Higgs physics @HL-LHC, discussion

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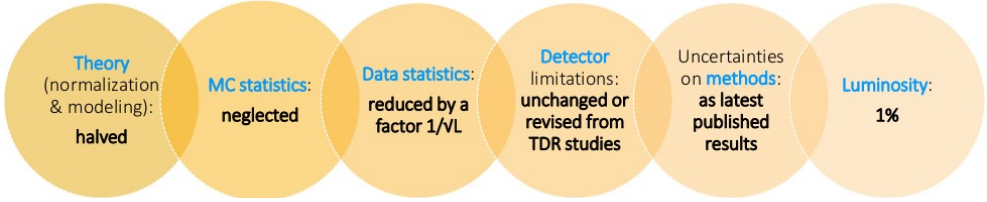
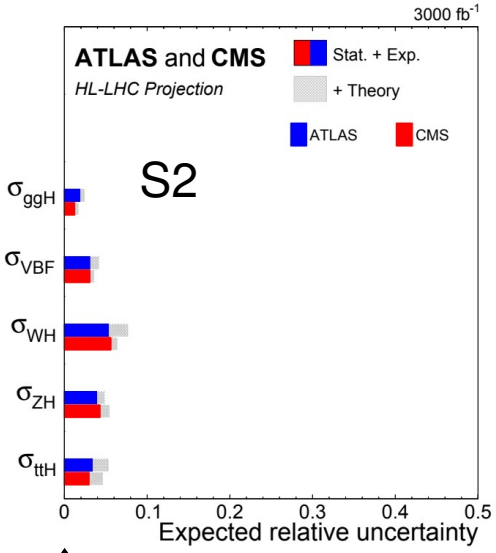
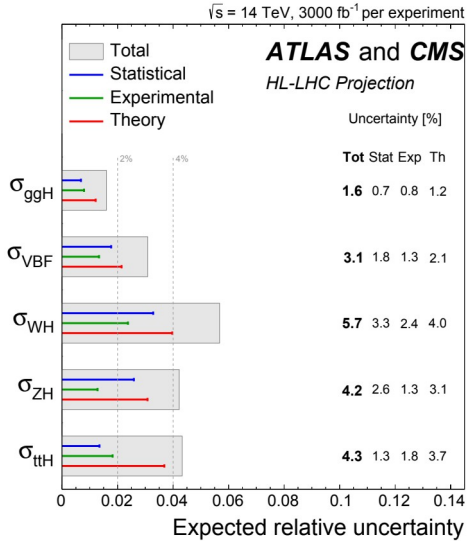
Higgs Hunting
30th of July 2019

Coupling measurements

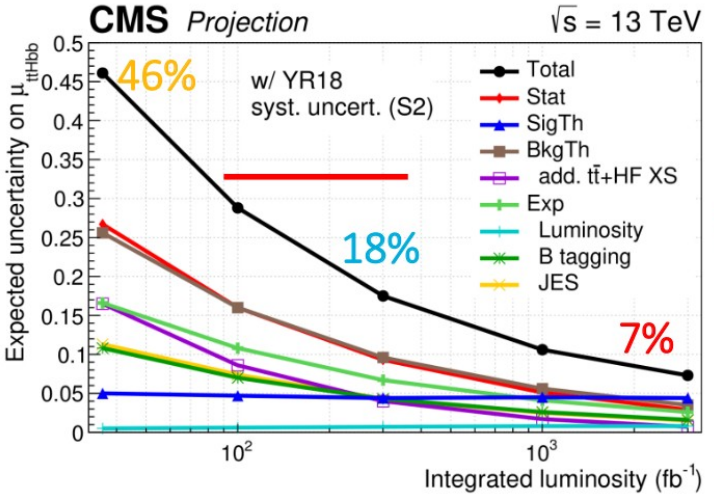
- Two scenarios for systematics
  - S1: Run-2 systematics
  - S2: Baseline





