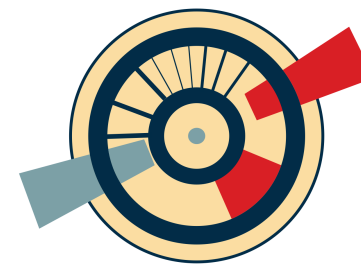
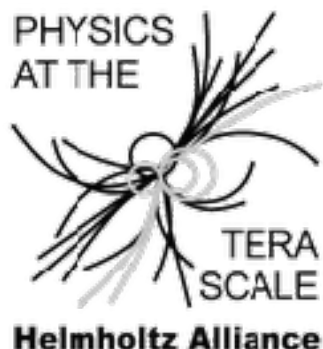


Measurement of the Scattering of Electroweak Gauge Bosons in the $WZjj$ Final State with the ATLAS Detector

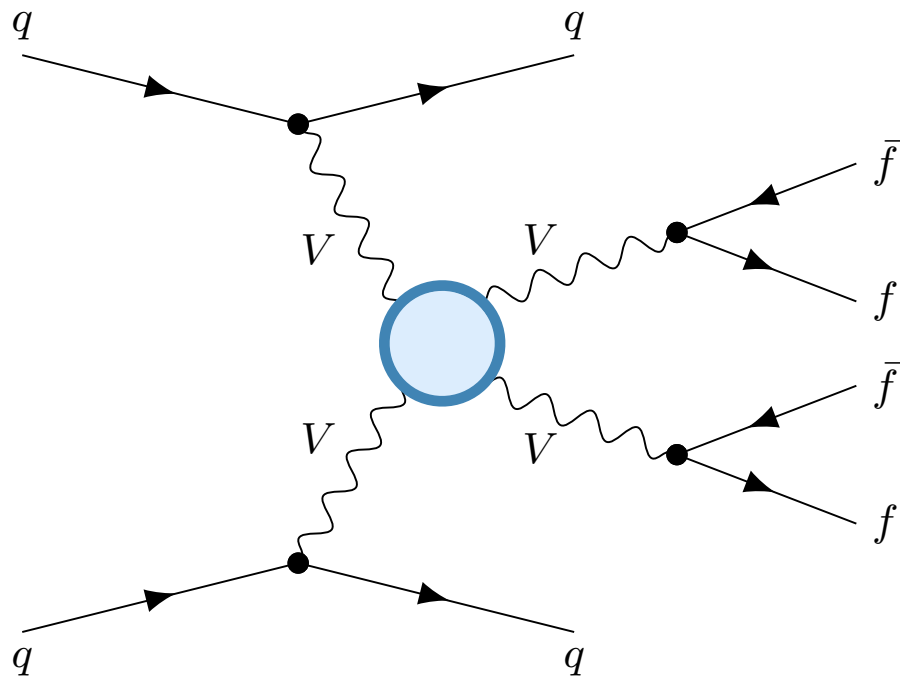
Carsten Bittrich (carsten.bittrich@cern.ch)

Institut für Kern- und Teilchenphysik, TU Dresden



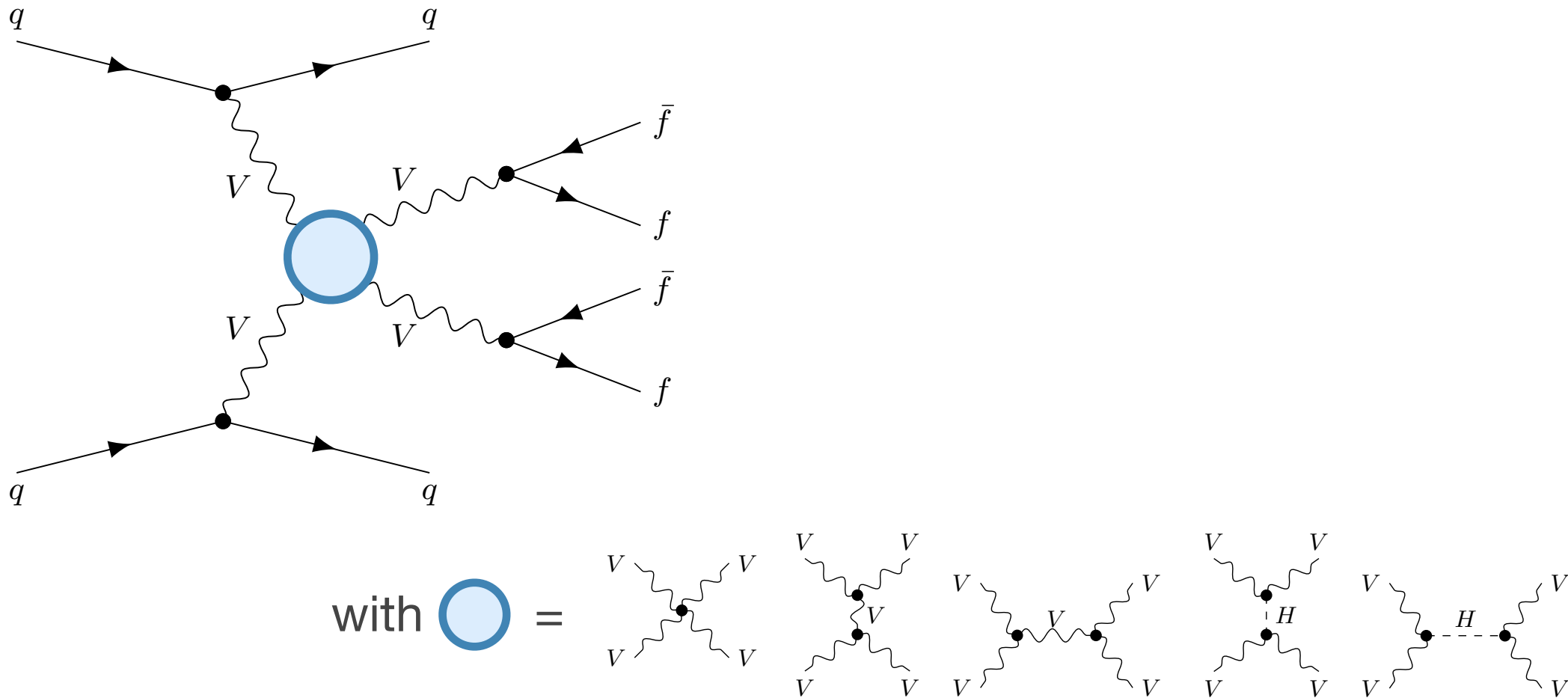
Vector Boson Scattering

$O(\alpha_W^6)$ process with following diagrams at LO:



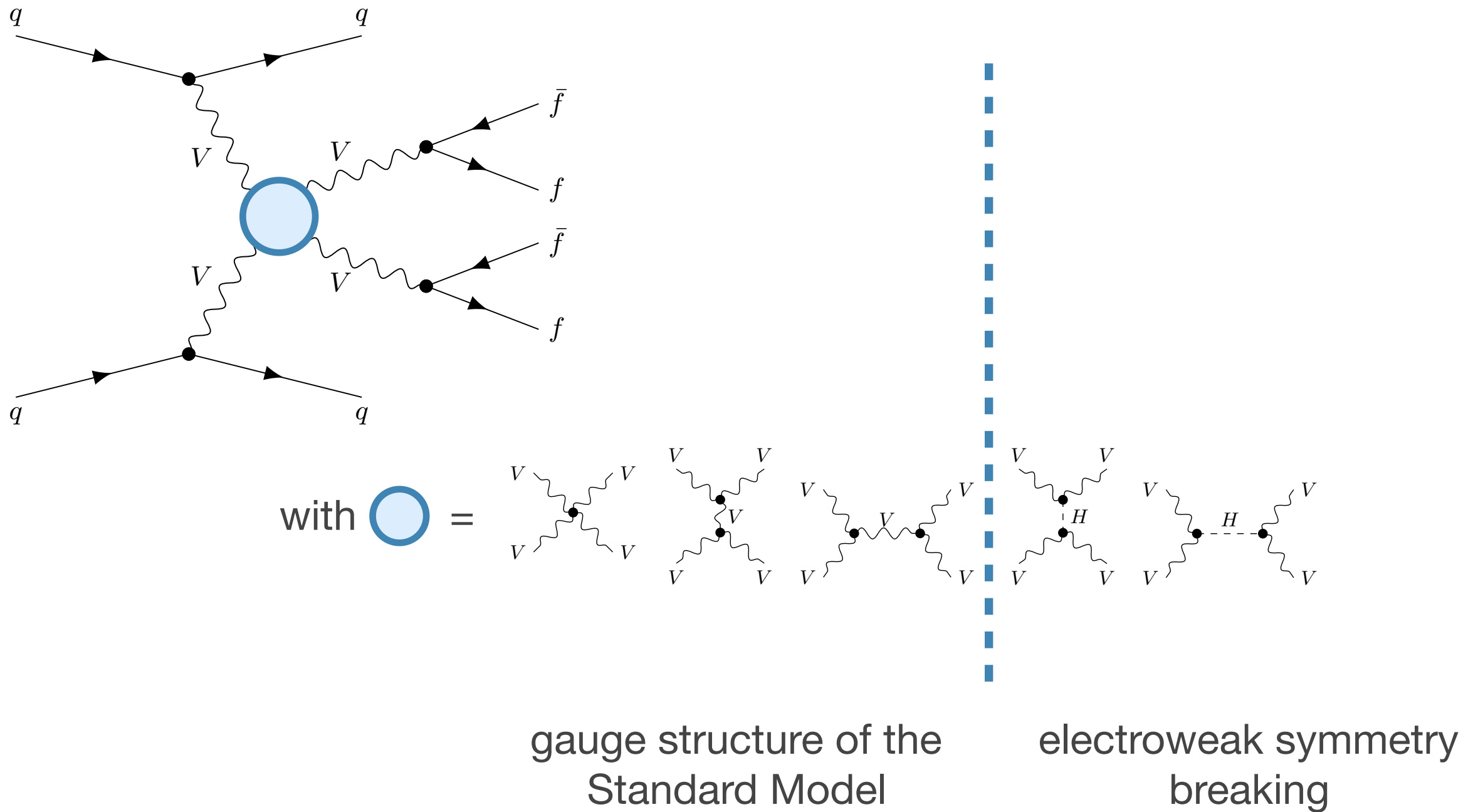
Vector Boson Scattering

$O(\alpha_W^6)$ process with following diagrams at LO:



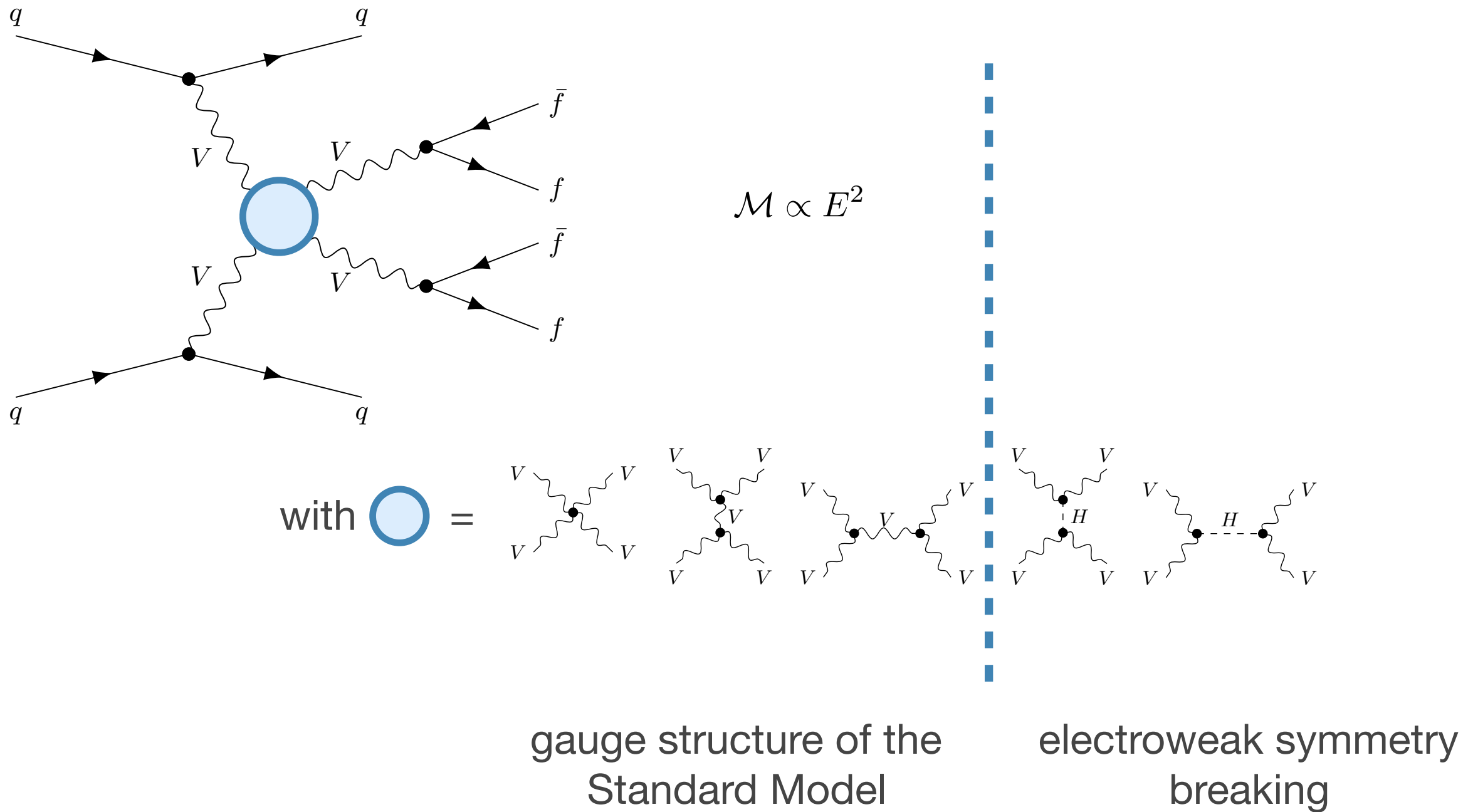
Vector Boson Scattering

$O(\alpha_W^6)$ process with following diagrams at LO:



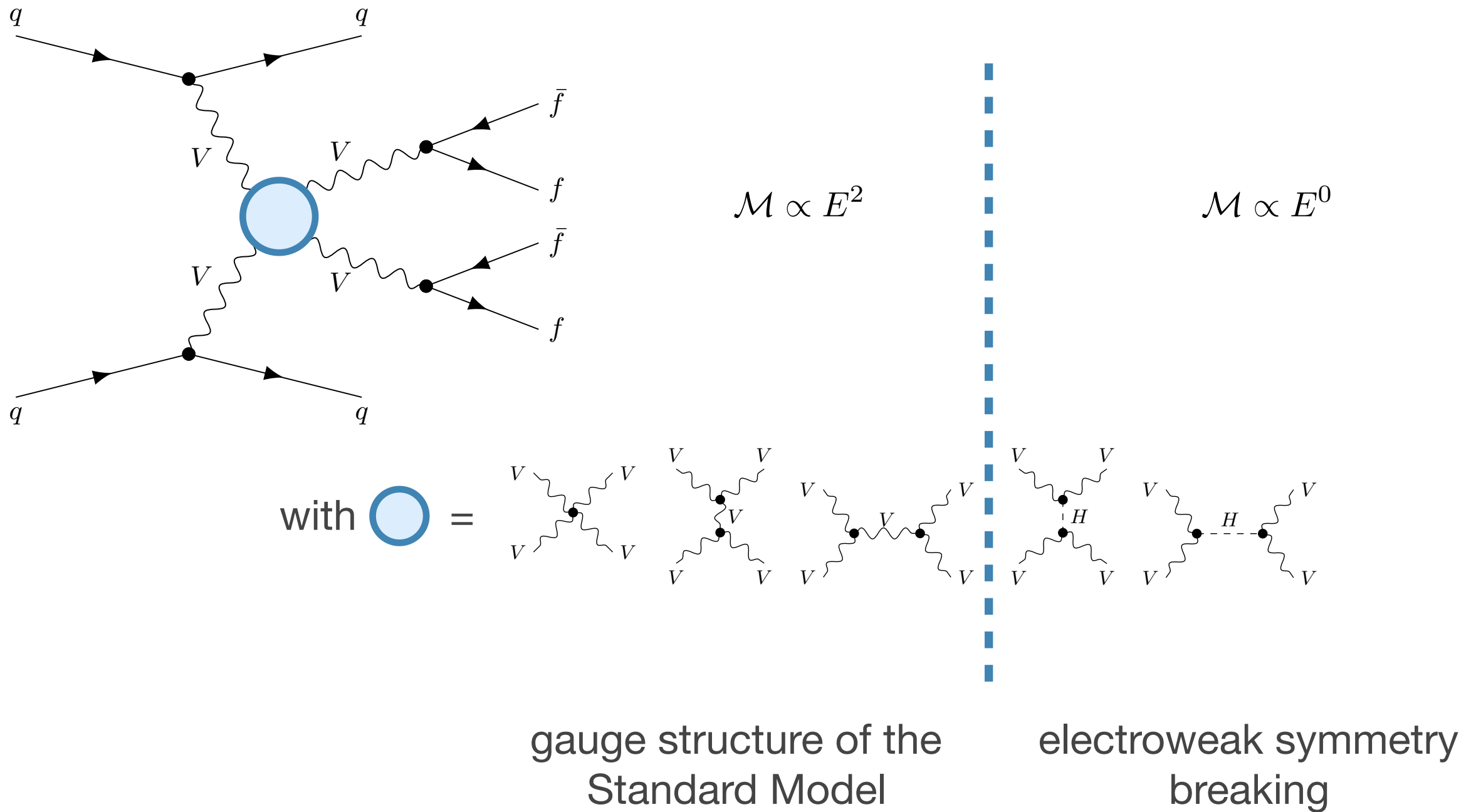
Vector Boson Scattering

$O(\alpha_W^6)$ process with following diagrams at LO:

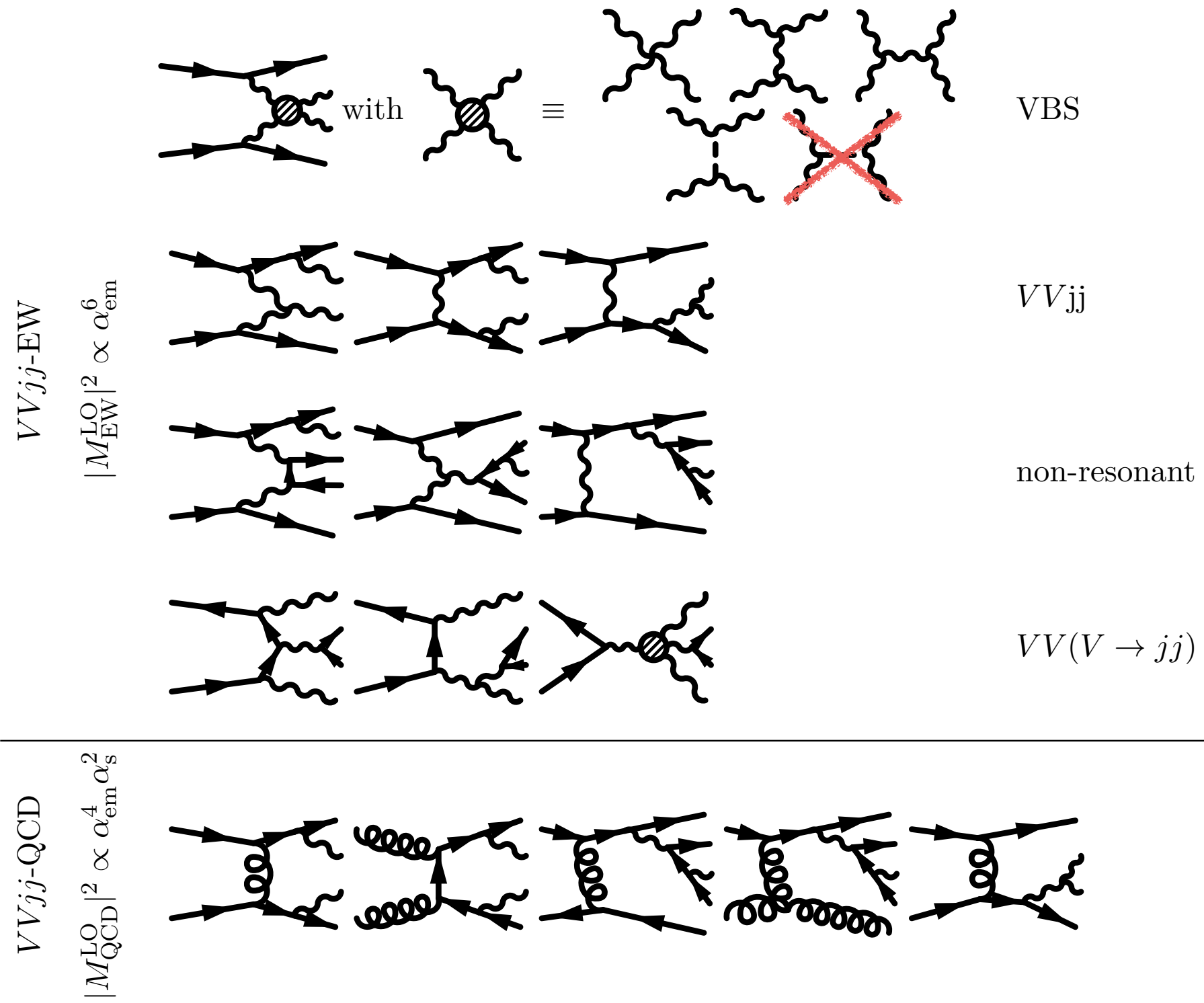


Vector Boson Scattering

$O(\alpha_W^6)$ process with following diagrams at LO:



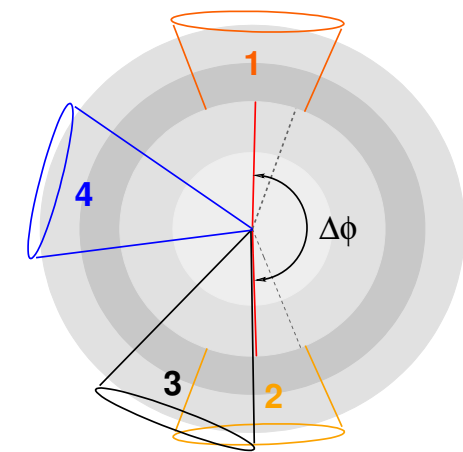
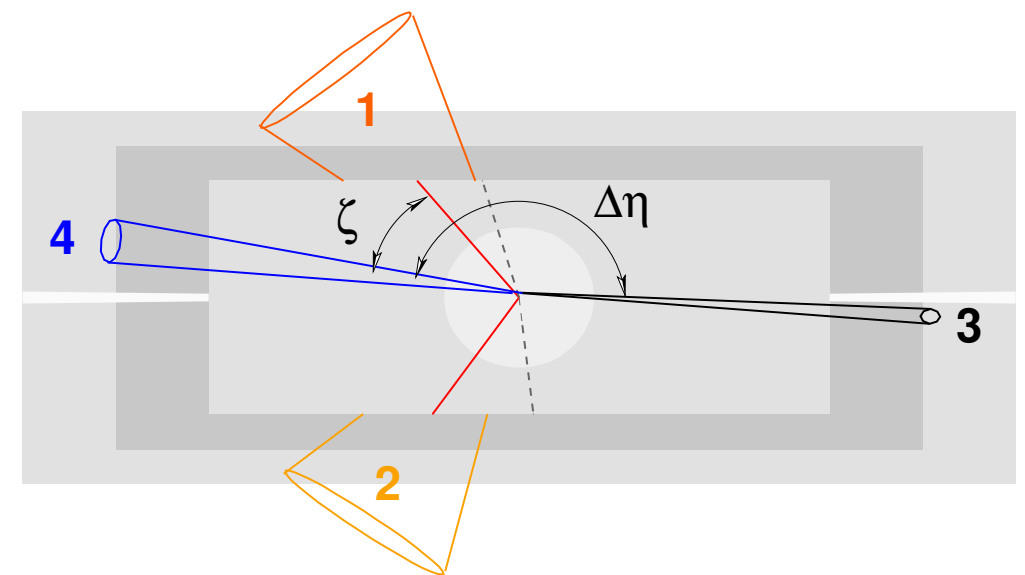
WZjj-EW Process Definition



