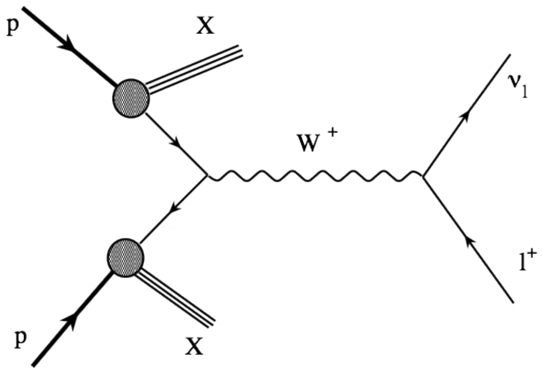
WG3 Highlights

A. Oh, A. Vicini, M. Stoye

Drell-Yan processes



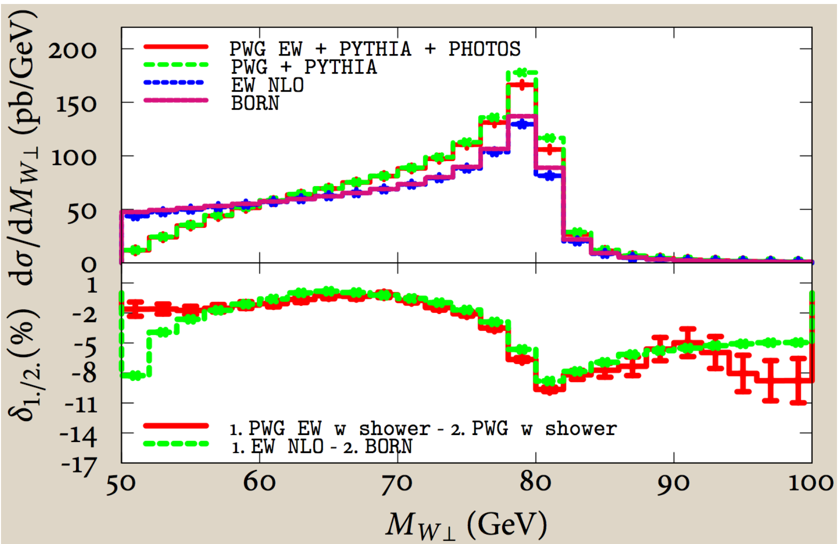
$$\sigma_{had} = \sum_{a,b} \int_0^1 dx_1 dx_2\, f_{h_1,a}(x_1, M_F) f_{h_2,b}(x_2, M_F)\, \hat{\sigma}_{ab}(x_1 P_1, x_2 P_2, \alpha_s(\mu), M_F)$$

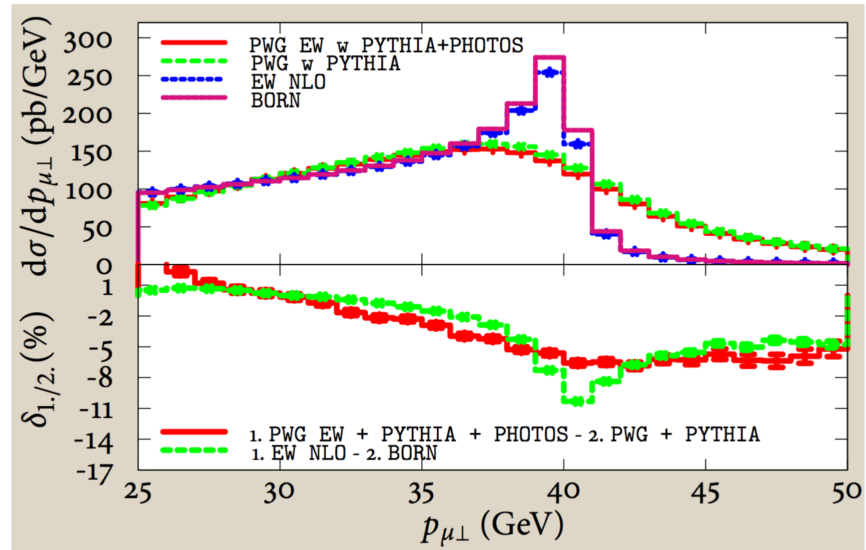
- precision measurement of EW parameters (MW, $\sin^2\theta$ w)
- background to new physics searches (Z' ,W' , more exotic states)
- constraints to PDFs

- improvements in Montecarlo codes and in matrix element calculations
- progress in the development of PDF sets with QED evolution
- discussion of observables sensitive to the different parton density

Montecarlo developments

- the MW measurement at the 10 MeV level requires a control at the per mille level of the shape of the distributions
- new POWHEG release includes consistently NLO-(QCD+EW) matched with (QCD+QED) Parton Shower
  relevance of mixed higher order O(α α _s) terms, both in NC and CC channels **see talk by L.Barzè**





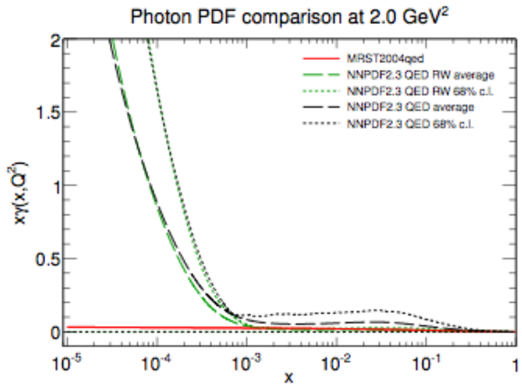
- the full NLO-EW calculations imply, at parton level, the appearance of initial state QED collinear singularities which have to be subtracted and reabsorbed into an appropriate redefinition of the parton densities, whose evolution should be governed also by a QED kernel
  existing set MRST2004QED

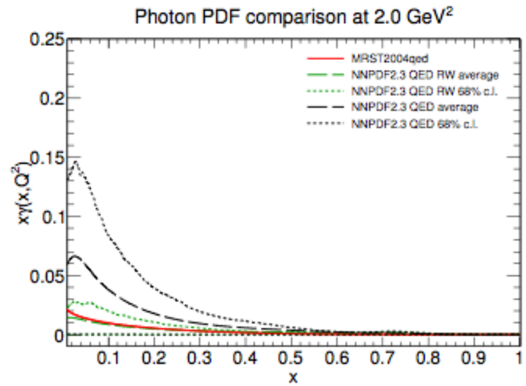
  recent progress by NNPDF to include QED evolution **see talk by S.Carrazza**

PDF including with QED evolution

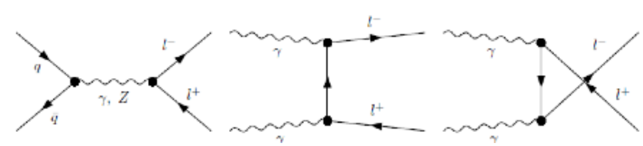
see talk by S.Carrazza

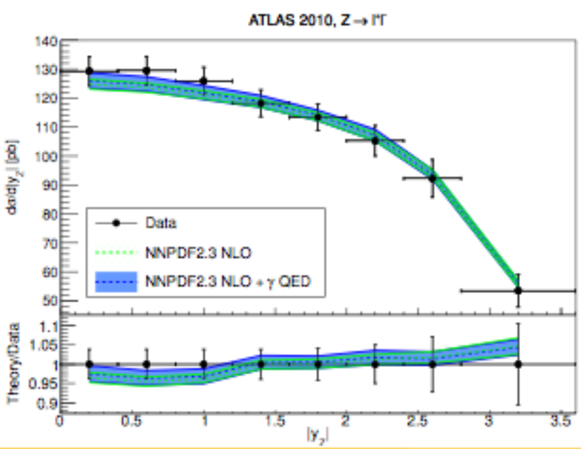
- the photon density has been extracted by NNPDF fitting DIS data and including LHC data (η l, yZ, inv.mass) via reweighting

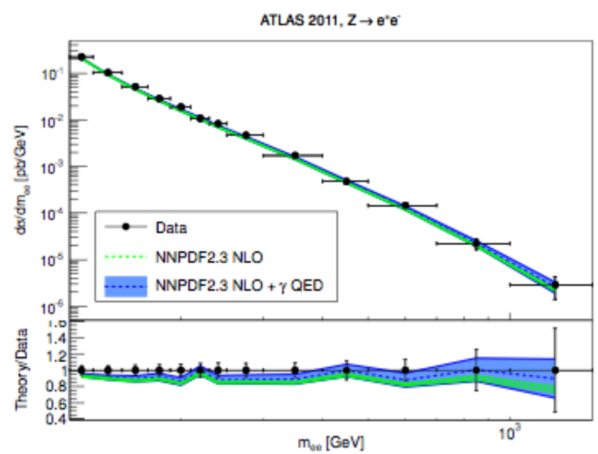




- the photon density can be constrained from Drell-Yan data; the process $\gamma\,\gamma \rightarrow l^+l^-$ contributes at Born level

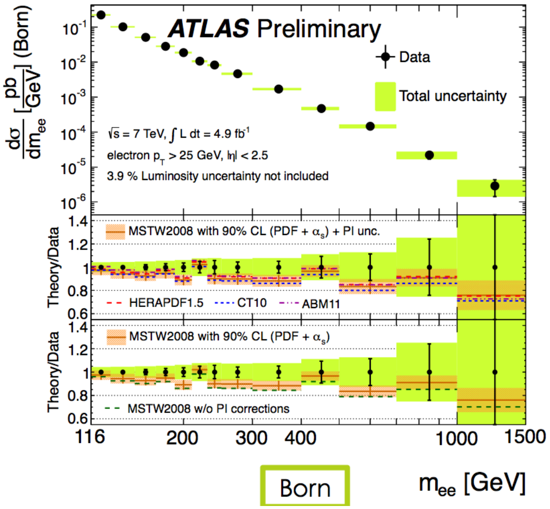


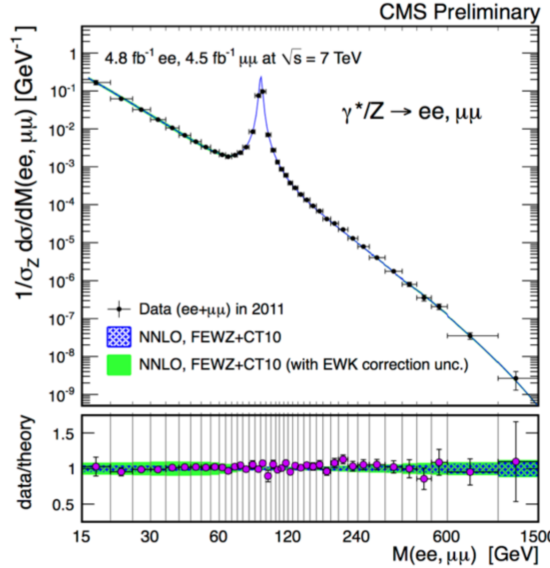




PDF set	χ^2/d.o.f.
NLO pure QCD	0.830
NLO + Photon DIS	5.715
NLO + Photon RW	0.590

