

# US ATLAS SUPER

Trigger rate predictions in the ACR  
& VBF+ $\gamma$   $H \rightarrow$ invisible analysis



University of  
Pittsburgh



Nick Felice\*  
Ben Carlson  
Joerg Stelzer  
Tae Min Hong



August 10, 2020

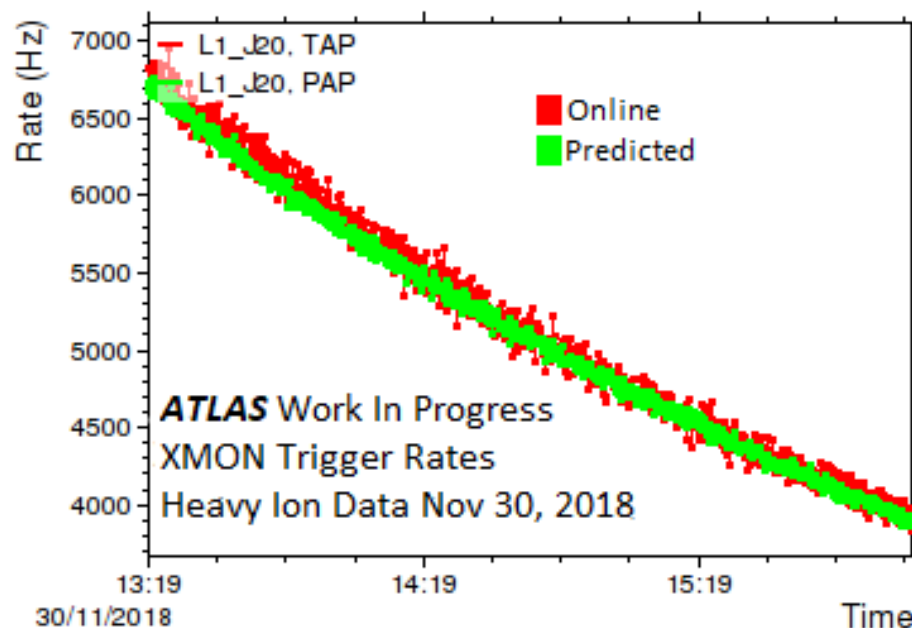
<https://indico.cern.ch/event/932415/>



- Xmon Trigger Rate Prediction Adapter
  - What is it?
  - Example of Xmon in action
  - Run-3 Updates
  - Testing
- VBF+ $\gamma$ H $\rightarrow$ invisible Analysis
  - Intro
  - Yields
  - $W\rightarrow e\nu$  Study
  - 7-point Scale Variations
  - Dark photon analysis



- Main feature: provides luminosity-based **trigger rate prediction** to compare to the **trigger rates online** (see figure)
- Helps monitor & diagnose problems real-time (example given in next slide)



Plot from Trigger Rate Presenter (TRP) that shifters and experts use at P1

Xmon on Git: <https://gitlab.cern.ch/atlas-tdaq-software/TRP/-/tree/master/predadapter/src>

Twiki documentation: <https://twiki.cern.ch/twiki/bin/view/AtlasProtected/PittXmonDoc>  
<https://twiki.cern.ch/twiki/bin/view/AtlasProtected/PittXmonNews>

