March 5th, 2014
SCGT14Mini

LHC Results and Future Prospects for BSM Searches

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Outline

- Run I Results
- Prospects for Run II and beyond
- (Preliminary) look at one-family WTC model

SM Higgs

ATLAS-CONF-2013-108

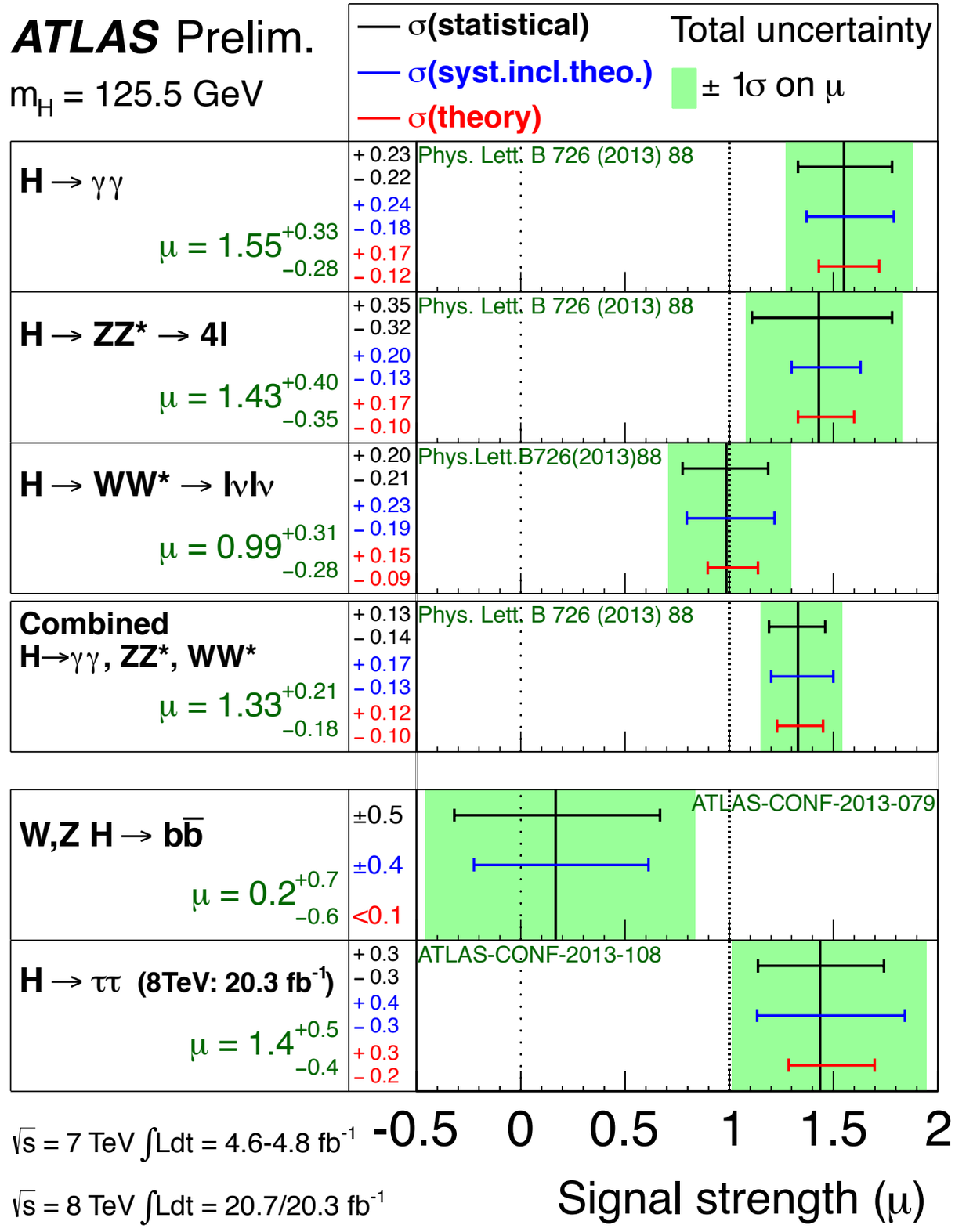
Now we know

- Mass 125.5 ± 0.6 GeV (ATLAS)
- Confirmed $\gamma\gamma$, WW, ZZ, $\tau\tau$ production
- VBF production in $\gamma\gamma$, WW, $\tau\tau$
- Yukawa coupling (indirectly by ggF, $\gamma\gamma$)
- Cross-section, spin, coupling all consistent with SM predictions

➡ SM(-like) Higgs strongly preferred

Next : **Precision measurement**

- Confirmation of H→bb
- Rare decay processes
- Yukawa coupling
- Self-coupling (two Higgs process)



... and search for additional (heavy) Higgses

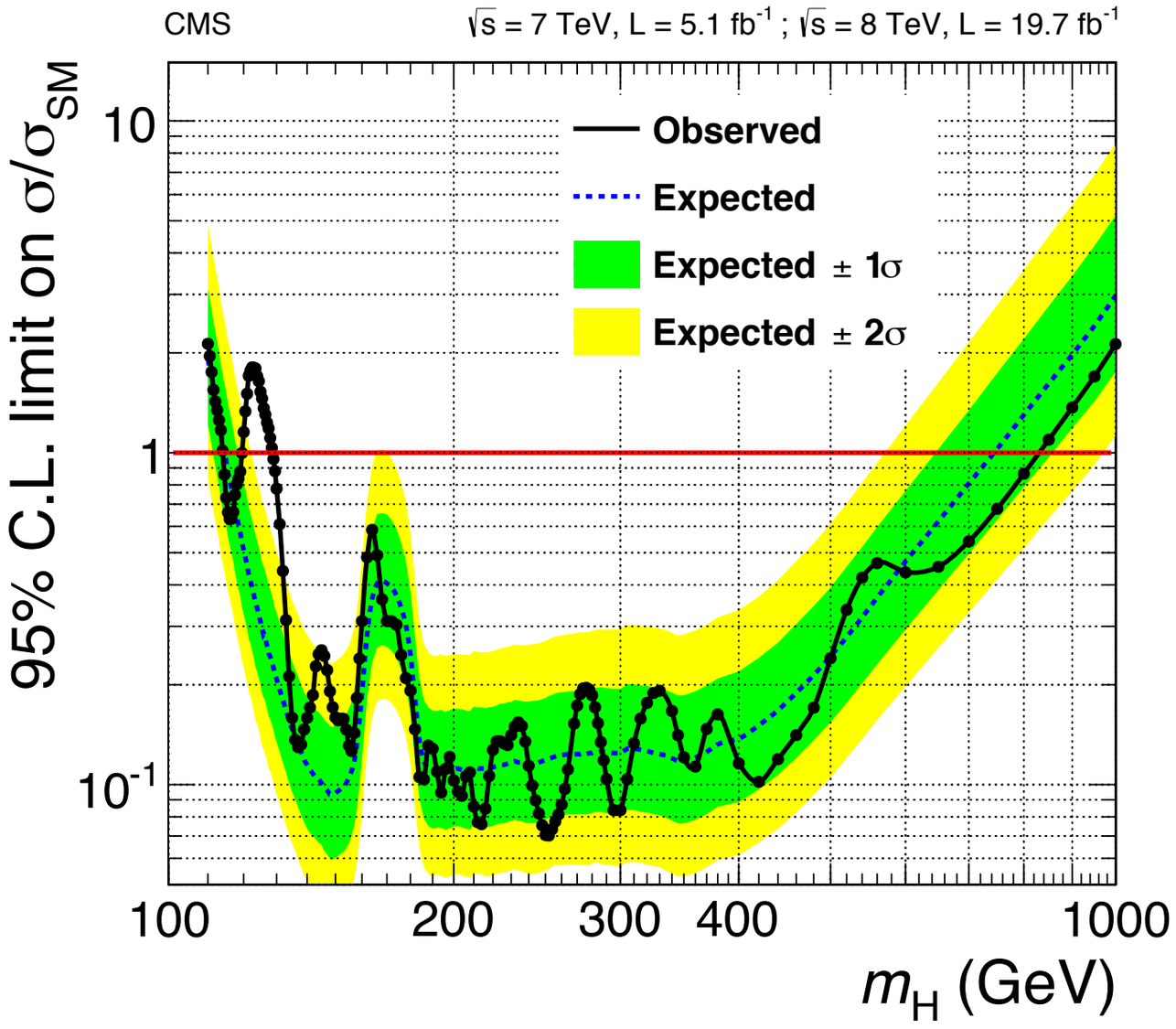
Heavy Higgs Searches

arXiv:1312.5353
CMS PAS HIG-13-021

SM-like Higgs

$H \to ZZ \to 4e/2e2\mu/4\mu$

- 4 leptons p_T>20,10,7(5),7(5) GeV for e(μ)
- 40<m_{Z1}<120 GeV, 12<m_{Z2}<120 GeV

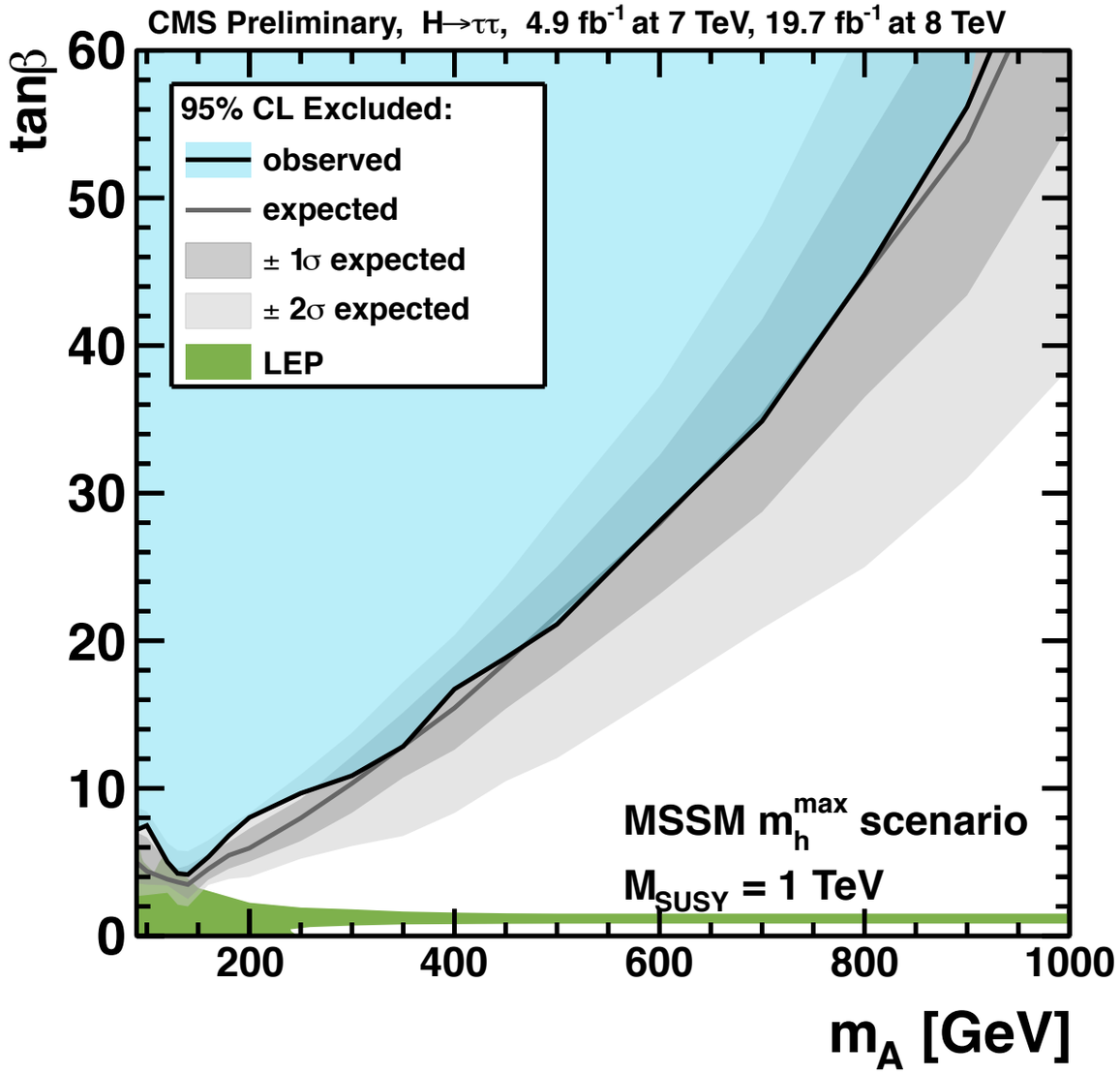


➡ Excluded up to ~800 GeV as "SM Higgs"

CP-even/odd Higgs in MSSM

$\Phi \to \tau\tau$ ($bb\Phi \to bb\tau\tau$)

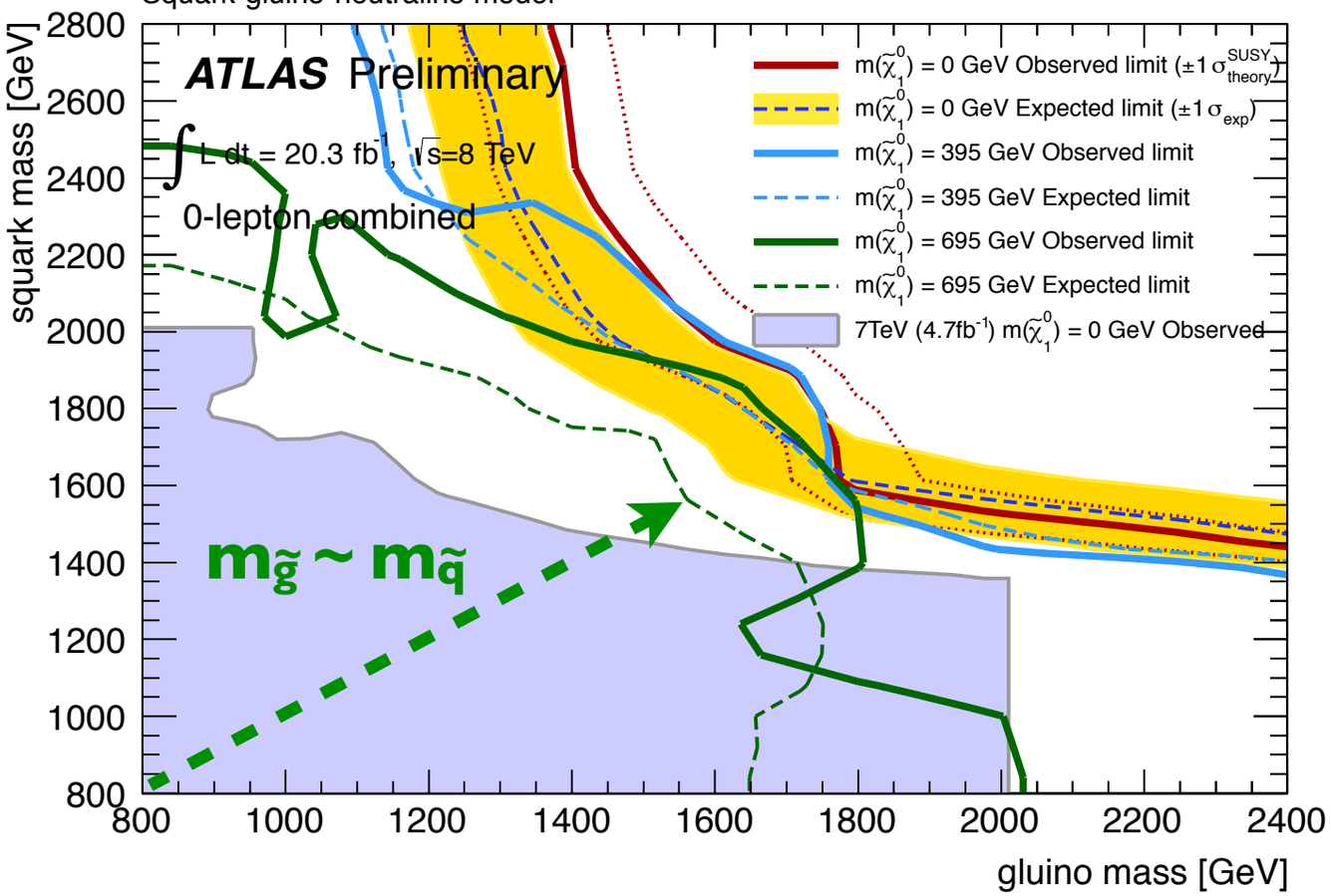
- $e\tau_h$, $\mu\tau_h$: $p_T^{e(\mu)}$ > 24(20)GeV (2012)
- $e\mu$, $\mu\mu$: $p_T^{1(2)}$ > 20(10)GeV
- $\tau_h\tau_h$: p_T^{τ} > 45GeV
- b-tag ($p_T^{b\text{-jet}}$>20GeV) and no-btag



SUSY Searches

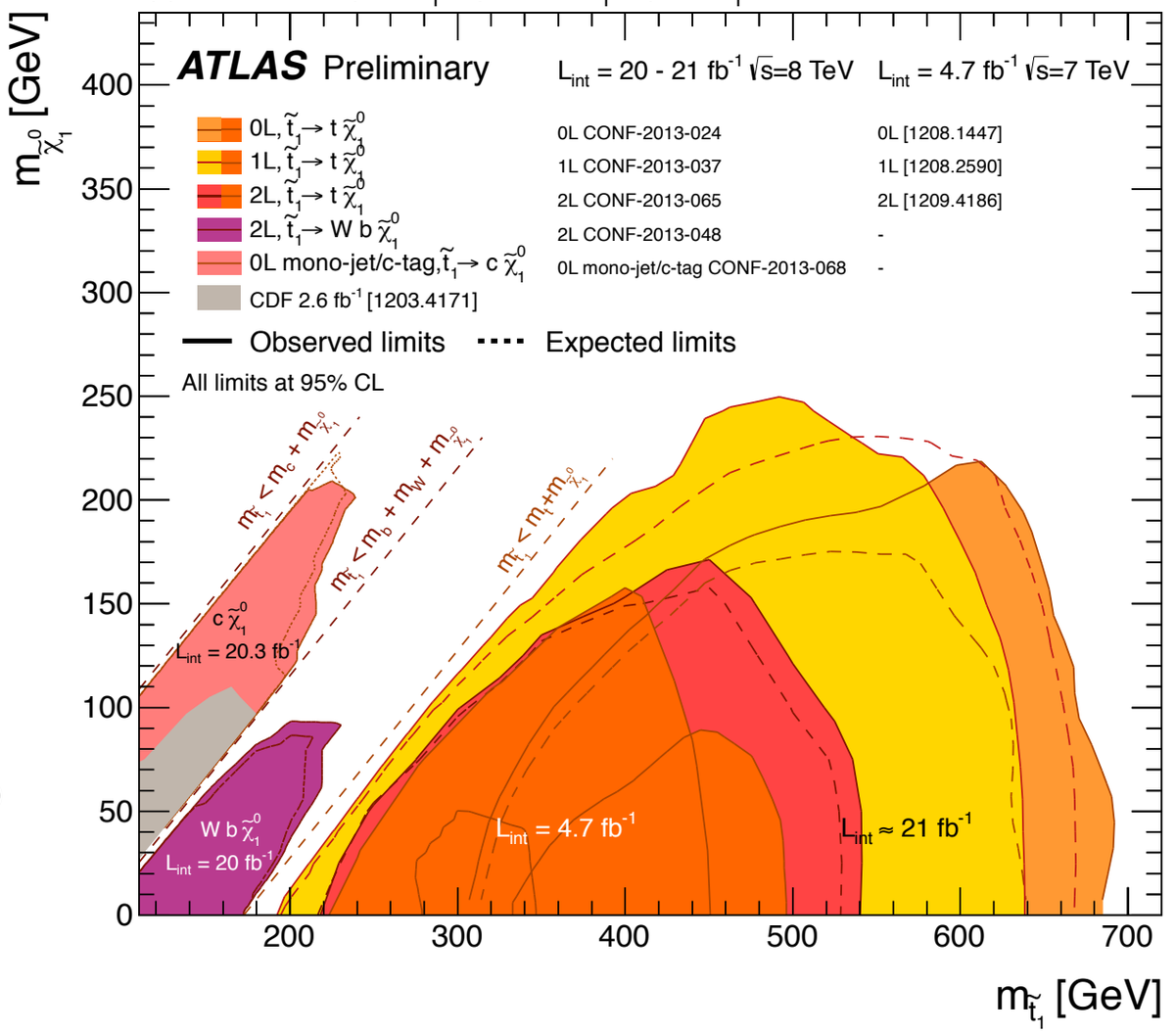
ATLAS-CONF-2013-047
Stop search summary

Squark/Gluino searches



Excluded up to ~1.8 TeV ($m_{\tilde{g}} \sim m_{\tilde{q}}$) for $m_{LSP} < 700$ GeV

