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measurement of EWK γjj production with 13 TeV data

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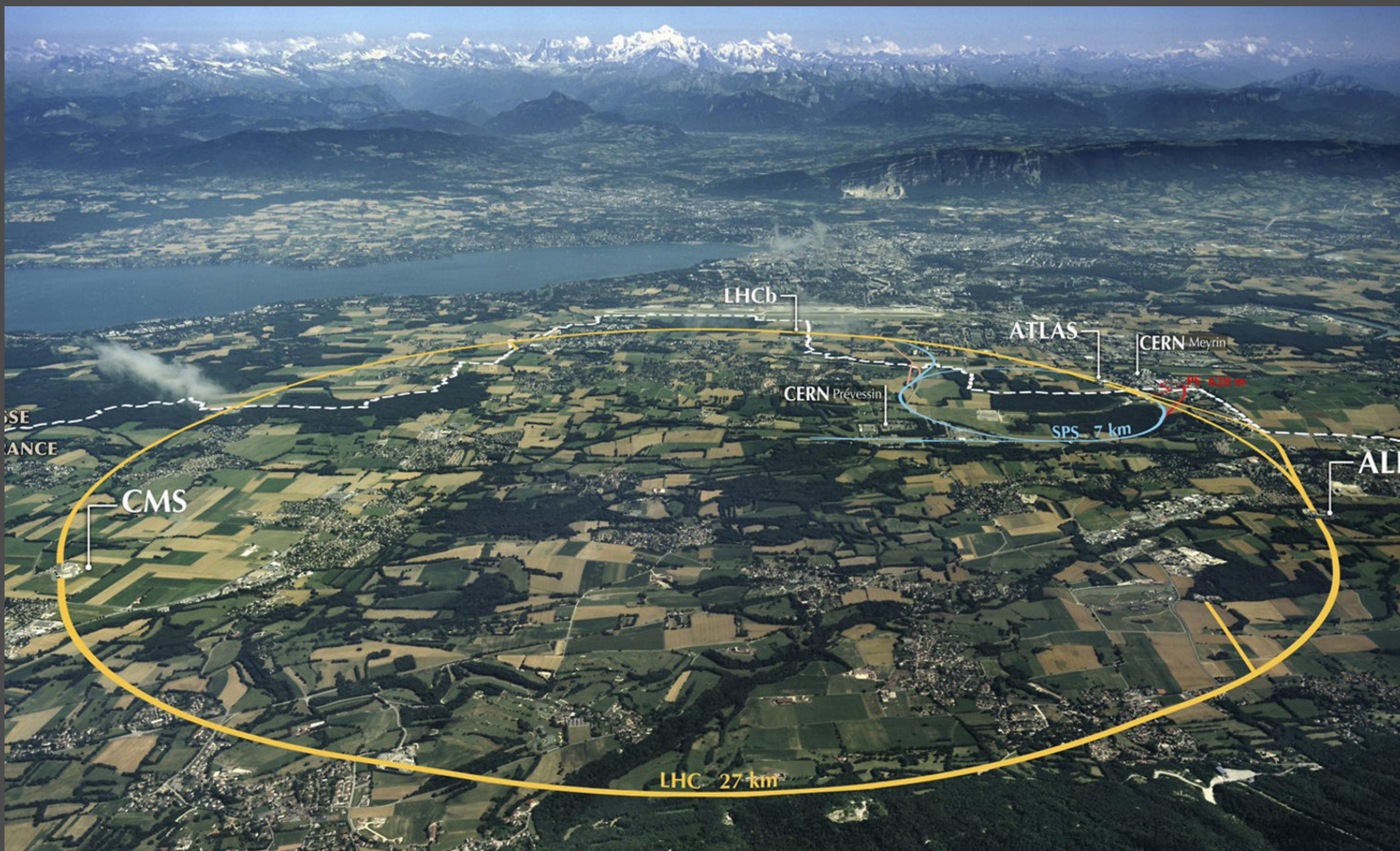
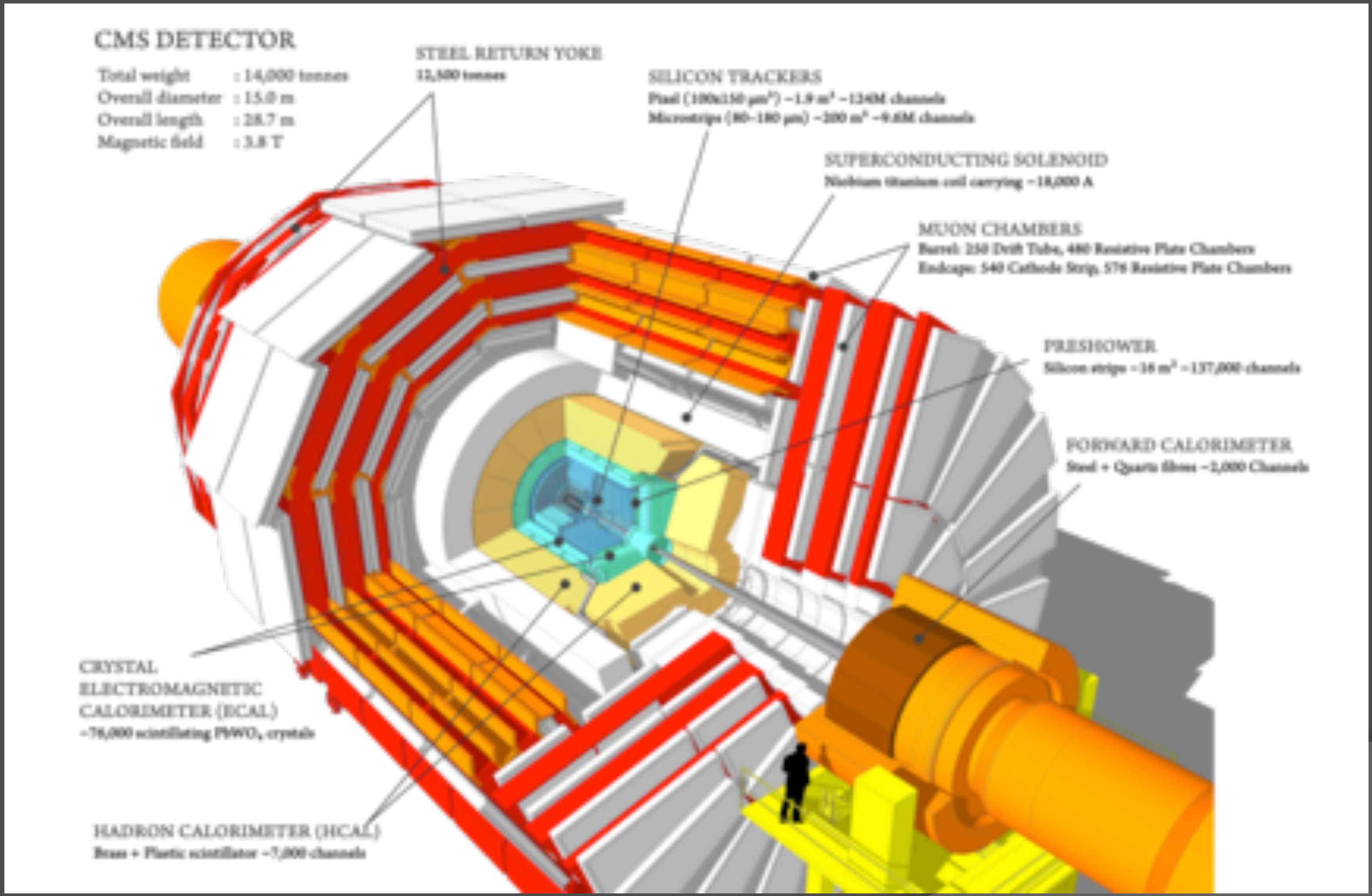
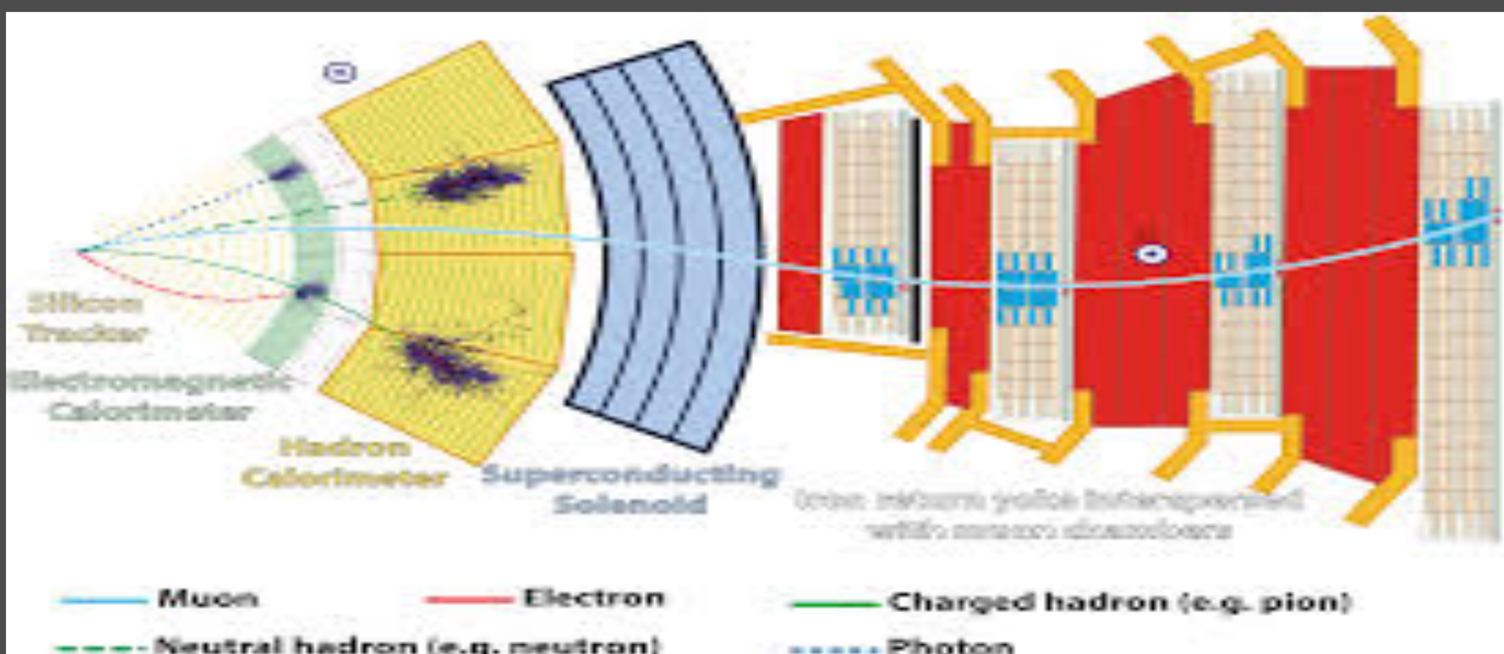
The Large Hadron Collider is the proton-proton collider.



The CMS experiment at the Large Hadron Collider



- The CMS detector is designed to measure and detect particles based on their interactions with detector materials. CMS consists of many layers of silicon as tracking system, an electromagnetic calorimeter, a hadronic calorimeter and a muon system, within an onion-like design. Every layer takes a cylindrical shape in which the components parallel to the beam line are called the barrel regions, and components closing the detector on both sides are usually referred as the endcaps.

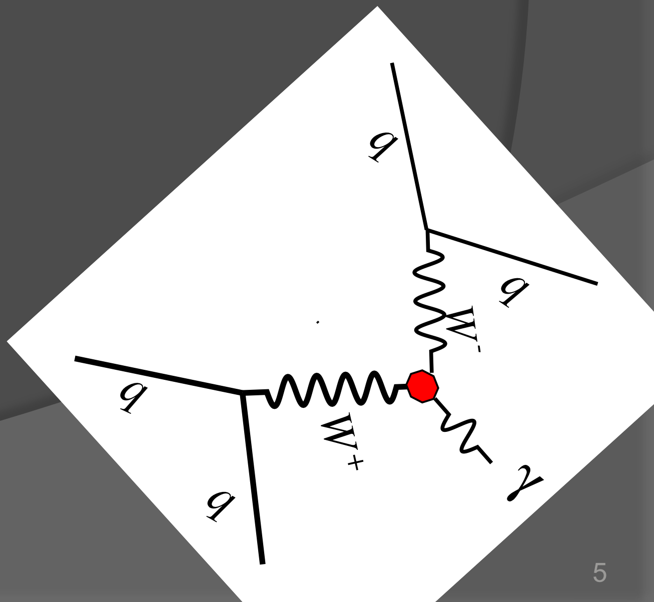


VBF event topology

- VBF in p-p collision (vector-boson fusion) topology shows distinct signature
  - Two forward jets come from two intial quark
  - reduced jet activity in central region
  - two tagging jets in forward region

VBF γ

- Photon between tagging jets



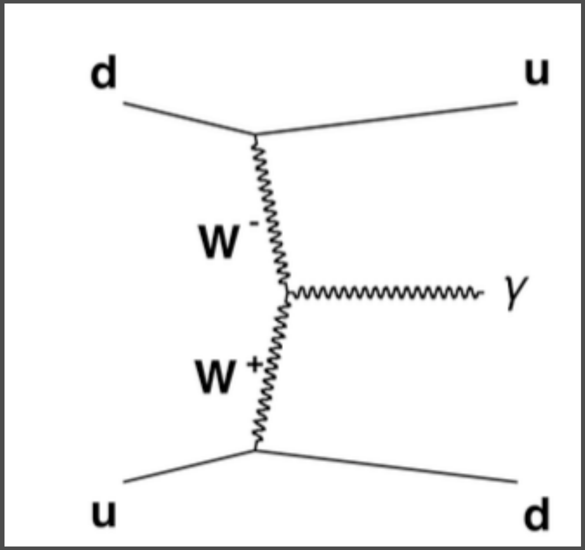
Motivation for this measurement

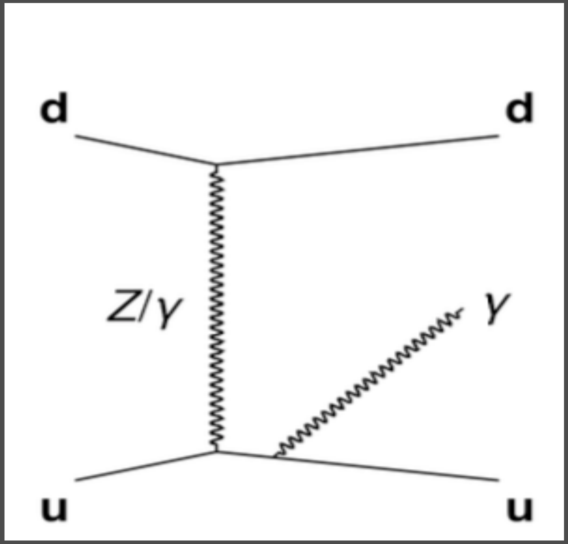
- First observation: final piece to complete set of EWK Vjj measurements
- It has higher cross section with respect to EWK Zjj
- Similar colour structure to VBFH

EWK signal γjj production

The signal is generated with MadGraph with all tree-level electroweak contributions to the γjj final state.

The most relevant diagram for signal, EW γjj definition is:

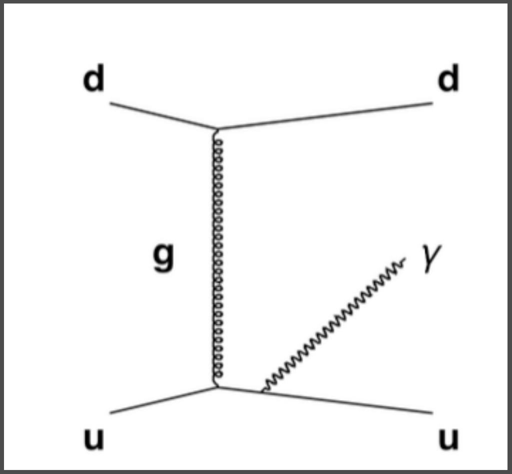


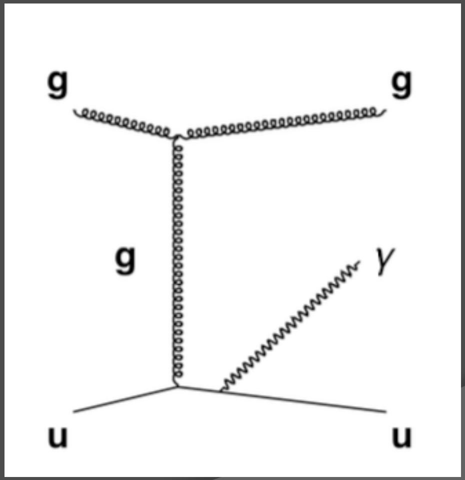


diagrams with identical final states contributes, and it has negative interference so can not be neglect as additional diagrams

Background

- The main background is γ + QCD jets production is modeled by MadGraph.
- Typical photon plus two jets diagrams that produce γjj final states in proton-proton collisions with mixed electroweak and QCD interactions :



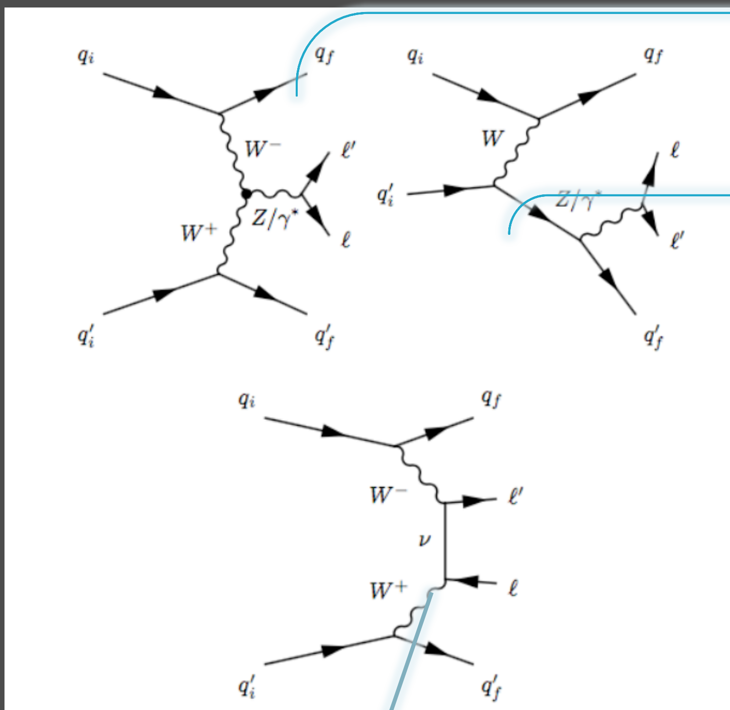


Control region

- We use another process to improve our modeling for backgrounds.
- This region has same characteristic as our signal region so it is good candidate for estimation of our signal.
  - The production of Z boson in associated with 2 jets in p-p collision is analogue signal of our main signal with same kinematic.
  - Inside this region we have another component which is DY electroweak production of a Z boson in association with two jets processes share the same final state of two jets and two leptons which are decay products from a Z boson.

Control signal and background diagrams

Z->ll signal

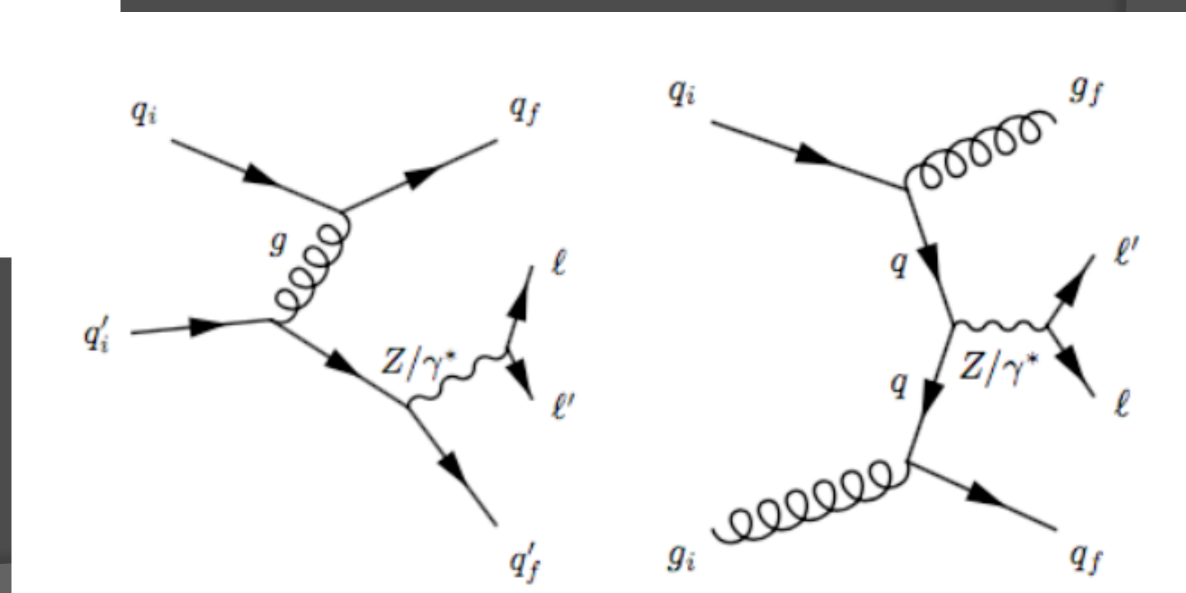


vector boson fusion

bremsstrahlung-like

multiperipheral production.

DY background



Data and trigger

- The proton-proton collision data of 2016 and 2017 are used for this analysis with integrated luminosity of 35.8 fb^{-1} and 41.4 fb^{-1}.
- Two independent trigger path one is inclusive photon trigger and the other is VBF trigger (photon with two jets) for both year.
- For 2016 (2017) the 75 < $p_T\gamma$ < 175(200) GeV is triggered with VBF trigger path and single-photon trigger is used to selecte events with $p_T\gamma$ >175(200) GeV.

Events selection

- The selections are applied on photons, leptons and jets, reconstructed using the CMs PF algorithm.

- Photon
  - Exactly one central ($|\eta| < 2.4$) photon with pT > 75 GeV
  - Jets
  - At least two jets with pT > 25 GeV and $|\eta| <4.7$, $\Delta R(j,l \text{ or } \gamma)>0.4$

- Muons for Z+jets
  - pT>30 GeV $|\eta|<2.1$ and photons are cleaned from leptons with $\Delta R>0.4$

Event categorization used in analysis

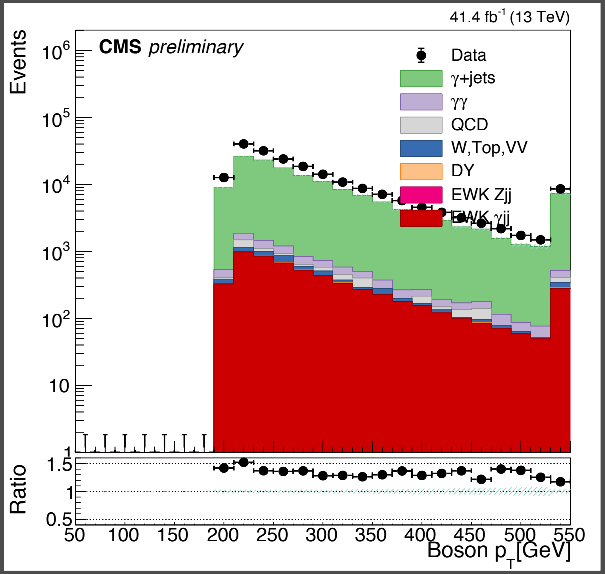
	$75 < P_T(\gamma) < 175(200)$	$P_T(\gamma) > 175(200)$
Mjj>500GeV	LowVPt	HighVPt

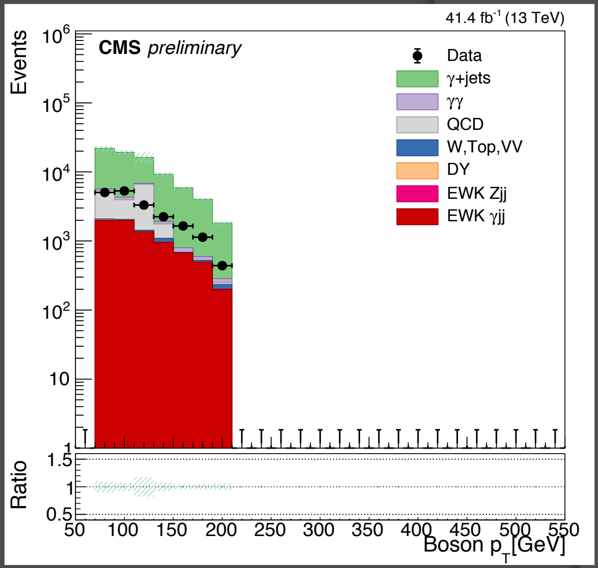
Control distributions – boson p_T

HighVPt

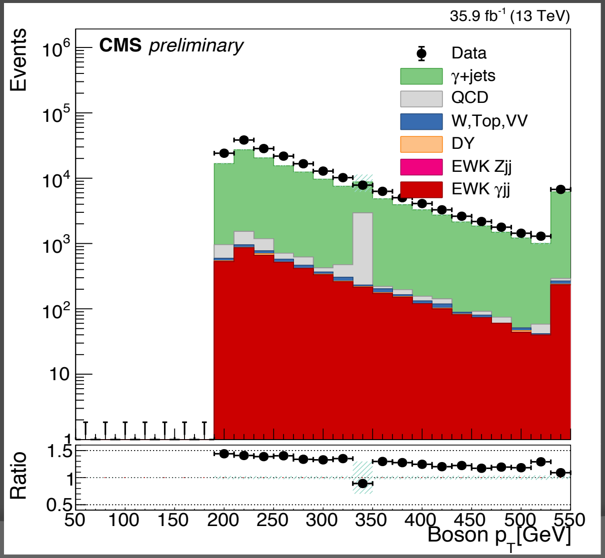
LowVPt

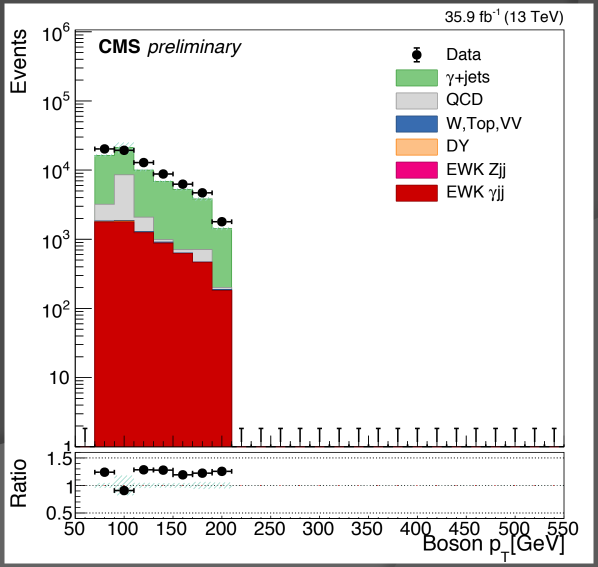
2017





2016

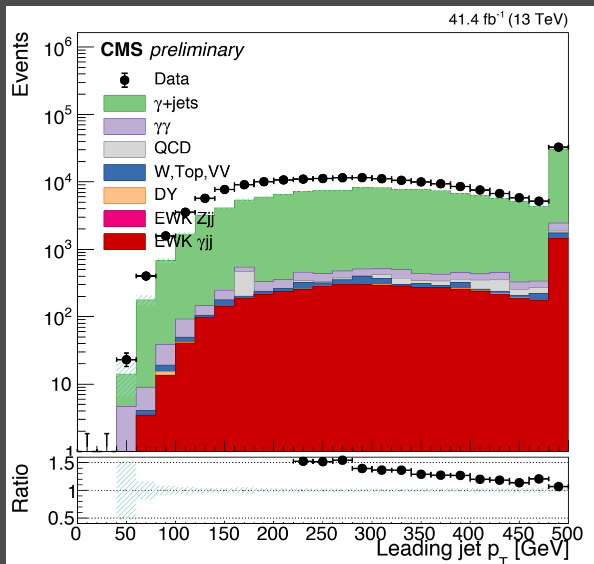


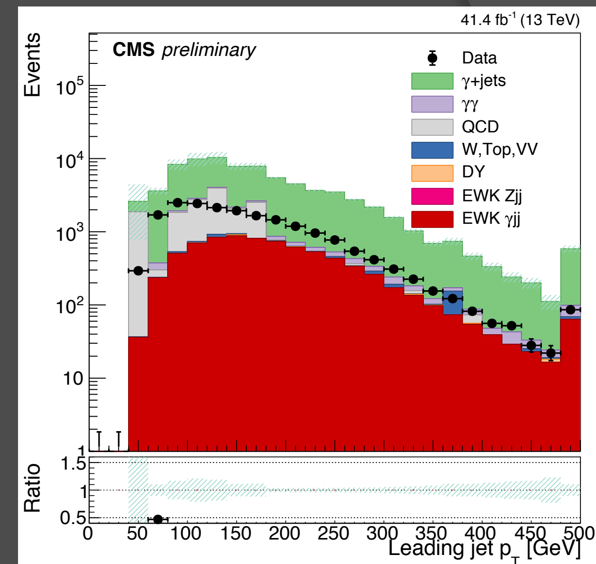


Control distributions – lead jet p_T

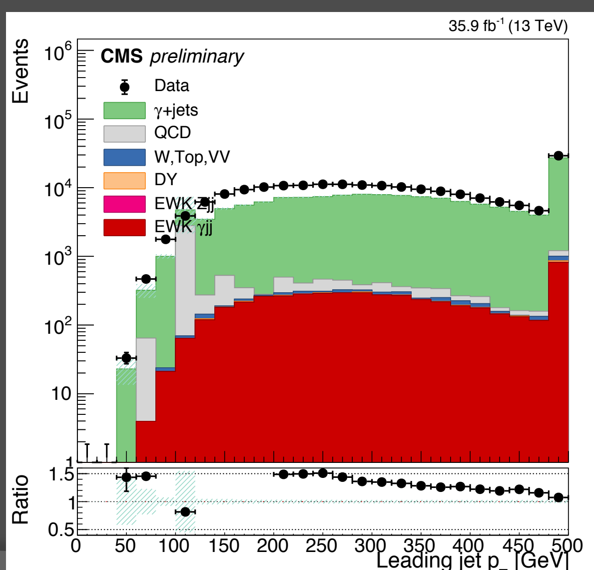
HighVPt | LowVPt

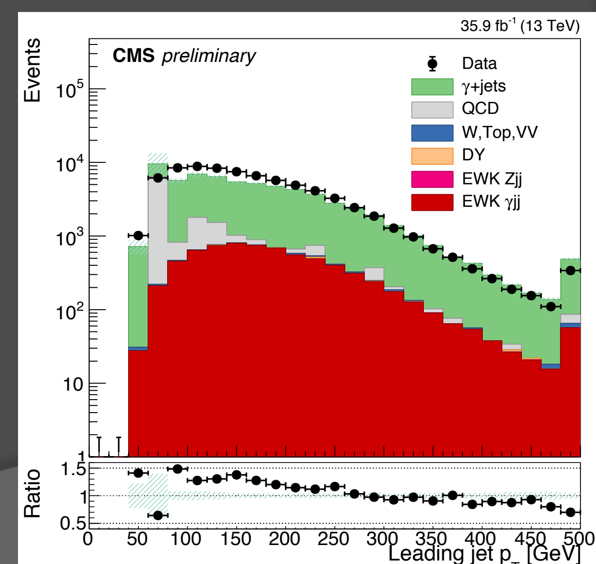
2017





2016

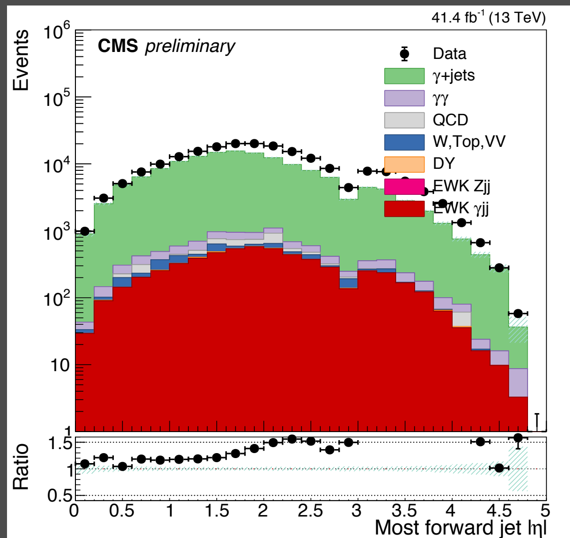


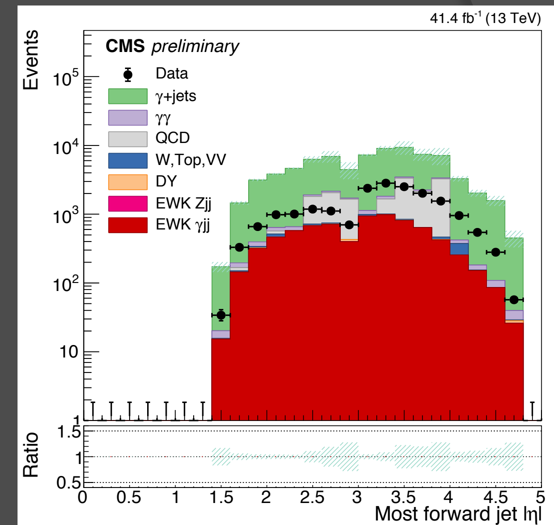


Control distributions – most forward η

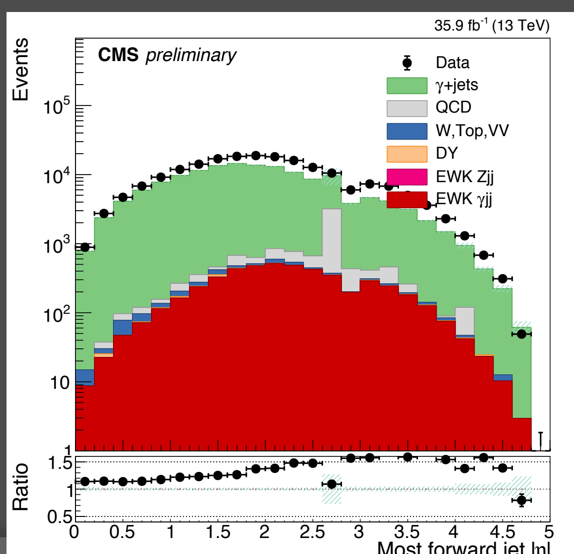
HighVPt | LowVPt

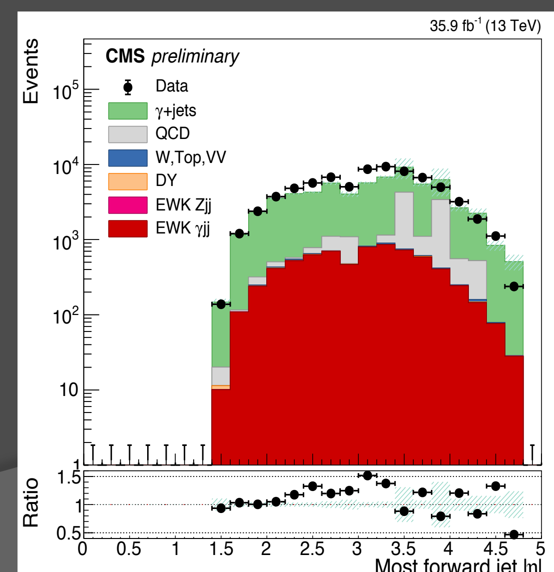
2017





2016



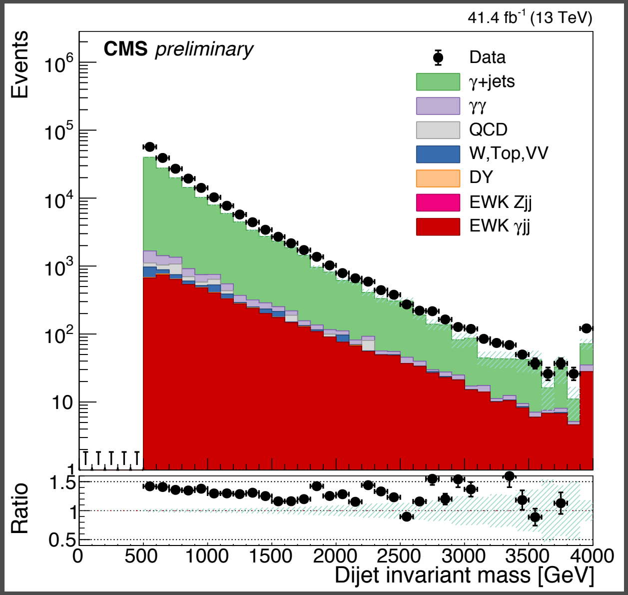


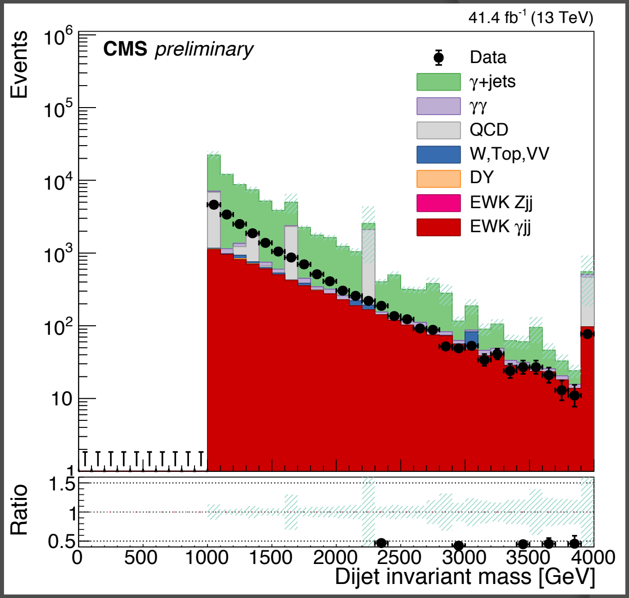
Control distributions – m_{jj}

HighVPt

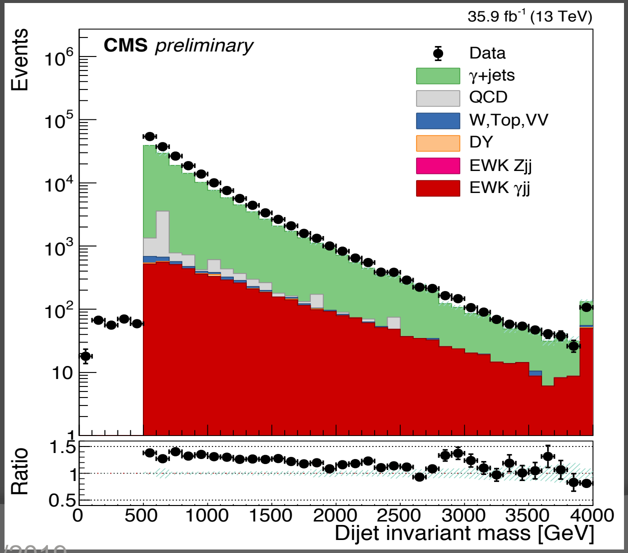
LowVPt

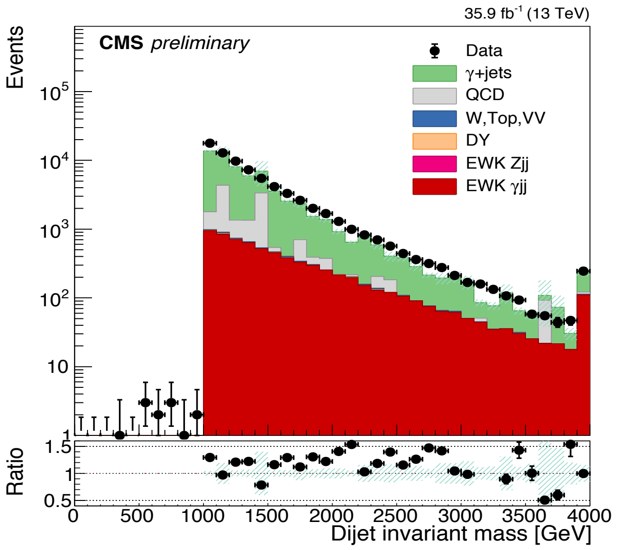
2017





2016



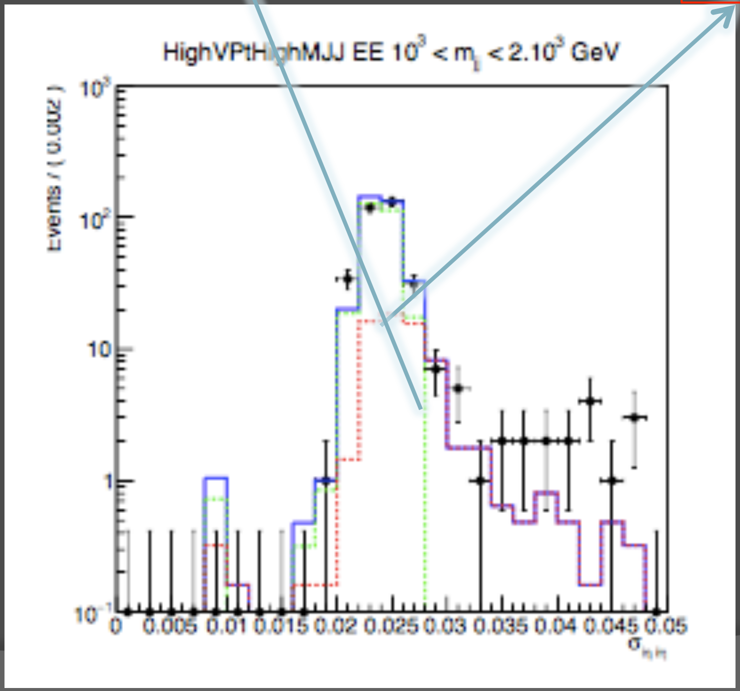


Estimation of other backgrounds

- **Fake rate**
  - fake photons that are mainly high energy jets, with fragmentations of isolated π0 or η hadrons.
  - We use alternative way to reduce this background.

Signal like

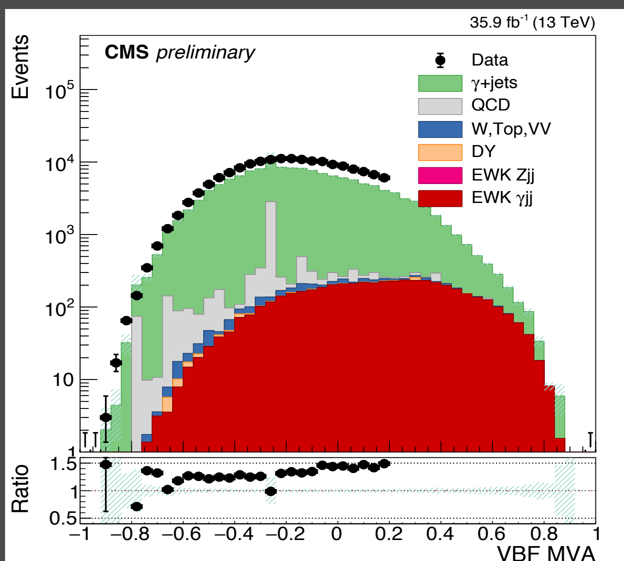
Fake like



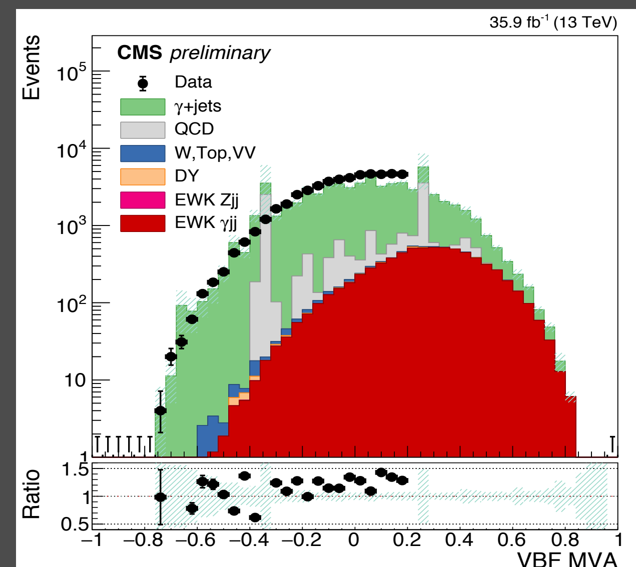
BDT training

- We use Multivariate techniques to separate our signal from backgrounds efficiently.
- **To increase the sensitivity of analysis We train a BDT in each category**
- We use variables which are expected to have low correlation to extra jets

HighVPt



LowVPt



Next steps

- Going to Lowmjj region in CR to improve uncertainty
- Comparison of NLO/LO γjj to figure out how much our modeling is well fit.

Back up

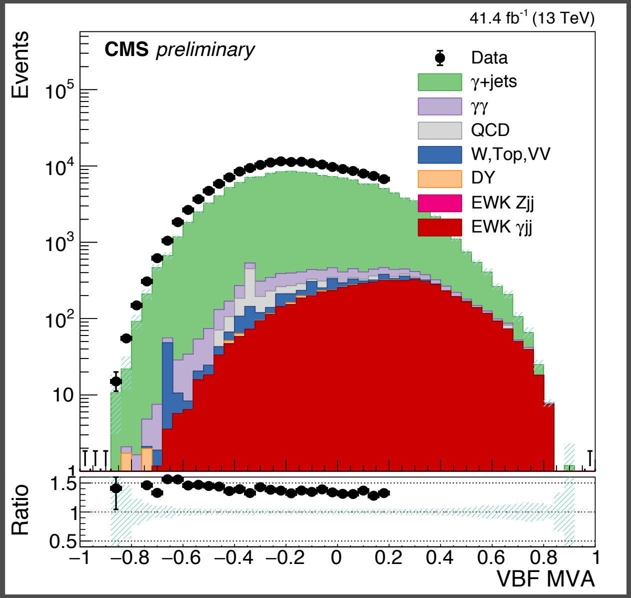
m_{jj}	dijet invariant mass	1	1
y^*	boson rapidity in dijet rest frame	2	3
$\delta\phi_{\mathrm{jj}}$	dijet azimuthal angle opening	3	10
$\mathrm{rel.}p_{\mathrm{T}}$	scalar p_{T}-sum of the jets over boson	4	—
d^1_{qg}	quark-gluon discriminator of leading jet	5	8
$\Delta\phi(\mathrm{b},\mathrm{jj})$	azimuthal angle between boson and dijet	6	6
circularity	event circularity	7	—
d^2_{qg}	quark-gluon discriminator of subleading jet	8	7
$p_{\mathrm{T,jj}}$	dijet p_{T}	9	11
$\Delta\phi(\mathrm{b},\mathrm{j}_1)$	azimuthal angle between boson and leading jet	10	9
D	event D, $27(q_1 q_2 q_3)$	11	—
$\Delta\phi(\mathrm{b},\mathrm{j}_2)$	azimuthal angle between boson and subleading jet	—	2
$p_{\mathrm{T,j_2}}$	subleading jet p_{T}	—	4
$\Delta\eta_{\mathrm{jj}}$	Psudorapidity opening of the two jets	—	5

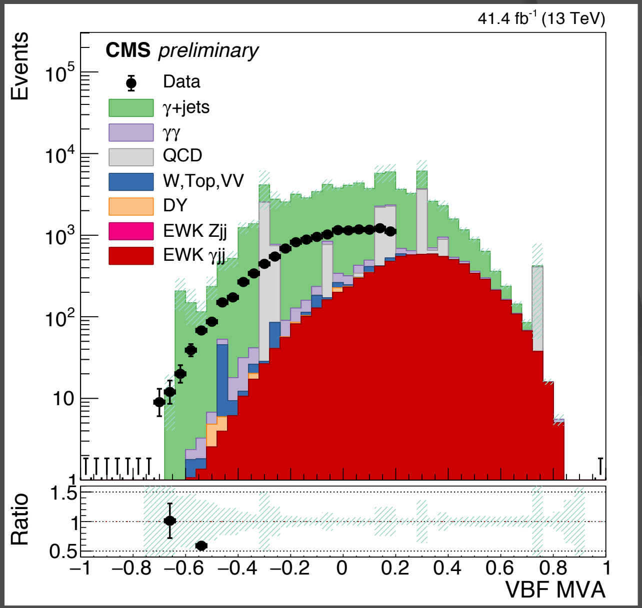
Discriminator in 2017/2016 data

HighVPt

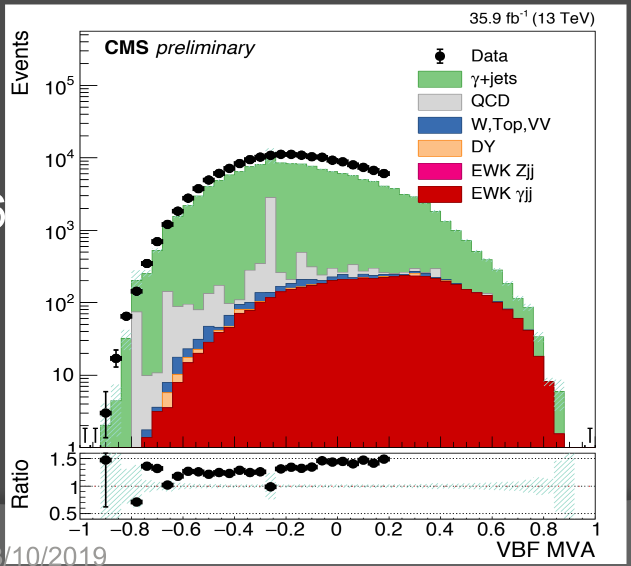
LowVPt

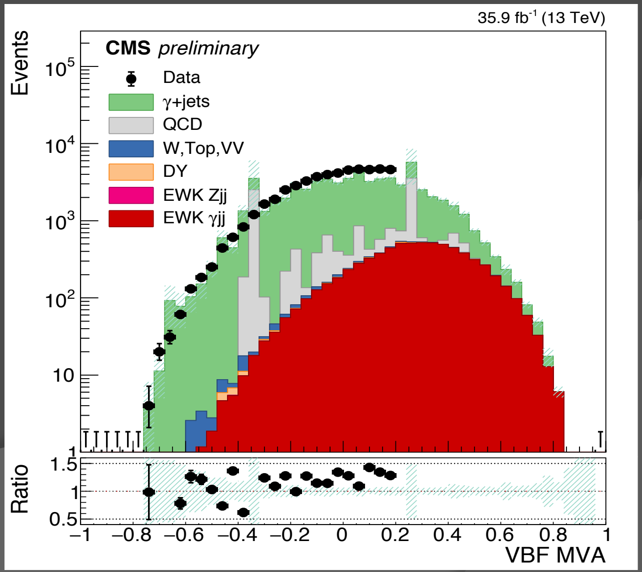
2017





2016





Event categorization used in analysis

	$75 < P_T(\gamma) < 175(200)$	$P_T(\gamma) > 175(200)$
Mjj>500GeV	LowVPt $\|\eta(\gamma)\|<1.442$, $R_9 > 0.9$ $\|\eta(jj)\|>3.0$	HighVPt Single-photon sample