# Xmon in action (example)

Nick Felice



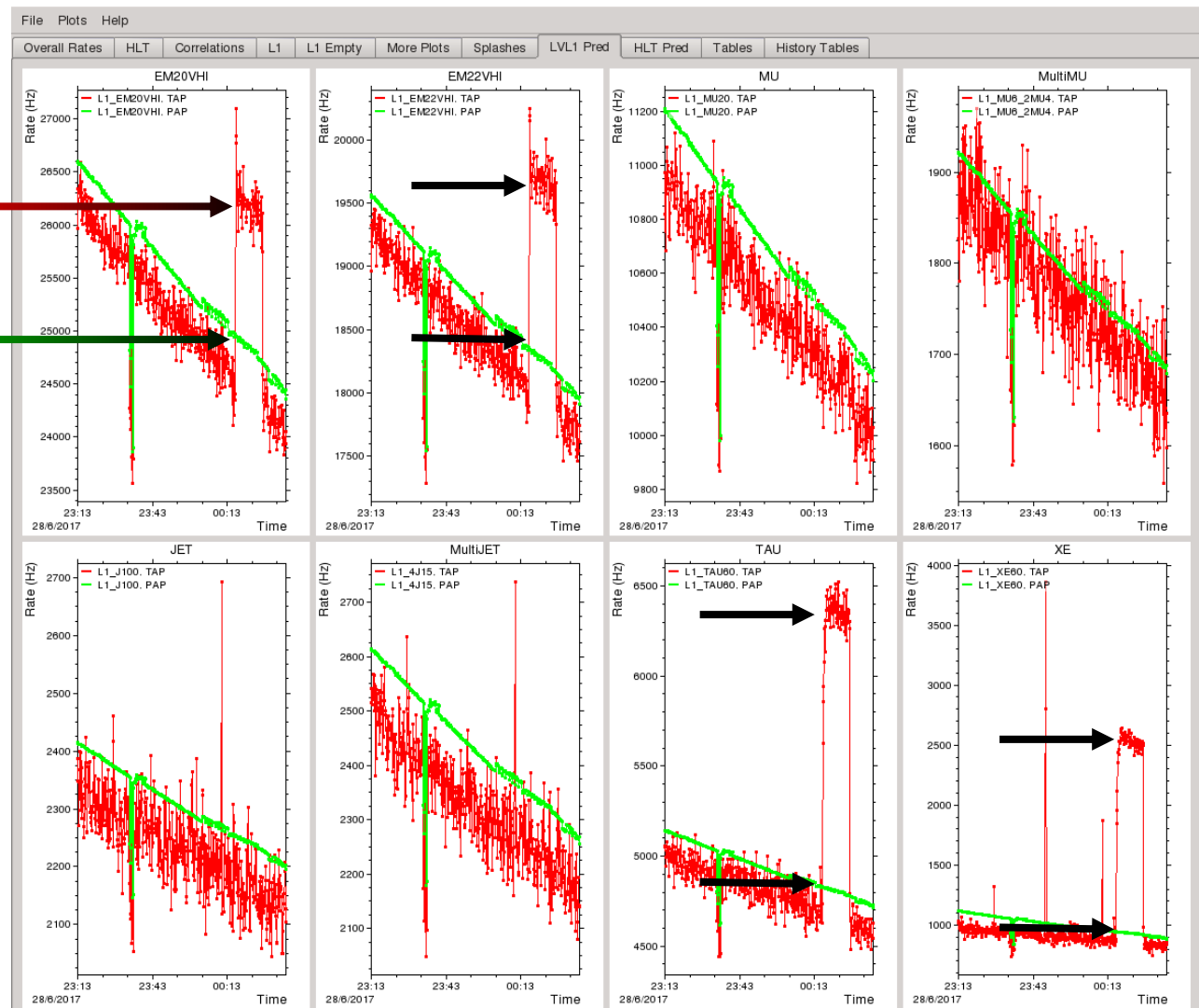
From the Trigger Shifter in the ACR

2017-06-29 00:43, <https://atlasop.cern.ch/elisa/display/346209>

Some of L1 trigger rates (EM, TAU, XE) went up and off the reference for a short period of time ~10 min, screenshot attached.

Observed rate

Predicted rate



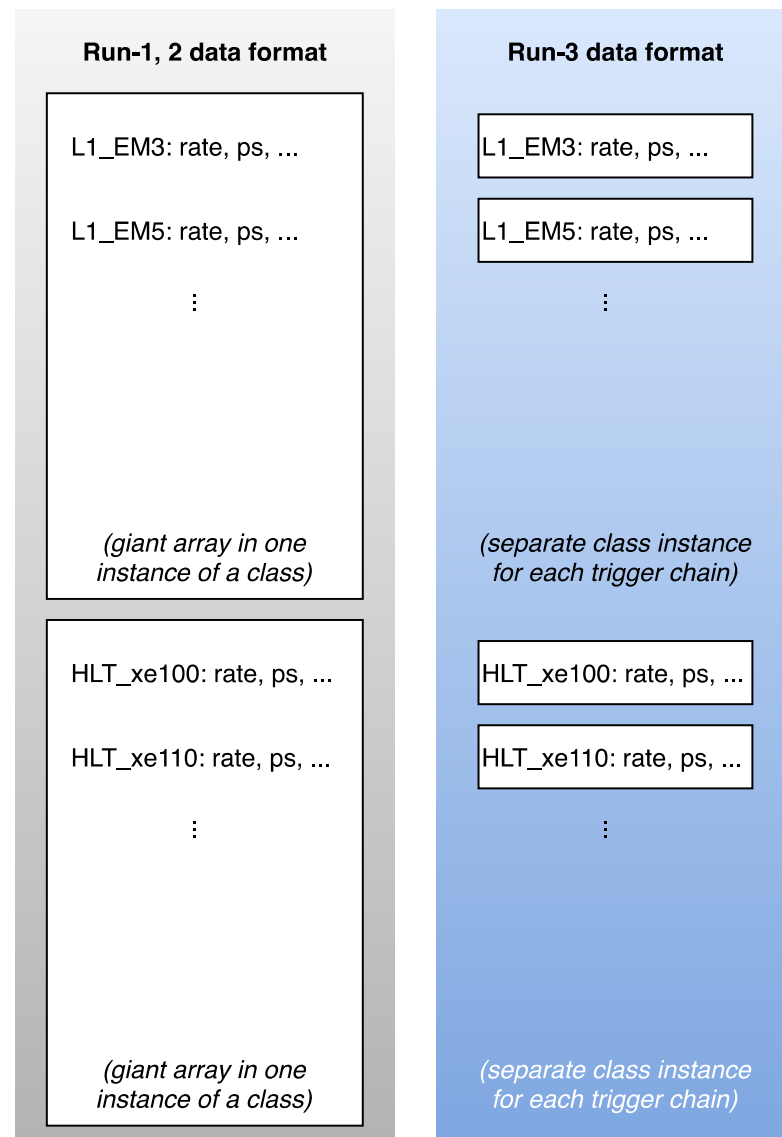


## New data format in Information Service (IS)

- Run-1, 2 (2010 - 2018)
  - Rates are in giant arrays in one instance of class (see left diagram)
- Run-3 (2021 -)
  - Rate information is stored separately for each trigger (see right diagram)
  - Allows for faster access time and less data transmission when accessing only a few triggers

## New Xmon publishing format

- Mimic IS structure
  - Rate predictions are published separately for each trigger chain
  - Testing & Integration (next slide)





## Test bench

- Test bench
  - Developed for testing outside of P1 on Ixplus
- Playback script
  - Gets previous run data from PBeast, then feeds it into an IS server (see below)

## Testing history

- Done
  - Tested during Technical Run (TR9)
  - Tested updated data format on test bench
- Pending
  - Further testing at Point-1

Name	Type	Modified	Description
L1_2EM10VH	L1_Rate	16/7/20 23:59:24,815351	The class responsible for
L1_2EM12	L1_Rate	16/7/20 23:59:24,855836	The class responsible for
L1_2EM15	L1_Rate	16/7/20 23:59:24,815620	The class responsible for
L1_2EM15VH	L1_Rate	16/7/20 23:59:24,815751	The class responsible for
L1_2EM15VHI	L1_Rate	16/7/20 23:59:24,849878	The class responsible for
L1_2EM20VH	L1_Rate	16/7/20 23:59:24,854911	The class responsible for
L1_2EM3	L1_Rate	16/7/20 23:59:24,815077	The class responsible for
L1_2EM3_VTE50	L1_Rate	16/7/20 23:59:24,861339	The class responsible for

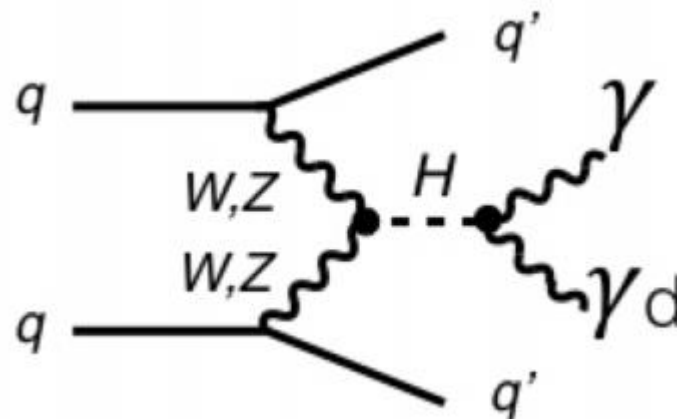
Value	Type	Name	Description
24855,5	Float	TBP	TBP
457,8987	Float	TAP	TAP
449,9004	Float	TAV	TAV
50,59993	Float	PS	PS
0,01746726	Float	DT	DT



