

# ATLAS Plans for New Physics Searches

## Monika Wielers & Tina Potter On behalf of ATLAS Collaboration

- Will cover status and plans for ECFA for
  - SUSY searches
  - Exotics searches
    - LLP covered in talk by James Beacham later today
  - Will not cover BSM Higgs here, for details see
    - <http://indico.cern.ch/event/522144/> (di-Higgs)
    - <http://indico.cern.ch/event/536274/> (SM and BSM Higgs)
- Outlook

# ATLAS approach for Upgrade studies

- Typically done using MC samples with generator level information
- Apply “Smearing Functions” on “truth”
  - Parameterisation of
    - Detector resolution and pile up effects on  $e$ ,  $\gamma$ ,  $\mu$ ,  $\tau$ , jets,  $E_T^{\text{miss}}$   
Reconstruction and trigger/offline identification efficiencies and fake rates (includes also b-tagging)
    - Done mostly in  $\eta$  &  $p_T/E_T$  bins and extracted using full sim.
  - Can also add new additional pile-up jets
  - Note, these functions will be updated soon using the most recent detector layout(s) and used for the studies for ECFA WS
- Depending on analysis assume systematic uncertainties based on extrapolation
- Unless stated otherwise pileup is  $\langle\mu\rangle=140$
- Only few studies in ATLAS extrapolate predictions from Run-1 data

# Past Upgrade SUSY Studies

Prompt

Long-lived

R-Parity Conserving

R-Parity Violating

**Strong**  
gluinos,  
1<sup>st</sup>, 2<sup>nd</sup>  
gen.  
squarks

**3<sup>rd</sup> gen.**  
stop,  
sbottom

**EWK**  
EWKinos,  
sleptons

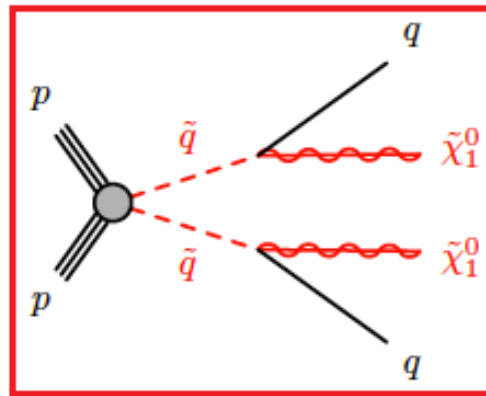
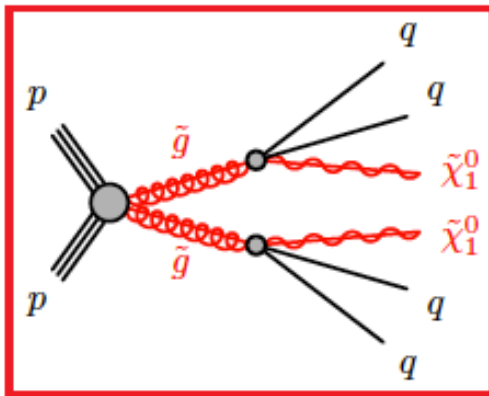
**RPC**  
prod.  
RPV  
decays

**RPV**  
prod.  
RPV  
decays

RPC or  
RPV.

Various  
ranges of  
lifetimes

0l + 2-6 jets  
ATL-PHYS-PUB-2014-010



10 signal regions,

with 2-6 jets selected,

$$m_{\text{eff}}, E_{\text{T}}^{\text{miss}} + \sum |p_{\text{T}}^{\text{jet}}|,$$

$$E_{\text{T}}^{\text{miss}}/m_{\text{eff}} \text{ and } E_{\text{T}}^{\text{miss}}/\sqrt{H_{\text{T}}}$$

requirements

Reoptimised studies using gen.level + smearing functions.

