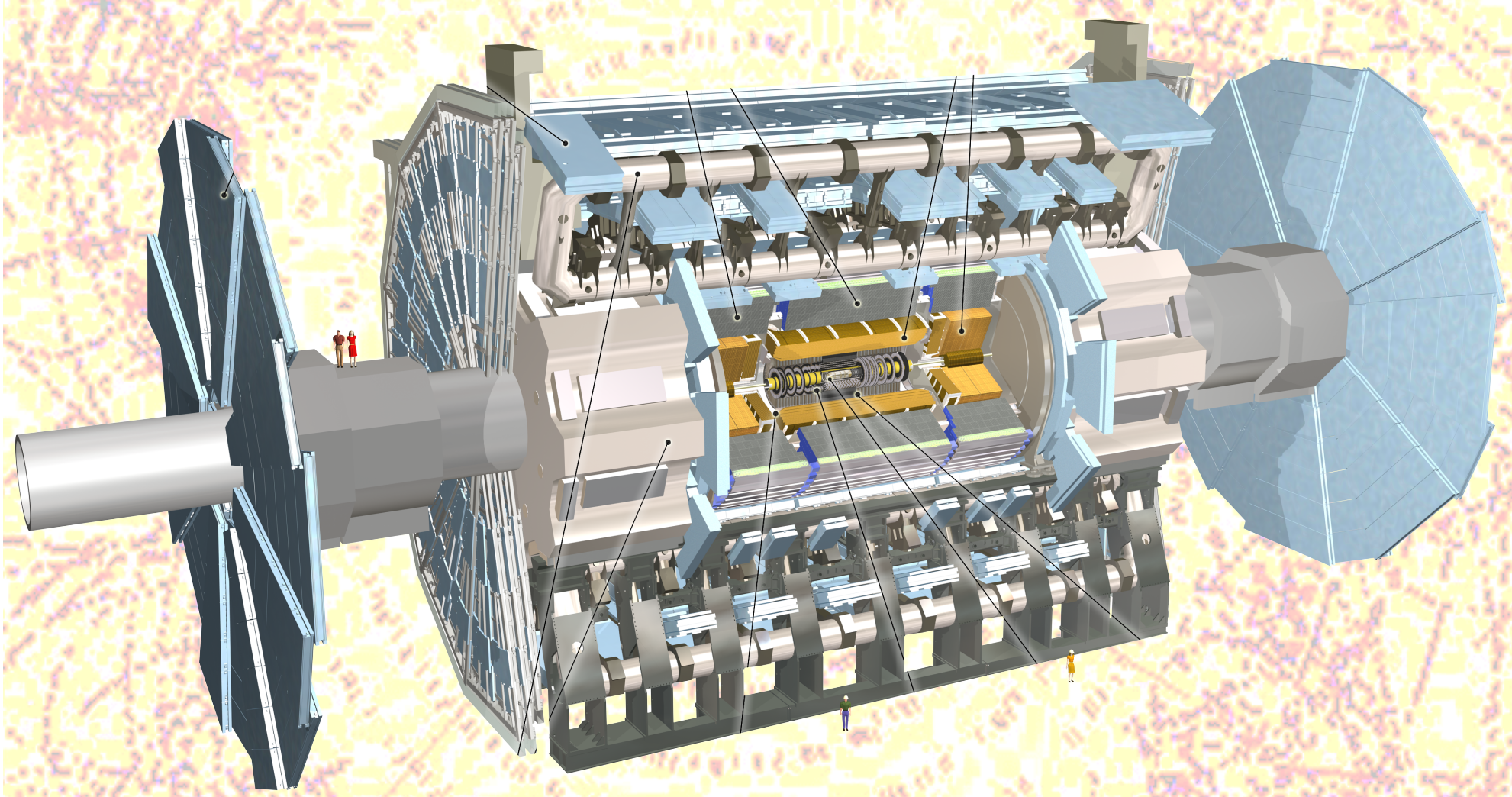
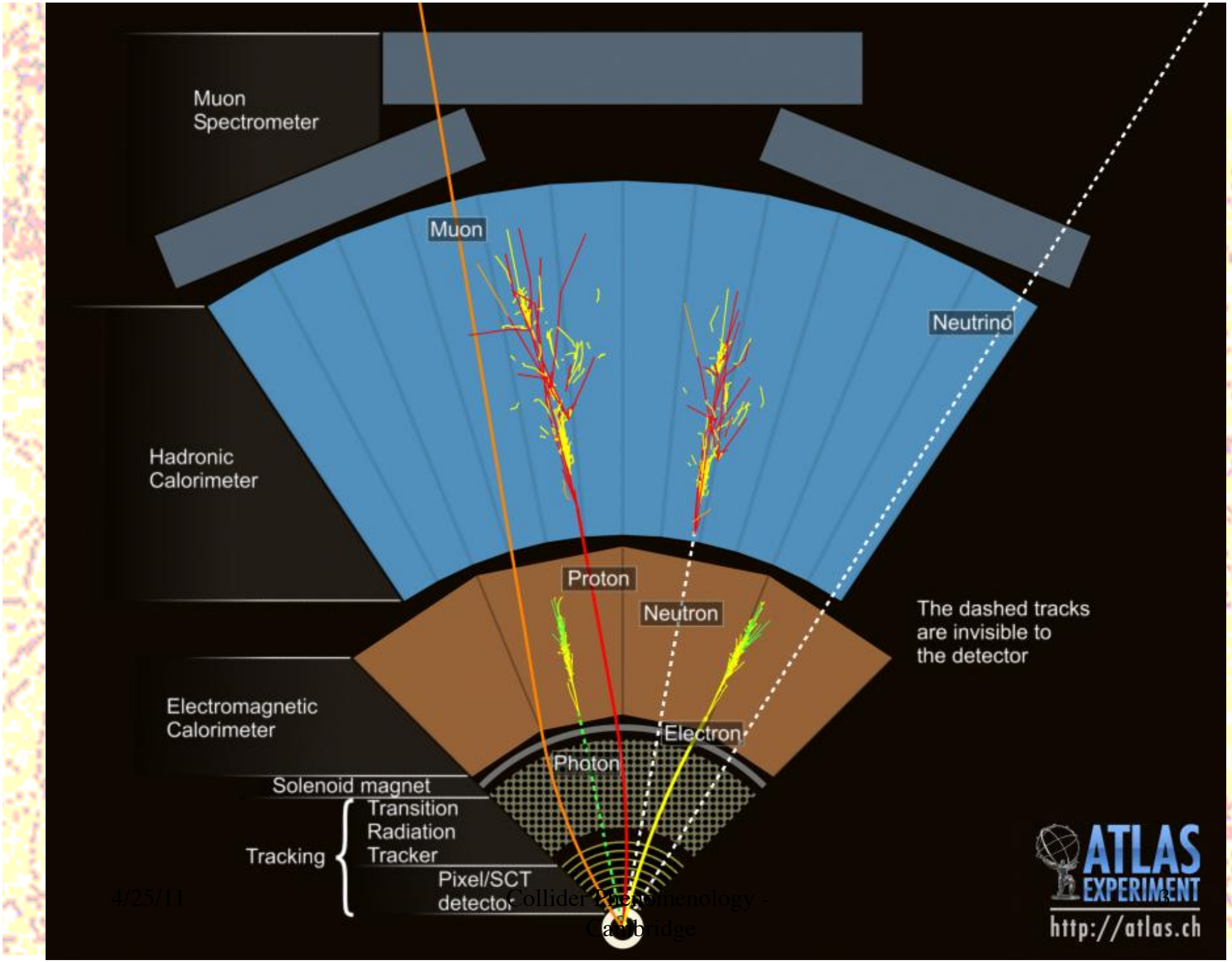
Latest results from ATLAS