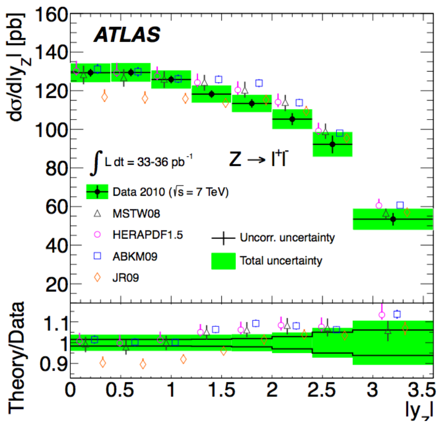
Drell-Yan processes

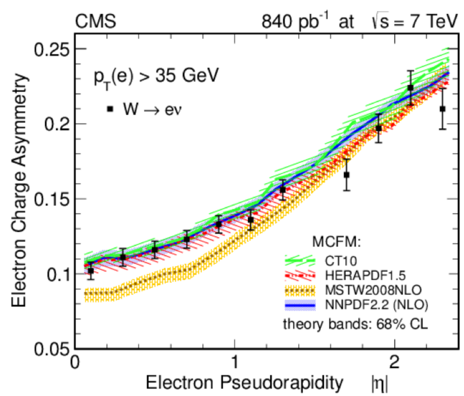




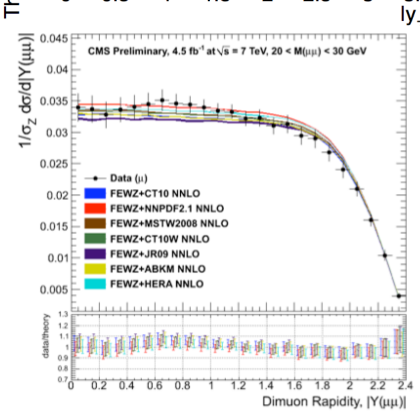
see talks by A.Khukhunashvili (CMS) and K.Nikolics (ATLAS)

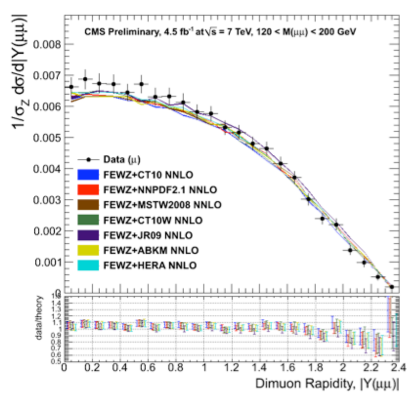
- good agreement with NNLO-QCD + NLO-EW
- the photon induced contribution improves the description at large inv.masses
- interesting to test the role of photon induced processes in low-mass NC-DY





- sensitivity of (pseudo-)rapidity distribution to PDF choice
- large statistics allows to study different invariant mass bins both at low- and at high-mass



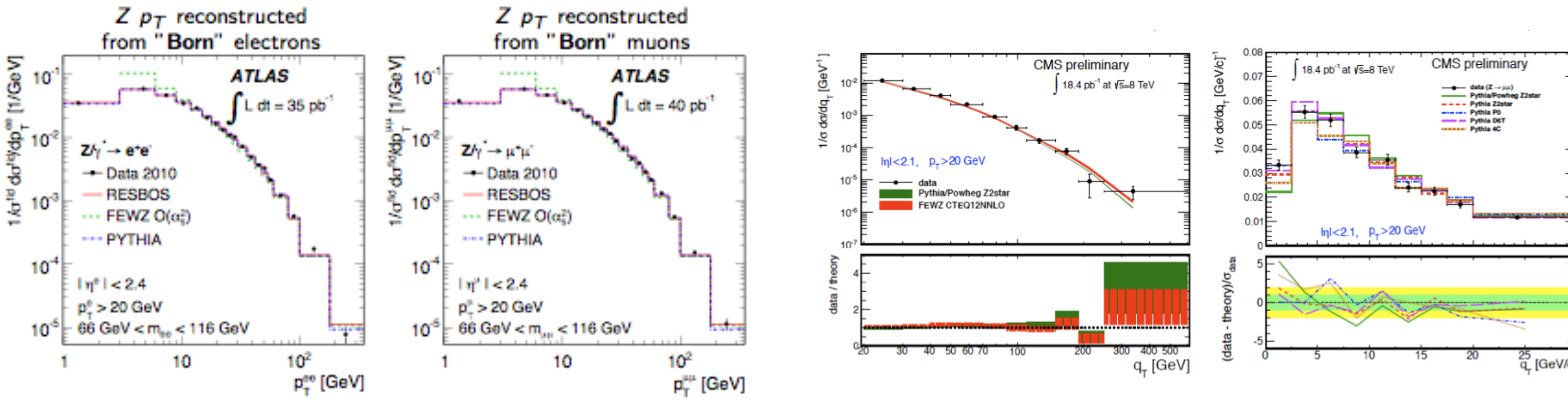


Drell-Yan processes: ptZ

see talks by E. Yatsenko (ATLAS) and A.Khukhunashvili (CMS)

- the lepton pair (gauge boson) transverse momentum distribution plays a crucial role in the MW measurement because it enters in the description of the W lepton pt and lepton-pair transverse mass

- the measurement of ptZ represent an important test of QCD, but it is quite hard from the experimental point of view and is sensitive to QCD details to all orders and to non-perturbative effects



- the Parton Shower parameters controlling the non-perturbative low-energy physics can be fitted from the data

- for precision measurements, where NLO accuracy is crucial, the tuning of POWHEG + PYTHIA rather than PYTHIA stand alone is mandatory

- accounting for QED radiation effects is important for an accurate tuning

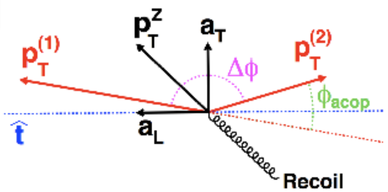
- the exclusive signature V+jet can help to constrain the gluon density, thanks to the important contribution of the gluon-induced subprocess $qg \rightarrow Vq$, and the strange density in the W+charm final state

see talks by Du Pree and by Vryonidou

Drell-Yan processes: Φ*

see talks by E. Yatsenko (ATLAS) and L.Tomlinson

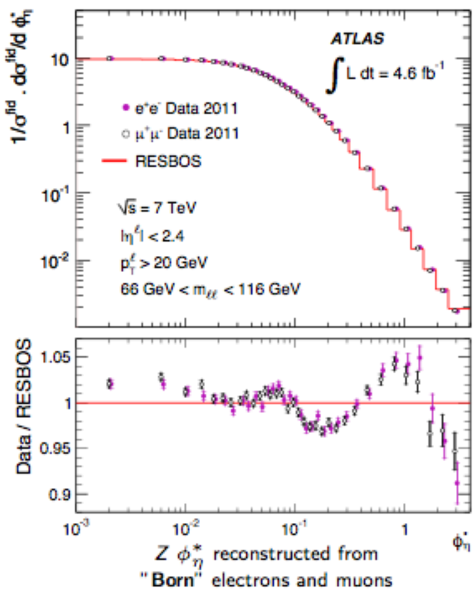
- a new variable introduced 3 years ago is Φ*, probing the same physics / phase-space region of ptZ, with a simpler definition in terms only of the measurement of angles with the possibility of a finer binning in the region interested by non-perturbative effects, which can be better fitted from the data

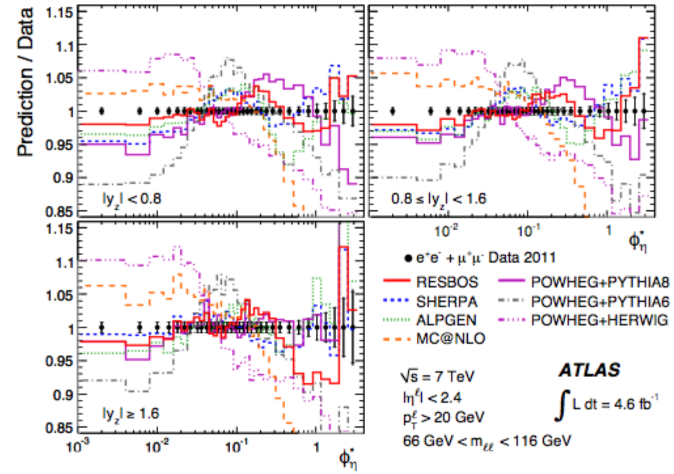


$$\phi^*_\eta \equiv tan(\phi_{acop}/2)sin(\theta^*_\eta)$$

$$\phi_{acop} \equiv \pi - \Delta\phi$$

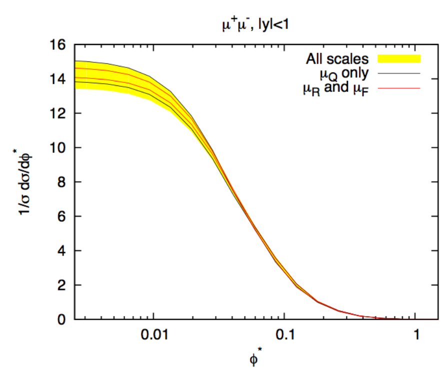
$$cos\theta^*_\eta \equiv tanh[\frac{\eta^- - \eta^+}{2}]$$

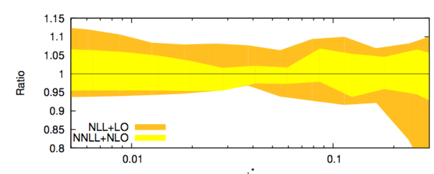




- intense activity ongoing, both theoretical and experimental

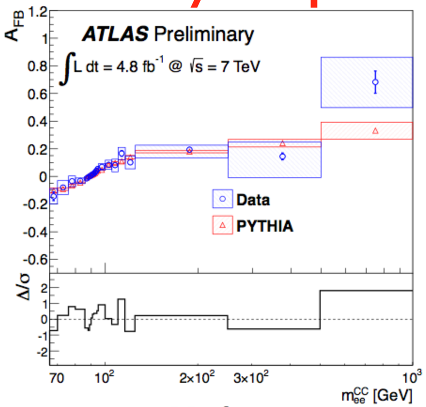
	$\phi^*_\eta < 0.5$	
	e^+e^- channel [%]	$\mu^+\mu^-$ channel [%]
Bin-by-bin correlated		
Background	0.1	0.1
Tracking resolution	0.1-0.2	0.1-0.2
Unfolding procedure	0.1	0.1
Energy/momentum scale and resolution	0.1	0.03
Identification efficiency	0.05	0.03
Trigger efficiency	0.04	0.02
Pile-up	0.05	0.05
Bin-by-bin uncorrelated		
MC sample statistics	0.1-0.2	0.1-0.2
Tracking bias	0.1	0.1
QED FSR	0.3	0.3



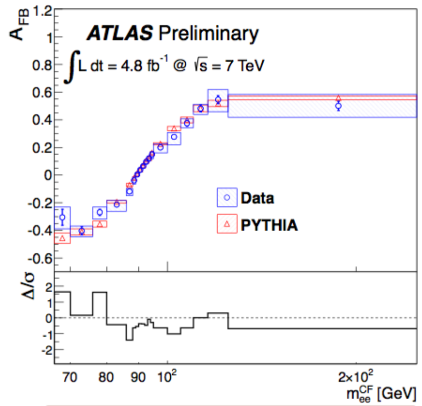


Impact of PDF uncertainties on precision observables

see talk by R.Caputo



CC electron



CF electron

$$A_{FB}(M_{l^+l^-}) = \frac{F(M_{l^+l^-}) - B(M_{l^+l^-})}{F(M_{l^+l^-}) + B(M_{l^+l^-})}$$

