Central jets in $H \rightarrow WW^{(*)} \rightarrow l\nu l\nu$ + 2 jets

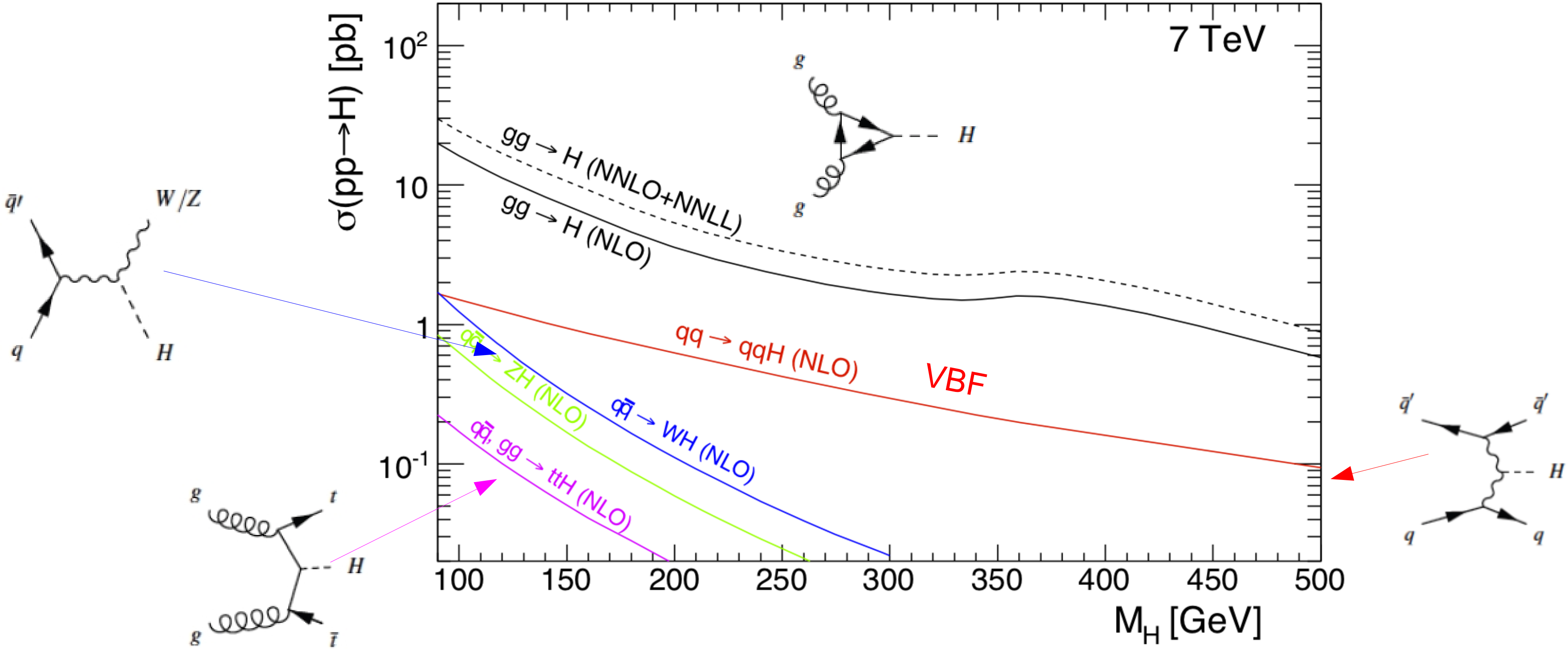
Pai-hsien Jennifer Hsu

Johannes-Gutenberg Universitaet Mainz

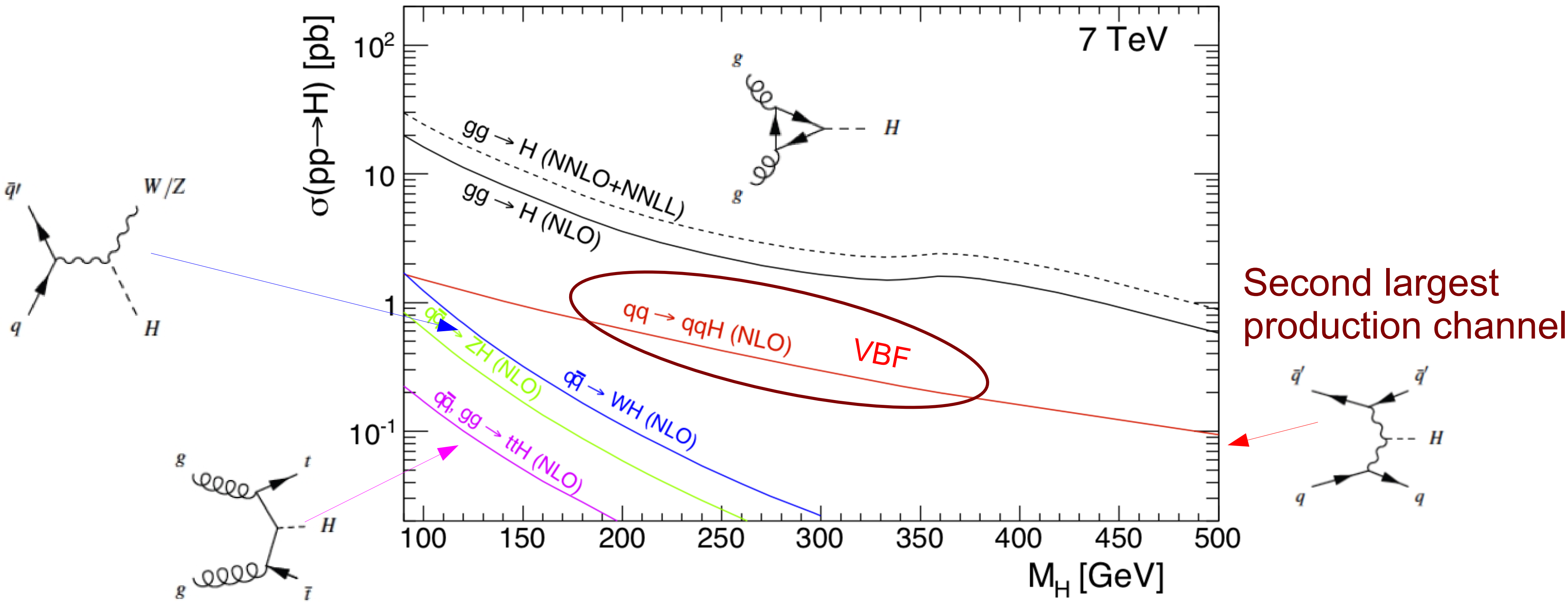
Outline

- Introduction to VBF analysis for $H \rightarrow WW^{(*)} \rightarrow l\nu l\nu$ in ATLAS.
- Generator-level studies on central jet veto (CJV) in VBF $H \rightarrow WW^{(*)} \rightarrow l\nu l\nu$

