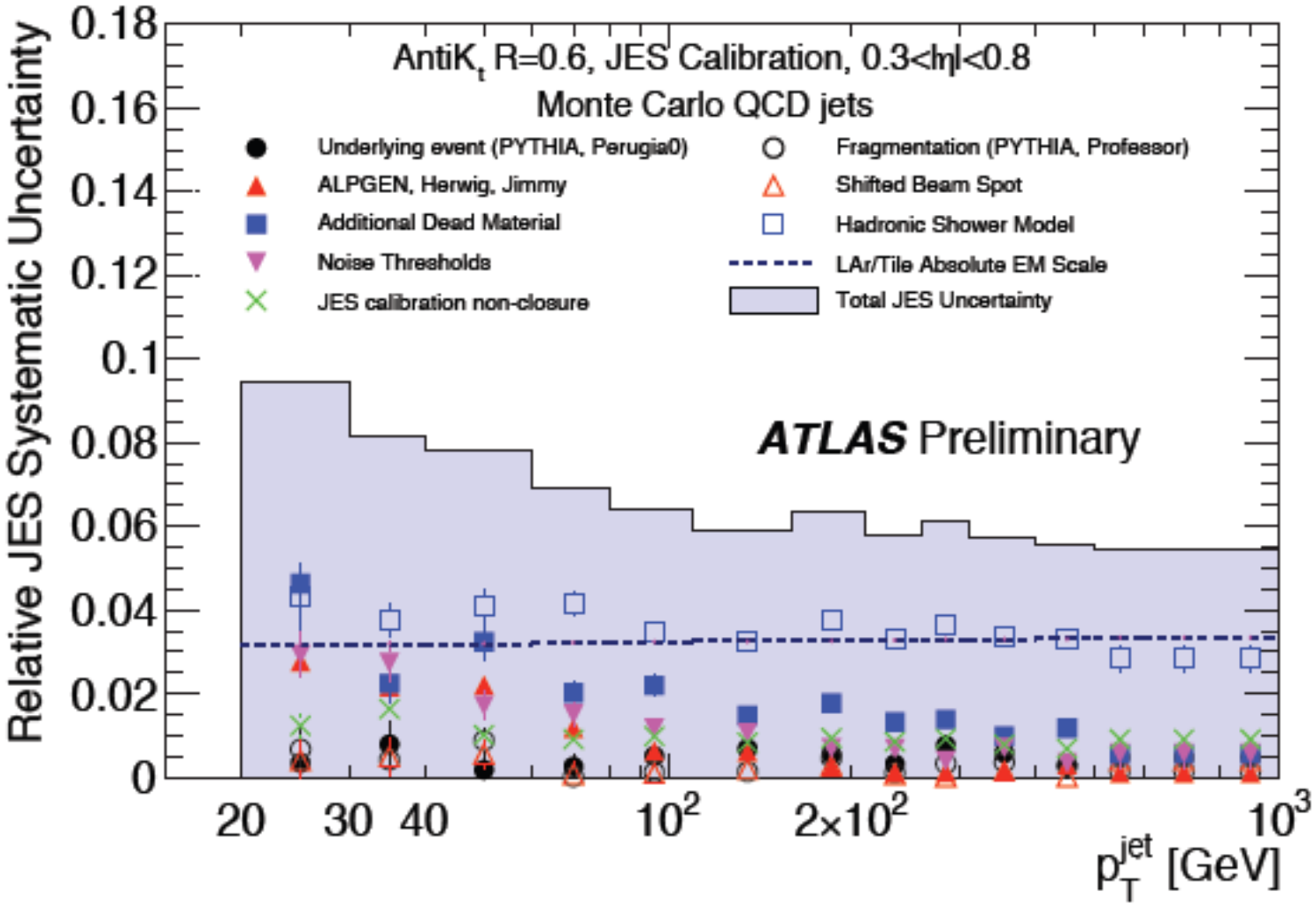






Jet Energy Scale (Uncertainty)

- Already pretty good
- Would like to get to ~1% though



Di-jet Resonance Search

- You're too late! We already started publishing searches!

Search for New Particles in Two-Jet Final States in 7 TeV Proton-Proton Collisions with the ATLAS Detector at the LHC

The ATLAS Collaboration

(Dated: August 17, 2010)

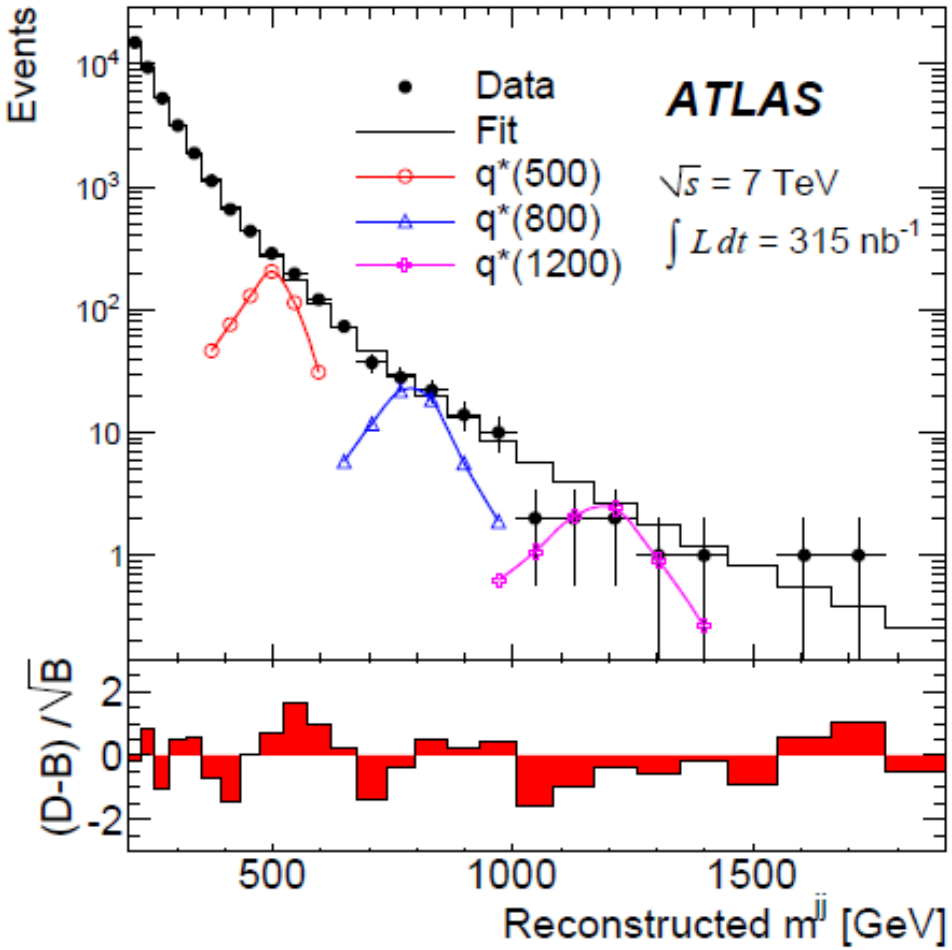
A search for new heavy particles manifested as narrow resonances in two-jet final states is presented. The data were produced in 7 TeV proton-proton collisions by the Large Hadron Collider (LHC) and correspond to an integrated luminosity of 315 nb^{-1} collected by the ATLAS detector. No resonances were observed. Upper limits were set on the product of cross section and detector acceptance for excited-quark (q^*) production as a function of q^* mass. These exclude at the 95% CL the q^* mass interval $0.40 < m_{q^*} < 1.26$ TeV, extending the reach of previous experiments.

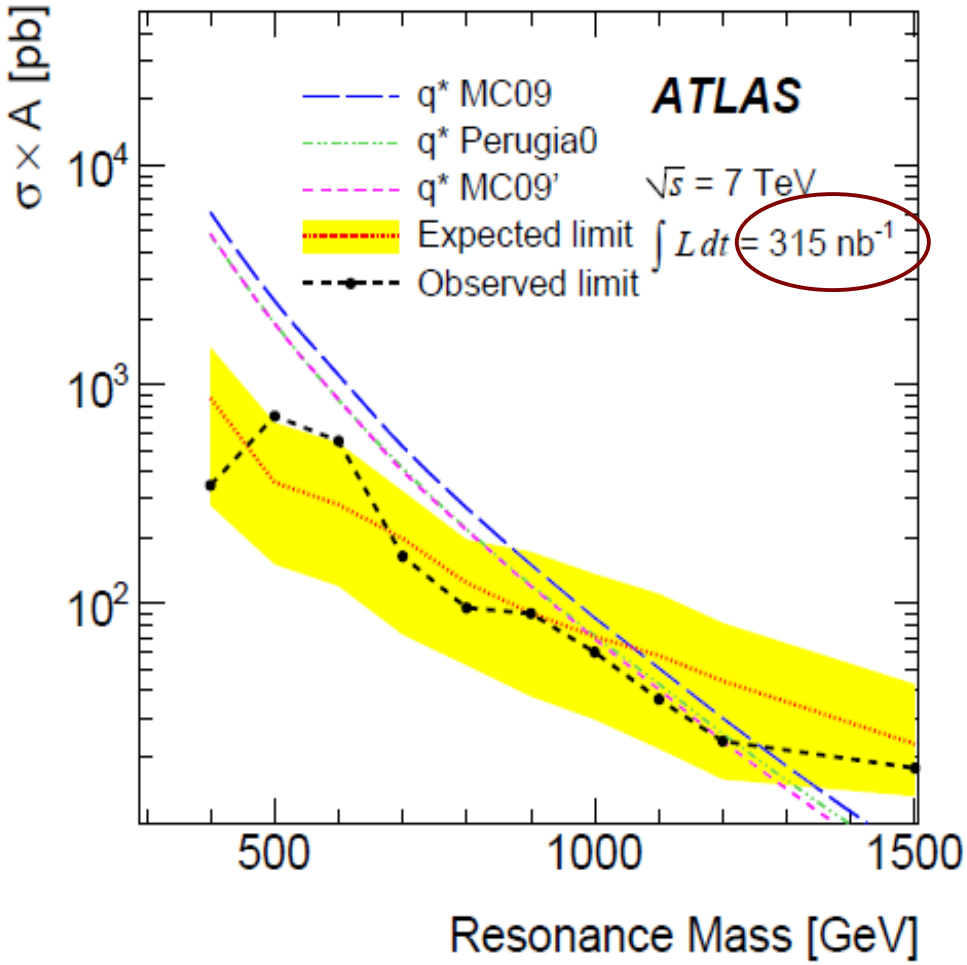
PACS numbers: 13.85.-t, 13.85.Rm, 14.80.-j, 12.60.Rc

arXiv:1008.2461

Accepted by PRL

Di-jet Resonance Search

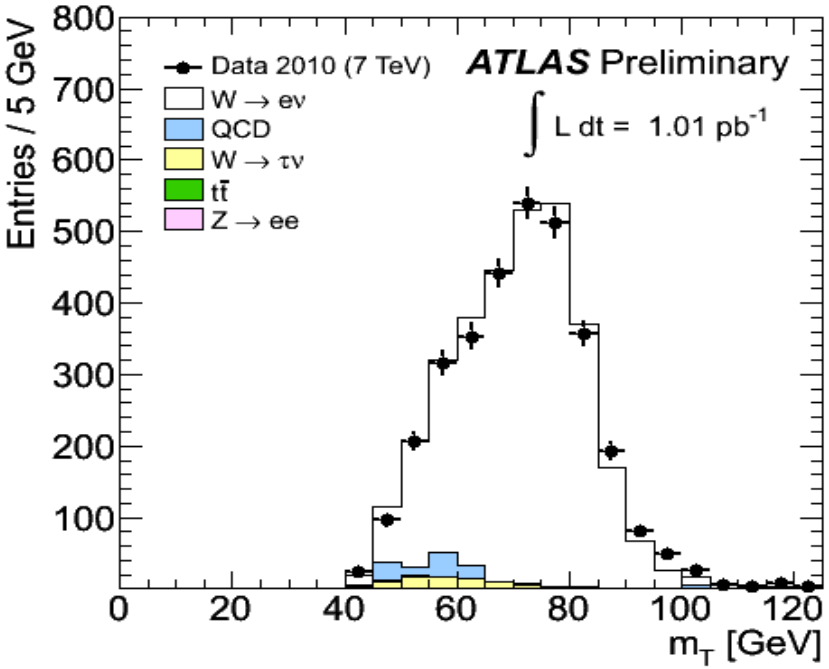


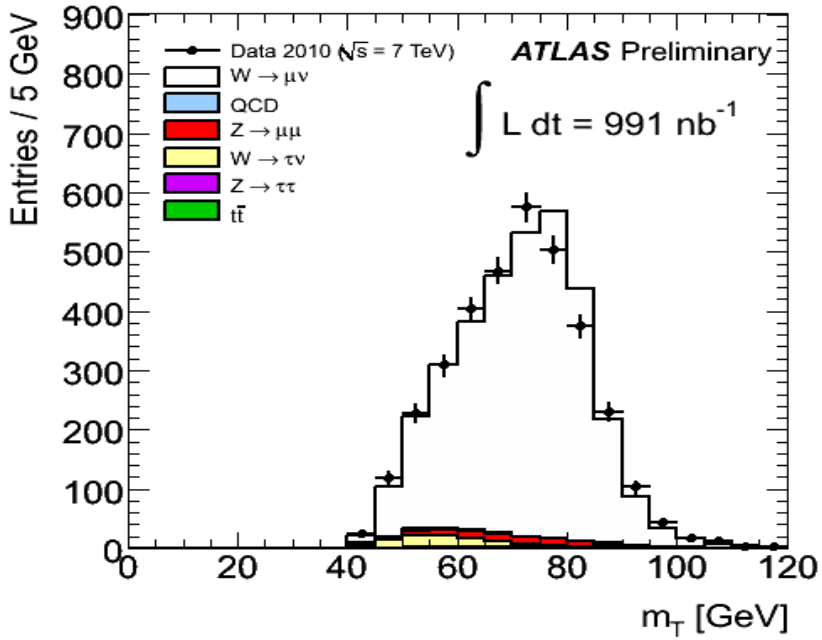


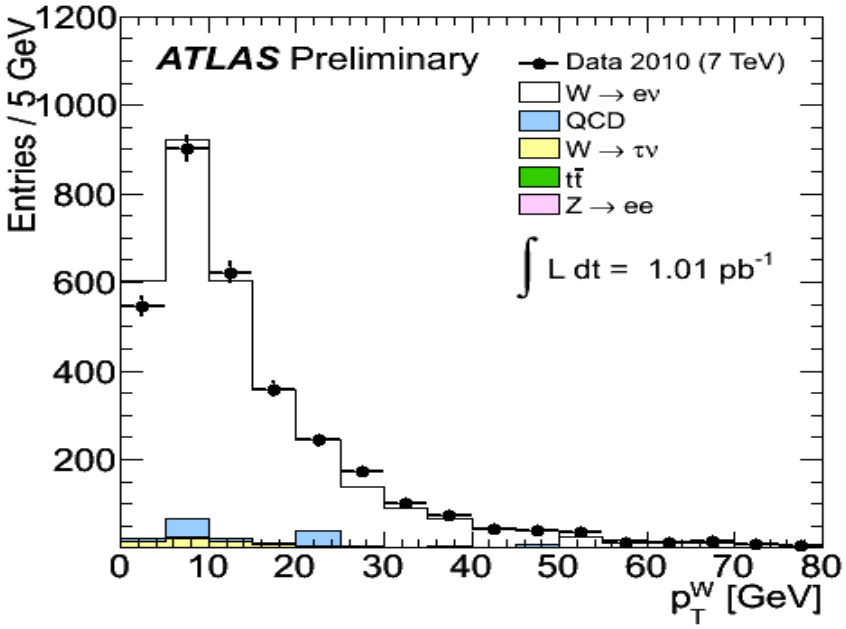
m(q*)>1260 GeV (0.315/pb)

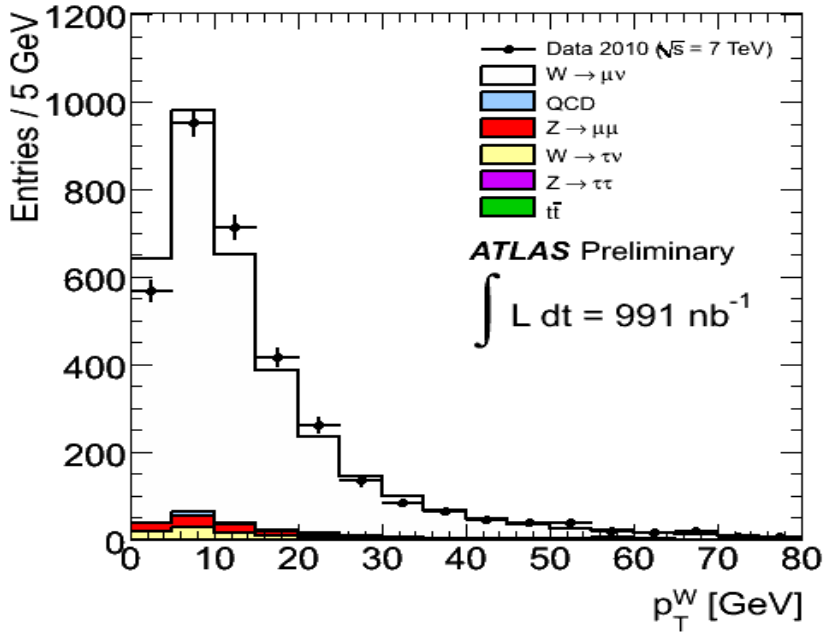
CDF limit: m(q*)>870 GeV (1130/pb)