# Past Upgrade SUSY Studies

Prompt

Long-lived

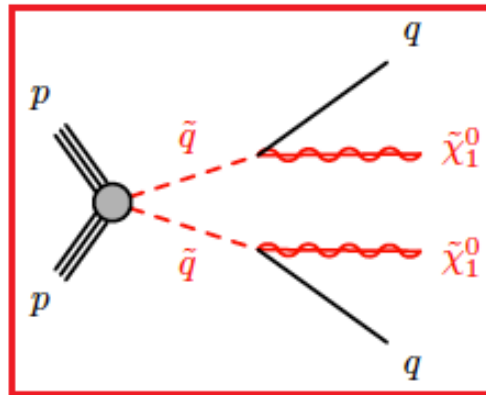
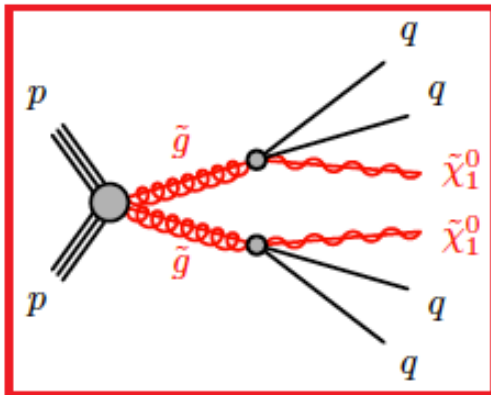
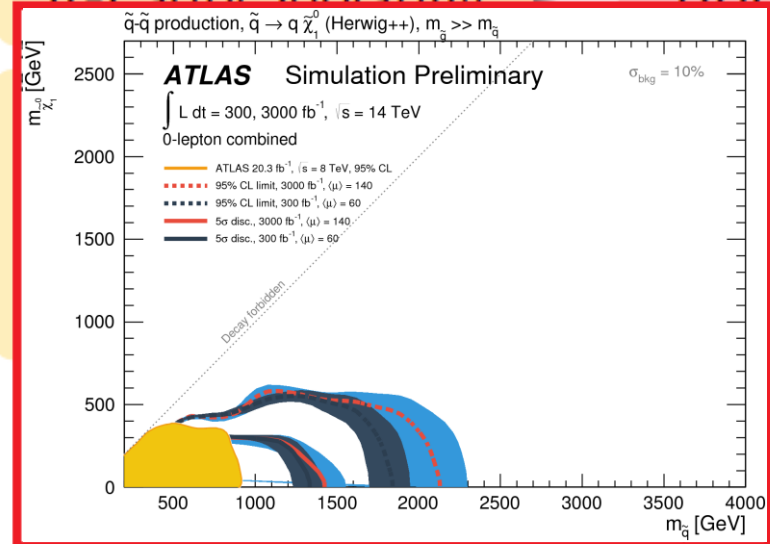
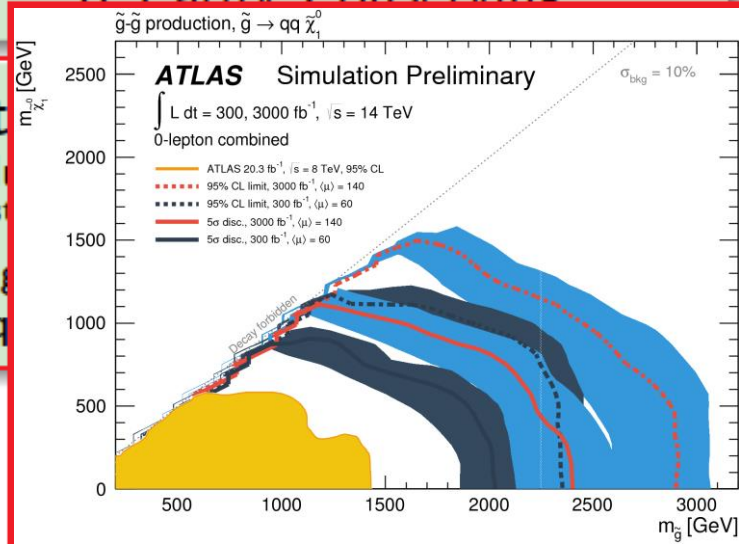
R-Parity Conserving

R-Parity Violating

DDC or V.

V.

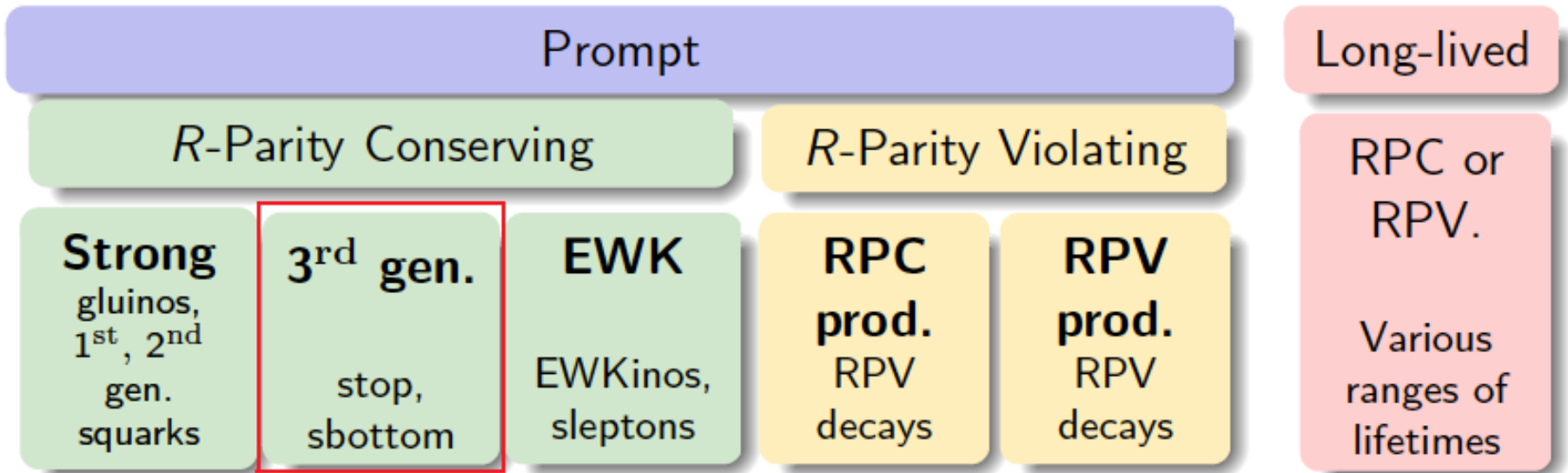
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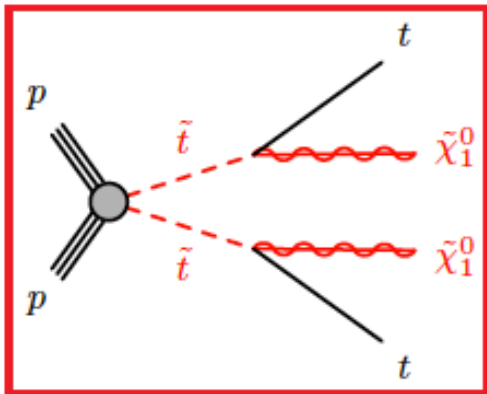
Discovery for  
 $\tilde{g}$  up to 2.35 TeV  
 $\tilde{q}$  up to 1.4 TeV  
 with HL-LHC.

Reoptimised studies using gen.level + smearing functions.

