



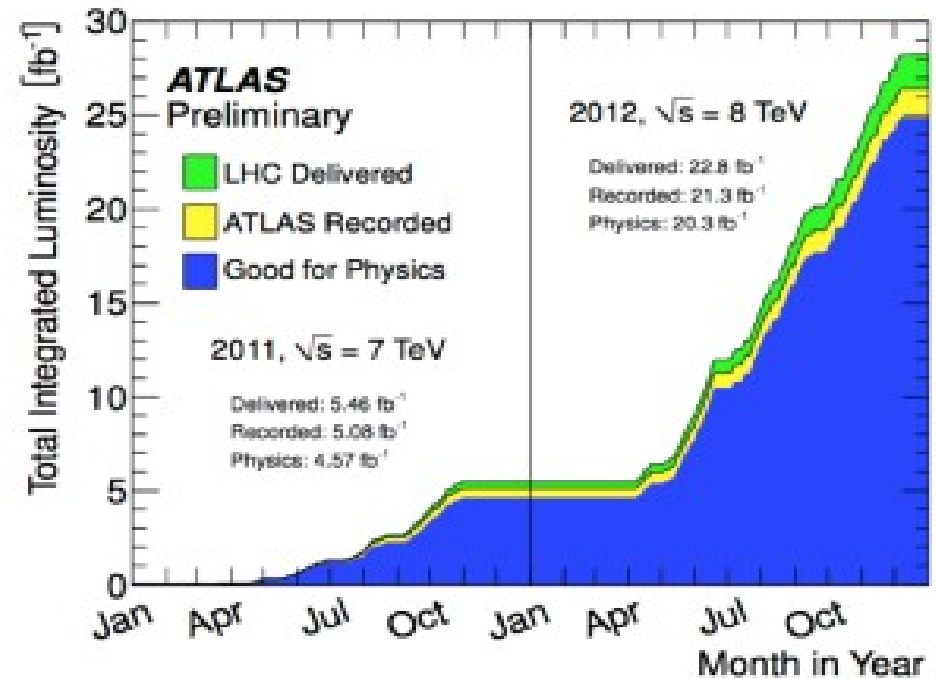
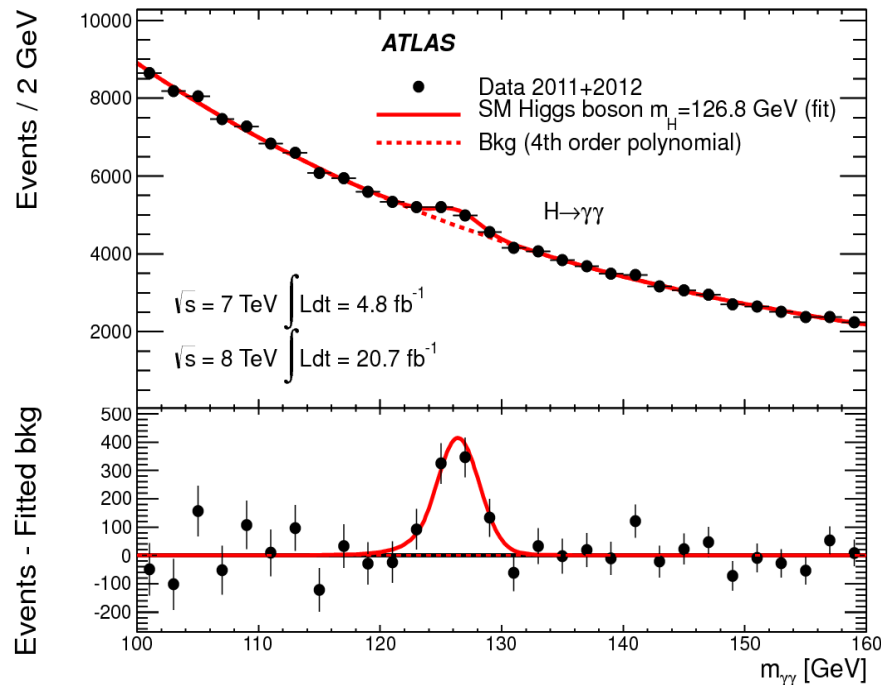
# Prospects for finding Leptoquarks and other lepton+X signatures with the first Run-II Atlas data

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Athens

# Run I ended successfully

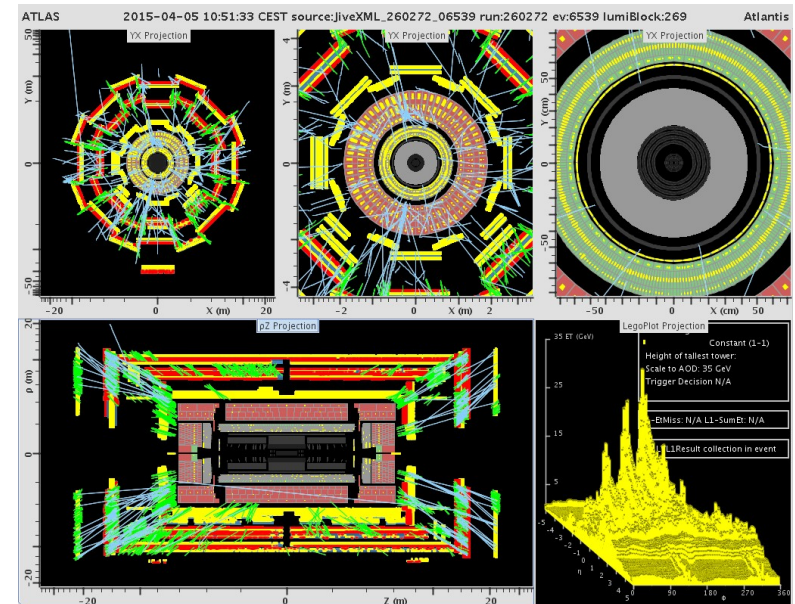
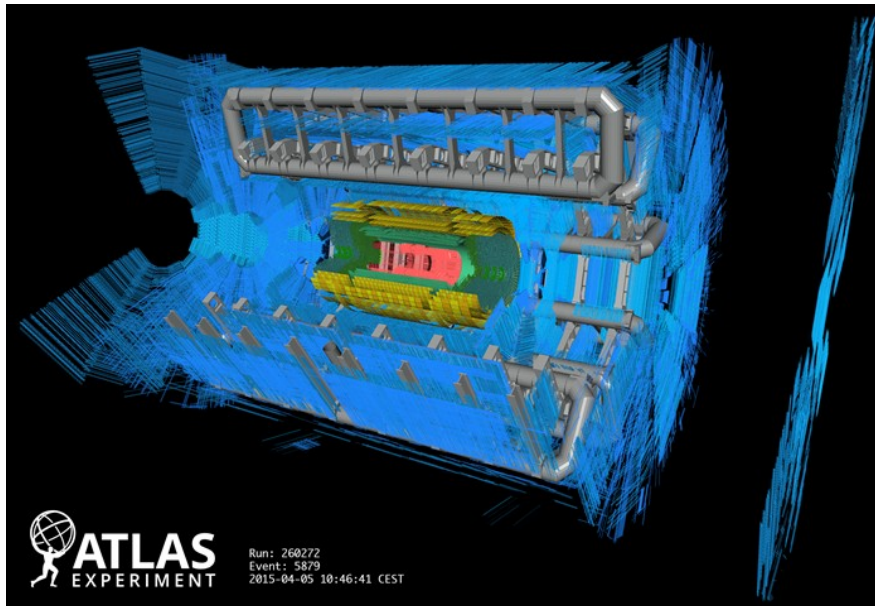
ATLAS recorded ~all collisions