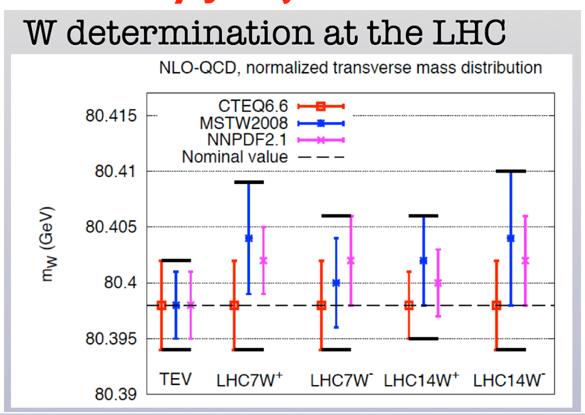
$$B(M_{l^+l^-}) = \int_{-1}^{0} \frac{d\sigma}{d\cos\theta^*} d\cos\theta^*$$

$$F(M_{l^+l^-}) = \int_{0}^{1} \frac{d\sigma}{d\cos\theta^*} d\cos\theta^*$$

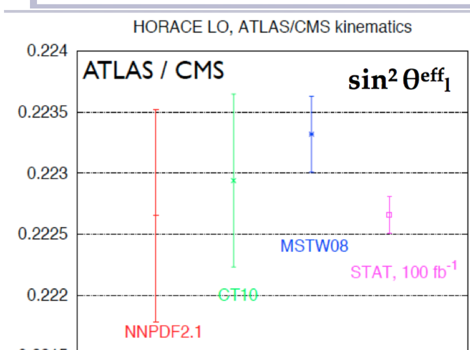
ATLAS **Preliminary**

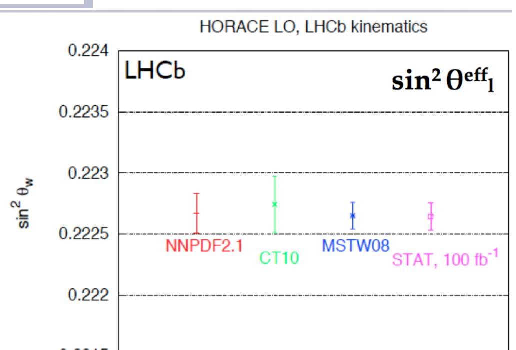
$$\sin^2\theta^{\rm eff}_{\rm W\ combined} = 0.2297 \pm 0.0004({\rm stat.}) \pm 0.0009({\rm syst.})$$

see talk by J.Rojo



- template fit technique applied to PDF replicas treated as pseudodata; each PDF replica distorts the shape of the distributions; the distortion is interpreted as a shift in MW ($\sin^2\theta$ w); the set of MW ($\sin^2\theta$ w)values obtained are combined according to PDF rules

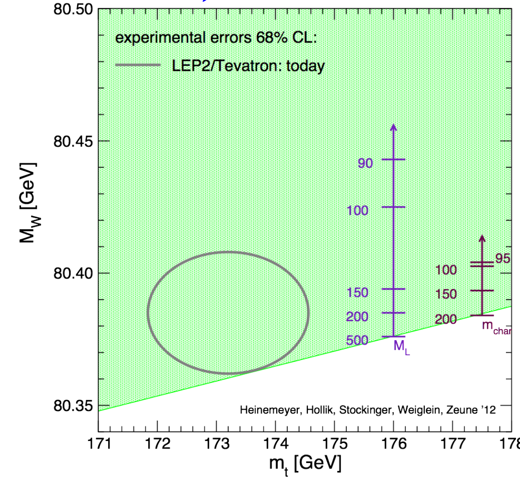




- a LO study shows that a measurement of $\sin^2\theta$ w competitive with LEP (error $1 \cdot 10^{-4}$) at LHCb is not PDF limited but statistically limited at ATLAS/CMS central is PDF limited

Implications of precision measurements: BSM, inflation models

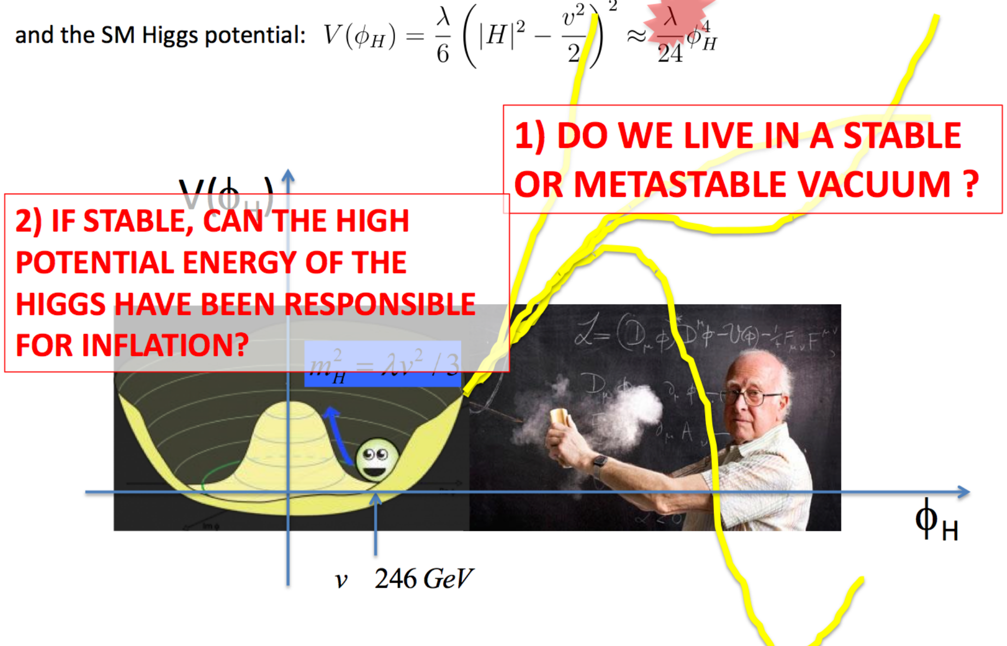
- which could be the implications of a very precise MW measurement?
- is a 10 MeV measurement possible? is 5 MeV conceivable? are PDFs a limiting factor?
- which is the precise correlation between PDFs and the observables from which we extract MW?
- progress in the understanding of EW corrections to dijet production (relevant for large-x gluon determination) the size of the corrections depends on the observable **see talk by A.Huss**

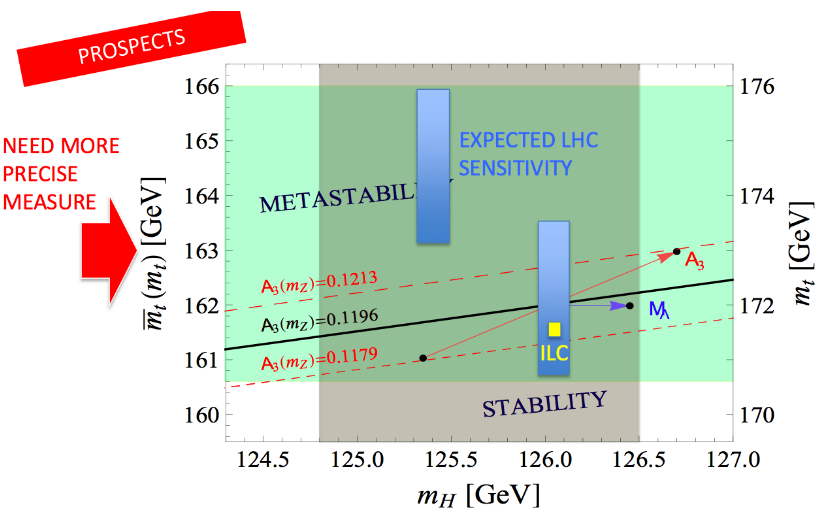


see talk by I.Masina

Consider the Higgs doublet $H = (0, (\phi_H + v)/\sqrt{2})$

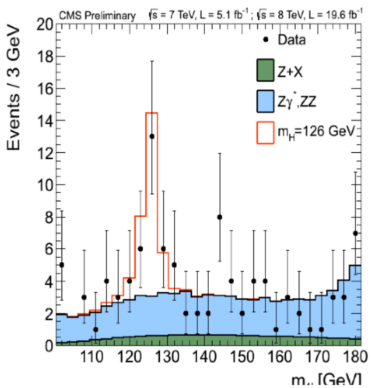
and the SM Higgs potential: $V(\phi_H) = \frac{\lambda}{6}\left(|H|^2 - \frac{v^2}{2}\right)^2 \approx \frac{\lambda}{24}\phi_H^4$

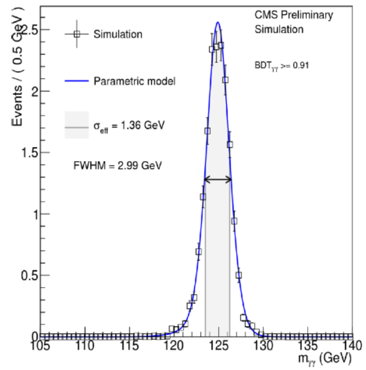


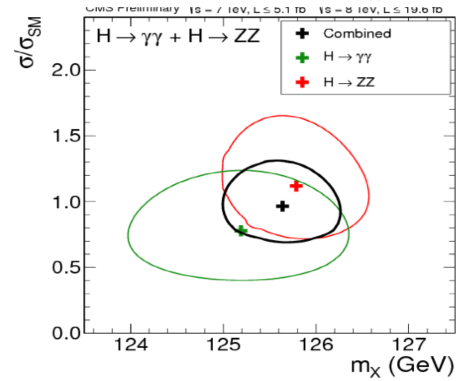


Higgs results

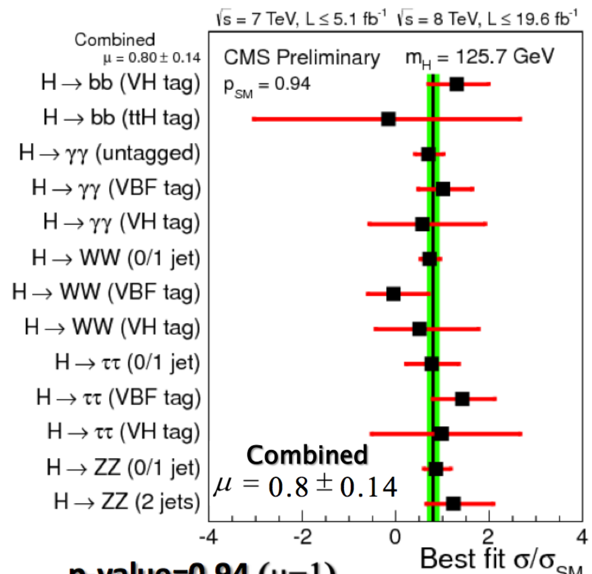
see talk by S.Meola







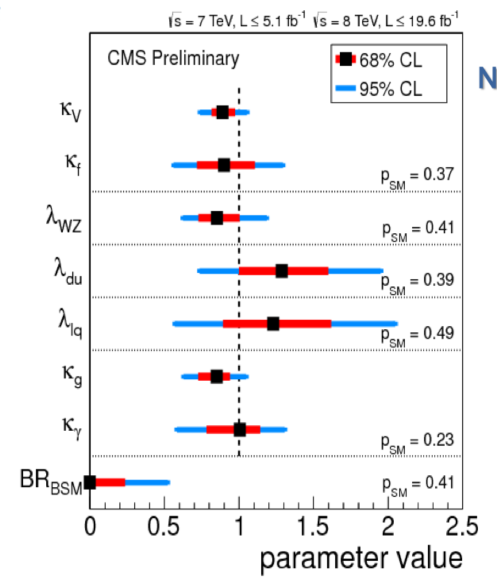
$m_H = 125.7 \pm 0.4$ GeV.