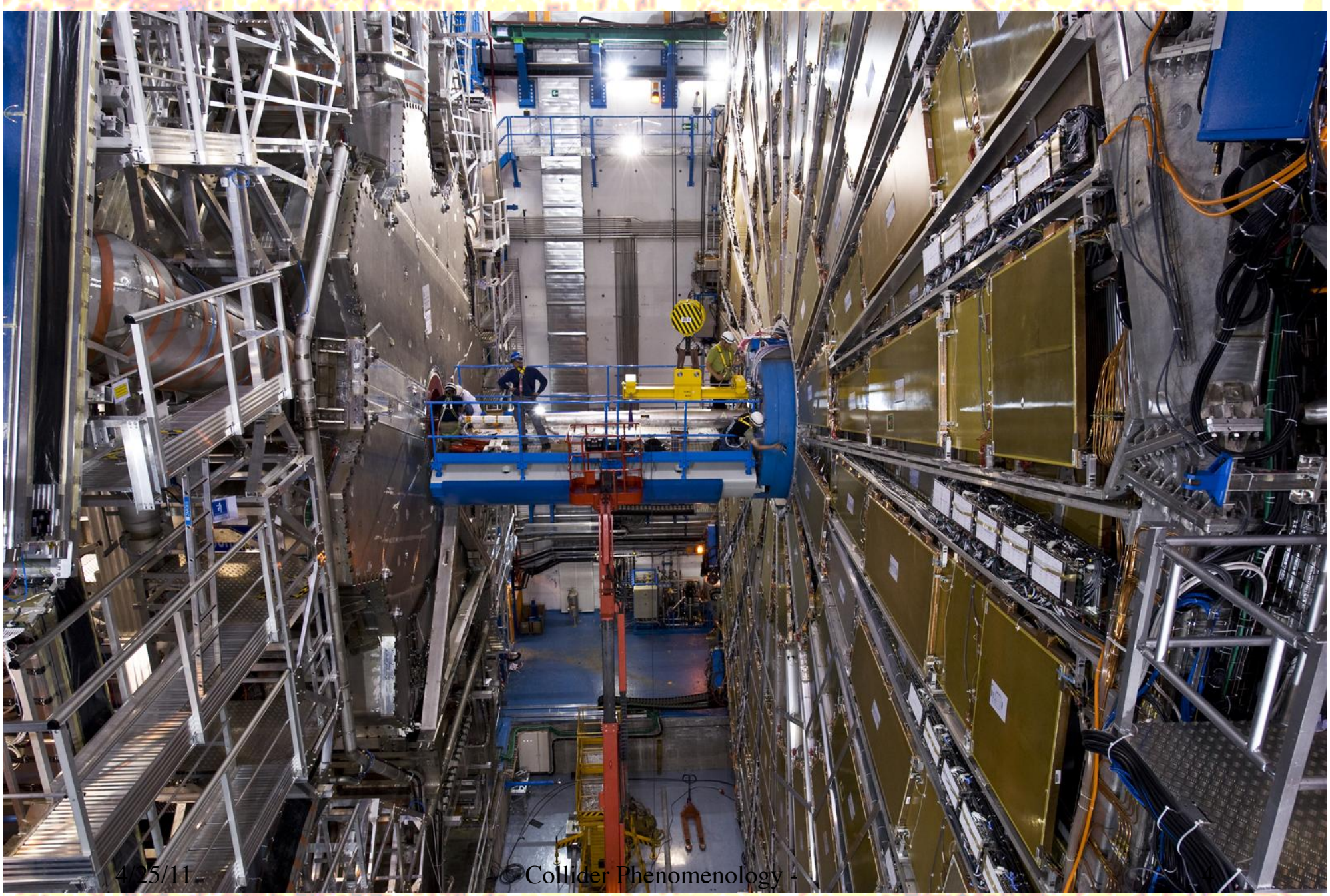
Andy Parker
Cavendish Laborator

On behalf of the ATLAS Collaboration

The ATLAS detector

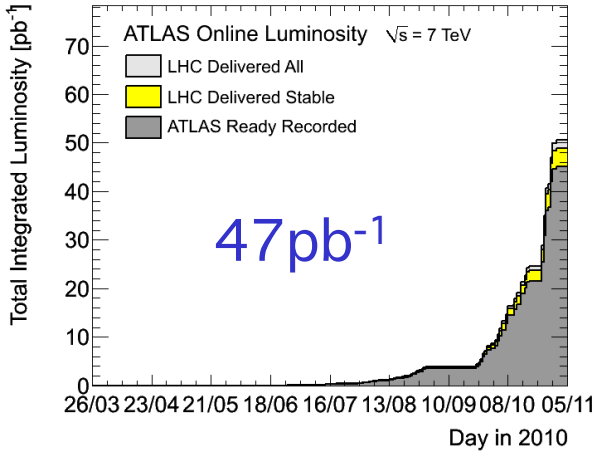


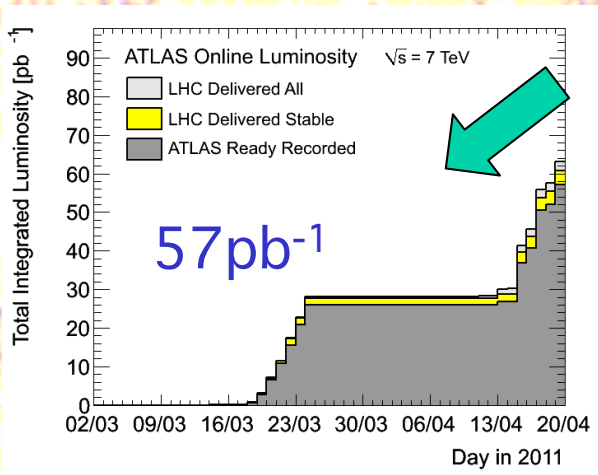

Muon
Spectrometer
Muon
Neutrino
Hadronic
Calorimeter
Proton
Neutron
The dashed tracks
are invisible to
the detector
Electromagnetic
Calorimeter
Electron
Photon
Solenoid magnet
Tracking
Transition
Radiation
Tracker
Pixel/SCT
detector
ATLAS
EXPERIMENT
http://atlas.ch



Luminosity evolution

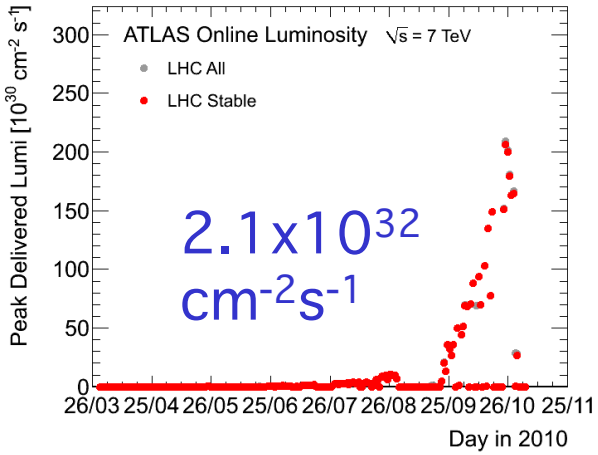
2010 Integrated 2011

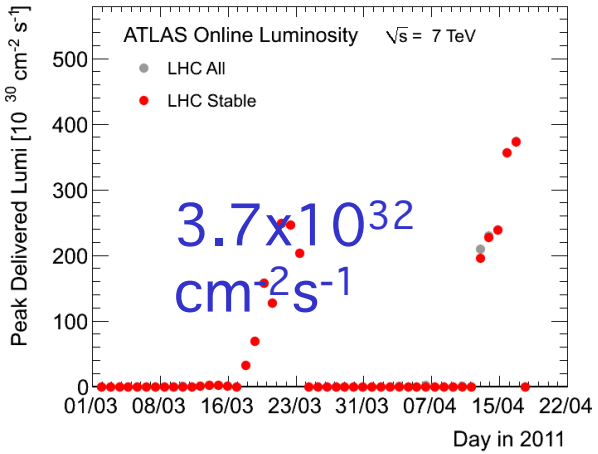




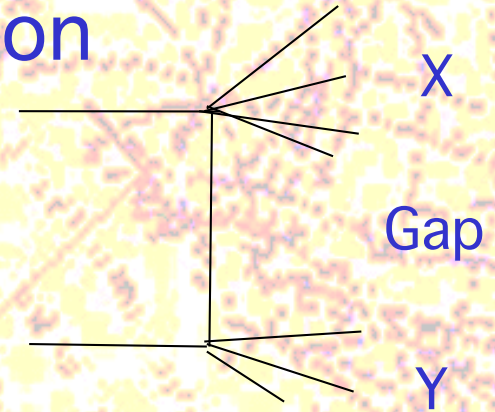
Beam scrubbing

Peak

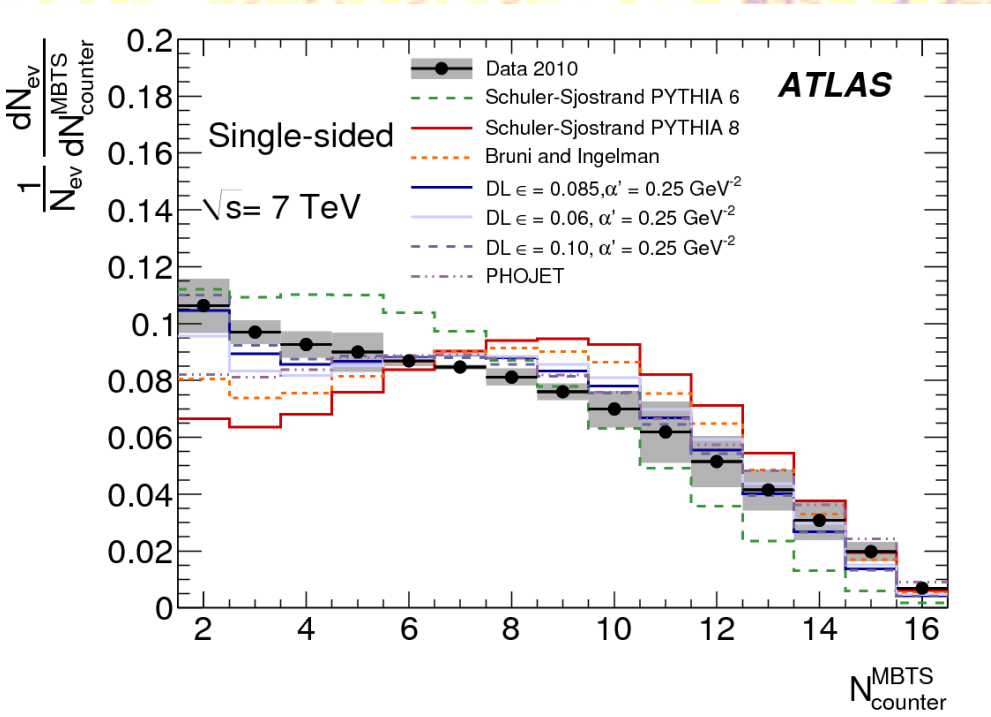




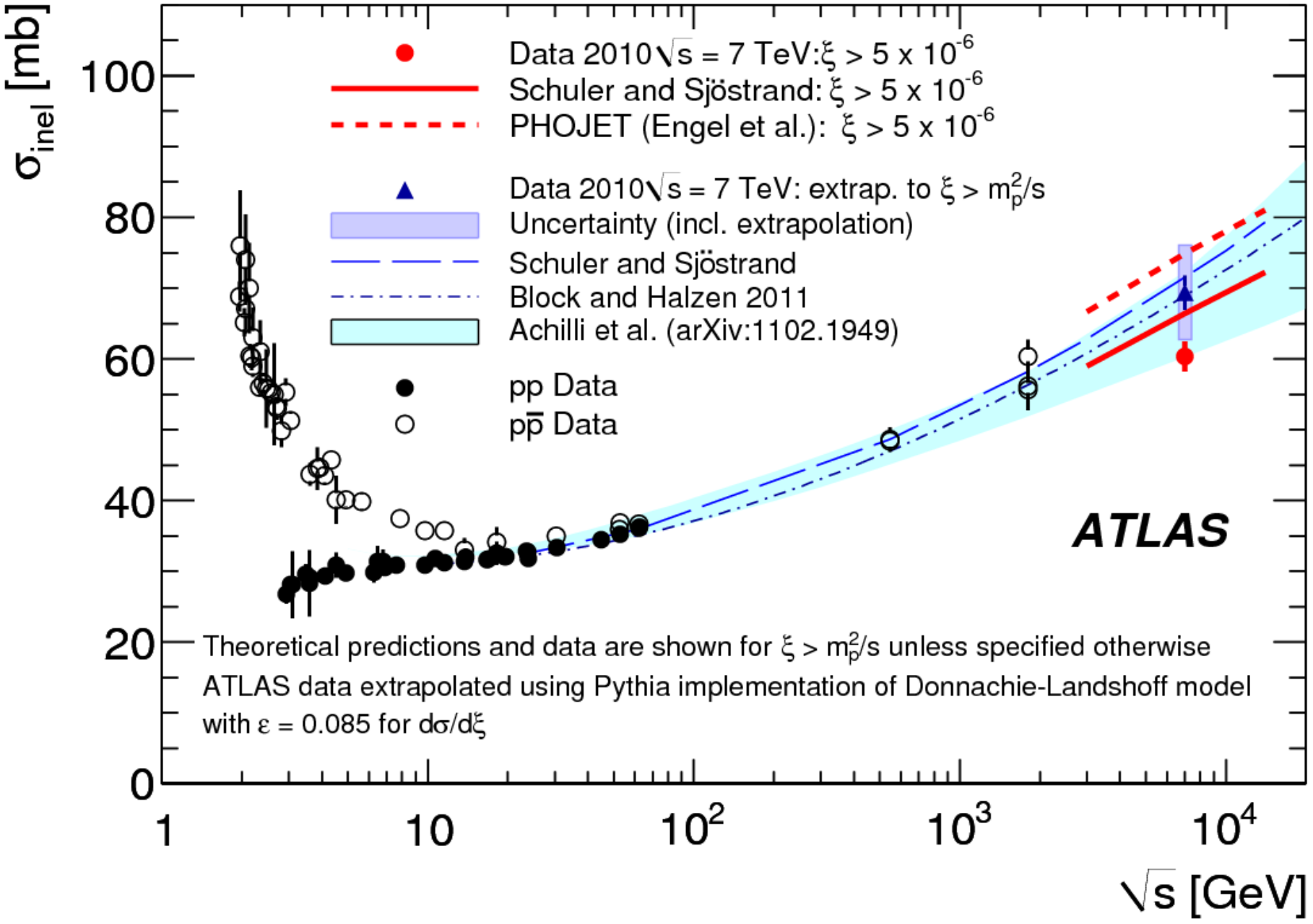
Inelastic Cross Section



- 20 μb^{-1} of data
- Use MBTS scintillators at $2.09 < |\eta| < 3.84$
- Acceptance matches $\xi = M^2_X/s > 5 \times 10^{-6}$
- Poor theoretical description of multiplicity data: Problem to extrapolate to $M_x = M_p$