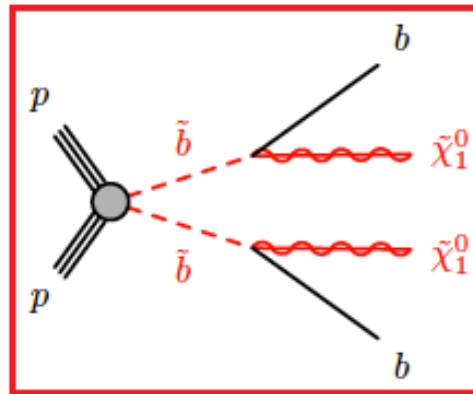
# Past Upgrade SUSY Studies



0l+2b, 1l+1b  
ATL-PHYS-PUB-2013-011



2b-jets  
ATL-PHYS-PUB-2014-010



$\tilde{t}\tilde{t}$  signal regions:  
 $m(\tilde{t})$ -dependent  
 $m_T, E_T^{\text{miss}}$  requirements

6  $\tilde{b}\tilde{b}$  signal regions:  
 $m_{CT}, m_{bb}, E_T^{\text{miss}}/m_{\text{eff}}$   
requirements

$$m_{CT}^{\text{max}} = \frac{m^2(\tilde{b}) - m^2(\tilde{\chi}_1^0)}{m(\tilde{b})}$$

Reoptimised studies using gen.level + smear

# Past Upgrade SUSY Studies

Prompt

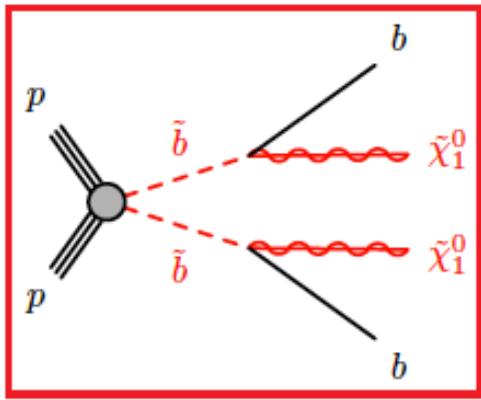
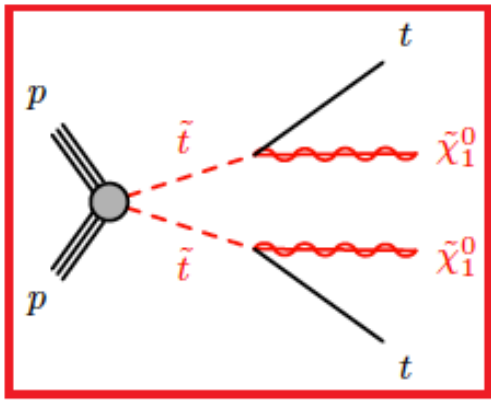
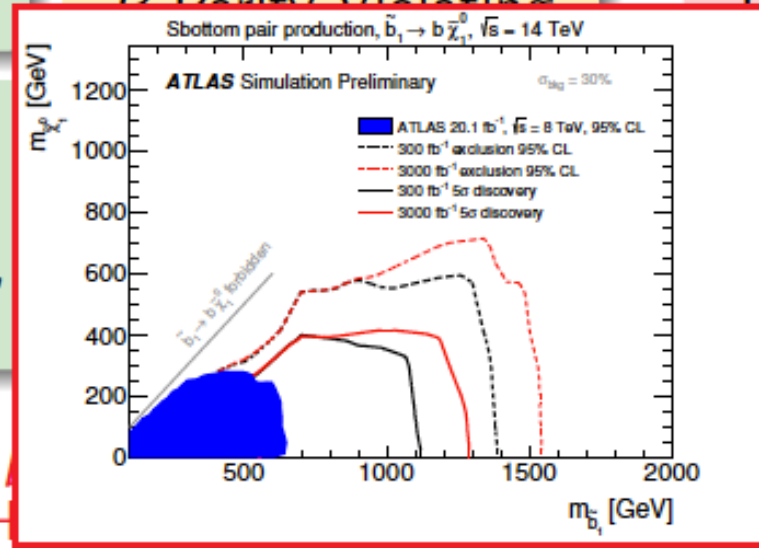
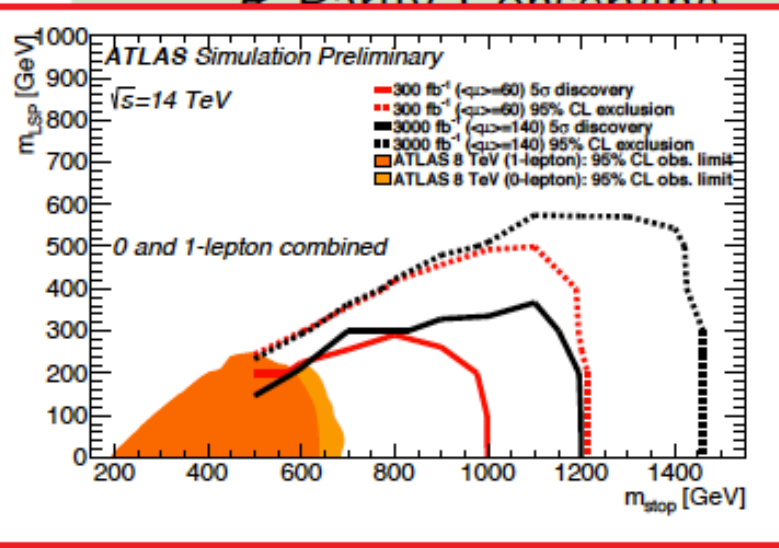
Long-lived

$P$  Parity Conserving

$P$  Parity Violating

RPC or RPV.