- > 90% ended in physics papers
- $0.05 \text{ fb}^{-1}$  (7 TeV, 2010)
- $4.6 \text{ fb}^{-1}$  (7 TeV, 2011)
- $20.6 \text{ fb}^{-1}$  (8 TeV, 2012)



Higgs discovery is the highlight but many other interesting results were announced in the more than 350 published all these years!

# A new season started

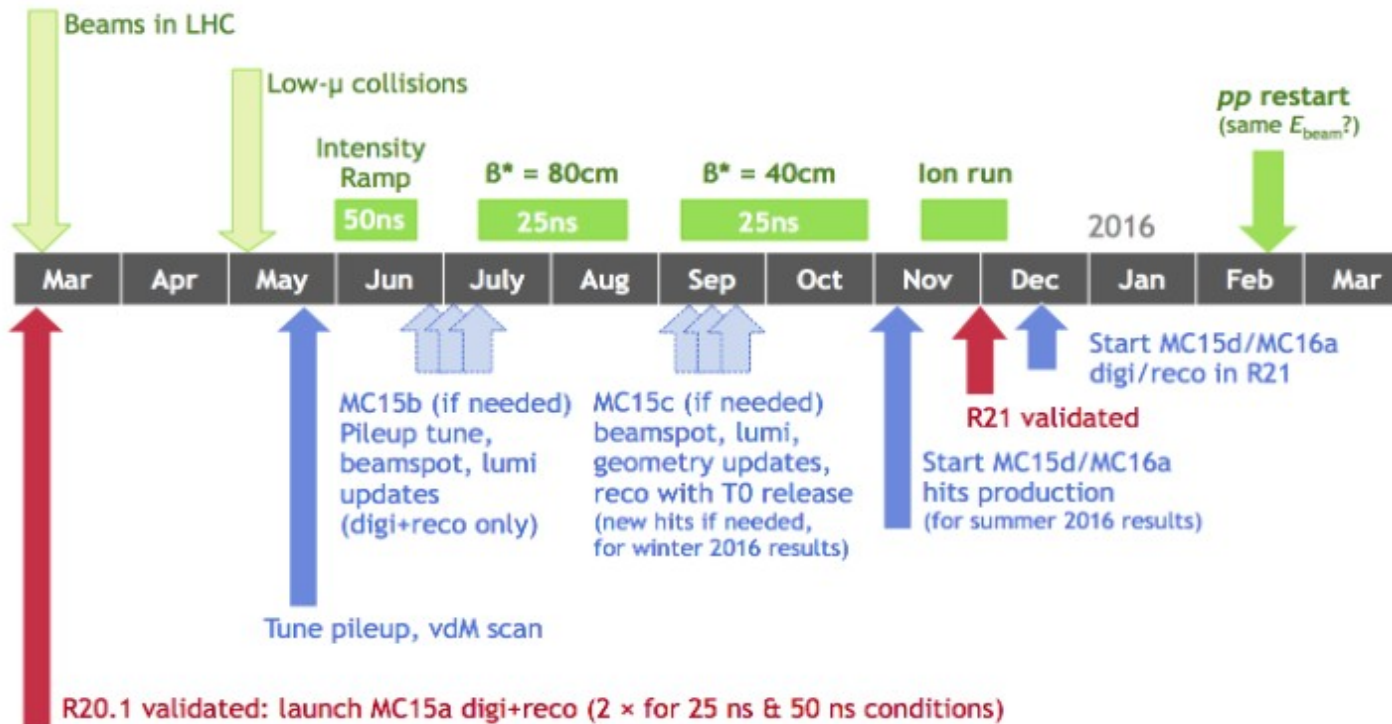


April 5, after two years beams were injected at LHC!

# 2015 data taking plan

## Schedule Reminder

All the fun stuff goes here



[https://twiki.cern.ch/twiki/bin/viewauth/AtlasProtected/Run2OfflineSchedule#Schedule\\_Highlights](https://twiki.cern.ch/twiki/bin/viewauth/AtlasProtected/Run2OfflineSchedule#Schedule_Highlights)

4 Feb 2015

Z Marshall - MC15

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10 fb<sup>-1</sup> of 13TeV data are expected to be collected by ATLAS detector during 2015.

~3 fb<sup>-1</sup> of them by the end of summer.

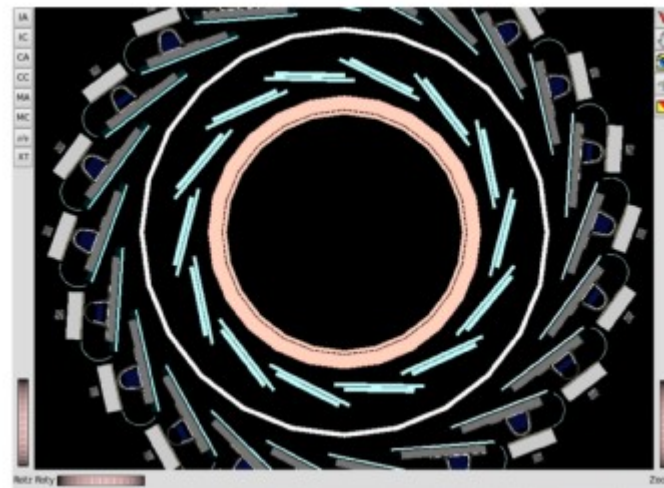
Is this enough statistics to supersede Run I results?



# Is ATLAS ready for the new beams?

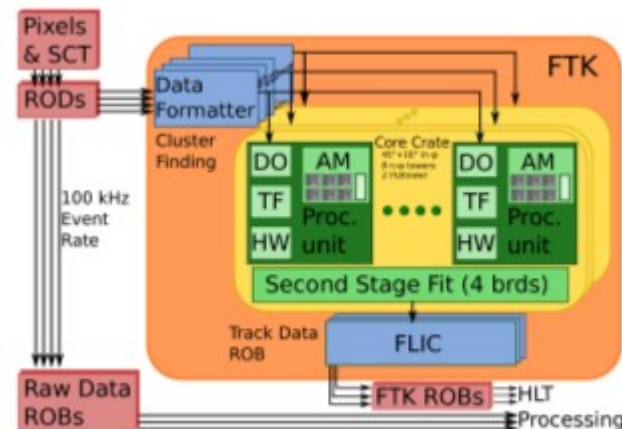
## Insertable b-layer (IBL) pixel detector

- Additional layer of pixels
- Built/Installed during 2013-2014
- Improved radiation tolerance (will survive to  $300 \text{ fb}^{-1}$ )
- Improved impact parameters
- Improve b-tagging



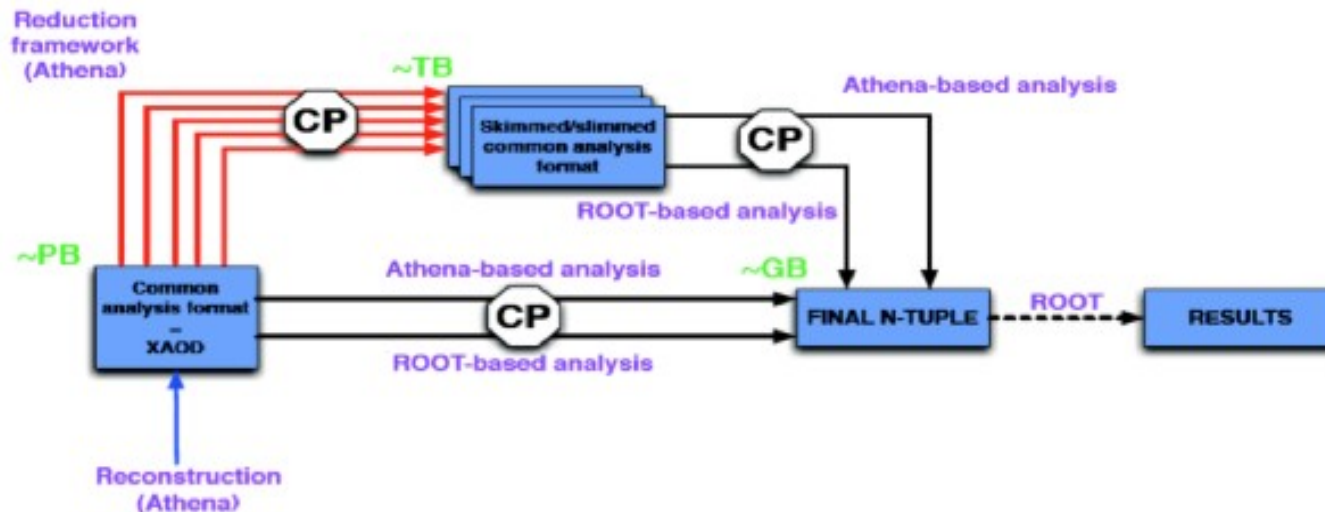
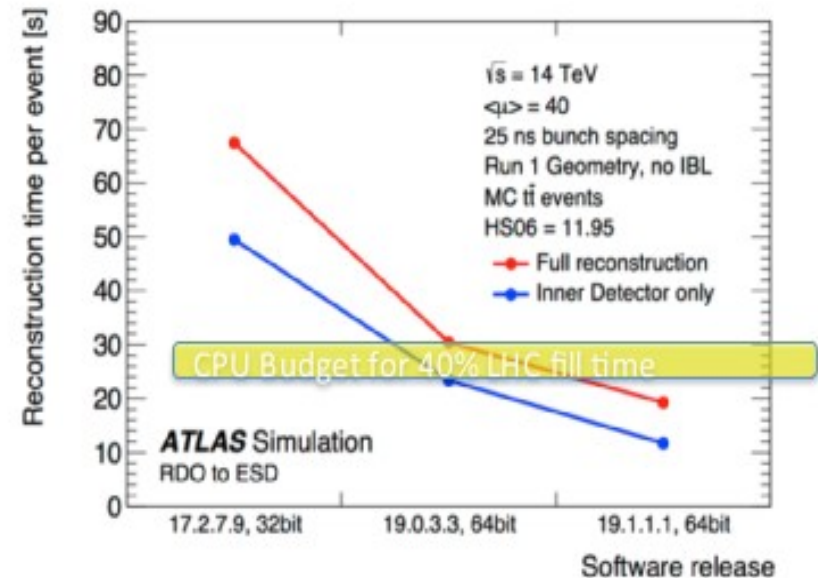
## Fast Track Trigger (FTK)

- As luminosity increases, trigger must become more selective
- Push global tracking to Level 1 (100kHz)
- Receives all SCT/pixel hits
- Compute helix parameters
- Provides full track fit for electron muon trigger decisions
- Key to maintain single lepton pt thresholds



# Computer, Software and Analysis

- Physics algorithm and mathematical fitting changes
  - Factors of 3+ improved speed
  - Robustness against pileup
- Root readable mini-DSTs
- Reducing disk usage
  - Computing may limit analysis



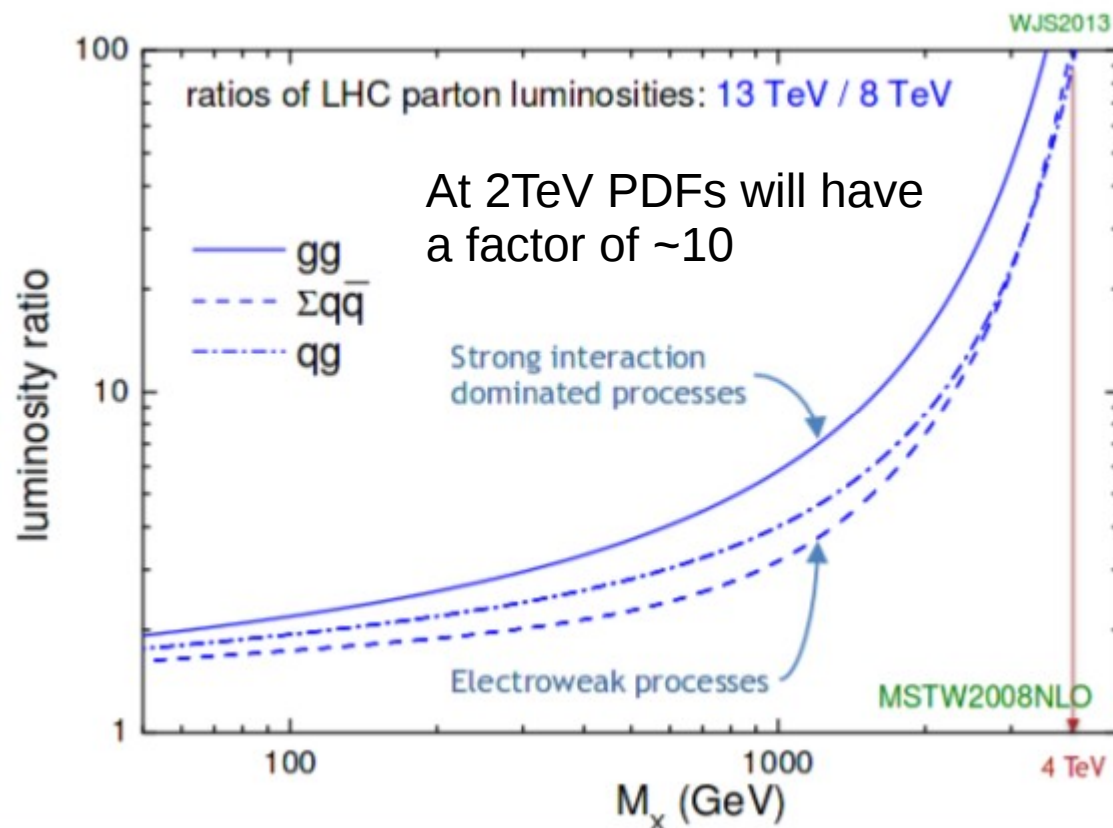
# Prospects for exotic searches in Run-II

## LHC Run II

- Larger energy (13TeV)
- More intense beams

Access processes with smaller crosssections and higher mass!

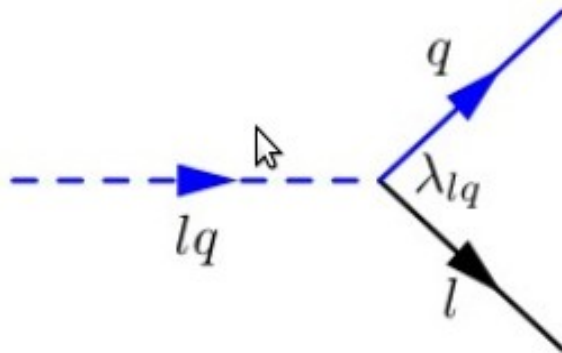
$\frac{\sigma(\sqrt{s}=13\text{ TeV})}{\sigma(\sqrt{s}=8\text{ TeV})}$	gg	$\Sigma q\bar{q}$
$M_X = 1\text{ TeV}$	~6	~3.5
$M_X = 2\text{ TeV}$	~15	~7
$M_X = 3\text{ TeV}$	~50	~25
$M_X = 4\text{ TeV}$	~400	~100



We can have a closer look beyond the Standard Model!

# Leptoquarks and their decays

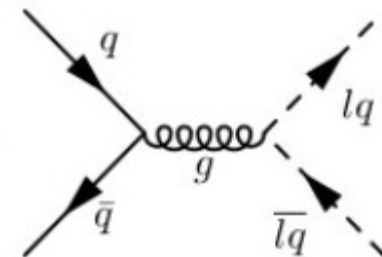
- leptoquarks (LQ) are hypothetical BSM bosons with non-zero baryon and lepton numbers as a possible connection between quarks and lepton. They appear as a consequence in many theories beyond Standard Model
- they can decay to a lepton and a quark of the same generation (constraints from flavor changing neutral currents)



## free parameters

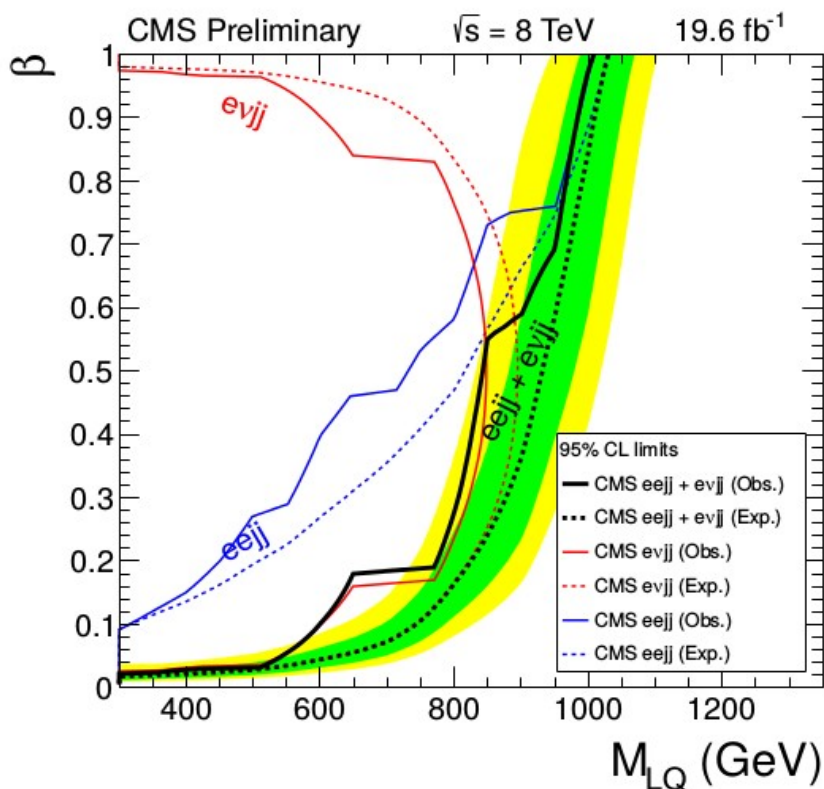
- ♦  $\lambda$  Yukawa coupling
- ♦  $\beta$  branching ratio
- ♦  $M_{LQ}$  LQ mass

- in LHC LQs could be produced mainly on pairs
- production cross-section on LQ pairs does not depend on Yukawa coupling





# Leptoquark results at 8TeV data

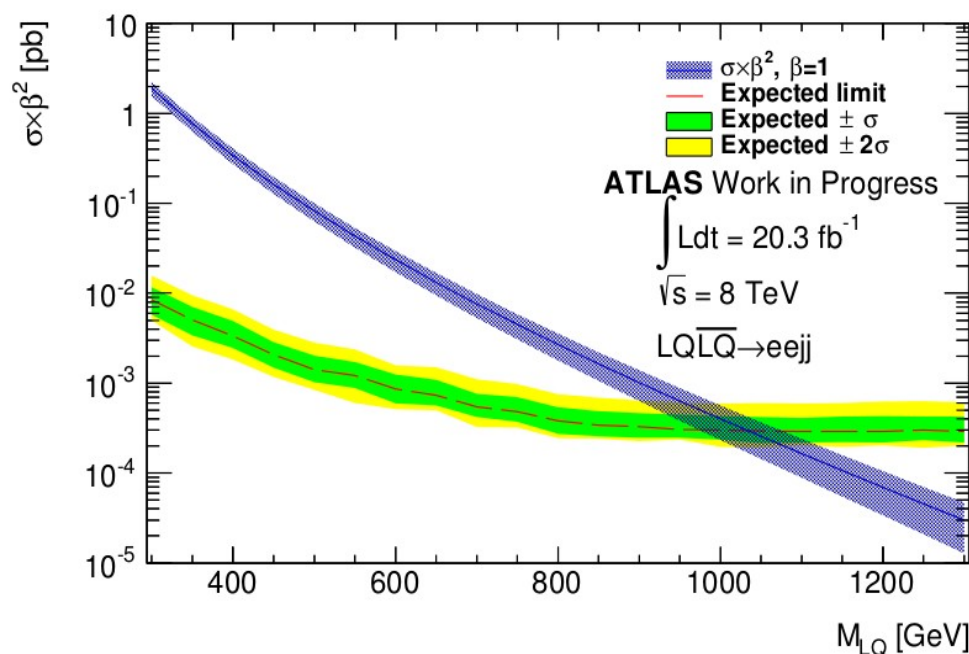


CMS observed an excess of  $ee(\nu)jj$  events looking for a LQ with a mass of 650 GeV ( $\sigma=2,4$ )

