ATLAS: Physics Results, Performance and Prospects

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Kick-off meeting Indo-French Collaboration

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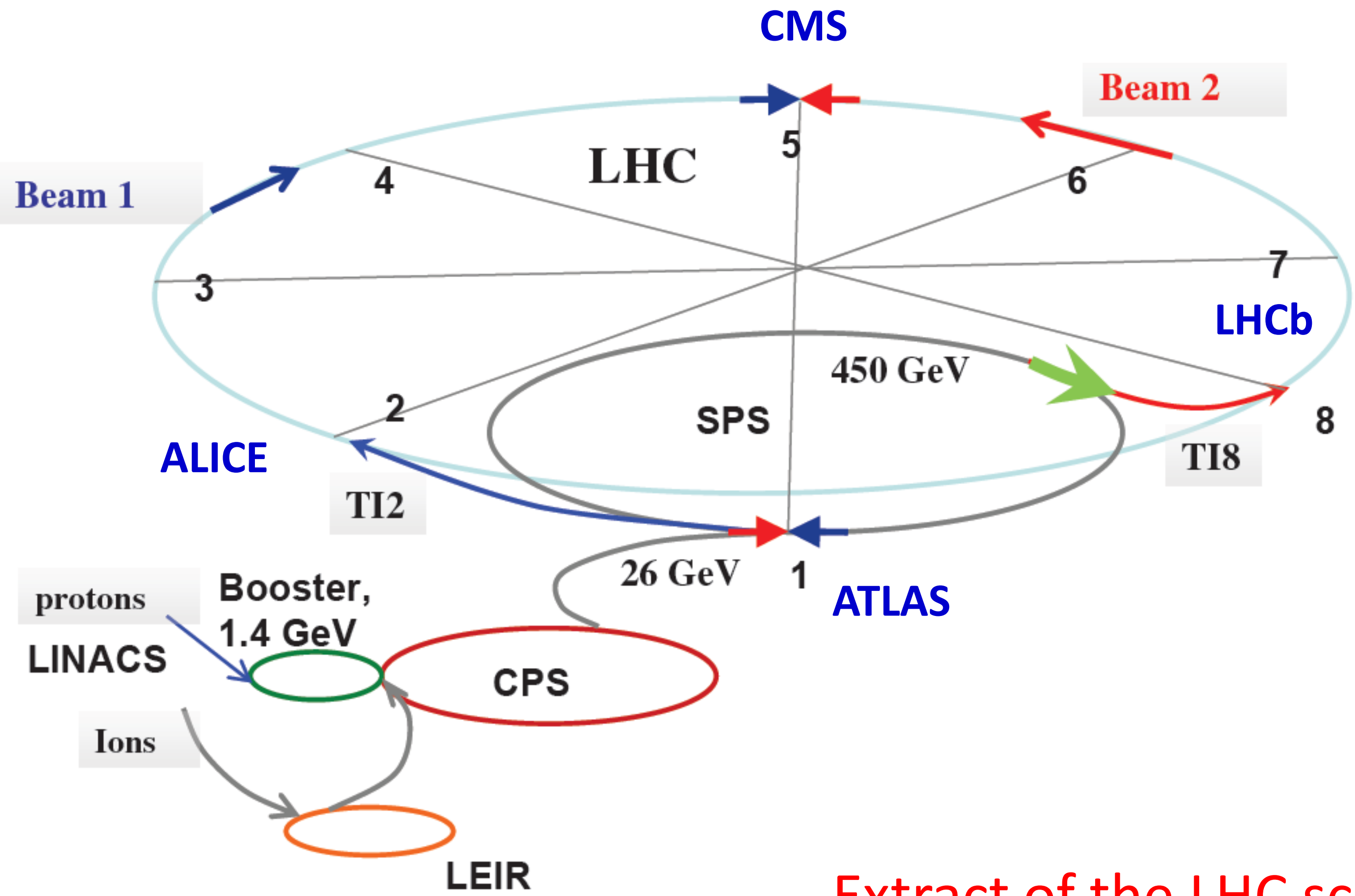
Outline

- The Large Hadron Collider
- The ATLAS Detector & Performance
- ATLAS Physics results
  - Higgs physics
  - Non-Higgs Standard Model (SM) physics
  - Searches for phenomena beyond SM

The Large Hadron Collider (LHC)

CERN accelerator complex



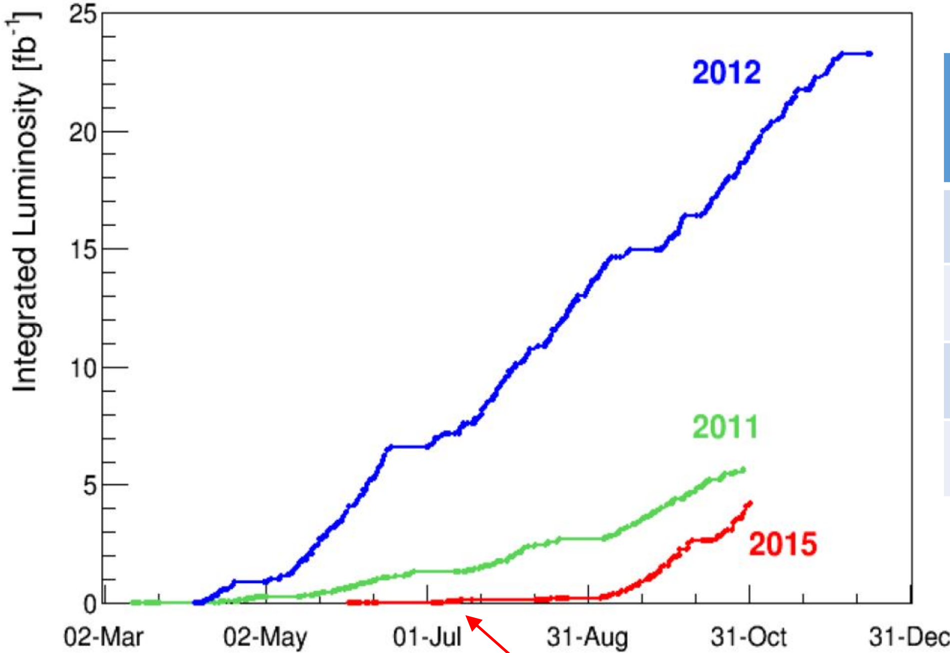
LHC Design:

- Centre-of-mass energy (√s) of proton-proton collisions 14TeV
- Peak luminosity 10^{34} $cm^{-2}s^{-1}$
- Collisions each 25ns (2808 bunches)
- Pile-up 25 events

Use Nb-Ti dipoles @ 1.4 K (B filed 8.3T) in 27km tunnel

Extract of the LHC schedule

LHC Run 2: 2015

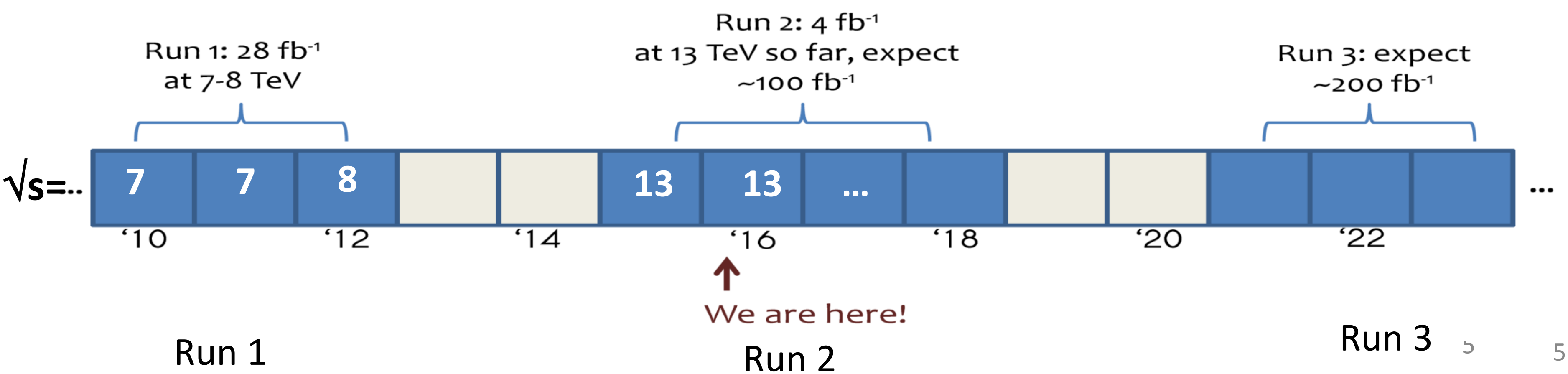


Year	Peak Lumi $10^{33}cm^{-2}s^{-1}$	Bunch Spacing	Pile-up*	Lumi [fb^{-1}]
2011	0.37	50	9	5
2012	0.77	50	23	23
2015	0.5	25	14	4
2016*	~1	25	43	25

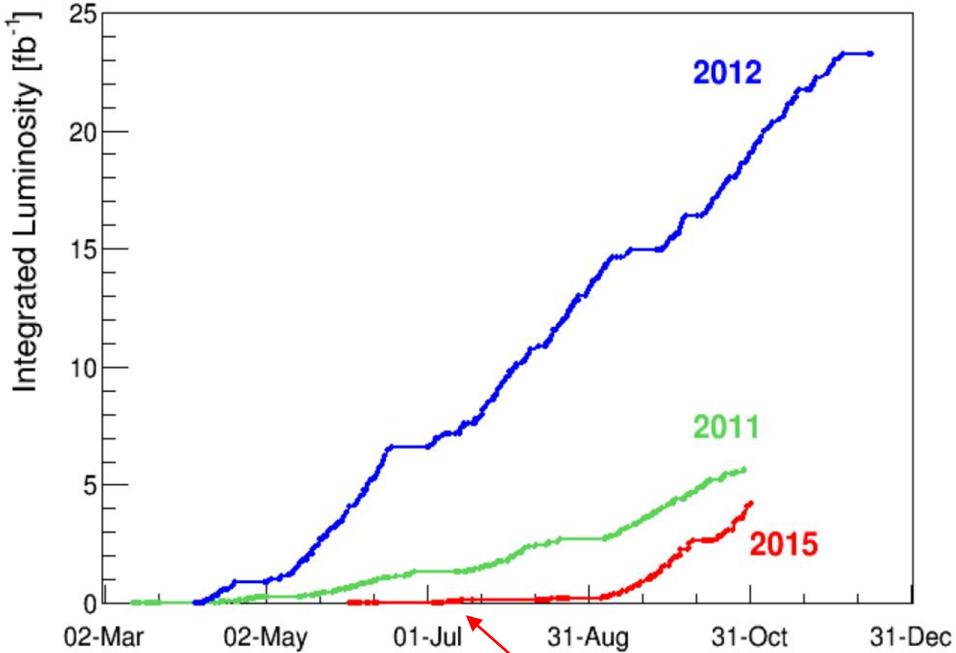
*expected values

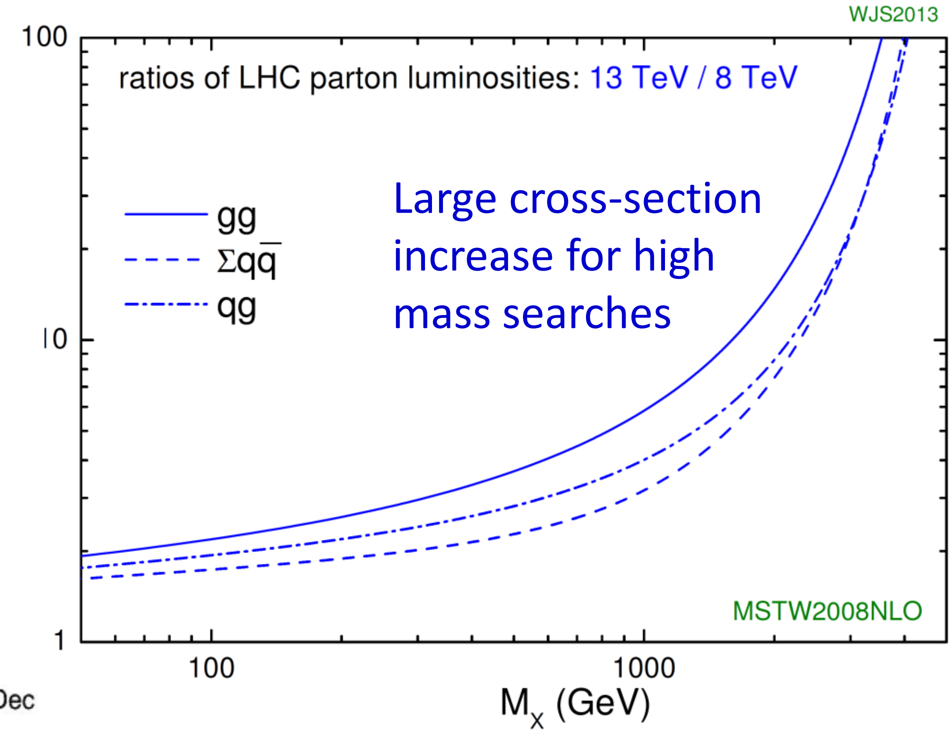
Problems with radiation resistance of tunnel quench protection system lead to slow start.

Extract of the LHC schedule



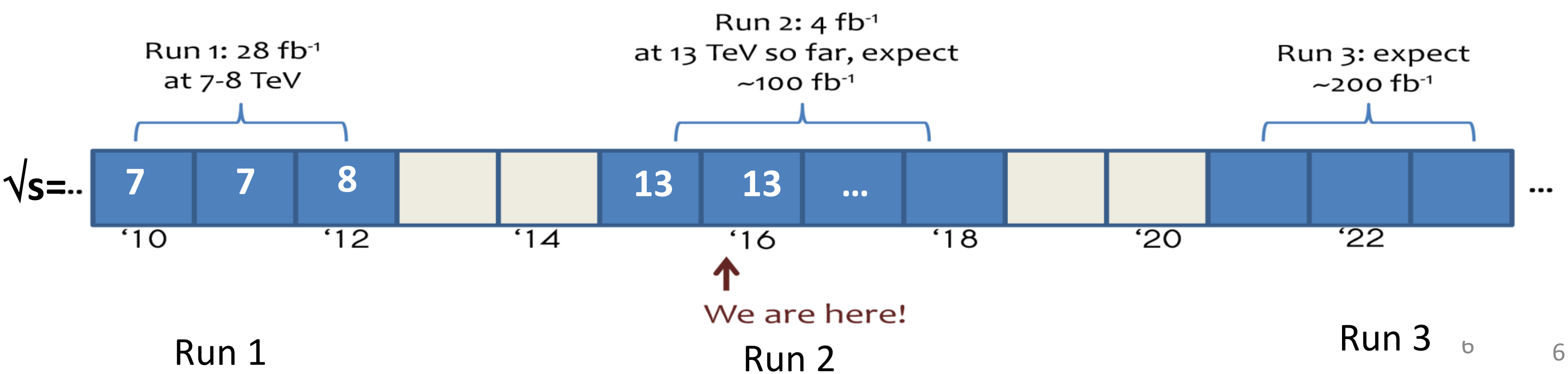
LHC Run 2: 2015

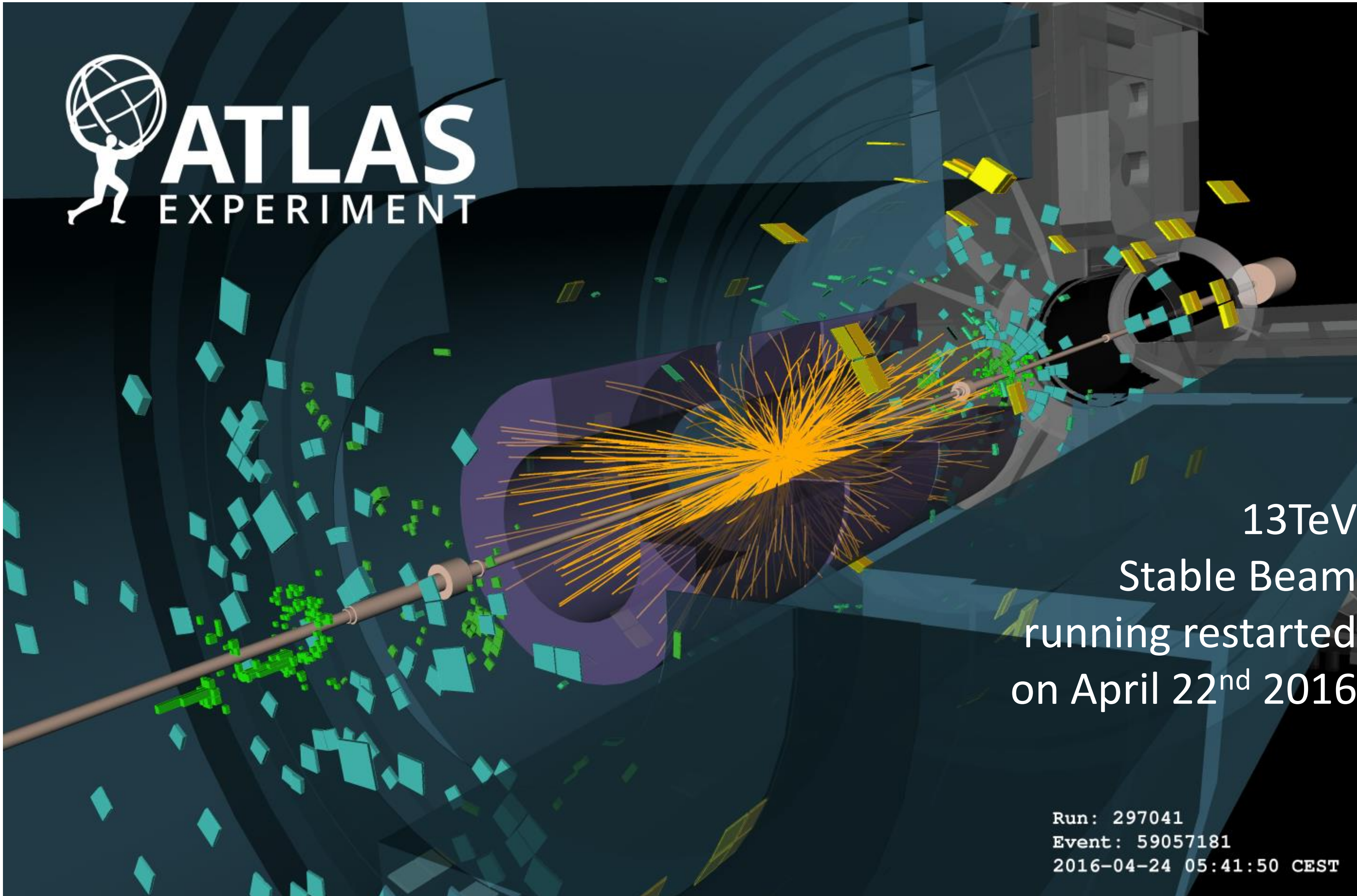


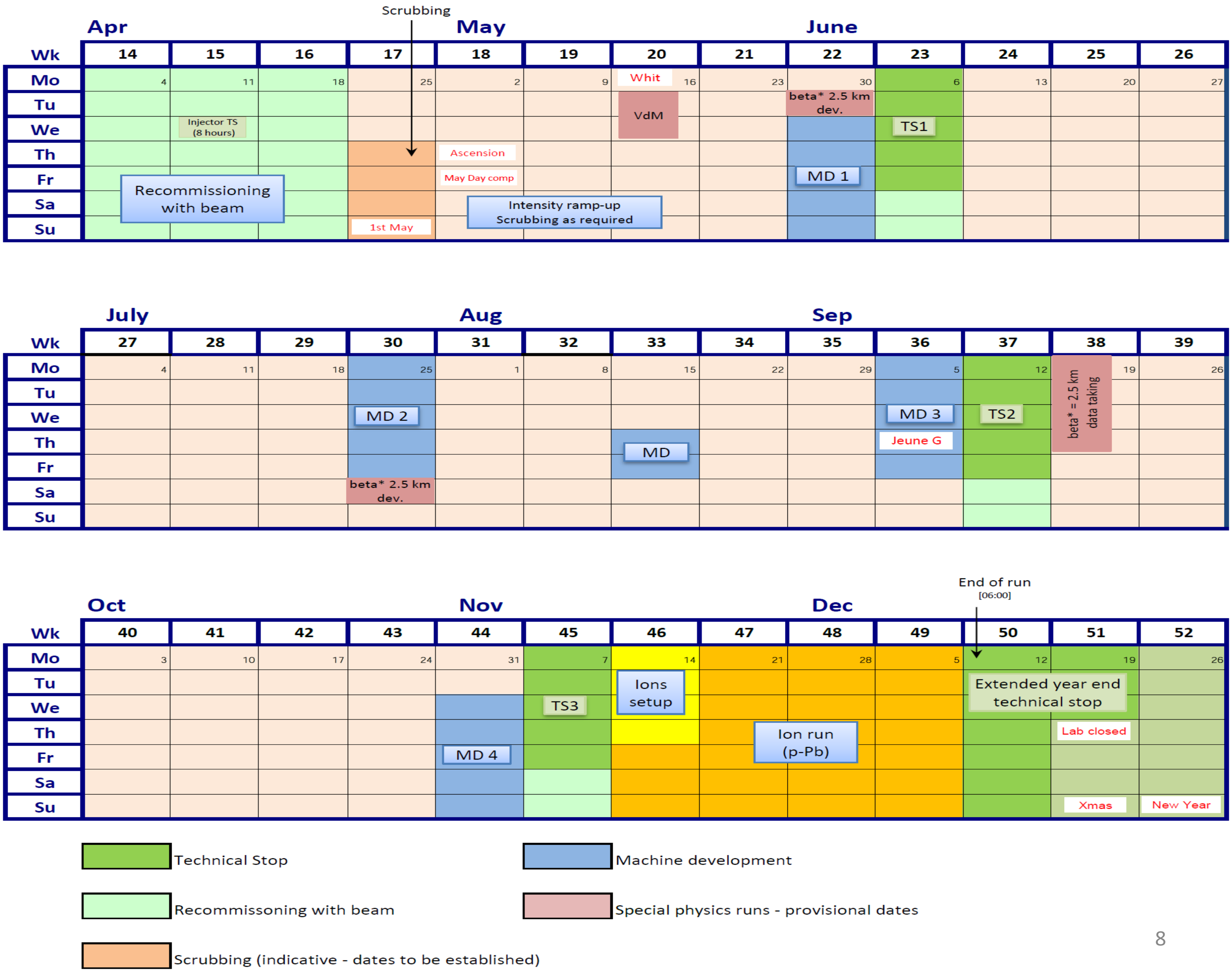


Problems with radiation resistance of tunnel quench protection system lead to slow start.

Extract of the LHC schedule




ATLAS
EXPERIMENT
13TeV
Stable Beam
running restarted
on April 22nd 2016
Run: 297041
Event: 59057181
2016-04-24 05:41:50 CEST


Scrubbing
Apr
May
June
Wk
14
15
16
17
18
19
20
21
22
23
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25
26
Mo
Tu
We
Th
Fr
Sa
Su
4
11
18
25
2
9
16
23
30
6
13
20
27
Whit
beta* 2.5 km dev.
VdM
Injector TS (8 hours)
TS1
Ascension
MD 1
May Day comp
Recommissioning with beam
Intensity ramp-up Scrubbing as required
1st May
July
Aug
Sep
27
28
29
30
31
32
33
34
35
36
37
38
39
4
11
18
25
1
8
15
22
29
5
12
19
26
MD 2
MD 3
TS2
beta* = 2.5 km data taking
Jeune G
MD
beta* 2.5 km dev.
End of run [06:00]
Oct
Nov
Dec
40
41
42
43
44
45
46
47
48
49
50
51
52
3
10
17
24
31
7
14
21
28
5
12
19
26
Ions setup
Extended year end technical stop
TS3
Ion run (p-Pb)
Lab closed
MD 4
Xmas
New Year
Technical Stop
Machine development
Recommissoning with beam
Special physics runs - provisional dates
Scrubbing (indicative - dates to be established)

Weasel

Wk	14	15	16	17	18	19	20	21	22	23	24	25	26
	Apr				**May**				**June**				
Mo	4	11	18	25	2	9	Whit 16	23	30 beta* 2.5 km dev.	6	13	20	27
Tu							VdM		beta* 2.5 km dev.				
We		Injector TS (8 hours)					VdM			TS1			
Th					Ascension								
Fr	Recommissioning with beam	Recommissioning with beam	Recommissioning with beam		May Day comp				MD 1				
Sa	Recommissioning with beam	Recommissioning with beam	Recommissioning with beam		Intensity ramp-up Scrubbing as required	Intensity ramp-up Scrubbing as required	Intensity ramp-up Scrubbing as required						
Su													

Wk	27	28	29	30	31	32	33	34	35	36	37	38	39
	July				**Aug**				**Sep**				
Mo	4	11	18	25	1	8	15	22	29	5	12	19 beta* = 2.5 km data taking	26
Tu													
We				MD 2						MD 3	TS2		
Th							MD			Jeune G			
Fr													
Sa				beta* 2.5 km dev.									
Su													

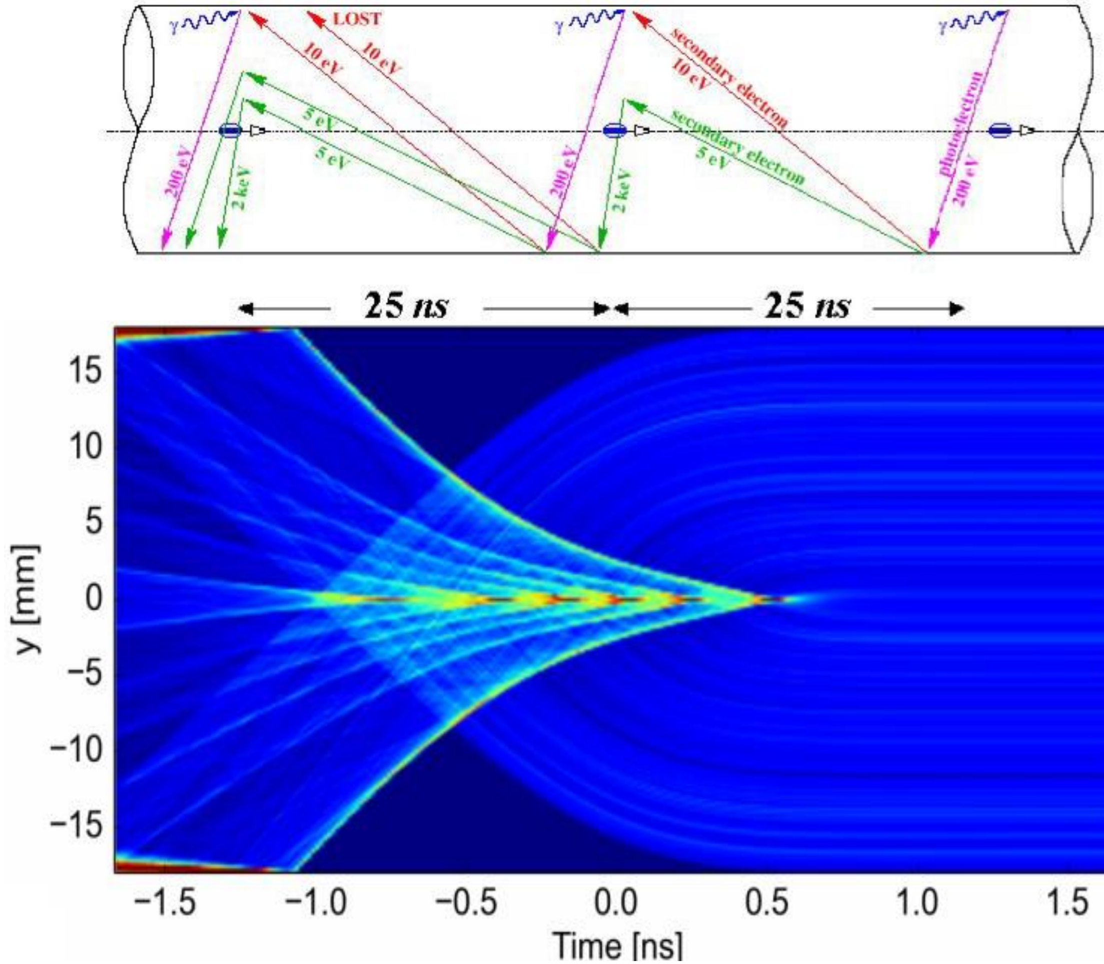
End of run [06:00]

Wk	40	41	42	43	44	45	46	47	48	49	50	51	52
	Oct				**Nov**				**Dec**				
Mo	3	10	17	24	31	7	14	21	28	5	12	19	26
Tu							Ions setup				Extended year end technical stop	Extended year end technical stop	
We						TS3							
Th								Ion run (p-Pb)	Ion run (p-Pb)			Lab closed	
Fr					MD 4								
Sa													
Su												Xmas	New Year

- Technical Stop
- Machine development
- Recommissoning with beam
- Special physics runs - provisional dates
- Scrubbing (indicative - dates to be established)

Run 2 LHC (cont)