Dub-yah's

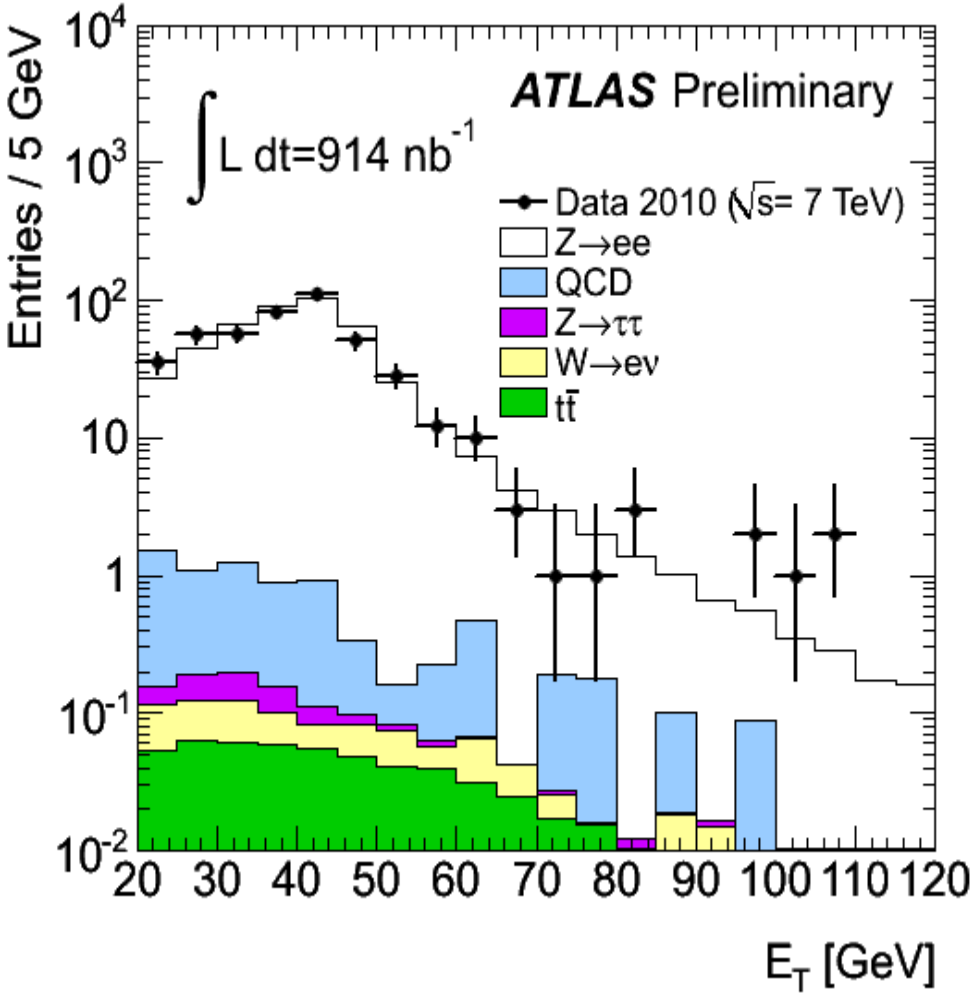

Data 2010 (7 TeV)
ATLAS Preliminary
W → eν
QCD
W → τν
tt̄
Z → ee
∫ L dt = 1.01 pb-1
Entries / 5 GeV
mT [GeV]

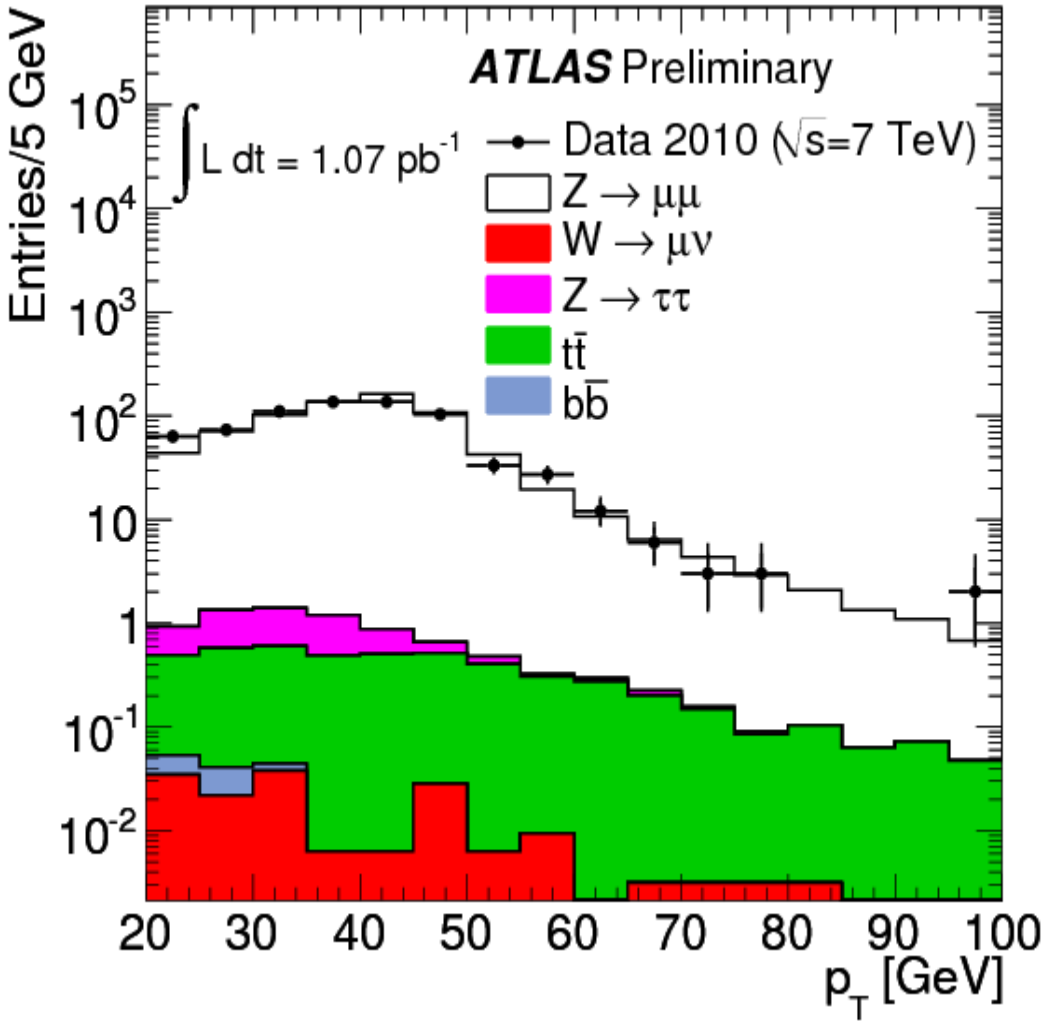

Data 2010 (√s = 7 TeV)
ATLAS Preliminary
W → μν
QCD
Z → μμ
W → τν
Z → ττ
tt̄
∫ L dt = 991 nb-1
Entries / 5 GeV
mT [GeV]


ATLAS Preliminary
Data 2010 (7 TeV)
W → eν
QCD
W → τν
tt̄
Z → ee
∫ L dt = 1.01 pb-1
Entries / 5 GeV
pTW [GeV]

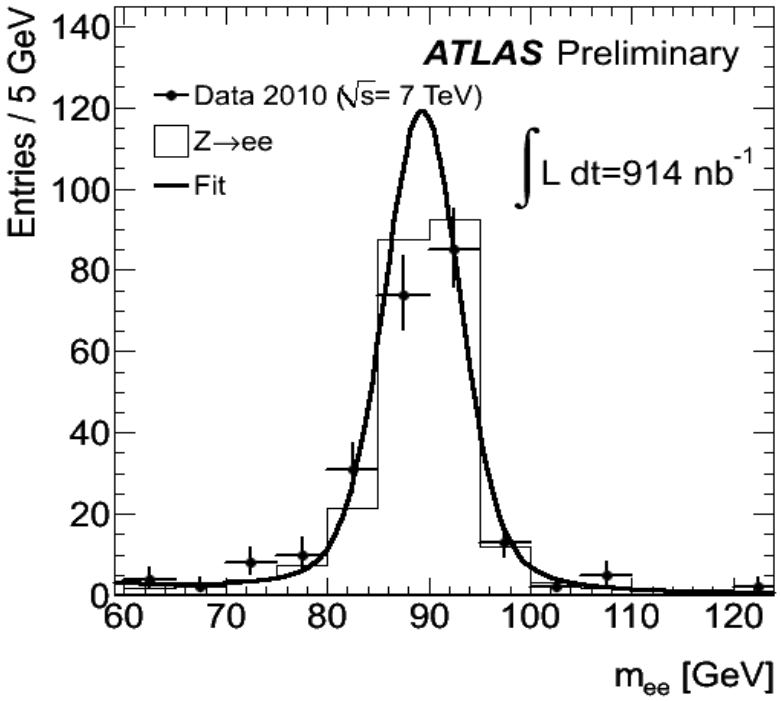

Data 2010 (√s = 7 TeV)
W → μν
QCD
Z → μμ
W → τν
Z → ττ
tt̄
ATLAS Preliminary
∫ L dt = 991 nb-1
Entries / 5 GeV
pTW [GeV]

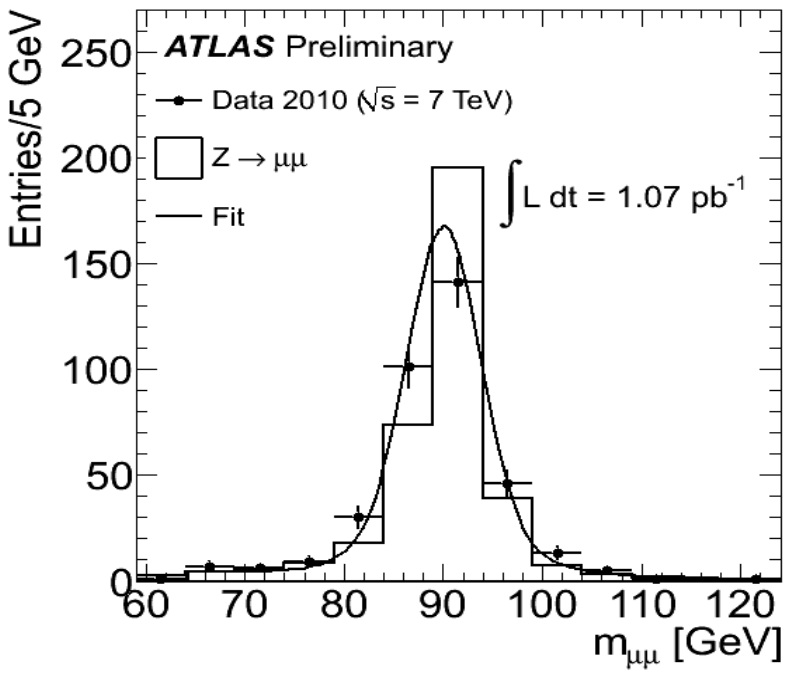
Z's

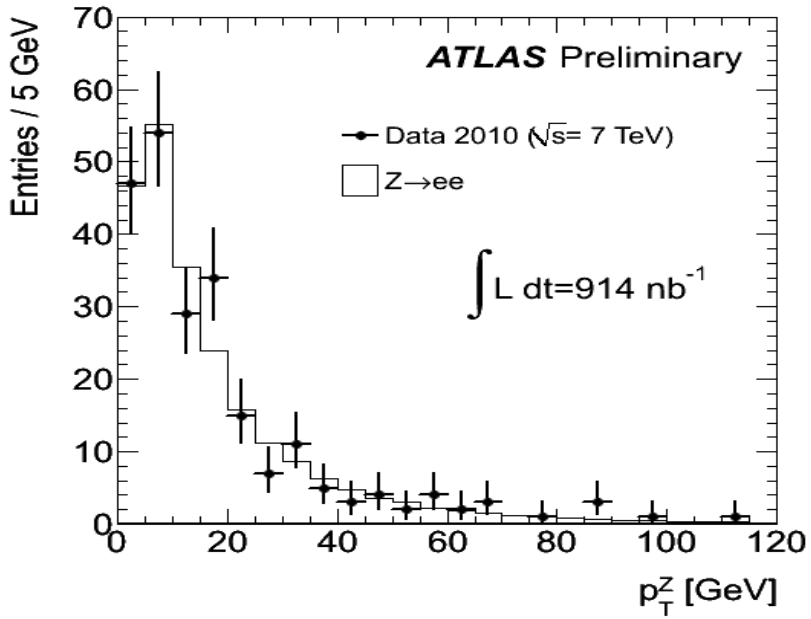

ATLAS Preliminary
∫ L dt=914 nb-1
Data 2010 (√s= 7 TeV)
Z→ee
QCD
Z→ττ
W→eν
tt̄
Entries / 5 GeV
ET [GeV]

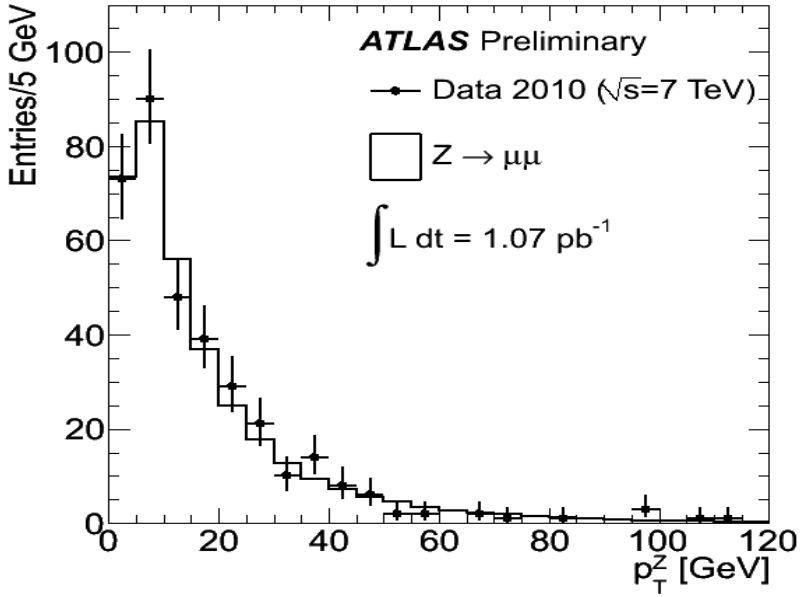

ATLAS Preliminary
∫ L dt = 1.07 pb-1
Data 2010 (√s=7 TeV)
Z → μμ
W → μν
Z → ττ
tt̄
bb̄
Entries/5 GeV
pT [GeV]

Z's

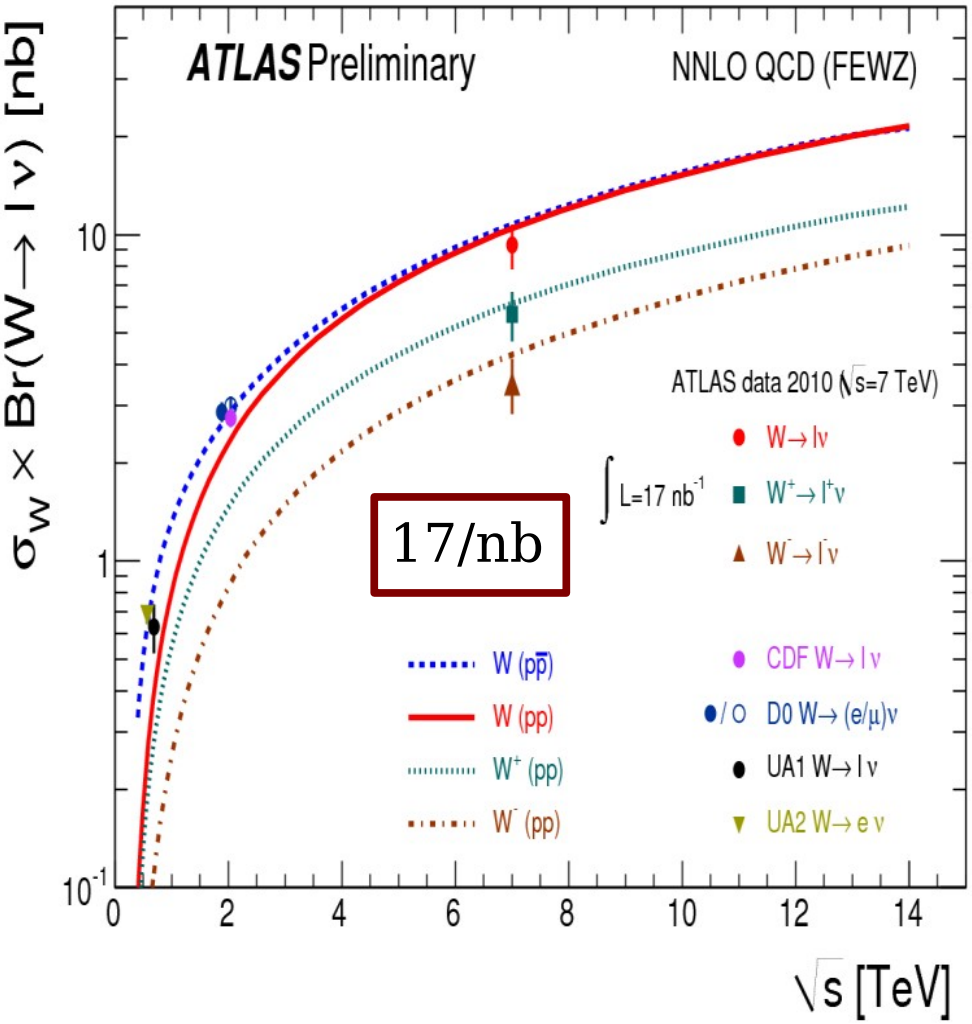

ATLAS Preliminary
Data 2010 (√s= 7 TeV)
Z→ee
Fit
∫L dt=914 nb-1
Entries / 5 GeV
mee [GeV]

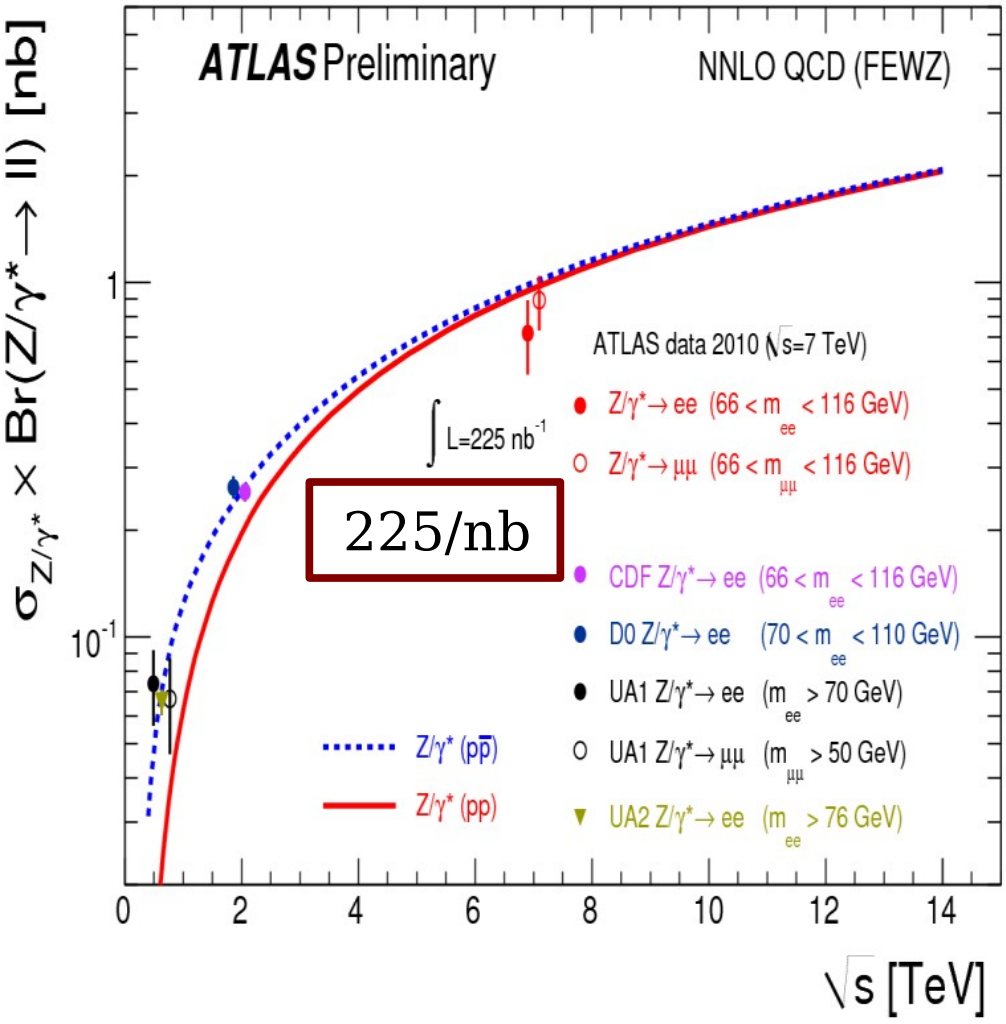

ATLAS Preliminary
Data 2010 (√s = 7 TeV)
Z → μμ
Fit
∫L dt = 1.07 pb-1
Entries/5 GeV
mμμ [GeV]