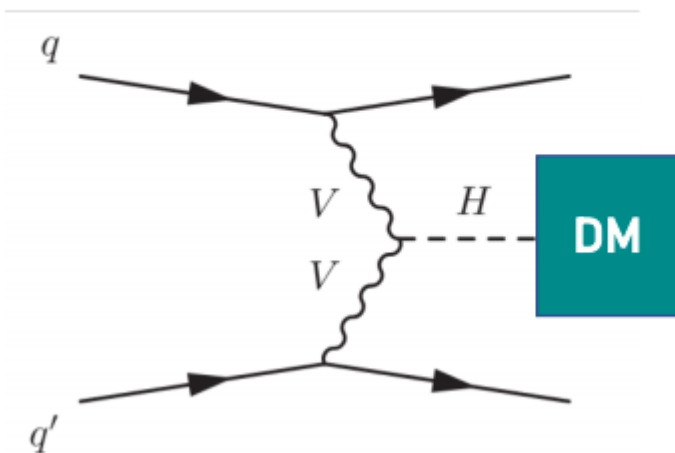
- Xmon Trigger Rate Prediction Adapter
  - What is it?
  - Example of Xmon in action
  - Run-3 Updates
  - Testing
- **VBF+ $\gamma$ H $\rightarrow$ invisible Analysis**
  - Intro
  - Yields
  - $W\rightarrow ev$  Study
  - 7-point Scale Variations
  - Dark photon analysis



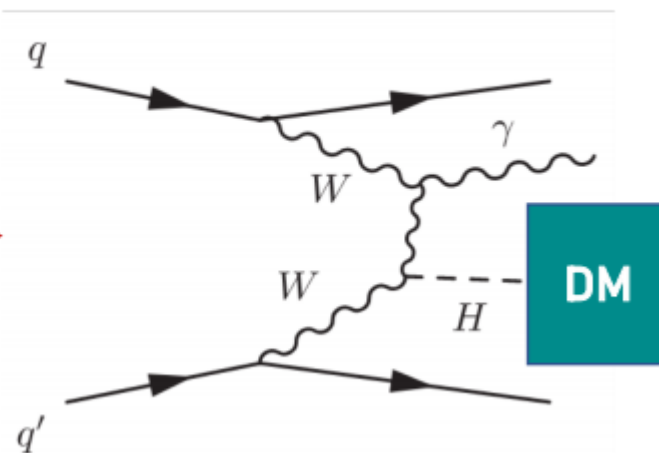
- First search for VBF+ $\gamma$ +H $\rightarrow$ invisible
- Using full Run-2 dataset
- Photon requirement suppresses the background
- Using MET trigger
- Also searching for H $\rightarrow$  $\gamma$ + $\gamma_{\text{dark}}$