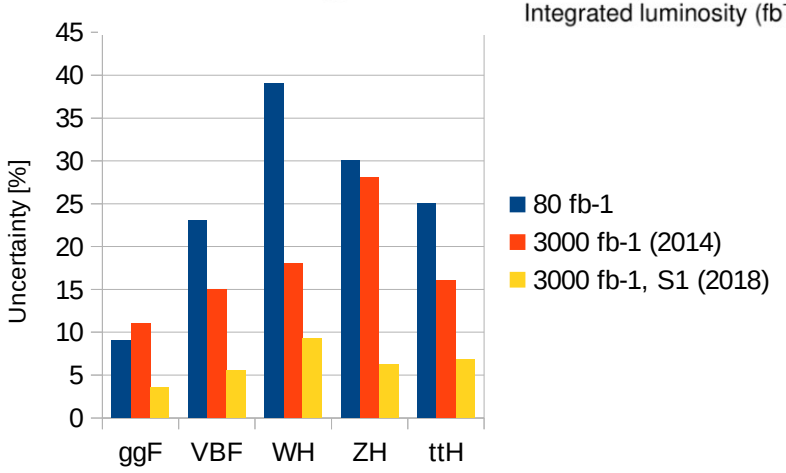


- Systematics dominated (except for Zγ and μμ)
  - Q: ideas for improvements?
  - theory systematics halved:
    Q: realistic? how to reach this?



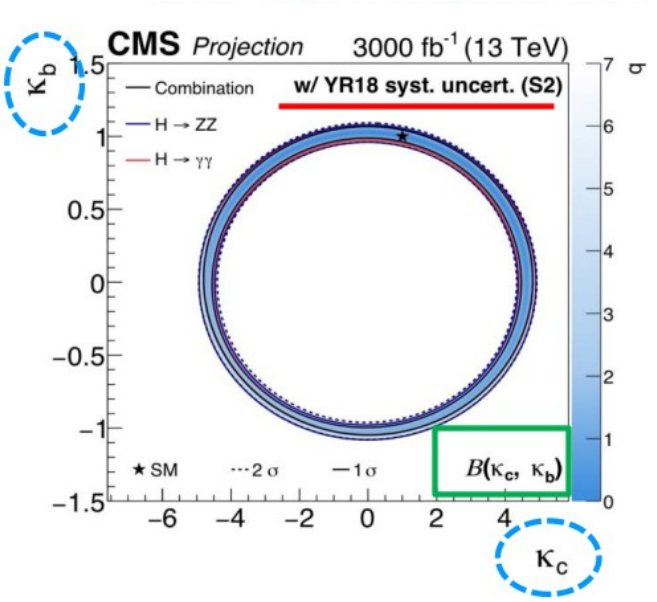
Run2 LHC HL

- Comparison to previous extrapolations
  - Q: do we understand what changed?
  - Q: can we expect more improvements?

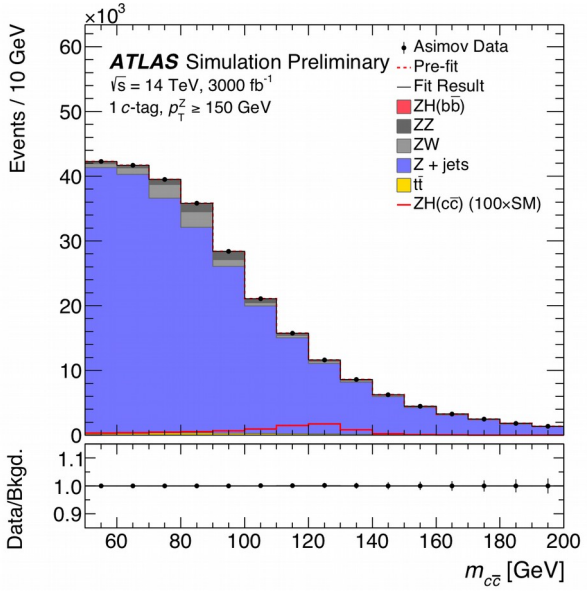


Couplings to 2nd generation fermions (c quark)

- Charm: Differential cross-section Higgs pT
  - CMS, HL-LHC: $-4.9 < \kappa_c < 4.8$ (and $-1.1 < \kappa_b < 1.1$)
  - ATLAS, Run-2, 139 fb^{-1}: $-15 < \kappa_c < 19$
  - $\mathcal{Q}$: assumptions? model-dependence?



- VH($\rightarrow c\bar{c}$)
  - ATLAS, HL-LHC: 6.3*SM
  - Run-2, ~36 fb^{-1}:
    - ATLAS: 150*SM → extrapolated to 3000 fb^{-1}: ~4*SM
    - CMS: 37*SM → extrapolated to 3000 fb^{-1}: ~15*SM
  - $\mathcal{Q}$: sensitivity to κ_c?