ATLAS Preliminary
Data 2010 (√s= 7 TeV)
Z→ee
∫L dt=914 nb-1
Entries / 5 GeV
pTZ [GeV]


ATLAS Preliminary
Data 2010 (√s=7 TeV)
Z → μμ
∫L dt = 1.07 pb-1
Entries/5 GeV
pTZ [GeV]

EW cross-sections

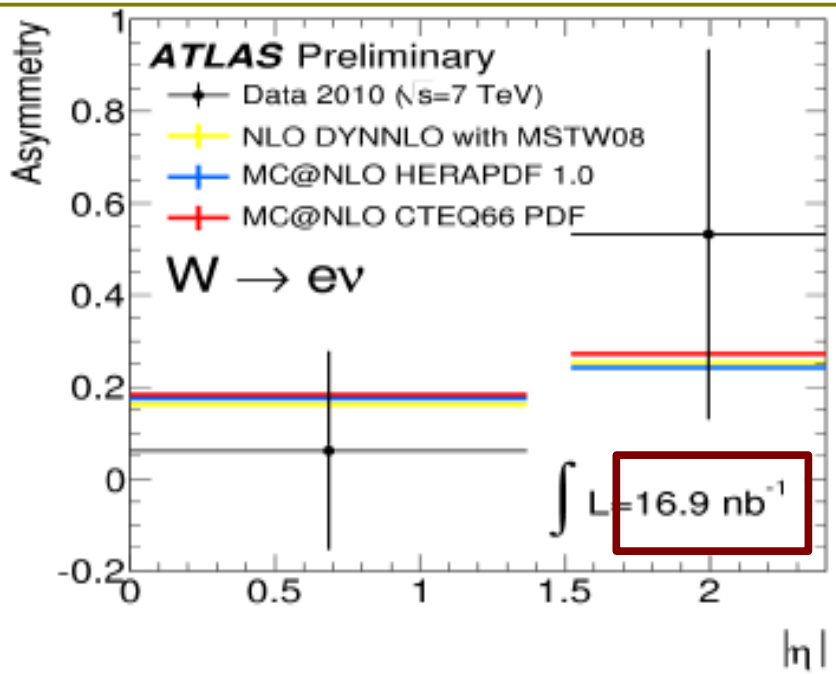




σ (W → eν) = 8.5 ± 1.3 (stat) ± 0.7 (syst) ± 0.9 (lumi) nb
σ (W → μν) = 10.3 ± 1.3 (stat) ± 0.8 (syst) ± 1.1 (lumi) nb

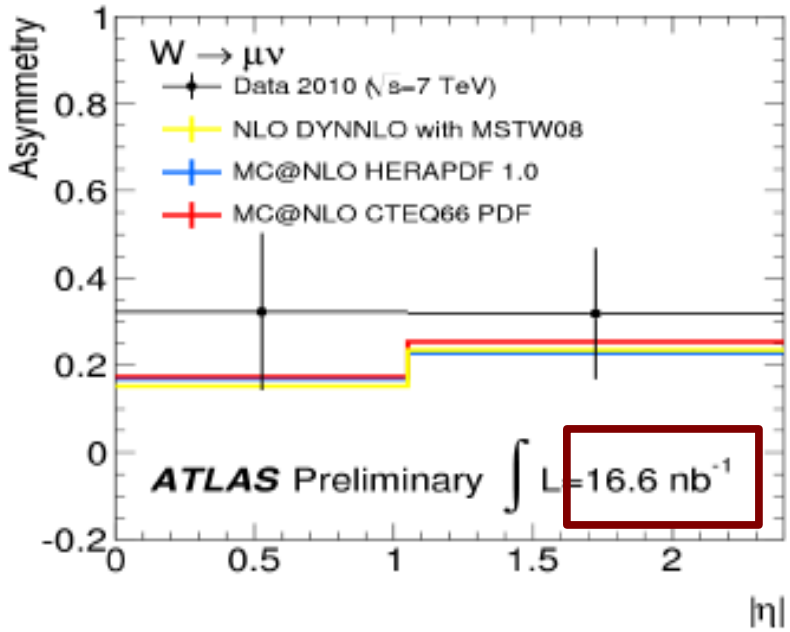
σ (Z → ee) = 0.72 ± 0.11 (stat) ± 0.10 (syst) ± 0.08 (lumi) nb
σ (Z → μμ) = 0.89 ± 0.10 (stat) ± 0.07 (syst) ± 0.10 (lumi) nb

W charge asymmetry



Will hopefully show with more stats soon…

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



ATLAS data:

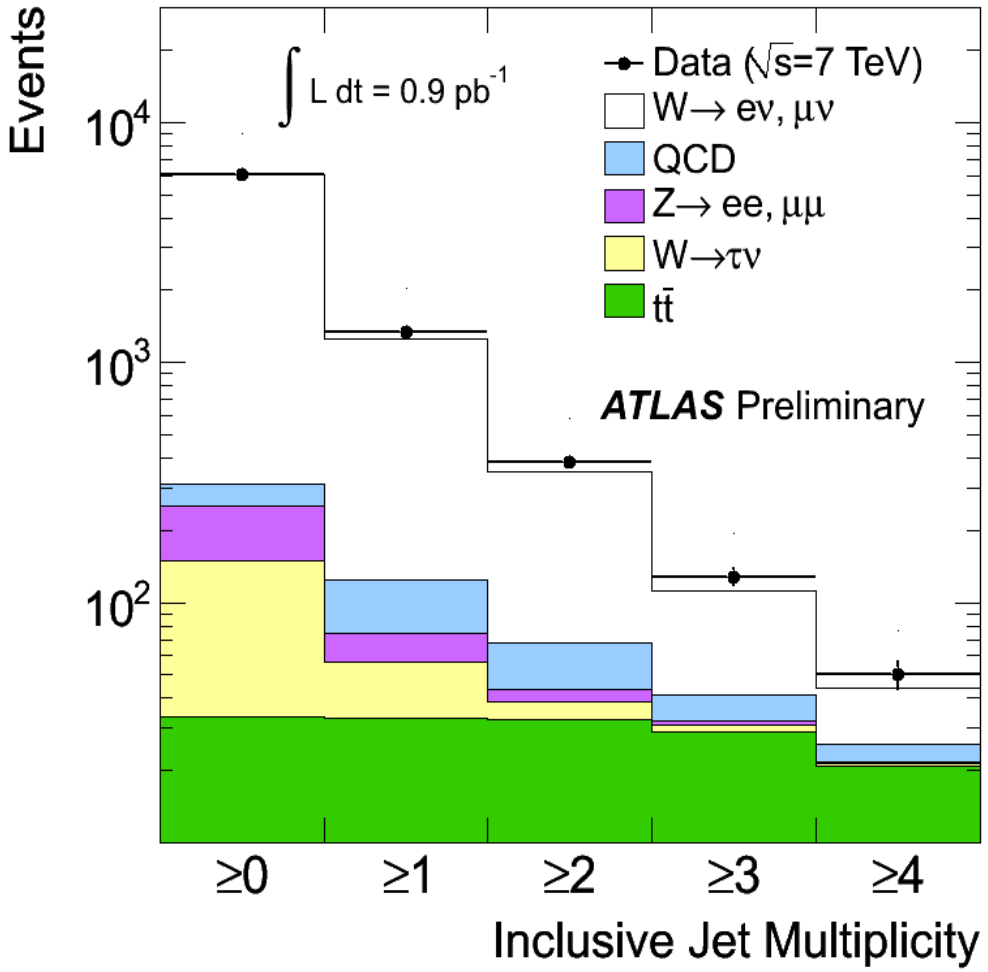
A (W→ eν) = 0.21 ± 0.18 (stat) ± 0.01 (syst)

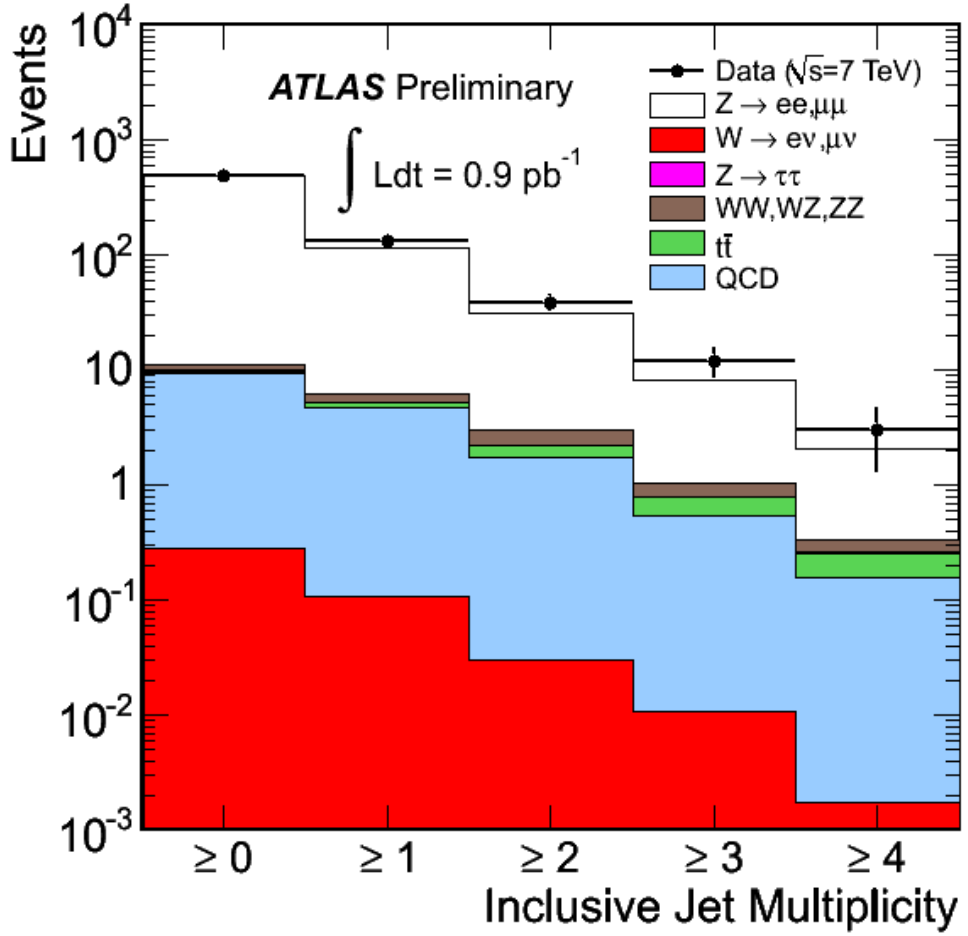
A (W→ μν) = 0.33 ± 0.12 (stat) ± 0.01 (syst)

NNLO theory prediction: A=0.2

W/Z + jets

Anti-kT with R=0.4, |eta|<2.8 and pT>20 GeV



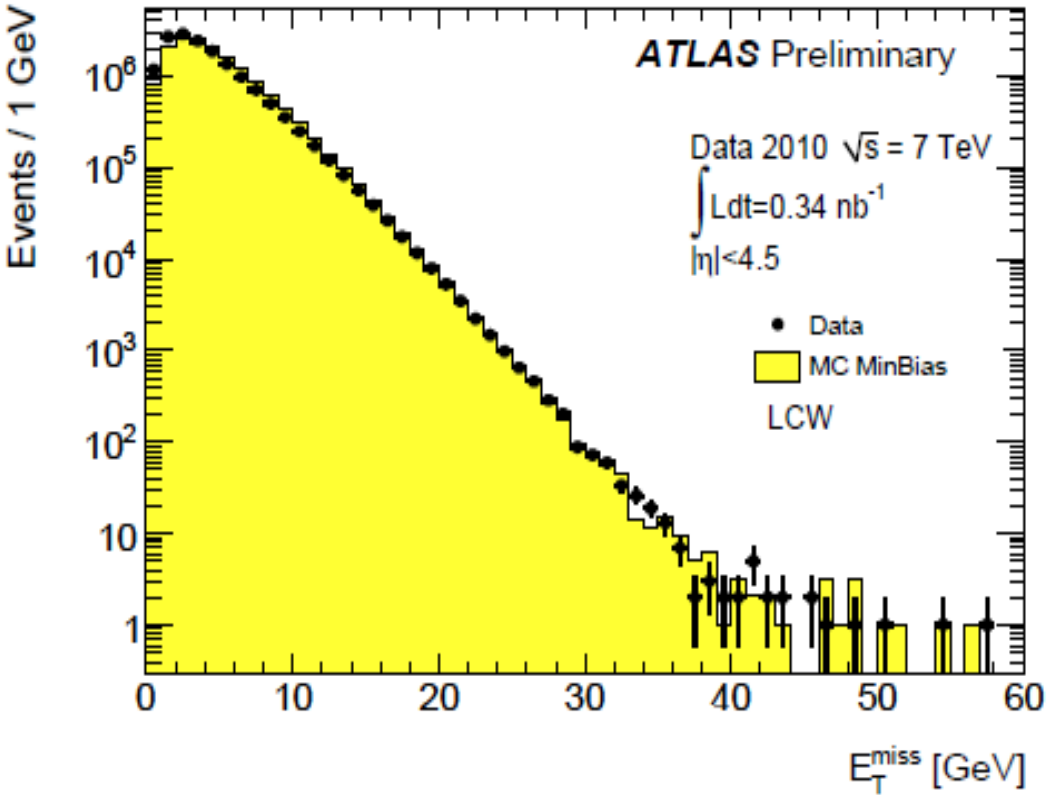


Pythia doesn't make enough hard jets (no surprise)

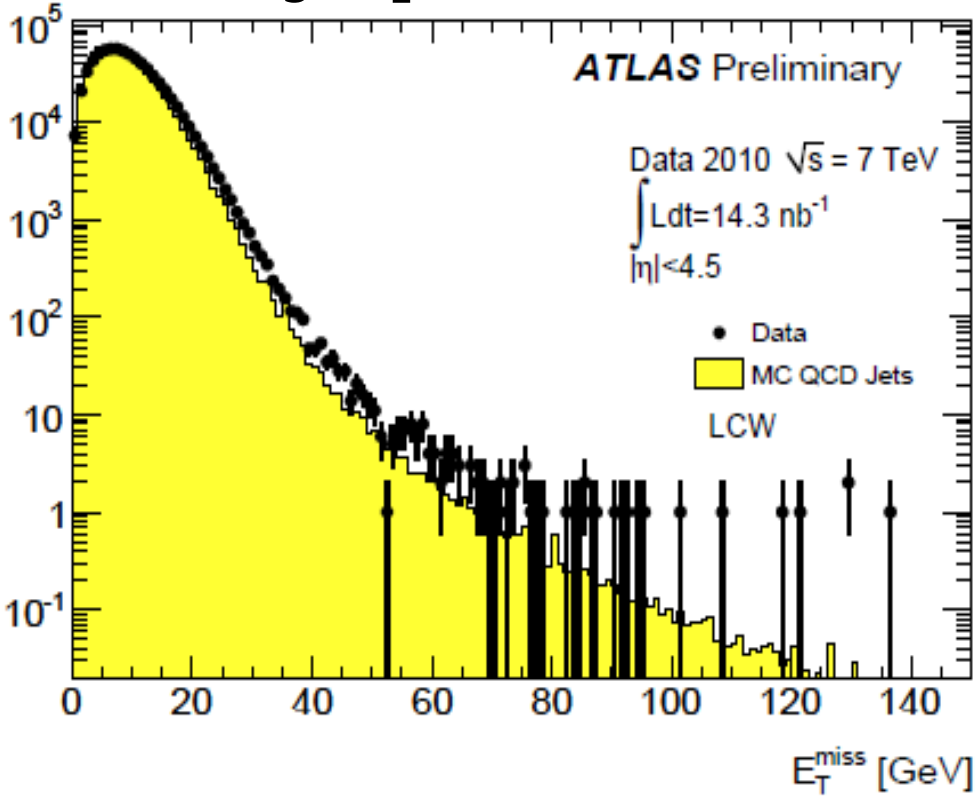
MET

- Good data/MC agreement already, for low energy events
- Excess of tail in data for events with jets
  (jet resolution / corrections not perfectly modeled)