p-value=0.94 (μ=1)

$$(\sigma \cdot BR)(x \to H \to ff) = \frac{\sigma_x \cdot \Gamma_{ff}}{\Gamma_{tot}}$$

$$\kappa_i^2 = \frac{\Gamma_i}{\Gamma_i^{SM}} \qquad \Gamma_{ZZ}, \Gamma_{WW}, \Gamma_{\tau\tau}, \Gamma_{bb}, \Gamma_{\gamma\gamma}, \Gamma_{gg}, \Gamma_{tt}, \Gamma_{Tot}$$



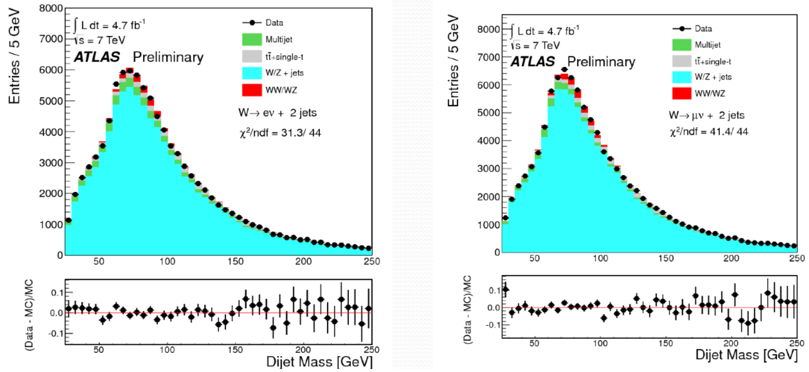
N

- spin 0^+ favored respect to spin 0^-, 1,2
- test of custodial symmetry yields a positive indication
- difficult direct access to fermionic couplings;

important a separate parametrization for up/down type quarks (relevant in 2HDM like MSSM)

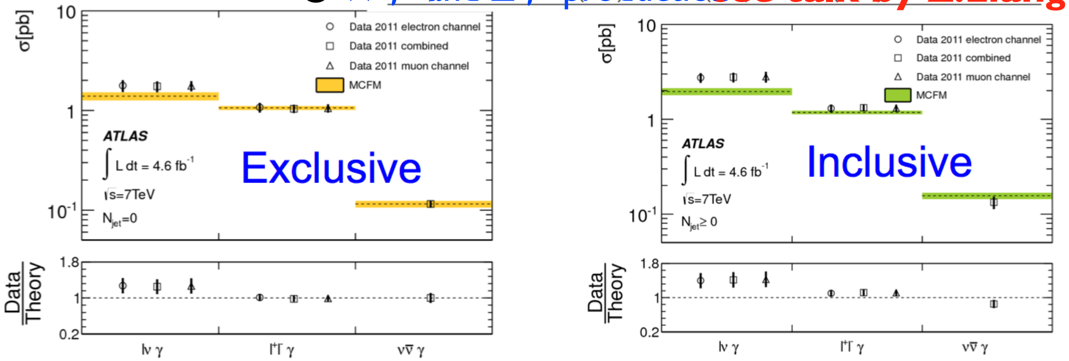
see talks by S.Choudhury and P.Giardino

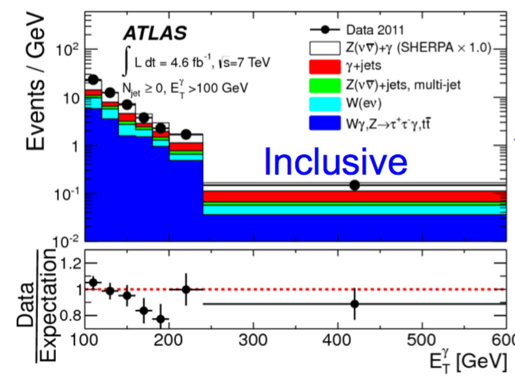
Diboson production cross sections



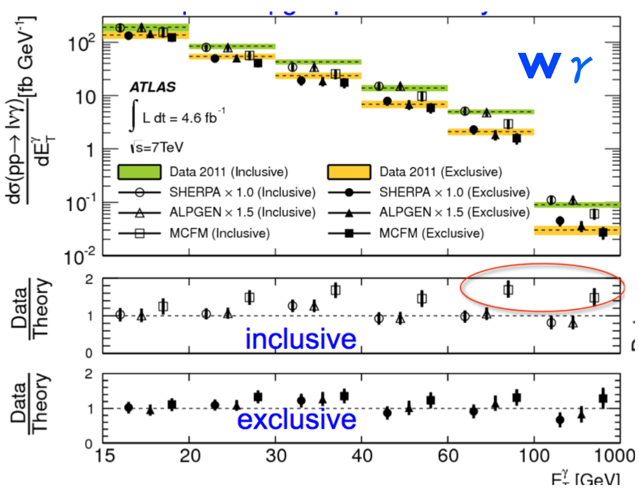
- WW and WZ production with one W decaying hadronically
  see talk by B.Lindquist
  - $\sigma(\text{fitted})/\sigma(\text{SM}) = 1.13 \pm 0.34$
  - $\sigma(WW+WZ) = 72 \pm 9\ (\text{stat}) \pm 15\ (\text{syst}) \pm 13\ (\text{MC stat})$ pb
  - SM prediction: $\sigma = 63.4 \pm 2.6$ pb

- W γ and Z γ production **see talk by Z.Liang**

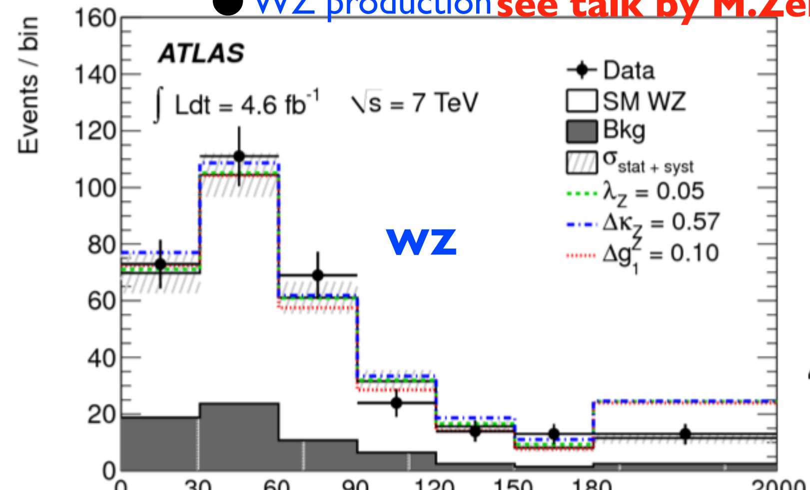




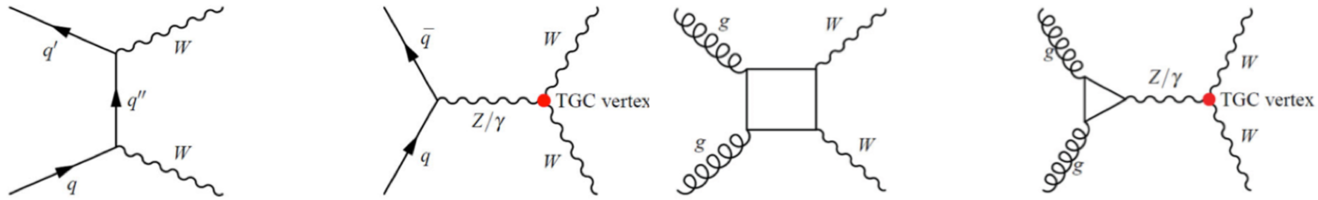
$\nu\ \nu\ \gamma$ final state



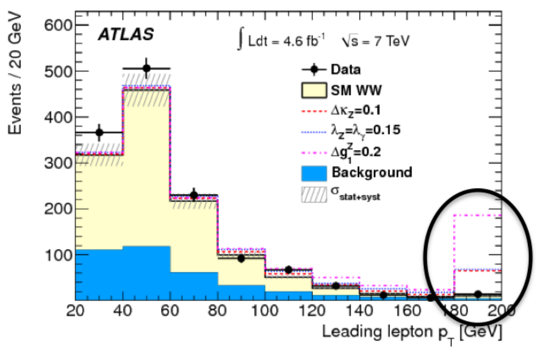
- WZ production **see talk by M.Zeman**

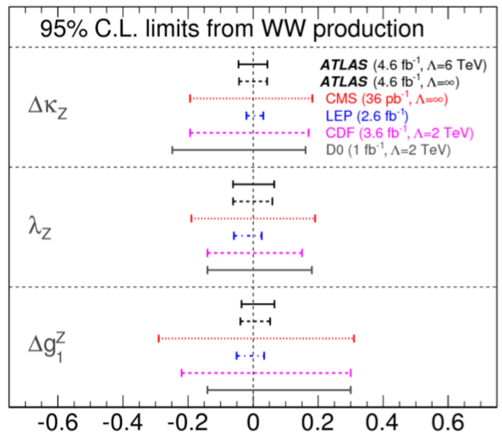


Diboson production and anomalous couplings measurements



- Sensitive at p_T > 120 GeV



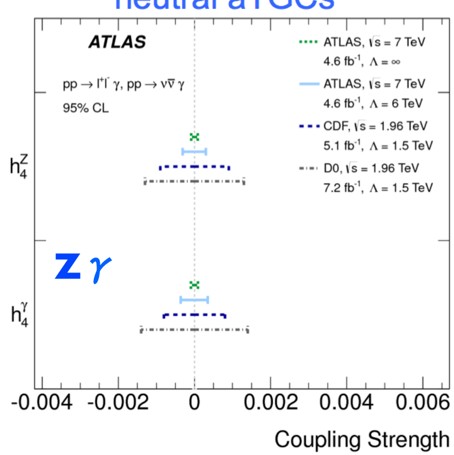


- aTGCs considered in 3 scenarios:

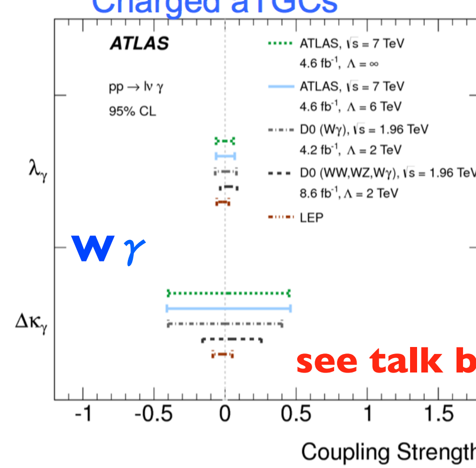
see talk by M.Zeman

- WW $\rightarrow 2l2\nu$
- the results are compatible with the SM predictions

neutral aTGCs



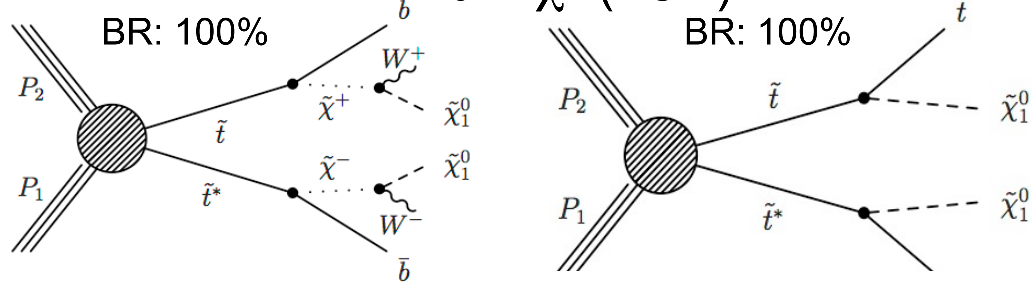
Charged aTGCs

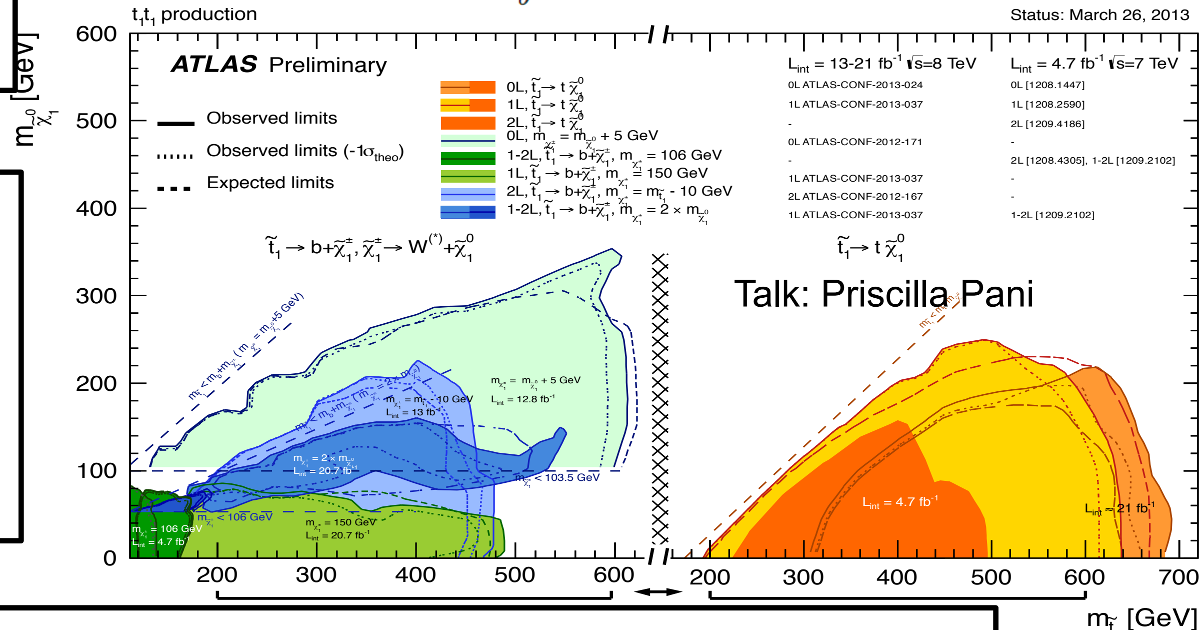


see talk by Z.Liang

Natural SUSY

MET from χ^0 (LSP)





10% Fine Tuning:

Giudice '95
Dimopulus

- M_{stops} < 600GeV
- M_{gluino} < 1400GeV

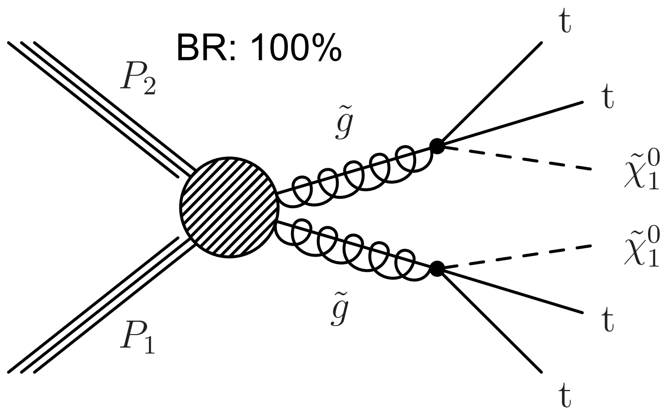
➔ 3rd generation squark searches

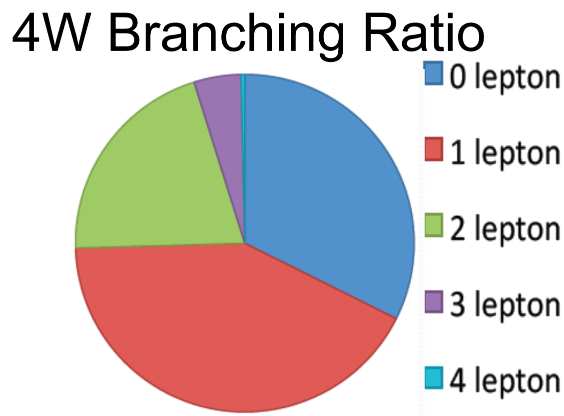
Direct production

- Production cross-section small and significant background (e.g. tt).
- Sophisticated methods e.g. hadronic top tagging.

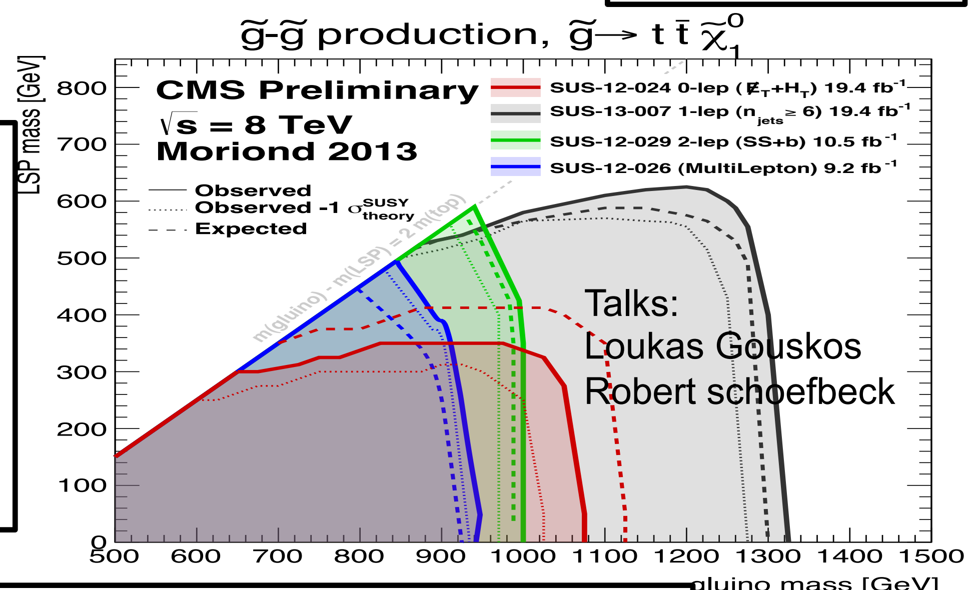
- M_{stop} limit > 500 GeV
- No sensitivity to M_{stop}~M_{LSP}+M_{top} and high M_{LSP}

Gluino induced 3rd generation squarks





- One lepton 19.4 fb^{-1}
- No lepton 19.4 fb^{-1}
- same sign leptons 10.5 fb^{-1}
- ≥3 leptons 9.2 fb^{-1}



Talks:
Loukas Gouskos
Robert schoefbeck

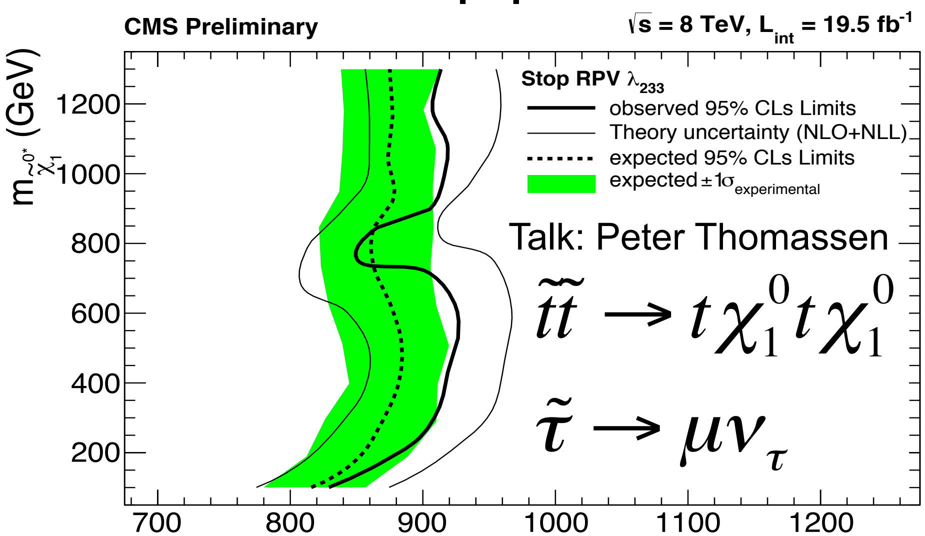
- Spectacular events, many jets, b-tags and leptons ➔ small background
- Sensitivity expected also for M_{stop}~M_{LSP}+M_{top}
- Good S/B

- M_{gluino} > (1.2) TeV and for M_{LSP} < 500 GeV

RPV (low MET) SUSY

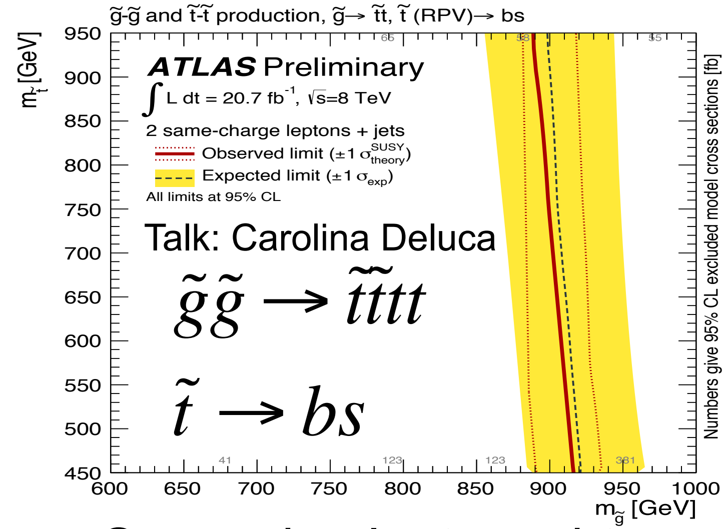
R-Parity Violating SUSY ➔ no LSP, i.e. **small MET**

stop pair:



Multi-lepton search

Gluino induced



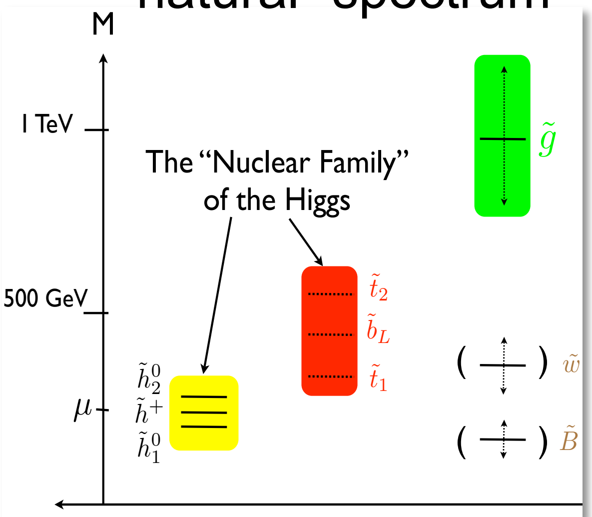
Same sign leptons+btags

Truly spectacular signatures used to search for RPV SUSY

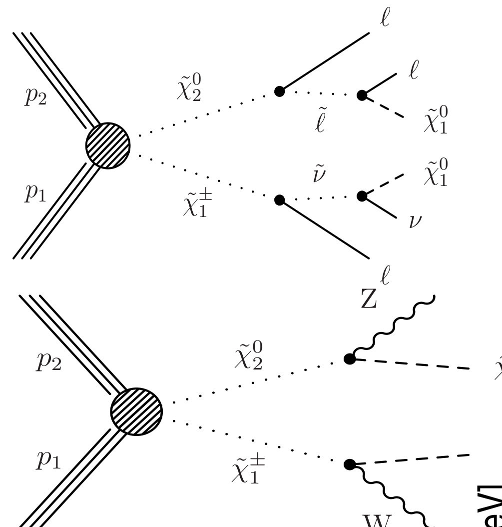
- Many leptons or same sign and/or jets **btags** required
- Limits M_{gluino} (>900 GeV) and M_{stop} (>800 GeV) depending on RPV caracterisrics

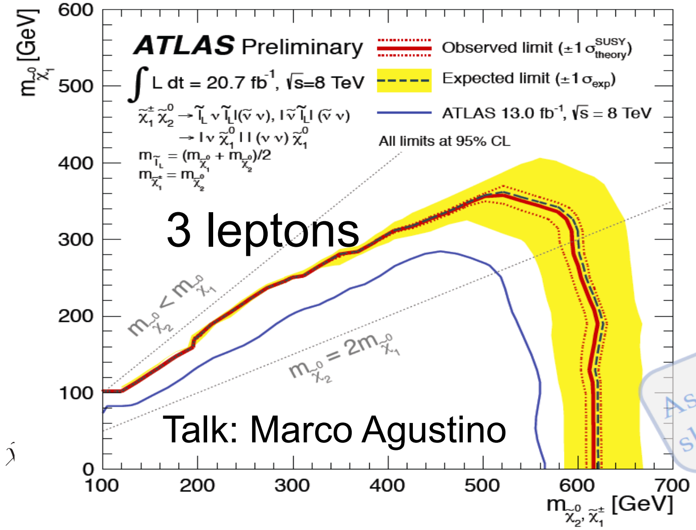
Direct EWKinos Production

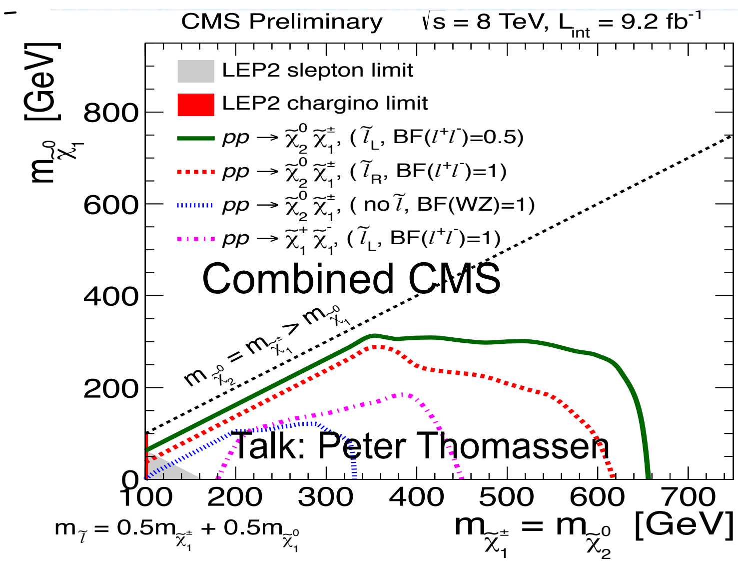
"natural" spectrum



Example illustrations







- Small x-section, but clean signature
- MET and leptons and/or V-Bosons
- Very few background

Exclusions > few hundred GeV for M_{LSP}< 300 GeV

(Resonant) BSM searches

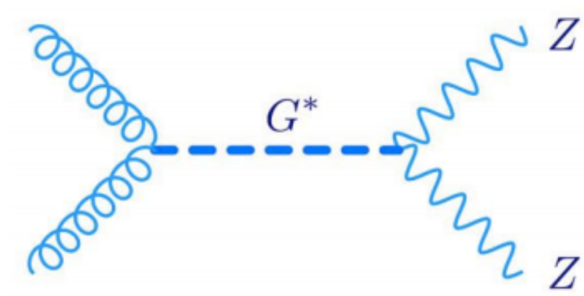
- **di-boson:**
  V', technicolor, graviton …
- **di-jets:**
  string resonances, scalar diquarks, excited quarks, axigluons, color-octet colorons, technicolor s8 resonances, W', Z', graviton …
- **jets + leptons:**
  VLQ, leptophobic Z', …
- **multi-lepton:**
  Heavy fermions, excited leptons, 4^{th} generation quark, H^{++} , …
- **Multileptons and γ:**
  Excited leptons, …

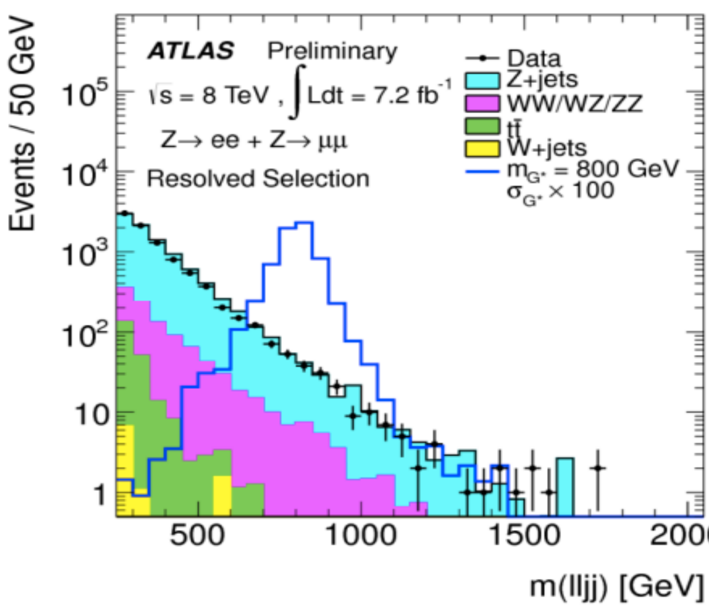
Examples in the following slides

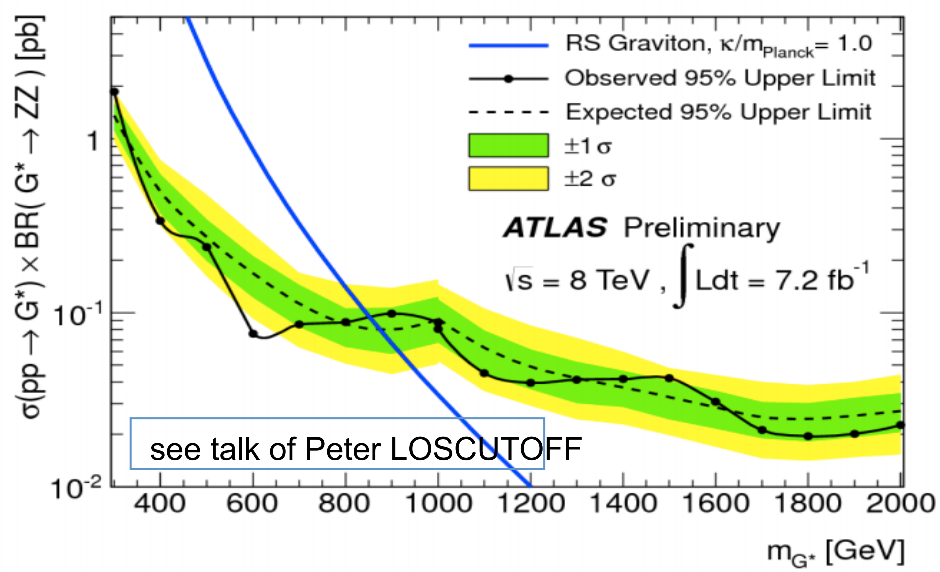
Di-Boson Resonances

di-boson: e.g. graviton

- ZZ->lljj narrow resonance search for RS graviton.
- Enhanced x-section to ZZ.
- Resolved and Merged jet region (>1 TeV) to cover large mass range.







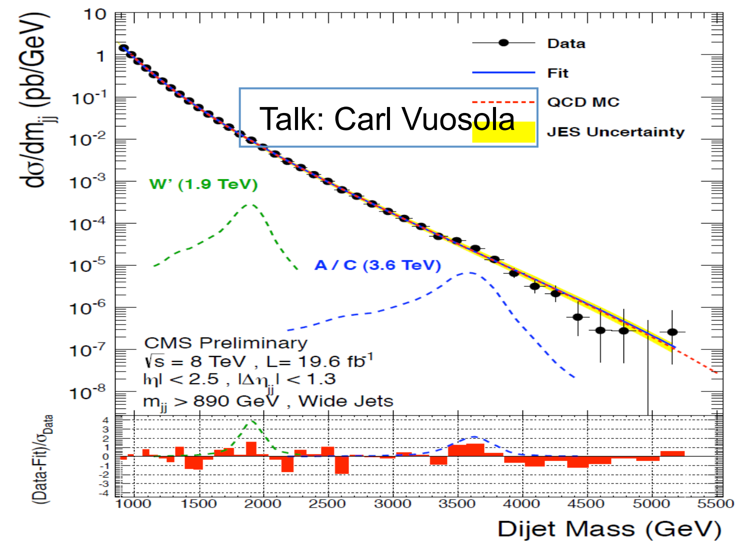
see talk of Peter LOSCUTOFF

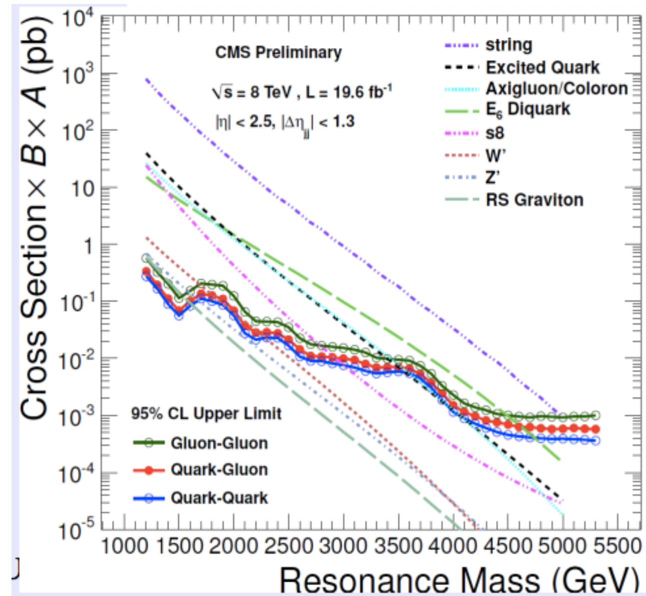
Di-jet Resonances

di-jets:
Many models can be covered

Model	Final State	Obs. Mass Excl. [TeV]	Exp. Mass Excl. [TeV]
String Resonance (S)	qg	[1.20,5.08]	[1.20,5.00]
Excited Quark (q^*)	qg	[1.20,3.50]	[1.20,3.75]
E_6 Diquark (D)	qq	[1.20,4.75]	[1.20,4.50]
Axigluon (A)/Coloron (C)	$q\bar{q}$	[1.20,3.60] + [3.90,4.08]	[1.20,3.87]
Color Octet Scalar (s8)	gg	[1.20,2.79]	[1.20,2.74]
W′ Boson (W′)	$q\bar{q}$	[1.20,2.29]	[1.20,2.28]
Z′ Boson (Z′)	$q\bar{q}$	[1.20,1.68]	[1.20,1.87]
RS Graviton (G)	$q\bar{q}$+gg	[1.20,1.58]	[1.20,1.43]

