Higgs and Flavour: Experimental Status

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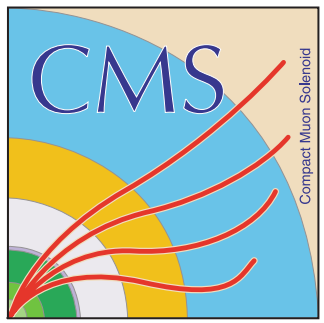
on behalf of the ATLAS, CMS, and LHCb collaborations

UNIVERSITY OF BIRMINGHAM

June 19, 2018



HL-LHC June Workshop

Some Useful Links

- HL-LHC Workshop TWiki page
- WG2 (Higgs) TWiki page
- WG2 conveners: Maria Cepeda, Stefania Gori, Philip Ilten, Marumi Kado, Francesco Riva
- WG4 (Flavour) TWiki page
- WG4 conveners: Jorge Martin Camalich, Alex Cerri, Vladimir Gligorov, Sanda Malvezzi, Jure Zupan

- October 2017 CERN workshop
- April 2018 FNAL workshop
- this June 2018 CERN workshop

- list of WG2 (Higgs) meetings
- list of WG4 (Flavour) meetings

Wishlist Summary

- nice summary by Marianna, *et. al.* from May meeting
- legend: previous study, 2017 TDR study, to be done/expanded

	ATLAS	CMS	LHCb
couplings	✓ ✓ ✓	✓ ✓ ✓	
$\mathrm{d}\sigma/\mathrm{d}X$	✓ ✓	✓ ✓	
width	✓		
CPV	✓	✓ ✓	
rare decays	✓ ✓ ✓	✓ ✓	✓
exotic decays		✓	✓
di-Higgs	✓ ✓ ✓	✓ ✓ ✓	
additional scalars	✓ ✓	✓ ✓	(✓)

(✓) what about $B^+ \to K^+ \chi(\mu\mu)$ from LHCb?

- **not much new today but things are underway**

Yellow Report (YR) Outline

- editors: **Kostas Nikopoulos** (ATLAS), **Alexander Schmidt** (CMS), **Lorenzo Sestini** (LHCb), **Yotam Soreq** (theory)

7. Higgs flavor and rare decays (**WG2**)
   a. Flavor aspects Yukawa modifications in flavor models (**Bishara**)
   b. Exclusive Higgs decays (**Soreq**)
   c. Flavor tagging (charm and strange) (**Schlaffer**)
   d. LFV decays of the Higgs
   e. Yukawa constraints from Higgs distributions (**Soreq**)
   f. CP violation in Higgs couplings (τ, ttH) (**Harnik**)

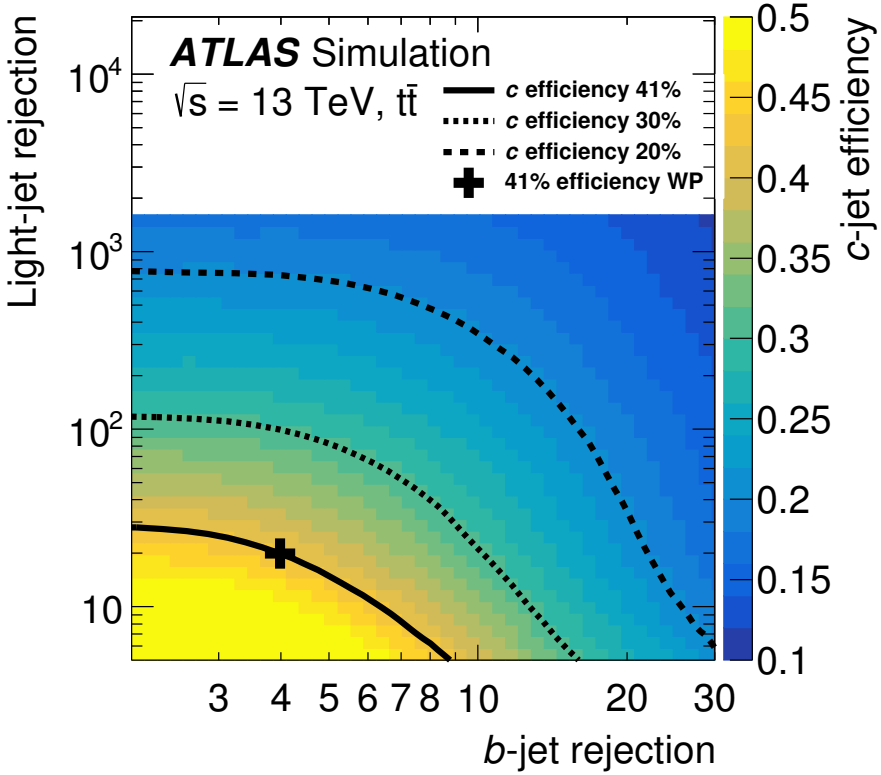
9. Flavor aspects of Higgs (**WG4**)
   a. Yukawa modifications in flavor models
   b. Exclusive Higgs decays
   c. Flavor tagging (charm and strange)
   d. LFV decays of the Higgs
   e. Yukawa constraints from Higgs distributions
   f. CP violation in Higgs couplings (τ, ttH)
   g. Experimental perspective

