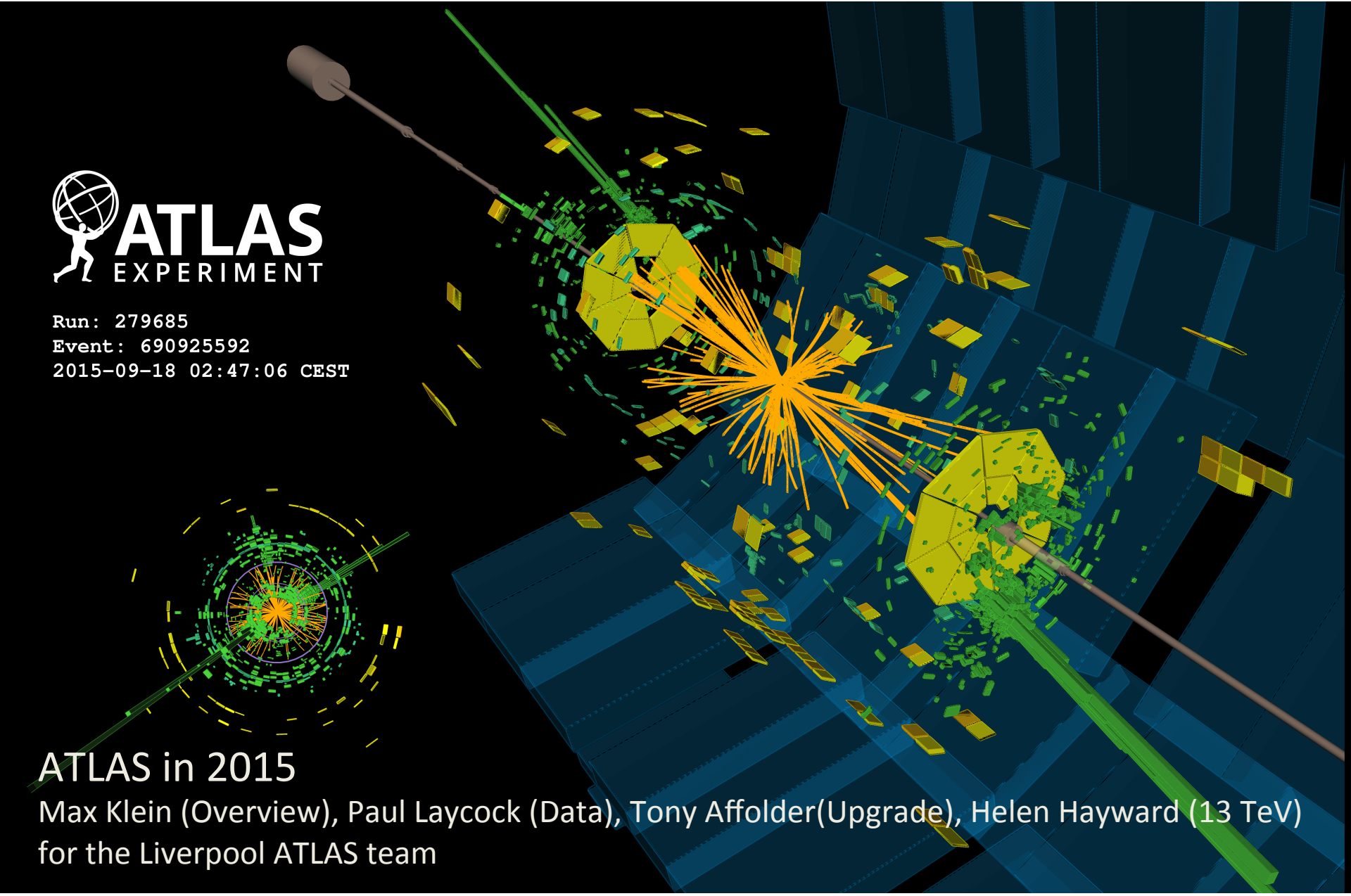
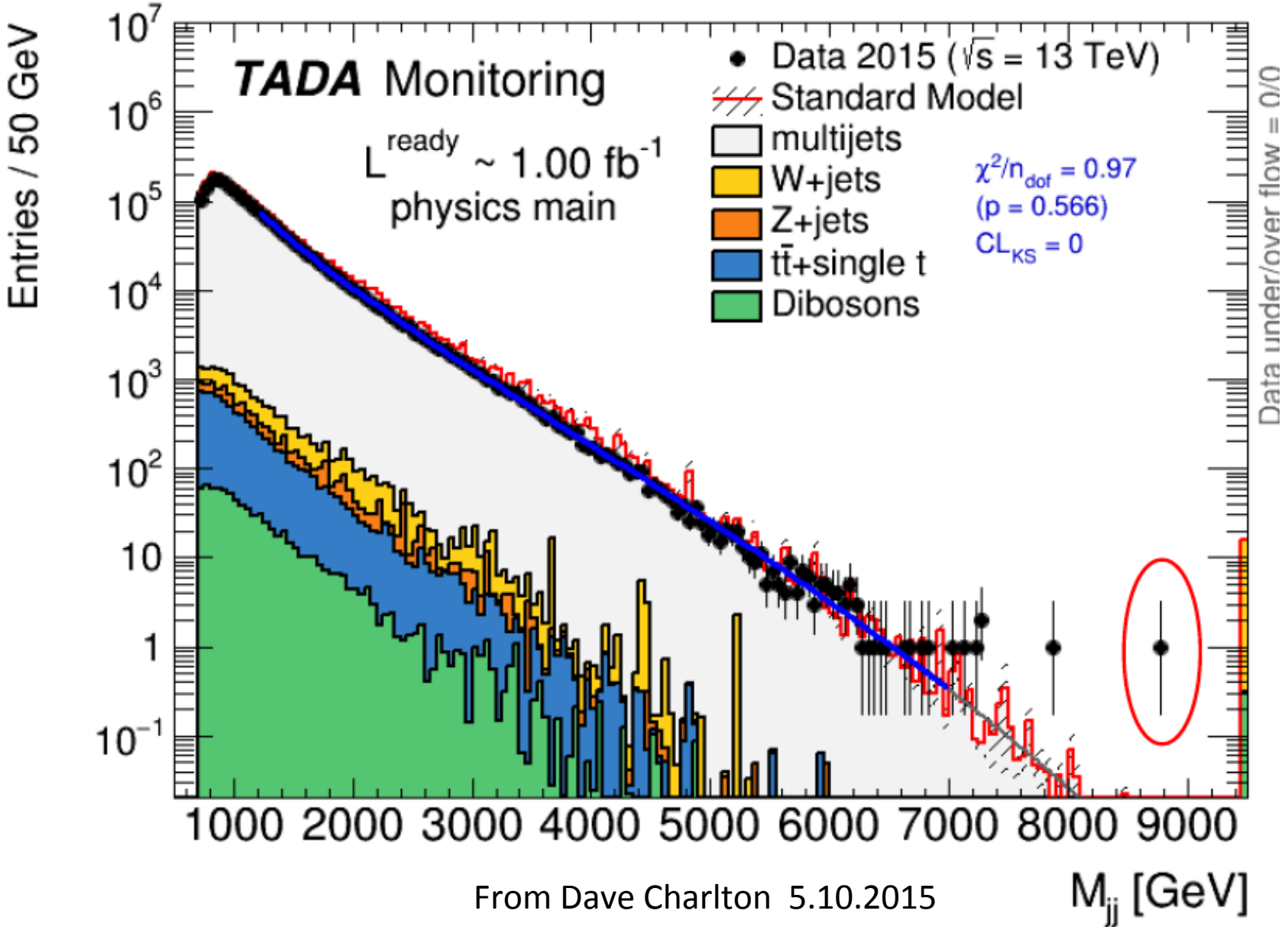


ATLAS in 2015

Max Klein (Overview), Paul Laycock (Data), Tony Affolder(Upgrade), Helen Hayward (13 TeV)
for the Liverpool ATLAS team

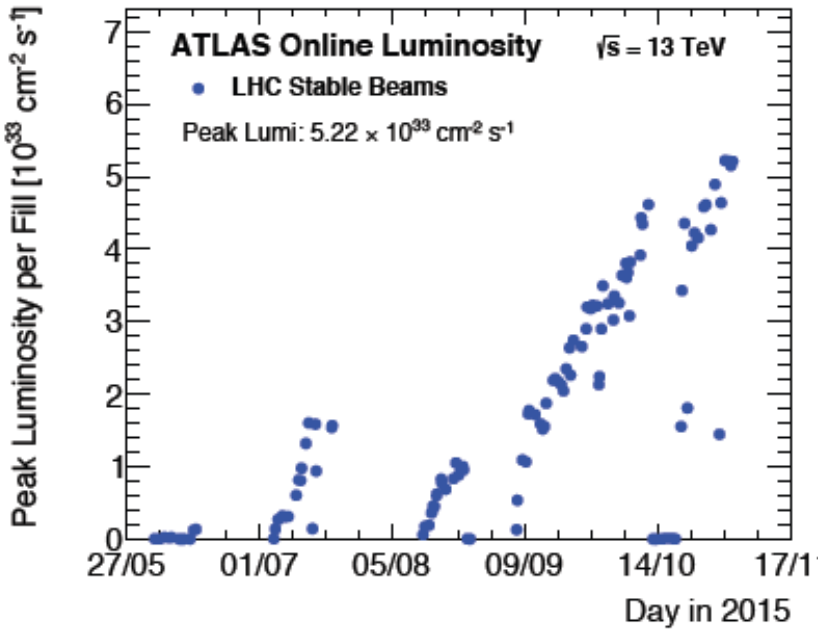
13 TeV event: The two central high-p_T jets have an **invariant mass of 8.8 TeV**, the highest-p_T jet has a p_T of 810 GeV, and the subleading jet has a p_T of 750 GeV. The missing E_T for this event is 60 GeV.

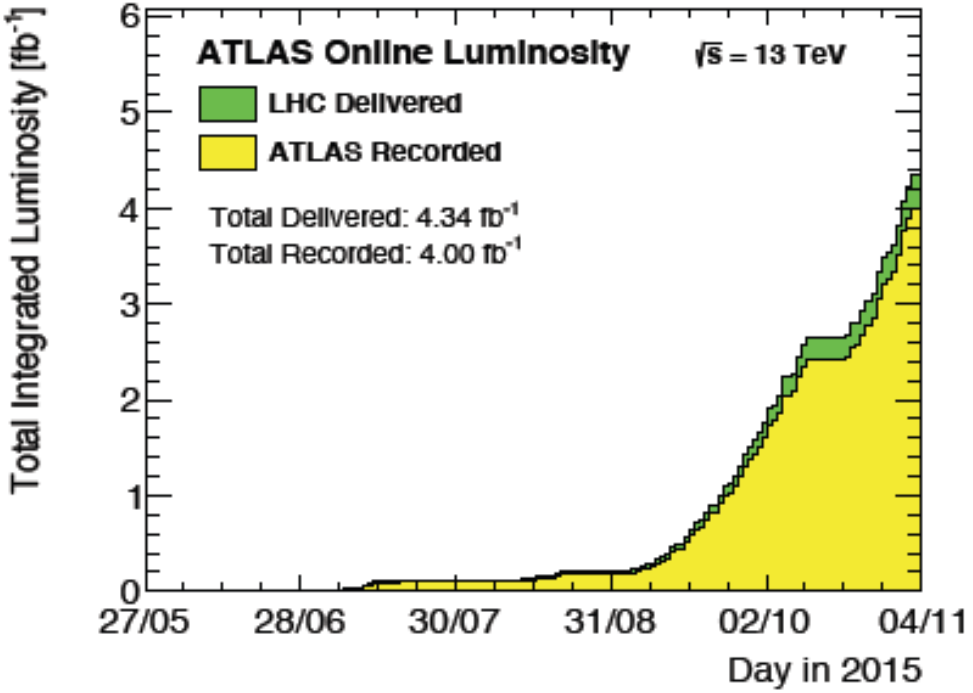
LHC is approaching 10 TeV reconstructed scales



From Dave Charlton 5.10.2015

LHC and ATLAS in 2015



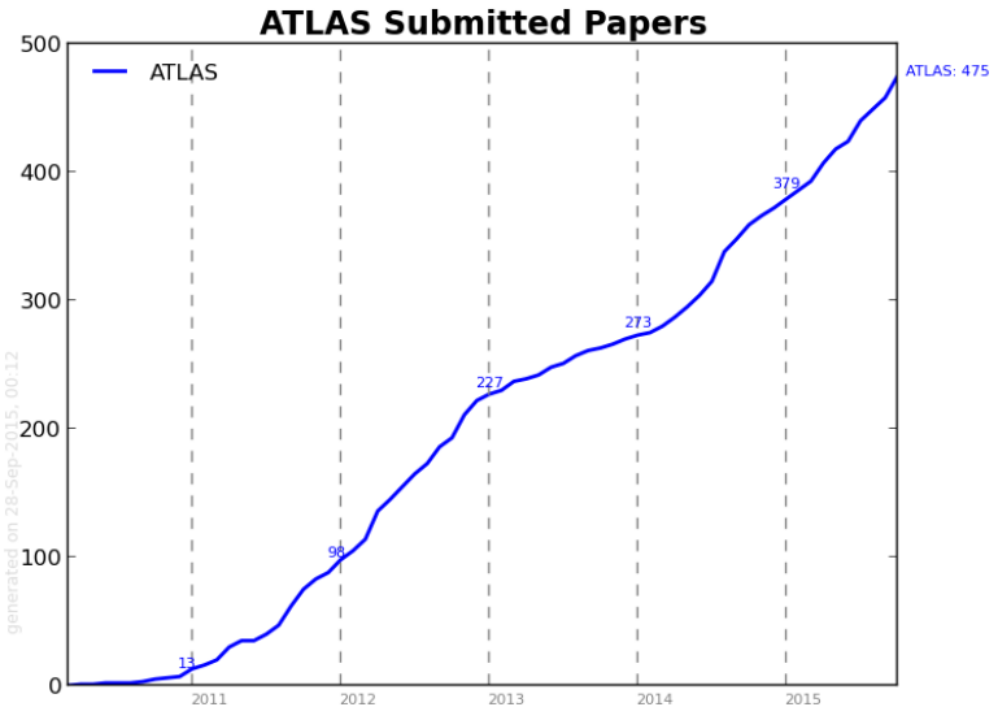


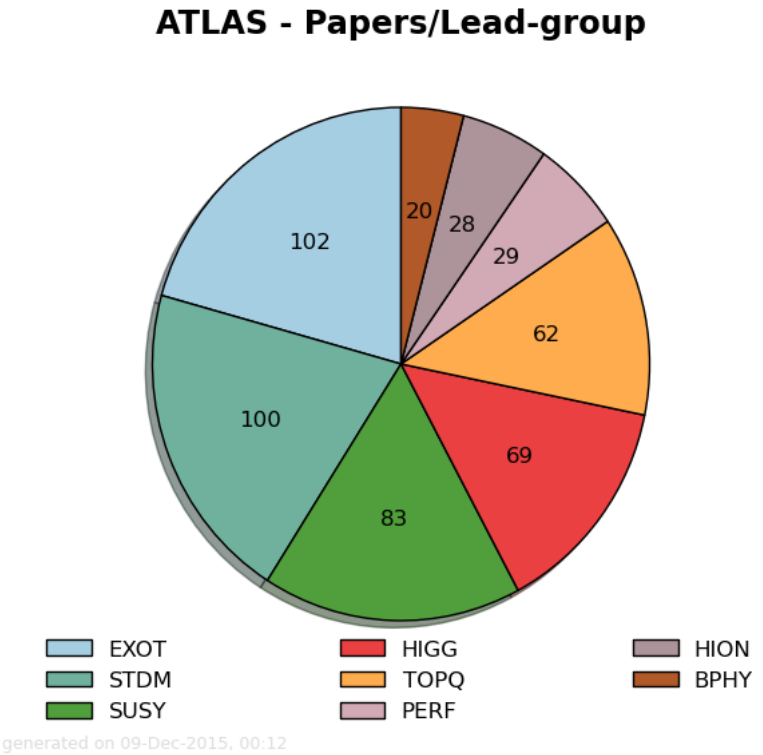
High luminosity, up to $5 * 10^{33}$

High data taking efficiency, >90%

Publications

ATLAS continues to publish 100 papers/y
It has ~3 times more employees than CERN,
as such is its own laboratory to much extent.
A typical analysis group has 20 members →
Strong international collaboration on all papers





