

Dear authors, congratulation to the accomplishment of this important analysis! The information in the paper is complete, however the presentation of the results can be improved. Please find the comments by DESY (Institutional Review) below.

### **General comments:**

- Did Statistics Committee review the analysis? Unfortunately no details on the unfolding are given in the paper.
- For clarity, please list numbers for or address 13 TeV and 8 TeV in the same order everywhere. Since there is a lot of repetitions with muon/electron and 8/13 TeV, it would be good to try to compile results into tables (inline enumeration are hard to read)
- Please check consistency throughout the whole text: either "Tab./Fig." or "Table/Figure"
- While referring to a method from the previous analysis, please be consistent in its description and citation, e.g. "This is done <short description of the method/algorithm>, as explained (described) in details in Ref. <citation>".
- Fig 2-6: Labels are too small and it is difficult to distinguish between the models. Further, in the lower panels the axis label (data / MC) is repeated for each panel, one could save this space and make the label bigger instead.
- The R is different for 13 and 8 TeV analyses. Please indicate R for jet quantities in the figures.
- Systematic uncertainties: some systematic uncertainty sources are not explained (pileup) and some are explained only later or in another section Please check that all uncertainty sources are summarized in the section "Systematic Uncertainties". We would suggest itemizing uncertainty sources for clarity.
- The summary should reflect the statements made in the introduction of importance of this measurement to get insight into VBS and the measurement of couplings.
- Please check the consistency in referring to MC or calculations, either with "v" or without.

### **Type B Comments**

- L79: only POWHEG is scaled with a K-factor or the Madgraph is scaled up too?
- L84: you probably mean that MCFM7.0 was used for 13 TeV? Did you check if the EWK constants are the same in different MCFM versions?
- L107 are tau decays also included?

- L135-136: make clear how/when the tracks found outside-in and inside-out are used? Which one is selected if both are found?
- L140-141: the pT-thresholds are below the trigger thresholds. Are there any tighter offline requirements on the leading pT leptons than the ones listed in the trigger description? -> perhaps move the lines to L178-182?
- L147: is the cone size the same for electrons and muons? Is this the case in both 13 and 8 TeV?
- L153: Is the isolation cut value the same for electrons and muons?
- L185-187: are here the invariant mass cuts not superfluous given the cuts in L192-193, which are tighter?
- L195: what is the uncertainty on these numbers?
- L219-220: why is the full difference between the data and MC trigger efficiency used as systematic uncertainty? Is there no systematic uncertainty provided on the scale factor?
- L271-275: This part is expected to appear before the description of uncertainties, maybe in a dedicated (sub)section. Please describe how the unfolding is performed and which method is used.
- Is it possible to include a figure showing migrations? Have purities being studied?
- Were the usual cross checks, as requested by the StatComm, performed? Did you apply alternative methods like SVD in RooUnfold, or Tikhonov in TUnfold? Is it demonstrated that regularization is needed? If the D'Agostini unfolding is used, could you please specify the number of iterations and how this number is defined?
- L304: only parton shower? Could you please provide details also on MPI and fragmentation?
- Fig. 4-5 (potentially all figures): the gray bands seem sometimes smaller than the error bars. Could you please check if the error plotting is correct? (e.g. JES are 17%, so a difference should be visible)

## **Type A Comments**

### **Abstract:**

- move "in pp collisions at  $\sqrt{s} = 8$  TeV and  $\sqrt{s} = 13$  TeV." to the next sentence so that the "respectively" points to the same sentence.
- based on data samples collected -> based on data collected
- "The differential cross sections as a function of the jet multiplicity, the transverse momentum, and pseudorapidity of the pT-leading and subleading jets are presented. In addition, the differential cross sections are presented

as a function of the invariant mass of the two pT-leading jets and their pseudorapidity separation." -> The differential cross sections are presented as a function of the jet multiplicity, the transverse momentum, and pseudorapidity of the pT-leading and subleading jets, in addition the cross sections are measured as a function of the invariant mass of the two pT-leading jets and their pseudorapidity separation."

Introduction:

### 1. Introduction

- L4 symmetry breaking mechanism -> symmetry-breaking mechanism?
- L4: simultaneous -> associated?
- L5: measurement -> measurement
- L4-7: the sentence sounds a bit clumsy: "simultaneous production of VV and jets allows for measurement of jets associated with VV" which is kind of obvious but probably not what you want to say. Would a following change make sense? "Measurement of the associated production of jets and vector boson pairs gives insight into the vector boson scattering processes and probes the quadratic gauge couplings [1]."

-It would make the description in the first paragraph clear, if some examples (Feynman graphs) showing one VBS and a QCD process with the same final state could be included.

- L10: has been designed to provide -> provides (intend to test...) since there is no strong statement possible taken the results of the measurement, we can think of a somewhat more modest statement
- L12-18: example of the general comment about order of c.m.s. energies
- L19: no paragraph here.
- L19-20. In particular, the cross sections as a function of jet multiplicity are measured, providing important tests of QCD corrections to ZZ production. (repeating "as a function" twice (following sentence) is absolutely ok, you measure many distributions)
- L20: ... and important test of the QCD corrections to ...
- L23: The study of the  $m_{jj}$  distribution ...
- L26-27: are any QCD+EWK predictions at fixed order you can compare to (MCFM) ?
- L26: analysis -> analysis

### 3. Signal and background simulation:

- L71: could you please remove "to statistically remove experimental effects from the data distributions" or reformulate it? Probably you want to say that you use unfolding to correct for detector effects and model bias (not for "experimental effects").
- L78: you write explicitly "NLO in QCD" because there is the LO EWK contribution?
- L78: 1 jets -> 1 jet
- L80: "at both 8 and 13 TeV datasets" -> rephrase
- L84: MCFM v7.0 for 13 TeV?

- L92: For 8 TeV dataset -> for the 8 TeV dataset

#### 4. Event selection:

- general: a few subsections would help the reader
- 2nd paragraph: related to general comments on reference... unclear whether you repeat here the method or not (which would be preferable for readability)
- L106 Suggest removing "loosely" since it is not specified what it means
- L108: sub-leading lepton -> mention again "sub-leading electron (muon)" for clarity
- L109: dielectron and dimuon triggers require that the tracks corresponding to the leptons originate from within 2 mm of each other along the beam axis. -> is this also the case for the opposite flavour triggers? if so, replace "dielectron and dimuon triggers" with "dilepton triggers".
- L111: isolation request -> isolation requirement
- L112: 27 GeV and 22 GeV -> 27 GeV and 22 GeV respectively
- L112: help increasing -> help to increase
- L116: mention particle flow, or is that considered jargon?
- L119: Due to pileup the selected event can have several ...
- L201-210: give numbers for specific background contributions, maybe a table would be useful?
- L121 and L123: primary vertex and primary pp interaction vertex -> please use one definition consistently
- L123: mention anti-kt and cone size radii already here
- L139: "small energy deposits" sounds vaguely defined, rephrase as "taking into account the compatibility of the energy deposits in the calorimeter by a minimum-ionizing particle"?
- L140-141: in relation to Tab. 2 (4 pages later) there are several inconsistencies (muon range, pt cuts, 8/13 TeV, ...) Please check.
- L143: the "impact parameter significance" does not seem to be defined. Could a reference be added, or a definition be given?
- L145-154: references to other analysis using the same isolation (indeed, it is quite standard at CMS, but as far as we know, there is no standard reference to it)
- L149-150: suggestion of rephrasing: "the contributions of neutral particles from pileup to the surrounding activity of the leptons is referred to as  $p_T^{\text{PU}}$ . It is obtained with different methods for electrons and for muons: for electrons ...; for muons..."
- L155: tag-and-probe
- L156: the correction happens with a scale factor? the formulation sounds as if the absolute efficiency from data is applied to MC, perhaps a better formulation is possible?
- L162: lepton -> lepton
- L161-162 can this be moved to the description of the isolation in L145-154?
- L163-165: put the jet description at only one place (see L123)
- L160: "an" algorithm?
- L173: ... are extracted from the data ..
- L179-180: (second) highest? why not (sub)leading? is there a difference?

maybe better use standard phrasing

## **5. Background estimation:**

- first paragraph: the largest sources (and replace "or" by "and")
- L201: remove "However"
- L208-209: see general comments about references (here it could be enough to say "this reference...")
- L213-214: uncertainties on these numbers?

## **6. Systematic uncertainties:**

- L216-218: unfolding was not described yet
- L227: the contribution -> the uncertainty contribution
- L233: increases with the jet multiplicity as well?
- L236-237: the unfolding procedure hasn't been described up to this point
- L245-246: both directions, systematic uncertainty source
- L246: systematic uncertainty contribution
- L260: Due to the limited number of events ...

## **7. ZZ + jets differential cross section measurements:**

- general (L321): the statement on the overall agreement seems not justified, as otherwise statements are made that very few predictions are actually describing well the measurement
- Tab. 2: it should come in the event selection + muon coverage is likely wrong (muon chambers go only up to 2.4, or are you using tracker muons?)
- all figures: add "anti kt ( $R = 0.x$ )", especially relevant here where different cone size radii are presented simultaneously
- Figure 1: the hatched band indicate -> the hatched band indicates, with data driven method -> with a data driven method, legend: Syst. -> syst. unc.
- L282: The uncertainties include also -> The uncertainties also include
- L297-298: yielding a lower uncertainty with respect to the non-normalized case causing a lower uncertainty with respect to the non-normalized case -> yielding a lower uncertainty with respect to the non-normalized case
- L304-308: In the data, jets tend to have a lower  $p_T$ -value than in the simulations and therefore, on average, they are less likely to pass the 30 GeV threshold, thus increasing the number of events with no jets. The observation of fewer events than expected with at least one jet can be ascribed to a softer distribution of the transverse momentum of the hadronic particles recoiling against the diboson system. -> Second sentence seems redundant.
- L 313: ... at 8 and 13 TeV for  $NN_{jets} \geq 1$  as functions of ...

## **8. Summary:**

- L328: a space between 3.59 and (19.7)

- L334: "most recent version" -> give version number
- L336: measurements -> measurements

**References:**

- 8: doi: 10.1016/j.physletb.2017.10.020