New Physics at the (HL)LHC and LHeC

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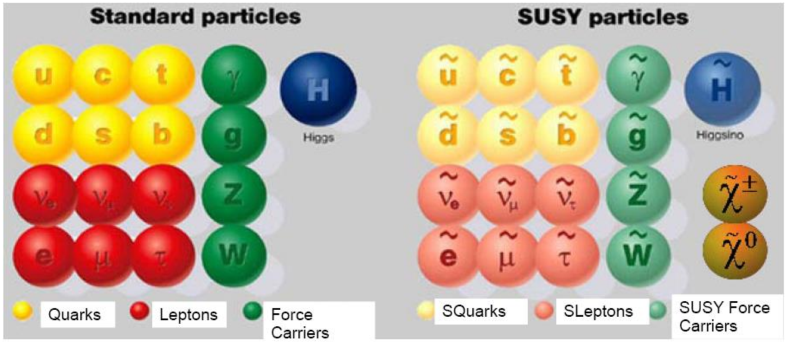
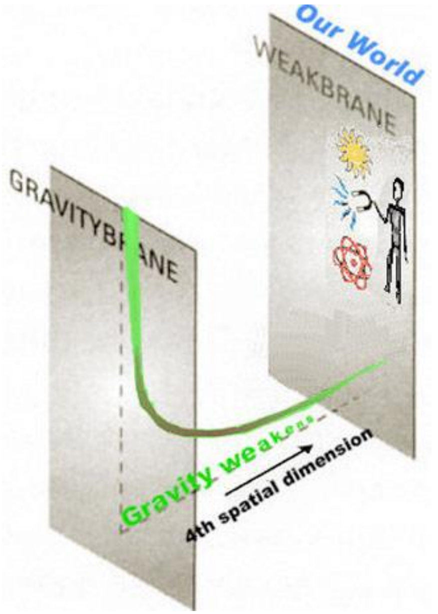
Supersymmetry



Extra Dimension and RS resonances

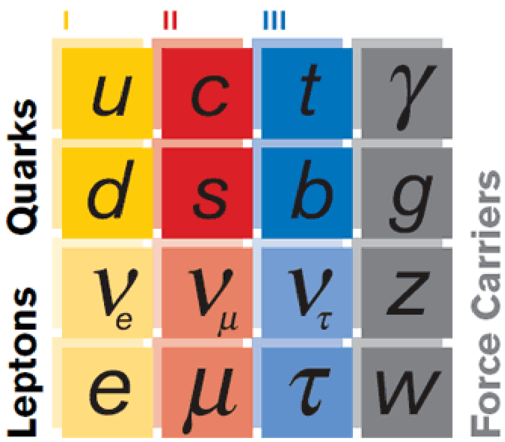


New gauge bosons (W', Z') and more

LHeC MiniWorkshop, LPCC-CERN
April 18th 2013

Searching for new physics

Standard Model: remarkably successful description of known phenomena, **but** requires new physics at the (multi)TeV scale.



Three Generations of Matter

Extra Dimensions

- Large, warped, or universal extra dimensions
- Might provide:
  - Dark Matter candidate
  - Solution to Hierarchy problem
  - Unification of forces
- Searches for new heavy particles, black holes..

Strong EW symmetry breaking

- Modern variants of Technicolor
- Might provide:
  - Dark Matter
  - Hierarchy problem
- Possibly search for composite Higgs, new heavy vector bosons (Z', W'…), 4th generation of quarks

Composite (SUSY) theories

- Composite Higgs and top

Supersymmetry

- Introduce heavy superpartners, scalar particles, light neutral Higgs
- More than100 parameters even in MSSM

Outline

“ The LHC is the primary machine to search for physics beyond the SM at the TeV scale. The role of the LHeC is to complement and possibly resolve the observation of new phenomena…”

LHeC CDR

- Overview of the New Physics program @ LHeC
  - Contact interactions, excited leptons, Extra Dimension
  - Leptoquarks
  - R-parity violation SUSY and other uncharted scenarios

Emphasis on complementarities with (High Lumi) LHC:

- Implication of LHC findings for LHeC reach
- How LHeC can complement and resolve observation of new phenomena at the LHC
- Implication of LHeC PDF constraints for the LHC

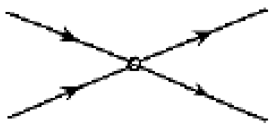
Based on LHeC CDR studies (100 fb-1 @ 10^{33} instead of current 10^{34} expected) and High Luminosity LHC studies made for ATLAS European Strategy document

NP in inclusive DIS at high Q^2

- At these small scales new phenomena not directly detectable may become observable as deviations from the Standard Model predictions.
- A convenient tool: effective four-fermion contact interaction

Observed as modification of the Q^2 dependence → all information in $d\sigma/dQ^2$
Also parametrized as form factors

4-fermion interaction $\Rightarrow M_{eq\rightarrow eq} \sim \Lambda^{-2}$



Λ : Compositeness scale

→ LQ mass (>> $\sqrt{s}$) *or*
Modified Planck Scale in ED models

$$\mathcal{L} = \frac{4\pi\,\varepsilon}{\Lambda^2}\, j_\mu^{(e)} j^{\mu(q)}; \quad q = u, d; \quad \varepsilon = \pm 1$$

$$j_\mu^{(f=e,q)} = \eta_L\, \bar{f}_L \gamma_\mu f_L + \eta_R\, \bar{f}_R \gamma_\mu f_R + h.c.$$

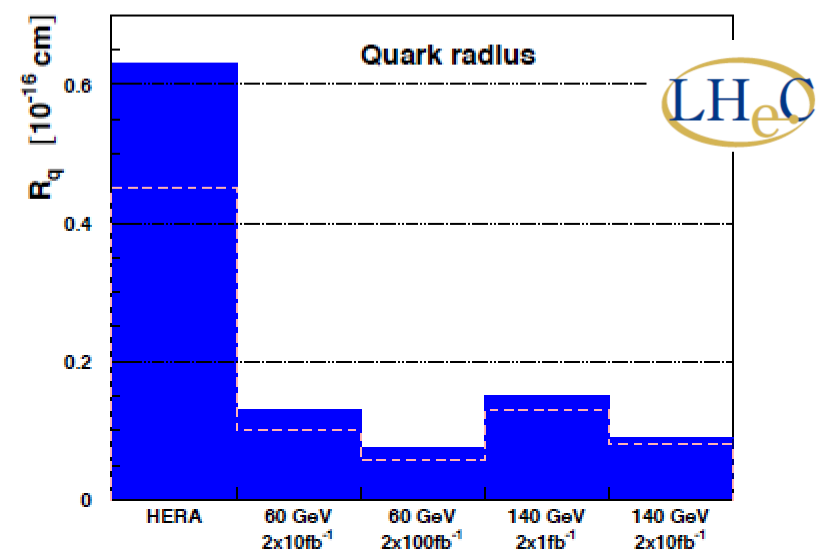
$$\Rightarrow \quad \text{all combinations of couplings } \eta_{ab} = 4\pi\,\varepsilon \frac{\eta_a^{(e)} \eta_b^{(q)}}{\Lambda_{ab}^2}$$

Quark substructure

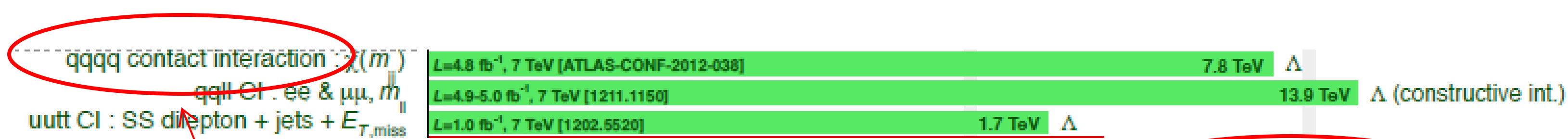
- If contact terms originate from a model where fermions are composite, scale proportional to composite object radius

$$f(Q^2) = 1 - \frac{1}{6}\langle r^2\rangle Q^2 ,$$

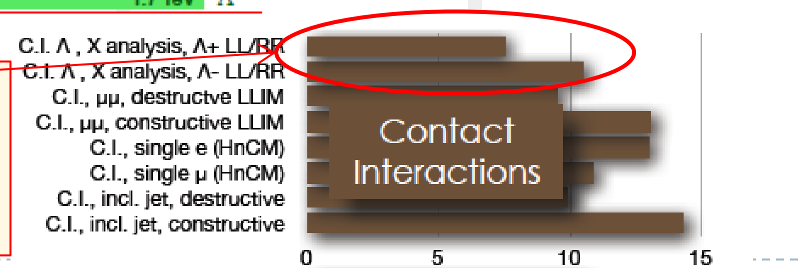
$$\frac{d\sigma}{dQ^2} = \frac{d\sigma^{SM}}{dQ^2} f_e^2(Q^2) f_q^2(Q^2)$$



Radius (→ distribution of EWK charge within q) reach below 10-19 cm

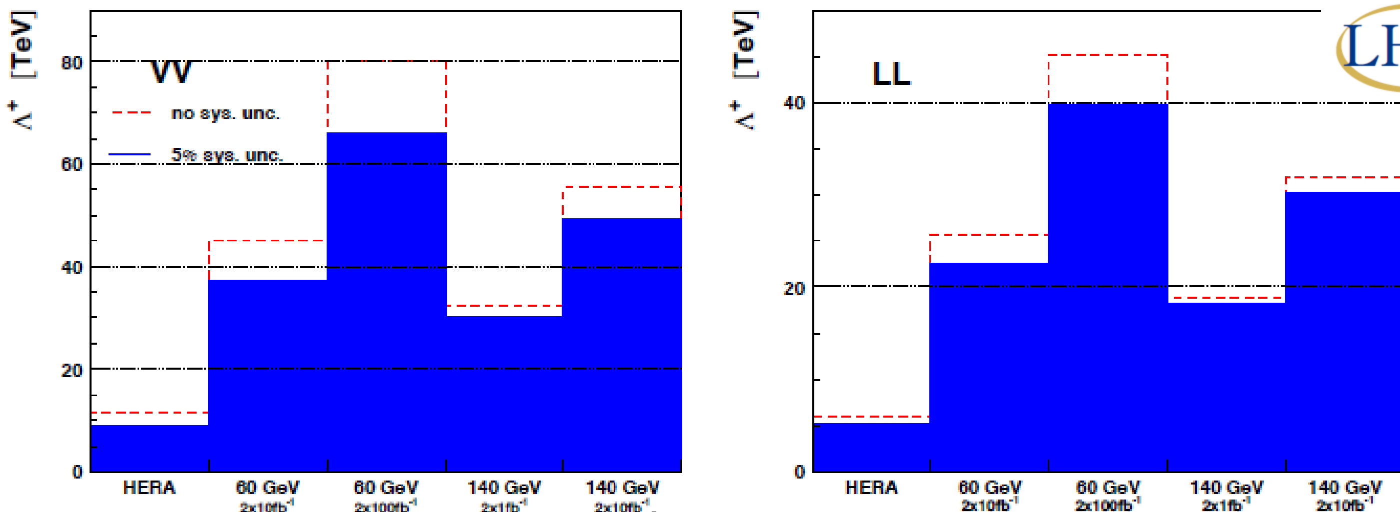


ATLAS and CMS constraints on 4-quarks CI (expected @ few 10’s TeV for 14 TeV LHC - not directly related to EWK R)



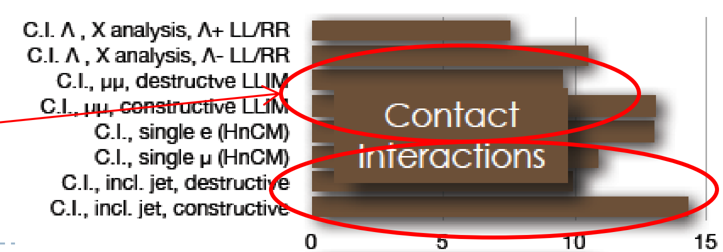
Contact interactions (eeqq)

- New currents or heavy bosons may produce indirect effect via new particle exchange interfering with γ/Z fields.
- Reach for Λ (CI eeqq): 25-45 TeV with 10 fb-1 of data depending on the model



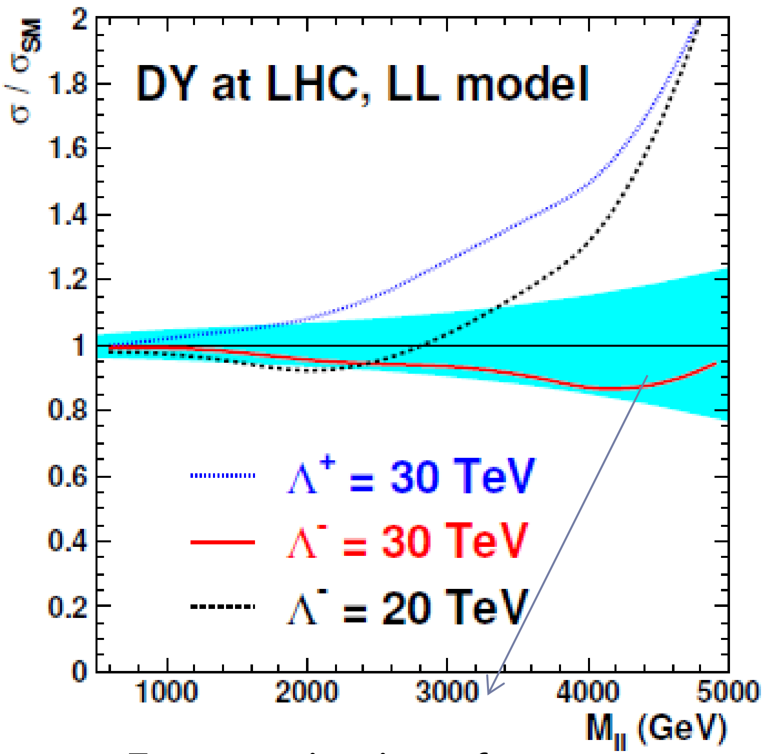
Similar to LHC

ATLAS and CMS constraints on eeqq CI (expected up to 30-40 TeV at c.o.m. 14 TeV LHC)