Stop searches



Excluded up to 0.6-0.7 TeV for $m_{LSP} < 200$ GeV

except a few low-mass "gap" regions
(e.g, $m_{stop} \sim m_{top} + m_{LSP}$)

Signature-based Searches

Non-SUSY (aka "Exotics") searches aim to cover as many final states/topologies as possible

	ADD			RS1	Bulk RS		UED	Technicolor	New Fermion	New Boson
	G	s-ch	t-ch	G	G	g				
Di-jet		●	●	△	△			●	?	●
Di-lepton/Di-photon		●		●			○?	●	●	●
Di-top					○?	●				○
Di-boson (W, Z)					●	●		●	●	○
Jet(s) + E_T^{miss}	●						●	○		
Multi-jets			●							●
Multi-leptons							●?	○?	○?	○
Same-sign di-lepton			○							●

Signature-based Searches

Non-SUSY (aka "Exotics") searches aim to cover as many final states/topologies as possible

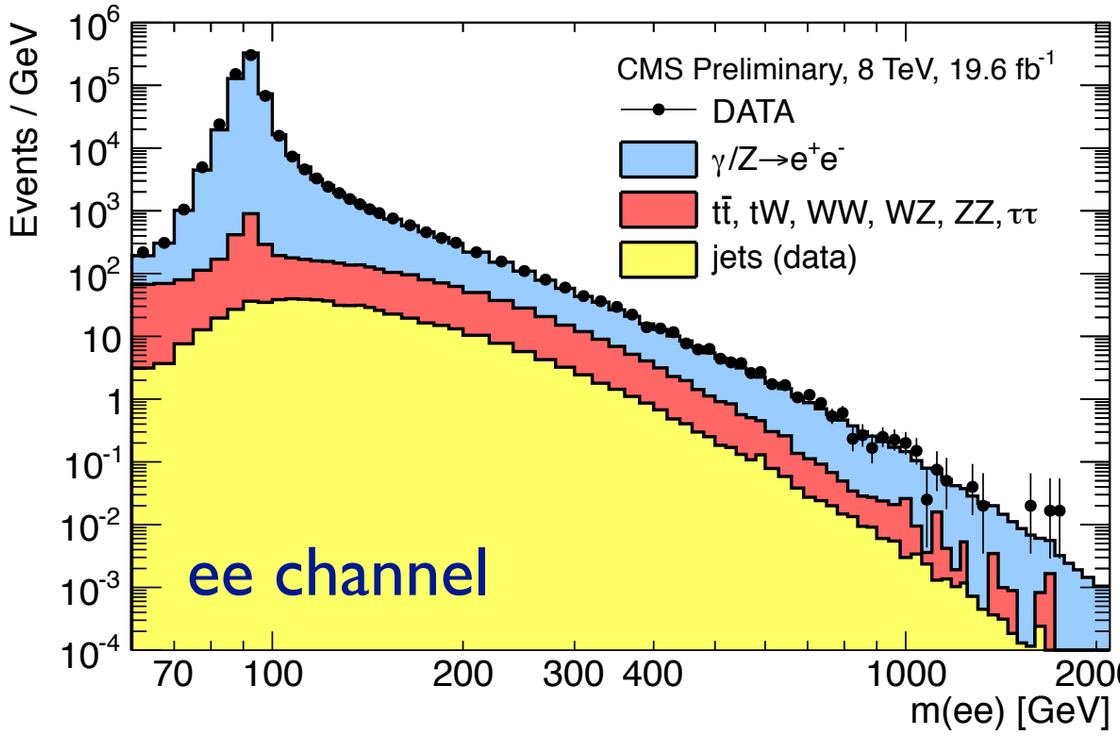
	ADD			RS1	Bulk RS		UED	Techni color	New Fermion	New Boson
	G	s-ch	t-ch	G	G	g				
Di-jet		●	●	△	△			●	?	●
Di-lepton/Di-photon		●		●			○?	●	●	●
Di-top					○?	●				○
Di-boson (W, Z)					●	●		●	●	○
Jet(s) + E_T^{miss}	●						●	○		
Multi-jets			●							●
Multi-leptons							●?	○?	○?	○
Same-sign di-lepton			○							●

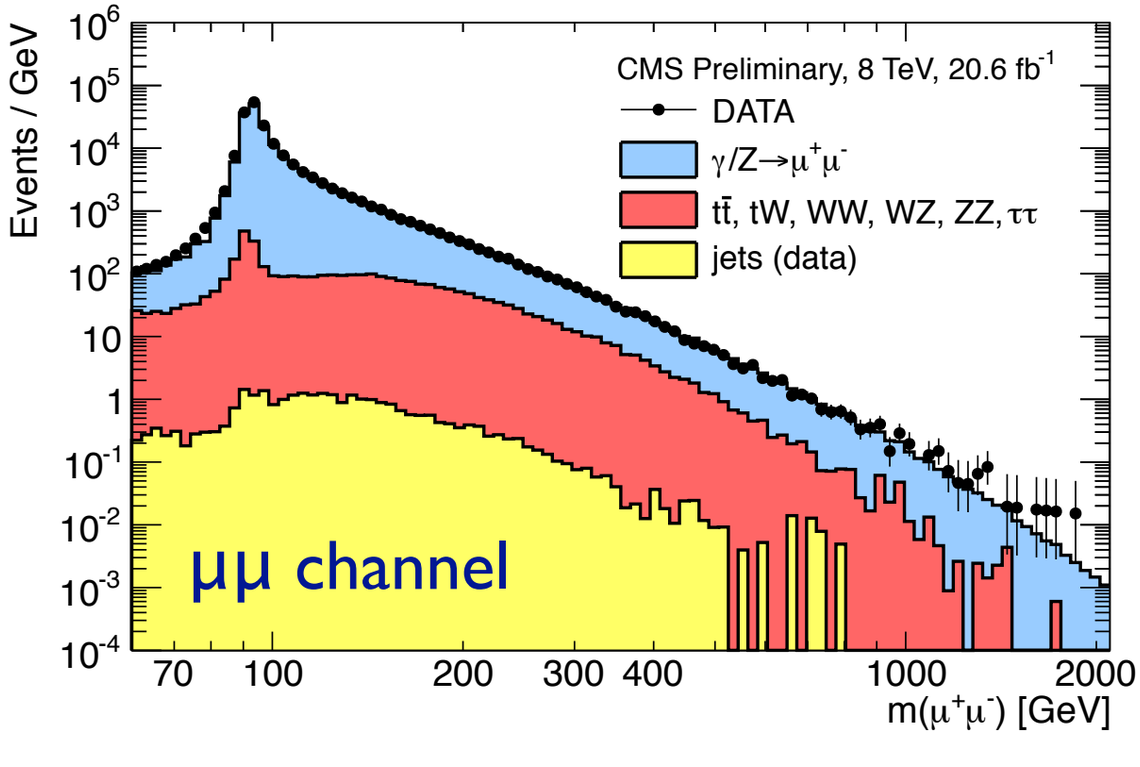
Present a few results on searches expected to be sensitive to heavy gauge bosons and technicolor and relevant interpretations

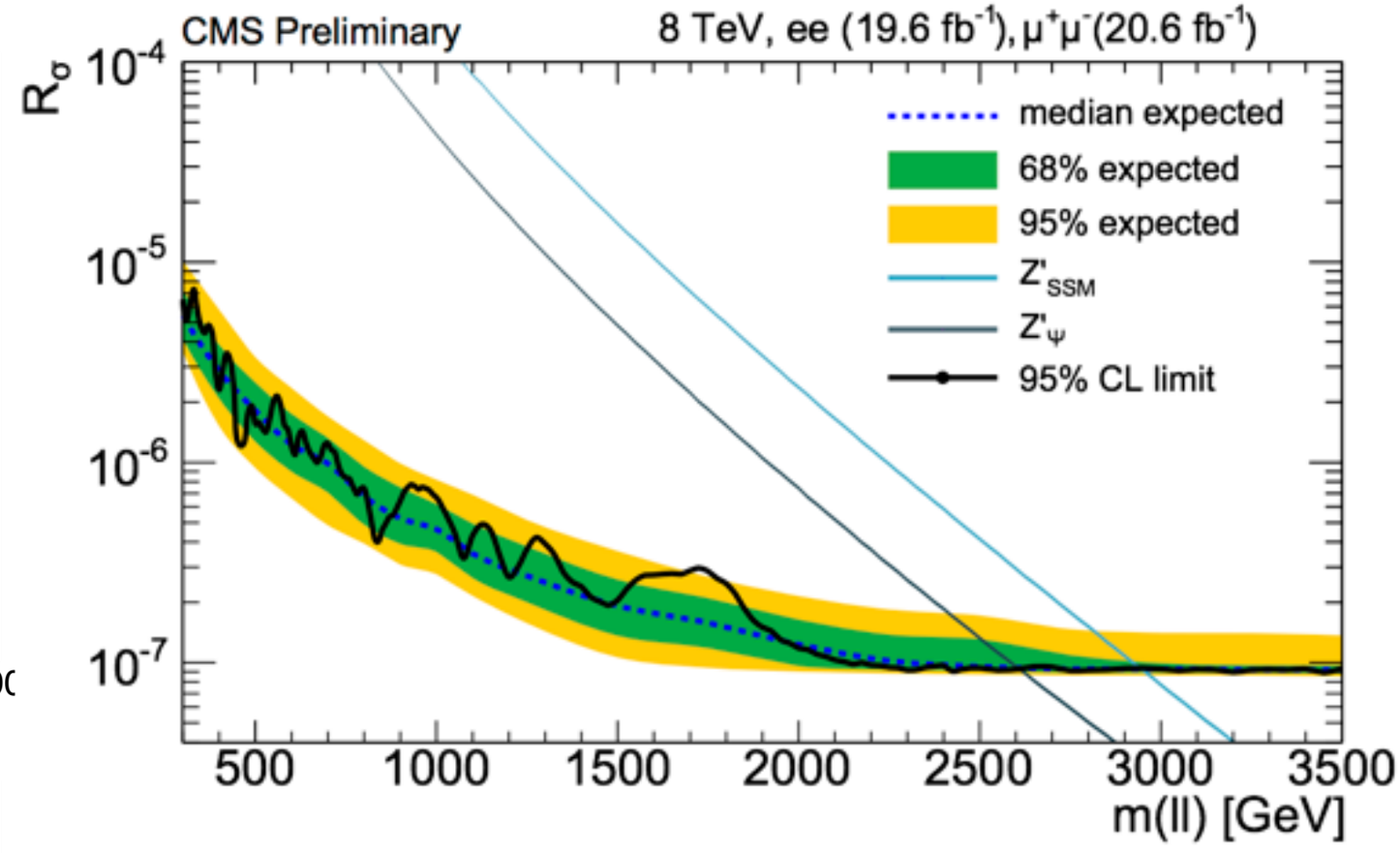
Dilepton

ATLAS-CONF-2013-017
CMS PAS EXO-12-061

2 isolated leptons $p_T^{e(\mu)}$ > 35(45) GeV at CMS, >40/30(25) GeV at ATLAS







- Drell-Yan BG estimated by POWHEG (NLO)
- Total simulated background scaled to data at Z-peak ($60<M_{ll}<120$ GeV)
- Limits set on $R_\sigma = \dfrac{\sigma(pp \to Z' + X \to \ell\ell + X)}{\sigma(pp \to Z + X \to \ell\ell + X)}$

Z'_{SSM} excluded up to 2.96 TeV (CMS)

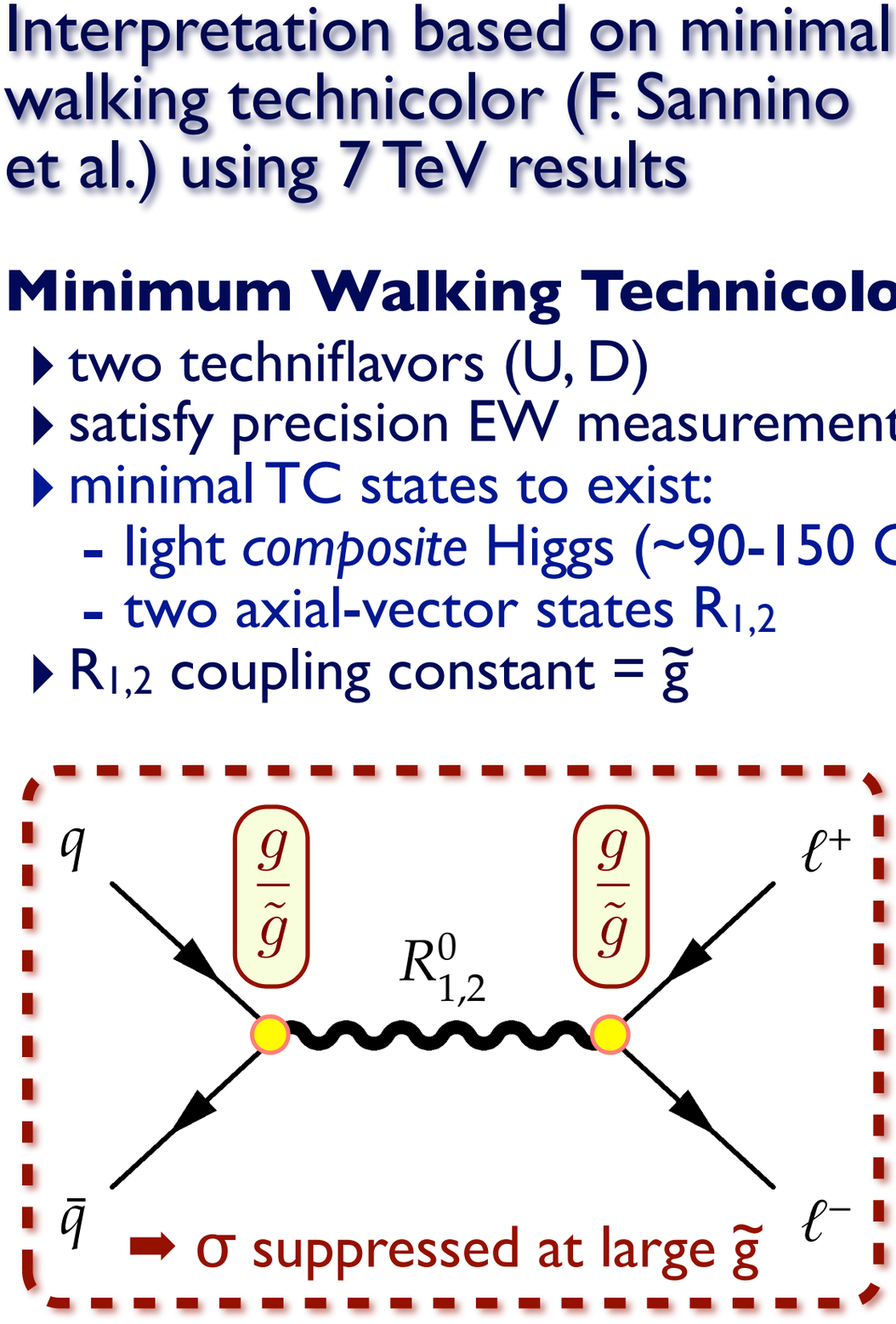
Dilepton Interpretation

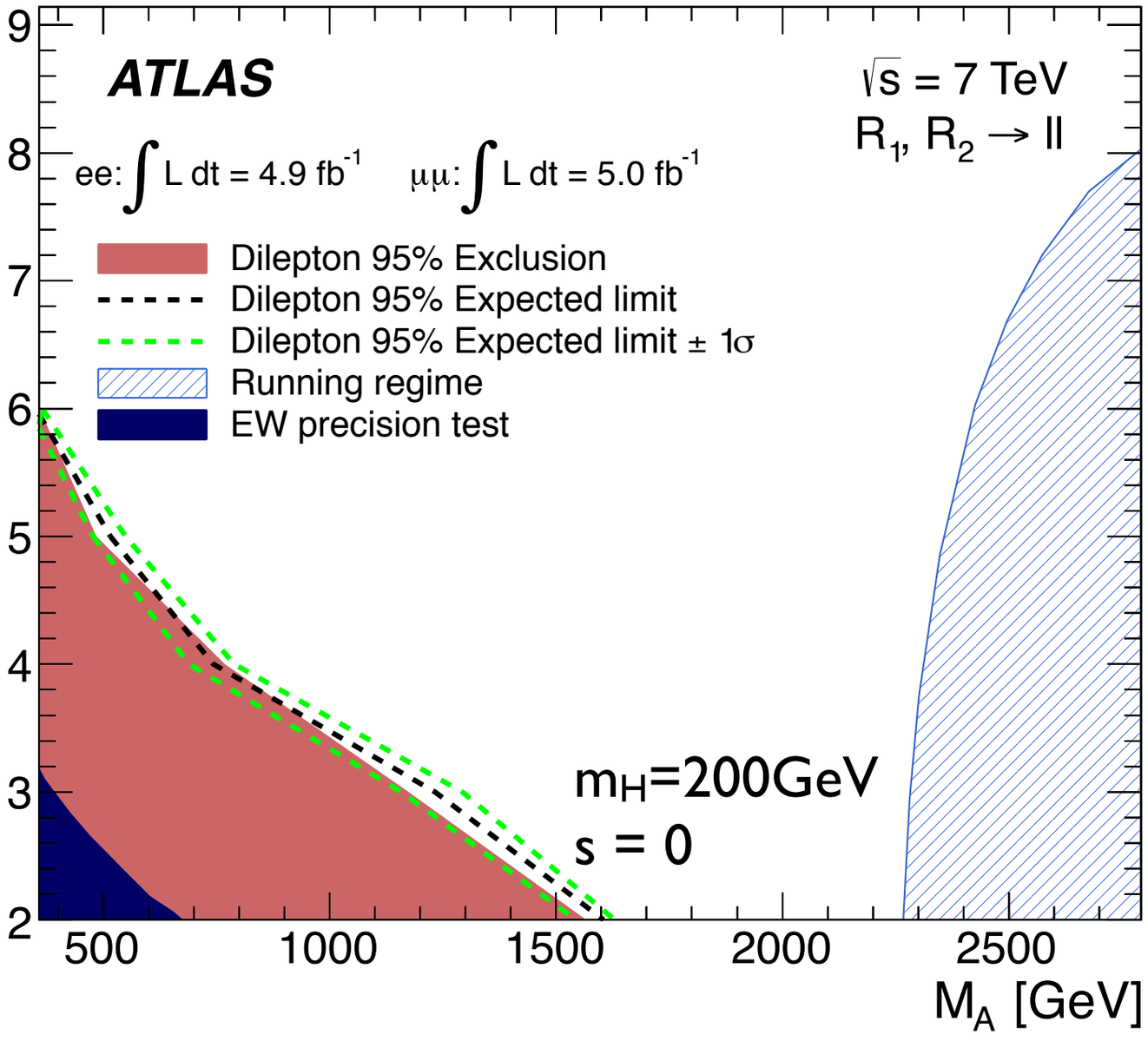
JHEP 1211, 138 (2012)

Interpretation based on minimal walking technicolor (F. Sannino et al.) using 7 TeV results

Minimum Walking Technicolor

- two techniflavors (U, D)
- satisfy precision EW measurements
- minimal TC states to exist:
  - light *composite* Higgs (~90-150 GeV)
  - two axial-vector states $R_{1,2}$
- $R_{1,2}$ coupling constant = $\tilde{g}$





No significant improvement expected at large $\tilde{g}$ with 8 TeV data (large BG)

Diboson

Sensitive to various BSM scenarios including EDs and technicolor

Wide variety of final states being covered

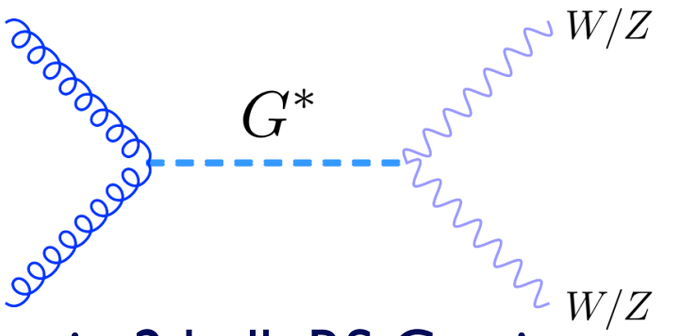
Benchmark models used in ATLAS

Process	WW	ZZ	WZ	VH	HH	Vγ
Final State	qq+qq lν+qq	qq+qq ll+qq ll+νν qq+νν	qq+qq lν+qq ll+qq lν+ll qq+νν	lν+bb ll+bb νν+bb	bb+bb	lν+γ ll+γ

Bulk Randall-Sundrum (SM fields in the bulk) K. Agashe et al.	G → WW, ZZ, HH KK W/Z → WH/ZH
Sequential SM (+ EGM) G. Altarelli et al.	W' → WZ, WH, Z' → ZH
Minimal walking technicolor F. Sannino et al.	$R_{1,2}$ → WZ, WH, ZH
Low-scale technicolor K. Lane et al.	ρ_T/a_T → WZ, Wγ/Zγ, WW

→ Dropped after 125 GeV Higgs discovery

SSM+EGM spin-1 W'
- $g_{W'WZ}/g_{WWZ}^{SM} = (M_W/M_{W'})^2$



spin-2 bulk RS Graviton

Diboson (VV → qqqq)

CMS PAS EXO-12-024

Large BR beneficial

➡ QCD BG suppression is a key!