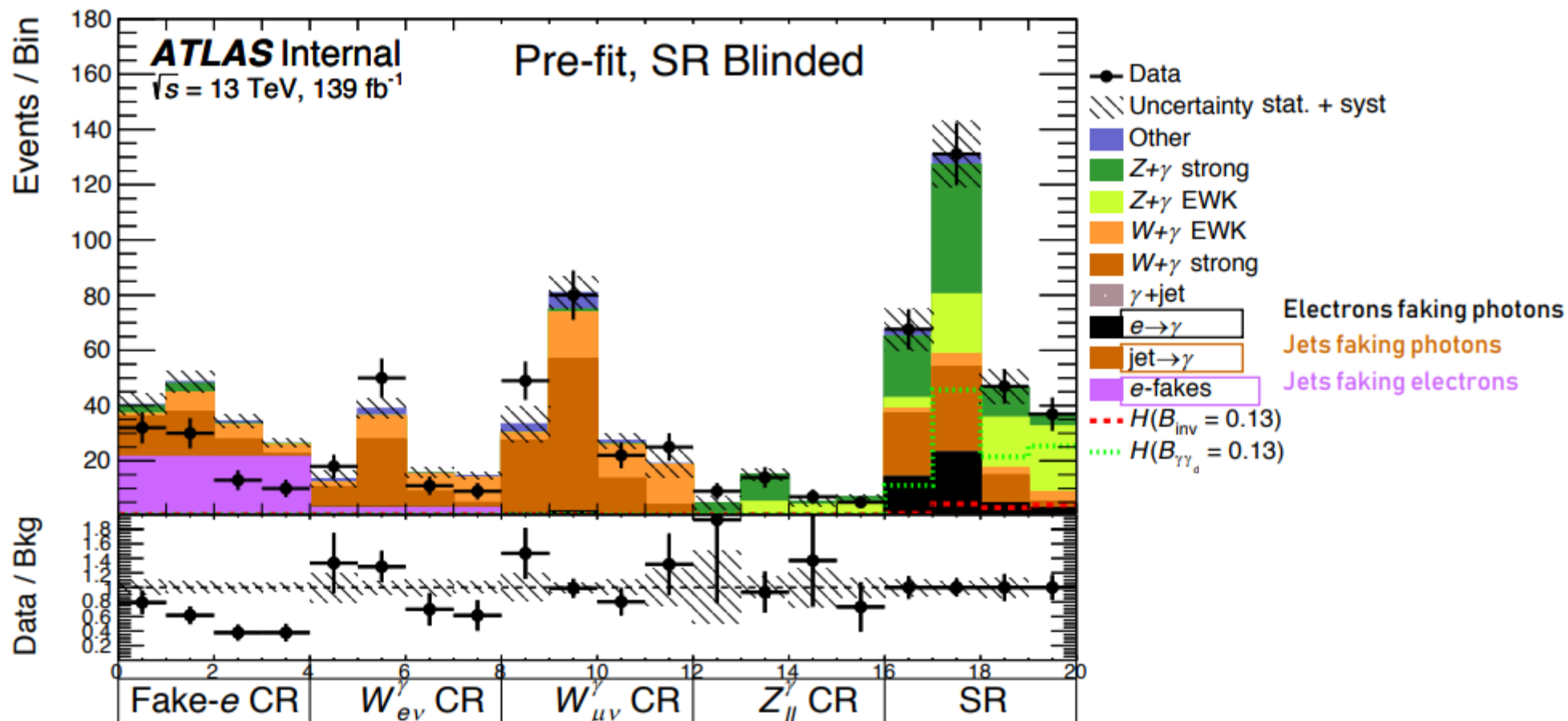
## VBF + MET



## VBF + MET + photon





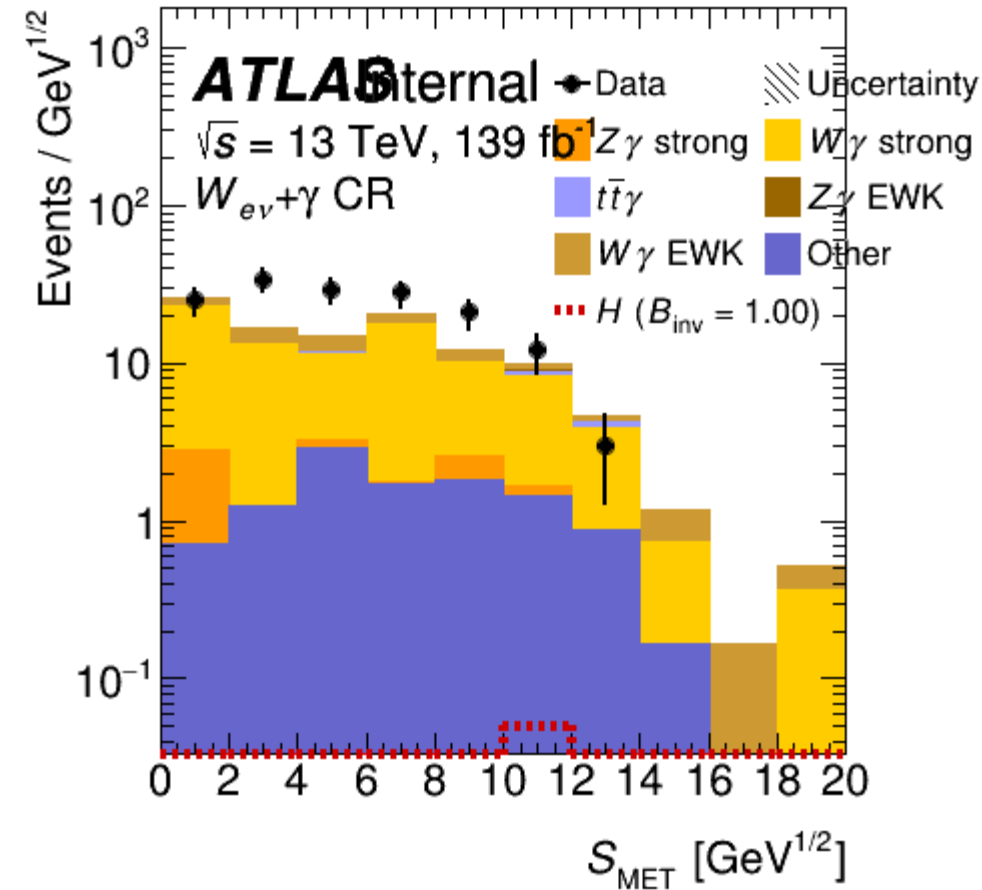
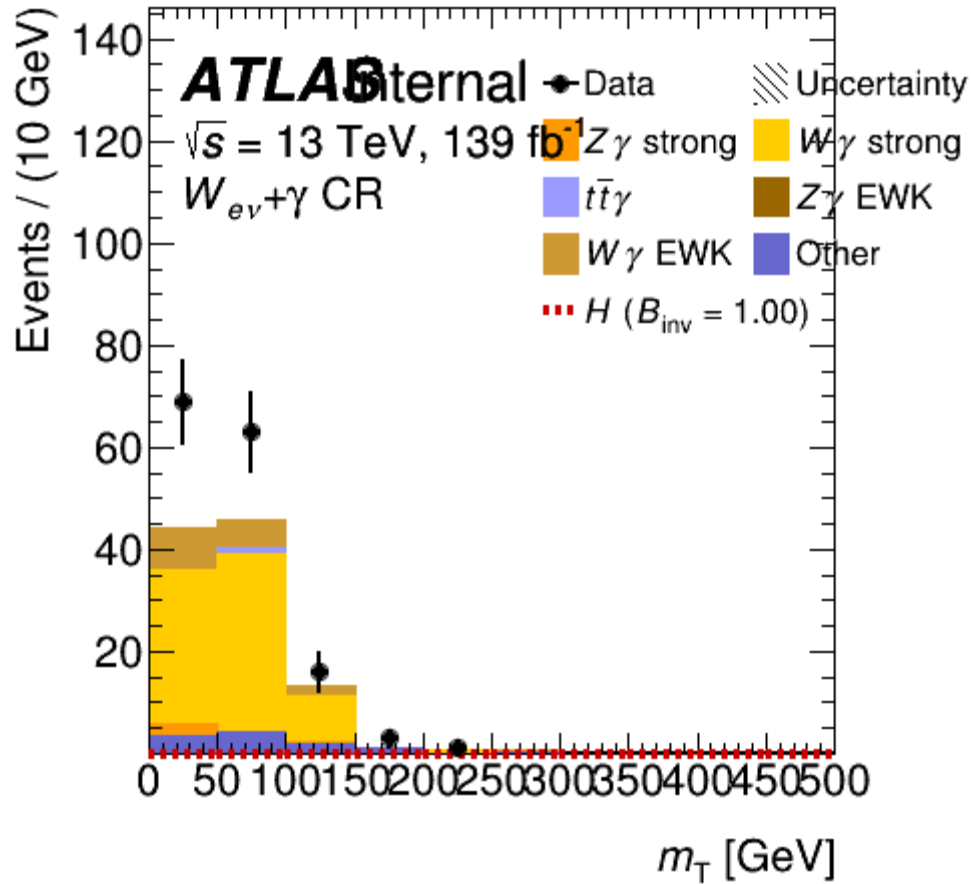


Expected limit of 36% using a DNN, 40% using cut-based approach

[https://indico.cern.ch/event/944029/contributions/3966285/attachments/2085037/3502684/VBF\\_MET\\_ph\\_EB.pdf](https://indico.cern.ch/event/944029/contributions/3966285/attachments/2085037/3502684/VBF_MET_ph_EB.pdf)

# $W \rightarrow e\nu$ Control Region

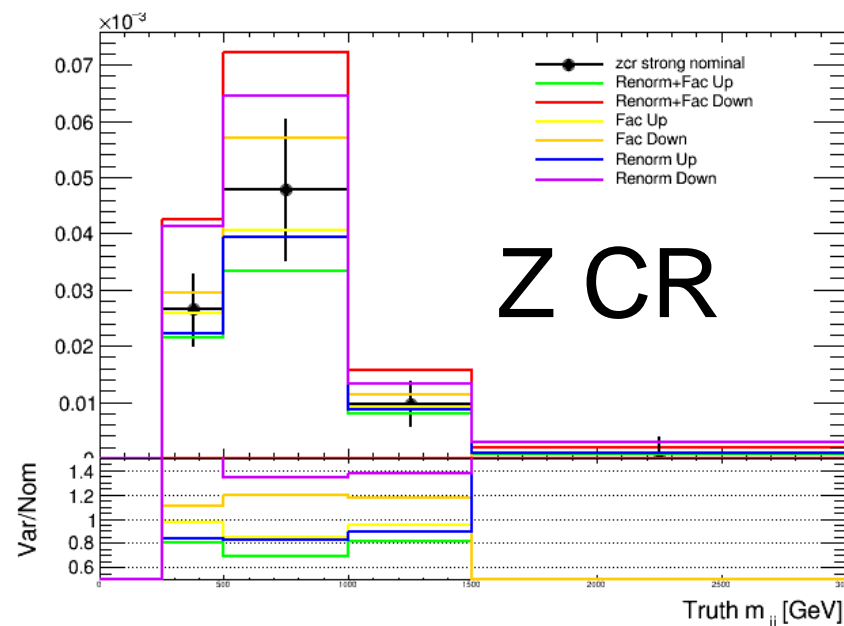
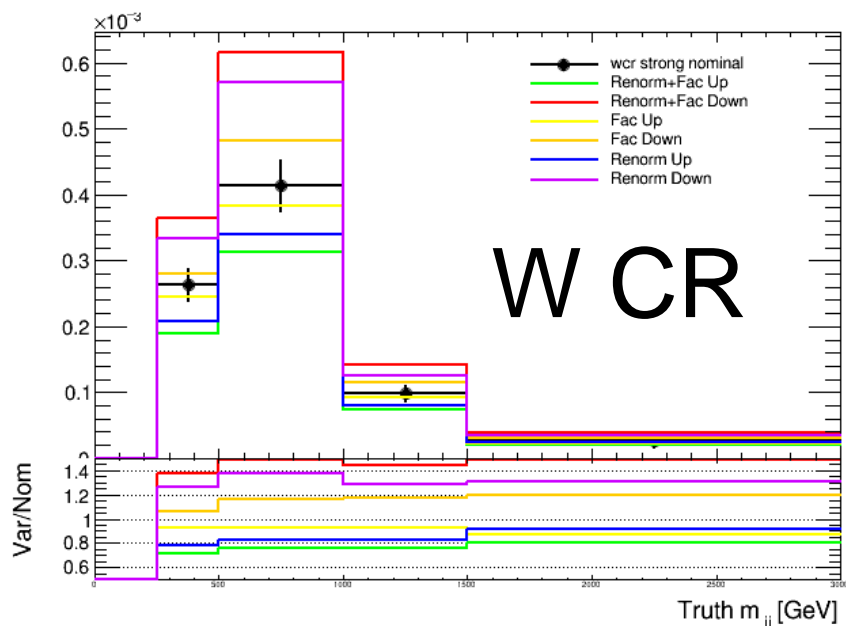
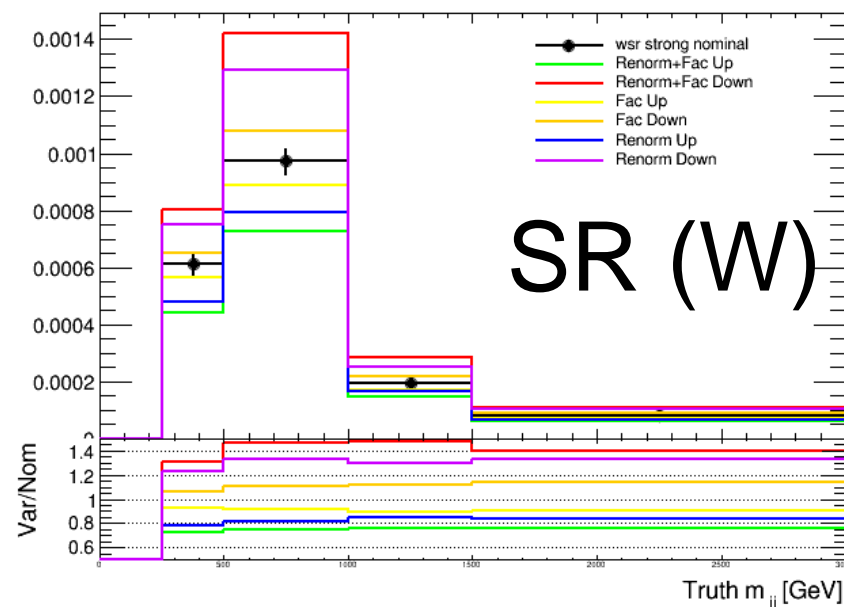
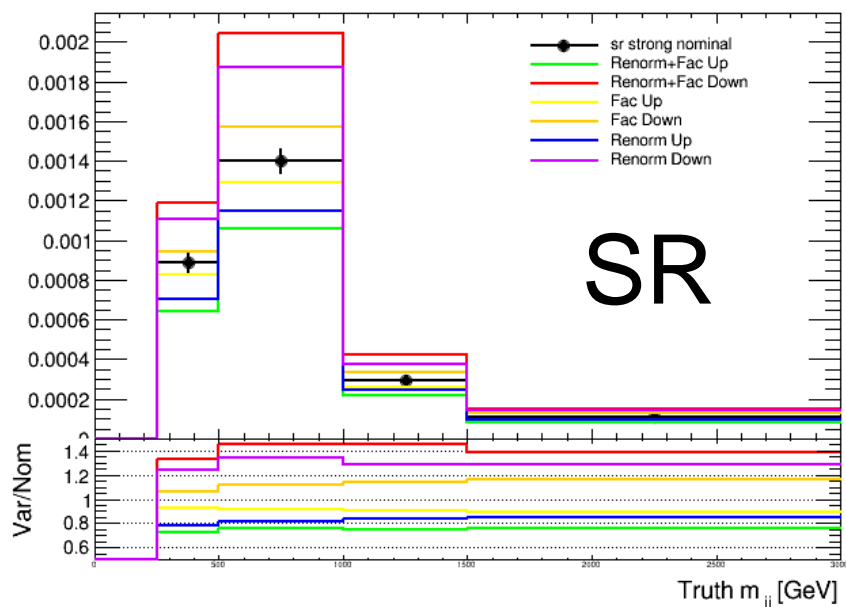
Nick Felice



Excess of events at low  $m_T$  due to electron fakes  
We now have a method to estimate these fakes

# Strong Scale Variations

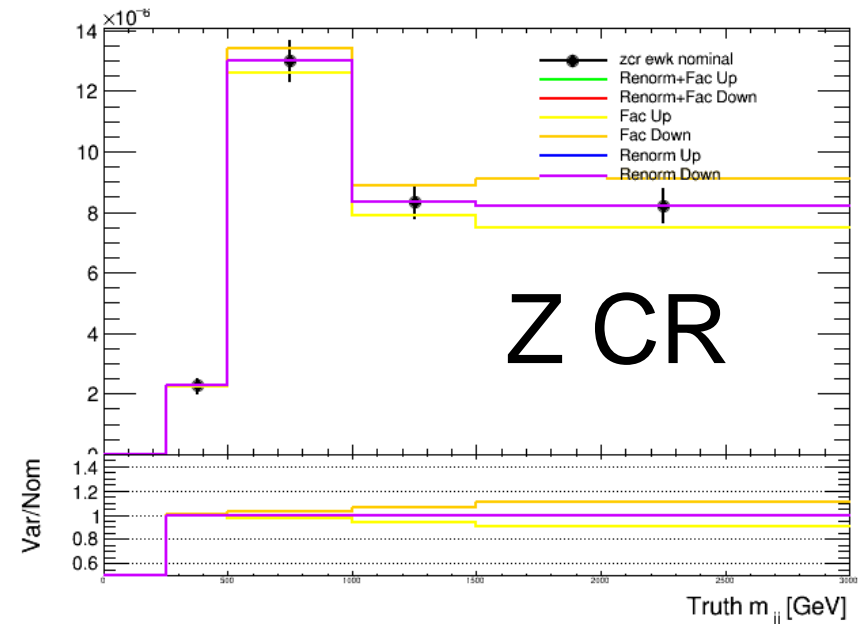
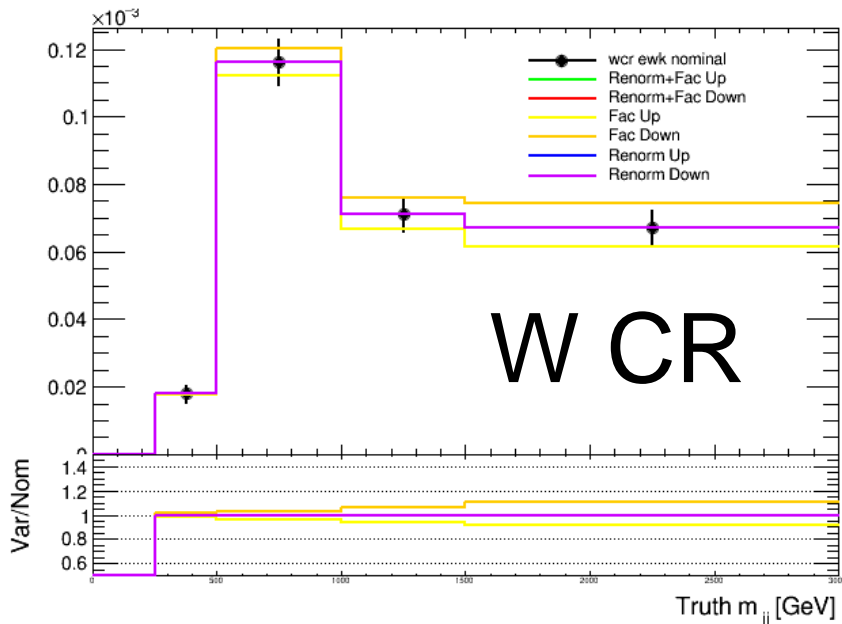
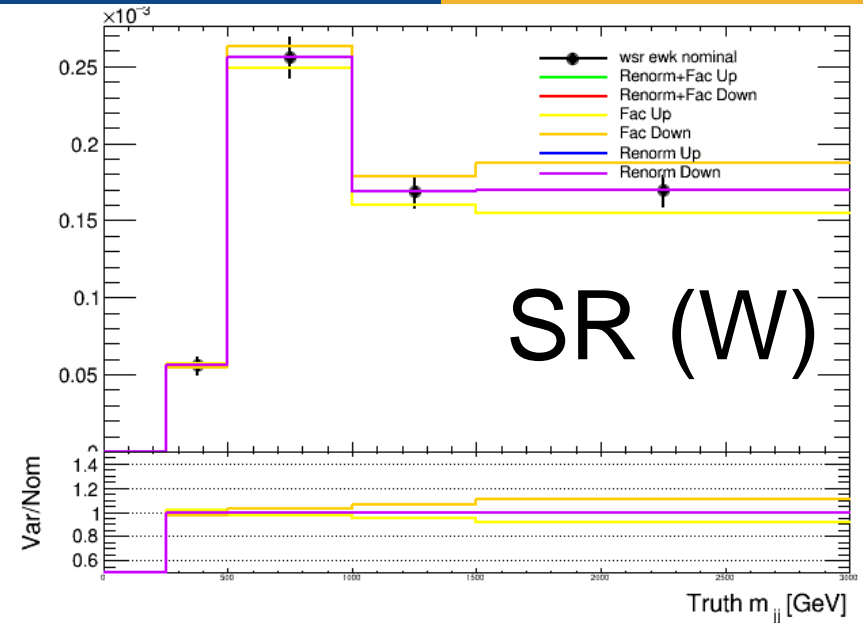
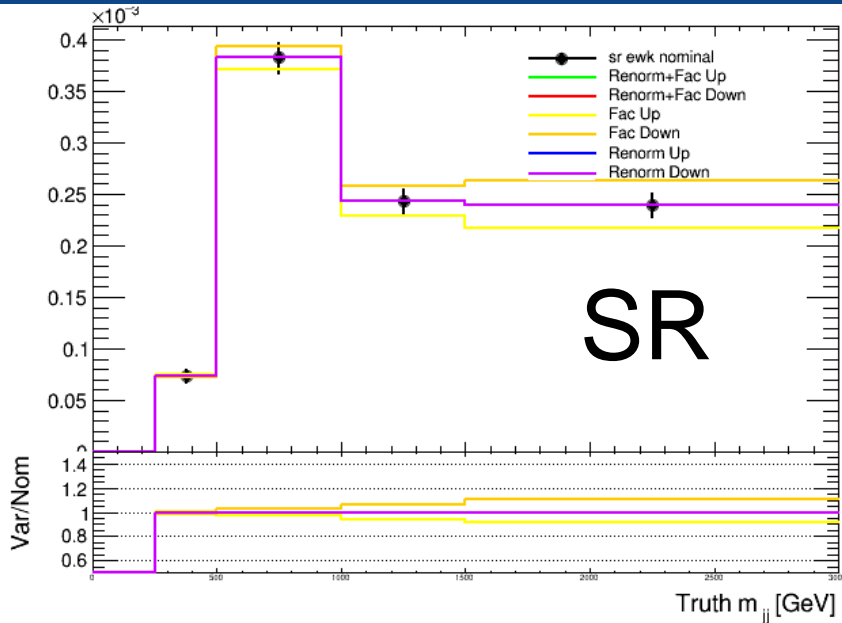
Nick Felice



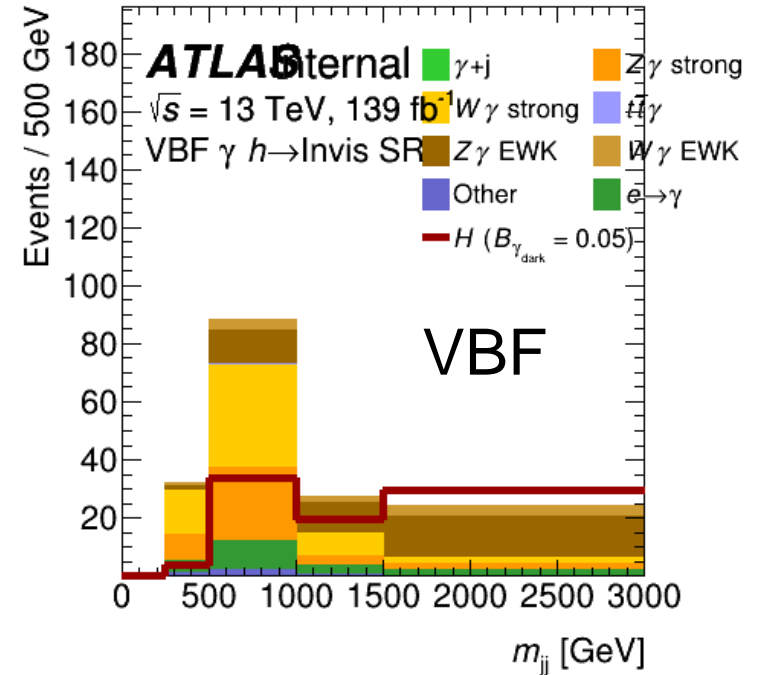
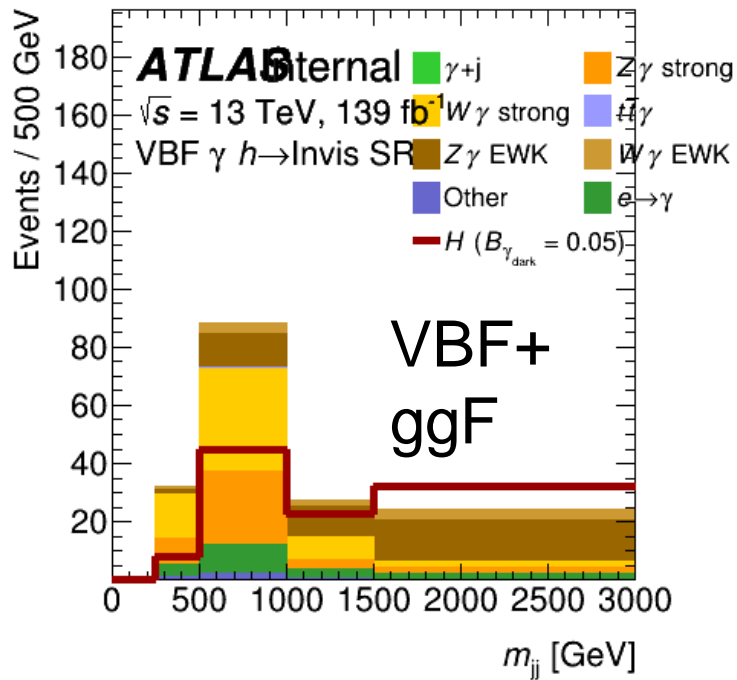
Envelope of scale variations gives uncertainty  
Still developing techniques to estimate the background

# EWK Scale Variations

Nick Felice



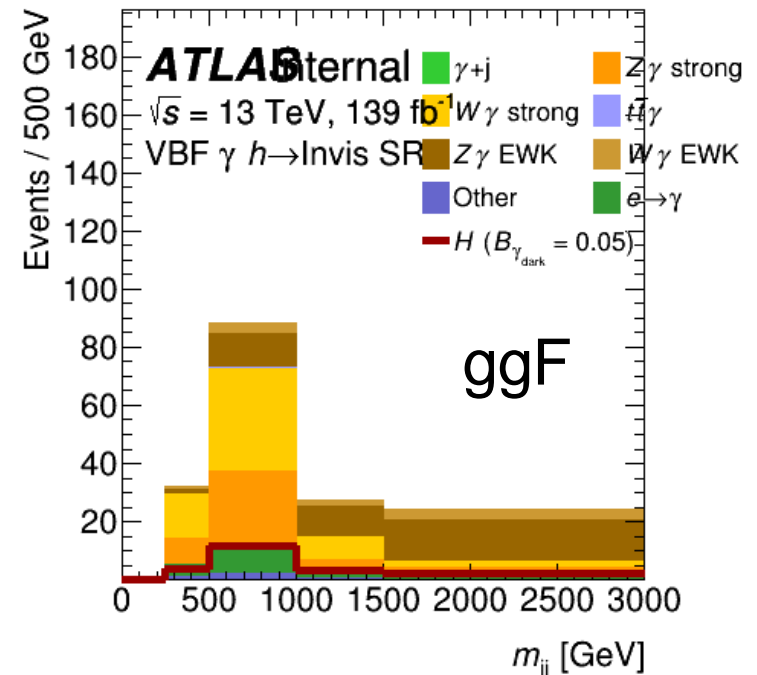
\*Renormalization is 0% for EWK



No  $\Delta\phi(\gamma, \text{MET})$  cut  
 No photon  $p_T < 110$  GeV cut  
 $m_T(\gamma, \text{MET}) > 100$  GeV  
 $m_T(\gamma, \text{MET}) < 160$  GeV  
 VBF+ggF signal above; VBF & ggF separated on right