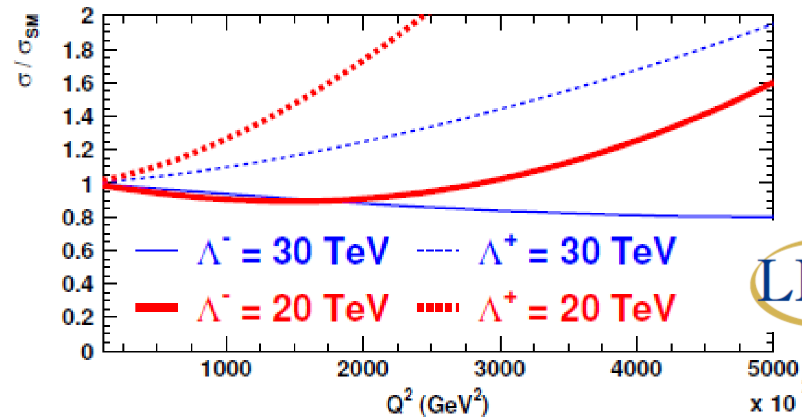
CI at LHC and LHeC

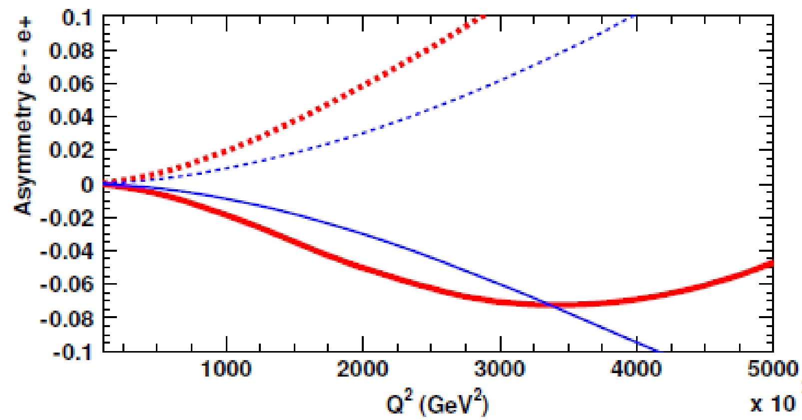
- LHC: Variation of DY cross section for CI model
  - Cannot determine simultaneously Λ and sign of interference of the new amplitudes wrt SM (ε)



Ex: negative interference too small to be disentagled

LHeC: sign ε from asymmetry of σ/σ_{sm} in e+p and e-p data

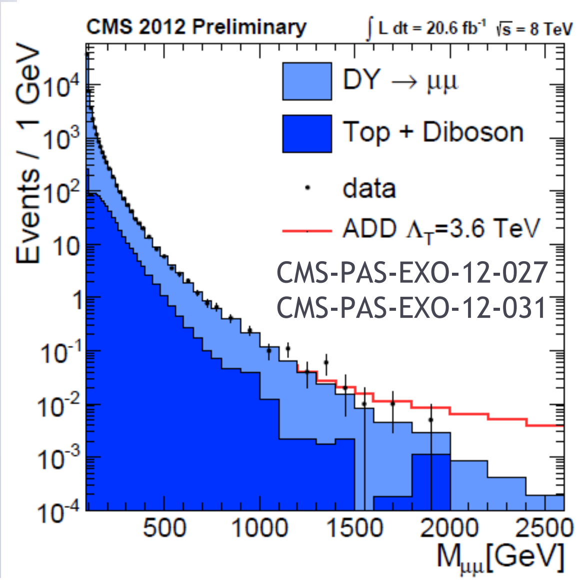


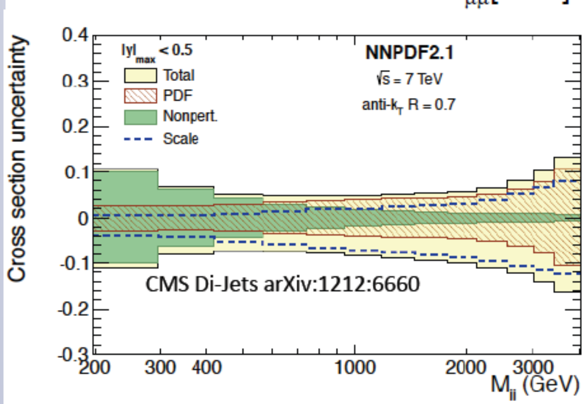


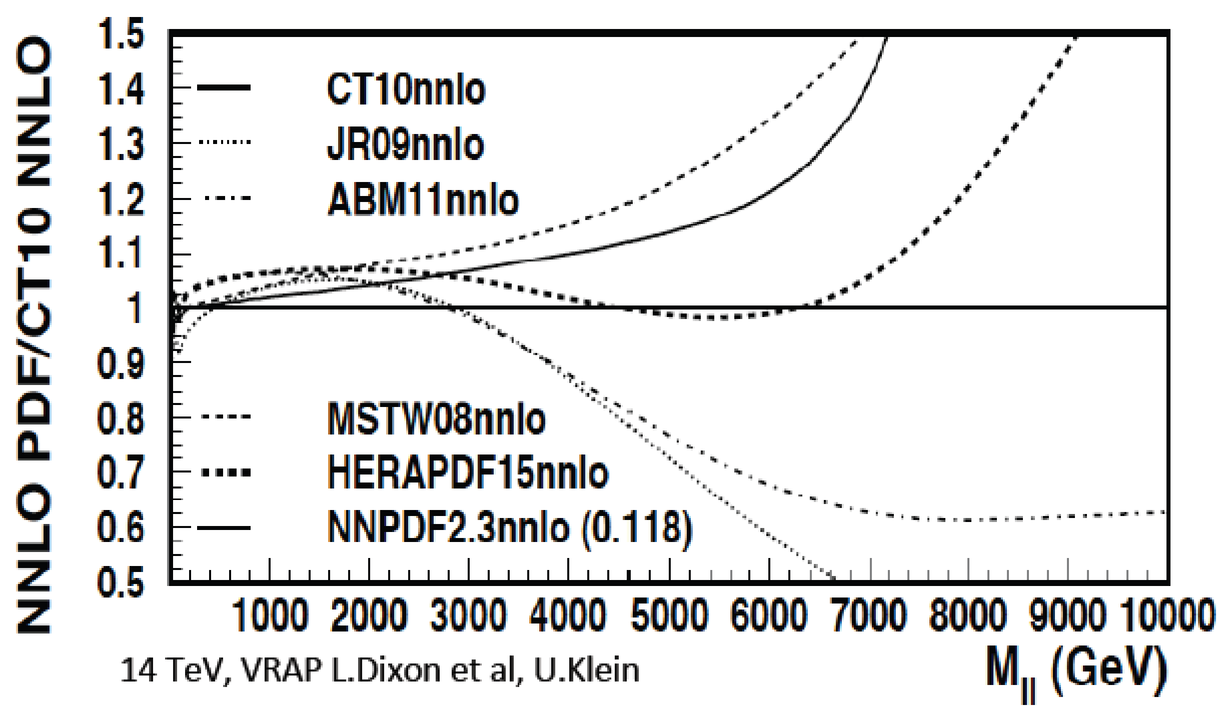
High mass Drell-Yan

Both CMS and ATLAS searching for deviations in m(ll) tails

- Non resonant searches for ED (interference) sensitive to tails of DY distributions thus to PDF
- For HL-LHC need to study in context with experimental uncertainties (calibrations)

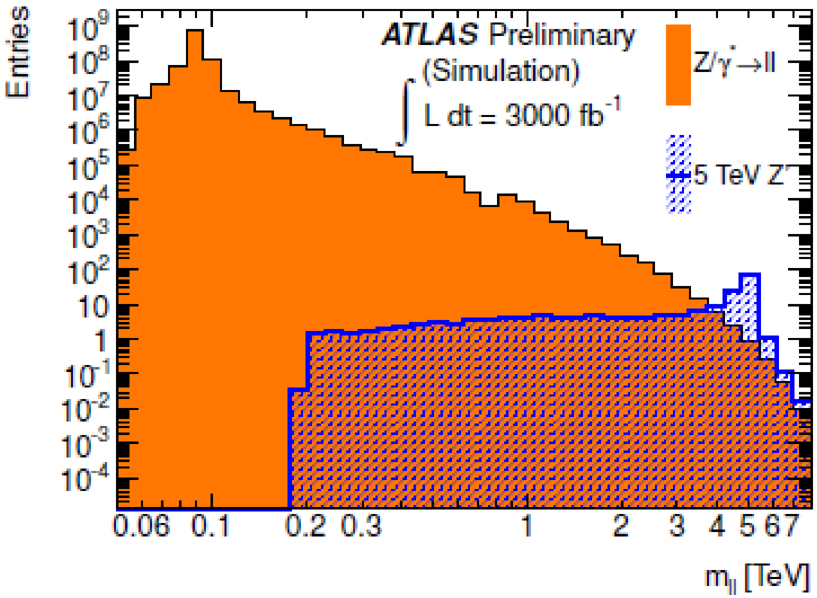


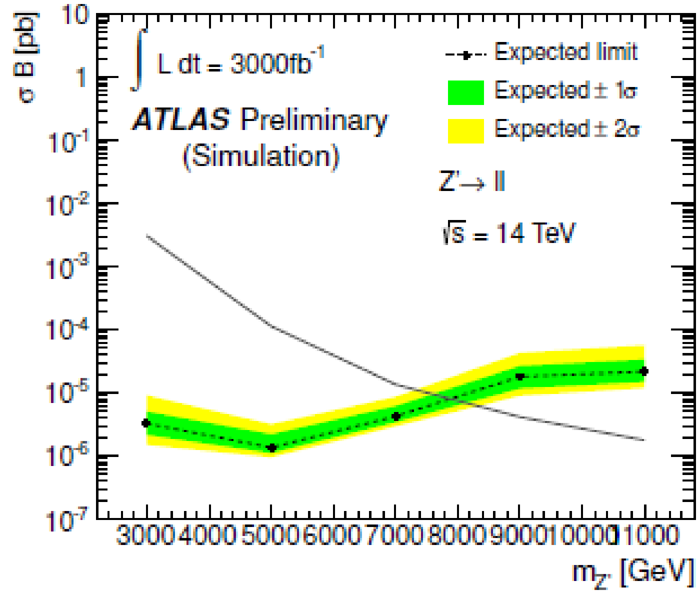




HL-LHC: Dilepton Resonances

- Dielectron and dimuon channels explored for 14 TeV and Phase I (II) luminosity:
  - Example from dielectron selection:

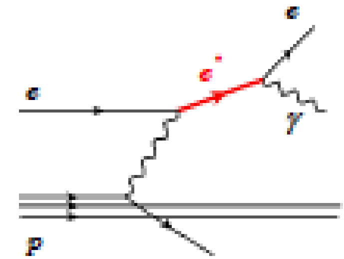




model	300 fb^{-1}	1000 fb^{-1}	3000 fb^{-1}
$Z'_{SSM} \to ee$	6.5	7.2	7.8
$Z'_{SSM} \to \mu\mu$	6.4	7.1	7.6

→ Sensitivity up to about 8 TeV

Excited fermions



- Can be produced directly if their mass is below the compositness scale

- gauge interaction Lagrangian

$$\mathcal{L} = \frac{1}{2\Lambda}\bar{f}^{*}_{R}\sigma_{\mu\nu}\left[gf\frac{\tau_a}{2}W^{a}_{\mu\nu} + g'f'B_{\mu\nu} + g_s f_s \frac{\lambda_a}{2}G^{a}_{\mu\nu}\right] f_L \;\Rightarrow\; \sigma \sim \frac{|f|^2}{\Lambda^2}$$

conventional reference point: $\frac{f}{\Lambda} = \frac{1}{m^{*}}$

similar Lagrangian for 4th family lepton: replace couplings by anomalous couplings

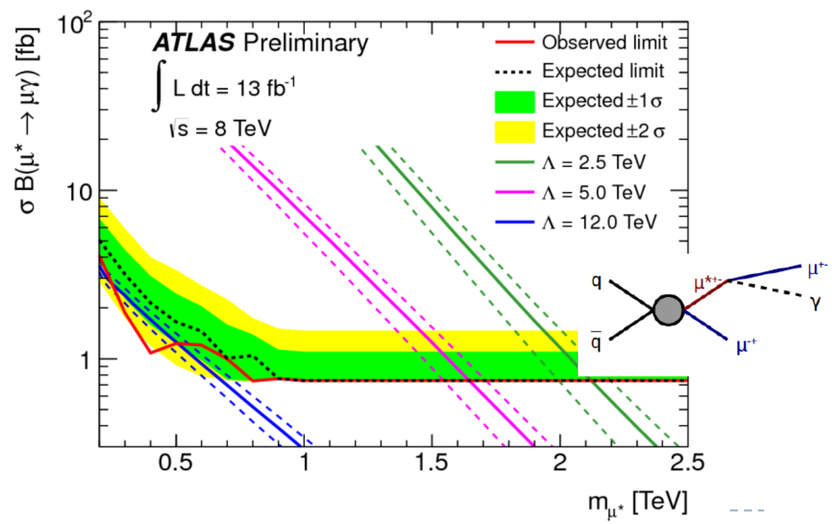
- contact interaction Lagrangian

conventional reference point: $\Lambda = m^{*}, \quad \eta_L = +1, \quad \eta_R = 0$

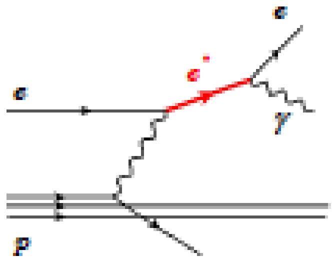
$$\mathcal{L} = \frac{4\pi}{2\Lambda^2} j_\mu j^\mu; \quad j_\mu = \eta_L \bar{f}_L \gamma_\mu f_L + \eta'_L \bar{f}^{*}_L \gamma_\mu f^{*}_L + \eta''_L \bar{f}^{*}_L \gamma_\mu f_L + h.c. + (L \leftrightarrow R) \;\Rightarrow\; \sigma \sim \frac{\hat{s}|\eta|^2}{\Lambda^4}$$

At the LHC:
Stringent limits, which only apply to the contact interaction case

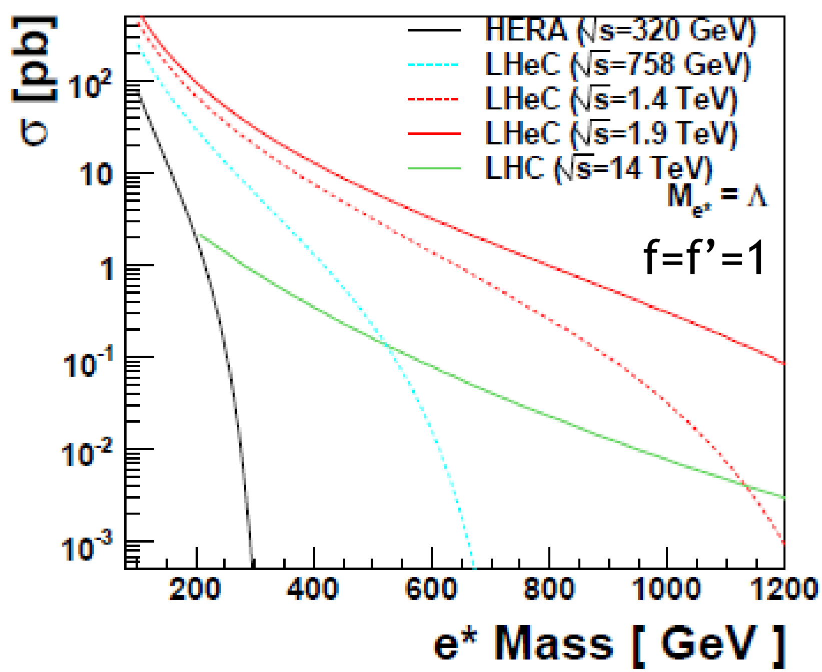
Λ = 2.5 TeV	e*	μ*
expected limit (TeV)	2.28	2.13
observed limit (TeV)	2.17	2.13