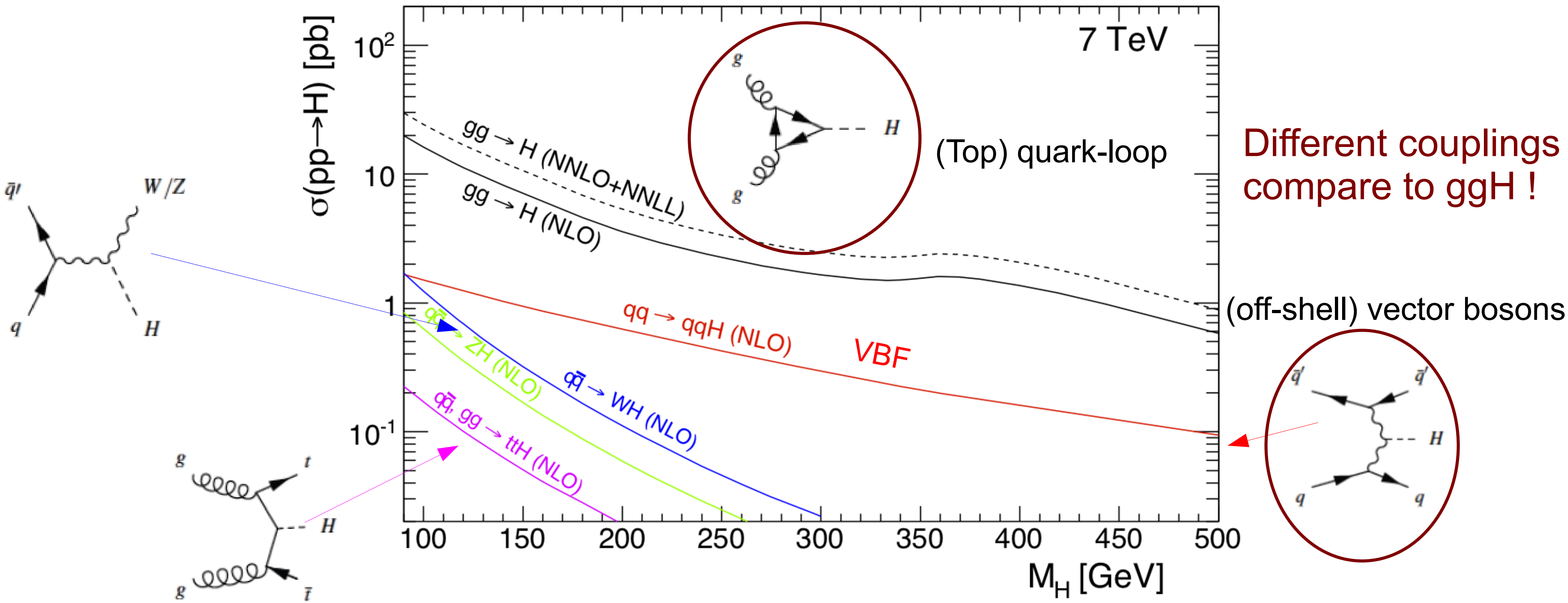
Higgs Production at LHC



Higgs Production at LHC

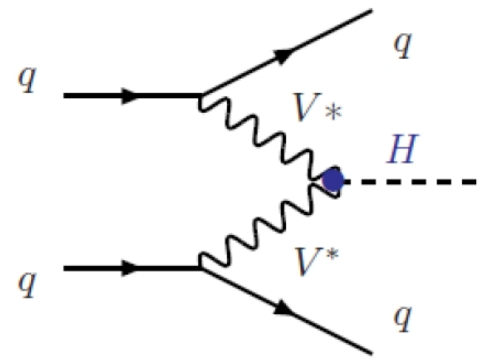


Higgs Production at LHC

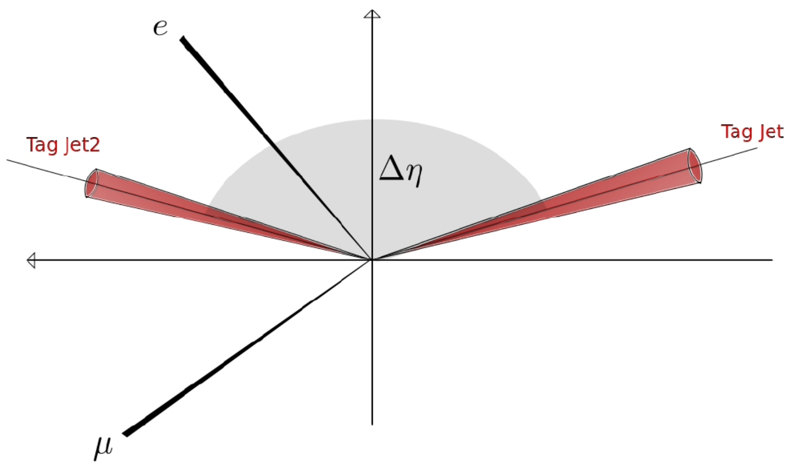


$H \rightarrow WW^{(*)} \rightarrow l\nu l\nu$ from VBF

- What the Feynman diagram shows:



- What we see in the detector:

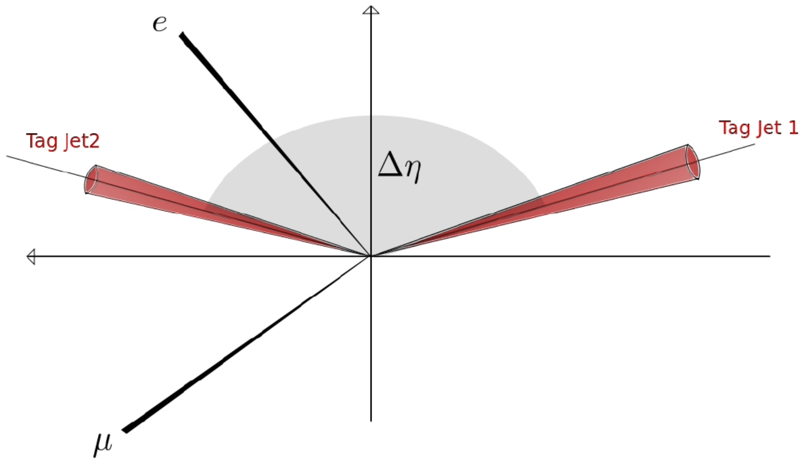


$H \rightarrow WW^{(*)} \rightarrow l\nu l\nu$ from VBF

- Signal: Di-lepton (ee,eμ,μμ) + Missing E_T (ν)