Minimum bias



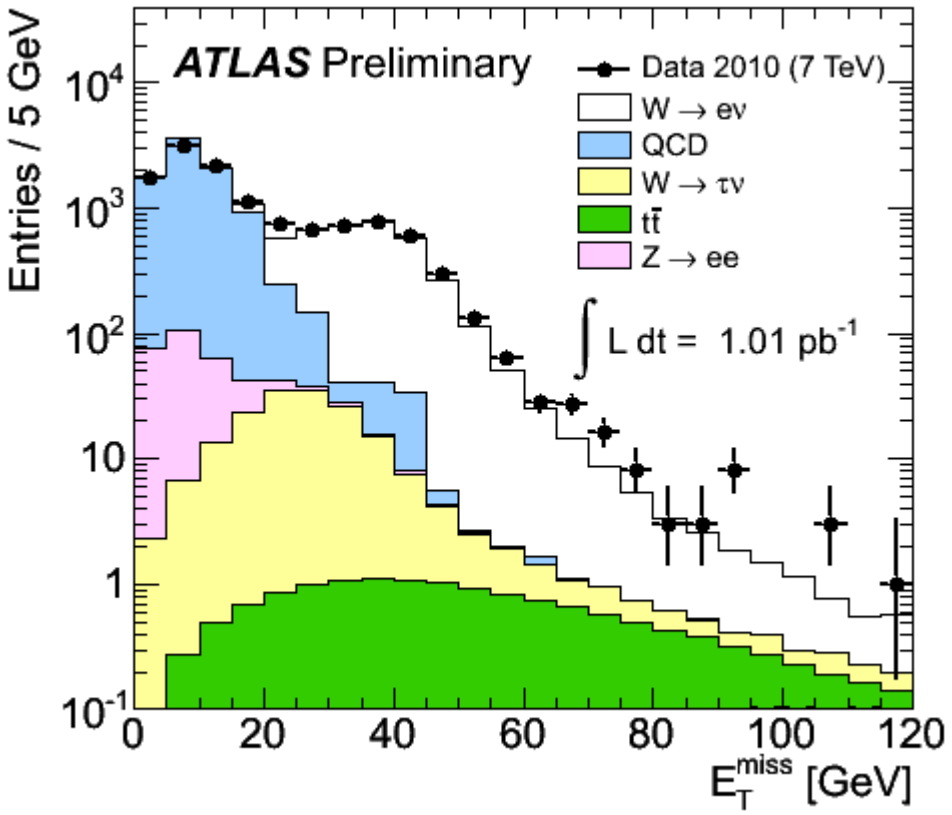
Jet pT>20 GeV

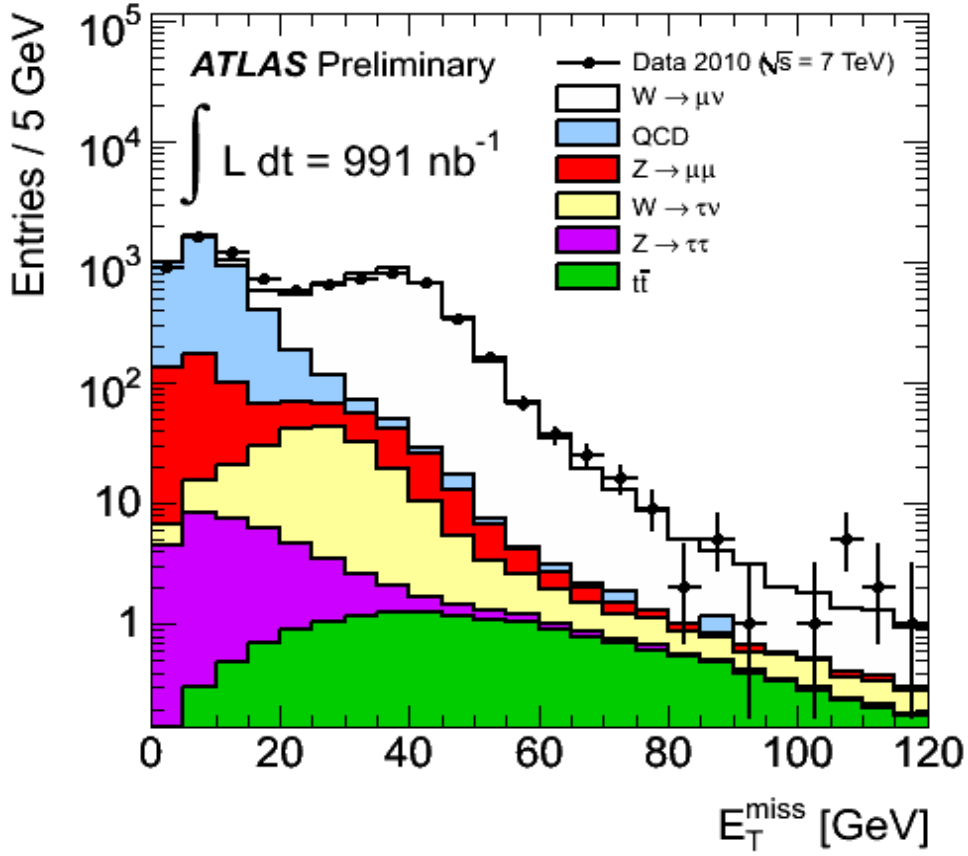


MET

W's are a calibration source

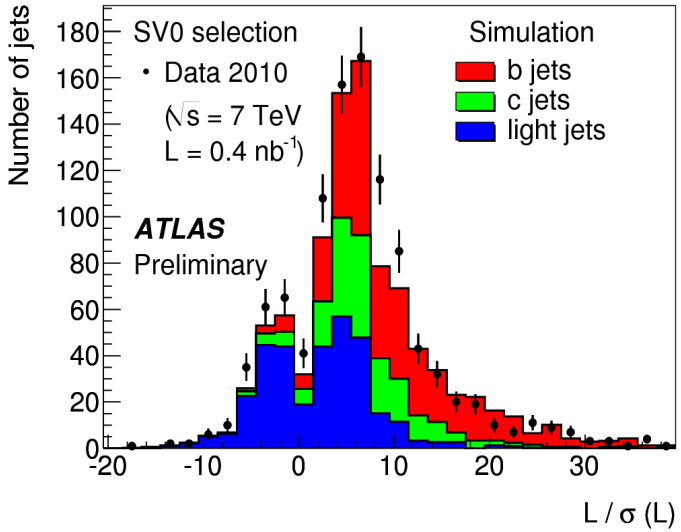
- Pretty good data/MC agreement already, including μ corrections
- Slight excess of tail in data (MET resolution slightly worse)

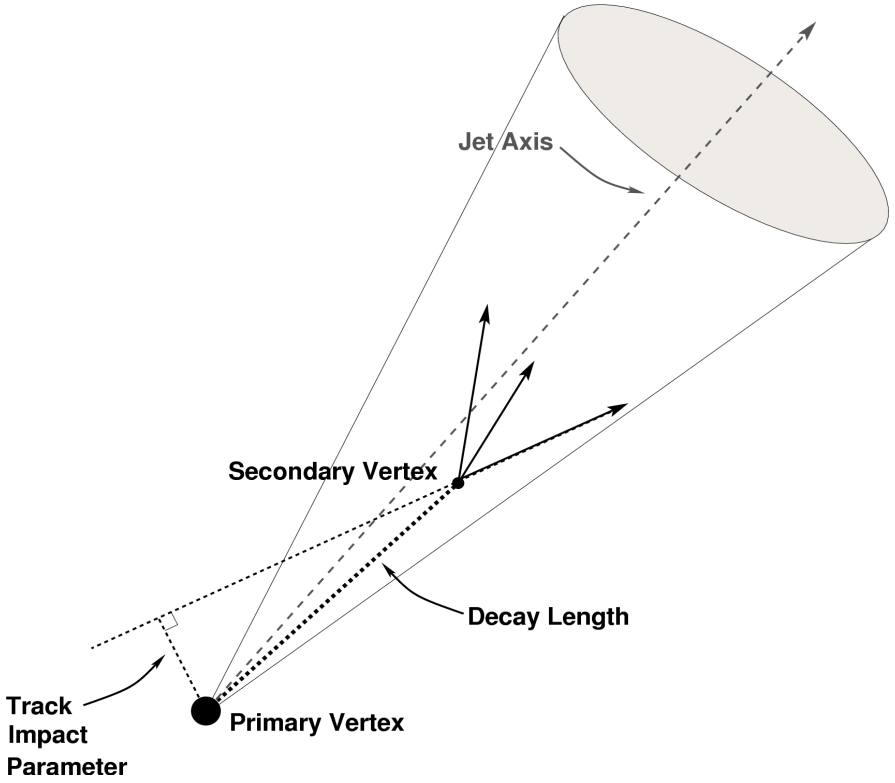


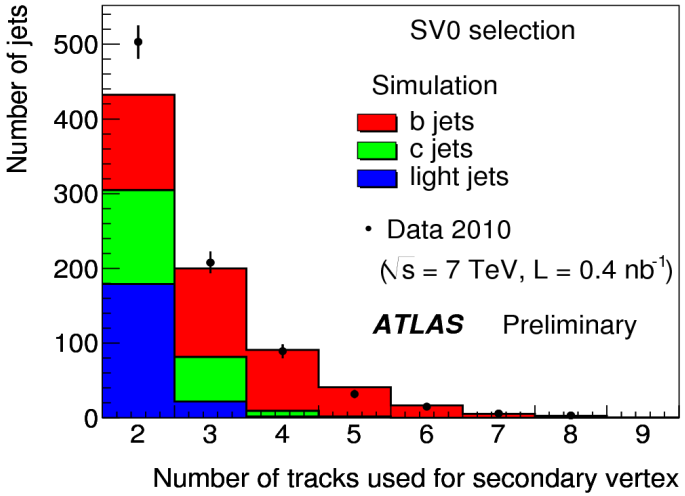


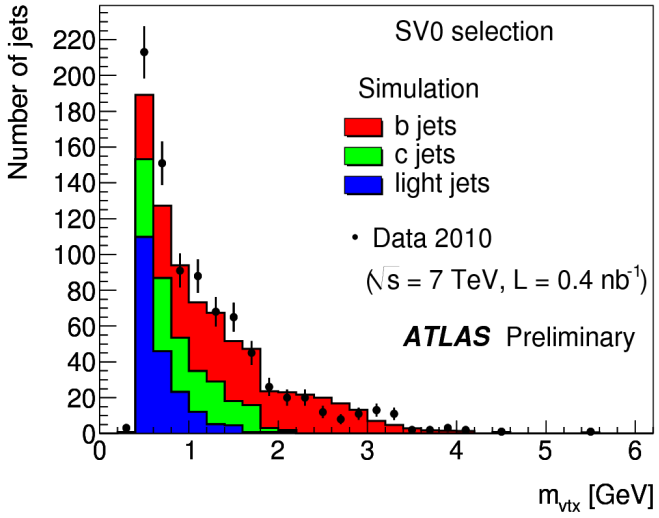
b-tagging

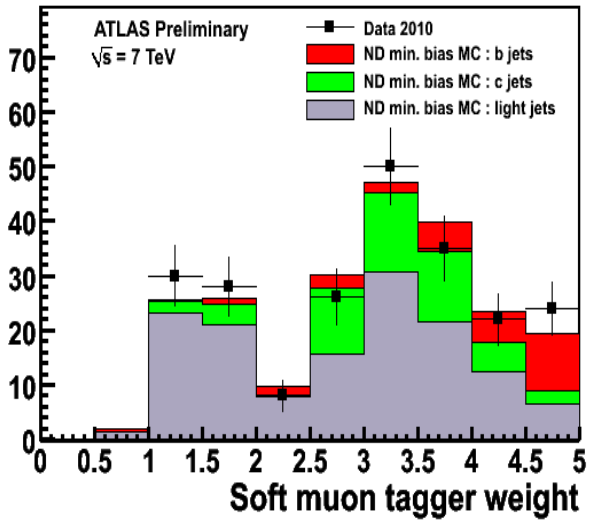
- Start with the basic algorithms
- Already pretty well understood



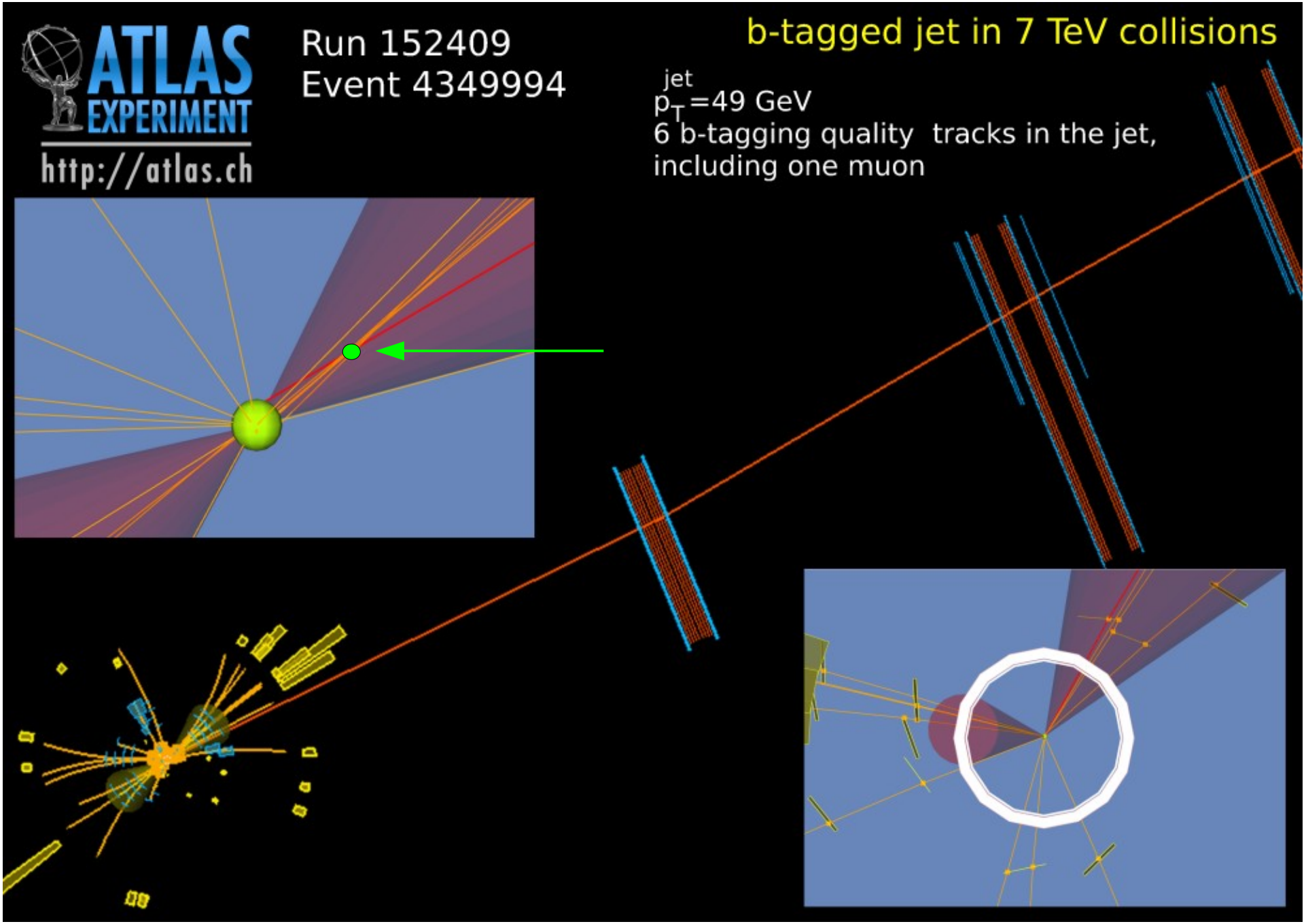






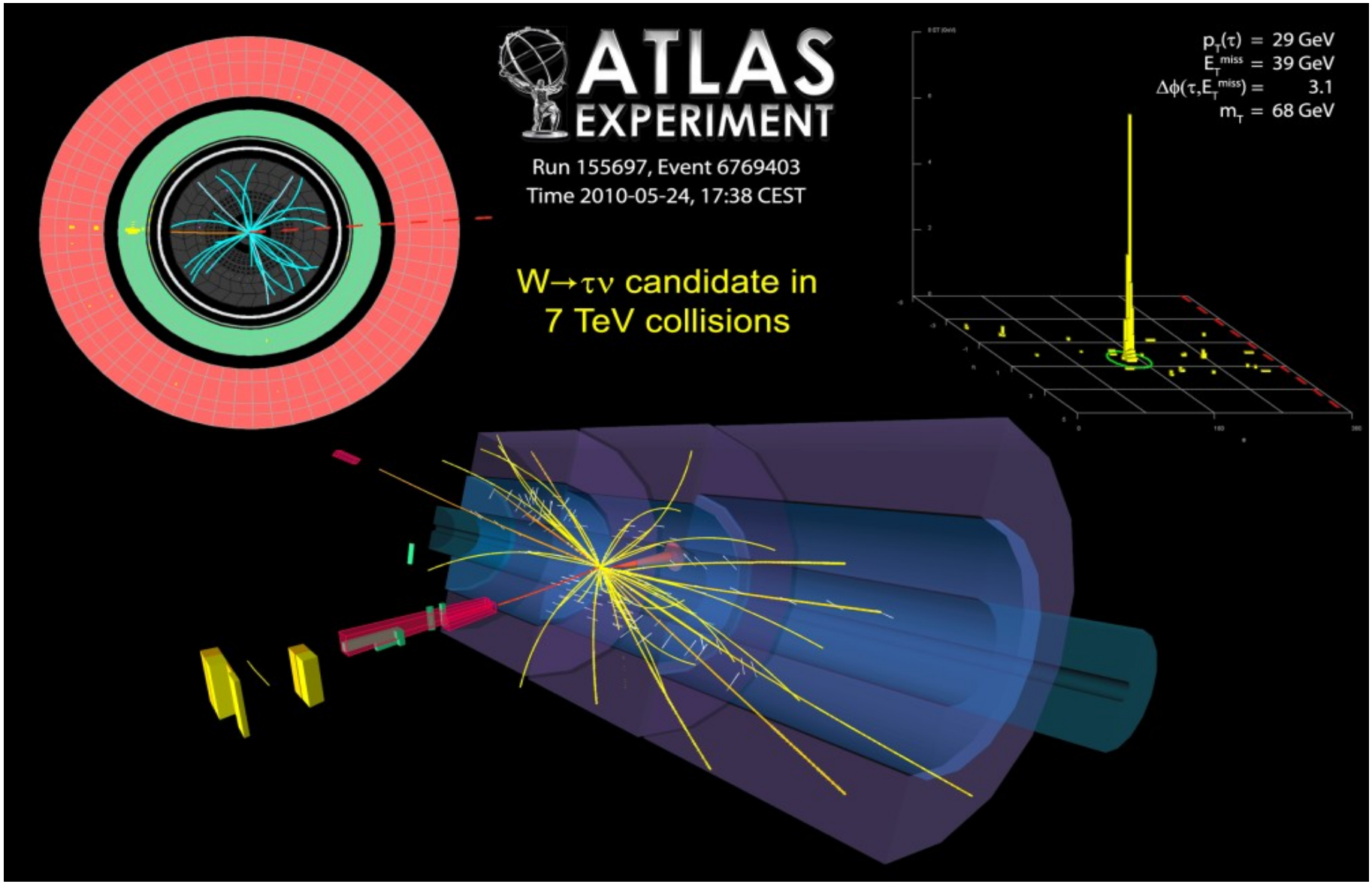


b-tagging


ATLAS EXPERIMENT
http://atlas.ch
Run 152409
Event 4349994
b-tagged jet in 7 TeV collisions
jet
p_T=49 GeV
6 b-tagging quality tracks in the jet,
including one muon

