Higgs and Flavour

Chapter 2, Section 7

Philip Ilten
on behalf of Working Group 2

UNIVERSITY OF BIRMINGHAM

March 1, 2019

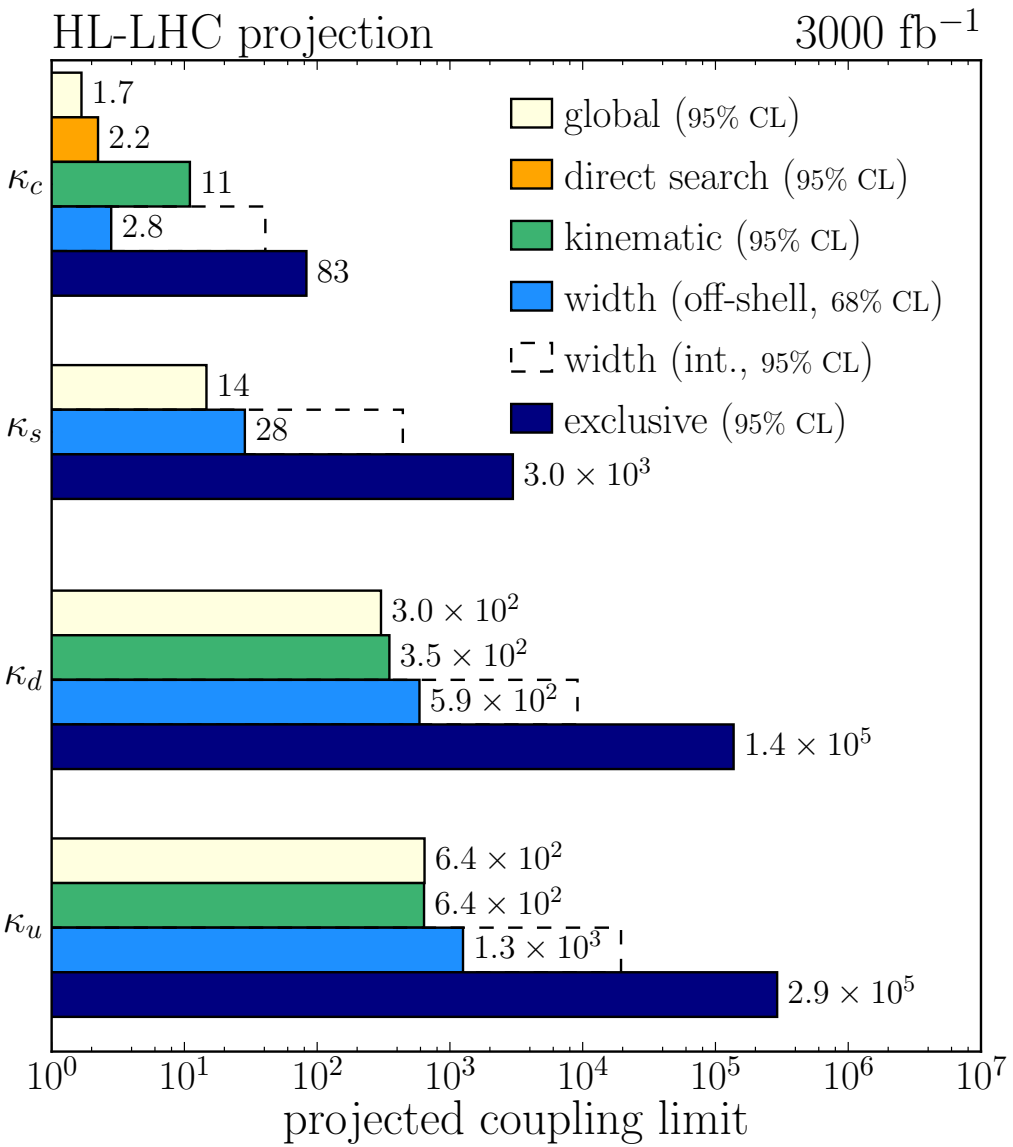
HL-LHC Jamboree

Outline

- light quark couplings (not b or t)
  - exclusive Higgs decays
  - inclusive light quark searches
  - global and kinematic fits
- lepton flavour violating decays
- CP violation

There is a lot of material in this chapter, so I apologise in advance if I missed your favourite bit.

Light Quark Summary



1. global fits
2. inclusive decays
3. kinematic fits
4. Higgs widths
5. exclusive decays

Exclusive Higgs Decays

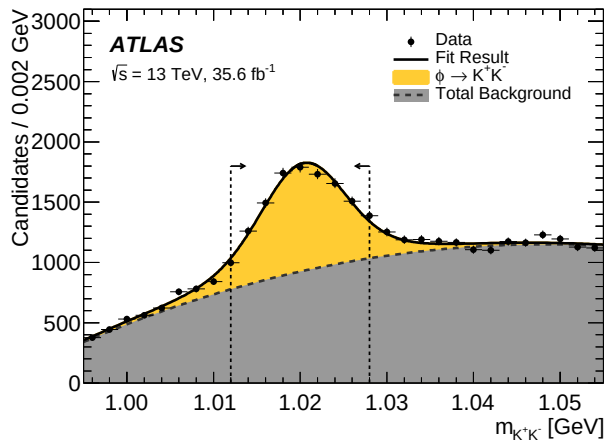
$H \to \phi\gamma$ and $H \to \rho\gamma$

- search by ATLAS for $H/Z \to \rho/\phi\gamma$: arXiv:1712.02758

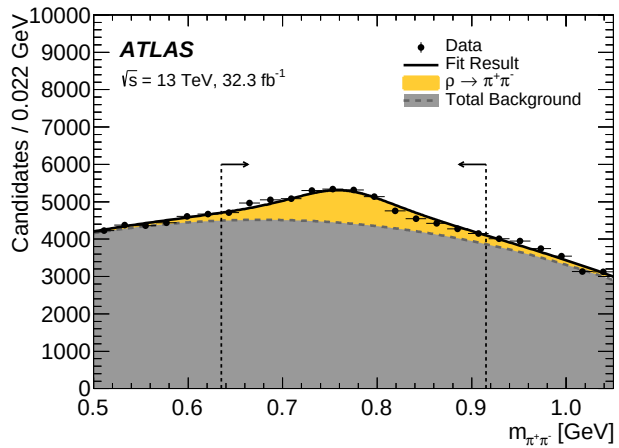
	$\mathcal{B}(H \to \phi\gamma)$	$\mathcal{B}(Z \to \phi\gamma)$
SM	2.3×10^{-6}	1.0×10^{-8}
Run 2	4.8×10^{-4}	9.0×10^{-7}