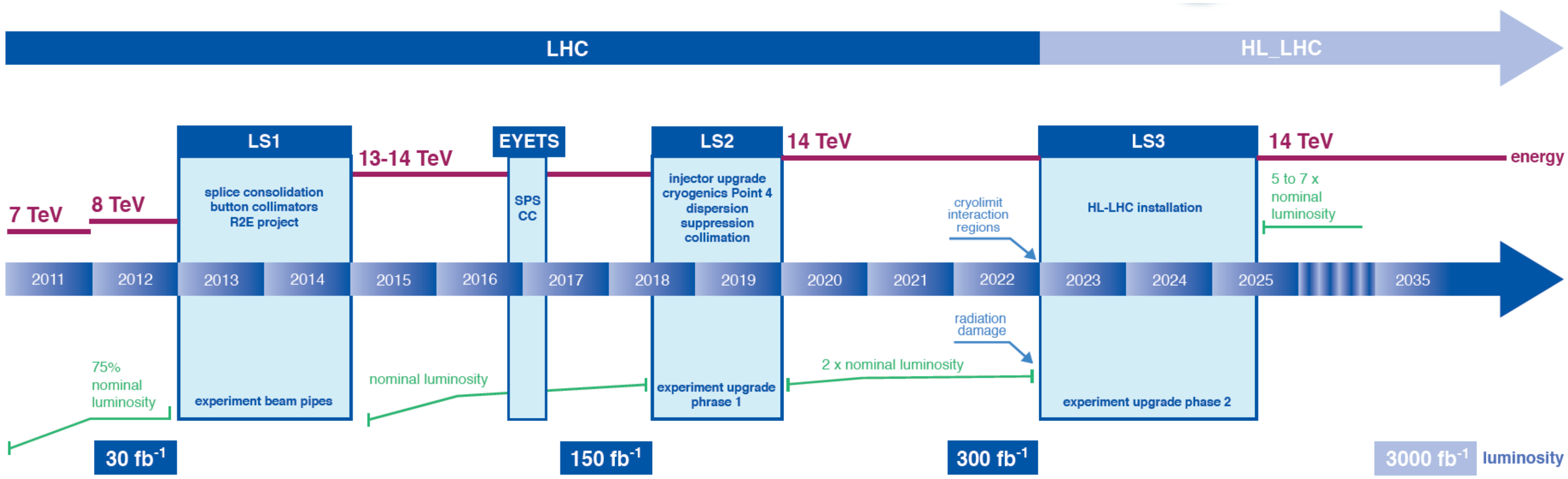
- Electron cloud effects reduce with data-taking and scrubbing (running high number of bunches at low energy)
- To be able to increase energy to 14TeV magnets need to undergo a certain number of quenches which happen during data-taking



Extract of the LHC schedule

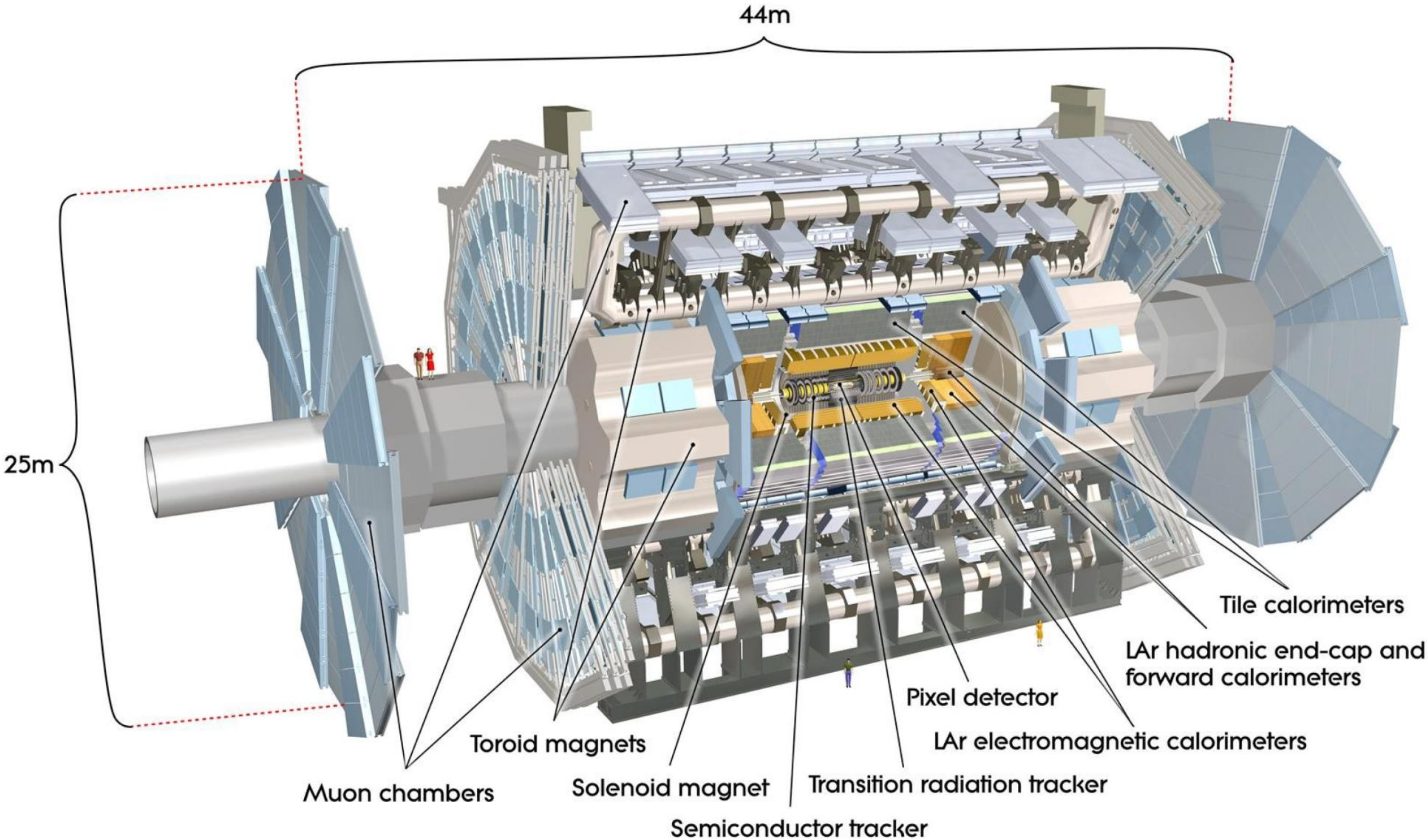
http://home.web.cern.ch/fr/about/updates/2015/06/chasing-clouds-lhc

LHC beyond Run 2



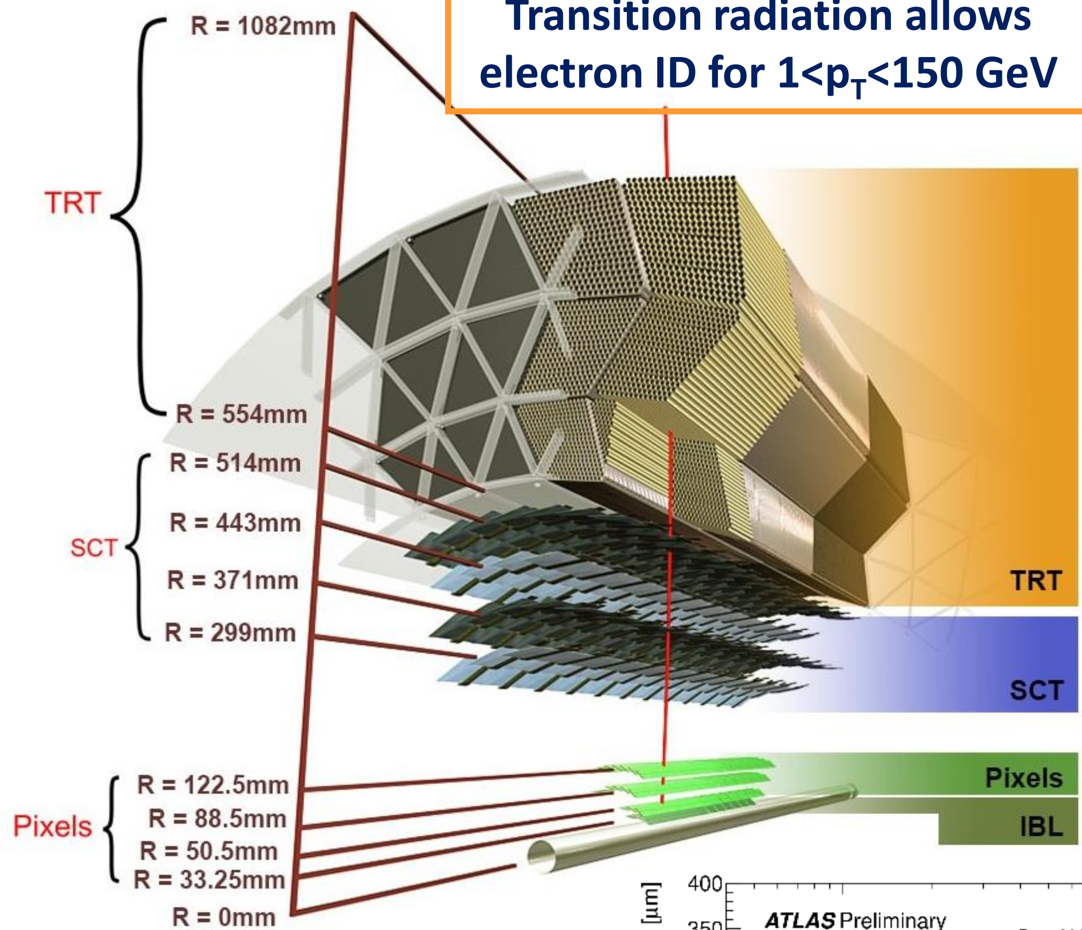
- 100 fb^{-1} in the end of Run 2 (2018)
- 300 fb^{-1} in the end of Run 3 (2023)
- 3000 fb^{-1} in the end of the LHC program (~2037)

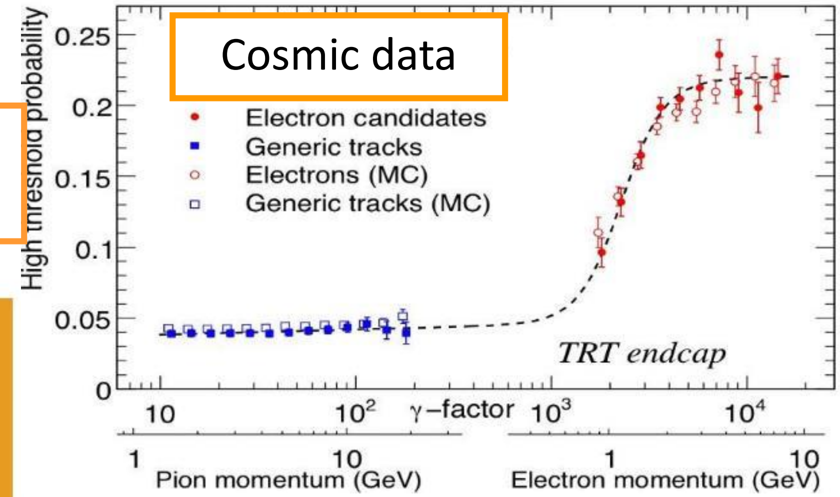
The ATLAS Detector & Performance



Inner Detector

Transition radiation allows electron ID for $1<p_T<150$ GeV



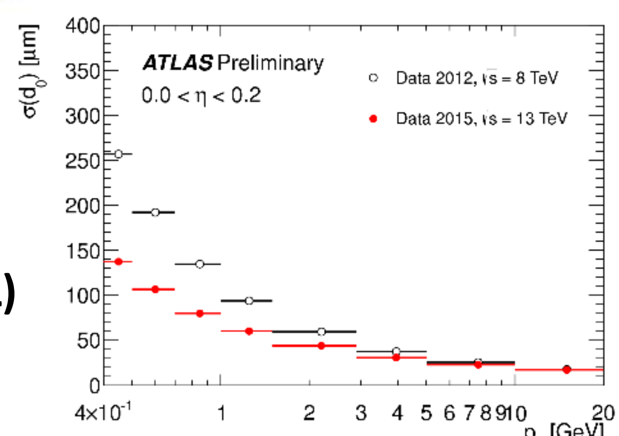


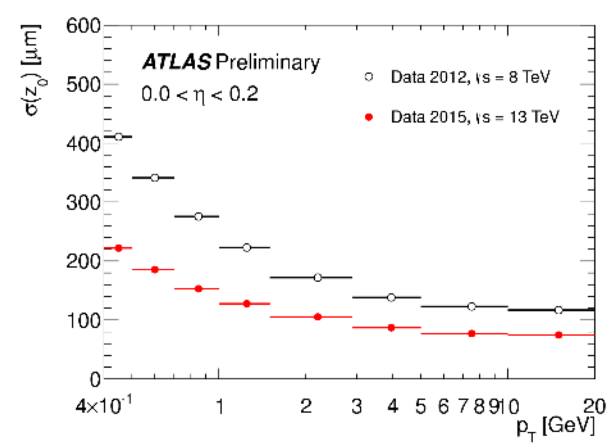
Transition Radiation Tracker (TRT): drift tubes with gas (Xe or Kr), 350 k channels, 36 measurement points

Semiconductor Tracker (SCT) Silicon, 6.2 M channels, 4 layers

Pixel Detector: Silicon, 92 M channels, 4 layers

Impact parameter resolution improvement due to Insertable B-Layer (IBL) added for Run 2





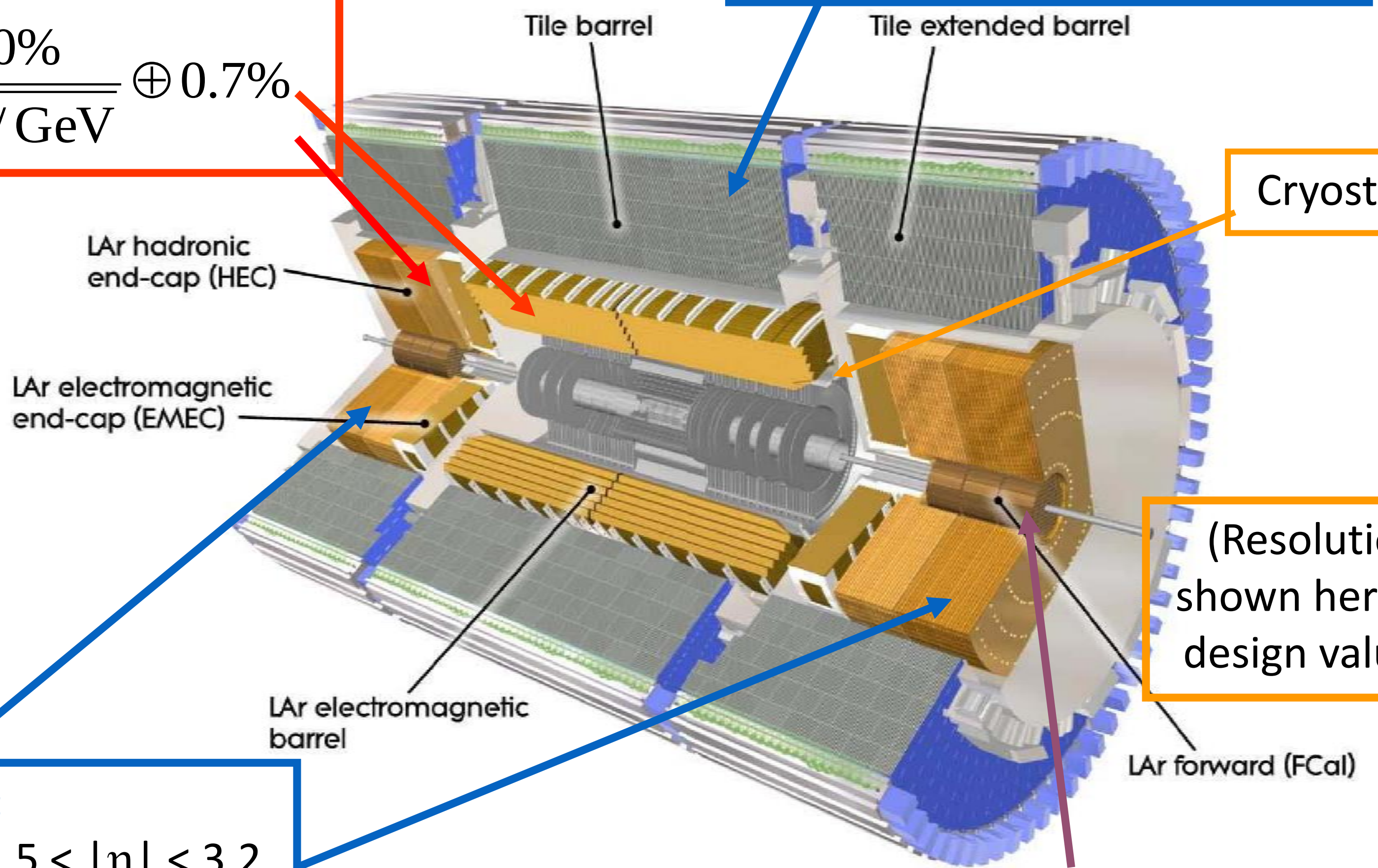
ATLAS Calorimeters

Hadronic Barrel :
Scintillator/Fe, |η| < 1.7

$$\left.\frac{\sigma(E)}{E}\right|_{Jet} \cong \frac{50\%}{\sqrt{E/\mathrm{GeV}}} \oplus 3\%$$

EM Calorimetry :
Liquid-Argon/Pb accordeon, |η|<3.2

$$\left.\frac{\sigma(E)}{E}\right|_{e/\gamma} \cong \frac{10\%}{\sqrt{E/\mathrm{GeV}}} \oplus 0.7\%$$



Cryostat

(Resolutions shown here are design values.)

Hadronic End-cap:
Liquid Argon/Cu, 1.5 < |η| < 3.2

$$\left.\frac{\sigma(E)}{E}\right|_{Jet} \cong \frac{50\%}{\sqrt{E/\mathrm{GeV}}} \oplus 3\%$$

Forward Calorimeters:
Liquid Argon/Cu/W,
3.1 < |η| < 4.9

$$\left.\sigma(E)/E\right|_{Jet} \cong \frac{100\%}{\sqrt{E/\mathrm{GeV}}} \oplus 10\%$$

Electron and photon identification (ID)

Electron ID

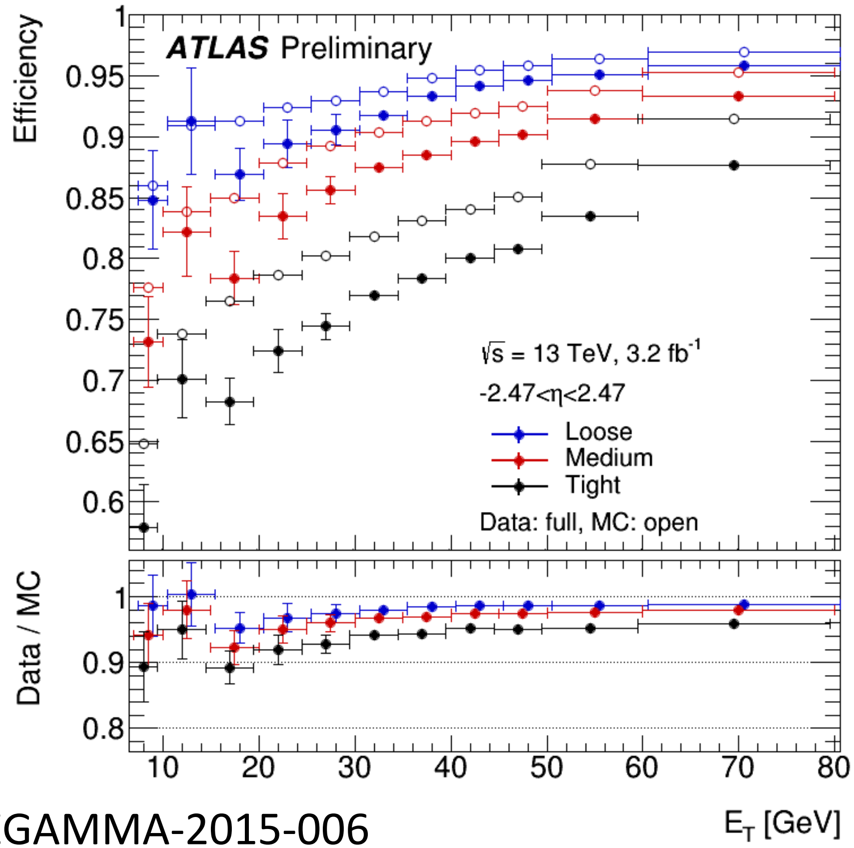
Likelihood identification improves background rejection wrt cut-based by 50% for the same efficiency

Inputs: calorimeter shower shapers, tracking and track-cluster matching, TRT PID

Photon ID

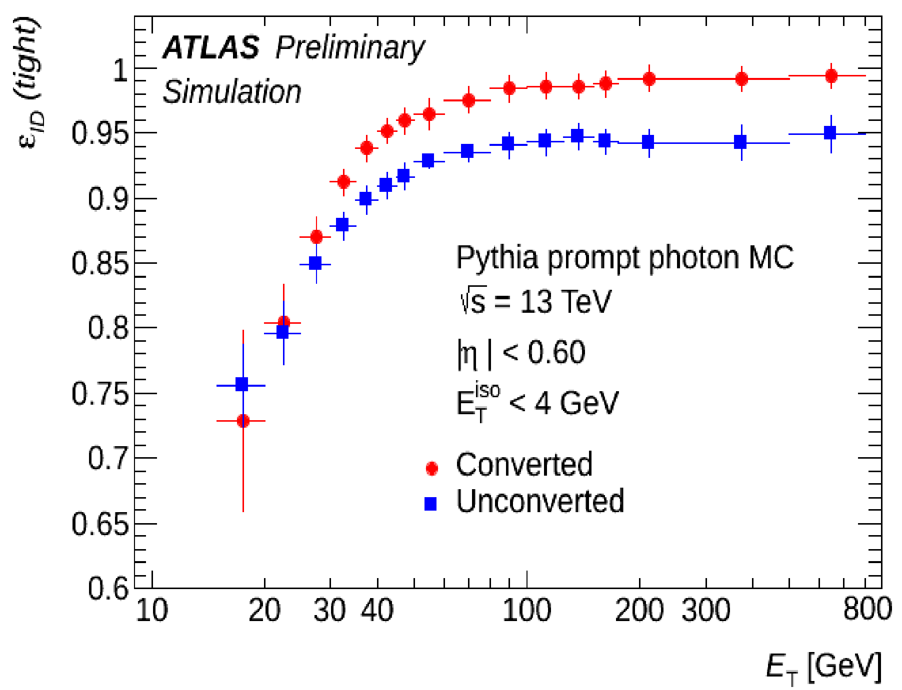
Using *cut-based selection*

Inputs: calorimeter shower shapers for unconverted photons; add tracking and track-cluster matching for converted photons



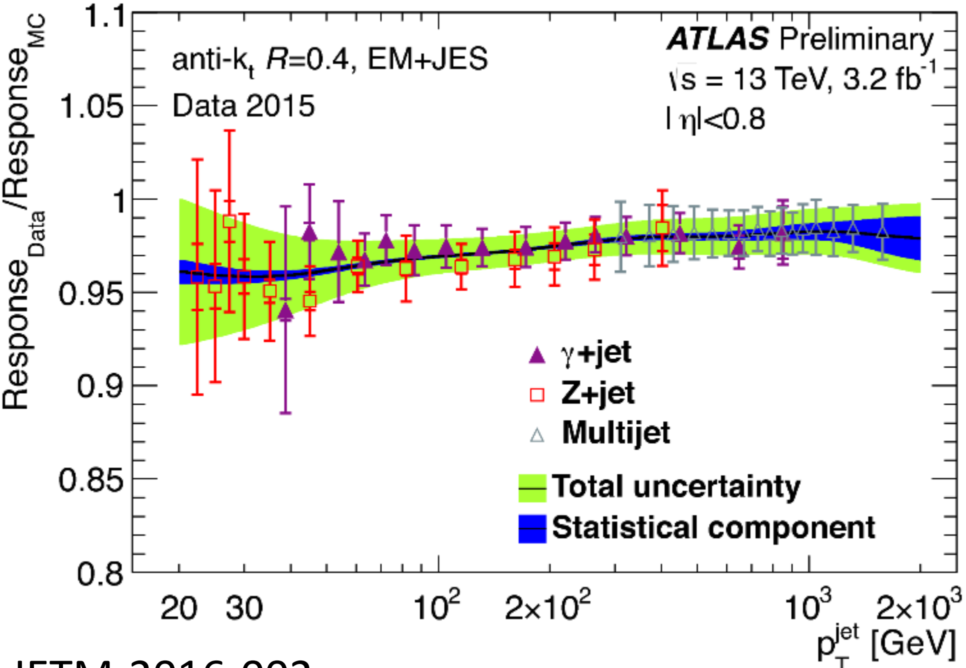
EGAMMA-2015-006

EGAMMA-2015-002



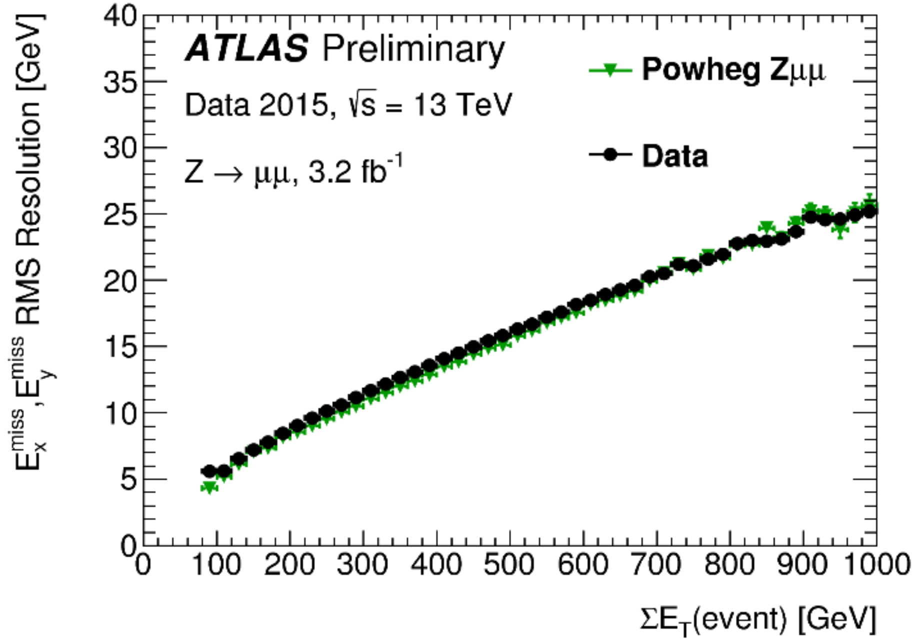
Jets and E_T^{Miss} reconstruction

In-situ energy scale correction



JETM-2016-002

E_T^{Miss} resolution



JETM-2016-006

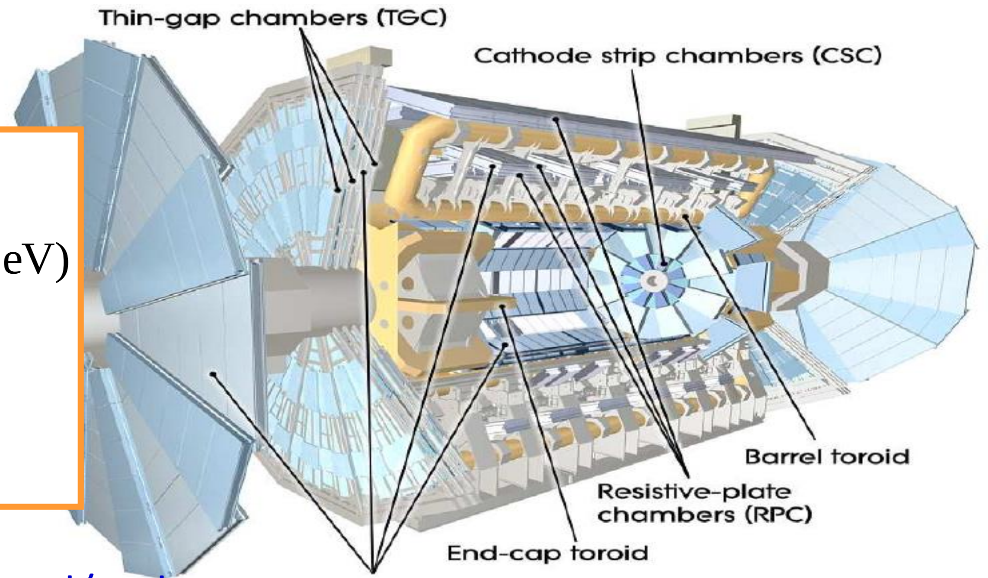
Jet energy scale and resolution extracted from data