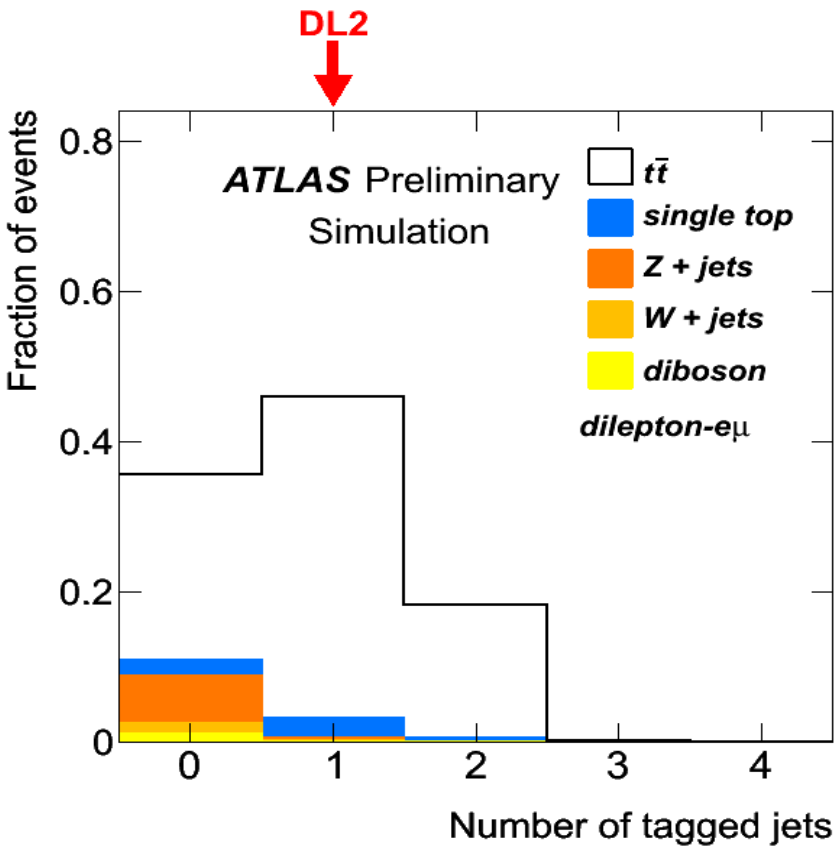
tau

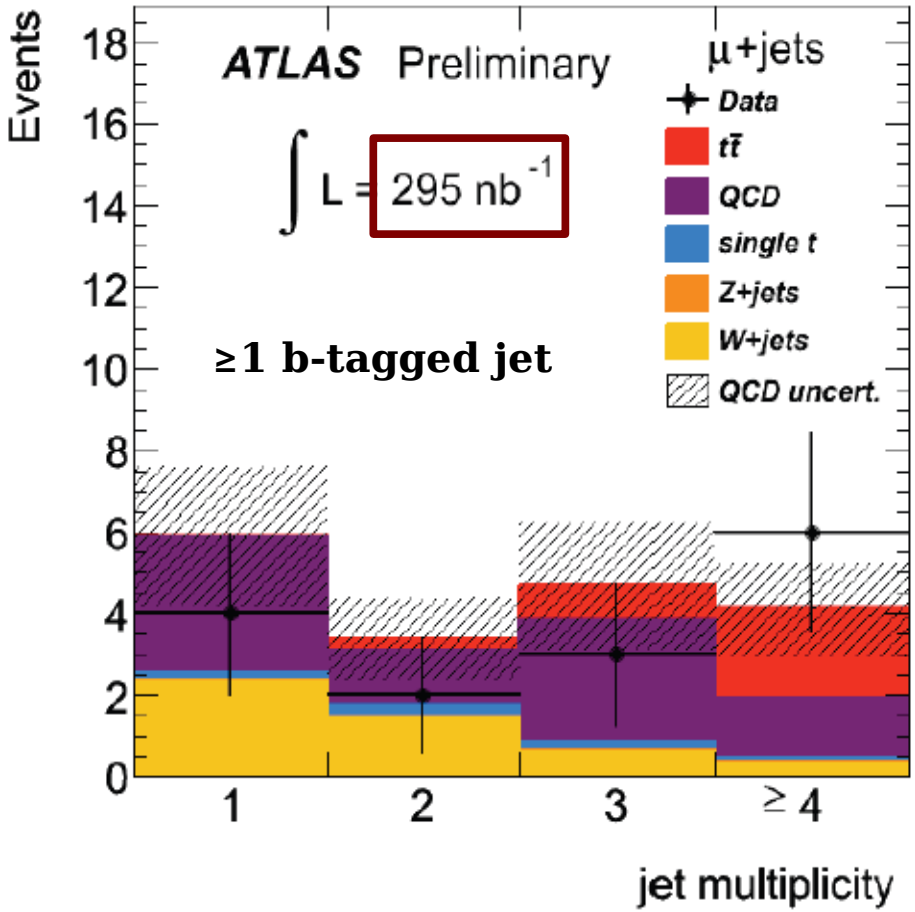
- We have candidates…



Top

- We have candidates, even in the first ~10% of our data...

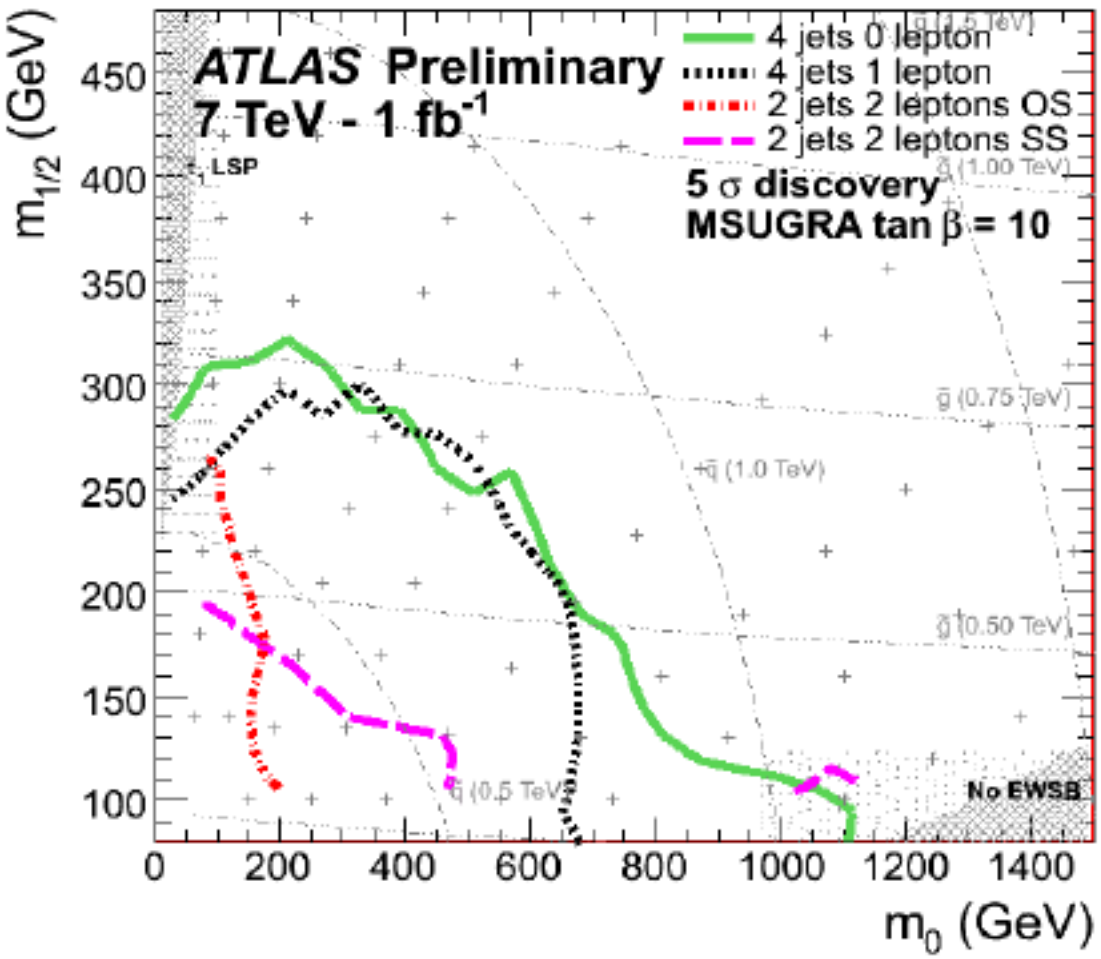




- 10/pb → Top re-discovery (next month?!)
- 100+/pb → BSM top - M(tt), Afb, 4th gen, etc. (next year)

SUSY

- Because parameter space is so large, just consider mSUGRA

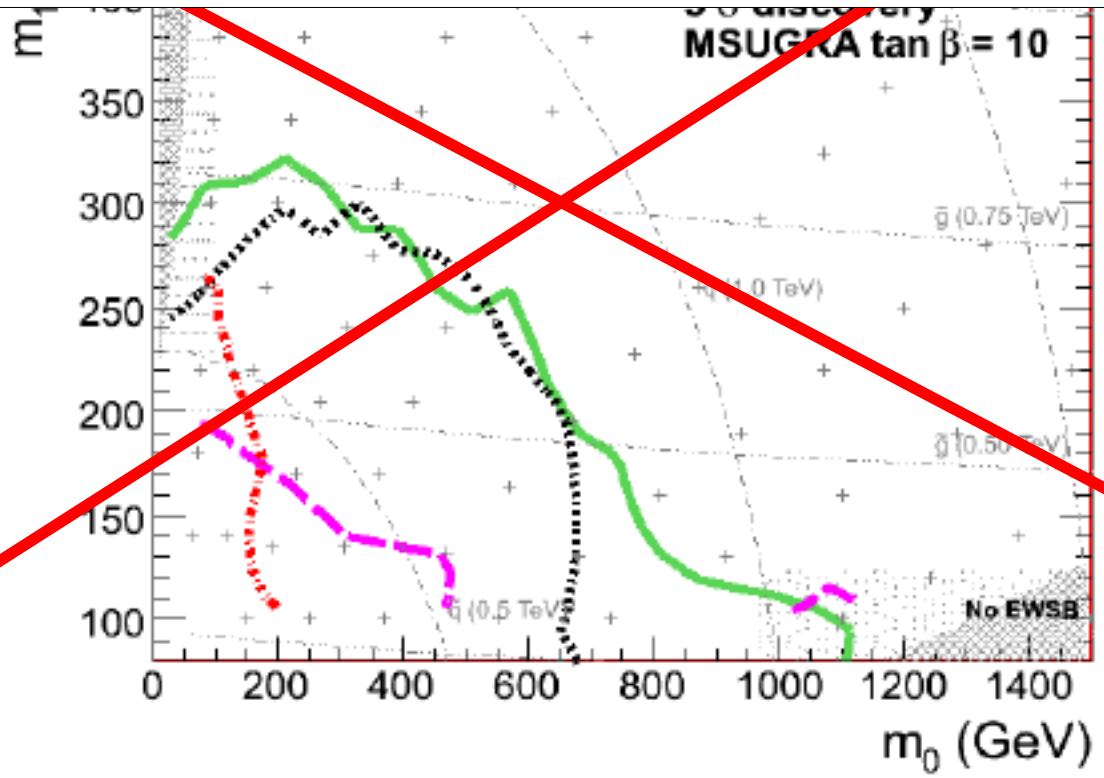


SUSY

- Because parameter space is so large, just consider mSUGRA

Just kidding!

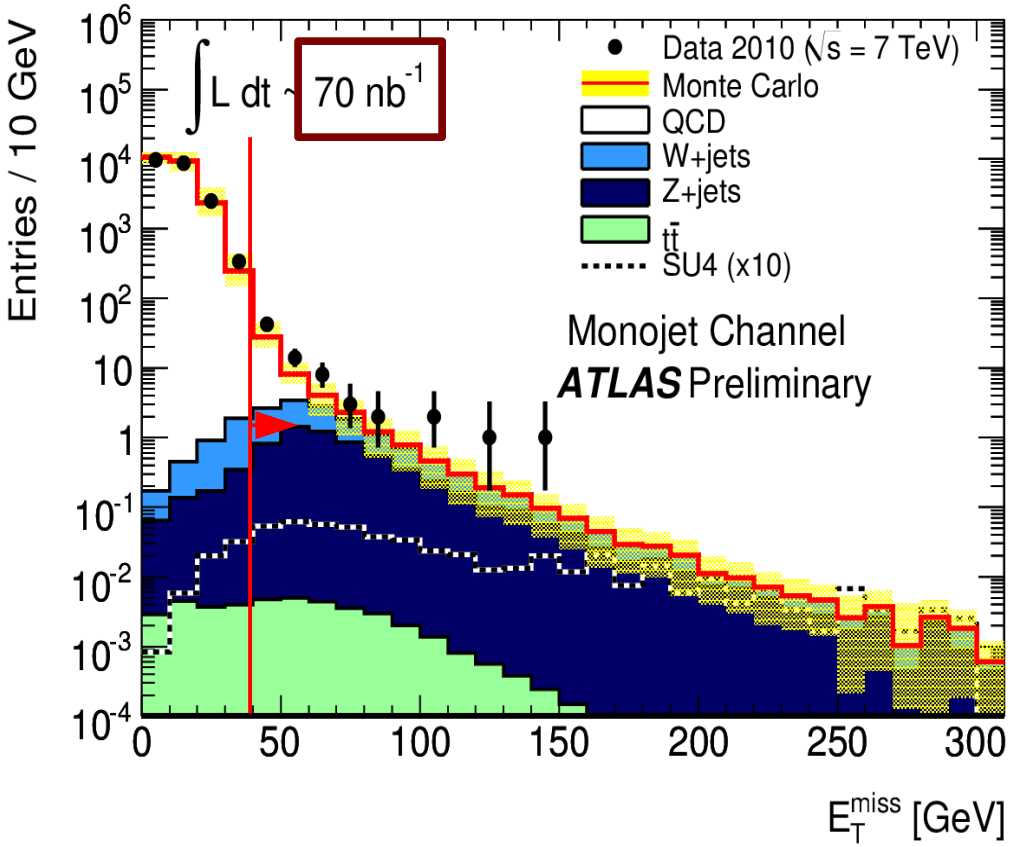
Put down the tomatoes!

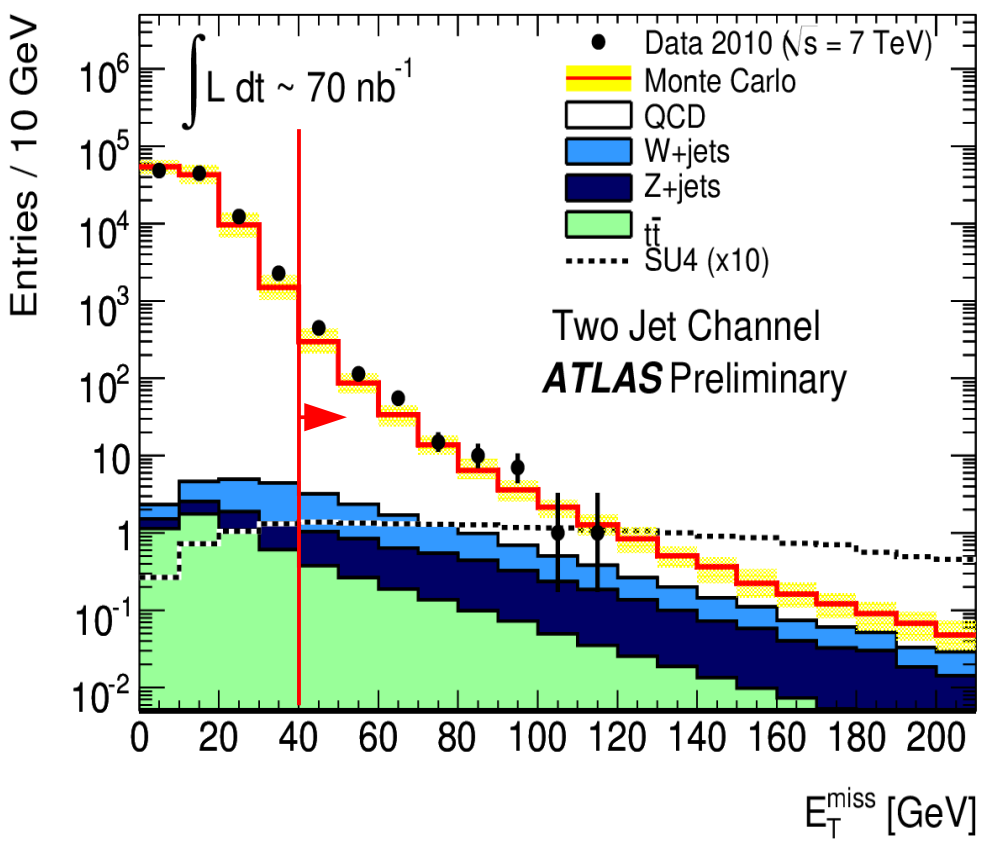


SUSY, jets+MET(+0 leptons)

Number of jets	Monojets	≥ 2 jets	≥ 3 jets	≥ 4 jets
Leading jet p_T (GeV)	> 70	> 70	> 70	> 70
Subsequent jets p_T (GeV)	veto if > 30	> 30	> 30 (Jets 2 and 3)	> 30 (Jets 2 to 4)
E_T^{miss}	> 40 GeV	> 40 GeV	> 40 GeV	> 40 GeV
$\Delta\phi(\text{jet}_i, \vec{E}_T^{miss})$	no cut	$[> 0.2, > 0.2]$	$[> 0.2, > 0.2, > 0.2]$	$[> 0.2, > 0.2, > 0.2, > 0]$
$E_T^{miss} > f \times M_{eff}$	no cut	$f = 0.3$	$f = 0.25$	$f = 0.2$

Veto events if there are any e/μ with pt>10GeV



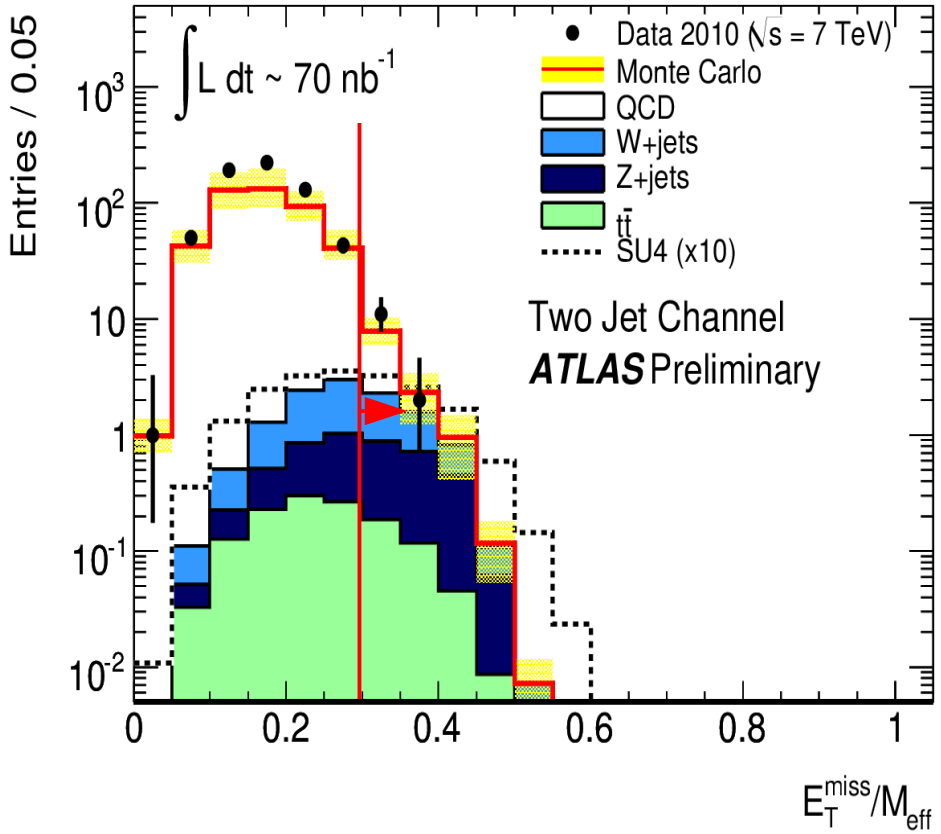


SUSY, jets+MET(+0 leptons)

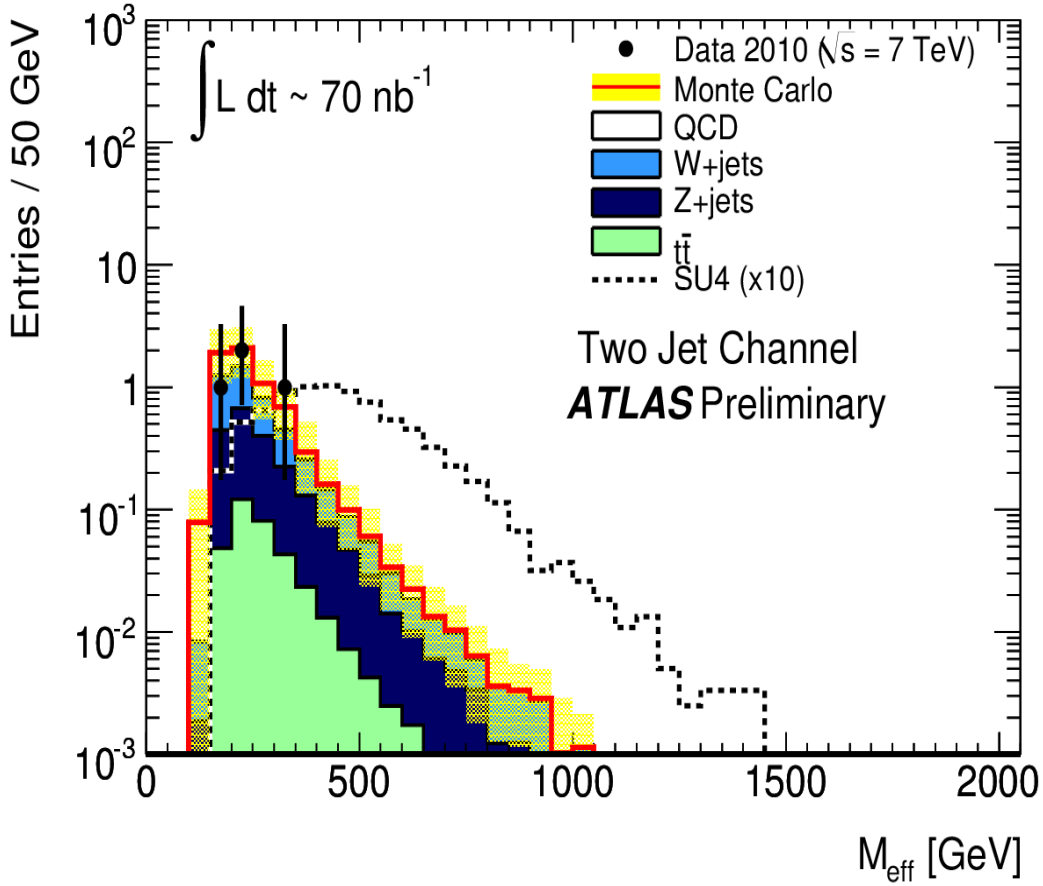
2-jet channel

- *Data agrees, within large systematic uncertainties*

MET>40 GeV



Final selections

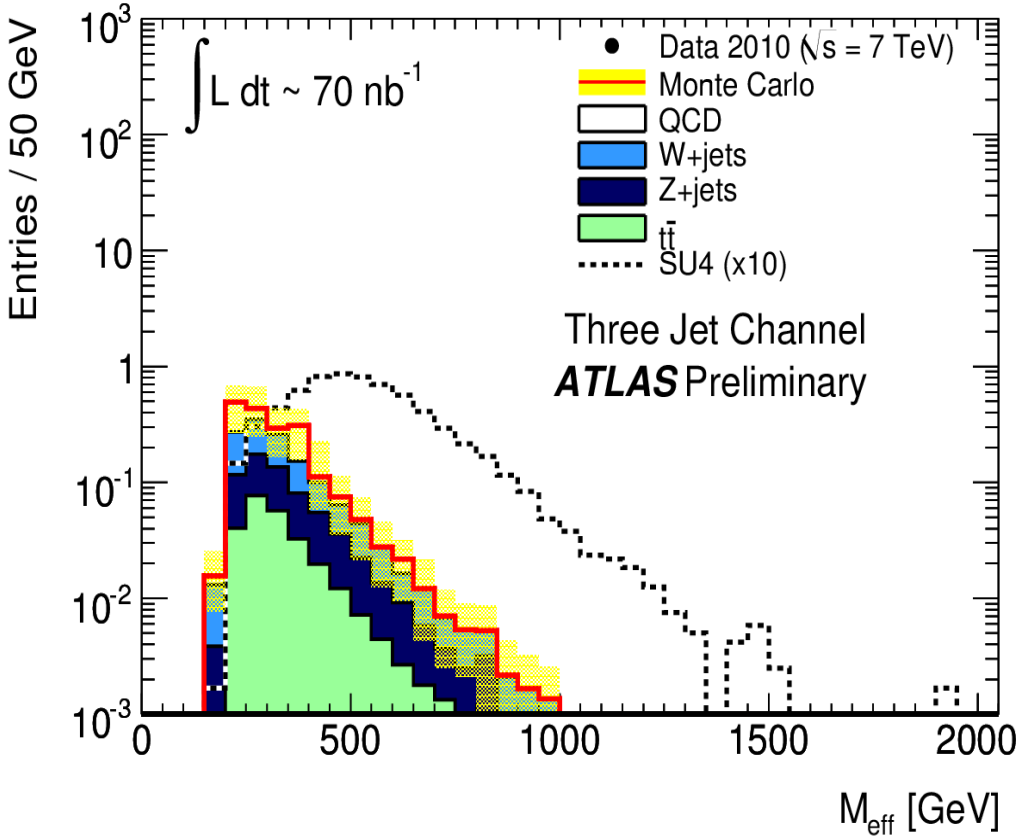


SUSY, jets+MET(+0 leptons)

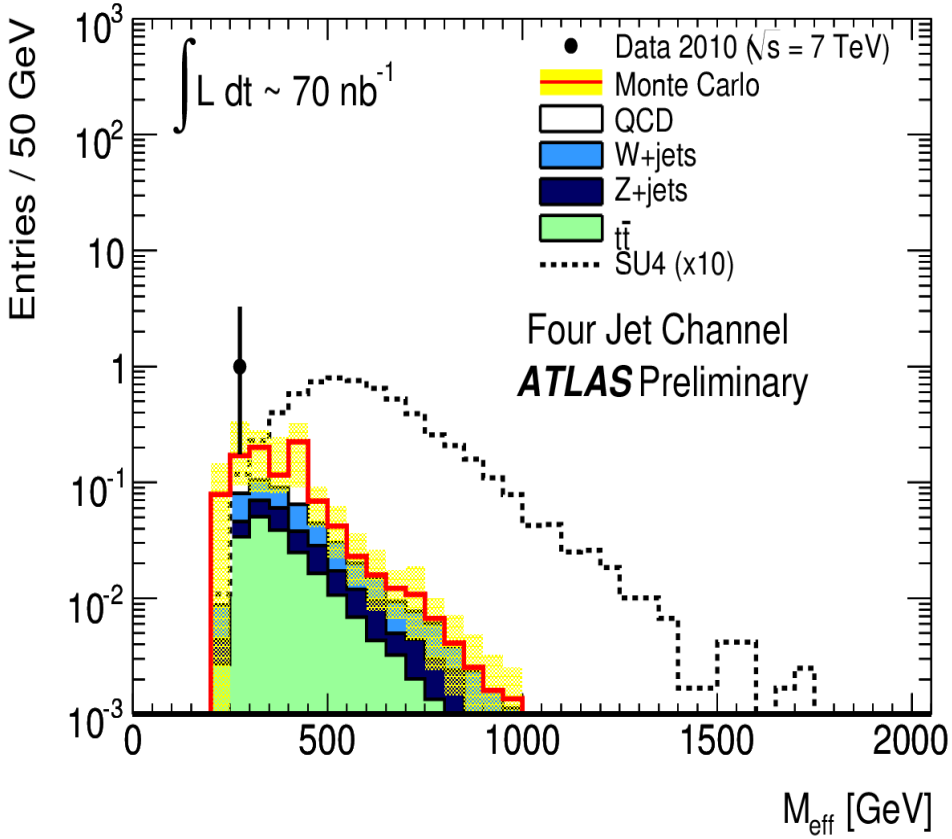
3 and 4 jet channels

- Looking forward to more statistics!
- *Can we understand the background shape well enough?*

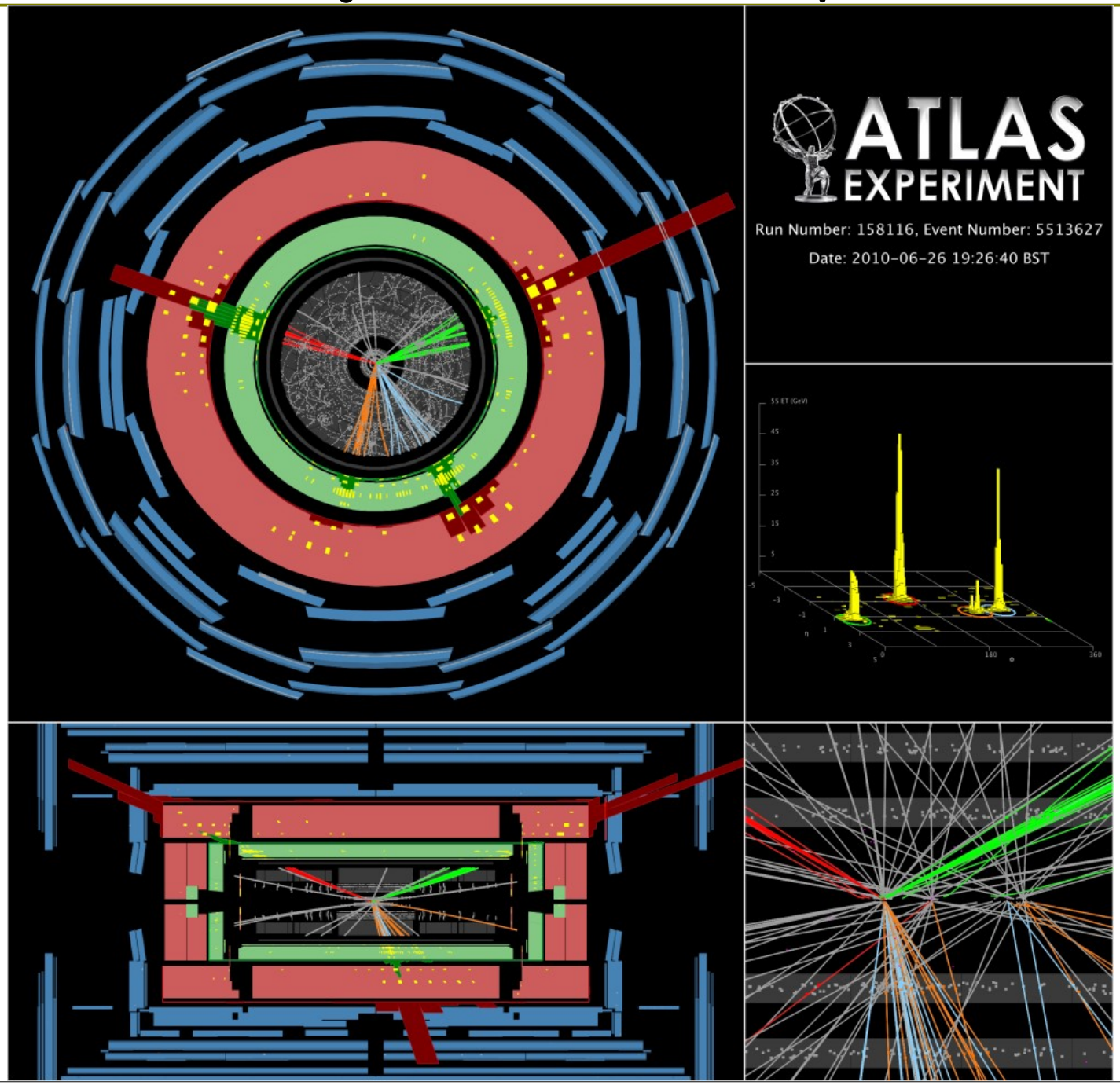
Final selections



Final selections

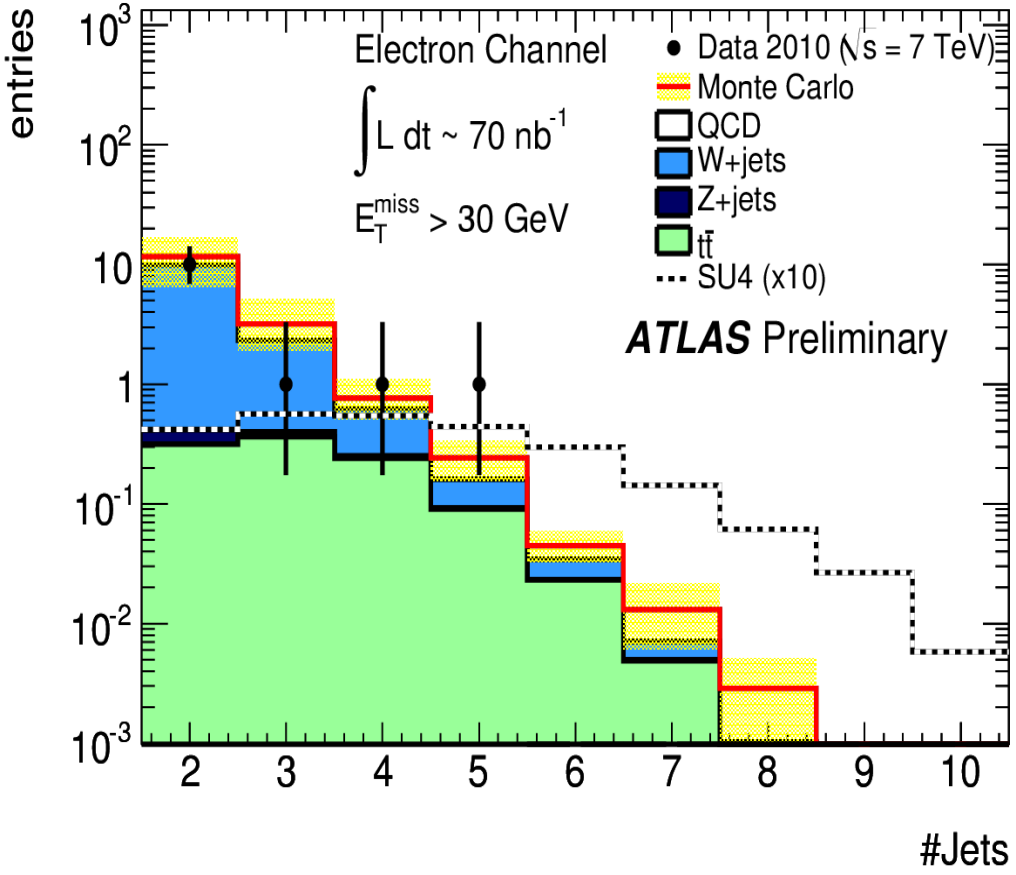


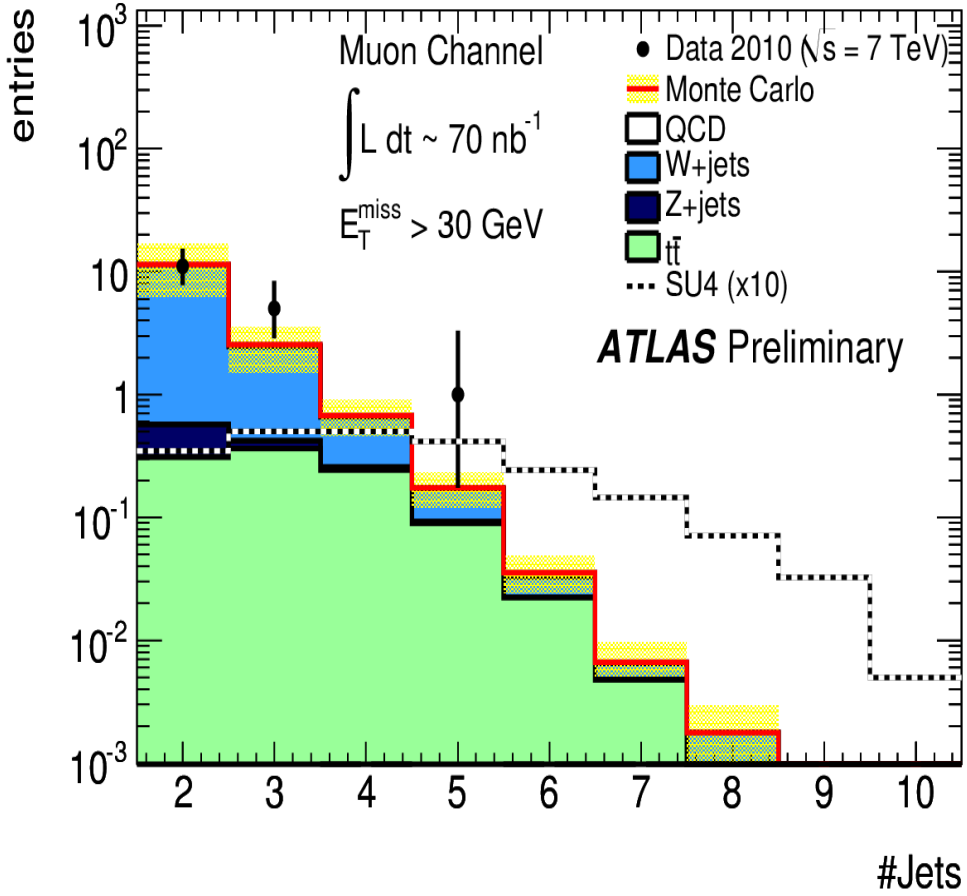
SUSY, jets+MET(+0 leptons)



