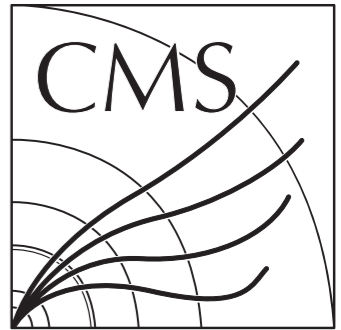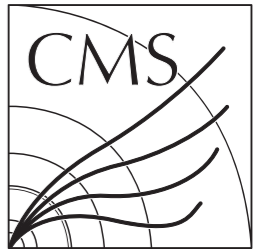# Differential combination discussion

A. Gilbert, N. Wardle (IC) for CMS
6 May 2020

Introduction

- Last discussions almost a year ago:
  - https://indico.cern.ch/event/823272/
  - Saw overviews from each experiment and discussed some differences, but few firm decisions made

- Need to harmonise on several aspects for the future combination:
  - Choice, definition and binning of observables
  - Which channels will be included for which observables
  - Which fiducial regions we unfold to (common regions for single-channel combination?)

- Goal of these slides is
  - To briefly give the status of CMS results
  - Recap the issues we need to address

Twiki

- We want to compile a twiki page summarising all the key information side-by-side
  - https://twiki.cern.ch/twiki/bin/view/LHCPhysics/DifferentialRun2

- Information for analyses-in-progress should be included where possible (no actual results of course)

- Basic information has been filled for CMS analyses

Information to gather
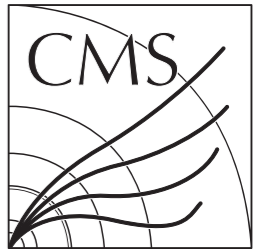
- Definition of fiducial regions (relevant if making combined measurements for single channels)
  - Object level definitions
  - Background subtracted or not (e.g. pp→4l vs pp→H→4l)

- Which observables have been / will be measured
 - Are there ambiguities in the definition?

- Two binnings we need to keep track of:
  - Measurement bins: set of bins measured by analysis, i.e. aligned with reco. selection
  - Workspace bins: splitting of signal processes in the workspace, possibly finer than above
    - In principle each analysis should implement finest possible combined measurement bins

- How is the binning determined? E.g. based on expected sensitivity threshold?
  - Also consider possible future combinations with Run 3

- Which MC is used in the unfolding? How are different production modes treated?

- What value of m_H is assumed? Can it be changed easily?

- Treatment of out-of-acceptance: constrained to SM vs scales with in-acceptance? (or something different...)

- Use of regularisation

- Systematics that may be common across channels (including theoretical uncertainties)

CMS differential analysis status
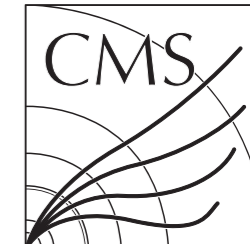
	Reference	Luminosity	Status
H→ZZ→4l	HIG-19-001	137 fb⁻¹	Preliminary
H→γγ	HIG-17-025	35.9 fb⁻¹	Published
H→WW→2l2ν	HIG-19-002	137 fb⁻¹	Preliminary
H→bb (boosted)	HIG-19-003	137 fb⁻¹	Preliminary
Combination: ZZ+γγ+bb	HIG-17-028	35.9 fb⁻¹	Published