Characteristic VBS Signature

Expected kinematic differences between WZjj-EW and WZjj-QCD

- tagging jets:
 - transverse momenta: $p_T(j_1)$ $p_T(j_2)$
 - invariant mass: M_{jj}
 - rapidity difference: ΔY_{jj}
- central jet veto
- centrality: $\max \left(\left| \frac{y_i - 0.5(y(j_1) + y(j_2))}{y(j_1) - y(j_2)} \right| \right)$
- boson/diboson decay products
- third jet
- p_T balance: $\frac{\sum_i \vec{p}_{T_i}}{\sum_i |\vec{p}_{T_i}|}$
- boson/diboson decay products and jets

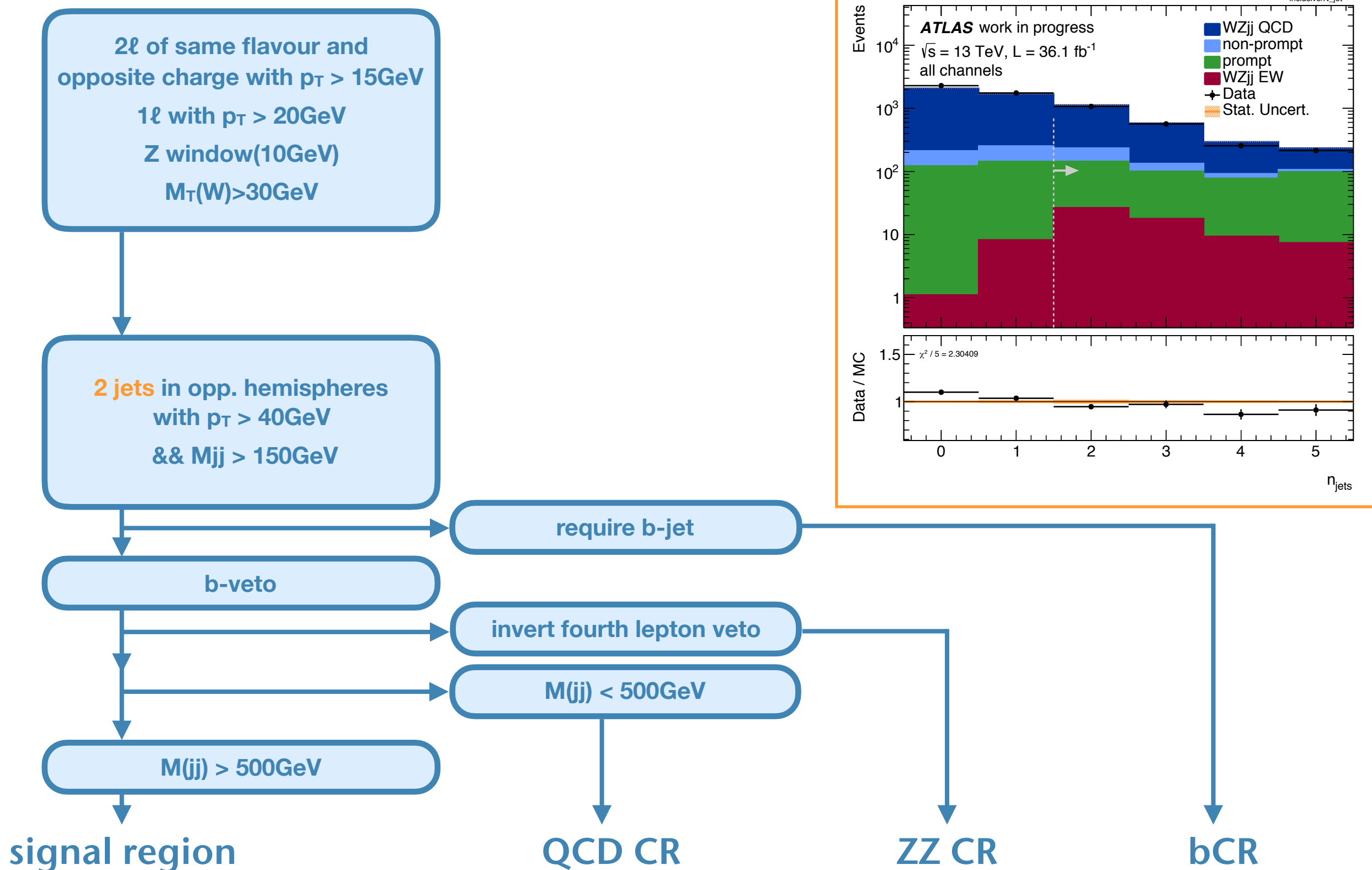


Analysis Strategy

- Previous analysis did cut&count measurement only using p_T and invariant mass of tagging jets. Result:
 - Rejected background only hypothesis with $> 1.8 \sigma$
- We are aiming for first evidence of this process in 2015+16 datasets employing more advanced techniques:
 - Train BDT in signal region to distinguish between WZjj-EW and backgrounds
⇒ uses more of the characteristic signature for each event
 - Perform simultaneous template fit of BDT score in signal region and other observables in different control regions
⇒ uses information of more events

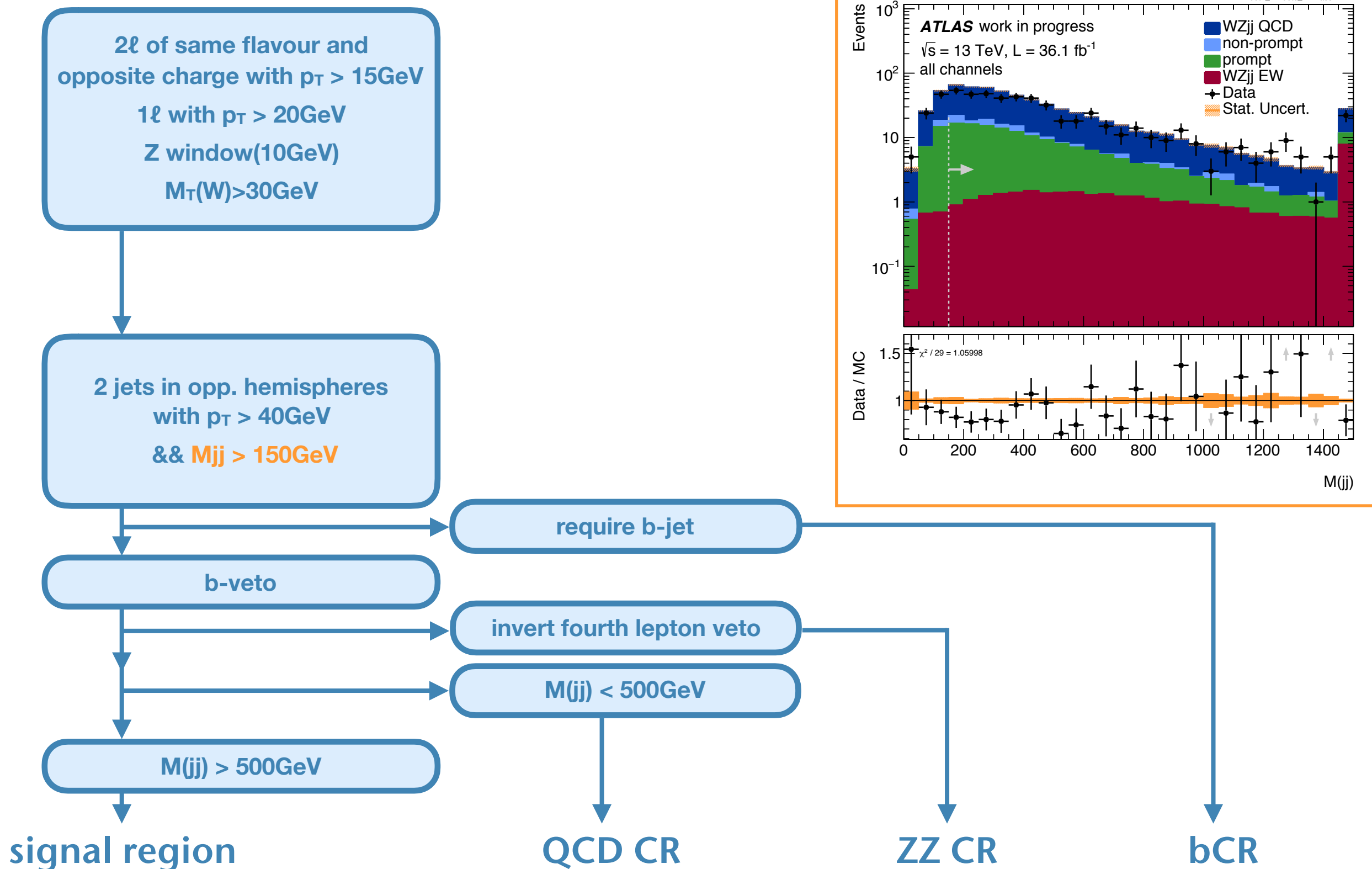
Outline Event Selection

WZ selection:



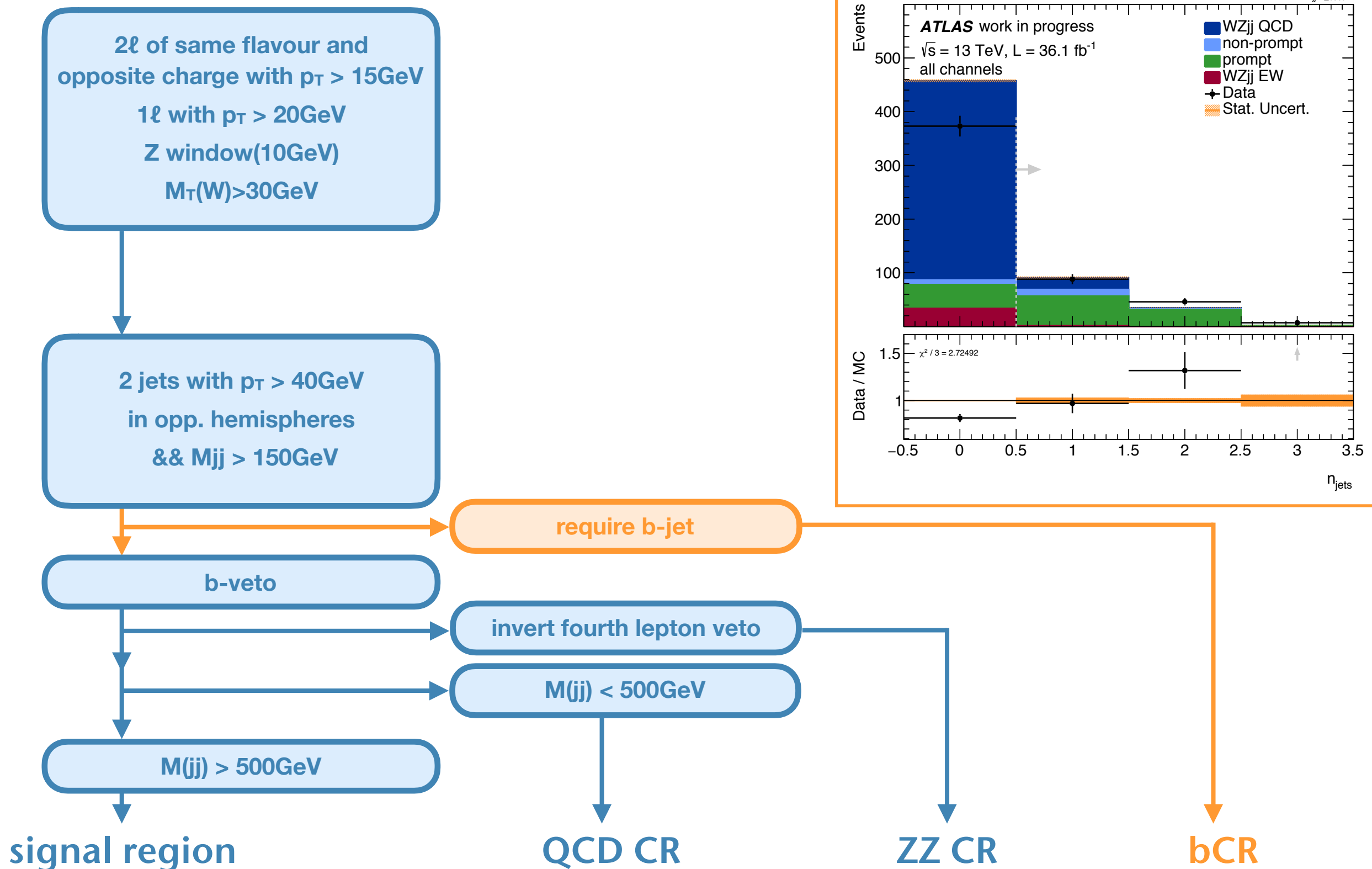
Outline Event Selection

WZ selection:



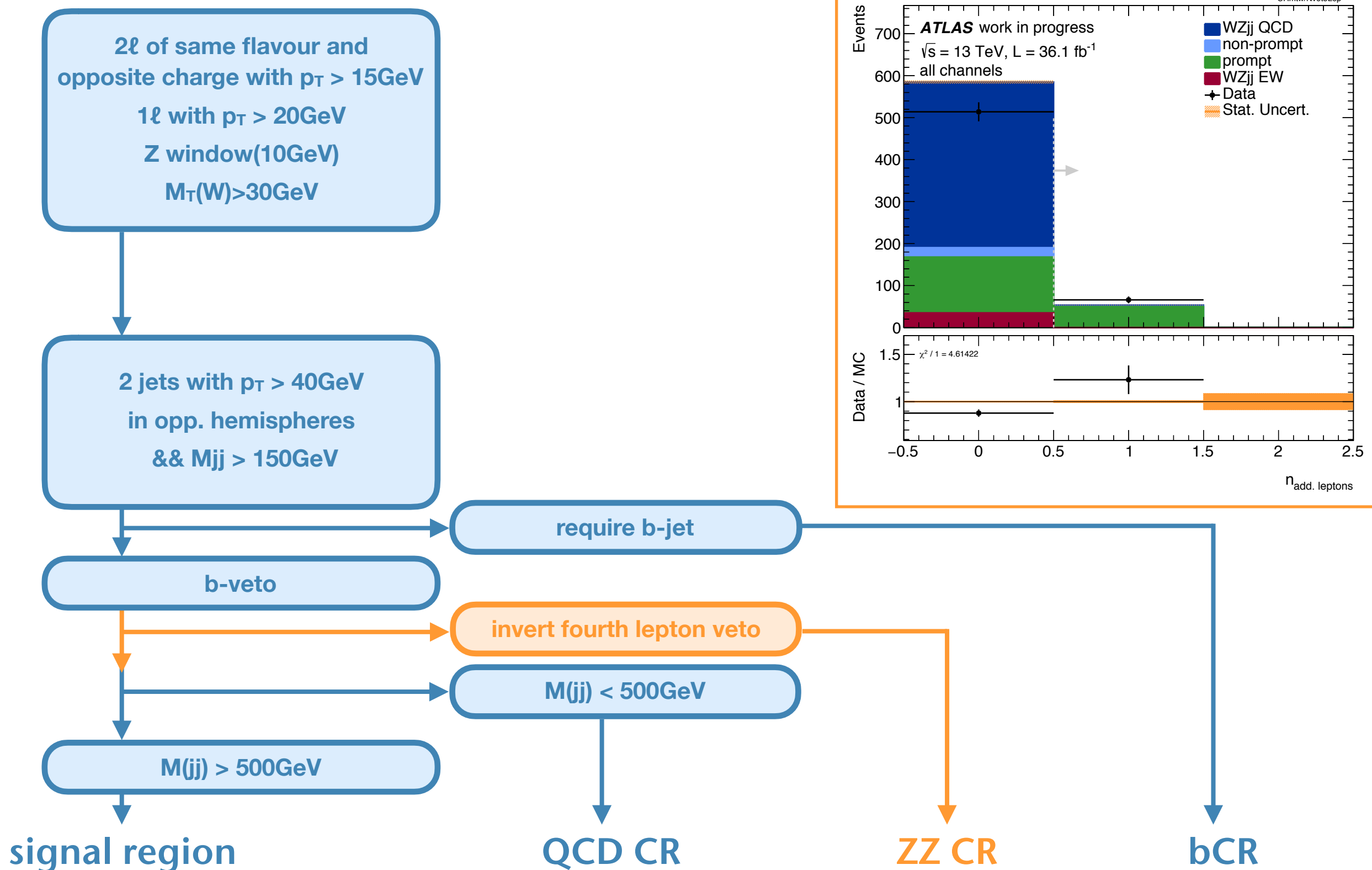
Outline Event Selection

WZ selection:



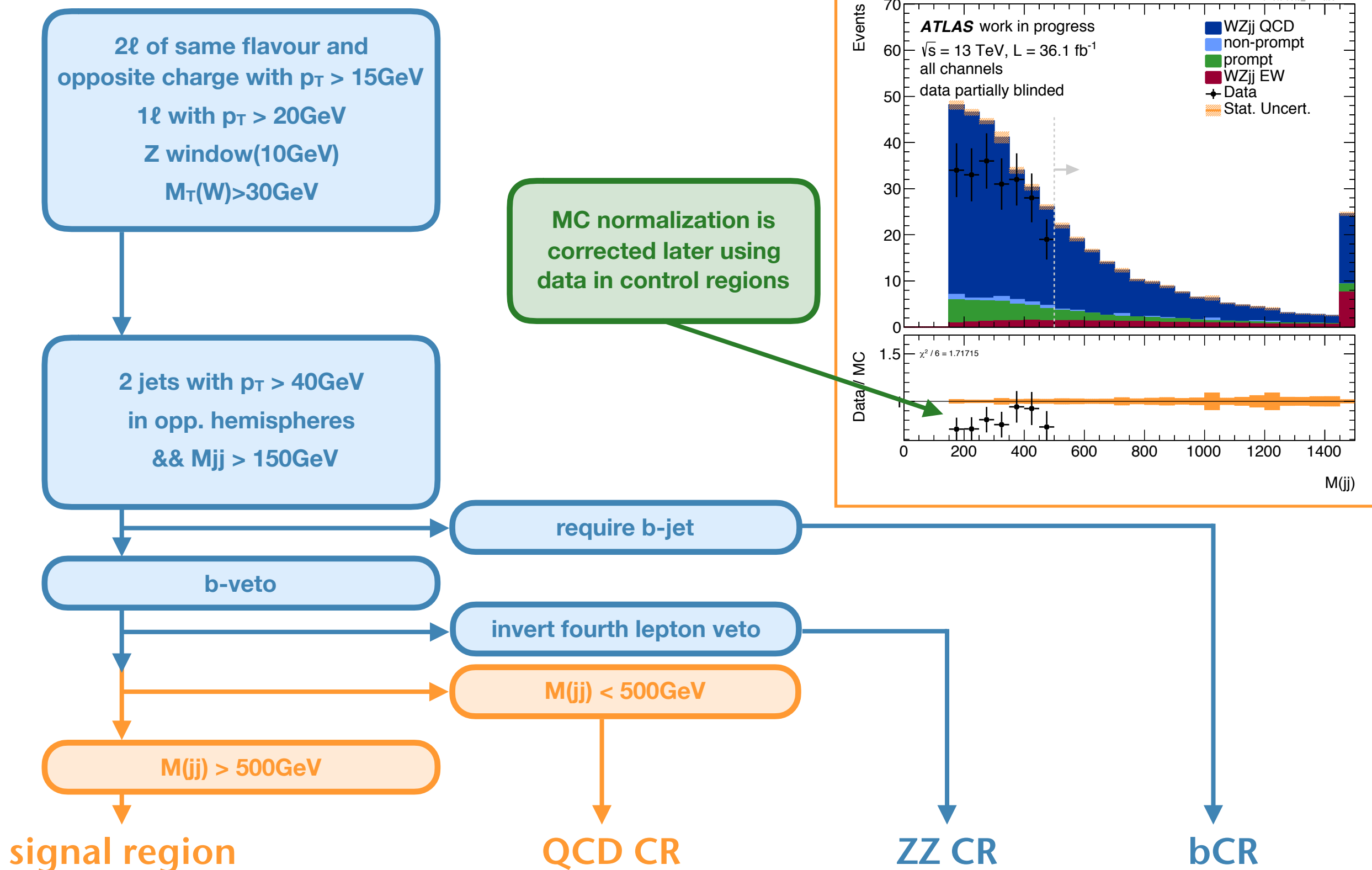
Outline Event Selection

WZ selection:



Outline Event Selection

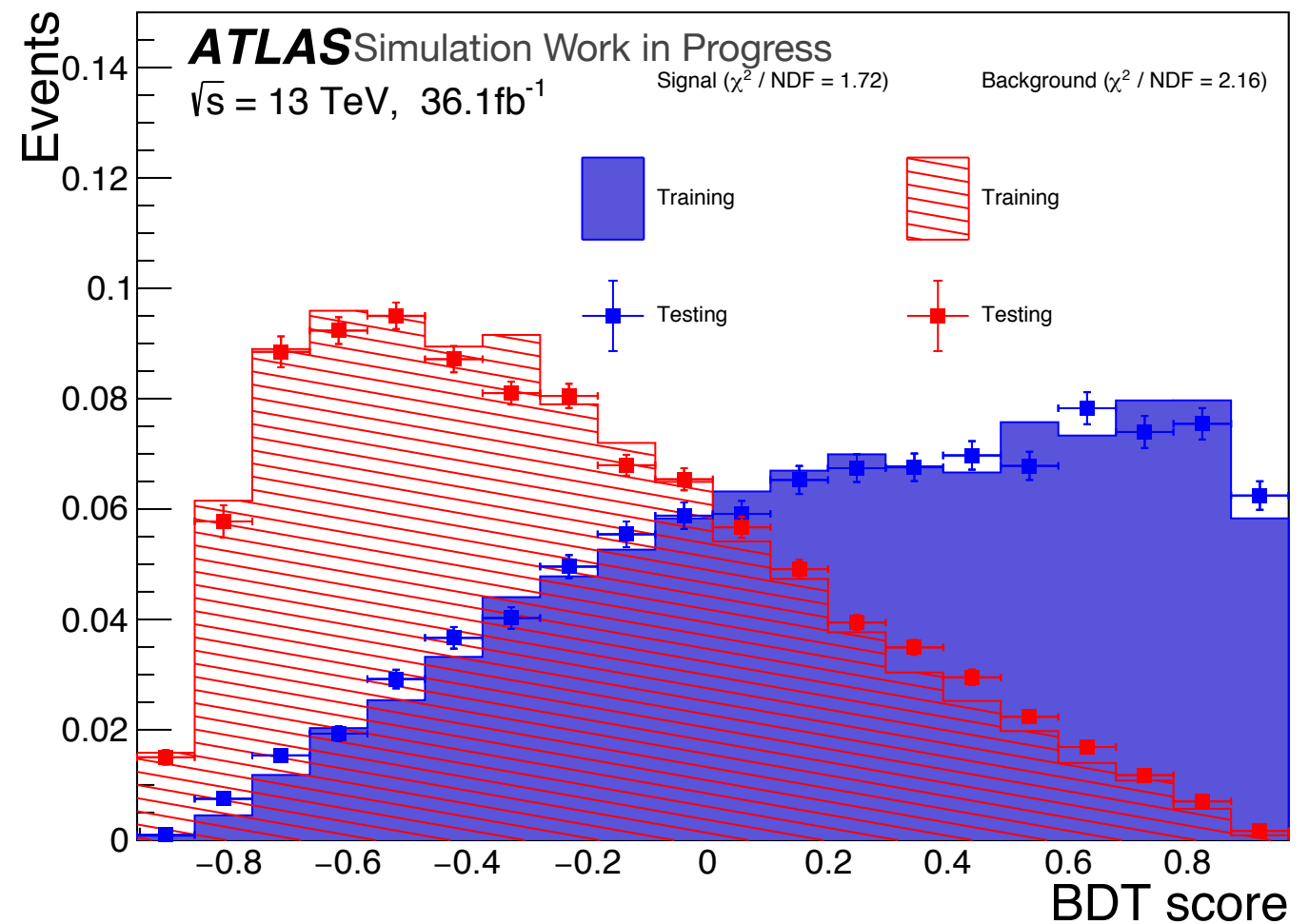
WZ selection:



Boosted Decision Tree

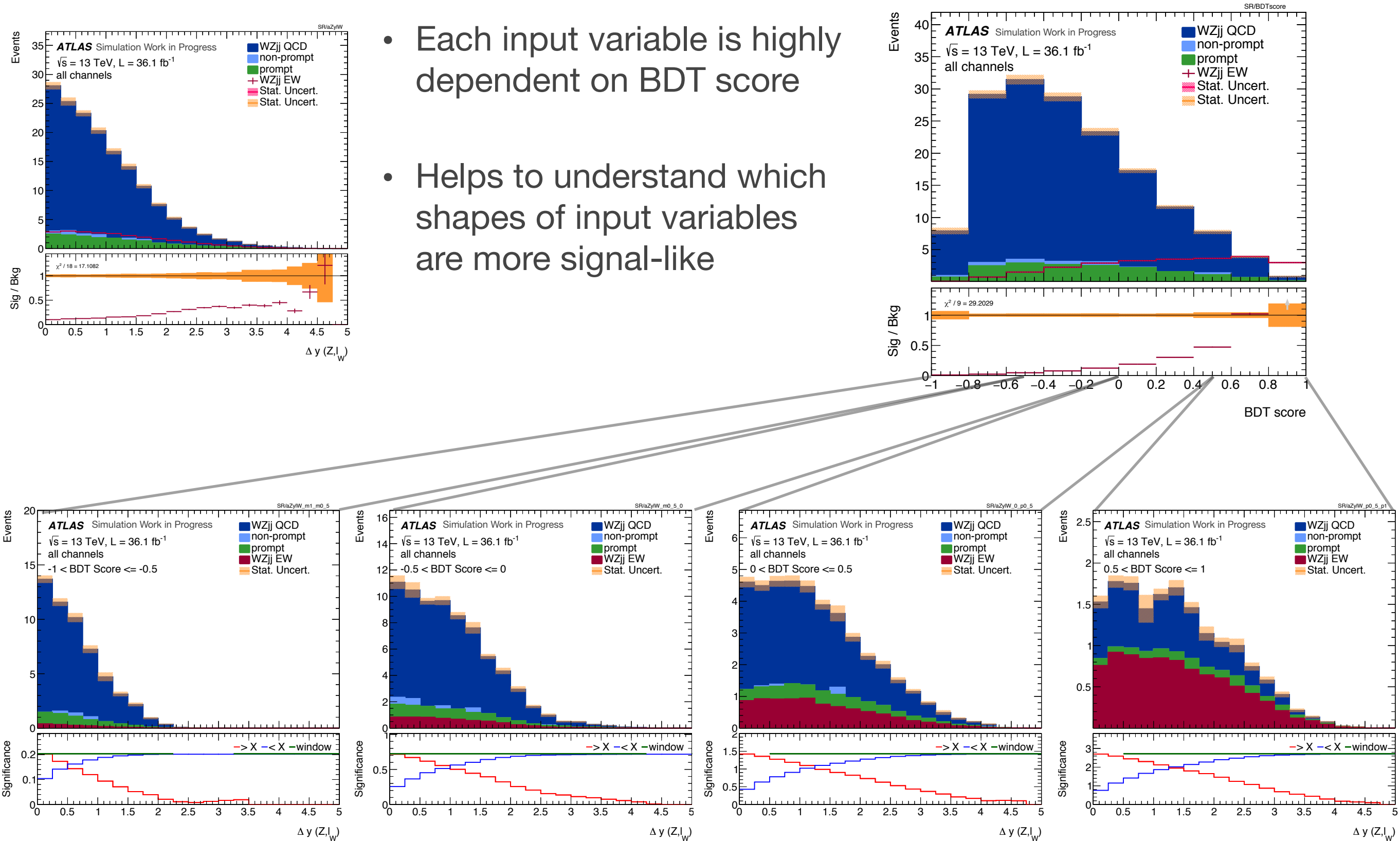
- BDT is trained to distinguish between WZjj-EW and backgrounds using 16 observables:

	Variable	Importance [%]
1	$\Delta y(\ell_W, Z)$	38.0
2	ζ	19.1
3	N_{jets}	11.6
4	$R_{p_T^{hard}}$	8.5
5	$\Delta R(j1, Z)$	4.3
6	η_W	3.5
7	η_{j1}	2.8
8	p_T^{j2}	2.4
9	p_T^{j1}	2.2
10	p_T^W	1.9
11	$\Delta\phi(j1, j2)$	1.4
12	m_{jj}	1.2
13	p_T^Z	1.1
14	$\Delta\eta(j1, j2)$	0.8
15	ζ_{jj}	0.7
16	m_T^{WZ}	0.6



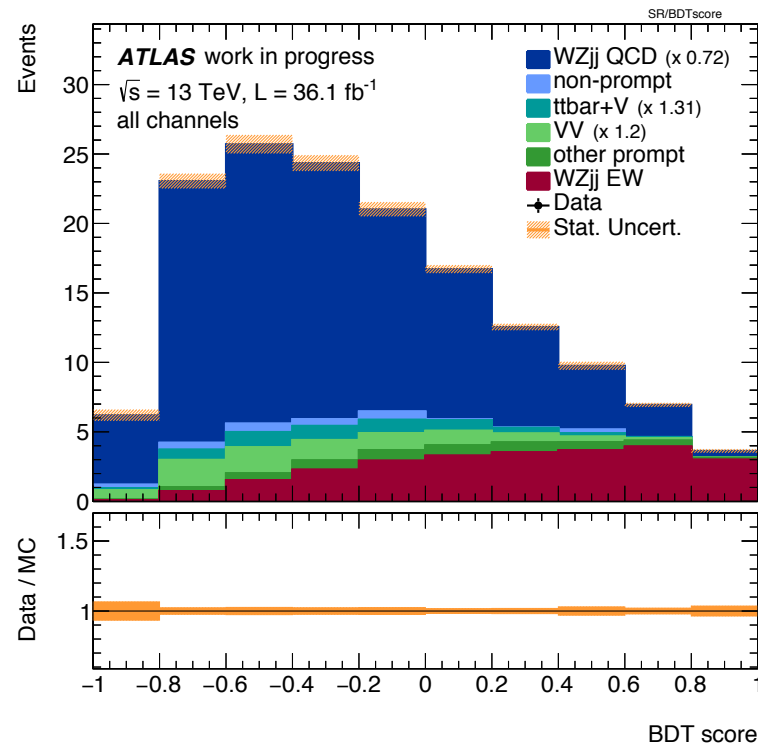
BDT Dependency for $\Delta y (\ell_w, Z)$

- Each input variable is highly dependent on BDT score
- Helps to understand which shapes of input variables are more signal-like