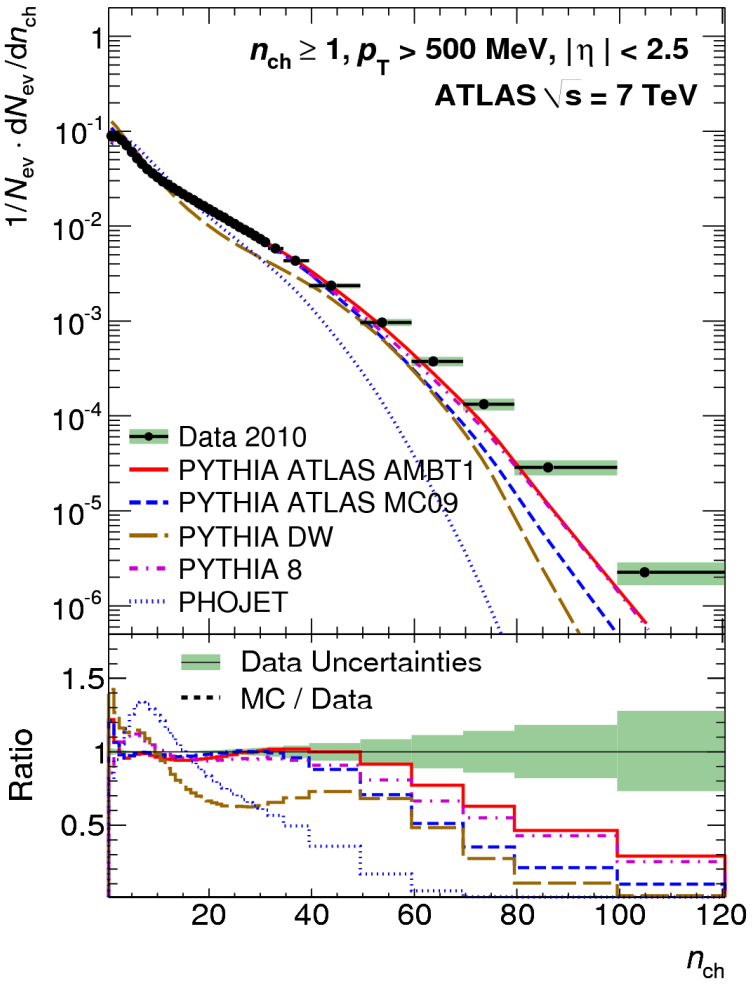


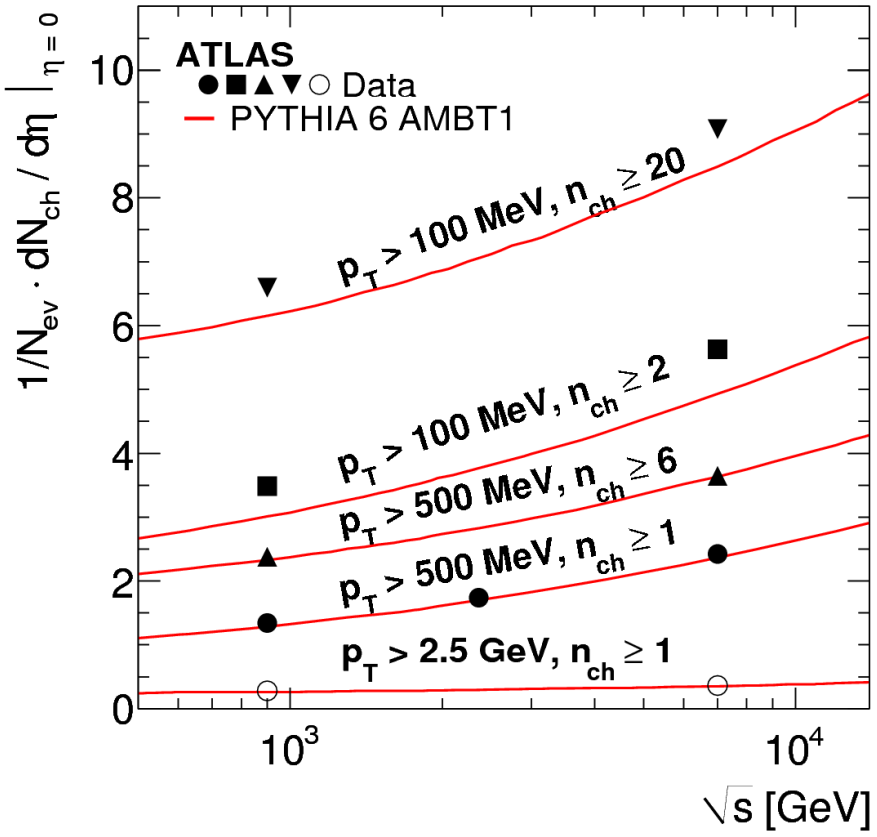
Submitted to Nature Comm
(2 April 2011)


σ_{inel} [mb]
100
80
60
40
20
0
1
10
10^2
10^3
10^4
$\sqrt{s}$ [GeV]
Data 2010 $\sqrt{s}$ = 7 TeV: $\xi > 5 \times 10^{-6}$
Schuler and Sjöstrand: $\xi > 5 \times 10^{-6}$
PHOJET (Engel et al.): $\xi > 5 \times 10^{-6}$
Data 2010 $\sqrt{s}$ = 7 TeV: extrap. to $\xi > m_p^2/s$
Uncertainty (incl. extrapolation)
Schuler and Sjöstrand
Block and Halzen 2011
Achilli et al. (arXiv:1102.1949)
pp Data
$p\bar{p}$ Data
ATLAS
Theoretical predictions and data are shown for $\xi > m_p^2/s$ unless specified otherwise
ATLAS data extrapolated using Pythia implementation of Donnachie-Landshoff model
with $\varepsilon = 0.085$ for $d\sigma/d\xi$

Lots of minimum bias event data

Charged-particle multiplicity

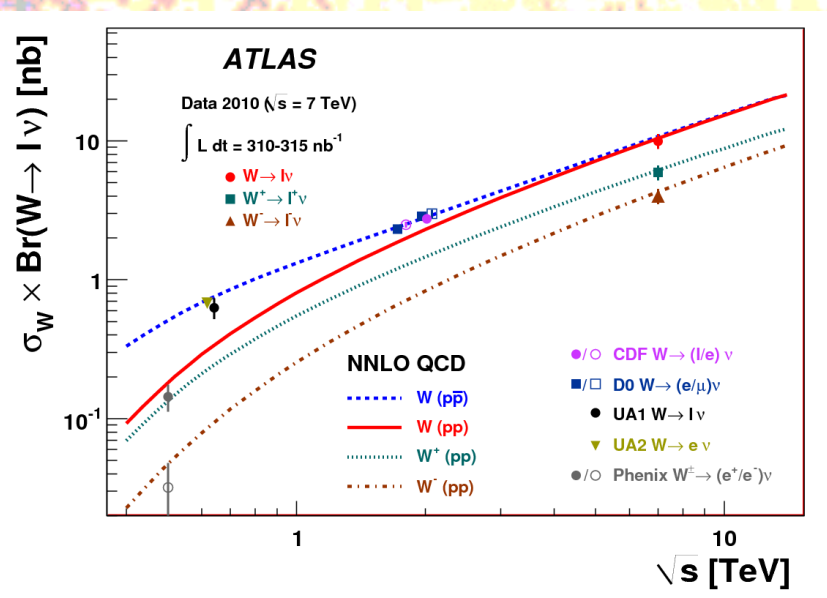


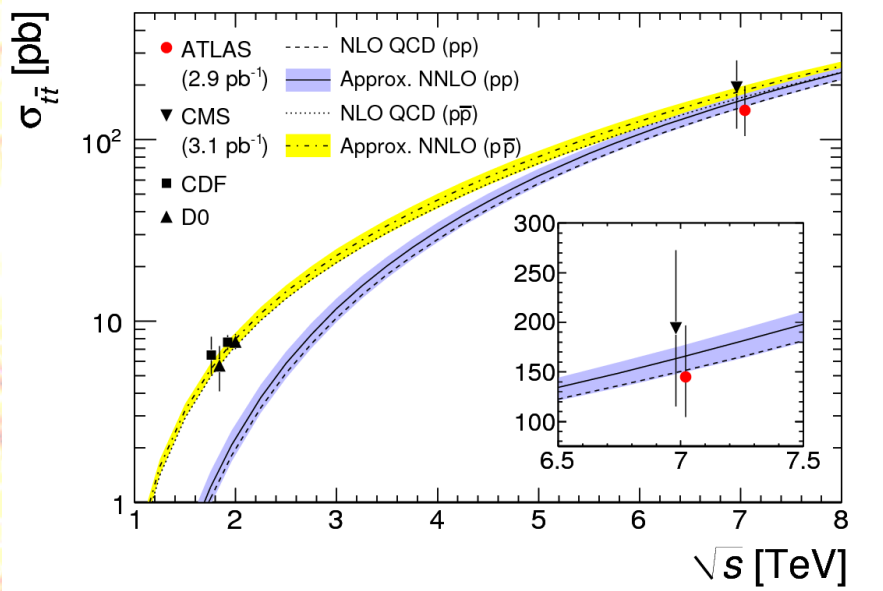


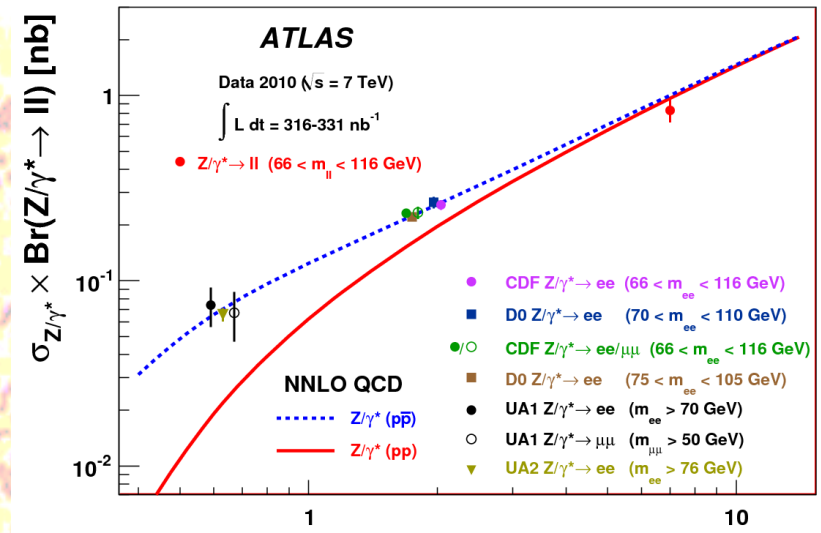
Average charged particle multiplicity per unit of rapidity for eta = 0

accepted by New J Phys

Standard model physics revisited







W, Z and top production cross-sections

Supersymmetry searches

- SUSY is prime candidate for new physics. Many search channels. Describe 0-lepton in some detail, and then show results from lepton modes.

- Target $\tilde{g}\tilde{g}, \tilde{q}\tilde{q}, \tilde{q}\tilde{g}$

with $\tilde{q} \rightarrow q\tilde{\chi}^0$

$\tilde{g} \rightarrow qq\tilde{\chi}^0$

Construct jets using anti-k_t (0.4), calibrated, with p_T>20 GeV and $|\eta|$<4.9

Electron candidates with p_T>10 GeV and $|\eta|$<2.47 (medium)

Muon candidates with p_T>10 GeV and $|\eta|$<2.4, energy within ΔR<0.2 less than 1.8 GeV.

Missing E_T calculated, and then jets with $|\eta|$>2.5 discarded.

Events with leptons discarded.