E_T^{Miss} uncertainties extracted from data

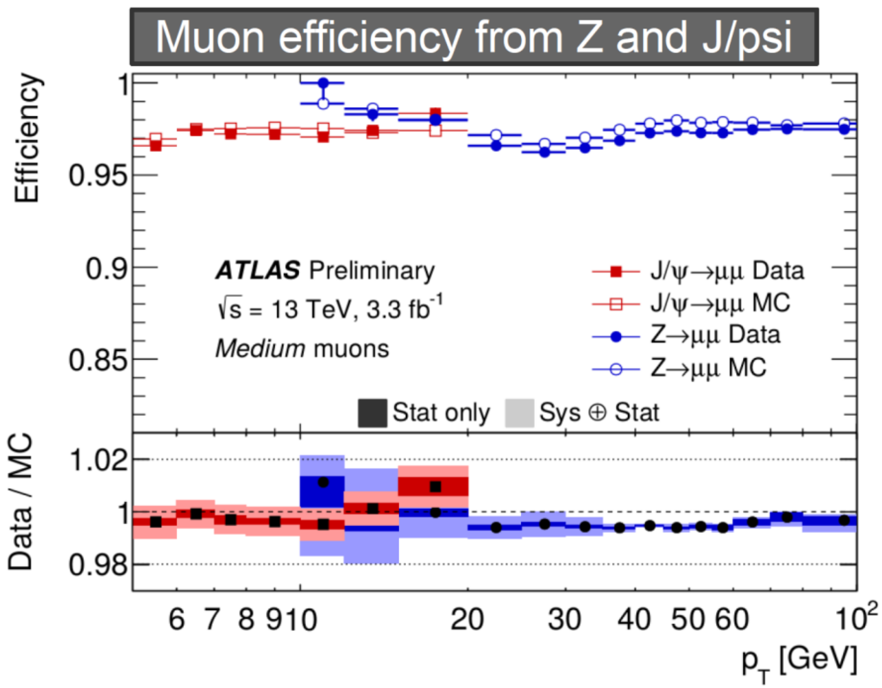
Muon Spectrometer

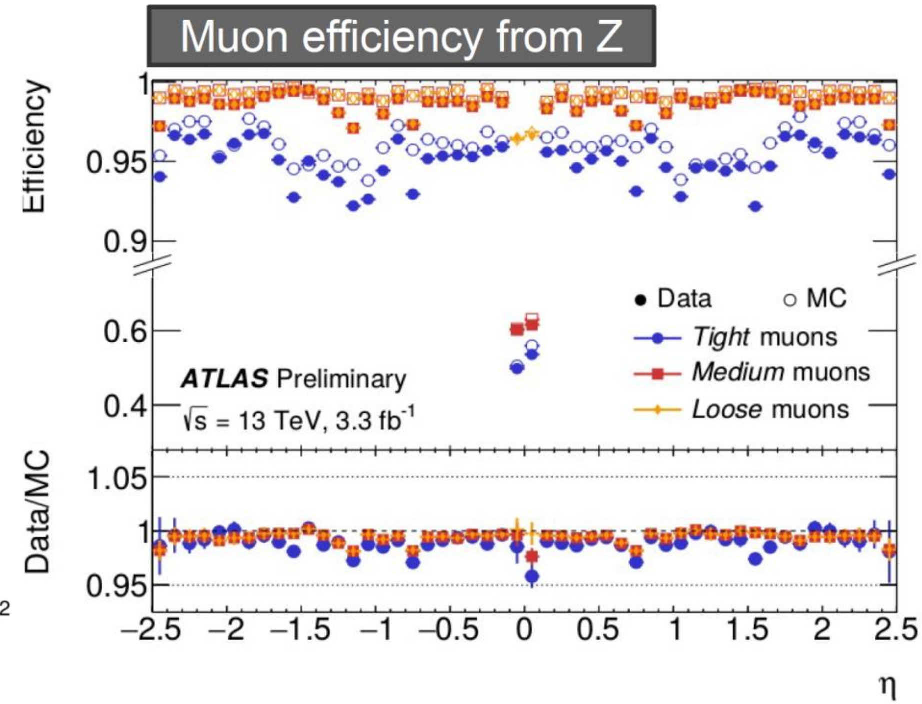
Muon Spectrometer : $|\eta| < 2.7$

- Standalone: $\left.\frac{\sigma(p)}{p}\right|_{\mu} \cong 3\%(100\,\mathrm{GeV}) - 10\%(1\,\mathrm{TeV})$
- Combined with inner tracker: $\left.\frac{\sigma(p)}{p}\right|_{\mu} \cong 2\% \;\; (p_T < 50\,\mathrm{GeV})$



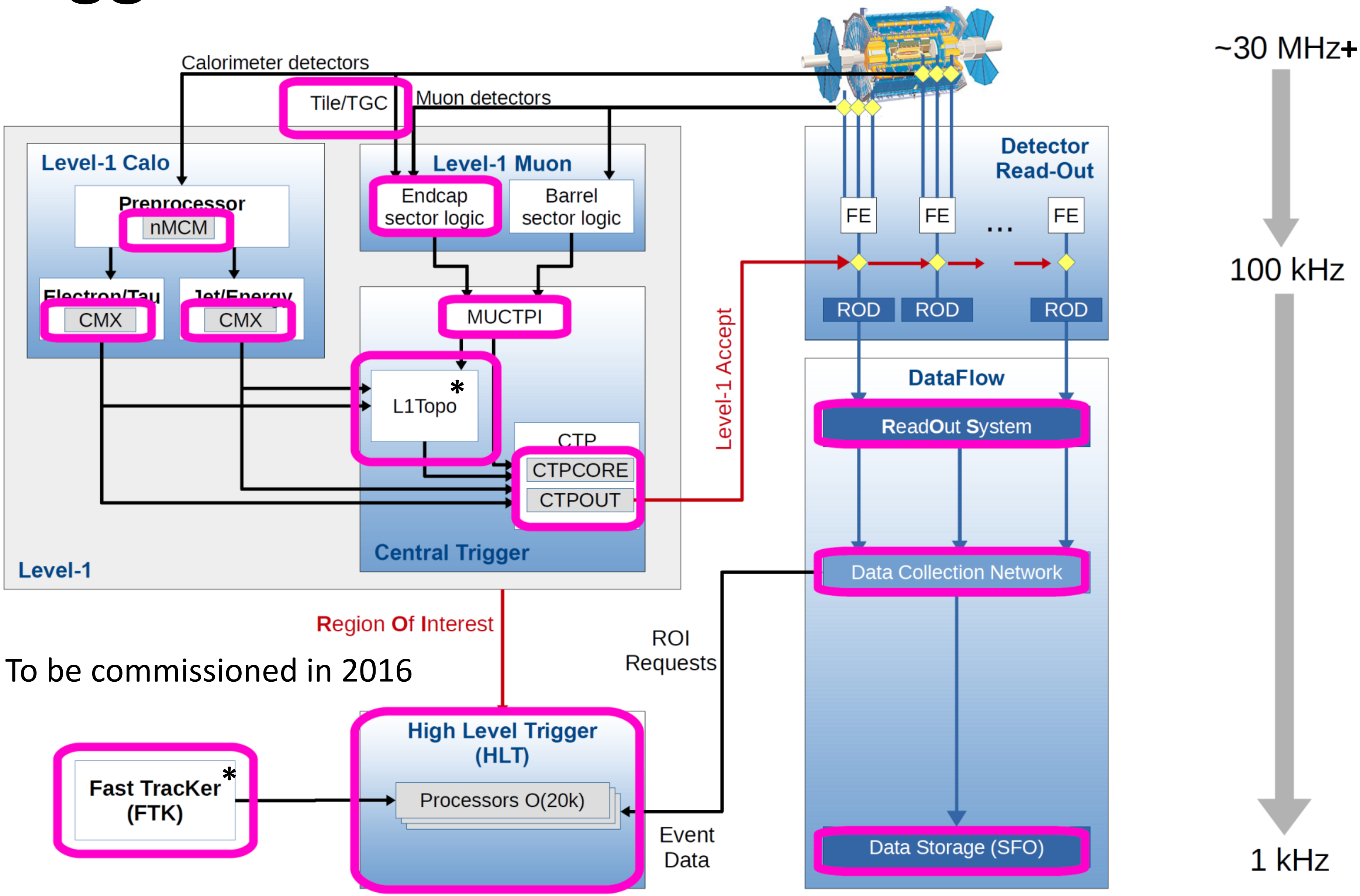
2015 alignment better than O(50/100μm) in barrel/endcap.





Very good data/MC agreement.

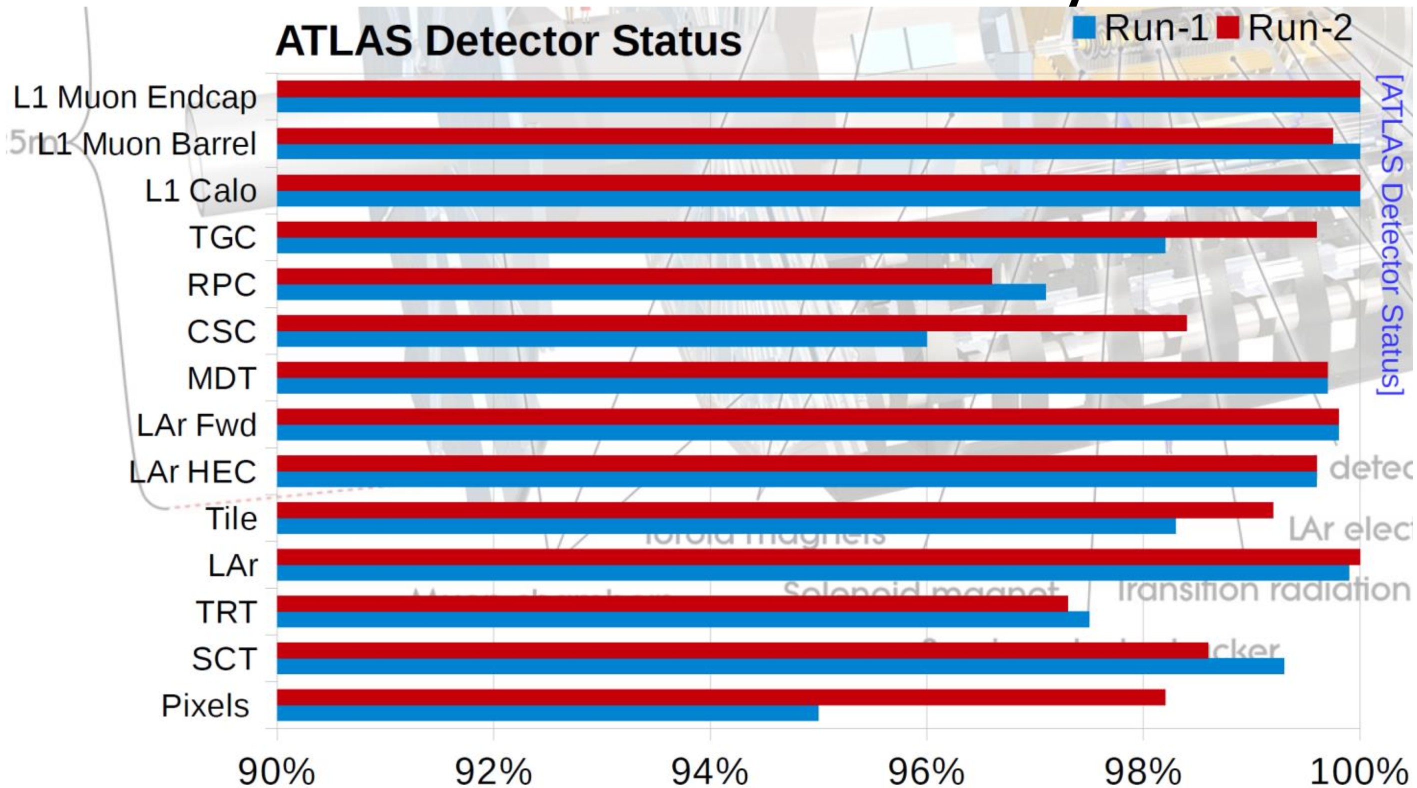
Trigger & DAQ in Run 2



* To be commissioned in 2016

2015 triggers very similar or even lower than the Run 1 ones.

Detector status and Data Quality



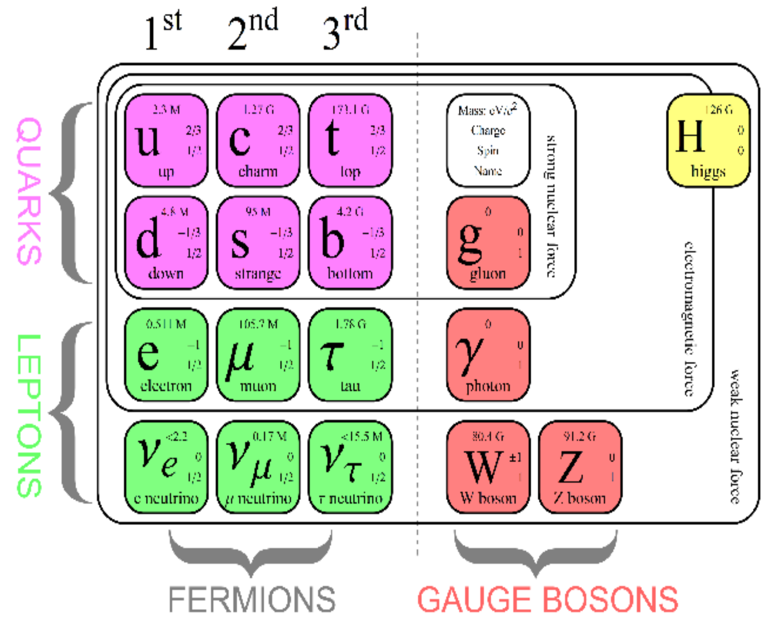
ATLAS pp 25ns run: August-November 2015										
Inner Tracker			Calorimeters		Muon Spectrometer				Magnets	
Pixel	SCT	TRT	LAr	Tile	MDT	RPC	CSC	TGC	Solenoid	Toroid
93.5	99.4	98.3	99.4	100	100	100	100	100	100	97.8
All Good for physics: 87.1% (3.2 fb^{-1})										

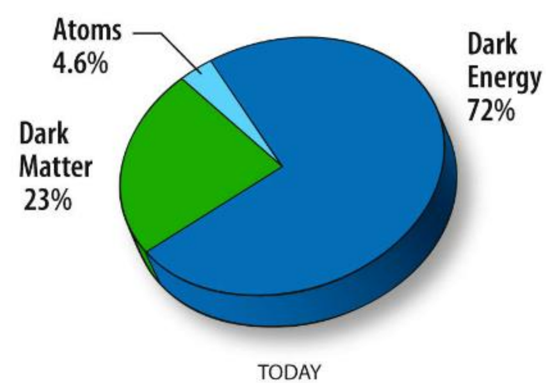
Luminosity weighted relative detector uptime and good data quality (DQ) efficiencies (in %) during stable beam in pp collisions with 25ns bunch spacing at $\sqrt{s}$=13 TeV between August-November 2015, corresponding to an integrated luminosity of 3.7 fb^{-1}. The lower DQ efficiency in the Pixel detector is due to the IBL being turned off for two runs, corresponding to 0.2 fb^{-1}. Analyses that don't rely on the IBL can use those runs and thus use 3.4 fb^{-1} with a corresponding DQ efficiency of 93.1%. [Ref]

ATLAS Physics results

Physics Introduction

- Following a discovery of a scalar boson in Run 1 of LHC Standard Model (SM) is complete and self-consistent
- Certain aspects of SM do not have an explanation
  - Why is Higgs light?
  - What is dark matter?
  - How to accommodate gravity?
  - What is the solution of the hierarchy problem?
  - Why are there three generations?
  - …





Physics Introduction (cont)

Search for any deviations from Standard Model predictions

Direct observation:
new (e.g. Exotic) resonant or
non-resonant structures

"Physics Beyond SM"

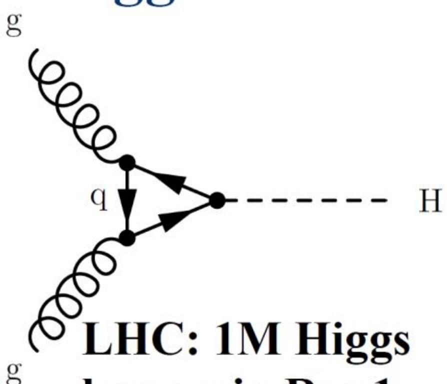
Indirect observation:
discrepancies in rates of rare processes,
couplings measurements, etc.

"SM Physics (Higgs & Non-Higgs)"

Higgs Physics

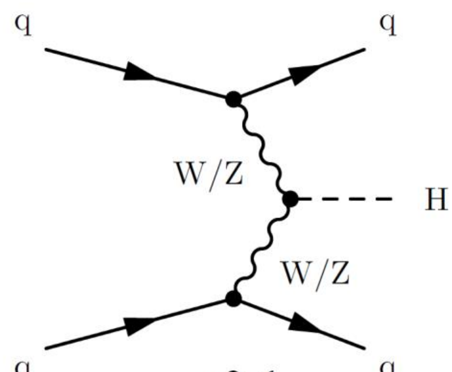
Higgs Boson Production

gg fusion



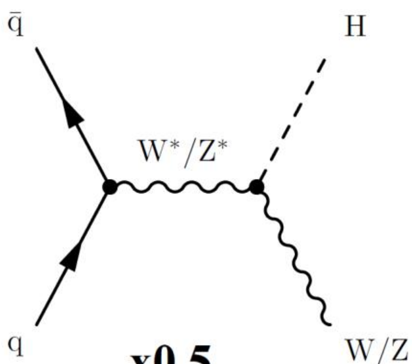
LHC: 1M Higgs bosons in Run1

VBF



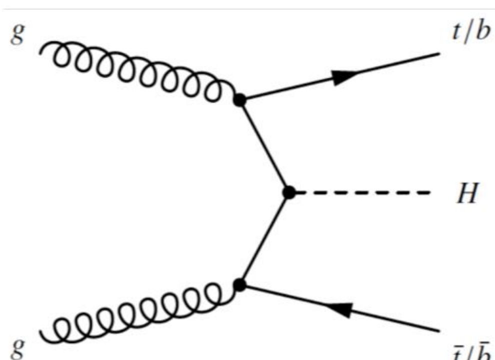
x0.1

VH

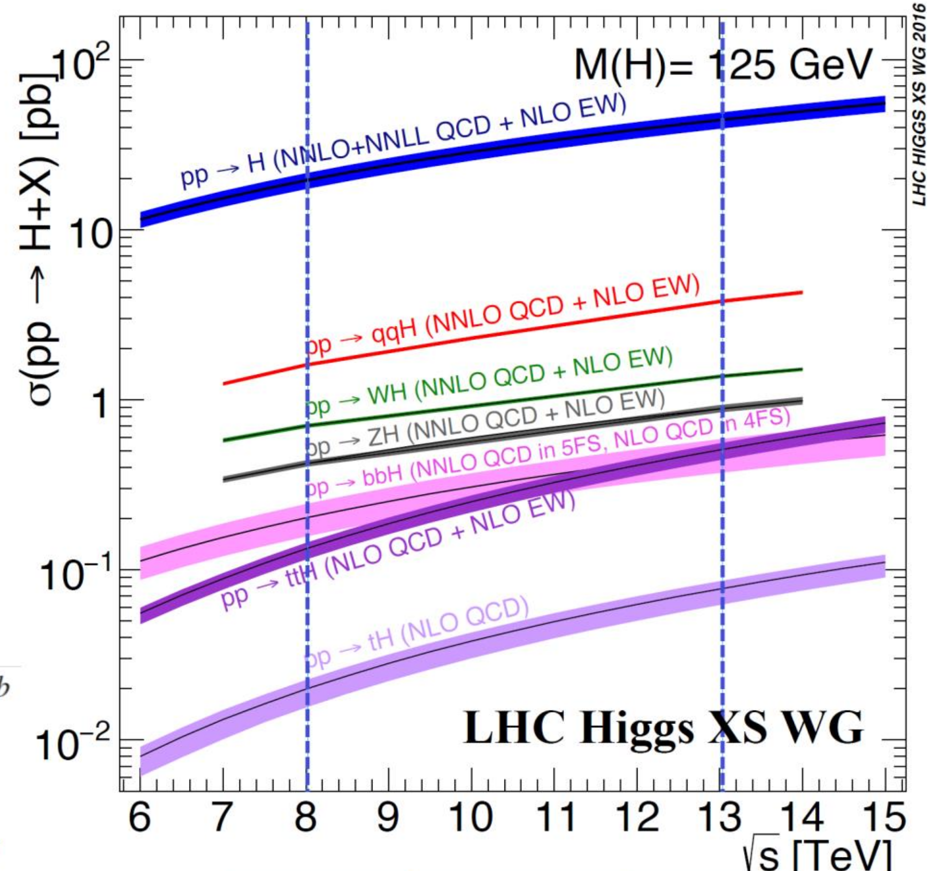


x0.5

ttH



x(0.1—0.2)



σ [pb], mH=125 GeV

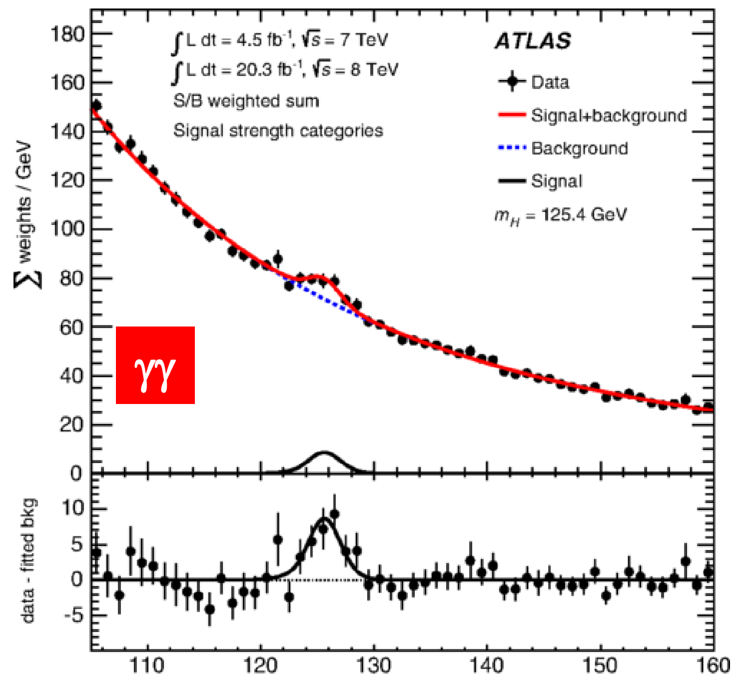
Mode	8 TeV	13 TeV
ggF	19	44
VBF	1.6	3.8
WH	0.70	1.4
ZH	0.42	0.88
ttH	0.13	0.51
bbH	0.20	0.49

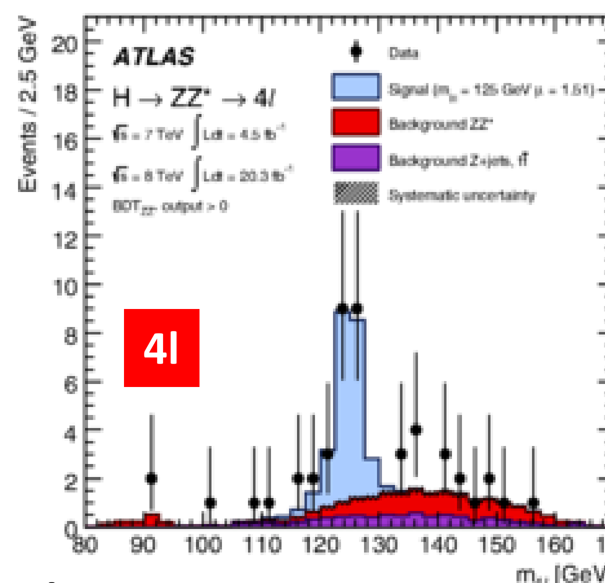
Higgs Boson Decays (m_H=125GeV)

Mode	Sensitivity	Mass res.	S/B (incl)	rate	comments
ZZ*→4l					very pure; m_H; SpinCP
γγ					m_H; via loop
WW→lνlν					high rate
ττ					mainly VBF (sensitivity)
bb					mainly VH (trigger,QCD)
ZZ*→llqq/llνν					high-mass (mainly)
WW→lνqq					high-mass (mainly)
μμ					rare
Zγ					

Mode	BR
bb	57.7%
WW	21.5%
gg	8.6%
ττ	6.3%
cc	2.9%
ZZ	2.6%
γγ	0.23%
Zγ	0.15%
μμ	0.022%

Phys. Rev. D 90, 112015





Phys. Rev. D 91, 012006

Higgs Mass & Width Measurement

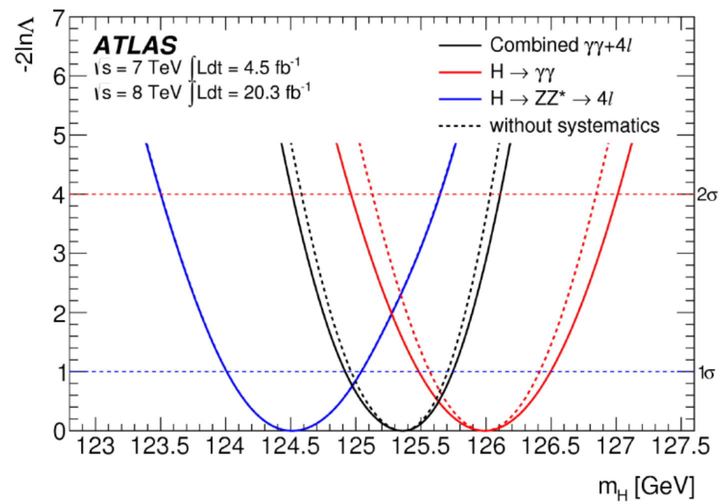
- Higgs mass only unknown parameter in the SM
- Use the two channels with best mass resolution:

m_{4l} = 124.51 ± 0.52 (stat) ± 0.06 (syst) GeV

$m_{\gamma\gamma}$ = 125.98 ± 0.42 (stat) ± 0.28 (syst) GeV

- Measurement in the two channels is model independent (production mode, spin,..)

Phys. Rev. D. 90, 052004 (2014)



- Ratio of the cross sections of different production modes fixed to SM values
- Combination: use profile likelihood ratio $\Lambda(m_H)$

m_h= 125.36 ± 0.37 (stat) ± 0.18 (syst) GeV

Values used in spin and coupling studies.

Direct width measurement

- Assume no interference with the SM background processes (Γ_H^{SM}~4.1MeV)
- Γ_H derived from fits to the mass peak
  - $\Gamma_H^{\gamma\gamma}$ < 5.0 GeV & Γ_H^{ZZ*}< 2.6 GeV (exp 6.2 GeV) @ 95% CL

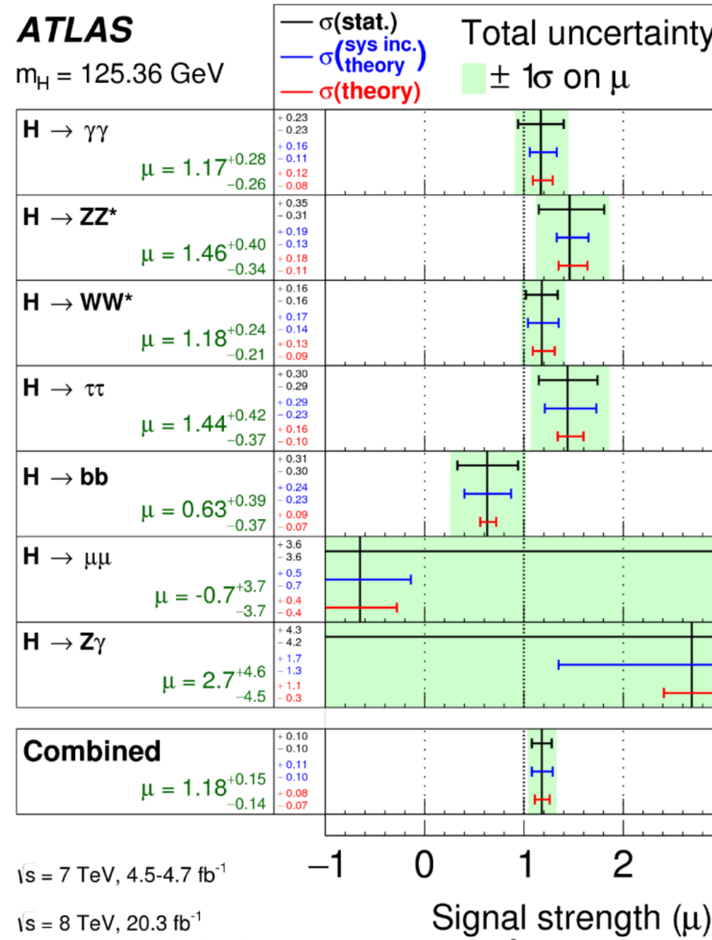
Decay signal strength

- Decay signal strength: $\mu_f = (\sigma * BR)_{obs} / (\sigma * BR)_{SM}$
- Assumption:
  - Higgs SM-like (p_T and y-distributions assumed to be as in SM)
  - SM relative ratios of production modes
- Largest systematic from background estimations in single decays
- Likelihood fits to the data for decay-dependent μ_f (independent of σ_i)
- Combining all μ_f-measurements:

$$\mu = 1.18^{+0.15}_{-0.14} = 1.18 \pm 0.10\,(\text{stat.}) \pm 0.07\,(\text{syst.})^{+0.08}_{-0.07}\,(\text{theo.})$$

(Consistent with the SM expectation with a *p*-value of 18%)

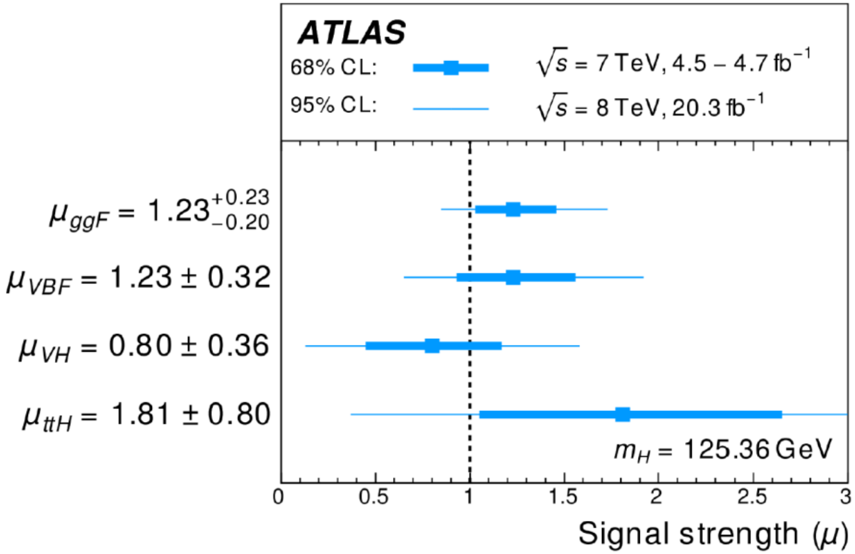
arXiv:1507.04548

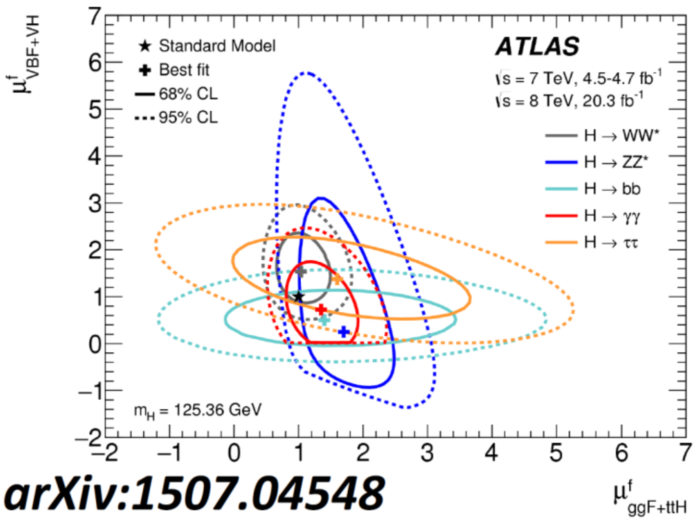


No sensitivity to Zγ and μμ decays yet

Production Signal Strength

- Production signal strength: $\mu_i = \sigma_{obs}/\sigma_{SM}$ corresponding to: μ_{ggF}, μ_{VBF}, μ_{VH} and μ_{ttH}
- Assumption: SM values for the ratios of the BR of different Higgs decays
- ttH needs more data to be firmly established





arXiv:1507.04548

- Can divide into bosonic and fermionic production signal strengths: μ_{VBF+VH} $\mu_{ggF+ttH}$
- Probe relative production cross section for all decay channels combined:

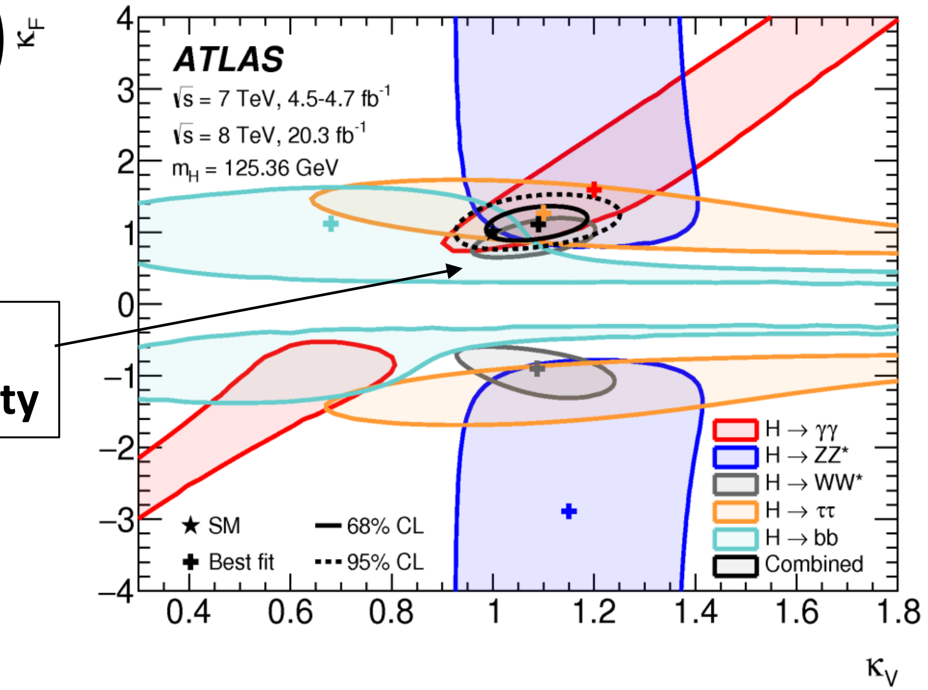
$$R = \mu_{VBF+VH} / \mu_{ggF+ttH} = 0.96^{+0.43}_{-0.31}$$

Coupling Strength (1)

Coupling strength modifier κ (ratio to SM expectation):

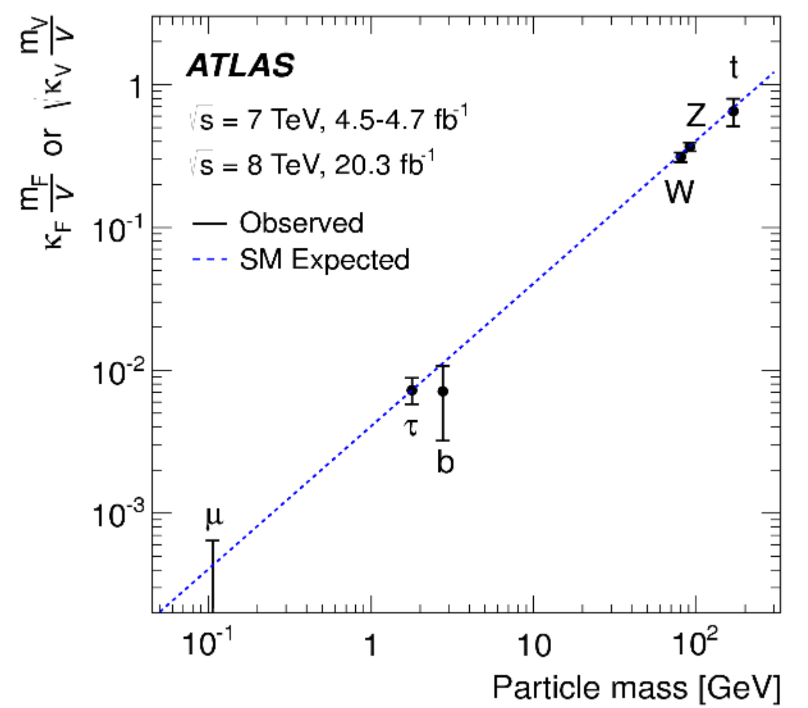
- $\kappa_i^2 = \sigma_i / \sigma_i^{SM}$
- $\kappa_f^2 = \Gamma_f / \Gamma_f^{SM}$

41% SM compatibility



Total width

- Assume no BSM contribution
- No BSM decays



Eur. Phys. J. C76 (2016) 6

Coupling Strength (2)

Coupling strength modifier κ (ratio to SM expectation):

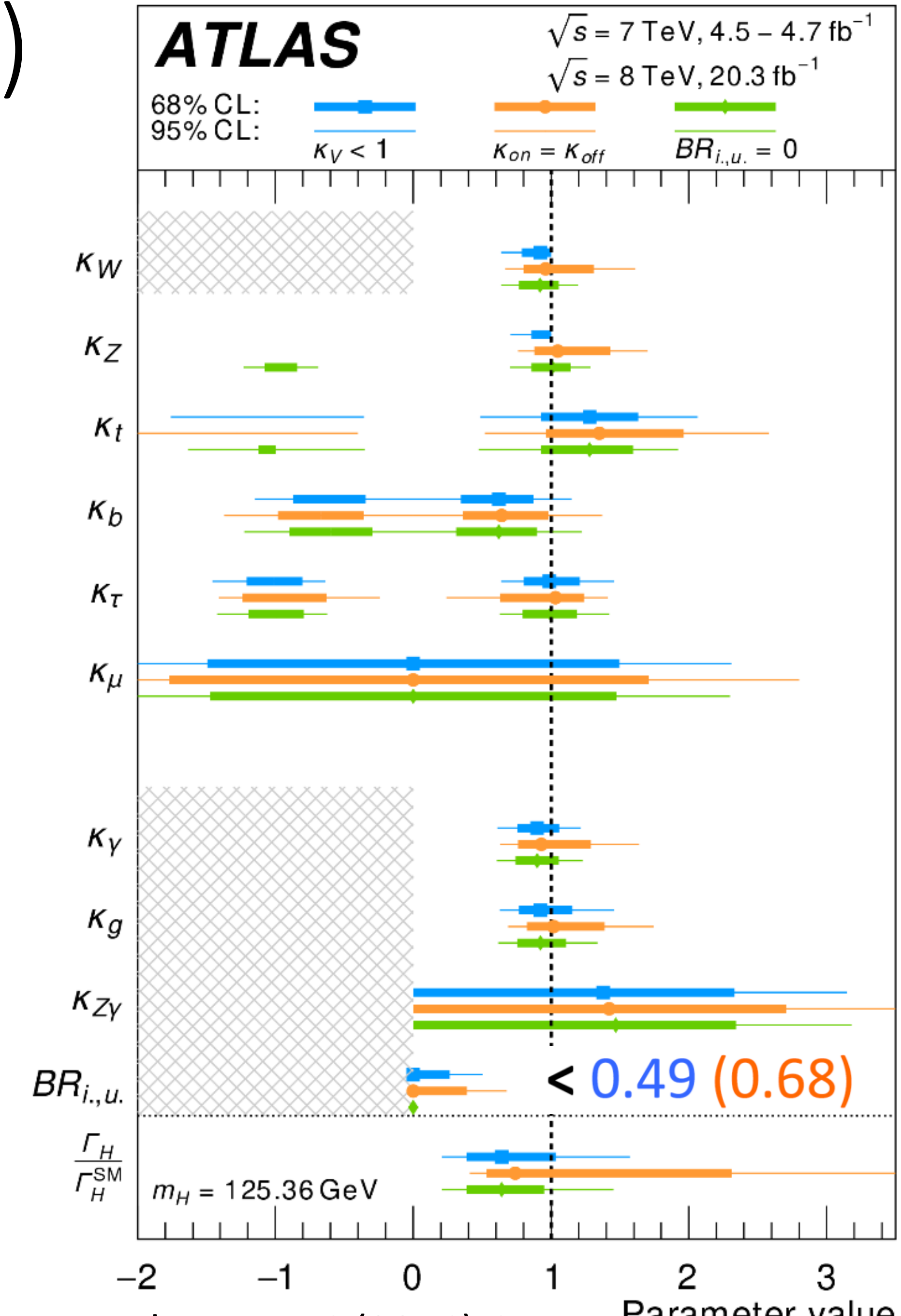
- $\kappa_i^2 = \sigma_i / \sigma_i^{SM}$
- $\kappa_f^2 = \Gamma_f / \Gamma_f^{SM}$

Total width

- Assume no BSM contribution
- Allow BSM decays

Compatibility with SM

80%, 57% and 73%



Eur. Phys. J. C76 (2016) 6

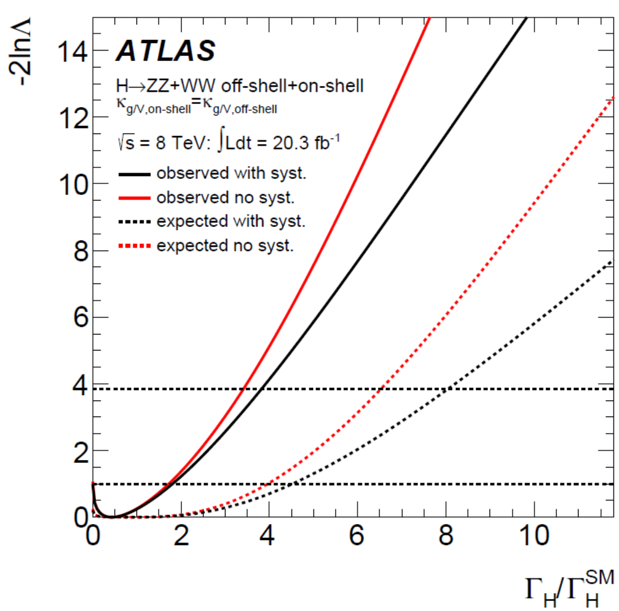
Width via off-shell production

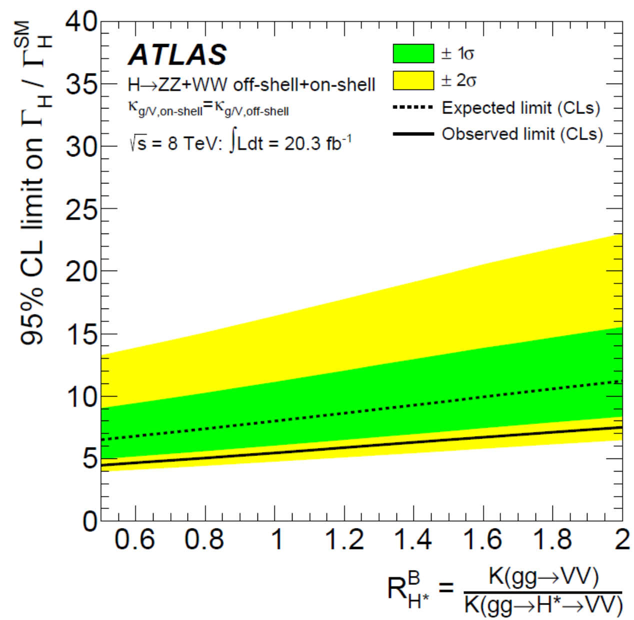
- High mass off-peak region (> 2*m_V) in H->VV is sensitive to Higgs off-shell production and background interference effects, use gg->$H^{(*)}$→ WW→eνμν, gg->$H^{(*)}$→ ZZ→4l/2l2ν
- **Assume**: relevant Higgs boson couplings independent of the energy scale of the Higgs production
- **Only** signal strength $\mu_{\text{on-shell}}$ depends on Γ_H/Γ_H^{SM} -> assuming identical off-shell and on-shell boson coupling scale factor: $\mu_{\text{off-shell}}(s) / \mu_{\text{on-shell}} = \Gamma_H / \Gamma_H^{SM}$

- Upper limit range: $\Gamma_H / \Gamma_H^{SM} < 4.5\text{-}7.5$ (exp: 6.5-11.2) at 95% CL

Range from varying the unknown gg->VV background k-factor from higher order QCD corrections (0.5x and 2x known signal k-factor)

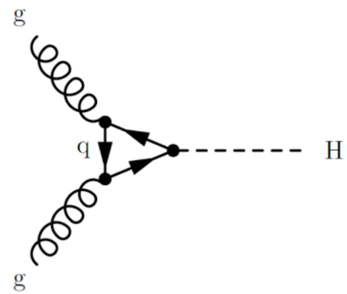
Eur. Phys. J. C (2015) 75:335



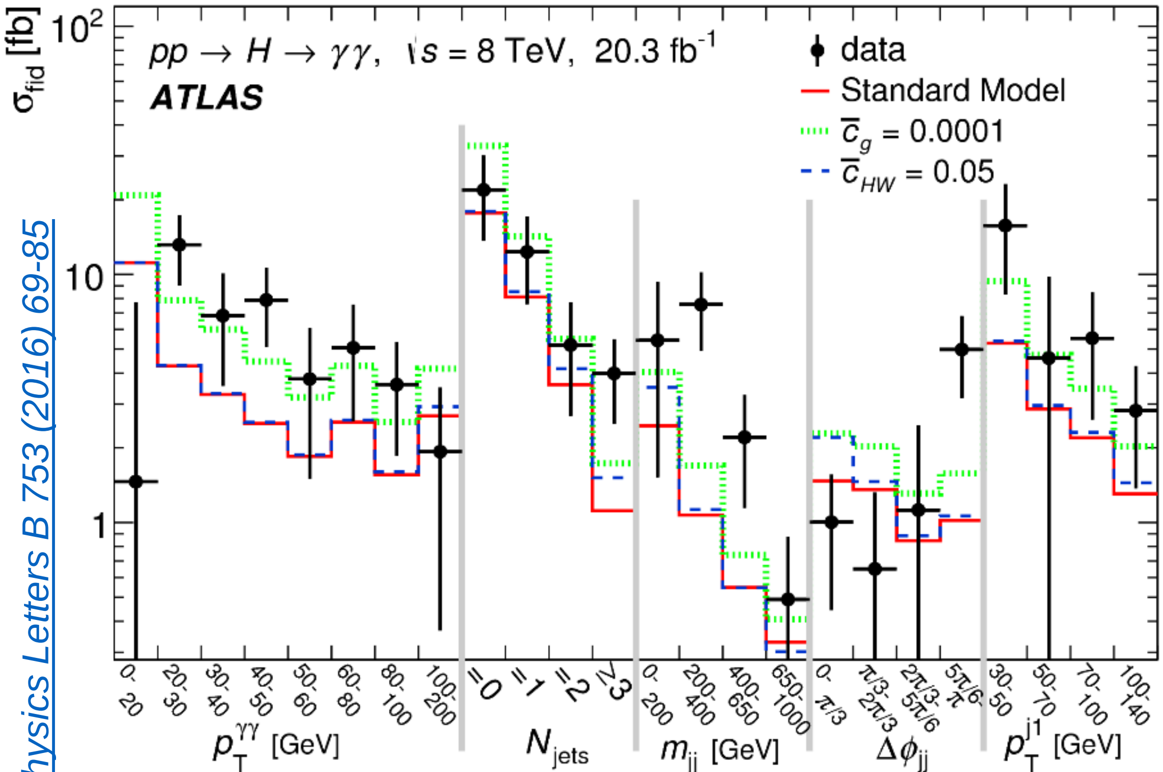


Total and Differential Cross-section

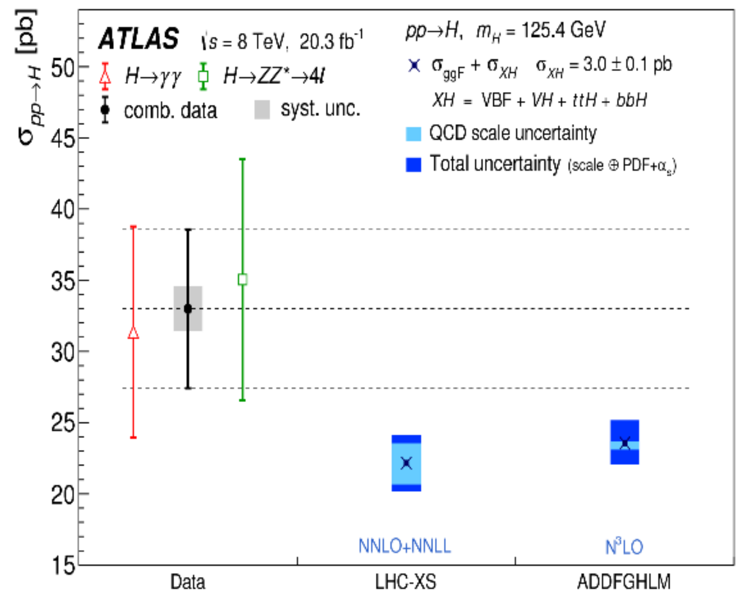
- Differential distributions in H events: test for BSM interactions.
  - $d\sigma / dp_T^H$: BSM in (ggF production) loops
  - $d\sigma / dN_{jets}$: QCD calculations
  - $d\sigma / d\Delta\varphi^{jj}$: CP properties



- No significant deviation from SM expectation



Physics Letters B 753 (2016) 69-85

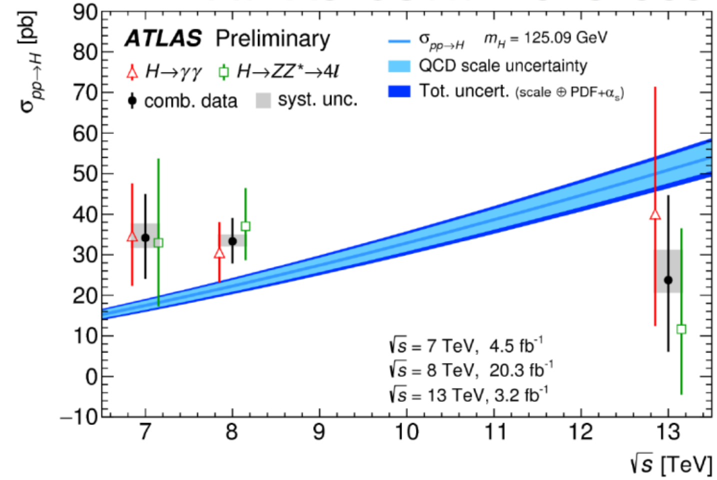


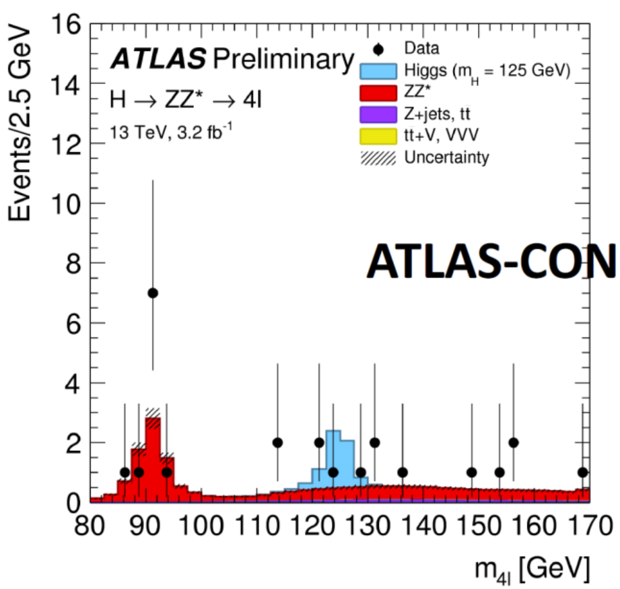
Phys. Rev. Lett. 115 (2015) 091801

First Run 2 results

- Luminosity of 3.2 fb^{-1} at 13 TeV not enough to reach Run-1 sensitivity for h(125)
- ATLAS performed fiducial cross-section measurements in 4l and γγ channels (1.4σ (obs) 3.4σ (exp.) combined sensitivity)

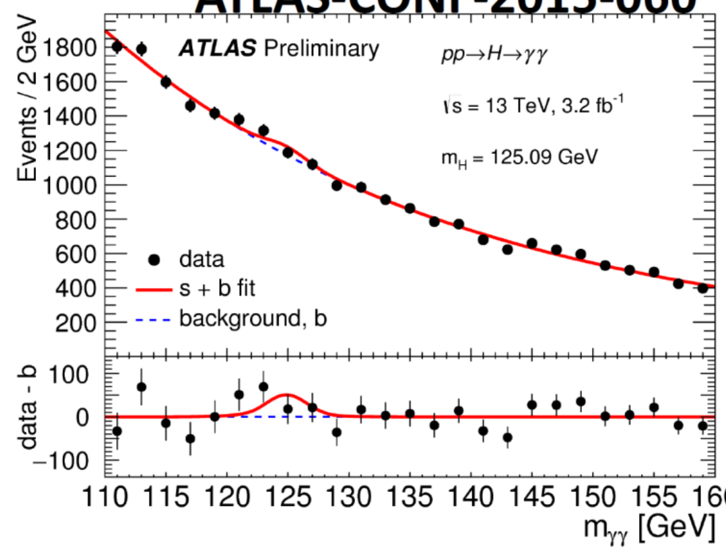
ATLAS-CONF-2015-069





ATLAS-CONF-2015-059

ATLAS-CONF-2015-060

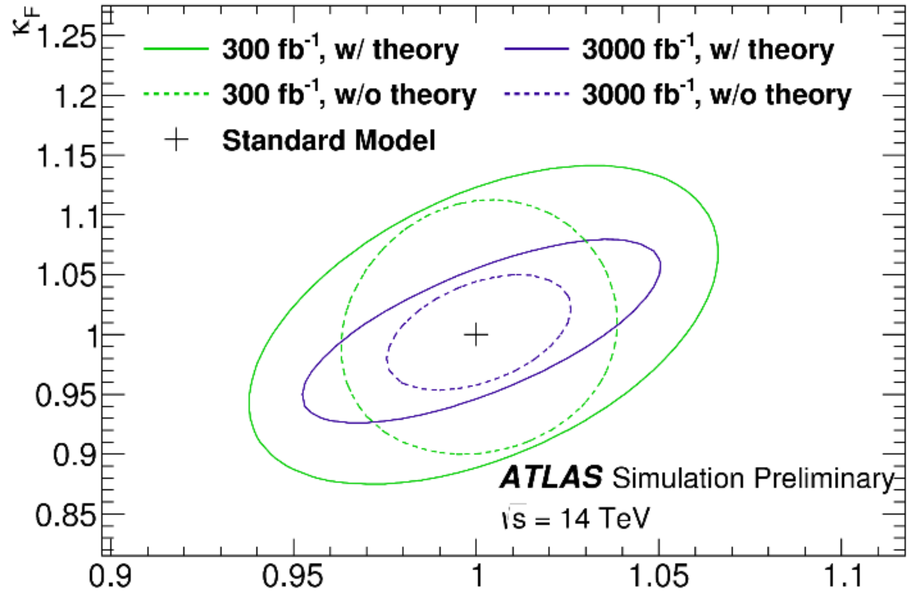


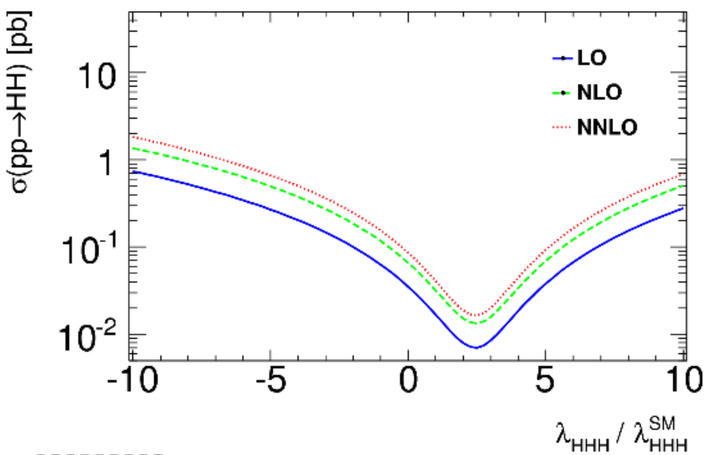
Future outlook for Higgs sector

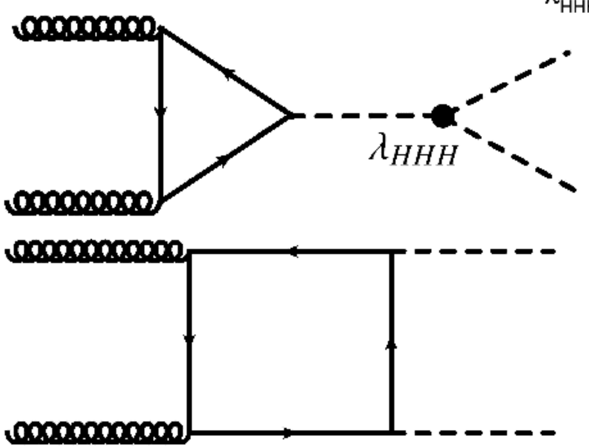
Future measurements: ttH, HH production, $H \to Z\gamma$, $\mu\mu$ decays

Couplings (now/0.3ab^{-1}/3ab^{-1}):

- Fermions 30/10/5%
- Bosons 20-30/5/3%

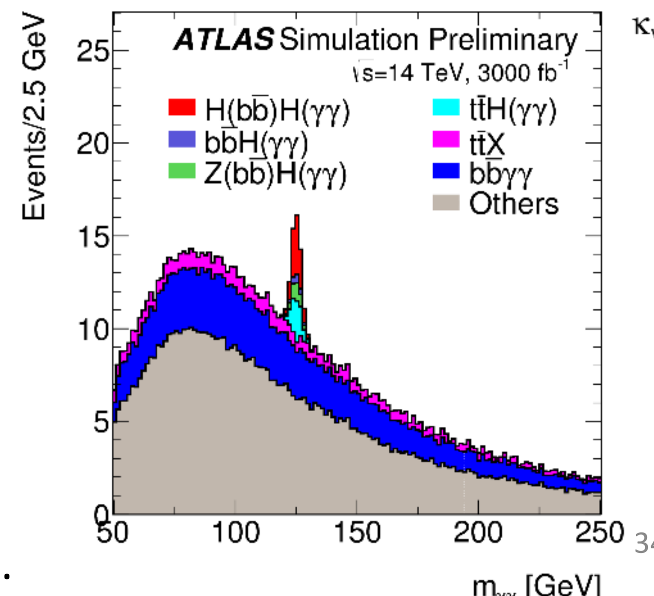






Negative interference between HH production with and w/o HHH vertex.

Expect 8-10 events in 3 ab^{-1}: measurement potential is low (exp. significance 1.3σ).



Double Higgs production

- In Run 1 observed 5 events ~300GeV (<1 exp.)
  - 3σ local/2σ global tension with SM

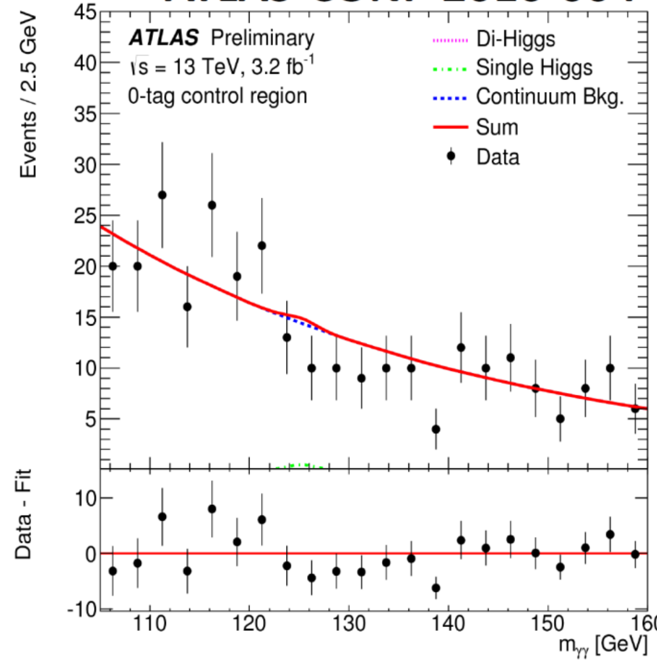
- Search for both resonant (BSM) and non-resonant (SM) pairs of higgs (hh)

- Final state $\gamma\gamma$bb-bar with enhanced BR (bb-bar) and clean signature ($\gamma\gamma$)

- Event selection using cut on: $m_{\gamma\gamma}$ (analysis dep.) $95 < m_{bb} < 135$ GeV and $275 < m_X < 400$ GeV

- Background from side-band regions using fit resp. counting approach with efficiencies

ATLAS-CONF-2016-004



- Upper limits on the production cross section are derived from pseudo-experiment assuming SM BR:

Non-resonant: σ_{hh} < 3.9 pb at 95% CL

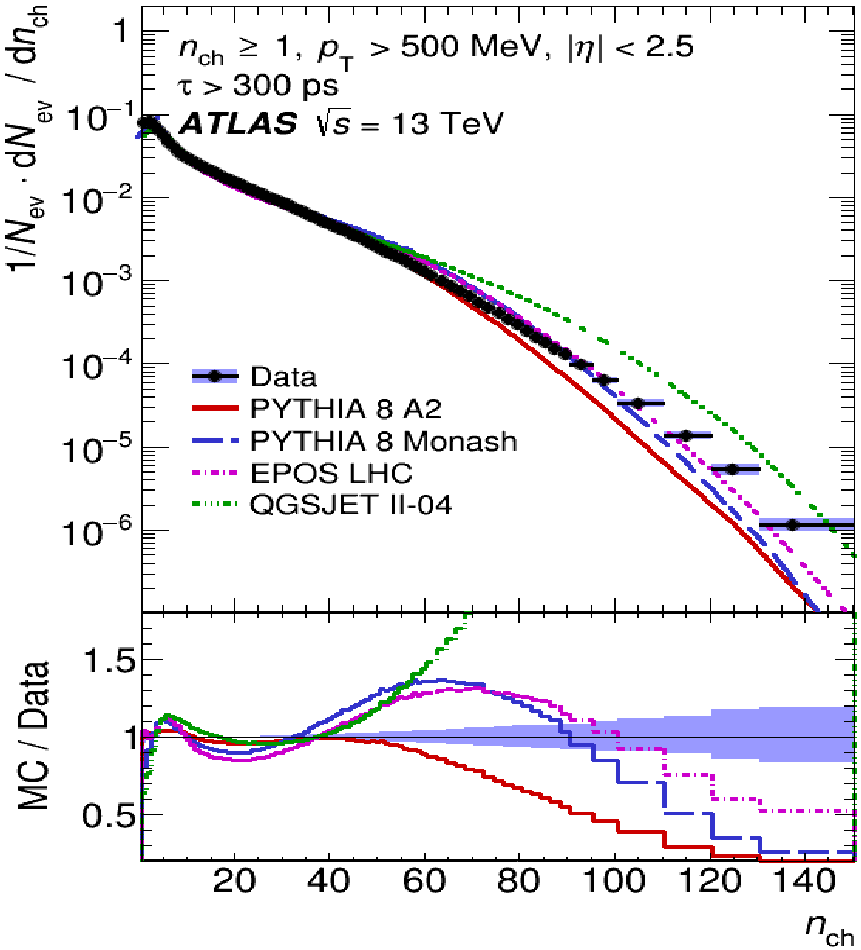
Resonant: σ_{hh} < 7.5 pb (m_X = 275 GeV); σ_{hh} < 4.4 pb (m_X = 400 GeV) at 95% CL

Non-Higgs SM Physics

QCD physics

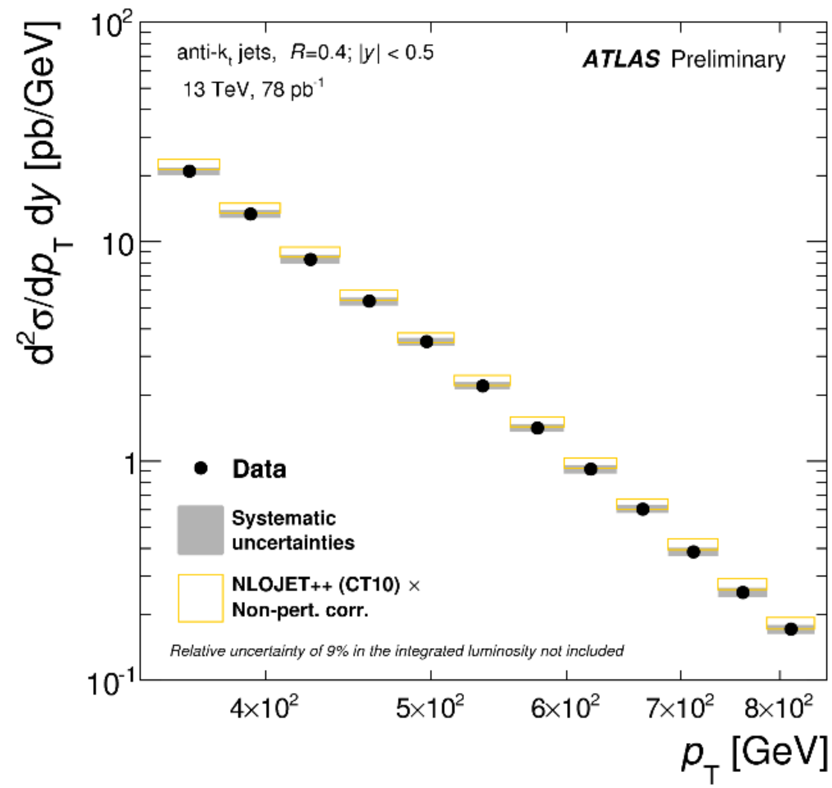
arXiv:1602.01633, ATLAS-CONF-2015-034

Inclusive charged particle measurements provide insight into the strong interaction in the low-energy, non-perturbative QCD region



MC tunes describe data well at 13 TeV.

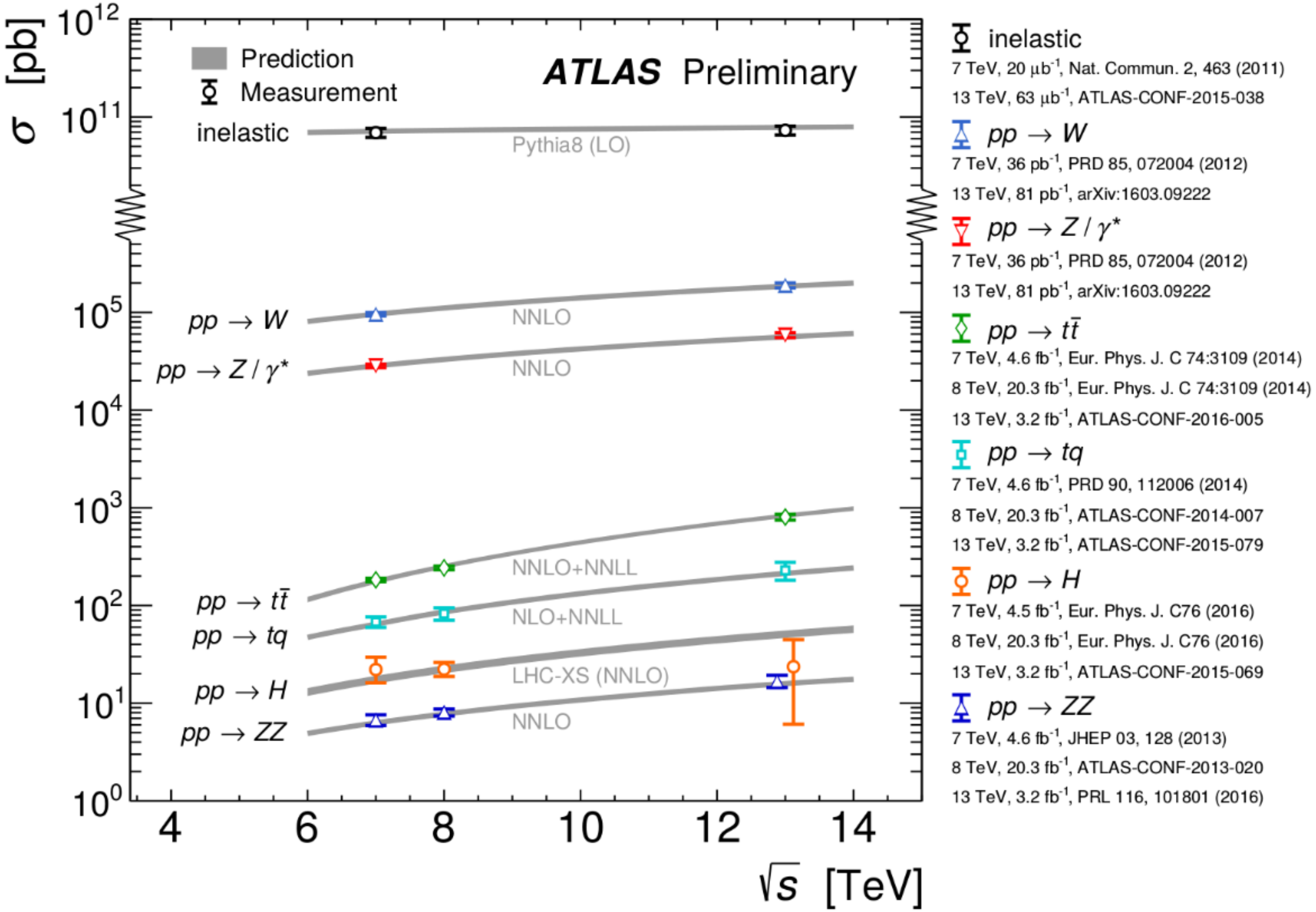
Inclusive jet cross-section measurement provides test of the validity of perturbative QCD



The predictions are consistent with measured cross-sections (within uncertainties)

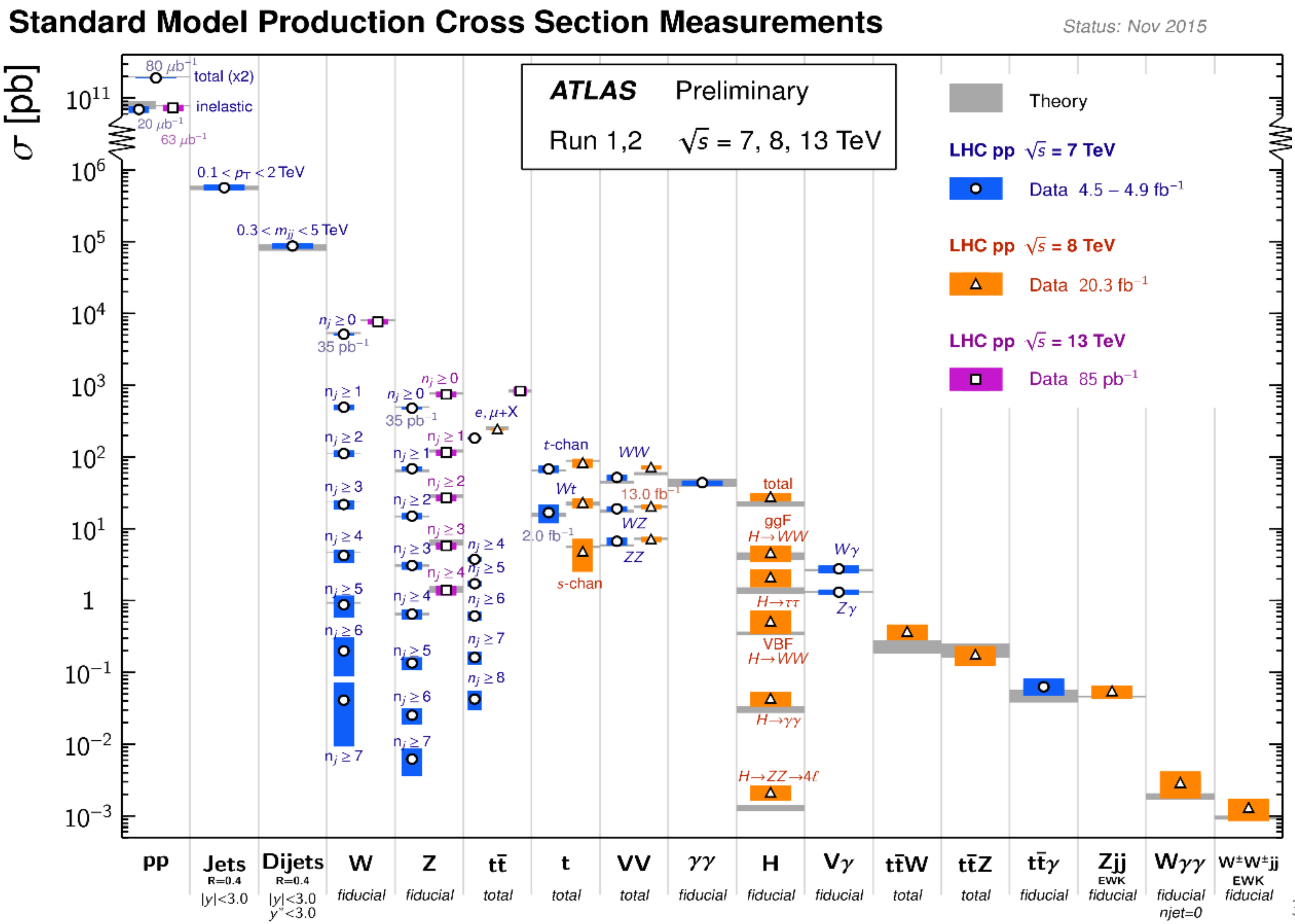
Cross-section measurements

- Increase in √s allows study of SM processes in new kinematic regime
- SM processes are background processes to searches for new physics
- Theoretical predictions at (N)NLO+(N)NLL compatible with measured total/differential cross-section of different SM processes.

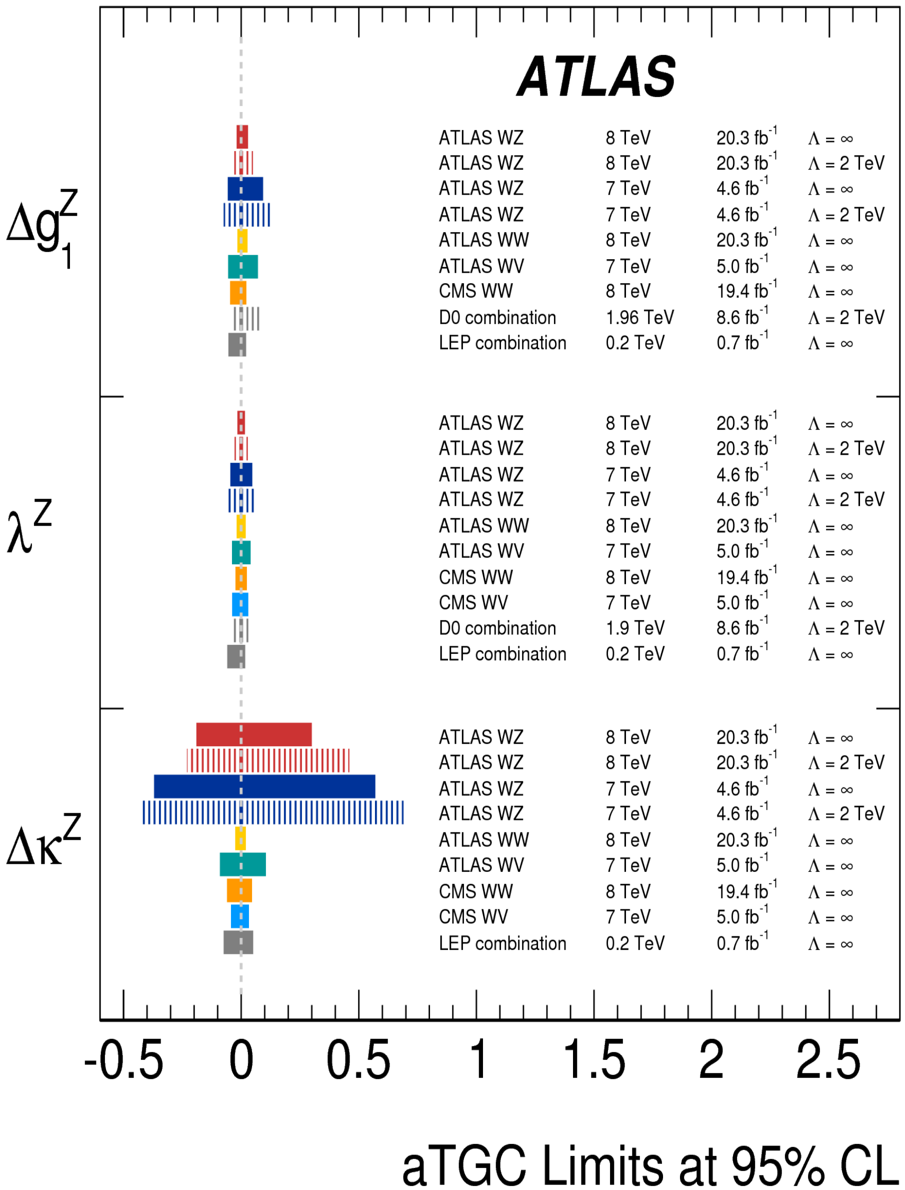


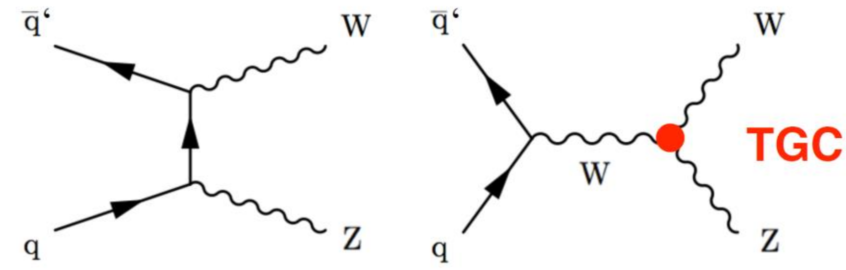
Cross-section measurements

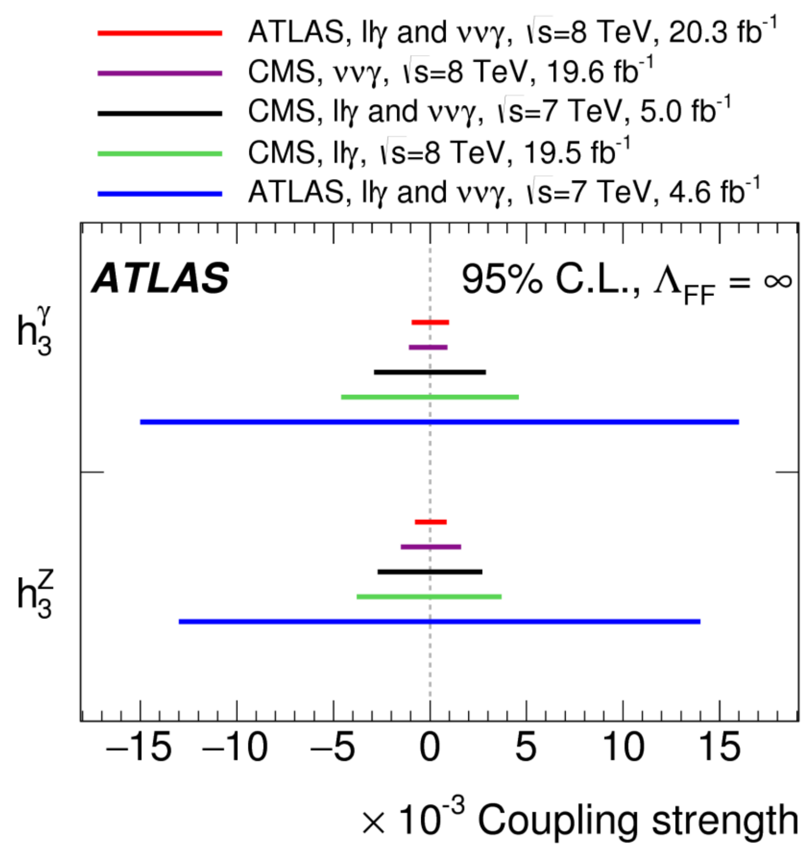
Calculations at NNLO accuracy are in excellent agreement with measurements of SM cross-sections.



Anomalous Triple Gauge Couplings

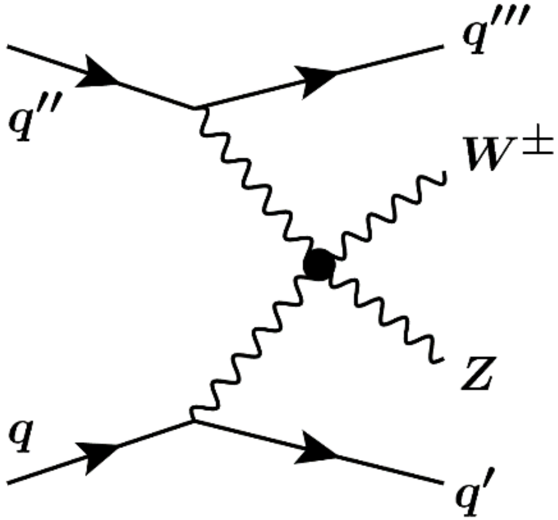


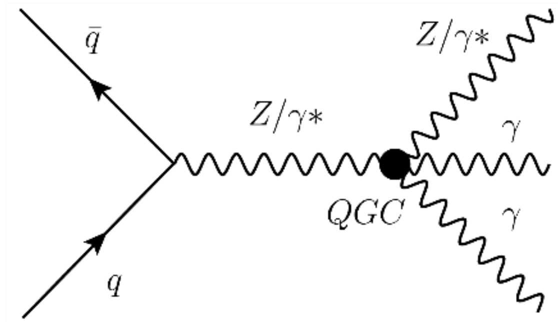


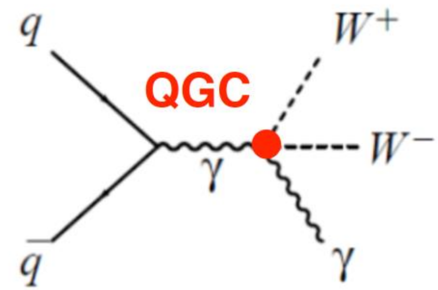


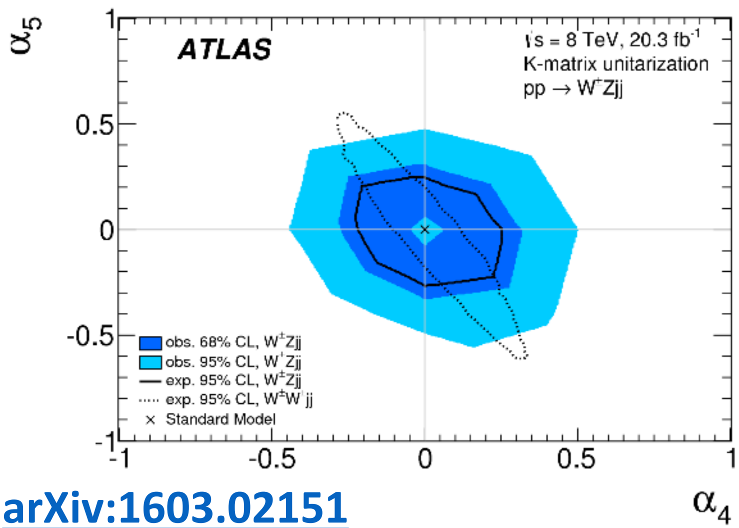
arXiv:1603.02151 arXiv:1604.05232

Anomalous Quartic Gauge Couplings

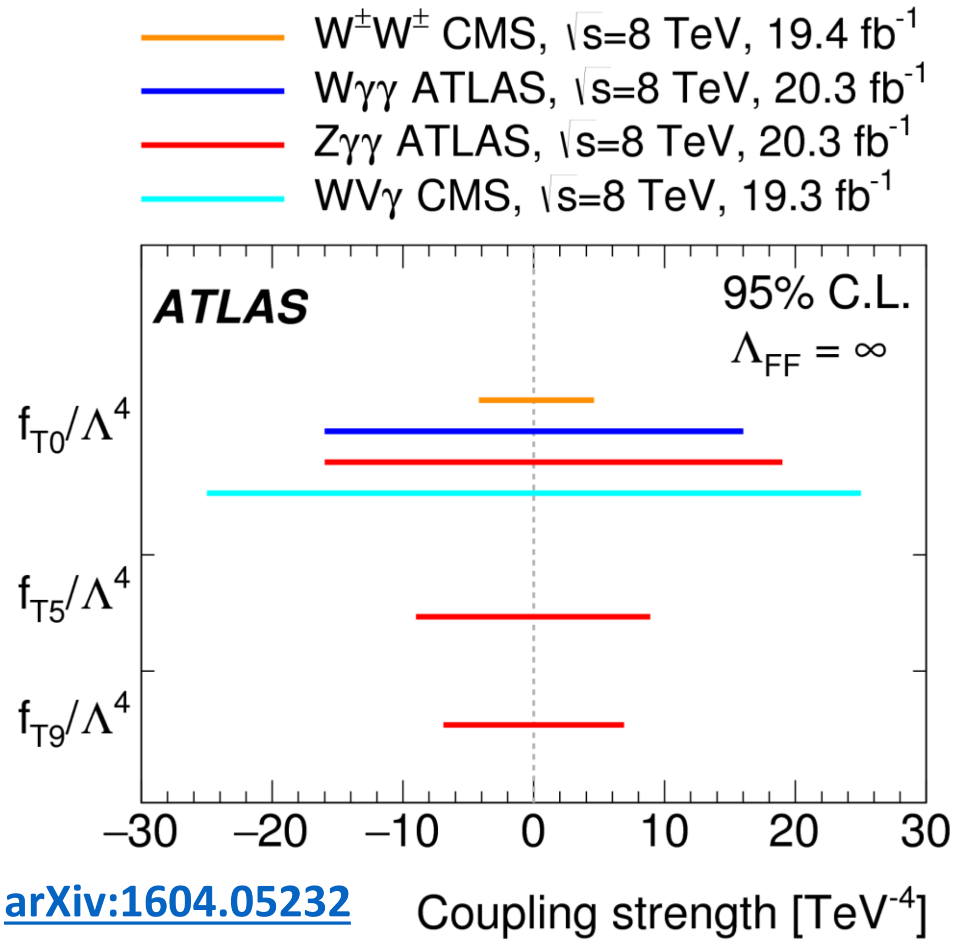








arXiv:1603.02151

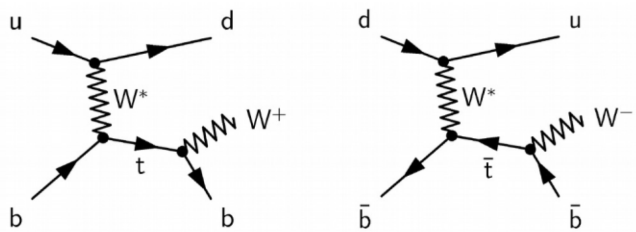


No hint of aT/QGC seen.

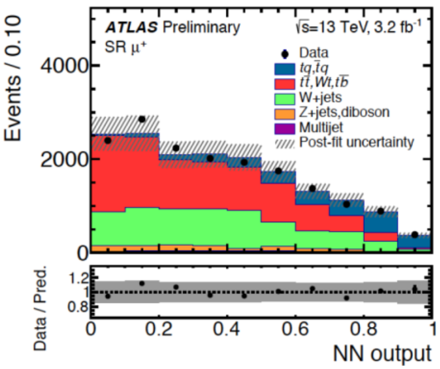
arXiv:1604.05232

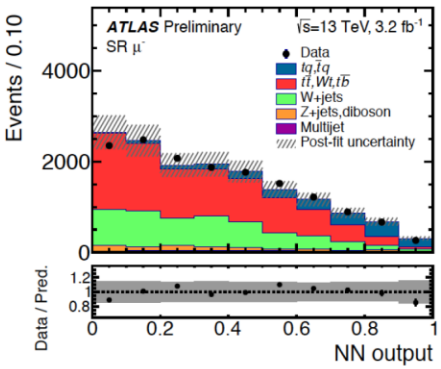
Top quark production

Electroweak production of single top quark



10 variables are used in the training of a Neural Network.
One output node which gives a continuous output in the interval [0; 1].

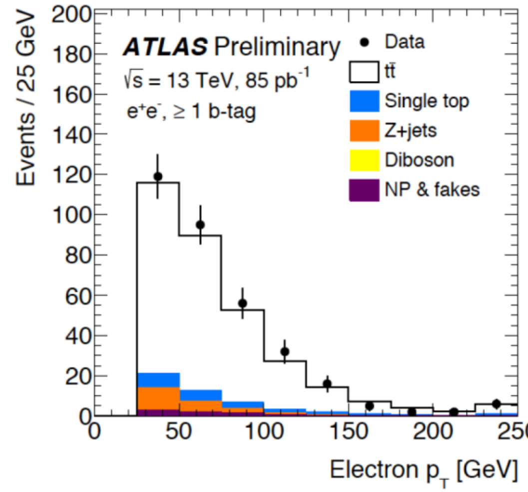


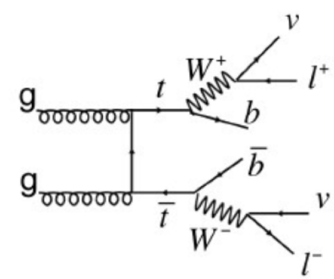


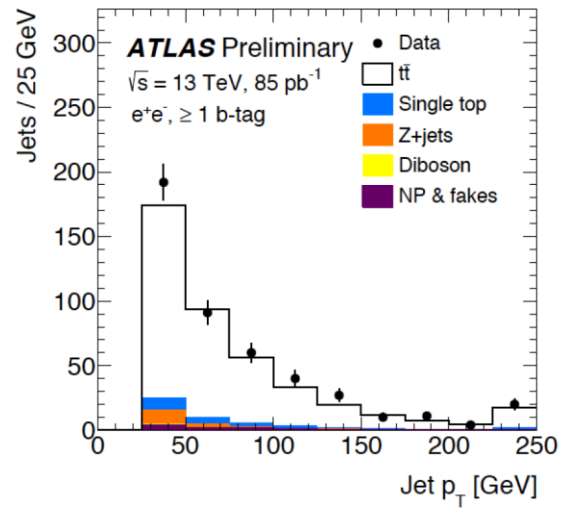
$$\sigma(tq) = 133 \pm 6\,(\text{stat.}) \pm 24\,(\text{syst.}) \pm 7\,(\text{lumi.})\ \text{pb}$$
$$= 133 \pm 25\ \text{pb},$$
$$\sigma(\bar{t}q) = 96 \pm 5\,(\text{stat.}) \pm 23\,(\text{syst.}) \pm 5\,(\text{lumi.})\ \text{pb}$$
$$= 96 \pm 24\ \text{pb},$$

(limited by systematics)

Top pair production in lepton channels ($ee,\mu\mu,e\mu$) and b-tags jets



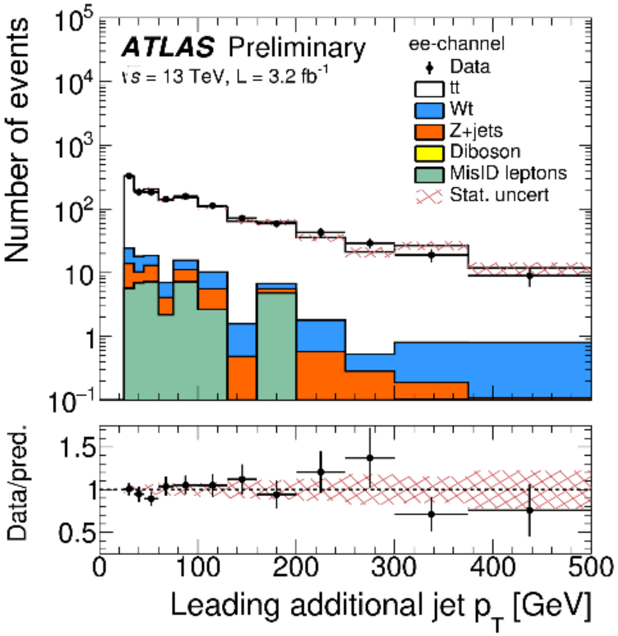


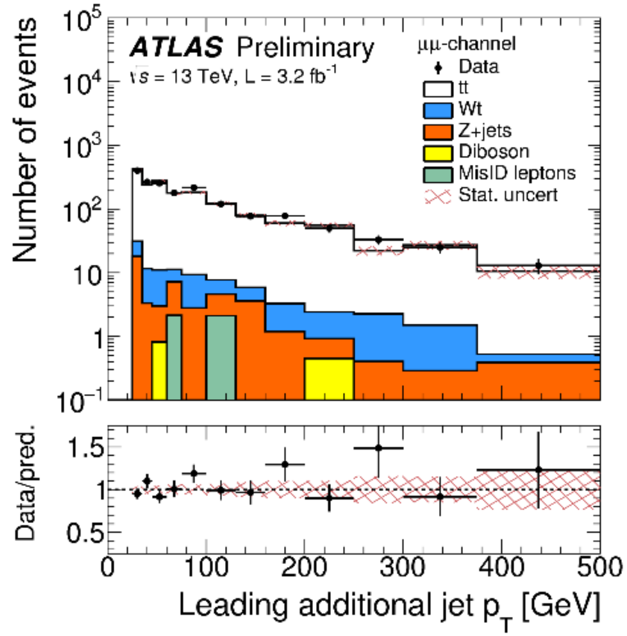


Good agreement in cross-sections and kinematics with NLO/NNLO MC predictions

ATLAS−CONF−2015−079 ; ATLAS−CONF−2015−033 ; ATLAS−CONF−2015−049

Production of tt+jets

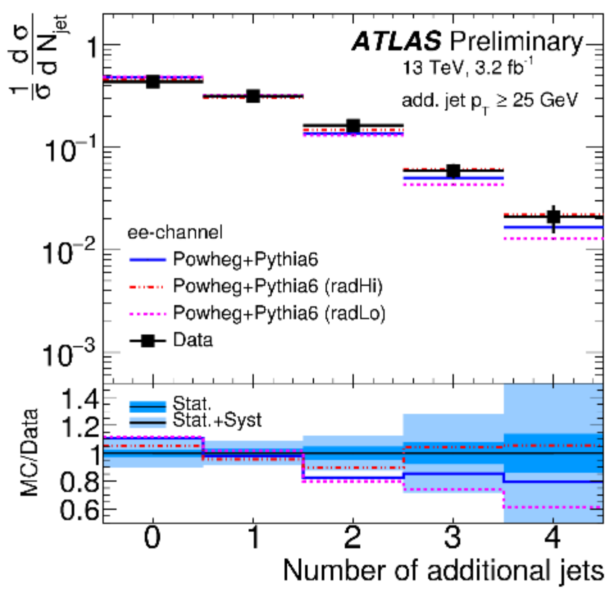


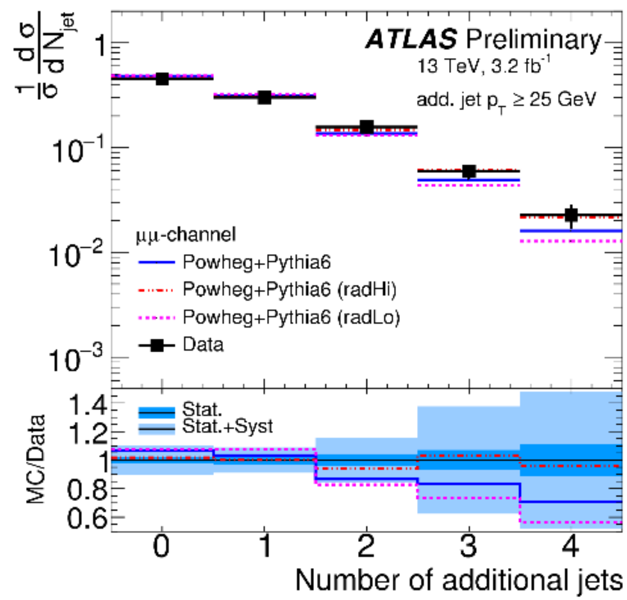


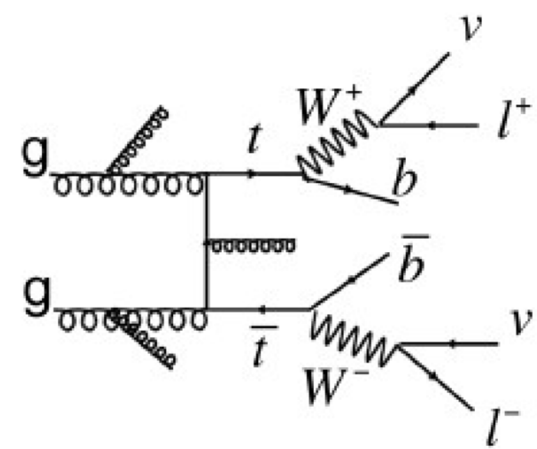
Important for ttH MC tuning to estimate ISR/FSR uncertainties.

Dilepton channels (ee,μμ, μe) have good agreement of jet kinematics.

Unfolded jet multiplicity in good agreement with MC predictions



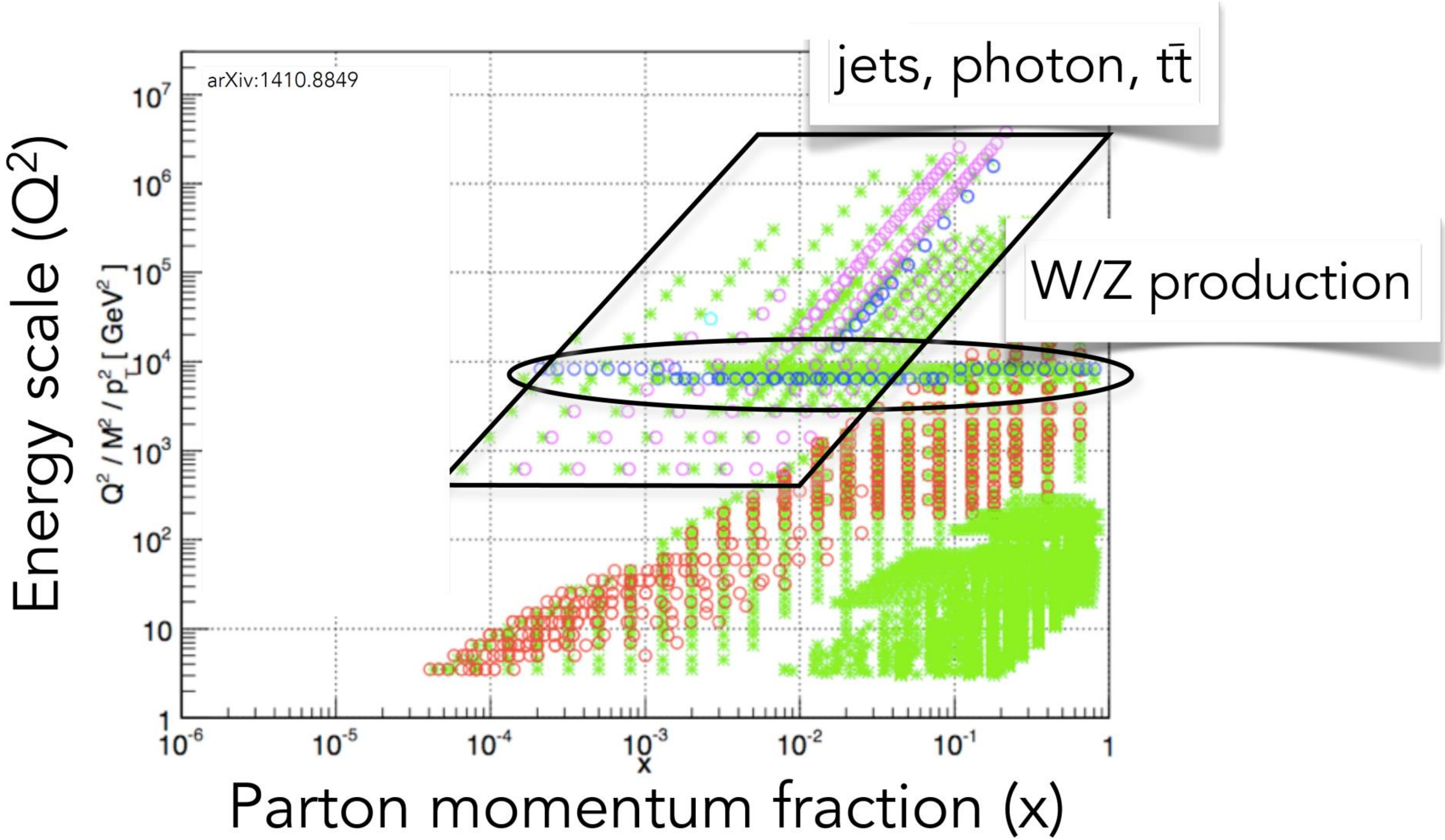




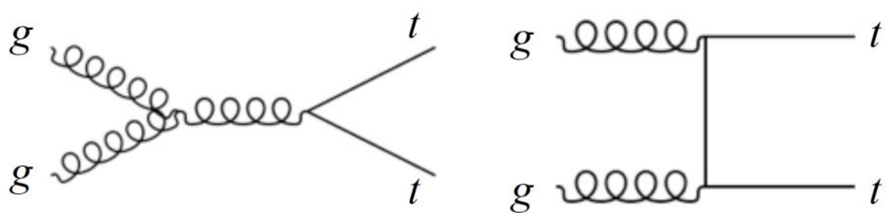
ATLAS-CONF-2015-065

Constraints on PDFs

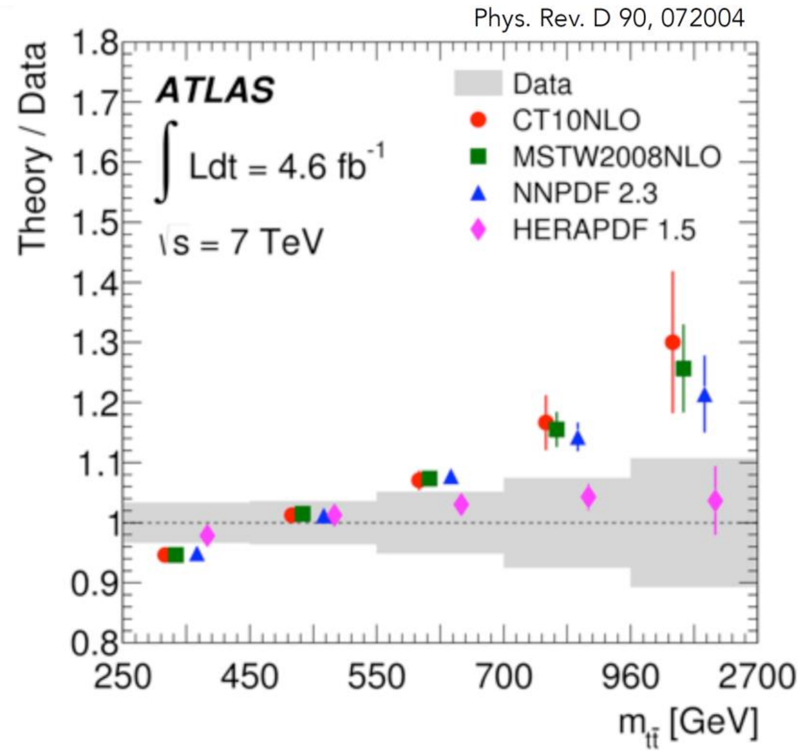
Extraction of PDF via global fits to fixed-target, collider DIS, collider pp data

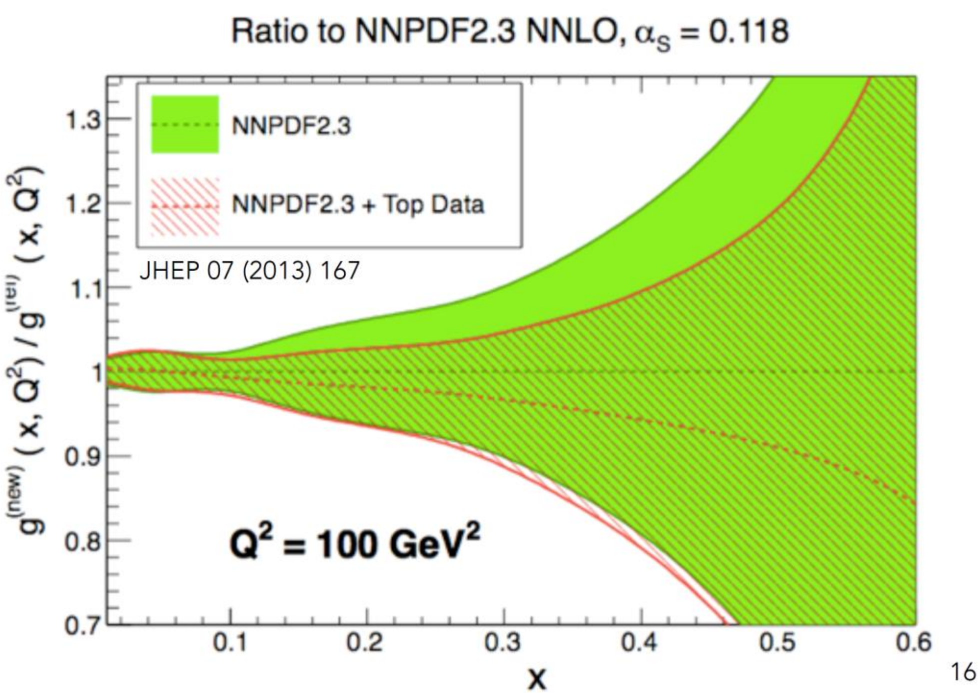


PDF constraints from top quark



Top pair differential cross-section now available at NNLO

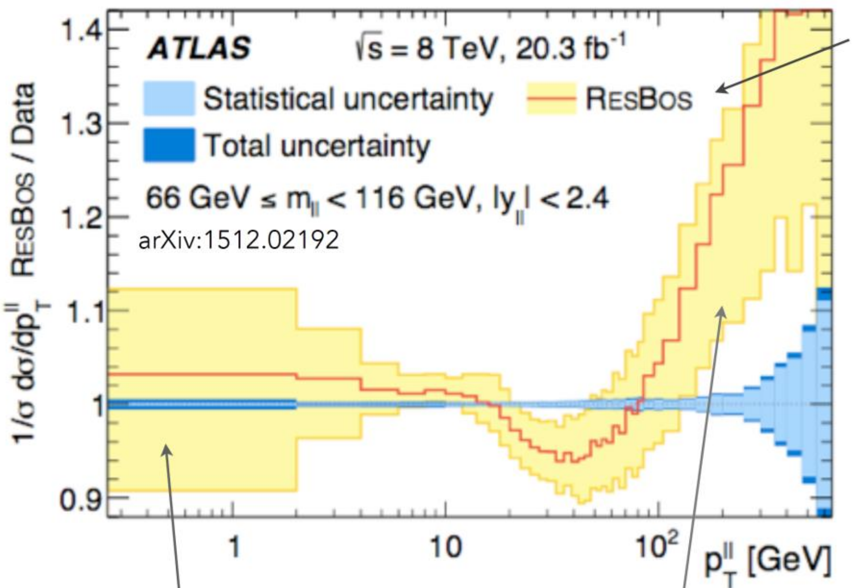




Improved knowledge of gluon PDF over wide region of x by up to 20%

Precision Tests of SM predictions

$pp \rightarrow Z/\gamma \rightarrow \ell^+\ell^-$



approximate NNLO (QCD ISR) + full NNLL

Data much more precise than predictions!

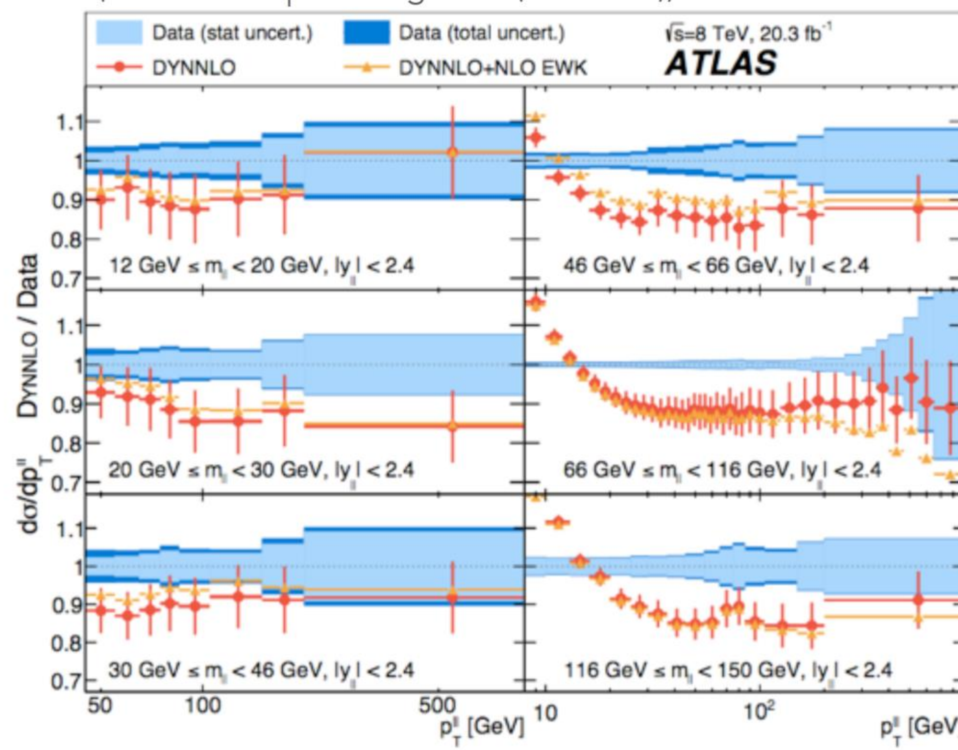
non-perturbative effects and soft-gluon resummation are most important

sensitive to the emission of hard partons

Not quite sensitive to EW corrections.

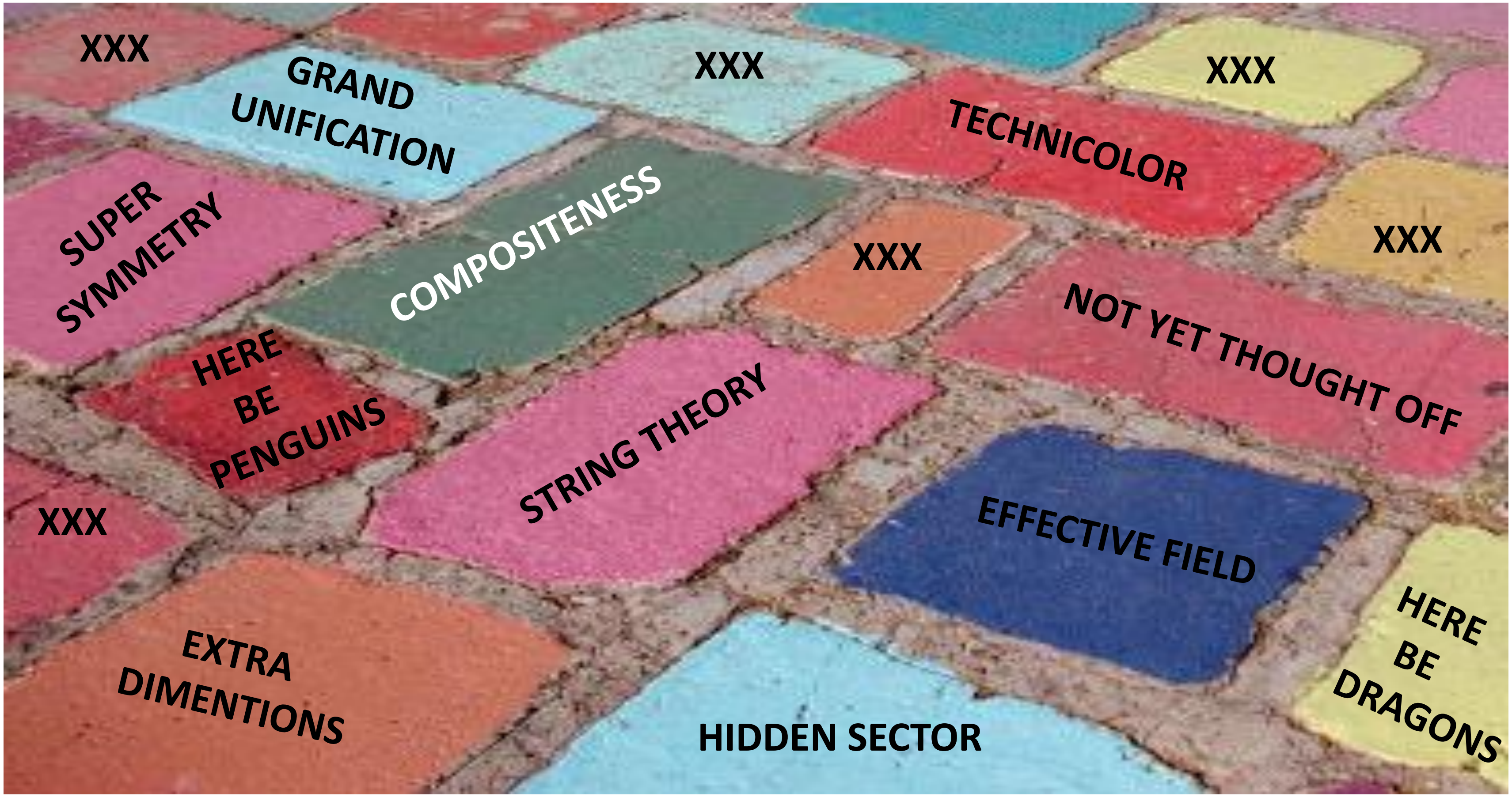
DYNNLO: Full NLO (QCD ISR)+NLO EWK added

(but no multiple soft gluons (i.e. no LL))



Searches Beyond Standard Model

Theoretical Approach: Exotic Theory



Balboa Park, San Diego, USA, from https://beautifulbalboapark.wordpress.com

Theories not enough! Need models to derive phenomenology (particle spectrum, production & decays modes)

Theoretical Approach: what to look for

EXTRA DIMENSIONS

Kaluza-Klein excitations of particles (G^*, Z_{KK}, W_{KK}, g_{KK}, q_{KK}, …), Black Holes, string resonances…

GRAND UNIFICATION

new vector bosons (Z', W',..), heavy fermions (t',b', T, B…), ν_R, leptoquarks, diquarks, Higgses, etc.

SUPPERSYMMETRY

sleptons, squarks, stops, gluinos, etc…

COMPOSITENESS

excited states of known particles (l^*, q^*, Z^*, W^*,…), leptoquarks, etc…

DARK MATTER

TECHNICOLOR

new composite particles: techni-hadrons (ρ_{TC}, η_{TC}, etc…), leptoquarks, $T_{5/3}$,…

HIDDEN/DARK SECTOR

dark photons, hidden particles, stealth-susy-particles etc...