- $\mathcal{Q}$: Comparison between methods?
- $\mathcal{Q}$: What about H$\rightarrow$J/ψγ ?
- $\mathcal{Q}$: Access to μμ coupling?

Higgs self-couplings

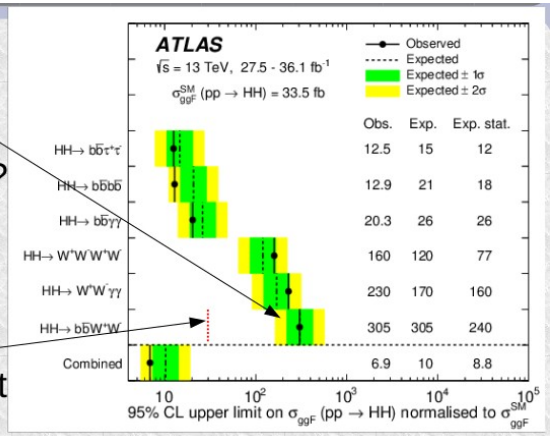
- Comparison of expected significance of HH production (YR):

	Statistical-only		Statistical + Systematic	
	ATLAS	CMS	ATLAS	CMS
$HH \to b\bar{b}b\bar{b}$	1.4	1.2	0.61	0.95
$HH \to b\bar{b}\tau\tau$	2.5	1.6	2.1	1.4
$HH \to b\bar{b}\gamma\gamma$	2.1	1.8	2.0	1.8
$HH \to b\bar{b}VV(ll\nu\nu)$	-	0.59	-	0.56
$HH \to b\bar{b}ZZ(4l)$	-	0.37	-	0.37
combined	3.5	2.8	3.0	2.6
	Combined		Combined	
	4.5		4.0	

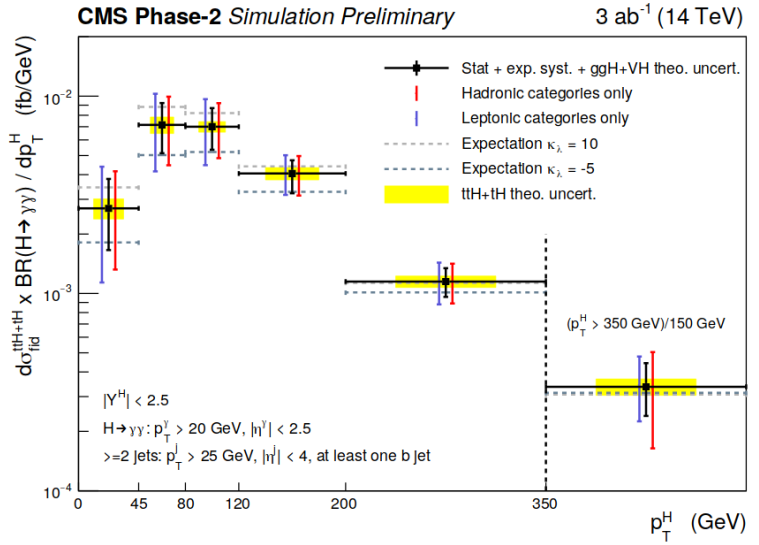
  - Q: Differences between experiments?
  - Q: Where could we gain to reach 5σ?

- Low mass is harder to trigger for bb and ττ modes

- ATLAS 36fb^{-1} HH summary
  - bbWW at 305 x SM!
  - Looks pretty hopeless?
- But 139fb^{-1} bbWW
  - Dileptonic; previous was single-lepton
  - Expected limit 29xSM
  - Factor 10 improvement
- Good ideas and hard work can still improve all the results



- Differential/fiducial cross-sections of single-Higgs
  - real sensitivity at HL-LHC?
    Q: Complementarity? Assumptions?
  - For Run-2, similar sensitivity as HH
    Q: Up to which luminosity?