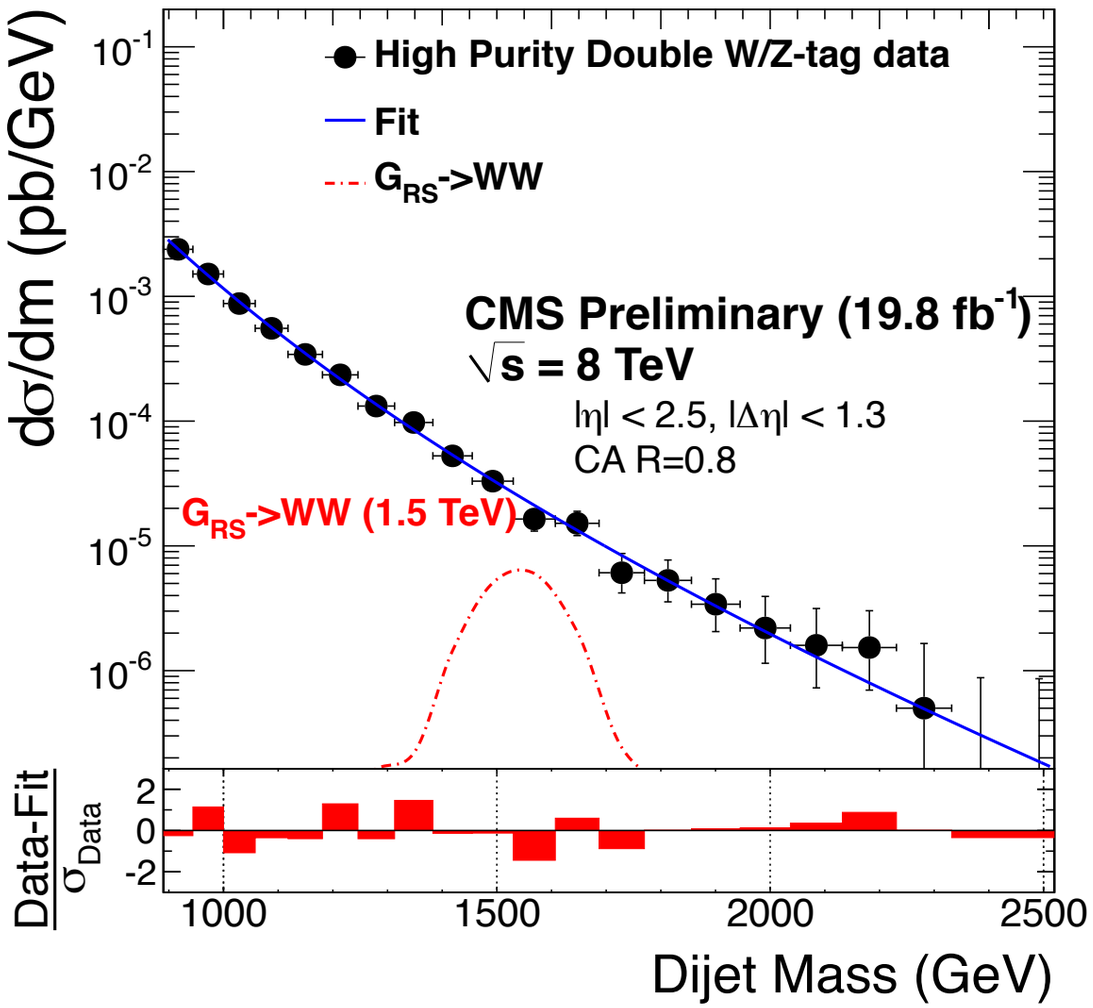
Baseline selection

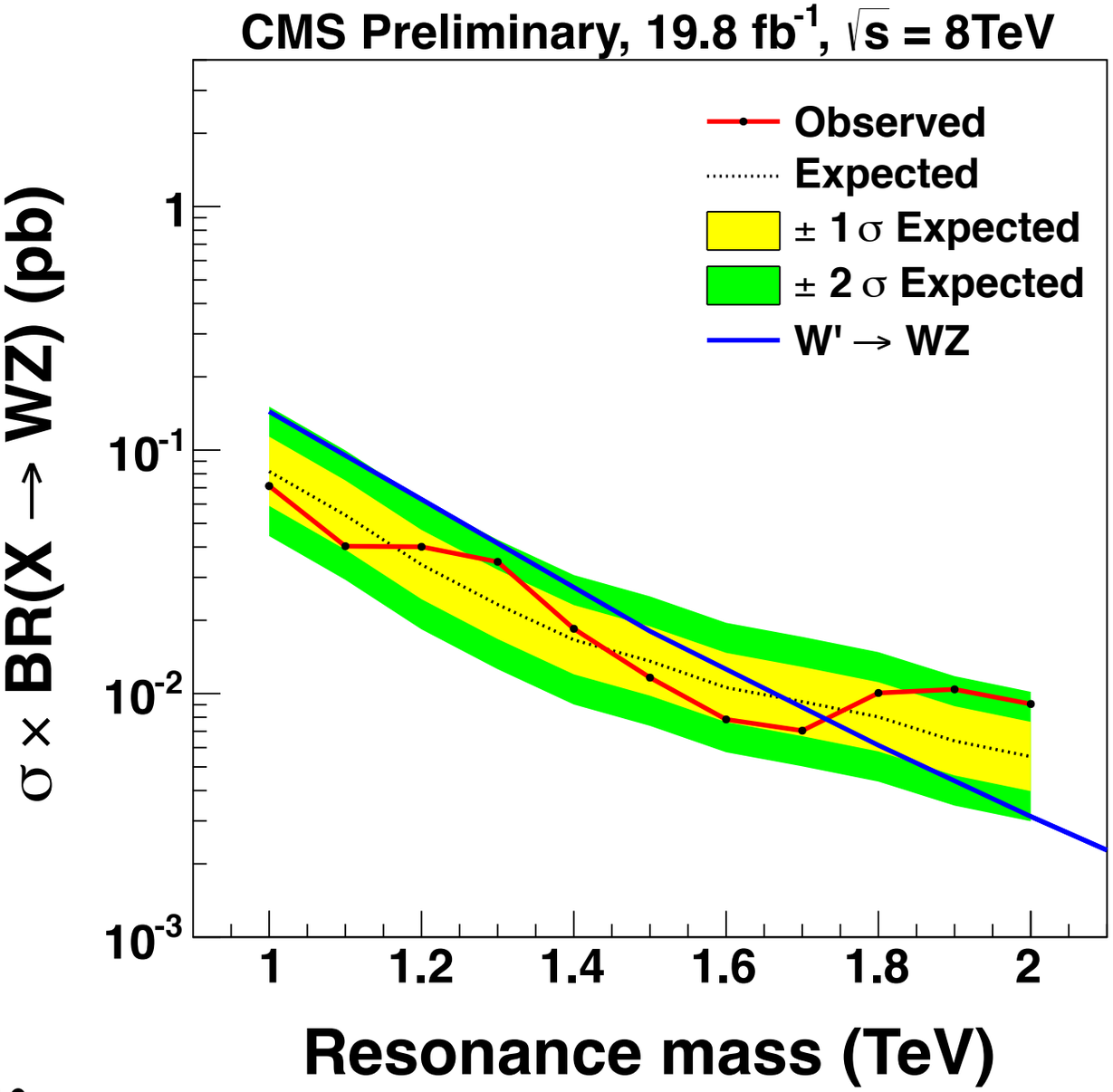
- ≥2 C/A R=0.8 jets p_T >30 GeV
- $|\Delta\eta_{jj}| < 1.3$, $M_{jj} > 890$ GeV

Exploit jet substructure technique :

- Pruned jet mass : $70 < M_{jet}^{Pruned} < 100$ GeV
- N-subjettiness : $\tau_{21} < 0.5$ (tight), 0.5-0.75 (medium)

⇒ Tight double-tag : ε_{SIGNAL}~10-20%, ε_{BG}<0.1%!!





For SSM+EGM W'→WZ coupling

W'$_{SSM}$ excluded up to 1.73 TeV

Diboson ($WZ \rightarrow l\nu ll$)

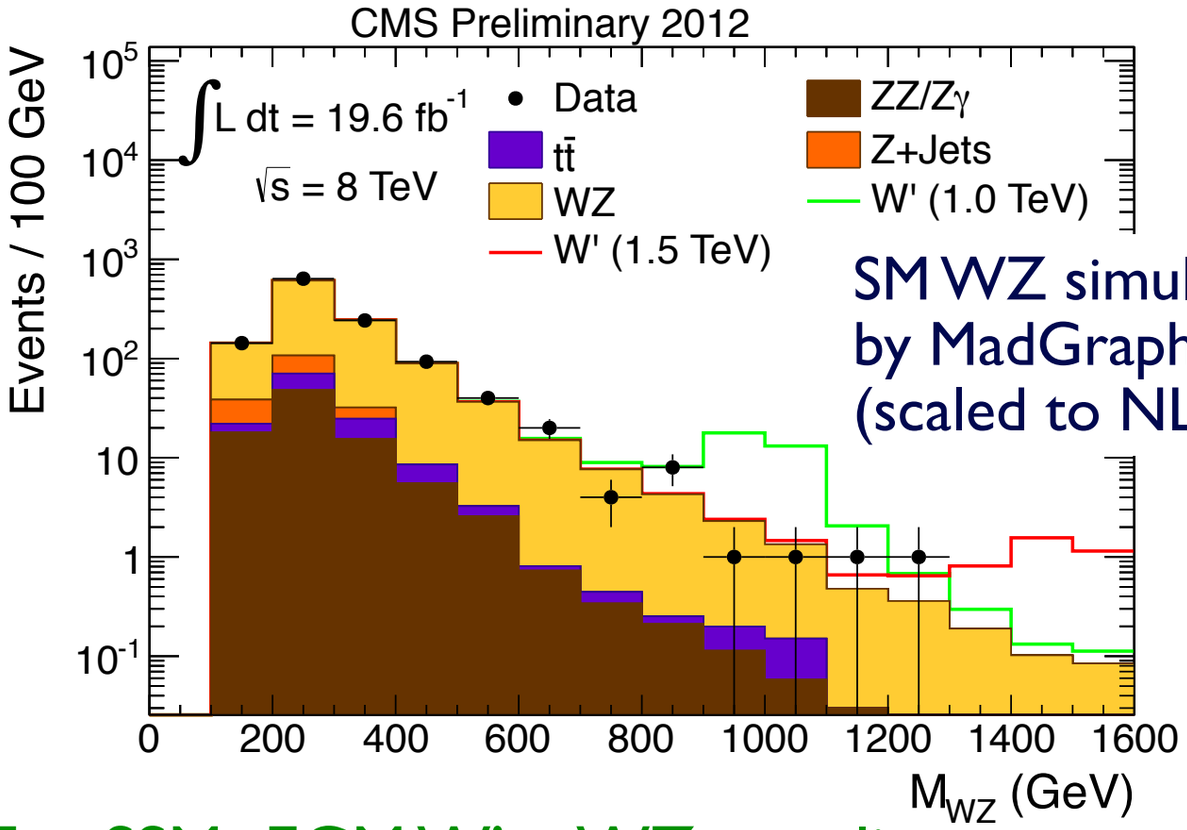
CMS PAS EXO-12-025

Small BR but much smaller background

➡ Very powerful at low mass region!

WZ→lνll selection

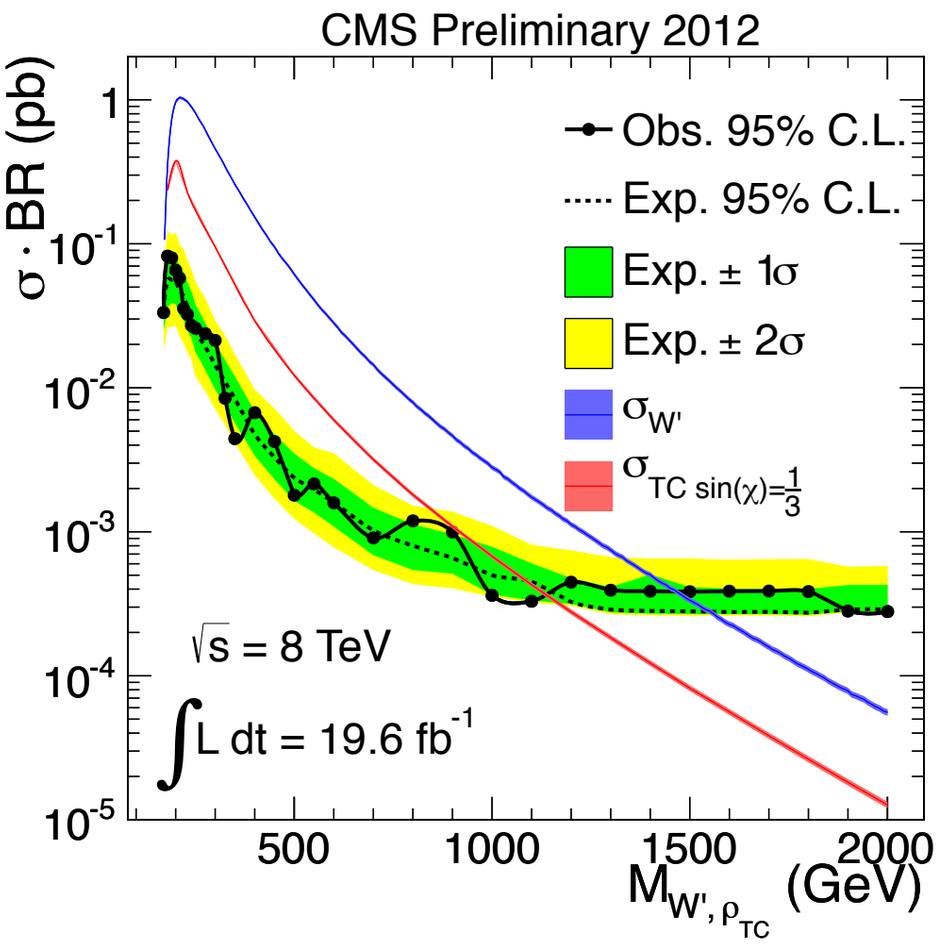
- 2 leptons p_T >35(25/10) GeV for Z→ee(μμ)
- OSSF pair of $|M_{ll}-M_Z|$ <20 GeV
- 1 lepton p_T >20 GeV, E_T^{miss} >30 GeV for W→lν
- Varying cuts on $\sum|p_T^{lepton}|$ and M_{WZ}

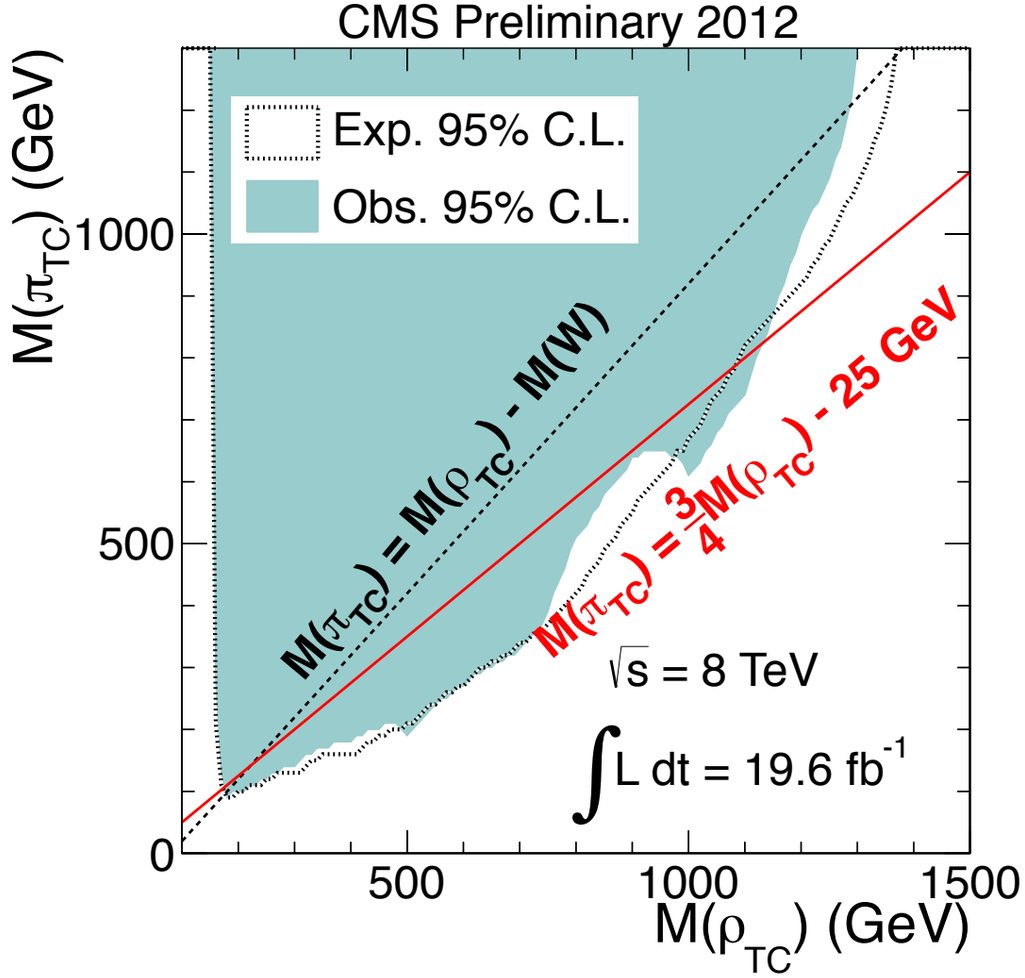


SM WZ simulated by MadGraph (scaled to NLO)

For SSM+EGM W'→WZ coupling

W'_{SSM} excluded up to 1.45 TeV





W/Z + X (→ jj)

ATLAS-CONF-2013-074

Search strategy

- Select leptonic W/Z + ≥2 jet events (no b-tag)
- MC background estimate with CR validation (fully data-driven for QCD background)
- Fit dijet mass to look for a resonance peak

Specific LSTC interpretation with

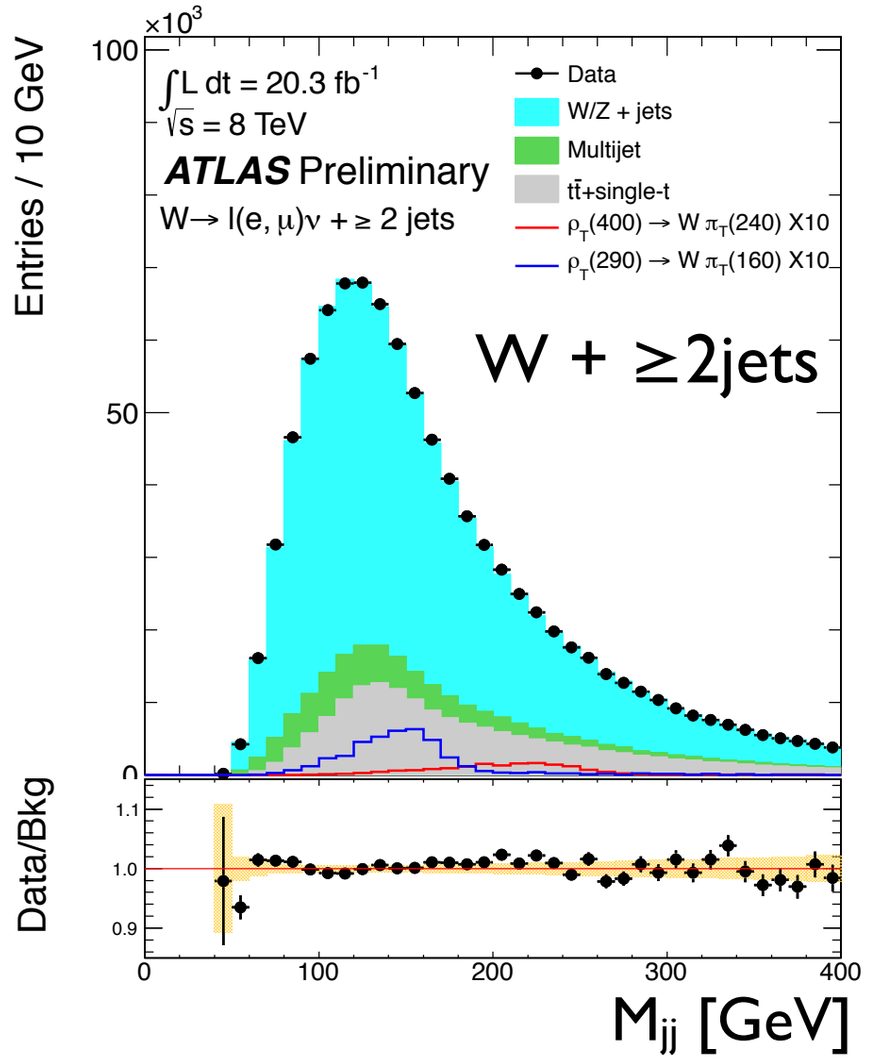
- $\rho_T^{\pm,0} \rightarrow W + \pi_T^{0,\pm}$
- $\rho_T^{\pm} \rightarrow Z + \pi_T^{\pm}$

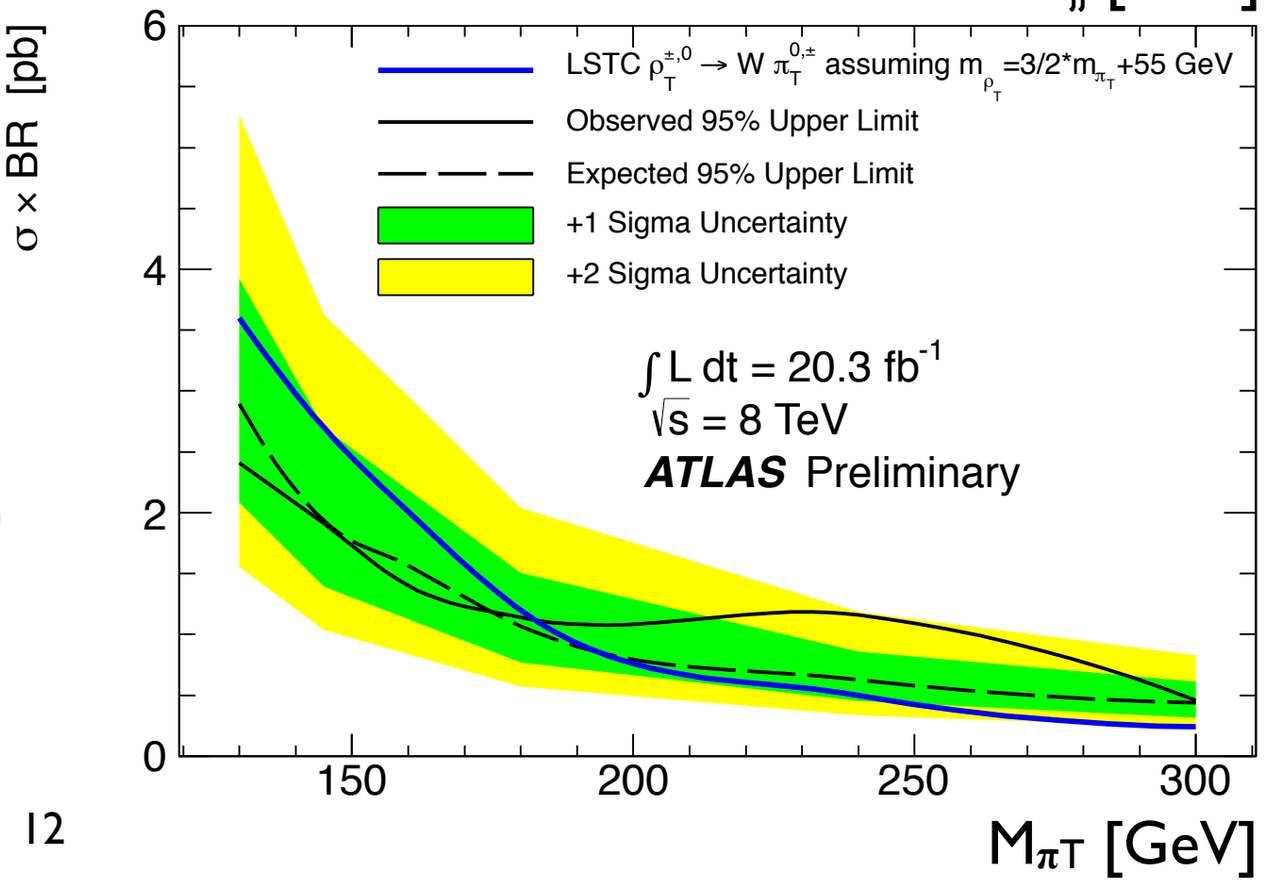
including a ρ_T - π_T mass point compatible with "CDF dijet anomaly", which is gone by now... :-(

ρ_T - π_T mass relation :

- $m(\rho_T) \sim 1.5m(\pi_T)+55$ GeV < $2m(\pi_T)$

➡ No significant excess observed





Heavy "Higgs" → hh/Zh

CMS PAS HIG-13-025

Dedicated searches for heavy Higgs (H/A) → hh/Zh in 2HDM scenario

Search stratey

- Emphasis on multilepton signatures (less SM background)
- ≤1 lepton events considered only if two photons exist in events
- Lepton = e, μ, τ_{had} (1 or 3-prong)
- on/off-Z OSSF pair or no OSSF pair for hh, only on-Z OSSF pair for Zh

e/μ/τ : p_T>10/10/20 GeV
γ : p_T>20 GeV

H→hh : decay modes and search channels

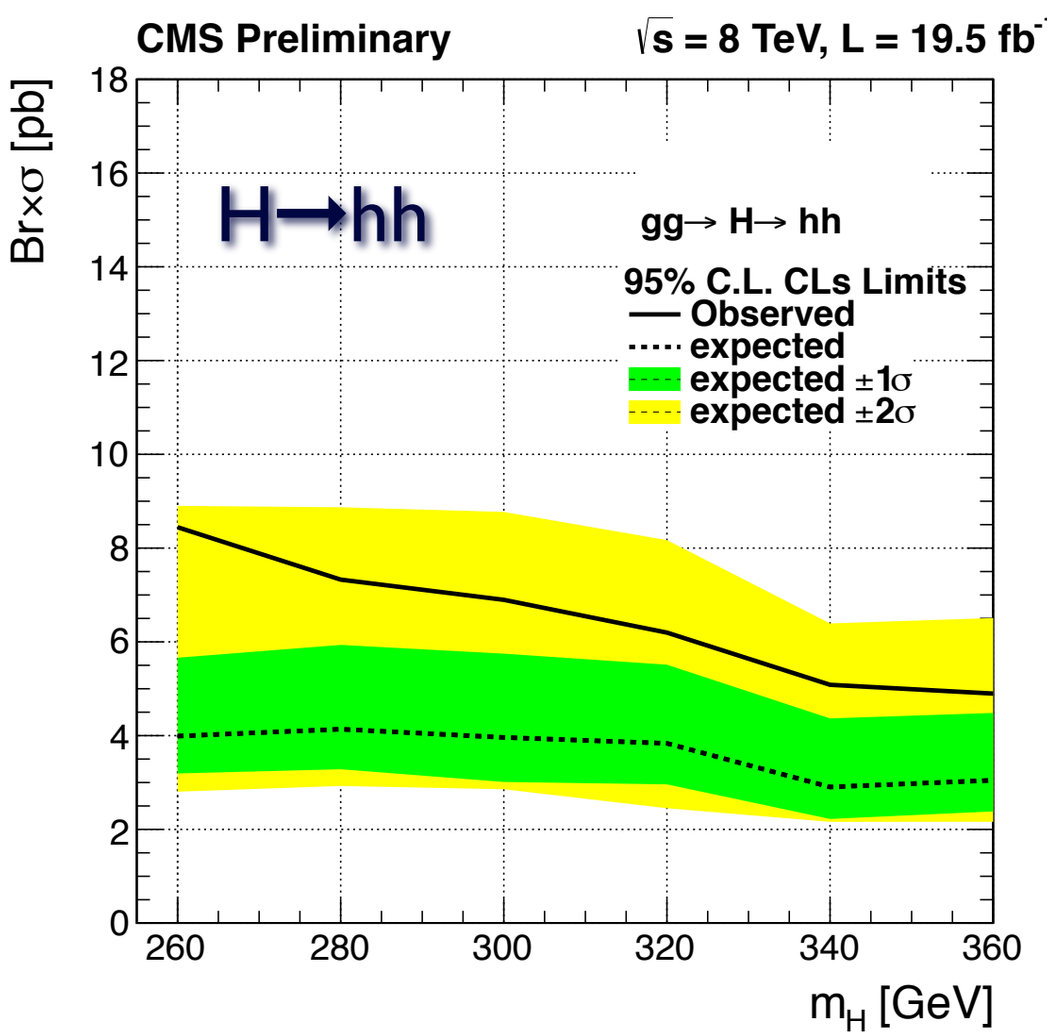
	WW*	ZZ*	ττ	bb	γγ
WW*	✔	✔	✔	✘	✔
ZZ*		✔	✔	✔	✔
ττ			✔	✘	✔
bb				✘	✘
γγ					✘

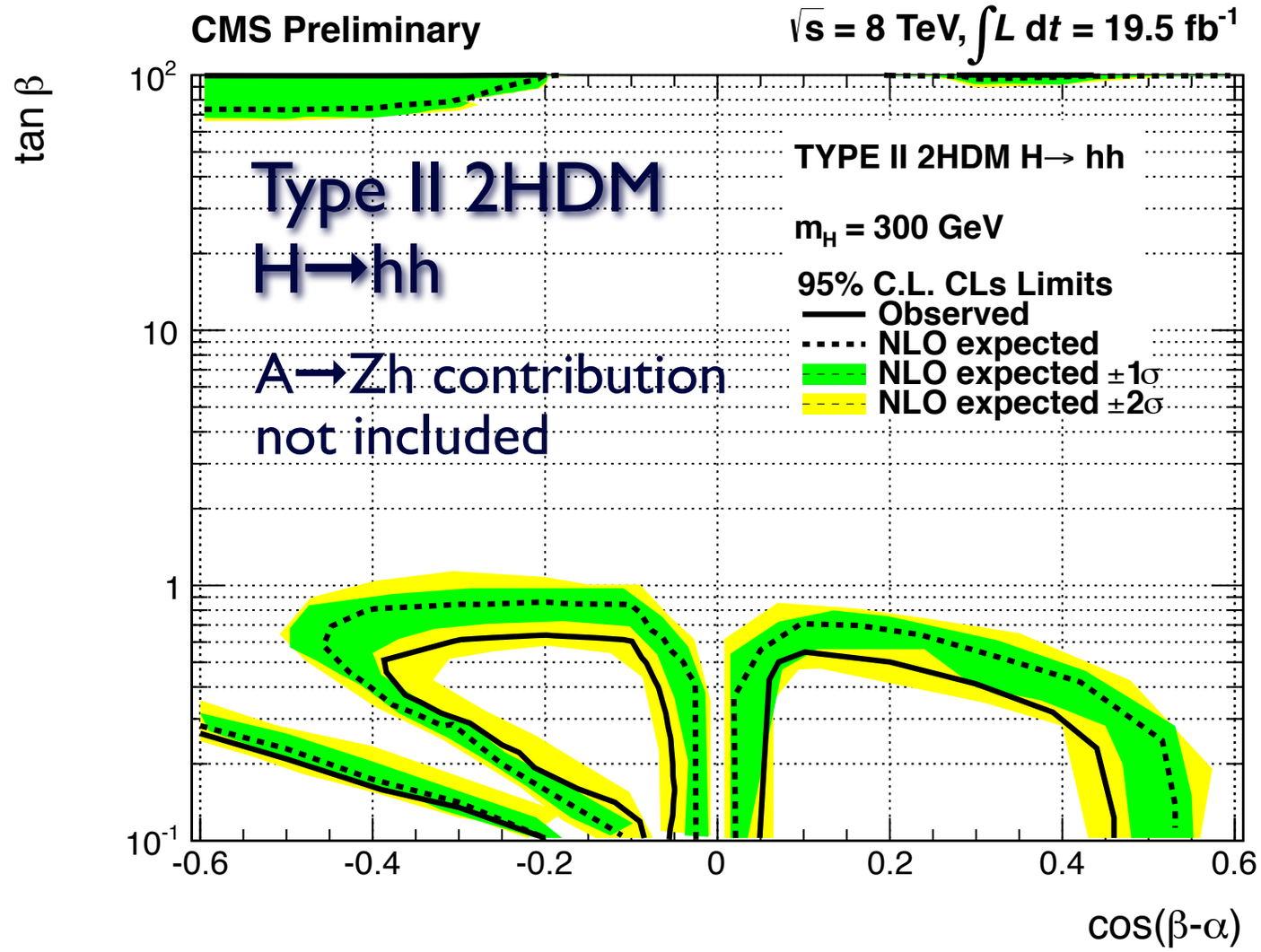
Final States	Search Channels
γγWW* γγZZ* γγττ	2 photons (120<$M_{\gamma\gamma}$<130GeV) + ≥1 leptons (up to 2 τ_{had}) in bins of E_T^{miss}
All others	3/4 leptons (up to 1 τ_{had}), on/off-Z OSSF pair or no OSSF pair, in bins of E_T^{miss} and b-tag

H → hh

CMS PAS HIG-13-025

- Counting in ~40 signal regions binned by [#leptons, OSSF pair (on/off-Z), #τ_{had}, #b-tag, E_T^{miss}]
- Limits placed on $\sigma \cdot Br(H \to hh)$ and $\tan\beta$ vs $\cos(\beta-\alpha)$ in 2HDM Type-I/II scenarios

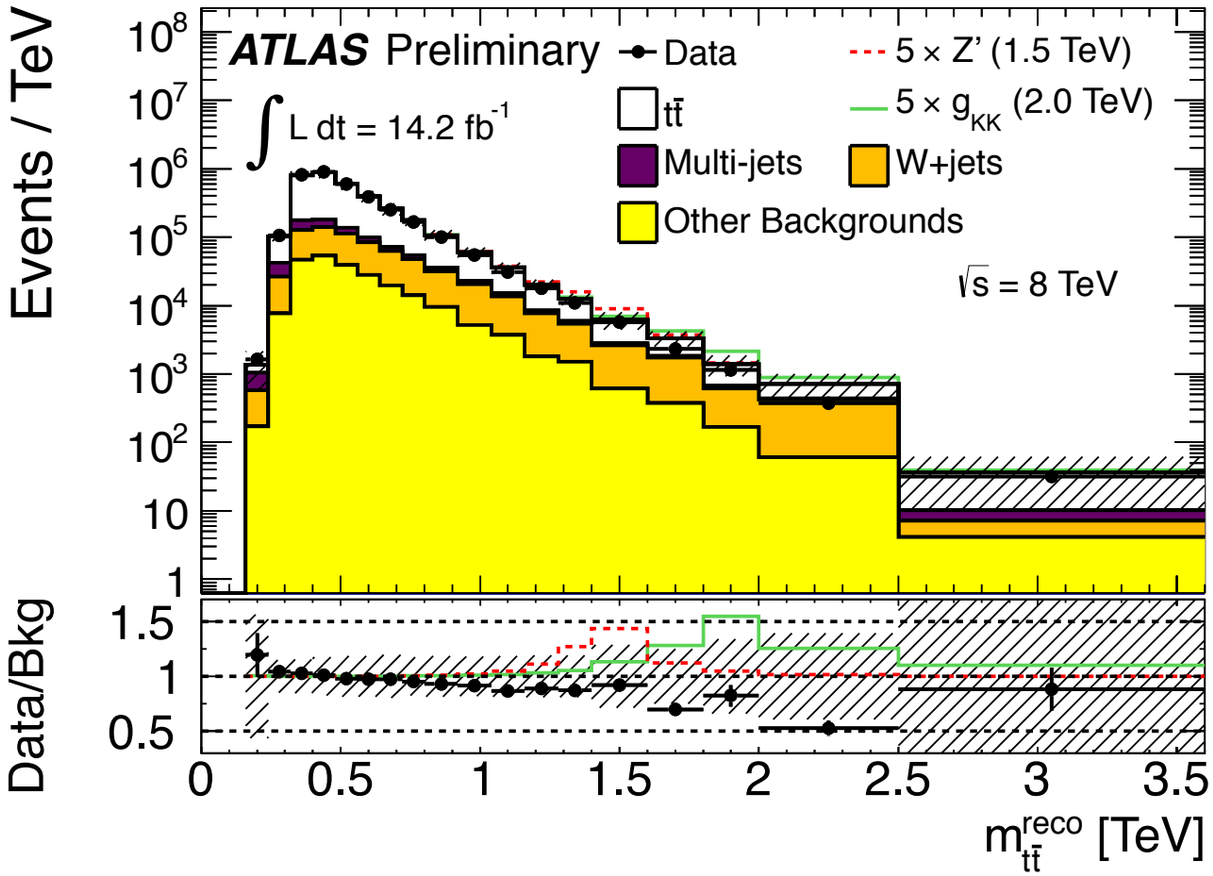


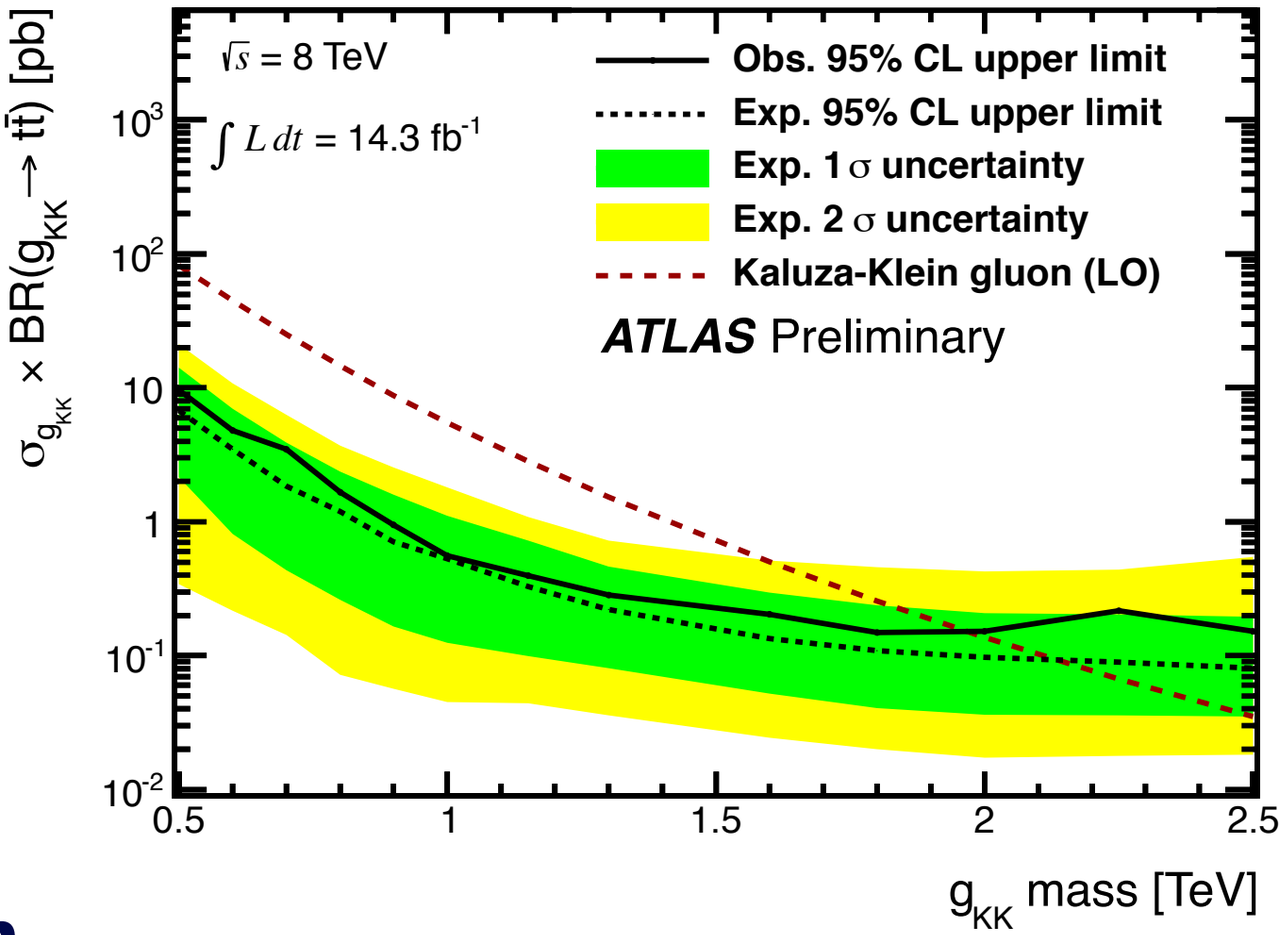


Ditop

ATLAS-CONF-2013-052
CMS PAS B2G-12-006

$t\bar{t}$ resonance : prominent signature in bulk Randall-Sundrum scenario





ATLAS $g^{KK} \rightarrow tt \rightarrow lvbqqb$ selection

- 1 lepton p_T >25 GeV, E_T^{miss} and M_T^W cuts
- Boosted : R=1.0 "trimmed" jet with
  m_{jet} >100 GeV, $\sqrt{d_{12}}$ >40 GeV
- Resolved : ≥4 R=0.4 jets
  (≥3 jets if m_{jet} >60 GeV)
- ≥1 b-tagged R=0.4 jets

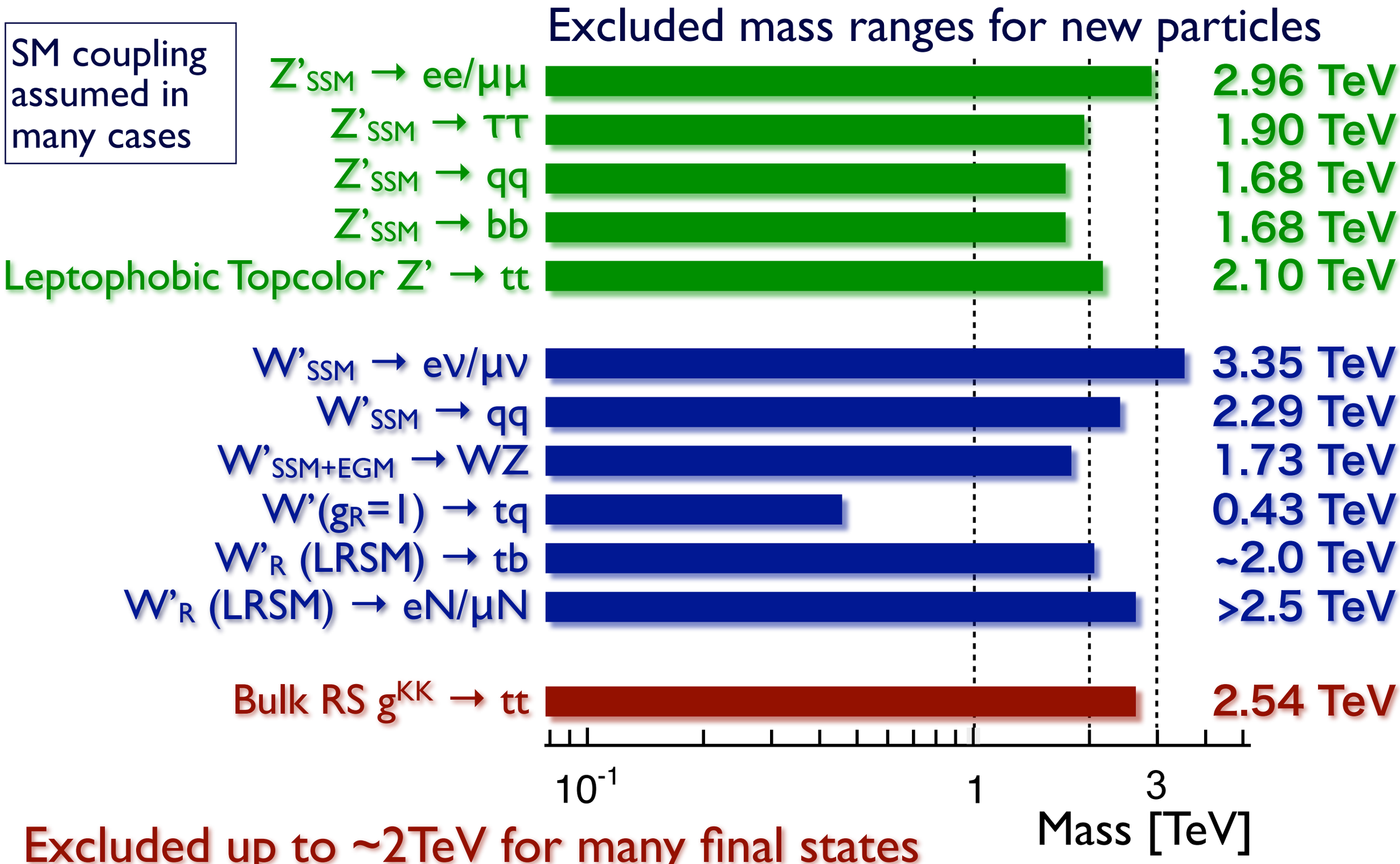
g^{KK} excluded up to 2.54 TeV (CMS)

➡ Entering into regime predicted from precision EW measurements

Topcolor Z' excluded up to 2.10 TeV

Run I Summary

SM coupling assumed in many cases



Excluded up to ~2TeV for many final states

LHC Future Prospects

Public results for future prospects

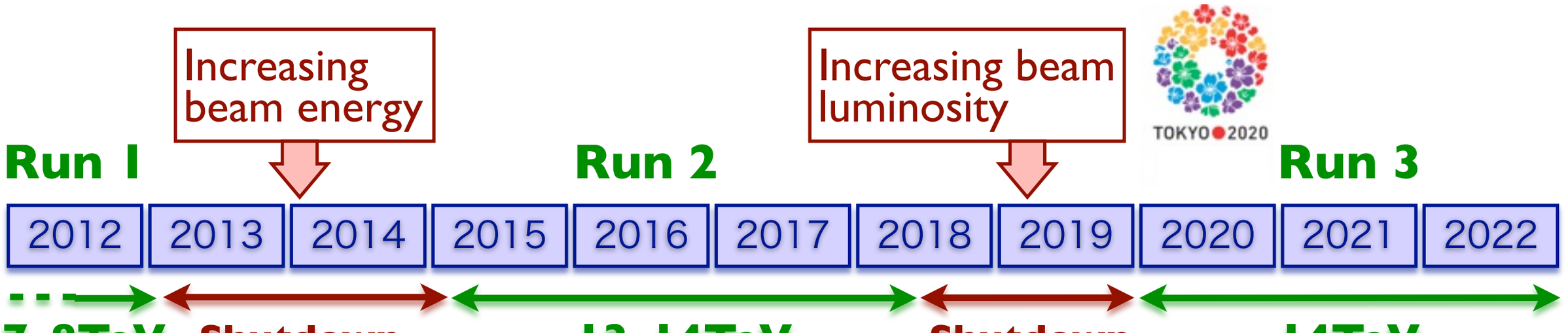
ATLAS : https://twiki.cern.ch/twiki/bin/view/AtlasPublic/UpgradePhysicsStudies

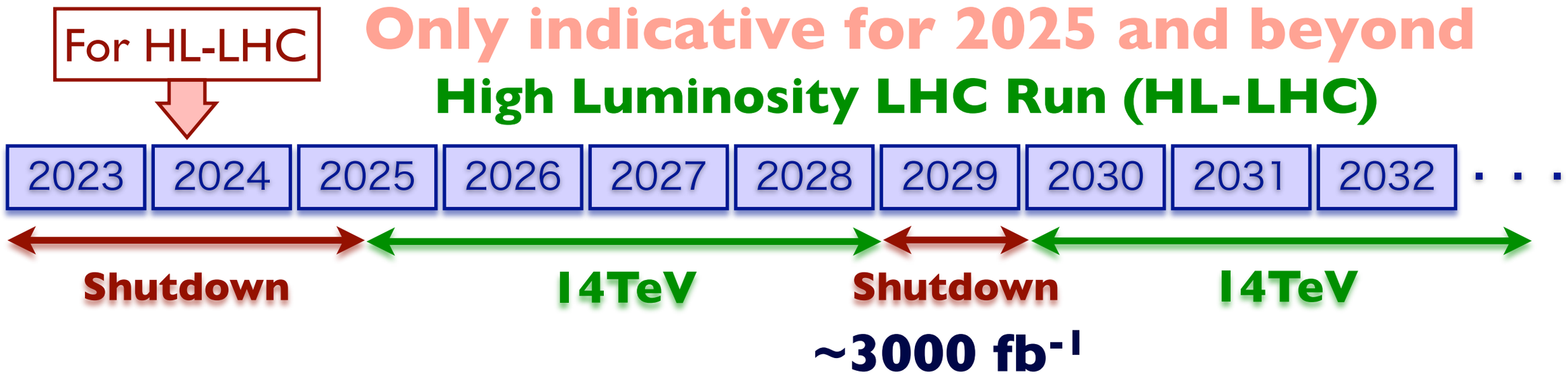
CMS : https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsFP

LHC Upgrade

New baseline schedule established in Dec 2013

- Luminosity projection might be revisited with the new schedule
- 2015 start-up scenario under discussion (13 TeV? 12.5 TeV? or ...)





Higgs Signal Strength

ATLAS-PHYS-PUB-2013-014

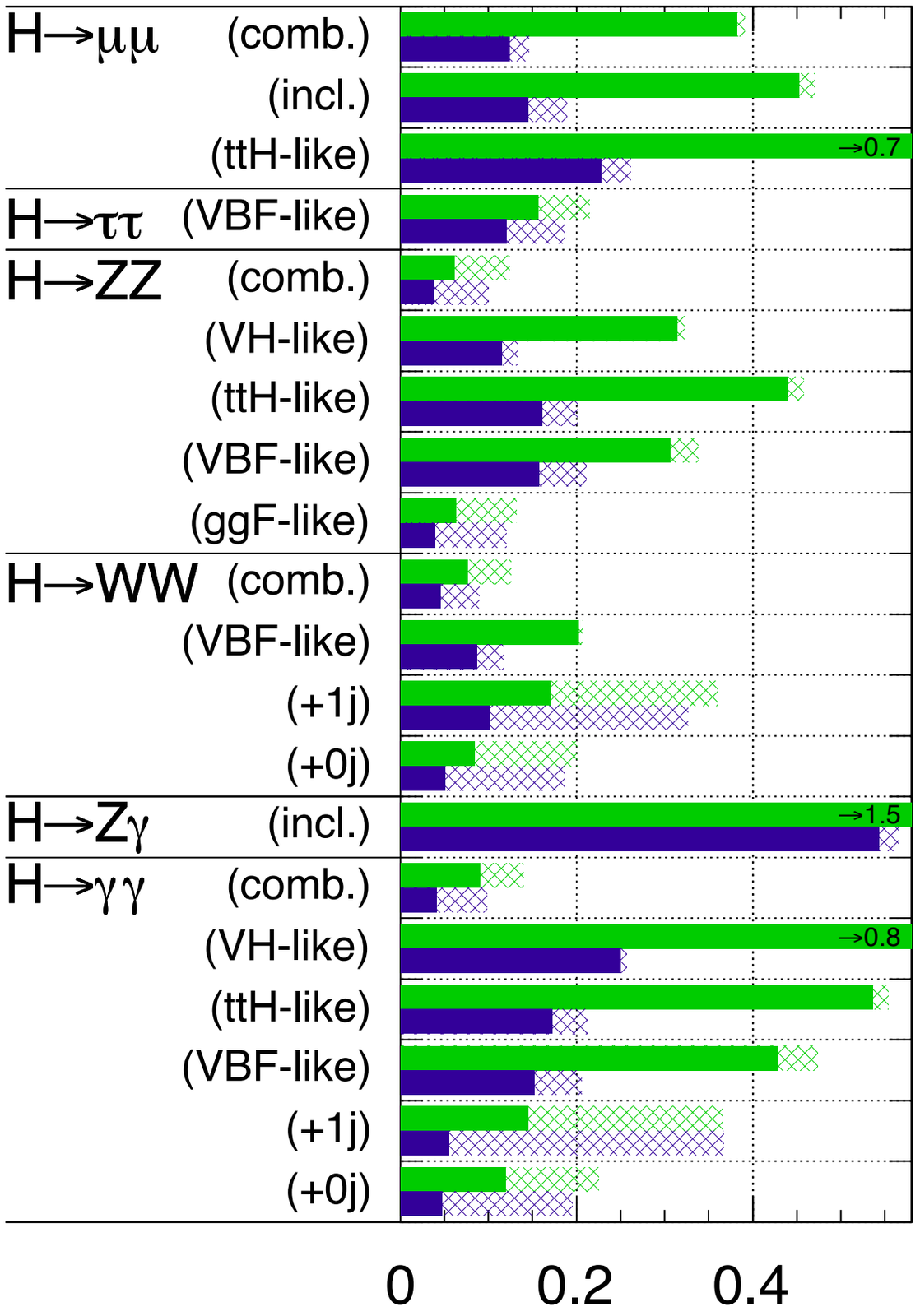
Signal strength $\mu = \dfrac{\sigma_{\rm obs}}{\sigma_{\rm SM}}$

Precision of μ in rare processes

	300 fb^{-1}	3000 fb^{-1}
ttH (H→γγ)	55%	21%
μμ	39%	15%
Zγ	147%	57%

Theory uncertainties quite important

3000 fb^{-1}	w/o → w/ theo. uncert.
γγ	4% → 10%
WW	5% → 9%
ZZ	4% → 10%



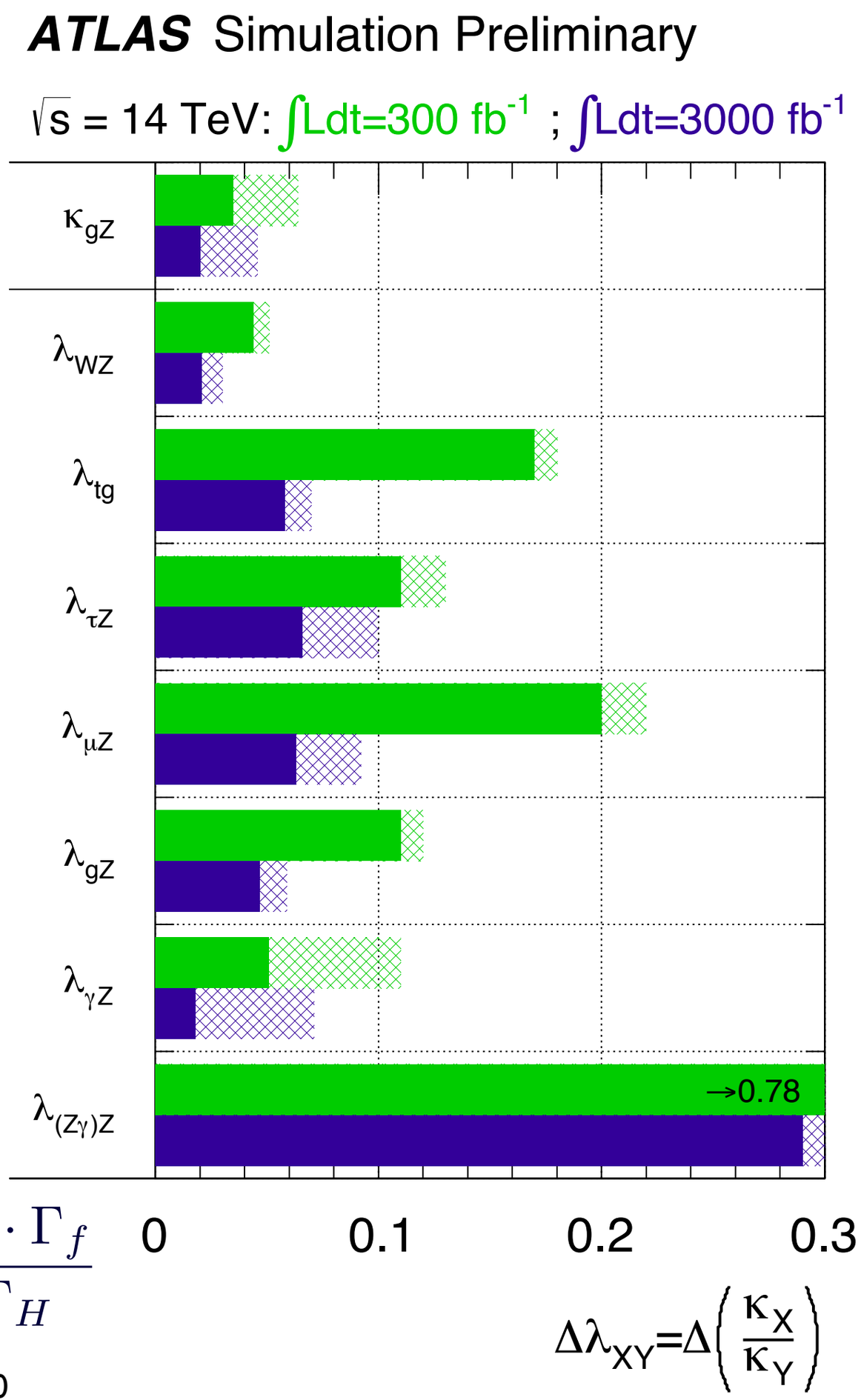
Higgs Coupling

Following channels considered in the combined fits

- H → γγ ggF(0,1-jet),VBF, ttH,VH
- H → WW ggF(0,1-jet),VBF
- H → ZZ ggF, VBF, ttH,VH
- H → ττ VBF
- H → Zγ Inclusive
- H → μμ Inclusive

Higgs coupling scale factor ratio $\lambda_{ab} = \frac{\kappa_a}{\kappa_b}$

Assumed
- Zero width : $\sigma \cdot B(i \to H \to f) = \frac{\sigma_i \cdot \Gamma_f}{\Gamma_H}$
- No H→invisible/BSM decay



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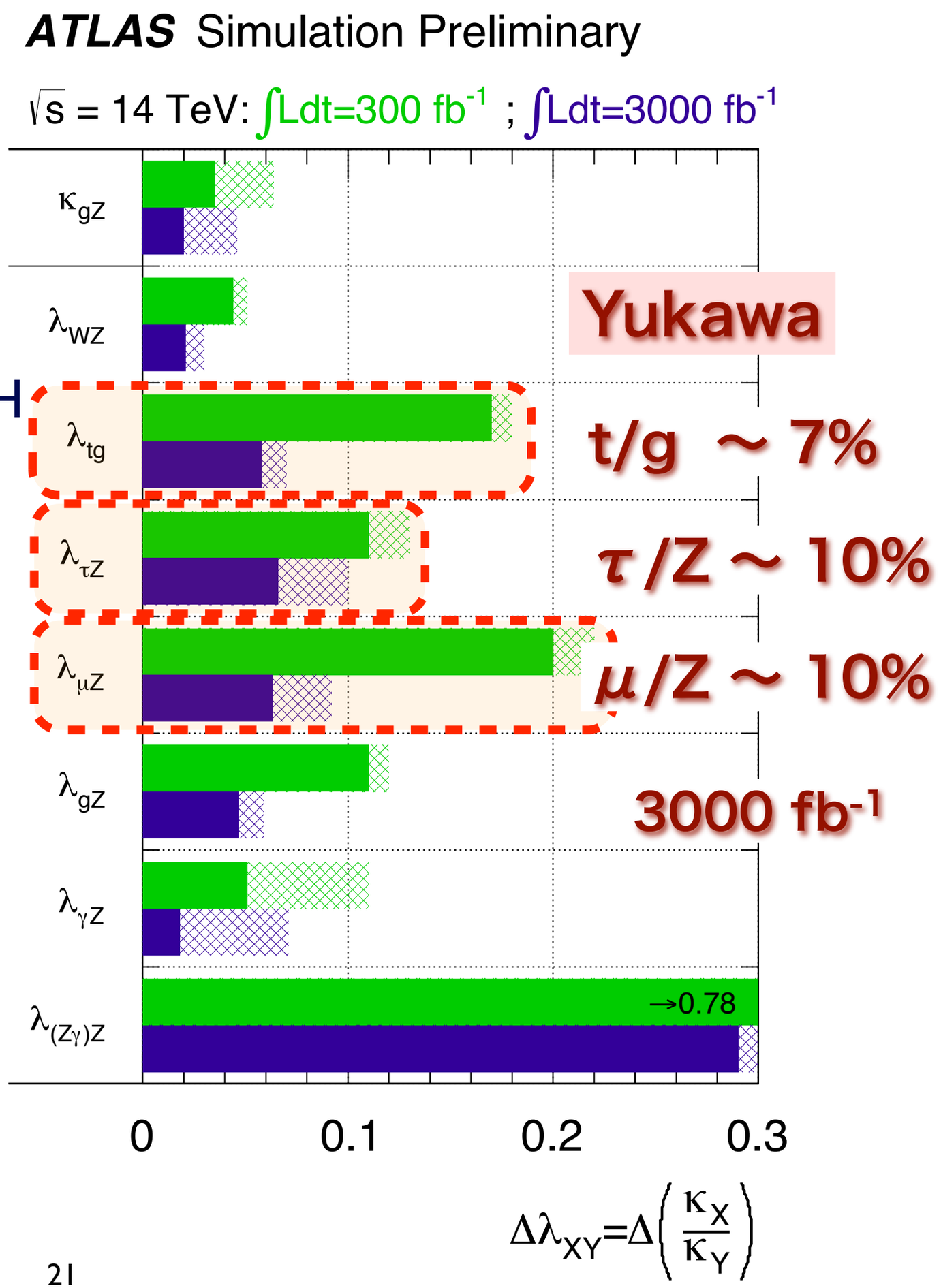
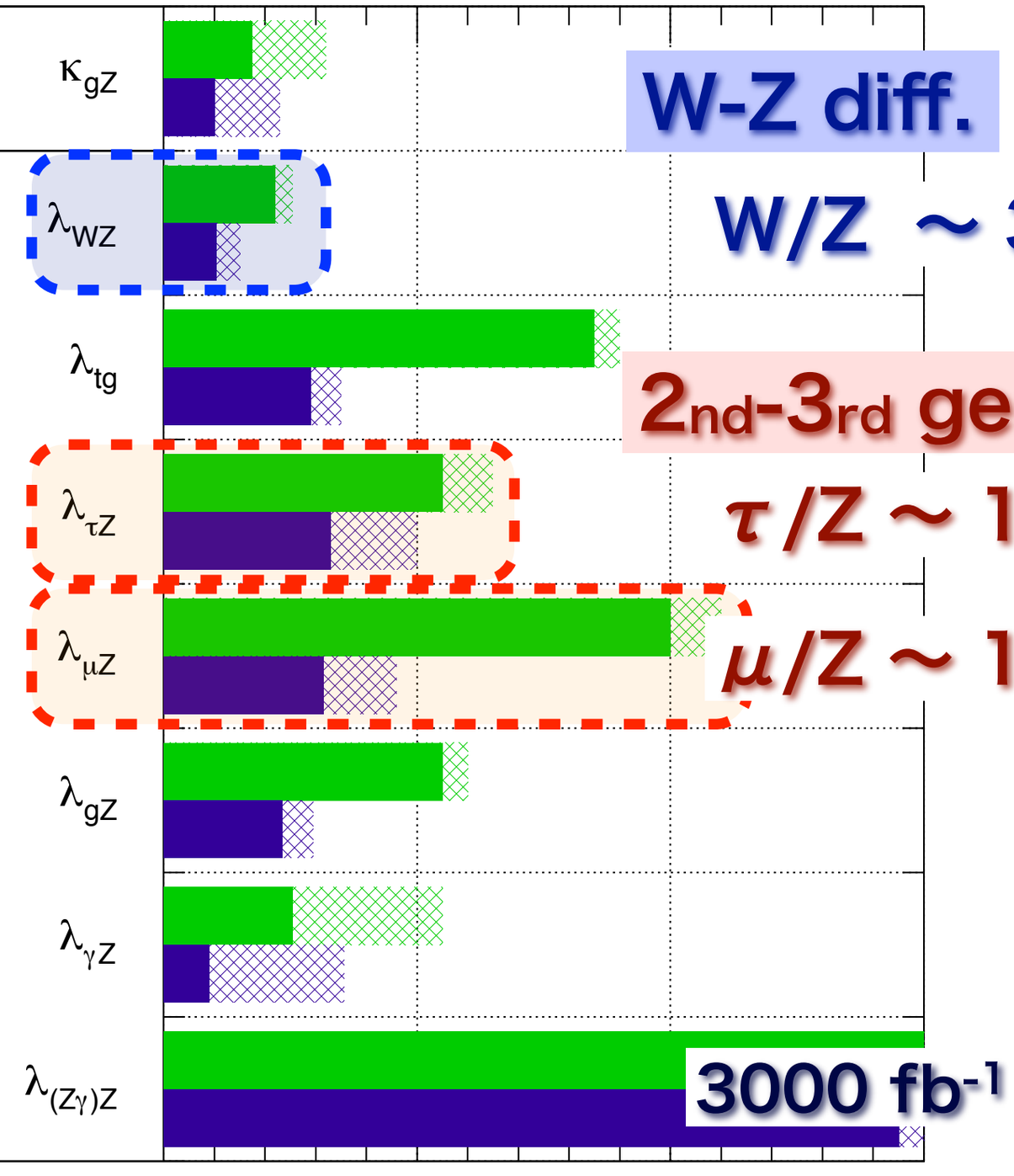


ATLAS Simulation Preliminary

$\sqrt{s}$ = 14 TeV: $\int$Ldt=300 fb^{-1} ; $\int$Ldt=3000 fb^{-1}



W-Z diff.

W/Z ~ 3%

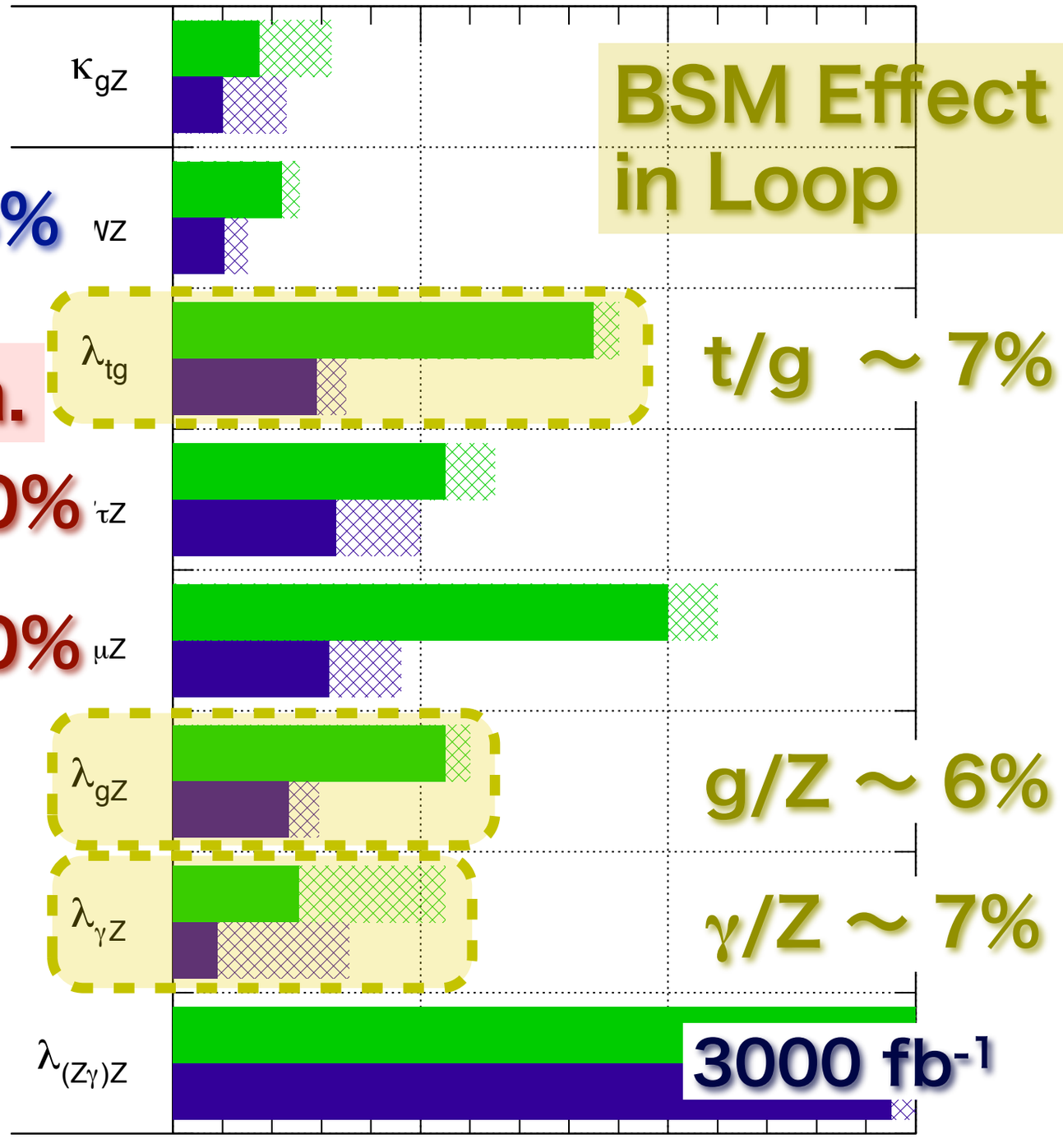
2nd-3rd gen.

τ/Z ~ 10%

μ/Z ~ 10%

ATLAS Simulation Preliminary

$\sqrt{s}$ = 14 TeV: $\int$Ldt=300 fb^{-1} ; $\int$Ldt=3000 fb^{-1}



BSM Effect in Loop

t/g ~ 7%

g/Z ~ 6%

γ/Z ~ 7%

Constraints from Higgs Coupling

arXiv:1310.8361

Possibility of extended Higgs sector including SM-like 125GeV Higgs

- 125 GeV "Higgs" particle with non-SM coupling
- Indirect constraints from high-precision coupling measurement
- Direct search for "2nd" Higgs boson at high mass region

Expected deviation from SM coupling in case of ~1 TeV new particle

Higgs Snowmass Report

	$\Delta\kappa_V$	$\Delta\kappa_\gamma$	$\Delta\kappa_b$
2HDM	**~ 1%**	**~ 1%**	**~ 10%**
MSSM (decoupling)	**$\sim 10^{-5}$**	**<~0.4%**	**~1.6%**
Composite Higgs	**~ −3%**	**~ −9%**	**~ −(3-9)%**
Top Partner	**~ −2%**	**~ +1%**	**~ -2%**

Possible to reach at 3000 fb^{-1} :

$\kappa_\gamma \sim 9(4)\%$, $\kappa_V \sim 3(2)\%$, $\kappa_f \sim 4(3)\%$

with (without) theory uncertainty

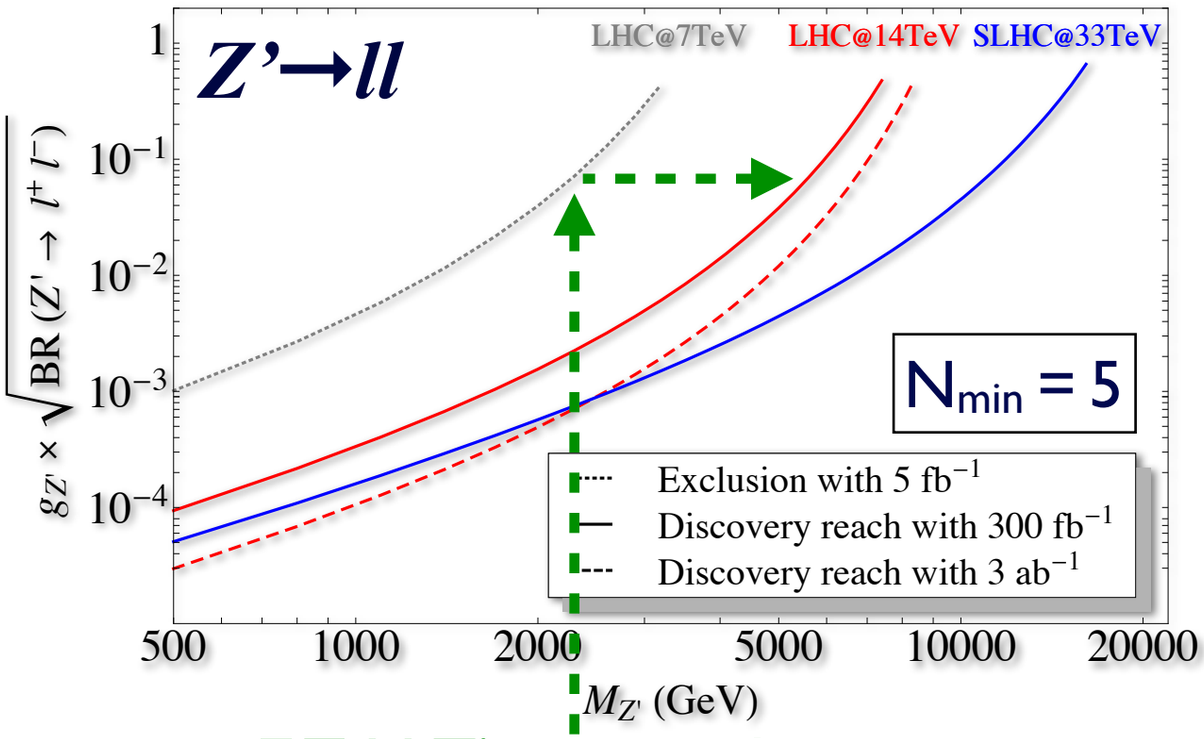
Z' → ll, W' → qq

Assume universal left-handed coupling to up and down quarks

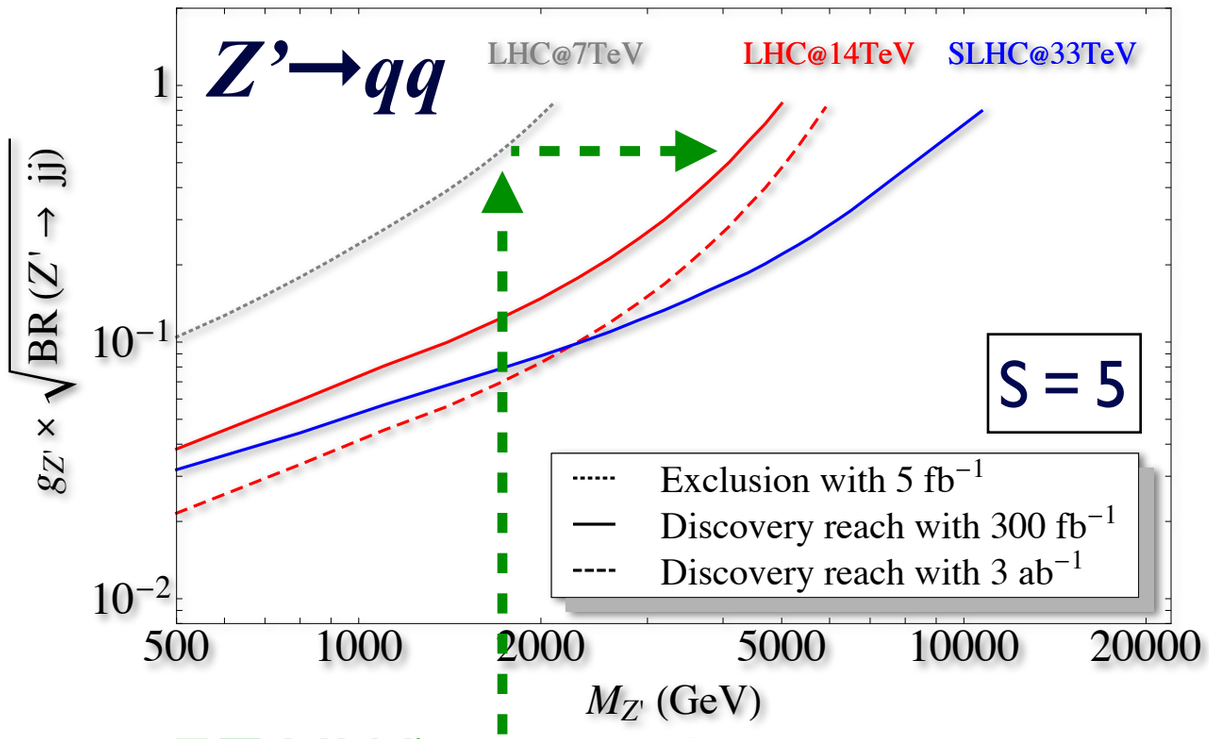
$$\mathcal{L}_{Z'} \sim g_{Z'} Z'_\mu \left(\bar{q}_i \gamma^\mu \frac{1-\gamma_5}{2} q^i \right)$$

$$g_{Z'} \sqrt{\mathrm{BR}(Z' \to l^+ l^-)} = \left(\frac{N_{\mathrm{min}}}{\sigma(q\bar{q} \to Z')|_{g_{Z'}=1} \, A\epsilon L} \right)^{1/2}$$

$$g_{Z'} \sqrt{\mathrm{BR}(Z' \to l^+ l^-)} = \left(\frac{S\sqrt{N_{\mathrm{BG}}}}{\sigma(q\bar{q} \to Z')|_{g_{Z'}=1} \, A\epsilon L} \right)^{1/2}$$



7 TeV Z'_{SSM} mass limit



7 TeV W'_{SSM} mass limit

Possible to discover up to

~5.5(7.0)TeV for $Z'_{SSM} \to ee/\mu\mu$

~4.0(5.0)TeV for $W'_{SSM} \to qq$

at 14TeV with 300(3000) fb^{-1}

First Look at One-Family Walking Technicolor Predictions

This is NOT ATLAS result

Preliminary look at MC sensitivity to *unique* topologies predicted by one-family WTC model in collaboration with S. Matsuzaki, M. Kurachi and K. Yamawaki

Probing the Model

Probing techni-pion dynamics with rich LHC phenomenology

- e.g, *color-octet/singlet, iso-singlet techni-pion* → *tt*

Focus here on techni-rho → boson + "Higgs" processes :

➡ Color-singlet technirho : $\rho_0 \rightarrow \gamma + \Phi$ ($\Phi \rightarrow gg$)

➡ Color-octet technirho : $\rho_8 \rightarrow g + \Phi$ ($\Phi \rightarrow gg$)

Φ = "Higgs" (techni-dilaton)

See talks by M. Kurachi and S. Matsuzaki for more details about the model

MC Sensitivity Study

Focus on two characteristic signatures:

- ➡ Color-singlet technirho : $\rho_0 \rightarrow \gamma + \Phi$ ($\Phi \rightarrow gg$)
  - use PYTHIA low-scale TC implementation
  - emulated by $\rho^{TC}/\omega^{TC} \rightarrow \gamma + \pi^{TC}$ ($\pi^{TC} \rightarrow gg$)
- ➡ Color-octet technirho : $\rho_8 \rightarrow g + \Phi$ ($\Phi \rightarrow gg$)
  - use PYTHIA genetic particle interface
  - introduce a new particle X with same quantum numbers as ρ_8
  - emulated by $gg \rightarrow X \rightarrow g + \rho_8^{TC}$ ($\rho_8^{TC} \rightarrow gg$)

- Fix Φ mass at 125 GeV and consider only $\Phi \rightarrow gg$ decay
- Set ρ_0/ρ_8 mass above current experimental limits from other decay channels
- Cross section normalized to model prediction (m_Φ=125 GeV, BR($\Phi \rightarrow gg$)=75%)
- Parameterized jet and photon momentum smearing (due to pileup), photon efficiency and jet fakes are applied to generated events

Color-Singlet $\rho_0 \rightarrow \gamma + \Phi$

$\sqrt{s}$ = 8 TeV

$m_{\rho 0}$ [TeV]	$\sigma \cdot BR$ [fb]
1.4	~0.9

Color-singlet technirho : $\rho_0 \rightarrow \gamma + \Phi$ ($\Phi \rightarrow gg$)

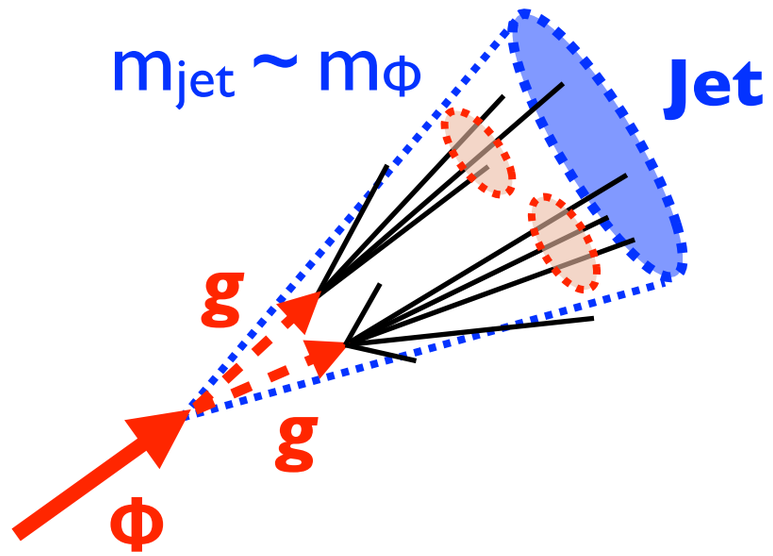
$m_{\rho 0} \lesssim 1.3$ TeV excluded by 8 TeV Z'→dilepton search

➡ $m_{\rho 0}$ = 1.4 TeV chosen as a benchmark point

Event Selection :
- 1 photon p_T >450 GeV
- ≥1 jet p_T >350 GeV, 110 < m_{jet} < 140 GeV