Higgs to Inclusive Charm

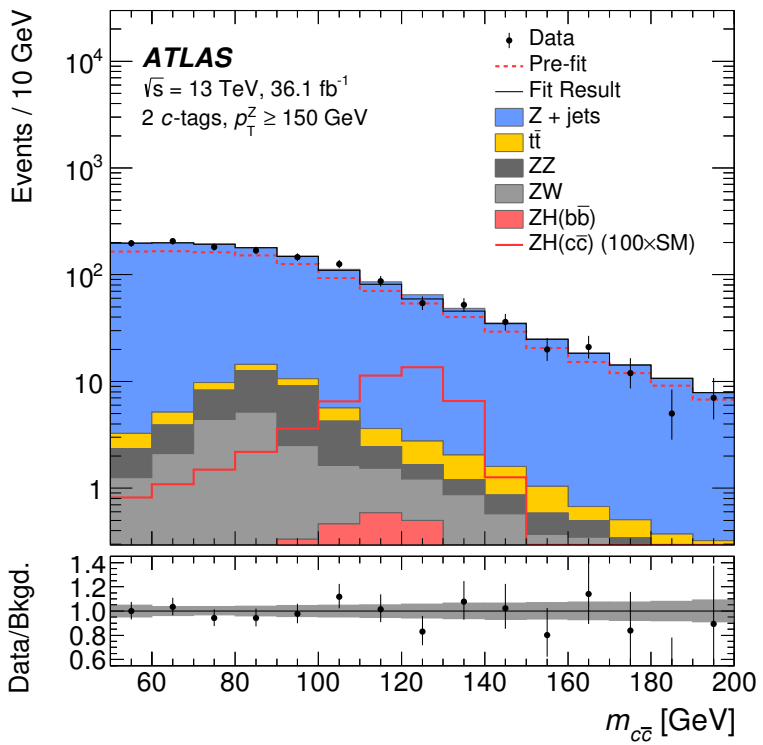
ATLAS

- see talk by Elliot Reynolds for more details
- ATLAS measurement of $ZH \to \ell\ell cc$: arXiv:1802.04329
- current limit is roughly 100× SM
- projection now available!

arXiv:1802.04329



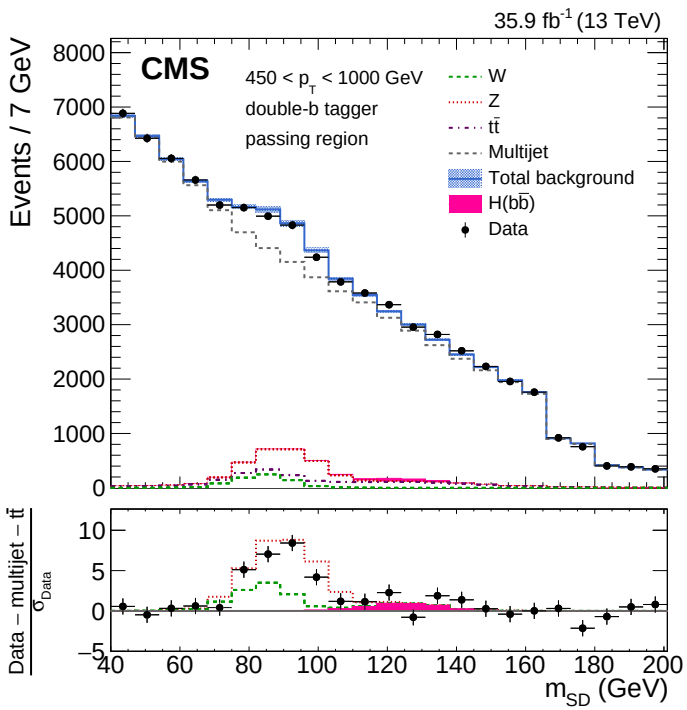
arXiv:1802.04329



CMS

- no dedicated analysis from CMS
- plan to recast and extrapolate $H \to bb$ results to $H \to cc$
- CMS measurement of boosted $H \to bb$: arXiv:1709.05543
- CMS evidence for $H \to bb$: arXiv:1709.07497