Experimental Approach:

Search for any deviations from Standard Model predictions

Direct observation:
new (e.g. Exotic) resonant or
non-resonant structures

LOOK FOR SIGNATURES MADE OF BASIC OBJECTS

Jets, b-jets, E_T^{Miss}

Bosons (γ, W, Z)

Leptons (e, μ, τ)

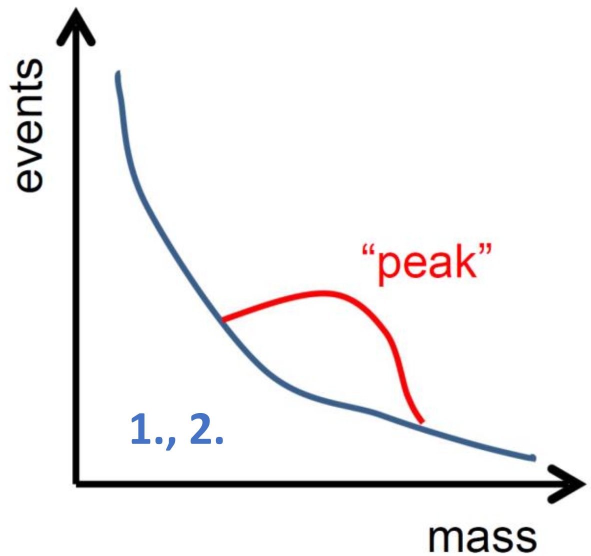
Unconventional Particles

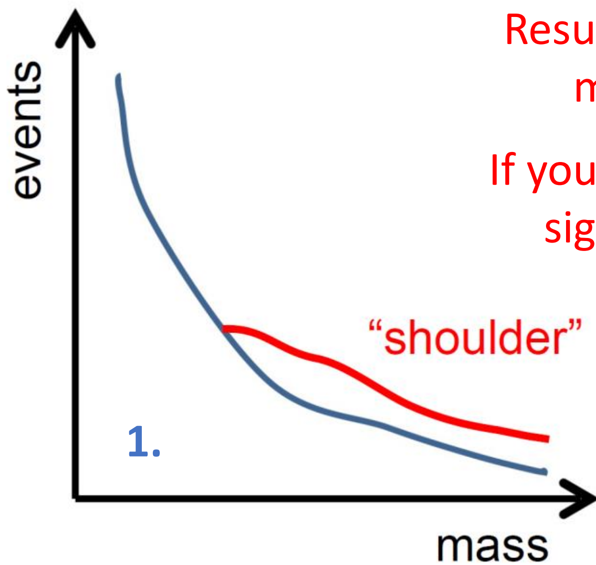
AS MANY SIGNATURES AS POSSIBLE

AS MODEL INDEPENDENT AS POSSIBLE

PROVIDE BENCHMARK MODEL RESULTS

Signature-Based Searches





Caveat:

Need signal-shape hypothesis
Results are not completely model-independent

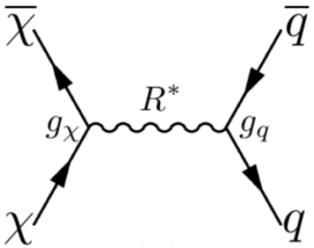
If your model does not have signal shape as studied tricky to interpret

To estimate background:

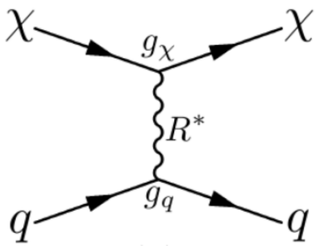
1. Detailed simulations of mass-spectrum shape
2. Smooth functional form fitted from data

Dark Matter searches

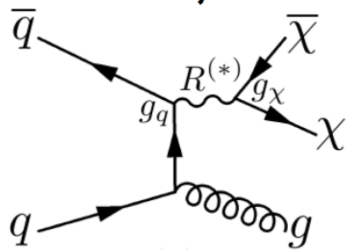
indirect detection



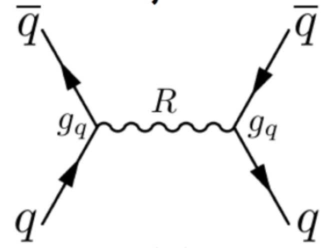
direct detection



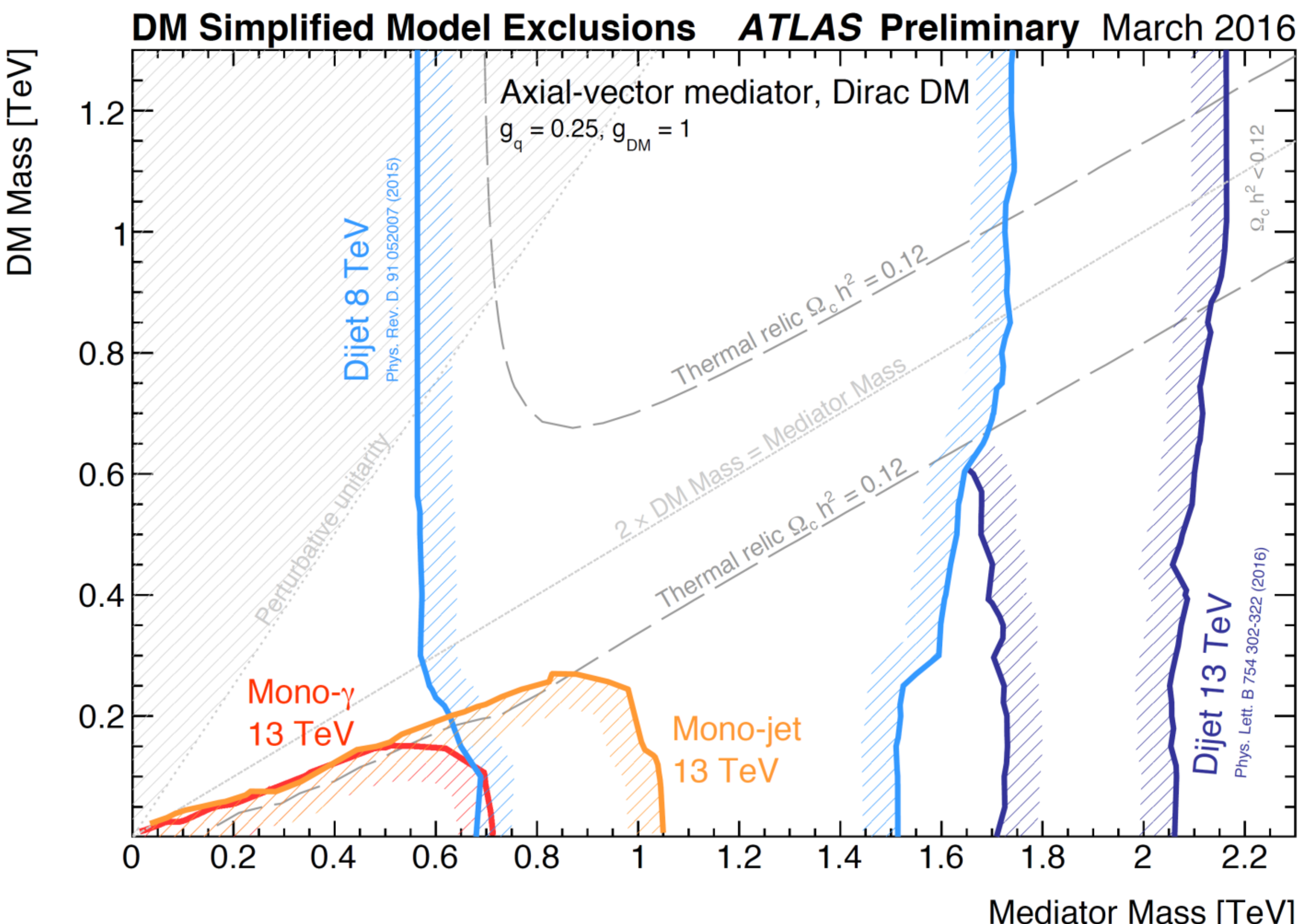
mono-jets



di-jets



s-channel simplified models
4 free parameters:
m_χ, m_R, g_q, g_χ

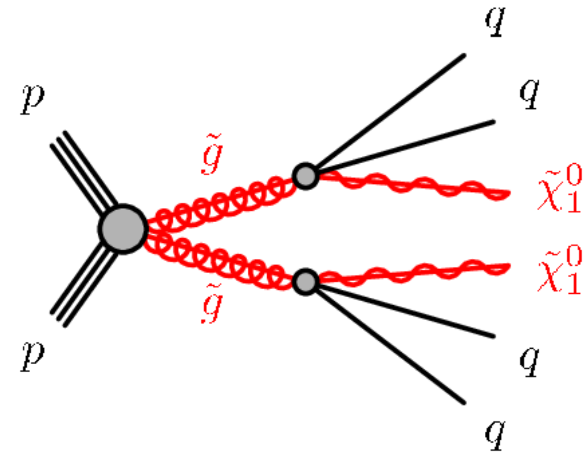


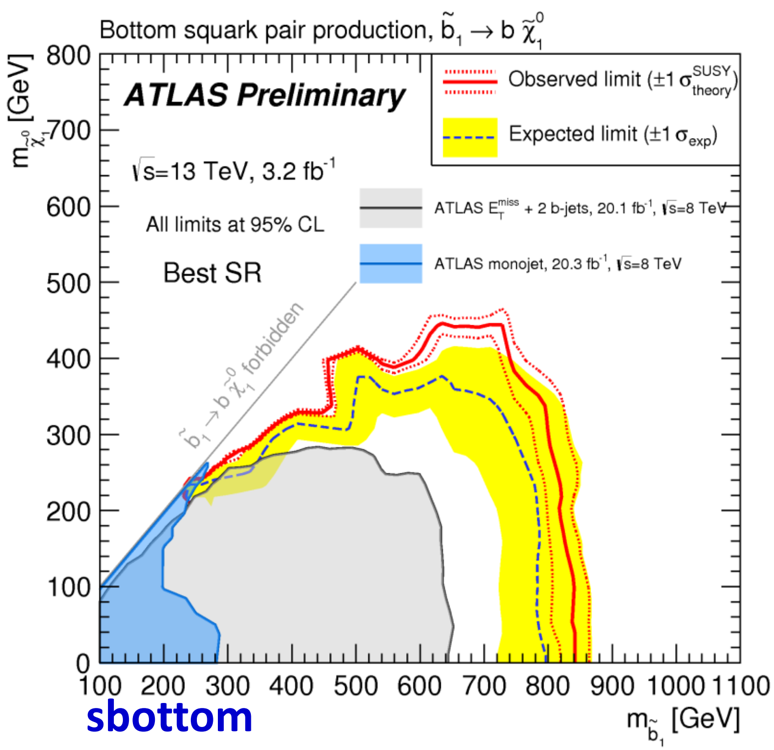
SUSY searches: jets+MET

ATLAS-CONF-2015-062
ATLAS-CONF-2015-066
ATLAS-CONF-2015-067
ATLAS-CONF-2015-077

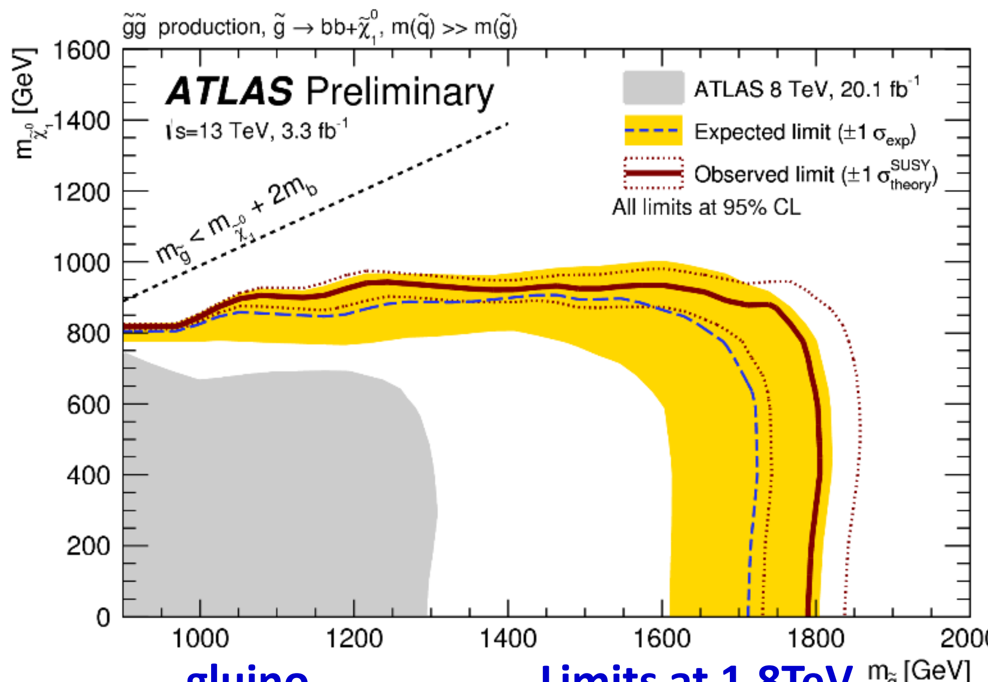
Searches for squarks and gluinos

- Many regions depending on jet multiplicity, number of b-jets
- Increasing complexity of decay chain
- Sensitivity to sbottom quarks
- No excess found





sbottom

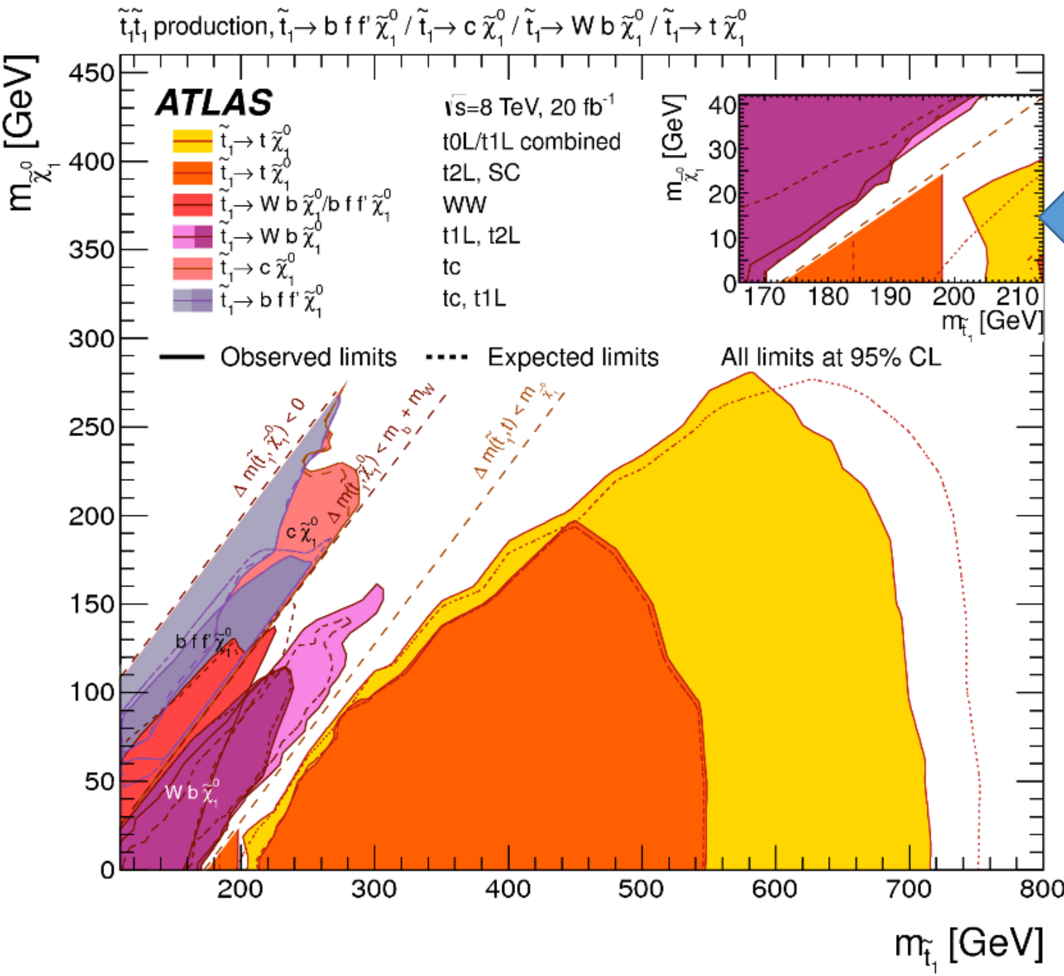


gluino **Limits at 1.8TeV**

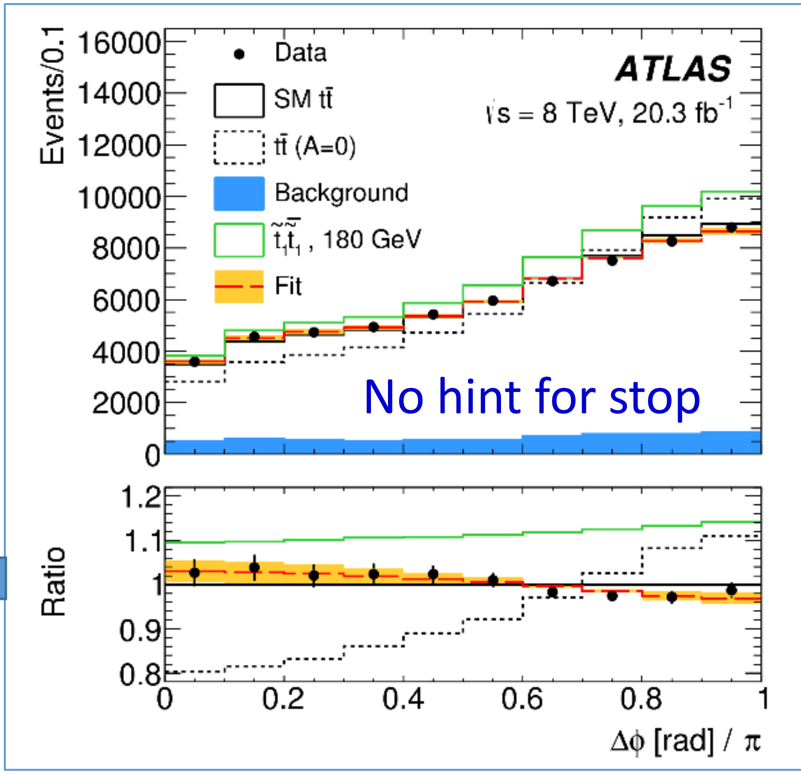
SUSY searches: stop

Searches are done in every corner.

Top property measurements are used for complimentary exclusion



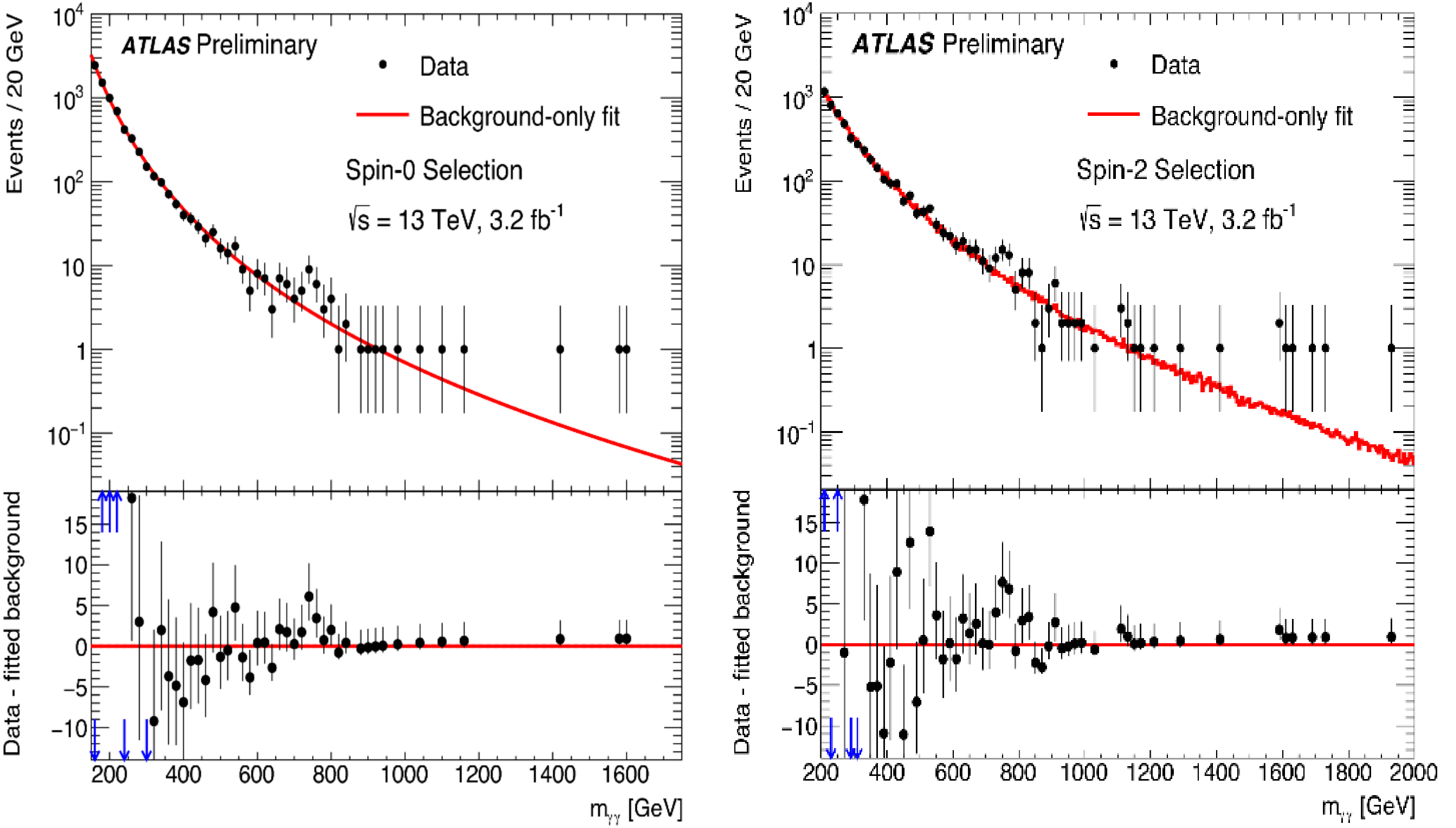
Top spin correlation measurement



Phys. Rev. Lett. 114, 142001 (2015)

Note that most SUSY limits assume signal BF of 100% so in reality exclusions could be weaker than plotted.

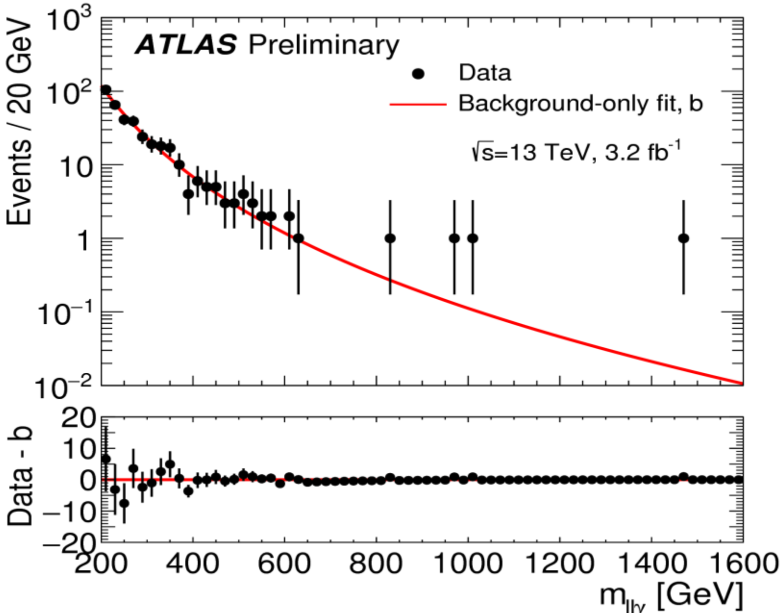
Diphoton Searches

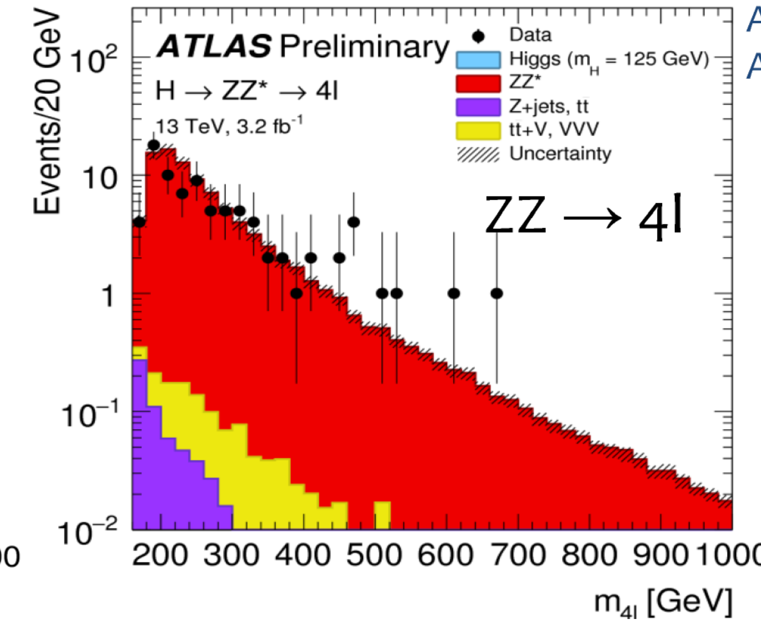


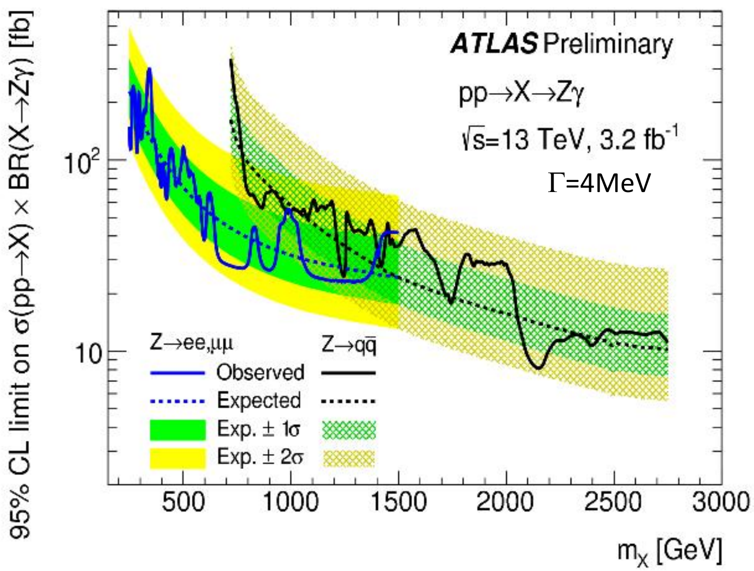
More details in N. Berger's talk on Thursday

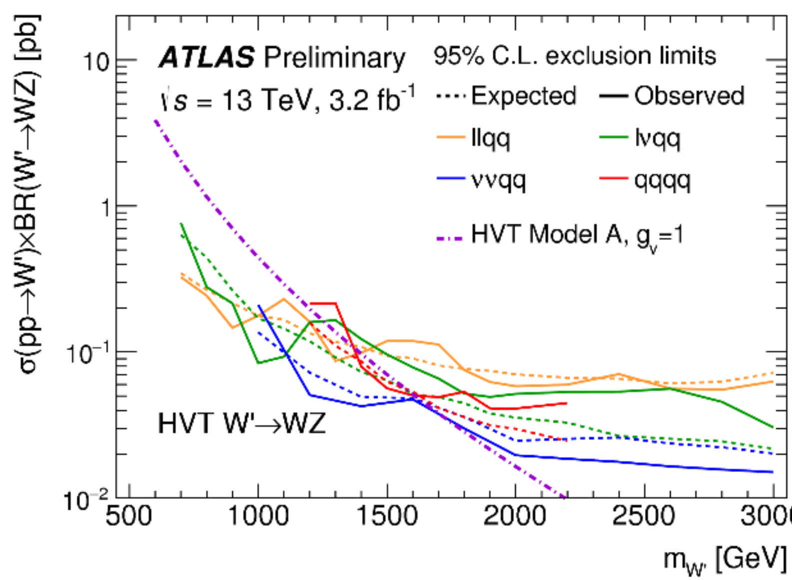
Other di-boson channels

ATLAS-CONF-2015-068
ATLAS-CONF-2015-071
ATLAS-CONF-2015-073
ATLAS-CONF-2015-074
ATLAS-CONF-2015-075



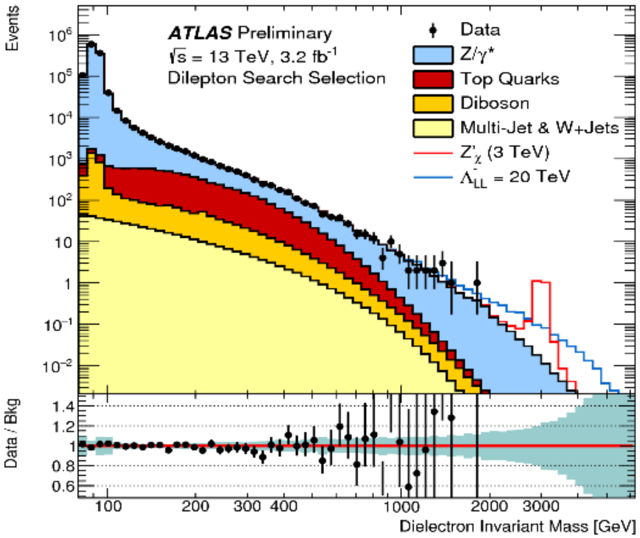


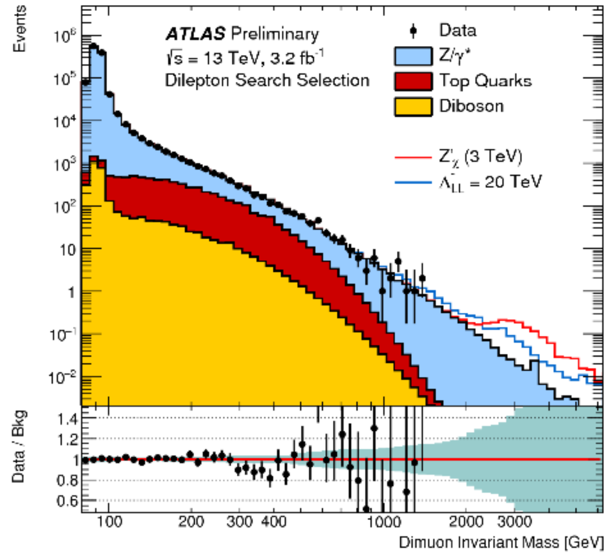


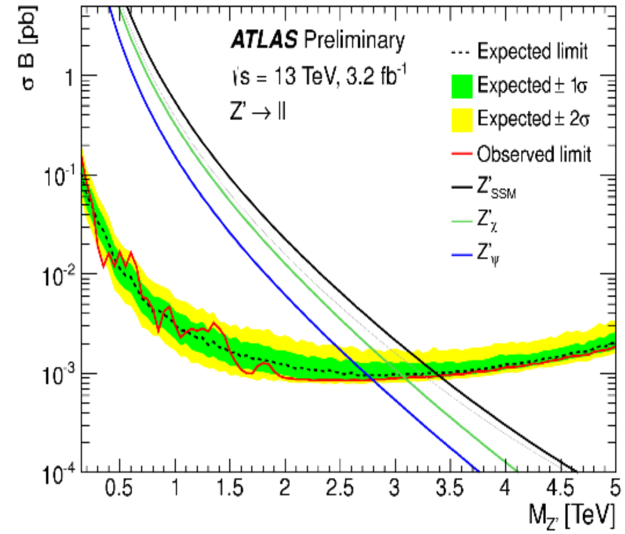


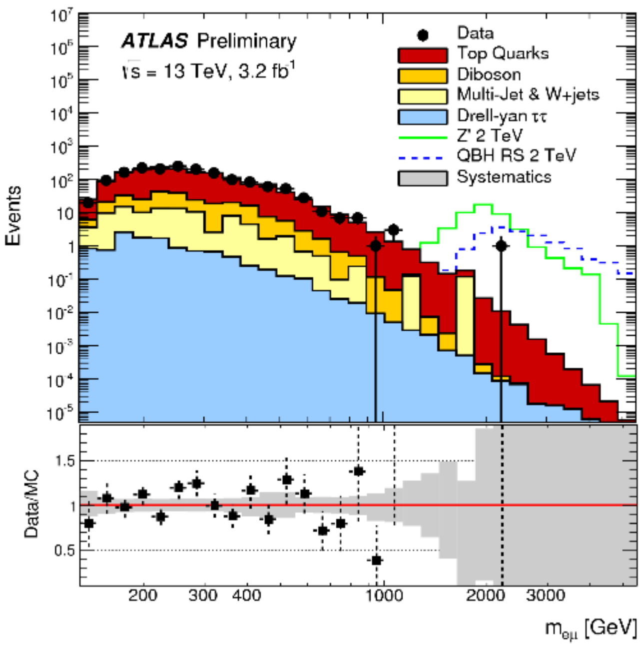
Dileptons

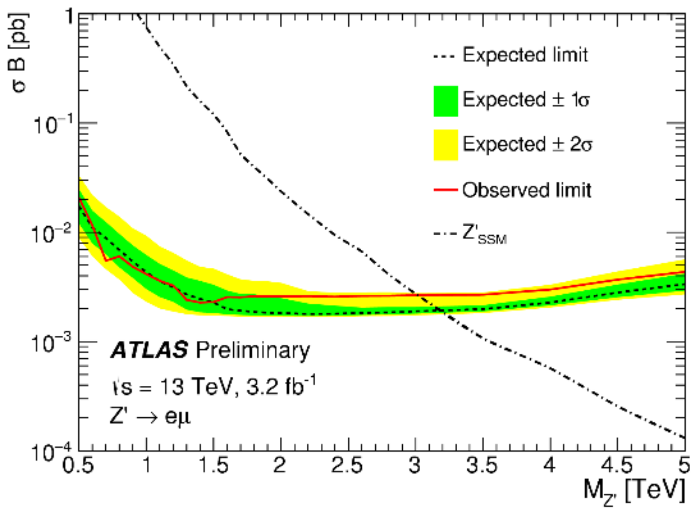
ATLAS-CONF-2015-070,
ATLAS-CONF-2015-072









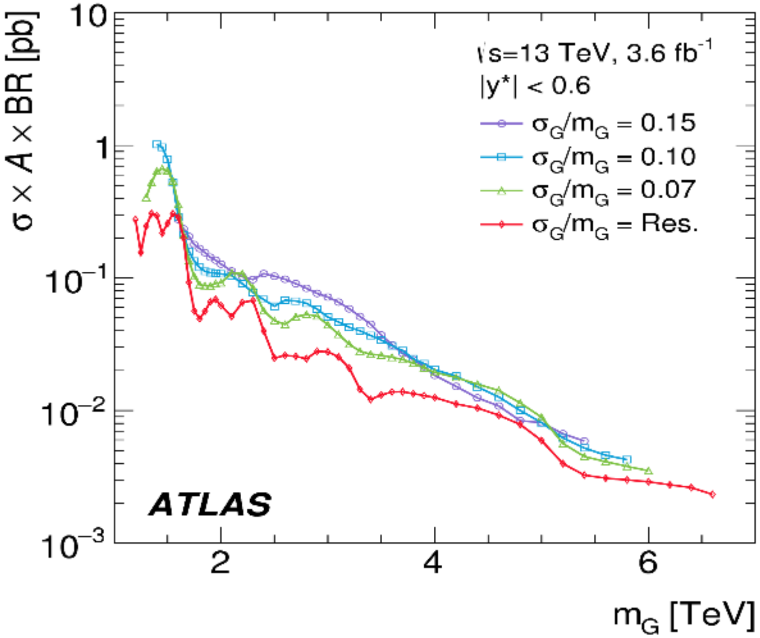


No excesses seen.

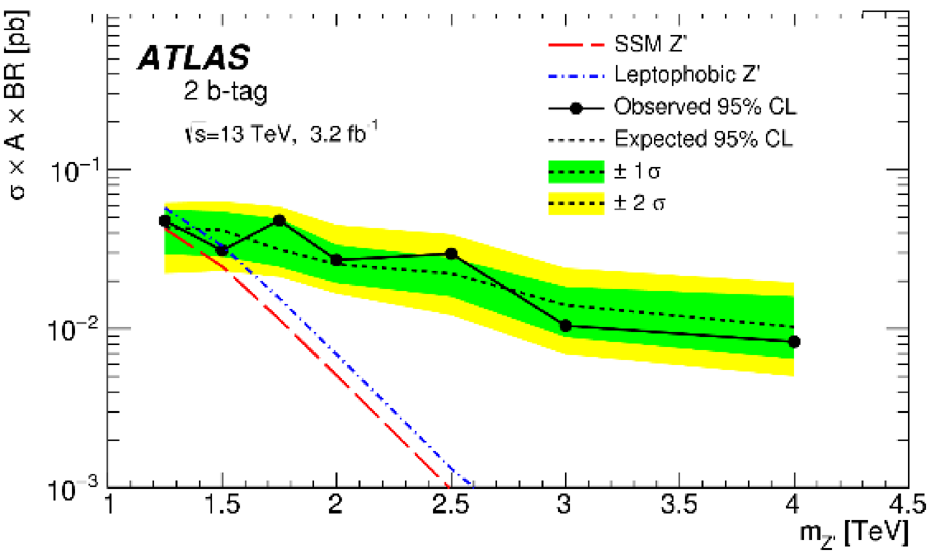
Cross-section limits for same flavor close to $\gamma\gamma$ ones.

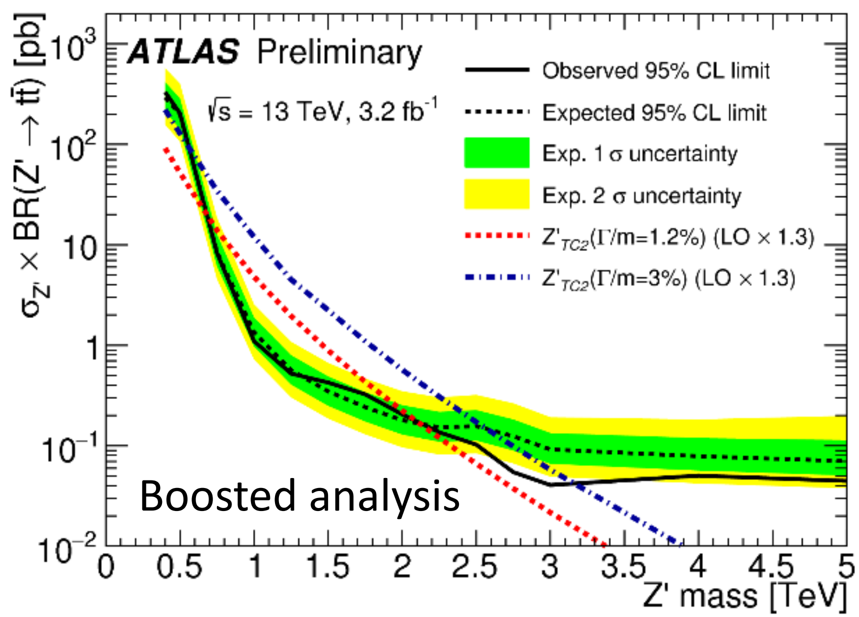
“Di-jet” searches

ATLAS Physics Letters B 754 (2016) 302-322
ATLAS-CONF-2016-014, arxiv:1603.08791



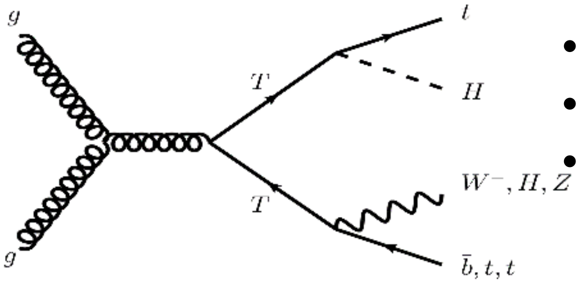
- No excesses seen in dijet channels
- Backgrounds are very high, leading to weak limits
- Very limited sensitivity at masses below 1TeV, need to wait for
  - trigger level analysis for dijets
  - resolved analysis for ttbar
  - and much more data



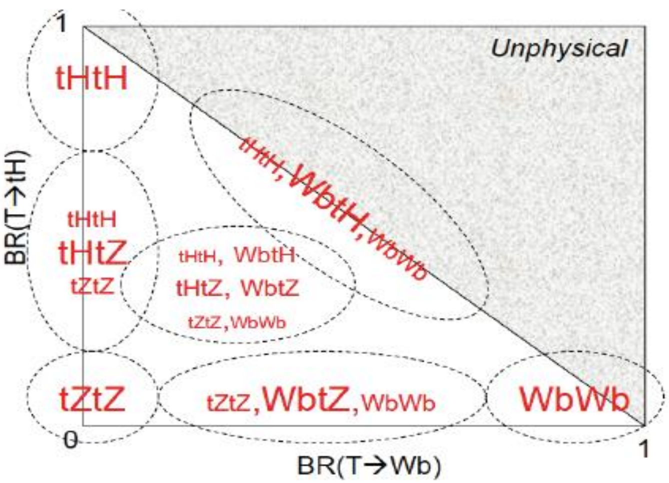


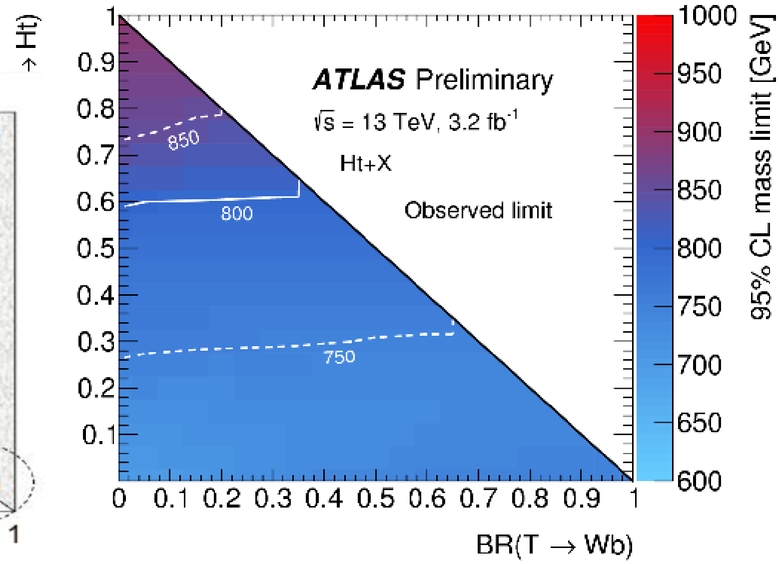
Heavy Vector-Like-Quarks

ATLAS-CONF-2016-013



- Appear in BSM theories with strong EWSB
- same EW charges for LH and RH components
- T stabilizes Higgs mass divergence (like stop in SUSY)





No excess of events seen in leptons+jets channel.

ATLAS: m(T)>900GeV @ BR(T→Ht)=100%

- As the limits for VLQ are already high, rather unusual VLQs (e.g. with large electric charges) need to be considered
- the limits for VLL are weaker → interesting area to explore

Where did we look in Run 1 & Run 2?*

↓,→	jet	bjet	top	γ	W,Z	lepton	Higgs	E^T_{Miss}
jet	Many	1,1	1,1	1,1		Many, 1-3		Many
bjet		2-4	1,1		1,1	2,2	1,1	1-2
top			2-4		1,1	2,2	1,1	1
γ				2-4	1,1	1,1		1
W,Z					2	1,1	1,1	1
lepton						2-4		1
Higgs							2	1
E^T_{Miss}								Done

A large fraction of conventional signatures are covered (but not all!), unconventional signatures are important.

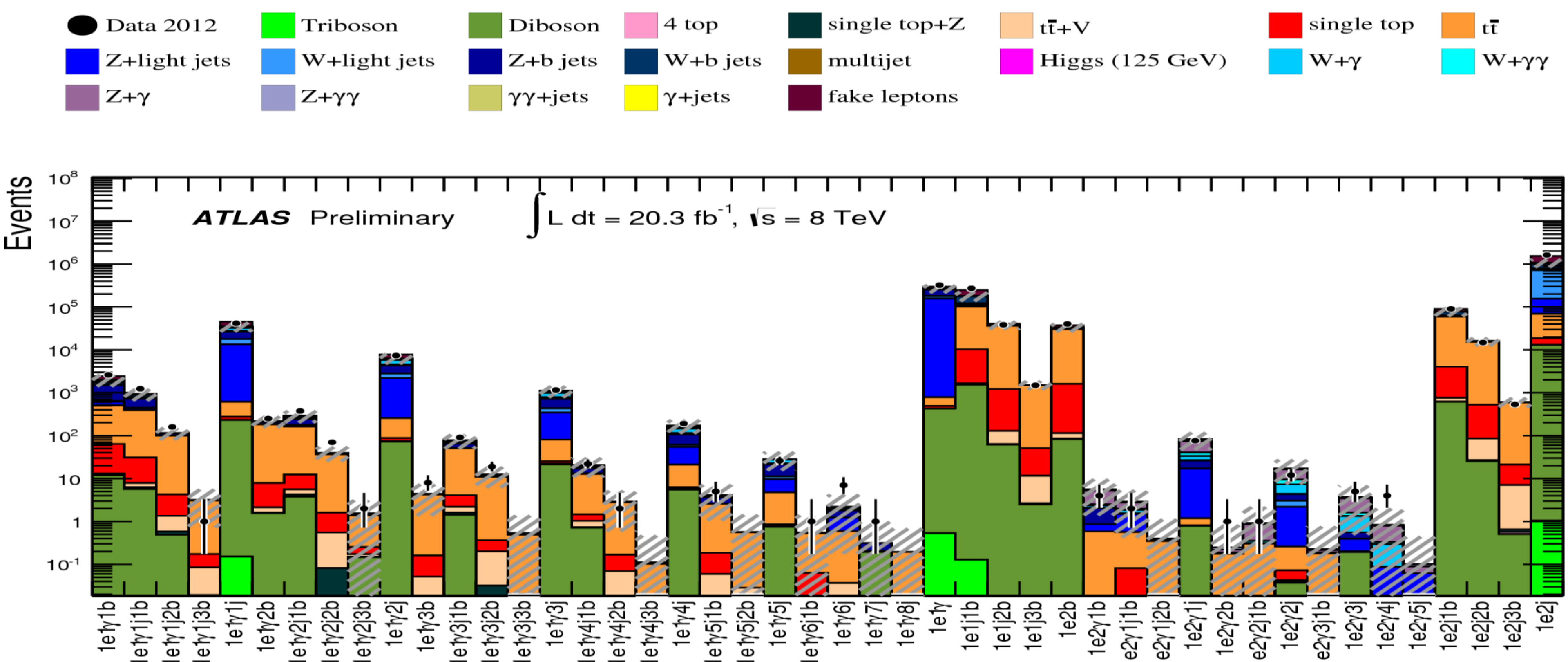
*This table is not exhaustive

General Search

ATLAS-CONF-2014-006

No evidence for New Phenomena Seen!

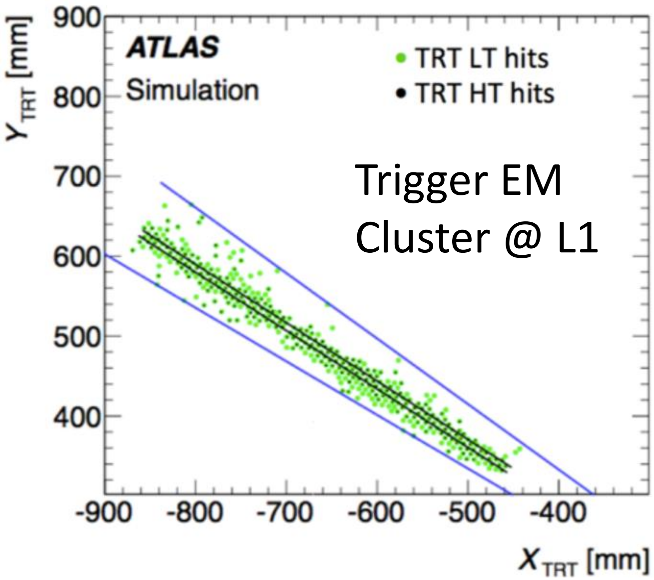
- A search based on combinations of high-p_T objects (e, μ, γ, ν, jet, bjet)
- Standard Model backgrounds from MC only
  - 573 categories have data events; 697 have >0.1 events in MC simulation
- Searches for largest data/MC variations (MC mis-modelling is a problem)
- Need dedicated analysis if discrepancy is observed

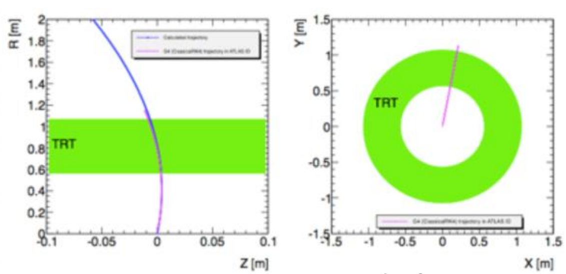


Unconventional Signatures @ LHC

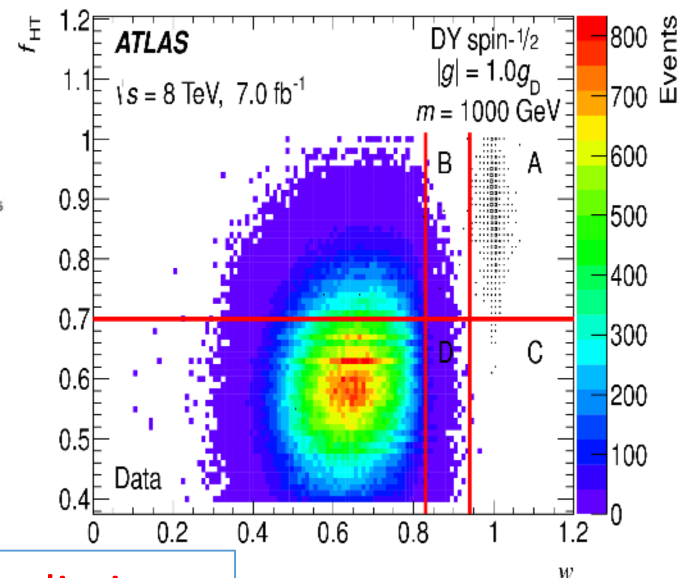
Analysis need dedicated reconstruction techniques & triggers.

- Low mass (pseudo)scalars
- Highly ionizing particles (HIP) / monopoles
- Charged particles decaying into heavy neutral particles (disappearing tracks, kinks etc.)
- Long-lived particles decaying only in the outer detector components
- Boosted final states: objects close together or overlapping
- Neutral particles (delayed photons) decaying late into neutral states
- …





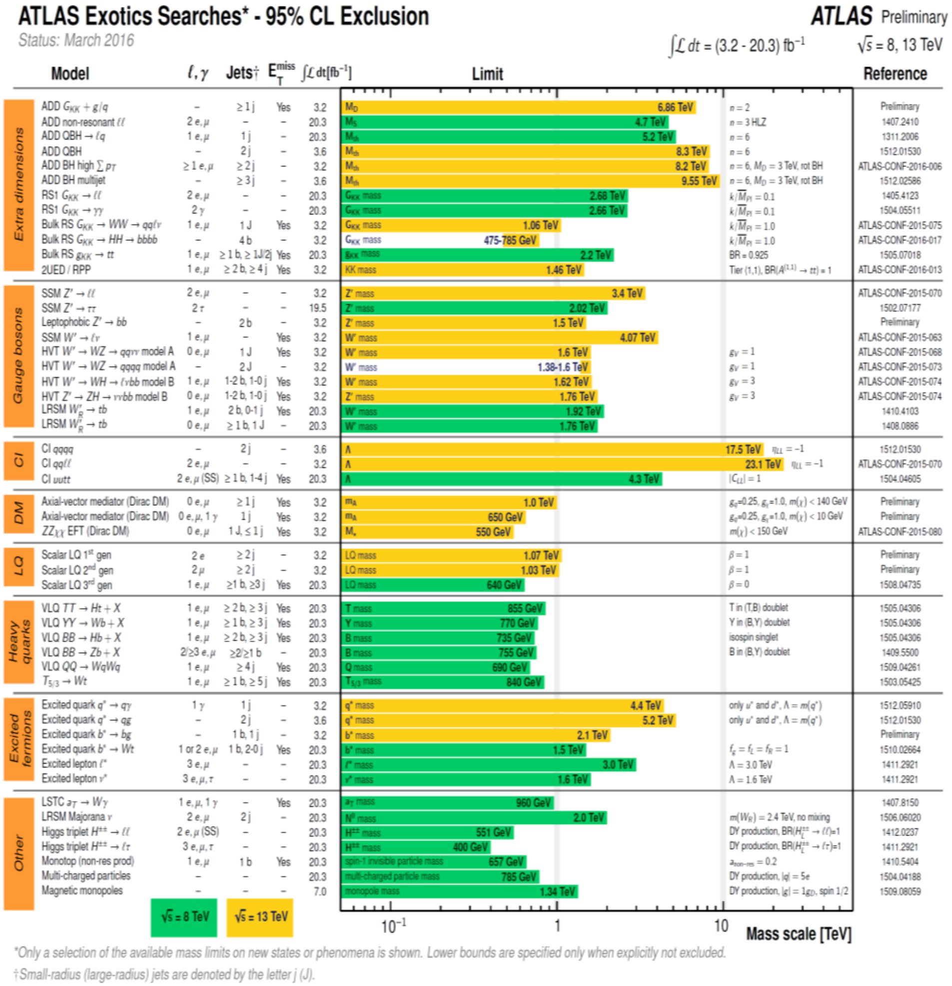
Some model dependence inevitable: Monopoles bend in r-z plane ⇒ use TRT-hit information

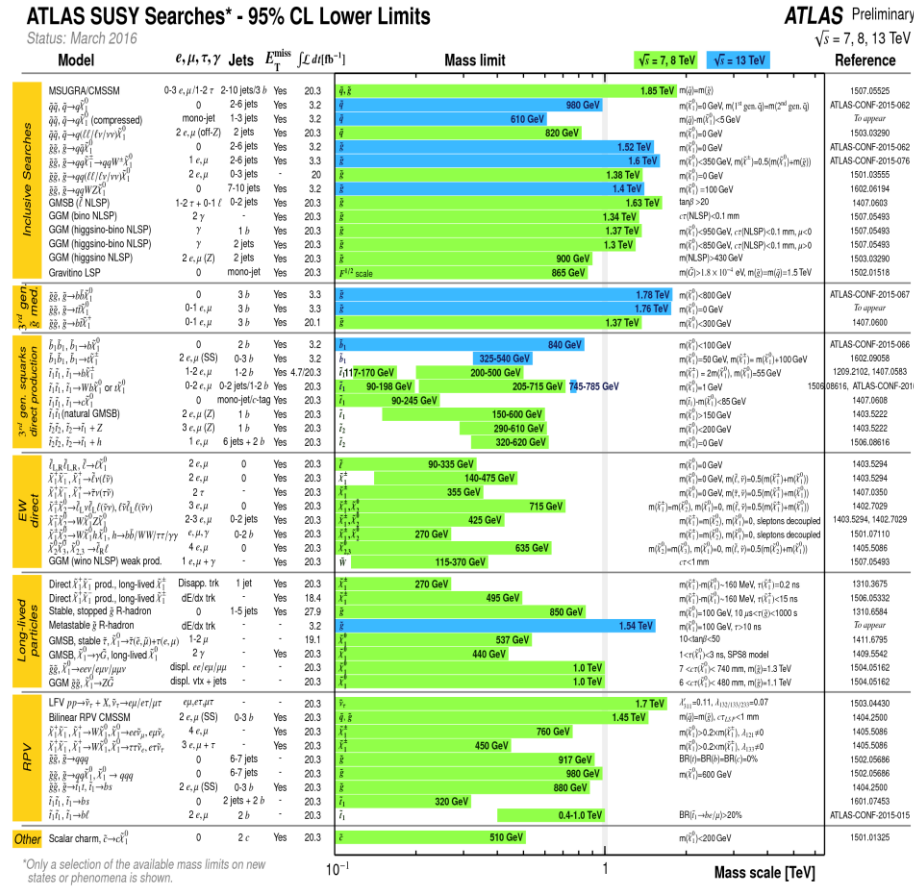


[PRD 93, 052009 (2016)](#)

Results consistent with SM predictions.

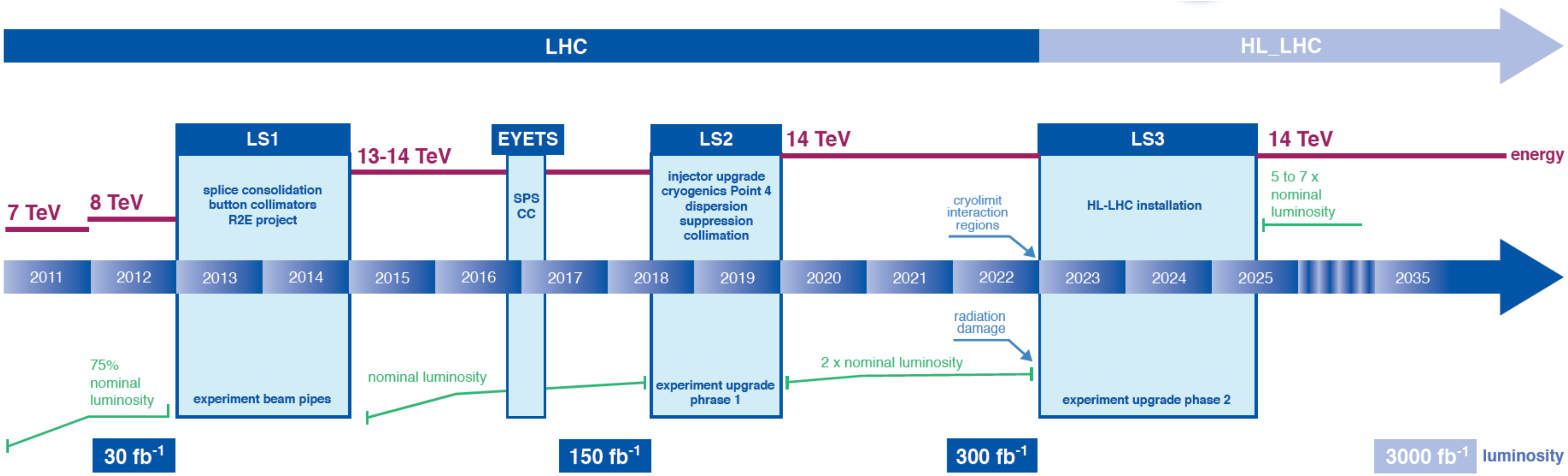
A lot of results available…





Many limits are reaching 1TeV and beyond.

Outlook



- We are in regime of non-linear luminosity increase
  - 2016 dataset = 6 x 2015 dataset!
- Stay tuned to 2016 results

Acknowlegements

All information used for this talk can be found at:

https://twiki.cern.ch/twiki/bin/view/AtlasPublic/

This talk derived inspiration and images from the following talks:

Frank Wilkenmeier & Hernan Wahlberg @ HEP in LHC era January 2016

Brigitte Vachon @ CNPLHC 2016

Nicolas Venturi & Martin Flechl @ LHCski, April 2016