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

arXiv:1712.02758



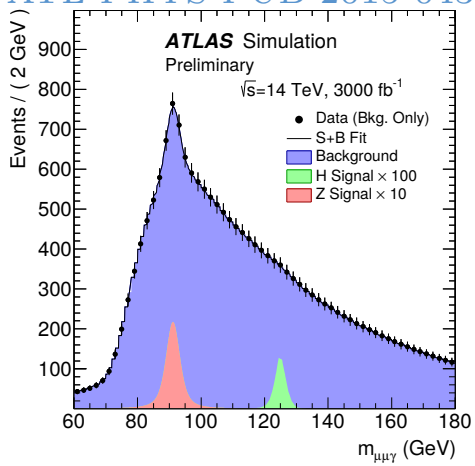
arXiv:1712.02758



$H \to J/\psi\gamma$

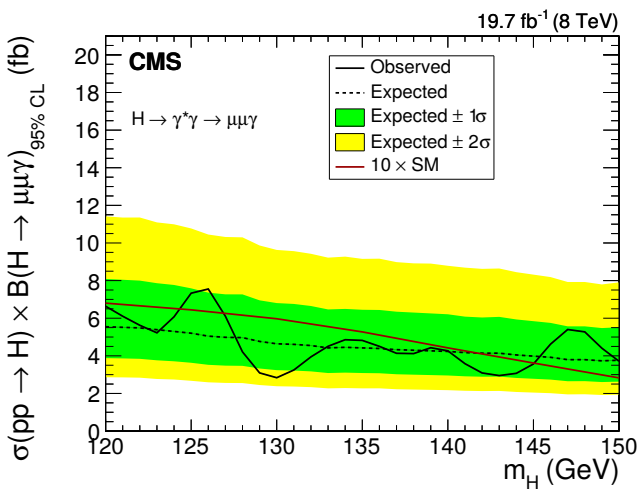
- search by ATLAS for $H/Z \to Q\bar{Q}\gamma$: arXiv:1501.03276
- search by CMS for $H \to \gamma^*\gamma$ arXiv:1507.03031
- projections by ATLAS for HL-LHC: ATL-PHYS-PUB-2015-043

ATL-PHYS-PUB-2015-043

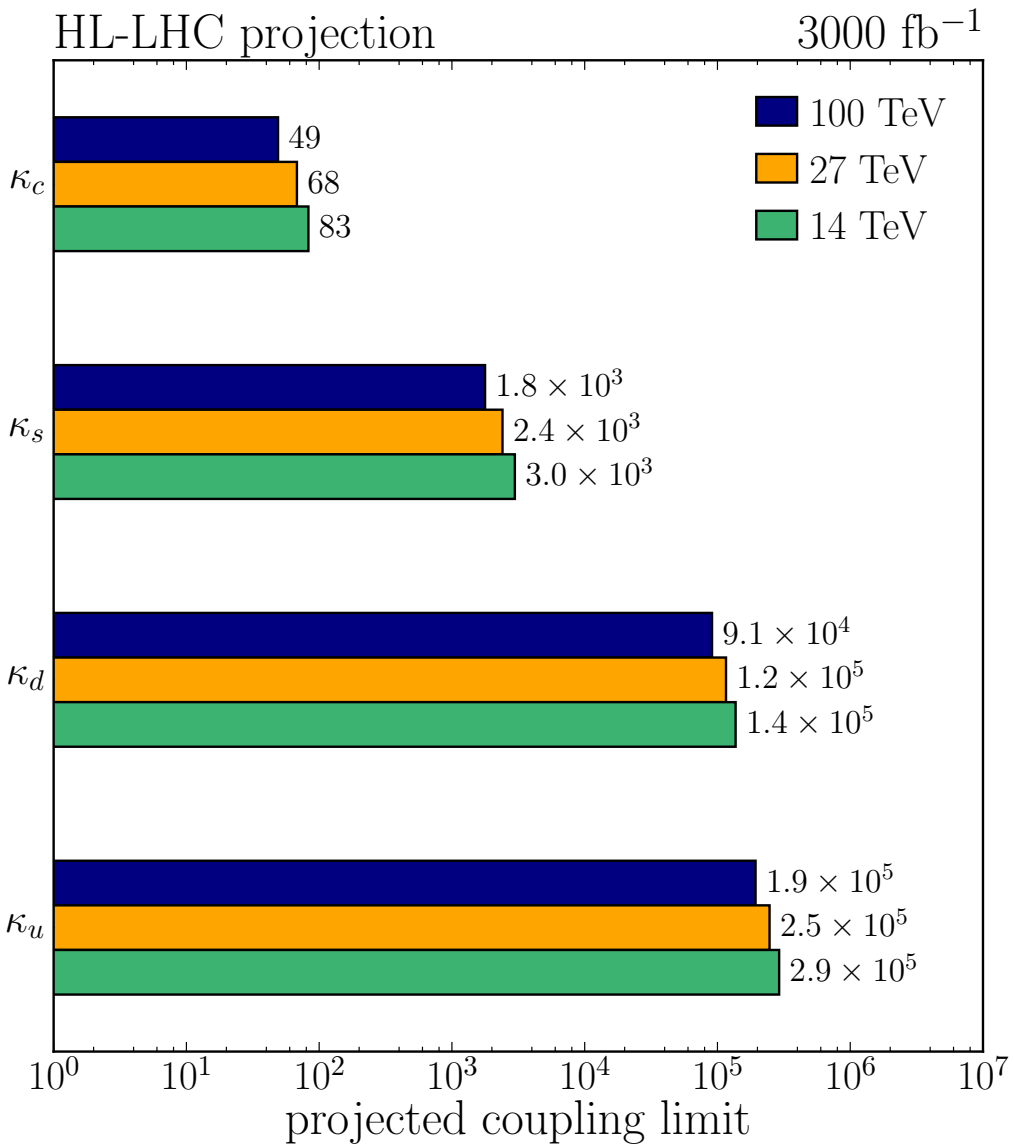


	$\mathcal{B}(H \to J\psi\gamma)$	$\mathcal{B}(Z \to J/\psi\gamma)$
SM	2.9×10^{-6}	8.0×10^{-8}
Run 1	1.5×10^{-3}	2.6×10^{-6}
HL-LHC	4.4×10^{-5}	4.4×10^{-7}

arXiv:1507.03031



$H \to V\gamma$ Projections



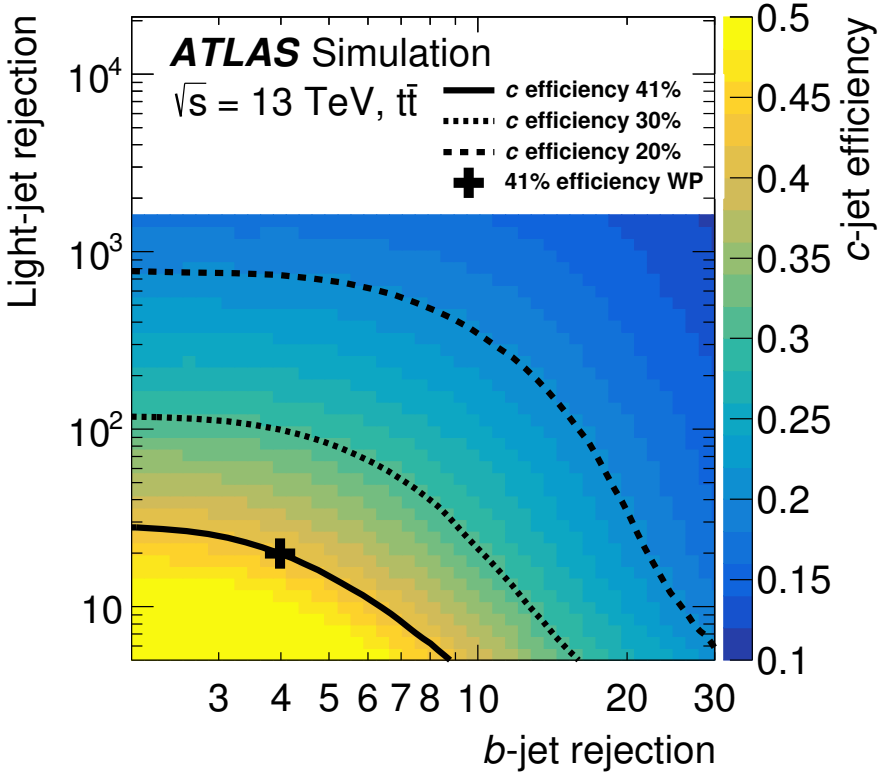
- pheno projections for different future scenarios: arXiv:1505.06689
- match ATLAS projections for $H \to J/\psi\gamma$