arXiv:1709.05543



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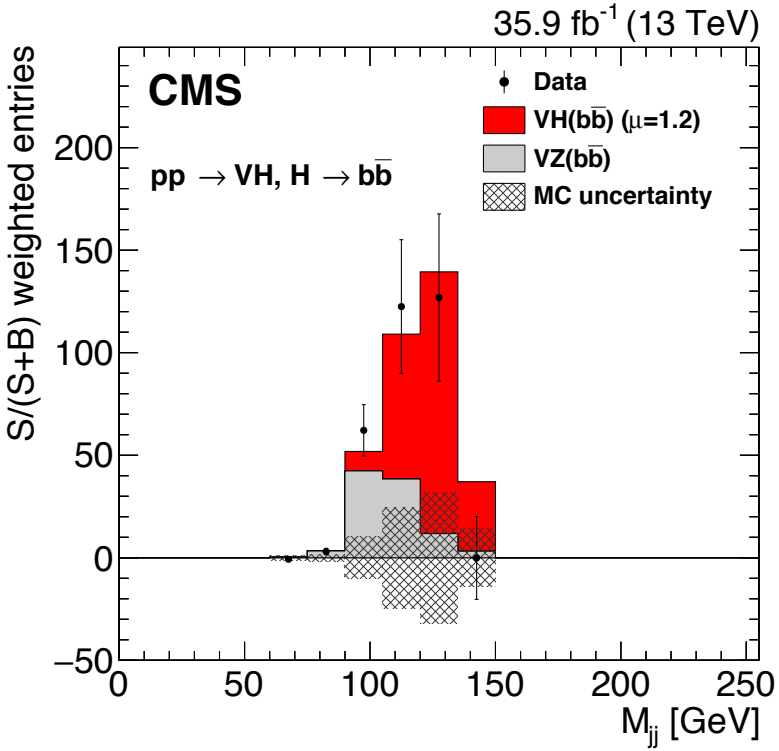
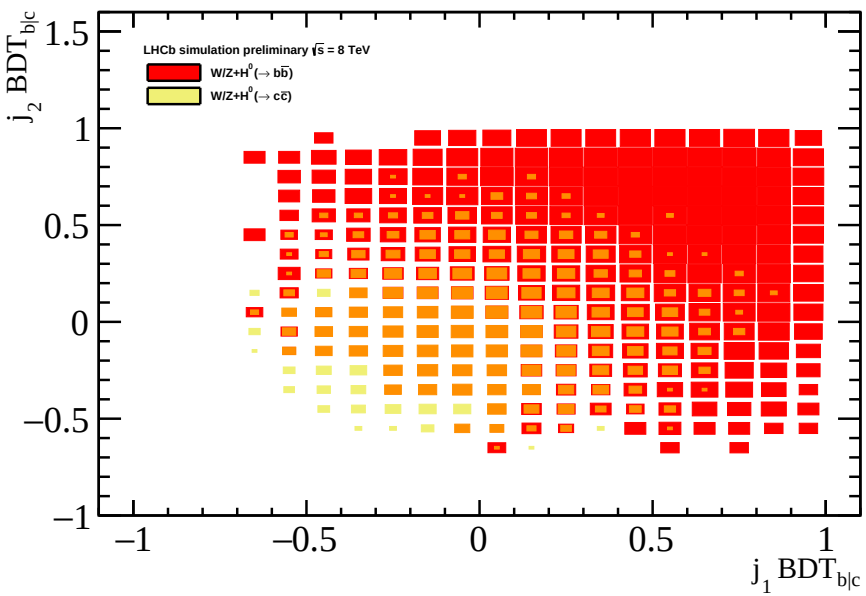


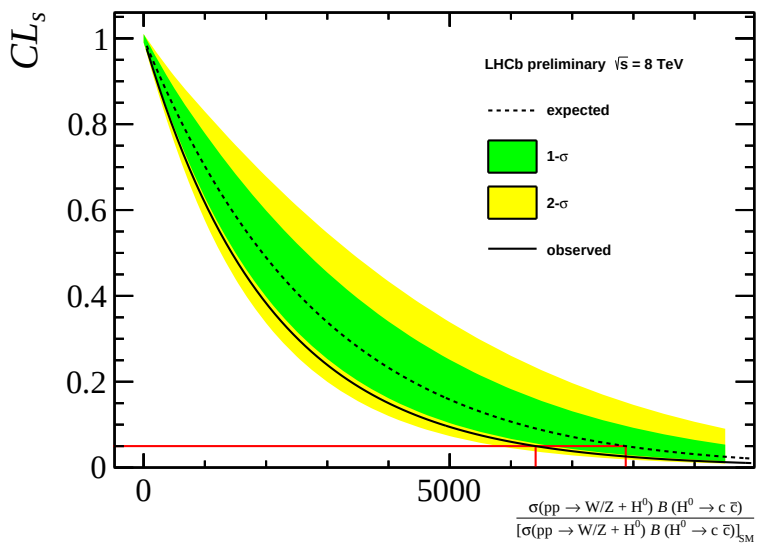
LHCb

- LHCb measurement of $VH \to cc\ell$: LHCb-CONF-2016-006
- current limit is roughly 6400× SM
- rough projection of 4× SM
- detailed study underway including $H \to bb$