- Recap: CMS combination of ZZ + γγ (+bb for p_T^H) using 2016 dataset (HIG-17-028)
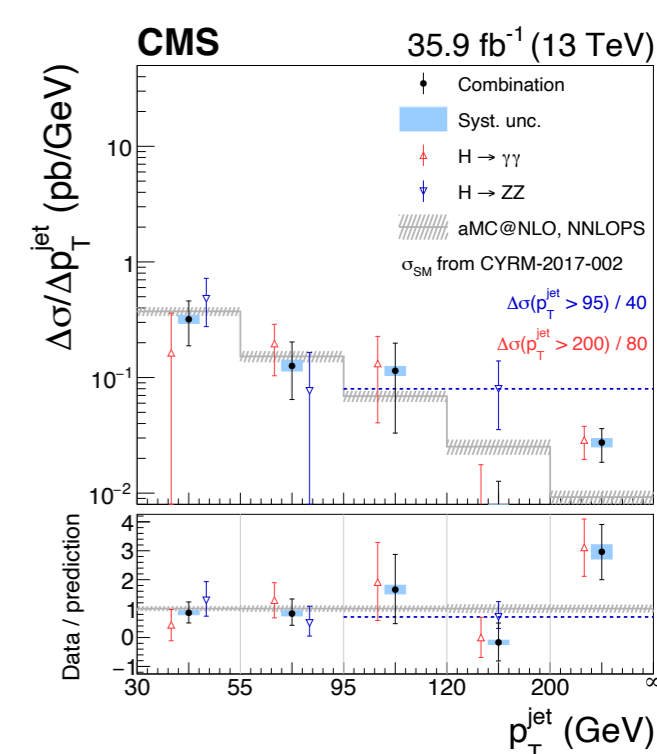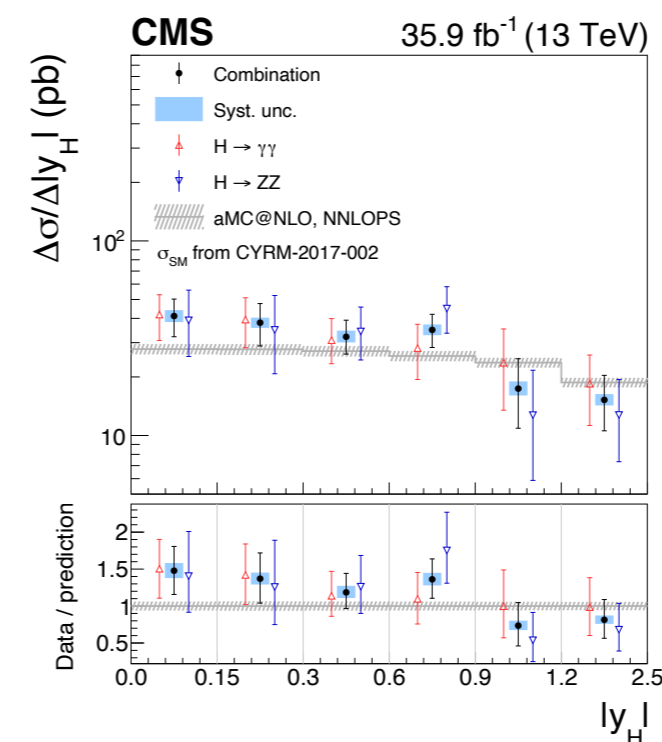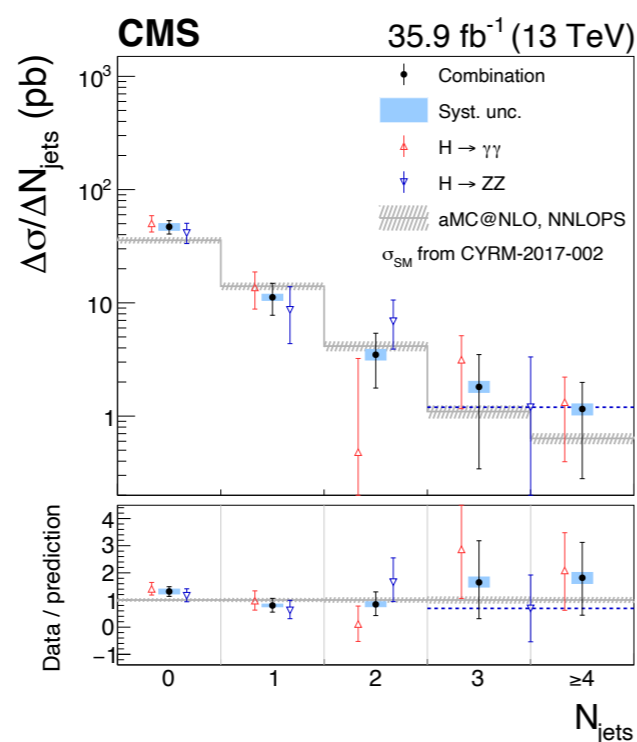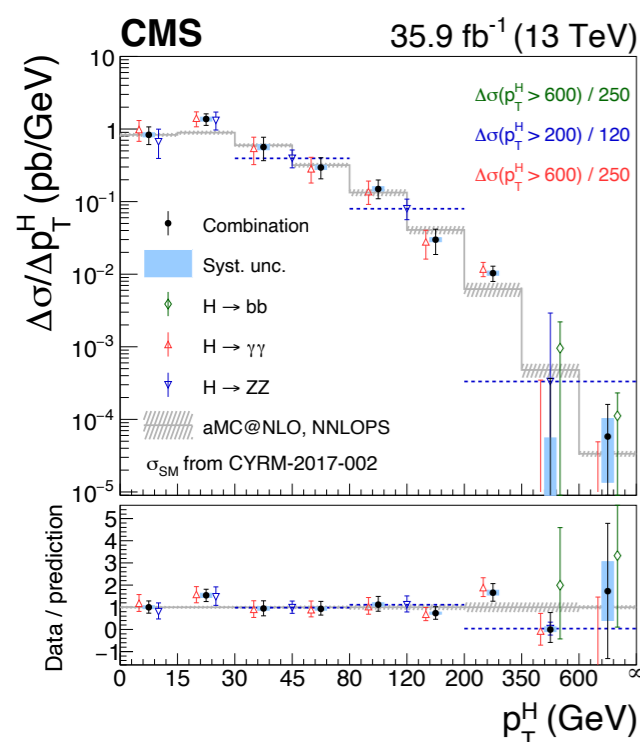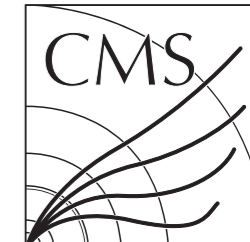
Analysis overviews
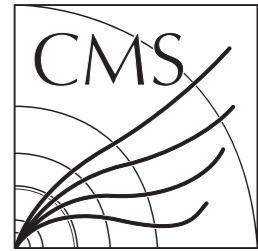
H→ZZ→4l	CMS
Public results	HIG-19-001 ⬀ (Preliminary) 137.1 fb-1
Analysis contacts	*tbc*
Observables	
Higgs pT	`0,15,30,45,80,120,200,inf`
Higgs rapidity	`0.0,0.15,0.3,0.6,0.9,1.2,2.5`
nJets	`0:1:2:3:4-inf`
Leading jet pT	`0,30,55,95,200,inf`
Object definitions	
Jets	`pT > 30 GeV, |eta| < 2.5`