Signal regions

arXiv:1102.5290

- 4 signal regions defined, with 2 and 3 jets, different kinematic cuts to target different scenarios:

A: light squark

B: heavy squark

C: gluino

D: squark-gluino

$\Delta\phi$ cut targets mismeasured jets

		A	B	C	D
Pre-selection	Number of required jets	≥ 2	≥ 2	≥ 3	≥ 3
	Leading jet p_T [GeV]	> 120	> 120	> 120	> 120
	Other jet(s) p_T [GeV]	> 40	> 40	> 40	> 40
	E_T^{miss} [GeV]	> 100	> 100	> 100	> 100
Final selection	$\Delta\phi(\text{jet}, \vec{p}_T^{miss})_{min}$	> 0.4	> 0.4	> 0.4	> 0.4
	E_T^{miss}/m_{eff}	> 0.3	–	> 0.25	> 0.25
	m_{eff} [GeV]	> 500	–	> 500	> 1000
	m_{T2} [GeV]	–	> 300	–	–

$\tilde{q}\tilde{q} \rightarrow qq\tilde{\chi}^0\tilde{\chi}^0$ 2 hard jets

$\tilde{g}\tilde{g}, \tilde{q}\tilde{g}$ extra jets from $\tilde{g} \rightarrow qq\tilde{\chi}^0$

$$M_{eff} = \left|E_T^{miss}\right| + \sum_{jets} \left|p_T\right|$$

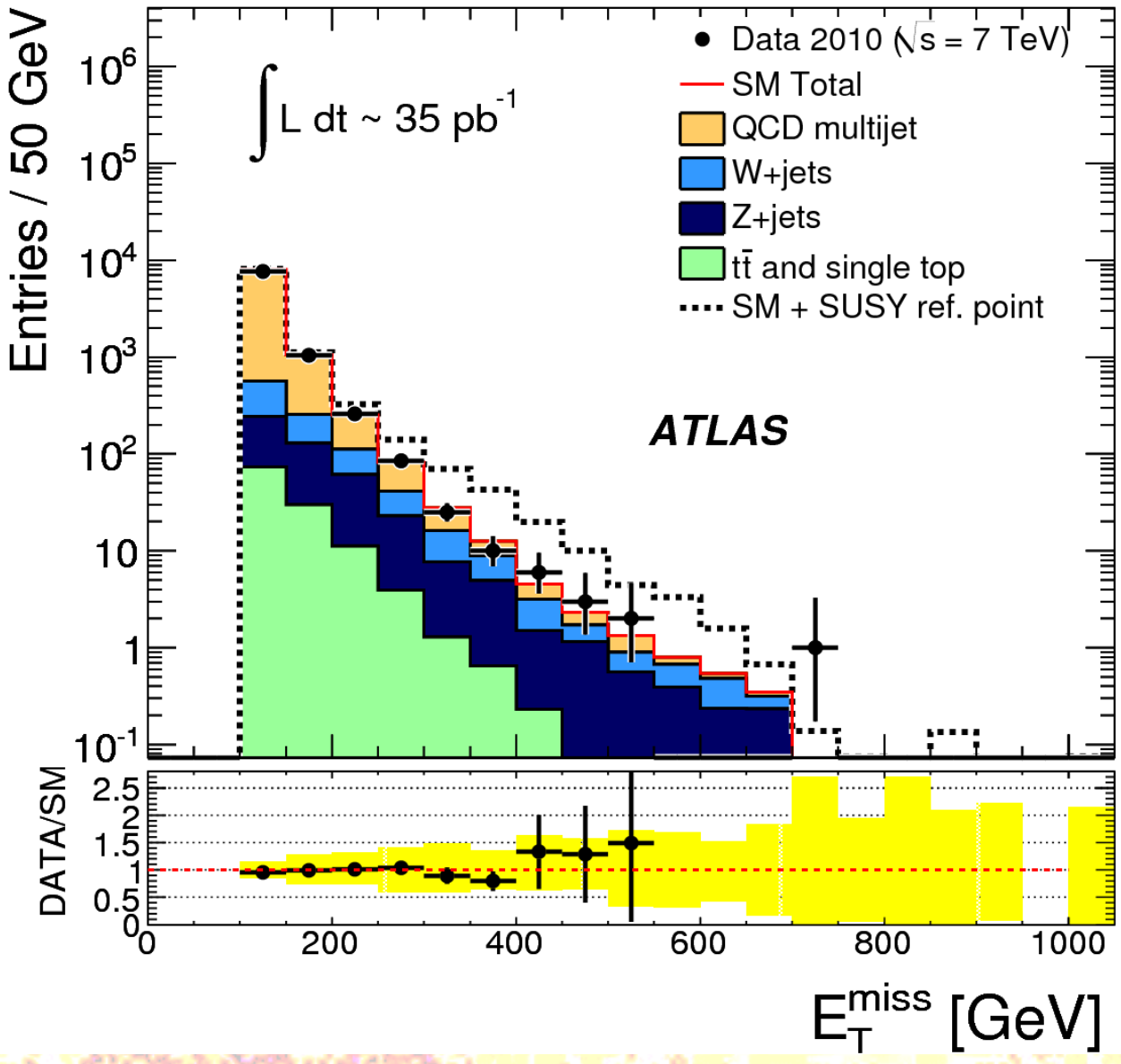
Event counts and backgrounds

	Signal region A	Signal region B	Signal region C	Signal region D
QCD	$7\ ^{+8}_{-7}$[u+j]	$0.6\ ^{+0.7}_{-0.6}$[u+j]	$9\ ^{+10}_{-9}$[u+j]	$0.2\ ^{+0.4}_{-0.2}$[u+j]
W+jets	50 ± 11[u] $^{+14}_{-10}$[j] $\pm$ 5[$\mathcal{L}$]	4.4 ± 3.2[u] $^{+1.5}_{-0.8}$[j] ± 0.5[$\mathcal{L}$]	35 ± 9[u] $^{+10}_{-8}$[j] ± 4[$\mathcal{L}$]	1.1 ± 0.7[u] $^{+0.2}_{-0.3}$[j] ± 0.1[$\mathcal{L}$]
Z+jets	52 ± 21[u] $^{+15}_{-11}$[j] $\pm$ 6[$\mathcal{L}$]	4.1 ± 2.9[u] $^{+2.1}_{-0.8}$[j] ± 0.5[$\mathcal{L}$]	27 ± 12[u] $^{+10}_{-6}$[j] ± 3[$\mathcal{L}$]	0.8 ± 0.7[u] $^{+0.6}_{-0.0}$[j] ± 0.1[$\mathcal{L}$]
$t\bar{t}$ and t	10 ± 0[u] $^{+\ 3}_{-\ 2}$[j] $\pm$ 1[$\mathcal{L}$]	0.9 ± 0.1[u] $^{+0.4}_{-0.3}$[j] ± 0.1[$\mathcal{L}$]	17 ± 1[u] $^{+\ 6}_{-\ 4}$[j] ± 2[$\mathcal{L}$]	0.3 ± 0.1[u] $^{+0.2}_{-0.1}$[j] ± 0.0[$\mathcal{L}$]
Total SM	118 ± 25[u] $^{+32}_{-23}$[j] ± 12[$\mathcal{L}$]	10.0 ± 4.3[u] $^{+4.0}_{-1.9}$[j] ± 1.0[$\mathcal{L}$]	88 ± 18[u] $^{+26}_{-18}$[j] ± 9[$\mathcal{L}$]	2.5 ± 1.0[u] $^{+1.0}_{-0.4}$[j] ± 0.2[$\mathcal{L}$]
Data	87	11	66	2

Table 2: Expected and observed numbers of events in the four signal regions. Uncertainties shown are due to "MC statistics, statistics in control regions, other sources of uncorrelated systematic uncertainty, and also the jet energy resolution and lepton efficiencies" [u], the jet energy scale [j], and the luminosity [$\mathcal{L}$].

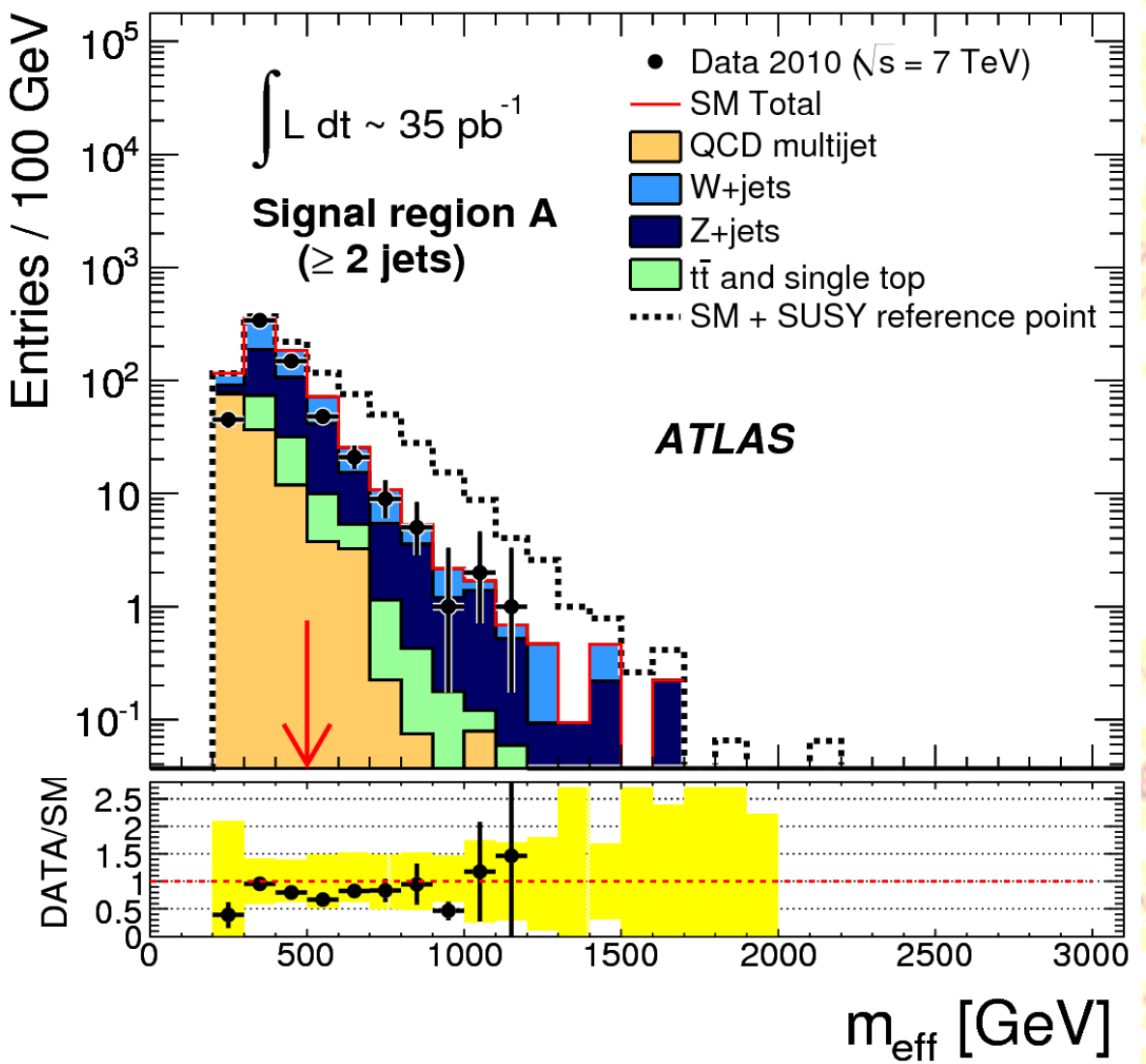
- Dominant background from W/Z+jets giving missing energy.
- W, Z and ttbar backgrounds taken from MC which agrees very well with data in control regions.
- QCD normalized to data in regions with $\Delta\phi$ cut reversed, and cross-checked against empirical smearing of low Etmiss events using measured jet energy resolution.
- Systematics estimated for jet energy scale, energy resolution, lepton efficiencies, and lumunosity.