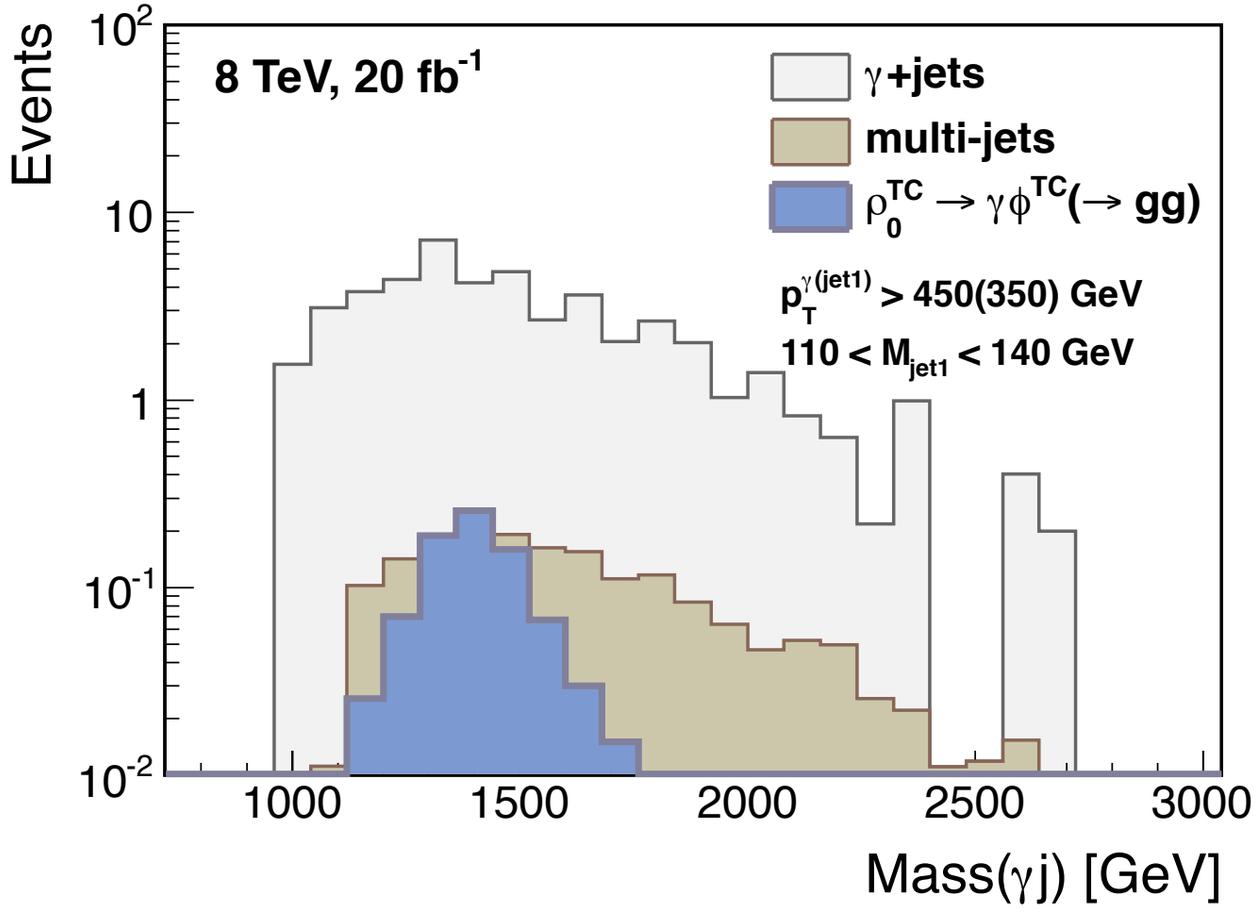
Considered Backgrounds : γ+jets, multi-jets (PYTHIA)

Cut and count in a sliding $M_{\gamma j}$ window



Boosted Φ(→gg)

➡ Merged into a single jet



$m_{\rho 0}$=1.4 TeV, 1.2<$M_{\gamma j}$<1.6 TeV

$\sqrt{s}$ [TeV]	L_{int} [fb^{-1}]	S	S/√B
8	20	0.7	0.15
14	100	21	0.97

➡ Hard due to small signal yield...

Color-Octet $\rho_8 \rightarrow g + \Phi$

Color-octet technirho : $\rho_8 \rightarrow g + \Phi$ ($\Phi \rightarrow gg$)

$m_{\rho 8} \lesssim 1.6$ TeV excluded by 8 TeV dijet resonance search

➡ $m_{\rho 8}$ = 1.7, 2.0 and 2.3 TeV chosen as benchmark points

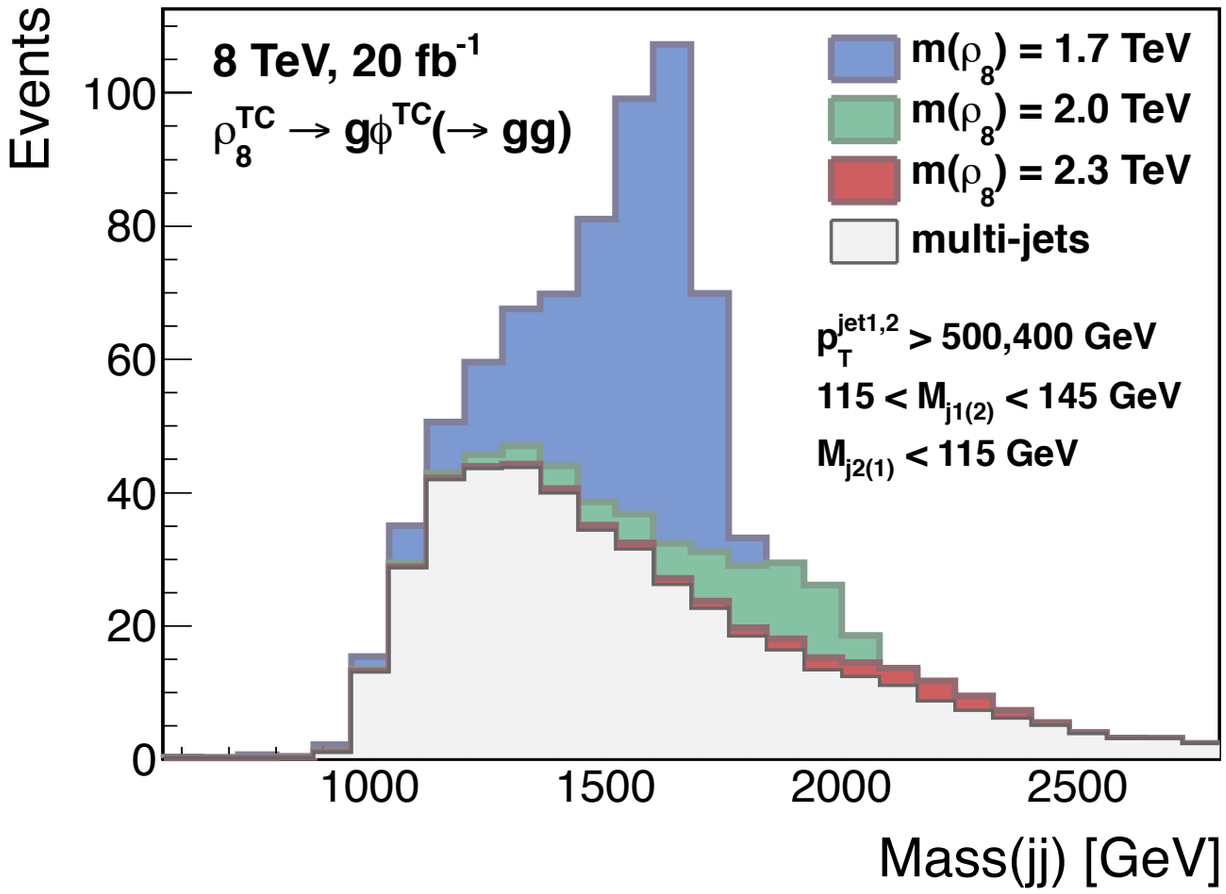
$\sqrt{s}$ = 8 TeV

$m_{\rho 8}$ [TeV]	1.7	2.0	2.3
$\sigma \cdot BR$ [fb]	~300	~70	~20

Event Selection :
- ≥2 jets p_T >500,400 GeV
- Either one of them = 115 < m_{jet} < 145 GeV, other jet = m_{jet} < 115 GeV

Considered Backgrounds : multi-jets (PYTHIA)

Cut and count in a sliding M_{jj} window



$\sqrt{s}$ = 8 TeV, 20 fb^{-1}

$m_{\rho 8}$ [TeV]	M_{jj} [TeV]	S	S/$\sqrt{B}$
2.0	1.7-2.0	45	5.3
2.3	2.1-2.3	8 (46)	1.5 (4.3)

($\sqrt{s}$ = 14 TeV, 10 fb^{-1})

➡ Promising channel to probe the model

Summary

Towards understanding the dynamics of electroweak symmetry breaking

- Properties of "SM-like" Higgs (rare processes, yukawa/gauge/λ, ...)
- Direct search for additional (heavy) Higgses
- Longitudinal gauge boson scattering
- Probing technicolor scenarios with various topologies

Significant increase in sensitivity for new particles at 14 TeV LHC (300 fb^{-1})

- W'/Z' → ff ➡ ~ 4-5 TeV
- W' → WZ ➡ >~ 3 TeV
- KK Gluon ➡ ~ 3-4 TeV
- Top Partner ➡ ~ 1.3 TeV
- Squark/Gluino ➡ ~ 2-2.5 TeV ($m_{\tilde{q}} = m_{\tilde{g}}$)
- Stop ➡ ~ 0.8-1 TeV ($m_{\tilde{\chi}_1^0} = 0$)
- $Chargino_1/Neutralino_2$ ➡ ~ 0.5-0.7 TeV ($m_{\tilde{\chi}_1^0} = 0$)

Backup

ATLAS Upgrade

Phase-0 (2013-2014)

- New silicon detector (IBL)
- Fast Track trigger
- Level-1 hardware trigger, ...

➡ **~1×10^{34}, ~25 collisions/event**

Phase-1 (2018-2019)

- LAr calorimeter triggers
- Endcap muon detector (NSW)
- Fast Tracker completion, ...

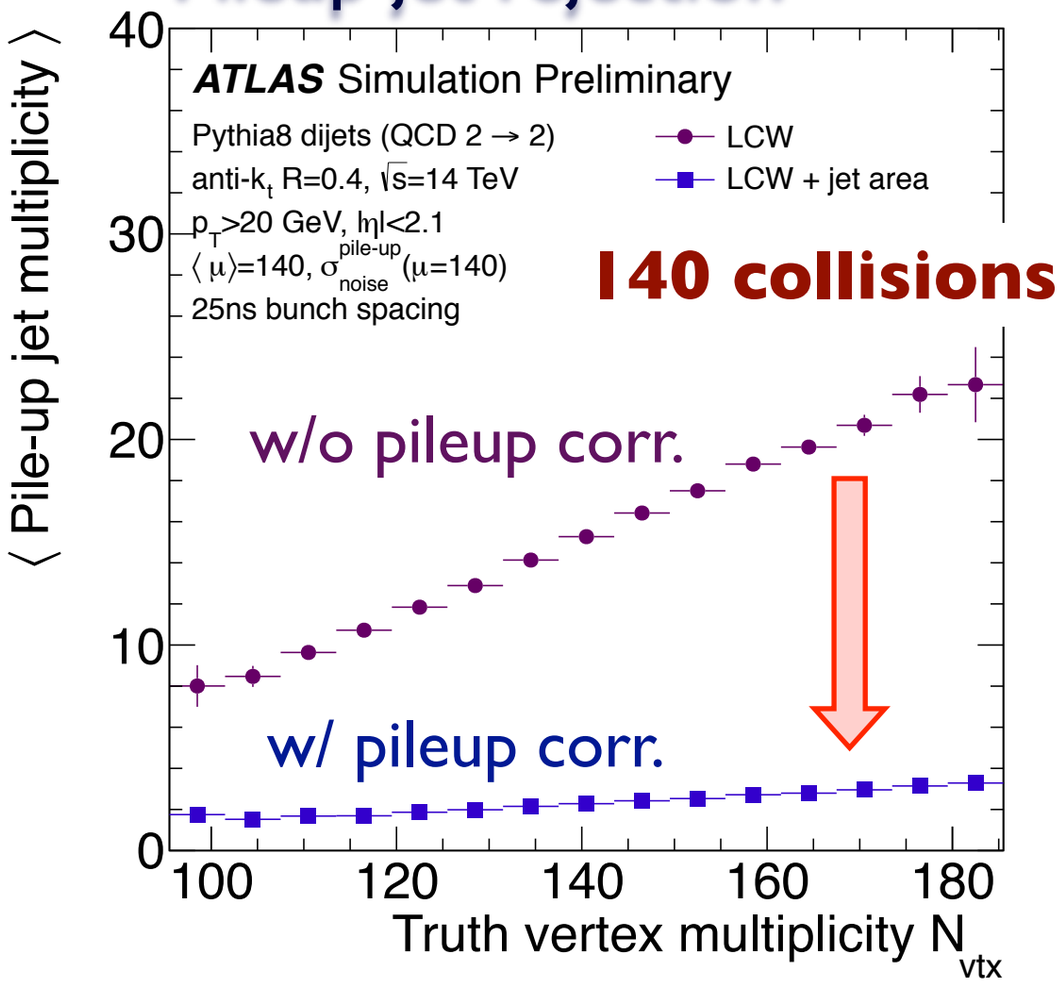
➡ **~2×10^{34}, ~70 collisions/event**

Phase-II (2023-2024)

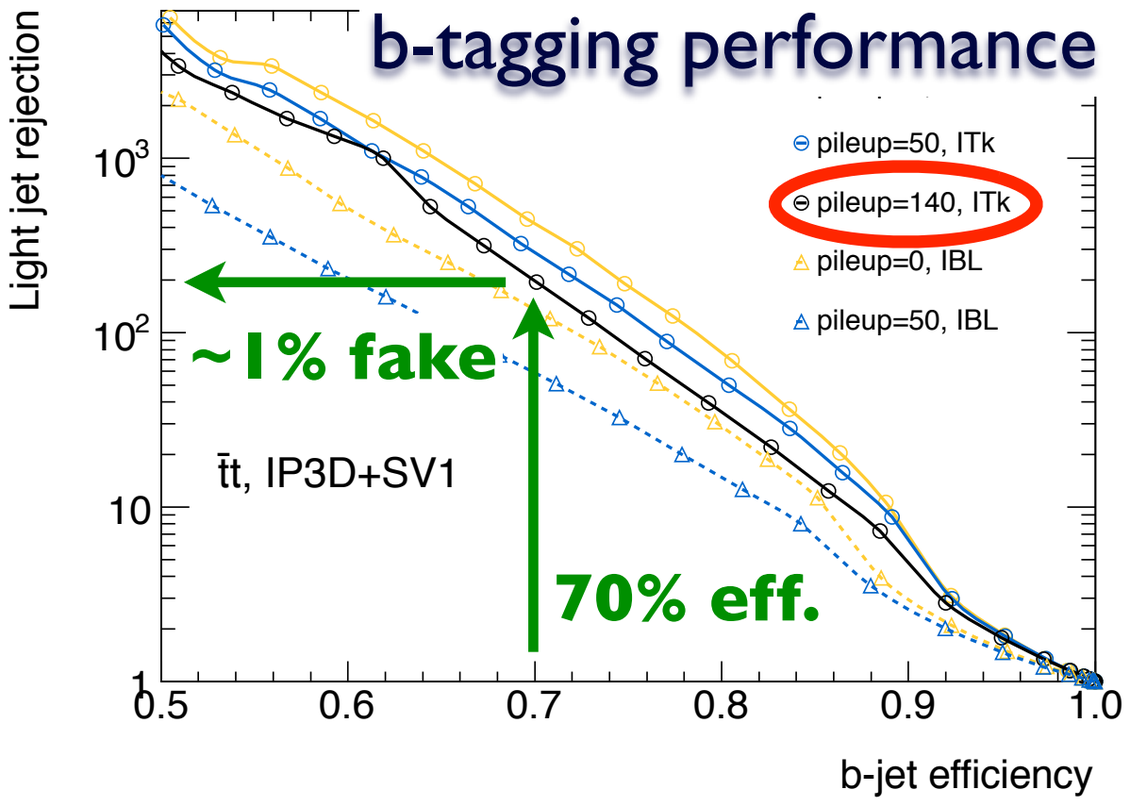
- All-silicon inner detector
- New DAQ/trigger design
- New Calo./Muon triggers, ...

➡ **~5×10^{34}, ~140 collisions/event**

Pileup jet rejection



b-tagging performance

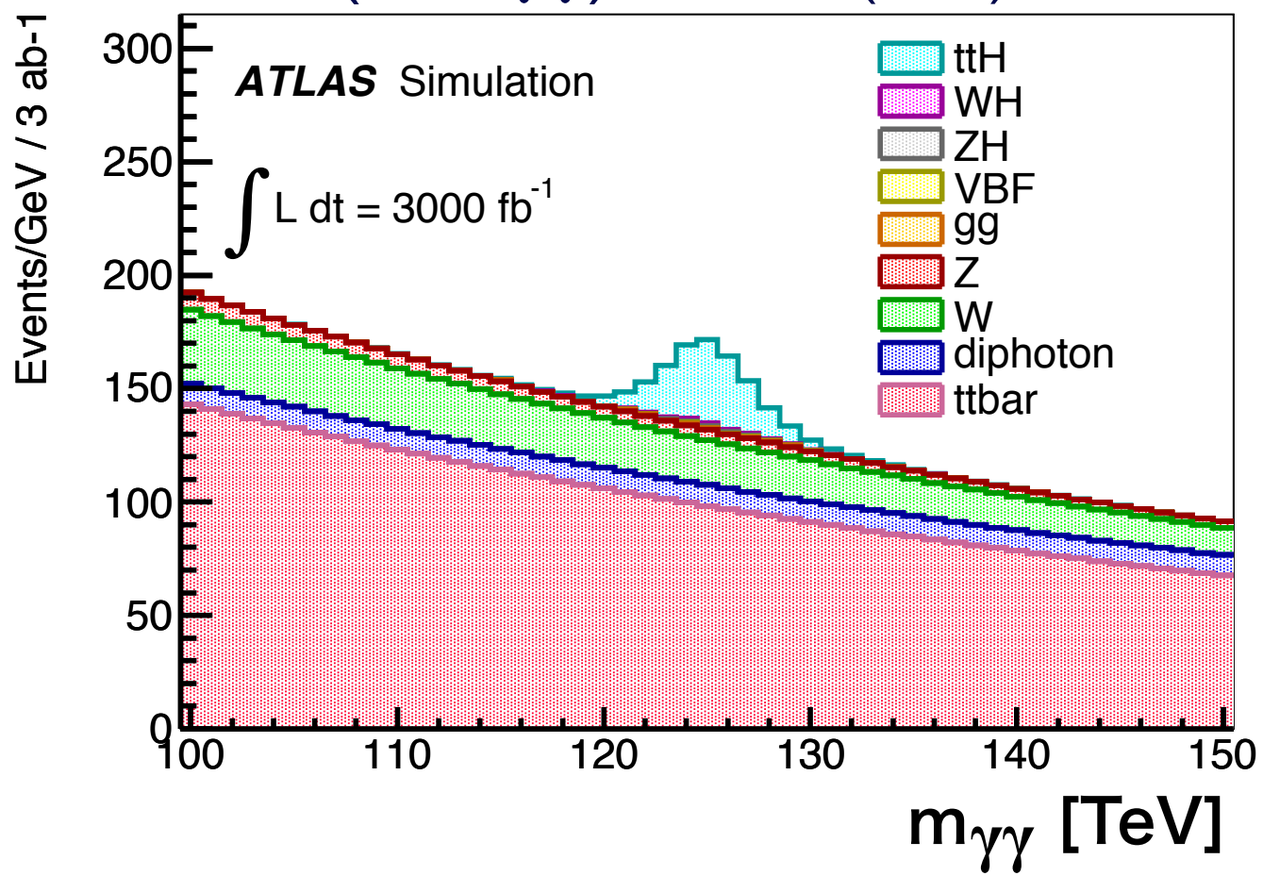


Rare Higgs Decay

ATLAS-PHYS-PUB-2013-014

Sensitivity significantly improved for rare processes

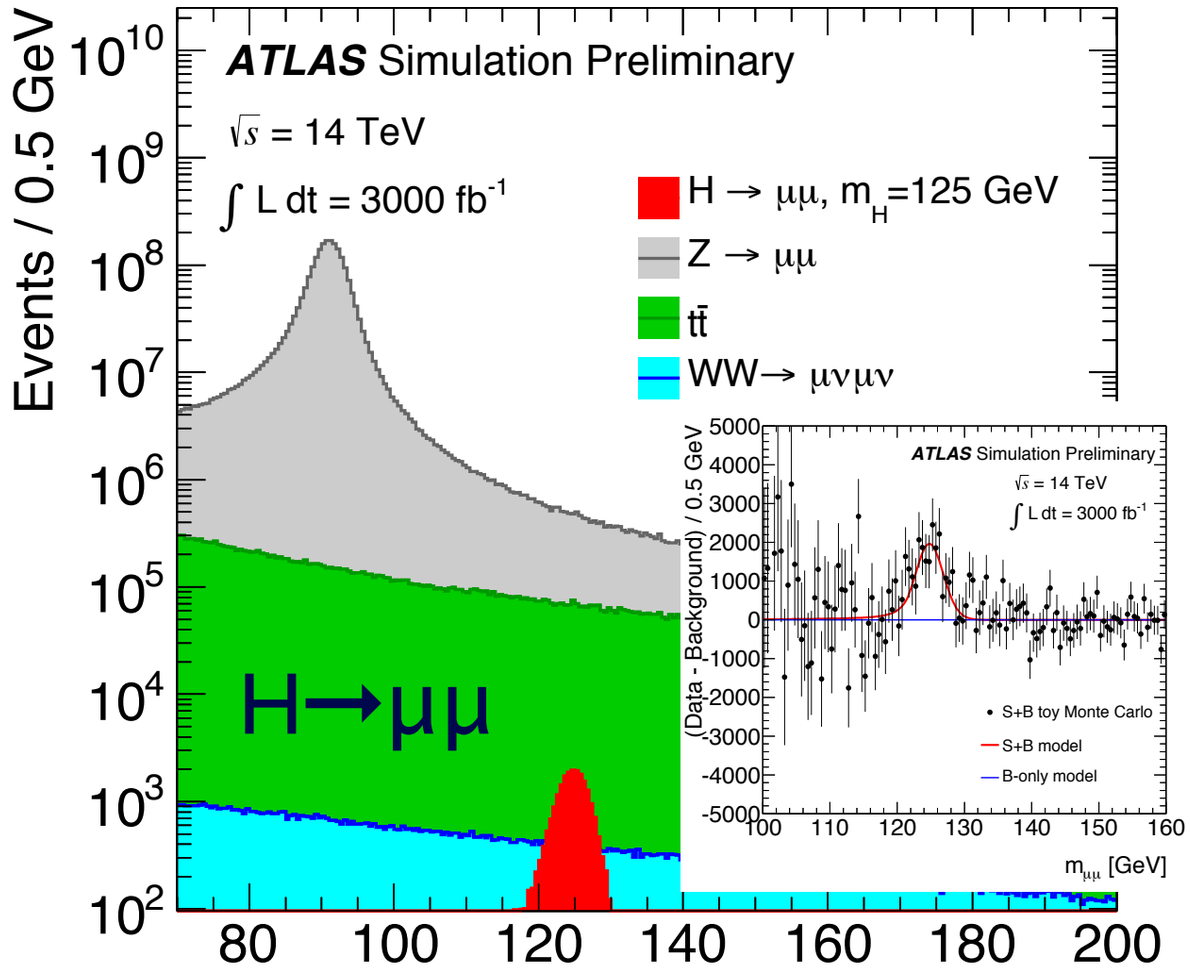
ttH (H→γγ) O(100) events



- 2-photon selection (same as inclusive H→γγ analysis)
- one or two leptons
- multiple jets