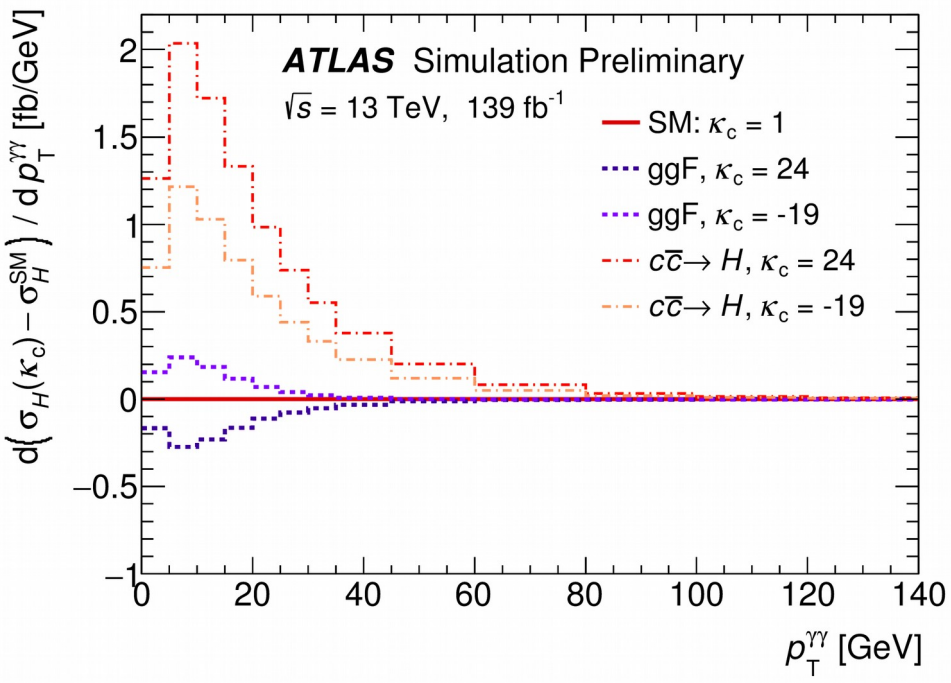
Back-up

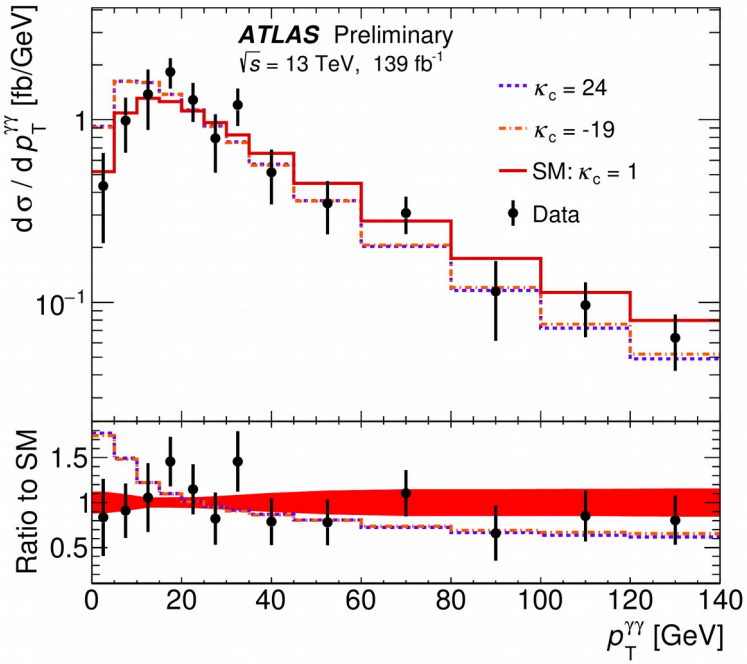
Higgs couplings @HL-LHC

ATLAS		3000 fb^{-1} uncertainty [%]				
		Total	Stat	Exp	SigTh	BkgTh
σ_{ggH}	S1	3.5	0.8	2.1	2.1	1.6
	S2	2.4	0.8	1.7	1.2	1.0
σ_{VBF}	S1	5.5	2.0	2.7	3.7	2.1
	S2	4.2	2.0	2.3	2.2	1.7
σ_{WH}	S1	9.3	4.0	4.0	5.1	5.4
	S2	7.7	4.0	3.4	3.3	4.5
σ_{ZH}	S1	6.2	3.4	2.4	3.4	3.0
	S2	4.8	3.4	1.8	2.0	2.1
σ_{ttH}	S1	6.7	1.9	3.1	3.7	4.3
	S2	5.3	1.9	2.8	2.4	3.3