Missing ET



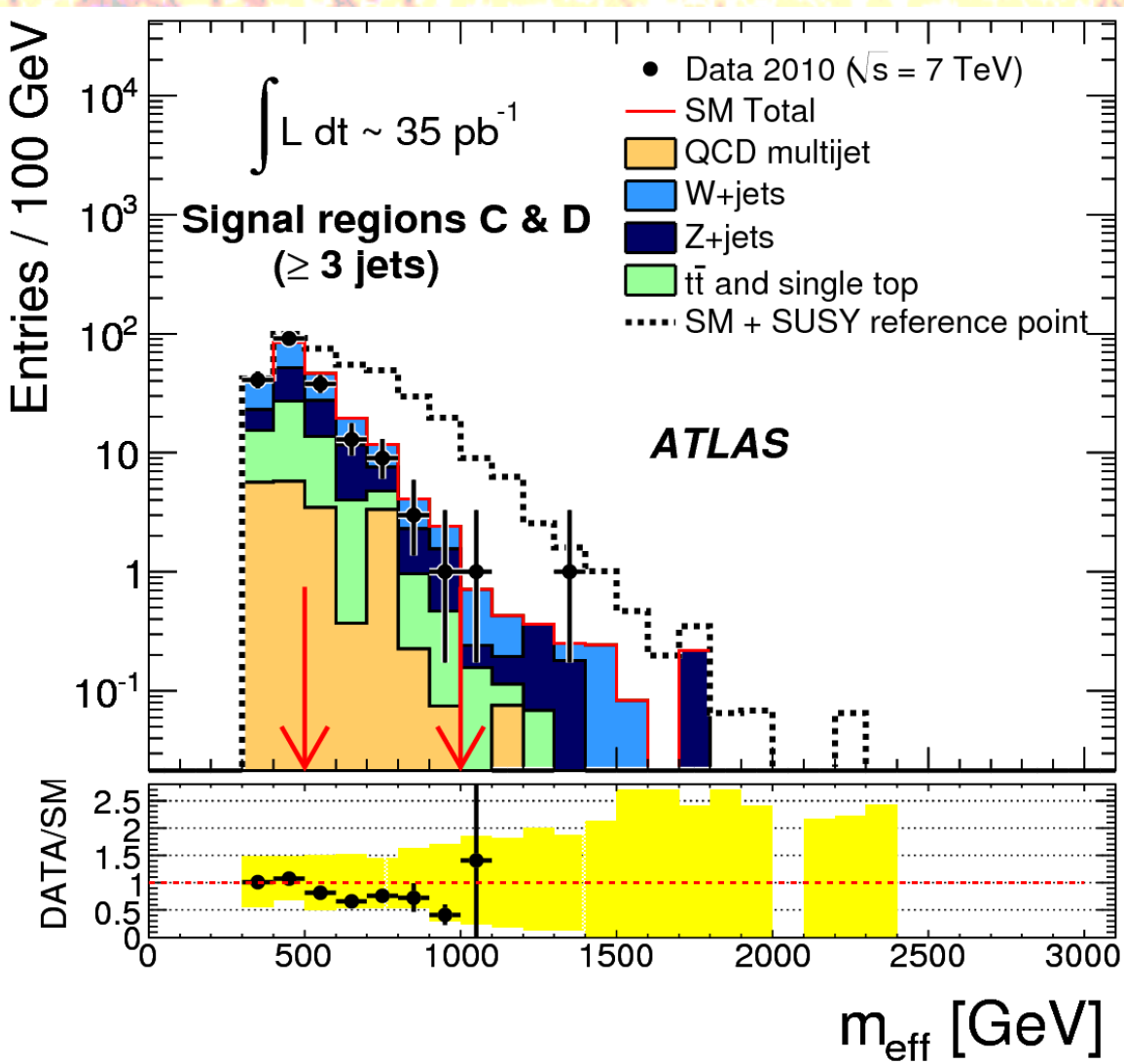
- No excess observed.
- Dominant background from W/Z+jets at high ETmiss

Two jet signal in Meff



- No excess observed.
- Cut at red arrow for search limits

Three jet signal in Meff



- No excess observed.
- Cut at red arrow for search limits (regions C and D)

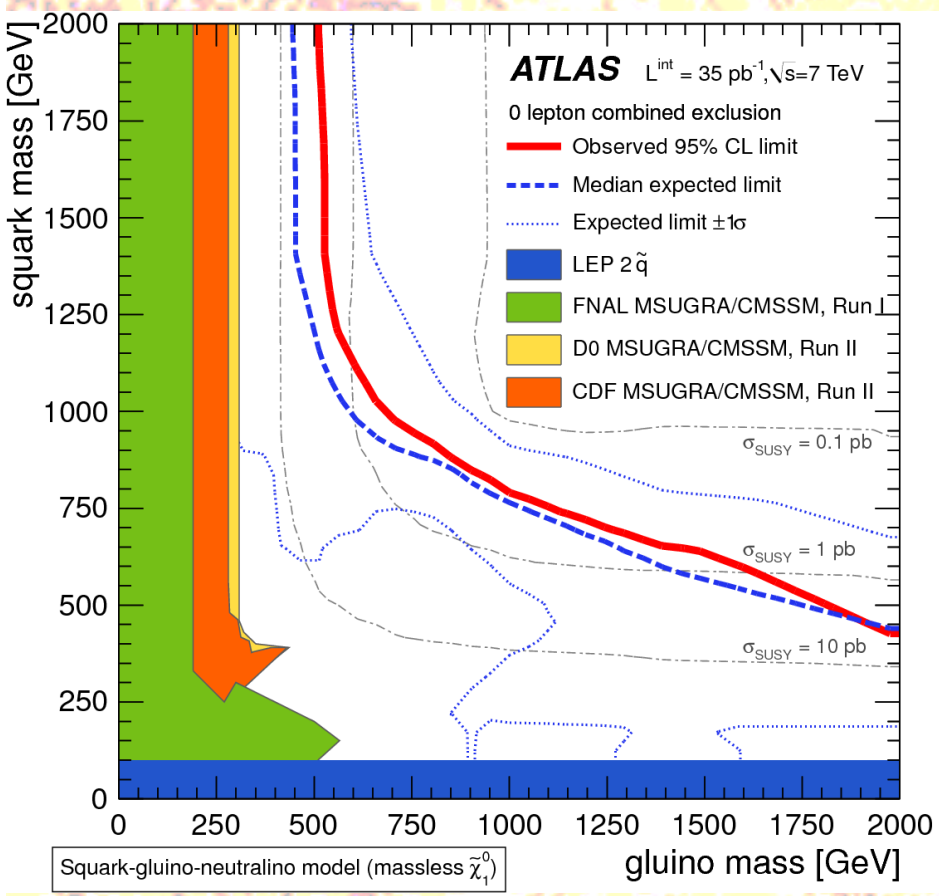
SUSY reference points

- Grid of models in gluino/squark mass plane with LSP mass set to zero.
- First two generations of squarks degenerate, all other SUSY particles at 5 TeV (decoupled from experiment) apart from gluino.
- -> exclude gluino below 500 GeV to 870 GeV for equal mass squarks and gluinos.

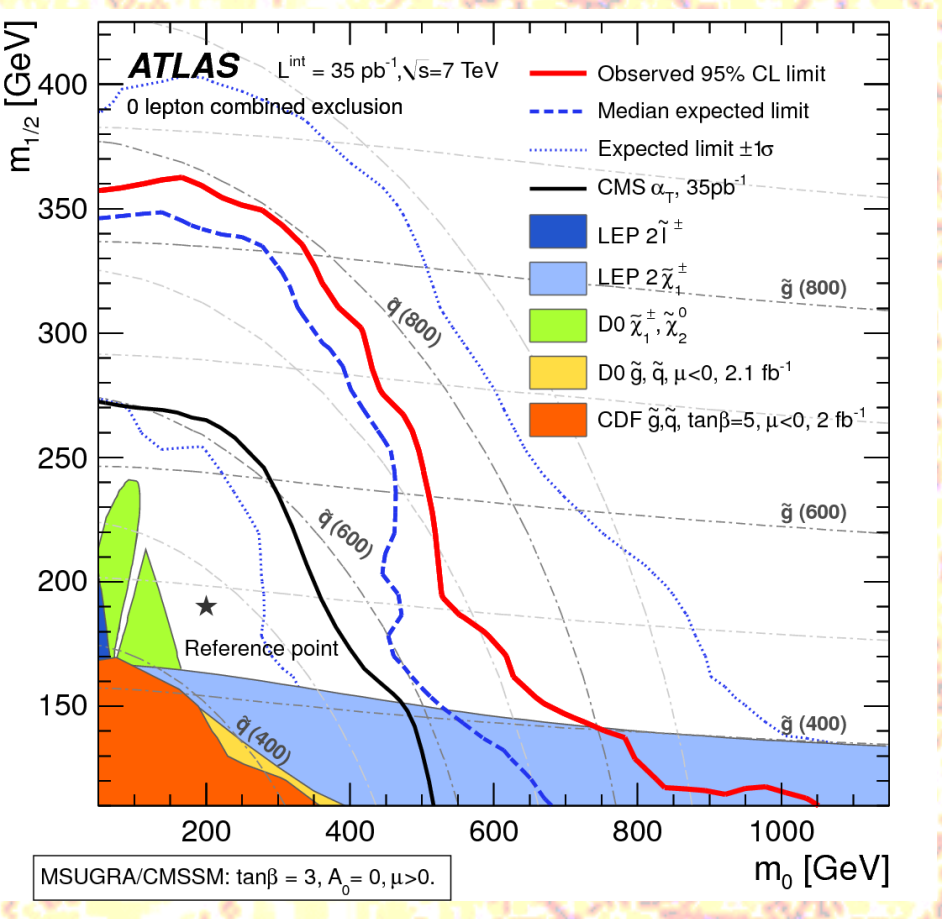
- Also shown for $\tan\beta=3$, $A_0=0$, $\mu>0$ in MSUGRA/CMSSM space.
- -> equal mass squarks/gluinos excluded below 775 GeV