Inclusive Light Quark Searches

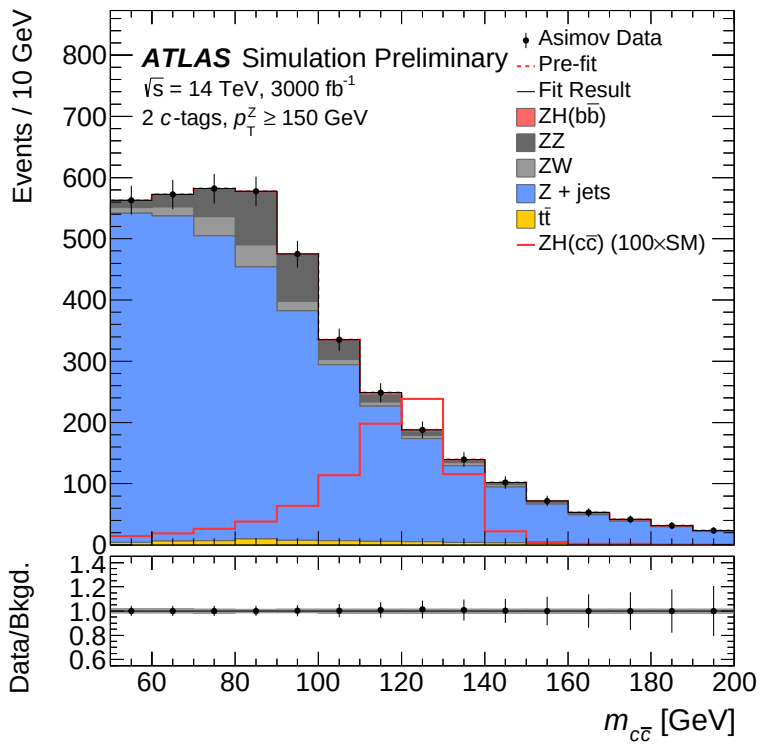
ATLAS

- ATLAS measurement of $ZH \to \ell\ell cc$: arXiv:1802.04329
- current limit is roughly $100 \times$ SM
- ATLAS projection of $ZH \to \ell\ell cc$: ATL-PHYS-PUB-2018-016
- rough projection of $6 \times$ SM

arXiv:1802.04329



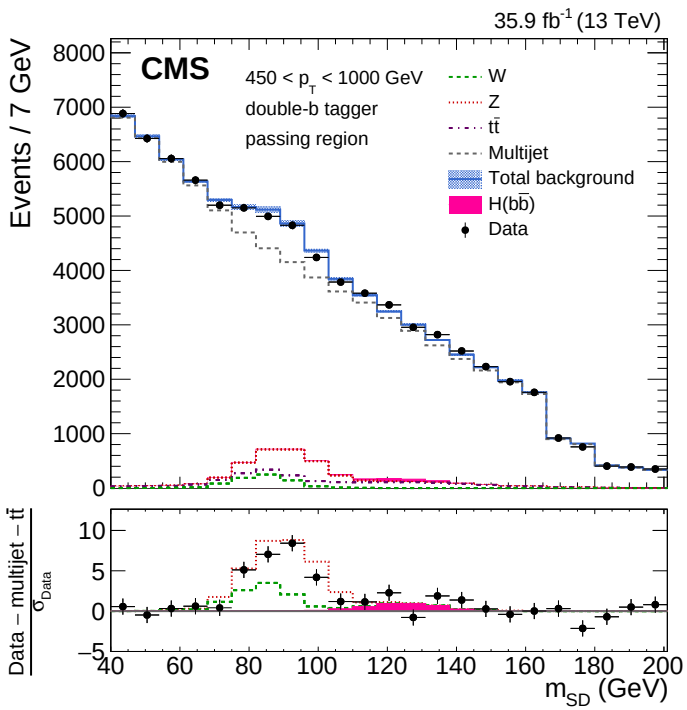
ATL-PHYS-PUB-2018-016



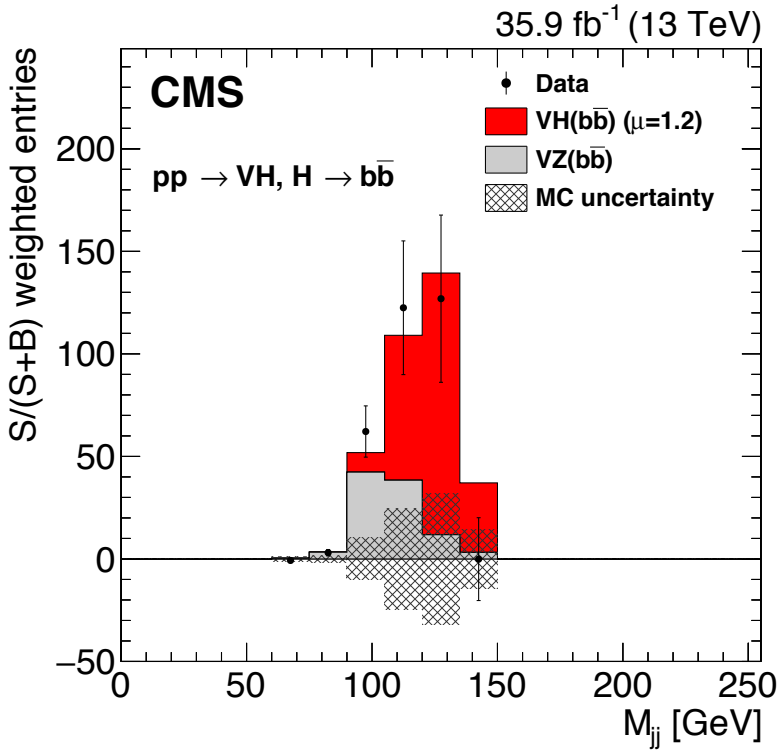
CMS

- CMS measurement of boosted $H \to bb$: arXiv:1709.05543
- CMS evidence for $H \to bb$: arXiv:1709.07497

