

FRONTIER PARTICLE
PHYSICS WITH THE ATLAS
DETECTOR AT THE LARGE
HADRON COLLIDER

ISRAEL SCIENCE FOUNDATION RESEARCH CENTER WORKSHOP
1.10.2014

OVERALL PROGRAM

S. TAREM

TECHNION, ISRAEL INSTITUTE OF TECHNOLOGY

SUBPROGRAMS

Sub-program 1: Studies with di-muon final states

- PIs: Erez Etzion, Gideon Bella

Sub-program 2: Search for long lived heavy new particles

- PIs: Shlomit Tarem, Abner Soffer

Sub-program 3: Search for Supersymmetry with Hadronic events

- PI: Ehud Duchovni

Sub-program 4: Search for Higgs bosons

- PIs: Eilam Gross, Yoram Rozen

Sub-program 5: R&D towards ATLAS upgrade

- PIs: Giora Mikenberg, Lorne Levinson

Sub-program 6: Operation, monitoring and maintenance of the muon detector

- PI: Daniel Lellouch

BACK TO THE BEGINNING

This center started in 2011, as we were analyzing the first year of data and collecting the second year

- Low p_T muons, J/ψ A few Z
- Trigger efficiencies, reconstruction efficiencies, fake rates

■

2011 data

- Many Z, momentum resolution
- tag-and-probe

■

■

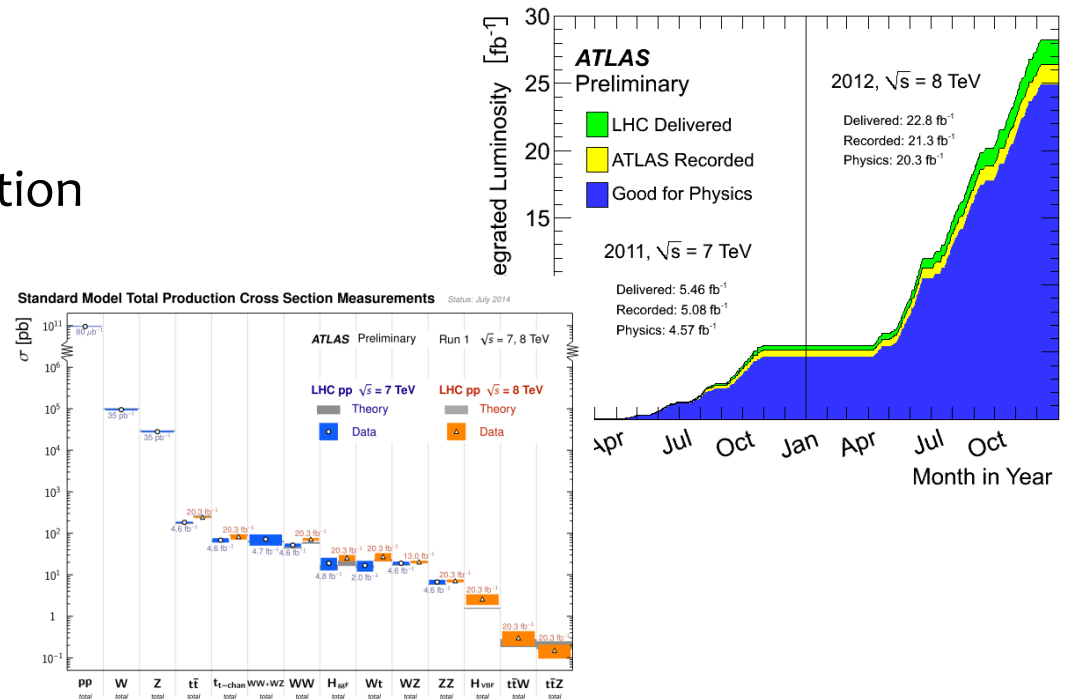
2012 data

- Z+high p_T jets, Z', W', $H \rightarrow 4l$

■

LS1

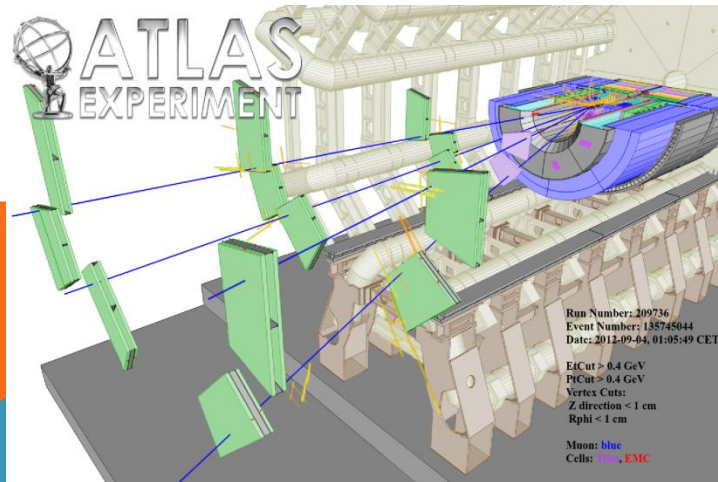
- Chamber replacement, trigger improvements, DCS improvements