Exclusion limits

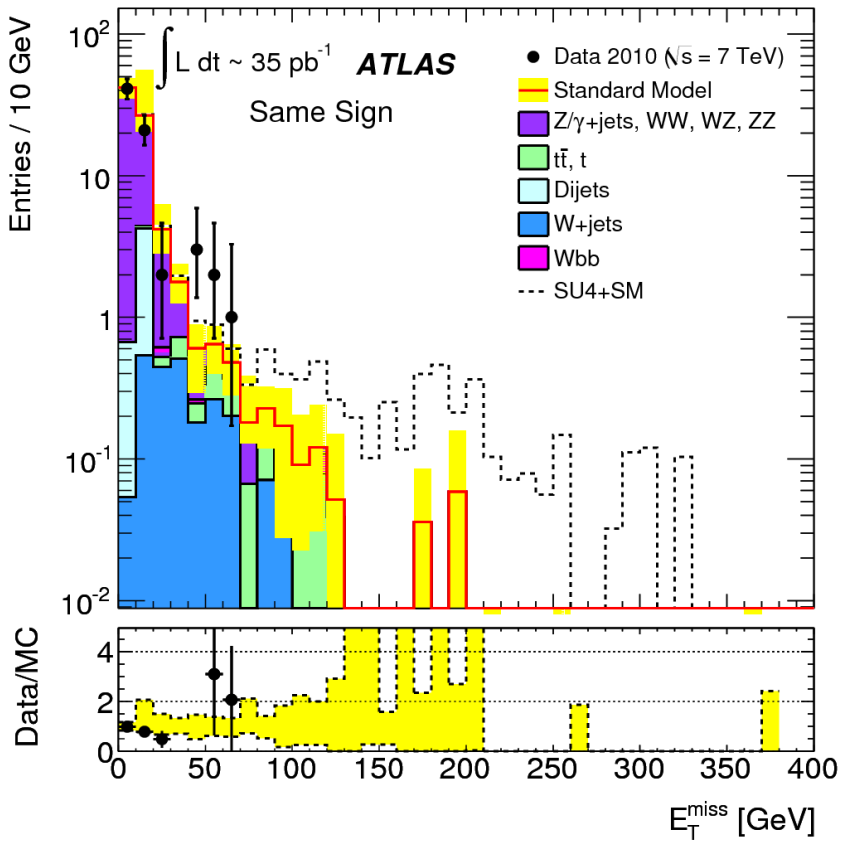
Simplified model

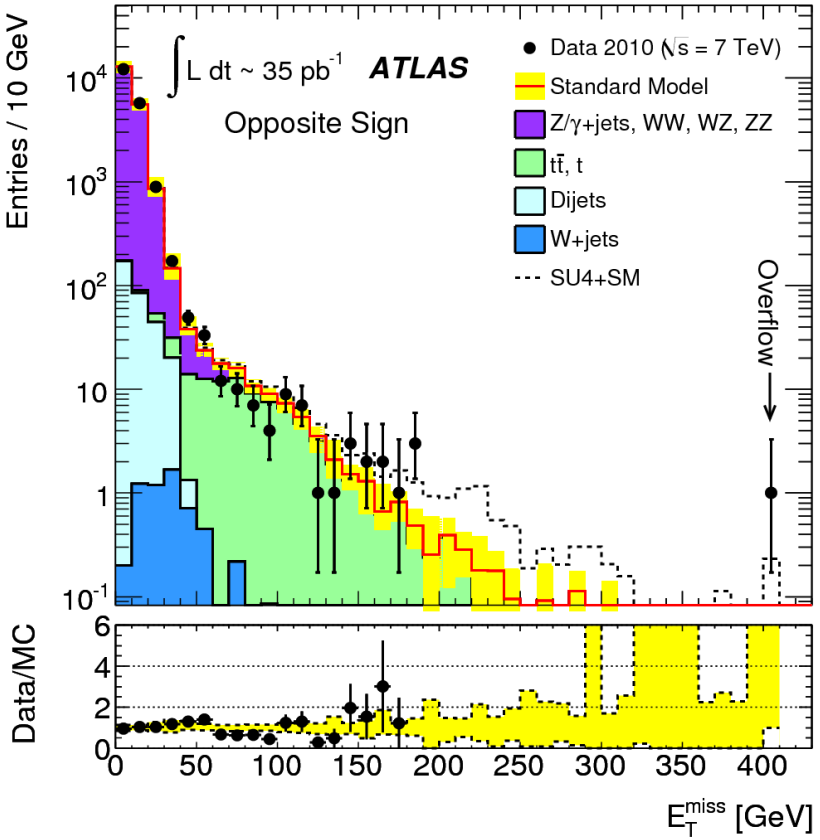


MSUGRA



SUSY search in dilepton events

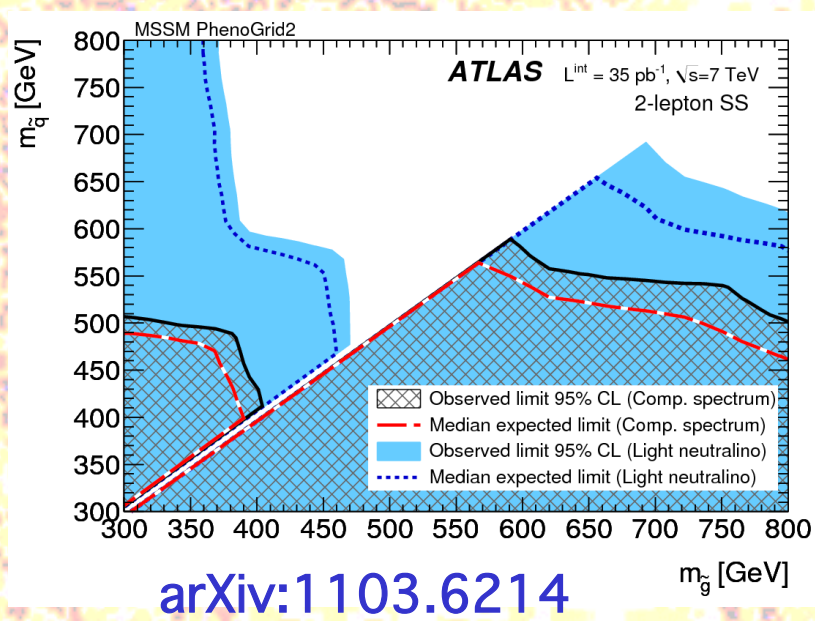




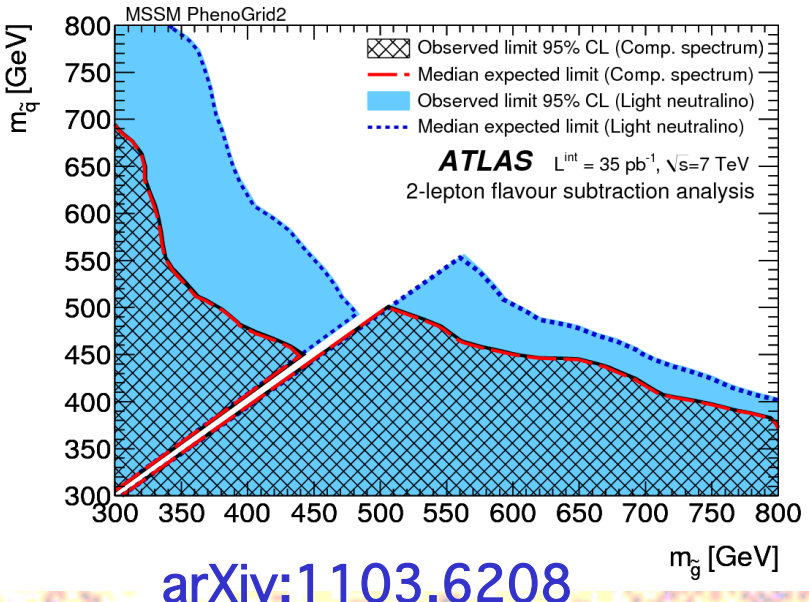
SM leptons pair backgrounds are mostly correlated sources. Eg dominant sources at high Etmiss is ttbar.
SUSY can produce leptons from uncorrelated decay chains: look at opposite sign, same sign and same flavour samples.

arXiv:1103.6214

Two lepton exclusions regions



arXiv:1103.6214



arXiv:1103.6208

2D grids in a 24 parameter MSSM model (PhenoGrid2). Generic MSSM with flavour and CP violation.

2 spectra: "compressed": 50 GeV mass splittings: soft final states

"Light chi0" : M_χ=100 GeV, hard final states.

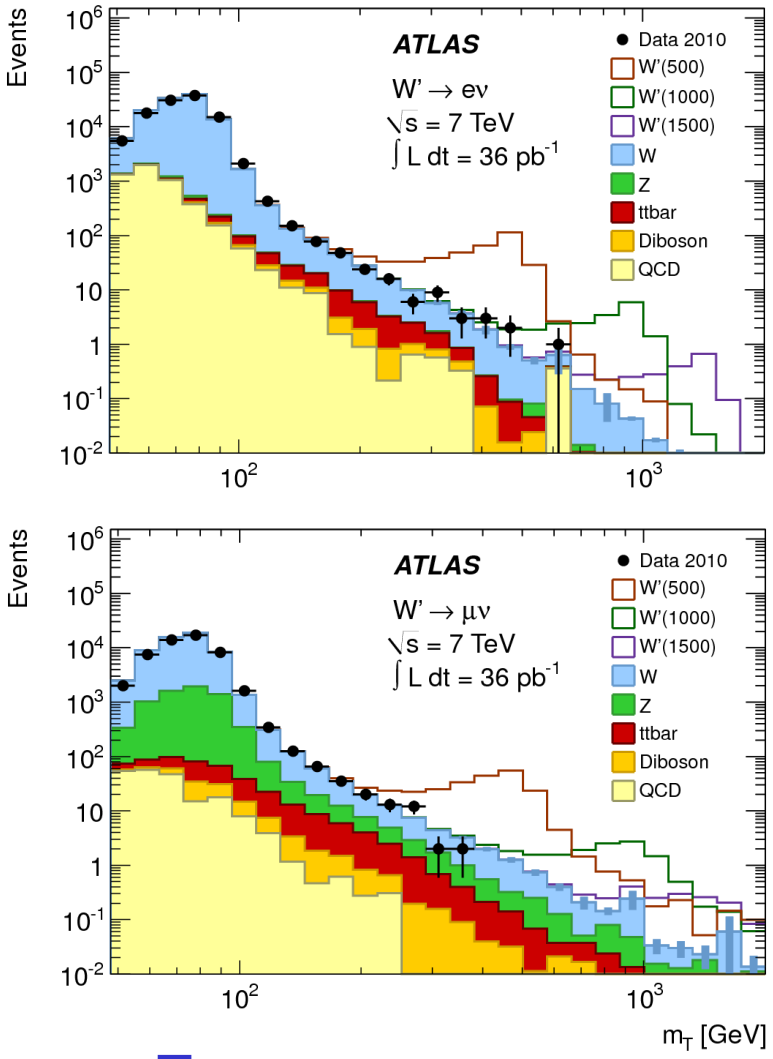
Very large parameter space! Do not rely on exclusion grids – test your model against the data distributions…

Experimentalists interested in models which evade these bounds.

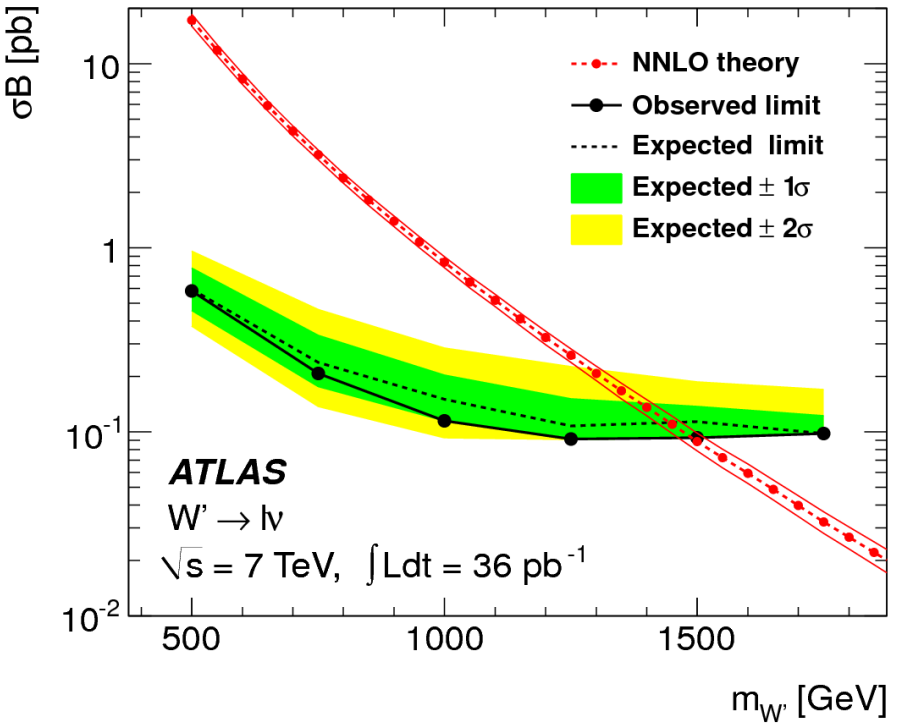
Search for W'