Most papers are on Exotics, SM, SUSY, H
"mainstream" on which we focus our work

28.9.2015

Leading Roles

Liverpool ATLAS in 2015

A Affolder: Deputy Strip Upgrade Project Leader, Upgrade (and UK) Strip Module Convenor

G Casse: Upgrade Sensor Procurement Group

P Dervan: UK Irradiation Coordination, UK Upgrade Pixel Module Deputy Convenor

M D'Onofrio: Physics Modelling Working Group Convenor, **Member of Physics Coordination**

C Gwilliam: Physics Validation Convenor and BSM Higgs Convenor

H Hayward: Upgrade Tracker Simulation Convenor, UK Super-symmetry & Exotics Convenor

T Jones: Upgrade Strip Local Support Assembly Convenor, UK Upgrade Strip Mechanics Convenor

M Klein: Team Leader, Collaboration Board, PDF Forum Convenor

U Klein: Advisory Board to Chair of the Collaboration Board, LPCC Contact

J Kretzschmar: Standard Model Working Group Convenor, **Member of Physics Coordination**

P Laycock: Data Preparation Coordinator and **Member of the Executive Board**

A Mehta: Higgs to bb Group Convenor and Analysis Release Coordinator

J Vossebeld: UK Silicon Tracker Project Leader

A.Greenall Strip Hybrid and Module Design

I Tsurin Pixel Sensor, Hybrid and Module and Design

Various further roles in ATLAS (editorial boards) and outside

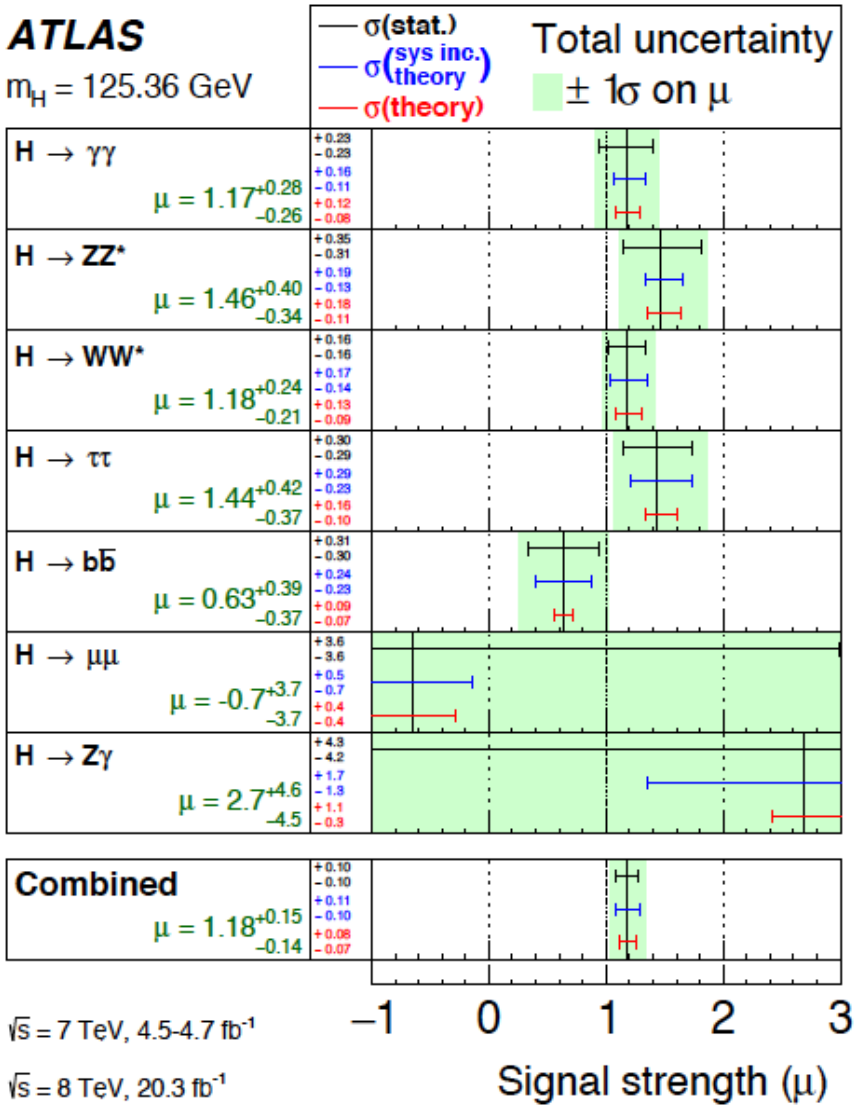
and further important leadership in ITK upgrade (cf Tony's talk):

"Liverpool is seen as focus of activity and expectation is lots of people will travel to Liverpool``

Statement in the minutes of Cosener's House ITK upgrade meeting last week, and K. Einsweiler

Run 1 legacy (H)

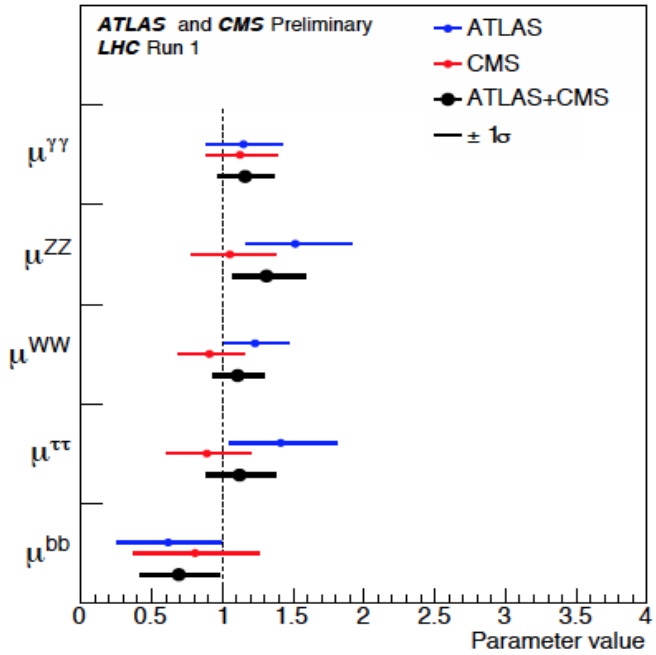
Higgs Couplings from Run 1



Andy

arXiv:1507.04548

ATLAS + CMS



$m_H = 125.09 \pm 0.21(stat.) \pm 0.11(syst.)$ GeV

$\mu = 1.09 \pm 0.11$

No indication for departure from SM H

Good agreement of ATLAS and CMS

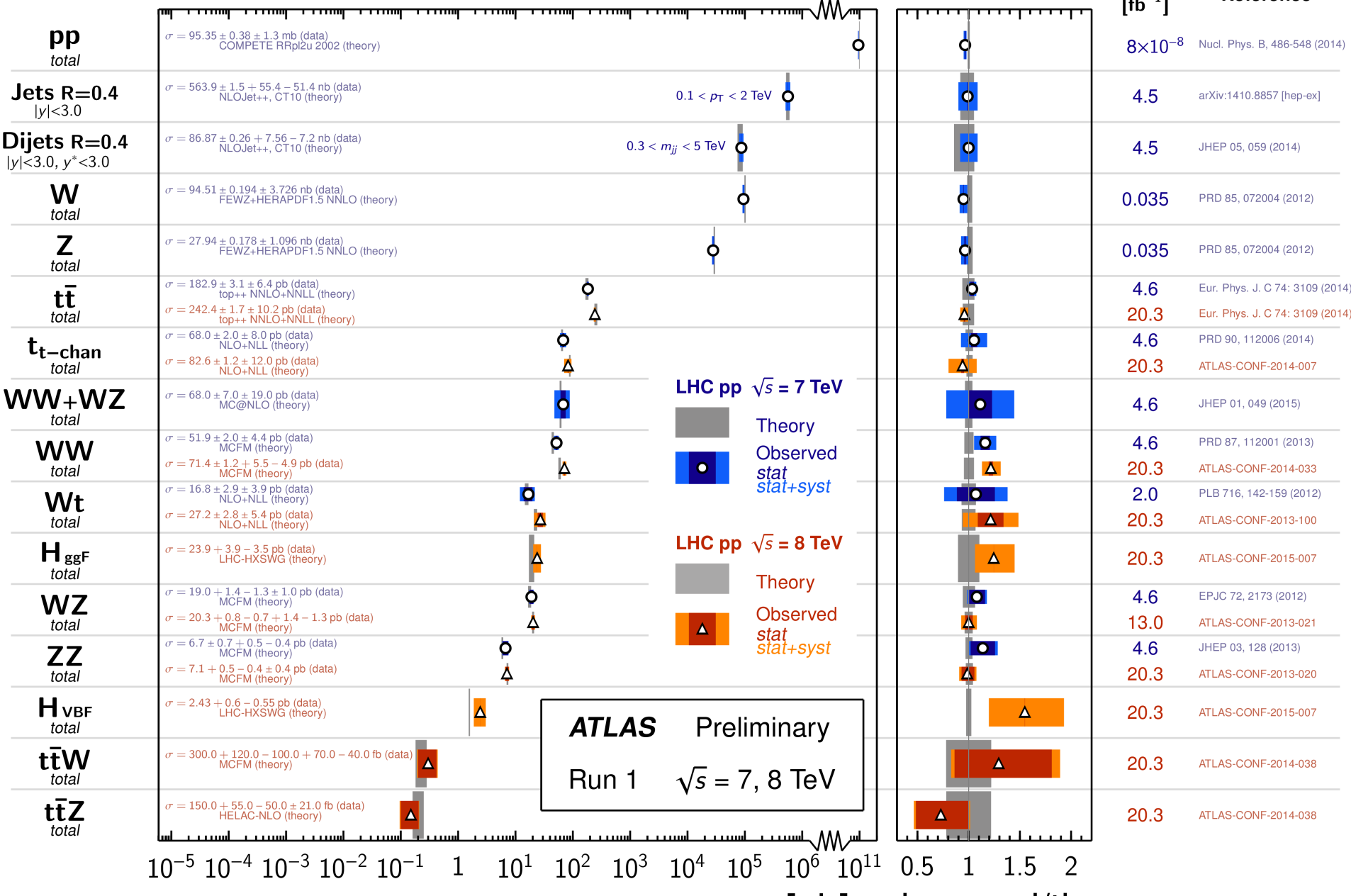
…High precision [HL-LHC 100*L, 2*E_p]

Lpool worked on μμ + Zγ searches

Jan + Nathan, Helen, Sergey

Standard Model Total Production Cross Section Measurements

Status: March 2015

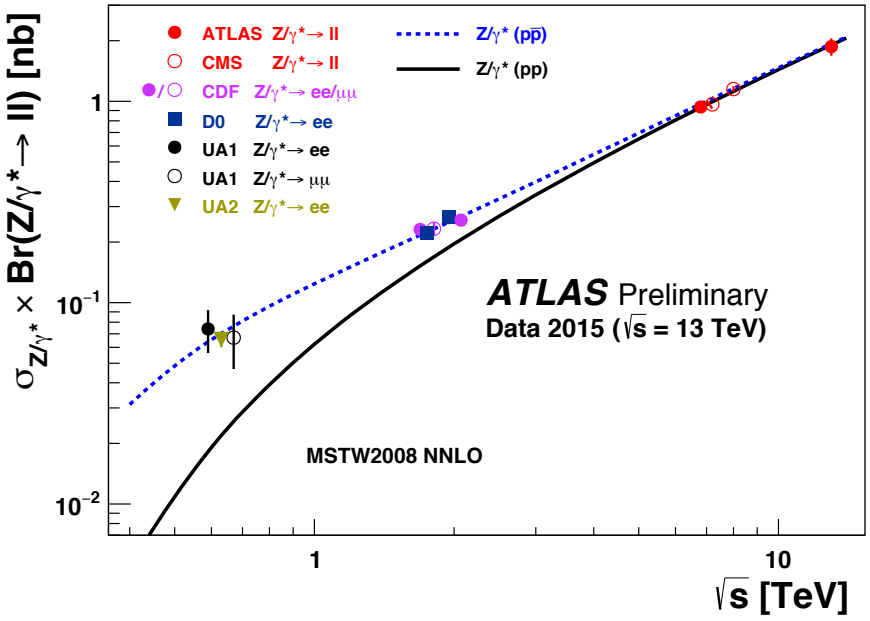


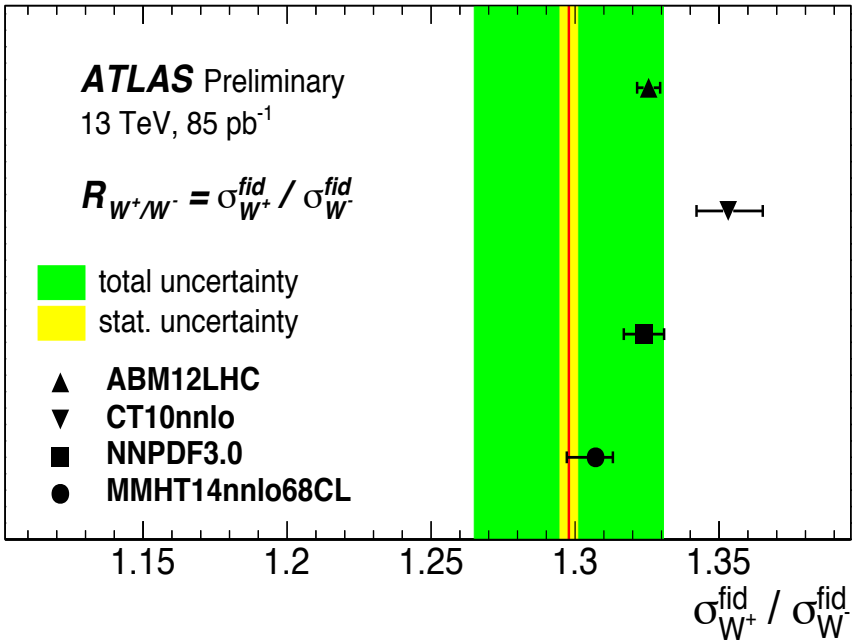
Run 1 legacy (SM)

Summer 15 – Rapid W,Z Measurements 13 TeV

CONF-2015-039

Jan





Also prompt results on the inelastic cross section, mbias event properties, jets, photoproduction and ZZ

PDF on ATLAS – a classification

Max PDF forum 5.11.15

1. Acceptance and Background Simulations

MC's with different PDFs, mostly chosen for practical reasons (e.g. Sherpa2.2 and NNPDF3.0) – simple (x,Q^2) reweight used for effect from different PDFs - see PMG Twiki

2. Limit Calculations

Uncertainties and differences of PDFs affect the value of limits, e.g. on M(Z'). PDF effect may dominate (high mass – high Bjorken x) or not. Case by case + conservative treatment required.