Back-of-the-envelope limit: 1.2%

CMS: <http://cms-results.web.cern.ch/cms-results/public-results/preliminary-results/EXO-20-005/index.html>





- Xmon
  - Updated to Run-3 data format
  - Tested adapter both inside and outside of Point-1
  - Next: continue with more thorough testing in Point-1
- Analysis
  - Investigated excess in CR at low  $m_T$
  - Calculated scale variations at the truth level
  - Plotted dark photon signal using revised cuts
  - Next: calculate scale variations for  $W \rightarrow e\nu$  and  $Z \rightarrow ee$  CRs and NLO EWK corrections

## • Presentations Given

- Exotics Jet + Dark Matter, March 13
  - [https://indico.cern.ch/event/896434/contributions/3779901/attachments/2003555/3345361/Felice\\_VBFy\\_March13\\_2020.pdf](https://indico.cern.ch/event/896434/contributions/3779901/attachments/2003555/3345361/Felice_VBFy_March13_2020.pdf)
- VBF+MET+Photon, May 8
  - [https://indico.cern.ch/event/917655/contributions/3857521/attachments/2035187/3407109/CarlsonFelice\\_VBFy\\_May8\\_2020.pdf](https://indico.cern.ch/event/917655/contributions/3857521/attachments/2035187/3407109/CarlsonFelice_VBFy_May8_2020.pdf)
- VBF+MET+Photon, May 22
  - [https://indico.cern.ch/event/922163/contributions/3875163/attachments/2043313/3422665/Felice\\_VBFy\\_May22\\_2020.pdf](https://indico.cern.ch/event/922163/contributions/3875163/attachments/2043313/3422665/Felice_VBFy_May22_2020.pdf)
- VBF+MET+Photon, June 5
  - [https://indico.cern.ch/event/926715/contributions/3896611/attachments/2051851/3439384/vbfgamma\\_jun5.pdf](https://indico.cern.ch/event/926715/contributions/3896611/attachments/2051851/3439384/vbfgamma_jun5.pdf)
- VBF+MET+Photon, June 26
  - [https://indico.cern.ch/event/933384/contributions/3921949/attachments/2064645/3464680/Felice\\_VBFy\\_June26\\_2020.pdf](https://indico.cern.ch/event/933384/contributions/3921949/attachments/2064645/3464680/Felice_VBFy_June26_2020.pdf)
- VBF+MET+Photon, July 3
  - [https://indico.cern.ch/event/934939/contributions/3932417/attachments/2068709/3472326/NFelice20200702\\_VBFy\\_RatioPlots.pdf](https://indico.cern.ch/event/934939/contributions/3932417/attachments/2068709/3472326/NFelice20200702_VBFy_RatioPlots.pdf)
- Trigger General Meeting, July 22
  - [https://indico.cern.ch/event/935622/contributions/3944237/attachments/2077914/3489666/FeliceRoche20200701\\_TGM\\_xMonUpdate.pdf](https://indico.cern.ch/event/935622/contributions/3944237/attachments/2077914/3489666/FeliceRoche20200701_TGM_xMonUpdate.pdf)
- VBF+MET+Photon, July 24
  - [https://indico.cern.ch/event/941966/contributions/3958509/attachments/2079625/3492844/Felice\\_VBFy\\_July24\\_2020.pdf](https://indico.cern.ch/event/941966/contributions/3958509/attachments/2079625/3492844/Felice_VBFy_July24_2020.pdf)





## Analysis Cuts:

Cut	SR
$N_{\text{photon}}$	=1
$N_{\text{baseline-lepton}}$	=0
$N_{\text{jet}}$	=2,3
$N_{\text{b-jet}}$ (77% WP)	<2
$p_T(j_1)$	> 60 GeV
$p_T(j_2)$	> 50 GeV
MET	> 150 GeV
MET_CST_jet	> 120 GeV
$\eta(j_1) \times \eta(j_2)$	<0
$\Delta\eta(j_1, j_2)$	> 3.0
$\Delta\phi(j_1, j_2)$	< 2
$\Delta\phi(j_{1,2,3}, \text{MET})$	> 1
abs. $\Delta\phi(\text{MET}, \text{photon})$	> 1.8
Photon Centrality	> 0.4
Third jet centrality	< 0.7
$M(j_1, j_2)$	> 250 GeV
Photon $p_T$	< 110 GeV

## Control Region Definitions

Cut	$W \rightarrow e^- \nu$	$W \rightarrow e^+ \nu$	$Z \rightarrow ee$	$W \rightarrow \mu^- \nu$	$W \rightarrow \mu^+ \nu$	$Z \rightarrow \mu\mu$	MET
Trigger	Single electron			Single muon			MET
Lepton	$e^-$	$e^+$	$e^-e^+$	$\mu^-$	$\mu^+$	$\mu^-\mu^+$	-
$p_T(\ell_1)$	> 30 GeV	> 30 GeV	> 30 GeV	> 30 GeV	> 30 GeV	> 30 GeV	-
$M(\ell_1, \ell_2) - M_Z$	-	-	< 25 GeV	-	-	< 25 GeV	-
MET Significance	> 4 $\text{GeV}^{1/2}$	> 4 $\text{GeV}^{1/2}$	-	-	-	-	-
Veto	any (other) lepton. $N_{\text{baseline-lepton}}=1$ for WCR and $N_{\text{baseline-lepton}}=2$ for ZCR						
Photons	$N_{\text{photon}}=1$						

Note: No transverse mass cut for W events.