arXiv:1103.1391

e/mu combined



Transverse mass

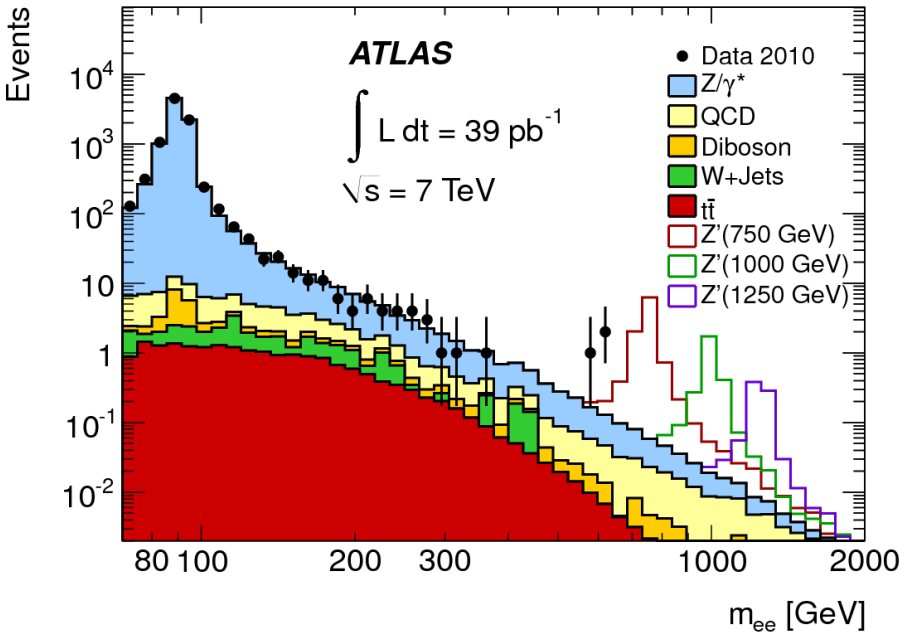


Benchmark sequential SM.

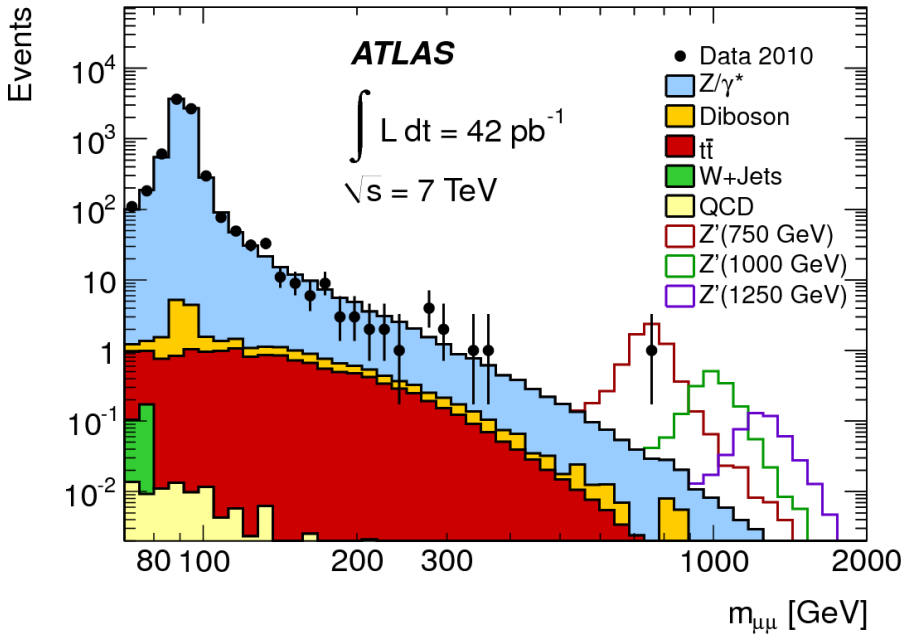
$M_{W'} > 1.49$ TeV (95% cl).

Search for high mass dilepton resonances

e^+e^-



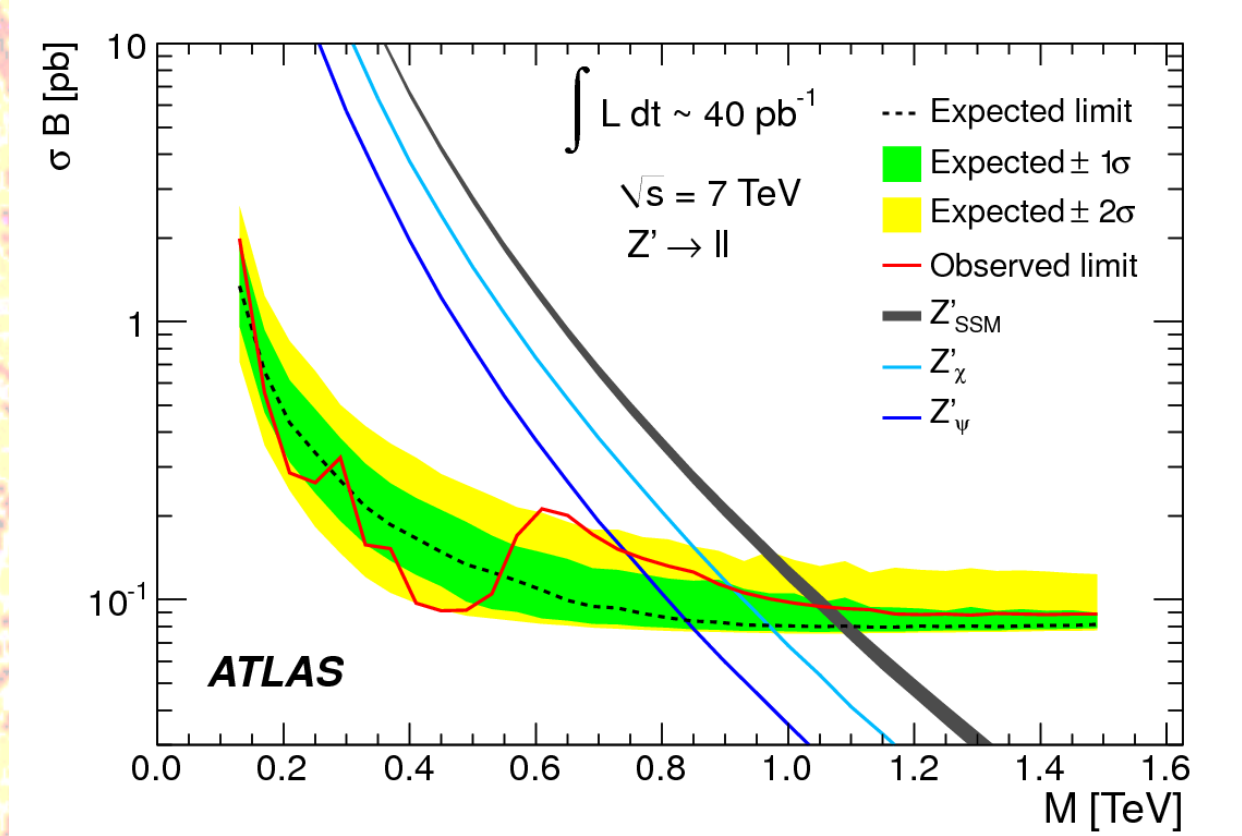
$\mu^+\mu^-$



Dilepton mass distributions in good agreement with SM expectation.

arXiv:1103.6218

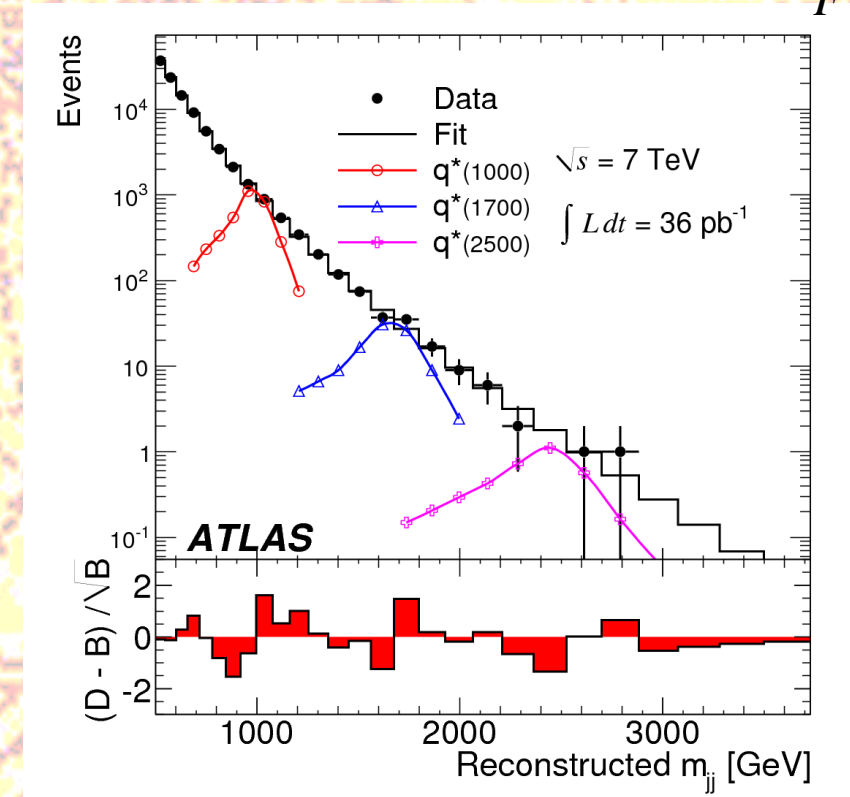
Confidence limits on Z'

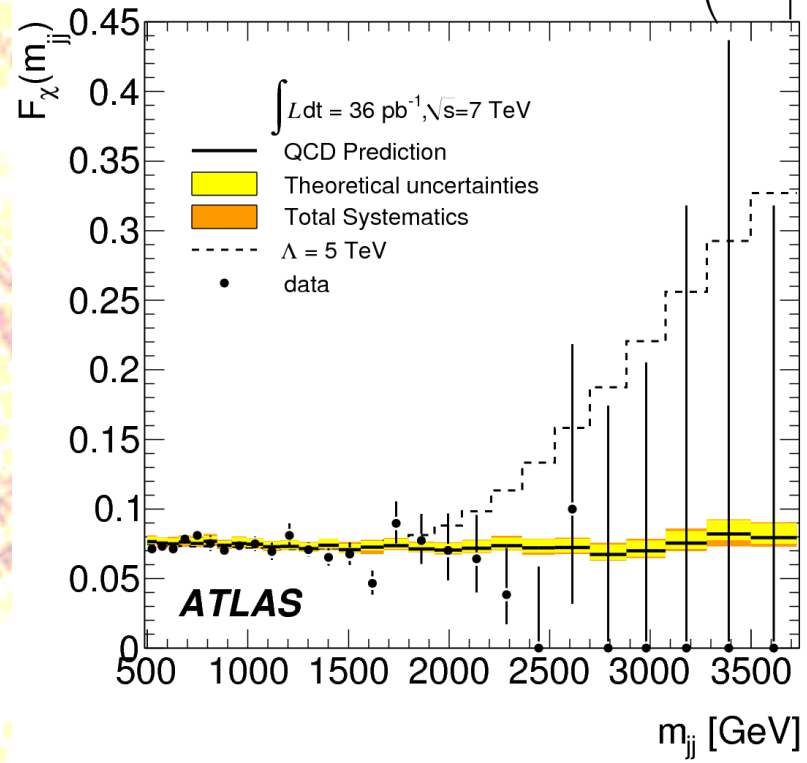


- Mass of SSM Z'>1.048 TeV at 95% CL.
- Narrow width assumed.
- cf Tevatron (1.071 TeV) and CMS (1.140 TeV)
- Also shows range of E(6) inspired models