3. Uncertainties caused by limited PDF control

"Typical" example are the Higgs couplings and the mass of the W boson.
complex issues: NNLO-N^3LO, strong coupling, PDF differences+errors, scales

4. QCD fits of our own data

Some processes, best example inclusive Dell Yan (NC and CC), can be used to constrain PDFs. New insight may be gained on parton distributions [main activity of the forum]

5. Illustration

Data-Theory comparisons – should be as complete as is possible

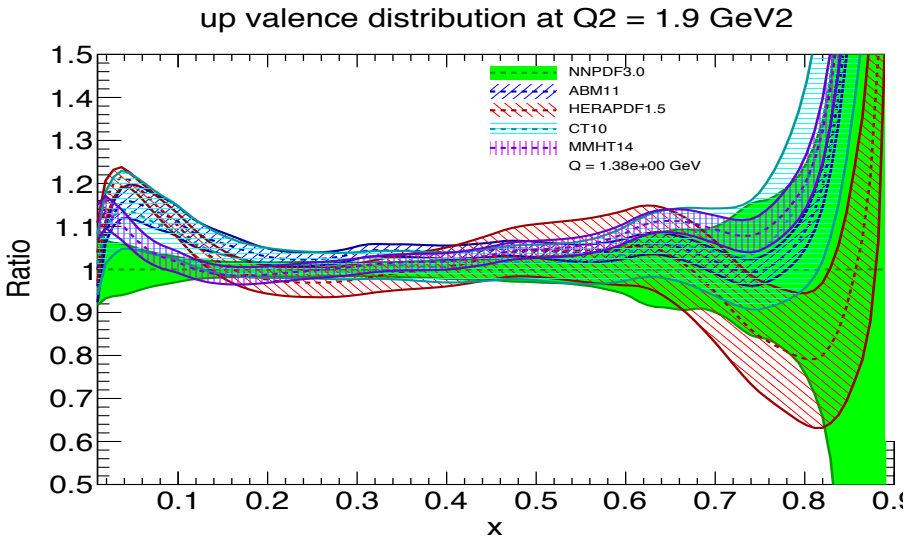
→ There is no general rule as to how PDFs shall be treated but case by case study needed.

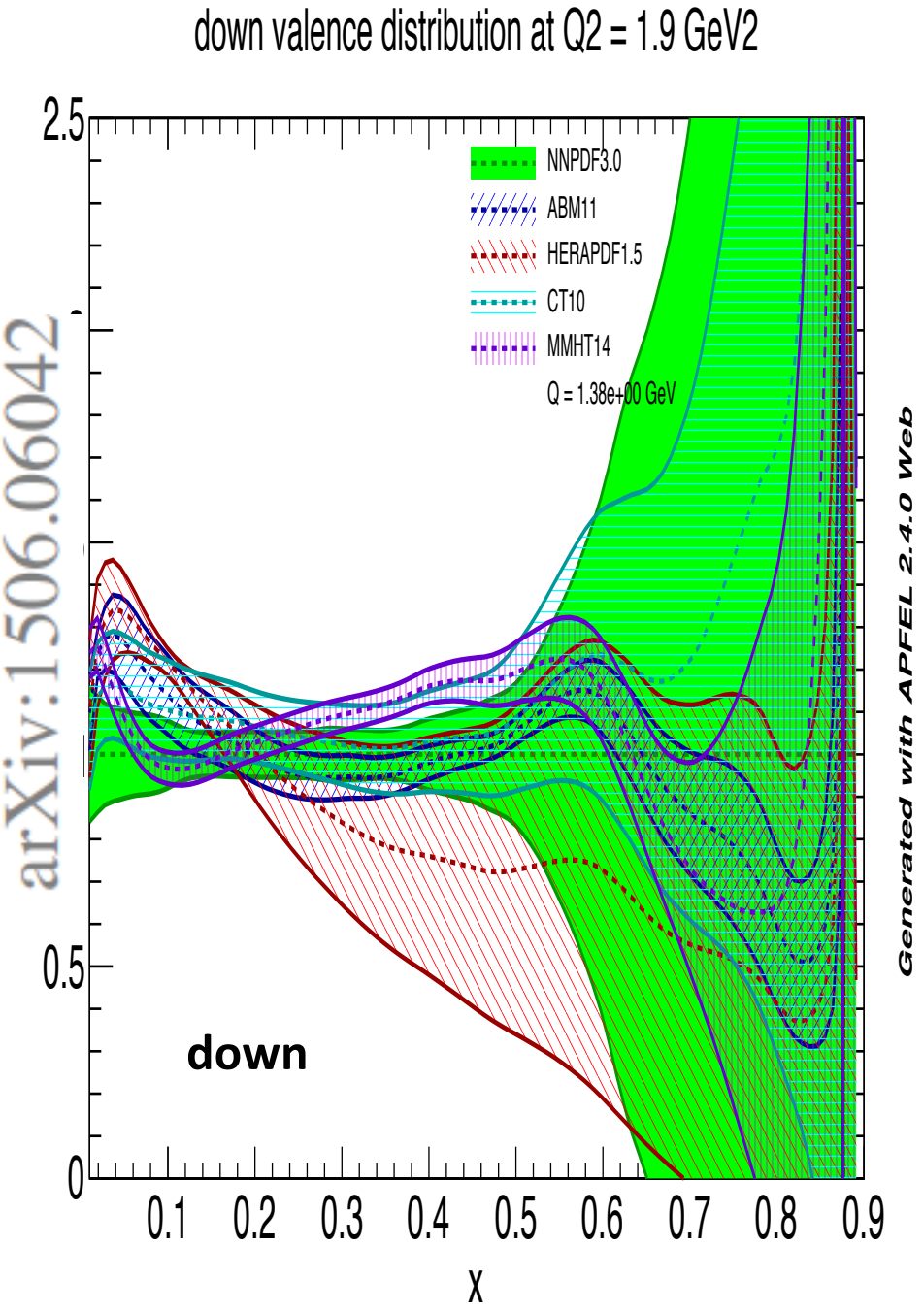
PDF sets and their assumptions

V.Radescu 10/15	CT14	MMHT15	NNPDF3.0	HERAPDF2.0	ABM12	CJ12	JR14
HQ scheme	VFNS (ACOT-χ)	VFNS (TR opt)	VFNS (FONLL)	VFNS (TR opt)	FFNS Run mc (ABM)	VFNS (ACOT)	FFNS (JR)
orders	LO, NLO, NLLO	LO, NLO, NLLO	LO, NLO, NLLO	LO, NLO, NLLO	NLLO	NLO	NLO, NLLO
α(Mz)	fixed(fitted)	fixed (fitted)	fixed	fixed	fitted	fixed	fitted
α(Mz) LO α(Mz) NLO α(Mz) NNLO	0.1300 0.1180 (0.117) 0.1180 (0.115)	0.1350 0.1180 (0.1201) 0.1180 (0.1172)	0.1180 0.1180 0.1180	0.1300 0.1180 0.1180	- - 0.1132	- 0.118 -	- 0.1158 0.1136
Nr param.	Pol. Bernst. 28	Pol. Cheb. 25	NN (259)	Pol. 14	Pol. 24	Pol. 22	Pol.25
PDF assumptions	ubar/dbar=1(x->0) u/d=1 (x->0)	s-sbar=fit. dbar-ubar=fit.	dbar-ubar=fit	ubar=dbar (x->0) sbar=0.67*dbar	s=sbar dbar-ubar=fit	dv/uv=const s+sbar=k(ubar+dbar)	dbar-ubar=fit
Stat. treatm.	Hessian $\Delta\chi$2=100 (90% CL)	Hessian $\Delta\chi$2 Dynamical (68% CL)	Monte Carlo (68% CL)	Hessian $\Delta\chi$2=1 (68% CL)	Hessian $\Delta\chi$2=1 (68% CL)	Hessian $\Delta\chi$2=1 (68% CL)	Hessian $\Delta\chi$2=1 (68% CL)
Q2min	2	2	3.5	3.5	2.5	1.69	2
HERA data	HERA I+ charm	HERA I charm jets	HERA I+ H1 and ZEUS II charm	HERA I+II	HERA I charm	HERA I	HERA I charm jets
Fix. Target DIS	✓	✓	✓	N/A	✓	JLAB, high x ✓	JLAB, high x ✓
Tevatron W,Z	✓	✓	✓	N/A	✗	✓	✗
Tevatron Jets	✓	✓	✓	N/A	✗	✗	✓
Fix. Target DY	✓	✓	✓	N/A	✓	✓	✓
LHC WZ	✓	✓	✓	N/A	✓	✗	✗
LHC jets	✓	✓	✓	N/A	✗	✗	✗
LHC top	✗	✓	✓	N/A	✓	✗	✗
LHC charm	✗	✗	✓	N/A	✗	✗	✗
References	arXiv:1506.07443	arXiv:1412.3989	arXiv:1410.8849	arXiv:1506.06042	arXiv:1310.3059	arXiv:1212.1702	arXiv:1403.1852

Valence quarks

up





Related to DY , W mass etc

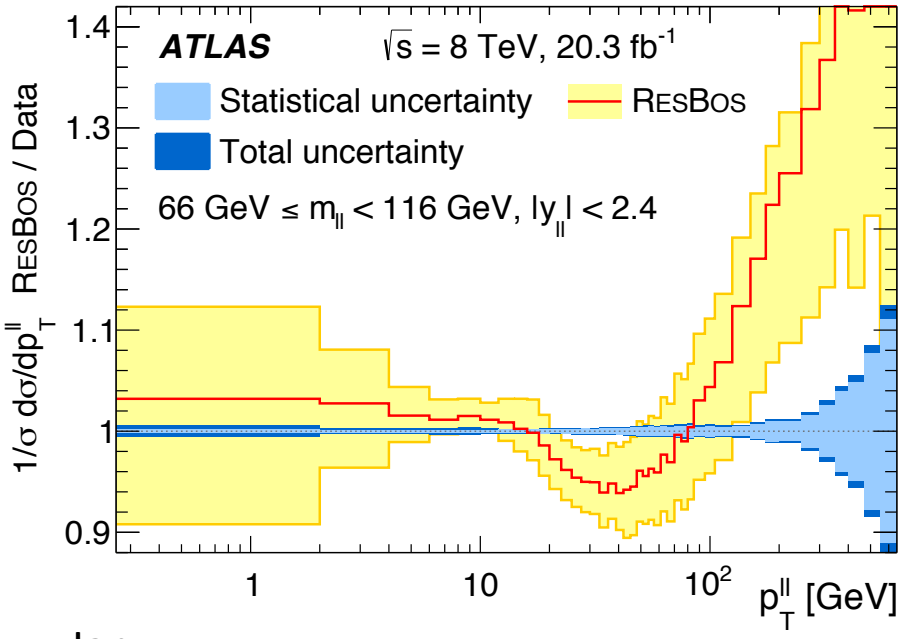
Recall $xq_v \sim (1-x)^3$

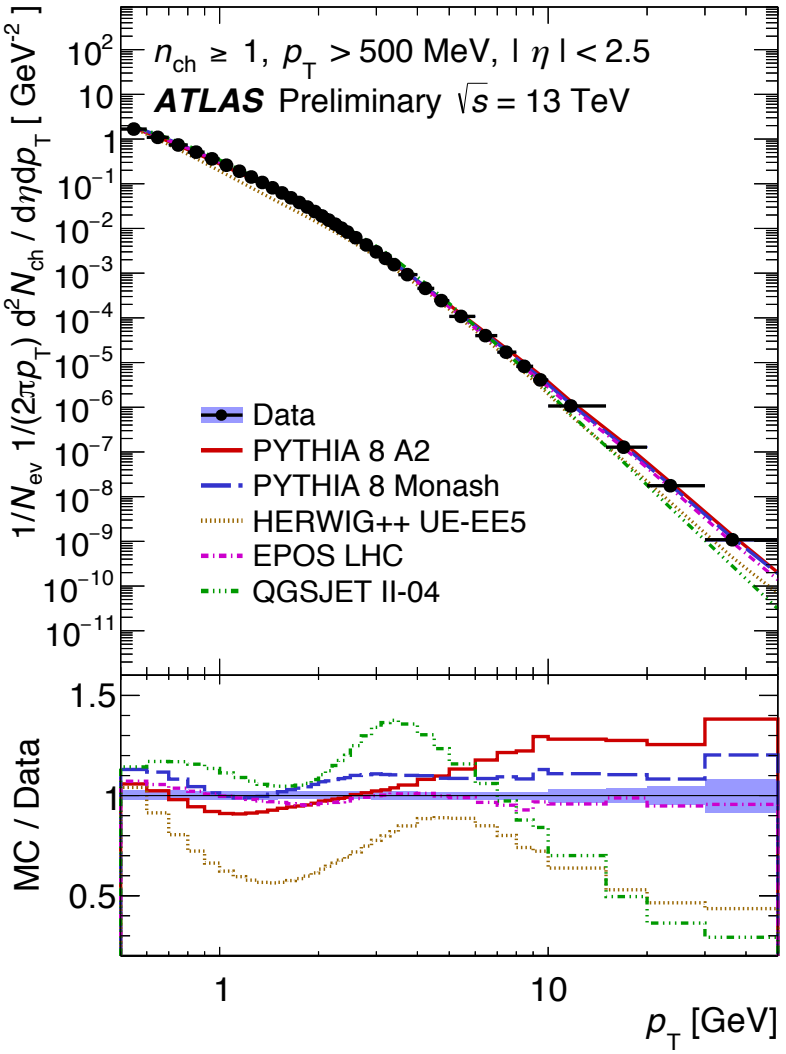
d/u → 1 a classic question

Standard Model

Variety of crucial measurements as input to QCD, MC simulations, searches and forthcoming precision measurements (top and W mass for example)

arXiv:1512.02192 [SM paper nr 100]