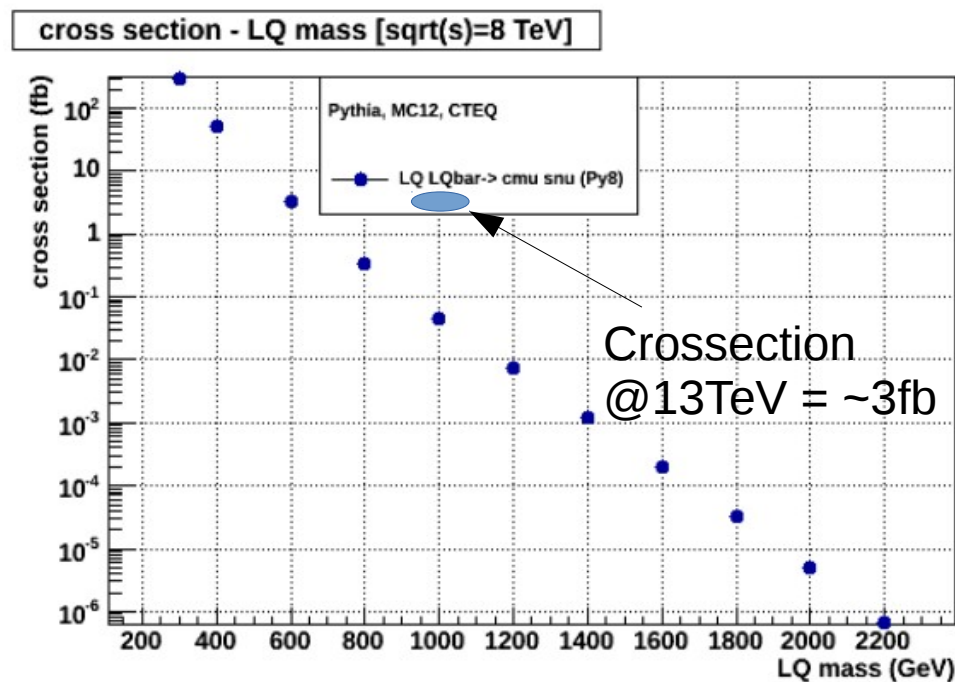
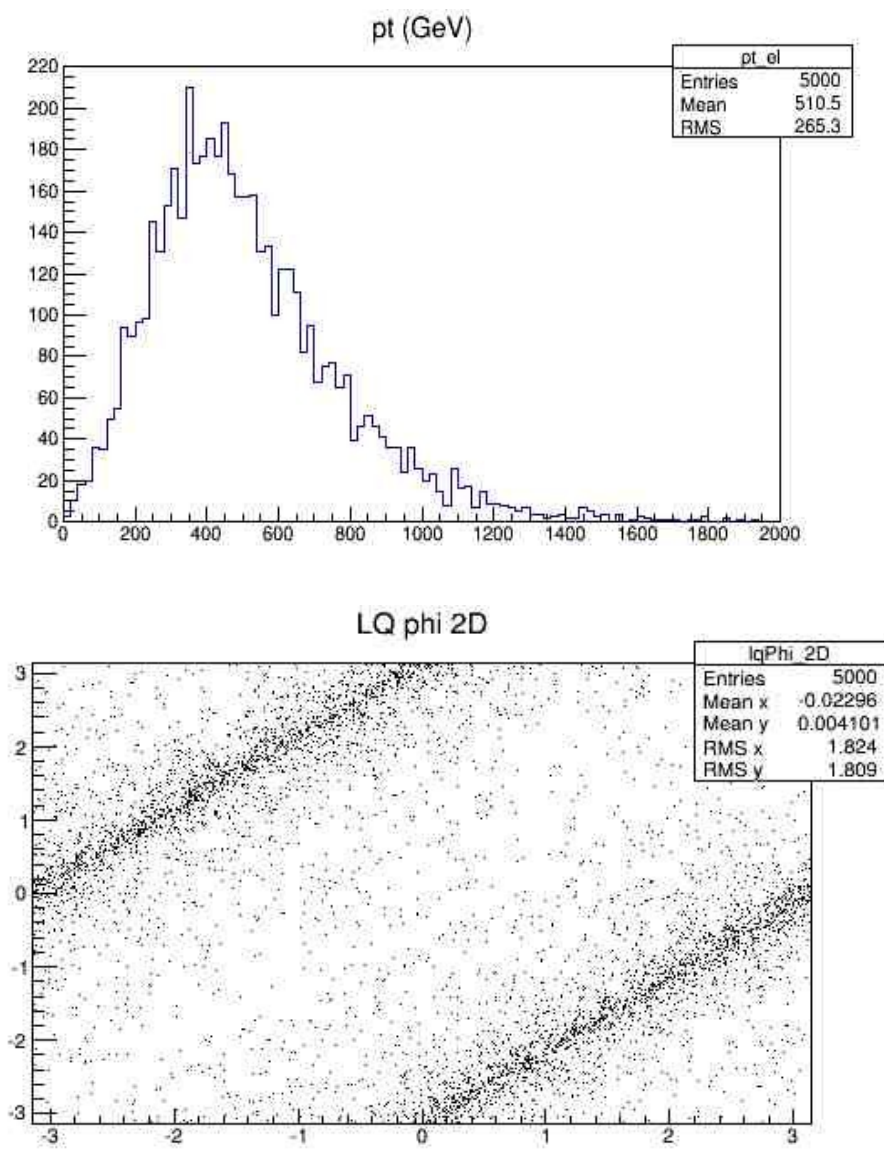
No similar excess found looking the second generation LQ decay

ATLAS hasn't released yet results on Lqs using 8 TeV data.

Expected limits (based only on MC) could be set up to 1TeV LQs if no excess is found.



# Leptoquarks at Run II



LQs will have larger production crosssection at 13TeV

Less luminosity needed to be observed if occur.

**LQLQ-> $\mu j$   $\nu j$ , 13TeV Pythia 8.186 PDF = CTEQ6L1 (truth variables)**<sup>10</sup>

# Leptoquarks at Run II

## Preliminary sensitivity study

- LQLQ- $\rightarrow \mu\mu jj$  channel
- Study based on Run I signal region results
- expected singal events calculated using the luminosity from Pythia8 @13TeV
- expected background events are the expected from RunI analysis normalized to the new crossections and luminosities (only Zmumu and tt used)