arXiv:1709.05543



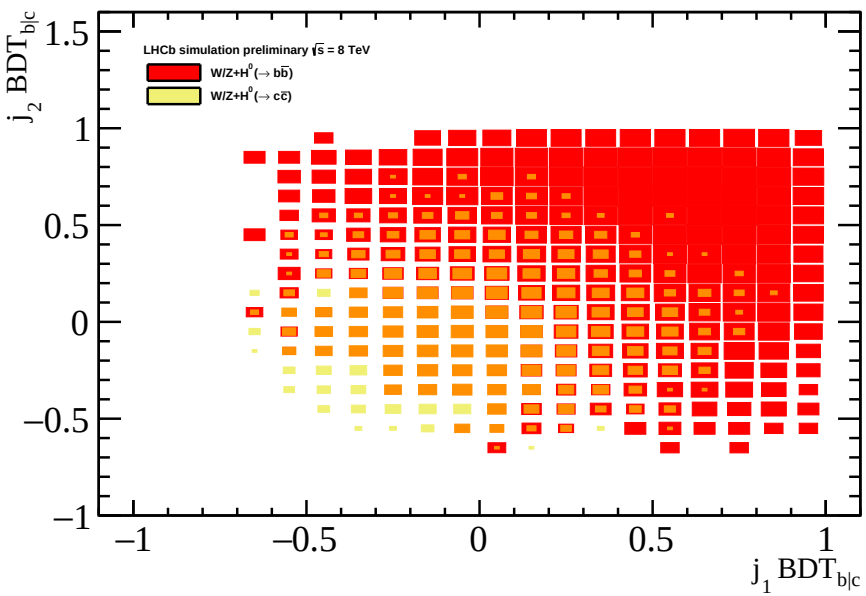
arXiv:1709.07497



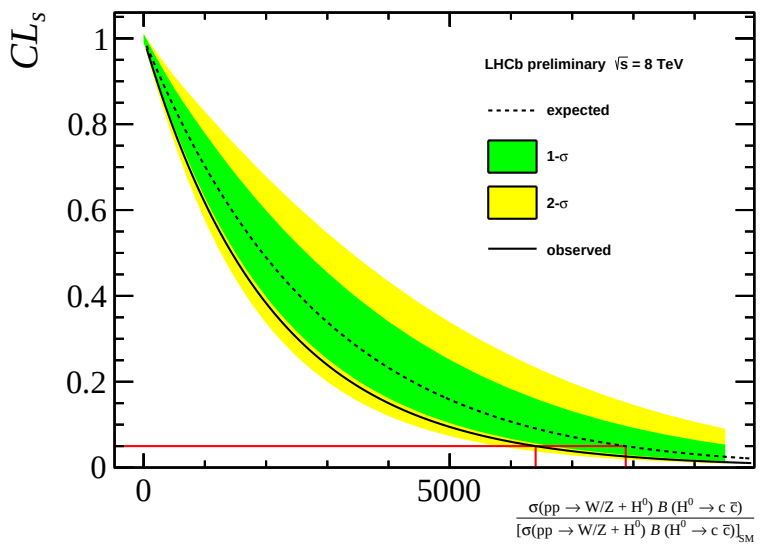
LHCb

- LHCb measurement of $VH \to cc\ell$: LHCb-CONF-2016-006
- current limit is roughly 6400 × SM
- LHCb projection of $VH \to cc\ell$: arXiv:1808.08865
- rough projection of 4 × SM

LHCb-CONF-2016-006



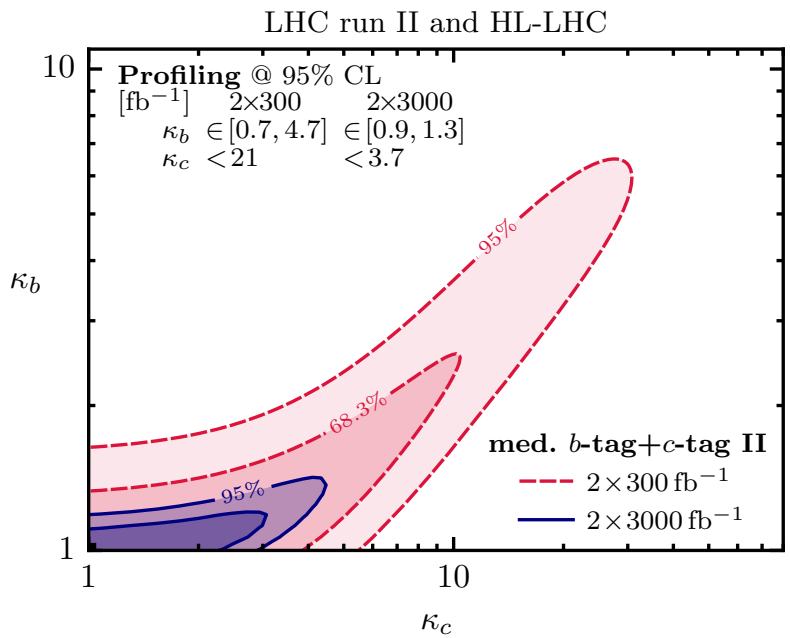
LHCb-CONF-2016-006



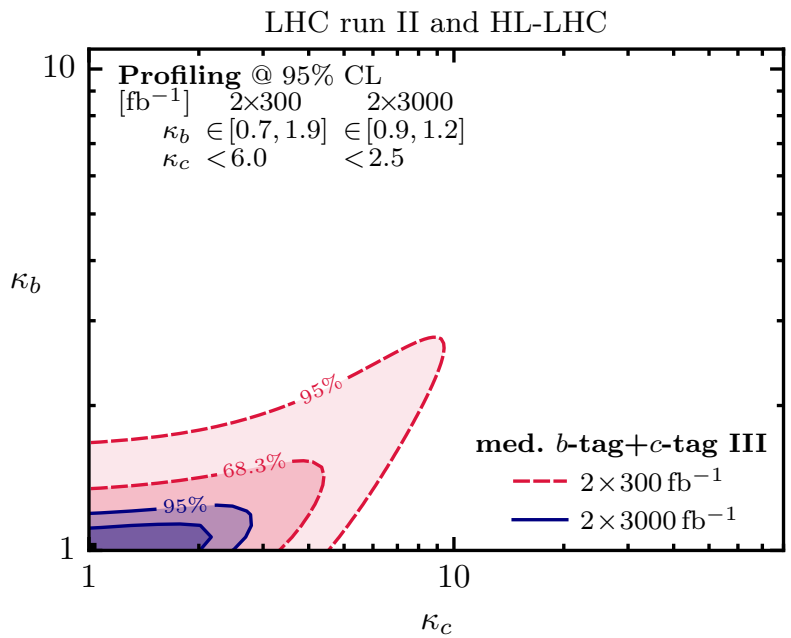
$H \to cc$ vs. $H \to bb$ Couplings

- pheno study of tagging correlations: arXiv:1505.06689
- depends on a number of tagging assumptions