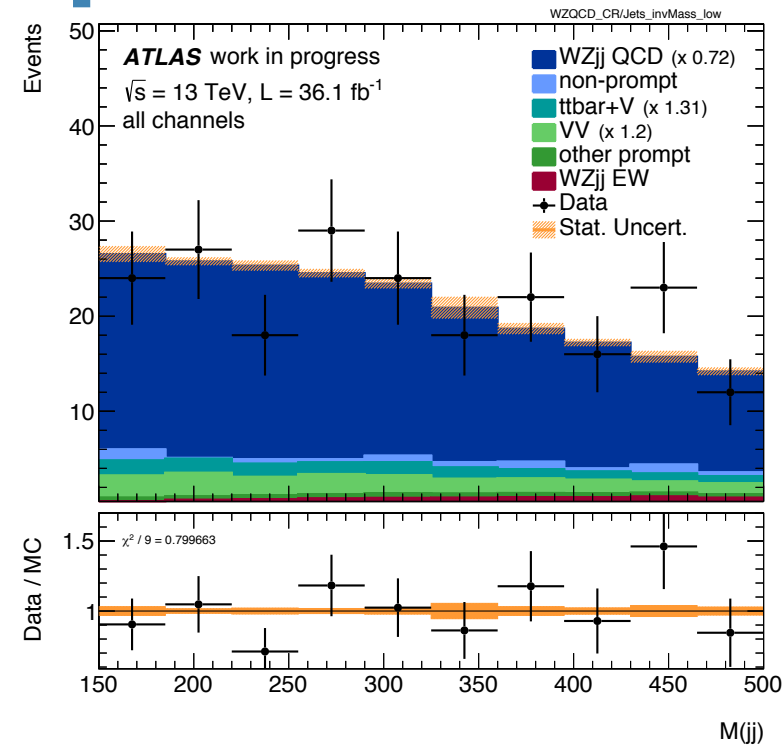


Fit input

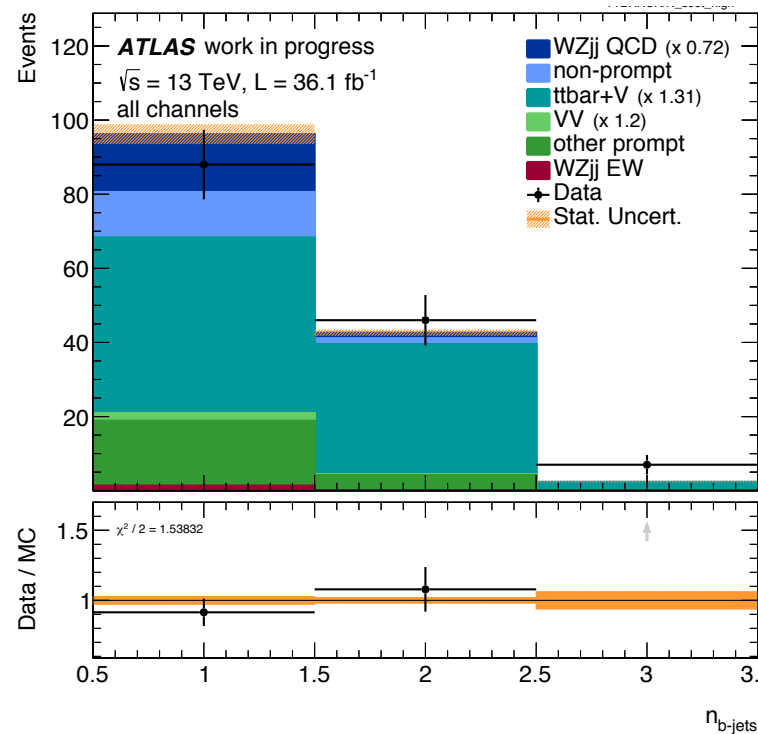
SR
(data
blinded)



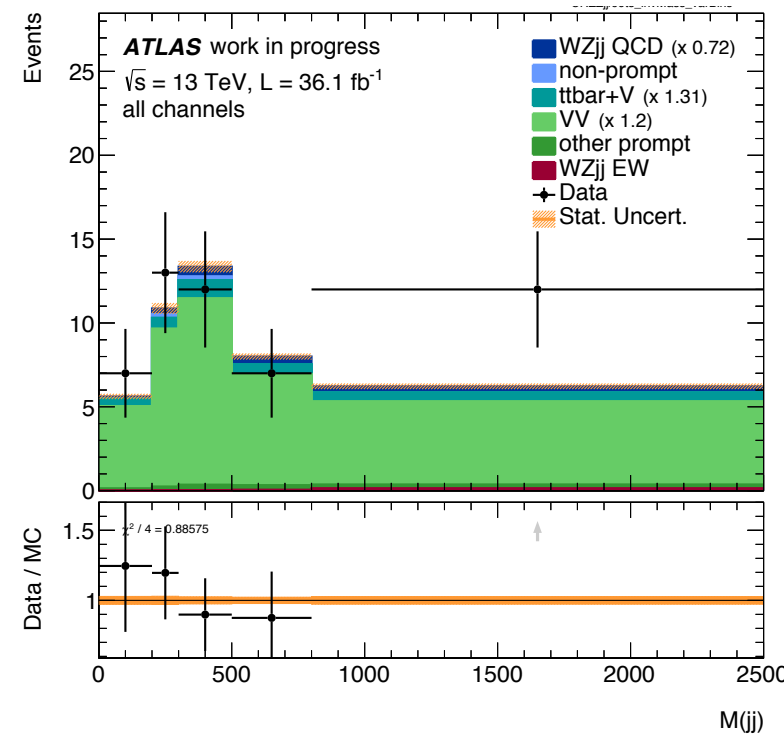
CR



bCR



ZZ CR



- Normalization of WZjj-QCD, ttV, ZZ only constrained directly from data
- Initial normalizations fitted using bkg-only fit in control regions before actual fit

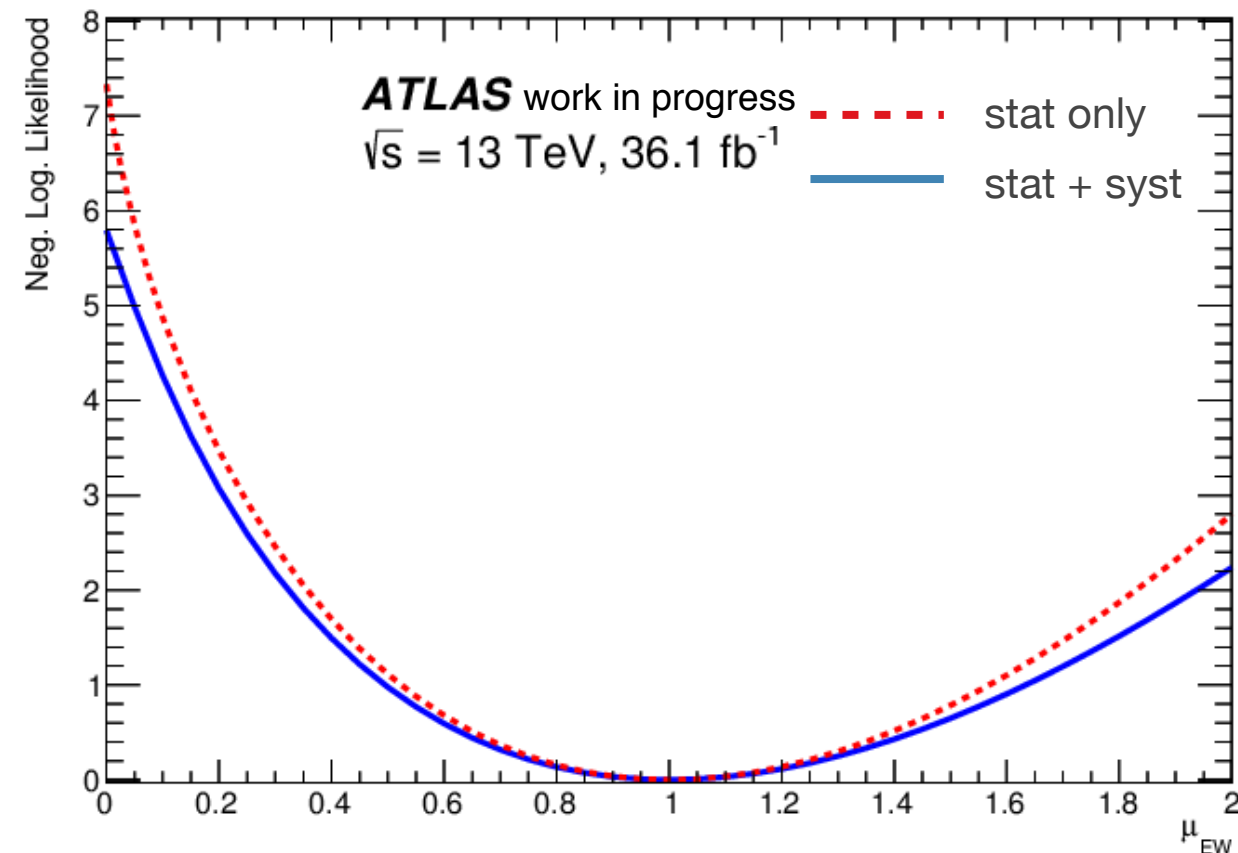
Result

Template fit with input from all 4 regions

Systematics:

- all objects systematics considered
- theory uncertainties on shape+normalization for WZjj QCD and WZjj EW
- conservative normalization uncertainties for all backgrounds

Expected signal strength:



$$\begin{aligned}\mu &= 1 + 0.40 - 0.35 \text{ (stat.)} + 0.19 - 0.14 \text{ (syst.)} \\ &= 1 + 0.44 - 0.38 \text{ (tot.)}\end{aligned}$$

Summary

- 2015 and 2016 dataset provides helpful information to investigate existence of WZjj EW process
- Still limited by statistical uncertainty
- Aiming for first evidence for WZjj EW using simultaneous template fit of BDT output score in signal region and distributions in three different control regions
- New methodology yields significantly better results than cut and count analysis performed in Run 1

Thank you for your attention!