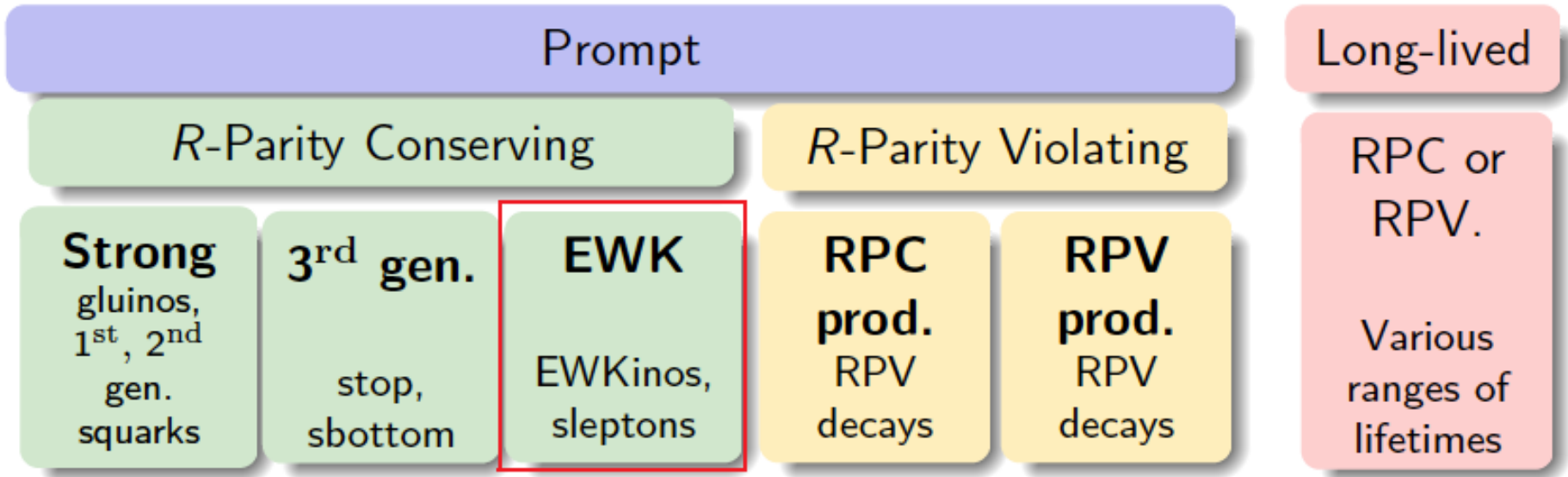
Various ranges of lifetimes



Discovery for  $\tilde{t}$  up to 1.2 TeV  
 $\tilde{b}$  up to 1.3 TeV  
 with HL-LHC.

Reoptimised studies using gen.level + smearing functions.

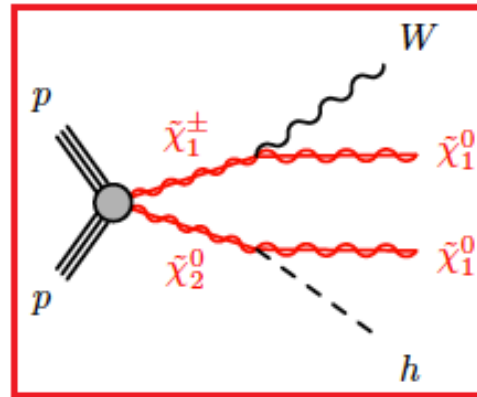
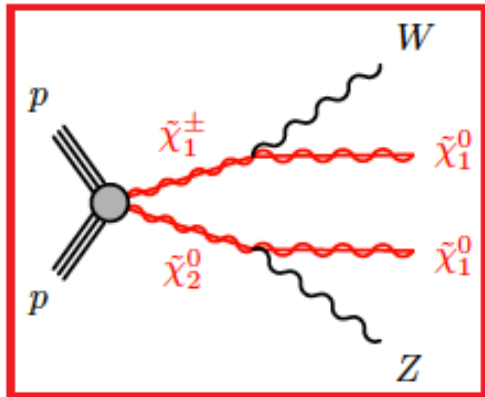
# Past Upgrade SUSY Studies



3 $l$

ATL-PHYS-PUB-2014-010

3 $l$ ,  $l\tau\tau$



3-4 signal regions:

$l$  flavour,  $m_{\ell\ell}$ ,

$m_T$ ,  $E_T^{\text{miss}}$  requirements

Reoptimised studies using gen.level + smearing functions.