  + 2 high-Pt jets in the forward regions ("tag jets")

- Major Backgrounds:
  - Top quark pairs (ttbar)
  - WW
  - W + jets

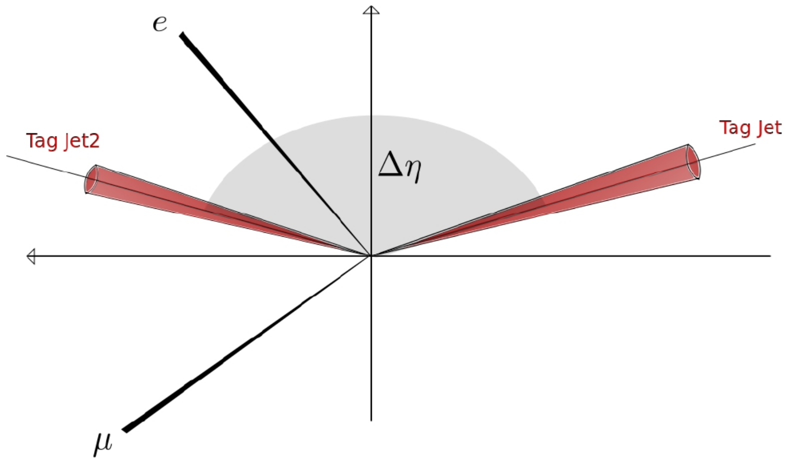


$H \rightarrow WW^{(*)} \rightarrow l\nu l\nu$ from VBF

- Signal: Di-lepton (ee,eμ,μμ) + Missing E_T (ν)

  + 2 high-Pt jets in the forward regions ("tag jets")

- Major Backgrounds:
  - Top quark pairs (ttbar)
  - WW
  - W + jets



$H \rightarrow WW^{(*)} \rightarrow l\nu l\nu$ + 2j cuts

- Signal: Di-lepton (ee,eμ,μμ) + Missing E_T (ν)
  + 2 high-Pt jets in the forward regions ("tag jets") → tag jets are well-separated in pseudorapidity η
- No color charge flow in the central region → central jet activity is suppressed.
- Can reject ttbar by
  - b-tagging (reject events with b-tagged jets)
  - Central jet veto (CJV)

CJV in H → WW @ ATLAS

- Central jets: Additional jets between the *rapidity* gap spanned by the two tag jets. → $y_{j1} < y < y_{j2}$
- With jet Pt threshold at 20 GeV, rejecting ~50% ttbar.
- Cutting away ~10% H → WW VBF signal.
- → Generator-level study on central jets in VBF H → WW*

* Study by Marc Geisen, student from Mainz.

Central jets in VBF H → WW

- Datasets: VBF H → WW* → *lνlν* from Powheg+Pythia
- Take the following variations:

Data	Description
nominal	standard
ue_low	low value for the underlying event
ue_high	high value for the underlying event
mpioff*	underlying event switched off
radiation_off	radiation of the tagging-jets switched off
really_all_off	all radiations switched off

*MPI = Multi-parton interactions

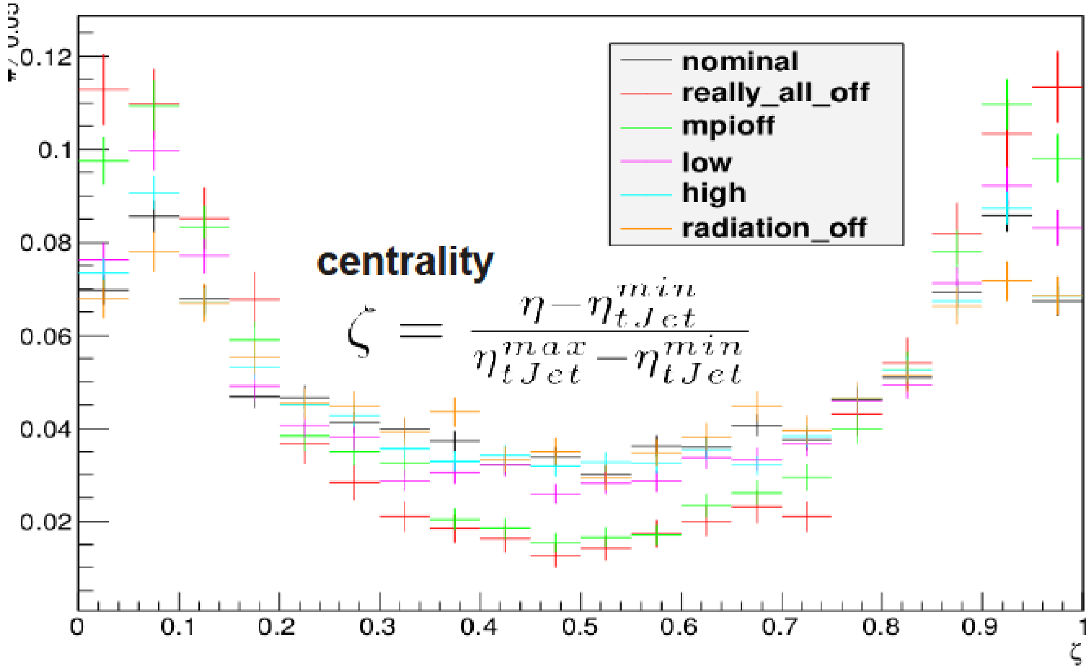
Central jets in VBF H → WW

- Datasets: VBF H → WW* → *lvlv* from Powheg+Pythia
- Apply the following cuts on truth jets:

  - Identification of „pseudo"-jets (a single lepton fakes a jet)
    - $\Delta R(\mathrm{jet,lepton}) < 0.2$
  - Identification of the tagging-jets (tJet) (defined as the 2 jets with highest p_t)
    - $\eta_{tJet1} * \eta_{tJet1} < 0$
    - $|\eta_{tJet1} - \eta_{tJet2}| > 3.8$
    - $M_{tJet1,tJet2} = ||p_{tJet1} + p_{tJet2}|| > 500$ GeV
    - $\Delta R(\mathrm{tJet,parton}) < 0.5$
  - Central-jet-veto
    - $\eta_{tJet1}^{min} < \eta < \eta_{tJet1}^{max}$

Central jets in VBF H → WW

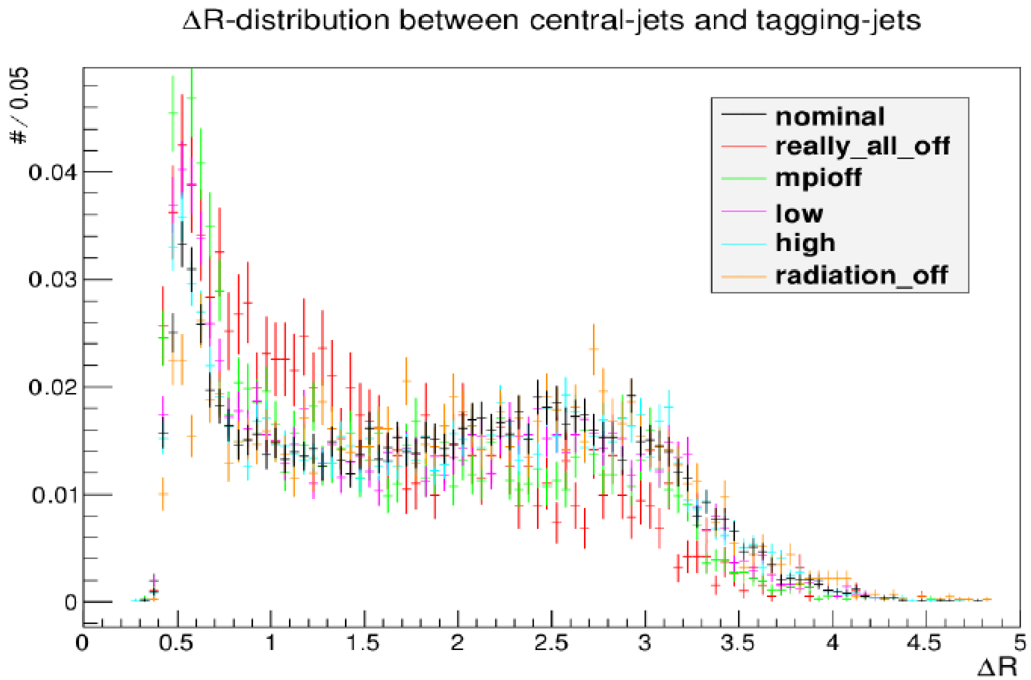
- Shape comparison of "centrality": 0 or 1 = near one of the t-jets.
- A lot of central jets in signal are near the tag jets. → FSR



Generator-level study

Central jets in VBF H → WW

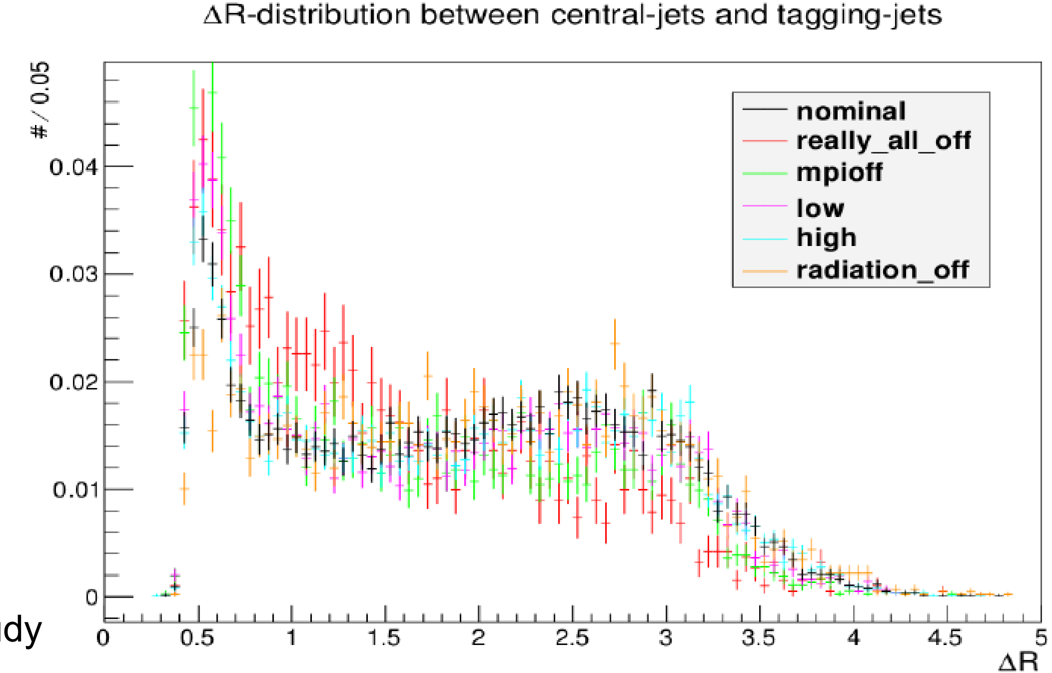
- A lot of central jets in signal are near the tag jets. → FSR
- A ΔR-cut can help keeping those signals.



Generator-level study

Central jets in VBF H → WW

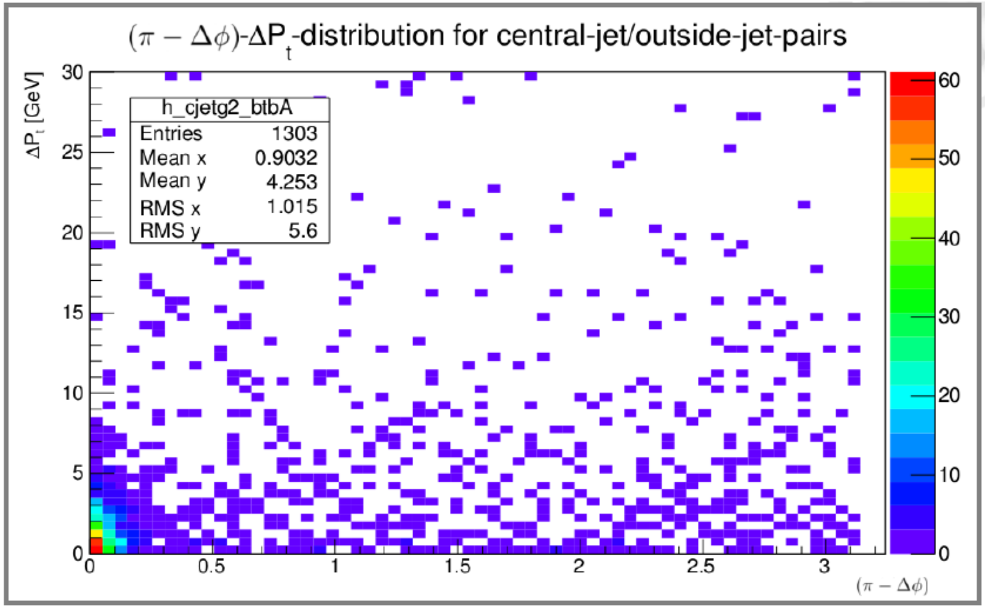
- Central jets that are NOT close to tag jets: Pile-up?
- May be able to identify pile-up jets by pairing central jets and additional jets that are back-to-back.
- Work in progress: $\chi 2$ discriminant of back-to-back central jets.



Generator-level study

Central jets in VBF H → WW

- Central jets that are NOT close to tag jets: Pile-up?
- May be able to identify pile-up jets by pairing central jets and additional jets that are back-to-back.
- Work in progress: $\chi 2$ discriminant of back-to-back central jets.



Generator-level study

data: „radiation_off“

Conclusion and Outlook

- Understanding the origin of central jets in VBF signals can help improving the significance.
- Generator-level studies using VBF H $\rightarrow$ WW* $\rightarrow$ *lvlv* shows that the potential sources of central jets are FSR from tag jets and pile-up.
- CJV including a ΔR and/or a χ2 cut may keep those signals.
- Next step: Comparing to background processes.

Backup

$H \rightarrow WW^{(*)} \rightarrow l\nu l\nu$ + 2j cuts

- Standard 2j cut flow (after basic pre-selection):

ATLAS: (5.8 fb-1)

H+ 2-jet	Signal	WW	$WZ/ZZ/W\gamma$	$t\bar{t}$	$tW/tb/tqb$	Z/γ^{*} + jets	W + jets	Total Bkg.	Obs.
$\geq$ 2 jets	14.5 ± 0.2	139 ± 3	30 ± 2	7039 ± 24	376 ± 11	104 ± 12	71 ± 4	7759 ± 29	7845
b-jet veto	9.6 ± 0.2	95 ± 2	19 ± 1	356 ± 6	44 ± 4	62 ± 9	21 ± 2	597 ± 12	667
$\lvert\Delta Y_{jj}\rvert > 3.8$	2.0 ± 0.1	8.3 ± 0.6	2.0 ± 0.4	31 ± 2	5 ± 1	4 ± 2	1.4 ± 0.5	52 ± 3	44
Central jet veto (20 GeV)	1.6 ± 0.1	6.5 ± 0.5	1.3 ± 0.3	16 ± 1	4 ± 1	1 ± 1	0.5 ± 0.3	29 ± 2	22
$m_{jj} > 500$ GeV	1.1 ± 0.0	3.2 ± 0.4	0.7 ± 0.2	6.2 ± 0.7	1.8 ± 0.6	0.0 ± 0.0	0.0 ± 0.2	12 ± 1	13
$\lvert p_T^{tot}\rvert < 30$ GeV	0.8 ± 0.0	1.7 ± 0.3	0.3 ± 0.1	2.5 ± 0.5	0.8 ± 0.4	0.0 ± 0.0	0.0 ± 0.2	5.4 ± 0.7	6
$Z \rightarrow \tau\tau$ veto	0.7 ± 0.0	1.8 ± 0.3	0.3 ± 0.1	2.4 ± 0.4	0.8 ± 0.4	0.0 ± 0.0	0.0 ± 0.2	5.2 ± 0.7	6
$m_{\ell\ell} < 80$ GeV	0.7 ± 0.0	0.6 ± 0.2	0.1 ± 0.1	0.8 ± 0.3	0.3 ± 0.2	0.0 ± 0.0	0.0 ± 0.2	1.9 ± 0.5	3
$\Delta\phi_{\ell\ell} < 1.8$	0.6 ± 0.0	0.5 ± 0.2	0.1 ± 0.1	0.5 ± 0.3	0.3 ± 0.2	0.0 ± 0.0	0.0 ± 0.2	1.4 ± 0.4	2

ATLAS-CONF-2012-098