SUSY, =1 lepton(s)+jets+MET

- Also study events with 1 lepton (e or μ) with pT>20 GeV
- Example: #jets with pT>30 GeV, in events with MET>30 GeV

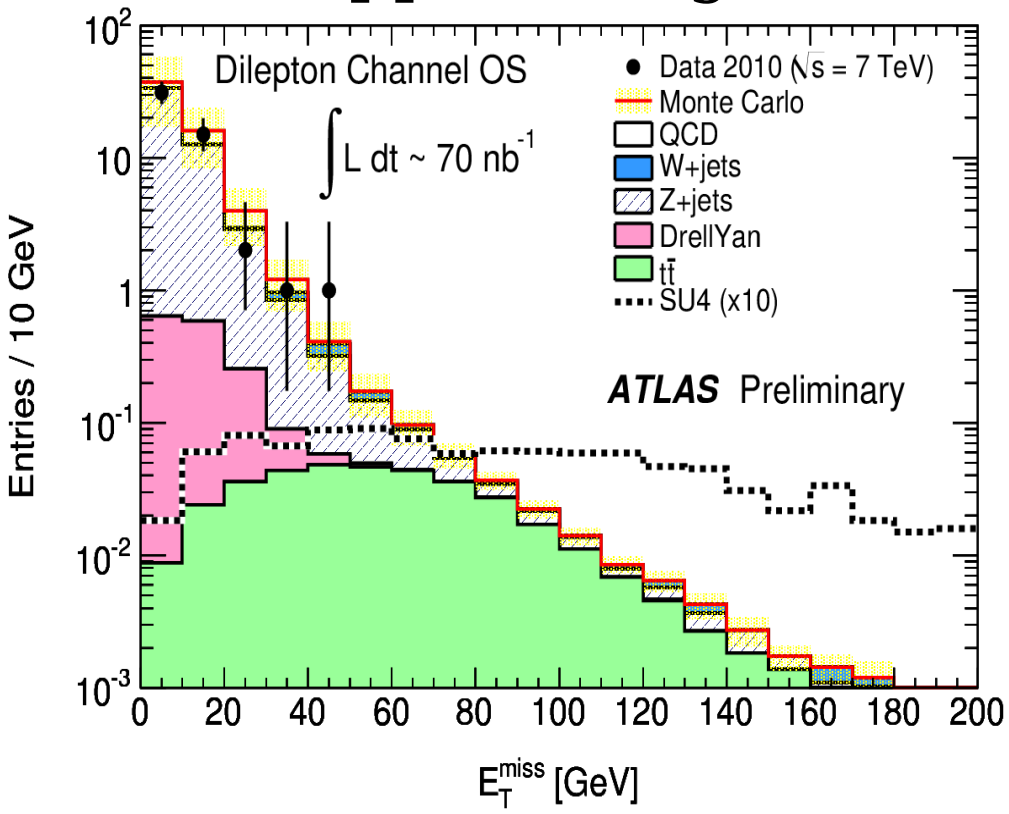




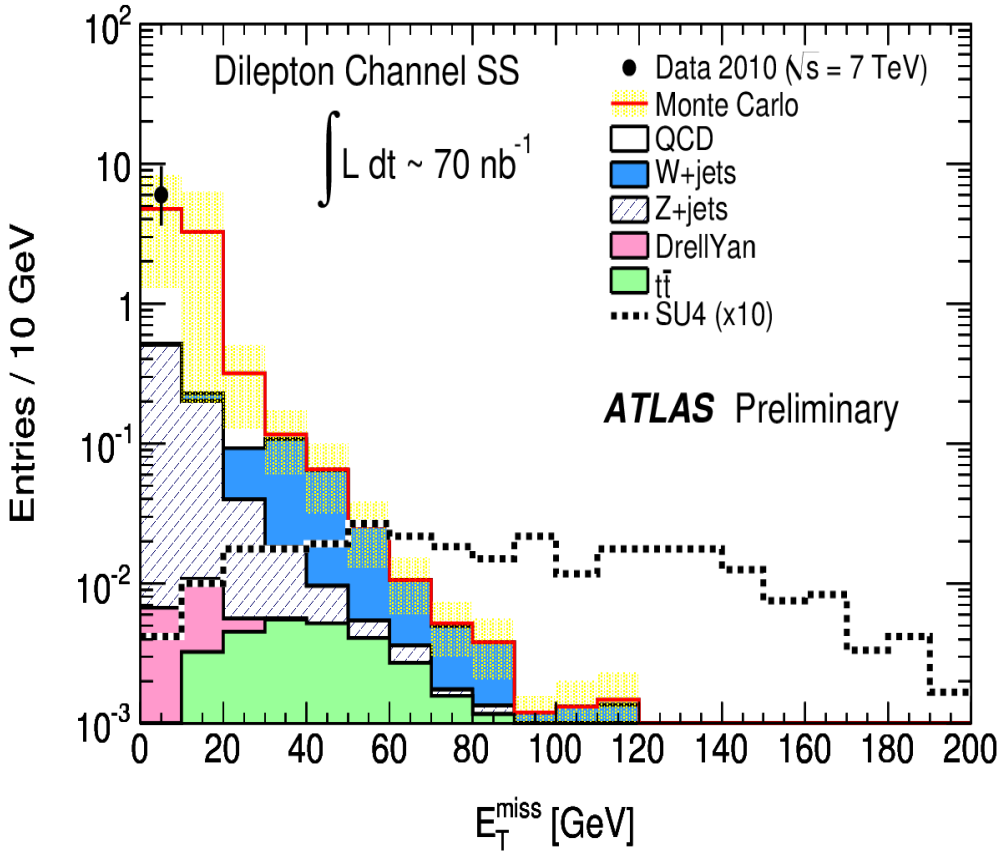
SUSY, =1 lepton(s)+jets+MET

- Also study events with 2 leptons (e or μ) with pT>20 GeV
- We have a lot of "handles" on SUSY…

Opposite-sign

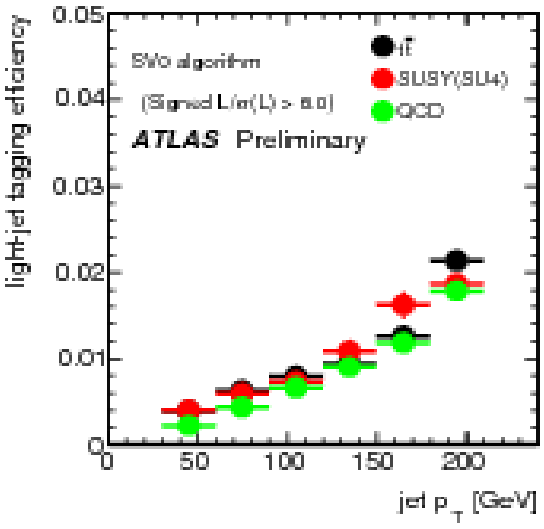


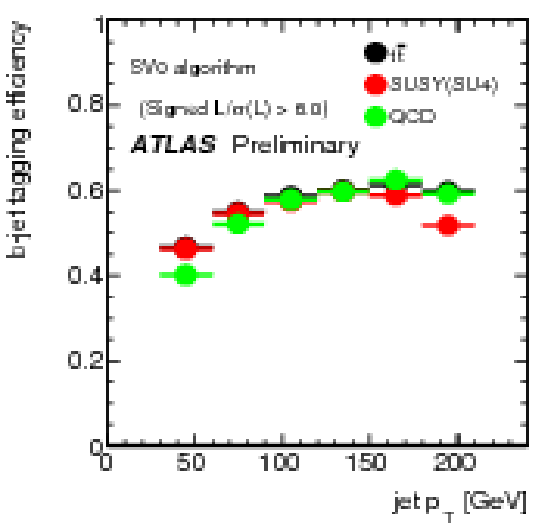
Same-sign

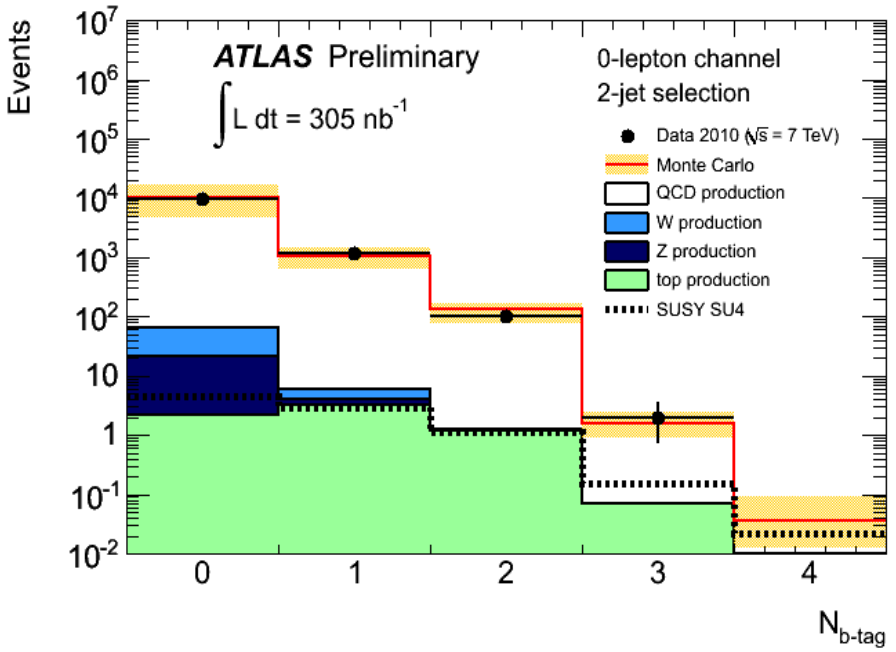


SUSY, b-jets+MET

0-lepton	Electron	Muon
Pre-selection cuts: data quality, trigger requirements clean up for misidentified jets; electron fiduciality; $\geq$1 primary vertex with $\geq$5 tracks		
No lepton ($p_T > 10$ GeV)	$\geq$ 1 electron ($p_T > 20$ GeV)	$\geq$ 1 muon ($p_T > 20$ GeV)
2-jet: jet $p_T > (70, 30)$ GeV 3-jet: 3rd jet $p_T > 30$ GeV	jet $p_T > (30, 30)$ GeV -	jet $p_T > (30, 30)$ GeV -
$E_T^{miss} / \sqrt{\sum E_T} > 2$ GeV$^{1/2}$		
At least 1 b-tagged jet ($L/\sigma(L) > 6$, $p_T > 30$ GeV)		





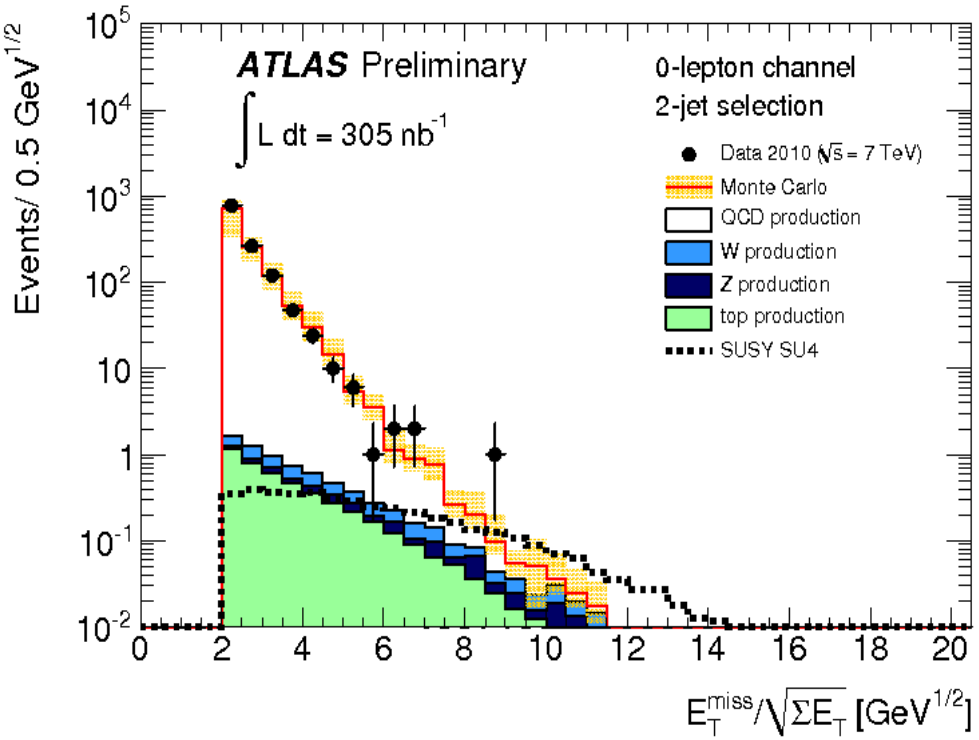


SUSY, b-jets+MET(+0 leptons)

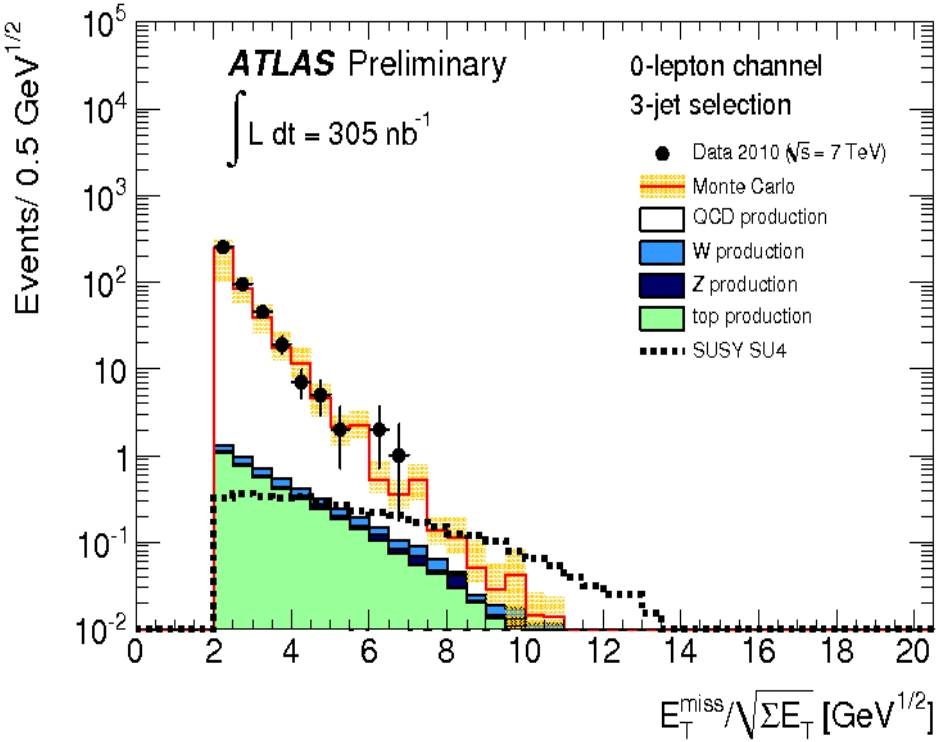
Require ≥1 b-jet

- Study MET "significance"
- Good modeling of QCD events

2-jet channel

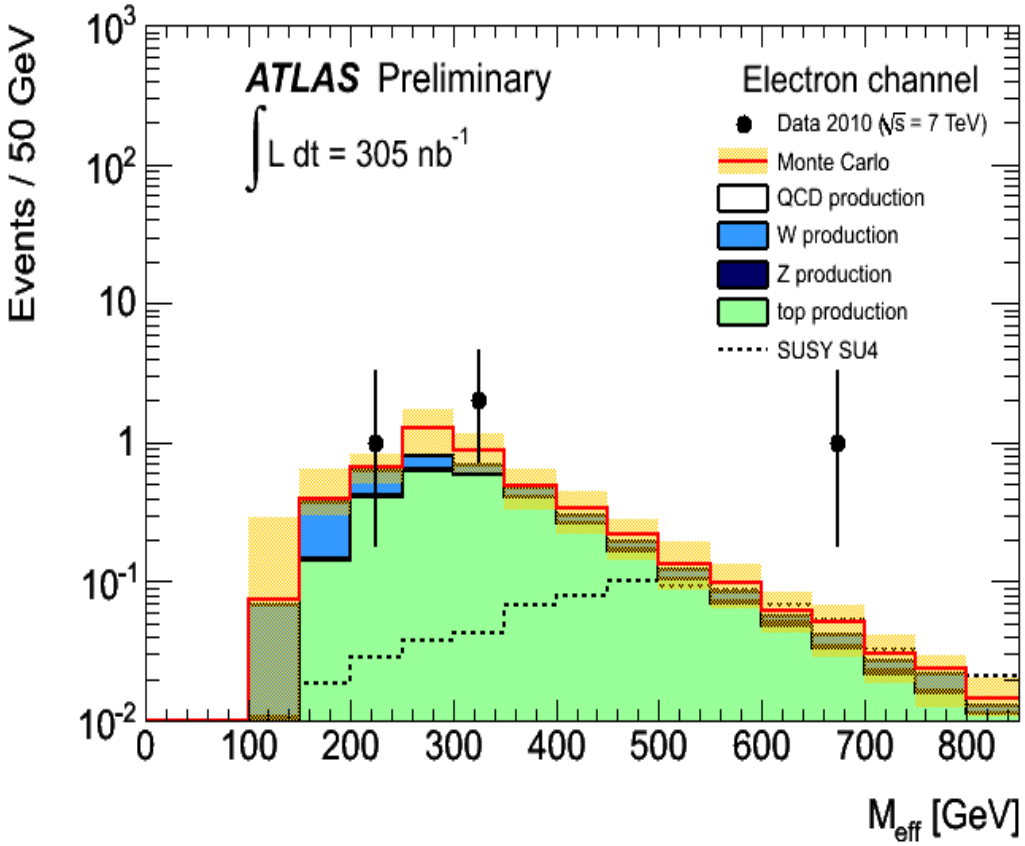


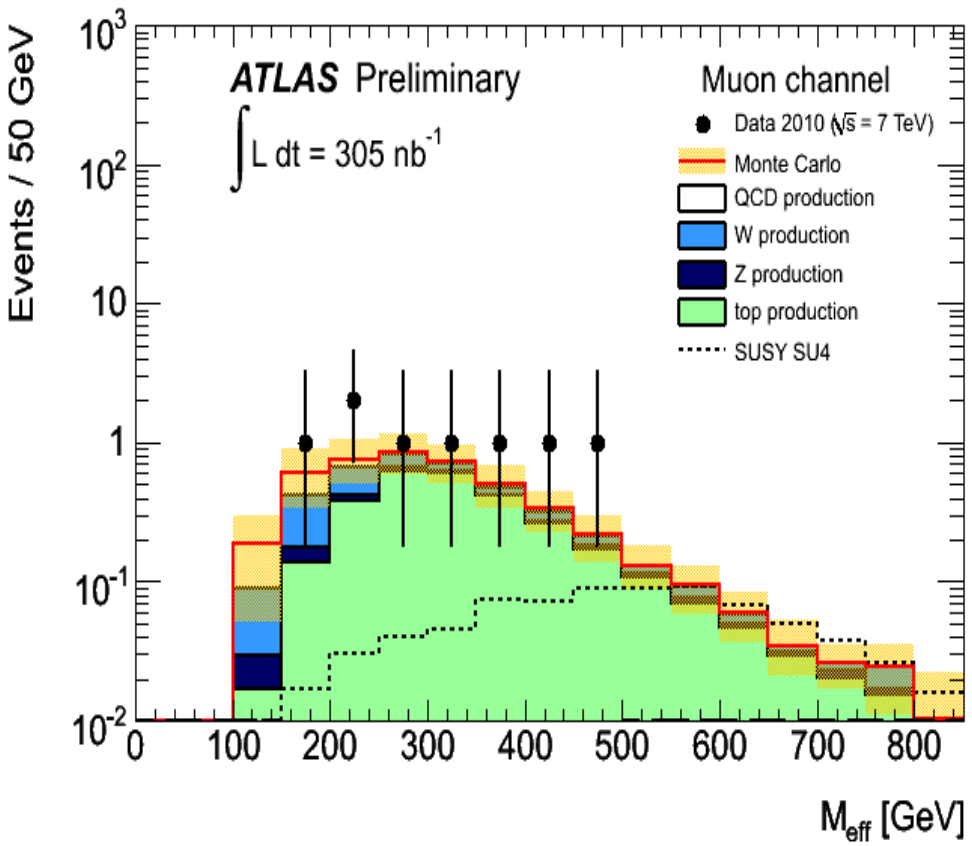
3-jet channel



SUSY, b-jets+MET(+1 lepton)