H→gg	CMS
Public results	HIG-17-025 ⬀ 35.9 fb-1
Analysis contacts	Thomas Reitenspiess (thomas.reitenspiess@cernSPAMNOT.ch), Simone Pigazzini (simone.pigazzini@cernSPAMNOT.ch), Mauro Donega (mauro.donega@cernSPAMNOT.ch)
Observables	
Higgs pT	`0,5,10,15,20,30,45,60,80,100,120,140,170,200,250,350,inf`
nJets	`0:1:2:3:4-inf`
Object definitions	
Jets	`pT > 30 GeV, |eta| < 2.5` `pT > 30 GeV, |eta| < 4.7` STXS definition NOT used, clustering algo: anti-kt 0.4, neutrinos NOT included

H→WW	CMS
Public results	HIG-19-002 ⬀ 137 fb-1
Analysis contacts	*tbc*
Observables	
Higgs pT	`0,20,45,80,120,200,inf`
nJets	`0:1:2:3:4-inf`
Object definitions	
Jets	`pT > 30 GeV, no eta restriction` STXS definition is used, clustering algo: anti-kt 0.4, all final-state particles except from H decay & leptons from any V decay

H→bb	CMS
Public results	HIG-19-003 ⬀ (Preliminary) 137 fb-1
Analysis contacts	Javier Duarte (javier.mauricio.duarte@cernSPAMNOT.ch), Nick Smith (nick.smith@cernSPAMNOT.ch), Martin Kwok (martin.kwok@cernSPAMNOT.ch)
Observables	
Higgs pT	`300,450,650,inf`

Binning

- Snapshot of measurement bins (for full-dataset analyses)

- p_T^H:

H→ZZ	|0	15	30	45	80	120	200			inf|
H→WW	|0		20	45	80	120	200			inf|
H→bb							|300	450	650	inf|
ATLAS H→ZZ	|0 10 20 30		45 60 80		120		200		350	1000|

  - For 0-30 GeV aligning on multiple-of-ten boundaries seems pragmatic

H→ZZ	| 0	1	2	3	>=4 |
H→WW	| 0	1	2	3	>=4 |
ATLAS H→ZZ	| 0	1	2	>=3	|

  - Main issue is jet definition - which particles are clustered and what η restriction
  - Discussed use of STXS definition: **anti-k_T R=0.4 jets with p_T > 30 GeV and no η restriction**
    - Clusters all final-state particles, including neutrinos, except: Higgs decay products & leptons from any V decay

Summary
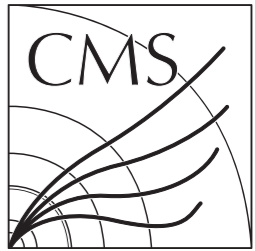
- Aim to continue compiling information on the twiki to identify areas where early agreement is useful
  - E.g. workspace binning, object definitions

- Should also consider our publication goals and timeline
  - Relevant analyses in each experiment clearly need to be completed first