Zmumu	1,9 nb
ttbar	0,7 nb
LQ (500GeV)	314 fb
LQ (1TeV)	3,4 fb

**crossections**

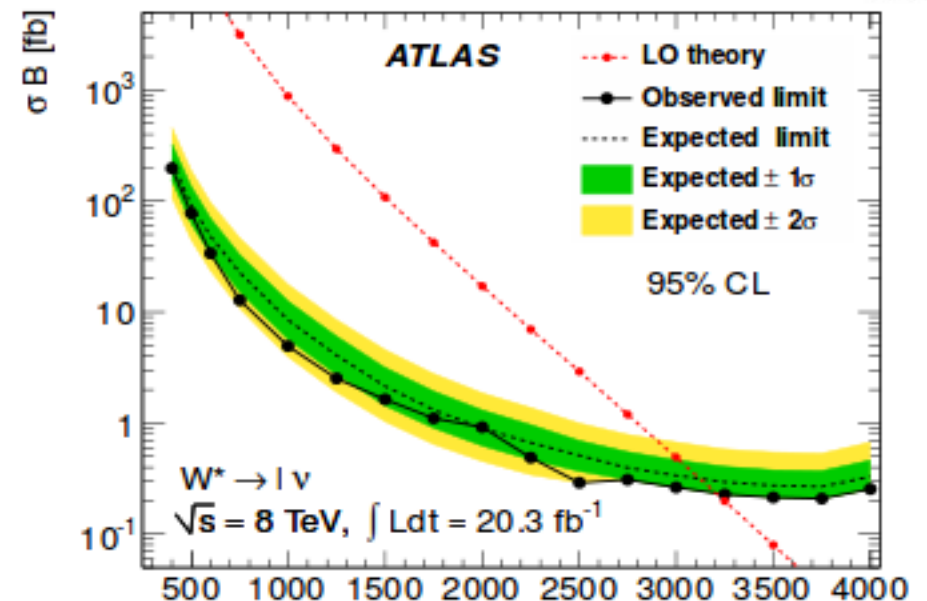
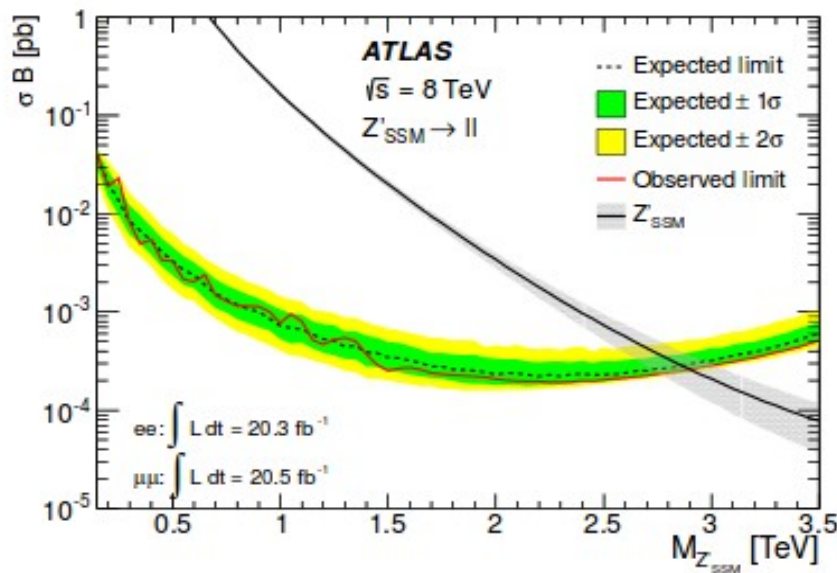
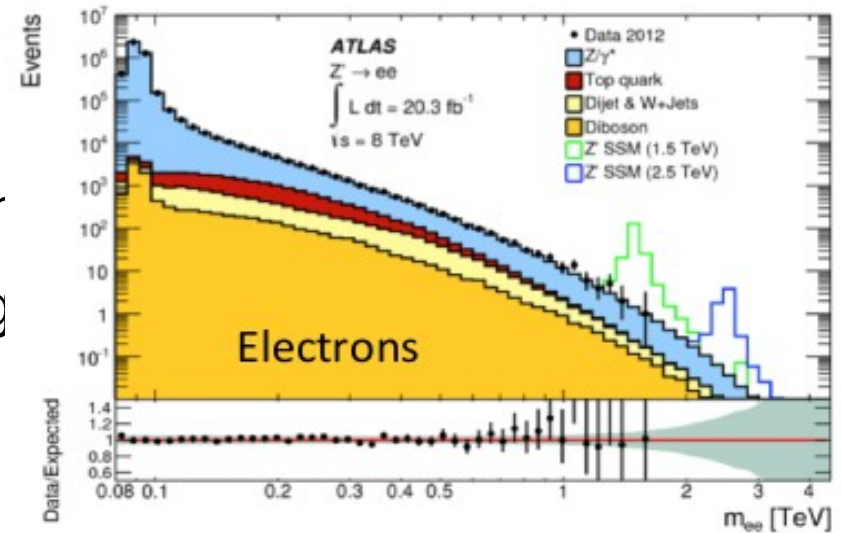
L\Mass	500 GeV	1000 GeV
1 fb <sup>-1</sup>	61	3
10 fb <sup>-1</sup>	193	9
30 fb <sup>-1</sup>	334	16
100 fb <sup>-1</sup>	610	30

**S/sqrt(B)**

Already with  $\sim 1\text{-}2 \text{ fb}^{-1}$  of 13TeV data can reach Run-I sensitivity

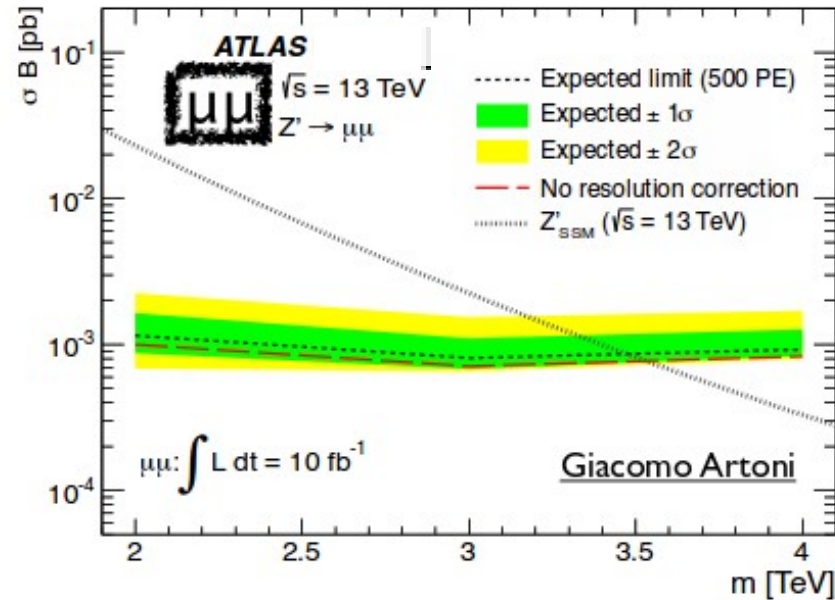
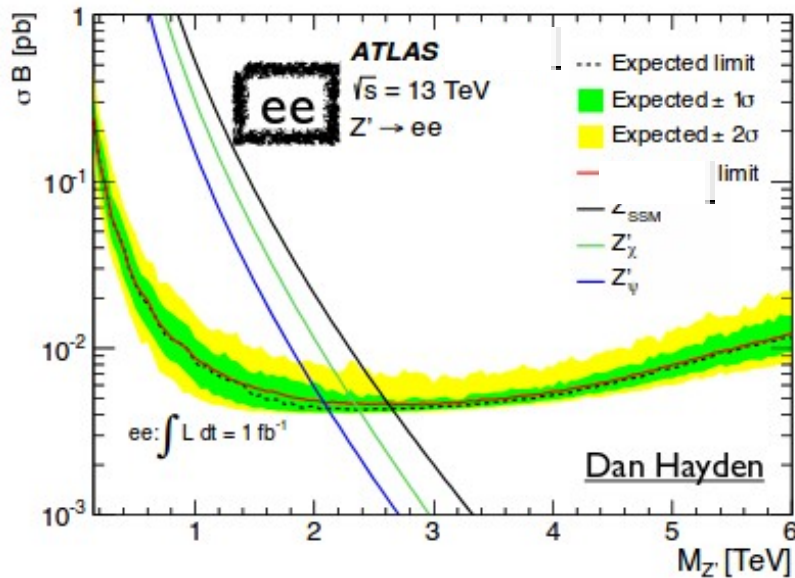
# Z'/W' Searches

- Many theories Beyond the Standard Model (BSM) predict new phenomena which give rise to dilepton final states, such as narrow resonances or broad non-resonant deviations from the SM in the dilepton invariant mass spectrum.
- Additional Spin-1 Gauge Bosons.
- SSM: Simple extension to the SM invoking an additional U(1) symmetry, with same coupling as Z, W.
- Also motivated by (GUT), such as E6.





# Sensitivity study: Z'/W'



Upper limits on  $\sigma_B$  converted into lower limits on  $M_{Z'}$  using theory relation.

Z' Model	8 TeV (20 ifb)	13 TeV (1ifb)	13 TeV (5ifb)	13 TeV (10 ifb)
SSM [ee]	2.76 TeV	2.65 TeV	3.29 TeV	3.61 TeV
SSM [ $\mu\mu$ ]	2.53 TeV	-	-	3.48 TeV

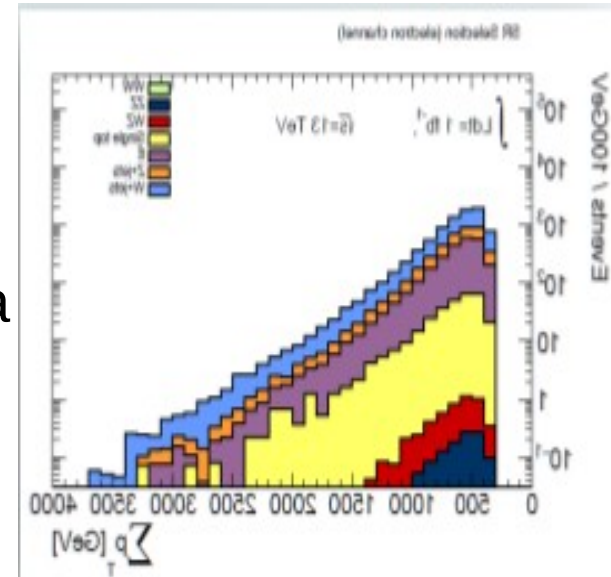
- Expected mass limit: 3.4 TeV (current limit 3.24 TeV)

	ATLAS	CMS	Lumi @ 13 TeV	1 fb <sup>-1</sup>	2 fb <sup>-1</sup>	5 fb <sup>-1</sup>	10 fb <sup>-1</sup>
W' Limit	3.24 TeV	3.28 TeV	Expected Limit	3.4 TeV	3.7 TeV	4.2 TeV	4.5 TeV

Expect to exceed Run1 sensitivity with 1-3 fb<sup>-1</sup>

# Quantum black Holes with early 13TeV data

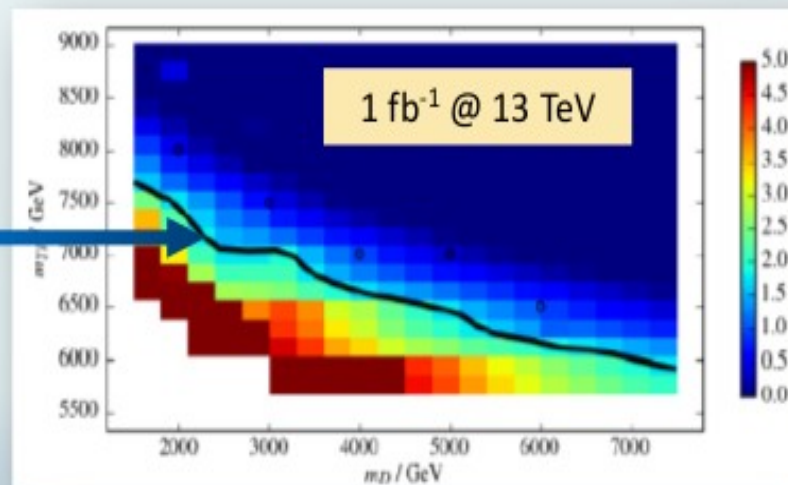
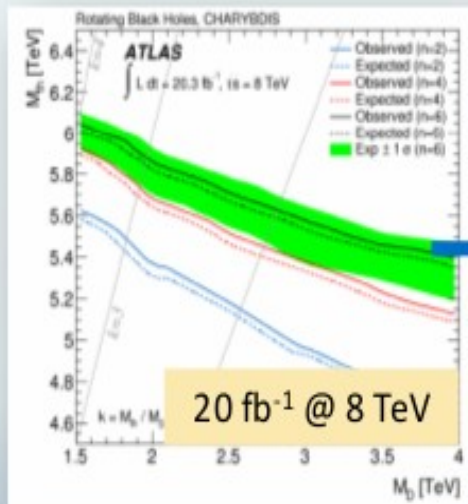
- Quantum Black Holes are predicted in low scale quantum gravity theories that offer solutions to mass hierarchy problem of the Standard Model by lowering the scale of quantum gravity from the Planck scale to a value of about 1 TeV.
- The QBH are assumed to decay into a final state characterized by a lepton (electron or muon) and a jet



\*lepton/jet  $p_T > 100\text{GeV}$

\*Search on the spectra of  $\Sigma p_T$

Sensitivity surpass Run-1 with  $1\text{ fb}^{-1}$



# Conclusions

- LHC restarts its operation after 2 years of upgrade
- Many upgrades have been made to the detector and also to the computing infrastructure of the experiment in order to be ready for the new period.
- About 10 pb<sup>-1</sup> of 13 TeV data are expected to be collected by ATLAS detector by the end of the year.
- Many exotic analysis looking for a final state with leptons and jets will reach and supersede their sensitivity of 8TeV data even with the first 2-3 pb<sup>-1</sup> data.
- Observation of a new signal is possible by the end of summer!