arXiv:1505.06689

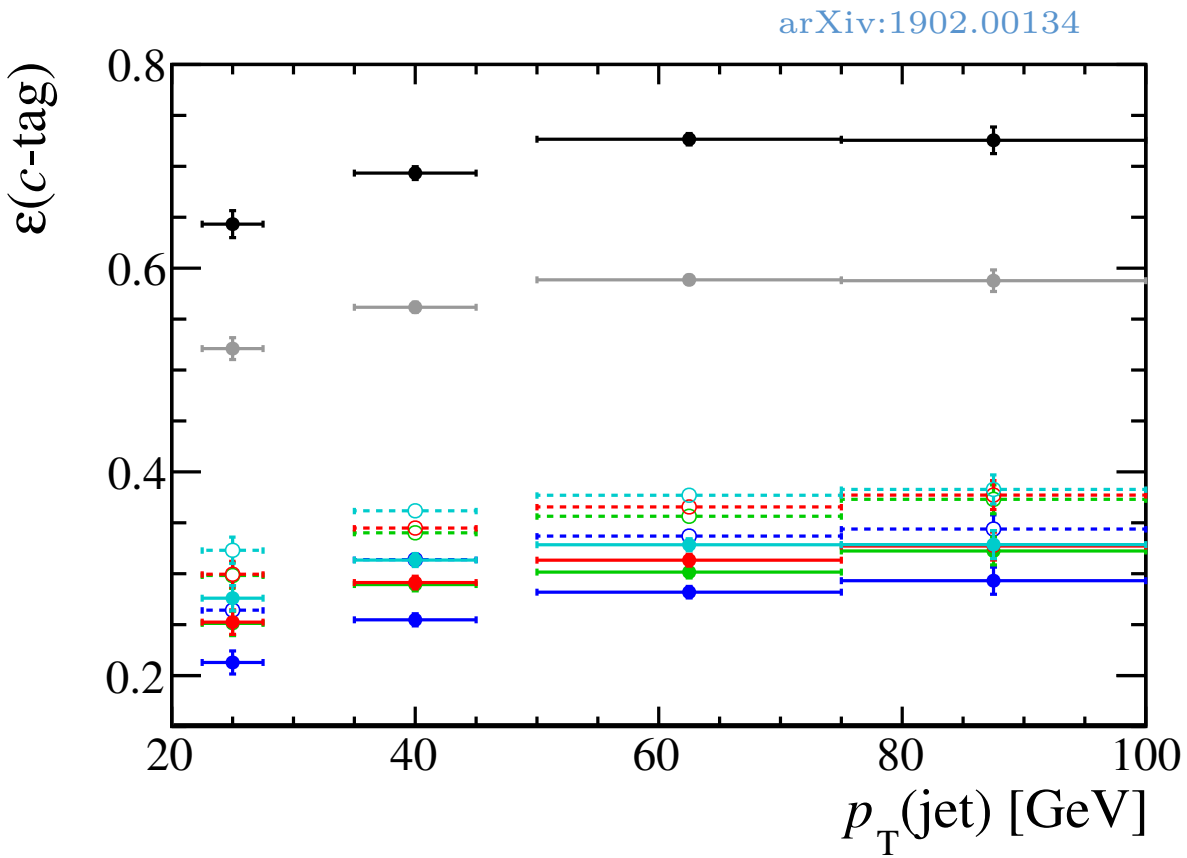


arXiv:1505.06689



Charm Tagging

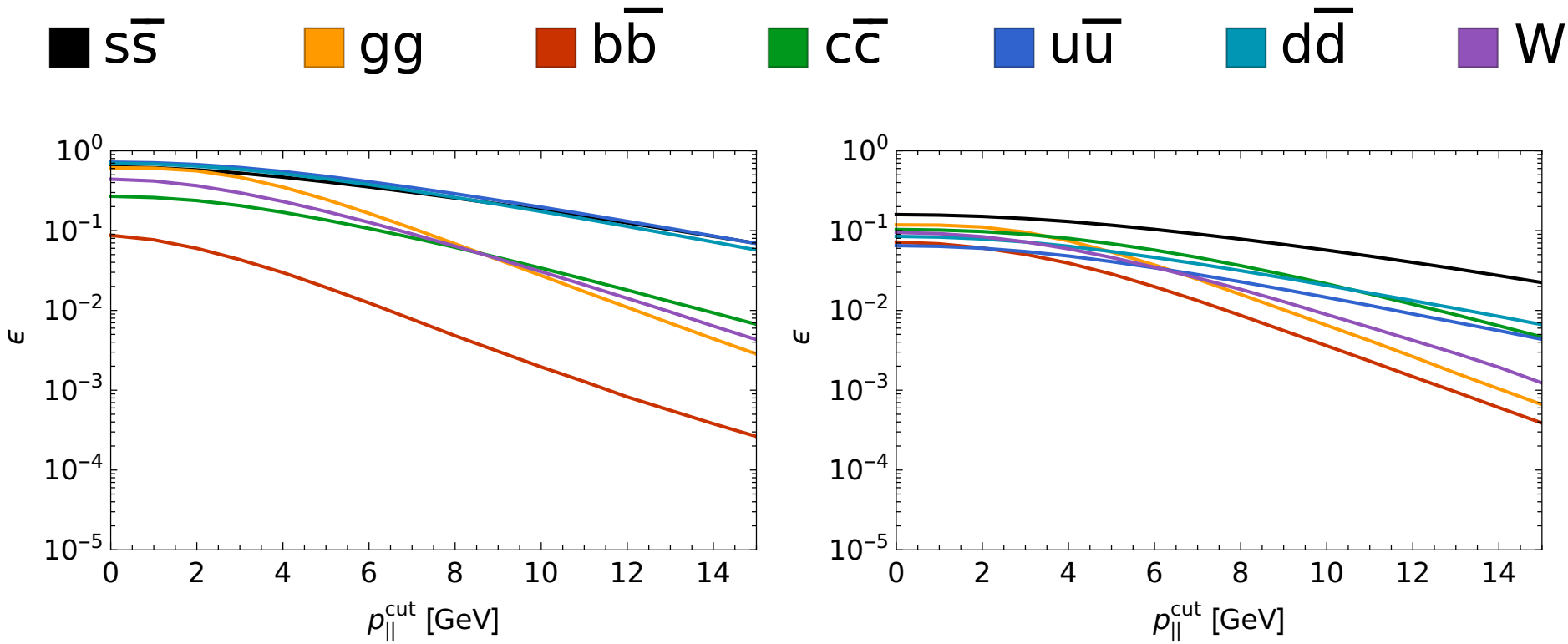
- jet tagging performance is critical for these measurements



Strange Tagging

- strange quarks hadronise to prompt kaons - carry large fraction of jet momentum
- separated into charged-charged (left), charged-neutral (right), and neutral-neutral