# Past Upgrade SUSY Studies

Prompt

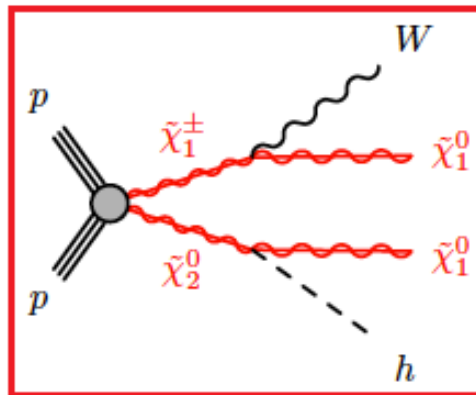
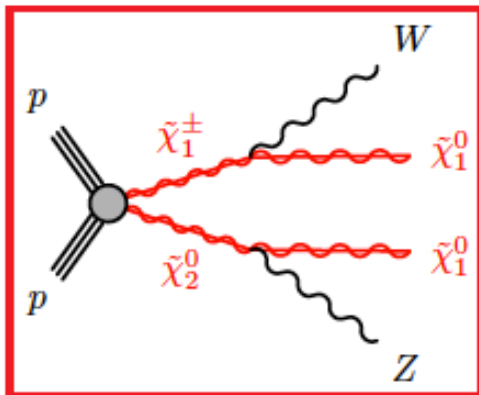
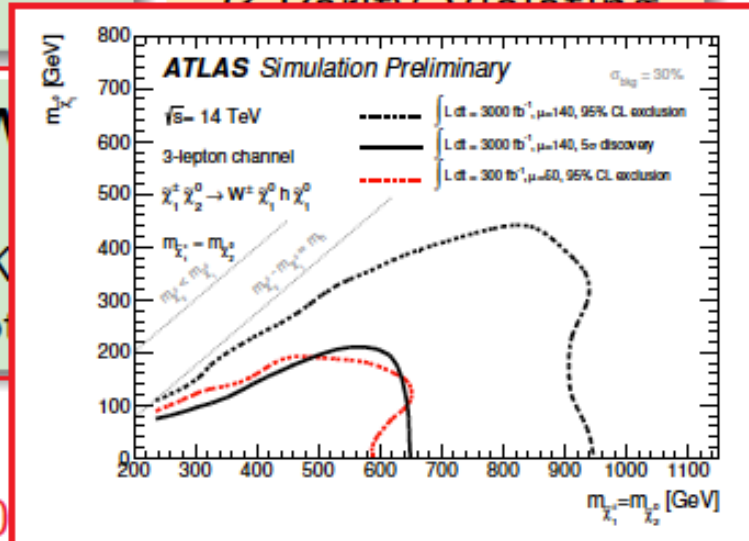
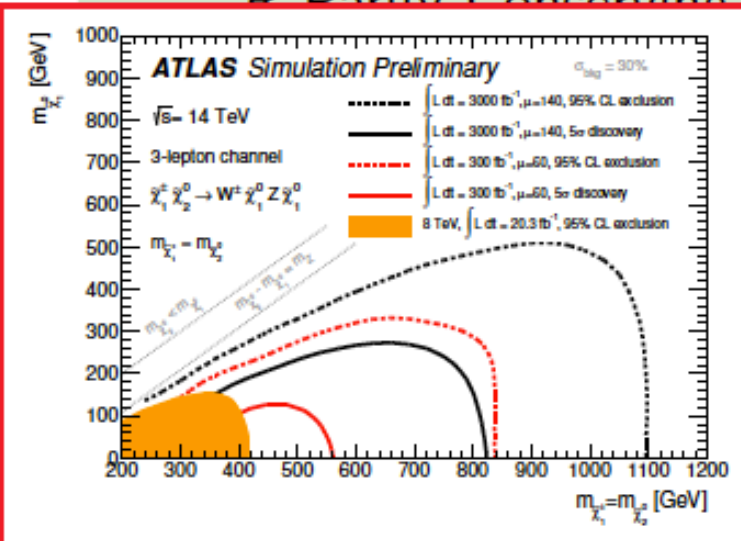
Long-lived

$P$  Parity Conserving

$P$  Parity Violating

RPC or RPV.

Various ranges of lifetimes



Discovery for  
 $\tilde{\chi}_1^\pm, \tilde{\chi}_2^0(WZ)$  up to 820 GeV  
 $\tilde{\chi}_1^\pm, \tilde{\chi}_2^0(Wh)$  up to 650 GeV  
 with HL-LHC.

Reoptimised studies using gen.level + smearing functions.



# Recent Upgrade SUSY Studies

Prompt

Long-lived

R-Parity Conserving

R-Parity Violating

**Strong**  
gluinos,  
1<sup>st</sup>, 2<sup>nd</sup>  
gen.  
squarks

**3<sup>rd</sup> gen.**  
stop,  
sbottom

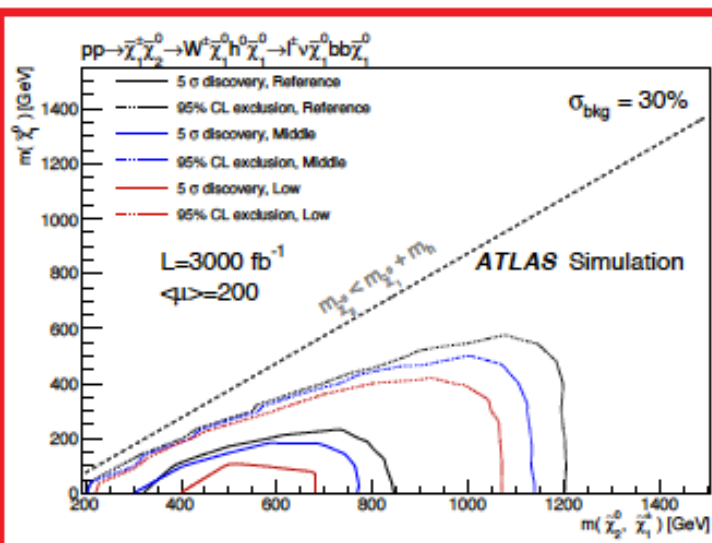
**EWK**  
EWKinos,  
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**RPC**  
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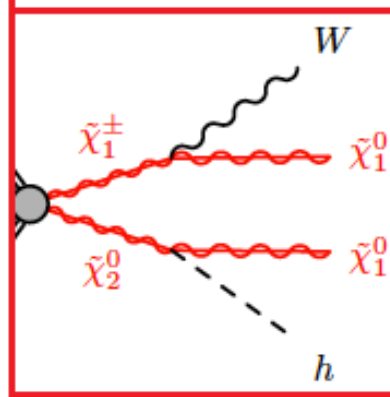
RPC or  
RPV.