CONF-2015-028 for PU tuning

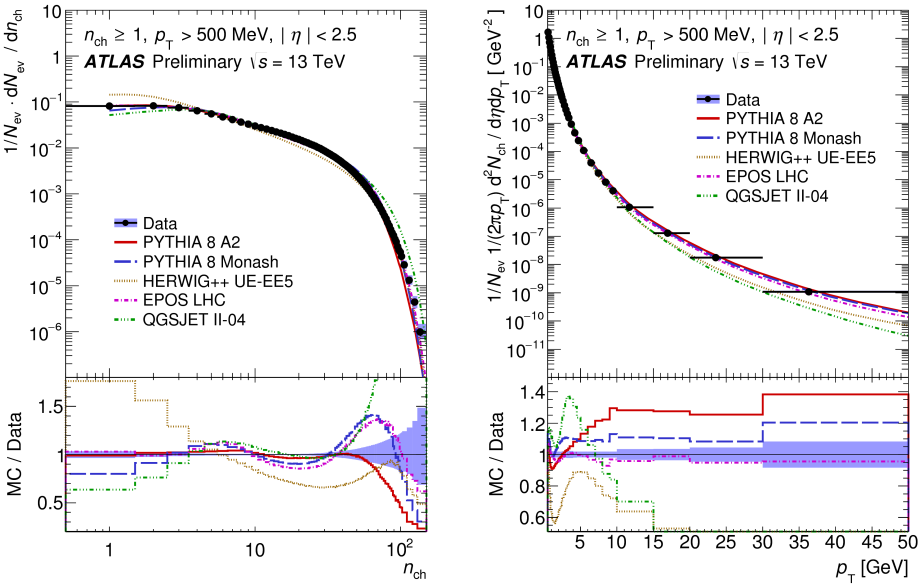
Jan

Physics Modelling

All 13TeV

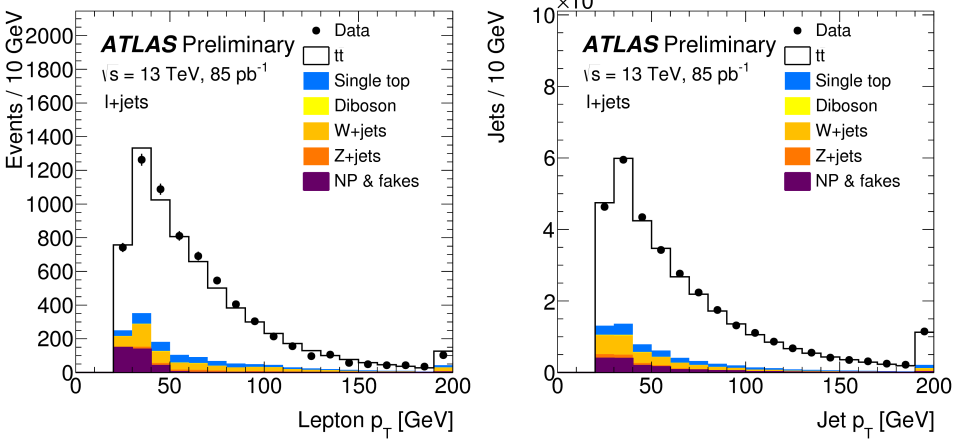
Minbias A2 tune (for PU)

Pythia 6 and 8 (using 7 teV ATLAS data only)



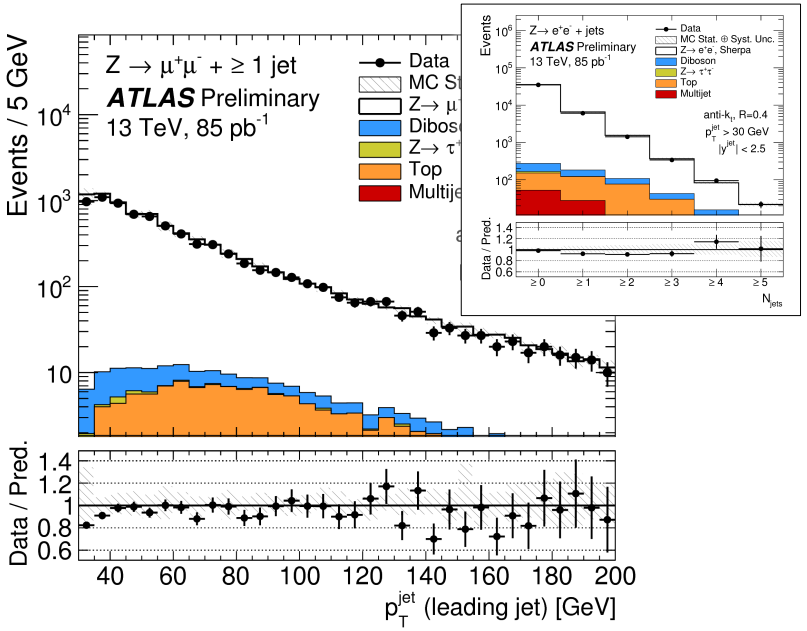
Top pair production

Powheg-Box v2 (hdamp =m_t) – Pythia 6.428 – EvtGen (HF decays) - CT10 PDFs – Perugia 2012 tune



V+jets, Dibosons, Tribosons: Sherpa 2.1.1 NLO

E.g.: for V+jets, NLO up to 2 partons and LO up to 4 (big improvements wrt Run 1)



For all processes: more than one generator used, e.g. MadGraph5 LO and NLO, Pythia8 and Herwig++ standalone and interfaced to Powheg and aMC@NLO

PDF for ME: CT10 or NNPDF3.0nlo

Tuning: A14, AZNLO and new ones developed by ATLAS

Theory: High order x-sections calculations where available

Monica (LPCC workshop 1/16, ... cf backup)

ATLAS Papers in 2015 with arXiv:2015 and CONF Notes*)

* CP-odd A → hZ	arXiv:1502.04478 (PLB)	WW,WZ,ZZ resonances?	CONF 2015-056
Charged Higgs → WZ	arXiv:1503.04233 (PRL)	* Di-l 13 TeV Z' + CI	CONF-2015-070
R → Z/Wh	arXiv:1503.08089 (EPJC)		(yesterday)
* Heavy Higgs → ZZ	arXiv:1507.05930 (EPJC)	* New physics in l+MET W'	CONF-2015-63
* Higgs Couplings	arXiv:1507.05048 (EPJC)		(yesterday)
* pT and Φ* of Z	arXiv:1512.02192 (EPJC)	Sbottom	CONF-2015-066
*3rd generation SUSY	arXiv:1506.08616 (EPJC)		

Further Papers

MCSANC integrator arXiv:1509.03052
H-HH in ep arXiv:1509.04016 (PRL)

Proceedings to many conferences

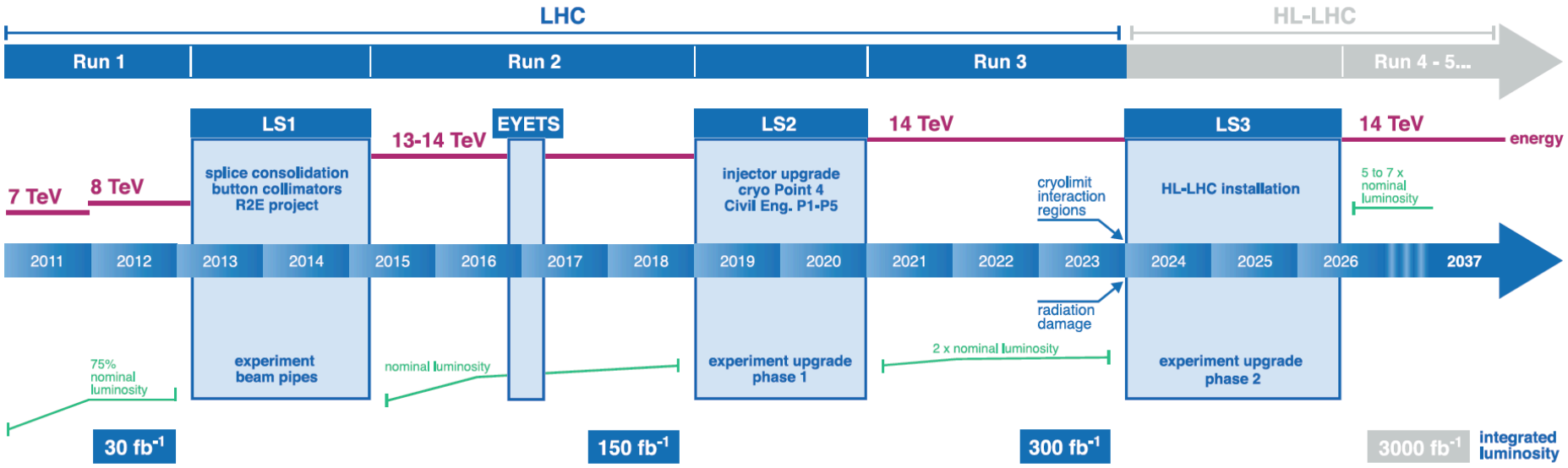
A large number of (our) analyses on Run 1 and 13 TeV data still await publication in 2016 (exotics, SUSY..)

ATLAS provides first class basis for fundamental publications now and in the future. Important for our science and its REF monitor.

Results on the 2015 Data at 13 TeV will be shown later today by Helen (W',Z',ZZ,Z+MET,A-ττ)

*) list not complete

LHC / HL-LHC Plan



Today

Start of Run 3

RG15

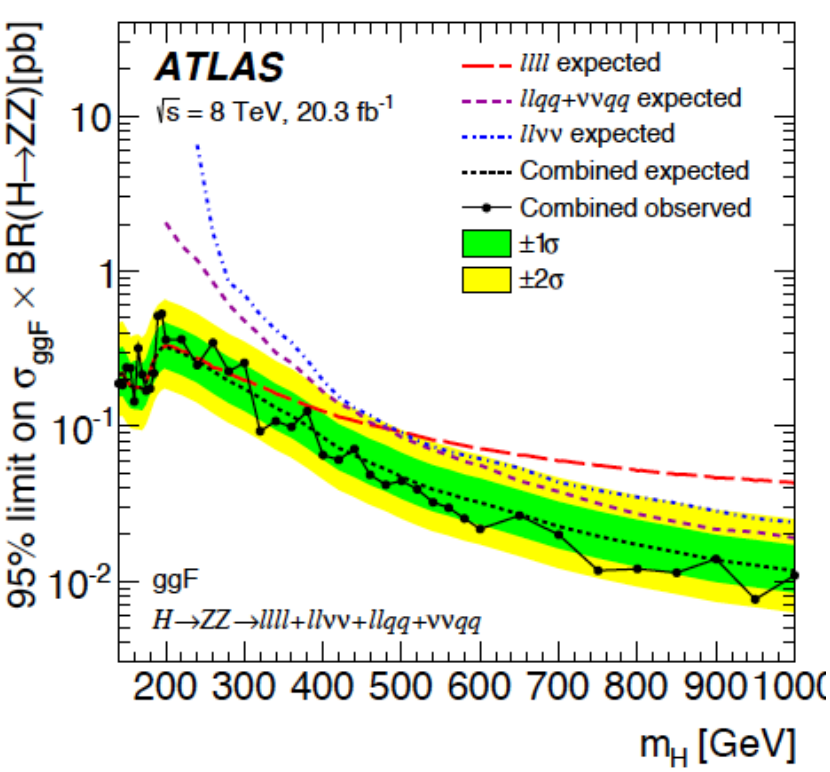
RG18

REF19

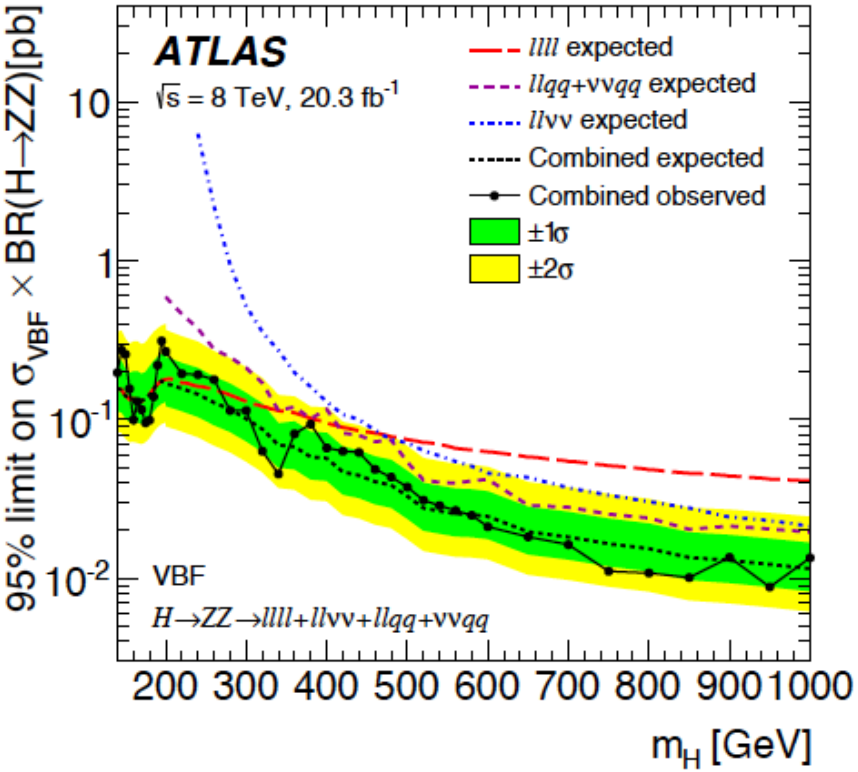
Search for an additional, heavy Higgs boson in the $H \to ZZ$ decay channel at $\sqrt{s} = 8$ TeV in pp collision data with the ATLAS detector

arXiv:1507.05930

Andy+Carl



(a) ggF

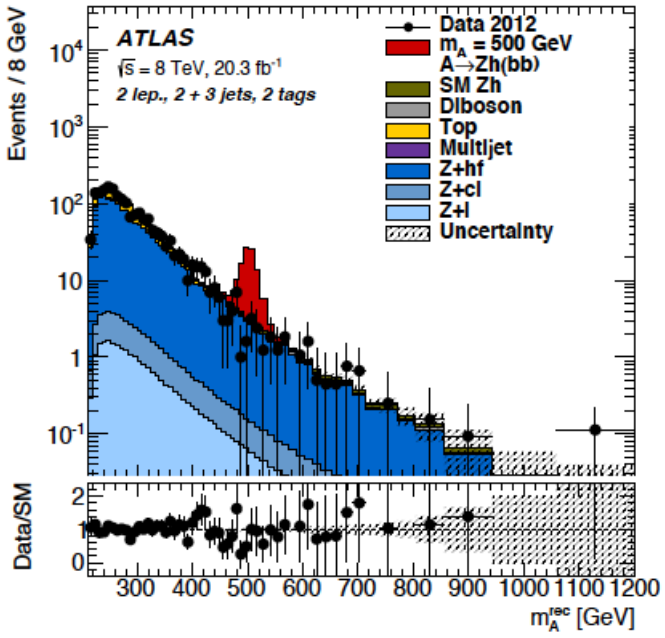


(b) VBF

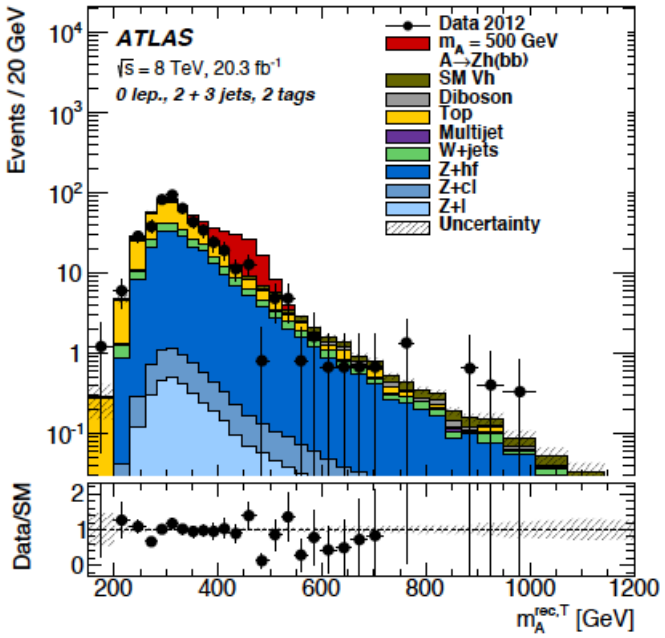
decay modes, 95% CL upper limits range from 0.53 pb at $m_H = 195$ GeV to 0.008 pb at $m_H = 950$ GeV for the gluon-fusion production mode and from 0.31 pb at $m_H = 195$ GeV to 0.009 pb at $m_H = 950$ GeV

Search for a CP-odd Higgs boson decaying to Zh in pp collisions at $\sqrt{s} = 8$ TeV with the ATLAS detector

arXiv:1502.04478



(a) $\ell\ell bb$



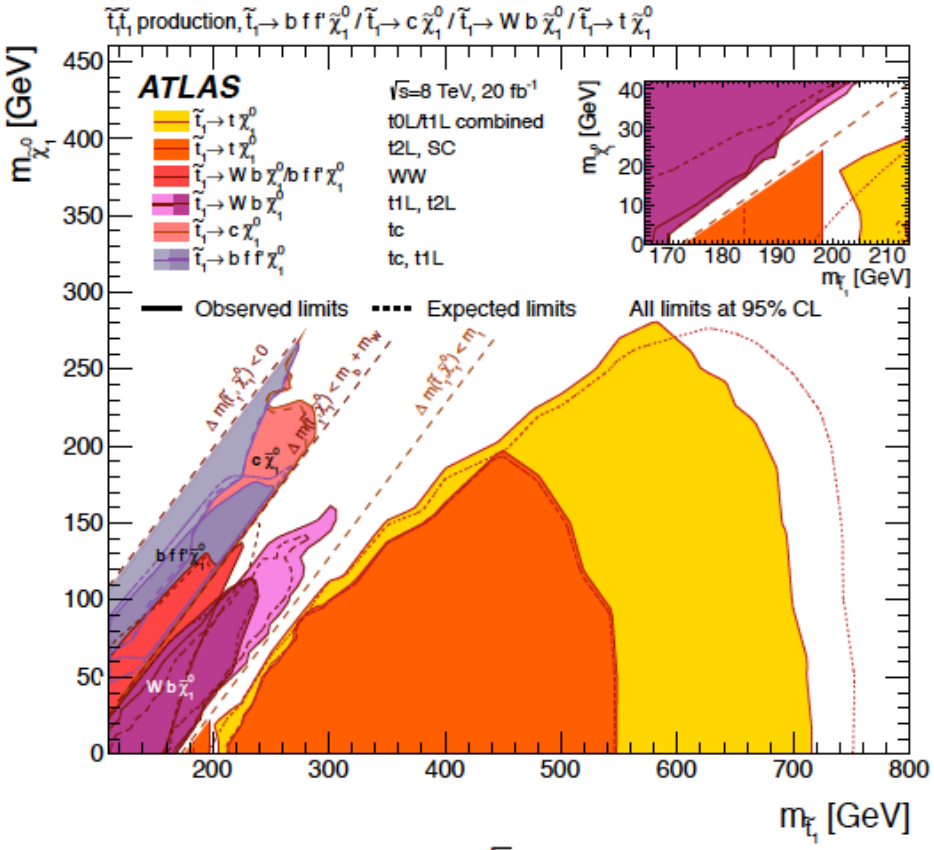
(b) $\nu\nu bb$

Andy+Carl

Fig. 2. Distributions of the reconstructed A boson mass for the $\ell\ell bb$ final state (a) and the A boson transverse mass for the $\nu\nu bb$ final state (b). The signal shown in both cases corresponds to $\sigma(gg \to A) \times \mathrm{BR}(A \to Zh) \times \mathrm{BR}(h \to bb) = 500$ fb with $m_A = 500$ GeV. The predicted distributions are shown after the profile likelihood fit to the data. The uncertainty is shown as a hatched area, and the overflow is included in the last bin.

ATLAS Run 1 searches for direct pair production of third-generation squarks at the Large Hadron Collider

arXiv:1506.08616

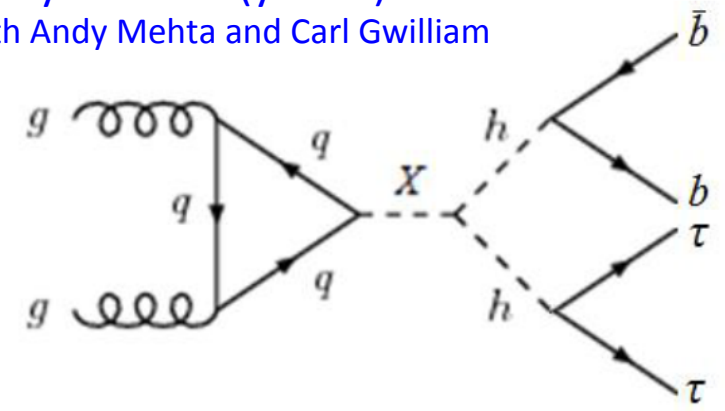


Monica, John

ATLAS in 2012 at a centre-of-mass energy $\sqrt{s} = 8$ TeV. Exclusion limits in the context of simplified models are presented. In general, stop and sbottom masses up to several hundred GeV are excluded, although the exclusion limits significantly weaken in the presence of compressed SUSY mass spectra or multiple allowed decay chains. Three classes of pMSSM models, based on general arguments of

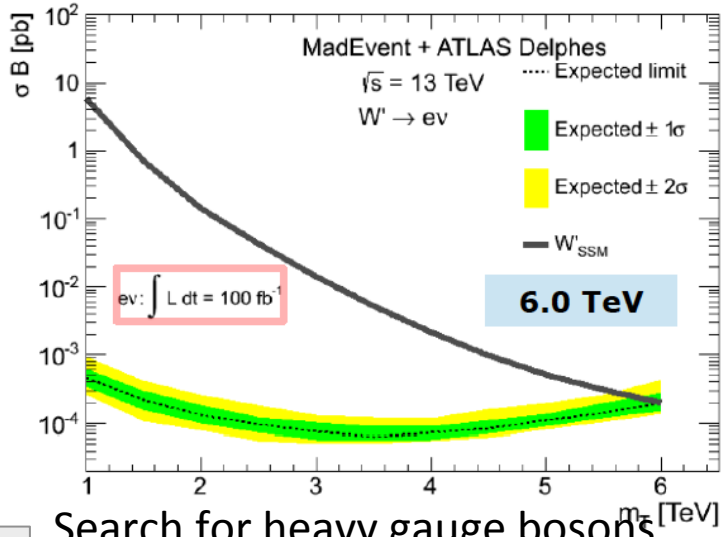
PhD Students

Emily Graham (year 1)
with Andy Mehta and Carl Gwilliam



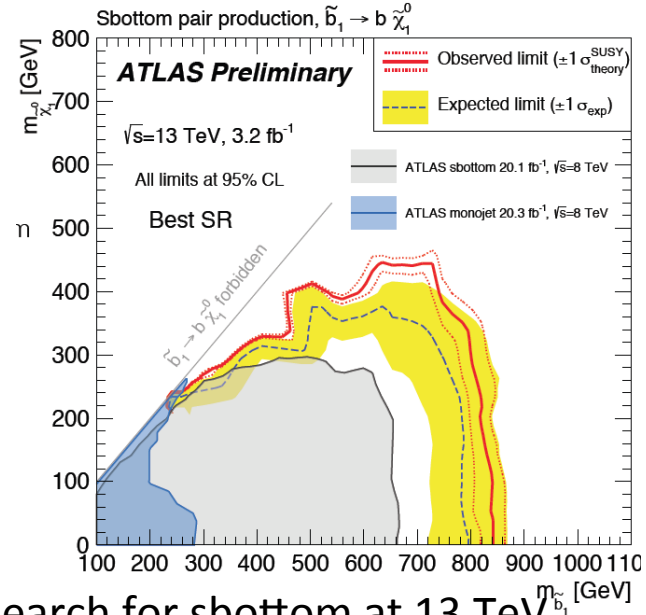
h-hh, X=RS graviton, heavy CP-even H^0

Ellis Kay (year 2)
with Uta Klein and Paul Laycock



Search for heavy gauge bosons

John Anders (year 3)
with Monica D'Onofrio and Jan Kretzschmar

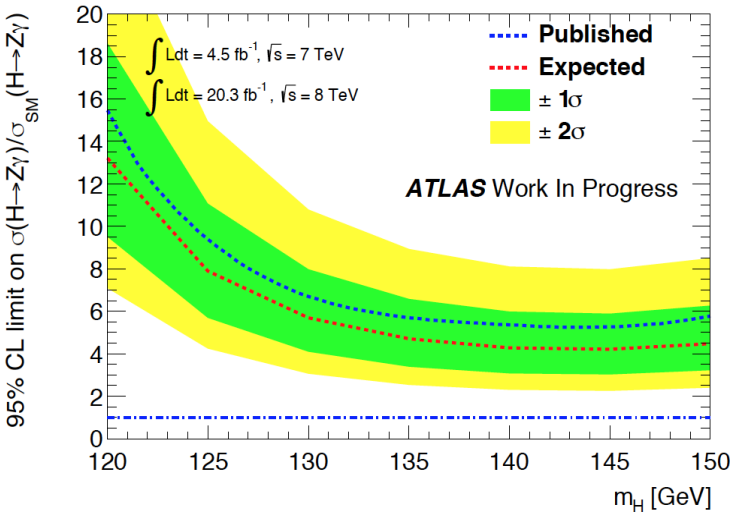


Search for sbottom at 13 TeV

Six proposals made for GTA PhDs on Physics and Pixels, joint academic and technical super-vision (for two)

Many thanks to Steve Maxfield for his strong and positive role in the supervision, and for ATLAS+H1.

Nathan Readioff (year 4)
with Helen Hayward and Sergey Burdin

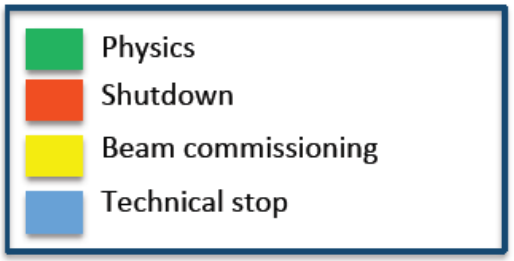


Search for Higgs into Z and photon

LHC schedule beyond LS1

Slide shown Dec 2014

LS2 starting in 2018 (July) => 18 months + 3 months BC
LS3 LHC: starting in 2023 => 30 months + 3 months BC
Injectors: in 2024 => 13 months + 3 months BC

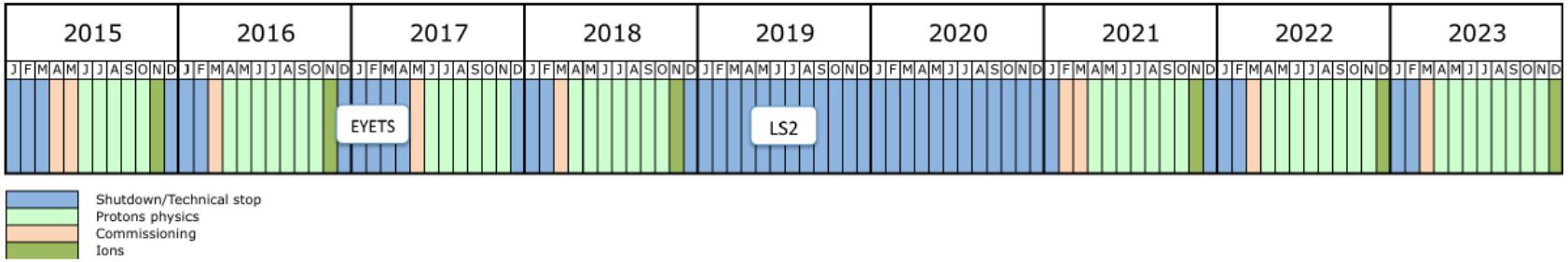


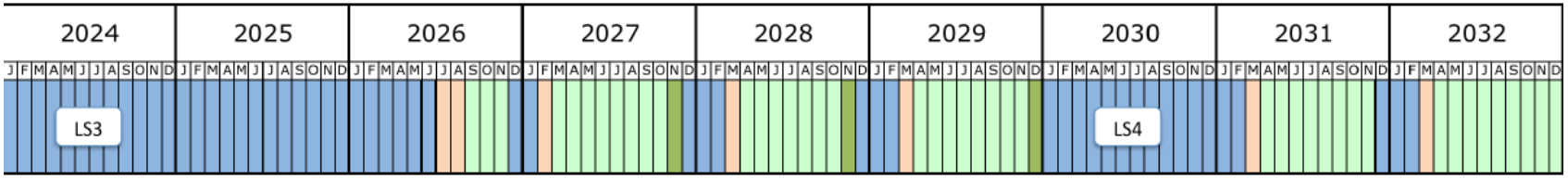
(Extended) Year End Technical Stop: (E)YETS

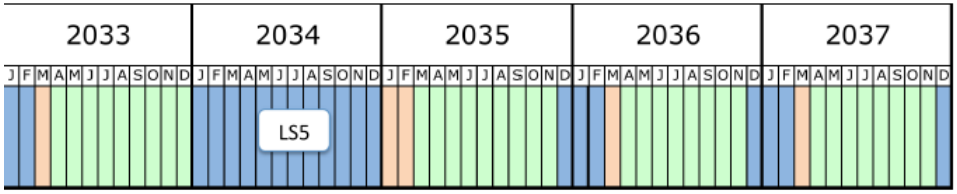
Goal of 3'000 fb^{-1} by mid 2030ies

High Luminosity LHC

Modified Schedule for HL-LHC (December 2015)







The LS2 shutdown is now two years for CE when LHC stops, it moved fwd by ½ year
The HL LHC shutdown is now almost 3 years and moved to 2024+, LHC to run to 2037

LHC Luminosity Upgrade - Accelerator

- Technical bottle necks (e.g. cryogenics) ➔ New addit. Equipment
- Insertion magnet lifetime and aperture:

  ➔ New insertion magnets and low-β with increased aperture
- Geometric Reduction Factor: ➔ SC Crab Cavities

  ➔ New technology and a first for a hadron storage ring!
- Performance Optimization: Pileup density ➔ luminosity levelling

  ➔ devise parameters for virtual luminosity >> target luminosity
- Beam power & losses ➔ additional DS (cold region) collimators
- Machine effciency and availability:

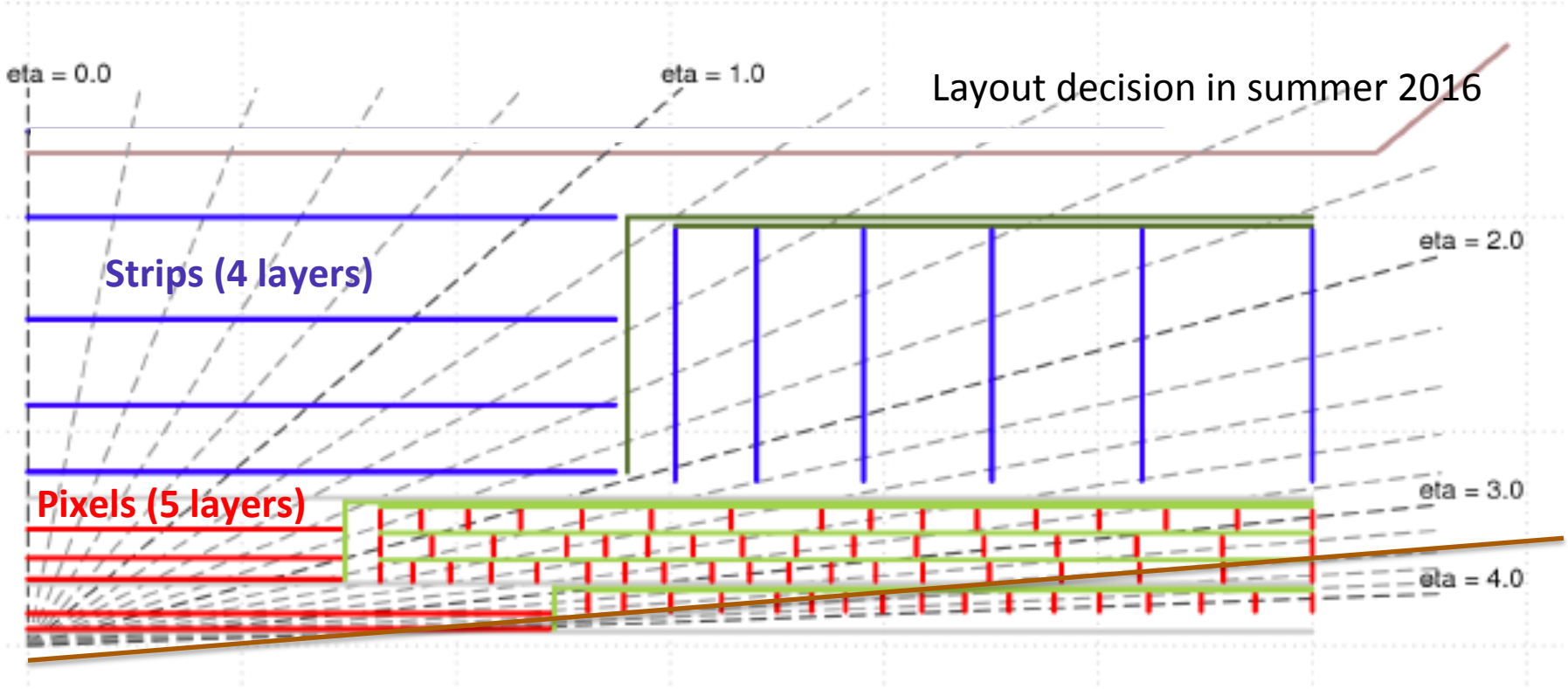
  # R2E ➔ removal of all electronics from tunnel region

  # e-cloud ➔ beam scrubbing (conditioning of surface)

  # UFOs ➔ beam scrubbing (conditioning of surface)

Upgrade of the Inner Semiconductor Tracker

ATLAS will replace its complete inner tracker during LS3 (>=2024) to cope with HL LHC. This happens after 10 years of operation and 10 years hence of high luminosity runs.

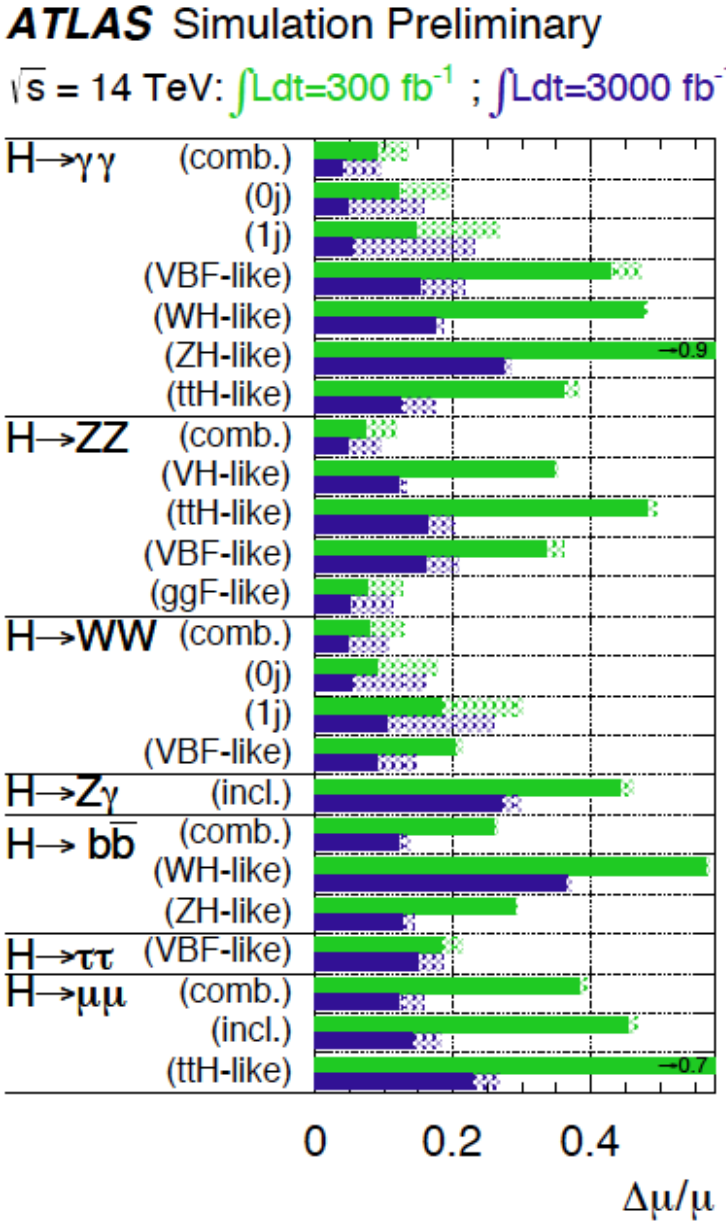


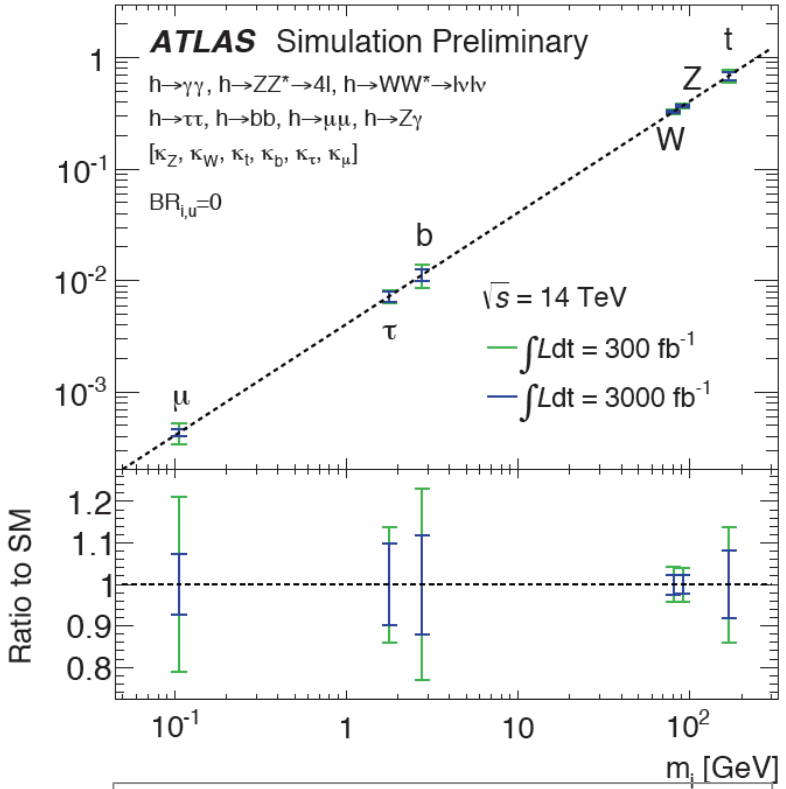
Helen leads ITK simulation group

UK with Liverpool are key institutions in the ITK

Studies on maximum rapidity range, optimum arrangement of sensors and technology. TDR strips is due 4/2016, TDR pixels planned for 4/2017. Scoping Document with finance and performance variations: endorsed by CERN, RRB, LHCC. UK Project to begin 4/17, Submitted bridge proposal for 2 years early December to STFC. → Tony's presentation

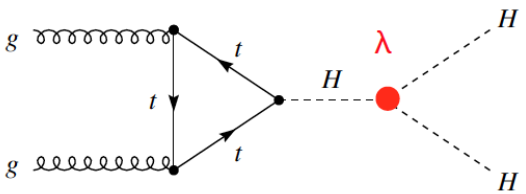
Higgs HL LHC





ep doesH-bb to 1%, adds H-cc (Uta) and delivers PDFs and as at N^{3}LO

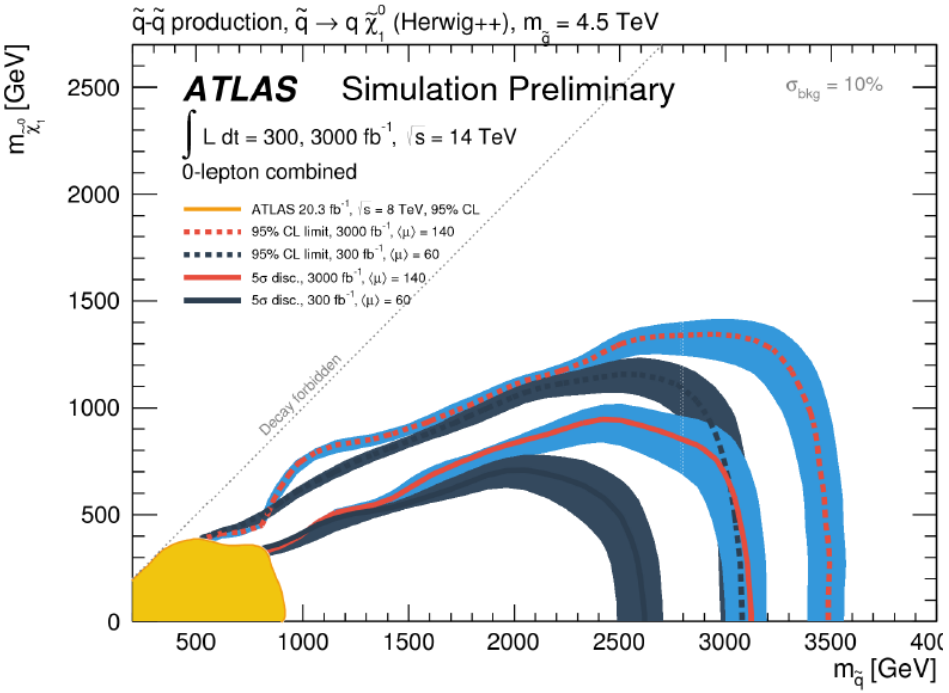
Self-coupling



Number of events	
bbWW	30000
bbττ	9000
WWWW	6000
γγ bb	320
γγγγ	1

also Higgs coupling to DM… + **Surprises-exotics!?**

Luminosity Upgrade – SUSY?



5σ up to ~3TeV squarks

5σ up to ~1.2 TeV stops

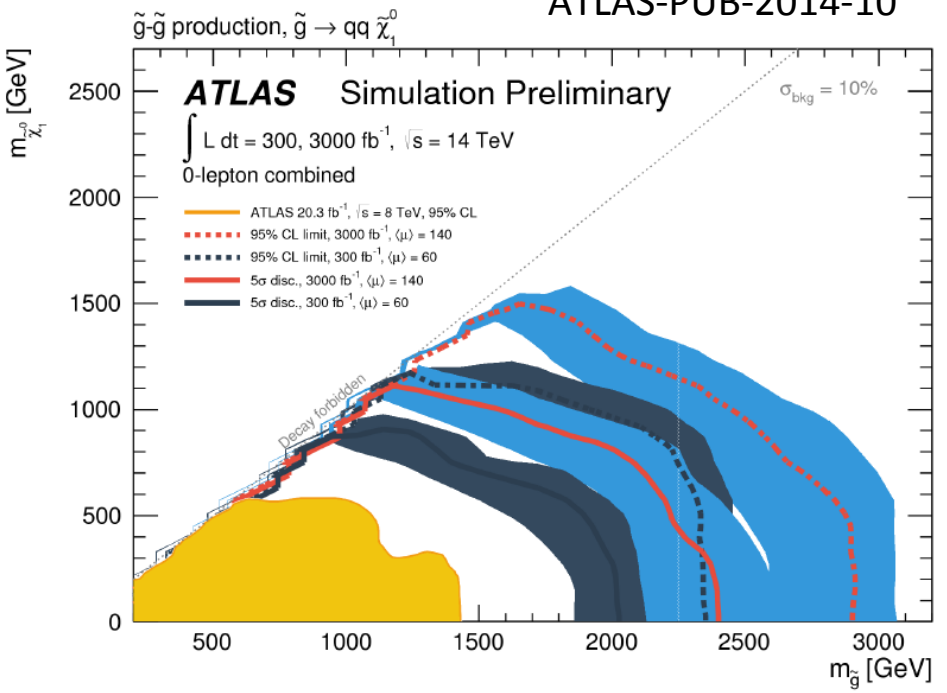
5σ up to ~1.3 TeV sbottoms

@ HL-LHC

5σ up to ~2.5TeV gluinos

@ HL-LHC

ATLAS-PUB-2014-10

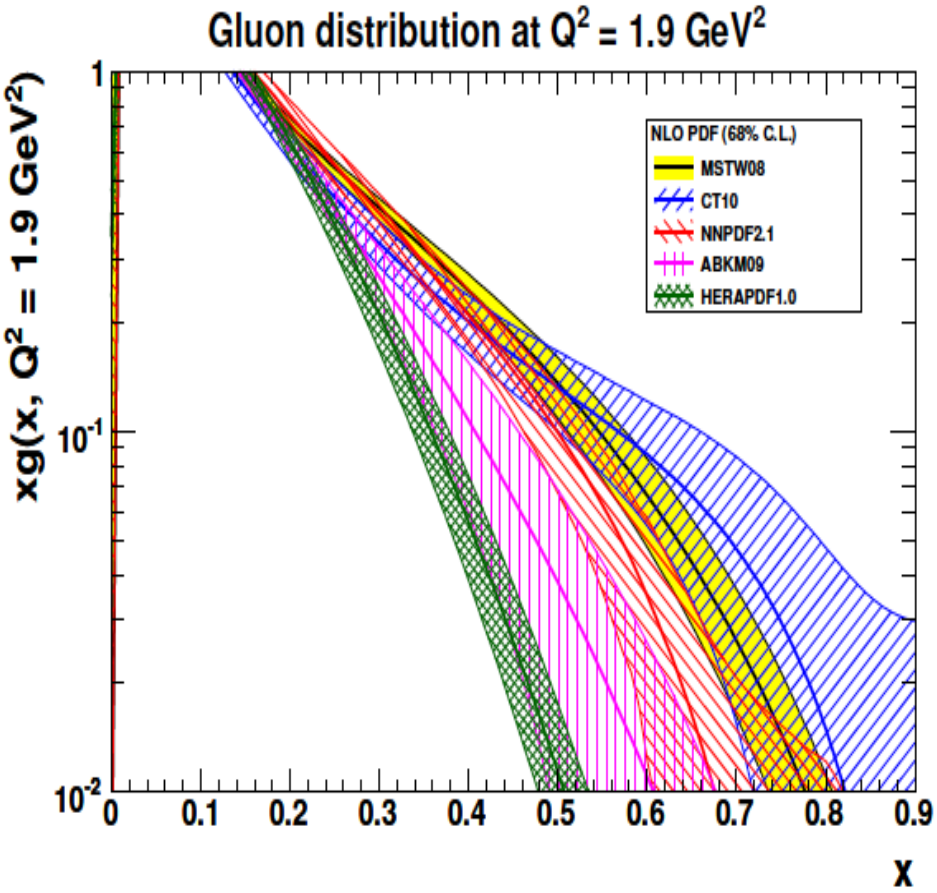


cf Flera Rizatdinova at this workshop

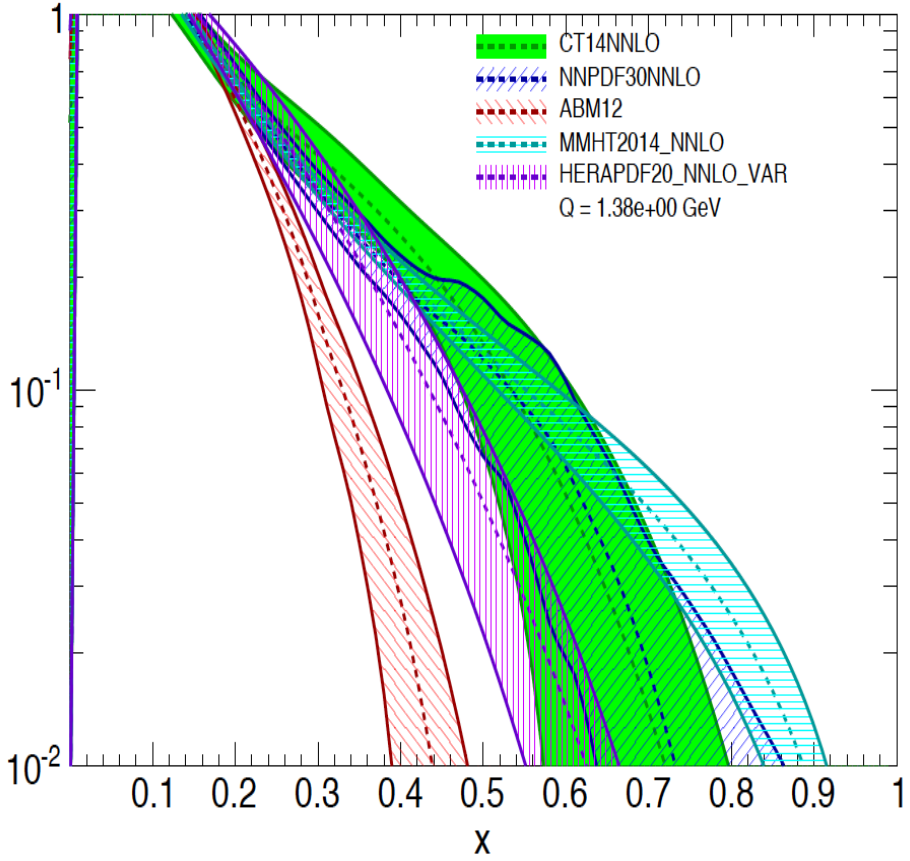
Note that RUN 2 is for 100 fb^{-1} until LS2. Searches need **energy**, clarity and luminosity

Gluon at High x ?

A QCD problem by itself and a key question for searches as luminosity increases …



Gluon prior to LHC data (2011)



Gluon with (first) LHC data (2015)

used by CT14,NNPDF,MMHT

Related to quark distributions, low x, α_s , heavy flavour treatment, to resummation

C.Gwenlan+M.Klein, ATLAS, Lecce 6.10.15

Summary Grant Referee Reports on ATLAS Liverpool

The group certainly belongs to the leading institutes of the ATLAS collaboration. The list of leadership positions in ATLAS taken by group members is very impressive. They have contributed very significantly to many key analyses in the past years. Also, Liverpool is one of the leading international institutes in the operation and for the development and construction of the ATLAS inner tracker. There is no doubt that the group does have the expertise to play again a similar role for the upgraded detector. For instance, the group is leading in the field of sensor development and studies on radiation hardness as well as in hybrid development and mechanics.

The LHC programme, including the high luminosity phase until about 2035, are ranked as highest priority in all international particle physics roadmaps. Most importantly, the update of the European Strategy as approved by CERN Council in 2013 gives the highest priority to the LHC. The LHC programme foresees to increase the number of proton-proton collisions by a factor of about 100 until 2035 and major scientific results are expected from experiments like ATLAS. To fully exploit the scientific potential of the high luminosity LHC replacements and upgrades of several detector components are required.

The proposed project addresses key physics analyses of the LHC run II like Higgs studies, searches for Supersymmetry and for new gauge bosons. It also includes the upgrade of the inner tracker of ATLAS (pixel and strip detectors) which is the central component to be replaced of the detector. The science goals of this project theme are thus of highest importance.

Thanks to ATLAS and to Liverpool for firm support in an outstandingly successful year.

Merry Christmas and a Peaceful, Happy New Year 2016.

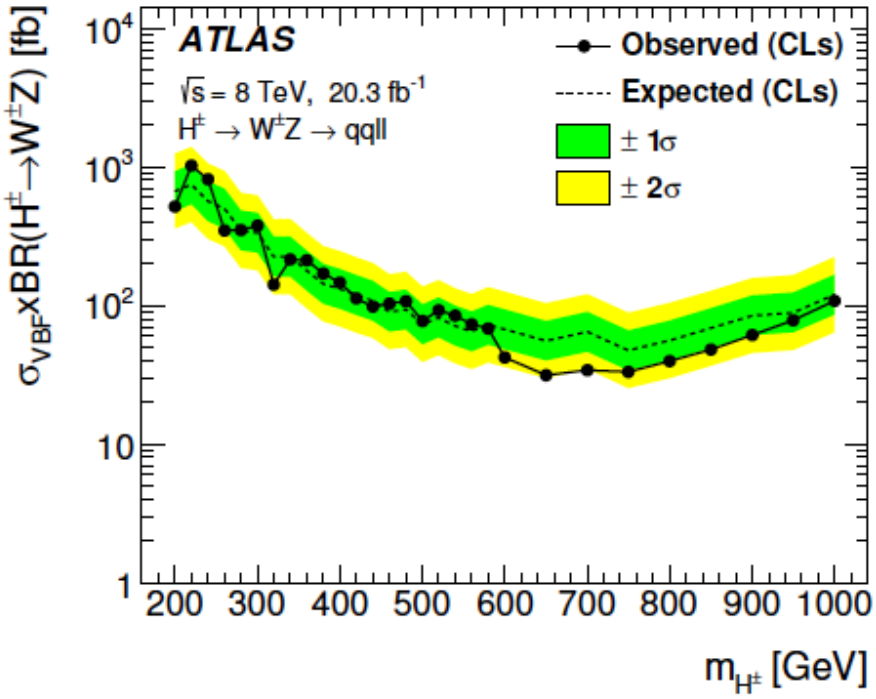
backup

Physics Modeling Group

- Aim to provide harmonic basis for MC samples of all SM and BSM processes used by ATLAS analyses. Several tasks involved, including:
  - Definition of baseline and alternative generators
  - Development of MC tools and optimal set up with theorists and phenomenologists (PDF, tuning, NLO + tools)
  - Theoretical modeling uncertainties and high order cross section calculations
- 3 sub-groups focusing on MC performance, MC tuning and MC validation
- For 13 TeV analyses, the MC15 campaign led to production of > 4B simulated events covering all relevant processes and offering alternatives and wide kinematic coverage
  - Huge improvement with respect to Run 1, which facilitate the tasks of physics analyses hence our capability to discover new physics and perform precision measurements
- Currently organizing an ATLAS/CMS/LPCC international workshop at CERN: 11-12 January.
- The group is therefore preparing 5 public documents with studies and results to be presented and discussed with experimentalists and theorists.
- Few examples:

Search for a Charged Higgs Boson Produced in the Vector-boson Fusion Mode with Decay $H^{\pm} \rightarrow W^{\pm}Z$ using pp Collisions at $\sqrt{s} = 8$ TeV with the ATLAS Experiment

arXiv:1503.04233



Andy+Carl

Figure 2: Exclusion limits in fb at the 95% CL for the vector-boson fusion production cross section of a $H^{\pm}$ boson times its branching fraction to $W^{\pm}Z$ assuming the signal has a narrow intrinsic width. Also included on the plot are the median, $\pm 1\sigma$ and $\pm 2\sigma$ values within which the limit is expected to lie in the absence of a signal.

We often hear the statement that all the relevant info on pdf's can directly be obtained from the LHC without need of the LHeC

Not really true. Certainly not at the same level of precision
One example:

The factorization "theorem" is essential.
Not fully proved theoretically (beware of non pert. effects)
[nearly complete arguments only for Drell-Yan & similar]
Should finally be experimentally tested with precision

$$\sigma(s) = \sum_{A,B} \int \frac{dx_1}{x_1} \frac{dx_2}{x_2} p_A(x_1, Q^2) p_B(x_2, Q^2) \hat{\sigma}_{AB}(x_1 x_2 s, Q^2)$$

x times density of parton A

reduced X-section

One way: precisely measure gluons and quarks at large x in DIS, evolve in Q^2, and predict the jet rates at large p_T at the LHC

Guido Altarelli, https://indico.cern.ch/event/356714/ opening of the LHeC workshop 24/6/2015

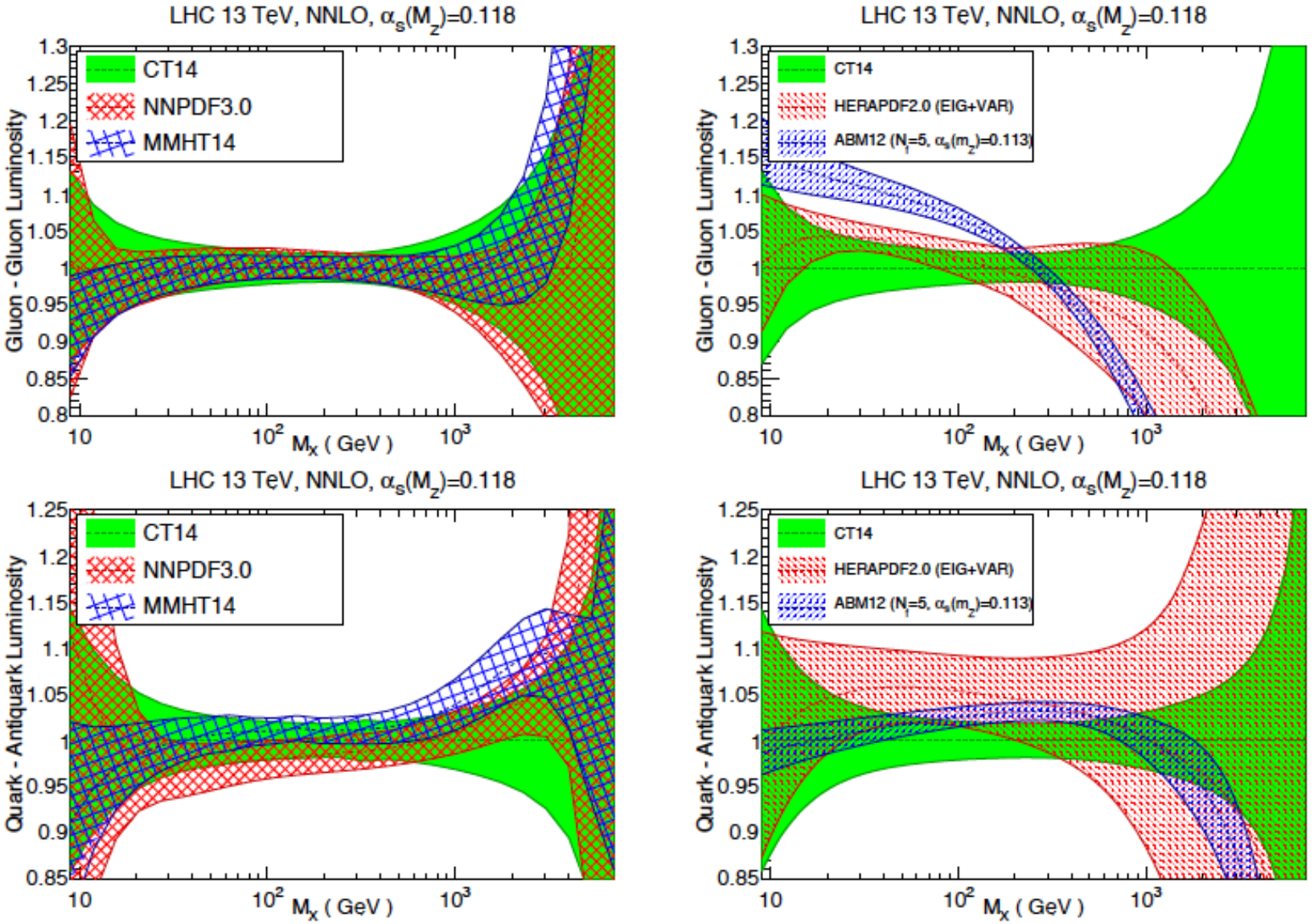
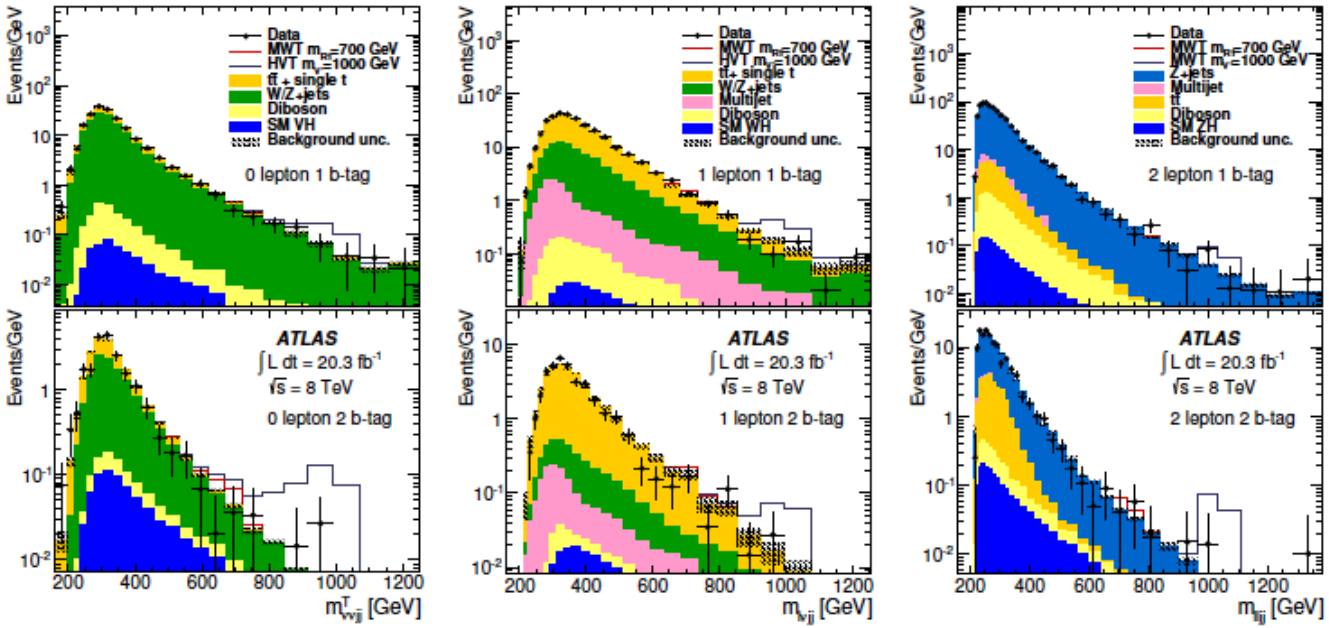


Figure 5: Comparison of the gluon-gluon (upper plots) and quark-antiquark (lower plots) PDF luminosities from the CT14, MMHT14 and NNNPDF3.0 NNLO sets (left plots) and from the NNPDF3.0, ABM12 and HERAPDF2.0 NNLO sets (right plots), for a center-of-mass energy of 13 TeV, as a function of the invariant mass of the final state M_X.

Search for a new resonance decaying to a W or Z boson and a Higgs boson in the $\ell\ell/\ell\nu/\nu\nu + b\bar{b}$ final states with the ATLAS Detector

arXiv:1503.08089



(a) $\nu\nu b\bar{b}$ (b) $\ell\nu b\bar{b}$ (c) $\ell\ell b\bar{b}$

Figure 1: Distributions of the reconstructed (a) transverse mass $m^{\mathrm{T}}_{\nu\nu jj}$ for the $\nu\nu b\bar{b}$ final state, (b) invariant mass $m_{\ell\nu jj}$ for the $\ell\nu b\bar{b}$ final state and (c) invariant mass $m_{\ell\ell jj}$ for the $\ell\ell b\bar{b}$ final state for the 1-b-tag (upper) and 2-b-tag (lower) channels. The background expectation is shown after the profile likelihood fit to the data. Any overflow is included in the last bin. The signals are shown stacked on top of the background and correspond to the benchmark models MWT with $m_{R1} = 700$ GeV and HVT with $m_{V'} = 1000$ GeV normalized to the expected cross sections.

Andy+Carl

Milestones Strips (KE)

R&D Milestones (Strips):

- Management Review of progress towards TDR: Nov 2015
- Finalize sensor design (critical for procurement): Mar 2016
- Final prototype of FE chip and Controller chip: Mar 2016
- Design of hybrids for interconnections on staves and petals: Mar 2016
- LV/HV powering systems and re-use of external services: May 2016

Major Decision Points (Strips):

- ITk Layout baseline decision: Jun 2016

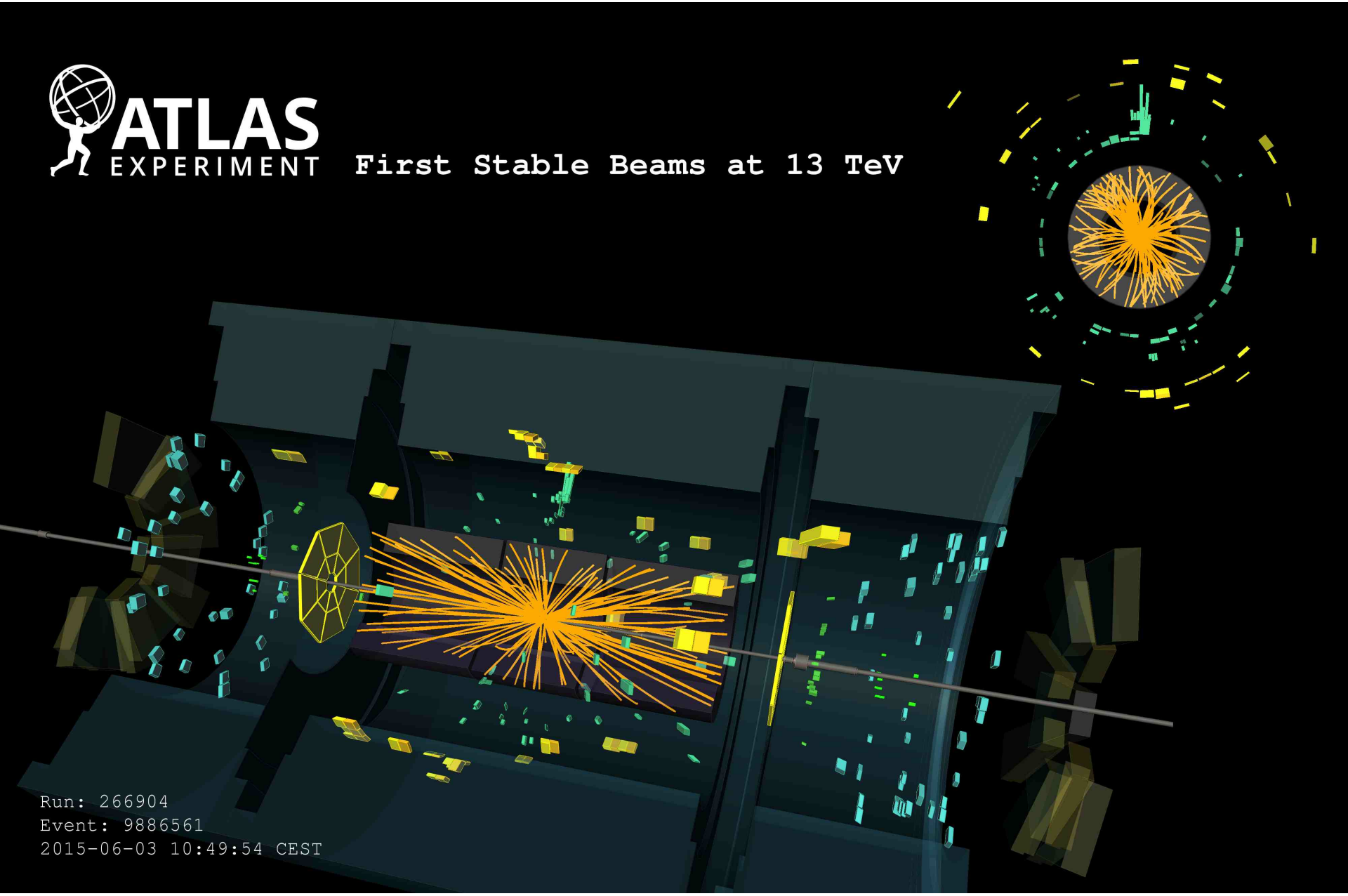
Milestones Pixels (KE)

R&D Milestones (Pixels):

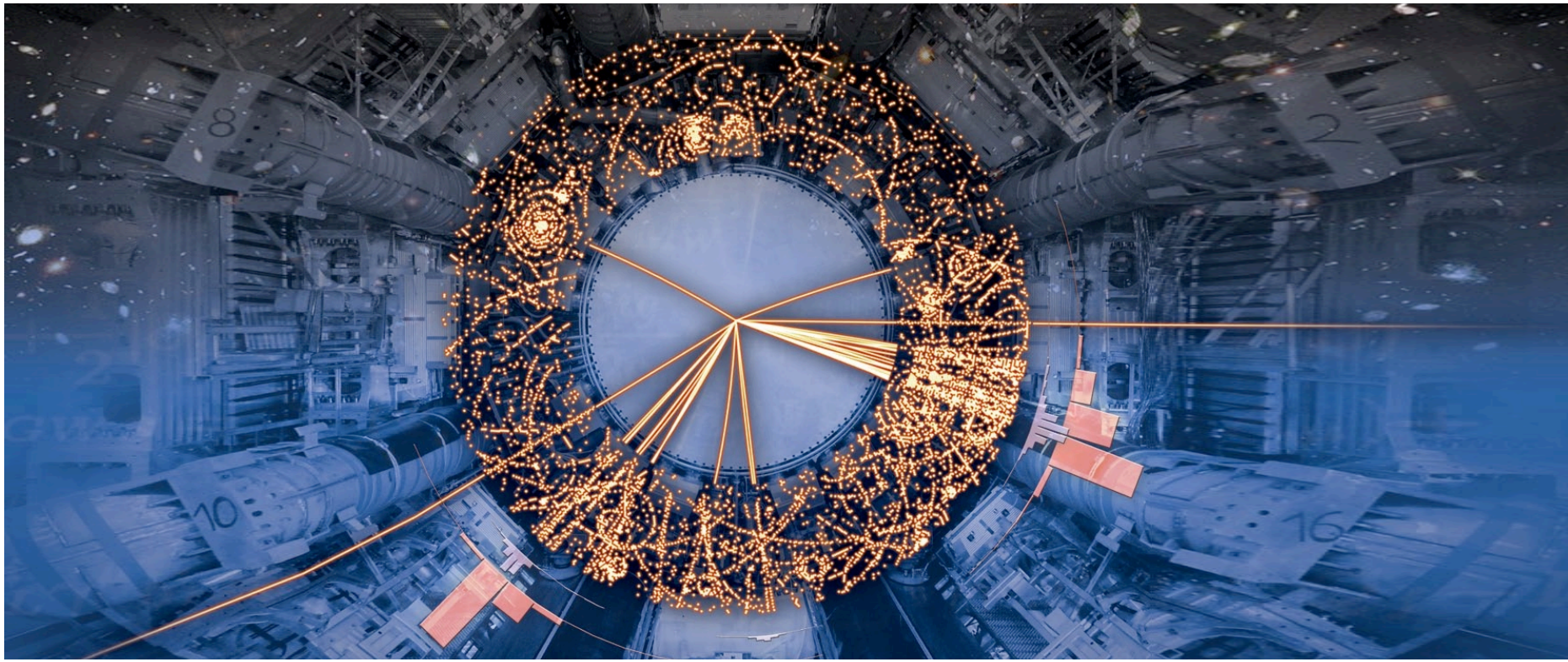
- First prototype of FE chip with most capabilities: Dec 2016
- Qualify LV/HV system and data transmission cables: Dec 2016
- Finalize sensor design (qualified): Mar 2017
- Vendor qualification for bump-bonding of 3 vendors: Mar 2017

Major Decision Points (Pixels):

- ITk Layout decision through Layout TF: Jun 2016
- Decision to use CMOS sensors or stay with current baseline: Dec 2016


ATLAS
EXPERIMENT
First Stable Beams at 13 TeV
Run: 266904
Event: 9886561
2015-06-03 10:49:54 CEST

ATLAS near Christmas 2015



LHC
ATLAS Collaboration
Group Matters
Run 2 and HL-LHC

+

Paul: ATLAS 2015
Helen: Results 15
Tony: Upgrade

Max Klein - for the ATLAS Group - Liverpool 15.12.2014