arXiv:1811.09636

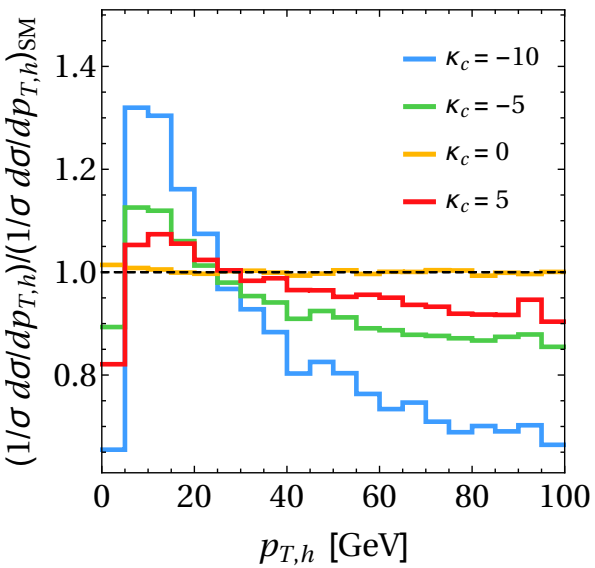


Differential Cross-sections

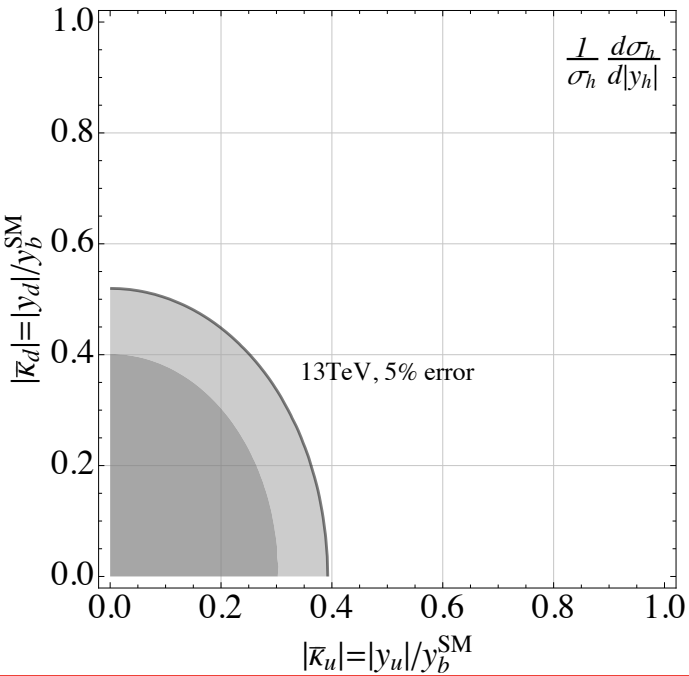
Higgs Distributions

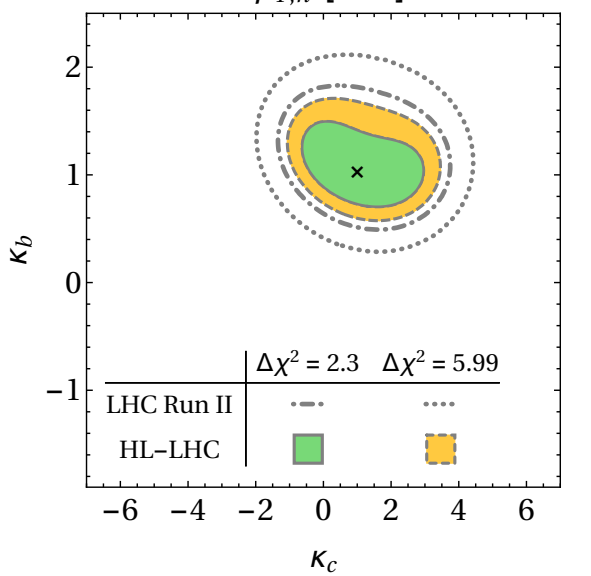
- differential spectrum pheno studies: arXiv:1606.09621 and arXiv:1606.09253
- both p_T and y are sensitive