Various  
ranges of  
lifetimes



*lbb* ATL-PHYS-PUB-2015-032

+ Phase-II Upgrade Scoping Document  
CERN-LHCC-2015-020



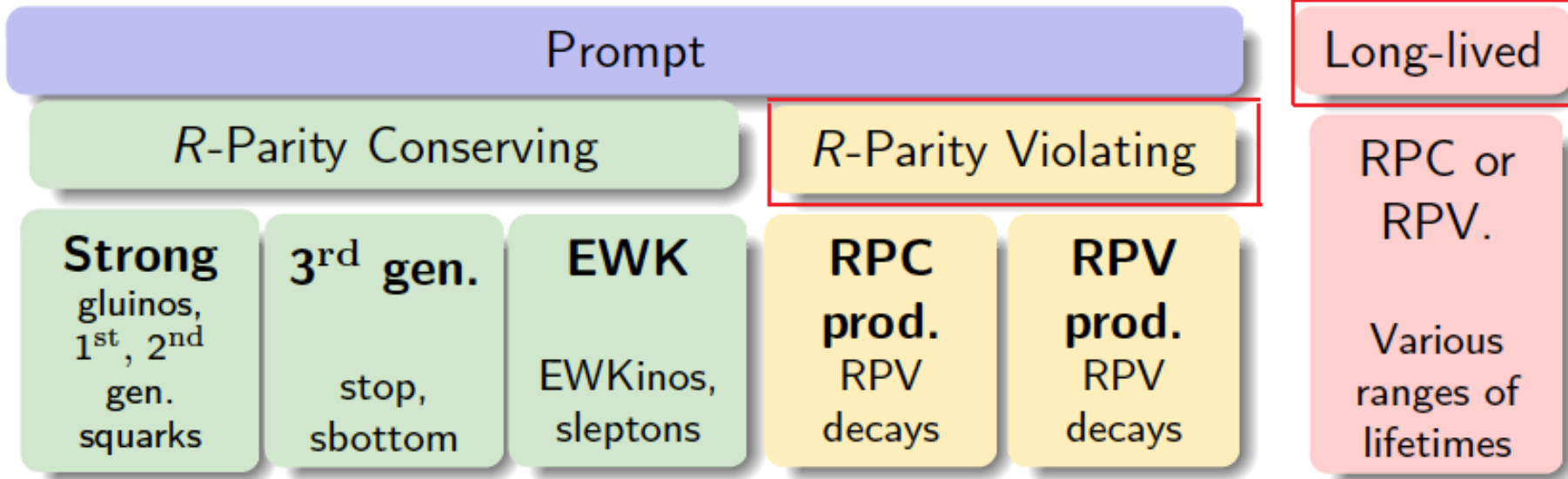
4 signal regions:

$m_{bb}$ ,  $m_{CT}$ ,  $m_T$ ,  $E_T^{\text{miss}}$  req.

Discovery for  
 $\tilde{\chi}_1^\pm, \tilde{\chi}_2^0(W h)$  up to 850 GeV  
with HL-LHC.

Reoptimised studies using gen.level + smearing functions.

# Past Upgrade SUSY Studies



- ❖ Complex analyses that are less suitable for upgrade studies with current modelling
- ❖ Long lived particles not yet studied but are important test cases for the upgraded detector layouts (needs dedicated reconstruction algorithms)

# Plans for ECFA Workshop

SUSY searches with  $e$ ,  $\mu$ ,  $\tau$ , jets,  $b$ -tagged jets and  $E_T^{\text{miss}}$  are already well covered.

Planning to have for ECFA:

- Measurement example with HL-LHC
- More third generation scenarios (compressed  $\tilde{t}$ , Gtt)
- Third-generation sleptons

# Previous exotics analyses: dilepton resonances

## ATL-PHYS-PUB-2013-003:

<https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/PUBNOTES/ATL-PHYS-PUB-2013-003/>

## Motivation

- Extended gauge groups, RS, QBH...

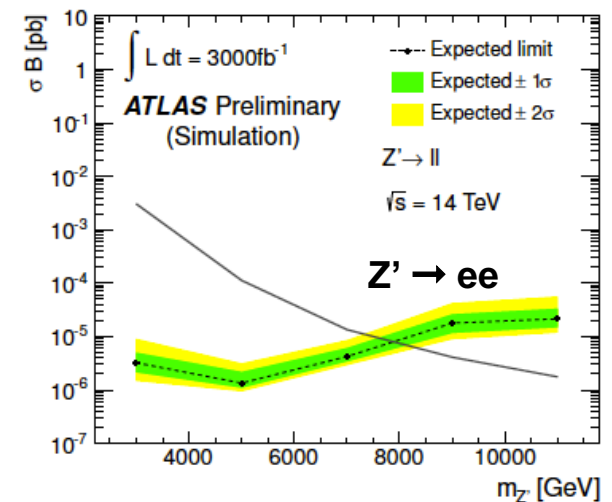
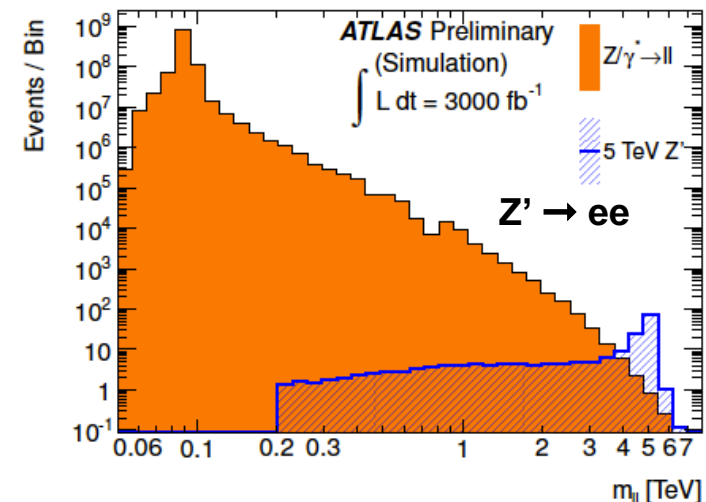
## Main backgrounds

- DY (only one used), ttbar, diboson, multi-jet

## Expected limit on $Z'$ up to $m = 7.8$ TeV (no syst uncertainties included)

model	$300 \text{ fb}^{-1}$	$1000 \text{ fb}^{-1}$	$3000 \text{ fb}^{-1}$
$Z'_{SSM} \rightarrow ee$	6.5	7.2	7.8
$Z'_{SSM} \rightarrow \mu\mu$	6.4	7.1	7.6

## Plan to extend analyses for ECFA WS for non-resonant searches, e.g. contact interaction



# Previous analyses: tt resonance search

## ATL-PHYS-PUB-2013-003:

<https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/PUBNOTES/ATL-PHYS-PUB-2013-003/>

## Motivation

- Extradim, KK gluons, topcolour, other extended gauge theories

## Reconstruction

- Use semileptonic decay channel from 1 or 2 tops
  - Electron or muon
- In lepton + jets channel:
  - reconstruct top use boosted jets

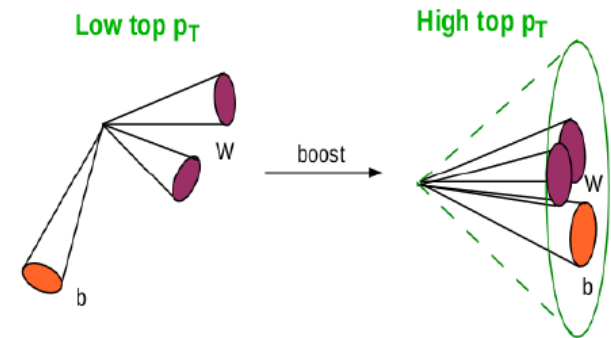
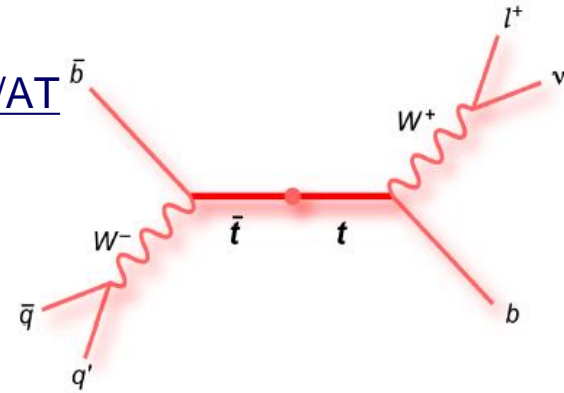
## Backgrounds

- ttbar, W+jets, Z+jets, single top

## Expected mass limits

(no syst uncert.,  
lepton+jets (dilepton channel))

model	300 fb <sup>-1</sup>	1000 fb <sup>-1</sup>	3000 fb <sup>-1</sup>
$g_{KK}$	4.3 (4.0)	5.6 (4.9)	6.7 (5.6)
$Z'_{\text{topcolor}}$	3.3 (1.8)	4.5 (2.6)	5.5 (3.2)



# Recent analyses: tt resonance search

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- Use also lepton + resolved jet channel
- Re-optimisation of selection cuts
- This analysis will be updated for ECFA WS

# Previous analyses: mono jet

• ATL-PHYS-PUB-2014-007 <https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/PUBNOTES/ATL-PHYS-PUB-2014-007/>

## • Motivation

• Dark matter (here EFT approach)

## • Reconstruction

• At most 2 jets with  $p_T > 50$  GeV in  $|\eta| < 3.6$ , no leptons

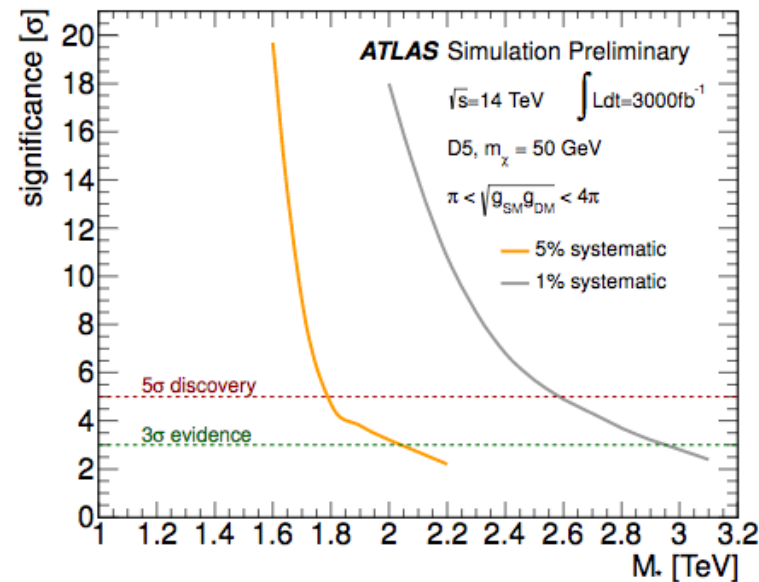
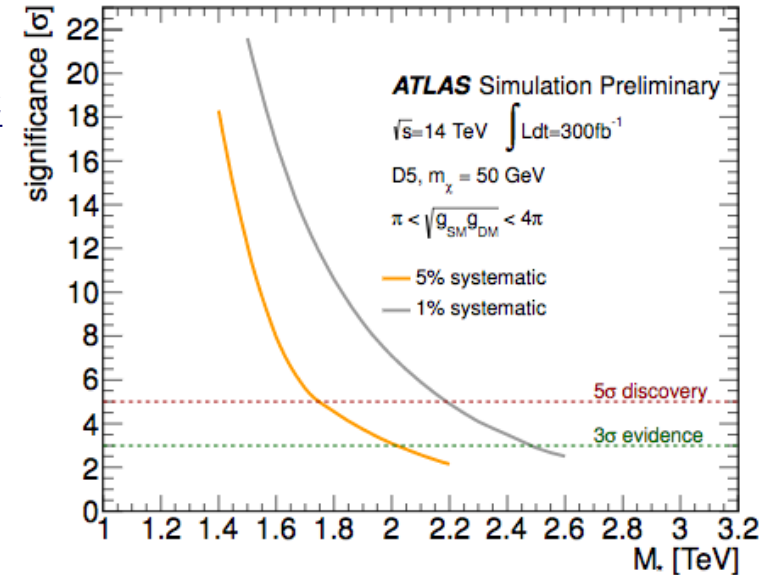
• Leading jet  $p_T > 300$  GeV in  $|\eta| < 2.0$

• MET > 400, 600, 800 GeV,  $\Delta\theta(\text{jet}, \text{MET}) > 0.5$

## • Backgrounds

• EW ( $Z \rightarrow \nu\nu + \text{jets}$ ,  $W \rightarrow \nu + \text{jets}$ ,  $Z \rightarrow \ell\ell + \text{jets}$ ), ttbar, single top, diboson, multi-jet, non-collisions

• Discovery reach extended from 2.2 TeV ( $300\text{fb}^{-1}$ ) to 2.6 TeV ( $3\text{ab}^{-1}$ ) assuming bkg systematics known to 1% level



# Recent analyses: dijet resonances

## ATL-PHYS-PUB-2015-004

<https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/PUBNOTES/ATL-PHYS-PUB-2015-004/>

## Motivation

- Excited quarks, quantum black holes

## Reconstruction

- 2 jets with  $p_T > 50 \text{ GeV}$ ,  $|\eta| < 2.8$

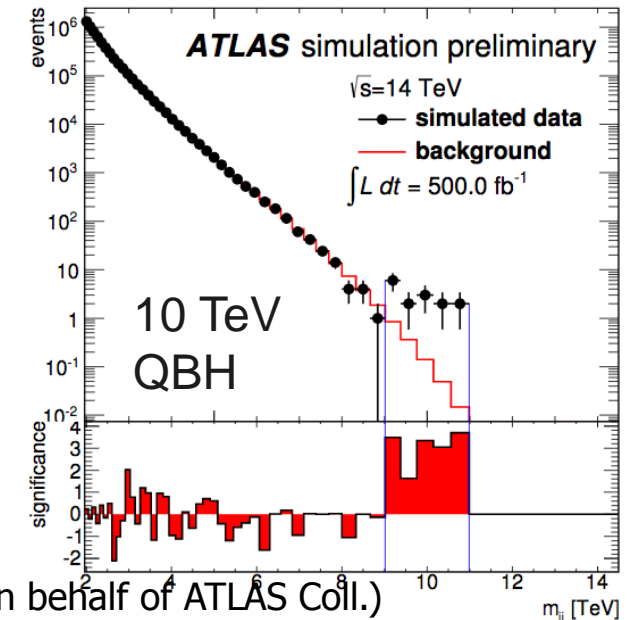
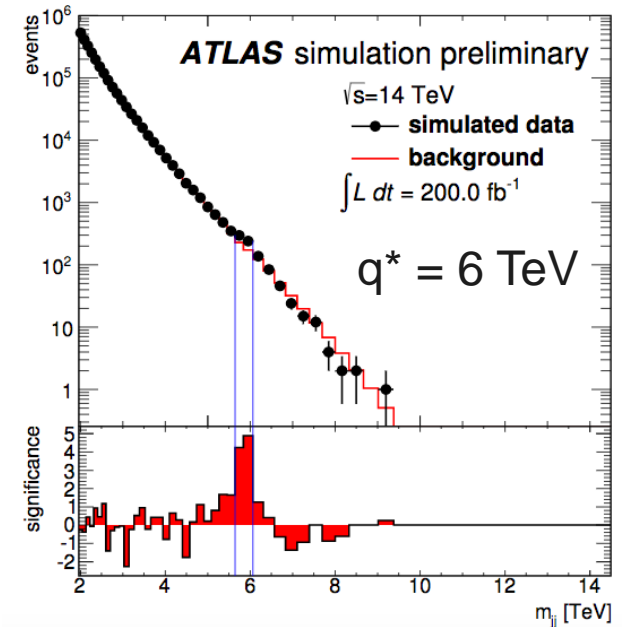
## Background

- QCD jet production

## Expected mass limits

integrated luminosity [ $\text{fb}^{-1}$ ]	$m_{q^*}$ [TeV]	$m_{\text{QBH}}$ [TeV]
0.1	4.0	8.2
1	5.0	8.9
5	5.9	9.2
25	6.6	9.7
300	7.4	10.0
3000	8.0	10.1

- Discovery reach for 3  $\text{ab}^{-1}$   $\sim 7 \text{ TeV}$  for  $q^*$  and 10 TeV for QBH





# Outlook

- Various exotics and SUSY analyses studied in the past
  - In particular SUSY searches with  $e$ ,  $\mu$ ,  $\tau$ , jets, b-tagged jets and  $E_T^{\text{miss}}$ , are already well covered
- For most no updates expected due to conflict with Run 2 analyses
  - Results not expected to change significantly using newer det. layout
- Updates expected for ECFA WS
  - Susy
    - More third generation scenarios (compressed  $\tilde{t}$ , Gtt)
    - Third-generation sleptons
  - Exotics
    - ttbar resonances (both in boosted and resolved jets)
    - Non resonant dilepton searches
    - Long lived particles (see talk later today)