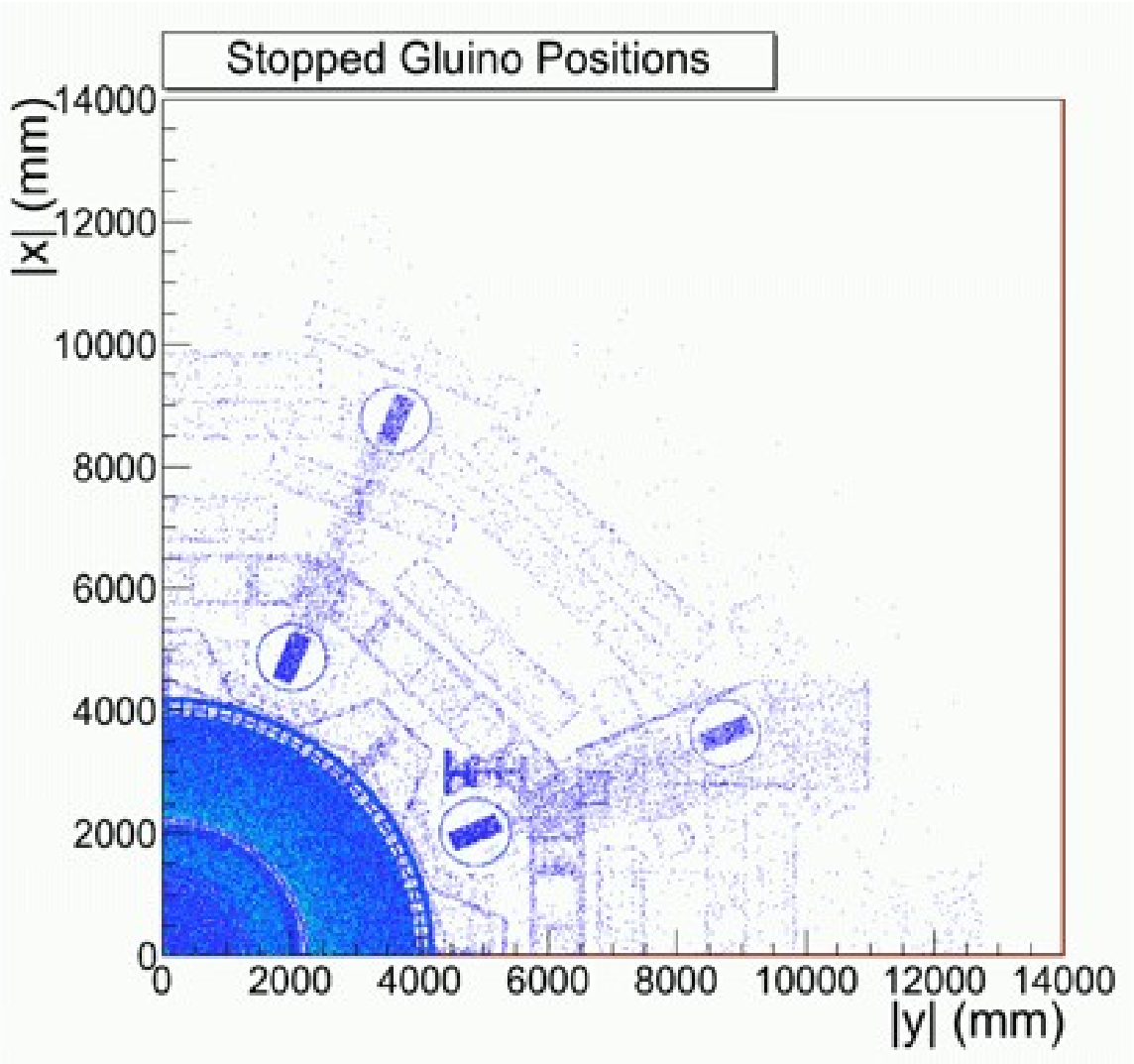
- Require ≥1 b-jet and a lepton (e or μ)...
- Dominated by top at large M_{eff} !





Exotic SUSY

- Search for out-of-time decays in the calorimeter (i.e Stopped Gluinos)



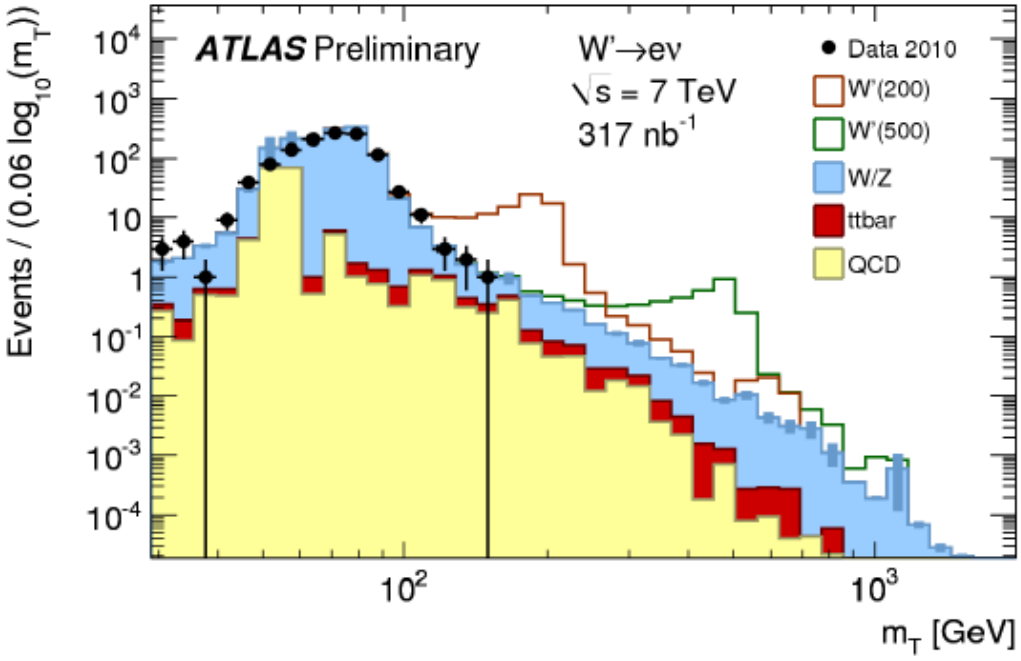
Exotic SUSY

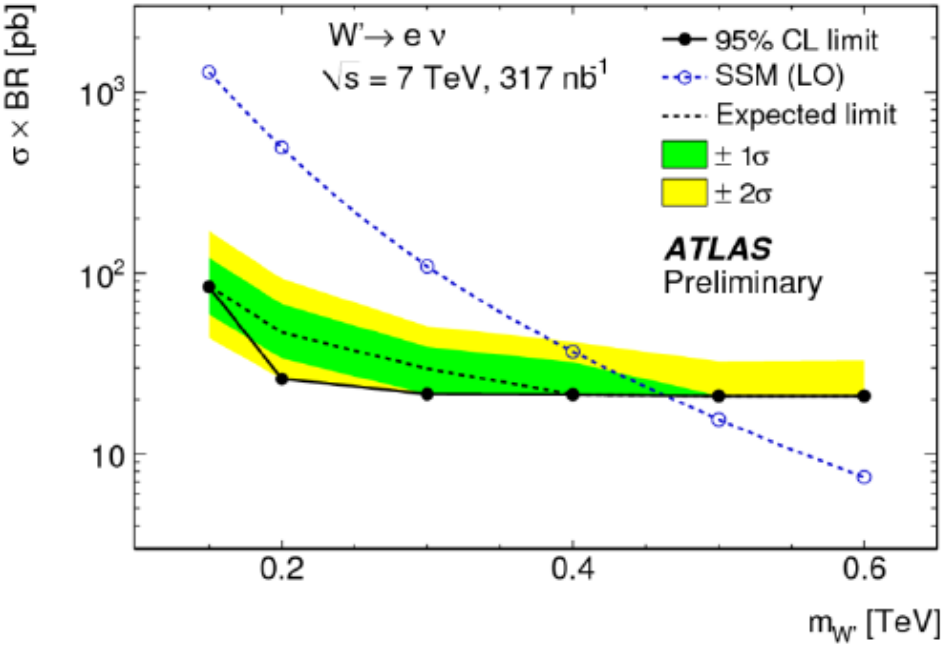
- Search for out-of-time decays in the calorimeter (i.e Stopped Gluinos)
- Background (mostly cosmics) are small and understood
  - ~10 background events/"year" (independent of luminosity!)

	2009 Cosmic Data		2010 Collision Data
Selection Criteria	Yield of cosmics	Cosmics (scaled)	Yield of data
Good runs and data quality cuts	9.43×10^5	–	1.58×10^6
Leading Jet $\|\eta\|<1.2$	6.26×10^5	1.29×10^6	1.29×10^6
Jet n90>3	3.83×10^5	7.89×10^5	7.90×10^5
number of Jets<4	3.82×10^5	7.87×10^5	7.83×10^5
Muon Segment Veto	530 ± 23.0	1092 ± 47.4	1170
Leading Jet Energy > 50 GeV	39 ± 6.2	80 ± 12.8	75
Leading Jet Width > 0.05	6 ± 2.4	12 ± 4.9	8
Jet n50<6	3 ± 1.7	6 ± 3.5	4
Leading Jet EMF<0.95	2 ± 1.4	4 ± 2.9	4

Exotics

- Look for W' → eν



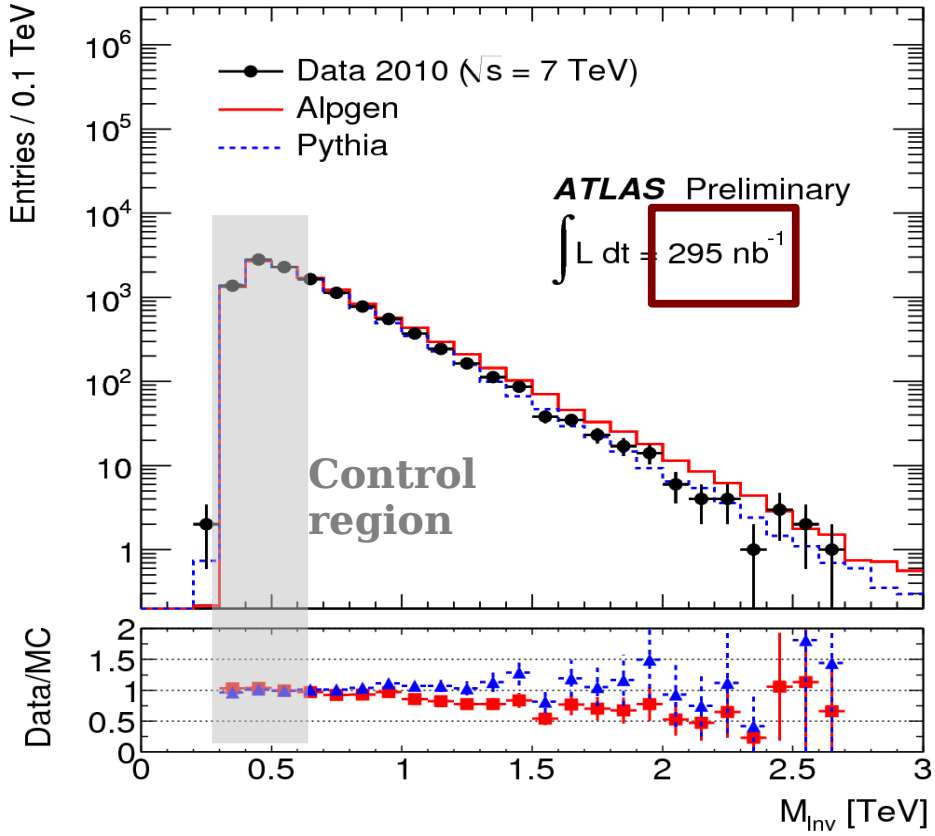


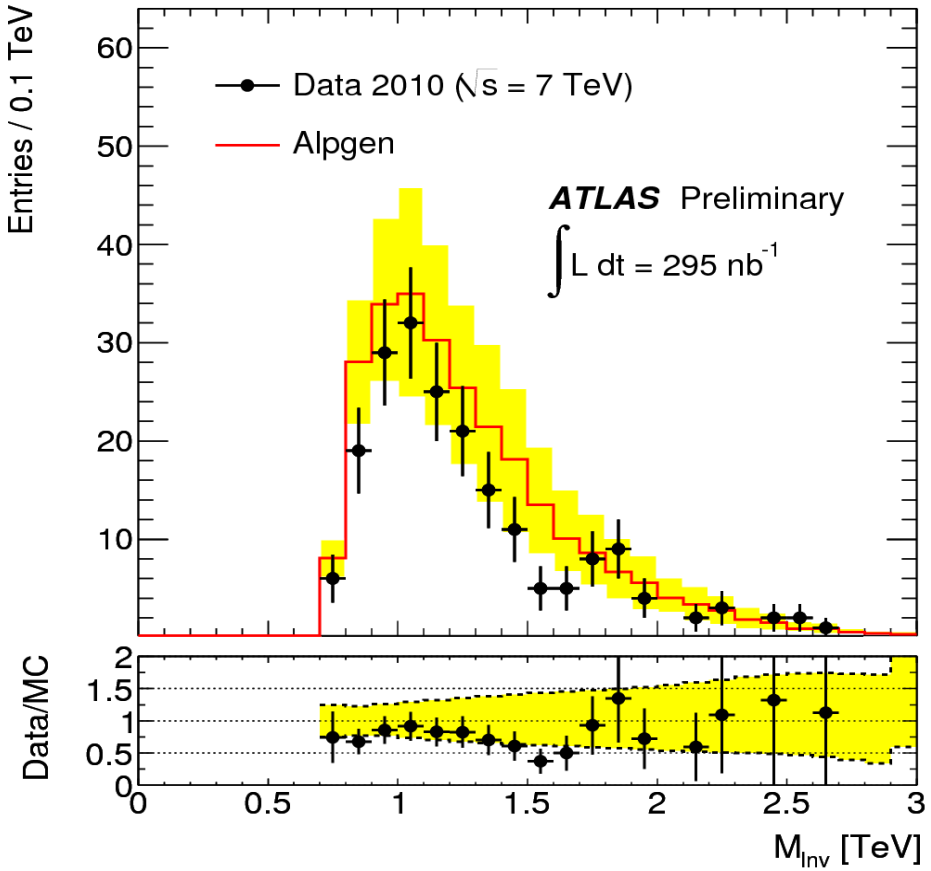
- Good data/MC agreement, understanding of backgrounds

- m(W') > 465 GeV
  - Tevatron limit is ~1 TeV

Exotics

- Look for black-holes
- High mass object decaying to jets, photons, leptons, …
- Agreement of data with MC, within generator uncertainties



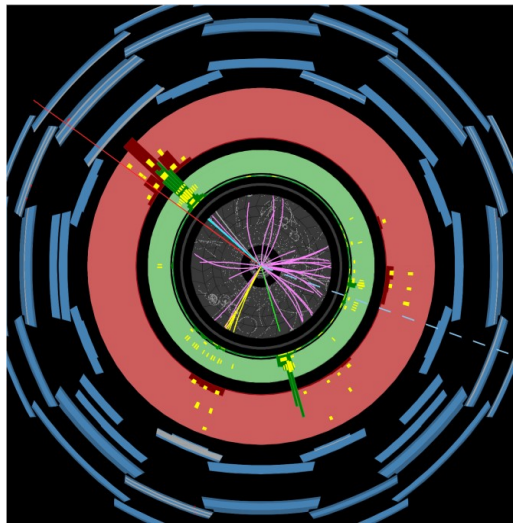


Conclusions

QCD / jets
MET / b-tagging / tau's
W/Z (+jets)
Top
SUSY / Exotics

A complete physics program.

7 TeV data just began ~6 months ago!



One search for new physics already published!

Many many more are underway.

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

Expect 100's pb^{-1} in 2011 → golden year of opportunity

ATLAS is ready!

Thank you for helping us make the most of it!