arXiv:1606.09253



arXiv:1606.09621

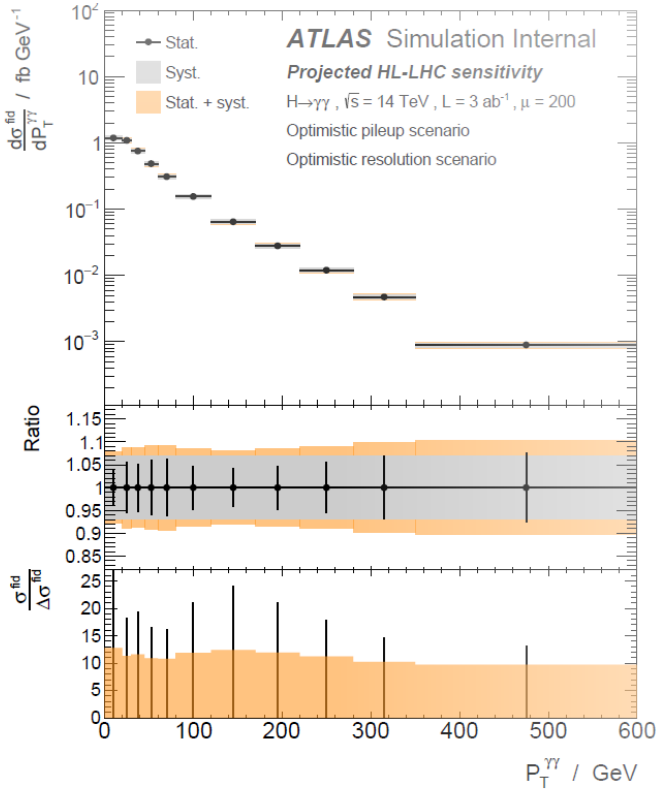




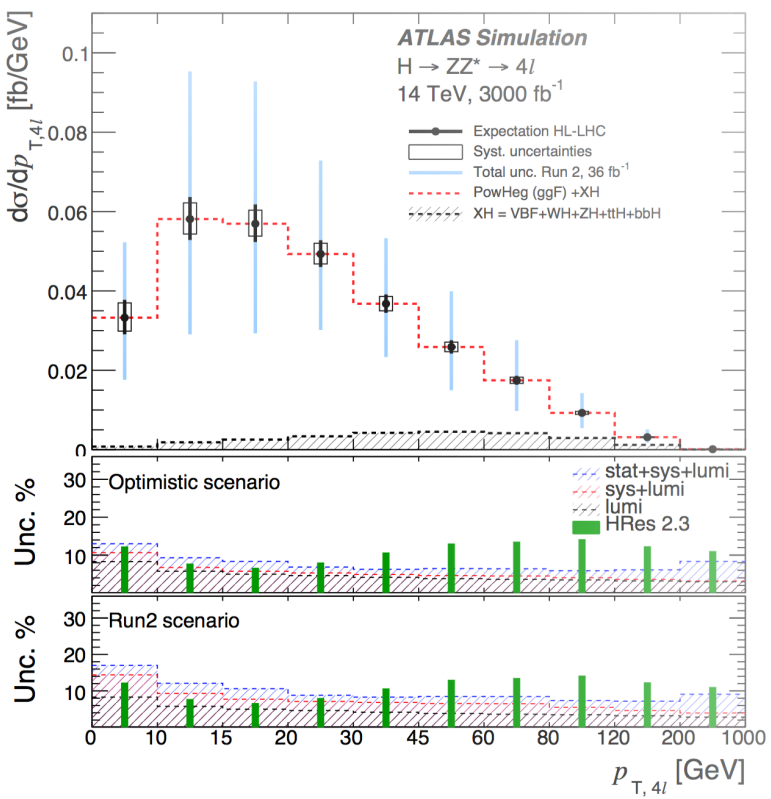
ATLAS

- $H \to \gamma\gamma$: 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



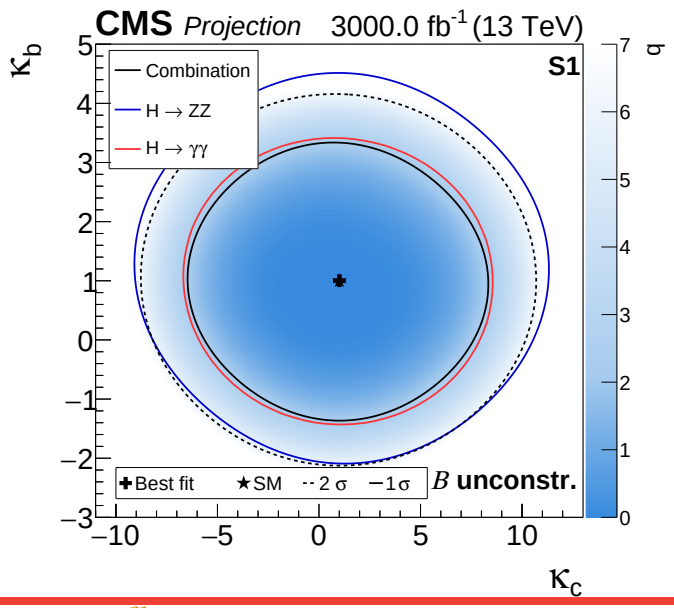
ATLAS-TDR



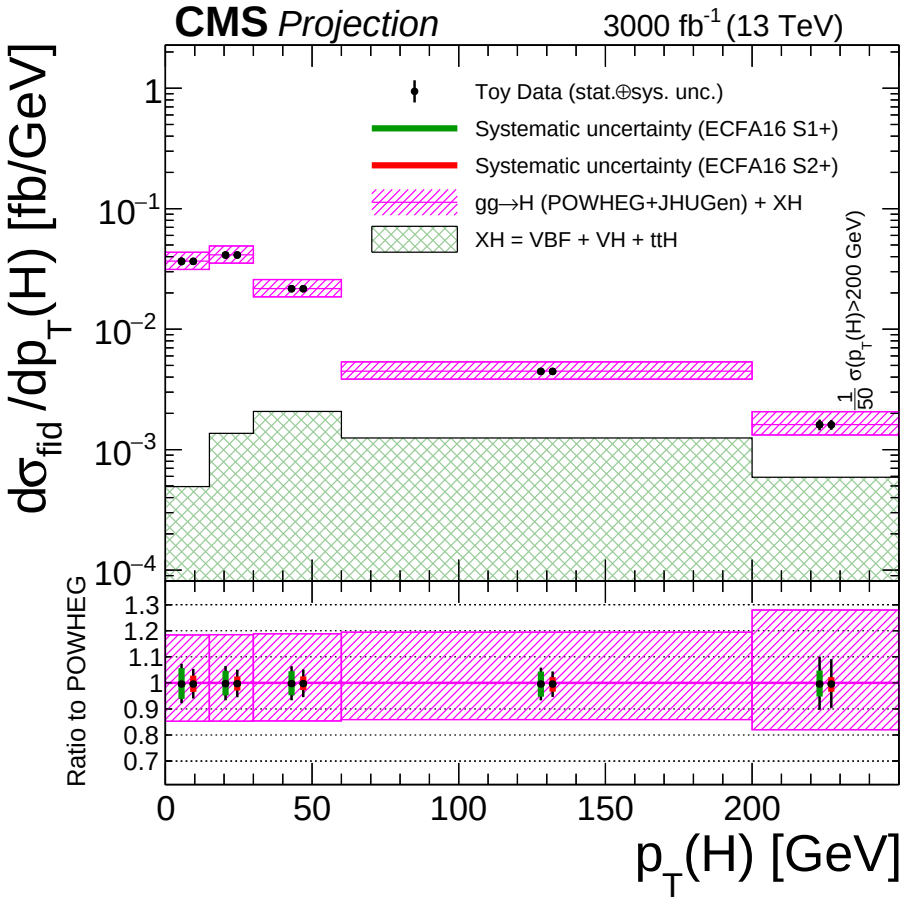
CMS

- $H \to \gamma\gamma$: CMS-PAS-HIG-17-029
- $H \to ZZ$: arXiv:1706.09936
- κ_b and κ_c projections: arXiv:1812.06504