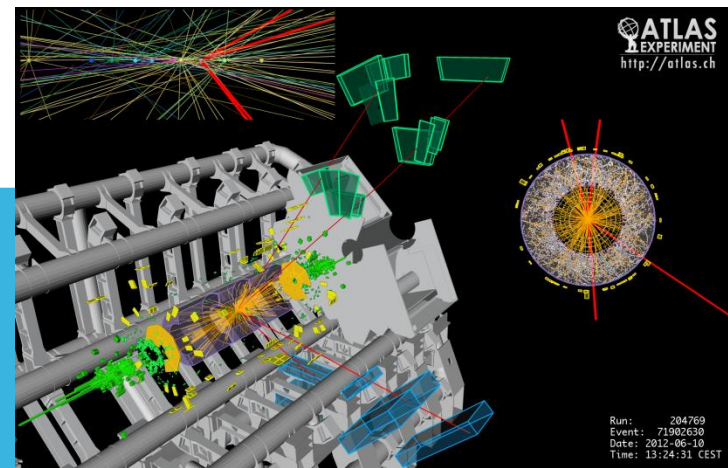
HIGHLIGHTS – 1

Discovery of the Higgs Boson in 2012

- The biggest discovery in many years – Nobel prize for the theorists
- Although the center proposed a search for charged Higgs, much of the work went into the discovery of the neutral (SM?) Higgs Boson and measurement of it's properties
- Eilam – Higgs convener at time of discovery, editor of the paper
- Yoram – contributed to Higgs properties measurements
- Students, postdocs to be mentioned in detailed talks
- TGCs, Muon ID, statistics – all needed for the discovery too



4 muons in the TGC

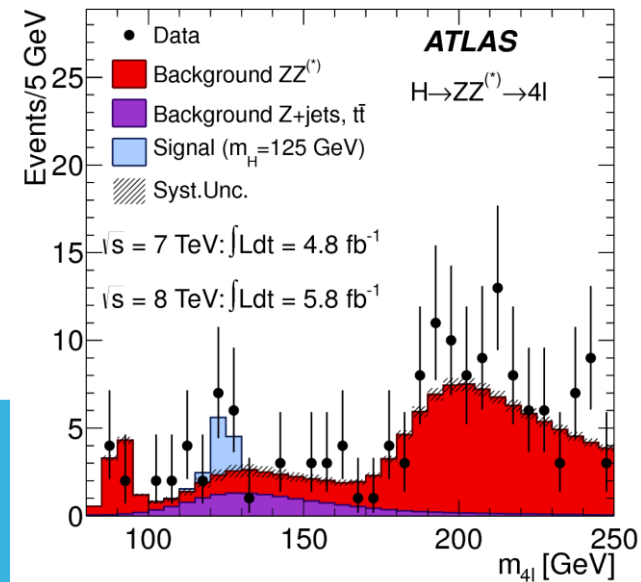
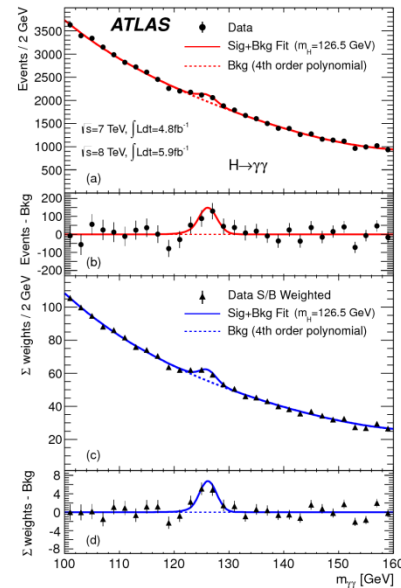
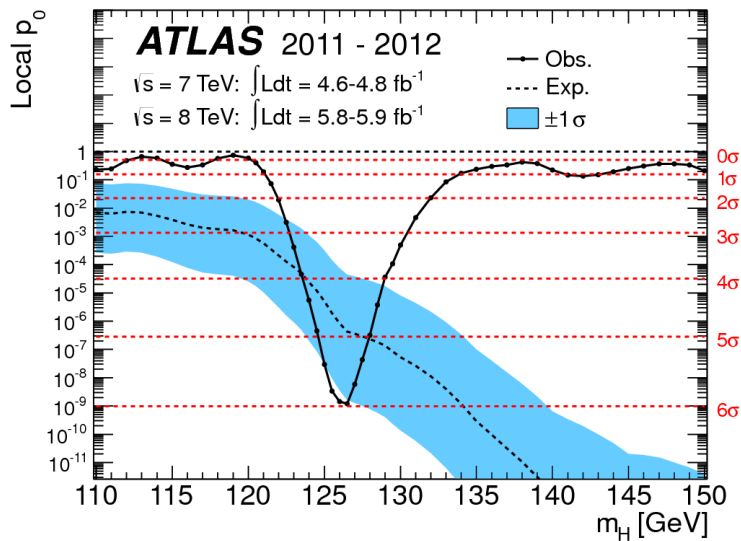