LHCb-CONF-2016-006

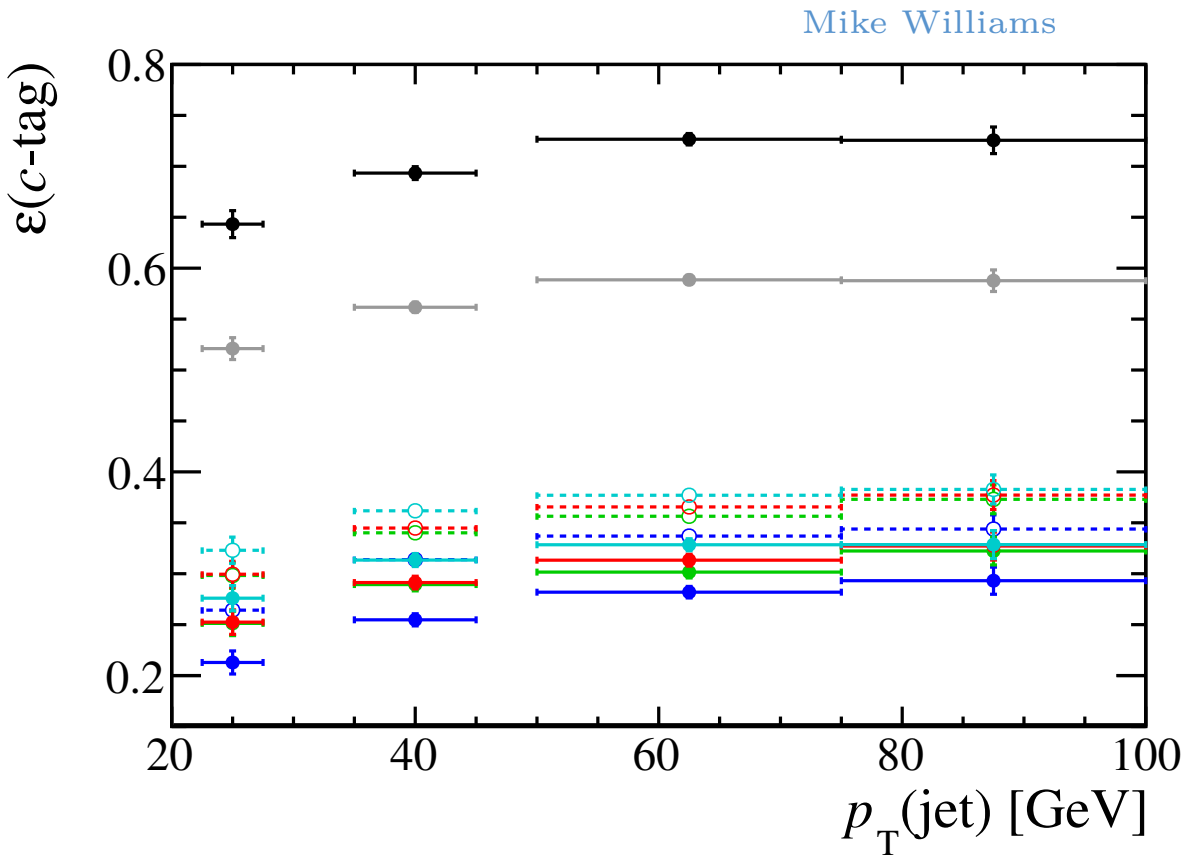


LHCb-CONF-2016-006



Jet Tagging

- jet tagging performance is critical for these measurements



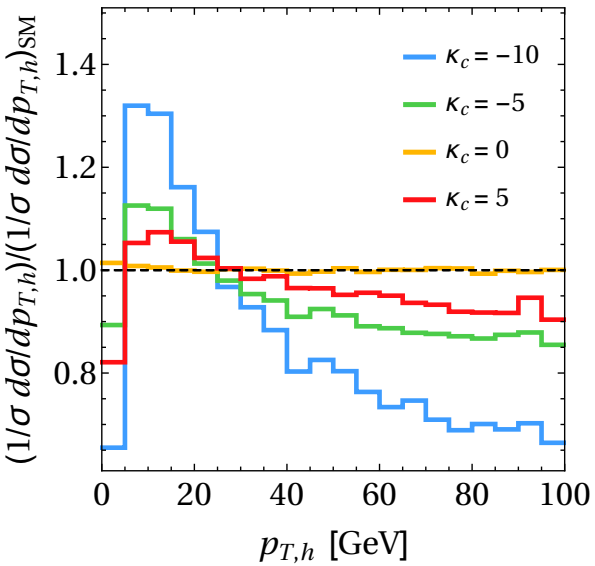
Phase-II Scenario 2
Phase-II Scenario 1
Run 3
Run1
Solid: IP $X^2 > 16$ (as in Run 1)
Dashed: IP $X^2 > 9$

Differential Cross-sections

Distributions

- see talk by Thomas Klijnsma
- p_T spectrum sensitive to couplings (low) and top mass (high)
- rapidity spectrum depends on gluon PDF