arXiv:1812.06504

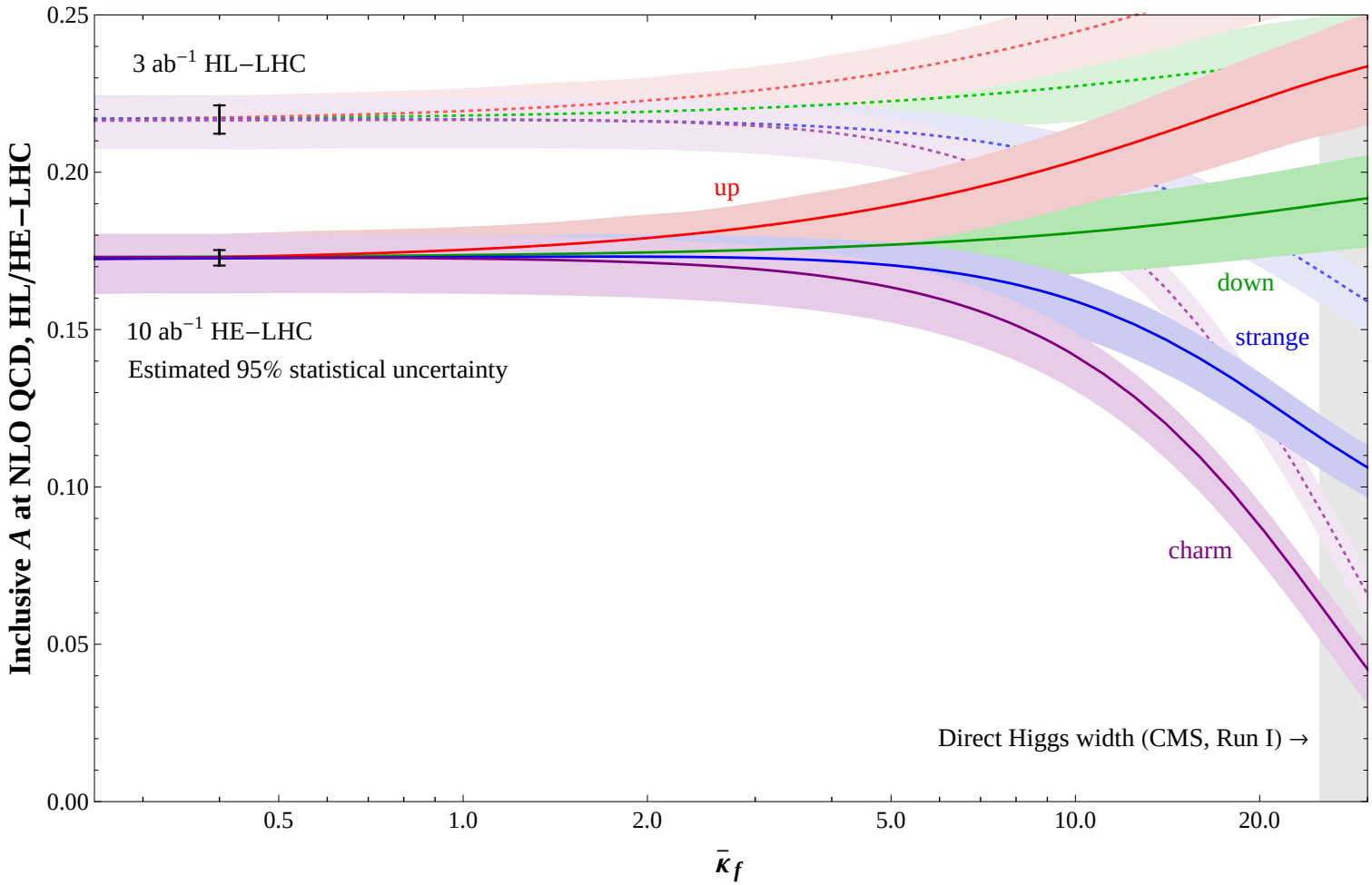


CMS-PAS-FTR-16-002



Charge Asymmetry in WH

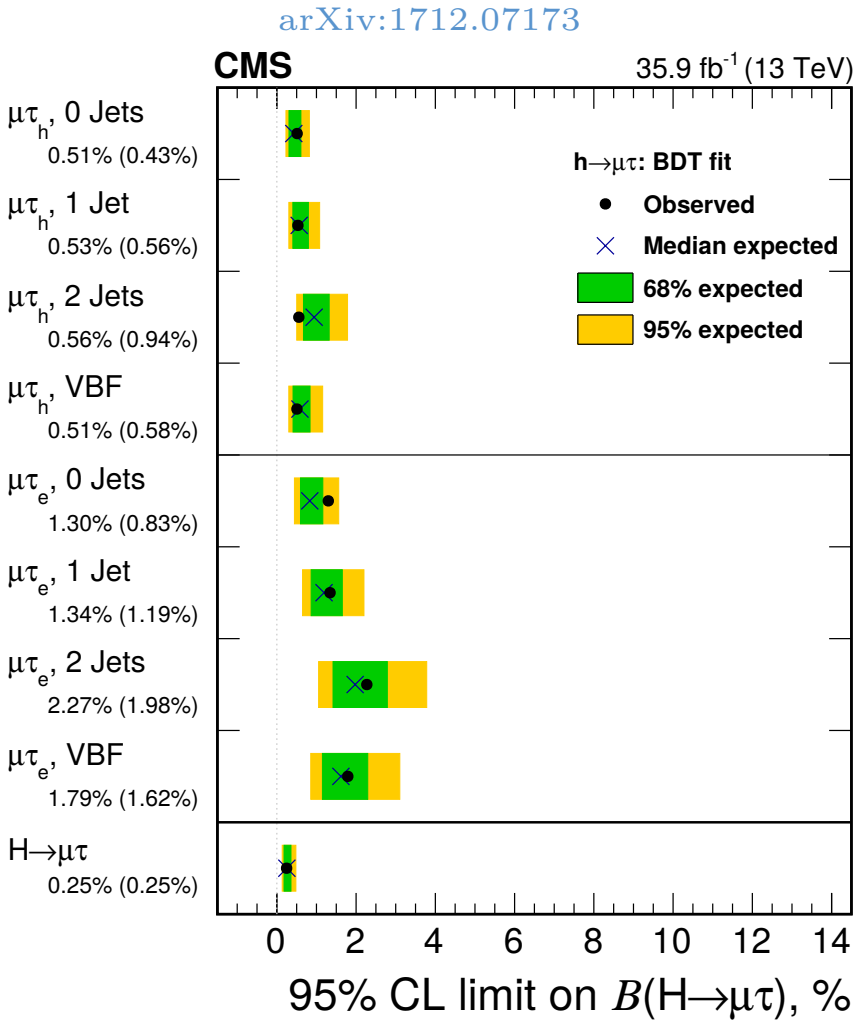
- charge asymmetry in WH production sensitive to fermion couplings



Lepton Flavour Violation and CP Violation

ATLAS and CMS LFV

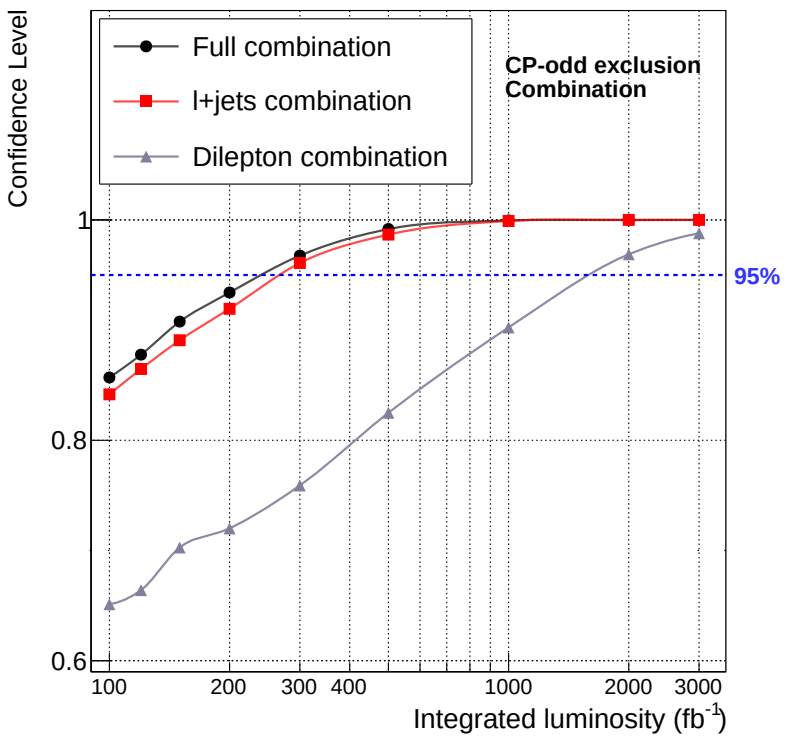
- search by ATLAS for $H \to \tau\mu$: arXiv:1508.03372
- search by CMS for $H \to e\mu$ and $H \to e\tau$: arXiv:1607.03561
- search by CMS for $H \to e\tau$ and $H \to \mu\tau$: arXiv:1712.07173
- projected branching ratio limits $\mathcal{O}(5 \times 10^{-4})$

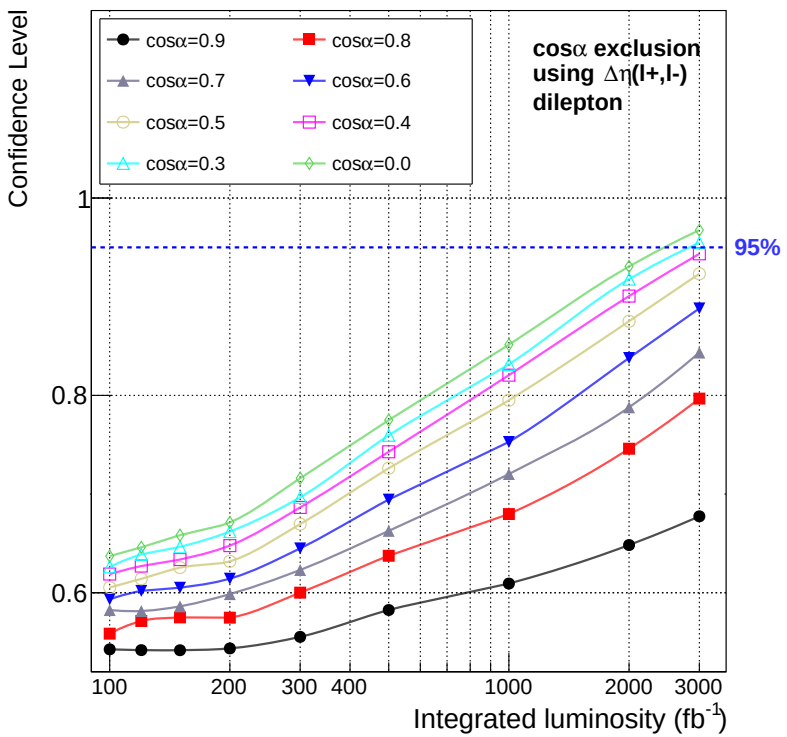


CP Violation

- at low energy, flavor diagonal CPV couplings constrained by electron, neutron, and mercury EDMs
- relaxing these constraints, ttH and $H \to \tau\tau$ provide bounds

$$\mathcal{L}_{ttH} = y_t \bar{t}(\cos\alpha - i\gamma_5 \sin\alpha) tH$$





Conclusions

Outlook

- consistent picture of Higgs flavour sector from phenomenology and experimental projections
- inclusive charm searches comparable to global fits
- observation might be possible with combinations and some clever ideas
- $H \to V\gamma$ decays not competitive for SM couplings, but important for rare decays
- strong constraints on LFV and CPV

Thanks to everyone whose hard work made this possible!