2 muons in the TGC

OBSERVATION OF A NEW PARTICLE IN THE SEARCH FOR THE STANDARD MODEL HIGGS BOSON WITH THE ATLAS DETECTOR AT THE LHC

PHYS. LETT. B 716 (2012) 1-29

CITED BY: 4570



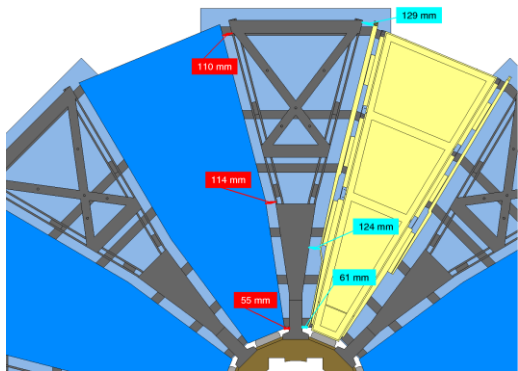
HIGHLIGHTS – 2

Choice of sTGC for NSW

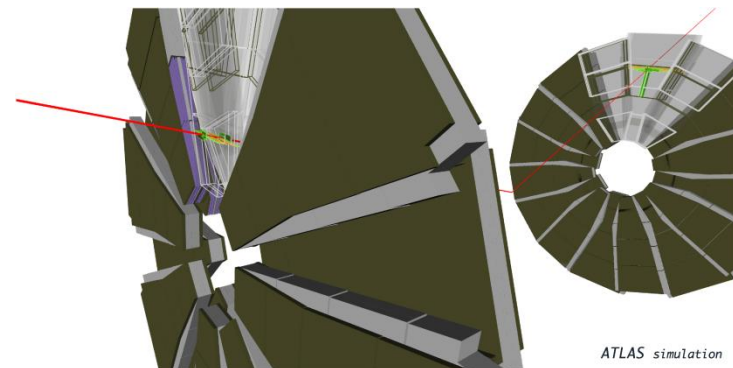
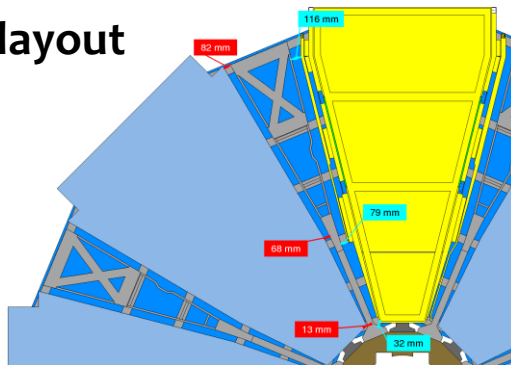
- R&D under this center brought the evidence that sTGC is the right technology for the NSW (OK, MM too)
- Giora – project leader of sTGC
- Lorne – leader of NSW electronics
- Contributions from many more in our groups
- TDR approved in 2014
- Many other groups participating in further testing and production
- Latest results from testbeam at FNAL

NSW TDR

Printed Sept-2013

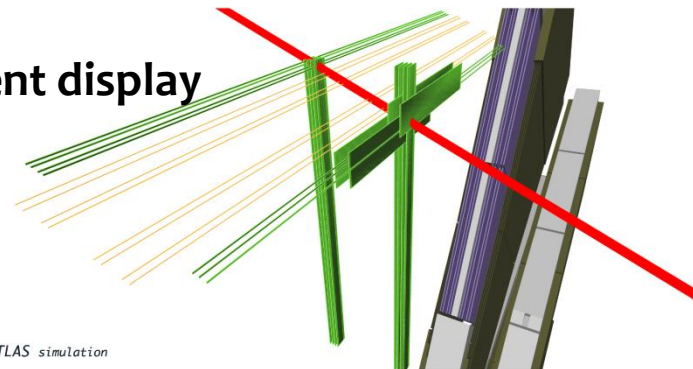


layout

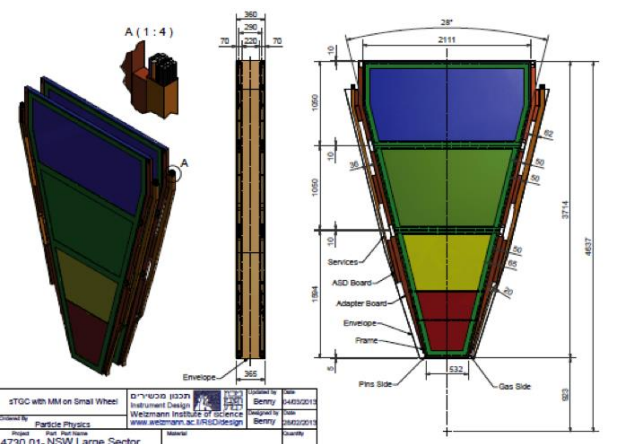


ATLAS simulation

Event display

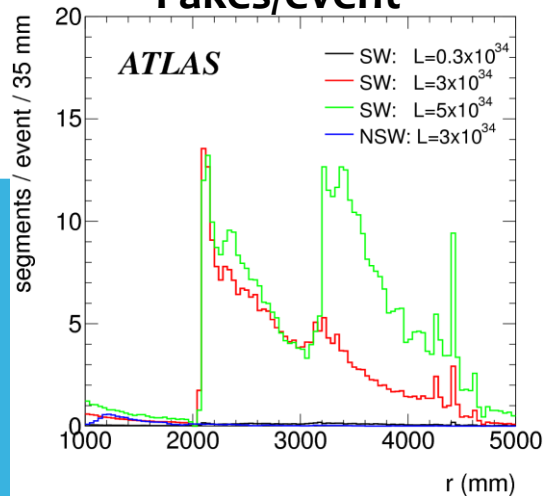


ATLAS simulation

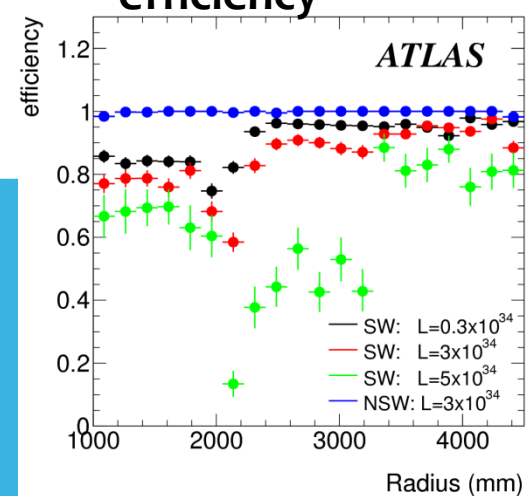


services

Fakes/event

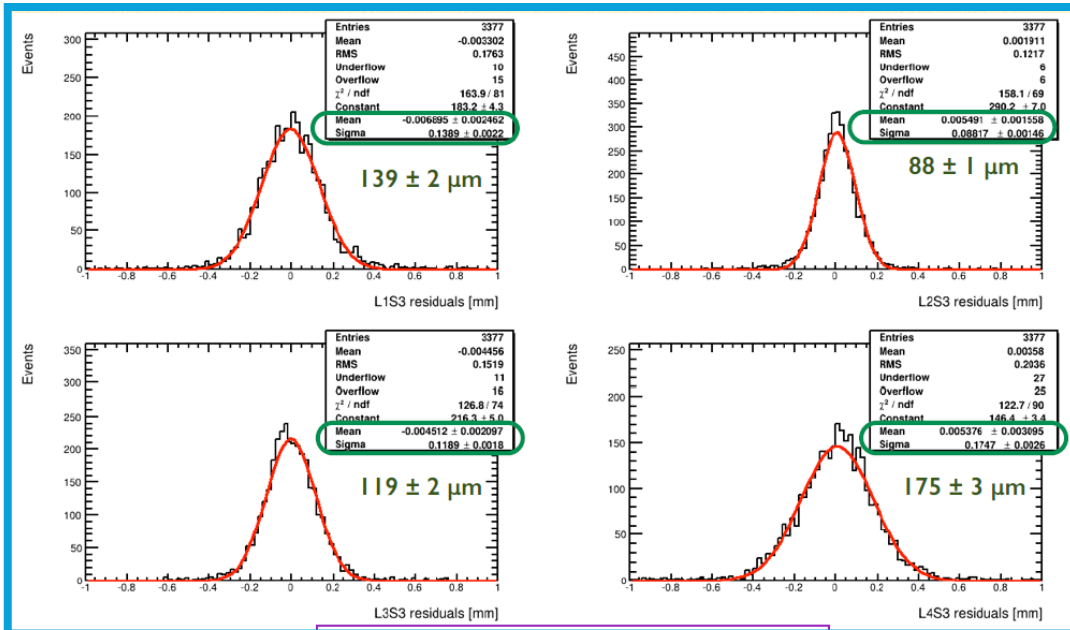


efficiency



FERMILAB TEST-BEAM MAY 2014

First testbeam with sTGC Canada



From Alain Bellerive

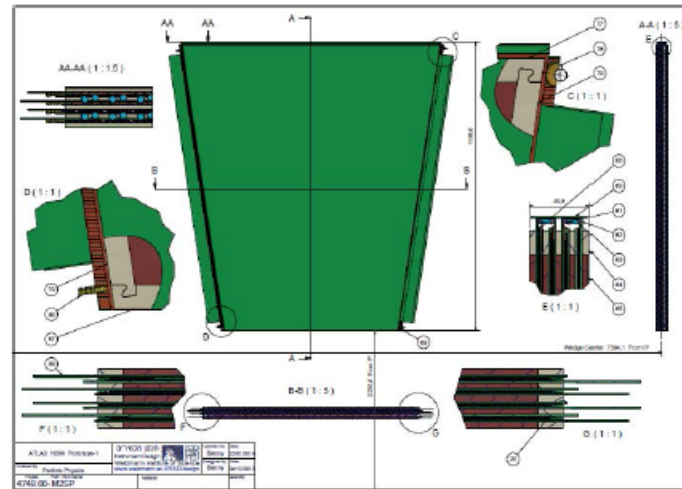


STGC PRODUCTION IS UNDER A DIFFERENT GRANT

Some R&D expected to continue in the center

sTGC status: production sites

- Israel
 - Weizmann: assembly facility complete
 - Weizmann – working on production of second full size prototype and qualifying cathode boards.
 - Tel Aviv: chamber test facility - status?
 - Made first full size prototype used in May beam test at Fermilab



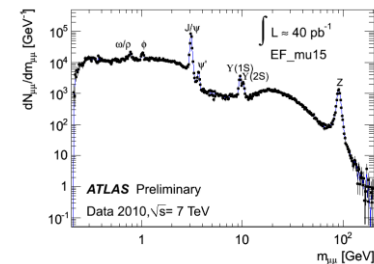
From Gerald Okham

SUBPROGRAM 1 - 2μ & MORE

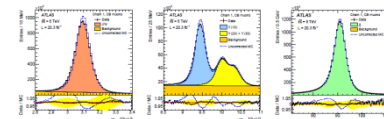
See also slide 2

2μ invariant mass

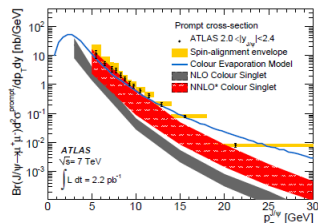
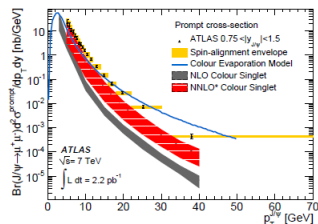
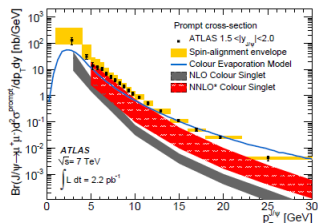
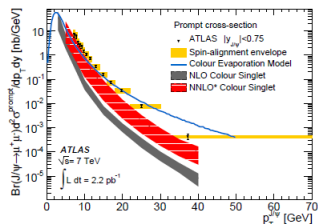
2010



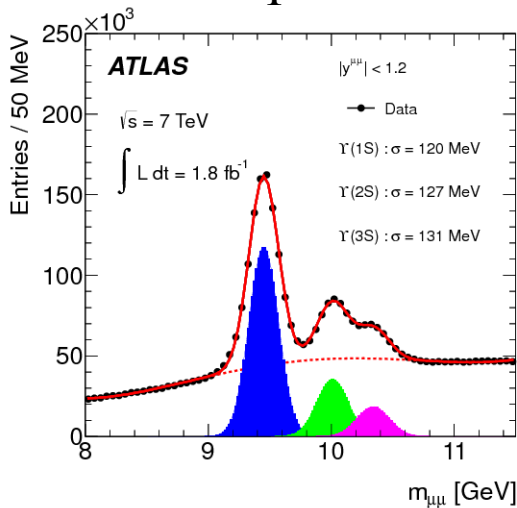
2012



J/ψ



Y



Z^0

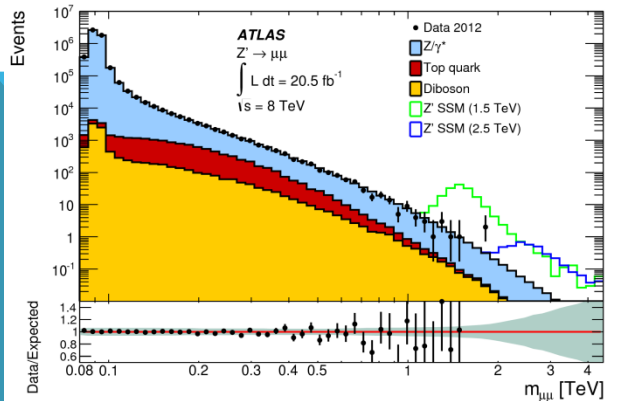


Figure 11: Prompt J/ψ production cross-section as a function of J/ψ transverse momentum in the four rapidity bins. Overlaid is a band representing the variation of the result under various spin-alignment scenarios (see text) representing a theoretical uncertainty on the prompt component. Predictions from NLO and NNLO^{*} calculations, and the Colour Evaporation Model are overlaid. The luminosity uncertainty (3.4%) is not shown.

STUDIES WITH 2μ FINAL STATES & MORE

PAPERS OF SUBPROGRAM 1

- Search for contact interactions and large extra dimensions in the dilepton channel using proton-proton collisions at $\sqrt{s} = 8$ TeV with the ATLAS detector, ATLAS Collaboration, arXiv:1407.2410 [hep-ex].
- Search for new phenomena in the dijet mass distribution using pp collision data at $\sqrt{s} = 8$ TeV with the ATLAS detector, ATLAS Collaboration, arXiv:1407.1376 [hep-ex].
- Search for WZ resonances in the fully leptonic channel using pp collisions at $\sqrt{s} = 8$ TeV with the ATLAS detector, ATLAS Collaboration, Phys.Lett. B737 (2014) 223-243.
- Search for high-mass dilepton resonances in pp collisions at $\sqrt{s} = 8$ TeV with the ATLAS detector, ATLAS Collaboration, arXiv:1405.4123 [hep-ex].
- Measurement of dijet cross sections in pp collisions at 7 TeV centre-of-mass energy using the ATLAS detector, ATLAS Collaboration, JHEP 1405 (2014) 059.
- Search for $t\bar{t}$ resonances in the lepton plus jets final state with ATLAS using 4.7 fb^{-1} of pp collisions at $\sqrt{s} = 7$ TeV, ATLAS Collaboration, Phys.Rev. D88 (2013) 1, 012004.
- Search for resonances decaying into top-quark pairs using fully hadronic decays in pp collisions with ATLAS at $\sqrt{s} = 7$ TeV, ATLAS Collaboration, JHEP 1301 (2013) 116.

MORE PAPERS OF SUBPROGRAM 1

- Search for contact interactions and large extra dimensions in dilepton events from pp collisions at $\sqrt{s} = 7$ TeV with the ATLAS detector, ATLAS Collaboration, Phys.Rev. D87 (2013) 015010.
- ATLAS search for new phenomena in dijet mass and angular distributions using pp collisions at $\sqrt{s} = 7$ TeV, ATLAS Collaboration, JHEP 1301 (2013) 029.
- Search for high-mass resonances decaying to dilepton final states in pp collisions at $\sqrt{s} = 7$ TeV with the ATLAS detector, ATLAS Collaboration, JHEP 1211 (2012) 138.
- A search for ttbar resonances in lepton+jets events with highly boosted top quarks collected in pp collisions at $\sqrt{s} = 7$ TeV with the ATLAS detector, ATLAS Collaboration, JHEP 1209 (2012) 041.
- A search for ttbar resonances with the ATLAS detector in 2.05 fb⁻¹ of proton-proton collisions at $\sqrt{s} = 7$ TeV, ATLAS Collaboration, Eur.Phys.J. C72 (2012) 2083.
- Search for contact interactions in dilepton events from pp collisions at $\sqrt{s} = 7$ TeV with the ATLAS detector, ATLAS Collaboration, Phys.Lett. B712 (2012) 40-58.
- Search for New Physics in the Dijet Mass Distribution using 1 fb⁻¹ of pp Collision Data at $\sqrt{s} = 7$ TeV collected by the ATLAS Detector, ATLAS Collaboration, Phys.Lett. B708 (2012) 37-54.
- Search for dilepton resonances in pp collisions at $\sqrt{s} = 7$ TeV with the ATLAS detector, ATLAS Collaboration, Phys.Rev.Lett. 107 (2011) 272002.

MORE PAPERS OF SUBPROGRAM 1

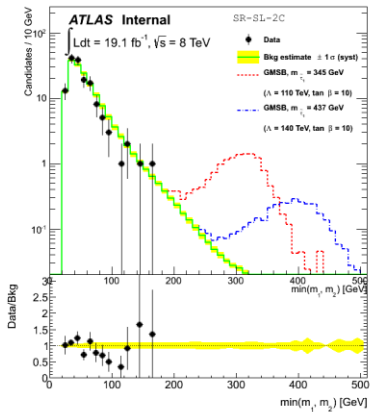
- Search for Contact Interactions in Dimuon Events from pp Collisions at $\sqrt{s}=7$ TeV with the ATLAS Detector, ATLAS Collaboration, Phys.Rev. D84 (2011) 011101.
- Search for high mass dilepton resonances in pp collisions at $\sqrt{s}=7$ TeV with the ATLAS experiment, ATLAS Collaboration, Phys.Lett. B700 (2011) 163-180.
- Search for New Physics in Dijet Mass and Angular Distributions in pp Collisions at $\sqrt{s}=7$ TeV Measured with the ATLAS Detector, ATLAS Collaboration, New J.Phys. 13 (2011) 053044.
- Measurement of the differential cross-sections of inclusive, prompt and non-prompt J/ψ production in proton-proton collisions at $\sqrt{s}=7$ TeV, ATLAS Collaboration, Nucl.Phys. B850 (2011) 387-444.
- Streamlined Calibrations of the ATLAS Precision Muon Chambers for Initial LHC Running, By N. Amram, R. Ball, Y. Benhammou, M. Ben Moshe, T. Dai, E.B. Diehl, J. Dubbert, E. Etzion et al. Nucl.Instrum.Meth. A671 (2012) 40-50.
- $X^0_S \Lambda^0$ production in pp interactions at $\sqrt{s} = 0.9$ and 7 TeV measured with the ATLAS detector at the LHC, ATLAS Collaboration, Phys.Rev. D85 (2012) 012001
- Observation of leading ϕ -mesons in high p_T jets with the ATLAS detector at $\sqrt{s} = 7$ TeV, ATLAS Collaboration, ATLAS-CONF-2011-146.
- Measurement of Upsilon production in 7 TeV pp collisions at ATLAS, ATLAS Collaboration, Phys. Rev. D87 (2013) 052004.

SUBPROGRAM 2 - LLP

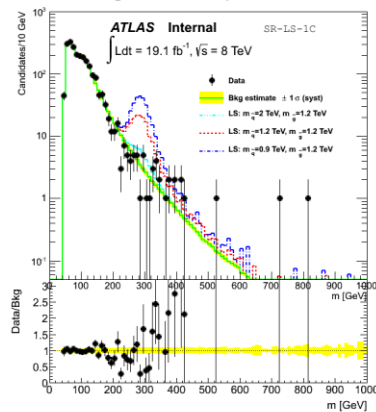
CHARGED LLP

$$m = p/\beta\gamma$$

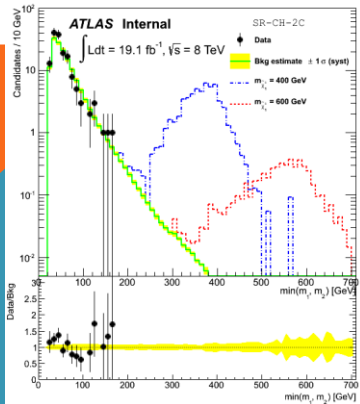
GMSB stau



LeptoSusy stau



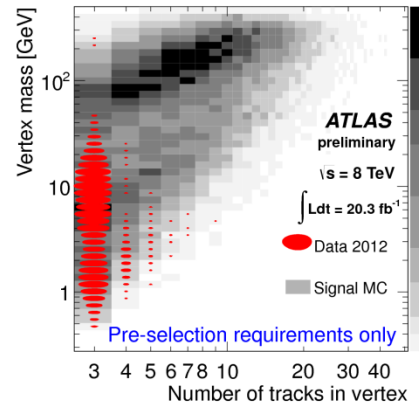
LL chargino



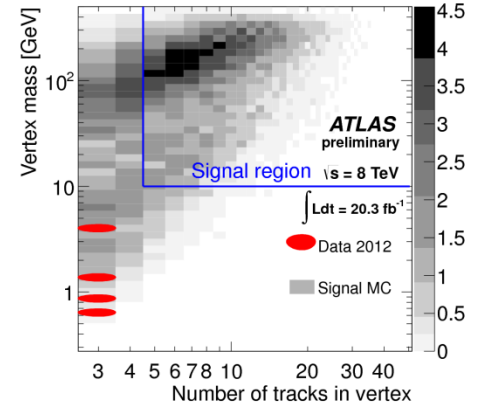
NEUTRAL LLP

High mass displaced vtx

Pre-selection



Final selection



NO SIGNAL!
IMPROVED LIMITS

PAPERS ON NEUTRAL LL PARTICLES

- The ATLAS Collaboration, Phys. Lett. B 707, 478 (2012), “Search for displaced vertices arising from decays of new heavy particles in 7 TeV pp collisions at ATLAS”
- The ATLAS Collaboration, Phys. Lett. B 719, 280 (2013), “Search for long-lived, heavy particles in final states with a muon and multi-track displaced vertex in proton-proton collisions at $\sqrt{s} = 7$ TeV with the ATLAS detector”

And the most recent conf note on 8 TeV data (now adding more final states and writing as a paper):

- The ATLAS Collaboration, ATLAS-COM-CONF-2013-108, “Search for long-lived, heavy particles in final states with a muon and a multi-track displaced vertex in proton-proton collisions at $\sqrt{s} = 8$ TeV with the ATLAS detector”

CHARGED LLP SEARCHES - PAPERS

- “Searches for Heavy Long-Lived Sleptons and R-hadrons with the ATLAS detector in pp collisions at $\sqrt{s} = 7$ TeV”, The ATLAS Collaboration, Phys. Lett. B 720, 277 (2013).
- “Search for Heavy Long-Lived Charged Particles with the ATLAS detector in pp collisions at $\sqrt{s} = 7$ TeV”, ATLAS Collaboration, Phys. Lett. B 703, 428 (2011).
- "A search for heavy long-lived sleptons using 16 fb⁻¹ of pp collisions at $\sqrt{s}=8$ TeV with the ATLAS detector", The ATLAS collaboration, ATLAS-CONF-2013-058. - 2013

The final paper on 2012 data with new signal types is between first and second reading

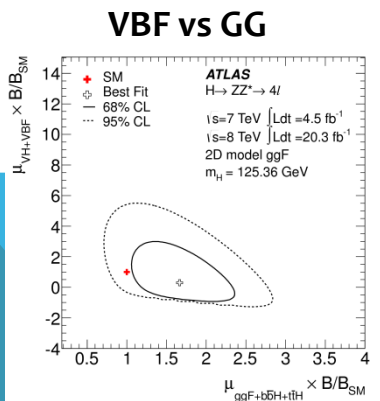
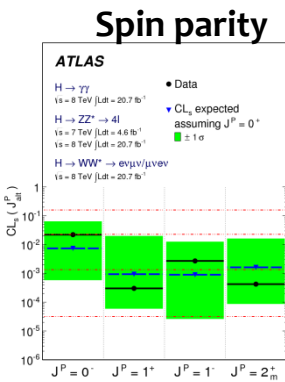
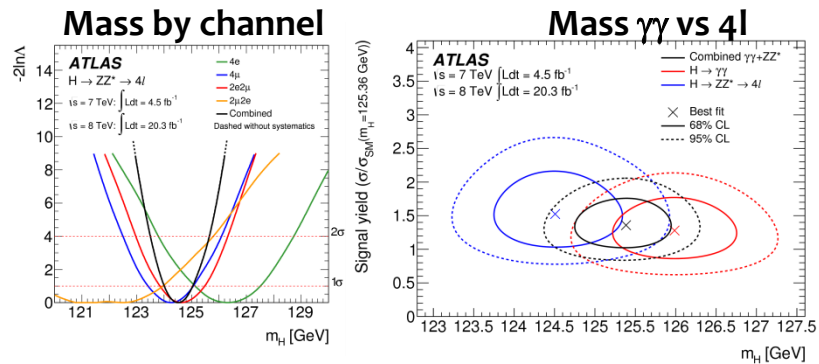
HADRONIC SUSY - PAPERS

- "Search for Supersymmetry in Events with Large Missing Transverse Momentum, Jets, and at Least One Tau Lepton in 7 TeV Proton-Proton Collision Data with the ATLAS Detector", The ATLAS Collaboration, Eur.Phys.J. C72 (2012) 2215.

SUBPROGRAM 4 - HIGGS

NEUTRAL HIGGS

The work continues

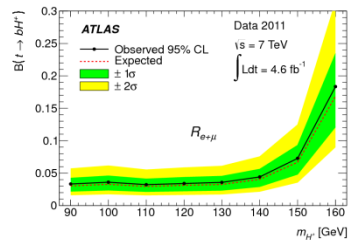


CHARGED HIGGS

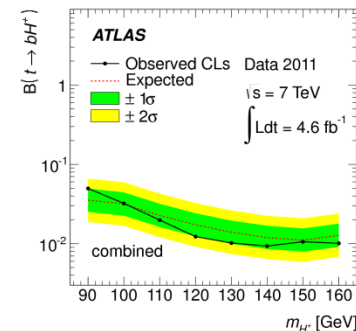
Pre-empted somewhat by H^0 ?

2011 data

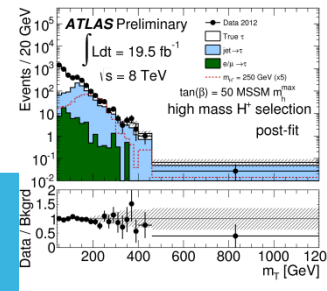
Universality violation



$\tau\nu$



2012 data
 Conf note



NO SIGNAL!
 IMPROVED LIMITS

HIGGS - PAPERS

- ATLAS Collaboration, Search for the Standard Model Higgs boson in the decay channel $H \rightarrow ZZ(*) \rightarrow 4l$ with 4.8 fb⁻¹ of pp collisions at $\sqrt{s} = 7$ TeV with the ATLAS detector, [Phys.Lett. B710 \(2012\) 383-402](#).
- ATLAS Collaboration, Observation of a New Particle in the Search for the Standard Model Higgs Boson with the ATLAS Detector at the LHC, [Phys. Lett. B 716 \(2012\) 1-29](#).
- ATLAS Collaboration, Search for charged Higgs bosons through the violation of lepton universality in $t\bar{t}$ events using pp collision data at $\sqrt{s} = 7$ TeV with the ATLAS experiment, [JHEP03\(2013\)076](#).
- ATLAS Collaboration, Search for charged Higgs bosons decaying via $H \rightarrow \tau \nu$ in top quark pair events using pp collision data at $\sqrt{s} = 7$ TeV with the ATLAS detector, [JHEP 1206 \(2012\) 039](#).
- Search for a light charged Higgs boson in the decay channel $H^+ \rightarrow c\bar{s}$ in $t\bar{t}$ events using pp collisions at $\sqrt{s} = 7$ TeV with the ATLAS detector, [Eur. Phys. Jour. C 73 \(2013\)](#)
- Search for charged Higgs bosons in the τ +jets final state with pp collision data recorded at $\sqrt{s}=8$ TeV with the ATLAS experiment, [ATLAS-CONF-2013-090](#)
- Search for charged Higgs bosons decaying via $H^\pm \rightarrow \tau \nu$ using pp collision data at $\sqrt{s} = 8$ TeV with the ATLAS detector, [ATLAS-CONF-2014-050](#)

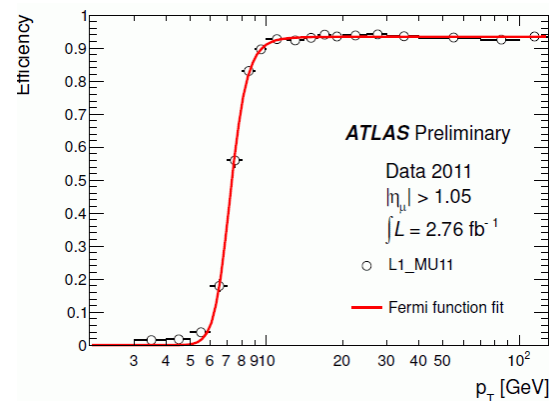
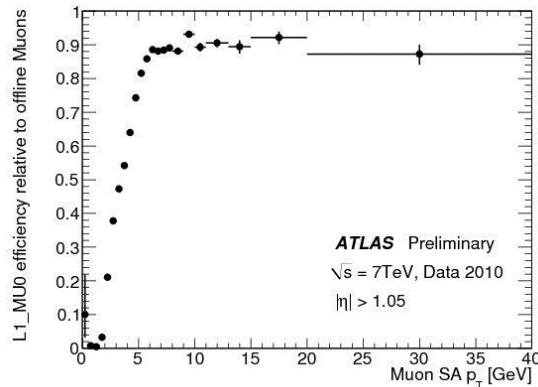
STGC - PAPERS

- “New Small Wheel Technical Design Report”, CERN-LHCC-2013-006 ATLAS-TDR-020-2013
- Simulation for ATLAS nSW Thin Gap Chambers, J. Chapman, et al. 2013. Published in PoS EPS-HEP2013 (2013) 093
- Test of spatial resolution and trigger efficiency of a combined Thin Gap and Fast Drift Tube Chambers for high-luminosity LHC upgrades, Y. Benhammou et al.. Oct 2011. DOI: [10.1109/NSSMIC.2011.6154678](https://doi.org/10.1109/NSSMIC.2011.6154678)

SUBPROGRAM 6 – OPERATION, MONITORING AND MAINTENANCE OF THE TGC

Results to be proud of with 98.2% operational fraction

- And thank the people who are doing this important work on our behalf so we and all of ATLAS have good data



TGC system response to muons from Z, for a 10 GeV (left) 18GeV(right) μ threshold

SUBPROGRAM 6 - PAPERS

- Performance of the ATLAS muon trigger in pp collisions at $\sqrt{s}=8$ TeV, CERN-PH-EP-2014-154, arXiv:1408.3179 [hep-ex]
- Performance of the ATLAS muon trigger in 2011, [ATLAS-CONF-2012-099](#)

SUMMARY / OUTLOOK

The last few years have been very successful

Run2 starts in a few months – let's discover some BSM evidence (please)

We need to propose an extension to the center by December – discussion later today