➡ S/√B ~ 6 at 3000 fb^{-1}

~17000 events



- Very small BR = 2.2×10^{-4}
- Good muon momentum resolution

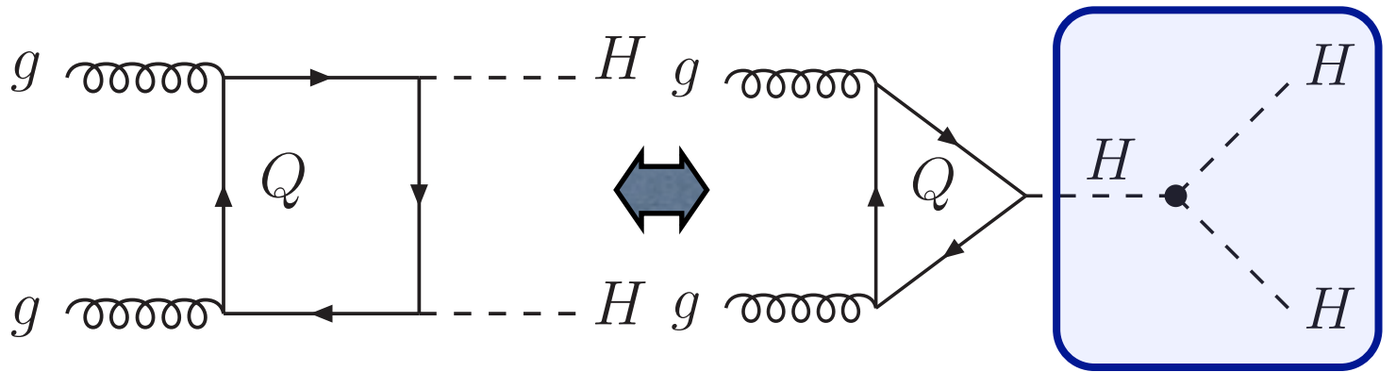
➡ S/√B ~ 7 at 3000fb^{-1}

ttH (H→μμ) : ~30 events at 3000 fb^{-1}

Higgs Self-Coupling

Measure Higgs self-coupling ➡ Determine the form of Higgs potential

Any deviation from SM prediction? $\lambda_{HHH} = \dfrac{3m_H^2}{v}$

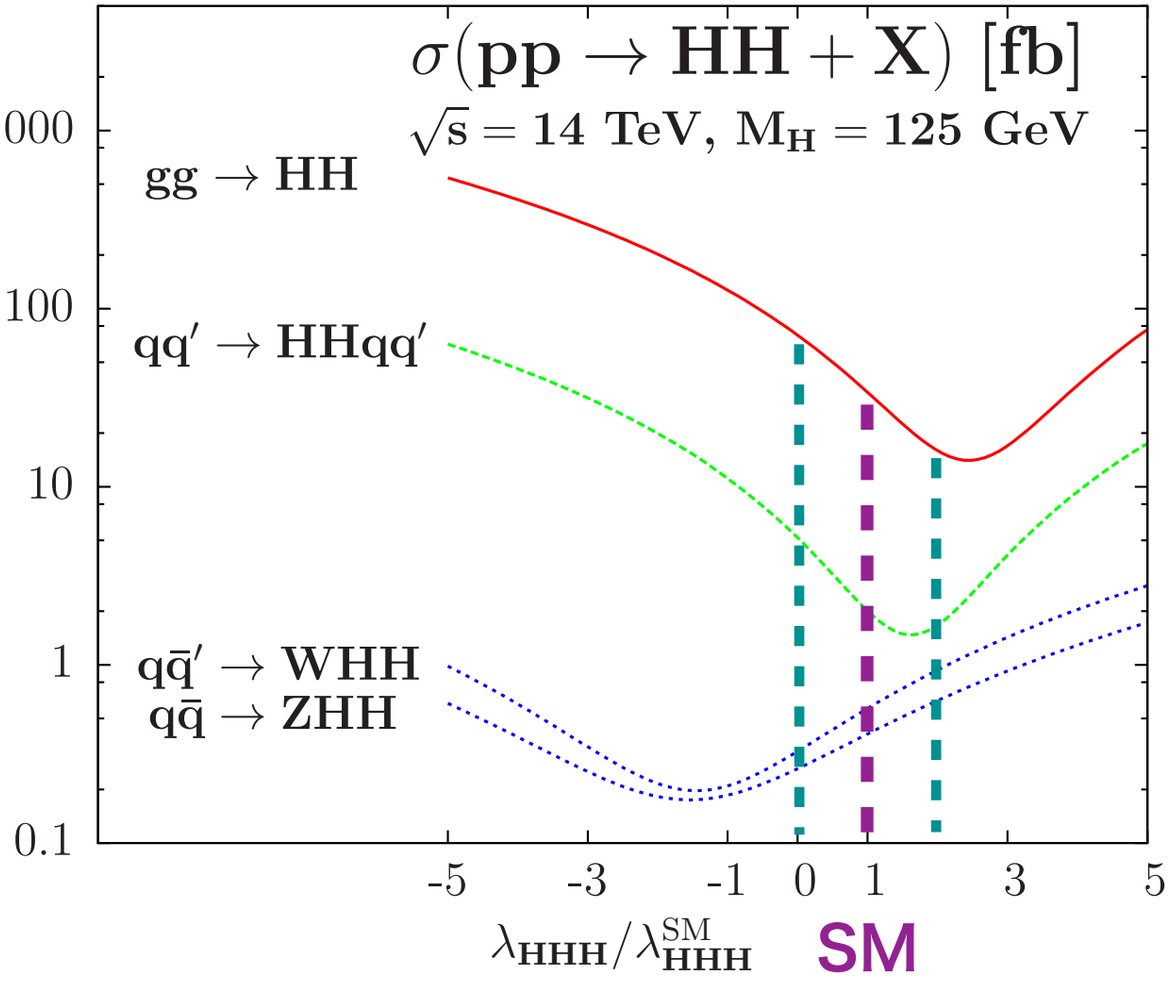


➡ Higgs pair production

gg→HH production cross section

$\lambda_{HHH}/\lambda_{HHH}^{SM}$	$\sigma_{gg\to HH}^{NLO}$ [fb]
0	71
1	34 ($^{+18\%}_{-15\%}$)
2	16

➡ Large interference effect



Higgs Self-Coupling

HH→bbγγ

- BR(HH→bbγγ) = 0.27%
- ~270 events at 3000 fb^{-1}
- Main backgrounds
  - γγbb
  - ttH(H→γγ)
  - Z(→bb)H(→γγ)

3000 fb^{-1} : #Events after cuts			
HH→bbγγ Signal			Background
$\lambda_{HHH}=0$	$\lambda_{HHH}=1$	$\lambda_{HHH}=2$	
~18	**~10**	**~5**	**~35**

HH→bbττ

- BR(HH→bbττ) = 7%
- ~7000 events at 3000 fb^{-1}
- Optimization study in progress
- Promising channel?
  - ➡ S/B ~ 0.5 (arXiv:1206.5001)

HH→bbWW

- Huge tt background
  - ➡ S/B ~ 10^{-5} (after lepton+jets cuts)

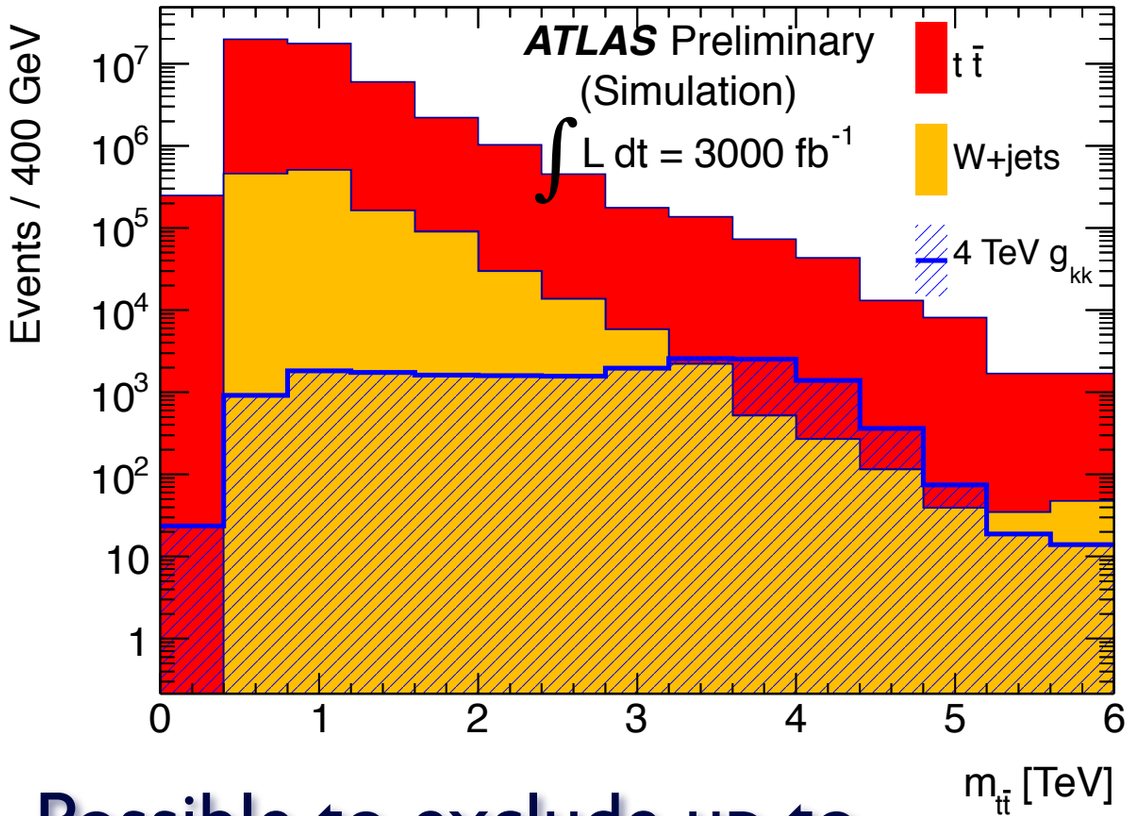
- **Combination could enable us to reach >3σ?**
- **Possible to measure λ_{HHH} with ~30% accuracy?**

$g^{KK}/Z' \rightarrow tt$

ATLAS-PHYS-PUB-2013-003

Lepton+jets channel

- 1 lepton p_T >25 GeV, E_T^{miss} >50 GeV
- ≥1 R=0.4 jet p_T >25 GeV
- ≥1 R=1.0 jet p_T >250 GeV, m_{jet} >120 GeV

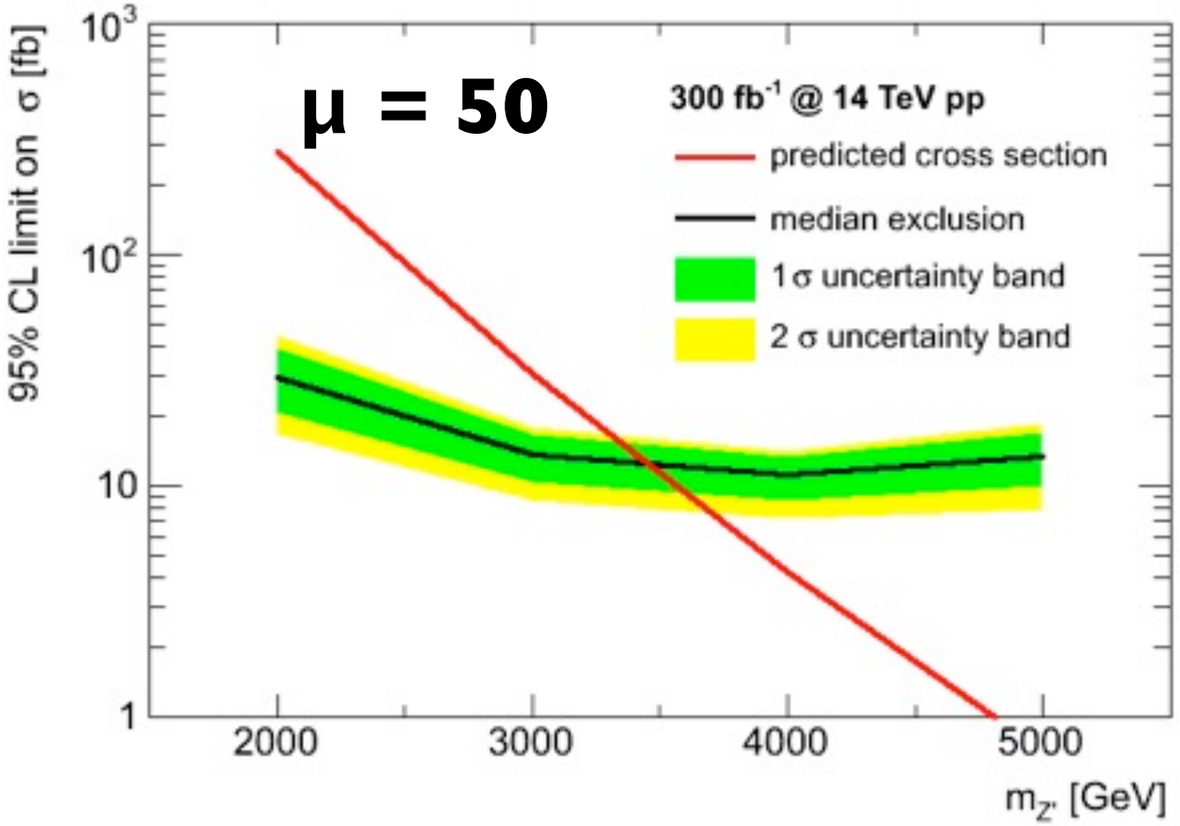


Possible to exclude up to

~4.3(6.7)TeV for $g^{KK} \rightarrow tt$

Full hadronic channel

- 2 C/A R=0.8 jets p_T >750 GeV
- Top-tag : Q_W>70 GeV, $m_{jet}^{Trimmed}$>70 GeV
- b-tag : ε = 50(30)% at 0.75(1.5) TeV
  f_{mistag} = 2.5(5)% at 0.75(1.5) TeV
  f_{mistag} raised by 30(70)% for μ=50(140)



~3.7(4.1)TeV for Z' → tt

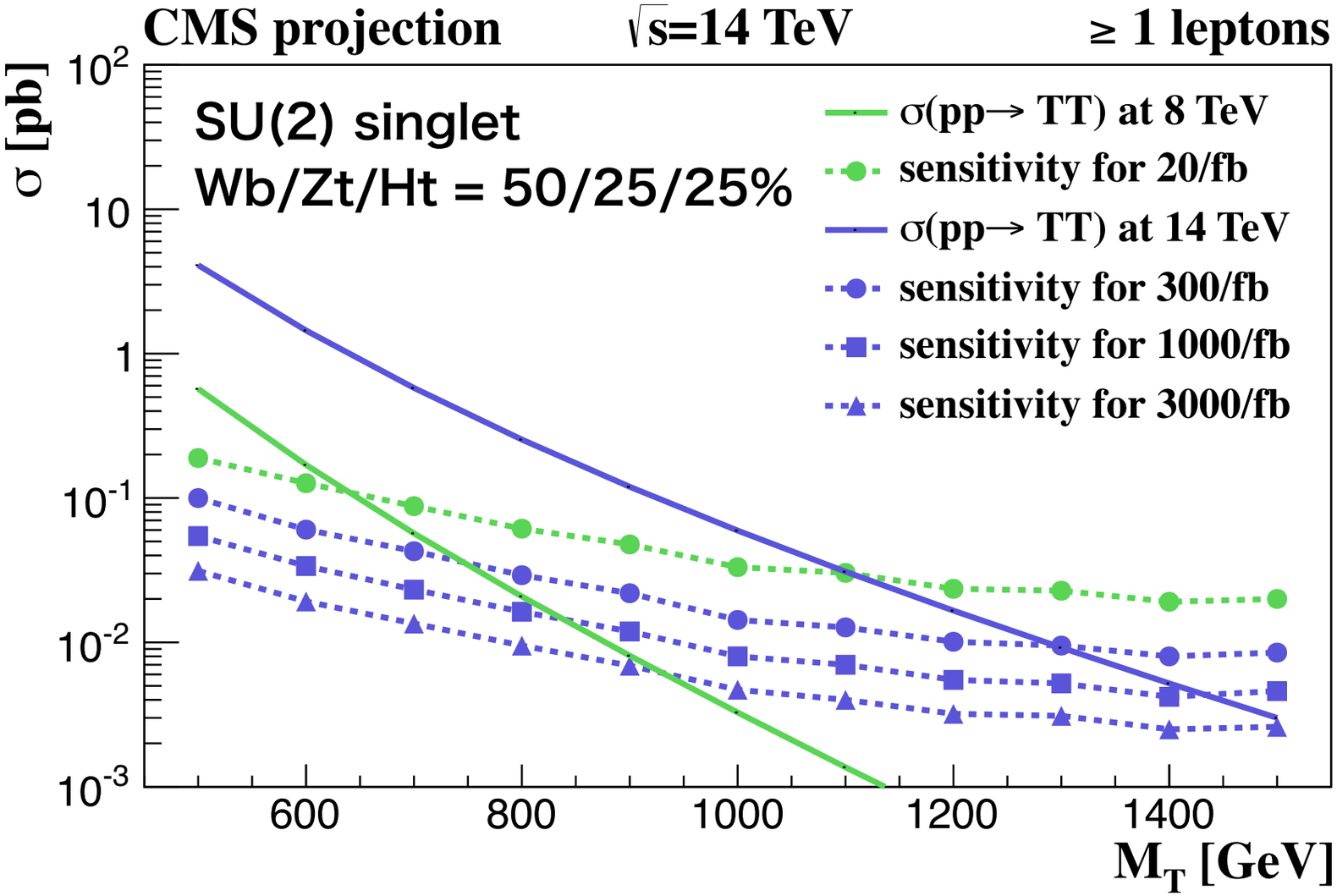
at 14TeV with 300(3000) fb^{-1}

Top-Partners

arXiv:1307.7135

Top-quark partner with vector-like coupling

- Commonly appear in strongly-coupled EWSB scenarios (e.g, composite Higgs)
- Canceling radiative correction to Higgs mass by SM top quarks



Indirect constraints from Higgs coupling measurement

Composite Higgs		
$\Delta\kappa_V$	$\Delta\kappa_\gamma$	$\Delta\kappa_b$
~ –3%	~ –9%	~ –(3-9)%

Discovery reach of vector-like top-partner

➡ ~1.3(1.5) TeV at 300(3000) fb^{-1}