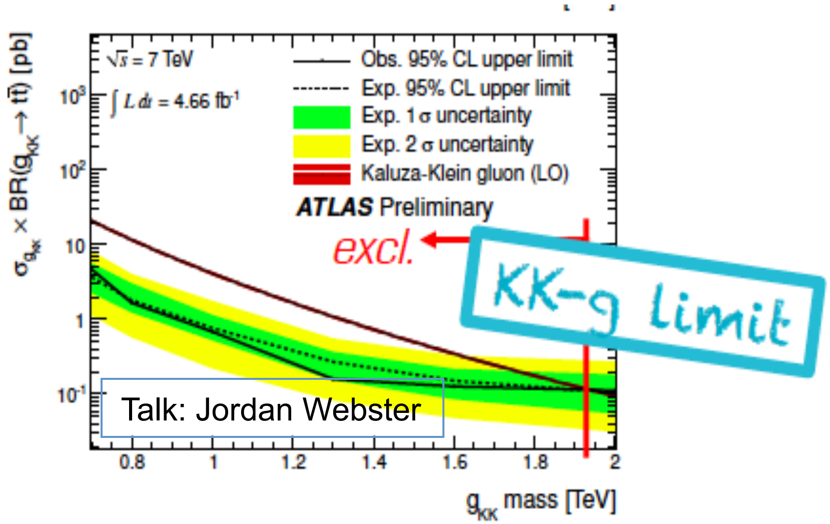
- No excess found
- Limits reach up to 5 TeV
- B-tags added

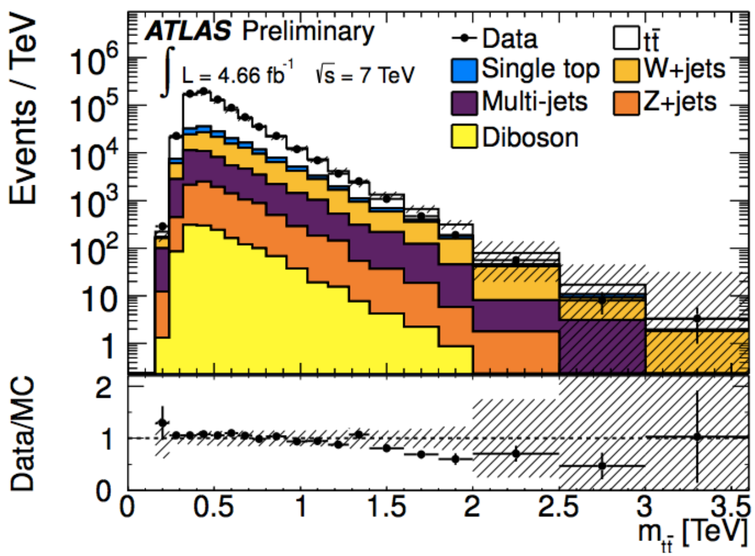


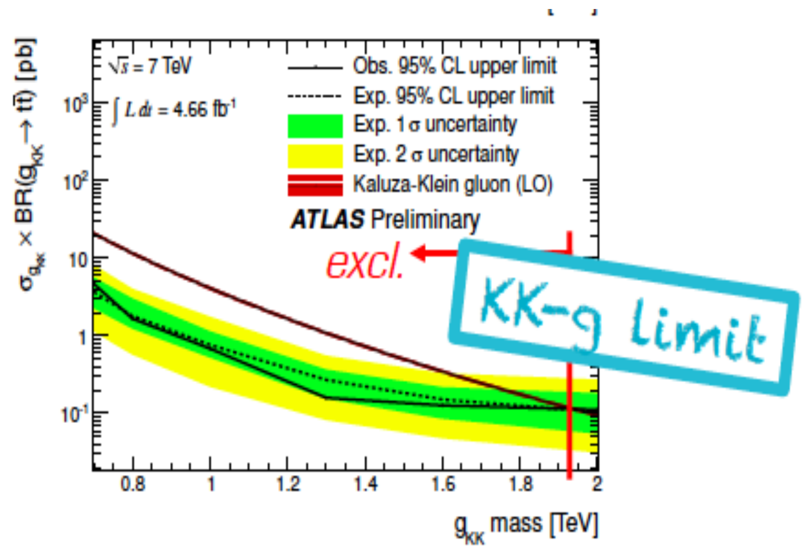


tt pair-Resonances

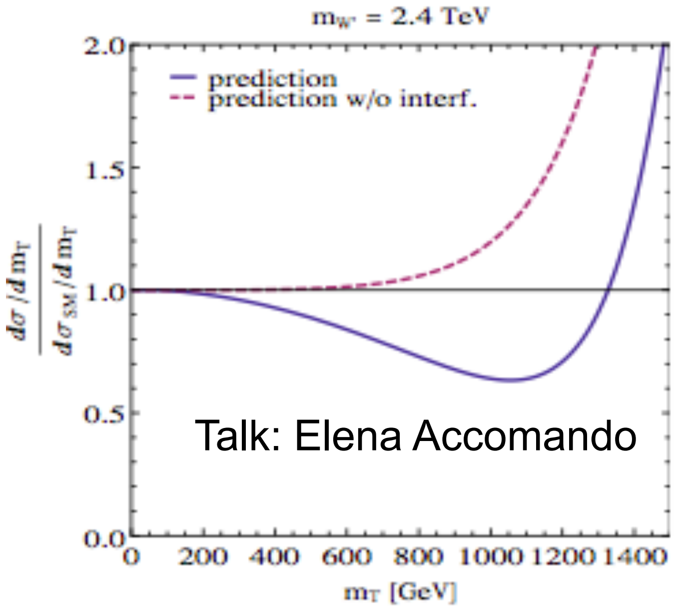
- Semi and fully leptonic top pairs used
- require b-tagged jet and boosted jets
- dominant background source multi-jets, use data driven methods.
- Using Hep top-tagger and template-top tagger

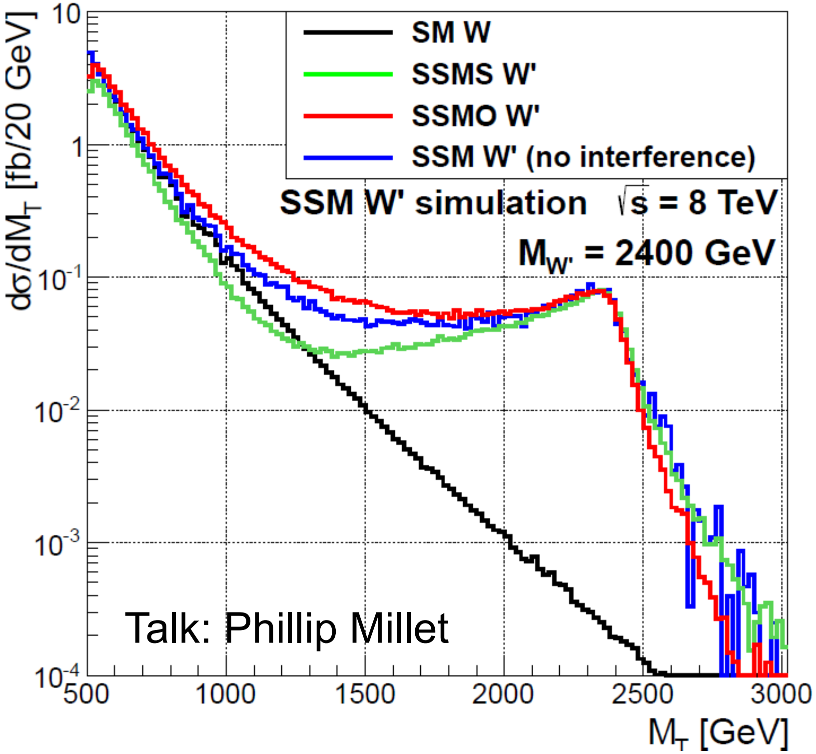






Z' and W' to leptons





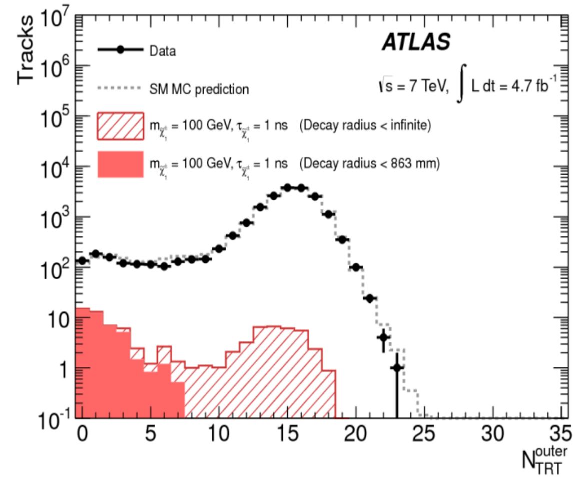
- Interference between SM and BSM can be significant
- Presented CMS analysis did take this already into account
- Interference also relevant for other signatures

	constructive	destructive
Model	**SSMO**	**SSMS**
Observed Limit	$m_{W'} < 3.80$ TeV	$m_{W'} < 3.10$ TeV
Expected Limit	$m_{W'} < 3.80$ TeV	$m_{W'} < 3.20$ TeV

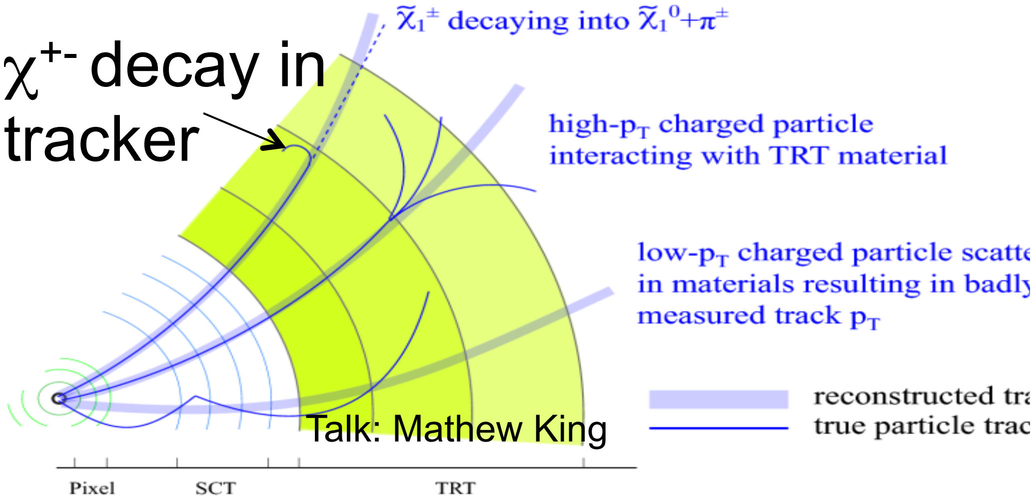
Long lived particles

BSM theories can predict long lived particles:

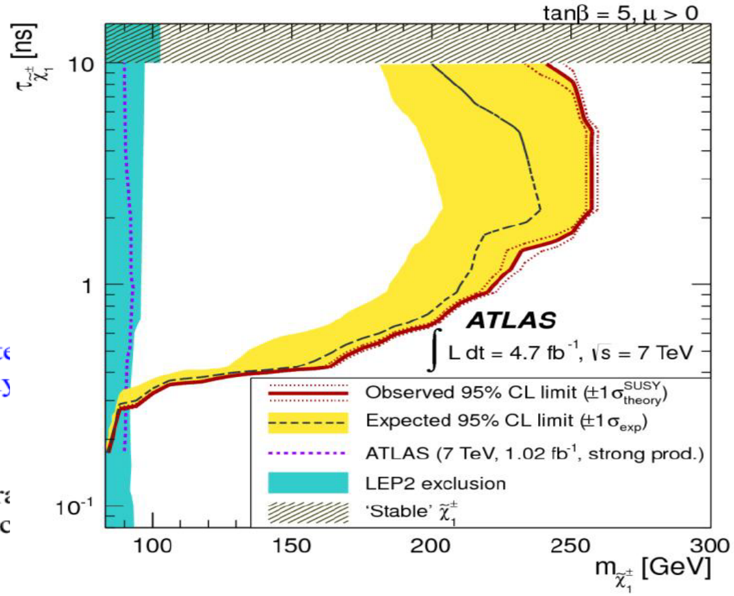
- Displaced vertices
- Disappearing tracks (e.g. below)
- Photons not pointing to vertex



χ^{+-} decay in tracker



Talk: Mathew King



Even longer lived particles

Several BMS model predict "detector "stable heavy particles

Special searches of ATLAS and CMS presented for "slow" heavy particles.

Unusual inputs used:

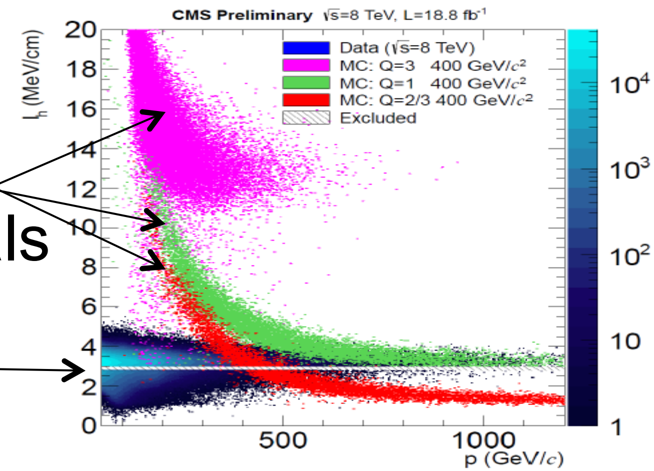
- Time of flight used (e.g, muon system CMS)
- dE/dx used of tracker

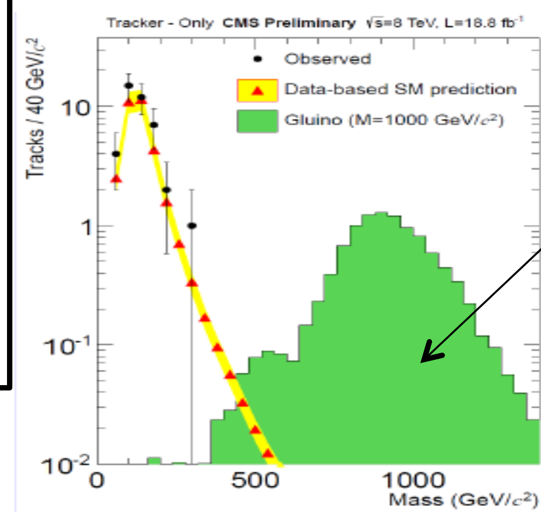
Special challenges for reconstruction mastered

dE/dx vs momentum

BSM Signals

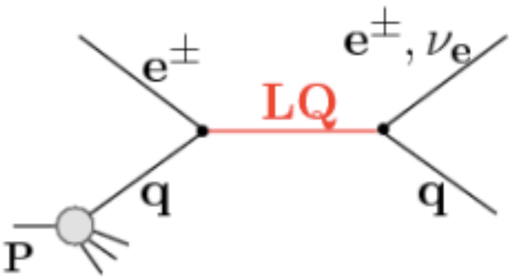
SM

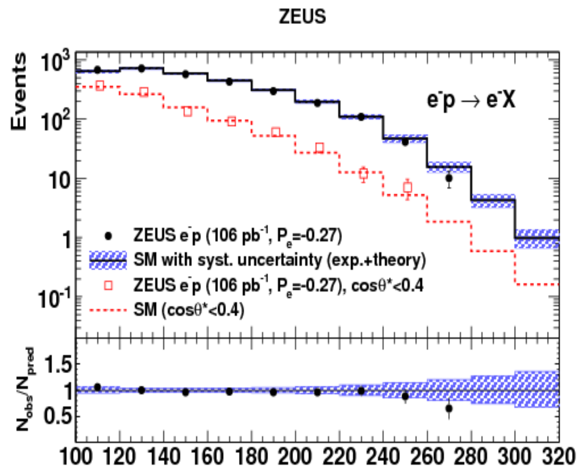


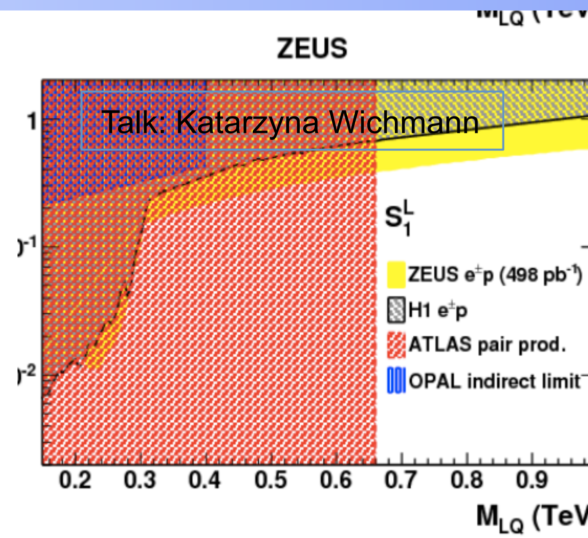


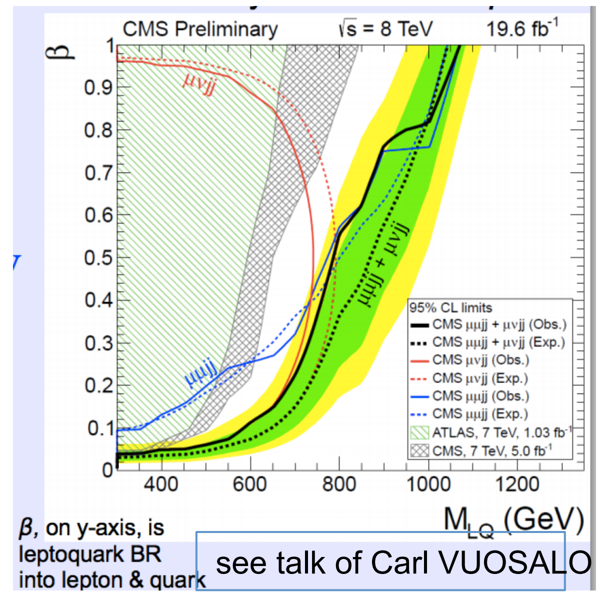
Signal Benchmark mass from dE/dx

Lepto-Quarks









- Results from ZEUS and CMS.
- No evidence of lepto-quarks observed.
- HERA and LHC limits complementary.

WG3: Electroweak physics and searches

51 contributions

- **Standard Model EW processes**:

Z.Liang, M.Zeman, B.Linquist, T.Du Pree, J.Kraus, A.K hukhunaishvili, K.Nikolics, S.Carrazza, J.Rojo, S.Tourneur, M.Kuze, E.Vryonidou, A.Huss, C.Lange, B.Surrow, L.Barzè, R.Caputo, L.Tomlinson, E.Yatsenko

- **Higgs boson (SM and BSM):**

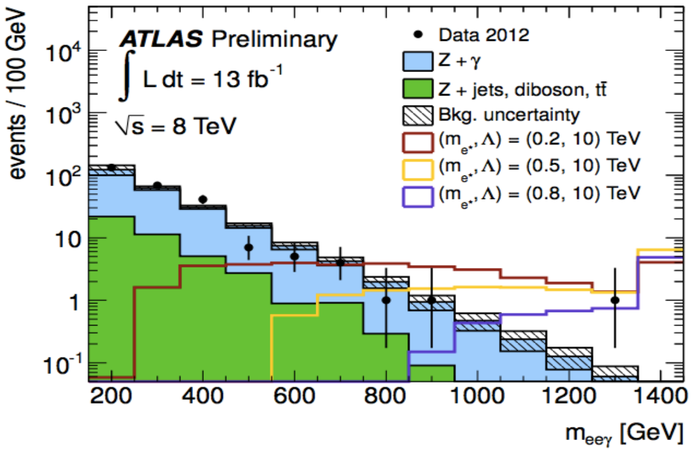
S.Meola, A.Holzner, S.Choudhury, P.Giardino,J.Kraus,L. Perez, I.Masina, P.Ilten, A.Perieanu, J.Andersen

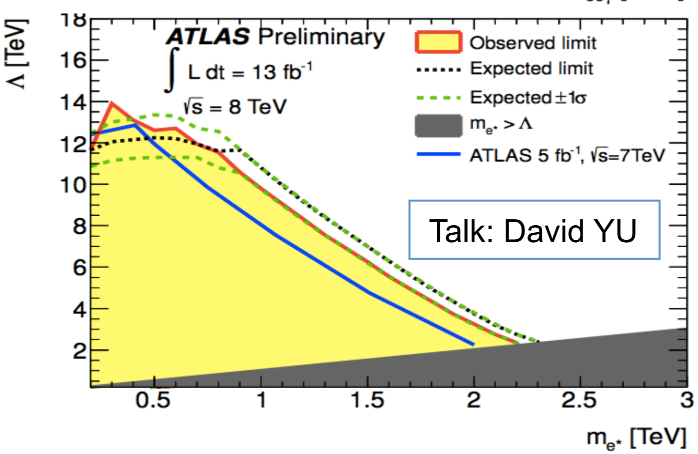
- **BSM searches:**

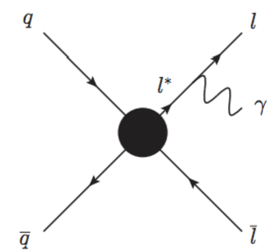
M.Agustoni, P.Thomassen,L.Gouskos, P.Pani, E.Romera Adam, C.Deluca, M.King, R.Schoefbeck, D.Pagano, K.Wichman, S.Zimmermann, P.Loscutoff, P.Pais, R.Caminal Armadans, J.Webster, D.Yu, C.Vuosalo, P.Millet, S.Schmitz, E.Accomando, S.Podolsky

Resonant BSM searches

- multi-lepton:
  Exited leptons







Search for excited e^*/μ^* using $l\bar{l}\gamma$ final state.

- Dominant background is Z +g, with smaller contributions from Z+jets, diboson, and ttbar.
- No significant excesses observed.
- p0 = 0.16 for m(llγ) > 1050 GeV (e*).
- For m(l*) = Λ, m(l*) < 2.2 TeV excluded.