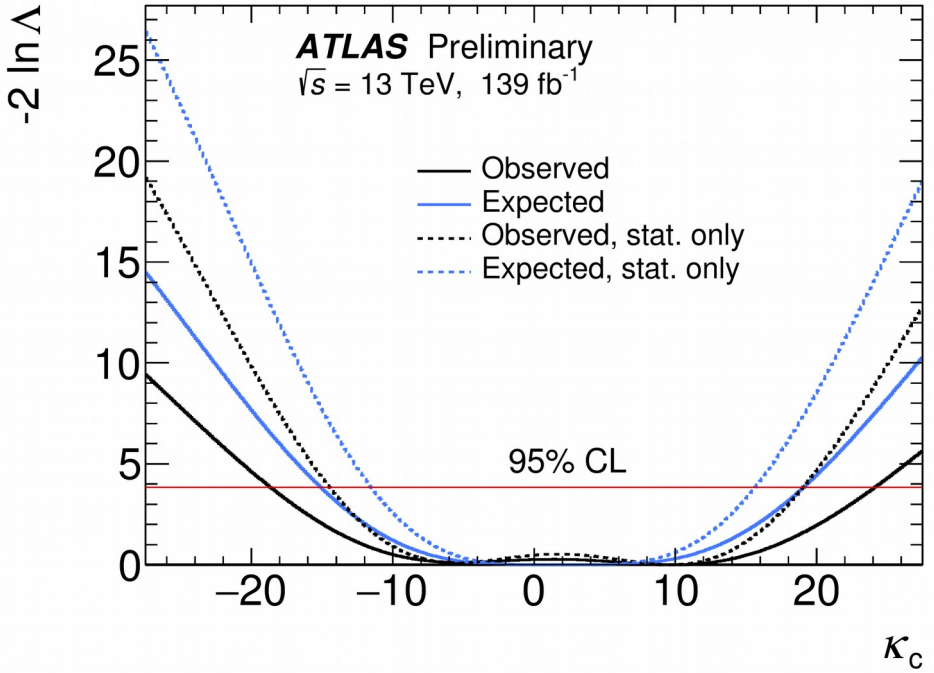
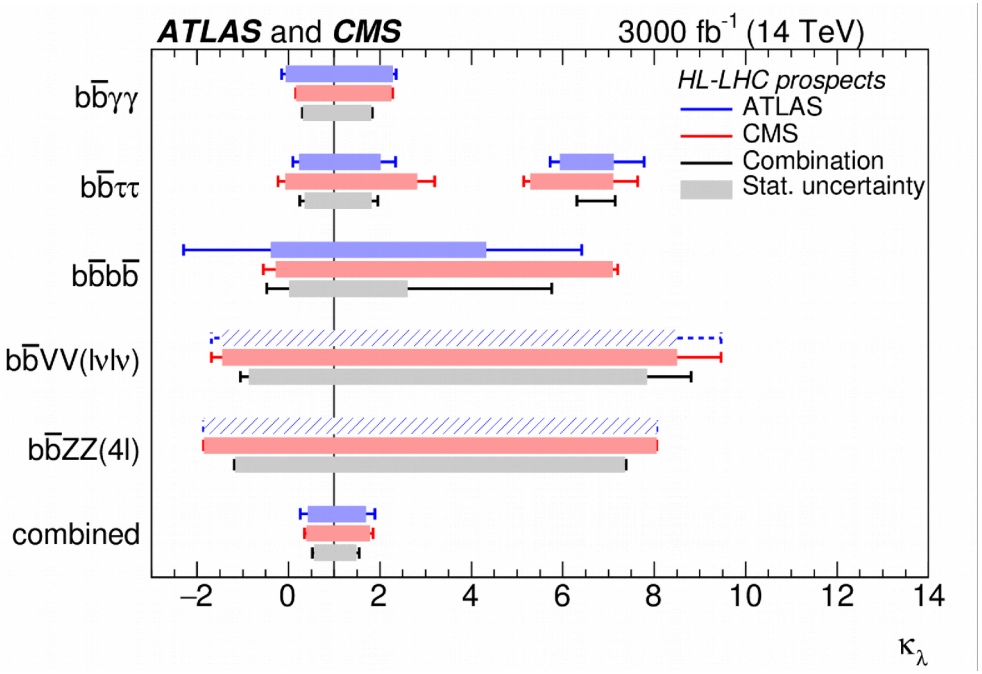
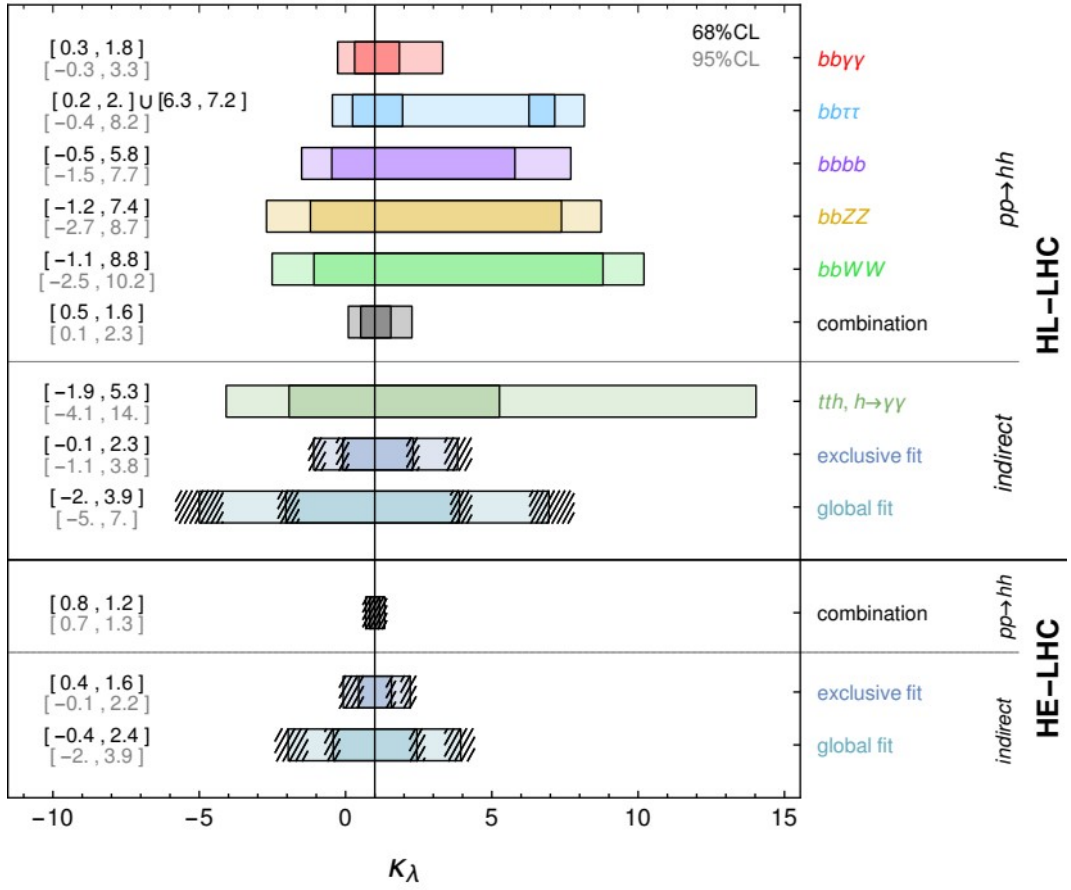
CMS		3000 fb^{-1} uncertainty [%]				
		Total	Stat	Exp	SigTh	BkgTh
σ_{ggH}	S1	2.4	0.8	1.2	1.6	0.9
	S2	1.7	0.8	0.9	0.9	0.6
σ_{VBF}	S1	4.1	2.6	2.1	2.0	1.3
	S2	3.5	2.6	1.6	1.8	0.3
σ_{WH}	S1	8.1	4.6	5.2	2.6	3.3
	S2	6.4	4.6	3.2	1.5	2.7
σ_{ZH}	S1	6.7	3.9	2.1	4.3	2.5
	S2	5.4	3.9	1.7	2.4	2.3
σ_{ttH}	S1	5.8	1.8	3.1	1.9	4.1
	S2	4.6	1.8	2.4	1.1	3.4

ATLAS Run-2: κ_c from diff xsec





♦ ATLAS-CONF-2019-029



- 68% CL precision on κλ: