WG3 Summary

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Mandate

WG3: experimental measurements	
Main aim	Foster the optimal deployment of VBS studies in the hadron collider experiments data analyses.
Tasks & Deliverables	• Promote the development of VBS-specific target-oriented reconstruction algorithms, pile-up-resilient, adapted to high-multiplicity environments • Foster the deployment of the data analyses in the experiments • Perform a joint interpretation of the public results in light of the Action knowledge
Milestones	• First tests of dedicated reconstruction algorithms at the end of the year 1 • First coherent data analyses deployment, following the recommendations of WG1 and WG2, within year 2
	• Updating of the analyses with new data throughout the Action. Final results interpretation in year 4

Particle reconstruction

Strong focus on jet reconstruction:

- Flavour tagging, quark/gluon discrimination
- Pileup mitigation
- Substructure techniques

Talks by experts in all early in-person meetings

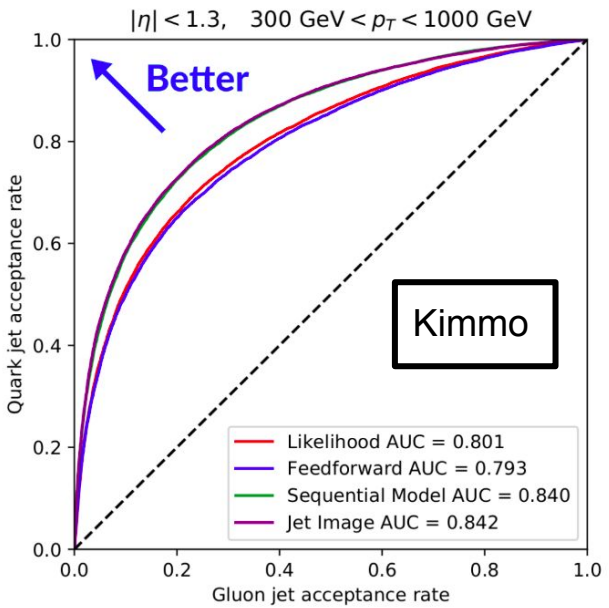
WG3 at Split Meeting

WG3 introduction	*Lucrezia Stella Bruni et al.*	
Split, Croatia	16:30 - 16:40	
Boosted jets tagging techniques in ATLAS	*Christoph Falk Anders*	
Split, Croatia	16:40 - 17:05	
Boosted jets tagging techniques in CMS	*Andreas Hinzmann*	
Split, Croatia	17:05 - 17:30	
Quark/gluon discrimination techniques in ATLAS	*Johannes Balz*	
Split, Croatia	17:30 - 17:55	
Quark/gluon discrimination and systematic uncertainties	*Philippe Gras*	
Split, Croatia	17:55 - 18:20	

Particle reconstruction

- Review of existing reco algorithms
- Training on theoretical aspects of quark fragmentation to a jet
- Tutorials on machine learning techniques
- Understanding of limitations of existing reco algorithms, that were accounted for in analyses

See e.g. our workshop on "New techniques in particle reconstruction for VBS" in Krakow: https://indico.cern.ch/event/751034/



Data analysis in experiments

When VBSCan started, none of the VBS processes had been experimentally confirmed!

	ATLAS	CMS
same-sign WWjj	6.5σ 	>>5σ
WZjj	5.3σ 	6.8σ 
ZZjj	5.5σ	4.0σ 
Wyjj	---	5.3σ
Zyjj	9.7σ 	9.4σ

Today, all relevant diagrams are observed (W^+W^- and semi-leptonic VV are still missing, but are not fundamentally different)

ATLAS+CMS Comparisons

- Forum for detailed comparison of corresponding ATLAS and CMS analyses, with talks by the relevant experts from each experiment
- Discussing all aspects
  - Selection
  - Bkg estimates
  - Systematics
  - MC predictions

⇒ Last few editions were held together with the LHC EW multiboson group

Main sources of systematic uncertainty

Iro

ATLAS WWjj analysis

Source	Impact [%]
Experimental	
Electron energy scale and resolution, and efficiency	0.6
Muon momentum scale and resolution, and efficiency	1.3
Jet energy and E_T^{miss} scale and resolution	3.2
b-tagging inefficiency	2.1
Pileup modeling	1.6
Background, statistical	3.2
Background, misid. leptons	3.3
Background, charge misrec.	0.3
Background, other	1.8
Theory modeling	
$W^{\pm}W^{\pm}jj$ electroweak-strong interference	1.0
$W^{\pm}W^{\pm}jj$ electroweak, EW corrections	1.4
$W^{\pm}W^{\pm}jj$ electroweak, shower, scale, PDF & α_s	2.8
$W^{\pm}W^{\pm}jj$ strong	2.9
WZ	3.3
Luminosity	2.4

Main unc:
- ***jet and E_T^{miss} reconstruction and calibration***
- ***Contamination from WZ events***
- ***Fake background***

CMS: 7% on the yields

CMS: 20–40%, on the yields (statistically dominated)

CMS: 30%, on the yields

QCD scale: *10-15% for signal*
PDF uncertainties: 1-2%
scale and PDF considered shape (and normalization) uncertainties

CMS: similar effect

Parton shower uncertainty:
- **$W^{\pm}W^{\pm}$ EW and QCD:** internal shower variations in Sherpa (larger effect than Sherpa vs Powheg+Pythia)
- **WZ:** Powheg-Box v2 generator at NLO, interfaced either to Pythia 8.210 or Herwig++ 2.7.1

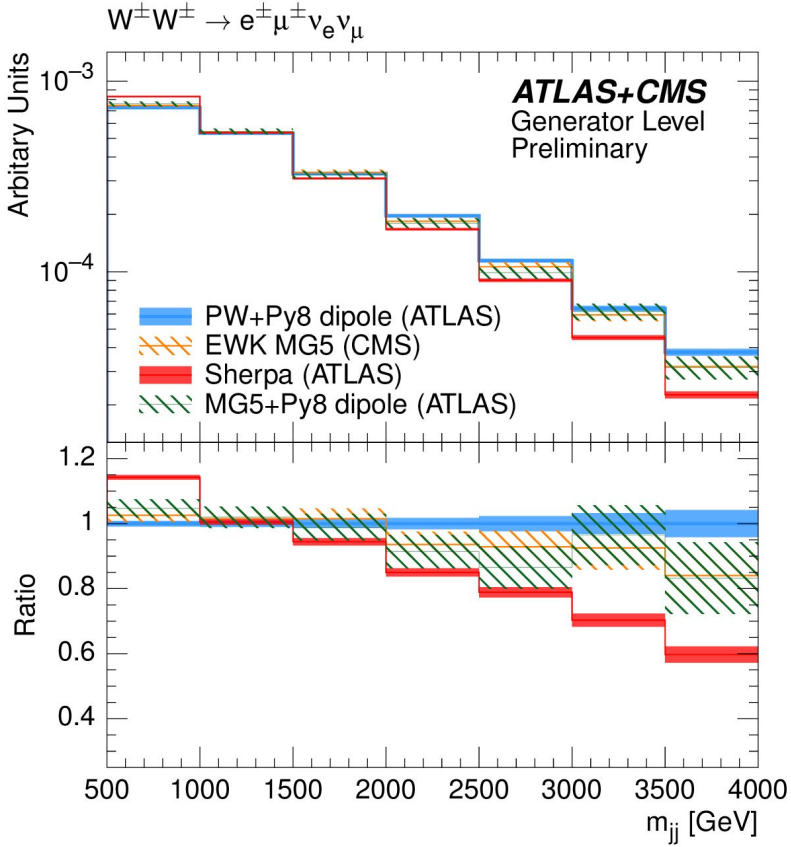
Additional shape uncertainty for:
- NLO EW correction (provided in m_{jj} bins)
- QCD-EW interference (computed using MadGraph, as in WZjj analysis)

ATLAS+CMS Comparisons

Comparisons of our theory modelling:

LHCEWMB Note:
[ATL-PHYS-PUB-2020-026]

⇒ Will be incorporated in a future Yellow report



The analyses in the experiments have greatly benefited from the personal relations formed in VBSCan, between ATLAS+CMS colleagues, and between experimentalists and theorists!

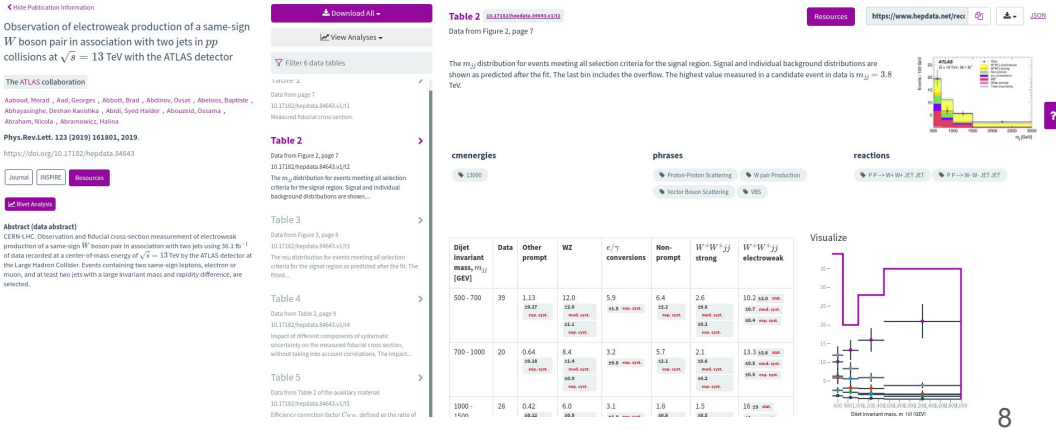
Combination Efforts

Early on we had plans for a combined ATLAS+CMS EFT interpretation

- Definition of information/material to be published by experiments
- However, resistance to share internal information on experiment's side

Several meetings discussing tools, available data, …

see e.g.
https://indico.cern.ch/event/787344/

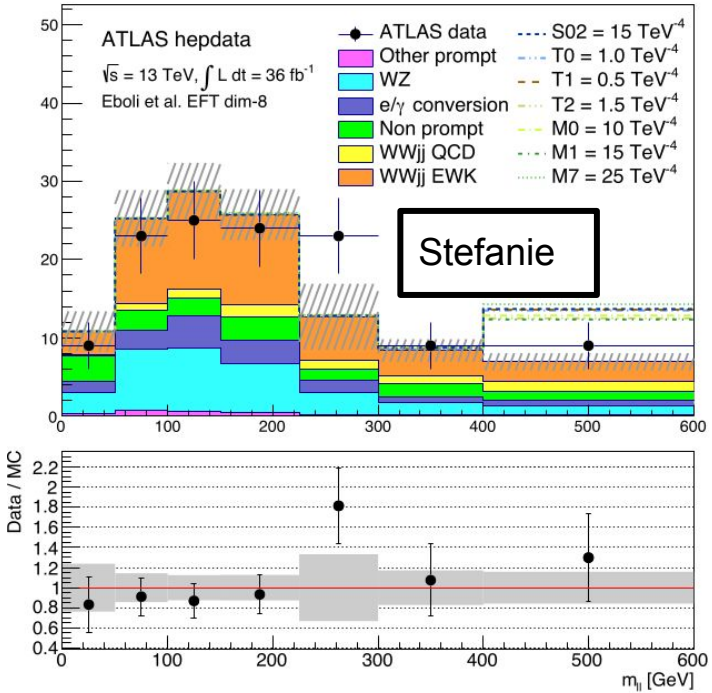


ATLAS Combination

- The reinterpretation of ATLAS VBS same-sign WW and WZ data is still ongoing
- Results anticipated in autumn this year

⇒ However, again this needed to be done as “ATLAS Collaboration” while work was largely carried out with support of VBSCan

EFT model
and unitarisation techniques have very well been aligned between experiments!



Conclusions

- Progress in understanding the limitations of jet-reconstruction techniques in VBS signatures, with promising developments ahead (e.g. phase-II upgrades)

- Strong involvement of the VBSCan community in the experimental confirmation and the measurement of all VBS channels in ATLAS and CMS

- Public material available for reinterpretation (e.g. in a combination); the interpretation within experiments largely aligned