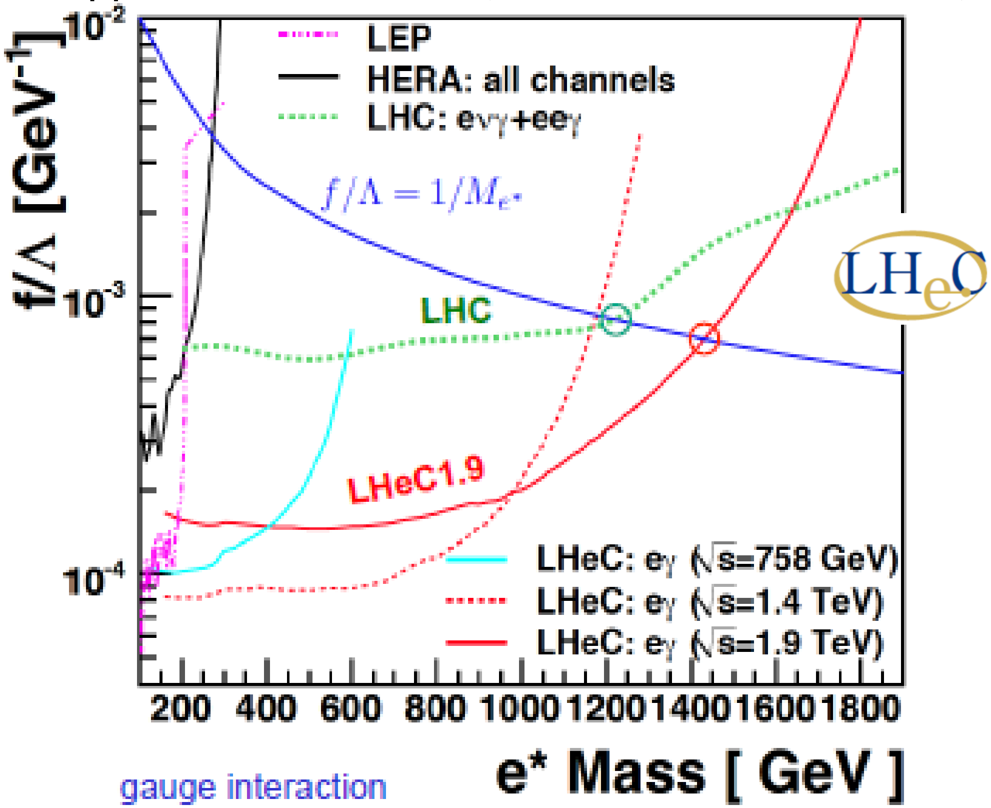
Excited fermions



- For gauge interaction, LHeC cross section much higher
- Very good sensitivity



Upper limit @ 95% CL (area above curves excluded)

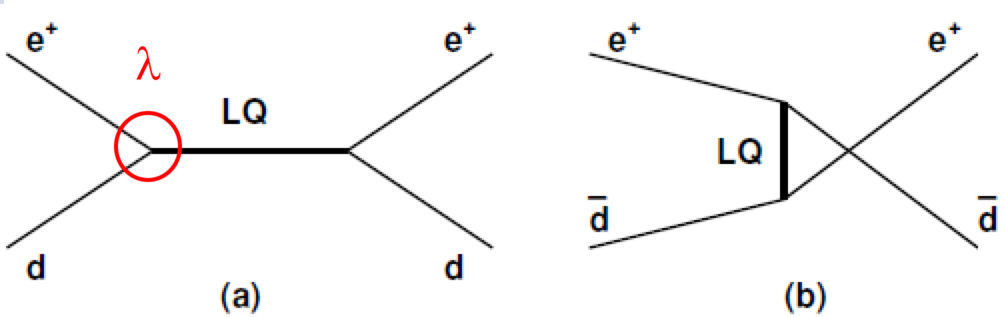


LHeC could probe smaller couplings f/Λ

Exclusion $f/\Lambda = 1/M^*$ → 1.2 (1.5) TeV for √s 1.4(1.9) TeV

Leptoquarks (LQ)

- By providing both B and L in the initial state, the LHeC is ideal to study the properties of new bosons with couplings to an e-q pair
- **Leptoquarks**
  - Color-triplet bosons, couple to leptons and baryons of same generation
  - Can be scalar or vector
  - Masses at GUT scale, in various GUT theories as E6, some extended TC models also predict LQ at TeV-scale
  - Also → squarks in RPV SUSY *(see later)*

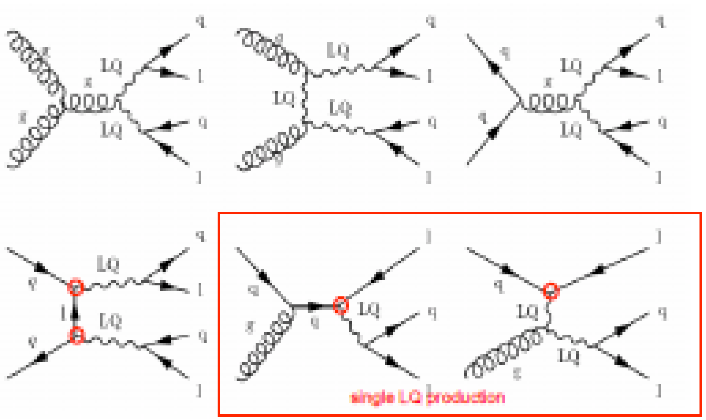


In narrow-width approx, production cross section ~

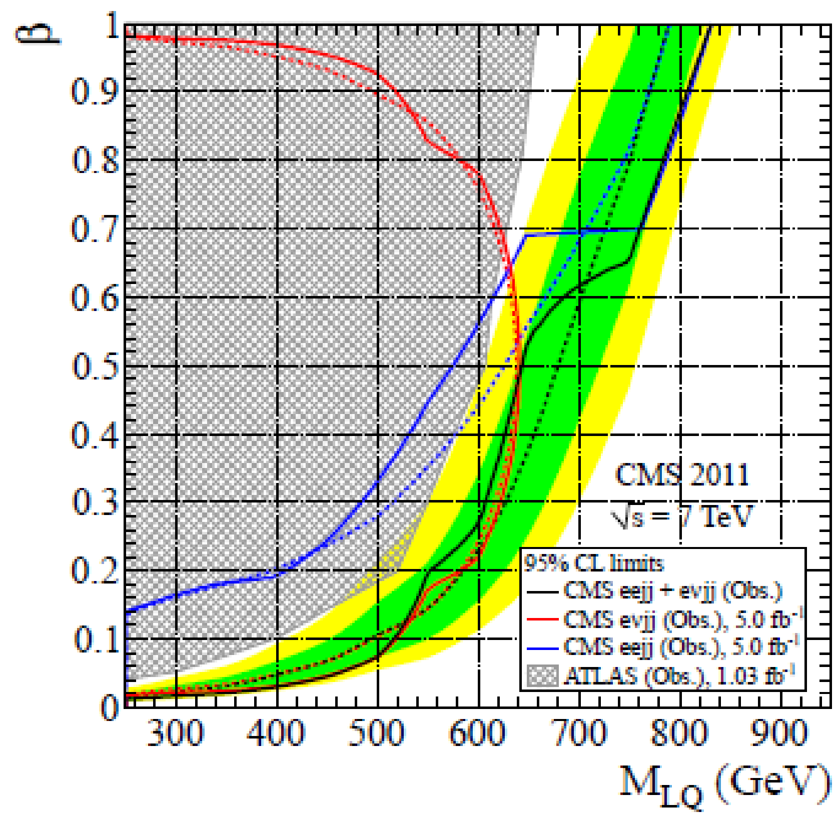
$$\lambda^2 q(x)$$

LQ production at LHC ad LHeC

- At LHC, mostly pair production (from gg or qq)
  - if λ not too strong (0.3 or lower), cross section independent on λ
  - Exclude up to 900 GeV for 1° generation
  - Expect to exclude up to 1.2 (1.5) TeV at 14 TeV 300 fb^{-1} for scalar (vector)-LQ

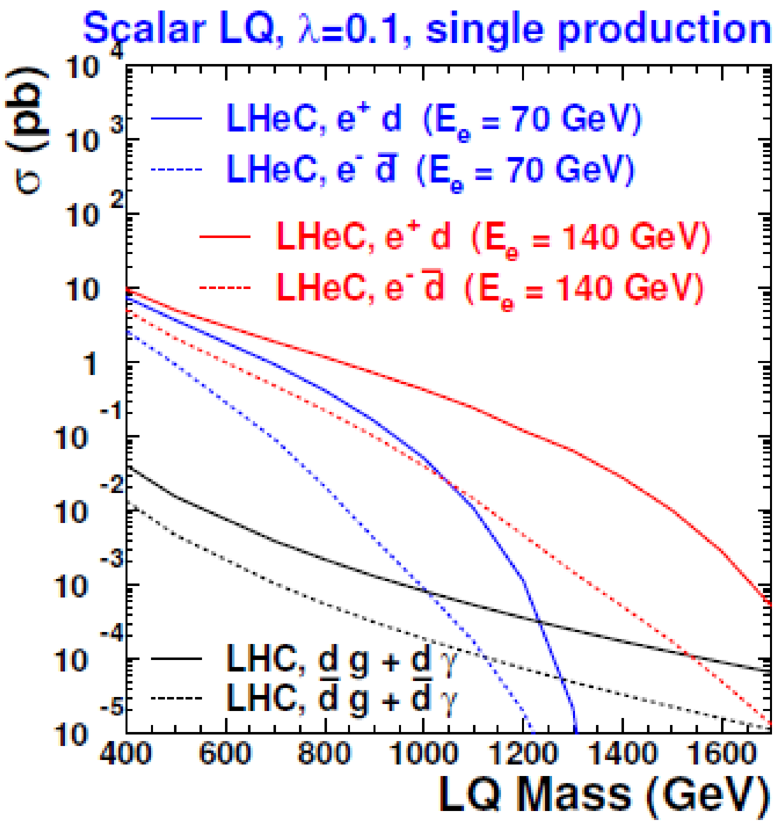


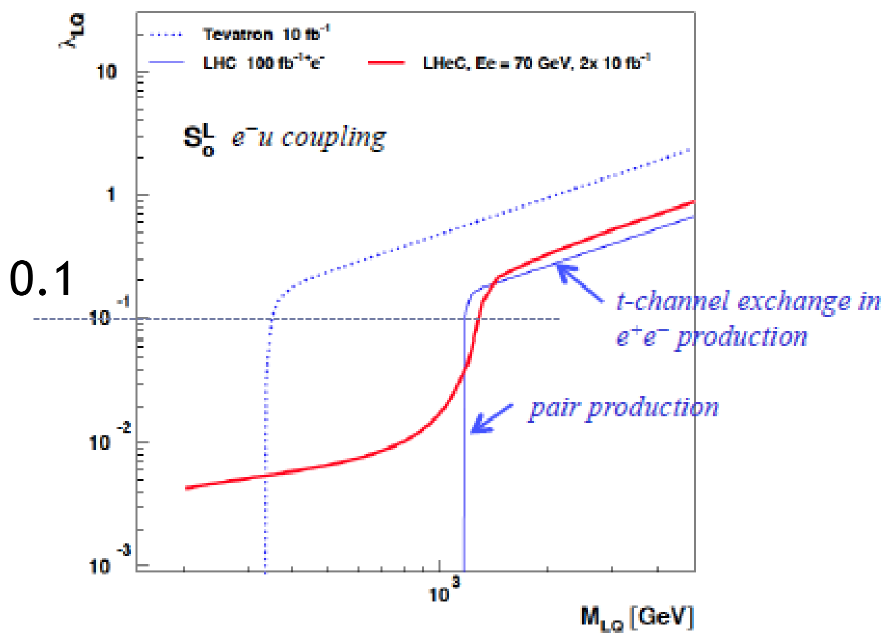
At the LHC, pair production is essentially independent of the $LQ-q-e$ coupling λ $\rightarrow$ pair production abundant



LQ production at LHC and LHeC

- At LHeC, single particle production
  - Probe LQ up to TeV scale

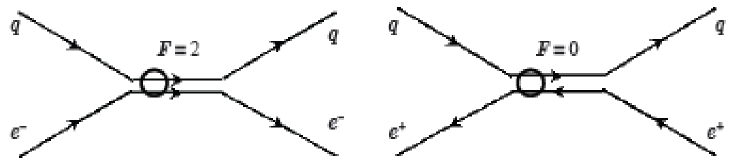




contact term for high mass LQ
➔ distortion of NC cross section

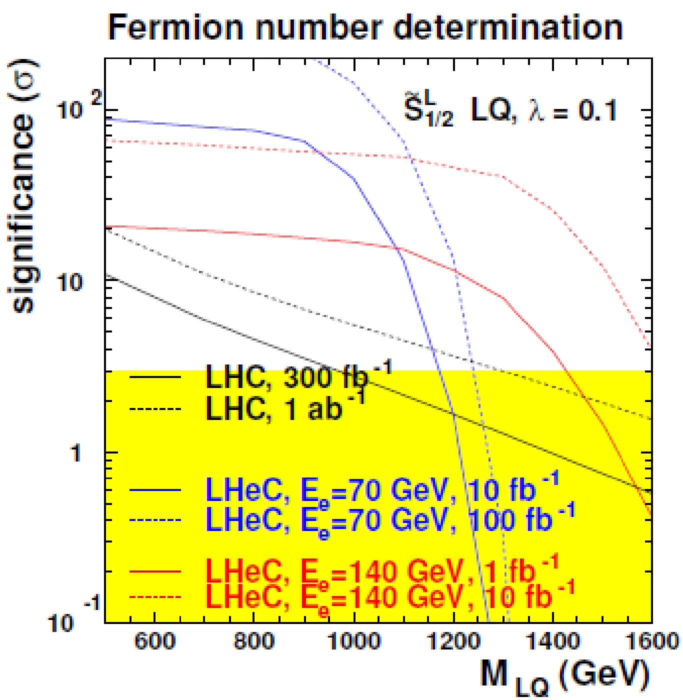
LQ properties

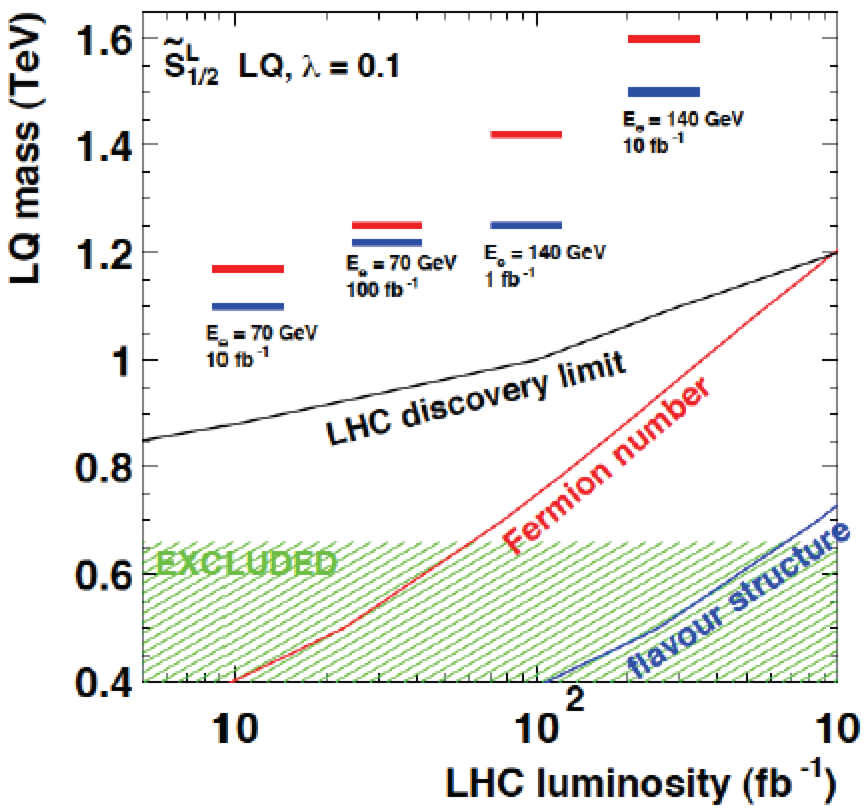
- If LQ observed at LHC → At LHeC can measure fermion number, flavor structure, chiral structure (from polarization of beam)
  - Ex.: Fermion number:



Parton density u,d >> ubar,dbar →
σ(F=0) larger in e+p, σ(F=2) larger in e-p

$$A = \frac{\sigma_{e^+} - \sigma_{e^-}}{\sigma_{e^-} + \sigma_{e^+}} \begin{cases} < 0 \text{ for F=2} \\ > 0 \text{ for F=0} \end{cases}$$





R-parity violating SUSY

Squarks in RPV models could be an example of ‘Leptoquarks’

- R-parity = $(-1)^{3(B-L)+2s}$ (R = 1 for SM particles, -1 for MSSM partners)

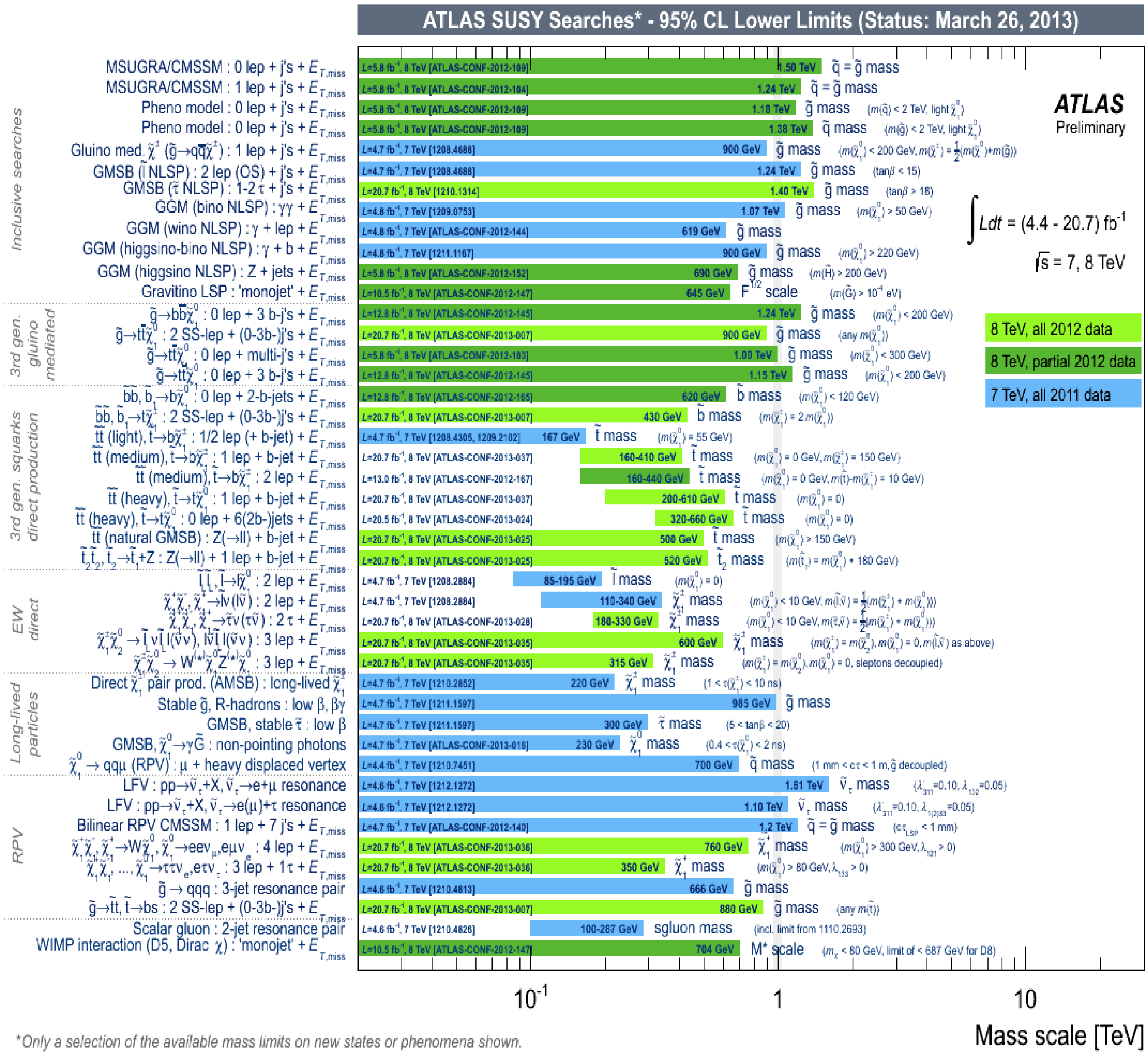
If not conserved (RPV) → different terms, couplings constraint by proton decay

$$W_{\not R_p} = \overbrace{\lambda_{ijk}\hat{L}_i\hat{L}_j\hat{E}^C_k + \lambda'_{ijk}\hat{L}_i\hat{Q}_j\hat{D}^C_k + \underbrace{\epsilon_i\hat{L}_i\hat{H}_u}_{\text{bilinear terms}}}^{L\text{-number violating terms}} + \underbrace{\lambda''_{ijk}\hat{U}^C_i\hat{D}^C_j\hat{D}^C_k}_{B\text{-number violating terms}}$$

$\Delta L = 1$, 9 λ couplings, 27 λ’ couplings

Plethora of new couplings, only partially constraints (m/100 GeV)

	$\lambda_{ijk}L_iL_j\bar{E}_k$	$\lambda'_{1jk}L_1Q_j\bar{D}_k$	$\lambda'_{2jk}L_2Q_j\bar{D}_k$	$\lambda'_{3jk}L_3Q_j\bar{D}_k$
weakest	0.07	0.28	0.56	0.52
strongest	0.05	$5.\cdot 10^{-4}$	0.06	0.11



*Only a selection of the available mass limits on new states or phenomena shown.
All limits quoted are observed minus 1σ theoretical signal cross section uncertainty.

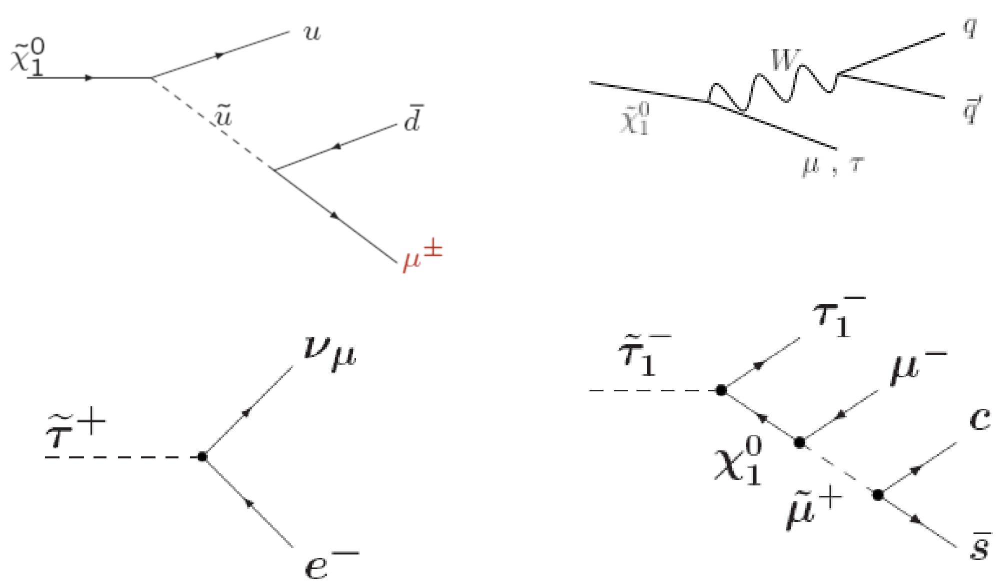
Various constraints on RPV scenarios

SUSY and RPV scenarios

- Still, several final states to explore:
  - LSP no longer stable
  - Can be something like

> 700 possibilities + bilinear couplings!

$$\begin{pmatrix} \text{pair production}: \ \tilde{q}\tilde{q},\ \tilde{q}\tilde{g},\ \tilde{g}\tilde{g} \\ \text{resonant } \tilde{\ell} \text{ production} \end{pmatrix} \otimes \begin{pmatrix} \underline{\text{LSP}} \\ \tilde{\chi}_1^0 \\ \tilde{\chi}_1^+ \\ \tilde{\nu}_L \\ \tilde{\ell}_{L,R}^{\pm} \\ \tilde{\tau}_1^{\pm} \\ \tilde{q}_{L,R} \\ \tilde{t}_1 \\ \tilde{g} \end{pmatrix} \otimes \begin{pmatrix} \underline{\text{Operator}} \\ L_1 L_2 \bar{E}_1 \\ \vdots \\ L_2 L_3 \bar{E}_3 \\ L_e Q_1 \bar{D}_1 \\ \vdots \\ L_\mu Q_1 \bar{D}_1 \\ \vdots \\ L_\tau Q_3 \bar{D}_3 \\ \bar{U}_i \bar{D}_j \bar{D}_k \end{pmatrix}$$



Result:

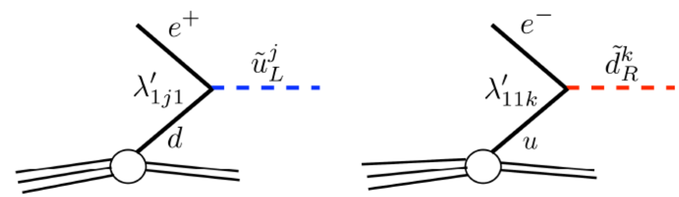
-- RPV SUSY under-constrained although several searches in progress

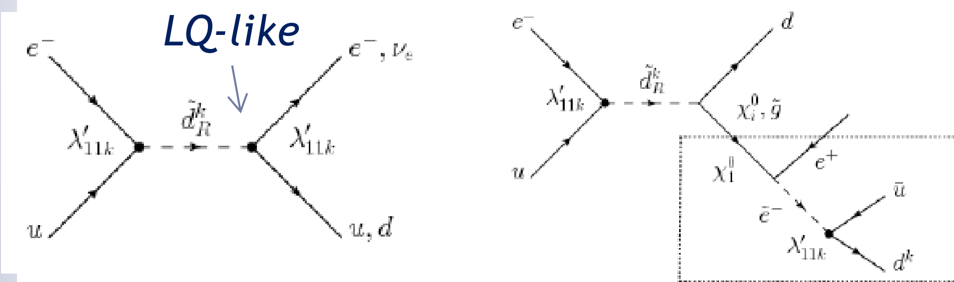
-- limits depend on couplings assumptions

SUSY @ LHeC: RPV scenarios

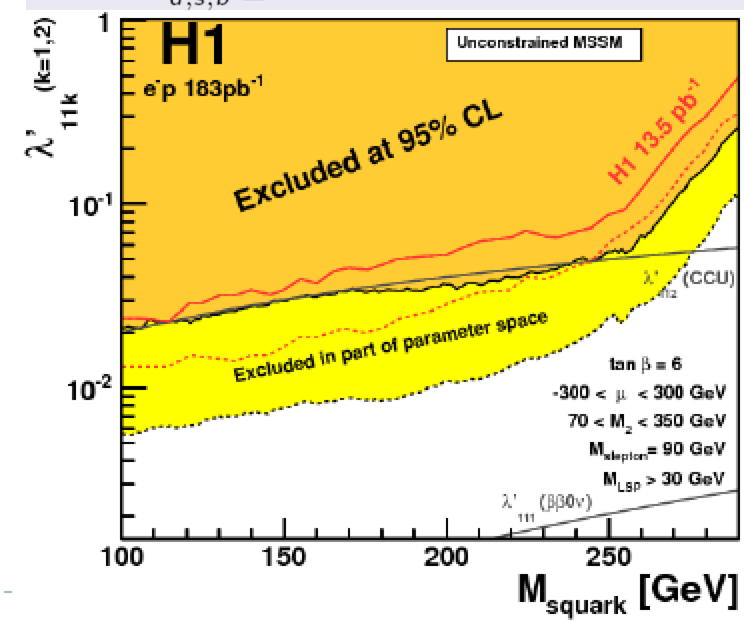
$$\lambda_{ijk} L_i L_j \overline{E}_k + \underbrace{\lambda'_{ijk} L_i Q_j \overline{D}_k} + \lambda''_{ijk} \overline{U}_i \overline{D}_j \overline{D}_k$$

- For squark production:
  - λ' couplings relevant in e-p production
- Decays: direct or via cascade





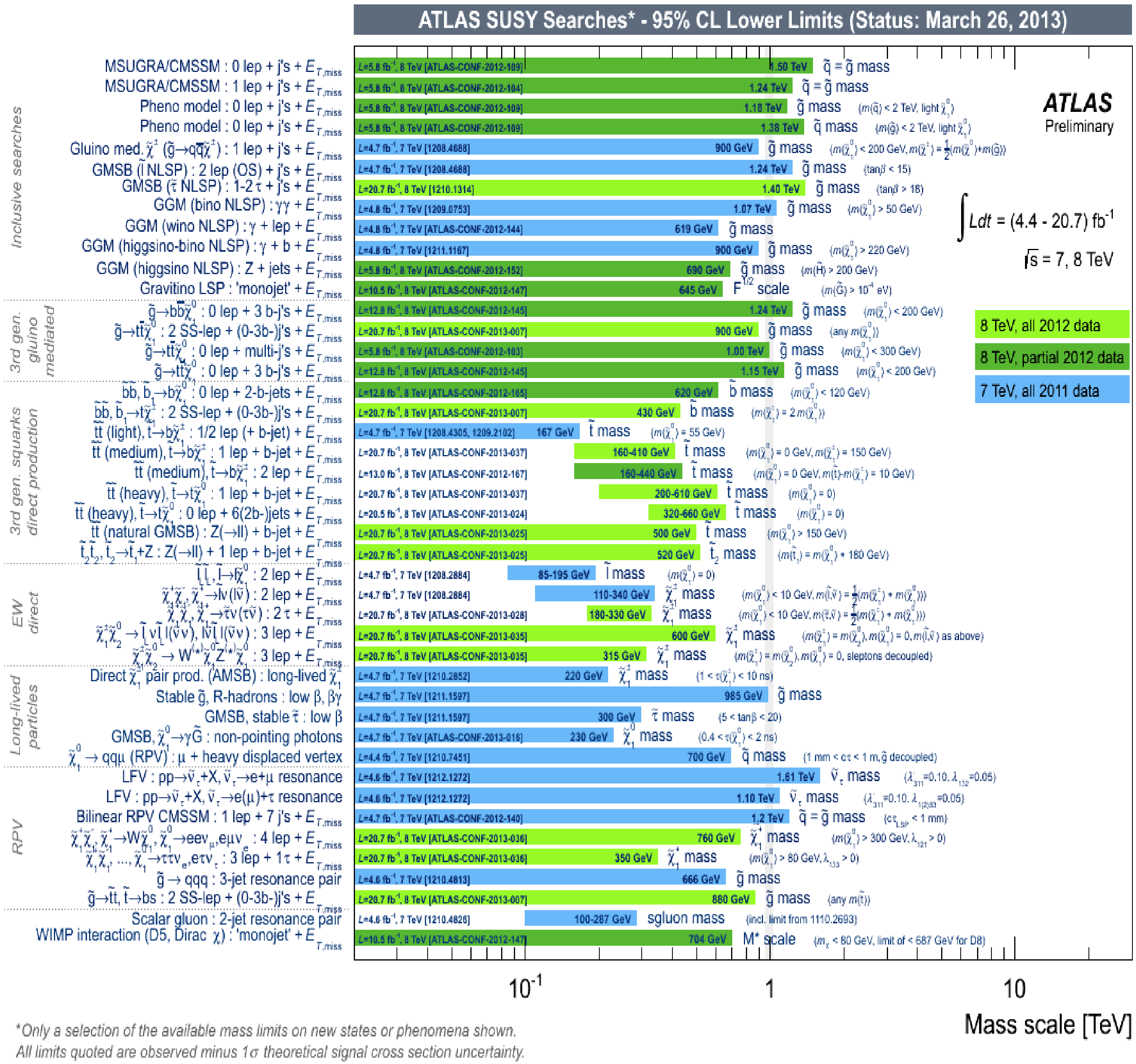
- For couplings of em. strength ($\lambda'_{1j1}, \lambda'_{11k} \simeq 0.3$)
  - $M_{\tilde{u},\tilde{c},\tilde{t}} \geq 275$ GeV at 95% CL.
  - $M_{\tilde{d},\tilde{s},\tilde{b}} \geq 290$ GeV at 95% CL.



  - Current limits up to HERA mass-bound
    - Strong lepto-quark constraints from LHC to be taken into account if RPV~100%
    - Cascade decays (via RPC vertex) lead to more complex and under-constrained signatures
  - Reach up to 1 TeV with LHeC
    - Feasibility of these searches will depend on LHC findings (useful in case of evidence ☺)

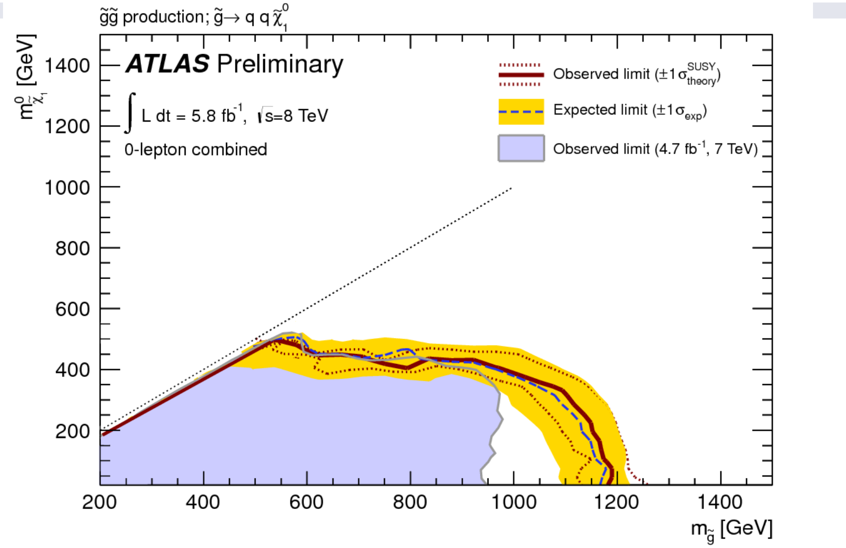
Lot of efforts on RPC scenarios

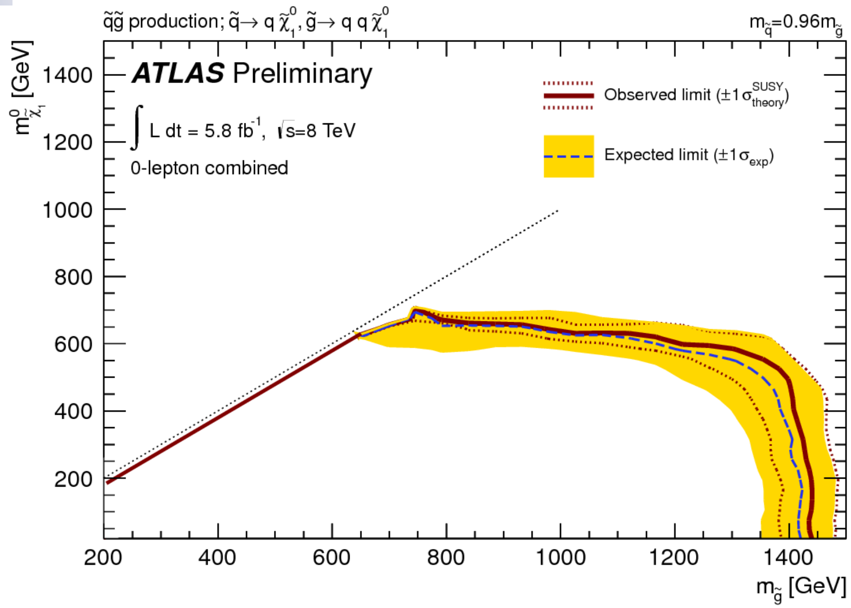
Strong constraints on first (and second) generation squarks and other scenarios

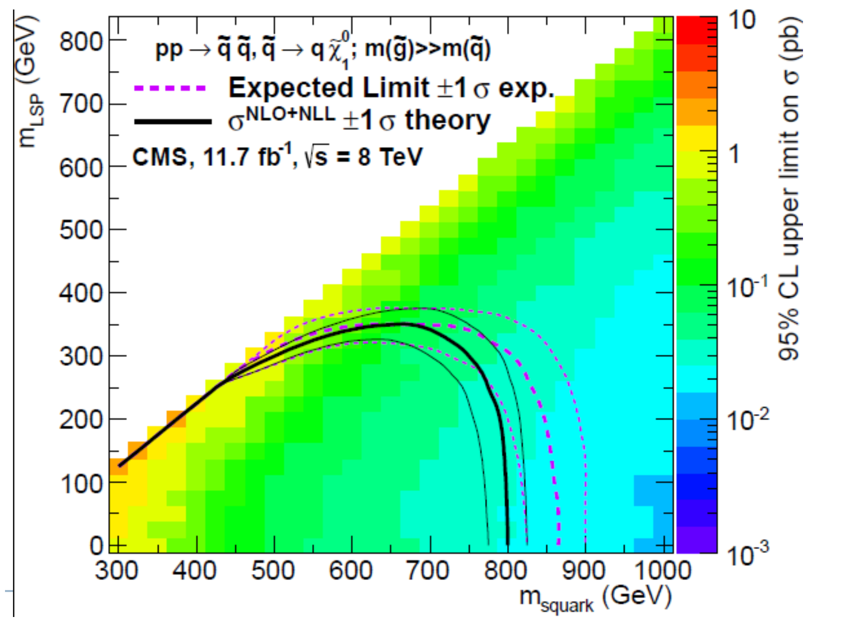


RPC scenarios: strong production

- Strong constraints on gluino (1.4 TeV) and squark masses (up to 1.6 TeV) under certain assumptions
  - 1st and 2nd generation squarks degenerate
  - Compressed scenarios difficult



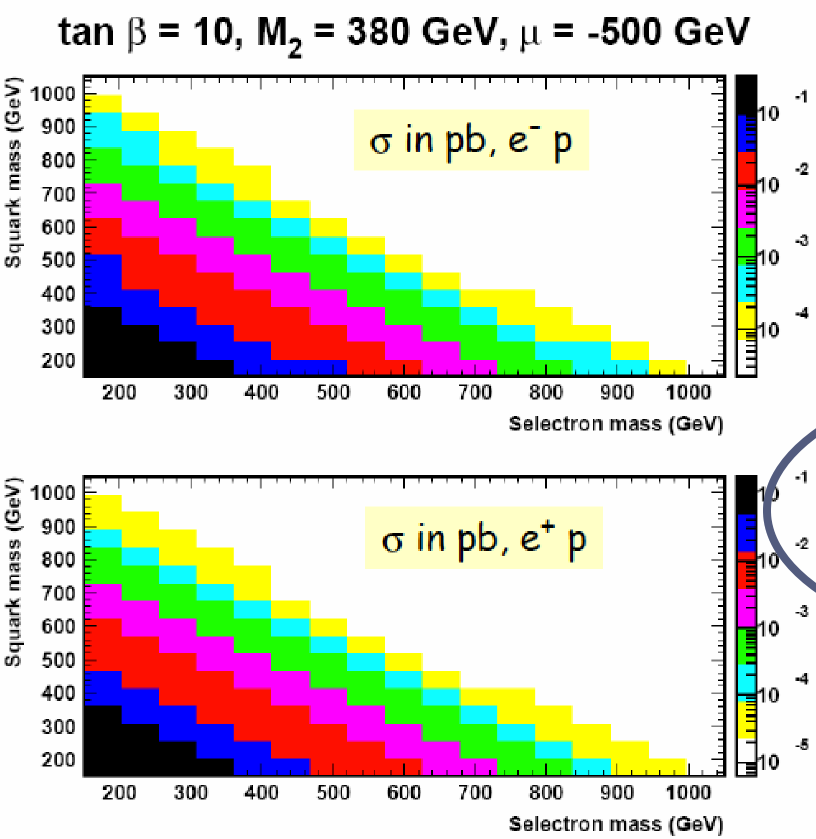


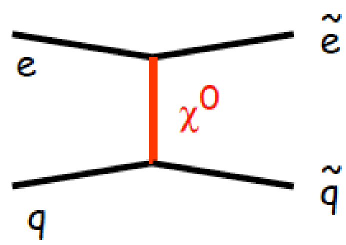


SUSY @ LHeC: RPC scenarios

- Selectron-squark pair production
- From last workshop:

Current LHC slepton limits: 250 GeV for m(LSP)<50 GeV





Pair production via t-channel exchange of a neutralino.

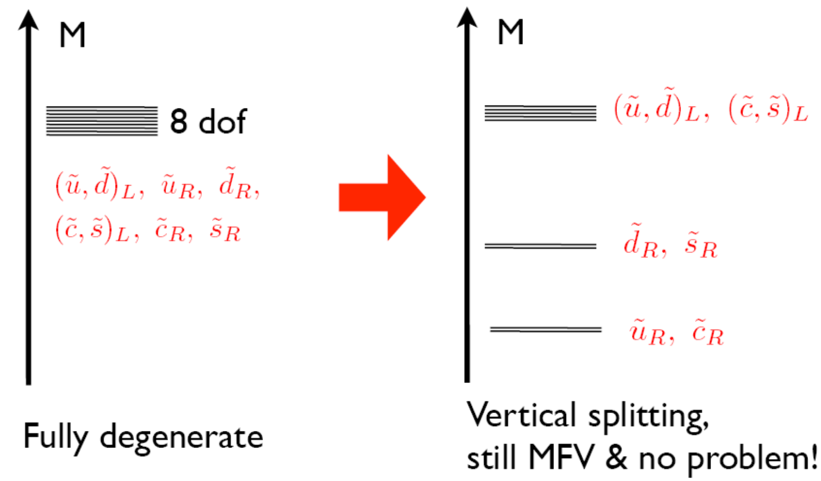
Cross-section sizeable when ΣM < 1 TeV i.e. if squarks are "light", could observe selectrons up to ~ 500 GeV.

- Could extend a bit over the LHC slepton sensitivity
- Possible information on couplings by playing with e+ / e- / L / R

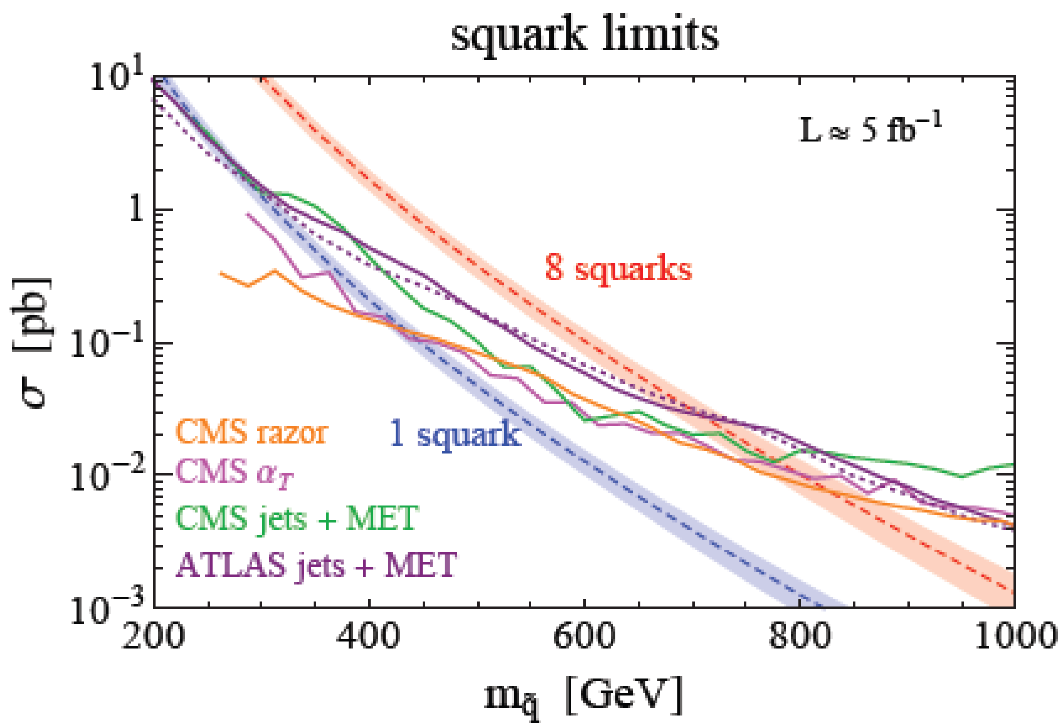
Are the current constraints really strong enough?

Non-degenerate 1st and 2nd generation squarks

- Review of current constraints on usual assumption on mass degenerate of 1st and 2nd generation squarks:



http://arxiv.org/abs/1212.3328



Will depend on LHC boundaries on these scenarios → might be hard considering the increasing trigger thresholds in MET and jet pT

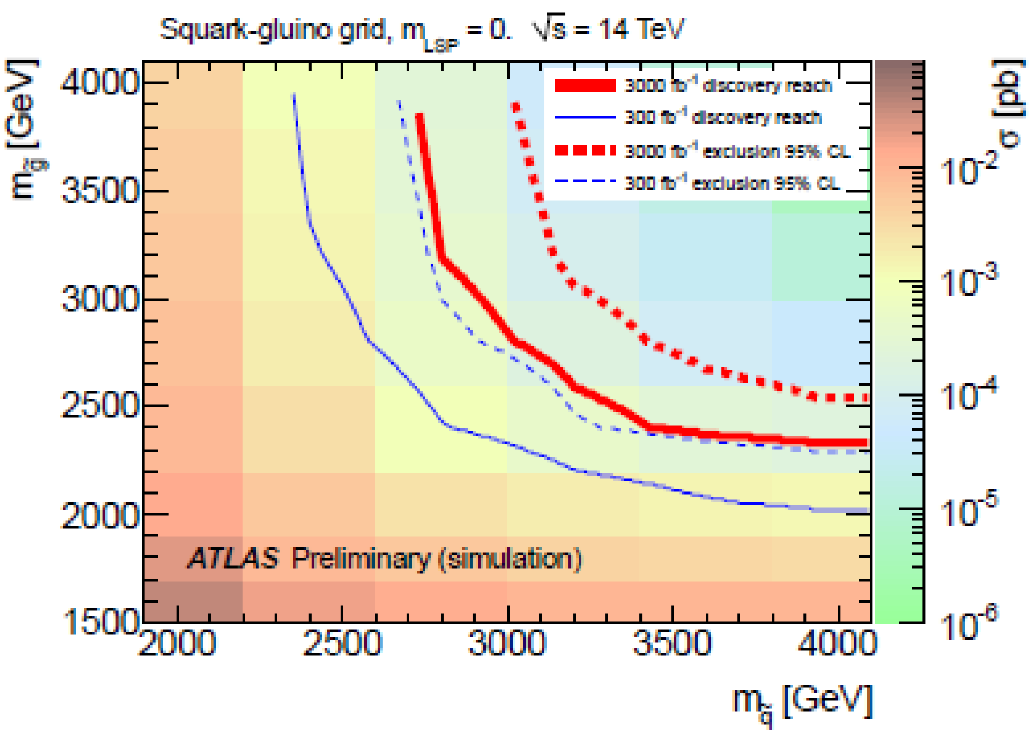
LHC - LHeC interplay for SUSY

- If no evidence for RPC SUSY is found in Run II, sparticles might become out of reach for LHeC
- Still, interplay in terms of PDF quite relevant
- Based on results shown for ES document and ATLAS PhaseII LoI
- Strategy:
  - Consider three benchmark kind of processes: **squark-gluino**, stop,chargino/neutralino production

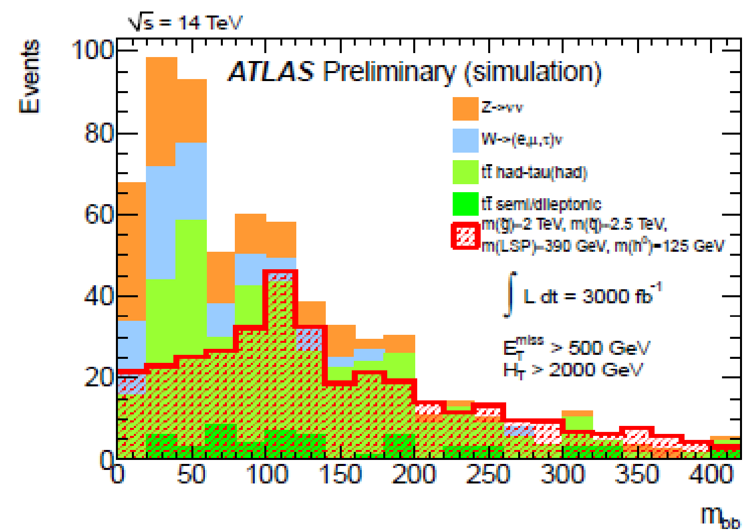
- **If No deviations from the SM observed in 300/fb**
  - Extension of sensitivity (mass & cross section reach) with 3000/fb
- **Deviations from the SM observed in 300/fb**
  - Signal characterization with 3000/fb

Search for squark/gluinos

- Select events with high pT jets, high MET and HT
  - Sensitivity expressed as 95% CL exclusion limit and 5σ discovery
- An increase of integrated luminosity from 300 fb^{-1} to 3000 fb^{-1} improves the sensitivity to sq/gl by approximately 400-500 GeV
- Decay chain might be complex, including Z or Higgs → exploit m(bb)

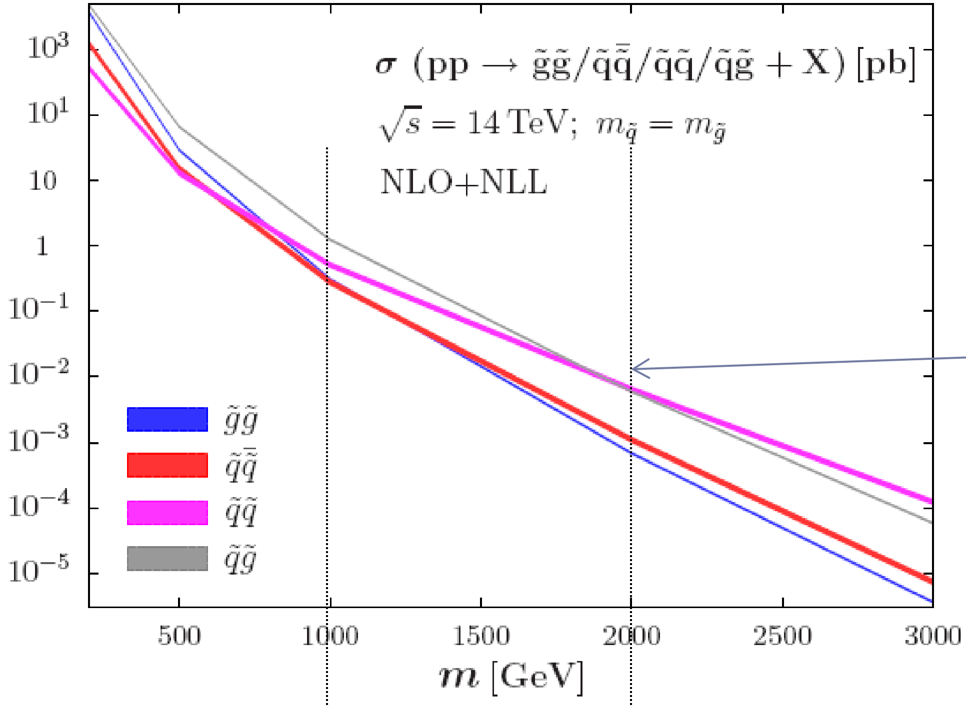


Higgs boson in complex SUSY decay chain can be identified

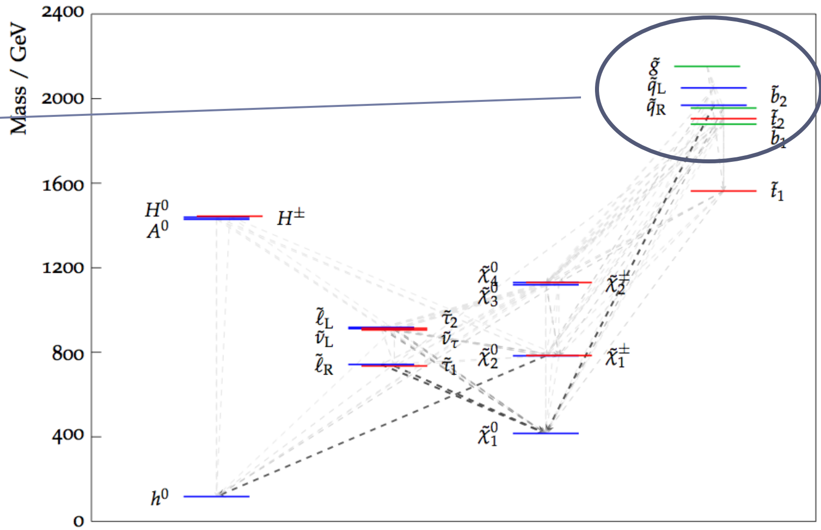


Strong production

- xsection ~ 2.5 pb for m = 1000 GeV, ~ 0.01 pb for m(squark, gluino) = 2 TeV → clearly, high stats samples are needed.



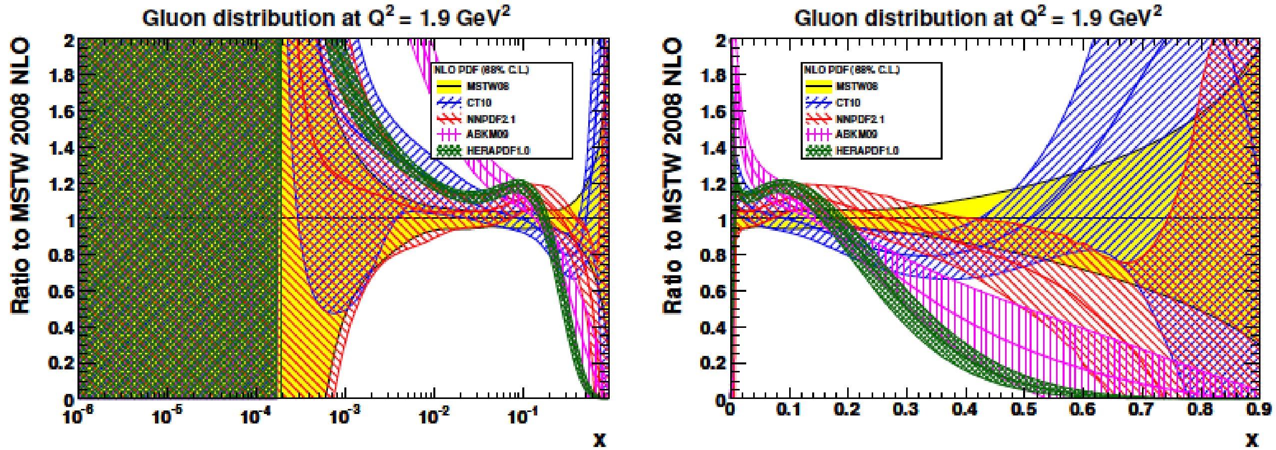
mSUGRA reference point:
m0=650, m1/2=975, xs 1.1E-05 nb



Decay chain might be complex, including Z or Higgs

Gluon distributions

now



then

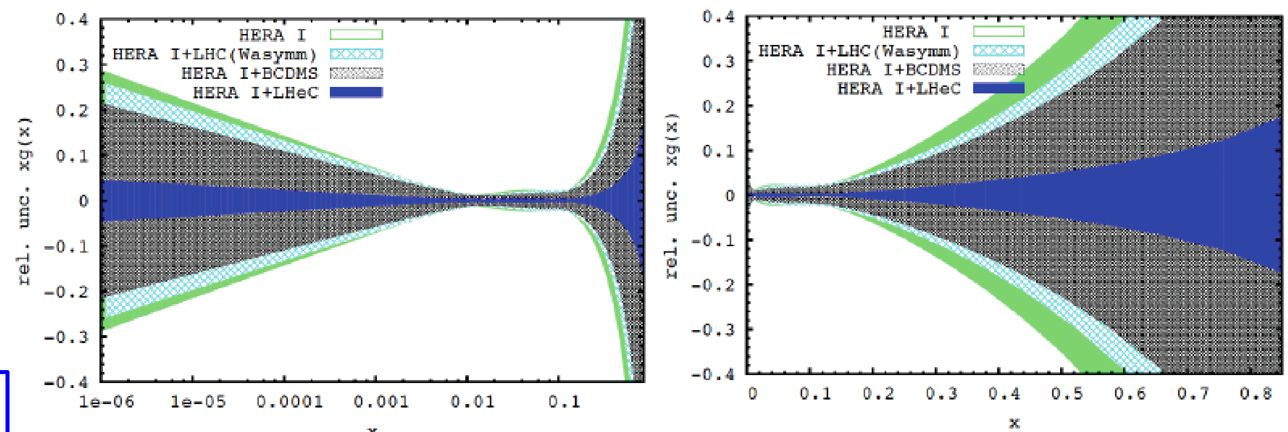
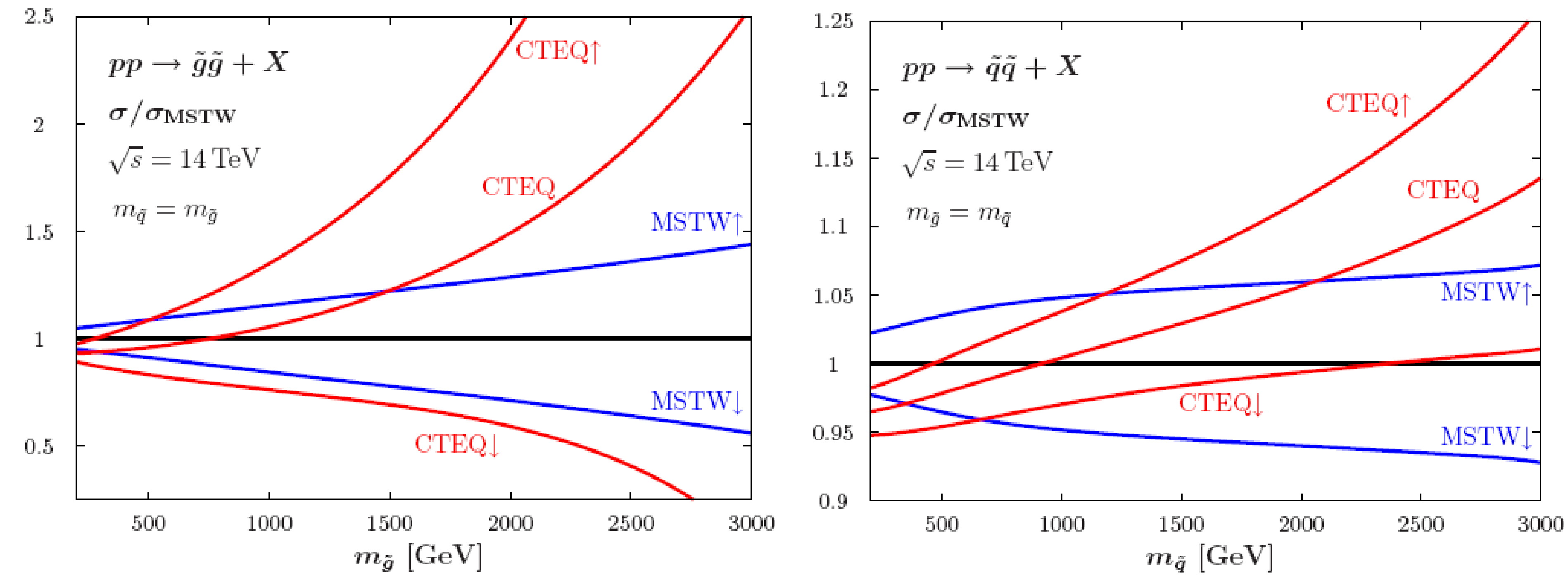


Figure 4.17: Relative uncertainty of the gluon distribution at $Q^2 = 1.9$ GeV^2, as resulting from an NLO QCD fit to HERA (I) alone (green, outer), HERA and BCDMS (crossed), HERA and LHC (light blue, crossed) and the LHeC added (blue, dark). Left: logarithmic x, right: linear x.

High x: xg and valence quarks: resolving new high mass states!

Importance of PDF

- If we see deviations from SM, will be important to characterize the physics underneath. First studies on the case of strong production M.Kramer 2011)



→ driven by gluon pdf at large x

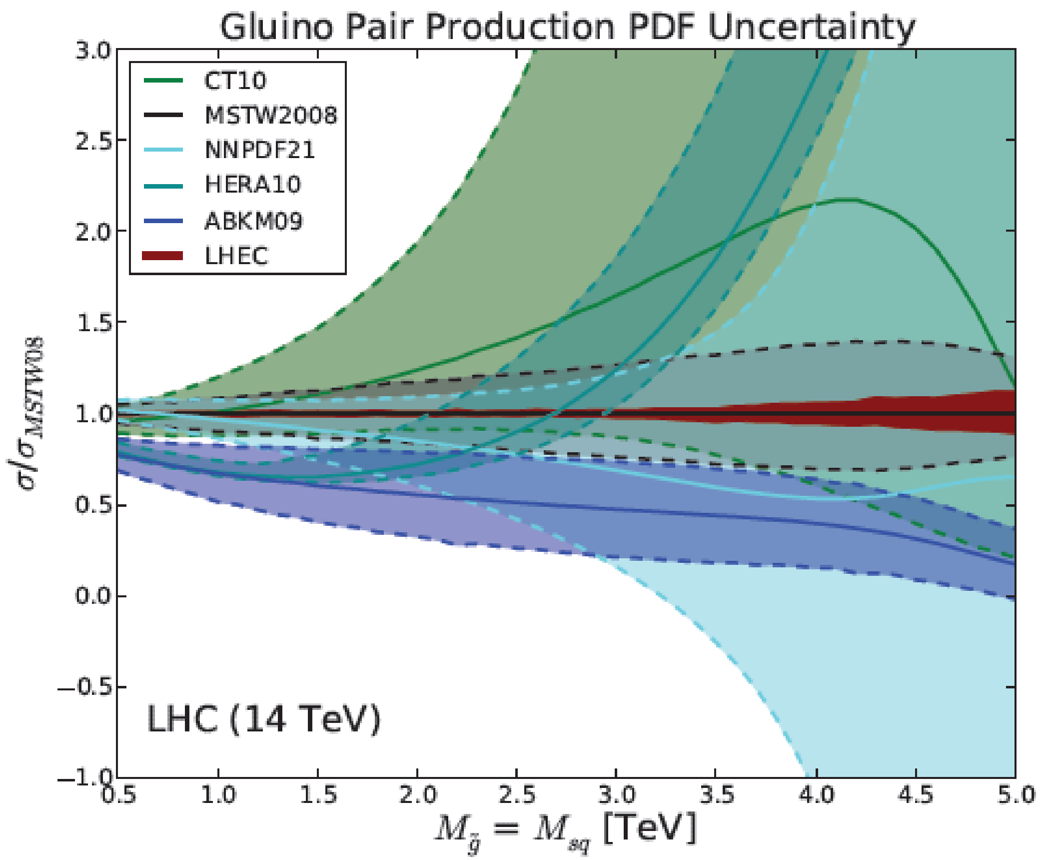
→ sizeable uncertainty $\approx \pm 25\%$ for $m \approx 1$ TeV

→ driven by valence quark pdfs at large x

→ small uncertainty $\approx \pm 5\%$ for $m \approx 1$ TeV

PDF for gluinos production

- Impact of improved PDF fits on theoretical predictions for SUSY process:
  - Example: gl-gl production (assuming m_gl = m_sq)

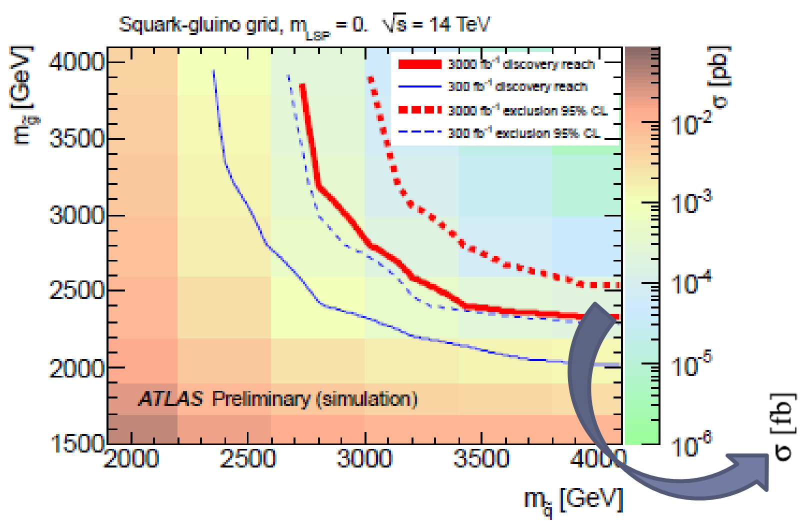


[arXiv:1211:4831+5102]

Figure 5: Calculation of gluino pair production in NLO SUSY-QCD using Prospino [16] and assuming squark mass degeneracy and equality of squark and gluino masses for illustration. The error bands are around central values (solid lines) and correspond to the uncertainty quotations of the various PDF groups. The red band of uncertainty for the LHeC corresponds to the statistical and systematic errors including their correlations as treated in the NLO QCD fit described in the CDR.

Impact on discovery/exclusion reach

- PDF uncertainties impact discovery / exclusion reach:
  - Total yields
  - Shape variations on discriminating quantities (in progress)

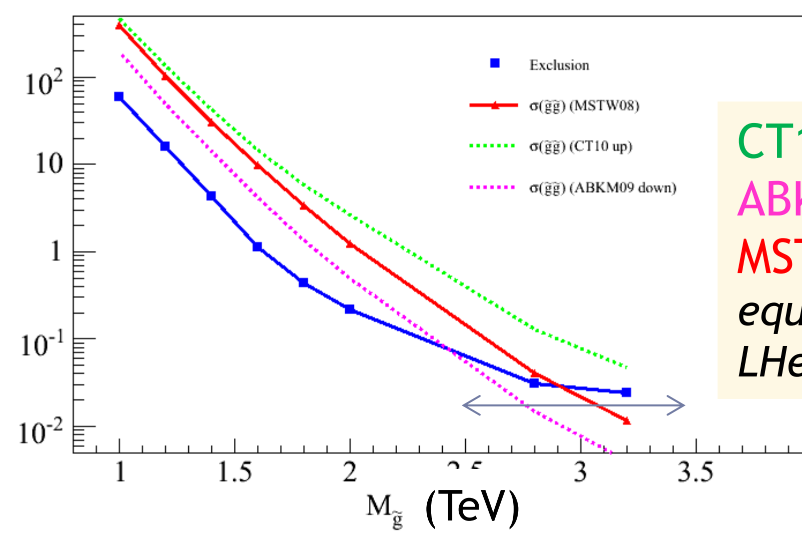


Caution: **very very** preliminary, mostly as illustration

(UL for gl-gl courtesy of G.Redlinger)

Impact on discovery/exclusion contours under various PDF hypothesis in progress

LHC @ 14 TeV 3 ab-1, M(squark) > 4 TeV



CT10 up
ABKM09 down
MSTW08
equivalent to LHeC PDF

Note: impact of PDF uncertainties on SM background also not negligible
However → mitigated by usage of Control Regions and semi data-driven estimate

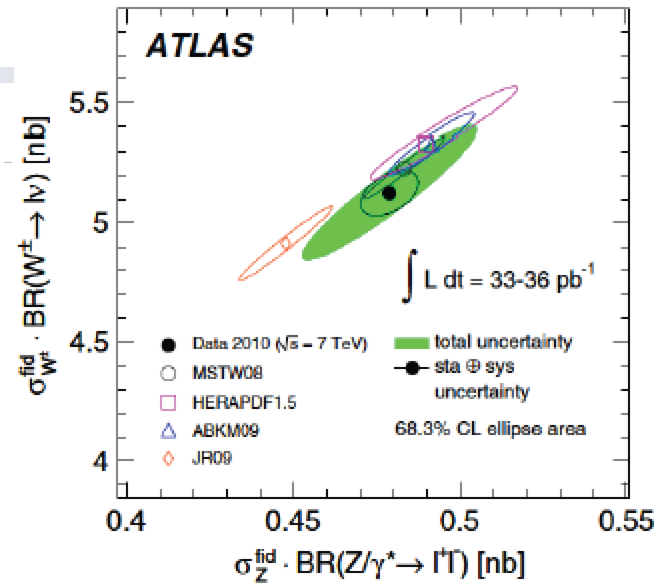
Summary and outlook

- LHeC provides complementarities to the LHC SUSY search program in the twenties
  - Ideal to search and study properties of new bosons with couplings to electron-quark
  - Direct searches for CI, excited fermions, leptoquark, RPV SUSY, RPC SUSY in specific scenarios such as compressed, non-degeneracy for squarks
  - Interplay with HL-LHC to constraints on PDF crucial for model testing in case of observed deviations → an independent precision measurement of PDFs will be important for an efficient use of the high luminosity for setting reliable high mass limits

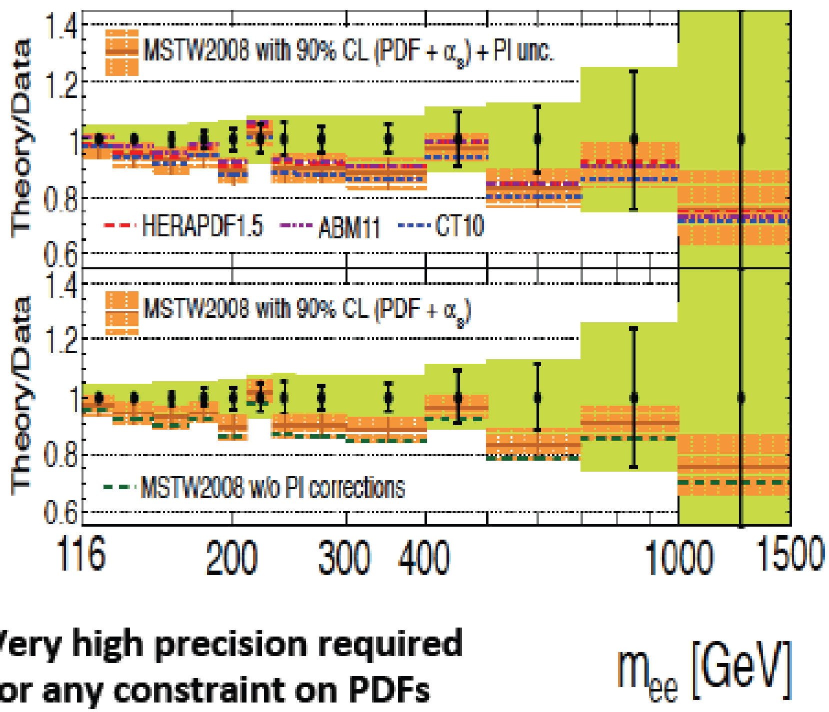
Back-up

PDF for LHC

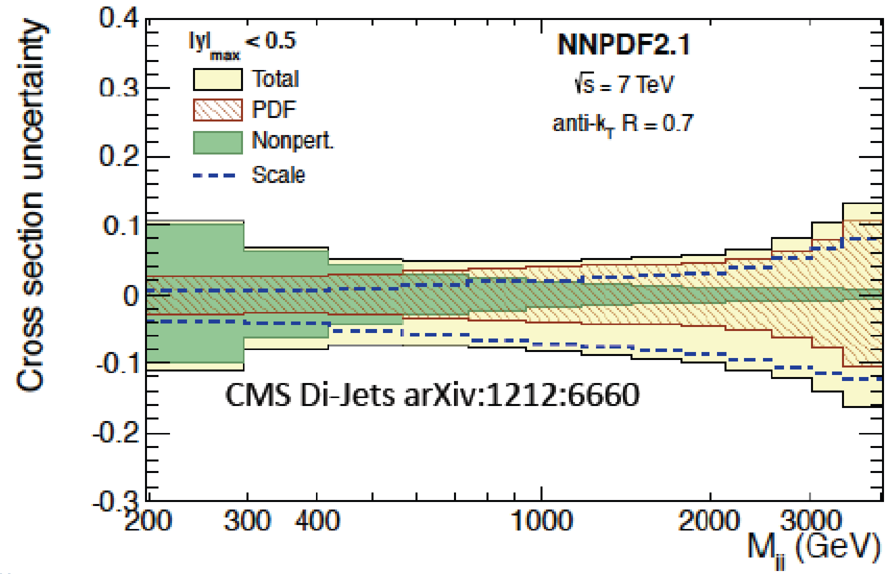
- Use precision Drell-Yan (W,Z) data to constraint PDFs



PRD D85 (2012) 072004



Very high precision required for any constraint on PDFs



Towards high mass the PDF uncertainties rise, strongly towards the edge ($\sqrt{s}$) $x \to 1$...

Other properties of LQs

- Spin:
  - LHC: LQ-LQ leads to angular distributions depending on g-LQ-LQ coupling
  - LHeC: cosθ* distribution of LQ decay is sensitive to spin

$$\text{scalar: flat } d\sigma/dy$$

$$\text{vector: } d\sigma/dy \sim (1-y)^2 \qquad \left[y = \frac{1}{2}(1+\cos\theta^*) \right]$$

$$NC: \sim y^{-2}$$

- BR to neutrinos (good S/B for ν-q)
- Coupling measurement, once spin and charge is determined

$$\sigma_{prod} \sim (2J+1)\lambda^2$$

LQ isospin family

- Classification used here (BRW framework)

$F=2$	Prod./Decay	β_e	$F=0$	Prod./Decay	β_e
Scalar Leptoquarks					
${}^{1/3}S_0$	$e_L^- u_L \to e^- u$	1/2	${}^{5/3}S_{1/2}$	$e_L^- \bar{u}_L \to e^- \bar{u}$	1
	$e_R^- u_R \to e^- u$	1		$e_R^- \bar{u}_R \to e^- \bar{u}$	1
${}^{4/3}\tilde{S}_0$	$e_R^- d_R \to e^- d$	1	${}^{2/3}S_{1/2}$	$e_R^- \bar{d}_R \to e^- \bar{d}$	1
${}^{4/3}S_1$	$e_L^- d_L \to e^- d$	1	${}^{2/3}\tilde{S}_{1/2}$	$e_L^- \bar{d}_L \to e^- \bar{d}$	1
${}^{1/3}S_1$	$e_L^- u_L \to e^- u$	1/2			
Vector Leptoquarks					
${}^{4/3}V_{1/2}$	$e_R^- d_L \to e^- d$	1	${}^{2/3}V_0$	$e_R^- \bar{d}_L \to e^- \bar{d}$	1
	$e_L^- d_R \to e^- d$	1		$e_L^- \bar{d}_R \to e^- \bar{d}$	1/2
${}^{1/3}V_{1/2}$	$e_R^- u_L \to e^- u$	1	${}^{5/3}\tilde{V}_0$	$e_R^- \bar{u}_L \to e^- \bar{u}$	1
${}^{1/3}\tilde{V}_{1/2}$	$e_L^- u_R \to e^- u$	1	${}^{5/3}V_1$	$e_L^- \bar{u}_R \to e^- \bar{u}$	1
			${}^{2/3}V_1$	$e_L^- \bar{d}_R \to e^- \bar{d}$	1/2

Table 5.1: Leptoquark isospin families in the Buchmüller-Rückl-Wyler model. For each leptoquark, the superscript corresponds to its electric charge, while the subscript denotes its weak isospin. β_e denotes the branching ratio of the LQ into $e+q$.