New physics searches in dijets

$$F(\chi) = N(|y^*| < 0.6)/N(|y^*| < 1.7) \quad y^* = \frac{1}{2}\ln\left(\frac{1+|\cos\theta^*|}{1-|\cos\theta^*|}\right)$$



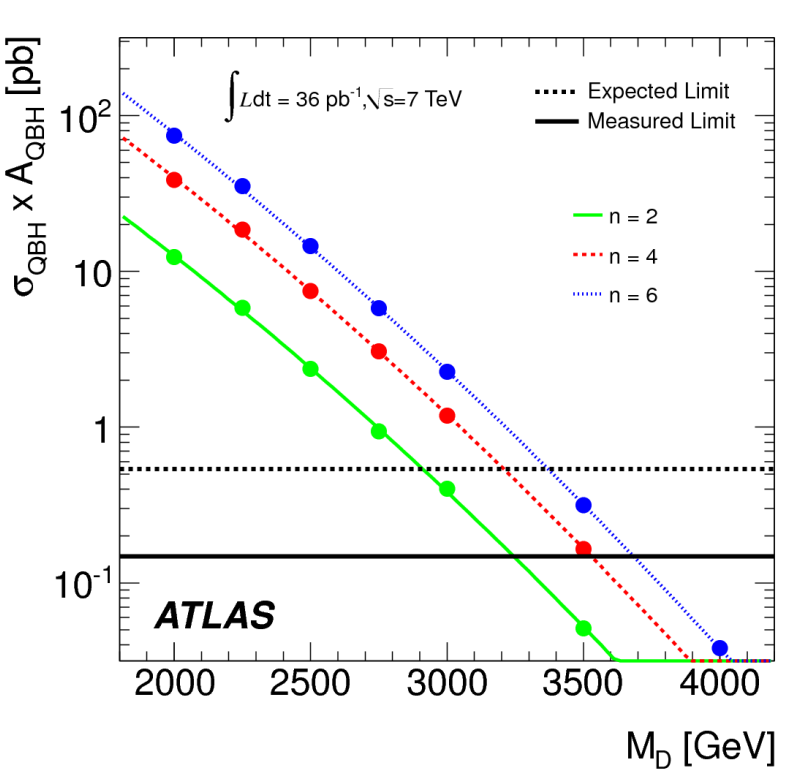


Dijet mass spectrum, and angular distributions sensitive to resonances and to other new physics
J1>60 GeV, J2>30 GeV, |η|<2.5, |Δη|<1.3

arXiv:1103.3864

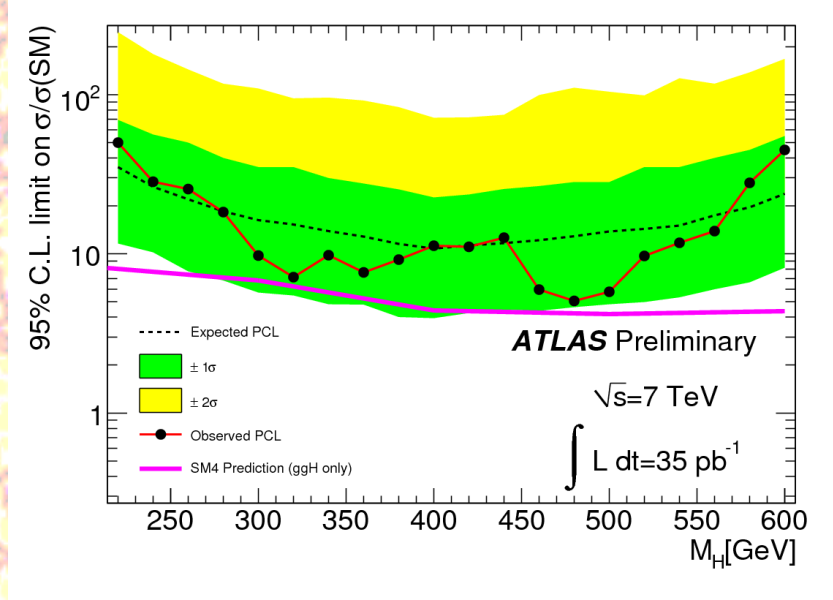
Limits from dijets

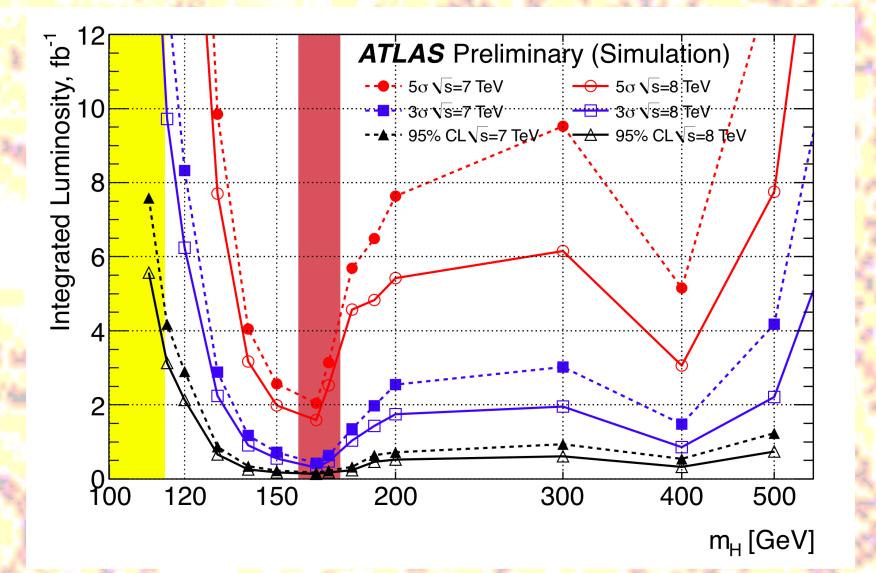
- Excited quarks: $0.6<M_{q^*}<2.64$ TeV
- Axigluon: $0.6<M_A<2.10$ TeV
- Randall-Meade Quantum BH (n=6) $0.75<M_D<3.67$
- Contact interactions $\Lambda>9.5$ TeV



Exclusion for QBH

Standard Model Higgs





ATLAS H->WW results

SM prediction = 1
1.2 excluded for
M_H=160 GeV

Prospects: 3 fb^{-1} allows:

95% exclusion 120<M_H<500 GeV
3 sigma evidence 130<M_H<450 GeV
5 sigma discovery 150<M_H<175 GeV

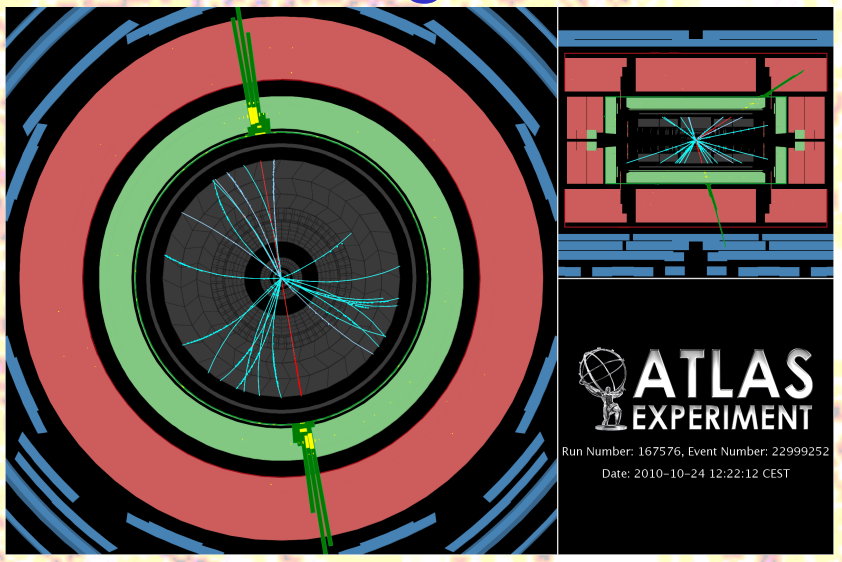
Prospects for the future

- Expect several(?) fb^{-1} at 7 TeV
- Already more data than in 2010, and detector operating even better.
- Higgs will be hard to hide from $3fb^{-1}$
- New physics models will be pushed hard in >TeV regime.

Start thinking now where theory can go next!

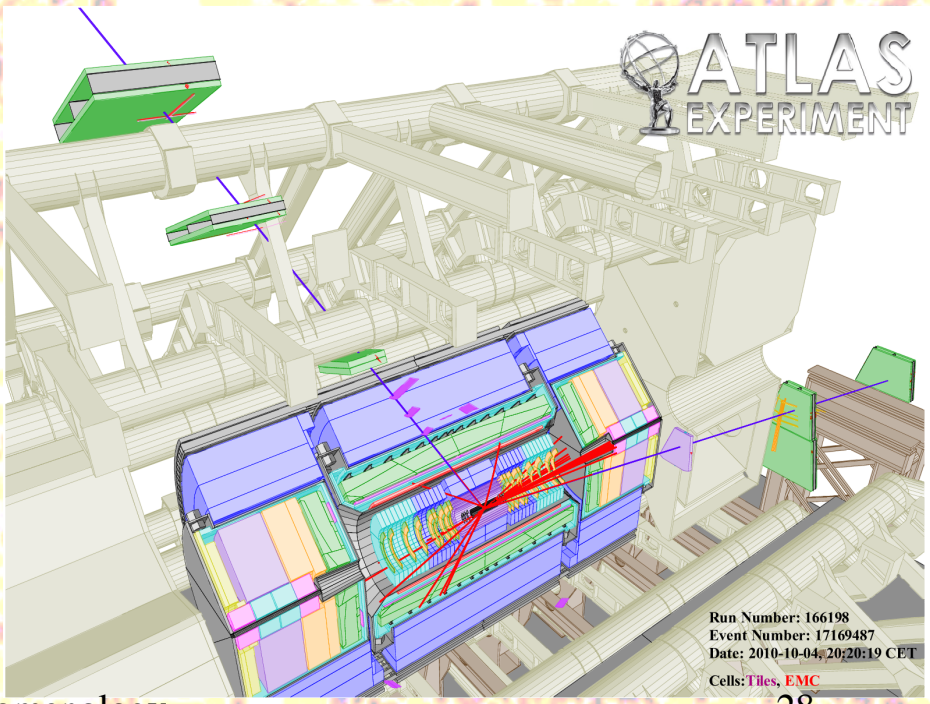
Backup

Highest mass lepton pair events



Highest mass dimuon event.
Muon pT =186 GeV
(eta, phi) = (-2.39, -1.54).
Second muon pT = 165 GeV
(eta, phi) = (0.46, 1.95).
Invariant mass of pair =768 GeV.
ETmiss <25 GeV

Highest mass dielectron event.
Electron pT = 279 GeV
(eta, phi) =(1.22, 1.74).
Second electron
pT=276 GeV,
(eta, phi) = (0.28, -1.40).
Invariant mass of pair =
617 GeV.



SUSY papers so far:

- Search for supersymmetry using final states with one lepton, jets, and missing transverse momentum arXiv:1102.2357
- Search for squarks and gluinos using final states with jets and missing transverse momentum arXiv:1102.5290
- Search for stable hadronising squarks and gluinos arXiv:1103.1984
- Search for supersymmetry in pp collisions at sqrt{s} = 7TeV in final states with missing transverse momentum and b-jets arXiv:1103.4344
- Search for supersymmetric particles in events with lepton pairs and large missing transverse momentum arXiv:1103.6214
- Search for an excess of events with an identical flavour lepton pair and significant missing transverse momentum arXiv:1103.6208