arXiv:1606.09253



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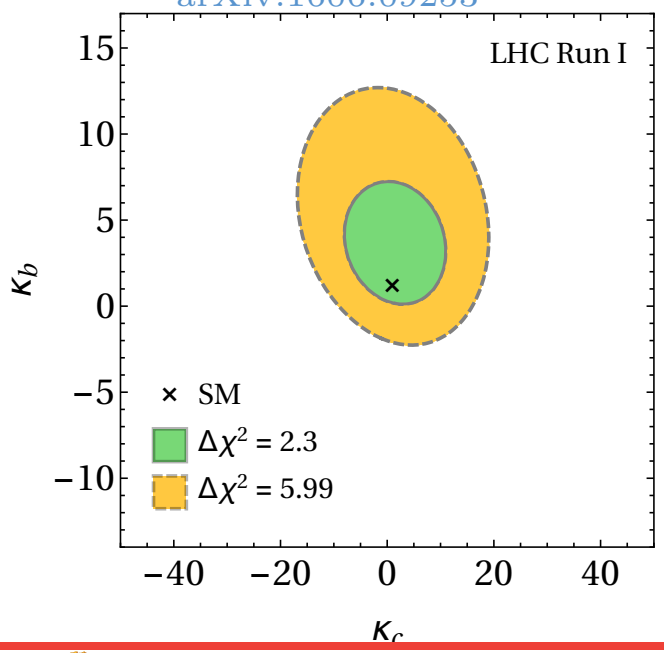
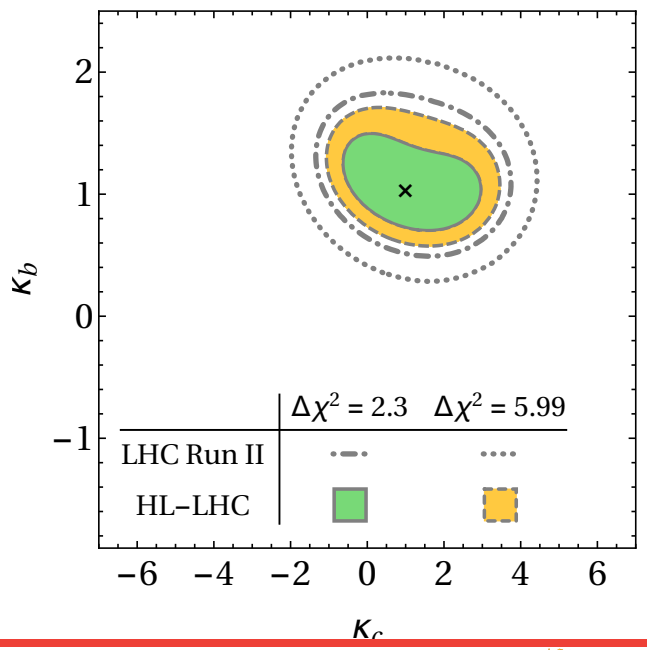
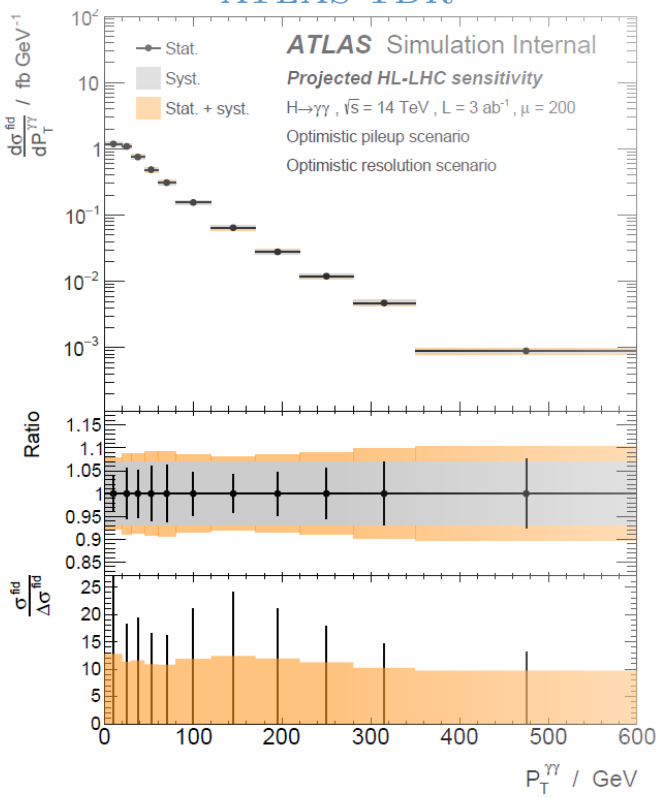




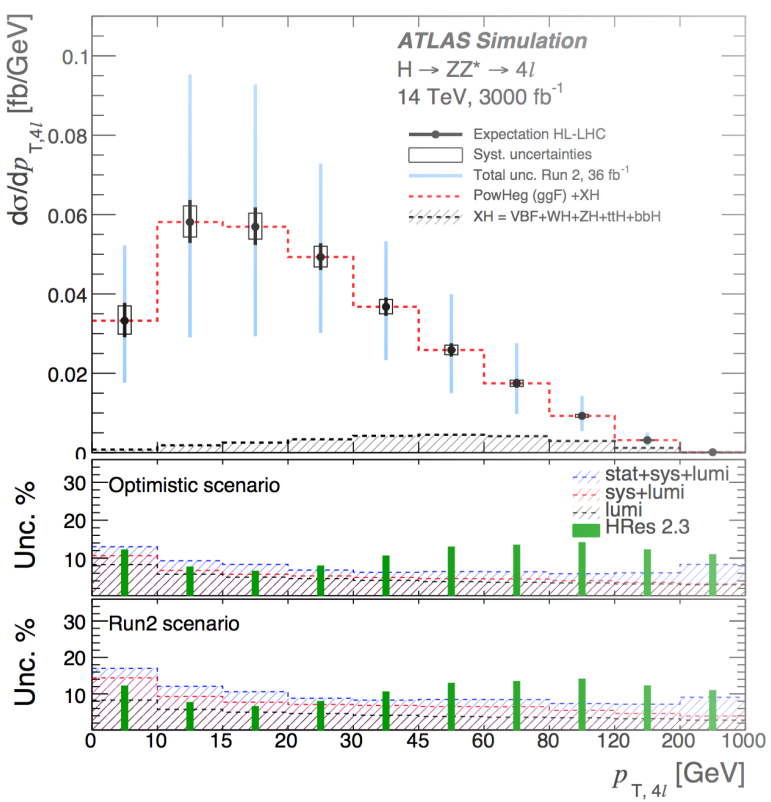
ATLAS

- $H \to \gamma\gamma$: arXiv:1802.04146
- $H \to ZZ$: arXiv:1712.02304
- combined: ATLAS-CONF-2018-002
- projected 5% uncertainty for $\gamma\gamma$, $5-10\%$ for ZZ, $< 5\%$ combined

ATLAS-TDR



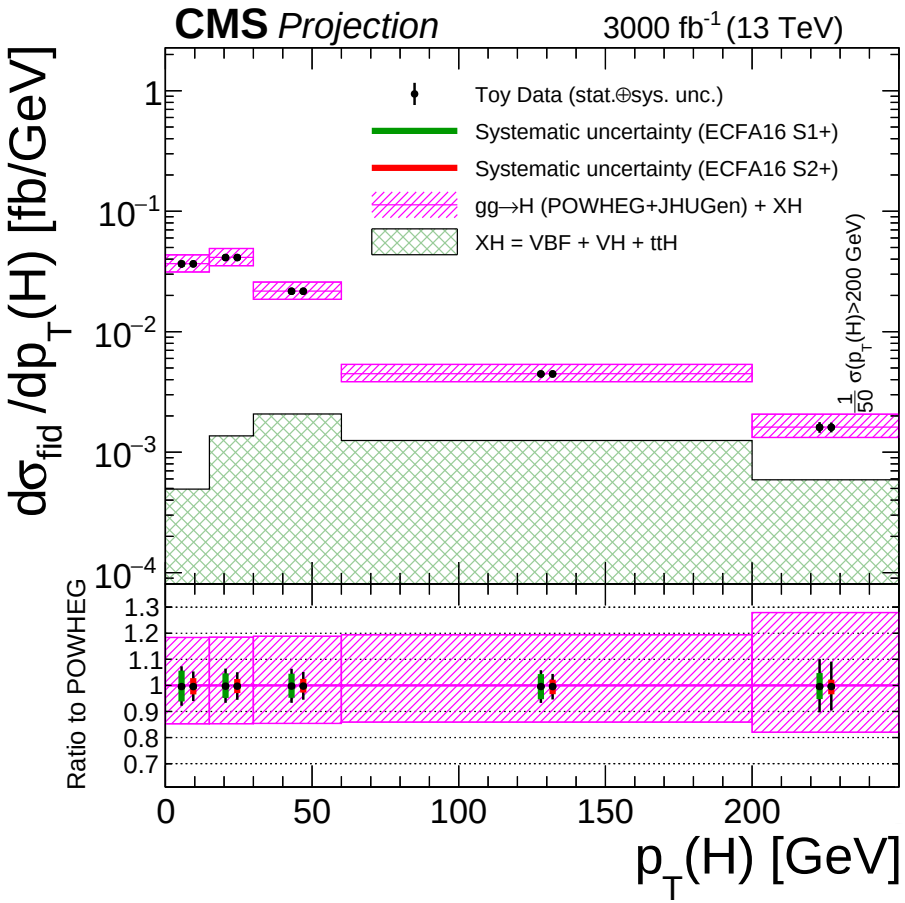
ATLAS-TDR



CMS

- $H \to \gamma\gamma$: CMS-PAS-HIG-17-029
- $H \to ZZ$: arXiv:1706.09936
- projected $5 - 10\%$ for ZZ, no combined but expected $\approx 5\%$
- work on official combined projection underway
- plan to extract κ_b and κ_c in projection

CMS-PAS-FTR-16-002

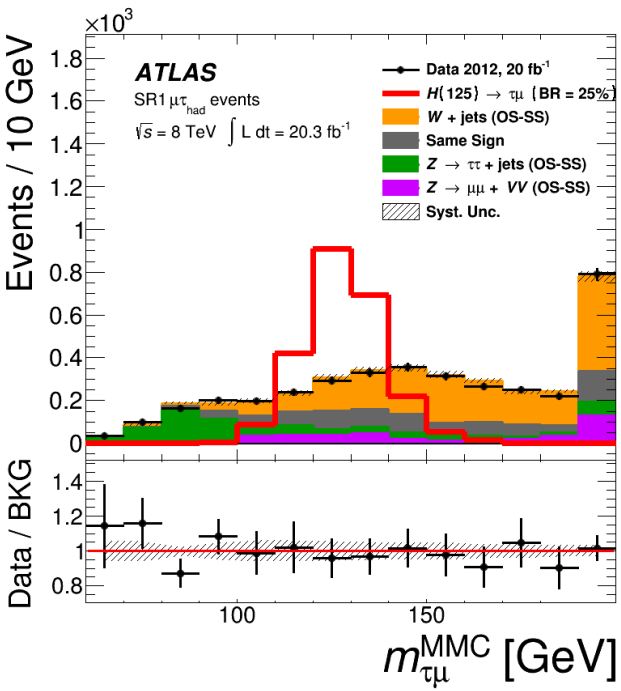


Lepton Flavour Violation

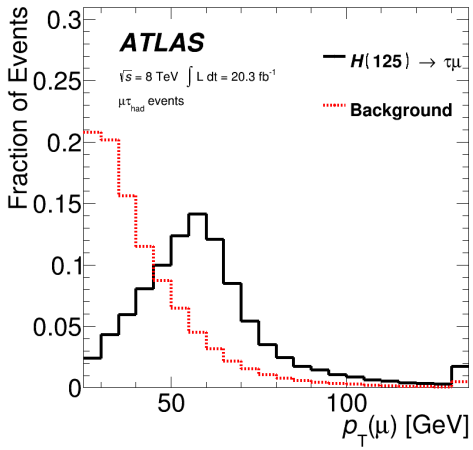
ATLAS

- search by ATLAS for $H \to \tau\mu$: arXiv:1508.03372
- with 20 fb^{-1} of data
  $\mathcal{B}(H \to \tau\mu) < 1.85\%$
- no current plans for projections

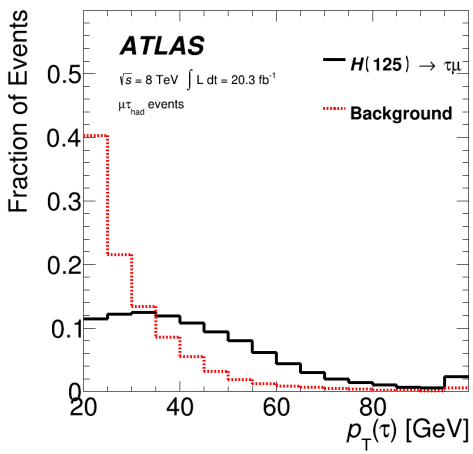
arXiv:1508.03372



arXiv:1508.03372



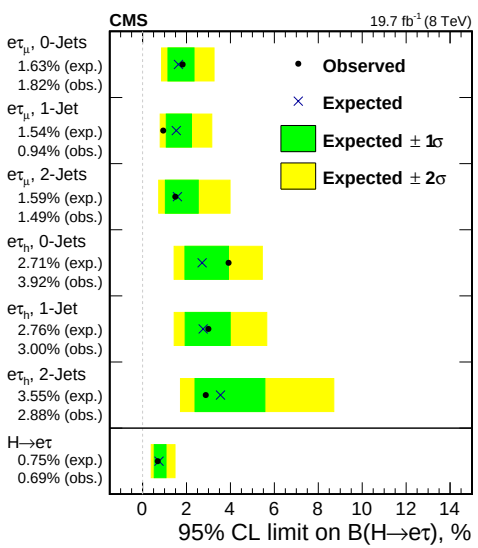
arXiv:1508.03372

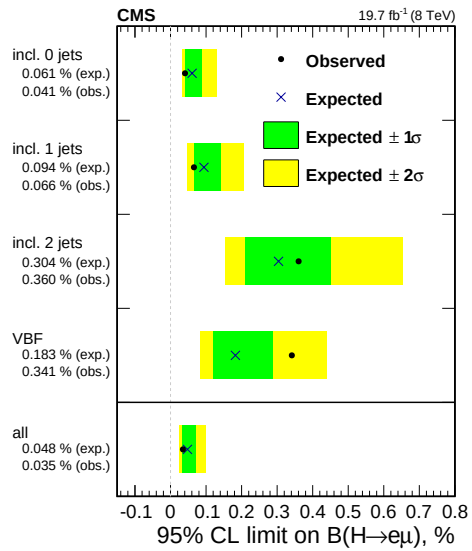


CMS

- search by CMS for $H \to \tau\mu$ and $H \to \tau e$ arXiv:1712.07173
- search by CMS for $H \to e\mu$ and $H \to e\tau$: arXiv:1607.03561
- projections of results underway

arXiv:1607.03561





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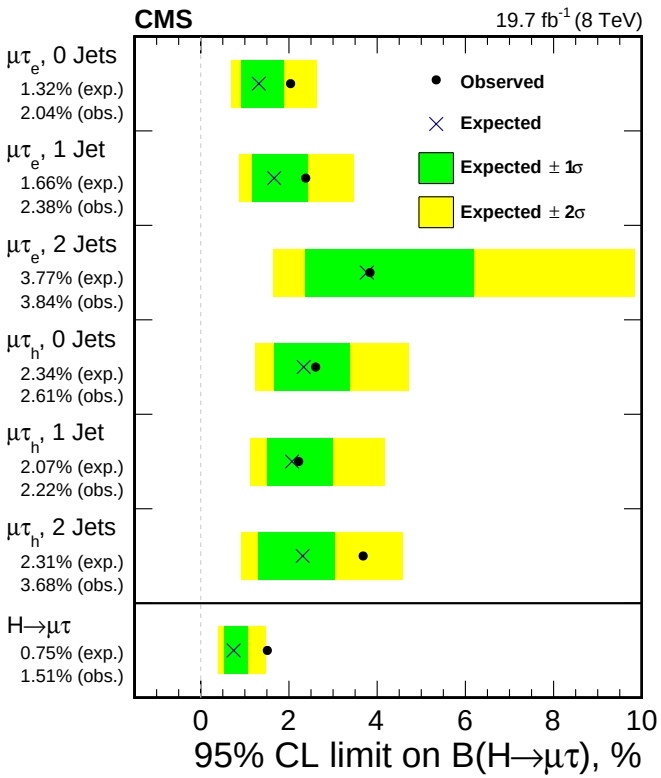


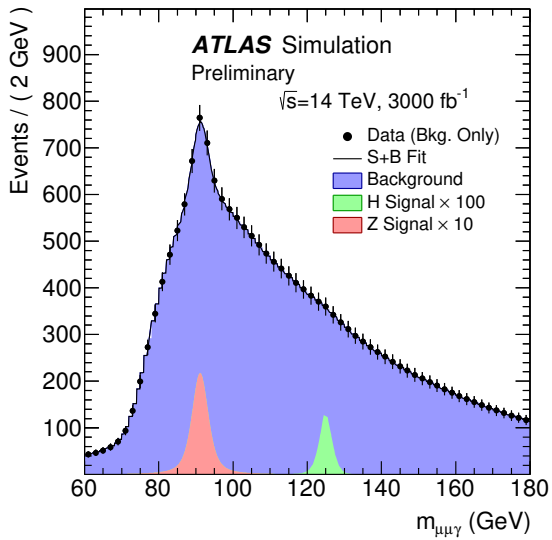
Rare Decays

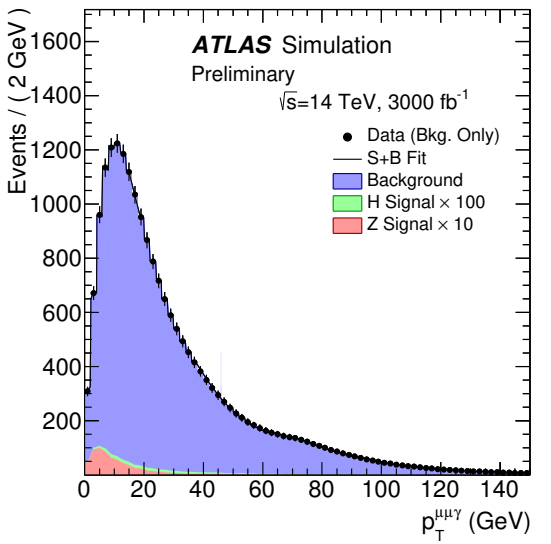
$H \to J/\psi\gamma$

- search by ATLAS for $H/Z \to Q\bar{Q}\gamma$: arXiv:1501.03276
- projections by ATLAS for HL-LHC: ATL-PHYS-PUB-2015-043
- no plans for CMS or LHCb projections

	$\mathcal{B}(H \to J\psi\gamma)$	$\mathcal{B}(Z \to J/\psi\gamma$
SM	2.9×10^{-6}	8.0×10^{-8}
Run 1	1.5×10^{-3}	2.6×10^{-6}
HL-LHC	4.4×10^{-5}	4.4×10^{-7}

ATL-PHYS-PUB-2015-043





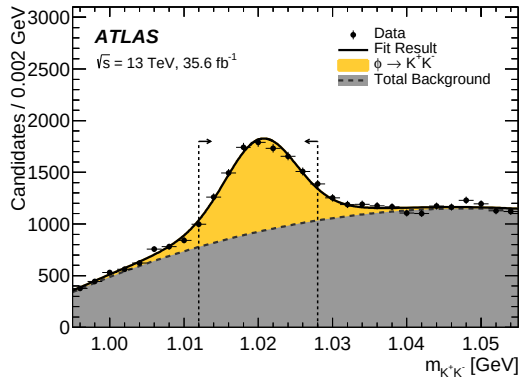
$H \to \phi\gamma$ and $H \to \rho\gamma$

- search by ATLAS for $H/Z \to \rho/\phi\gamma$: arXiv:1712.02758
- ATLAS projections are underway
- no plans for CMS or LHCb projections

	$\mathcal{B}(H \to \phi\gamma)$	$\mathcal{B}(Z \to \phi\gamma$
SM	2.3×10^{-6}	1.0×10^{-8}
Run 2	4.8×10^{-4}	9.0×10^{-7}

	$\mathcal{B}(H \to \rho\gamma)$	$\mathcal{B}(Z \to \rho\gamma$
SM	1.7×10^{-5}	4.2×10^{-8}
Run 2	8.8×10^{-4}	2.5×10^{-5}

arXiv:1712.02758



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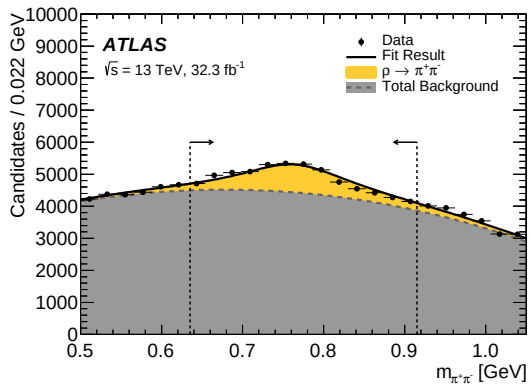

Conclusions

Outlook and Plans

- Higgs to inclusive charm projections planned by ATLAS, CMS, and LHCb
  - ATLAS projections already available!
  - what about c-tagging performance benchmarks?
- Yukawa constraints from differential distributions planned by CMS
- lepton flavour violation projection from CMS underway
- exclusive $H \to J/\psi\gamma$ projection available from ATLAS
- $H \to \rho\gamma$ and $H \to \phi\gamma$ projections underway by ATLAS
- $H \to \mu\mu$ studies already available from ATLAS and CMS TDRs
- CP violation from $H \to \tau\tau$ planned by CMS using simulation