Squark mass splitting

- Large splitting is possible

(A. Weiler)

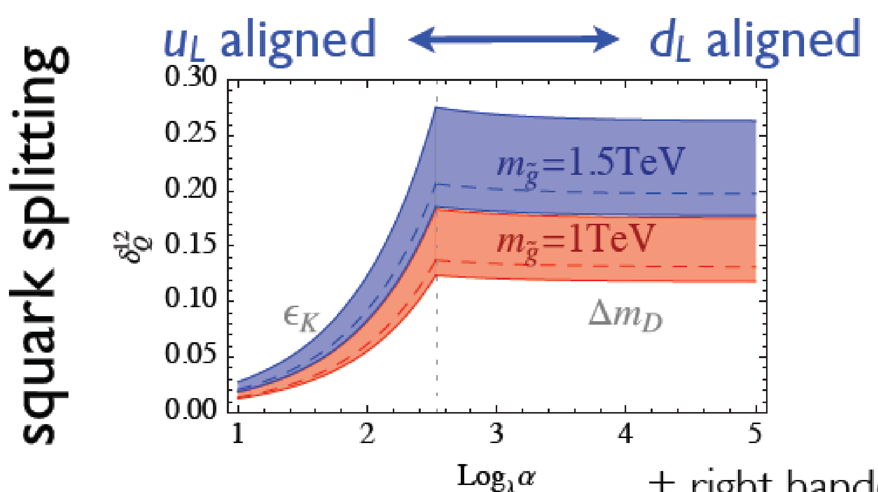
Seiberg & Nir

$$(\delta^q_{ij})_{MM} = \frac{1}{\tilde{m}_q^2} \sum_\alpha \boxed{(K^q_M)_{i\alpha}(K^q_M)^*_{j\alpha}} \Delta \tilde{m}^2_{q_\alpha}$$

mixing / misalignment between
SM Yukawas and squark mass matrices

If by symmetry: K_{ij} ~ diagonal => O(1) mass splitting allowed!

Gedalia et. al



Example:
m_{gluino} = 1.3 TeV
m_{Q1} = 550 GeV
m_{Q2} = 950 GeV

+ right handed squarks split by arbitrary amount

LHC: The Roadmap to 2030

- *ESPP-Cracow meeting:*

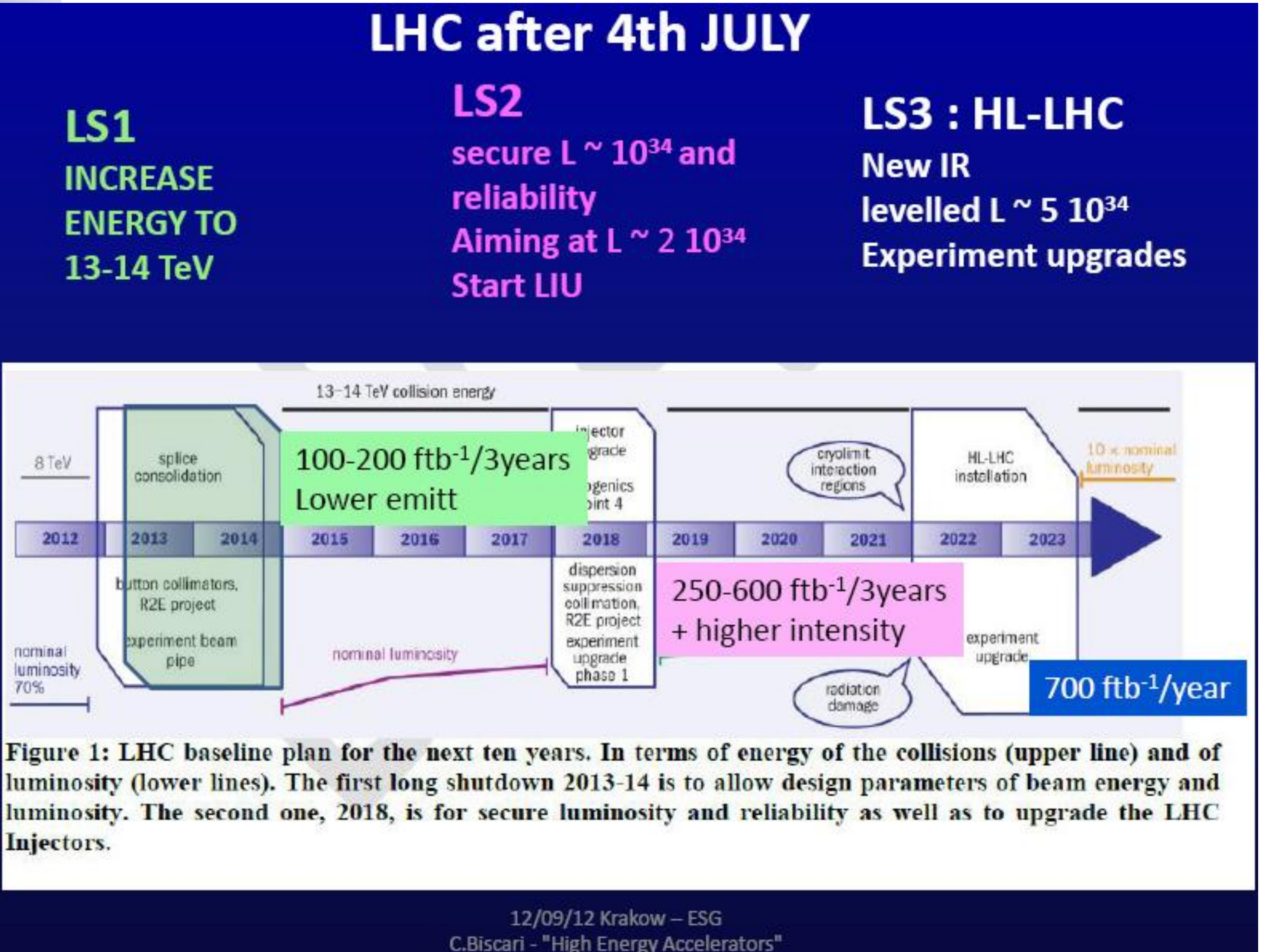


Figure 1: LHC baseline plan for the next ten years. In terms of energy of the collisions (upper line) and of luminosity (lower lines). The first long shutdown 2013-14 is to allow design parameters of beam energy and luminosity. The second one, 2018, is for secure luminosity and reliability as well as to upgrade the LHC Injectors.

LHC has still only delivered a small fraction of the effective parton-parton lumi →discovery physics programme just getting started!

- Accelerator timescale driven by several aspects:
  - Radiation damage of LHC components
  - R&D and construction of LHC upgrades
  - Required schedule of detector upgrades
- **Long Shutdown (LS)** periods to install upgrades
- Possibility of an HE (High Energy) LHC still under discussion

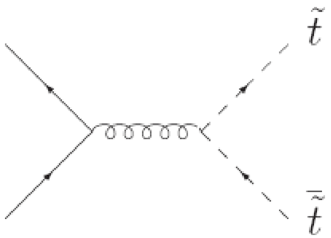
Searches for SuperSymmetry

- Very stringent constraints from LHC on strongly produced sparticles (1^{st}, 2^{nd} generation squarks, gluinos) → can be quite heavy **(multi-TeV)**
- Direct production of 3^{rd} generation squarks and weak gauginos is becoming accessible as the amount of integrated luminosity increases **(low cross sections)**

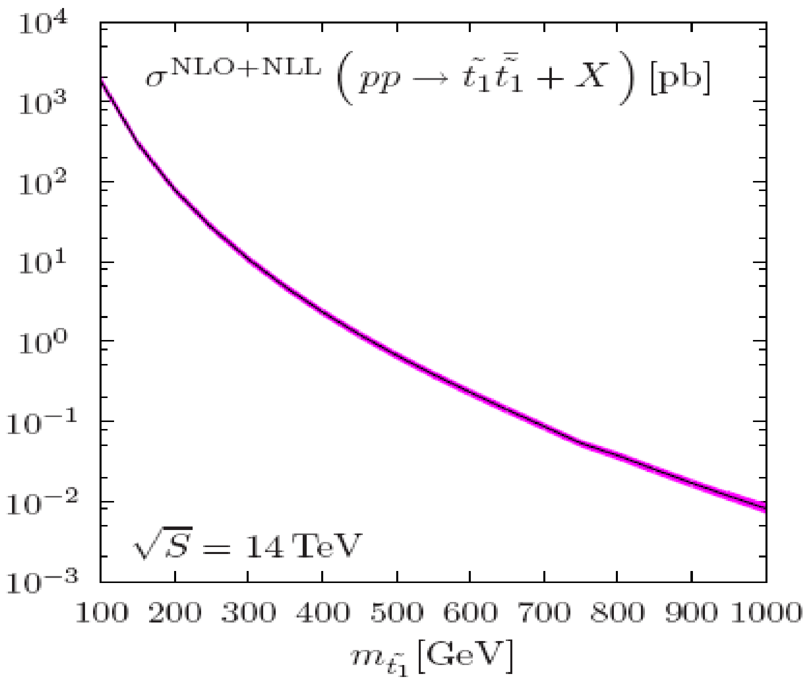
- **If No deviations from the SM observed in 300/fb**
  - Extension of sensitivity (mass & cross section reach) with 3000/fb
- **Deviations from the SM observed in 300/fb**
  - Signal characterization with **3000/fb**

- Determination of masses by measuring endpoints of visible mass distributions
- Measurement of couplings and spin (via angular analysis)

Third generation



- If sq/gl are not found < 3 TeV
  - Still the stop (and possibly sbottom) are among the most important SUSY particles to be found!
  - At 14 TeV, stop cross section ~ 10-20 x xsect @ 7 TeV



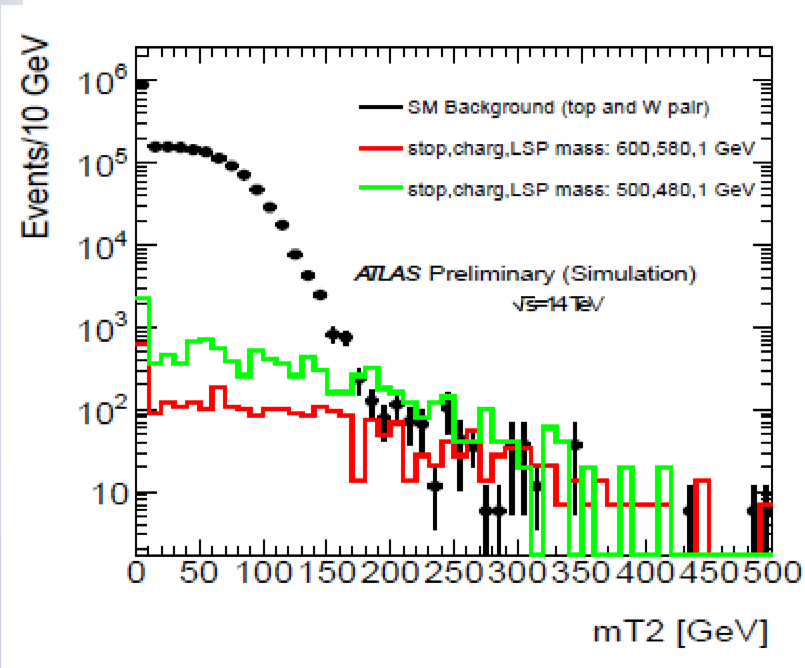
Mass	MSTW2008	CTE6.6
400 GeV	2.34 pb	2.19 pb
600 GeV	0.24 pb	0.23 pb
1 TeV	0.008 pb	0.008 pb

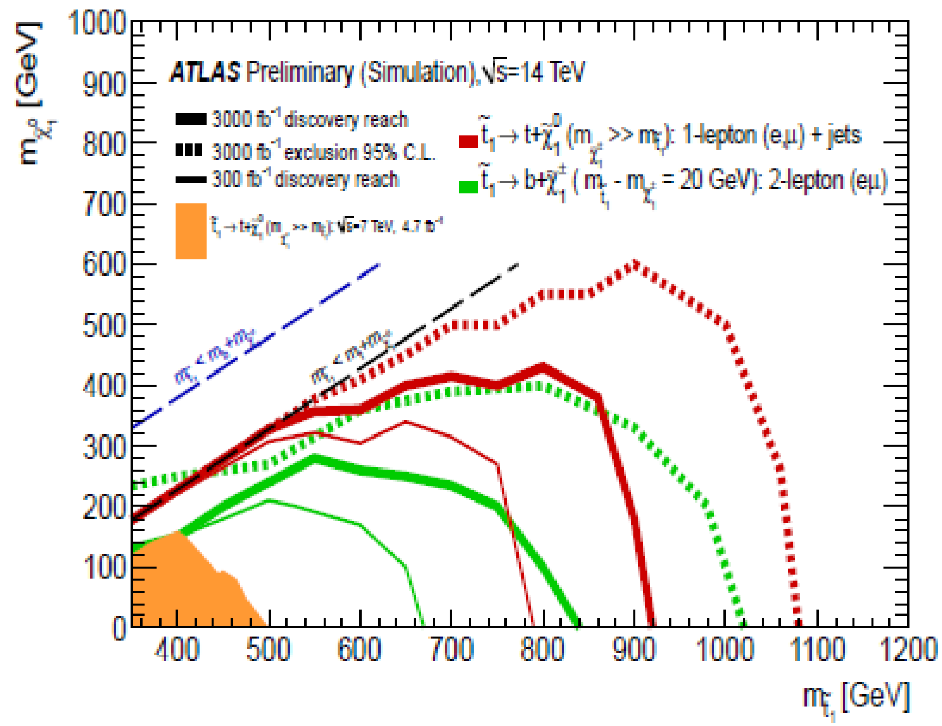
For 3000 fb-1 of lumi @ 14 TeV
@ 600 GeV: 720 x 10^3 events
@ 1 TeV: 24 x 10^3 events

- Analysis < 1 % efficiency
- Acceptance depends on the decay mode

Stop analyses

- For stop → t+LSP: 1-lepton + MET + jets
- For stop→ b+chargino (C1 into W+N1): 2-lepton (+MET,jets)
  - Discriminant: MET, MT2





- An increase of integrated luminosity from 300 fb-1 to 3000 fb-1 improves the sensitivity to sq/gl by approximately 200 GeV
- Can do more adding shape discriminants and / or boosted top reconstruction

Weak Production

- As for light stop, light gauginos well motivated by naturalness
- Rare process
  - @ 500 GeV chargino / neut 2 mass, expect ~ 6 x 10^4 events for 3 ab^{-1}
- Direct access to weak gauginos
  - Mass hierarchy via kinematic edge studies (potential model dependen fit), couplings
- Search in the 'classical' **three-lepton and ETmiss final state** originating from the decay of $\chi 1\pm$ and $\chi 20$ as W+ $\chi 10$ and Z+ $\chi 10$ respectively
  - arxiv.org/abs/1207.4846 by H. Baei addressed $\chi 20 \rightarrow$ higgs+$\chi 10$